Propeller Wash Effects on Spray Drift

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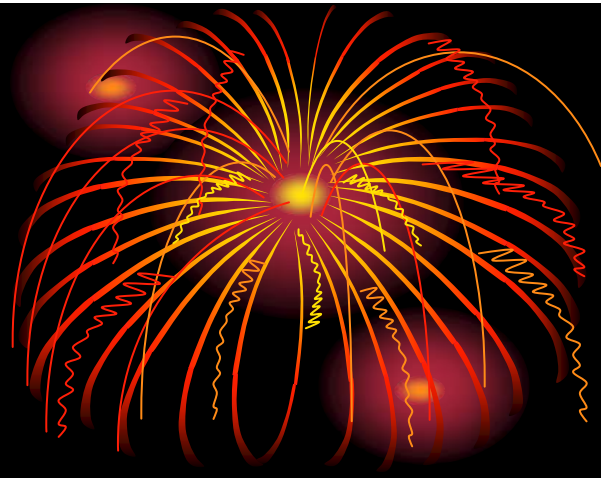


Objective

To determine the effect of boom (left or right), boom orientation (upwind or downwind), and/or direction of propwash rotation on spray drift.

This information is important if closing one side for drift reduction near field boundaries or other reasons.

History of this project

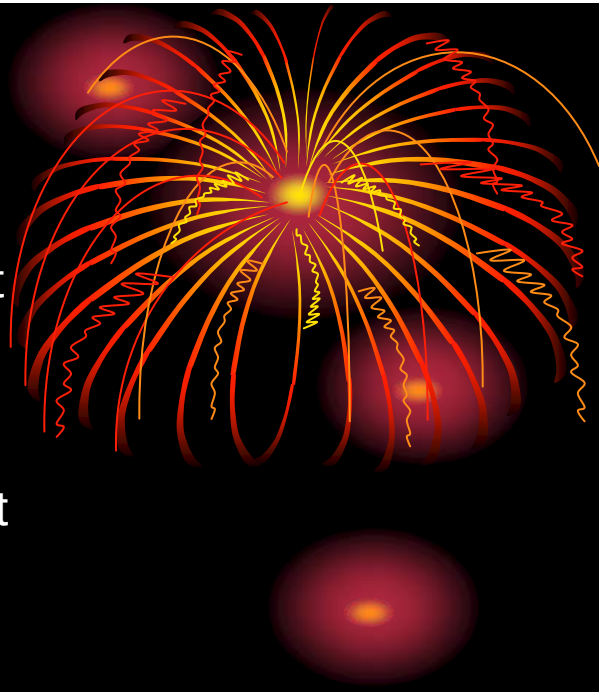
The field experiment was conducted in 1996 by Womac, Mulrooney, Deck, and samples were processed using HPLC.

- S. Deck left the position with data in spreadsheets (un-analyzed)

- Thomson came on board in ’97, attempted to analyze data in ’98. Drift data showed definite trends, but weather data could not be found.

- Weather data taken from field microloggers were found on diskette in 2002 (Thanks to Benjy Naron).

Previous work



Huddleston et al. (1994) performed a test where left and right booms of an aircraft were switched and drift of malathion and chlorpyrifos were detected using string samplers placed 33- and 91-m downwind.

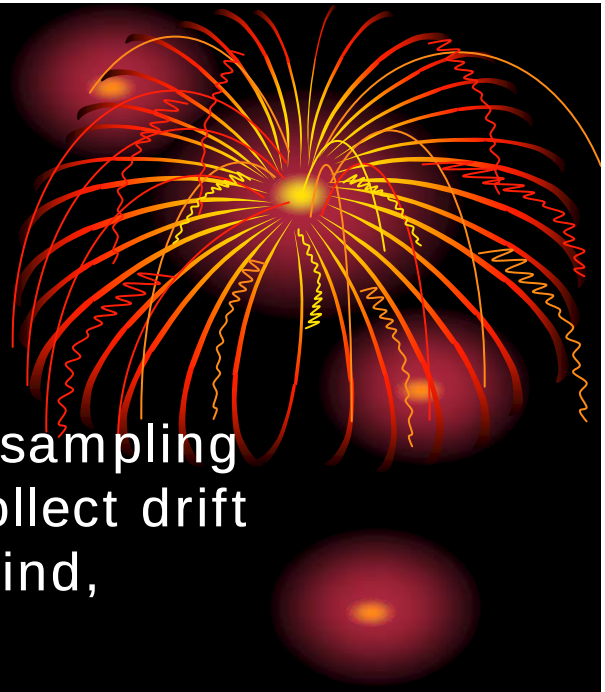
- Wind speeds ranged from 1.3 to 3.1 m/s throughout the test, but it was not clear whether wind speed or direction were accounted for in the statistical design.

- Results suggested that the right boom contributed more to drift than the left boom ($p=0.0251$) 33-m downwind.

- Results also suggested that the right boom contributed more to drift than the left boom ($p=0.0968$) 91-m downwind.

Results were due to (Boom*Boom Orientation) interaction. So, this was probably a propwash direction issue as his results (and ours) suggested no significant difference which boom was downwind.

