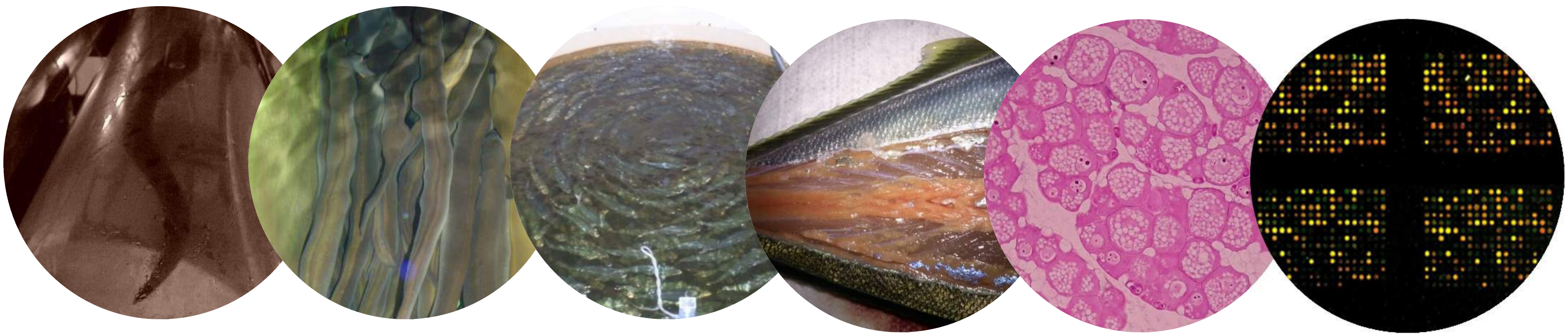
FITFISH course

Swimming Economy and Applications

Dr. Ir. Arjan P. Palstra (PhD) – Senior researcher and project leader aquaculture (fish physiology)

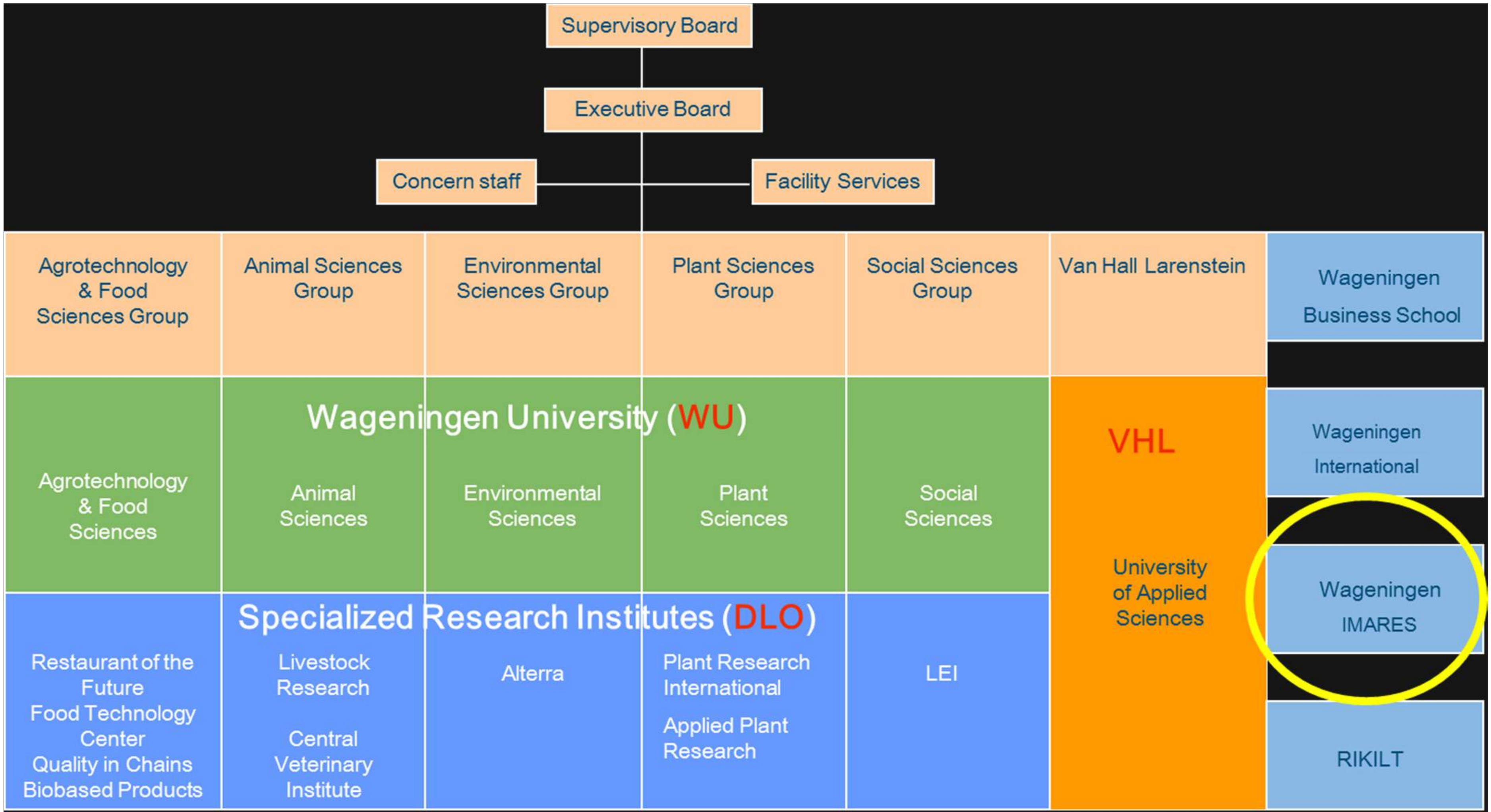
The Institute for Marine Resources and Ecosystem Studies (IMARES), Wageningen University & Research Centre, Yerseke, The Netherlands



IMARES WAGENINGEN UR

June 17 2015, Yerseke

Wageningen UR



IMARES
WAGENINGEN UR

IMARES locations, labs & offices

IJmuiden

Texel

Den Helder, Harssens

Den Helder, Ambachtsweg

Yerseke

IMARES
WAGENINGEN UR

IMARES facilities

- Indoor & outdoor
- Controlled & exposed
- Recirculation & flow-through
- Micro - meso & macro
- Fresh, salt, cold & warm water
- Flexibility
- Optimal monitoring
- Bio-secure & Hygienic
- Camera observation










Who are you?

- Introduce yourself
- Attendence form

FITFISH COST COURSE						
trainee	Daniel Nyqvist	PhD student	Karlstads University	Karlstad	Sweden	daniel.nyqvist@kau.se
trainee	Deniz D. Tosun	PhD	Istanbul University	Istanbul	Turkije	deniztosun@gmail.com
trainee	Ragnhild Aven Svalheim	PhD student	Nofima AS	Tromsø	Norway	Ragnhild.Svalheim@Nofima.no
trainee	Radu Suciu	PhD	Danube Delta National Institute	Tulcea	Romania	radu@ddni.ro
trainee	Marija Smederevac-Lalic	PhD	University of Belgrade	Belgrade	Serbia	marijasmederevac@imsi.rs
trainee	Stina Gustafsson	PhD student	Karlstads Universitet	Karlstad	Sweden	stina.gustafsson@kau.se
trainee	Maria Christou	PhD student	University of Crete		Greece	mchristou_1987@hotmail.com
trainee	Marian Paraschiv		Danube Delta National Institute	Tulcea	Romania	marian_psc@yahoo.com
trainee	Marisa Vedor	PhD student	University of Porto	Porto	Portugal	marisavedor@gmail.com
trainee	Carlos M. Alexandre	post doc	Universidade de Lisboa	Lisboa	Portugal	cmalexandre@fc.ul.pt
trainee	Anastasia Dimitriadi		University of Crete		Greece	ntavisia@gmail.com
trainee	Stefan Skorić	PhD	University of Belgrade	Belgrade	Serbia	stefanskoric@ibiss.bg.ac.rs
trainee	Ştefan Hontz		Danube Delta National Institute	Tulcea	Romania	stefan.hontz@ddni.ro
trainee	Marco Graziano	PhD	IMARES Wageningen UR	Yerseke	Netherlands	marco.graziano@wur.nl

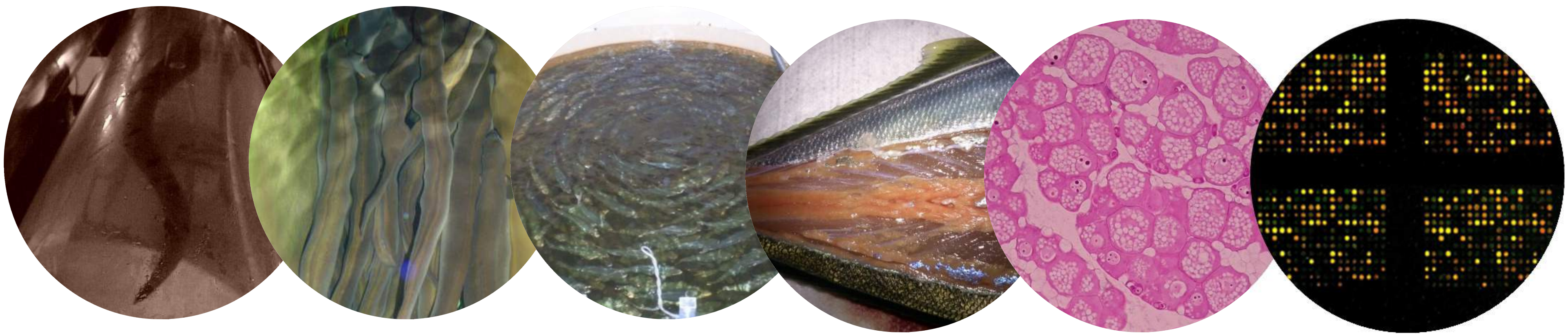
Programme

9.00	Coffee and introduction
9.30	Lecture I. Swimming economy of eel
10.00	Lecture II. Swimming for reproduction
10.30	Coffee
10.45	Lecture III. Optimal swimming and applications
11.15	Instructions Uopt experiment
11.45	Tour facilities
12.15	Lunch
14.00	Uopt experiment
16.00	Coffee
16.15	Analyses and synthesis of results

FITFISH course

Swimming Economy and Applications

Introduction COST Action FA1304: Swimming of fish and implications for migration and aquaculture (FITFISH)



IMARES
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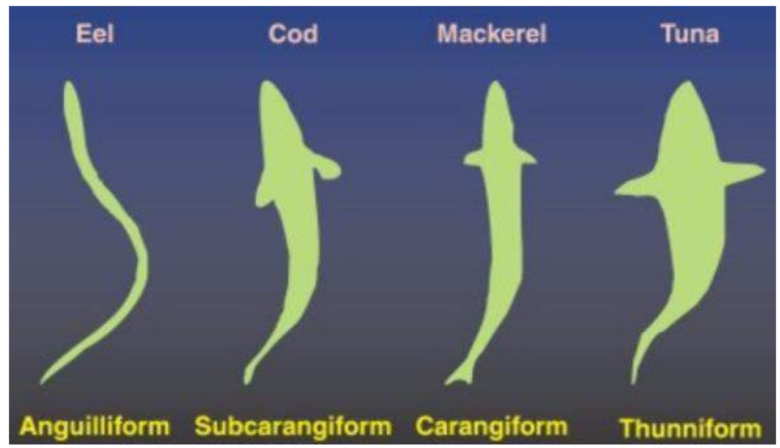
Beneficial effects of swimming exercise and implementation in aquaculture

The problem: Expansion of aquaculture is hindered by suboptimal fish health and welfare

Exercise has shown to:

1. Increase feeding efficiency;
2. Stimulate growth;
3. Improve health;
4. Reduce stress;
5. Lead to higher filet quality

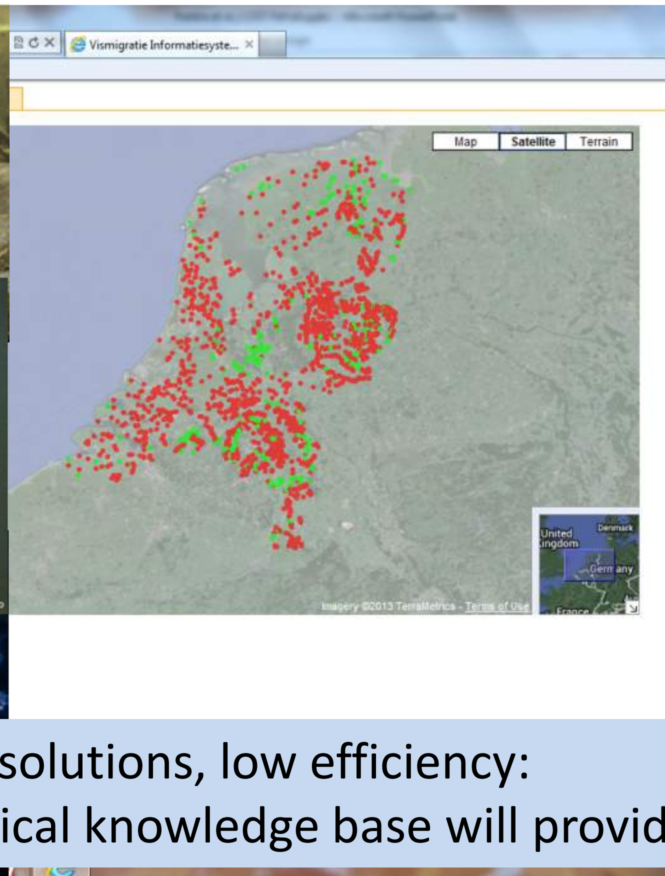


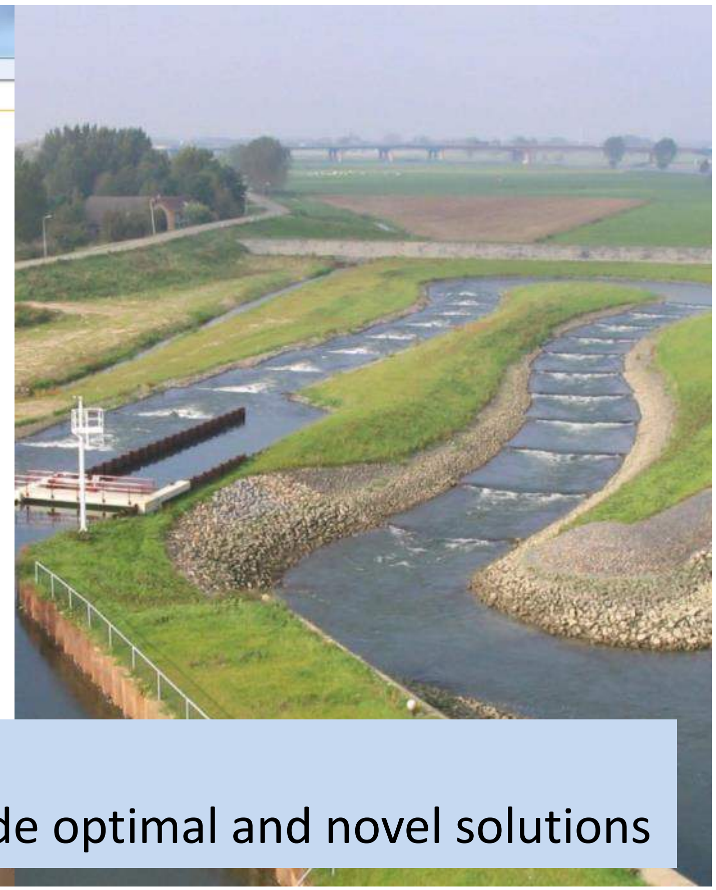
Exercise could be a tool!
a natural, non-invasive and economical approach to farm fit fish in aquaculture
and to improve health, welfare, growth and filet quality

FitFish

Expand knowledge base on swimming of fish and use for migration restoration

The problem: knowledge base not sufficient to provide biological solutions to restore fish migration



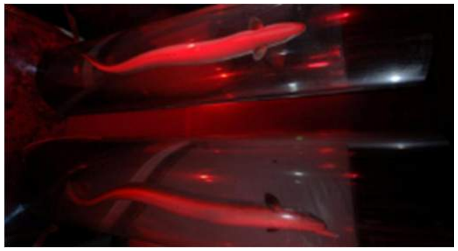


Many obstacles, few solutions, low efficiency:
expanding the biological knowledge base will provide optimal and novel solutions

Species and conditions

Aquaculture – practical examples of exercise as tool:

- Improve survival and general performance of Atlantic salmon (*Salmo salar*) smolts (Nofima)
- Reduce the incidence of precocious maturation in male seabass (University of Barcelona)
- To optimise growth and product quality of yellowtail kingfish (*Seriola lalandi*) (IMARES)



Migration – practical examples where knowledge is required:

- Hydropower bypass design e.g. for downstream silver eel migration in autumn
- Reintroductions of migrants Atlantic salmon and sturgeon
- Impact of noise (shipping), contamination, fisheries on fish migration
- Abrupt vs gradual migration transitions (e.g. fresh – seawater)

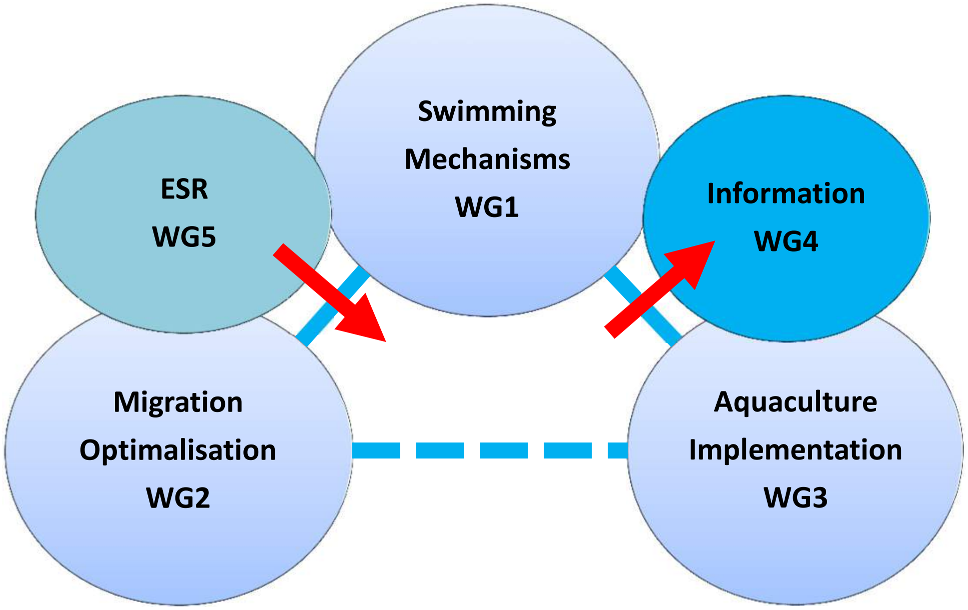
(let's not forget that it also works the other way around: because of obstructions we learn about migration mechanisms!)

Key objectives (I)

to strengthen and improve our knowledge on **swimming of fish**
and its applicability in improving the status of **wild** and **farmed** fish
by bringing together **research** and **industrial partners** with **policy makers**:

A novel research line that will be essential for a sustainable future of fit fish in nature and in aquaculture

Key words: capacity building; integration; leverage national investments; global relevance; impact; early stage researchers; inter-disciplinarity



Key objectives (II)

1) Evaluation of existing knowledge on the functional **mechanisms** behind beneficial exercise effects and identification of gaps in our knowledge for targeting future research efforts;
2) Evaluation of existing fish **migration** data, monitoring methodology for tracking migrant fish and bypass design, and the use of expertise within the platform to identify potential improvements;
3) The use of expertise within the platform to evaluate existing swimming data, to identify gaps in our knowledge for targeting future research efforts and to design **optimal exercise protocols** for specific species and conditions;
4) The use of expertise within the platform for the development of **new technology**;
5) The use of the established research network to search for **collaborative project opportunities**;
6) Set-up communication with policy makers (aquaculture, fisheries, environment and food authorities) for setting **directions for policy and future studies**;
7) Set-up communication with the industry to explore the feasibility for **application of exercise enhancement** in aquaculture;
8) Transfer of **knowledge** between scientists, industry and policy makers;
9) The use of the multidisciplinary nature of the platform to **disseminate** scientific reviews;
10) Construction of a **website**;
11) **Training** of early stage researchers;
12) **Exchange** of early stage researchers.

Structure and management of the Action and participants

1) Management Committee (MC) representing 21 COST countries with each 1-2 representatives and the Chair (the Proposer) and Vice-Chair
2) 5 Working Groups (WGs) each consisting of a Working Group leader and vice leader and participants

Chair of the Action:
Dr Arjan PALSTRA (NL)
Vice Chair of the Action:
Dr Josep PLANAS (ES)
Science officer of the Action:
Dr Ioanna STAVRIDOU
Administrative officer of the Action:
Mr Christophe PEETERS

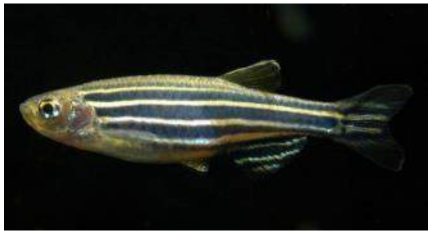
COST member countries

Austria	Lithuania
Belgium	Luxembourg
Bosnia and Herzegovina	Malta
Bulgaria	Netherlands
Croatia	Norway
Cyprus	Poland
Czech Republic	Portugal
Denmark	Romania
Estonia	Serbia
Finland	Slovakia
France	Slovenia
Germany	Spain
Greece	Sweden
Hungary	Switzerland
Iceland	Turkye
Ireland	UK
Italy	Macedonia
Latvia	

Workshop and training school topics

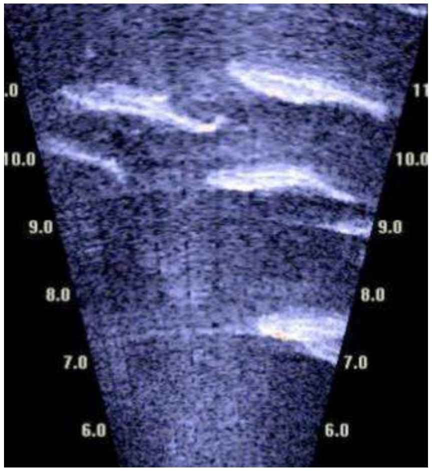
WG1

- Physiological responses to swimming: species and conditions
- Functional mechanisms behind the beneficial effects of swimming and ways to study them
- Methods for the induction of swimming



WG2

- Monitoring fish behaviour in real-life situations
- Experimental approaches to study disturbing cues on behaviour and physiology
- Modelling the effects of mitigating measures on population dynamics

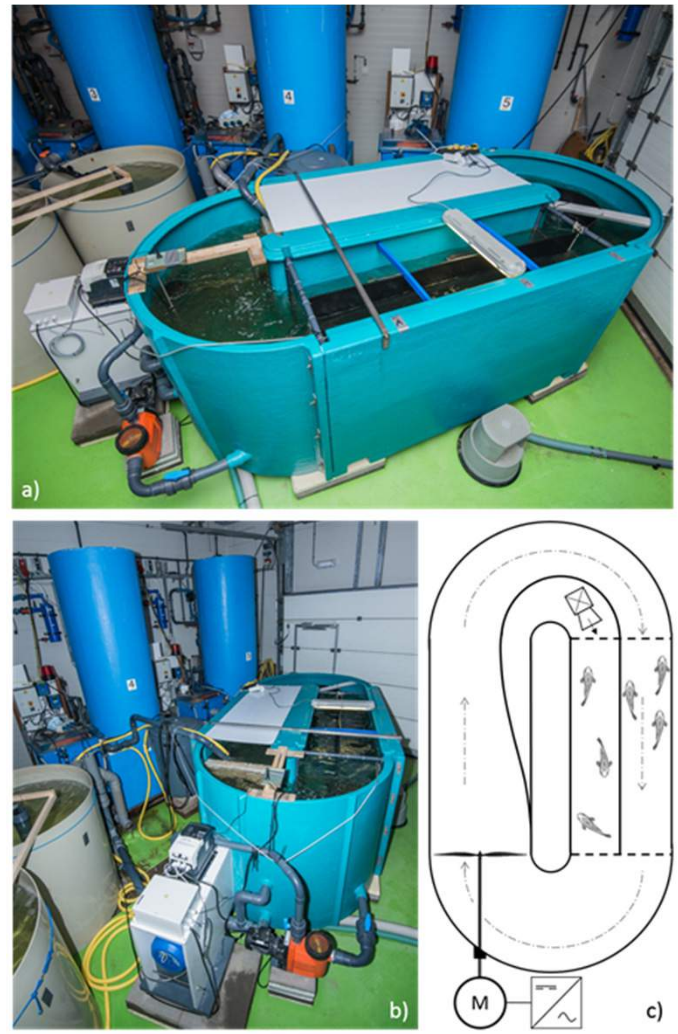


WG3

- State-of-the-art in exercise training by swimming in farmed fish
- Methods for measuring water current in land and sea-based systems
- Methods for manipulation of swimming behaviour in production systems

Examples on how to study fish swimming

Swim-tunnels and a swim-carousel at IMARES



Examples on how to study fish swimming

Optoswim: aquaculture lighting technology that stimulates the fish's optomotor response in order to encourage exercise through sustained swimming at optimal speeds

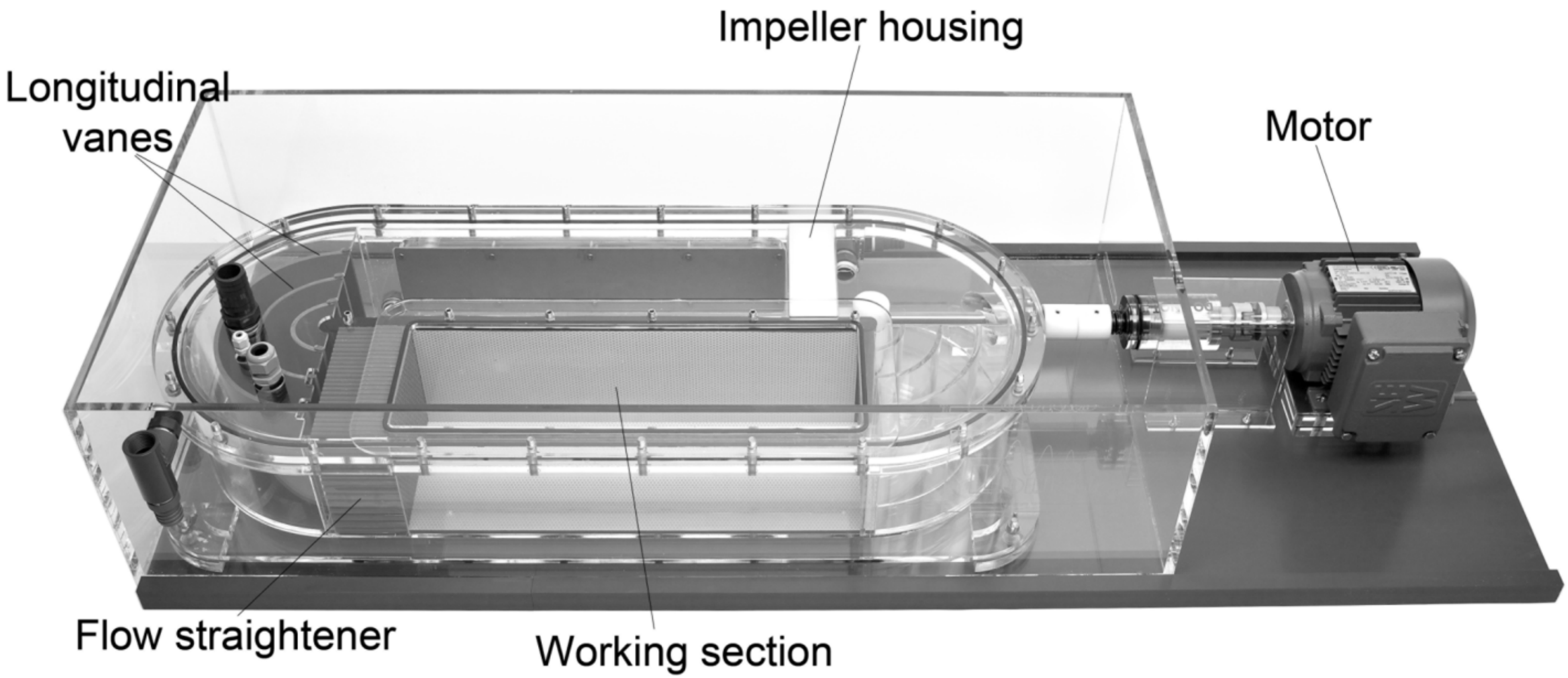
OptoSwim

UNIVERSITY OF STIRLING

University of Glasgow

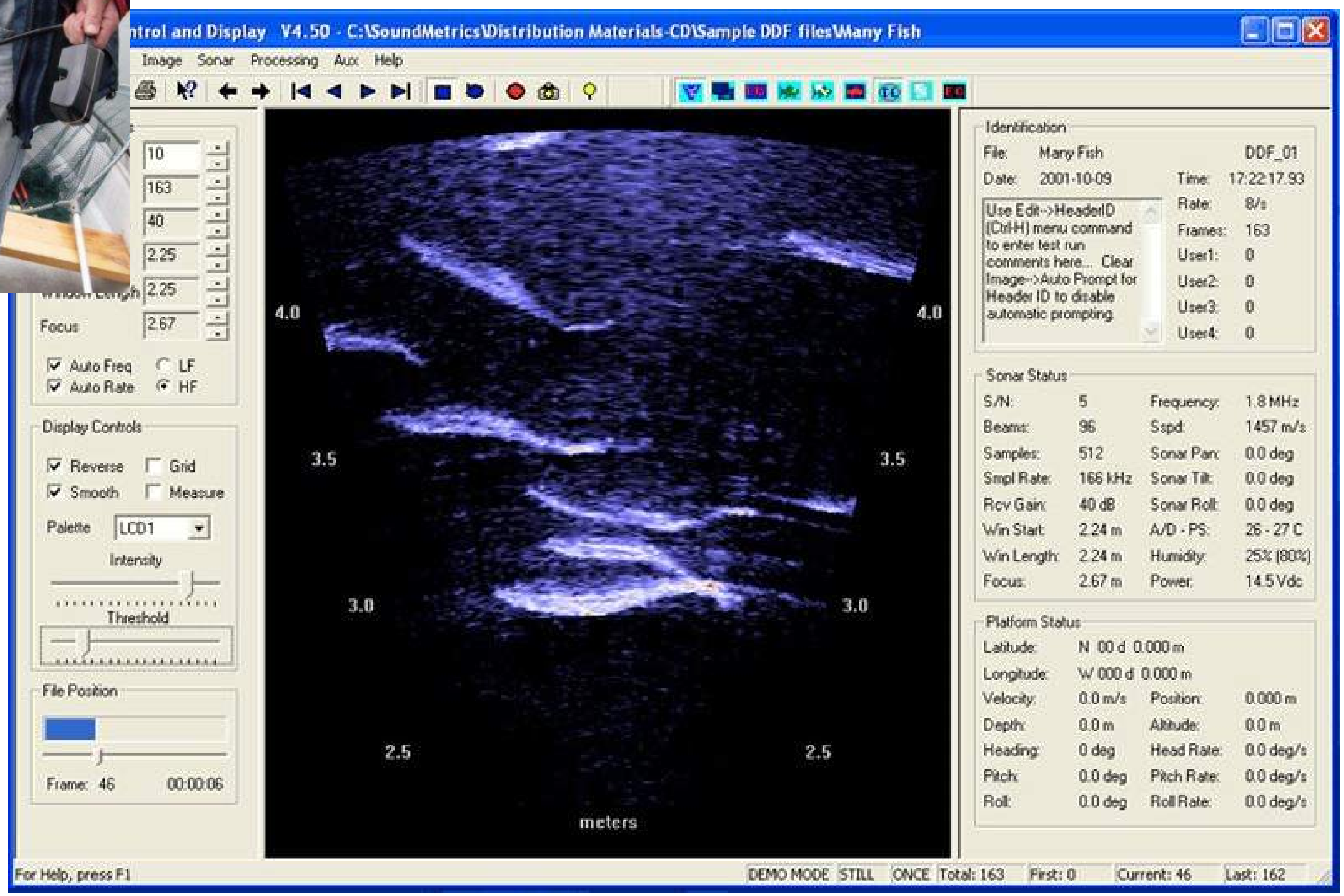
Examples on how to study fish swimming

Loligo: products for aquatic animal ecophysiology and behavior analysis: swim-tunnels and respirometry



