# Telemetry in fish – update

## *Fish telemetry in a welfare perspective*

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## 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)



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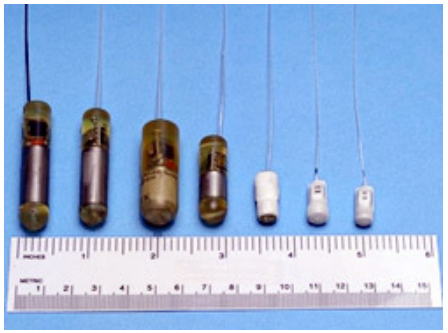
# Electronic fish telemetry tags

(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

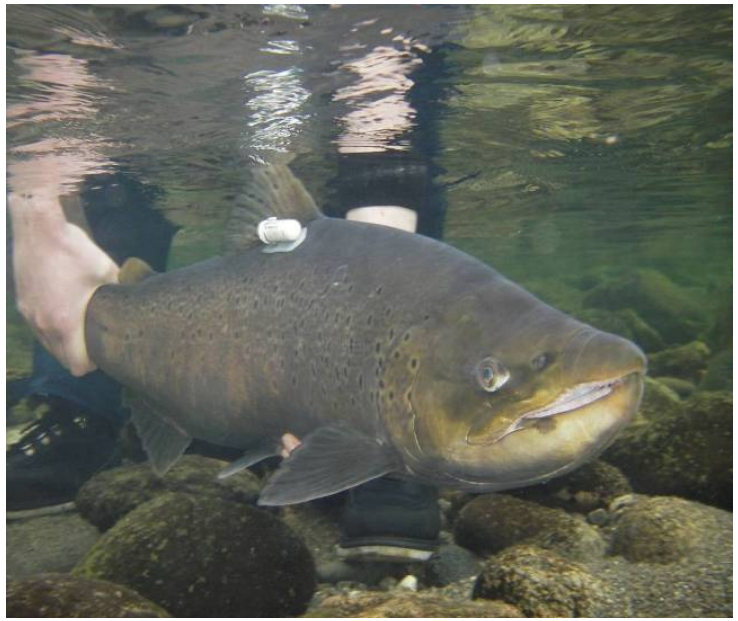


Radio tags (with antenna)
- used in FW only

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)*



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# 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.



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# 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



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# 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.*



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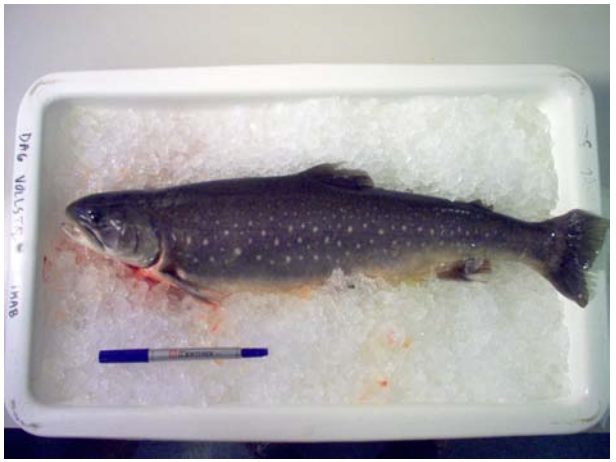
# Monitoring and documenting fish welfare in captive fish

## 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*



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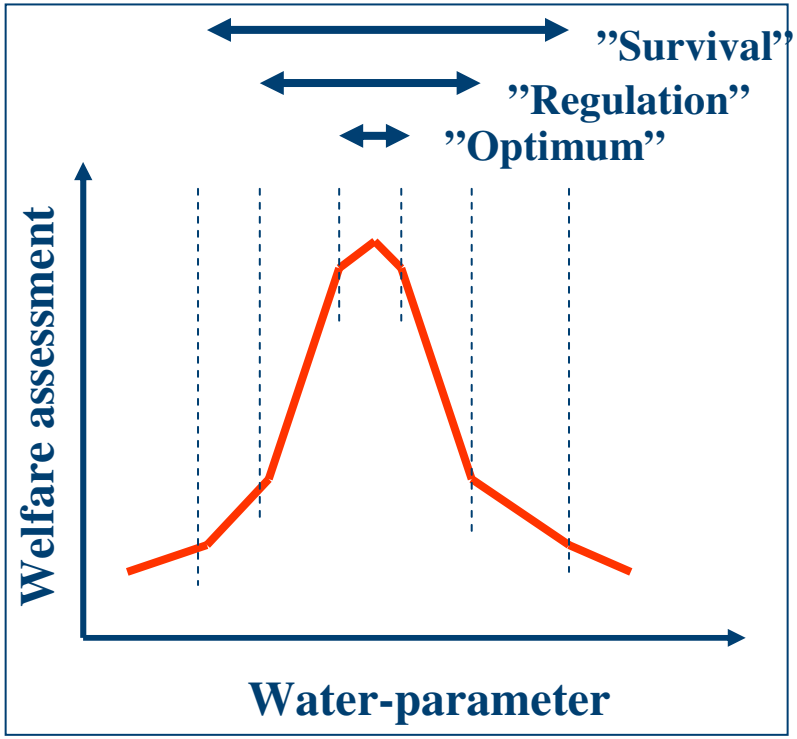
# Monitoring and documenting fish welfare in captive fish

