An Australian Government Initiative

Australian & New Zealand GUIDELINES FOR FRESH & MARINE WATER QUALITY

Toxicant default guideline values for aquatic ecosystem protection

Ametryn in marine water

Technical brief

October 2026

Water Quality Guidelines is a joint initiative of the Australian and New Zealand governments, in partnership with the Australian states and territories.

© Commonwealth of Australia 2026

Ownership of intellectual property rights
Unless otherwise noted, copyright (and any other intellectual property rights, if any) in this publication is owned by the Commonwealth of Australia (referred to as the Commonwealth).

Creative Commons licence
All material in this publication is licensed under a Creative Commons Attribution 4.0 Australia Licence, save for content supplied by third parties, photographic images, logos and the Commonwealth Coat of Arms.

Creative Commons Attribution 4.0 Australia Licence is a standard form licence agreement that allows you to copy, distribute, transmit and adapt this publication provided you attribute the work. See the summary of the licence terms or the full licence terms.

Inquiries about the licence and any use of this document should be emailed to copyright@dcceew.gov.au.

Cataloguing data
This publication (and any material sourced from it) should be attributed as: ANZG 2026, *Toxicant default guideline values for aquatic ecosystem protection: Ametryn in marine water.* Australian and New Zealand Guidelines for Fresh and Marine Water Quality. CC BY 4.0. Australian and New Zealand Governments and Australian state and territory governments, Canberra, ACT, Australia.

This publication is available at waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/toxicants.

Contact
Australian Government Department of Climate Change, Energy, the Environment and Water
GPO Box 858 Canberra ACT 2601
Switchboard +61 2 6272 3933 or 1800 900 090
Email waterquality@dcceew.gov.au

Disclaimer
The author(s) of this publication, all other entities associated with funding this publication or preparing and compiling this publication, and the publisher of this publication, and their employees and advisers, disclaim all liability, including liability for negligence and for any loss, damage, injury, expense or cost incurred by any person as a result of accessing, using or relying on any of the information or data in this publication to the maximum extent permitted by law.

Acknowledgements
The default guideline values (DGVs) were derived by Olivia C King and Dr Rachael A Smith (Queensland Department of the Environment, Tourism, Science and Innovation (DETSI)), Gabrielle Dern (Griffith University) and Dr Michael St J Warne (University of Queensland, DETSI, and Coventry University, UK). The DGVs were peer reviewed by two anonymous reviewers and by contracted technical advisors Dr Rick van Dam and Dr Melanie Trenfield.

Contents

Summary ..... **iv**

1 Introduction **1**

2 Aquatic toxicology **2**

2.1 Mechanisms of toxicity 2

2.2 Relative toxicity 3

3 Factors affecting toxicity **3**

4 Default guideline value derivation **4**

4.1 Toxicity data used in derivation 4

4.2 Species sensitivity distribution 6

4.3 Default guideline values 7

4.4 Reliability classification 8

Glossary **9**

Appendix A: Toxicity data that passed the screening and quality assessment and were used to derive the default guideline values **11**

Appendix B: Modality assessment for ametryn **13**

References **16**

Figures

Figure 1 Structure of ametryn 1

Figure 2 Species sensitivity distribution, ametryn in marine water 7

Tables

Table 1 Summary, physico-chemical properties of ametryn 1

Table 2 Summary of single chronic toxicity values, all species used to derive default guideline values for ametryn in marine water 5

Table 3 Default guideline values, ametryn in marine water, high reliability 8

Appendix figures

Figure B 1 Box plot, freshwater and marine species sensitivities to ametryn 13

Figure B 2 Histogram, freshwater and marine species dataset 14

Figure B 3 Box plot, phototroph and heterotroph sensitivity to ametryn 14

Figure B 4 Species sensitivity distribution, phototroph and heterotroph sensitivity to ametryn 15

Appendix tables

Table A 1 Summary, chronic toxicity that passed the screening and quality assessment processes, ametryn in marine water 11

Summary

The default guideline values (DGVs) and associated information in this technical brief should be used in accordance with the detailed guidance provided in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality website (www.waterquality.gov.au/anz-guidelines).

Ametryn (N^2-ethyl-N^4-isopropyl-6-methylthio-1,3,5-triazine-2,4-diamine, CAS no. 834-12-8) is a selective, systemic triazine herbicide or, more specifically, a methylthiotriazine herbicide. Other methylthiotriazine herbicides include prometryn, terbutryn and simetryn. Ametryn is a photosynthesis-inhibiting herbicide used to control most annual grasses and broad-leaved weeds in a variety of crops (University of Hertfordshire 2013).

Previously, no Australian and New Zealand DGVs existed for ametryn in freshwater or marine environments. More data on ametryn toxicity to marine species are now available, including data for phototrophic species (e.g. plants, algae), and have been used to derive the DGVs.

The available data indicate that ametryn is more toxic to phototrophs than to heterotrophs. The lowest reported acute and chronic toxicity values to marine species are 36 µg/L (marine macroalga, 3-d EC50) and 1.16 µg/L (marine microalga, 3-d EC10), respectively.

High reliability DGVs for ametryn in marine water were derived based on chronic EC10 and chronic NOEC data for nine marine species from four phyla and six classes, with a good fit of the species sensitivity distribution (SSD) to the toxicity data.

The DGVs are expressed in terms of the active ingredient (ametryn) and relate to ametryn only—not its breakdown products. The DGVs for 99%, 95%, 90% and 80% species protection are 0.21 µg/L, 0.93 µg/L, 1.8 µg/L and 3.4 µg/L, respectively. The 95% species protection DGV of 0.93 µg/L is recommended for adoption in the assessment of slightly-to-moderately disturbed ecosystems.

1 Introduction

Ametryn ($C_9H_{17}N_5S$) is a selective, systemic herbicide (Figure 1). Ametryn is the active ingredient of a variety of commercial herbicide formulations. The physico-chemical properties of ametryn that may affect its environmental fate and toxicity are presented in Table 1.

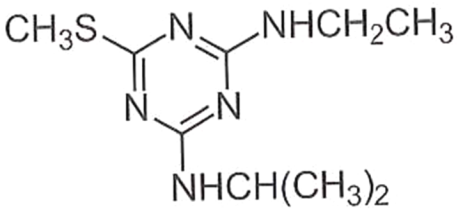


Figure 1 Structure of ametryn

Table 1 Summary, physico-chemical properties of ametryn

Physico-chemical property	Value
Molecular weight	227.3 amu [a]
Aqueous solubility	200 mg/L at pH 7.1 and 22°C [a]
Logarithm of the octanol-water partition coefficient (log K_{ow})	2.63 at pH 7 and 20°C [b]
Logarithm of the organic carbon water partition coefficient (log K_{oc})	1.98–2.97 [a] 2.5 [b]
Logarithm of the bioconcentration factor (log BCF)	1.52 [b]
Half-life in water ($t_{1/2}$)	>1 week [c] Stable at pH 5, 7 and 9 [d]
Half-life in soils ($t_{1/2}$)	11–280 days, median 62 days [a]

a BCPC (2012).
b Pesticide Properties Database (University of Hertfordshire 2013).
c USEPA (1987).
d USEPA (2013).

