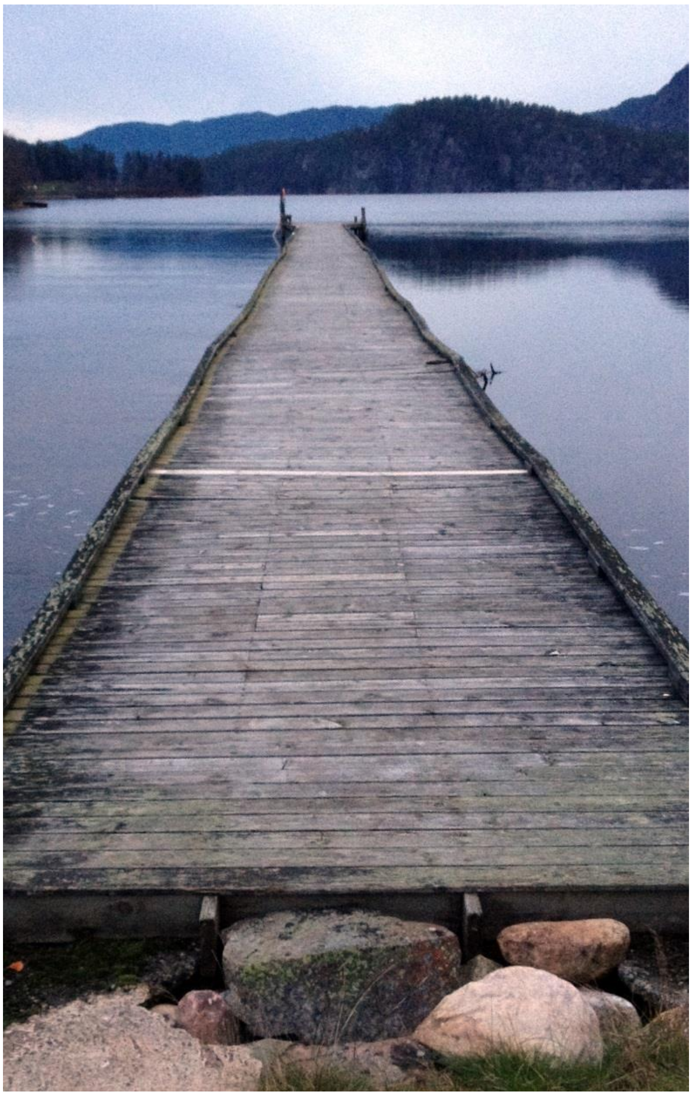
Høgskolen i Telemark

Recruitment and spawning by brown trout (*Salmo trutta*) in the River Bjønndøla with delta

- An impact analysis for the proposed development of Hegna Camping



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Preface

This is a report written as a part of the master course 4311 Ecological Methods at Høgskolen i Telemark, Bø. This project was given to us through our supervisor professor Jan Heggenes, who was contacted by the landowner of Hegna Camping. Thanks to professor Jan Heggenes who has given us guidance through the process, and associate professor Andreas Zedrosser who has helped us with some of the statistics.

Bø, 12.11.2014

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Abstract

Lake Seljordsvatn in Telemark, Norway, has a dominant population of brown trout, including an ecotype of fish-eating big brown trout. River Bjønndøla enters the lake in the southeast end, close to a wetland area. The owner of Hegna Camping wants to expand the campground by building cabins in the wetland area by the lake outlet. The development will require large amounts of fill material, which means that the natural habitat will be lost. It is relevant to know if the development can be done without having a negative impact on the spawning and recruitment areas for brown trout. Five different stations were selected which were representative for the area of interest, and data of depth, water velocity, substrate, fish density and spawning activity were collected.

Electro fishing gave a density of fish on 18 per 100 m^2 in the river. The number of fish were highest closest to the river outlet, and decreased further up in the river. A total of 191 spawning fish was observed.

Based on the results from the river stations it seems like this area is an important nursery habitat for fish, with a dominance of juvenile brown trout. Observations of potential spawning beds and number of spawning fish gives an indication that the pier and delta area are spawning locations for brown trout. Based on the observations of spawning activity and related important key habitats, the construction and subsequent land use will likely have a negative effect on the biotic and abiotic factors for a healthy and sustainable population of brown trout in the south-east part of Lake Seljordsvatn and in River Bjønndøla.

Sammendrag

Seljordsvatnet ligger i Telemark, Norge, og har en stor populasjon av brunørret og storørret. Elva Bjønndøla renner ut i sørøst-enden av innsjøen, nær et våtmarksområde. Eieren av Hegna Camping ønsker å utvide campingplassen ved å bygge hytter i nevnte våtmarksområdet. Utbyggingen vil kreve store mengder fyllmasse, noe som betyr at habitater vil gå tapt. Det er relevant å vite om utbyggingen kan gjennomføres uten å ha en negativ innvirkning på gyte- og rekrutteringsområder for brunørret. Fem representative stasjoner ble valgt i interesseområdet, og data angående dybde, vannhastighet, substrat, fisketetthet og gyteaktivitet ble samlet inn.

Elektrofisking ga en fisketetthet på 18 per 100 m^2 i elva. Antallet fisk var høyest nær utløpet av elva, og sank gradvis videre oppover. Det ble observert 191 gytefisk totalt.

Basert på resultatene fra stasjonene i elva virker det som at området er et viktig oppvekstområde for fisk, med en dominans av ungfisk. Observasjoner av potensielle gytegroper og antall gytefisk gir en indikasjon på at området rundt brygga og deltaområdet er gyteområder for brunørret. Basert på observasjonene av gyteaktivitet og viktige relaterte nøkkelområder, vil utbygging og påfølgende arealbruk mest sannsynlig ha en negativ effekt på de biotiske og abiotiske faktorene som kreves for å opprettholde en bærekraftig populasjon av brunørret i sørøst-enden av Seljordsvatnet og i Bjønndøla.

Introduction

The most important environmental factor causing extinction of species today is loss and fragmentation of habitat, largely as a consequence of human impacts (Fahrig 2001). Fragmentation will divide an area into smaller fragments with different physical barriers between, and thereby decrease the biotas ability to move freely within the area (Collinge 1996). Loss and fragmentation also contribute to reduced population sizes, depending on the amount of fragmentation and the isolation of habitat patches (Fahrig 1997). What surrounds the habitat patches, i.e. the matrix, may be as important as the size of the patches. Consequently, it is crucial to understand the connection between population sizes, extinction, fragmentation, loss of habitat, and how much and what types of spatial structures are needed to preserve populations (Fahrig 2001). Freshwater ecosystems and wetlands are nature types which are especially affected and threatened by human influence, and are important for biological diversity whether there are proven endangered species or not (Direktoratet for Naturforvaltning 2007). One of the most important threats against wetlands in Norway is deposition of fill material for development, including industrial areas and recreational use (Larsen, Alvereng et al. 2011). This changes the natural habitat, and strongly affect living conditions and the ecosystems. Human-caused habitat changes is one of the main causes of the decline of freshwater fish populations (Gosset, Rivers et al. 2006). Studies has shown that fragmentation can prevent mobility, i.e. migration, in brown trout (*Salmo trutta*) (Gosset, Rivers et al. 2006). Lake Seljordsvatn in Telemark, Norway, has a dominant population of brown trout, including an ecotype of fish-eating big brown trout. This ecotype is of particular interest because they are rare and there has been a general decline in these populations in Norway. The major causes of this decline might be caused by changes in spawning and growth habitat (Wollebæk, Thue et al. 2003). Previous research has shown that spawning need to be located and are often in need to be protected through physical planning, (Heggenes and Dokk 1994). In Norway Plan – og Bygningsloven (PBL) is the most important legal and regulatory instrument to carry this out. The owner of Hegna Camping wants to expand the campground by building cabins in the wetland area by the lake outlet. The existing campground is located approximately 350 meters from Lake Seljordsvatn, and not far from the main outlet river, Bøelva (fig. 1).

