Ambient Water Toxicity in San Francisco Bay: 1993-2002

Dr. Scott Ogle, *Pacific EcoRisk*
Dr. Andrew Gunther, *Applied Marine Sciences*

Paul Salop, David Bell, Jordan Gold, and Staff
Applied Marine Sciences

Jeffrey Cotsifas, Stephen Clark, and Staff
Pacific EcoRisk

RMP Status & Trends Monitoring

1993 (Year One):

Ambient water samples were collected from 8 stations in March, May, and September of 1993

2 Toxicity Tests:

- Bivalve embryo test w/ *Mytilus* and *Crassostrea*
- Algal growth test w/ diatom *Thalassiosira*

Results:

No toxicity observed

Thalassiosira exhibited biostimulation

RMP Status & Trends Monitoring

1994 (Year Two):

Ambient water samples were collected from 13 stations in February and September

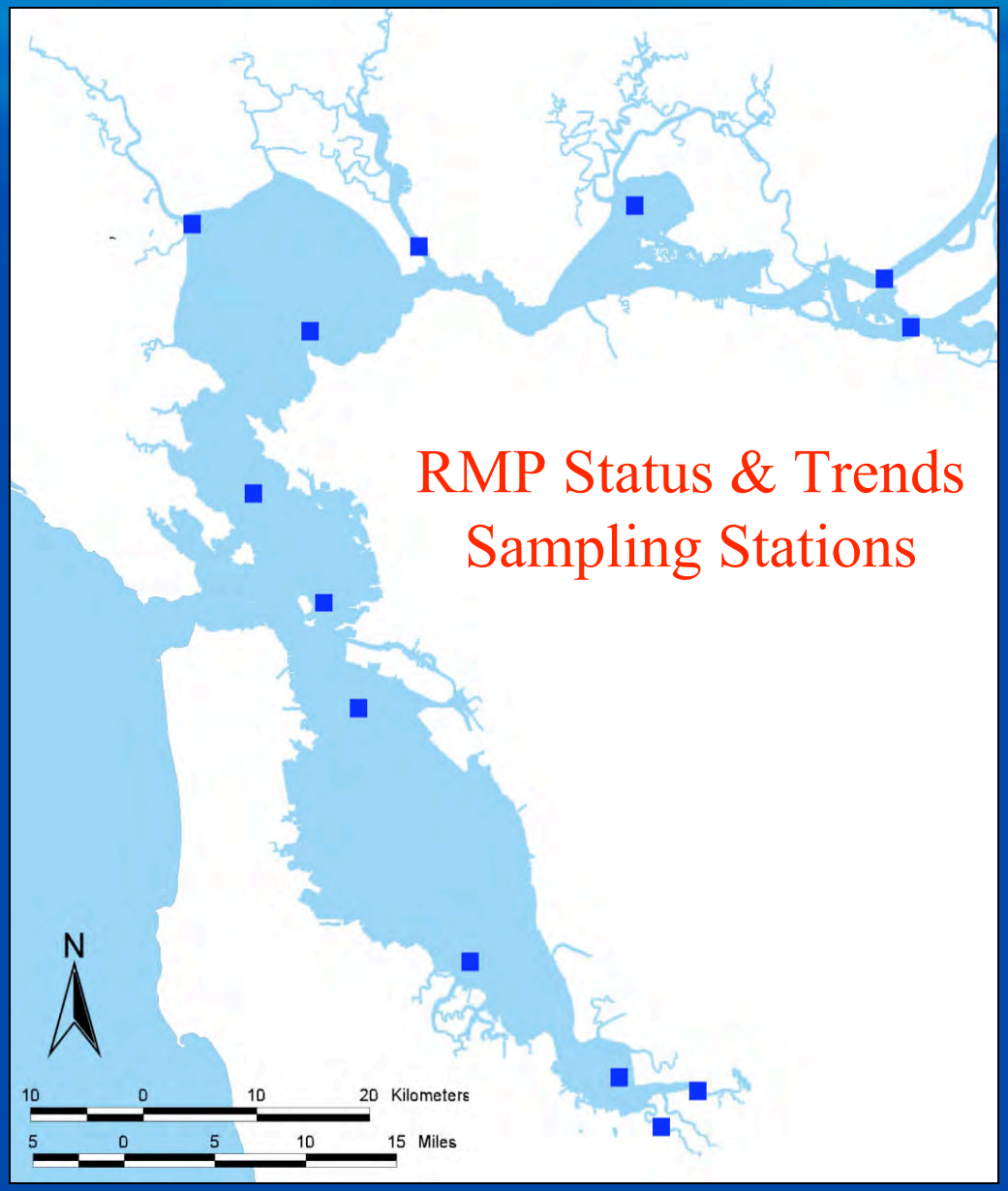
2 Toxicity Tests:

- Bivalve embryo test w/ *Mytilus* and *Crassostrea*
- *Thalassiosira* discontinued
- 7-day Mysid survival test with *Americamysis bahia*

Results:

No toxicity to bivalve embryo development;

Slight toxicity to mysid at the Napa River and Red Rock stations


RMP Status & Trends
Sampling Stations
N
10 0 10 20 Kilometers
5 0 5 10 15 Miles

RMP Status & Trends Monitoring

1995 (Year Three):

Ambient water samples were collected from 13 stations in February and September

2 Toxicity Tests:

- Bivalve embryo test w/ *Mytilus* and *Crassostrea*
- 7-day Mysid survival test with *Americamysis bahia*

Results:

No toxicity to bivalve embryo development observed

Slight toxicity to mysid at the San Joaquin River station

RMP Status & Trends Monitoring

1996 (Year Four):