Ametryn belongs to the methylthiotriazine group within the triazine family of herbicides, which also includes prometryn, terbutryn and simetryn. Ametryn is extensively used in Australian agriculture, forestry and grazing applications to control most annual grasses and broad-leaved weeds in a variety of crops, such as pineapples and sugarcane (APVMA 2020). Ametryn is also approved for use on commercial and industrial land, right-of-way areas, roadsides, railway lines, footpaths and drains (APVMA 2020). Ametryn is not approved for use in New Zealand (ACVM 2021).

Information on the degradation of ametryn in water is limited. Decomposition of ametryn due to hydrolysis is not expected due to the lack of appropriate functional groups; loss due to volatilisation is also not expected to occur (PubChem 2021). Microbial degradation will contribute to the decomposition of ametryn in water, but binding to suspended solids and sediment is expected to be the major pathway for such decomposition (PubChem 2021). Ametryn has a low soil adsorption capacity and a moderate aqueous solubility (Table 1), suggesting it has a high capacity to leach to groundwater and be transported in surface water; however, leaching studies indicate that ametryn

does not leach significantly (BCPC 2012). A study of surface water and groundwater samples in six US states found ametryn in approximately 0.2% of surface water samples, compared to approximately 4% of groundwater samples (USEPA 1987). A more recent assessment of ametryn by USEPA (2013) concluded that because ametryn is highly persistent and relatively mobile, it may leach into aquatic systems after exaggerated rainfall, floods or from spray drift after application to control invasive weeds.

Australian data from 2011 to 2015 show that ametryn was detected in approximately 15.5% of surface water samples in catchments monitored as part of the Great Barrier Reef Catchment Loads Monitoring Program (based on data in Turner et al. 2012, 2013; Wallace et al. 2014, 2015, 2016; Garzon-Garcia et al. 2015). More recently, Taucare et al. (2022) reported that ametryn was detected in 37% of 11 inshore Great Barrier Reef monitoring sites based on data between 2005 and 2018. In other Australian monitoring studies, ametryn has been detected in estuarine and brackish waters in the Hervey Bay region (McMahon et al. 2005), coastal lagoons associated with seagrass beds and inshore coral reefs (Lewis et al. 2009), mangrove forests in the Mackay Whitsundays (Duke et al. 2005) and marine ecosystems including inshore Great Barrier Reef monitoring sites (Prange et al. 2007).

2 Aquatic toxicology

2.1 Mechanisms of toxicity

Ametryn is absorbed through the roots and leaves of plants. It is then translocated acropetally (i.e. movement upwards from the base of plants to the apex) in the xylem and accumulates in the apical meristems (BCPC 2012). Ametryn exerts its toxicity in aquatic plants by inhibiting electron transport in the photosystem II (PSII) complex (University of Hertfordshire 2013), a key process in photosynthesis that occurs in the thylakoid membranes of chloroplasts. Photosynthesis-inhibiting herbicides bind to the plastoquinone B protein binding site on the D1 protein in PSII. This prevents the transport of electrons to synthesise adenosine triphosphate (used for cellular metabolism) and nicotinamide adenine dinucleotide phosphate (used in converting CO_2 to glucose), therefore preventing CO_2 fixation (Wilson et al. 2000).

In addition to its main mode of action, exposure to PSII-inhibiting herbicides can increase the formation of reactive oxygen species (ROS), including the synthesis of singlet oxygen ($^1O_2$), superoxide (O_2^-) and hydrogen peroxide (H_2O_2) (Halliwell 1991). ROS are highly reactive forms of oxygen that react with, and bind to, biomolecules, including deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). ROS are created during normal cellular functions, particularly in biochemical processes that involve the generation of energy (e.g. photosynthesis in chloroplasts; Krebs cycle in mitochondria), and are involved in a number of cellular processes (Chen et al. 2012). In phototrophs, ROS are formed when the absorbed light energy exceeds the ability to convert CO_2 to organic molecules (Chen et al. 2012). Prolonged exposure to elevated concentrations of ROS in plants, generated by biotic (e.g. disease) and/or abiotic (e.g. PSII-inhibiting herbicides) stressors, can cause irreversible cell damage and ultimately lead to cell death (apoptosis).

2.2 Relative toxicity

There were toxicity data for 12 marine species that passed the screening and quality assessment processes. These consisted of 10 phototrophs and two heterotrophs. The phototrophs consisted of six diatoms, one green alga, one red alga, one brown-golden alga and one haptophyte. The heterotrophs consisted of one fish and one crustacean.

The available evidence indicates that phototrophs are more sensitive to ametryn than heterotrophs (Appendix B). One heterotroph had a toxicity value within the range of the phototroph toxicity values.

There does not appear to be any difference in the sensitivity between different types of marine phototrophs, with chronic toxicity values ranging as follows:

- 19–97 µg/L (both 3-d EC50s, biomass) (USEPA 2015) for the diatoms
- 20–40 µg/L (both 10-d EC50s, biomass) (USEPA 2015) for the green alga
- 1.31 µg/L (3-d EC10, abundance) (Seery and Pradella 2014) to 10 µg/L (10-d EC50, biomass) (USEPA 2015) for the haptophyte
- 36 µg/L for the red alga (3-d EC50, biomass) (USEPA 2015)
- 14 µg/L for the golden-brown algae (3-d EC50, biomass) (USEPA 2015).

The heterotrophic species had values ranging from 50 µg/L (28-d NOEL, mortality) to 5 800 µg/L (4-d LC50) (USEPA 2015). The fish and crustaceans appear to have similar sensitivities to ametryn; however, as there is minimal data available, it is difficult to confirm differences in sensitivity.

- Fish toxicity ranged from 2 800 µg/L (4-d NOEL, juvenile mortality) to 5 800 µg/L (4-day LC50, juvenile mortality) (USEPA 2015).
- Crustacean toxicity data ranged from 50 µg/L (28-d NOEL, larval mortality) to 2 300 µg/L (4-d LC50, juvenile mortality) (USEPA 2015).

There is a paucity of data on the toxicity of ametryn to marine plant species such as mangroves and seagrasses. The data that exist are not suitable for DGV derivation, as they are based on ametryn formulations (Bell and Duke 2005) or measured responses that have not demonstrated ecological relevance (Bell and Duke 2005; Wilkinson et al. 2015). Reported toxicity values for mangroves include chronic NOECs of 400 µg/kg and >4 000 µg/kg (15-d sediment-borne exposure based on photosynthesis as measured as maximum potential quantum yield) for *Aegiceras corniculatum* and four other mangrove species, respectively (Bell and Duke 2005), based on the ametryn formulation Viking. For the seagrass *Halophila ovalis*, Wilkinson et al. (2015) reported an acute 2-d EC50 of 3.5 µg/L (photosynthesis as measured as maximum potential quantum yield).

