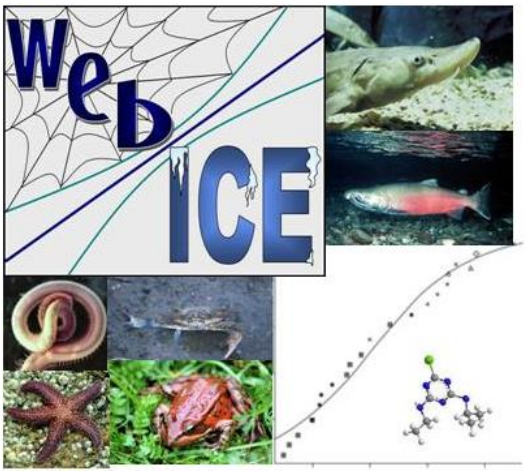
ICE Aquatic Toxicity Database Version 3.3 Documentation



Prepared by:

Sandy Raimondo, Crystal R. Lilavois, Morgan M. Willming and Mace G. Barron

U.S. Environmental Protection Agency
Office of Research and Development
National Health and Environmental Effects Research Laboratory
Gulf Ecology Division
Gulf Breeze, Fl 32561

Table of Contents

1 Introduction

This document describes the compilation, review, standardization, and quality assurance/quality control (QA/QC) of the ICE Aquatic Toxicity Database (herein, database) developed and maintained by the US EPA Gulf Ecology Division. The database is composed of acute toxicity records for aquatic animal species and is used in the development of toxicological models that include, but may not be limited to, Interspecies Correlation Estimation (ICE) models (Raimondo et al., 2010), Species Sensitivity Distributions (SSDs) (Barron et al. 2012), and Quantitative Structure-Activity Relationship (QSAR) models. ICE models are least squares regressions of the relative sensitivity between the taxa of interest and that of a surrogate species (e.g., standard test species). Validated ICE models are available on the US Environmental Protection Agency (US EPA) internet application, Web-based Interspecies Correlation Estimation (Web-ICE) (http://www.epa.gov/ceampubl/fchain/webice/index.html). SSDs are cumulative probability distributions of toxicity values for multiple species that may be used to derive a hazard level for ecological risk assessment based on a specified percentile of the distribution. QSARs are regression models describing the relationship between chemical structures and biological activity and can be used to predict activity of new chemicals.

The document is organized by section, including: 1) Introduction, 2) data sources used in developing the ICE database, 3) the quality acceptance criteria applied to the master database, 4) additional standardization applied to data used in ICE models, 5) quality assurance and control procedures, 6) data fields, 7) references, and technical appendices.

A separate database is maintained for algae toxicity data, the documentation for which is listed in Appendix B.

2 Data Sources

The database is composed entirely of secondary data (data previously collected for a different intended use). This section describes each data source in detail, its acquisition, and format. Data sources include both electronic and hard-copy formats. Hard-copy sources are entered into separate excel files identified by source(s) and original hardcopies are retained by the database manager or placed in the project study file. Those received electronically are saved as original, unaltered files and housed on a GED network drive. All data sources go through an extensive review process to ensure that each record meets acceptance criteria. A summary of the number of records from each data source are in Appendix A-1, which will be updated with each version of the database.

2.1 ECOTOX

The ECOTOXicology database (http://cfpub.epa.gov/ecotox/), developed by the USEPA/ORD/NHEERL Mid Continent Ecology Division, provides chemical toxicity information for aquatic organisms, terrestrial plants, and wildlife. It consists of toxicity data predominately from peer-reviewed literature, although there are some EPA records within the database as well. To obtain records for the database, ECOTOX is queried for acute, aquatic, animal records, which are downloaded in excel format. The procedure for preparing ECOTOX downloads for inclusion into the database is provided in Appendix A-2.

2.2 Ambient Water Quality Criteria (AWQC)

EPA is required by the Clean Water Act (Section 304(a)(1)) to develop criteria for water quality that accurately reflects the latest scientific knowledge. These criteria are based on data and scientific judgment on pollutant concentrations and environmental or human health effects. EPA's compilation of national recommended Ambient Water Quality Criteria (AWCQ) are published and publically available sources of toxicity data for fresh and saltwater organisms that maybe exposed to surface water pollutants. Data was compiled from 69 AWQC documents published from 1987-2013 (Appendix A-3). Minimum data provided from the document's Table 1 are chemical name, species tested, water type, test and concentration type (e.g. static, measured), and toxicities (EC/LC50). Additional information provided by some documents include active ingredient, age, hardness, pH and corrected toxicity values for metals. Toxicity data are entered if records meet database acceptance criteria.

2.3 Office of Pesticide Program (OPP) Ecotoxicity Database

The Office of Pesticide Program's Environmental Fate and Effects Division (EFED) Ecotoxicity database contains published and registrant submitted toxicity data for pesticides. Their database was acquired for this project in January 2007 and contained acute and chronic toxicity records for both aquatic and wildlife organisms. Additional acute mollusc data was acquired in April 2013. Data fields include chemical information, active ingredient, use category, taxa, test organism, test organism age, test conditions, toxicity values, and acceptance category (i.e. acceptable, supplemental). Water quality parameters are not provided, however each study is evaluated by EFED for conformance to Office of Chemical Safety and Pollution Prevention guidelines. Studies that contain major deviations from guidelines that affected the scientific integrity of the study are classified as unacceptable. Supplemental studies are those that are generally well conducted and employed Good Laboratory Practice (GLP), but the study did not meet all requirements listed for satisfaction of the OPP testing requirements (e.g. raw data not submitted). Core studies meet all OPP testing requirements, are well conducted, and all reported endpoints are validated by independent statistical analysis Only core and

supplemental data are accepted into the database and receive an additional level of QA/QC outlined in Section 3.0.

2.4 OPPT Premanufacture Notification (PMN)

Premanufacture Notification (PMN) data that is submitted to EPA under the Toxic Substance Control Act (TOSCA) is Confidential Business Information (CBI). GED personnel with CBI certifications obtain PMN toxicity data summaries in pdf format. Those data that meet the database acceptance criteria are entered into excel spreadsheets. Information includes chemical tested, species information and toxicities. In accordance with CBI procedures, the chemical identities are masked and data are not identifiable by chemical name and CAS number in files accessible by network connections. To censure data, a confidential identifier number (CIN) less than 100 (e.g., 1, 2, 3) is assigned to each CBI chemical in place of the chemical CAS, and a letter assigned in place of the chemical name. All chemicals with that same CAS number, regardless if they were CBI, are also assigned the same CIN in the database to allow development of ICE models while maintaining CBI requirements.

2.5 High Production Volume (HPV)

Under the High Production Volume (HPV) Challenge Program, companies make health and environmental effects data publicly available on chemicals produced or imported in the United States in quantities of 1 million pounds or more per year. HPV chemicals and associated information are publically available through the EPA (www.epa.gov/HPV/) as downloadable pdf documents for each chemical. HPV toxicity studies are encouraged to follow GLP and report test quality information for each chemical/species tested. Information obtained included chemical information and active ingredients, species information, toxicities, test information and water quality parameters. In addition, notes on test guidance were included (i.e. ASTM, OECD 203). Questionable data (i.e. missing information, species name errors) were not included into the database.

2.6 Mayer and Ellersieck 1986

The “Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals” is a compilation of records for freshwater aquatic organisms assembled to assess the influence of test conditions and physical, biological, and chemical properties on species sensitivity. Tests were conducted at the Columbia National Fisheries Research Laboratory (U.S. Department of Interior) from 1965-1984. The manual includes 4901 tests and provides information on chemicals tested, active ingredients, species and age information, test conditions, toxicities (EC/LC50), temperature, pH and hardness.

2.7 ORD

Mayer 1987. "A Handbook of Acute Toxicity Tests of Estuarine Organisms" includes toxicity tests conducted at the Gulf Ecology Division of the U.S. EPA Office of Research and Development (ORD) from 1961-1986. Data include chemical tested, active ingredient, species tested and age, test conditions, toxicities, temperature and salinity.

Mayer et al. 2008. This U.S. EPA report contains acute toxicity for 29 endangered and surrogate species using five chemicals. The report provided chemical and species information, toxicities, test conditions.

2.8 Open Literature

Data from published studies that are not currently in ECOTOX are acquired for taxa of interest (e.g. mussels, endangered species). Careful review of each source determines if the information meets acceptance criteria. The source must provide chemical tested, active ingredient, test species, age, test conditions, and toxicity. In addition, temperature and dissolved oxygen or indication that an appropriate test guidelines was used (i.e. ASTM) must be provided. Appendix A-4 provides a list of peer reviewed studies included in the database.

2.9 Procter & Gamble

Algal and zebrafish embryo toxicity data were developed under a Cooperative Research and Development Agreement between the Office of Research and Development of the U.S. EPA and the Procter and Gamble Company (P&G). The development of the algal database is described in Appendix B. Zebrafish embryo toxicity data were compiled from public (ECOTOX and scientific literature), P&G-owned sources, and OECD (2012).

3 Master Database QC and Acceptance Criteria

Data are only included in the database if they adhere to pre-determined acceptance criteria. These criteria evaluate test organisms (e.g., taxa, species confirmation), test chemicals (e.g. active ingredient), test duration and reported toxicity endpoint (e.g. mortality). The original source of data must clearly provide adequate information to assess these criteria for inclusion.

Data are subjected to two rounds of filtering; 1) first round filter for general criteria which determined data suitability for primary database, described in this Section and 2) second round filter for species-specific test conditions which determined data suitability for ICE model subset detailed in Section 5. It should be noted that some records included in hard copy data (e.g.

Mayer and Ellersieck 1986) were not entered into electronic format if they did not meet some of the standardization criteria (e.g. active ingredient $\geq$ 90%) described below.

Standardization/quality criteria that are applied to all data sources in the first round of filtering are summarized in Table 1 and described in Sections 3.1- 3.4.

Table 1. Checklist of standardization criteria for inclusion into primary database.

Category	Data Information	Criteria
Chemical	Identity	Reported CAS, name or structure confirmed CAS corresponds to single compound or element
	Compound	Mixtures excluded except for chemical salts and specific congener mixtures[1]
	Purity	Active ingredient $\geq$ 90%
	Grade	If Purity is "NR", test grade must be one listed in Appendix A-5
	Name	Synonyms conformed to ICE chemical name
Organism	Species	Fish, invertebrates, amphibians Name & taxonomy verified
	Life stage	Eggs excluded except for zebrafish embryos[2]
Test Conditions	Test Media	Aquatic (no sediment, dietary, mixed dose or phototoxicity)
	Exposure type	Flow through (F), static (S), or static renewal (R)
	Exposure duration	Acute; 24 (fairy shrimp), 48 & 96 hrs
	Endpoint	EC50 or LC50
	Measurement	Mortality or immobility
	Test Location	Laboratory
Toxicity Value	Concentration	~, > or < excluded
	Units	µg/L, converted if needed
	Chemical Normalization[3]	Pentachlorophenol to pH 6.5; Ammonia to TAN[4], FW to pH 7, FW inverts to 20°C; Specific metals[5] to hardness 50 mg/L
	Element Conversions[6]	Ag, Al, Cu, Cd, Co, Cr(III), Cr(VI), Hg, NH_4, Ni, Pb, Zn

[1] Included metal and other chemical salts, and specific congener mixtures

[2] Zebrafish embryo toxicity tests conducted using methods similar to OECD (2013) fish embryo toxicity test (FET).

[3]FW only, normalized according to AWQC

[4] Total Ammonia Nitrogen

[5] Ag, Cu, Cd, Cr(III), Pb, Ni, Zn

[6] Metals reported as salts were normalized to element

3.1 Chemicals

3.1.1 Active Ingredient and Mixtures

Inclusion of chemicals in the database required that the chemical tested have an active ingredient purity of ≥90%. This is determined from either the reported purity or the source/grade of the tested compound. Chemicals whose purity is not reported are accepted if the reported chemical grade is listed in Appendix A-5. If the chemical purity or grade is not reported or could not be determined through internet searches of commercial products, the record was not included. Mixtures are excluded, except for tests of single chemical salts and specific congener mixtures such as PCB, Arochlors, and toxaphene. Any degredates and metabolites are also excluded unless they are identified as the tested compound (e.g., met identity and purity requirements). Formulations of chemicals are excluded unless they contained 90% or greater of the test compound as the active ingredient.

