MINING WATER SYMPOSIUM
ADAPTATIONS AND RESPONSES TO METAL STRESS

ASSESSING THE POTENTIAL FOR RECOVERY OF ZOOPLANKTON FROM MINING IMPACTS

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CONACYT

Natural Sciences and Engineering Research Council of Canada
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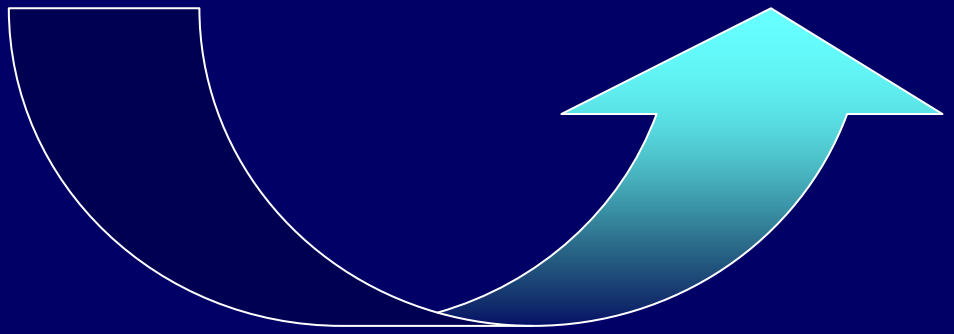
Photo by the RCMP

Restoration



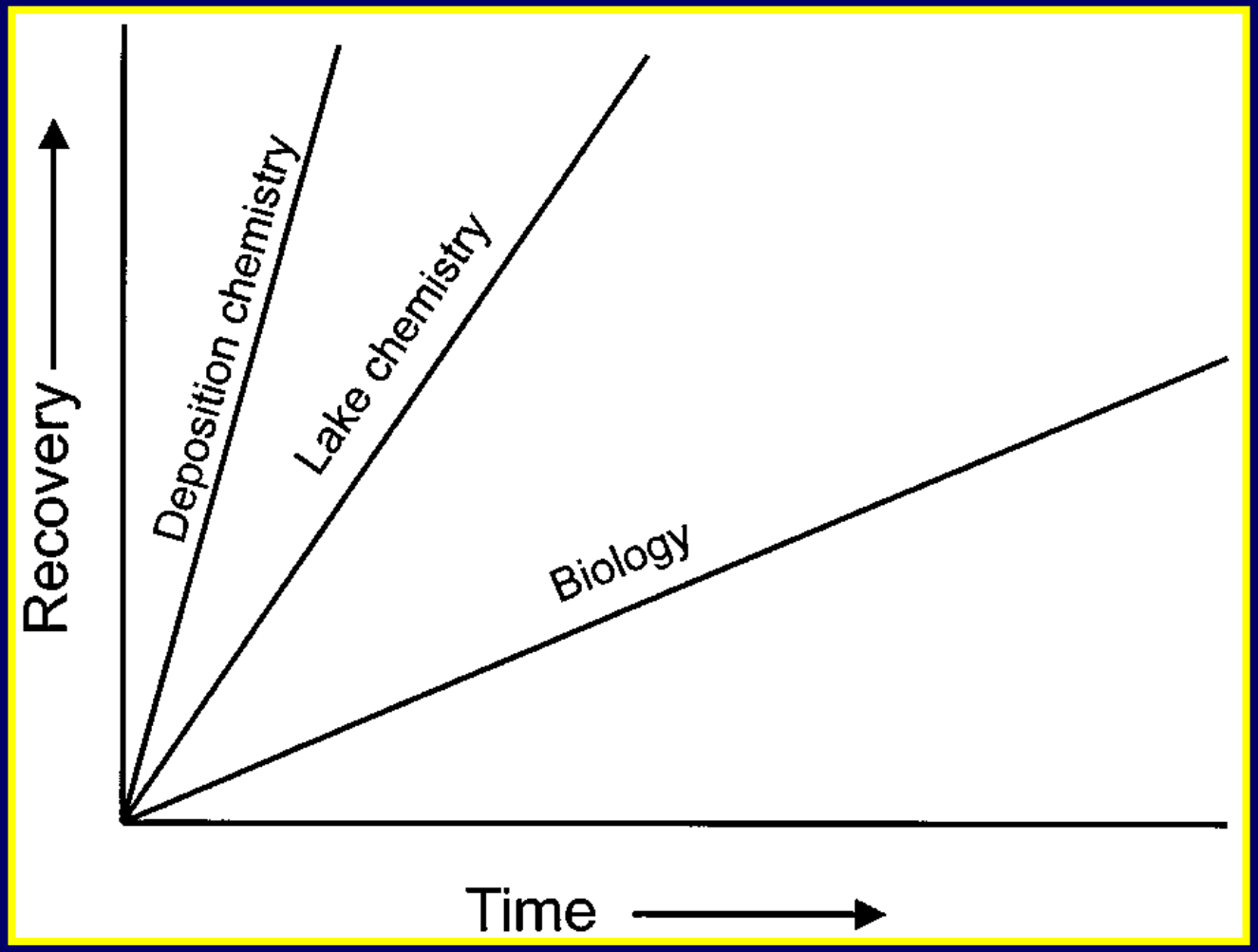
OBJECTIVES

Determine if current [Cu] and [Ni] in Sudbury lakes are regulating Daphniid recovery

Levels?

Multiple stressors?

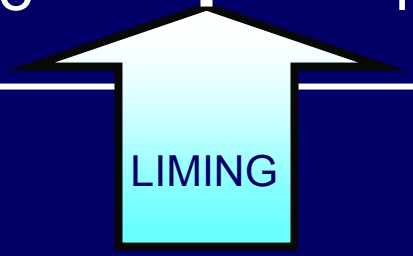
[Cu] laboratory bioassays



General sequence of recovery (Keller, Gunn and Yan, 1999)

Copper concentrations in restored lakes

Lake	1973 [Cu] µg/L	1979 [Cu] µg/L	2005 [Cu] µg/L
Hannah N	1090	25	15.8
Middle N	496	25	15.4
Clearwater	98	49	7.4



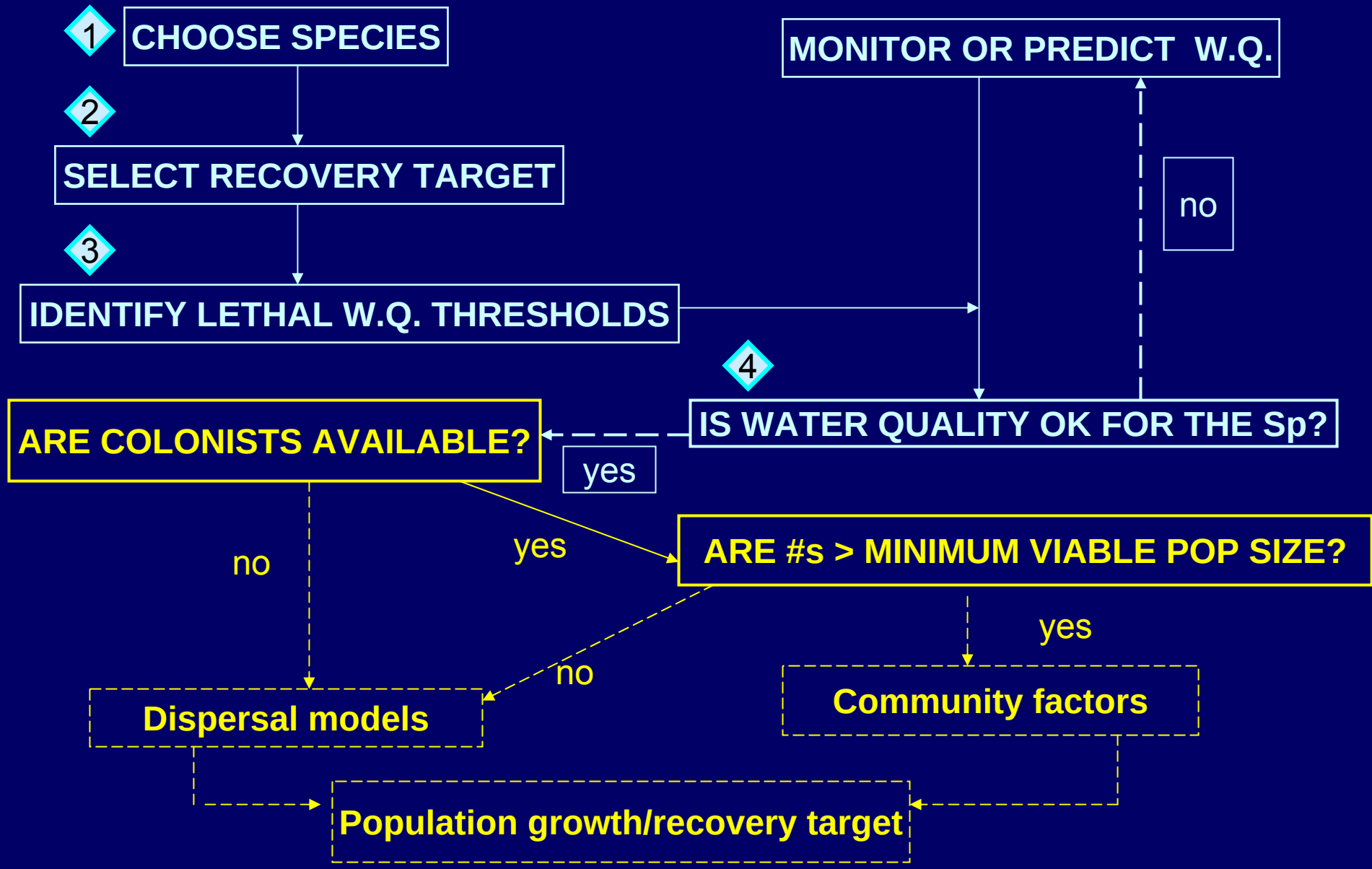
Successful Recovery of zooplankton (Keller 1992; Locke1994,Keller 1998)

