2,4-Dichlorophenoxyacetic Acid
Analysis of Risks
to
Endangered and Threatened Salmon and Steelhead

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Summary

2,4-D is a widely used herbicide applied to many crop sites and non-crop sites in the Pacific Northwest. Acid and amine salt forms of 2,4-D are "practically non-toxic" to “slightly toxic,” while ester forms of 2,4-D are “slightly toxic” to “highly toxic” to fish. Some forms of 2,4-D may lead to adverse acute and chronic effects. Some esters are “moderately toxic” to freshwater invertebrates, which may be sources of food for salmonids. All forms of 2,4-D that were tested had relatively high toxicity to vascular plants, which could lead to loss of cover for salmonid adults and young.

Terrestrial uses of 2,4-D in the Pacific Northwest pose no direct or indirect risk to fish. 2,4-D acid and amine salts pose an indirect risk to fish when used on rice crops and for aquatic weed control. 2,4-D esters pose acute and chronic risk directly and indirectly when used for aquatic weed control.

This endangered species risk assessment is developed for Federally listed Pacific salmon and steelhead. 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 are applied to determine the potential risks to the 26 listed threatened and endangered Evolutionarily Significant Units (ESUs) of Pacific salmon and steelhead. We determined that use on terrestrial crops of 2,4-D will cause no effect to any ESUs when used according to labeled application directions. When used on rice, 2,4-D may affect but is not likely to adversely affect 4 ESUs, but will have no effect on 22 ESUs. Aquatic weed control usage information for 2,4-D is too deficient to perform an analysis for each ESU. However, we determined that any use of 2,4-D on aquatic weeds may affect threatened and endangered salmon and steelhead of all 26 ESUs.

Introduction

This analysis was prepared by the US Environmental Protection Agency (EPA) Office of Pesticides Programs (OPP) to evaluate the risks of 2,4-D to threatened and endangered Pacific salmon and steelhead.

Problem Formulation: The purpose of this analysis is to determine whether the registration of 2,4-D as an herbicide for use on various treatment sites may affect threatened and endangered (T&E or listed) Pacific anadromous salmon and steelhead and their designated critical habitat.

Scope: Although this analysis is specific to listed Pacific anadromous salmon and steelhead and the watersheds in which they occur, it is acknowledged that 2,4-D 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. We understand that any subsequent analyses, requests for consultation and resulting Biological Opinions may necessitate that Biological Opinions relative to this request be revisited, and could be modified.

Contents

Section **Page**
1. Background 7
2. Description and use of 2,4-D 16
   a. Chemical overview 16
   b. Registered uses 17
   c. Application rates and methods 18
   d. 2,4-D usage 25
3. General aquatic risk assessment for endangered and threatened salmon and steelhead 34
   a. Aquatic toxicity of 2,4-D 34
   b. Environmental fate and transport 48
   c. Incidents 52
   d. Estimated and actual concentrations of 2,4-D in water 53
   e. Water quality criteria 61
   f. Recent changes in 2,4-D registrations 61
   g. Existing protections 61
   h. Discussion and general risk conclusions for 2,4-D 63
4. Description of Pacific salmon and steelhead Evolutionarily Significant Units relative to 2,4-D use sites 69
5. Specific conclusions for Pacific salmon and steelhead ESUs 98
6. References 100

Attachments

A. Quantitative Usage Analysis for 2,4-D
B. EFED Risk Assessment for the RED for 2,4-D (draft EFED chapter)
C. 2,4-D Master Label
D. Washington State Use Summary
E. EFED Tier II Aquatic Exposure Assessment
F. Representative Labels

Tables

Table Number	Table Title	Page Number
1	Qualitative descriptors for categories of fish and aquatic invertebrate toxicity	8
2	Risk-quotient criteria for fish and aquatic invertebrates	14
3	Labeled crops and application methods/equipment for 2,4-D	19
4	Labeled crops and maximum application rates for 2,4-D	20

Table Number	**Table Title**	**Page Number**
5	Nationwide 2,4-D usage from most of 1992 through 2000.	25
6	Reported usage of 2,4-D in California, 1993-2000 (Total acres)	28
7	Reported usage of 2,4-D in California 1993-2002 (Total pounds of active ingredient)	28
8	Usage of 2,4-D by crop or site in California in 2001	28
9	Major usage of 2,4-D in Washington	32
10	Acute toxicity of 2,4-D TGAI to freshwater fish	34
11	Acute toxicity of 2,4-D formulated products to freshwater fish	35
12	Freshwater fish early life-stage and life-cycle toxicity under flow through conditions using TGAI	36
13	Acute toxicity of 2,4-D TGAI and formulated products to non-target invertebrates	37
14	Chronic toxicity of 2,4-D TGAI to freshwater invertebrates	38
15	Toxicity of 2,4-D TGAI and formulated products to nontarget aquatic plants	38
16	Acute toxicity of 2,4-D TGAI and formulated products to estuarine and marine fish	39
17	Chronic toxicity of 2,4-D TGAI to estuarine and marine fish	40
18	Acute toxicity of 2,4-D to estuarine and marine invertebrates	41
19	Acute toxicity of 2,4-D TGAI to freshwater fish	42
20	Acute toxicity of 2,4-D formulated products to freshwater fish	42
21	Chronic toxicity of 2,4-D TGAI to freshwater fish	43
22	Acute toxicity of 2,4-D TGAI and formulated products to non-target invertebrates	43
23	Chronic toxicity of 2,4-D acid formulated products to freshwater invertebrates	44
24	Acute toxicity of 2,4-D formulated products to estuarine and marine fish	44

Table Number	Table Title	Page Number
25	Acute toxicity of formulated products containing 2,4-D and other active ingredients to freshwater and marine fish (Toxdata)	45
26	Acute toxicity of formulated products containing 2,4-D and other active ingredients to freshwater and marine fish (AQUIRE)	45
27	Acute toxicity of formulated products containing 2,4-D and other active ingredients to freshwater and marine invertebrates	46
28	Toxicity of formulated products containing 2,4-D and other active ingredients to freshwater and marine plants	47
29	Half-lives of various 2,4-D chemical moieties under three metabolic conditions	50
30	1 in 10 year estimated environmental concentrations of 2,4-D in the Pacific Northwest	54
31	Pesticide residues of 2,4-D reported in surface water (SW) and groundwater (GW) in NAWQA summary publications for HSUs contained within Washington, Oregon, Idaho, and California	57
32	California DPR database pesticide residue concentrations for surface waters (1990-2003)	58
33	Aquatic organism risk quotient calculations for 2,4-D acid and amine salts	64
34	Aquatic organism risk quotient calculations for 2,4-D rice applications and aquatic weed control	68
35	Usage of 2,4-D on rice in counties located within the California Coastal Chinook Salmon ESU	71
36	Usage of 2,4-D on rice in counties located within the Central Valley Spring-Run Chinook Salmon ESU	72
37	Usage of 2,4-D on rice in counties located within the Sacramento River Winter-Run Chinook ESU	75
38	Usage of 2,4-D on rice in counties located within the Sacramento River Winter-Run Chinook ESU	89
39	Summary conclusions on specific ESUs of salmon and steelhead for 2,4-D use on rice	99

Figures

Figure Number	Figure Title	Page Number
1	Estimated annual agricultural 2,4-D usage	18

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 0.5-5.0 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 (LC50) or immobility in aquatic invertebrates (EC50). Typically, a standard fish acute test will include concentrations that cause no mortality, 100% mortality, and no observable sublethal effects. By looking at the effects per each test concentration, a dose-response curve can be derived to help 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 effect of a modern pesticide (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 LC50 or EC50 for pesticides that are practically non-toxic; the LC50 or EC50 would simply be expressed as >100 ppm. When no lethal or sublethal effects are observed at 100 ppm, OPP considers the pesticide to have “no effect” on a species.

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

LC50 or EC50	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. 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 as sensitive as their non-endangered counterparts to a variety of pesticides and other chemicals, on an acute basis.

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 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, we can find no product 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. We 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. We consider this approach to be 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. We do note, however, that 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 US. 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 have used the older approach. However, it is 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 the 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.

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 risks 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 expect that in some areas few homeowners will use pesticides, whereas many will in other areas. As a result, OPP has insufficient information to develop a scenario or address the extent of pesticide use in residential areas. It is also important to note that pesticides used in urban areas can be expected to transport considerable distances if they should run off onto concrete or asphalt, such as with streets (e.g., TDK Environmental, 1991). This makes quantitative analyses that address aquatic exposure from home use, very difficult. 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 particularly 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, first order streams may be upstream from pesticide use, but in other areas, or for some non-agricultural uses such as forestry, first order streams may receive pesticide runoff and drift. Larger streams and lakes will very likely have lower, often considerably lower, concentrations of pesticides due to dilution by 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 not often 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, routinely assessed indirect concerns entail food and cover.

The primary indirect effect of concern is the listed fish’s food source. These are best represented by potential effects on aquatic invertebrates, although aquatic plants or plankton may be relevant food sources for some fish species as well. 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 from pesticide effects.

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 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 herbicide will degrade through photolysis, hydrolysis, or other processes. In addition, terrestrial herbicide applications are efficacious in part, due to the fact that the product will tend to stay in contact with the foliage or the roots and/or germinating plant parts, when soil applied. 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 their populations that serve as cover for T&E fish might be affected.

For most pesticides applied to terrestrial environments, the effects in water, even lentic water, are 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 indirect effects on fish, we consider what effect pesticide use on land has on the critical habitat of aquatic species, in some 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 pose a problem for listed salmonids, the primary concern would be 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 EECs. Such modeling can and does take into account the presence and nature of riparian vegetation as it effects pesticide transport to a water body.

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 the criteria of concern presented in Table 2 by Urban and Cook (1986).

Table 2. Risk-quotient criteria for fish and aquatic invertebrates (Urban and Cook, 1986).

Test data	Risk quotient	Presumption
Acute LC50	>0.5	Potentially high acute risk
Acute LC50	>0.1	Risk that may be mitigated through restricted use classification
Acute LC50	>0.05	Endangered species may be affected acutely, including sublethal effects
Chronic NOEC	>1	Chronic risk; endangered species may be affected chronically, including effects on reproduction and progeny
Acute invertebrate LC50	>0.5	May be indirect effects on threatened and endangered fish through food supply reduction
Aquatic plant acute EC50	>1.0	May be indirect effects on aquatic vegetative cover for threatened and endangered fish

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 the result), that the probability of mortality occurring when the LC50 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, non-target organisms will rarely be exposed to such concentrations over a period of time, especially fish living 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 toward 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 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.

In recent years, Moore and Waring (1996) exposed Atlantic salmon to diazinon, observing 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. 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 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 sublethal effects until there are additional data.

2. Description and use of 2,4-D

a. Chemical Overview

Common name: 2,4-D
Chemical name: 2,4-Dichlorophenoxyacetic acid
Molecular formula: $C_8H_6Cl_2O_3$
CAS Number: 94-75-7
Molecular weight: 221.04
Physical state: White crystalline solid
Melting point: 138 - 141 ^{o}C
Vapor pressure: 1.47 x 10^{-7} mm Hg at 25 ^{0}C
Henry's Law: 4.74 x 10^{-10} atm-m3/mol at 25C
Solubility: 569 mg/L at 20^{o}C
Log K_{ow}: 2.81
Chemical forms:

- 2,4-Dichlorophenoxyacetic acid (2,4-D acid)
- Sodium salt of 2,4-D (equivalent to 2,4-D acid)
- Dimethylamine salt of 2,4-D (2,4-D DMA)
- Diethanolamine salt of 2,4-D (2,4-D DEA)
- Isopropylamine salt of 2,4-D (2,4-D IPA)
- Triisopropanolamine salt of 2,4-D (2,4-D TIPA)
- Butoxyethyl ester of 2,4-D (2,4-D BEE)
- Isopropyl ester of 2,4-D (2,4-D IPE)
- 2-Ethylhexyl ester of 2,4-D (2,4-D EHE)
- Other isooctyl esters (2-octyl ester and 2-ethyl-4-methylpentyl ester) of 2,4-D (2,4-D EHE)

Trade and Other Names: "Agent White", Bladex-B, Brush Killer 64, Dicofur, Dormon , Ipaner, Moxon, Netagrone, Pielik, Verton 38, Mota Maskros, Silvaprop 1, Agricorn D, Acme LV4, Croprider, Fernesta, Lawn-Keep, Pennamine D, Plantgard, Tributon, Weed-B-Gon, Weedatul, Agroxone, Weedar, Salvo, Green Cross Weed-No-More 80, Red Devil Dry Weed Killer, Scott's 4XD, Weed-Rhap LV40, Weedone 100, and 2,4-Dichloro-phenoxyacetic acid.
Basic Manufacturers: Dow AgroSciences, Nufarm Ltd., and Agro-Gor.

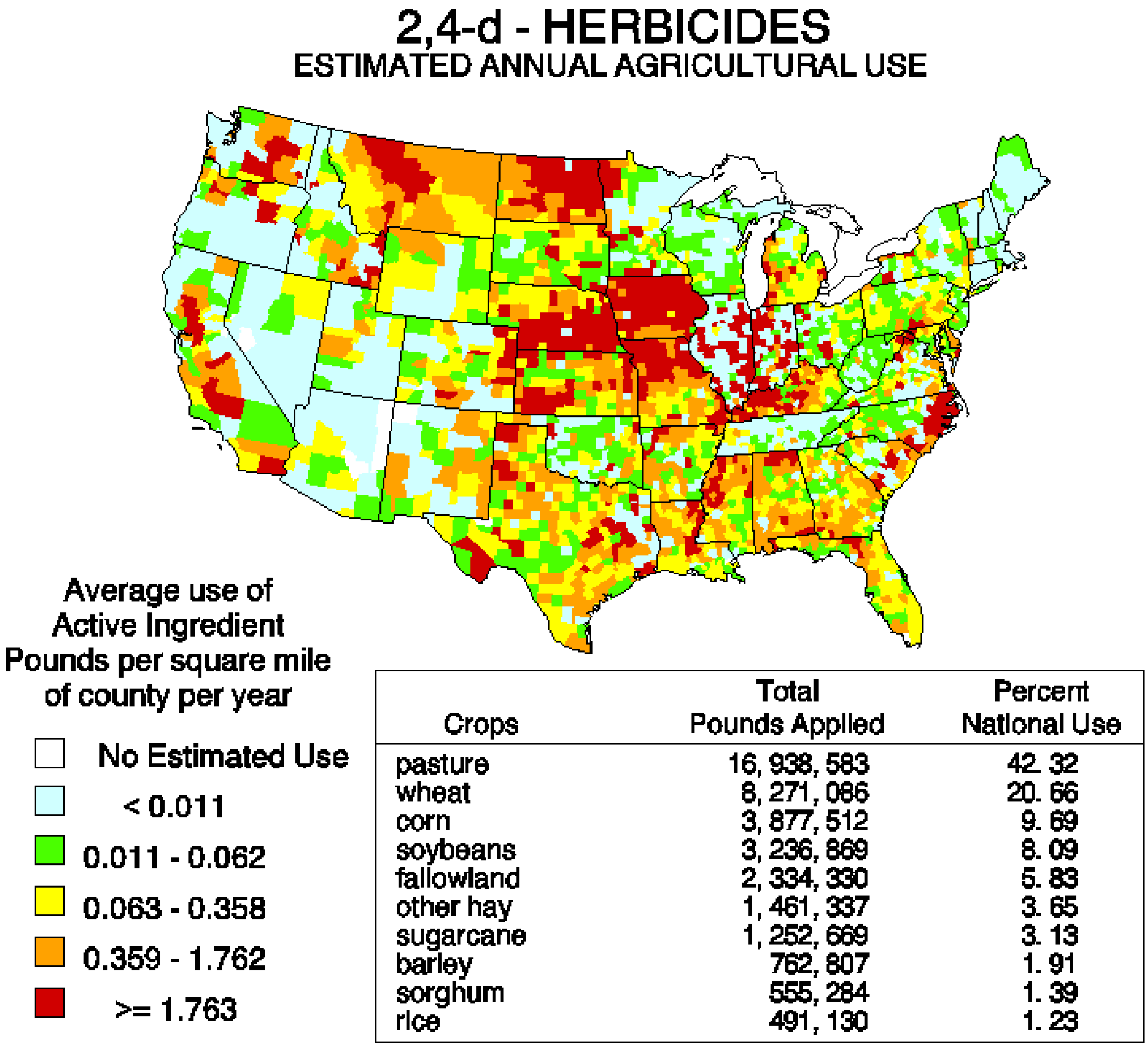
The term "2,4-D" as used in this risk assessment refers to 2,4-D acid and to the other chemical forms of 2,4-D as well, unless otherwise specified. We are considering all chemical forms of 2,4-D in this assessment because acceptable bridging data exist indicating that all currently used 2,4-D chemicals degrade rapidly into 2,4-D acid under most environmental conditions, as discussed below under "Environmental fate and transport." This commonality allows us to access each 2,4-D chemical form separately, in groups of salts and esters, or all together as "2,4-D" in general, as environmental conditions warrant.

b. Registered Uses

2,4-D, introduced in the 1940's, is one of the most widely used herbicides in the world. It is currently under review for Registration Eligibility Decision (RED). According to the OPP's Qualitative Use Analysis (QUA) for 2,4-D from 2001 (Attachment A), 2,4-D is applied in a variety of sites. Representative uses include alfalfa, barley, beans, canola, cotton, corn, fallow ground, hay, millet, oats, pasture and rangeland, peanuts, potatoes, rice, wild rice, rye, turf, seed crops, sorghum, soybeans, sugarcane, sunflowers, wheat, almonds, apples, apricots, asparagus, blueberries, cherries, cranberries, filberts, grapefruit, grapes, lemons, nectarines, oranges, peaches, pears, pecans, pistachios, prunes and plums, strawberries, sweet corn, walnuts, and various non-crop uses, such as aquatic site, ditch bank, right-of-way, homeowner, and forestry uses.

The following USGS Pesticide National Synthesis Project (PNSP) map (Figure 1) displays the extent to which 2,4-D is used for agriculture across the country based on state-level estimates compiled by the National Center for Food and Agricultural Policy (NCFAP) for 1995 to 1998 and on 1997 Census of Agriculture county-level data (US Geological Survey, 2003). Heavy usage occurs in each state of the Pacific Northwest and California.

Figure 1. Estimated annual agricultural 2,4-D usage (US Geological Survey, 2003).



Crops	Total Pounds Applied	Percent National Use
pasture	16,938,583	42.32
wheat	8,271,086	20.66
corn	3,877,512	9.69
soybeans	3,236,869	8.09
fallowland	2,334,330	5.83
other hay	1,461,337	3.65
sugarcane	1,252,669	3.13
barley	762,807	1.91
sorghum	555,284	1.39
rice	491,130	1.23

c. Application rates and methods

2,4-D is a plant growth regulator thought to increase cell-wall plasticity, protein biosynthesis, and ethylene production, as discussed in the draft EFED chapter (Attachment B), page 8. The increase in these processes due to 2,4-D is thought to result in uncontrolled cell division and growth, which damages vascular tissue. Target organisms include a wide variety of broadleaf weeds and aquatic weeds.

