Atrazine
Analysis of Risks
Endangered and Threatened Salmon and Steelhead Trout

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Candy Brassard, M.A., Lauren Gill, Ann Stavola, M.S.,
James Lin Ph.D, and Larry Turner, Ph.D.
Policy and Regulatory Services Branch and Environmental Field Branch
Field and External Affairs Division and
Environmental Fate and Effects Division

Summary

Atrazine is an herbicide registered mainly to control broadleaf weeds in a number of sites. The most use occurs in agricultural applications to corn, although substantial use also occurs in sorghum and sugarcane. There is considerable use on non-agricultural sites, particularly turf sites. Atrazine is moderately toxic to slightly toxic to most fish species, and somewhat less toxic to aquatic invertebrates. As an herbicide, it is highly toxic to aquatic vascular plants and algae. Modeling of atrazine estimated environmental concentrations (EECs) indicates that exposure will be well below the risk levels for direct effects on fish and also below the risk levels for indirect effects on fish. We conclude that the use of atrazine in accordance with labels will have no effect on any ESU of listed Pacific salmon or steelhead.

Introduction

Problem Formulation- The purpose of this analysis is to determine whether the registration of atrazine as an herbicide for use on various crops and on residential areas during a phase out of that use 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 western salmon and steelhead and the watersheds in which they occur, it is acknowledged that atrazine 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.

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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 habitats. 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. Indirect effects include but are not limited to loss of habitat, e.g. macrophytes being severely damaged so that there is no cover for the salmon or steelhead during spawning, etc.

Acute Toxicity - Relevant acute data are derived from standardized toxicity tests with lethality as the primary endpoint. These tests are conducted with what is generally accepted as the most sensitive life stage of fish, i.e., very young fish from 0.5-5 grams in weight, and with species that are usually among the most sensitive. These tests for pesticide registration include analysis of observable sublethal effects as well. The intent of acute tests is to statistically derive a median effect level; typically the effect is lethality in fish (LC50) or immobility in aquatic invertebrates (EC50). Typically, a standard fish acute test will include concentrations that cause no mortality, and often no observable sublethal effects, as well as concentrations that would cause 100% mortality. By looking at the effects at various test concentrations, a dose-response curve can be derived, and one can statistically predict the effects likely to occur at various pesticide concentrations; a well done test can even be extrapolated, with caution, to concentrations below those tested (or above the test concentrations if the highest concentration did not produce 100% mortality).

OPP typically uses qualitative descriptors to describe different levels of acute toxicity, the most likely kind of effect of modern pesticides (Table 1). These are widely used for comparative purposes, but must be associated with exposure before any conclusions can be drawn with respect to risk. Pesticides that are considered highly toxic or very highly toxic are required to have a label statement indicating that level of toxicity. The FIFRA regulations [40CFR158.490(a)] do not require calculating a specific 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 will have "no effect" on the species.

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

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

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

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

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

Inert Ingredients - OPP does take into account the potential effects of what used to be termed “inert” ingredients, but which are beginning to be referred to as “other ingredients”. OPP has classified these ingredients into several categories. A few of these, such as nonylphenol, can no longer be used without including them on the label with a specific statement indicating the potential toxicity. Based upon our internal databases, I 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. I 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. I 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. I 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 U. S. The site choice was intended to yield a maximum exposure, or “worst-case,” scenario applicable nationwide, particularly with respect to runoff. The model is based on a 10 hectare watershed that surrounds a one hectare pond, two meters deep. It is assumed that all of the 10 hectare area is treated with the pesticide and that any runoff would drain into the pond. The model also incorporates spray drift, the amount of which is dependent primarily upon the droplet size of the spray. OPP assumes that if this model indicates no concerns when compared with the appropriate toxicity data, then further analysis is not necessary as there would be no effect on the species.

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

When there is a concern with the comparison of toxicity with the EECs identified in the 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 would expect that in some areas, few homeowners will use pesticides, but in other areas, a high percentage could. As a result, OPP has insufficient information to develop a scenario or address the extent of pesticide use in a residential area.

It is, however, quite necessary to address the potential that home and garden pesticides may affect T&E species, even in the absence of reliable data. Therefore, I have developed a hypothetical scenario, by adapting an existing scenario, to address pesticide use on home lawns where it is most likely that residential pesticides will be used outdoors. It is exceedingly important to note that there is no quantitative, scientifically valid support for this modified scenario; rather it is based on my best professional judgement. I do note that the original scenario, based on golf course use, does have a sound technical basis, and the home lawn scenario is effectively the same as the golf course scenario. Three approaches will be used. First, the treatment of fairways, greens, and tees will represent situations where a high proportion of homeowners may use a pesticide. Second, I will use a 10% treatment to represent situations where only some homeowners may use a pesticide. Even if OPP cannot reliably determine the percentage of homeowners using a pesticide in a given area, this will provide two estimates. Third, where the risks from lawn use could exceed our criteria by only a modest amount, I can back-calculate the percentage of land that would need to be treated to exceed our criteria. If a smaller percentage is treated, this would then be below our criteria of concern. The percentage here would be not just of lawns, but of all of the treatable area under consideration; but in urban and highly populated suburban areas, it would be similar to a percentage of lawns. Should reliable data or other information become available, the approach will be altered appropriately.

