FITFISH 2016 Swimming Respirometry

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Preparing for the experiments

- Measurement of water velocity in all the section of the swimming tunnel (flowmeter)

  water velocity (cm/s):

33	28	36
39	34	40
45	40	45

- Flow speed calibration

- Calibration of O2 sensors (0% with natrium sulfit and 100% with oxygenated water)

The species we used

Dicentrarchus labrax
(European seabass)

Trachinotus carolinus
(Pompano)

http://www.ag.auburn.edu/fish/mediagallery/files/2013/08/448.jpg

Background respiration

- We measured the O2 consumption with empty tank respirometry to determine the background respiration

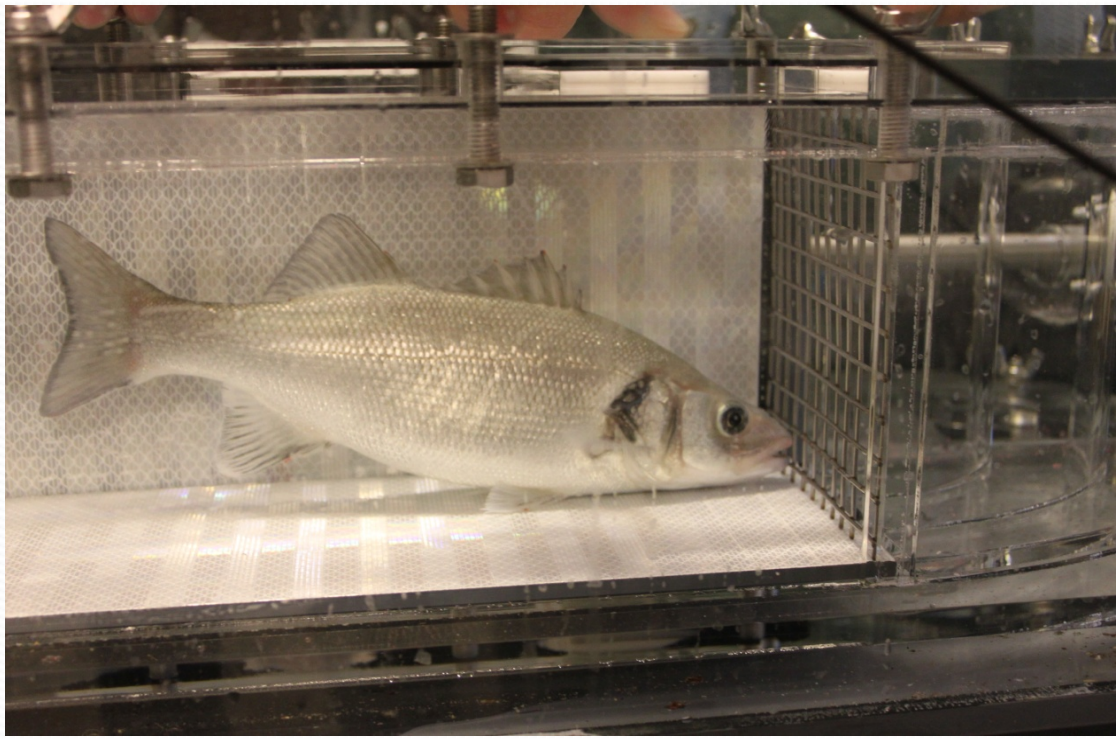
7.7 mgO2/kg/hr
11.8 mgO2/kg/hr
2.2 mgO2/kg/hr

} 7.3 mgO2/kg/hr

This was subtracted from all the measurements

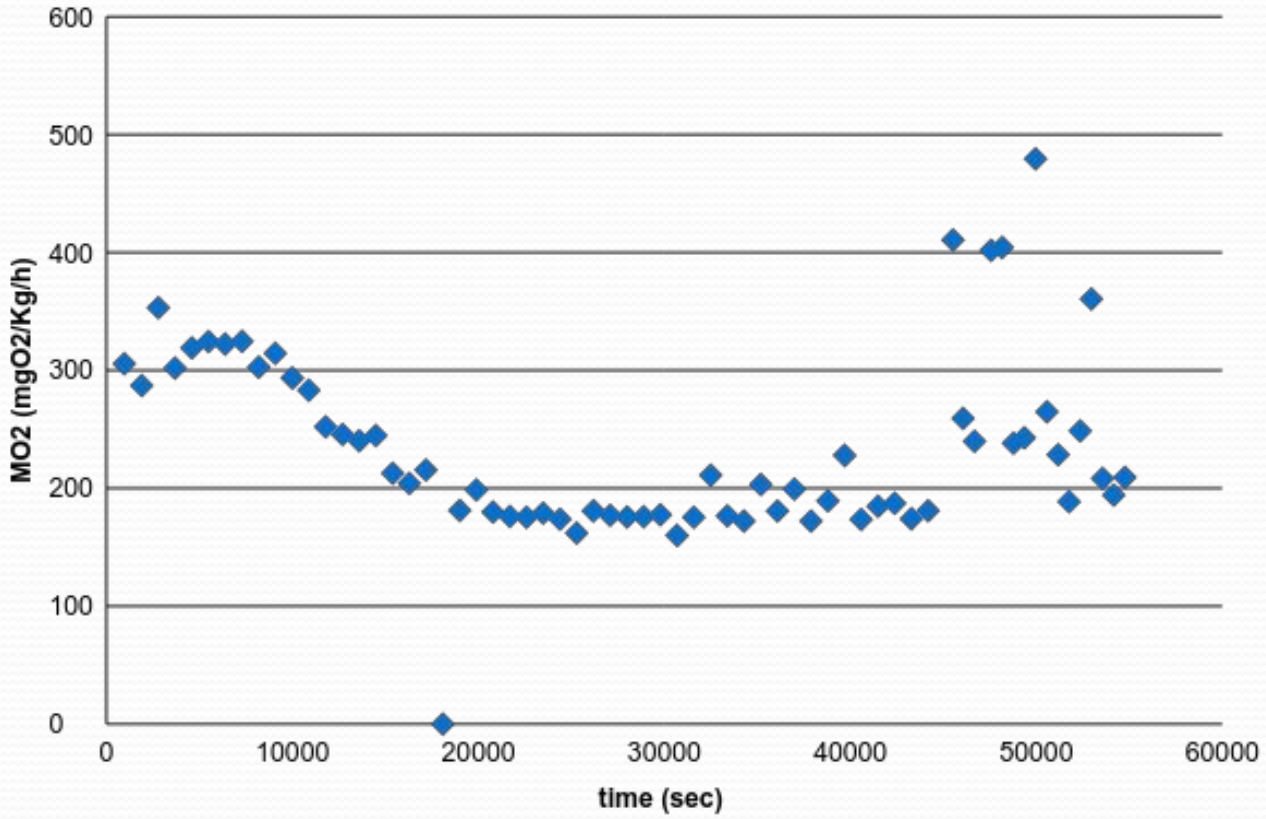
Sea Bass 1

Weight:238,7 g
Length:22,2 cm
High (depth):3,35 cm
Width:5,4 cm

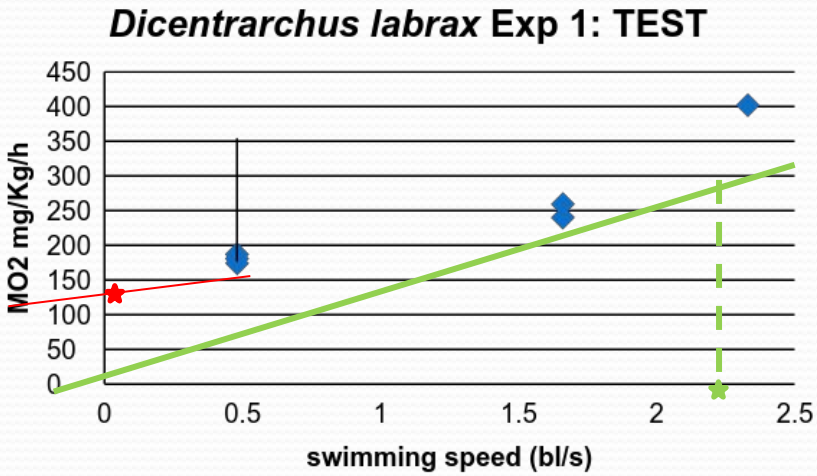


- In the tunnel over night at 0.5 bl/s
- Swam it until Ucrit

Dicentrarchus labrax (Sea Bass) Experiment 1: TEST



Dicentrarchus labrax (Sea Bass) Experiment 1: TEST



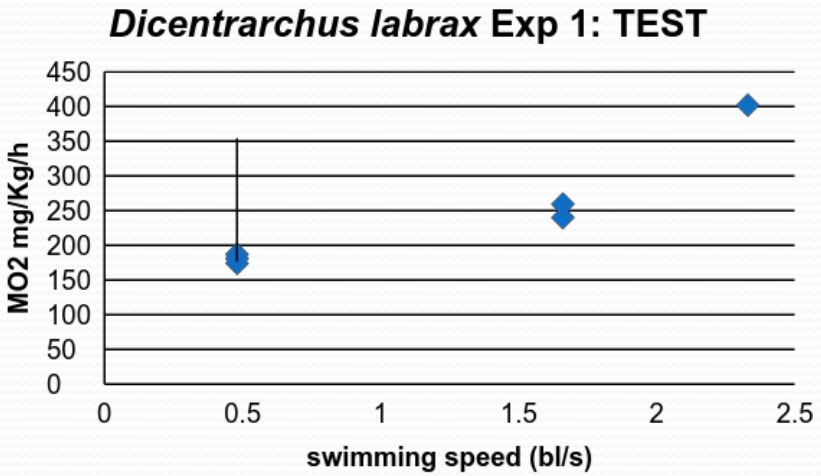
$y = 147.12\ e^{0.3774\,x}$

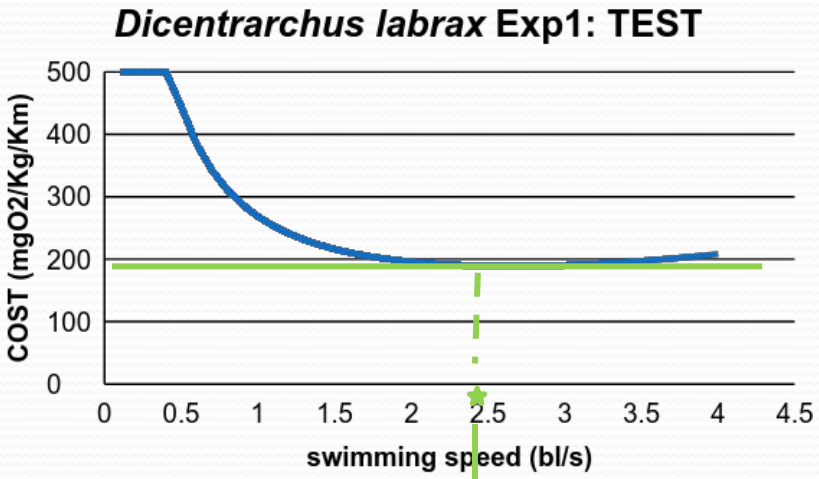
SMR
Standard Metabolic rate

Uopt
Optimal swimming velocity
Uopt=1/0.3774=2.64

SMR	147.12
Uopt	2.64
Ucrit	-

Dicentrarchus labrax (Sea Bass) Experiment 1: TEST

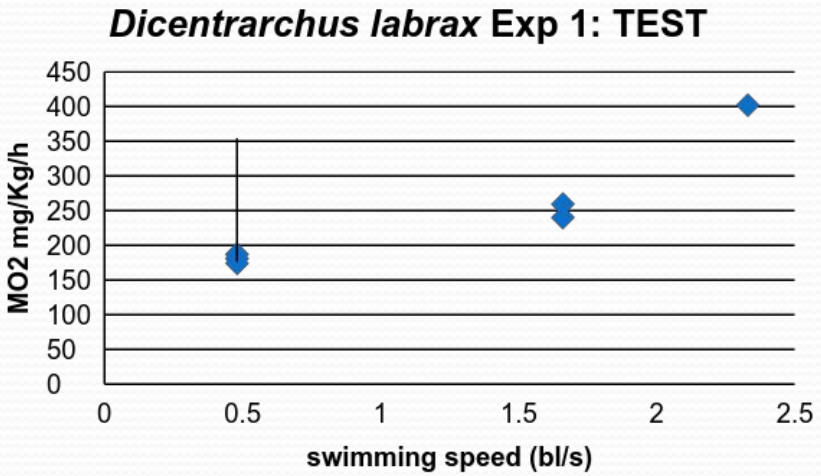


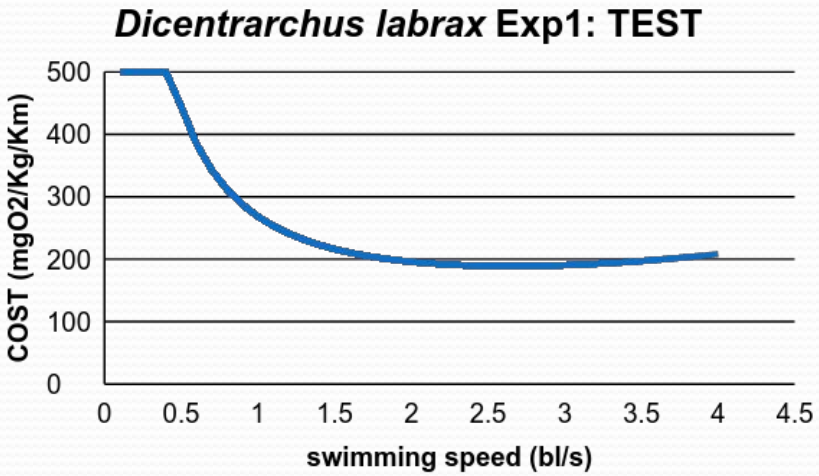


SMR	147.12
Uopt	2.64
Ucrit	-

Uopt
Optimal swimming velocity
Uopt=1/0.3774=2.64

Dicentrarchus labrax (Sea Bass) Experiment 1: TEST





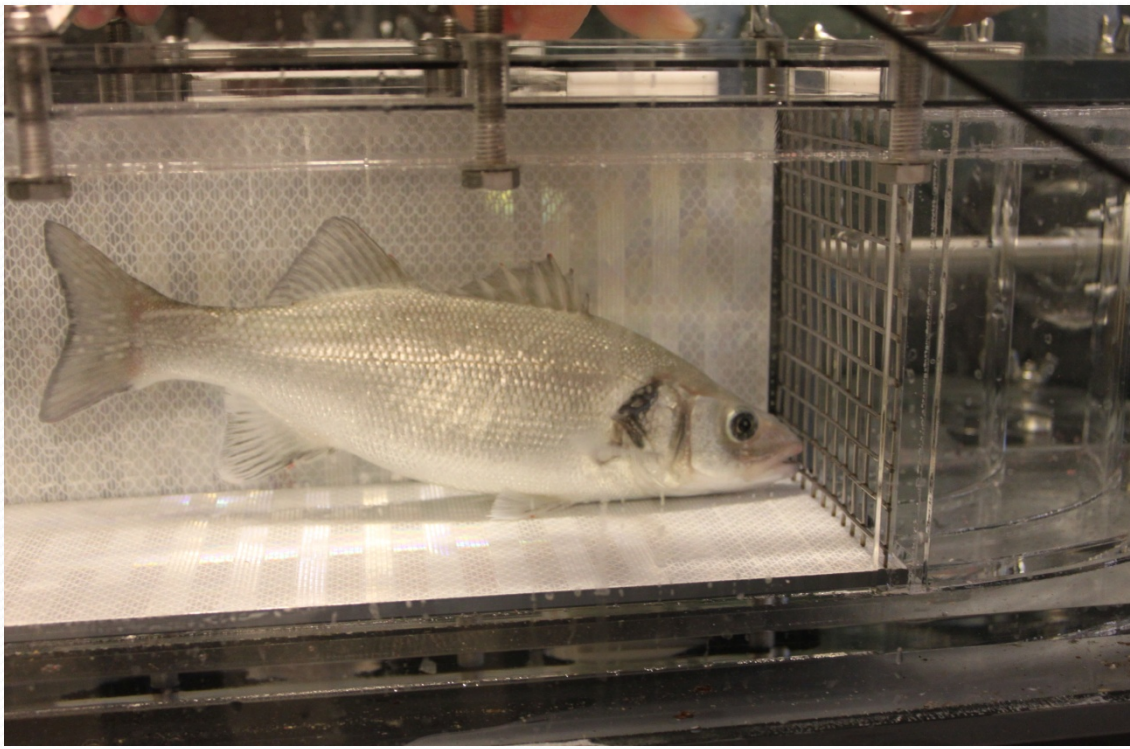
SMR 147.12
Uopt 2.64
Ucrit

$$Ucrit = Last\ ss + \frac{Increment * t\ in\ last\ ss}{total\ t\ in\ each\ ss}$$

We don't calculate Ucrit because the loop repeats were not the apropriate

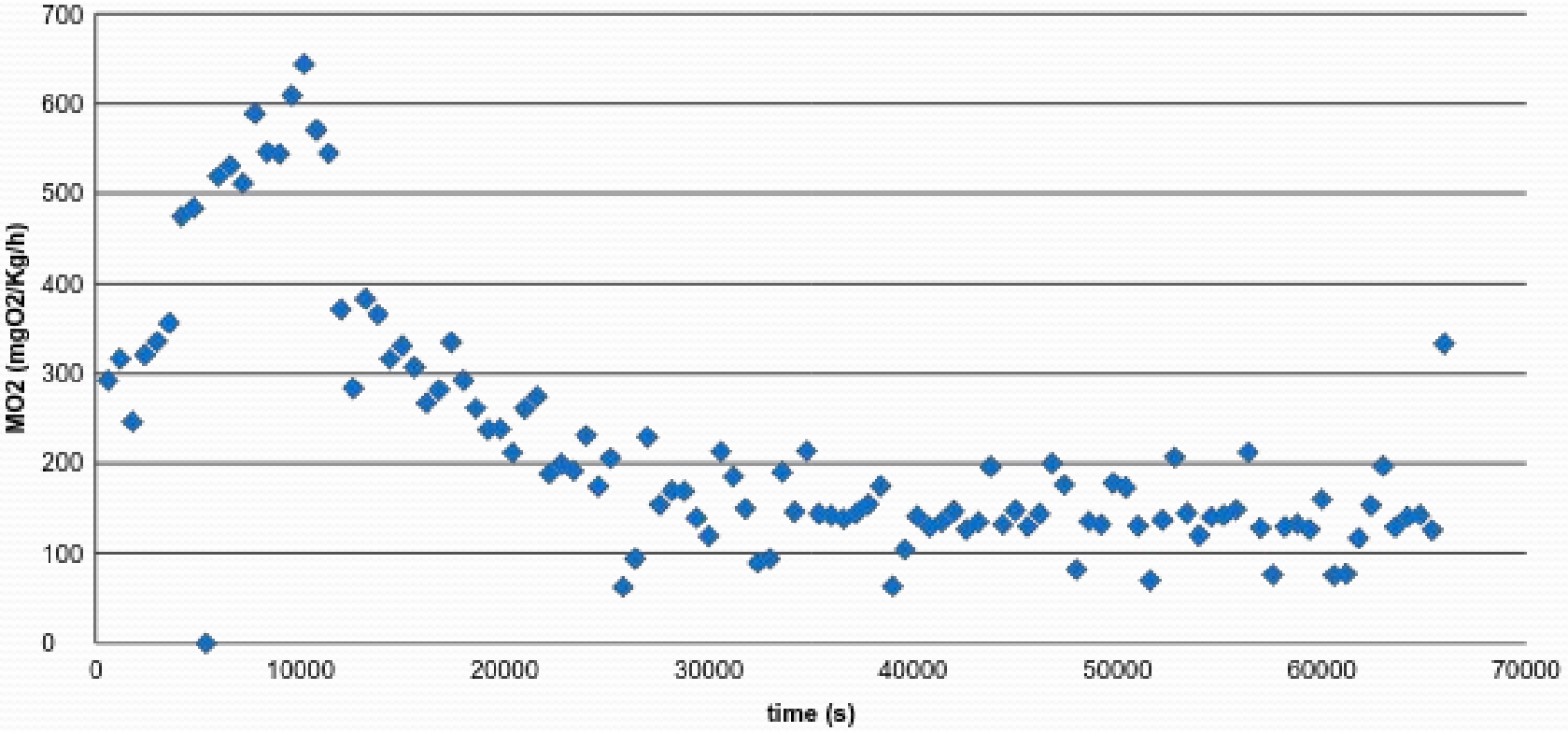
Sea Bass 2

Weight:241 g
Length:26,5 cm
High (depth):5,2 cm
Width:2,7 cm

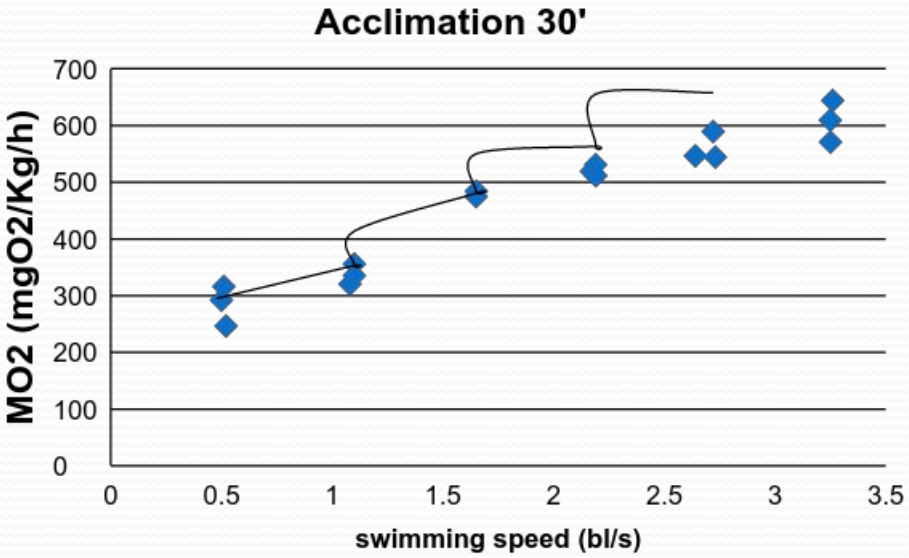


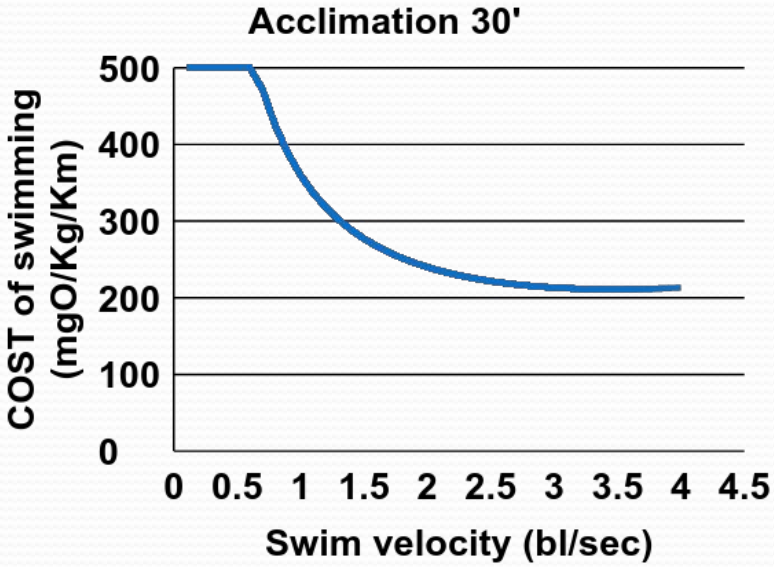
- Acclimate for 30 minutes at 0.5 bl/s.
- Swim it until Ucritical
- Over night at 0.5 bl/s

Dicentrarchus labrax (Sea Bass)
Experiment 2: Acclimation of 30' vs O.N.



Dicentrarchus labrax (Sea Bass) Experiment 2: Acclimation of 30' vs O.N.





SMR = 257.59 mgO2/kg/h
Uopt = 3.48 BL/s
Ucrit = 3.6 BL/s

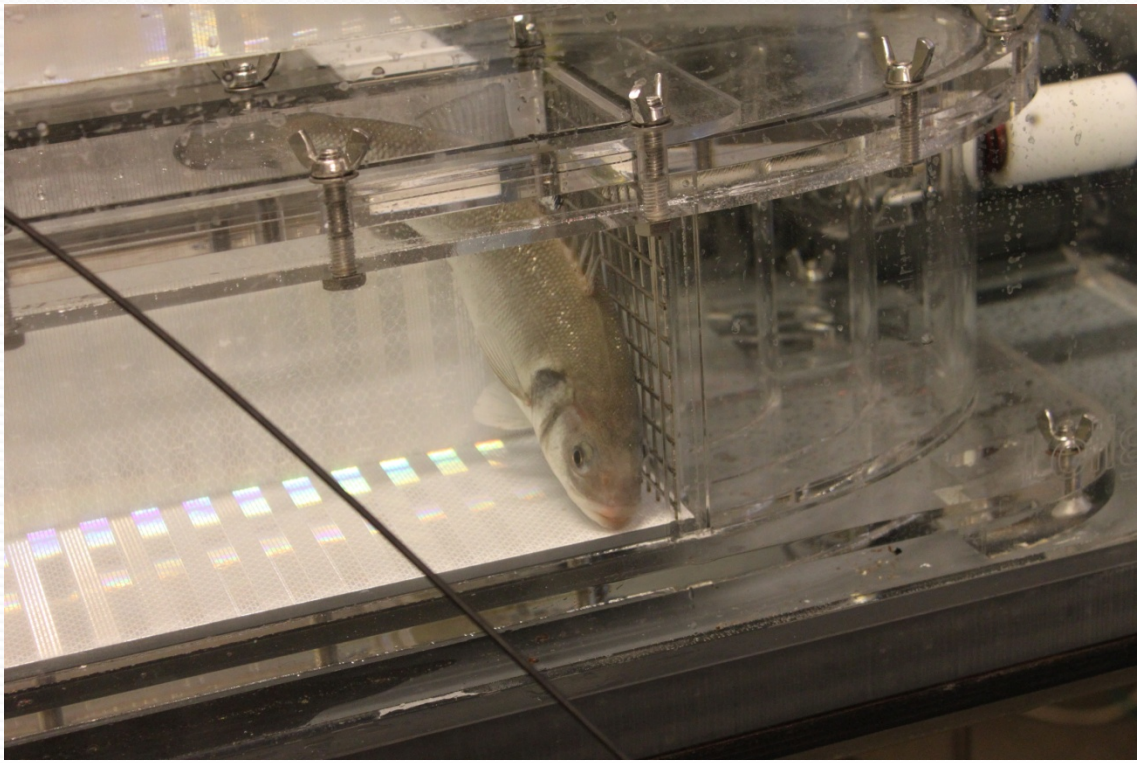
Dicentrarchus labrax (Sea Bass)
Experiment 2: Acclimation of 30' vs O.N.

