Post-atomization Impact Behavior of COREXIT® 9500 and COREXIT® 9527 on Oil Slicks

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Laboratory for Pest Control Application Technology

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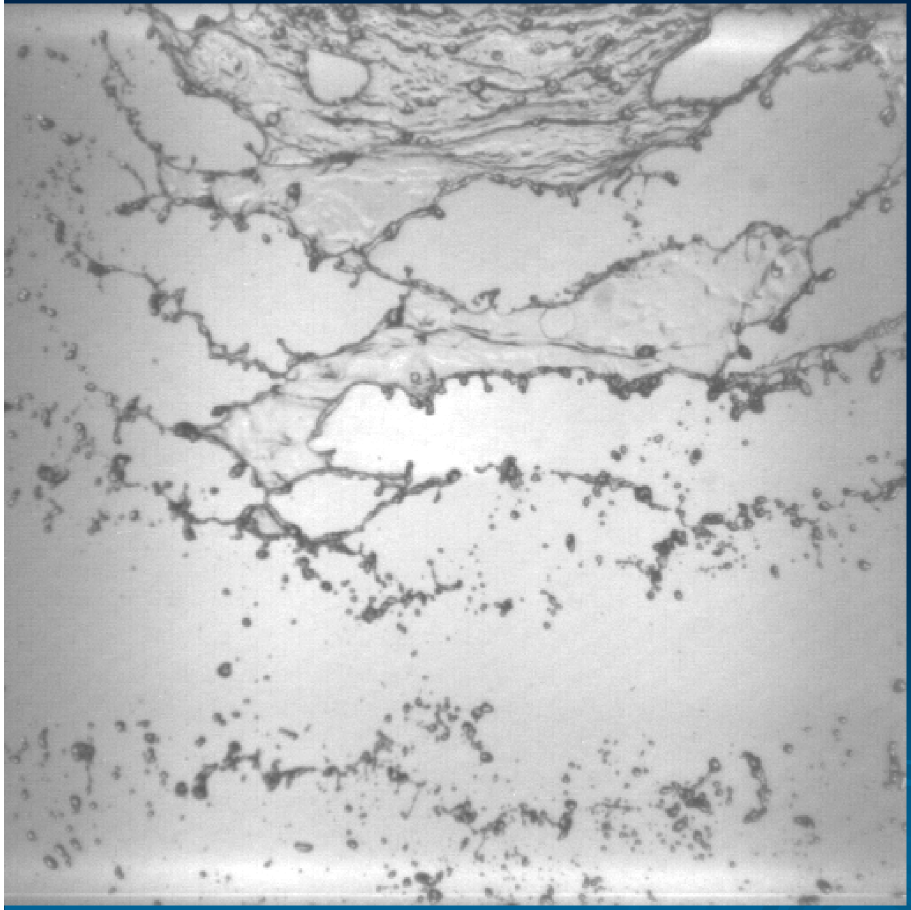
Application Technology

