Relative sensitivity of juvenile fatmuckets (*Lampsilis siliquoidea*) and four other invertebrates to sulfate.

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Objectives:

- Generate acute toxicity data for sodium sulfate in moderately hard reconstituted water (MHRW) for several invertebrates
- Determine influence of hardness on sodium sulfate toxicity
- Determine influence of chloride on sulfate toxicity

Hyalella azteca

Sphaerium simile

Chironomus tentans

Photos: Mike Jeffords, INHS

Lampsilis siliquoidea

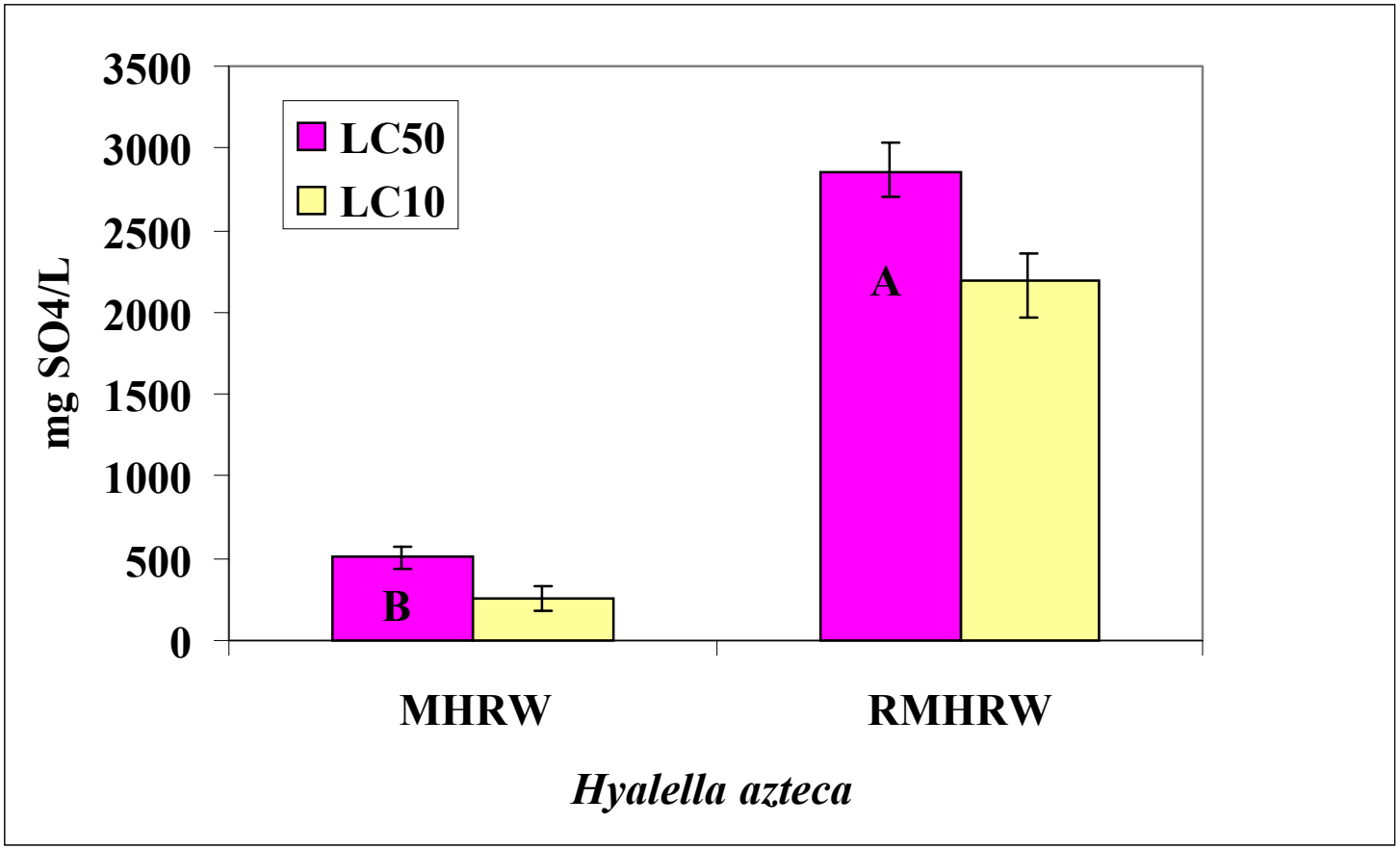
Photo by Kevin Cummings, INHS

Toxicity of sulfate to freshwater invertebrates in MHRW (U.S. EPA, 1993). Hardness = 90-100 mg/L. LC50s expressed as mg **SO_4**/L.