Figure 1: the study area with Lake Seljordsvatn, River Bjønndøla, River Bøelva, and Hegna camping before the planned development. Edited from www.norgeskart.no

Next to the wetland there is also a small tributary, Bjønndøla, which enters the lake in the southeast end of Lake Seljordsvatn (fig. 1). The development will require large amounts of fill material, which means that the natural habitat will be lost. The owner has submitted a development application to the municipal physical planning authorities, and in figure 2 the draft of the planned development area is combined with an aerial photo. This picture is not taken from the development application, yet based on the photo it seems like a major part of the gravel in the wetland and potential spawning area is going to be relocated. This will cause damage to the area. The application does not include an ecological impact analysis, which has now been required by the municipal authorities. The county governor wants to know if the area is important for recruitment of brown trout. It is relevant to know if the development can be done without having a negative impact on the spawning and recruitment areas for brown trout. Our project was a part of this impact analysis, and the goal was to find out how important the delta area and River Bjønndøla are for the recruitment and spawning of brown trout.

Figure 2: the planned development of cabins in the delta area. Edited from www.norgeskart.no

1. Material and methods

1.1 Study area:

Lake Seljordsvatn is located 160 meters above sea level (appendix 1) in the southern part of Norway, in Telemark County (fig 3). The lake size is 1500 ha, with a mean depth of 50 meters (Knudsen and Sægrov 2002) and a measured maximum depth of 145 meters (Østrem, Flakstad et al. 1984) .

The main species are brown trout, smelt (*Osmerus eperlanus*), arctic char (*Salvelinus alpinus*), perch (*Perca fluviatilis*), whitefish (*Coregonus lavaretus*) and eel (*Anguilla anguilla*) (Knudsen and Sægrov 2002). The eurasian minnow (*Phoxinus phoxinus*) can be found in large numbers, while three-spined stickleback

Figure 3: Telemark County, Norway. Lake Seljordsvatn is marked with a square. Edited from www.norgeskart.no

(*Gasterosteus aculeatus)* and european brook lamprey (*Lampetra planeri)* occur in lower numbers (Heggenes, Bergan et al. 2011). There are two main rivers which flow into Lake Seljordsvatn; Vallaråi and Bygdaråi (fig. 4). These rivers are located in the north-east end of the lake. River Vallaråi is an essential spawning area for the brown trout in Lake Seljordsvatn, while the smaller river Bygdaråi might be important as well, though it is not fully investigated (Heggenes and Dokk 1994). There has been carried out several studies in River Vallaråi regarding important spawning areas, density of spawning fish, fish biology, and physical improvements regarding these issues (Heggenes and Dokk 1994, Wollebæk, Thue et al. 2003, Heggenes, Bergan et al. 2011, Heggenes, Bergan et al. 2012). River Vallaråi is regulated by Sundsbarm Kraftverk, with a significant amount of hydro peaking resulting in changes in both temperature and water flow. The result is a higher winter temperature (3-4^{o} C) and a lower summer temperature (5-10^{o} C) than natural, because the water inlet to the hydro power plant is located in a depth where the temperature naturally is 3-5° C throughout most of the year (Heggenes, Bergan et al. 2012).

Figure 4: River Vallaråi and River Bygdaråi, the two main inlet rivers to Lake Seljordsvatn. Edited from

The regulated river Bøelva is the main outlet of Lake Seljordsvatn, and is located in the south-east end. The river ends in Lake Norsjø, with a total length of 33, 75 km (Vann-nett 2014). The upper part of River Bøelva may be an important spawning area for big brown trout in Lake Seljordsvatn.

Herrefossen is a natural barrier 1800 meters downstream the river, which prevent upstream migration (fig. 5) (Wollebæk, Thue et al. 2003). Bjønndøla is a small river which ends in Lake Seljordsvatn (fig. 1). River Hønseåi comes from Lake Hønsevatni at Lifjell mountain area, joining River Bjønndøla approximately one kilometer upstream.

Figure 5: Herrefossen waterfall, located approximately 1800 m downstreams River Bøelva. Edited from www.norgeskart.no

It seems like River Bjønndøla has different names, and is sometimes referred to as Hønseåi or Myklestulåa. The name Bjønndøla will be used in this report, because it is the approved and recommended name by Statens Kartverk. There are no information available about ecological status and spawning activity in River Bjønndøla. Since the outflow of River Bjønndøla is located approximately 300 meters from River Bøelva, it is interesting to study the spawning and recruitment of brown trout in this river. Electro fishing is the most common and standardized method for estimating fish populations, and became therefore the method of choice. Spawning activity in the peak of the spawning season was also observed.

1.2 Fieldwork:

After an inspection of the area five different stations were selected which were representative for the area of interest, and could be important for spawning and recruitment of brown trout (Standard Norge 2003). Two stations were chosen in the delta area (station 4 and 5) and three in the river (station 1-3) (fig. 6). All the stations were measured 50 meters in length with a tape measure, as recommended in Norsk Standard NS-EN 14011. Stations 1-3 started at the southern riverbank, and stopped four meters out in the river. This equals 200 m^2 per station, which is considered a sufficient size of area for estimating population structures in small rivers (Standard Norge 2003). Each station in the river were divided into transects of two meters, with markings along the riverside with signal spray. These transects make it possible to divide the stations into smaller segments, and gather detailed information about habitat, depth and water velocity. The data can afterwards be compared with catchment rates and thereby indicate the preferred types of habitat. The stations in the delta were only marked with start and stop marks, because of uniform physical conditions, bed substrate and water velocity (pers.com Jan Heggenes, October 29, 2014). Station 4 and 5 stopped four meters out, with a total of 200 m^2 each.

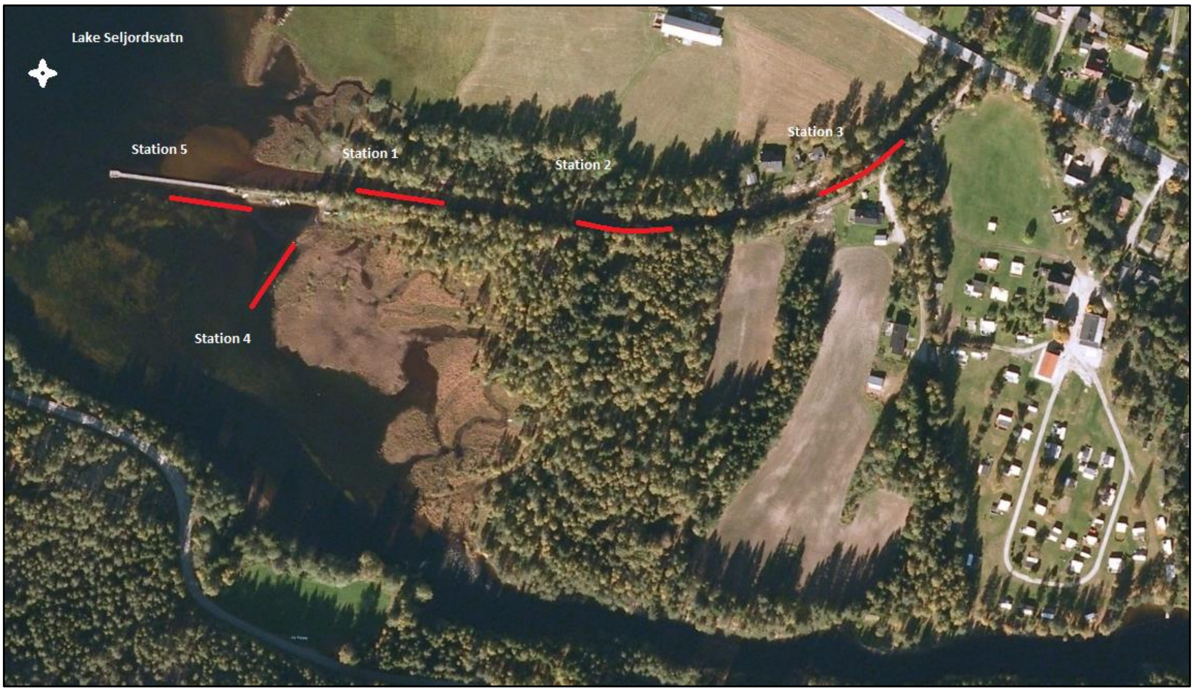

Figure 6: the five different stations that were examined. Edited from www.norgeskart.no

Conductivity and water temperature were measured in each station. On station 1-3 the conductivity meter WTW LF91 was used, while WTW LF320 was used on station 4 and 5. The change of conductivity meter was done because WTW LF320 stopped working.

