Evolution of scour induced by propeller wash

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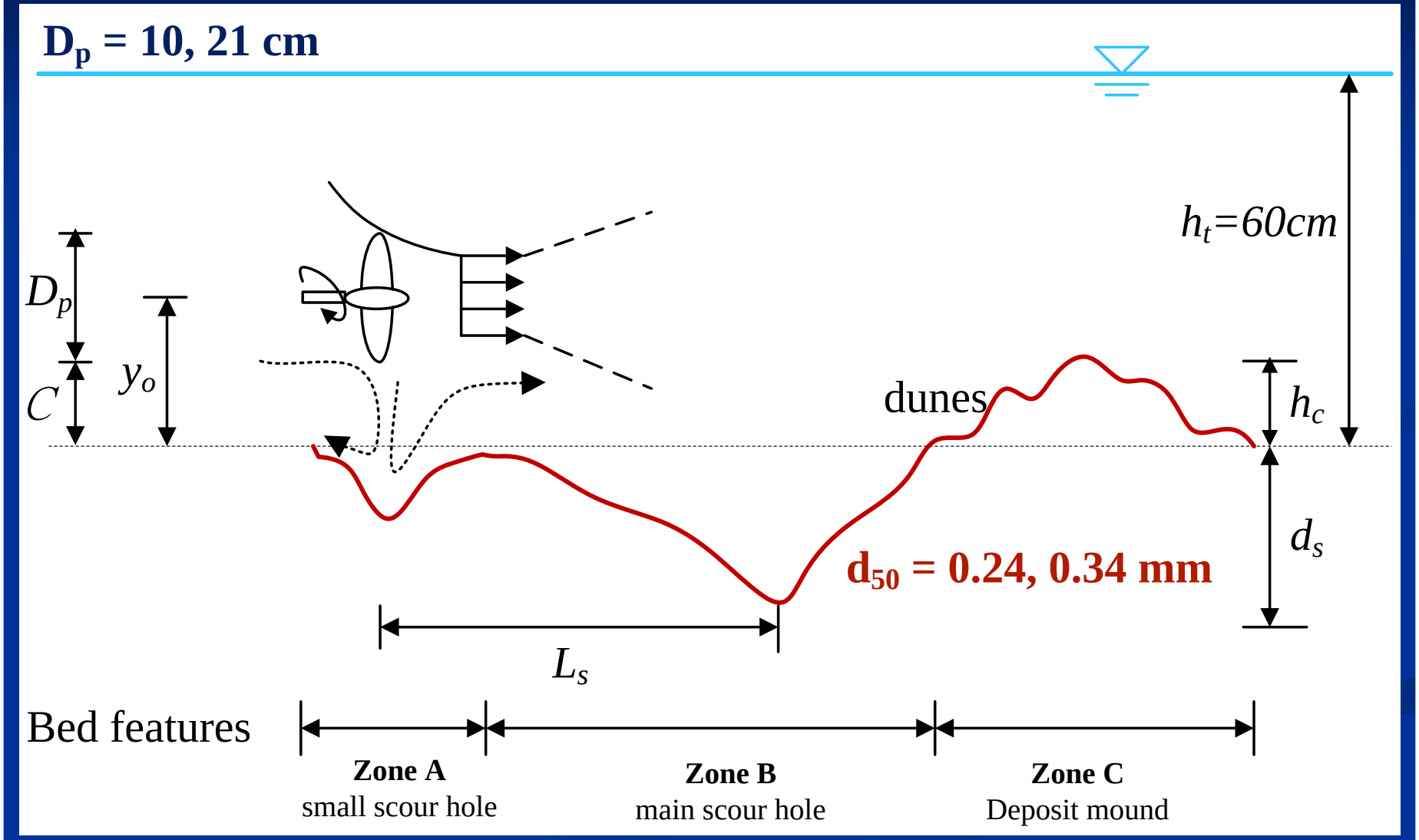
Objective

- To investigate the development of a scour hole in non-cohesive sediments due to the jet induced by a rotating propeller.
- To examine the similarity of equilibrium scour profile
- To study the time-dependent max. scour depth and the max. equilibrium scour depth