3 Factors affecting toxicity

There are no studies on factors affecting the toxicity of ametryn; however, such information is available for other PSII-inhibiting herbicides including diuron, atrazine and terbuthylazine, which are discussed below. This information provides insights on factors that may affect the toxicity of ametryn.

The potential effect of particulate matter (e.g. natural black carbon, combusted black carbon, and suspended solids) and dissolved organic matter on ametryn toxicity is not clear. Knauer et al. (2007) found that the addition of natural black carbon and combusted black carbon could reduce or completely remove the impact of diuron on photosynthesis. In contrast, a comprehensive review by Knauer et al. (2017) reported that suspended solids did not significantly affect the toxicity and bioavailability of atrazine and terbuthylazine (PSII-inhibiting herbicides) to aquatic organisms in 13 out of 16 datasets. The review included a series of studies on the effect of suspended solids on the toxicity of atrazine to Australian freshwater heterotrophs (i.e. cladocerans *Ceriodaphnia* cf. *dubia* and *Daphnia carinata*, shrimp *Paratya australiensis*, midge *Chironomus tepperi*, and fish *Melanotaenia fluviatilis* (Phyu et al. 2004, 2005a, 2005b, 2006, 2008)).

One of the modes of action of ametryn in phototrophs is to increase the formation of ROS (Section 2.1). Given that the formation of ROS is dependent on light intensity, increased turbidity (e.g. from increased suspended solids) may decrease ametryn toxicity. Elevated light intensity was found to interact additively or synergistically with another PSII-inhibiting herbicide (diuron) to damage the PSII of the seagrass *Halophila ovalis*, while lower light generally resulted in impacts that were sub-additive (Wilkinson et al. 2015). King et al. (2022a) found that the chronic toxicity of diuron to the marine diatom *Phaeodactylum tricornutum* under low light conditions varied depending on the stressor intensity and endpoint measured; they reported a mild inhibition of photosynthesis but a major inhibition of growth (i.e. cell density). King et al. (2022b) found that diuron and reduced light resulted in additive, antagonistic or synergistic interactions, depending on the stressor intensity, exposure period and the measured biological response.

Wilkinson et al. (2017) also found that water temperatures greater or less than the thermal optima for *H. ovalis* tended to exert sub-additive (antagonistic) effects when combined with diuron. However, these sub-additive effects were still greater than the effect of each stressor alone.

This information indicates that the combined effects of PSII-inhibiting herbicides and other stressors may be species-specific and difficult to predict.

4 Default guideline value derivation

The DGVs were derived in accordance with the method described in Warne et al. (2018) and using Burrlioz 2.0 software.

4.1 Toxicity data used in derivation

To obtain data for ametryn toxicity to marine organisms, a search of the scientific literature was conducted. In addition, the following databases were searched: ECOTOX Knowledgebase (USEPA 2015); Australasian Ecotoxicology Database (Warne et al. 1998); and ANZECC/ARMCANZ (2000) and Sunderam et al. (2000) toxicant databases. There are now sufficient ametryn toxicity data available to derive DGVs for marine water (Appendix A). To derive higher reliability DGVs in the future, additional chronic toxicity tests of ametryn with marine phototrophic species should be conducted.

There were marine toxicity data for 12 species (seven phyla and nine classes) that passed the screening and quality assessment processes. The represented phyla were Arthropoda,

Bacillariophyta, Chlorophyta, Chordata, Haptophyta, Ochrophyta and Rhodophyta. Chronic toxicity data were available for 10 of the 12 species (nine phototrophs and one heterotroph), and acute toxicity data were available for three species (one phototroph and two heterotrophs).

Based on the mode of action of ametryn (Section 2) and the results of the modality assessment in Appendix B (i.e. toxicity data distribution is likely bimodal), it was concluded that phototrophs were more sensitive than heterotrophs to ametryn. Therefore, as recommended by Warne et al. (2018), only phototroph toxicity data were used to derive the DGVs.

There was only one chronic negligible effect (EC10/NOEC) toxicity value available to derive DGVs for ametryn in marine water. Therefore, this value (a chronic EC10) was combined with chronic estimated negligible effect data (EC50s converted to estimated NOECs by dividing by 5) for eight species. Toxicity data based on both measured and nominal concentrations were used as ametryn is water soluble, has low partition coefficients (K_{oc} and K_{ow}) (Table 1) and a low vapour pressure (2.74×10^{-6} mm Hg at 25°C (PubChem 2021)); therefore, nominal concentrations were not expected to differ markedly to measured concentrations. The final dataset consisted of chronic toxicity data for nine phototrophic species belonging to four phyla and six classes, which met the minimum data requirements (i.e. five species from four phyla) to use a species sensitivity distribution to derive the DGVs (Warne et al. 2018).

A summary of the toxicity data (one value per species) used to calculate the DGVs for ametryn in marine water is provided in Table 2. Further details of the water quality parameters for each species used to derive the DGVs are in Appendix A. Details of the data quality assessment and the chronic data that passed the quality assessment are provided as supporting information.

Table 2 Summary of single chronic toxicity values, all species used to derive default guideline values for ametryn in marine water

Taxonomic group	Species	Duration (days)	Toxicity measure [a] (endpoint)	Reported toxicity value (µg/L)	Final toxicity value (µg/L)
Green microalga	*Dunaliella tertiolecta*	10	EC50 (Biomass yield)	28.3 [e]	5.66 [d]
Brown microalga	*Isochrysis galbana* [b]	3	EC10 (Abundance)	1.16 [f]	1.16
Golden-brown microalga	*Monochrysis lutheri*	3	EC50 (Biomass yield, growth rate, AUC [c])	14	2.8 [d]
Diatom	*Achnanthes brevipes* [b]	3	EC50 (Biomass yield, growth rate, AUC [c])	19	3.8 [d]
	Navicula incerta	3	EC50 (Biomass yield, growth rate, AUC [c])	97	19.4 [d]
	Nitzschia closterium [b]	3	EC50 (Biomass yield, growth rate, AUC [c])	62	12.4 [d]
	Phaeodactylum tricornutum [b]	10	EC50 (Biomass yield, growth rate, AUC [c])	31.6 [e]	6.32 [d]

Taxonomic group	Species	Duration (days)	Toxicity measure [a] (endpoint)	Reported toxicity value (µg/L)	Final toxicity value (µg/L)
	Thalassiosira fluviatilis [b]	3	EC50 (Biomass yield, growth rate, AUC [c])	58	11.6 [d]
	Thalassiosira guillardii	3	EC50 (Biomass yield, growth rate, AUC [c])	55	11 [d]

a The measure of toxicity being determined. EC50: 50% effect concentration. EC10: 10% effect concentration.
b Species that originated from, or are distributed in, Australia and/or New Zealand.
c AUC: area under the growth curve.
d Chronic EC50 converted to chronic NOEC by dividing by 5 (Warne et al. 2018).
e Value represents a geometric mean of two toxicity values (Appendix A).
f Value represents a geometric mean of three toxicity values (Appendix A).

