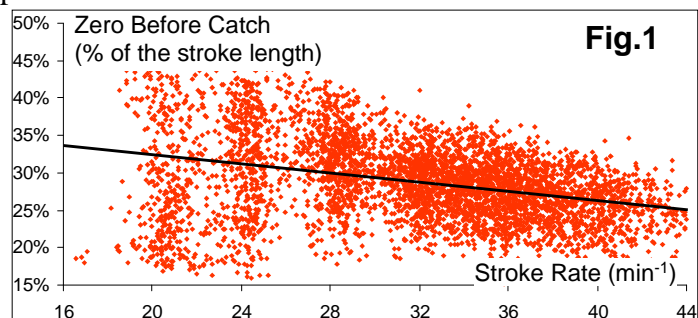## Evaluation of the boat acceleration

An analysis of boat acceleration (BA) was made in RBN 2012/11, and seven criteria were derived. Reliable evaluation of the BA is quite a difficult task, because its pattern varies significantly in different boat types, stroke rates and skill levels. However, further analysis was made with the purpose to relate the BA pattern with other biomechanical variables and find its most informative criteria of the best rowing performance.

Fig.1 — Zero Before Catch (% of the stroke length) vs Stroke Rate (min^{-1})

"Zero before catch" (**ZBC**) defines the moment when the boat acceleration becomes negative during the recovery. At low rates below 28, ZBC has very high variation (Fig. 1, n=8107), which could be explained by the dominating effect of an external drag resistance factor related to random weather conditions: in a head wind, the resistance is higher and the BA becomes negative earlier during recovery; in a tail wind it happens later. At higher stroke rates above 28 min^{-1}, ZBC is more consistent, because the effect of the rowers' movements becomes dominating, which was confirmed by a high correlation of ZBC with the position of the maximal seat velocity during recovery (r=0.80). At rate 28, the boat acceleration becomes negative at 32% of the stroke length before catch. At 44 min^{-1} this moment occurs later (only at 25%), which means rowers accelerate the seat longer during recovery and change its direction sharper at the catch. In eights, ZBC occurs earlier by about 3% of the stroke length, which is related to worse synchronisation of the rowers movements and a larger ratio of the boat+cox mass to the rower's mass. In Olympic and Worlds champions, no significant difference of ZBC was found compared to club level rowers (in spite of previous speculations), so it is not used as a criterion of the effective rowing technique.

**Fig.2** — Negative Peak (ms^{-2}) vs Stroke Rate (min^{-1}); 2-, 4-, 8+, 1x, 2x, 4x
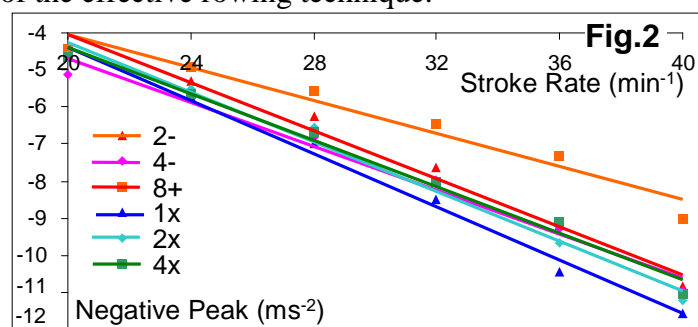
The magnitude of the **Negative Peak** (NP) is highly dependent on the stroke rate and the functions vary in boat types (Fig.2). At low rates, the NP magnitude is lower and quite similar in all boat types, but at higher rates above 28 min^{-1} its magnitude became more significant and different in various boat types. In eights, the NP has much lower magnitude, which could be explained by two factors: 1) a heavier boat+cox mass (about 18 kg per rower, compared to 13-15kg in smaller boats); 2) worse synchronisation between larger numbers of rowers. It was estimated that the first factor contributes only 15% and the second explains the remaining 85% of the difference in NP values. Therefore, **in bigger boats, boat dynamics at the catch depend mainly on the synchronisation of the rowers' movements**. For this reason, NP in singles had a higher magnitude, in spite of heavier boat mass per rower compare to doubles and fours.

To evaluate the NP value, three linear equations are used: 1) for singles; 2) for doubles and fours; 3) for eights. It was found that the best crews had about 1 SD deeper NP than average, but the value of SD also depends on stroke rate and varies in boat types. Therefore, other three linear equations are used for above boat types to determine the SD at specific conditions and evaluate NP.

The **First Peak** (FP) is one of the most important indicators of effective boat dynamics, as it is related to a "front-loaded" drive, the "initial boat acceleration" micro-phase and "the trampoline effect" (RBN 2006/02). In eights, the FP was not observed in 60% of crews at 20 min^{-1} and in 15% of crews at rate 40. In smaller boats, the FP is absent in 30-40% crews at rate 20 and was found practically in all crews at rate 40.

Fig.3 — First Peak (ms^{-2}) vs Stroke Rate (min^{-1}); 2-, 8+, 2x, 4-, 1x, 4x
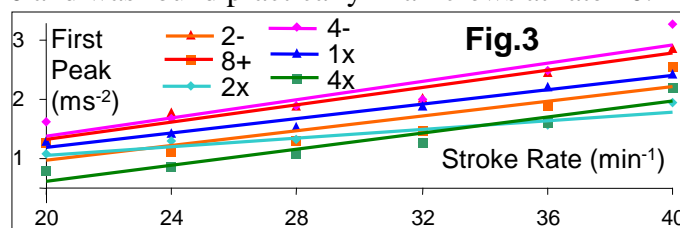
The FP average value increases two times from 1.25ms^{-2} at stroke rate 20, up to 2.5ms^{-2} at rate 40. (Fig.3). The trends slopes were quite similar in boat types, but the offsets were about 1 ms^{-2} higher in pairs and fours compared to doubles and quads. This could be explained by longer catch angles in sculling, which leads to a heavier gearing and lower acceleration. Surprisingly, the FP trends were very similar in singles and eights, so the same equation was used for their evaluation, and an offset +/-0.5ms^{-2} was added for medium sweep and sculling boats.

In champion crews, values of the First Peak were about one SD higher than average and none of them had it absent at any stroke rate. This confirms the importance of this variable as a criterion of effective rowing technique.