Ambient water samples were collected from 13 stations in February and September

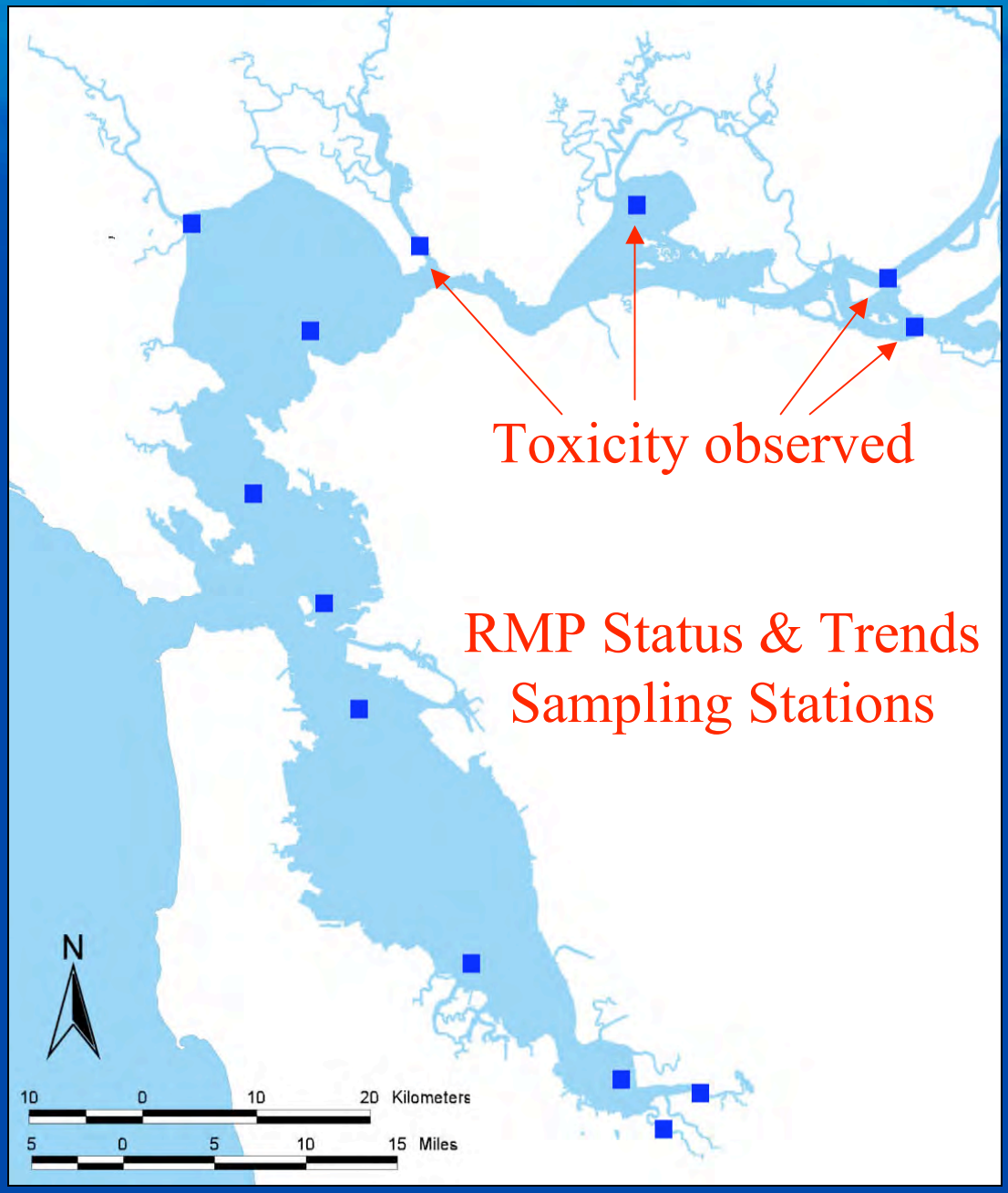
2 Toxicity Tests:

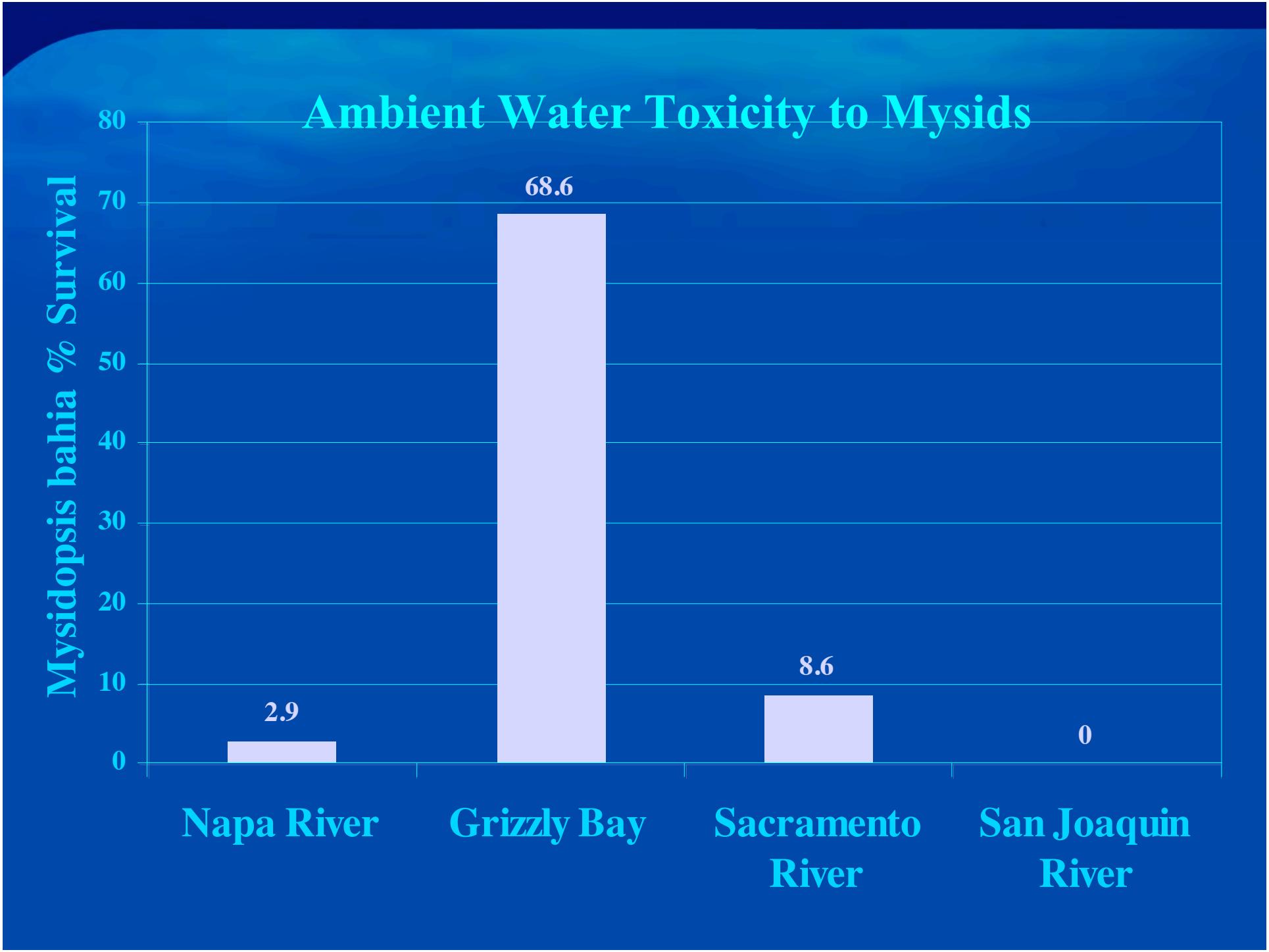
- Bivalve embryo test w/ *Mytilus* and *Crassostrea*
- 7-day Mysid survival test with *Americamysis bahia*

Results:

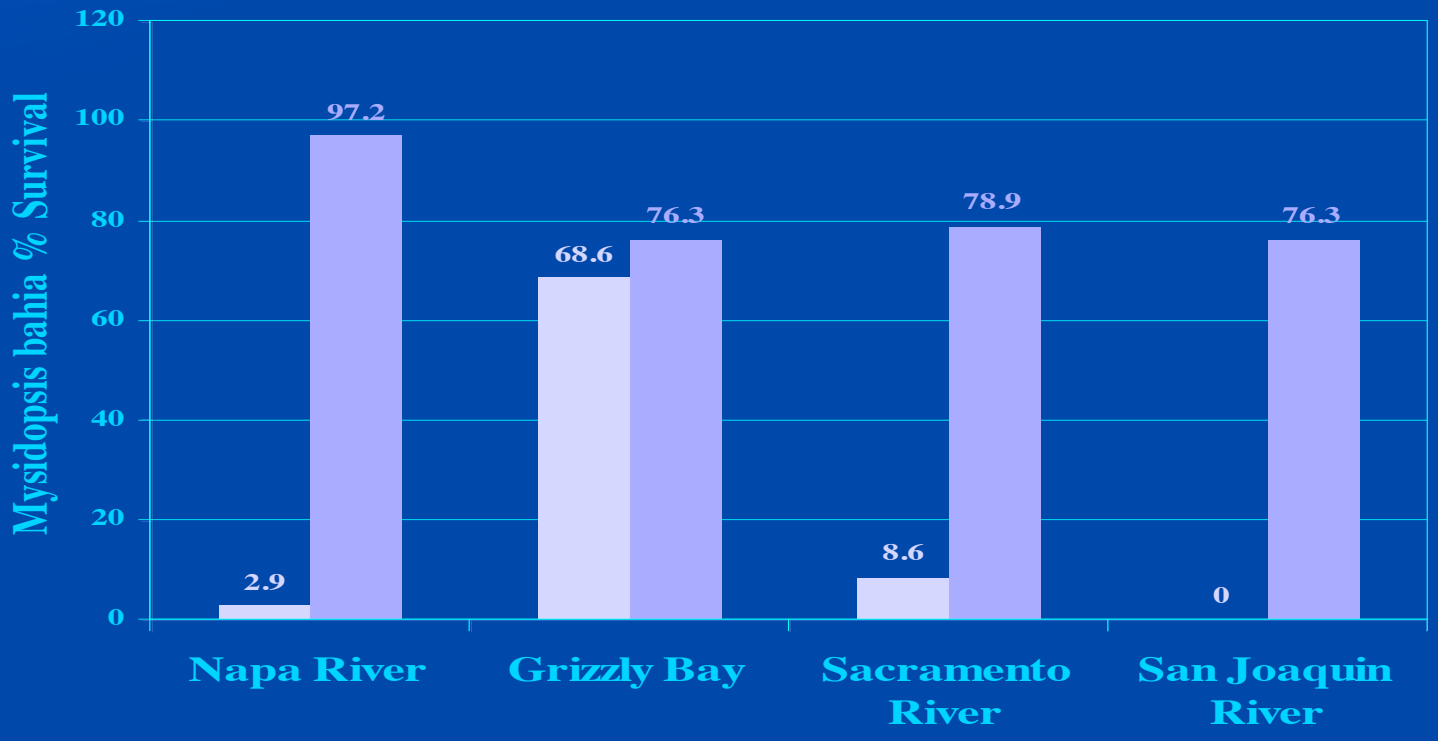
No toxicity to bivalve embryo development observed

Significant toxicity to mysid at the Napa River, Grizzly Bay, and Sacramento and San Joaquin River stations!


Toxicity observed
RMP Status & Trends
Sampling Stations
N
10 0 10 20 Kilometers
5 0 5 10 15 Miles


Ambient Water Toxicity to Mysids
Mysidopsis bahia % Survival
80
70
60
50
40
30
20
10
0
68.6
2.9
8.6
0
Napa River
Grizzly Bay
Sacramento River
San Joaquin River

Ambient Water Toxicity to Mysids



RMP Status & Trends Monitoring

1997 (Year Five):

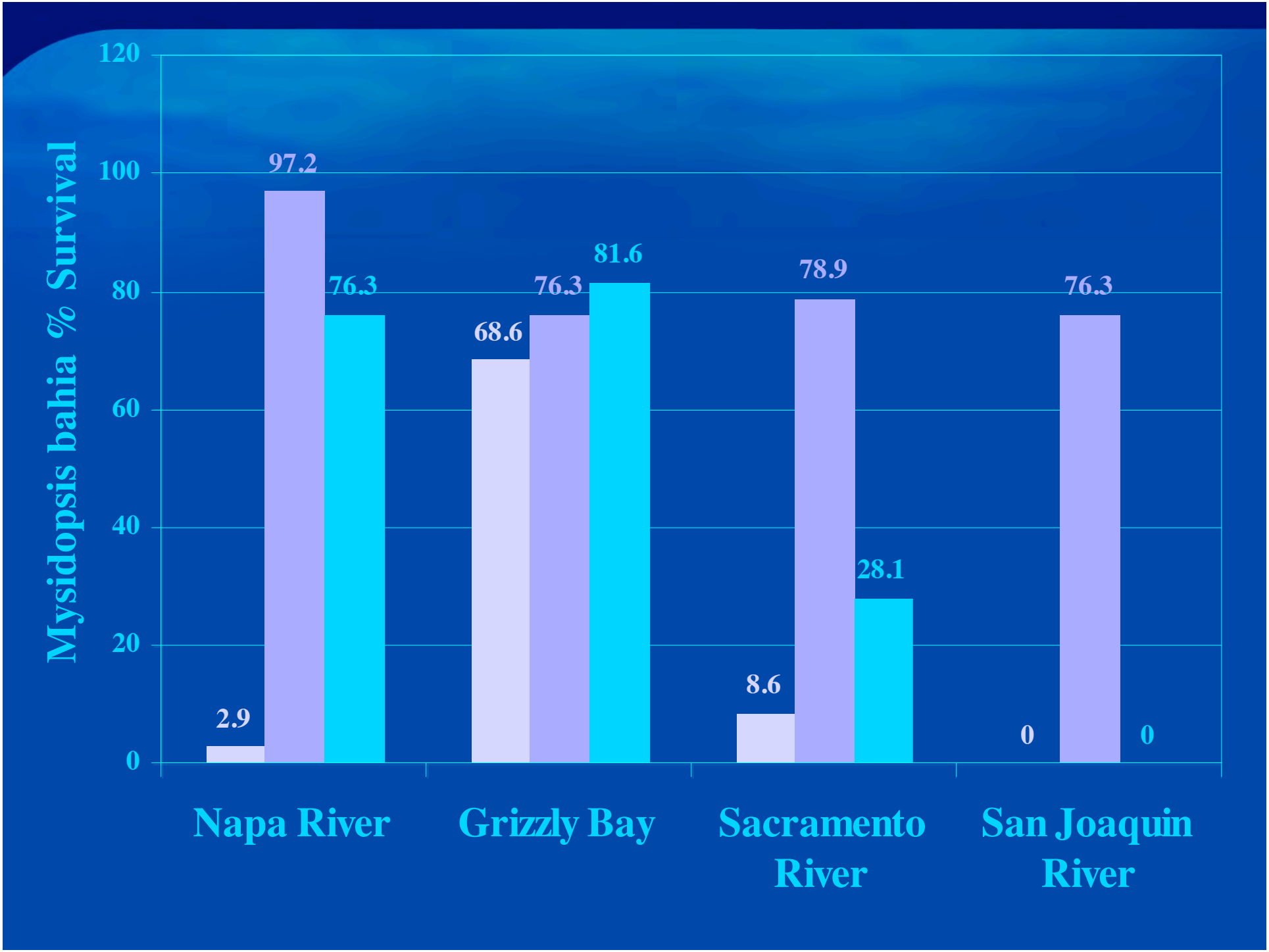
Ambient water samples were collected from 13 stations in February and September

2 Toxicity Tests:

- Bivalve embryo test w/ *Mytilus* and *Crassostrea*
- 7-day Mysid survival test with *Americamysis bahia*

Results:

Significant toxicity to mysid at the Napa River, Grizzly Bay, and Sacramento and San Joaquin River stations!

