LET THE RIVER LIVE
-CASCADE-EFFECTS OF RESTORATION IN BOGNELV

LA ELVA LEVE
-KASKADE-EFFEKTER AV RESTAURERINGEN AV BOGNELV

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Master Thesis 60 credits 2012

PREFACE

This master thesis is written at the department of Ecology and Natural Resource Management at the Norwegian University of Life Sciences. The thesis provides 60 credits for my Master of Science degree in Natural Resource Management.

I wish to thank my supervisors Professor Jonathan Colman for the good help with fieldwork and writing and Professor Thrond Haugen for guidance with statistics and writing. I also wish to thank Trond Andreassen for help with the electro fishing and Joachim Braathen Schedel for help with data and fieldwork. Furthermore, I wish to thank Knut Aune Hoseth and Anders Bjordal at the Norwegian Water Resources and Energy Directorate (NVE) for guidance and background information, and Langfjordbotn hunting and fishing association (LJFF) for background information. Finally, I wish to thank Ivar Mikalsen and his family for their hospitality when lending me their house and for good company during my fieldwork.

Ås, 12.5.2012

UNIVERSITETET FOR MILJØ- OG BIOVITENSKAP MDCCCLIX

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ABSTRACT

Numerous river processes regarded as problems by today's society, such as flooding and erosion, are vital to many organisms depending upon unstable environments. Several rivers have been altered to safeguard settlements and agricultural land with negative ecological consequences; red listing of flood- and river dependent species and eco-sites, and severely reduced ecosystem services once provided by such rivers.

Previous to the late 1900s, the River Bognelv appeared as a meandering river, a fact that the name states well, as Bognelv means "the curling river". Following decades of channelization and straightening, the river was heavily changed, and its salmonid fish populations severely reduced. Fortunately, channels were only closed and not cultured, making a nearly full restoration possible. Early in the 21th century, an extensive restoration of Bognelv was initiated and the work is still in progress. A study in Bognelv in 2008 revealed that the density of Sea trout (*Salmo trutta*) increased compared to earlier records, concluding that re-opening of sidechannels and tributaries were the most positive restoration measures conducted for this species.

In 2011, I conducted a new study of Bognelv, including sampling of macroinvertebrates and other environmental factors as well as humans. In light of the European Water Framework Directive, this study aimed to apply quantitative and qualitative sampling in a holistic approach towards the effects of river restoration. The effect on an entire ecosystem was studied, spanning from abiotic variables, through lower trophic levels of riparian vegetation and invertebrates, onto fish populations and finally, also the effects on us humans. Despite short recovery time, a tendency towards increased 0+ Sea trout density was found, coherent with increase in time since restoration. The results strongly indicate that sidechannels are important, also for the macroinvertebrates, though further structural improvements with in-flow are required if they are to function also during low-flow. Increasing tree density on the riverbank and construction of additional pools could further improve conditions for invertebrates and fish.

Additional to an aesthetic demolition, interventions often diminish the social and ecosystem value provided to humans by rivers. Bognelv provided an opportunity to explore human aspects of river restoration in Norway, and specifically, the non- monetary benefits provided by rivers. Residents and non- residents were interviewed regarding their relationship to, and awareness of, the river Bognelv. The river was important for residents and non-residents, anglers and non-anglers, who seemed to appreciate the values of both active use, and a more intangible, yet potentially positive, non-use. The amount of fish in the river was important even to non-anglers who claimed that an increased fish density would not make them start fishing. Fish were appreciated as a sign of a "living river", which seemed important to all groups. Other wildlife, especially birds, and the river's importance for these species was emphasized.

SAMMENDRAG

Tallrike elve- prosesser ansett som problemer i dagens samfunn, for eksempel flom og erosjon, er avgjørende for mange organismer som avhenger av ustabile miljøer. Flere elver har blitt endret for å ivareta bosetting og jordbruksareal med negative økologiske konsekvenser; rødlisting av flom- og elveavhengige arter og naturtyper, og sterkt reduserte økosystemtjenester en gang tilbydd av elver.

Før slutten av 1900-tallet var Bognelv ei buktende elv, noe navnet sier tydelig. Bognelv betyr nemlig "den buktende elva". Etter tiår med kanalisering og retting var elva fullstendig endret, og laksefisk- bestandene sterkt redusert. Heldigvis ble kanaler bare avstengt og ikke oppdyrket, noe som muliggjør en nesten full restaurering. Tidlig i det 21 århundre ble en omfattende restaurering av Bognelv innledet, et arbeid som fortsatt pågår. En studie i Bognelv i 2008 viste at tettheten av sjøørret *(Salmo trutta)* hadde økt i forhold til tidligere registreringer. Studien konkluderte med at gjenåpning av sidekanaler og sideelver var de mest positive restaurerings tiltak utført for denne arten.

I 2011 gjennomførte jeg en ny studie av Bognelv, hvor invertebrater og andre miljøfaktorer i tillegg til mennesker ble inkludert. Denne studien siktet på å benytte kvantitative og kvalitative undersøkelser i en helhetlig tilnærming til virkningene av en elverestaurering. Effektene på hele økosystemet ble studert, fra abiotiske variabler, via lavere trofiske nivåer av elvebredd- vegetasjon og invertebrater, til fiskepopulasjoner og til slutt oss mennesker.

Til tross for kort restitusjonstid, ble en trend mot økte tettheter av 0 + sjøørret funnet sammenfallende med økning i tid siden restaurering av elva. Resultatene indikerer at sidekanalene er viktige, også for invertebrater, skjønt ytterligere strukturelle forbedringer av innstrømmingen av vann er nødvendig hvis de skal fungere også når det er lav vannstand. En økt tetthet av trær på elvebredden og konstruksjon av flere kulper vil kunne forbedre forholdene for virvelløse dyr og fisk ytterligere.

I tillegg til en estetisk ”ødeleggelse”, reduserer ofte menneskelige intervensjoner i elver økosystemets verdi for mennesker. Bognelv ga mulighet til å utforske de menneskelige aspektene ved elve-restaurering i Norge, og spesielt de ikke-økonomiske økosystemtjenestene som elver kan tilby. Fastboende og ikke-fastboende ble intervjuet om deres forhold til, og bevissthet omkring Bognelv. Elva var viktig både for fastboende og ikke-fastboende, sportsfiskere og ikke-sportsfiskere. Alle syntes å sette pris på verdier av både aktiv bruk, og en mer immateriell, men potensielt positiv, ikke-bruk. Mengden av fisk i elva var viktig selv for ikke-sportsfiskere som hevdet at en økt fisketetthet ikke ville føre til at de begynner å fiske. Fisk ble verdsatt som et tegn på en ”levende elv”, som syntes viktig for alle grupper. Andre dyr, især fugler, og elvas betydning for disse artene ble fremhevet av mange av intervjuobjektene.

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INTRODUCTION

Rivers were once termed *"the blue arteries of the earth"* (Postel & Richter 2003), appreciating their great importance to life on earth. The title on this thesis refers to the tug-of-war over the damming of the Alta River. The slogan*"let the river live"*, which arose during this conflict, demonstrates peoples' perceptions of rivers as living entities, while the ensuing "Alta river demonstrations" illustrate a community's will towards preserving river systems.

In Norway, fish and fishing provides supplementary food to our commercial consumption, as well as providing income to professional fishermen, land owners and to society as a whole through socio-economic benefits of fishing as a hobby and sport (Miljøverndepartementet 1999). Additional economic values arise from river ecosystems, benefiting both private stakeholders, diverse user groups such as fishing clubs, and society as a whole (Bennett 2002). Furthermore, important non-monetary values exist in the form of recreational activities (Bennett 2002; Postel & Richter 2003).

For centuries, humans all over the world have changed rivers in order to extract resources like food and energy, or control flooding, the movement of water for irrigation, timber transportation and more (Postel & Richter 2003). These impacts often alter river systems and change the environment by changing the hydrologic and geomorphic processes (Wohl 2005). Only recently has the need for understanding the full range of costs and consequences of these actions become a priority and focus of research (Postel 2002). Today, human impacts are regarded as the main threat to species decline, also for aquatic environments in which plants, animals and humans rely (Feld et al. 2011; Postel & Richter 2003; Sih et al. 2000).

Channelization and straightening increases current velocity, rapidly creating an environment many river organisms are un-adapted to (Kristiansen 2011). Flood protection often produces similar results, separating a river from the river bank (Kristiansen 2011). Declining fish populations have been observed following channelization of rivers (Whalen et al. 2002). Loss of structural diversity also decreases natural ecological processes in the river/river basin (Josefsen & Hoseth 2005). Anthropogenic influence may have cascading impacts on trophic interactions; physical structure in the river/river basin changes the river/floodplain by changing plant abundance and communities/species, resulting in invertebrate changes, affecting fish, birds, mammals and finally humans (Josefsen & Hoseth 2005; Samaritani et al. 2011). Such over-all negative ecosystem effects also provide a platform to study potential positive effects of restoration at numerous trophic levels, i.e. a holistic approach.

While temporarily lost, natural variation can be restored to a river and/or river basin (Samaritani et al. 2011), potentially increasing their value to plants, fish and humans (Bennett 2002). Ecological restoration, defined as *"the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed"* (Society for Ecological Rehabilitation International Science & Policy Working Group 2004), is a relatively new field in Scandinavia of increasing interest (Hagen & Skrindo 2010; Roni et al. 2008). The number of river restoration projects in Norway have been increasing, while standardized following-up studies are lacking (Hansen 1996; Kondolf & Micheli 1995; Vehanen et al. 2010).

Norway agreed to the WFD (The Water Framework Directive) when it was implemented in the EØS agreement in 2008, and rectified from 2009 (Direktoratsgruppa 2011; St.prp. nr 75 (2007-2008) 2008). The WFD establishes a framework for protection of all water bodies within the EU (St.prp. nr 75 (2007-2008) 2008; Vannforskriften 2006; WFD 2000). To date, rehabilitation and restoration measures in

Norwegian rivers have often been initiated by local involvement, or responsible parties themselves have seen the need for improvement (Direktoratsgruppa 2009; Hoseth 2012a). However, assignment of the ecological status and required improvements in accordance with the WFD is now being accomplished for all water sources (WS) in Norway (Hoseth 2012a). The goal is that all natural surface WS will have "*minimum good ecological and chemical condition*" within 2021 (Vannforskriften 2006, §4) and restoration is described as a tool to accomplish this (Vannforskriften 2006). A central element in the WFD classification system is the degree of anthropogenic influence on a WS (Direktoratsgruppa 2011; Rustadbakken et al. 2011). An expected consequence of the implementation of the WFD, and the focus on physical change and restoring rivers to their pre- impact (natural) state, is that river restoration will become more frequent in Norway in the future.

Restoration of the River Bognelv in Norway represents an ideal opportunity to investigate ecosystem dynamics and the potential cascading effects of restoration within a river basin context in northern regions. In 2008, Schedel (2010) conducted a study in Bognelv aiming at revealing whether the restoration efforts improved the conditions for young salmonid species. The examined species were Sea Trout, Arctic char (*Salvelinus alpines*) and Atlantic salmon (*Salmo salar*), from here on referred to as trout, char and salmon, respectively. Schedel (2010) found that restoration likely had a positive impact leading to increased populations of young (under 12 cm) fish, especially trout, but also salmon, while there were too few char to include in the study. It was assumed that suitable habitats and food access were improved after the restoration. However, Schedel (2010) did not investigate the connection between plant and invertebrate density with fish abundance, nor did he explore the human dimension towards restoration of Bognelv. Thus, these aspects, as well as additional environmental variables in- and by the river were sampled in the present study. I also electro- fished the same 3 fish species as in 2008 and compared densities and lengths with Schedels (2010) findings.