It is also important to note that pesticides used in urban areas can be expected to transport considerable distances if they should run off on to concrete or asphalt, such as with streets (e.g., TDK Environmental, 2001). This makes any quantitative analysis very difficult to address aquatic exposure from home use. It also indicates that a no-use or no-spray buffer approach for protection, which we consider quite viable for agricultural areas, may not be 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, those first order streams may be upstream from pesticide use, but in other areas, or for some non-agricultural uses such as forestry, the first order streams may receive pesticide runoff and drift. However, larger streams and lakes will very likely have lower, often considerably lower, concentrations of pesticides due to more dilution by the receiving waters. In addition, where persistence is a factor, streams will tend to carry pesticides away from where they enter into the streams, and the models do not allow for this. The variables in size of streams, rivers, and lakes, along with flow rates in the lotic waters and seasonal variation, are large enough to preclude the development of applicable models to represent the diversity of T&E species' habitats. We can simply qualitatively note that the farm pond model is expected to overestimate EECs in larger bodies of water.

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

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

In general, but with some exceptions, pesticides applied in terrestrial environments will not affect the plant material in the water that provides aquatic cover for listed fish. Application rates for herbicides are intended to be efficacious, but are not intended to be excessive. Because only a portion of the effective application rate of an herbicide applied to land will reach water through runoff or drift, the amount is very likely to be below effect levels for aquatic plants. Some of the applied herbicides will degrade through photolysis, hydrolysis, or other processes. In addition, terrestrial herbicide applications are efficacious in part, 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 populations of aquatic macrophytes that would serve as cover for T&E fish would be affected.

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

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

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

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

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

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 reproduction and effects on progeny
Acute invertebrate LC50[a]	>0.5	May be indirect effects on T&E fish through food supply reduction
Aquatic plant acute EC50[a]	>1[b]	May be indirect effects on aquatic vegetative cover for T&E fish

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

The Ecological Risk Assessment SEP (pages 2-6) discusses the quantitative estimates of how the acute toxicity data, in combination with the slope of the dose-response curve, can be used to predict the percentage mortality that would occur at the various risk quotients. The discussion indicates that using a "safety factor" of 10, as applies for restricted use classification, one individual in 30,000,000 exposed to the concentration would be likely to die. Using a "safety factor" of 20, as applies to aquatic T&E species, would exponentially increase the margin of safety. It has been calculated by one pesticide registrant (without sufficient information for OPP to validate that number), that the probability of mortality occurring when the 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, it is rare that a non-target organism would be exposed to such concentrations over a period of time, especially for fish that live in lakes or in streams (best professional judgement). Thus, there is no additional safety factor used for the no-observed-effect-concentration, in contrast to the acute data where a safety factor is warranted because the endpoints are a median probability rather than no effect.

Sublethal Effects - With respect to sublethal effects, Tucker and Leitzke (1979) did an extensive review of existing ecotoxicological data on pesticides. Among their findings was that sublethal effects as reported in the literature did not occur at concentrations below one-fourth to one-sixth of the lethal concentrations, when taking into account the same percentages or numbers affected, test system, duration, species, and other factors. This was termed the "6x hypothesis". Their review included cholinesterase inhibition, but was largely oriented towards externally observable parameters such as growth, food consumption, behavioral signs of intoxication, avoidance and repellency, and similar parameters. Even reproductive parameters fit into the hypothesis when the duration of the test was considered. This hypothesis supported the use of lethality tests for use in assessing 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.

2. Description of atrazine

Atrazine is a triazine herbicide currently registered for use to control many broadleaf and some grassy weeds. Atrazine is currently registered for use on corn (field and sweet); guavas;

macadamia nuts; sorghum; sugarcane; sudangrass; range grasses for the establishment of permanent grass cover on rangelands and pastures under USDA's Conservation Reserve Program in OK, NE, TX, and OR; wheat (where application is to fallow land following wheat harvests); coniferous forests; Christmas tree farms; sod farms; golf courses and residential lawns (Southern turfgrasses). Given the specific nature of the lawn uses, much of atrazine's use on lawns is confined to Florida and the Southeast. Atrazine degrades into hydroxy compounds and chlorotriazine degradates. Atrazine was first registered in 1958 as an herbicide. Use data from 1990 to 1997 indicate that approximately 76.5 million pounds of atrazine active ingredient are used domestically each year.