Photo by CGB Indiana State University

Copepods but not Cladocera after pH 6.0 was achieved

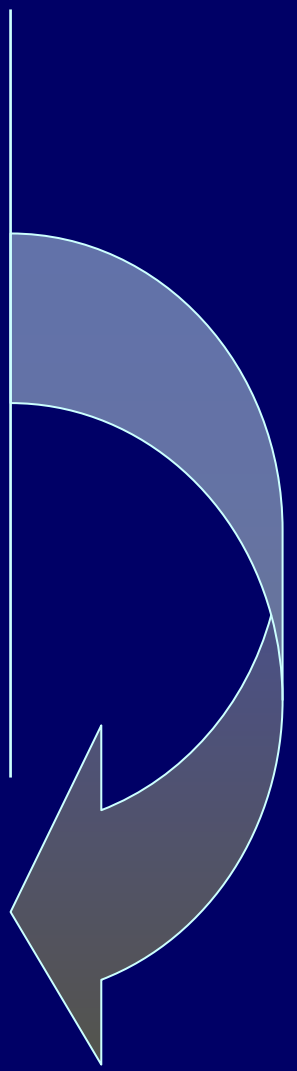
(Yan et al, 1996; Yan et al 2004)

First conceptual framework of the processes in the ecological recovery of a species from historical acidification (Yan et al. 2003)



1. Choose species: Reference Lakes

2. Identify lethal WQ thresholds
    . Lab bioassays
        . Short term acute toxicity
        . Partial life cycle
    . In situ bioassays



3. Is the Water Quality good for the Sp?

Literature Review

Metals?

Cu

Ni

Species of Interest?

Soft Water?

Ca

Mg

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SPECIES OF INTEREST IN REFERENCE LAKES

	A	B
	(Mean Biomass mg/m^3 d.w.)	
Holopedium gibberum	*7.7-11.6*	*4.34*
D. mendotae	*3.3 -9.4*	*4.43*
D. pulex	*2.14 to 4.2*	*5.85*
D. catawba	*0.74*	*1.42*
D. ambigua	*0.11 to 0.37*	*0.02*

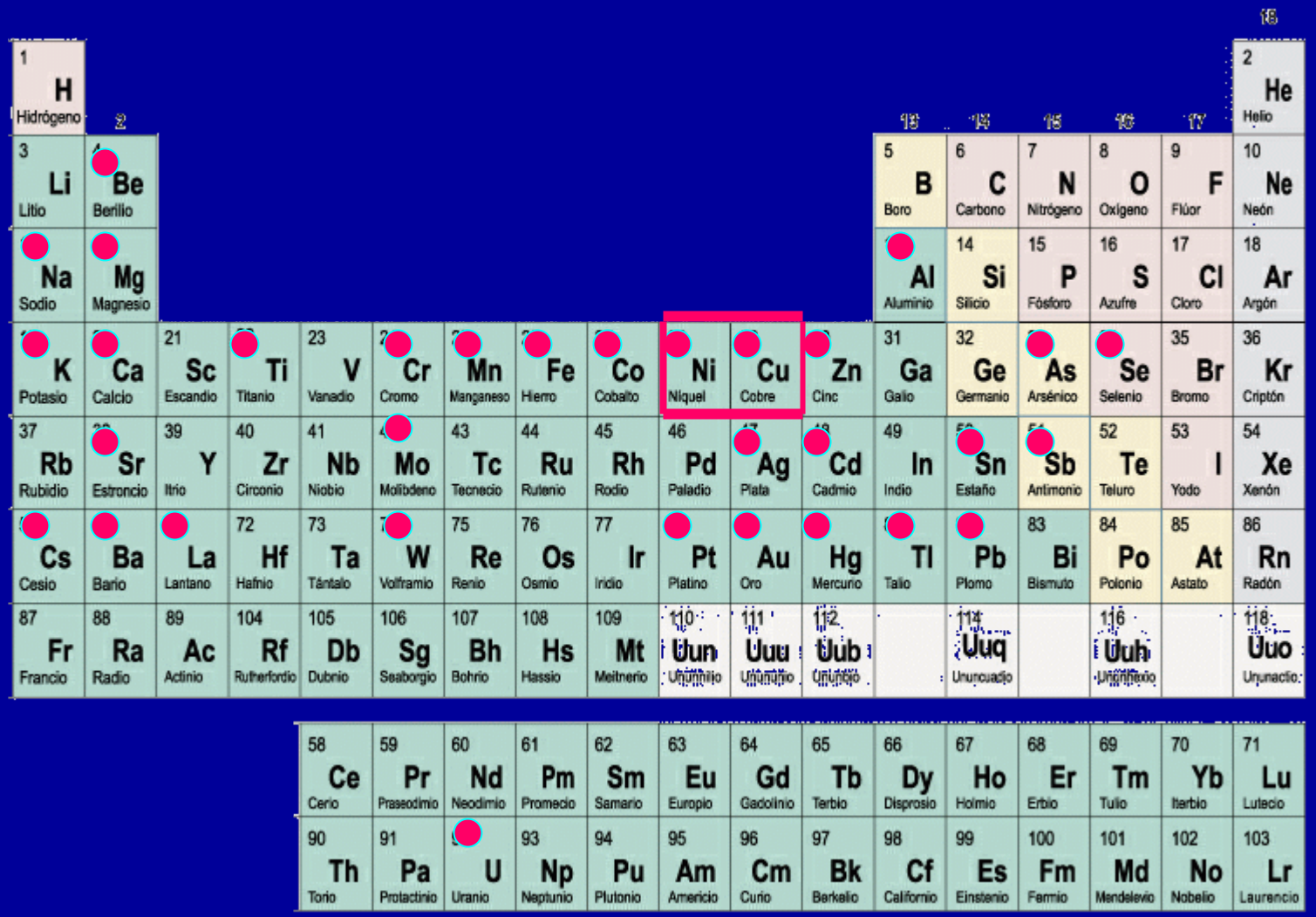
Sources:

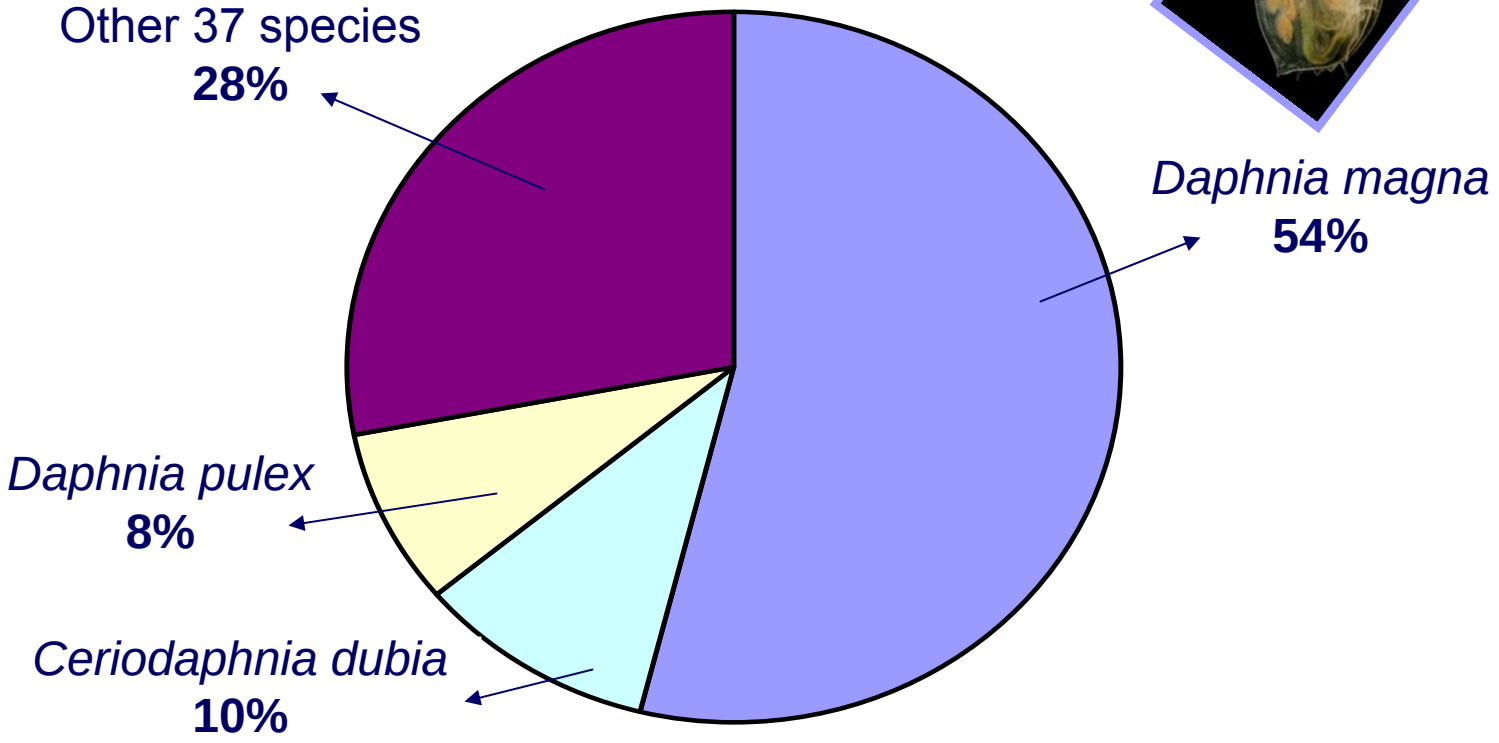
A: 259 lakes survey, 10 years (Yan, Keller, Pitblado and Mackie. 1988)