To identify species that were regionally relevant to Australia and New Zealand ecosystems, the following databases were searched: AlgaeBase (Guiry and Guiry 2017); Atlas of Living Australia (ALA 2017); Catalogue of Life (Roskov et al. 2017); Integrated Taxonomic Information System (ITIS 2017); and World Register of Marine Species (WoRMS 2017). The dataset used in the DGV derivation for ametryn in marine water (Table 2) includes toxicity data for five marine species that either originated from or are distributed within Australia and/or New Zealand.

4.2 Species sensitivity distribution

The cumulative frequency (species sensitivity) distribution (SSD) of the nine marine species in Table 2 is presented in Figure 2. The SSD was plotted using the Burrlioz 2.0 software. The model provided a good fit to the data (Figure 2).

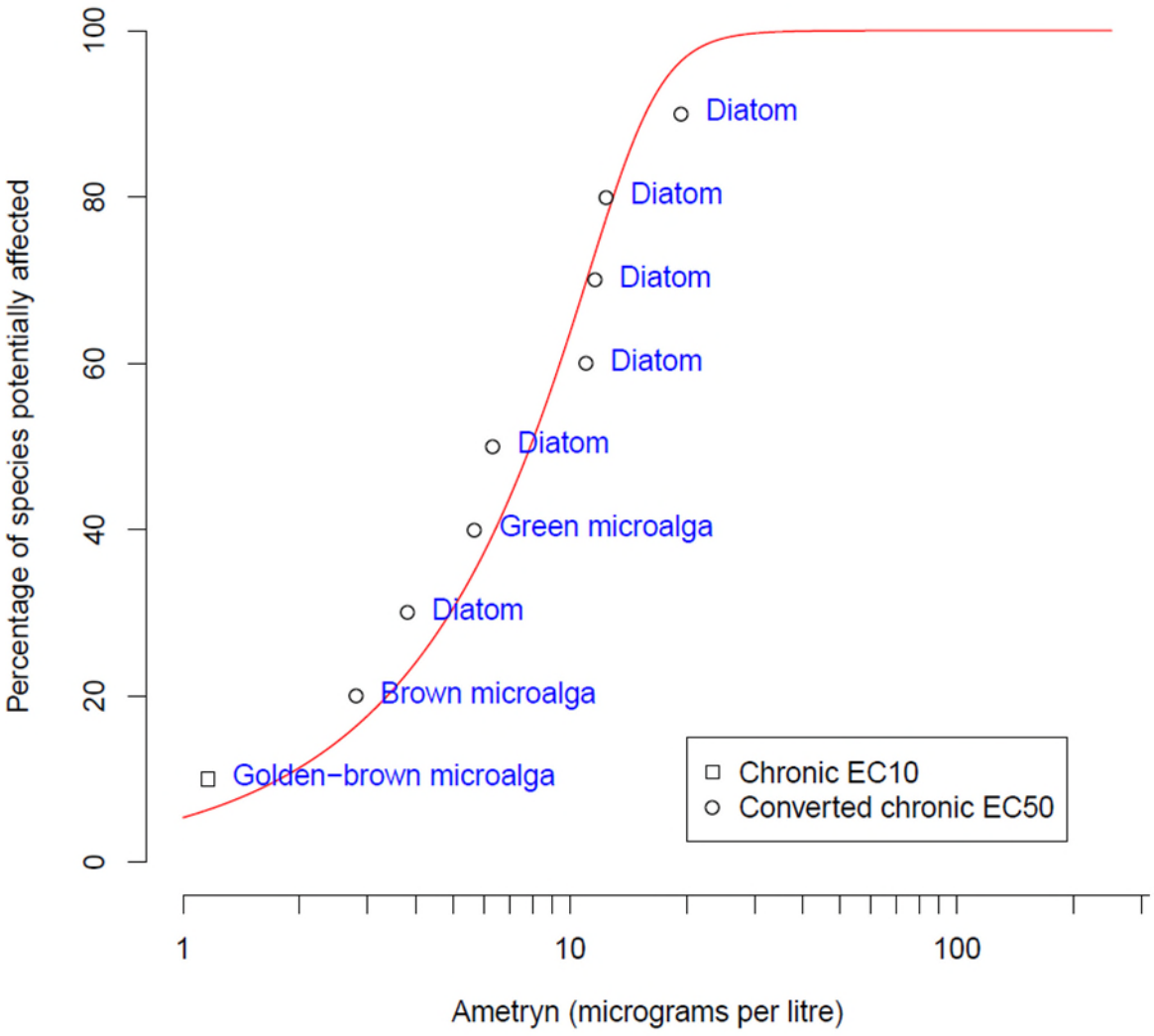


Figure 2 Species sensitivity distribution, ametryn in marine water

4.3 Default guideline values

It is important that the DGVs (Table 3) and associated information in this technical brief are used in accordance with the detailed guidance provided in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality website (ANZG 2018).

The DGVs are expressed in terms of the concentration of the active ingredient; they relate to ametryn only—not its breakdown products. ANZG (2018) provides guidance on what to do if the DGVs are under-protective due to formulation-related factors.

Measured log BCF values for ametryn are low (Table 1) and below the threshold at which secondary poisoning must be considered (i.e. threshold log BCF = 4 (Warne et al. 2018)). Therefore, the DGVs for ametryn do not account for secondary poisoning.

The DGVs for ametryn in marine water are provided in Table 3. The 95% species protection DGV of 0.93 µg/L is recommended for application to slightly-to-moderately disturbed ecosystems.

Table 3 Default guideline values, ametryn in marine water, high reliability

Level of species protection (%)	DGV for ametryn in marine water (µg/L) [a]
99	0.21
95	0.93
90	1.8
80	3.4

a Default guideline values were derived using the Burrlioz 2.0 software and rounded to two significant figures.

4.4 Reliability classification

The ametryn marine water DGVs have a high reliability classification (Warne et al. 2018) based on the outcomes for the following three criteria:

- Sample size—9 (good)
- Type of toxicity data—chronic (EC10 and converted chronic EC50s)
- SSD model fit—good (Burr type III).