3.1.2 Chemical names and CAS QA/QC

Each toxicity record in the database required a Chemical Abstracts Service (CAS) registry number or a chemical name for the compound tested. A toxicity record is only included if the source provides sufficient information to identify the test compound (e.g., chemical name, formula, smiles string, CAS). CAS and chemical name congruency are checked and/or assigned using public domain databases: the Allanwood Compendium of Pesticides (http://www.alanwood.net/pesticides/), Chemical Book (http://www.chemicalbook.com), or Sigma-Aldrich (http://www.sigmaaldrich.com). The CAS and name associated with each toxicity record are entered into the database as either the tested compound, as the element for Aluminum, Cadmium, Cobalt, Copper, Chromium (III), Chromium (VI), Lead, Mercury, Nickel, Silver, and Zinc, or as Pentachlorophenol or Ammonia for salts containing these chemicals . For records where CAS and chemical name are inconsistent or uncertain, additional internet sources, such as PubMed Compound (http://www.ncbi.nlm.nih.gov/pccompound), are consulted. The CAS or chemical name is either corrected or, in the case of uncertain chemical identity, the record removed. Chemical name as reported in the original source is maintained in the database, as well as the assignment of an ICE chemical name for synonym control. ICE chemical names were curated using DSSTox (www.epa.gov/ncct/dsstox/). A single name and the confirmed chemical abstract services registry number (CAS-RN) from the source material were checked against DSSTox to validate their consistency. Names that were not contained within DSSTox's list of synonyms for a particular chemical were manually checked to validate the agreement between the chemical identifiers and confirm the chemical-data linkage with ICE.

A separate database is maintained for mode of action (MOA) assignments. For complete description of MOA assignments see the Mode of Action and QSAR Databases and Modeling Quality Assurance Project Plan (QAPP-GED/BPRB/MB/2014-01-001). In brief, chemicals are assigned a broad MOA (e.g. AChE inhibition) and a specific MOA (e.g. AChE inhibition -

Organophosphate). Data fields in the MOA chemical database included CAS, chemical name, broad and specific MOA assignments, chemical class assignment (for narcosis chemicals only), MOA source, and a notes column.

3.2 Organism

The aquatic database contains only animal records and excludes the egg stages except for zebrafish embryos. Data sources must provide either common name and/or species names of the organisms tested. Verification of species, genus and family names is performed with the Integrated Taxonomic Information System (ITIS; www.itis.gov). If verification cannot be found in ITIS, other public domain internet websites (i.e. www.fishbase.com) or literature are used. Species names that cannot be verified are excluded. After verification, species are grouped into broader taxonomic categories (e.g., fish, crustaceans). If only a common name is provided that is too general to determine species, genus or family (i.e. Ostracod, Amphipod) then the record is not included. Any organism that could only be verified at or is tested at taxonomic level of Order or higher was not included. Test organisms identified by only genus or family are accepted. Species synonyms are standardized to reflect the most current nomenclature and common name.

3.3 Test Conditions

No sediment, dietary, mixed dose exposures**,** or photo-enhanced toxicity results are included in the database. The databases includes exposure types: static (S), flow through (F), and static renewal (R). Toxicity values reported as both measured (M) and nominal/unmeasured (U) are included. Acute toxicity results must be either immobilization (EC50) or mortality (EC/LC50). Test durations accepted were 24h (fairy shrimp), 48h and 96h tests.

Each species is designated as freshwater (FW) or saltwater (SW; estuarine or marine) based on the salinity of the test media and general knowledge of the species habitat requirements. If water type cannot be determined, records are designated as not reported (NR). Toxicity records classified as FW are stenohaline FW species or where reported test salinity is $\leq$ 1 ppt. Records classified as SW are SW species or where the salinity recorded is > 1 ppt.

3.4 Toxicity Values

3.4.1 Concentrations and Units

Open-ended toxicity values (i.e. > 100 µg/L or <100 µg/L) and approximate values (~100 µg/L) are excluded. All toxicity records are converted to µg/L (Table 2). If units could not be determined, the toxicity records are not included.

Table 2. Toxicity units and conversion factors

Unit	Alternate name	Conversion to ug/L
µg/L	PPB	= µg/L
mg/L	PPM	=mg/L * 1000
ng/L	PPT	= ng/L/ 1000
µmol/L	micromolar	= (µmol/L)*MW

3.4.2 Data normalization

The AWQC documents outline normalization procedures for pentachlorophenol (normalized to pH 6.5), ammonium compounds (converted to total ammonia nitrogen, at a pH 7 for freshwater and 20°C for freshwater organisms) and specific metal salts (hardness of 50 mg/L $CaCO_3$; reporting as metal element). These normalizations are applied to records for these compounds prior to inclusion into the database according to the Operating Procedure for ICE database chemical conversions and normalizations (OP-GED/BPRB/CRL/2015-01-001). Large metal salts and organometals are not normalized because of uncertainty in the relationship between their toxicity, hardness, and dissociation, and are treated as separate compounds in the database. These exceptions are further explained in the chemical normalization OP.

4 Standardization for ICE Models

Data are further standardized for the development of ICE models to ensure models reflect species sensitivity and contained minimal extraneous variation. Toxicity records that meet these requirements are designated as a “True” in the “Meets model requirements” column. This section explains the additional standardization for data used to develop ICE models (herein, model data subset), summarized in Table 3.

Table 3. Standardization criteria for data included in ICE model development

Component	Information required	Acceptance requirements
Test organism	Life stage[1]	juvenile only: fish, decapods juvenile and spat: molluscs[2] immature aquatic lifestages: amphibians (includes embryo), insects all life stages: all other species no egg or embryo test for any species other than zebrafish embryos[3]
Test conditions	Test duration	24-48 hr: fairy shrimp 48 hr: water fleas, midges, mosquitoes 96 hr: all other species
	Temperature[4]	species specific ($\pm$ 3 ^{o}C)
	Dissolved oxygen	Static: $\leq$48 hr 60-100%; >48 hr 40-100%. Static renewal or flow-through: 60-100%.
	Salinity	<1 ppt: FW species[5] $\geq$15 ppt: SW species[6]

[1] if life stage not reported, determined through reported age/size; Appendix A-8

[2] glochidia excluded

[3] Zebrafish embryo toxicity tests conducted using methods similar to OECD (2013) fish embryo toxicity test (FET).

[4] based on ASTM and equivalent test guidelines for test species; Appendix A-9

[5] Salmonid tests included are freshwater

[6] Striped bass (*Morone saxatilis*) tests are saltwater

4.1 Life stage

The life stage of each species is broadly defined as embryo, larvae, juvenile, or adult. In the model data subset, only the juvenile stages of fish (with the exception of zebrafish embryos) and decapods; juvenile and spat of molluscs; and immature aquatic lifestages of amphibians and aquatic insects are used. For all other species, all life stages (except embryo) are included. Embryos are included as an immature lifestage for amphibians when the tadpole is considered an embryo. A specified life stage is recorded as reported in the original source. If a specific stage is not identified in the original source, life history and organism size are used to determine life stage (Appendix A-6). Fish larvae include hatchlings through full fin development. Juvenile fish are those with full fin development lacking sexual maturity, and adult fish are those that are sexually mature. In cases where only a weight is provided for a fish species, life stage is determined using length-weight regressions in the Fish Base Life History Tool (Froese and Pauly 2008). When length-weight regressions are not available or adequate information is not provided, age class is designated as unknown. Records with an "unknown" life stage designation are only included in the model data subset for those species where all life stages are included, and where the egg and embryo stage can be ruled out. Zebrafish embryo

data were included where the tests were conducted using methods similar to OECD (2013) fish embryo toxicity test (FET). In model development, zebrafish embryo were kept separate form zebrafish juveniles such that separate models were developed for each life stage.

4.2 Freshwater (FW) or Saltwater (SW) Water Type

Only records designated as freshwater (FW) or saltwater (SW) with ≥15 ppt salinity are included in the ICE model subset, with the following specific exceptions. Only FW records for salmonid species are accepted to limit potential variability due to wide differences in test salinity for these euryhaline species. Only SW records for striped bass (*Morone saxatilis*) are accepted because of their juvenile life history characteristics.

4.3 Temperatures

To limit variability associated with temperature, a 6 °C range (+/- 3°C) of temperatures optimal for each species was chosen based on standard test guidelines where provided, or life history where guidelines did not specify species-appropriate conditions. This range was chosen because (1) acceptable within-test temperature is typically +/-2 °C and (2) it maximized data retention while maintaining a relatively narrow temperature range. Temperature ranges were assigned for species where the reported temperatures exceeded a 6°C range. Temperature ranges were generally consistent with ASTM and OPPTS recommend test ranges (Appendix A-7). If temperature was reported in a record as a range (i.e., 19-22 °C), the average temperature was calculated to determine if temperature fell within the acceptable range. If the reported range was greater than 6 °C, then the record was excluded.

4.4 Dissolved Oxygen

Dissolved oxygen (DO) must be reported for inclusion into the model data subset or the record reported following standardized testing procedures which would meet the DO guidelines. If DO was reported as a range (i.e., 30-70%), then the average was used. Where necessary, DO values are converted to % saturation to verify compliance with ASTM standards. Conversions to % saturation are calculated as:

$$\text{DO (\% saturation)} = \frac{\text{measured DO (mg/L)}}{\text{DO (mg/L at 100 \% saturation and 760 mm Hg)}} \times 100$$

Only records that met ASTM (2007) dissolved oxygen requirements are included in the model data subset:

- S tests ≤ 48 h, 60-100%;
- S tests > 48 h, 40-100%;
- F or SR tests, 60-100%.

4.5 Check for outliers

When more than one toxicity value is available for a chemical and species using the standardization criteria for model development outlined in this section, the ratio of the maximum and minimum values is calculated. Toxicity records with max/min ratios greater than 10 are examined for outliers and original sources of the data consulted. For example, if an outlier data record was obtained from ECOTOX, the original published research article that was entered into ECOTOX was obtained and checked. Outliers identified through this process to be questionable are removed.

5 Quality Assurance and Control

All records in the database are subjected to strict quality assurance and control in accordance to the Quality Assurance Project Plan (QAPP-GED/BPRB/MB/2015-01-001 July 2015). Once all standardization is complete, duplicate records are identified and removed. Duplicate records are defined by having the same source citation or authors, CAS, species, age and toxicity value.

6 Data fields

The data fields and associated code definitions included in the database are outlined in Appendix A-8.

7 References

Barron, M.G., C.R. Jackson, J.A. Awkerman. 2012. Evaluation of an *in silico* approach to developing aquatic toxicity species sensitivity distributions. Aquat Toxicol.

Froese, R. and D. Pauly. Editors. 2008.FishBase. World Wide Web electronic publication. http://www.fishbase.org/

Mayer, F.L. 1987. Acute toxicity handbook of chemicals to estuarine oganisms. EPA/600/8-87/017. Gulf Breeze, Fl.

Mayer, F.L., D.R. Buckler, F.J. Dwyer, M.R. Ellersieck, L.C. Sappington, J.M. Besser, and C.M. Bridges. 2008. Endangered aquatic vertebrates: comparative and probabilistic based toxicology. EPA/600/R-08/045. Gulf Breeze, Fl.

OECD (Organization for Economic Cooperation and Development). 2012. Annexes to the Validation Report (Phase 2) for the Zebrafish Embryo Toxcity Test. Series on Testing and Assessment No. 179. Environment Directorate. ENV/JM/MONO(2012)25/ANN.

OCED (Organization for Economic Cooperation and Development). 2013. OECD Guidelines for the Testing of Chemicals. Test No. 236: Fish Embryo Acute Toxicity (FET) Test. July 26, 2013. 22p.

Raimondo, S., C.R. Jackson, M.G. Barron. 2010. Influence of taxonomic relatedness and chemical mode of action in acute interspecies estimation models for aquatic species. Environmental Science and Technology. 44: 7711-7716.

Russom, C.L., S.P. Bradbury, S.J. Broderius, D.E. Hammermeister and R.A. Drummond. 1997. Predicting modes of toxic action from chemical structure: Acute toxicity in the fathead minnow (Pimephales promelas). Environ Toxicol Chem. 16: 948-967.

U.S. EPA. 1986. Quality criteria for water. EPA 440/5-86-001. Washington, DC.

U.S. EPA. 2007. ECOTOX User Guide: ECOTOXicology Database System. Version 4.0. Available: http:/www.epa.gov/ecotox/

8 Appendix A

Appendix A-1. Total number of records collected and retained by source for database version 3.3.

Data Source	Approx. # records obtained	# records in database	Dates
AWQC	5080	4232	See Appendix A-3 for document and year
Mayer et al. 2008	87	87	2008
ECOTOX	299500	11022	Last download 2014
HPV	4700	430	Downloaded Feb 2008
Literature	1090	670	1976-2014
Mayer 1987	375	307	1987
Mayer and Ellersieck 1986	2740	2703	1986
OPP	19400	2081	January 2007
OPPTS_PMN	110	61	December 2007
P&G	303	303	December 2015
Total	333378	21896	

Appendix A-2. Process for preparing Ecotox downloads for inclusion into the database.