B: DESC 2000-2002 Zooplankton Data Set: Blue Chalk & Red Chalk Lakes

WATER QUALITY: soft, slightly acidic

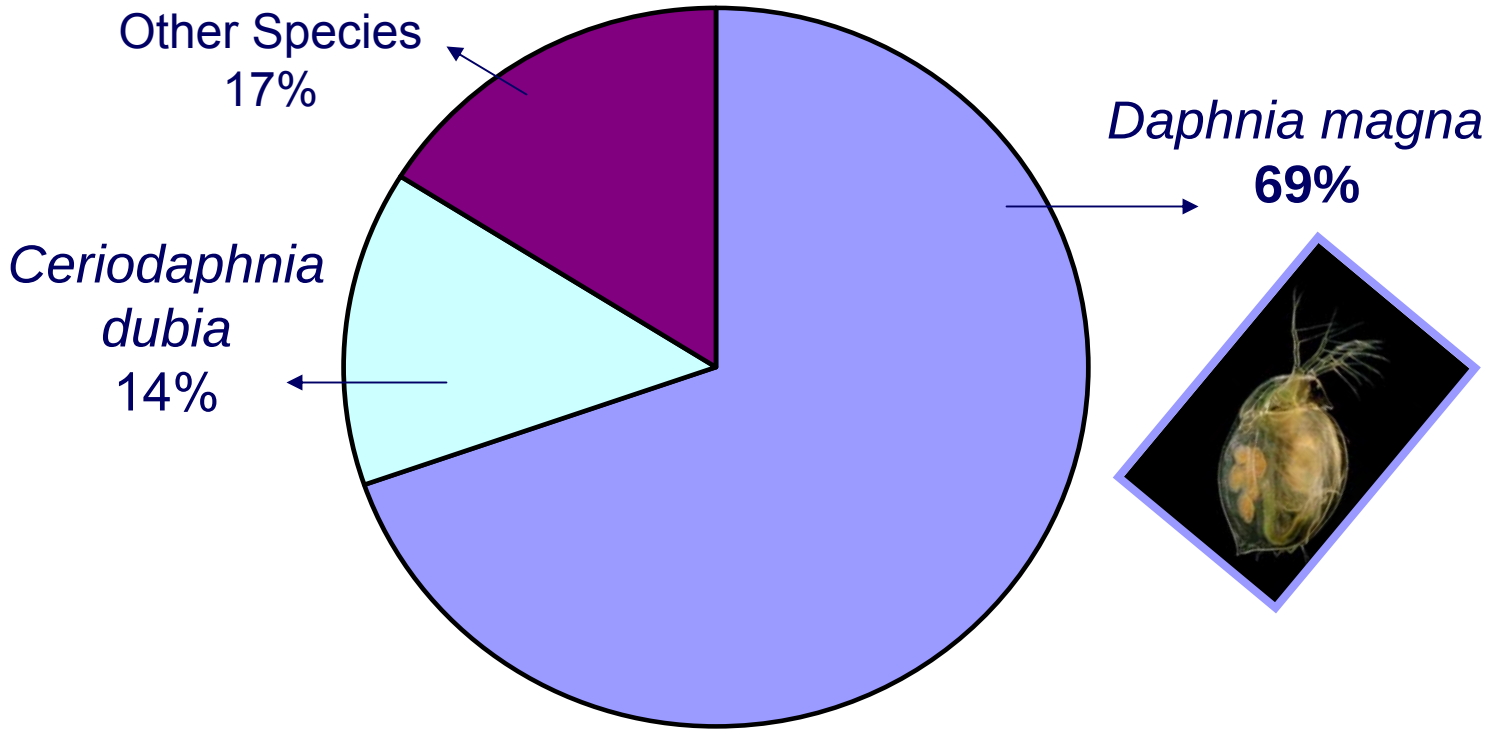
Elements tested in 641 toxicity studies with *Daphnia spp.*





Percentage of Copper studies in Cladocera

Photo by Fraunhofer Institute of Molecular Biology



Percentage of Nickel studies in Cladocera

Photo by Fraunhofer Institute of Molecular Biology

Number of studies with Cu and Ni on Species of Interest

Species of *Daphnia*	Cu	Ni
D. ambigua	3	0
D. catawba	0	0
D. pulex	12	1
D. galeata	3	1 SW
Total	18	2

NO STUDIES ON CLADOCERA WITH THESE 2 METALS MIXED

Why not… *Daphnia magna*?

Why not… the previous studies with the species of interest?

Photo by Fraunhofer Institute of Molecular Biology

CULTURE MEDIA

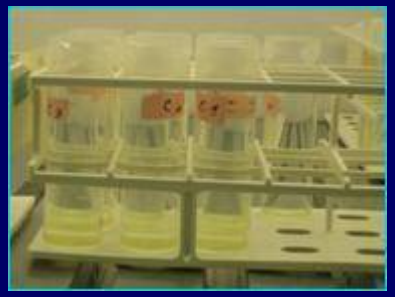
COMPARISON OF HARDNESS IN DIFFERENT CULTURE MEDIA

Medium	Ca	Mg	Hardness	Classification*
ISO	80	12	250	Very Hard
Combo	10	3	40	Soft
RFW	1.75	1.75	10	Soft
FLAMES	2.5	0.75	9.40	Soft
Shield LAKES	2.5	0.75	6 to 16	Soft

* Classification based on the US Geological Survey 2003

Chemical composition of soft water media for standard bioassays

Major Ions mg/L	Lakes mg/L	Reconstituted Freshwater mg/L	Soft Combo mg/L	FLAMES mg/L
Ca	2.536	1.75	10.02	2.536
Cl	0.388	0.24	18.53	0.388
Mg	0.749	1.51	3.65	0.749
SO4	9.049	10.17	14.42	9.049
K	0.369	0.26	3.91	0.370
Na	1.103	3.28	31.95	1.103
Trace Elements and Vitamins	mix	none	mix	mix