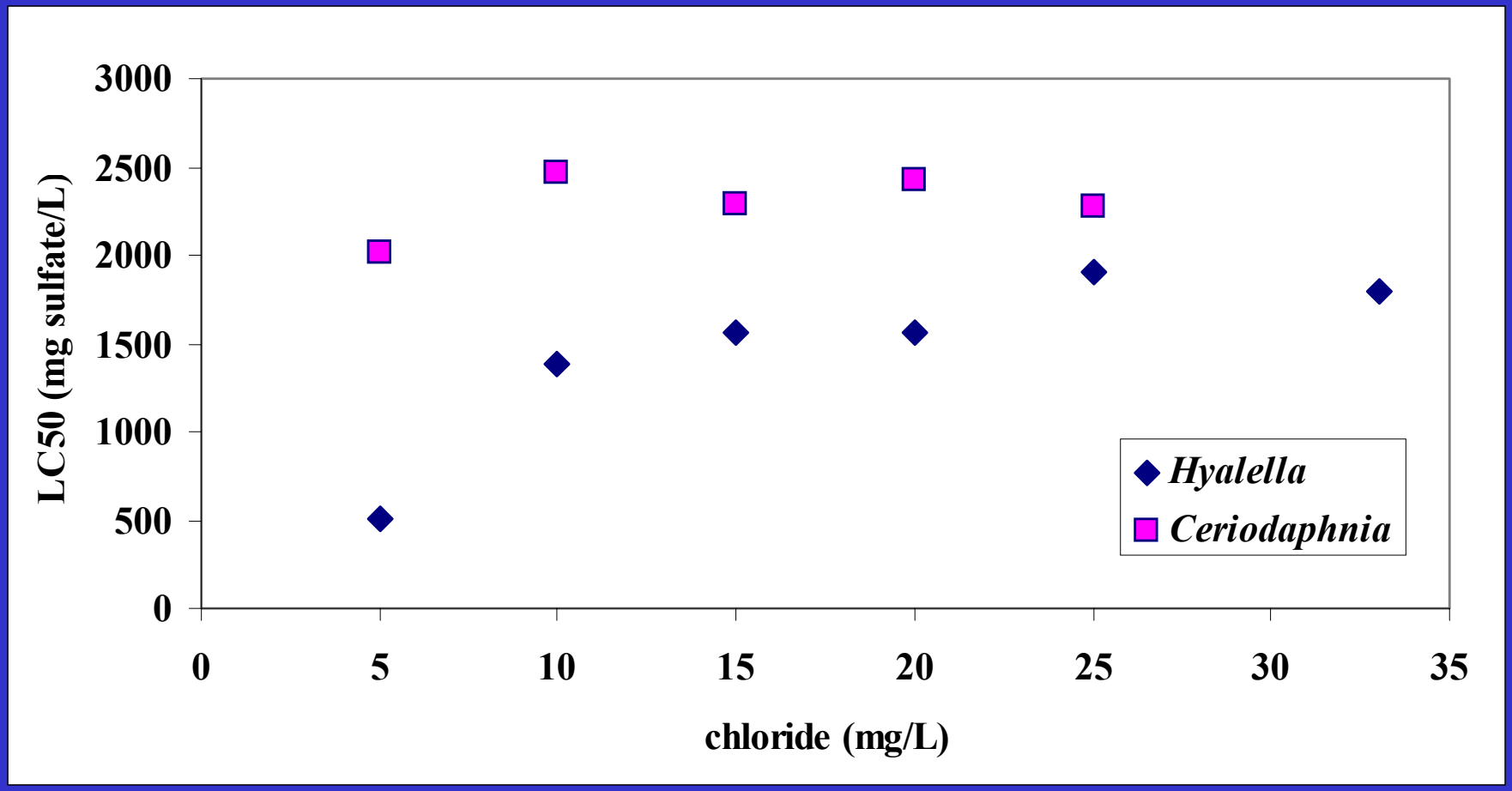
Species	Duration	Temp	Mean LC50	Range	control survival
Ceriodaphnia dubia	48 h	25 °C	2,050 mg/L	1,869 – 2,270	56/60 (93.3%)
Lampsilis siliquoidea	48 h 96 h	20 °C	1,702 mg/L 1,727 mg/L	Unrel. 1,598 – 1,812	20/20 (100 %)
Chironomus tentans	48 h	22 °C	14,134 mg/L	14,123 - 14,146	39/40 (97.5 %)
Sphaerium simile	96 h	22 °C	2,078 mg/L	1,901 - 2,319	48/48 (100%)
Hyalella azteca	96 h	22 °C	512 mg/L	431 - 607	56/60 (93.3 %)