Glossary

Term	Definition
acute toxicity	A lethal or adverse sub-lethal effect that occurs as the result of a short exposure period to a chemical relative to the organism's life span.
BCF	Bioconcentration factor.
bimodal	When the distribution of the sensitivity of species to a toxicant has two modes. This typically occurs with chemicals with specific modes of action. For example, herbicides are designed to affect plants at low concentrations but most animals are only affected at high concentrations.
CAS no.	Chemical Abstracts Service number. Each chemical has a unique identifying number that is allocated by the American Chemical Society.
chronic toxicity	A lethal or sublethal adverse effect that occurs after exposure to a chemical for a period of time that is a substantial portion of the organism's life span or an adverse effect on a sensitive early life stage.
DGV (default guideline value)	A guideline value recommended for generic application in the absence of a more specific guideline value (e.g. site-specific) in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality.
EC50 (median effective concentration)	The concentration of a substance in water or sediment that is estimated to produce a 50% change in the response being measured or a certain effect in 50% of the test organisms relative to the control response, under specified conditions.
ECx	The concentration of a substance in water or sediment that is estimated to produce an x% change in the response being measured or a certain effect in x% of the test organisms, under specified conditions.
endpoint	The specific response of an organism that is measured in a toxicity test (e.g. mortality, growth, a particular biomarker).
haptophyte	Haptophytes are a large group of predominantly marine algae that have calcium carbonate scales on their surface and a flagellum-like (lash or whip-like) structure used for feeding and/or for attaching to surfaces.
heterotroph	An organism that cannot manufacture its own energy and needs to obtain energy from external sources (i.e. by consuming other organisms).
LC50 (median lethal concentration)	The concentration of a substance in water or sediment that is estimated to be lethal to 50% of a group of test organisms, relative to the control response, under specified conditions.
mode of action	The means by which a chemical exerts its toxic effects. For example, triazine herbicides inhibit the photosystem II component of plants' photosynthesis biochemical reaction.
NOEC (no observed effect concentration)	The highest concentration of a material used in a toxicity test that has no statistically significant adverse effect on the exposed population of test organisms as compared with the controls.
NOEL (no observed effect level)	Synonymous with NOEC.
phototrophs	An organism that photosynthesises as its main means of obtaining energy (e.g. plants and algae).
PSII	Photosystem II of the photosynthetic biochemical pathway.
ROS	Reactive oxygen species.
species (biological)	A group of organisms that resemble each other to a greater degree than members of other groups and that form a reproductively isolated group that will not produce viable offspring if bred with members of another group.

Term	Definition
SSD (species sensitivity distribution)	A method that plots the cumulative frequency of species' sensitivities to a toxicant and fits a statistical distribution to the data. From the distribution, the concentration that should theoretically protect a selected percentage of species can be determined.
toxicity	The inherent potential or capacity of a material to cause adverse effects in a living organism.
toxicity test	The means by which the toxicity of a chemical or other test material is determined. A toxicity test is used to measure the degree of response produced by exposure to a specific level of stimulus (or concentration of chemical) for a specified test period.

Appendix A: Toxicity data that passed the screening and quality assessment and were used to derive the default guideline values

Table A 1 Summary, chronic toxicity that passed the screening and quality assessment processes, ametryn in marine water

Taxonomic group	Species	Exposure duration (days)	Toxicity measure (test endpoint)	Test medium	Salinity (‰)	Temp. (°C)	pH	Concentration (µg/L)	Reference
Diatom	*Achnanthes brevipes* [c]	3	EC50 (Biomass yield, growth rate, AUC [a])	ASTM Type I water with synthetic salt water or filtered natural salt water	30 ± 5	20 ± 2	8 ± 0.1	19	USEPA (2015)
	–							**3.8** [b]	**Value used in SSD**
	Navicula incerta	3	EC50 (Biomass yield, growth rate, AUC [a])	ASTM Type I water with synthetic salt water or filtered natural salt water	30 ± 5	20 ± 2	8 ± 0.1	97	USEPA (2015)
	–							**19.4** [b]	**Value used in SSD**
	Nitzschia closterium [c]	3	EC50 (Biomass yield, growth rate, AUC [a])	ASTM Type I water with synthetic salt water or filtered natural salt water	30 ± 5	20 ± 2	8 ± 0.1	62	USEPA (2015)
	–							**12.4** [b]	**Value used in SSD**
	Phaeodactylum tricornutum [c]	10	EC50 (Biomass yield, growth rate, AUC [a])	ASTM Type I water with synthetic salt water or filtered natural salt water	30 ± 5	20 ± 2	8 ± 0.1	20	USEPA (2015)
		10	EC50 (Biomass yield, growth rate, AUC [a])	ASTM Type I water with synthetic salt water or filtered natural salt water	30 ± 5	20 ± 2	8 ± 0.1	50	USEPA (2015)
	–							*31.6*	*Geometric mean*
	–							**6.32** [b]	**Value used in SSD**

Taxonomic group	Species	Exposure duration (days)	Toxicity measure (test endpoint)	Test medium	Salinity (‰)	Temp. (°C)	pH	Concentration (µg/L)	Reference
	Thalassiosira fluviatilis [c]	3	EC50 (Biomass yield, growth rate, AUC [a])	ASTM Type I water with synthetic salt water or filtered natural salt water	30 ± 5	20 ± 2	8 ± 0.1	58	USEPA (2015)
	–							**11.6** [b]	**Value used in SSD**
	Thalassiosira guillardii	3	EC50 (Biomass yield, growth rate, AUC [a])	ASTM Type I water with synthetic salt water or filtered natural salt water	30 ± 5	20 ± 2	8 ± 0.1	55	USEPA (2015)
	–							**11** [b]	**Value used in SSD**
Green microalga	*Dunaliella tertiolecta*	10	EC50C (Biomass yield)	F/2 marine media	20	25	–	40	USEPA (2015)
		10	EC50 (Biomass yield)	F/2 marine media	20	25	–	20	USEPA (2015)
	–							*28.3*	*Geometric mean*
	–							**5.66** [b]	**Value used in SSD**
Brown microalga (Haptophyte)	*Isochrysis galbana*	3	EC10 (Abundance)	Marine	31 ± 2	29 ± 1	8.2 ± 0.2	0.94	Seery and Pradella (2014)
		3	EC10 (Abundance)	Marine	31 ± 2	29 ± 1	8.2 ± 0.2	2.26	Seery and Pradella (2014)
		3	EC10 (Abundance)	Marine	31 ± 2	29 ± 1	8.2 ± 0.2	0.73	Seery and Pradella (2014)
	–							1.16	Geometric mean
	–							**1.16**	**Value used in SSD**
Golden-brown microalga	*Monochrysis lutheri*	3	EC50 (Biomass yield, growth rate, AUC [a])	ASTM Type I water with synthetic salt water or filtered natural salt water	30 ± 5	20 ± 2	8 ± 0.1	14	USEPA (2015)
	–							**2.8** [b]	**Value used in SSD**

a AUC: area under the growth curve.

b Chronic EC50s converted to chronic NOECs by dividing by 5 (Warne et al. 2018).

c Species that originated from, or are distributed in, Australia and/or New Zealand.

