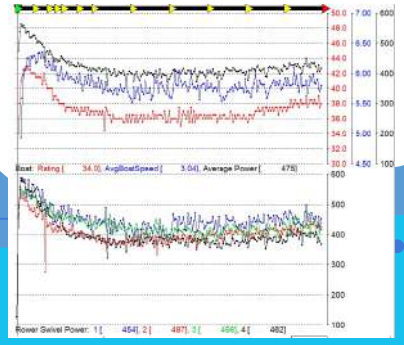
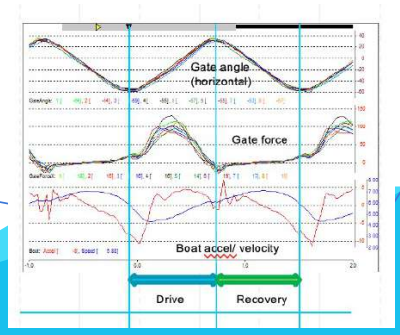
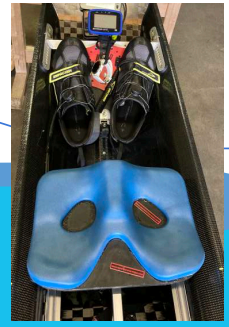
Rudersymposium Hannover
25. Januar 2025



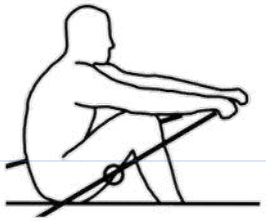


WANN LÄUFT DAS BOOT

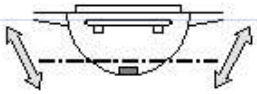
Biomechanische & hydrodynamische Grundsätze

CONNY DRAPER PhD
APPLIED SPORTS BIOMECHANIST ◆ conny.draper@gmail.com

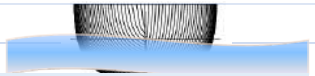
Rudern: Biomechanische & hydrodynamische Grundsätze



Rower's anthropometry



Rower's boat rigging



Boat hull design
Fluid dynamics

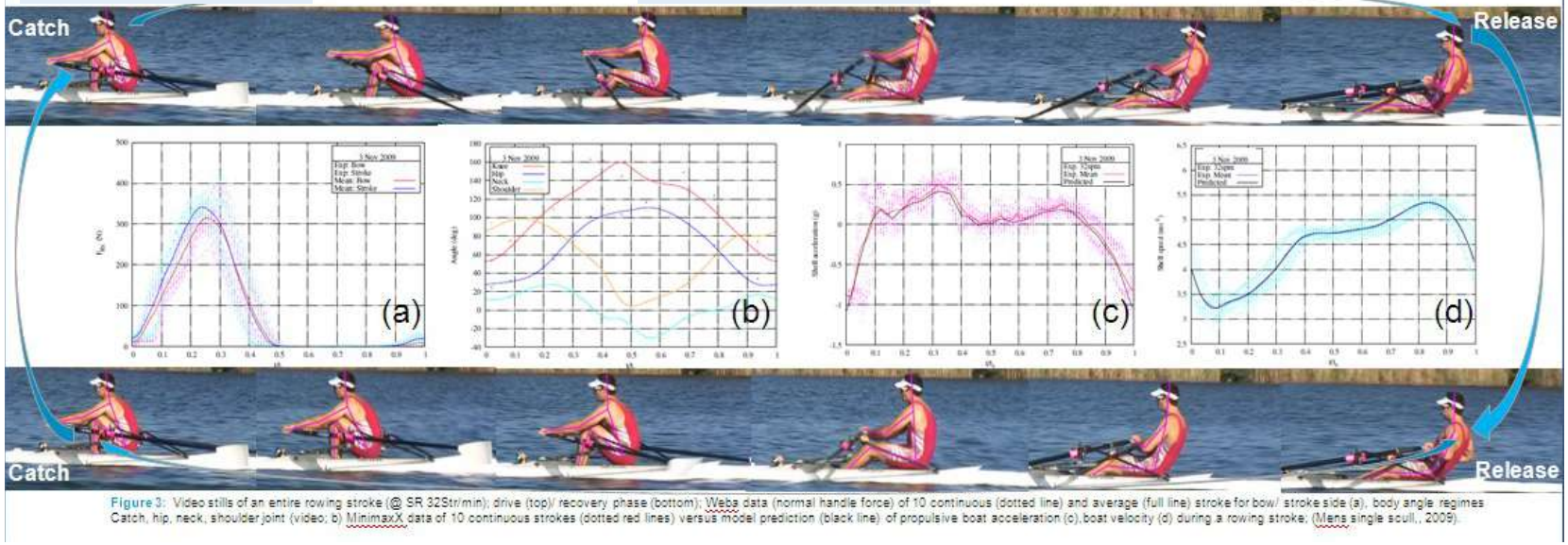
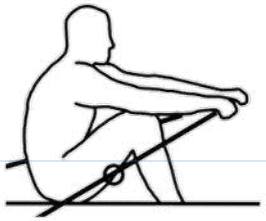
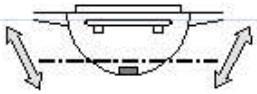


Figure 3: Video stills of an entire rowing stroke (@ SR 32Str/min); drive (top)/ recovery phase (bottom); Webs data (normal handle force) of 10 continuous (dotted line) and average (full line) stroke for bow/ stroke side (a); body angle regimes Catch, hip, neck, shoulder joint (video; b) MinimaxX data of 10 continuous strokes (dotted red lines) versus model prediction (black line) of propulsive boat acceleration (c),boat velocity (d) during a rowing stroke; (Mens single scull., 2009).

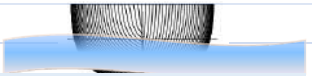
Rudern: Biomechanische & hydrodynamische Grundsätze



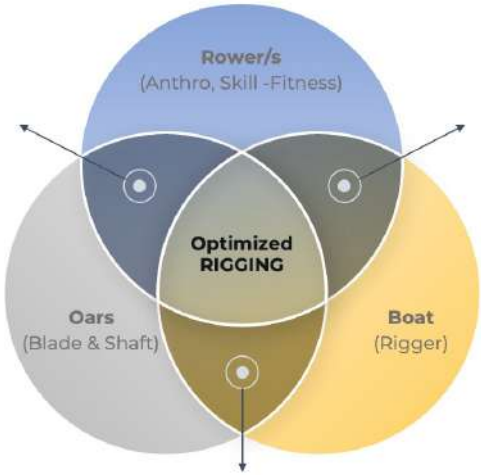
Rower's anthropometry



Rower's boat rigging



Boat hull design
Fluid dynamics



Coaching heterogeneous group of athletes

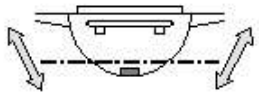
Rower's anthropometry

- ✓ various sizes, ages, experiences, strengths and capabilities
- ✓ Growing athletes – Pathway athletes
- ✓ how coaching can use the 'objective eye' of biomechanics & evidence-based feedback

OPTIMIZED RIGGING

ROWER/S

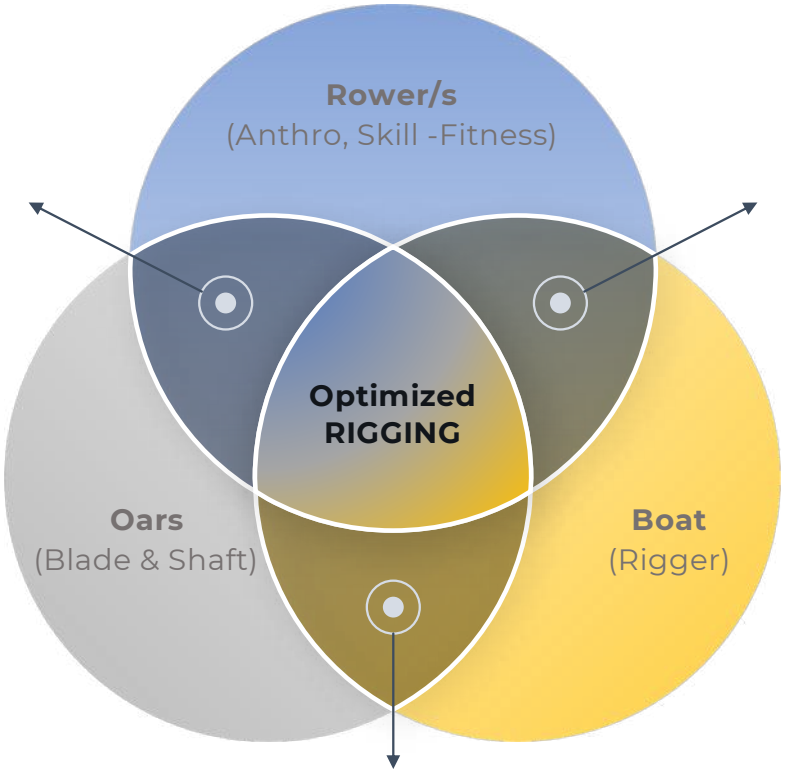
Height, Weight
Arm spread, etc



Rower's boat rigging

OARS – ROWER/S

Overall Oar Length (cm)
Oar Inboard/ Outboard Length (cm)
Overlap (cm)
Pitch (deg) swivel



ROWER/S – BOAT/ RIGGER

Span (cm) Scull/ Spread (cm) Sv
Pitch (deg) swivel

Distance through work (cm)
Line of work – Toes (cm)
Stretcher position from swivel (c
Foot stretcher angle (deg)

Swivel above seat (cm)
Seat above heels (cm)

OARS (BLADE & SHAFT)

Manufacturer
Model
Shaft type & flex
Blade shape
Blade length/ width (cm)
Vortex edge

BOAT/ RIGGER

Manufacturer
Model no.
Average crew weight
Rigger type
Stern/ bow mounted
Backstay

OARS – BOAT/ RIGGER

Pitch (deg) swivel

Rowing motion & orientation

Boat hull design
Fluid dynamics

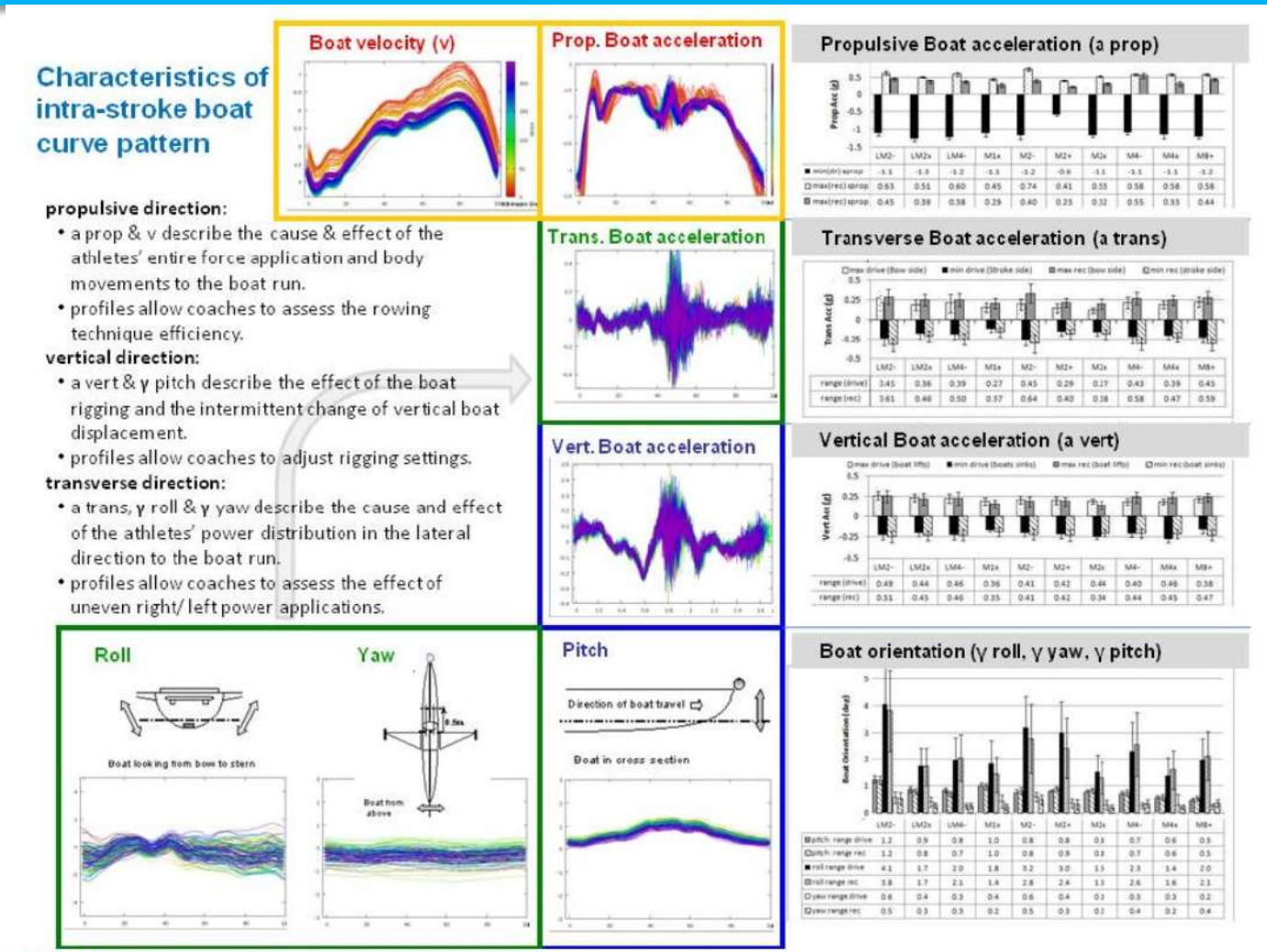


Figure 1: Characteristic intra-stroke curve patterns for all seven boat variables, shown on the example of a gold medal winning crew, OG2008, Beijing (right); Comparison of the key discrete values for all seven boat variables between the Mens' boat classes (M, n=10; 71 races) (left).

Wann läuft das Boot – Warum läuft das Boot?

2 Types of Forces in Rowing:

Propulsive Forces:

forces applied by muscles mainly to the handle of the oar & the stretcher force

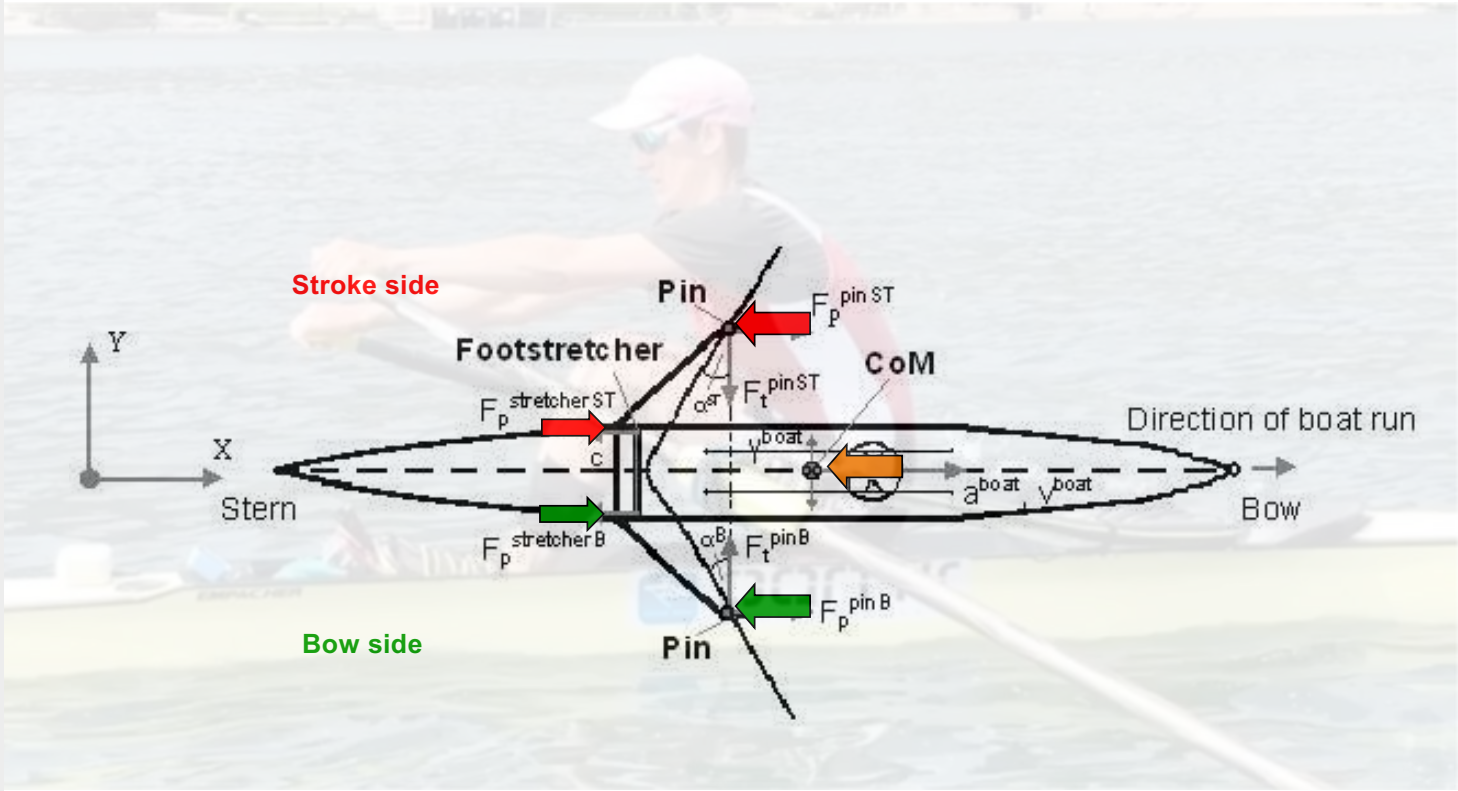
Resistive Forces -

frictional, form and wave drag,

added water mass

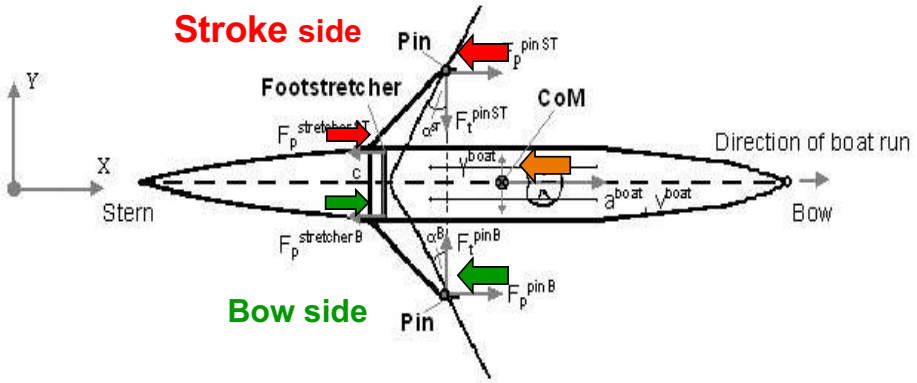
Wind

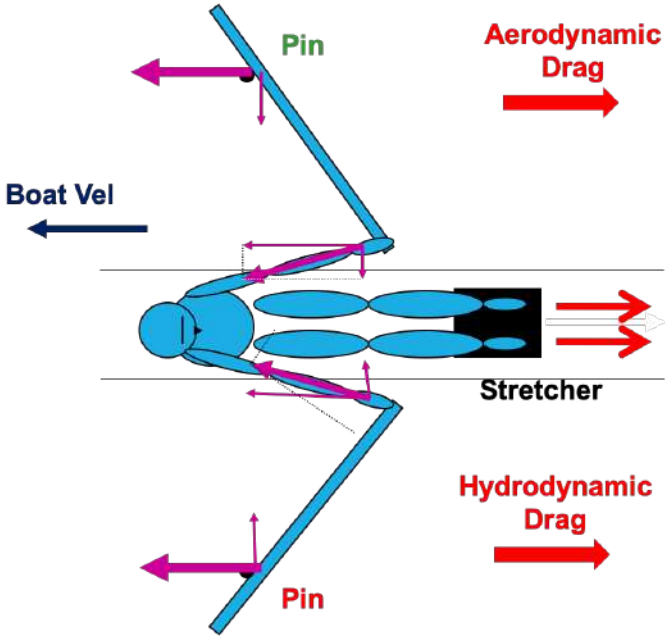
Forces in on-water rowing



Theoretical Model: 2D representation of external forces (in reality, all forces are in 3D)

Theoretical Model... Applied Forces on the boat





Boat-specific Variables	
a^{boat}	Boat acceleration (3D)
v^{boat}	Boat linear velocity
y^{boat}	Boat angular velocity (3D)

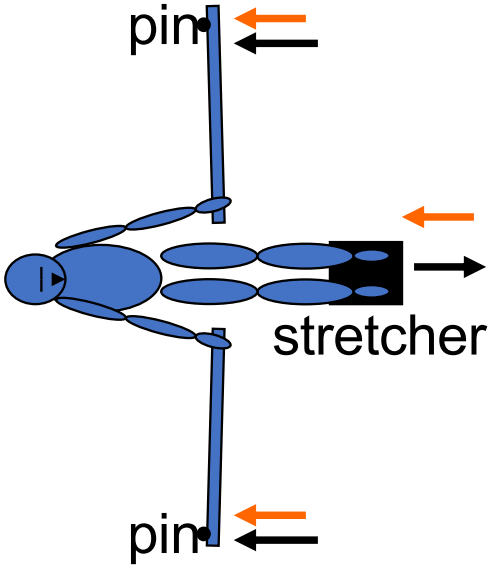
Athlete-generated Variables	
α	Oar angle (bow/ stroke) (2D)
F^{pin}	Pin forces (bow/ stroke) (3D)
$F^{stretcher}$	Footstretcher force (bow/ stroke)

Applied Forces during on-water rowing

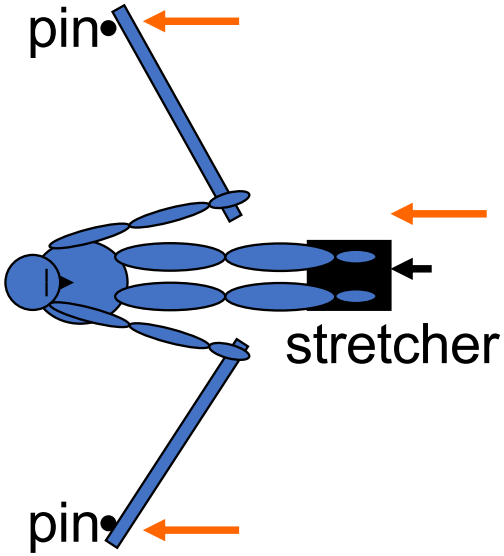
boat velocity

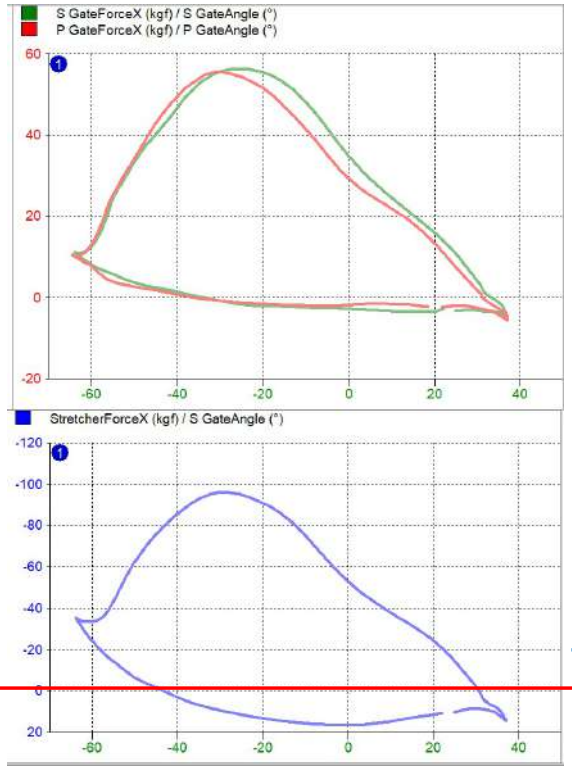
force

drive phase



recovery phase





+: pre-load against stretcher before next catch

+: push against stretcher

-: slight pull (hang) on stretcher

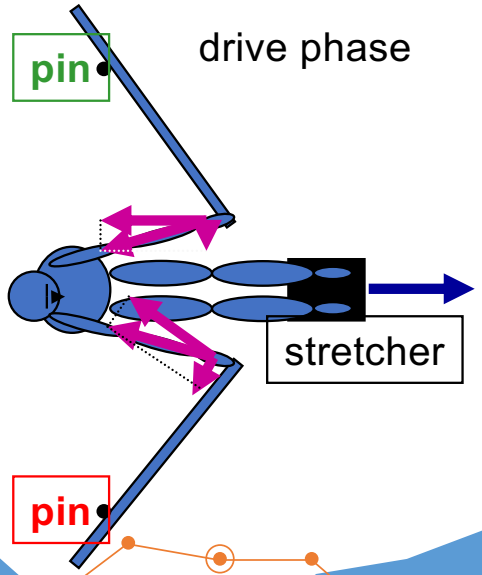
Sum of Propulsive pin forces (Fpin)

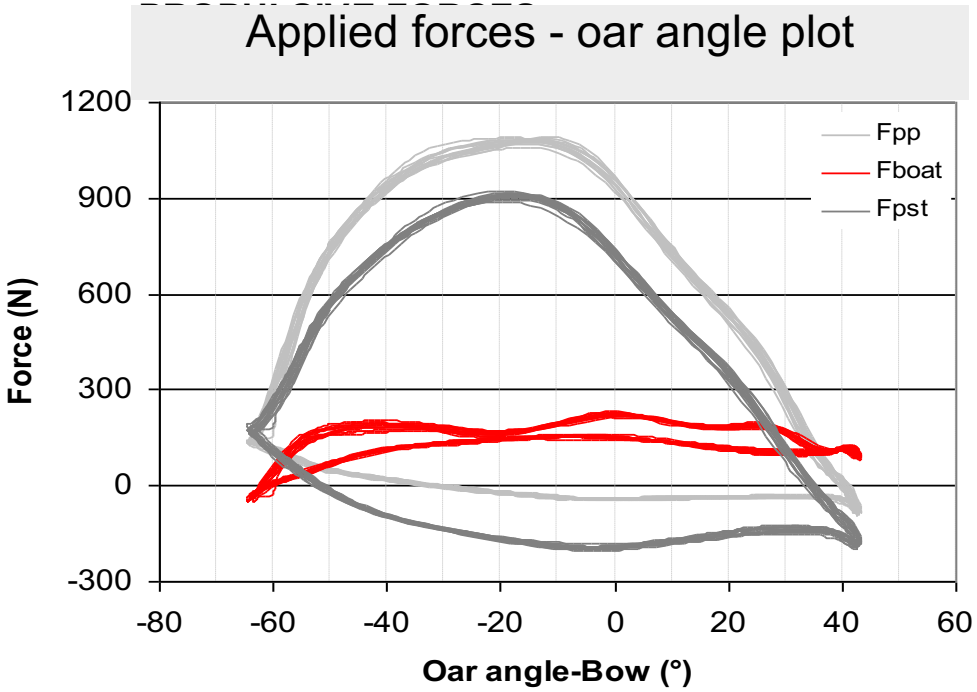
+

Sum of Propulsive stretcher force (Fpst)

=

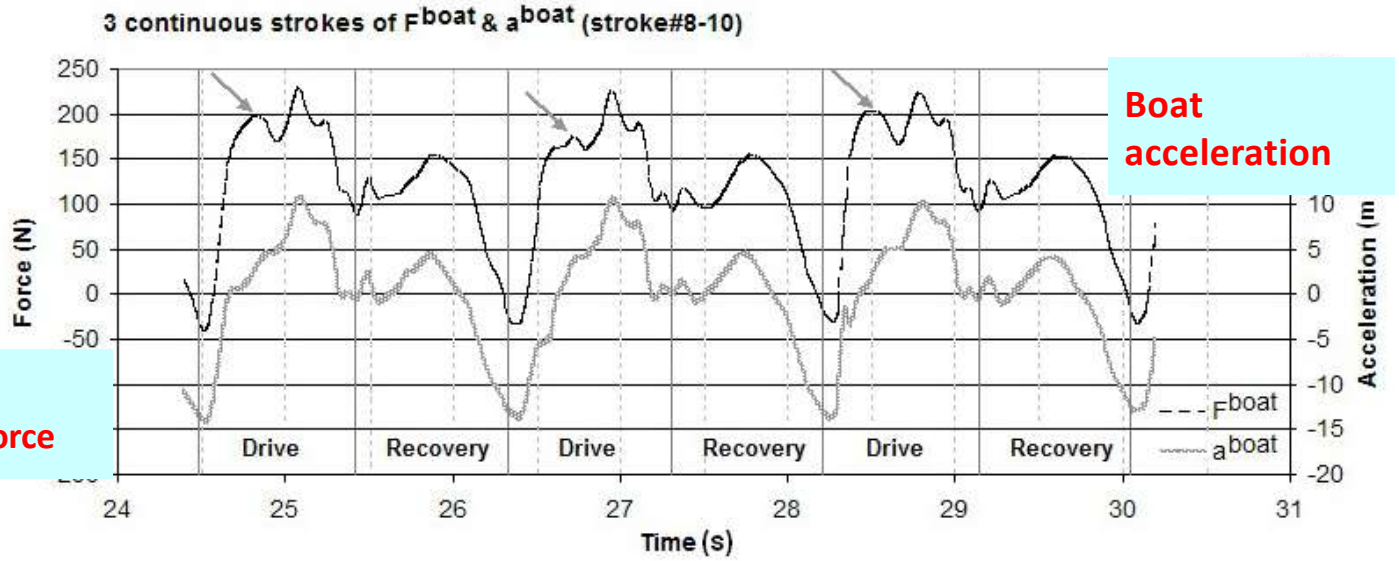
Net applied boat force (Fboat)





3D Boat Results:

Boat acceleration - Net applied boat force (W1x)



- highly significant positive relationship during the drive phase (r^2=0.904, p<0.000; W1x; n=12; 5 stroke rates).
- High relationships found especially in small boats (1x, 2-)

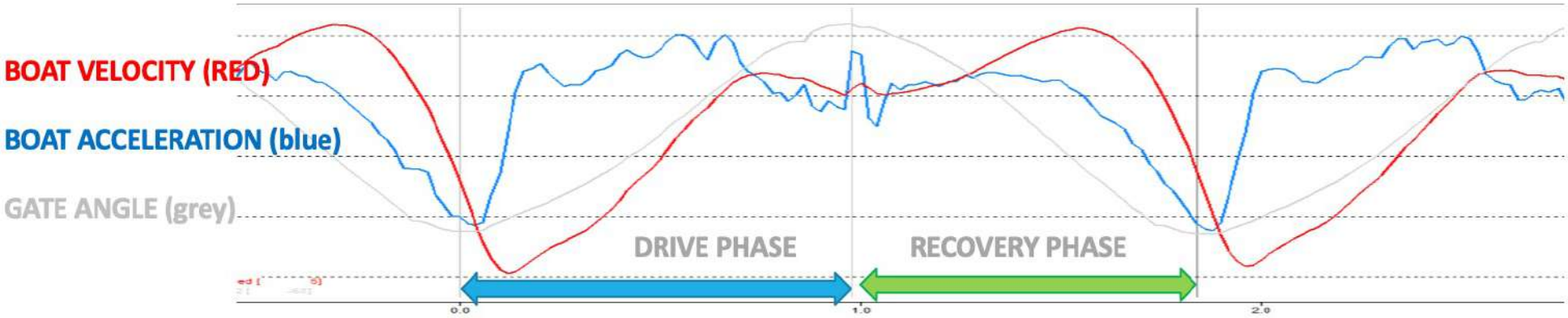
SPORT: Rowing

a cyclic motion- divided into two phases (Drive & Recovery)

- ✓ combination of…consistent technique, strength & endurance
- ✓ exposed to changing external & internal conditions (SR, boat velocity, fatigue, team member influence)

AIM OF THE ROWING MOTION

- ✓ …periodic motion to find the best compromise between the range of movement and the applied power (Saver B, 1996).
- ✓ … important that the muscles of the rower/s are utilised for producing power to propel the boat by efficient oxygen usage (Mattes K, 2000).



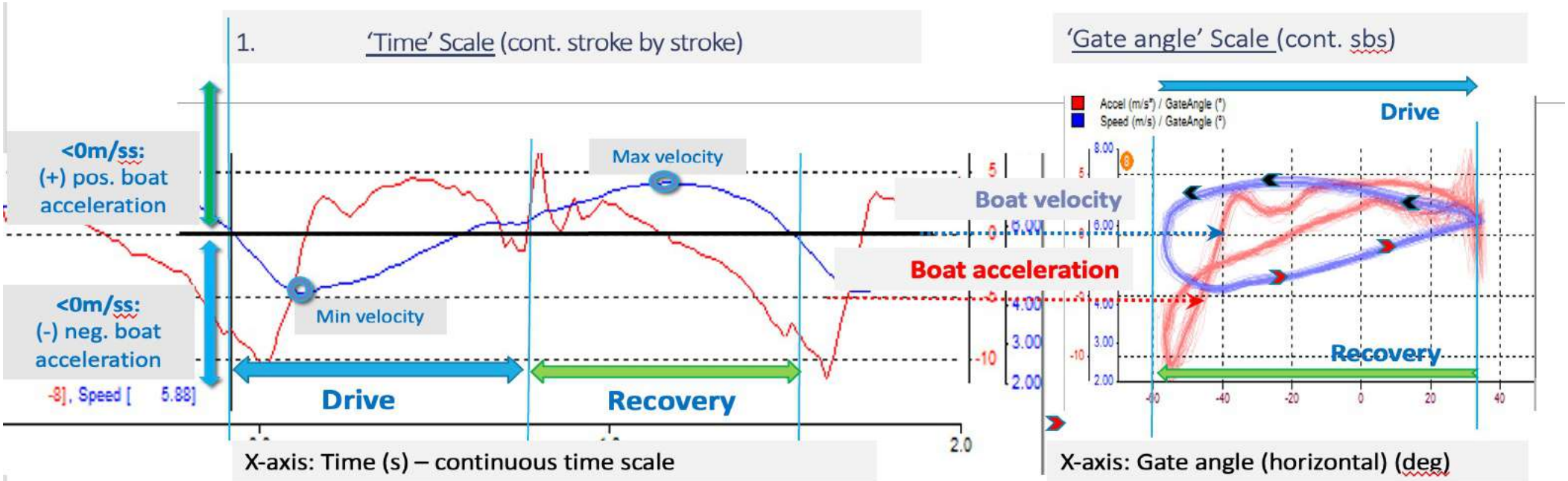
AIM of DRIVE (or stroke) phase	AIM of RECOVERY phase
to achieve high boat propulsion by applying an efficient sub-maximal force on the oar handle over an optimal stroke length. The handle speed should increase towards the end of the drive phase.	the rower should control the force on the stretcher, making it equal to the water resistance for as long as possible, so the boat velocity remains at a high value and fluctuates as little as possible (Mattes K, 2000).