Backpack electro fishing equipment (Geomegal1400 V) was used to fish each station, with a voltage of 1400 volt. The fishing was done in an upstream direction (Standard Norge 2003). Each station were fished three times, and by using a removal method and looking at the decline in fish caught from the first to the second, and from the second to the third catchment, there were possible to estimate the total population density of each station. The electrofishing was systematically done in all stations, and at station 1-3 we also collected data on how far from the shore each fish was caught (Tr. Dist.). All captured fish were collected, species and fish length were noted from each transect by using a standard electro fishing scheme (appendix 2). All fish were released after each station were fished three times. The total number of fish from each station made it possible to calculate fish density pr. 100 m^2 in the river, by dividing with 2.

Depth was measured in each transect, by measuring for each meter out from the riverbank. Water velocity was measured with a portable mechanical flowmeter (Höntzsch µp-flowtherm) at the same location as the water depth (fig. 7). The one-point method was used by measuring the water velocity at 60 % of the total depth. This gives reliable results of depth-average flow in turbulent water (Julien 1998). A habitat scheme was used to categorize the substrate, with codes for different substrate sizes (appendix 3). These measurements were done in each transect for each meter out from the riverbank, at all stations.

Figure 7: measures of water velocity taken with a portable mechanical flowmeter. Photo: © Tobias Andrés.

All measurements in each station were completed in one day with the same equipment on each station, according to Norsk Standard NS-EN 14011 (2003). This is important because water flow and temperature fluctuate from one day to another, and can affect the catchment and the results from the electro fishing. There should not be too much change in water flow between measuring each station, so the comparability of the measurements from each station is as high as possible (Bohlin, Hamrin et al. 1989).

Spawning fish were observed after nightfall by using flashlights. The area was systematically searched, and number of fish and size were registered. Fish under 200 mm were ignored, because they were considered too small to spawn (pers.com. Jan Heggenes, November, 2014).

The approximate fish size was estimated by eye. In the delta area the search was performed by vading, while in the other area by foot at the pier. The search was done during two weeks in the peak of the spawning season, with a total of three days each week. The different areas were searched six times each in total.

To estimate the population size the function “catch-effort models for exploited populations” in the program Ecological Methodology (version 7.2) was used to calculate catchability and confidence limits for the catch in each station. The catchability gives an estimate on how much of the population that was actually caught. The 95% confidence interval means if the study was repeated, the result would be the same in 95% of the cases. Excel was used to organize the data, and make different diagrams. To test if there was a correlation between the variables fish – depth and fish – water velocity, the program R was used to perform a Spearman Rank correlation on the different datasets. By using the p-value and a significance level of 0,05, it was determined if there was a correlation or not, and if the trend line in the diagram was significant. Spearman Rank correlation was the method of choice because the data was non-parametric, with a relative small sample size (Whitlock and Schluter 2014).

1.3 Lab work:

Age estimation of fish longer than 150 mm were done by counting annuli at fish scales and otoliths. Fish scales were taken from the upper back of the lateral line, between the dorsal and adipose fin. The otoliths were found inside the ear section of the head. Propandiol was first applied on the otoliths to change the refraction; then they were slightly burned and cut over at the middle to make it possible to count the annuli in a stereo loupe. The dark lines indicate winter stagnation and the area between represents growth periods. In this way age estimation can be done by counting the number of dark lines. Scales can also be used to estimate age, because they have winter stagnations zones where the annuli are located closer to each other.

The otoliths are the best parameter to estimate the age when the population has a low growth rate, and when the fish has reached growth stagnation (Abecasis, Bentes et al. 2008).

2. Results

2.1 Station 1

Date:	15.10.2014
Water temperature:	5.6 °C
Conductivity:	19 µs/ cm

Station 1 is located in the lower part of River Bjønndøla (fig. 6). The main watercourse is approximately four meters out in the river from the left shore, seen in downstream direction. Transect 1 is located at the same level as Lake Seljordsvatn. On the north side of the river (right side in fig. 8) the landscape is influenced by agricultural activity and grazing livestock. This side of the river is shallow and above water level when the water flow is low. On the south side there is a road which runs from R36 and down to the pier in Lake Seljordsvatn. The riverbanks on both sides of the river are dominated by birch (*Betula pubescens*) with elements of spruce (*Picea abies*), maple (*Acer platanoides*), rowan (*Sorbus aucuparia),* pine (*Pinus sylvestris)* and goat willow (*Salix caprea*). The ground is covered by different types of mosses, grasses and heathers. There is a low incline gradient on both sides of the river.

Figure 8: station 1 at low water velocity. Lake Seljordsvatn seen in the background. Photo: © Jan Heggenes.

A total of 60 brown trout with a length between 40-136 mm were caught on station 1 (fig. 9), with an average of 63 mm. In the first round 30 fish were caught, while round 2 and 3 resulted in respectively 22 and eight fish. Density of fish pr. 100 m^2 is 30. The results given by Ecological Methodology (version 7.2) were a catchability of 0,4177 and 95% confidence limits: 56,16-98,72. A catchability at 0,4177 are within the normal range for electro fishing, which is 0,4-0,6 (Hvidsten 2010). The confidence interval means that the real population size lies within 59,16 and 98,72 for this station.

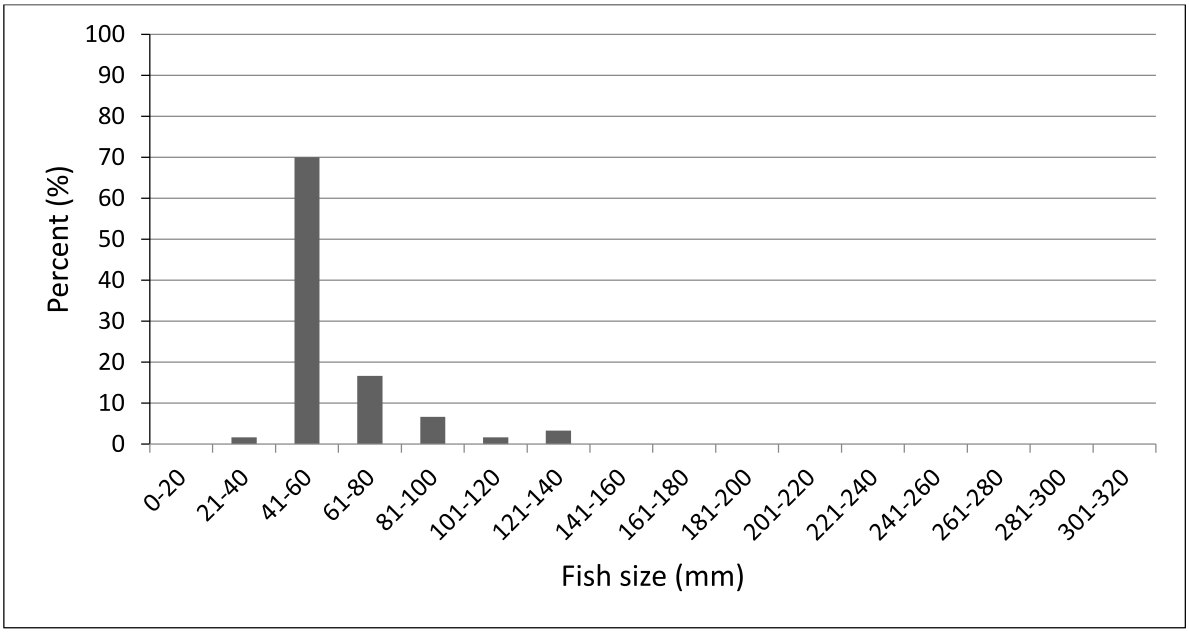

Figure 9: length distribution of brown trout caught on station 1.

Figure 10 illustrates the distribution, size and position of the 60 brown trout caught on station 1. It displays a higher density along the shore with relative small fish, with an increased size and decreased density further out in the river. The bolder circles are a result of two or more fish at more or less the same size, caught at the same distance transect. According to depth measurements (appendix 4) the average water depth increased from the shore and out to 2-3 meters, then decreased on 4 meters.

