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Spatial and temporal ecological risk assessment of unionized ammonia nitrogen in Tai Lake, China (2004–2015)

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ABSTRACT

Ammonia toxicity varies largely due to its pH- and temperature-dependent speciation (unionized ammonia nitrogen, NH_3-N). The seasonal and long-term trend of ammonia risk in ecologically significant sections of Tai Lake, China was unknown. In this study, a two-level (deterministic and quantitative) method was developed to assess the special ecological risks posed by NH_3-N at 37 sites during two seasons (February and September) of 2014 in Tai Lake. The long-term temporal (2004–2015) risk posed by NH_3-N was also assessed by comparing annual quantitative risk values (probability of exceeding acute or chronic threshold values) in three key sections of Tai Lake. The results indicated the species living in the Tai Lake were at a 0.04% and 32.45% chance of risk due to acute exposure, and a 1.97% and 92.05% chance of risk due to chronic exposure in February and September of 2014, respectively. Alarmingly, the chronic ecological risks of NH_3-N in the Lanshanzui section of the Tai Lake remained > 30% from 2004 to 2011. The chronic risk of NH_3-N in all three key sections of Tai Lake started to decrease in 2011. This was likely the consequence of the control practice of eutrophication implemented in the Tai Lake. A significant decline in diversity of the benthic invertebrate community of the Tai Lake could be associated with continuous exposure to ammonia over decades given different sensitivity of taxa to ammonia. The results laid a scientific foundation for risk assessment and management of ammonia in Tai Lake, China, and the developed two-level risk assessment approach can also be applied to other similar aquatic regions.

1. Introduction

Ammonia has attracted increasing attentions due to its exacerbation of lake eutrophication by misbalancing the nitrite-producing and nitrite-consuming processes (Chen et al., 2010). A number of chemicals of potential concern (COPCs) were evaluated for the impact on the aquatic community in the Keelung River in northern Taiwan, indicating that ammonia posed the greatest risk (Chen, 2005). Commonly, ammonia refers to the total ammonia nitrogen (TAN), which is composed of unionized ammonia nitrogen (NH_3-N) and ionized ammonia nitrogen ($NH_4{}^+$-N) (Constable et al., 2003). Proportions of these two species depend on pH and temperature (T), based on the Henderson-Hasselbach equation (USEPA, 2013) (Fig. S1). It has been shown that NH_3-N is more toxic than $NH_4{}^+$-N to aquatic species, especially for benthic invertebrates (USEPA, 2013). Mummert et al. (2003) assessed the sensitivities of two mussel species to both NH_3-N and TAN, suggesting NH_3-N as the limiting factor for the population growth of mussels, with the acute LC_{50} of 0.28 and 0.12 mg/L for wavy-rayed lamp mussels (*Lampsilis fasciola*) and rainbow mussels (*Villosa iris*), respectively. A study on the seasonal variations of ammonia toxicity showed an increasing toxicity of ammonia with increasing temperature in three common freshwater shredders (Arnaud et al.,

Abbreviations: TAN, total ammonia nitrogen; NH_3-N, unionized ammonia nitrogen; $NH_4{}^+$-N, ionized ammonia nitrogen; DO, Dissolved Oxygen; EU, European Union; OECD, Organization for Economic Co-operation and Development; EEC, Estimated Exposure Concentration; HQs, Hazard Quotients; GMAV, Genus Mean Acute Values; GMCV, Genus Mean Chronic Values; AIC, Akaike Information Criterion; HC_5,, Hazard Concentration for 5% species; IDW, Inverse Distance Weighted; PRAT, Probabilistic Risk Assessment Tool

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2013). Concentrations of NH_3-N were inversely proportional to concentrations of dissolved oxygen (DO), which led to significant alterations in the community of macrozoobenthos (Arauzo, 2003; Cosme et al., 2015). Changes in the communities of benthic invertebrates in lakes were recommended as indicators of adverse effects of NH_3-N (ANZECC and ARMCANZ, 2000).

In order to protect aquatic organisms and manage nutrients in freshwater bodies, several guideline values and risk assessments of ammonia were proposed (Chen, 2005; USEPA, 2013). The acute and chronic water quality criteria provided by the US Environmental Protection Agency (USEPA) are 81 and 17 mg TAN/L at pH 7.0 and 20 °C, which are equivalent to 9.1 and 1.9 µg/L of NH_3-N, respectively (USEPA, 2013). The Organization for Economic Cooperation and Development (OECD) suggests that the level of NH_3-N in waters for salmonid and cyprinids should be less than 25 µg NH_3-N/L, while the mandatory criterion for TAN is 1 mg/L (OECD, 1978). Concentrations of 15 and 1.5 µg NH_3-N/L at pH 7.0 and 25 °C are recommended as interim acute and chronic water quality guideline values, respectively (Wang and Leung, 2015). The criteria for human health risk assessment and ecological risk assessment are increasingly suggested as risk-based considering both degree and likelihood of exposure (USEPA, 2000; Crane and Babut, 2007).

Tai Lake, with the average depth of 1.95 m and surface area of 2338 km^2, situates at the center of Tai Lake basin. Along with the Tai Lake, located big cities such like Wuxi, Huzhou, Yixing that are well developed and densely-populated. Point (e.g. industrial effluent) and non-point (e.g. agricultural runoff) were consistently the major pollution sources in Tai Lake due to the frequent human activities. Tai Lake is located in the subtropical monsoon climate zone, the surface water temperature in Tai Lake varies from 1.7 to 3.9 °C in January to 27.4–28.6 °C in July (TBA, 2008). As the third largest lake in China, Tai Lake provides critical habitats for many ecologically and economically important aquatic species such as carp fish, white shrimp, etc, however, Tai Lake has been reported from moderate to hypereutrophic (TBA, 2014). The ecological risk posed by ammonia likely fluctuates in different seasons in Tai Lake. It is because the toxic potency of ammonia is pH- and temperature- dependent, Unfortunately, such seasonal variation of ammonia toxicity has often been ignored in the local management of ammonia in Tai Lake and other lakes in China. The urgency of ecological risk assessment on ammonia in Tai Lake is highlighted by the current decreasing diversity of benthic invertebrates in Tai Lake compared with that in 1980s (Chen et al., 2016). It is therefore, important to assess the long-term ecological risk posed by ammonia considering seasonal variation, and identify the possible driving stresses to the historical change of benthic invertebrates.

In this study, a two-level risk assessment was, for the first time, performed to assess the spatial risks posed by NH_3-N at 37 sites in Tai Lake, China in two seasons of 2014. The possible causal relationships among NH_3-N exposure and changes in benthic macroinvertebrates in the Tai Lake were further discussed by assessing the long-term temporal risks posed by NH_3-N at three key sections of Tai Lake from 2004 to 2015.

2. Methods

2.1. Sampling and water parameters monitoring

Water samples were collected using water sampler from 37 sites in the Tai Lake at a depth of 0.5 m (Fig. 1a) in February (dry season) and September (wet season) during 2014. Water quality parameters, including pH, T, Chlorophyll (Chl, µg/L), oxidation-reduction potential (ORP, mV), specific conductivity (SpCond, µS/cm), turbidity (Turb, NTU), unionized ammonia nitrogen (NH3-N, µg/L), nitrate-nitrogen (NO_3-N, mg/L), and dissolved oxygen (DO, mg/L) were measured with a portable Manta2 multi-parameter monitor (Eureka, Texas, USA). Concentrations of TAN in the water from the 37 sites were converted to NH_3-N using the Henderson-Hasselbach equation (Eq. (1)).

$$f_{NH3} = 1/(1 + 10^{pk-pH}), \quad (1)$$

where pH = -Log (H^+); pK = 0.09018 + 2729.92/(273.2 + T); T is temperature in °C. Values were provided in Table S1.

2.2. Spatial and temporal risk assessment on NH_3-N

2.2.1. Calculation of threshold values

Toxicity data of ammonia were derived from the U.S. EPA database (USEPA, 2013). Only data provided with pH and T were used (Tables S2 and S3). Genus mean, acute, or chronic values (GMAV or GMCV) were used to calculate the acute and chronic threshold values.

Data on toxic potencies were ranked in ascending order with rank *i* and given probabilities (Eq. (2)) to develop a species sensitivity distribution (SSD).

$$p = (i + c)/(N + 1 - 2c), \quad (2)$$

where N is the total number of toxicity data, and c was assigned with 0.5 (Posthuma et al., 2001). The ranked toxicity data were then fitted with three parametric regression models (i.e., Log-normal, Log-logistic and Weibull model). Goodness of fit for all models was tested with the Kolmogorov–Smirnov test (K-S test), and Akaike information criterion (AIC) values were also calculated. 5% Hazard concentrations (HC_5) were defined as the threshold, and 95% confidence intervals were also calculated. Fitting model with the maximum P value in the K-S test and relative low AIC value was given preference to be applied. The acute threshold value was obtained by dividing the acute HC_5 by a factor of 2, while the chronic HC_5 was used as the chronic threshold value (Shi et al., 2014; Wang and Leung, 2015).

2.2.2. Two-level spatial risk assessment on NH_3-N

A two-level assessment method was developed (Fig. 2). The screening-level assessment (deterministic) was used to determine potential risk scenarios based on hazard quotients (HQs). HQs equal to the conservative measured exposure concentrations (MEC) divided by threshold value. NH_3-N poses no significant risk to the environment if HQs are less than 1.0 (Constable et al., 2003). A probabilistic approach quantitative-level assessment was further conducted using the Probabilistic Risk Assessment Tool (PRAT) (Solomon et al., 2000; Brain et al., 2006). Compared with the conservative screening-level method, the probabilistic assessment integrates distributions of environmental exposure data and chemical effects data and quantitatively describes the occurrence probability of adverse effects (Jin et al., 2013). The two-level risk assessments were performed with exposure data for all 37 sites determined in February (dry season) and September (wet season) of 2014.

2.2.3. Long-term temporal risk assessment on NH_3-N

The long-term temporal risk posed by NH_3-N from 2004 to 2015 was assessed by comparing annual quantitative risk values (probability of exceeding acute or chronic threshold values) in three key sections of Tai Lake (i.e., Shazhu in the city of Wuxi, Jiangsu, Lanshanzui in Yixing, Jiangsu and Xishan in Suzhou, Jiangsu; Fig. 1b). The concentrations of ammonia were collected from the Ministry of Environmental Protection of the People's Republic of China Data Center (http://datacenter.mep.gov.cn/) (Table S4). Exposure data were transformed by use of pH and T then reported as NH_3-N (Chen et al., 2009). The probability risk of the NH_3-N was then calculated using the Probabilistic Risk Assessment Tool (PRAT) (Solomon et al., 2000; Brain et al., 2006) at three key monitoring locations in Tai Lake annually from 2004 to 2015.

2.3. Biodiversity of the benthic invertebrates of Tai Lake

The historical biodiversity data of the benthic invertebrates' species

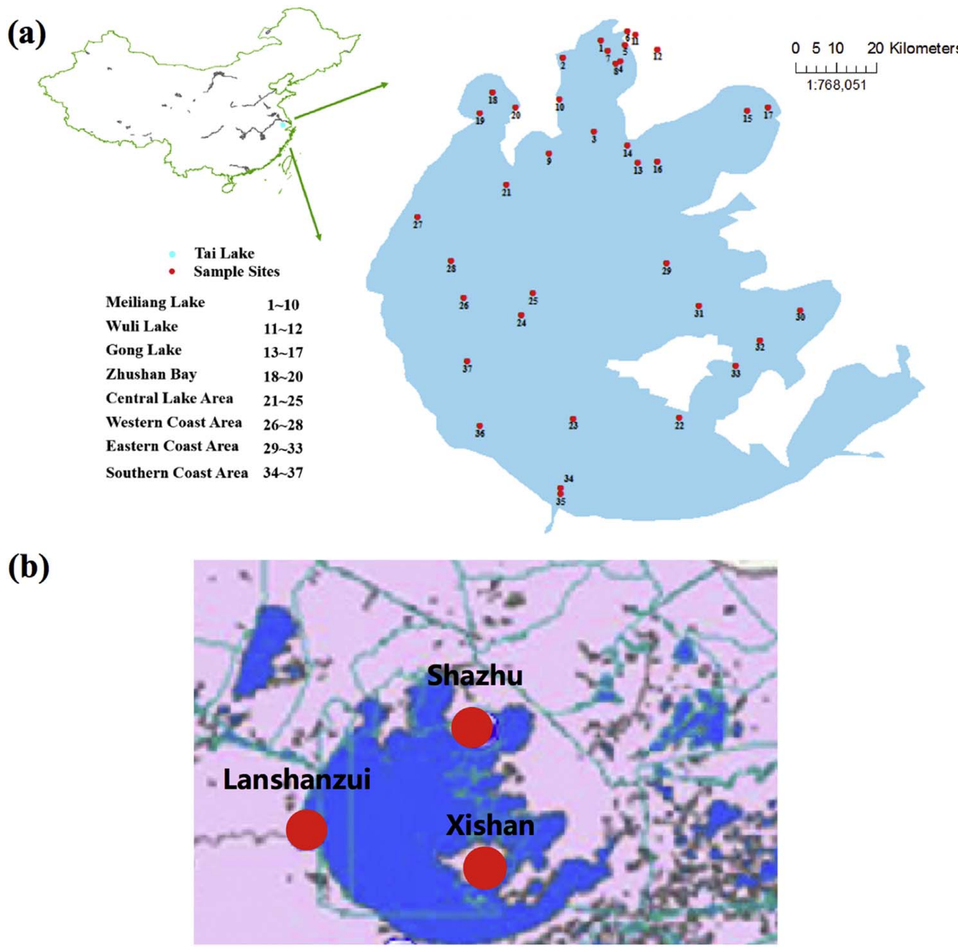

Fig. 1. (a) Geographical location of Tai Lake in China and the sampling sites in February and September of 2014 in Tai Lake, China; (b) three key monitoring sections (Shazhu in Wuxi, Jiangsu; Lanshanzui in Yixing, Jiangsu and Xishan in Suzhou, Jiangsu).

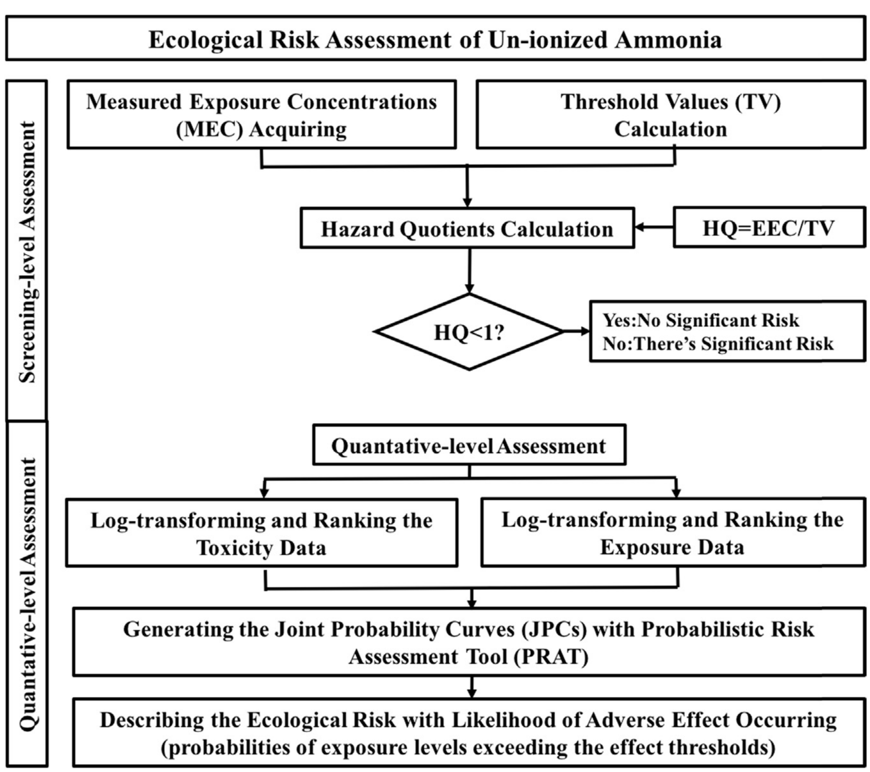

Fig. 2. Flow chart of ecological risk assessment on unionized ammonia nitrogen (NH_3-N).

Table 1
Number of taxa of benthic invertebrates identified in Tai Lake, China, in 1980 and 2008.

Phyla	1980	2008
Coelenterata	1	0
Aschelminthes	11	0
Annelida	7	14
Mollusca	24	12
Arthropoda	25	14
Total	68	40

in 1980 and 2008 were derived from open literature, CNKI China and Weipu (Chen and Liu, 2003; Cai et al., 2010), and are summarized in Table 1. In April and August of 2014, the benthic macroinvertebrates were sampled from 15 sites in the Tai Lake (marked with asterisks Table S1) by the Jiangsu Environmental Monitoring Center. The Shannon diversity index was calculated (Eq. (3)) to describe the diversity of benthic macroinvertebrates. In order to elucidate the possible effect of NH_3-N on benthic invertebrates' diversity, correlation analysis was performed between acute and chronic hazard quotients and the Shannon diversity index at seven sites.

$$H_2' = -\sum_{i=1}^{S} P_i \times \log_2 P_i, \tag{3}$$

where $P_i = n_i/N$; N is the total species individual number in the investigating community, n_i is the species individual number of species i, and S is the species number in the community (Sun and Liu, 2004).