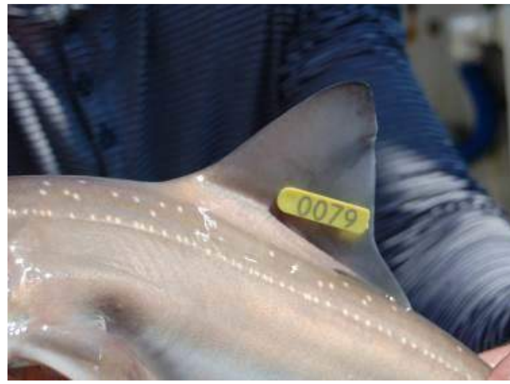
Examples on how to study fish swimming

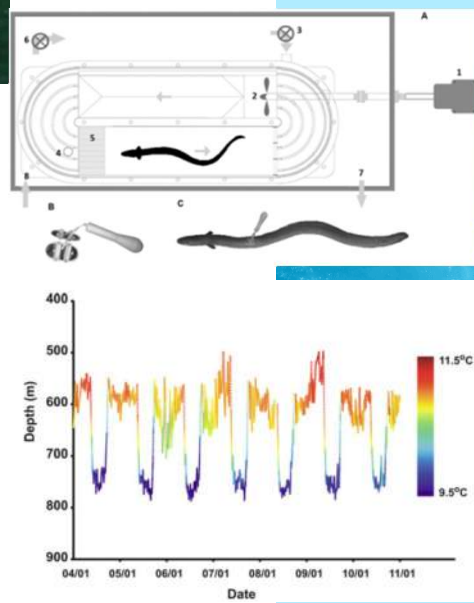
DIDSON: Dual frequency IDentfication SONar

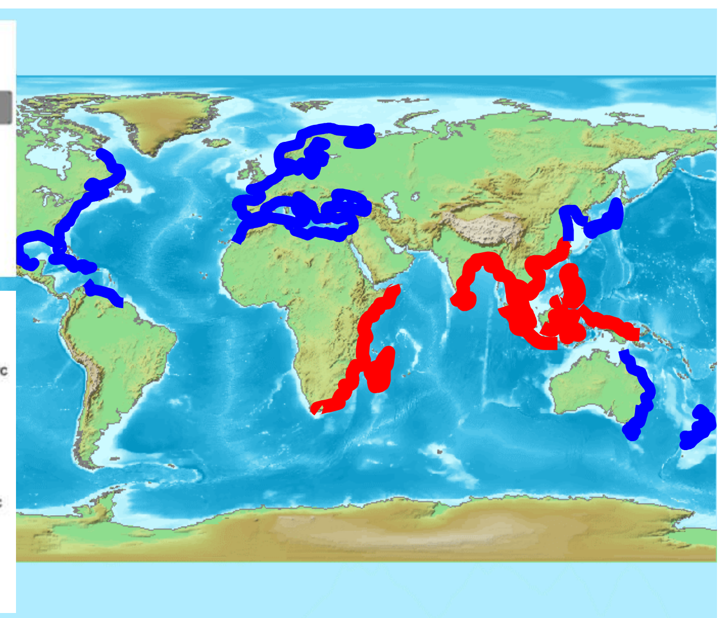


Examples on how to study fish swimming

Telemetry (data collected at remote or inaccessible points and transmitted to receiving equipment for monitoring)







Scientific deliverables

- Integrative new insights on the basic swimming physiology of fish;
- Improved understanding of how fish migrate and how that changes in the light of a changing environment;
- Improved fish welfare and production;
- Technological breakthroughs:
  - Monitoring of migrant fish;
  - Improved telemetry and tracking software;
  - Fish migration bypass design;
  - Exercise raceway design;
  - Design of exercise-“friendly” fish farming facilities;
  - Technologies to induce swimming;
  - Technologies to measure swimming performance;
  - Development of tailor made feeds for athletic fish;
  - Development of robotic fish to lead the school.

- Training ground for early stage researchers
- Dissemination and communication of new scientific knowledge and technological development (*next slides*)

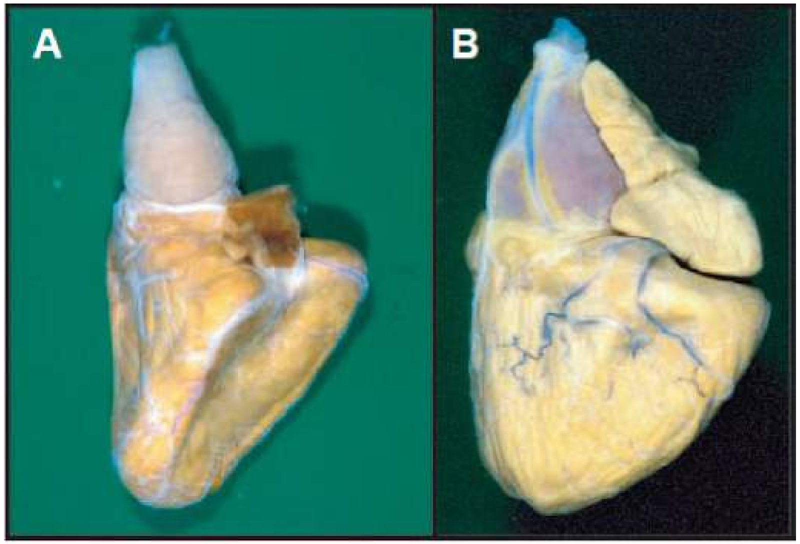
Dissemination – Who?

End users:

- Aquaculture industry (farmers, designers, engineers, processors and traders)
  faster production, higher production, higher quality production, improved welfare conditions
- Fish food industry
  producing new custom made feeds for athletic fishes
- Environmental agencies
  newly designed tracking devices
  improved fish bypasses
- Recently / to be established SMEs
  develop swimming technologies

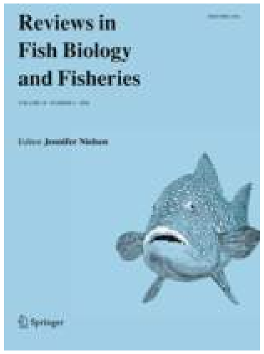
- International, national and regional governmental bodies
- Scientists
- General public

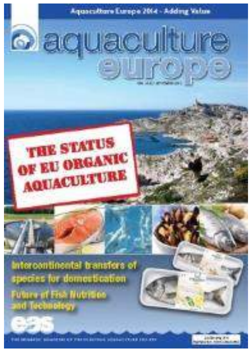
Heart of exercised (A) and non-exercised (B) smolts (Castro, 2012):



Dissemination – What and how?

- "e-group" communication system, WG meetings, a WG reporting system and meetings of the MC
- annual workshops and training schools as satellite events to international congresses
- 4 progress reports as basis for at least 2 reviews
  - opportunities for exercise implementation in aquaculture
  - strengthening the scientific base for fish migration
- Popular scientific papers in national and international magazines
- ready-to-apply recommendations for the aquaculture industry, environmental agencies and governments
- website, press release(s) and Social media





e.g. REPROSWIM project EC succes story:

Scientific fitness trials show exercise helps fish reach sexual maturity

Exercise has been proved to make farmed fish happier and healthier, in turn providing consumers with better-quality food. Now, a team of European researchers have applied the fitness model to reproduction studies in fish in a bid to speed up their sexual maturity and increase stocks. The research has already shown increases in rates of growth in zebrafish.

FITFISH evolution

2010 FitFish workshop on Swimming Physiology of Fish

2011 Special issue of Fish Physiology and Biochemistry

2013 Springer book: Swimming Physiology of Fish. Towards using exercise to farm fit fish in sustainable aquaculture

2-yearly symposia at the Int. Congress on the Biology of Fish (Barcelona 2010; Madison 2012; Edinburgh 2014)

2014 COST action
to consolidate and continue the development and activities of the already established network of experts

(FitFish received the full score on A4: need for networking, and B3: involvement of stakeholders)

FitFish

Industry stakeholders

aquacultureinnovation

SKRETTING
a Nutreco company

Loligo® Systems

atkb
CONSULTANCY FOR WATER, SOIL AND ECOLOGY

Grontmij

SILT
YELLOWTAIL KINGFISH

VisAdvies
Ecological consultancy & research

WANNINGEN
WATER CONSULT

Related COST actions and running projects

- FA COST Action 867 “Welfare of fish in European aquaculture”
- FA COST Action 1004 “Conservation Physiology of Marine Fishes”
- FA COST Action 1205 “Assessing and improving the quality of aquatic animal gametes to enhance aquatic resources”

- EU FP7 FISHBOOST
- EU FP7 DIVERSIFY
- EU FP7 COPEWELL
- EU FP7 AQUAEXCEL (SWIMBASS)
- EU FP7 Marie Curie reintegration grant SWIMFIT
- VIP / EFF KINGKONG
- VIP / EFF Innovative Eel Reproduction
- 5 NRC projects on salmon smolts

Programme 2014-2015

24/04/2014	MC meeting 1 in Brussels
06/08/2014	FITFISH satellite event at ICBF2014 in Edinburgh
09-10/10/2014	The 2nd international workshop on the Swimming Physiology of Fish in Barcelona, MC meeting 2 and WG meetings
15-19/06/2015	Training school

- Short Term Scientific Missions
- Special issue Frontiers Aquatic Physiology: Physiological Adaptations to Swimming in Fish
- Website www.fitfish.eu

Programme 2015 WG meetings 1-2-3

FISH PASSAGE 2015

International conference on river connectivity best practices and innovations

June 22-24, 2015 | Groningen (The Netherlands)

ELSEVIER

aquaculture 2015

Cutting Edge Science in Aquaculture

23-26 August 2015
Montpellier, France

Aquaculture, Nature and Society

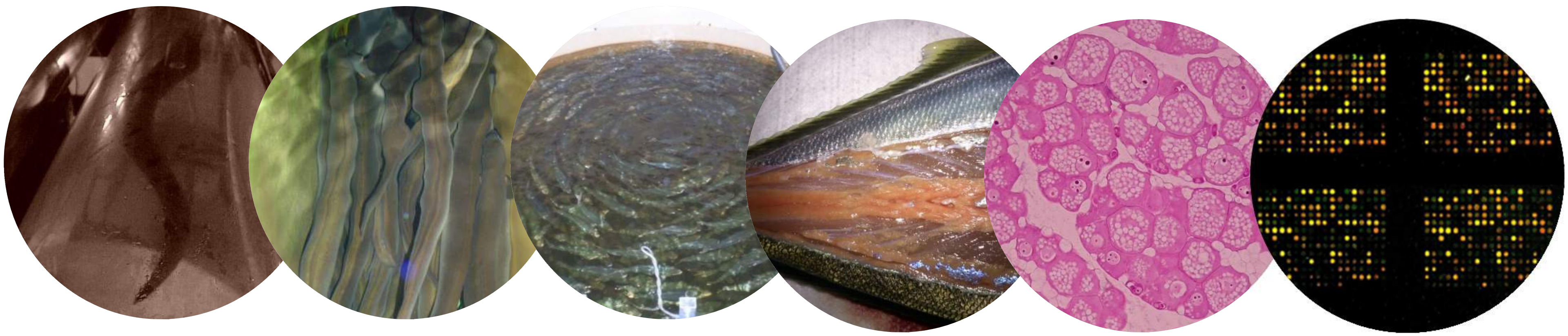
aquaculture europe 15

ROTTERDAM • OCTOBER 20-23, 2015

FITFISH course

Swimming Economy and Applications

Instructions Uopt experiment



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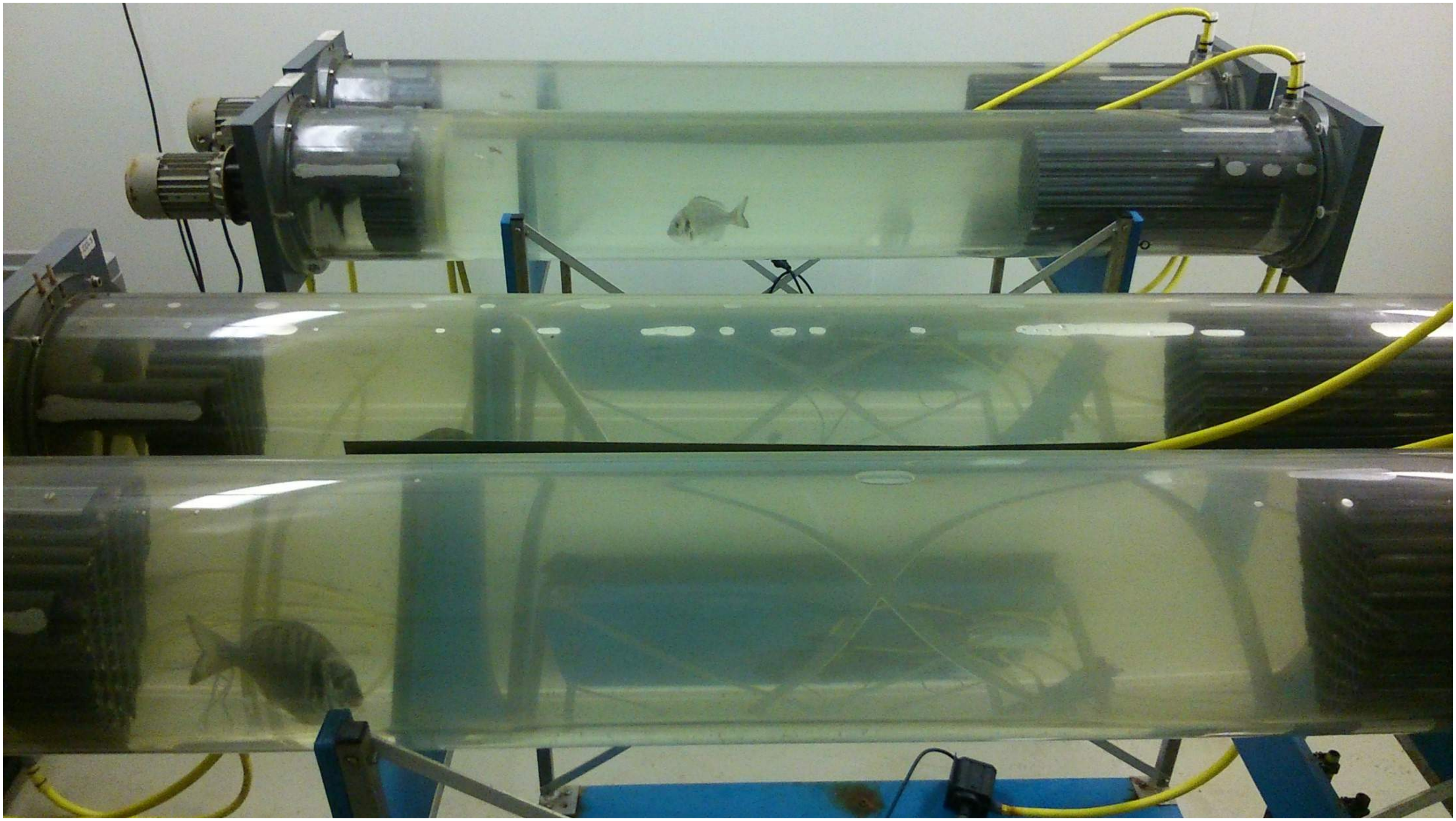
DEMO

- 4 Blazka type swim-tunnels
- Loligo oxygen electrodes
- 2 eels, 2 salmons
- Swimming speeds: 0.4, 0.6, 0.8 m/s
- 40 min per speed: 30 min closed, 10 min flush