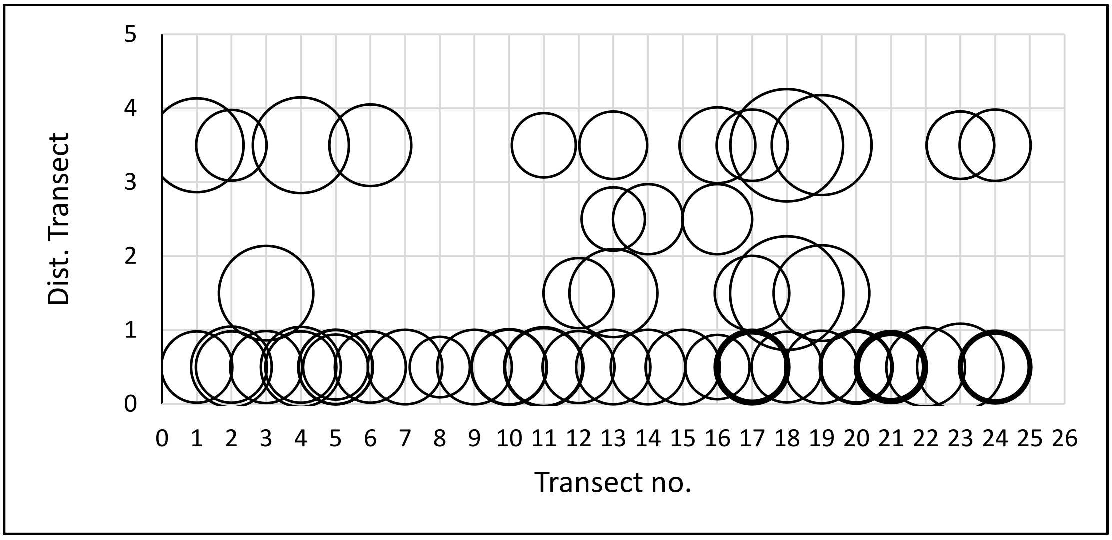

Figure 10: the distribution of fish size relative to transect distance on station 1.

Substrate with type code 9 and 10 covered 96 % of the area in station 1, while substrate with type code 11 and 13 only were present in smaller areas. The first 26 meters of the station had only substrate 9 and 10; the remaining 24 meters contained bigger substrate types. This indicates that the size of the substrate increases further up in the river. The largest part of the fish was caught on substrate code 9 (52,5 %) and 10 (39,4 %) (fig. 11), but these were also the substrate types with highest frequency.

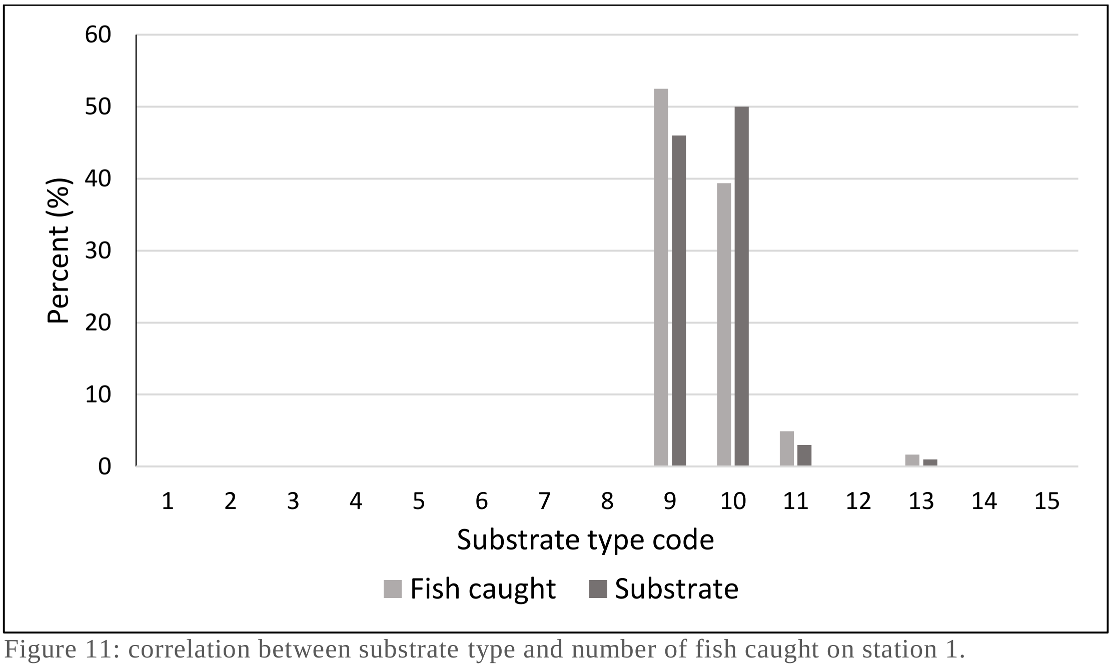

Figure 11: correlation between substrate type and number of fish caught on station 1.

The depth varied between 17 and 99 cm, with an average depth of 39,5 cm. Most of the fish were caught in the interval 23 – 41 cm. The trend line in figure 12 indicates a correlation between water depth and the fish preferences (p-value 0.0006419), with a general decrease in caught fish with an increasing depth.

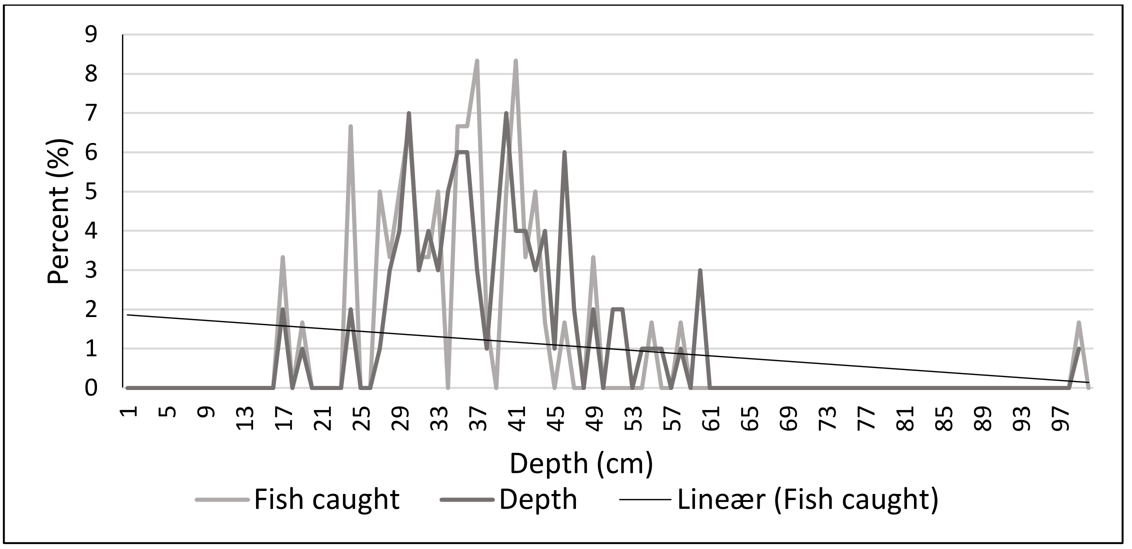

Figure 12: correlation between depth and number of fish caught on station 1.

Station 1 had the lowest total water velocity, ranging from 0,02 – 0,42 m/s (avg. 0,22 m/s). The water surface was calmer than on the other stations, with little turbulence. Most of the fish were caught at 0,13-0,16 m/s, and the trend line in figure 13 indicates that there is a correlation between water velocity and presence of fish (p-value = 0.01248). The number of caught fish decreased with increasing water velocity.