Rowing stroke profile - Graphical description of Rowing technique

Characteristic 'rowing' patterns of boat velocity & acceleration

1. 'Time' Scale (cont. stroke by stroke)

'Gate angle' Scale (cont. sbs)



Drive phase:

- 'working phase' – blades move through the water
- Boat reaches its minimum boat velocity after the catch (when blades are 'locked in the water again'

Recovery phase:

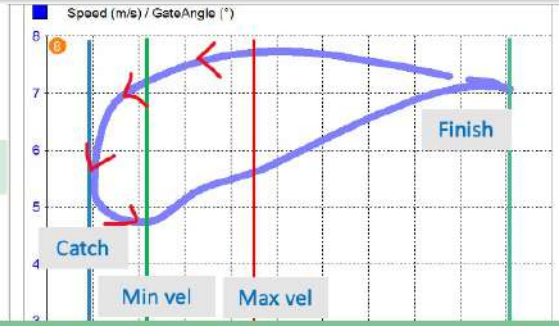
- blades are out of the water
- Boat reaches its max. boat velocity during the recovery (depending on boat cat. & skill level)
- Once the feet load the stretcher again towards the catch, boat velocity decreases

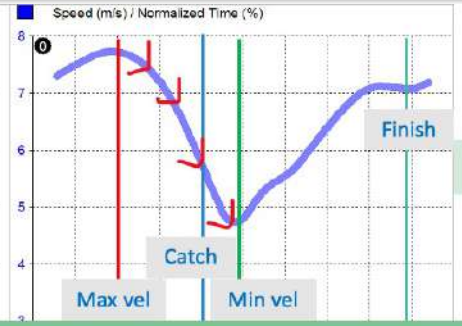
CHECK for relationships: How do the rowers affect the boat run?
- during the drive & recovery

Relationship between boat velocity – boat acceleration – force profile

Display of angle position & time(%) to reach min and max boat velocity @ race pace

Boat velocity vs. Angle

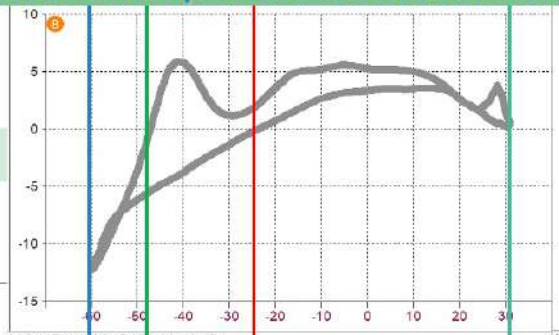


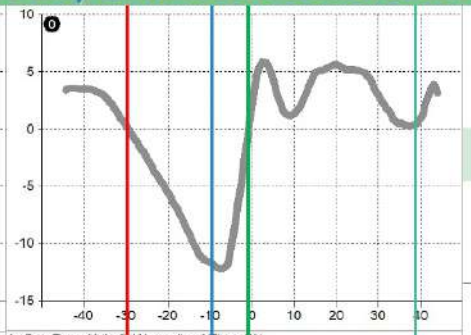


vs. Time (%)

Relationship between Boat velocity and boat acceleration

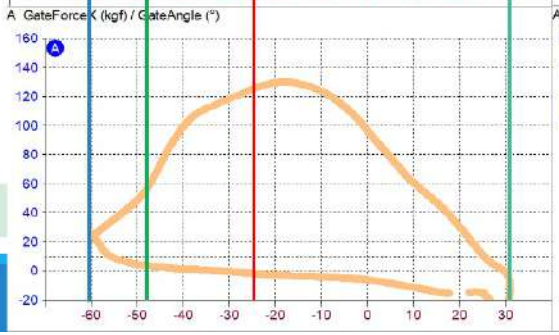
Acceleration vs. Angle

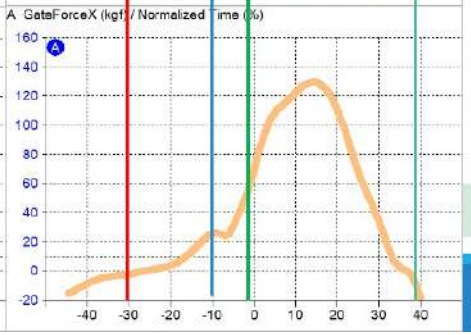




vs. Time (%)

Gate force vs. Angle



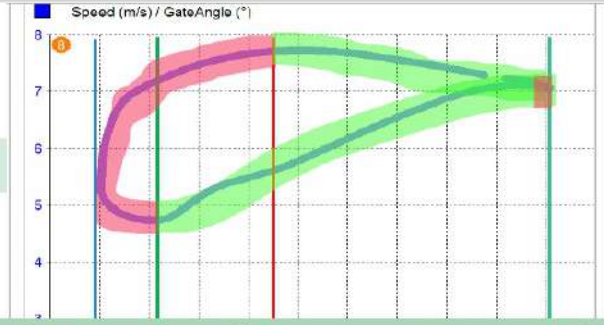


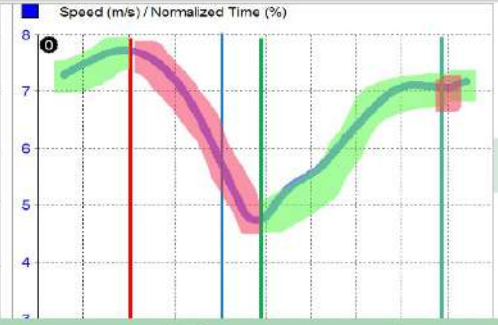
vs. Time (%)

Relationship between boat velocity – boat acceleration – force profile

Display of distance & time(%/str) spent in acceleration (green) vs. deceleration (red)

Boat velocity vs. Angle

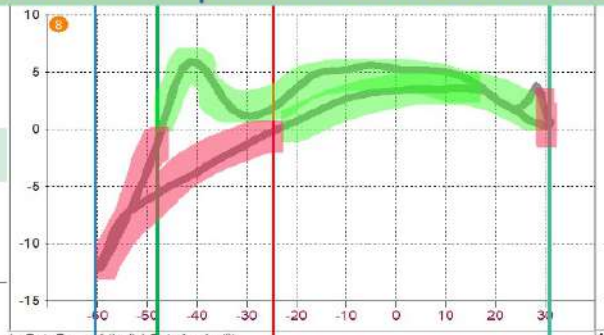


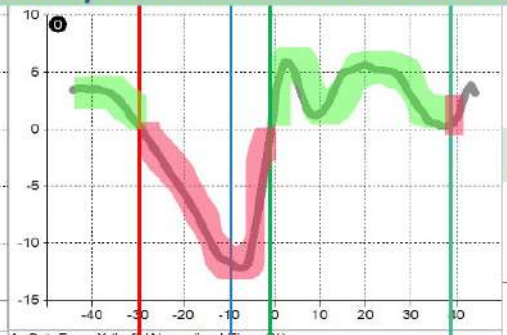


vs. Time (%)

Relationship between Boat velocity and boat acceleration

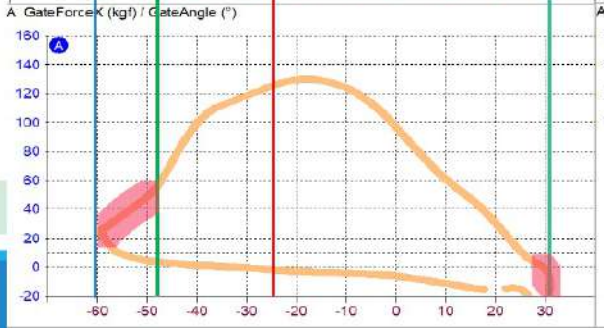
Acceleration vs. Angle

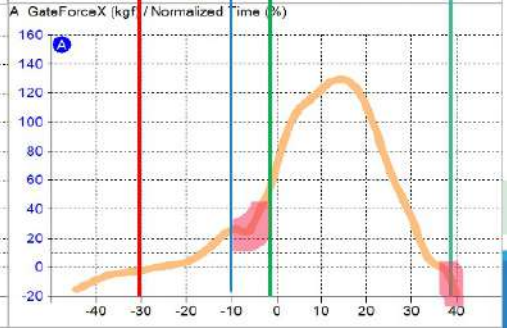




vs. Time (%)

Gate force vs. Angle





vs. Time (%)

In Practice: Rowing Biomechanics

At the boat level

- Understanding boat movement
- Understanding basic hydrodynamics
- Materials

OF HIGH IMPORTANCE

- understanding what factors are important in **generating** boat speed & acceleration
- understanding what factors **decrease** boat speed

In Practice: Rowing Biomechanics

At the rower level

- understand how the human body works mechanically (as opposed to physiologically)
- understand how muscular input/power can be translated into boat movement (transfer of forces/summation of forces etc)
- understand rowing efficiency

In Practice: Rowing Biomechanics

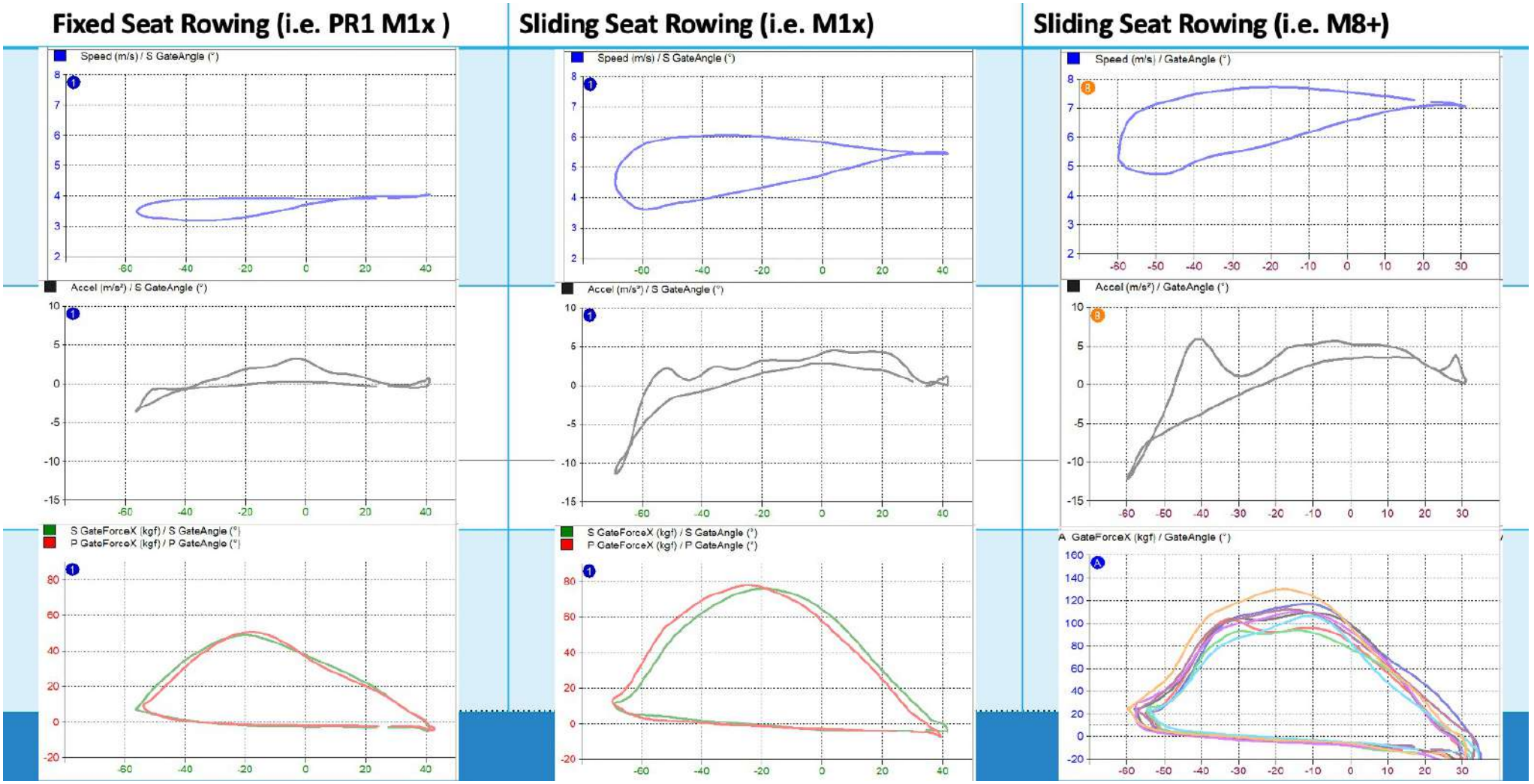
At the coach level

- boat set up (gearing/ rigging footstretcher/seat positioning, etc)
- Crew selection
- Seat selection
- race performance a.s.o.

An orientation for diagnostics & technique training & racing

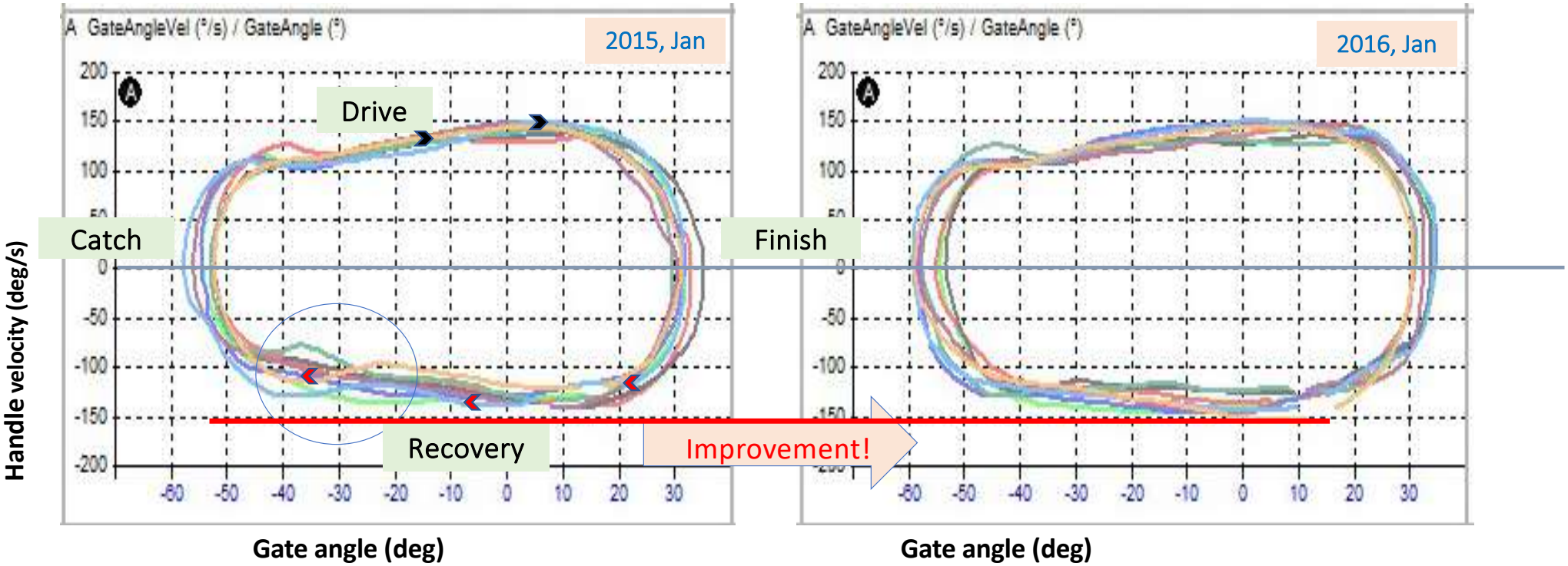
Boat Categories: PR1 1x – 1x – 8+ (Men):

Gate force, Boat Speed & Acceleration



Influence of crew dynamic – Comparison of Handle speed applications

W8+: Comparison of Handle speed – Gate angle Profiles



…during the recovery - different ind. handle velocities during the recovery towards the next catch slowing down and cause shorter catches at higher stroke rate.

