SmartTag technology for monitoring fish welfare in aquaculture

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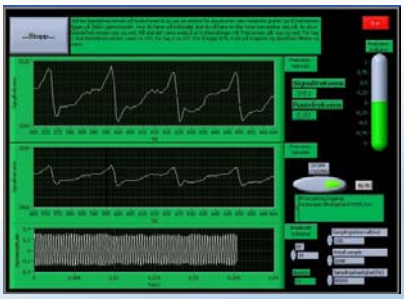
SmartTag technology for monitoring fish welfare in aquaculture

1) What is SmartTag?

SEAFOODplus Session AQUA 2006, 11 May 2006, Firenze

What is SmartTag?



The SmartTag provides online measurements of breathing pattern in free-swimming fish

- Monitor and document fish welfare status in aquaculture
- Early warning system
- Optimize production regimes
- Assess feed intake rates

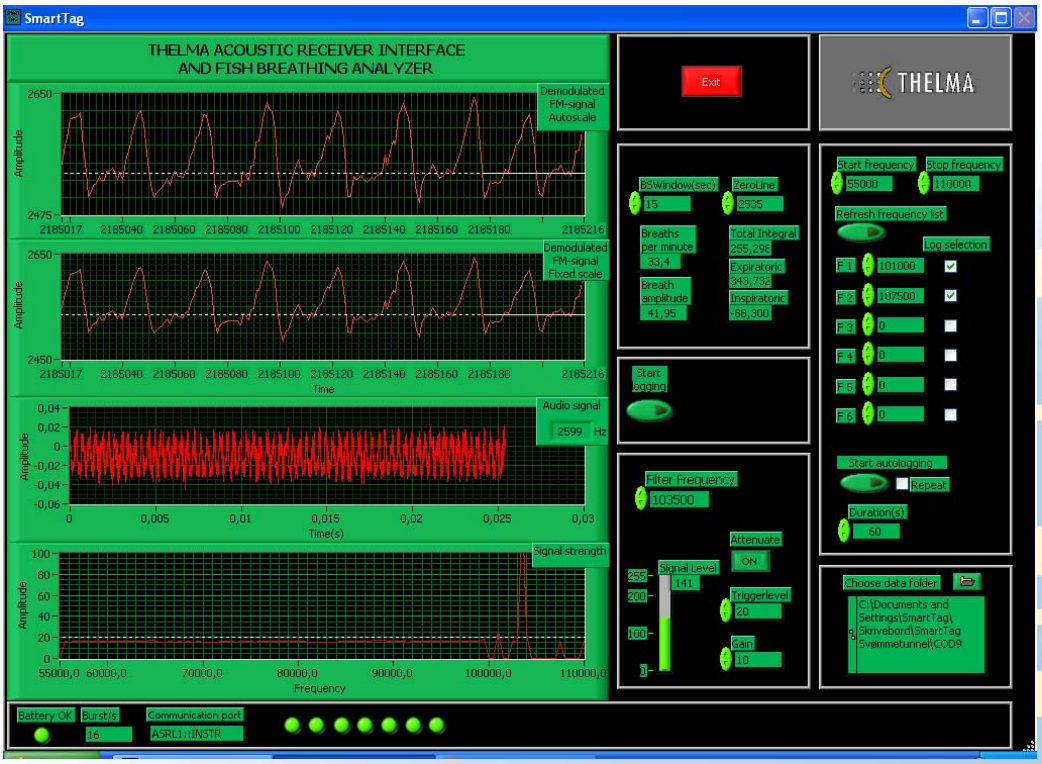
What is SmartTag? (II)

1) SmartTag prototype
- 46 x 16 mm, 6 / 15 g in water/air
- 60 - 130 kHz acoustic transmission
- produced by THELMA, Norway

2ab) The tag is attached externally, on the back of the anaesthetized fish

3ab) A water-filled tube (1.6 mm ID) is sutured inside the mouth and connected to the tag for online pressure measurements, thus producing detailed data on fish breathing activity.