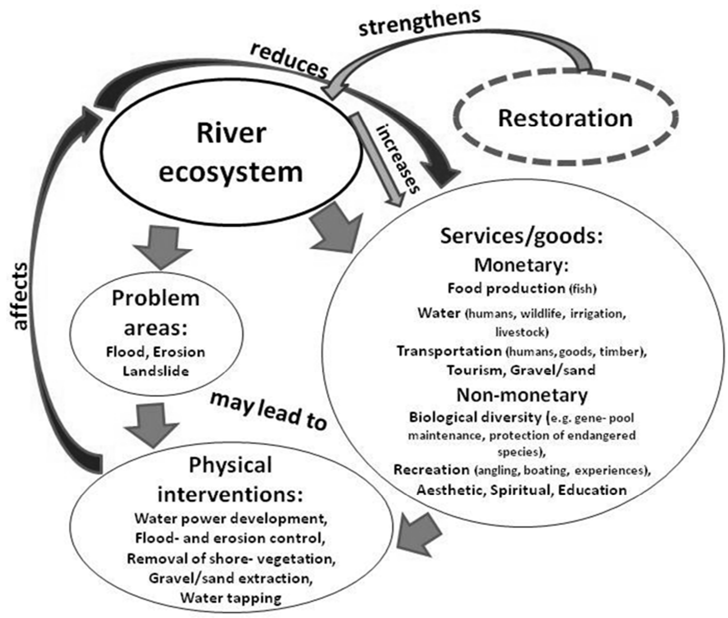

Figure 1 River ecosystems provides several ecosystem goods, but problem areas also exist. Both human extractions of these goods and efforts to reduce the problems involved often lead to physical interventions, affecting ecosystems negatively and further reducing the quantity and quality of goods for people and wildlife. Restoration might, however, strengthen river ecosystem and thereby increase its ability to provide goods for humans as well as wildlife. The figure is based on the following literature: (Bennett 2002; Carpenter et al. 2006; De Groot et al. 2010; Fergus et al. 2010).

The definition, and focus, of ecological restoration has changed since its birth in the late 1900's and increasingly includes a human aspect (Dufour & Piegay 2009). The definition by Karr (1999, p. 222) highlights the importance of human benefit goals: "*An environment is healthy when the supply of goods and services required by both human and non-human residents is sustained".* Further, inclusion of public support is stressed when measuring river restoration success (Weber & Stewart 2009).

The human aspect of river restorations has been examined in a few cases (e.g.Navrud 2001; Weber & Stewart 2009). However, this dimension is different in Bognelv than in many other instances because much value arising from the river is primarily non- monetary and "non-use" value, value of thought and feelings not involving an active use or physical product (Navrud 2001). Hence, Bognelv provided a chance to study non- monetary and non-use values arising from a river, the inhabitant's emotional relationship to the river and how channelization, and later restoration, affects this. Accordingly, I conducted a survey amongst the local population to gain insight into how they use the river and whether restoration has resulted in cascading improvements of river services for humans in the area. The need for research into revealing the validity of non-use values of fish stocks has been emphasized (Navrud 2001). Though no monetary estimate was conducted, the present study highlights some important economic aspects as well.

The main aim of this study was to investigate holistically whether habitat improvement (restoration) of Bognelv has led to increased density of riparian vegetation (land), macroinvertebrates and fish (river), and whether this has further increased the rivers (non- monetary, use- and non- use) values to humans (fig 1).

MATERIAL AND METHODS

STUDY SITE

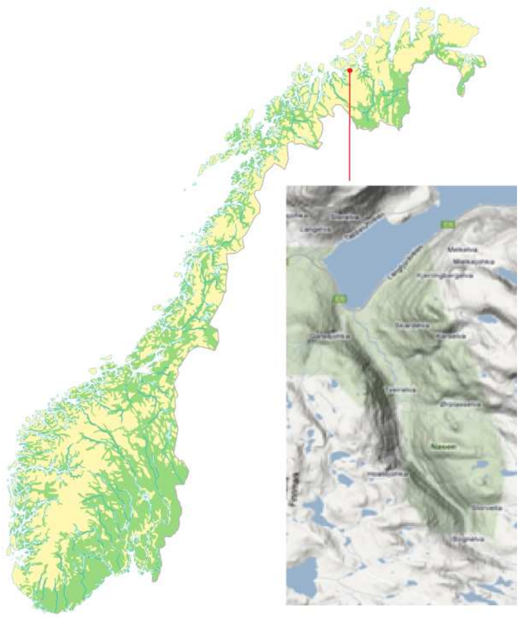

Figure 2 The study area in Norway where the BognelvRiver is situated. Map showing Norway adapted from: Statens kartverk (cc-by-sa-3.0). Map showing Bognelvdalen adapted from: *www.ut.no*

The study was conducted in the Bognelv (Bávnnajohka) River Valley (watercourse number 211.8Z). Bognelv is situated in Alta municipality, in the western part of Finnmark (Fig. 2), the northernmost County in Norway. According to Vann-nett (*Vann-Nett www...* 2012a), Bognelv is presently divided into two WS sections: the uppermost section, starting some hundred meters above the outlet of Ørplasselva to Vesterkråelva (211-55-R), and the second section at the uppermost car bridge to the start of the uppermost section (211-54-R). The lowermost stretch of the river is defined as part of the fjord and comprises the last 200 meters of the river together with the innermost stretch of the fjord (0420030401-2.C). The streams draining into Bognelv are labeled WS 211-44-R. None of the above management units have so far been assigned ecological or chemical status, but 211-54-R and 211-55-R are both listed with "risk" (*Vann-Nett www...* 2012a). Reported influences on WS 211-54-R are water utilization, morphological changes and contamination from diffuse sources, and is listed as a candidate for HMWB (Heavily modified water body) (*Vann-Nett www...* 2012b). Reported influences on WS 211-55-R are the same as for 211-54-R, but this section is not listed as a candidate to becoming a SMVF (*Vann-Nett www...* 2012c). Influence on WS 0420030401-2.C is contamination from diffuse sources.

Bognelv drains into Langfjorden (UTM: 549400 E, 7768800 N), a fjord arm of the larger Alta fjord, and has its origin in the mountains. The catchment area of Bognelv is 88, 5 km² (Josefsen & Hoseth 2005). The nearest community is Langfjordbotn, with app. 140 inhabitants, concentrated near the discharge of Bognelv. In July, the average discharge from the river is about 7 m^3/s, in August, September and October about 3 m^3/s, while the yearly mean flow is app. 27 m^3/s (Josefsen & Hoseth 2005).

Before Bognelv empties into the sea, it runs about 4 km through a landscape characterized by agricultural activities (Josefsen & Hoseth 2005). It was in this agricultural landscape that several interventions, such as channelization and dikes constructed to prevent erosion and flooding took place in the time period between the 1930's and the early 1990's (Josefsen & Hoseth 2005).

An intact forested belt separates the river and agricultural areas in the lower part of Bognelv along several stretches. This riparian belt consists of old forested floodplains where Grey Alder (*Alnus incana*) and Willow *(Salix sp.)* are the dominating tree species (Strann & Frivoll 2009). The riparian zone is also rich in birdlife, holding riverine species like the White-throated Dipper (*Cinclus cinclus*) and Common Sandpiper (*Actitis hypoleucos*), as well as Eurasian Treecreeper (*Certhia familiaris*) (Strann & Frivoll 2009).

The fish species present in Bognelv are trout, char and salmon. The anadrome reach in the main channel is app.6,5 km, of which 3,5 km (55%) was channelized (Josefsen & Hoseth 2005). In the early 70's, Langfjordbotn hunting- and fishing association (LJFF) consulted the Norwegian Water- and Energy directorate (NVE), bringing to light that the fish population in Bognelv was severely reduced to the point of almost non-existence. Some minor changes were attempted then to improve the conditions in the river, but the real restoration work began in 2006, following a plan prepared in autumn 2005 after an inspection of the river by LJFF and NVE in 2003 and 2004 (Dønnum & Colman 2004; Hoseth & Bjordahl 2009) (restoration measurement description: appendix 1).

QUANTITATIVE DATA

STUDY SPECIES AND PREPARATIONS

Fieldwork was conducted in 2011 during two separate visits, the first stay lasting from 21.6.11 to 4.7.11, and the second from 24.8.11 to 2.9.11. During my first visit, I located the stations along Bognelv and the surrounding floodplain/river bed used in the survey conducted by Schedel (2010). I was able to find the red-marks of 46 out of 54 stations. By looking at a sketch and a map I marked seven new stations where I estimated the old ones to have been situated. One station had been changed and was no longer sensible to electro fish. Since Schedel (2010) sampled in 2008, new parts of the river had been restored prior to 2011. Following the same design as Schedel (2010), I made nine new, additional stations where new restoration efforts had been completed since 2008; 15 meter long stations with at least 20 meters distance were measured using measuring tape and then marked with red spray well above the water line. All new stations were placed in the upper part of the river, but not any further than Schedel's (2010) sample site furthest up-stream. Six of the stations were placed in an unrestored stretch of the river, providing "control" sites. All sites were located from the outlet of the River to about 3, 5 km upstream. In total, 63 stations were sampled; 38 in the main river and 25 in side channels and tributaries. All stations were situated in WS 211-54-R, except 51 and 52 (WS 0420030401-2.C). These stations were further assigned zone numbers ranging from 1 to 9 as they were clustered at nine sections of the river (appendix 2).

SAMPLING

The sampling of fish was carried out using the electro fishing method, which is a suitable way of catching fish in rivers and is extensively used in Norway (Bergan et al. 2011; Bohlin 1984; Forseth & Forsgren 2009). During summer, 17 of the stations (all in side channels) had dried up and consequently only 46 stations were possible to electro fish. These 46 stations were divided into four transects at 0, 5, 15 and 20 meters, where overhanging branches over the river and the riverbank and riverbank vegetation were measured. In addition, the mean water depth, substrate, water temperature, water velocity, cover of algae, number of pools, invertebrates in the river and number, size and species of fish were registered at each station (appendix 3). Taxonomy was only appointed to fish and not invertebrates, due to the time-consuming analysis of collections of insects (Rosenberg et al. 1986).

The electro fishing was conducted in the latter field- period by two persons, with one person doing the actual electro fishing and both netting the fish and collecting them in a bucket. A standard method of three removals and 30 min between each removal was used when electro fishing (Bohlin et al. 1989; Seber & Lecren 1967; Zippin 1956; Zippin 1958). When high density of fish, two or three removals were conducted so that density of fish pr. 100 km^2 and catch efficiency could be estimated (Bohlin et al. 1989). If the density was low or if no fish were caught during the first removal, only two removals were carried out at the station. The fish caught during each removal were stored in a bucket with water and sedated with clove- oil before they were measured. When electro fishing at a station was completed, we recorded the specie and length (to the nearest mm) of all fish collected. The taxonomic level of fish examined was in relation to the EU WFD (i.e: amount, composition and age- structure. For further information see:Bergan et al. 2011; Direktoratsgruppa 2009). The fish were allowed to recover from the effects of the anesthetic, after which they were released back into the river. Little mortality was observed. The device used during electro fishing was a Terik Geomega FA4 *(http://www.terik.no/index.php?option=com_content&task=view&id=19&Itemid=45).*

DATA TREATMENT AND STATISTICS

Microsoft excel 2007 SP2 (Microsoft Corporation, Redmond, Washington, USA) was used for data processing and the creation of some figures. However, most of the figures and statistics were created in R version 2.14.2 (R Development Core Team 2011), which was also used to perform the statistical tests. Esri ArcMap 10.0 (ESRI, Redlands, California, USA) was used for making maps and some data extraction. Model selection was performed by using Akaike's Information Criterion (AIC) as a criterion for all zone/year models (Anderson 2008; Burnham & Anderson 2002). Linear models (lm procdure in R) were fitted to quantify possible effects of side channels on macroinvertebrate density, time since restoration/maintenance and side channel on fish density, and to test whether year and/or zones differed from each other. By applying anovas (anova procedure in R) to these linear models Fisher-based test statistics were retrieved with corresponding p-values. In general, count-based response variables (such as fish density) were ln-transformed as such data tend to be log-normal distributed (Sokal & Rohlf 1995).Because no fish were caught at several stations, densities of trout and salmon were log X+1 transformed (log(0) is not defined). Pearson's Chi-squared tests (chisq.test procedure in R) were applied to test for possible effects of side channels on macroinvertebrate density and differences between restored and unrestored stations. P-values were considered significant <0.05. The length variation between the groups compared was dissimilar, hence length was also log transformed in order to homogenize the variation among groups.