2.4. Statistical analyses and map generation

All statistical calculations were performed with the statistical computing software R (R Development Core Team, http://www.rproject.org/) and Microsoft Excel (version 2013; Microsoft, Redmond, USA). Column analyses were applied to describe the selected water parameters in dry and wet seasons of 2014. A paired *t*-test was performed to test the differences of measured water parameters between the dry and wet seasons of 2014. The Shapiro–Wilk normality test was performed to examine normality of the exposure data. The Pearson correlation was used to examine relationships among different measured water parameters in each season of 2014. Statistical tests and column analyses were performed with GraphPad Prism (GraphPad Prism Development Core Team, http://www.graphpad.com/scientific-software/prism/). The Inverse Distance Weighting (IDW) method was used to describe the pH, T, NH_3-N, and Shannon diversity index of benthic macroinvertebrates. All maps were generated with ArcGIS (version 10.2; ESRI, Redlands, CA).

3. Results and discussion

3.1. Seasonal variations of water parameters and ammonia concentrations

Significant differences in physicochemical parameters were observed for water temperature, specific conductance (SpCond.), DO, and pH between February and September (Table S5). The pH values in September (26 out of the 37 sites) were greater than those in February with the greatest rise over 1 pH unit (Fig. S2a). This could increase the proportion of ammonia as NH_3-N by approximately nine-fold (USEPA, 2013). The mean increase of temperature at all sites was over 15 °C from February to September (Fig. S2b).

In February, the maximum concentration of NH_3-N was below 30 µg/L, while in September the mean concentration was over 100 µg/L at most sites (Table S1). The highest concentrations of NH_3-N were found in the Meiliang and Wuli Bays (Fig. S2c). In both seasons, the NH_3-N levels were significantly correlated with NO_3-N, DO, pH and T, with the correlation coefficients of 0.403, −0.476, −0.420 and

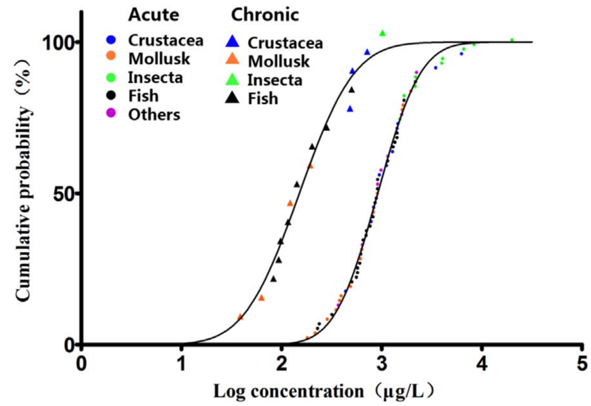

Fig. 3. Acute and chronic species sensitivity distribution (SSDs) of unionized ammonia nitrogen (NH_3-N) using Log-normal model. Acute and chronic sensitivities for different taxa were also shown in the curves.

0.611 in February, and −0.512, 0.871, −0.922 and 0.485 in September, respectively. The higher concentration of NH_3-N in September could result from greater ammonia input, changes in pH and T, or both. Results of previous investigations of Tai Lake have indicated that concentrations of major ions, such as HCO_3^- have changed over the last six decades (Yu et al., 2013). This might be due to frequent blooms of cyanobacteria (Yu et al., 2013). Higher water temperatures facilitate the growth of cyanobacteria (Foy et al., 1976), and higher consumption of CO_2 and adsorption of organic acids by algae can result in higher pH levels (Liu et al., 2005).

3.2. Calculation of threshold values

Sixty-five and 16 taxa of acute and chronic toxicity data were selected to calculate threshold values, respectively. The four most sensitive genera in acute tests were two freshwater mussels, *Lasmigona* and *Venustaconcha*, followed by *Prosopium* and *Salmo* fish. The four most sensitive taxa in chronic tests were the freshwater mussels, *Lampsilis* and *Villosa*, followed by the fish *Oncorhynchus* and *Esox*. The results suggested that benthic invertebrates are more sensitive to NH_3-N exposure (Fig. 3). The GMCV ranged from 38.7 µg NH_3-N/L for *Lampsilis* to 1016.7 µg NH_3-N/L for *Pteronarcella*.

There is no consensus on the choice of SSD models to derive the threshold values. The present study applied and compared three different models to derive SSDs (i.e., Log-logistic, Log-normal, and Weibull). AIC values were 62.37 (Log-logistic), 65.12 (Log-normal), and 78.34 (Weibull) for acute toxicity data, and 19.90 (Log-normal), 20.52 (Weibull), and 21.14 (Log-logistic) for chronic toxicity data, respectively (Fig. S3 and Table S6). The Log-normal model was selected to calculate the threshold values due to the relatively low AIC values (Table S6). Sensitivities of different taxa were also shown with symbols in different colors. Both the acute and chronic SSD curves indicated that mollusks were among the taxa sensitive to NH_3-N exposure. The calculated acute and chronic threshold values for protecting aquatic life were 118.0 and 45.9 µg NH_3-N/L, respectively (Table 2).

3.3. Spatial ecological risk assessment in 2014

The screening-level risk assessment is conservative and commonly used in Tier 1 risk assessments (Jin et al., 2012). This HQ-based approach has been widely used due to its simplicity and effectiveness (Jin et al., 2012). Hazard Quotients (HQs) for all the sites in February and September are provided in Fig. 4b. The mean acute and chronic HQs were 0.05 and 0.13 in February, indicating no significant risk of NH_3-N to aquatic organisms. In contrast, the mean acute and chronic HQs were 1.6 and 4.1 in September, indicating ecological risk of NH_3-N. In February, the highest HQs were observed along the western coast,

Table 2
Calculated HC_5, threshold values, HQs and probability.

HC_5 (μg/L)		Threshold (μg/L)		Months	HQs		Probability[a] (%)	
Acute	Chronic	Acute	Chronic		Acute	Chronic	Acute	Chronic
235.96	45.86	117.98	45.86	Feb.	0.05	0.13	0.01	1.97
				Sept.	1.58	4.05	32.45	92.05

[a] - Probabilities of concentrations of NH_3-N in Tai Lake, China exceeding both acute and chronic threshold values.

Zhushan Bay, and the southern coast, while in September the highest HQs were observed in the Wuli and Zhushan Bays and along the western coast. In the quantitative assessment, data for both toxic potencies and exposure were log-normally distributed. Graphical descriptions, including probability density curves and joint probability curves (JPC) of NH_3-N risk in Tai Lake are shown in Fig. 5a. Probabilities of NH_3-N concentrations exceeding both acute and chronic threshold values were less than 2.0% in February, but were 32.45% and 92.05%, respectively, in September (Table 2).

The two-level assessment suggested that the ecological risks to aquatic species in September were greater than those in February. The current sources of nutrients to Tai Lake are mostly non-point (Xia and Yang, 2003), but inputs of ammonia from agriculture were greater during the wet season (Hofmeier et al., 2015). Again, the higher T and pH could increase the fraction of NH_3-N. Therefore, in the wet season, the greater loading together with the higher fraction of NH_3-N could elevate ecological risks to the benthic invertebrates in Tai Lake.

3.4. Long-term temporal ecological risk assessment (2004–2015)

The probabilities of exceeding threshold values of NH_3-N at three key monitoring locations in Tai Lake from 2004 to 2015 are shown in Fig. 5b. In general, the probabilities of exceeding chronic threshold value were higher than those of acute threshold value. Among the three locations, Lanshanzui showed the highest probabilities, followed by Shazhu and Xishan. These results were consistent with previous studies showing that the western and northern coasts were more polluted than other regions of Tai Lake (Shen et al., 2000). Alarmingly, the chronic probabilities were over 30% from 2004 to 2011 at Lanshanzui in Yixing, with the maximum of 66.51% in 2011. Since 2011, the probabilities of exceeding threshold values of NH_3-N at all three key monitoring locations have largely decreased. This may be a consequence of the control practice of nutrient inputs implemented in the ninth five-year plan as well as the "Year 2010 program', which aimed to mitigate the pollution in Tai Lake (Jin and Hu, 2003; Lu et al., 2008).

3.5. Change of benthic macroinvertebrates' diversity

Sixty-eight species of benthic invertebrates were recorded in Tai Lake in 1980, belonging to five phyla, i.e., coelenterata, nematode, annelida, mollusca, and arthropoda (Chen and Liu, 2003). By 2008, the number of benthic invertebrate species had decreased to 40, belonging to three phyla, i.e., annelida, mollusca, and arthropoda (Table 1). The previously dominant benthic mollusca (i.e. *Corbicula fluminea*, *Viviparus quadratus,* and *Stenothyra glabra*) were replaced by the pollution-tolerant species *T. chinensis* and *L. hoffmeisteri*. During the same period, the concentrations of Chlorophyll *a* increased and reached its maximum in 2006, which suggested a possible association between the eutrophication and the decreased diversity of the benthic invertebrates in Tai Lake over the last two decades (Ye et al., 2011). Furthermore, the extrapolation of the Shannon diversity index of benthic invertebrates' diversity at 15 sites in Tai Lake in April and August 2014 are shown in Fig. 4a. A significant correlation was observed between Shannon diversity index and NH_3-N hazard quotients with correlation coefficient of −0.250 in April and −0.286 in August, suggesting the potential relationship between decreasing benthic diversity and increasing NH_3-

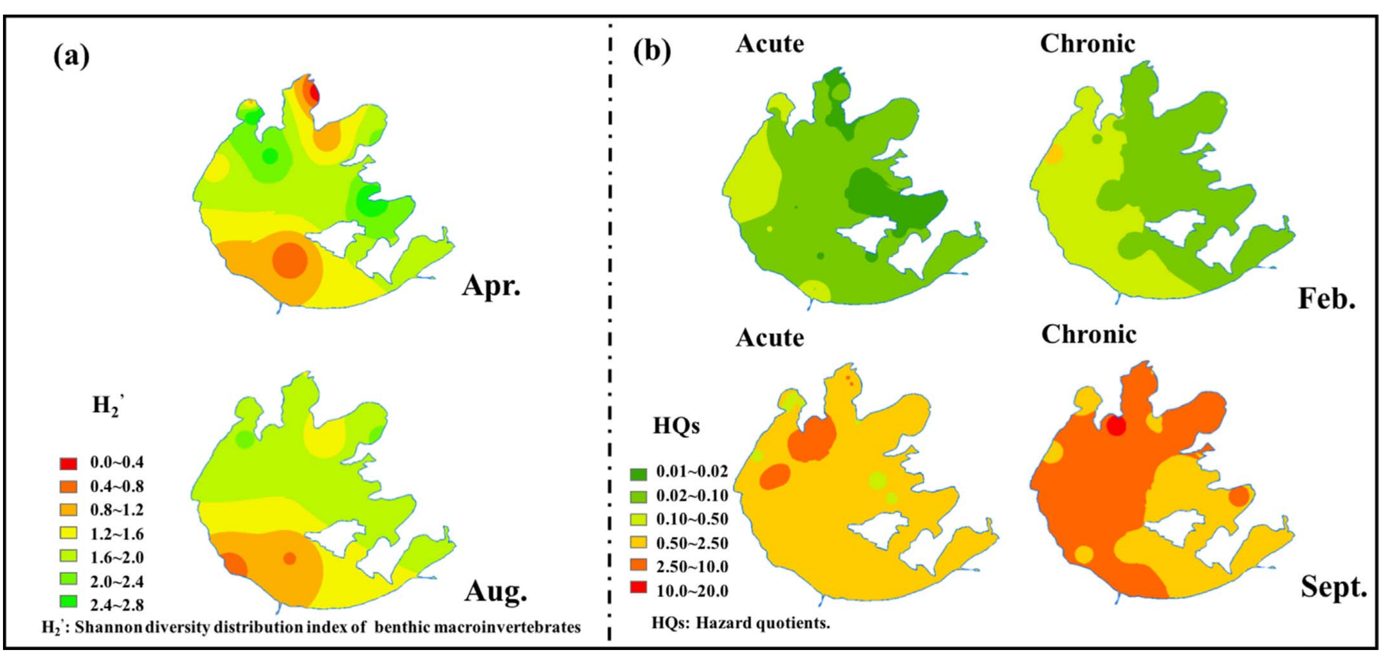

Fig. 4. (a) Shannon diversity index of benthic invertebrates in April and August of 2014. (b) Distribution of acute and chronic hazard quotients (HQs) of unionized ammonia nitrogen (NH_3-N) in February and September of 2014.

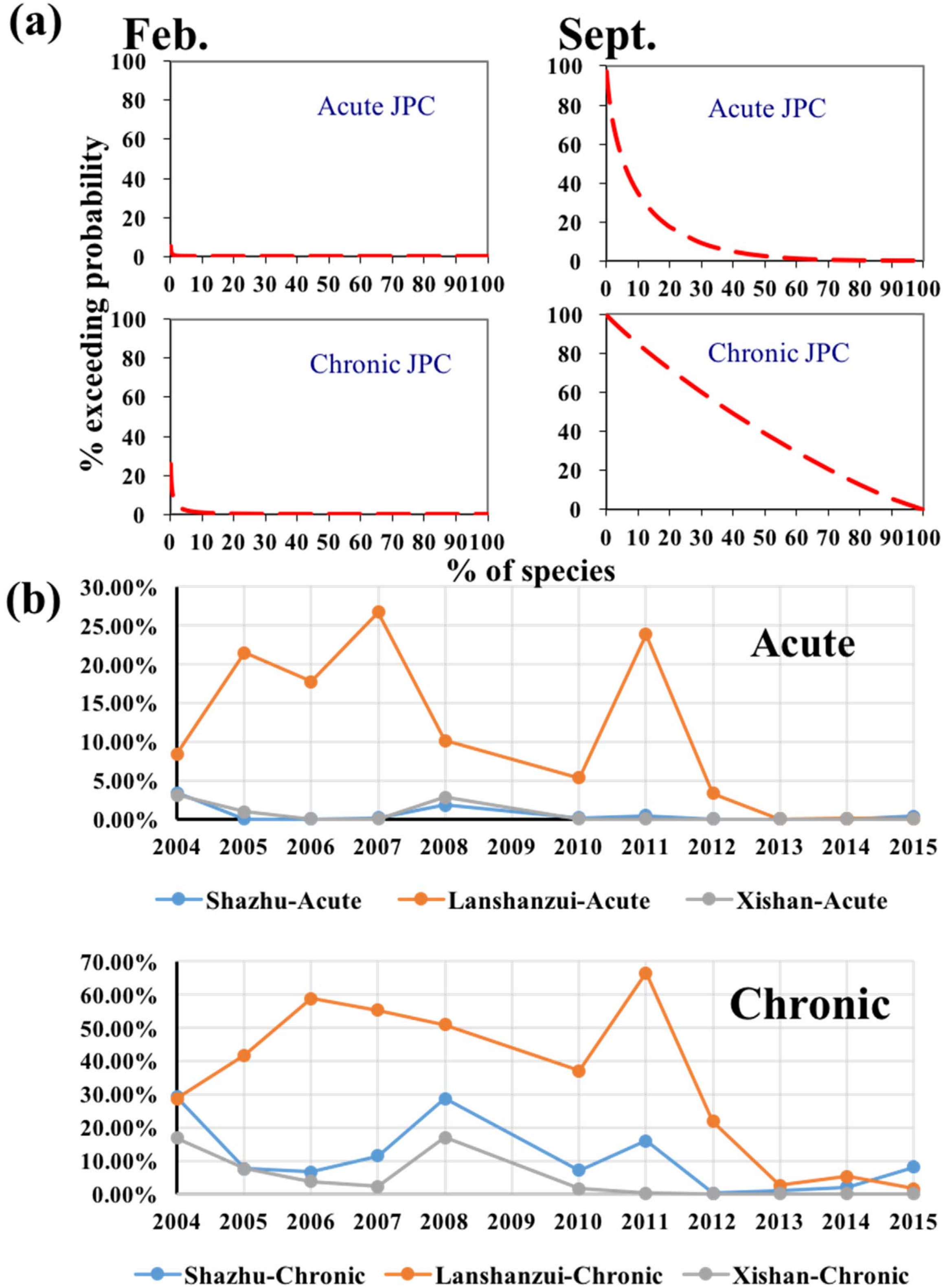

Fig. 5. (a) Acute and chronic joint probability curves for February and September 2014 in Tai Lake, China. Areas under the joint probability curves represent the probabilities of concentrations of unionized ammonia nitrogen (NH_3-N) in Tai Lake exceeding effect thresholds. (b) The probabilities of exceeding threshold of NH_3-N in three key monitoring sections (Shazhu in Wuxi, Lanshanzui in Yixing and Xishan in Suzhou, Jiangsu) of Tai Lake from 2004 to 2015.

N concentration. However, other major environmental pollutants (such as cyanobacteria and persistent organic pollutants) (Jin et al., 2003; Yu et al., 2013; Shi et al., 2014; Chen et al., 2016) in Tai Lake can not be ruled out, which deserves further investigations.

3.6. Uncertainties in ecological risk assessment

Uncertainties in ecological risk assessments may come from deficient knowledge, systematic errors in computational and analytical process, or nonsystematic errors, such as random errors, and some of these are inevitable (Solomon et al., 1996). In this study, uncertainties were reduced by considering both the wet and dry seasons, applying the best model to derive the threshold values, and applying probabilistic methods. Uncertainties in this study could also come from the use of various sources of toxicity data, limited chronic data, limited sampling time, and other confounding stressors, such as DO and T. Only three sites were assessed for long-term temporal risk due to limited data. More frequent biological and physicochemical monitoring is called in Tai Lake that polluted by ammonia and other pollutants in order to enhance the ecological risk assessment.