What is SmartTag? (III)



The fish breathing is visualised and stored on a computer

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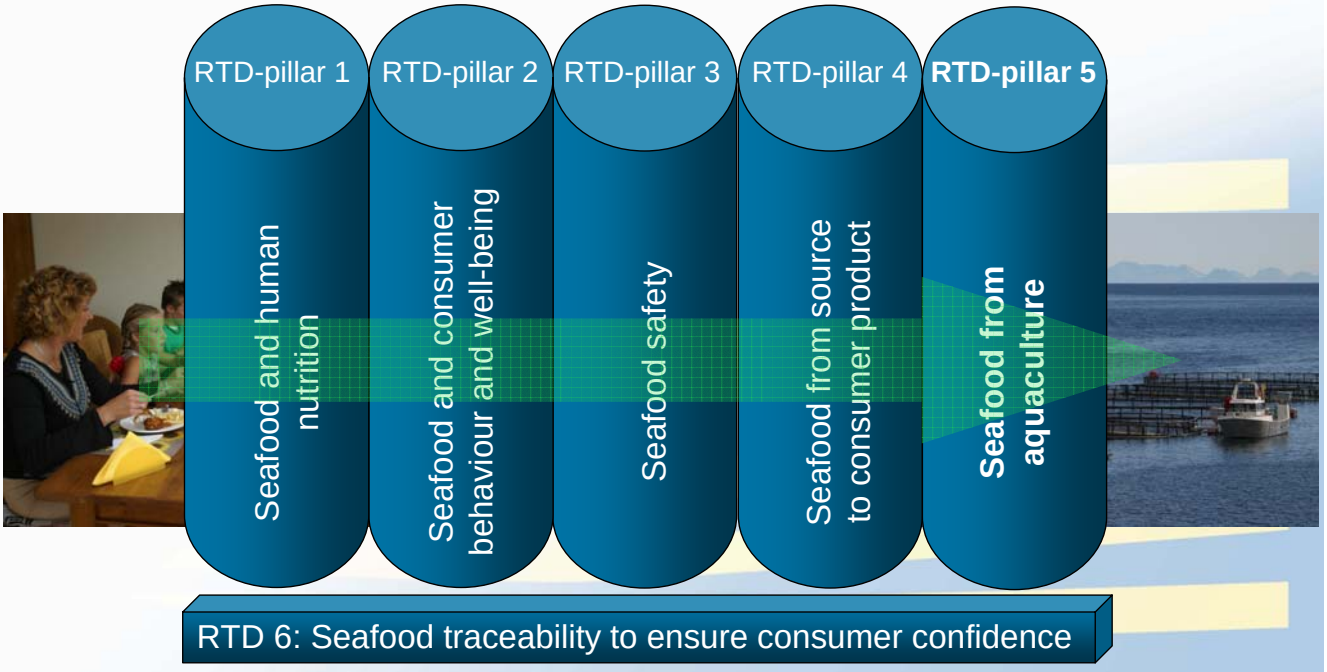
2) Background

SEAFOODplus:
A value-chain - “fork to fish farm” perspective



Trends in today’s aquaculture (I)

- **Larger fish production units**
- **More intensive production:**
  - **more fish pr volume water**
  - **artificial oxygenation, accumulation of CO_2 and other metabolites**
- **More off-shore and submerged production facilities**
- **Rationalization of man-work (fewer people pr kg fish produced)**

Large off-shore facility

Submerged facility

Trends in today's aquaculture (II)

- **Increased scepticism among consumers on food safety and animal welfare issues (Damsgård 2006)**

➢ ***Need for <u>monitoring</u> and <u>documenting</u> fish welfare and rearing conditions***

Fish farm

Product offered consumers / retailers

Monitoring and documenting fish welfare in aquaculture

Traditional approach (1):