ECOTOX Columns	ICE Column	Concatenate or Delete Columns	Notes
Result Number (unique identifier; previously called AQUIRE or Test Number prior to March 2012)	Dsource specific	Add ECO before #	Designates ECOTOX as original source in ICE database
CAS Number	cas reported	---	---
Chemical Name	chemical tested	---	---
Chemical Grade & Chemical Purity	AI	Concatenate: Purity (Grade)	Delete records with <90% Purity or Grades not in Appendix 6
Chemical Formulation	---	Deleted Column	---
Chemical Comment	---	---	---
Species Number	---	Deleted Column	---
Species Scientific Name	Species	---	---
Species Common Name	common name	---	---
Species, Kingdom, Phylum, Sub Phylum, Superclass, Class, Order	---	Deleted Columns	---
Species Family	Family	---	---
Species Genus	Genus	---	---
Organism Age, Age Units, Organism Lifestage, Organism Comment	age	Concatenate: Organism Age Units, Lifestage (Comment)	Delete records with codes EG, EM, BL
Endpoint	Dose Type	---	Delete EC50s for verts
Effect, Effect Measurement	---	Concatenate: Effect (Meas)	Only keep codes ITX(IMBL), ITX (MBLT), MOR (MORT), MOR (SURV). Use code list to idenitify other acceptable codes.
Exposure Type	Test Type	---	Only keep codes F, S, R
Chemical Analysis	Concentration Type	---	---
Exposure Duration Op (Days)	---	---	Delete Records with Operators (>,<,~)
Exposure Duration, Units	Test duration	Concatenate: Duration Unit	Only keep 2 or 4 d, 48 or 96 hr

ECOTOX Columns	ICE Column	Concatenate or Delete Columns	Notes
Exposure Duration Min Op, Min, Max OP, Max	---	Deleted Column	---
Conc 1 Type, Ionic Fraction 1	---	Concatenate: Type, Fraction	Use for conversions
Conc 1 Op (µg/L)	---	---	Delete Records with Operators (>,<,~)
Conc 1 (µg/L)	---	---	Deleted NR
Conc 1 Min Op, Min 1, 1 Max OP, 1 Max	---	---	Deleted record with conc ranges (min and max)
Conc 2 Type, Ionic Fraction 2	---	Concatenate: Type, Fraction	Use for conversions
Conc 2 Op (µg/L)	---	---	Delete Records with Operators (>,<,~)
Conc 2 (µg/L)	---	---	Moved records with 2nd conc to another tab.
Conc 2 Min Op, Min 2, 2 Max OP, 2 Max	---	---	Deleted record with conc ranges (min and max)
Conc Units (µg/L)	---	---	Applies to both Conc 1 and 2. Moved those with non-µg/L units to another tab
Media Type	Water type	---	---
Test Location	---	Deleted Column once only lab records remained.	Only kept records with Lab test.
Temperature Mean Op, Mean, Min OP, Min, Max OP, Max, Units	Temp	Concatenate: OP Mean (OP Min-OP Max) Units	---
Hardness Mean Op, Mean, Min OP, Min, Max OP, Max, Units	Hardness	Concatenate: OP Mean (OP Min-OP Max) Units	---
pH Mean Op, Mean, Min OP, Min, Max OP, Max	pH	Concatenate: OP Mean (OP Min-OP Max)	---
Salinity Mean Op, Mean, Min OP, Min, Max Op, Max, Units	Salinity	Concatenate: OP Mean (OP Min-OP Max) Units	---
Dissolved Oxygen Mean Op, Mean, Min OP, Min, Max OP, Max, Units	Dissolved Oxygen	Concatenate: OP Mean (OP Min-OP Max) Units	---
General Comments	---	---	---
Author, Title, Source, Publication Year, Reference Number	---	Concatenate: Author. (Year) Title. Source. (ECOTOX Ref #)	---

Appendix A-3. List of AWQC documents and publication years entered into the database

Document Name	Year
AWQC updates	1995
2,4-dichlorophenol	1980
2,4-dimethylphenol	1980
2-chlorophenol	1980
Acenaphthene	1980
Acrolein	1980
Acrylonitrile	1980
Aldrin/Dieldrin	1980
Aluminum	1988
Ammonia	2013
Antimony	1980
Arsenic	1984
Atrazine (draft)	2003
Benzene	1980
Benzidine	1980
Beryllium	1980
Cadmium	2001
Carbon tetrachloride	1980
Chlordane	1980
Chloride	1988
Chlorinated benzenes	1980
Chlorinated ethanes	1980
Chlorinated napthalenes	1980
Chlorinated phenols	1980
Chlorine	1984
Chloroalkyl ethers	1980
Chloroform	1980
Chlorpyrifos	1986
Chromium	1984
Copper	1984
DDT	1980
Diazinon	2005
Dichlorobenzenes	1980
Dichloroethylenes	1980

Document Name	Year
Dichloropropane/propenes	1980
Dinitrotoluenes	1980
Diphenylhydrazine	1980
Endosulfan	1980
Endrin	1980
Ethylbenzene	1980
Fluoranthene	1980
Haloethers	1980
Halomethanes	1980
Heptachlor	1980
Hexachlorobutadiene	1980
Hexachlorocyclohexane	1980
Hexachlorocyclopentadiene	1980
Isophorone	1980
Lead (draft)	2008
Mercury	1984
Naphthalene	1980
Nickel	1986
Nitrobenzene	1980
Nitrophenols	1980
Nitrosamines	1980
Nonylphenol	2005
Parathion	1986
Pentachlorophenol	1986
Phenol	1980
Phthalate esters	1980
Selenium (draft)	2004
Silver (update)	2007
Thallium	1980
Toluene	1980
Toxaphene	1986
Trichloroethylene	1980
Zinc	1987

Appendix A-4. Bibliography of references in database obtained from open literature.

Adams WJ, Biddinger GR, Robillard KA, Gorsuch JW. 1995. A summary of the acute toxicity of 14 phthalate esters to respresentative aquatic organisms. Environ Toxicol Chem 14(9) 1569-1574.

Belanger SE, Rawlings JM, Carr GJ. 2013. Use of fish embryo toxicity tests for the prediction of acute fish toxicity to chemicals. Environ Toxicol Chem 32:1768-1783.

Bentley RE, Dean JW, Ells SJ, Hollister TA, LeBlanc GA, Sauters S, Sleight BH. 1977. Laboratory evaluation of the toxicity of cyclotrimethylene trinitramine (RDX) to aquatic organisms. Final Report US Army Medical Research and development Command, Frederick Maryland Contract No: DAMD-17-74-C-4101.

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

Black, M. C. (2003). Water quality standards for North Carolina's endangered mussels. Athens, GA. University of Georgia, Department of Environmental Health Science.

Brecken-Folse JA, Mayer FL, Pedigo LE, Marking LL. 1994. Acute toxicity of 4-nitrophenol, 2,4-dinitrophenol, terbufos and trichlorfon to grass shrimp (Palaemonetes spp.) and sheepshead minnows (Cyprinodon variegatus) as affected by salinity and temperature. Environ Toxicol Chem 13: 67-77.

Bringolf, R. B., Cope, W. G., Barnhart, M. C., Mosher, S., Lazaro, P. R., and Shea, D. (2007). Acute and chronic toxicity of pesticide formulations (atrazine, chlorpyrifos, and permethrin) to glochidia and juveniles of Lampsilis siliquoidea. Environmental Toxicology and Chemistry, 26(10), 2101-2107.

Bringolf, R. B., Cope, W. G., Eads, C. B., Lazaro, P. R., Barnhart, M. C., and Shea, D. (2007). Acute and chronic toxicity of technical-grade pesticides to glochidia and juveniles of freshwater mussels (Unionidae). Environmental Toxicology and Chemistry, 26(10), 2086-2093.

Bringolf, R. B., Cope, W. G., Mosher, S., Barnhart, M. C., and Shea, D. (2007). Acute and chronic toxicity of glyphosate compounds to glochidia and juveniles of Lampsilis siliquoidea (Unionidae). Environmental Toxicology and Chemistry,26(10), 2094-2100.

Buhl KJ, Hamilton SJ. 1996. Toxicity of inorganic contaminants, individually and in environmental mixtures, to three endangered fishes (Colorado squawfish, bonytail, razorback sucker). Arch. Environ. Contam. Toxicol. 30: 84-92.

Burton DT, Turley SD, Peters GT. 1994. The acute and chronic toxicity of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) to the fathead minnow (Pimephales promelas). Chemosphere 29(3) 567-579.

Busquet F, Strecker R, Rawlings JM, Belanger SE, Braunbeck T, Carr GJ, Cenijn P, Fochtman P, Gourmelon A, Hübler N, Kleensang A, Knöbel M, Kussatz C, Legler J, Lillicrap A, Martínez-Jerónimo F, Polleichtner C, Rzodeczko H, Salinas E, Schneider KE, Scholz S, van den Brandhof E-J, van der Ven LTM, Walter-Rohde S, Weigt S, Witters H, Halder M. 2014. OECD validation study to assess intra- and inter-laboratory reproducibility of the

zebrafish embryo toxicity test for acute aquatic toxicity testing. Reg Tox Pharm 69:496-511.

Cherry, D. S, Farris J. L., and Neves R. J. (1991). Laboratory and Field Ecotoxicological Studies at the Clinch River Plant, Virginia. Blacksburg, VA. Virginia Polytechnic Institute and State University.

Cherry, D. S., Valenti, T. W., Currie, R. J., Neves, R. J., Jones, J. W., Mair, R. A., and Kane, C. M., 2005. Chlorine toxicity to early life stages of freshwater mussels. Blacksburg, VA. Biology Department and Department of Fisheries and Wildlife Science, Virginia Polytechnic Institute and State University.

Clearwater, S. J., Thompson, K. J., and Hickey, C. W. (2013). Acute Toxicity of Copper, Zinc, and Ammonia to Larvae (Glochidia) of a Native Freshwater Mussel Echyridella menziesii in New Zealand. Archives of environmental contamination and toxicology, 1-14.

Clem S. A. 1998. Complexities in early lifestage testing of freshwater mussels to selected metals. (M.S. Thesis). Arkansas State University, Jonesboro, AR.

Colombo I, de Wolf W, Thompson RS, Farrar DG, Hoke RA, L'Haridon J. 2008. Acute and chornic aquatic toxicity of ammonium perfluorooctanoate (APFO) to freshwater organisms. Ecotox Environ Safety 71: 749-756.

Conners, D. E., and Black, M. C. (2004). Evaluation of lethality and genotoxicity in the freshwater mussel Utterbackia imbecillis (Bivalvia: Unionidae) exposed singly and in combination to chemicals used in lawn care. Archives of environmental contamination and toxicology, 46(3), 362-371.

Douda, K. (2010). Effects of nitrate nitrogen pollution on Central European unionid bivalves revealed by distributional data and acute toxicity testing. Aquatic Conservation: Marine and Freshwater Ecosystems, 20(2), 189-197.

Dwyer FJ, Mayer FL, Sappington LC, Buckler DR, Bridges CM, Greer IE, Hardesty DK, Henke CE, Ingersoll CG, Kunz JL, Whites DW, Augspurger T, Mount DR, Hattala K, Neuderfer GN. 2005. Assessing contaminant sensitivity of endangered and threatened aquatic species: Part I. Acute toxicity of five chemicals. Arch Environ Contam Toxicol 48: 143-154.

Farag, A. M., and Harper, D. D. (2012). The potential effects of sodium bicarbonate, a major constituent of produced waters from coalbed natural gas production, on aquatic life. Virginia, USA, US Department of the Interior, US Geological Survey. p. 101.

Fritts, A. K., Barnhart, M. C., Bradley, M., Liu, N., Cope, W. G., Hammer, E., and Bringolf, R. B. (2014). Assessment of toxicity test endpoints for freshwater mussel larvae (glochidia). Environmental Toxicology and Chemistry, 33(1), 199-207.

Gillis, P. L. (2011). Assessing the toxicity of sodium chloride to the glochidia of freshwater mussels: Implications for salinization of surface waters.Environmental Pollution, 159(6), 1702-1708.

Gillis, P. L., Mitchell, R. J., Schwalb, A. N., McNichols, K. A., Mackie, G. L., Wood, C. M., and Ackerman, J. D. (2008). Sensitivity of the glochidia (larvae) of freshwater mussels to copper: Assessing the effect of water hardness and dissolved organic carbon on the sensitivity of endangered species. Aquatic toxicology, 88(2), 137-145.