The second part of the experiment went wrong: the fish started to hit the grid 1 minute after we turned up the velocity to 1 bl/s

We don't have any results ☹

Sea Bass 3

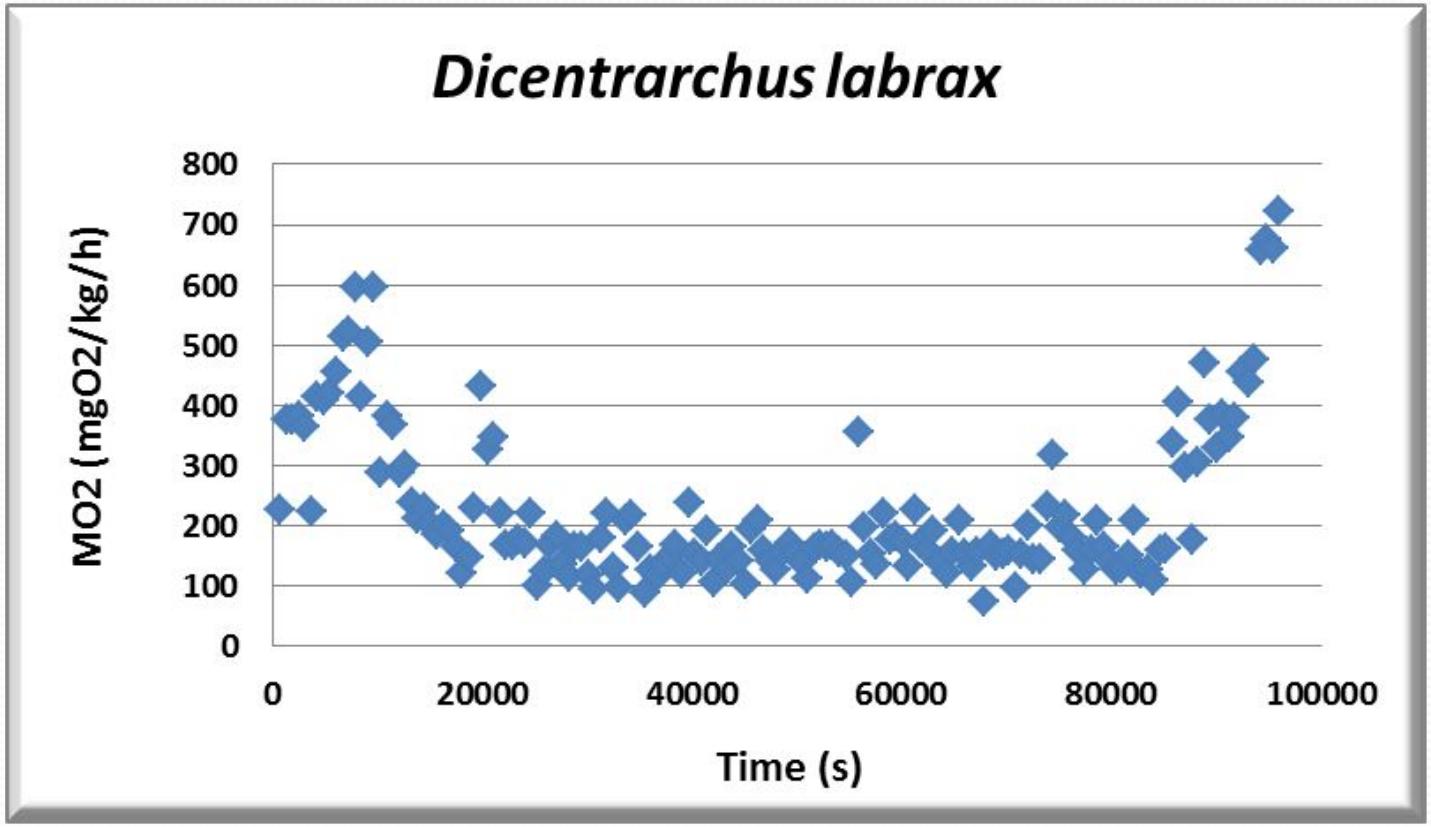
Weight:259,8 g
Length:25,5 cm
High (depth):6,2 cm
Width:2,9 cm



- We chased the fish in the bucket for 2 minutes.
- Acclimated for 30 minutes at 0.5 bl/s.
- Swim it until Ucrit
- Over night at 0.5 bl/s
- Swam it until Ucrit

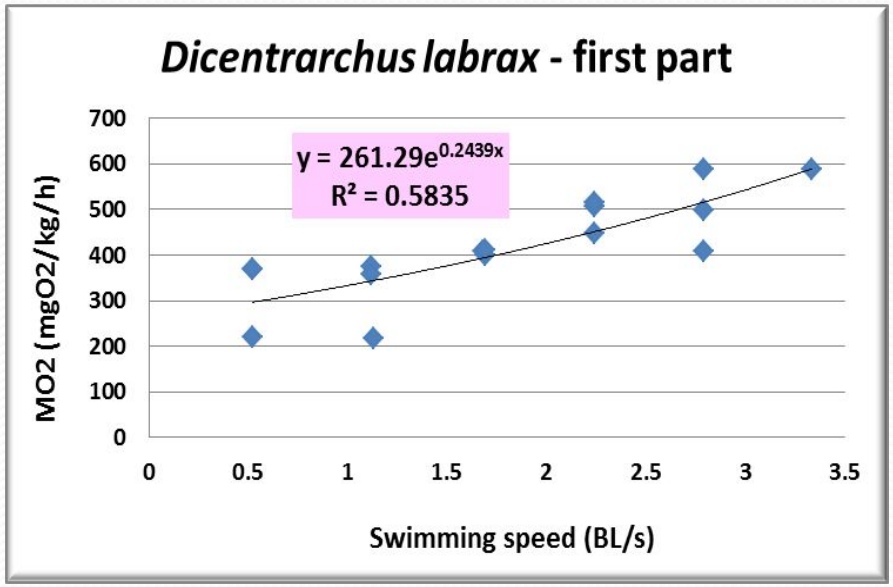
Dicentrarchus labrax (Sea bass)

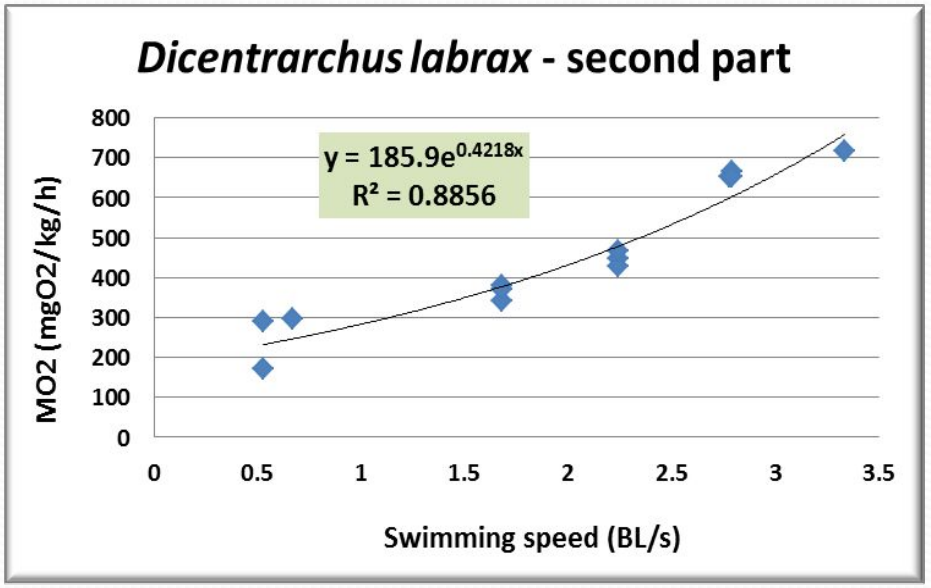
Experiment 3 : Results



Dicentrarchus labrax (Sea bass)

Experiment 3 : Results





First part:

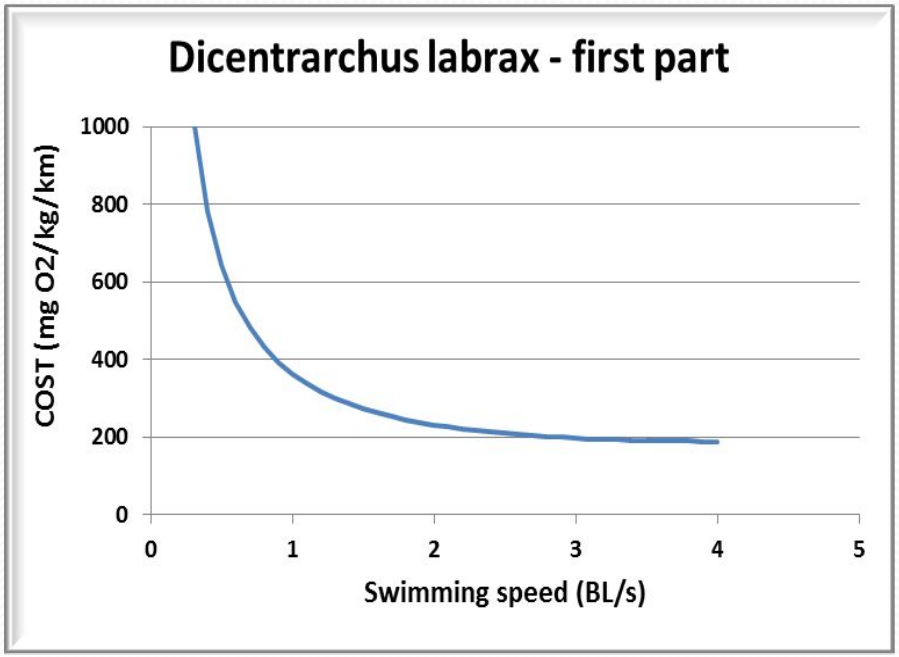
SMR = 261.29 mgO2/kg/h
Uopt = 4.10 BL/s
Ucrit = 3.27 BL/s

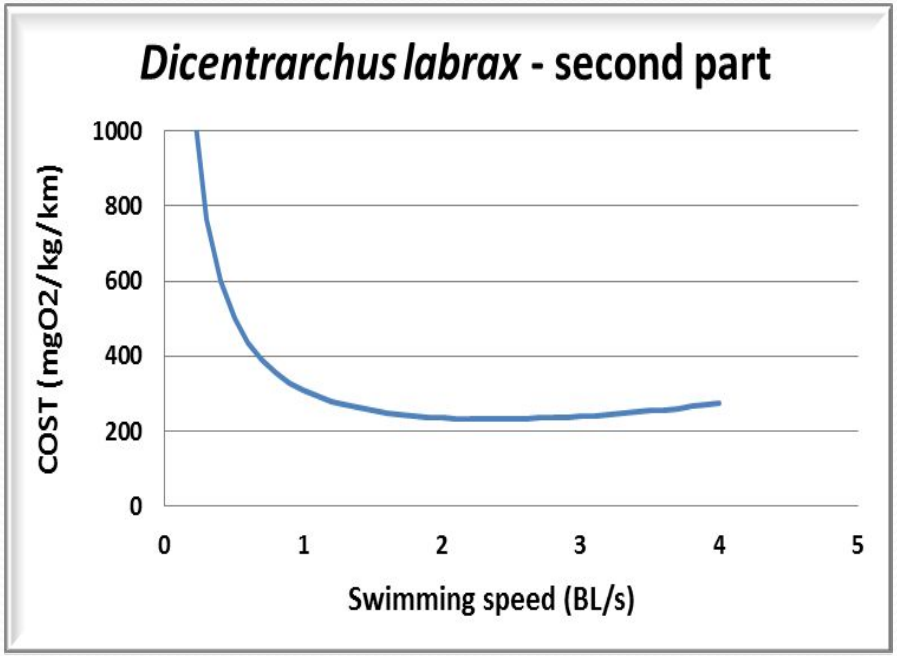
Second part:

SMR = 185.90 mgO2/kg/h
Uopt = 2.37 BL/s
Ucrit = 3.27 BL/s

Dicentrarchus labrax (Sea bass)

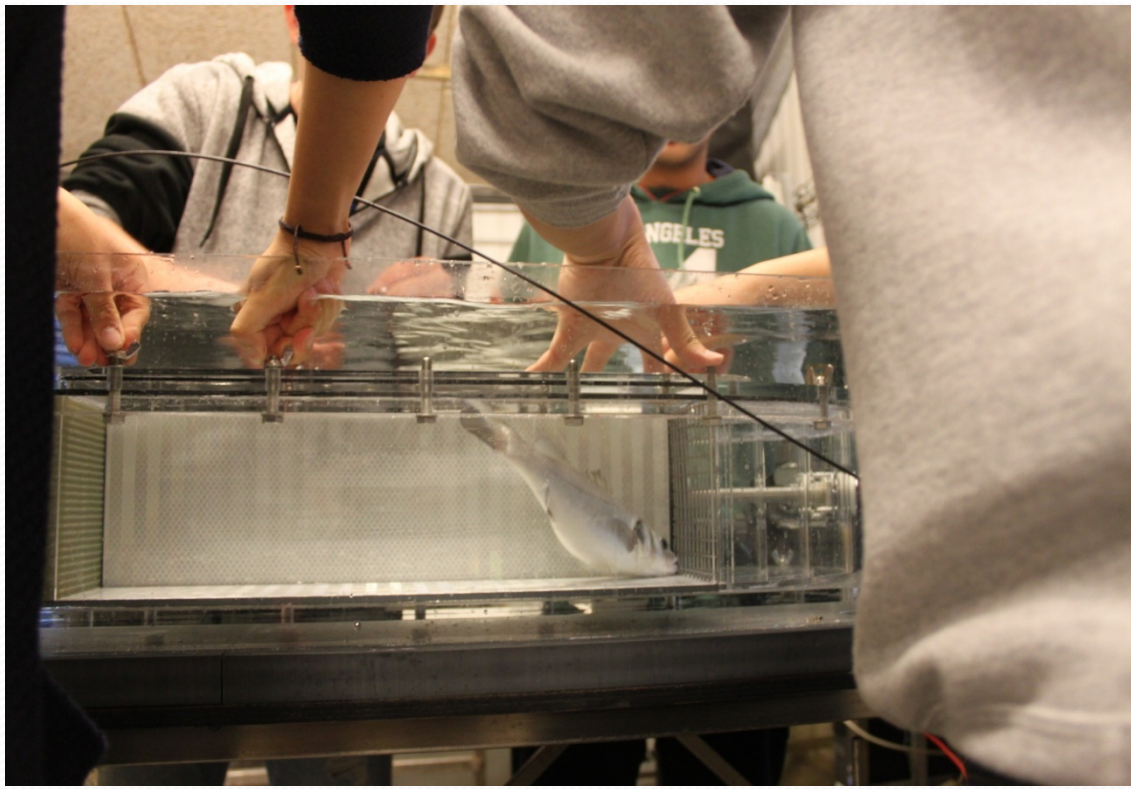
Experiment 3 : Results





Sea Bass 4

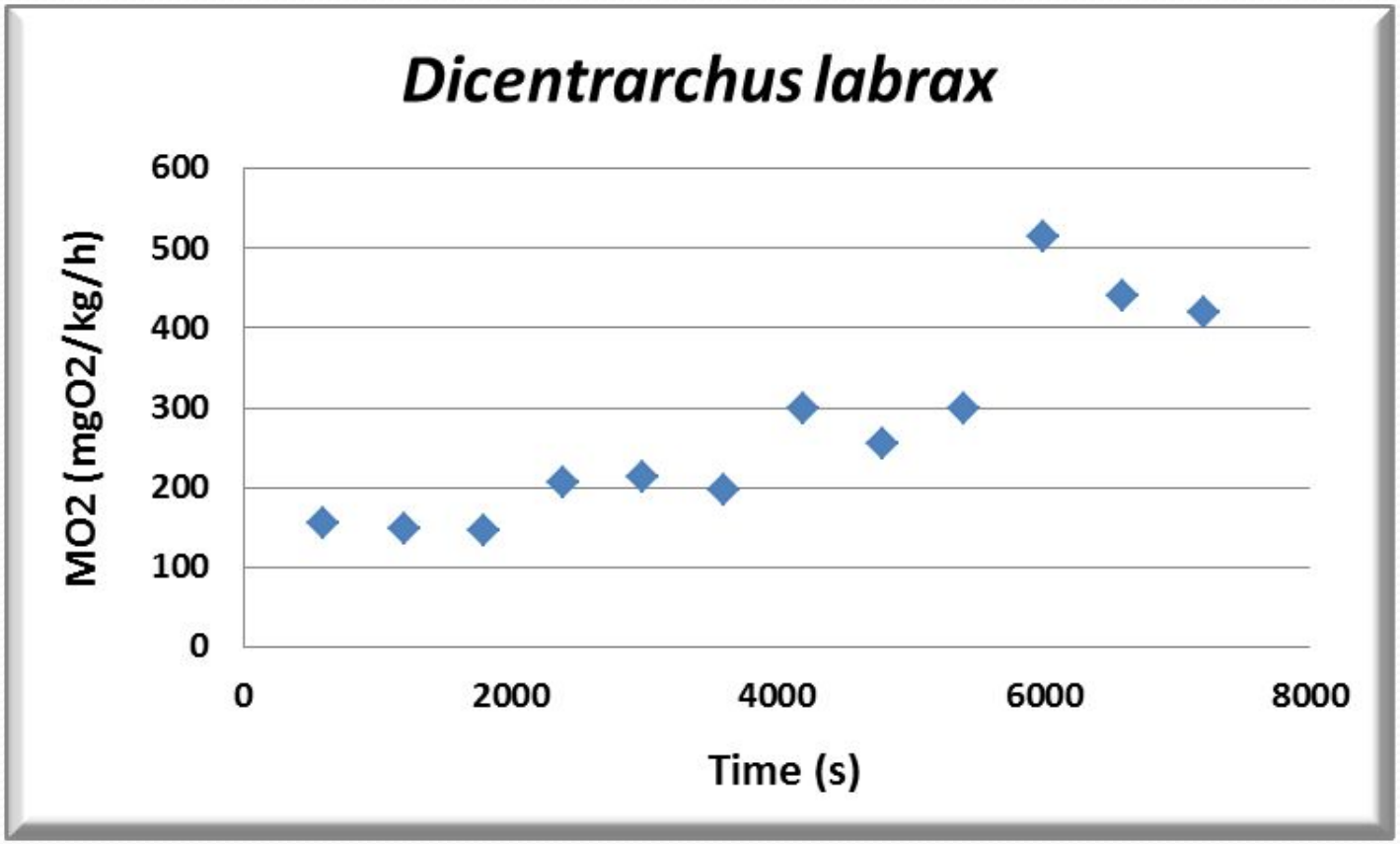
Weight:276,8 g
Length:26 cm
High (depth):5,9 cm
Width:2,9 cm



- In the tunnel over night at 0.5 bl/s.
- Swam it until Ucrit

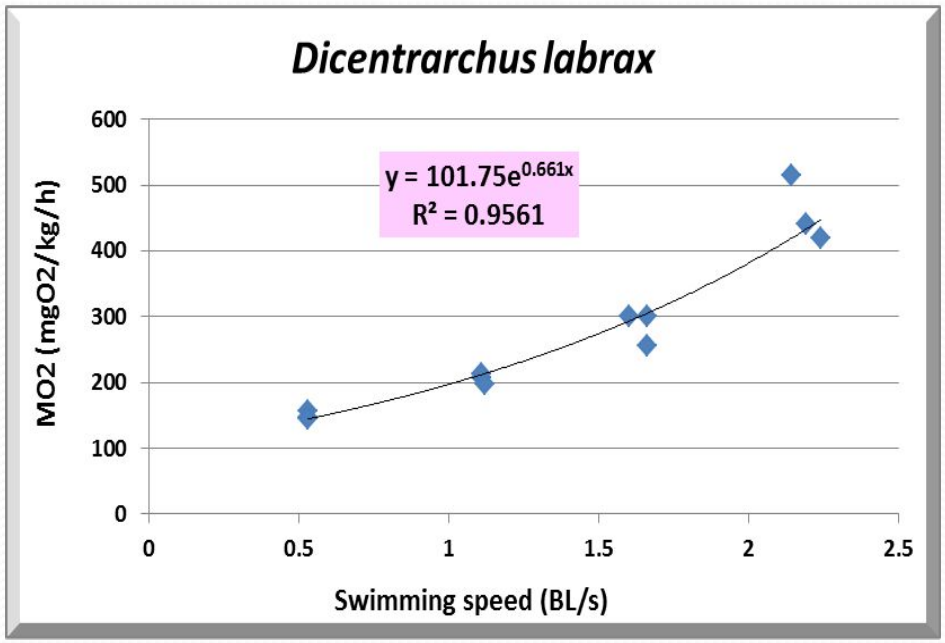
Dicentrarchus labrax (Sea bass)

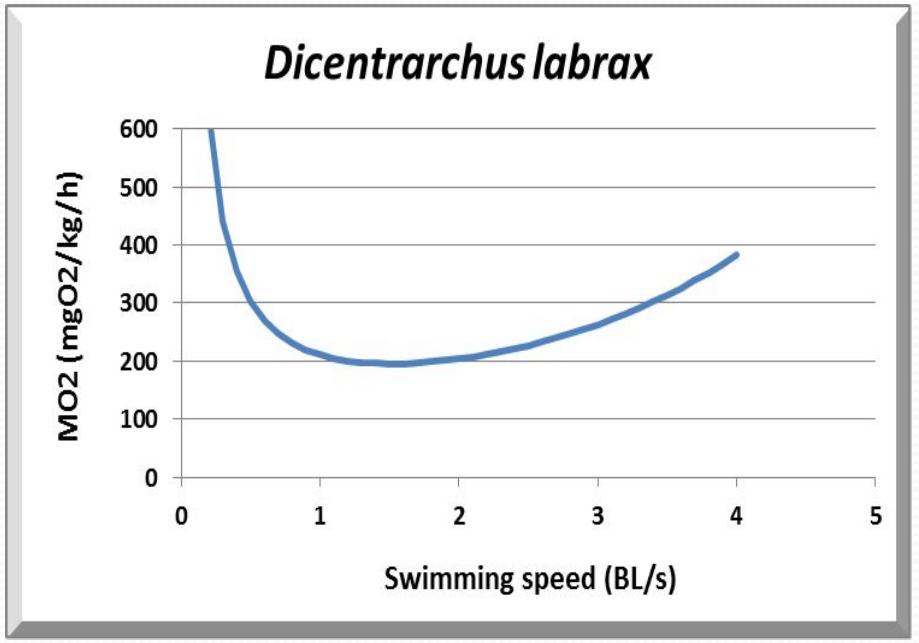
Experiment 4 : Results



Dicentrarchus labrax (Sea bass)

Experiment 4 : Results





SMR = 101.75 mgO2/kg/h
Uopt = 1.51 BL/s
Ucrit = 3.06 BL/s

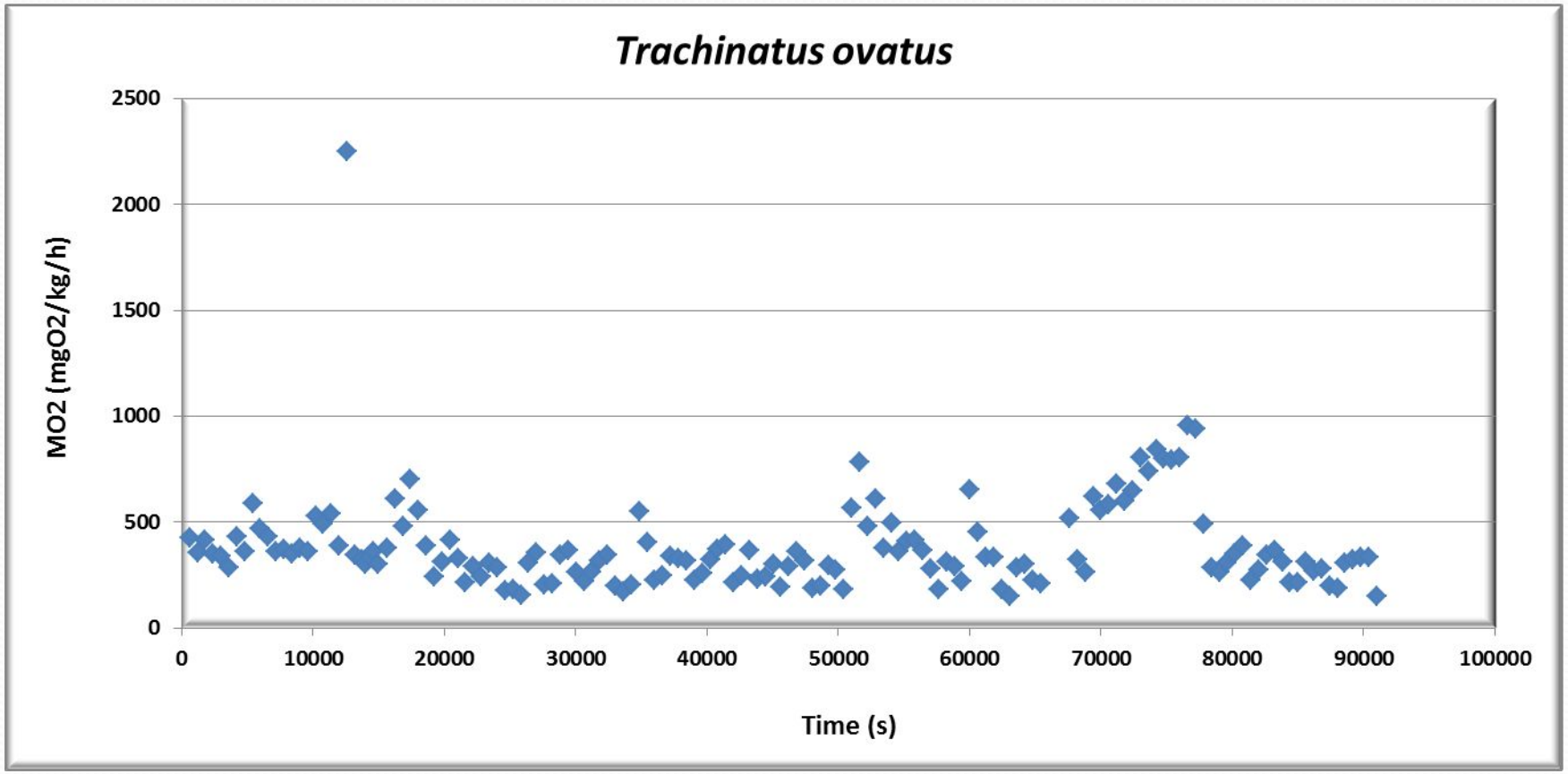
Pompano

Weight:197 g
Length:19 cm
High (depth): 11,7 cm
Width:1,5 cm

- In the tunnel over night at 1 bl/s.
- Swam it until Ucrit.