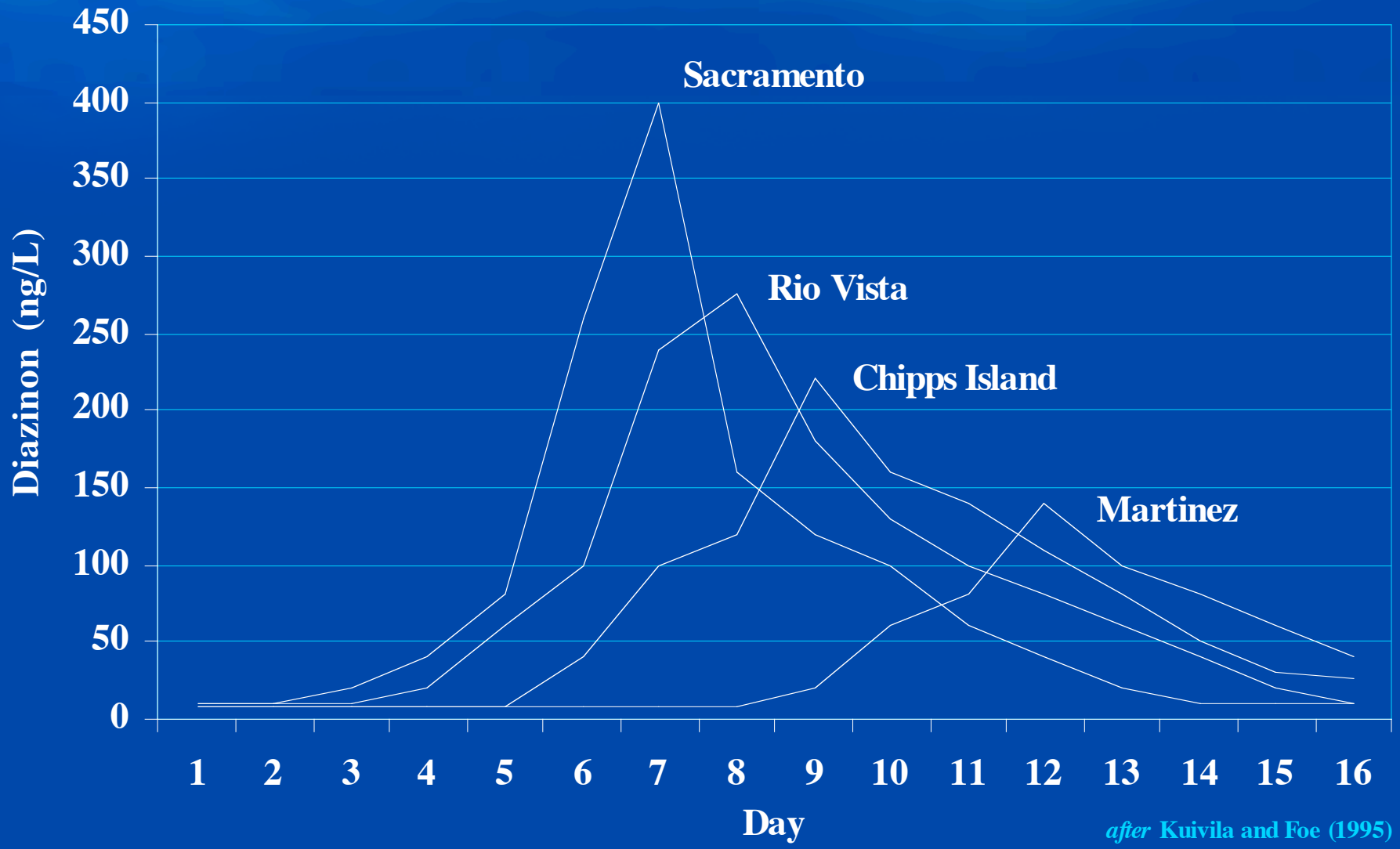

Mysidopsis bahia % Survival
120
100
80
60
40
20
0
97.2
76.3
68.6
76.3
81.6
78.9
28.1
76.3
2.9
8.6
0
0
Napa River
Grizzly Bay
Sacramento River
San Joaquin River

RMP Status & Trends
Ambient Water Toxicity

- Key observations:
  - Toxicity in February 1996 and January 1997 followed rainstorm events;
  - Studies in the Sacramento and San Joaquin watersheds had revealed significant ambient water toxicity associated with stormwater runoff of agricultural pesticides

    (e.g., diazinon and chlorpyrifos)

Pesticide Transport Through the Estuary Watershed



after Kuivila and Foe (1995)