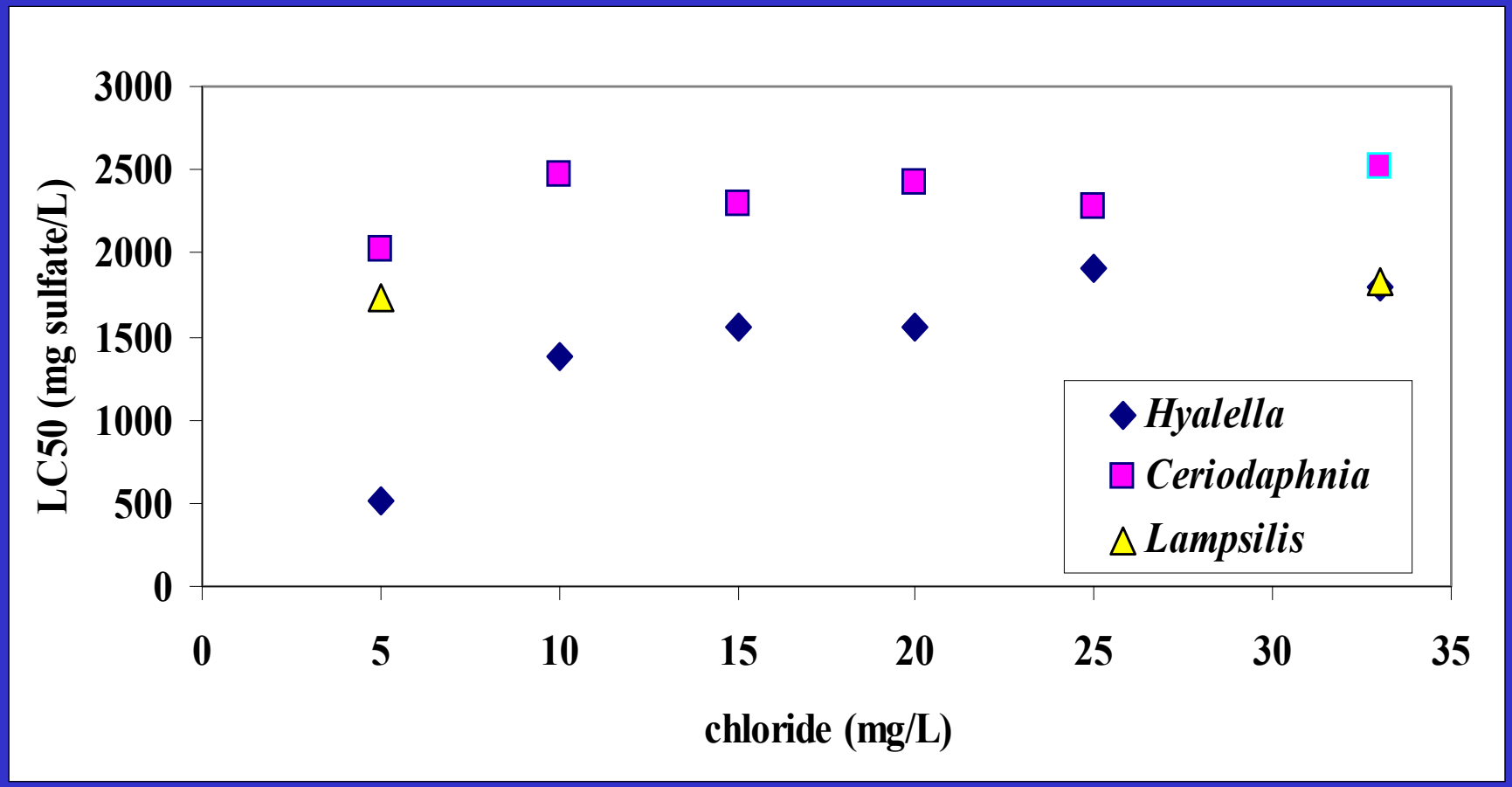
Nominal chemical composition of MHRW (U.S. EPA, 1993) and RMHRW (Smith et al., 1997)