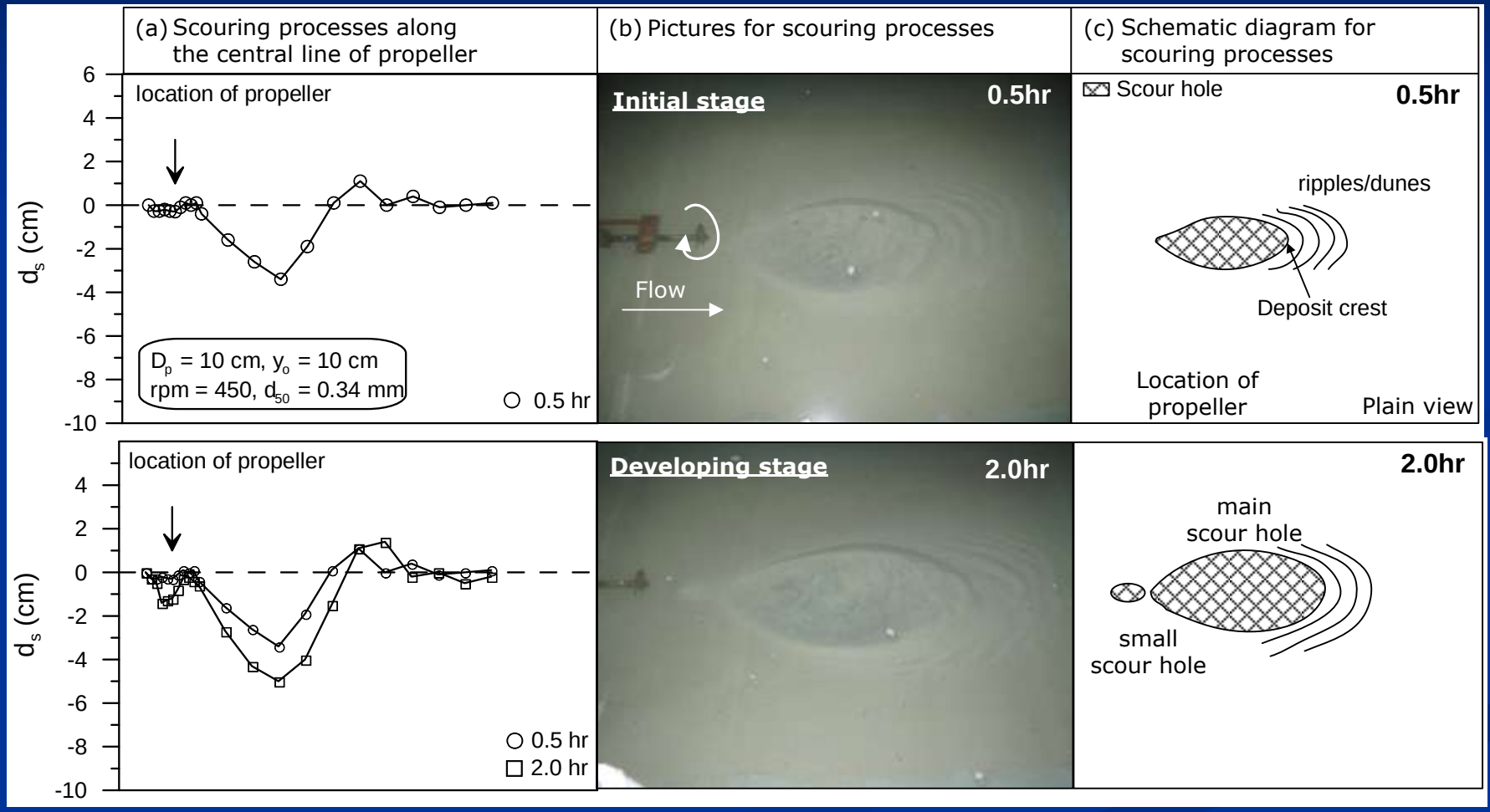
Experimental setup



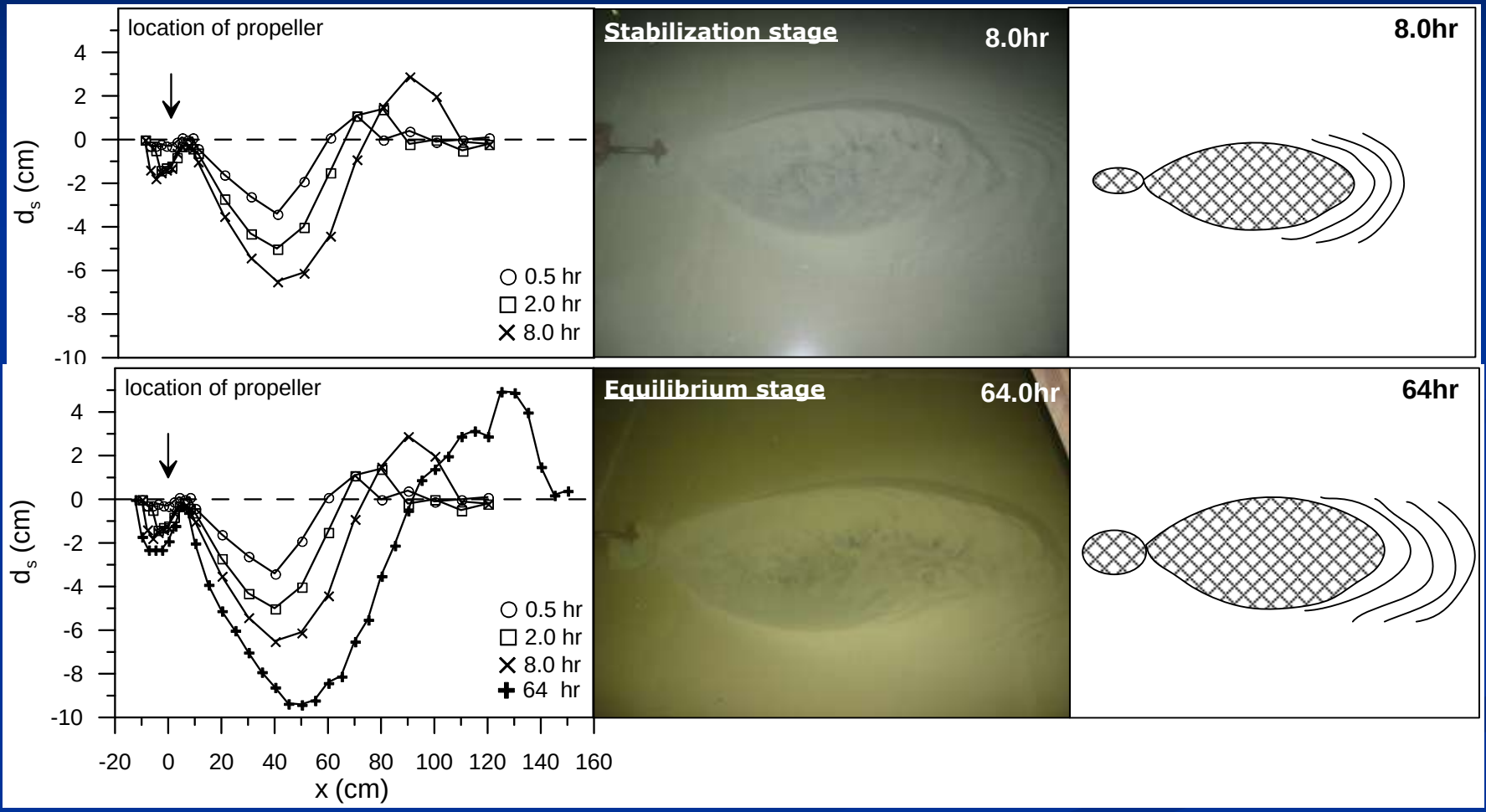
Experimental parameters

Tests investigator	D_p (cm)	d_{50} (mm)	y_0 (cm)	y_0/D_p	Rpm	F_0	R_{ej}
R-1	10	0.34	15	1.5	600	9.19	68,150
R-2	10	0.34	15	1.5	450	6.11	45,250
R-3	10	0.34	10	1.0	450	6.96	51,610
THN-1	21	0.24	10.5	0.5	200	6.08	79,170
THN-2	21	0.24	10.5	0.5	250	7.73	100,716
THN-3	21	0.24	10.5	0.5	300	8.94	116,550
THN-4	21	0.24	10.5	0.5	350	10.69	139,230
THN-5	21	0.24	21	1.0	200	6.08	79,170
THN-6	21	0.24	21	1.0	250	7.73	100,716
THN-7	21	0.24	21	1.0	300	8.94	116,550
THN-8	21	0.24	21	1.0	350	10.69	139,230
Hamill (1987), H-1	15.4	1.46	17.5	1.14	400	5.55	116,000
Hamill (1987), H-2	15.4	0.76	17.5	1.14	400	7.73	116,000