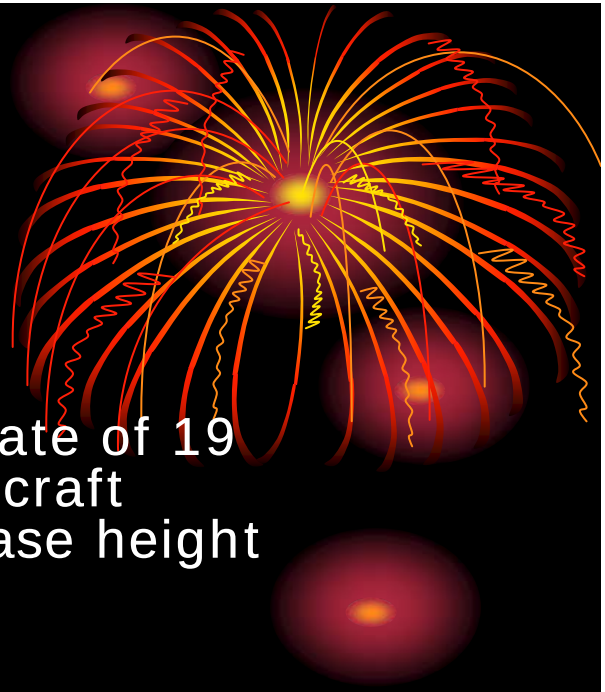
Experimental Design



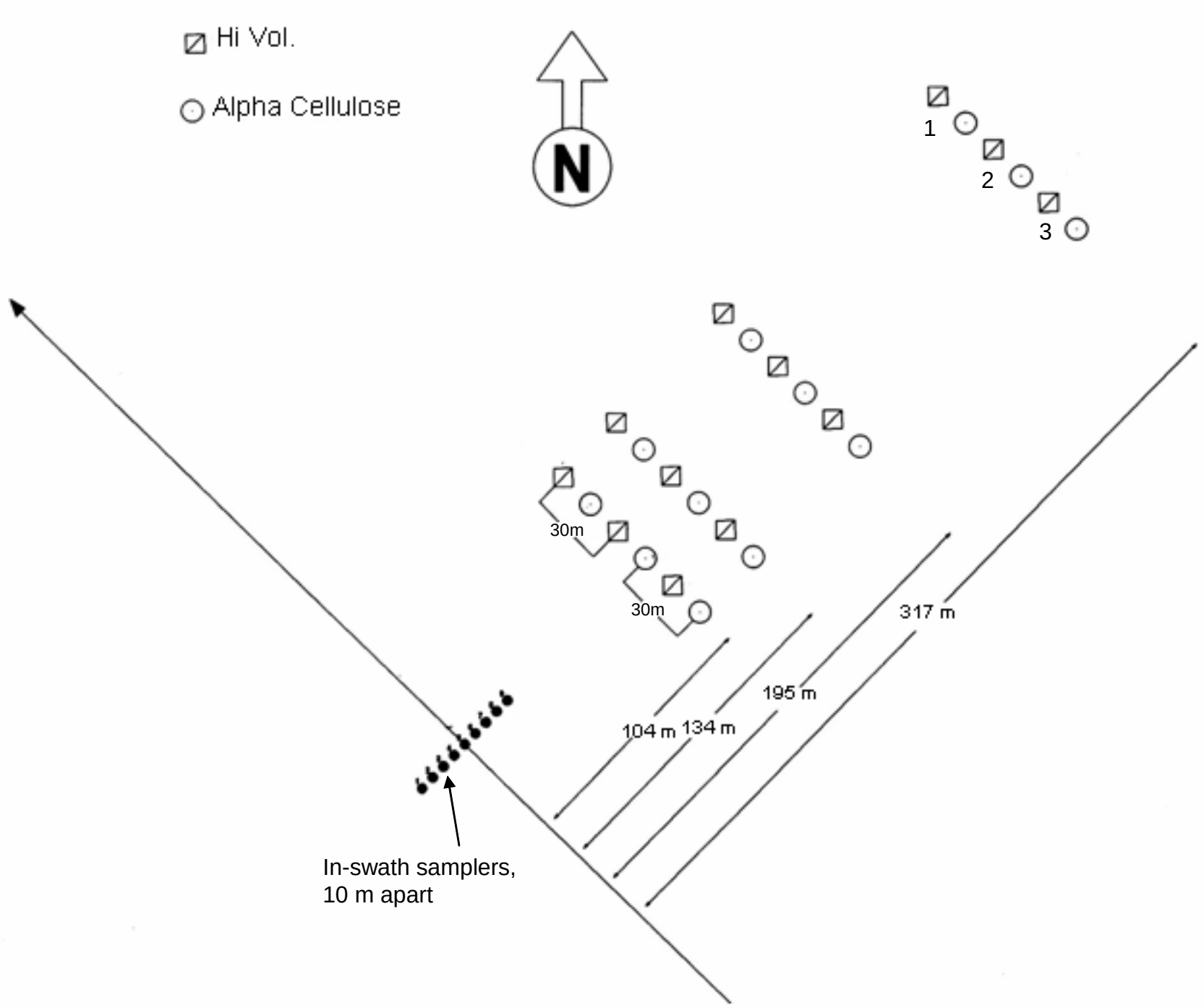
- Both high volume and alpha cellulose spray sampling sheets were placed at three sample lines to collect drift fallout 104, 134, 195, and 317 meters downwind, perpendicular to the flight path.

- The high volume (Hi-Vol) vacuum motor air samplers with 10.2-cm diameter (81-cm^2 surface area) TFA2133 glass fiber filters were oriented vertically, mounted at a height of 1.8-m above ground level. Airflow was 0.68 m^3/min.

- Weather conditions were measured on-site at 1.8-, 3-, and 9-m tower heights using a Campbell Scientific 21X logger.



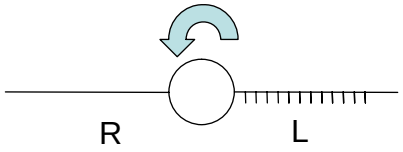
- An aqueous mixture of malathion at a spray rate of 19 L/ha was applied from an Air Tractor 402B aircraft through fifty D6-46 hollow cone tips at a release height of 3.7-m. Four passes were made per run.
- Five total replications were conducted over two days. Each replication had four treatment combinations of boom switch (left or right, on or off) and airplane direction.
- For statistical analysis, downwind distances were adjusted for each run to account for wind direction and boom position from the swath


Hi Vol.
Alpha Cellulose
N
1
2
3
30m
30m
104 m
134 m
195 m
317 m
In-swath samplers,
10 m apart

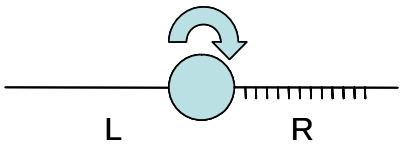
Wind direction

Treatment

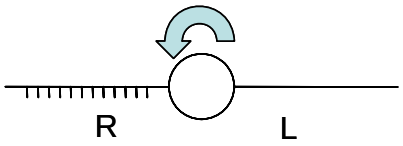
1 (LD)



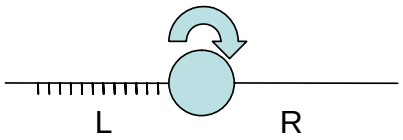
4 (RD)



3 (RU)



2 (LU)



Plane travel towards

Plane travel away

Table 1. Meteorological conditions during study.