Registered formulation types of 2,4-D include emulsifiable concentrate, granular, soluble concentrate/solid, water dispersible granular (dry flowable), and wettable powder. 2,4-D can be applied with a broad range of application equipment including fixed wing aircraft, helicopter, backpack sprayer, band sprayer, boom sprayer, hooded boom sprayer, granule applicator, handheld sprayer, injection equipment, wick, dip, tractor-mounted granule applicator, and tractor-mounted sprayers. 2,4-D application methods may include band treatment, basal spray treatment, broadcast, frill treatment, girdle treatment, aerial spray, ground spray, soil band treatment, soil broadcast treatment, spot treatment, cut stump treatment, tree injection treatment, ground wipe, dip, and boat spray. Table 3 displays the application method and equipment used per crop as directed by the master label (Attachment C).

Table 3. Labeled crops and application methods/equipment for 2,4-D (Master Label).

Crop	Application method	Application equipment
Cereal grains, soybeans, fallowland, crop stubble, potatoes, asparagus, strawberries	Aerial spray, ground spray, broadcast	Aircraft: Fixed wing, helicopter Ground: Boom sprayer
Field corn, popcorn, sweet corn, sorghum	Aerial spray, ground spray, broadcast, directed band	Aircraft: Fixed wing, helicopter Ground: Boom/directed sprayer or granule spreader
Established grass pastures, rangeland, grasslands, rice, wild rice	Aerial spray, ground spray, broadcast, spot	Aircraft: Fixed wing, helicopter Ground: Boom sprayer, spot, hand-held nozzle sprayer
Sugarcane	Aerial spray, ground spray, broadcast, band	Aircraft: Fixed wing, helicopter Ground: Boom/directed sprayer
Pome fruits, stone fruits, nut orchards, pistachios, filberts	Broadcast, ground spray, spot treatment	Ground: Boom sprayer, hand-held nozzle sprayer
Ornamental turf, grass	Broadcast, ground spray, spot treatment	Ground: Boom sprayer, spreader, hand-held nozzle sprayer, backpack/knapsack sprayer
Non-cropland	Aerial spray, ground spray, broadcast, spot	Aircraft: Fixed wing, helicopter Ground: Boom sprayer, spreader, hand-held nozzle sprayer, backpack/knapsack sprayer
Forestry	Aerial spray, ground spray, broadcast, spot, basal, frill, cut stump, injection	Aircraft: Fixed wing, helicopter Ground: Boom sprayer, hand-held nozzle sprayer, backpack/knapsack sprayer, tree injector

Crop	Application method	Application equipment
Aquatic weed control	Aerial spray, boat spray, broadcast, spot	Aircraft: Fixed wing, helicopter Ground: Boom sprayer, hand-held nozzle sprayer, backpack/ knapsack sprayer
Blueberries	Directed, ground wipe, spot	Wick, directed boom sprayer, hand-held nozzle sprayer, backpack/knapsack sprayer
Grapes	Ground directed	Hooded boom sprayer or equivalent
Cranberries	Ground wipe, spot	Wick, hand-held nozzle sprayer, backpack/knapsack sprayer
Citrus	Aerial spray, ground spray, broadcast, directed	Aircraft: Fixed wing, helicopter Ground: Sprayer
Citrus (lemons, postharvest)	Lemon dip, spray	Dip or sprayer

2,4-D application timing may include many crop stages, such as emergence, before bud break, dormant, dough, established planting, foliar, post-emergence, pre-emergence, pre-harvest, and pre-plant. Table 4 presents the maximum 2,4-D application rates, application intervals, and the maximum amounts to apply per season, as indicated on the master label (Attachment C). All crops have maximum seasonal application amounts indicated, except for aquatic weeds undergoing surface applications, low bush blueberries, and citrus. Low bush blueberries undergo spot treatments, which makes a seasonal application limit unnecessary. In contrast, aquatic weeds and citrus have some of the highest outdoor maximum application treatment rates (10.8 lb ae/acre foot and 200 ppm, respectively) as well as no seasonal application limits.

Table 4. Labeled crops and maximum application rates for 2,4-D (Master Label).

Crop	Crop stage/ treatment type	Maximum rate per application (lb ae/A)[1]	Application interval (days)	Maximum amount per season (lb ae/A)[1]
Cereal grains (wheat, barley, millet, oats, and rye)	Postemergence	1.25	N/A	1.75
	Preharvest	0.5		

Crop	**Crop stage/ treatment type**	**Maximum rate per application (lb ae/A)[1]**	**Application interval (days)**	**Maximum amount per season (lb ae/A)[1]**
Field corn and popcorn	Preplant or preemergence	1.0	N/A	3.0
	Postemergence	0.5	N/A	
	Preharvest	1.5	N/A	
Sweet corn	Preplant or preemergence	1.0	N/A	1.5
	Postemergence	0.5	21	
Established grass pastures, rangeland, and perennial grasslands not in ag. production	Postemergence	2.0	30	4.0
Grain or forage sorghum	Postemergence	1.0 for acid, amines, salts	N/A	1.0 for acid, amines, salts
		0.5 for esters		0.5 for esters
Soybeans	Preplant	0.5-1.0	N/A	1.0
Sugarcane (Acid, amines, salts only)	Preemergence or Postemergence	2.0	N/A	4.0
Rice (Acid, amines, salts only)	Preplant	1.0	N/A	1.5
	Postemergence	1.5		
Wild rice (In MN only) (Acid, amines, salts only)	Postemergence	0.25	N/A	0.25
Pome fruits (Acid, amines, salts only)	Postemergence	2.0	75	4.0

Crop	**Crop stage/ treatment type**	**Maximum rate per application (lb ae/A)[1]**	**Application interval (days)**	**Maximum amount per season (lb ae/A)[1]**
Stone fruits (Acid, amines, salts only)	Postemergence	2.0	75	4.0
Nut orchards, pistachios (Acid, amines, salts only)	Postemergence	2.0	30	4.0
Filberts (Acid, amines, salts only)	Postemergence	1.0 lb ae/100 gal solution	30	4 app./year
Ornamental turf	Postemergence	2.0	N/A	2 broadcast app./year/site plus spot treatments
Grass grown for seed and sod	Postemergence	2.0	21	4.0
Non-cropland	Postemergence	2.0 (annual and perennial weeds)	30	4.0
		4.0 (woody plants)		
Fallowland and crop stubble	Idle land, postharvest to crops, or between crops	2.0	30	4.0
Forestry	Use on broadleaf weeds, brush	4.0	N/A	4.0 per 12 months for broadcast app.
Tree and brush control	Basal spray	8.0 lb ae/100 gal diluent	N/A	4.0 per 12 months for broadcast app.
	Cut surface, stumps			
	Frill			

Crop	Crop stage/ treatment type	Maximum rate per application (lb ae/A)[1]	Application interval (days)	Maximum amount per season (lb ae/A)[1]
	Injection	2 ml of 4.0 lb ae solution/ injection site		
Aquatic weed control (ditchbank app.) (Acid, amines, salts, BEE only)	Postemergence	2.0	30	4.0 (or 2 app.)
Aquatic weed control (surface app.) (Acid, amines, salts, BEE only)	Use in quiescent sites with emergent weeds	4.0	21	N/A
Aquatic weed control (surface app. or sub-surface injection) (Acid, amines, salts, BEE only)	Use in quiescent sites with emergent weeds	10.8 lb ae/acre foot	N/A	4 ppm
Potatoes (Fresh market only)	Postemergence	0.07 lb ae	10-14	0.14 (or 2 app.)
Asparagus (Acid, amines, salts only)	After cutting	2.0	30	4.0 (or 2 app.)
Strawberries (Outside of CA or FL) (Acid, amines, salts only)	Dormant or after last picking	1.5	N/A	1.5
Low bush blueberries (Acid, amines, salts only)	Postemergence	Wiper solution of 0.0375 lb ae/gal	N/A	N/A
	Postharvest	Solution of 1.0 lb ae/10 gal oil		
High bush blueberries (Acid, amines, salts only)	Postemergence or postharvest	1.4	N/A	2.8

Crop	**Crop stage/ treatment type**	**Maximum rate per application (lb ae/A)[1]**	**Application interval (days)**	**Maximum amount per season (lb ae/A)[1]**
Grapes (In CA only) (Acid, amines, salts only)	After shatter following bloom and before shoots reach the ground, or dormant season	1.36	N/A	1.36
Cranberries	Dormant	4.0 (granular ester only)	N/A	4.0 (1 app.)
	Postemergence	1.2 (acid, amines, salts only)		2.4 (2 app.)
Citrus (IPE only)	Growing Navel oranges, Valencia oranges, and grapefruit - increasing size	0.05-0.10 based on fruit size	N/A	N/A
	Growing Navel oranges, and Valencia oranges - reducing pre-harvest drop	200 ppm for aerial and ground concentrate app.		
Citrus (IPE only)	Fall sprays on lemons, Navel oranges, Valencia oranges, and Tangelos - preventing pre-harvest fruit drop and leaves the next spring	4-24 ppm depending on specific app.	N/A	N/A

Crop	Crop stage/ treatment type	Maximum rate per application (lb ae/A)[1]	Application interval (days)	Maximum amount per season (lb ae/A)[1]
	Postharvest packing house app. to lemons - retaining buttons	500 ppm		

1. "lb ae/A" means "pounds of active equivalent per acre."

d. 2,4-D usage

Based on OPP's QUA for 2,4-D dated August, 2001 (Attachment A), and based on usage information from 1992 through 2000, total annual domestic usage of 2,4-D has been approximately 46,000,000 pounds active ingredient (lb ai). About 30,000,000 lb ai of 2,4-D annual domestic usage was for agriculture. The greatest agricultural annual usage was on pasture and rangeland, over 10,900,000 lb ai. Spring wheat and winter wheat were the next largest annual crop usages, with 3,800,000 and 3,300,000 lb ai, respectively. Agriculture rates per application and annual rates were generally less than 1.50 lb ai/acre and 2.00 lb ai/acre, respectively.

About 16,000,000 lb ai of 2,4-D annual domestic usage was non-agricultural. The largest non-agricultural usage was on "lawn by householder with fertilizer," with 5,500,000 lb ai. Lawn/garden by lawn care operators/landscape maintenance contractors (LCO/LMC) and "lawn by household, alone" were the next largest annual non-agricultural usages, with 3,300,000 and 2,800,000 lb ai, respectively.

Usage data listed by site from OPP's QUA is displayed in Table 5 below. The table indicates that 100% of 2,4-D usage on almonds and lemons occurred in California. 100% of usage on filberts occurred in Oregon. Over 80% of usage on grape, orange, pear, prune or plum, and walnut crops and a sizable amount of usage on potato, seed, asparagus, bean, pea, cherry, cranberry, and grapefruit crops also occurred in the Pacific Northwest. These data may not reflect the most recent usage.

Table 5. Nationwide 2,4-D usage from most of 1992 through 2000. Tabulated values are temporal averages (Appendix A).

Site	**Acres grown**	**Acres treated**	**% crop treated**	**lb ai applied**	**States of most usage (% of total lb ai used on the crop)**
Agriculture, Dry					
Alfalfa	23,704,000	46,000	0.2%	23,000	GA AR TX MT WA ID (56%)
Barley	5,914,000	2,138,000	36%	1,008,000	ND MT -
Beans/Peas, Dry	2,133,000	20,000	1%	12,000	MN WA UT MI ID FL (53%)
Canola/Rapeseed	1,281,000	10,000	1%	6,000	-
Corn, Field	75,241,000	6,413,000	9%	2,938,000	IL IN OH IA MN NE (68%)
Cotton	13,793,000	173,000	1%	117,000	SC TX LA GA (85%)
Fallow, Summer	22,879,000	1,549,000	7%	1,386,000	KS CO ND WA MT SD (83%)
Flax	143,000	6,000	4%	3,000	ND MN (100%)
General Farm Use	-	-	-	1,082,000	-
Hay, Other	33,777,000	1,921,000	6%	1,330,000	TX OK KS -
Millet	318,000	48,000	15%	21,000	SD ND NE (86%)
Oats	4,036,000	611,000	15%	284,000	SD TX -
Pasture/Rangeland	469,536,000	15,024,000	3%	10,914,000	-
Peanuts	1,416,000	25,000	2%	18,000	MS AL GA TX (81%)
Potatoes	1,291,000	9,000	1%	1,000	ND CA FL ID OR MT (82%)
Rice	3,231,000	431,000	13%	404,000	LA AR MS (87%)
Rye	298,000	48,000	16%	24,000	GA SC ND MN NE SD (85%)
Seed Crops	1,383,000	401,000	29%	220,000	OR CA MT MO FL WA (82%)
Sorghum	9,077,000	1,061,000	12%	534,000	KS NE TX OK SD MO (83%)
Soybeans	70,993,000	3,659,000	5%	1,708,000	IL IN IA OH MO NE (80%)
Sugarcane	939,000	340,000	36%	335,000	LA FL (100%)
Sunflowers	2,040,000	27,000	1%	14,000	KS MN SD ND (90%)
Wheat, Spring	18,903,000	9,684,000	51%	3,786,000	ND MT (83%)
Wheat, Winter	42,403,000	6,564,000	15%	3,330,000	KS MT WA CO OK SD (63%)
Wild Rice	26,000	2,000	8%	400	MN (100%)
Woodland	60,478,000	629,000	1%	397,000	OR ND KS MT WA CO (59%)
Agriculture, Produce					

Site	**Acres grown**	**Acres treated**	**% crop treated**	**lb ai applied**	**States of most usage (% of total lb ai used on the crop)**
Almonds	583,000	40,000	7%	51,000	CA (100%)
Apples	477,000	94,000	20%	129,000	WA NY PA MI ME VA (70%)
Apricots	23,000	1,000	5%	2,000	-
Asparagus	77,000	7,000	9%	10,000	MI CA WA (95%)
Beans/Peas, Vegetable	667,000	3,000	0.4%	3,000	WA OR CA NY WI (85%)
Blueberries	62,000	100	0.2%	100	MI OR NJ (100%)
Cherries	105,000	16,000	15%	18,000	OR MI UT WA (87%)
Cranberries	32,000	2,000	6%	4,000	WI WA OR (100%)
Filberts	31,000	15,000	49%	26,000	OR (100%)
Grapefruit	165,000	2,000	1%	600	CA FL (100%)
Grapes	1,006,000	5,000	1%	4,000	CA WA (90%)
Lemons	72,000	400	0.5%	400	CA (100%)
Nectarines	34,000	2,000	6%	1,000	-
Oranges	940,000	21,000	2%	7,000	CA (88%)
Peaches	458,000	12,000	8%	16,000	CA SC PA NJ MI WA (75%)
Pears	70,000	7,000	10%	11,000	CA OR WA (88%)
Pecans	496,000	12,000	3%	12,000	TX GA KS AR (86%)
Pistachios	100,000	3,000	3%	3,000	-
Prunes/Plums	151,000	12,000	8%	13,000	CA (83%)
Strawberries	47,000	2,000	4%	3,000	PA OH NY WI NC MI (67%)
Sweet Corn	678,000	20,000	3%	10,000	MN ID NE WI UT CT (54%)
Walnuts	229,000	14,000	6%	29,000	CA (96%)
Non-agriculture					
Aquatic Areas	-	-	-	512,000	-
Electric Utilities	-	-	-	164,000	-
Forestland	-	-	-	136,000	-
Golf Courses	-	-	-	414,000	-
Horticulture	-	-	-	18,000	-

Site	**Acres grown**	**Acres treated**	**% crop treated**	**lb ai applied**	**States of most usage (% of total lb ai used on the crop)**
Indus Facil./Pipelines	-	-	-	406,000	-
Institutional Turf	-	-	-	654,000	-
Lawn/Garden by LCO/LMC	-	-	-	3,294,000	-
Lawn by Household, Alone	-	-	-	2,757,000	-
Lawn by Household w/ Fert.	-	-	-	5,512,000	-
Railroads	-	-	-	213,000	-
Roadways	-	-	-	1,319,000	-
Turf Farms	-	-	-	351,000	-

The following data tables contain comprehensive 2,4-D usage data for California and Washington. 2,4-D usage data for selected crops in Oregon and Idaho are available from the USDA National Agricultural Statistics Service (NASS), however this information is very limited and not comprehensive (US Department of Agriculture, 2002). NASS reports that approximately 130 lb ai of 2,4-D are applied to wheat in Idaho, while about 240 lb ai of 2,4-D are applied to wheat in Oregon with additional minimal applications to apples, asparagus, cherries, grapes, hazelnuts, pears, and prunes.

The latest information on California pesticide use is 2002 data from the California Environmental Protection Agency’s Department of Pesticide Regulation (CEPA, 2002). The information reported to the County Agricultural Commissioners includes pounds used, acres treated for agricultural and certain other uses, and the specific location treated. The pounds and acres are reported to the state, but the specific location information is retained by the county and is not readily available.

As seen in tables 6 and 7, the overall usage of 2,4-D in California has decreased, although it appears to have risen again in 2002. Trends can be further analyzed once EPA receives more current data. Table 8 is a comprehensive presentation of the usage of 2,4-D in California.

Table 6. Reported usage of 2,4-D in California, 1993-2002 (Total acres) (CEPA, 2002).

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
860,920	949,260	964,000	973,220	890,692	742,026	606,449	690,810	631,882	667,010

Table 7. Reported usage of 2,4-D in California, 1993-2002 (Total pounds of active

ingredient) (CEPA,2002).

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
581,721	655,290	670,454	670,564	608,872	561,008	488,559	483,786	451,770	477,828

Table 8. Usage of 2,4-D by crop or site in California in 2001 (CEPA, 2002).

Crop	Total Pounds of Active Ingredient Used [1]	Number of Applications	Acres Treated
Alfalfa	10,873	262	16,836
Almond	89,331	2641	116,613
Apple	262	21	486
Corn (forage- Fodder)	10,383	306	16,388
Corn (human consumption)	2,139	121	3,801
Cotton	189	2	218
Landscape Maintenance[2]	28,006	-	-
Outdoor Flowers in containers	548	46	388
Outdoor plants in containers	1,200	74	822
Nectarine	3,135	672	3,336
Pear	2,665	160	7,665
Plum	2,330	510	3,146
Walnut	12,044	770	29,138
Barley	27,601	363	31,984
Cherry	1,270	1244	3,251
Forage Hay/Silage	8,161	181	10,088
Grape (human consumption and wine)	11,586	585	29,319
Pastureland	11,918	307	14,015

Crop	**Total Pounds of Active Ingredient Used** [1]	**Number of Applications**	**Acres Treated**
Rangeland	5,963	160	10,331
Rights of Way[2]	38,542	-	-
Uncultivated Ag and Non-Ag	22,525	426	27,962
Wheat	91,993	1825	108,087
Wheat - forage/fodder	6,396	158	8,611
Asparagus	204	1	70
Sorghum/Milo (human consumption and forage/fodder)	2,049	101	4,332
Structural Pest Control[2]	1,815	-	-
Regulatory Pest Control[2]	13,194	-	-
Forest/Timberland	23,225	332	11,988
Peach	5,667	596	9,789
Pistachio	3,942	108	3,484
Prune	5,506	282	12,693
Rice	13,812	373	24,155
Apricot	532	35	1,040
Bermudagrass	13,241	137	11,085
Citrus	147	1	110,197
Clover	467	10	473
Ditch Bank	681	6	237
Grain	301	6	312
Grapefruit	85	11	93
Grass, Seed	102	3	93
Lemon	630	32	180,738

Crop	Total Pounds of Active Ingredient Used [1]	Number of Applications	Acres Treated
Mint	59	1	62
Oat (both for consumption and for forage/fodder)	23,371	575	26,830
Orange	9,427	4,262	108,547
Potato	68	3	102
Research Commodity[2]	42	-	-
Rye	332	10	333
Ryegrass	2,042	48	2,008
Safflower	57	1	101
Soil Fumigation/Preplant	2,543	51	2,639
Sudangrass	536	24	823
Sugarbeet	85	1	150
Sugarcane	3	1	2
Sunflower	79	1	140
Tangelo	269	191	3,803
Tangerine	56	12	104
Turf/Sod	2,948	241	552
Unknown	357	4	320
Vertebrate Control[2]	12	-	-
Christmas Tree[2]	34	-	8
Total	516,980	18,294	959,790

1. California database only reports total number of pounds used. This number should be divided by the application rate to calculate the actual amount used per application.
2. The number of acres treated and/or the number of applications was not reported for these crop usages.

