# **APPENDIX 2-3. Open Literature Review Summaries for Atrazine**

Included in this appendix are the open literature review summaries for studies that were reviewed for the effects characterization for atrazine. Below in Table 1 are the ECOTOX numbers associated with the available reviews.

**Table 1. ECOTOX numbers associated with the available open literature reviews.**

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| Carrasco JM;Sabater C. 1997. Toxicity of Atrazine and Chlorsulfuron to Algae Toxicol. Environ. Chem. 59: 89-99 Ecotox # 6712 |
| Nieves-Puigdoller K;Bjornsson BT;McCormick SD. 2007. Effects of Hexazinone and Atrazine on the Physiology and Endocrinology of Smolt Development in Atlantic Salmon Aquat. Toxicol. 84: 27-37. Ecotox #93473 |

Table 2 includes a list of plant studies found in the ECOTOX report with existing Open Literature Review Summaries (OLRS). The reviews can be found in the registration review docket for atrazine [regulations.gov, DOCKET #EPA-HQ-OPP-2013-0266]. These studies were considered again and found suitable for use in deriving the species sensitivity distribution (SSD) for all aquatic plants.

**Table 2. Studies with Existing Open Literature Review Summaries (OLRS).**

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| --- |
| Scott CH. 2011. A Comparison of Vegetation Indices and Conventional Ecotoxicological Plant Growth Metrics to Assess the Lethal and Sublethal Effects of Atrazine in Smooth Cordgrass, Spartina alterniflora M.S. Thesis, University of South Carolina : 168 p. Ecotox # 165210 |
| Hoberg JR. 1991. Atrazine Technical - Toxicity to the Freshwater Green Alga Selenastrum capricornutum Final SLI Rep.No.91-1-3600, Springborn Lab.Inc., Environ.Sci.Div., Wareham, MA : 50 p. Ecotox # 69631 |
| Seguin F;Leboulanger C;Rimet F;Druart JC;Berard A. 2001. Effects of Atrazine and Nicosulfuron on Phytoplankton in Systems of Increasing Complexity Arch. Environ. Contam. Toxicol. 40(2): 198-208 Ecotox # 62246 |
| McGregor EB;Solomon KR;Hanson ML. 2008. Effects of Planting System Design on the Toxicological Sensitivity of Myriophyllum spicatum and Elodea canadensis to Atrazine Chemosphere 73: 249-260 Ecotox # 103765 |
| Carrasco JM;Sabater C. 1997. Toxicity of Atrazine and Chlorsulfuron to Algae Toxicol. Environ. Chem. 59: 89-99 Ecotox # 6712 |
| DeLorenzo ME;Leatherbury M;Weiner JA;Lewitus AJ;Fulton MH. 2004. Physiological Factors Contributing to the Species-Specific Sensitivity of Four Estuarine Microalgal Species Exposed to the Herbicide Atrazine Aquat. Ecosyst. Health Manag. 7(1): 137-146 Ecotox # 81739 |
| Carrasco JM;Sabater C. 1997. Toxicity of Atrazine and Chlorsulfuron to Algae Toxicol. Environ. Chem. 59: 89-99 Ecotox # 6712 |
| Debelius B;Forja JM;Del Valls A;Lubian LM. 2008. Effect of Linear Alkylbenzene Sulfonate (LAS) and Atrazine on Marine Microalgae Mar. Pollut. Bull. 57(6-12): 559-568 Ecotox # 103270 |
| DeLorenzo ME;Leatherbury M;Weiner JA;Lewitus AJ;Fulton MH. 2004. Physiological Factors Contributing to the Species-Specific Sensitivity of Four Estuarine Microalgal Species Exposed to the Herbicide Atrazine Aquat. Ecosyst. Health Manag. 7(1): 137-146 Ecotox # 81739 |
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| Kemp WM;Boynton WR;Cunningham JJ;Stevenson JC;Jones TW;Means JC. 1985. Effects of Atrazine and Linuron on Photosynthesis and Growth of the Macrophytes, Potamogeton perfoliatus L. and Myriophyllum spicatum L. in an Estuarine Environment Aquat. Toxicol. 9(2/3): 190-191 Ecotox # 11142 |
