Telemetry in fish – update

Fish telemetry in a welfare perspective

Øyvind Aas-Hansen*
Nofima Marine, Tromsø, Norway

Audun H. Rikardsen
University of Tromsø, Norway

Fish telemetry =

Wireless measurement of behavioural or physiological data in fish by use of electronic tags

(modified from def. *biotelemetry* by Cooke *et al.* 2004)

Nofima

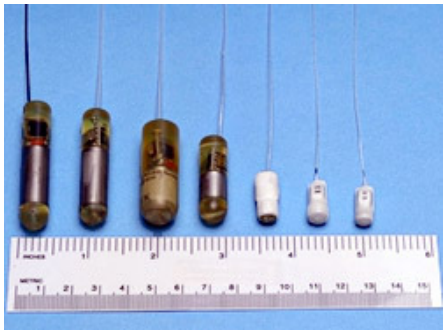
Electronic fish telemetry tags

(classified according to means of data communication)

Transmitters: ***Radio tags*** – Electromagnetic (radiowave) transmission of data
Acoustic tags – Acoustic (ultrasound) transmission of data

Dataloggers: ***Archival tags***, *DSTs* – data are stored in the tag until recapture

Combinations: ***CHAT tags*** – Combination of datalogger, transmitter & receiver
Pop-up tags – Datalogger and GPS transmitter

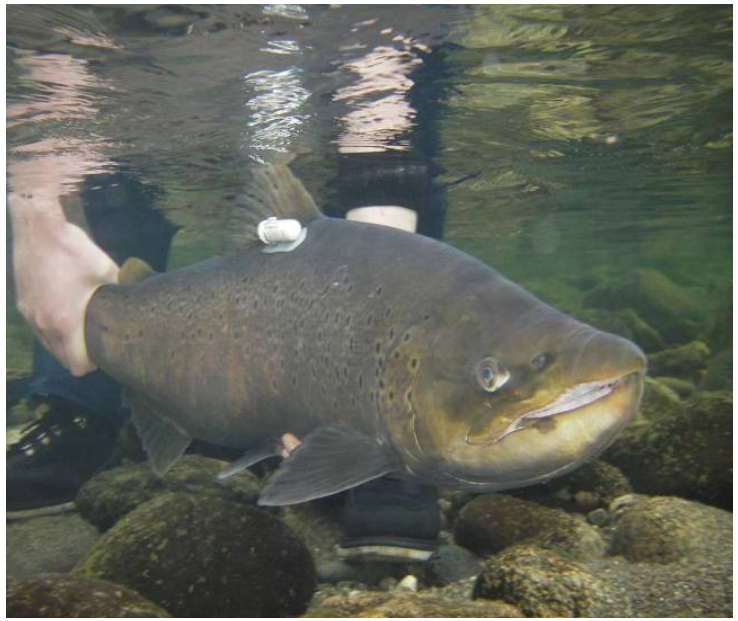


Radio tags (with antenna)
- used in FW only

Acoustic and dataloggers
- used in FW & SW

Pop-up tags (with antenna + float)
- can be used in FW & SW

Most common types of telemetry tag attachment



External tag

Internal tag: gastric

Internal tag: intraperitoneal

Depending on type of **sensor** and aim of the study, biotelemetry is often classified into behavioural and physiological telemetry

Behavioural telemetry

For example:
- vertical movements and habitat change by depth or ambient light tags
- behavioural signatures by 4D acceleration tags

Physiological telemetry:

For example:
- heart rate (ECG tag)
- breathing patterns (e.g. SmartTags)
- muscle activity (e.g. EMG tags)

Nofima

Fish telemetry in a fish welfare perspective

- Fish telemetry has its fundamental strength in enabling remote measurements in individual free-swimming fish
- It's usage has exploded over the last decades and resulted in a vast amount of new knowledge which otherwise would have been inaccessible
- More recently fish telemetry is increasingly used also to assess fish welfare.