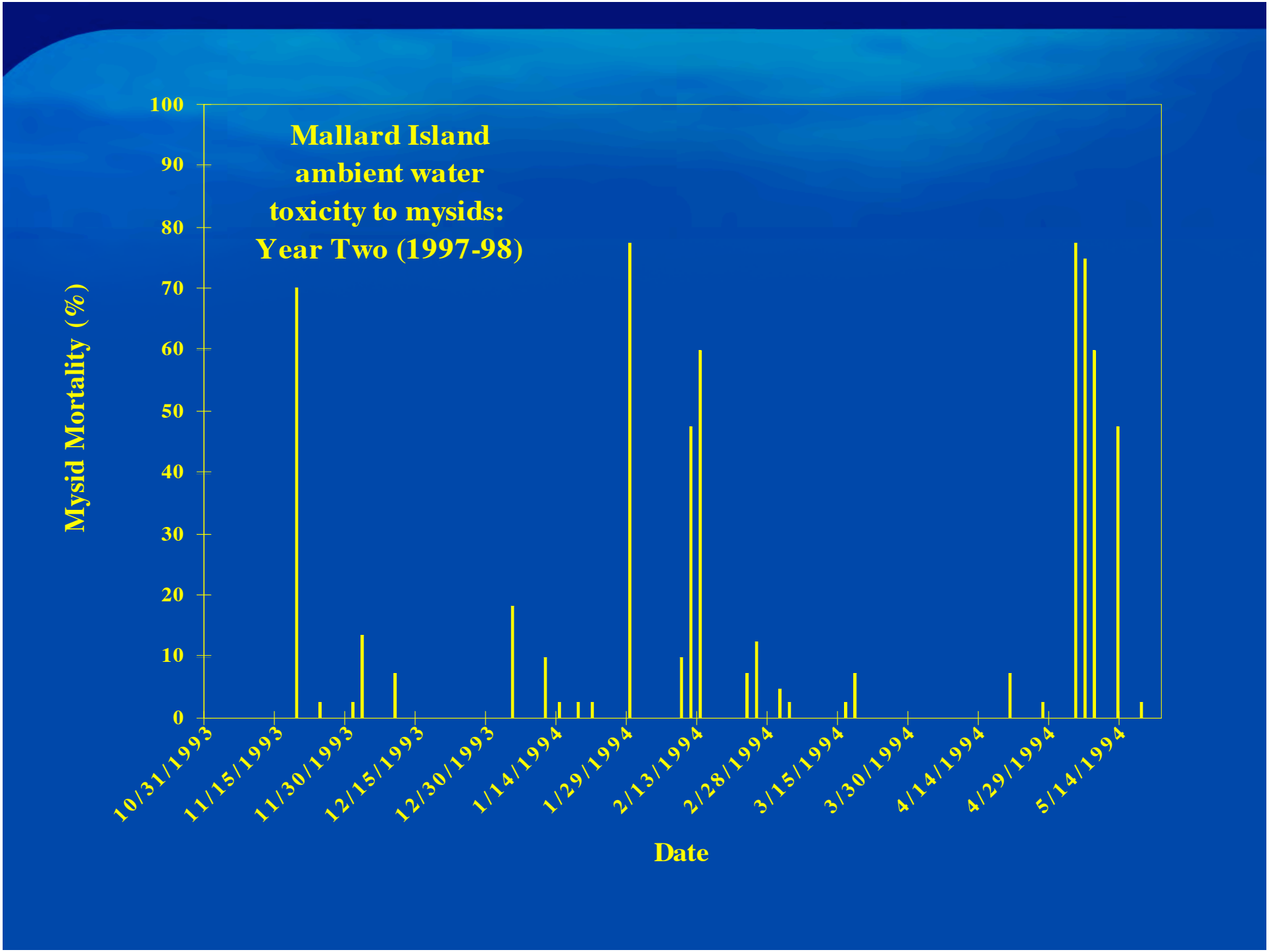
RMP Status & Trends
Ambient Water Toxicity

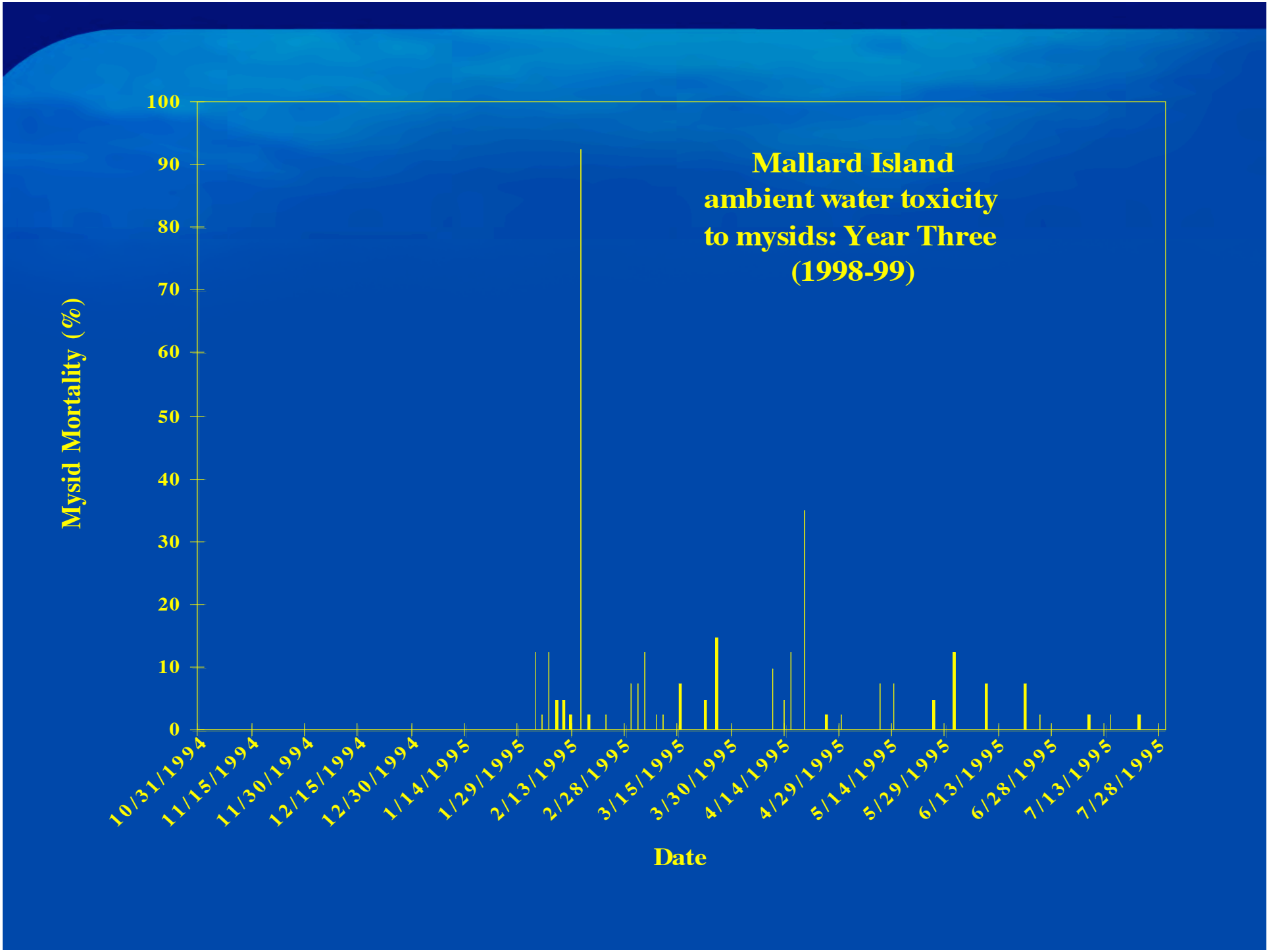
- Hypothesis:
  - "Episodic" transport of toxicants through the Estuary (e.g., following rainstorm events) are causing the observed ambient water toxicity