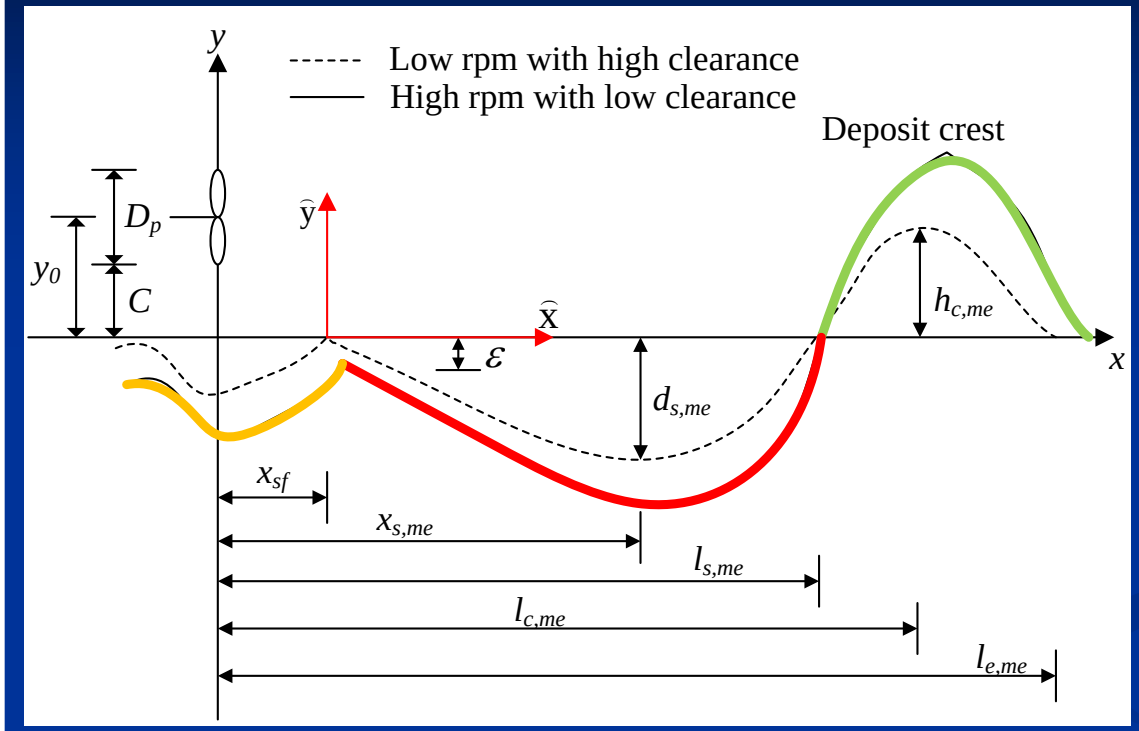
Scouring process (1/2)



Scouring process (2/2)



Equilibrium scour profiles (1/3)



$$\hat{x} = (x - x_{sf}) / (l_{s,me} - x_{sf})$$

$$\hat{y} = y / d_{s,me}$$

$$\hat{y}(\hat{x} < 0) = c_0 + c_1\hat{x} + c_2\hat{x}^2 + c_3\hat{x}^3$$

$$\hat{y}(0 \le \hat{x} \le 1) = a_0 + a_1\hat{x} + a_2\hat{x}^2 + a_3\hat{x}^3$$

B.C.

(1) at x = 0, y = ε
(2) at $x=x_{s,me}$; $y=d_{s,me}$
(3) at $x=x_{s,me}$; $dy/dx=0$
(4) at $x=l_{s,me}$; y=o