Gooding, M. P., Newton, T. J., Bartsch, M. R., and Hornbuckle, K. C. (2006). Toxicity of synthetic musks to early life stages of the freshwater mussel Lampsilis cardium. Archives of environmental contamination and toxicology,51(4), 549-558

Hansen JA, Lipton J, Welsh PG. 2002. Relative sensitivity of bull trout (Salvelinus confluentus) and rainbow trout (Oncorhynchus mykiss) to acute copper toxicity. Environ Toxicol Chem 21(3):633-639.

Hansten, C., Heino, M., and Pynnönen, K. (1996). Viability of glochidia of Anodonta anatina (Unionidae) exposed to selected metals and chelating agents. Aquatic toxicology, 34(1), 1-12.

Hazelton, P. D., Cope, W. G., Mosher, S., Pandolfo, T. J., Belden, J. B., Barnhart, M. C., and Bringolf, R. B. (2013). Fluoxetine alters adult freshwater mussel behavior and larval metamorphosis. Science of the Total Environment, 445, 94-100.

Hazelton, P. D., Cope, W. G., Pandolfo, T. J., Mosher, S., Strynar, M. J., Barnhart, M. C., and Bringolf, R. B. 2012. Partial life-cycle and acute toxicity of perfluoroalkyl acids to freshwater mussels. Environmental Toxicology and Chemistry, 31(7), 1611-1620.

Hedtke SF, West CW, Allen KN, Norberg-King TJ, Mount DI. 1986. Toxicity of pentachlorophenol to aquatic organisms under naturally varying and controlled environmental conditions. Environ Toxicol Chem 5: 531-542.

Ivey, C., Besser, J. and Ingersoll, C. 2015. USGS-CERC. Final data summary for USEPA Regional Methods Development Project, "Toxicity estimation in threatened and endangered species: fairy shrimp," [EPA reference: DW-14-95797401-2]

Johnson, I. C., Keller, A. E., and Zam, S. G. (1993). A method for conducting acute toxicity tests with the early life stages of freshwater mussels. In: Landis, W. G., Hughes, J. S., and Lewis, M. A., Eds. ASTM Special Technical Publication. American Society for Testing and Materials, Philadelphia, PA. pp. 381-396.

Keller, A. E., and Augspurger, T. (2005). Toxicity of fluoride to the endangered unionid mussel, Alasmidonta raveneliana, and surrogate species. Bulletin of environmental contamination and toxicology, 74(2), 242-249.

Kováts, N., Abdel-Hameid, N. A., Kovács, K., and Paulovits, G. (2010). Sensitivity of three unionid glochidia to elevated levels of copper, zinc and lead. Knowledge and Management of Aquatic Ecosystems, (399), 04.

Lasee, B. A. (1991). Histological and ultrastructural studies of larval and juvenile Lampsilis (Bivalvia) from the upper Mississippi River (Doctoral dissertation). Iowa State University, Ames, IA.

Little EE, Calfee RD. 2008. Toxicity of chlorine and copper to rainbow trout and to white sturgeon from the Kootenai River and Columbia River. Administrative Report for US Fish and Wildlife Service

Mancini ER, Steen A, Rausina GA, Wong DCL, Arnold WR, Gostomski GE, Davies T, Hockett JR, Stubblefield WA, Drottar KR, Springer TA, Errico P. 2002. MTBE Ambient water quality criteria development: A public/private partnership. Enviro. Sci. Technol. 36: 125-129.

Marking LL, Bills TD. 1975. Toxicity of potassium permanganate to fish and its effectiveness for detoxifying antimycin. Trans Am Fish Soc 104(3): 579-583.

Marking LL, Hogan JW. 1967. Toxicity of Bayer 73 to Fish. United States Fish and Wildlife Service, Investigations in Fish Control 19:1-13.

Marking LL, Olson LE. 1975. Toxicity of the lampricide 3-Trifluoromethyl-4-nitrophenol (TFM) to nontarget fish in static tests. United States Fish and Wildlife Service, Investigations in Fish Control 60.

Marking LL. 1970. Juglone (5-hydroxy-1,4-naphthoquinone) as a fish toxicant. Trans Amer Fish Soc 3: 510-514.

Mauck WL, Olson LE, Marking LL. 1976. Toxicity of natural pyrethrins and five pyrethroids to fish. Arch Environ Contamin Toxicol 4:18-29.

McCann, M. (1993). Toxicity of zinc, copper, and sediments to early life stages of freshwater mussels in the Powell River, Virginia. (Masters' Thesis). Virginia Polytechnic Institute, Blacksburg, VA.

Milam, C. D., Farris, J. L., Dwyer, F. J., and Hardesty, D. K. (2005). Acute toxicity of six freshwater mussel species (glochidia) to six chemicals: Implications for daphnids and Utterbackia imbecillis as surrogates for protection of freshwater mussels (Unionidae). Archives of environmental contamination and toxicology, 48(2), 166-173.

OECD (Organization for Economic Cooperation and Development). 2012. Annexes to the Validation Report (Phase 2) for the Zebrafish Embryo Toxcity Test. Series on Testing and Assessment No. 179. Environment Directorate. ENV/JM/MONO(2012)25/ANN.

Pandolfo, T. J., Cope, W. G., Young, G. B., Jones, J. W., Hua, D., and Lingenfelser, S. F. (2012). Acute effects of road salts and associated cyanide compounds on the early life stages of the unionid mussel Villosa iris. Environmental Toxicology and Chemistry, 31(8), 1801-1806.

Randall RC, Ozretich RJ, Boese BL. 1983. Acute toxicity of butyl benzyl phthalate to the saltwater fish English sole, Parophrys vetulus. Enviro. Sci. Technol. 17(11): 670-672.

Rausina GA, Wong DCL, Arnold WR, Mancini ER, Steen AE. 2002. Toxicity of methyl tert-butyl ether to marine organisms: ambient water quality criteria calculation. Chemosphere 47: 525-534.

Scholz S, Ortmann J, Klüver N, Leonard M. 2014. Extensive review of fish embryo acute toxicities for the prediction of GHS acute systemic toxicity categories. Regul Toxicol Pharm. 69:572-579.

Schuytema GS, Nebeker AV. 1999. Comparative toxicity of ammonium and nitrate compounds to Pacific treefrog and African clawed frog tadpoles. Environ Toxicol Chem 18 (10): 2251-2257.

Shaw JR, Wood CM, Birge WJ, Hogstrand C. 1998. Toxicity of silver to the marine teleost (Oligocottus maculosus) effects of salinity and ammonia. Environ Toxicol Chem 17(4): 594-600.

Soucek, D. J., and Dickinson, A. (2012). Acute toxicity of nitrate and nitrite to sensitive freshwater insects, mollusks, and a crustacean. Archives of environmental contamination and toxicology, 62(2), 233-242.

Soucek, D. J., Dickinson, A., and Koch, B. T. (2011). Acute and chronic toxicity of boron to a variety of freshwater organisms. Environmental Toxicology and Chemistry, 30(8), 1906-1914.

Soucek, D. J., Linton, T. K., Tarr, C. D., Dickinson, A., Wickramanayake, N., Delos, C. G., and Cruz, L. A. (2011). Influence of water hardness and sulfate on the acute toxicity of chloride to sensitive freshwater invertebrates. Environmental Toxicology and Chemistry, 30(4), 930-938.

Stratus Consulting, Inc. 1999. Sensitivity of bull trout (Salvelinus confluentus) to cadmium and zinc in water characteristic of the Coeur D'Alene River Basin: acute toxicity report. Final Report to U.S. EPA Region 10. 55 pp.

Valenti, T. W., Cherry, D. S., Neves, R. J., and Schmerfeld, J. (2005). Acute and chronic toxicity of mercury to early life stages of the rainbow mussel, Villosa iris (Bivalvia: Unionidae). Environmental toxicology and chemistry, 24(5), 1242-1246.

Valenti, T. W., Cherry, D. S., Neves, R. J., Locke, B. A., & Schmerfeld, J. J. Case Study: Sensitivity of Mussel Glochidia and Regulatory Test Organisms to Mercury and a Reference Toxicant. In: Freshwater Bivalve Ecotoxicology. Farris, J. L., & Van Hassel, J. H. (Eds.). (2006). Freshwater bivalve ecotoxicology. SETAC, Pensacola, FL, USA 357-373.

Wan MT, Buday C, Schroeder G, Kuo J, Pasternak J. 2006. Toxicity to Daphnia magna, Hyalella azteca, Oncorhynchus kisutch, Oncorhynchus mykiss, Oncorhynchus tshawytscha, and Rana catesbeiana of Atrazine, Metolachlor, Simazine, and their formulated products. Bull Environ Contam Toxicol 76: 52-58

Wan MT, Kuo J, Buday C, Schroeder G, Van Aggelen G, Pasternak J. 2005. Toxicity of α-, β-, (α + β)- Endosulfan and their formulated and degradation products to Daphnia magna, Hyalella azteca, Oncorhynchus mykiss, Oncorhynchus kisutch, and biological implications in streams. Environ Toxicol Chem 24(5): 1146-1154.

Wang, N., Ingersoll, C. G., Greer, I. E., Hardesty, D. K., Ivey, C. D., Kunz, J. L., Brumbaugh, W. G., Dwyer, F. J., Roberts, A. D., Augspurger, T., Kane, C. M., Neves, R. J., and Barnhart, M. C. (2007). Chronic toxicity of copper and ammonia to juvenile freshwater mussels (Unionidae). Environmental Toxicology and Chemistry, 26(10), 2048-2056.

Wang, N., Ingersoll, C. G., Hardesty, D. K., Ivey, C. D., Kunz, J. L., May, T. W., Dwyer, F. J., Roberts, A.D., Augspurger, T., Kane, C. M., Neves, R. J., and Barnhart, M. C. (2007). Acute toxicity of copper, ammonia, and chlorine to glochidia and juveniles of freshwater mussels (Unionidae).Environmental Toxicology and Chemistry, 26(10), 2036-2047.

Wang, N., Ingersoll, C. G., Ivey, C. D., Hardesty, D. K., May, T. W., Augspurger, T., Roberts, A. D., van Genderen, E., and Barnhart, M. C. (2010). Sensitivity of early life stages of freshwater mussels (Unionidae) to acute and chronic toxicity of lead, cadmium, and zinc in water. Environmental Toxicology and Chemistry, 29(9), 2053-2063.

Wang, N., Mebane, C. A., Kunz, J. L., Ingersoll, C. G., Brumbaugh, W. G., Santore, R. C., Gorsuch, J. W., and Arnold, W. R. (2011). Influence of dissolved organic carbon on toxicity of copper to a unionid mussel (Villosa iris) and a cladoceran (Ceriodaphnia dubia) in acute and chronic water exposures. Environmental Toxicology and Chemistry, 30(9), 2115-2125.

Ware GW (ed). 1999. Reviews of Environmental Contamination and Toxicology. Springer-Verlag, New York, NY.

Warren, L. W. (1996). The use of juvenile mussels, Utterbackia imbecillis Say (Bivalvia: Unionidae), as a standardized toxicity testing organism (Doctoral dissertation). Clemson University, Clemson, SC.

Yin D, Hu S, Jin H, Yu L. 2003. Deriving freshwater quality criteria for 2,4,6-trichlorophenol for protection of aquatic life in China. Chemosphere 52: 67-73.

Appendix A-5. Acceptable Chemical Grades with purities ≥ 90% from Ecotox

Code	Definition	Code	Definition
A	Analytical Grade	PAN	Pestanal Grade
A or R	Analytical or Reagent Grade	PFG	Purified Grade
A or S	Analytical or Spectrophotometric Grade	PG	Pure Grade
A or GU	Analytical or Guaranteed Grade	PH	Pharmaceutical Grade
AASG	Atomic Absorbtion Spectometry Grade	PRG	Pesticide Residue Grade
ACS	American Chemical Society Grade	PST	Pesticide Grade
AL	Analysis Grade	R	Reagant Grade
AN	Analar Grade	RE	Reasearch Grade
AN or R	Analar or Reagant Grade	RE or A	Research or Analytical Grade
AR	A.R. Grade (Analytical Reagant Grade)	RFG	Reference Grade
CH	Chromatographic Grade	RS	Residue Grade
CL	Clinical Grade	S	Spectrophotometric Grade
CT	Certified Grade	SC	Scintillation Grade
DG	Distilled in Glass Grade	SO	Solvent Grade
EL	Electrophoresis Grade	SPC	Spectrochemical Grade
GC	Gas Chromatography Grade	T	Technical Grade
GU	Guaranteed Grade	T or P	Technical or Purified Grade
GUR	Guaranteed Reagant Grade	T or PU	Technical Grade or Pure
HG	Histological Grade	TA	Technical Acid Grade
HPLC	High Performance Liquid Chromatography Grade	TAR	Technical, Analytical or Reagant Grade
L	Laboratory Grade	TIS	Tissue Culture Grade
ME	Monsanto Electrical Grade	ULV	ULV Grade
MK	Merck Grade	UP	Ultrapure Grade
NAF	National Formulary Grade	USP	United States Pharmacopeia Grade
NP	Normapur Grade	UV	UV Grade

Appendix A-6. Age classifications used to designate life stage in the database.