## 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*



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# 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



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*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)



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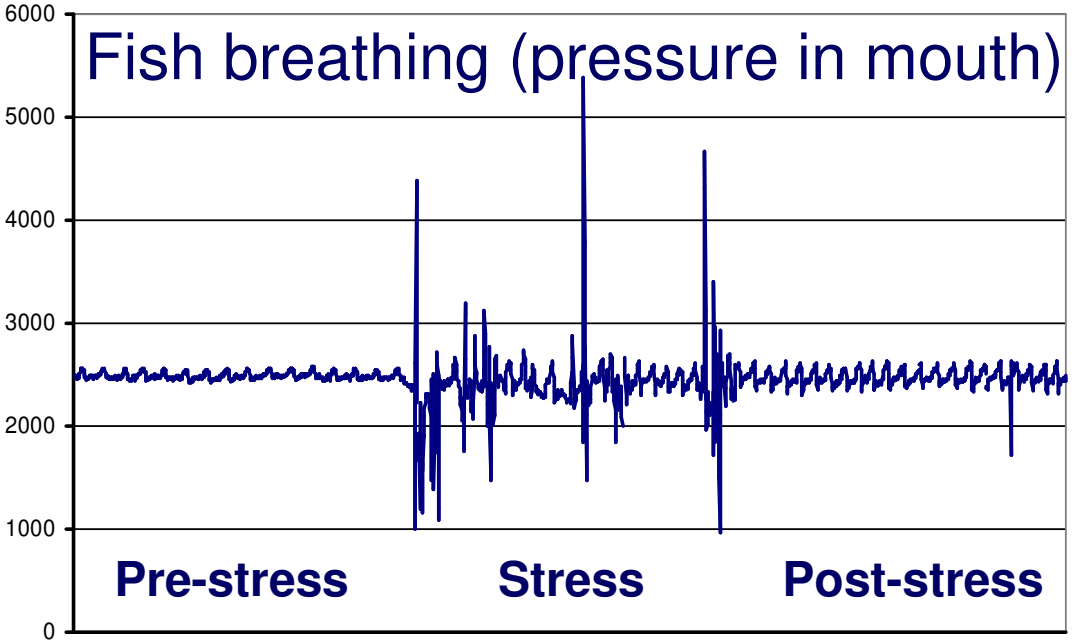
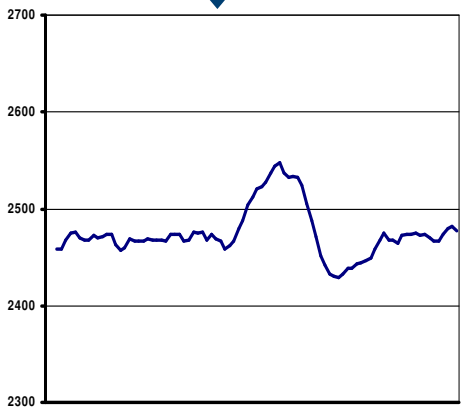
# Example: SmartTags - Responses to handling stress

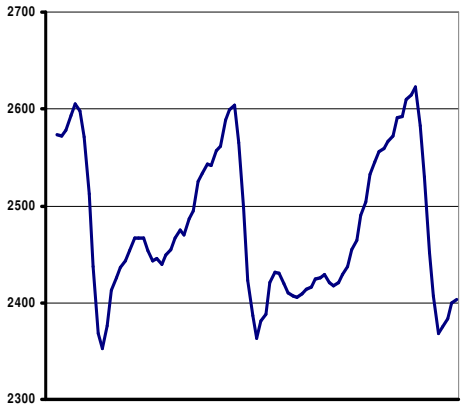



Method: 2 min dip-netting in small sea cage




Stress:
RF = ?, $\Delta P$ up to 50 $cmH_2O$

RF = 16
$\Delta P$ = 1 $cmH_2O$




RF = 22
$\Delta P$ = 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**



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# 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



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# 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.*



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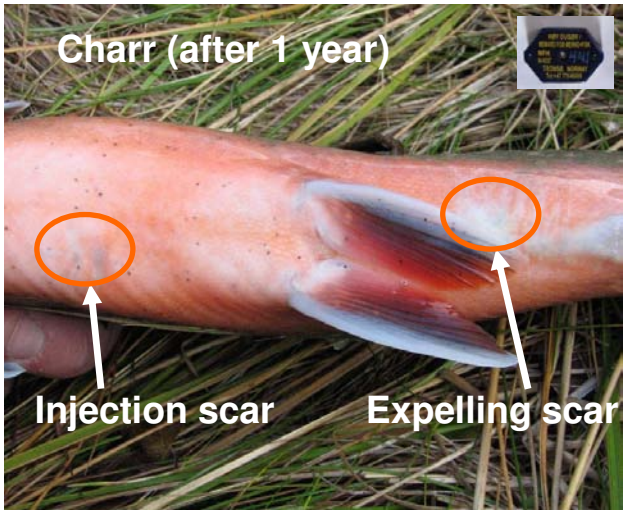
# Shedding




*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*



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# 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



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# 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*



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# 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*



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# 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*



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# 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



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# 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



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# 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.



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# 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**



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# 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)