	REP	Treatment	Mean Air Temp (C)	Mean RH (%)	Mean Solar Irradiance (kW/m^2)	Mean Wind Velocity (m/s)	Std. Dev.of Wind Velocity (m/s)	*Mean Wind Direction (degrees)	Std. Dev of Wind Direction (degrees)	Stability Ratio ($°Cs^2/m^2$)
Day 1	1	1	27.86	47.81	0.95	4.09	2.21	1.63	9.46	-0.22
	1	2	28.35	46.32	0.89	5.69	0.97	-3.10	11.01	-0.22
	1	3	29.03	44.24	0.84	5.58	0.68	-0.83	6.30	-0.22
	1	4	28.48	45.31	0.37	5.19	0.55	4.90	12.46	-0.17
	2	1	28.84	44.05	0.62	4.78	0.51	2.41	11.17	-0.22
	2	2	28.97	42.63	0.53	5.02	0.80	-7.97	4.00	-0.22
	2	3	29.04	42.39	0.43	4.80	0.51	2.78	13.15	-0.21
	2	4	29.02	42.77	0.35	4.37	0.66	-3.35	4.06	-0.22
Day 2	3	1	24.79	74.56	0.68	5.47	0.86	-9.71	9.41	-0.19
	3	2	25.28	74.24	0.63	3.28	0.50	-28.60	18.67	-0.49
	3	3	26.64	64.10	0.96	3.98	0.60	-6.46	14.33	-0.40
	3	4	28.23	55.00	0.94	3.61	1.18	8.34	14.78	-0.57
	4	1	28.65	56.63	0.91	3.93	0.64	-17.48	12.48	-0.38
	4	2	29.04	54.52	0.96	4.29	0.87	-14.71	13.81	-0.35
	4	3	29.61	54.35	0.93	3.90	0.75	-29.36	18.99	-0.44
	4	4	29.51	55.59	0.79	3.31	1.15	-26.84	13.37	-0.65
	5	1	29.82	50.88	0.86	3.80	0.91	-21.78	13.68	-0.51
	5	2	29.62	50.95	0.42	4.07	0.55	10.37	11.81	-0.33
	5	3	29.53	52.13	0.32	3.97	0.73	-42.07	18.70	-0.36
	5	4	29.38	52.17	0.28	3.94	0.55	-55.30	5.02	-0.28

* Mean wind direction is relative to the sampler line

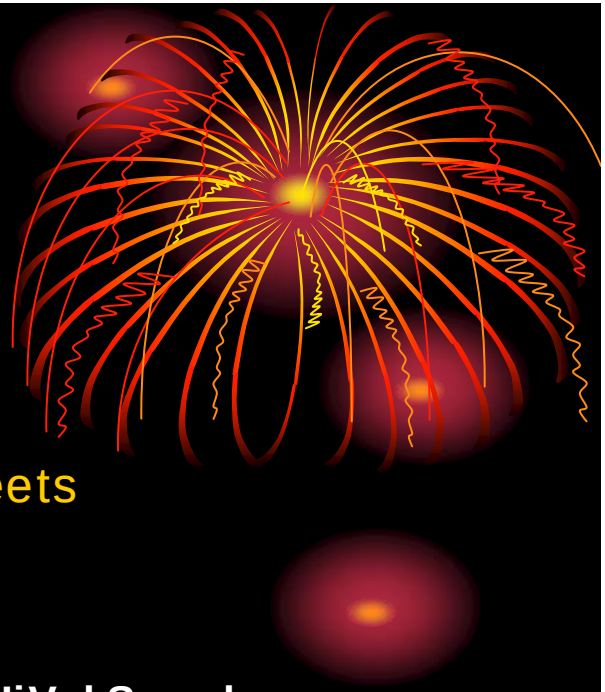
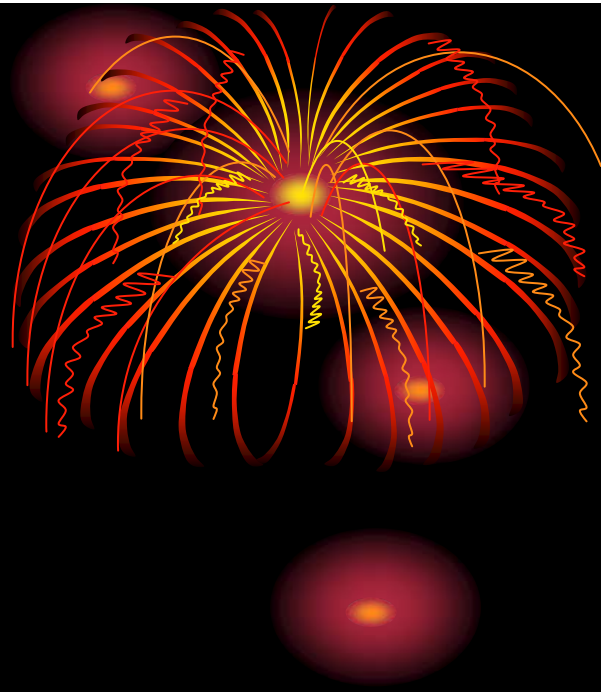


Table 2. Pearson correlations (R) between selected weather variables and spray collections for fallout sheets and Hi-Vol samplers at four downwind distances