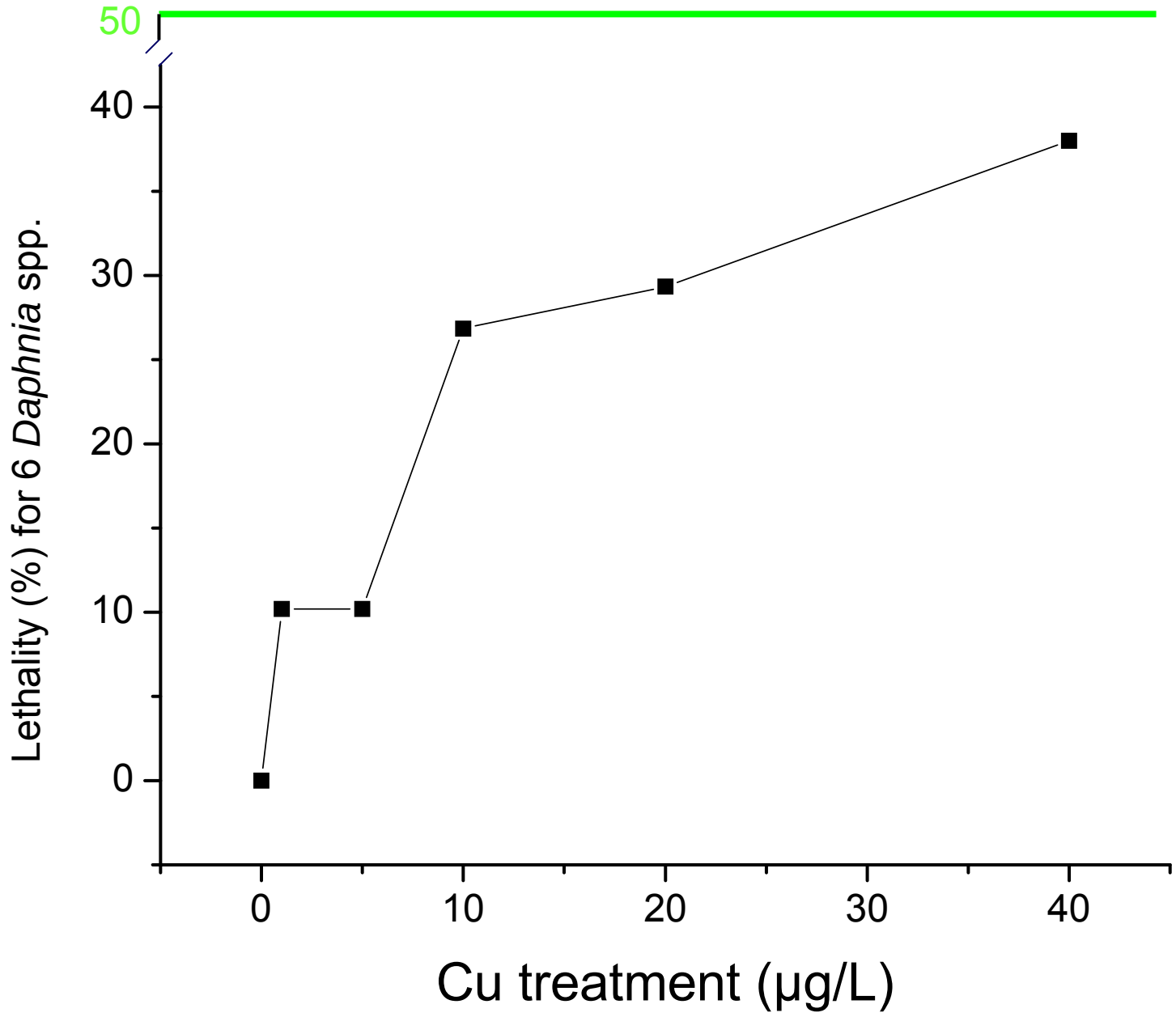
All bioassays done in culture chambers

FLAMES Laboratory, Dorset, Ontario

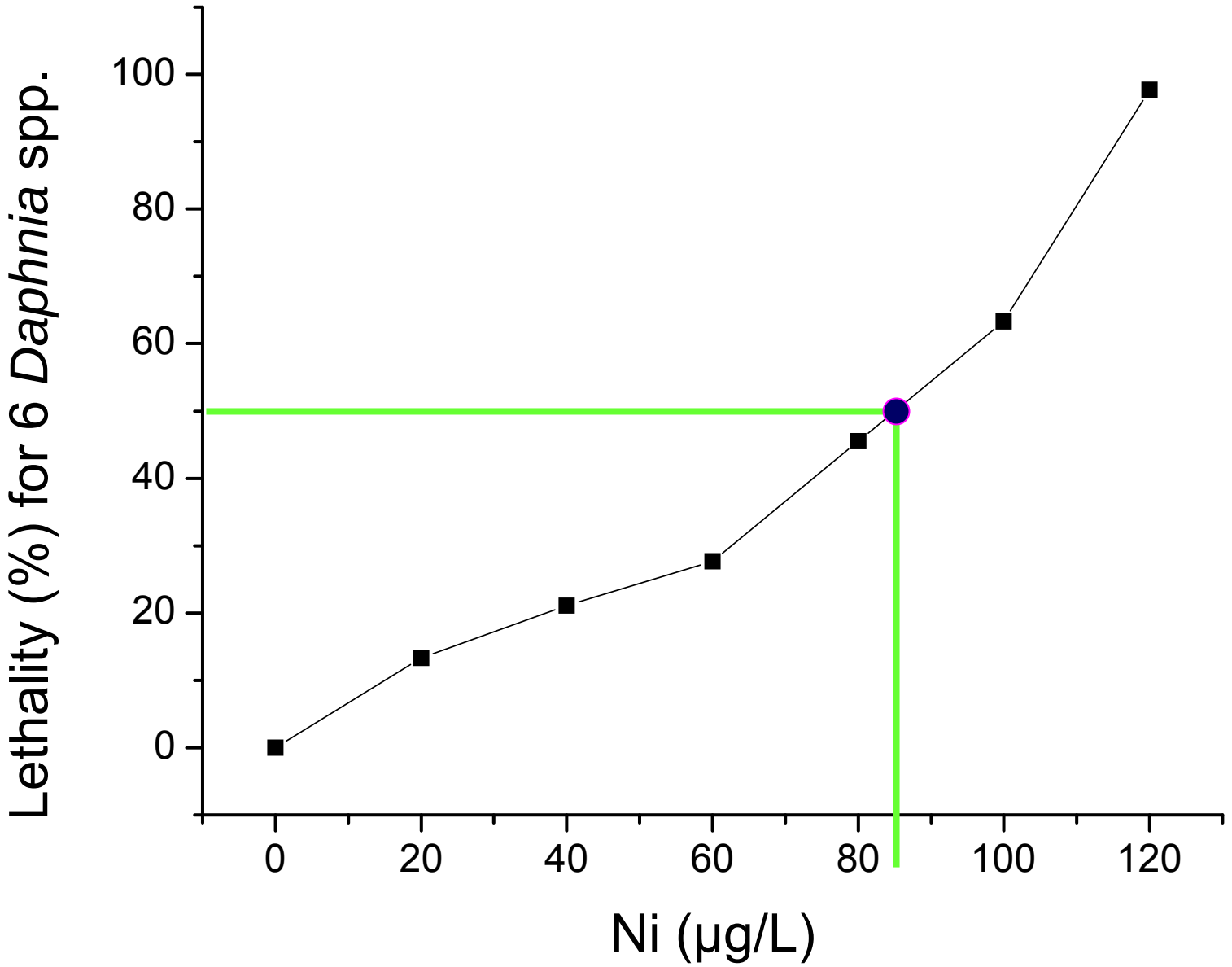
ACUTE TOXICITY testing

RANGE FINDING

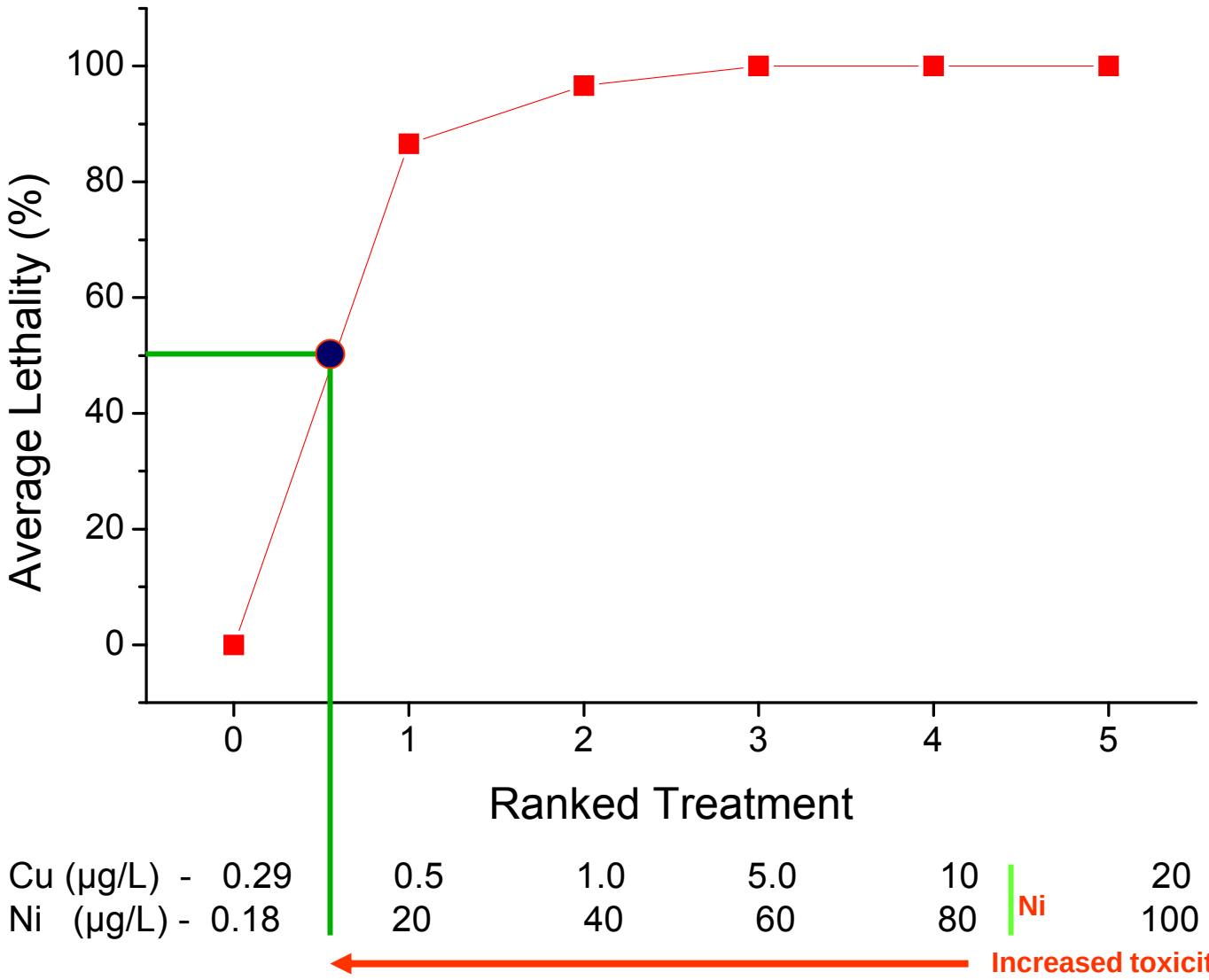
Copper	[5]	0.28 to 40 µg/L
Nickel	[5]	0.18 to 120 µg/L