Target Pests:

The target pests for atrazine consist of a wide variety of broadleaf and some grassy weeds. Many major pest weeds of registered sites are controlled, but often additional herbicides are used with atrazine to widen the spectrum of grassy weeds controlled. Because several species of severe pest broadleaf weeds have developed scattered populations that are resistant to atrazine, additional broadleaf herbicides are sometimes added. Because atrazine's action is chiefly preemergence, a postemergence broadleaf herbicide is sometimes added to make it more useful in no-till situations.

Mode of Action:

Atrazine blocks electron transport in photosystem II complex in chloroplast, thus halting CO_2 fixation and production of ATP and $NADPH_2$, all needed for plant growth. Plant death occurs mostly by desiccation as the result of membrane damage due to formation of singlet oxygen and triplet state chlorophyll, which abstract hydrogen from unsaturated lipids and initiate a chain reaction of lipid peroxidation. Pigments are destroyed and membranes made leaky.

a. Registered uses relevant to Pacific salmon and steelhead:

Agricultural uses

. Agricultural fallow/idleland (after wheat harvest in wheat/fallow/wheat or wheat/corn or sorghum/fallow rotations)
. Corn, field
. Corn, pop
. Corn, sweet
. Rye (one technical label only)
. Sorghum
. Wheat
. Bermudagrass
. Grasses grown for seed
. Agricultural fallow/idleland (CRP & related acreage)
. Conifers (seed orchard)
. Rangeland
. Christmas tree plantations
. Nonagricultural rights-of-way/fencerows/hedgerows

Ornamental and residential

. Golf course turf
. Commercial/industrial lawns
. Industrial areas (outdoor)
. Ornamental and/or shade trees
. Ornamental lawns and turf
. Ornamental sod farm (turf)
. Recreation area lawns (e.g., parks, ballfields)

Forestry

. Forest plantings (reforestation programs)(tree farms, tree plantations, etc.)
. forest trees (softwoods, conifers)

Atrazine, as stated previously, is an herbicide registered mainly to control broadleaf weeds in a number of sites. The most use occurs in corn, although substantial use also occurs in sorghum and sugarcane. Agricultural crops that receive smaller total use include sweet corn and winter wheat. Atrazine is also used on several non-agricultural sites, primarily on turf sites by lawn care operators as well as golf courses and sod production. Table 3 is derived from OPP's Preliminary Quantitative Use Assessment and includes usage data for those uses relevant to Pacific salmon and steelhead This table shows that the primary use of atrazine, by far, is on corn in the midwest. A distant second, but still with considerable usage is sorghum in the midwest, followed by sugarcane in the southeastern U. S. Based on Table 3, it is evident that the primary uses are not within OR, ID, WA, and CA, the states in which we are concerned about for endangered and threatened salmon and steelhead.

Table 3. Use Patterns and Percent Crops Treated

Site	Acres Grown (000)	Acres Treated (000)		% of Crop Treated		LB AI Applied (000)		Average Application Rate			States of Most Usage
		Wtd Avg	Est Max	Wtd Avg	Est Max	Wtd Avg	Est Max	lb ai/ acre/yr	#appl / yr	lb ai/ A/appl	(% of total lb ai used on this site)
Food Crops											
Sweet Corn, Fresh	222	110	133	49.5%	59.9%	160	180	1.5	1.0	1.5	FL NY GA MI NJ 84%
Sweet Corn, Proc.	464	270	300	58.2%	64.6%	250	350	0.9	1.0	0.9	WI MN OR NY IL 85%
Sorghum	11,140	6,520	8,213	58.5%	73.7%	7,790	12,575	1.2	1.1	1.1	KS TX NE MO 82%
Corn	72,425	59,500	69,900	75%	84%	63,800	74,495	1.1	1.1	1.0	IL IA NE IN OH MO 63%
Barley[1]	7,326	0	0	--	--	0	0	--	--	--	ND ID MN SD 81%
Oats/Rye[1]	6,184	0	0	--	--	0	0	--	--	--	OH AL SD OK VA NM 77%
Rice[1]	2,989	0	0	--	--	0	0	--	--	--	LA AR 82%
Wheat, Winter	44,491	280	480	0.6%	1.1%	300	583	1.1	1.0	1.1	KS NE OK AL CO MS 76%
Sugarcane	855	650	810	76.0%	95%	2,550	4,900	3.9	1.5	2.6	FL LA 97%
Non-food Agriculture											
Hay, Other	33,881	120	233	0.4%	0.7%	150	311	1.2	1.1	1.1	TX PA OK SD MN CA 68%
Pasture	75,719	30	60	0.0%	0.1%	46	92	1.5	1.0	1.5	LA 82%
Summer Fallow	28,567	16	32	0.1%	0.1%	8	16	0.5	1.1	0.5	KS NE SD CO MO 82%
Sudangrass		--	--	--	--	12	--	--	--	--	
Silviculture											
Ornamentals, Woody	--	--	--	--		140	--	--	–		