	Fallout Sheets				Hi-Vol Samplers			
Variable	104m	134m	195m	317m	104m	134m	195m	317m
Temperature	0.0283	0.2410	0.3828	0.2956	**0.5530**	0.5139	0.4541	0.4595
Relative Humidity	-0.2966	-0.4390	**-0.5715**	**-0.6611**	**-0.5162**	-0.4668	-0.4704	**-0.6707**
Solar Radiation	-0.4486	-0.3341	**-0.7117**	**-0.7252**	**-0.6236**	**-0.6830**	**-0.8004**	**-0.8019**
Wind Velocity	0.2492	0.1405	0.3311	**0.5313**	0.1414	0.1005	0.1718	0.4012

Statistical Results

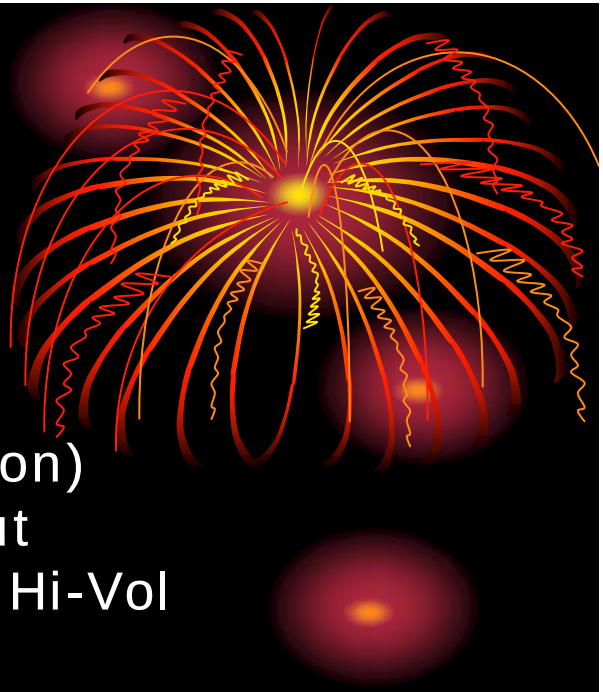


For the entire test (over two days, five replications):

Neither actively spraying boom nor boom orientation (UD, up or down) were statistically significant for either sampling method, although boom orientation showed some influence for Hi-Vol samplers ($p=0.1530$).

There was significant influence of horizontal sampler location (LOC) at downwind distances for the Hi-Vol samplers ($p=0.0347$).

Variability of downwind sample collections was lower when propeller wash direction was upwind.



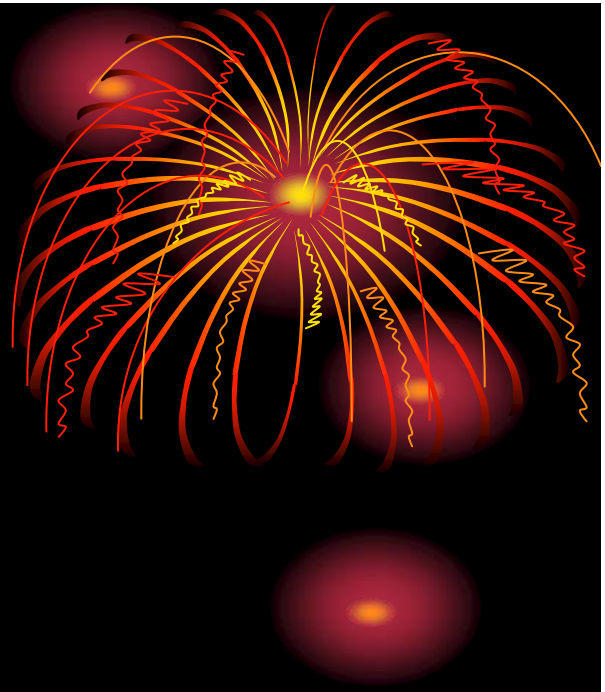
For analysis limited to the second day of testing (three replications):

Propeller wash direction (BOOM*UD interaction) was significant at the 0.10 level for the fallout sheets (P=0.0773), and at the 0.05 level for Hi-Vol samplers (P=0.0200).

Boom orientation was significant at the 0.05 level (P=0.0254) for the Hi-Vol samplers.

Ldist*UD (Log of downwind distance*Boom orientation) interaction was significant for the Hi-Vol samplers (P=0.0295).