Lethality of different [Cu] to the Daphniid species in 72 hr. bioassay



Lethality of different [Ni] to the Daphniid species in 72 hr. bioassay

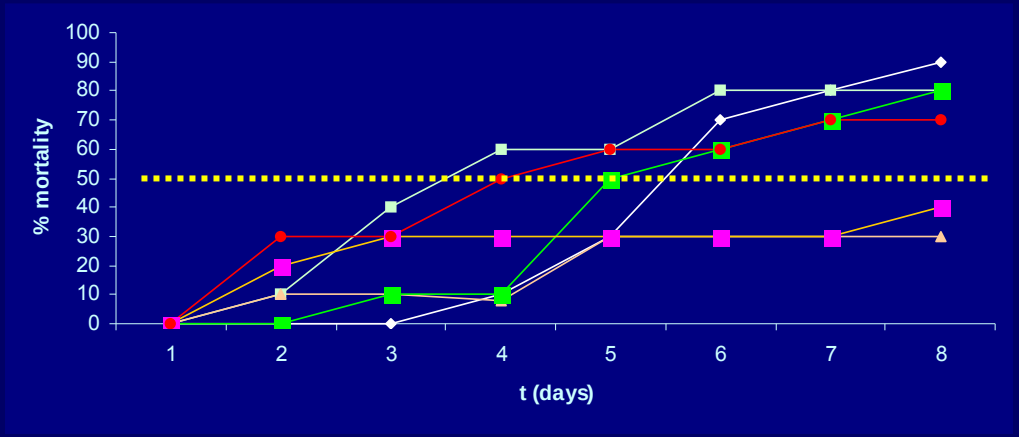


Lethality of mixes of Cu and Ni to the Daphniid species in 72 hr. bioassay

14 DAY PARTIAL LIFE CYCLE

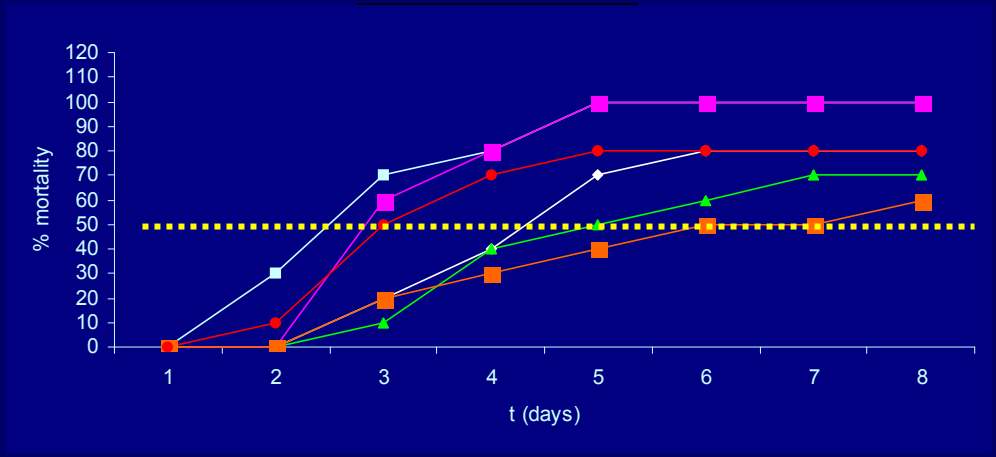
[Cu] 2.5 to 20 µg/L

0.29 - 2.5 - 5 - 10 - 15 - 20