Based on the total number of pounds of active ingredient used and number of acres treated, the primary uses in California include almonds (89,331 lbs ai; 116,614 acres), wheat (91,993 lbs ai; 108,087 acres), landscape maintenance (28,010 lbs ai), rights-of-way (38,542 lbs ai), forest and timberland (23, 225 lbs ai; 11,988 acres), and oats (23,371 lbs ai; 26,830 acres). Information on non-agricultural usages is incomplete because of the difficulty with tracking the number of acres treated.

The Washington State Department of Agriculture (WSDA) Washington State 2,4-D Use Summary (2004) presents acreage and treatment data for the state's major 2,4-D-treated crops. Tabulated usage data by crop is reproduced below in Table 9; additional information follows and is expanded in the full report, included as Attachment D.

Table 9. Major usage of 2,4-D in Washington (WSDA, 2004).

Crop	**Est. Acres Planted**[1]	**Est. % Acres Treated**	**Est. lbs ai/A**	**# App.s**	**Est. Acres Treated**	**Est. lbs ai Applied**
Apples	164,000	20	0.70	1.5	32,800	34,400
Aquatic Weed Control[2]	N/A[3]	N/A	N/A	N/A	N/A	N/A
Asparagus	17,000	10	0.70	1.0	1,700	1,200
Barley	350,000	15	0.40	1.0	52,500	21,000
Blueberries[2]	2,000	< 20	1.43	1.0	400	570
Cherries	25,000	10	0.60	1.5	2,500	2,250
Christmas Trees	23,000	15	0.35	1.0	3,450	1,200
Conservation Reserve Program	N/A	N/A	N/A	N/A	N/A	N/A
Corn, Grain & Silage	130,000	15	0.75	1.0	19,500	14,625
Corn, Sweet	97,900	3	0.50	1.0	2,950	1,470
Cottonwood[2]	40,000	10	0.50	1.0	4,000	2,000
Cranberries[2]	1,700	Minimal[4]	N/A	N/A	Minimal	Minimal
Grapes	49,800	Minimal	N/A	N/A	Minimal	Minimal

Crop	Est. Acres Planted[1]	Est. % Acres Treated	Est. lbs ai/A	# App.s	Est. Acres Treated	Est. lbs ai Applied
Forest[2]	22,000,000	N/A	N/A	N/A	N/A	N/A
Landscape	N/A	N/A	0.17 - 0.33	2	N/A	N/A
Oats	35,000	20	0.50	1.0	7,000	3,500
Peaches & Nectarines	4,200	8	1.00	1.0	336	336
Peas, Dry & Wrinkled Seed[2]	> 70,000	N/A	N/A	N/A	N/A	N/A
Pears	24,800	15	0.80	1.5	3,750	4,500
Rights-of-way[2]	N/A	N/A	N/A	N/A	N/A	N/A
Strawberries	1,800	N/A	N/A	N/A	N/A	N/A
Turf, Golf Course[2]	Minimal	Minimal	N/A	N/A	Minimal	Minimal
Turf, Sod	2,500	80	0.75	2.0	2,000	3,000
Wheat	2,490,000	40	0.50	1.0	996,000	498,000

1. Acre estimates are from 2002 by the Washington Agricultural Statistics Service (WASS).
2. Statistics for these eight crops are peer reviewed.
3. “N/A” indicates that data is insufficient or unreported for this statistic.
4. “Minimal” indicates that usage is minimal for this crop.

Non-crop usages, such as for aquatic weed control, the conservation reserve program, forests, landscapes, and rights-of-way, are not easily quantified or predicted. Therefore, non-crop usages in Table 9 have numerous data gaps. For example, 2,4-D total usage for aquatic weed control is known to include over 2,000 gallons and 13,000 lbs of 2,4-D formulations (State of Washington Department of Agriculture, 2004). However, the 2,4-D-treated area, the total amount of lbs of 2,4-D applied, and the number of 2,4-D applications are unknown for aquatic weed control.

Usage on strawberries and peas generally occurs postharvest or when the crops are dormant, which may explain why the extent of treated area and the amount of 2,4-D applied to these crops is not known. 2,4-D usage on grapes, cranberries, and golf course turf is expected to be minimal.

The largest crops treated with 2,4-D in Washington are wheat (996,000 acres), barley (52,500 acres), apples (32,800 acres), and corn (22,500 acres). These crops also endure the largest applications of 2,4-D in Washington: 498,000 lbs ai on wheat, 21,000 lbs ai on barley, 34,400 lbs ai on apples, and 16,100 lbs ai on corn. The highest rates of 2,4-D application occur on blueberries (1.43 lb ai/A), peaches and nectarines (1.00 lb ai/A), pears (0.80 lb ai/A), sod turf (0.75 lb ai/A), grain and silage corn (0.75 lb ai/A), apples (0.70 lb ai/A), asparagus (0.70 lb ai/A), and cherries (0.60 lb ai/A).

The major agricultural uses of 2,4-D in the Pacific Northwest and California appear to include wheat, barley, apples, corn, almonds, forestry, and oats. Major non-agricultural uses include aquatic weed control, rights-of-way, and landscape maintenance. Non-agricultural usages cannot be broken down by state or county as can agricultural usages. However, because they are major uses of 2,4-D, we must assume that they are likely to occur in salmonid Evoluntionarily Significant Units (ESUs) in the Pacific Northwest and California.

3. General aquatic risk assessment for endangered and threatened species

Acceptable bridging data exist indicating that all currently used 2,4-D chemicals degrade rapidly into 2,4-D acid under most environmental conditions, as discussed in the Environmental fate and transport section. Therefore, all 2,4-D chemical forms are termed “2,4-D” in this assessment, unless otherwise specified.

a. Aquatic toxicity of 2,4-dichlorophenoxyacetic acid

Toxicity data for 2,4-dichlorophenoxyacetic acid, salts, amines, and esters are available through several resources. The draft EFED chapter contains information cited in EPA’s Toxdata database, and results are presented in the sections that follow. Since toxicity categories are reported in that document, they are also included in these tables.

i. Freshwater fish, acute toxicity

Freshwater studies using the technical grade active ingredient (TGAI) are required to determine the toxicity of 2,4-D to fish. The preferred test species are rainbow trout (a cold water fish) and bluegill sunfish (a warm water fish). Results of tests on these and other sensitive species are tabulated below. The draft EFED chapter presents toxicity data in units of milligrams of acid equivalent per liter (ppm). EPA’s AQUIRE database contains toxicity information on other species, including other species of trout and salmon. These results are presented below in subsection viii.

2,4-D acids and salts are practically non-toxic to freshwater fish, while esters are slightly to highly toxic (Table 10). The difference between these classes is greater than one order of magnitude in most of the results presented here, and higher for others (e.g., the difference in toxicity of 2,4-D isopropyl ester [0.58 mg/L] and 2,4-D dimethylamine salt [358 mg/L] for rainbow trout).

Table 10. Acute toxicity of 2,4-D TGAI to freshwater fish (draft EFED chapter).

Species	Scientific name	% a.i.	96-hour LC50 (ppm)[1]	Toxicity Category
2,4-D Acid				
Rainbow trout	*Oncorhynchus mykiss*	98.7	358	Practically non-toxic
Bluegill sunfish	*Lepomis macrochirus*	98.7	263	Practically non-toxic
Fathead minnow	*Pimephales promelas*	98.7	320	Practically non-toxic
2.4-D Sodium salt				
Rainbow trout	*Oncorhynchus mykiss*	80	>91	Practically non-toxic
2.4-D Diethanolamine salt				
Rainbow trout	*Oncorhynchus mykiss*	73.1	>81.6	Slightly toxic
Bluegill sunfish	*Lepomis macrochirus*	73.1	>82.3	Slightly toxic
Bluegill sunfish	*Lepomis macrochirus*	73.1	234	Practically non-toxic
Fathead minnow	*Pimephales promelas*	N.R.[2]	101	Practically non-toxic
2,4-D Dimethylamine salt				
Rainbow trout	*Oncorhynchus mykiss*	67.3	>830	Practically non-toxic
Bluegill sunfish	*Lepomis macrochirus*	73.1	>100	Practically non-toxic
Bluegill sunfish	*Lepomis macrochirus*	67.3	207.5	Practically non-toxic
Fathead minnow	*Pimephales promelas*	67.3	264	Practically non-toxic
2,4-D Triisopropylamine salt				
Rainbow trout	*Oncorhynchus mykiss*	69.2	162	Practically non-toxic
Bluegill sunfish	*Lepomis macrochirus*	69.2	217	Practically non-toxic
2,4-D Butoxyethyl ester				
Rainbow trout	*Oncorhynchus mykiss*	97.4	1.44	Moderately toxic
Bluegill sunfish	*Lepomis macrochirus*	N.R.[2]	0.828	Moderately toxic
Bluegill sunfish	*Lepomis macrochirus*	97.4	0.428	Highly toxic
Fathead minnow	*Pimephales promelas*	97.4	1.79	Moderately toxic
2,4-D 2-Ethylhexyl ester				
Rainbow trout	*Oncorhynchus mykiss*	92	14.5	Slightly toxic
Bluegill sunfish	*Lepomis macrochirus*	92	11.9	Slightly toxic
2,4-D Isopropyl ester				
Rainbow trout	*Oncorhynchus mykiss*	98.2	0.58	Highly toxic
Bluegill sunfish	*Lepomis macrochirus*	98.2	0.26	Highly toxic

[1] Milligrams acid equivalent per liter.

[2] N.R. = Not Reported.

The same trends in toxicity to freshwater fish are observed with formulated products (Table 11), where formulations with 2,4-D esters demonstrate 96-hour LC50s that are more than three orders of magnitude greater than products with 2,4-D salts, acids, and amines. For example, the LC50 for 2,4-D isopropyl ester for rainbow trout is 0.66 mg/L, whereas the LC50 for 2,4-D isopropylamine salt for this species is 2,244 mg/L.

Table 11. Acute toxicity of 2,4-D formulated products to freshwater fish (draft EFED chapter).

Species	Scientific Name	% a.i.	96-hour LC50 (ppm)[1]	Toxicity Category
2,4-D Dimethylamine salt				
Bluegill sunfish	*Lepomis macrochirus*	51.1	>830	Practically non-toxic

Species	**Scientific Name**	**% a.i.**	**96-hour LC50 (ppm)[1]**	**Toxicity Category**
2.4-D Isopropylamine salt				
Rainbow trout	*Oncorhynchus mykiss*	48.7	2,244	Practically non-toxic
Bluegill sunfish	*Lepomis macrochirus*	48.7	1,343	Practically non-toxic
Fathead minnow	*Pimephales promelas*	48.7	1,722	Practically non-toxic
2.4-D 2-Ethylhexyl ester				
Rainbow trout	*Oncorhynchus mykiss*	66.9	3.2	Moderately toxic
2,4-D Isopropyl ester				
Rainbow trout	*Oncorhynchus mykiss*	45.8	0.66	Highly toxic
Bluegill sunfish	*Lepomis macrochirus*	45.8	0.26	Highly toxic

[1] Milligrams acid equivalent per liter.

ii. Freshwater fish, chronic toxicity

Freshwater fish early life-stage and life-cycle tests using the TGAI is required because residues may reach surface water. The preferred species for these tests is the rainbow trout. The results of these tests are shown in Table 12, as presented in the draft EFED chapter.

The relationship between 2,4-D esters and the acid, salt, and amine forms of 2,4-D in the chronic toxicity data is similar to that in the acute toxicity data. The NOEC values for esters appear to be approximately two orders of magnitude higher than that of the amines and salts tested. For example, the toxicity to fathead minnows is much greater with the 2,4-D ethylhexyl ester (NOEC = 0.0792 mg/L) than with the 2,4-D acid (NOEC = 63.4 mg/L). According to the draft EFED chapter (page 229), life cycle tests for 2.4-D butoxyethyl ester are not available. However, given the higher toxicity of 2,4-D ethylhexyl ester, compared to the amine salts, further testing may be required to characterize its toxicity. Also, no chronic data are available for 2,4-D sodium salt, 2,4-D isopropylamine salt, 2,4-D triisopropylamine salt, and 2,4-D isopropyl ester.

Table 12. Freshwater fish early life-stage and life-cycle toxicity under flow through conditions using TGAI (draft EFED chapter and EFED Toxdata database).

Species	**Scientific name**	**% a.i.**	**NOEC/ LOEC (ppm)[1]**	**Endpoint**
Early Life Stage - ERA				
2,4-D Acid				
Fathead minnow	*Pimephales promelas*	96.1	63.4/<102	Larval survival
2,4-D Diethanolamine salt				
Fathead minnow	*Pimephales promelas*	73.8	19.8/66.6	Larval survival
2,4-D Dimethylamine salt				
Fathead minnow	*Pimephales promelas*	66.5	14.2/23.6	Length
Early Life Stage - Toxdata				
2,4-D Dimethylamine salt				
Fathead minnow	*Pimephales promelas*	99.3	17.1/28.4[2]	Not reported
2,4-D Isooctyl ester				
Fathead minnow	*Pimephales promelas*	94.7	0.12/0.22[2]	Not reported

Species	Scientific name	% a.i.	NOEC/ LOEC (ppm)[1]	Endpoint
Life Cycle - ERA				
2,4-D Ethylhexyl ester				
Fathead minnow	*Pimephales promelas*	94.7	0.0792/<0.1452	Larval fish survival

[1] Milligrams acid equivalent per liter.

[2] Parts per million as a.e./L or a.i./L is not specified.

iii. Freshwater invertebrates, acute toxicity

A freshwater aquatic invertebrate toxicity test using the TGAI is required to establish the toxicity of 2,4-D to aquatic invertebrates. The preferred test species is *Daphnia magna*. Results of tests with *Daphnia* using the TGAI and formulated products that were included in the draft EFED chapter are provided in Table 13. The 2,4-D acid and diethanolamine salt were slightly toxic to *Daphnia*, while other salts tested were practically non-toxic. All esters tested were slightly to moderately toxic. A test for a formulated product with 2,4-D dimethylamine salt showed that this product was practically non-toxic to *Daphnia*.

Table 13. Acute toxicity of 2,4-D TGAI and formulated products to non-target invertebrates (draft EFED chapter).

Species	Scientific Name	% a.i.	48-hour EC50 (ppm)[1]	Toxicity Category
Technical Material				
2,4-D Acid				
Water flea	*Daphnia magna*	98.7	25	Slightly toxic
2,4-D Diethanolamine salt				
Water flea	*Daphnia magna*	73.1	>68	Slightly toxic
2,4-D Dimethylamine salt				
Water flea	*Daphnia magna*	67.3	153	Practically non-toxic
2,4-D Isopropylamine salt				
Water flea	*Daphnia magna*	48.7	461	Practically non-toxic
2,4-D Triisopropylamine salt				
Water flea	*Daphnia magna*	69.2	340.2	Practically non-toxic
2,4-D Butoxyethanol ester				
Water flea	*Daphnia magna*	97.4	4.97	Moderately toxic
2,4-D 2-Ethylhexyl ester				
Water flea	*Daphnia magna*	92	11.88	Slightly toxic
Water flea	*Daphnia magna*	96.2	3.4	Moderately toxic
2,4-D Isopropyl ester				
Water flea	*Daphnia magna*	98.2	2.2	Moderately toxic
Formulated Products				
2,4-D Dimethylamine salt				
Water flea	*Daphnia magna*	51.1	642.8	Practically non-toxic

[1] Milligrams acid equivalent per liter.

iv. Freshwater invertebrates, chronic toxicity

As stated in the draft EFED chapter (page 24), some levels of concern (LOCs) are exceeded for freshwater invertebrates under certain use patterns for 2,4-D products. Since the end-use product may be applied directly to water or is expected to be transported to water from the application site, freshwater aquatic invertebrate life-cycle tests using the TGAI are required to establish the toxicity of products containing the 2,4-D acid, salts, amines, and esters. Results of chronic toxicity tests for freshwater invertebrates contained in the draft EFED chapter are presented in Table 14. NOEC values for 2,4-D butoxyethyl ester were several orders of magnitude lower than the values for the 2,4-D acid and salts that were tested. For example, the NOEC value for the ester is 0.2 ppm, while the NOEC value for the acid is 79 mg/L.

Table 14. Chronic toxicity of 2,4-D TGAI to freshwater invertebrates (draft EFED chapter).

Species	Scientific Name	% ai	21-day NOEC/LOEC (ppm)[1]	Endpoints Affected
2,4-D Acid				
Water flea	*Daphnia magna*	91.3	79/151	Number of young
2,4-D Diethanolamine salt				
Water flea	*Daphnia magna*	73.8	16.05/25.64	Survival and reproduction
2,4-D Dimethylamine salt				
Water flea	*Daphnia magna*	66.8	LOEC = 75.7 (NOEC not established)	Survival
2,4-D Butoxyethyl ester				
Water flea	*Daphnia magna*	96	0.2/0.483	Survival and reproduction

[1] Milligrams acid equivalent per liter.

v. Nontarget aquatic plants

According to the draft EFED chapter, “aquatic plant testing is required for products containing the 2,4-D acid, salts, amines, and esters because most formulations of 2,4-D are soluble, applied by air, and in some cases, applied directly to aquatic use sites” (page 241). The preferred species for Tier II tests are *Kirchneria subcapitata*, *Lemna gibba*, *Skeletonema costatum*, *Anabaena flos-aquae*, and a freshwater diatom. Results of Tier II testing on nontarget aquatic freshwater plants included in the draft EFED chapter are presented in Table 15. Tier II tests indicate that duckweed (*Lemna gibba*) is the most sensitive of the species tested, except for the test for 2,4-D 2-ethylhexyl ester in which it appears that blue-green algae (*Anabaena flos-aquae*) may be more sensitive.

