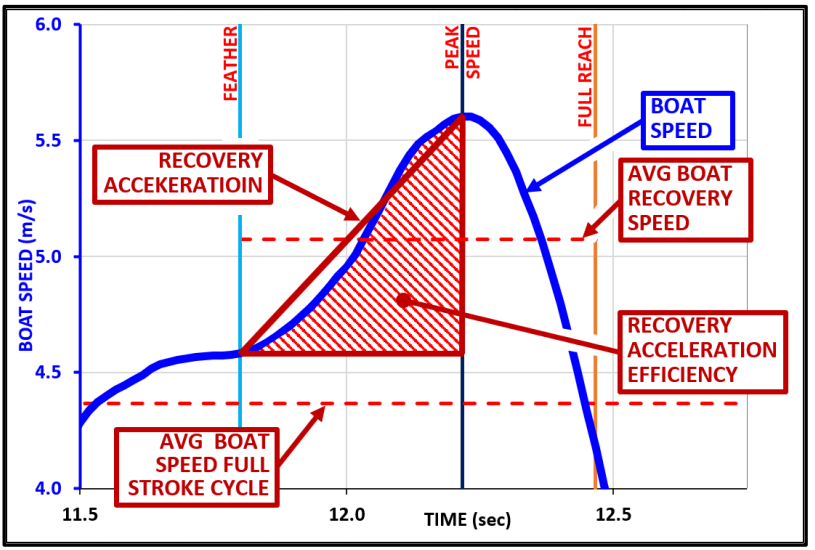
2.9.5 Recovery Acceleration

During the recovery at a racing rate, the boat will accelerate and decelerate as the athletes move from the finish position to the full reach position at the catch. In the first half of the recovery, the boat accelerates as the athletes pull their footstops toward their seats. The recovery acceleration technique factor is the measured linear boat acceleration between the feather (finish position) and the boat's peak speed, Figure 2.9.5a.

Figure 2.9.5a *Recovery Acceleration*



Recovery acceleration is calculated as the change in speed divided by the change in time between the feather and peak boat speed.

$$\textbf{RECOVERY ACCELERATION} = \frac{(Vs_{pk} - Vs_f)}{(Vt_{pk} - Vt_f)}$$

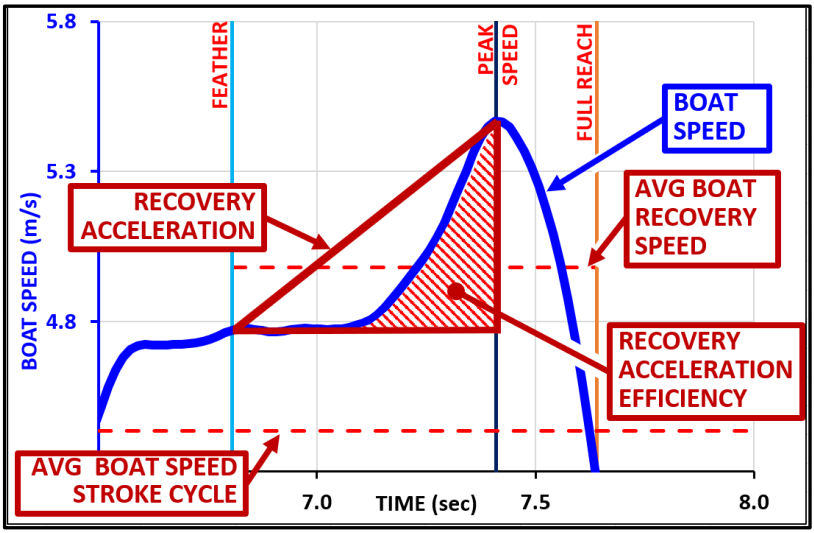
where: Vs_f - video frame interval speed feather
Vs_{pk} - video frame interval speed peak
Vt_f - video frame time feather
Vt_{pk} - video frame time peak speed

Boat acceleration on the recovery is possible because the athletes' centre of mass (COM) slows as they transfer their momentum to accelerate the boat. The boat's acceleration is much greater than the athlete's deceleration because the athlete or crew have a much greater mass than the boat and, therefore, much more momentum.

Boat acceleration is only possible when the athlete's mass accelerates toward the stern. The force applied by the athletes pulling on the footstops to accelerate the boat is calculated as F=ma and must be greater than the resistance on the boat. Higher acceleration rates increase the force applied, resulting in greater boat speeds on the recovery. At lower practice stroke rates, the athletes' acceleration on the slide is low, resulting in lower force and minimum or lost boat acceleration.

Another related technique factor is recovery acceleration efficiency (RAE). Recovery acceleration efficiency is shown in Figure 3.9.5b, represented by the hatched area under the boat speed curve between feather and peak speed.

Figure 2.9.5b *Recovery Acceleration Efficiency*



Recovery acceleration efficiency reflects the actual boat movement, and the area under the boat speed curve is a

percentage of the straight-line acceleration between feather and peak speeds. The recovery acceleration efficiency represents the crew's ability to accelerate the boat effectively.

Boat acceleration is most effective at a consistent rate without quick or uneven changes. Sudden increases in the rate of acceleration will lead to short surges in boat speed, increasing wave propagation and resistance on the hull. Constant acceleration continued as long as possible during the recovery will be most effective for maximum recovery speed.