| DeLorenzo ME;Leatherbury M;Weiner JA;Lewitus AJ;Fulton MH. 2004. Physiological Factors Contributing to the Species-Specific Sensitivity of Four Estuarine Microalgal Species Exposed to the Herbicide Atrazine Aquat. Ecosyst. Health Manag. 7(1): 137-146 Ecotox # 81739 |
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| Faust M;Altenburger R;Backhaus T;Blanck H;Boedeker W;Gramatica P;Hamer V;Scholze M;Vighi M;Grimme LH. 2001. Predicting the Joint Algal Toxicity of Multi-Component s-Triazine Mixtures at Low-Effect Concentrations of Individual Toxicants Aquat. Toxicol. 56(1): 13-32 Ecotox # 62304 |
| Baxter L;Brain RA;Lissemore L;Solomon KR;Hanson ML;Prosser RS. 2016. Influence of Light, Nutrients, and Temperature on the Toxicity of Atrazine to the Algal Species Raphidocelis subcapitata: Implications for the Risk Assessment of Herbicides Ecotoxicol. Environ. Saf. 132: 250-259 Ecotox # 174384 |
| DeLorenzo ME;Leatherbury M;Weiner JA;Lewitus AJ;Fulton MH. 2004. Physiological Factors Contributing to the Species-Specific Sensitivity of Four Estuarine Microalgal Species Exposed to the Herbicide Atrazine Aquat. Ecosyst. Health Manag. 7(1): 137-146 Ecotox # 81739 |
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| Forney DR;CXvis DE. 1981. Effects of Low Concentrations of Herbicides on Submersed Aquatic Plants Weed Sci. 29: 677-685 Ecotox # 4634 |
| Kemp WM;Boynton WR;Cunningham JJ;Stevenson JC;Jones TW;Means JC. 1985. Effects of Atrazine and Linuron on Photosynthesis and Growth of the Macrophytes, Potamogeton perfoliatus L. and Myriophyllum spicatum L. in an Estuarine Environment Aquat. Toxicol. 9(2/3): 190-191 Ecotox # 11142 |
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| Burrell RE;Mayfield CI;Inniss WE;Kummer K. 1983. A Rapid Technique for Determining Toxicant Effects on a Green Alga Can. Tech. Rep. Fish. Aquat. Sci. : 307-313 Ecotox # 86245 |
| DeLorenzo ME;Leatherbury M;Weiner JA;Lewitus AJ;Fulton MH. 2004. Physiological Factors Contributing to the Species-Specific Sensitivity of Four Estuarine Microalgal Species Exposed to the Herbicide Atrazine Aquat. Ecosyst. Health Manag. 7(1): 137-146 Ecotox # 81739 |
| Fairchild J;Ruessler S;Nelson M;Haverland P. 1994. Bioavailability and Toxicity of Agricultural Chemicals in Runoff from MSEA Sites: Potential Impacts on Non-Target Aquatic Organisms: An Aquatic Hazard Assessment of Four Herbicides Using Six Species of Algae and Five Species of Aquatic Macrophytes Final report for IAG DW14935600-01-2. Environmental Research Laboratory, U.S. Environmental Protection Agency, Duluth, MN : 123 p. Ecotox # 152770 |
| DeLorenzo ME;Leatherbury M;Weiner JA;Lewitus AJ;Fulton MH. 2004. Physiological Factors Contributing to the Species-Specific Sensitivity of Four Estuarine Microalgal Species Exposed to the Herbicide Atrazine Aquat. Ecosyst. Health Manag. 7(1): 137-146 Ecotox # 81739 |
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| Forney DR;CXvis DE. 1981. Effects of Low Concentrations of Herbicides on Submersed Aquatic Plants Weed Sci. 29: 677-685 Ecotox # 4634 |
| Jones TW;Winchell L. 1984. Uptake and Photosynthetic Inhibition by Atrazine and Its DegraCXtion Products on Four Species of Submerged Vascular Plants J. Environ. Qual. 13(2): 243-247 Ecotox # 4727 |
| Jones TW;Kemp WM;Estes PS;Stevenson JC. 1986. Atrazine Uptake, Photosynthetic Inhibition, and Short-Term Recovery for the Submersed Vascular Plant, Potamogeton perfoliatus L. Arch. Environ. Contam. Toxicol. 15(3): 277-283 Ecotox # 12281 |
| Forney DR;CXvis DE. 1981. Effects of Low Concentrations of Herbicides on Submersed Aquatic Plants Weed Sci. 29: 677-685 Ecotox # 4634 |
