Malathion
Analysis of Risks
to
Endangered and Threatened Salmon and Steelhead

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Summary

Malathion is a broad spectrum, non-systemic organophosphorous insecticide that is used on a wide variety of crop sites and on various non-crop sites, including greenhouses, nurseries, home and garden, and public health. It is very highly toxic to fish and aquatic invertebrates but does not appear to be toxic to plants. Some residential and agricultural uses can have rather high application rates and resulting exposure.

An endangered species risk assessment is developed for federally listed Pacific salmon and steelhead. This assessment applies the findings of the Office of Pesticide Program's Environmental Risk Assessment developed for non-target fish and wildlife as part of the reregistration process to determine the potential risks to the 26 listed threatened and endangered Evolutionarily Significant Units (ESUs) of Pacific salmon and steelhead. The use of malathion on agricultural and non-agricultural sites may affect 24 ESUs when used according to labeled application directions and will have no effect on 2 ESUs. Effects are expected from agricultural, public health, structural pest control, and homeowner use.

Introduction

This analysis was prepared by the U.S. Environmental Protection Agency (EPA) Office of Pesticides Progams (OPP) to evaluate the risks of malathion to threatened and endangered Pacific salmon and steelhead. We have used the general aquatic risk assessment presented in the "EFED Chapter" issued in November, 2000 as the starting basis for our assessment (Attachment A). This document (US EPA, 2000) is on line at: http://www.epa.gov/oppsrrd1/op/malathion.htm. Then we included data from the OPP Quantitative usage analysis (2000), NAQWA, CDPR water and pesticide database (2002), Washington State Department of Agriculture report (2004), NASS, NCFAP, as well as EPA Eco Tox and AQUIRE database that provided additional scientific information to make the effects determination for the 26 ESUs.

Problem Formulation - The purpose of this analysis is to determine whether the registration of malathion as an insecticide for use on various crop and non-crop sites may affect threatened and endangered (T&E or listed) Pacific anadromous salmon and steelhead or adversely modify their designated critical habitat.

Scope - This analysis is specific to listed Pacific salmon and steelhead and the watersheds in which they occur. It is acknowledged that malathion is registered for uses that may occur outside this geographic scope and that additional analyses may be required to address other T&E species in the Pacific states as well as across the United States.

Contents

Summary
Introduction
1. Background
2. Description of Malathion
    a. Chemical overview
    b. Registered uses
    c. Application rates and methods
    d. Malathion usage
3. General aquatic risk assessment for endangered and threatened salmon and steelhead
    a. Aquatic toxicity of Malathion
    b. Aquatic toxicity of other pesticide ingredients in malathion products
    c. Synergism with multi active ingredients
    d. Environmental fate and transport
    e. Incidents
    f. Estimated and actual concentrations of Malathion in water
    g. Water Quality Criteria
    h. Existing protections
    i. Biological opinion
    j. Discussion and general risk conclusions for Malathion
4. Listed salmon and steelhead ESUs and comparison with Malathion use areas
5. References

Attachments:
A. EFED Chapter Malathion
B. Malathion Quantitative Usage Analysis
C. Washington State Malathion Use Analysis
D-1. Malathion Aquatic Exposure Assessment for Agricultural Uses
D-2 Malathion Aquatic Exposure Assessment for Mosquito Uses
E. Malathion CDPR County Usage
F. Actual Malathion Usage in California Counties
G. Maximum Estimated Malathion Usage for Pacific Northwest States
H. Malathion Sample Labels

1. Background

Under section 7 of the Endangered Species Act, the Office of Pesticide Programs (OPP) of the U. S. Environmental Protection Agency (EPA) is required to consult on actions that 'may affect' Federally listed endangered or threatened species or that may adversely modify designated critical habitat. Situations where a pesticide may affect a fish, such as any of the salmonid species listed by the National Marine Fisheries Service (NMFS), include either direct or indirect effects on the fish. Direct effects result from exposure to a pesticide at levels that may cause harm.

Acute Toxicity - Relevant acute data are derived from standardized toxicity tests with lethality as the primary endpoint. These tests are conducted with what is generally accepted as the most sensitive life stage of fish, i.e., very young fish from 0.5-5 grams in weight, and with species that are usually among the most sensitive. These tests for pesticide registration include analysis of observable sublethal effects as well. The intent of acute tests is to statistically derive a median effect level; typically the effect is lethality in fish (LC_{50}) or immobility in aquatic invertebrates (EC50). Typically, a standard fish acute test will include concentrations that cause no mortality, and often no observable sublethal effects, as well as concentrations that would cause 100% mortality. By looking at the effects at various test concentrations, a dose-response curve can be derived, and one can statistically predict the effects likely to occur at various pesticide concentrations; a well done test can even be extrapolated, with caution, to concentrations below those tested (or above the test concentrations if the highest concentration did not produce 100% mortality).

OPP typically uses qualitative descriptors to describe different levels of acute toxicity, the most likely kind of effect of modern pesticides (Table 1). These are widely used for comparative purposes but must be associated with exposure before any conclusions can be drawn with respect to risk. Pesticides that are considered highly toxic or very highly toxic are required to have a label statement indicating that level of toxicity. The FIFRA regulations [40CFR158.490(a)] do not require calculating a specific LC_{50} or EC_{50} for pesticides that are practically non-toxic; the LC_{50} or EC_{50} would simply be expressed as >100 ppm. When no lethal or sublethal effects are observed at 100 ppm, OPP considers the pesticide will have "no effect" on the species.

Table 1. Qualitative descriptors for categories of fish and aquatic invertebrate toxicity (from Zucker, 1985)

LC_{50} or EC_{50}	Category description
< 0.1 ppm	Very highly toxic
0.1- 1 ppm	Highly toxic
>1 < 10 ppm	Moderately toxic
> 10 < 100 ppm	Slightly toxic

> 100 ppm	Practically non-toxic

Comparative toxicology has demonstrated that various species of scaled fish generally have equivalent sensitivity within an order of magnitude to other species of scaled fish tested under the same conditions. Exceptions are known to occur for only an occasional pesticide, as based on the several dozen fish species that have been frequently tested. Sappington et al. (2001), Beyers et al. (1994) and Dwyer et al. (1999), among others, have shown that endangered and threatened fish tested to date are similarly sensitive, on an acute basis, to a variety of pesticides and other chemicals as their non-endangered counterparts.

Chronic Toxicity - OPP evaluates the potential chronic effects of a pesticide on the basis of several types of tests. These tests are often required for registration, but not always. If a pesticide has essentially no acute toxicity at relevant concentrations, or if it degrades very rapidly in water, or if the nature of the use is such that the pesticide will not reach water, then chronic fish tests may not be required [40CFR158.490]. Chronic fish tests primarily evaluate the potential for reproductive effects and effects on the offspring. Other observed sublethal effects are also required to be reported. An abbreviated chronic test, the fish early-life stage test, is usually the first chronic test conducted and will indicate the likelihood of reproductive or chronic effects at relevant concentrations. If such effects are found, then a full fish life-cycle test will be conducted. If the nature of the chemical is such that reproductive effects are expected, the abbreviated test may be skipped in favor of the full life-cycle test. These chronic tests are designed to determine a “no observable effect level” (NOEL) and a “lowest observable effect level” (LOEL). A chronic risk requires not only chronic toxicity, but also chronic exposure, which can result from a chemical being persistent and resident in an environment (e.g., a pond) for a chronic period of time or from repeated applications that transport into any environment such that exposure would be considered “chronic”.

As with comparative toxicology efforts relative to sensitivity for acute effects, EPA, in conjunction with the U. S. Geological Survey, has a current effort to assess the comparative toxicology for chronic effects also. Preliminary information indicates, as with the acute data, that endangered and threatened fish are again of similar sensitivity to similar non-endangered species.

Metabolites and Degradates - Information must be reported to OPP regarding any pesticide metabolites or degradates that may pose a toxicological risk or that may persist in the environment [40CFR159.179]. Toxicity and/or persistence test data on such compounds may be required if, during the risk assessment, the nature of the metabolite or degradate and the amount that may occur in the environment raises a concern. If actual data or structure-activity analyses are not available, the requirement for testing is based upon best professional judgement.

Inert Ingredients - OPP does take into account the potential effects of what used to be termed “inert” ingredients, but which are beginning to be referred to as “other ingredients”. OPP has classified these ingredients into several categories. A few of these, such as nonylphenol, can no longer be used without including them on the label with a specific statement indicating the potential toxicity. Based upon our internal databases, there are no products in which nonylphenol is now an ingredient. Many others, including such ingredients as clay, soybean oil, many polymers, and chlorophyll, have been evaluated through structure-activity analysis or data and determined to be of minimal or no toxicity. There exist also two additional lists, one for inerts with potential toxicity which are considered a testing priority, and one for inerts unlikely to be toxic, but which cannot yet be said to have negligible toxicity. Any new inert ingredients are required to undergo testing unless it can be demonstrated that testing is unnecessary.

The inerts efforts in OPP are oriented only towards toxicity at the present time rather than risk. It should be noted, however, that very many of the inerts are in exceedingly small amounts in pesticide products. While some surfactants, solvents, and other ingredients may be present in fairly large amounts in various products, many are present only to a minor extent. These include such things as coloring agents, fragrances, and even the printers ink on water soluble bags of pesticides. Some of these could have moderate toxicity, yet still be of no consequence because of the negligible amounts present in a product. If a product contains inert ingredients in sufficient quantity to be of concern relative to the toxicity of the active ingredient, OPP attempts to evaluate the potential effects of these inerts through data or structure-activity analysis where necessary.

For a number of major pesticide products, testing has been conducted on the formulated end-use products that are used by the applicator. The results of fish toxicity tests with formulated products can be compared with the results of tests on the same species with the active ingredient only. A comparison of the results should indicate comparable sensitivity, relative to the percentage of active ingredient in the technical versus formulated product, if there is no extra activity due to the combination of inert ingredients. Note that the “comparable” sensitivity must take into account the natural variation in toxicity tests, which is up to 2-fold for the same species in the same laboratory under the same conditions, and which can be somewhat higher between different laboratories, especially when different stocks of test fish are used.

The comparison of formulated product and technical ingredient test results may not provide specific information on the individual inert ingredients, but rather is like a “black box” which sums up the effects of all ingredients. This approach is more appropriate than testing each individual inert and active ingredient because it incorporates any additivity, antagonism, and synergism effects that may occur and which might not be correctly evaluated from tests on the individual ingredients. However, we do not have aquatic data on most formulated products, although we often have testing on one or perhaps two formulations of an active ingredient.

Risk - An analysis of toxicity, whether acute or chronic, lethal or sublethal, must be combined with an analysis of how much will be in the water to determine risks to fish. Risk is a combination of exposure and toxicity. Even a very highly toxic chemical will not pose a risk if there is no exposure, or very minimal exposure relative to the toxicity. OPP uses a variety of chemical fate and transport data to develop “estimated environmental concentrations” (EECs) from a suite of established models. The development of aquatic EECs is a tiered process.

The first tier screening model for EECs is with the GENEEC program, developed within OPP, which uses a generic site (in Yazoo, MS) to stand for any site in the U. S. The site choice was intended to yield a maximum exposure, or “worst-case,” scenario applicable nationwide, particularly with respect to runoff. The model is based on a 10 hectare watershed that surrounds a one hectare pond, two meters deep. It is assumed that all of the 10 hectare area is treated with the pesticide and that any runoff would drain into the pond. The model also incorporates spray drift, the amount of which is dependent primarily upon the droplet size of the spray. OPP assumes that if this model indicates no concerns when compared with the appropriate toxicity data, then further analysis is not necessary as there would be no effect on the species.

It should be noted that prior to the development of the GENEEC model in 1995, a much more crude approach was used to determining EECs. Older reviews and Reregistration Eligibility Decisions (REDs) may use this approach, but it was excessively conservative and does not provide a sound basis for modern risk assessments. For the purposes of endangered species consultations, we will attempt to revise this old approach with the GENEEC model, where the old screening level raised risk concerns.

When there is a concern with the comparison of toxicity with the EECs identified in GENEEC model, a more sophisticated PRZM-EXAMS model is run to refine the EECs if a suitable scenario has been developed and validated. The PRZM-EXAMS model was developed with widespread collaboration and review by chemical fate and transport experts, soil scientists, and agronomists throughout academia, government, and industry, where it is in common use. As with the GENEEC model, the basic model remains as a 10 hectare field surrounding and draining into a 1 hectare pond. Crop scenarios have been developed by OPP for specific sites, and the model uses site-specific data on soils, climate (especially precipitation), and the crop or site. Typically, site-scenarios are developed to provide for a worst-case analysis for a particular crop in a particular geographic region. The development of site scenarios is very time consuming; scenarios have not yet been developed for a number of crops and locations. OPP attempts to match the crop(s) under consideration with the most appropriate scenario. For some of the older OPP analyses, a very limited number of scenarios were available. As more scenarios become available and are geographically appropriate to selected T&E species, older models used in previous analyses may be updated.

One area of significant weakness in modeling EECs relates to residential uses, especially by homeowners but also to an extent by commercial applicators. There are no usage data in OPP that relate to pesticide use by homeowners on a geographic scale that would be appropriate for an assessment of risk to listed species. For example, we may know the maximum application rate for a lawn pesticide, but we do not know the size of the lawns, the proportion of the area in lawns, or the percentage of lawns that may be treated in a given geographic area. There is limited information on soil types, slopes, watering practices, and other aspects that relate to transport and fate of pesticides. We do know that some homeowners will attempt to control pests with chemicals and that others will not control pests at all or will use non-chemical methods. We would expect that in some areas, few homeowners will use pesticides, but in other areas, a high percentage could. As a result, OPP has insufficient information to develop a scenario or address the extent of pesticide use in a residential area.

It is also important to note that pesticides used in urban areas can be expected to transport considerable distances if they should run off on to concrete or asphalt, such as with streets (e.g., TDK Environmental, 2001). This makes any quantitative analysis very difficult to address aquatic exposure from home use. It also indicates that a no-use or no-spray buffer approach for protection, which we consider quite viable for agricultural areas, may not be as useful for urban areas.

Finally, the applicability of the overall EEC scenario, i.e., the 10 hectare watershed draining into a one hectare farm pond, may not be appropriate for a number of T&E species living in rivers or lakes. This scenario is intended to provide a "worst-case" assessment of EECs, but very many T&E fish do not live in ponds, and very many T&E fish do not have all of the habitat surrounding their environment treated with a pesticide. OPP does believe that the EECs from the farm pond model do represent first order streams, such as those in headwaters areas (Effland, et al. 1999). In many agricultural areas, those first order streams may be upstream from pesticide use, but in other areas, or for some non-agricultural uses such as forestry, the first order streams may receive pesticide runoff and drift. However, larger streams and lakes will very likely have lower, often considerably lower, concentrations of pesticides due to more dilution by the receiving waters. In addition, where persistence is a factor, streams will tend to carry pesticides away from where they enter into the streams, and the models do not allow for this. The variables in size of streams, rivers, and lakes, along with flow rates in the lotic waters and seasonal variation, are large enough to preclude the development of applicable models to represent the diversity of T&E species' habitats. We can simply qualitatively note that the farm pond model is expected to overestimate EECs in larger bodies of water.

Indirect Effects - We also attempt to protect listed species from indirect effects of pesticides. We note that there is often not a clear distinction between indirect effects on a listed species and adverse modification of critical habitat (discussed below). By considering indirect effects first, we can provide appropriate protection to listed species even where critical habitat has not been designated. In the case of fish, the indirect concerns are routinely assessed for food and cover.

The primary indirect effect of concern would be for the food source for listed fish. These are best represented by potential effects on aquatic invertebrates, although aquatic plants or plankton may be relevant food sources for some fish species. However, it is not necessary to protect individual organisms that serve as food for listed fish. Thus, our goal is to ensure that pesticides will not impair populations of these aquatic arthropods. In some cases, listed fish may feed on other fish. Because our criteria for protecting the listed fish species is based upon the most sensitive species of fish tested, then by protecting the listed fish species, we are also protecting the species used as prey.

In general, but with some exceptions, pesticides applied in terrestrial environments will not affect the plant material in the water that provides aquatic cover for listed fish. Application rates for herbicides are intended to be efficacious but are not intended to be excessive. Because only a portion of the effective application rate of an herbicide applied to land will reach water through runoff or drift, the amount is very likely to be below effect levels for aquatic plants. Some of the applied herbicides will degrade through photolysis, hydrolysis, or other processes. In addition, terrestrial herbicide applications are efficacious in part when soil applied, due to the fact that the product will tend to stay in contact with the foliage or the roots and/or germinating plant parts. With aquatic exposures resulting from terrestrial applications, the pesticide is not placed in immediate contact with the aquatic plant, but rather reaches the plant indirectly after entering the water and being diluted. Aquatic exposure is likely to be transient in flowing waters. However, because of the exceptions where terrestrially applied herbicides could have effects on aquatic plants, OPP does evaluate the sensitivity of aquatic macrophytes to these herbicides to determine if populations of aquatic macrophytes that would serve as cover for T&E fish would be affected.

For most pesticides applied to terrestrial environment, the effects in water, even lentic water, will be relatively transient. Therefore, it is only with very persistent pesticides that any effects would be expected to last into the year following their application. As a result, and excepting those very persistent pesticides, we would not expect that pesticidal modification of the food and cover aspects of critical habitat would be adverse beyond the year of application. Therefore, if a listed salmon or steelhead is not present during the year of application, there would be no concern. If the listed fish is present during the year of application, the effects on food and cover are considered as indirect effects on the fish rather than as adverse modification of critical habitat.

Designated Critical Habitat - OPP is also required to consult if a pesticide may adversely modify designated critical habitat. In addition to the indirect effects on the fish, we consider that the use of pesticides on land could have such an effect on the critical habitat of aquatic species in a few circumstances. For example, use of herbicides in riparian areas could affect riparian vegetation, especially woody riparian vegetation, which possibly could be an indirect effect on a listed fish. However, there are very few pesticides that are registered for use on riparian vegetation, and the specific uses that may be of concern have to be analyzed on a pesticide by pesticide basis. In considering the general effects that could occur and that could be a problem for listed salmonids, the primary concern would be for the destruction of vegetation near the stream, particularly vegetation that provides cover or temperature control, or that contributes woody debris to the aquatic environment. Destruction of low growing herbaceous material would be a concern if that destruction resulted in excessive sediment loads getting into the stream, but such increased sediment loads are insignificant from cultivated fields relative to those resulting from the initial cultivation itself. Increased sediment loads from destruction of vegetation could be a concern in uncultivated areas. Any increased pesticide load as a result of destruction of terrestrial herbaceous vegetation would be considered a direct effect and would be addressed through the modeling of estimated environmental concentrations. Such modeling can and does take into account the presence and nature of riparian vegetation on pesticide transport to a body of water.

Risk Assessment Processes - All of our risk assessment procedures, toxicity test methods, and EEC models have been peer-reviewed by OPP's Science Advisory Panel. The data from toxicity tests and environmental fate and transport studies undergo a stringent review and validation process in accordance with "Standard Evaluation Procedures" published for each type of test. In addition, all test data on toxicity or environmental fate and transport are conducted in accordance with Good Laboratory Practice (GLP) regulations (40 CFR Part 160) at least since the GLPs were promulgated in 1989.

The risk assessment process is described in "Hazard Evaluation Division - Standard Evaluation Procedure - Ecological Risk Assessment" by Urban and Cook (1986) (termed Ecological Risk Assessment SEP below), which has been separately provided to National Marine Fisheries Service staff. Although certain aspects and procedures have been updated throughout the years, the basic process and criteria still apply. In a very brief summary: the toxicity information for various taxonomic groups of species is quantitatively compared with the potential exposure information from the different uses and application rates and methods. A risk quotient of toxicity divided by exposure is developed and compared with criteria of concern. The criteria of concern presented by Urban and Cook (1986) are presented in Table 2.

Table 2. Risk quotient criteria for direct and indirect effects on T&E fish

Test data	Risk quotient	Presumption
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	Endangered species may be affected acutely, including sublethal effects
Chronic NOEC	>1	Chronic risk; endangered species may be affected chronically, including reproduction and effects on progeny
Acute invertebrate LC_{50} [a]	>0.5	May be indirect effects on T&E fish through food supply reduction
Aquatic plant acute EC_{50} [a]	>1[b]	May be indirect effects on aquatic vegetative cover for T&E fish

a. Indirect effects criteria for T&E species are not in Urban and Cook (1986); they were developed subsequently.
b. This criterion has been changed from our earlier requests. The basis is to bring the endangered species criterion for indirect effects on aquatic plant populations in line with EFED's concern levels for these populations.

The Ecological Risk Assessment SEP (pages 2-6) discusses the quantitative estimates of how the acute toxicity data, in combination with the slope of the dose-response curve, can be used to predict the percentage mortality that would occur at the various risk quotients. The discussion indicates that using a "safety factor" of 10, as applies for restricted use classification, one individual in 30,000,000 exposed to the concentration would be likely to die. Using a "safety factor" of 20, as applies to aquatic T&E species, would exponentially increase the margin of safety. It has been calculated by one pesticide registrant (without sufficient information for OPP to validate that number), that the probability of mortality occurring when the LC_{50} is 1/20th of the EEC is 2.39×10^{-9}, or less than one individual in ten billion. It should be noted that the discussion (originally part of the 1975 regulations for FIFRA) is based upon slopes of primarily organochlorine pesticides, stated to be 4.5 probits per log cycle at that time. As organochlorine pesticides were phased out, OPP undertook an analysis of more current pesticides based on data reported by Johnson and Finley (1980), and determined that the "typical" slope for aquatic toxicity tests for the "more current" pesticides was 9.95. Because the slopes are based upon logarithmically transformed data, the probability of mortality for a pesticide with a 9.95 slope is again exponentially less than for the originally analyzed slope of 4.5.

The above discussion focuses on mortality from acute toxicity. OPP is concerned about other direct effects as well. For chronic and reproductive effects, our criteria ensures that the EEC is below the no-observed-effect-level, where the "effects" include any observable sublethal effects. Because our EEC values are based upon "worst-case" chemical fate and transport data and a small farm pond scenario, it is rare that a non-target organism would be exposed to such concentrations over a period of time, especially for fish that live in lakes or in streams (best professional judgement). Thus, there is no additional safety factor used for the no-observed-effect-concentration, in contrast to the acute data where a safety factor is warranted because the endpoints are a median probability rather than no effect.

Sublethal Effects - With respect to sublethal effects, Tucker and Leitzke (1979) did an extensive review of existing ecotoxicological data on pesticides. Among their findings was that sublethal effects as reported in the literature did not occur at concentrations below one-fourth to one-sixth of the lethal concentrations when taking into account the same percentages or numbers affected, test system, duration, species, and other factors. This was termed the "6x hypothesis". Their review included cholinesterase inhibition but was largely oriented towards externally observable parameters such as growth, food consumption, behavioral signs of intoxication, avoidance and repellency, and similar parameters. Even reproductive parameters fit into the hypothesis when the duration of the test was considered. This hypothesis supported the use of lethality tests for use in assessing acute ecotoxicological risk, and the lethality tests are well enough established and understood to provide strong statistical confidence, which can not always be achieved with sublethal effects. By providing an appropriate safety factor, the concentrations found in lethality tests can therefore generally be used to protect from sublethal effects. As discussed earlier, the entire focus of the early-life-stage and life-cycle chronic tests is on sublethal effects.

In recent years, Moore and Waring (1996) challenged Atlantic salmon with diazinon and observed effects on olfaction as relates to reproductive physiology and behavior. Their work indicated that diazinon could have sublethal effects of concern for salmon reproduction. However, the nature of their test system, direct exposure of olfactory rosettes, could not be quantitatively related to exposures in the natural environment. Subsequently, Scholz et al. (2000) conducted a non-reproductive behavioral study using whole Chinook salmon in a model stream system that mimicked a natural exposure that is far more relevant to ecological risk assessment than the system used by Moore and Waring (1996). The Scholz et al. (2000) data indicate potential effects of diazinon on Chinook salmon behavior at very low levels with statistically significant effects at nominal diazinon exposures of 1 ppb, with apparent, but non-significant effects at 0.1 ppb.

It would appear that the Scholz et al (2000) work contradicts the 6x hypothesis for acute effects. The research design, especially the nature and duration of exposure of the test system used by Scholz et al. (2000), along with a lack of dose-response, precludes comparisons with lethal levels in accordance with the 6x hypothesis as used by Tucker and Leitzke (1979). Nevertheless, it is known that olfaction is an exquisitely sensitive sense. And this sense may be particularly well developed in salmon, as would be consistent with its use by salmon in homing (Hasler and Scholz, 1983). So the contradiction of the 6x hypothesis is not surprising. As a result of these findings, the 6x hypothesis needs to be re-evaluated with respect to olfaction. At the same time, because of the sensitivity of olfaction and because the 6x hypothesis has generally stood the test of time otherwise, it would be premature to abandon the hypothesis for other acute sublethal effects until there are additional data.

2. Description of Malathion

a. Chemical overview

- Common Name: Malathion
- Chemical Name: O,O-Dimethyl phosphorodithioate of diethyl mercaptosuccinate
- Chemical Family: Organophosphate
- CAS Registry Number: 121-75-5
- OPP Chemical Code: 057701
- Molecular Weight: 330.3 g/mol.
- Empirical Formula: $C_{10}H_{19}O_6PS_2$

- ❑ Trade and Other Names: Fyfanon, Drexel, Maldison, Carbofos, Compound 4049, Sadofos, Cythion, Fosfothion, Mercaptothion

- ❑ Basic Manufacturer: Cheminova

Technical Malathion is a clear amber liquid with a melting point of 2.85EC.

b. Registered uses

Cheminova has divided the malathion market into four major portions: USDA special program use, commercial agricultural, public health use, and home and garden use. Actual tonnage sales estimates are considered confidential business information. The percentage of use can be broadly summarized, however, as USDA, 59-61%; General Agriculture, 16-20%; Public Health, 8-15 %; and Home and Garden Use, 10%. These percentages of use may vary with fluctuations in pest pressure or concerns for public health, which might occur following natural disasters, e.g. a hurricane (EFED chapter).

The following is based on the currently registered uses of Malathion:

- ❑ Type of Agent: Insecticide

- ❑ Classification: General

- ❑ Summary of Sites:

  - Terrestrial Food/Feed Crops: alfalfa; apple; apricot; asparagus; avocado; barley; bean (succulent and dry); beets (garden; table; and sugar); birdsfoot trefoil; blackberry; blueberry; boysenberry; broccoli; broccoli raab; Brussels sprout; cabbage (including Chinese); carrot; cauliflower; celery; chayote; cherry; chestnut; clover; collards; corn (field; sweet; and pop); cotton; cucumber; currant; dandelion; date; dewberry; eggplant; endive; escarole; potato; fig; filbert; flax; garlic; gooseberry; grape; grapefruit; guava; hay grass; hops; horseradish; kale; kohlrabi; kumquat; leek; lemon; lentil; lespedeza; lettuce (head and leaf); lime; loganberry; lupine; macadamia nut; mango; melon; mint; mushroom; mustard greens; nectarines; oats; okra; onion; orange; papaya; parsley; parsnip; passion fruit; pea; peach; pear; pecan; pepper; pineapple; plumes; prunes; potato; pumpkin; quince; radish; raspberry; rice; rutabaga; rye; salsify; shallot; sorghum grain; spinach; spring wheat; squash; strawberry; sweet potato; Swiss chard; tangelo; tangerine; tomato (including tomatillo); turnip; vetch; walnut; watercress; watermelon; wheat; wild rice; winter wheat; and yam; indoor stored commodity treatment and empty storage facilities for, barley, corn, oats, rye, and wheat.

- Terrestrial Non-Food and Feed Crop: Homeowner outdoor uses: ornamental flowering plants, ornamental lawns, ornamental turf, vegetable gardens and fruit trees; ornamental flowers, shrubs, and trees; Christmas tree plantations; slash pine; ornamental nursery stock; woody plants; outdoor dwellings (domestic and commercial); uncultivated nonagricultural areas; outdoor garbage dumps; intermittently flooded areas; irrigation systems; sewage systems; pastures; and rangeland.