Nofima

Monitoring and documenting fish welfare in captive fish

Traditional approaches:

- **Visual observation** of fish appearance and swimming behaviour
- Monitoring of **feed intake** or feed waste
- Veterinarian **inspections** and analyzes of sick or dead fish
- Monitor **environmental factors** and ensure these are within a pre-determined, acceptable range

Nofima

Monitoring and documenting fish welfare in captive fish

Traditional approaches (1, 2):

- **Visual observation** of fish appearance and swimming behaviour
- Monitoring of **feed intake** or feed waste

➢ *Visual observation depends on experienced observer and is difficult in intensive systems or large-scale aquaculture.*

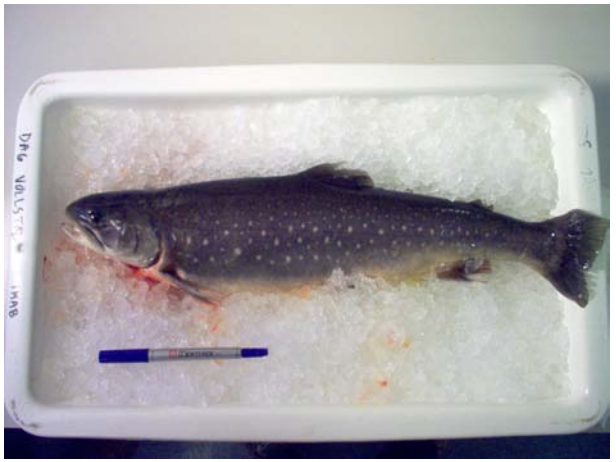
➢ *Monitoring of feed intake requires specialized systems and normally conceal individual variation.*

Nofima

Monitoring and documenting fish welfare in captive fish

Traditional approach (3):

- Veterinarian inspections and analyzes of sick or dead fish



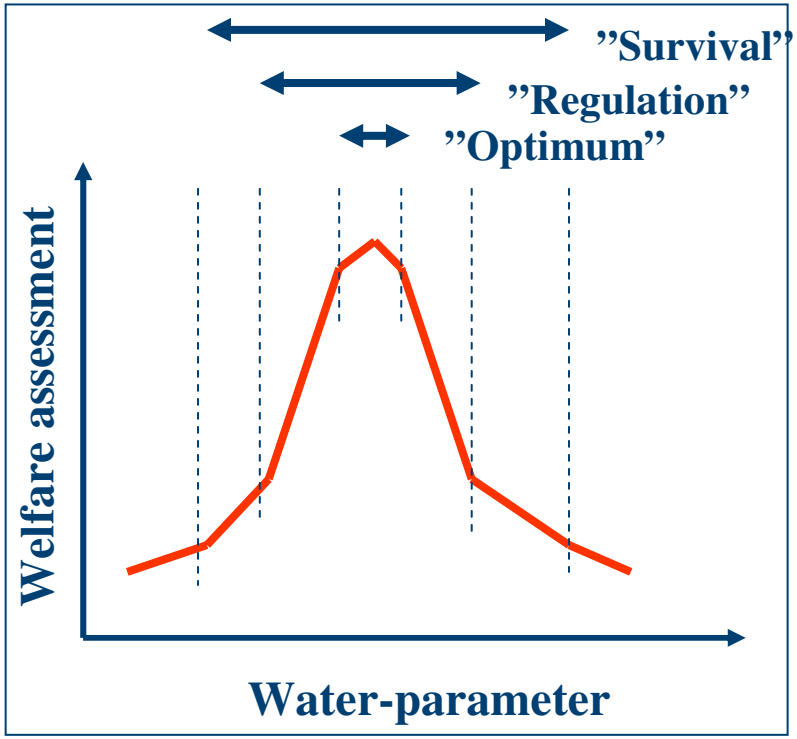
➢ *Inspections are periodical and/or based on prior suspicion of something being wrong, and may often be too late*