Table 15. Toxicity of 2,4-D TGAI and formulated products to nontarget aquatic plants (draft EFED chapter).

Species	Scientific Name	% ai	EC50/NOEC (mg ae/L)
2,4-D Acid			

Species	**Scientific Name**	**% ai**	**EC50/NOEC (mg ae/L)**
Duckweed	*Lemna gibba*	96.2	0.695/0.0581
2,4-D Diethanolamine salt			
Duckweed	*Lemna gibba*	73.8	0.2992/0.0476
Green algae	*Selenastrum capricornatum*	73.8	7.48/0.34
Blue-green algae	*Anabaena flos-aquae*	73.8	>65.3/65.3
Freshwater diatom	*Navicula pelliculosa*	73.8	>66/66
Marine diatom	*Skeletonema costatum*	73.8	>64.6/64.6
2,4-D Dimethylamine salt			
Duckweed	*Lemna gibba*	66.7	0.48/0.23
Green algae	*Selenastrum capricornatum*	66.7	42.5/16
Blue-green algae	*Anabaena flos-aquae*	66.7	156.5/56.32
Freshwater diatom	*Navicula pelliculosa*	66.7	3.88/1.41
Marine diatom	*Skeletonema costatum*	66.7	123.3/79.89
2,4-D Isopropylamine salt			
Green algae	*Selenastrum capricornatum*	51.3	34.29/10.98
2,4-D Triisopropylamine salt			
Duckweed	*Lemna gibba*	70.9	1.28/1.28
Green algae	*Selenastrum capricornatum*	73.8	40.88/29.92
Blue-green algae	*Anabaena flos-aquae*	70.9	71.82/25.87
Freshwater diatom	*Navicula pelliculosa*	70.9	50.98/2.89
Marine diatom	*Skeletonema costatum*	70.9	38.29/No NOEC reported
2,4-D Butoxyethyl ester			
Duckweed	*Lemna gibba*	96	0.3974/0.141
Green algae	*Selenastrum capricornatum*	96	17.14/8.6
Blue-green algae	*Anabaena flos-aquae*	96	4.4/2.2
Freshwater diatom	*Navicula pelliculosa*	96	1.28/0.59
Marine diatom	*Skeletonema costatum*	96	1.02/0.538
2,4-D 2-Ethylhexyl ester			
Duckweed	*Lemna gibba*	94.7[1]	0.33/0.062
Green algae	*Selenastrum capricornatum*	94.7[1]	19.8/2.48
Blue-green algae	*Anabaena flos-aquae*	94.7[1]	>0.21/0.21
Freshwater diatom	*Navicula pelliculosa*	94.7[1]	1.25/1.24
Marine diatom	*Skeletonema costatum*	94.7[1]	0.66/0.62

[1] 62.8% acid equivalent

vi. Estuarine and marine fish, acute toxicity

As stated in the draft EFED chapter, 2,4-D acids, amines, and salts are practically non-toxic to estuarine and marine fish, whereas esters are highly toxic. This document also states that acute toxicity testing with estuarine and marine fish using the TGAI is required to establish the toxicity of products containing the 2,4-D acid, salts, amines, or esters. The active ingredient is expected to reach this environment because of its use in coastal counties. Results of these tests, which are include in the draft EFED chapter, are provided in Table 16 below. The 2,4-D acid and salts that were tested were practically non-toxic, with the exception of 2,4-D diethanolamine salt which was slightly toxic.

Table 16. Acute toxicity of 2,4-D TGAI and formulated products to estuarine and marine fish (draft EFED chapter).

Species	Scientific name	% ai	96-hour LC50 ppm (mg ae/L)	Toxicity category
2,4-D Acid				
Tidewater silverside	*Menidia peninsulae*	96.1	175	Practically non-toxic
2,4-D Diethanolamine salt				
Tidewater silverside	*Menidia peninsulae*	73.8	>80.24	Slightly toxic
2,4-D Dimethylamine salt				
Tidewater silverside	*Menidia peninsulae*	66.8	389	Practically non-toxic
Sheepshead minnow	*Cyprinodon variegatus*	51[1]	465	Practically non-toxic
2,4-D Isopropylamine salt				
Tidewater silverside	*Menidia peninsulae*	50.2	187	Practically non-toxic
2,4-D Triisopropylamine salt				
Tidewater silverside	*Menidia peninsulae*	70.4	203	Practically non-toxic
2,4-D 2-Ethylhexyl ester				
Tidewater silverside	*Menidia peninsulae*	95.39	>0.1564	Highly toxic
Tidewater silverside	*Menidia peninsulae*	66.6[1]	>0.48	Moderately toxic

[1] Formulated product

vii. Estuarine and marine fish, chronic toxicity

According to the draft EFED chapter, an estuarine/marine fish early life-stage toxicity test using the TGAI is required for the 2,4-D acid, salts, amines, and esters because the end-use product may be applied directly to the estuarine/marine environment or is expected to be transported to this environment from the application site. Only the results of one chronic test using 2,4-D butoxyethyl ester TGAI are available from the draft EFED chapter. These results are presented in Table 17.

Table 17. Chronic toxicity of 2,4-D TGAI to estuarine and marine fish (Draft EFED Chapter).

Species	Scientific name	% ai	NOEC/LOEC ppm (mg ae/L)	Endpoint Affected
2,4-D Butoxyethyl ester				
Sheepshead minnow	*Cyprinodon variegatus*	96	0.05554/0.0791	Survival

viii. Estuarine and marine invertebrates, acute toxicity

According to the draft EFED chapter, tests measuring the acute toxicity of 2,4-D acid, salts, amines, and esters on estuarine and marine invertebrates is required because the end-use product may be applied directly to the estuarine/marine environment or is expected to be transported to this environment from the application site. Results of these tests performed with TGAI are presented in Table 18. Results of tests with typical end use products (TEP) are also available for 2,4-D dimethylamine salt and 2,4-D ethylhexyl ester, and these are presented in the table, as well.

The toxicity of 2,4-D acid and amine salts that were tested was variable among the species tested, but in general they were practically non-toxic to slightly toxic to estuarine and marine invertebrates. The 2,4-D esters that were tested were slightly toxic to very highly toxic to the species tested, and the toxicity varied greatly between the two species tested with 2,4-D ethylhexyl ester (e.g., >66 mg ae/L and >0.092 mg ae/L for the eastern oyster and grass shrimp, respectively). The toxicity of the two formulated products that were tested did not differ greatly from the toxicity of their TGAI material.

Table 18. Acute toxicity of 2,4-D to estuarine and marine invertebrates (draft EFED chapter).

Species	Scientific name	% ai	96- hour LC50/EC50 ppm (mg ae/L)	Toxicity Category
2,4-D Acid				
Eastern oyster	*Crassostrea virginica*	95.1	57	Slightly toxic
Pink shrimp	*Penaeus duorarum*	96.1	467	Practically non-toxic
2,3-D Diethanolamine salt				
Eastern oyster	*Crassostrea virginica*	73.8	>76.6	Slightly toxic[1]
Pink shrimp	*Penaeus duorarum*	73.1	>67.73	Slightly toxic
2,4-D Dimethylamine salt				
Eastern oyster	*Crassostrea virginica*	49.3	>174.3	Practically non-toxic
Eastern oyster	*Crassostrea virginica*	66.8	84.66	Slightly toxic[1]
Mysid	*Americamysis bahia*	67.3	152.7	Practically non-toxic
Pink shrimp	*Penaeus duorarum*	66.8	150.2	Practically non-toxic
Pink shrimp	*Penaeus duorarum*	73.1	>82.7	Slightly toxic[1]
Fiddler crab	*Uca purgilator*	51.1 (TEP)	830	Practically non-toxic
Grass shrimp	*Palaemonetes pugio*	51.1 (TEP)	104.5	Practically non-toxic
2,4-D Isopropyl amine				
Eastern oyster	*Crassostrea virginica*	50.2	49.6	Slightly toxic
Pink shrimp	*Penaeus duorarum*	50.2	478	Practically non-toxic
2,4-D Triisopropanolamine salt				
Eastern oyster	*Crassostrea virginica*	70.4	89.1	Slightly toxic[1]
Pink shrimp	*Penaeus duorarum*	70.4	401.8	Practically non-toxic
2,4-D Butoxyethyl ester				
Eastern oyster	*Crassostrea virginica*	70	1.8	Moderately toxic
Pink shrimp	*Penaeus duorarum*	70	3.8	Moderately toxic
2,4-D Ethylhexyl ester				
Eastern oyster	*Crassostrea virginica*	95.39	>66	Slightly toxic[1]
Grass shrimp	*Palaemonetes pugio*	95.39	>0.092	Very highly toxic[2]
Eastern oyster	*Crassostrea virginica*	66.6 (TEP)	>0.469	Highly toxic
Grass shrimp	*Palaemonetes pugio*	66.6 (TEP)	>0.942	Highly toxic[3]

[1] Based on mg a.i./L units, this LC50 is categorized as practically non-toxic in the draft EFED chapter.
[2] Based on mg a.i./L units, this LC50 is categorized as highly toxic in the draft EFED chapter.
[3] Based on mg a.i./L units, this LC50 is categorized as moderately toxic in the draft EFED chapter.

Chronic toxicity data for estuarine/marine invertebrates is not available from the draft EFED chapter. According to this document, chronic tests are not required for 2,4-D acid, salts, and amines because the RQs for the freshwater chronic studies were well below the levels of concern, and the chronic risk would be expected to be low. However, it states that chronic RQs are significantly exceeded for the BEE, and EFED will require chronic toxicity data to reduce the uncertainty to marine invertebrates.

ix. Additional toxicity data from AQUIRE

Additional toxicity data for aquatic organisms are available from EPA's AQUIRE database (http://www.epa.gov/ecotox). This database contains information from the open literature that has passed EPA's evaluation criteria that ensure the use of good data. We did not search the papers included in the tables below, but the reference numbers for these studies are provided.

The papers available for freshwater fish only contained information about the 2,4-D acid and two ester forms (Table 19). However, the trends that were seen in the data included in the draft EFED chapter are also apparent here, where the LC50s of the esters are several orders of magnitude lower than the LC50s for the acid. For example, the LC50 for 2,4-D butoxyethyl ester in the chinook salmon is 0.24 ppm, while the LC50 for 2,4-D acid in medaka is 1,200 ppm. We note, however, that LC50s are available for different species, and that the species differences in sensitivity are not known. Similar trends are seen with the formulated 2,4-D products (Table 20).

Table 19. Acute toxicity of 2,4-D TGAI to freshwater fish.

Species	Scientific Name	96-hour LC50 (ppm)	Reference Number
2.4-D Acid			
Carp	*Cyprinus carpio*	5.1	6386
Zebra danio	*Danio rerio*	160	2877
Rohu	*Labeo rohita*	1,120	19021
Medaka	*Oryzias latipes*	2,450	14908
Mozambique tilapia	*Tilapia mossambica*	1,200	19021
2.4-D Butyl ester			
Rainbow trout	*Oncorhynchus mykiss*	1.0	2776
Coho salmon	*Oncorhynchus kisutch*	1.0	2776
Sockeye salmon	*Oncorhynchus nerka*	1.0	2776
Dolly yarden	*Salvelinus malma*	1.0	2776
2.4-D Butoxyethyl ester			
Rainbow trout	*Oncorhynchus mykiss*	0.402	10642
Pink salmon	*Oncorhynchus gorbuscha*	0.4	3499
Chum salmon	*Oncorhynchus keta*	0.700	3499
Coho salmon	*Oncorhynchus kisutch*	1.1	3499
Sockeye salmon	*Oncorhynchus nerka*	1.4	3499
Chinook salmon	*Oncorhynchus tshawytscha*	0.240	10642

Table 20. Acute toxicity of 2,4-D formulated products to freshwater fish.

Species	Scientific Name	96-hour LC50 (ppm)	Reference
2.4-D Acid			
American eel	*Anguilla rostrata*	300.6	859
Snake-head catfish	*Channa punctata*	1,212.5	13698
Walking catfish	*Clarias batrachus*	60.0	17010
Carp	*Cyprinus carpio*	96.5	859
Banded killifish	*Fundulus diaphanus*	26.7	859
Bogabata	*Labeo boga*	3.8	6386
Pumpkinseed	*Lepomis gibbosus*	94.6	859
White perch	*Morone americana*	40.0	859
Striped bass	*Morone saxatilis*	70.1	859
Guppy	*Poecilia reticulata*	6.3	11567
Slender rasbora	*Rasbora daniconia*	2,000	14215
Cyprinid fish	*Rasbora neilgherriensis*	5.6	6386
Tench	*Tinca tinca*	800	20178
2,4-D Ethyl ester			
Goldfish	*Carassius auratus*	3.2	15192
Carp	*Cyprinus carpio*	1.0	15192
Bluegill	*Lempomis macrochirus*	1.4	612
Medaka	*Oryzias latipes*	3.2	3682
2,4-D Butyl ester			
Carp	*Carassius sp.*	2.9	6270
Striped bass	*Morone saxatilis*	0.150	2012
Tench	*Tinca tinca*	2.8	6270

One chronic test is available for freshwater fish species in AQUIRE. The results are presented in Table 21. The NOEC/LOEC values for 2,4-D acid in the medaka are lower than those for 2,4-D acid in the fathead minnow (63.4/<102 ppm) (see Table 12).

Table 21. Chronic toxicity of 2,4-D TGAI to freshwater fish.

Species	Scientific Name	28-day NOEC/LOEC (ppm)	Reference
2.4-D Acid			
Medaka	*Oryzias latipes*	27.2/56.5	14908

AQUIRE also contains some information on acute toxicity of 2,4-D TGAI and formulated products to non-target invertebrates (Table 22). Generally, similar trends in toxicity are seen between the 2,4-D acid and ester forms. However, with the formulated products, the toxicity is varied. For example, the 96-hour LC50 for the stonefly is 1.6 ppm, while it is 144.1 ppm for the calanoid copepod. These tests were performed using formulated products, however, and it is possible that different formulations were used for the two tests.

Table 22. Acute toxicity of 2,4-D TGAI and formulated products to non-target invertebrates.

Species	**Scientific Name**	**Test**	**Concentration (ppm)**	**Reference Number**
Technical Material				
2,4-D Acid				
Water flea	*Ceriodaphnia dubia*	48-hour LC50	236	3590
Oligochaete	*Lumbriculus variegatus*	96-hour LC50	122.2	6502
Formulated Products				
2,4-D Acid				
Water flea	*Daphnia magna*	48-hour LC50	17.6	11504
Water flea	*Ceriodaphnia dubia*	48-hour LC50	122.2	18961
Calanoid copepod	*Eudioptomus gracilis*	96-hour LC50	144.1	12427
Stonefly	*Pteronarsys californicus*	96-hour LC50	1.6	2871
2,4-D Ethyl ester				
Water flea	*Daphnia pulex*	3-hour LC50	10.0	15192
2,4-D Butyl ester				
Mosquito	*Aedes aegypti*	96-hour LC50	35.0	6270
Water flea	*Daphnia magna*	96-hour LC50	20.5	6270
2,4-D Butoxyethanol ester				
Stonefly	*Pteronarcys californicus*	96-hour LC50	1.3	889

Some data on chronic toxicity to freshwater invertebrates are also available for 2,4-D acid in AQUIRE. These results are presented in Table 23.

Table 23. Chronic toxicity of 2,4-D acid formulated products to freshwater invertebrates.

Species	**Scientific Name**	**Duration**	**NOEC/LOEC (ppm)**	**Endpoints Affected**	**Reference No.**
2,4-D Acid					
Rotifer	*Brachionus calyciflorus*	2 Days	58/83	Reproduction	3963
Water flea	*Daphnia magna*	21 Days	32/100	Population change	16782

AQUIRE also contains some information for acute toxicity of 2,4-D formulated products to estuarine and marine fish. These data are presented below in Table 24. A similar trend is seen between the 2,4-D acid and ester forms as has been seen in other tests and tests with other taxa. The 96-hour LC50 for the ester forms is about two orders of magnitude less than the LC50 for the acid form. For example, the LC50 for 2,4-D butoxyethyl ester in the bleak is 3.2 ppm, whereas the LC50 for 2,4-D acid in the tooth carp is 242.22 ppm. Note, however, that the difference in sensitivity between these species is not known.

Table 24. Acute toxicity of 2,4-D formulated products to estuarine and marine fish.

Species	**Scientific name**	**Material**	**96-hour LC50 (ppm)**	**Reference No.**
2,4-D Acid				
Tooth carp	*Aphanius fasciatus*	Formulation	242.22	5365
2,4-D 3-Butoxypropyl ester				
Longnose killifish	*Fundulus similis*	Formulation	4.8 (48-hour)	2188

Species	Scientific name	Material	96-hour LC50 (ppm)	Reference No.
2,4-D Butoxyethyl ester				
Bleak	*Alburnus alburnus*	Formulation	3.2	5185

x. Multiple active ingredients

Several 2,4-D products contain multiple active ingredients. Results of acute and chronic tests available from EFED's Toxdata database and EPA's AQUIRE database are provided for freshwater and marine fish, invertebrates, and plants in Tables 25 through 28.

Table 25. Acute toxicity of formulated products containing 2,4-D and other active ingredients to freshwater and marine fish (Toxdata).

Species	Scientific name	% ai	96-hour LC50 (ppm)
2,4-D Acid/Picloram potassium salt			
Sheepshead minnow	*Cyprinodon variegatus*	21/5.4	131
Inland silverside	*Meridia beryllina*	21/5.4	57.2
2,4-D Isooctyl ester/2,4,5-T			
Rainbow trout	*Oncorhynchus mykiss*	2/1	7.8
Bluegill sunfish	*Lepomis macrochirus*	15/15	4.9

Table 26. Acute toxicity of formulated products containing 2,4-D and other active ingredients to freshwater and marine fish (AQUIRE).