- Atomization



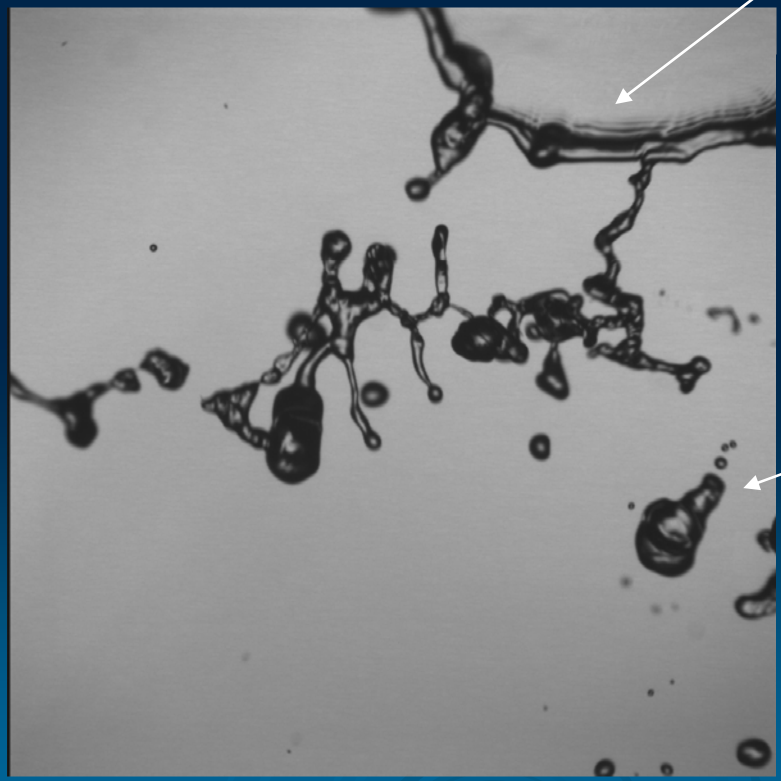
Water, still air, TeeJet 8003

Impaction

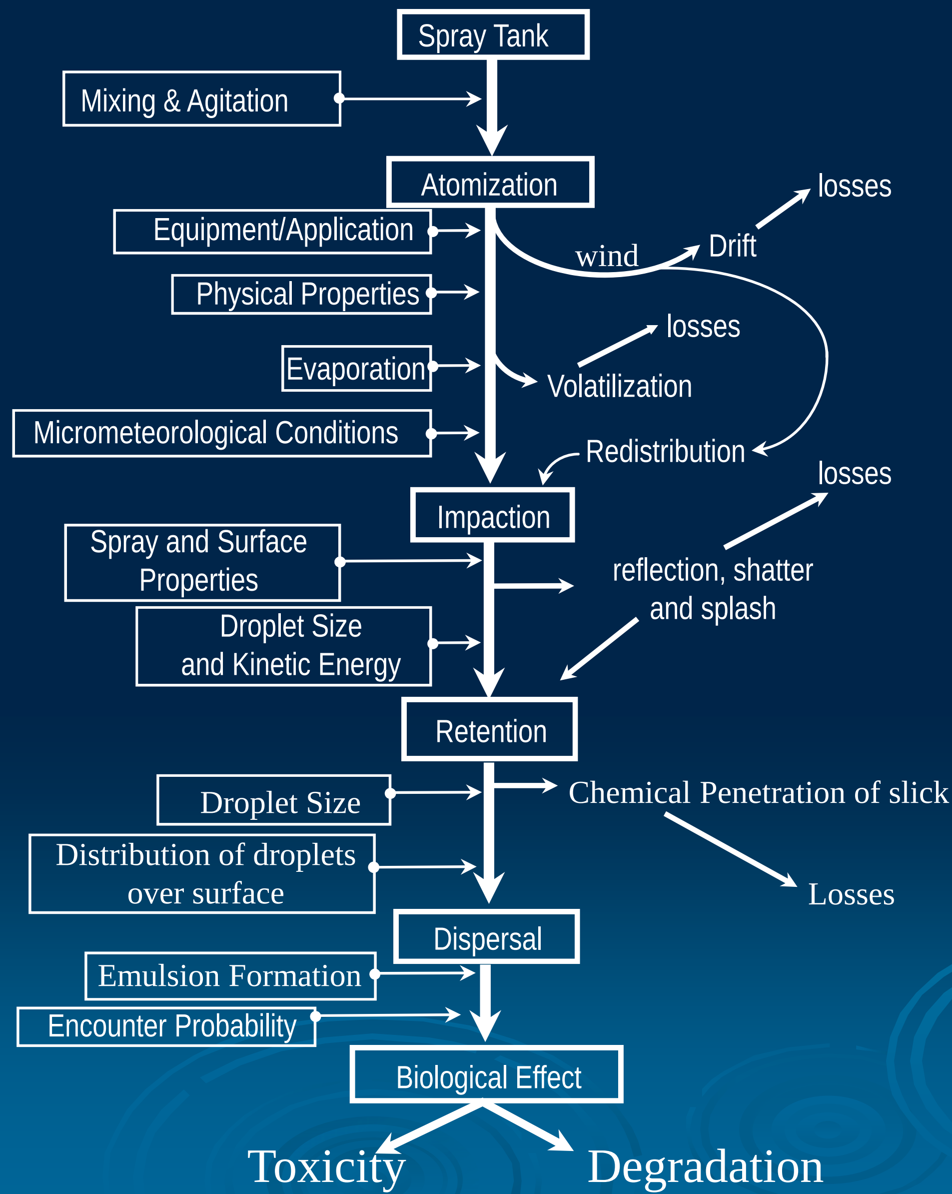
Impaction on poinsettia leaf

Atomization

Wavy Sheet Disintegration



The Dose Transfer Process



Introduction

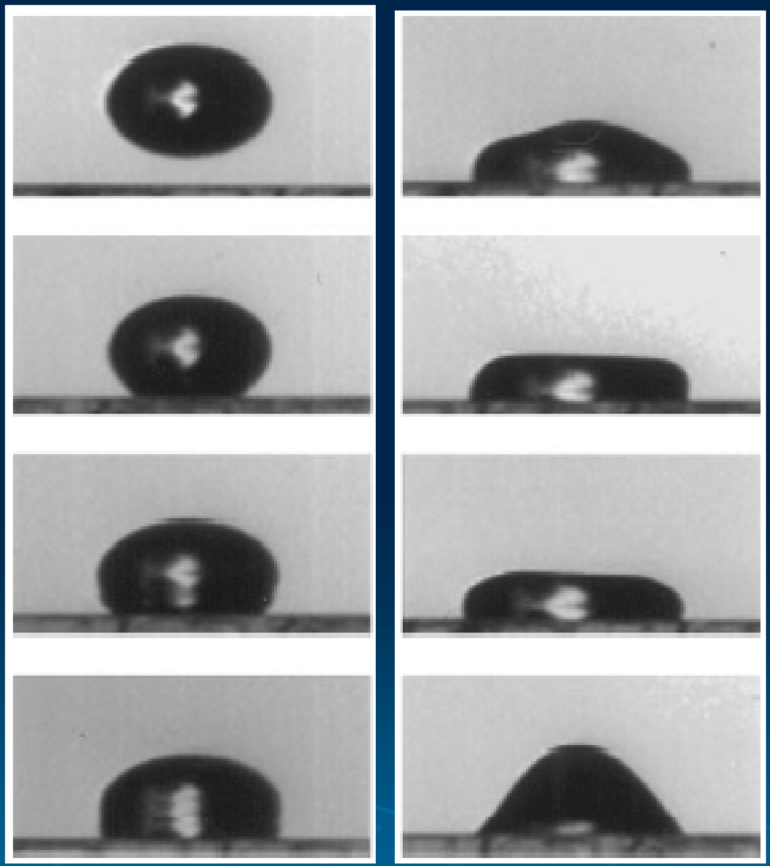
- What is the maximum droplet size that does not penetrate an oil slick?
- Oil composition
- Physical Properties
- Impaction energy
- Slick Thickness
- Scale

The Right Scales

- Time
- Size and Volume
- Area

Time

- The impaction process on a hard surface



Impaction, deformation, and initial recovery of a 330 μm diameter water droplet impacting a glass surface.
Time interval between successive frames 0.1 ms.

Size and Volume

Diameter (μm)	Volume (μl)	Number per Gallon
10	0.00000052	7.23E+12
50	0.00006545	5.78E+10
100	0.00052360	7.23E+09
500	0.06544985	5.78E+07
1000	0.52359878	7.23E+06
1500	1.76714587	2.14E+06