- **Veterinarian inspections and analyzes of sick or dead fish**

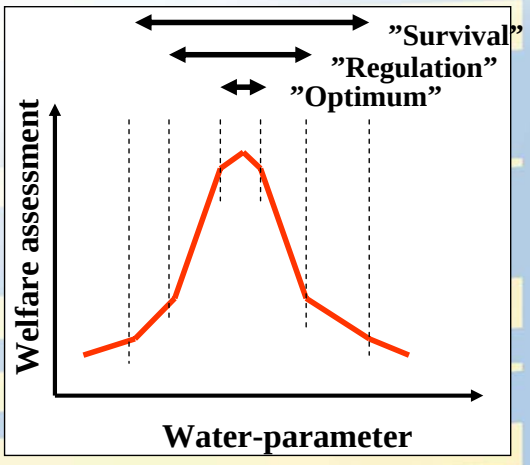
➢ ***Periodical, and/or based on prior suspicion of something being wrong, and may often be too late***

Monitoring and documenting fish welfare in aquaculture

Traditional approach (2):

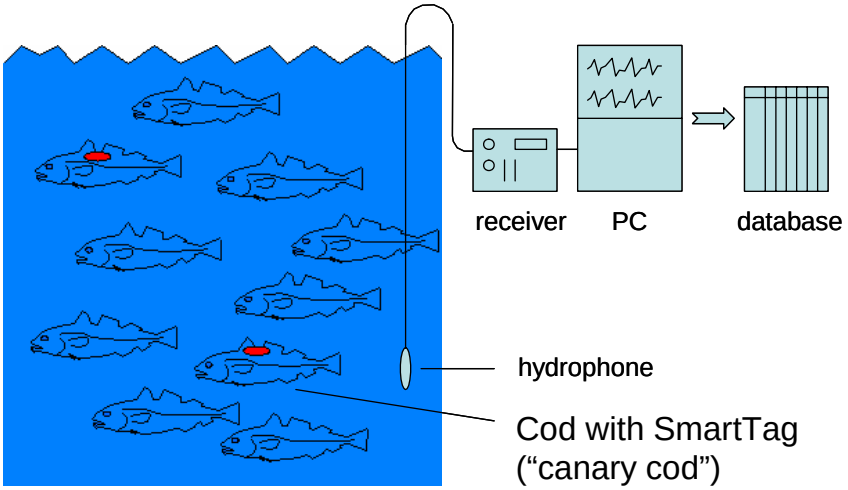
- **Monitor environmental factors and ensure that these are within a pre-determined, acceptable range**

➢ ***Does not take in to account the "sum of factors", and that fish responses to such factors are variable***



New approach:
SmartTag and the "canary cod" principle

-Online monitoring of how individual fish respond to their aquaculture environment



Small cage with canary bird used in testing for carbon monoxide gas in Hollinger Mine, Timmons, Ontario, Canada. (http://www.msha.gov)

A physiological parameter is continuously monitored by the tags, picked up by a reception system, and processed online on a computer with relevant parameters being automatically stored in a database.

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3) Validation of the SmartTag system and of fish breathing as welfare indicator

Validation of the SmartTag system:
A. Existing scientific literature

We know from the scientific literature that fish breathing activity responds to factors such as:

- Hypoxia, hypercapnea and water pH (e.g. Smith & Jones 1982; Reid et al. 2000)
- Toxic or sub-toxic levels of metabolites and xenobiotics in feed and water (e.g. Pane et al. 2004)
- Parasite infection, disease, anaemia (e.g. Byrne et al. 1991)
- General stress response (e.g. Laitinen et al. 1996)
- Fear and pain (e.g. Sneddon et al. 2003)

Validation of the SmartTag system:
B. Controlled experiments

I) Responses to water quality manipulation

- SmartTagged cod swimming in a swim tunnel respirometer
- Breathing activity at normal (good) water quality is compared with breathing activity during short-term exposure to different water qualities relevant to the aquaculture industry

II) Responses to handling disturbance (pilot studies)