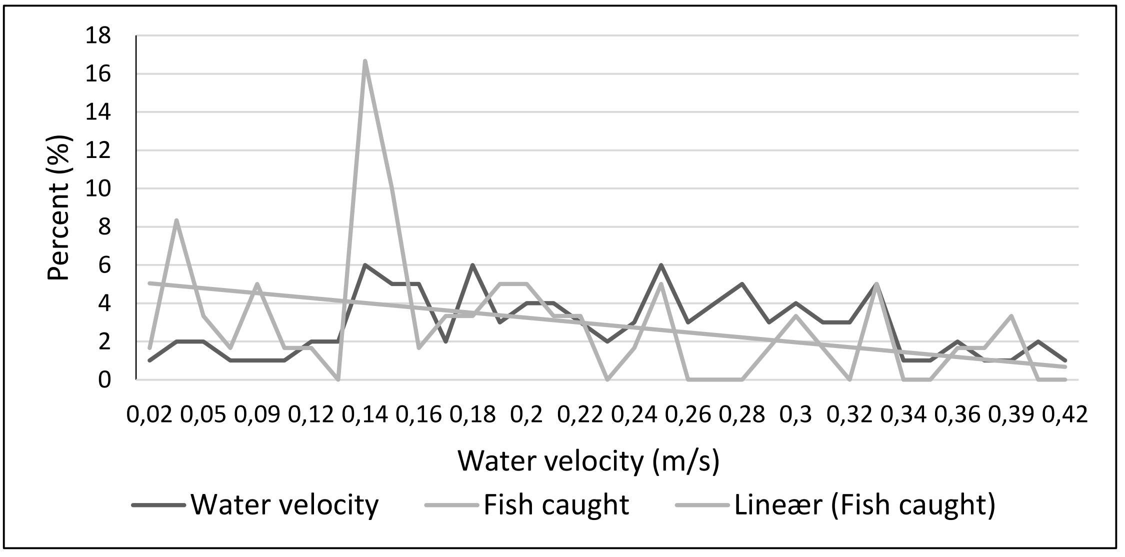

Figure 13: correlation between water velocity and number of fish caught on station 1.

The water velocity was lowest closest to the shore, and increased out in the river. Number of fish caught decreased with increasing water velocity and distance from shore (fig. 14).

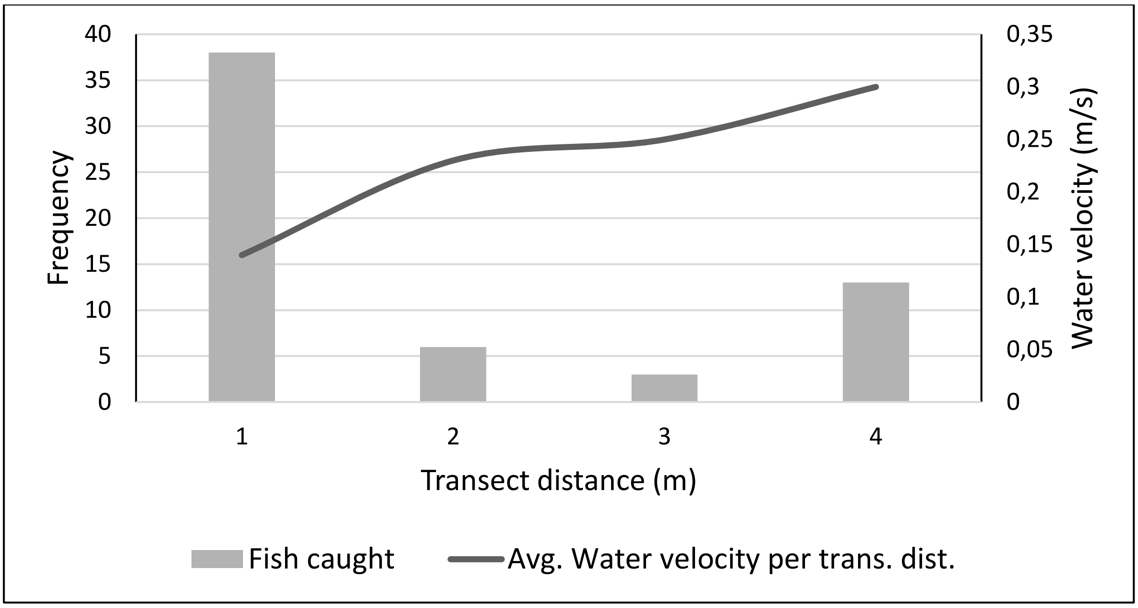

Figure 14: correlation between average water velocity per transect distance, and number of fish caught on each transect distance on station 1.

2.2 Station 1 (1):

Date:	03.10.2014
Water temperature:	6,8 °C
Conductivity:	24,3 µs/ cm

When station 1 was electro fished the first time, depth and dist. trans. were not measured. The whole station was therefore refished at a later date. Still we have chosen to include the data from the first time (appendix 6), because it is interesting how water velocity influences catchability and confidence limits. A total of 145 brown trout were caught within a size of 41-115 mm (fig. 15), with an average of 59,9 mm. Density of fish pr. 100 m^2 is 72,5. The results given by Ecological Methodology (version 7.2) were a catchability of 0,4861 and 95% confidence limits: 98,04-228,78. A catchability at 0,4861 are within the normal range for electro fishing, which is 0,4-0,6 (Hvidsten 2010). The confidence interval means that the real population size lies within 98,04 and 228,78 for this station.

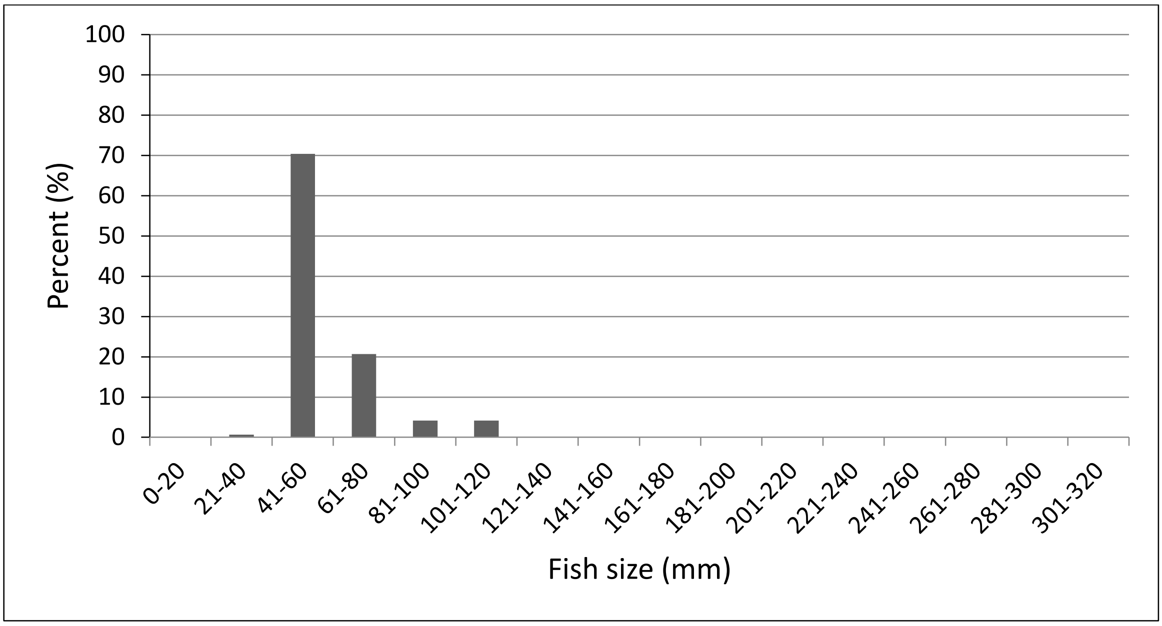

Figure 15: length distribution of brown trout on station 1(1).

Lower water velocity resulted in smaller fish, but a higher number caught.

2.3 Station 2

Date:	17.10.2014
Water temperature:	3.4 °C
Conductivity:	18.2 µs/ cm

Station 2 is located about 150 meters upstream from station 1 (fig. 6). The main watercourse is approximately two meters out in the river from the right shore, seen in upstream direction. On the north side of the river (left side in fig. 16) the landscape is influenced by agricultural activity and grazing livestock. This side of the river is shallow, and above water level at a low water flow. On the south side there is a road which runs from R36 and down to the pier in Lake Seljordsvatn. The riverbank on both sides are very similar to what were found on station 1, but the proportion of spruce is higher on station 2 and the birch is not as prominent.

Figure 16: station 2 seen in upstream direction, at low water velocity. Photo: © Jan Heggenes.