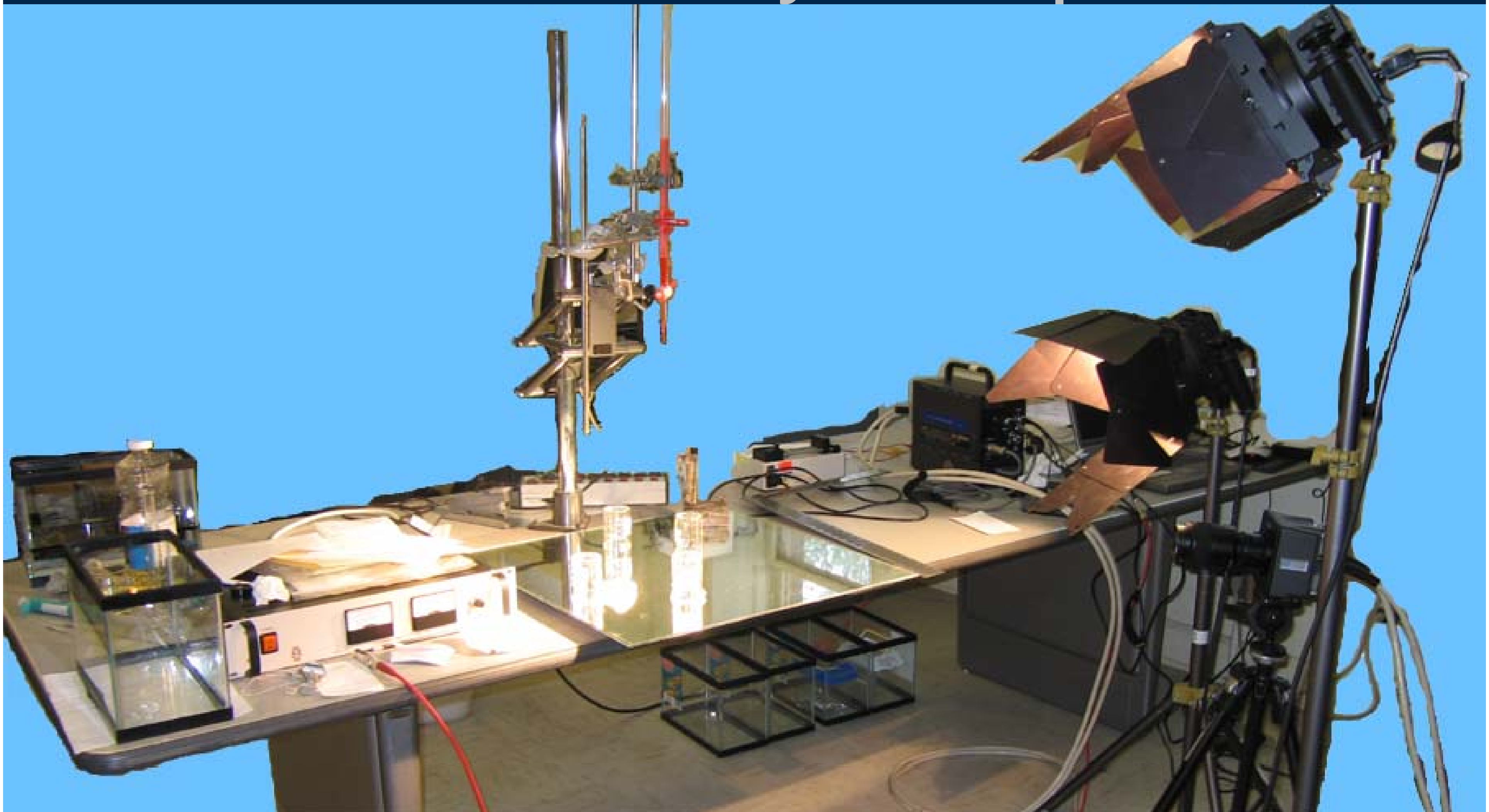
Area

- Droplets per cm^2 given an application rate of 1 gallon per acre

Diameter (µm)	Number per Gallon	Number cm2
10	7.23E+12	1.79E+05
50	5.78E+10	1.43E+03
100	7.23E+09	1.79E+02
500	5.78E+07	1.43E+00
1000	7.23E+06	1.79E-01
1500	2.14E+06	5.29E-02

563 µm will provide 1 droplet per cm^2

Laboratory set-up

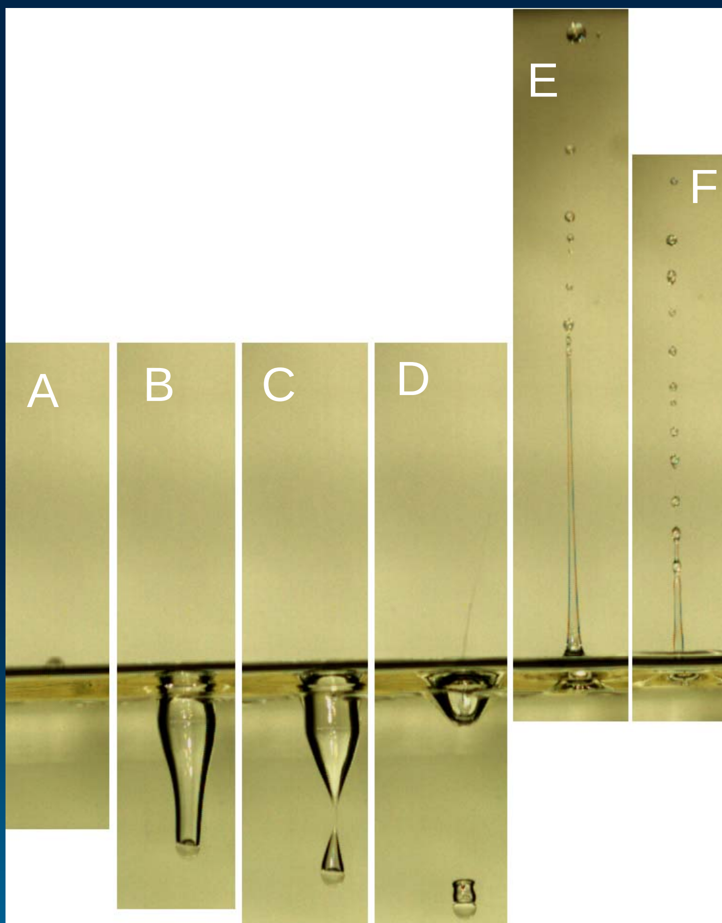


Options

- Droplets could act as marbles, penetrating and continuing into the water column.
- Droplets could shatter upon impact, thereby mixing with the water column.
- Droplets could retain cohesion, float, and remain at the water-oil interface.