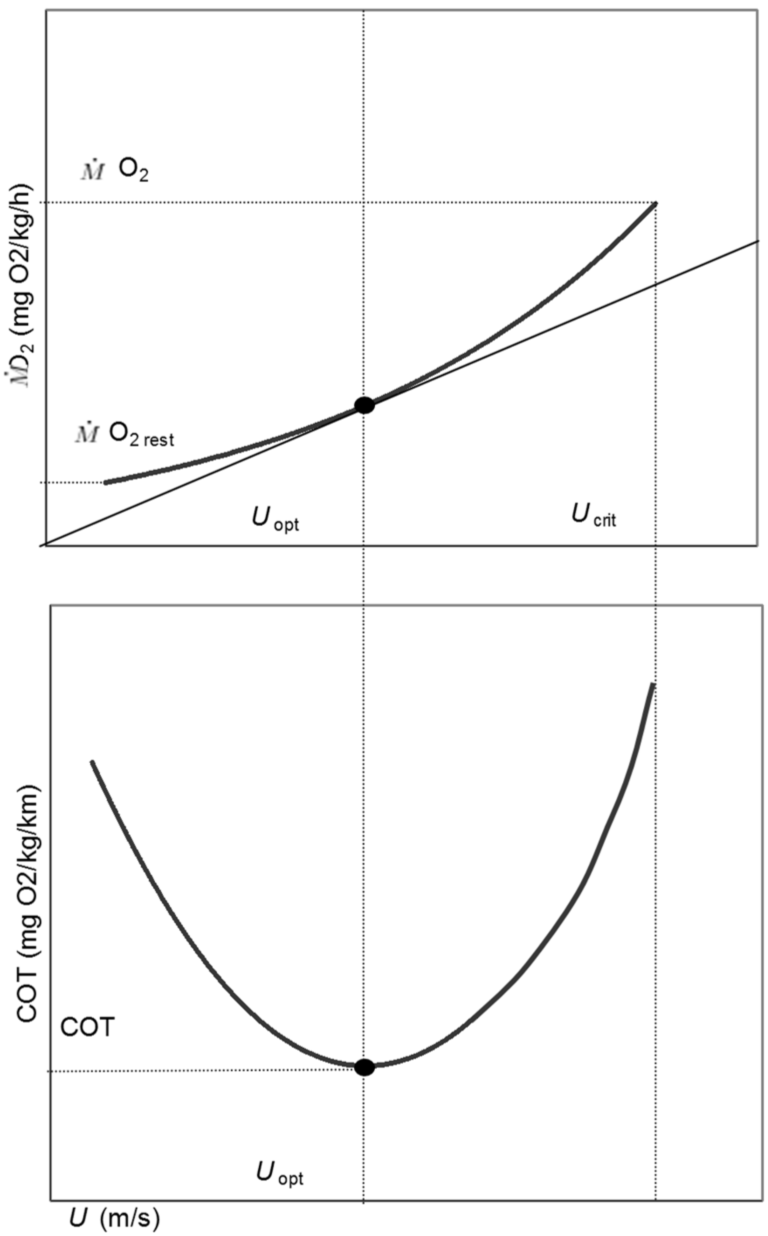
Experimental fish

		TL (cm)	BW (g)
Tunnel 15	salmon 1	15.0	37.7
Tunnel 16	**salmon 2**	**15.8**	**43**
Tunnel 11	eel 1	39.1	130
Tunnel 12	**eel 2**	**44.1**	**162**

7 persons individually for eel, 7 persons individually for salmon

Assignments:

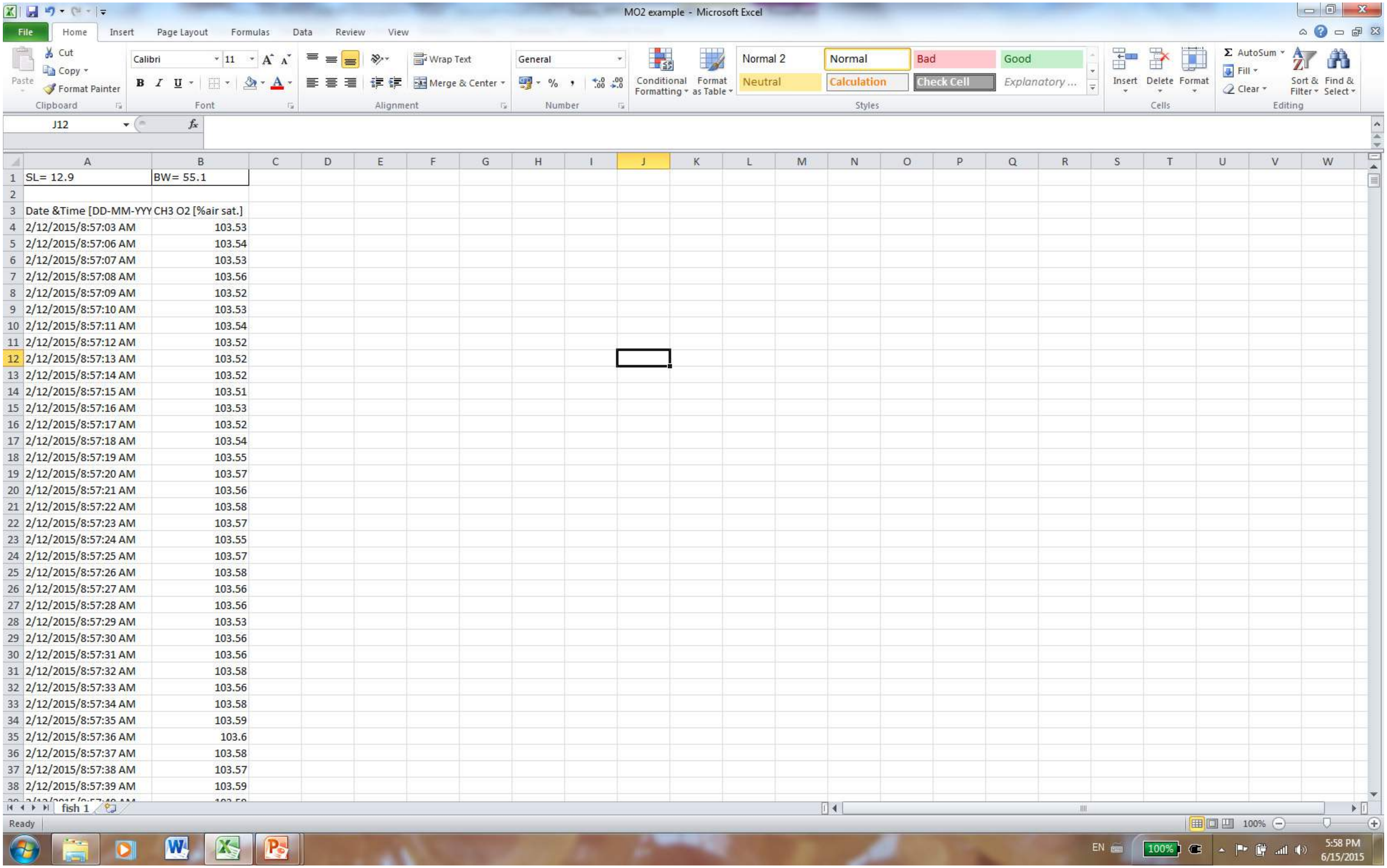
1. Calculate COT at 0.4, 0.6 m/s for 1 salmon (t16-ch4)
2. Calculate COT at 0.4 and 0.6 m/s for 1 eel (t12-ch2)
3. Compare COT at 0.4 and 0.6 m/s eel vs salmon



Swim Parameters following a.o. Brett (1964):

- MO_2 rest (mg/kg/h)
- MO_2 max (mg/kg/h) at sub-critical swim speeds
- U_{crit} - Critical Swim Speed (BL/s or m/s)
- U_{opt} - Optimum Swim Speed (BL/s or m/s) at lowest COT
- COT - Cost of Transport (mg/kg/km)

Raw data: SL, BW, date-time, % air sat.



	A	B
1	SL= 12.9	BW= 55.1
2		
3	Date &Time [DD-MM-YYY	CH3 O2 [%air sat.]
4	2/12/2015/8:57:03 AM	103.53
5	2/12/2015/8:57:06 AM	103.54
6	2/12/2015/8:57:07 AM	103.53
7	2/12/2015/8:57:08 AM	103.56
8	2/12/2015/8:57:09 AM	103.52
9	2/12/2015/8:57:10 AM	103.53
10	2/12/2015/8:57:11 AM	103.54
11	2/12/2015/8:57:12 AM	103.52
12	2/12/2015/8:57:13 AM	103.52
13	2/12/2015/8:57:14 AM	103.52
14	2/12/2015/8:57:15 AM	103.51
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20	2/12/2015/8:57:21 AM	103.56
21	2/12/2015/8:57:22 AM	103.58
22	2/12/2015/8:57:23 AM	103.57
23	2/12/2015/8:57:24 AM	103.55
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25	2/12/2015/8:57:26 AM	103.58
26	2/12/2015/8:57:27 AM	103.56
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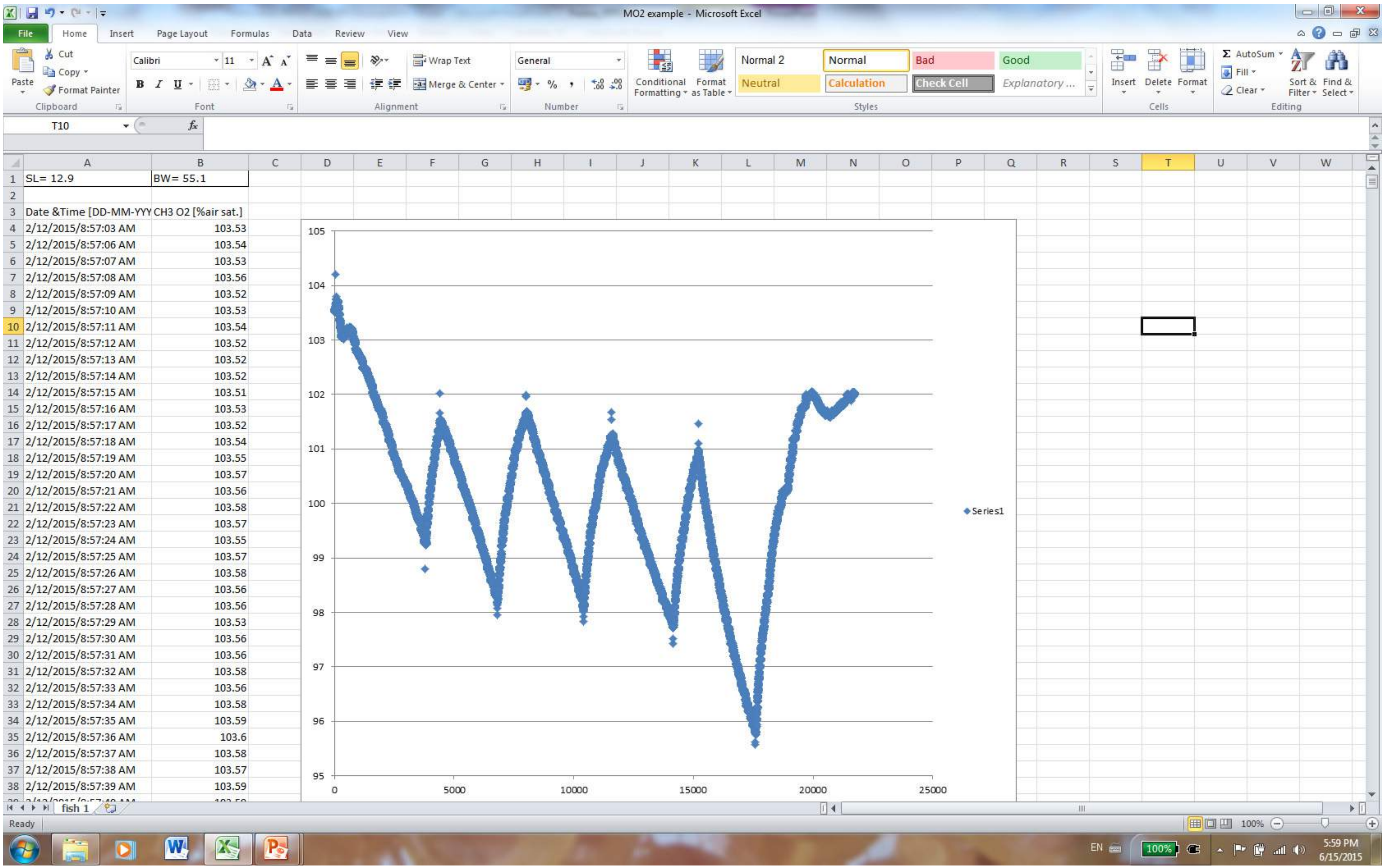
32	2/12/2015/8:57:33 AM	103.56
33	2/12/2015/8:57:34 AM	103.58
34	2/12/2015/8:57:35 AM	103.59
35	2/12/2015/8:57:36 AM	103.6
36	2/12/2015/8:57:37 AM	103.58
37	2/12/2015/8:57:38 AM	103.57
38	2/12/2015/8:57:39 AM	103.59

Plot % air sat. vs. time



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9	2/12/2015/8:57:10 AM	103.53
10	2/12/2015/8:57:11 AM	103.54
11	2/12/2015/8:57:12 AM	103.52
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33	2/12/2015/8:57:34 AM	103.58
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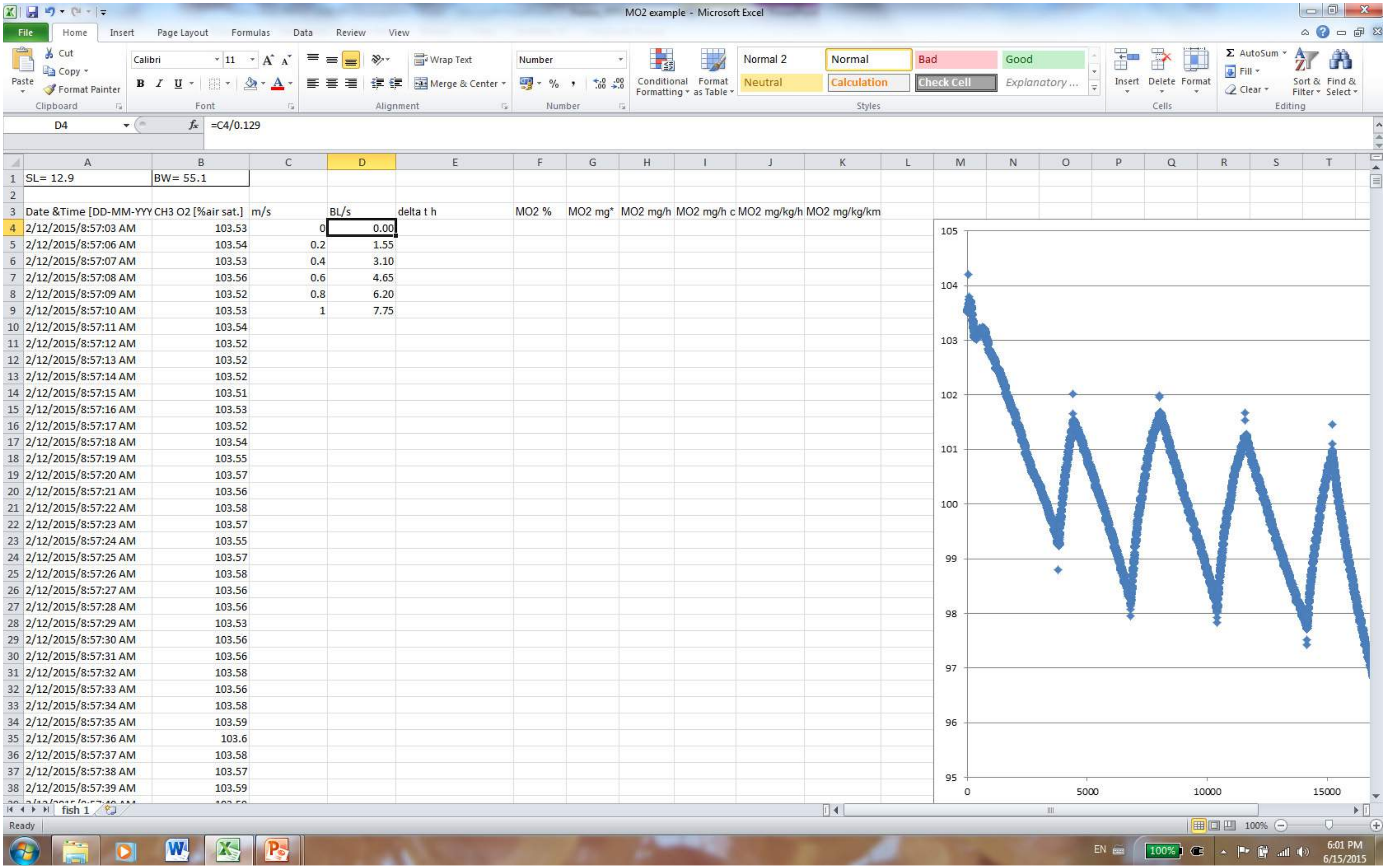
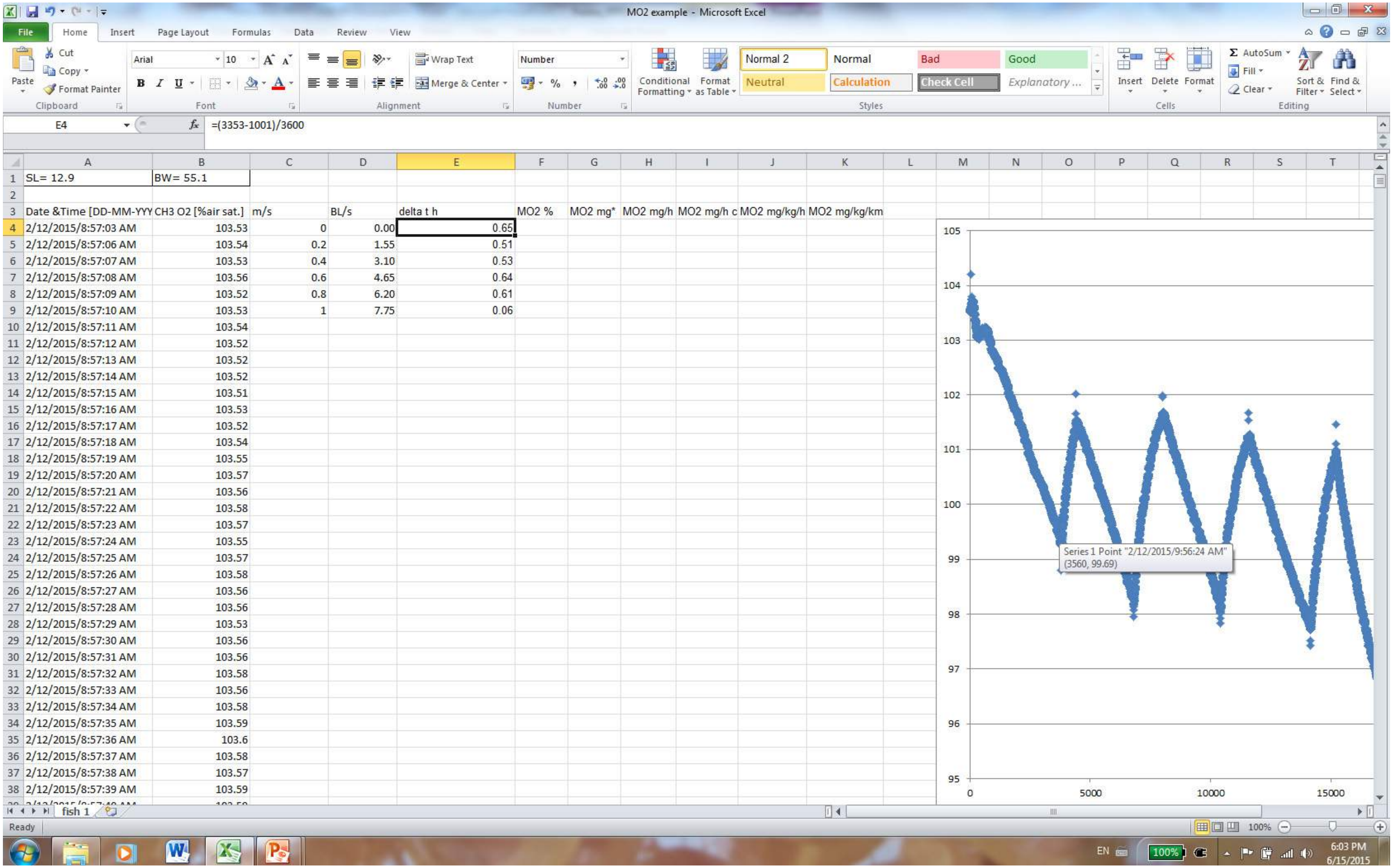
35	2/12/2015/8:57:36 AM	103.6
36	2/12/2015/8:57:37 AM	103.58
37	2/12/2015/8:57:38 AM	103.57
38	2/12/2015/8:57:39 AM	103.59