A total of 37 brown trout with a length between 41-188 mm were caught on station 2 (fig. 17), with an average of 81,8 mm. In the first round 19 fish were caught, while round 2 and 3 resulted in respectively 12 and 6 brown trout. Density of fish pr. 100 m^2 is 18,5. The results given by Ecological Methodology (version 7.2) were a catchability of 0,3996 and 95% confidence limits: 38,38-59,01. The catchability it is a bit lower than the normal range for electro fishing, which is 0,4-0,6 (Hvidsten 2010). The confidence interval means that the real population size lies within 38,38 and 59,01 for this station.

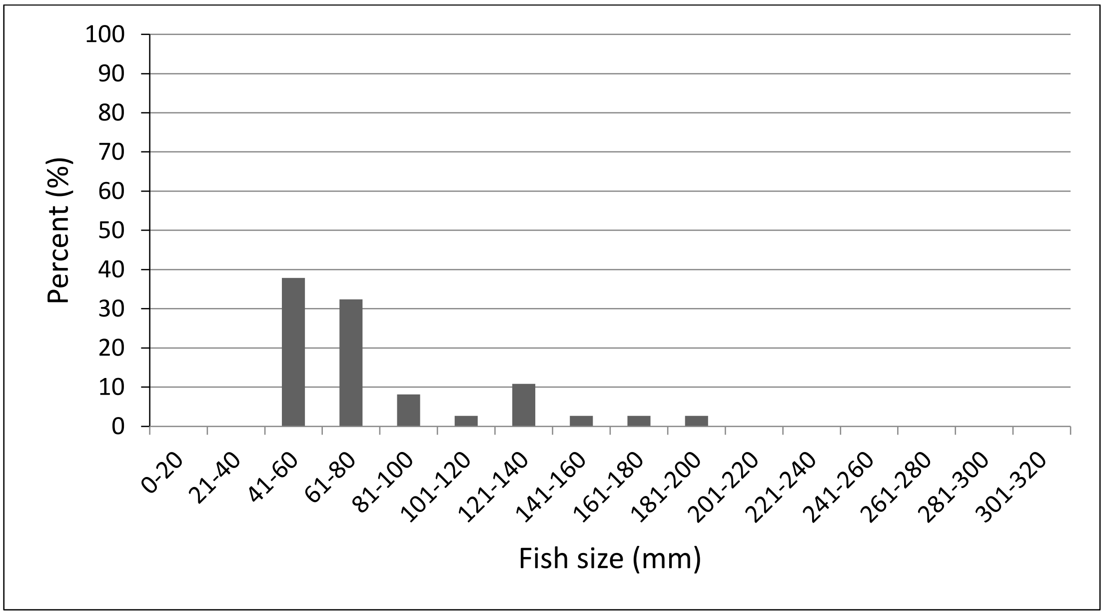

Figure 17: length distribution of brown trout caught on station 2.

Figure 18 displays a high fish density along the shore with a clear decrease when moving out in the river. The relative size distribution has a slight indication of smaller fish along the shore, just as station 1.

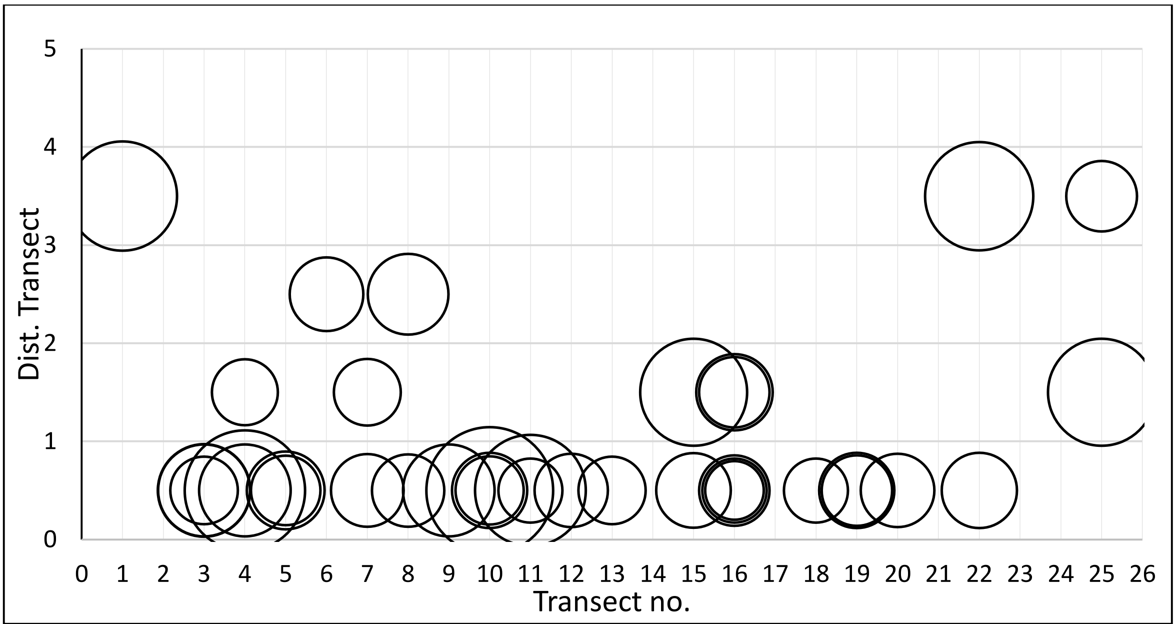

Figure 18: the distribution of fish size relative to transect distance on station 2.

Substrate with type code 9, 10 and 11 covered 97 % of the area in station 2 (fig. 19); type code 12 were only present in the last four meters. The largest part of the fish was caught on substrate code 10 (48, 6 %) and 11 (29, 7 %).

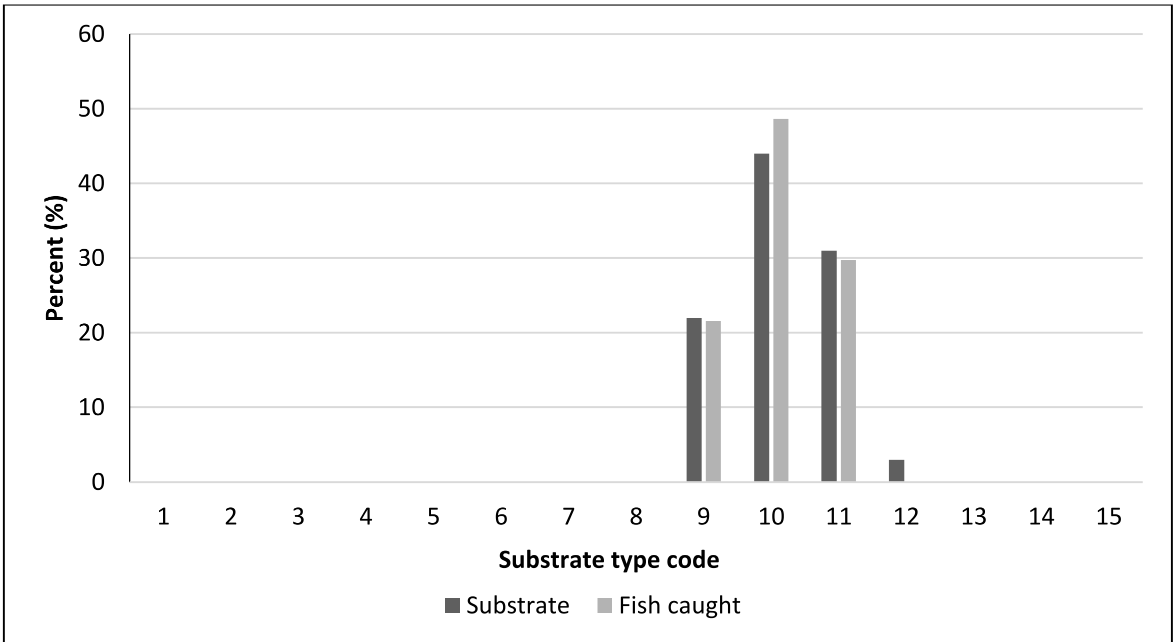

Figure 19: correlation between substrate type and number of fish caught on station 2.

The depth varied between 10 – 70 cm (fig. 20), with an average depth at 32,6 cm. The general trend was a decreasing depth from the shore and out (appendix 4). Most of the fish were caught in the interval 24 – 41 cm. A p-value at 0.2063 indicates that there is no correlation between water depth and the fish' preferences.