Penetration: Glass spheres

- No chemical interactions
- No physical interactions
- Surface deformation and recovery



0.016 0.022 0.029 0.079 0.099

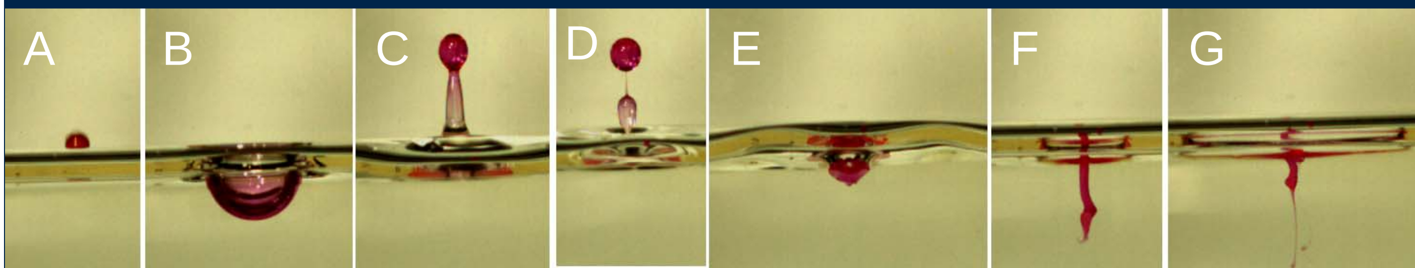
Time in Seconds

A: Time zero, bead is just above surface
B: Maximum width of displacement
C: Glass bead continues down and the filament connecting bead to surface is thinnest.
D: A thin stream of liquid is seen above surface
E: Initial droplets continue up beyond the picture frame.
F: Ligament is at maximum extension and droplets form along its entire length.

Chemical interactions

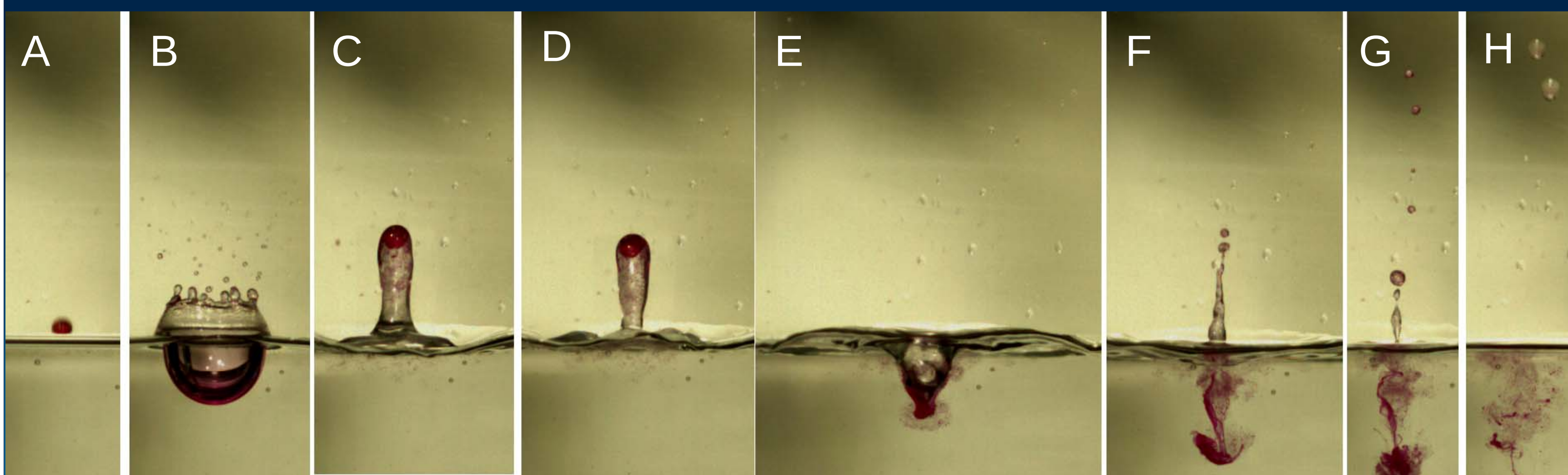
- Physical interactions
- Droplet Cohesion

3.21 mm 9500 into 2mm soybean



0 0.020 0.085 0.103 0.153 0.315 0.634

3.42mm 9527 into water



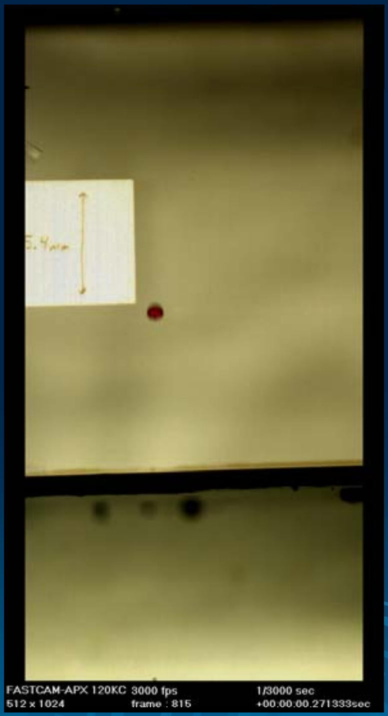
0 0.021 0.104 0.122 0.184 0.215 0.256 0.430