QUALITATIVE DATA

I conducted 28 semi- structured interviews with residents and cottagers of the Bognelv Valley ("Bognelvdalen"). The aim of these interviews was to measure the human aspect of the restoration project. The questions focused on interactions between the people and the river and what benefits, if any, they receive from the river. The qualitative interview form was chosen because it is a suitable way of receiving this kind of information about a group of persons thoughts and to complement my quantitative data (Dalen 2011).

TARGET GROUP AND INTERVIEW TECHNIQUE

The target group of this interview research was relatively small as it comprised only the residents and cottagers of Bognelvdalen. A random selection of people was therefore futile; hence, I decided to conduct the interviews on all willingly residents/cottagers. I set a lower age limit of 10 years and no highest age limit. The interviews were carried out at randomly selected hours and days. Only one person refused to participate. Eighteen of the participants were male and ten female.

I wanted to conduct interviews face to face, thus I chose to sample by knocking on doors. All the respondents were informed about how I was going to use the interviews. As stated by Horrocks and King (2010), recording might encourage the participants to aspire to give the interviewer the answers they think she would want. In addition, several issues, like "missing context", and poor recording quality might lead to misinterpretations of recorded interviews during transcription (Horrocks & King 2010; Kvale & Brinkmann 2009). Undesirable differences, as a result of varying methods might also arise if some refuse to be recorded. Therefore, after conducting some test- interviews, I chose not to use recording because of the few and relatively short-answered questions and thereby the short duration of the interviews. Instead, during interviews, I noted the essence of what people told me, and straight after leaving, I added in as much further details as recalled. Thus, I managed to get detailed handwritten records from every interview conducted.

PERIOD AND DURATION OF THE INTERVIEWS

I conducted the initial 28 interviews during my first field visit in Bognelvdalen, while one final interview was conducted in the latter period. The interviews lasted from 10 to 20 min. The reason I chose semi-structured interviews as a sampling method was that too much structure in an interview heading to intercept the interviewee's perspective might lead to some important aspects being disregarded (Ryen 2002). A main issue was to be certain that I got information about the same topics regarding the respondents' relationship to Bognelv, but at the same time have the possibility to be flexible, important when conducting qualitative interviews (Horrocks & King 2010). Some structure is also advantageous for making a potential future comparison easier (or even possible) (Ryen 2002). Consequently, I made an interview-guide and chose a full sentence style, which also helped me avoid leading questions (Horrocks & King 2010) (appendix 4).

ANALYSIS AND PRESENTATION OF THE RESULTS

All answers were coded separately and then thematically put together following the topics in the interview guide. Coding helped decipher whether the answers belonged to residents or non- residents, anglers or non- anglers, app. age of respondent and sex (e.g. would DRFM mean: 41- 60 years old, Resident, Fisher, and Male), ensuring an effective analyses and comparisons amongst the answers.

The answers received from different respondents were often highly analogous, but the non-residents answers tended to be more alike among them than when compared with the residents. Hence, I chose to divide the participants in two categories, and use this when presenting the results; residents and non- residents. All respondents who lived permanently in Bognelvdalen were classified as residents, while those who stayed there only part of the year were termed non- residents. All non- residents had a house/cabin in the valley and stayed there for considerable parts of the year. Residents made up 18, while the non- residents 10, of the respondents. Both residents and non- residents are termed “locals” in the text. When it provided insight, I also compared anglers with non- anglers.

Typical, essential and rare quotations were identified and used in the analysis as recommended by Dalen (2011). A narrative with the results divided in different themes was then prepared.
I used “him” and “her” in the analyses independent of true gender, ensuring the respondents anonymity.

GENERALIZABILITY

One strength of the applied approach, its highly contextual nature, also presents a limitation. The study captured experiences and perceptions of 28 locals in Bognelvdalen in the spring/autumn 2011. Thus, it is not inevitably generalizable to experiences and perceptions of all locals living within the vicinity of a river. This study’s goal was not to represent the entire population living within the vicinity of a river, but to gain an understanding of locals’ relationship to, and use of, a degraded and then restored nearby salmon river. Nevertheless, many shared perspectives emerged in the study that might be applicable to similar settings elsewhere in the world. Knowledge about local’s use of, and relationship to, a nearby river is essential to understand the human dimension of river restoration, an increasingly important activity (Dufour & Piegay 2009).

RESULTS

QUANTITATIVE DATA

Previous to the statistical tests, length groups of 0+ and ≥1+ trout and salmon in 2008 and 2011 were defined by creating histograms in R and applying the *abline* function. The 0+ age group of trout was originally set to be 25-60 mm in 2008 (Schedel 2010), however the *abline* function revealed that this was slightly skewed and that the 0+ age group was more likely to have been 25- 52 mm in 2008, hence this length group was applied on the 0+ age group of 2008 in further analysis. In 2011 the 0+ age group of trout was set to be 21-57 mm (fig 3). For the 0+ age group of salmon, lengths were estimated to 30- 50 mm for both 2008 and 2011(fig 3). Only one char was caught in 2011, and hence char were excluded from further analysis.

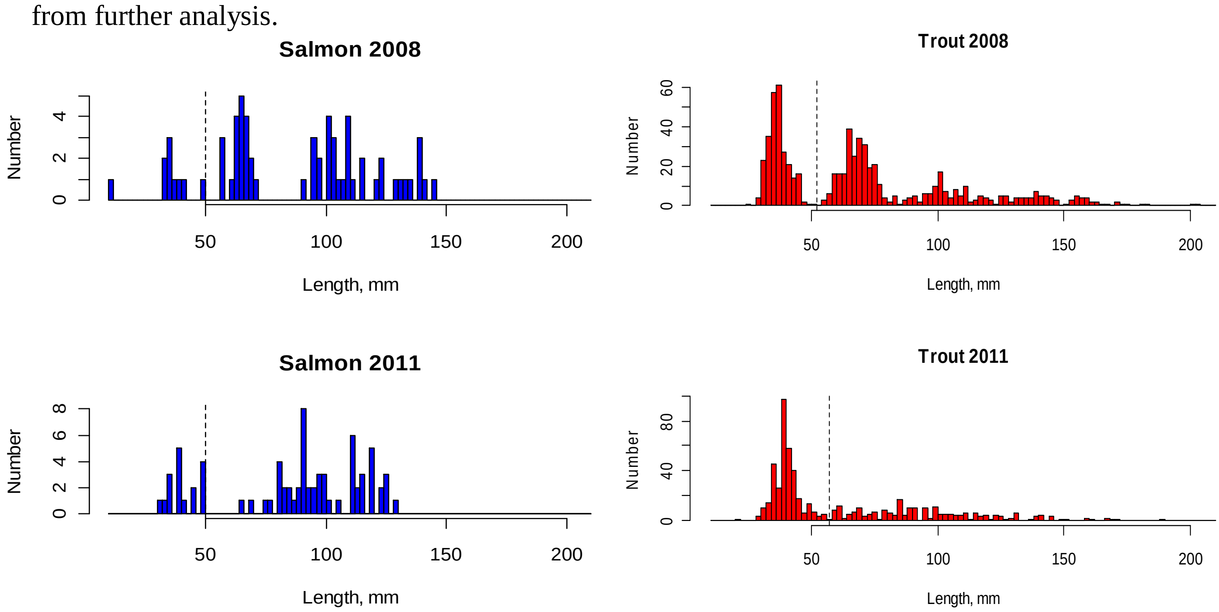

Figure 3 The length groups of 0 + and ≥1 + salmon and trout in 2008 and 2011 were estimated by applying the *abline* function in R.

EFFECTS ON FISH DENSITY OF YEAR AND ZONE

When testing for **year and zone effects on fish density** in 2008 and 2011, estimated AIC values showed that the best predictor of 0+ trout densities in the river included additive effects of year and zone (table 1). This implies that the 0+ density differences between zones are similar for the two years (2008 and 2011), but the highest densities were found in 2011 (fig. 4).

Table 1. AIC for models fitted to predict trout 0+ densities. The densities were ln (X+1)-transformed. When transformed to real numbers, the density of 0+ was 35.23 in 2008 and 61.18 in 2011.

Model	*df*	*AIC*
ln(density+1)=Year+Zone	11	220.2253
ln(density+1)=Year	3	220.2705
ln(density+1)=Zone	10	223.0126
ln(density+1)=Year*Zone	17	227.9035

However, an ANOVA revealed that the year and zone effects on differences in densities of 0+ trout were not significant. However, there was a clear tendency for similar differences in densities between zones for the two years (table a.1, fig. 4).

For >0+ trout, the most supported model included only a year effect, hence of those tested, "year" is the most influencing factor on >0+ densities of trout, with the highest densities in 2008 (table 2, fig. 4).

Table 2. AIC for models fitted to predict trout >0+ densities. The densities were ln (X+1)-transformed. When transformed to real numbers, the density of >0+ in 2008 was 26.94, and 14.33 in 2011.

Model	*df*	*AIC*
ln(density+1)=Year	3	214.1419
ln(density+1)=Year+Zone	11	221.1301
ln(density+1)=Year*Zone	18	225.9160
ln(density+1)=Zone	10	226.4805

An ANOVA revealed significant differences in >0+ trout densities between the years (difference estimate=-0.61±0.22 (se) p=0.006), with the highest densities in 2008 (fig. 5).

Based on AIC assessment, the best predictor of 0+ salmon densities in the river included only a year effect, with the highest densities in 2008 (table 3).

Table 3. AIC for models fitted to predict 0+ densities. The densities were ln (X+1)-transformed. When transformed to real numbers, the density of 0+ in 2008 was 5.17 and 4.60 in 2011

Model	*df*	*AIC*
ln(density+1)=Year	3	22.72210
ln(density+1)=Zone	7	27.09482
ln(density+1)=Year+Zone	8	28.93683
ln(density+1)=Year*Zone	11	30.75987

There were no significant differences in 0+ salmon densities between the years (p=0.58) (fig. 4).

The best predictor of >0+ salmon densities in the river included only a year effect, with the highest densities in 2008 (table 4).

Table 4. AIC for models fitted to predict >0+ densities. The densities were ln (X+1)-transformed. When transformed to real numbers, the density of >0+ salmon was 7.67 in 2008 and 7.27 in 2011

Model	*df*	*AIC*
ln(density+1)=Year	3	91.39087
ln(density+1)=Zone	10	92.32845
ln(density+1)=Year+Zone	11	93.29801
ln(density+1)=Year*Zone	15	99.58856

There were no significant differences in >0+ salmon densities between the years (p=0.86) (fig. 5).

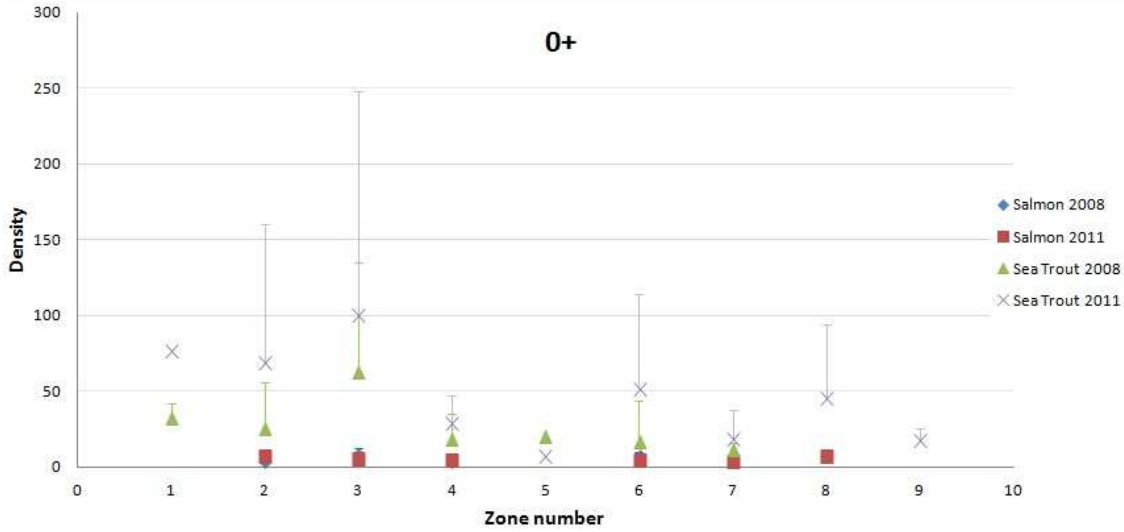

Figure 4 Densities of 0+ trout and salmon sampled in each zone in 2008 and 2011.