4. Conclusion

In summary, a two-level (deterministic and quantitative) ecological risk assessment method was developed in the present study to assess the seasonal and long-term trend of ammonia risk in ecologically significant sections of Tai Lake, China. The results indicated the species living in the Tai Lake were at a high chance of risk due to chronic unionized ammonia nitrogen exposure in both dry and wet seasons, especially the Lanshanzui section of the Tai Lake. A significant decline in diversity of the benthic invertebrate community of the Tai Lake could be associated with the increasing ammonia over decades. The results highlighted the urgency and importance of the implementation of appropriate risk assessment and management on ammonia in Tai Lake.

Acknowledgments

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.ecoenv.2017.02.050.

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Supplementary data

Spatial and temporal ecological risk assessment of unionized ammonia nitrogen in Tai Lake, China (2004-2015)

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Fig. S1. Ammonia as a function of pH and temperature (°C). Blue and green surfaces are proportions of NH_3-N (unionized ammonia nitrogen) and NH_4^+ -N (ionized ammonia nitrogen), respectively.

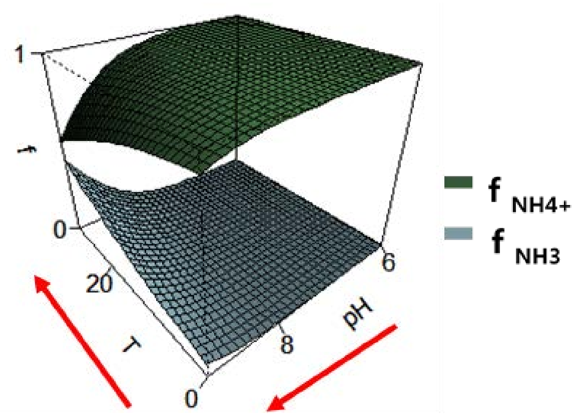
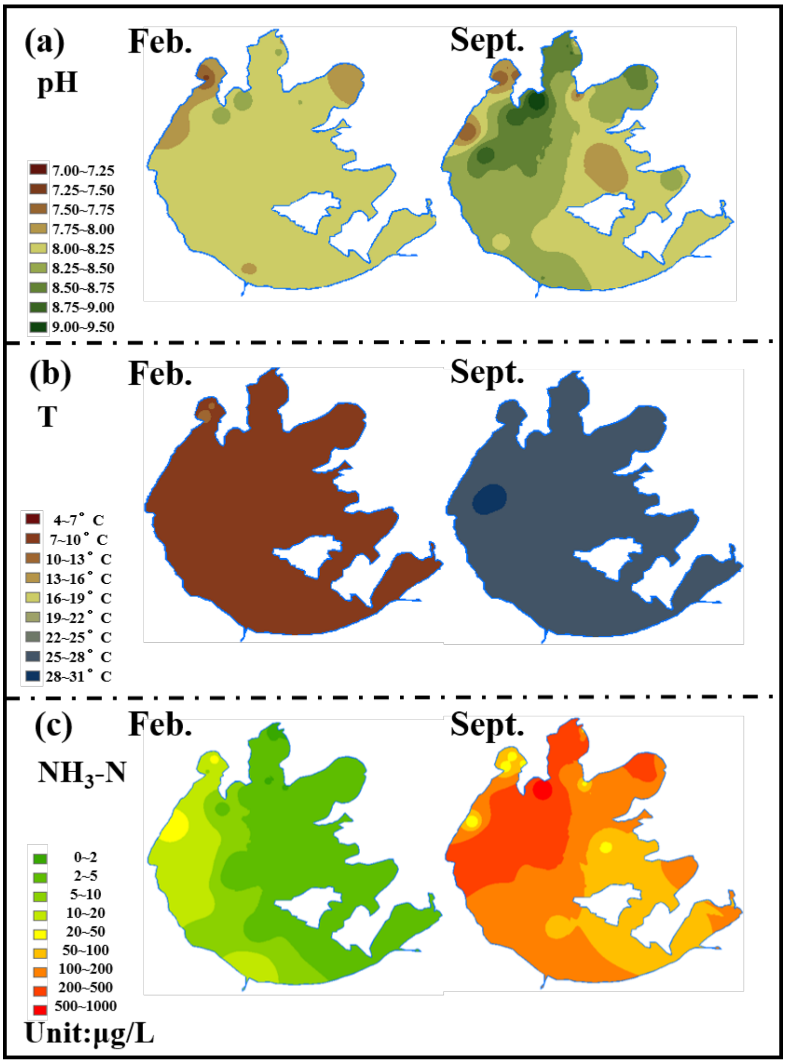


Fig. S23. The distribution of pH (a), surface temperature (b), and NH_3-N (c) in February and September of 2014 in Tai Lake, China



(a)
pH
Feb.
Sept.
7.00~7.25
7.25~7.50
7.50~7.75
7.75~8.00
8.00~8.25
8.25~8.50
8.50~8.75
8.75~9.00
9.00~9.50
(b)
T
Feb.
Sept.
4~7° C
7~10° C
10~13° C
13~16° C
16~19° C
19~22° C
22~25° C
25~28° C
28~31° C
(c)
NH3-N
Feb.
Sept.
0~2
2~5
5~10
10~20
20~50
50~100
100~200
200~500
500~1000
Unit:μg/L

Fig. S34. Acute and chronic SSDs of unionized ammonia nitrogen (NH3-N) with three3 parameter models. 95% confidence intervals are indicated by dotted lines

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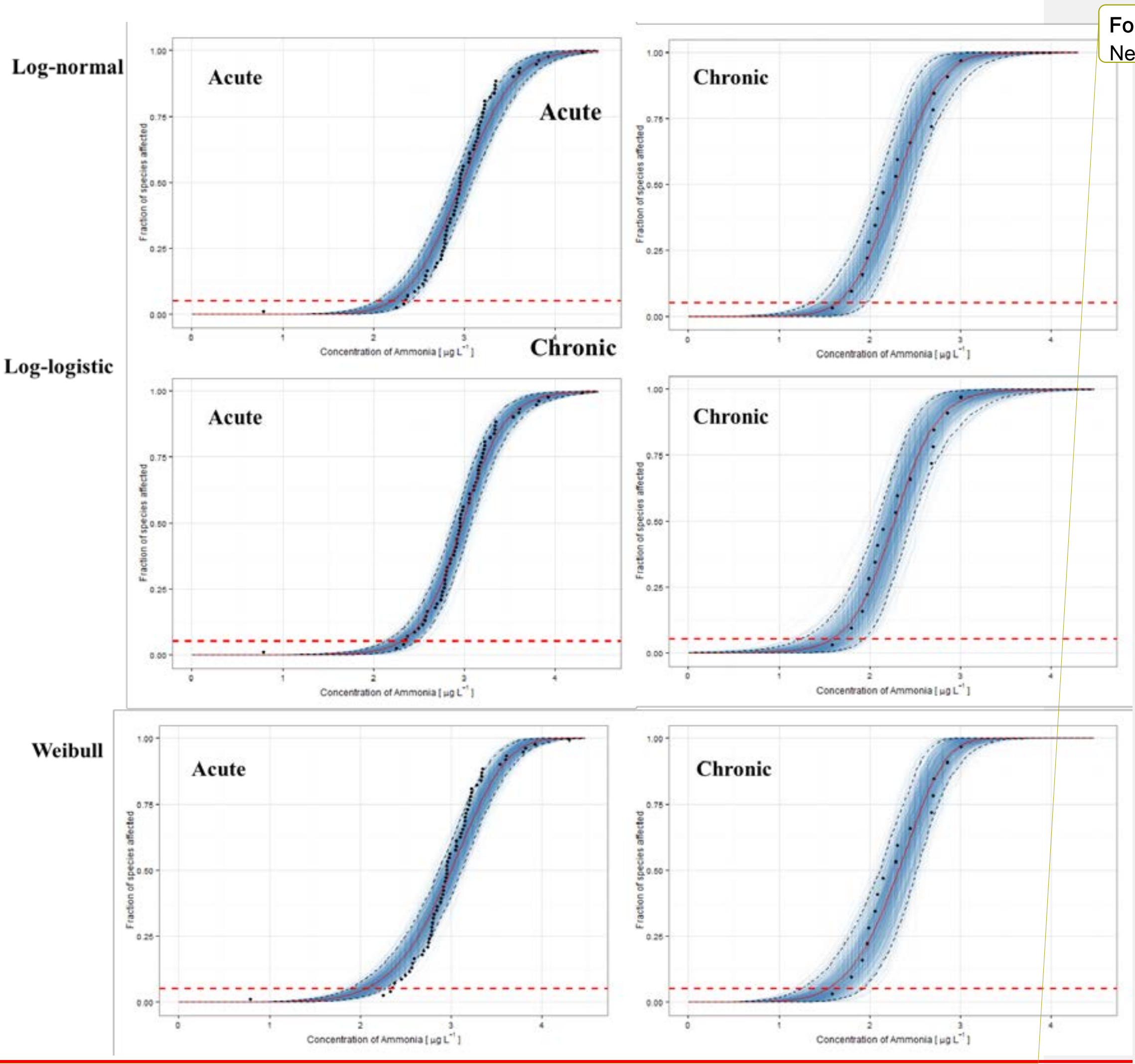

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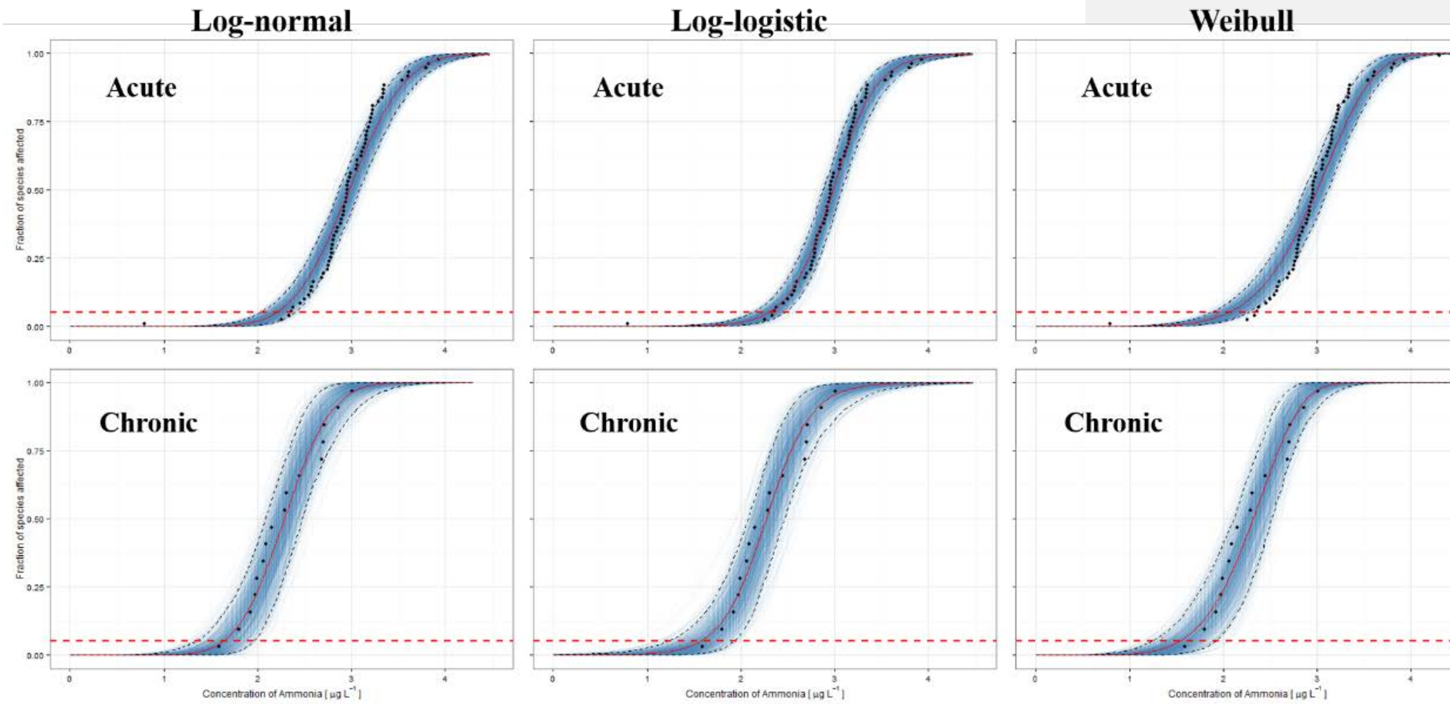

Log-normal
Log-logistic
Weibull
Acute
Acute
Acute
Chronic
Chronic
Chronic
Fraction of species affected
Concentration of Ammonia [μg L⁻¹]

Table S1. Physicochemical parameters of Tai Lake, China in February and September of 2014

Area	Sample number	Latitude (°)	Longitude (°)	Chl (μg/L)		ORP (mV)		SpCond (μS/cm)		Turb (NTU)		NO3-N (mg/L)		DO (mg/L)		pH		T (°C)		NH3-N (μg/L)	
				Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.	Feb.	Sept.
Meiliang Lake	1	31.525	120.184	22.72	25.79	233.50	175.23	613.23	470.00	25.55	34.29	2.88	2.09	10.46	7.94	8.03	8.65	8.74	26.13	1.78	222.86
	2	31.503	120.136	45.86	13.72	190.92	172.33	667.02	462.03	27.48	42.33	4.63	2.52	10.99	8.13	8.19	8.75	8.89	26.11	2.59	267.09
	3	31.411	120.174	10.15	11.66	220.36	185.55	396.94	452.21	28.15	104.29	3.93	2.07	10.68	7.54	8.04	8.34	8.48	25.98	1.80	126.69
	4*	31.499	120.208	23.37	16.27	196.00	284.73	676.84	469.50	10.15	40.01	4.13	2.17	11.47	7.59	8.26	8.25	7.71	26.06	2.74	122.48
	5	31.520	120.213	19.46	31.29	226.82	299.92	642.55	456.23	55.28	29.19	3.16	2.24	10.53	7.37	7.91	7.79	7.98	26.23	1.27	43.00
	6*	31.537	120.217	19.22	25.73	190.71	161.10	639.19	456.77	18.41	48.14	2.51	2.09	10.58	8.68	8.03	8.81	7.71	27.28	1.66	367.61
	7	31.512	120.191	24.97	21.77	177.55	214.46	640.92	477.93	207.87	53.32	2.39	1.92	10.54	8.64	8.05	8.77	8.23	27.16	1.77	323.67
	8	31.496	120.203	67.56	18.52	197.00	228.38	696.31	467.72	23.48	41.67	3.97	1.82	10.99	8.67	8.34	8.91	7.75	26.88	3.29	362.33
	9	31.384	120.119	40.42	23.97	161.08	146.17	465.08	430.08	45.07	107.74	3.57	2.11	11.21	11.49	8.38	9.46	9.34	27.76	4.08	773.03
	10	31.452	120.132	64.64	11.73	189.58	170.00	513.60	444.42	960.60	44.68	5.08	2.13	11.02	7.71	8.23	8.68	9.18	26.08	2.90	242.23
Wuli Lake	11*	31.533	120.226	7.62	19.44	185.30	157.55	460.83	385.04	18.75	51.78	0.80	1.41	10.81	10.14	8.08	8.75	8.89	27.17	1.61	260.77
	12*	31.514	120.254	7.22	39.07	188.77	161.18	468.38	389.29	29.41	36.95	1.04	1.55	10.71	11.29	8.09	8.97	9.21	27.64	2.09	402.51
Gong Lake	13	31.373	120.230	46.78	10.09	189.90	232.83	646.64	480.43	44.65	42.31	3.73	1.86	11.12	7.99	8.18	8.16	7.79	27.11	2.30	99.55
	14	31.395	120.216	20.88	11.94	214.00	279.82	396.00	488.75	40.88	54.39	4.14	2.06	11.18	7.49	8.08	7.70	8.39	26.50	1.93	38.39
	15	31.437	120.365	14.79	1.93	228.33	239.82	424.45	496.93	32.78	41.24	4.15	1.99	10.37	8.34	7.86	8.61	9.20	26.88	3.73	239.29
	16	31.375	120.254	65.02	13.78	208.73	247.31	663.28	460.59	41.65	38.57	3.70	1.86	11.06	8.59	8.26	8.38	7.93	27.69	2.79	162.06
	17	31.442	120.390	17.44	3.35	196.60	236.80	454.75	500.38	223.30	71.71	4.37	1.93	10.17	7.88	7.83	8.41	9.20	26.92	4.64	168.39
Zhushan Lake	18	31.461	120.049	19.96	32.17	171.67	184.18	775.66	415.13	22.50	29.11	8.96	3.75	9.36	7.47	7.77	7.75	10.04	26.28	22.51	34.93