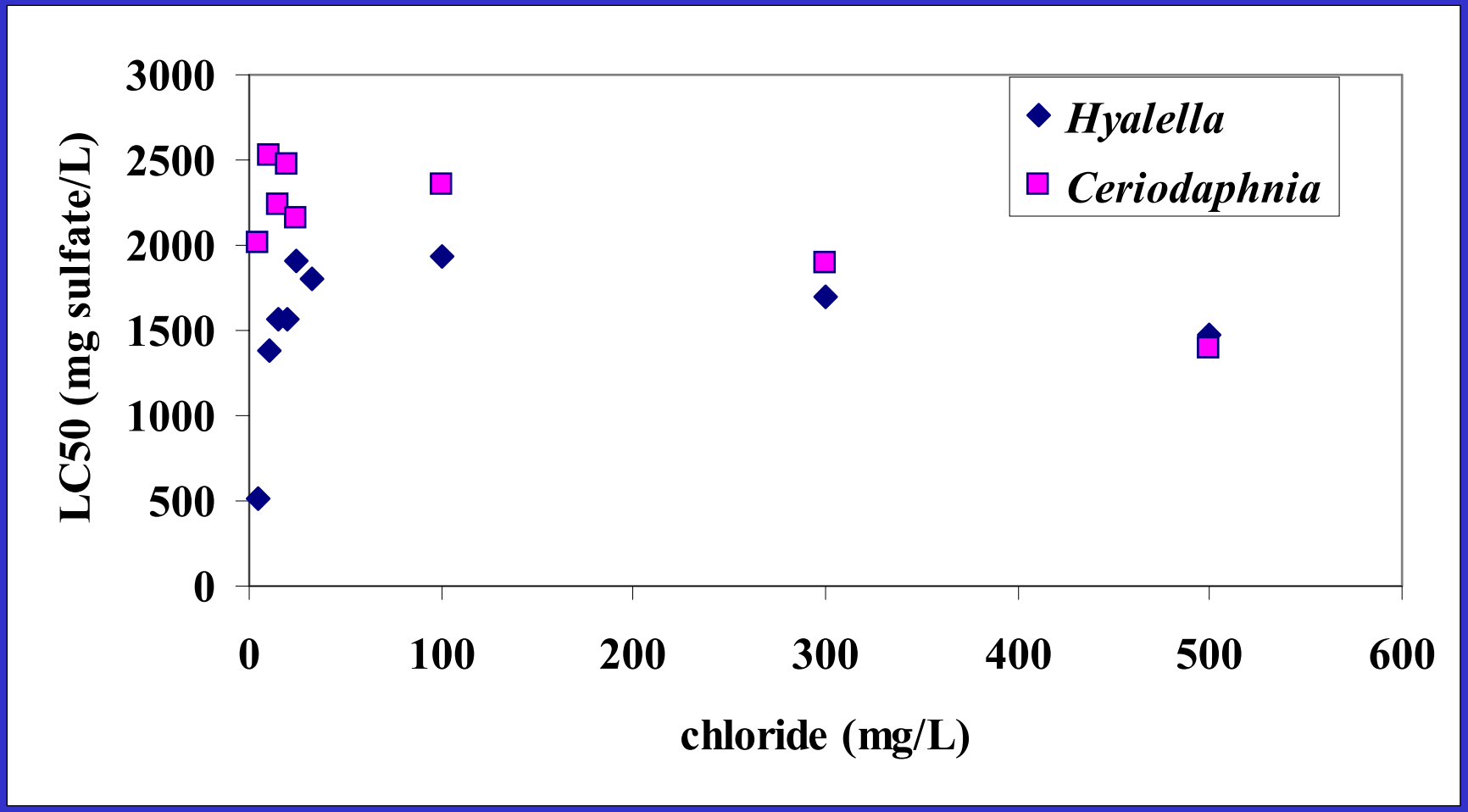
Component	MHRW	RMHRW
K^+ (mg/L)	2.1	2.1
Na^+ (mg/L)	26.3	26.3
Ca^{2+} (mg/L)	17.6	32.7
Mg^{2+} (mg/L)	12.1	6.1
SO_4^{2-} (mg/L)	90.2	59.2
Cl^- (mg/L)	1.9	33.9
HCO_3^- (mg/L)	69.7	69.7
hardness (mg/L as $CaCO_3$)	94	107
Ca/Mg molar ratio	0.88	3.25
pH	7.9	7.9
conductivity (µS/cm)	295	341


