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Received: 2017-02-04 / Published: 2017-09-26

Keywords

brown trout, age, growth, spawning, capture-mark-recapture, hydropower dam, fish ladder, migration, smoltification, fish scale

Short description of the dataset/summary

The dataset contains individual data for almost 8,000 brown trout (Salmo trutta L., 1758) captured during their spawning migration from Lake Mjøsa to the main tributary River Gudbrandsdalslågen in Norway during the period 1966 to 2005. These individuals belong to the large-sized piscivorous population of brown trout named Hunderørret (Hunder brown trout). A majority of these trout spawn upstream the waterfall Hunderfossen. Ascending this large waterfall, the migration length and characteristics of the spawning areas, are probably selection drivers for the large body sizes this population achieves compared to any other populations of piscivorous brown trout spawning in other rivers draining to Lake Mjøsa.

A hydropower dam was established at Hunderfossen between 1961 and 1964, causing a migration barrier for the Hunder brown trout. A fish ladder was also built, making the ascent possible from 1966, but not without negative effects (Aass 1990). The functionality seems to vary due to water temperature and water flow (Jensen & Aass 1995). The body size seems to affect the success of both entering and ascending the ladder. Additionally, the dam reduced survival of both smolt and kelt, due to predation in the dammed area and turbine passage mortality during downstream migration. The damming also reduced the areas of productive fish habitats in the river both upstream and downstream the dam (Aass et al. 1989).

When the fish ladder was opened, allowing the spawners to pass the dam, a capture-mark-recapture program was initiated. Trap capture, individual measurements, tagging, scale sampling and registration of recaptured repeated spawners in the fish ladder, were then implemented in a monitoring program. All spawners caught in the trap were individually measured and tagged with numbered Carlin tags (Carlin 1955).

To abate the reduced natural production of Hunder brown trout in the regulated river, a stocking program was initiated during the mid-1960s. The stocked fish are mainly released as 2-years old both in the river and directly into the lake (15,000-20,000 individuals per year). The stocked fish also returns to the river on spawning runs as mature adults. This long-time data series has been continued more or less unchanged until it was terminated in 2016. All stocked brown trout were tagged by cutting the adipose fin prior to release. To evaluate and optimize the stocking strategy, a large number of stocked smolt individuals were also tagged. Hence more than 30,000 individuals (both wild and stocked, spawners and smolts) have been marked individually with Carlin tags before release both upstream and downstream the Hunderfossen dam during 1966-2015. For a subset of these fish, approximately 8,000 individuals who climbed the fish ladder between 1966 and 2005, information on age, growth, time of migration and spawning history has been obtained from schlerochronological analysis of the sampled scales. This data has also been used to back-calculate yearly growth and to identify important life-history information such as hatching year, growth in river, age and size at smoltification, growth in lake, age and size at sexual maturation, and number of spawning events (e.g. Haugen et al. 2008).

Based on the 1966-2005 data the Hunder brown trout typically spend their first three to five years as parr in the river before migrating downstream to Lake Mjøsa (corresponding to smoltification and seaward migration in anadromous salmon and trout). In the lake they typically prey on fish for two to four years before maturation and migration back to the river to spawn. The Hunder brown trout typically perform biennial spawning runs and average age at first spawning run is ca. 7 years. Average size at first spawning run is ca. 3.5 kg and 65 cm. The Hunder brown trout seem to have a potential maximum life span of 15-20 years and a potential maximum size of 15-20 kg and >100 cm. However, less than 10% of the spawners reach age above 10 years, and less than 1% of the spawners reach weight above 10 kg.

General information

dataset entry ID:	FWM_7
name of the dataset:	
full name of the dataset:	Life-history data on Hunder brown trout (Salmo trutta) from Lake Mjøsa, Norway
dataset short name:	Life-history data on Hunder trout
type of dataset:	species (taxonomic group) per site database including environmental information
data type:	point data/observation data
science keywords according to GCMD:	
topic:	Agriculture, Biosphere, Biological Classification, Climate Indicators, Human Dimensions, Terrestrial Hydrosphere
ISO topic category according to ISO 19115:	
	Farming, Biota, Climatology/Meteorology/Atmosphere, Economy, Elevation, Environment, Inland Waters, Location, Society, Structure, Utilities/Communications
own science keywords:	lake, brown trout, Salmo trutta, hydropower dam, migration, growth, spawning, capture-mark-recapture, schlerochronology, scales, smoltification, monitoring, fishing, Hunderfossen, Hunder trout, age