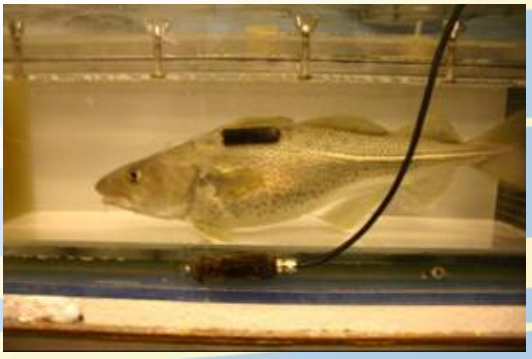
- Free-swimming, SmartTagged Atlantic cod (*Gadus morhua*) are exposed to a handling disturbance
- Fish breathing activity compared before, during and after stress

1. Responses to water quality manipulation:
experimental design

Experimental day 1:

Fish SmartTagged and introduced to swim tunnel respirometer at normal (excellent) water quality

Experimental room with swim tunnel



SmartTagged 1.5 kg cod swimming at 0.5 BLs^{-1} at 10°C in the swim tunnel respirometer.

1. Responses to water quality manipulation:
experimental design (II)

Experimental day 2:

1) Control measurements (3 x 0.5 hours)
2) Treatment exposure (A, B, C, D, E or F) at low level (3 x 0.5 hours)
3) Treatment exposure (as above) at high level (3 x 0.5 hours)
4) Blood sampling

Treatments:

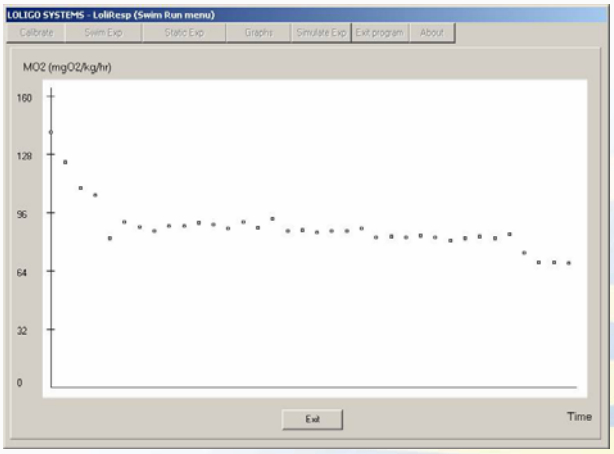
A. Control	D. Hypercapnea
B. Hypoxia	E. Hypoxia + hypercapnea (B + D)
C. Hyperoxia	F. Hyperoxia + hypercapnea (C + D)

Blood is sampled for cortisol analysis at day 1, and for analyses of cortisol, glucose, lactate, ions and gas tensions at day 2.

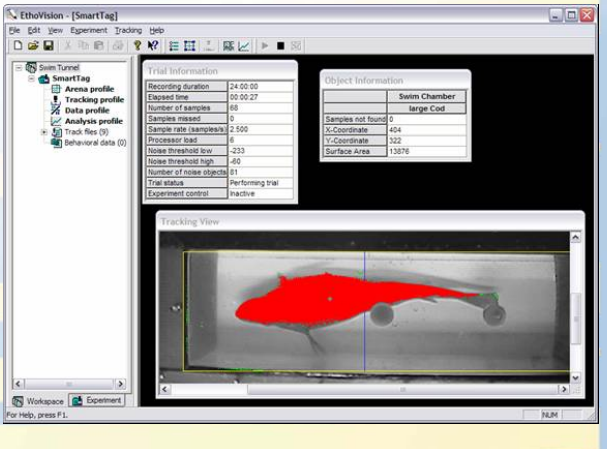
1. Responses to water quality manipulation:
experimental design (III)

Experimental day 1 *and* 2:

- Continuous registration of fish metabolism (30 min cycles)
- Continuous registration of fish behaviour (online video analysis)