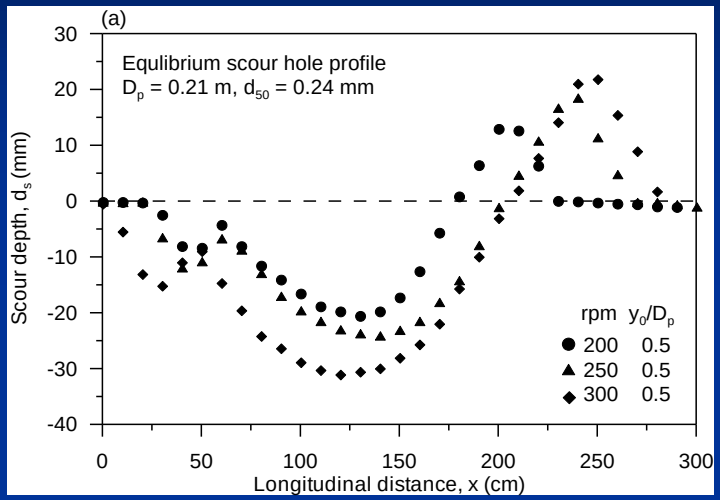
$$\hat{y}(\hat{x} > 1) = b_0 + b_1\hat{x} + b_2\hat{x}^2 + b_3\hat{x}^3$$

B.C.

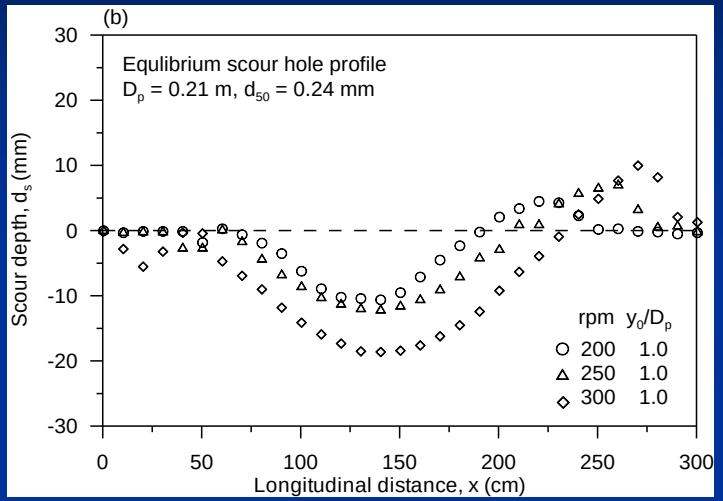
(1) at $x = l_{s,me}$, $dy(y<0)/dx = dy(y>0)/dx$
(2) at $x=l_{s,me}$; y=o
(3) at $x=l_{c,me}$; $y=h_{c,me}$
(4) at $x=l_{e,me}$; y=0

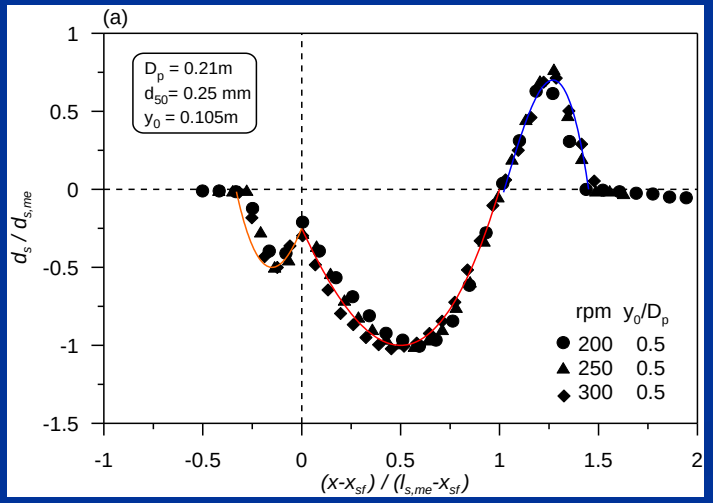
Equilibrium scour profiles (2/3)