3500
3000
2500
2000
1500
1000
500
0
mg SO4/L
LC50
LC10
A
B
MHRW
RMHRW
Hyalella azteca

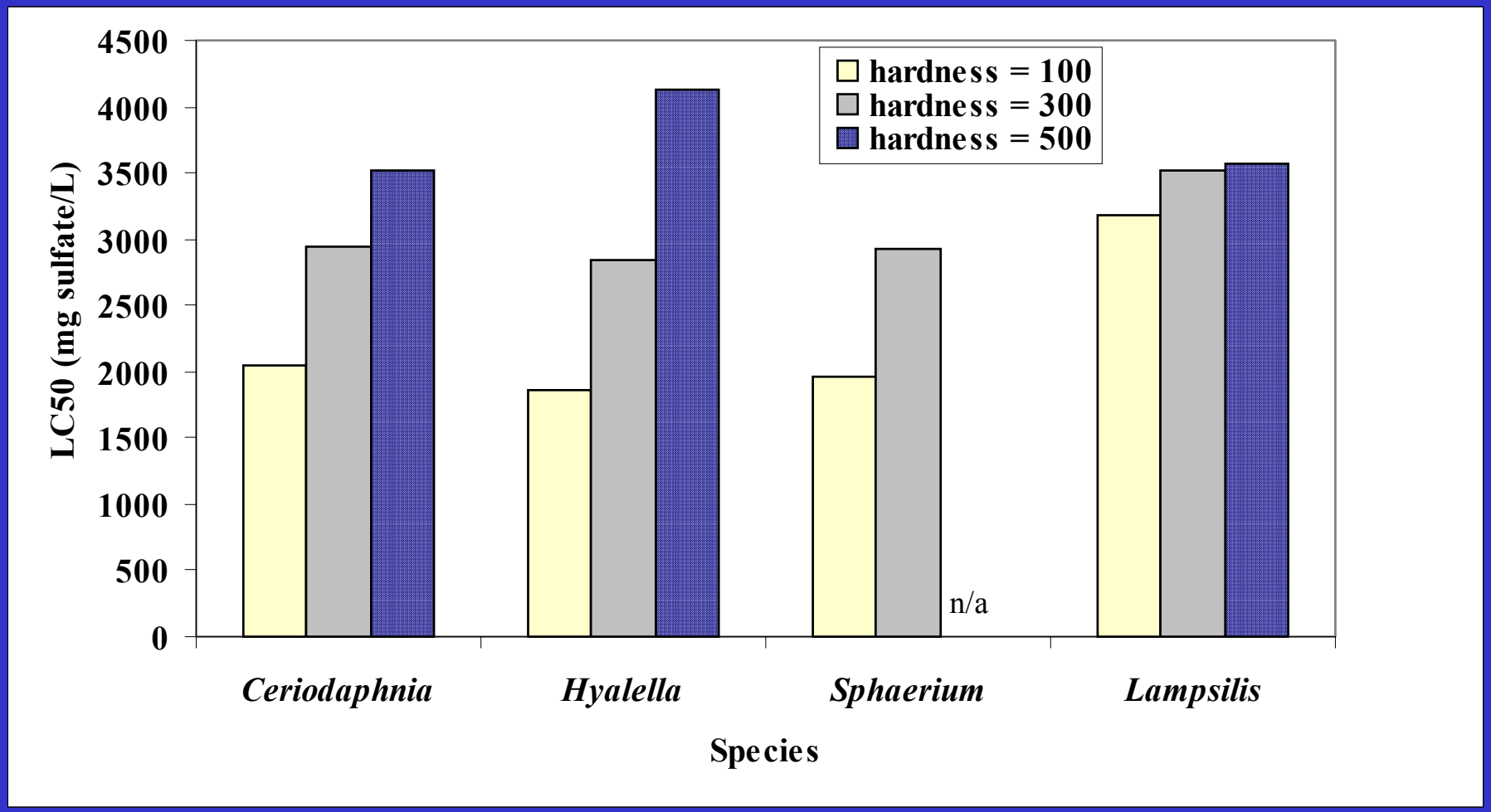
Does chloride affect the toxicity of sulfate to invertebrates?