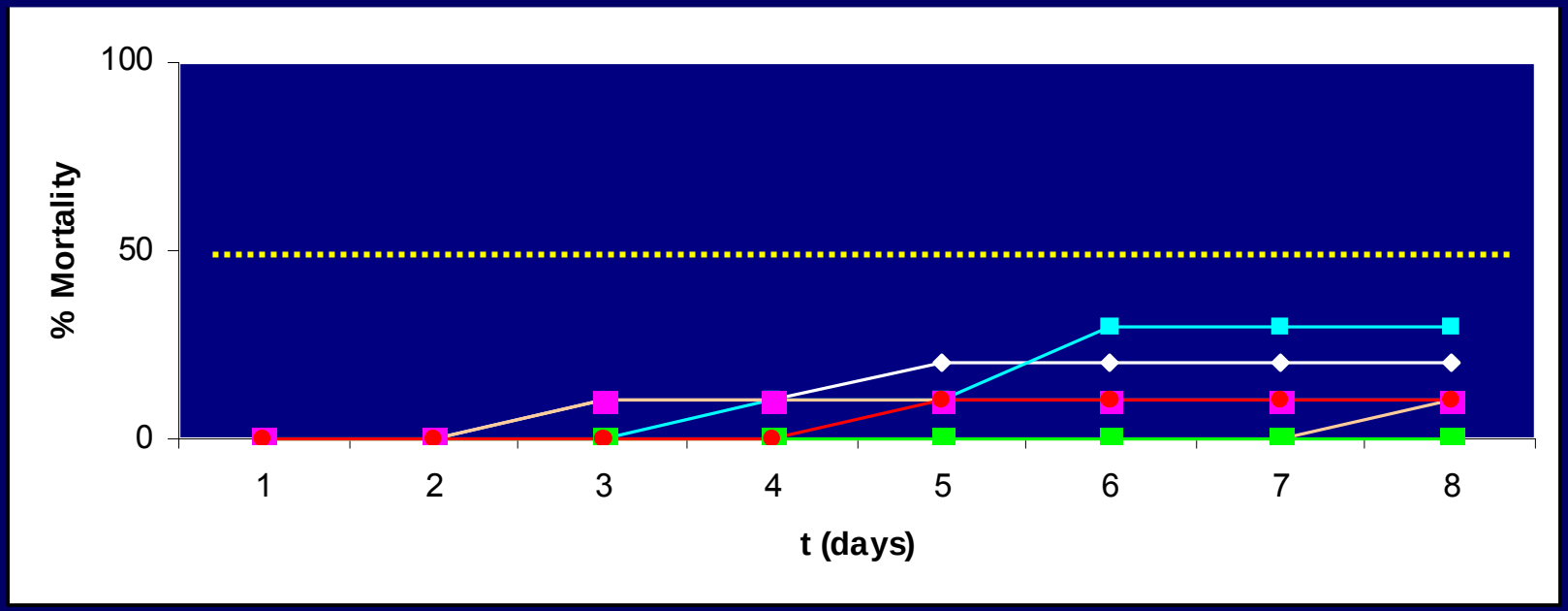


Daphnia ambigua mortalities in 14 days

[Cu] µg/L : Control 2.5 5 10 15 20

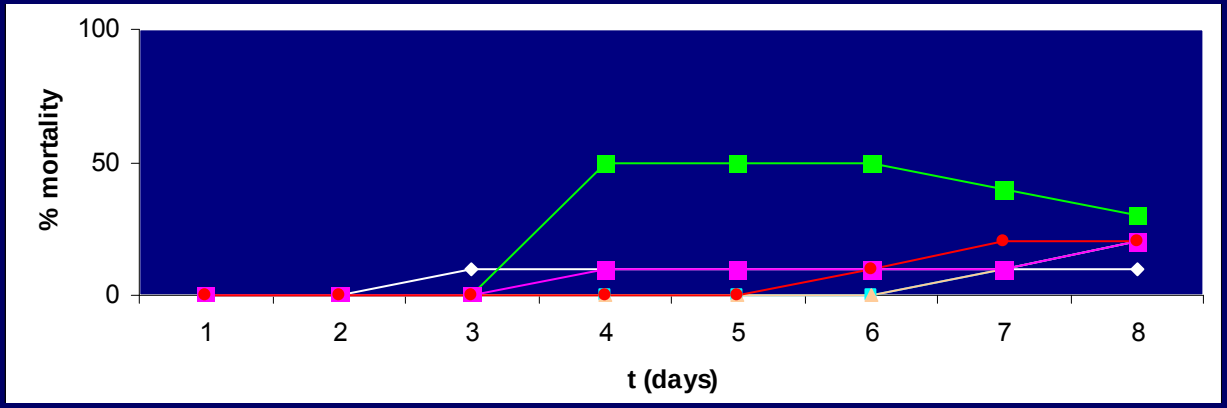


Daphnia catawba mortalities in 14 days



Daphnia pulex mortalities in 14 days

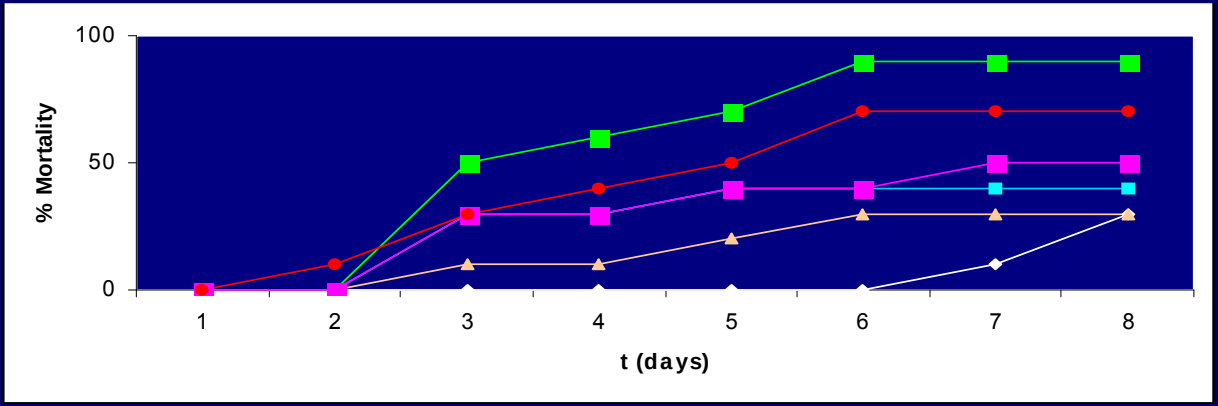
[Cu] µg/L : Control 2.5 5 10 15 20



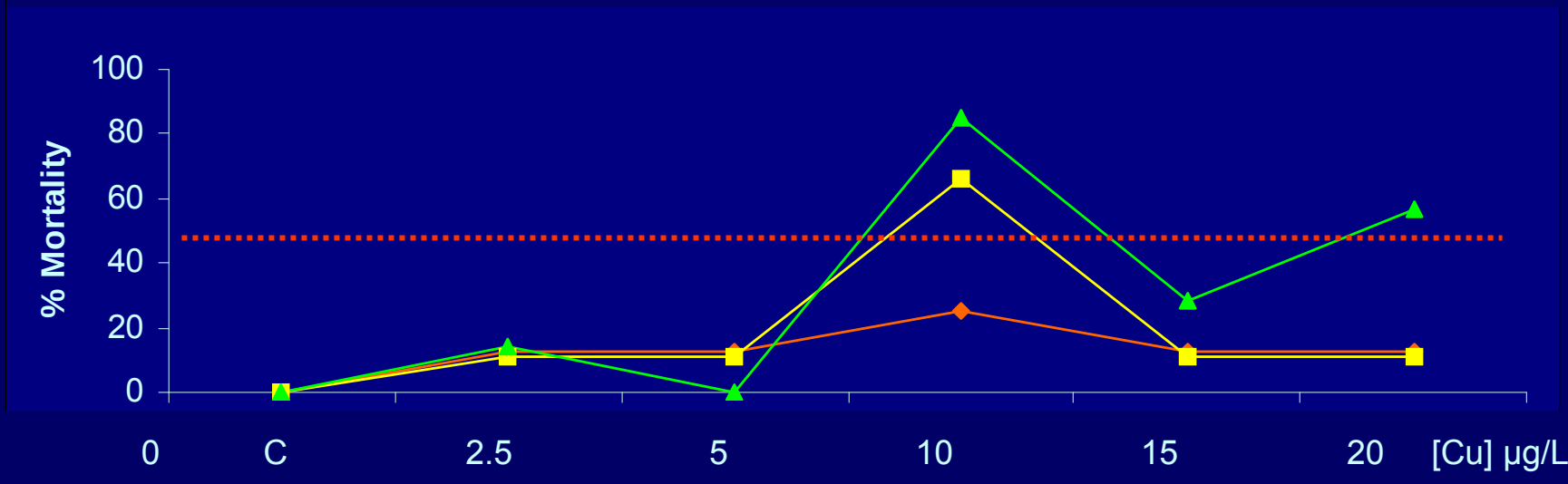
Daphnia pulicaria mortalities in 14 days