Swimming speed in BL/s



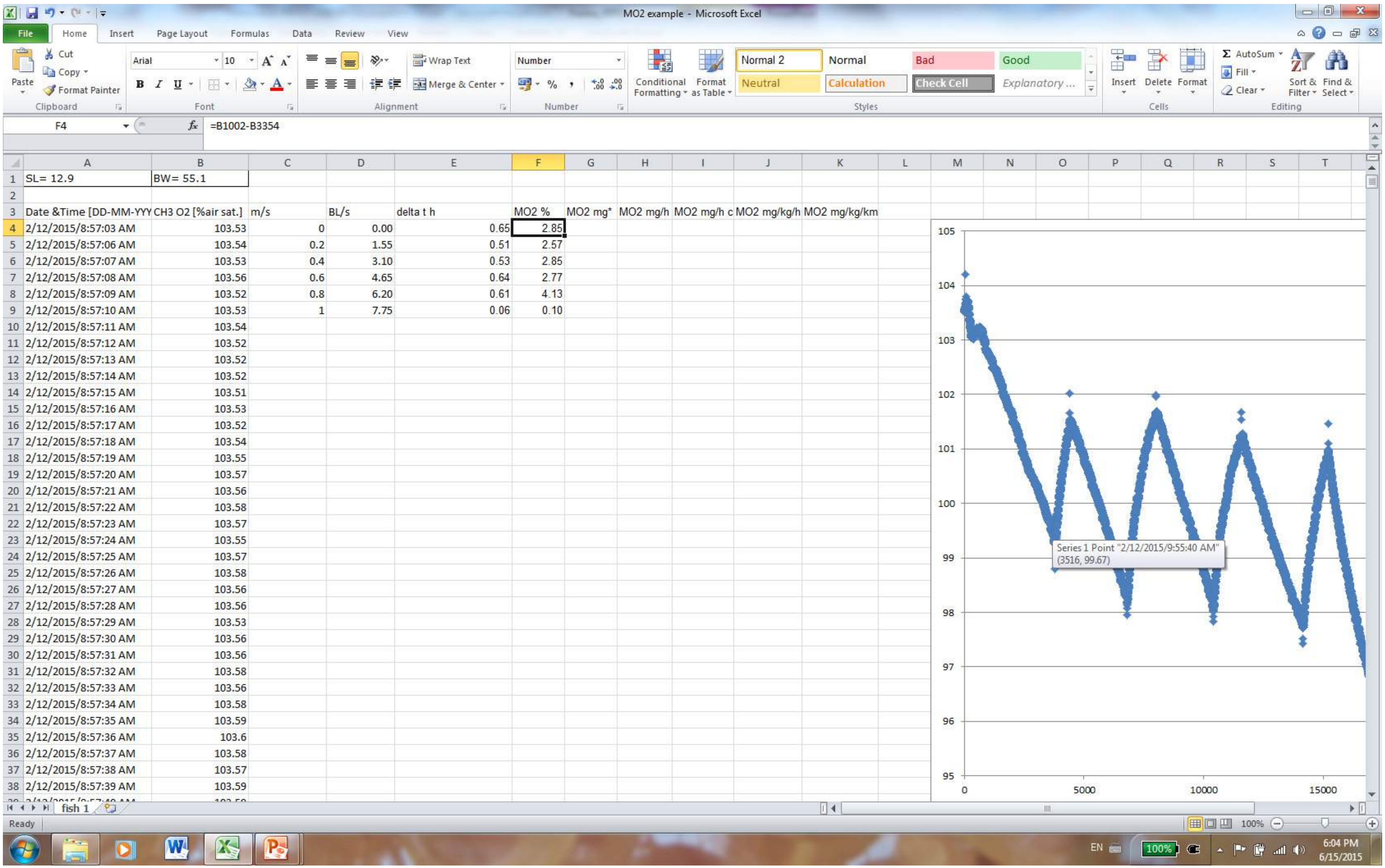
	A	B	C	D	E	F	G	H	I	J	K
1	SL= 12.9	BW= 55.1									
2											
3	Date &Time [DD-MM-YYY	CH3 O2 [%air sat.]	m/s	BL/s	delta t h	MO2 %	MO2 mg*	MO2 mg/h	MO2 mg/h c	MO2 mg/kg/h	MO2 mg/kg/km
4	2/12/2015/8:57:03 AM	103.53	0	0.00							
5	2/12/2015/8:57:06 AM	103.54	0.2	1.55							
6	2/12/2015/8:57:07 AM	103.53	0.4	3.10							
7	2/12/2015/8:57:08 AM	103.56	0.6	4.65							
8	2/12/2015/8:57:09 AM	103.52	0.8	6.20							
9	2/12/2015/8:57:10 AM	103.53	1	7.75							
10	2/12/2015/8:57:11 AM	103.54									
11	2/12/2015/8:57:12 AM	103.52									
12	2/12/2015/8:57:13 AM	103.52									
13	2/12/2015/8:57:14 AM	103.52									
14	2/12/2015/8:57:15 AM	103.51									
15	2/12/2015/8:57:16 AM	103.53									
16	2/12/2015/8:57:17 AM	103.52									
17	2/12/2015/8:57:18 AM	103.54									
18	2/12/2015/8:57:19 AM	103.55									
19	2/12/2015/8:57:20 AM	103.57									
20	2/12/2015/8:57:21 AM	103.56									
21	2/12/2015/8:57:22 AM	103.58									
22	2/12/2015/8:57:23 AM	103.57									
23	2/12/2015/8:57:24 AM	103.55									
24	2/12/2015/8:57:25 AM	103.57									
25	2/12/2015/8:57:26 AM	103.58									
26	2/12/2015/8:57:27 AM	103.56									
27	2/12/2015/8:57:28 AM	103.56									
28	2/12/2015/8:57:29 AM	103.53									
29	2/12/2015/8:57:30 AM	103.56									
30	2/12/2015/8:57:31 AM	103.56									
31	2/12/2015/8:57:32 AM	103.58									
32	2/12/2015/8:57:33 AM	103.56									
33	2/12/2015/8:57:34 AM	103.58									
34	2/12/2015/8:57:35 AM	103.59									
35	2/12/2015/8:57:36 AM	103.6									
36	2/12/2015/8:57:37 AM	103.58									
37	2/12/2015/8:57:38 AM	103.57									
38	2/12/2015/8:57:39 AM	103.59									

Time period (use plot)



	A	B	C	D	E	F	G	H	I	J	K
1	SL= 12.9	BW= 55.1									
2											
3	Date &Time [DD-MM-YYY	CH3 O2 [%air sat.]	m/s	BL/s	delta t h	MO2 %	MO2 mg*	MO2 mg/h	MO2 mg/h c	MO2 mg/kg/h	MO2 mg/kg/km
4	2/12/2015/8:57:03 AM	103.53	0	0.00	0.65						
5	2/12/2015/8:57:06 AM	103.54	0.2	1.55	0.51						
6	2/12/2015/8:57:07 AM	103.53	0.4	3.10	0.53						
7	2/12/2015/8:57:08 AM	103.56	0.6	4.65	0.64						
8	2/12/2015/8:57:09 AM	103.52	0.8	6.20	0.61						
9	2/12/2015/8:57:10 AM	103.53	1	7.75	0.06						
10	2/12/2015/8:57:11 AM	103.54									
11	2/12/2015/8:57:12 AM	103.52									
12	2/12/2015/8:57:13 AM	103.52									
13	2/12/2015/8:57:14 AM	103.52									
14	2/12/2015/8:57:15 AM	103.51									
15	2/12/2015/8:57:16 AM	103.53									
16	2/12/2015/8:57:17 AM	103.52									
17	2/12/2015/8:57:18 AM	103.54									
18	2/12/2015/8:57:19 AM	103.55									
19	2/12/2015/8:57:20 AM	103.57									
20	2/12/2015/8:57:21 AM	103.56									
21	2/12/2015/8:57:22 AM	103.58									
22	2/12/2015/8:57:23 AM	103.57									
23	2/12/2015/8:57:24 AM	103.55									
24	2/12/2015/8:57:25 AM	103.57									
25	2/12/2015/8:57:26 AM	103.58									
26	2/12/2015/8:57:27 AM	103.56									
27	2/12/2015/8:57:28 AM	103.56									
28	2/12/2015/8:57:29 AM	103.53									
29	2/12/2015/8:57:30 AM	103.56									
30	2/12/2015/8:57:31 AM	103.56									
31	2/12/2015/8:57:32 AM	103.58									
32	2/12/2015/8:57:33 AM	103.56									
33	2/12/2015/8:57:34 AM	103.58									
34	2/12/2015/8:57:35 AM	103.59									
35	2/12/2015/8:57:36 AM	103.6									
36	2/12/2015/8:57:37 AM	103.58									
37	2/12/2015/8:57:38 AM	103.57									
38	2/12/2015/8:57:39 AM	103.59									

Oxygen consumption (use plot)

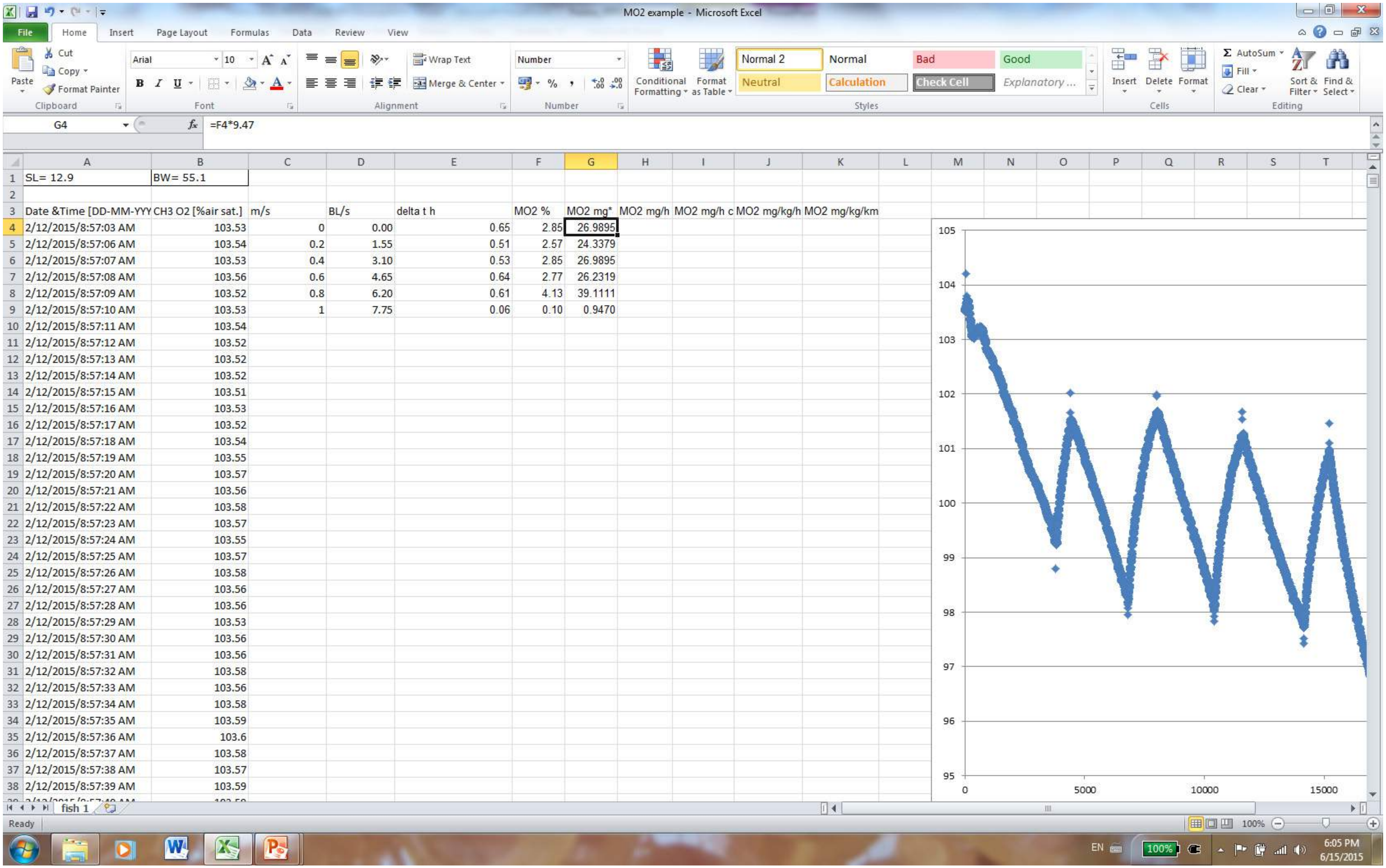


Date &Time [DD-MM-YYY	CH3 O2 [%air sat.]	m/s	BL/s	delta t h	MO2 %	MO2 mg*	MO2 mg/h	MO2 mg/h c	MO2 mg/kg/h	MO2 mg/kg/km
2/12/2015/8:57:03 AM	103.53	0	0.00	0.65	2.85					
2/12/2015/8:57:06 AM	103.54	0.2	1.55	0.51	2.57					
2/12/2015/8:57:07 AM	103.53	0.4	3.10	0.53	2.85					
2/12/2015/8:57:08 AM	103.56	0.6	4.65	0.64	2.77					
2/12/2015/8:57:09 AM	103.52	0.8	6.20	0.61	4.13					
2/12/2015/8:57:10 AM	103.53	1	7.75	0.06	0.10					
2/12/2015/8:57:11 AM	103.54									
2/12/2015/8:57:12 AM	103.52									
2/12/2015/8:57:13 AM	103.52									
2/12/2015/8:57:14 AM	103.52									
2/12/2015/8:57:15 AM	103.51									
2/12/2015/8:57:16 AM	103.53									
2/12/2015/8:57:17 AM	103.52									
2/12/2015/8:57:18 AM	103.54									
2/12/2015/8:57:19 AM	103.55									
2/12/2015/8:57:20 AM	103.57									
2/12/2015/8:57:21 AM	103.56									
2/12/2015/8:57:22 AM	103.58									
2/12/2015/8:57:23 AM	103.57									
2/12/2015/8:57:24 AM	103.55									
2/12/2015/8:57:25 AM	103.57									
2/12/2015/8:57:26 AM	103.58									
2/12/2015/8:57:27 AM	103.56									
2/12/2015/8:57:28 AM	103.56									
2/12/2015/8:57:29 AM	103.53									
2/12/2015/8:57:30 AM	103.56									
2/12/2015/8:57:31 AM	103.56									
2/12/2015/8:57:32 AM	103.58									
2/12/2015/8:57:33 AM	103.56									
2/12/2015/8:57:34 AM	103.58									
2/12/2015/8:57:35 AM	103.59									
2/12/2015/8:57:36 AM	103.6									
2/12/2015/8:57:37 AM	103.58									
2/12/2015/8:57:38 AM	103.57									
2/12/2015/8:57:39 AM	103.59									

Oxygen consumption % to mg

Use O2 solubility in FW at 15 degrees and swim-tunnel volume.