Species	Scientific name	Test material	96-hour LC50 (ppm)	Reference No.
2,4-D monoester/1,2-propanediol butyl ether				
Bluegill sunfish	*Lepomis macrochirus*	Formulation	0.447	6797
Cutthroat trout	*Oncorhynchus clarki*	Formulation	0.280	6797
Rainbow trout	*Oncorhynchus mykiss*	Formulation	0.821	6797
Rainbow trout	*Oncorhynchus mykiss*	Analytical	0.281	10642
Chinook salmon	*Oncorhynchus tshawytscha*	Analytical	0.126	10642
Lake trout	*Salvelinus namaycush*	Formulation	0.334	6797
2,4-D acid compound/N-methylmethanamine (1:1)				
Goldfish	*Carrassius auratus*	Formulation	154	6507
Grass carp	*Ctenopharyngodon idella*	Formulation	1,116	575
Western mosquitofish	*Gambusia affinis*	Formulation	405	867
Channel catfish	*Ictalurus punctatus*	Formulation	758	6615
Bluegill sunfish	*Lepomis macrochirus*	Formulation	870	344
Inland silverside	*Menidia beryllina*	Formulation	403	344
Rainbow trout	*Oncorhynchus mykiss*	Formulation	215	11504
Rainbow trout	*Oncorhynchus mykiss*	Analytical	1,000	10390

Species	**Scientific name**	**Test material**	**96-hour LC50 (ppm)**	**Reference No.**
Chinook salmon	*Oncorhynchus tshawytscha*	Formulation	100	6797
Fathead minnow	*Pimephales promelas*	Formulation	216	6797
Snake-skinned gourami	*Trichogaster pectoralis*	Formulation	153	16863
2,4-D Acid compound/N,N-diethylethanamine (1:1)				
Bluegill sunfish	*Lepomis macrochirus*	Formulation	>0.113	344
2,4-D Acid compound/ N-9-octadecenyl-1,3-propanediamine (2:1)				
Channel catfish	*Ictalurus punctatus*	Formulation	210	6797
Bluegill sunfish	*Lepomis macrochirus*	Formulation	639	6797
2,4-D Acid compound/ Isopropylamine (1:1)				
Bluegill sunfish	*Lepomis macrochirus*	Formulation	1,410	344
Inland silverside	*Menidia beryllina*	Formulation	205	344
Rainbow trout	*Oncorhynchus mykiss*	Formulation	2,350	344
Fathead minnow	*Pimephales promelas*	Formulation	1,910	344
2,4-D Acid compound/ 2,2-iminobis[ethanol] (1:1)				
Bluegill sunfish	*Lepomis macrochirus*	Formulation	121	344
Atlantic silverside	*Menidia menidialina*	Formulation	118	344
Rainbow trout	*Oncorhynchus mykiss*	Formulation	120	344
2,4-D isooctyl ester/2,4,5-Trichlorophenoxyacetic acid				
Cherry salmon	*Oncorhynchus masou*	Formulation	0.6	6034
Japanese barbel	*Tribolodon hakonensis*	Formulation	1.3	6034
2,4-D isooctyl ester/1,1',1"-nitrilotris[2-propanol]				
Bluegill sunfish	*Lepomis macrochirus*	Formulation	0.378	344
Inland silverside	*Menidia beryllina*	Formulation	0.399	344
Rainbow trout	*Oncorhynchus mykiss*	Formulation	0.268	344

Table 27. Acute toxicity of formulated products containing 2,4-D and other active ingredients to freshwater and marine invertebrates (AQUIRE).

Species	**Scientific name**	**Test material**	**96-hour LC50 (ppm)**	**Reference No.**
2,4-D monoester/1,2-propanediol butyl ether				
Aquatic sowbug	*Asellus brevicaudus*	Formulation	2.2 (48-hr)	886
Scud	*Gammarus fasciatus*	Formulation	1.2	6797; 885
Crayfish	*Orconectes nais*	Formulation	100	886
Grass shrimp	*Palaemonetes kadiakensis*	Formulation	0.093	6797
Stonefly	*Pteronarcella badia*	Formulation	1.86	6797
Stonefly	*Pteronarcys californicus*	Formulation	1.34	6797
2,4-D monoester/N-methylmethanamine				
Cyclopoid copepod	*Acanthocyclops vernalis*	Formulation	46.45	550
Asiatic clam	*Corbicula manilensis*	Formulation	561	418
Scud	*Gammarus fasciatus*	Formulation	100	885
Daggerblade grass shrimp	*Palaemonetes pugio*	Formulation	>0.140	344
2,4-D Acid compound/ Isopropylamine (1:1)				
Northern pink shrimp	*Penaeus duorarum*	Formulation	525	344
2,4-D Acid compound/ 2,2-iminobis[ethanol] (1:1)				
Northern pink shrimp	*Penaeus duorarum*	Formulation	>99.6	344
2,4-D isooctyl ester/2,4,5-Trichlorophenoxyacetic acid				
Aquatic sowbug	*Asellus brevicaudus*	Formulation	3.0 (24-hour)	6034
2,4-D isooctyl ester/1,1',1"-nitrilotris[2-propanol]				

Species	Scientific name	Test material	96-hour LC50 (ppm)	Reference No.
Northern pink shrimp	*Penaeus duorarum*	Formulation	1,057	344

Table 28. Toxicity of formulated products containing 2,4-D and other active ingredients to freshwater and marine plants (AQUIRE).

Species	Scientific name	Test material	Endpoints Affected	EC50 in ppm	Ref. No.
2,4-D monoester/N-methylmethanamine					
Bluegreen algae	*Anabaena flosaquae*	Formulation	Abundance	160.7 (120 hr)	344
Duckweed	*Lemna gibba*	Formulation	Abundance	0.370 (14 d)	344
Diatom	*Navicula pelliculosa*	Formulation	Abundance	3.85 (120 hr)	344
Green algae	*Selenastrum capricornutum*	Formulation	Abundance	51.2 (5 d)	344
Diatom	*Skeletonema costatum*	Formulation	Abundance	148.5 (5 d)	344
2,4-D isooctyl ester/1,1',1"-nitrilotris[2-propanol]					
Bluegreen algae	*Anabaena flosaquae*	Formulation	Abundance	97.1 (5 d)	344
Duckweed	*Lemna gibba*	Formulation	Abundance	1.91 (14 d)	344
Diatom	*Navicula pelliculosa*	Formulation	Abundance	60.2 (5 d)	344
Green algae	*Selenastrum capricornutum*	Formulation	Abundance	30.9 (5 d)	344
Diatom	*Skeletonema costatum*	Formulation	Abundance	50.4 (5 d)	344

xi. Sublethal and endocrine effects

Sublethal and endocrine effects are addressed in the draft EFED chapter under the section titled "Endocrine Disruption Assessment" beginning on page 30. This section describes reproductive effects that were observed in mammals and birds. Specifically, decreased body weight gains were observed in the parental generation of rats that were tested, as well as male renal tube alteration in the parental generation and their offspring. These effects occurred in test subjects receiving the high dose range that was tested. Decreased offspring weight was also observed. For birds, effects on egg shell strength and the number of offspring were observed, but were not specifically described. However, the NOEC was 962 ppm. The draft EFED chapter states that "these reproductive effects could be an indicator of potential endocrine disruption in birds." The draft EFED chapter does not contain any information about the potential for 2,4-D to be an endocrine disruptor in fish. We note that 2,4-D may in fact have endocrine disruptor potential, but this has yet to be determined in fish.

Endocrine disruptor effects for 2,4-dichlorophenol (2,4-DCP), a degradate of 2,4-D, have not been submitted by the registrant or requested by the Agency. The draft EFED chapter states that until 2,4-DCP is determined to be a potential endocrine disruptor, an evaluation of endocrine effects for this degradate will not be required.

The following statement is also included in the draft EFED chapter: "EPA is required under the Federal Food, Drug, and Cosmetic Act (FFDCA), as amended by the Food Quality Protection Act (FQPA), to develop a screening program to determine whether certain substances (including all pesticide active and other ingredients) *'may have an effect in humans that is similar to an effect produced by a naturally occurring estrogen, or other such endocrine effects as the Administrator may designate.'* Following the recommendations of its Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC), EPA determined that there was scientific basis for including, as part of the program, the androgen and thyroid hormone systems, in addition to the estrogen hormone system. EPA also adopted EDSTAC's recommendation that the Program include evaluations of potential effects in wildlife. For pesticide chemicals, EPA will use The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and, to the extent that effects in wildlife may help determine whether a substance may have an effect in humans, FFDCA authority to require the wildlife evaluations. As the science develops and resources allow, screening of additional hormone systems may be added to the Endocrine Disruptor Screening Program (EDSP). When the appropriate screening and/or testing protocols being considered under the Agency's EDSP have been developed, 2,4-D and 2,4-DCP may be subjected to additional screening and/or testing to better characterize effects related to endocrine disruption."

xii. Toxicity of degredates

The risks presented in this assessment could be underestimated if degradates also exhibit toxicity under the conditions of use proposed on the label. According to the draft EFED chapter, the Metabolite Assessment Review Committee (MARC) of the Health Effects Division (HED) of OPP has determined that none of the degradates of 2,4-D are of concern for the human health risk assessment. Therefore, no degradates were included in the drinking water assessment or in the ecological risk assessment performed by EFED.

b. Environmental fate and transport

The environmental fate and transport of 2,4-D is summarized below, based on the discussions in section IV and appendix A of the draft EFED chapter (Attachment B), on pages 33-41 and 117-168, respectively. The sodium salt of 2,4-D is not discussed in this assessment because it is equivalent to 2,4-D acid, undergoing the same fate and transport routes as 2,4-D acid.

Evidence from registrant-sponsored data and open-literature indicates that 2,4-D amine salts (DMA, DEA, IPA, TIPA) and 2,4-D esters (EHE, BEE, IPE) are not persistent under most environmental conditions. In most environments, 2,4-D amine salts undergo dissociation in less than three minutes, and 2,4-D esters decompose at a slower but relatively rapid rate of less than 2.9 days. The major degradation products of 2,4-D amines and esters are 2,4-D acid and the respective amine and alcohol moieties. An environmental fate strategy based on these findings has been proposed to bridge 2,4-D amines and esters to 2,4-D acid (Registration Standard for 2,4-Dichlorophenoxyacetic acid (2,4-D), 1988, 540/RS-88-115). Therefore, this assessment discusses all currently used 2,4-D chemical forms separately, in groups of salts and esters, or all together as “2,4-D” in general, as environmental conditions warrant.

2,4-D is a phenoxy or phenoxyacetic acid herbicide that is used postemergence most often, for selective control of broadleaf weeds. Pure 2,4-D is a white crystalline solid with a melting point of 138-141 ^{o}C. The major dissipation routes appear to be oxidative microbial-mediated mineralization, photodegradation in water, and leaching. 2,4-D acid is stable to abiotic hydrolysis. Major degradates of 2,4-D acid include 1,2,4-benzenetriol, 2,4-dichlorophenol (2,4-DCP), 2,4-dichloroanisol (2,4-DCA), chlorohydroquinone (CHQ), 4-chlorophenol, volatile organics, bound residues, and carbon dioxide (CO_2). However, 1,2,4-benzenetriol is a photodegradate observed under abiotic conditions and not likely to commonly occur under natural conditions.

2,4-D acid has a moderate to high potential for soil mobility under normal agricultural practices. Dissipation from the surface soil layer is moderately rapid to rapid ($t_{½}$=6.1 days). Overall degradation is also moderately rapid to rapid ($t_{½}$=2.9 days). Granular applications degrade less rapidly than concentrate forms.

Aquatic dissipation studies indicate that 2,4-D amine salts and esters dissipate quickly from the water column by quickly converting to 2,4-D acid and amine or alcohol moieties, respectively. However, 2,4-D ester dissipation rates are pH dependant, decreasing as acidity increases. Therefore, esters may dissipate from the water column less rapidly than amine salts.

Degradation of 2,4-D acid is rapid ($t_{½}$=6.2 days) in aerobic mineral soils. Soil degradates are 2,4-DCP and 2,4-DCA. 2,4-D degradation is less rapid ($t_{½}$=15 days) in aerobic aquatic environments. Degradates are 2,4-DCP, 4-chlorophenol, 4-chlorophenoxyacetic acid, and CHQ. The major volatile degradate in soil and aquatic environments is CO_2. Some 2,4-D acid or its degradates persist in stable soil organic matter components (*e.g.*, fulvic acid, humic acid, and humin). Unaltered 2,4-D acid persists in fulvic acid components of organic matter in soil. 2,4-D acid is moderately persistent to persistent ($t_{½}$=41 to 333 days) in anaerobic aquatic environments. Intermediate degradates are 2,4-DCP, 4-chlorophenol , and 2-chlorophenol. Volatile degradates are CO_2, 2,4-DCA, and 4-chlorophenol.

Photodegradation of 2,4-D acid is moderately rapid ($t_{½}$=12.9 calendar days at pH 5) in aquatic environments and fairly slow ($t_{½}$=68 calendar days) on sterile soil. Major photodegradates include 1,2,4-benezenetriol and CO_2.

Atmospheric transport of 2,4-D formulations may occur via spray drift and volatilization. The Association of American Pesticide Control Officials (AAPCO) has found that 2,4-D is the most commonly confirmed active ingredient in drift complaints (Liemandtl, 1999). Spray drift is a well studied process that is incorporated into EFED’s current risk assessment models. Transport after volatilization, however, is not well studied. Its impact away from the target site is not quantitatively considered because volatilization is not expected to be a major route of exposure. EFED’s simple fugacity model predicts that the relative percentage of 2,4-D acid that will partition into air is 0.37 percent, while the relative percentage for a 2,4-D ester is 0.48 percent. However, uncertainties exist in the model due to ester to soil partitioning and to plant surface interactions.

Fate studies for the moieties of common chemical forms of 2,4-D were submitted for aerobic soil metabolism, aerobic aquatic metabolism, and anaerobic aquatic metabolism conditions. Table 29 displays the half-lives of the moieties of currently used 2,4-D chemicals that these studies recorded under the abovementioned metabolic conditions.

Table 29. Half-lives of various 2,4-D chemical moieties under three metabolic conditions (Draft EFED Chapter).

	Metabolic Condition		
2,4-D Chemical	**Aerobic Soil**	**Aerobic Aquatic**	**Anaerobic Aquatic**
DMA	4 to 14 days	2.8 days	1732 days
DEA	1.7 days	5.8 days	10.9 days
IPA	11.8 to 18.2 hrs	21.6 hrs	408 days
TIPA	0.9 to 1.6 days	14.3 days	15.3 days
EHE	5.3 hrs	No data	15.3 days
BEE	13.3 to 35.5 hours	0.6 to 3.4 days	1.4 days
IPE	0.9 hrs	13 hrs	14.55 days

Moieties of 2,4-D DMA and 2,4-D IPA were the lone persistent chemicals under anaerobic aquatic conditions. In aerobic soil and aerobic aquatic conditions, no 2,4-D moieties were found to accumulate. The data indicate that degradation products of currently used 2,4-D chemicals should not accumulate under normal agricultural conditions, except for some uses in rice crops, which can create anaerobic aquatic conditions.

Bridging data based on the weight of evidence from open-literature and registrant sponsored data indicate that the esters of 2,4-D (2,4-D EHE, 2,4-D BEE, and 2,4-D IPE) are rapidly hydrolyzed in alkaline aquatic environments, soil/water slurries, and moist soils and that the 2,4-D amine salts (2,4-D DMAS, 2,4-D IPA, 2,4-D TIPA, 2,4-D DEA) dissociate rapidly in water (Registration Standard for 2,4-Dichlorophenoxyacetic acid (2,4-D), 1988, 540/RS-88-115). Under extremely dry soil conditions, these degradation mechanisms may be inhibited to increase 2,4-D ester and 2,4-D amine salt persistence. However, environmental exposure from 2,4-D esters and 2,4-D amine salts is expected to be minimal in most terrestrial and aquatic environments, including most sustainable agricultural conditions. Further analysis is required to better understand 2,4-D ester persistence in aquatic field sediments, in forest field leaf litter, and on forest field foliage.

Direct evidence of the stability of 2,4-D amine salts in soil and aquatic environments is difficult to obtain due to the lack of analytical methods. Based on maximum application rates for 2,4-D amine salts (at 4 lbs ai/A), 2,4-D amine salts are expected to fully dissociate in soil environments because their theoretical concentrations in soil solution do not exceed water solubilities. Additionally, dissociation studies indicate the time for complete dissociation is rapid (< 3 minutes) under most environmental conditions. However, the analytical methods in field dissipation studies were designed to detect only 2,4-D, 2,4-DCP and, 2,4-DCA. Therefore, a half-life of 2,4-D amine salts could not be determined from the terrestrial, aquatic, and forest field dissipation studies. Even so, the most conservative half-lives of 2,4-D DMA would be equivalent to the 2,4-D acid half-lives in field studies, which range from 1.1 days to 30.5 days with a median half-life of 5.6 days.

De-esterification of 2,4-D esters is dependent on microbial-mediated, surface-catalyzed and alkaline-catalyzed hydrolysis and leads to the formation of 2,4-D acid and associated alcohol moieties (Schwarzenbach et al.,1993). A study has found the average de-esterification half-life of 2,4-D BEE in natural waters to be 2.6 hours (Paris et al., 1981). Various mineral surfaces (Fe, Al, Ti oxides), soil properties (clay mineralogy, organic carbon content, temperature, moisture content), and other environmental variables that influence microbial populations can affect the persistence of 2,4-D esters (Torrents and Stone, 1994; Wolfe et al., 1989; Wolfe, 1990).

Alkaline environments are expected to increase 2,4-D ester hydrolysis. Several field studies show that phenoxy herbicide esters are more persistent under extremely dry soil [< soil wilting point (~15 bars)] conditions (Smith and Hayden, 1980; Smith, 1972; Smith, 1976). Phenoxy herbicide esters have degraded rapidly (>85% degradation) in moist soils [~50 to 80% field capacity (~0.3 bars)] and soil slurries during a 48-hour incubation period. These hydrolysis studies indicate the alkyl chain configuration affects hydrolysis rates in soils and soil slurries. 2,4-D EHE has slower hydrolysis rates than n-butyl and isopropyl esters of 2,4-D.

Registrant sponsored research indicates that the 2,4-D esters degrade rapidly ($t_{½}$< 24 hours) in soil slurries, aerobic aquatic environments, and anaerobic, acidic aquatic environments. Terrestrial field dissipation studies for 2,4-D EHE yield half-lives for 2,4-D EHE ranging from 1 to 14 days with a median half-life of 2.9 days. 2,4-D BEE, applied as granules in aquatic field dissipation studies with alkaline conditions, degraded rapidly in the water column, although residues were detected in the sediment up to 186 days post-treatment. It is not understood whether the 2,4-D BEE persistence in sediment was due to a slow decomposition of the granule formulation or to a slow de-esterification of the sediment-bound 2,4-D BEE, although the former explanation is better supported by registrant data and by the literature. In forest dissipation studies, 2,4-D EHE degraded slowly on foliage and in leaf litter.

Appendix A of the draft EFED chapter reviews local field studies on 2,4-D, by US state and chemical form, that may yield data more specific to nearby and similar localities. Field drift evaluations of 2,4-D DMA occurred in Louisiana, Oregon, and Kansas. Drift was found 1,320 feet downwind from the site in Oregon, with spray heights of 15 to 20 feet at 25 psi and with crosswinds of 2 to 13 mph. Terrestrial field dissipation studies of 2,4-D DMA occurred in California, Colorado, North Carolina, North Dakota, Nebraska, Ohio and Texas. Surface soil half-lives for the first application at the California site were 6.8 days on bare ground, 4.1 days on pasture, and 29.1 days on turf. The second application yielded half-lives of 4.1 days on bare ground, 30.5 days on pasture, and 8 days on turf. Aquatic field dissipation studies of 2,4-D DMA took place in North Dakota, North Carolina, and Louisiana. Aquatic dispersion studies of 2,4-D DMA were performed in Florida and Minnesota. A forest field dissipation study of 2,4-D DMA is mentioned. Lastly, a study of field accumulation of 2,4-D DMA in aquatic organisms in Georgia is reviewed.