Graphical Results



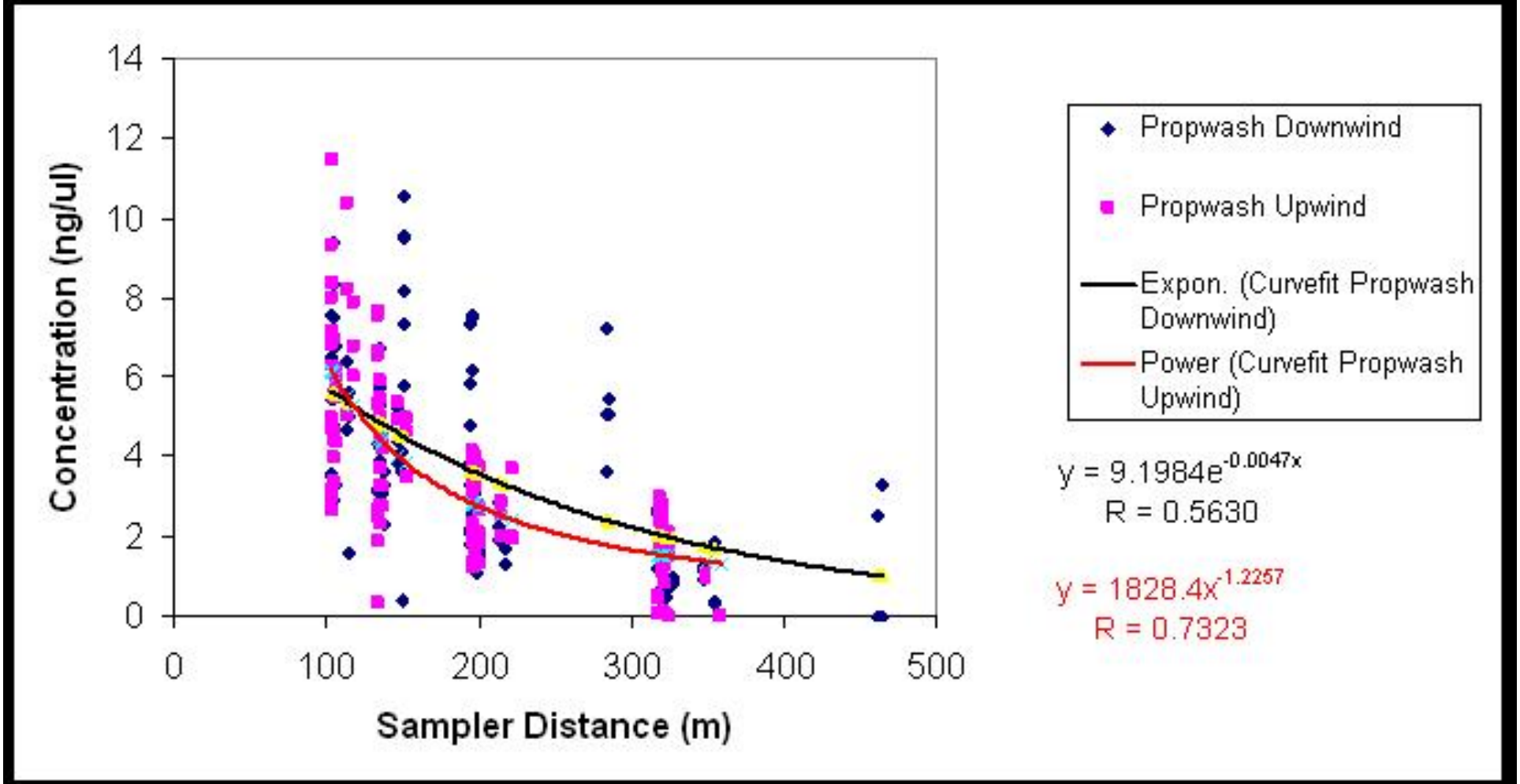


Figure 3a. Propeller wash effects illustrated by sampler distance vs. lab concentrations of malathion across all replications for Hi-Vol samplers.

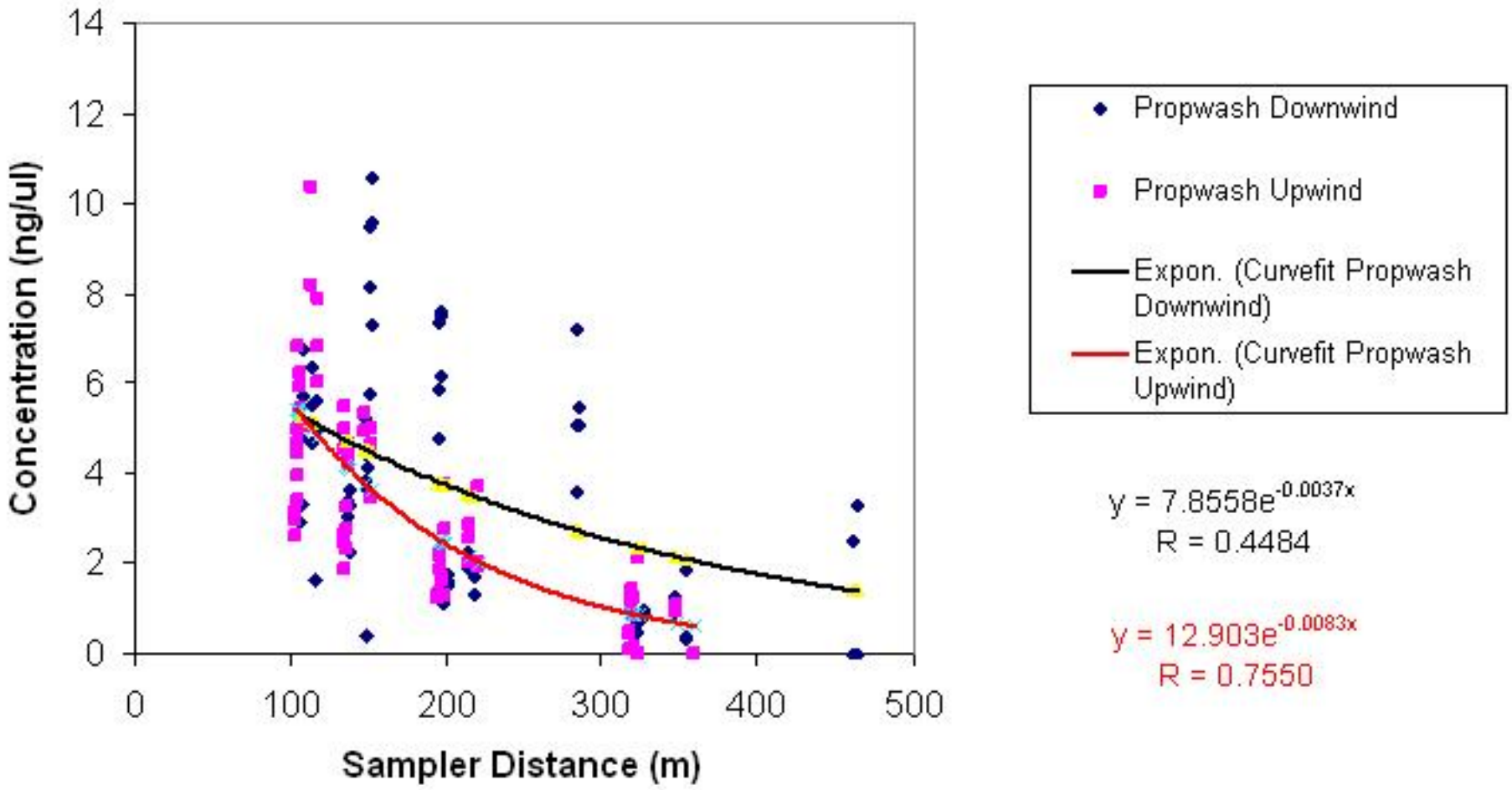


Figure 3b. Propeller wash effects illustrated by sampler distance vs. lab concentrations of malathion across replications 3, 4, and 5 on second day of testing for Hi-Vol samplers.