- Public Health: Mosquito and fly control

- Target Pests: Ant, aphid, apple mealybug, armyworm, bagworm, bean beetle, boll weevil, casebearer, blackheaded fireworm, blueberry maggot, cabbage looper, cadelle, cattle lice, cherry fruitworm, cockroach, corn earworm, corn rootworm, cotton fleahopper, cotton leaf perforator, cotton leafworm, cranberry fruitworm, cricket, cucumber beetle, currant cutworm, earwig, European fruit lecanium, fall cankerworm, fleahopper, flea, flea beetle, fungus gnats, garden webworm, grain borer, grape phylloxera, grasshoppers, green cloverworm, greenbug, groundpearl, house fly, hornet, imported cabbageworm, imported currantworm, ked, leafhopper, leafroller, leafminer, looper, mealy bug, Mediterranean fruit fly, millipede, mosquito (adult, larvae), kerme, mushroom fly, omnivorous leaftier, onion maggot, orange tortrix, orangeworm, pear psylla, pecan phylloxera, pepper maggot, pickleworm, pillbug, pine needle sheathminer, plant bug, plum curculio, poultry lice, rose chafer, sawfly, scale insects, scorpion, silverfish, sorghum midge, sowbug, spider, spider mites, spittlebug, springtail, squash beetle, strawberry leafroller, sugarbeet root maggot, tadpole shrimp, thrips, ticks, tingid, tomato fruitworm, vegetable weevil, vetch bruchid, wasp, whitefly, wild rice worm

(http://myweb.cableone.net/tfcox/pests.htm)
(http://www.epa.gov/pesticides/op/malathion/overview.htm)

❑ Formulation Types Registered:

Technical Grade/Manufacturing-Use Product (MUP)

End-use Product: Malathion is formulated as an emulsifiable concentrate (EC), a dust (D), a wettable powder (WP), a ready-to-use liquid (RTU), and as a pressurized liquid (PL). The EC and RTU formulations may contain up to 82% and 95% active ingredient (ai), respectively.

❑ Methods of Application:

- Equipment: Aircraft (fixed wing), duster, fogger, ground boom, helicopter, irrigation, shaker can, shovel, sprayer, and spreader

- Method and Rate: The majority of agricultural and public health uses involve the mixture or dilution of EC formulations with water for aerial or ground spray application to target areas either as Ultra Low Volume applications, standard ground application sprays, or ground fogs. Wettable powders are generally diluted in 1 to 100 gallons of water and applied to plant surfaces by ground spray methods. Dust formulations are often used for treatment of grain storage areas or the actual grain itself. Ready to use formulations are often used in the home and applied directly to the insect pest or to areas where the pest is observed. There are also labels that support malathion use on livestock. Forest uses on public lands are not being supported, though use on tree farms (Christmas trees, cottonwood, orchard trees) is still permitted.

c. Application rates and Methods

Malathion is a non-systemic insecticide that is applied as a spray to foliage in agricultural and homeowner settings. It is also used in the public health sector to control indoor and outdoor pests. It may be applied by aerial or ground equipment. Table 3 lists national label application rates, application intervals, and the maximum number of applications in a year for all national uses.

Table 3. Malathion use sites and application information (source: product labels)

Use sites	Appl rate (lbs a.i./acre)	Application interval	Maximum # of applications/ year
Vineyards	0.94 - 2.79	7 - 10 days	as needed
Orchards (i.e. apple, cherry, plum, prune)	0.63 - 14.4	7 - 10 days	NS
Tree nut (i.e. walnut, Macadamia nut, pecan)	0.31 - 15.33	7 - 10 days	NS
Fruits (i.e. citrus, bramble, melon, fig, date)	0.63 - 25.37	7 - 12 days	NS
Vegetables (i.e. squash, bean, lettuce, broccoli, spinach, onion)	0.19 - 4.3	7 - 10 days	NS
Grains (i.e. sorghum, rice, hops, barley, rye)	0.63 - 2.46	3 - 10 days	NS
Cotton	1.88 - 4.91	3 - 10 days	as needed

Homeowner (i.e. vegetable and flower garden, trees, indoor and outdoor pest control)	0.006 -2.23	NS	NS
Open space (pasture land, range land, hay)	0.94 - 1.41	NS	NS
Turf (i.e. lawn, golf course, ornamental)	0.51 - 54.45	NS	NS
Public health (mosquito, fly)	0.001 - 0.74	NS	NS
Ornamentals (i.e. flower, tree, nursery stock)	1.28 - 2.91	7 - 10 days	repeat as necessary
Tree farms (i.e. Christmas tree plantations)	6.4	NS	2
Outdoor dwellings (commercial and domestic)	0.51 - 54.45		NS
Livestock	0.04 - 10	10 days - 8 weeks	repeat as necessary
Outdoor surfaces (painted)	8.54 - 696.96	NS	NS

*NS = not specified

Table 4 lists some of the major crops grown in the Pacific Northwest and California. Maximum label application rates for agricultural uses are significantly higher than homeowner and commercial uses for the same crop. Other uses are unique to the homeowner and commercial sector and have high application rates as well (i.e. outdoor painted surfaces). While some labels indicate application intervals and maximum number of applications in a year, many labels do not specify this information. For these cases, we denoted a 'Not Specified' (NS) in the respective column.

Table 4. Registered uses and maximum application rates for malathion in western salmon and steelhead states (source: national labels)

Crop or Site	**Maximum rate per application (lb ai/A)**	**Application interval (days)**	**Average # of applications/ year**
Alfalfa (CA)	2.46	7-10	NS
Apples (WA, OR)	14.4	repeat as necessary	NS
Asparagus (WA, CA)	1.27	NS	NS
Barley (ID)	1.25	7-10	as needed
Blueberries (OR)	2.5	7-10	NS
Cherries (OR, WA)	8	7-10	NS
Citrus (CA)	25.37	25	NS

Dates (CA)	4.25	NS	7
Lettuce (CA)	2.46	NS	NS
Mint (OR, ID)	1.84	7-10	as needed
Strawberries (CA, OR)	10	NS	NS
Sugarbeet (CA, ID)	2.54	NS	NS
Ornamentals (WA, ID, CA, OR)	2.91	NS	NS
Slash Pine, pine seed, orchards, Christmas tree, plantations (WA, ID, CA, OR)	6.4	NS	2
Residential mosquito control - adults (WA, ID, CA, OR)	0.74	NS	NS
Ticks - residential lawn use (WA, ID, CA, OR)	17.9	21	NS
Flies - outside building (WA, ID, CA, OR)	19.2	NS	NS
Pest control painted surfaces of buildings around homes, yards, food processing plants (WA, ID, CA, OR)	696.9**	NS	NS

** 8 lbs of a.i. are in each gallon; the label suggests to use 2 gallons/ 1000 square feet; this amounts to 696. 9 lbs/A. ((16 lbs/2gal)*(2gal/1000sq. ft) * 43560 sq. ft)

d. Malathion usage

Based on available pesticide survey usage information for the years of 1988 through 1999, OPP's Quantitative Use Assessment (QUA) calculated an average annual estimate of malathion's domestic usage as approximately 6.4 million pounds of active ingredient (a.i.) without cotton usage as part of the Boll Weevil Eradication Program, and 16.7 million pounds a.i. including the cotton usage as part of the Program.

There are two estimates provided for cotton: one for cotton usage not including usage as part of the United States Department of Agriculture's Boll Weevil Eradication Program (listed in parentheses and bold), and one including cotton usage as part of the Program. The majority of the malathion usage on cotton is for the control of the boll weevil as part of the Program, however, it is estimated that malathion usage on cotton will decline over the next 5-8 years as the boll weevil is eradicated from the remaining major cotton growing regions of the U.S. (Including Texas, Mississippi, and Louisiana). The usage estimate provided for cotton not including the usage in the Program is an estimate of what malathion usage may be when the boll weevil eradication is complete.

Including cotton usage, approximately 74% of the estimated average total amount of malathion applied per year to all sites, or 12.5 million pounds, is used on agricultural crops. Without cotton usage this number shrinks to 33% or 2.1 million pounds of malathion. On average, approximately 3.1 million acres of agricultural crops are treated per year with malathion or 1.2 million acres without cotton. Most of the acreage is treated with an average of $\leq$1 pound of active ingredient (a.i.) per acre per application and $\leq$5 pounds of a.i. per acre per year (see attachment B).

Cotton represents malathion's largest agricultural crop market in terms of total pounds a.i. applied, followed by alfalfa. Nearly 90% (**40%**) of the total pounds of malathion applied to agricultural crops is applied to cotton, and 3% (**16%**) is applied to alfalfa. No other crop accounts for more than 1% (**4%**) (wheat) of the estimated pounds of malathion applied. Crops with a high percentage of their total U.S. planted acres treated with malathion include blueberries (29%), raspberries (36%), sweet cherries (30%), and dates (29%). The application of malathion to cotton acreage accounts for more than 70% (**25%**) of the total agricultural crop acreage treated with malathion. On average, an estimated 17% (**3%**) of the U.S. cotton acreage is treated with malathion.

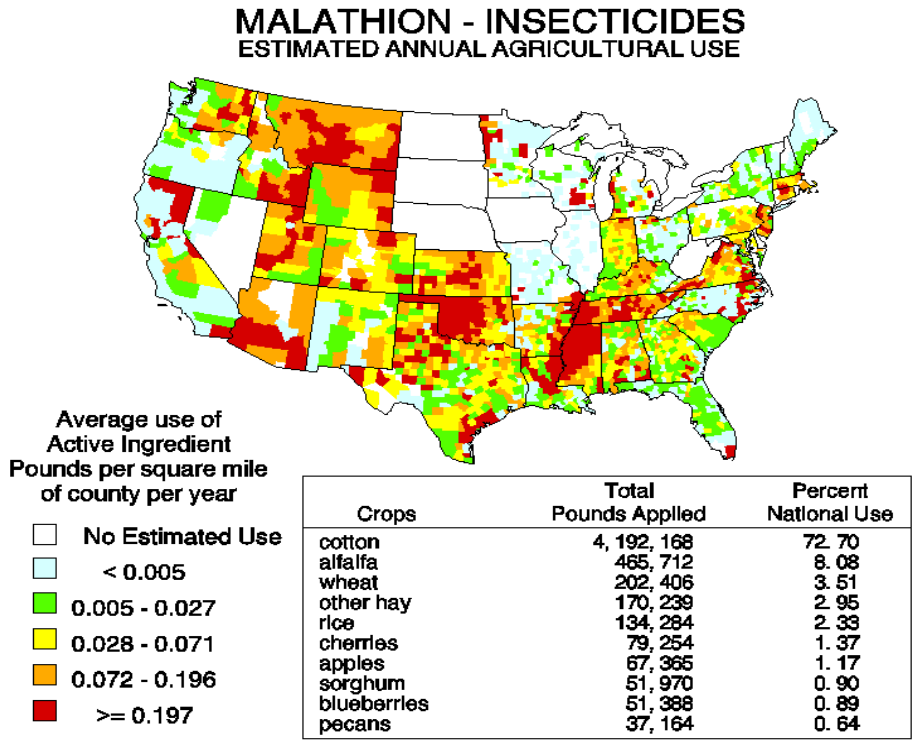
Malathion is applied as a post harvest grain treatment to corn, wheat, and oats. Post harvest applications to these grains accounted for, on average, 2% (**5%**) (or 344,000 pounds) of the total pounds of malathion applied to all sites. Wheat receives the majority of the post harvest usage of malathion. On average, more than 30% of the bushels of wheat are treated with malathion.

Other agricultural sites, such as cattle and agricultural buildings, account for approximately 3% (**8%**) (or 534,000 pounds) of the total malathion pounds applied to all sites. Applications to beef cattle, grain storage facilities, and roads, ditches, and miscellaneous farm use account for more than 85% of malathion usage on other agricultural sites.

Approximately 3.4 million pounds of malathion are applied to non-agricultural sites, such as medlfy quarantine, mosquito abatement districts, and homeowner use for outdoor insect control. This usage represents approximately 20% (**53%**) of the total malathion applied to all sites. Outdoor application by homeowners (1.5 million pounds) and application for mosquito control (800,000 pounds) accounts for nearly 60% of the malathion usage on non-agricultural sites. The majority of the non-agricultural site acre treatments are for the control of mosquitos (an estimated 12 million acre treatments or approximately 80% of the total). (extracted from OPP QUA, 2000) Home owner uses make up a large portion of the non-agricultural malathion market but states do not assign poundage to this category of users. This represents a large unknown.

We present a summary of the OPP QUA (2000) with respect to malathion usage and crops grown in the Pacific Northwest and California. For a complete list of national crops and usage, attachment B can be reviewed. The % listed in the states column refers to how much of the crop is grown in that particular state compared to the national crop production. If no % is listed, then either the data is not known or more states grow this crop but are not the four states of concern (WA, OR, ID, CA).

Furthermore, we compared the usage of malathion in the four states (ID, OR, WA, CA) to the national usage based on a pesticide usage map developed by the USGS, which is based on the 1997 Census of Agriculture county crop acreage. Qualitatively we determined that Washington State and Idaho have large areas with high average use of malathion per square mile of county per year and could be rated among the ten states nationally that have the highest malathion usage. Oregon has relatively large areas with low average use per square mile of county, while California has some large areas with low average use and some large areas with high average use of malathion per square mile of county. In California, the higher averages seem to concentrate in the agricultural and orchard areas as well as in the Northeast corner of the state.



(URL: http://ca.water.usgs.gov/cgi-bin/pnsp/pesticide_use_maps_1997.pl?map=W6033)

Using the weighted average provided by the OPP QUA (see table 5), we calculated that PNW and California combined used approximately 772,000 lbs of malathion annually on agricultural crops. This value is the sum of weighted averages for all states growing the crops mentioned in the time period between 1988 - 1999.

Table 5. Uses of malathion in the Pacific Northwest and California from 1988-1999 (source: OPP QUA, 2000)

Crop	Lbs a.i./Acre		% Crop treated est. max	Average appl. rate # appl/yr.	States
	est. max	wtd. avg.			
Blackberries	1000	1000	13%	1.1	OR 100%
Cranberries	<1000	<1000	1%	1.0	WA 100%
Rasperries	7000	5000	46%	1.0	WA, OR 81%
Strawberries	73000	52000	28%	3.5	CA 95%
Grapefruit	4000	2000	2%	3.7	CA

Oranges	21000	10000	1 %	1.5	CA
Apples	85000	63000	13%	1.3	WA
Pears	1000	<1000	1%	2.0	WA
Figs	<1000	<1000	1%	1.0	CA 100%
Cherries, sweet	72000	50000	35%	1.1	WA, OR 100%
Cherries, tart	<1000	<1000	1%	1.0	OR
Peaches	18000	7000	4%	1.7	CA
Apricots	<1000	<1000	<1%	1.0	CA 100%
Plums & prunes	1000	1000	<1%	2.0	CA 90%
Nectarines	<1000	<1000	<1%	1.3	CA 100%
Dates	16000	8000	58%	2.0	CA 100%
Avocados	5000	2000	4%	2.0	CA
Grapes	23000	12000	1%	1.3	CA, WA
Almonds	2000	1000	<1%	1.0	CA 100%
Walnuts	50000	26000	9%	1.3	CA 100%
Vegetables, bulb	23000	12000	9%	1.0	CA
Garlic	<1000	<1000	<1%	1.0	CA 100%
Onions	32000	16000	10%	1.5	WA, CA, OR, ID
Eggplant	<1000	<1000	4%	1.0	CA 100%
Peppers, hot	<1000	<1000	<1%	1.0	CA 100%
Celery	3000	2000	7%	1.3	CA
Lettuce	18000	9000	4%	1.1	CA
Spinach	4000	2000	4%	1.6	CA 100%
Broccoli	2000	1000	1%	1.6	CA 99%
Brussels sprouts	<1000	<1000	4%	1.0	CA 100%
Cabbage	3000	2000	2%	1.3	CA
Cauliflower	1000	<1000	1 %	1.0	CA 100 %
Cucumbers	6000	2000	3%	1.4	CA
Pumpkins	14000	11000	11%	1.0	CA
Squash	4000	2000	6%	1.0	CA
Cantaloupes	4000	2000	3%	1.3	CA 95 %
Watermelons	8000	3000	3%	1.4	CA

Asparagus	11000	6000	7%	1.6	WA, CA 87 %
Beets	<1000	<1000	2%	1.0	CA 99%
Carrots	11000	6000	4%	1.6	CA
Potatoes	14000	5000	<1%	1.2	OR, ID
Radishes	<1000	<1000	<1%	1.0	CA 100 %
Sweet corn	13000	4000	1%	1.4	CA
Tomatoes	31000	14000	2%	2.0	CA
Beans, snap	1000	1000	<1%	1.3	OR, CA 100%
Peas, dry	14000	7000	6%	1.0	ID, CA
Peas, green	6000	3000	2%	1.0	CA
Barley	10000	5000	<1%	1.0	CA, WA
Oats/Rye	14000	5000	<1%	1.0	CA
Hay, other	76000	37000	<1%	1.3	CA
Alfalfa	560000	330000	2%	1.2	CA, ID
Sugarbeets	64000	32000	3%	1.0	CA 94 %

CDPR(http://www.cdpr.ca.gov) reports for 2002 that a total of 1,018,961.46 lbs of malathion were sold by 30 registrants in California. This represents a drop of about 106,000 lbs compared to the prior year. In 2001, a total of 1,124,940.09 lbs of malathion were sold by 31 registrants in California, which is an increase of about 74,000 lbs from the prior year. It is important to note that not all the poundage sold by the registrants were used in that year by the consumer, which is not unusual.

Table 6 and 7 list the latest malathion usage and acres treated with malathion in California for 1993-2002 [URL: http://www.cdpr.ca.gov/docs/pur/purmain.htm]. For specific county level information, see section 4.

Table 6 shows that usage of malathion in California has not been constant over the course of ten years. Usage was down by almost 100,000 lbs in 2002 compared to 1993. However, usage was up by about 80,000 lbs and 125,000 lbs in 2002 compared to 2001 and 2000, respectively.

Table 6. Reported use of malathion in California, 1993-2002 (lb ai)

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
708,781	750,415	806,168	676,921	775,880	646,984	682,413	493,107	539,914	618,138

Table 7 shows that the number of acres treated with malathion has fluctuated in California over the last decade. Reported acres treated have remained constant when we compare the years 1993 and 2002. In 2002, about 25,000 acres more were treated with malathion than the prior year. This increase may partially account for the 80,000 lbs increase in usage from 2001 to 2002.

Table 7. Reported acres treated with malathion in California, 1993-2002

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
355,841	398,897	422,850	360,556	409,363	382,281	402,875	323,346	289,919	314,361

Tables 8- 15 list all of the malathion uses in California (2002), Oregon (2002), Idaho (2002), and Washington (2002). For the major crop uses (>1000 lb ai/yr), a comparison of the acreage treated and pounds used indicates that average application rates for California are consistently below 2 lb ai/A with the exception of a few crops. Lemon, walnut, and dates, however, had an average rate of 38.3 lbs/acre, 3.4 lbs/acre, and 2.8 lbs/acre, respectively. The CDPR data cannot be used to estimate the numbers of applications per year nor the actual acreage treated for agricultural crops because each application is counted as being applied to separate acreage (e.g., 5 applications to the same 200 acres, will be counted as application to 1000 acres).

Table 8. Use of malathion by crop or site in California in 2002 (ordered alphabetically)

Crop	Pounds of Active Ingredient Used	Acres Treated	Unit Type
Alfalfa	162,199.1	128,608.7	A
Alfalfa	264.7	265.1	S
Almond	61.3	10	A
Animal premise	256.8	163	U
Animal premise	122.4	3,309	A
Apple	5.5	25.3	A
Apricot	4.1	1	A
Arrugula	7.5	5.9	A
Asparagus	40.7	30	A
Avocado	813.1	7,107.9	A
Avocado	2.6	6,000	U
Barley	2,818.2	2,722.8	A
Bean, dried	4,523.9	5,119.5	A
Bean, succulent	1,720.4	1,344.8	A
Bean, unspecified	398.3	273.2	A

Beet	355.9	133	A
Bermudagrass	3,565	3,390	A
Blackberry	2,320.6	696.5	A
Blueberry	17.3	9	A
Bok Choy	1,430	748.5	A
Broccoli	3,682.8	2,147.8	A
Broccoli	4.8	267,705	S
Brussels sprout	33.9	24.1	A
Cabbage	702.6	669.4	A
Canola (rape)	147	76.5	A
Cantaloupe	228.8	200	A
Carrot	231.2	221	A
Cauliflower	403.5	211.3	A
Celery	15,343.3	10,894.8	A
Celery	2.3	1.5	S
Cherry	0.1	0.2	A
Chicken	40.3	80,000	U
Chinese cabbage (Nappa)	4,102.7	1,908.4	A
Chinese greens	84.4	89	A
Chinese greens	5.9	480,000	S
Citrus	535.7	169.1	A
Collard	83	33.5	A
Commodity fumigation	111.8	--	--
Corn (forage- fodder)	941.8	854	A
Corn, human consumption	1,076.2	1,285.2	A
Cotton	1,526.3	2,018.1	A
Cucumber	392.7	214.6	A
Date	9,118.2	3,267.5	A
Eggplant	22.2	23.5	A
Endive	825.5	544.8	A

Fig	180.5	118	A
Forage hay/silage	3,686.2	2,788.7	A
Gai Lon	526.2	278	A
Garlic	773.7	492.5	A
Grape	1,412.9	1,058.8	A
Grape, wine	2,318	1,482.2	A
Grapefruit	897	379.3	A
Kale	1,359.4	695.6	A
Kale	3.1	1.5	S
Kohlrabi	0.05	8	A
Landscape maintenance	4,937.3	--	A
Leek	76.8	40	A
Lemon	17,454.1	456.2	A
Lettuce, head	28,617.6	19,800.8	A
Lettuce, leaf	22,689.7	16,075.9	A
Melon	19.9	8.3	A
Mint	23.8	154.9	A
Mustard	300.7	156.1	A
N-Grnhs flowers	154.5	202.8	A
N-Grnhs flowers	51.1	847,448.3	S
N-Grnhs plants in containers	440.6	170.7	A
N-Grnhs plants in containers	169.2	2,452,657	S
N-Grnhs plants in containers	0.3	5	U
N-Grnhs transplants	36.7	34.3	A
N-Grnhs transplants	1.2	4,000	S
N-Grnhs transplants	0.01	2,666	U
N-Outdr flower	418.9	375.6	A
N-Outdr flower	4.0	17,600	S
N-Outdr flower	0.5	12	U
N-Outdr plants in containers	4,039.3	9471.8	A

N-Outdr plants in containers	57.8	815,323.4	S
N-Outdr plants in containers	44.2	77,960	U
N-Outdr transplants	428.5	323.9	A
N-Outdr transplants	32.7	2,933	U
N-Outdr transplants	7.7	483,570	S
Nectarine	67	20.5	A
Oat	257.5	295	A
Oat (Forage - Fodder)	234.9	197	A
Onion, dry	1,259.8	988.6	A
Onion, green	2,757.3	1,391.2	A
Orange	10,739.8	5,582.6	A
Parsley	2	2	A
Pastureland	25	25	A
Peach	21.6	18.3	A
Pear	130.8	8	A
Pear	0.9	150	U
Peas	1,036.6	1,803.8	A
Pecan	0.1	0.1	A
Pepper, fruiting	490.1	422.7	A
Pepper, spice	0.5	0.5	A
Plum	1.2	0.8	A
Potato	201	206	A
Prune	1.5	30	A
Public Hlth	35,733.6	--	--
Pumpkin	582.3	356.1	A
Radish	89.9	52.3	A
Raspberry	2,348.6	1,824.6	A
Regulatory Pest Control	86,359.6	--	--
Regulatory Pest Control	4,672.1	8,000	U
Regulatory Pest Control	95.4	1	A

Research Commodity	64.9	--	--
Rice	181	147.6	A
Rice, wild	967.6	653.7	A
Rights of way	94	--	--
Sorghum (forage - fodder)	0.7	24	A
Spinach	956.5	637.9	A
Squash	271.1	166.8	A
Squash, summer	644.7	391	A
Squash, winter	1.7	9	A
Strawberry	73,358.8	40,853.5	A
Strawberry	26	27	S
Structural Pest Control	34,681.4	--	--
Structural Pest Control	18.4	18	S
Sunflower	5.3	162,659	A
Sunflower	0.01	22	S
Sweet Potato	122.8	13	S
Swiss Chard	107.4	57.7	S
Tangelo	219.5	22	S
Tangerine	1,736.6	323.5	S
Tomatillo	25.8	40	S
Tomato	224.5	174.8	S
Tomato, Processing	8,960.9	8,064.6	S
Tropical/subtropical fruit	0.1	94.8	U
Turnip	190.5	94.8	A
Uncultivated Non-Ag	51.4	30	A
Uncultivated Non-Ag	20	2,000	S
Unknown	39	27.2	A
Vertebrate control	2.6	1	A
Vertebrate control	0.2	--	--
Walnut	32,718	9,606.7	A

Walnut	6	95	S
Walnut	3.2	20	U
Watercress	24	245	A
Watermelon	41.7	26	A
Wheat	4,771.9	6,171.8	A
Wheat (forage - fodder)	424.5	339	A

*A = acres
*S = square feet
*U = units, not specified

The Washington State Department of Agriculture (WSDA) has provided information on the acreage of major malathion-treated crops and additional details on pounds used for some of these crops (WSDA, 2004). For complete information see attachment C. We present a summary of this usage information.

Cherry orchards comprise 25,000 acres, and 50% of this acreage was treated with malathion. Approximately 12,500 acres were treated with 37,000 lbs of malathion. While alfalfa was planted on 490,000 acres, only 1% of this acreage was treated with malathion. To approximately 4,900 acres of alfalfa, 9,800 lbs of malathion were applied. Apple orchards comprise 164,000 acres, and 0.3% of this acreage was treated with malathion. Approximately 500 acres were treated with 4,000 lbs of malathion. Asparagus was planted on 17,000 acres, and < 10% were treated with malathion. Approximately 1,700 acres were treated with 3,400 lbs of malathion. Raspberries were grown on 9,500 acres, and 50% of this acreage was treated with malathion. Approximately 4,750 acres were treated with 4,750 lbs of malathion. No information is reported for non-agricultural uses.

Table 9. Major usage of malathion in Washington (provided by WSDA, 2004)

Crop	Acres planted[1]	Acres treated (% treated)	lbs ai/A	# of Appl	est. acres treated	est. lbs a.i. applied
Alfalfa, hay	490,000	1	1	2	4,900	9,800
Alfalfa, seed	12,000	1	1	2	125	250
Apple	164,000	0.3	4	2	500	4,000
Asparagus	17,000	< 10	1	2	1,700	3,400
Barley	350,000	< 1	1	1	3,500	3,500
Bean, dry	41,000	Little to no use. See narrative in attachment.				
Bean, lima	2,000					
Bean, snap	unknown					
Blueberry[2]	2,000	5	1.5	1	100	150

Carrot	10,000	50	1	1	5,000	5,000
Cherry	25,000	50	1.5	2	12,500	37,500
Clover, hay	unknown	No current use and limit acreage. See attachment for narrative.				
Clover, seed	2000					
Corn, field & silage	130,000					
Corn, sweet	97,900					
Cottonwood[2]	40,000	No current use	See attachment for narrative.			
Currant	< 100	Not applicable. Limited acreage - see attachment for narrative				
Grape[2]	49,800	Little current use. See attachment for narrative.				
Mint[2]	33,900	< 3	1	1	1,000	1,000
Oat	35,000	<1	1	1	350	350
Onion, dry bulb	17,100	10	1	2	1,700	3,400
Pea, green	36,800					
Peach & nectarine	4,300	16	4	1	688	2,750
Red raspberry[2]	9,500	50	1	1	4,750	4,750
Strawberry	1,800		2	1		
Vegetable crop	< 10,000	Includes all vegetable crops. Limited use. See attachment for narrative.				
Vetch, seed	unknown	limited use and acreage				
Wheat	2,490,000	<010	1	1	249,000	249,000

[1] = Washington Agricultural Statistics Service
[2] = commodities have been peer reviewed

There are limited data available on the amount of malathion used for Idaho and Oregon, and for "less than major" crops in Washington. The National Agricultural Statistics Service (NASS) and National Center for Food and Agricultural Policy (NCFAP) provide some information on malathion usage for the Pacific Northwest.

NASS reports that in Washington State, apples and sweet cherry have been the main agricultural crop treated with 63,600 lbs (1993) and 25,400 lbs (1991) of malathion, respectively. Active ingredient was applied to these crops at 1.59 lbs/acre (1995) and 2.8 lbs/acre (1991), respectively. To asparagus and raspberries, malathion was applied at 2.63 lbs/acre (1996) and 1.6 lbs/acre (1991). These crops received 6,400 lbs (1994) and 5,600 lbs (2001) of malathion, respectively.