Site	Acres Grown (000)	Acres Treated (000)		% of Crop Treated		LB AI Applied (000)		Average Application Rate			States of Most Usage
		Wtd Avg	Est Max	Wtd Avg	Est Max	Wtd Avg	Est Max	lb ai/ acre/yr	#appl / yr	lb ai/ A/appl	(% of total lb ai used on this site)
Forestry		--	--	--	--	48	--	--	--	--	
Woodland	62,089	10	20	0%	0%	21	46	2.1	1.1	1.9	OR WI NY AR LA 80%
Turf											
Lawn Care Operators	31,048	--	--	--		600	--	--	--		
Sod	152	70	--	--	--	160	--	2.3	1.0	2.3	FL TX 91%
Golf Courses	1,440	--	--	--	--	78	--	--	--	--	
Professional, Commercial Applicators											
Roadways		--	--	--	--	100	--	--	--	–	
Other outdoor residential, industrial, etc.	--	--	--	--		230	--	--	--		
Total		67,602	67,604			76,480	84,924				

[1] EPA records indicate that these crops were not treated with atrazine after 1996.
Usage data primarily covers 1990 - 1996.

Information for selected crops in the Pacific Northwest and California is available from the USDA/NASS Washington Agricultural Statistics Service in their "Agricultural Chemical Usage" reports (http://jan.mannlib.cornell.edu/reports/nassr/other/pcu-bb/#vegetables and http://jan.mannlib.cornell.edu/reports/nassr/other/pcu-bb/#nursery) but the data are not reported at the county level. The sweet corn data for 2002 indicates that 24,000 acres, 33,000 acres 97,700 acres in California, Oregon and Washington, respectively. Atrazine was applied to 91% of the sweet corn in Oregon with an average of only one application and the rate of 1.1 pounds per acre. It was applied to 68% of the sweet corn in Washington with an average rate of 0.84 pounds per acre. Atrazine was not used on sweet corn in California in 2002. Christmas trees are grown in California, Oregon and Washington, but the data is presented as number of producers and trees sold, not the number of acres in production (2000 year data). California had 7 producers, Oregon 70 and Washington 22. The report indicated that 3% of the Christmas tree operations in California and 49% in Oregon used atrazine in 2000. They did not provide data on the use in Washington.

The 2001 Annual Report for California (California DPR Pesticide Use Report) is presented below.

Table 4. Usage Data for California

California County	Crop or other use site	Usage (pounds)	Acres treated
Alameda	none	0	0
Amador	none	0	0
Butte	forest, timberland	143	36
Calaveras	forest, timberland landscape maintenance	393 8	138 nr
Colusa	none	0	0
Contra Costa	corn (forage-fodder) landscape maintenance	598 <1	300 nr
Del Norte	forest, timberland	856	245
El Dorado	Christmas trees forest, timberland landscape maintenance rights-of-way	80 2986 428 3	28 754 nr nr
Glenn	corn (forage-fodder) sorghum/milo sudangrass	456 45 105	366 25 86
Humboldt	forest, timberland rights-of-way	1529 20	376 nr
Lake	none	0	0
Los Angeles	corn (forage-fodder) landscape maintenance	9 <1	2 nr
Marin	none	0	0
Mendocino	none	0	0
Merced	none	0	0
Monterey	sweet corn	72	47

California County	Crop or other use site	Usage (pounds)	Acres treated
Napa	none	0	0
Nevada	forest, timberland	368	90
Placer	corn (forage-fodder)	601	401
	forest, timberland	139	47
	sudangrass	1295	610
Sacramento	corn (forage-fodder)	2644	2840
	sweet corn	1567	1194
	sorghum/milo	35	21
	sudangrass	4095	2028
San Benito	none	0	0
San Diego	none	0	0
San Francisco	none	0	0
San Joaquin	corn (forage-fodder)	2474	2069
	sudangrass	60	35
San Luis Obispo	sweet corn	5	2
San Mateo	none	0	0
Santa Barbara	none	0	0
Santa Clara	sweet corn	3	1
Santa Cruz	none	0	0
Shasta	forest, timberland	5063	1279
	nursery outdoor flowers	54	14
	nursery outdoor transplants	81	18
Siskiyou	forest, timberland	551	152
Solano	corn (forage-fodder)	289	347
Sonoma	none	0	0
Sonoma	none	0	0
Sonoma	none	0	0
Stanislaus	walnut	11	40
Sutter	sudangrass	163	82
Tehama	none	0	0
Trinity	none	0	0
Trinity	none	0	0
Tuolumne	forest, timberland	6603	1731
	landscape maintenance	11	
Ventura	turf/sod	35	36
Yolo	corn (forage-fodder)	17	14
Yuba	forest, timberland	1735	459

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

a. Aquatic toxicity of atrazine

The acute toxicity data (Table 5) indicate that technical atrazine is slightly to moderately toxic to freshwater fish, practically nontoxic to highly toxic to freshwater and estuarine invertebrates, and slightly to highly toxic to estuarine fish. Several formulations were tested on an acute basis. These formulations were in the range of slightly toxic to freshwater fish and invertebrates and practically nontoxic to moderately toxic to estuarine invertebrates. Adverse chronic effects on growth and reproduction of freshwater fish and invertebrates occurred at exposure concentrations greater than 0.06 ppm for freshwater invertebrates and greater than 0.065 ppm for freshwater fish (Table 6).