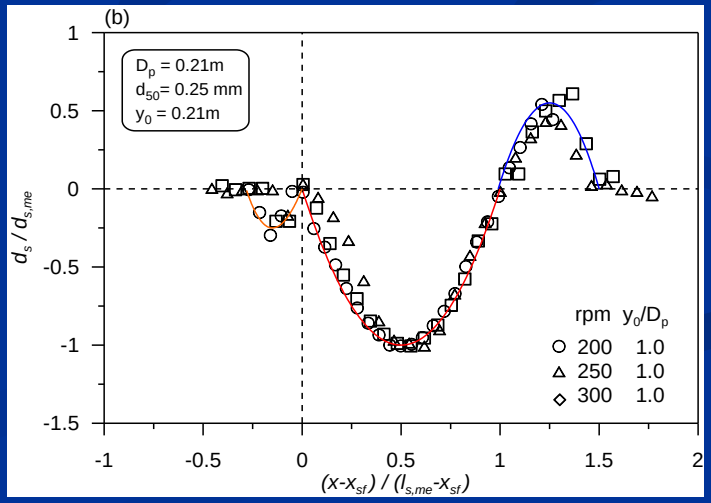
High Rpm, low offset height



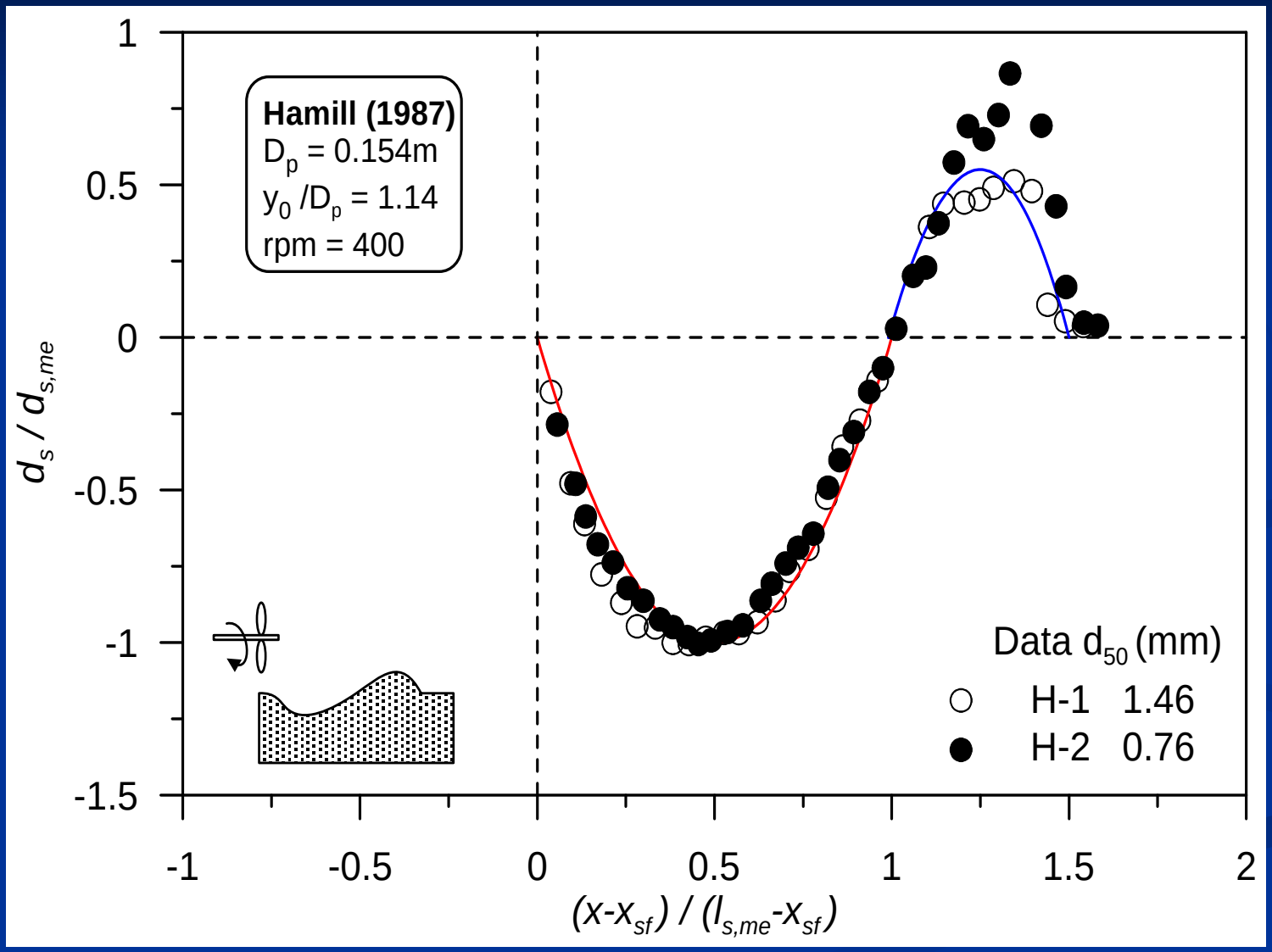
Low Rpm, high offset height







Equilibrium scour profiles (3/3)