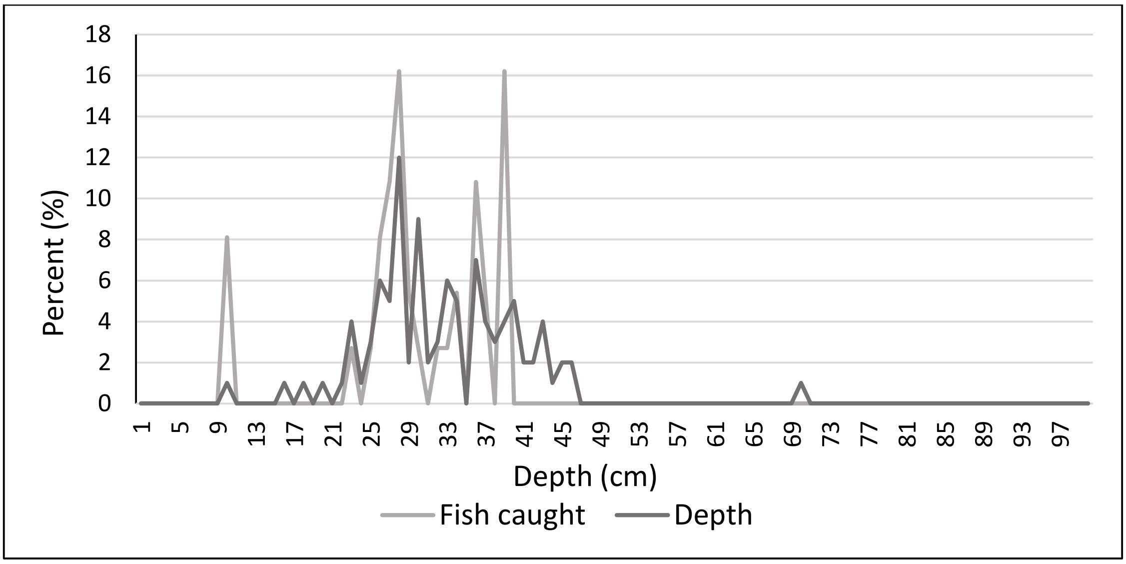

Figure 20: the relationship between depth and number of fish caught on station 2.

Station 2 had a higher total water velocity than station 1, with more turbulence. The water velocity ranged from 0,05-0,93 m/s (fig. 21), with an average of 0,47 m/s. Most of the fish were caught between 0,34 – 0,38 m/s. A p-value at 0.1725 indicates that there is no correlation between water velocity and presence of fish.

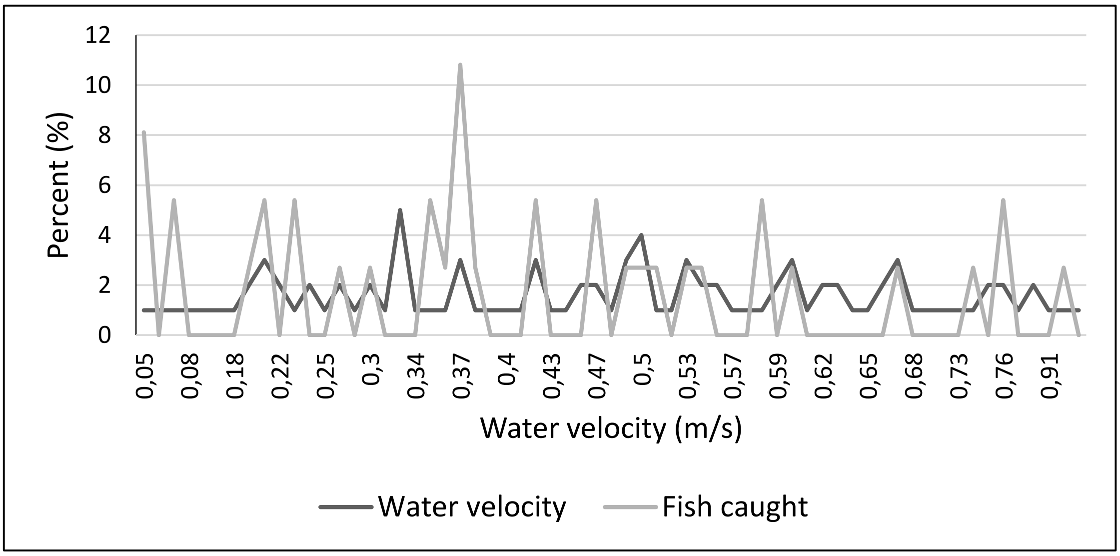

Figure 21: the relationship between water velocity and fish caught on station 2.

The water velocity was lowest closest to the shore, increased 2 meters out in the river, and decreased again at 3 and 4 meters. Number of fish caught was highest closest to the shore where the water velocity was lowest, and decreased with increasing water velocity and distance from shore (fig. 22).

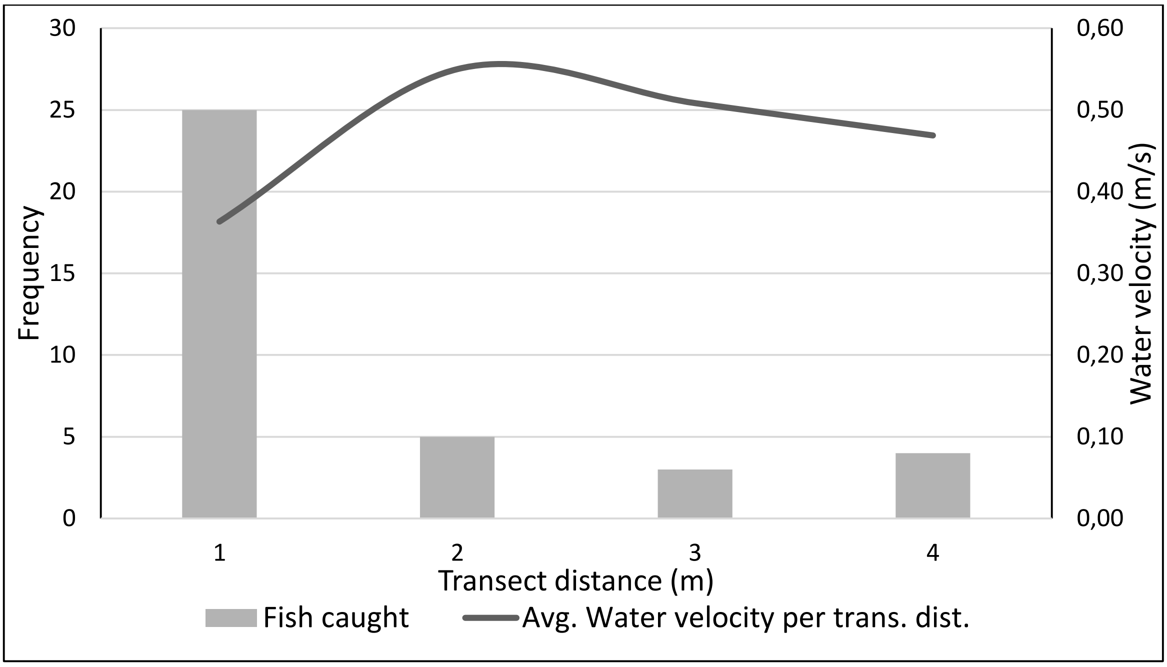

Figure 22: correlation between average water velocity per transect distance, and number of fish caught on each transect distance on station 2.

2.4 Station 3

Date:	16.10.2014
Water temperature:	4.9 °C
Conductivity:	17.1 µs/ cm

Station 3 is located about 150 meters upstream from station 2 (fig. 6), and is the station furthest up in the river. The main watercourse is approximately four meters out in the river from the right shore, seen in upstream direction. The landscape on both north (left side in fig. 23) and south side are influenced by agricultural activity and rural settlement. North side of the river is shallow, and above water level at a low water flow. On the south side there is a road which runs from R36 and down to the pier in Lake Seljordsvatn. The incline gradient on both sides of the river is much steeper than on station 1 and 2, and there are almost exclusively birch growing along the shore.

Figure 23: measuring the transects on station 3 at low water velocity. Seen in upstream direction. Photo: © Jan Heggenes.