Table 10. Major usage of malathion in Washington for multiple years (NASS Agricultural Chemical Database)

Crop	Max Lb a.i. applied/Acre	Max. Total Lbs a.i./year
Apples	1.59 (1995)	63,600 (1993)
Asparagus	2.63 (1996)	6,400 (1994)
Cherries - sweet	2.8 (1991)	25,400 (1991)
Onions - bulb	1.91 (1992)	2,400 (1994)
Peaches	3.74 (1999)	1,500 (1999)
Raspberries	1.6 (1991)	5,600 (2001)

We also consulted the NCFAP National Pesticide Use database for usage information regarding Washington. The most recent data (1997) reported apple (63,858 lbs) and cherry (34,688 lbs) as the main recipient of malathion, which was applied to 53,215 acres and 12,895 acres, respectively. Alfalfa (8,752 lbs) and carrots (4,658 lbs) were the next two crops receiving large amounts of active ingredient, which was applied to 4,488 acres and 4,658 acres, respectively.

Table 11. Major usage of malathion in Washington for 1997 (Source: NCFAP National Pesticide Use Database)

Crops	Total Acres planted	Acres treated	Lb a.i./year	Application rate (Lbs/acre)
Alfalfa	448,822	4,488	8,752	1.95
Apples	204,674	53,215	63,858	1.2
Asparagus	20,187	1,817	1,671	0.92
Blueberries	1,311	52	80	1.52
Carrots	9,315	4,658	4,658	1.0
Cherries	22,623	12,895	34,688	2.69
Cranberries	1,575	32	50	1.58
Mint	41,486	1,659	1,991	1.2
Onions	17,716	3,012	3,403	1.13
Raspberries	7,863	3,460	3,771	1.09

NASS reports that in Oregon State, sweet cherry has been the main agricultural crop treated with 40,800 lbs (1991) of malathion. Active ingredient was applied to this crop at 5.55 lbs/acre (2001). To onions and raspberries, malathion was applied at 2.9 lbs/acre (2000) and 3.13 lbs/acre (2001). These crops received 7,200 lbs (1998) and 4,800 lbs (1999) of malathion, respectively. Green peas and apples were treated with an application rate of 0.73 lbs/acre (1994) and 1.79 lbs/acre (1997). These crops received 3,300 lbs (1994) and 2,900 lbs (1995), respectively.

Table 12. Major usage of malathion in Oregon (NASS Agricultural Chemical Database)

Crop	Max Lb a.i. applied/Acre	Max. Total Lb a.i./year
Apples	1.79 (1997)	2900 (1995)
Blackberries	2.0 (1995)	700 (1995)
Blueberries	2.43 (1999)	600 (1993)
Cherries - sweet	5.55 (2001)	40800 (1991)
Cherries - tart	2.92 (1991)	800 (1991)
Onions - bulb	2.9 (2000)	7200 (1998)
Peas - green	0.73 (1994)	3300 (1994)
Raspberries	3.13 (2001)	4800 (1999)

We also consulted the NCFAP National Pesticide Use database for usage information regarding Oregon. The most recent data was for 1997 and listed cherry as the main recipient of malathion with 43,847 lbs applied to 8,769 acres. This amounts to an application rate of approximately 5 lbs/acre. Onion (7,687 lbs), green peas (2,768 lbs), and raspberries (2,711 lbs) were the next three crops receiving large amounts of active ingredient applied to 4,319 acres, 3,791 acres, and 1,291 acres, respectively. This amounts to application rates of 0.56 lbs/acre, 1.37 lbs/acre, and 0.50 lbs/acre, respectively.

Table 13. Major usage of malathion in Oregon for 1997 (Source: NCFAP National Pesticide Use Database)

Crops	Total Acres planted	Acres treated	Lb a.i./year	Application rate (Lbs/acre)
Apples	10,254	615	1,101	1.79
Blackberries	5,145	360	720	2.0
Blueberries	2,483	99	151	1.52
Carrots	2,281	1,140	1,140	1.0
Cherries	15,385	8,769	43,847	5.0
Green peas	31,594	3,791	2,768	0.73
Mint	45,221	904	868	0.96
Onion	20,565	4,319	7,687	1.78
Raspberries	4,610	1,291	2,711	2.1

Walnuts	1,953	586	1,406	2.4

NASS does not provide usage information for Idaho. Therefore, we were only able to consult the NCFAP National Pesticide Use database for the usage information. The most recent data was very limited and from 1997. Since usage information for Idaho is so limited, we decided to also include usage information for 1992.

In 1997 barley, mint and sugarbeet are listed as three agricultural crops having received malathion treatments. Their respective acres treated and lbs of malathion applied were 14,230 acres (21,345 lbs), 476 acres (457 lbs), and 1,957 acres (2,935 lbs).

Table 14. Major usage of malathion in Idaho for 1997 (NCFAP National Pesticide Use Database)

Crops	Total Acres planted	Acres treated	Lb a.i./year	Application rate (Lbs/acre)
Barely	711,504	14,230	21,345	1.5
Mint	23,790	476	457	0.96
Sugarbeet	195,651	1,957	2,935	1.5

In 1992, dry peas, mint, and onion are three agricultural crops that have been treated with malathion. The respective acres treated and lbs of malathion applied were 1,700 acres (1,700 lbs), 1,780 acres (303 lbs), and 2,520 acres (3,024 lbs).

Table 15. Major usage of malathion in Idaho for 1992 (NCFAP National Pesticide Use Database)

Crops	Total Acres planted	Acres treated	Lbs a.i./year	Application rate (Lbs/acre)
Dry peas	84,979	1,700	1,700	1.0
Mint	17,800	1,780	303	0.17
Onion	8,400	2,520	3,024	1.2

According to these databases, the major agricultural uses for malathion were cherry, onion, raspberry, and apple in Oregon; apple, cherry, and asparagus in Washington; barley, onion, sugarbeet and dry peas in Idaho. Reported application rates are: Idaho (0.17- 1.5 lbs/A), Oregon (0.73-2.4 lbs/A), and Washington (0.92- 4 lbs/A). In California the major crops were: alfalfa, lettuce, strawberry, lemon, orange, date, walnut, barley, bean, Chinese cabbage. The major non-agricultural uses in California were: regulatory pest control, public health, structural pest control, and landscape maintenance.

3. General aquatic risk assessment for endangered and threatened salmon and steelhead

a. Aquatic toxicity of malathion

There is a great amount of aquatic toxicity data available for malathion. Data submitted to support registration were generated in accordance with Good Laboratory Practice regulations and have been through OPP's rigorous validation requirements for data used in assessments; these data are used in preference to other data.

(1) Acute toxicity to freshwater (FW) and Marine/Estuarine (SW) fish (source: EFED chapter)

Malathion can enter surface water through spray drift, during application, and runoff following rainfall events. Acute toxicity tests are essential to evaluate the impact of this pesticide on freshwater fish as well as marine/estuarine fish. Table 16 and 17 show the results of selected malathion studies that determine the endpoint values (LC_{50}) for freshwater and marine/estuarine fish for the active ingredient.

We determine that malathion may be highly to very highly toxic to most freshwater fish. Generally, endpoint values seem to fall into the range of 4.1 ppb (Rainbow trout) to 263 ppb (Yellow perch). Some species appear to be less affected by the toxicity of malathion, and their endpoint values range from 2000 ppb for tilapia (moderately toxic) to 11,700 ppb for the black bullhead catfish (slightly toxic).

Table 16. Acute toxicity to freshwater fish (source: EFED chapter and Pesticide Ecotoxicity Database)

Species	Scientific name	% a.i.	LC_{50} (96h) (ppb)	Toxicity category
Bluegill sunfish	*Lepomis macrochirus*	95	30	very highly toxic
			20	
Redear sunfish	*Lepomis microlophus*	95	62	very highly toxic
Rainbow trout	*Oncorhynchus mykiss*	95	4.1	very highly toxic
			32	very highly toxic
			30	very highly toxic
Yellow perch	*Perca flavescens*	95	263	highly toxic
Largemouth bass	*Micropterus salmoides*	95	250	highly toxic
Carp	*Cyprinus carpio carpio*	95	6590	moderately toxic
Fathead minnow	*Pimephales promelas*	95	8650	moderately toxic
Channel catfish	*Ictalurus punctatus*	95	7620	moderately toxic

Coho salmon	*Oncorhynchus kisutch*	95	170	highly toxic
Cutthroat trout	*Oncorhynchus clarki*	95	174	highly toxic
Brown trout	*Salmo trutta*	95	101	highly toxic
Lake trout	*Salvelinus namaycush*	95	76	very highly toxic
Black bullhead catfish	*Ameiurus melas*	95	11700	slightly toxic
Green sunfish	*Lepomis cyanellus*	95	146	highly toxic
Walleye	*Stizostedion vitreus*	95	64	very highly toxic
Tilapia	*Tilapia mossambica*	95	2000	moderately toxic
Goldfish	*Carassius auratus*	95	10700	moderately toxic

The limited toxicity data for marine and estuarine fish suggest that malathion is a very highly toxic pesticide to marineestuarine fish. Endpoint values are 33 ppb and 55 ppb for the Sheepshead minnow and 60ppb for the Striped bass.

Table 17. Acute toxicity to estuarine/marine fish (source: EFED chapter)

Species	**Scientific name**	**% a.i.**	**LC_{50} (96h) (ppb)**	**Toxicity category**
Sheepshead minnow	*Cyprinodon variegatus*	95	33.0	very highly toxic
		57 EC	55	very highly toxic
Striped bass	*Morone saxatilis*	95	60	very highly toxic

(2) Acute toxicity to freshwater and marine invertebrates and terrestrial insects with an aquatic life-stage (source: EFED chapter and Pesticide Ecotoxicity Database)

A number of studies on invertebrates conducted by the U.S. Fish and Wildlife laboratories indicate that malathion is highly to very highly toxic to terrestrial insects with a larval aquatic life stage (Table 18). Aquatic larvae are an important resource for aquatic predators such as fish. If larval survival is affected by malathion toxicity in surface waters, insect population densities are likely to decrease. Therefore, fish may experience a decrease in aquatic resources, and their own population densities may decrease in response.

All the data reported in table 18 suggest that malathion is very highly toxic to the aquatic life-stage of terrestrial insects. The range of toxicity values for this group of aquatic invertebrates is 0.69 ppb (stonefly) - 10 ppb (damselfly). The endpoint value for snipefly is 385 ppb, which is higher than for other insects reported here. We do not feel confident naming this data point either an outlier or using it to conclude that malathion may be highly toxic to some of these terrestrial insects with an aquatic lifestage. More data are needed to make this particular determination.

Table 18. Acute toxicity of malathion to terrestrial insects with an aquatic life stage

Species	**Scientific Name**	**% a.i.**	**LC_{50} (96h) (ppb)**	**Toxicity Category**
Stonefly	*Claasenia sabulosa*	95	2.8	very highly toxic
Stonefly	*Pteronarcella badia*	95	1.1	very highly toxic
Stonefly	*Isoperla sp.*	95	0.69	very highly toxic
Damselfly	*Lestes congener*	95	10	very highly toxic
Caddisfly	*Hydropsyche sp.*	95	5.0	very highly toxic
Caddisfly	*Limnephalus sp.*	95	1.3	very highly toxic
Snipefly	*Atherix variegata*	95	385	highly toxic

The toxicity data for freshwater invertebrates that spend all their life in the aquatic environment suggest that malathion is highly to very highly toxic to this group of organisms. Endpoint values range from 0.5 ppb (scud) to 180 ppb (crayfish). The endpoint value for the sowbug is 3000 ppb, which is much higher than for other freshwater invertebrates. We do not feel confident naming this data point either an outlier or using it to conclude that malathion may be moderately toxic to some of these freshwater invertebrates. More data are needed to make this particular determination.

Table 19. Acute toxicity of malathion to freshwater invertebrates

Species	**Scientific Name**	**% a.i.**	**Endpoint**	**Value (ppb)**	**Toxicity Category**
Water flea	*Daphnia pulex*	95	EC_{50} (48h)	1.8	very highly toxic
Scud	*Gammarus lacustris*	Tech	LC_{50} (48h)	1.8	very highly toxic
Scud	*Gammarus lacustris*	95	LC_{50} (96h)	0.5	very highly toxic
Daphnid	*Simocephalus serrulatus*	95	LC_{50} (48h)	0.69	very highly toxic
Crayfish	*Orconectes nais*	95	LC_{50} (96h)	180	highly toxic
Glass shrimp	*Palaemonetes kadiakensis*	95	LC_{50} (96h)	12	very highly toxic

Species	Scientific Name	% a.i.	Endpoint	Value (ppb)	Toxicity Category
Seed shrimp	*Cypridopsis vidua*	95	LC_{50} (49h)	47	very highly toxic
Water flea	*Daphnia magna*	57 EC	EC_{50} (48h)	2.2	very highly toxic
Water flea	*Daphnia magna*	95	EC_{50} (48h)	1.0	very highly toxic
Sowbug	*Asellus brevicaudus*	95	LC_{50} (96h)	3000	moderately toxic

Very little data are available on the acute toxicity of malathion to estuarine and marine invertebrates. From the limited data listed by EFED, we conclude that malathion may be moderately to highly toxic to this group of organisms. The range of endpoint values is 280 ppb for pink shrimp to 2960 ppb for Eastern oyster. Malathion may potentially be very highly toxic to some invertebrates as in the case of the mysid (2.2 ppb). More data are needed to gain a more conclusive picture.

Table 20. Acute toxicity of malathion to estuarine/marine invertebrates

Species	Scientific Name	% a.i.	Endpoint	Value (ppb)	Toxicity Category
Pink shrimp	*Penaeus duorarum*	95	LC_{50} (48h)	280	highly toxic
Eastern Oyster	*Crassostrea virginica*	95	LC_{50} (96h)	>1000	not conclusive
Eastern Oyster	*Crassostrea virginica*	57 EC	EC_{50} (96h)	2960	moderately toxic
Mysid	*Mysidopsis bahia*	94	LC_{50} (96h)	2.2	very highly toxic
Blue crab	*Callinectes sapidus*	95	LC_{50} (48h)	>1000	not conclusive

(3) Chronic toxicity of malathion to fish and invertebrates

The chronic toxicity data available are limited to three fish and one invertebrate study; specifically, the rainbow trout, fathead minnow, flagfish, and the water flea have been tested.

Table 21 shows that adverse chronic effects on reproduction or growth occurred at exposure concentrations of 11 ppb, 44 ppb, and 350 ppb for the flagfish, fathead minnow, and rainbow trout, respectively. The limited data suggest that malathion has the capacity to cause long-term effects in freshwater and estuarine and marine fish at low level exposure.

Table 21. Chronic toxicity to freshwater and estuarine/marine fish (source:EFED chapter)

species	scientific name	% a.i.	LOEC (ppb)	NOEC (ppb)
Rainbow trout	*Oncorhynchus mykiss*	94	44 (97 day)	21
Fathead minnow	*Pimephales promelas*	tech	350 (158 day)	N.D.
Flagfish	*Jordanella floridae*	tech	11 (110 day)	8.6

*N.D. = not determined

Table 22 shows that adverse chronic effects on reproduction, growth, and survival for the water flea occurred at exposure concentrations as low 0.10 ppb. Daphnid survival and number of young per adult were significantly lower than in the control population; time to first brood was significantly increased compared to the control population. The limited data seem to suggest that malathion may have the capacity to cause long-term effects to invertebrates at low level exposure.

Table 22. Chronic toxicity to invertebrates (source: EPA Pesticide Ecotoxicity database)

Species	Scientific name	% a.i.	Days	LOEC (ppb)	NOEC (ppb)	Reference
Water flea	*Daphnia magna*	94	21	0.10	0.06	MRID# 41718401

(4) Acute toxicity of malathion to freshwater, estuarine and marine fish and invertebrates (source: EPA AQUIRE data base)

There is a wealth of information available on the toxicity of malathion to freshwater fish in the EPA AQUIRE database. Endpoint values range from slightly toxic to very highly toxic. Even within a single species, this range of toxicity can be found (i.e. walking catfish, common carp). Overall endpoint values range from 0.7 ppb for the Western mosquito fish to 45,000 ppb for the Indian catfish. We conclude that malathion has the capacity to be slightly to very highly toxic to freshwater fish.

Table 23. Acute toxicity to freshwater fish (source: EPA AQUIRE data base)

Species	Scientific Name	Material	LC_{50} (96 h) (ppb)	Reference
Walking catfish	*Clarias batrachus*	Form	12000, 47	12689
			12	3971
			5600, 6200, 4800, 5000	15547
Channel catfish	*Ictalurus punctatus*	Form.	9650	822
Snake-head catfish	*Channa punctata*	Form	920	5648
			1.5	5883
			920	5583
			2900	11346
			4510, 3890	11888
			3220	5347
			1740	765

Species	Scientific Name	Material	LC_{50} (96 h) (ppb)	Reference
			874	17200
			7000, 8000	17548
			350	11701
American eel	*Anguilla rostrata*	Form.	500	859
			82	628
Tooth carp	*Aphanius fasciatus*	Form.	314	5365
Two spot African barb	*Barbus dorsalis*	Active	3700	6722
Two spot barb, dotted barb	*Barbus sophore*	Form.	1650	765
			3200	9276
Pool barb	*Barbus stigma*	Form.	19.50	13301
Two spot barb	*Barbus ticto*	Form.	8.9	962
		Active	4000	10764
Goldfish	*Carassius auratus*	Active	11.3	19981
			2610, 3150	563
		Form.	790	2893
Zebra danio	*Danio rerio*	Form.	210	12047
Smooth breasted snakefish	*Channa orientalis*	Form.	7600, 7350, 7050, 6950	5736
Silver carp	*Hypophthalmichthys molitrix*	Form	250, 1250	17359
Common carp	*Cyprinus carpio*	Form.	1900	859
			2500	17359
			2	13515
			3150	9277
		Active	85	10385
			12930, 710, 2100	6999
			13800, 12810, 10210, 10380	7219
Carp, hawk fish	*Cirrhinus mrigala*	Active	880.0	10575
		Form.	2250	9277

Species	Scientific Name	Material	LC_{50} (96 h) (ppb)	Reference
			9360, 10500, 9100	14166
Fathead minnow	*Pimephales promelas*	Active	14100	12859
			10800, 10100	640
		Form.	12500, 12500	2155
			23000, 16000, 25000	2893
Rainbow dace	*Cyprinella lutrensis*	Form.	25	8101
Eastern mudminnow	*Umbra pygmaea*	Active	240	672
Mud minnow, Mummichog	*Fundulus heteroclitus*	Form.	70	2814
			80, 400	628
			22.51	8870
		Active	22.51	4909
Banded killifish	*Fundulus diaphanus*	Form.	240	859
			250	628
Western mosquitofish	*Gambusia affinis*	Form.	200	5806
			300	20475
			660	5165
		Active	0.7	19981
Threespine stickleback	*Gasterosteus aculeatus*	Form.	94, 76.9	522
Indian catfish	*Heteropneustes fossilis*	Form.	45000, 3800, 42000	470
			45000	11831
			7300	12914
			11798	5994
			45	5064
			8500	17539
			11676	52490
			15000	15179
		Active	85000	10512

Species	Scientific Name	Material	LC_{50} (96 h) (ppb)	Reference
Channel catfish	*Ictalurus punctatus*	Form.	52200	934
Medaka, high-eyed	*Oryzias latipes*	Active	40000	14285
Flagfish	*Jordanella floridae*	Active	349	995
Rohu	*Labeo rohita*	Form.	4980	9277
Green sunfish	*Lepomis cyanellus*	Form.	600	2893
Pumpkin seed	*Lepomis gibbosus*	Form.	480	859
Bluegill	*Lepomis macrochirus*	Form.	120, 46	2085
			48	73
			120	942
			100	7603
			90, 550, 1200, 88	2893
		Active	131, 89	640
Redear sunfish	*Lepomis microlophus*	Active	170	610
Crimson spotted rainbow fish	*Melanotaenia fluviatilis*	Active	2090	15030
Largemouth bass	*Micropterus salmoides*	Form.	250	2893
White perch	*Morone americana*	Form.	1100	859
Asiatic knifefish	*Notopterus notopterus*	Active	77	4022
Coho salmon	*Oncorhynchus kisutch*	Form.	265	964
		Active	101	610
Rainbow trout	*Oncorhynchus mykiss*	Form.	122	964
			110	2871
			70	10212
			190, 200, 191, 234, 111	10656
			161, 115	12210
			160	12182
			2.8, 2.8	8101
		Active	250	19981

Species	Scientific Name	Material	LC_{50} (96 h) (ppb)	Reference
			170	610
Chinook salmon	*Oncorhynchus tshawytscha*	Form.	33.7	6615
			23.0	522
			120	2159
Guppy	*Poecilia reticulata*	Form.	1200	859
			3100	5370
			840	2893
Hill trout	*Barilius vagra*	Active	7660, 7390	7219
Cutthroat trout	*Oncorhynchus clarki*	Form.	150, 201	964
Brown trout	*Salmo trutta*	Active	200	610
Brook trout	*Salvelinus fontinalis*	Form.	130, 120	964
Java tilapia	*Tilapia niloticus*	Form	5880	166
Nile tilapia	*Tilapia nilotica*	Active	4.6	19981
Mozambique tilapia	*Tilapia mossambica*	Form.	290.1, 778.7	11603
			500	17691
		Active	140	3296

* Form. = Test was conducted with formulated products. The product composition and percent active ingredient were not given.
* Active = Test was conducted with the active ingredient

Acute toxicity of malathion to estuarine and marine fish ranges from moderately to very highly toxic with most endpoint values falling into the very highly toxic range. The range of values is 1.1 ppb (Rivulus) to 3250 ppb (Northern puffer). The available data for these organisms are not as extensive as for freshwater fish. Therefore, based on the data available, we conclude that malathion may be very highly toxic to most estuarine and marine fish.

Table 24. Acute toxicity to estuarine/marine fish (source: EPA AQUIRE data base)

Species	Scientific Name	Material	LC_{50} (96 h) (ppb)	Reference
Northern puffer	*Sphoeroides maculatus*	Form.	3250	628
Bluehead wrasse	*Thalassoma bifasciatum*	Form.	27	628
Rivulus	*Rivulus marmoratus*	Form.	1.10	13431
Striped mullet	*Mugil cephalus*	Form.	550	628
Striped bass	*Morone saxatilis*	Form.	17.8	602

Species	Scientific Name	Material	LC_{50} (96 h) (ppb)	Reference
			240	966
			39	859
			14	6615
			60	344
		Active	24.5, 65	11334
			16, 25, 12, 64, 100, 66	15472
Inland silverside	*Menidia beryllina*	Form.	0.03, 0.19, 0.25	13431
Atlantic silverside	*Menidia menidia*	Form.	125	628
Spot croacker	*Leiostomus xanthurus*	Form.	220	46522
Sheepshead minnow	*Cyprinodon variegatus*	Form.	51	5074
Giant gourami	*Colisa fasciata*	Form.	2150	7881

An abundance of studies conclude that malathion is very highly toxic to most freshwater and marine invertebrates, such as mayflies, stoneflies, caddisflies, true bugs, midges, beetles, and some shrimp. Endpoint values range from 1.14 (water flea) to 1000 ppb (beetle). Malathion seems practically non-toxic to many mussels, bivalves, and snails. Their endpoint values range from 12 ppb to 350,000 ppb with most values in the tens of thousands. A few studies indicate that even among some of these more resilient aquatic invertebrates, there may be some species for which malathion can be highly to very highly toxic (references 10787, 6665). From the limited data that is available on some species, we tentatively report that malathion can be practically non-toxic to moderately toxic for crayfish and moderately to very highly toxic for crabs and shrimp.

Table 25. Acute toxicity of malathion to aquatic invertebrates (Source: EPA AQUIRE database)

Species	*Order/suborder*	Material	Endpoint	Value (ppb)	Reference
Water flea	*Cladocera*	Form.	EC_{50} (48 h)	13	6956
				2.0	786
				2.12	821
				1.14	18961
				9	6102
				1.6	5370
				2	10337
				3	58990

Species	*Order/suborder*	Material	Endpoint	Value (ppb)	Reference
		Active	EC_{50} (48 h)	33	5675
		Form	EC_{50} (48 h)	100	5194
		Active	EC_{50} (48 h)	2.2, 1.6, 1.7, 2.1	6449
Mussels, Bivalves, snails	*Gastropoda*	Form.	EC_{50} (96 h)/ LC_{50} (96h)	5000, 975	12389
				(C.I.) 10000-100000	14258
				100, 12, 120	10787
				219000, 74000, 215000, 40000, 24000,109000, 111000, 74000, 142000, 180000, 28000, 350000, 350000, 350000	17860
				25000, 25000	2896
				80, 310	6665
				118.55, 248.97, 284.11, 168.36, 55.63	12537
				6136	14311
				1510, 1680, 2340	2331
		Active	EC_{50} (96 h)/ LC_{50} (96h)	6900, 39400	8127
				4700	17020
				37000	17307
Mayflies	*Ephemeroptera*	Form.	LC_{50} (96 h)	100	528
Beetle	*Coleoptera*	Form.	LC_{50} (96 h)	1000	7775
True bugs	*Hemiptera*	Form.	LC_{50} (96 h)	80	7775
Stoneflies	*Plecoptera*	Form.	LC_{50} (96 h)	56, 7.2	2161
				7.00, 50	528
				100	2161
				7.0, 50	2667
Caddisflies	*Trichoptera*	Form.	LC_{50} (96 h)	32	528
				32	2161

Species	*Order/suborder*	Material	Endpoint	Value (ppb)	Reference
				22.5	528
				22.5	2161
Midges	*Diptera*	Form.	LC_{50} (96 h)	(C.I.) 10-1000	17488
Crayfish	*Decapoda*	Active	LC_{50} (96 h)	<100,000	887
				1600	12517
Crabs	*Pleocyemata*	Form.	LC_{50} (96 h)	3780	12790
		Active	LC_{50} (96 h)	1.2	6793
				1330	
Shrimp	*Natantia*	Form.	LC_{50} (96 h)	4.0, 3.2, 5.2, 5.7, 5.0, 5.4	2280
				81.5, 9.0	6615
				11	13513
				33	627
				12	13513
				82	627
				1360, 1520, 1120, 1930	14969
		Active	LC_{50} (96 h)	3.0, 3.1, 2.6	968
				21.46	16752
				9.06, 13.24, 38.19	14346
				10.43	4909
				3.8, 2.2, 1.5, 1.4	9936
Amphipod	*Amphipoda*	Form.	LC_{50} (96 h)	1.62	528
				1.62	2094
				1.8	885
		Active	LC_{50} (96 h)	4.65, 2.29	51439
Copepoda	*Copepoda*	Form.	LC_{50} (96 h)	2.0	786
				(C.I.) 100-1000	17488
		Active	LC_{50} (96 h)	7.2, 20.5, 24.3	19281
Isopod	*Isopoda*	Form.	LC_{50} (96 h)	(C.I.) 20-1000	17488

Species	*Order/suborder*	Material	Endpoint	Value (ppb)	Reference
Flatworm	--	Active	LC_{50} (96 h)	4400	13793

* F = ingredient were not given.
*Active = Test was conducted with the active ingredient
*C.I. = 95 % Confidence Interval given when average value for LC_{50} is not available

We did not look at the original papers but report the toxicity values for the toxicity test periods that are analogous to those required by OPP testing requirements as a means of comparison. The AQUIRE reference numbers for each reported value are provided.

The AQUIRE database is not always reliable regarding the test being conducted with the formulation or the active ingredient; unless the test indicates an active ingredient, it is input into AQUIRE as formulation testing. However, we have seen values reported for the technical material in Mayer & Ellersieck (1986) to be reported in AQUIRE as a formulation test. We report the information on formulation versus active ingredient, but we need to note that it is not completely reliable.

A comparison between EFED and AQUIRE results shows that while EFED reports malathion to be highly to very highly toxic to freshwater fish, AQUIRE expands the toxicity range from slightly to very highly toxic for this category of fish. EFED reports that malathion is very highly toxic to marine and estuarine fish, while AQUIRE reports that the toxicity ranges from moderately to very highly toxic with, however, most endpoints being in the latter category. For invertebrates, EFED and AQUIRE concur and report that malathion is very highly toxic to most invertebrates with the exception of mussle, bivalve, and snail (AQUIRE). Overall, the abundance of data in AQUIRE supports the less abundant data in the EFED chapter.

(5) Toxicity to aquatic plants and algae

Malathion is a non-systemic insecticide and is applied as a spray to foliage to kill sucking and chewing insects before they damage crop. Malathion is not known to cause mortality in plants. No data are available in the EFED or EPA Aquire database on toxicity of malathion to plants.

(6) Toxicity of degradates (sources: EFED chapter, EPA AQUIRE)

Malaoxon and isomalathion are two of multiple degradates that result due to oxidation and isomerization of malathion, respectively. Their presence increases the level of toxicity created by the active ingredient malathion. Little data are available in the EPA databases on the toxicity of malaoxon, and no data could be found for isomalathion.