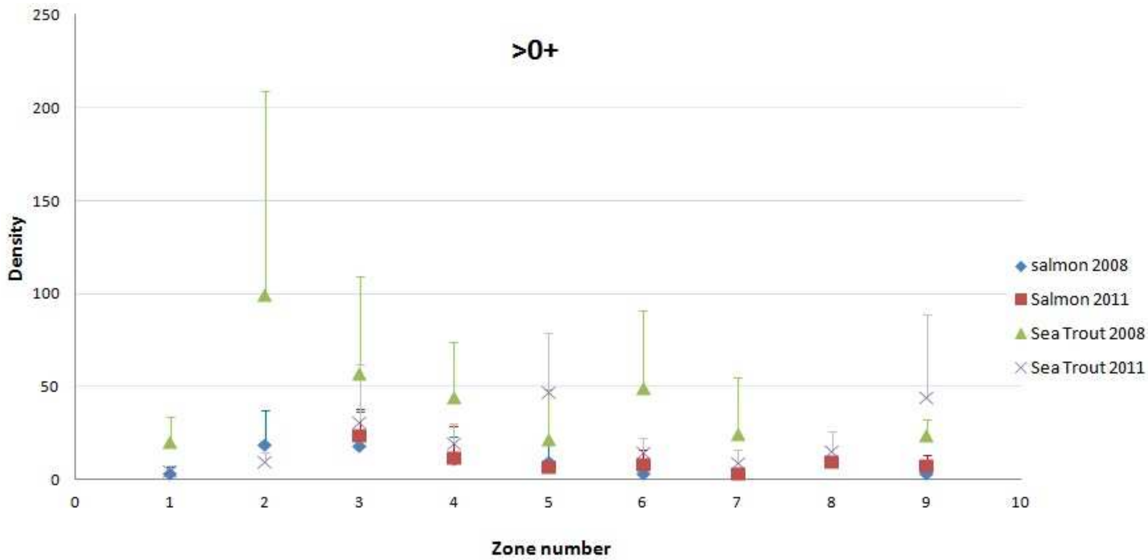

Figure 5 Densities of >0+ trout and salmon sampled in each zone in 2008 and 2011.

RESTORATION EFFECTS

Restored sites had significantly less (χ^2= 12.77, df = 5, p = 0.03) **overhanging branches over the river** than the un-restored sites (fig. 6), but there was no effect of restoration on **overhanging branches over the riverbed** (p= 0.44).

No significant difference between side channels and the main channel was found **for overhanging branches over the river** (χ^2= 5.77, df = 5, p = 0.33), this relationship was however significant for **overhanging branches over the riverbed** (p = 0.04).

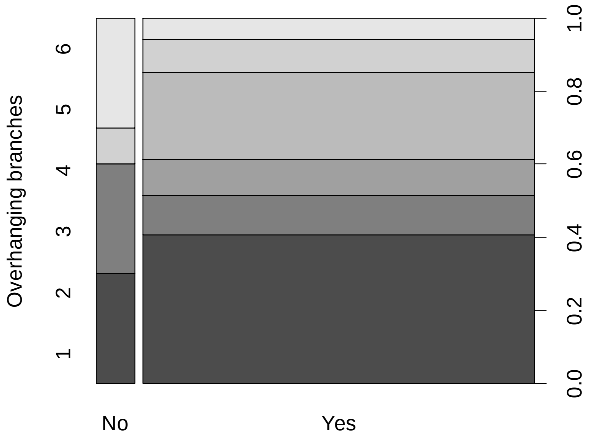

Figure 6 Significantly more overhanging branches over the river were found in the main channel compared with side channels.

No significant differences between restored and un-restored stations regarding **cover of plants on the riverbank** (χ^2= 6.08, df = 5, p= 0.30) or **cover of plants in the floodplain area** were found (χ^2= 4.87, df = 4, p= 0.30).

There was no significant difference **in number of pools** between restored and un-restored stations (χ^2= 2.62, df = 2, p = 0.27).

RESTORATION EFFECTS ON FISH DENSITY

An ANOVA revealed no significant difference in **density** for any of **the four fish** groups between restored and un- restored stations (p= >0.05).

A significantly higher **density of macroinvertebrates** was found in restored versus un-restored stations (χ^2= 28.64, df = 4, p = <0.0005) (fig 7), as well as significant higher **density of macroinvertebrates** in side channels compared to the main channel (χ^2= 59.96, df = 4, p = <0.0005). (fig 7).

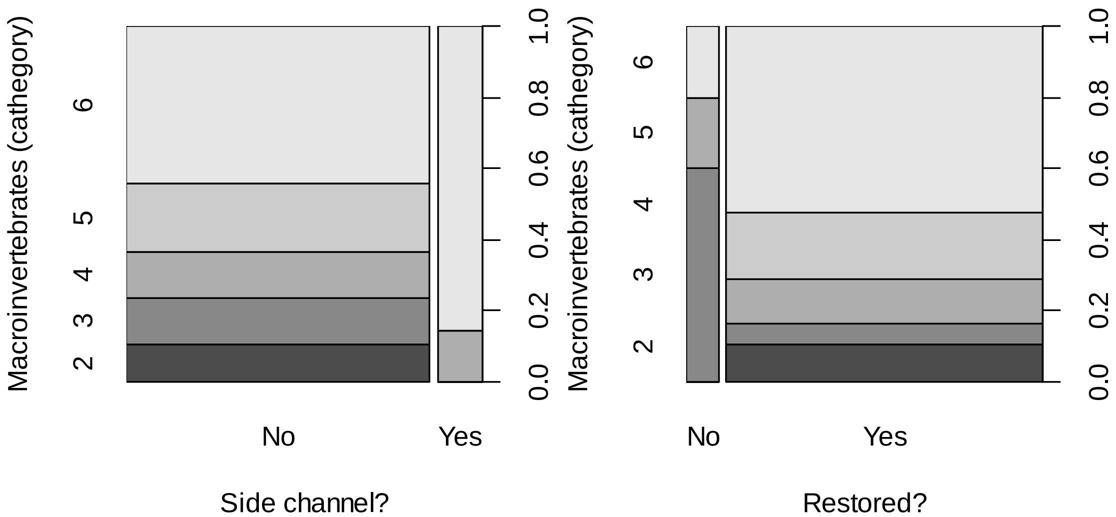

Figure 7 Macroinvertebrate density was significantly higher in side channels compared with the main channel (left figure) and in restored- than in un-restored stations (right figure).

MACROINVERTEBRATES AND FISH DENSITIES

No significant effects were found for **density of macroinvertebrates** on 0+ and >0+ trout densities, (p=0.35 & p=0.33, respectively), or 0+ and >0+ salmon (p=0.38 & p=0.98, respectively).

EFFECTS ON FISH DENSITY BY ENVIRONMENTAL VARIABLES

Few environmental variables had significant effects on fish densities (Table 5), with the exception of **depth** on 0+ trout, with densities decreasing with increasing depth (Table 5), **water velocity** on density of 0+ trout, with a trend for decreasing density with increased velocity (Table 5) and **algae** on >0+ trout, with fish densities increasing with increasing cover of algae (Table 6).

Table 5 Parameter estimates and corresponding test statistics for the effects of different environmental variables on fish densities

Variables	0+ trout	>0+ trout	0+ salmon	>0+ salmon
Depth	slope estimate= -0.03±0.01(s.e.) p=0.02	p=0.11	p=0.58	p=0.95
Temperature	p=0.50	p=0.31	p=0.90	p=0.20
Substrate type (ST)	p=0.54	p=0.76	p=0.41	p=0.49
Cover of branches over the river (BR)	p=0.34	p=0.22	p=0.93	p=0.29
Interaction BR/ST	p=0.44	p=0.37	p=0.86	p=0.26
Water velocity (WV)	slope estimate=-0.01±0.009(s.e.), p=0.07	p=0.91	p=0.13	p=0.24
Interaction WV/BR	p=0.15	p=0.27	p=0.83	p=0.16
Algae	p=0.18	p=0.01	p=0.86	p=0.98

Table 6 Parameter estimates and corresponding test statistics for the effects of algae on >0+ trout density

Parameter estimates				Test statistics			
Parameter	estimate	se		Effect	F	df	p
Intercept	3.26	0.15		*Algae*	3.38	4	0.01
Algae (>66%)	0.67	0.60					
Algae (0%)	-0.67	1.01					
Algae (1-33%)	-0.83	0.30					
Algae (34-36%)	-0.68	0.28					

SIDE CHANNEL EFFECTS ON FISH DENSITY

There was no significant effects when testing whether the **vicinity of a side channel** influenced overall fish density in the main river (p=0.13). To adjust for the dissimilar densities of salmon and trout in the river, a two-way ANOVA on whether the same vicinity influenced density **related to specie** was done, revealing a positive additive tendency for this for both species (difference estimate=0.26±0.16 (se) p=0.09).

There were no significant results when testing if the **vicinity of a side channel** influenced the densities at **specific stations** for 0+ trout (p=0.53). For >0+ trout there was a tendency for **vicinity of a side channel** to positively affect densities **at specific stations** (slope estimate=0.43±0.25 (se) p=0.09). For 0+ salmon and >0+ salmon densities, this relationship was non- significant (p=0.57 and p=0.25, respectively). There was no significant effect of the **vicinity of a side channel** on density in **specific zones** for 0+ trout, >0+ trout, 0+ salmon, nor >0+ salmon (p=0.16, p=0.46, p=0.69 and p=0.26, respectively). Whether a station was **placed in a side channel** did not significantly influence densities of any of the three fish groups (p=0.42, p=0.74, p=0.17, and p=0.80, respectively). Removal of two, almost dried-up side channel stations did not improve these result (p=0.42, p=0.59, p=0.17, and p=0.80, respectively).

TIME SINCE RESTORATION AND MAINTENANCE

An ANOVA revealed that there was a tendency towards increased **0+ trout** density with time since restoration (slope estimate=0.15±0.09 (s.e.), p=0.09) (fig. 8), but no significant effects for **>0+ trout, 0+ salmon** or **>0+ salmon** densities were found (p= >0.05). There was no significant effect of **time since maintenance** for any of the four fish groups (p= >0.05).

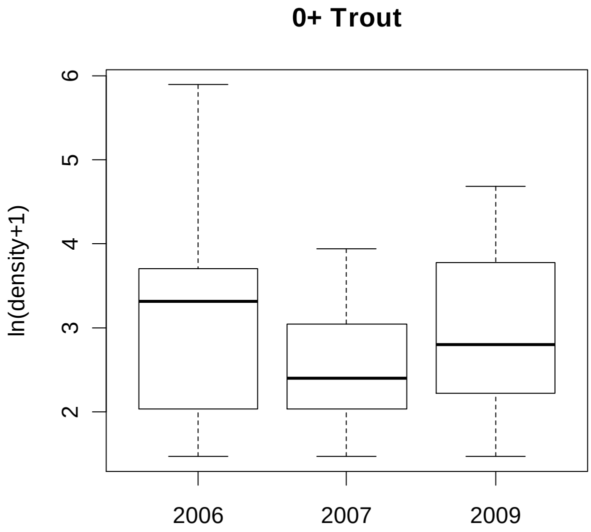

Figure 8 A trend towards increasing >0+ trout density with time since maintenance was found.

EFFECTS ON FISH LENGTH OF YEAR AND ZONE

When testing for year and zone effects on fish length in 2008 and 2011, an AIC showed that the best predictor of 0+ trout length included interaction effect between year and zone (table 7). This implies that the 0+ trout length varies between zones in a different way between years.

Table 7 AIC for models fitted to predict trout 0+ lengths. The lengths were ln (X+1)-transformed. When transformed to real numbers, the mean lengths of 0+ were 37.47 in 2008 and 45.06 in 2011.