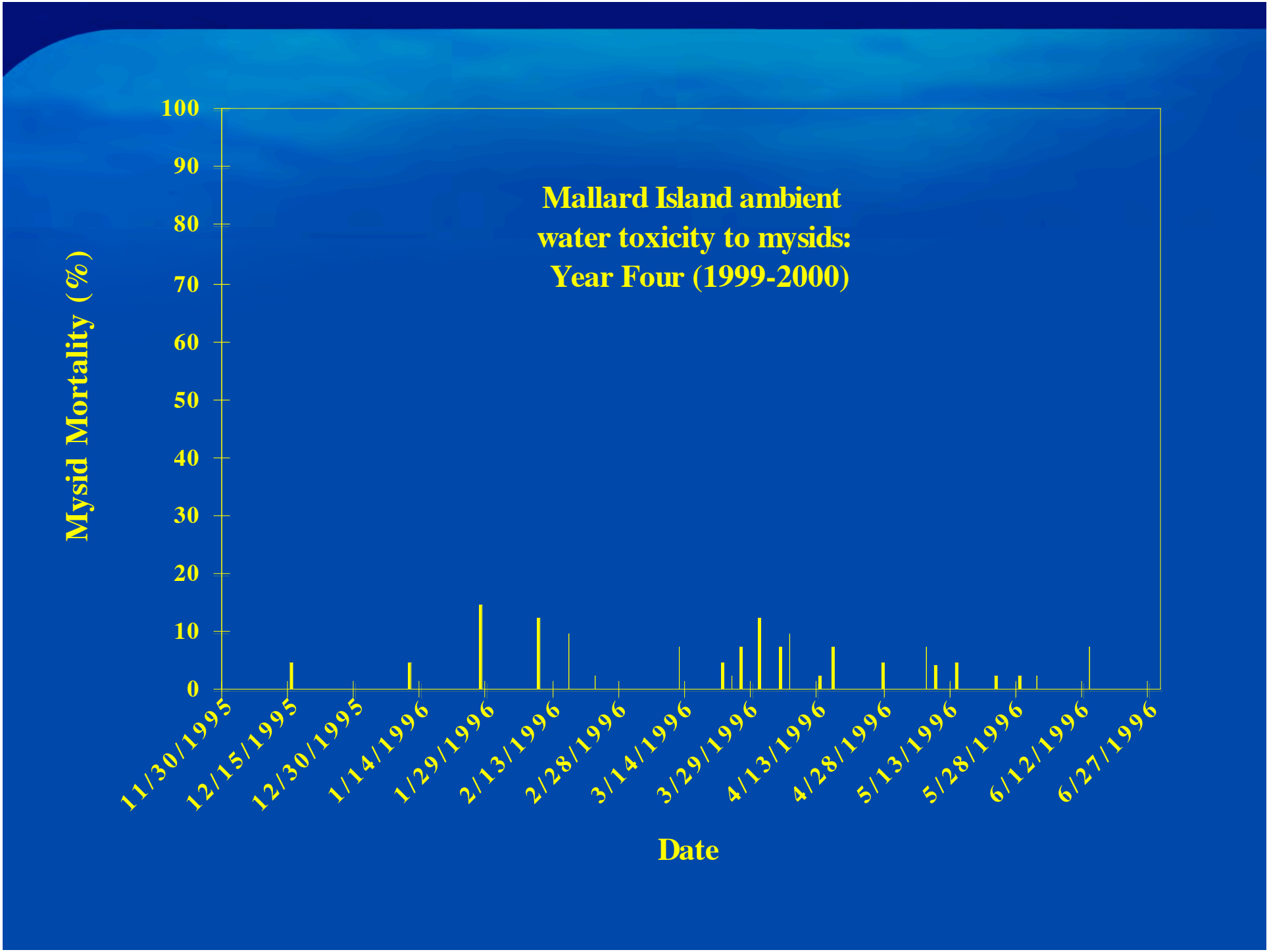
RMP Episodic Toxicity Study

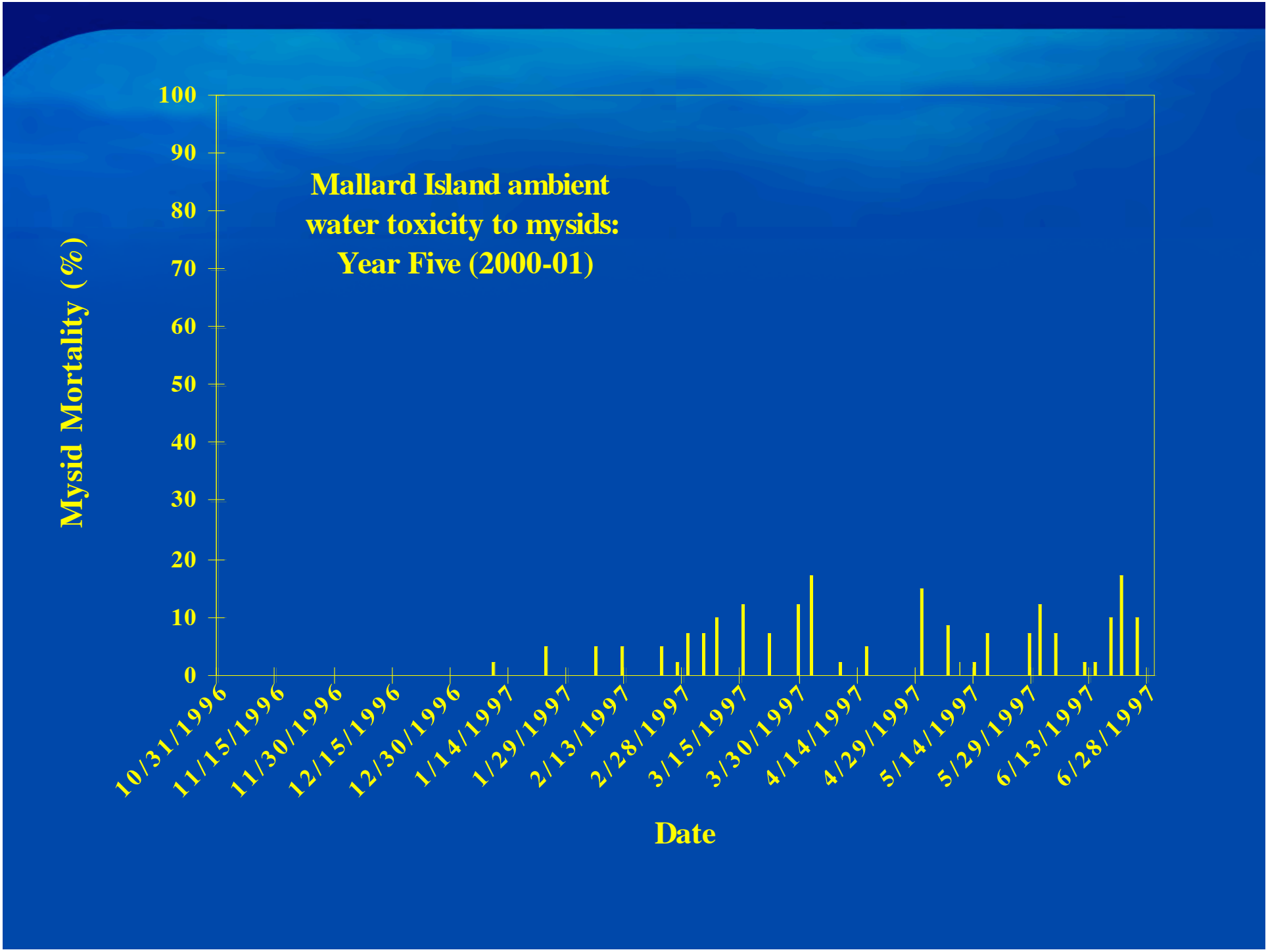
- Event-based Monitoring at Selected Tributaries:
  - Ambient water samples were collected near the mouth of selected tributaries following significant storm events, and were tested for toxicity using the 7-day mysid test.
- Regular Monitoring at Mallard Island:
  - Ambient water samples were collected at the DWR Mallard Island Station following storm events from October through December, and bi-weekly/tri-weekly from December through June
  - The water samples were tested for toxicity using the 7-day mysid test.