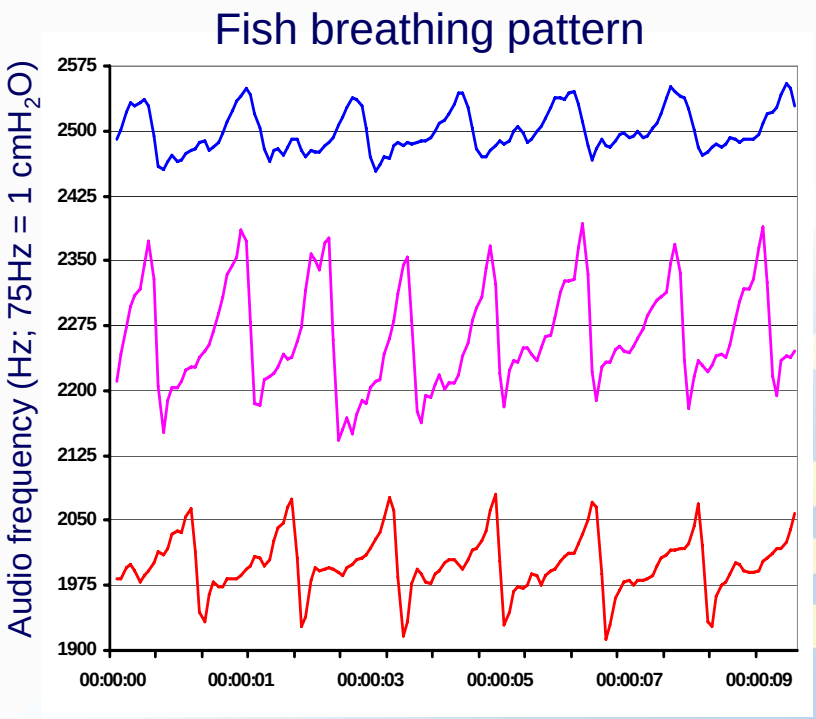


Changes in metabolism following introduction into the swim tunnel respirometer



Automatic video-tracking and analysis of fish behaviour in the swim tunnel respirometer

1. Responses to water quality manipulation:
some results I: hypoxia

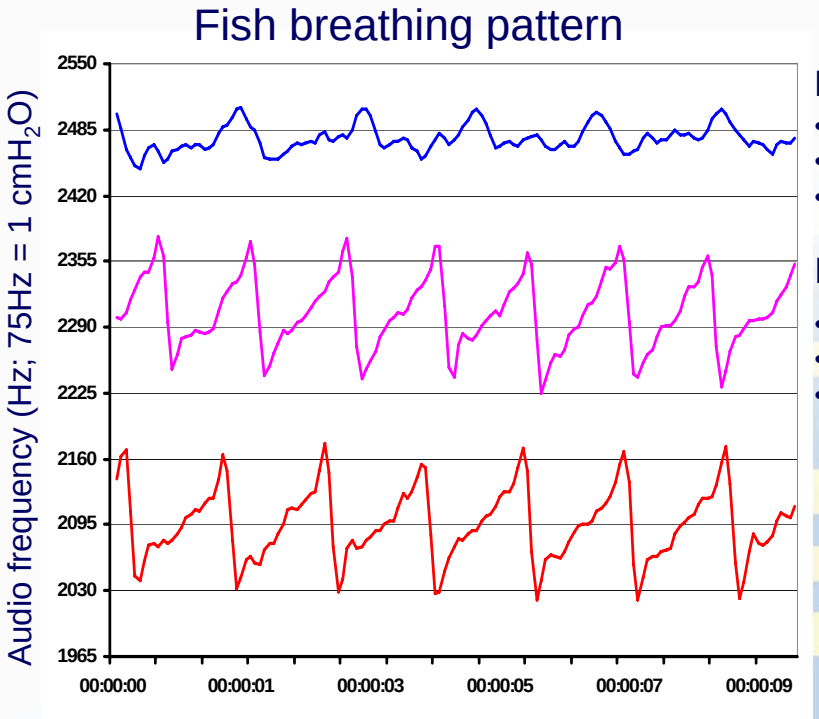


Normoxia; O_2=8.8mg/L(100%)
- Respiration frequency = 38 min^{-1}
- Breath amplitude = 1.2 cm H_2O
- Metabolism = 97 $mgO_2kg^{-1}hr^{-1}$