Table 5. Acute toxicity to fish and aquatic invertebrates (from the EFED database).

Species	**Scientific Name**	**%a.i.**	**Study Time**	**Toxicity (EC50/ LC50)** (ppm)	**Toxicity Category**
Freshwater Invertebrates					
Midge	*Chironomus tentans*	94	48 hr	0.72	Highly Toxic
Scud	*Gammarus fasciatus*	94	48 hr	5.7	Moderately Toxic
Water flea	*Daphnia magna*	94	48 hr	6.9	Moderately Toxic
Water flea	*Daphnia magna*	80 WP	48 hr	49	Slightly Toxic
Water flea	*Daphnia magna*	Tech	48 hr	115	Practically Non-Toxic
Freshwater Fish					
Rainbow trout	*Oncorhynchus mykiss*	43Lq	96 hr	24	Slightly toxic
Rainbow trout	*Oncorhynchus mykiss*	98.8	96 hr	4.5	Moderately Toxic
Rainbow trout	*Oncorhynchus mykiss*	15 G	96 hr	14.7	Slightly Toxic
Bluegill sunfish	*Lepomis macrochirus*	43Lq	96 hr	42	Slightly toxic
Bluegill sunfish	*Lepomis macrochirus*	94	96 hr	6.7	Moderately Toxic
Bluegill sunfish	*Lepomis macrochirus*	98.8	96 hr	24	Slightly Toxic
Bluegill sunfish	*Lepomis macrochirus*	100	96 hr	54.51	Slightly Toxic
Bluegill sunfish	*Lepomis macrochirus*	15 G	96 hr	69.0	Slightly Toxic
Goldfish	*Carassius auratus*	98.8	96 hr	60.0	Slightly Toxic
Brook trout	*Salvelinus fontinalis*	94	96 hr	4.9	Moderately Toxic

Species	Scientific Name	%a.i.	Study Time	Toxicity (EC50/ LC50) (ppm)	Toxicity Category
Fathead minnow	*Pimephales promelas*	94	96 hr	15	Slightly Toxic
Emerald shiner	*Notropis atherinoides*	WP	96 hr	15.6	Slightly Toxic
Estuarine/Marine Invertebrates and Fish					
Brown shrimp	*Penaeus aztecus*	99.7	48 hr	1.0	Highly Toxic
Eastern oyster	*Crassostrea virginica*	99.7	96 hr	1.0	Highly Toxic
Eastern oyster	*Crassostrea virginica*	98.2	96 hr	>1.0	Moderately Toxic
Eastern oyster	*Crassostrea virginica*	80 WP	N.R.	>1.0	Moderately Toxic
Mud crab	*Neopanope texana*	Tech	96 hr	>1000	Practically Non-Toxic
Fiddler crab	*Uca pugilator*	80 WP	96 hr	197	Practically Non-Toxic
Mysid	*Mysidopsis bahia*	97.1	96 hr	5.4	Moderately Toxic
Sheepshead minnow	*Cyprinodon variegatus*	97.1	96 hr	13.4	Slightly Toxic
Spot	*Leiostomus xanthurus*	99.7	48 hr	1.0	Highly Toxic

Table 6. Chronic toxicity to fish and aquatic invertebrates (from the EFED database).

Species	Scientific Name	% a.i.	Study Time	LOEC (ppm)	NOEC (ppm)
Water flea	*Daphnia magna*	94	21 D	0.25	0.14
Scud	*Gammarus lacustris*	94	30 D	0.14	0.06
Midge	*Chironomus tentans*	94	N.R.	0.23	0.11
Bluegill sunfish	*Lepomis macrochirus*	94	90 D	0.50	0.095
Fathead minnow	*Pimephales promelas*	94	60 D	0.87	0.21
Fathead minnow	*Pimephales promelas*	96.3	274 D	0.46	0.25
Brook trout	*Salvelinus fontinalis*	94	44WKS	0.12	0.065

The following aquatic plant data for freshwater and marine species were provided by the EFED database. OPP does not categorize toxicity to plants. The data indicate that ranges of toxicity to aquatic vascular plants and algae overlap, and atrazine is toxic to both groups of plants.