	19	31.434	120.033	24.50	12.50	186.92	179.10	584.92	417.74	948.47	40.36	27.68	3.95	6.74	7.17	7.46	7.61	10.12	26.62	9.66	28.67
	20	31.441	120.077	51.68	44.67	189.00	194.00	733.00	438.53	24.01	32.97	8.85	5.03	10.40	7.15	7.94	7.54	9.97	26.59	17.95	22.14
Central Lake Area	21	31.346	120.066	54.98	22.95	181.22	162.70	625.89	435.75	122.09	188.73	3.83	2.90	10.63	9.90	8.33	8.90	8.93	26.95	3.55	363.65
	22	31.057	120.281	17.94	6.72	193.00	182.18	525.67	461.40	210.11	19.42	0.90	2.70	10.65	7.79	8.09	8.02	9.28	27.52	2.12	68.12
	23*	31.057	120.149	14.87	1.29	205.71	194.25	538.36	449.38	260.13	51.48	1.41	2.93	10.82	7.73	8.10	8.12	8.26	25.97	1.99	79.78
	24	31.184	120.085	17.23	11.12	180.00	181.91	588.91	429.81	78.37	31.88	2.71	2.27	10.65	8.00	8.15	8.37	8.35	26.68	2.26	175.03
	25*	31.212	120.099	10.12	3.02	180.22	177.27	580.13	467.50	77.61	41.02	2.23	1.96	10.46	8.14	8.21	8.54	8.76	26.64	2.66	204.56
Western Coast Area	26	31.206	120.013	17.85	8.45	187.18	175.83	661.23	427.09	97.45	21.96	3.19	2.33	10.45	8.36	8.11	8.47	8.79	27.81	14.12	239.34
	27	31.306	119.956	16.40	14.91	181.46	185.90	701.82	349.62	43.51	70.29	6.83	3.80	9.34	6.50	7.88	7.51	9.93	26.76	27.43	20.48
	28	31.252	119.997	16.23	15.68	209.70	163.83	588.79	465.77	509.93	89.60	5.32	2.05	10.63	9.64	8.09	8.98	9.04	29.27	18.23	453.25
Eastern Coast Area	29	31.249	120.265	32.22	6.24	219.00	191.27	537.96	501.61	42.19	75.35	2.94	3.21	10.75	7.51	8.14	7.85	8.52	26.39	2.22	43.74
	30	31.191	120.430	10.01	3.11	213.90	176.50	515.46	434.06	51.75	13.50	1.22	1.95	10.48	7.59	8.10	8.32	9.15	27.03	2.14	125.33
	31	31.196	120.305	19.47	13.45	206.60	205.67	522.14	506.13	53.76	85.80	1.89	3.40	10.96	7.58	8.16	7.93	8.33	26.64	2.33	54.95
	32	31.154	120.380	19.77	6.89	202.80	177.30	522.97	492.95	52.27	32.93	1.98	3.27	11.00	7.80	8.15	8.05	8.41	26.89	2.29	75.77
	33	31.122	120.351	11.30	4.99	201.50	178.64	511.99	490.96	108.05	21.81	1.06	3.20	10.75	7.78	8.13	8.10	8.99	27.49	2.28	82.95
Southern Coast Area	34*	30.971	120.133	13.10	16.40	220.67	174.09	315.54	458.29	66.73	34.05	5.55	3.20	9.72	8.08	7.93	8.40	8.86	27.32	11.48	146.07
	35	30.963	120.133	11.59	16.96	192.71	172.60	669.33	434.18	44.09	114.47	3.42	3.30	10.46	8.24	8.08	8.53	9.05	27.24	16.00	186.71
	36	31.048	120.034	24.52	19.94	196.50	191.77	483.38	448.32	28.03	48.73	6.13	3.46	9.95	7.93	8.09	8.22	9.65	25.96	8.68	99.99
	37	31.128	120.017	25.16	5.75	163.69	182.00	357.95	463.17	130.45	114.04	5.29	2.93	10.47	8.10	8.07	8.40	8.93	27.75	11.90	148.35

NOTE: Chl-Chlorophyll; ORP- Oxidation-Reduction Potential; SpCond-Specific Conductance; Turb-Turbidity; NO_3-N-Nitrate Nitrogen; DO-Dissolved Oxygen; T-Temperature; NH3-N: unionized ammonia nitrogen. Sample sites marked with asterisks contained benthic invertebrates' information.

~~**Table S2.** Coordinates of sampling sites and measured values of pH, T and NH_3-N in Tai Lake in February and September of 2014.~~

Table ~~S3~~S2. Acute toxicity data of ammonia (before and after conversion) applied in this study

Species	Genus	Duration	Method	pH	Temp. (℃)	Total Ammonia (mgTAN/L)	NH_3-N (mg/L)	SMAV (mg/L)	GMAV (mg/L)	Reference
Erythromma najas	*Erythromma*	4 d	R,U	7.5	25	589.00	10.41	19.976	19.976	Beketov 2002
Erythromma najas	*Erythromma*	4 d	R,U	8.7	25	168.00	37.28			Beketov 2002
Erythromma najas	*Erythromma*	4 d	R,U	9.1	25	49.20	20.54			Beketov 2002
Philarctus quaeris	*Philarctus*	4 d	F,M	7.8	21.9	296.50	8.29	8.346	8.346	Arthur et al. 1987
Philarctus quaeris	*Philarctus*	4 d	F,M	7.8	13.3	561.70	8.40			West 1985; Arthur et al. 1987
Stenelmis sexlineata	*Stenelmis*	4 d	F,M	8.7	25	29.70	6.59	6.591	6.591	Hazel et al. 1979
Orconectes immunis	*Orconectes*	4 d	F,M	7.9	17.1	488.10	12.12	15.101	6.258	Arthur et al. 1987
Orconectes immunis	*Orconectes*	4 d	F,M	8.2	4.6	999.40	18.81			West 1985; Arthur et al. 1987
Orconectes nais	*Orconectes*	4 d	F,M	8.3	26.5	23.15	2.59	2.594		Evans 1979
Chironomus riparius	*Chironomus*	4 d	R,M	7.7	21.7	357.70	7.88	7.881	4.044	Monda et al. 1995
Chironomus tentans	*Chironomus*	4 d	S,M	6.69	23	430.00	1.04	2.076		Besser et al. 1998
Chironomus tentans	*Chironomus*	4 d	S,M	7.56	23	564.00	9.93			Besser et al. 1998
Chironomus tentans	*Chironomus*	4 d	F,M	6.5	25	371.00	0.67			Schubauer-Berigan et al. 1995
Chironomus tentans	*Chironomus*	4 d	F,M	8.1	25	78.10	5.22			Schubauer-Berigan et al. 1995
Chironomus tentans	*Chironomus*	4 d	F,M	6.5	25	368.00	0.66			Schubauer-Berigan et al. 1995

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Chironomus tentans	*Chironomus*	4 d	F,M	8.1	25	50.50	3.38			Schubauer-Berigan et al. 1995
Drunella grandis	*Drunella*	4 d	F,M	7.84	12.8	259.10	4.09			Thurston et al. 1984b
Drunella grandis	*Drunella*	4 d	F,M	7.84	13.2	195.60	3.18	3.976	3.976	Thurston et al. 1984b
Drunella grandis	*Drunella*	4 d	F,M	7.85	12	319.00	4.84			Thurston et al. 1984b
Caecidotea racovitzai	*Caecidotea*	4 d	F,M	7.8	22	148.80	4.19			Arthur et al. 1987
Caecidotea racovitzai	*Caecidotea*	4 d	F,M	8	4	357.80	4.08	3.458	3.458	West 1985; Arthur et al. 1987
Caecidotea racovitzai	*Caecidotea*	4 d	F,M	7.81	11.9	176.00	2.42			Thurston et al. 1983
Asellus aquaticus	*Asellus*	4 d	F,M	7.05	12	878.70~~2.60~~	2.14~~0.01~~			Dehedin et al. 2012
Asellus aquaticus	*Asellus*	4 d	F,M	7.05	12	321.06~~1.25~~	0.78~~0.00~~			Dehedin et al. 2012
Asellus aquaticus	*Asellus*	4 d	F,M	7.05	12	229.81~~1.70~~	0.56~~0.00~~			Dehedin et al. 2012
Asellus aquaticus	*Asellus*	4 d	F,M	7.05	18	560.91~~2.61~~	2.15~~0.01~~			Dehedin et al. 2012
Asellus aquaticus	*Asellus*	4 d	F,M	7.05	18	60.17~~1.40~~	0.23~~0.01~~	0.436~~006~~	0.436~~006~~	Dehedin et al. 2012
Asellus aquaticus	*Asellus*	4 d	F,M	7.05	18	34.39~~1.95~~	0.13~~0.01~~			Dehedin et al. 2012
Asellus aquaticus	*Asellus*	4 d	F,M	7.05	24	144.85~~1.00~~	0.86~~0.01~~			Dehedin et al. 2012
Asellus aquaticus	*Asellus*	4 d	F,M	7.05	24	22.29~~1.00~~	0.13~~0.01~~			Dehedin et al. 2012
Asellus aquaticus	*Asellus*	4 d	F,M	7.05	24	13.93~~2.00~~	0.08~~.01~~			Dehedin et al. 2012
Gasterosteus aculeatus	*Gasterosteus*	4 d	S,M	7.1	23.3	198.10	1.25	1.633	1.633	Hazel et al. 1971

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Gasterosteus aculeatus	*Gasterosteus*	4 d	S,M	7.15	15	577.00	2.22			Hazel et al. 1971
Gasterosteus aculeatus	*Gasterosteus*	4 d	S,M	7.25	23.3	203.80	1.81			Hazel et al. 1971
Gasterosteus aculeatus	*Gasterosteus*	4 d	S,M	7.5	15	143.90	1.24			Hazel et al. 1971
Gasterosteus aculeatus	*Gasterosteus*	4 d	S,M	7.5	23.3	78.70	1.24			Hazel et al. 1971
Gasterosteus aculeatus	*Gasterosteus*	4 d	S,M	7.5	23.3	115.40	1.81			Hazel et al. 1971
Gasterosteus aculeatus	*Gasterosteus*	4 d	S,M	7.5	15	259.00	2.22			Hazel et al. 1971
Callibaetis skokianus	*Callibaetis*	4 d	F,M	7.7	10.8	263.50	2.59	3.209	2.181	Arthur et al. 1987
Callibaetis skokianus	*Callibaetis*	4 d	F,M	7.9	13.3	211.70	3.97			West 1985; Arthur et al. 1987
Callibaetis sp.	*Callibaetis*	4 d	F,M	7.81	11.9	107.80	1.48	1.483		Thurston et al. 1984b
Pachydiplax longipennis	*Pachydiplax*	4 d	F,M	8	12	76.92	1.64	2.158	2.158	Diamond et al. 1993
Pachydiplax longipennis	*Pachydiplax*	4 d	F,M	8	20	74.37	2.84			Diamond et al. 1993
Cottus bairdii	*Cottus*	4 d	F,M	8.02	12.4	49.83	1.14	1.145	1.145	Thurston and Russo 1981
Gambusia affinis	*Gambusia*	4 d	S,U	7.75	19	129.60	2.64	2.167	2.167	Wallen et al. 1957
Gambusia affinis	*Gambusia*	4 d	S,U	8.2	19.5	34.54	1.98			Wallen et al. 1957
Gambusia affinis	*Gambusia*	4 d	S,U	8.5	23	14.64	1.98			Wallen et al. 1957
Gambusia affinis	*Gambusia*	4 d	S,U	8	24	42.53	2.14			Wallen et al. 1957
Lumbriculus variegatus	*Lumbriculus*	4 d	S,M	7.56	23	286.00	5.03	0.983	0.983	Besser et al. 1998
Lumbriculus variegatus	*Lumbriculus*	4 d	S,M	6.69	23	302.00	0.73			Besser et al. 1998
Lumbriculus variegatus	*Lumbriculus*	4 d	R,M	8.2	15	13.66	0.57			Hickey and Vickers 1994
Lumbriculus variegatus	*Lumbriculus*	4 d	F,M	6.5	25	100.00	0.18			Schubauer-Berigan et al. 1995
Lumbriculus variegatus	*Lumbriculus*	4 d	F,M	6.5	25	200.00	0.36			Schubauer-Berigan et al. 1995
Lumbriculus variegatus	*Lumbriculus*	4 d	F,M	8.1	25	34.00	2.27			Schubauer-Berigan et al. 1995
Lumbriculus variegatus	*Lumbriculus*	4 d	F,M	8.1	25	43.50	2.91			Schubauer-Berigan et al. 1995
Tubifex tubifex	*Tubifex*	4 d	S,U	8.2	12	66.67	2.22	2.224	2.224	Stammer 1953
Planorbella trivolvis	*Planorbella*	4 d	F,M	7.9	22	47.73	1.68	1.954	1.954	Arthur et al. 1987

Planorbella trivolvis	*Planorbella*	4 d	F,M	8.2	12.9	63.73	2.27			Arthur et al. 1987
Hyalella azteca	*Hyalella*	4 d	R,M	8.3	25	39.80	4.06	0.782	0.782	Ankley et al. 1995
Hyalella azteca	*Hyalella*	4 d	R,M	7.31	25	64.00	0.74			Ankley et al. 1995
Hyalella azteca	*Hyalella*	4 d	R,M	6.43	25	105.00	0.16			Ankley et al. 1995
Skwala americana	*Skwala*	4 d	F,M	7.81	13.1	109.30	1.65	1.671	1.671	Thurston et al. 1984b
Skwala americana	*Skwala*	4 d	F,M	7.76	13.8	119.60	1.70			Thurston et al. 1984b
Oreochromis mossambicus	*Oreochromis*	4 d	R,U	7.2	28	151.50	1.67	1.667	1.667	Rani et al. 1998
Crangonyx pseudogracilis	*Crangonyx*	4 d	S,U	7.5	12	43.36	0.30	1.794	1.424	Prenter et al. 2004
Crangonyx pseudogracilis	*Crangonyx*	4 d	F,M	8	4	199.50	2.27			West 1985; Arthur et al. 1987
Crangonyx pseudogracilis	*Crangonyx*	4 d	F,M	8	12.1	216.00	4.64			West 1985; Arthur et al. 1987
Crangonyx pseudogracilis	*Crangonyx*	4 d	F,M	8	13.3	115.30	2.71			West 1985; Arthur et al. 1987
Crangonyx pseudogracilis	*Crangonyx*	4 d	F,M	8	24.9	25.10	1.34			West 1985; Arthur et al. 1987
Crangonyx pseudogracilis	*Crangonyx*	4 d	F,M	8.2	13	81.60	2.93			West 1985; Arthur et al. 1987
Crangonyx sp.	*Crangonyx*	4 d	F,M	8	12	79.23	1.69	1.131		Diamond et al. 1993
Crangonyx sp.	*Crangonyx*	4 d	F,M	8	20	19.83	0.76			Diamond et al. 1993
Limnodrilus hoffmeisteri	*Limnodrilus*	4 d	F,M	7.9	11.5	96.62	1.58	1.581	1.581	Williams et al. 1986
Physa gyrina	*Physa*	4 d	F,M	8	4	114.90	1.31	1.603	1.603	West 1985; Arthur et al. 1987
Physa gyrina	*Physa*	4 d	F,M	8.2	5.5	85.13	1.72			West 1985; Arthur et al. 1987
Physa gyrina	*Physa*	4 d	F,M	8.1	12.1	76.29	2.05			West 1985; Arthur et al. 1987
Physa gyrina	*Physa*	4 d	F,M	8.2	12.8	50.25	1.78			West 1985; Arthur et al. 1987
Physa gyrina	*Physa*	4 d	F,M	8	13.3	62.39	1.47			West 1985; Arthur et al. 1987
Physa gyrina	*Physa*	4 d	F,M	8	24.9	26.33	1.41			West 1985; Arthur et al. 1987
Enallagma sp.	*Enallagma*	4 d	F,M	7.9	11.5	93.10	1.52	1.524	1.524	Williams et al. 1986
Chydorus sphaericus	*Chydorus*	4 d	S,M	8	20	37.88	1.45	1.447	1.447	Dekker et al. 2006
Pimephales promelas	*Pimephales*	4 d	S,U	7.6	20	37.56	0.58	0.881	0.881	Markle et al. 2000

Pimephales promelas	*Pimephales*	4 d	S,M	7.52	20.25	36.73	0.49			EA Engineering 1985
Pimephales promelas	*Pimephales*	4 d	S,M	7.48	19.85	40.93	0.48			EA Engineering 1985
Pimephales promelas	*Pimephales*	4 d	S,M	7.52	20.25	37.49	0.50			EA Engineering 1985
Pimephales promelas	*Pimephales*	4 d	S,M	7.48	19.85	41.79	0.49			EA Engineering 1985
Pimephales promelas	*Pimephales*	4 d	S,M	7.48	19.85	43.49	0.51			EA Engineering 1985
Pimephales promelas	*Pimephales*	4 d	R,M	8.01	25	14.40	0.79			Buhl 2002
Pimephales promelas	*Pimephales*	4 d	R,M	8	20	5.39	0.21			Diamond et al. 1993
Pimephales promelas	*Pimephales*	4 d	R,M	8	20	6.10	0.23			Diamond et al. 1993
Pimephales promelas	*Pimephales*	4 d	F,M	7.9	3.4	229.70	1.98			West 1985; Arthur et al. 1987
Pimephales promelas	*Pimephales*	4 d	F,M	8.1	12.1	56.07	1.51			West 1985; Arthur et al. 1987
Pimephales promelas	*Pimephales*	4 d	F,M	8	17.1	52.22	1.62			West 1985; Arthur et al. 1987
Pimephales promelas	*Pimephales*	4 d	F,M	8.1	26.1	29.23	2.10			West 1985; Arthur et al. 1987
Pimephales promelas	*Pimephales*	4 d	F,M	8.05	14	47.29	1.31			DeGraeve et al. 1980
Pimephales promelas	*Pimephales*	4 d	F,M	7.46	6	97.27	0.38			DeGraeve et al. 1987
Pimephales promelas	*Pimephales*	4 d	F,M	7.46	10	101.70	0.54			DeGraeve et al. 1987
Pimephales promelas	*Pimephales*	4 d	F,M	7.41	15	76.58	0.54			DeGraeve et al. 1987
Pimephales promelas	*Pimephales*	4 d	F,M	7.41	20	78.22	0.79			DeGraeve et al. 1987
Pimephales promelas	*Pimephales*	4 d	F,M	7.45	20	66.94	0.74			DeGraeve et al. 1987
Pimephales promelas	*Pimephales*	4 d	F,M	7.4	25	81.81	1.15			DeGraeve et al. 1987
Pimephales promelas	*Pimephales*	4 d	F,M	7.41	25	91.40	1.32			DeGraeve et al. 1987
Pimephales promelas	*Pimephales*	4 d	F,M	7.44	30	64.12	1.39			DeGraeve et al. 1987
Pimephales promelas	*Pimephales*	4 d	F,M	8.14	22	25.16	1.50			Mayes et al. 1986
Pimephales promelas	*Pimephales*	4 d	F,M	7.9	20.6	28.90	0.92			Nimmo et al. 1989
Pimephales promelas	*Pimephales*	4 d	F,M	8.2	6.2	7.32	0.16			Nimmo et al. 1989
Pimephales promelas	*Pimephales*	4 d	F,M	7.8	20.1	18.73	0.46			Nimmo et al. 1989