Summary of RMP Episodic Toxicity Study Results for Mysid Toxicity						
Sampling Site	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02
Guadalupe Slough Area	3 of 16 **(19%)**	2 of 14 **(14%)**				
Napa River			2 of 10 **(20%)**	2 of 11 **(18%)**	0 of 14 **(0%)**	
Pacheco Slough		5 of 13 **(38%)**	3 of 11 **(27%)**	3 of 12 **(25%)**	1 of 12 **(8%)**	
Mallard Island		10 of 70 **(14%)**	3 of 61 **(5%)**	2 of 56 **(4%)**	3 of 53 **(6%)**	0 of 53 **(0%)**
Petaluma River						0 of 5 **(0%)**
Sonoma Creek						0 of 5 **(0%)**
San Lorenzo Creek						0 of 6 **(0%)**
Coyote Creek						1 of 5 **(20%)**


Mallard Island
ambient water
toxicity to mysids:
Year Two (1997-98)
Mysid Mortality (%)
100
90
80
70
60
50
40
30
20
10
0
10/31/1993
11/15/1993
11/30/1993
12/15/1993
12/30/1993
1/14/1994
1/29/1994
2/13/1994
2/28/1994
3/15/1994
3/30/1994
4/14/1994
4/29/1994
5/14/1994
Date


Mallard Island
ambient water toxicity
to mysids: Year Three
(1998-99)
Mysid Mortality (%)
100
90
80
70
60
50
40
30
20
10
0
10/31/1994
11/15/1994
11/30/1994
12/15/1994
12/30/1994
1/14/1995
1/29/1995
2/13/1995
2/28/1995
3/15/1995
3/30/1995
4/14/1995
4/29/1995
5/14/1995
5/29/1995
6/13/1995
6/28/1995
7/13/1995
7/28/1995
Date


Mallard Island ambient water toxicity to mysids: Year Four (1999-2000)
Mysid Mortality (%)
100
90
80
70
60
50
40
30
20
10
0
11/30/1995
12/15/1995
12/30/1995
1/14/1996
1/29/1996
2/13/1996
2/28/1996
3/14/1996
3/29/1996
4/13/1996
4/28/1996
5/13/1996
5/28/1996
6/12/1996
6/27/1996
Date


Mallard Island ambient water toxicity to mysids: Year Five (2000-01)
Mysid Mortality (%)
100
90
80
70
60
50
40
30
20
10
0
10/31/1996
11/15/1996
11/30/1996
12/15/1996
12/30/1996
1/14/1997
1/29/1997
2/13/1997
2/28/1997
3/15/1997
3/30/1997
4/14/1997
4/29/1997
5/14/1997
5/29/1997
6/13/1997
6/28/1997
Date

DPR studies indicate a reduction in OP pesticide usage

- Reported use of diazinon in the Central Valley has decreased steadily since 1993. The reported use in 2000 was 40% of 1993 usage.

- Reported use of chlorpyrifos in the Central Valley doubled from 1991 to 1997, but has steadily declined since then. The reported use in 2000 was 40% of 1997 usage.

from Spurlock 2002

USGS studies indicate a decrease in OP pesticides in surface waters

- Approximately one-sixth of the amount of diazinon and one-third of the amount methidathion were applied as dormant sprays in the San Joaquin River watershed in 2000 as compared to 1992.
- The measured surface water concentrations of diazinon and methidathion were below levels toxic to *Ceriodaphnia*.
- However, there has been a corresponding increase in the use of pyrethroid pesticides

from Kuivila and Orlando 2002

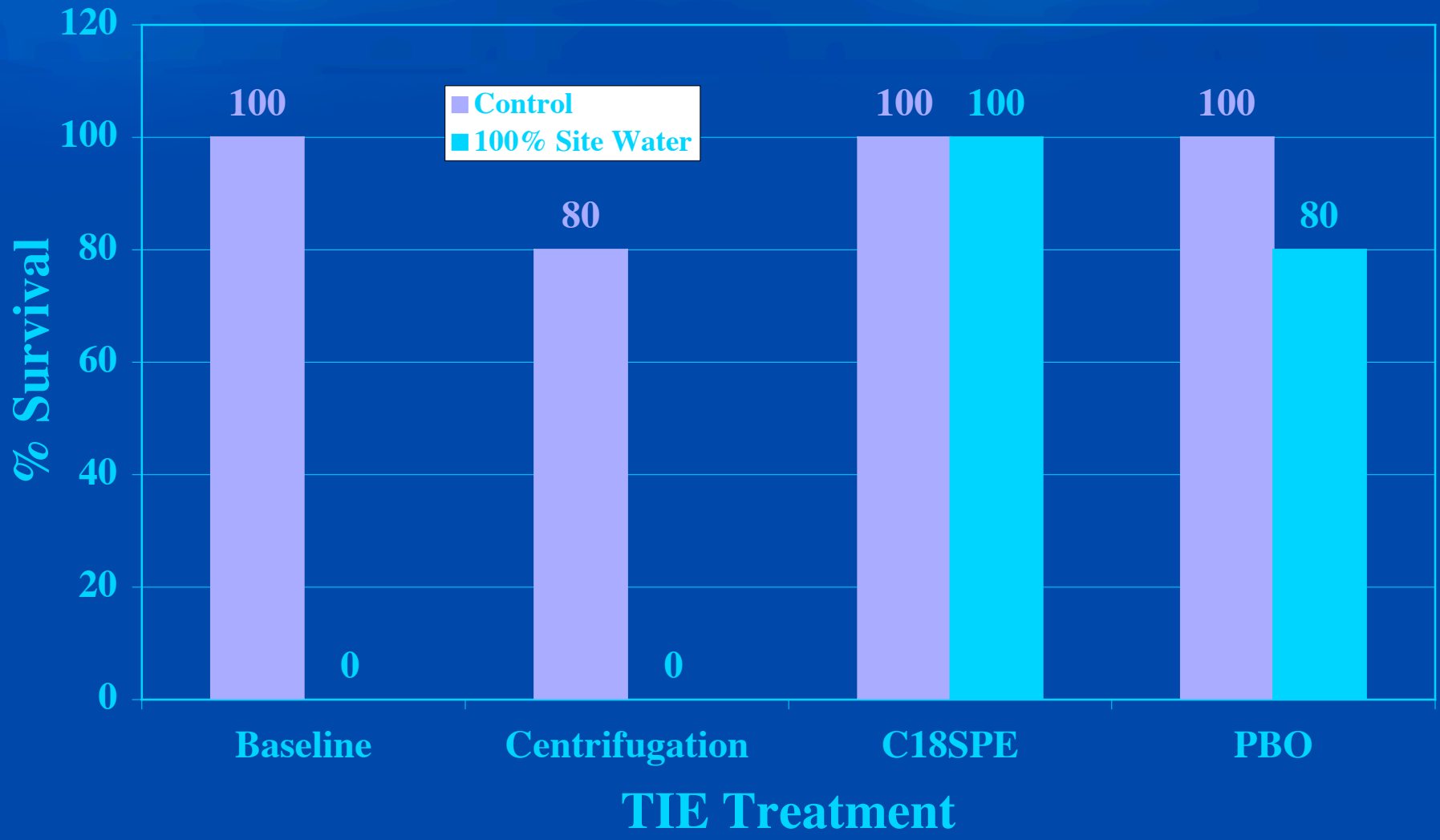
Problems are not over yet …

- As part of the current (2002-03) sampling, water samples have been collected from 4 selected tributaries and assessed for toxicity.
- Ambient water collected from San Lorenzo Creek in November caused 100% mortality of both mysids and *Ceriodaphnia*