Technical and administrative specifications

data format:	Access
operating system:	all Windows systems
data language:	English
specify:	Originally Norwegian, translated to English.
current access level:	restricted access

others/details:	The dataset is currently not publicly available, but may be obtained on request, on certain conditions.
currently available through GBIF:	no
exchange planned:	no
data in data repository:	no

Do you plan to publish the data on the Freshwater Biodiversity Data Portal:
no

update level:	update planned
others/details:	The life-history data are obtained from fish scale samples during 1966-2005. A large amount of additional scales have been sampled and stored, but not yet analysed (2006-2015).
documentation:	
type:	internal description
others/details:	More information is also available in various reports (in Norwegian).
language:	English

contact details:

metadata contact person:	
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postal code, city:	2306 Hamar
country	Norway
web address:	https://www.fylkesmannen.no/en/Hedmark/Climate-and-the-environment/
technical contact person:	
first, last name:	Jannicke Moe
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institution:	Norwegian Institute for Water Research (NIVA)
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postal code, city:	0349 Oslo
country:	Norway
web address:	http://www.niva.no/se-ansatt?navn=Jannicke%20Moe
scientific contact person:	
first, last name:	Per Aass
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email:	per.aass@nhm.uio.no
institution:	Zoological Museum, The Natural History Museums and Botanical Garden, University of Oslo, Oslo, Norway
address:	Sars gate 1
postal code, city:	0562 Oslo
country:	Norway
web address:	http://www.nhm.uio.no/english/

comments: Per Aass is retired, but affiliated at the Zoological Museum of the University of Oslo.

Intellectual property rights and citation

dataset creator (data compiler):

contact name:	Atle Rustadbakken
contact email:	atle@rustadbakken.no
contact institution:	The Environment Agency, County Governor of Hedmark

data contributors to/owners of this dataset:

	multiple
number:	2

data contributor/owner 1:

contact name:	Atle Rustadbakken
contact email:	atle@rustadbakken.no
contact institute:	County Governor of Hedmark
criteria for using this part of the dataset:	
	The dataset needs to be requested from dataset creator with specific conditions of use.
comments:	The Norwegian Institute for Water Research (NIVA) by Jannicke Moe has been given the administrator rights for a period of five years (2016-2020) with option for prolongation.

data contributor/owner 2:

contact name:	Per Aass
contact email:	per.aass@nhm.uio.no
contact institute:	University of Oslo
criteria for using this part of the dataset:	
	The dataset needs to be requested from dataset creator with specific conditions of use.
comments:	As for data contributor/owner 1.

citation of this dataset:

author(s):	Aass, P. & Rustadbakken, A.
title and journal (name, number, pages):	
	Life-history data on Hunder brown trout (Salmo trutta) from Lake Mjøsa, Norway (dataset)
year:	2017
version:	1

citation of the metadata:

author(s):	Aass, P., Rustadbakken, A., Moe, S.J., Lund, E. & Qvenild, T.
title and journal (name, number, pages):	
	Life-history data on Hunder brown trout (Salmo trutta) from Lake Mjøsa, Norway. Freshwater Metadata Journal 25: 1-11
year:	2017
doi:	https://doi.org/10.15504/fmj.2017.25

dataset related references:

reference 1:

author(s):	Haugen, T.O., Aass, P., Stenseth, N.C. & Vøllestad, L.A.,
title:	Changes in selection and evolutionary responses in migratory brown trout following the construction of a fish ladder. Evolutionary Applications. 1: 319-355.
year:	2008

reference 2:

author(s):	Aass, P., Sondrup Nielsen, P. & Brabrand, Å.

title: Effects of river regulation on the structure of fast-growing brown trout (Salmo trutta L.) population. Regulated Rivers: Research & Management 3: 255-266.
year: 1989

reference 3:
author(s): Jensen, A. J. & Aass, P.
title: Migration of a fast-growning population of brown trout (Salmo trutta) through a fish ladder in relation to water flow and water temperature. Regulated Rivers: Research & Management 10: 217-228.
year: 1995

reference 4:
author(s): Løvik, J.E., Skjelbred, B., Eriksen, T.E. & Kile, M.
title: Tiltaksorientert overvåking i vannområde Mjøsa. Årsrapport for 2015. Norsk institutt for vannforskning: NIVA-rapport 7028-2016. 105 s. (in Norwegian)
year: 2016