| Baxter L;Brain RA;Lissemore L;Solomon KR;Hanson ML;Prosser RS. 2016. Influence of Light, Nutrients, and Temperature on the Toxicity of Atrazine to the Algal Species Raphidocelis subcapitata: Implications for the Risk Assessment of Herbicides Ecotoxicol. Environ. Saf. 132: 250-259 Ecotox # 174384 |
| DeLorenzo ME;Leatherbury M;Weiner JA;Lewitus AJ;Fulton MH. 2004. Physiological Factors Contributing to the Species-Specific Sensitivity of Four Estuarine Microalgal Species Exposed to the Herbicide Atrazine Aquat. Ecosyst. Health Manag. 7(1): 137-146 Ecotox # 81739 |
| Kemp WM;Boynton WR;Cunningham JJ;Stevenson JC;Jones TW;Means JC. 1985. Effects of Atrazine and Linuron on Photosynthesis and Growth of the Macrophytes, Potamogeton perfoliatus L. and Myriophyllum spicatum L. in an Estuarine Environment Aquat. Toxicol. 9(2/3): 190-191 Ecotox # 11142 |
| Jones TW;Winchell L. 1984. Uptake and Photosynthetic Inhibition by Atrazine and Its DegraCXtion Products on Four Species of Submerged Vascular Plants J. Environ. Qual. 13(2): 243-247 Ecotox # 4727 |
| Fairchild JF;Ruessler DS;Carlson AR. 1998. Comparative Sensitivity of Five Species of Macrophytes and Six Species of Algae to Atrazine, Metribuzin, Alachlor, and Metolachlor Environ. Toxicol. Chem. 17(9): 1830-1834 Ecotox # 19461 |
| Burrell RE;Mayfield CI;Inniss WE;Kummer K. 1983. A Rapid Technique for Determining Toxicant Effects on a Green Alga Can. Tech. Rep. Fish. Aquat. Sci. : 307-313 Ecotox # 86245 |
| Pennington PL;Scott GI. 2001. Toxicity of Atrazine to the Estuarine Phytoplankter Pavlova sp. (Prymnesiophyceae): Increased Sensitivity After Long-Term, Low-Level Population Exposure Environ. Toxicol. Chem. 20(10): 2237-2242 Ecotox # 62448 |
| Delistraty CX;Hershner C. 1984. Effects of the Herbicide Atrazine on Adenine Nucleotide Levels in Zostera marina L. (Eelgrass) Aquat. Bot. 18(4): 353-369 Ecotox # 11471 |
| Jones TW;Winchell L. 1984. Uptake and Photosynthetic Inhibition by Atrazine and Its DegraCXtion Products on Four Species of Submerged Vascular Plants J. Environ. Qual. 13(2): 243-247 Ecotox # 4727 |
| Fairchild J;Ruessler S;Nelson M;Haverland P. 1994. Bioavailability and Toxicity of Agricultural Chemicals in Runoff from MSEA Sites: Potential Impacts on Non-Target Aquatic Organisms: An Aquatic Hazard Assessment of Four Herbicides Using Six Species of Algae and Five Species of Aquatic Macrophytes Final report for IAG DW14935600-01-2. Environmental Research Laboratory, U.S. Environmental Protection Agency, Duluth, MN : 123 p. Ecotox # 152770 |
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| Hoberg JR. 1993. Atrazine Technical - Toxicity to the Freshwater Green Alga, (Selenastrum capricornutum) Final SLI Rep.No.93-4-4751, Springborn Lab.Inc., Environ.Sci.Div., Wareham, MA : 63 p. Ecotox # 69630 |
| Fairchild J;Ruessler S;Nelson M;Haverland P. 1994. Bioavailability and Toxicity of Agricultural Chemicals in Runoff from MSEA Sites: Potential Impacts on Non-Target Aquatic Organisms: An Aquatic Hazard Assessment of Four Herbicides Using Six Species of Algae and Five Species of Aquatic Macrophytes Final report for IAG DW14935600-01-2. Environmental Research Laboratory, U.S. Environmental Protection Agency, Duluth, MN : 123 p. Ecotox # 152770 |
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| Girling AE;Pascoe D;Janssen CR;Peither A;Wenzel A;Schafer H;Neumeier B;Mitchell GC;Taylor EJ;Maund SJ;Lay JP;Juttner I;Crossland NO;Stephenson RR;Persoone G. 2000. Development of Methods for Evaluating Toxicity to Freshwater Ecosystems Ecotoxicol. Environ. Saf. 45(2): 148-176 Ecotox # 49576 |