Appendix B: Modality assessment for ametryn

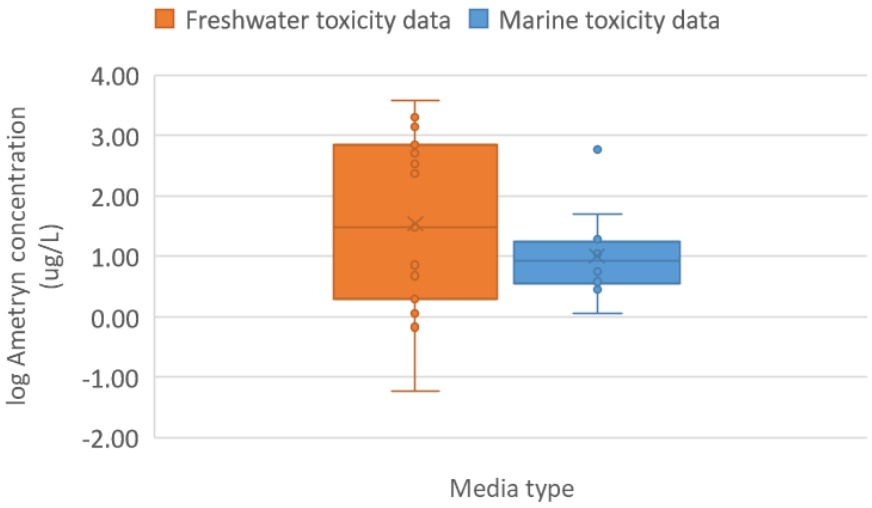
A modality assessment was undertaken for ametryn according to the weight of evidence approach specified in Warne et al. (2018).

Is there a specific mode of action that could result in taxa-specific sensitivity?
Ametryn exerts its toxicity in aquatic plants (including aquatic macrophytes and algae) by inhibiting electron transport in the photosystem II (PSII) complex (University of Hertfordshire 2013), a key process in photosynthesis that occurs in the thylakoid membranes of chloroplasts.

In addition to its main mode of action, exposure to PSII-inhibiting herbicides can increase the formation of reactive oxygen species (ROS) (Halliwell 1991). Prolonged exposure to elevated concentrations of ROS in plants, due to biotic (e.g. disease) and/or abiotic (e.g. PSII-inhibiting herbicides) stressors, can cause irreversible cell damage and ultimately lead to cell death (apoptosis).

These modes of action suggest that ametryn is be more toxic to phototrophs than to heterotrophs.

Does the dataset suggest bimodality?
Modality was assessed using a dataset that combined all ametryn freshwater and marine data that passed the screening and quality assessment schemes (*n* = 27). This was done to increase the sample size of the dataset being assessed. All data that were not chronic negligible effect values (e.g. EC10, NOEC) were converted to this type of data using the methods recommended by Warne et al. (2018). Box and whisker plots for the freshwater data and marine data indicated that there was no difference in the sensitivities of the two groups (Figure B 1). Therefore, the pooled dataset was retained for the modality assessment. Calculation of the bimodality coefficient (BC) on log-transformed data yielded a value of 0.38, which—being below the indicative threshold BC for bimodality of 0.55—suggested the dataset does not exhibit bimodality. However, a frequency histogram indicated that the dataset may not be unimodal (Figure B 2).



Note: 'x' denotes the mean; circles represent the individual toxicity values.

Figure B 1 Box plot, freshwater and marine species sensitivities to ametryn

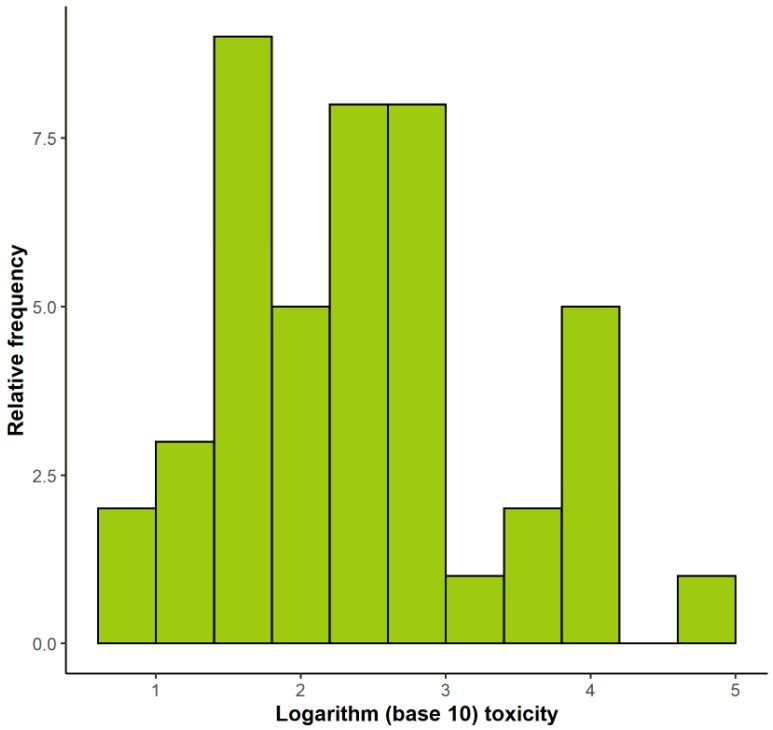
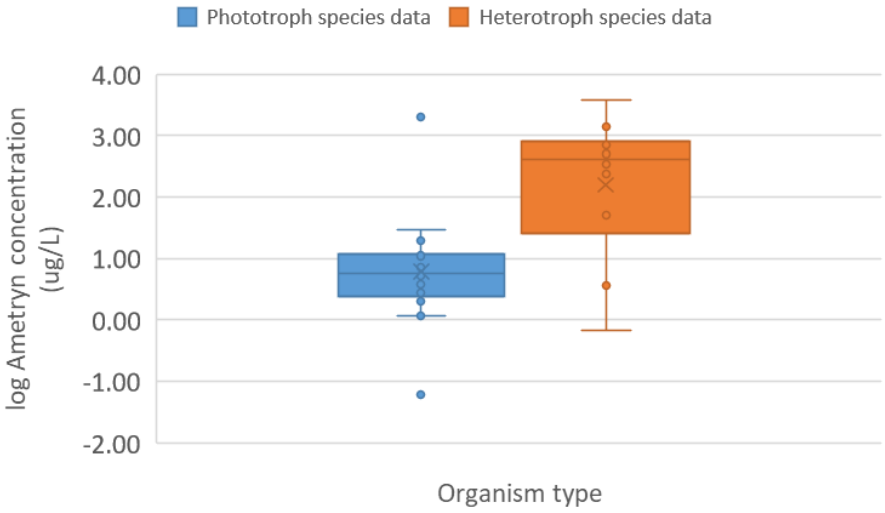


Figure B 2 Histogram, freshwater and marine species dataset

Do data show taxa-specific sensitivity (i.e. through distinct groupings of different taxa types)?
The relative sensitivity of different taxa groups to ametryn was compared using box and whisker plots (Figure B 3) and a species sensitivity distribution (SSD) (Figure B 4). These analyses indicated that there is an incomplete separation in the sensitivity of phototrophs and heterotrophs to ametryn. Also, the inclusion of toxicity data for heterotrophs resulted in an offset of datapoints towards the top of the SSD (Figure B 4). This pattern is typically seen in chemicals with a specific mode of action and is a strong visual indication of bimodality.