Hypoxia; O_2= 5.7mg/L (65%)
- Respiration frequency = 47 min^{-1}
- Breath amplitude = 3.0 cm H_2O
- Metabolism = 106 $mgO_2kg^{-1}hr^{-1}$

Hypoxia; O_2=4.0mg/L (45%)
- Respiration frequency = 41
- Breath amplitude = 2.3 cmH_2O
- Metabolism = 88 $mgO_2kg^{-1}hr^{-1}$
- Increased inspiratoric effort(?)

1. Responses to water quality manipulation:
some results II: hypercapnea



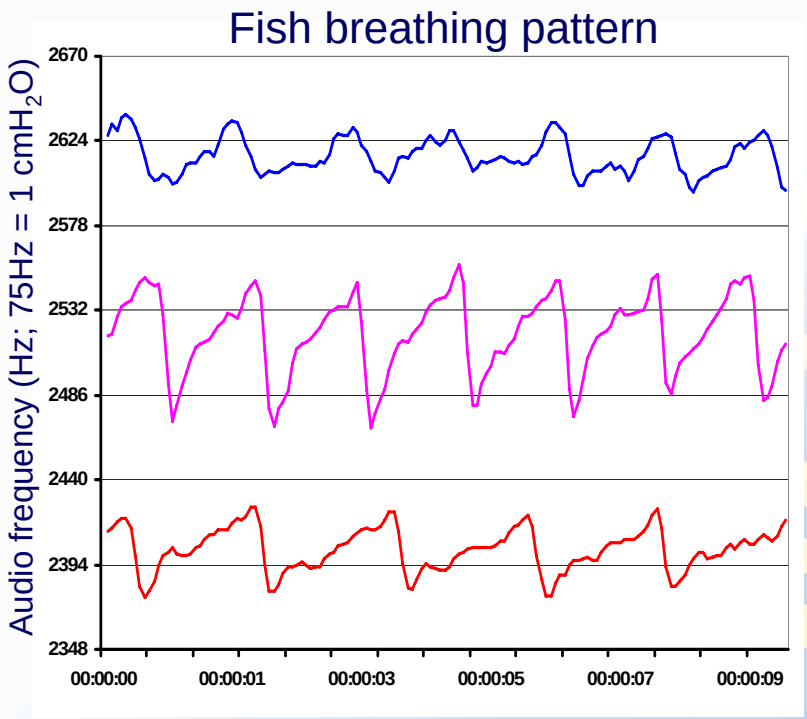
Normal water; CO_2 < 1 mg/L
- Respiration frequency= 35 min^{-1}
- Breath amplitude = 0.8 cm H_2O
- Metabolism = 82 $mgO_2kg^{-1}hr^{-1}$

Hypercapnea; CO_2= 17 mg/L
- Respiration frequency= 45 min^{-1}
- Breath amplitude = 2.2 cm H_2O
- Metabolism = 84 $mgO_2kg^{-1}hr^{-1}$

Hypercapnea; CO_2= 30 mg/L
- Respiration frequency= 41 min^{-1}
- Breath amplitude = 2.4 cmH_2O
- Metabolism = 68 $mgO_2kg^{-1}hr^{-1}$

1. Responses to water quality manipulation:

some results III: hypoxia + hypercapnea



Normal water

- Respiration frequency= 38 min^{-1}
- Breath amplitude = 0.8 cm H_2O
- Metabolism = 99 $mgO_2kg^{-1}hr^{-1}$

Hypoxia + Hypercapnea

O_2=5.5mg/L (65%), CO_2=13mg/L

- Respiration frequency= 42 min^{-1}
- Breath amplitude = 1.7 cm H_2O
- Metabolism = 91 $mgO_2kg^{-1}hr^{-1}$