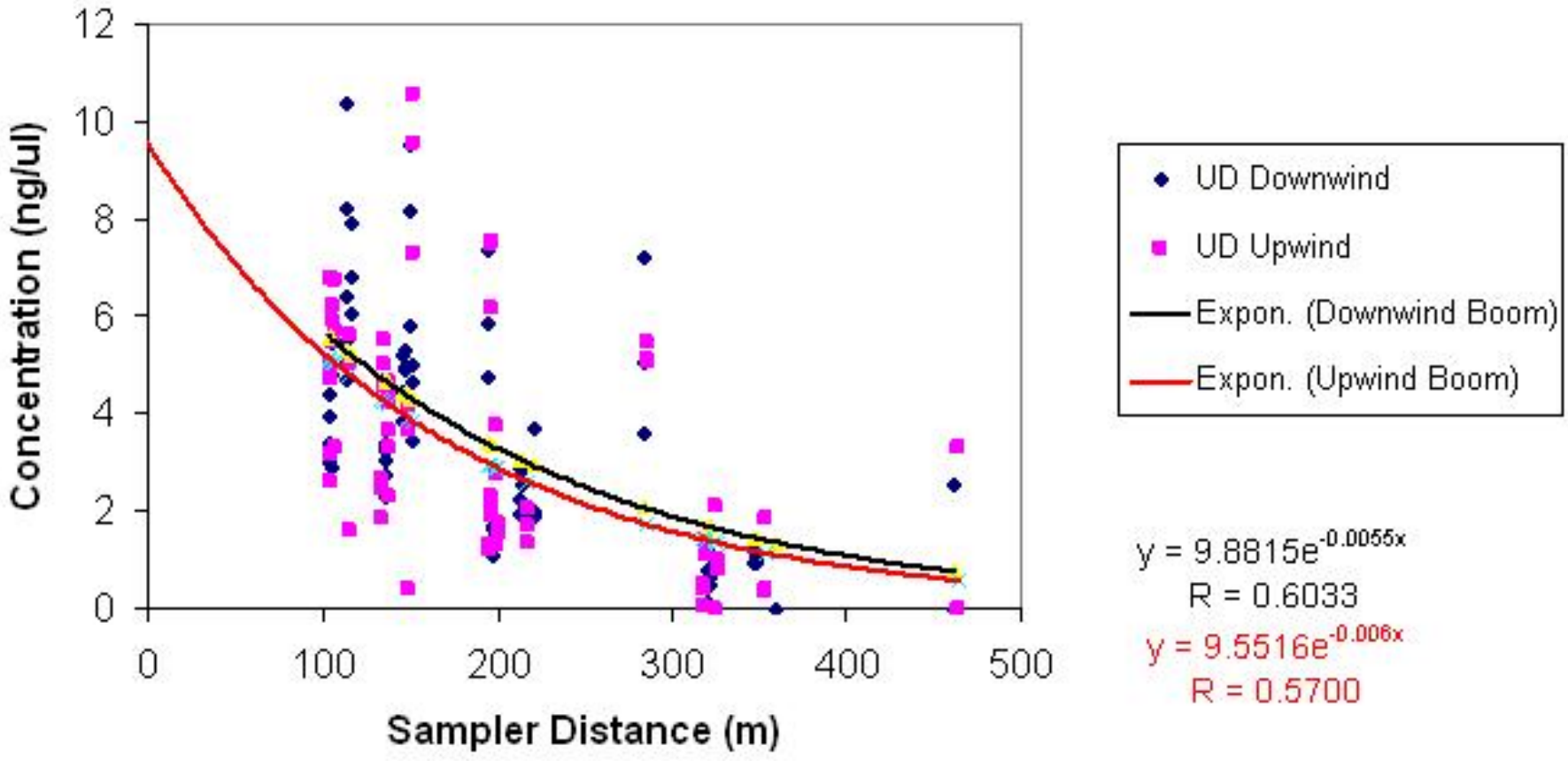
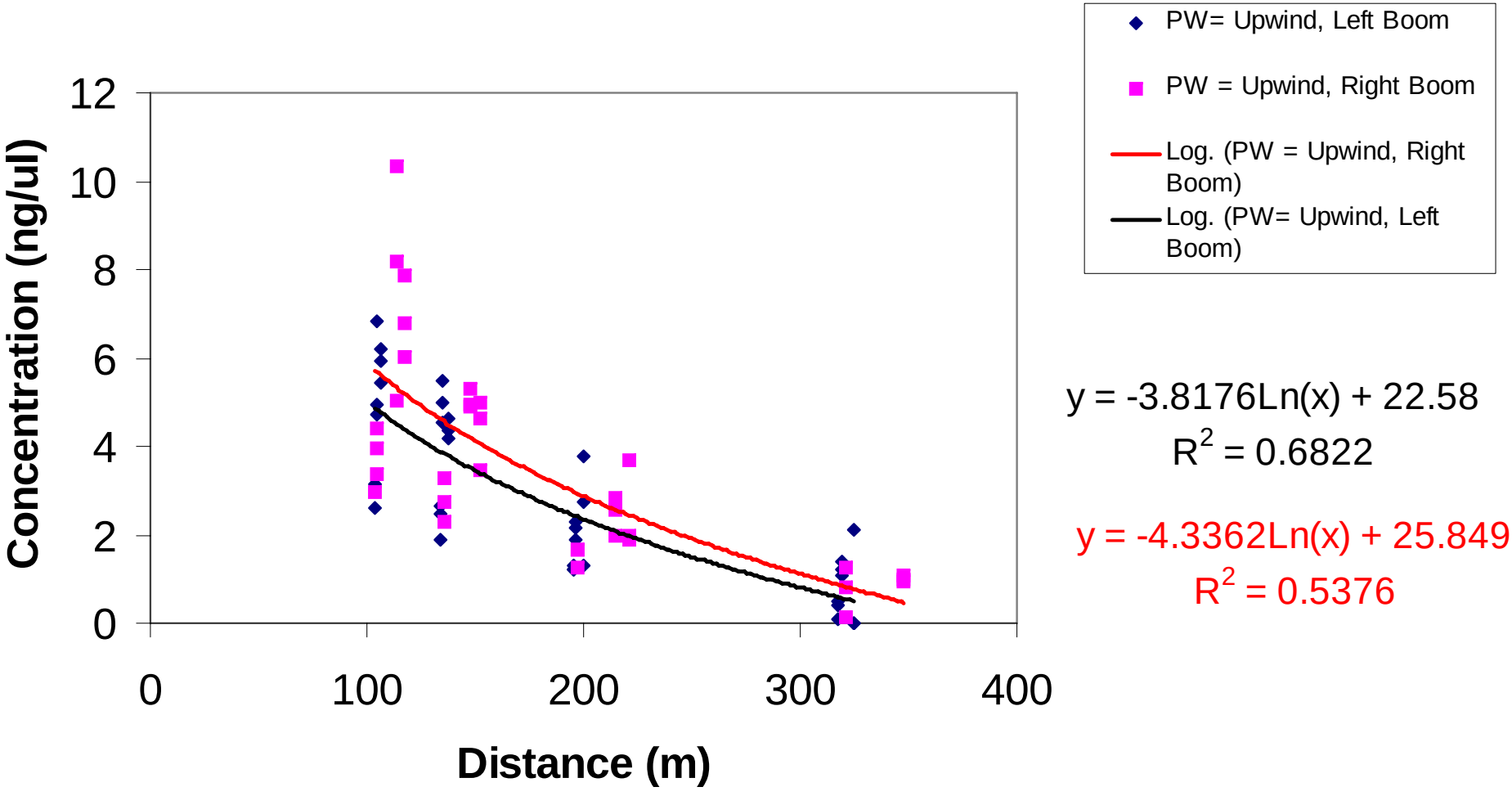