Control

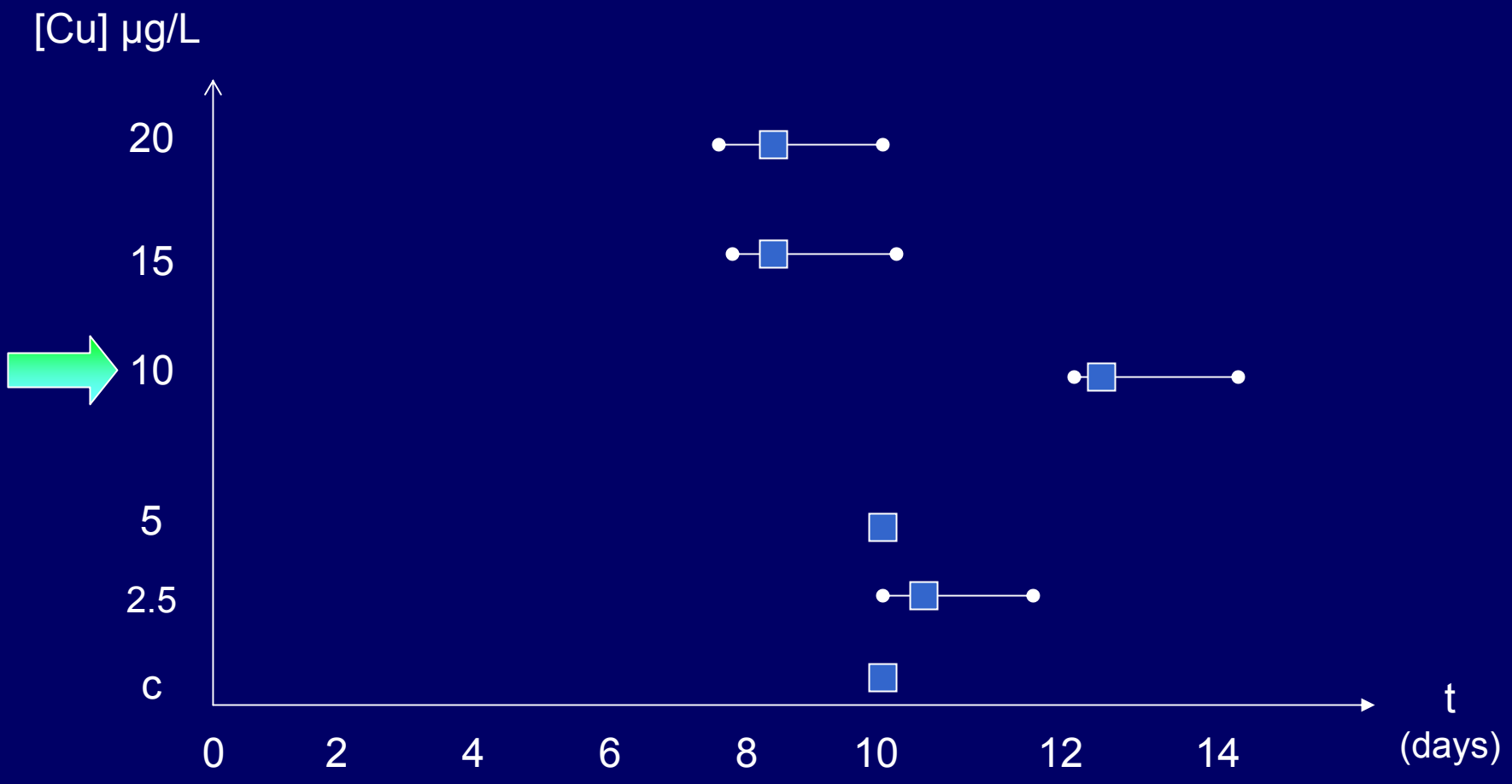
[Cu] µg/L: 2.5 5 10 15 20



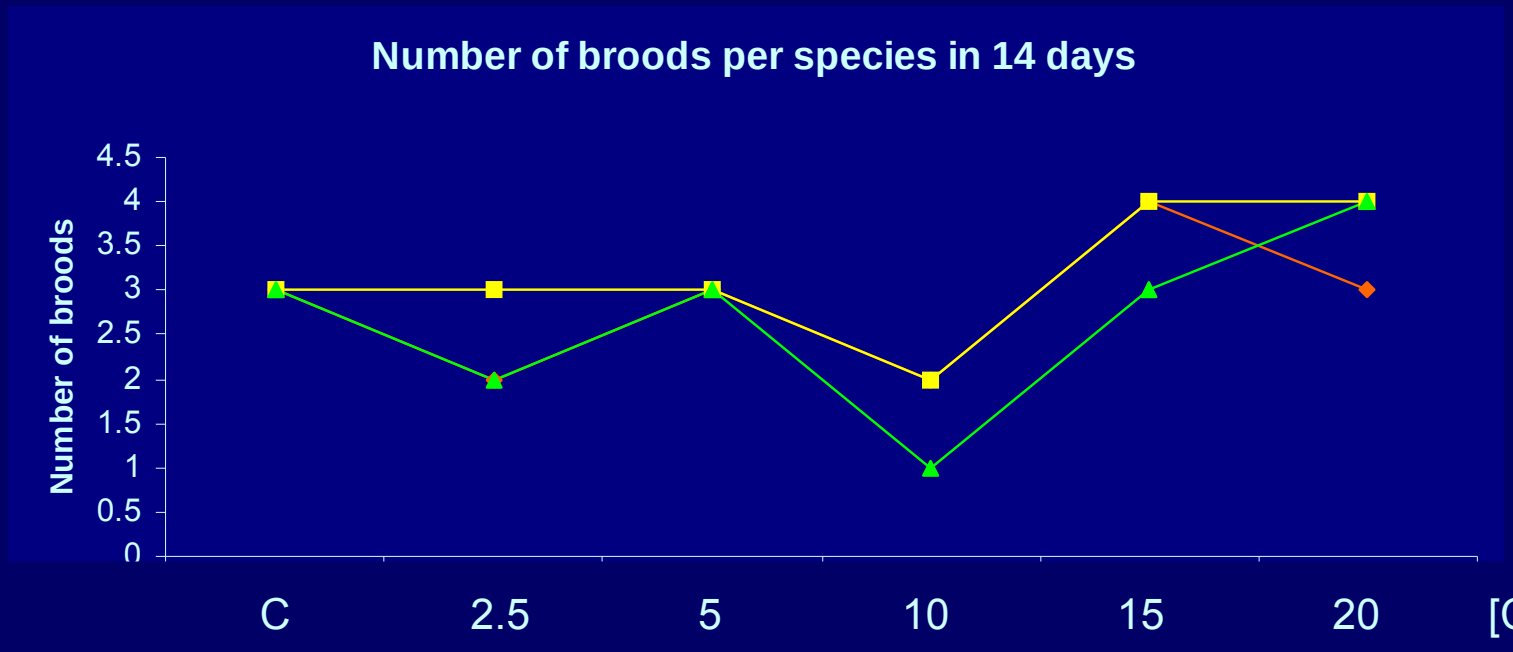
Daphnia mendotae mortalities in 14 days



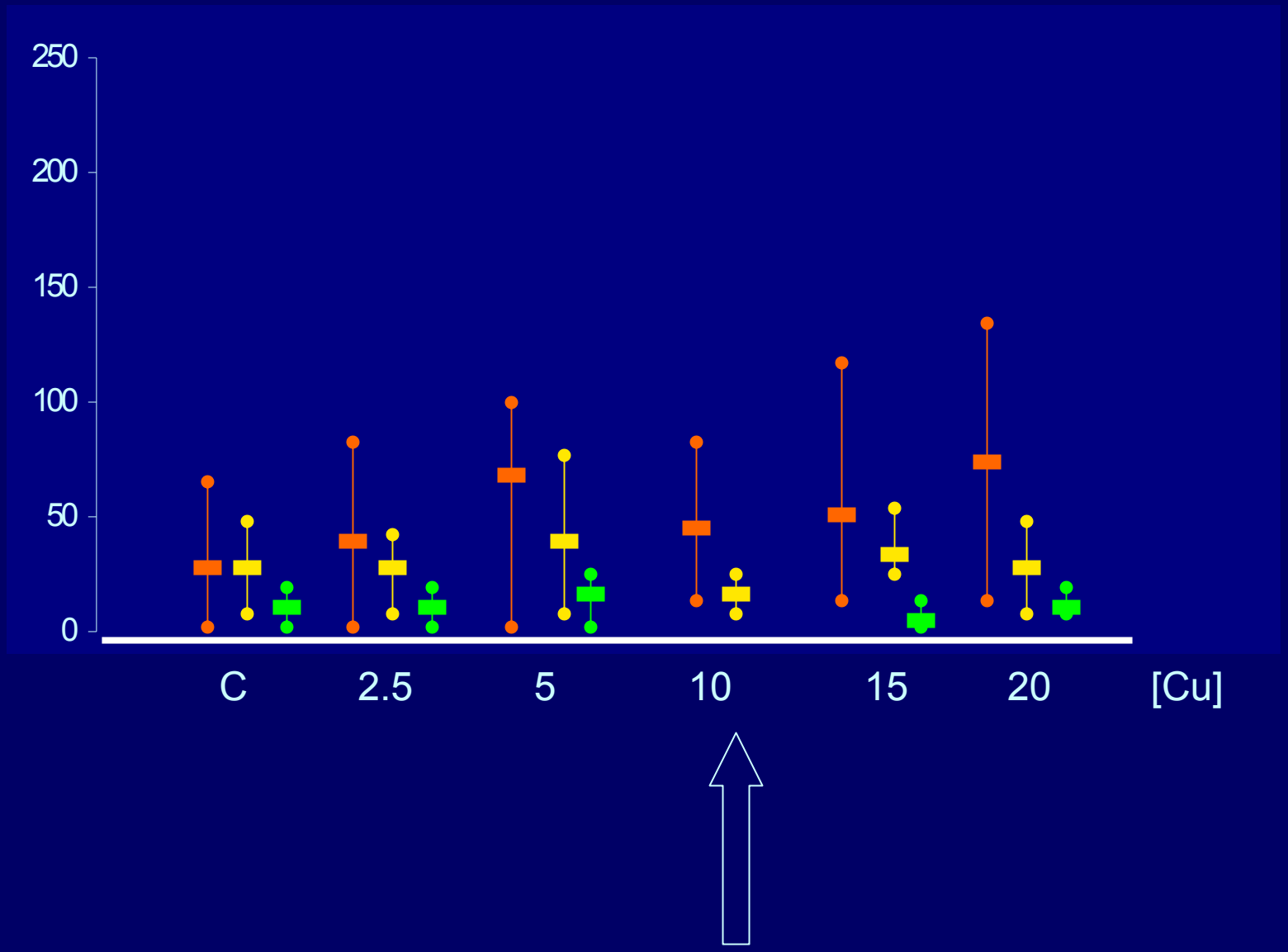
Mortality values at different copper concentrations for *Daphnia pulex*, *D. pulicaria* and *D. mendotae* corrected with Abbot's formula