		Larvae[a]			Juvenile[b]			Adult			
Family	**Species**	**Lengths (mm)**	**Age**	**weights (g)**	**Lengths (mm)**	**Age**	**weights (g)**	**Lengths (mm)**	**Age**	**weights (g)**	**Source**
Acipenseridae		< 30		< 0.2	30-700		0.2-900	> 700		> 900	Jones et al. 1978, Bath and O'Connor 1981, Hastings et al. 1987, Froese and Pauly 2008
	Polyodon spathula							>565		>3644	Mims and Knaub 1993, Froese and Pauly 2008
Anguillidae	*Anguilla sp.*	< 70		< 0.5	70-400		0.5-100	> 400		> 100	Hardy 1978a, Froese and Pauly 2008
	Anguilla anguilla	<80		<.65	80-500		.65-236.47	>500		236.47	Froese and Pauly 2008
Atherinopsidae	*Menidia sp.*	< 10	<7-10 d	< 0.1	10-75	7- 60 d	0.1-2.5	> 75	>50-60 d	> 2.5	Martin and Drewry 1978, Froese and Pauly 2008, personal communication Scott Kellman, Aquatic Biosystems, Ft Collins, CO 2015
	Menidia beryllina	<10			10-50			>50			Wurtsbaugh and Li 1985, Froese and Pauly 2008
	Menidia menidia	5			<9.3			>9.3			Froese and Pauly 2008, Conover et al. 2005
	Menidia peninsulae	3.89			32.5			>42.5			Middaugh and Hemmer 1987
Melanotaeniidae	*Melanotaenia nigrans*	<21			21-70			>70			Crowley and Ivanstoff 1982
	Melanotaenia splendida							>129			Crowley and Ivanstoff 1982
Pseudomugilidae	*Pseudomugil signifer*							>28			Froese and Pauly 2008
Adrianichthyidae	*Oryzias latipes*		<2 w			>2-6 w			>5 w		Personal communitcation Rodney Johson, EPA, MED, 2015
Anostomidae	*Leporinus obtusidens*				<21.6		<189.54	>21.6		>189.54	Froese and Pauly 2008
Clupeidae		< 30		< 0.2	30-180		0.2-100	> 180		> 100	Jones et al. 1978, Froese and Pauly 2008
Catostomidae	*Catostomus sp.*	< 17		< 0.1	17-200		0.1-100	> 200		> 100	Jones et al. 1978, Froese and Pauly 2008

		Larvae[a]			Juvenile[b]			Adult			
Family	**Species**	**Lengths (mm)**	**Age**	**weights (g)**	**Lengths (mm)**	**Age**	**weights (g)**	**Lengths (mm)**	**Age**	**weights (g)**	**Source**
Cyprinidae	*Abramis brama*							>387		>607	Froese and Pauly 2008
	Barilius bendelisis	<70			70-83			>83			Gairola et al. 1990, Froese and Pauly 2008
	Campostoma anomalum	< 20		< 0.1	20-100		0.1-2	> 100		> 2	Buynak and Mohr 1980b, Froese and Pauly 2008
	Carassius sp.	< 12		< 0.1	12-300		0.1-500	> 300		> 500	Jones et al. 1978, Froese and Pauly 2008
	Cirrhinus mrigala	< 20		< 0.1	20-525		0.1-500	> 525		> 500	Alikunhi 1956, Chakrabarty and Murty 1972, Froese and Pauly 2008
	Cyprinus carpio	< 19		< 0.1	19-250		0.1-200	> 250		> 200	Jones et al. 1978, Scott and Crossman 1979, Froese and Pauly 2008
	Cyprinella spiloptera							>38			Gotelli and Pyron 1991
	Cyprinella whipplei							>106			Gotelli and Pyron 1991
	Gibelion catla	< 20		< 0.1	20-440		0.1-500	> 440		> 500	Alikunhi 1956, Chakrabarty and Murty 1972, Froese and Pauly 2008
	Gila elegans	<28			28-260			> 260			Kaeding and Zimmerman 1983, Marsh 2004, Froese and Pauly 2008
	Hybognathus amarus	<9.2			9.2-18.8			>60	18 m		Magana 2007
	Labeo sp.	< 20		< 0.2	20-100		0.2-20	> 100		> 20	Alikunhi 1956, Chakrabarty and Murty 1972, Cambray 1985, Weyl and Booth 1999, Tedesco and Hugueny 2006, Froese and Pauly 2008
	Notemigonus crysoleucas	<14.7		0.09	14.7-64		.09-5.31	>64		>5.31	Buynak and Mohr 1980a, Froese and Pauly 2008
	Notropis sp.	< 15		< 0.1	15-40		0.1-0.5	> 40		> 0.5	Saksena 1962, Ross 2001, Froese and Pauly 2008
	Phoxinus eos	5.6-15			15-28			>28			Froese and Pauly 2008
	Pimephales sp.	< 10		< 0.1	10-50		0.1-1.4	> 50		> 1.4	Scott and Chapman 1979, Ross 2001, Froese and Pauly 2008

		Larvae[a]			Juvenile[b]			Adult			
Family	**Species**	**Lengths (mm)**	**Age**	**weights (g)**	**Lengths (mm)**	**Age**	**weights (g)**	**Lengths (mm)**	**Age**	**weights (g)**	**Source**
	Pimephales promelas	4-5.2		<.01	5.2-57	<4 m	.01-2	>57	>3-4 m	>2	Froese and Pauly 2008, personal communication Tim Dawson, EPA, MED, 2015
	Pseudorasbora parva							>20			Froese and Pauly 2015
	Ptychocheilus lucius	< 25			25-420	>25 d	>0.05 g	>420			Vanicek and Kramer 1969, Tyus and Haines 1991, Froese and Pauly 2008
	Puntius conchonius	<8			8-60			>60			Amenla and Dey 2013
	Puntius sophore							>50		>1.8	Hossain et al. 2012, Froese and Pauly 2008
	Puntius ticto	<14	<14 d	<.1	14-80	14-48 d	.1-15.1	>80	>48 d	15.1	Banik and Saha 2012, Froese and Pauly 2008
	Rasbora daniconius							>72		>3.3	Froese and Pauly 2008
	Rhinichthys osculus	<9		<.1	9-40		.1-4.6	>40		4.6	COSEWIC 2006, Froese and Pauly 2008
	Scardinius erythropthalmus	<12		<0.01	12-81		.01-6.37	>81		>6.37	Wolnicki et al. 2009, Froese and Pauly 2008
	Trigonostigma heteromorpha	4+						>38			Froese and Pauly 2008
Aplocheilidae	*Rivulus marmoratus*	< 12			12-40			> 40			Grageda et al. 2004; Froese and Pauly 2008
Cyprinodontidae	*Cyprinodon sp.*	< 12		< 0.1	12-30		0.1-0.5	> 30		> 0.5	Hardy 1978a, personal communication Gerry Cripe EPA, GED 2008
	Jordanella floridae	>4	<8 d		<25	>8 d	<0.3 g	>25		>0.3g	Nasuti 2006; Holdway and Dixon 1986
Fundulidae	*Fundulus sp.*	< 25		< 0.1	25-40		0.1-1	> 40		> 1	Hardy 1978a, Able and Fahay 1998, Froese and Pauly 2008
Poeciliidae		< 10		< 0.1	10-25		0.1-0.25	> 25		> 0.25	Hardy 1978b, Froese and Pauly 2008
	Poecilia reticulata	6			<20		<.58	>20	>1 m	>.58	Reznick 1983, Reznick et al. 1990, Froese and Pauly 2008

		Larvae[a]			Juvenile[b]			Adult			
Family	**Species**	**Lengths (mm)**	**Age**	**weights (g)**	**Lengths (mm)**	**Age**	**weights (g)**	**Lengths (mm)**	**Age**	**weights (g)**	**Source**
	Xiphophorus maculatus							>31		0.7	Froese and Pauly 2008
Esocidae	*Esox sp.*	< 20		< 0.1	20-200		0.1-55	> 200		> 55	Jones et al. 1978, Scott and Chapman 1979, Froese and Pauly 2008
Umbridae	*Umbra pygmaea*	< 8.5		<.01	8.5-37		.01-.44	>37		>.44	Froese and Pauly 2008
Gasterosteidae		< 15			15-45			> 45			Hardy 1978a, Able and Fahay 1998
	Culaea inconstans	< 26			26-38			>38	>1 y		Acere 1986
	Gasterosteus aculeatus	< 16	<9 d	<.03	16-45	>9 d-1 yr	.03-.94	>45	>1 yr	>.94	Norenburg and Ritgers 2015, Froese and Pauly 2008
Mugilidae		< 35		< 0.2	35-350		0.2-300	> 350		> 300	Martin and Drewry 1978, Froese and Pauly 2008
Anabantidae	*Anabas testudineus*	< 10		< 0.1	10-110		0.1-25	> 110		> 25	Mookerjee and Mazumdar 1946, Froese and Pauly 2008
Centrarchidae	*Lepomis sp.*	< 13		< 0.1	13-125		0.1-25	> 125		> 25	Hardy 1978b, Scott and Chapman 1979, Ross 2001, Froese and Pauly 2008
	Lepomis macrochirus	<26		<.32	26-72	<1 y	.32-7.93	>72	>1 y	>7.93	Belk 1998, Froese and Pauly 2008
	Micropterus sp.	< 17		< 0.2	17-250		0.2-175	> 250		> 175	Hardy 1978b, Scott and Chapman 1979, Ross 2001, Froese and Pauly 2008
	Micropterus salmoides	<9		<.01	9-285	<9 m-1 y	.01-358.06	>285	>9 m-1 y	>358.06	Froese and Pauly 2008
	Pomoxis sp.	< 15		< 0.1	15-200		0.1-70	> 200		> 70	Hardy 1978b, Froese and Pauly 2008
Channidae	*Channos channos*	<13		<.03	13-918		.03-5890	>918		>5890	Froese and Pauly 2008
	Channa orientalis							>201			Froese and Pauly 2008
	Channa punctata	<40		<.99	10-120		.99-23.27	>120		23.27	Froese and Pauly 2008, Dehadrai and Tripathi 1976

		Larvae[a]			Juvenile[b]			Adult			
Family	**Species**	**Lengths (mm)**	**Age**	**weights (g)**	**Lengths (mm)**	**Age**	**weights (g)**	**Lengths (mm)**	**Age**	**weights (g)**	**Source**
Cichlidae		< 20		< 0.3	20-80		0.3-30	> 80		> 30	Global invasive species database 2005, Froese and Pauly 2008, Hassan-Williams and Bonner 2008, personal communication M.Peterson
Embiotocidae	*Micrometrus minimus*							>106		>20	Schultz et al. 1991, Froese and Pauly 2008
Gobiidae	*Gobiosoma bosc*	< 7			7-30			> 30			Ruple 1984, Froese and Pauly 2008
Moronidae	*Morone americana*	< 20			20-150			> 150			Hardy 1978b, Froese and Pauly 2008
	Morone chrysops	<17.2			17.2-280	>4 w	>5.9	>280	>1 y	>250g	Denson and Smith 1996, Froese and Pauly 2008, Smith 1995
	Morone saxatilis	< 25	5-30 d		25-400	30 d-2 y		> 400	>2 y		Hardy 1978b, Froese and Pauly 2008, Fay et al. 1983
Percidae	*Etheostoma sp.*	< 18		< 0.1	18-35		0.1-0.4	> 35		> 0.4	Johnson 1984, Fisher 1990, Froese and Pauly 2008
	Perca flavescens	< 20		< 0.1	20-125		0.1-20	> 125		> 20	Hardy 1978b, Froese and Pauly 2008
	Sander vitreus	< 20		< 0.1	20-250		0.1-177	> 250		> 177	Hardy 1978b, Froese and Pauly 2008
Sciaenidae	*Leiostomus xanthurus*	< 15		< 0.1	15-200		0.1-90	> 200		> 90	Johnson 1978, Froese and Pauly 2008
Sparidae	*Lagadon rhomboides*	< 15		< 0.1	15-120		0.1-60	> 120		> 60	Johnson 1978, Froese and Pauly 2008
Terapontidae	*Bidyanus bidyanus*	3.6						>238		>412.7	Rowland 2004
	Terapon jarbua	< 23		< 0.3	23-130		0.3-46.92	>130		>46.92	Froese and Pauly 2008
Pleuronectidae	*Platichthys sp.*	< 7		< 0.1	7-200		0.1-80	> 200		> 80	Ahlstrom et al. 1984, Froese and Pauly 2008
Salmonidae	*Oncorhynchus sp.*	< 25		< 0.2	25-200		0.2-100	> 200		> 100	Scott and Chapman 1979, Kendall and Behnke 1984, Ross 2001, Froese and Pauly 2008, Ueberschar and Froese 2008
	Oncorhynchus mykiss	<40		<0.3	40-192	>19 d	0.3-70	>192		>70	Froese and Pauly 2008; USEPA 1996