Malaoxon is a neuroactive toxic agent with a higher acute toxicity than malathion. Conversion of malathion to malaoxon ranges from 1.8% (registrants) to 10.7% (Cal EPA), depending on study conditions (see EFED chapter p. 16). The toxicity data available for malaoxon list studies with an LC_{50} up to 48 hours and not the 96 hours that we usually report on.

Nonetheless, we believe it is important to look at this toxicity data as well since it is all that is available and because the data indicate that the degradate has the potential to be very highly toxic.

When malathion degrades, malaoxon is created in small quantities (see above for %). From residential use of malathion, actual surface water concentrations are higher than expected due to a lack of microbial oxidation on asphalt. Therefore, malaoxon concentrations in surface waters may be higher than predicted as well. Malaoxon levels may pose a greater risk to aquatic life forms than currently assumed. The fact that malaoxon has a longer expected environmental persistence than malathion is an additional point of concern. The cumulation of these points further indicates that there is a need to look at chronic exposure of malaoxon to aquatic invertebrates and fish. The limited acute toxicity data indicate that malaoxon is highly to very highly toxic to some fish and has the potential to be very highly toxic to aquatic invertebrates.

Table 26. Malaoxon acute toxicity to fish and invertebrates (sources: EPA AQUIRE)

Species	Scientific name	Outcome	Material	Endpoint	Value (ppb)	Reference
Medaka	*Oryzias latipes*	M	Active	LC_{50} (24h)	450	18398
				LC_{50} (48h)	280	
Pumpkinseed	*Lepomis gibbosus*	M	Form.	LC_{50} (2h)	250	2669
				NS (2h)	0.25	
					0.25	
Perch	*Perca fluviatilis*	M	Form.	LC_{50} (48h)	150	86
Black bullhead	*Ameiurus melas*	M	Form	NS (2h)	2.5	2669
Midge	*Chironomus thummi*	IMBL	Active	LC_{50} (24h)	5.4	6830

* IMBL = immobility
*M = mortality
*NS = not stated

b. Aquatic Toxicity of other pesticide ingredients in malathion products to freshwater and marine fish, and invertebrates (source EPA AQUIRE, EFED database, Meyer & Ellersieck, 1986)

There are no available fish toxicity data on malathion products that contain other active pesticide ingredients. The following tables in section (3) present species toxicity data on other ingredients that are formulated with malathion. Several of these ingredients are as toxic as malathion itself.

Piperonyl butoxide is a chemical that inhibits the detoxification of the pesticide by the target organism. Because of this characteristic and the fact that with its presence less active ingredient is needed to achieve the death of target pests, piperonyl butoxide is used in a wide variety of insecticides. It is very highly toxic to aquatic invertebrates and fish.

Methoxychlor is an organo-chlorine insecticide that is very highly toxic to fish and aquatic invertebrates. It is often found in formulations with malathion, piperonyl butoxide, and others.

Resmethrin is a synthetic pyrethroid insecticide that is used to control flying insects in homes, greenhouses, etc, and for mosquito control. It is very highly toxic to fish and aquatic invertebrates.

Captan is a non-systemic fungicide used on fruit trees, ornamentals, and vegetables. It is very highly toxic to fish and aquatic invertebrates.

Carbaryl is a wide spectrum carbamate insecticide that controls pest on many different crops as well as livestock, poultry, and pets. It is moderately to highly toxic to fish, and moderately toxic to aquatic invertebrates. It has shown to bioaccumulate in aquatic species including plants (EcoToxNet).

In most multi active products except two, malathion is the predominant active ingredient. One fruit tree spray contains 3.00 % malathion, 5.87 % captan, and 90.5 % carbaryl. The toxicity of carbaryl and captan when comparing toxicity studies seem equivalent to the toxicity of malathion. Another product, a home fruit spray, contains 7.5% of malathion and 9.78% of captan. An agricultural alfalfa spray contains 13.787 % of methoxychlor and 23.807 % of malathion. Methoxychlor is very highly toxic to aquatic invertebrates, and its toxic effects are comparable to malathion.

These multi active ingredients seem as toxic to fish and aquatic invertebrates as malathion itself. Endpoint values (LC_{50}) range from 0.056 ppb for captan (Chinook and Coho salmon) to 8.8 ppb for piperonyl butoxide (Sheepshead minnow). Piperonyl butoxide, which is used sometimes in combination with malathion to control mosquitoes, seems to be very highly toxic to mussels and appears more toxic to such organisms than malathion. For carbaryl an endpoint value of 0.000693 ppb was reported for a dragonfly. At this point, this particular value may represent an outlier until further data can support this lower endpoint limit for carbaryl.

Table 27. Acute toxicity of piperonyl butoxide to freshwater, estuarine/marine fish, and invertebrates

Species	Scientific Name	Material	Endpoint	Value (ppb)
Rainbow trout	*Oncorhynchus mykiss*	Form.	LC_{50} (96 h)	2.4, 6.1
Sheepshead minnow	*Cyprinodon variegatus*	Form.	LC_{50} (96 h)	8.8
		90.5% a.i.	LC_{50} (96 h)	1.8
				3.94

Species	Scientific Name	Material	Endpoint	Value (ppb)
Water flea	*Daphnia magna*	90.78 a.i.	EC_{50} (48 h)	0.51
		87% a.i.	EC_{50} (48 h)	1.7
Eastern oyster	*Crassostrea virginica*	90.78% a.i.	EC_{50} (96 h)	0.23

Table 28. Acute toxicity of resmethrin to freshwater fish and invertebrates

Species	Scientific Name	Material	Endpoint	Value (ppb)
Coho salmon	*Oncorhynchus kisutch*	84%	LC_{50} (96 h)	1.77
		Form.	LC_{50} (96 h)	1.5, 0.277
Brown trout	*Salmo trutta*	84%	LC_{50} (96 h)	0.75
Water flea	*Daphnia magna*	90%	LC_{50} (48 h)	3.1

Table 29. Acute toxicity of methoxychlor to freshwater, estuarine fish, and invertebrates

Species	Scientific Name	Material	Endpoint	Value (ppb)
Atlantic salmon	*Salmo salar*	Form (50GR)	LC_{50} (96 h)	1.7
Scud	*Gammarus lacustris*	89.5% a.i.	LC_{50} (96 h)	0.8
Midge	*Chironomus tentans*	Active	LC_{50} (96 h)	1.62
Caddisfly	*Cheumatopsyche species*	Active	LC_{50} (96 h)	3.24
Stonefly	*Pteronarcys californica*	89.5% a.i.	LC_{50} (96 h)	1.4
Water flea	*Daphnia pulex*	89.5% a.i.	EC_{50} (48 h)	0.78

Table 30. Acute toxicity of captan to freshwater, marine fish, and invertebrates

Species	Scientific Name	Material	Endpoint	Value (ppb)
Opossum shrimp	*Americamysis bahia*	Form.	LC_{50} (96 h)	8.4
Sheepshead minnow	*Cyprinodon variegatus*	Form.	LC_{50} (96 h)	1.9
Bluegill sunfish	*Lepomis macrochirus*	88.4	LC_{50} (96 h)	0.072
Coho salmon	*Oncorhynchus kisutch*	90	LC_{50} (96 h)	0.056
Chinook salmon	*Oncorhynchus tshawytscha*	90	LC_{50} (96 h)	0.056

Table 31. Acute toxicity of carbaryl to freshwater fish and invertebrates

Species	Scientific Name	Material	Endpoint	Value (ppb)
Rainbow trout	*Oncorhynchus mykiss*	99.5	LC_{50} (96 h)	1.2

Species	Scientific Name	Material	Endpoint	Value (ppb)
Yellow perch	*Perca flavescens*	99.5	LC_{50} (96 h)	0.35
Seed shrimp	*Cydridopsis vidua*	99.5	LC_{50} (96 h)	0.114
Water flea	*Ceriodaphnia dubia*	Active	LC_{50} (48 h)	3.06
				6.66
				7.2
Dragonfly	*Brachythermis contaminata*	Form.		0.000693

Chronic toxicity of multi actives to fish and invertebrates (source: EFED toxicity database)

The limited data suggest that piperonyl butoxide has the capacity to cause long-term effects to freshwater fish and invertebrates at low level exposure. Piperonyl butoxide may cause chronic effects in fish and invertebrates at concentrations as low as 0.11 ppb and 0.12 ppb, respectively.

Table 32. Chronic toxicity of piperonyl butoxide to freshwater fish and invertebrates (source: EFED toxicity database)

Species	Scientific name	% a.i.	Days	LOEC (ppb)	NOEC (ppb)
Water flea	*Daphnia magna*	90.78	21	0.12	0.066
		92.43	21	47	30
Fathead minnow	*Pimephales promelas*	87	35	0.48	0.23
		92.4	N.R.	0.11	0.04
Rainbow trout	*Oncorhynchus mykiss*	Tech	90	1.66	1.31

The limited data suggest that resmethrin has the capacity to cause long-term effects to freshwater, marine and estuarine fish and invertebrates at low level exposure. Resmethrin may cause chronic effects in fish and invertebrates at concentrations as low as 0.59 ppb and 0.062 ppb, respectively.

Table 33. Chronic toxicity of resmethrin to freshwater, estuarine and marine fish and invertebrates (source: EFED toxicity database)

Species	Scientific name	% a.i.	Days	LOEC (ppb)	NOEC (ppb)
Water flea	*Daphnia magna*	86.85	21	0.062	<0.062
Sheepshead minow	*Cyprinodon variegatus*	86.3	20	75	7.05
Fathead minnow	*Pimephales promelas*	90	30	0.59	0.3

Species	Scientific name	% a.i.	Days	LOEC (ppb)	NOEC (ppb)
Rainbow trout	*Oncorhynchus mykiss*	90	52	0.59	0.32

The limited data suggest that carbaryl has the capacity to cause long-term effects to freshwater fish and invertebrates at low level exposure. Carbaryl may cause chronic effects in fish and invertebrates at concentrations as low as 680 ppb and 1.0 ppb, respectively.

Table 34. Chronic toxicity of carbaryl to freshwater fish and invertebrates (source: EFED toxicity database)

Species	Scientific name	% a.i.	Days	LOEC (ppb)	NOEC (ppb)
Water flea	*Daphnia magna*	99	8-21	6000	3300
Fathead minnow	*Pimephales promelas*	99	270	680	210
Midge	*Chironomus riparius*	99	28	1.0	0.5

c. Synergism of multi active ingredients in malathion products

Synergistic ingredients serve to reduce the cost of active ingredients while increasing the efficiency of the pesticide. Resmethrin, piperonyl butoxide, captan, carbaryl, and methoxychlor are all ingredients that have been added to products containing malathion. For piperonyl butoxide, carabaryl, and malathion we were able to find studies on synergism and will address results here briefly. For the remaining chemicals, synergistic studies were not found.

Lenova and Slynko (2004) tested synergistic effects between piperonyl butoxide, S,S,S-TBPT, DEM and pesticides of different chemical classes in beetworm larvae and adults. They report that piperonyl butoxide can enhance the toxic effect of carbaryl in larvae 15 fold but not in adults. They did not test piperonyl butoxide - malathion combination for synergistic effects but S,S,S-TBPT- malathion, which resulted in a 100 fold toxic effect increase. Maybe the combination of piperonyl butoxide and malathion did not need to be tested because of such work by Losada *et al.* (1991), who found that the effect of piperonyl butoxide on malathion resistant strains of mosquitoes did not cause mortality. Takahashi *et al.* (1982) discuss and show evidence of synergistic effects between carbamate pesticides (but not carbaryl) and malathion in mice and rats. The EFED chapter reports on additive but not synergistic effects when malathion and carbaryl are mixed (p.78).

Resmethrin is used in conjunction with malathion to provide a quick knockdown while malathion gets a chance to kill the target pest. No apparent synergism is reported between the two chemicals. Captan, a fungicide, and methoxychlor, a substitute for DDT, have yet to show synergistic effects with other pesticides.

The multi active products that we report on do not seem to produce synergistic effects but some have the capacity to produce additive effects in insect pests.

d. Environmental fate and transport (source EFED chapter)

The environmental fate and transport of malathion are presented in the EFED chapter on pages 13-26. An assessment of water resources, including surface and ground water monitoring, is on pages 28-48. EECs and model inputs are on pages 31-36.

Malathion is a broad-spectrum, non-systemic organophosphorous insecticide with generally little persistence in the environment under alkaline conditions and higher degree of persistence under acidic conditions.

Hydrolysis data show that malathion hydrolyzes rapidly and has a half-life of 6.21 days under neutral and alkaline conditions, while it remains hydrolytically stable with a half-life of 107 days in buffered acidic environment.

Malathion is considered stable under *photodegradation in natural* and *distilled waters* as well as *in soil*. The half-lives for water and soil are 0.67-42 days and 173 days, respectively. Photodegradation on soil is not a major route of dissipation.

Photodegradation in the air is considered a minor route of dissipation since malathion has a low vapor pressure. Since ULV applications commonly used to spray against mosquitos have very small droplets of pesticides (~10µm), malathion concentrations are likely to increase in the air. Higher concentrations may lead to higher contributions of aerial photodegradation. No open literature references were found on photodegradation in the air.

The primary mode of dissipation and important route of degradation is through *aerobic soil metabolism*. Half-lives vary from just hours to 11 days. Generally, it can be said that microbial activity (oxidation), moisture, and higher pH increase the degradation of malathion.

Malathion persistence in an *anaerobic aquatic* environment seems to be short, and one study produced a half-life of 2.5 days (sediment pH 7.8, water pH 8.7).

Aerobic aquatic degradation in flowing and standing water bodies strongly depends on local physical and biochemical conditions. Degradation occurs through the routes of biodegradation and hydrolysis and depends on soil types and pH of material.

One study records that in river water, 75% and 90% of malathion had degraded in one week and two weeks, respectively. Another study found that the half-life of malathion varied from 0.5 days to 10 days based on the pH in ponds, lakes, rivers and other water bodies.

The highest level of malathion surface water contamination in urban areas is due to urban use patterns (i.e. homeowner, residential mosquito control). Malathion degrades slowly on non-soil surfaces and is expected to run off into surface water.

Mobility of malathion in soils, such as sandy loam, sand, loam, and silt loam, appears to be high. Malathion's short persistence in soil is expected to reduce the risk of leaching into groundwater; nonetheless, presence of malathion in ground water was found in several states (US EPA 1992; see EFED Chapter p. 23). Malathion contamination of ground water seems to be a greater problem than predicted by modeling and stresses the need for data on environmental conditions that do not favor degradation. No such data have been provided at this point.

Spray drift of malathion is the greatest problem for ULV applications. Currently, ecological models assume a 5% drift from aerial and orchard airblast applications, but ULV studies for malathion show significantly higher levels of drift. Modeling assumptions will have to be reviewed and corrected in the future (personal communication with Mark Corbin, EFED). Agricultural uses where ULV drift prone applications are made are most likely to contribute to surface water contamination.

Dissipation of malathion in terrestrial fields is considered to occur fastest under microbial degradation. Varying rates of dissipation are stated in the open literature and range from 'no residues after 6 months' to'85% degradation in 3 days' and '97% degradation in 8 days'. An aquatic dissipation field study in Missouri showed a vary rapid dissipation of malathion (<1 day) in a flooded rice paddy. An accurate half-life could not be determined because of this rapid dissipation. In another aquatic field dissipation study in California, 0.58 lbs of a.i. were applied to a rice paddy once a week over the course of three weeks. The study was inconclusive, and no half-life could be determined because only 1-2% of the intended malathion reached the experimental site.

Bioaccumulation of Malathion has been studied in the following crops: corn, grain sorghum, soybeans, and sweet potato. No bioaccumulation was recorded. However, the study (MRID 42058402) was rejected because the authors did not report on other residues aside of malathion and malaoxon. Minor, non-significant bioaccumulation of [^{14}C]malathion was reported by the registrant in bluegill sunfish in a 28 day study conducted in a flow through system at constant exposure of 0.99 ppb. Average concentration in edible fish parts were 3.9 to 18 ppb, 21 to 130 ppb in the whole fish, and 34 to 200 ppb in non-edible parts. Malathion monocarboxylic acid (MCA), another degradate of malathion, was the only substantial residue detected in fish tissue and was found in concentrations of 33.3% to 35.9% of total radioactive residues. Malaoxon was present in concentrations $\leq$ 2.7 ppb, while malathion was present in 0.2 ppb. No comments were provided on whether MCA is expected to have toxic effects and, specifically, how the high concentration of MCA may affect fish.

e. Incidents (source: EIIS pesticide database)

There are quite a few incident reports from 1970-2003 listed in our database, and some go as far back as the 1970s. We list incidents from 1980-2003, with the most recent first. Approximately 2000 fish died in North Carolina (Craven County) in March 2003 (#I014123-006). The report does not reveal what activity caused the disaster and whether it was accidental, intentional, or from a registered use activity. In 2000, fifty-six bee hives were destroyed when cherry orchards were treated with malathion in Washington state (Klickitat and Franklin counties) (#I014341-043, I014341-044). We are reporting on the matter to (1) convey how very highly toxic malathion is to insects and (2) because there are seven ESUs in Franklin county that could potentially have such a terrestrial accident. In 1999, 1500 bluegill sunfish and 1500 unknown fish were killed during a non-identified activity in New York (Richmond County) (#I009790-001). In 1998, hundreds of bream and sunfish were killed in Tennessee (Haywood County) when cotton fields were sprayed with malathion (#B0000-600-01). The report states that the activity occurred as a registered use. Numerous incidents are listed without giving numbers of fish killed, nature and legality of activity. Many of them indicate that a 'large number' or 'unknown number' of fish were killed (#B0000-500-14, B0000-600-03, #B0000-503-52). These incidents are from late 1980 to late 1990. Many more incidents are reported from 1970-1980 where great numbers of fish were killed (thousands, ten thousands) due to agricultural activities in Missouri, Michigan, North Carolina, California, Alabama, Georgia, and South Dakota. Since these incidents are over 20 years old, we mention their existence but do not elaborate on specifics.

f. Estimated and actual concentrations of malathion in water

(1) Measured residues in the environment

NAWQA data

Monitoring data on malathion is available from the NAQWA program as obtained from USGS" data warehouse" (at URL
http://infotrek.er.usgs.gov/servlet/page?_pageid=543&_dad=portal30&_schema=PORTAL30).

Table 35 presents a summary of these monitoring data for the U. S. as a whole and in study sites in states within the range of Pacific salmon and steelhead. As of November 2004, the database listed a total of 18,238 samples taken nationally from 1984 to 2004 for malathion. There were 1,366 detects for malathion, a rate of 7.5% detection, with a maximum value of 9.58 ppb. California data included two residue values above 1 ppb at 1.14 ppb and 1.35 ppb. The former was collected in Merced County and the other in San Bernadino County, which is not included within the ESUs. The PNW did not include any residue values greater than 1 ppb.

We must note that the NAWQA sampling data, while considered high quality, are not targeted to sites and times where malathion is used. Even regular sampling according to a predetermined schedule may not detect peak residues unless the samples happen to be taken shortly afterwards and adjacent to sites treated with malathion. It seems likely, but may not be correct, that when samples are taken, the highest NAWQA residues may actually represent peaks that occur in natural waters. There were no data for malaoxon in this database for the PNW and California.

Table 35. Malathion residues: detection frequency and maximum amounts found

State	# samples	# detects	% detects	max residue (ppb)	# >1 ppb	Note
National	18238	1366	7.5	9.58	6	Values >1 range from 1.14 to 9.58
California	1808	299	16.5	1.35	2	Values >1 are 1.14 and 1.35
Oregon	456	21	4.6	0.237	0	
Washington	1098	119	10.8	0.235	0	
Idaho	369	5	1.4	0.02	0	

The EFED chapter indicated that within the NAWQA data the residues in the urban sites were higher than their agricultural counterparts. Table 36 presents a summary of agriculture and urban monitoring data from 1984 to 2004 for the U. S. as a whole, and in study sites in states within the range of Pacific salmon and steelhead. Nationally, the maximum detection that was in urban areas (9.58 ppb) was significantly higher than the maximum detected in agricultural settings (1.14 ppb). In California, the maximum residue detected in urban settings (1.35 ppb) was only slightly higher than the agriculture counterpart (1.14 ppb). In the PNW, however, the maximum detection for agriculture sites was higher than that of urban sites.

Table 36. Comparison of urban and agricultural malathion residues: detections and amounts found.

State	**Urban**		**Agricultural**	
	# detects	**Range of Residue Values (ppb)**	**# detects**	**Range of Residue Values (ppb)**
National	458	0.0030-9.580	418	0.00170-1.140
California	58	0.0044-1.35	90	0.0017-1.14
Oregon	6	0.0066-0.052	13	0.007-0.237
Washington	18	0.01-0.0868	74	0.0023-0.235
Idaho	0	N/A	1	0.02

California DPR County Data

Surface water monitoring data for malathion are included in the California DPR surface water database (DPR). Table 37 presents a summary of these monitoring data for malathion for the California counties. A total of 4,744 samples had 215 detections ranging from 0.026 ppb to 6.0 ppb. Nine detections had residue values greater than 1 ppb. Table 38 presents data for malaoxon, a degradate of malathion. A total of 635 samples had only 1 detection with a residue of 0.06 ppb.

Table 37. California DPR Database: Malathion Residue Concentrations for Surface Waters(1990-2003).

County	Number of Samples	Number of Detects	% Detects	Maximum Residue (ppb)	Number >1ppb
Butte	42	1	2.4	0.026	0
Colusa	237	30	12.7	6.0	4
Contra Costa	1	0	0		
Imperial	165	58	35.2	1.34	1
Merced	342	9	2.6	0.39	0
Monterey	135	6	4.4	0.544	0
Orange	204	26	12.7	5.553	4
Sacramento	1133	18	1.6	0.634	0
San Joaquin	948	4	0.4	0.10	0
Santa Cruz	8	0	0		
Shasta	4	0	0		
Solano	5	0	0		
Sonoma	51	0	0		
Stanislaus	893	49	5.5	0.42	0
Sutter	423	5	1.2	0.639	0
Tehama	15	0	0		
Yolo	105	9	8.6	0.24	0
Yuba	33	0	0		
Total	4744	215	4.5	6.0	9

Table 38. California DPR Database: Malaoxon Residue Concentrations for Surface Waters(1990-2003).

County	Number of Samples	Number of Detects	% Detects	Maximum Residue (ppb)	Number >1ppb
Imperial	65	1	1.5	0.06	0
Merced	127	0	0		
Monterey	65	0	0		
San Joaquin	18	0	0		
Sonoma	51	0	0		
Stanislaus	257	0	0		
Sutter	52	0	0		
Total	635	1	0.2	0.06	0

(2) EECs from models

Agricultural Uses

In the EFED chapter, malathion aquatic EECs were estimated using two models, the GENEEC and PRZM-EXAMS models. All of the sites were based on climate and soils relative to the southeastern U.S., and are not likely to be representative of the western U. S. Consequently, additional efforts were made by EFED to use more recently developed sites to be more representative of the areas where Pacific salmon and steelhead occur. EFED provided western PRZMS-EXAMS results. The results of this assessment are presented in Table 26. See attachment D-1 for the full report.

In both models, it is considered that a 10-hectare watershed will be treated with the maximum rate, maximum numbers of applications, and minimum intervals between applications. Runoff and drift from this 10-hectare watershed will go into a 1-hectare pond, 2 meters deep. This is a conservative model for salmon and steelhead. While first order streams may be reasonably predicted for a single application, salmon and steelhead, except sockeye, occur primarily in streams and rivers where natural flow of water, and any contaminants in the water column, will move downstream and preclude continued exposure from a single application. Multiple applications may provide for chronic exposure, most likely in a pulsed mode.

Table 39. Estimated Environmental Concentrations (EECs) for malathion using PRZM-EXAMS models.

Summary of Predicted EECs				
State & Crop	**Scenario Modeled**	**Peak (ppb)**	**21-Day Average (ppb)**	**60-Day Average (ppb)**

California Alfalafa (ULV)	CA alfalfa	39.1	11.2	3.9
California Alfalfa	CA alfalfa	7.8	2.2	0.8
California Strawberries	CA lettuce	36.2	18.7	8.9
California Lettuce	CA lettuce	8.5	3.1	1.1
California Walnuts	CA almond	48.9	14.7	5.2
California Citrus	CA citrus	77.4	28.7	13.4
California Dates	CA fruit	15.1	7.0	4.6
Oregon Cherries (ULV)	OR apple	42.7	20.3	9.6
Oregon Cherries	OR apple	32.1	14.9	6.9
Oregon Apples	OR apple	47.6	15.5	5.5
Oregon Asparagus	OR snapbean	7.7	2.4	0.9
Oregon Onions	OR snapbean	12.3	1.4	0.9
Idaho Potatoes	ID potato	16.6	6.5	2.4

Mosquito Control

The two assessment scenarios evaluated were intended to represent a vulnerable static aquatic environment (*e.g.* a lake or estuarine area) and a vulnerable flowing water body (*e.g.* a small stream). The Environmental Fate and Effects Division's (EFED's) interim rice model (10/29/2002 policy) was used in conjunction with the measured aquatic half-life for malathion to estimate concentrations in a static surface water body. This model resulted in a peak estimated concentration of 306 ppb. The result of this calculation is conservative for the salmonids as it represents a shallow static water body, whereas, salmonids are generally found in deeper, flowing water bodies. Also, the concentrations found in salmonid supporting waters impacted by spraying shallow slow moving water bodies would be expected to be less than this value (in some cases much less) due to degradation of the malathion and dilution by untreated water.

The stream module of the AGDISP model was used to estimate concentrations in flowing water bodies and resulting direct and indirect risks to listed salmonids. Using application conditions simulating an aerial application treating streamside vegetation, the model resulted in an estimated aquatic concentration of 120 ppb. This model does not take into account partitioning or degradation which would reduce concentrations. Another difference is that only pesticide drift is considered in the stream assessment. Direct application to stream which would result in higher concentrations is not considered. See attachment D-2 for full report.

Field studies

The EFED chapter lists multiple targeted studies that have been conducted to observe effects to multiple groups of terrestrial organisms as well as aquatic species. We report on aquatic studies only.

In a 20 acre watershed study in Ohio (deciduous forest), 2 lbs/acre and 4 applications of radio tagged malathion were made. Residue analysis was conducted under application areas and above canopy, in trees, shrubs, and soil/leaf litter. Radioactivity was high in plant tissue samples that were retrieved from treated areas suggesting systemic uptake of malathion. Fungi had a higher radioactive concentration than plants in their vicinity but were not seemingly affected by the pesticide. Soil arthropods were temporarily affected and exhibited mortality; birds seemed to have shown temporary sublethal effect, which subsided after 48 hours; chipmunk density were reduced by half in treated areas; white footed mice density was reduced up to 45%; large mammals seemed unaffected. In stream nets, 1270 dead insects were collected one hour after spraying; 640 and 598 insects were collected two and three hours, respectively, after spraying the water shed.

Studies looking at stonefly larval survival after 96 hour acute exposure under static conditions found that when larvae exhibited sublethal effects and were removed into uncontaminated water, they generally died within the next day.

g. Water Quality Criteria

EPA's Office of Water established Water Quality Criteria of 0.1 ppb for malathion for aquatic organisms (http://www.epa.gov/waterscience/criteria/goldbook.pdf) and a lifetime Health Advisory (HA) Level of 100 ppb (http://www.epa.gov/waterscience/drinking/standards/dwstandards.pdf). Malathion does not have an established Maximum Contaminant Level or a criterion for drinking water.

h. Existing protections

Nationally, there are no specific protective measures for endangered and threatened species beyond the generic statements on the current malathion labels. As stated on product labels, it is a violation of Federal law to use a product in a manner inconsistent with its labeling. The current "master label" (Atrapa 8E) for the 81.43% active ingredient states in the environmental hazard section:

> "This product is toxic to fish, aquatic invertebrates and aquatic life stages of amphibians. For terrestrial uses, do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters.

"This product is highly toxic to bees exposed to direct treatment on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds if bees are visiting the treatment area."

Other malathion labels have similar statements, but there is minor variation depending upon the age of the label.

Malathion is also included in bulletins for California. There, the Department of Pesticide Regulation (DPR) in the California Environmental Protection Agency creates county bulletins consistent with those developed by OPP. However, California also has a system of County Agricultural Commissioners responsible for pesticide regulation, and all agricultural and commercial applicators must get a permit for the use of any restricted use pesticide and must report all pesticide use, restricted or not. The California bulletins for protecting endangered species have been in use for about 5 years. Although they are currently "voluntary " in nature, the Agricultural Commissioners strongly promote their use by pesticide applicators. Malathion is currently included in these bulletins for the protection of aquatic organisms. The specific limitations are:

#10 Do not use in currently occupied habitat (see Species Descriptions table for possible exceptions)

#15 Provide a 20 foot minimum strip of vegetation (on which pesticides should not be applied) along rivers, creeks, streams, wetlands, vernal pools and stock ponds or on the downhill side of fields where run-off could occur. Prepare land around fields to contain run-off by proper leveling, etc. Contain as much water "on-site" as possible. The planting of legumes, or other cover crops for several rows adjacent to off-target water sites is recommended. Mix pesticides in areas not prone to runoff such as concrete mixing/loading pads, disked soil in flat terrain or graveled mix pads, or use a suitable method to contain spills and/or rinsate. Properly empty and triple-rinse pesticide containers at the time of use.