Overall, the specificity of the mode of action of ametryn (to a protein that is only found in phototrophs) and the incomplete separation in sensitivity indicate that the sensitivity of ametryn is bimodal, with phototrophs being the more sensitive group.



Note: 'x' denotes the mean; circles represent the individual toxicity values.

Figure B 3 Box plot, phototroph and heterotroph sensitivity to ametryn

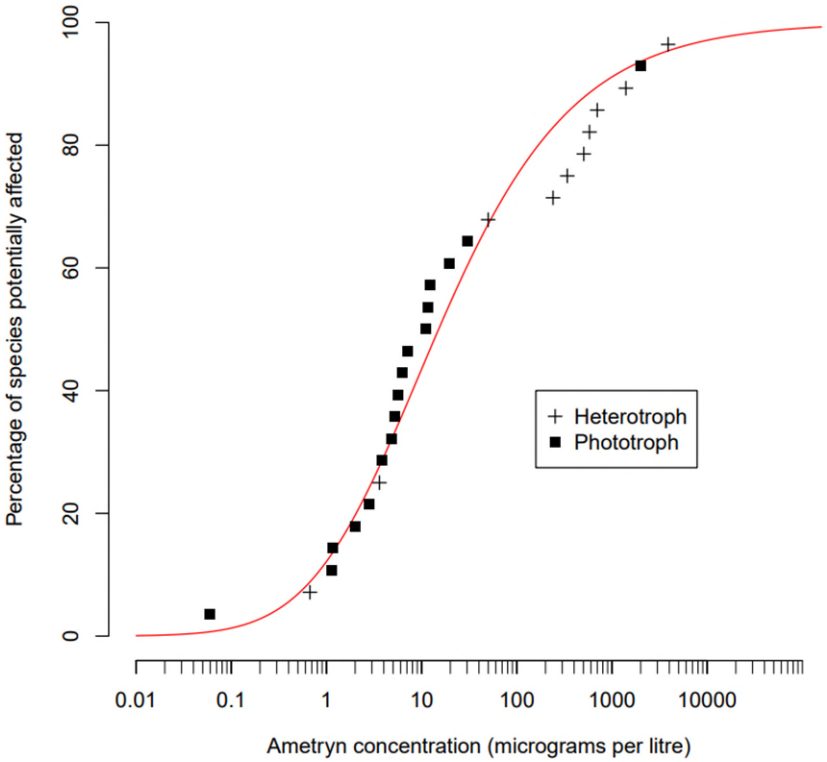


Figure B 4 Species sensitivity distribution, phototroph and heterotroph sensitivity to ametryn

Is it likely that indications of bimodality or multimodality or distinct clustering of taxa groups are not due to artefacts of data selection, small sample size, test procedures, or other reasons unrelated to a specific mode of action?

Given that there are ecotoxicity data for 17 phototrophs and 10 heterotrophs, the distributions are likely representative.

Overall, the specificity of the mode of action of ametryn and the partial separation in sensitivity indicate that the toxicity of ametryn is bimodal, with phototrophs being the more sensitive group.

References

ACVM (2021) *Agricultural Compounds and Veterinary Medicines (ACVM) register* [website], Ministry for Primary Industries New Zealand, accessed February 2021.

ALA (2017) Atl*as of Living Australia* [website], National Research Infrastructure for Australia and Commonwealth Scientific and Industrial Research Organisation, accessed May 2017.

ANZECC/ARMCANZ (2000) *Australian and New Zealand guidelines for fresh and marine water quality*, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

ANZG (2018) *Australian and New Zealand Guidelines for Fresh & Marine Water Quality* [website], Australian and New Zealand governments and Australian state and territory governments.

APVMA (2020) *Public Chemical Registration Information System Search (PubCRIS)* [website], Australian Pesticides and Veterinary Medicines Authority, accessed February 2021.

BCPC (2012) *A world compendium: the pesticide manual*, 16th edn, MacBean C (ed), British Crop Production Council, United Kingdom.

Bell AM and Duke NC (2005) 'Effects of photosystem II inhibiting herbicides on mangroves – preliminary toxicology trials', *Marine Pollution Bulletin*, 51(1-4):297–307.

Chen S, Yin C, Strasser RJ, Govinjee, Yang C and Qiang S (2012) 'Reactive oxygen species from chloroplasts contribute to 3-acetyl-5-isopropyltetramic acid-induced leaf necrosis of *Arabidopsis thaliana*', *Plant Physiology and Biochemistry*, 52:38–51.

Duke NC, Bell AM, Pederson DK, Roelfsema CM and Nash SB (2005) 'Herbicides implicated as the cause of severe mangrove dieback in the Mackay region, NE Australia: consequences for marine plant habitats of the GBR World Heritage Area', *Marine Pollution Bulletin*, 51:308–324.

Garzon-Garcia A, Wallace R, Huggins R, Turner RDR, Smith RA, Orr D, Ferguson B, Gardiner R, Thomson B and Warne MStJ (2015) *Total suspended solids, nutrients and pesticide loads (2013–2014) for rivers that discharge to the Great Barrier Reef: Great Barrier Reef catchment loads monitoring program* [website], Queensland Department of Science, Information Technology, Innovation and the Arts.

Guiry MD and Guiry GM (2017) *AlgaeBase* [online database], University of Galway, accessed May 2017.

Halliwell B (1991) 'Oxygen radicals: their formation in plant tissues and their role in herbicide damage', in Baker NR and Percival MP (eds), *Herbicides*, Elsevier Science, Amsterdam.

ITIS (2017) *Integrated Taxonomic Information System* [online database], accessed May 2017.

King OC, van de Merwe JP, Brown CJ, Warne MStJ and Smith RA (2022a) 'Individual and combined effects of diuron and light reduction on marine microalgae', *Ecotoxicology and Environmental Safety*, 241:113729.

King OC, van de Merwe JP, Campbell MD, Smith RA, Warne MStJ and Brown CJ (2022b) 'Interactions among multiple stressors vary with exposure duration and biological response', *Proceedings of the Royal Society B: Biological Sciences*, 289:20220348.

Knauer K, Homazava N, Junghans M and Werner I (2017) 'The influence of particles on bioavailability and toxicity of pesticides in surface water', *Integrated Environmental Assessment and Management*, 13(4):585–600.

Knauer K, Sobek A and Bucheli TD (2007) 'Reduced toxicity of diuron to the freshwater green alga *Pseudokirchneriella subcapitata* in the presence of black carbon', *Aquatic Toxicology*, 83(2):143–148.

Lewis S, Brodie J, Bainbridge Z, Rohde K, Davis A, Masters B, Maughan M, Devlin M, Mueller J and Schaffelke B (2009) 'Herbicides: a new threat to the Great Barrier Reef', *Environmental Pollution*, 157:2470–2484.

