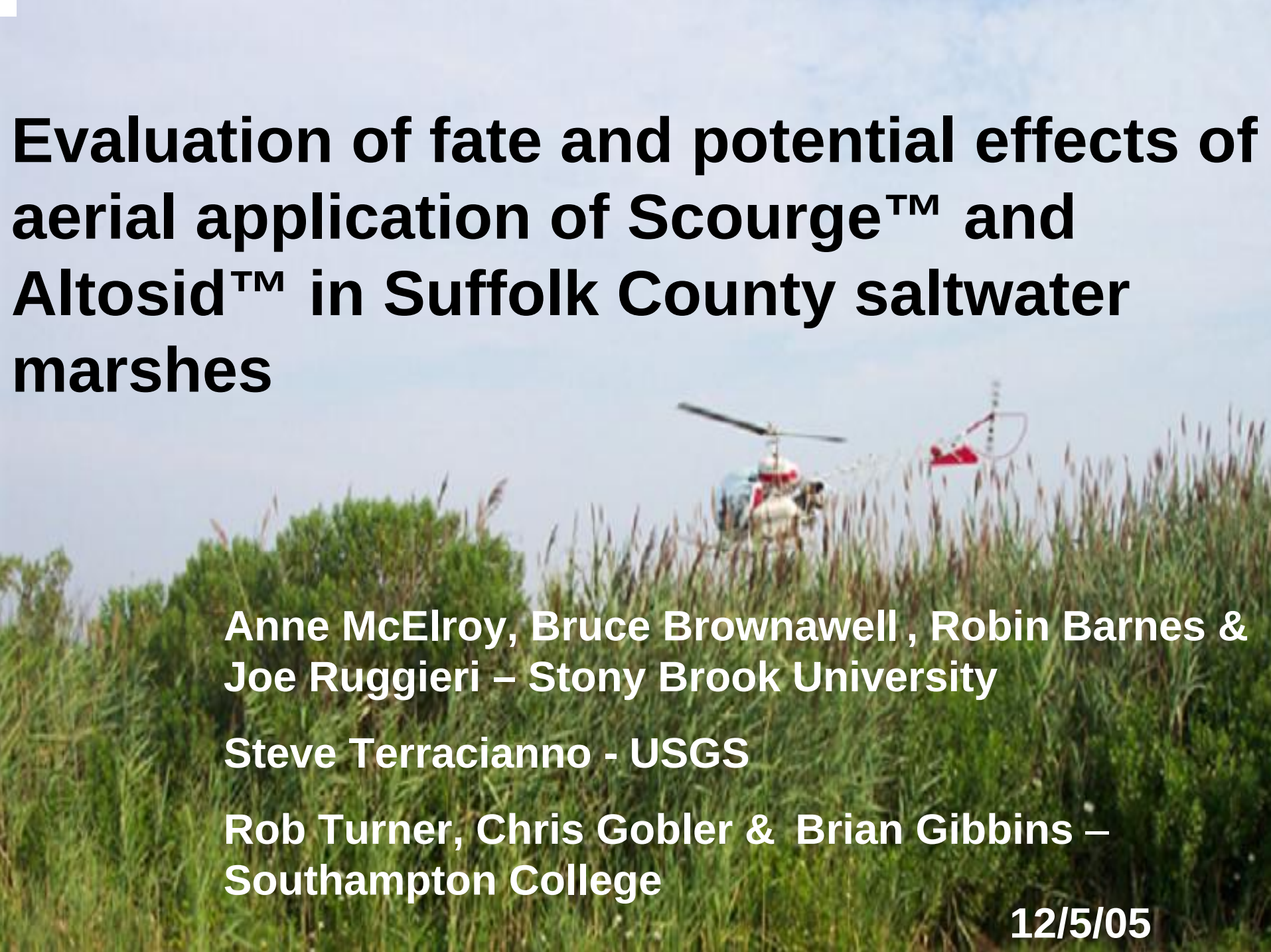
Evaluation of fate and potential effects of aerial application of Scourge™ and Altosid™ in Suffolk County saltwater marshes



Anne McElroy, Bruce Brownawell , Robin Barnes & Joe Ruggieri – Stony Brook University

Steve Terracianno - USGS

Rob Turner, Chris Gobler & Brian Gibbins – Southampton College

12/5/05

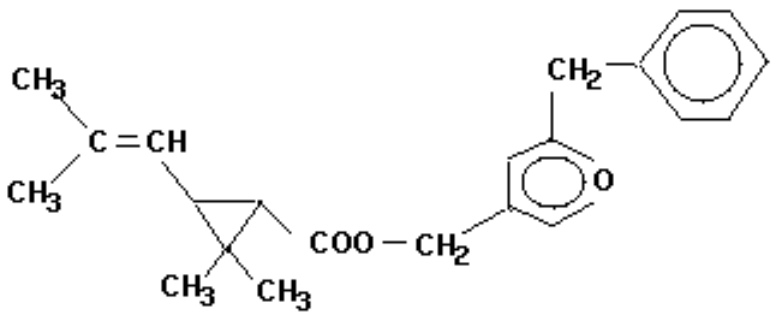
“Caged Fish” – Objectives

- **Evaluate the effects of real life aerial applications of Scourge™ and Altosid™ on non-target salt marsh organisms – juvenile fish (sheepshead minows *Cyprinodon variegatus*) and adult grass shrimp (*Palaemonetes pugio*)**
- **Assess the fate and distribution of these pesticides in salt marsh waters and sediments (including documentation of exposure of caged organisms**

Add-on

- **Take a snap-shot look at potential chronic effects of pesticide application on benthic infaunal community structure**

Pesticides used on Long Island



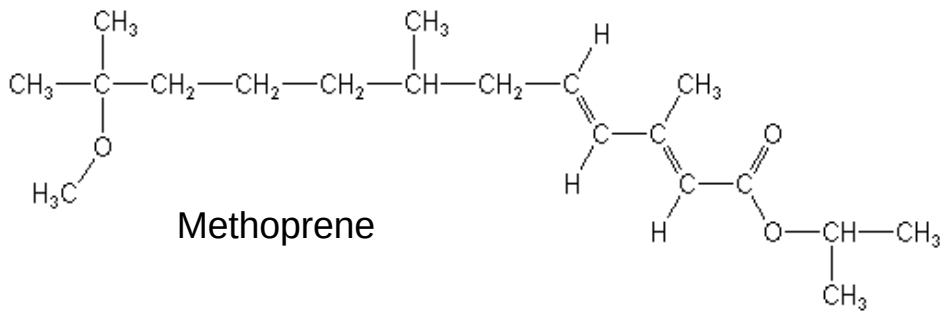
Resmethrin

Resmethrin:

- Pyrethroid (Scourge®) neurotoxin
- [1]LC50s (fish) ~ generally < 10 μg/L
- [1]LC50s (shrimp) ~ typically < 1μg/L
- Log K_{ow} = 5.4 - 6.5

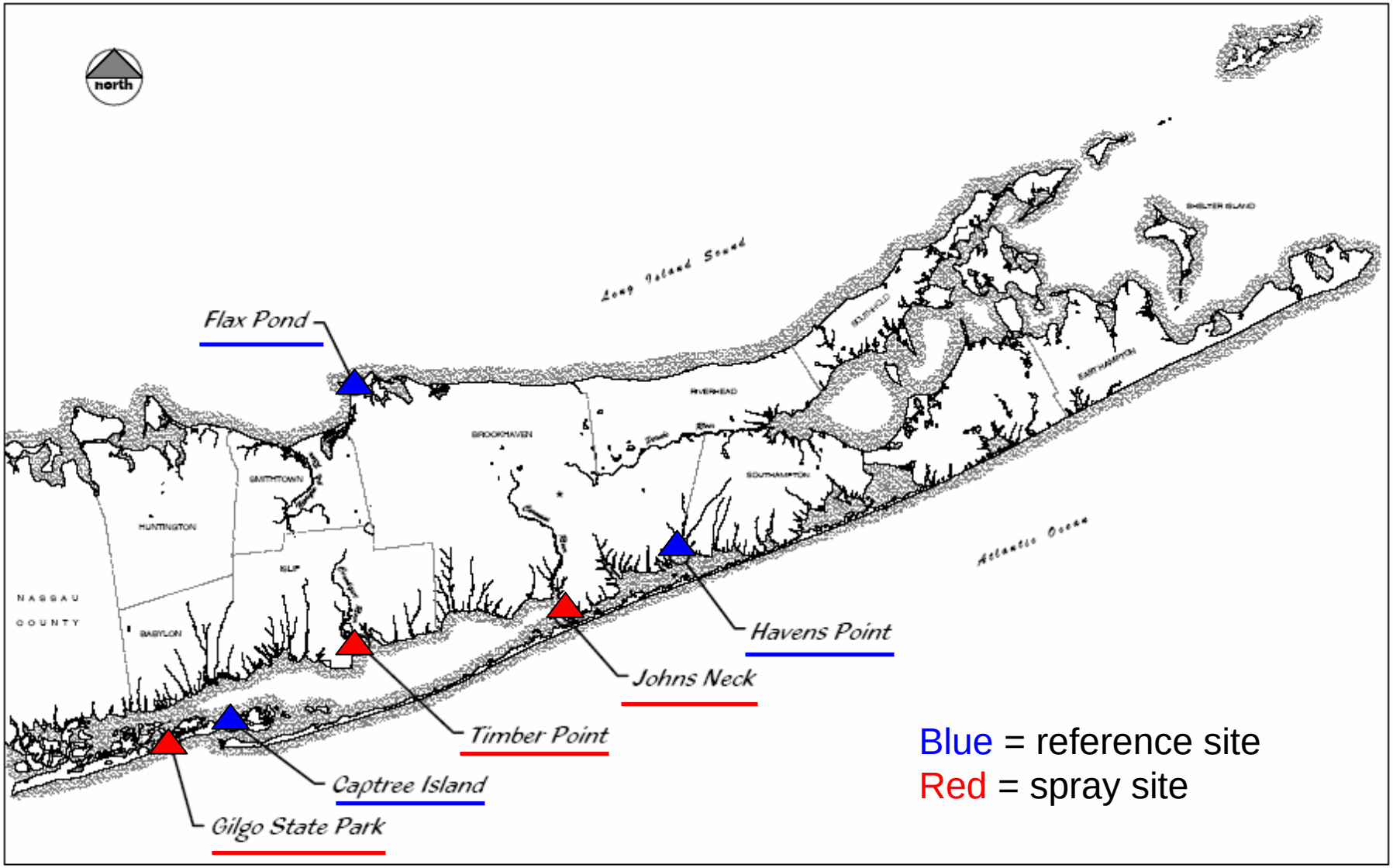
Methoprene:

- Insect growth regulator (Altosid®)
- [2]LC50s (fish) ~ > 100 mg/L
- [3]LC50s (shrimp) ~ not usually observed on adults even at 1 mg/L
- [4]LC50's of S-methoprene (shrimp) ~ 14 μg/L
- Log K_{ow} > 6



Methoprene

[1] Bradbury & Coats, 1989
[2] http://pesticideinfo.org
[3] Wirth et al., 2001
[4] Brown et al., 1996



FIELD SITES

Cashin Associates, P.C.
ENGINEERING PLANNING CONSTRUCTION MANAGEMENT

Captree Island field site

Timber Point field site

Johns Neck field site

Havens Point field site

Flax Pond field site

Experimental Approach

Toxicological Endpoints

- Survival of caged organisms – with continuous DO and temp monitoring
- 96 hr static renewal shrimp tox. Tests using water collected 30 min. post spray
- Fish growth during cage deployment
- Prey capture ability in surviving shrimp

EFFECTS

Comparing results between sprayed and non-sprayed marshes with similar hydrology

EFFICACY Endpoints

- **Mortality in caged mosquitoes**
- **Fly-up of field collected pupae**
- **Surface deposition of spray**
- **Modeling of aerosol deposition**

FATE

Chemistry Endpoints

- **Water concentrations pre and 30 min to 96 hrs post spray**
- **Sediment concentrations pre spray and post spray**

Suffolk County

Juvenile Sheepshead minnows *Cyprinodon variegatus*

20 fish per cage

3 cages per site

Grass shrimp *Paleomonetes pugio*, 14 per cage, 3 cages per site

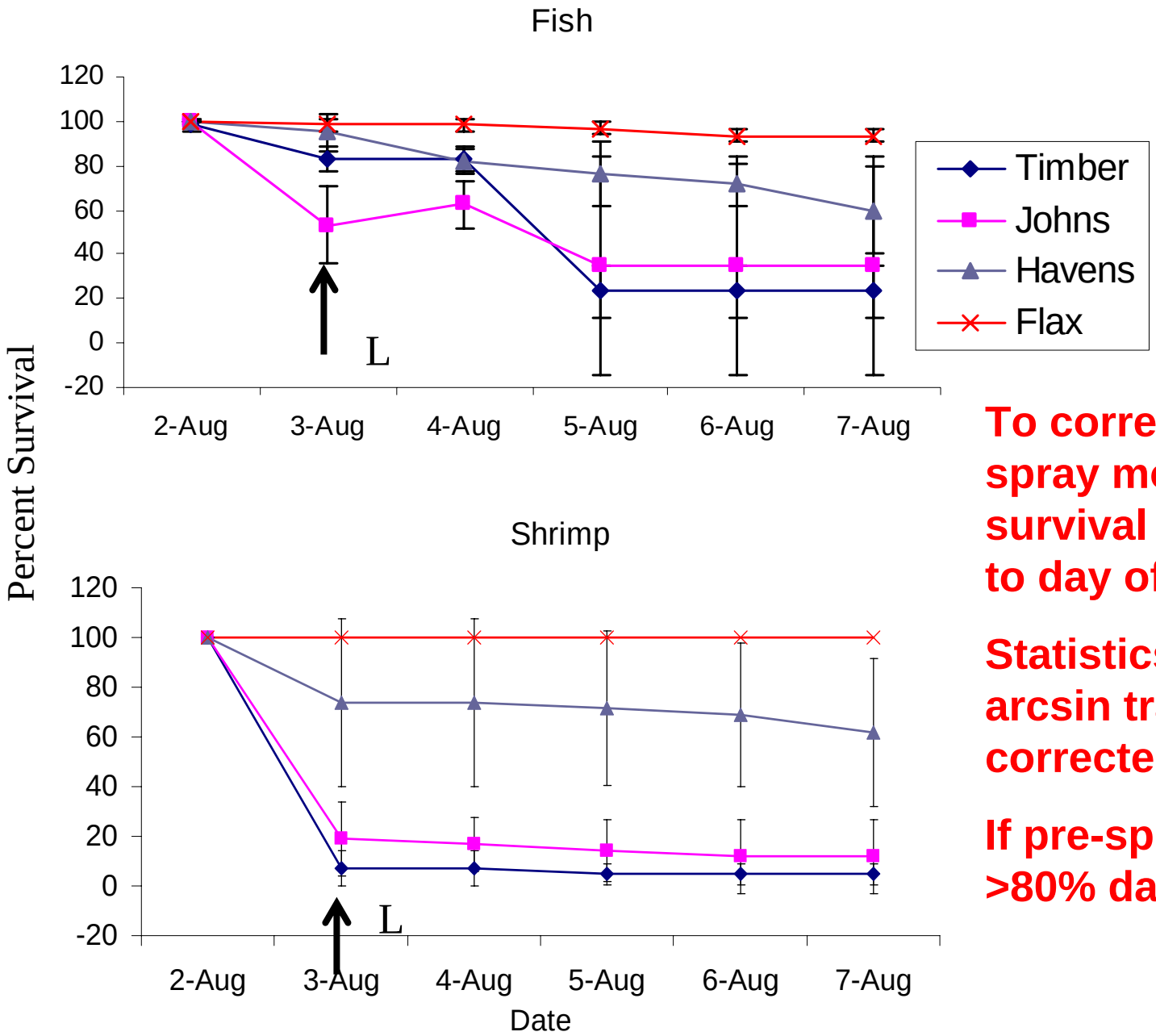
Fish and shrimp cages at Johns Neck

Mosquito cages at site

5 Spray events studied in detail

- **Altosid™ larvicide sprays at Johns Neck and Timber Point on 8/3, 8/10, and at Timber Point only on 9/1 (methoprene)**
- **Scourge™ adulticide sprays at Johns Neck on 8/18 and 8/25 – note on 8/18 Altosid was also sprayed at Johns Neck (resmethrin and PBO)**