3000
2500
2000
1500
1000
500
0
LC50 (mg sulfate/L)
0
5
10
15
20
25
30
35
chloride (mg/L)
Hyalella
Ceriodaphnia

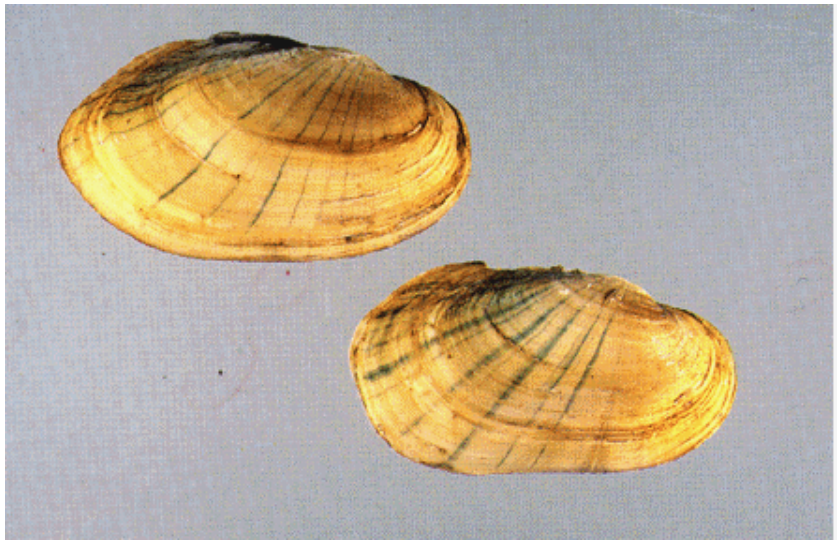

3000
2500
2000
1500
1000
500
0
LC50 (mg sulfate/L)
0
5
10
15
20
25
30
35
chloride (mg/L)
Hyalella
Ceriodaphnia
Lampsilis


3000
2500
2000
1500
1000
500
0
LC50 (mg sulfate/L)
0
100
200
300
400
500
600
chloride (mg/L)
Hyalella
Ceriodaphnia

Does hardness ameliorate sodium sulfate toxicity?


4500
4000
3500
3000
2500
2000
1500
1000
500
0
LC50 (mg sulfate/L)
hardness = 100
hardness = 300
hardness = 500
n/a
Ceriodaphnia
Hyalella
Sphaerium
Lampsilis
Species

Conclusions



•Sensitivity to sulfate in MHRW: *Hyalella* > *Lampsilis*> *Ceriodaphnia* = *Sphaerium* > *Chironomus*

•Increased hardness reduced toxicity of sulfate (when sodium was dominant cation) to *Hyalella*, *Ceriodaphnia,* and *Sphaerium*. *Lampsilis* was the least sensitive organism at hardness = 100 and 300 and Ca:Mg = 2.33, but did not appear to benefit from increased hardness.

•At concentrations between 5 and 25 mg/L, increased chloride reduced toxicity of sulfate to *Hyalella*. At concentrations >25, increased chloride increased sulfate toxicity to both *Hyalella* and *Ceriodaphnia*. *Lampsilis* did not appear to be affected by chloride concentration.