Table 7. Toxicity of atrazine to freshwater and estuarine/marine algae and vascular plants

Species	Scientific Name	% a.i.	Study Time	Toxicity (EC50) ppb
Freshwater Species				
Algae	*Isochrysis galbana*	99.7	10 D	100
Algae	*Chlorella sp.*	99.7	3 D	140
Algae	*Porphyridium cruentum*	99.7	3 D	79
Algae	*Monochrysis lutheri*	99.7	3 D	77
Algae	*Isochrysis galbana*	99.7	2-24h	100
Algae	*Navicula incerta*	99.7	3 D	460
Algae	*Nitzschia closterium*	99.7	3 D	290
Algae	*Isochrysis galbana*	97.4	5 D	22
Algae	*Porphyridium cruentum*	97.4	5 D	308
Algae	*Microcystis seruginosa*	97.4	5 D	129
Freshwater algae	*Scenedesmus costatum*	97.1	5 D	53
Green algae	*Selenastrum capricornutum*	97.4	5 D	53
Green algae	*Dunaliella tertiolecta*	99.7	10 D	300
Green algae	*Chlorella pyrenoidosa*	97.4	5 D	282
Green algae	*Dunaliella tertiolecta*	97.4	5 D	431
Green algae	*Chlorococcum sp*	99.7	10 D	100
Green algae	*Chlamydomonas sp.*	33.7	3 D	60
Green algae	*Neochloris sp.*	99.7	3 D	82
Green algae	*Platymonas sp.*	99.7	3 D	100
Green algae	*Selenastrum capricornutum*	97	5 D	120
Green algae	*Dunaliella tertiolecta*	97	5 D	180
Green algae	*Selenastrum capricornutum*	97.1	5 D	49
Green algae	*Dunaliella tertiolecta*	80WP	10 D	400
Green algae	*Chlorococcum sp*	80WP	10 D	100
Bluegreen algae	*Anabaena flos-aquae*	97	5 D	230

Species	Scientific Name	% a.i.	Study Time	Toxicity (EC50) ppb
Freshwater diatom	*Navicula pelliculosa*	97	5 D	60
Diatom	*Thalassiosira fluviatilis*	99.7	3 D	110
Duckweed	*Lemna gibba*	97	5 D	170
Duckweed	*Lemna gibba*	97	7 D	170
Duckweed	*Lemna gibba*	97	7 D	120
Duckweed	*Lemna gibba*	97.1	14 D	37
Duckweed	*Lemna gibba*	97.4	14 D	43
Marine Species				
Marine diatom	*Phaeodactylum tricornutum*	80WP	10 D	200
Marine diatom	*Skeletonema costatum*	97.4	5 D	24
Marine diatom	*Skeletonema costatum*	97.1	5 D	53
Marine diatom	*Skeletonema costatum*	99.7	10 D	260
Marine diatom	*Phaeodactylum tricornutum*	99.7	10 D	200
Marine haptophyte	*Isochrysis galbana*	80WP	10 D	100

The EFED ERA 2002 contains an extensive discussion on the substantial amount of toxicity data available for atrazine. This discussion does note the differences that are seen in studies in lentic and lotic waters, which is unusual because for most pesticides, data are available only on ponds and other lentic waters.

The pond field data, including that from pond mesocosm studies, showed fish populations are likely to be reduced at 20 ppb from loss of food and habitat; a reduction in invertebrate populations by 59% to 65% at 10 ppb; and 42% reduction in phytoplankton productivity; and 60% reduction in macrophyte populations at 20 ppb.

Data from artificial and natural streams showed a depression of algal photosynthesis at 10 ppb; 79% reduction in phytoplankton at 2.62 ppb; and a significant increase in daytime and nighttime invertebrate drift at 22 ppb from increased predation.

In addition to the studies reviewed for the EFED ERA 2002 and the data in the EFED database, the data in the EPA's ECOTOX database were also reviewed to determine if there were any studies relevant to Pacific salmon and steelhead that were not included in these data sets.

Mortality was studied in yearling coho salmon that were exposed to atrazine in freshwater and then transferred to seawater (Lorz, et al.1988). The authors reported a 5% to 25% mortality rate at nominal concentrations of 8 to 15 ppm, respectively, in freshwater. Upon transfer to seawater the group that had been exposed to a nominal concentration of 15 mg/l (18.0-18.8 measured) atrazine suffered 25% mortality. Death was attributed to the poor condition of the fish (due to toxicant exposure) and not osmoregulatory failure.

Moore, et al. (2003) studied the effects of 4-nonyl-phenol and atrazine on Atlantic salmon (*Salmo salar*) smolts. The study authors determined that when smolts were exposed to mixtures of 4-nonylphenol and atrazine at concentrations of 5.0/1.0 and 10.0/2.0 ug/L , respectively, there were effects on smoltification processes and increased mortality upon transfer to seawater. However, attribution of the results to atrazine is problematic, given the well-known ability of nonylphenol to disrupt physiological processes at very low levels.

There is some evidence (Saglio & Trijasse, 1998) that atrazine can have effects on fish swimming behavior at concentrations well below lethality levels. In tests with various swimming behaviors, atrazine at 5 ppb affected grouping and surfacing behaviors in goldfish (*Carrasius auratus*), and conspecific skin extracts caused decreases in sheltering and grouping behaviors. Burst swimming was observed to increase at levels as low as 0.5 ppb. Burst swimming is a typical fish escape response elicited by predators, tapping on aquaria glass, exposure to certain amino acids, and probably a variety of other stimuli.