Unadjusted Fish and Shrimp Survival for 8/3/04

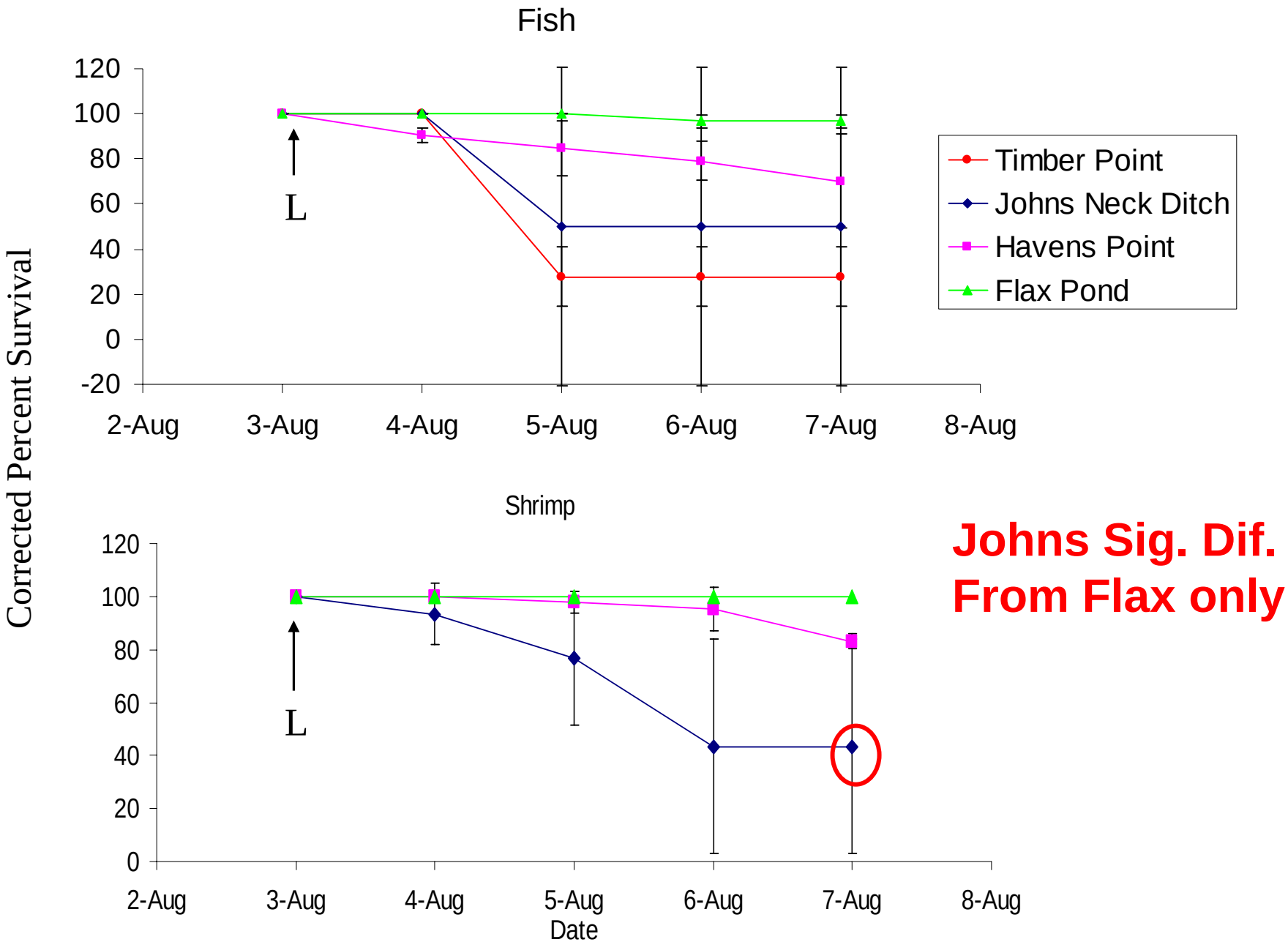


To correct for pre-spray mortality, survival date corrected to day of spray.

Statistics done on arcsin transformed corrected data

If pre-spray mortality >80% data not included

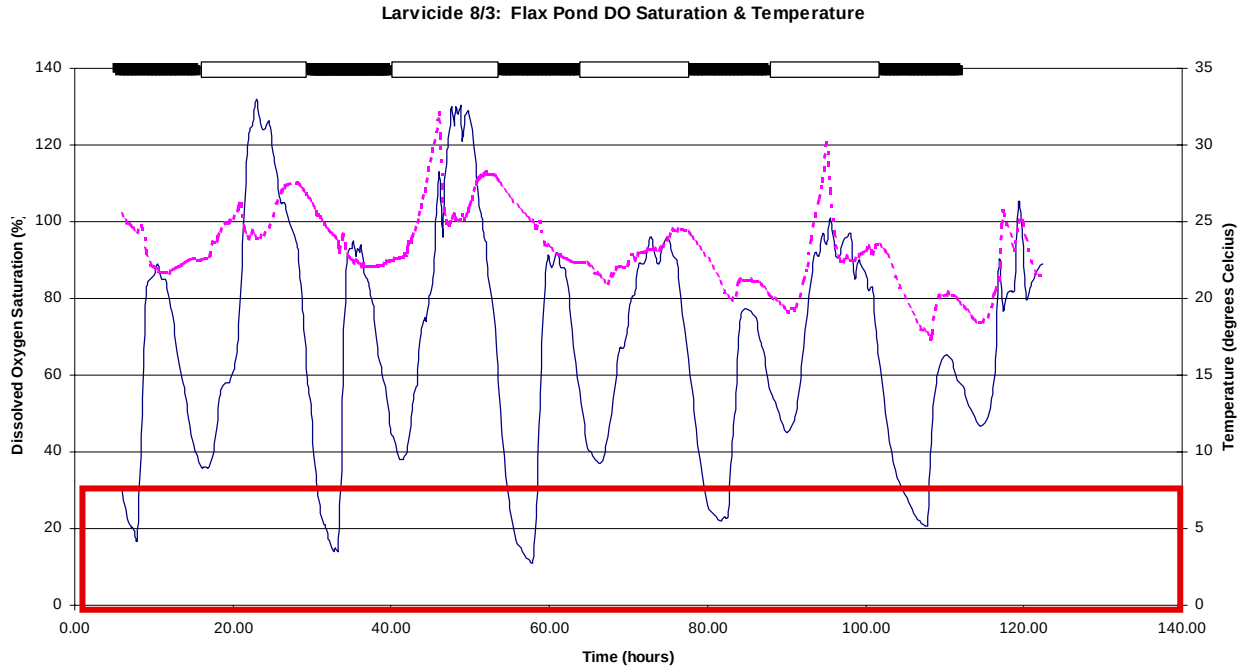
Corrected Fish and Shrimp Survival for 8/3/04