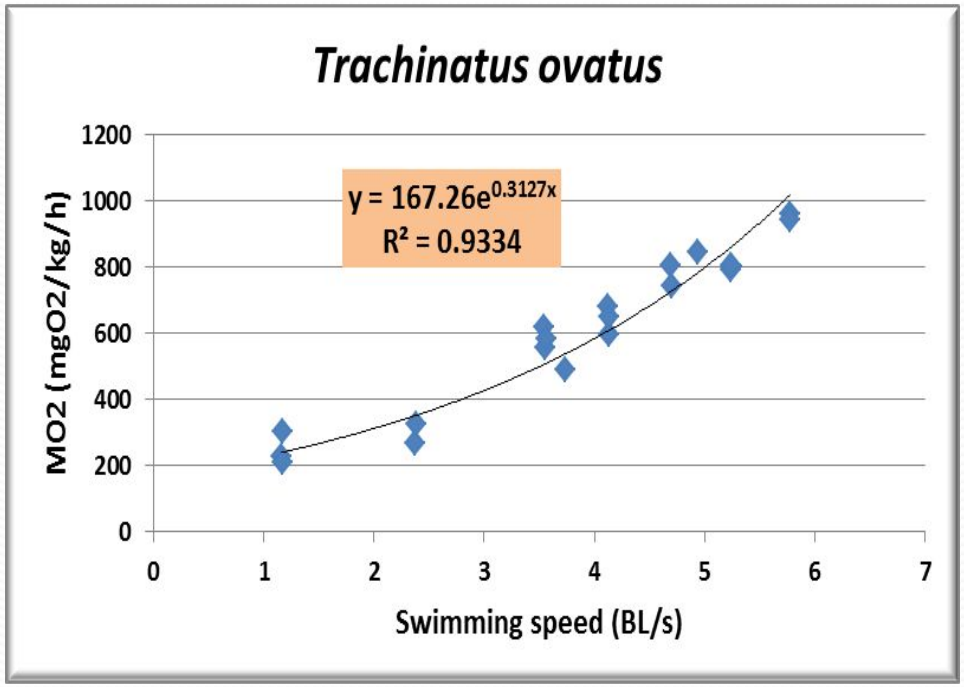
Trachinatus ovatus (Pompano)

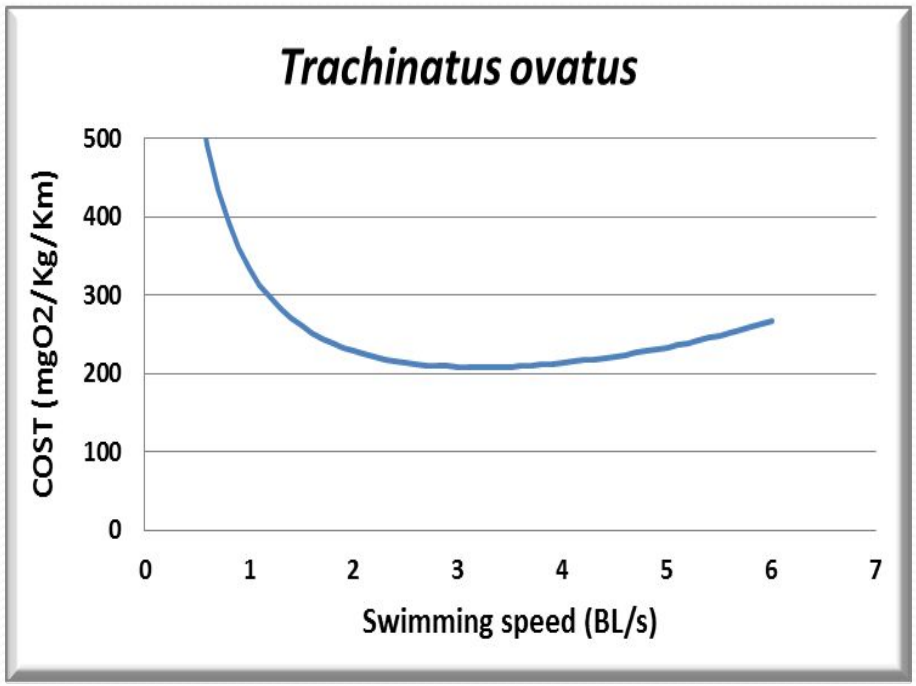
Experiment 5 : Results



Trachinatus ovatus (Pompano)

Experiment 5 : Results



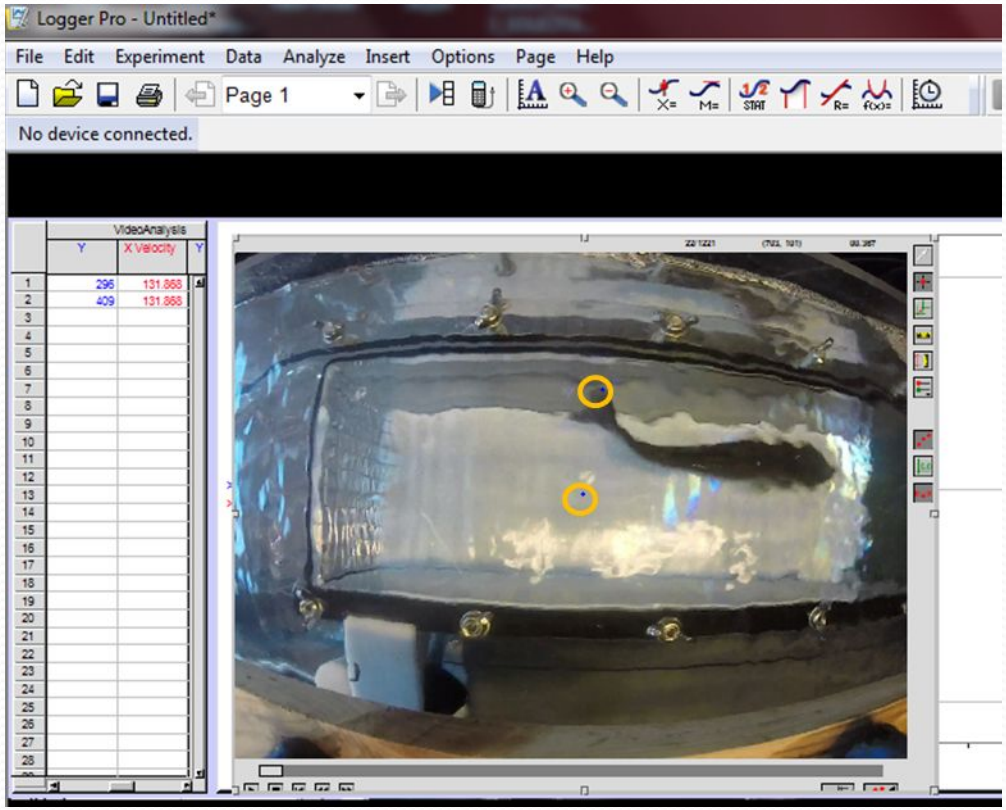


SMR = 167.26 mgO2/kg/h
Uopt = 3.20 BL/s
Ucrit = 5.43BL/s

Tail movement/second

Dicentrarchus labrax vs Trachinatus ovatus

BL/s	Tail movements/second	
	Dicentrarchus labrax	Trachinatus ovatus
0.50	2.34	
1.00	3.55	2.5
1.50	2.98	
2.00	4.84	
2.50	5.22	
3.00		5.66
3.50		6.52
4.00		7.89
4.50		6.82
5.00		6.82



Conclusions

Experiment 1: Seabass (acclimation over night, swam once)
Very much unconclusive, we did just about everything wrong!

Experiment 2: Seabass (acclimation 30 min, swam 2 times)
Unconclusive, we probably let the fish swim with its tail against the grid for too long the first round (ca 45 min).
New protocol: 5 minutes with tail against the grid = stop the experiment

Experiment 3: Seabass (chased in bucket, acclimation 30 min, swam 2 times)
Unconclusive, **Uopt = 4.10 BL/s VS Ucrit = 3.27 BL/s**

Conclusions

Experiment 4: Seabass (acclimation over night, swam once)
Clearly the best way to do it, the results were clear and it had the lowest SMR (**101.75 mgO2/kg/h)** = less stressed

Experiment 5: Pompano (acclimated over night, swam once)
We let it rest for 5 hours on 1 bl/sec after swimming, it was as expected back to resting metabolism by that time. **Ucrit = 5.43BL/s**

Compared to the best Seabass which only had **Ucrit= 3.6 BL/s** it was a very good swimmer!

Tail movement compared:
The Pompano had a higher frequency as expected

Thank you for the attention

Resting Respirometry Group

Jingwei Song
Jeppe Vismann
Miran Babic

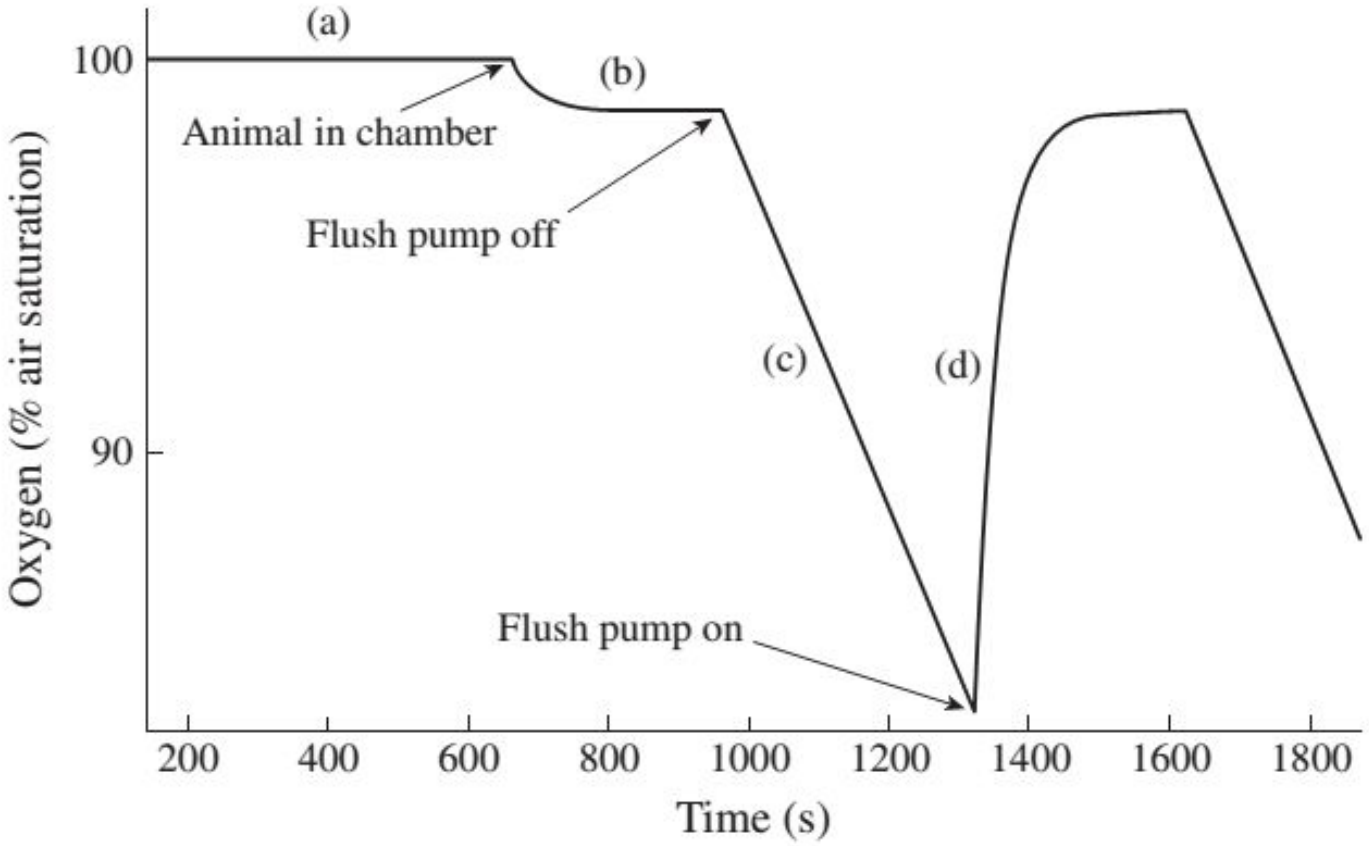
5-19-2016

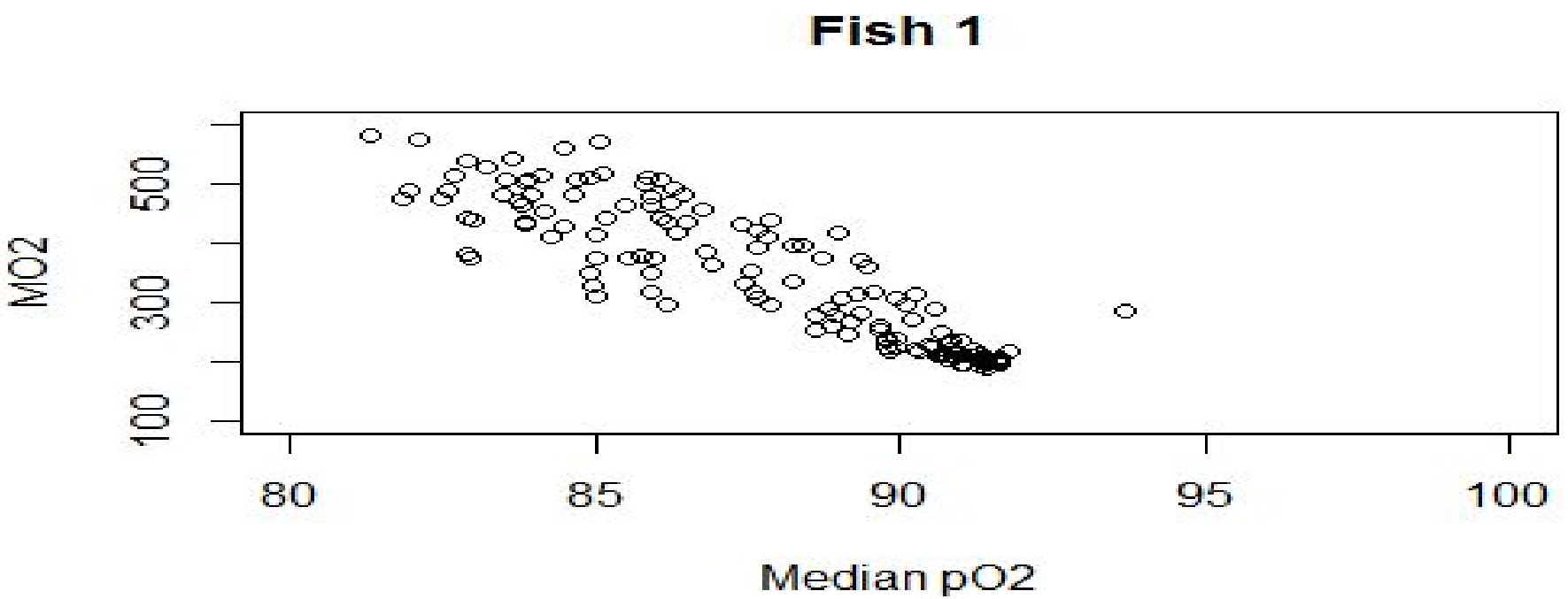
Overview

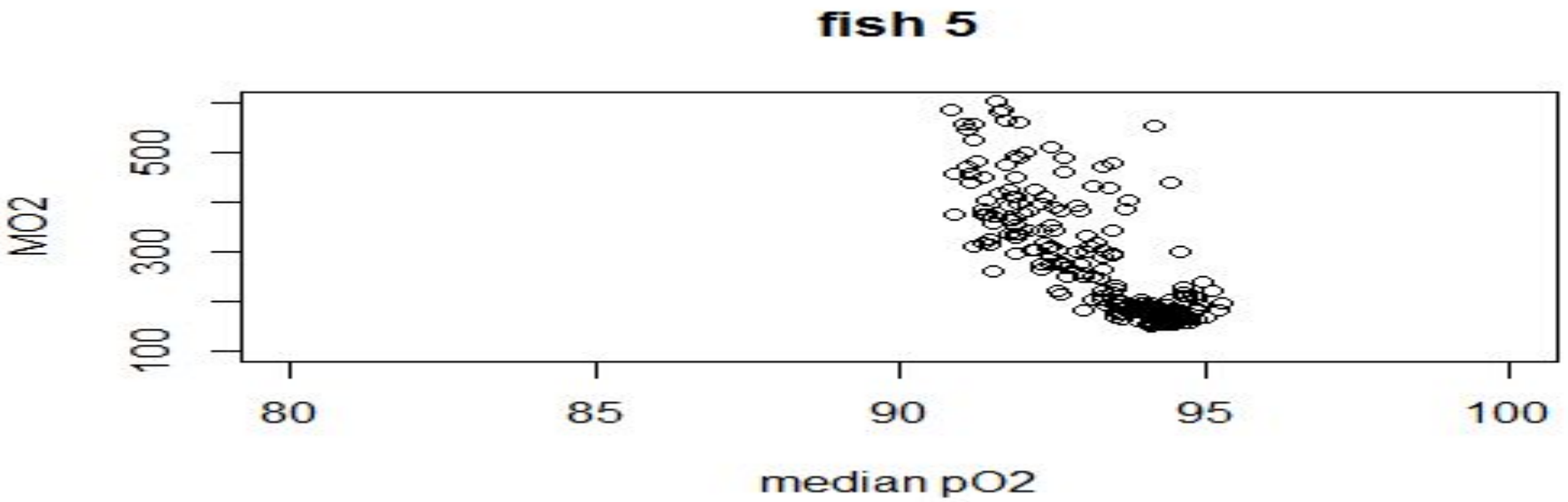
- General respirometry
- Comparing chasing methods
- Sensor positioning
- Comparing hypoxia methods
- Background respiration
- Low temperature