The Impaction Process

No Oil

Soybean Oil

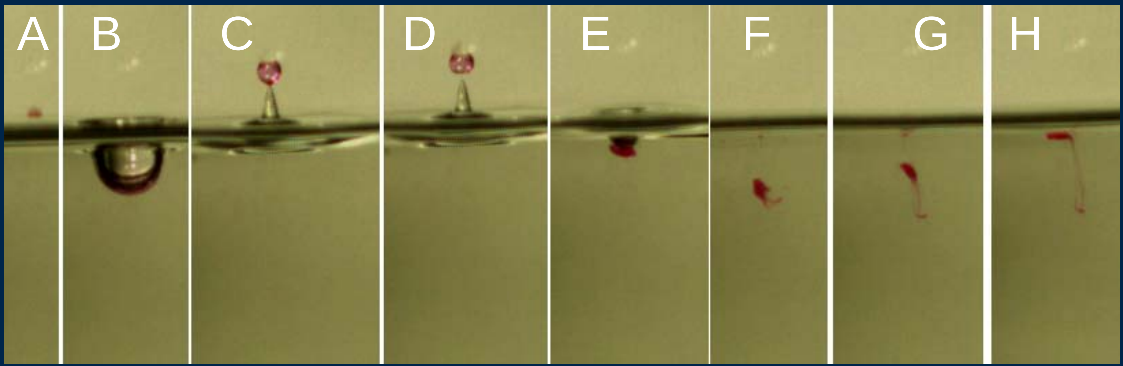
0.3mm Fuel Oil



Dispersant Impaction into Water

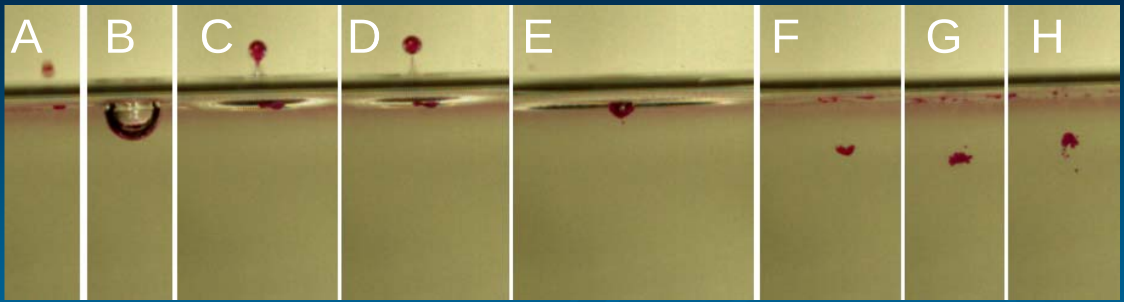
- All material rises to the surface

Corexit 9500



0 0.011 0.051 0.053 0.112 0.294 0.514 0.680

Corexit 9527



0 0.010 0.044 0.048 0.097 0.224 0.405 0.762

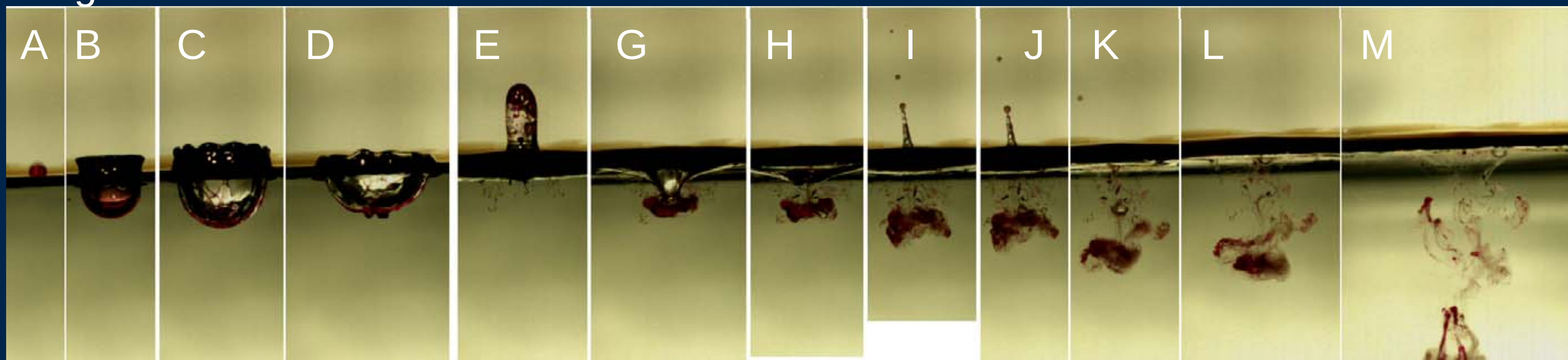
	9500	9527
Temperature (C)	30	30
Droplet Size (mm)	1.33	1.04
Velocity (m s-1)	2.57	4.26
% of Terminal V	52%	97%
Energy (uJ)	3.91	5.24
Energy/area (J m-2)	2.80	6.16
Max Depth (mm) in B	5.34	5.01
Max Height (mm) in C	7.15	5.30

Video #2 Time in Seconds

Impaction Energy

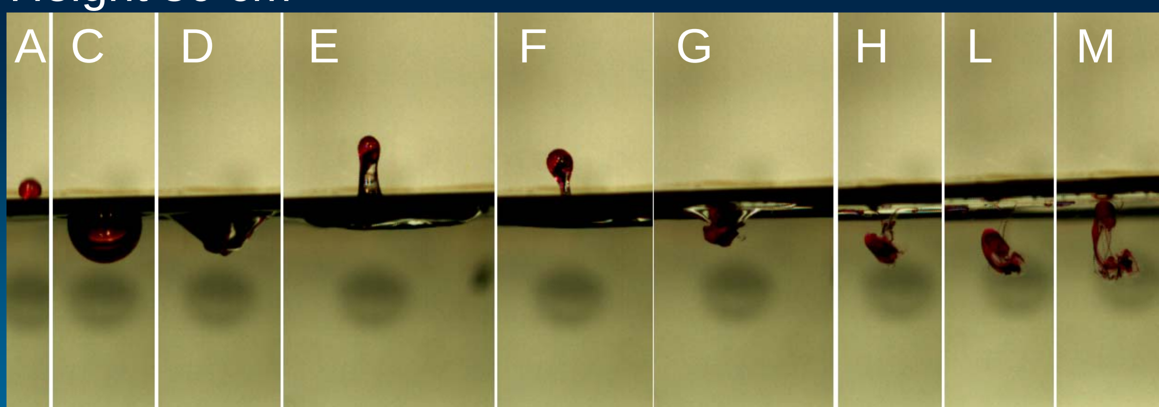
A 3.37 and a 3.32 mm droplet of Corexit 9500 impacting a 0.5 mm ISO380 slick from 107 and 30 cm respectively.