…improvement towards a more synchronised crew recovery handle velocity – pos. effect – easier to maintain absolute catch angle length at higher rate without losing effectiveness.

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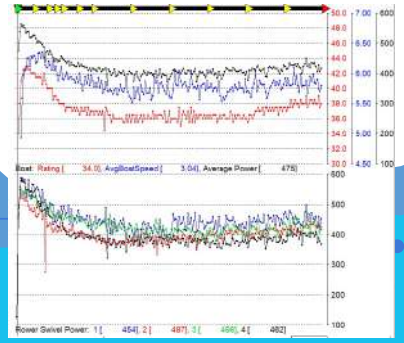
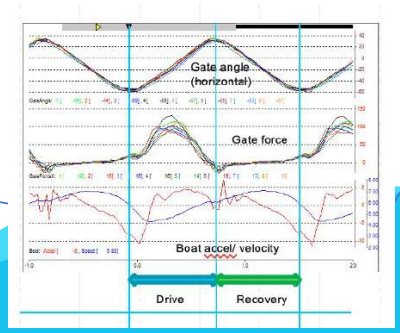
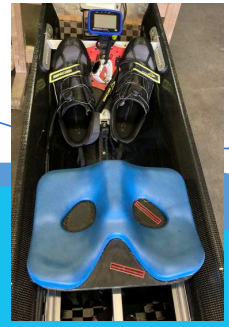
25. Januar 2025



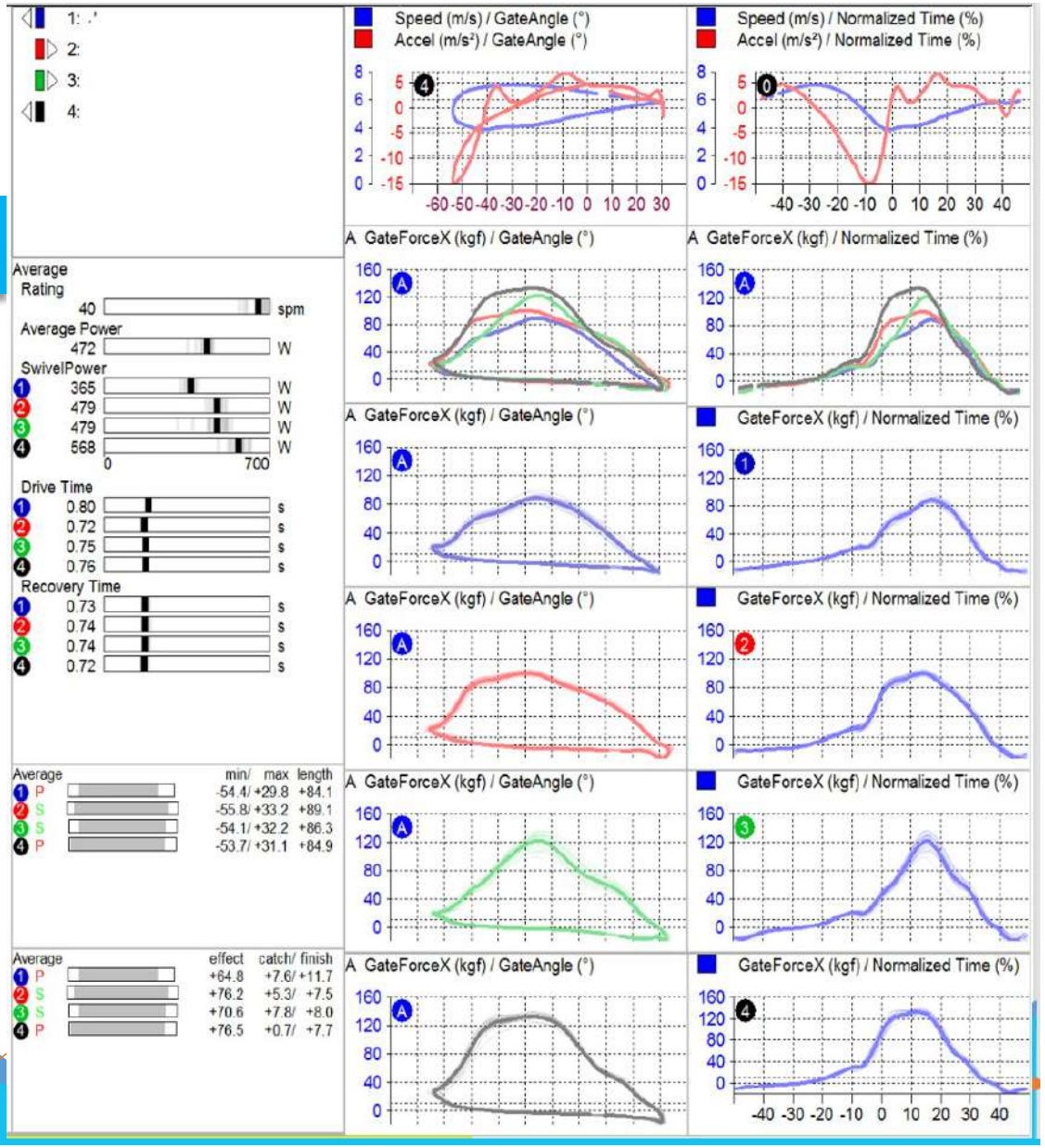


WANN LÄUFT DAS BOOT

Teil 2: Anwendung biomechanischer & hydrodynamischer Grundsätze

CONNY DRAPER PhD
APPLIED SPORTS BIOMECHANIST ◆ conny.draper@gmail.com

Example: M4- (medal winning boat)



Example: M4- (medal winning boat)

GATE FORCE PROFILE

Pos. value (pulling gate force),
neg. value (back-splash)

FOOTSTRETCHER FORCE PROFILE

Horizontal footstretcher force (blue)

Main foot force appl.

Pos. value (push), neg. value (pull 'draw')

Vertical footstretcher force (black)

Secondary foot force appl.

Pos. value (downward force), neg. value (upward force)

FOOTSTRETCHER LOADING (MOMENT) PROFILE

Horizontal 'right-left' footstretcher loading (blue)

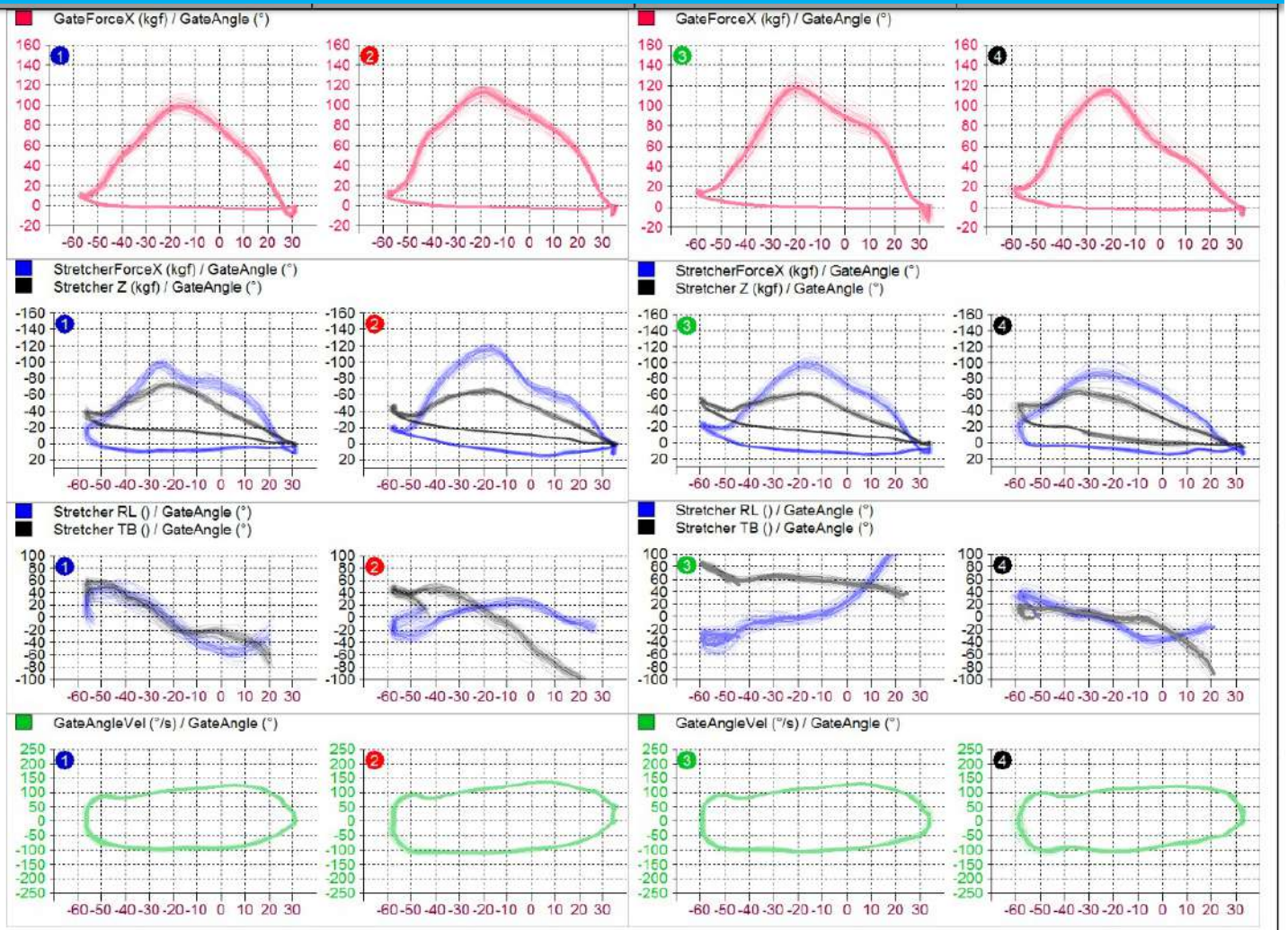
Pos. value (tow. right foot), neg. value (tow. Left foot)

Vertical 'toe-heel' footstretcher loading (black)

Pos. value (tow. toe), neg. value (tow. heel)

HANDLE VELOCITY PROFILE

Pos. value (drive phase velocity), neg. value (recovery phase velocity)



Example: M2x (medal winning athletes)

GATE FORCE PROFILE

Pos. value (pulling gate force),
neg. value (back-splash)

FOOTSTRETCHER FORCE PROFILE

Horizontal footstretcher force (blue)
Main foot force appl.
Pos. value (push), neg. value (pull 'draw')
Vertical footstretcher force (black)
Secondary foot force appl.
Pos. value (downward force), neg. value (upward force)

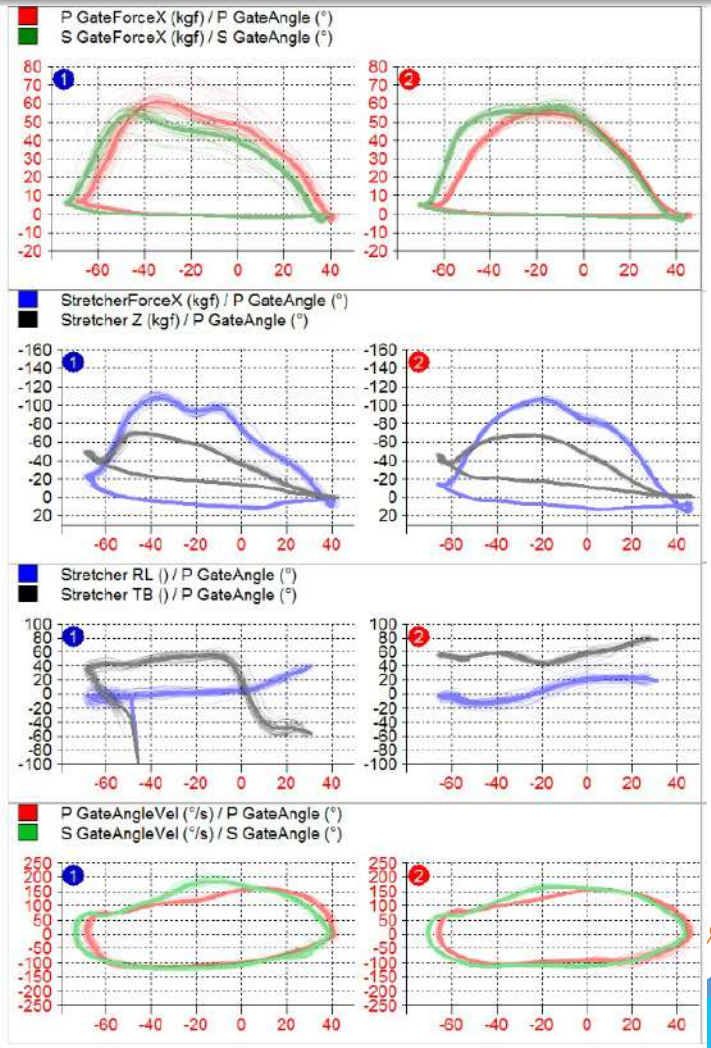
FOOTSTRETCHER LOADING (MOMENT) PROFILE

Horizontal 'right-left' footstretcher loading (blue)
Pos. value (tow. right foot), neg. value (tow. Left foot)

Vertical 'toe-heel' footstretcher loading (black)
Pos. value (tow. toe), neg. value (tow. heel)

HANDLE VELOCITY PROFILE

Pos. value (drive phase velocity), neg. value (recovery phase velocity)

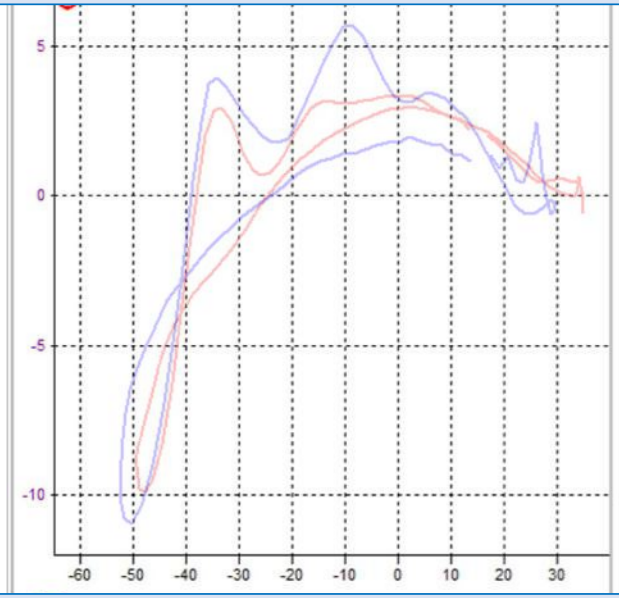


W2- BOAT ACCELERATION PROFILES

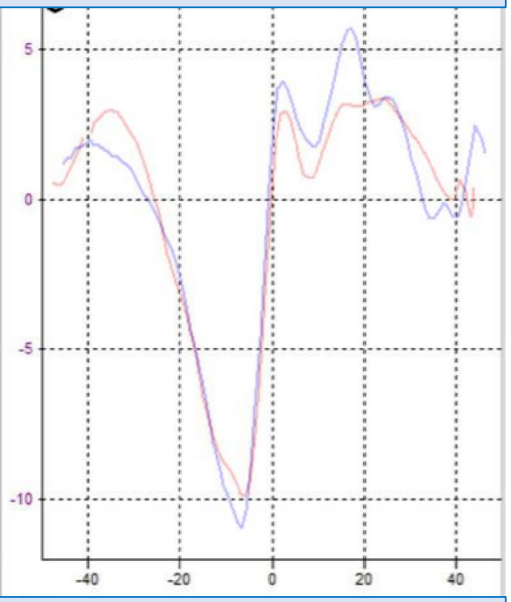
	W2- OG/ WCH Medallist	W2- (OG/ WCH medalist)	
Work load	1km race	2km race	
Stroke rate (Str/min)	34.2 (1km) 33.3 (2nd 500m)	36.6 (2km) 37.2 (2nd 500m)	
500m split (min:ss.0)	1:56.1	1:47.5	
Boat speed (m/s)	4.3	4.6	
Dist/str (m/Str)	7.5	7.6	
Crew power (W)	293 (86deg)	302 (80-82deg) 291 (80-82deg)	
Min velocity (drive)	2.95	3.15	
Max velocity (recovery)	5.35	5.5	
Time% in deceleration (vel ($^{Max\ (rec)}$ _ $^{Min(drive)}$)	26	27	
Angle^{Rec} (deg) = 0m/s^2 Start of deceleration	-24	-24	
Displacement (deg) (catch–angle $^{(pos.\ accel(drive)}$	11	13	