#16.Conduct irrigations efficiently to prevent excessive loss of irrigation waters through run-off. Schedule irrigations and pesticide applications to maximize the interval of time between the pesticide application and the first subsequent irrigation. Allow at least 24 hours between the application of pesticides listed in this bulletin and any irrigation that results in surface run-off into natural waters. Time applications to allow sprays to dry prior to rain or sprinkler irrigations. Do not make aerial applications while irrigation water is on the field unless surface run-off is contained for 72 hours following the application.

#17 For sprayable or dust formulations: when the air is calm or moving away from habitat, commence applications on the side nearest the habitat and proceed away from the habitat. When air currents are moving toward habitat, do not make applications within 200 yards by air or 40 yards by ground upwind from occupied habitat. The county agricultural commissioner may reduce or waive buffer zones following a site inspection if there is an adequate hedgerow, windbreak, riparian corridor, or other physical barrier that substantially reduces the probability of drift.

No specific malathion limitations exist in PNW states. However, other states aside from California have implemented protections for aquatic species through county bulletins. Some of these suggest the following measures to protect T & E species:

1. 100 yard or 1/4 mile or 1 mile buffer zones from the edge of water for ground, aerial, and ULV applications, respectively
2. Exclusion of tributaries ½ mile upstream from malathion applications
3. No direct application of malathion to water within a particular zone

OPP currently has proposed (67 *Federal Register* 231, 71549-71561, December 2, 2002) a final implementation program that includes labeling products to require pesticide applicators to follow provisions in county bulletins. A final Federal Register Notice is under development and is anticipated to be published in March 2005. After this notice becomes final, it is expected that pesticide registrants will be required, as appropriate, to put on their product label statements mandating that applicators follow the label and county bulletins. It is also anticipated that these will be enforceable under FIFRA, including the California bulletins. Any geographically specific measure necessary to protect T & E salmon and steelhead from malathion would most likely be promulgated through this system.

i. Biological Opinion

There is a Biological Opinion for the rangeland cluster analysis from December 11th, 1984, a revised Biological Opinion provided by RPA's and RPM's for listed aquatic species from June 14th, 1989, and a Biological Opinion for the corn cluster analysis from February 28th, 1993.

j. Discussion and general risk conclusions for malathion

The risk conclusions in this assessment are based on risk quotients (RQs) derived from the available toxicity data (Tables 16 to 22) and EECs (Table 39) from the PRZM-EXAMS model for currently maximum labeled rates. The acute RQs for fish and invertebrates range from 0.39 ppb to 3.87 ppb and 3.50 ppb to 112.17 ppb, respectively. The chronic RQs for freshwater fish and invertebrates range from 0.04 ppb to 0.64 ppb and 23.33 ppb to 478.33 ppb, respectively. All RQ values are presented in table 40.

Table 40. Risk Quotients (RQ) for Freshwater and Estuarine Fish and Invertebrates.

Crop	**Peek EEC**	**Acute FW Fish RQ[1]**	**Acute FW Invert RQ[2]**	**Acute Est. Fish RQ[3]**	**Acute Est. Invert RQ[4]**	**21-day EEC**	**Chronic FW Invert RQ[5]**	**60-day EEC**	**Chronic FW Fish RQ[6]**
California Alfalfa (ULV)	39.1	1.95	56.67	1.18	17.77	11.2	186.67	3.9	0.19
California Alfalfa	7.8	0.39	11.30	0.24	3.55	2.2	36.67	0.8	0.04
California Strawberries[7]	36.2	1.81	52.46	1.10	16.45	18.7	311.67	8.9	0.42
California Lettuce	8.5	0.43	12.32	0.26	3.86	3.1	51.67	1.1	0.52
California Walnuts[8]	48.9	2.45	70.87	1.48	22.23	14.7	245.00	5.2	0.25
California Citrus	77.4	3.87	112.17	2.35	35.18	28.7	478.33	13.4	0.64
California Dates[9]	15.1	0.76	21.88	0.46	6.86	7.0	116.67	4.6	0.22
Oregon Cherries[10] (ULV)	42.7	2.14	61.88	1.29	19.41	20.3	338.33	9.6	0.46
Oregon Cherries[10]	32.1	1.61	46.52	0.97	14.59	14.9	248.33	6.9	0.33
Oregon Apples	47.6	2.38	68.99	1.44	21.64	15.5	258.33	5.5	0.26
Oregon Asparagus[11]	7.7	0.39	11.16	0.23	3.50	2.4	40.00	0.9	0.04
Oregon Onions[12]	12.3	0.62	17.83	0.37	5.59	1.4	23.33	0.9	0.04
Idaho Potatoes	16.6	0.83	24.06	0.50	7.55	6.5	108.33	2.4	0.11

[1] Bluegill sunfish LC_{50} = 20 ppb
[2] Daphnia EC_{50} = 0.69 ppb
[3] Sheepshead minnow LC_{50} = 33.0 ppb
[4] Mysid LC_{50} = 2.2 ppb
[5] Water flea NOEC = 0.06 ppb
[6] Rainbow Trout NOEC = 21 ppb
[7] In absence of a strawberry scenario, the lettuce scenario was used as a surrogate scenario.
[8] In absence of a walnut scenario, the almond scenario was used as a surrogate scenario.
[9] In absence of a date scenario, the fruit scenario was used as a surrogate scenario.
[10] In absence of a cherry scenario, the apple scenario was used as a surrogate scenario.
[11] In absence of a asparagus scenario, the snapbeans scenario was used as a surrogate scenario.
[12] In absence of an onion scenario, the snapbeans scenario was used as a surrogate scenario.

Table 41 presents RQs derived from the available toxicity data (Tables 16 to 21) and EECs (Table 39) from the Interim Rice Model (static water) and the AGDISP (flowing water) model for currently maximum labeled rates for mosquito uses. The acute RQs for fish and invertebrates range from 3.64 ppb to 15.3 ppb and 10 ppb to 443.5 ppb, respectively.

Table 41. Risk Quotients (RQ) for Freshwater and Estuarine Fish and Invertebrates based on maximum application rates for mosquito control.

Model Scenario	Peek EEC (ppb)	Acute FW Fish RQ[1]	Acute FW Invert RQ[2]	Acute Est. Fish RQ[3]	Acute Est. Invert RQ[4]
Static water	306	15.3	443.5	9.27	139.09
Flowing water	120	6	173.9	3.64	54.55

[1] Bluegill sunfish LC_{50} = 20 ppb
[2] Daphnia EC_{50} = 0.69 ppb
[3] Sheepshead minnow LC_{50} = 33.0 ppb
[4] Mysid LC_{50} = 2.2 ppb

The acute freshwater RQ_S are based on the sensitive species tested with malathion, the bluegill. However, the rainbow trout is a better model for the listed salmonids and more accurately represents the risks of malathion to these listed species. The toxicity data indicate that the lowest acute LC_{50} for the rainbow trout, based on the technical grade of the active ingredient is 4.1 ppb. This value seems to be overly sensitive considering that other tests on rainbow trout had values that ranged from 30 ppb to 200 ppb. The next lowest acute LC_{50} for rainbow trout is 30 ppb, compared to the bluegill value of 20 ppb, which was used in the calculations in Tables 40 and 41. A comparison of the acute RQs are in Table 42.

Table 42. Comparison of the acute risk quotients with the rainbow trout and bluegill.

Use Site	Peak EEC	Bluegill RQ[1]	Rainbow Trout RQ[2]
Agricultural Use			
California Alfalfa (ULV)	39.1	1.95	1.30
California Alfalfa	7.8	0.39	0.26
California Strawberries	36.2	1.81	1.21
California Lettuce	8.5	0.43	0.28
California Walnuts	48.9	2.45	1.63
California Citrus	77.4	3.87	2.58
California Dates	15.1	0.76	0.50
Oregon Cherries (ULV)	42.7	2.14	1.42
Oregon Cherries	32.1	1.61	1.07
Oregon Apples	47.6	2.38	1.59

Use Site	Peak EEC	Bluegill RQ[1]	Rainbow Trout RQ[2]
Oregon Asparagus	7.7	0.39	0.26
Oregon Onions	12.3	0.62	0.41
Idaho Potatoes	16.6	0.83	0.55
Mosquito Use			
Static water	306	15.3	10.2
Flowing water	120	6	4

[1] Bluegill sunfish LC_{50} = 20 ppb
[2] Rainbow trout LC_{50} = 30 ppb

As discussed above, the EECs were based on maximum label rates, whereas the state data for CA and WA indicate malathion is used at lower rates (Tables 8 & 9). However, the EECs would have to be lower than 1 ppb to not have a concern for direct effects on endangered fish species (1 ppb/20 ppb = 0.05). The application rates would have to be significantly reduced, even lower than those commonly used in California and the PNW, to be below the level of concern.

(1) Fish

Based solely on the most sensitive species and maximum EECs, the criteria of concern (RQ > 0.05) for malathion are exceeded for direct acute effects on fish from all uses, including mosquito control. In addition, the criteria of concern (RQ > 1.0) are not exceeded for direct chronic effects from all agricultural uses. This suggests that malathion may have a direct acute effect on the Pacific salmon and steelhead.

With a most sensitive fish (bluegill sunfish) LC_{50} of 20 ppb, the LOCs for direct acute effects would be exceeded when malathion concentrations in water exceed 1.0 ppb. The concern for chronic risk is less at 2 ppb, based on the fish NOEC for aquatics of 2 ppb.

(2) Invertebrates

Aquatic invertebrates, which may serve as a food source for T&E fish, are more sensitive than fish, with a daphnid LC_{50} of 0.69 ppb and a chronic NOEC at 0.06 ppb. The criteria of concern (RQ > 0.5) for acute effects are exceeded for all uses. All agricultural uses exceed the criteria of concern (RQ > 1.0) for indirect chronic effects. Therefore, there may be indirect effects on listed Pacific salmon and steelhead through the food supply reduction.

(3) Cover

No data was provided for malathion's toxicity to plants but its use as an insecticide and its mode of action in animals (the nervous system) suggests that plants are not likely to be affected.

(4) Conclusions

The EFED chapter is intended to determine the maximum potential risk that may occur from the use of malathion. Therefore, it can be expected that any site-specific or species-specific analysis is likely to determine that risks are less than the maximum potential. In part, this is reflected in the western EEC scenarios, which are modified by less runoff and somewhat higher drift than eastern scenarios. A number of considerations are relevant to the risks of malathion and Pacific salmon and steelhead.

1. The most sensitive species is a bluegill sunfish. Rainbow trout are less sensitive in EFED validated tests. There is an LC_{50} value for rainbow trout lower than that for bluegill sunfish; however, this value seemed to be overly sensitive, and we did not use it for RQ calculations.

2. Application rates per acre are generally lower in California than label rates. Based upon table 8, for crops on which over 10,000 lbs ai was used in 2002, the application rate was 1.62 lbs ai/A for alfalfa, 1.41 lbs ai/A for celery, 38.3 lbs ai/A for lemon, 1.4 lbs ai/A for lettuce, and 1.92 lbs ai/A for orange, 1.8 lbs ai/A for strawberry, and 3.4 lbs ai/A for walnut. Lemons were treated at higher rates than the current maximum citrus label rate listed in table 3 and 4. Alfalfa, celery, lettuce, orange, strawberry, and walnut were all treated with below maximum label rates. The available data from DPR cannot be used to determine the typical numbers or frequency of applications for a crop because each application is reported independently, relative to the number of acres treated for that application.

Data are not as complete for the Pacific northwest. According to the report by the Washington State Department of Agriculture (2004), apple and peach received the highest application rate with 4 lbs ai/acre each. For apples, this represents an increase from the 1.2 lbs ai/A reported by NCFAP in 1997. Blueberry and cherry both received 1.5 lbs ai/acre (data has not been peer reviewed except for blueberry). For cherry, this represents a decrease from the 2.69 lbs ai/A reported by NASS in 1997. Other rates used in practice appear to be lower than labeled rates and are comparable to NCFAP rates (Tables 6 and 7).

3. Spray drift of malathion is a problem arising from aerial and orchard airblast applications. But spray drift for ULV applications is even more severe. The fine droplets are dispersed into the air above fields for agricultural or residential use and can travel long distance before settling on land or water bodies. Wind speed and air temperature are important factors that determine how far the fine mist can travel. The level of drift from ULV applications is currently underestimated needs to be adjusted in future ecological models . Such adjusted modeling parameters are likely to result in higher EECs than are already reported for certain commodities. Agricultural uses where ULV drift prone applications are made are most likely to contribute to surface water contamination.

Urban use patterns are yet another concern. The highest level of malathion surface water contamination in urban areas is due to urban use patterns (i.e. homeowner, public health). Since malathion degrades slowly on non-soil surfaces, it contributes heavily to concentrations in surface waters via run off. States do not generally report on non-agricultural use patterns of pesticides (except California), even less so on their homeowner uses. Specifically, homeowner uses represent a big unknown in terms of use and poundage. CDPR reports on regulatory pest control, public health, structural pest control, and landscape maintenance usage. All these categories use a very high poundage of malathion. Note that no acreage is associated with these uses.

4. NAWQA monitoring for malathion resulted in 6 samples nationally in more than 18,000 taken being above 1 ppb. Two of the samples were collected in California with values of 1.14 ppb and 1.35 ppb. The former was collected in Merced County and the other in San Bernadino County, which is not included within the pacific salmon and steelhead ESUs. The concentration in Merced County is slightly above the 1 ppb concern level for fish. The PNW did not include any residue values greater than 1.

5. California DPR surface water monitoring resulted in 9 samples greater than 1 ppb in more than 4,000 taken. These were found in 3 counties: Colusa, Imperial, and Orange. The former had 4 residues over 1 ppb with values at 1.033 ppb, 1.158 ppb, 3.27 ppb, 6.0 ppb. These last two values significantly exceed the 1 ppb concern for fish. The counties of Imperial and Orange had 1 and 4 values greater than 1 ppb, respectively. These counties are not included within the Pacific salmon and steelhead ESUs.

6. The potential for runoff appears to be less likely, possibly much less likely, than is modeled to estimate EECs, even where those models are based upon the more arid, western scenarios. Precipitation would wash the material off of the foliage to be treated, and therefore, efficacy dictates that malathion would not typically be applied when significant precipitation is likely, such as that which would result in a runoff event. In some parts of the country, however, including western Oregon and Washington, it may not be feasible to time applications when there is no precipitation.

7. In California, malathion is included in DPR's county bulletins. While they are expected to be enforceable in the relatively near future after OPP's program becomes final, they are not currently. However, most county Agricultural Commissioners are expecting that applicators are following the protections indicated in these bulletins.

Agricultural uses

Use of malathion exceeds LOCs for all uses for acute effects. For chronic effects, LOCs are not exceeded for all agricultural uses. Based upon the toxicity data for malathion (EFED, EPA AQUIRE), and the residues found in surface waters (NAWQA) and the CA DPR water data, we conclude generically that there could be a chronic effect of malathion on listed Pacific salmon and steelhead.

Mosquito uses

The use of malathion exceeds LOCs for both static and flowing water for fish. As for their food supply of invertebrates, malathion exceeds the LOC for static water but not for freshwater invertebrates found in flowing water. These are conservative estimates for pacific salmon and steelhead. The static water model represents direct application to a 4 inch deep water body and no dilution from other water sources.

The exposure scenario used in the stream assessment is considered to be conservative in that 1 mile of streamside vegetation is assumed to be treated while the wind is blowing into the water. The depth of the water and lack of dilution also contribute to the conservatism of the assessment. A flowing water body that is 5 or more feet deep would not be expected to result in an exceedance of the LOCs.

Both models used the maximum labeled rates; however, maximum rates are not always applied. In the case of mosquito control, the use of malathion will depend on outbreaks and most likely whether West Nile Virus is present in a particular state.

Currently, Washington State follows an Integrated Pest Management system (IPM) policy to control mosquito populations, and it does not appear likely that malathion will be used unless a health emergency situation arises. Washington State lists as their first step to control mosquitos the need to control mosquito habitat and their larval stage. The next management steps are listed in sequential order of action taken: control of rearing sites, biological controls, bacterial control, growth interrupters, surface film oils, and lastly malathion and temephos (Washington State Department of Ecology, http://www.ecy.wa.gov/pubs/0210057.pdf).

The Oregon Department of Health and Department of Fish and Wildlife encourage an integrated pest management approach to control mosquitos. Any plan to control mosquitos needs to be approved by these two agencies. The use of larvacide is encouraged, and a three tiered system is suggested. Malathion is supposed to be used as a last resort and falls into the last tier of options (3 total) (http://www.dhs.state.or.us/publichealth/acd/wnile/wnvrevue.pdf).

The Idaho Department of Health and Welfare reports that it uses an IPM approach to controlling mosquitos (http://www.healthandwelfare.idaho.gov/_Rainbow/Documents/health/overallplan%5B1%5D.pdf)IPM in Idaho consists of using *Bacillus thuringiensis* (Bt), *Bacillus israelensis* (Bi), and *Bacillus sphaericus* (Bs) as mosquito larvacides. The current mosquito adulticide is a malathion based ultra low-volume (ULV) concentrate, which is used in crop land areas, while pyrethrin based concentrates are used in residential areas. ULV spraying is expected to increase during higher WNV occurrences.

In California, IPM is followed by mosquito and vector control districts and other public agencies and consists of surveillance, prevention, and control. The use of pesticides to control adult mosquitos is used as a last resort when other measures under ‘control’ are ineffective (http://www.cityoftemecula.org/safety/home/mosquito.pdf). In general, larvacides seem to be preferred over adulticides because they are more effective at killing mosquitoes.

With the arrival of the West Nile Virus (WNV) on the West Coast, the possibility of malathion being used to control mosquitoes (larvae and adults) may increase. Currently the USGS (http://westnilemaps.usgs.gov/us_mosquito.html) reports that there are no WNV occurrences in Oregon, Washington, and Idaho; however, samples have been submitted for testing in Washington (Snohomish, Jefferson, King, Kitsap, Pierce, Yakima, Benton, Cowlitz, and Clark counties) and Idaho (Kootenai, Benewah, Latah, Valley, Gem, Canyon, Ada, Twin, Jefferson, Bonneville, Bannok, Bear Lake counties). On the other hand, the Oregon Department of Health reports that there have been WNV occurrences in the following counties: Benton, Crook, Grant, Jackson, Josepine, Lane, Linn, and Malheur (http://www.dhs.state.or.us/publichealth/acd/wnile/countymap.pdf). The Idaho Department of Health & Welfare reports that it has had WNV cases in the following counties: Washington, Payette, Gem, Canyon, Ada, Owyhee, Gooding, Elmoore, Bingham, Jerome, Twin Falls (http://www.healthandwelfare.idaho.gov/DesktopModules/Articles/ArticlesView.aspx?TabID=0&Alias=Rainbow&Lang=en-US&ItemID=1256&mid=10941). California already has numerous positive test results as well that confirm the arrival of the WNV. The counties where West Nile occurrences have been documented with positive test results are: Butte, Fresno, Imperial, Kern, Lake, Los Angeles, Merced, Orange, Placer, Riverside, Sacramento, San Bernardino, San Joaquin, San Luis Obisbo, Shasta, Solano, Stanislaus, Sutter, and Tulare.

Due to the present Integrated Pest Management plans targeting mosquitos in California and the PNW region, we conclude that malathion usage for mosquito control will not affect listed Pacific salmon and steelhead in Washington, Oregon, and California. Due to the malathion based ULV applications in Idaho, we conclude that malathion may affect listed Pacific salmon and steelhead in Idaho.

Home and garden use

This category is a big enigma in terms of application rate, application intervals, and total lbs ai/year. Many of the application rates for home and garden uses of malathion do not specify numeric application rates. Some label instructions read ‘spray thoroughly until dripping off leaves’ and ‘repeat as necessary’. It is difficult to quantify this kind of usage and predict its effects on the environment. Potentially, a great amount of malathion could be applied per square foot. Therefore, we conclude that the use of malathion on residential fruits and vegetables and lawns may have an effect on listed Pacific salmon and steelhead.

4. Listed salmon and steelhead ESUs and comparison with malathion use areas

Effects determination Criteria

To determine whether malathion usage poses a risk to ESUs in the PNW and California, we included the following considerations into our assessment: hydrolysis and aerobic aquatic half-life of malathion, toxicity of compound, CDPR and NAWQA surface water data, actual usage, potential usage, and application intervals and timing (if provided) as stated on labels.

PNW county usage determination

For Washington, we rely on 1997 Ag Census data, Washington State Department of Agriculture data (2004: actual data for 2002 and 2003), NASS and NCFAP data, as well as the OPP QUA report. For Oregon and Idaho, we have very little actual data and rely strongly on 1997 Ag Census data, but also on the OPP QUA report (2000), NASS (not available for Idaho), and NCFAP.

From the OPP QUA report (2000), we extracted the crops that were not grown in any ESUs and that had very little '% of crop treated' ($\leq$4 % generally), which therefore would be very unlikely to trigger any ESUs in Oregon, Washington, and Idaho. The crops we focused our attention on were: raspberry, apple, cherry, onion, asparagus, dry pea, barley, corn, sugarbeet, and mint. From the Washington State Department report we additionally include: alfalfa, carrot, peach, and nectarine.

Attachment G - malathion usage for PNW states by ESU- was generated using Ag Census data and maximum application rates from labels. Actual application rates were not available, therefore, we assumed that 100% of crop acres were treated with malathion to err on the side of salmon and steelhead. This assumption produced the highest amount of lbs of malathion that could potentially be used in a county located in an ESU. Attachment G lists crops, crop acres, and county acreage. We use our best professional judgement to determine which crops would potentially affect salmon and steelhead in each ESU in the PNW states.

California county usage determination

The sources of data available on malathion use are considerably different for California than for other states. California has full pesticide use reporting by all applicators except homeowners; commercial applications in residential areas do have to be reported. The latest information for California county pesticide use is for the year 2002 (see Attachment E).

To determine malathion use in ESUs in California, we relied solely on actual data from the CDPR (2002) county information. This information was used to generate attachment F - malathion usage for California counties by ESU - which shows the crops, lbs of active ingredient, and crop acres in each county located in an ESU. The crops we focused our attention on were alfalfa, walnuts, strawberry, raspberry, lettuce, celery, green onion, Bok choi, Chinese cabbage, lemon, and blackberry. We use our best professional judgement to determine which crops would potentially affect salmon and steelhead in each ESU in California.

In the following discussion of specific ESUs, we present information on the listed salmon and steelhead ESUs and discuss the potential and actual malathion usage where they occur. The information on the various ESUs was taken almost entirely from various Federal Register Notices relating to listing, critical habitat, or status reviews.

A. Chinook

Chinook salmon *(Oncorhynchus tshawytscha)* is the largest salmon species; adults weighing over 120 pounds have been caught in North American waters. Like other Pacific salmon, chinook salmon are anadromous and die after spawning.

Juvenile stream- and ocean-type chinook salmon have adapted to different ecological niches. Ocean-type chinook salmon, commonly found in coastal streams, tend to utilize estuaries and coastal areas more extensively for juvenile rearing. They typically migrate to sea within the first three months of emergence and spend their ocean life in coastal waters. Summer and fall runs predominate for ocean-type chinook. Stream-type chinook are found most commonly in headwater streams and are much more dependent on freshwater stream ecosystems because of their extended residence in these areas. They often have extensive offshore migrations before returning to their natal streams in the spring or summer months. Stream-type smolts are much larger than their younger ocean-type counterparts and are therefore able to move offshore relatively quickly.

Coastwide, chinook salmon typically remain at sea for 2 to 4 years, with the exception of a small proportion of yearling males (called jack salmon) which mature in freshwater or return after 2 or 3 months in salt water. Ocean-type chinook salmon tend to migrate along the coast, while stream-type chinook salmon are found far from the coast in the central North Pacific. They return to their natal streams with a high degree of fidelity. Seasonal ‘‘runs’’ (i.e., spring, summer, fall, or winter), which may be related to local temperature and water flow regimes, have been identified on the basis of when adult chinook salmon enter freshwater to begin their spawning migration. Egg deposition must occur at a time to ensure that fry emerge during the following spring when the river or estuary productivity is sufficient for juvenile survival and growth.

Adult female chinook will prepare a spawning bed, called a redd, in a stream area with suitable gravel composition, water depth and velocity. After laying eggs in a redd, adult chinook will guard the redd from 4 to 25 days before dying. Chinook salmon eggs will hatch, depending upon water temperatures, between 90 to 150 days after deposition. Juvenile chinook may spend from 3 months to 2 years in freshwater after emergence and before migrating to estuarine areas as smolts, and then into the ocean to feed and mature. Historically, chinook salmon ranged as far south as the Ventura River, California, and their northern extent reaches the Russian Far East.

1. California Coastal Chinook Salmon ESU

The California coastal chinook salmon ESU was proposed as threatened in 1998 (63FR11482-11520, March 9, 1998) and listed on September 16, 1999 (64FR50393-50415). Critical habitat was designated February 16, 2000 (65FR7764-7787) to encompass all river reaches and estuarine areas accessible to listed chinook salmon from Redwood Creek (Humboldt County, California) to the Russian River (Sonoma County, California), inclusive.

The hydrologic units and upstream barriers are Mad-Redwood, Upper Eel (upstream barrier - Scott Dam), Middle Fort Eel, Lower Eel, South Fork Eel, Mattole, Big-Navarro-Garcia, Gualala-Salmon, Russian (upstream barriers - Coyote Dam; Warm Springs Dam), and Bodega

Bay. Counties with agricultural areas where pesticides could be used are Humboldt, Trinity, Mendocino, Lake, Sonoma, and Marin. A small portion of Glenn County is also included in the Critical Habitat, but malathion would not be used in the forested upper elevation areas. A small portion of Lake County contains habitat for this ESU, but is entirely within the Mendocino National Forest.

Table F-1 (see Attachment F) contains usage information for the California counties supporting the California coastal chinook salmon ESU. Reported usage of malathion is 82 lbs on 50 acres in this ESU, all in Sonoma county. The total number of acres in the ESU is 9,647,730 acres; therefore, only 0.00051% of the crops in the ESU was treated. Walnuts was the only crop with 50 acres (82 lbs).

Based upon the relatively low use, we conclude that agricultural use of malathion will not affect the California coastal chinook ESU. Also, because there is only a small density of housing where malathion could be used, we conclude no effect from residential use.

2. Central Valley Spring-run Chinook Salmon ESU

The Central valley Spring-run chinook salmon ESU was proposed as threatened in 1998 (63FR11482-11520, March 9, 1998) and listed on September 16, 1999 (64FR50393-50415). Critical habitat was designated February 16, 2000 (65FR7764-7787) to encompass all river reaches accessible to listed chinook salmon in the Sacramento River and its tributaries in California, along with the down stream river reaches into San Francisco Bay, north of the Oakland Bay Bridge, and to the Golden Gate Bridge.

Hydrologic units and upstream barriers within this ESU are the Sacramento-Lower Cow-Lower Clear, Lower Cottonwood, Sacramento-Lower Thomes (upstream barrier - Black Butte Dam), Sacramento-Stone Corral, Lower Butte (upstream barrier - Centerville Dam), Lower Feather (upstream barrier - Oroville Dam), Lower Yuba, Lower Bear (upstream barrier - Camp Far West Dam), Lower Sacramento, Sacramento-Upper Clear (upstream barriers - Keswick Dam, Whiskeytown dam), Upper Elder-Upper Thomes, Upper Cow-Battle, Mill-Big Chico, Upper Butte, Upper Yuba (upstream barrier - Englebright Dam), Suisin Bay, San Pablo Bay, and San Francisco Bay. These areas are said to be in the counties of Shasta, Tehama, Butte, Glenn, Colusa, Sutter, Yolo, Yuba, Placer, Sacramento, Solano, Nevada, Contra Costa, Napa, Alameda, Marin, Sonoma, San Mateo, and San Francisco. However, San Mateo County is south of the Oakland Bay Bridge and is not included in the analysis.