Height 107 cm



0 0.007 0.021 0.034 0.100 0.174 0.183 0.212 0.221 0.304 0.383 1.089

Height 30 cm



0 0.015 0.029 0.068 0.091 0.136 0.208 0.338 0.502

Time in Seconds

	107	30
Temperature (C)	19	18
Droplet Size (mm)	3.37	3.32
Velocity (m s-1)	5.44	2.69
% of Terminal V	66%	33%
Energy (uJ)	281.54	67.96
Energy/area (J m-2)	31.59	7.83
Max Depth (mm) in C	20.34	9.72
Max Height (mm) in E	16.33	14.70

Conclusion

- Droplets up to 1000 μm will not penetrate an oil slick and disperse into the underlying water column. They do not have the energy.
- This is a conservative estimate because it does not take into account the energy absorption by the oil slick and does not account for any oil in the slick coating the penetrating droplet.
- Our estimate does not account for subsurface turbulence at the oil-water interface.

End of Presentation
Start Appendix 1

- The following is atomization as a mixture design: 8 slides

Developing a Model

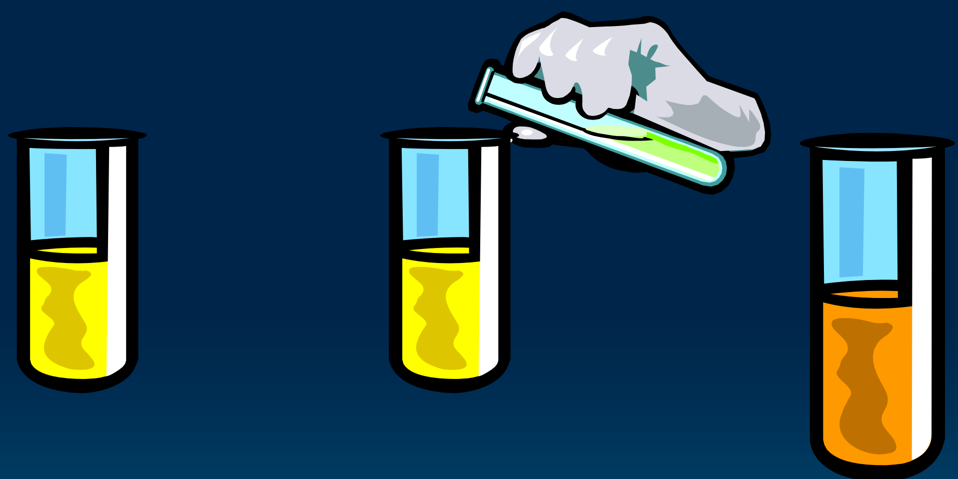
- Dose does not equate to efficacy in any simple way in our greenhouse studies.

- Are there missing components to the dose- response model?

A Digression: Mixture Designs

General Relationship: the total is the sum of the parts

$\%V_1 + \%V_2 + \%V_3 + \ldots + \%V_n = 100\%$



500 ml Water
500 ml Ethanol + 500 ml Ethanol = 500 ml Water
1000 ml Ethanol

Factorial Model

50% Water
50% Ethanol + 500 ml Ethanol = 33% Water
66% Ethanol

Mixture Model

Atomization: A Mixture Design?