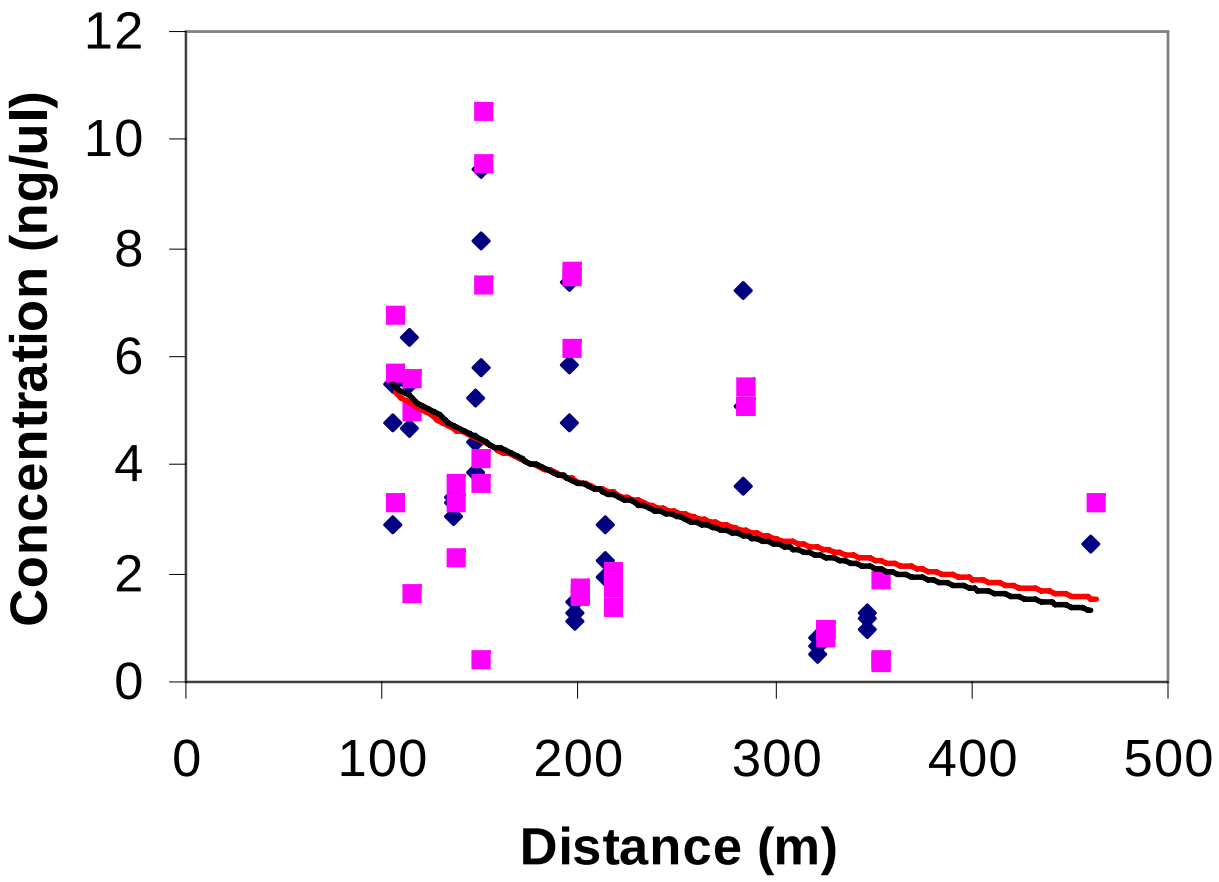