Table F-2 contains usage information for the California counties supporting the Central Valley spring-run chinook salmon ESU. The habitat residency of this ESU had a total reported agricultural usage of 53,851 lbs of malathion on 191,782 acres, after excluding San Mateo County. The total number of acres in the ESU is 14,405,422 acres; therefore, only 2% of the crops in the ESU was treated. Yolo County had the highest poundage (11,712 lbs) used on 171,318 acres. Glenn and Tehama had the next highest reported uses at 10,481 lbs (5,657 acres treated) and 10,100 lbs (3,563 acres treated), respectively. Alfalfa and walnuts were the crops that had the most usage in this ESU with a total of 25,835 lbs (18,704.65 acres treated) and 21,361 lbs (5,330.62 acres treated), respectively. Yolo County comprised almost half of the malathion usage on alfalfa with 11,041 lbs used and Tehama County had the most usage on walnuts (7,700 lbs). Also, some areas in this ESU are heavily urban/suburban. The public health sector used 19,306 lbs. In addition, an unspecified amount of homeowner use could occur (CDPR does not report homeowner use).

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

California DPR surface water monitoring resulted in 63 detections in 2,046 samples taken (3.1 % detection) within this ESU. In Colusa County 4 samples were greater than 1 ppb with values at 1.033 ppb, 1.158 ppb, 3.27 ppb, 6.0 ppb. These last two values significantly exceed the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC_{50} = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb).

Because of these factors, we conclude that agricultural, public health, and residential use of malathion may affect the Central Valley spring run chinook ESU.

3. Lower Columbia River Chinook Salmon ESU

The Lower Columbia River chinook salmon ESU was proposed as threatened in 1998 (63FR11482-11520, March 9, 1998) and listed a year later (64FR14308-14328, March 24, 1999). Critical habitat was designated February 16, 2000 (65FR7764-7787) to encompass all river reaches accessible to listed chinook salmon in Columbia River tributaries between the Grays and White Salmon Rivers in Washington and the Willamette and Hood Rivers in Oregon, inclusive, along with the lower Columbia River reaches to the Pacific Ocean.

The hydrologic units and upstream barriers are the Middle Columbia-Hood (upstream barriers - Condit Dam, The Dalles Dam), Lower Columbia-Sandy (upstream barrier - Bull Run Dam 2), Lewis (upstream barrier - Merlin Dam), Lower Columbia-Clatskanie, Upper Cowlitz, Lower Cowlitz, Lower Columbia, Clackamas, and the Lower Willamette. Habitat residency would include the counties of Hood River, Wasco, Columbia, Clackamas, Marion, Multnomah, and Washington in Oregon, and Klickitat, Skamania, Clark, Clatsop, Cowlitz, Lewis, Wahkiakum, Pacific, and Pierce in Washington. Only small forested parts of Wasco County and Marion County intersect the hydrologic units, and these were excluded from the analysis because malathion would not be used there.

According to the Agricultural census data (Attachment G-3), there are 12,434,488 acres of land in the entire ESU. There was 68,669 acres grown which could have been treated with 235,614 lbs of malathion (0.76 % potentially treated acres in the ESU). Klichitat County had the highest acres and pounds of estimated malathion usage at 36,851 acres and 90,222 lbs (3%

potentially treated within the county). The major crops grown were alfalfa (34,661 acres), barley (9,799 acres), raspberries (4,509 acres), and apples (3904 acres) that could have been treated with 85,267 lbs, 3,596 lbs, 20,776, and 56,218 lbs of malathion, respectively. The USDA census indicates that there are no crops where malathion would be used in Idaho counties within this ESU. In addition, some areas in this ESU are heavily urban/suburban where home owner use could occur.

The WSDA data states that Clark County had the most acres of strawberries (320 acres) grown in this ESU. They reported that 2 lbs of malathion could be applied per acre for this crop, which would amount to 640 lbs. Cowlitz had the most acres of red raspberries (600 acres) grown in this ESU. They reported that 1 lb of malathion could be applied per acre for this crop, which would amount to 600 lbs. There are 35,000 acres of oats grown in the state of Washington with the largest concentration grown in Klickitat County. However, no specific acreage was reported for this crop in this county.

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC_{50} = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the high estimated agricultural usage for Klicktat, Washington, and Hood River counties and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the habitat residency of the Lower Columbia River chinook ESU. We also cannot discount the concern from homeowner use for the Portland metropolitan area. Therefore, it is possible that the home lawn use of malathion may affect the Lower Columbia chinook ESU.

4. Puget Sound Chinook Salmon ESU

The Puget Sound chinook salmon ESU was proposed as threatened in 1998 (63FR11482-11520, March 9, 1998) and listed a year later (64FR14308-14328, March 24, 1999). Critical habitat was designated February 16, 2000 (65FR7764-7787) to encompass all marine, estuarine, and river reaches accessible to listed chinook salmon in Puget Sound and its tributaries, extending out to the Pacific Ocean.

The hydrologic units and upstream barriers are the Strait of Georgia, San Juan Islands, Nooksack, Upper Skagit, Sauk, Lower Skagit, Stillaguamish, Skykomish, Snoqualmie (upstream barrier - Tolt Dam), Snohomish, Lake Washington (upstream barrier - Landsburg Diversion), Duwamish, Puyallup, Nisqually (upstream barrier - Alder Dam), Deschutes, Skokomish, Hood Canal, Puget Sound, Dungeness-Elwha (upstream barrier - Elwha Dam). Affected counties in Washington are Skagit, Whatcom, San Juan, Island, Snohomish, King, Pierce, Thurston, Lewis, Grays Harbor, Mason, Clallam, Jefferson, and Kitsap. Grays Harbor County was excluded because the very small amount of habitat is within the Olympic National Forest.

According to the Agricultural census data (Attachment G-4), there are 13,023,307 acres of land in the entire ESU. There was 58,577 acres grown which could have been treated with 154,327 lbs of malathion (0.45 % potentially treated acres in the ESU). Whatcom and Skagit Counties had the highest acres at 23,633 acres (1.7% potentially treated acres in the county) and 17,843 acres (1.6% potentially treated acres in the county) and the highest pounds of estimated malathion usage at 57,835 lbs and 56,363 lbs, respectively. The major crops grown were alfalfa (7,818 acres), raspberries (6,586 acres), barley (2,833 acres), and apples (945 acres) that could have been treated with 19,233 lbs, 29,637 lbs, 4,362 lbs, and 13,609 lbs of malathion, respectively. The USDA census indicates that there are no crops where malathion could be used in Idaho and Oregon counties within this ESU. In addition, some areas in this ESU are heavily urban/suburban where home owner use could occur.

The WSDA data states that Whatcom County had the most acres of red raspberries (6,400 acres) and corn, grain, silage (16,000 acres) grown in this ESU. They reported that 1 lb of malathion could be applied per acre for red raspberries and 1.25 lbs for corn, grain, and silage, which would amount to 6,400 lbs and 20,000 lbs applied, respectively.

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC_{50} = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the high estimated usage for Whatcom, WA and Skagit, WA Counties and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the habitat residency of the Puget Sound chinook ESU. We also cannot discount the concern from homeowner use for this ESU. Therefore, it is possible that the home use of malathion may affect this ESU.

5. Sacramento River Winter-run Chinook Salmon ESU

The Sacramento River Winter-run chinook was emergency listed as threatened with critical habitat designated in 1989 (54FR32085-32088, August 4, 1989). This emergency listing provided interim protection and was followed by (1) a proposed rule to list the winter-run on March 20, 1990, (2) a second emergency rule on April 20, 1990, and (3) a formal listing on November 20, 1990 (59FR440-441, January 4, 1994). A somewhat expanded critical habitat was proposed in 1992 (57FR36626-36632, August 14, 1992) and made final in 1993 (58FR33212-33219, June 16, 1993). In 1994, the winter-run was reclassified as endangered because of significant declines and continued threats (59FR440-441, January 4, 1994).

Critical Habitat has been designated to include the Sacramento River from Keswick Dam, Shasta County (river mile 302) to Chipps Island (river mile 0) at the west end of the Sacramento-San Joaquin delta, and then westward through most of the fresh or estuarine waters, north of the Oakland Bay Bridge, to the ocean. Estuarine sloughs in San Pablo and San Francisco bays are excluded (58FR33212-33219, June 16, 1993). Counties with agricultural areas where pesticides could be used include Alameda, Butte, Colusa, Contra Costa, Glenn, Marin, Sacramento, San Mateo, San Francisco, Shasta, Solano, Sonoma, Sutter, Tehama, and Yolo.

Table F-5 shows the malathion usage in California counties supporting the Sacramento River winter-run chinook salmon ESU. In the habitat residency 51,072 lbs of malathion were applied in this ESU. The total number of acres in the ESU is 16,263,326 acres.; therefore, 1.8% of the land in the ESU was treated. Yolo County had the highest usage (11,712 lbs) that could affect habitat residency. The next highest counties were Glenn and Tehama at 10,481 lbs, and 10,100 lbs, respectively. Potentially affecting the spawning and growth residency, Tehama had the highest estimated usage of malathion at 10,100 lbs. Alfalfa and walnuts are the crops that had the most usage in this ESU with a total of 25,835 lbs and 18,228 lbs, respectively. In the habitat residency Yolo County had the most usage of malathion on alfalfa (11,041 lbs) and Tehama had the most usage on walnuts (7,700 lbs). In the spawning and growth residency, Tehama had the largest usage of malathion on alfalfa (2,280 lbs) and walnuts (7,700). In addition to the agricultural use sites, some of these areas in this ESU are heavily urban and suburban. The public health sector and structural pest control totaled 35,701 lbs used. In addition, an unspecified amount of homeowner use could occur (CDPR does not report homeowner use).

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

California DPR surface water monitoring resulted in 63 detections in 2,046 samples taken (3.1 % detection) within this ESU. In Colusa County 4 samples were greater than 1 ppb with values at 1.033 ppb, 1.158 ppb, 3.27 ppb, 6.0 ppb. These last two values significantly exceed the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC_{50} = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb).

Because of these factors, we conclude that agricultural, public health, structural pest control, and residential use of malathion may affect the Sacramento River winter-run chinook ESU.

6. Snake River Fall-run Chinook Salmon ESU

The Snake River fall-run chinook salmon ESU was proposed as threatened in 1991 (56FR29547-29552, June 27, 1991) and listed about a year later (57FR14653-14663, April 22, 1992). Critical habitat was designated on December 28, 1993 (58FR68543-68554) to include all tributaries of the Snake and Salmon Rivers accessible to Snake River fall-run chinook salmon, except reaches above impassable natural falls and Dworshak and Hells Canyon Dams. The Clearwater River and Palouse River watersheds are included for the fall-run ESU, but not for the spring/summer run. This chinook ESU was proposed for reclassification on December 28, 1994 (59FR66784-57403) as endangered because of critically low levels, based on very sparse runs. However, because of increased runs in subsequent year, this proposed reclassification was withdrawn (63FR1807-1811, January 12, 1998).

In 1998, NMFS proposed to revise the Snake River fall-run chinook to include those stocks using the Deschutes River (63FR11482-11520, March 9, 1998). The John Day, Umatilla, and Walla Walla Rivers would be included; however, fall-run chinook in these rivers are believed to have been extirpated. It appears that this proposal has yet to be finalized. I have not included these counties here; however, I would note that the Middle Columbia River steelhead ESU encompasses these basins, and crop information is presented in that section of this analysis.

Hydrologic units with spawning and rearing habitat for this fall-run chinook are the Clearwater, Hells Canyon, Imnaha, Lower Grande Ronde, Lower North Fork Clearwater, Lower Salmon, Lower Snake-Asotin, Lower Snake-Tucannon, and Palouse. Counties in this ESU are Baker, Umatilla, Wallowa, Marrow, Gilliam, Sherman, Wasco, Hood River, Multnomah, Columbia, Clatsop, and Union counties in Oregon; Adams, Asotin, Benton, Clark, Columbia, Cowlitz, Franklin, Garfield, Klickitat, Lincoln, Pacific, Skamania, Spokane, Wahkiakum, Walla Walla, and Whitman counties in Washington; and Adams, Benewah, Clearwater, Idaho, Latah, Lewis, Nez Perce, Shoshone, and Valley counties in Idaho. We note that Custer and Lemhi counties in Idaho are not listed as part of the fall-run ESU, although they are included for the spring/summer-run ESU. Because only high elevation forested areas of Baker and Umatilla counties in Oregon are in the spawning and rearing areas for this fall-run chinook, we have excluded them from consideration because malathion would not be used in these areas.

According to the Agricultural census data (Attachment G-6), there are 39,702,778 acres of land in the entire ESU. There was 1,110,068 acres grown which could have been treated with 3,447,509 lbs of malathion (2.8% potentially treated acres in the ESU). Franklin County had the highest acres and pounds of estimated malathion usage at 141,219 acres (17.4% potentially treated acres in the county) and 504,342 lbs. Benton had the next highest at 83,239 acres and 472,127 lbs (7.4% potentially treated within the county). The major crops grown were barley (569,277 acres), alfalfa (338,476 acres), and apples (40,228 acres) that could have been treated with 876,687 lbs, 832,652 lbs, and 579,284 lbs of malathion.

The WSDA data states that Benton County had the most acres of apples (18,425 acres) grown in this ESU. They reported that 4 lbs of malathion could be applied per acre for this crop, which would amount to 73,700 lbs applied. Franklin County had the most acres of sweet corn (18,000 acres) followed by Benton County (15,000 acres) grown in this ESU. They reported that 1 lb of malathion could be applied per acre for this crop, which would amount to 18,000 lbs in Franklin County and 15,000 lbs in Benton County. Benton also had the most cherry acreage (3,219 acres) with a malathion usage of 3,927.18 lbs (1.22 lbs/acre application rate). Whitman County had a significantly large number of acres of wheat grown (493,500 lbs), which could amount to 690,900 lbs of malathion being applied (application rate of 1.4 lbs/acre). However, generally one application of a given pesticide is made per year and because of the low economic return on small grains, chemicals are not used extensively for insect control. Simple economics precludes many growers' use of seed or foliar treatments. Insecticide applications are often limited to outbreak conditions or in response to threats of insect-vectored diseases (WSDA 1994).

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC_{50} = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the high agricultural use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the Snake River fall-run Chinook ESU. We also cannot discount the concern from homeowner use for this ESU. Therefore, it is possible that the home use of malathion may affect this ESU.

7. Snake River Spring/Summer-run Chinook Salmon

The Snake River Spring/Summer-run chinook salmon ESU was proposed as threatened in 1991 (56FR29542-29547, June 27, 1991) and listed about a year later (57FR14653-14663, April 22, 1992). Critical habitat was designated on December 28, 1993 (58FR68543-68554) to include all tributaries of the Snake and Salmon Rivers (except the Clearwater River) accessible to Snake River spring/summer chinook salmon. Like the fall-run chinook, the spring/summer-run chinook ESU was proposed for reclassification on December 28, 1994 (59FR66784-57403) as endangered because of critically low levels, based on very sparse runs. However, because of increased runs in subsequent years, this proposed reclassification was withdrawn (63FR1807-1811, January 12, 1998).

Hydrologic units in the potential spawning and rearing areas include Hells Canyon, Imnaha, Lemhi, Little Salmon, Lower Grande Ronde, Lower Middle Fork Salmon, Lower Salmon, Lower Snake-Asotin, Lower Snake-Tucannon, Middle Salmon-Chamberlain, Middle Salmon - Panther, Pahsimerol, South Fork Salmon, Upper Middle Fork Salmon, Upper Grande Ronde, Upper Salmon, and Wallowa. Areas above Hells Canyon Dam are excluded, along with unnamed "impassable natural falls". Napias Creek Falls, near Salmon, Idaho, was later named an upstream barrier (64FR57399-57403, October 25, 1999). The Grande Ronde, Imnaha, Salmon, and Tucannon subbasins, and Asotin, Granite, and Sheep Creeks were specifically named as inhabited watersheds in the Critical Habitat Notice.

Counties mentioned in the Critical Habitat Notice include Morrow, Gilliam, Sherman, Wasco, Hood River, Multnomah, Columbia, Clatsop, Union, Umatilla, Wallowa, and Baker counties in Oregon; Adams, Blaine, Custer, Idaho, Lemhi, Lewis, Nez Perce, and Valley counties in Idaho; and Klickitat, Skamania, Benton, Clark, Cowlitz, Wahkiakum, Pacific, Asotin, Columbia, Franklin, Garfield, Walla Walla, and Whitman counties in Washington. We have excluded Valley County, Idaho because that portion in the Salmon River watershed is all in forested areas where malathion would not be used.

According to the Agricultural census data (Attachment G-7), there are 40,292,564 acres of land in the entire ESU. There was 1,051,996 acres grown which could have been treated with 2,840,067 lbs of malathion (2.6 % potentially treated acres in the ESU). Franklin County had the highest acres and pounds of estimated malathion usage at 141,219 acres (17.4% potentially treated acres in the county) and 504,342 lbs. Benton had the next highest at 83,239 acres and 472,127 lbs (7.4% potentially treated within the county). The major crops grown were barley (440,802 acres) and alfalfa (379,654 acres) that could have been treated with 678,835 lbs and 933,949 lbs of malathion, respectively.

The WSDA data states that Benton County had the most acres of apples (18,425 acres) grown in this ESU. They reported that 4 lbs of malathion could be applied per acre for this crop, which would amount to 73,700 lbs. Franklin County had the most acres of sweet corn (18,000 acres) followed by Benton County (15,000 acres) grown in this ESU. They reported that 1 lb of malathion could be applied per acre for this crop, which would amount to 18,000 lbs in Franklin County and 15,000 lbs in Benton County. Benton also had the most cherry acreage (3,219 acres) with a malathion usage of 3,927.18 lbs (1.22 lbs/acre application rate). Whitman County had a significantly large number of acres of wheat grown (493,500 lbs), which could amount to 690,900 lbs of malathion being applied (application rate of 1.4 lbs/acre). However, generally one application of a given pesticide is made per year and because of the low economic return on small grains, chemicals are not used extensively for insect control. Simple economics precludes many growers' use of seed or foliar treatments. Insecticide applications are often limited to outbreak conditions or in response to threats of insect-vectored diseases (WSDA 1994).

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC_{50} = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the potentially high agricultural use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the Snake River spring/summer chinook ESU. We also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

8. Upper Columbia River Spring-run Chinook Salmon ESU

The Upper Columbia River Spring-run Chinook Salmon ESU was proposed as endangered in 1998 (63FR11482-11520, March 9, 1998) and listed a year later (64FR14308-14328, March 24, 1999). Critical habitat was designated February 16, 2000 (65FR7764-7787) to encompass all river reaches accessible to listed chinook salmon in Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam in Washington, excluding the Okanogan River, as well as all down stream migratory corridors to the Pacific Ocean. Hydrologic units and their upstream barriers are Chief Joseph (Chief Joseph Dam), Similkameen, Methow, Upper Columbia-Entiat, Wenatchee, Upper Columbia-Priest Rapids, Middle Columbia-Lake Wallula, Middle Columbia-Hood, Lower Columbia-Sandy, Lower Columbia-Clatskanie, Lower Columbia, and Lower Willamette. Counties in which habitat residency occurs are Clatsop, Columbia, Gilliam, Hood River, Morrow, Multnomah, Sherman, Umatilla, and Wasco Counties in Oregon, and Benton, Grant, Chelan, Douglas, Okanogan, Clark, Cowlitz, Franklin, Kittitas, Klickitat, Skamania, Wahkiakum, Walla Walla, Yakima, and Pacific Counties in Washington (see Table D-8).

According to the Agricultural census data (Attachment G-8), there are 27,361,604 acres of land in the entire ESU. There was 1,018,662 acres grown which could have been treated with 5,067,122 lbs of malathion (3.7% potentially treated acres in the ESU). Benton and Okanagan Counties had the highest acres and pounds of estimated malathion usage at 83,239 acres (7.4%

potentially treated acres in the county) and 46,703 acres (1.4% potentially treated in the county), respectively. This could amount to 472,127 lbs and 403,317 lbs being applied, respectively. The major crops grown were alfalfa (365,752 acres), apples (182,576 acres), and barley (84,339 aces) that could have been treated with 899,750 lbs, 182,576 lbs, and 151,098 lbs of malathion, respectively.

The WSDA data states that there is an extensive amount of acreage that could be treated with malathion in this ESU (minimum of 535,839 acres). Yakima County has the most acres of apples (75,264 acres) grown in this ESU. They reported that 4 lbs of malathion could be applied per acre for this crop, which would amount to 301,056 lbs applied. Grant County produces nearly one-quarter of the state's alfalfa hay crop (119,000 acres). With an application rate of 1.5 lbs/acre, this could amount to 178,500 lbs of malathion being applied.

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC_{50} = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the potentially high agricultural use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the upper Columbia River spring-run chinook ESU. We also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

9. Upper Willamette River Chinook Salmon ESU

The Upper Willamette River Chinook Salmon ESU was proposed as threatened in 1998 (63FR11482-11520, March 9, 1998) and listed a year later (64FR14308-14328, March 24, 1999). Critical habitat was designated February 16, 2000 (65FR7764-7787) to encompass all river reaches accessible to listed chinook salmon in the Clackamas River and the Willamette River and its tributaries above Willamette Falls, in addition to all down stream river reaches of the Willamette and Columbia Rivers to the Pacific Ocean.

The hydrologic units included are the Lower Columbia-Sandy, Lower Columbia-Clatskanie, Lower Columbia, Middle Fork Willamette, Coast Fork Willamette (upstream barriers - Cottage Grove Dam, Dorena Dam), Upper Willamette (upstream barrier - Fern Ridge Dam), McKenzie (upstream barrier - Blue River Dam), North Santiam (upstream barrier - Big Cliff Dam), South Santiam (upstream barrier - Green Peter Dam), Middle Willamette, Yamhill, Molalla-Pudding, Tualatin, Clackamas, and Lower Willamette. Habitat residency includes the Oregon counties of Clackamas, Douglas, Lane, Benton, Lincoln, Linn, Polk, Marion, Yamhill, Washington, Tillamook, Multnomah, Columbia, and Clatsop Counties in Oregon, and Clark, Cowlitz, Wahkiakum, and Pacific Counties in Washington. However, Lincoln and Tillamook counties include salmon habitat only in the forested parts of the coast range where malathion would not be used. Salmon habitat for this ESU is exceedingly limited in Douglas County also, but we cannot rule out future malathion use on a small amount of acreage in Douglas County.

According to the Agricultural census data (Attachment G-9), there are 16,017,795 acres of land in the entire ESU. There was 82,103 acres grown which could have been treated with 267,937 lbs of malathion (0.5 % potentially treated acres in the ESU). Marion County had the highest acres and pounds of estimated malathion usage at 16,398 acres and 58,586 lbs (2.1% acres potentially treated within the county). Washington, OR had the next highest acreage at 10,634 acres and potentially 46,342 lbs applied (2.3% acres potentially treated within the county). The major crops grown were alfalfa (14,933 acres), apples (3,508 acres), and raspberries (5,483 acres) that could have been treated with 36,736 lbs lbs, 30,558 lbs, and 24,674 lbs of malathion, respectively. The Willamette Valley can have moderate amounts of homes throughout, and the Portland area is heavily urban and suburban.

The WSDA data states that Clark County had the most acres of red raspberries (860 acres) grown in this ESU. They reported that 1 lbs of malathion could be applied per acre for this crop, which would amount to 860 lbs applied. Cowlitz County had the next highest acreage of red raspberries (600 acres), which could amount to 600 lbs applied.

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC_{50} = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the high potential agricultural but presently low actual use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect, but is not likely to adversely affect the Upper Willamette River chinook ESU. We cannot discount the concern from residential use for this ESU. Therefore, it is possible that the home use of malathion may affect this ESU.

B. Chum Salmon

Chum salmon, *Oncorhynchus keta*, have the widest natural geographic and spawning distribution of any Pacific salmonid, primarily because its range extends farther along the shores of the Arctic Ocean. Chum salmon have been documented to spawn from Asia around the rim of the North Pacific Ocean to Monterey Bay in central California. Presently, major spawning populations are found only as far south as Tillamook Bay on the northern Oregon coast.

Most chum salmon mature between 3 and 5 years of age, usually 4 years, with younger fish being more predominant in southern parts of their range. Chum salmon usually spawn in coastal areas, typically within 100 km of the ocean where they do not have surmount river blockages and falls. However, in the Skagit River, Washington, they migrate at least 170 km.

During the spawning migration, adult chum salmon enter natal river systems from June to March, depending on characteristics of the population or geographic location. . In Washington, a variety of seasonal runs are recognized, including summer, fall, and winter populations. Fall-run fish predominate, but summer runs are found in Hood Canal, the Strait of Juan de Fuca, and in southern Puget Sound, and two rivers in southern Puget Sound have winter-run fish.

Redds are usually dug in the mainstem or in side channels of rivers. Juveniles outmigrate to seawater almost immediately after emerging from the gravel that covers their redds. This means that survival and growth in juvenile chum salmon depend less on freshwater conditions than on favorable estuarine and marine conditions.

10. Columbia River Chum Salmon ESU

The Columbia River chum salmon ESU was proposed for listing as threatened, and critical habitat was proposed, in 1998 (63FR11774-11795, March 10, 1998). The final listing was published a year later (63FR14508-14517, March 25, 1999), and critical habitat was designated in 2000 (65FR77647787).

Critical habitat for the Columbia River chum salmon ESU encompasses all accessible reaches and adjacent riparian zones of the Columbia River (including estuarine areas and tributaries) downstream from Bonneville Dam, excluding Oregon tributaries upstream of Milton Creek at river km 144 near the town of St. Helens. These areas are the hydrologic units of Lower Columbia-Sandy (upstream barrier - Bonneville Dam), Lewis (upstream barrier – Merlin Dam), Lower Columbia-Clatskanie, Lower Cowlitz, Lower Columbia, Lower Willamette in the counties of Clark, Skamania, Cowlitz, Wahkiakum, Pacific, Lewis, Washington and Multnomah, Clatsop, Columbia, and Washington, Oregon. It appears that there are three extant populations in Grays River, Hardy Creek, and Hamilton Creek. Because the ESU extends on the Oregon side only up to Milton Creek, and because we cannot see that Milton Creek reaches into Washington County, we have excluded Washington County from this ESU. Washington County was named in the Critical Habitat FR Notice. It appears that the Washington County connection with the hydrologic unit is with the Willamette River which is upstream from Milton Creek. We solicit NMFS comment.

According to the Agricultural census data (Attachment G-10), there are 6,292,479 acres of land in the entire ESU. There was 22,046 acres grown which could have been treated with 80,140 lbs of malathion (0.35 % potentially treated acres in the ESU). Washington County in Oregon had the highest acres and pounds of estimated malathion usage at 10,634 acres and 46,342 lbs (2.3% potentially treated within the county). The major crops grown were alfalfa (4,478 acres), raspberries (2,965 acres), and apples (568 acres) that could have been treated with 11,420 lbs, 13,342 lbs, and 8,180 lbs of malathion, respectively.

The WSDA data states that Cowlitz County had the most acres of red raspberries (600 acres) grown in this ESU. They reported that 1 lbs of malathion could be applied per acre for this crop, which would amount to 600 lbs applied. Lewis County had the highest acreage (190 acres) of blueberries, which could amount to 238 lbs applied (1.25 lb/acre application rate).

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC_{50} = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the relatively low agricultural use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect, but is not likely to adversely affect the Columbia River chum ESU. We cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

11. Hood Canal Summer-run chum salmon ESU

The Hood Canal summer-run chum salmon ESU was proposed for listing as threatened, and critical habitat was proposed, in 1998 (63FR11774-11795, March 10, 1998). The final listing was published a year later (63FR14508-14517, March 25, 1999), and critical habitat was designated in 2000 (65FR7764-7787).

Critical habitat for the Hood Canal ESU includes Hood Canal, Admiralty Inlet, and the straits of Juan de Fuca, along with all river reaches accessible to listed chum salmon draining into Hood Canal as well as Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington. The hydrologic units are Skokomish (upstream boundary - Cushman Dam), Hood Canal, Puget Sound, Dungeness-Elwha, in the counties of Mason, Clallam, Jefferson, Kitsap, and Island.

Streams specifically mentioned, in addition to Hood Canal, in the proposed critical habitat Notice include Union River, Tahuya River, Big Quilcene River, Big Beef Creek, Anderson Creek, Dewatto River, Snow Creek, Salmon Creek, Jimmy comelately Creek, Duckabush 'stream,' Hamma Hamma 'stream,' and Dosewallips 'stream.'

According to the Agricultural census data (Attachment G-11), there are 3,312,830 acres of land in the entire ESU. There was 6,024 acres grown which could have been treated with 13,963 lbs of malathion (0.18 % potentially treated acres in the ESU). Island County had the highest acres and pounds of estimated malathion usage at 3,469 acres and 7,276 lbs (2.6% potentially treated within the county). The major crops grown were alafalfa (4015 acres) and apples (78 acres) that could have been treated with 9.877 lbs and 1,123 lbs of malathion, respectively.