- RED: W2- WCH/ OG medallist
- BLUE: W2- WCH/ OG medallist

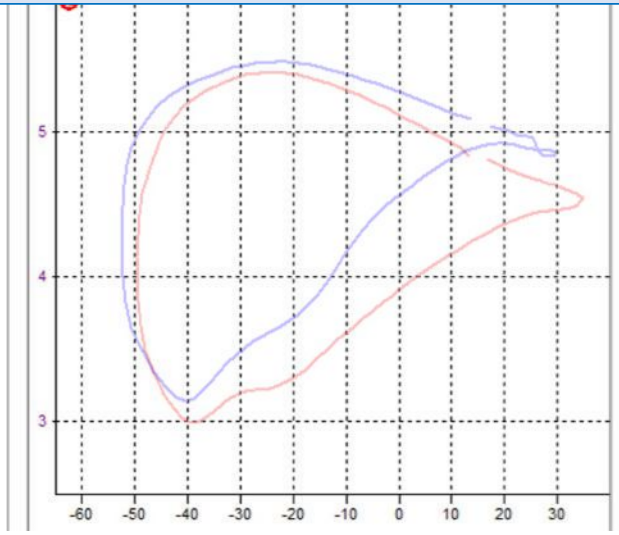
Boat accel vs. gate angle



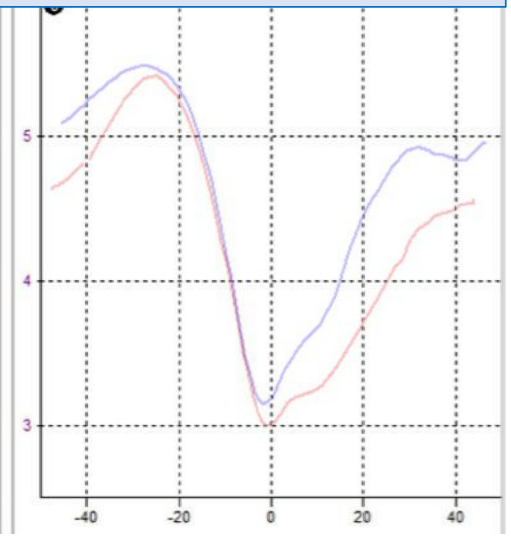
Boat accel vs. Time normalized (%)



Boat velocity vs. gate angle



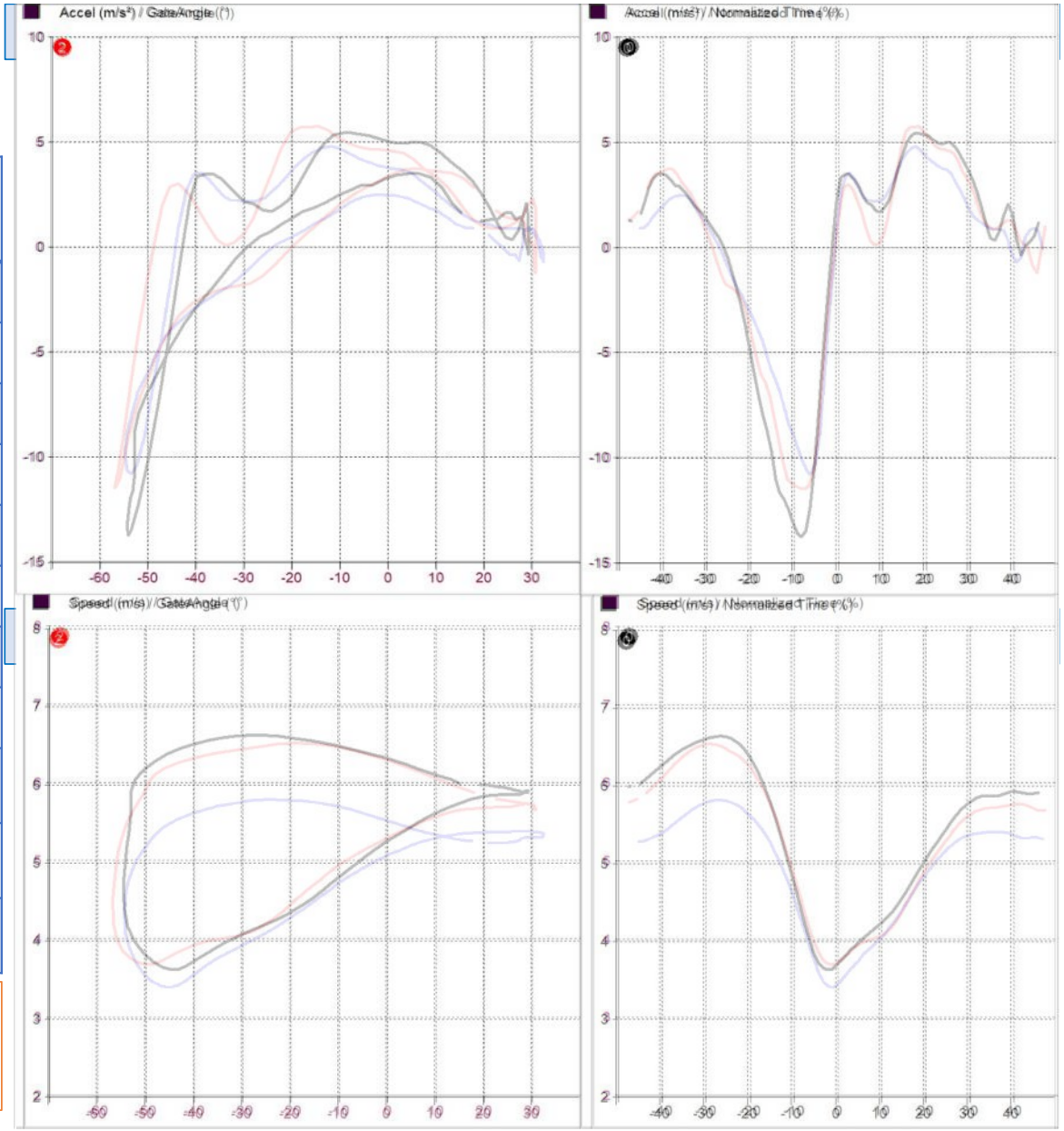
Boat velocity vs. Time normalized (%)



M2- BOAT ACCELERATION PROFILES

	M2- OG/ WCH Medallist	M2- (WCH medalist)	JM2- (JWCH Medalist)
Work load	1km	500m	1' SR32-34
Stroke rate (Str/min)	36.6	38.8	35.3
500m split (min:ss.0)	1:34.5	1:31.8	1:40.8
Boat speed (m/s)	5.29	5.44	4.96
Dist/str (m/Str)	8.7	8.4	8.4
Crew power	437	480	349
Min velocity (drive)	3.8	3.7	3.45
Max velocity (recovery)	6.5	6.75	5.8
Time% in deceleration (vel ($^{Max\ (rec)}$ _ $^{Min(drive)}$)	28	26	28
Angle^{Rec} (deg) = 0m/s^2 Start of deceleration	-20	-29	-23
Displacement (deg) (catch–angle $^{(pos.\ accel(drive)}$	8	12	11

- RED: M2- WCH/ OG medallist
- BLACK: M2- WCH medalist
- BLUE: JM2- JWCH medalist

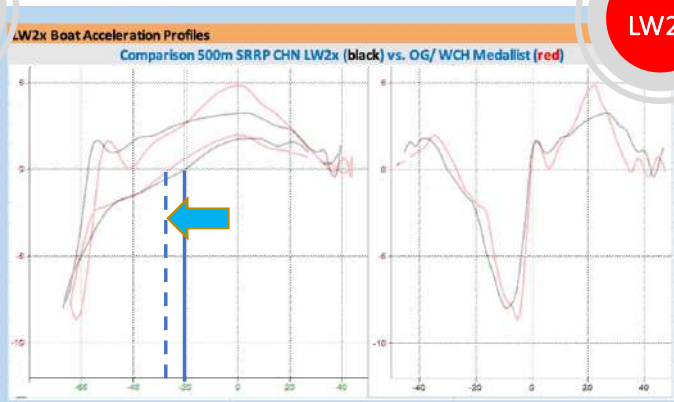


Overview: Boat acceleration of national crews (**black**) vs. OG/ WCH Medal Crews (**red**)

W4x

W2x

LW2x



W4-

Finding 'FREE SPEED'

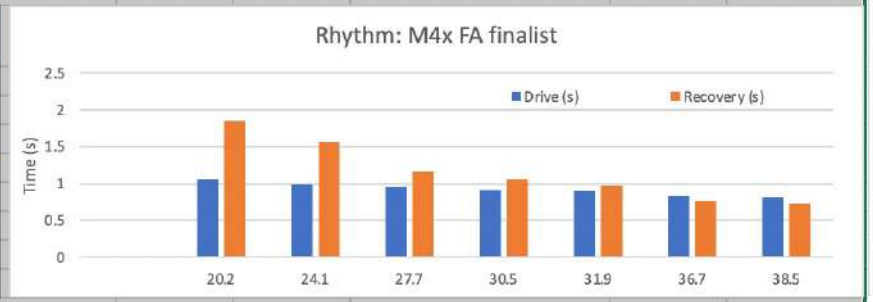
There in an area of opportunity for these 5 boats to improve the active recovery phase!

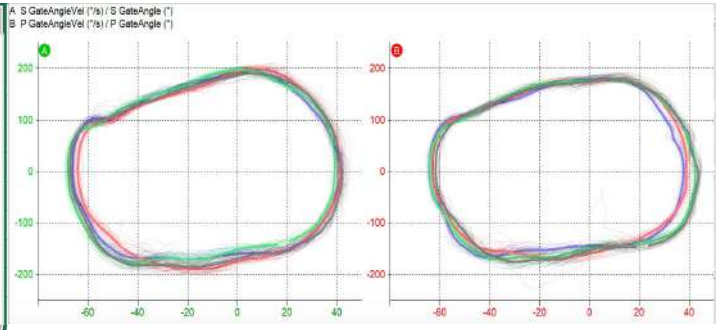
M4x

Rhythm: Relationship between the Drive & Recovery Phase (2 M4x)

M4x (World FA finalist):

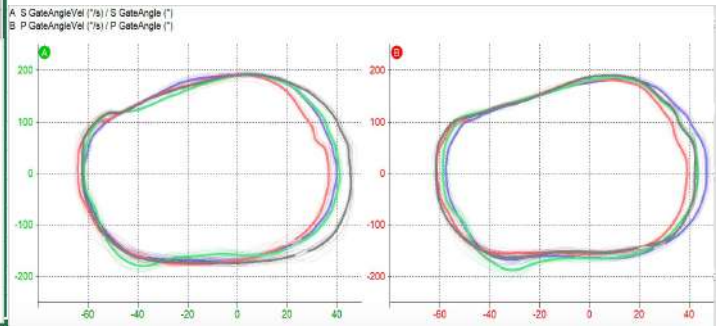
Stroke rate (Str/min)	Time/ stroke (s)	Measured SR (Str/min)	Drive (s)	Recovery (s)
18	3.33			
20	3.00	20.2	1.06	1.85
24	2.50	24.1	0.99	1.56
28	2.14	27.7	0.96	1.16
30	2.00	30.5	0.91	1.06
32	1.88	31.9	0.89	0.97
36	1.67	36.7	0.84	0.76
38	1.58	38.5	0.81	0.72





M4x (OG Medallist):

Stroke rate (Str/min)	Time/ stroke (s)	Measured SR (Str/min)	Drive (s)	Recovery (s)
18	3.33			
20	3.00	20.6	0.98	1.91
24	2.50	24.3	0.93	1.51
28	2.14	27.7	0.89	1.26
30	2.00	30.7	0.93	1.01
32	1.88	32.9	0.87	0.91
36	1.67	35.4	0.78	0.87
38	1.58	36.5	0.80	0.82



TRAIN YOUR COACHES' EYE: POSTURE

HIP FLEXIBILITY / PELVIC TILT

@GRowingBODIES

Technique vs. Common technical Breakdowns:

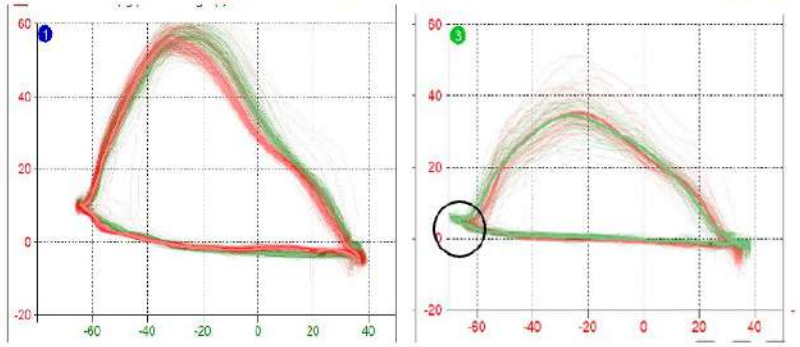
The CATCH

IDEAL TECHNIQUE:
CATCH

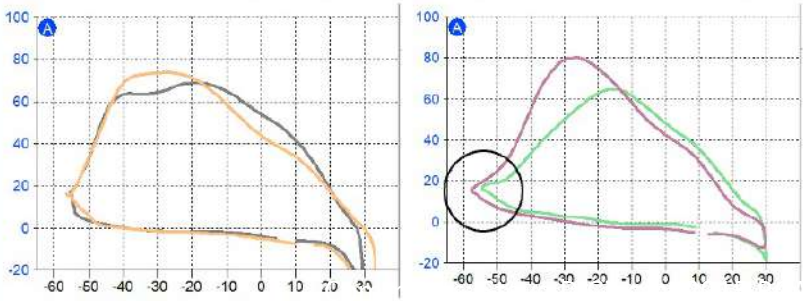
CATCH:
- Heels slightly off
- Pelvis forward
- Pressure on front of sit bones
- Hip sightly externally rotated (ER)
- Spine neutral
- Shoulders mid socket
- Upper arms slightly ER

BIOMECHANICAL ON-WATER DISPLAY

CATCH: 2 Sculling profiles (Elite W (left) vs. Junior W (right))



CATCH: 2 Sweep profiles (Elite W (left) vs. Junior W (right))



Common technical BREAKDOWNS
CATCH

CATCH:
- Poor ankle compression
- Poor hip compression
- Poor pelvic/ rock over
- Lower spine flexion
- Upper spine flexion
- Forward head posture
- Shoulder forward (sublux)

Technique vs. Common technical Breakdowns:

The FINISH/ RELEASE

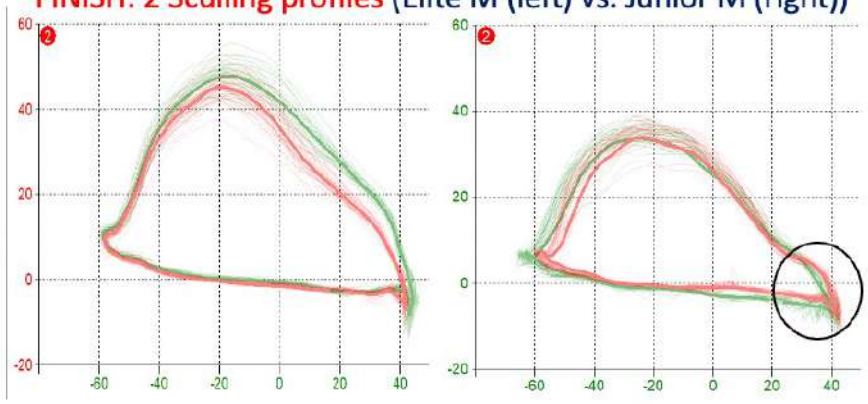
IDEAL TECHNIQUE: FINISH

FINISH:

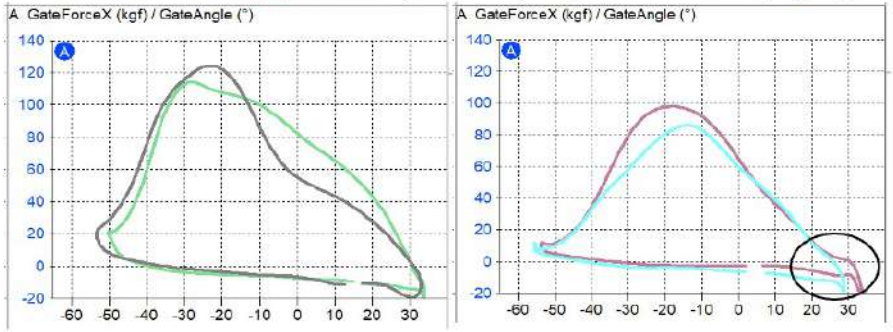
- Pelvis just past neutral
- Pressure on back of sit bones
- Neutral spine
- Glutes engaged
- Shoulders set

BIOMECHANICAL ON-WATER DISPLAY

FINISH: 2 Sculling profiles (Elite M (left) vs. Junior M (right))



FINISH: 2 Sweep profiles (Elite M (left) vs. Junior M (right))