*For our experiment: 1%= (10.29 mg/l O2 * 127 l)/100= 13.06 mg*

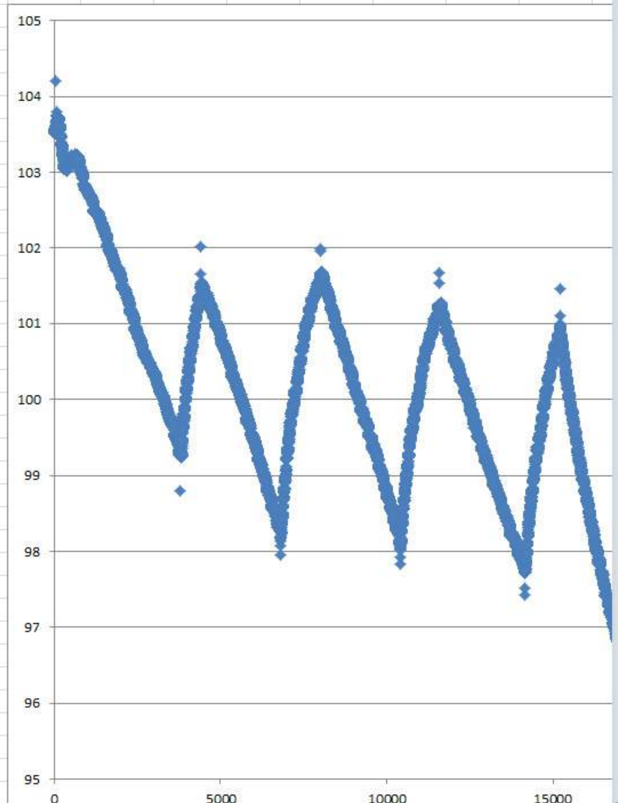


	A	B	C	D	E	F	G	H	I	J	K
1	SL= 12.9	BW= 55.1									
2											
3	Date &Time [DD-MM-YYY	CH3 O2 [%air sat.]	m/s	BL/s	delta t h	MO2 %	MO2 mg*	MO2 mg/h	MO2 mg/h c	MO2 mg/kg/h	MO2 mg/kg/km
4	2/12/2015/8:57:03 AM	103.53	0	0.00	0.65	2.85	26.9895				
5	2/12/2015/8:57:06 AM	103.54	0.2	1.55	0.51	2.57	24.3379				
6	2/12/2015/8:57:07 AM	103.53	0.4	3.10	0.53	2.85	26.9895				
7	2/12/2015/8:57:08 AM	103.56	0.6	4.65	0.64	2.77	26.2319				
8	2/12/2015/8:57:09 AM	103.52	0.8	6.20	0.61	4.13	39.1111				
9	2/12/2015/8:57:10 AM	103.53	1	7.75	0.06	0.10	0.9470				
10	2/12/2015/8:57:11 AM	103.54									
11	2/12/2015/8:57:12 AM	103.52									
12	2/12/2015/8:57:13 AM	103.52									
13	2/12/2015/8:57:14 AM	103.52									
14	2/12/2015/8:57:15 AM	103.51									
15	2/12/2015/8:57:16 AM	103.53									
16	2/12/2015/8:57:17 AM	103.52									
17	2/12/2015/8:57:18 AM	103.54									
18	2/12/2015/8:57:19 AM	103.55									
19	2/12/2015/8:57:20 AM	103.57									
20	2/12/2015/8:57:21 AM	103.56									
21	2/12/2015/8:57:22 AM	103.58									
22	2/12/2015/8:57:23 AM	103.57									
23	2/12/2015/8:57:24 AM	103.55									
24	2/12/2015/8:57:25 AM	103.57									
25	2/12/2015/8:57:26 AM	103.58									
26	2/12/2015/8:57:27 AM	103.56									
27	2/12/2015/8:57:28 AM	103.56									
28	2/12/2015/8:57:29 AM	103.53									
29	2/12/2015/8:57:30 AM	103.56									
30	2/12/2015/8:57:31 AM	103.56									
31	2/12/2015/8:57:32 AM	103.58									
32	2/12/2015/8:57:33 AM	103.56									
33	2/12/2015/8:57:34 AM	103.58									
34	2/12/2015/8:57:35 AM	103.59									
35	2/12/2015/8:57:36 AM	103.6									
36	2/12/2015/8:57:37 AM	103.58									
37	2/12/2015/8:57:38 AM	103.57									
38	2/12/2015/8:57:39 AM	103.59									

Oxygen consumption mg to mg/h

H4 =G4/E4

	A	B	C	D	E	F	G	H	I	J	K
1	SL= 12.9	BW= 55.1									
2											
3	Date &Time [DD-MM-YYY	CH3 O2 [%air sat.]	m/s	BL/s	delta t h	MO2 %	MO2 mg*	MO2 mg/h	MO2 mg/h c	MO2 mg/kg/h	MO2 mg/kg/km
4	2/12/2015/8:57:03 AM	103.53	0	0.00	0.65	2.85	26.9895	**41.3105**			
5	2/12/2015/8:57:06 AM	103.54	0.2	1.55	0.51	2.57	24.3379	**47.4629**			
6	2/12/2015/8:57:07 AM	103.53	0.4	3.10	0.53	2.85	26.9895	**50.7374**			
7	2/12/2015/8:57:08 AM	103.56	0.6	4.65	0.64	2.77	26.2319	**41.1481**			
8	2/12/2015/8:57:09 AM	103.52	0.8	6.20	0.61	4.13	39.1111	**64.6168**			
9	2/12/2015/8:57:10 AM	103.53	1	7.75	0.06	0.10	0.9470	**16.4696**			
10	2/12/2015/8:57:11 AM	103.54									
11	2/12/2015/8:57:12 AM	103.52									
12	2/12/2015/8:57:13 AM	103.52									
13	2/12/2015/8:57:14 AM	103.52									
14	2/12/2015/8:57:15 AM	103.51									
15	2/12/2015/8:57:16 AM	103.53									
16	2/12/2015/8:57:17 AM	103.52									
17	2/12/2015/8:57:18 AM	103.54									
18	2/12/2015/8:57:19 AM	103.55									
19	2/12/2015/8:57:20 AM	103.57									
20	2/12/2015/8:57:21 AM	103.56									
21	2/12/2015/8:57:22 AM	103.58									
22	2/12/2015/8:57:23 AM	103.57									
23	2/12/2015/8:57:24 AM	103.55									
24	2/12/2015/8:57:25 AM	103.57									
25	2/12/2015/8:57:26 AM	103.58									
26	2/12/2015/8:57:27 AM	103.56									
27	2/12/2015/8:57:28 AM	103.56									
28	2/12/2015/8:57:29 AM	103.53									
29	2/12/2015/8:57:30 AM	103.56									
30	2/12/2015/8:57:31 AM	103.56									
31	2/12/2015/8:57:32 AM	103.58									
32	2/12/2015/8:57:33 AM	103.56									
33	2/12/2015/8:57:34 AM	103.58									
34	2/12/2015/8:57:35 AM	103.59									
35	2/12/2015/8:57:36 AM	103.6									
36	2/12/2015/8:57:37 AM	103.58									
37	2/12/2015/8:57:38 AM	103.57									
38	2/12/2015/8:57:39 AM	103.59									



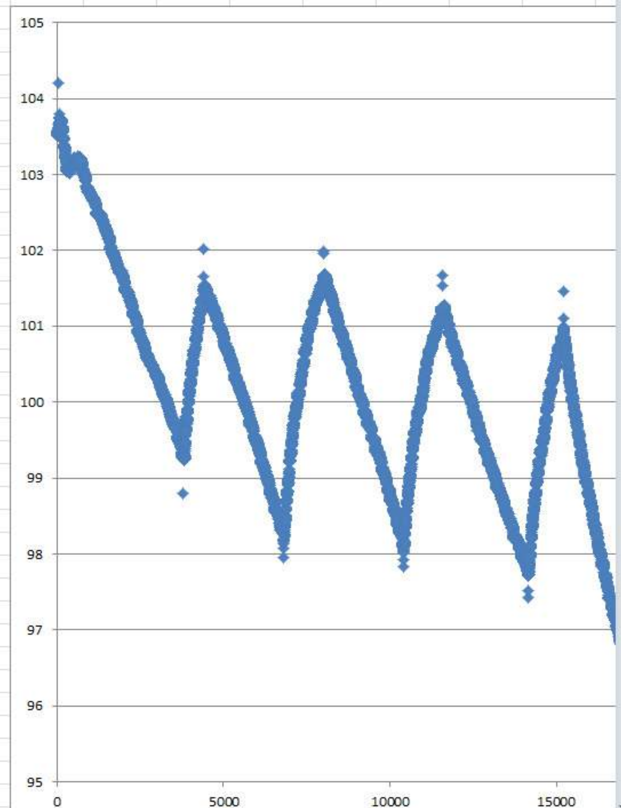
fish 1

Oxygen consumption in mg/h and compensated for background consumption (*we will not do that in our experiment*)

MO2 example - Microsoft Excel

I4 =H4-I11

	A	B	C	D	E	F	G	H	I	J	K
1	SL= 12.9	BW= 55.1									
2											
3	Date &Time [DD-MM-YYY	CH3 O2 [%air sat.]	m/s	BL/s	delta t h	MO2 %	MO2 mg*	MO2 mg/h	MO2 mg/h c	MO2 mg/kg/h	MO2 mg/kg/km
4	2/12/2015/8:57:03 AM	103.53	0	0.00	0.65	2.85	26.9895	**41.3105**	**29.4730**		
5	2/12/2015/8:57:06 AM	103.54	0.2	1.55	0.51	2.57	24.3379	**47.4629**	**32.9087**		
6	2/12/2015/8:57:07 AM	103.53	0.4	3.10	0.53	2.85	26.9895	**50.7374**	**31.2367**		
7	2/12/2015/8:57:08 AM	103.56	0.6	4.65	0.64	2.77	26.2319	**41.1481**	**27.1704**		
8	2/12/2015/8:57:09 AM	103.52	0.8	6.20	0.61	4.13	39.1111	**64.6168**	**56.7666**		
9	2/12/2015/8:57:10 AM	103.53	1	7.75	0.06	0.10	0.9470	**16.4696**	**14.7650**		
10	2/12/2015/8:57:11 AM	103.54									
11	2/12/2015/8:57:12 AM	103.52							**11.8375**		
12	2/12/2015/8:57:13 AM	103.52							**14.5542**		
13	2/12/2015/8:57:14 AM	103.52							**19.5007**		
14	2/12/2015/8:57:15 AM	103.51							**13.9777**		
15	2/12/2015/8:57:16 AM	103.53							**7.8501**		
16	2/12/2015/8:57:17 AM	103.52							**1.7046**		
17	2/12/2015/8:57:18 AM	103.54									
18	2/12/2015/8:57:19 AM	103.55									
19	2/12/2015/8:57:20 AM	103.57									
20	2/12/2015/8:57:21 AM	103.56									
21	2/12/2015/8:57:22 AM	103.58									
22	2/12/2015/8:57:23 AM	103.57									
23	2/12/2015/8:57:24 AM	103.55									
24	2/12/2015/8:57:25 AM	103.57									
25	2/12/2015/8:57:26 AM	103.58									
26	2/12/2015/8:57:27 AM	103.56									
27	2/12/2015/8:57:28 AM	103.56									
28	2/12/2015/8:57:29 AM	103.53									
29	2/12/2015/8:57:30 AM	103.56									
30	2/12/2015/8:57:31 AM	103.56									
31	2/12/2015/8:57:32 AM	103.58									
32	2/12/2015/8:57:33 AM	103.56									
33	2/12/2015/8:57:34 AM	103.58									
34	2/12/2015/8:57:35 AM	103.59									
35	2/12/2015/8:57:36 AM	103.6									
36	2/12/2015/8:57:37 AM	103.58									
37	2/12/2015/8:57:38 AM	103.57									
38	2/12/2015/8:57:39 AM	103.59									



fish 1

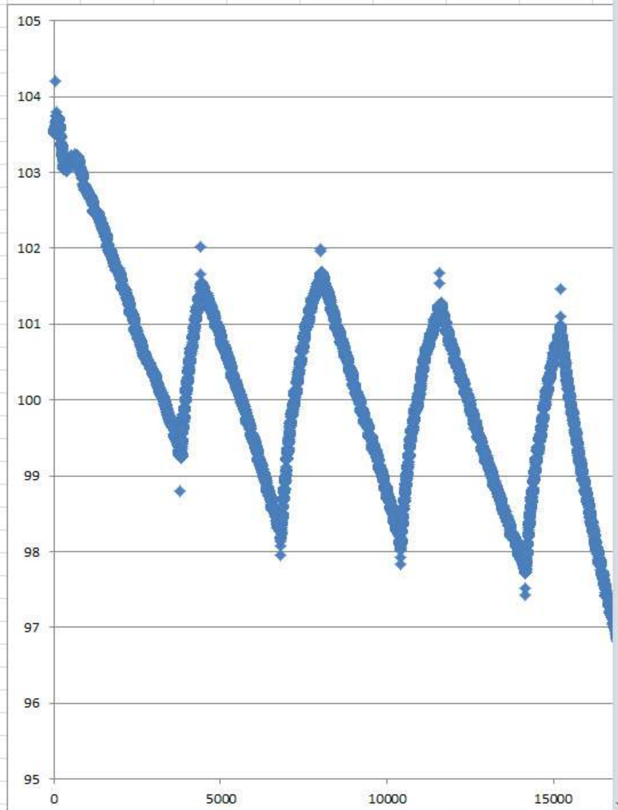
Ready

Oxygen consumption mg/h to mg/kg/h

MO2 example - Microsoft Excel

J4 f_x =I4/0.0551

	A	B	C	D	E	F	G	H	I	J	K
1	SL= 12.9	BW= 55.1									
2											
3	Date &Time [DD-MM-YYY	CH3 O2 [%air sat.]	m/s	BL/s	delta t h	MO2 %	MO2 mg*	MO2 mg/h	MO2 mg/h c	MO2 mg/kg/h	MO2 mg/kg/km
4	2/12/2015/8:57:03 AM	103.53	0	0.00	0.65	2.85	26.9895	**41.3105**	**29.4730**	535	
5	2/12/2015/8:57:06 AM	103.54	0.2	1.55	0.51	2.57	24.3379	**47.4629**	**32.9087**	597	
6	2/12/2015/8:57:07 AM	103.53	0.4	3.10	0.53	2.85	26.9895	**50.7374**	**31.2367**	567	
7	2/12/2015/8:57:08 AM	103.56	0.6	4.65	0.64	2.77	26.2319	**41.1481**	**27.1704**	493	
8	2/12/2015/8:57:09 AM	103.52	0.8	6.20	0.61	4.13	39.1111	**64.6168**	**56.7666**	1030	
9	2/12/2015/8:57:10 AM	103.53	1	7.75	0.06	0.10	0.9470	**16.4696**	**14.7650**	268	
10	2/12/2015/8:57:11 AM	103.54									
11	2/12/2015/8:57:12 AM	103.52							**11.8375**		
12	2/12/2015/8:57:13 AM	103.52							**14.5542**		
13	2/12/2015/8:57:14 AM	103.52							**19.5007**		
14	2/12/2015/8:57:15 AM	103.51							**13.9777**		
15	2/12/2015/8:57:16 AM	103.53							**7.8501**		
16	2/12/2015/8:57:17 AM	103.52							**1.7046**		
17	2/12/2015/8:57:18 AM	103.54									
18	2/12/2015/8:57:19 AM	103.55									
19	2/12/2015/8:57:20 AM	103.57									
20	2/12/2015/8:57:21 AM	103.56									
21	2/12/2015/8:57:22 AM	103.58									
22	2/12/2015/8:57:23 AM	103.57									
23	2/12/2015/8:57:24 AM	103.55									
24	2/12/2015/8:57:25 AM	103.57									
25	2/12/2015/8:57:26 AM	103.58									
26	2/12/2015/8:57:27 AM	103.56									
27	2/12/2015/8:57:28 AM	103.56									
28	2/12/2015/8:57:29 AM	103.53									
29	2/12/2015/8:57:30 AM	103.56									
30	2/12/2015/8:57:31 AM	103.56									
31	2/12/2015/8:57:32 AM	103.58									
32	2/12/2015/8:57:33 AM	103.56									
33	2/12/2015/8:57:34 AM	103.58									
34	2/12/2015/8:57:35 AM	103.59									
35	2/12/2015/8:57:36 AM	103.6									
36	2/12/2015/8:57:37 AM	103.58									
37	2/12/2015/8:57:38 AM	103.57									
38	2/12/2015/8:57:39 AM	103.59									