Resting respirometry

$$y = \beta O_2 V_{RE} W_o^{-1} \frac{\delta p O_2}{\delta t}$$



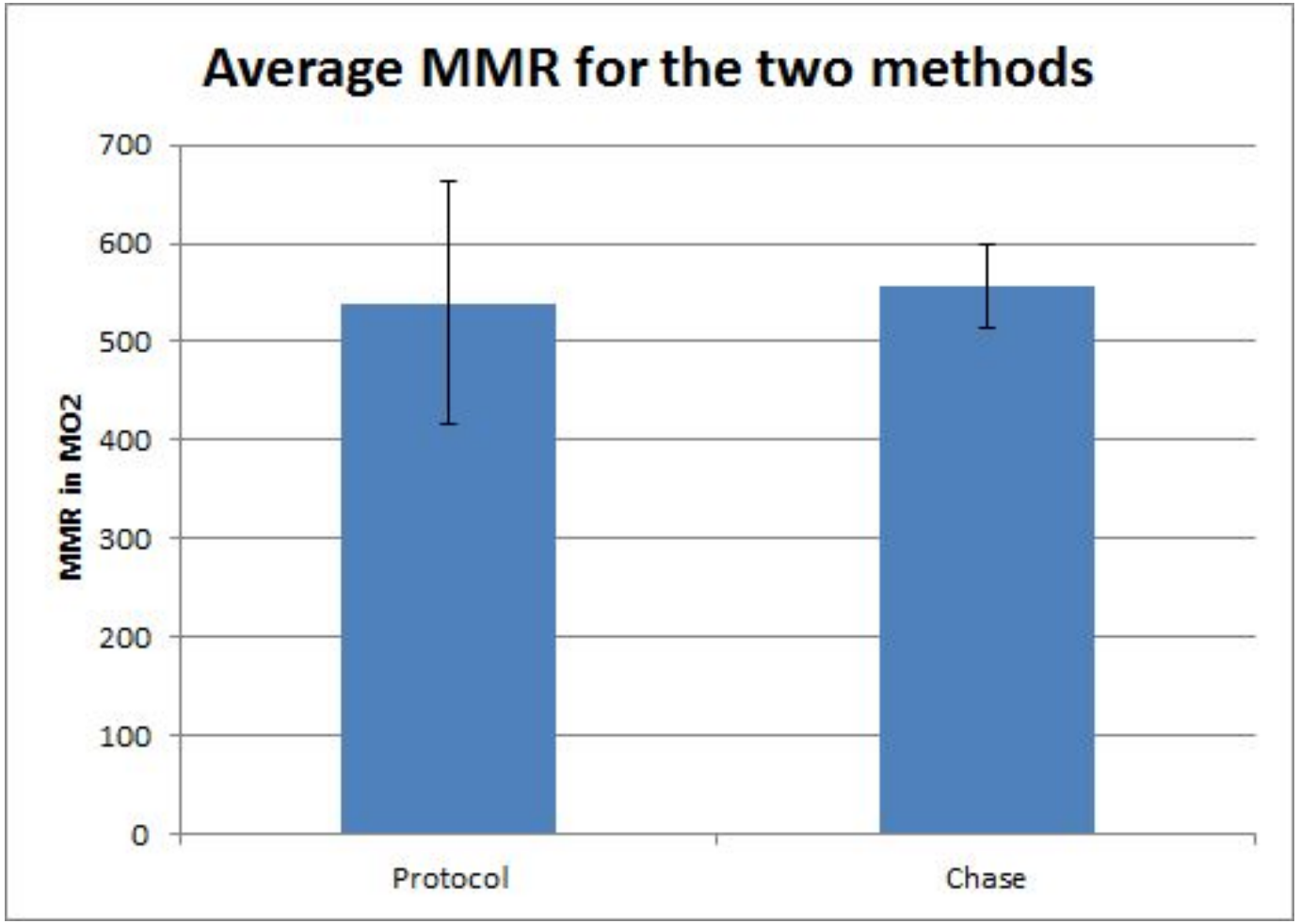

Fish 1
MO2
100
300
500
80
85
90
95
100
Median pO2

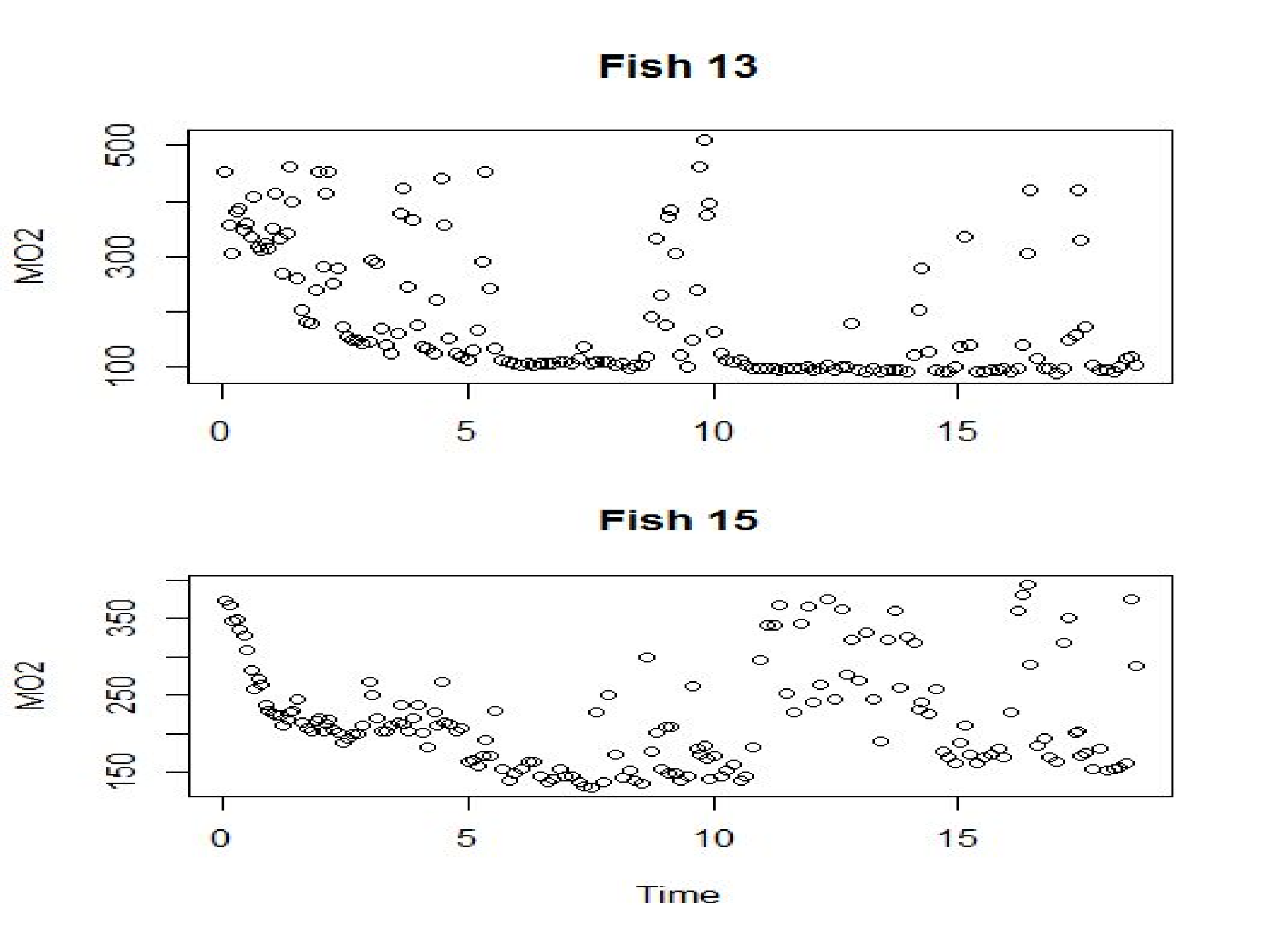

fish 5
MO2
100
300
500
80
85
90
95
100
median pO2

experiment 1: comparing the effect of different chasing methods on SMR and MMR

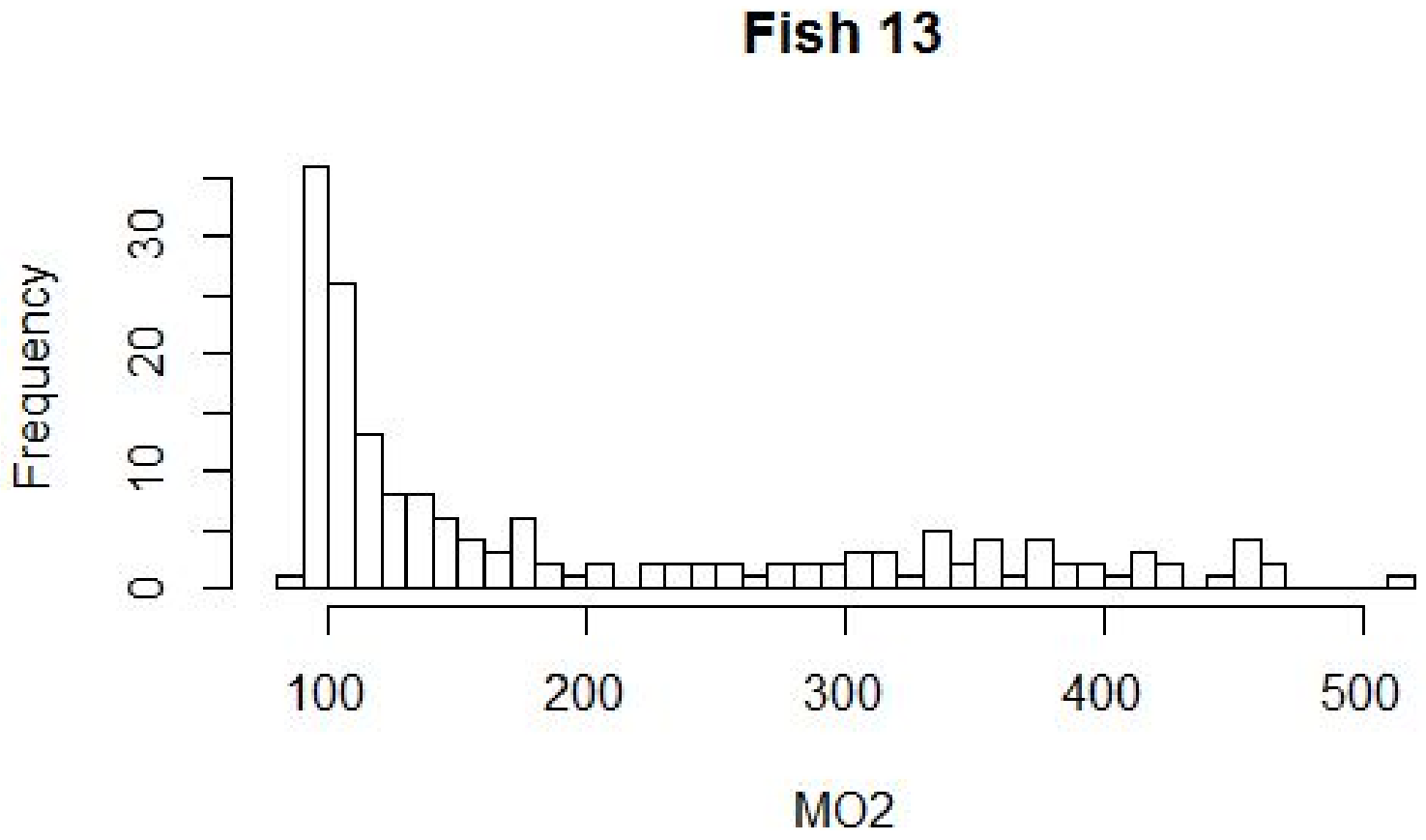
- Protocol
- Chasing
- MMR + SMR

2 methods for MMR



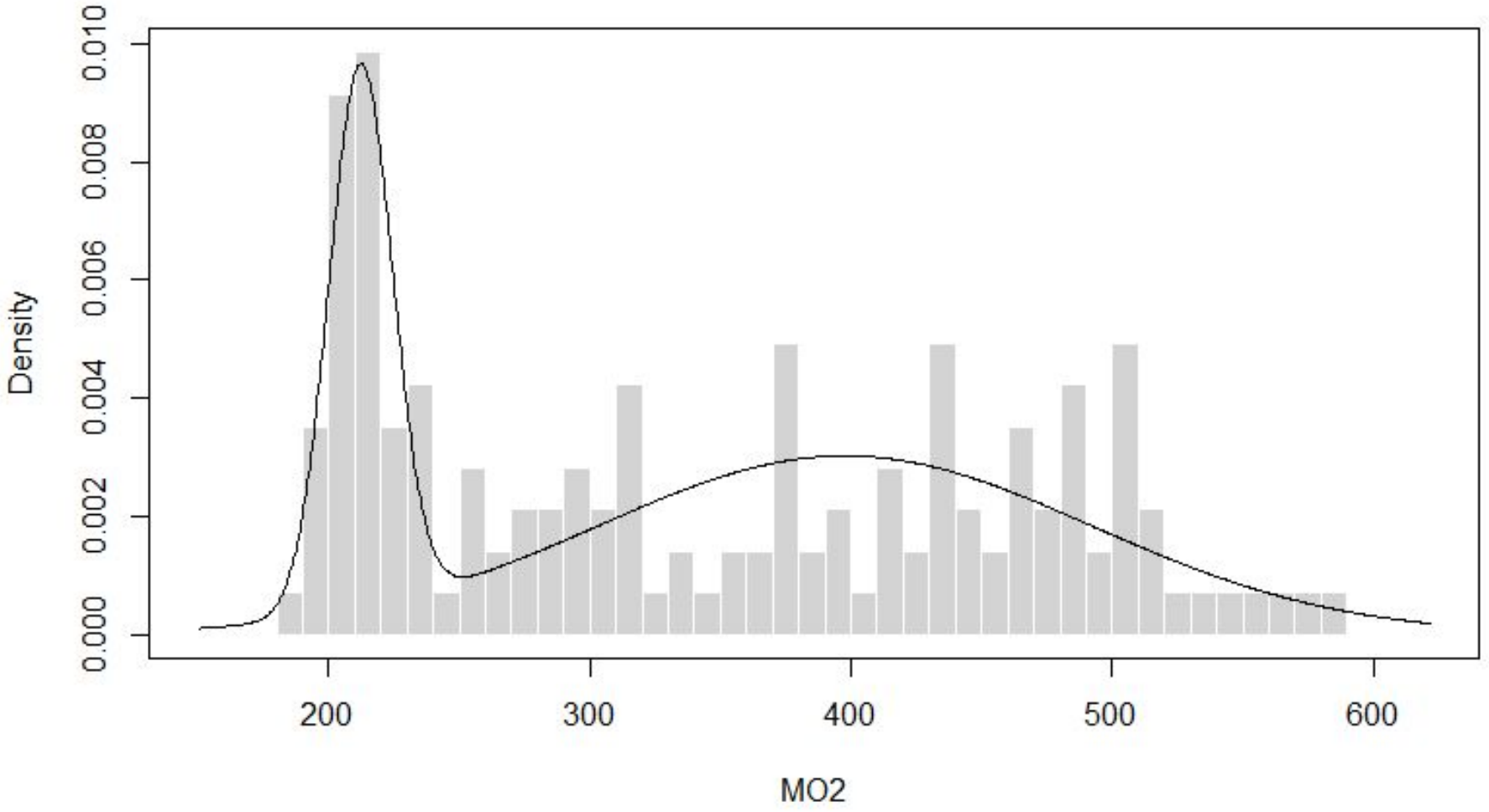

Fish 13
MO2
100
300
500
0
5
10
15
Fish 15
MO2
150
250
350
0
5
10
15
Time

Histogram

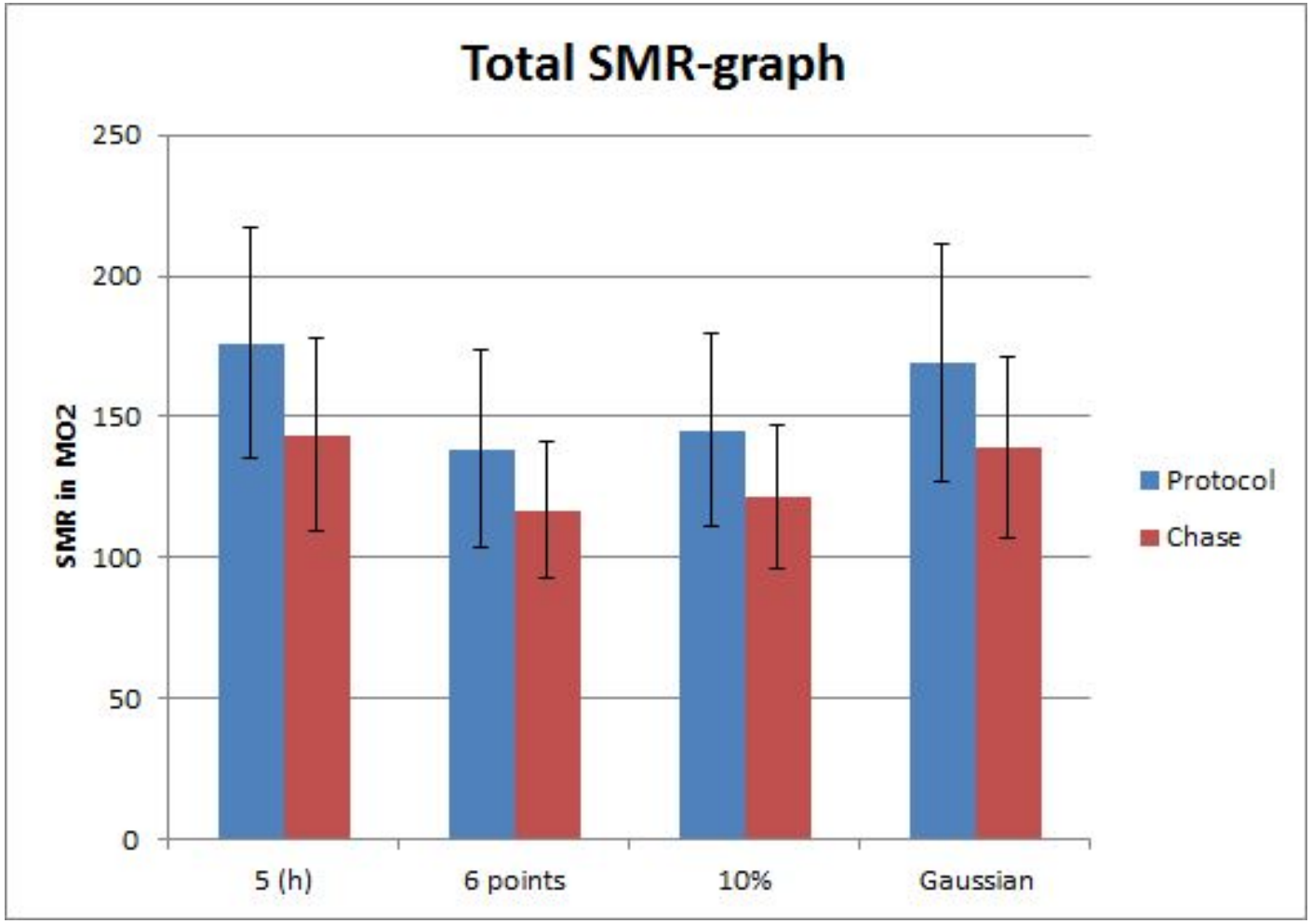


Estimate SMR (fish 1)

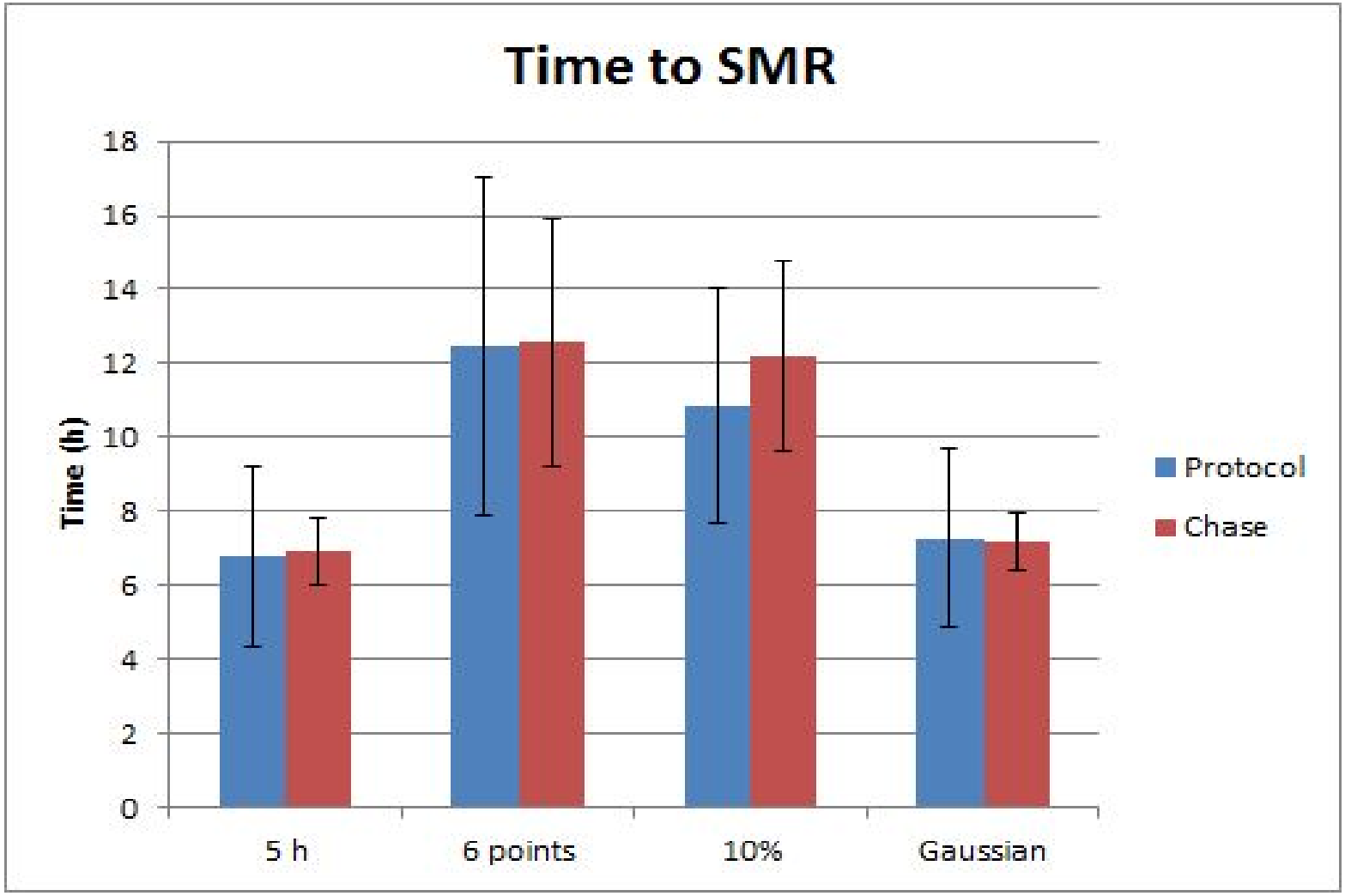
Mclust package in R

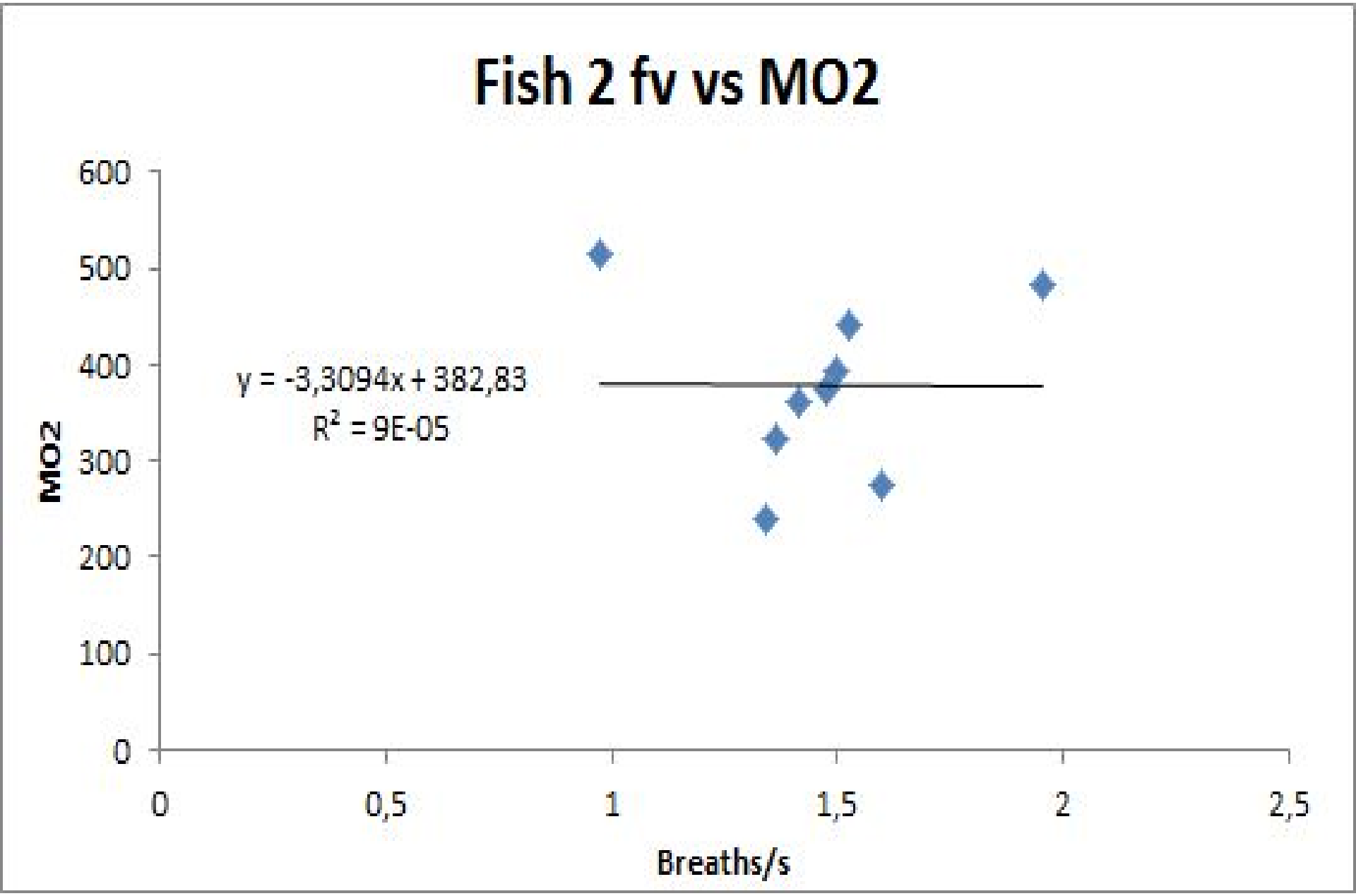


Different SMR estimations



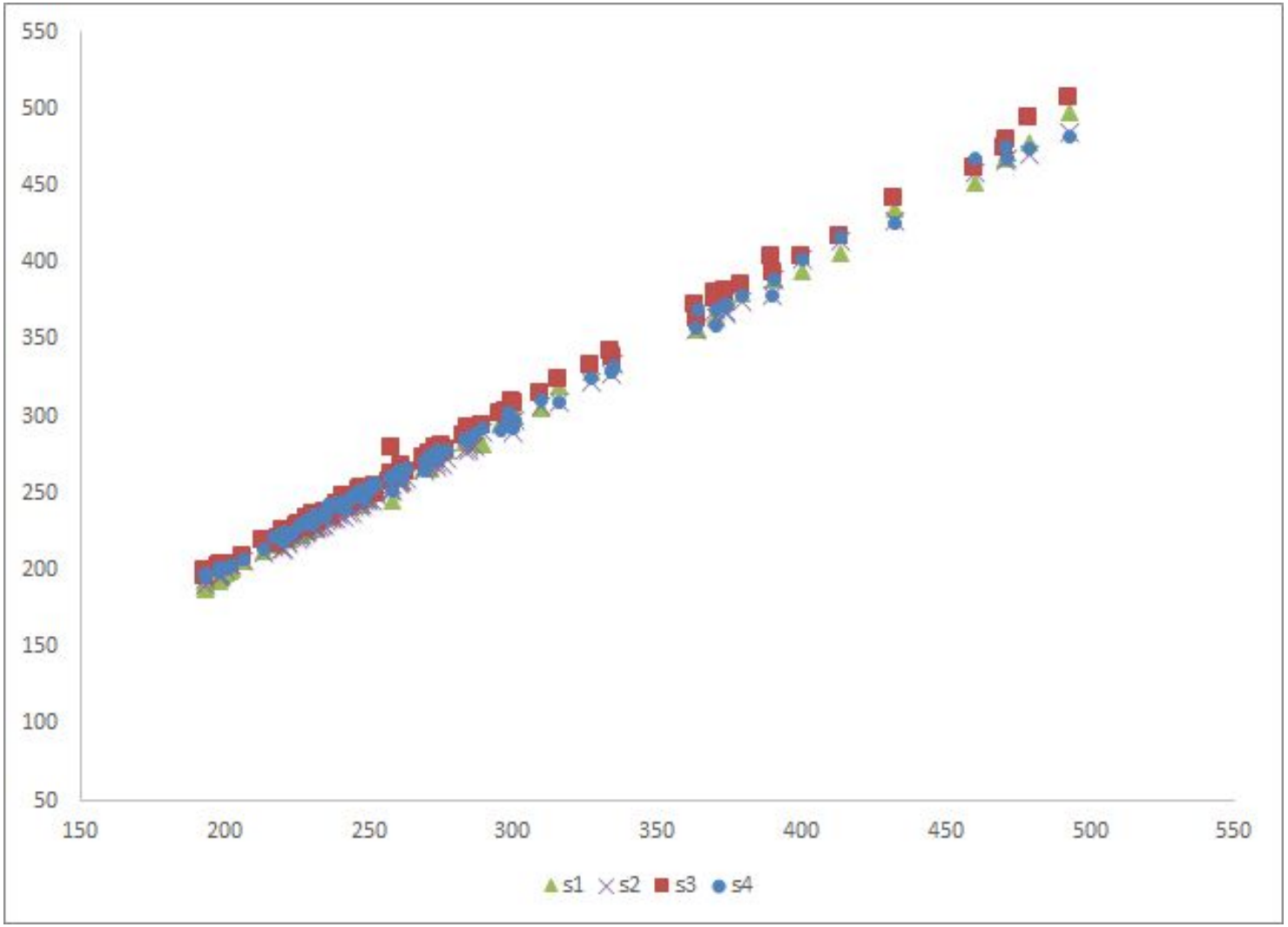
Time to SMR


Time to SMR
Time (h)
18
16
14
12
10
8
6
4
2
0
5 h
6 points
10%
Gaussian
Protocol
Chase


Fish 2 fv vs MO2
600
500
400
300
200
100
0
MO2
y = -3,3094x + 382,83
R² = 9E-05
0
0,5
1
1,5
2
2,5
Breaths/s

Does the positioning of sensors matter?

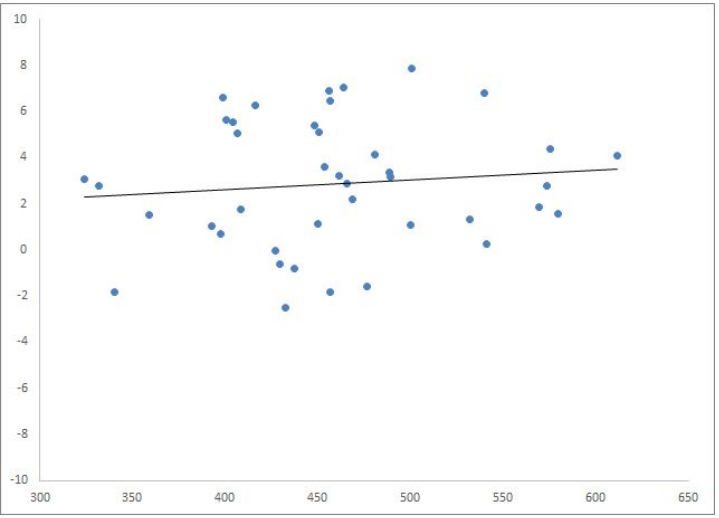
MO2



Average MO2

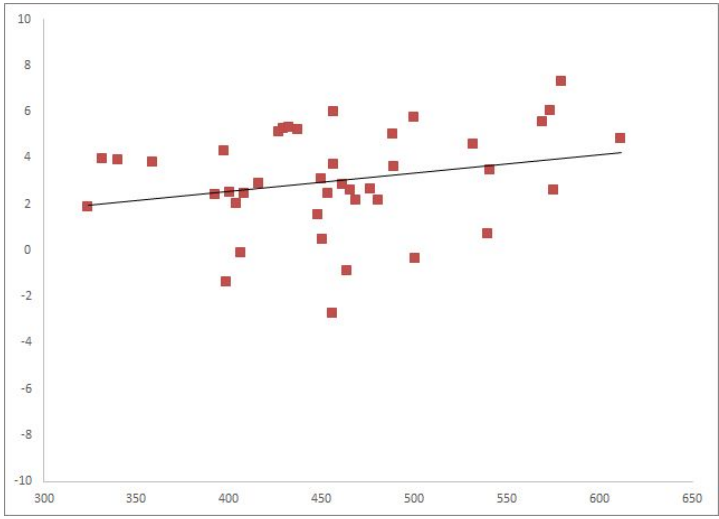
Deviation from average vs MO2

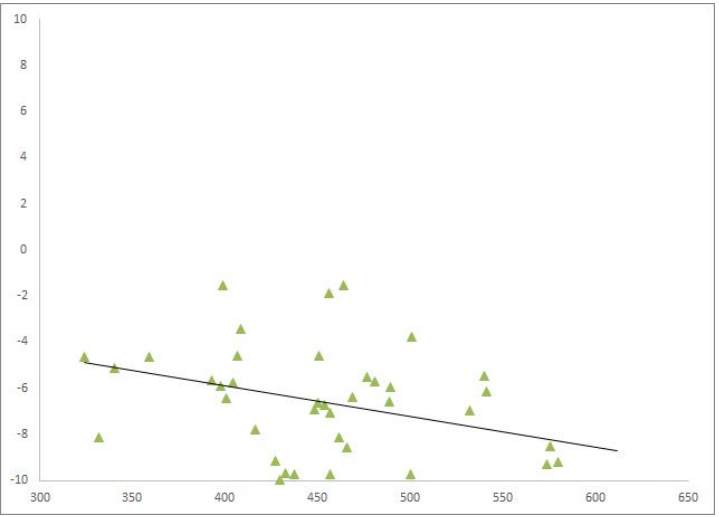
- Position 1, just put in the fish
- sensor 1&2 are right before the pump



