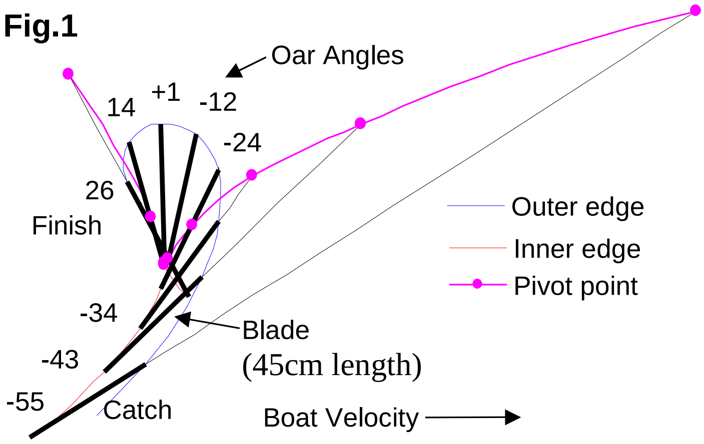
Blade depth

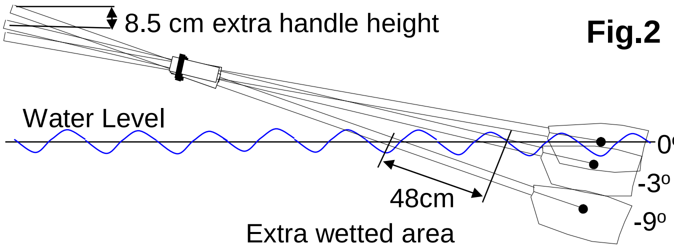
Recently, some articles were published advocating deeper placement of the blade during the drive. The main argument for this was a higher blade efficiency due to less slippage, and at negligible extra drag on the shaft, because "the oar pivot (an imaginary stationary point – the centre of oar rotation) is located far inside from the blade, so the velocity of the shaft movement though the water is not high". Is this really true though?

Of course, the blade must be fully covered in the water during the drive, but its excessive depth is quite doubtful. No clear evidence on correlation of blade efficiency and depth has yet been presented. We have published a number of articles on blade depth (RBN 2009/10) and efficiency (RBN 2007/12, 2012/06, 2013/11-12), but we have to revisit these topics again. In RBN 2014/02 the pivot position was already discussed, and Fig.1 represents it again for better clarity (reconstructed from the data of M1x at 33 min^{-1} measured with our BioRow™ system).

Fig.1



The pivot is located on the oar shaft (about 5cm inside from the blade) only at ±10° from the perpendicular oar position. It is located on the spoon at the oar angles from -30° at the catch till 25° at finish, but at sharper angles, it is located outside of the outer edge: more than 4m away at catch angle 65°. By the way, this is a good illustration of the dynamic oar gearing (RBN 2015/06): distance from the pin to the pivot represents imaginary acting outboard, which became much longer at sharper oar angles, so the gearing became heavier. Therefore, the oar shaft moves through the water nearly as fast as the boat.



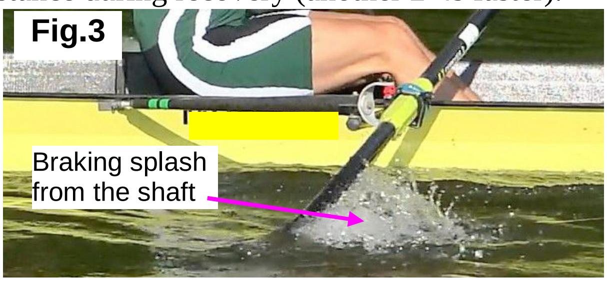
On average, every degree of deeper blade placement put 8cm more of the shaft into the water. So, the difference between normal placement at 6° (40cm of the shaft under the water) and very deep placement at 12° (88cm) is about half a meter extra shaft length in the water (Fig.2). An accurate calculation of the extra drag resistance force ***Fd*** produced by this deeper blade is quite complicated, as the wetted shaft area and its angle of attack to the water is changing continuously during the drive. However, it could be estimated using equation 1:

$$Fd = 0.5\, \rho\, c_d\, v^2 A \qquad (1)$$

where ρ is water mass density (= 1000 kg/m^3), c_d is the drag coefficient (=0.47 for a cylinder), v – velocity of the shaft through the water (ranges from 1.7 to 5.2m/s during the drive), A – cross-section area of the wetted shaft section, which depends on the shaft diameter (38mm for the standard sculling oar) and angle of attack. **An extra 6° of the blade depth increases drag resistance by 12N during the drive, consumes nearly 50W (≈10%) of a rower's power and decreases the speed by 3,5% (14s over 2km race at 6:40)**.

This energy waste could be clearly seen during the drive as fountains of water coming from the shaft (Fig.3) and could be avoided or significantly decreased with better blade work. At the same blade depth, using a thinner oar shaft is beneficial: A Concept2 Skinny shaft (32mm thickness at the middle of the shaft) decreases speed losses by 0.7%, and **WinTech RDS shaft (28mm) saves about 1.2% of the speed (5s over 2k) during the drive.** This is an extra advantage of thinner shafts in addition to their lower aerodynamic resistance during recovery (another 2-4s faster).

Fig.3



Deeper blade placement has another negative effect: it increases the handle height (Fig.2) by about 1.5cm for every degree of extra depth, which increases leverage and torque of the handle force and puts more strain on the spine and core muscles.

What is the optimal blade depth? Statistics collected during the last five years of measurement and evaluation with the BioRow™ system (more than 20k data samples) gives the average minimal oar angle from the water level -5.9±1.4° for rowing and -7.6±1.5° for sculling. This allowed us to develop a scale for the blade depth evaluation (Table 1), which will be constantly used in BioRow™ reports together with evaluation of catch and release slips and effective angle:

Table.1	Very Shallow	Shallow	Normal	Deep	Very Deep
Sweep	<1.5	<3.0	4.5-7.5	>9.0	>10.5
Scull	<3.0	<4.5	6-9	>10.5	>12.0

The simplest practical method to control the blade depth is to wrap the oar shaft with a bright electric tape at 40cm from the blade inner edge. Then, try to keep this mark at water level during the drive, which gives you an optimal 6-7° depth.

©2015 Dr. Valery Kleshnev ***www.biorow.com***
valery@biorow.com, *kleval@btinternet.com*