Pimephales promelas	*Pimephales*	4 d	F,M	7.8	19.8	32.12	0.77			Nimmo et al. 1989
Pimephales promelas	*Pimephales*	4 d	F,M	8.1	19.6	24.89	1.15			Nimmo et al. 1989
Pimephales promelas	*Pimephales*	4 d	F,M	8.2	6.2	11.56	0.25			Nimmo et al. 1989
Pimephales promelas	*Pimephales*	4 d	F,M	8.1	5.8	19.94	0.33			Nimmo et al. 1989
Pimephales promelas	*Pimephales*	4 d	F,M	8.1	5.8	21.44	0.35			Nimmo et al. 1989
Pimephales promelas	*Pimephales*	4 d	F,M	7.7	20.1	32.25	0.63			Nimmo et al. 1989
Pimephales promelas	*Pimephales*	4 d	F,M	8.46	4.1	18.54	0.60			Reinbold and Pescitelli 1982b
Pimephales promelas	*Pimephales*	4 d	F,M	8.02	23.9	19.55	1.02			Reinbold and Pescitelli 1982b
Pimephales promelas	*Pimephales*	4 d	F,M	8.26	4.6	30.57	0.66			Reinbold and Pescitelli 1982b
Pimephales promelas	*Pimephales*	4 d	F,M	8.16	25.2	17.65	1.36			Reinbold and Pescitelli 1982b
Pimephales promelas	*Pimephales*	4 d	F,M	7.7	21.65	63.02	1.38			Sparks 1975
Pimephales promelas	*Pimephales*	4 d	F,M	7.78	25.9	40.85	1.44			Swigert and Spacie 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.8	25.6	42.65	1.54			Swigert and Spacie 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.83	11.8	45.71	0.65			Thurston et al. 1981c
Pimephales promelas	*Pimephales*	4 d	F,M	7.82	12	62.72	0.89			Thurston et al. 1981c
Pimephales promelas	*Pimephales*	4 d	F,M	6.51	13	260.00	0.20			Thurston et al. 1981c
Pimephales promelas	*Pimephales*	4 d	F,M	9.03	13.2	5.94	1.21			Thurston et al. 1981c
Pimephales promelas	*Pimephales*	4 d	F,M	8.51	13.5	18.88	1.38			Thurston et al. 1981c
Pimephales promelas	*Pimephales*	4 d	F,M	7.01	13.8	145.90	0.37			Thurston et al. 1981c
Pimephales promelas	*Pimephales*	4 d	F,M	7.91	16.3	51.55	1.24			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.89	13.1	50.20	0.91			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.64	13.6	58.40	0.62			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.68	13.5	64.70	0.75			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	8.03	22.1	47.60	2.25			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	8.06	22	42.60	2.13			Thurston et al. 1983

Pimephales promelas	*Pimephales*	4 d	F,M	7.67	13.9	58.80	0.68			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	8.05	13	74.65	1.92			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	8.05	13.6	66.48	1.79			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.94	19.1	42.30	1.33			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.76	19	50.28	1.05			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.66	13.4	58.20	0.64			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.87	15.8	58.91	1.24			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.83	22	50.60	1.52			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.91	18.9	49.30	1.43			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.77	14.3	66.70	1.00			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.77	14.1	72.71	1.08			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	8.04	22.4	36.59	1.80			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	8.08	21.4	44.80	2.25			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	8.16	21.4	47.39	2.83			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.88	21.7	50.90	1.68			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.68	12.9	91.80	1.01			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.63	13.2	89.85	0.91			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.76	12.9	107.50	1.42			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.84	21.7	55.43	1.67			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.76	13.1	66.73	0.90			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.74	12.8	52.20	0.66			Thurston et al. 1983
Pimephales promelas	*Pimephales*	4 d	F,M	7.91	15.9	47.43	1.10			Thurston et al. 1983
Salvelinus fontinalis	*Salvelinus*	4 d	F,U	7.86	13.6	45.21	0.79	0.828		Thurston and Meyn 1984
Salvelinus fontinalis	*Salvelinus*	4 d	F,U	7.83	13.8	52.03	0.86		0.603	Thurston and Meyn 1984
Salvelinus namaycush	*Salvelinus*	4 d	S,M	7.45	8.5	90.43	0.42	0.439		Soderberg and Meade 1992

Salvelinus namaycush	*Salvelinus*	4 d	S,M	7.45	8.5	110.20	0.51			Soderberg and Meade 1992
Salvelinus namaycush	*Salvelinus*	4 d	S,M	7.45	8.5	96.25	0.45			Soderberg and Meade 1992
Salvelinus namaycush	*Salvelinus*	4 d	S,M	7.45	8.5	83.11	0.39			Soderberg and Meade 1992
Acipenser brevirostrum	*Acipenser*	4 d	S,M	7.05	18	149.80	0.57	0.574	0.574	Fontenot et al. 1998
Catostomus commersonii	*Catostomus*	4 d	F,M	7.8	3.6	89.57	0.63			West 1985; Arthur et al. 1987
Catostomus commersonii	*Catostomus*	4 d	F,M	8.1	11.3	60.86	1.54			West 1985; Arthur et al. 1987
Catostomus commersonii	*Catostomus*	4 d	F,M	8.2	12.6	40.85	1.42			West 1985; Arthur et al. 1987
Catostomus commersonii	*Catostomus*	4 d	F,M	8.2	15.3	43.01	1.83			West 1985; Arthur et al. 1987
Catostomus commersonii	*Catostomus*	4 d	F,M	7.8	20.2	31.21	0.77	0.970		Nimmo et al. 1989
Catostomus commersonii	*Catostomus*	4 d	F,M	7.8	20.2	18.93	0.47		0.763	Nimmo et al. 1989
Catostomus commersonii	*Catostomus*	4 d	F,M	8.16	15	30.28	1.15			Reinbold and Pescitelli 1982c
Catostomus commersonii	*Catostomus*	4 d	F,M	8.14	15.4	29.65	1.11			Reinbold and Pescitelli 1982c
Catostomus commersonii	*Catostomus*	4 d	F,M	7.8	22.5	22.30	0.65			Swigert and Spacie 1983
Catostomus platyrhynchus	*Catostomus*	4 d	F,U	7.67	12	66.91	0.67			Thurston and Meyn 1984
Catostomus platyrhynchus	*Catostomus*	4 d	F,U	7.69	13.2	47.59	0.55	0.600		Thurston and Meyn 1984
Catostomus platyrhynchus	*Catostomus*	4 d	F,U	7.73	11.7	51.62	0.58			Thurston and Meyn 1984
Ceriodaphnia acanthina	*Ceriodaphnia*	2 d	F,M	7.06	24	104.80	0.63	0.634		Mount 1982
Ceriodaphnia dubia	*Ceriodaphnia*	2 d	S,M	8.02	24.8	21.26	1.18			Andersen and Buckley 1998
Ceriodaphnia dubia	*Ceriodaphnia*	2 d	S,M	7.5	25	47.05	0.83			Bailey et al. 2001
Ceriodaphnia dubia	*Ceriodaphnia*	2 d	S,M	7.5	25	56.84	1.00			Bailey et al. 2001
Ceriodaphnia dubia	*Ceriodaphnia*	2 d	S,M	8.16	22	24.77	1.54	1.088	0.831	Black 2001
Ceriodaphnia dubia	*Ceriodaphnia*	2 d	S,M	8.4	23	28.06	3.10			Black 2001
Ceriodaphnia dubia	*Ceriodaphnia*	2 d	S,M	8.4	23	32.63	3.60			Black 2001
Ceriodaphnia dubia	*Ceriodaphnia*	2 d	S,M	8	25	14.52	0.78			Scheller 1997
Ceriodaphnia dubia	*Ceriodaphnia*	2 d	S,M	8.08	24.75	15.60	0.98			Andersen and Buckley 1998

Ceriodaphnia dubia	*Ceriodaphnia*	2 d	R,M	8.4	26.4	7.41	1.01			Cowgill and Milazzo 1991
Ceriodaphnia dubia	*Ceriodaphnia*	2 d	R,NR	7.4	23	48.59	0.60			Manning et al. 1996
Ceriodaphnia dubia	*Ceriodaphnia*	2 d	R,M	7.8	25	33.98	1.18			Nimmo et al. 1989
Ceriodaphnia dubia	*Ceriodaphnia*	2 d	R,M	8.2	7	16.65	0.38			Nimmo et al. 1989
Ceriodaphnia dubia	*Ceriodaphnia*	2 d	S,M	7.85	23	28.65	0.97			Sarda 1994
Ceriodaphnia dubia	*Ceriodaphnia*	2 d	S,M	7.85	23	28.77	0.97			Sarda 1994
Simocephalus vetulus	*Simocephalus*	2 d	F,M	8.3	17	31.58	1.89	0.947	0.947	West 1985; Arthur et al. 1987
Simocephalus vetulus	*Simocephalus*	2 d	F,M	8.1	20.4	21.36	1.05			Arthur et al. 1987
Simocephalus vetulus	*Simocephalus*	2 d	F,M	7.25	24.5	83.51	0.81			Mount 1982
Simocephalus vetulus	*Simocephalus*	2 d	F,M	7.06	24	83.51	0.51			Mount 1982
Ictalurus punctatus	*Ictalurus*	4 d	S,U	8.7	22	10.56	1.98	1.298	1.298	Colt and Tchobanoglous 1976
Ictalurus punctatus	*Ictalurus*	4 d	S,U	8.7	26	10.19	2.39			Colt and Tchobanoglous 1976
Ictalurus punctatus	*Ictalurus*	4 d	S,U	8.7	30	10.88	3.13			Colt and Tchobanoglous 1976
Ictalurus punctatus	*Ictalurus*	4 d	S,M	7.49	19.7	131.50	1.56			EA Engineering 1985
Ictalurus punctatus	*Ictalurus*	4 d	S,M	7.53	19.75	99.67	1.30			EA Engineering 1985
Ictalurus punctatus	*Ictalurus*	4 d	R,M	8.2	23.8	13.03	1.00			Bader and Grizzle 1992
Ictalurus punctatus	*Ictalurus*	4 d	R,M	8.2	23.9	17.22	1.33			Bader and Grizzle 1992
Ictalurus punctatus	*Ictalurus*	4 d	F,M	7.8	19.6	44.71	1.06			West 1985; Arthur et al. 1987
Ictalurus punctatus	*Ictalurus*	4 d	F,M	8	3.5	37.64	0.41			West 1985; Arthur et al. 1987
Ictalurus punctatus	*Ictalurus*	4 d	F,M	8.1	14.6	24.94	0.81			West 1985; Arthur et al. 1987
Ictalurus punctatus	*Ictalurus*	4 d	F,M	8.4	28	10.71	1.61			Colt and Tchobanoglous 1978
Ictalurus punctatus	*Ictalurus*	4 d	F,M	7.46	10	124.80	0.67			DeGraeve et al. 1987
Ictalurus punctatus	*Ictalurus*	4 d	F,M	7.41	15	113.10	0.79			DeGraeve et al. 1987
Ictalurus punctatus	*Ictalurus*	4 d	F,M	7.41	20	89.63	0.91			DeGraeve et al. 1987
Ictalurus punctatus	*Ictalurus*	4 d	F,M	7.45	20	72.15	0.80			DeGraeve et al. 1987

Ictalurus punctatus	*Ictalurus*	4 d	F,M	7.4	25	89.41	1.26			DeGraeve et al. 1987
Ictalurus punctatus	*Ictalurus*	4 d	F,M	7.41	25	85.69	1.24			DeGraeve et al. 1987
Ictalurus punctatus	*Ictalurus*	4 d	F,M	7.44	30	65.25	1.42			DeGraeve et al. 1987
Ictalurus punctatus	*Ictalurus*	4 d	F,M	8	20	15.09	0.58			Diamond et al. 1993
Ictalurus punctatus	*Ictalurus*	4 d	F,M	7.94	23.8	33.10	1.44			Reinbold and Pescitelli 1982d
Ictalurus punctatus	*Ictalurus*	4 d	F,M	7.98	23.8	30.49	1.45			Reinbold and Pescitelli 1982d
Ictalurus punctatus	*Ictalurus*	4 d	F,M	8.08	28	44.44	3.46			Roseboom and Richey 1977
Ictalurus punctatus	*Ictalurus*	4 d	F,M	8.09	22	32.33	1.73			Roseboom and Richey 1977
Ictalurus punctatus	*Ictalurus*	4 d	F,M	7.93	20	74.35	2.43			Sparks 1975
Ictalurus punctatus	*Ictalurus*	4 d	F,M	7.8	25.7	32.85	1.19			Swigert and Spacie 1983
Ictalurus punctatus	*Ictalurus*	4 d	F,M	8	26	32.34	1.86			West 1985
Ictalurus punctatus	*Ictalurus*	4 d	F,M	8.1	17	40.83	1.57			West 1985
Procambarus clarkii	*Procambarus*	4 d	F,M	8	20	26.08	1.00	1.278	1.278	Diamond et al. 1993
Procambarus clarkii	*Procambarus*	4 d	F,M	8	12	76.92	1.64			Diamond et al. 1993
Salmo salar	*Salmo*	4 d	S,M	6.4	1.8	123.00	0.03	0.097	0.229	Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6.4	1.8	133.90	0.03			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6	2.1	297.20	0.03			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6	2.1	341.10	0.03			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6.05	2.5	400.00	0.05			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6.05	2.5	491.70	0.06			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6	7.3	581.50	0.09			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6	7.3	587.60	0.09			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6.45	7.4	171.30	0.07			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6.45	7.4	214.40	0.09			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6.45	12.5	230.60	0.15			Knoph 1992

Salmo salar	*Salmo*	4 d	S,M	6.45	12.5	248.30	0.16			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6.05	12.5	403.50	0.10			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6.05	12.5	451.50	0.11			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6.05	17.1	356.10	0.13			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	6.05	17.1	373.00	0.13			Knoph 1992
Salmo salar	*Salmo*	4 d	S,M	7.45	8.5	60.29	0.28			Soderberg and Meade 1992
Salmo salar	*Salmo*	4 d	S,M	7.45	8.5	35.74	0.17			Soderberg and Meade 1992
Salmo salar	*Salmo*	4 d	S,M	7.45	8.5	118.20	0.55			Soderberg and Meade 1992
Salmo salar	*Salmo*	4 d	S,M	7.45	8.5	70.62	0.33			Soderberg and Meade 1992
Salmo trutta	*Salmo*	4 d	F,U	7.85	13.2	29.58	0.49	0.541		Thurston and Meyn 1984
Salmo trutta	*Salmo*	4 d	F,U	7.86	13.8	32.46	0.58			Thurston and Meyn 1984
Salmo trutta	*Salmo*	4 d	F,U	7.82	14.2	33.30	0.56			Thurston and Meyn 1984
Morone americana	*Morone*	4 d	S,M	8	16	14.93	0.43	0.230	0.572	Stevenson 1977
Morone americana	*Morone*	4 d	S,M	6	16	418.40	0.12			Stevenson 1977
Morone chrysops	*Morone*	4 d	S,M	7.09	19.7	132.40	0.63	0.630		Ashe et al. 1996
Morone saxatilis	*Morone*	4 d	S,M	7.4	23.3	92.17	1.15	1.705		Hazel et al. 1971
Morone saxatilis	*Morone*	4 d	S,M	7.5	23.3	73.45	1.15			Hazel et al. 1971
Morone saxatilis	*Morone*	4 d	S,M	7.35	15	259.70	1.58			Hazel et al. 1971
Morone saxatilis	*Morone*	4 d	S,M	7.5	15	182.30	1.57			Hazel et al. 1971
Morone saxatilis	*Morone*	4 d	S,M	7.93	23.3	48.03	1.98			Hazel et al. 1971
Morone saxatilis	*Morone*	4 d	S,M	7.5	23.3	125.90	1.98			Hazel et al. 1971
Morone saxatilis	*Morone*	4 d	S,M	7.84	15	165.70	3.08			Hazel et al. 1971
Morone saxatilis	*Morone*	4 d	S,M	7.5	15	354.90	3.05			Hazel et al. 1971
Morone saxatilis	*Morone*	4 d	S,M	8.3	21	12.86	1.01			Oppenborn and Goudie 1993
Morone saxatilis x	*Morone*	4 d	S,M	8.5	18.7	3.90	0.40	0.434		Harcke and Daniels 1999

chrysops										
Morone saxatilis x chrysops	*Morone*	4 d	S,M	8.3	21	8.15	0.64			Oppenborn and Goudie 1993
Morone saxatilis x chrysops	*Morone*	4 d	S,M	7	25	63.62	0.36			Weirich et al. 1993
Morone saxatilis x chrysops	*Morone*	4 d	S,M	7	25	83.06	0.47			Weirich et al. 1993
Morone saxatilis x chrysops	*Morone*	4 d	S,M	7	25	56.55	0.32			Weirich et al. 1993
Morone saxatilis x chrysops	*Morone*	4 d	S,M	7	25	65.39	0.37			Weirich et al. 1993
Morone saxatilis x chrysops	*Morone*	4 d	S,M	7	25	60.09	0.34			Weirich et al. 1993
Morone saxatilis x chrysops	*Morone*	4 d	S,M	7	25	64.51	0.37			Weirich et al. 1993
Morone saxatilis x chrysops	*Morone*	4 d	S,M	7	25	79.53	0.45			Weirich et al. 1993
Morone saxatilis x chrysops	*Morone*	4 d	S,M	7	25	86.60	0.49			Weirich et al. 1993
Morone saxatilis x chrysops	*Morone*	4 d	S,M	7	25	95.43	0.54			Weirich et al. 1993
Morone saxatilis x chrysops	*Morone*	4 d	S,M	7	25	105.20	0.60			Weirich et al. 1993
Daphnia magna	*Daphnia*	2 d	S,M	8.5	20	26.34	2.94			Gersich and Hopkins 1986
Daphnia magna	*Daphnia*	2 d	S,M	7.92	21	9.46	0.32	1.300	1.114	Gulyas and Fleit 1990
Daphnia magna	*Daphnia*	2 d	S,M	8.2	25	20.71	1.71			Parkhurst et al. 1979, 1981