1

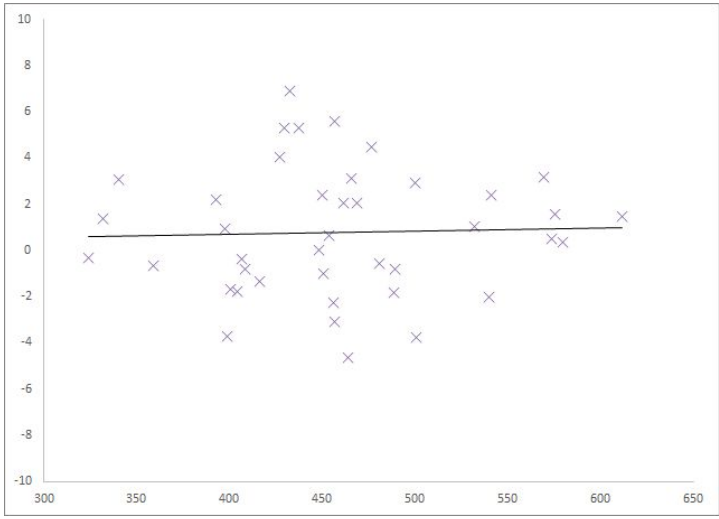
2





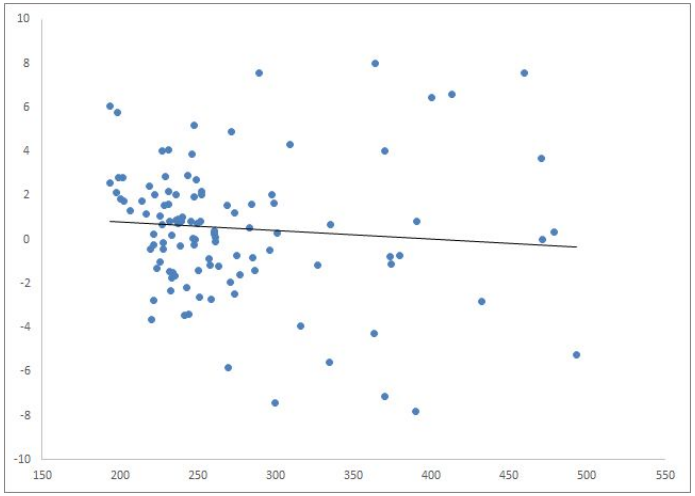
3

4



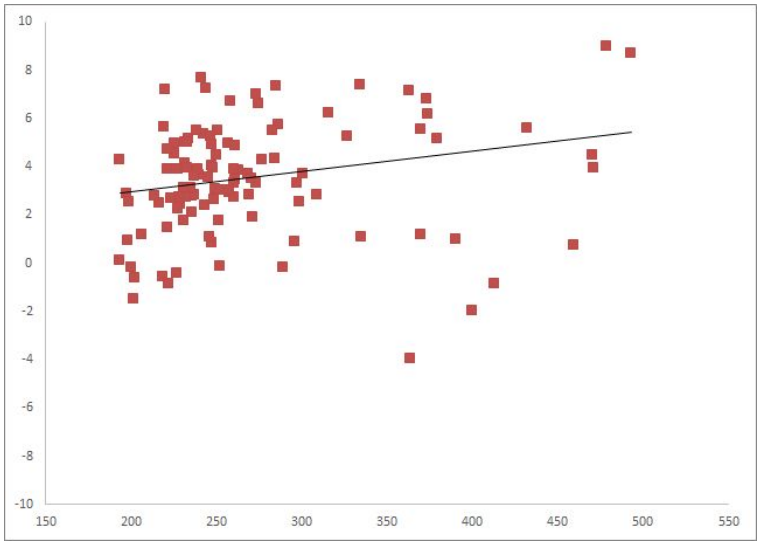
Deviation from average vs MO2

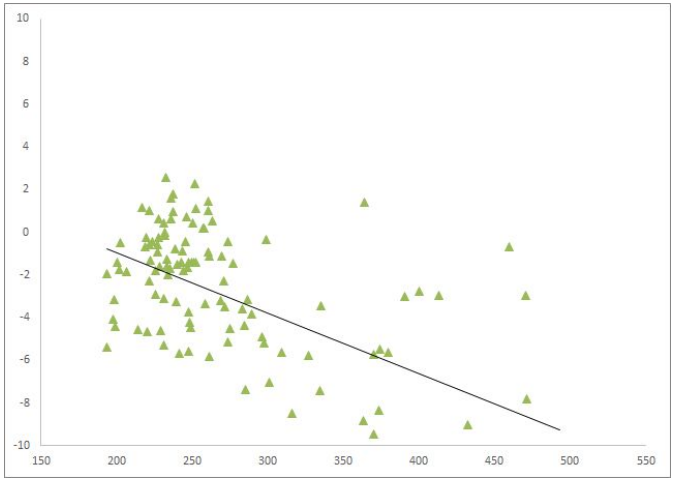
- Position 4
- sensor 2&3 are right before the pump



1

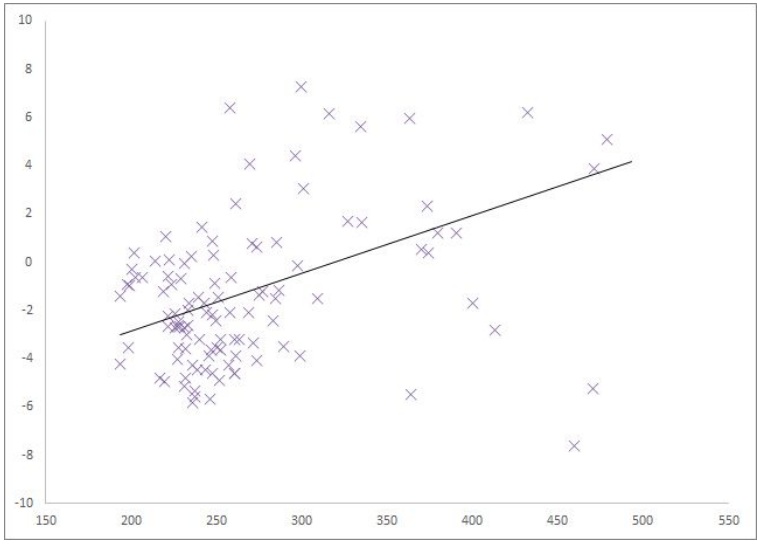
2

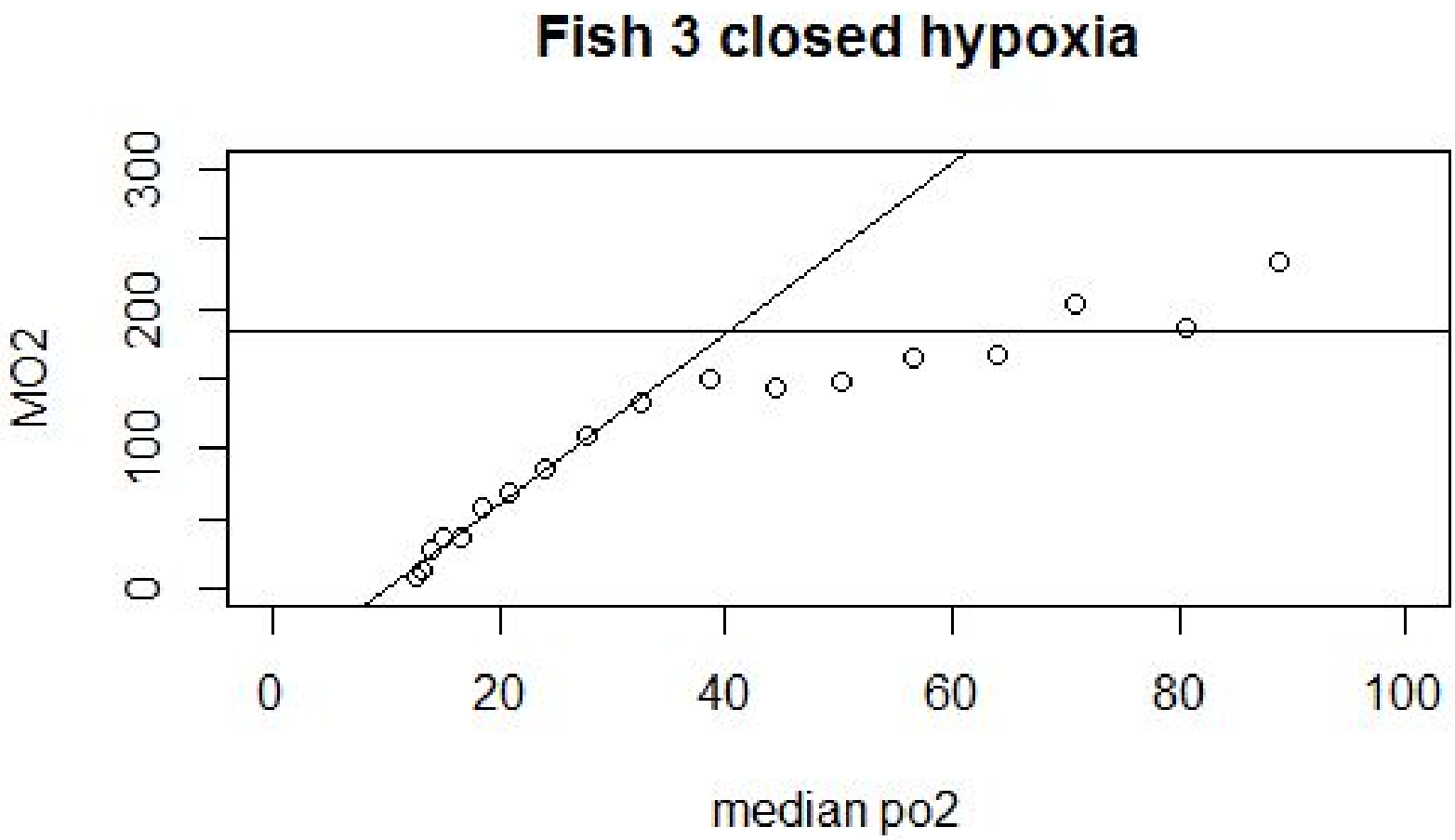


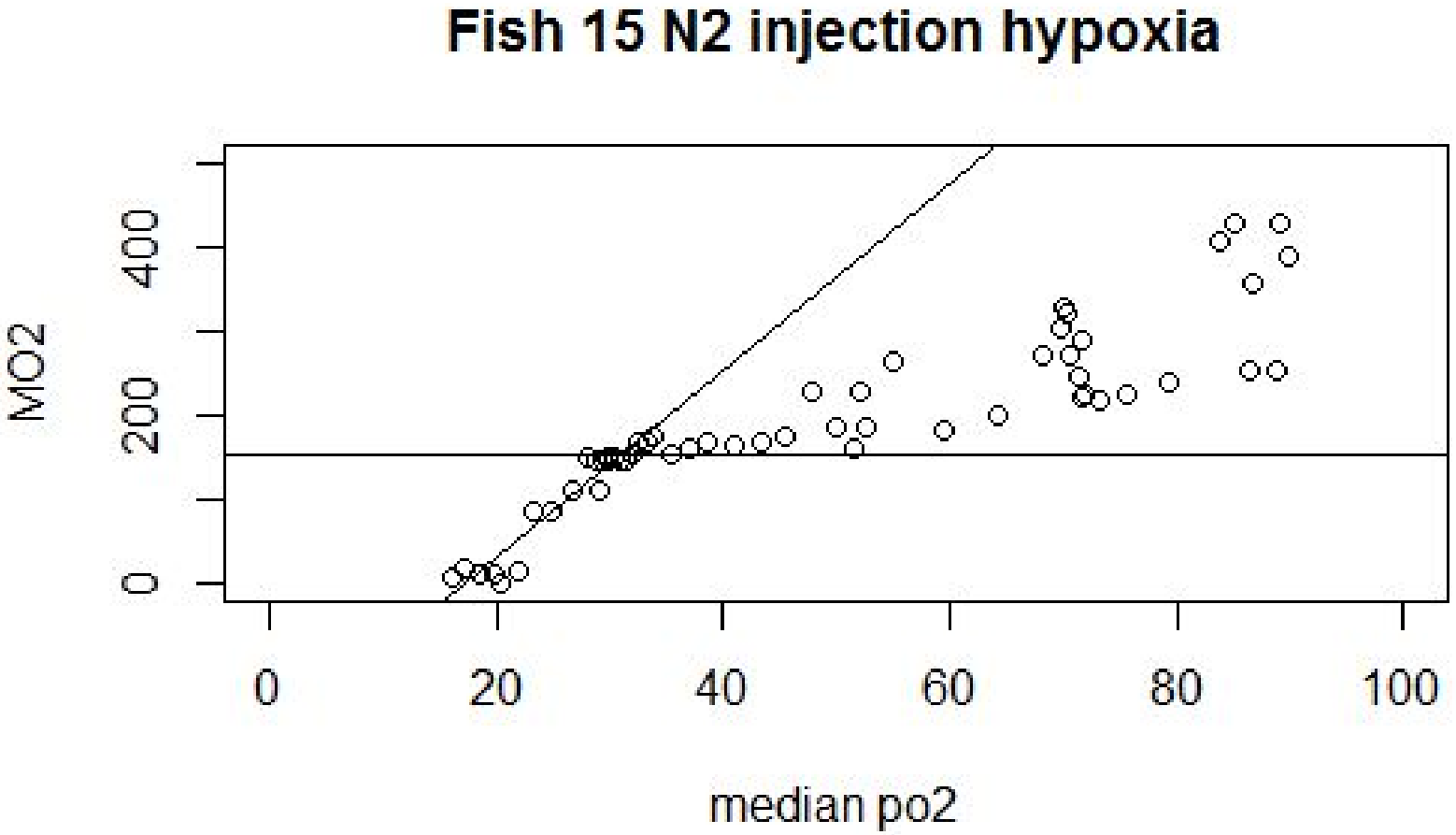


3

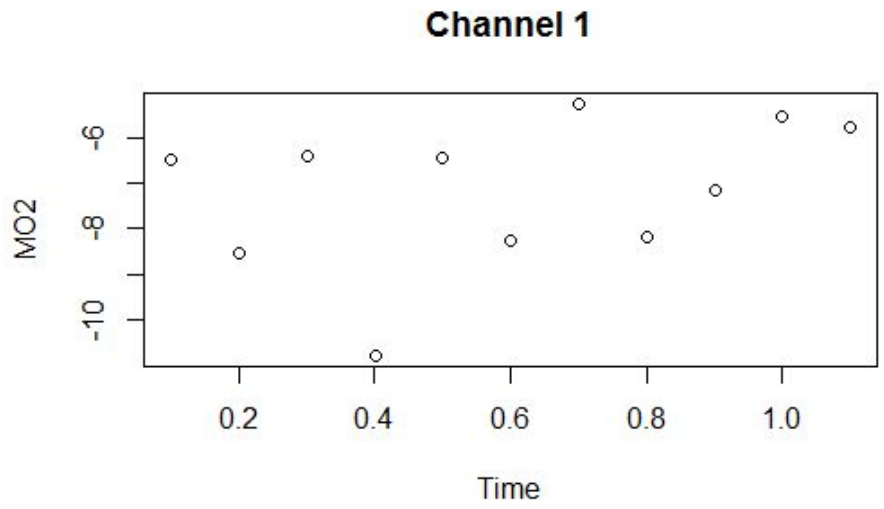
4

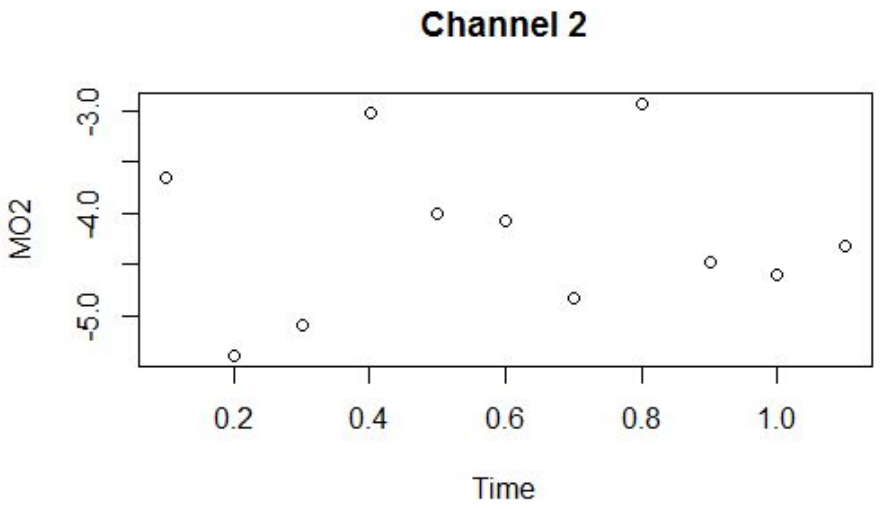


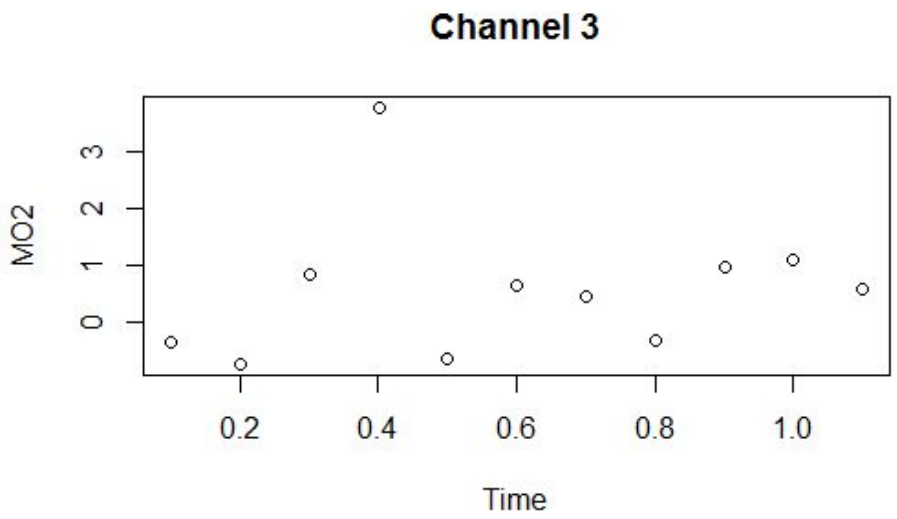

Fish 3 closed hypoxia
MO2
0
100
200
300
0
20
40
60
80
100
median po2

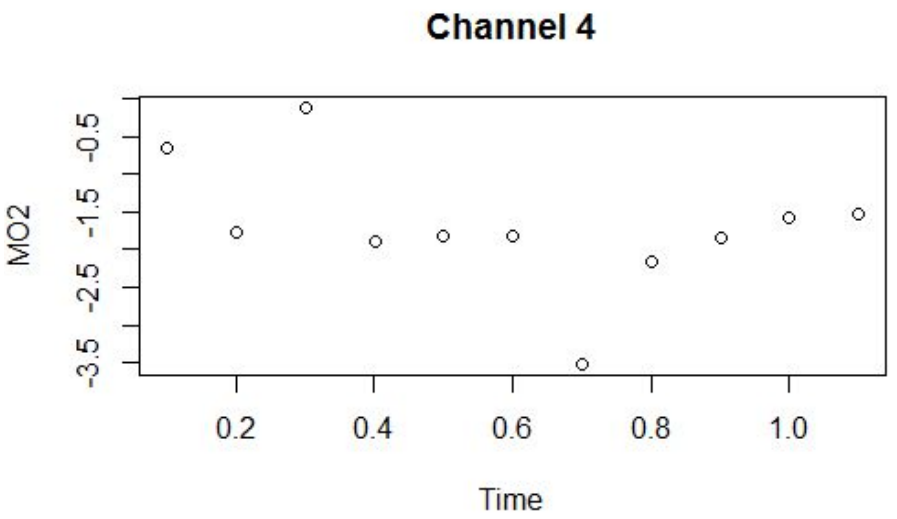

Fish 15 N2 injection hypoxia
MO2
0
200
400
0
20
40
60
80
100
median po2

Background respiration

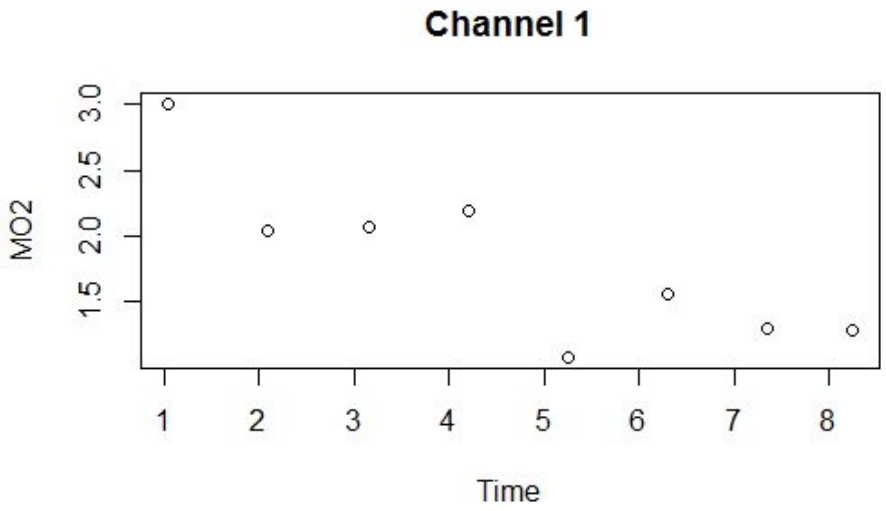


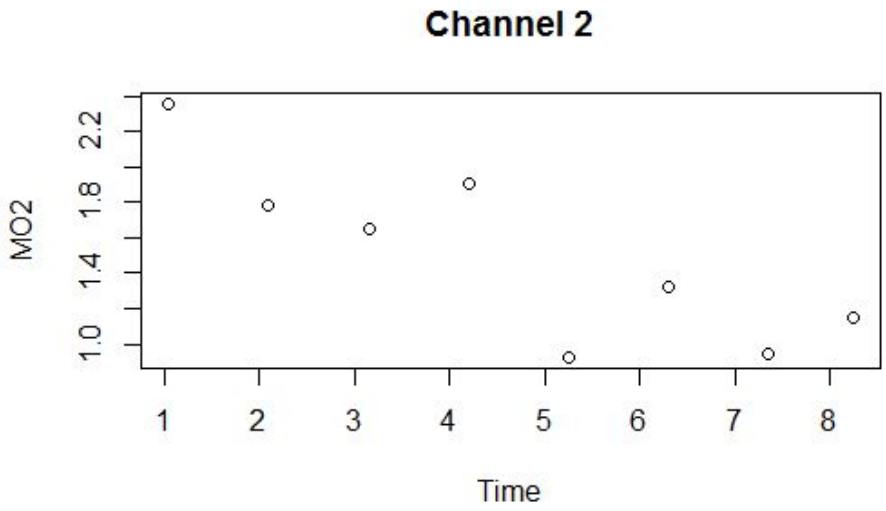


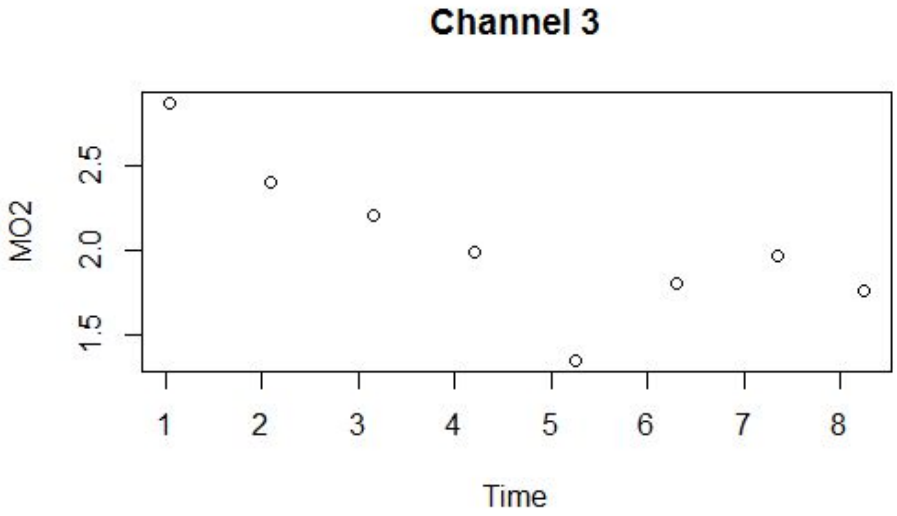


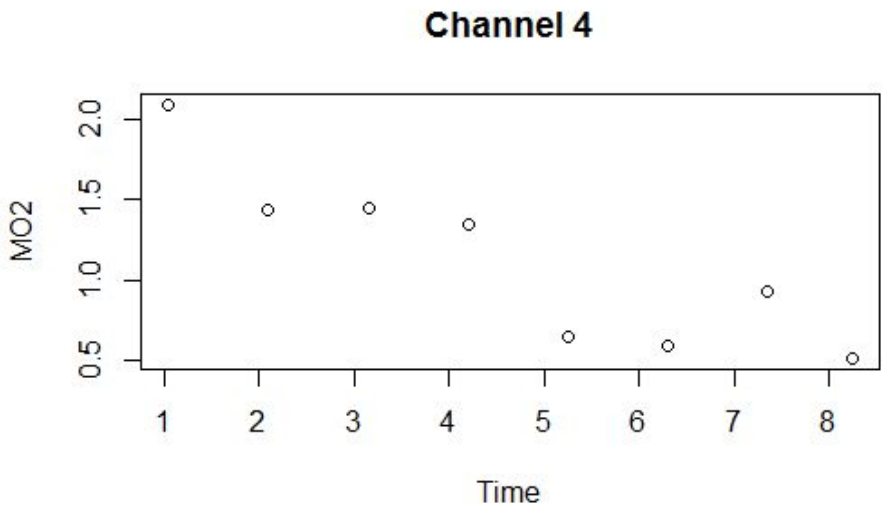


Background respiration

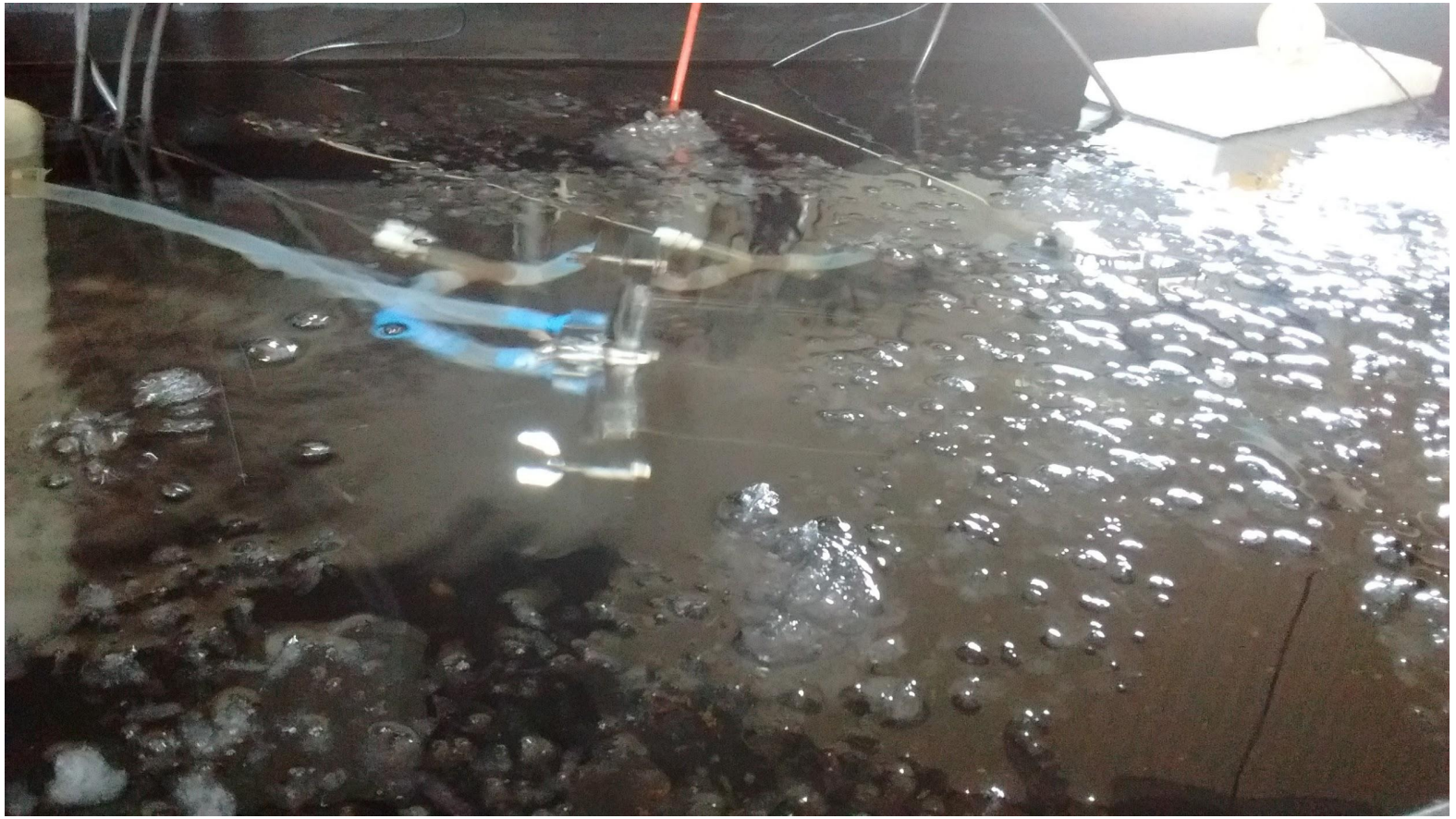








Low temperature



Resting all the way!