		Larvae[a]			Juvenile[b]			Adult			
Family	**Species**	**Lengths (mm)**	**Age**	**weights (g)**	**Lengths (mm)**	**Age**	**weights (g)**	**Lengths (mm)**	**Age**	**weights (g)**	**Source**
	Prosopium williamsoni	<60			60-200			>200	>2 y	>100g	McPhail and Troffe 1998, Stalnaker and Gresswell 1974
	Salmo sp.	< 25		< 0.2	25-200		0.2-5.3	> 200		> 75	Kendall and Behnke 1984, Jonsson 1985, Gorodilov 1996, Marschall et al. 1998, Froese and Pauly 2008, Ueberschar and Froese 2008
	Salvelinus sp.	<20		< 0.2	20-200		0.2-100	> 200		> 100	Kendall and Behnke 1984, Froese and Pauly 2008, Ueberschar and Froese 2008
	Salvelinus fontinalis	<18		<.1	18-150		0.1-42.1	>150		>42.1	Froese and Pauly 2008
Cottidae	*Cottus bairdii*	<9			9-41			>41			Grossman et al. 2002, Froese and Pauly 2008
Ariidae	*Ariopsis felis*	<45			68-88			>126			Froese and Pauly 2008, Merriman 1940
Bagridae		< 10			10-90			> 90			Rahman et al. 2004, Froese and Pauly 2008
Clariidae	*Heterobranchus longifilis*	>3.1		0.2	3.1-597		0.2-1588	>597		1588	Froese and Pauly 2008, Legendre 1986
Heteropneustidae		< 12			12-120			> 120			Thakur et al. 1974, Froese and Pauly 2008
Ictaluridae		< 20		< 0.1	20-250		0.1-100	> 250		> 100	Jones et al. 1978, Scott and Crossman 1979; Froese and Pauly 2008
	Ameiurus nebulosus	4-22		<.13	22-178		0.13-71.06	>178		>71.06	Froese and Pauly 2008
Mastacembilidae	*Macrognathus aculeatus*	<10.8	<30 d	< 0.1	10.8-160		0.1-14.6	>160		14.6	Das and Kalita 2003, Froese and Pauly 2008
	Monopterus albus							>400		>60.2	Froese and Pauly 2015
Syngnathidae	*Syngnathus fuscus*	9+						>99		>1.1	Froese and Pauly 2015, Campbell and Able 1998
Monacanthidae	*Stephanolepis hispidus*	< 8 mm		< 0.1	8-75		0.1-9	> 75		> 9	Martin and Drewry 1978, Rogers et al. 2001, Froese and Pauly 2008

[a] also included nauplii, zoea (Crustaceans); Yolk-sac fry, fry alevin, glass eel stage (Fishes); glochidia (Mollusca)
[b] also included immature, Young of year, black eel stage, fingerling, parr, yearling (Fishes); spat (Mollusca)

Sources for Age Classifications

Able, K.W. and M. P. Fahay. 1998. The first year in the life of estuarine fishes in the Middle Atlantic Bight. Rutgers University Press New Brunswick, NJ.

Acere, T.O. and C.C. Lindsey. 1986. Age, growth and life history of *Culaea inconstans* (Pisces: Gasterostidae) in Delta Marsh Lake Manitoba. Hydrobiologia 135: 35-44.

Ahlstrom, E.H., K. Amaoka, D.A. Hensley, H.G. Moser, and B.Y. Sumida. 1984. Pleuoronectiformes: Development. In: Ontogeny and systematics of fishes. American Society of Ichthyologists and Herpetologists, La Jolla, California.

Alikunhi, K.H. 1956. Observations on the fecundity, larval development and early growth of *Labeo bata* (Hamilton). Indian J. Fishes 3(1): 216-229.

Amenla and S.C. Dey. 2013. Accretion profile of the Rosy Barb, Puntius conchonius (Hamilton- Buchanan, 1822) From the water bodies of Nagaland, India. IOSR Journal of Pharmacy and Biological Sciences 5(6): 20-22.

Banik, S. and S. Saha. 2012. Puntius ticto (Hamilton, 1822) of Tripura, India: Reproductive physiology and biology. Journal of Environment 1(4): 136-141.

Bath, D.W., J.M. O'Connor. 1981. Development and Identification of larval Atlantic Sturgeon (*Acipenser oxyrhynchus*) and shortnose sturgeon (*A. brevirostrum*) from the Hudson River Estuary, New York. Copeia 1981 (3): 711-717.

Belk, M.C. 1998. Predator-induced delayed maturity in bluegill sunfish (*Lepomis macrochirus*): variation among populations. Oecologia 113: 203-209.

Buynak, G.L. and H.W. Mohr. 1980a. Larval Development of Golden Shiner and Comely Shiner from the Northeastern Pennsylvania. The Progressive Fish-Culturist 42(4): 206-211.

Buynak, G.L. and H.W. Mohr. 1980b. Larval development of stoneroller, cutlips minnow, and river chub with diagnostic keys, including four additional cyprinids. The Progressive Fish Culturist 42 (3): 127-135.

Cambray, J.A. 1985. Early ontogeny of Labeo capensis (Pisces: Cyprinidae). S. Afr. J. Zool. 20: 190-196.

Campbell, B.C., and K.W. Able. 1998. Life History Characteristics of the Northern Pipefish, *Syngnathus fuscus*, in Southern New Jersey. Estuaries 21 (3): 470-475.

Chakrabarty, R.D. and D.S. Murty. 1972. Life history of Indian major carps, Cirrhinus mrigala (Ham.), Catla catla (Ham.), and Labeo rohita (Ham.). J. Inldand Fish. Soc. India. Vol IV: 132-161.

Conover, D.O., S.A. Arnott, M.R. Walsh, and S.B. Munch. 2005. Darwinian fishery science: lessons from the Atlantic silverside (*Menidia menidia*). Can. J. Fish. Aquat. Sci. 62: 730-737.

COSEWIC 2006. COSEWIC assessment and update status report on the speckled dace *Rhinichthys osculus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 27pp. (www.sararegistry.gc.ca/status/status_e.cfm)

Crowley, L.E.L.M. and W. Ivanstoff. 1982. Reproduction and early stages of development in two species of Australian rainbowfishes, *Melanotaenia nigrans* (Richardson) and *Melanotaenia splendida inornata* (Castelnau). Aust. Zool. 21(1): 85-95.

Das, S.K. and N. Kalita. 2003. Captive breeding of Peacock Eel, *Marcognathus aculeatus*. Aquaculture Asia 8(3):17-18.

Dehadrai, P. V. and Tripathi, S. D. 1976. Environment and ecology of freshwater air-breathing teleosts. *Respiration of amphibious vertebrates*, 39-72.

Denson, M.R. and T.I.J. Smith. 1996. Larval rearing and weaning techniques for White Bass Morone chrysops. Journal of the World of Aquaculture Society 27(2): 194-201.

Fay, C.W., R.J. Neves, and G.B. Pardue. 1983. Species profile: life histories and environmetal requirements of coastal fishes and invertebrates (Mid-Atlantic)—striped bass. U.S. Fish and Wildlife Service, Divison of Biological Services, FWS/OBS-82/11.8. U.S. Army Corps of Engineers, TR EL-82-4. 36 pp.

Fisher, W.L. 1990. Life history and ecology of the orangefin darter *Etheostoma bellum* (Pisces: Percidae). American Midland Naturalist 123 (2) 268-281.

Froese, R. and D. Pauly. Editors. 2008. FishBase. World Wide Web electronic publication. www.fishbase.org, version (06/2008).

Froese, R. and D. Pauly. Editors. 2015. FishBase. World Wide Web electronic publication. www.fishbase.org, version (04/2015).

Gairola, D., A.V. Singh, S.K. Malhotra, S. Nando and R.P. Ghildiyal. 1990. Parasites, ponderal index and length-weight relationship of *Barilius bendelisis* (Ham.) and *Puntius ticto* (Ham.) Indian J. Fish. 37(4): 361-365.

Global Invasive Species Database, 2005. Oreochromis mossambicus. Available from http://www.issg.org/database/species/ecology.asp?fr=1&si=131 [Accessed July 29, 2008].

Gorodilov, Y.N. 1996. Description of the early ontogeny of the Atlantic salmon, *Salmo salar*, with a novel system of interval (state) identification. Environmental Biology of Fishes 47: 109-127.

Gotelli, N.J. and M. Pyron. 1991. Life history variation in North American freshwater minnows: Effects of latitude and phylogeny. OIKOS 62:30-40.

Grageda, M.V.C., Y. Sakakura, and A. Hagiwara. 2004. Early development of the self-fertilizing mangrove killifish *Rivulus marmoratus* reared in the laboratory. Ichthyological Research 51: 309-315.

Grossman, G.D., K. McDaniel, R.E. Ratajczak. 2002. Demographic charactersitics of female mottled sculpin, Cottus bairdi, in the Coweets Creek drainage, North Carolina. Environmental Biology of Fishes 63:299-308.

Hardy, J.D. 1978a. Development of Fishes of the Mid-Atlantic Bight, an atlas of egg, larval and juvenile stages: Volume 2 Anguillidae through Syngnathidae. Biological Services Program FWS/OBS-78/12. US Department of the Interior, Fish and Wildlife Service, Solomons, Maryland.

Hardy, J.D. 1978b. Development of Fishes of the Mid-Atlantic Bight, an atlas of egg, larval and juvenile stages: Volume 3 Aphredoderidae through Rachycentridae. Biological Services Program FWS/OBS-78/12. US Department of the Interior, Fish and Wildlife Service, Solomons, Maryland.

Hassan-Williams, C. and T. H. Bonner. Texas State University – San Marcos Biology Department/ Aquatic Station http://www.bio.txstate.edu/~tbonner/txfishes/oreochromis%20mossambicus.htm [Accessed July 29, 2008]

Hastings, R.W., J.C. O'Herron II, K. Schick, M.A. Lazzari. 1987. Occurrence and distribution of shortnose sturgeon, *Acipenser brevirostrum*, in the Upper Tidal Delaware River. Estuaries 10(4) 337-341.

Holdway, D.A. and D.G. Dixon. 1986. Impact on pulse exposure to methoxychlor on Flagfidh (Jordanella floridae) over one reproductive cycle. Canadian Journal of Fisheries and Aquatic Science 43(7): 1410-1415.

Hossain, M.Y., M. Mosaddequr Rahman, R. Miranda, P.M. Leundam, J. Oscoz, M.A.S. Jewel, A.Naif, and J.Ohtomi. 2012. Size at first sexual maturity, fecundity, length-weight, and length-length relationships of Puntius sophore (Cyprinidae) in Bangladeshi waters. J. Appl. Ichtyol. 28:818-822.

Johnson, G.D. 1978. Development of Fishes of the Mid-Atlantic Bight, an atlas of egg, larval and juvenile stages: Volume 4 Carangidae through Ephippidae. Biological Services Program FWS/OBS-78/12. US Department of the Interior, Fish and Wildlife Service, Solomons, Maryland.

Johnson, G.D. 1984. Percoidei: Development and Relationships. In: Ontogeny and systematics of fishes. American Society of Ichthyologists and Herpetologists, La Jolla, California.

Jones, P.W., F.D. Martin and J.D. Hardy. 1978. Development of Fishes of the Mid-Atlantic Bight, an atlas of egg, larval and juvenile stages: Volume 1 Acipenseridae through Ictaluridae. Biological Services Program FWS/OBS-78/12. US Department of the Interior, Fish and Wildlife Service, Solomons, Maryland.

Jonsson, B. 1985. Life history patterns of freshwater resident and sea-run migrant brown trout in Norway. Transactions of the American Fisheries Society 114: 182-194.

Kaeding, L.R. and M.A. Zimmerman. 1983. Life history and ecology of the humpback chub in the little Colorado and Colorado rivers of the Grand Canyon. Transactions of the American Fisheries Society 112: 577-594.

Kendall, A.W. and R.J. Behnke. 1984. Salmonidae: Development and Relationships. In: Ontogeny and systematics of fishes. American Society of Ichthyologists and Herpetologists, La Jolla, California.

Legendre, M. 1986. Seasonal changes in sexual maturity and fecundity, and HCG-induced breeding of the catfish, *Heterobranchus longifilis* Val. (Clariidae), reared in Ebrie Lagoon (Ivory Coast). Aquaculture 55: 201-213.