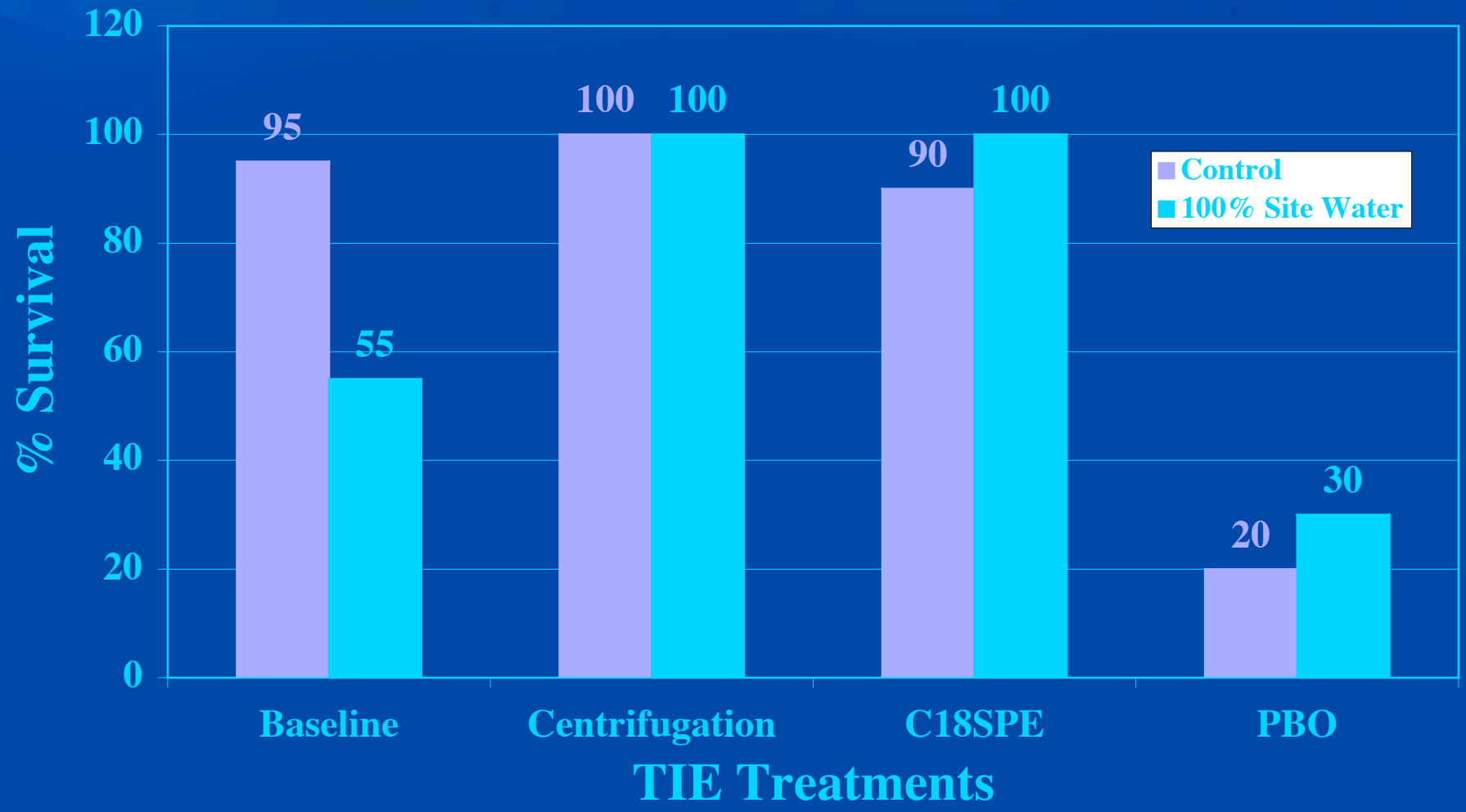
A "targeted" TIE was performed

- ELISA indicated elevated OP concentrations:
  - 673 ng/L diazinon
  - 201 ng/L chlorpyrifos
- TIE was targeted towards OP pesticides:
  - Fractionations: Centrifugation, C_{18}SPE, and PBO

Evaluation of San Lorenzo Creek Toxicity to Ceriodaphnia Survival



Evaluation of San Lorenzo Creek Toxicity to Mysid Survival



Pesticide	Measured Concentration	*Ceriodaphnia*		*Americamysis bahia*	
		Acute LC50	Toxic Units	Acute LC50	Toxic Units
Diazinon	673 ng/L	320-510 ng/L	1.3-2.1	4200-8500 ng/L	0.08-0.16
Chlorpyrifos	201 ng/L	53-130 ng/L	1.5-3.8	35-56 ng/L	3.6-5.7
			2.8-5.9 TU		3.7-5.9 TU

Conclusion

- *Ceriodaphnia* toxicity due to both diazinon and chlorpyrifos
- Mysid toxicity due primarily to chlorpyrifos
  - Hence, greater loss of toxicity over time;
  - Hence, removal of toxicity by centrifugation.

Problems are not over yet …

- As OP pesticide usage is reduced (EPA phase-out, outreach to growers, etc), other "alternate" pesticides will be used as replacements.
- Example: Agricultural and urban use of pyrethroid pesticides is increasing.

Agricultural and urban use of pyrethroid pesticides is increasing

- The fate and effects of pyrethroids will be different from the OP pesticides:
  - Pyrethroid pesticides are much more “sticky”, and will rapidly adsorb to suspended particulates and sediments.
  - Pyrethroid pesticides can be expected to persist longer in the environment.
  - Pyrethroid pesticides are typically much more toxic than are the OP pesticides
    - Relative to the OP pesticides, pyrethroids are comparatively more toxic to fish

"Adaptive Management"

- The RMP must maintain awareness of changes in land use activities (e.g., pesticide use) in the Estuary's watersheds, and must adapt the monitoring tools (e.g., sampling design, toxicity tests, and chemical analyses) to reflect those changes.
- For example, appropriate monitoring for the potential effects of pyrethroids will likely require a shift to assessing the toxicity of suspended particulates and surficial sediments in the areas of agricultural and/or urban stormwater runoff.