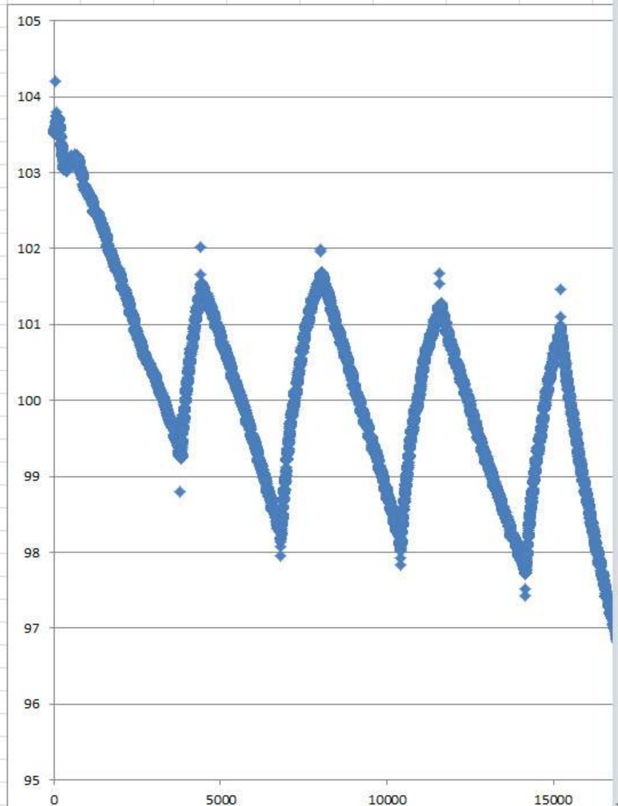
fish 1

Oxygen consumption mg/h to mg/kg/km (=COT)

MO2 example - Microsoft Excel

K5 =J5/((3600*C5))*1000

	A	B	C	D	E	F	G	H	I	J	K
1	SL= 12.9	BW= 55.1									
2											
3	Date &Time [DD-MM-YYY	CH3 O2 [%air sat.]	m/s	BL/s	delta t h	MO2 %	MO2 mg*	MO2 mg/h	MO2 mg/h c	MO2 mg/kg/h	MO2 mg/kg/km
4	2/12/2015/8:57:03 AM	103.53	0	0.00	0.65	2.85	26.9895	**41.3105**	**29.4730**	535	
5	2/12/2015/8:57:06 AM	103.54	0.2	1.55	0.51	2.57	24.3379	**47.4629**	**32.9087**	597	830
6	2/12/2015/8:57:07 AM	103.53	0.4	3.10	0.53	2.85	26.9895	**50.7374**	**31.2367**	567	394
7	2/12/2015/8:57:08 AM	103.56	0.6	4.65	0.64	2.77	26.2319	**41.1481**	**27.1704**	493	228
8	2/12/2015/8:57:09 AM	103.52	0.8	6.20	0.61	4.13	39.1111	**64.6168**	**56.7666**	1030	358
9	2/12/2015/8:57:10 AM	103.53	1	7.75	0.06	0.10	0.9470	**16.4696**	**14.7650**	268	74
10	2/12/2015/8:57:11 AM	103.54									
11	2/12/2015/8:57:12 AM	103.52							**11.8375**		
12	2/12/2015/8:57:13 AM	103.52							**14.5542**		
13	2/12/2015/8:57:14 AM	103.52							**19.5007**		
14	2/12/2015/8:57:15 AM	103.51							**13.9777**		
15	2/12/2015/8:57:16 AM	103.53							**7.8501**		
16	2/12/2015/8:57:17 AM	103.52							**1.7046**		
17	2/12/2015/8:57:18 AM	103.54									
18	2/12/2015/8:57:19 AM	103.55									
19	2/12/2015/8:57:20 AM	103.57									
20	2/12/2015/8:57:21 AM	103.56									
21	2/12/2015/8:57:22 AM	103.58									
22	2/12/2015/8:57:23 AM	103.57									
23	2/12/2015/8:57:24 AM	103.55									
24	2/12/2015/8:57:25 AM	103.57									
25	2/12/2015/8:57:26 AM	103.58									
26	2/12/2015/8:57:27 AM	103.56									
27	2/12/2015/8:57:28 AM	103.56									
28	2/12/2015/8:57:29 AM	103.53									
29	2/12/2015/8:57:30 AM	103.56									
30	2/12/2015/8:57:31 AM	103.56									
31	2/12/2015/8:57:32 AM	103.58									
32	2/12/2015/8:57:33 AM	103.56									
33	2/12/2015/8:57:34 AM	103.58									
34	2/12/2015/8:57:35 AM	103.59									
35	2/12/2015/8:57:36 AM	103.6									
36	2/12/2015/8:57:37 AM	103.58									
37	2/12/2015/8:57:38 AM	103.57									
38	2/12/2015/8:57:39 AM	103.59									



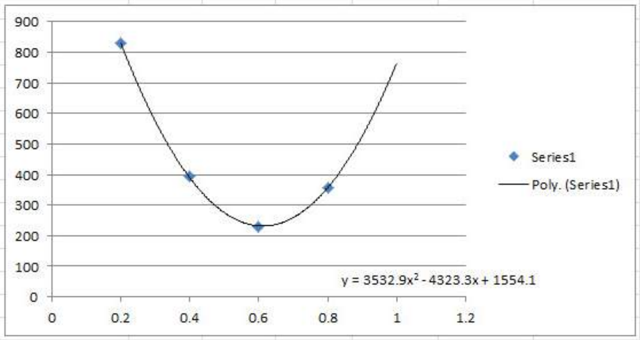
fish 1

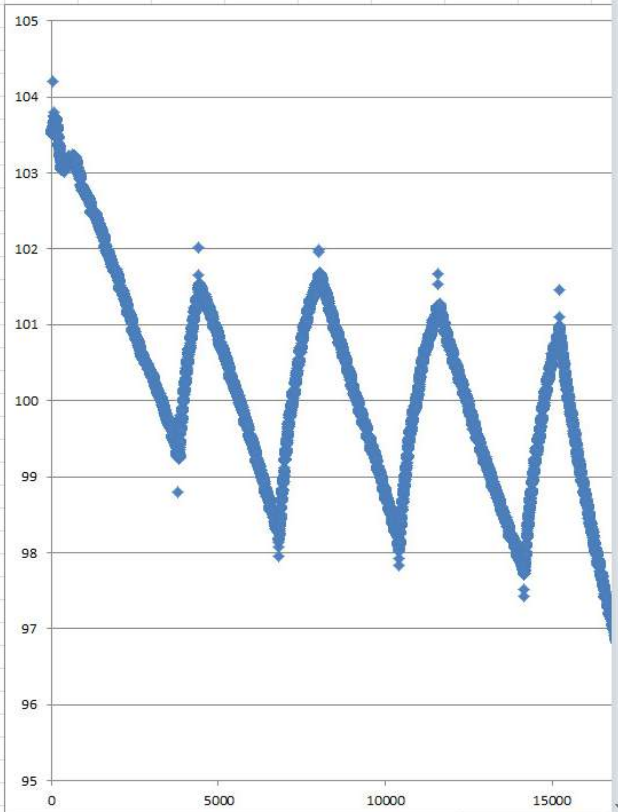
Plot COT vs. swimming speed

MO2 example - Microsoft Excel

C18 = 0.2

	A	B	C	D	E	F	G	H	I	J	K
1	SL= 12.9	BW= 55.1									
2											
3	Date &Time [DD-MM-YYY	CH3 O2 [%air sat.]	m/s	BL/s	delta t h	MO2 %	MO2 mg*	MO2 mg/h	MO2 mg/h c	MO2 mg/kg/h	MO2 mg/kg/km
4	2/12/2015/8:57:03 AM	103.53	0	0.00	0.65	2.85	26.9895	**41.3105**	**29.4730**	535	
5	2/12/2015/8:57:06 AM	103.54	0.2	1.55	0.51	2.57	24.3379	**47.4629**	**32.9087**	597	830
6	2/12/2015/8:57:07 AM	103.53	0.4	3.10	0.53	2.85	26.9895	**50.7374**	**31.2367**	567	394
7	2/12/2015/8:57:08 AM	103.56	0.6	4.65	0.64	2.77	26.2319	**41.1481**	**27.1704**	493	228
8	2/12/2015/8:57:09 AM	103.52	0.8	6.20	0.61	4.13	39.1111	**64.6168**	**56.7666**	1030	358
9	2/12/2015/8:57:10 AM	103.53	1	7.75	0.06	0.10	0.9470	**16.4696**	**14.7650**	268	74
10	2/12/2015/8:57:11 AM	103.54									
11	2/12/2015/8:57:12 AM	103.52							**11.8375**		
12	2/12/2015/8:57:13 AM	103.52							**14.5542**		
13	2/12/2015/8:57:14 AM	103.52							**19.5007**		
14	2/12/2015/8:57:15 AM	103.51							**13.9777**		
15	2/12/2015/8:57:16 AM	103.53							**7.8501**		
16	2/12/2015/8:57:17 AM	103.52							**1.7046**		
17	2/12/2015/8:57:18 AM	103.54									
18	2/12/2015/8:57:19 AM	103.55	0.2	830							
19	2/12/2015/8:57:20 AM	103.57	0.4	394							
20	2/12/2015/8:57:21 AM	103.56	0.6	228							
21	2/12/2015/8:57:22 AM	103.58	0.8	358							
22	2/12/2015/8:57:23 AM	103.57	1								
23	2/12/2015/8:57:24 AM	103.55									
24	2/12/2015/8:57:25 AM	103.57									
25	2/12/2015/8:57:26 AM	103.58									
26	2/12/2015/8:57:27 AM	103.56									
27	2/12/2015/8:57:28 AM	103.56									
28	2/12/2015/8:57:29 AM	103.53									
29	2/12/2015/8:57:30 AM	103.56									
30	2/12/2015/8:57:31 AM	103.56									
31	2/12/2015/8:57:32 AM	103.58									
32	2/12/2015/8:57:33 AM	103.56									
33	2/12/2015/8:57:34 AM	103.58									
34	2/12/2015/8:57:35 AM	103.59									
35	2/12/2015/8:57:36 AM	103.6									
36	2/12/2015/8:57:37 AM	103.58									
37	2/12/2015/8:57:38 AM	103.57									
38	2/12/2015/8:57:39 AM	103.59									