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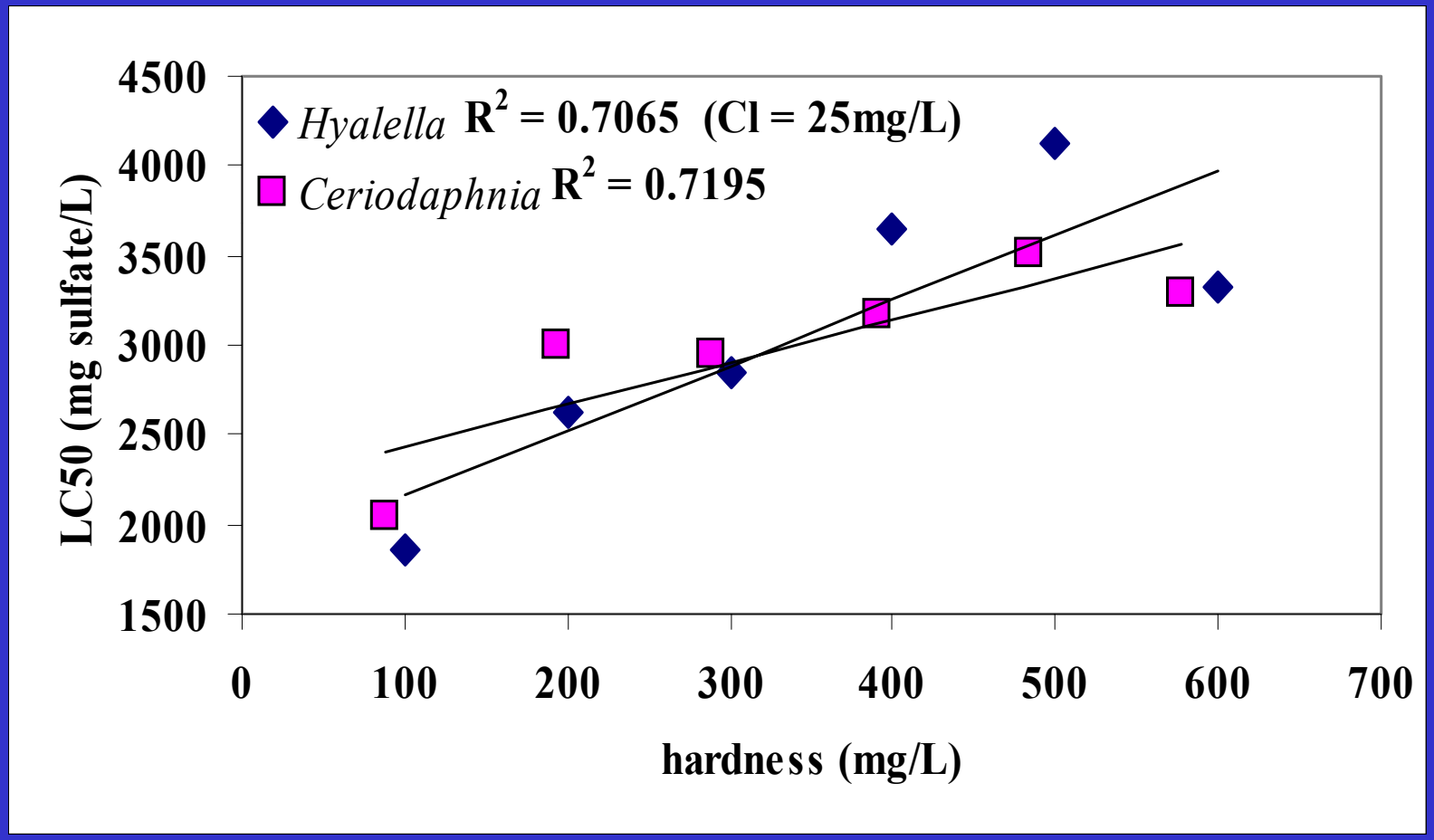
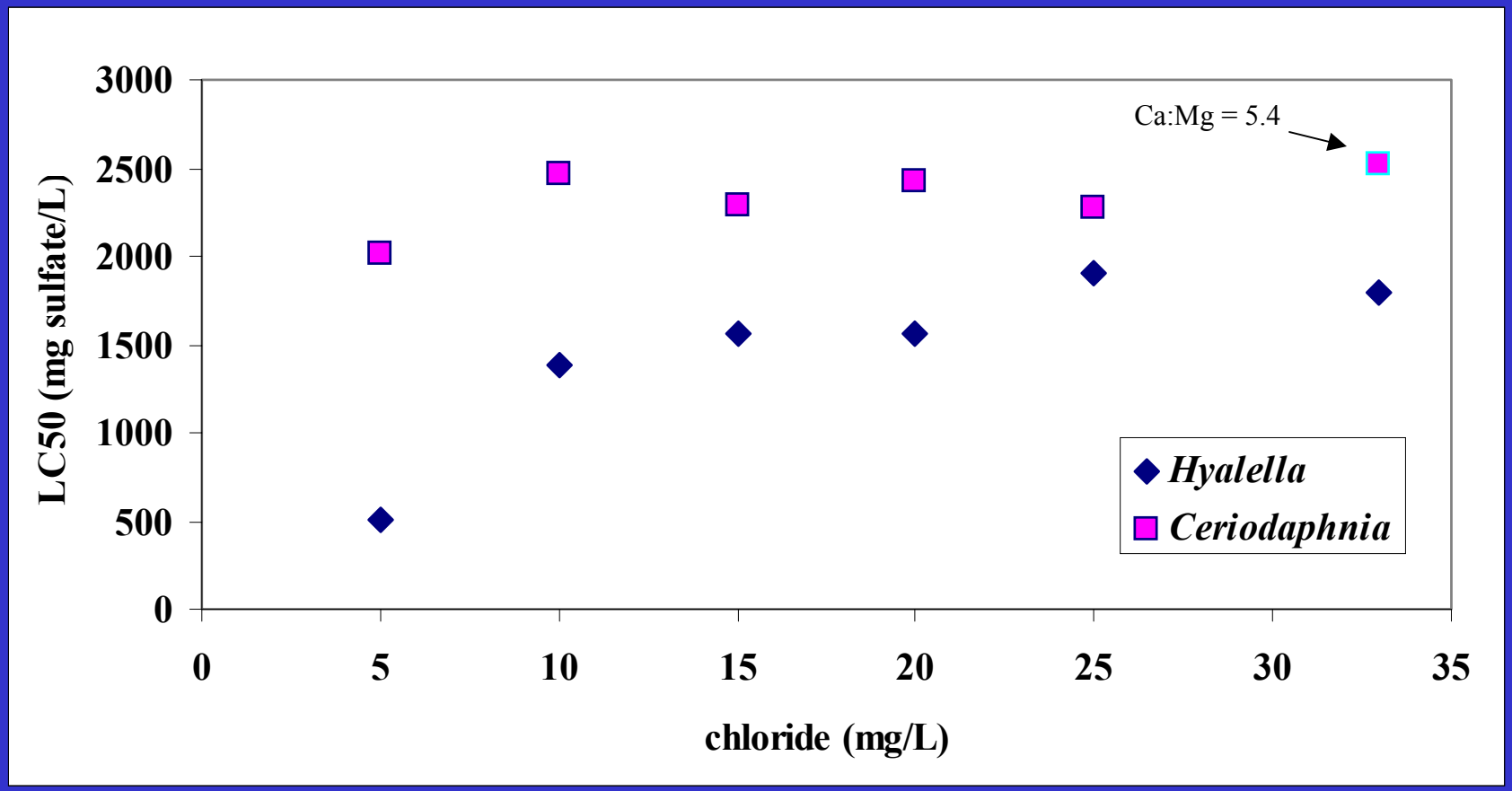

Hyalella R2 = 0.7065 (Cl = 25mg/L)
Ceriodaphnia R2 = 0.7195
LC50 (mg sulfate/L)
4500
4000
3500
3000
2500
2000
1500
0
100
200
300
400
500
600
700
hardness (mg/L)


3000
2500
2000
1500
1000
500
0
LC50 (mg sulfate/L)
0
5
10
15
20
25
30
35
chloride (mg/L)
Ca:Mg = 5.4
Hyalella
Ceriodaphnia