Johns Sig. Dif. From Flax only

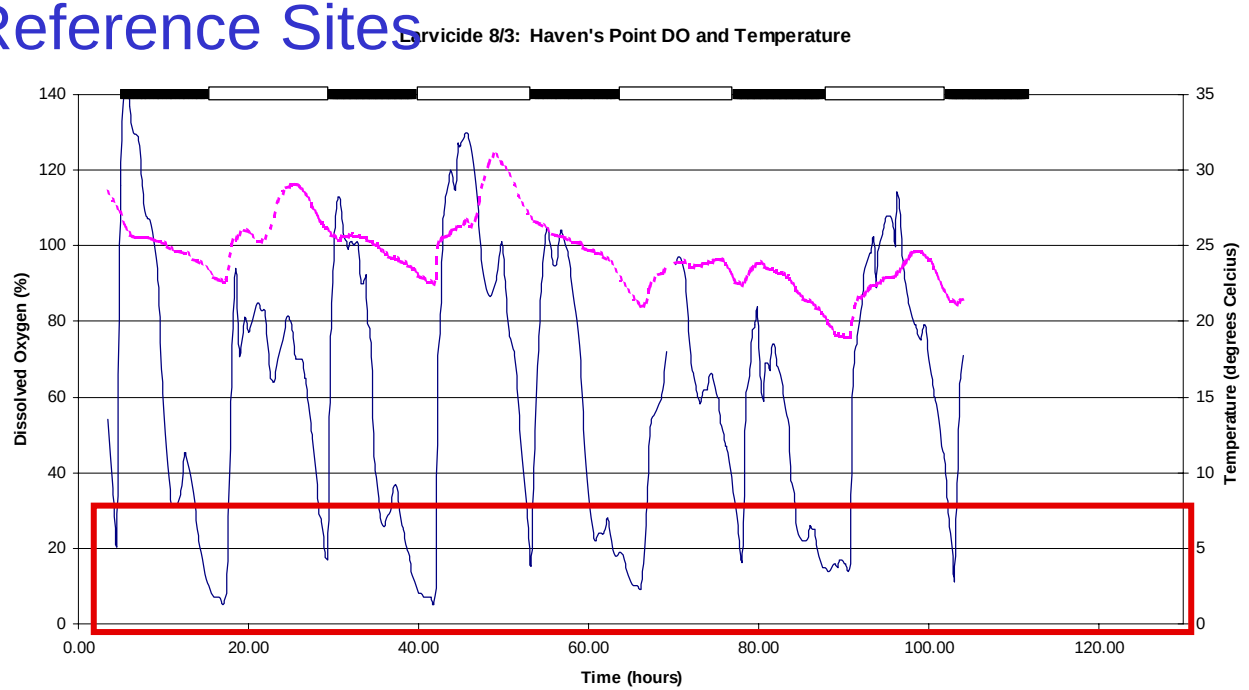
Diel DO - Reference Sites

Flax Pond



DO <30%

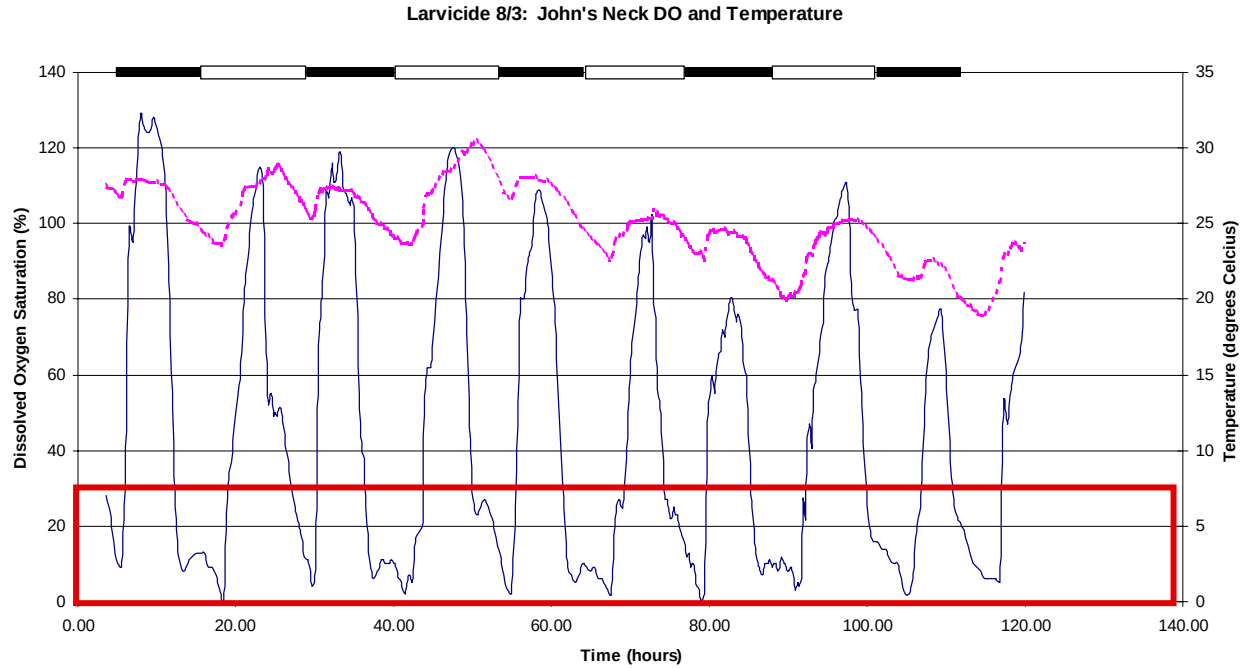
Havens



DO

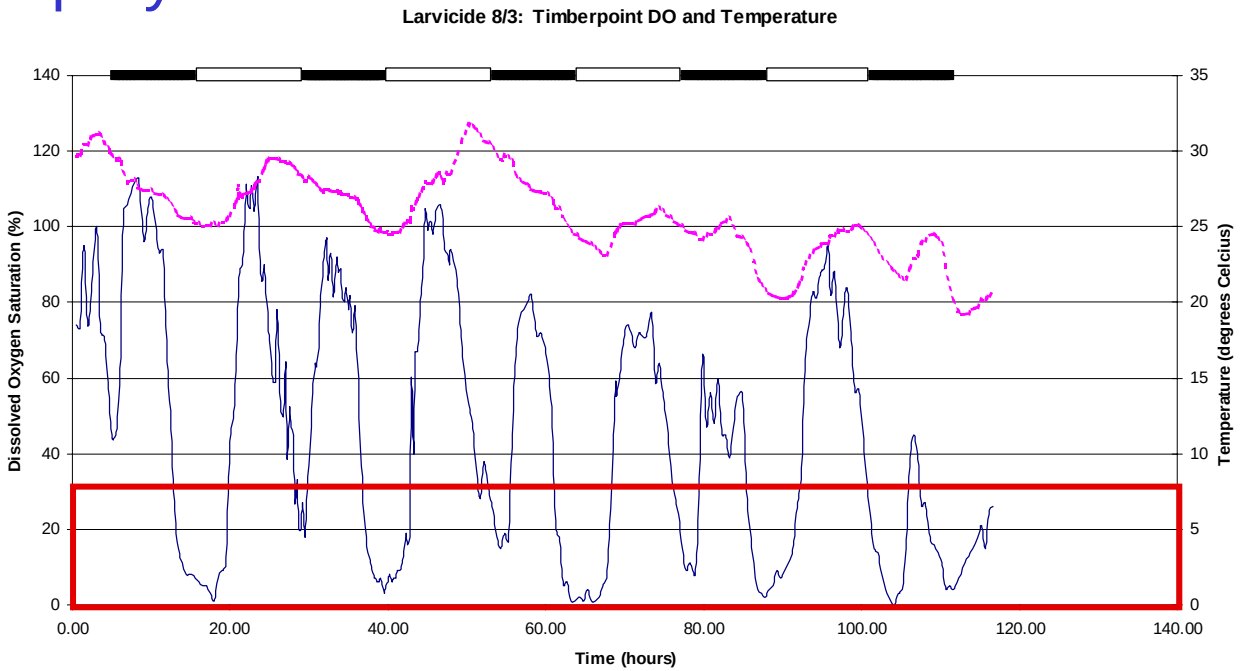
TEMP

Johns Neck



Diel DO - Spray Sites

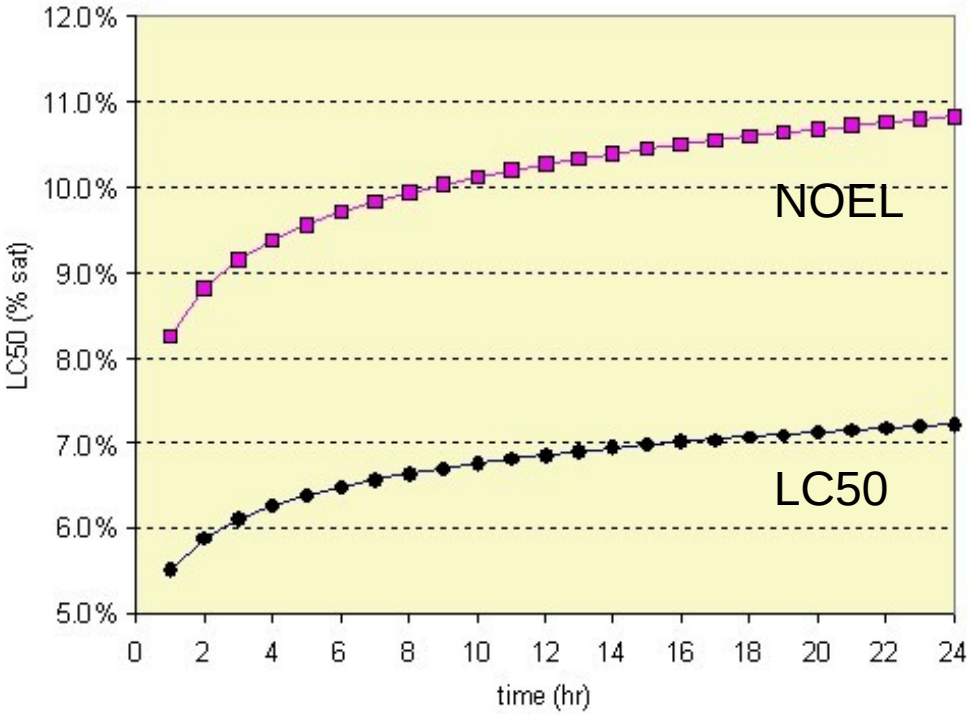
Timber Point



DO

TEMP

Time to death approach using daily cumulative low DO excursions



Adult *P. pugio* data

Sum up time below criteria DO per day

LC50

<5% for > 1 hr

5-7 % for > 4 hrs

NOEL

<9 % for >2 hrs

EPA-822-R-00-012 & G. Thursby

Caging Study: Summary of DO

Summary of Mortaltiy Observed in Caged Organisms - Oxygen Effect

			Spray Sites:		Control Sites:	
Spray Type:	**Dates:**	**Species**	**TP**	**JN**	**FP**	**HP**
Larvicide	**8/3/04**	**Fish**				
		Shrimp				
	8/10/04	**Fish**				
		Shrimp				
	9/1/04	**Fish**				
		Shrimp				
Adulticide	**8/18/04**	**Fish**				
		Shrimp				
	8/25/04	**Fish**				
		Shrimp				

denotes when cages were moved to deeper water

Denotes when low DO could have caused mortality

Denotes that the DO is unknown

Caging Study: Summary of Survival

Summary of Mortaltiy Observed in Caged Organisms

			Spray Sites:		Control Sites:	
Spray Type:	**Dates:**	**Species**	**TP**	**JN**	**FP**	**HP**
Larvicide	8/3/04	Fish	☠	☠		
		Shrimp	☠	☠		
	8/10/04	Fish				☠
		Shrimp		☠		☠
	9/1/04	Fish				☠
		Shrimp				
Adulticide	8/18/04	Fish				☠
		Shrimp		☠		
	8/25/04	Fish				☠
		Shrimp				☠

denotes when cages were moved to deeper water

☠ Statistically significant mortality relative to another site at one or more days

Summary of DO & mortality

Summary of Mortaltiy Observed in Caged Organisms - Oxygen Effect

Spray Type:	Dates:	Species	Spray Sites: TP	Spray Sites: JN	Control Sites: FP	Control Sites: HP
Larvicide	8/3/04	Fish				
		Shrimp				
	8/10/04	Fish				
		Shrimp				
	9/1/04	Fish				
		Shrimp				
Adulticide	8/18/04	Fish				
		Shrimp				
	8/25/04	Fish				
		Shrimp				

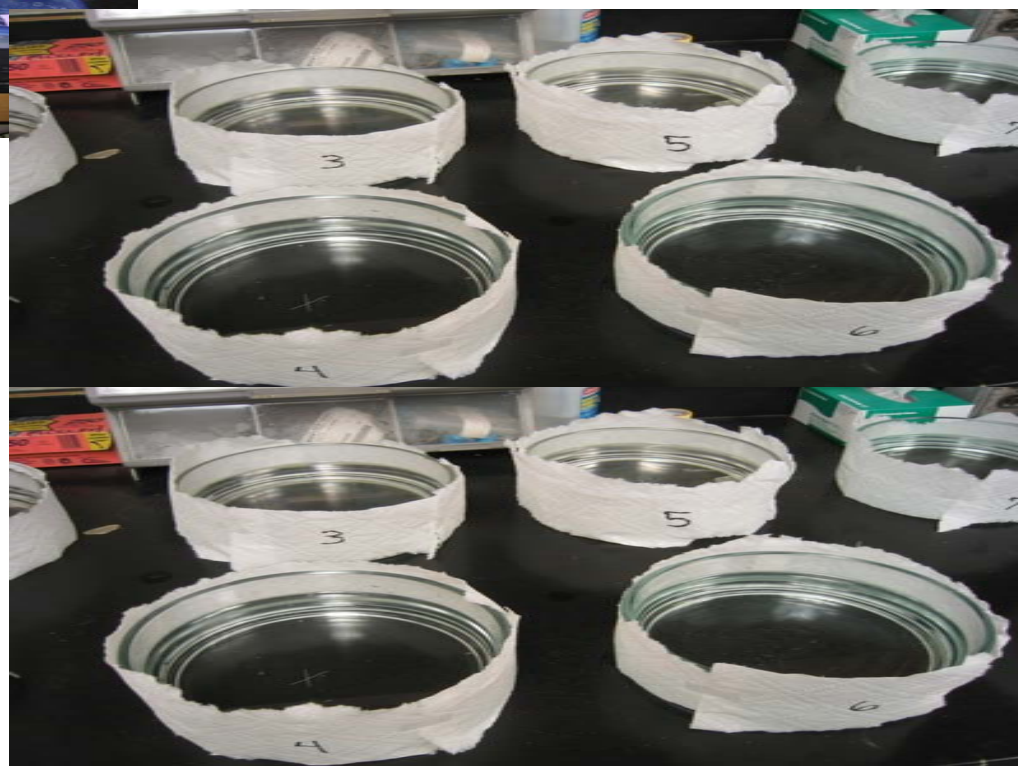
Denotes when low DO could have caused mortality

