Dagger Boards - How Big Should They Be?

Martin Schöön, Jan. 2002 (rev. A), in English in Dec. 2004, minor adjustments in Feb. 2007

Introduction

This article shows one way to determine the size of the dagger boards for a catamaran. I assume the boards see the highest load when the boat is fully powered up while going to windward. The goal is the find a size that minimises drag. It is very important to have a good estimate of the speed of the boat to get a reasonable design.

Data:

Boat mass: $bw := 800 \cdot kg$ Hull centre spacing: $dcc := 4.5 \cdot m$

Mass of crew: $cw := 280 \cdot kg$ Centre of effort of sails above water: $hce := 5.5 \cdot m$

Boat speed (10 knots): $v := 5 \cdot \frac{m}{sec}$ Density of water: $\delta := 1000 \cdot \frac{kg}{m^3}$

Calculating max side force

Righting moment: $RM := g \cdot dcc \cdot \left(\frac{bw}{2} + cw \right)$ $RM = 3.001 \cdot 10^4 \cdot m \cdot newton$

Side force: $Fs := \frac{RM}{hce}$ $Fs = 5.456 \cdot 10^3 \cdot newton$

Calculating the resistance as a function of board dimensions

I assume the rudders take on some 5% of the side force. NB by "board dimensions" I mean the part in the water. If you want total draft you have to add the hull contribution.

$i := 0 .. 10$ $j := 0 .. 10$

Cord: $C_i := (0.3 + 0.05 \cdot i) \cdot m$ Length: $L_j := (0.7 + 0.1 \cdot j) \cdot m$

Area: $A(C,L) := C \cdot L$ Aspect ratio: $AR(C,L) := \frac{L^2}{A(C,L)} \cdot 2$

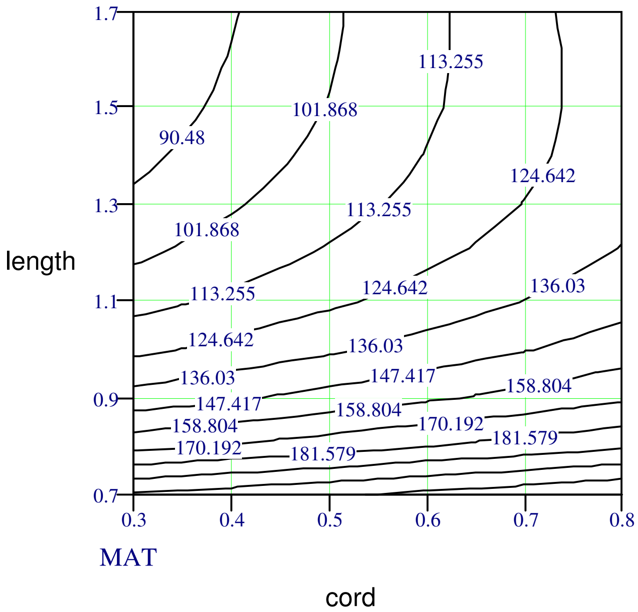
Required lift coefficient: $Cl(C,L) := \frac{Fs \cdot 0.95}{v^2 \cdot A(C,L) \cdot \delta}$ (The missing "2" is due to two boards sharing the load. "0.95" is due to the rudder contribution.)

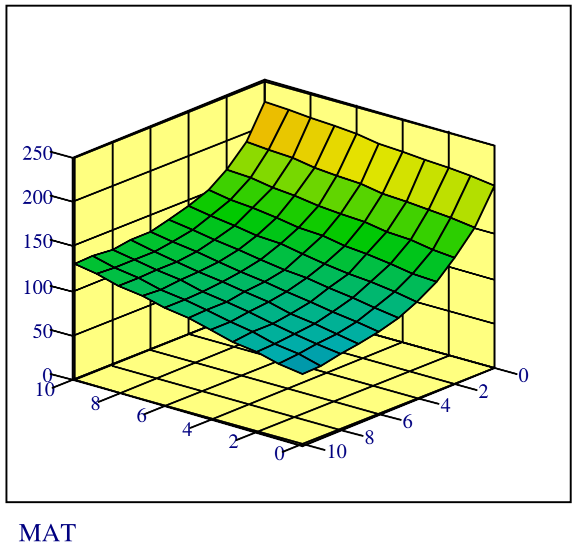
The resulting drag of the section (simple model): $Cdp(C,L) := \begin{cases} 0.006 & \text{if } Cl(C,L) < 0.15 \\ 0.0069 \cdot Cl(C,L) + 0.00496 & \text{otherwise} \end{cases}$

Here I add induced drag to section drag: $Cdb(C,L) := Cdp(C,L) + \frac{Cl(C,L)^2}{\pi \cdot AR(C,L)}$

Drag force for one board: $Fdb(C,L) := \frac{Cdb(C,L) \cdot v^2 \cdot A(C,L) \cdot \delta}{2}$

Preparing graphs: $MAT_{i,j} := Fdb\left(C_i, L_j\right)$





X and Y are in m, Z is in N.
Note how efficient it is to add length to the boards.

Some words on assumptions and simplified modelling

1) The interference between hull and board is not part of the model.
2) The model is incapable of stalling.
3) Note that speed hits the result very hard - speed^2 !
4) I don't model hull lift or drag.
5) There is no input on plan form here.
6) Section thickness is left out of the picture.
7) Note that the board area is governed by how fast and stable the boat is but not by the sail area!
8) I assume all members of the crew hikes out on the windward hull.