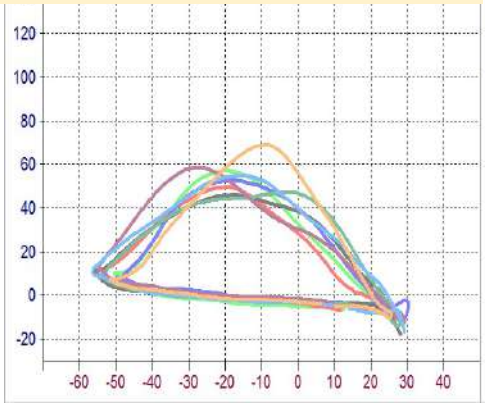
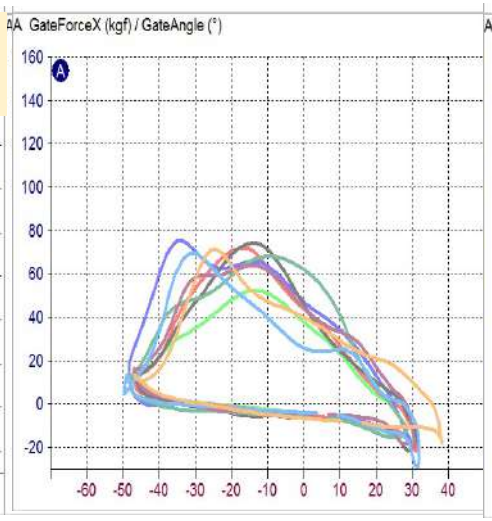
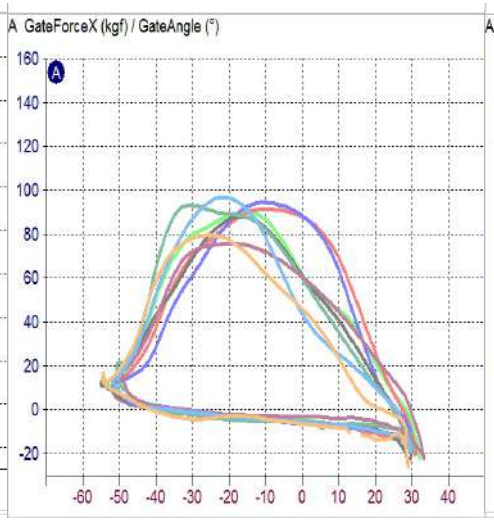
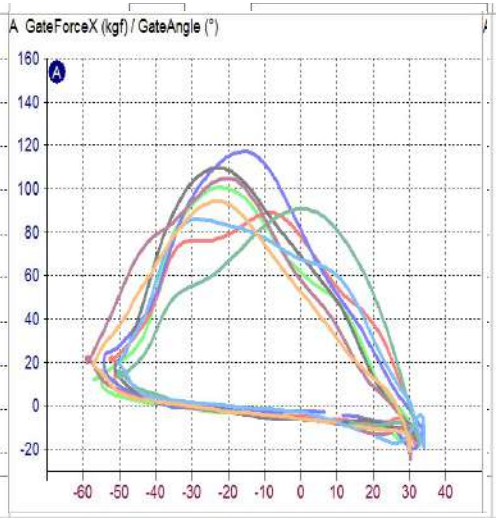
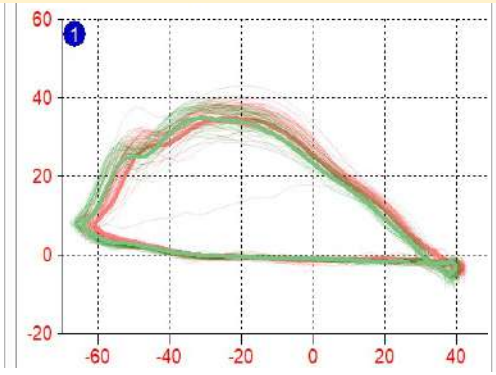
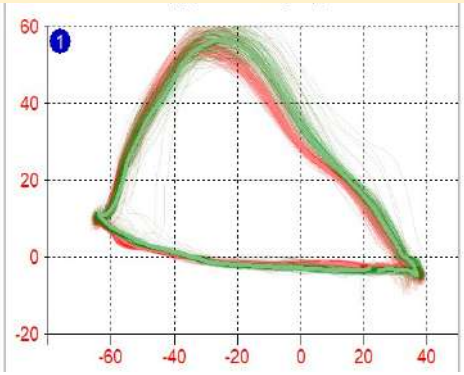
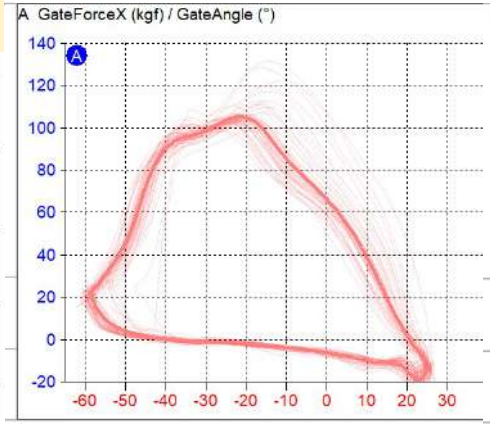
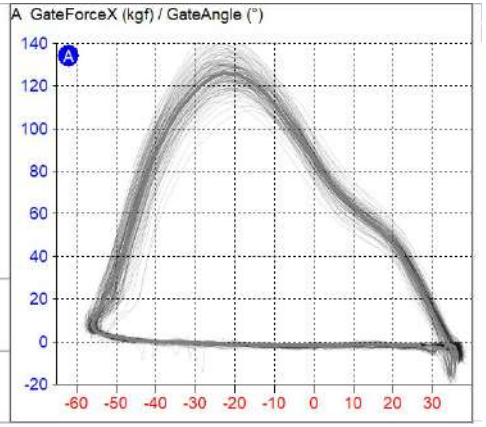


Common technical BREAKDOWNS FINISH

FINISH:

- Glutes off too early/ over reliance on hip flexor
- Collapse at back end
- Over extension of upper Tx
- Forward head posture

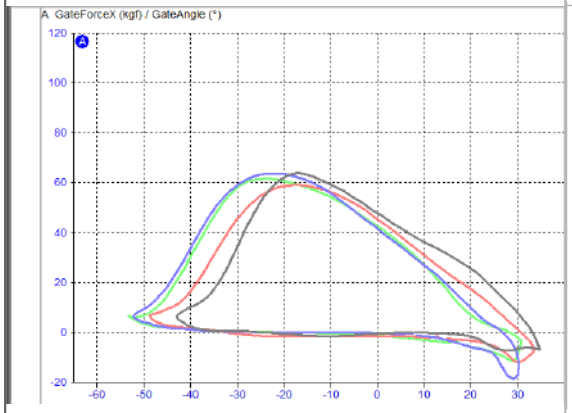
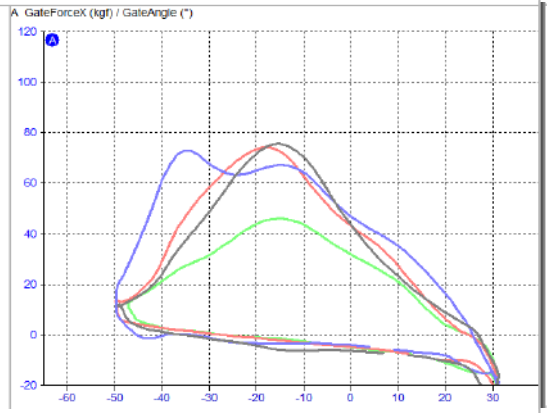
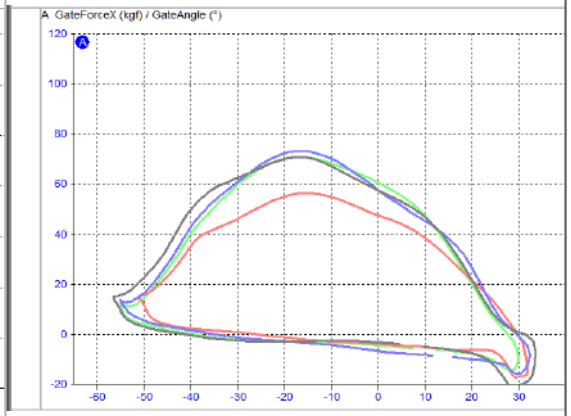
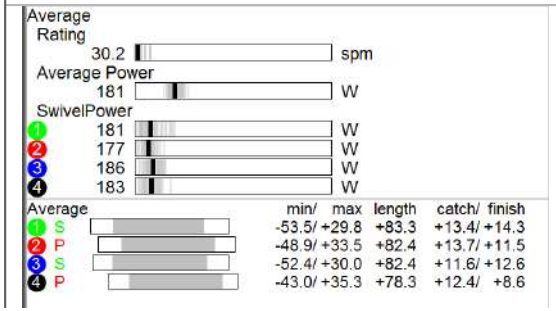
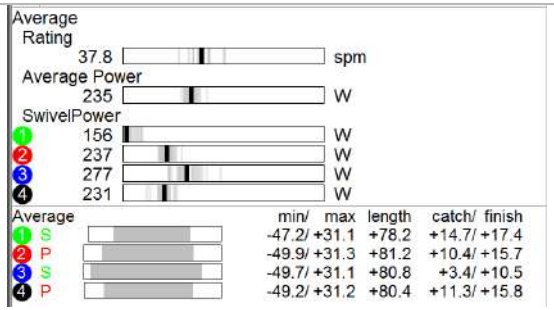
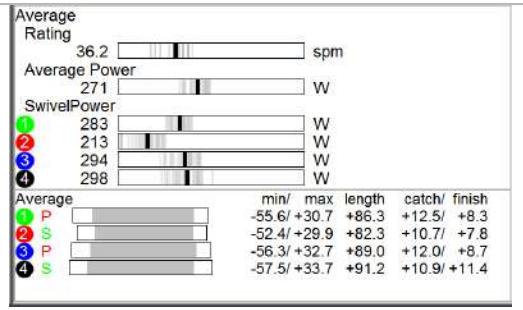
College Rowers vs. Elite Rower (examples of Top 10 Erg rowers)

	LW8+	OW8+	LM8+	HM8+
	5min # SR30-32	2000m race	2000m race	2000m race
College Level:				
International Top 10 Erg rower:				

WOMENS' SWEEP: Skill Level Comparison 'School – Collegiate – Elite'

Gate force vs angle Profile

Women's Sweep Comparison: 5min SRRP pieces

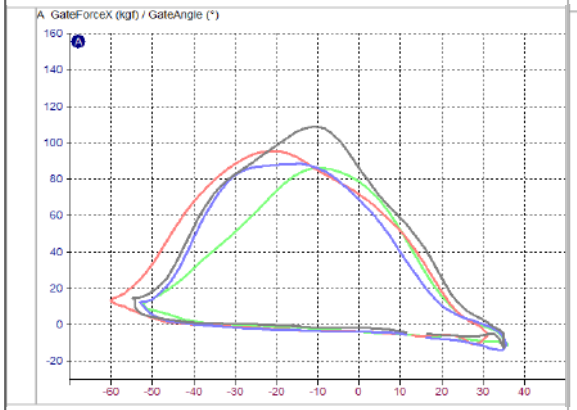
School girls (JW4+) Sweep	Collegiate Rowing (OW8+) Sweep	National Team (W8+) Sweep
		
		

MENS' SWEEP: Skill Level Comparison 'School – Collegiate – Elite'

Gate force vs angle Profile

Men's Sweep Comparison: 5min SRRP pieces

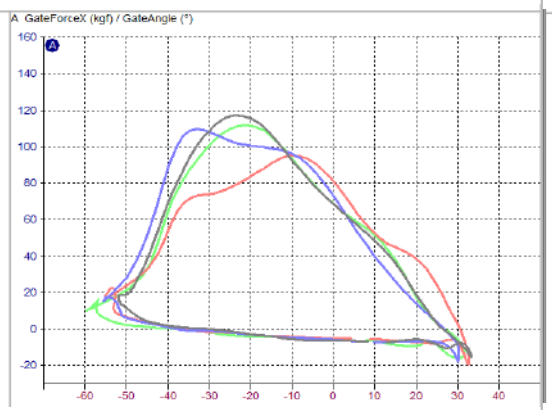
School boys (JM4+) Sweep



Average
Rating 33.7 spm
Average Power 333 W
SwivelPower
1 285 W
2 360 W
3 308 W
4 381 W

Average		min/	max	length	catch/	finish
1 P		-52.3/	+36.3	+88.6	+12.3/	+16.2
2 S		-60.8/	+30.5	+91.2	+10.2/	+9.7
3 S		-53.2/	+35.9	+89.1	+9.8/	+17.9
4 P		-56.2/	+35.4	+91.6	+11.6/	+12.6

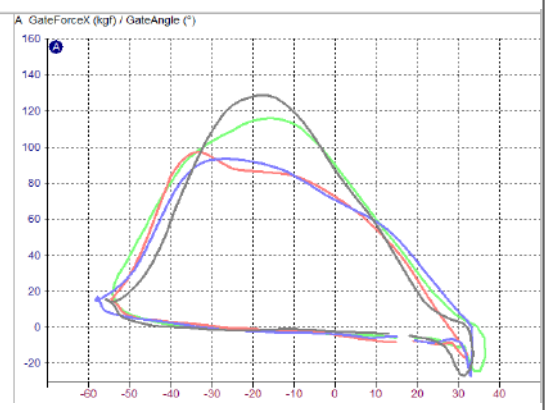
Collegiate Rowing (M8+) Sweep



Average
Rating 37.3 spm
Average Power 384 W
SwivelPower
1 409 W
2 394 W
3 414 W
4 406 W

Average		min/	max	length	catch/	finish
1 S		-60.8/	+31.6	+92.4	+15.8/	+10.9
2 P		-55.9/	+33.0	+88.9	+9.9/	+5.9
3 S		-56.0/	+30.3	+86.3	+7.2/	+10.6
4 P		-51.8/	+33.5	+85.3	+5.4/	+12.2

National Team (M8+) Sweep



Average
Rating 37.4 spm
Average Power 435 W
SwivelPower
1 484 W
2 400 W
3 418 W
4 467 W

Average		min/	max	length	catch/	finish
1 S		-54.1/	+36.6	+90.7	+1.7/	+10.9
2 P		-54.7/	+32.3	+86.9	+5.2/	+9.1
3 S		-58.5/	+33.2	+91.8	+9.3/	+5.4
4 P		-55.7/	+33.8	+89.5	+9.7/	+12.3

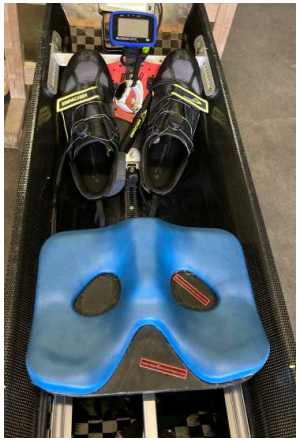
TECHNICAL CHANGE: Identify strength & weaknesses

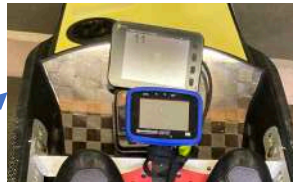
Movement Before Muscles

1. Starting point – what are you aiming to achieve:

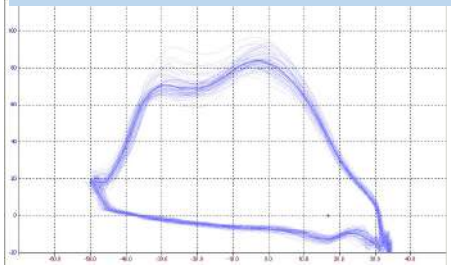
   Structural-functional strengths & weaknesses

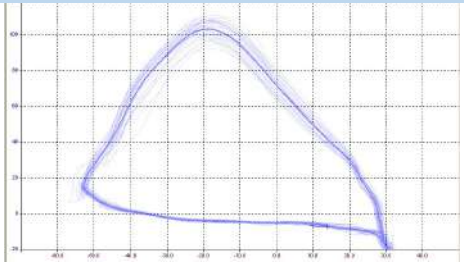
2. Define fundamental *movement patterns* and *physical technical demands* of rowing



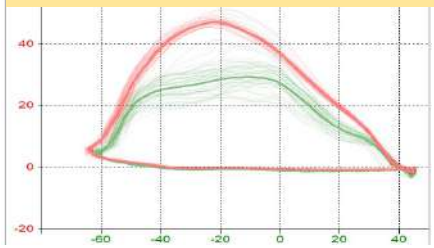


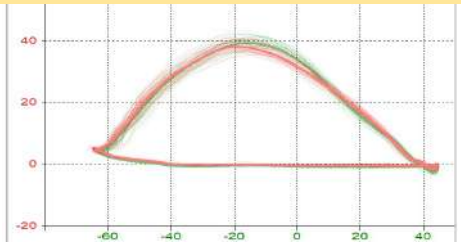
W1x: Development over 4 years (Slip vs. Non-slip)