Calculation for Recovery Acceleration Efficiency (RAE):

$$\mathbf{RAE} = \frac{[\,(Vd_{pk} - Vd_f) - Vs_f \bullet (Vt_{pk} - Vt_f)\,]}{[\,(Vs_{pk} - Vs_f) \bullet (Vt_{pk} - Vt_f) / 2\,]}$$

where: Vd_f - video boat distance feather
Vd_{pk} - video boat distance speed peak
Vs_f - video frame interval speed feather
Vs_{pk} - video frame interval speed peak
Vt_f - video frame time feather
Vt_{pk} - video frame inetrval speed peak

Figure 2.9.5b Recovery Acceleration Efficiency shows a speed curve with no increase in boat speed in the first third of the recovery. This rowing technique may be less effective as the RAE technique factor value is 46.1 percent, while the average for the boat class is 82.4 percent. The ineffective rowing technique supposition is supported by the boat's average recovery speed compared to the overall boat's average speed.

The *Recovery Speed as a Percentage of Boat Speed* (RSPBS) provides another technique factor evaluation. This factor requires a calculation of the boat's average recovery speed (ARS) between the feather and the full reach positions. It also involves calculating the average boat speed (ABS) through the complete stroke cycle.

The average boat speed on the recovery compared to the average boat speed for the full stroke cycle reflects the ability of the crew to transfer their body momentum to the boat on the recovery. The following calculations will provide the value for the RSPBS.

Average recovery speed (ARS)

$$\mathbf{ARS} = (Vd_{fr2} - Vd_f) \;/\; (Vt_{fr2} - Vt_f)$$

Average boat speed (ABS)

$$\mathbf{ABS} = (Vd_{c2} - Vd_{c1}) \;/\; (Vt_{c2} - Vt_{c1})$$

Recovery speed as a percent of boat speed (RSPBS)

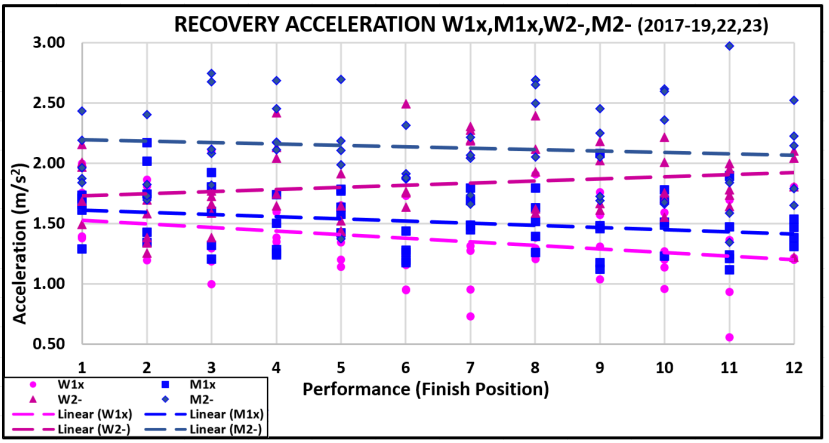
$$\mathbf{RSPBS} = \mathbf{ARS} / \mathbf{ABS}$$

where: Vd_{c1} = video boat distance catch 1
Vd_{c2} = video boat distance catch 2
Vd_f = video boat distance feather (finish)
Vd_{fr2} = video boat distance full reach 2
Vt_{c1} = video boat distance catch 1
Vt_{c2} = video boat distance catch 2
Vt_f = video boat distance feather (finish)
Vt_{fr2} = video boat distance full reach 2

The recovery speed as a percentage of the average boat speed shown in Figure 2.9.5b represents a factor value of 112.3%, indicating the boat speed is 12.3% above average. The average from the World Championship data for the boat class is 113.5%, which supports the low RAE factor value and suggests an ineffective recovery.

Figure 2.9.5c Recovery Acceleration Singles Pairs shows data from crews at the World Championships plotting their recovery accelerations with their finish positions (1st to 12th).

Figure 2.9.5c *Recovery Acceleration Singles Pairs*



The resistance on the system reflects the drag on the hull water, wind, and wave propagation. Unsteady flow may increase resistance.

Figure 2.9.5d *Recovery Acceleration Data*

Boat Class	Rec. Accel.	Standard Deviation	Rec. Eff.	Standard Deviation	Av. Spd % Cyc.	Standard Deviation	Data Ref. (# of crews)
W1x	**1.40**	0.35	**82.4%**	13.2%	**113.5%**	1.2%	(59) WC '17,'18,'19,'22,'23
W2x	**1.73**	0.32	**90.6%**	9.2%	**112.9%**	1.1%	(16) WC '19, '22, '23
W4x	**1.74**	0.36	**95.8%**	7.4%	**112.6%**	1.3%	(18) WC '17,'23
W2-	**1.83**	0.30	**94.2%**	9.5%	**114.1%**	1.1%	(59) WC '17,'18,'19,'22,'23
W4-	**1.96**	0.27	**97.1%**	7.2%	**113.7%**	1.0%	(18) WC '19,'23
W8+	**1.98**	0.25	**101.6%**	7.0%	**111.9%**	0.8%	(40) WC '17,'18,'19,'22,'23
M1x	**1.52**	0.25	**86.3%**	11.2%	**113.7%**	1.1%	(59) WC '17,'18,'19,'22,'23
M2x	**1.56**	0.31	**92.9%**	11.9%	**112.6%**	1.0%	(17) WC' 19,' 22, '23
M4x	**1.78**	0.29	**95.2%**	6.7%	**112.5%**	0.7%	(14) WC '17,'23
M2-	**2.13**	0.41	**97.8%**	9.1%	**114.5%**	1.4%	(60) WC '17,'18,'19,'22,'23
M4-	**2.33**	0.34	**99.5%**	7.8%	**114.3%**	0.9%	(18) WC '17,'19,'23
M8+	**2.14**	0.32	**101.8%**	9.5%	**111.9%**	0.6%	(51) WC '17,'18,'19,'22,'23

The movement of the athletes during recovery is key to effective rowing technique. Higher stroke rates with lower recovery times will increase the boat's recovery speed. However, the recovery must address acceleration and acceleration efficiency to maximize efficiency.