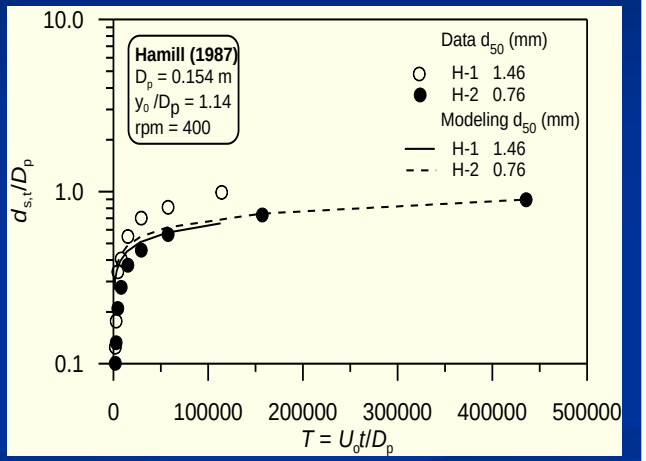
Evolution of maximum scour depth

$$d_{s,t} = f_1\left(U_0, D_p, d_{50}, y_0, \rho, g, \Delta\rho, \upsilon, t\right)$$

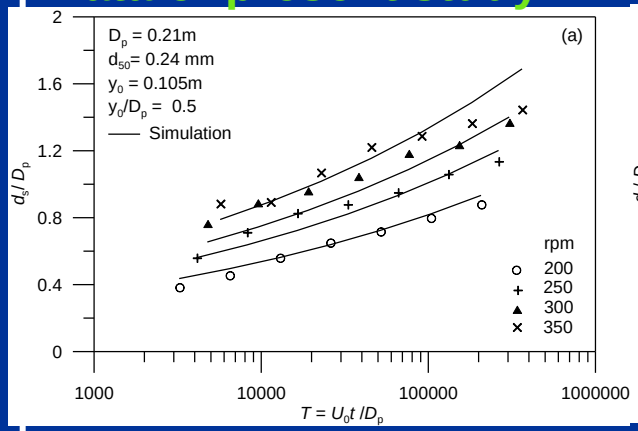
$$\frac{d_{s,t}}{D_p} = f_2\left(\mathbf{F}_0, \frac{y_0}{D_p}, \frac{d_{50}}{D_p}, \frac{t}{\left(D_p/U_0\right)}\right)$$

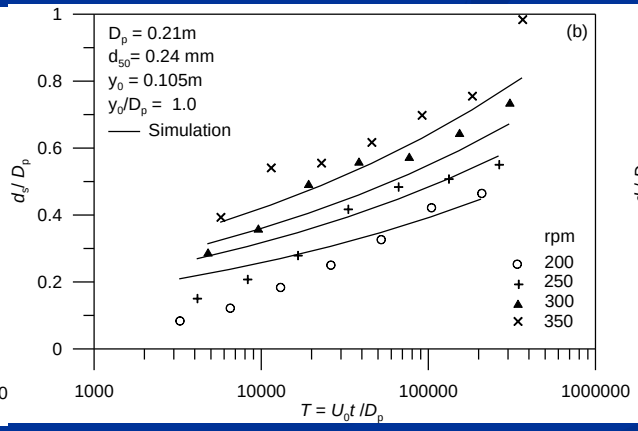
$$\frac{d_{s,t}}{D_p} = 0.105\mathbf{F}_0^{0.852}\left(\frac{y_0}{D_p}\right)^{-0.991}\left(\frac{d_{50}}{D_p}\right)^{0.315}\left(\frac{U_o t}{D_p}\right)^{0.168}$$