Fischer- Scherl et al. (1991) indicated that there were morphological effects to the kidney of rainbow trout (*Oncorhynchus mykiss*) when this species was exposed to atrazine for 28 days at a level of 5 ppb. (LOEC). The study authors indicated it had been previously identified that in fish atrazine-metabolites are mostly excreted via the gills. In addition, this study determined that there is possible additional excretion of atrazine metabolites via the kidney with glomerular filtration and tubular reabsorption in fish.

The sensitivity of five species of macrophytes to atrazine were evaluated (Fairchild, et al.1998). The data indicated that *Elodea* was the most sensitive species (EC50 of 21 ppb) of macrophytes and *Myriophyllum* the least sensitive (EC50 of 132 ppb). The other species that were tested, and their EC50 values are: *Ceratophyllum* = 22 ppb; *Najas* = 24 ppb and *Lemna* = 92 ppb.

Endocrine Disruption

The Agency is concerned about potential endocrine disruption of a variety of pesticides and is working to develop a testing regimen to determine the validity of purported endocrine disruptors and to determine effect levels of those that exhibit these characteristics. Atrazine is a candidate for this program based on various data that have been developed. This current assessment is oriented towards fish; demonstrated endocrine disruption in other taxa may not relate to fish and it is necessary to determine effect levels for fish to develop a valid risk assessment for this taxon.

There is evidence that atrazine may have effects on endocrine processes in fish, based upon a Syngenta study with largemouth bass. Syngenta conducted a study on adult largemouth bass, *Micropterus salmoides*, exposed to atrazine (97.1% purity) at concentrations of 25, 35, 50, 75 and 100 ppb for 20 days and also to commercial grade (purity 42.1 %) atrazine at 100 ppb.

There were significant effects on plasma estradiol in females at 100 ppb and plasma 11-ketotestosterone in males at 50 and 100 ppb. There were no significant effects at concentrations below 50 ppb.

Moore and Waring (1998) found endocrine effects of atrazine on Atlantic salmon when excised olfactory bulbs were perfused with atrazine solutions. This is indicative of endocrine disruption, but the test levels of an *in vitro* study cannot be assigned to whole fish in natural environments.

The ability of atrazine to affect certain endocrine processes has been established. However, the available data do not indicate that such effects happen at the kinds of concentrations expected from use of atrazine in the salmon and steelhead areas of western states. EECs from PRZM/EXAMS models are 5 ppb in California corn with a 1.1 lb ai/A rate, 15 ppb in Oregon sweet corn with a 1.5 lb ai/A rate, and 29 ppb in Oregon Christmas trees at a 5 lb ai/A application rate. Effects were not found in the bass study at concentrations below 50 ppb, and most environmental concentrations will be well below that. OPP will be keeping up with scientifically valid information that is developed on atrazine and its potential for endocrine disruption. Should effect levels be found in fish at expected concentrations of atrazine, OPP will initiate consultation.

Summary of Aquatic Toxicity Data

Acute toxicity data indicates atrazine is moderately to practically non-toxic to freshwater fish with values ranging from 4,500 ppb to 69,000 ppb depending on species and percent active ingredient being tested. Acute toxicity to marine and estuarine fish ranged from slightly to highly toxic with values from 1,000 ppb to 13,400 ppb. Chronic toxicity values ranged with NOEC's from 60 ppb to 250 ppb for freshwater invertebrates and fish. On an acute basis, atrazine is highly to practically nontoxic to freshwater invertebrates with values ranging from 720 ppb to 115,000 ppb; for estuarine invertebrates acute toxicity range from 94 ppb to 197,850 ppb.

The freshwater plant data, specifically the *Lemna gibba*, indicated the values ranged from 37 ppb to 170 ppb. Algae data indicated the EC50 value ranged from 22 to 460 ppb. There were studies that reported lower values on algae, with values as low as 3.7 ppb. Aquatic vascular macrophytes are the preferred species for assessing indirect effects on plant cover for salmon and steelhead.

b. Environmental Fate and Transport Assessment

The following was summarized from the EFED ERA for atrazine:

Atrazine is expected to be mobile and persistent in the environment. The main route of dissipation is microbial degradation under aerobic conditions. Because of its persistence and mobility, atrazine is expected to get into surface and ground water. This is confirmed by the widespread detections of atrazine in surface water and ground water. Atrazine has been observed to remain at elevated concentrations longer in some reservoirs than in flowing surface water or in reservoirs in which there is advective (lateral) transport that greatly limits its persistence.