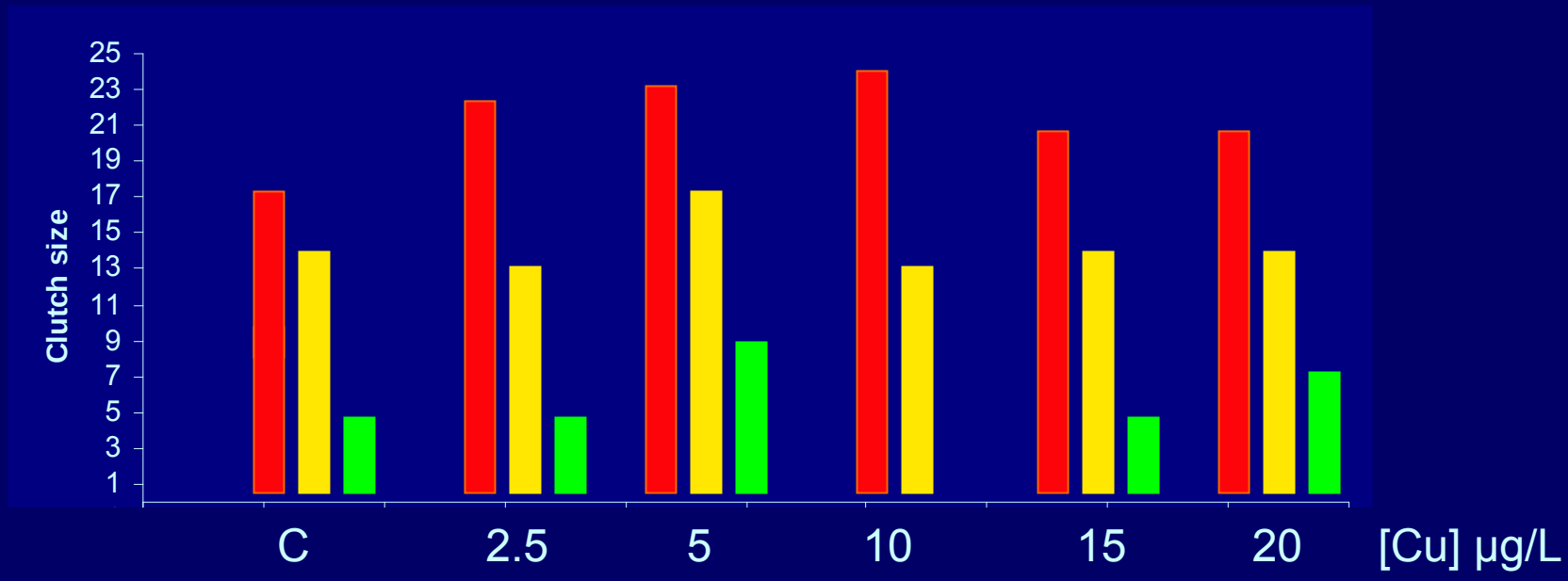


Day of primaparity per [Cu] concentration for the 3 sp

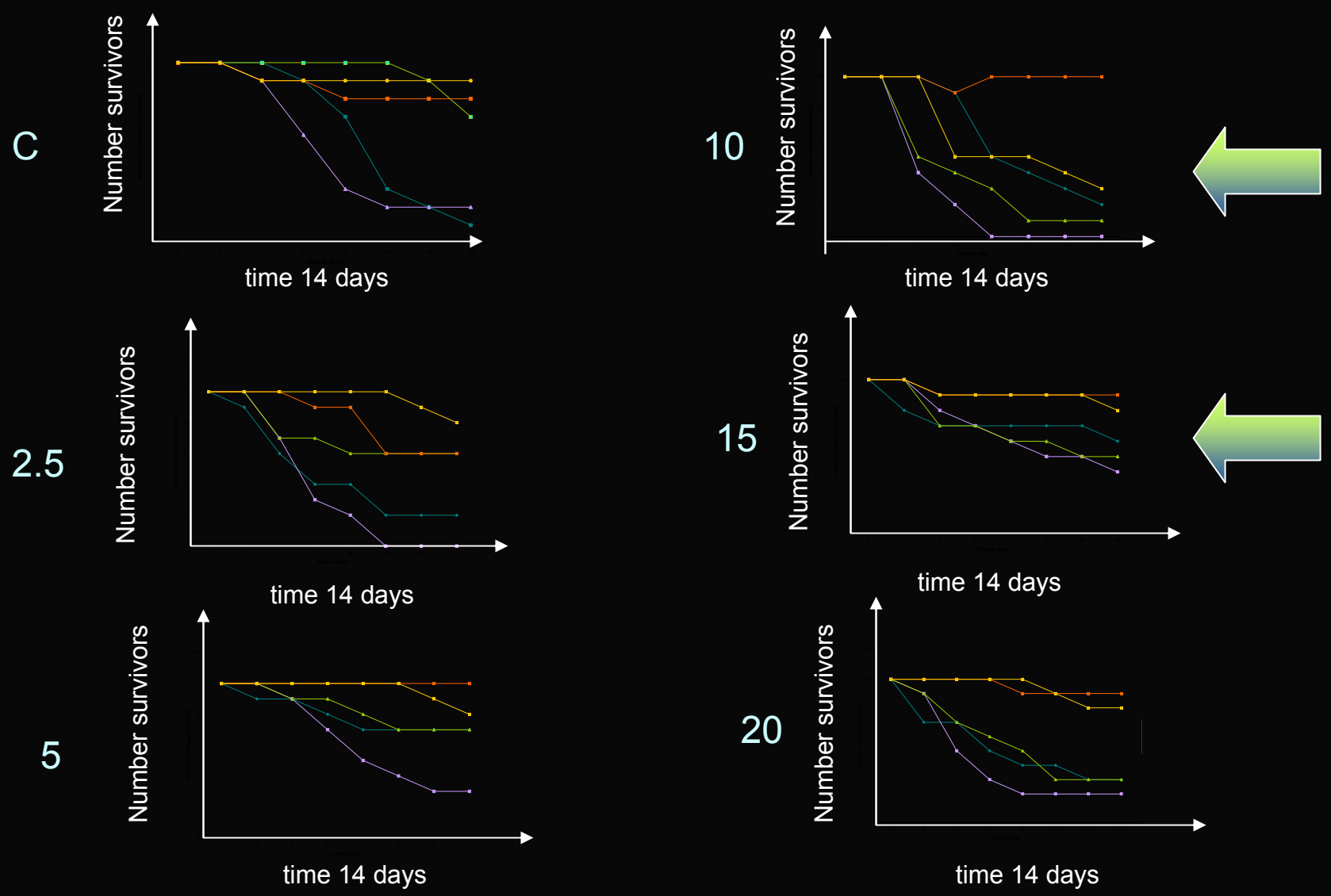

Number of broods per species in 14 days
Number of broods
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
C
2.5
5
10
15
20
[Cu] µg/L

Number of neonates produced per species per [Cu] in 14 days





Maximum clutch size per Daphniid in each copper concentration



Daphniid survival (days) in different [Cu] (µg/L)

PRELIMINARY CONCLUSIONS

FLAMES medium

Short term acute toxicity tests

[Cu + Ni] >>> [Cu] > [Ni]

LC 50 Cu: > 40 (µg/L)

LC 50 Ni : ~ 85 (µg/L)

LC50 mix: < 0.5 Cu + < 20 Ni (µg/L)

Partial life cycle toxicity tests

Non monotonic responses

Mortality values higher at 10

Delayed reproduction at 10

Number of broods diminished at 10 and increased at 15 and 20

Neonate production diminished at 10 and increased at 15 and 20

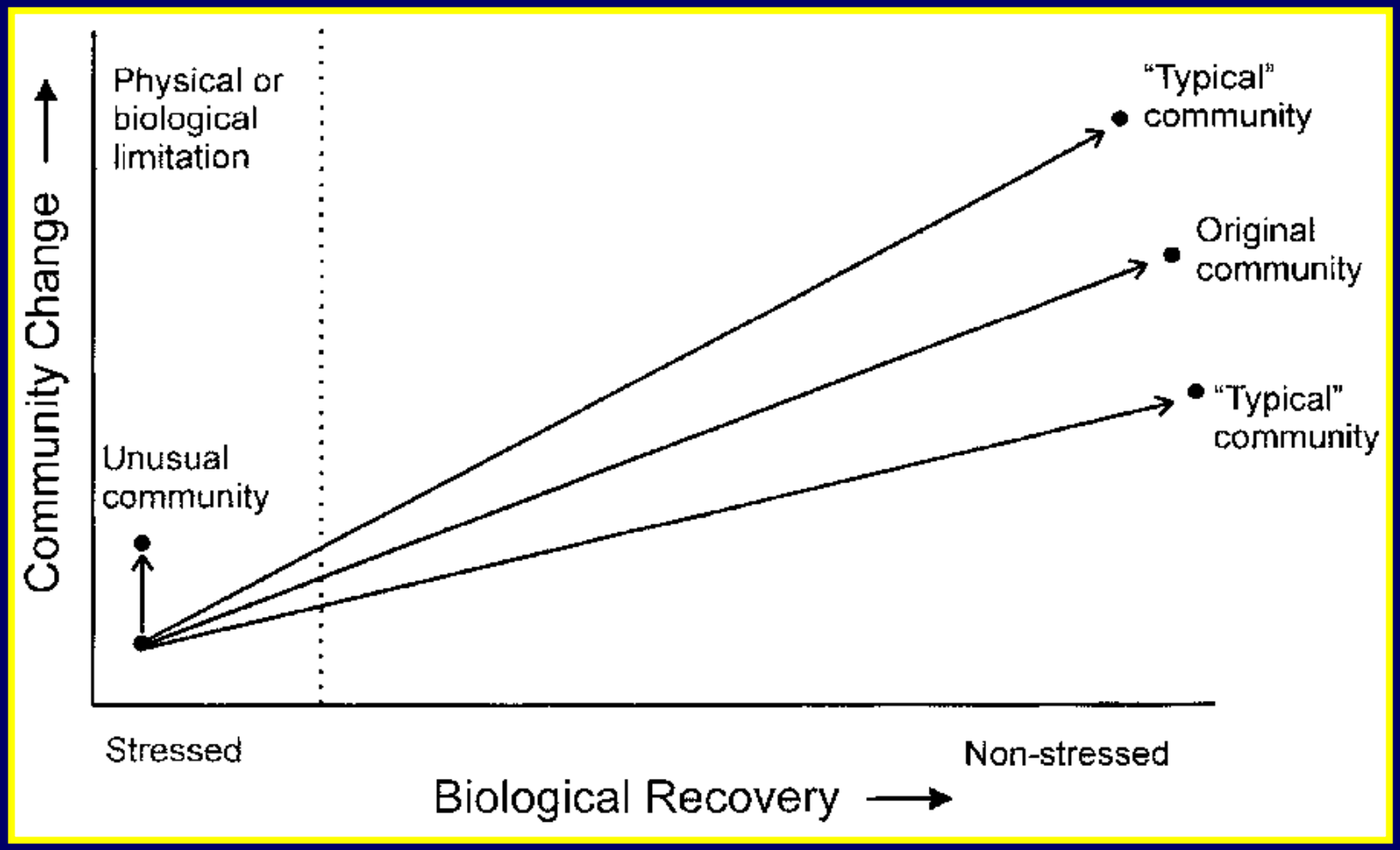
Maximal clutch size at 5 minimal at 10 for *D. mendotae*

Shifts in survival between 10 and 15

Need for refinement of culture techniques for species of Cladocera

Next Steps

Partial life cycle bioassays with Nickel
and mix of Cu and Ni
Speciation of metals in FLAMES medium
Analysis of data
Selection of lakes for in situ bioassays
Field bioassays



Possible trajectories of biological recovery

(Keller, Gunn and Yan, 1999)

Acknowledgements

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