Fish		Weight(gram)				volume(m	T.flush	T.wait	T.measurement	Resp to fish ratio
1	12-maj	66,1	stick	MMR	hypoxia	1119	2	1	3	15,92889561
2	12-maj	54,8	stick	MMR	hypoxia	1113	2	1	3	19,31021898
3	12-maj	42	no stress		hypoxia	1104	2	1	3	25,28571429
4	12-maj	103	no stress		hypoxia	1134	2	1	3	10,00970874
5	13-maj	54,4	stick	MMR		1119	2	1	3% pO2 drop	19,56985294
6	13-maj	51,7	stick	MMR		1113	2	1	3% pO2 drop	20,52804642
7	13-maj	52,1	air exposu	MMR		1104	2	1	3% pO2 drop	20,19001919
8	13-maj	32,6	air exposu	MMR		1134	2	1	3% pO2 drop	33,78527607
9	14-maj	26,3	stick			1119	2	1	3% pO2 drop	41,54752852
10	14-maj	43,8	stick			1113	2	1	3% pO2 drop	24,4109589
11	14-maj	45,2	air exposure			1104	2	1	3% pO2 drop	23,42477876
12	14-maj	52,6	air exposure			1134	2	1	3% pO2 drop	20,55893536
13	15-maj	45,8	stick		hypoxia (5-16)	1119	2	1		23,43231441
14	15-maj	60,9	stick		hypoxia (5-16)	1113	2	1		17,27586207
15	15-maj	41,5	air exposure		hypoxia (5-16)	1104	2	1		25,60240964
16	15-maj	28	air exposure		hypoxia (5-16)	1134	2	1		39,5

Tank group

Presented to you by:
Gökhan Tunçelli
Maria João Peixoto
Patrícia Ferreira

Tank5

Tvol ≈ 677 L
TBM ≈ 4.2 kg
N = 60 fish

Tank8

Tvol ≈ 638 L
TBM ≈ 4.9 kg
N = 60 fish

Tank12

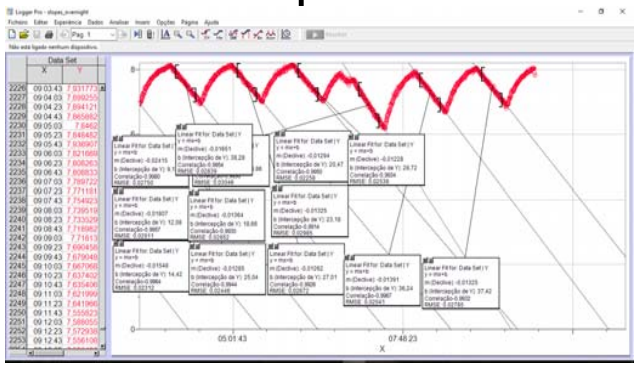
Tvol ≈ 612 L
TBM ≈ 11 kg
N = 80 fish

1) Difusion Time vs Cover
2) Cost of handling
3) RMR
4) SDA
5) MMR
6) Velocity vs Fish prefered velocity
7) TailBeat/min vs Velocity

Basic Calculations

- Oxygen measurements (M: 20 min; F: 40 min)

- Use LoggerPro to calculate slopes for each measurement period

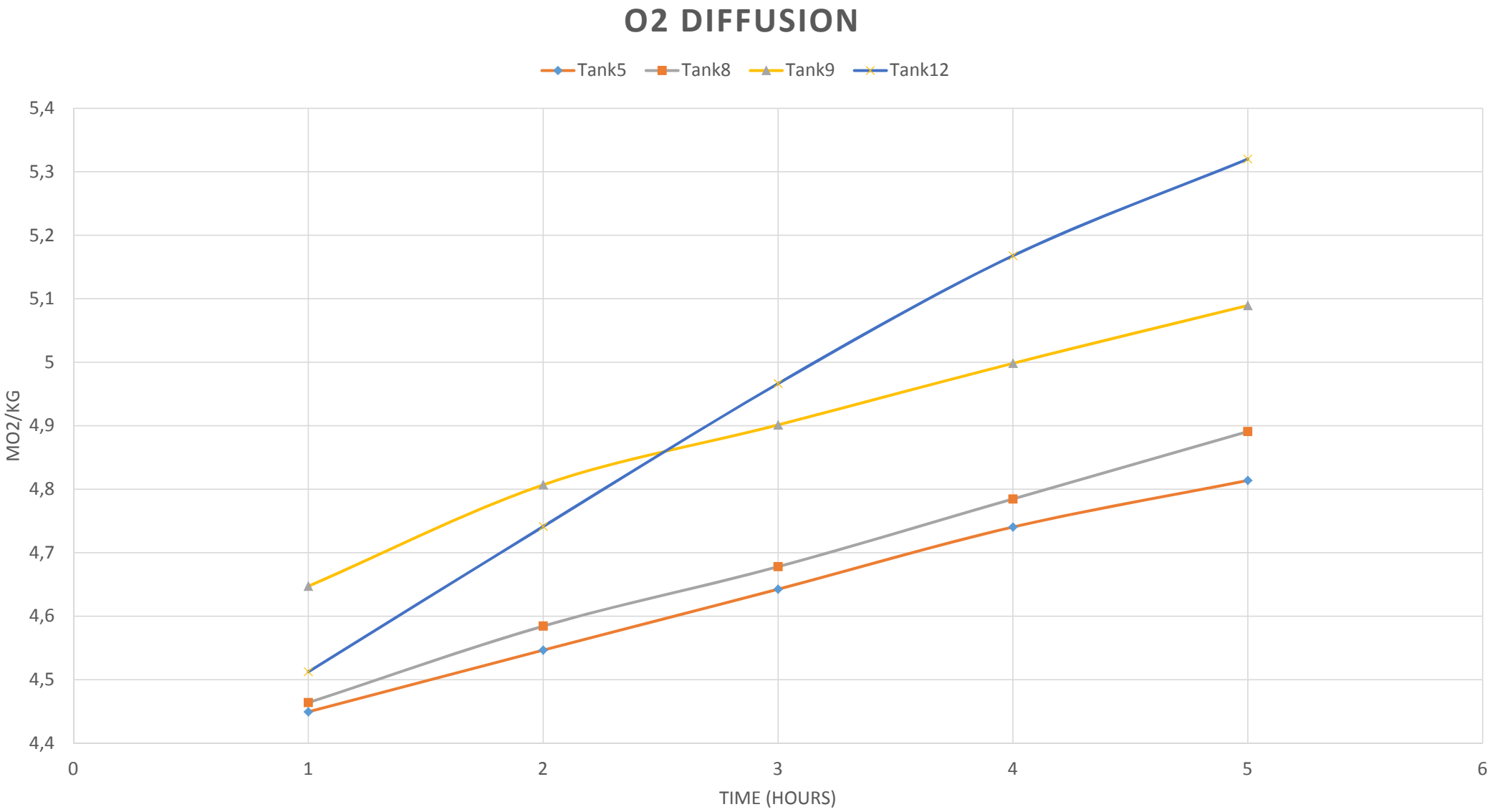


- Apply

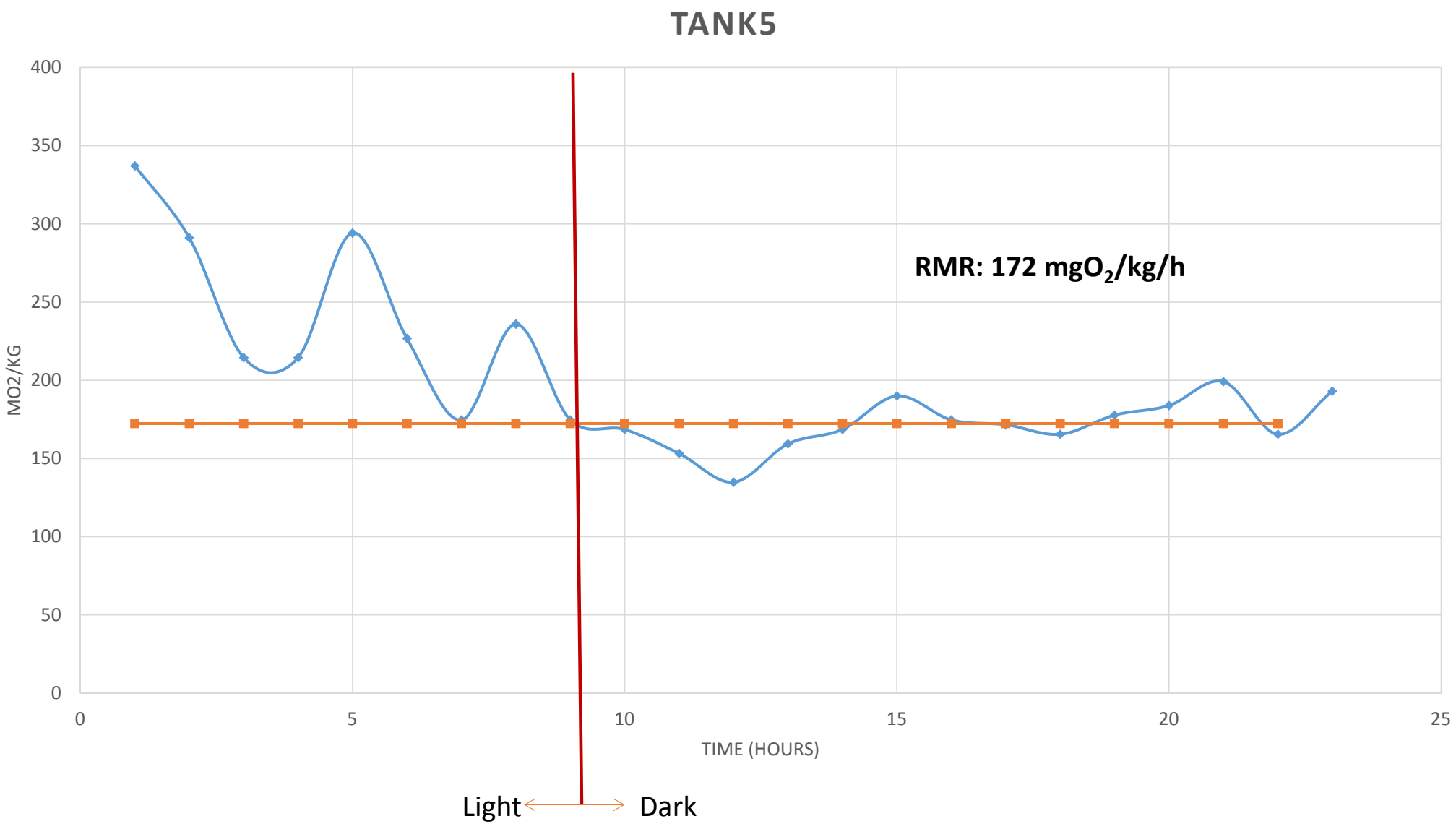
$$MO_2 = \frac{K \times V}{BM}$$

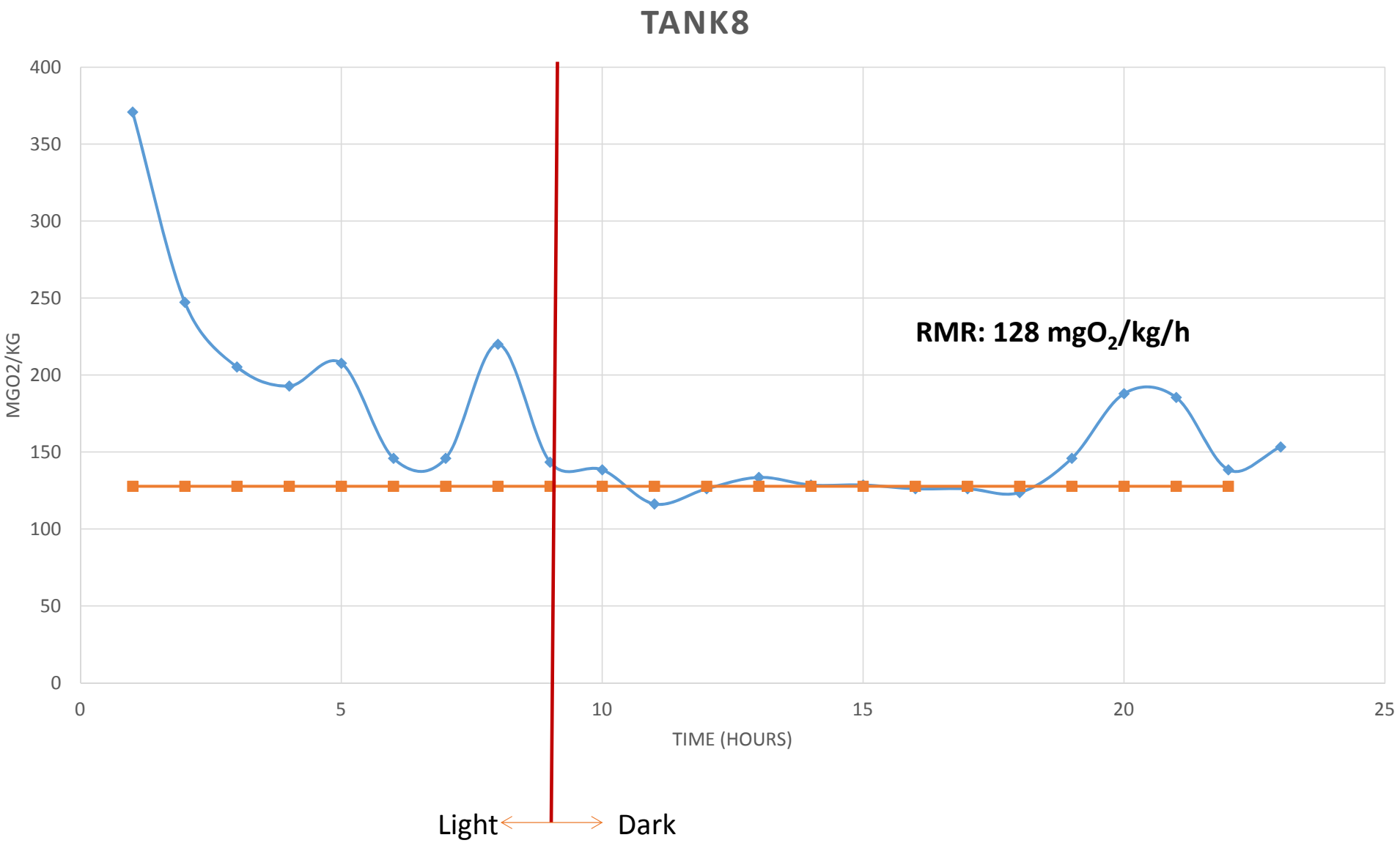
SDA Calculations

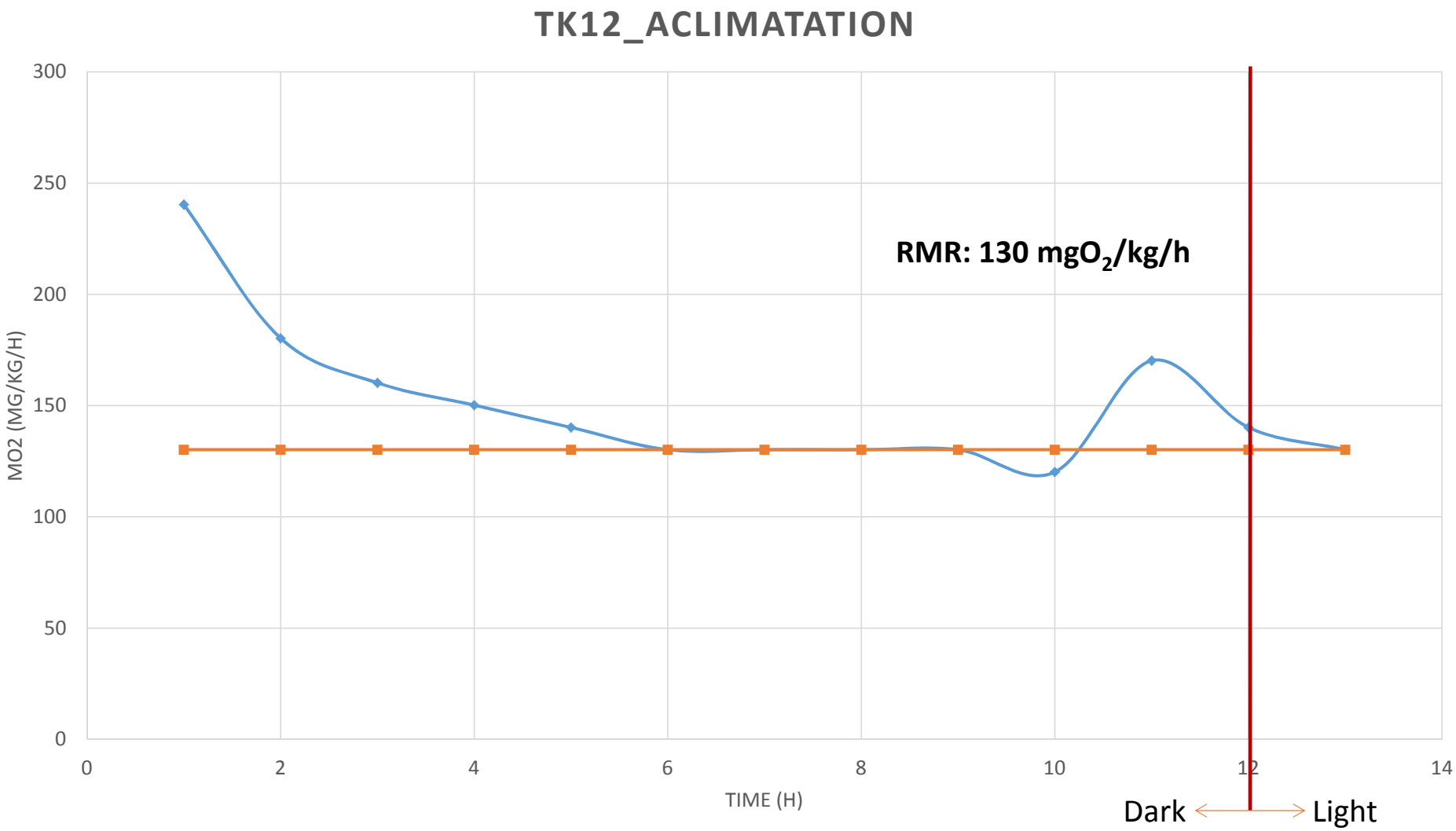
- Fish fed 3% BM for 4H
- O_2 measurements RMR VS O_2 measurements after feeding
- SDA = ΣMO_2
- $_tPeak$
- SDA_{cost}
- SDA_{coef}


O2 DIFFUSION
Tank5
Tank8
Tank9
Tank12
5,4
5,3
5,2
5,1
5
4,9
4,8
4,7
4,6
4,5
4,4
MO2/KG
0
1
2
3
4
5
6
TIME (HOURS)

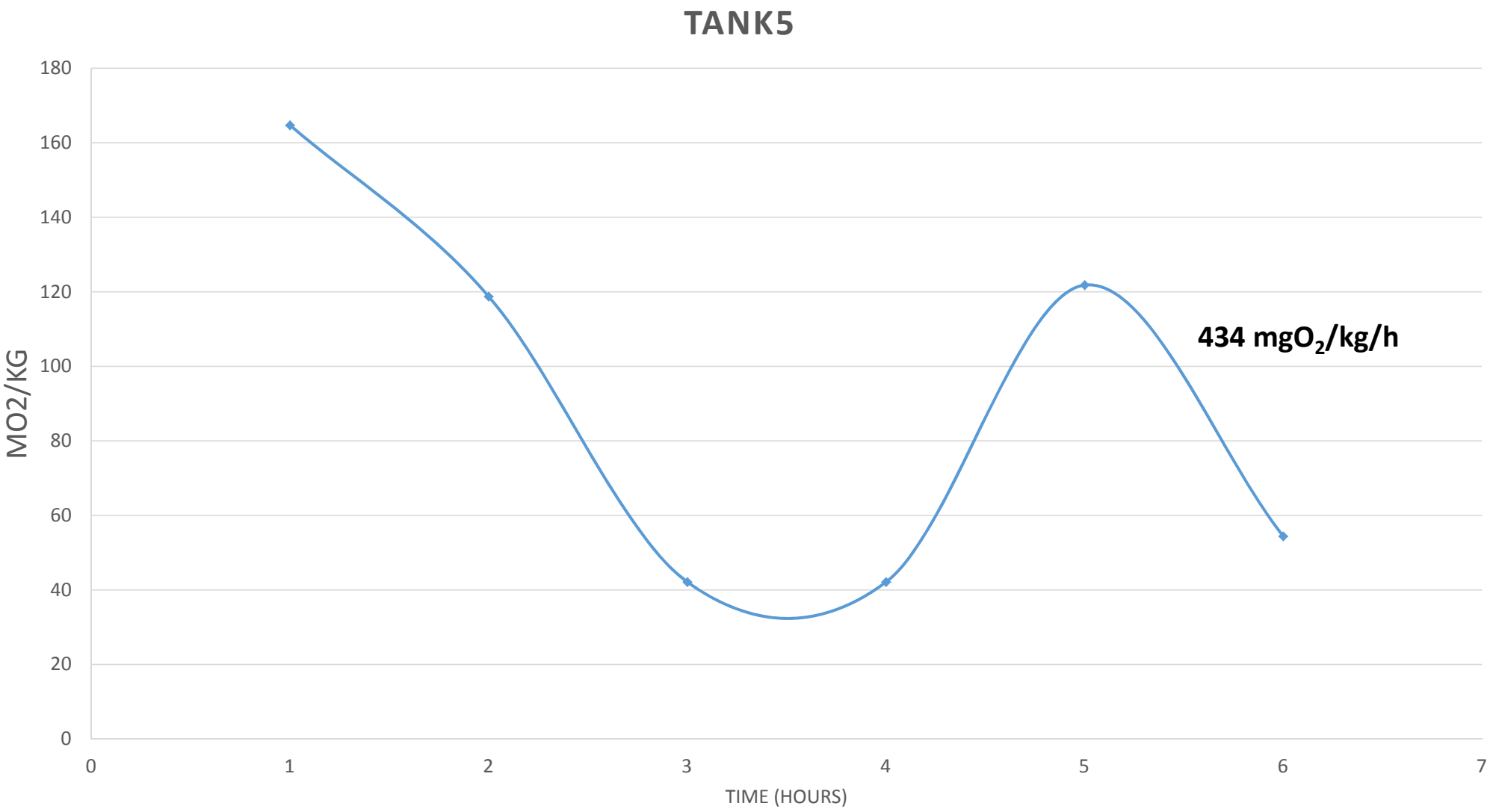
Acclimation of fishes

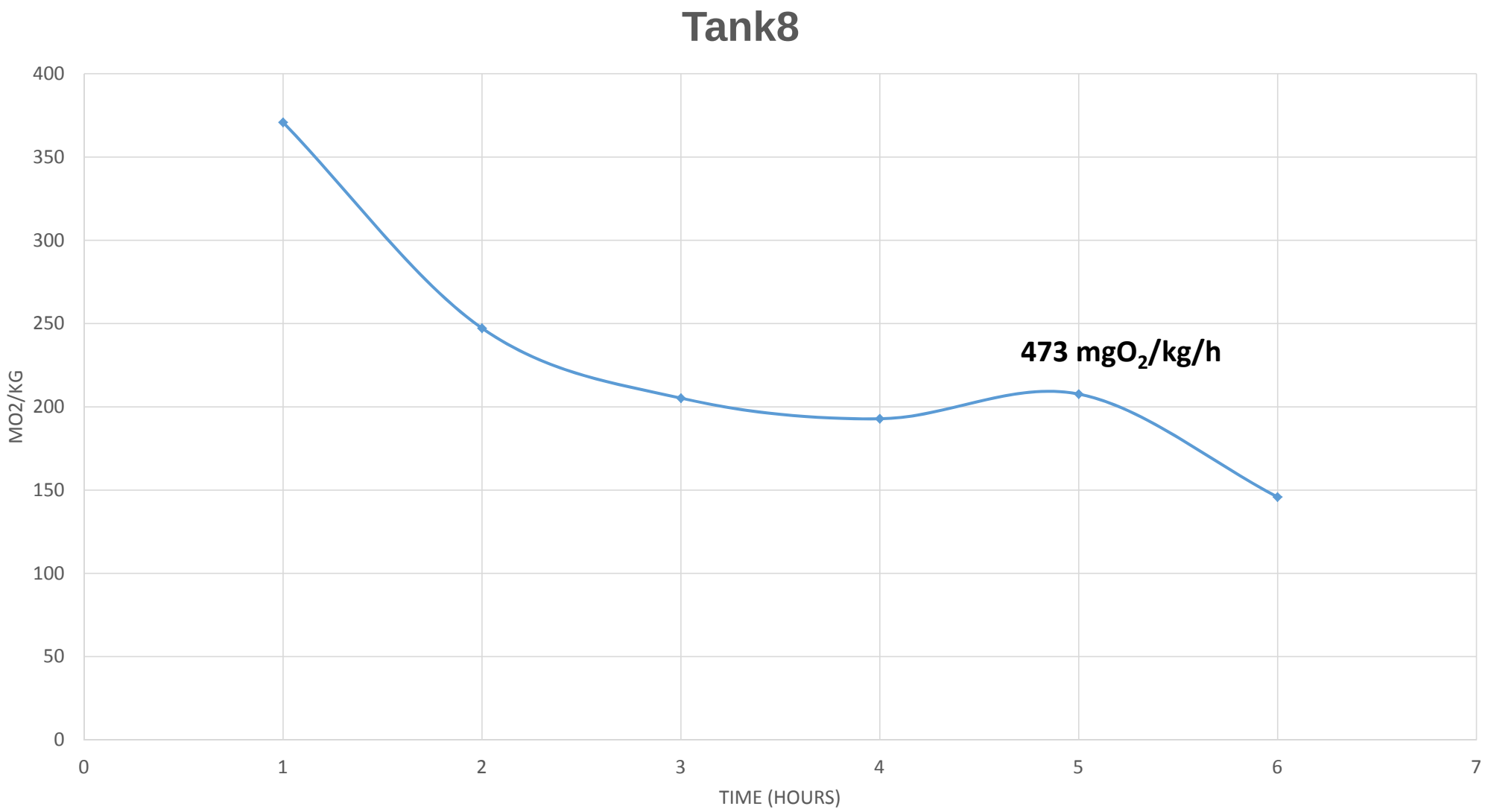

TANK5
400
350
300
250
200
150
100
50
0
MO2/KG
0
5
10
15
20
25
TIME (HOURS)
RMR: 172 mgO2/kg/h
Light
Dark