Denotes DO is unknown…

denotes when cages were moved to deeper water

Statistically significant mortalit

Lab tests done on shrimp to access acute toxicity of water collected from the field after spraying



And to determine if exposure in the field or to water collected in the field impaired food capture ability

Table 2: Shrimp Static Exposure Experiments Concurrent with Spray Events

Start Date:	Site:	Mean % Survival (after 96 hours)	Std. Dev.:
8/3/2004	Flax Pond	100.0	0.0
	Timberpoint	100.0	0.0
	John's Neck	83.3	40.8
8/10/2004	Flax Pond	100.0	0.0
	Timberpoint	100.0	0.0
	John's Neck	100.0	0.0
8/18/2004	John's Neck	100.0	0.0
	Haven's Point	100.0	0.0
8/25/2004	John's Neck	100.0	0.0
	Haven's Point	100.0	0.0
9/1/2004	Timberpoint	83.3	40.8
	Haven's Point	66.7	51.6

No evidence of toxicity resulting from exposure to water collected from the spray sites

Table 4: Shrimp Prey Capture

Date:	Site ID:	Number of Shrimp Tested	Avg. eaten after 60 min.:	Std. Dev.:
8/3/04 Larvicide	Flax	7	9.14	7.01
	Haven's	7	10.29	5.44
	John's Neck	5	18.60	1.67
	Timberpoint	2	9.00	9.90
	Flax static (#1)	5	8.40	5.98
	J.N. static (#1)	5	10.00	4.64
	T.P. static (#1)	5	8.60	2.19
8/9/04 Larvicide	Flax	10	12.10	4.72
	Haven's	10	12.90	5.07
	J.N. static (#1)	6	12.50	6.69
	T.P	10	10.20	5.03
8/18/04 Adulticide	Haven's	10	11.80	4.85
	J.N. static (#1)	5	10.20	3.27
	H.P. static (#1)	5	9.40	4.72
8/25/04 Adulticide	H.P.	6	12.67	2.73
	H.P. static #1	5	11.00	1.22
	J.N. channel	14	11.00	3.26
	J.N. static #1	5	9.00	1.41
9/1/04 Larvicide	Haven's	9	12.78	2.95
	John's Neck	10	5.80	3.55
	T.P	11	9.82	4.60

The ability of surviving shrimp to capture prey was highly variable, but no statistical decreases associated with pesticide exposure

Table 3: Fish Growth						
Date:	Site:	Total Growth: (cm)	Total Growth (mm)	Growth Rate (mm/day)	Average Growth Rate (mm/day)	Standard Deviation:
20-Jul	Haven's	0.140	1.400	0.280	0.280	0.000
		0.140	1.400	0.280		
	John's	0.228	2.280	0.456	0.048	0.577
		-0.180	-1.800	-0.360		
	Timber	0.270	2.700	0.540	0.550	0.014
		0.280	2.800	0.560		
	Old Fort Pond	0.120	1.200	0.240	0.440	0.283
		0.320	3.200	0.640		
3-Aug	Timber	0.075	0.750	0.150	0.139	0.019
		0.075	0.750	0.150		
		0.058	0.583	0.117		
	John's	0.120	1.200	0.240	0.240	n/a
	Haven's	0.080	0.800	0.160	0.150	0.026
		0.060	0.602	0.120		
		0.085	0.850	0.170		
	Flax	0.075	0.750	0.150	0.197	0.090
		0.150	1.500	0.300		
		0.070	0.700	0.140		
9-Aug	Timber	0.050	0.500	0.100	0.067	0.067
		0.055	0.550	0.110		
		-0.005	-0.050	-0.010		
	John's	0.003	0.033	0.007	0.051	0.039
		0.038	0.383	0.077		
		0.035	0.350	0.070		
	Haven's	0.053	0.525	0.105	0.072	0.046
		0.020	0.200	0.040		
	Flax	0.025	0.250	0.050	0.027	0.068
		-0.025	-0.250	-0.050		
		0.040	0.400	0.080		

Fish growth was low, averaging only 0.05 to 0.5 mm/day with no differences observed between sites

18-Aug	John's	0.085	0.850	0.170	0.120	0.071
		0.035	0.350	0.070		
	Haven's	0.115	1.150	0.230	0.165	0.092
		0.050	0.500	0.100		
25-Aug	John's--normal				0.160	n/a
	normal					
	normal	0.080	0.800	0.160		
	channel	0.135	1.350	0.270	0.225	0.064
	channel	0.090	0.900	0.180		
	surface ditch	0.050	0.500	0.100	0.145	0.064
	surface ditch	0.095	0.950	0.190		
	Haven's--norma	0.058	0.583	0.117	0.044	0.064
	normal	0.010	0.100	0.020		
	normal	-0.003	-0.025	-0.005		
	surface	0.077	0.775	0.155	0.144	0.015
	surface	0.067	0.667	0.133		
1-Sep	Haven's				0.221	n/a
		0.051	0.510	0.102		
	Timberpoint	0.025	0.250	0.050	0.078	0.040
		0.030	0.300	0.060		
		0.062	0.620	0.124		
	John's--normal				0.471	n/a
	normal					
	normal	0.109	1.088	0.218		
	channel	0.150	1.500	0.300	0.258	0.040
	channel	0.110	1.100	0.220		
	channel	0.127	1.268	0.254		

(Note: n/a was inserted where there was too few data to perform the functions)

What happened to the pesticides sprayed on these marshes?

Disposition of Methoprene in marsh

- Methoprene not detected in water pre spray or in reference marshes.
- [Methoprene] exceeding 1,000 ng/L were observed 30 min post spray in waters after 3 of 4 sprays. Interface values not always highest.
- 2 hrs post spray [methoprene] < 25 ng/L with detectable levels persisting for 1 to 2 days post spray.
- Methoprene in sediment was more persistent with concentrations ranging between 3-60 ng/g in samples collected within a week of spraying, but no evidence of build-up after repeated sprays was observed.

Disposition of Scourge® active ingredients in marsh

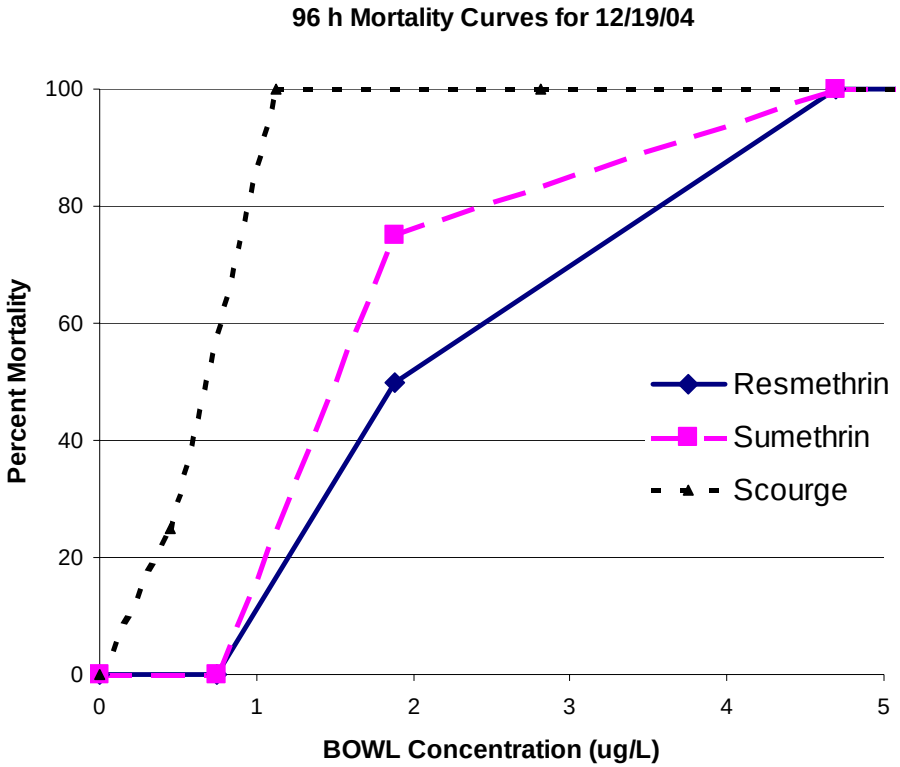
- Neither PBO nor resmethrin found in pre-spray samples of water or sediment, nor in sediments after spraying
- [Resmethrin] much higher at water interface (320 ng/L) than inches below water surface (60 ng/L) – highest levels found
- [Resmethrin] drops rapidly in water becoming undetectable >2 hrs after spray
- PBO more persistent with trace amounts detected up to two days after spray
- PBO/Resmethrin in water samples >> than in Scourge® formulation (3:1) with median values of 46:1
- The first spray event delivered much more Scourge® to the water the second