**Open Literature Review Summary**

**ECOTOX Record Number and Citation:** E6712

Carrasco J.M; Sabater C. 1996. Toxicity of atrazine and chlorsulfuron to algae. Toxicol. Environ. Chem. Vol. 59: 89-99.

**Purpose of Review:** ESA risk assessment—for quantitative threshold use.

**Date of Review:** 9/24/2020

**Summary of Methodology/Study Findings:**

The study evaluated the sensitivity of three algal species, *Chlorella vulgaris*, *Scenedesmus acutus*, and *Pseudanabaena galeata*, exposed to atrazine in single species toxicity tests. The algae were exposed to various concentrations of atrazine for 96 hours according to OECD guidelines. The assays were conducted at 24 ± 2 °C under continuous illumination. Light intensity was suitable for optimal growth of each algal species. Flasks were randomly moved in the climatic chamber and shaken manually twice a day. The pH and turbidity were measured throughout the study.

Table 1 (copied from the study report) presents the mean measured concentrations of atrazine for each test. Concentrations were determined by GC analysis at the beginning and end of the assays. Initial measured concentrations were used for calculating toxicities.



Significant effects on algal growth were 0.027 to 5.7 mg/L for C. saccharophila, 0.008 to 0.042 mg/L for S. acutus and from 0.006 to 0.1 mg/L for P. galeata (based on initial concentrations). The average specific growth rates (presented in Table 3 from the study report and copied below) show a reduction in growth rate with increased atrazine concentrations. C. saccharophila, S. acutus, and P. galeata growth rates were significant decreased at 5.7, 0.042, and 0.10 mg/L, respectively.

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96-h EC50 values the three species are presented in Table 4 from the study report (copied below).

****

**Description of Use in Document (QUAL, QUAN, INV):** Quantitative

**Rationale for Use:** Endpoints from this study are suitable for deriving thresholds.

**Limitations of Study:** Raw data are not available.

**Primary Reviewer:** Elizabeth Donovan, Senior Biologist, OPP/EFED/ERB 3

**Secondary Reviewer:** Colleen Rossmeisl, Senior Biologist, OPP/EFED/ERB 3

**Open Literature Review Summary**

**ECOTOX Record Number and Citation:** E93473,

Nieves-Puigdoller K;Bjornsson BT;McCormick SD. 2007. Effects of Hexazinone and Atrazine on the Physiology and Endocrinology of Smolt Development in Atlantic Salmon Aquat. Toxicol. 84: 27-37.

**Purpose of Review:** ESA Biological Evaluation (atrazine)

**Date of Review:** 08/24/2020

**Summary of Methodology/Study Findings:**

The objective of this study was to determine the effects of hexazinone and atrazine on Atlantic Salmon (*Salmo Salar)* smolt undergoing saltwater challenge (only atrazine is evaluated herein). Juvenile salmon (1 year old, >25 g) were exposed to atrazine at 10 and 100 ug/L in freshwater for 21 days then transferred to saltwater (no atrazine exposure in salt water). 2 tanks with 18 fish per tank were included in each control and each treatment group. Fish (6 per tank) were sampled at the end of 21 days in freshwater and after a 24 hour challenge in saltwater at 30 ppt salinity. The remaining fish were allowed to grow in saltwater at 30 ppt (25 ppt for first week) and sampled every four weeks (only 9 fish remained in the 100 ug/l group due to 9% mortality during the freshwater exposure period.) Endpoints measured included multiple biochemical parameters (cortisol, glucose, hematocrit, growth hormone (GH), insulin growth factor I (IGF-I), thyroxine (T4) and plasma 3,5,3’-triiodo-l-thyronine (T3), Cl−, Mg2+, Na+, Ca2+, gill Na-K ATPase activity and brain cholinesterase), hepatosomatic (HSI) and gonadosomatic (GSI) index, weight, length, growth rate and food consumption.

*Results*

During the freshwater exposure period, 9% of the fish exposed to atrazine at 100 ug/L died. Fish in this treatment group also exhibited significantly reduced feeding after 10 days of exposure (with zero food consumption reported when measured on day 15), decreased growth rate in freshwater and decreased growth after the first month in saltwater. A compensatory growth period occurred in the second and third month in saltwater. Freshwater smolts in the 100 ug/l group also had decreased plasma Cl−, Mg2+, Na+ and Ca2+ ions and increased cortisol. No effect on plasma levels of GH, IGF-I, T4 or T3 was found in FW smolts in this group. Following the SW challenge, fish previously exposed to 100 ug/L atrazine had significant increases in hematocrit, plasma cortisol, Cl−, Mg2+, Na+, Ca2+ and a decrease in T4 and T3. There was an increase in the HSI in females in the 100 ug/L group and a decrease in the male GSI in this group after 21 days atrazine exposure. The study authors also reported decreased activity and response to external stimuli in the 100 ug/L treatment group.

**Description of Use in Document**: Quantitative for inclusion in data arrays and consideration as potential threshold values for risk estimation

**Rationale for Use:** Study provides useful information on the sensitivity of fish to atrazine in freshwater and subsequent saltwater challenge. The NOAEL/LOAEL/MATC values from this study may serve as a source of threshold values for direct and indirect effects.

**Limitations of Study:** No raw data was presented.

**Primary Reviewer**: Colleen M. Rossmeisl, DVM, Senior Biologist, OPP/EFED/ERB 3

**Secondary Reviewer:** Elizabeth Donovan, Senior Biologist, OPP/EFED/ERB 3