Terrestrial field dissipation studies of 2,4-D EHE occurred in California, Colorado, North Carolina, North Dakota, Nebraska, Ohio, and Texas. Surface soil half-lives for the first application at the California site were 3.8 days on bare ground, 7.5 days on pasture, and 6.2 days on turf. The second application yielded half-lives of 6.2 days on bare ground, 39.2 days on pasture, and 9.7 days on turf. Forest field dissipation studies of 2,4-D EHE were performed in Georgia. Aquatic field dissipation studies of 2,4-D BEE took place in North Carolina, Minnesota, and Washington. 2,4-D BEE was broadcast applied onto a man-made pond in Washington, dissipating with a half-life of 2 days in water and 5 days in sediment. Aquatic field dissipation studies of 2,4-D acid occurred in Washington and Oklahoma, yielding half-lives of less than 3 days in reservoirs at both sites. 2,4-D acid residue accumulation was found at < 0.0421 ug/g in largemouth bass and carp. No 2,4-D residues were observed in white suckers.

The State of California has implemented rice field studies regarding the holding of irrigation water for a period of time after pesticide applications and before release into local waterways to improve local drinking water (CDPR, 2002). However, these studies focus mostly on the pesticides thiobencarb and molinate. Instances of a 2,4-D-focused study have not been found.

c. Incidents

The OPP Ecological Incident Information System (EIIS) database reports pesticide incidents that have been voluntarily submitted to the EPA by state agencies and others. In autumn of 2004, the EIIS database reported 386 incidents that involve 2,4-D, some of which are discussed in the EFED chapter on pages 55, 56, 85, and 86.

Eleven of the EIIS incident reports involving 2,4-D are “highly probably related” to the pesticide, which means that there is high certainty that 2,4-D caused the incidents. Three of these incidents affected aquatic organisms, two of which were registered uses: Fish kills occurred in a residential pond in Missouri after periodic lawn treatments (#I000636-017). 23,000 fish were killed in an area below a railroad crossing in West Virginia (#I000925-001).The third incident to affect aquatic organisms (#I004875-001) was a misuse involving drum leaks in Louisiana that released 2,4-D, bromacil, and degreaser into a creek, killing hundreds of fish along 1.6 miles. The remaining eight “highly probably related” 2,4-D incidents affected terrestrial organisms. Two of them were registered uses in California and Idaho. The other six incidents involved four misuses in Iowa, Idaho, and Oregon, and two undetermined uses in Washington and Florida.

Looking at the type of use instead of at the certainty of an incident’s relationship to 2,4-D, 148 of the 386 2,4-D incidents in EIIS involve registered uses of 2,4-D. Six of the 2,4-D registered use incidents were determined to be “unrelated” or “unlikely to be related” to the pesticide. 59 were “possibly related”; 79 were “probably related”; four were “highly probably related”, as mentioned in the paragraph above. Two of the “highly probably related” registered uses affected aquatic organisms in Missouri and West Virginia; two affected terrestrial plants in California and Idaho. One of the “probably related” registered uses affected about 1,000 aquatic organisms in Delaware (#I003601-001). One affected both aquatic and terrestrial organisms in Illinois (#B000150-002). The remaining 77 “probably related” incidents affected terrestrial organisms in KS, TX, WA, FL, NY, IL, MN, MS, WI, IA, ND, OH, NE, MA, SC, VA, MI, NJ, CT, MD, PA, CO, TN, and DE.

d. Estimated and actual concentrations of 2,4-D in water

i. EECs from models

In the draft EFED chapter (Attachment B), 18 aquatic estimated environmental concentrations (EECs) are determined using two models, depending upon the site. GENEEC exposure estimates are used in the first-tier assessment of risk to aquatic organisms. If EECs from GENEEC simulations exceed levels of concern (LOCs), the assessment is refined using the second-tier exposure model, PRZM-EXAMS. As indicated below, GENEEC-derived EECs for 2,4-D exceed LOCs for many aquatic organisms. Therefore, a refined assessment was performed, using PRZM-EXAMS to simulate direct application to major crops.

All of the sites were based on climate and soils relative to the southeastern US, and are not likely to be representative of the western US. Consequently, additional efforts were made to use more recently developed sites to be more representative of the areas where Pacific salmon and steelhead occur. EFED provided western EECs for Oregon wheat, California corn, Oregon apples, and Oregon Filberts (draft EFED chapter). We also requested additional EECs specifically for this assessment so that we could have a better idea of the impact of 2,4-D in the states specific to the salmonids (California, Washington, Idaho, and Oregon), as the draft EFED chapter’s EECs span the nation. Subsequently, EFED prepared a Tier II Aquatic Exposure Assessment (Attachment E) of 2,4-D use on pasture, turf, and wheat in Pacific Northwest states.

Both models assume that an entire 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 of greater water flow. Contaminants in the water column will tend to move downstream and preclude continued exposure from a single application. Multiple applications may provide for chronic exposure, most likely in a pulsed mode. Table 30 contains a summary of EECs for states in the Pacific Northwest.

Table 30. 1 in 10 year estimated environmental concentrations of 2,4-D in the Pacific Northwest (Draft EFED Chapter and Attachment E).

State and Crop	Estimated Environmental Concentration (μg/L)		
	Peak	21 day average	60 day average
California Pasture	23.0	19.7	18.5
Oregon Pasture	23.9	22.4	19.2
Oregon Turf	19.3	18.1	15.6
California Turf	14.2	12.1	9.4
California Wheat	3.7	3.5	3.0
Oregon Wheat	9.0	8.4	7.5
California Corn	9.7	8.8	8.2
Oregon Filberts	8.8	8.1	7.4
Oregon Apples	12.2	11.2	9.9

To calculate a first approximation of an aquatic herbicide EEC, EFED assumed direct application to the standard pond. The model is described in the draft EFED chapter beginning on page 63. The draft EFED chapter states: “EFED developed a simple spreadsheet model that incorporates degradation based on an acceptable aerobic aquatic metabolism study for the EFED standard pond with no flow. Each of the scenarios evaluated includes that assumption that 2,4-D is uniformly applied to the EFED standard pond with a surface area of 1 hectare and a volume of 20,000,000 liters. In this model, the 21-day average and 60-day average concentrations were calculated assuming first-order dissipation from aerobic aquatic degradation."

A main difference in this model is that the target rate for 2,4-D use is based on concentration and not application rate. To account for this scenario, it was assumed that 2,4-D would be applied at a rate to meet the target concentration of 4000 ug/l. According to the draft EFED chapter, the assumption is applicable across all water bodies since the target rate is based on a rate per acre foot of water (10.8 lbs ae/acre foot), making it independent of water body geometry/volume. The draft EFED chapter states: "Modeling for this scenario predicts direct water application of 2,4-D will yield surface water concentrations of 2,4-D in the EFED standard pond of 4000 ug ae/l for peak, 3417 ug ae/l for the 21-day average, and 2610 ug ae/l for the 60-day average." Thus, these are the concentrations that were used to calculate acute and chronic RQs for aquatic organisms exposed to 2,4-D through direct application for aquatic weed control.

The EECs resulting from the use of 2,4-D on rice were determined by using a screening level model developed by EFED. The model assumes uniform application of pesticide to a rice paddy and calculates an EEC in the water column, which is recommended for both acute and chronic exposures from 2,4-D use on rice. The model assumes partitioning of the pesticide between water and the upper 1 cm of sediment but does not include degradation. The model is provided in the draft EFED chapter on page 51.

Modeling a maximum seasonal application rate of 1.5 pounds acid equivalents results in an estimated 2,4-D concentration in the rice paddy of 1431 ug ae/l. The draft EFED chapter states, "this value is expected to represent upper percentile concentrations for edge of paddy concentrations because of the lack of consideration for degradation, dilution and dispersion. However, the exact level of conservativeness has not been fully evaluated in the context of regionally-dependent management practices, pesticide management practices, and universe of pesticide fate properties. Once released from the paddy, the concentrations are expected to decrease due to degradation, dilution and dispersion." Thus, 1431 ug ae/l was used to calculate RQs for aquatic organisms exposed to 2,4-D through application to rice paddies.

ii. Measured residues in the environment

Water quality monitoring data

The draft EFED chapter contains a comprehensive description of 2,4-D residues detected in ground and surface waters from several sources of information. This description begins on page 42. EFED scientists searched several sources for this information, including the USGS National Water Quality Assessment (NAWQA) Program, the EPA STOrage and RETrieval System for Water and Biological Monitoring Data (STORET), the USGS/EPA Pilot Reservoir Monitoring Study, and the USEPA Office of Water National Contaminant Occurrence Database (NCOD). The magnitude and frequency of 2,4-D occurrence in information presented by these sources was evaluated, and annual maximum concentrations and frequencies of detection were determined from each data set.

The following results from EFED's search is presented below:

> "2,4-D was detected in both source and finished ground and surface waters. Maximum concentrations of 2,4-D in the monitoring data reviewed were 58 ug ae/l in finished drinking water from NCOD and 14.8 ug ae/l from NAWQA in groundwater. Although higher concentrations are reported in STORET, the highest value reported is higher than that for any other monitoring data and the lack of documentation of QA/QC in STORET limits the ability to confirm the validity of the measurement. The highest median 2,4-D concentration of 1.18 ug ae/l was derived from finished water samples in the NCOD database. The highest [Time Weighted Annual Mean] concentration was 1.45 ug ae/l from the NAWQA data. It is important to note the [Maximum Contaminant Level] and Maximum Contaminant Level Goal (MCLG) for 2,4-D are both 70 ug ae/l, while the One-Day [Health Advisory] is 1000 ug ae/l and the Ten-Day [Health Advisory] is 300 ug ae/l."

The draft EFED chapter also states:

> "In particular, 2,4-D was detected along the Mississippi River Valley stretching from Louisiana north to Minnesota, in Ohio, Indiana, and Pennsylvania possibly associated with use on corn and wheat, in Florida possibly associated with use on sugarcane, in Washington and Oregon possibly associated with use on wheat, in the Central Valley of California possibly associated with corn, wheat and rice, and scattered locations in Michigan, Texas, Georgia, and Colorado."

It must be noted that the monitoring data available from these sources, while considered high quality, are not targeted to sites and times where 2,4-D 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 2,4-D. It seems likely, but may not be true, that when samples are taken, the highest residues may actually represent peaks that occur in natural waters.

Additional NAWQA monitoring data

Some information on 2,4-D residues in water is available from the USGS NAWQA summary publications for the Hydrologic Study Units (HSUs) contained within the Pacific Northwest (PNW). The PNW states contain 11 HSUs, some of which span into surrounding states. These publications provide information for surface water and groundwater in each HSU, and are available at URL: http://water.usgs.gov/nawqa/nawqasum/.

The results of the studies in each HSU are presented in Table 31. Sample sizes for detection rates are indicated where possible. The publications do not provide exact values of 2,4-D concentrations, so approximate values are presented. In HSUs in which the concentrations are available, all detections occurred at concentrations below the freshwater chronic criterion for protection of aquatic life and the drinking water standard or guideline for 2,4-D. Detection rates in surface waters were varied, and most were below 20%. However, in the Yakima River Basin HSU, 2,4-D was the most frequently detected pesticide, and was frequently detected in mixtures with other pesticides. Concentrations in this HSU did not exceed 1 µg/L, which was also true of most of the detections in the other HSUs in the PNW.

Table 31. Pesticide residues of 2,4-D reported in surface water (SW) and groundwater (GW) in NAWQA summary publications for HSUs contained within Washington, Oregon, Idaho, and California.

HSU	Approximate Conc. in SW (Detection rate)	Approximate Conc. in GW (Detection Rate)	States Included	Circular No.; Years Studied
Central Columbia Plateau	0.01 - 2.0 µg/L (27%)	0.01 - 0.5 µg/L (2%)	WA and ID	1144; 1992-1995
San-Joaquin-Tulare Basin	0.01 - 1.0 µg/L (12%)	Not detected	CA	1159; 1992-1995
Upper Snake River Basin	0.02 - 0.5 µg/L (14%)	0.02 - 2.0 µg/L (1%)	ID and WY	1160; 1992-1995
Willamette Basin	0.01 - 0.5 µg/L (12%)	Not detected	OR	1161; 1991-1995
Nevada Basin and Range	0.05 - 2.0 µg/L (11%)	Not detected	NV and CA	1170; 1992-1996
Sacramento River Basin	0.02 - 2.0 µg/L[1] (17%)	Not detected	CA	1215; 1994-1998
Puget Sound Basin	~0.5 µg/L[2] (0.9%)	Not detected	WA and British Columbia	1216; 1996-1998
Northern Rockies Intermontane Basin	No information[3]	No information[3]	ID, MT, and WA	1235;1999-2001
Great Salt Lake Basins	Detected[4]	Detected[4]	UT, ID, and WY	1236; 1998-2001
Yakima River Basin	0.05 - 0.8 µg/L[5]	No information	WA	1237; 1999-2000

HSU	Approximate Conc. in SW (Detection rate)	Approximate Conc. in GW (Detection Rate)	States Included	Circular No.; Years Studied
Santa Ana Basin	Not detected	Not detected	CA	1238; 1999-2001

[1] n=77 for surface water; n=71 for groundwater
[2] n=115 for surface water, n=77 for groundwater
[3] In general, pesticides were detected in low concentrations in surface and groundwater in this HSU. 2,4-D was not reported as being detected in groundwater or surface water; however, it is unclear whether samples were tested for 2,4-D.
[4] 2,4-D was listed as having been detected, but details about location (ground and/or surface water), detection rate, and concentrations were not provided.
[5] Detection rates were reported for surface waters as 67% in the Yakima River and 59% in its tributaries.

Monitoring data from sites within the PNW

Some monitoring data are available from individual states within the PNW. The California Department of Pesticide Regulation (DPR) maintains a Surface Water Database that contains monitoring information from a variety of studies. This information is available to the public at URL: http://www.cdpr.ca.gov/docs/sw/surfdata.htm. A search of this database on November 3, 2004 resulted in the information provided in Table 32. Residues of 2,4-D were detected in only six of California's counties. The number of detections were varied, ranging from about 5% of samples taken in Merced and Sacramento Counties to nearly 38% in Yolo County. Yolo County also had the highest maximum concentration detected. Most detected concentrations were low in all counties, and only four of the total detections had residue concentrations greater than 1µg/L.

Table 32. California DPR database pesticide residue concentrations for surface waters (1990-2003).

County	Total No. Samples	Total No. Detects	Max. Detected Concentration (ug/L)	No. Samples with Conc. >1 ug/L
Colusa	15	5	0.73	0
Merced	39	2	1.2	1
Sacramento	189	10	1.39	1
Stanislaus	20	2	0.26	0
Sutter	49	7	0.3	0
Yolo	37	14	2.78	2

The Washington State Department of Ecology (WSDE) has a program that monitors pesticides in surface waters. Samples are taken at intervals during spring, summer, and fall, and the sampling sites change yearly. The latest available report contains data collected biweekly at two urban streams in Kirkland and Olympia, Washington in 1997 (WSDE, 1997). 2,4-D was among the most frequently detected herbicide, and was found in nearly every sample (9 out of 10) taken at the Kirkland site. 2,4-D was found in three of 10 samples from the Olympia site. None of the positive detects had concentrations exceeding water quality criteria, and concentrations of all samples were very low (ranging from 0.0057 [estimated value] to 0.17 µg/L).

The report also contains information from previous monitoring studies conducted from 1992 through 1996 at other locations around the state. In 1992, 2,4-D was detected in four out of six sites (concentrations: 0.055 - 0.98 µg/L). In 1993, samples were taken four times at nine sites, and 2,4-D was detected in 11 out of 36 samples (concentrations: 0.024 - 0.34 µg/L). Three sites monitored in this year had no detections of 2,4-D. In 1994, samples were taken three times from eight sites, and 2,4-D was detected in nine out of 24 samples (concentrations: 0.014 - 0.22 µg/L). 2,4-D was detected in only half of these sites. In 1995, samples were taken four times from eight sites, and 2,4-D was detected in 26 out of 32 samples (concentrations: 0.003 [estimated concentration] - 0.93 µg/L). In this year, five sites had positive detections in every sample, and no sites had no detections of 2,4-D. In 1996, three samples were taken from eight sites, and 2,4-D was detected in 19 of the 24 samples (concentrations: 0.007 [estimated concentration] - 0.78 µg/L). In this year, five sites had positive detections in every sample, and one site had no detections. In the studies from all of these years, none of the residues detected at the study sites exceeded water quality criteria.

National Pollutant Discharge Elimination System (NPDES) permits must be issued for direct applications of 2,4-D to water in Washington. Washington State Department of Ecology requires monitoring of 2,4-D residues in treated waters and posts the data online (WSDE, 2004). Data are available for monitoring efforts on seven lakes in which samples were taken at one and three days post-application both inside and outside the treatment area.

Lake Sacheen in Pend Oreille County was treated with Aqua-Kleen in 2002, Aqua-Kleen and DMA*4IVM in 2003, and DMA*4IVM in 2004. In 2002, samples were collected inside and outside the treatment areas at one and three days post-treatment. Concentrations at one and three days post-application did not exceed 66.8 ppb, which was the amount detected 200 feet outside the treated area on Day 1. Concentrations were less on Day 3, with the highest detected inside the treated area at 36.9 ppb. In 2003, residue concentrations were highest on Day 1 at 44.8 ppb, and lowest on Day 3 inside the treated area at 3.4 ppb. In 2004, residues were much higher, and exceeded the EPA standard for drinking water (70 ppb). The highest concentration was 488 ppb, which occurred on Day 1 within the treated area. The lowest concentration was detected 10 days post-application inside the treated area, at a concentration of 77.5 ppb.

Steel Lake, located in King County, was treated and monitored in 2002 with Aqua-Kleen and in 2004 with DMA*4IVM. Residues in 2002 were lowest on Day 1 outside the treated area

(13.1 ppb) and highest on Day 4 inside the treated area (33.1 ppb). In 2004, residues were higher overall with the lowest post-application concentration detected at 68.4 ppb on Day 1 inside the treatment area and the highest detected inside the treatment area at 87.3 ppb.

Newman Lake, located near Spokane, WA, was treated in Summer and Fall 2003 with Aqua-Kleen. Following the summer treatment, residues were detected at levels between 19.9 ppb (on Day 1 outside the treatment area) and 111 ppb (on Day 3 inside the treatment area). After the fall treatment, residues were 1.1 ppb (taken Day 3 at the water's surface) and 24.0 ppb (taken Day 3 one foot above the lake bottom).

Diamond Lake, Spring Lake, and Washington Lake (at Hunt's Point) were treated in 2003 with Aqua-Kleen, DMA*4IVM, and Aqua-Kleen + DMA*4IVM, respectively. In Diamond Lake, 2,4-D residues ranged from 1.1 ppb (Day 1, outside the treatment area) to 72.4 ppb (Day 1, inside the treatment area). Spring Lake residues ranged from 0.545 ppb 49 days after treatment to 158 ppb at 35 days post-treatment to 405 ppb at five days post-application. All of these samples were taken outside the treatment area. At Hunt's Point, residues ranged from 38.6 ppb on Day 5 and 1,570 ppb on Day 1. An additional site, Liberty Lake, was monitored in 2004 following applications of Navigate. Residues ranged from 4.8 ppb on Day 3 post-treatment 43.7 ppb. Both of these concentrations were measured inside the treatment area.