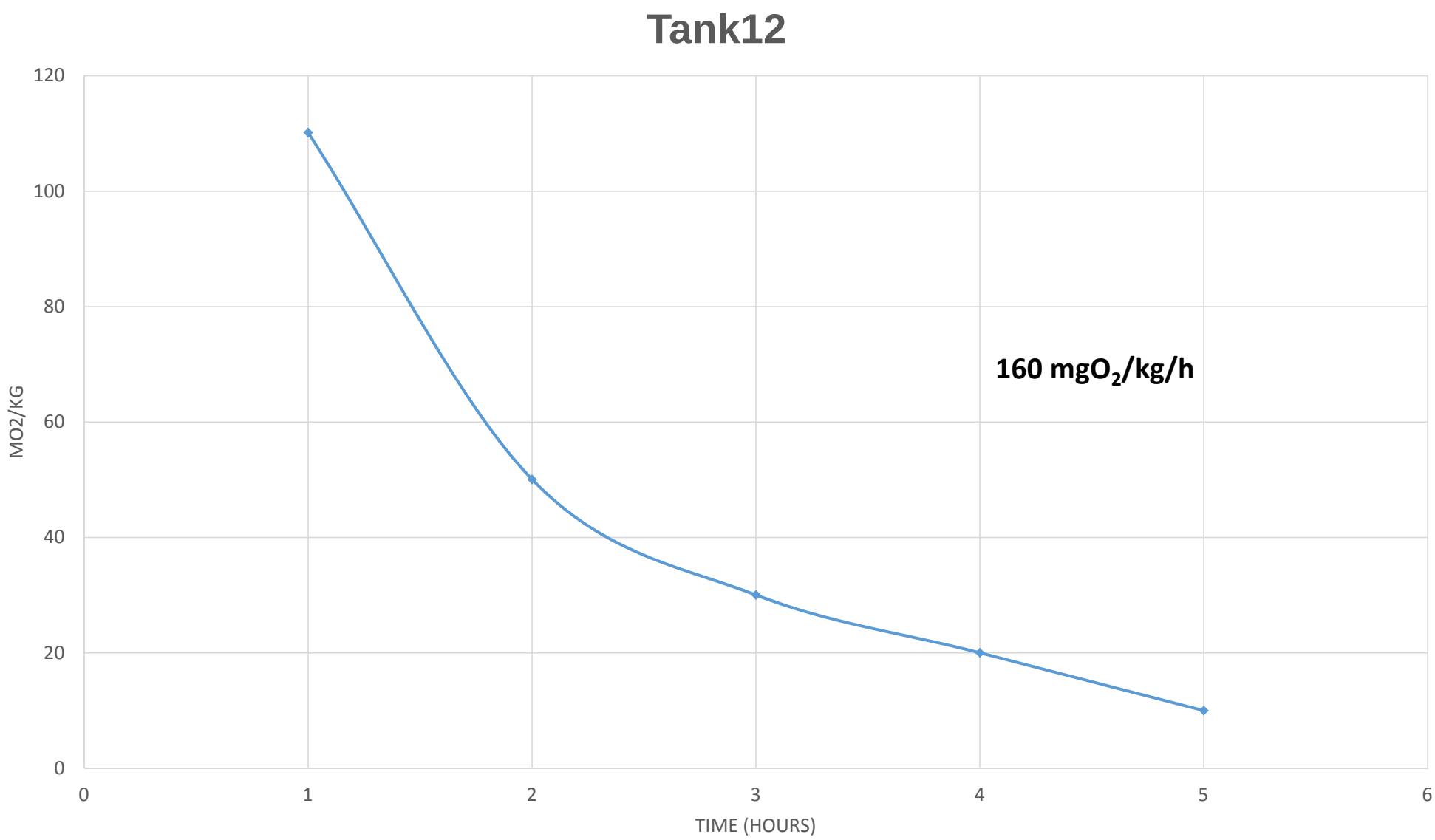

TANK8
400
350
300
250
200
150
100
50
0
MGO2/KG
0
5
10
15
20
25
TIME (HOURS)
RMR: 128 mgO2/kg/h
Light
Dark


TK12_ACLIMATATION
300
250
200
150
100
50
0
MO2 (MG/KG/H)
0
2
4
6
8
10
12
14
TIME (H)
RMR: 130 mgO2/kg/h
Dark
Light

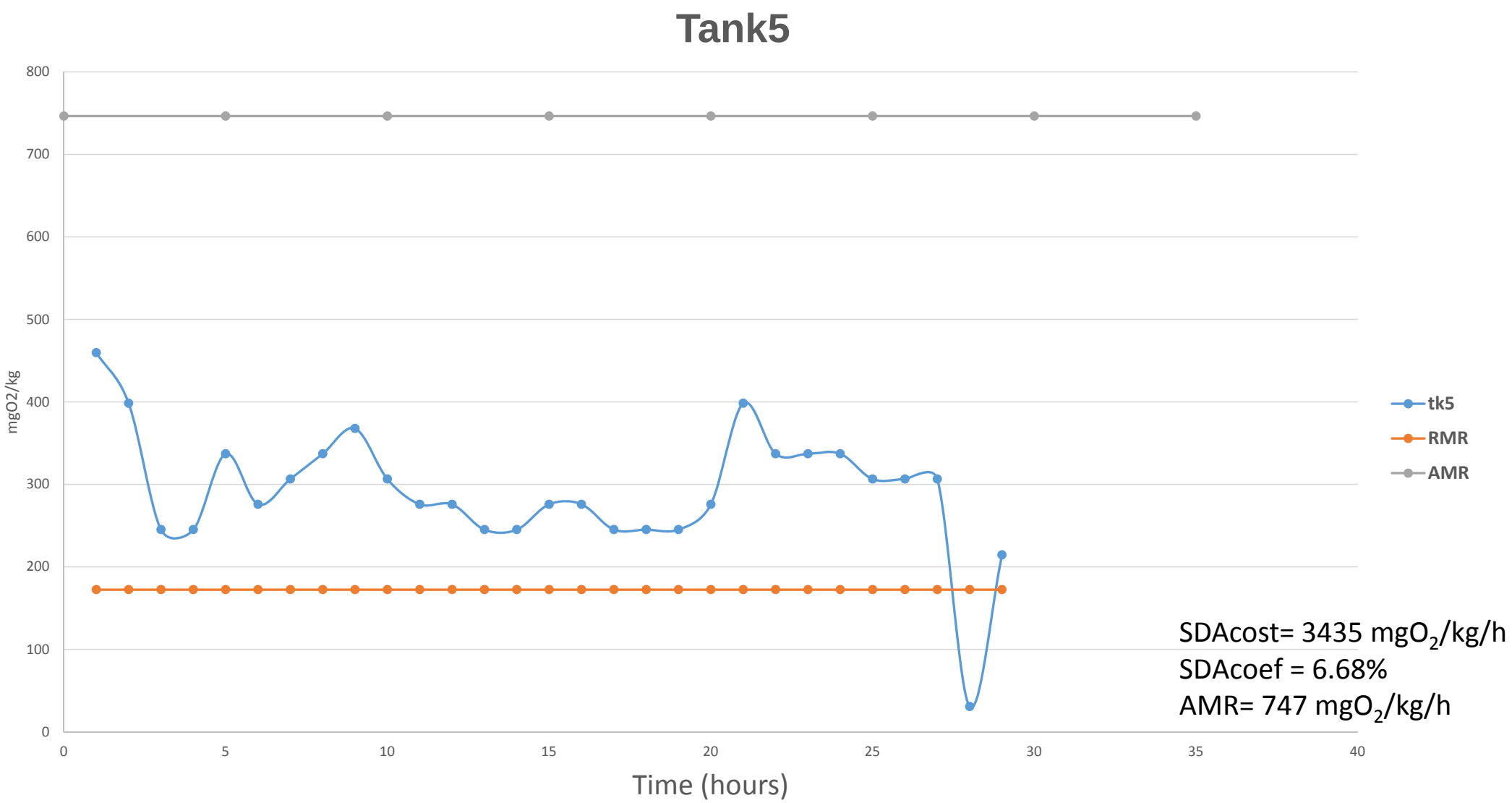
Cost of handling
(when putting fish on tanks)

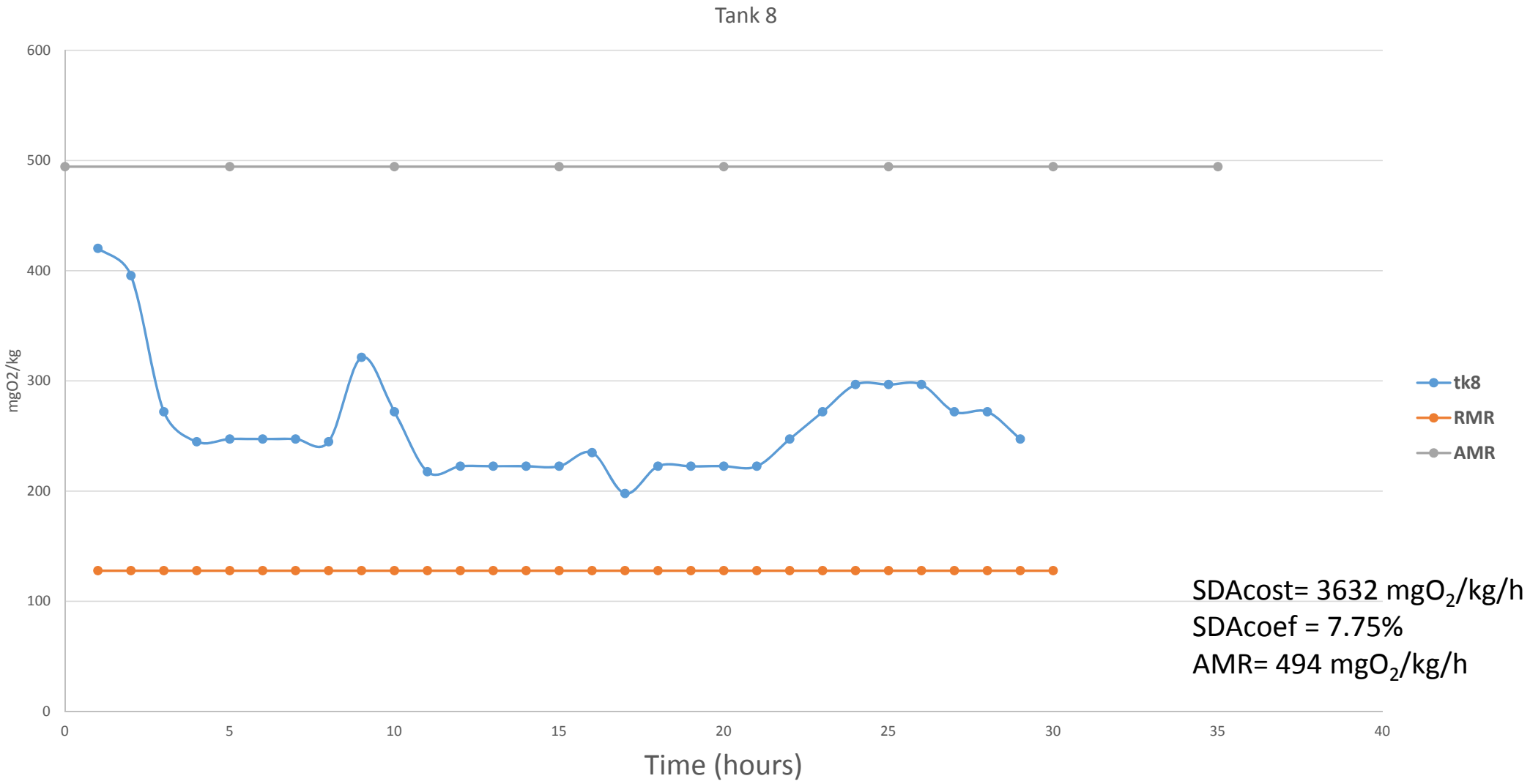

TANK5
180
160
140
120
100
80
60
40
20
0
MO2/KG
0
1
2
3
4
5
6
7
TIME (HOURS)
434 mgO2/kg/h


Tank8
400
350
300
250
200
150
100
50
0
MO2/KG
0
1
2
3
4
5
6
7
TIME (HOURS)
473 mgO2/kg/h

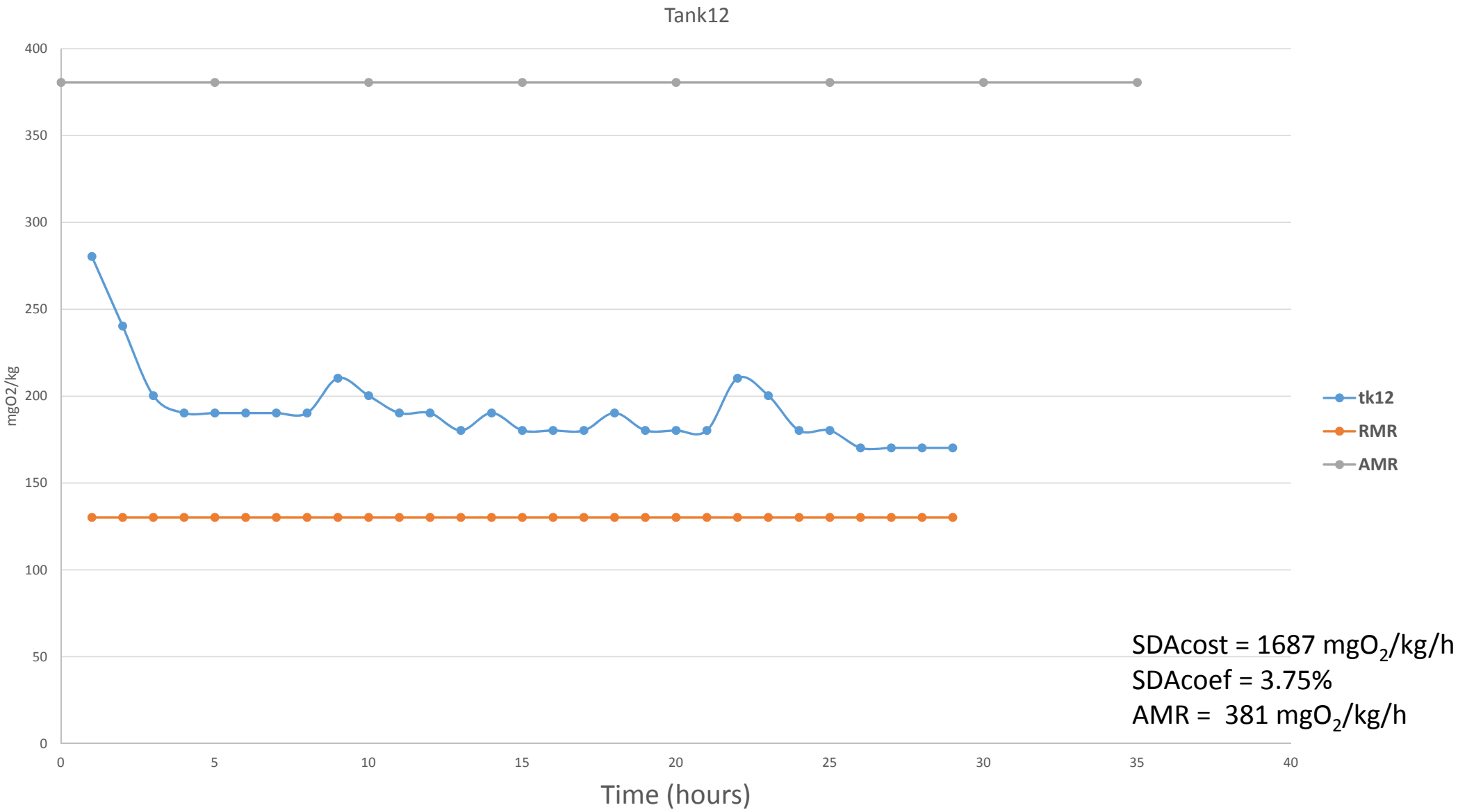

Tank12
120
100
80
60
40
20
0
MO2/KG
0
1
2
3
4
5
6
TIME (HOURS)
160 mgO2/kg/h

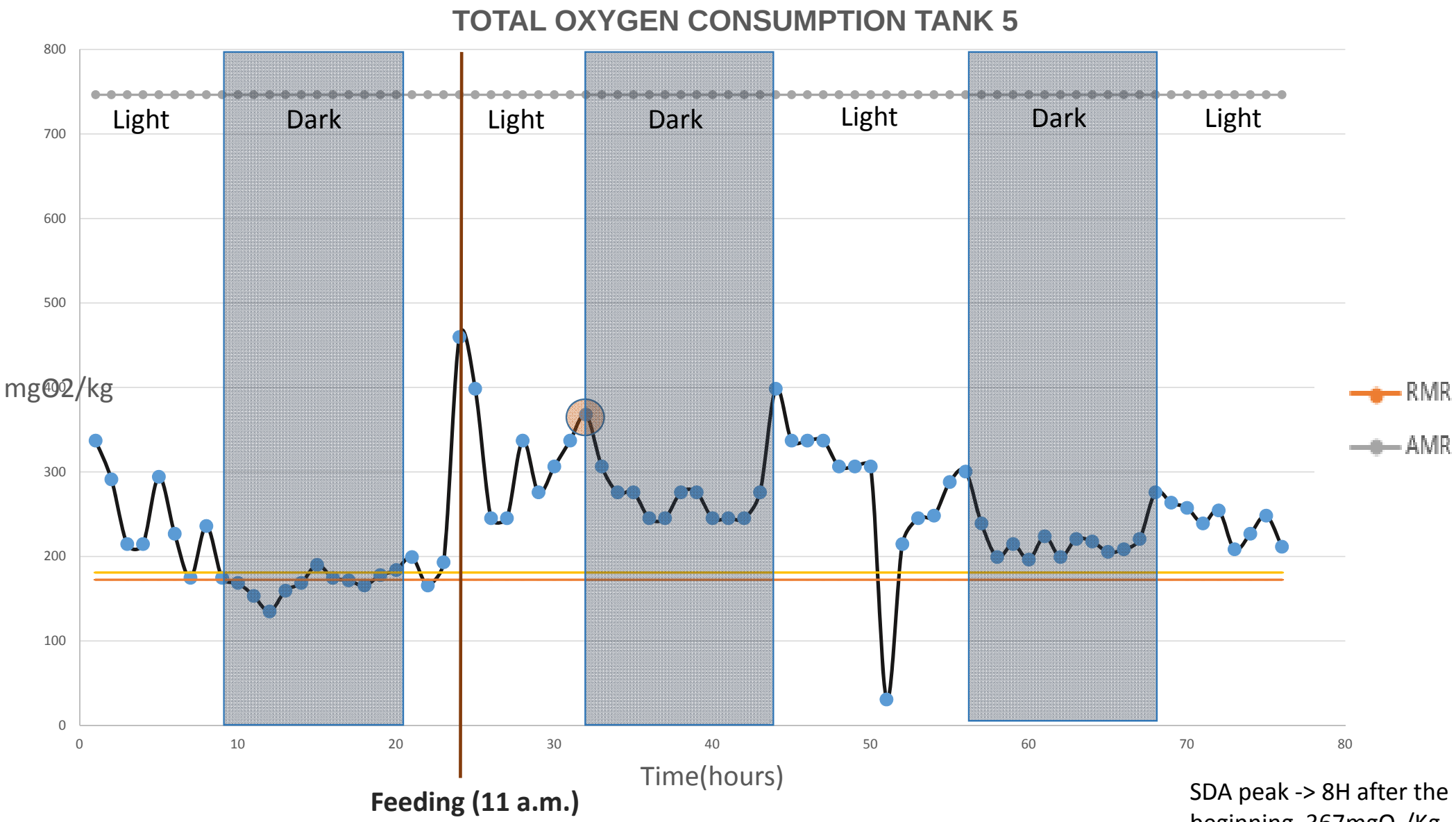
SDA experiment


Tank5
800
700
600
500
400
300
200
100
0
mgO2/kg
0
5
10
15
20
25
30
35
40
Time (hours)
tk5
RMR
AMR
SDAcost= 3435 mgO2/kg/h
SDAcoef = 6.68%
AMR= 747 mgO2/kg/h

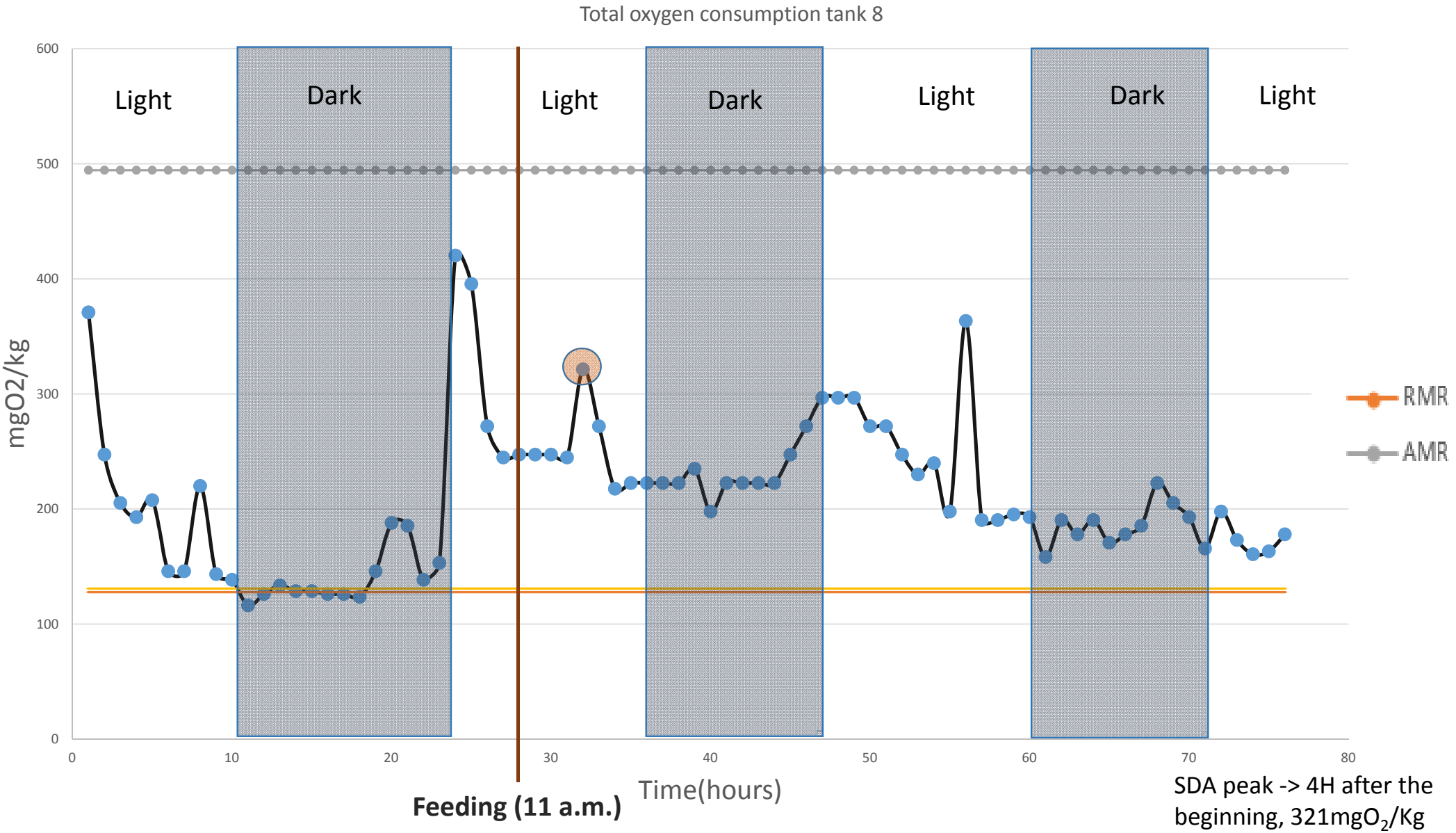


SDAcost= 3632 $mgO_2/kg/h$
SDAcoef = 7.75%
AMR= 494 $mgO_2/kg/h$

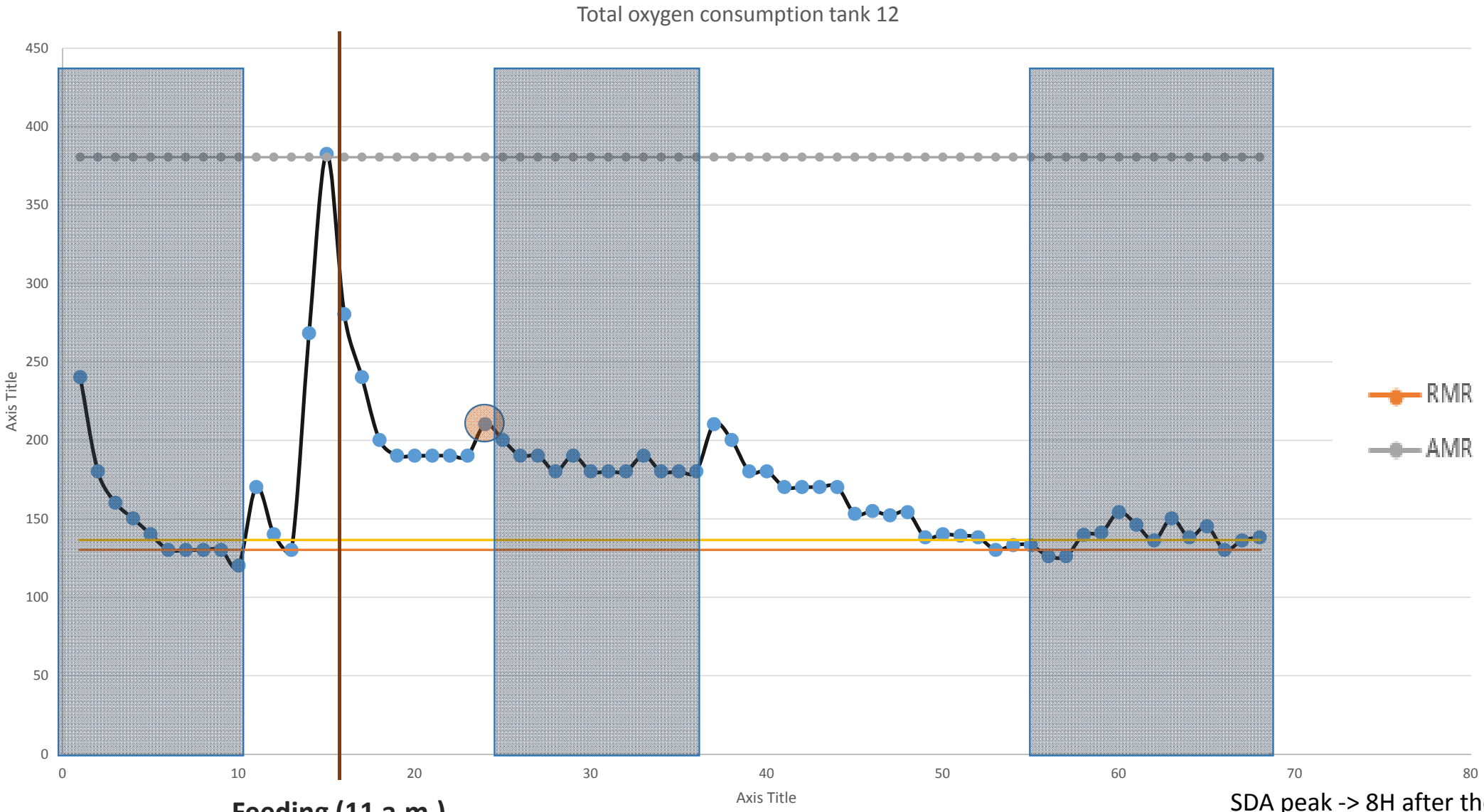

Tank12
400
350
300
250
200
150
100
50
0
mgO2/kg
0
5
10
15
20
25
30
35
40
Time (hours)
tk12
RMR
AMR
SDAcost = 1687 mgO2/kg/h
SDAcoef = 3.75%
AMR = 381 mgO2/kg/h