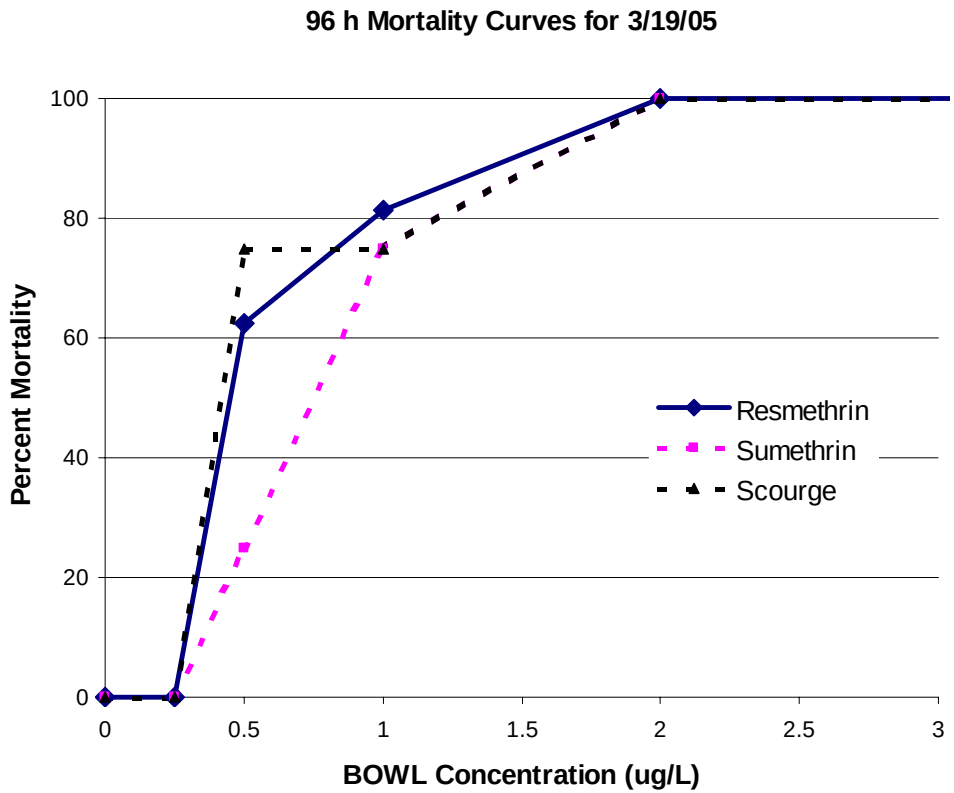
Dosing studies were done to determine what level of pesticides would be expect to cause toxicity in shrimp

Static renewal 96-hr LC50s with

- **Resmethrin™**
- **Sumitrhin**
- **Scourge**
- **Methoprene – mixed isomers**
- **S-methoprene**
- **Altosid™**

Dosing Experiment Results





Average LC50s:
Scourge® ~ 0.58 μg/L
Sumethrin: ~ 1.1 μg/L
Resmethrin ~ 1.2 μg/L

TOXICITY:
Scourge® > Sumethrin ~ Resmethrin

NOTE: no methoprene-based chemical was toxic up to 1 mg/L concentrations

Benthic Community Structure Analysis

Benthic cores taken at marshes approximately 1 month after cessation of spraying in October. 3 cores taken at each of 5 sites (3 reference – 2 sprayed).

Sediment sieved and all infaunal organisms preserved and identified to lowest taxon.

Hypothesis tested – long term spraying activity would result in changes in species composition or abundance.

26 Species identified in samples

Number	Organism ID	Phylum
1	oligochaete	Annelida
2	*Paranaitis speciosa*	Annelida
3	Spionidae	Annelida
4	*Nereis succinea*	Annelida
5	Streblospio	Annelida
6	trumpet-butt worm	Annelida
7	Cirratulidae	Annelida
8	fan worm	Annelida
9	Amphareidae	Annelida
10	crustacean #1	Arthropoda
11	tick	Arthropoda
12	cladocerans	Arthropoda
13	midge larvae	Arthropoda
14	isopod	Arthropoda
15	amphipod	Arthropoda
16	snout beetle	Arthropoda
17	Trombidiid mite	Arthropoda
18	crustacean #2	Arthropoda
19	Corophium crust.	Arthropoda
20	Cumacean	Arthropoda
21	Polyps	Cnidaria
22	snail #1	Mollusca
23	snail #2	Mollusca
24	clams	Mollusca
25	worms	Nematoda
26	foram	Sarcodina

Worms

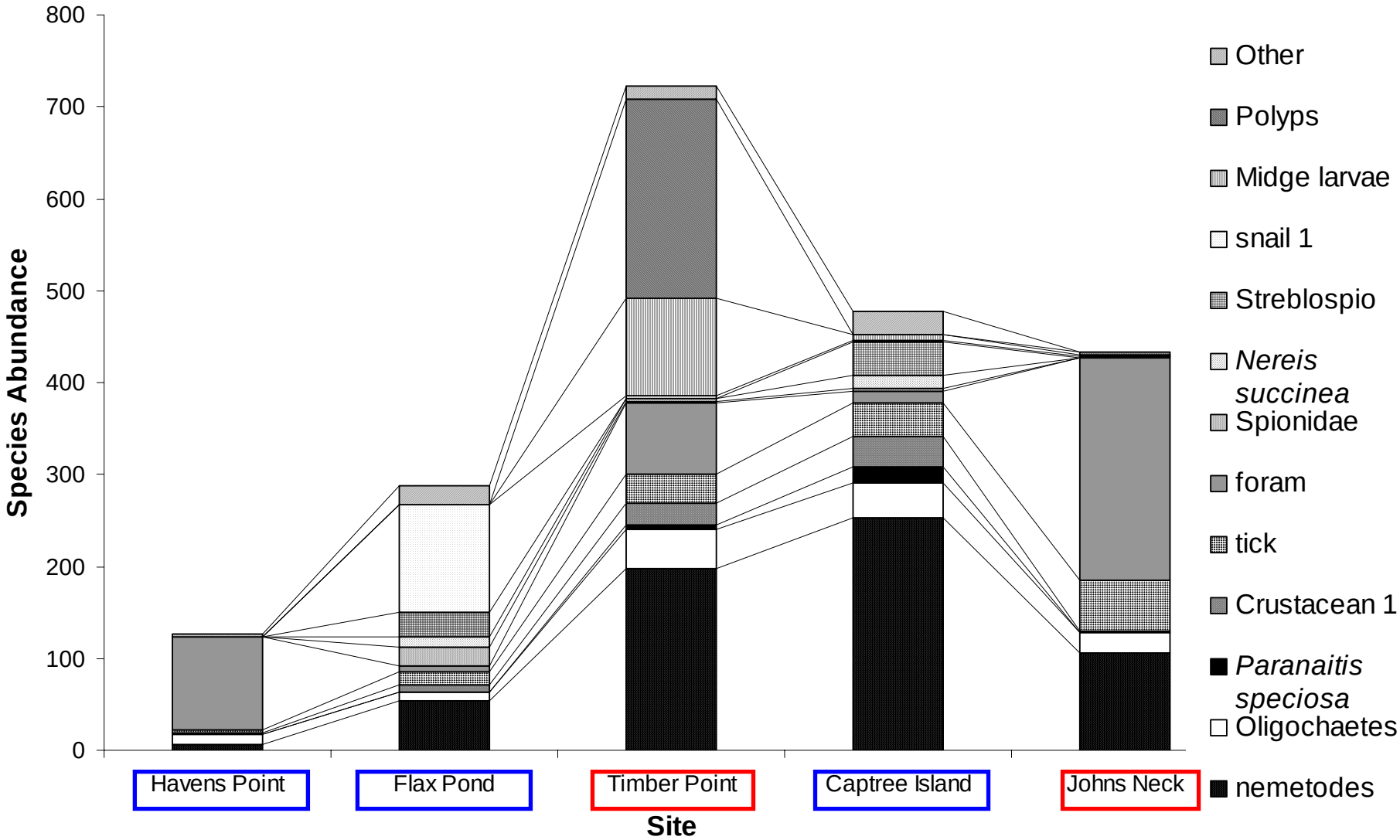
Insects/Crustaceans

Anemones

Nemetodes

Foraminifera

Species abundance of 99% of species



Benthic community statistical analysis

- PERMANOVA v. 1.6 was used to analyze site differences with respect to species abundance and type

- Program runs ANOVAs on multivariate data

  - Data was run using a two-way nested ANOVA

- Data was analyzed in four ways

  - all species; marine animals only; crustaceans only; all Arthropods

- No significant differences between spray and reference sites during any of the four runs

Conclusions

• Aerial application of Altosid® and Scourge® on Suffolk County marine wetlands had no demonstrable effect on caged fish and shrimp, or on naïve shrimp exposed to water collected after the spray event.

• Low dissolved oxygen appeared to be the primary source of mortality observed in caged organisms. Minor changes in placement of cages had significant impacts on survival.

•Data observed is consistent with the low and rapidly declining concentrations of pesticides measured in waters where cages were deployed after pesticide application, and data available on the toxicity of these compounds to fish and shrimp (LC50 of 0.5 µg/L for Scourge®, > 1mg/L for Altosid®).

• Greater persistence of methoprene in sediments suggests that chronic effects on infaunal organisms should also be assessed – but preliminary study showed no effects.