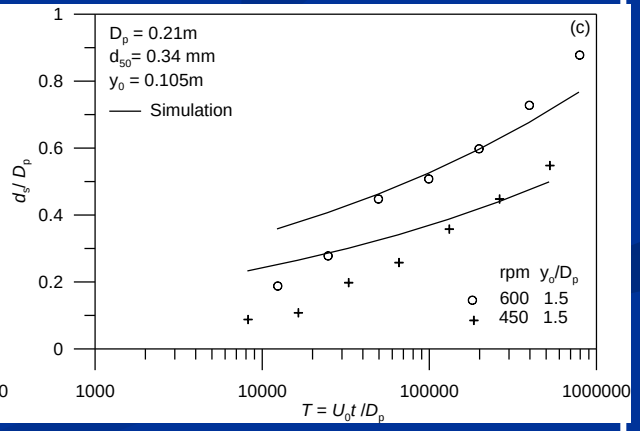
Data of Hamill (1987)



Data of present study

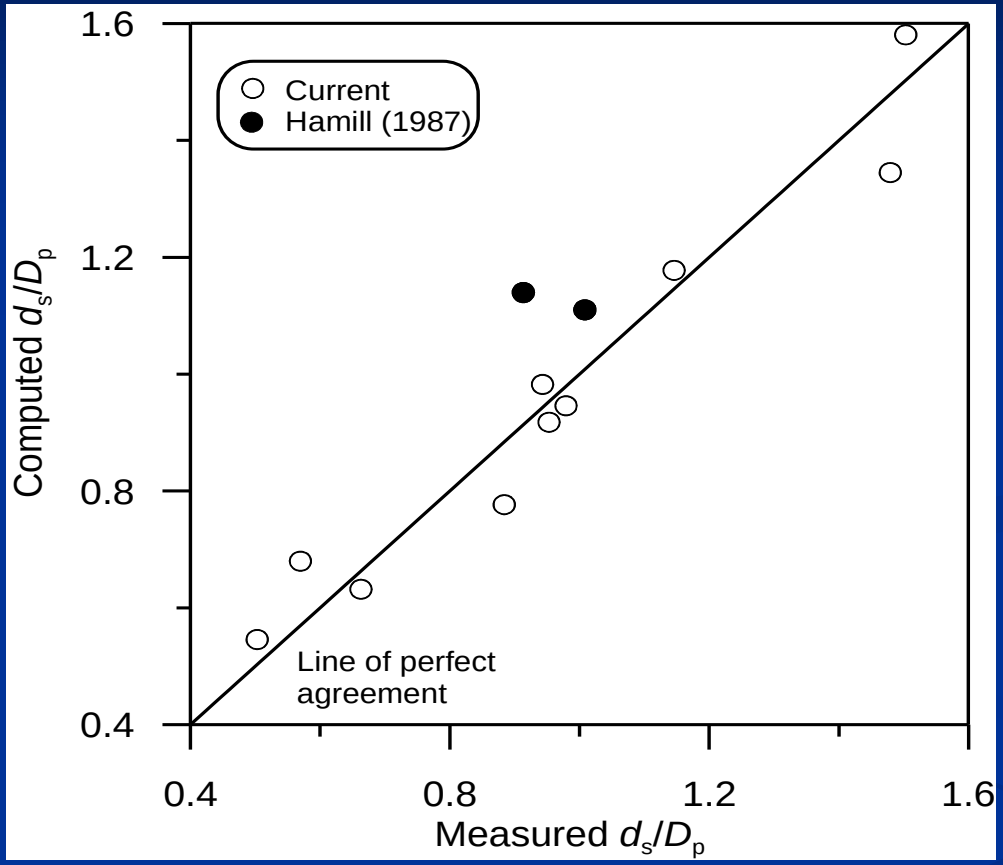






y_0/D_p=0.5 y_0/D_p=1.0 y_0/D_p=1.5

Maximum equilibrium scour depth



$$\frac{d_{s,me}}{D_p} = 1.171 F_0^{0.872} \left(\frac{y_0}{D_p}\right)^{-0.761} \left(\frac{d_{50}}{D_p}\right)^{0.340}$$

Conclusions (1/2)

1. The equilibrium scour profile induced by propeller wash, including the small scour hole beneath the propeller, main scour hole and the deposition mound follows a particular geometrical similarity which can be expressed by a with suitable boundary conditions. combination of three polynomials

2. Based on the experimental data and the Buckingham π theorem, a semi-empirical formula is proposed to estimate the temporal development of the scour depth. The simulated results compare reasonably well with the experimental data.

Conclusions (2/2)

3. The maximum equilibrium scour depth increases with the increase in densimetric Froude and decrease in offset height ratio .

Thank you for your attention

Questions & Comments ?