Daphnia magna	*Daphnia*	2 d	S,M	8.34	19.7	51.92	4.07			Reinbold and Pescitelli 1982a
Daphnia magna	*Daphnia*	2 d	S,M	8.07	19.6	51.09	2.22			Russo et al. 1985
Daphnia magna	*Daphnia*	2 d	S,M	7.51	20.1	48.32	0.62			Russo et al. 1985
Daphnia magna	*Daphnia*	2 d	S,M	7.53	20.1	55.41	0.74			Russo et al. 1985
Daphnia magna	*Daphnia*	2 d	S,M	7.5	20.3	43.52	0.55			Russo et al. 1985
Daphnia magna	*Daphnia*	2 d	S,M	7.4	20.6	42.31	0.44			Russo et al. 1985
Daphnia magna	*Daphnia*	2 d	S,M	8.09	20.9	41.51	2.06			Russo et al. 1985
Daphnia magna	*Daphnia*	2 d	S,M	7.95	22	51.30	2.02			Russo et al. 1985
Daphnia magna	*Daphnia*	2 d	S,M	8.15	22	37.44	2.28			Russo et al. 1985
Daphnia magna	*Daphnia*	2 d	S,M	8.04	22.8	38.70	1.96			Russo et al. 1985
Daphnia pulicaria	*Daphnia*	2 d	F,M	8.05	14	34.50	0.96	0.955		DeGraeve et al. 1980
Xenopus laevis	*Xenopus*	4 d	R,M	7.2	22	38.59	0.28			Schuytema and Nebeker 1999a
Xenopus laevis	*Xenopus*	4 d	R,M	7.2	22	119.60	0.86			Schuytema and Nebeker 1999a
Xenopus laevis	*Xenopus*	4 d	R,M	7.2	24	32.37	0.27			Schuytema and Nebeker 1999a
Xenopus laevis	*Xenopus*	4 d	R,M	7.2	24	60.71	0.51			Schuytema and Nebeker 1999a
Xenopus laevis	*Xenopus*	4 d	R,M	7.15	22	101.40	0.65	0.909	0.909	Schuytema and Nebeker 1999b
Xenopus laevis	*Xenopus*	4 d	R,M	7.15	22	135.90	0.88			Schuytema and Nebeker 1999b
Xenopus laevis	*Xenopus*	4 d	R,M	7.15	22	128.30	0.83			Schuytema and Nebeker 1999b
Xenopus laevis	*Xenopus*	4 d	R,M	8.43	25	37.30	4.95			Tietge et al. 2000
Xenopus laevis	*Xenopus*	4 d	R,M	8.62	25	28.70	5.50			Tietge et al. 2000
Dendrocoelum lacteum	*Dendrocoelum*	4 d	S,U	8.2	18	22.37	1.15	1.153	1.153	Stammer 1953
Sander vitreus	*Sander*	4 d	F,U	8.08	18.2	17.43	0.70			Reinbold and Pescitelli 1982a
Sander vitreus	*Sander*	4 d	F,M	7.9	3.7	48.37	0.43	0.653	0.653	West 1985; Arthur et al. 1987
Sander vitreus	*Sander*	4 d	F,M	7.7	11.1	89.93	0.91			West 1985; Arthur et al. 1987
Sander vitreus	*Sander*	4 d	F,M	8.3	19	6.12	0.42			West 1985; Arthur et al. 1987

Sander vitreus	*Sander*	4 d	F,M	8.06	21.5	21.49	1.04			Mayes et al. 1986
Campostoma anomalum	*Campostoma*	4 d	F,M	7.8	25.7	38.97	1.42	1.417	1.417	Swigert and Spacie 1983
Cyprinella lutrensis	*Cyprinella*	4 d	F,M	8.3	24	24.37	2.33	2.463	1.423	Hazel et al. 1979
Cyprinella lutrensis	*Cyprinella*	4 d	F,M	9.1	24	6.50	2.60			Hazel et al. 1979
Cyprinella spiloptera	*Cyprinella*	4 d	F,M	7.95	26.5	18.52	0.99	1.136		Rosage et al. 1979
Cyprinella spiloptera	*Cyprinella*	4 d	F,M	8.15	26.5	16.27	1.33			Rosage et al. 1979
Cyprinella spiloptera	*Cyprinella*	4 d	F,M	7.9	25.7	24.52	1.11			Swigert and Spacie 1983
Cyprinella whipplei	*Cyprinella*	4 d	F,M	7.9	25.7	22.72	1.03	1.030		Swigert and Spacie 1983
Lepomis cyanellus	*Lepomis*	4 d	F,U	8.28	26.2	8.43	0.89	0.904	0.703	Reinbold and Pescitelli 1982a
Lepomis cyanellus	*Lepomis*	4 d	F,M	7.84	12.3	33.09	0.50			Jude 1973
Lepomis cyanellus	*Lepomis*	4 d	F,M	7.2	22.4	142.90	1.06			McCormick et al. 1984
Lepomis cyanellus	*Lepomis*	4 d	F,M	6.61	22.4	254.50	0.49			McCormick et al. 1984
Lepomis cyanellus	*Lepomis*	4 d	F,M	7.72	22.4	55.79	1.35			McCormick et al. 1984
Lepomis cyanellus	*Lepomis*	4 d	F,M	8.69	22.4	9.24	1.74			McCormick et al. 1984
Lepomis gibbosus	*Lepomis*	4 d	F,M	7.77	12	9.11	0.12	0.439		Jude 1973
Lepomis gibbosus	*Lepomis*	4 d	F,M	7.77	14	48.09	0.71			Thurston 1981
Lepomis gibbosus	*Lepomis*	4 d	F,M	7.77	14.5	42.02	0.64			Thurston 1981
Lepomis gibbosus	*Lepomis*	4 d	F,M	7.71	15.7	48.54	0.71			Thurston 1981
Lepomis macrochirus	*Lepomis*	4 d	S,M	7.51	20.35	40.41	0.53	0.875		EA Engineering 1985
Lepomis macrochirus	*Lepomis*	4 d	S,M	7.51	20.35	41.96	0.55			EA Engineering 1985
Lepomis macrochirus	*Lepomis*	4 d	S,M	7.52	20.65	41.90	0.57			EA Engineering 1985
Lepomis macrochirus	*Lepomis*	4 d	S,M	7.51	20.35	44.30	0.58			EA Engineering 1985
Lepomis macrochirus	*Lepomis*	4 d	S,M	7.52	20.65	42.63	0.58			EA Engineering 1985
Lepomis macrochirus	*Lepomis*	4 d	S,M	7.52	20.65	44.10	0.60			EA Engineering 1985
Lepomis macrochirus	*Lepomis*	4 d	F,M	8	20	21.56	0.82			Diamond et al. 1993

Lepomis macrochirus	*Lepomis*	4 d	F,M	8	12	25.12	0.54			Diamond et al. 1993
Lepomis macrochirus	*Lepomis*	4 d	F,M	8.11	18.5	16.73	0.73			Emery and Welch 1969
Lepomis macrochirus	*Lepomis*	4 d	F,M	8.24	18.5	42.01	2.45			Emery and Welch 1969
Lepomis macrochirus	*Lepomis*	4 d	F,M	8.75	18.5	12.70	2.12			Emery and Welch 1969
Lepomis macrochirus	*Lepomis*	4 d	F,M	9.05	18.5	6.58	1.88			Emery and Welch 1969
Lepomis macrochirus	*Lepomis*	4 d	F,M	9.19	18.5	3.76	1.33			Emery and Welch 1969
Lepomis macrochirus	*Lepomis*	4 d	F,M	9.62	18.5	0.79	0.47			Emery and Welch 1969
Lepomis macrochirus	*Lepomis*	4 d	F,M	9.85	18.5	1.35	0.96			Emery and Welch 1969
Lepomis macrochirus	*Lepomis*	4 d	F,M	8.6	24	5.51	0.96			Hazel et al. 1979
Lepomis macrochirus	*Lepomis*	4 d	F,M	7.9	24.25	33.06	1.36			Lubinski et al. 1974
Lepomis macrochirus	*Lepomis*	4 d	F,M	8.1	22	19.39	1.06			Mayes et al. 1986
Lepomis macrochirus	*Lepomis*	4 d	F,M	8.4	4	14.64	0.41			Reinbold and Pescitelli 1982b
Lepomis macrochirus	*Lepomis*	4 d	F,M	8.12	25	23.37	1.63			Reinbold and Pescitelli 1982b
Lepomis macrochirus	*Lepomis*	4 d	F,M	8.16	4.5	12.55	0.21			Reinbold and Pescitelli 1982b
Lepomis macrochirus	*Lepomis*	4 d	F,M	8.09	24.8	17.22	1.11			Reinbold and Pescitelli 1982b
Lepomis macrochirus	*Lepomis*	4 d	F,M	8	22	12.75	0.56			Roseboom and Richey 1977
Lepomis macrochirus	*Lepomis*	4 d	F,M	8.2	28	14.81	1.48			Roseboom and Richey 1977
Lepomis macrochirus	*Lepomis*	4 d	F,M	7.93	22	24.08	0.91			Roseboom and Richey 1977
Lepomis macrochirus	*Lepomis*	4 d	F,M	8.07	22	8.85	0.45			Roseboom and Richey 1977
Lepomis macrochirus	*Lepomis*	4 d	F,M	7.6	21.7	44.03	0.77			Smith et al. 1984
Lepomis macrochirus	*Lepomis*	4 d	F,M	7.85	22.05	59.93	1.89			Sparks 1975
Lepomis macrochirus	*Lepomis*	4 d	F,M	7.8	24.2	33.88	1.11			Swigert and Spacie 1983
Lepomis macrochirus	*Lepomis*	4 d	F,M	7.6	26.5	58.69	1.44			Swigert and Spacie 1983
Lepomis macrochirus	*Lepomis*	4 d	F,M	7.8	26.6	37.52	1.45			Swigert and Spacie 1983
Cyprinus carpio	*Cyprinus*	4 d	R,M	7.72	28	51.78	1.84	1.357	1.357	Hasan and MacIntosh 1986

Cyprinus carpio	*Cyprinus*	4 d	R,M	7.72	28	48.97	1.74			Hasan and MacIntosh 1987
Cyprinus carpio	*Cyprinus*	4 d	R,M	7.4	28	45.05	0.78			Rao et al. 1975
Oncorhynchus aguabonita	*Oncorhynchus*	4 d	F,M	8.06	13.2	23.30	0.62	0.622	0.317	Thurston and Russo 1981
Oncorhynchus clarkii	*Oncorhynchus*	4 d	F,M	7.7	10	17.30	0.16	0.332		Thurston et al. 1981a
Oncorhynchus clarkii	*Oncorhynchus*	4 d	F,M	7.7	10	29.10	0.27			Thurston et al. 1981a
Oncorhynchus clarkii	*Oncorhynchus*	4 d	F,M	7.7	10	19.30	0.18			Thurston et al. 1981a
Oncorhynchus clarkii	*Oncorhynchus*	4 d	F,M	7.7	10	26.30	0.24			Thurston et al. 1981a
Oncorhynchus clarkii	*Oncorhynchus*	4 d	F,M	7.78	12.2	32.57	0.43			Thurston et al. 1978
Oncorhynchus clarkii	*Oncorhynchus*	4 d	F,M	7.8	12.4	36.55	0.51			Thurston et al. 1978
Oncorhynchus clarkii	*Oncorhynchus*	4 d	F,M	7.8	12.8	37.75	0.54			Thurston et al. 1978
Oncorhynchus clarkii	*Oncorhynchus*	4 d	F,M	7.81	13.1	43.72	0.66			Thurston et al. 1978
Oncorhynchus gorbuscha	*Oncorhynchus*	4 d	S,M	6.4	4.3	230.50	0.07	0.075		Rice and Bailey 1980
Oncorhynchus gorbuscha	*Oncorhynchus*	4 d	S,M	6.4	4.3	277.70	0.08			Rice and Bailey 1980
Oncorhynchus kisutch	*Oncorhynchus*	4 d	F,M	8.1	17.2	11.59	0.45	0.428		Buckley 1978
Oncorhynchus kisutch	*Oncorhynchus*	4 d	F,M	7	15	82.02	0.22			Wilson 1974; Robinson-Wilson and Seim 1975
Oncorhynchus kisutch	*Oncorhynchus*	4 d	F,M	7	15	84.43	0.23			Wilson 1974; Robinson-Wilson and Seim 1975
Oncorhynchus kisutch	*Oncorhynchus*	4 d	F,M	7.5	15	50.65	0.43			Wilson 1974; Robinson-Wilson and Seim 1975
Oncorhynchus kisutch	*Oncorhynchus*	4 d	F,M	7.5	15	52.76	0.45			Wilson 1974; Robinson-Wilson and Seim 1975
Oncorhynchus kisutch	*Oncorhynchus*	4 d	F,M	8	15	21.63	0.58			Wilson 1974; Robinson-Wilson and Seim 1975
Oncorhynchus kisutch	*Oncorhynchus*	4 d	F,M	8	15	22.00	0.59			Wilson 1974; Robinson-Wilson

										and Seim 1975
Oncorhynchus kisutch	*Oncorhynchus*	4 d	F,M	8.5	15	9.09	0.72			Wilson 1974; Robinson-Wilson and Seim 1975
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,U	7.95	15	51.06	1.22	0.420		Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	6.84	12	112.00	0.17			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.55	15	34.23	0.33			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	6.95	14.7	163.60	0.39			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	6.97	14.5	144.00	0.35			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.02	15.4	146.70	0.43			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.02	14.6	159.00	0.44			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.03	15.1	156.60	0.46			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.18	15.1	141.60	0.59			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.45	15.1	104.40	0.81			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.47	14.7	72.65	0.57			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.47	14.5	79.67	0.62			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.51	14.2	73.71	0.61			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.54	14.6	75.30	0.69			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.59	13.9	59.40	0.58			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.87	15.1	42.90	0.86			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.93	15.2	41.15	0.95			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.97	15.2	36.17	0.91			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.98	15.1	35.29	0.91			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	8.03	14.9	23.03	0.65			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	8.04	14.3	25.84	0.72			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	8.34	15.3	19.15	1.11			Environment Canada 2004

Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	8.39	15.3	12.05	0.78			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	8.4	14.9	12.84	0.82			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	8.44	14.7	14.41	0.99			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	8.46	14.5	11.82	0.84			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	8.47	14.3	17.20	1.22			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	8.93	14.2	4.80	0.86			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	8.93	15	5.40	1.02			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	9.46	14.6	1.60	0.69			Environment Canada 2004
Oncorhynchus mykiss	*Oncorhynchus*	4 d	S,M	7.5	15	38.37	0.33			Holt and Malcolm 1979
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,U	7	15	207.50	0.57			Blahm 1978
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,U	7.4	14.5	20.03	0.13			Calamari et al. 1981
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,U	7.4	14.5	46.31	0.30			Calamari et al. 1981
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,U	7.4	14.5	55.07	0.36			Calamari et al. 1981
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,U	8	15	70.00	1.87			Blahm 1978
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.7	3.6	38.52	0.21			West 1985; Arthur et al. 1987
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.7	9.8	55.15	0.50			West 1985; Arthur et al. 1987
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.9	16.2	15.23	0.35			West 1985; Arthur et al. 1987
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.9	11.3	30.15	0.49			West 1985; Arthur et al. 1987
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.3	18.7	12.75	0.86			West 1985; Arthur et al. 1987
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.95	10	35.14	0.57			Broderius and Smith Jr. 1979
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.4	14.4	40.99	0.27			Calamari et al. 1977
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.05	14	22.90	0.63			DeGraeve et al. 1980
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.16	14.2	23.39	0.84			Reinbold and Pescitelli 1982b
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.28	12.8	15.40	0.65			Reinbold and Pescitelli 1982b
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.34	5	17.32	0.46			Reinbold and Pescitelli 1982b

Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.43	3	11.86	0.33			Reinbold and Pescitelli 1982b
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.5	14.9	10.09	0.80			Reinbold and Pescitelli 1982b
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.6	3.3	15.27	0.63			Reinbold and Pescitelli 1982b
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.44	12.8	32.49	0.21			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.5	14.5	24.20	0.20			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.59	12.7	32.62	0.29			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.6	13	23.80	0.22			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.6	12.9	25.14	0.23			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.62	7.9	20.53	0.13			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.62	14.4	28.62	0.31			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.63	12.9	25.65	0.25			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.64	9.8	25.82	0.21			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.64	13.1	29.28	0.30			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.64	10	31.85	0.26			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.65	9.8	19.46	0.16			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.65	13.2	28.64	0.30			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.65	14.3	29.02	0.33			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.66	9.8	25.95	0.22			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.66	13.6	28.27	0.31			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.66	12.8	33.97	0.36			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.67	14	27.30	0.32			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.68	13	33.15	0.37			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.69	10.4	17.75	0.17			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.69	10.7	20.18	0.19			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.69	10.7	25.62	0.24			Thurston and Russo 1983

Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.69	13.4	27.51	0.32			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.9	12.7	20.03	0.36			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.71	11.5	30.22	0.32			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.71	11.4	32.02	0.34			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.74	10.4	25.76	0.27			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.75	11.8	31.53	0.38			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.75	12.3	33.94	0.42			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.76	10	22.44	0.24			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.77	13.6	31.81	0.45			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.79	12.4	41.97	0.57			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.8	9.7	23.65	0.27			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.8	13.3	42.02	0.63			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.8	12.4	47.87	0.67			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.82	13.2	33.67	0.52			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.83	13.5	33.55	0.55			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.84	12.2	24.54	0.37			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.84	12.9	32.30	0.51			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.84	13.8	33.09	0.56			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.84	13	38.69	0.62			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.85	12.5	29.77	0.47			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.85	13.1	31.55	0.52			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.85	13.1	33.59	0.55			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.85	12.3	33.99	0.53			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.85	16.1	34.17	0.70			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.86	12	20.70	0.32			Thurston and Russo 1983

Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.86	13.4	23.71	0.41			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.86	12.7	28.77	0.47			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.86	14.1	34.95	0.64			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.86	10.2	35.31	0.48			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.87	12.9	16.81	0.29			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.87	12.9	18.99	0.32			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.87	13.1	19.08	0.33			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.87	12.2	20.02	0.32			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.87	13	21.15	0.36			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.87	12.1	31.80	0.51			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.87	13	34.32	0.59			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.88	12.8	11.07	0.19			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.88	12.9	15.91	0.28			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.88	13.4	19.43	0.35			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.88	10	28.60	0.40			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.89	12.4	36.73	0.63			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.9	13.4	19.44	0.37			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.7	13.9	28.54	0.36			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.9	11.9	33.65	0.57			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.9	13	35.75	0.66			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.9	13	37.41	0.69			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.91	13.1	12.68	0.24			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.91	13	20.99	0.39			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.91	19	25.36	0.74			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.91	19.1	26.44	0.78			Thurston and Russo 1983

Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.94	12.8	26.49	0.52			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.94	12.5	39.25	0.76			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.95	12.5	19.75	0.39			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.96	19.2	23.21	0.77			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.98	12.5	27.02	0.57			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.06	13.2	33.64	0.90			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.08	12.8	23.05	0.62			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.1	13.9	18.14	0.56			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.12	13.6	17.34	0.55			Thurston and Russo 1983
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.62	7.9	21.60	0.14			Thurston et al. 1981a
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.67	7.7	17.00	0.12			Thurston et al. 1981a
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.71	8.5	20.70	0.17			Thurston et al. 1981a
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.72	8.2	10.50	0.09			Thurston et al. 1981a
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.72	8.1	19.80	0.17			Thurston et al. 1981a
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.74	8.3	22.30	0.20			Thurston et al. 1981a
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.74	8.1	28.00	0.24			Thurston et al. 1981a
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.86	9.6	19.30	0.25			Thurston et al. 1981a
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.86	9.7	31.60	0.41			Thurston et al. 1981a
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.75	12.7	32.09	0.41			Thurston et al. 1981b
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.75	12.5	36.97	0.46			Thurston et al. 1981b
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.76	12.5	39.08	0.50			Thurston et al. 1981b
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.79	12.9	40.88	0.58			Thurston et al. 1981b
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.83	12.8	36.49	0.56			Thurston et al. 1981b
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	6.51	14.1	157.40	0.13			Thurston et al. 1981c
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	6.8	14.1	94.05	0.15			Thurston et al. 1981c

Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.3	14	74.20	0.37			Thurston et al. 1981c
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.29	14.1	13.85	0.66			Thurston et al. 1981c
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	8.82	13.9	3.95	0.56			Thurston et al. 1981c
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	9.01	14.5	2.51	0.53			Thurston et al. 1981c
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	7.2	10	174.00	0.51			Wicks and Randall 2002
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	6.97	16.6	32.38	0.09			Wicks et al. 2002
Oncorhynchus mykiss	*Oncorhynchus*	4 d	F,M	6.97	16.6	207.00	0.60			Wicks et al. 2002
Oncorhynchus tshawytscha	*Oncorhynchus*	4 d	S,M	7.96	7	28.03	0.37	0.366		Servizi and Gordon 1990
Oncorhynchus tshawytscha	*Oncorhynchus*	4 d	F,U	7.87	13.5	18.47	0.33			Thurston and Meyn 1984
Oncorhynchus tshawytscha	*Oncorhynchus*	4 d	F,U	7.82	12.2	27.23	0.39			Thurston and Meyn 1984
Oncorhynchus tshawytscha	*Oncorhynchus*	4 d	F,U	7.84	12.3	24.74	0.38			Thurston and Meyn 1984
Notropis topeka	*Notropis*	4 d	F,M	7.85	24.6	21.40	0.81	0.907	0.907	Adelman et al. 2009
Notropis topeka	*Notropis*	4 d	F,M	8.05	25	18.70	1.12			Adelman et al. 2009
Notropis topeka	*Notropis*	4 d	F,M	8.09	13.2	28.90	0.82			Adelman et al. 2009
Rana pipiens	*Rana*	4 d	F,M	8	20	31.04	1.19	0.640	0.640	Diamond et al. 1993
Rana pipiens	*Rana*	4 d	F,M	8	12	16.23	0.35			Diamond et al. 1993
Musculium transversum	*Musculium*	4 d	F,M	8.1	14.6	32.83	1.06	0.903	0.903	West 1985; Arthur et al. 1987
Musculium transversum	*Musculium*	4 d	F,M	8.2	5.4	38.18	0.77			West 1985; Arthur et al. 1987
Musculium transversum	*Musculium*	4 d	F,M	8.6	20.5	6.43	0.91			West 1985; Arthur et al. 1987
Micropterus dolomieu	*Micropterus*	4 d	F,M	7.16	22.3	123.40	0.83	0.911	0.817	Broderius et al. 1985
Micropterus dolomieu	*Micropterus*	4 d	F,M	6.53	22.3	359.90	0.57			Broderius et al. 1985
Micropterus dolomieu	*Micropterus*	4 d	F,M	7.74	22.3	39.30	0.99			Broderius et al. 1985
Micropterus dolomieu	*Micropterus*	4 d	F,M	8.71	22.3	7.56	1.47			Broderius et al. 1985
Micropterus salmoides	*Micropterus*	4 d	F,M	8.04	28	19.59	1.40	1.074		Roseboom and Richey 1977
Micropterus salmoides	*Micropterus*	4 d	F,M	7.96	22	20.48	0.82			Roseboom and Richey 1977

Micropterus treculii	*Micropterus*	4 d	S,M/	8	22	12.70	0.56	0.558		Tomasso and Carmichael 1986
Lymnaea stagnalis	*Lymnaea*	4 d	F,M	7.9	11.5	50.33	0.82	0.824	0.824	Williams et al. 1986
Poecilia reticulata	*Poecilia*	4 d	S,U	7.5	27.55	5.93	0.12			Kumar and Krishnamoorthi 1983
Poecilia reticulata	*Poecilia*	4 d	S,U	7.22	25	129.40	1.21	0.697	0.697	Rubin and Elmaraghy 1976
Poecilia reticulata	*Poecilia*	4 d	S,U	7.45	25	75.65	1.19			Rubin and Elmaraghy 1976
Poecilia reticulata	*Poecilia*	4 d	S,U	7.45	25	82.95	1.31			Rubin and Elmaraghy 1976
Etheostoma nigrum	*Etheostoma*	4 d	F,M	7.9	20.6	28.90	0.92			Nimmo et al. 1989
Etheostoma nigrum	*Etheostoma*	4 d	F,M	8	20.1	24.61	0.95			Nimmo et al. 1989
Etheostoma nigrum	*Etheostoma*	4 d	F,M	8.2	6.2	6.94	0.15	0.385		Nimmo et al. 1989
Etheostoma nigrum	*Etheostoma*	4 d	F,M	8.1	5.8	11.47	0.19		0.558	Nimmo et al. 1989
Etheostoma nigrum	*Etheostoma*	4 d	F,M	8.1	5.8	13.46	0.22			Nimmo et al. 1989
Etheostoma nigrum	*Etheostoma*	4 d	F,M	8	20.1	15.63	0.60			Nimmo et al. 1989
Etheostoma spectabile	*Etheostoma*	4 d	F,M	8.1	22	16.12	0.88	0.808		Hazel et al. 1979
Etheostoma spectabile	*Etheostoma*	4 d	F,M	8.4	21	7.65	0.74			Hazel et al. 1979
Hybognathus amarus	*Hybognathus*	4 d	R,M	8	25	16.90	0.91	0.910	0.910	Buhl 2002
Pseudacris crucifer	*Pseudacris*	4 d	F,U	8	12	17.78	0.38	0.407		Diamond et al. 1993
Pseudacris crucifer	*Pseudacris*	4 d	F,U	8	20	11.42	0.44			Diamond et al. 1993
Pseudacris regilla	*Pseudacris*	4 d	R,M	6.7	22	41.19	0.09			Schuytema and Nebeker 1999a
Pseudacris regilla	*Pseudacris*	4 d	R,M	6.7	22	60.44	0.14		0.368	Schuytema and Nebeker 1999a
Pseudacris regilla	*Pseudacris*	4 d	R,M	6.7	22	103.10	0.24	0.333		Schuytema and Nebeker 1999a
Pseudacris regilla	*Pseudacris*	4 d	R,M	7.3	22	136.60	1.24			Schuytema and Nebeker 1999b
Pseudacris regilla	*Pseudacris*	4 d	R,M	7.3	22	116.40	1.06			Schuytema and Nebeker 1999b
Actinonaias ligamentina	*Actinonaias*	1 d	S,M	8.6	20	6.14	0.84	0.622	0.633	Wang et al. 2007b
Actinonaias ligamentina	*Actinonaias*	1 d	S,M	8.4	20	8.10	0.73			Wang et al. 2007b

Actinonaias ligamentina	*Actinonaias*	1 d	S,M	8.3	20	5.07	0.37			Wang et al. 2007b
Actinonaias ligamentina	*Actinonaias*	1 d	S,M	8.3	20	8.90	0.65			Wang et al. 2007b
Actinonaias pectorosa	*Actinonaias*	4 d	S,M	7.9	25	14.06	0.61	0.643		Keller 2000
Actinonaias pectorosa	*Actinonaias*	4 d	S,M	7.95	25	14.08	0.68			Keller 2000
Pyganodon grandis	*Pyganodon*	4 d	S,M	7.71	25	18.84	0.53	0.487	0.487	Scheller 1997
Pyganodon grandis	*Pyganodon*	4 d	S,M	7.5	25	25.13	0.44			Scheller 1997
Chasmistes brevirostris	*Chasmistes*	4 d	S,M	8	20	11.42	0.44	0.617	0.617	Saiki et al. 1999
Chasmistes brevirostris	*Chasmistes*	4 d	S,M	8	20	22.85	0.87			Saiki et al. 1999
Pleurocera uncialis	*Pleurocera*	4 d	R,M	8.1	22	11.18	0.61	0.611	0.611	Goudreau et al. 1993
Notemigonus crysoleucas	*Notemigonus*	4 d	S,M	7.5	19.6	89.61	1.08			EA Engineering 1985
Notemigonus crysoleucas	*Notemigonus*	4 d	S,M	7.55	19.5	73.85	0.99	0.859	0.859	EA Engineering 1985
Notemigonus crysoleucas	*Notemigonus*	4 d	S,M	7.5	24.5	34.73	0.59			Swigert and Spacie 1983
Deltistes luxatus	*Deltistes*	4 d	F,M	8	20	16.81	0.64	0.504	0.504	Saiki et al. 1999
Deltistes luxatus	*Deltistes*	4 d	F,M	8	20	10.35	0.40			Saiki et al. 1999
Prosopium williamsoni	*Prosopium*	4 d	F,U	7.68	12.1	11.30	0.12			Thurston and Meyn 1984
Prosopium williamsoni	*Prosopium*	4 d	F,U	7.84	12.4	25.47	0.39	0.238	0.238	Thurston and Meyn 1984
Prosopium williamsoni	*Prosopium*	4 d	F,U	7.8	12.3	21.20	0.29			Thurston and Meyn 1984
Fusconaia masoni	*Fusconaia*	6 h	S,M	7.6	24.9	15.90	0.35	0.350	0.350	Black 2001
Utterbackia imbecillis	*Utterbackia*	4 d	S,M	7.9	24	8.24	0.33			Keller 2000
Utterbackia imbecillis	*Utterbackia*	4 d	S,M	8.35	25	3.27	0.37			Keller 2000
Utterbackia imbecillis	*Utterbackia*	4 d	S,M	7.9	25	9.36	0.40			Keller 2000
Utterbackia imbecillis	*Utterbackia*	4 d	R,M	7.8	24	14.29	0.46	0.393	0.393	Wade et al. 1992
Utterbackia imbecillis	*Utterbackia*	4 d	R,M	8.16	25	5.25	0.40			Black 2001
Utterbackia imbecillis	*Utterbackia*	4 d	R,M	8.17	25	5.78	0.45			Black 2001
Utterbackia imbecillis	*Utterbackia*	4 d	R,M	8.29	25	8.85	0.88			Black 2001

Utterbackia imbecillis	*Utterbackia*	4 d	R,M	8	25.1	2.73	0.15			Black 2001
Utterbackia imbecillis	*Utterbackia*	1 d	S,M	8.02	25	7.40	0.42			Black 2001
Lampsilis abrupta	*Lampsilis*	4 d	R,M	8.3	20	1.92	0.14	0.189	0.379	Wang et al. 2007b
Lampsilis abrupta	*Lampsilis*	4 d	F,M	8.4	20	2.80	0.25			Wang et al. 2007a
Lampsilis cardium	*Lampsilis*	4 d	S,M	8.2	20.5	23.50	1.44	0.653		Newton et al. 2003
Lampsilis cardium	*Lampsilis*	4 d	S,M	8.2	21.2	23.70	1.52			Newton et al. 2003
Lampsilis cardium	*Lampsilis*	4 d	F,M	7.6	21.2	23.10	0.39			Newton and Bartsch 2007
Lampsilis cardium	*Lampsilis*	4 d	F,M	7.1	21.2	38.90	0.21			Newton and Bartsch 2007
Lampsilis fasciola	*Lampsilis*	4 d	R,M	7.83	12.6	14.90	0.23	0.459		Mummert et al. 2003
Lampsilis fasciola	*Lampsilis*	4 d	R,M	8.5	20	6.18	0.69			Wang et al. 2007b
Lampsilis fasciola	*Lampsilis*	1 d	S,M	8.3	20	7.74	0.57			Wang et al. 2007b
Lampsilis fasciola	*Lampsilis*	1 d	S,M	8.4	20	5.52	0.50			Wang et al. 2007b
Lampsilis higginsii	*Lampsilis*	4 d	F,M	7.6	21.2	19.50	0.33	0.239		Newton and Bartsch 2007
Lampsilis higginsii	*Lampsilis*	4 d	F,M	7.1	21.2	31.70	0.17			Newton and Bartsch 2007
Lampsilis rafinesqueana	*Lampsilis*	4 d	R,M	8.3	20	9.19	0.67	0.675		Wang et al. 2007b
Lampsilis rafinesqueana	*Lampsilis*	4 d	R,M	8.4	20	9.27	0.84			Wang et al. 2007b
Lampsilis rafinesqueana	*Lampsilis*	1 d	S,M	8.3	20	7.39	0.54			Wang et al. 2007b
Lampsilis siliquoidea	*Lampsilis*	4 d	S,M	8.3	24	1.28	0.12	0.324		Myers-Kinzie 1998
Lampsilis siliquoidea	*Lampsilis*	4 d	F,M	8.35	20	8.80	0.72			Miao et al. 2010
Lampsilis siliquoidea	*Lampsilis*	4 d	R,M	8.1	20	4.09	0.19			Wang et al. 2007b
Lampsilis siliquoidea	*Lampsilis*	4 d	F,M	8.2	20	4.60	0.27			Wang et al. 2007a
Lampsilis siliquoidea	*Lampsilis*	4 d	F,M	7.6	20.5	11.00	0.18			Wang et al. 2008
Lampsilis siliquoidea	*Lampsilis*	4 d	F,M	8.1	20.6	5.20	0.26			Wang et al. 2008
Lampsilis siliquoidea	*Lampsilis*	4 d	F,M	8.5	20.6	3.40	0.39			Wang et al. 2008
Lampsilis siliquoidea	*Lampsilis*	4 d	F,M	9	20.6	0.96	0.28			Wang et al. 2008