Cashin Associates

Suffolk County

Department of Health Services
Division of Environment Quality &
Department of Public Works –
Vector Control

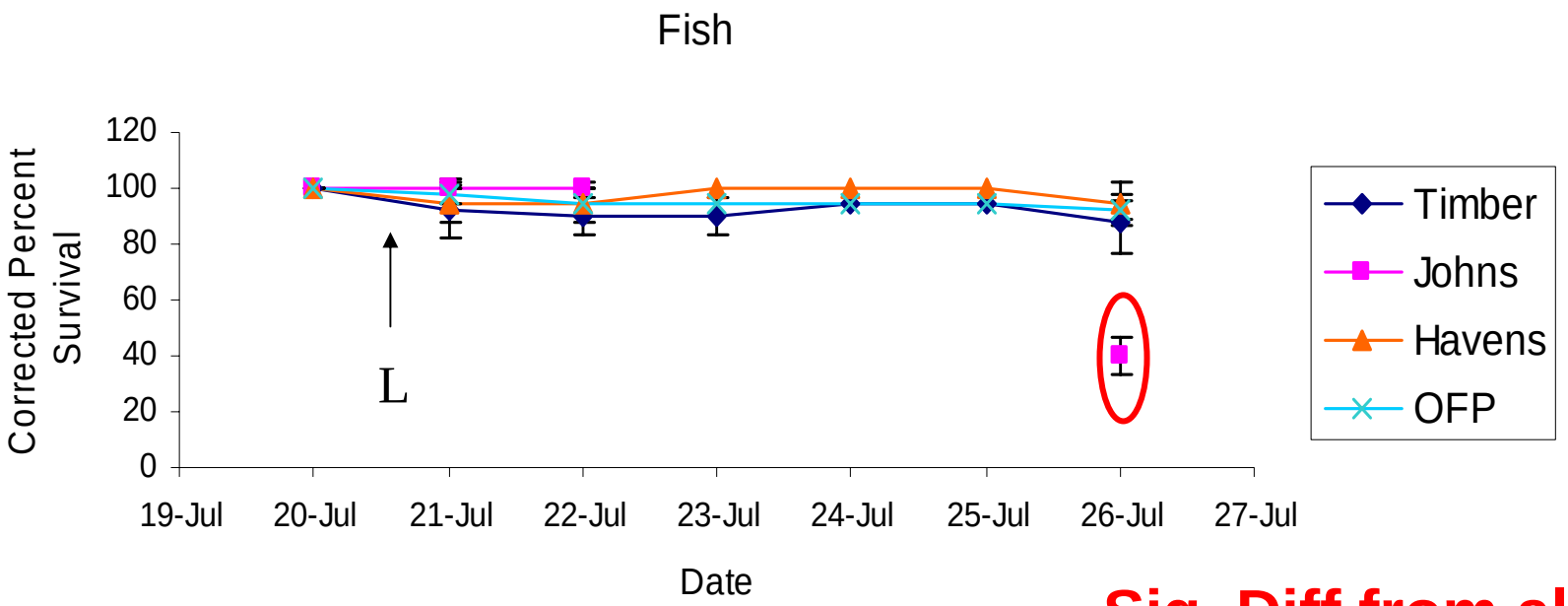
Additional information -

Plots of corrected survival for the remainder of the caging experiments not shown in talk.

“A” indicates adulticide spray

“L” indicates larvicide spray

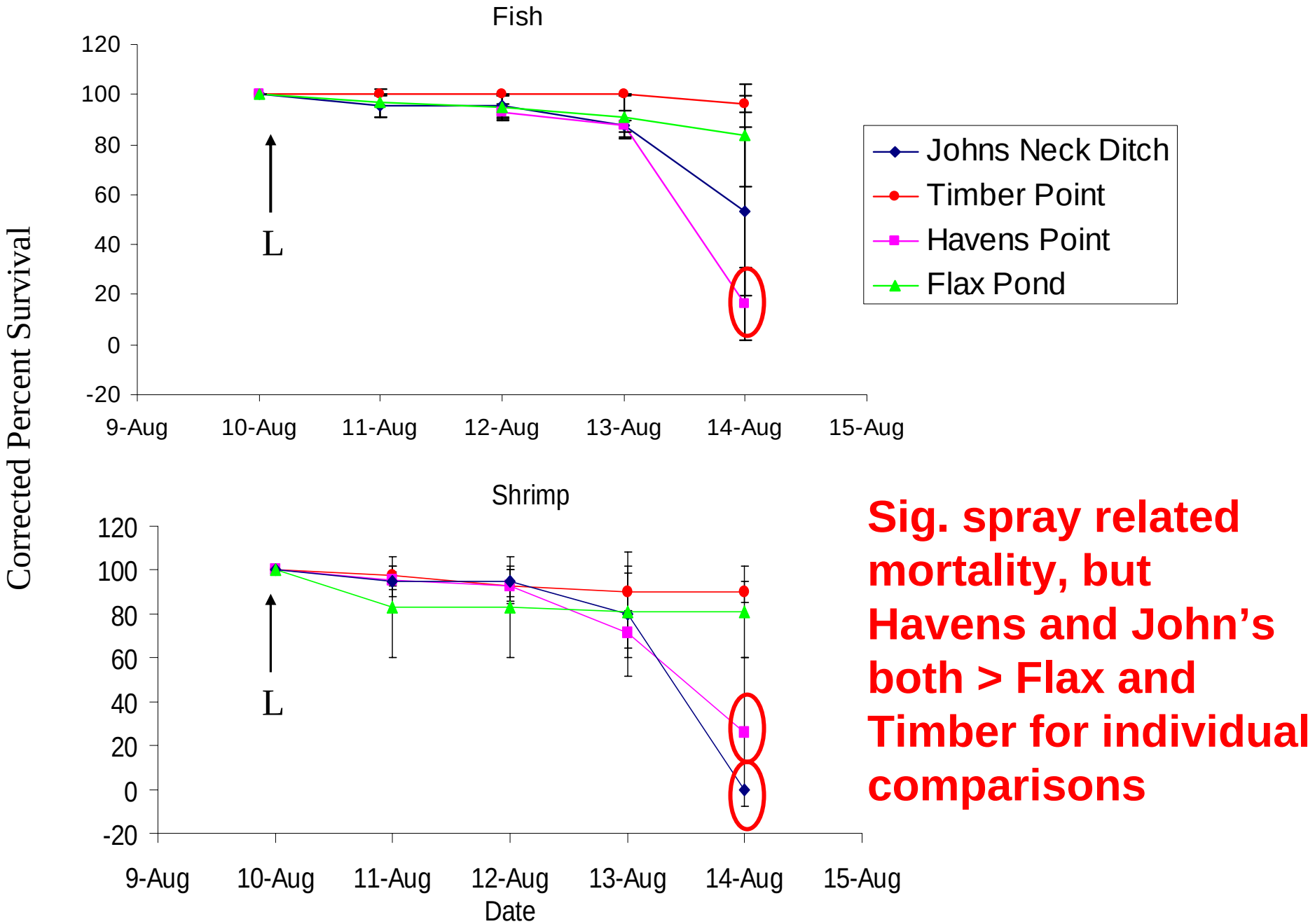
Corrected Fish Survival for 7/20/04



Sig. Diff from all other sites

NOTE: no shrimp were put in for this spray experiment

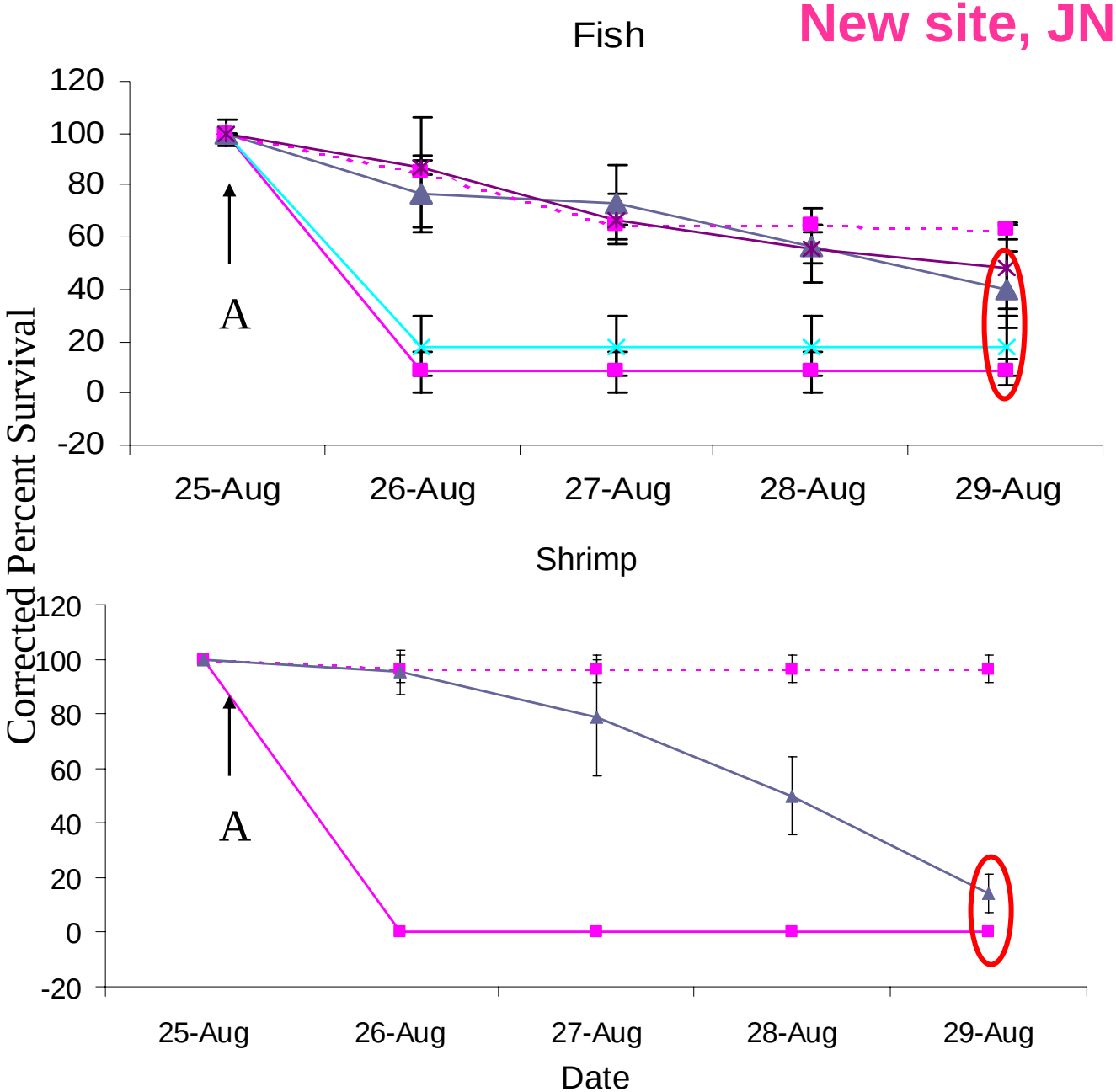
Corrected Fish and Shrimp Survival for 8/10/04