SDA peak -> 8H after the beginning, 367mgO_2/Kg

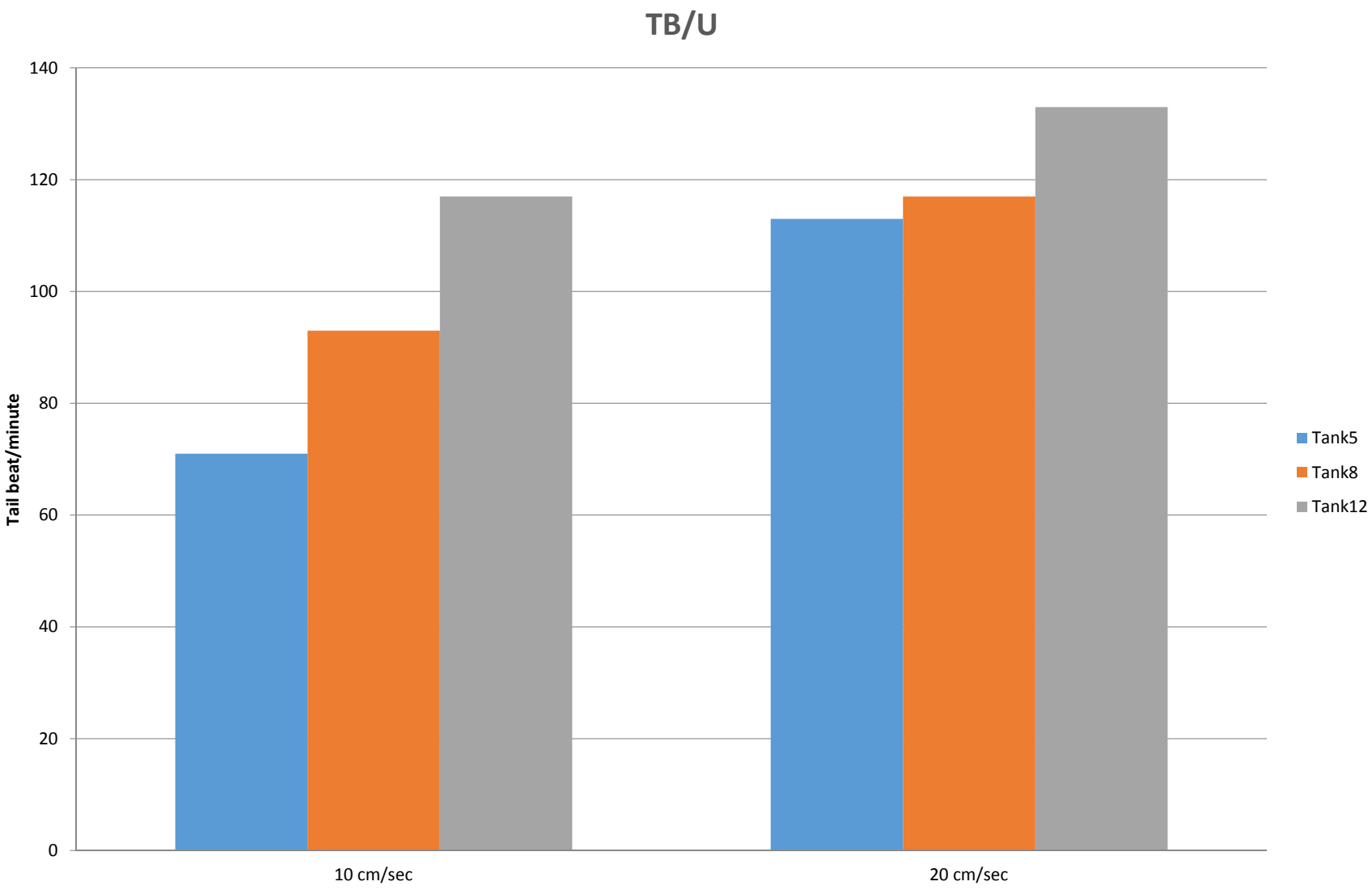


SDA peak -> 4H after the beginning, 321mgO_2/Kg



Feeding (11 a.m.)

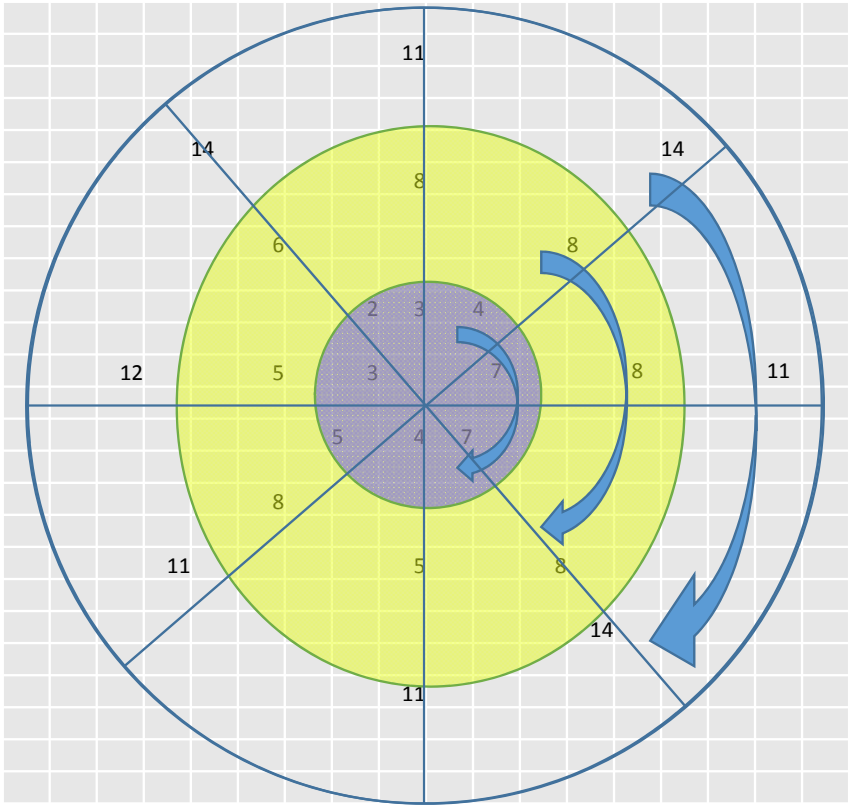
SDA peak -> 8H after the beginning, 210mgO_2/Kg


TB/U
Tail beat/minute
140
120
100
80
60
40
20
0
10 cm/sec
20 cm/sec
Tank5
Tank8
Tank12

Swimming experiment

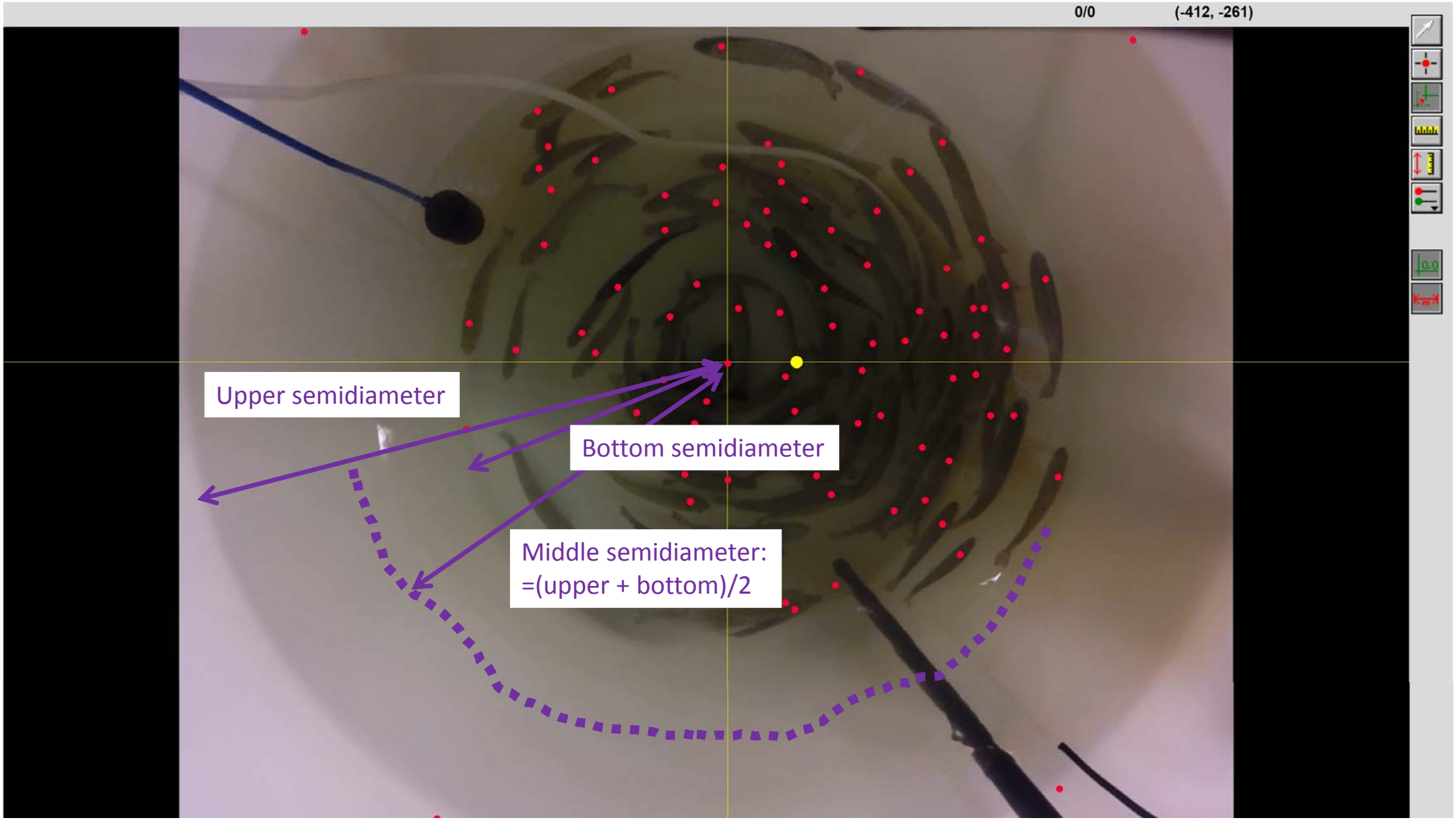
Fishes choice of velocity=
(% of inner area x estimated* velocity) + (% of middle area * estimated* velocity)+(% of outer area * *20)

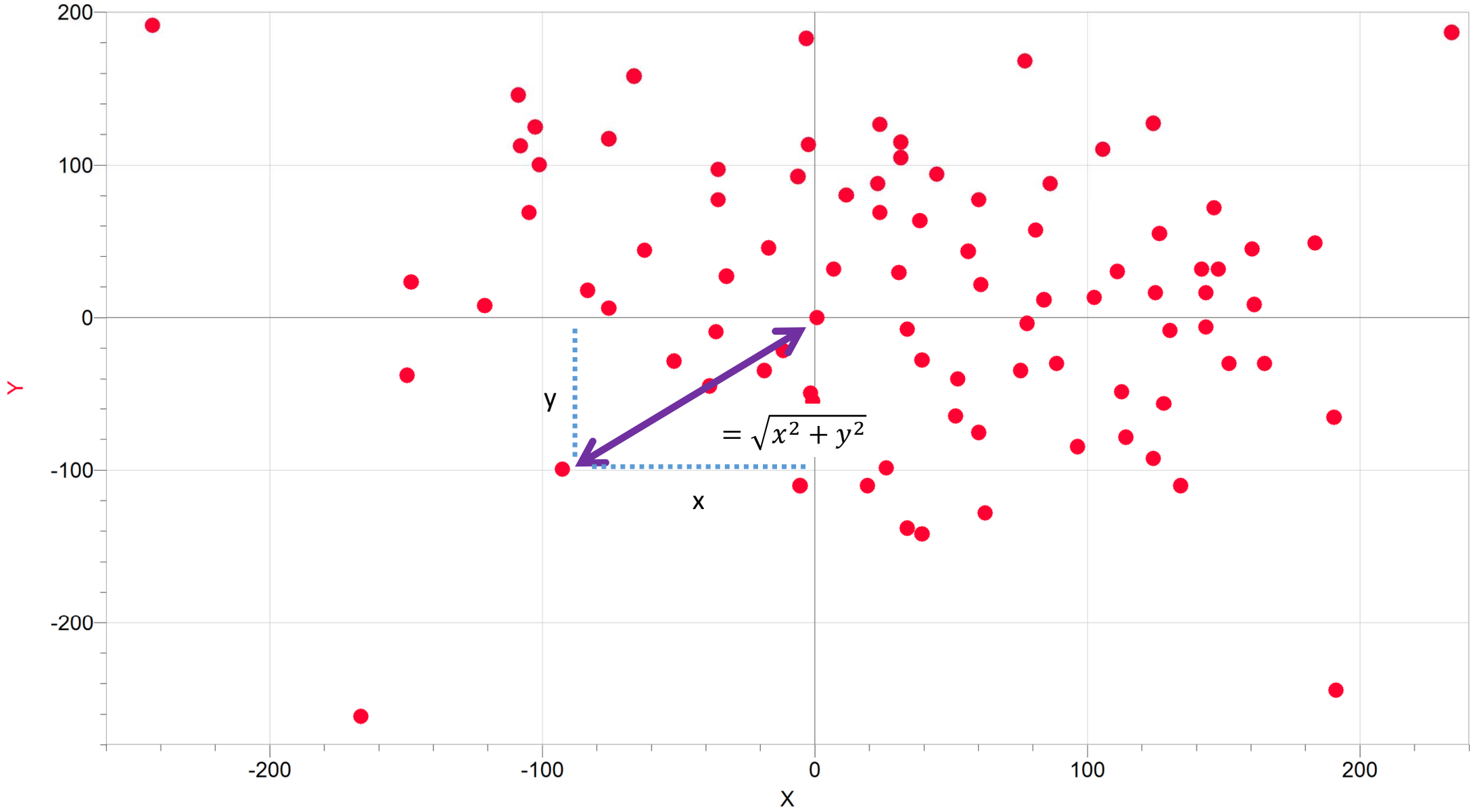
*: we measured one empty tank and its velocity distribution as follows:



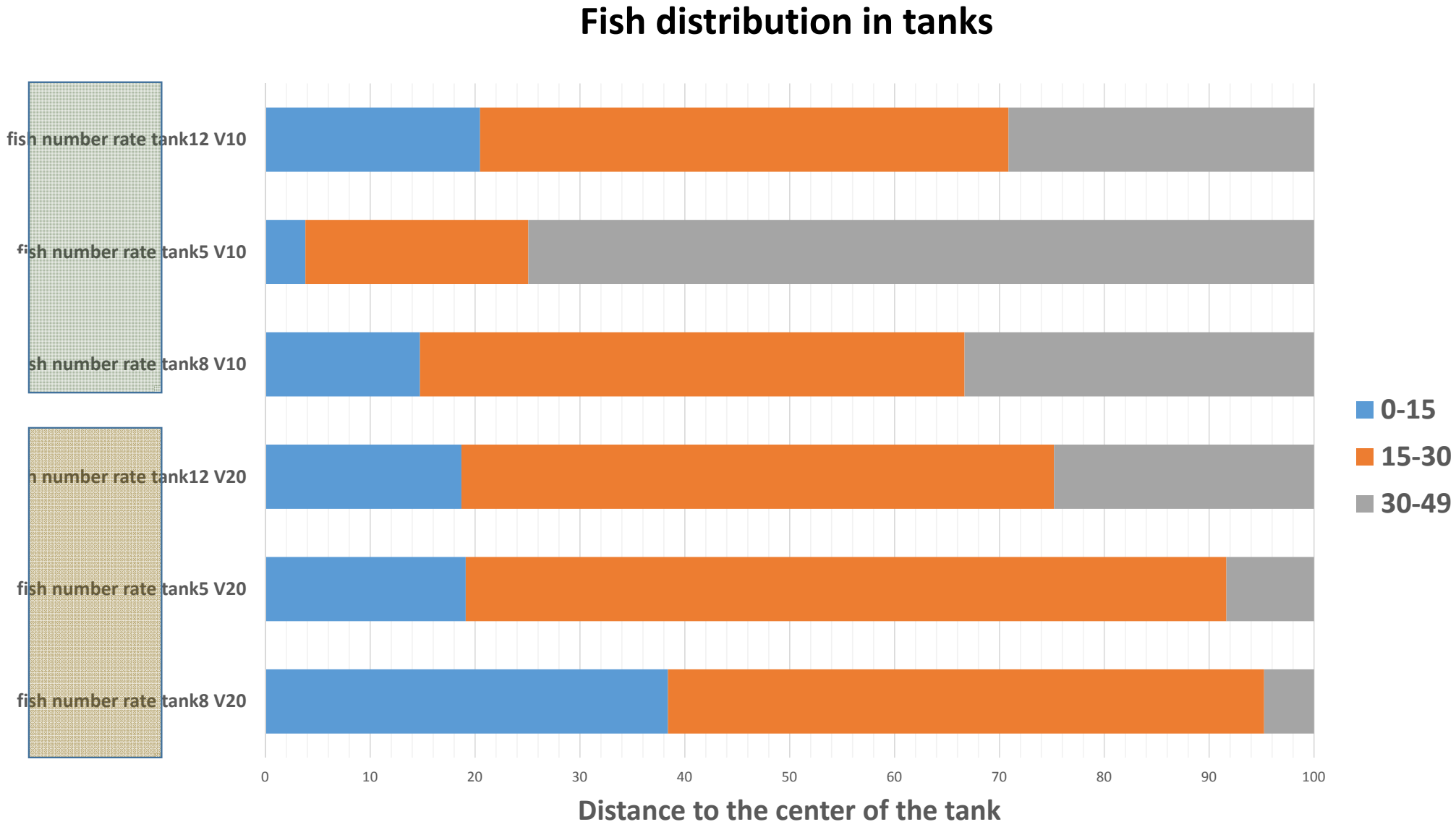
Measured Velocity:	**12,25**	**7**	**4,375**
Estimated Velocity:	**10**	5,71**	3,57**
Estimated Velocity:	**20**	11,43**	7,14**

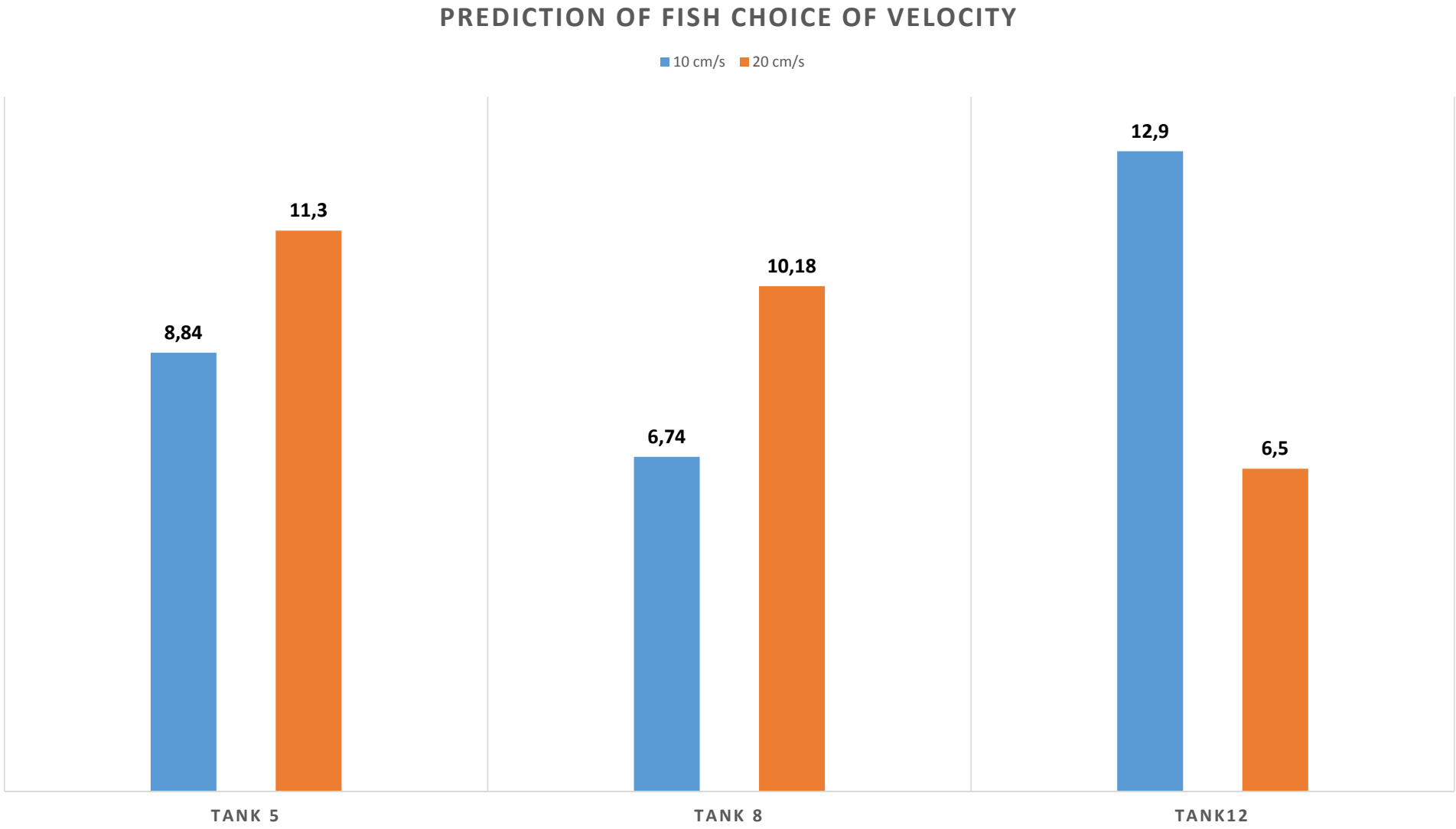
**: this values found by ratio and proportion
example: (10x7)/12,25 = 5,71


0/0
(-412, -261)
Upper semidiameter
Bottom semidiameter
Middle semidiameter:
=(upper + bottom)/2


200
100
0
-100
-200
Y
-200
-100
0
100
200
X
y
x
$= \sqrt{x^2 + y^2}$

		1st Counting	2nd Counting	3rd Counting	average	in 1 min	in 1 hour
Camera 2 (tank5)	20 cm/s	58	54	57	56	113	6760
	10 cm/s	40	32	34	35	71	4240
Camera 3 (tank12)	20 cm/s	74	64	62	67	133	8000
	10 cm/s	58	62	55	58	117	7000
Camera 1 (tank8)	20 cm/s	57	64	55	59	117	7040
	10 cm/s	50	47	43	47	93	5600


Fish distribution in tanks
fish number rate tank12 V10
fish number rate tank5 V10
sh number rate tank8 V10
n number rate tank12 V20
fish number rate tank5 V20
fish number rate tank8 V20
0-15
15-30
30-49
0
10
20
30
40
50
60
70
80
90
100
Distance to the center of the tank


PREDICTION OF FISH CHOICE OF VELOCITY
10 cm/s
20 cm/s
8,84
11,3
6,74
10,18
12,9
6,5
TANK 5
TANK 8
TANK12