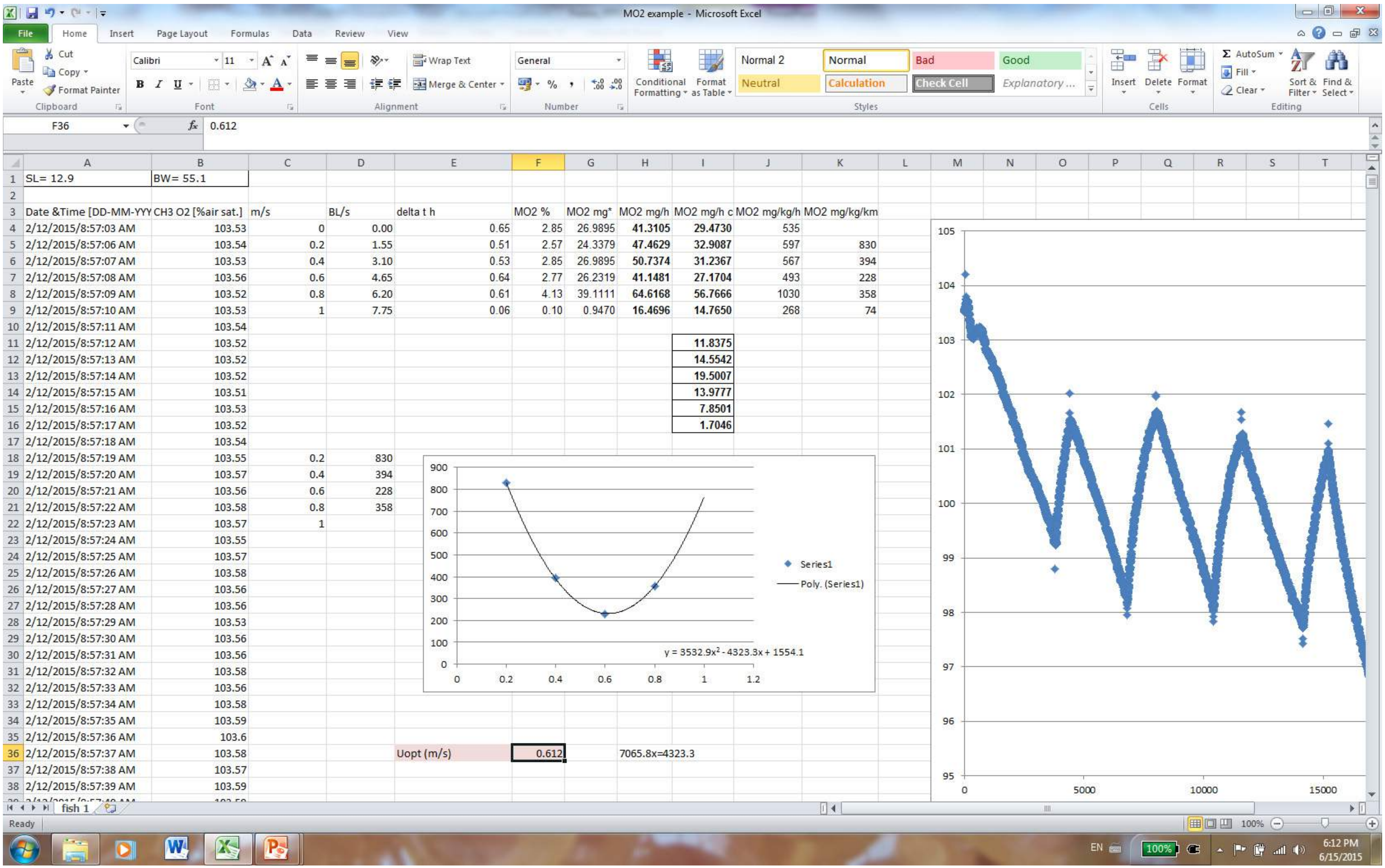




fish 1

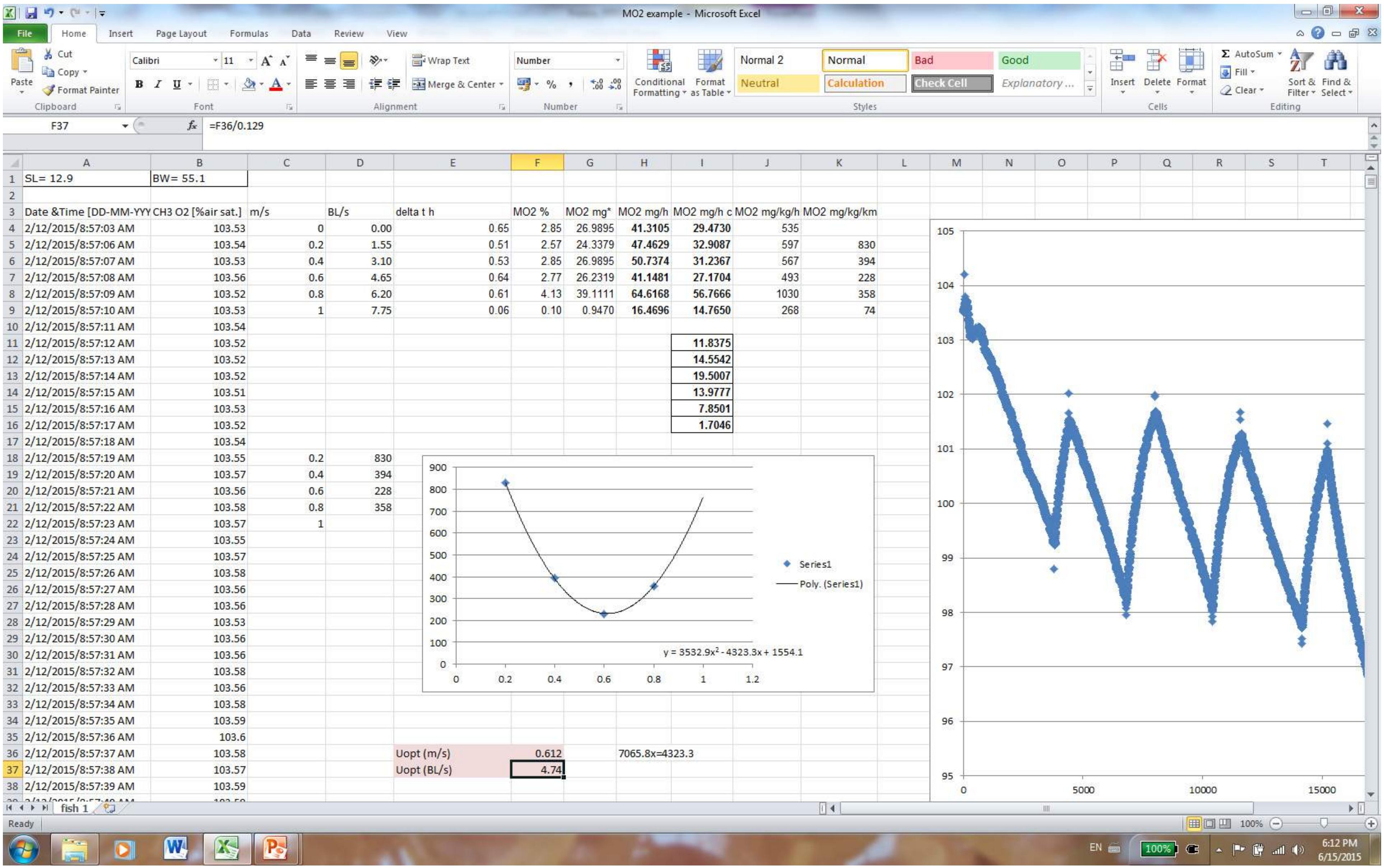
Ready

Determine Uopt in m/s



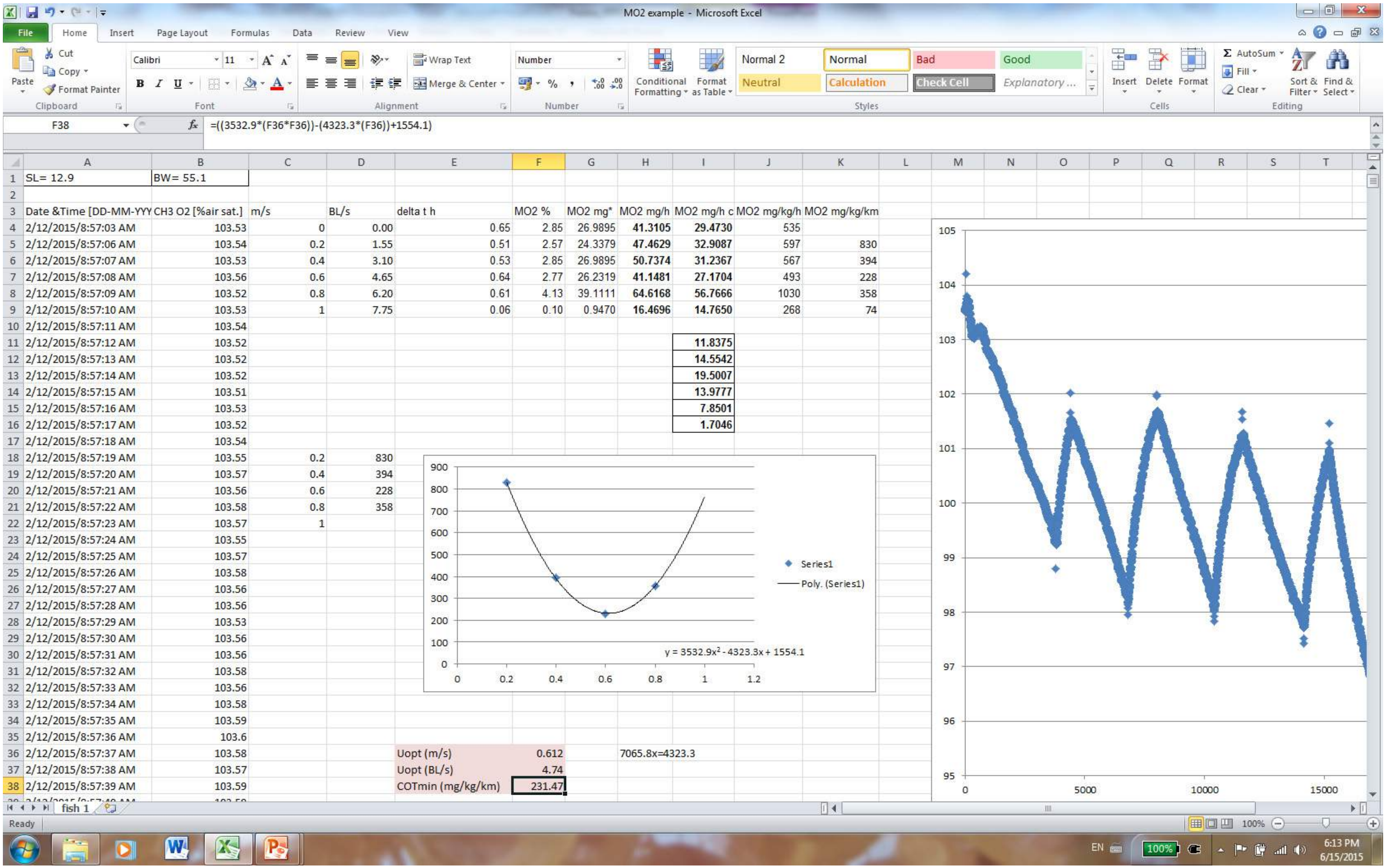
	A	B	C	D	E	F	G	H	I	J	K
1	SL= 12.9	BW= 55.1									
2											
3	Date &Time [DD-MM-YYY	CH3 O2 [%air sat.]	m/s	BL/s	delta t h	MO2 %	MO2 mg*	MO2 mg/h	MO2 mg/h c	MO2 mg/kg/h	MO2 mg/kg/km
4	2/12/2015/8:57:03 AM	103.53	0	0.00	0.65	2.85	26.9895	**41.3105**	**29.4730**	535	
5	2/12/2015/8:57:06 AM	103.54	0.2	1.55	0.51	2.57	24.3379	**47.4629**	**32.9087**	597	830
6	2/12/2015/8:57:07 AM	103.53	0.4	3.10	0.53	2.85	26.9895	**50.7374**	**31.2367**	567	394
7	2/12/2015/8:57:08 AM	103.56	0.6	4.65	0.64	2.77	26.2319	**41.1481**	**27.1704**	493	228
8	2/12/2015/8:57:09 AM	103.52	0.8	6.20	0.61	4.13	39.1111	**64.6168**	**56.7666**	1030	358
9	2/12/2015/8:57:10 AM	103.53	1	7.75	0.06	0.10	0.9470	**16.4696**	**14.7650**	268	74
10	2/12/2015/8:57:11 AM	103.54									
11	2/12/2015/8:57:12 AM	103.52							**11.8375**		
12	2/12/2015/8:57:13 AM	103.52							**14.5542**		
13	2/12/2015/8:57:14 AM	103.52							**19.5007**		
14	2/12/2015/8:57:15 AM	103.51							**13.9777**		
15	2/12/2015/8:57:16 AM	103.53							**7.8501**		
16	2/12/2015/8:57:17 AM	103.52							**1.7046**		
17	2/12/2015/8:57:18 AM	103.54									
18	2/12/2015/8:57:19 AM	103.55	0.2	830							
19	2/12/2015/8:57:20 AM	103.57	0.4	394							
20	2/12/2015/8:57:21 AM	103.56	0.6	228							
21	2/12/2015/8:57:22 AM	103.58	0.8	358							
22	2/12/2015/8:57:23 AM	103.57	1								
23	2/12/2015/8:57:24 AM	103.55									
24	2/12/2015/8:57:25 AM	103.57									
25	2/12/2015/8:57:26 AM	103.58									
26	2/12/2015/8:57:27 AM	103.56									
27	2/12/2015/8:57:28 AM	103.56									
28	2/12/2015/8:57:29 AM	103.53									
29	2/12/2015/8:57:30 AM	103.56									
30	2/12/2015/8:57:31 AM	103.56									
31	2/12/2015/8:57:32 AM	103.58									
32	2/12/2015/8:57:33 AM	103.56									
33	2/12/2015/8:57:34 AM	103.58									
34	2/12/2015/8:57:35 AM	103.59									
35	2/12/2015/8:57:36 AM	103.6									
36	2/12/2015/8:57:37 AM	103.58			Uopt (m/s)	0.612		7065.8x=4323.3			
37	2/12/2015/8:57:38 AM	103.57									
38	2/12/2015/8:57:39 AM	103.59									

Determine Uopt in BL/s



	A	B	C	D	E	F	G	H	I	J	K
1	SL= 12.9	BW= 55.1									
2											
3	Date &Time [DD-MM-YYY	CH3 O2 [%air sat.]	m/s	BL/s	delta t h	MO2 %	MO2 mg*	MO2 mg/h	MO2 mg/h c	MO2 mg/kg/h	MO2 mg/kg/km
4	2/12/2015/8:57:03 AM	103.53	0	0.00	0.65	2.85	26.9895	**41.3105**	**29.4730**	535	
5	2/12/2015/8:57:06 AM	103.54	0.2	1.55	0.51	2.57	24.3379	**47.4629**	**32.9087**	597	830
6	2/12/2015/8:57:07 AM	103.53	0.4	3.10	0.53	2.85	26.9895	**50.7374**	**31.2367**	567	394
7	2/12/2015/8:57:08 AM	103.56	0.6	4.65	0.64	2.77	26.2319	**41.1481**	**27.1704**	493	228
8	2/12/2015/8:57:09 AM	103.52	0.8	6.20	0.61	4.13	39.1111	**64.6168**	**56.7666**	1030	358
9	2/12/2015/8:57:10 AM	103.53	1	7.75	0.06	0.10	0.9470	**16.4696**	**14.7650**	268	74
10	2/12/2015/8:57:11 AM	103.54									
11	2/12/2015/8:57:12 AM	103.52							**11.8375**		
12	2/12/2015/8:57:13 AM	103.52							**14.5542**		
13	2/12/2015/8:57:14 AM	103.52							**19.5007**		
14	2/12/2015/8:57:15 AM	103.51							**13.9777**		
15	2/12/2015/8:57:16 AM	103.53							**7.8501**		
16	2/12/2015/8:57:17 AM	103.52							**1.7046**		
17	2/12/2015/8:57:18 AM	103.54									
18	2/12/2015/8:57:19 AM	103.55	0.2	830							
19	2/12/2015/8:57:20 AM	103.57	0.4	394							
20	2/12/2015/8:57:21 AM	103.56	0.6	228							
21	2/12/2015/8:57:22 AM	103.58	0.8	358							
22	2/12/2015/8:57:23 AM	103.57	1								
23	2/12/2015/8:57:24 AM	103.55									
24	2/12/2015/8:57:25 AM	103.57									
25	2/12/2015/8:57:26 AM	103.58									
26	2/12/2015/8:57:27 AM	103.56									
27	2/12/2015/8:57:28 AM	103.56									
28	2/12/2015/8:57:29 AM	103.53									
29	2/12/2015/8:57:30 AM	103.56									
30	2/12/2015/8:57:31 AM	103.56									
31	2/12/2015/8:57:32 AM	103.58									
32	2/12/2015/8:57:33 AM	103.56									
33	2/12/2015/8:57:34 AM	103.58									
34	2/12/2015/8:57:35 AM	103.59									
35	2/12/2015/8:57:36 AM	103.6									
36	2/12/2015/8:57:37 AM	103.58			Uopt (m/s)	0.612		7065.8x=4323.3			
37	2/12/2015/8:57:38 AM	103.57			Uopt (BL/s)	4.74					
38	2/12/2015/8:57:39 AM	103.59									

Determine COTmin in mg/kg/km



F38 =((3532.9*(F36*F36))-(4323.3*(F36))+1554.1)

	A	B	C	D	E	F	G	H	I	J	K
1	SL= 12.9	BW= 55.1									
2											
3	Date &Time [DD-MM-YYY	CH3 O2 [%air sat.]	m/s	BL/s	delta t h	MO2 %	MO2 mg*	MO2 mg/h	MO2 mg/h c	MO2 mg/kg/h	MO2 mg/kg/km
4	2/12/2015/8:57:03 AM	103.53	0	0.00	0.65	2.85	26.9895	**41.3105**	**29.4730**	535	
5	2/12/2015/8:57:06 AM	103.54	0.2	1.55	0.51	2.57	24.3379	**47.4629**	**32.9087**	597	830
6	2/12/2015/8:57:07 AM	103.53	0.4	3.10	0.53	2.85	26.9895	**50.7374**	**31.2367**	567	394
7	2/12/2015/8:57:08 AM	103.56	0.6	4.65	0.64	2.77	26.2319	**41.1481**	**27.1704**	493	228
8	2/12/2015/8:57:09 AM	103.52	0.8	6.20	0.61	4.13	39.1111	**64.6168**	**56.7666**	1030	358
9	2/12/2015/8:57:10 AM	103.53	1	7.75	0.06	0.10	0.9470	**16.4696**	**14.7650**	268	74
10	2/12/2015/8:57:11 AM	103.54									
11	2/12/2015/8:57:12 AM	103.52							**11.8375**		
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13	2/12/2015/8:57:14 AM	103.52							**19.5007**		
14	2/12/2015/8:57:15 AM	103.51							**13.9777**		
15	2/12/2015/8:57:16 AM	103.53							**7.8501**		
16	2/12/2015/8:57:17 AM	103.52							**1.7046**		
17	2/12/2015/8:57:18 AM	103.54									
18	2/12/2015/8:57:19 AM	103.55	0.2	830							
19	2/12/2015/8:57:20 AM	103.57	0.4	394							
20	2/12/2015/8:57:21 AM	103.56	0.6	228							
21	2/12/2015/8:57:22 AM	103.58	0.8	358							
22	2/12/2015/8:57:23 AM	103.57	1								
23	2/12/2015/8:57:24 AM	103.55									
24	2/12/2015/8:57:25 AM	103.57									
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29	2/12/2015/8:57:30 AM	103.56									
30	2/12/2015/8:57:31 AM	103.56									
31	2/12/2015/8:57:32 AM	103.58									
32	2/12/2015/8:57:33 AM	103.56									
33	2/12/2015/8:57:34 AM	103.58									
34	2/12/2015/8:57:35 AM	103.59									
35	2/12/2015/8:57:36 AM	103.6									
36	2/12/2015/8:57:37 AM	103.58			Uopt (m/s)	0.612		7065.8x=4323.3			
37	2/12/2015/8:57:38 AM	103.57			Uopt (BL/s)	4.74					
38	2/12/2015/8:57:39 AM	103.59			COTmin (mg/kg/km)	231.47					