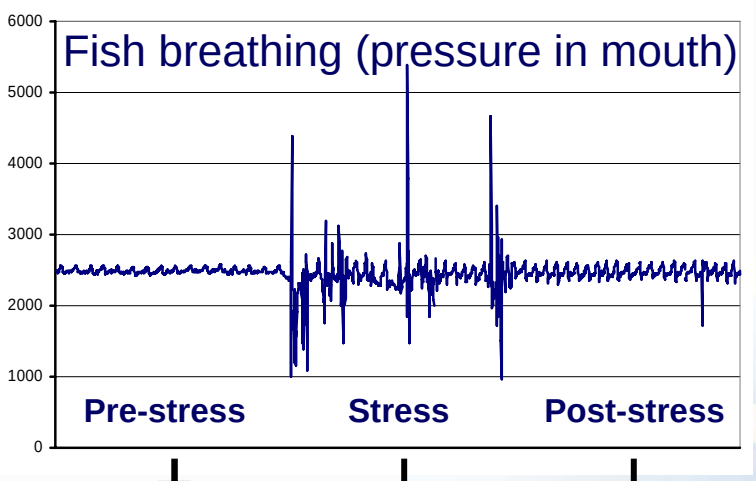
Hypoxia + Hypercapnea

O_2=4 mg/l (45%), CO_2=35 mg/L

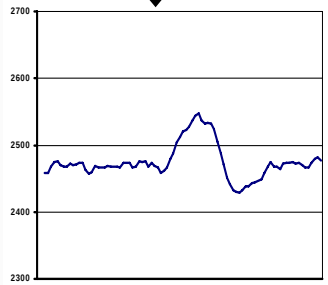
- Respiration frequency= 31 min^{-1}
- Breath amplitude = 1.1 cmH_2O
- Metabolism = 38 $mgO_2kg^{-1}hr^{-1}$

Validation of SmartTag:

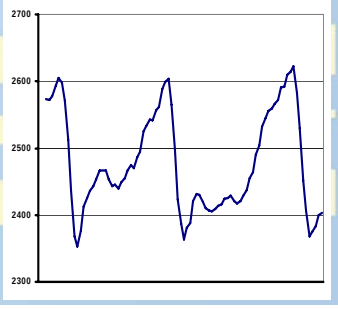
2. Responses to handling disturbance



Method: 2 min dip-netting in small sea cage



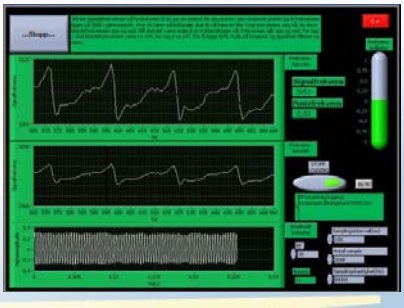
Stress:
RF = ?, ΔP up to 50 cmH_2O



RF = 16
ΔP = 1 cmH_2O

RF = 22
ΔP = 3 cmH_2O

SmartTag technology for monitoring fish welfare in aquaculture - CONCLUSIONS



- Provides online measurements of breathing activity in free-swimming fish
- Indication and documentation of fish welfare status as influenced by rearing conditions
- May also function as an early warning system and to optimize production regimes
- Excellent research tool, -but further development and validation is needed to become operational for the Aquaculture industry

Acknowledgements

- SEAFOODplus, ETHIQUAL-group
- Tor H. Evensen & Dr. Hilde Toften, Fiskeriforskning, Norway
- Prof Bård Holand, Jan Eyolf Bjørnsen, Torodd Tennøy, THELMA AS, Norway
- Dr. Jo Arve Alfredsen and MSc Torfinn Solvang, Institute of Technical Cybernetics, Norwegian University of Science and Technology, Trondheim, Norway and the Norwegian Research Council funded project FEEDTAG
- Dr. Julian Metcalfe, CEFAS, UK
- Havbruksstasjonen i Tromsø, Norway

Fiskeriforskning

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