reference 5:
author(s): Hobæk, A., Løvik, J.E., Rohrlack, T., Moe, S.J., Grung, M., Bennion, H., Clarke, G. & Piliposyan, G.T.
title: Eutrophication, recovery and temperature in Lake Mjøsa: detecting trends with monitoring data and sediment records. Freshwater Biology 57: 1998-2014.
year: 2012

reference 6:
author(s): Løvik, J.E. & Moe, S.J.
title: Time series of plankton data from Lake Mjøsa, Norway. Freswhater Metadata Journal 18: 1-9.
year: 2016
doi: https://doi.org/10.15504/fmj.2016.18

reference 7:
author(s): Aass, P.
title: Utsetting av Hunderørret i Mjøsa og Lågen, 1965-1989. Fylkesmannen i Oppland, Miljøvernavdelingen. (in Norwegian)
year: 1990

reference 8:
author(s): Panfili, J., De Pontual, H., Troadec, H. & Wright, P.J. (eds.)
title: Manual of fish sclerochronology. Brest, France: Ifremer-lRD coedition, 464 p.
year: 2002

reference 9:
author(s): Carlin, B.
title: Tagging of salmon smolts in the river Lagan. Rep. Inst. Freshwat. Res. Drott. 36: 57?74
year: 1955

General data specifications

regional coverage of the dataset:
spatial extent of the dataset: catchment
continents: Europe

spatial extent (bounding coordinates):
southernmost latitude [°]: 60.400
northernmost latitude [°]: 61.220

westernmost longitude [°]:	10.433
easternmost longitude [°]:	11.294
minimum altitude:	123 metres
maximum altitude:	175 metres
countries:	Europe: Norway
world climatic regions according to Köppen:	
	Group C: temperate/mesothermal climates
freshwater ecoregions of the world (FEOW) according to WWF:	
	Europe: Northern Baltic Drainages
comments:	Capture, mark and recapture data of Hunder trout (without information on growth and spawning) are available for a larger number of individuals (30,000). These data will be described in a separate metadata paper.

Site specifications

coordinate system/grid data:	latitude/longitude, format: DD
datum (e.g. WGS84):	WGS84
grid data available:	no
comments:	For most data points a location is reported, but not coordinates.
site coding available:	no
number of sites:	<100
comments:	A large number of sites have been reported. In addition to the original site names, the sites are aggregated to larger regions (e.g. "lake", "river above dam" or "river below dam").

Climate and environmental data

climate related data:

available parameters per site:

mean annual temperature January, July
data source: www.met.no

mean annual temperature for each month
data source: www.met.no

minimal, maximal and mean winter and summer temperatures
data source: www.met.no

daily air temperatures
data source: www.met.no

mean annual precipitation
data source: www.met.no

winter and summer precipitation
data source: www.met.no

mean discharge
data source: www.nve.no

comments: Daily meteorological data can be downloaded from eklima.met.no, stations Kise (12550) and Toten (11500).

environmental data:

available parameters per catchment:

catchment size
data source: www.vann-nett.no
catchment geology
data source: www.ngu.no
catchment land cover/land use
data source: Løvik et al. 2016
population density
data source: Hobæk et al. 2012
presence of barriers/dams/reservoirs (fragmentation)
data source: www.nve.no
hydrological regime/flow regime
data source: www.nve.no

available parameters per site:

catchment land use upstream of sampling site
data source: Løvik et al. 2016
information on water uses (e.g., irrigation, fish ponds)
data source: Løvik et al. 2016
distance to next migration barrier upstream
data source: www.nve.no
distance to next migration barrier downstream
data source: www.nve.no
distance to the next lake upstream
data source: www.nve.no
distance to the next main village/town upstream
data source: www.norgeskart.no
river length
data source: www.nve.no
distance to source
data source: www.nve.no
distance to mouth
data source: www.nve.no
stream order (according to Strahler)
data source: www.nve.no
slope
data source: www.nve.no
altitude
data source: www.nve.no
hydrological regime/flow regime
data source: www.nve.no
discharge
data source: www.nve.no
maximum depth
data source: www.vann-nett.no
mean depth
data source: www.vann-nett.no

physico-chemical data: total P, nitrate, total N, hardness, alkalinity, TOC (total organic carbon), water temperature, pH, conductivity, chlorophyll, colour, Secci disc depth, thermocline depth

other physico-chemical parameters:

Other environmental data are available from NIVA (described by Løvik & Moe

2016). Other parameters (lake data): E. coli (2009-2011), ice cover (1949-2009), primary production, SiO2, turbidity.

availability of physico-chemical data, if there is more than one sample per site:
per sample

stressors influencing the sites:

reference sites available: no

stressor	restored sites available	data before/after restoration available	stressor gradient available	comments
eutrophication	yes	yes	yes	
organic pollution	no	no	no	
toxic stress	no	no	no	
hydrologic stress (e.g. impoundment, flow velocity reduction, hydropeaking, water abstraction, flow velocity increase, etc.)	yes	no	yes	Hunderfossen dam constructed in 1961-1964
thermal stress	yes	no	yes	Lake temperature has increased during the monitoring period.

Biological data

biological data origin: from sampling,
Monitoring program with annually registration and tagging of migrating trout in the fish ladder since 1966; various projects and funding sources.

organism group addressed: fish

comments: Data on other organism groups from Lake Mjøsa (phytoplankton, zooplankton) and River Gudbrandsdalslågen (phytobenthos, macroinvertebrates) are available from other sources (see Løvik et al. 2016, Løvik & Moe 2016).

Sample specifications/sample resolution

fish:

sample information:

covered timeframe: 1966 - 2005

historical data: yes

palaeo data: no

season: autumn

temporal resolution/frequency of sampling:
per year

time series data: yes

comments: Most of the samples were taken in autumn, when fish are caught in the fish ladder during spawning migration.
The data can be considered a time series since the same method has been applied to monitor a population over a long period of time.

taxonomic resolution:

level: species
percentage of species level data: 100
comments: All data are on one species (brown trout, Salmo trutta L.), from one population (Hunder brown trout).

taxonomic coding:
coding system: species name
example: Salmo trutta

sample specifications:
type: quantitative (abundance data), presence/absence
replicate samples: yes
number of samples: 7381
specification of method(s) used for sampling and sorting:

The fish were captured either in the fish ladder (and usually released), or by fishing (and usually killed). Information on capture location, date and method were reported for individually marked fish.

Ascending trout were trapped in the fish ladder at Hunderfossen hydropower dam on their spawning run. After registration of length and weight, some 4-6 scales were sampled with a small forceps. Scales were sampled from the area above the lateral line between the dorsal and the adipose fins. The fish were sexed based on secondary sex characteristics. The origin (wild or stocked) was registered based on whether the adipose fin was intact or not (removed = stocked). After registration and sampling, the fish were individually tagged with Carlin tags, consisting of a disc with information and a stainless steel thread to fix it to the fish (Carlin 1955). After tagging the fish were released into the fish ladder above the trap allowing them to pass the dam and migrate to their spawning areas. However, a number of fish were each year held in a river pool until time of spawning. These fish were used as brood fish in the stocking program and the fertilized eggs were placed in a hatchery located next to the dam.

The collected scales were stored dry in paper envelopes until preparation and reading. The majority of the scales were impressed on clear cellulose acetate plastic slides. These slides were analyzed on a microfilm projector. The last two years of available samples, 2004 and 2005, were digitized for computer-based reading and measuring.

The scales add sclerites as the fish grow. During periods of fast growth the distance between the sclerites are larger than during slow growth periods. Since fish are ectoterms, winter growth is considerably slower than summer growth at this latitude. Annuli are end-of-winter checks that represents the start of a new growth season. The age of the fish was determined by counting the number of annuli in the scales.

Based on the assumption that scale radius growth is linearly correlated to the body growth, it is possible to back-calculate the size of the fish during each year of its life. As annuli checks identifies seasonal patterns in the scales, the growth pattern can also reveal time of niche shifts. The age at migration from river to lake often corresponds to the shift between invertebrate and fish diet. Fish diet normally results in faster growth and the switch is therefore detectable in the sclerite pattern. Hence, age at smoltification can also be determined from scale

reading. Finally, spawning also creates checks in the scale. The standard output from a scale analysis of the Hunder trout is therefore river age and lake age (which sum to total age), yearly river growth and yearly lake growth, age at smoltification, age at maturity and number and time of spawning runs.

reference(s): Panfili et al. 2002

sample type (e.g. habitat specific samples, composite samples etc.):

Capture of individual fish (capture-mark-recapture).

specific sample location (e.g. littoral, profundal, transect, shoreline, hyporheic zone, etc.):

Any location in Lake Mjøsa and its main tributary River Gudbrandsdalslågen, including the trap in the fish ladder in Hunderfossen waterfall.

other important sample related informations:

Annually tagging and registering of all upstream migrating spawners at Hunderfossen and typical biennial spawning have resulted in a number of individuals sampled for scales at several occasions together with individual measurements of body length. We can compare back-calculated length at a given year with manually measured body lengths that have been collected on earlier spawning runs of the same fish. We can also calculate the precision and variability of the back-calculated year-specific body lengths on a number of scales sampled at several spawning occasions. The amount of fish with repeated scale sampling and measurements in this dataset allows us to validate the back-calculations against ground truth data.