Magana, H.A. 2007. A case for classifying the Rio Grande Silvery Minnow (Hybognathus amarus) as an omnivore (PhD. dissertation). Retrieved from http://www.treesearch.fs.fed.us/pubs/29161

Marschall, E.A., T.P. Quinn, D.A. Roff, J.A. Hutchings, N.B. Metcalfe, T.A. Bakke, R.L. Saunders, and N.L. Poff. 1998. A framework for understanding Atlantic salmon (*Salmo salar*) life history. Can. J. Fish. Aquat. Sci (55 Suppl 1): 48-58.

Marsh, P.C. 2004. Threatened fishes of the world: *Gila elegans* Baird and Girard 1853 (Cyprinidae). Environmental Biology of Fishes 70: 144.

Martin, F.D. and G.E. Drewry. 1978, Development of Fishes of the Mid-Atlantic Bight, an atlas of egg, larval and juvenile stages: Volume 6 Stromateidae through Ogcocephalidae. Biological Services Program FWS/OBS-78/12. US Department of the Interior, Fish and Wildlife Service. Solomons, Maryland.

McPhail, J.D. and P.M. Troffe. 1998. The mountain whitefish (Prosopium williamsoni): a potential indicator species for the Fraser System. Prepared for Environment Canada DOE FRAP 1998-16.

Merriman, D. 1940. Morphological and embryological studies on two species of marine catfish, Bagre marinus and Galeichthys felis. Zoologica *25*(13): 221-248.

Middaugh, D.P. and M.J. Hemmer. 1987. Influence of environmental temperature of sex-ratios in the Tidewater Silverside, *Menidia peninsulae* (Pisces: Atherinidae). Copeia 1987(4):958-964.

Mims, S.D. and R.S. Knaub. 1993. Condition facots and length-weight relationships of pond-cultured Paddlefish Polyodon spathula with reference to other morphogenetic relationships. Journal of the World Aquaculture Society 24(3): 429-433.

Mookerjee, H.K., and S.R. Mazumdar. 1946. On the life-history, breeding and rearing of Anabas testudineus (Bloch). J. Dept. Sci. Calcutta Univ. 2(1): 101-140.

Nasuti, M.A. 2006. Differential allocation in the flagfish, *Jordanella floridae*, in response to male condition (Master thesis). Retrieved from http://cms.uflib.ufl.edu/

Norenburg, J. and R. Ritgers, eds. "Gasterosteus aculeatus- Life Cycle." Encyclopedia of Life, available from http://eol.org/pages/223856/overview. Accessed 2015.

Rahman, M.R., M.A. Rahman, M.N. Khan, and M.G. Hussain. 2004. Observation on the embryonic and larval development of Silurid catfish, Gulsha (*Mystus cavasius* Ham.). Pakistan Journal of Biological Sciences 7 (6): 1070-1075.

Reznick, D.N. 1983. The Structure of Guppy Life Histories: The Tradeoff between Growth and Reproduction. Ecology 64(4): 862–873.

Reznick, D.A., H. Bryga, and J.A. Endler. 1990. Experimentally induced life-history evlolution in a natural population. Nature 346: 357-359.

Rogers, J.S., J.A. Hare and D.G. Lindquist. 2001. Otolith record of age, growth, and ontogeny in larval and pelagic juvenile *Stephanolepis hispidus* (Pisces: Monacanthidae). Marine Biology 138: 945-953.

Ross, S.T. 2001 Inland Fishes of Mississippi. University Press of Mississippi, Jackson, MS.

Rowland, S.J. 2004. Domestication of silver perch, *Bidyanus bidyanus*, broodfish. Journal of Applied Aquaculture 16(1-2): 75-83.

Ruple, D. 1984. Gobiodidei: Development. In: Ontogeny and systematics of fishes. American Society of Ichthyologists and Herpetologists, La Jolla, California.

Saksena, V.P. 1962. The post-hatching stages of the red shiner, *Notropis lutrensis*. Copeia 1962 (3): 539-544.

Schultz, E.T., L.M. Clifton, and R.R. Warner. 1991. Energetic constraints and size-based tactics: The adaptive significance of breeding-schedule variation in a marine fish (Embiotocidae: *Micrometrus minimus*). The American Naturalist 138(6):1408-1430.

Scott and Chapman 1979

Scott, W.B. and E.J. Crossman. 1979. Freshwater Fishes of Canada. Fisheries Research Board of Canada, Ottawa. Bulletin 184.

Smith, T.I., W.E. Jenkins, L.D. Heyward. 1995. Hatchery performance and reuse of domesticated white bass broodstock. Procedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 49:97-105.

Stalnaker, C.B. and R.E. Gresswell. 1974. Early life history and feeding of young mountain whitefish. Prepared for the Office of Research and Development, United States Environmental Protection Agency EPA-660/3-73-019.

Tedesco, P. and B. Hugueny. 2006. Life history strategies affect climate based spatial synchrony in population dynamics of West African freshwater fishes. Oikos 115: 117-127.

Thakur, N.K., R.N. Pal, and H.A. Khan. 1974. Embryonic and larval development of Heteropneustes fossilis (Bloch). J. Inldand Fish. Soc. India. VI: 33-44.

Tyus, H. and G.B. Haines. 1991. Distribution, habitat use, and growth of age-0 Colorado squawfish in the green river basin, Colorado and Utah. Transactions of the American Fisheries Society 120: 79-89.

Ueberschar, B and R. Froese. Editors. 2008. LarvalBase. World Wide Web electronic publication www.larvalbase.org, version (07/2008)

United States Environmental Protection Agency (USEPA). 1996. Ecological Effects Test Guidelines OPPTS 850.1400 Fish Early Life Stage Toxicity Test. EPA 712-C-96-121.

Vanicek, C.D. and R.H. Kramer. 1969. Life history of the Colorado squawfish, *Ptychocheilus lucius*, and the Colorado chub, *Gila robusta*, in the green river in Dinosaur National Monument, 1964-1966. Transactions of the American Fisheries Society 98(2): 193-208.

Weyl, O.L.F. and A.J. Booth. 1999. On the life history of a cyprinid fish, *Labeo cylindricus.* Environmental Biology of Fishes 55: 215-225.

Wolnicki, J., J. Sikorska, R. Kaminski. 2009. Response of larval and juvenile rudd *Scardinius erythropthalmus* (L.) to different diets under controlled conditions. Czech J. Anim. Sci. 54(7): 331-337.

Wurtsbaugh, W. and H. Li. 1985. Diel migrations of a zookplanktivorous fish (Menidia beryllina) in realtion to the distribution of it's prey in a large eutrophic lake. Limnol. Oceanogr. 30(3): 565-576.

Appendix A-7. Temperature ranges used to standardize species in the model data subset.

Species	ICE Temp Acceptance Range	Species from Guidelines	ASTM[1]	OPP[2]	OPPTS 1996[3]	OECD 203[4]	EPA 1975[5]	EPA 1993[6]
Acartia tonsa	20-26	x	x	x	x	x	x	x
Actinonaias pectorosa	20-26	x	x	x	x	x	x	x
Aedes aegypti	22-28	x	x	x	x	x	x	x
Aldrichetta forsteri	19-25	x	x	x	x	x	x	x
Ameiurus melas	18-24	x	x	x	x	x	x	x
Ameiurus nebulosus	18-24	x	x	x	x	x	x	x
Americamysis bahia	21-27	*Americamysis bahia*	25-29	21-23	23-27	x	x	19-21, 24-26
Ampelisca abdita	20-26	x	x	x	x	x	x	x
Asellus sp.	18-24	x	x	x	x	x	x	x
Asellus aquaticus	13-19	x	x	x	x	x	x	x
Astropecten sp.	19-25	x	x	x	x	x	x	x
Baetis sp.	15-21	x	x	x	x	x	x	x
Bidyanus bidyanus	20-26	x	x	x	x	x	x	x
Bufo bufo	16-22	x	x	x	x	x	x	x
Caecidotea brevicauda	15-21	x	x	x	x	x	x	x
Carassius auratus	17-23	*Carassius auratus*	15-24	x	x	x	20-24	x
Catostomus commersonii	10-16	x	x	x	x	x	x	x
Ceriodaphnia dubia	21-27	*Ceriodaphnia dubia*	23-27	x	x	x	x	19-21, 24-26
Chironomus sp.	17-23	*Chironomus* sp.	20-24	x	x	x	20-24	x
Chironomus plumosus	17-23	*Chironomus* sp.	20-24	x	x	x	20-24	x
Chironomus riparius	17-23	*Chironomus* sp.	20-24	x	x	x	20-24	x
Chironomus tentans	19-25	*Chironomus* sp.	20-24	x	x	x	20-24	x
Chironomus zealandicus	17-23	*Chironomus* sp.	20-24	x	x	x	20-24	x
Clarias batrachus	20-26	x	x	x	x	x	x	x
Coregonus fera	8-14	x	x	x	x	x	x	x
Corophium volutator	9-15	x	x	x	x	x	x	x
Crangonyx pseudogracilis	8-14	x	x	x	x	x	x	x
Crassostrea virginica	19-25	*Crassostrea virginica*	20-24	x	x	x	x	x
Ctenopharyngodon idella	19-25	x	x	x	x	x	x	x

Species	ICE Temp Acceptance Range	Species from Guidelines	ASTM[1]	OPP[2]	OPPTS 1996[3]	OECD 203[4]	EPA 1975[5]	EPA 1993[6]
Culicoides furens	19-25	x	x	x	x	x	x	x
Cyclops sp.	18-24	x	x	x	x	x	x	x
Cymatogaster aggregata	12-18	x	x	x	x	x	x	x
Cyprinodon variegatus	20-26	*Cyprinodon variegatus*	20-24	21-23	20-24	x	20-24	19-21, 24-26
Cyprinus carpio	18-24	*Cyprinus carpio*	x	x	20-24	20-24	x	x
Daphnia carinata	18-24	x	x	x	x	x	x	x
Daphnia magna	18-24	*Daphnia magna*	18-22	x	18-22	x	15-19	19-21, 24-26
Daphnia pulex	15-21	*Daphnia pulex*	18-22	x	18-22	x	15-19	19-21, 24-26
Diaptomus clavipes	16-22	x	x	x	x	x	x	x
Esox lucius	12-18	x	x	x	x	x	x	x
Eurytemora affinis	19-25	x	x	x	x	x	x	x
Farfantepenaeus duorarum	19-25	*Farfantepenaeus duorarum*	20-24	x	x	x	20-24	x
Fenneropenaeus indicus	23-29	x	x	x	x	x	x	x
Gambusia affinis	14-20	x	x	x	x	x	x	x
Gammarus fasciatus	15-21	*Gammarus fasciatus*	15-19	x	17-19	x	15-19	x
Gammarus lacustris	14-20	*Gammarus lacustris*	15-19	x	17-19	x	15-19	x
Gammarus pseudolimnaeus	15-21	*Gammarus pseudolimnaeus*	15-19	x	17-19	x	15-19	x
Gammarus pulex	13-19	x	x	x	x	x	x	x
Gasterosteus aculeatus	18-24	*Gasterosteus aculeatus*	15-19	x	10-14	x	20-24	x
Gibelion catla	24-30	x	x	x	x	x	x	x
Heteropneustes fossilis	20-26	x	x	x	x	x	x	x
Hexagenia bilineata	18-24	x	x	x	x	x	x	x
Hyalella azteca	18-25	x	x	x	x	x	x	x
Ictalurus punctatus	17-23	*Ictalurus punctatus*	15-24	x	20-24	x	20-24	x
Ischnura sp.	13-19	x	x	x	x	x	x	x
Ischnura verticalis	15-21	x	x	x	x	x	x	x
Labeo rohita	24-30	x	x	x	x	x	x	x
Lagodon rhomboides	20-26	*Lagodon rhomboides*	20-24	x	x	x	20-24	x
Lates calcarifer	24-30	x	x	x	x	x	x	x
Leiostomus xanthurus	21-27	x	x	x	x	x	x	x
Lepomis cyanellus	17-23	*Lepomis cyanellus*	15-24	x	x	x	x	x
Lepomis macrochirus	18-24	*Lepomis macrochirus*	15-24	x	20-24	21-25	20-24	x
Lepomis microlophus	18-24	x	x	x	x	x	x	x
Lestes congener	19-25	x	x	x	x	x	x	x