Model	*df*	*AIC*
ln(length)=Year*Zone	17	-927.5859
ln(lenght)=Year+Zone	11	-925.1925
ln(length)=Year	3	-896.7782
ln(lenght)=Zone	10	-859.7660

An ANOVA of the best model showed that year was the most influencing factor on 0+ trout lengths, but test results of year and zone together were also significant. The 0+ trout were overall longer in 2011 compared to 2008 (table a.2).
Due to low catches and consequently poor data on 0+ salmon in the river, a similar test could not be performed on this fish group.

QUALITATIVE DATA

The findings have been separated into three sections. The first section presents the locals use of the River Bognelv, including how an increased fish population in the river would affect this. The second section focuses on the locals' relation to Bognelv and whether it has any meaning to them. The third section presents if, and why, the locals would want the fish population in Bognelv to increase and if they think the life in and around the river is of importance.

THE LOCALS USE OF BOGNELV

The rivers important role as a provider of several ecosystem goods like *water* (for people and irrigation), *recreation*, and of course, even though complained scarce; *fish*, was mentioned. All the residents had used the river in some respect. Only one of the non- residents stated that he had never used it.

The river was used in a myriad different activities, both by residents and non- residents. One resident who had recently moved to the valley did not hesitate when telling how she planned to use the river:

I am planning to use the river for angling. The whole family likes angling…It is the joy in angling which is the motivation, not necessarily to catch a lot of fish. If the river had been deeper I could have used it in other ways too, like snorkeling and boating. I have been snorkeling in the Alta River, but Bognelv is too shallow. The river is a way of recreation to me. The family goes for walks along the river, lights a fire and does some angling. I am certain that it will become of importance to our well-being here, in the future….since we've just moved here.

Most had fished in Bognelv, and some fished there regularly. However, the most emphasized activity was hiking. Even for those fishing regularly in Bognelv, hiking was often mentioned as an important reason for visiting the river. All but one of the anglers claimed that they used the river for other activities in addition to fishing. One angler expressed it like this:

The river does definitely mean something to me; not only because of the angling opportunities it provides, but also for hiking trips…we are often making fire by the riverside and just enjoying the river.

Bognelvdalen is situated in an area that offers a myriad of different natural environments, like mountain plateau, seashore and forest. Nevertheless, the river seemed to be a preferred place to go hiking, and a motivator for this activity to many of the participants. Like stated by one respondent:

It is nice that the river is so close; it makes it easy to go hiking.

THE LOCALS RELATION TO THE RIVER

The locals stated relationships to the river were merely positive and several declared that the river did have an importance to their well-being in the Valley. The word *recreation* was often used by the locals to describe their use of, and relationship to, the river. As stated by one of them:

The river has some meaning to me as recreation. I enjoy listening to it while sitting outside my house drinking coffee.

Almost all respondents answered that the river did have a positive meaning to them, regardless of if they used it for fishing or not. One of the residents explained his relationship to the river like this:

The river does absolutely mean something to me. Without the river, the valley would have been much less valuable. It's the river that makes the valley valuable, because of its beauty…not the fishing opportunities; it's not that good anyway.

Only one of the residents told that the river was not of importance to him *today*, but at the same time he stressed that this was because of his high age and thereby lack of possibilities to experience it:

The river doesn't mean that much to me today, but earlier when I was young and able to use it, it did.

Similarly two of the non- residents stated that the river did not have much value to them, one of them explaining this by purely practical reasons:

I don't think that the river has a meaning to me…it would have been better to our livestock if the river wasn't here…it would have meant less drowning and more grazing area...

Evidently, not all had philosophized over their perception of, and relationship to, Bognelv. Some clearly pondered the question for the first time. One non-resident began his answer unsure of if its presence was of importance to him, but before completing his answer he had recognized some importance:

The river does not really mean that much to me since I only stay here during my holidays and because my cabin is some kilometers away from it. I don't really know if the river means anything for my well-being here, I think I would have been just as fine without it. Even so, it would have been sad if it disappeared. It is a nice hiking- area and that is of some importance… The "bubbelen" is especially nice.

The importance of the river for other wildlife was also emphasized, as well as the healthy expression of the environment with clean water and lush vegetation. Many participants thought that if the river "disappeared", something would be missing in the valley and did not want this to happen:

> The most important thing is that the river is there. It has its mission…it would have been quiet without it…in a strange and negative way. Because we are so used to the river always being there we take it for granted, but if it had disappeared we would have noticed of course.

As expected since the Alta River is known for being a good angling- river, most of the respondents would pay more to fish in Alta than in Bognelv. Still, many respondents would pay less to fish in Alta than in Bognelv, this was especially true for the anglers, who explained this by their relationship to the rivers:

> I would pay more to fish in Bognelv than in the Alta River because I care more about this river and the place.

APPRECIATION OF FISH AND OTHER LIFE IN, AND BY, THE RIVER

Nearly all of the anglers, and all non- anglers, preferred a river with much fish compared with less. The reasons claimed for this were varying e.g.: "because it's much more fun to fish in a river with a lot of fish compared to one with only a few", "not only to me but for my grandchildren" or that it will have importance to "the tourism in the area". Not all knew exactly how to explain their view, like expressed by one of the anglers:

> The river would mean more to me with a lot of fish compared with only a few. I don't know how to explain this since I don't care that much about fishing, but it would!

One other respondent explained her view like this:

> I think it is important to know that other people can catch some fish, and for that reason the river would also be more valuable to me if there was a lot of fish in it compared to only few fishes…

AMOUNT OF FISH AND ANGLING ACTIVITY

Regarding amount of fish in the river and how this affects the desire to fish, the views from the locals varied. Some of the anglers claimed the joy of fishing as the most important factor when fishing and not necessarily catching lots of fish, although it was important that there were *some* fish in the river. Also, the area offers several other good angling opportunities. Many lakes and smaller streams in addition to the fjord were mentioned by respondents. One participant answered this when asked if she would angle more in Bognelv if the fish population increased:

> Maybe some more, but I like fishing in the mountains as well and I don't think I would fish in the river instead of the mountains, so it is not certain that I would have fished more in the river if there were more fish in it.

The most common view, however, was that the amount of fish in the river did affect their will of fishing, and that they probably would have fished more in the river if there were more fish in it:

> Yes, that's for sure. I don't care about fishing when nothing bites or when I can't see any fish...but I would have been fishing more often in the river if it had been more fish in it…

In most cases, more fish in the river would not make the non-anglers start fishing, even though they preferred more fish above less. One respondent answered like this when first asked if a river with much fish would be more valuable for him than one with less:

> Yes, much fish in the river would make it more valuable both to me personally, but also in knowing that my kids will have a living river to explore.

…and second when asked if more fish in the river would make him start fishing:

> I wouldn't have been fishing anyway since I don't care about fishing.

LIFE IN THE RIVER: OF IMPORTANCE?

Many of the locals used the strongly negative phrase “dead river” to explain a river without any fish, and did not want that to happen with Bognelv. This view was common for both the anglers/non-anglers and the residents/non- residents, who seemed to care just as much about the life in the river. This answer from a non- angler underlines this notion:

> It is nice knowing that Bognelv is a living river, that it is sustainable. It will be good for the kids to have a living river when they grow older, so that there are different things to look at by- and in the river.

When asked about the life in the river, all responded that this was of importance to them and several involved other wildlife than fish in their answer; birdlife was especially emphasized:

> It would have been really sad with a “dead” river. It is great to see the fish swimming in the river. Other wildlife such as birds is also an important part of the river.

DISCUSSION

QUANTITATIVE DATA

In Norway, hydro morphological interference is a major anthropogenic disturbance on river systems, and several fish populations have been lost or are threatened with extinction due to human influence (Bergan et al. 2011; Hansen et al. 2008; Jonsson et al. 2009; Kristiansen 2011). With similar ecological requirements, the quality and quantity of rivers are of great importance when managing and conserving trout and salmon (Heggenes et al. 1999). In rivers, salmonids are regarded as good indicator species and often correlate well with benthic fauna regarding the over-all quality of the environment (Bergan et al. 2011; Degerman & Henrikson 2004; Dieperink 2003; Jackson & Harvey 1993; Kilgour & Barton 1999; Mortensen 2010). Habitat is the main component influencing a stream’s salmonid carrying capacity (Heggenes et al. 1999), highlighting the significance of restoring a physically “damaged” river.

Although some environmental improvement measures in altered watercourses have long traditions in Norway (e.g. Fergus et al. 2010; Kristiansen 2011), ecological restoration of a river/water course is a relatively new and growing field in Norway (Berg 1999; Hagen & Skrindo 2010; Kristiansen 2011; Østdahl et al. 2001). As the focus revolves towards a long-term, ecosystem approach provoked by international conventions like the Convention on Biological Diversity, -Malawi principles and –WFD (Østdahl et al. 2001), more knowledge about the success of restoration efforts and the identification of the most effective restoration measures is needed (Feld et al. 2011; Kondolf & Micheli 1995; Vehanen et al. 2010). Thus, additional standardized follow-up studies, reporting of effects, and a database to collect knowledge gained through restoration efforts as studied here is crucial (Hoseth 2012b; Kristiansen 2011).

I found no significant difference in fish density between unrestored control stations and restored stations. However, this does not necessarily imply that the restoration activities in Bognelv have not improved overall conditions for fish. For instance, length test of 0+ trout were significantly longer in 2011 than in 2008. The positive results for 0+ trout in 2011 imply that the growth conditions for trout were better in 2011 than they were in 2008. This might also be true for salmon, but because of the low densities of 0+ salmon, a similar test was futile. Several details not included in this kind of test, and even in this study, can influence fish densities and size distributions in my data. The density of fish might have increased in unrestored stations because of overall improvements in the river resulting from restoration measures conducted elsewhere in the river. Because the uppermost, channelized stretch of the river is more or less restored, the unrestored stations for comparison had to be placed in the two lowermost zones.

This makes it more difficult to reveal differences because potential positive effects of restoration further up the river could improve the conditions downstream. Also, at the time of my sampling, the river was unusually dry. Drought often makes the fish move from side channels to the main channel, and downstream from upper areas. (Lowe-McConnell 1987; in Schlosser 1991; Ross et al. 1985). This might have impacted my fish- data in the way that usually preferred habitats (e.g. side channels) were less attractive or simply unavailable at the time of sampling because of a lack of water. Schedel (2010) found a significant higher density of >0+ trout in 2008 than what I sampled in 2011. However, at the time I was electro-fishing, many fish were observed trapped in small, isolated pools within mostly dried-up side channels. This might have led to a misleading low density estimate for fish in these side channels, as several fish, perhaps hundreds, were excluded from sampling. The lower density of >0+ trout in 2011 can also be due to natural, abiotic factors overruling possible effects of improvements from restoration. Salmonid stocks fluctuate naturally (Bergan et al. 2011), and long term monitoring has been stressed as essential for distinguishing natural from anthropogenic stress (Anon 2011; Schindler 1987; Vehanen et al. 2010). Hence, the lower density in 2011 might be due to natural fluctuations. Nevertheless, drought seems the most likely influence, as the side channels appeared to have more fish in 2011 than 2008 when visually monitored by locals and other scientist in mid-summer and before many of the side channels dried out (Colman 2012).

The total length of reopened side channels etc., and hence the increase in physical habitat that can be utilized by fish (Pedersen et al. 2007; Roni et al. 2008), can be used for measuring the benefits of re-meandering (Roni et al. 2008). In Bognelv, the stream length increased with 1440 m (22.15 % increases in the anadromous reach) after the reopening of 6 side channels/tributaries. When it comes to regulating populations of river dwelling salmonids, habitat competition has been suggested to be a dominating factor (Chapman 1966). This implies that an increase in available habitats within a river system over time might lead to enhanced populations of these species. Also, abundance of invertebrates may increase, as there is simply more space available.

The knowledge of differences in habitat preference between fish species underlines the importance of conserving/restoring connectivity between patches as well as heterogeneous river environments (Schlosser 1991); especially slow-flowing areas like side channels. Heterogeneous river environments will also make room for more fish as inter- and intra- specific competition probably affects the habitat use of the three species when living sympatrically (Heggenes & Saltveit 2007). This is especially true for the smallest individuals as they might be driven off by larger fish (Bohlin 1977).