According to the draft EFED chapter (page 3), direct application of 2,4-D to water for control of aquatic weeds presents the greatest potential risk to aquatic organisms. The applications made above were to slow-moving waters, but monitoring in streams draining the lake was not performed. Although the above concentrations may exceed guidelines for protection of aquatic life, it is not known how the residues above may have affected aquatic life downstream.

iii. Targeted studies

The draft EFED chapter states that there have been no targeted studies of 2,4-D. However, it states on page 41 that a number of modeling approaches were used to provide estimated exposure concentrations (EECs) for drinking water. The highest exposure scenario is the direct application of 2,4-D to surface water bodies for the control of aquatic weeds with an EEC of 4000 ug ae/l for peak (acute) exposure and 627 ug ae/l for the annual mean (chronic) exposure. 2,4-D is regulated under the Safe Drinking Water Act (SDWA) and has a Maximum Contaminant Level (MCL) of 70 ug ae/l, a One-Day Health Advisory (HA) for children of 1000 ug ae/l, and a Ten-Day HA for children of 300 ug ae/l. Although of high quality, EFED deemed this monitoring data to be non-targeted to 2,4-D use. However, the data provide context to model results and indicate that there is little evidence that concentrations are likely to be found exceeding these standards.

e. Water quality criteria

EPA's Office of Water (OW) has established a one-day Health Advisory (HA) Level of

1,000 ppb, a 10-day HA of 300 ppb, and a lifetime HA of 70 ppb. The Maximum Contaminant Level and Maximum Contaminant Level Goal are also 70 ppb. Drinking water concentrations for ground water were estimated after considering model estimates from the Tier 1 SCI-GROW model and ground-water monitoring data. Drinking water concentrations for surface water were estimated after considering the Tier 2 PRZM/EXAMS surface water model estimates and limited targeted surface water monitoring data. Please see the draft EFED chapter for a complete discussion of the ground and surface water monitoring studies.

f. Recent changes in pesticide registrations

Both the RED and the master label for 2,4-D are currently under development. Once the master label is complete, it will be applied to all 2,4-D labels that are in use. After this has occurred, the changes that take place can be assessed.

g. Existing protections

The current master label for the nine forms of 2,4-D (2,4-D acid, 2,4-D dimethylamine salt, 2,4-D 2-ethylhexyl ester, 2,4-D triisopropanolamine salt, 2,4-D isopropylamine salt, 2,4-D 2-butoxyethyl ester, 2,4-D diethanolamine salt, 2,4-D isopropyl ester, and 2,4-D sodium salt) does not include precautionary environmental label statements, but these can be found on some labels for 2,4-D formulated products. The following are protections statements taken from the representative label EPA Reg. No. 2217-703; no endorsement is implied (Attachment F):

> "This product is toxic to aquatic invertebrates. Drift or runoff may adversely affect aquatic invertebrates and nontarget plants. 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 washwater.
>
> "Most cases of groundwater contamination involving phenoxy herbicides such as 2,4-D have been associated with mixing/loading and disposal sites. Caution should be exercised when handling 2,4-D pesticides at such sites to prevent contamination of groundwater supplies. Use of closed systems for mixing or transferring this pesticide will reduce the probability of spills. Placement of the mixing/loading equipment on an impervious pad to contain spills will help prevent groundwater contamination."

Other 2,4-D labels have similar statements, but there is minor variation depending upon the age of the label and the usage of the chemical.

We searched the biological opinions of the US Fish & Wildlife Service for jeopardy determinations and existing protections concerning 2,4-D and aquatic species and found none. Further searches for 2,4-D-related usage or limitation data have not yielded any more information.

California 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. 2,4-D is currently included in these bulletins for the protection of aquatic organisms. The specific limitations are:

> #11: Do not use in currently occupied habitat except: (1) as specified in Habitat Descriptors, (2) in organized habitat recovery programs, or (3) for selective control of invasive exotic plants.
>
> #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.

Regulations exist limiting the use of phenoxy herbicides in Groundwater Protection Areas (GWPAs), on timberland, and in other portions of California (3 CCR Div. 6, Ch. 2, Subch. 4, Sec. 6443, 6464, 6487). However, GWPAs are not generally found near salmon and steelhead ESUs. Other use limitation areas include canals, ditch banks, and artificial recharge basins, all below the high water line, and large areas of California below 1,000 feet of elevation. Use limitations include the prohibition of herbicide esters, aircraft applications, application near vineyards or cotton plantings, and application under low or strong winds, depending on time of year (3 CCR Div. 6, Ch. 2, Subch. 4, Sec. 6464, 6487). These limitations may reduce the potential for exposure in salmon and steelhead ESUs of California.

OPP currently has proposed a final implementation program (67 *Federal Register* 231, 71549-71561, December 2, 2002) that includes labeling products to require pesticide applicators to follow provisions in county bulletins. The comment period has closed, and 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 products 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 measures necessary to protect T&E salmon and steelhead from 2,4-D would most likely be promulgated through this system.

The following are protections developed for 2,4-D found in county bulletins in reference to endangered plants:

> #28: Do not apply within 100 yards of species habitat for aerial applications or within 20 yards of species habitat for ground applications.

> #29: Do not apply this pesticide in the species habitat (described under the shading key). For ground applications do not apply within 20 yards of the habitat, nor within 100 yards for aerial applications.

Agricultural and other commercial applicators are well sensitized to the need for protecting endangered and threatened species. DPR believes that the vast majority of agricultural applicators in California are following the limitations in these bulletins (Marovich, 2002).

h. Discussion and general risk conclusion for 2,4-D

Acid and amine salt forms of 2,4-D are "practically non-toxic" to “slightly toxic,” while ester forms of 2,4-D are “slightly toxic” to “highly toxic” to freshwater, marine, and estuarine fish. Some forms of 2,4-D may lead to adverse acute and chronic effects in these organisms. Estimated environmental concentrations suggest that levels of concern for acute toxicity to freshwater fish are exceeded only at the highest use rate. Other data suggest the potential for indirect effects to freshwater fish from 2,4-D exposure. Some esters are “moderately toxic” to freshwater invertebrates, which may be sources of food for salmonids. However, all forms of 2,4-D that were tested had relatively high toxicity to *Lemna gibba*. For example, the EC50/LOEC for 2,4-D acid in *Lemna* were 0.695/0.0581 mg a.e./L (see Table 15). Adverse effects on vascular plants could lead to loss of cover for salmonid adults and young.

As discussed in section 3d, EECs were requested for specific crops in the ESUs. Tier II PRZM/EXAMS modeling was conducted to estimate the impacts of runoff and spray drift of 2,4-D from a 10 ha field on estimated EECs in a small, static water body (Attachment E). Table 33 is based on these EECs for several crops in California and in the Pacific Northwest. Contained in the tables are the acute and chronic Risk Quotients (RQ). This table is for 2,4-D acids, amines and salts - esters are excluded. Although esters are known to be more toxic than acids, the application rates of esters are lower than those of acids. Therefore, the RQ values from esters are comparable to the RQ values from acids.

Table 33. Aquatic organism risk quotient calculations for 2,4-D acid and amine salts (Attachment E). [1]

Scenario	**Peak Water Concentration (mg ae/L)**	**21-day Average Water Concentration (mg ae/L)**	**60-day Average Water Concentration (mg ae/L)**	**Acute RQ**	**Chronic RQ**
Pasture - California (2.88lbai/acre, 4 applications)					
Estuarine Fish	0.023			0.00013	
Freshwater Fish	0.023		0.0185	0.00023	0.0013
Estuarine Invertebrates	0.023			0.00015	
Freshwater Invertebrates	0.023	0.0197		0.00092	0.00120
Freshwater Vascular Plants	0.023			0.077	
Pasture - Oregon (2.88lbai/acre, 2 applications)					
Estuarine Fish	0.0239			0.000014	
Freshwater Fish	0.0239		0.0192	0.00024	0.00135
Estuarine Invertebrates	0.0239			0.00016	
Freshwater Invertebrates	0.0239	0.0224		0.00096	0.00137
Freshwater Vascular Plants	0.0239			0.07967	
Turf - Oregon (2.85lbai/acre, 2 applications)					
Estuarine Fish	0.0193			0.00011	
Freshwater Fish	0.0193		0.0156	0.00019	0.0011
Estuarine Invertebrates/	0.0193			0.00013	
Freshwater Invertebrates	0.0193	0.0181		0.00077	0.0011
Freshwater Vascular Plants	0.0193			0.0643	
Turf - California (2.85lb/acre, 2 applications)					
Estuarine Fish	0.0142			0.00008	

Scenario	Peak Water Concentration (mg ae/L)	21-day Average Water Concentration (mg ae/L)	60-day Average Water Concentration (mg ae/L)	Acute RQ	Chronic RQ
Freshwater Fish	0.0142		0.0094	0.00014	0.00066
Estuarine Invertebrates	0.0142			0.000093	
Freshwater Invertebrates	0.0142	0.0121		0.00057	0.00074
Freshwater Vascular Plants	0.0142			0.0473	
Wheat - California (2.88lbai/acre, 1 application)					
Estuarine Fish	0.0037			0.00002	
Freshwater Fish	0.0037		0.003	0.00004	0.00021
Estuarine Invertebrates	0.0037			0.000024	
Freshwater Invertebrates	0.0037	0.0035		0.00015	0.00021
Freshwater Vascular Plants	0.0037			0.0123	
Wheat - Oregon (1.25lbai/acre, 1 application)					
Estuarine Fish	0.009			0.00005	
Freshwater Fish	0.009		0.0075	0.00009	0.00053
Estuarine Invertebrates	0.009			0.000059	
Freshwater Invertebrates	0.009	0.0084		0.00036	0.00051
Freshwater Vascular Plants	0.009			0.03	
Corn - California (1.0lbai/acre, 3 applications)					
Estuarine Fish	0.0097			0.00006	
Freshwater Fish	0.0097		0.0082	0.0001	0.00058
Estuarine Invertebrates	0.0097			0.000064	

Scenario	Peak Water Concentration (mg ae/L)	21-day Average Water Concentration (mg ae/L)	60-day Average Water Concentration (mg ae/L)	Acute RQ	Chronic RQ
Freshwater Invertebrates	0.0097	0.0088		0.00039	0.00054
Freshwater Vascular Plants	0.0097			0.0323	
Filberts - Oregon (1lbai/acre, 4 applications)					
Estuarine Fish	0.0088			0.00005	
Freshwater Fish	0.0088		0.0074	0.00009	0.00052
Estuarine Invertebrates	0.0088			0.000058	
Freshwater Invertebrates	0.0088	0.0081		0.00035	0.00049
Freshwater Vascular Plants	0.0088			0.0293	
Apples - Oregon (2lbai/acre, 2 applications)					
Estuarine Fish	0.0122			0.00007	
Freshwater Fish	0.0122		0.009	0.00012	0.00070
Estuarine Invertebrates	0.0122			0.00008	
Freshwater Invertebrates	0.0122	0.0112		0.00049	0.00068
Freshwater Vascular Plants	0.0122			0.0407	

[1] Based on fish LC50 (Bluegill sunfish) of 101 ppm, invertebrate LC50 (waterflea) of 25 ppm, estuarine fish LC50 (Silverside) of 175 ppm, estuarine invertebrate LC50 (mysid) of 152.7 ppm, plant LC50 (duckweed) of 0.30 ppm, chronic invertebrate NOEC (waterflea) of 16.1 ppm, chronic fish NOEC (Rainbow trout) of 14.2 ppm. Acute RQ = peak EEC/LC50; chronic invertebrate RQ = 21-day EEC/invertebrate NOEC; chronic fish RQ = 60-day EEC/chronic fish NOEC. Application rates are listed in Attachment E.

Fish

The acute RQ for direct effects to endangered species is calculated by dividing the concentration of the peak EEC by the LC50 of the most sensitive fish. If the acute RQ is greater than 0.05, then there is a risk for the endangered salmonids. Using 101 ppm as the LC50 for the most sensitive freshwater fish, the LOC for direct acute effects for endangered species would be exceeded when 2,4-D concentrations in water exceed 5.05 ppm. However, all of the acute RQ values are significantly lower than 0.05. Therefore, none of the above crop scenarios lead to an acute risk for salmonids. Chronic risk for an endangered species is exceeded if the 60-day EEC/chronic fish NOEC exceeds 1. None of the chronic RQ values approach 1; therefore, 2,4-D does not present a chronic risk to endangered fish.

Invertebrates

Aquatic invertebrates, which may serve as a food source for threatened and endangered fish, are more sensitive than fish, with a *Daphnia magna* LC50 of 25 ppm and a chronic NOEC at 16.4 ppm. The acute RQ for invertebrates (Peak EEC/LC50 of most sensitive invertebrate) poses a risk if it exceeds 0.5, and the chronic RQ for invertebrates (21-day EEC/chronic invertebrate NOEC) exceeds 1. For all of the crop scenarios modeled above, the acute RQ values are well below 0.5, and the chronic RQ values are well below 1, posing little risk to the invertebrates. There are no indirect effects on salmonids through loss of their food supply for agricultural uses.

Plants

Plants may serve as both a food source and as cover to salmonids, and are especially vulnerable to the herbicide 2,4-D. For duckweed (*Lemna gibba*), the LC50 of 0.30 ppm is more sensitive than that of the fish and invertebrates. However, in order to conclude a risk to aquatic plants, the RQ (peak EEC/LC50) must equal or exceed 1. All of the acute RQ values for *Lemna* from the crop scenarios listed in the table above are below 1, eliminating the risk. There are no indirect effects on salmonids through loss of cover for agricultural uses

Conclusions

Although 2,4-D is known to be toxic to plants, fish, and invertebrates, the usage scenarios of 2,4-D that were modeled did not produce RQ values that exceeded LOCs for any organisms. Therefore, the agricultural uses of 2,4-D do not present direct or indirect effects to endangered and threatened Pacific salmonids.

Risks From Aquatic Weed and Rice Uses

Table 34 lists the RQs resulting from applications to rice patties and for aquatic weed control for use in our assessment.

Table 34. Aquatic organism risk quotient calculations for 2,4-D rice applications and aquatic weed control (EFED Consultation).

Scenario	Peak Water Concentration (mg ae/L)	Acute RQ	Chronic RQ
Rice - 2,4-D acid and amine salts (1.5 lb ae/A, 1 application)			
Freshwater Fish	1.431	0.01	0.10
Estuarine Fish	1.431	0.01	–
Freshwater Invertebrates	1.431	0.06	0.09
Estuarine Invertebrates	1.431	0.03	–
Aquatic Vascular Plants	1.431	4.77*	–
Aquatic Weed Control - 2,4-D acid and amine salts (10.8 lb ae/acre foot)			
Freshwater Fish	4.000	0.04	0.28
Estuarine Fish	4.000	0.02	–
Freshwater Invertebrates	4.000	0.16	0.24
Estuarine Invertebrates	4.000	0.08	–
Aquatic Vascular Plants	4.000	13.33*	–
Aquatic Weed Control - 2,4-D BEE (10.8 lb ae/acre foot)			
Freshwater Fish	4.000	9.30*	43.50**
Estuarine Fish	4.000	–	43.50**
Freshwater Invertebrates	4.000	0.81*	13.05**
Estuarine Invertebrates	4.000	–	–
Aquatic Vascular Plants	4.000	10.00*	–

* exceeds Acute Risk LOC
** exceeds Chronic LOC

With applications of 2,4-D acid and amine salts to rice paddies, the endangered species acute LOC is exceeded for freshwater invertebrates and vascular plants. Since we are only considering endangered species LOCs for salmonids, exceedence of endangered species LOCs for freshwater invertebrates and vascular plants are not significant to this analysis. However, because the acute LOC is also exceeded for aquatic vascular plants, these results indicate that 2,4-D applications to rice may indirectly impact salmonids by reducing cover.

Runoff from rice fields may be prevented, restricted or diverted, allowing sufficient time for overall degradation of 2,4-D in the field before it enters waterways with salmonid habitat. However, because no 2,4-D runoff restrictions exist, we must assume that the 2,4-D applied to rice crops enters nearby waterways with salmonid habitat in each ESU where rice is grown. Therefore, the abovementioned risk of indirect effects on salmonids from 2,4-D applications to rice is valid.

With direct application of 2,4-D acid and amine salts to water for aquatic weed control, the restricted use acute LOC is exceeded for freshwater invertebrates. Endangered species acute LOCs were exceeded for aquatic plants and estuarine invertebrates, but these are also not of concern in this analysis. However, this use may be detrimental to threatened and endangered salmonids because acute LOCs were exceeded for aquatic vascular plants. Loss of these organisms may reduce cover for salmonids.

The greatest effects to salmonids are realized with the direct application of 2,4-D BEE to water for aquatic weed control. This use results in concentrations of 2,4-D BEE that exceed the acute LOC for freshwater fish and the chronic LOCs for freshwater and estuarine fish. These results indicate that threatened and endangered salmonids may be directly affected by these applications of 2,4-D. Indirect effects may also occur, since the acute and chronic LOCs were exceeded for freshwater invertebrates, and the acute LOC was exceeded for aquatic vascular plants. These results imply that indirect effects to fish may occur through the loss of cover and food resources.

4. Description of Pacific salmon and steelhead Evolutionarily Significant Units (ESU) relative to 2,4-D use sites

Please note that OPP will be transmitting a separate analysis of ESU locations and their critical habitat to NMFS. We have noted this in previous consultation requests, but this process is taking somewhat longer than anticipated. This analysis will include what we perceive to be the most appropriate boundaries for designated critical habitat. We will be requesting comments from NMFS on the counties to be included. Depending upon NMFS comments, we will make any corrections and then will compare the results with those consultation packages previously transmitted. We do not believe that any corrections will materially change the risk assessments. However, adjustments may result in changes on where protective measures need to be taken after consultation is completed. We are not asking for comments on ESU locations as part of this particular package.

The following subsections contain descriptions of each ESU for each species. 2,4-D usage information is only provided for the four ESUs in California in which rice is grown. No other uses, except aquatic weed control, had the potential to affect threatened and endangered salmonids in the Pacific Northwest and California. Usage information is not available for applications of 2,4-D for aquatic weed control, so this information cannot be presented.

(a) Chinook salmon

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.

Coast wide, 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 as far north as 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 included within this ESU are Humboldt, Trinity, Mendocino, Sonoma, and Marin. A small portion of Glenn County is also included in the Critical Habitat. A small portion of Lake

County contains habitat for this ESU, but is entirely within the Mendocino National Forest.

Table 35 shows the cropping information for rice grown in Glenn County, which is partially contained in the California Coastal Chinook Salmon ESU. 2,4-D applications account for only 0.04% of the acreage within this ESU, which has 9,647,730 acres.

Table 35. Usage of 2,4-D on rice in counties located within the California Coastal Chinook Salmon ESU.