McMahon K, Bengtson Nash S, Eaglesham G, Müller JF, Duke NC and Winderlich S (2005) 'Herbicide contamination and the potential impact to seagrass meadows in Hervey Bay, Queensland, Australia', *Marine Pollution Bulletin*, 51:325–334.

Phyu YL, Warne MStJ and Lim RP (2004) 'Toxicity of atrazine and molinate to the cladoceran *Daphnia carinata* and the effect of river water and bottom sediment on their bioavailability', *Archives of Environmental Contamination and Toxicology,* 46:308–315.

Phyu YL, Warne MStJ and Lim RP (2005a) 'The toxicity and bioavailability of atrazine and molinate to *Chironomus tepperi* larvae in laboratory and river water in the presence and absence of sediment', *Chemosphere,* 58:1231–1239.

Phyu YL, Warne MStJ and Lim RP (2005b) 'Toxicity and bioavailability of atrazine and molinate to a freshwater shrimp (*Paratya australiensis*) under laboratory and simulated field conditions', *Ecotoxicology and Environmental Safety*, 60:113–122.

Phyu YL, Warne MStJ and Lim RP (2006) 'Toxicity and bioavailability of atrazine and molinate to the freshwater fish *(Melanotenia fluviatilis)* under laboratory and simulated field conditions', *Science of the Total Environment*, 356(1–3):86–99.

Phyu YL, Warne MStJ and Lim RP (2008) 'Assessing the biological relevance of exposing freshwater organisms to atrazine and molinate in environmentally realistic exposure test systems', *Environmental Toxicology and Chemistry*, 27:420–424.

Prange J, Haynes D, Schaffelke B and Waterhouse J (2007) *Annual marine monitoring report. Reporting on data available from December 2004 to April 2006* [PDF], Great Barrier Reef Marine Park Authority, Townsville, accessed April 2017.

PubChem (2021) *PubChem Compound Summary for CID 13263, Ametryn* [website], National Library of Medicine, accessed May 2025.

Roskov Y, Abucay L, Orrell T, Nicolson D, Bailly N, Kirk PM, Bourgoin T, DeWalt RE, Decock W, De Wever A, Nieukerken E, Zarucchi J and Penev L (eds) (2017) *Species 2000 & ITIS catalogue of life*, Species 2000, Naturalis, Netherlands, accessed May 2017.

Seery C and Pradella N (2014) *Herbicide toxicity results: Isochrysis galbana bioassay and Lemna aequinoctilais bioassay*, Australian Catholic University report to Queensland Department of Environment and Science.

Sunderam RIM, Warne MStJ, Chapman JC, Pablo F, Hawkins J, Rose RM and Patra RW (2000) *The ANZECC/ARMCANZ water quality guideline database for toxicants*, supplied as CD-ROM in ANZECC/ARMCANZ Australian and New Zealand guidelines for fresh and marine water quality.

Taucare G, Bignert A, Kaserson S, Thai P, Mann RM, Gallen C and Mueller J (2022) 'Detecting long temporal trends of photosystem II herbicides (PSII) in the Great Barrier Reef lagoon', *Marine Pollution Bulletin*, 177:113490.

Turner R, Huggins R, Wallace R, Smith R, Vardy S and Warne MStJ (2012) *Sediment, nutrient and pesticide loads: Great Barrier Reef catchment loads monitoring 2009–2010* [website], Queensland Department of Science, Information Technology, Innovation and the Arts.

Turner RDR, Huggins R, Wallace R, Smith RA, Vardy S and Warne MStJ (2013) *Total suspended solids, nutrient and pesticide loads (2010–2011) for rivers that discharge to the Great Barrier Reef: Great Barrier Reef catchment loads monitoring 2010–2011* [website], Queensland Department of Science, Information Technology, Innovation and the Arts.

University of Hertfordshire (2013) *PPDB: The Pesticide Properties DataBase: Ametryn (Ref: G 34162)* [website], University of Hertfordshire, accessed May 2016.

USEPA (1987) *Health Advisory Summary: Ametryn* [website], United States Environmental Protection Agency, accessed May 2016.

USEPA (2013) *Preliminary problem formulation for the environmental fate, ecological risk, endangered species, and human health drink water exposure assessments in support of the registration review of ametryn* [website], Office of Pesticide Programs, United States Environmental Protection Agency, accessed May 2016.

USEPA (2015) *ECOTOX Knowledgebase* [website], United States Environmental Protection Agency, accessed May–September 2015.

Wallace R, Huggins R, King O, Gardiner R, Thomson B, Orr DN, Ferguson B, Taylor C, Severino Z, Smith RA, Warne MStJ, Turner RDR and Mann RM (2016) *Total suspended solids, nutrients and pesticide loads (2014–2015) for rivers that discharge to the Great Barrier Reef: Great Barrier Reef catchment loads monitoring program 2014–2015* [website], Queensland Department of Science, Information Technology, Innovation and the Arts.

Wallace R, Huggins R, Smith RA, Turner R, Garzon-Garcia A and Warne MStJ (2015) *Total suspended solids, nutrients and pesticide loads (2012–2013) for rivers that discharge to the Great Barrier Reef: Great Barrier Reef catchment loads monitoring program 2012–2013* [website], Queensland Department of Science, Information Technology, Innovation and the Arts.

Wallace R, Huggins R, Smith RA, Turner RDR, Vardy S and Warne MStJ (2014) *Total suspended solids, nutrient and pesticide loads (2011–2012) for rivers that discharge to the Great Barrier Reef: Great Barrier Reef catchment loads monitoring program 2011–2012* [website], Queensland Department of Science, Information Technology, Innovation and the Arts.

Warne MStJ, Batley GE, van Dam RA, Chapman JC, Fox DR, Hickey CW, and Stauber JL (2018) *Revised method for deriving Australian and New Zealand water quality guideline values for toxicants – update of 2015 version*, Australian and New Zealand governments and Australian state and territory governments.

Warne MStJ, Westbury A-M and Sunderam R (1998) 'A compilation of toxicity data for chemicals to Australasian aquatic species. Part 1: pesticides', *Australasian Journal of Ecotoxicology,* 4:93–144.

Wilkinson AD, Collier CJ, Flores F and Negri AP (2015) 'Acute and additive toxicity of ten photosystem-II herbicides to seagrass', *Scientific Reports*, 5:17443.

Wilkinson AD, Collier CJ, Flores F, Langlois L, Ralph PJ and Negri AP (2017) 'Combined effects of temperature and the herbicide diuron on Photosystem II activity of the tropical seagrass *Halophila ovalis*', *Scientific Reports*, 7(1):45404.

Wilson PC, Whitwell T and Klaine SJ (2000) 'Metalaxyl and simazine toxicity to and uptake by *Typha latifolia*', *Archives of Environmental Contamination and Toxicology,* 39:282–288.

WoRMS (2017) *World Register of Marine Species* [website], WoRMS Editorial Board, accessed May 2017.