In this study, a tendency towards increased densities of 0+ trout simultaneous with increase in time since restoration was revealed. The lack of significance might be due to the short recovery time of the river (Roni et al. 2002; Roni et al. 2008), as the timescale of recovery of restored rivers and responses with anadromous fish has been suggested to be considerably longer (Davies-Colley et al. 2009; Feld et al. 2011).

Habitat preferences normally differ between e.g. fish species, size, age classes, and rivers. When trout, salmon and char occur sympatric, they most often segregate their respective habitat use (Klemetsen et al. 2003). Salmon are more widespread in the faster flowing and shallow habitats than trout, though they show considerable spatial niche overlap (Heggenes & Saltveit 1990; Heggenes et al. 1999; Heggenes & Saltveit 2007). Char is described as a habitat generalist with high habitat flexibility (Klemetsen et al. 2003), but sympatric with the other two species in rivers, char have been observed to use slow or stillwater and deep habitat (Heggenes & Saltveit 2007). The catchability of fish when applying the electro fishing method may vary between different biotopes, consequently biasing the density estimate (Bohlin & Sundstrom 1977). My density estimates for the river as a whole, and differences between stations/zones might thus be biased. This is especially true regarding my char numbers, as electro fishing is stated to be inefficient in typical char habitats; deep, slow flowing (Bohlin et al. 1989) and midstream areas (Heggenes & Saltveit 2007). The use of underwater camera was therefore considered. Bognelv was, however, unusual low at the time when the electro fishing occurred, making electro fishing at usually deeper areas more efficient and cameras were unnecessary. However, midstream areas were not included after–all, since this would make a comparison with earlier density numbers inaccurate.

Because benthos are more stationary than fish, they probably are better indicators for local conditions, moreover, as their life cycles are short, they respond quickly to environmental changes, and probably similar to fish response (Kilgour & Barton 1999). Nevertheless, few studies have focused on macroinvertebrates response to river restoration (Miller et al. 2010), and according to Friberg et al. (1998), diversity and density of macroinvertebrates should both be low in channelized rivers. This community will nonetheless quickly recover if their habitats are restored (within ~1-2 yrs) (Niemi et al. 1990) and within 2 yrs, likely be of higher densities than before remeandering, but later decrease and stabilize (Friberg et al. 1998). However, post-restoration research has produced equivocal results of macroinvertebrate density response (Friberg et al. 1998; Nakano & Nakamura 2006). It was not possible to compare my macroinvertebrate data with earlier data, as no such data exist. Instead, the densities at restored and unrestored stations were compared. The significant higher density at restored stations compared with unrestored is similar to Friberg et al. (1994) two years after remeandering of the Danish River Gelså. Addition of pools in channelized reaches has shown to change these habitats, resulting in finer particle sizes and greater organic matter retention, favored by macroinvertebrates virtually absent from channelized reaches (Miller et al. 2010). This can, however, not explain the present difference in density of macroinvertebrates, as no significant difference in number of pools between restored and unrestored stations was found. The significant higher densities of macroinvertebrates in side channels compared with the main channel is probably the reason for the difference between restored and unrestored stations, as side channels are only found in the restored sections of Bognelv.

The non- significant relationship between macroinvertebrate- and fish densities in Bognelv agrees with the even distribution of fish in side channels/main channel despite the higher densities of macroinvertebrates in side channels. However, the positive relationship between the vicinity of a side channel and fish density related to specie likely reflects a connection between macroinvertebrates and fish. Probably, the side channels functions as "food- stations" for the fish in the nearby main channel area. Furthermore, a significant relationship between fish and benthos might have been found if benthos were identified to a more specific taxonomic level, for example family (Kilgour & Barton 1999).

The finding of significantly more overhanging branches over the river at unrestored compared with restored stations can easily be explained by the short timespan the river and riverbank have had for recovery after the restoration activities. This is also true for the significantly higher density of cover of branches over the riverbed in the main channel compared with the side channels, as all side channels are restored. Both density of trees and cover of plants on the riverbed/in the floodplain area were unnatural low at restored stations, and several places, the ground were bare because of recent construction work. Over time, this will improve, but when the remaining work with the river approves this, planting, at least of trees, at "bare" sites, might be necessary. Planting should then include those species occurring most frequently at undisturbed sites (Salinas & Guirado 2002). In addition to provide shade and food

(O'Driscoll et al. 2006), plants and trees reinforces the riverbank (Salinas & Guirado 2002) and might in this respect be a helpful tool in restoring the river's natural dynamics without too much erosion. A rich and lush vegetation on the riverbank and overhanging branches can increase a rivers production of invertebrates and fish (Josefsen & Hoseth 2005), but this relationship was not yet found in Bognelv. There are likely other, additional qualities with the side channels which make them provide better habitats for the macroinvertebrates, despite the less overhanging branches.

At unrestored stations, there are probably few pools as nothing has been done to improve the channelized stretches. Hence, the similar number of pools in restored and un-restored stations clearly shows a potential for increasing the number of pools in future restoration work. Salmonids often prefer pool habitats, which are especially important during low-flows (Bisson et al. 1988; Bohlin 1977; Reeves et al. 2011), as were the conditions in Bognelv in 2011. Consequently, more pools in the river might provide suitable habitats for a greater number of fish, especially in low- flow years. In the side channels, the importance of pools is likely even greater as they often are shallower than the main channel. This implies that if there had been more pools in the side channels, the catch in these might have been greater. However, regardless of how large a pool may have been in a side channel, if there was no longer any visible running water due to drying out, no electro-fishing was conducted here.

A general lack of significant effects for many of the remaining environmental variables might be due to the dry conditions in 2011. Of all environmental variables tested, the only significant effect was found for velocity (tendency) and depth for 0+ trout, with 0+ trout decreasing in density with increasing values of both, and for >0+ trout with increasing density with increasing density of algae. This agrees with Gosselin et al. (2012) for parr trout preferring slower flowing areas than adult trout, and that they usually favor shallower habitats (Klemetsen et al. 2003), but might also be a sampling flaw due to difficulties with spotting small fish under such conditions (Bohlin et al. 1989). Studies have indicated that cover in terms of vegetation might be of importance to young salmon (Heggenes & Traaen 1988; Heggenes 1991), and this might be a reason for the higher densities of >0+ trout with increasing density of algae. Depth is an important factor influencing habitat use of trout (Heggenes 1996; Heggenes et al. 1999), and there is a relatively strong correlation between trout length and water depth (Heggenes 1996). Bohlin (1977) found that allopatric 0+ preferred shallow habitats, albeit the largest 0+ were found deeper than the smallest.

Snout water velocity (SWV) is shown to be of importance for the habitat use of both trout and salmon parr and is proven more important than overall water velocity for salmon parr (DeGraaf & Bain 1986; Heggenes 1996). SWV is difficult to measure (DeGraaf & Bain 1986; Heggenes 1996), and hence was not included in my sampling. It is, however, often highly different from the water column velocity (WCV) applied in this study. This implicates that my measurements of WCV probably provided poor estimates of habitat suitability for salmon parr (DeGraaf & Bain 1986).

A positive tendency of the vicinity of a side channel was found for fish density related to both specie and for >0+ trout at specific stations, which is in accordance with Habersack & Nachtnebel (1995). The use, and importance of side channels for smaller salmonids in downstream reaches of rivers, like the reach examined of Bognelv, has been emphasized (Rosenfeld et al. 2000; Rosenfeld et al. 2008). Schedel (2010) found that 0+ trout in Bognelv preferred side channel habitats. A stronger positive effect of the side channels may have been masked by the dry condition in 2011 and the earlier mentioned impact this might have on habitat choice of fish. The importance of drought refuge areas for fish has been emphasized (Schlosser 1991; Vehanen et al. 2010). If severe drought, fish might be caught in small ponds (as observed in several dried up side channels in Bognelv in 2011) with high temperature and low oxygen levels, conditions detrimental to fish populations (Schlosser 1991).

Known effects of river restoration measurements differ greatly, and studies of restored rivers might require long- term surveillances to conclude on outcomes, as the timescale of recovery is largely unknown (Feld et al. 2011; Roni et al. 2008). Regarding "repairing" of riparian buffer zones, the timescale of recovery and hence the effects of restoration measures on e.g. wood recruitment, shade, nutrient provision is not known, but direct effects of measurements might be visible within 10 years, while large scale indirect effects may not be evident before 30-40 years or more (Davies-Colley et al. 2009; Feld et al. 2011). Similar, the timescale of in-stream mesohabitat improvements (e.g. placement of boulders and LWD) are unknown as long-term monitoring studies are lacking (Feld et al. 2011).

QUALITATIVE DATA

Water systems in Norway are traditionally used by many and are found to be important for recreational activities (Direktoratet for naturforvaltning 1994). Alterations like channelization can affect people's use and perception of water systems and landscapes, as water sources often are conspicuous nature elements (Direktoratet for naturforvaltning 1994).

The residents tended to have a closer and more reflected relationship to the river than the non-residents. However, most of the non-residents appreciated the river and mentioned that it was important to them during their stays in Bognelv. Similar to Faggi et al. (2011), no differences between gender was found regarding the importance of the river. A river provides an array of goods to humans, both monetary (e.g. harvesting of fish, irrigation of crops) and non-monetary (e.g. benefits arising from biological diversity, recreational activities) (Bennett 2002; Berg 1999; Postel & Richter 2003)

Humans relationship to, and perception of, water in landscapes have been the focus of several studies (Burmil et al. 1999; Faggi et al. 2011; Herzog 1985; Hubbard & Hubbard 1917; Kaltenborn & Bjerke 2002; Kaplan & Kaplan 1989; Vistad et al. 2009; Østdahl et al. 2001). Even as early as in the Mesopotamian and Egyptian gardens the aesthetics of water in landscapes was acknowledged (Burmil et al. 1999). Also in present time, water has been identified as an essential visual element in nature (e.g. Faggi et al. 2011; Hubbard & Hubbard 1917; Kaltenborn & Bjerke 2002; Kaplan & Kaplan 1989). In 1985, Herzog named this visual preference of water "Hydrophilia" and landscapes containing water "waterscapes".

The findings in my study indicate that Bognelv constitutes an essential part of the valley to the locals, though it did not seem like an important fishing river for the residents or the non-residents. However, the river was important when performing a myriad of activities (i.e. "use value" e.g. Bennett 2002; OECD 2002) and was expressed by most as a vital part of the valley. Both passive and active use were common among anglers as well as non- anglers who appreciated the river equally. This last notion is similar to Vistad et al. (2009) who found that harvesters and non- harvesters, valuated water just as much. The new resident with clear ambition of using the river in several activities and the overall high use of it by locals, shows the conspicuousness of the river and an awareness of the multiple uses it offers.

If more fish in the river would not make them start fishing, why do the non-anglers prefer this? Also, why do some anglers want more fish in the river if this would not affect their will of fishing there? The various other angling opportunities in the area partly explain why some of the anglers would not change their fishing habits in Bognelv. On the other hand, not all used this as an explanation and several could not find an answer to why they would prefer more fish in the river, which certainly cannot be explained by the use value (e.g. Bennett 2002; OECD 2002).

Krutilla (1967) articulated the thought that the awareness of the mere existence of nature elements has a certain “existence” value to some individuals, although they never intend to actively use these values. Existence value is part of the more comprehensive non-use value that also includes the “altruistic” value of knowing that others can make use of the resource, and the similar thought that the next generation should have the possibility to utilize the same resources as our generation (“bequest” value) (OECD 2002) (fig. 9). The non-use value is feasible to explain the appreciation of fish that you are not going to use in any way. Non-use value of rivers has been found in other inquiries and sometimes suggested to exceed the more obvious use-value, particularly because both users and non-users appreciate the non-use value (Navrud 2001; Weber & Stewart 2009). The altruistic and bequest values were both expressed in the answers from the respondents, but the existence value seemed most emphasized. There might be two different ways to interpret the locals use of the phrase “dead river”: either they regard the fish as an important indicator of a healthy (and desired) river ecosystem, or they do not appreciate other life (e.g. plants, birds) when it comes to the river. From the interviews, it was clear that the locals care about, and value, other life as well as the fish. It was also evident that many realized the river’s importance for other life, and that they prized this diversity similar to what has been found in other studies (Weber & Stewart 2009). Hence, the most reasonable explanation is that they appreciate the fish as a sign that the river is healthy.