Sig. spray related mortality, but Havens and John's both > Flax and Timber for individual comparisons

Fish and Shrimp Survival for 8/25/04

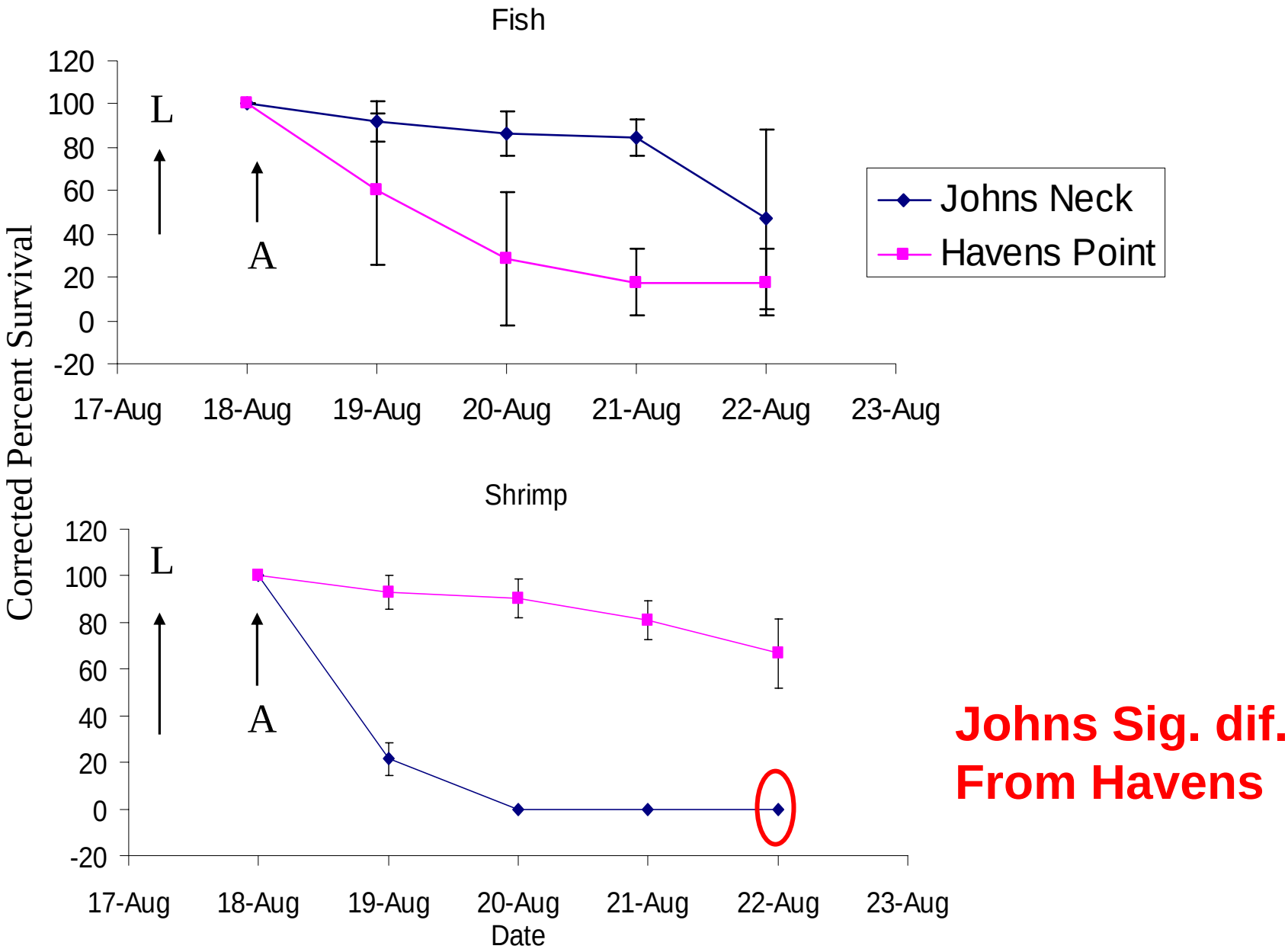
New site, JN Channel



JN Channel site Sig. greater survival than Havens or JN Ditch

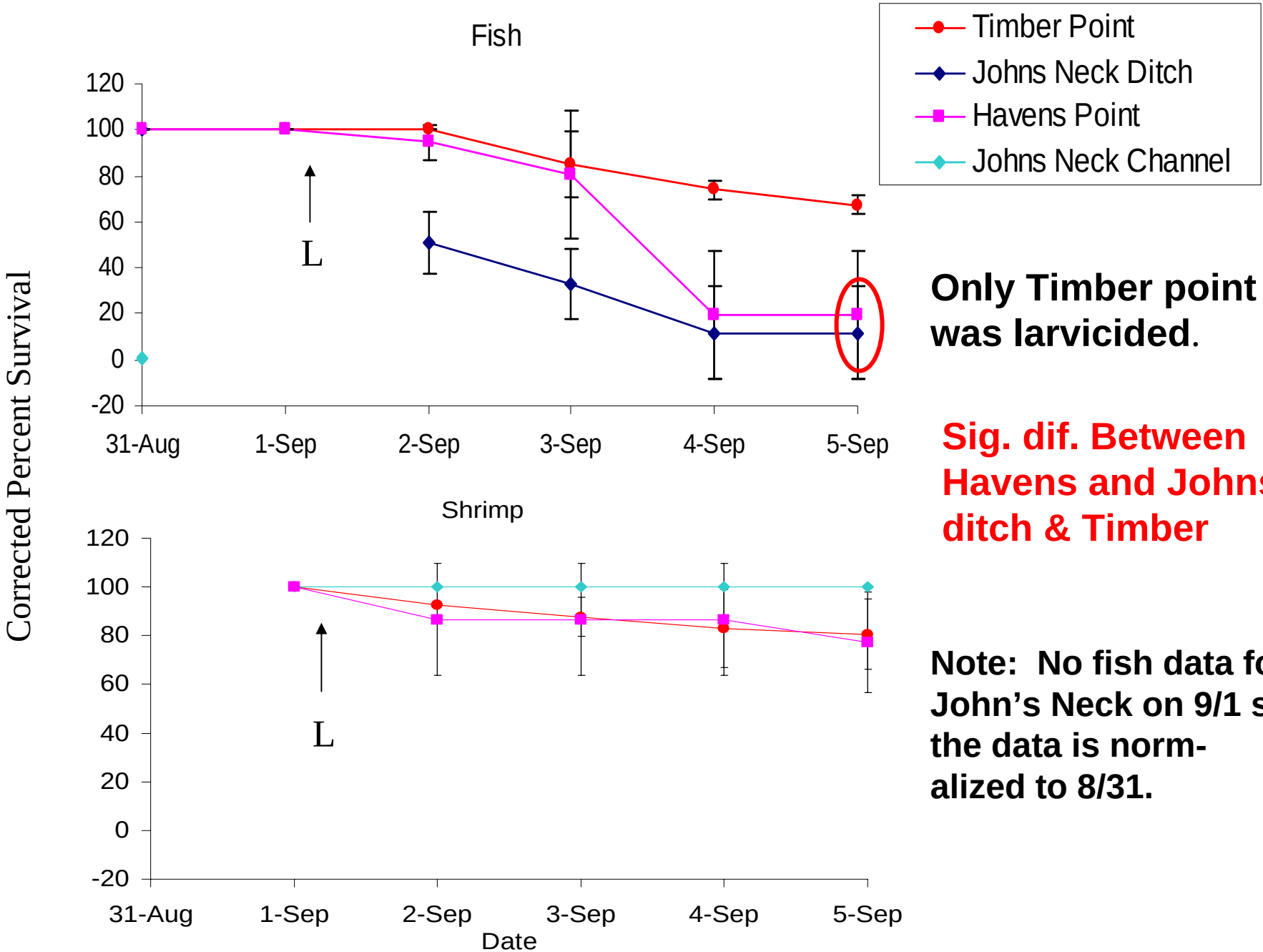
Note: cages were placed at the site the morning of the spray and therefore the corrected and uncorrected graphs are the same.

Corrected Fish and Shrimp Survival for 8/18/04



Johns Sig. dif. From Havens

Corrected Fish and Shrimp Survival for 9/1/04



Only Timber point was larvicided.

Sig. dif. Between Havens and Johns ditch & Timber

Note: No fish data for John's Neck on 9/1 so the data is norm-alized to 8/31.