Nofima

Monitoring and documenting fish welfare in captive fish

Traditional approach (4):

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



➢ *Does not take in to account interactions between factors (“sum of factors”) and that fish requirements to such factors are variable*

Nofima

Monitoring and documenting fish welfare in captive fish

New approach: Fish telemetry

- Continuous monitoring of welfare indicator in free-swimming fish

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

➢ Tool for online monitoring of how individual, free-swimming fish respond to the sum of factors present in their captive environment

Nofima

Example:

SmartTags for measuring fish welfare in captive fish

The SmartTag is an acoustical tag, which provides online measurements of breathing pattern in free-swimming fish

The SmartTag (46 x 16 mm, 6 / 15 g in water/air) is attached on the back of the anaesthetized fish.

A 1.6 mm ID tube inside the mouth and connected to the tag provide online pressure measurements, thus producing detailed data on fish breathing activity.

SmartTags - fish respiration as welfare indicator

Fish respiratory activity known to be sensitive towards 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 (e.g. Pane et al. 2004)

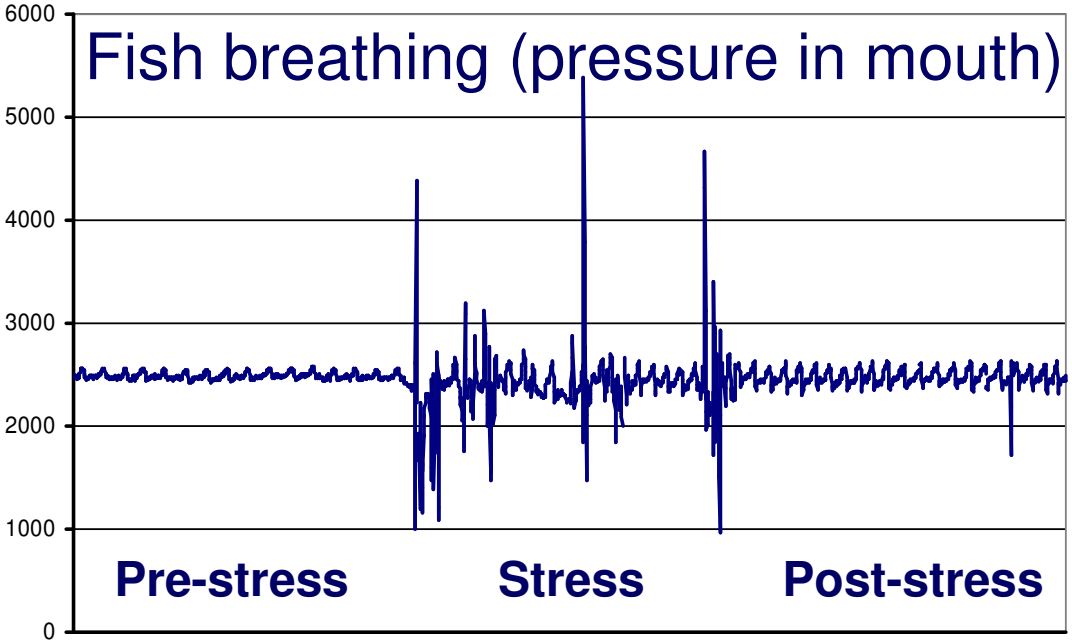
- Parasite infection, disease, anaemia (e.g. Byrne et al. 1991)

- General stress response (e.g. Laitinen et al. 1996)

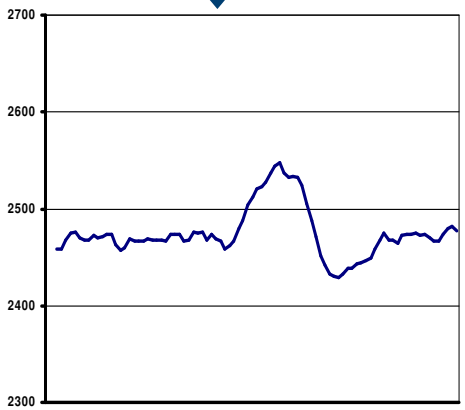
- Potential fear and pain (e.g. Sneddon et al. 2003)