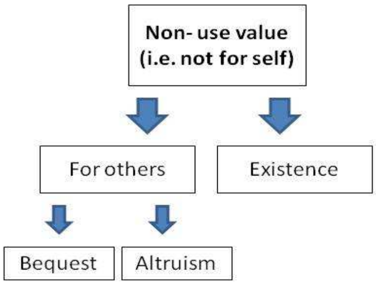

Figure 9 In addition to the obvious use-value of a good, there are different kind of non- use values: “existence value” is the value of knowing that a nature element exists, the “altruistic value” is the value of knowing that others can utilize a certain good, while “bequest value” is the appreciation of the next generation’s possibilities to use a good. Figure modified from: (OECD 2002)

The often mentioned word “recreation” demonstrates the local’s general perception of Bognelv as an important place where they can recuperate. Similar, a study in the Tana River revealed that the locals appreciated the river as an important source to recreation (Dervo et al. 2001) and in Alaska, one of the most appreciated recreation resources is the Kenai River (Whittaker & Shelby 2010).

HOW CAN THESE FINDINGS BE RELATED TO THE RESTORATION OF BOGNELV?

Channelizing of rivers often decreases its recreational value (Berg 1999).Through increased functioning of the ecosystem, the restoration efforts in Bognelv might thus lead to improved recreational potential (Bennett 2002). This is a long recognized relationship, and several have quantified and measured the change in recreational benefits for aquatic environments (e.g. Cameron et al. 1996; Eiswerth et al. 2000; Loomis 2002). Similar, Navrud (2001) found that rivers with the largest salmon stocks, and the least developed ones (in relation to hydroelectricity) had the highest recreational value to people. Efforts done to improve disturbed rivers recreational values have shown to be highly profitable investment, particularly for salmon and trout rivers (Navrud 2001). High public value of river restoration has been revealed in earlier research (Weber & Stewart 2009). Pigram (2002) stressed that most people appear to want healthier streams, and this seems also to be true for the locals in Bognelvdalen. Both actual use and both “paths” of the non-use value are the probable reasons for this wish, as all were recognized among the answers from the locals.

CONCLUSION AND SUGGESTIONS

As known effects and timescale of river restorations differ greatly, studies on restored rivers might require long-term surveillance to conclude on outcomes (Feld et al. 2011). Nevertheless, some aspects, important for further restoration work in Bognelv, and possibly applicable to other similar restorations, were revealed.

Schedel (2010) reported that re-opening of old side channels was the most positive measure conducted in Bognelv prior to 2008, and this was also an important relationship in my study. However, at the same time, he stressed the need of making the entrance angle out from the main channel less sharp to prevent side channels from drying out (Schedel 2010). Attempts were made in 2009 to improve the entrance to side channels showing signs of drying out the previous summer, but unfortunately, these were not successful enough in light of the drought of 2011. Summer and autumn of 2011 were unusually dry, and nearly all side channels were dry when I electro-sampled. To prevent fish from being caught in small ponds in dried-up side channels in the future, it will be necessary to increase the inflow of water and decrease the problem with filling of side channels with gravel if they are to function as refuge and development areas for small fish. More pools should also be established in the river, both in the main channel and in side channels, to create a more heterogeneous environment and habitats favored by salmonids (Bohlin 1977).

Additional cover of branches and vegetation on the riverbank might further improve the production of invertebrates and fish in the river when the river (bank) has recovered from the restoration work. Planting of trees on the riverbank might thus be a good restoration measure, providing flood protection, cover for the fish and addition of food.

If applied with caution, catch data can be a useful tool to monitor fish stocks (Svenning et al. 2012). In Bognelv, reporting of catch data is only recently been established, and hence, I could not apply this in my study. A proper routine on this in the future might make catch statistics from Bognelv a good tool for monitoring the fish stocks in the river, provided that the reporting percentage is high enough (Svenning et al. 2012). Establishment of fish traps is the most reliable way of gaining knowledge about the stock size of river dwelling char (Svenning et al. 2012). This simple method has been employed in several Northern Norwegian rivers by local fishing associations (Svenning et al. 2012) and could be employed in Bognelv e.g. by Langfjordbotn hunting and fishing association, thus providing information regarding the char population and, if repeated, also its development.

Further questions will be whether the results in Bognelv are transferable to other rivers, and if so; to which rivers can we adopt the knowledge provided here? Results of similar restoration efforts may differ greatly between rivers, and important in this respect is their ecological location (Jenkinson et al. 2006). However, if employing information on *inter alia* location, the experience from Bognelv could be applied in areas of similar ecological integrity (Jenkinson et al. 2006).

The river was much appreciated amongst most locals and non-residents, anglers and non-anglers even if no one received any monetary benefit from it, except as a water source. The appreciation of a healthy ecosystem was evident through the emphasized “existence value” and it seemed as though the river had a greater meaning to all groups when it involved more life (i.e. a “living river”). The findings indicate that a successful river restoration increases a river’s value to humans and that it might benefit even more people than those who actively use it. Not surprisingly, those who care the most about the river might often be those people living in close vicinity to it, but this is not necessarily always the case.

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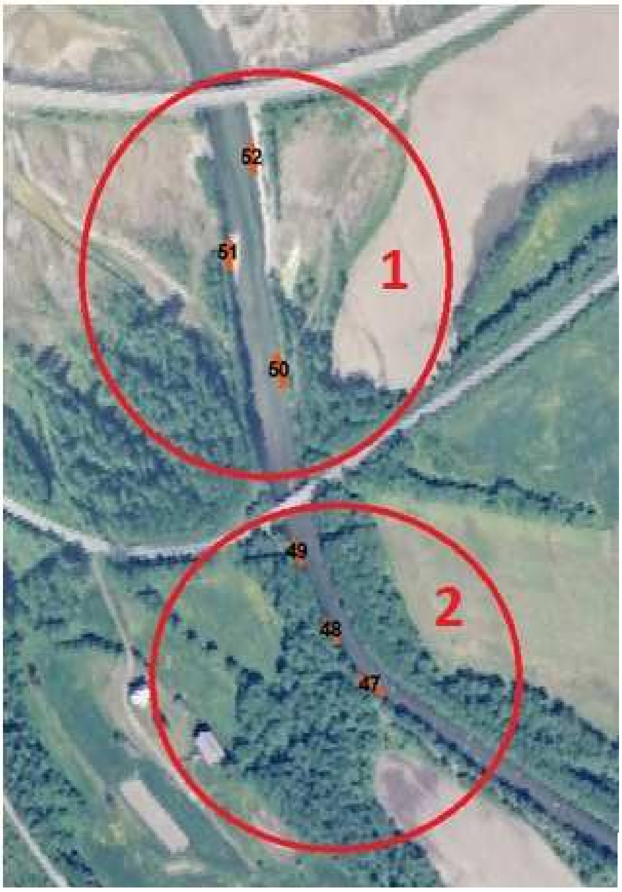
APPENDIX 1 RESTORATION MEASURES

Zone	Measure number and year	Measure	Year of Maintenance/ Improvement	Expected effect	Observed effects
1	1	*No measures conducted*			
2		*No measures conducted*			
3	2 3 2006	*Not conducted yet* Removal - short stretch of the flood banks, opening of one side channel, minor digging work, placement of stone groups.	2009: Placement of boulder groups to increase the water flow in side channels. 2010: Maintenance	More variable currents. Natural formation of deep pools. Side channels: Closer contact between river bank vegetation/ floodplain. Increased production of trout fry.	2009: Too early to conclude on anything, but observed increased activity by Dipper and Common Sandpiper. More variable currents
4	3 2006	Removal - short stretch of the flood banks, opening of one side channel, minor digging work, placement of stone groups.	2009: Placement of boulder groups to increase the water flow in side channels. 2010: Maintenance	More variable currents. Natural formation of deep pools. Side channels: Closer contact between river bank vegetation/ floodplain. Increased production of trout fry.	More variable currents
5	4 2007	Opening of Mikkelveita (stream).	2008 Maintenance		More variable currents
6	5 2006	Removal of flood banks and opening of side channel.	2008 Maintenance 2010 Maintenance		2009: Too early to conclude on anything, but probably positive effects on floodplain and terrestrial species. More variable currents
7	6 2007	Moving and improving of old flood banks, placement of boulder groups.	2009 Maintenance Widening of deep pool		More variable currents
8	7 2009	Removal of flood banks and opening of two side channels. Placement of boulder groups.	2010 Maintenance	More variable currents Increased natural erosion- and sedimentation processes. More natural river banks and closer contact between river bank vegetation/floodplain biotope and the river.	
9	7 2009	Removal of flood banks and opening of side channel. Placement of boulder groups.	2010 Maintenance	More variable currents Increased natural erosion- and sedimentation processes More natural river banks and closer contact between river bank vegetation/ floodplain biotope and the river.	

APPENDIX 2 STATIONS AND ZONE NUMBERS IN BOGNELV

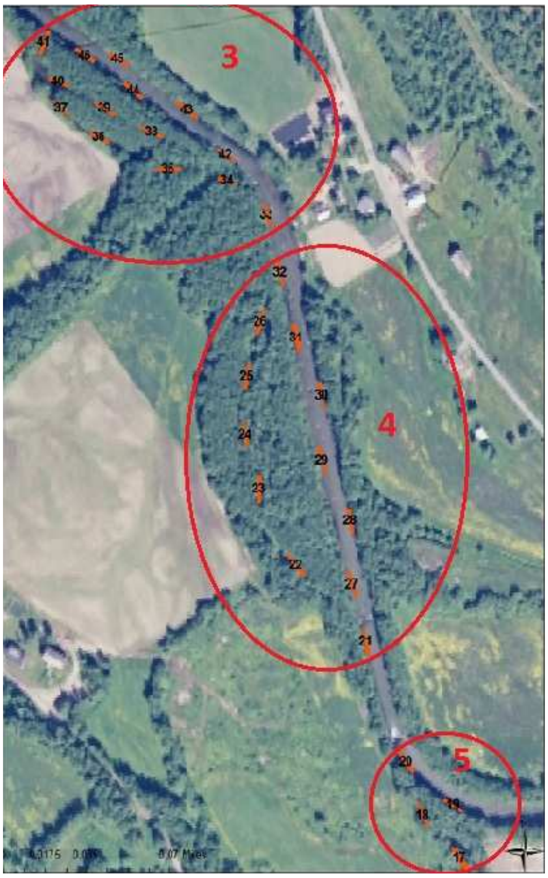
Zone number 1 is located by the outlet of the River, while number 9 is the uppermost zone.