The WSDA data does not indicate that there are many acres of crops in these counties where malthion could be used. Furthermore, for some crops, not all of the useage and/or areas are accounted for within the state's report. Therefore, it is difficult to quantify total acres treated and pounds used in an ESU.

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC_{50} = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the potentially low agricultural use, we conclude that agricultural use of malathion may affect but is not likely to adversely affect the Hood-canal summer-run chum ESU. We also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

C. Coho Salmon

Coho salmon, *Oncorhynchus kisutch*, were historically distributed throughout the North Pacific Ocean from central California to Point Hope, AK, through the Aleutian Islands into Asia. Historically, this species probably inhabited most coastal streams in Washington, Oregon, and central and northern California. Some populations may once have migrated hundreds of miles inland to spawn in tributaries of the upper Columbia River in Washington and the Snake River in Idaho.

Coho salmon generally exhibit a relatively simple, 3 year life cycle. Adults typically begin their freshwater spawning migration in the late summer and fall, spawn by mid-winter, then die. Southern populations are somewhat later and spend much less time in the river prior to spawning than do northern coho. Homing fidelity in coho salmon is generally strong; however their small tributary habitats experience relatively frequent, temporary blockages, and there are a number of examples in which coho salmon have rapidly recolonized vacant habitat that had only recently become accessible to anadromous fish.

After spawning in late fall and early winter, eggs incubate in redds for 1.5 to 4 months, depending upon the temperature, before hatching as alevins. Following yolk sac absorption, alevins emerge and begin actively feeding as fry. Juveniles rear in fresh water for up to 15 months, then migrate to the ocean as ‘‘smolts’’ in the spring. Coho salmon typically spend two growing seasons in the ocean before returning to their natal stream. They are most frequently recovered from ocean waters in the vicinity of their spawning streams, with a minority being recovered at adjacent coastal areas, decreasing in number with distance from the natal streams. However, those coho released from Puget Sound, Hood Canal, and the Strait of Juan de Fuca are caught at high levels in Puget Sound, an area not entered by coho salmon from other areas.

12. Central California Coast Coho Salmon ESU

The Central California Coast Coho Salmon ESU includes all coho naturally reproduced in streams between Punta Gorda, Humboldt County, CA and San Lorenzo River, Santa Cruz County, CA, inclusive. This ESU was proposed in 1995 (60FR38011-38030, July 25, 1995) and listed as threatened, with critical habitat designated, on May 5, 1999 (64FR24049-24062). Critical habitat consists of accessible reaches along the coast, including Arroyo Corte Madera Del Presidio and Corte Madera Creek, tributaries to San Francisco Bay.

Hydrologic units within the boundaries of this ESU are: San Lorenzo-Soquel (upstream barrier Newell Dam), San Francisco Coastal South, San Pablo Bay (upstream barrier – Phoenix Dam-Phoenix Lake), Tomales-Drake Bays (upstream barriers - Peters Dam-Kent Lake; Seeger Dam-Nicasio Reservoir), Bodega Bay, Russian (upstream barriers - Warm springs dam-Lake Sonoma; Coyote Dam-Lake Mendocino), Gualala-Salmon, and Big-Navarro-Garcia. California counties included are Santa Cruz, San Mateo, Marin, Napa, Sonoma, and Mendocino. San Francisco County lies within the north-south boundaries of this ESU, but was not named in the Critical Habitat FR Notice, presumably because there are no coho salmon streams in the county; it is excluded.

Table F-12 (see attachment F) contains usage information based on 1997 CDPR data for three California counties where malathion is used and where the Central California Coho ESU resides. Reported usage of malathion is 17,970 lbs in this ESU, which has a total number of acres of 4,682,140. Santa Cruz County had the most total pounds applied at 16,633 lbs (8,871 acres; 3% acres treated in the county). Strawberries (11,528 lbs), blackberries (2321 lbs), and raspberries (2111 lbs) had the highest number of pounds of malathion applied. All of these were in Santa Cruz County. San Mateo comprised all of the usage on beans with a total of 287 lbs and Sonoma comprised all of the usage on walnuts with a total of 82 lbs.

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

California DPR surface water monitoring resulted in 0 detections in 59 samples taken (0 % detection) within this ESU. Therefore, there were no detection values that exceed the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC_{50} = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb).

Based on the potential agricultural use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the Central California coast coho ESU. We also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

13. Oregon Coast coho salmon ESU

The Oregon coast coho salmon ESU was first proposed for listing as threatened in 1995 (60FR38011-38030, July 25, 1995), and listed several years later (63FR42587-42591, August 10, 1998). Critical habitat was proposed in 1999 (64FR24998-25007, May 10, 1999) and designated on February 16, 2000 (65FR7764-7787).

This ESU includes coastal populations of coho salmon from Cape Blanco, Curry County, Oregon to the Columbia River. Spawning is spread over many basins, large and small, with higher numbers further south where the coastal lake systems (e.g., the Tenmile, Tahkenitch, and Siltcoos basins) and the Coos and Coquille Rivers have been particularly productive. Critical Habitat includes all accessible reaches in the coastal hydrologic reaches Necanicum, Nehalem, Wilson-Trask-Nestucca (upstream barrier - McGuire Dam), Siletz-Yaquina, Alsea, Siuslaw, Siltcoos, North Umpqua (upstream barriers - Cooper Creek Dam, Soda Springs Dam), South Umpqua (upstream barrier - Ben Irving Dam, Galesville Dam, Win Walker Reservoir), Umpqua, Coos (upstream barrier - Lower Pony Creek Dam), Coquille, Sixes. Related Oregon counties are Douglas, Lane, Coos, Curry, Benton, Josephine, Lincoln, Polk, Tillamook, Yamhill, Washington, Columbia, and Clatsop. However, the portions of Yamhill, Washington, and Columbia counties that are within the ESU are primarily mountainous forested. Benton and Polk counties are primarily part of the Willamette River watershed, but the small parts that may drain into the Pacific Ocean do include agricultural areas, and therefore they are included in the tables.

According to the Agricultural census data (Attachment G-13), there are 13,480,118 acres of land in the entire ESU. There was 24,235 acres grown which could have been treated with 65,391 lbs of malathion (0.18 % potentially treated acres in the ESU). Lane (8,253 acres) and Polk (6,429 acres) Counties had the highest acres and pounds of estimated malathion usage at 20,450 lbs and 15,004 lbs, respectively (0.3 and 1.3% potentially treated within the county, respectively). The major crops grown were mint (10,723 acres), alfalfa (5,347 acres), and apples (799 acres) that could have been treated with 19,730 lbs, 13,154 lbs, 11,506 lbs of malathion, respectively.

The WSDA data states that Benton and Douglas Counties had the most acres of apples (18,425 acres and 14,383 acres, respectively) grown in this ESU. They reported that 4 lbs of malathion could be applied per acre for this crop, which would amount to 73,700 lbs and 57,532 lbs applied, respectively.

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC50 = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the potentially high agricultural use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the Oregon coast coho ESU. We also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

14. Southern Oregon/Northern California Coast Coho Salmon ESU

The Southern Oregon/Northern California coastal coho salmon ESU was proposed as threatened in 1995 (60FR38011-38030, July 25, 1995) and listed on May 6, 1997 (62FR24588-24609). Critical habitat was proposed later that year (62FR62741-62751, November 25, 1997) and finally designated on May 5, 1999 (64FR24049-24062) to encompass accessible reaches of all rivers (including estuarine areas and tributaries) between the Mattole River in California and the Elk River in Oregon, inclusive.

The Southern Oregon/Northern California Coast coho salmon ESU occurs between Punta Gorda, Humboldt County, California and Cape Blanco, Curry County, Oregon. Major basins with this salmon ESU are the Rogue, Klamath, Trinity, and Eel river basins, while the Elk River, Oregon, and the Smith and Mad Rivers, and Redwood Creek, California are smaller basins within the range. Hydrologic units and the upstream barriers are Mattole, South Fork Eel, Lower Eel, Middle Fork Eel, Upper Eel (upstream barrier - Scott Dam-Lake Pillsbury), Mad-Redwood, Smith, South Fork Trinity, Trinity (upstream barrier - Lewiston Dam-Lewiston Reservoir), Salmon, Lower Klamath, Scott, Shasta (upstream barrier - Dwinnell Dam-Dwinnell Reservoir), Upper Klamath (upstream barrier - Irongate Dam-Irongate Reservoir), Chetco, Illinois (upstream barrier - Selmac Dam-Lake Selmac), Lower Rogue, Applegate (upstream barrier – Applegate Dam-Applegate Reservoir), Middle Rogue (upstream barrier - Emigrant Lake Dam-Emigrant Lake), Upper Rogue (upstream barriers - Agate Lake Dam-Agate Lake; Fish Lake Dam-Fish Lake; Willow Lake Dam-Willow Lake; Lost Creek Dam-Lost Creek Reservoir), and Sixes. Related counties are Humboldt, Mendocino, Trinity, Lake, and Del Norte in California and Curry, Jackson, Josephine, Klamath, and Douglas in Oregon. The habitat in Glenn and Lake Counties, CA is within the Mendocino National Forest, and that in Douglas County, OR is entirely within the Rogue River and Umpqua National Forests where malathion would not be used. Glenn, Lake, and Douglas Counties are excluded from the crop acreage tables in this analysis.

According to the Agricultural census data (Attachments F- 14 and G-13), there are 19,153,948 acres of land in the entire ESU. There was 107,811 acres grown that could have been treated with 263,621 lbs (0.6 % potentially treated acres in the ESU). Klammath County had the highest acres and pounds of estimated malathion usage at 97,718 acres and 233,456 lbs (2.5% potentially treated within the county). The major crops grown were alfalfa (66,273 acres), barley (24,337 acres), and apples (601 acres), which could have been treated with 163,032 lbs, 37,478 lbs, and 8,654 lbs of malathion. In addition to the agricultural use sites, some of these areas may be urban/suburban, with a reported structural pest control use in California of 3,169 lbs. In addition, an unspecified amount of homeowner use could occur (CDPR does not report homeowner use).

The WSDA data states that Douglas Counties had the most acres of apples (14,383 acres, respectively) grown in this ESU. They reported that 4 lbs of malathion could be applied per acre for this crop, which would amount to 57,532 lbs applied. Cherry was the next highest crop in Douglas County with 1,842 acres, which could amount to 2,247 lbs applied.

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and

Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC50 = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the potentially high agricultural use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the Southern Oregon/Northern California coast coho ESU. We also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

D. Sockeye Salmon

Sockeye salmon, *Oncorhynchus nerka*, are the third most abundant species of Pacific salmon, after pink and chum salmon. Sockeye salmon exhibit a wide variety of life history patterns that reflect varying dependency on the fresh water environment. The vast majority of sockeye salmon typically spawn in inlet or outlet tributaries of lakes or along the shoreline of lakes, where their distribution and abundance is closely related to the location of rivers that provide access to the lakes. Some sockeye, known as kokanee, are non-anadromous and have been observed on the spawning grounds together with their anadromous counterparts. Some sockeye, particularly the more northern populations, spawn in mainstem rivers.

Growth is influenced by competition, food supply, water temperature, thermal stratification, and other factors, with lake residence time usually increasing the farther north a nursery lake is located. In Washington and British Columbia, lake residence is normally 1 or 2 years. Incubation, fry emergence, spawning, and adult lake entry often involve intricate patterns of adult and juvenile migration and orientation not seen in other *Oncorhynchus* species.

Upon emergence from the substrate, lake-type sockeye salmon juveniles move either downstream or upstream to rearing lakes, where the juveniles rear for 1 to 3 years prior to migrating to sea. Smolt migration typically occurs beginning in late April and extending through early July.

Once in the ocean, sockeye salmon feed on copepods, euphausiids, amphipods, crustacean larvae, fish larvae, squid, and pteropods. They will spend from 1 to 4 years in the ocean before returning to freshwater to spawn. Adult sockeye salmon home precisely to their natal stream or lake. River-and sea-type sockeye salmon have higher straying rates within river systems than lake-type sockeye salmon.

15. Ozette Lake Sockeye Salmon ESU

The Ozette Lake sockeye salmon ESU was proposed for listing, along with proposed critical habitat, in 1998 (63FR11750-11771, March 10, 1998). It was listed as threatened on March 25, 1999 (64FR14528-14536), and critical habitat was designated on February 16, 2000

(65FR7764-7787). This ESU spawns in Lake Ozette, Clallam County, Washington, as well as in its outlet stream and the tributaries to the lake. It has the smallest distribution of any listed Pacific salmon.

While Lake Ozette itself is part of Olympic National Park, its tributaries extend outside park boundaries, much of which is private land. There is limited agriculture in the whole of Clallam County.

According to the Agricultural census data (Attachment G-15), there are 1,141,259 acres of land in the entire ESU. Clallam County included 2,368 acres grown that could have been treated with 5,759 lbs of malathion (0.2% potentially treated acres in the ESU). The major crops grown were alfalfa (1,790 acres) and barley (453 acres) that could have been treated with 4,403 lbs and 698 lbs of malathion, respectively.

The WSDA data does not indicate that there are many acres of crops in these counties where malthion could be used. Furthermore, for some crops, not all of the useage and/or areas are accounted for within the state's report. Therefore, it is difficult to quantify total acres treated and pounds used in an ESU.

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington. The maximum residue value was 0.235 ppb. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC50 = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Despite the relatively low agricultural usage in this ESU, the salmon have limited and localized distribution, residing in only one county. Also, since their habitat is within a lake and not a flowing water body, the EEC modeling (Table 39) is more accurate for this ESU, than for others. In a lake the dilution factor is limited; therfore, accumulation of the pesticide is greater. Even a small amount of pesticide would have a greater effect in a static water body. Therefore, we conclude that agricultural use of malathion may affect the Ozette Lake sockeye ESU. We also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

16. Snake River Sockeye Salmon ESU

The Snake River sockeye salmon was the first salmon ESU in the Pacific Northwest to be listed. It was proposed and listed in 1991 (56FR14055-14066, April 5, 1991 & 56FR58619-

58624, November 20, 1991). Critical habitat was proposed in 1992 (57FR57051-57056, December 2, 1992) and designated a year later (58FR68543-68554, December 28, 1993) to include river reaches of the mainstem Columbia River, Snake River, and Salmon River from its confluence with the outlet of Stanley Lake down stream, along with Alturas Lake Creek, Valley Creek, and Stanley, Redfish, Yellow Belly, Pettit, and Alturas lakes (including their inlet and outlet creeks).

Spawning and rearing habitats are considered to be all of the above-named lakes and creeks, even though at the time of the critical habitat Notice, spawning only still occurred in Redfish Lake. Habitat residency occurs in Custer, Blaine, Idaho, Lemhi, Lewis, and Nez Perce Counties in Idaho; Asotin, Garfield, Whitman, Columbia, Wall Walla, Franklin, Benton, Klickitat, Skamania, Clark, Cowlitz, Wahkiakum, and Pacific Counties in Washington; and Wallowa, Umatilla, Morrow, Sherman, Wasco, Hood River, Multnomah, Columbia, Clatsop, Gilliam Counties in Oregon. However, the habitat area for salmon in Custer and Blaine Counties is at high elevation areas in a National Wilderness area and National Forest. Malathion cannot be used on such a site, and therefore there will be no exposure in these counties.

According to the Agricultural census data (Attachment G-16), there are 33,745,328 acres of land in the entire ESU. There was 894,773 acres grown that could have been treated with 2,476,321 lbs of malathion (2.7 % potentially treated acres in the ESU). Franklin County had the highest acres and pounds of estimated malathion usage at 141,219 acres (17.4% potentially treated acres in the county) and 504,342 lbs. Benton had the next highest at 83,239 acres and 472,127 lbs (7.4% potentially treated within the county). The major crops grown were barley (392,649 acres), alfalfa (270,668 acres), and apples (40,429 acres) that could have been treated with 604,679 lbs, 665,843 lbs, and 582,178 lbs of malathion.

The WSDA data states that Franklin County had the most acres of sweet corn (18,000 acres) grown in this ESU. They reported that 1 lb of malathion could be applied per acre for this crop, which could amount to 18,000 lbs applied. Franklin County also had the most asparagus acreage (7,000 acres) with a malathion usage of 8,750 lbs (1.25 lbs/acre application rate). Whitman County had a significantly large number of acres of wheat grown (493,500 lbs), which could amount to 690,900 lbs of malathion being applied (application rate of 1.4 lbs/acre). However, generally one application of a given pesticide is made per year and because of the low economic return on small grains, chemicals are not used extensively for insect control. Simple economics precludes many growers' use of seed or foliar treatments. Insecticide applications are often limited to outbreak conditions or in response to threats of insect-vectored diseases (WSDA 1994).

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC50 = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the potentially high agricultural use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the Snake River sockeye ESU. We also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

D. Steelhead

Steelhead, *Oncorhynchus mykiss*, exhibit one of the most complex suites of life history traits of any salmonid species. Steelhead may exhibit anadromy or freshwater residency. Resident forms are usually referred to as ‘‘rainbow’’ or ‘‘redband’’ trout, while anadromous life forms are termed ‘‘steelhead.’’ The relationship between these two life forms is poorly understood, however, the scientific name was recently changed to represent that both forms are a single species.

Steelhead typically migrate to marine waters after spending 2 years in fresh water. They then reside in marine waters for typically 2 or 3 years prior to returning to their natal stream to spawn as 4- or 5-year-olds. Unlike Pacific salmon, they are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying; most that do so are females. Steelhead adults typically spawn between December and June. Depending on water temperature, steelhead eggs may incubate in redds for 1.5 to 4 months before hatching as alevins. Following yolk sac absorption, alevins emerge as fry and begin actively feeding. Juveniles rear in fresh water from 1 to 4 years, then migrate to the ocean as ‘‘smolts.’’

Biologically, steelhead can be divided into two reproductive ecotypes. “Stream maturing,” or “summer steelhead” enter fresh water in a sexually immature condition and require several months to mature and spawn. “Ocean maturing,” or “winter steelhead” enter fresh water with well-developed gonads and spawn shortly after river entry. There are also two major genetic groups, applying to both anadromous and nonanadromous forms: a coastal group and an inland group, separated approximately by the Cascade crest in Oregon and Washington. California is thought to have only coastal steelhead while Idaho has only inland steelhead.

Historically, steelhead were distributed throughout the North Pacific Ocean from the Kamchatka Peninsula in Asia to the northern Baja Peninsula, but they are now known only as far south as the Santa Margarita River in San Diego County. Many populations have been extirpated.

17. Central California Coast Steelhead ESU

The Central California coast steelhead ESU was proposed for listing as endangered on August 9, 1996 (61FR41541-41561) and the listing was made final, as threatened, a year later (62FR43937-43954, August 18, 1997). Critical Habitat was proposed February 5, 1999 (64FR5740-5754) and designated on February 16, 2000 (65FR7764-7787). This coastal steelhead ESU occupies California river basins from the Russian River, Sonoma County, to Aptos Creek, Santa Cruz County, (inclusive), and the drainages of San Francisco and San Pablo Bays eastward to the Napa River (inclusive), Napa County. The Sacramento-San Joaquin River Basin of the Central Valley of California is excluded. Steelhead in most tributary streams in San Francisco and San Pablo Bays appear to have been extirpated, whereas most coastal streams sampled in the central California coast region do contain steelhead.

Only winter steelhead are found in this ESU and those to the south. River entry ranges from October in the larger basins, late November in the smaller coastal basins, and continues through June. Steelhead spawning begins in November in the larger basins, December in the smaller coastal basins, and can continue through April with peak spawning generally in February and March. Hydrologic units in this ESU include Russian (upstream barriers - Coyote Dam, Warm Springs Dam), Bodega Bay, Suisun Bay, San Pablo Bay (upstream barriers – Phoenix Dam, San Pablo Dam), Coyote (upstream barriers - Almaden, Anderson, Calero, Guadelupe, Stevens Creek, and Vasona Reservoirs, Searsville Lake), San Francisco Bay (upstream barriers - Calveras Reservoir, Chabot Dam, Crystal Springs Reservoir, Del Valle Reservoir, San Antonio Reservoir), San Francisco Coastal South (upstream barrier - Pilarcitos Dam), and San Lorenzo-Soquel (upstream barrier - Newell Dam).

Counties of occurrence for this ESU are Santa Cruz, San Mateo, San Francisco, Marin, Sonoma, Mendocino, Napa, Alameda, Contra Costa, Solano, and Santa Clara counties.

Table F-17 (see attachment F) contains usage information from CDPR (2002) for California counties where malathion is used and where the Central California Coast Steelhead ESU resides. This ESU contains 7,071,798 acres and there is a modest amount of acreage that was treated with malathion within this area. Total pounds of malathion used in all counties overlapping with ESU residency were 2,214 lbs. Solano County has the highest amount of acreage (1585) where malathion was used (1,251 lbs). Alfalfa, grapes, walnuts, and beans are the crops that had the most usage in this ESU with a total of 1,079 lbs, 434 lbs, 340 lbs, and 287 lbs, respectively. Solano County had the most usage of malathion on alfalfa (520 lbs), grapes (434 lbs)and walnuts (258 lbs). San Mateo County included all the usage on beans (287 lbs). Also, some areas in this ESU are heavily urban/suburban. For structural pest control 1,395 lbs was used. In addition, an unspecified amount of homeowner use could occur (CDPR does not report homeowner use).

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

California DPR surface water monitoring resulted in 0 detections in 5 samples taken (0 % detection) within this ESU. Therefore, there were no values that exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC50 = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb).

Because of the relatively low agricultural use, we conclude that malathion may affect but is not likely to adversely affect the central California coast steelhead ESU. However, we cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

18. California Central Valley Steelhead ESU

The California Central Valley steelhead ESU was proposed for listing as endangered on August 9, 1996 (61FR41541-41561) and the listing was made final in 1998 (63FR 13347-13371, March 18, 1998). Critical Habitat was proposed February 5, 1999 (64FR5740-5754) and designated on February 16, 2000 (65FR7764-7787).

This ESU includes populations ranging from Shasta, Trinity, and Whiskeytown areas, along with other Sacramento River tributaries in the North, down the Central Valley along the San Joaquin River to and including the Merced River in the South, and then into San Pablo and San Francisco Bays. Counties at least partly within this area are Alameda, Amador, Butte, Calaveras, Colusa, Contra Costa, Glenn, Marin, Merced, Nevada, Placer, Sacramento, San Francisco, San Joaquin, San Mateo, San Francisco, Shasta, Solano, Sonoma, Stanislaus, Sutter, Tehama, Tuloumne, Yolo, and Yuba. A large proportion of this area is heavily agricultural, but there are also large amounts of urban and suburban areas.

Table F-18 (see attachment F) contains CDPR 2002 usage information for California counties where malathion was used and where the California Central Valley Steelhead ESU resides. There is a large amount of acreage that was treated with 82,250 lbs of malathion within the area of this ESU. Yolo County has the largest acreage (171,318) where malathion was applied (11,712) followed by San Joaquin County with 12,532 acres (18,459 lbs) and Stanislaus with 6541 acres (9344 lbs). Alfalfa and walnuts are the crops that had the most usage in this ESU with a total of 31,216 lbs, and 29,605 lbs, respectively. Yolo County had the most usage of malathion on alfalfa (11,041 lbs) and Tehama County had the most usage on walnuts (7,700 lbs). Also, some areas in this ESU are heavily urban/suburban. For structural pest control and public health 40,745 lbs was used. In addition, an unspecified amount of homeowner use could occur (CDPR does not report homeowner use).

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

California DPR surface water monitoring resulted in 125 detections in 4,232 samples taken (3.0 % detection) within this ESU. In Colusa County 4 samples were greater than 1 ppb with values at 1.033 ppb, 1.158 ppb, 3.27 ppb, 6.0 ppb. These last two values significantly exceed the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC50 = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb).

Because of these factors and the fact that we cannot preclude residential use, we conclude that agricultural, public health, structural pest control, and residential use of malathion may affect the California central valley steelhead ESU.

19. Lower Columbia River Steelhead ESU

The Lower Columbia River Steelhead ESU was proposed for listing as endangered on August 9, 1996 (61FR41541-41561) and the listing was made final a year later (62FR43937-43954, August 18, 1997). Critical Habitat was proposed February 5, 1999 (64FR5740-5754) and designated on February 16, 2000 (65FR7764-7787).

This ESU includes all tributaries from the lower Willamette River (below Willamette Falls) to Hood River in Oregon, and from the Cowlitz River up to the Wind River in Washington. These tributaries would provide the spawning and presumably the growth areas for the young steelhead. It is not clear if the young and growing steelhead in the tributaries would use the nearby mainstem of the Columbia prior to downstream migration. The mainstem of the Columbia River from the mouth to Hood River constitutes the migration corridor. The habitat residency would occur in Hood River, Clackamas, Columbia, Clatsop, Marion, Washington, and Multnomah counties in Oregon, and Skamania, Clark, Cowlitz, Lewis, Pacific, and Wahkiakum counties in Washington. Tributaries of the extreme lower Columbia River, e.g., Grays River in Pacific and Wahkiakum counties, Washington and John Day River in Clatsop county, Oregon, are not discussed in the Critical Habitat FRNs; because they are not "between" the specified tributaries.

Hydrologic units for this ESU are Middle Columbia-Hood, Lower Columbia-Sandy (upstream barrier - Bull Run Dam 2), Lewis (upstream barrier - Merlin Dam), Lower Columbia-Clatskanie, Lower Cowlitz, Lower Columbia, Clackamas, and Lower Willamette.

According to the Agricultural census data (Attachment G-19), there are 8,601,364 acres of land in the entire ESU. There was 46,746 acres grown that could have been treated with 199,208 lbs of malathion (0.54 % potentially treated acres in the ESU). Marion (16,398 acres; 2.1% potentially treated) and Washington (10,634 acres; 2.3% potentially treated) County had the highest acres and pounds of estimated malathion usage at 58,586 lbs and 46,342 lbs, respectively. The major crops grown were alfalfa (7,472 acres), raspberries (4,947, strawberries (4,062 acres), and apples (3,882 acres) that could have been treated with 18,381 lbs, 22,261 lbs, 40,620 lbs, and 55,900 lbs of malathion, respectively.

The WSDA data states that Cowlitz County had the most acres of red raspberries (600 acres) grown in this ESU. They reported that 1 lbs of malathion could be applied per acre for this crop, which would amount to 600 lbs applied. Clark County had the highest strawberry acreage (320 acres), which could amount to 640 lbs being applied (2 lb/acre application rate).

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC50 = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the high potential agricultural but presently low actual use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect, but is not likely to adversely affect the Lower Columbia River steelhead ESU. We also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

20. Middle Columbia River Steelhead ESU

The Middle Columbia River steelhead ESU was proposed for listing as threatened on March 10, 1998 (63FR11798-11809) and the listing was made final a year later (64FR14517-14528, March 25, 1999). Critical Habitat was proposed February 5, 1999 (64FR5740-5754) and designated on February 16, 2000 (65FR7764-7787).

This steelhead ESU occupies “the Columbia River Basin and tributaries from above the Wind River in Washington and the Hood River in Oregon (exclusive), upstream to, and including, the Yakima River, in Washington.” The Critical Habitat designation indicates the downstream boundary of the ESU to be Mosier Creek in Wasco County, Oregon; this is consistent with Hood River being “excluded ” in the listing notice. No downstream boundary is listed for the Washington side of the Columbia River, but if Wind River is part of the Lower Columbia steelhead ESU, it appears that Collins Creek, Skamania County, Washington would be the last stream down river in the Middle Columbia River ESU. Dog Creek may also be part of the ESU, but White Salmon River certainly is, since the Condit Dam is mentioned as an upstream barrier.

The only other upstream barrier, in addition to Condit Dam on the White Salmon River, is the Pelton Dam on the Deschutes River. As an upstream barrier, this dam would preclude steelhead from reaching the Metolius and Crooked Rivers as well the upper Deschutes River and its tributaries.

In the John Day River watershed, we have excluded Harney County, Oregon because there is only a tiny amount of the John Day River and several tributary creeks (e.g., Utley, Bear Cougar creeks) which get into high elevation areas (approximately 1700M and higher) of northern Harney County where there are no crops grown. Union and Wallowa Counties, Oregon were excluded because the small reaches of the Umatilla and Walla Walla Rivers in these counties occur in high elevation areas where crops are not grown.

The Oregon counties that are in the habitat residency are Hood River, Multnomah, Columbia, Clatsop, Gilliam, Morrow, Umatilla, Sherman, Wasco, Crook, Grant, Harney, Wallowa, Union, Wheeler, and Jefferson counties. Washington counties include Benton, Columbia, Franklin, Kittitas, Klickitat, Skamania, Walla Walla, Clark, Cowlitz, Wahkiakum, Pacific, and Yakima.