Lampsilis siliquoidea	*Lampsilis*	4 d	F,M	6.6	19.6	88.00	0.13			Wang et al. 2008
Lampsilis siliquoidea	*Lampsilis*	4 d	F,M	8.1	19.4	11.00	0.50			Wang et al. 2008
Lampsilis siliquoidea	*Lampsilis*	4 d	R,M	8.5	20	8.35	0.93			Wang et al. 2007b
Lampsilis siliquoidea	*Lampsilis*	1 d	S,M	8.4	20	9.79	0.89			Wang et al. 2007b
Villosa iris	*Villosa*	4 d	S,M	8.18	25	7.81	0.62	0.285	0.285	Scheller 1997
Villosa iris	*Villosa*	4 d	R,M	7.29	12.6	20.60	0.09			Mummert et al. 2003
Villosa iris	*Villosa*	4 d	S,M	8.18	25	7.07	0.56			Scheller 1997
Villosa iris	*Villosa*	1 d	S,M	7.94	20	3.29	0.11			Scheller 1997
Villosa iris	*Villosa*	1 d	S,M	8.4	20	10.68	0.97			Wang et al. 2007b
Villosa iris	*Villosa*	1 d	R,M	8.1	22	3.57	0.20			Goudreau et al. 1993
Villosa iris	*Villosa*	1 d	R,M	8.1	22	4.28	0.23			Goudreau et al. 1993
Lasmigona subviridis	*Lasmigona*	4 d	R,M	7.73	24	6.61	0.18	0.181	0.181	Black 2001
Lasmigona subviridis	*Lasmigona*	4 d	R,M	7.73	24	6.61	0.18			Black 2001
Lasmigona subviridis	*Lasmigona*	4 d	R,M	7.92	24.8	3.97	0.18			Black 2001
Venustaconcha ellipsiformis	*Venustaconcha*	1 d	S,M	8.1	20	4.55	0.22	0.217	0.217	Wang et al. 2007b

Table S34. Chronic toxicity data of ammonia (before and after conversion) applied in this study

Species	Genus	Test and Effect	pH	Temp. (°C)	Total Ammonia (mg TAN/L)	NH_3-N (mg/L)	SMCV (mg/L)	GMCV (mg/L)	Reference
Pteronarcella badia	*Pteronarcella*	30-d Juv Survival	8.04	12.10	133.80	3.14	1.736	1.736	Thurston et al. 1984b
Pteronarcella badia	*Pteronarcella*	24-d Juv Survival	7.81	13.20	21.66	0.33			Thurston et al. 1984b
Ceriodaphnia acanthina	*Ceriodaphnia*	7-d LC Reproduction	7.15	24.50	44.90	0.35	0.346	0.573	Mount 1982
Ceriodaphnia dubia	*Ceriodaphnia*	7-d LC Reproduction	7.80	25.00	15.20	0.53	0.800		Nimmo et al. 1989

Ceriodaphnia dubia	*Ceriodaphnia*	7-d LC Reproduction	8.57	26.00	5.80	1.07			Willingham 1987
Daphnia magna	*Daphnia*	21-d LC Reproduction	8.45	19.80	7.37	0.73	0.716	0.716	Gersich et al. 1985
Daphnia magna	*Daphnia*	21-d LC Reproduction	7.92	20.10	21.70	0.70			Reinbold and Pescitelli 1982a
Hyalella azteca	*Hyalella*	28-d PLC Biomass	8.04	25.00	8.21	0.48	0.482	0.482	Borgmann 1994
Ictalurus punctatus	*Ictalurus*	30-d ELS Weight	7.80	25.80	12.20	0.45	0.513	0.513	Reinbold and Pescitelli 1982a
Ictalurus punctatus	*Ictalurus*	30-d Juv Survival	8.35	27.90	5.02	0.68			Colt and Tchobanoglous 1978
Ictalurus punctatus	*Ictalurus*	30-d ELS Biomass	7.76	26.90	11.50	0.41			Swigert and Spacie 1983
Esox lucius	*Esox*	52-d ELS Biomass	7.62	8.70	13.44	0.09	0.094	0.094	Harrahy et al. 2004
Cyprinus carpio	*Cyprinus*	28-d ELS Weight	7.85	23.00	8.36	0.28	0.282	0.282	Mallet and Sims 1994
Oncorhynchus clarkii henshawi	*Oncorhynchus*	103-d ELS Survival	7.57	13.70	17.89	0.16	0.163	0.083	Koch et al. 1980
Oncorhynchus mykiss	*Oncorhynchus*	42-d ELS Survival	7.50	10.00	<33.60	-	0.042		Burkhalter and Kaya 1977
Oncorhynchus mykiss	*Oncorhynchus*	72-d ELS Survival	7.40	14.50	2.60	0.02			Calamari et al. 1977, 1981
Oncorhynchus mykiss	*Oncorhynchus*	73-d ELS Survival	7.52	14.90	<2.55	-			Solbe and Shurben 1989
Oncorhynchus mykiss	*Oncorhynchus*	5-year LC	7.70	7.5-10.5	6.71	6.71			Thurston et al. 1984a
Oncorhynchus mykiss	*Oncorhynchus*	90-d ELS Survival	7.75	11.40	8.92	0.10			Brinkman et al. 2009
Oncorhynchus nerka	*Oncorhynchus*	62-d Embryos Hatchability	8.42	10.00	<2.13	-	-		Rankin 1979
Catostomus commersonii	*Catostomus*	30-d ELS Biomass	8.32	18.60	2.90	0.20	0.202	0.202	Reinbold and Pescitelli 1982a
Micropterus dolomieu	*Micropterus*	32-d ELS Biomass	6.60	22.30	9.61	0.02	0.156	0.156	Broderius et al. 1985
Micropterus dolomieu	*Micropterus*	32-d ELS Biomass	7.25	22.30	8.62	0.07			Broderius et al. 1985
Micropterus dolomieu	*Micropterus*	32-d ELS Biomass	7.83	22.30	8.18	0.25			Broderius et al. 1985
Micropterus dolomieu	*Micropterus*	32-d ELS Biomass	8.68	22.30	1.54	0.28			Broderius et al. 1985
Pimephales promelas	*Pimephales*	28-d ELS Survival	8.00	24.80	5.12	0.27	0.220	0.220	Mayes et al. 1986
Pimephales promelas	*Pimephales*	32-d ELS Biomass	7.95	25.50	7.46	0.37			Adelman et al. 2009
Pimephales promelas	*Pimephales*	30-d ELS Biomass	7.82	25.10	3.73	0.14			Swigert and Spacie 1983

Pimephales promelas	*Pimephales*	LC Hatchability	8.00	24.20	1.97	0.10			Thurston et al. 1986
Fluminicola sp.	*Fluminicola*	28-d Juv Change in Length	8.22	20.10	2.28	0.14	0.142	0.142	Besser 2011
Musculium transversum	*Musculium*	42-d Juv Survival	8.15	23.50	5.82	0.39	0.213	0.213	Anderson et al. 1978
Musculium transversum	*Musculium*	42-d Juv Survival	7.80	21.80	1.23	0.03			Sparks and Sandusky 1981
Lepomis cyanellus	*Lepomis*	30-d ELS Biomass	7.90	22.00	5.61	0.20	0.327	0.188	McCormick et al. 1984
Lepomis cyanellus	*Lepomis*	30-d ELS Biomass	8.16	25.40	5.84	0.46			Reinbold and Pescitelli 1982a
Lepomis macrochirus	*Lepomis*	30-d ELS Biomass	7.76	22.50	1.85	0.05	0.049		Smith et al. 1984
Villosa iris	*Villosa*	28-d Juv Survival	8.20	20.00	1.06	0.06	0.063	0.063	Wang et al. 2007a
Lampsilis siliquoidea	*Lampsilis*	28-d Juv Survival	8.25	20.00	0.90	0.06	0.042	0.042	Wang et al. 20011
Lampsilis fasciola	*Lampsilis*	28-d Juv Survival	8.20	20.00	0.43	0.03			Wang et al. 2007a

Table S4~~5~~. Average levels of toal ammonia nitrogen (TAN) (µ~~m~~g/L), pH ~~and surface water temperature (T)~~ in the three key sections ~~in dry (Jan., Feb., March, April, Nov. and Dec.) and wet seasons (May, June, July, August, Sept. and Oct.)~~ in Tai Lake, China (2004-2015), in dry (Jan., Feb., March, April, Nov. and Dec.) and wet seasons (May, June, July, August, Sept. and Oct.)
~~Shazhu in city Wuxi, Jiangsu~~

season	Section		2004		2005		2006		2007		2008		2010		2011		2012		2013		2014		2015	
			pH	TAN	pH	TAN	pH	TAN	pH	TAN	pH	TAN	pH	TAN	pH	TAN	pH	TAN	pH	TAN	pH	TAN	pH	TAN
Dry	WX	mean	7.906	412.1	7.910	571.7	7.904	467.6	7.864	428.8	7.936	479.2	7.998	249.6	8.106	270.4	7.485	301.7	7.824	212.0	7.705	134.0	7.708	162.8
		SD	0.070	234.1	0.048	435.8	0.050	215.2	0.219	245.4	0.235	241.0	0.375	135.4	0.311	101.4	0.235	76.50	0.392	92.50	0.292	60.00	0.247	42.40
	YX	mean	7.187	1002	7.439	600.0	8.214	1285	8.357	1010	7.875	1053	8.147	793.3	8.340	1081	8.023	626.2	7.580	436.0	7.706	528.8	7.742	458.4
		SD	0.593	411.0	0.833	354.7	0.309	619.0	0.547	779.6	0.491	680.4	0.314	458.5	0.373	636.9	0.292	529.8	0.193	291.1	0.357	437.8	0.255	231.3
	SZ	mean	7.718	234.6	7.395	331.3	7.652	322.8	7.975	196.0	7.913	230.4	8.023	137.9	7.762	191.6	7.675	141.2	7.762	205.6	7.991	205.6	7.989	158.0
		SD	0.711	70.71	0.599	97.48	0.307	105.1	0.501	80.40	0.534	142.6	0.389	88.41	0.382	99.83	0.345	35.74	0.258	94.32	0.113	155.6	0.181	34.41
Wet	WX	mean	7.911	583.5	7.948	183.3	7.941	268.8	7.964	301.9	7.993	385.2	7.768	191.5	8.065	215.9	7.160	330.0	7.872	113.7	7.870	154.4	8.017	215.2
		SD	0.036	114.6	0.058	50.55	0.055	165.0	0.412	421.2	0.258	60.51	0.401	31.00	0.321	60.63	0.277	52.00	0.202	42.53	0.278	50.21	0.269	31.67
	YX	mean	7.838	651.7	8.171	929.3	8.034	426.9	8.058	524.4	8.169	637.7	7.907	313.0	8.098	609.6	7.861	202.2	7.874	170.3	7.758	206.3	7.520	261.1
		SD	0.626	183.6	0.645	699.1	0.353	268.6	0.567	432.0	0.500	531.0	0.387	167.3	0.426	370.6	0.272	175.7	0.400	132.7	0.409	105.7	0.329	193.6
	SZ	mean	7.877	287.4	7.612	204.8	7.850	233.8	7.642	157.0	8.237	128.1	7.626	96.67	7.514	133.3	7.692	109.6	7.453	170.0	7.509	115.6	7.441	174.4
		SD	0.308	130.0	0.530	41.22	0.256	124.1	0.366	76.68	0.279	69.76	0.294	61.22	0.278	28.55	0.213	60.21	0.165	112.0	0.287	26.85	0.195	51.38

Note:~~T-Temperature,°C;~~ Missing parameter-surface water temperatures were supplemented according to the study of temperature variation in Tai Lake, China (Chen et al., 2009), in dry and wet seasons, the temperatures were 20 °C and 30 °C, respectively. ~~.~~TAN -Concentration of Total Ammonia nitrogen, µ~~m~~g/L. WX: Wuxishazhu; YX: Yixinglanshanzui; SZ: Suzhouxishan.

Table S56. Mean values of selected water parameters in Tai Lake, China in February and September of 2014.

Parameters		Chl. (μg/L)	ORP (mV)	SpCond. (uS/cm)	Turb. (uS/cm)	NO_3-N (mg/L)	DO (mg/L)	pH	T (°C)	NH_3-N (μg/L)
M±SE	Feb.	25.60±2.784	196.7±2.880	562.4±18.13	129.9±36.40	4.313±0.7248	10.50±0.1289	8.076±0.02848	8.810±0.1082	6.075±1.105
	Sept.	15.33±1.690	195.2±6.067	453.4±5.593	55.14±5.762	2.579±0.1311	8.215±0.1735	8.351±0.07507	26.90±0.1139	185.8±24.41
P value for t test		0.0014	0.7954	<0.0001	0.0499	0.0140	<0.0001	0.0001	<0.0001	<0.0001

NOTE: M±SE–Mean ± Standard Error; Chl.-Chlorophyll; ORP- Oxidation-Reduction Potential; SpCond.-Specific Conductance; Turb.-Turbidity; NO_3-N-Nitrate Nitrogen; DO-Dissolved Oxygen; T-Temperature; NH_3-N-Un-ionized Ammonia Nitrogen.

Table S7. Correlation coefficients of parameters in Feb of 2014 in Tai Lake, China

Correlation coefficients	Chl. (μg/L)	ORP (mV)	SpCond. (uS/cm)	Turb. (uS/cm)	NO_3-N (mg/L-N)	DO (mg/L)	pH	T (°C)	NH_3-N (μg/L)
Chl. (μg/L)		-0.174	0.362	0.182	0.138	0.214	0.414	-0.150	-0.084
ORP (mV)	-0.174		-0.235	-0.112	-0.162	0.113	-0.131	-0.287	-0.292
SpCond. (uS/cm)	0.362	-0.235		-0.062	0.151	-0.070	0.023	-0.054	0.327

Turb. (uS/cm)	0.182	-0.112	-0.062		0.581	-0.455	-0.306	0.302	0.070
NO3-N (mg/L-N)	0.138	-0.162	0.151	0.581		-0.856	-0.672	0.499	0.403
DO (mg/L)	0.214	0.113	-0.070	-0.455	-0.856		0.837	-0.618	-0.476
pH	0.414	-0.131	0.023	-0.306	-0.672	0.837		-0.517	-0.420
T (°C)	-0.150	-0.287	-0.054	0.302	0.499	-0.618	-0.517		0.611
NH_3-N(μg/L)	-0.084	-0.292	0.327	0.070	0.403	-0.476	-0.420	0.611	

NOTE: Chl- Chlorophyll; ORP- Oxidation-Reduction Potential; SpCond- Specific Conductance; Turb- Turbidity; NO_3-N-Nitrate Nitrogen; DO-Dissolved Oxygen; T-Temperature;

Table S8. Correlation coefficients of parameters in September of 2014 in Tai Lake, China

Correlation coefficients	Chl. (μg/L)	ORP (mV)	SpCond. (uS/cm)	Turb. (uS/cm)	NO_3-N (mg/L-N)	DO (mg/L)	pH	T (°C)	NH_3-N (μg/L)
Chl. (μg/L)		-0.054	0.402	0.024	0.186	0.304	0.073	-0.028	0.228
ORP (mV)	-0.054		-0.414	-0.215	-0.182	-0.378	-0.373	-0.294	-0.381
SpCond. (uS/cm)	0.402	-0.414		-0.028	-0.125	-0.217	0.017	-0.060	0.128
Turb. (uS/cm)	0.024	-0.215	-0.028		0.066	0.331	0.302	0.149	0.342
NO_3-N (mg/L-N)	0.186	-0.182	-0.125	0.066		-0.495	-0.646	0.217	-0.512
DO (mg/L)	0.304	-0.378	-0.217	0.331	-0.495		0.822	0.544	0.871
pH	0.073	-0.373	0.017	0.302	-0.646	0.822		0.411	0.922
T (°C)	-0.028	-0.294	-0.060	0.149	0.217	0.544	0.411		0.485
NH_3-N (μg/L)	0.228	-0.381	0.128	0.342	-0.512	0.871	0.922	0.485	

NOTE: Chl. Chlorophyll; ORP Oxidation-Reduction Potential; SpCond. Specific Conductance; Turb. Turbidity; NO_3^-N Nitrate Nitrogen; DO Dissolved Oxygen; T Temperature;

Table S69. Goodness of fit tests values and HC_5 with 95% confidence intervals for acute and chronic toxicity data.

Models	Log-normal			Log-logistic			Weibull		
	AIC value	P value	HC_5 with 95%CI (μg/L)	AIC value	P value	HC_5 with 95%CI (μg/L)	AIC value	P value	HC_5 with 95%CI (μg/L)
Acute	65.12	0.0996	235.96(169.57~327.80)	62.37	0.1644	234.72(163.40~322.15)	78.34	0.1550	136.52(85.79~218.17)
Chronic	19.90	0.8845	45.86(23.21~89.51)	21.14	0.3468	38.75(16.58~80.34)	20.52	0.3606	36.94(17.21~78.54)

NOTE: AIC value: Akaike Information Criterion value; P value for Kolmogorov-Smirnov test

Table S10. Correlation coefficients between Shannon diversity index and NH_3-N hazard quotients in 2014

	Acute HQs in Feb. VS H' in Apr.	Chronic HQs in Feb. VS H' in Apr.	Acute HQs in Sept. VS H' in Aug.	Chronic HQs in Sept. VS H' in Aug.
Correlation coefficient	-0.250	-0.250	-0.286	-0.286

NOTE: HQs: Hazard quotients; H': Shannon diversity index

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