Figure 4. Boom position effects illustrated by sampler distance vs. lab concentrations of malathion across replications 3, 4, and 5 on second day of testing for Hi-Vol samplers.



Boom effects illustrated by sampler distance vs. lab concentrations of malathion across replications 3, 4, and 5 on second day of testing for Hi-Vol samplers. Propwash direction is upwind.



PW= Downwind, Left Boom

PW= Downwind, Right Boom

Log. (PW= Downwind, Right Boom)

Log. (PW= Downwind, Left Boom)

$y = -2.8116\ln(x) + 18.572$

$R^2 = 0.25$

$y = -2.583\ln(x) + 17.383$

$R^2 = 0.1557$

Boom effects illustrated by sampler distance vs. lab concentrations of malathion across replications 3, 4, and 5 on second day of testing for Hi-Vol samplers. Propwash direction is downwind.

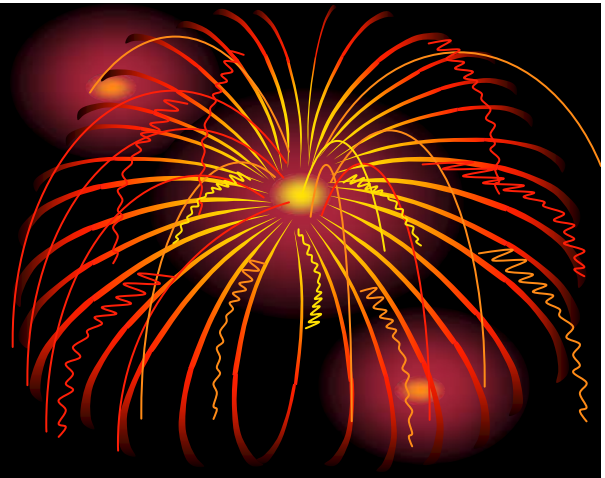
Summary (in English)

Variability of downwind sample collections was lower when propeller wash direction was upwind.

Propeller wash effects were more pronounced with increasing sampler distance for both sampling methods.

Treatments applied with the direction of propeller wash rotation that rolled in the upwind direction tended to reduce drift.

Results corroborate Huddleston's near-drift study using string samplers, but their study may actually have indicated the effect of propwash direction AND boom (right or left).



For a south wind, fly so that propwash direction is upwind. (Fly east to west).

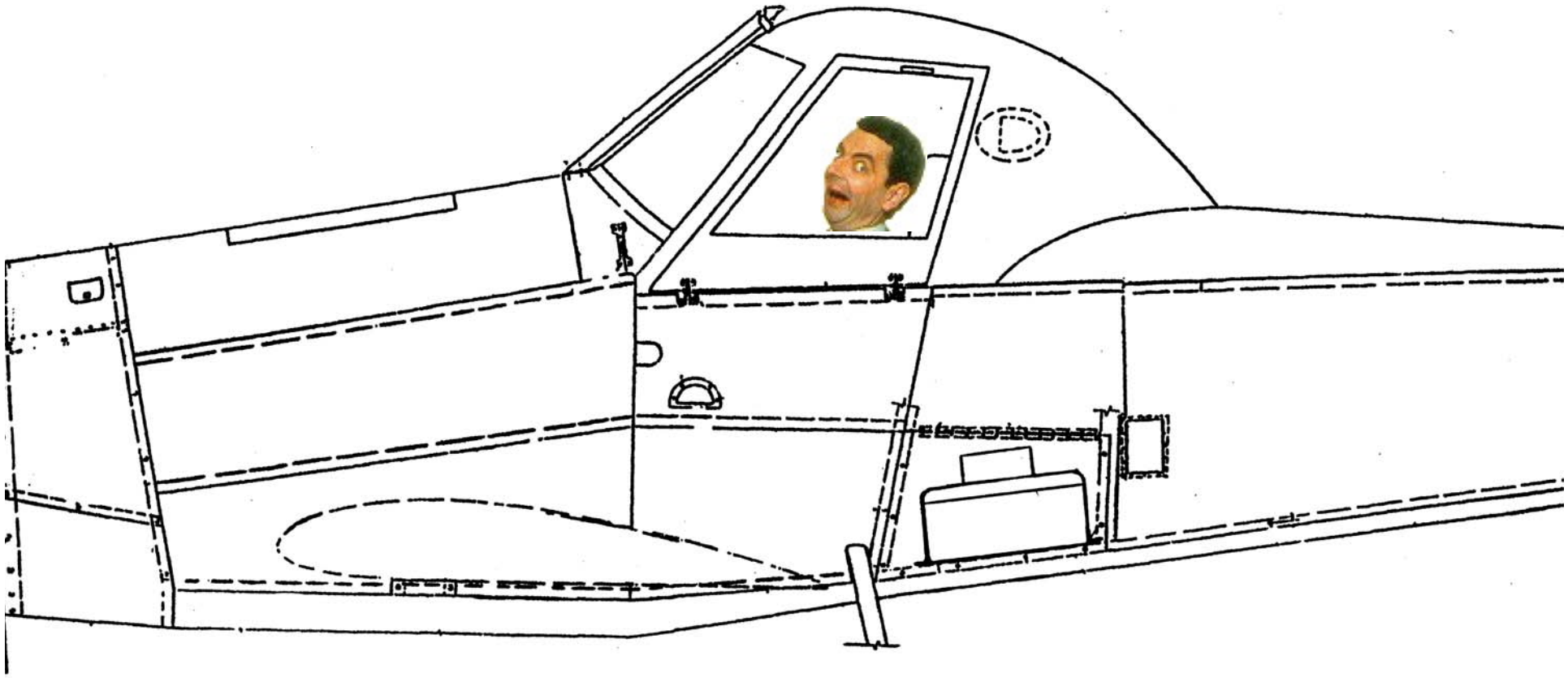
Boom effect was small by our data, but spraying from left boom indicated slightly less drift.

Observations and Future Work

1. Hi-Vol samplers did not collect all the spray, but relative concentrations could be determined

2. Mass balance estimate is being conducted using fallout data in the swath and downwind.

3. Another near-drift study to supplement this far-drift study will be conducted.



Thank you!