Nofima

Example: SmartTags - Responses to handling stress

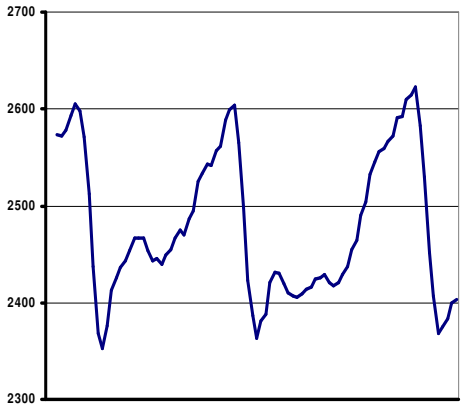


Method: 2 min dip-netting in small sea cage



Stress:
RF = ?, ΔP up to 50 cmH_2O

RF = 16
ΔP = 1 cmH_2O



RF = 22
ΔP = 3 cmH_2O

Fish telemetry for welfare assessment – limitations:

- Equipping fish with electronic tags may in it self represent a welfare concern as well as a scientific bias

Untagged, wild Arctic charr (photo A. Rikardsen)

➢ **Ideally, the use of fish telemetry should have no influence on the natural behaviour, physiology or health of the tagged fish following recovery**

Nofima

General effects of telemetry tagging on natural behaviour and physiology

- In general, telemetry studies have demonstrated
  - normal recovery of e.g. stress hormone levels takes at least 12 – 24 hours following tagging, and that
  - long-term growth and survival of tagged fish often is comparable to that of untagged fish.

- Apart from reporting growth and survival, few studies have investigated possible physiological or behavioural effects

- Mortality or severe sub-lethal short-term and long-term effects do occur, some of which could be reduced if more effort was put in developing and following validated protocols

Nofima

Wounds and fouling

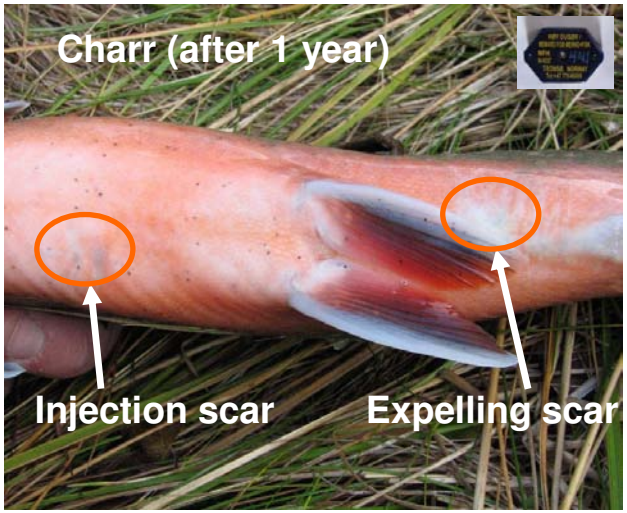
- *Both external and internal tags may cause wounds f.ex. if not performed properly or in fish at critical status*

Fouling of external tag

- *External tags may experience **fouling** (especially in coastal areas) which might interfere with fish natural behaviour and physiology.*

Nofima

Shedding



Shedding of internal tag in wild Arctic charr

- **Shedding** of both external and internal tags may occur in studies of more than some weeks, and normally cause wounds.