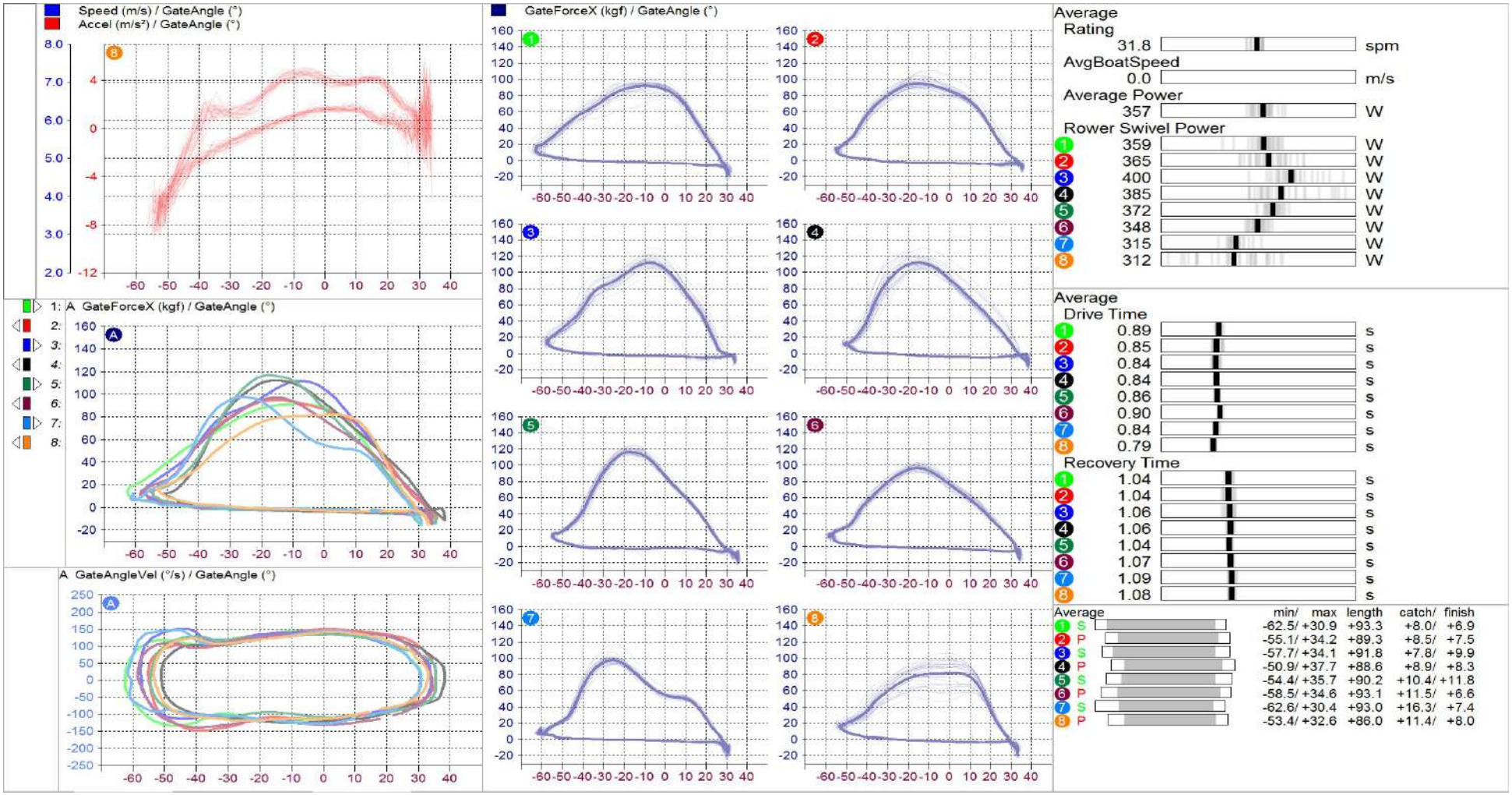


W1x: Development over 2 weeks (SR18-20: working with screen)





CREW BOATS: Identify strength & weaknesses

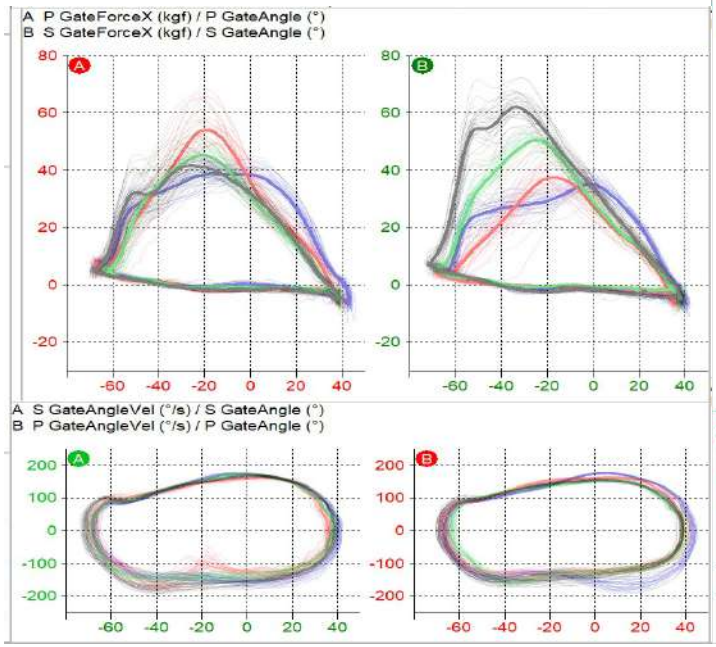


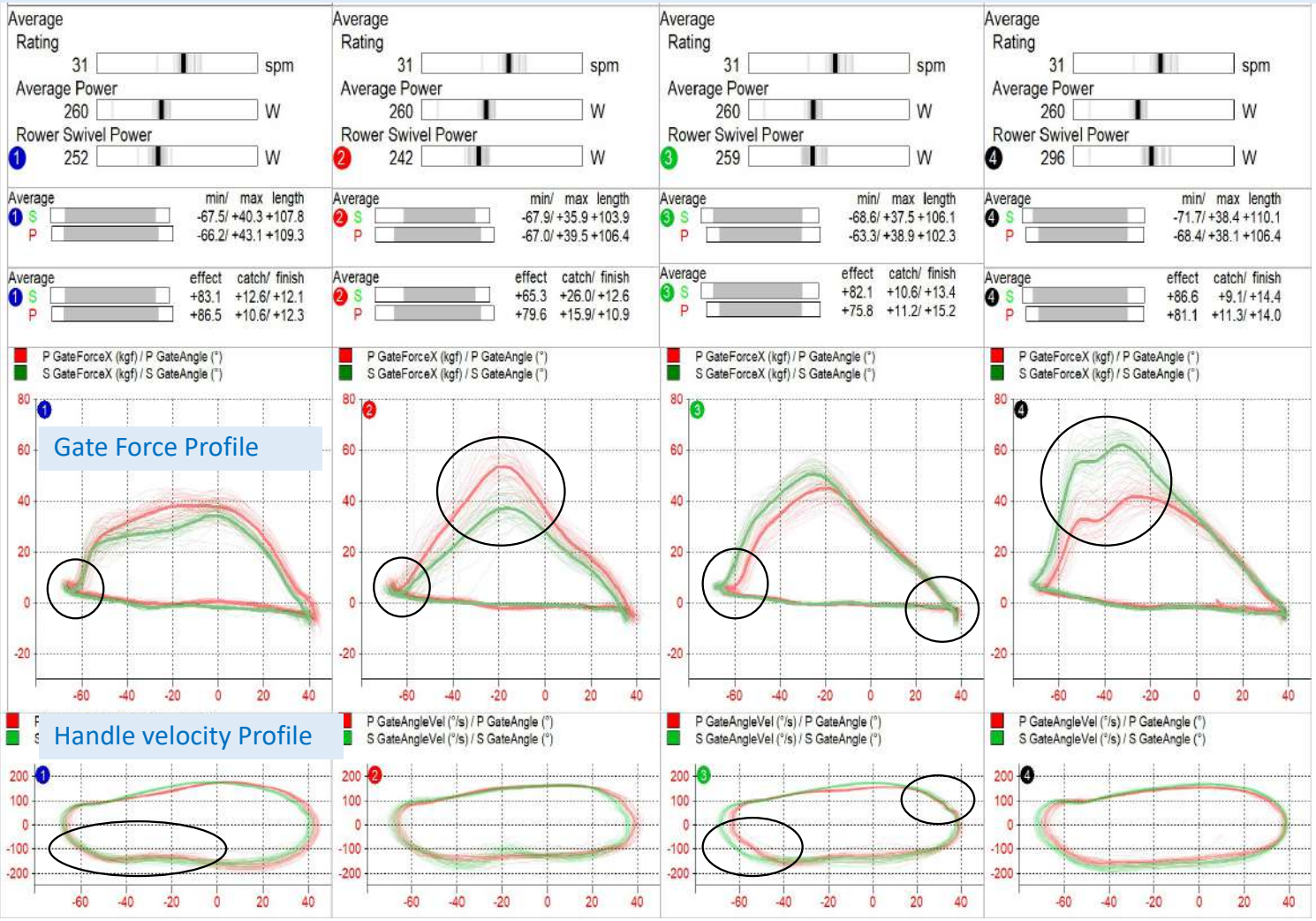
JM4x+: Youth Rowing: (90s @ SR32)

Crew Overlay:

(left (stroke/port); right (bow/ starboard)

- Gate Force Profile (top)
- Handle velocity Profile (bottom)



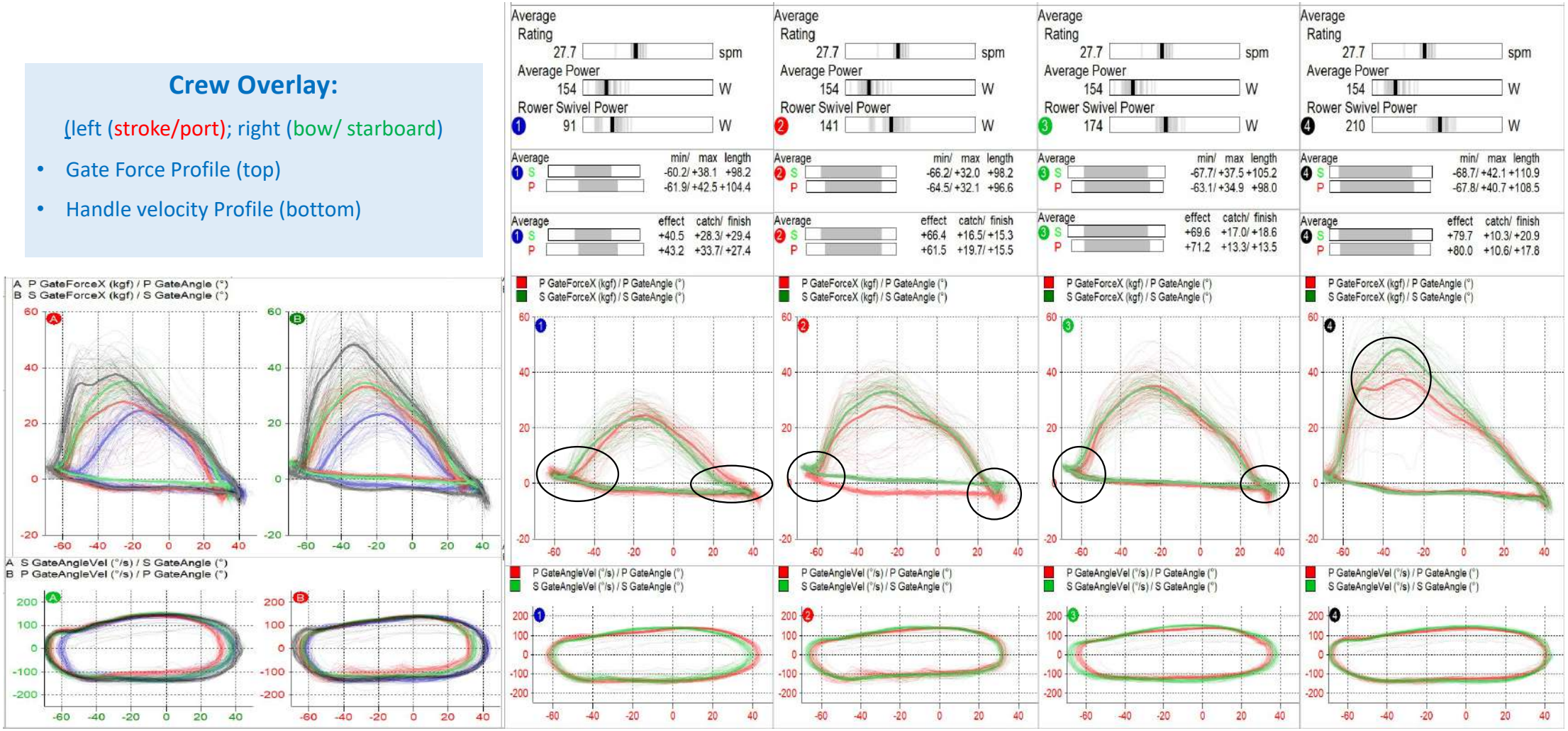


JW4x+ : Youth Rowing: JW4x+ (120s @ SR28)

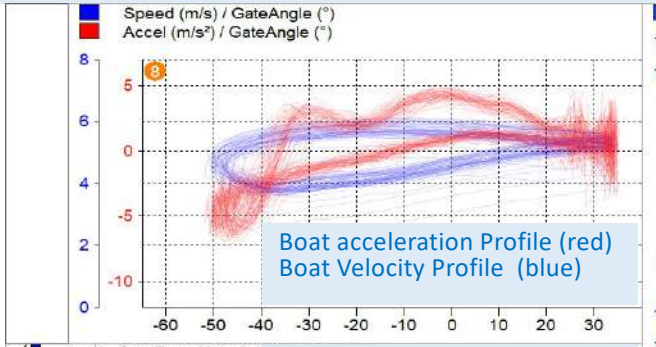
Crew Overlay:

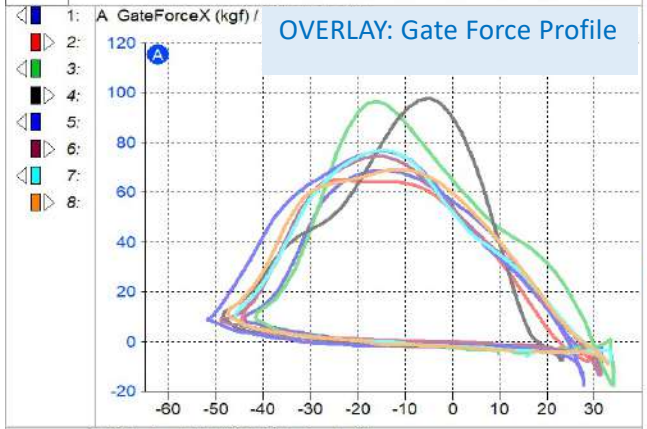
(left (stroke/port); right (bow/ starboard)

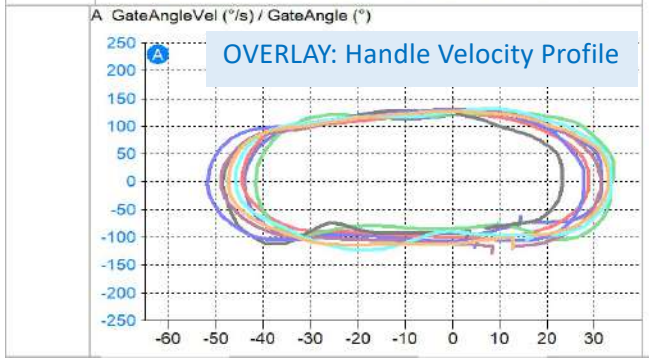
- Gate Force Profile (top)
- Handle velocity Profile (bottom)

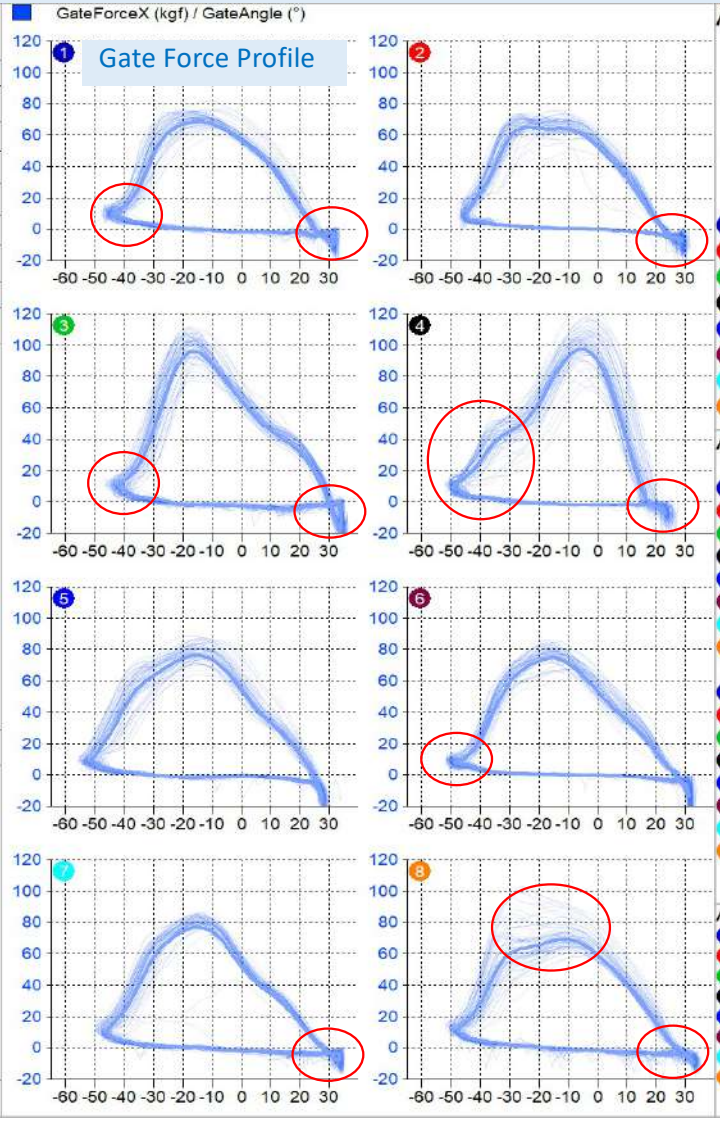


U19 W8+ : Youth Rowing: (500m @ SR34)