According to the Agricultural census data (Attachment G-20), there are 37,633,072 acres of land in the entire ESU. There was 743,423 acres grown that could have been treated with3,266,449 lbs of malathion in this ESU (2.0 % potentially treated acres in the ESU). Yakima County had the highest acres and pounds of estimated malathion usage at 160,492 acres and 1,272,598 lbs (5.8% potentially treated within the county). The next highest county was Franklin with 141,219 acres and 504,342 lbs (17.4% potentially treated acres). The major crops grown were alfalfa (268,926 acres), apples (117,543 acres), barley (106,353 acres), and potatoes (106,056 acres) that could have been treated with 661,558 lbs, 1,692,619 lbs, 163,784 lbs, and 456,041 lbs of malathion, respectively.

The WSDA data states that there is an extensive amount of acreage that could be treated with malathion in this ESU (minimum of 223,962 acres). Yakima County has the most acres of apples (75,264 acres) grown in this ESU. They reported that 4 lbs of malathion could be applied per acre for this crop, which would amount to 301,056 lbs applied. Benton County had the next highest acres of apples (18,425 acres) grown in this ESU. They reported that 4 lbs of malathion could be applied per acre for this crop, which would amount to 73,700 lbs applied, respectively.

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC50 = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the potentially high agricultural use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the Middle Columbia River steelhead ESU. We also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

21. Northern California Steelhead ESU

The Northern California steelhead ESU was proposed for listing as threatened on February 11, 2000 (65FR6960-6975) and the listing was made final on June 7, 2000 (65FR36074-36094). Critical Habitat has not yet been officially established. This Northern California coastal steelhead ESU occupies river basins from Redwood Creek in Humboldt County, CA to the Gualala River, inclusive, in Mendocino County, CA. River entry ranges from August through June and spawning from December through April, with peak spawning in January in the larger basins and in late February and March in the smaller coastal basins. The Northern California ESU has both winter and summer steelhead, including what is presently considered to be the southernmost population of summer steelhead, in the Middle Fork Eel River. Counties included appear to be Humboldt, Mendocino, Trinity, Lake, and Sonoma. Lake county is excluded from this particular analysis because the hydrologic units in this countys is entirely within the Mendocino National Forest, where there would be no malathion usage.

Malathion use appears to be in non ESU habitat (no reported data for the counties within this ESU). Therefore, we conclude that malathion will not affect the Northern California coastal Steelhead ESU in its habitat residency. Also, because there is only a small density of housing where malathion could be used, we conclude no effect from residential use.

22. Snake River Basin Steelhead ESU

The Snake River Basin Steelhead ESU was proposed for listing as endangered on August 9, 1996 (61FR41541-41561) and the listing was made final a year later (62FR43937-43954, August 18, 1997). Critical Habitat was proposed February 5, 1999 (64FR5740-5754) and designated on February 16, 2000 (65FR7764-7787).

Spawning and early growth areas of this ESU consist of all areas upstream from the confluence of the Snake River and the Columbia River as far as fish passage is possible. Hells Canyon Dam on the Snake River and Dworshak Dam on the Clearwater River, along with Napias Creek Falls near Salmon, Idaho, are named as impassable barriers. Critical Habitat also includes the migratory corridors of the Columbia River from the confluence of the Snake River to the Pacific Ocean. The habitat residency includes the counties of Wallowa, Baker, Union, and Umatilla, Gilliam, Morrow, Sherman, Wasco, Hood River, Multnomah, Columbia, and Clatsop in Oregon; Asotin, Garfield, Columbia, Whitman, Franklin, Benton, Klickitat, Skamania, Clark, Cowlitz, Wahkiakum and Walla Walla in Washington; and Adams, Idaho, Nez Perce, Blaine, Custer, Lemhi, Boise, Valley, Lewis, Clearwater, and Latah in Idaho.

We have excluded Baker County, Oregon, which has a tiny fragment of the Imnaha River. While a small part of Rock Creek extends into Baker County, this occurs at 7200 feet in the mountains (partly in a wilderness area) and is of no significance with respect to malathion use in agricultural and registered non-crop areas. In Idaho, Blaine and Boise counties technically have waters that are part of the steelhead ESU, but again, these are tiny areas which occur in the Sawtooth National Recreation Area and/or National Forest lands. These areas are not relevant to use of malathion. The agricultural areas of Valley County, Idaho, appear to be primarily associated with the Payette River watershed, but there is enough of the Salmon River watershed in this county to justify its inclusion.

According to the Agricultural census data (Attachment G-22), there are 45,502,642 acres of land in the entire ESU. There was 1,014,419 acres grown that could have been treated with 2,733,959 lbs of malathion in this ESU (2.2% potentially treated acres in the ESU). Franklin County had the highest acres and pounds of estimated malathion usage at 141,219 acres (17.4% potentially treated acres in the county) and 504,342 lbs. Benton had the next highest at 83,239 acres and 472,127 lbs (7.4% potentially treated within the county). The major crops grown were barley (427,637 acres), alfalfa (341,617 acres), potatoes (78,787 acres), and apples (40,471 acres) that could have been treated with 658,561 lbs, 840,378 lbs, 338,784 lbs, and 582,782 lbs of malathion.

The WSDA data states that Benton had the most aces of apples (18,425 acres) grown in this ESU. They reported that 4 lb of malahtion could be applied per acres for this crop, which could amount to 73,700 lbs applied. Franklin County had the most acres of sweet corn (18,000 acres) grown in this ESU. They reported that 1 lb of malathion could be applied per acre for this crop, which could amount to 18,000 lbs applied. Franklin County also had the most asparagus acreage (7,000 acres) with a malathion usage of 8,750 lbs (1.25 lbs/acre application rate). Whitman County had a significantly large number of acres of wheat grown (493,500 lbs), which could amount to 690,900 lbs of malathion being applied (application rate of 1.4 lbs/acre). However, generally one application of a given pesticide is made per year and because of the low economic return on small grains, chemicals are not used extensively for insect control. Simple economics precludes many growers' use of seed or foliar treatments. Insecticide applications are often limited to outbreak conditions or in response to threats of insect-vectored diseases (WSDA 1994).

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC50 = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the potentially high agricultural use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the Snake River Basin steelhead ESU. We also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

23. South Central California Steelhead ESU

The South Central California steelhead ESU was proposed for listing as endangered on August 9, 1996 (61FR41541-41561) and the listing was made final, as threatened, a year later (62FR43937-43954, August 18, 1997). Critical Habitat was proposed February 5,1999 (64FR5740-5754) and designated on February 16, 2000 (65FR7764-7787). This coastal steelhead ESU occupies rivers from the Pajaro River, Santa Cruz County, to (but not including) the Santa Maria River, San Luis Obispo County. Most rivers in this ESU drain the Santa Lucia Mountain Range, the southernmost unit of the California Coast Ranges (62FR43937-43954, August 18, 1997). River entry ranges from late November through March, with spawning occurring from January through April.

This ESU includes the hydrologic units of Pajaro (upstream barriers - Chesbro Reservoir, North Fork Pachero Reservoir), Estrella, Salinas (upstream barriers - Nacimiento Reservoir, Salinas Dam, San Antonio Reservoir), Central Coastal (upstream barriers - Lopez Dam, Whale Rock Reservoir), Alisal-Elkhorn Sloughs, and Carmel. Counties of occurrence include Santa Cruz, Santa Clara, San Benito, Monterey, and San Luis Obispo.

Table F-23 (see Attachment F) contains 2002 county usage information from the CDPR for California counties where malathion can be used and where the South Central California Steelhead ESU resides. There is a large amount of acreage that was treated with 90,150 lbs of malathion within the habitat residency of this ESU. Monterey County had the highest amount of acreage (44,984) where malathion was used (70,794 lbs) followed by San Luis Obispo County with 12,223 acres (18,755 lbs). Strawberries and lettuce are the crops that had the most usage in this ESU with a total of 41,435 lbs, and 35,315 lbs, respectively. Monterey County contained most of the usage of malathion on strawberries (40,028 lbs) and lettuce (24,392 lbs). San Luis Obispo County applied 10,923 lbs on lettuce.

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

California DPR surface water monitoring resulted in 6 detections in 143 samples taken (4.2 % detection) within this ESU. Monterey county had the maximum residue with a value of 0.544 ppb. There were no counties that had samples greater than 1 ppb. Therefore, no values exceed the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC50 = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb).

Based on the potentially high agricultural use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the South Central California steelhead ESU. Also, we also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

24. Southern California steelhead ESU

The Southern California steelhead ESU was proposed for listing as endangered on August 9, 1996 (61FR41541-41561) and the listing was made final a year later (62FR43937-43954, August 18, 1997). Critical Habitat was proposed February 5, 1999 (64FR5740-5754) and designated on February 16, 2000 (65FR7764-7787). This ESU ranges from the Santa Maria River in San Luis Obispo County south to San Mateo Creek in San Diego County. Steelhead from this ESU may also occur in Santa Barbara, Ventura and Los Angeles counties, but this ESU apparently is no longer considered to be extant in Orange County (65FR79328-79336, December 19, 2000). The San Mateo Creek watershed also includes a small portion of the southwest corner of Riverside County, but the area is in the Cleveland National Forest. Hydrologic units in this ESU are Cuyama (upstream barrier - Vaquero Dam), Santa Maria, San Antonio, Santa Ynez (upstream barrier - Bradbury Dam), Santa Barbara Coastal, Ventura (upstream barriers - Casitas Dam, Robles Dam, Matilja Dam, Vern Freeman Diversion Dam), Santa Clara (upstream barrier - Santa Felicia Dam), Calleguas, and Santa Monica Bay (upstream barrier - Rindge Dam). Counties comprising this ESU show a very high percentage of declining and extinct populations.

River entry ranges from early November through June, with peaks in January and February. Spawning primarily begins in January and continues through early June, with peak spawning in February and March.

Within San Diego County, the San Mateo Creek runs through Camp Pendleton Marine Base and into the Cleveland National Forest. While there are agricultural uses of pesticides in other parts of California within the range of this ESU, it would appear that there are no such uses in the vicinity of San Mateo Creek. Within Los Angeles County, this steelhead occurs in Malibu Creek and possibly Topanga Creek. Neither of these creeks drain agricultural areas.

Table F-24 (see Attachment F) contains 2002 county usage information from the CDPR for California counties where malathion can be used and where the Southern California Steelhead ESU resides. There is a large amount of acreage that was treated with 50,916 lbs of malathion within the habitat residency of this ESU. San Luis Obispo County had the highest amount of acreage (12,223) where malathion was used (18,755 lbs) followed by Ventura County with 9,638 acres (31,117 lbs). Lemons, lettuce, celery and strawberries are the crops that had the most usage in this ESU with a total of 16,877 lbs, 11,017 lbs, 7.603 lbs and 7,169 lbs, respectively. San Luis Obispo County contained most of the usage of malathion on lettuce (10,923 lbs). Ventura Conuty contained the all the usage on lemons and the most usage on strawberries (5,702 lbs), and celery

(5,504 lbs). Also, some areas in this ESU are heavily urban/suburban. For structural pest control and public health 3,955 lbs was used. In addition, an unspecified amount of homeowner use could occur (CDPR does not report homeowner use).

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

There were no samples of malathion taken by the California DPR surface water monitoring program. Therefore, we are unaware of any values that exceed the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC50 = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb).

Based on the potentially high agricultural use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the Southern California steelhead ESU. Also, we also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

25. Upper Columbia River Steelhead ESU

The Upper Columbia River steelhead ESU was proposed for listing as endangered on August 9, 1996 (61FR41541-41561) and the listing was made final a year later (62FR43937-43954, August 18, 1997). Critical Habitat was proposed February 5, 1999 (64FR5740-5754) and designated on February 16, 2000 (65FR7764-7787).

The Upper Columbia River Steelhead ESU ranges from several northern rivers close to the Canadian border in central Washington (Okanogan and Chelan counties) to the mouth of the Columbia River. The primary area for spawning and growth through the smolt stage of this ESU is from the Yakima River in south Central Washington upstream. Hydrologic units within the spawning and rearing habitat of the Upper Columbia River steelhead ESU and their upstream barriers are Chief Joseph (upstream barrier - Chief Joseph Dam), Okanogan, Similkameen, Methow, Upper Columbia-Entiat, Wenatchee, Moses-Coulee, and Upper Columbia-Priest Rapids. Areas downstream from the Yakima River are used for migration. Within the habitat residency counties include Chelan, Columbia, Douglas, Okanogan, Grant, Benton, Franklin, Kittitas, and Yakima, Walla Walla, Klickitat, Skamania, Clark, Cowlitz, Wahkiakum, and Pacific in Washington; and Gilliam, Morrow, Sherman, Umatilla, Wasco, Hood River, Multnomah, Columbia, and Clatsop, Oregon.

According to the Agricultural census data (Attachment G-25), there are 27,920,623 acres of land in the entire ESU. There was 1,037,982 acres grown that could have been treated with 5,098,523 lbs of malathion (3.7 % potentially treated acres in the ESU). Several counties had a significant number of acres that could lead to large amounts of malathion being applied. Yakima (160,492 acres) and Grant (266,369 acres) County had the highest acres and pounds of estimated malathion usage at 1,272,598 lbs and 1,092,404 lbs. The major crops grown were alfalfa (360,755 acres), apples (206,738 acres), potatoes (149,346 acres), and barley (115,662 acres) that could have been treated with 887,457 lbs, 2,977,027 lbs, 642,188 lbs, and 178,120 lbs of malathion.

The WSDA data states that there is an extensive amount of acreage that could be treated with malathion in this ESU (minimum of 489,872 acres). Several counties had a significant number of acres that could lead to large amounts of malathion being applied. Yakima County has th most acres of apples (75,264 acres) grown in this ESU, followed by Grant (33,615 acres). They reported that 4 lbs of malathion could be applied per acre for this crop, which would amount to 301,056 lbs and 134,460 lbs applied, respectively. Grant County produces a large amount of alfalfa, nearly one-quarter of the state's alfalfa hay crop (119,000 acres). With an application rate of 1.5 lbs/acre, this could amount to 178,500 lbs of malathion being applied.

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC50 = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the potentially high agricultural use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect the Upper Columbia River steelhead ESU. We also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

26. Upper Willamette River Steelhead ESU

The Upper Willamette River Steelhead ESU was proposed for listing as threatened on March 10, 1998 (63FR11798-11809) and the listing was made final a year later (64FR14517-14528, March 25, 1999). Critical Habitat was proposed February 5, 1999 (64FR5740-5754) and designated on February 16, 2000 (65FR7764-7787). Only naturally spawned, winter Steelhead trout are included as part of this ESU; where distinguishable, summer-run Steelhead trout are not included.

Spawning and rearing areas are river reaches accessible to listed Steelhead in the Willamette River and its tributaries above Willamette Falls up through the Calapooia River.

Hydrologic units where spawning and rearing occur are Upper Willamette, North Santiam (upstream barrier - Big Cliff Dam), South Santiam (upstream barrier - Green Peter Dam), Middle Willamette, Yamhill, Molalla-Pudding, and Tualatin. The areas below Willamette Falls and downstream in the Columbia River are considered migration corridors.

Areas within the habitat residency include Clark, Columbia, Cowlitz, Wahkiakum, and Pacific counties in Washington; and Multnomah, Columbia, and Clatsop, and most of Benton, Linn, Polk, Clackamas, Marion, Yamhill, and Washington counties, and small parts of Lincoln and Tillamook counties. However, the latter two counties are small portions in mountainous forested areas where malathion would not likely be used, and these counties are excluded from the analysis.

According to the Agricultural census data (Attachment G-26), there are 10,378,735 acres of land in the entire ESU. There was 90,142 acres grown that could have been treated with 267,040 lbs of malathion in this ESU (0.8 % potentially treated acres in the ESU). Marion (16,398 acres; 2.1% potentially treated acres) and Washington (10,634 acres; 2.3% potentially treated acres) Counties had the highest acres and pounds of estimated malathion usage at 58,586 lbs and 46,342 lbs, respectively. The major crops grown were barley (19,902 acres), alfalfa (13,743 acres), raspberries (5,449), and strawberries (4,418 acres) that could have been treated with 30,649 lbs, 33,808 lbs, 24,521 lbs, and 44,180 lbs of malathion, respectively.

The WSDA data states that Cowlitz County had the most acres of red raspberries (600 acres) grown in this ESU. They reported that 1 lbs of malathion could be applied per acre for this crop, which would amount to 600 lbs applied. Clark County had the most strawberry acres (320 acres), which could amount to 640 lbs being applied (2 lb/acre application rate).

Malathion is persistent in the environment with a half-life of up to 11 days. This combined with an application interval range of 0-10 days could potentially lead to malathion continually being in the environment. During this potentially continuous influx, malathion would degrade into malaoxon which is more toxic than the parent.

NAWQA surface water monitoring resulted in 119 detections in 1098 samples taken (10.8% detection) in Washington, 21 detections in 456 samples taken (4.6% detections) in Oregon, and five detections in 369 samples taken (1.4% detections) taken in Idaho. The maximum residue values were 0.235 ppb, 0.237 ppb, and 0.02 ppb for Washington, Oregon, and Idaho, respectively. No values exceeded the 1 ppb concern for fish, which is derived from the acute toxicity of bluegill sunfish (LC50 = 20 ppb) and the level of concern (0.05) for endangered species (20 ppb X 0.05 = 1 ppb). However, these data are not sampled directly next to agricultural or residential settings and may be less than expected in such areas.

Based on the high potential agricultural but presently low actual use and the characteristics of malathion discussed above, we conclude that agricultural use of malathion may affect, but is not likely to adversely affect the Upper Willamette River steelhead ESU. We also cannot discount the concern from residential use for this ESU. Therefore, it is possible that residential use of malathion may affect this ESU.

Recommendations

The areas of concern for malathion are both in the Pacific northwest and California. The concerns are sufficient to trigger the need for formal or informal consultation for many ESUs. There may be significant effects on individuals and populations due to the very high toxicity of malathion. We recommend that OPP develop county bulletins for use in the Pacific northwest states and that means of protection be developed in conjunction with these states. It has been OPP policy to work with states, even those without specific programs, to develop implementation methods that have a high potential to be effective within each state.

Table 43. Summary conclusions on specific ESUs of salmon and steelhead for malathion.

Species	**ESU**	**Attachment - Table**	**Conclusion**	
			Agricultural Use	**Residential Use**
Chinook Salmon	California Coastal	F-1	no effect	no effect
Chinook Salmon	Central Valley spring-run	F-2	may affect	may affect[1]
Chinook Salmon	Lower Columbia	G-3	may affect	may affect
Chinook Salmon	Puget Sound	G-4	may affect	may affect
Chinook Salmon	Sacramento River winter-run	F-5	may affect	may affect[1,2]
Chinook Salmon	Snake River fall-run	G-6	may affect	may affect
Chinook Salmon	Snake River spring/summer-run	G-7	may affect	may affect
Chinook Salmon	Upper Columbia	G-8	may affect	may affect
Chinook Salmon	Upper Willamette	G-9	may affect, but is not likely to adversely affect	may affect
Chum salmon	Columbia River	G-10	may affect, but is not likely to adversely affect	may affect
Chum salmon	Hood Canal summer-run	G-11	may affect, but is not likely to adversely affect	may affect
Coho salmon	Central California	F-12	may affect	may affect
Coho salmon	Oregon Coast	G-13	may affect	may affect

Coho salmon	Southern Oregon/Northern California Coast	G-14 F-14	may affect	may affect
Sockeye salmon	Ozette Lake	G-15	may affect	may affect
Sockeye salmon	Snake River	G-16	may affect	may affect
Steelhead	Central California Coast	F-17	may affect, but is not likely to adversely affect	may affect
Steelhead	Central Valley, California	F-18	may affect	may affect[1,2]
Steelhead	Lower Columbia River	G-19	may affect, but is not likely to adversely affect	may affect
Steelhead	Middle Columbia River	G-20	may affect	may affect
Steelhead	Northern California	F-21	no effect	no effect
Steelhead	Snake River Basin	G-22	may affect	may affect
Steelhead	South-Central California	F-23	may affect	may affect
Steelhead	Southern California	F-24	may affect	may affect
Steelhead	Upper Columbia River	G-25	may affect	may affect
Steelhead	Upper Willamette River	G-26	may affect, but is not likely to adversely affect	may affect

[1] This determination also applies to public health uses
[2] This determination also applies to structural pest control uses

5. References

Arizona Desert Gardening Guide: Contol of Garden Vegetable Pests. 29 May 2004. <http://myweb.cableone.net/tfcox/pests.htm>.

Beyers DW, Keefe TJ, Carlson CA. 1994. Toxicity of carbaryl and malathion to two federally endangered fishes, as estimated by regression and ANOVA. Environ. Toxicol. Chem. 13:101- 107.

California Department of Health Services, Vector-Borne Disease Section. 2002. Mosquito Control in California. <http://www.cityoftemecula.org/safety/home/mosquito.pdf>.

California Department of Pesticide Regulation. 2004. Pesticide Use Reporting (PUR). <http://www.cdpr.ca.gov/docs/pur/purmain.htm>.

California Department of Pesticide Regulation. 2004. Reports of Pesticides Sold in California. <http://www.cdpr.ca.gov/docs/mlassess/nopdsold.htm>.

California Department of Pesticide Regulation. 2004. Surface Water Database: Complete Chemical Analysis Results. <http://www.cdpr.ca.gov/docs/sw/surfcont.htm>.

California Department of Pesticide Regulation. 2004. U.S. EPA Interim Measures Bulletins. <http://www.cdpr.ca.gov/docs/es/intmenu.htm>.

Corbin, M. 2004. Personal communication, Mark Corbin, U.S. EPA, Environmental Fate and Effects Division, Washington, DC.

Dwyer FJ, Hardesty DK, Henke CE, Ingersoll CG, Whites GW, Mount DR, Bridges CM. 1999. Assessing contaminant sensitivity of endangered and threatened species: Toxicant classes. U.S. Environmental Protection Agency Report No. EPA/600/R-99/098, Washington, DC. 15 p.

Effland WR, Thurman NC, Kennedy I. 1999. Proposed Methods For Determining Watershed-Derived Percent Cropped Areas and Considerations for Applying Crop Area Adjustments To Surface Water Screening Models. USEPA Office of Pesticide Programs. Presentation to FIFRA Science Advisory Panel, May 27, 1999.

Hasler AD, Scholz AT. 1983. Olfactory Imprinting and Homing in Salmon. New York: Springer-Verlag. 134p.

Idaho Department of Health and Welfare. 2003. Arbovirus Surveillance and Mosquito Control in Idaho: Guidance for Counties. <http://www.healthandwelfare.idaho.gov/_Rainbow/Documents/health/overallplan%5B1%5D.pdf >.

Idaho Department of Health and Welfare. 2004. West Nile Virus Reports by County, Contact Numbers. <http://www.healthandwelfare.idaho.gov/DesktopModules/Articles/ArticlesView.aspx?TabID=0&Alias=Rainbow&Lang=en-US&ItemID=1256&mid=10941>.

Johnson WW and Finley MT. 1980. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. USFWS Publication No. 137.

Lenova IN and Slynko NM. 2004. Life stage variations in insecticidal susceptibility and detoxification capacity of the beet webworm, *Pyrausta sticticalis* L. (Lep., Pyralidae). Journal of Applied Entomology 128 (6): 419-425.

Losada EO, Lazcano ZB, Coto MMR, and Pantoja CD. 1991. Variability and resistance to organophosphorous and carbamate insecticides and its relationship to the activity of esterase enzymes in Culex quinquefaciatus Say 1823 (Diptera: Culicidae). Revista. Cubana de Medicina Tropical 43 (3): 171-174, cited in Elham MS, Mohamed SH, and El-Hosary SM. 2002. Synergism and antagonism of Baygon with some additives against Baygon-resistant strain of *Culex pipiens* larvae. Egyptian Journal of Biology 4: 127-132.

Mayer FLJ. and Ellersieck MR. 1986. Manual of acute toxicity: interpretation and data base for 410 chemicals and 66 species of freshwater animals. Resource Publ. No. 160, U. S. Dept. Interior, Fish and Wildlife Service, Washington, DC. 505 pp.

Moore A., Waring C.P. 1996. Sublethal effects of the pesticide diazinon on the olfactory function in mature male Atlantic salmon parr. J. Fish Biol. 48:758-775.

National Center for Food and Agricultural Policy. 1997. National Pesticide Use Database. <http://www.ncfap.org/database/default.htm>.

Oregon Department of Human Services. 2003. Mosquito Control Chemical Guide: 2003 West Nile Virus Response Plan. <http://www.dhs.state.or.us/publichealth/acd/wnile/wnvrevue.pdf>.

Oregon Department of Human Services. 2004. West Nile Virus Oregon Map 2004. <http://www.dhs.state.or.us/publichealth/acd/wnile/countymap.pdf>.

Sappington LC, Mayer FL, Dwyer FJ, Buckler DR, Jones JR, Ellersieck MR. 2001. Contaminant sensitivity of threatened and endangered fishes compared to standard species. Environ. Toxicol. Chem. 20:2869-2876.

Scholz N.T., Truelove N.K., French B.L., Berejikian B.A., Quinn T.P., Casillas E., Collier T.K. 2000. Diazinon disrupts antipredator and homing behaviors in chinook salmon (*Oncorhynchus tshawytscha*). Can. J. Fish. Aquat. Sci., 57:1911-1918.

Takahashi H, Miyaoka T, Tsuda S, and Shirasu Y. 1983. Combined toxicity of malathion and carbamate insecticides in mice and rats. J. Pesticide Sci. 8: 41-45.

TDK Environmental. 2001. Diazinon & Chlorpyrifos Products: Screening for Water Quality. Contract Report prepared for California Department of Pesticide Regulation. San Mateo, California.

Tucker RK, Leitzke JS. 1979. Comparative toxicology of insecticides for wildlife and fish. Pharmacol. The. 6:167-200.

University of California-Davis, Oregon State University, Michigan State University, Cornell University, and the University of Idaho. 1997. Ecotox Net: The Extension Toxicology Network <http://extoxnet.orst.edu/>.

Urban DJ, Cook NJ. 1986. Hazard Evaluation Division - Standard Evaluation Procedure - Ecological Risk Assessment. U.S. EPA Publication 540/9-86-001.

U.S. Department of Agriculture. 1997. Census of Agriculture. USDA National Agricultural Statistics Service. <http://www.nass.usda.gov/census/>

U.S. EPA. 1986. Quality Criteria for Water 1986. Office of Water, U.S. Environmental Protection Agency, Publication EPA 440/5-86-001, May 1986.

U.S. EPA. 2000. Malathion Reregistration Eligibility Document Environmental Fate and Effects Chapter. Office of Pesticides Program, <http://www.epa.gov/oppsrrd1/op/malathion/efedrra.pdf.>.

U.S. EPA. 2000. Overview of Malathion Risk Assessment. Prevention, Pesticides, and Toxic Substances, U.S. Environmental Proection Agency. <http://www.epa.gov/pesticides/op/malathion/overview.htm>.

U.S. EPA. 2000. Quantitative Usage Analysis. Biological and Economic Analysis Division, Prevention, Pesticides, and Toxic Substances, U.S. Environmental Protection Agency.

U.S. EPA. 2004. 2004 Edition of the Drinking Water Standards and Health Advisories. Office of Water, U.S. Environmental Protection Agency, Publication EPA 822-R-04-005, Winter 2004.

U.S. EPA. 2004. Ecotox Database. <http://www.epa.gov/ecotox/>.

U.S. Geological Survey. 1997. Pesticide National Synthesis Project: Malathion-Insecticides Estimated Annual Agricultural Use. <http://ca.water.usgs.gov/cgi-bin/pnsp/pesticide_use_maps_1997.pl?map=W6033>.

U.S. Geological Survey. 2004. National Water Quality Assessment Data Warehouse. <http://infotrek.er.usgs.gov/servlet/page?_pageid=543&_dad=portal30&_schema=PORTAL30>.

U.S. Geological Survey. 2004. West Nile Virus Maps: Mosquito. <http://westnilemaps.usgs.gov/us_mosquito.html>.

Washington State Department of Agriculture. 2004. Washington State: Malathion Use Summary. Unpublished report developed by the Washington State Department of Agriculture. 53p.

Washington State Department of Ecology. 2002. Focus on Mosquitos: General Permit for Insecticides Advocates Larvae Control to Halt Spread of West Nile Virus. WSDE Publication Number 02-10-057, October 2002.

Zucker E. 1985. Hazard Evaluation Division - Standard Evaluation Procedure – Acute Test for Freshwater Fish. U.S. EPA Publication 540/9-85-006.