Species	ICE Temp Acceptance Range	Species from Guidelines	ASTM[1]	OPP[2]	OPPTS 1996[3]	OECD 203[4]	EPA 1975[5]	EPA 1993[6]
Limnodrilus hoffmeisteri	20-26	x	x	x	x	x	x	x
Lithobates catesbeianus	17-23	x	x	x	x	x	x	x
Lithobates clamitans	17-23	x	x	x	x	x	x	x
Lithobates pipiens	17-24	x	x	x	x	x	x	x
Lumbriculus variegatus	19-25	x	x	x	x	x	x	x
Menidia beryllina	19-25	*Menidia* sp.	20-24	21-23	20-24	x	20-24	19-21, 24-26
Menidia menidia	22-28	*Menidia* sp.	20-25	21-24	20-25	x	20-25	19-21, 24-27
Micropterus dolomieu	17-23	x	x	x	x	x	x	x
Micropterus salmoides	17-23	x	x	x	x	x	x	x
Morone saxatilis	13-19	x	x	x	x	x	x	x
Mystus vittatus	22-28	x	x	x	x	x	x	x
Neanthes arenaceodentata	17-23	x	x	x	x	x	x	x
Neomysis americana	19-25	x	x	x	x	x	x	x
Nereis diversicolor	10-16	x	x	x	x	x	x	x
Notemigonus crysoleucas	16-22	x	x	x	x	x	x	x
Notropis topeka	19-25	x	x	x	x	x	x	x
Oncorhynchus clarkii	9-15	x	x	x	x	x	x	x
Oncorhynchus gorbuscha	9-15	x	x	x	x	x	x	x
Oncorhynchus keta	9-15	x	x	x	x	x	x	x
Oncorhynchus kisutch	9-15	*Oncorhynchus kisutch*	10-14	x	10-14	x	10-14	x
Oncorhynchus mykiss	9-15	*Oncorhynchus mykiss*	10-14	x	10-14	13-17	10-14	11-13
Oncorhynchus nerka	7-13	x	x	x	x	x	x	x
Oncorhynchus tshawytscha	9-15	x	x	x	x	x	x	x
Ophiogomphus sp.	15-21	x	x	x	x	x	x	x
Orconectes nais	15-21	*Orconectes* sp.	15-24	x	x	x	20-24	x
Oreochromis mossambicus	23-29	x	x	x	x	x	x	x
Oryzias latipes	19-25	*Oryzias latipes*	x	x	x	21-25	x	x
Palaemonetes sp.	19-25	x	x	x	x	x	x	x
Palaemonetes kadiakensis	15-21	x	x	x	x	x	x	x
Paratanytarsus dissimilis	18-24	x	x	x	x	x	x	x
Pelophylax nigromaculata	15-21	x	x	x	x	x	x	x
Penaeus merguiensis	29-35	x	x	x	x	x	x	x
Penaeus monodon	23-29	x	x	x	x	x	x	x
Penaeus semisulcatus	18-24	x	x	x	x	x	x	x

Species	ICE Temp Acceptance Range	Species from Guidelines	ASTM[1]	OPP[2]	OPPTS 1996[3]	OECD 203[4]	EPA 1975[5]	EPA 1993[6]
Perca flavescens	12-18	x	x	x	x	x	x	x
Pimephales promelas	20-26	*Pimephales promelas*	23-27	x	21-25	21-25	20-24	19-21, 24-26
Poecilia reticulata	23-29	*Poecilia reticulata*	x	x	21-25	21-25	x	x
Polypedilum sp.	18-24	x	x	x	x	x	x	x
Praunus flexuosus	9-15	x	x	x	x	x	x	x
Pseudacris regilla	17-23	x	x	x	x	x	x	x
Pteronarcella badia	10-16	x	x	x	x	x	x	x
Pteronarcys californica	10-16	*Pteronarcys* sp.	10-14	x	x	x	10-14	x
Puntius conchonius	13-19	x	x	x	x	x	x	x
Salmo salar	11-17	*Salmo salar*	x	x	10-14	x	x	x
Salmo trutta	11-17	x	x	x	x	x	x	x
Salvelinus confluentus	7-13	x	x	x	x	x	x	x
Salvelinus fontinalis	11-17	*Salvelinus fontinalis*	10-14	x	10-14	x	10-14	11-13
Salvelinus namaycush	9-15	x	x	x	x	x	x	x
Sander vitreus	12-18	x	x	x	x	x	x	x
Scylla serrata	23-29	x	x	x	x	x	x	x
Simocephalus serrulatus	15-21	x	x	x	x	x	x	x
Simocephalus vetulus	19-25	x	x	x	x	x	x	x
Streptocephalus proboscideus	19.5-25.5	x	x	x	x	x	x	x
Tilapia nilotica	21-27	x	x	x	x	x	x	x
Tilapia zillii	24-30	x	x	x	x	x	x	x
Tubifex tubifex	19-25	x	x	x	x	x	x	x
Utterbackia imbecillis	19-25	x	x	x	x	x	x	x
Villosa iris	19-25	x	x	x	x	x	x	x
Villosa lienosa	25-31	x	x	x	x	x	x	x
Villosa villosa	25-31	x	x	x	x	x	x	x
Xenopus laevis	22-28	x	x	x	x	x	x	x

References

1. ASTM. 2007. Standard guide for conducting acute toxicity tests on test materials with fishes, macroinvertebrates, and amphibians. E 729-96
2. Reider, D and A.C. Bryceland. 1986. Standard evaluation procedure acute toxicity test for estuarine and marine organisms. EPA 540/9-86-137.
3. Ecological Effects Test Guidelines. OPPTS 850.1075 Fish Acute Toxicity Test, Freshwater and Marine. EPA 712-C-96-118. April 1996
4.OECD. 1992. OECD guideline for testing of chemicals. 203.
5. US EPA. 1975. Methods for acute toxicity tests with fish, macroinvertebrates, and amphibians. EPA 660/3-75-009.
6. US EPA. 1993. Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. EPA 600/4-90/O27F

Appendix A-8. List of data fields in master database

Data Field	Description
ID	Unique Web-ICE record identification number
DSource specific	Specific data source (e.g. ECO12207 = Ecotox Acquire # 12207)
DSource category	General category of data (i.e. literature, ECOTOX, Mayer 1987)
Source citation	Citation of original source of data (i.e. the source listed in ECOTOX or AWQC for where they obtained the data)
Chemical tested	Chemical name as reported in original source
CAS reported	CAS reported by original source
ICE chemical	Standardized name
ICE CAS	CAS registry number
AI	Active ingredient or chemical grade of chemical tested
Water type	Freshwater (FW); Saltwater (SW); NR (not recorded)
Taxa	Broad taxa of test species
Common name	Common name of test species
Species	Species tested (“none” = genus only e.g. Daphnia sp.)
Genus	Genus name of test species
Family	Family name of test species
Age	Age as reported (size, weight, etc.)
Age class	ICE age class (L = larvae, J = juvenile, A = adult, U = unknown, E = embryo)
Test duration	48h; 96h; NR (not recorded)
Dose Type	LC50; EC50; NR (not recorded)
Test Type	F (flow through); S (static); R (static renewal); NR (not recorded)
Concentration Type	M (measured); U (nominal/unmeasured); NR (not recorded)
Temp	Test temperature as reported
SAL	Test salinity as reported
DO	Test dissolved oxygen as reported
pH	Test pH as reported
Hardness	Test hardness as reported
ICE toxicity (µg/L)	Toxicity used for ICE models after normalizations
Guidelines	Guidelines reported for test (i.e. ASTM). If field says confirmed then record was verified to meet ICE standardizations
Date entered	Date data entered
Meets Model Req	True/False field - does record meet ICE model standardization requirements
Comments	Any additional information from source that could be useful
MMR-False	If record does not meet model requirements (MMR), this column contains the reason(s) why record is false (e.g. age)

9 Appendix B. Algae ICE Module; Technical Basis of the Development of Algae ICE Models for Web-ICE

This technical basis was last updated April 10, 2013

Introduction

This document summarizes the data used in the Web-ICE v3.2.1 Algae Modules. The Algae Modules were developed under a Cooperative Research and Development Agreement between the Office of Research and Development of the U.S. EPA and the Procter and Gamble Company (P&G).

The Algae Modules allow estimation of toxicity in selected species or genera of freshwater or marine algae by inputting the known toxicity in another algal species. Both the Algae Modules and this technical basis document will be updated periodically as the database, interspecies algal models, or functionality is revised. Users are encouraged to report any issues to EPA via the Web-ICE contact page.

Overview of Algae Database and Model Development

The process of obtaining data and ICE model creation is provided below:

1. A compilation of public (ECOTOX and scientific literature), EPA (Office of Pesticide Programs Toxicity Database) and P&G-owned algal toxicity data were compiled into an ACCESS database. The database of acute toxicity data for freshwater or marine algae: EC50 or equivalent values for short-term algal growth in biomass or cell number.
2. Duplicate records were removed, as well as records containing open ended (greater than or less than) toxicity values. After initial processing, over 17,000 studies comprising over 500 species and nearly 1500 chemicals were included in the initial database.
3. A general quality review of each algal acute study was performed by assessing the source of the record for conformance to standard methods and guidelines, such as OECD, USEPA and ASTM.
4. The database was then restructured to include: (1) the 11 algal genera with sufficient toxicity records (EC50 or equivalent) to allow ICE model development, (2) only 72 or 96-hr acute toxicity data, (3) newly calculated toxicity values (i.e., over 80 EC50s were recalculated), (4) additional P&G studies, (5) harmonized algal taxonomic names, (6) test material names that were confirmed and coordinated, and (7) calculated geometric means and variance per taxon per chemical. This restructured database contained approximately 3500 EC50 records with 791 unique chemicals and 74 species of algae.
5. A preliminary assessment of the influence of type of EC50 (e.g., E_rC_{50} and E_bC_{50}) separately and combined was completed. An ErC50 was based on growth rate while an EbC50 was based on biomass. The same data is used to determine each endpoint but different statistical approaches are used. The biomass parameter generally provides a

lower value compared with growth rate, but both types of EC50s were included based on correlation analysis.

6. An extensive quality assurance review of the records in the restructured database was completed following general USEPA Science Advisory Board recommendations (Table 1) The final database used in Web-ICE models consisted of 1647 unique studies with approximately 457 chemicals, and 69 Species of Green Algae, Blue-Green Algae and Diatoms.
7. The final database was used to generate 44 Genus-level models and 58 species level models that were cross-validated (Raimondo et al. 2007).
8. Only significant models ($p<0.05$) that had three or more chemicals were included in the Algae Module.

References

ASTM (American Society for Testing and Materials). 2011. Standard Guide for Conducting Static Toxicity Tests with Microalgae. ASTM E1218 - 04e1. ASTM International, West Conshohocken, PA, 2006, DOI: 10.1520/E1218-04E01, www.astm.org.

OECD (Organization for Economic Cooperation and Development). 1996. OECD Guidelines for the Testing of Chemicals. Freshwater Alga and Cyanobacteria, Growth Inhibition Test. Paris, France 26p.

Raimondo, S., Mineau, P., and Barron, M.G. 2007. Estimation of Chemical Toxicity to Wildlife Species Using Interspecies Correlation models. Env. Sci. Technol 41(16):5888-5894.

USEPA. 1996. Ecological Effects Test Guidelines OPPTS 850.5400, Algal Toxicity, Tiers I and II. EPA 712-C-96-164, 11p.

Table 1. Checklist of standardization criteria for inclusion into algal database used to create ICE models.

Category	Data Information	Criteria
Chemical	Identity	Reported CAS, name or structure confirmed [a] CAS corresponds to single compound or element
	Compound	Mixtures excluded except for metal and specific chemical salts
	Purity	Active ingredient $\geq$ 90% [b, c]
	Grade	If Purity is "NR", test grade conformed to Web-ICE requirements
	Name	Harmonized within the algal database
Organism	Species	Algae and diatoms Name & taxonomy verified
Test Conditions	Test Media	Aquatic (FW/SW identified)
	Exposure type	F, S, SR (no sediment, dietary, mixed dose or phototoxicity)
	Exposure duration	Acute; 72 & 96 hrs
	Endpoint	EC50 (
	Measurement	growth rate, biomass or cell density
	Test Location	Laboratory only
Toxicity Value	Concentration	> or < excluded
	Units	ug/L, converted if needed
	Chemical Normalization	Metals: no hardness correction [c]
	Element Normalization [d]	Ag, Al, Cu, Cd, Co, Cr(III), Cr(VI), Hg, Ni, Pb, Zn

[a] Some proprietary data encoded with false CAS number to avoid chemical identification

[b] Includes chemicals with AI <90% if equivalent for all species tested with that chemical.

[c] Tests performed in standard test media [e.g., OECD 201: OECD Guideline for Freshwater Alga and Cyanobacteria, Growth Inhibition Test (2006); ASTM E1218-20: Standard Guide for Conducting Static Toxicity Tests with Microalgae (2009); EU Method C_3: Algal Inhibition Test]

[d] Metals reported as salts were normalized to element