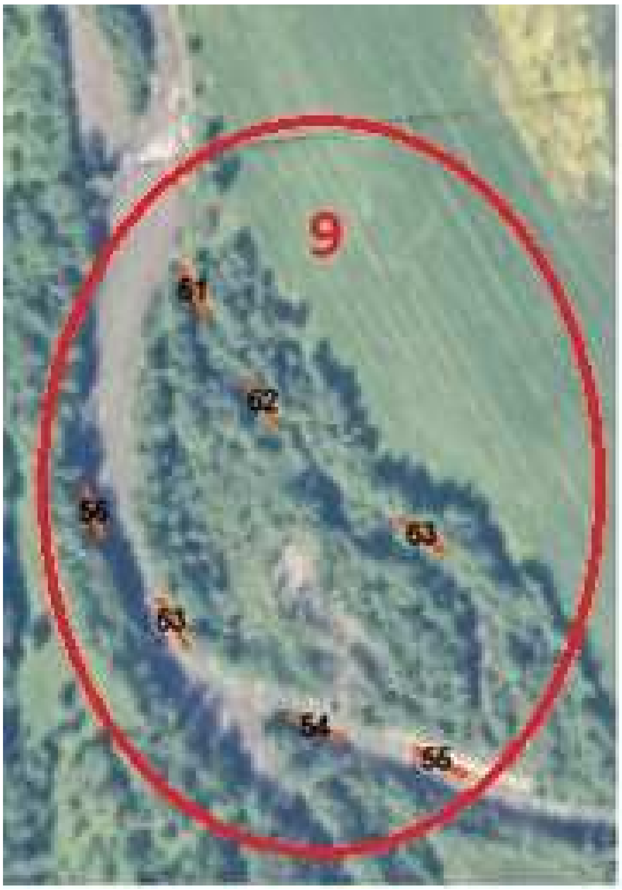
Zone 1: stations 50- 52
Zone 2: stations 47- 49

Zone 3: stations 46- 33
Zone 4: stations 32- 21
Zone 5: stations 20- 17

Zone 6: stations 16- 6

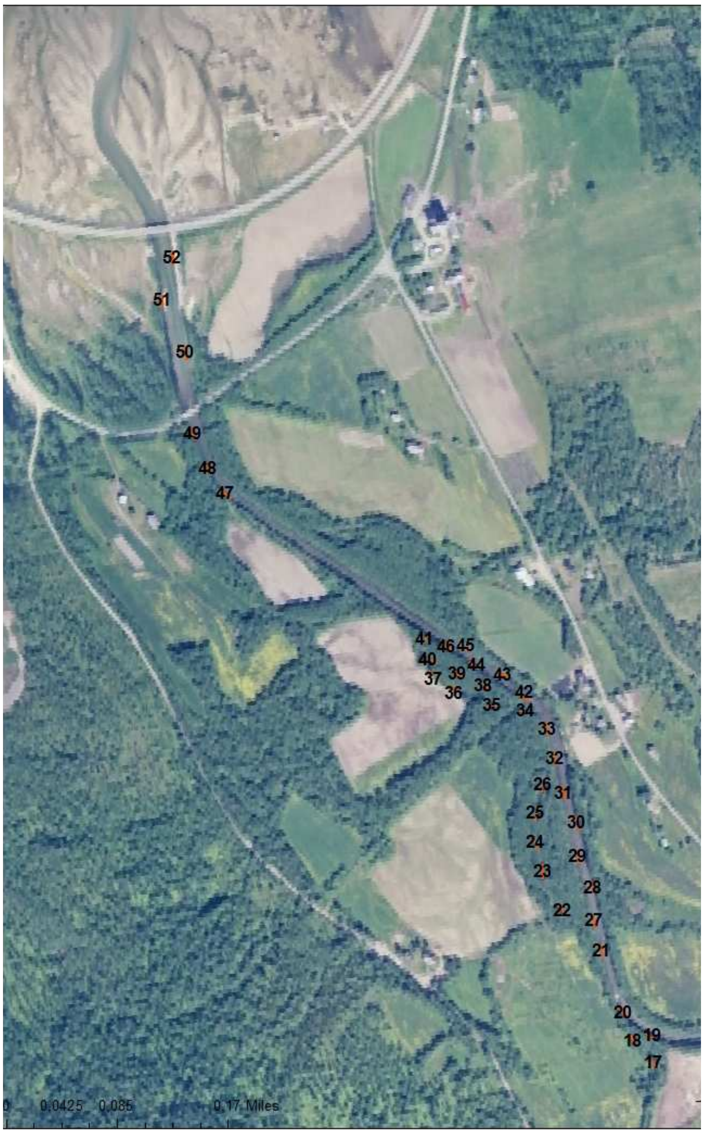


Zone 7: stations 5- 1

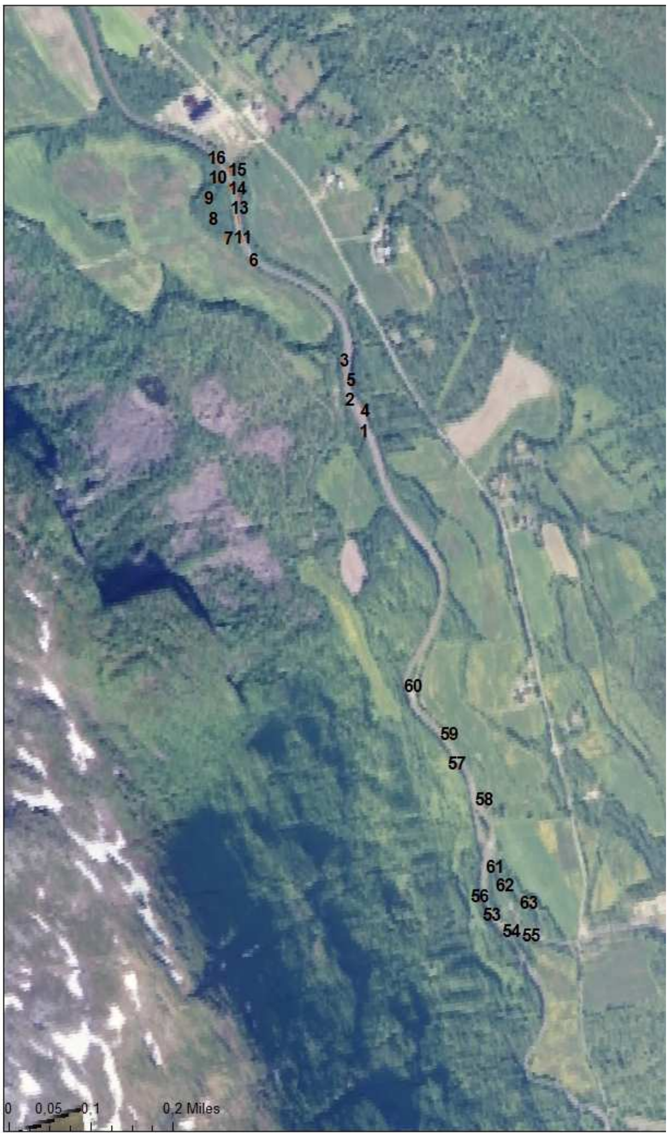


Zone 8: stations 60- 57

Zone 9: stations 56- 55 & 63- 61



Zone 1-5



Zone 6- 9

APPENDIX 3 QUANTITATIVE DATA SAMPLING

For all variables with more than one repeated measure per station, a mean was used in the analyses.

COVER OF BRANCHES (CANOPY)
River: Percent cover of branches measured from the edge of the riverbank and 2 m. out over the river (only wet areal). Four measurements per station (once per 5 meter) were conducted.
Riverbank: Percent cover of branches over the riverbank. Four measurements per station (once per 5 meter) in app. 10 cm broad lines were conducted. **Scale:**Cat. 1: 0% cover, cat. 2: 1- 25% cover, cat. 3: 26-50% cover, cat. 4: 51- 75% cover, cat. 5: 76- 90% cover, cat. 6: ≥ 91%
RIVERSIDE VEGETATION
Percent cover of field layer on the riverbed and in the flood plain respectively. Four measurements per station (once per 5 meter) were conducted. **Scale**: Cat. 1: 0% cover, cat. 2: 1- 25% cover, cat. 3: 26-50% cover, cat. 4: 51- 75% cover, cat. 5: 76- 90% cover, cat. 6: ≥ 91%
NUMBER OF POOLS
Large-scale characteristic of the 15x2 m stations based on the number of pools.
Cat. 1: 0 pools, cat. 2: 1-2 pools, cat. 3: 3-4 pools, cat. 4: 5-6 pools, cat. 5: 6-7 pools, cat. 6: ≥ 8 pools.
INVERTEBRATES
A surber-sampler was placed on the river bottom, covering an area of $1m^2$. A dish- brush was then used on the stones in the topmost layer. The loosened invertebrates were captured in the surber and emptied in a bucket. I counted the app. number of invertebrates. **Scale:** Cat. 1: 0-10 invertebrates, cat. 2: 11-20 inv., cat. 3: 21-30 inv., cat. 4: 31-40 inv., cat. 5: 41-50 inv., cat. 6: ≥ 51 inv.
WATER VELOCITY
Measurements on water velocity were obtained by visual estimates done by an experienced electro fisher and then categorized. **Scale:** Cat. 1: 0- 2,9 cm/s (stagnant), cat. 2: 3- 25.9 cm/s (slow) cat. 3: 26-51.9 cm/s (medium), cat. 4: ≥ 52 (strong).
RIVERBED STONES
A mean size of the stones at each station was registered. **Scale:** Cat. 1: <2mm, cat. 2: 2-20 mm, cat. 3: 20-100 mm, cat. 4: 100-250 mm, cat. 5: >250 mm.
ALGAE
Measurements of mean cover of algae were obtained for each station. **Scale:** Cat. 1: 0%, cat.2: 1-33%, cat.3: 34-66%, cat.4: >66%.

In addition; water temp. (app. 1 m from the riverbank and 10 cm over the bottom of the streambed), max and mean depth at each station, number, size and species of fish were registered.
DISTANCE TO ROAD E6
To measure the distance from the lower part of each station following the river to the road E6 (bridge) Arc Map 10 was used. In Arc Map I added a new layer and all 63 stations were transferred (as 15 m long stations) from the sketch to polygons (including those not electro fished). The base map used was added as a wms from www.norgeibilder.no. The stations were assigned the same numbers as earlier.

APPENDIX 4 INTERVIEW GUIDE

TOPIC	KEYWORDS FOR THE INTERVIEWS
Opening: People's perception of the Bognelvriver	- *What can you tell me about the river?*
Use: The locals use of Bognelv	- *Do you "use" the river in any respect? How? How often? Why?* - *Do you angle in the river? How often?*
Importance of life: The importance of Bognelvas a angling river and as a living eco-system	- *Would you angle more often in Bognelv if there were more fish in the river?* - *Is the river of greater importance to you if there is a lot of fish in it compared with few?* - *If any, is the value of the river greater to you if it is a living ecosystem?/holds birds, fishes, plants and animals*
Relation: Does the river have a value to people (except possibly as an angling river)?	- *Does the river mean anything to you? What/How?* - *Is the river of importance to your well-being here in Bognelv?* - *If he/she angles: Is the river of importance for you in other ways than as an angling river?* - *Would you pay to angle in Bognelv? How much? What about the Alta River?*
Expectations: Do people expect the restoration to change the river in the future? – How?	- *Expectations to the river for the future?* - *Are you satisfied with the conditions in the river as it is today?*

APPENDIX 5 FIGURES

Table a.1 Parameter estimates and corresponding test statistics for the most supported model predicting 0+ densities of trout in Bognelv in 2008 and 2011. Zone 1 in 2008 is *intercept.*

Parameter estimates

Parameter	estimate	se
Intercept	3.59	0.60
Year (2011)	0.54	0.26
Zone (2)	-0.94	0.79
Zone (3)	0.02	0.66
Zone (4)	-0.94	0.65
Zone (5)	-1.32	0.94
Zone (6)	-1.07	0.65
Zone (7)	-1.40	0.70
Zone (8)	-1.05	0.81
Zone (9)	-1.28	0.81

Test statistics

Effect	F	df	P
Year	1.70	1	0.20
Zone	1.93	8	0.07

Table a.2 Parameter estimates and corresponding test statistics for the most supported model predicting 0+ trout lengths in Bognelv in 2008 and 2011. Zone 1 in 2008 is *intercept*

Parameter estimates

Parameter	estimate	se
Intercept	3.65	0.03
Year(2011)	0.18	0.04
Zone (2)	-0.03	0.04
Zone (3)	-0.04	0.03
Zone (4)	-0.03	0.03
Zone (5)	-0.12	-0.12
Zone (6)	-0.05	0.03
Zone (7)	-0.04	0.05
Zone (8)	-0.12	0.03
Zone (9)	-0.16	0.04
Year (2011) Zone (2)	-0.03	0.08
Year (2011) Zone (3)	-0.08	0.04
Year (2011) Zone (4)	-0.13	0.05
Year (2011) Zone (5)	-0.06	0.14
Year (2011) Zone (6)	-0.14	0.04
Year (2011) Zone (7)	-0.08	0.06

Test statistics

Effect	F	df	P
Year	75.83	1	<0.0005
Zone	5.74	8	<0.005
Year: Zone	2.36	6	0.03