Atrazine is stable to hydrolysis and to aqueous photolysis. Its half-lives in water and sediment are 578 days and 330 days, respectively. It has a low potential to volatilize from surface water and foliage. In terrestrial field dissipation studies performed in Georgia, California, and Minnesota, atrazine dissipated with half lives of 13, 58, and 261 days, respectively; apparently atrazine is more persistent in colder climate. Long term field dissipation studies also indicated that atrazine could persist over a year in such climatic conditions. A forestry field dissipation study in Oregon indicated an 87 day half-life for atrazine on exposed soil, a 13 day half-life in foliage, and a 66 day half-life on leaf litter.

The metabolites of concern are desethylatrazine (DEA), desisopropylatrazine (DIA) and diaminochloratrazine (DACT). There were also hydroxycompounds, but EFED concluded that they are unlikely to significantly contaminate surface water. The chlorinated metabolites are found in well water at levels comparable to parent atrazine, but in surface waters the parent compound predominates.

c. Incidents

OPP maintains two databases of reported incidents. A number of incidents from these databases were discussed in the RED. There were eleven fish kills that were listed as "probable". Although the people submitting the reports to OPP inferred that atrazine was responsible for the fish kills, EFED concluded, as discussed in the RED, that there was little evidence that firmly demonstrated that atrazine was responsible for these incidents. There have also been fish kills associated with the runoff of atrazine into waterways. In these incidents atrazine killed aquatic vegetation with the decomposition of the plant matter causing oxygen depletion leading to fish deaths.

d. Estimated and Actual Environmental Concentrations of Atrazine in Water

The estimated environmental concentration calculated for the RED was based on corn, sorghum and sugar cane as being the primary crops of use within the midwest (IL, OH, etc.) . However, since this assessment was focusing on use sites in ID, CA, OR and WA, we calculated EECs that would better represent these sites. This required a use analysis that identified the crops that would be modeled, as well as identification of what models are available for the crops of interest. It was determined based on the crops, locations, and availability of data, that it was appropriate to complete PRZM/EXAMS model runs for corn in CA at a application rate of 1.1 lb. a.i./A, sweet corn in OR at a application rate of 1.5 lb. a.i./A, and Christmas trees at 5.0 lbs. a.i./A. The data are presented over time from peak to yearly data, and the results are as follows:

CA Corn - ground application of 1.1 lb a.i./A on April 1.
Water segment concentrations (ppb)

Prob.	Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.1	4.9628	4.911	4.7131	4.3031	4.0221	2.369

OR Sweet Corn - ground application of 1.5 lb a.i./A on May 1.
Water segment concentrations (ppb)

Prob.	Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.1	14.92	14.792	14.261	13.239	12.535	8.5238

Christmas Trees - One aerial application 5.0 lb a.i./A on March 15 of every year.
Water segment concentrations (ppb)

Prob.	Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.1	29.369	29.19	28.47	26.837	25.587	17.96

In addition to the PRZM/EXAMS analysis, the Agency also reviewed all the available data that is provided by the USGS National Water Quality Assessment Data Warehouse (NAWQA). These data were reviewed for the past 5 years within the four states and respective counties where endangered Pacific salmon and steelhead are found. The NAWQA data indicate that atrazine was detected at concentrations ranging from 0.001 ppb to 0.878 ppb. There were two detections above this range, 4.53 ppb was detected in Marion County, Oregon, 3.06 ppb in Benton County, Washington and 1.4 ppb in Whatcom County, Washington.

General risks conclusions

Our risk conclusions are based on risk quotients (RQs) derived from the available toxicity data and EECs from the PRZM/EXAMS model for the sweet corn and Christmas tree uses.

Risk Quotients				
LB ai/a	**96 hr EEC (ppb)**	**RQ FW Fish**	**RQ FW Invert.**	**RQ Plant**
1.1	4.9	0.001	0.007	0.13
1.5	14.8	0.003	0.020	0.40
5.0	29.2	0.006	0.040	0.79

The toxicity data used in the table are: rainbow trout = 4500 ppb, midge = 720 ppb and duckweed = 37 ppb. The RQ values indicate that the risks for direct effects on endangered fish are below the level of concern (LOC) of an RQ equal to 0.05. The LOCs for indirect effects caused by loss of invertebrate food supply and loss of plant cover are 0.5 and 1.0, respectively. The RQs for acute effects on invertebrates and aquatic plants are below these LOCs.

Chronic risk is determined by comparing the 21-day EECs to the NOEL from a chronic invertebrate study and the 60-day EECs to the NOEL from a chronic fish study. The 21-day EECs ranged from 4.7 ppb to 28.5 ppb. A comparison with the NOEL of 60 ppb from a midge chronic study and the NOEL of 95 ppb from a rainbow trout chronic study indicates minimal chronic risk to fish and invertebrates from atrazine in California and the Pacific Northwest.

Specific conclusions for Pacific salmon and steelhead

Based upon the available toxicity and environmental exposure data, we conclude that there are no direct effects to Pacific salmon and steelhead from direct exposure to atrazine and no indirect effects from the loss of their food supply or plant cover.

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