Average

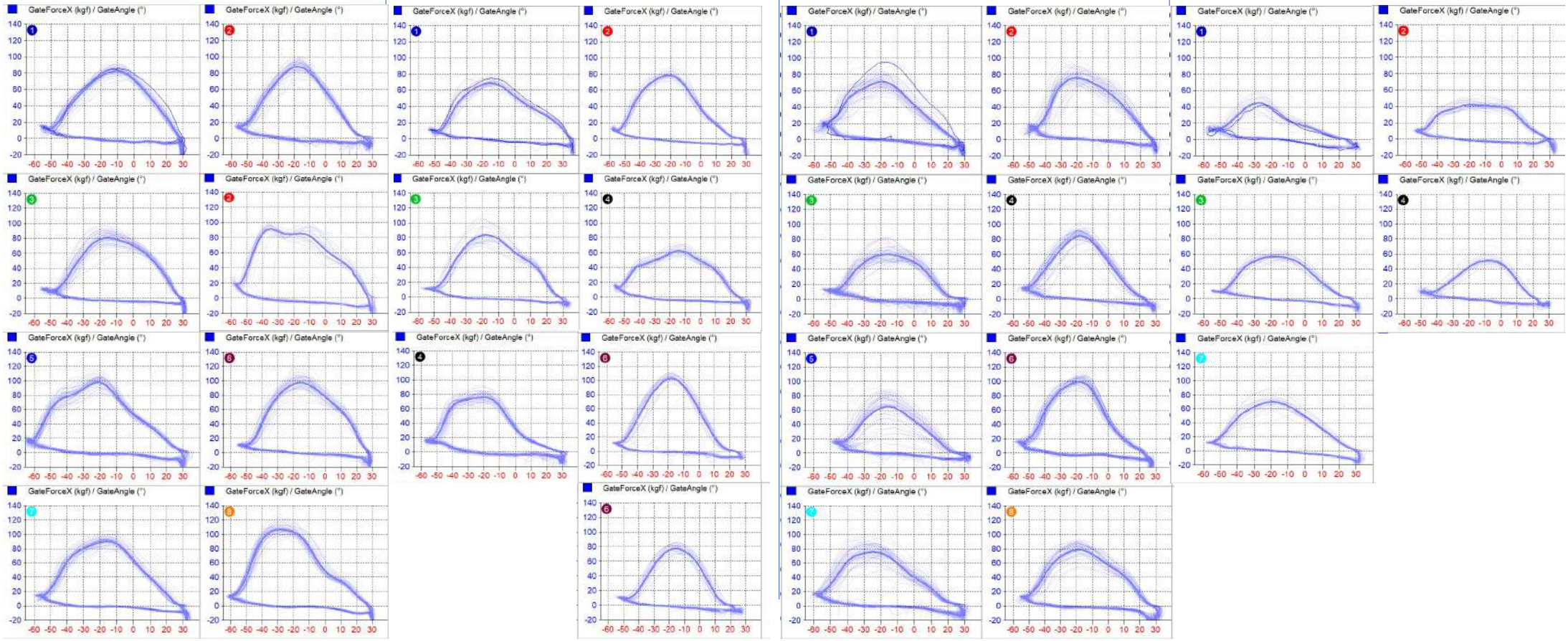
Rating	32.4	spm
AvgBoatSpeed	5.0	m/s
Average Power	240	W
Rower Swivel Power		
1	216	W
2	212	W
3	272	W
4	259	W
5	252	W
6	235	W
7	235	W
8	242	W

Average

	Drive Time		Recovery Time	
1	0.82	s	1.05	s
2	0.79	s	0.99	s
3	0.74	s	1.03	s
4	0.87	s	0.97	s
5	0.86	s	1.03	s
6	0.88	s	0.98	s
7	0.82	s	1.10	s
8	0.90	s	0.99	s

Average		min/ max	length	effect	catch/ finish
1	P	-45.3/ +32.3	+77.5	+54.6	+10.5/ +12.4
2	S	-45.5/ +29.2	+74.7	+55.2	+7.3/ +12.2
3	P	-43.0/ +35.3	+78.2	+60.7	+9.5/ +8.0
4	S	-49.6/ +23.6	+73.2	+53.1	+11.4/ +8.8
5	P	-53.0/ +28.2	+81.2	+64.0	+8.7/ +8.6
6	S	-50.2/ +31.8	+82.0	+58.8	+11.5/ +11.7
7	P	-47.3/ +33.9	+81.2	+59.2	+9.0/ +12.9
8	S	-48.7/ +33.2	+81.9	+60.5	+9.2/ +12.3

Sen. JM8+		Sen. JM8+		J16 JM8+		J16 JM8+	
Bow	Stroke	Bow	Stroke	Bow	Stroke	Bow	Stroke



Race pace #: 1km/ 500m/ 250m sessions – 2 squads (Sen/ J16) – 28 athletes

The Target tables (for the Peach System) are based on the Senior/ U23/ U19 WBT.

When working with Schools/ Clubs/ Universities & others, the targets need to be adjusted.

PEACH ON-WATER ROWING SYSTEM: **ESTIMATED CREW POWER & ANGLE RELATED VALUES TO ACHIEVE WBT**

2000m propulsive Handle Power & Gate-Angle Targets for low SR(20) & SRRP (mid-race)

last UPDATE: (Sept 2023)
by Conny Draper, PhD

ROWING MEN	Internat. Level	Power (W)			Length Total (deg)			Length Effective (deg)			Catch Angle (Min) (deg)			Finish Angle (Max) (deg)			Catch Slip (deg)			Finish Slip (deg)			Timing diff. between oars (s)***		
INTENSITY	Boat Category	Seniors	U23	U19	Seniors	U23	U19	Seniors	U23	U19	Seniors	U23	U19	Seniors	U23	U19	Seniors	U23	U19	Seniors	U23	U19	Seniors	U23	U19
		>	>(-30W)	>(-60W)	>	>(-2deg)	>(-4deg)	>	>(-3deg)	>(6deg)	>[-]	>[-1deg]	>[-3deg]		-1deg	-3deg	<	<(+1deg)	<(+3deg)	<	<(+1deg)	<(+3deg)	<	<(+0.01s)	<(+0.02s)
2km (SR20)	LM1x	250	220	190	108	106	104	92	88	82	<-68	<-67	<-65	+42 -45	+41 -45	+40 -45	7	8	10	9	10	12	0.04	0.05	0.06
	LM2x	250	220	190	108	106	104	92	88	82	<-68	<-67	<-65	+42 -45	+41 -45	+40 -45	7	8	10	9	10	12	0.04	0.05	0.06
	LM4x	230	200	170	108	106	104	92	88	82	<-68	<-67	<-65	+42 -45	+41 -45	+40 -45	7	8	10	9	10	12	0.04	0.05	0.06
	M1x	300	270	240	110	108	106	96	92	86	<-70	<-69	<-67	+42 -45	+41 -45	+40 -45	6	7	9	8	9	11	0.04	0.05	0.06
	M2x	290	260	230	110	108	106	96	92	86	<-70	<-69	<-67	+42 -45	+41 -45	+40 -45	6	7	9	8	9	11	0.04	0.05	0.06
	M4x	290	260	230	110	108	106	96	92	86	<-70	<-69	<-67	+42 -45	+41 -45	+40 -45	6	7	9	8	9	11	0.04	0.05	0.06
	M2-	290	260	230	90	88	86	78	74	68	<-60	<-59	<-57	+31 -33	+30 -33	+30 -34	5	6	8	7	8	10	0.04	0.05	0.06
	M4-	290	260	230	90	88	86	78	74	68	<-60	<-59	<-57	+31 -33	+30 -33	+30 -34	5	6	8	7	8	10	0.04	0.05	0.06
	M8+	290	260	230	90	88	86	78	74	68	<-60	<-59	<-57	+31 -33	+30 -33	+30 -34	5	6	8	7	8	10	0.04	0.05	0.06
2km race/ Mid-race SR*/**	LM1x	380	350	320	106	104	102	92	88	82	-66	-65	-63	+42 -45	+41 -45	+40 -45	6	7	9	8	9	11	0.04	0.05	0.06
	LM2x	380	350	320	105	103	101	91	87	81	-65	-64	-62	+42 -45	+41 -45	+40 -45	6	7	9	8	9	11	0.04	0.05	0.06
	LM4x	360	330	300	106	104	102	92	88	82	-66	-65	-63	+42 -45	+41 -45	+40 -45	6	7	9	8	9	11	0.04	0.05	0.06
	M1x	470	440	410	108	106	104	96	92	86	-68	-67	-65	+42 -45	+41 -45	+40 -45	5	6	8	7	8	10	0.04	0.05	0.06
	M2x	450	420	390	107	105	103	95	91	85	-67	-66	-64	+42 -45	+41 -45	+40 -45	5	6	8	7	8	10	0.04	0.05	0.06
	M4x	450	420	390	108	106	104	96	92	86	-68	-67	-65	+42 -45	+41 -45	+40 -45	5	6	8	7	8	10	0.04	0.05	0.06
	M2-	450	420	390	88	86	84	80	76	70	-58	-57	-55	+32 -34	+31 -34	+30 -34	3	4	6	5	6	8	0.04	0.05	0.06
	M4-	450	420	390	88	86	84	80	76	70	-58	-57	-55	+32 -34	+31 -34	+30 -34	3	4	6	5	6	8	0.04	0.05	0.06
	M8+	450	420	390	88	86	84	80	76	70	-58	-57	-55	+31 -33	+30 -33	+30 -33	3	4	6	5	6	8	0.04	0.05	0.06

* Rowing Race Pace (based on mid-race SR)

** estimated required Target Power values over a 2000m race distance to reach prog. Boat speed (WBT)

*** Timing difference betw. oars (s): rel. timing diffence betw. rowers/ oars throughout drive time/ recovery time

ROWING WOMEN	Internat. Level	Power (W)			Length Total (deg)			Length Effective (deg)			Catch Angle (Min) (deg)			Finish Angle (Max) (deg)			Catch Slip (deg)			Finish Slip (deg)			Timing diff. between oars (s)***		
INTENSITY	Boat Category	Seniors	U23	U19	Seniors	U23	U19	Seniors	U23	U19	Seniors	U23	U19	Seniors	U23	U19	Seniors	U23	U19	Seniors	U23	U19	Seniors	U23	U19
		>	>(-30W)	>(-60W)	>	>(-2deg)	>(-4deg)	>	>(-3deg)	>(6deg)	>[-]	>[-1deg]	>[-3deg]		-1deg	-3deg	<	<(+1deg)	<(+3deg)	<	<(+1deg)	<(+3deg)	<	<(+0.01s)	<(+0.02s)
2km (SR20)	LW1x	150	120	90	106	104	102	86	82	76	-66	-64	-62	+42 -45	+41 -45	+40 -45	9	10	12	11	12	14	0.04	0.05	0.06
	LW2x	150	120	90	106	104	102	86	82	76	-66	-64	-62	+42 -45	+41 -45	+40 -45	9	10	12	11	12	14	0.04	0.05	0.06
	LW4x	140	110	80	106	104	102	86	82	76	-66	-64	-62	+42 -45	+41 -45	+40 -45	9	10	12	11	12	14	0.04	0.05	0.06
	W1x	210	180	150	108	106	104	90	86	80	-68	-66	-64	+42 -45	+41 -45	+40 -45	8	9	11	10	11	13	0.04	0.05	0.06
	W2x	190	160	130	108	106	104	90	86	80	-68	-66	-64	+42 -45	+41 -45	+40 -45	8	9	11	10	11	13	0.04	0.05	0.06
	W4x	190	160	130	108	106	104	90	86	80	-68	-66	-64	+42 -45	+41 -45	+40 -45	8	9	11	10	11	13	0.04	0.05	0.06
	W2-	200	170	140	88	86	84	72	68	62	-58	-56	-54	+32 -34	+31 -34	+30 -34	7	8	10	9	10	12	0.04	0.05	0.06
	W4-	200	170	140	88	86	84	72	68	62	-58	-56	-54	+32 -34	+31 -34	+30 -34	7	8	10	9	10	12	0.04	0.05	0.06
	W8+	210	180	150	88	86	84	72	68	62	-58	-56	-54	+31 -33	+30 -33	+30 -33	7	8	10	9	10	12	0.04	0.05	0.06
2km race/ Mid-race SR*/**	LW1x	250	220	190	104	102	100	86	82	76	-63	-61	-59	+42 -45	+41 -45	+40 -45	8	9	11	10	11	13	0.04	0.05	0.05
	LW2x	250	220	190	103	101	99	85	81	75	-63	-61	-59	+42 -45	+41 -45	+40 -45	8	9	11	10	11	13	0.04	0.05	0.05
	LW4x	240	210	180	104	102	100	86	82	76	-63	-61	-59	+42 -45	+41 -45	+40 -45	8	9	11	10	11	13	0.04	0.05	0.05
	W1x	320	290	260	106	104	102	90	86	80	-66	-64	-62	+42 -45	+41 -45	+40 -45	7	8	10	9	10	12	0.04	0.05	0.05
	W2x	300	270	240	105	103	101	89	85	79	-66	-64	-62	+42 -45	+41 -45	+40 -45	7	8	10	9	10	12	0.04	0.05	0.05
	W4x	300	270	240	106	104	102	90	86	80	-66	-64	-62	+42 -45	+41 -45	+40 -45	7	8	10	9	10	12	0.04	0.05	0.05
	W2-	300	270	240	86	84	82	72	68	62	-56	-54	-52	+32 -34	+31 -34	+30 -34	6	7	9	8	9	11	0.04	0.05	0.05
	W4-	300	270	240	86	84	82	72	68	62	-56	-54	-52	+32 -34	+31 -34	+30 -34	6	7	9	8	9	11	0.04	0.05	0.05
	W8+	300	270	240	86	84	82	72	68	62	-56	-54	-52	+31 -33	+30 -33	+30 -33	6	7	9	8	9	11	0.04	0.05	0.05

* Rowing Race Pace (based on mid-race SR)

** estimated required Target Power values over a 2000m race distance to reach prog. Boat speed

*** Timing difference betw. oars (s): rel. timing diffence betw. rowers/ oars throughout drive time/ recovery time

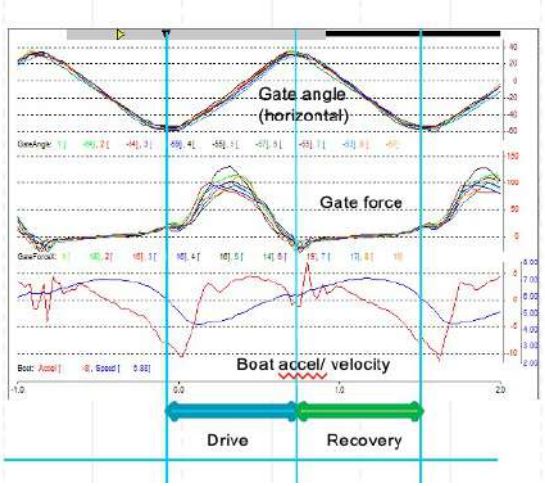
The following estimations & predictions have been generated using data collected from training assessment & racing (since 2011).
The predicted power and angle related values/ SR can be used as benchmarks for the various boat categories.
The benchmarks will be re-assessed and updated regularly.

Data collected and updated:
Conny Draper, PhD/ Sports Biomechanist
conny.draper@gmail.com

Summary & Outlook

- Utilising objective assessment tools – great 'Messaging tools':
  between coaches & athletes to evaluate sessions, crews, rower/s, coxswains
- Detailed information enhance knowledge:
  of athletes' & crew progress & quantify our coaching & training response
- When utilising on-water technique & performance feedback tools:
  look for relationships between
  - individual performances vs. crew performances &
  - Athletes' technique/ performance vs. the boat run & speed
- Understand the strength of your crew!
  Where are the areas of opportunity to improve technically?
- To understand progress of your crews/ ind. athletes -compare the same workout

Rudersymposium Hannover
25. Januar 2025



THANKS!

Questions?

You can contact me at

Conny Draper, PhD
conny.draper@gmail.com

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