Shedding of internal tag through injection wound in wild Atlantic salmon

Shedding of external tag in wild Arctic charr

12 months

Nofima

Equipping fish with electronic tags may in it self represent a welfare concern as well as a scientific bias

- It is in the interest of the scientists to do their very best to minimize the effects of the whole tagging procedure and thus improve fish welfare

- Critical steps for minimizing welfare concerns during tagging include:
  - a) general circumstances prior to tagging
  - b) capture and handling of the fish
  - c) protocol for anaesthesia
  - d) tag attachment and surgery
  - e) fish recovery and release

Nofima

Minimizing welfare concerns during tagging:

a) General circumstances prior to tagging

- *Need preceding knowledge and evaluation in relation to e.g.:*

  - the general biology of the species (*i.e.* seasonal changes, life stage dependent differences)

  - the specific biology of the species (i.e. physiological and behavioural stress responses, health/disease assessment, assessing level of anaesthesia)

  - condition and previous history of the fish to be tagged (e.g. feeding status, temperature acclimation, recent handling)

  - external local factors (*e.g.* rearing environment, temperature)

  Example: Atlantic salmon very sensitive to all handling at low temperatures in winter

Nofima

Minimizing welfare concerns during tagging:

b) Capture and handling

- *Choose best method and procedure in order to:*

  - avoid physical damage

  - minimize stress

  - minimize duration, especially time out of water

Example: Anaesthetize in the fish tank if possible, thus minimizing stress by avoiding capturing and handling the awake fish

Nofima

Minimizing welfare concerns during tagging:

c) Anaesthesia

- *Critical points regarding fish anaesthesia for tagging*

  - Choice of most appropriate anaesthetic and means of administration

  - Validated protocol with regard to dosages and exposure times (NB: concerns mentioned in a) above).

  - Maintain good oxygen levels

  - Minimize stress, anaesthetic load and total duration

Examples: *Use dark cover to minimise stress in the induction phase*

Maintenance anaesthesia during surgery except when very short duration

Nofima

Minimizing welfare concerns during tagging:

d) Tag attachment and surgery

- *General concerns:*

  - external vs internal tag attachment

  - tag size, shape and material

  - optimized tag attachment methodology

  - validated surgical procedure

  - sufficient prior training

Nofima

Minimizing welfare concerns during tagging:

e) Fish recovery and release

- *Critical concerns:*

  - recovery in tank or small cage with good opportunity for supervision of each individual fish

  - water of excellent quality and at acclimated temperature

  - minimize additional stressors

  - gentle release when signs of full recovery

Nofima

Fish telemetry - Conclusions

- ✓ Fish telemetry enable collection of large amount of data with relatively few fish compared to more traditional methods
- ✓ The impact of the tag on fish welfare following release is for practical reasons too often measured only in terms of growth and survival
- ✓ With this in place, telemetric measurements of welfare indicators will be a powerful new approach for monitoring the welfare of free-swimming captive fish.

Nofima

Fish telemetry – Research needs

- There is a clear research need for developing **validated protocols** to ensure best possible fish welfare and scientific validity of collected data.

- In particular, more research is needed with regard to:

  - **anaesthesia and anaesthetic procedure**
  - **tag attachment / surgical procedures**
  - **evaluating short- and long-term effects on natural behaviour and physiology**

Nofima

Thank you for your attention

And many thanks to our collaborators:

- **Børge Damsgård, Tor H. Evensen,** Hilde Toften (Nofima Marine)
- Tore Kristiansen, Lars Helge Stien (IMR)
- Jo Arve Alfredsen, Torfinn Solvang-Garten, Martin Føre (NTNU)
- Christian Koren (Fish health veterinarian)
- Anders Karlsson, Bjørn Olav Rosseland, Anders Kiessling (UMB)
- Marie-Laure Begout (Ifremer, France)
- Julian Metcalfe (Cefas, UK)

- **Thelma Biotel (Trondheim, Norway)**
- Tromsø Aquaculture Research Station
- The National Cod Breeding Programme

Funders:

- SEAFOODplus, Norwegian Research Council, The Fisheries and Aquaculture Industry Research Fund (FHF)