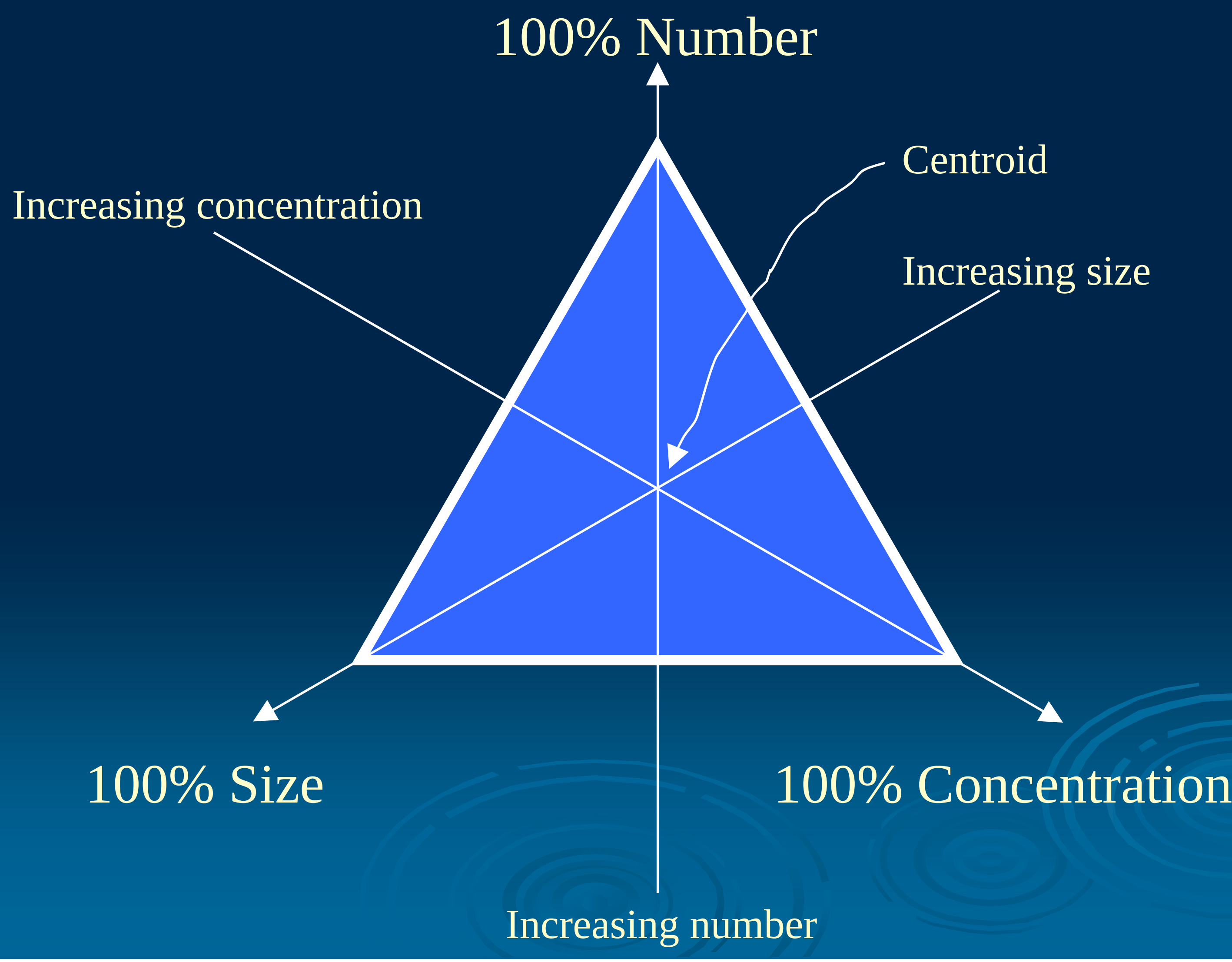
Assuming monosized droplets

$$Quantity \propto \left(\frac{4}{3}\pi\right) r^3 NC$$

The relationship needs to be additive

$$\log(Quantity) \propto 3\log(r) + \log(N) + \log(C)$$

Graphing The Mixture Model

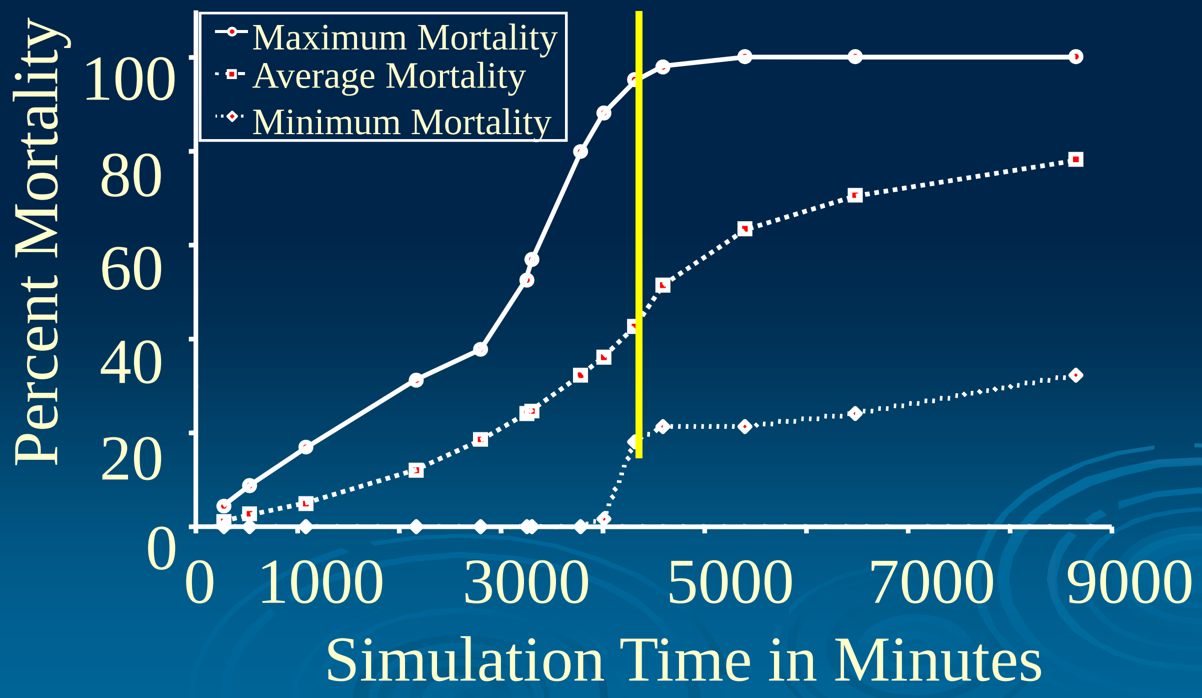


Effect of Toxicant Distribution

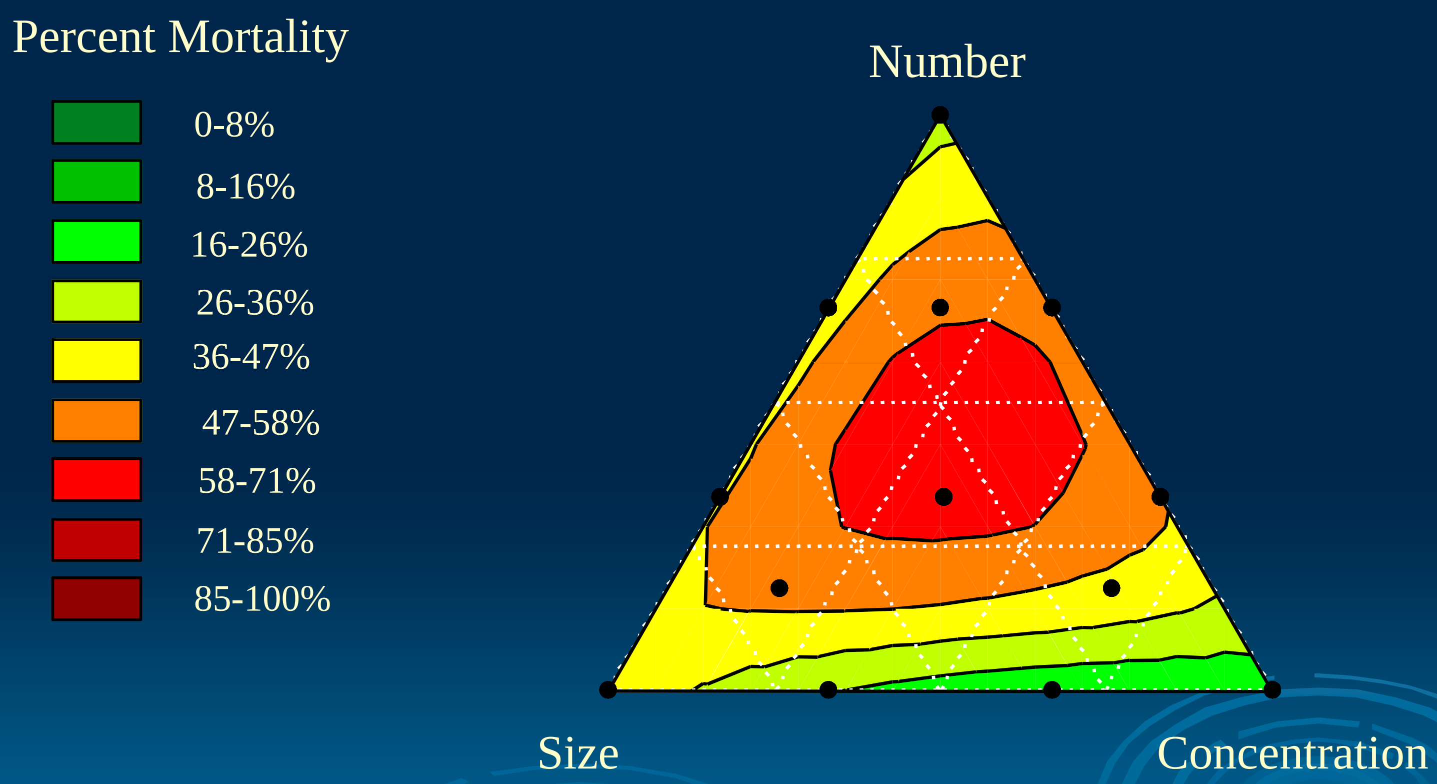
1) **Pesticide Dose Simulator (PDS) Model**: strategic model simulating a chewing insect herbivore feeding on leaves treated with discrete toxicant deposits. The model was originally tested using Diamondback moth feeding on cabbage.
2) **Cabbage looper feeding on cabbage treated with fipronil**