Other specifications

GIS layers, shape files related to the dataset:

no data available

availability of photos: yes

availability of maps: yes

quality control procedures:

Were any quality control procedures applied to your dataset?

no

comments: The authors have contributed as follows:

Per Aass initiated this important monitoring program when the dam was constructed, and was in charge of the tagging of fish in the fish ladder for several years. Tore Qvenild has supported with computer assistance, digitizing and establishing the first version of the database and early stage analysis of these data. Atle Rustadbakken has been responsible for data cleaning and data compilation. He has also worked closely together with P. Aass on the age and growth analyses of the scales from thousands of trout. Espen Lund has also been involved in the data cleaning process, developing digital documentation, the analysis process and reading growth structures from fish together with A. Rustadbakken. Jannicke Moe has been responsible for constructing a relational database structure in Microsoft Access, importing the data from various Microsoft Excel files, and exporting data for sharing with other researchers.

Acknowledgements

This work was supported by the project SUSTAIN (Sustainable management of renewable resources in a changing environment: an integrated approach across ecosystems), funded by the Research Council of Norway contract no.

244647. During the decades of registration and sampling, several persons have contributed in different ways. Åse Brenden and Frank Hansen have been responsible for the technical work (registration and tagging) through their positions at the hatchery and stocking facility, Eidsiva Vannkraft AS (the hydropower company) since 1988. In addition, Profs. Asbjørn Vøllestad and Thrond Haugen have contributed to the process of cleaning and processing the data during the last 15 years.

References

Aass, P., 1990. Utsetting av Hunderørret i Mjøsa og Lågen, 1965-1989. Fylkesmannen i Oppland, Miljøvernavdelingen. (in Norwegian)

Aass, P., Sondrup Nielsen, P. & Brabrand, Å. , 1989. Effects of river regulation on the structure of fast-growing brown trout (Salmo trutta L.) population. Regulated Rivers: Research & Management 3: 255-266. https://doi.org/10.1002/rrr.3450030125

Carlin, B., 1955. Tagging of salmon smolts in the River Lagan. Rep. Inst. Freshwat. Res. Drott. 36: 57-74.

Haugen, T.O., Aass, P., Stenseth, N.C. & Vøllestad, L.A., 2008. Changes in selection and evolutionary responses in migratory brown trout following the construction of a fish ladder. Evolutionary Applications. 1: 319-355.

Hobæk, A., Løvik, J.E., Rohrlack, T., Moe, S.J., Grung, M., Bennion, H., Clarke, G. & Piliposyan, G.T., 2012. Eutrophication, recovery and temperature in Lake Mjøsa: detecting trends with monitoring data and sediment records. Freshwater Biology 57: 1998-2014.

Jensen, P.E. & Aass, P. , 1995. Migration of a fast-growning population of brown trout (Salmo trutta) through a fish ladder in relation to water flow and water temperature. Regulated Rivers: Research & Management 10: 217-228. https://doi.org/10.1002/rrr.3450100216

Løvik, J.E. & Moe, S.J., 2016. Time series of plankton data from Lake Mjøsa, Norway. Freswhater Metadata Journal 18: 1-9. https://doi.org/10.15504/fmj.2016.18

Løvik, J.E., Skjelbred, B., Eriksen, T.E. & Kile, M.R., 2016. Tiltaksorientert overvåking i vannområde Mjøsa. Årsrapport for 2015. (in Norwegian). NIVA report no. 7028-2016.

Panfili, J., De Pontual, H., Troadec, H. & Wright, P.J. (eds.), 2002. Manual of fish sclerochronology. Ifremer-lRD coedition, 464 p. Brest, France.

Appendix

Appendices

Appendices for Aass P., Rustadbakken A., Moe S. J., Lund E. & Qvenild T., 2017.
Life-history data on Hunder brown trout (*Salmo trutta*) from Lake Mjøsa, Norway. Freshwater Metadata Journal.