County	Total Acres in County	Total Acres Treated	Percent Treated	No. of Applications	Total Lbs. 2,4-D Used
Glenn	849,369	4,661	0.5	68	2,302

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Furthermore, rice crops in the counties of this ESU may not drain into or be found near the waterways that T&E salmonids use. Regardless of the above observations, we do not have rice crop usage data on a smaller scale than the county level, nor do we have aquatic weed control usage data on a county-level or smaller scale. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D on rice is predicted to pose risk to aquatic plants, which leads to a loss of cover for T&E salmonids. While the amount of 2,4-D applied in this ESU is small, as well as the amount of area treated, the possibility remains of indirect effects on salmonids. Therefore, we conclude that 2,4-D use on rice may effect, but is not likely to adversely effect T&E salmonids in this ESU.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(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 downstream 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. Salmon and steelhead habitat are located 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.

Table 36 shows the cropping information for rice grown in California counties where the Central Valley Spring-run Chinook Salmon ESU is located. Only 0.4% of the acreage within this ESU receives 2,4-D applications.

Table 36. Usage of 2,4-D on rice in counties located within the Central Valley Spring-Run Chinook Salmon ESU.

County	Total Acres in County	Total Acres Treated	Percent Treated	No. of Applications	Total Lbs. 2,4-D Used
Butte	1,073,338	6,857	0.6	106	1,915
Colusa	739,987	506	0.07	6	221
Glenn	849,369	4,661	0.5	68	2,302
Placer	960,089	2,305	0.2	39	618
Sacramento	637,114	270	0.04	4	120
Sutter	389,635	6,782	1.7	100	7,446
Yuba	411,843	1,418	0.3	36	423
TOTALS[1]	**5,910,742**	**22,799**	**0.4**	**359**	**13,045**

1. Totals are across the entire ESU, which contains more counties than are listed here.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Furthermore, rice crops in the counties of this ESU may not drain into or be found near the waterways that T&E salmonids use. Regardless of the above observations, we do not have rice crop usage data on a smaller scale than the county level, nor do we have aquatic weed control usage data on a county-level or smaller scale. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D on rice is predicted to pose risk to aquatic plants, which leads to a loss of cover for T&E salmonids. While the amount of 2,4-D applied in this ESU is small, as well as the amount of area treated, the possibility remains of indirect effects on salmonids. Therefore, we conclude that 2,4-D use on rice may effect, but is not likely to adversely effect T&E salmonids in this ESU.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this 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 River 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. Salmon habitat is located in the counties of Hood River, Wasco, Clatsop, Columbia, Clackamas, Marion, Multnomah, and Washington in Oregon, and Klickitat, Skamania, Clark, Cowlitz, Lewis, Wahkiakum, Pierce, and Pacific in Washington.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this 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.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in 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 (including Santa Clara County) are excluded (58FR33212-33219, June 16, 1993). Counties containing habitat include Alameda, Butte, Colusa, Contra Costa, Glenn, Marin, Sacramento, San Francisco, San Mateo, Shasta, Solano, Sonoma, Sutter, Tehama, and Yolo. Spawning and growth habitat are also located in Shasta and Tehama counties.

Table 37 shows the cropping information for rice grown in California counties where the Sacramento River Winter-run Chinook Salmon ESU is located. Only 0.4% of the acreage within this ESU receives 2,4-D applications.

Table 37. Usage of 2,4-D on rice in counties located within the Sacramento River Winter-Run Chinook ESU.

County	Total Acres in County	Total Acres Treated	Percent Treated	No. of Applications	Total Lbs. 2,4-D Used
Butte	1,073,338	6,857	0.6	106	1,915
Colusa	739,987	506	0.07	6	221
Glenn	849,369	4,661	0.5	68	2,302
Sacramento	637,114	270	0.04	4	120
Sutter	389,635	6,782	1.7	100	7,446
TOTALS[1]	**4,538,810**	**19,076**	**0.4**	**284**	**12,004**

[1] Totals are across the entire ESU, which contains more counties than are listed here.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Furthermore, rice crops in the counties of this ESU may not drain into or be found near the waterways that T&E salmonids use. Regardless of the above observations, we do not have rice crop usage data on a smaller scale than the county level, nor do we have aquatic weed control usage data on a county-level or smaller scale. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D on rice is predicted to pose risk to aquatic plants, which leads to a loss of cover for T&E salmonids. While the amount of 2,4-D applied in this ESU is small, as well as the amount of area treated, the possibility remains of indirect effects on salmonids. Therefore, we conclude that 2,4-D use on rice may effect, but is not likely to adversely effect T&E salmonids in this ESU.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this 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 years, 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.

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. The proposed revision of the ESU adds the Lower Deschutes, Trout, Lower John Day, Upper John Day, North Fork - John Day, Middle Fork - John Day, Willow, Umatilla, and Walla Walla hydrologic units. It appears that no additions have been proposed for Washington tributaries to the Columbia River. In this ESU, spawning and growth habitat are located in Idaho in Adams, Benewah, Clearwater, Idaho, Latah, Lewis, Nez Perce, Shoshone, and Valley counties; in Washington state in Adams, Asotin, Columbia, Franklin, Garfield, Lincoln, Spokane, Walla Walla, and Whitman counties; and in Oregon in Union and Wallowa counties. Migration corridors are located in Washington in Benton, Clark, Cowlitz, Klickitat, Pacific, Skamania, Wahkiakum, and Walla Walla counties; and in Oregon in Clatsop, Columbia, Gilliam, Hood River, Morrow, Multnomah, Sherman, Umatilla, and Wasco counties.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in 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, Pashimerol, 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 in the Critical Habitat Notice.

Spawning and rearing counties include Union, Wallowa, and Baker counties in Oregon;

Adams, Custer, Idaho, Lemhi, Lewis, Nez Perce, and Valley counties in Idaho; and Asotin, Columbia, Franklin, Garfield, and Whitman counties in Washington. Other counties within migratory corridors are all of those down stream from the confluence of the Snake and Columbia Rivers: Umatilla, Morrow, Gilliam, Sherman, Wasco, Hood River, Multnomah, Columbia, and Clatsop Counties in Oregon; and Klickitat, Skamania, Clark, Cowlitz, Wahkiakum, Benton, and Walla Walla Counties in Washington. Salmon habitat is also located in Blaine County in Idaho.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in 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 spawning and rearing occur are Chelan, Douglas, Okanogan, Grant, Benton, and Kittitas Counties in Washington.. Migratory corridors include Clatsop, Columbia, Gilliam, Hood River, Morrow, Multnomah, Sherman, Umatilla, and Wasco Counties in Oregon; and Clark, Cowlitz, Franklin, Klickitat, Pacific, Skamania, Wahkiakum, Walla Walla, and Yakima Counties in Washington.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in 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. Spawning and rearing habitat is in the Oregon counties of Clackamas, Douglas, Lane, Benton, Linn, Polk, Marion, Yamhill, and Washington. Migration corridors include Multnomah, Columbia, and Clatsop Counties in Oregon, and Clark, Cowlitz, Wahkiakum, and Pacific Counties in Washington. Other habitat is located in Lincoln and Tillamook Counties in Oregon.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in 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 at 4, 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 to 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 winter runs occur in two rivers in southern Puget Sound.

Redds are usually dug in the mainstream or in side channels of rivers. Juveniles migrate out 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.

(1) 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 (65FR7764-7787).

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, and Lower Willamette in the counties of Clark, Skamania, Cowlitz, Wahkiakum, Pacific, and Lewis in Washington; and Multnomah, Clatsop, Columbia, and Washington in Oregon. It appears that there are three extant populations in Grays River, Hardy Creek, and Hamilton Creek.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(2) 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, Island, and Grays Harbor. Grays Harbor County was excluded because the very small amount of habitat is within the Olympic National Forest. 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.’

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect

T&E salmonids in 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 migrate 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.

(1) 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, therefore it is excluded.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(2) 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 Josephine, Douglas, Lane, Coos, Curry, Benton, Lincoln, Polk, Tillamook, Yamhill, Washington, Columbia, and Clatsop.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(3) 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.

Note: We previously included Klamath County, OR in this ESU, but have now omitted it because it appears to be entirely upstream of various named barriers. Again we will submit more details in a separate transmittal to NMFS.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in 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 that 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.

(1) 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.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(2) 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. These habitats are in Custer and Blaine counties in Idaho. Migration corridors occur in the counties of Asotin, Benton, Clark, Columbia, Cowlitz, Franklin, Farfield, Klickitat, Pacific, Skamania, Wahkiakum, Walla, Walla, and Whitman in Washington; Clatsop, Columbia, Gilliam, Hood River, Morrow, Multnomah, Sherman, Umatilla, Wallowa, and Wasco in Oregon; and Lewis, Idaho, Lemhi, and Nez Perce in Idaho.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(e) 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 (spawning beds) 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.

(1) 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). Affected counties include Alameda, Contra Costa, Marin, Mendocino, Napa, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, and Sonoma.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(2) 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. Usage of 2,4-D in counties where the California Central Valley Steelhead ESU occurs is presented in Table 38. Only 0.3% of the acreage within this ESU receives 2,4-D applications.

Table 38. Usage of 2,4-D on rice in counties located within the California Central Valley Steelhead ESU.

County	Total Acres in County	Total Acres Treated	Percent Treated	No. of Applications	Total Lbs. 2,4-D Used
Butte	1,073,338	6,857	0.6	106	1,915
Colusa	739,987	506	0.07	6	221
Glenn	849,369	4,661	0.5	68	2,302
Merced	1,261,957	1,357	0.1	14	766
Placer	960,089	2,305	0.2	39	618
Sacramento	637,114	270	0.04	4	120
Sutter	389,635	6,782	1.7	100	7,446
Yuba	411,843	1,418	0.3	36	423
TOTALS[1]	**7,172,699**	**24,156**	**0.3**	**373**	**13,811**

1. Totals are across the entire ESU, which contains more counties than are listed here.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Furthermore, rice crops in the counties of this ESU may not drain into or be found near the waterways that T&E salmonids use. Regardless of the above observations, we do not have rice crop usage data on a smaller scale than the county level, nor do we have aquatic weed control usage data on a county-level or smaller scale. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D on rice is predicted to pose risk to aquatic plants, which leads to a loss of cover for T&E salmonids. While the amount of 2,4-D applied in this ESU is small, as well as the amount of area treated, the possibility remains of indirect effects on salmonids. Therefore, we conclude that 2,4-D use on rice may effect, but is not likely to adversely effect T&E salmonids in this ESU.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(3) 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. If not, the spawning and rearing habitat would occur in Hood River, Clackamas, and Multnomah counties in Oregon, and Skamania, Clark, and Cowlitz 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, they do not appear part of the spawning and rearing habitat for this steelhead ESU. The mainstem of the Columbia River from the mouth to Hood River constitutes the migration corridor. This would additionally include Columbia and Clatsop counties, Oregon, and Pacific and Wahkiakum counties, Washington. Other habitat is located in Lewis County, Washington and in Marion and Washington Counties in Oregon.

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.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(4) 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.

The Oregon counties then that appear to have spawning and rearing habitat are Gilliam, Morrow, Umatilla, Sherman, Wasco, Crook, Grant, Wheeler, and Jefferson counties in Oregon. Washington counties providing spawning and rearing habitat include Columbia, Benton, Franklin, Kittitas, Klickitat, Skamania, Walla Walla, and Yakima. Only small portions of Franklin and Skamania Counties intersect with the spawning and rearing habitat of this ESU.

Migratory corridors include Hood River, Multnomah, Columbia, and Clatsop counties in Oregon, and Skamania, Clark, Cowlitz, Wahkiakum, and Pacific Counties in Washington. Additional habitat is located in Wallowa, Harney, and Union Counties in Oregon.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(5) 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, and Lake.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(6) 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. These areas include the counties of Wallowa and Union; Asotin, Garfield, Columbia, Whitman, Franklin, Adams, and Walla Walla in Washington; and Adams, Idaho, Nez Perce, Custer, Lemhi, Valley, Lewis, Clearwater, and Latah in Idaho.

Note: We are uncertain about the inclusion of Adams, Lincoln and Spokane counties in Washington in this ESU. They are not named in the Critical Habitat FR Notice, but they appear to include waters in the listed hydrologic unit. We have included them below, but will be seeking NMFS guidance in a separate request.

Critical Habitat also includes the migratory corridors of the Columbia River from the confluence of the Snake River to the Pacific Ocean. Additional counties in the migratory corridors are Umatilla, Gilliam, Morrow, Sherman, Wasco, Hood River, Multnomah, Columbia, and Clatsop in Oregon; and Walla Walla, Benton, Klickitat, Skamania, Clark, Cowlitz, Wahkiakum, and Pacific in Washington. Other habitat is included in Blaine and Boise Counties in Idaho, and Baker County, Oregon.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(7) 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.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(8) 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). 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.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(9) 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), Oanogan, Similkameen, Methow, Upper Columbia-Entiat, Wenatchee, Moses-Coulee, and Upper Columbia-Priest Rapids. Within the spawning and rearing areas, counties are Chelan, Douglas, Okanogan, Grant, Benton, Franklin, Kittitas, and Yakima, all in Washington.

Note: Adams County, WA was not one of the counties named in the critical habitat FR Notice, but appears to be included in a hydrologic unit named in that notice. We have included it here, but seek NMFS guidance for future efforts.

Areas downstream from the Yakima River are used for migration. Additional counties through which the ESU migrates are Walla Walla, Klickitat, Skamania, Clark, Cowlitz, Wahkiakum, and Pacific in Washington; and Gilliam, Morrow, Sherman, Umatilla, Wasco, Hood River, Multnomah, Columbia, and Clatsop in Oregon. Other habitat is located in Columbia County in Washington.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

(10) 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. This includes most of Benton, Linn, Polk, Clackamas, Marion, Yamhill, and Washington counties.

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, and include Multnomah, Columbia, and Clatsop counties in Oregon and Clark, Cowlitz, Wahkiakum, and Pacific counties in Washington. Other habitat is located in Columbia County in Washington and in Lincoln and Tillamook Counties in Oregon.

Many applications may occur at less than the maximum legal use rate. Most waterways contain flowing water that dilutes and disperses 2,4-D from its application site, as well. Nevertheless, we do not have county-level usage data on aquatic weed control. Therefore, our effects determinations are based on conservative PRZM/EXAMS modeling performed by EFED using data on the smallest scale available.

The maximum legal use rate of 2,4-D salts on aquatic weeds is predicted to pose risk to aquatic plants, which leads to indirect effects on salmonids due to loss of cover. The maximum legal use rate of 2,4-D esters on aquatic weeds is predicted to pose risk to freshwater fish, freshwater invertebrates, and aquatic plants, which leads to both direct and indirect effects on salmonids. Due to the lack of smaller-scale data, we must assume that all aquatic sites throughout all the counties in this ESU are treated with 2,4-D esters. Therefore, due to possible direct and indirect effects on salmonids, we conclude that 2,4-D use on aquatic weeds may effect T&E salmonids in this ESU.

5. Specific Conclusions for Pacific Salmon and Steelhead

Based on the RQs generated and on the ESU descriptions above, it is our professional opinion that 22 of the 26 ESUs of salmon and steelhead in the Pacific Northwest will have no effect from the legal use of 2,4-D on agricultural crops. However, 2,4-D may affect, but is not likely to adversely affect the remaining four ESUs when used on rice crops, as shown in Table 39 below. When used to control aquatic weeds, 2,4-D may effect all 26 ESUs.

Prior to the ESU analysis, we determined which of the agricultural uses of 2,4-D would exceed RQ values. As noted above in section 3 we found that none of the uses of 2,4-D on terrestrial crops exceeded the RQ values, thus we determined that these uses would not affect T&E salmonids and excluded them from further analysis. However, these uses did not include 2,4-D applications to rice or direct applications to water for aquatic weed control. The use of 2,4-D on rice may affect but is not likely to affect salmon in the Central Valley California Steelhead ESU, the Central Valley Spring Run Chinook ESU, the California Coastal Chinook ESU, and the Sacramento River Winter Run Chinook ESU. We have made this determination because although the RQs indicate the possibility of indirect effects to listed salmonids, 2,4-D is used in only a small portion of these ESUs. In addition, each of these four ESUs contain several of the same counties, but OPP only has county-level usage information. The usage within one county that occurs in several ESUs may be divided among the ESUs, where we can only assume that all usage in each county affects each ESU that contains it. In all of the other ESUs, the use of 2,4-D on rice will have no effect on Pacific salmon or steelhead. Little information exists about the usage of 2,4-D for aquatic weed control, since locations, rates, and frequencies of applications are largely unrecorded. As a result we cannot perform a detailed analysis of which ESUs may be adversely affected by this use of 2,4-D. However, the RQ values resulting from this use indicate that Pacific salmon and steelhead would be directly and indirectly affected by direct application of 2,4-D to water. Therefore, it is our professional opinion that when 2,4-D is used in this manner, Pacific salmon and steelhead in any of these ESUs could be adversely affected.

Table 39. Summary conclusions on specific ESUs of salmon and steelhead for 2,4-D use on rice.

Species	**ESU**	**Aquatic Weed Control Findings**	**Rice Findings**
Chinook Salmon	California Coastal	may affect	may affect, but not likely to adversely affect
Chinook Salmon	Central Valley spring-run	may affect	may affect, but not likely to adversely affect
Chinook Salmon	Lower Columbia	may affect	no effect
Chinook Salmon	Puget Sound	may affect	no effect
Chinook Salmon	Sacramento River winter-run	may affect	may affect, but not likely to adversely affect
Chinook Salmon	Snake River fall-run	may affect	no effect
Chinook Salmon	Snake River spring/summer-run	may affect	no effect
Chinook Salmon	Upper Columbia spring-run	may affect	no effect
Chinook Salmon	Upper Willamette	may affect	no effect

Species	**ESU**	**Aquatic Weed Control Findings**	**Rice Findings**
Chum salmon	Columbia River	may affect	no effect
Chum salmon	Hood Canal summer-run	may affect	no effect
Coho salmon	Central California	may affect	no effect
Coho salmon	Oregon Coast	may affect	no effect
Coho salmon	Southern Oregon/Northern California Coast	may affect	no effect
Sockeye salmon	Ozette Lake	may affect	no effect
Sockeye salmon	Snake River	may affect	no effect
Steelhead	Central California Coast	may affect	no effect
Steelhead	Central Valley, California	may affect	may affect, but not likely to adversely affect
Steelhead	Lower Columbia River	may affect	no effect
Steelhead	Middle Columbia River	may affect	no effect
Steelhead	Northern California	may affect	no effect
Steelhead	Snake River Basin	may affect	no effect
Steelhead	South-Central California	may affect	no effect
Steelhead	Southern California	may affect	no effect
Steelhead	Upper Columbia River	may affect	no effect
Steelhead	Upper Willamette River	may affect	no effect

Recommendations

Direct application of 2,4-D for aquatic weed control may affect threatened and endangered salmonids in all 26 ESUs. Therefore, during consultation with NOAA Fisheries we recommend discussions with the state agencies and aquatic weed control professionals in the Pacific Northwest and California to determine how to minimize risk from this use of 2,4-D. A potential also exists for 2,4-D use on rice in California to affect threatened and endangered salmonids in four ESUs, though we do not expect adverse effects to these species. As a result, we also recommend discussions with California state agencies and rice growers to decide how to minimize risks to salmonids from use of 2,4-D on rice.

6. References

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