Range in Efficacy

	PDS Model	Bioassay
Replication	13000	96
Range in Efficacy with no change in quantity.	18 to 95%	9% to 70%

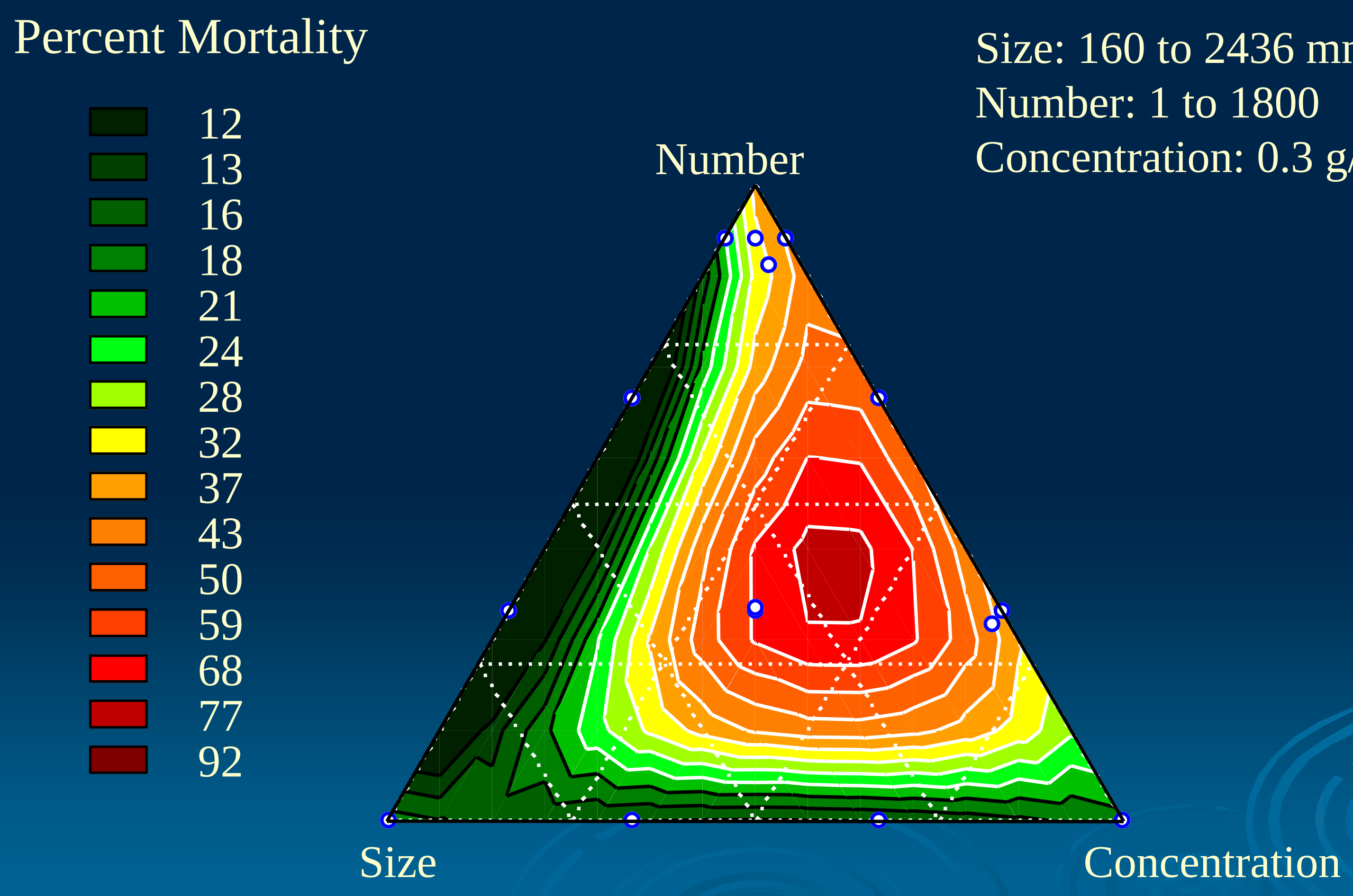


PDS Model Results



Bioassay Results

Size: 160 to 2436 mm
Number: 1 to 1800
Concentration: 0.3 g/l to pure formulation



Conclusion

1) Toxicant distribution can be modeled as a mixture of:
   a) Size of Droplets
   b) Numbers of Droplets
   c) Toxicant concentration
2) Toxicant distribution significantly affects efficacy.
3) Optimal distribution is a few very toxic deposits.
4) How does oil droplet size influence toxicity to marine ecosystems?
5) How does oil droplet size influence colonization and degradation rates?