Contents:

Appendix 1: Map showing Lake Mjøsa and River Gudbransdalslågen where the Hunder brown trout occurs. The fish ladder and the hatchery are located at the Hunderfossen dam. Sources: The Norwegian Mapping Authority (https://www.kartverket.no) and ESRI (https://www.esri.com).

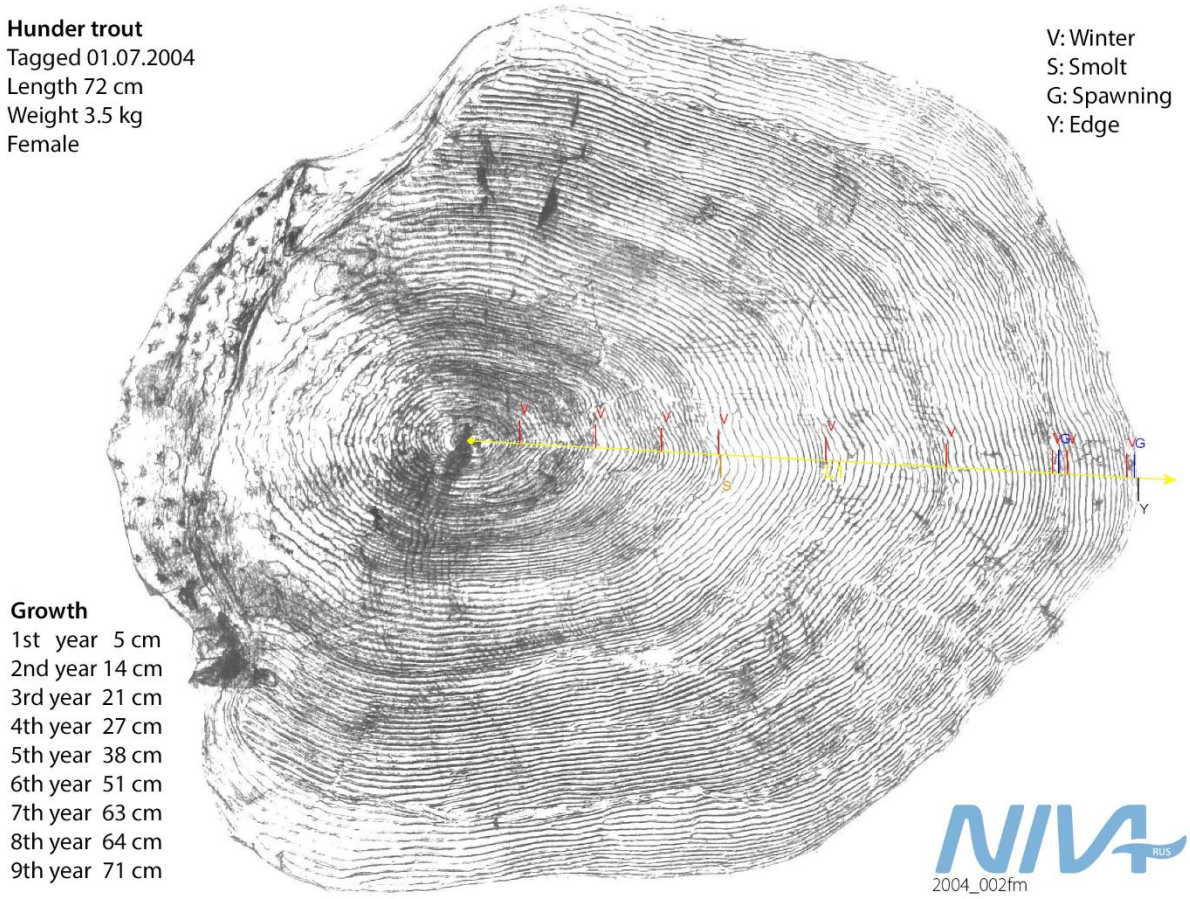
Appendix 2: Photos of Hunder brown trout.
Source: Atle Rustadbakken.

Figure 1. Example of Hunder brown trout with body length approximately 80 cm.

Figure 2. Example of fish tagged with a Carlin tag.

Figure 3. Detail of a Carlin tag with individual code.

Appendix 3: Illustration of fish scale and interpretation of growth and spawning.



Appendix 4: Illustration of the data model for the Hunder brown trout data base