A total of 11 brown trout with a length between 61 – 145 mm were caught on station 3 (fig. 24), with an average of 113,7 mm. Number of caught fish the first round were seven, while four fish were caught in round 2. Density of fish pr. 100 m^2 is 5,5. Since the number of fish was low in round 2, round 3 was not conducted. This is for avoiding a too high confidence interval (pers.com. Jan Heggenes, November, 2014). The results given by Ecological Methodology (version 7.2) were a catchability of 0,5322 and 95% confidence limits: 10,80-16,23. The catchability was 0,5322, and is therefore within the normal range for electro fishing, which is 0,4-0,6 (Hvidsten 2010). The confidence interval means that the real population size lies within 10,80 and 16,23 for this station.

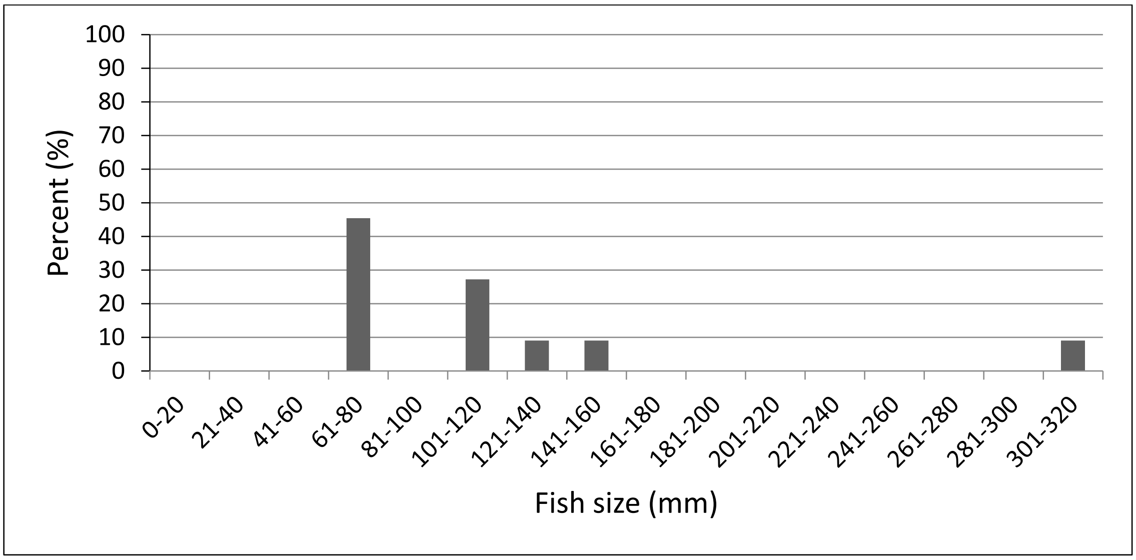

Figure 24: Length distribution of brown trout caught on station 3.

The dense distribution along the shore is not as clearly at station 3 as it is at station 1 and 2, according to figure 25. Still 9 of the 11 fish where caught at the first two dist. trans. The biggest fish from all the stations, measuring 305 mm, was caught at this station at dist. trans. 4.

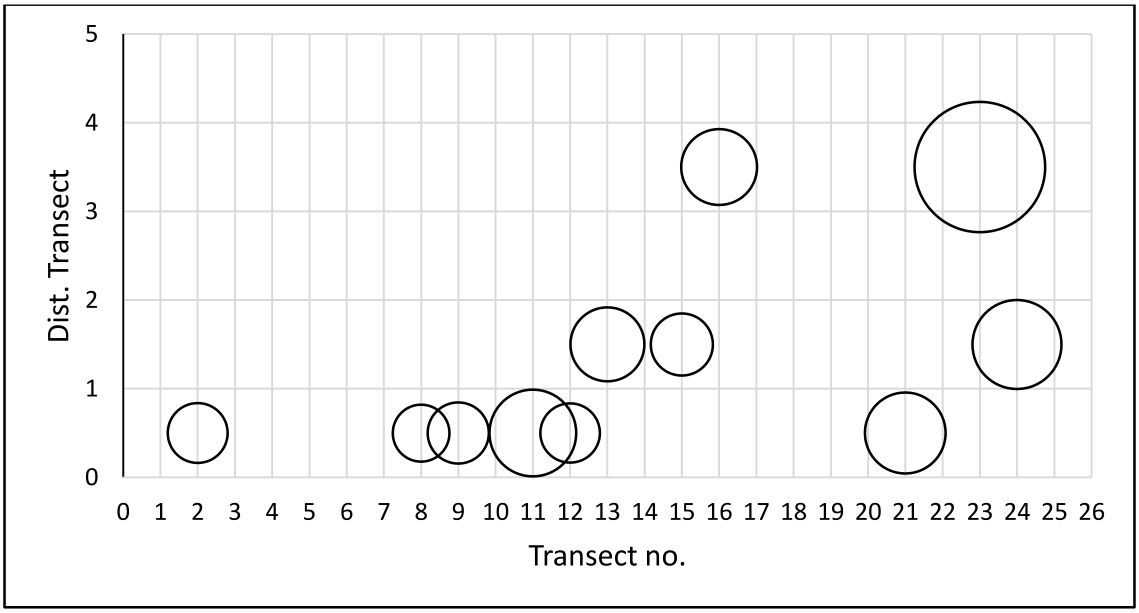

Figure 25: the distribution of fish size relative to transect distance on station 3.

Substrate with type code 9, 10 and 11 covered 76 % of the area in station 3 (fig. 26), while substrate with type code 12 and 13 were present in the remaining area. Type code 13 was only found the last 20 meters of the station, showing that the substrate is biggest furthest up in the river. The largest part of the fish was caught on substrate code 9 (54,4 %).

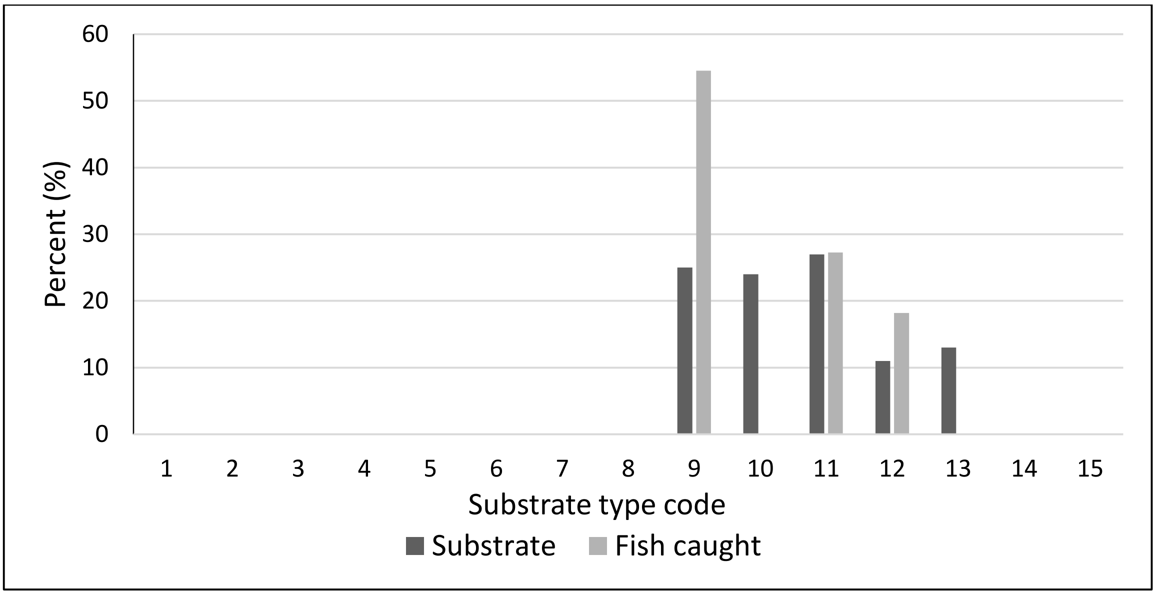

Figure 26: correlation between substrate type and number of fish caught on station 3.

The depth varied between 3 – 56 cm (avg. 34 cm). The general trend was an increasing depth from the shore and out (appendix 4). Most of the fish were caught in the interval 23 – 34 cm (fig. 27). A p-value at 0.7552 indicates that there is no correlation between water depth and the fish' preferences.

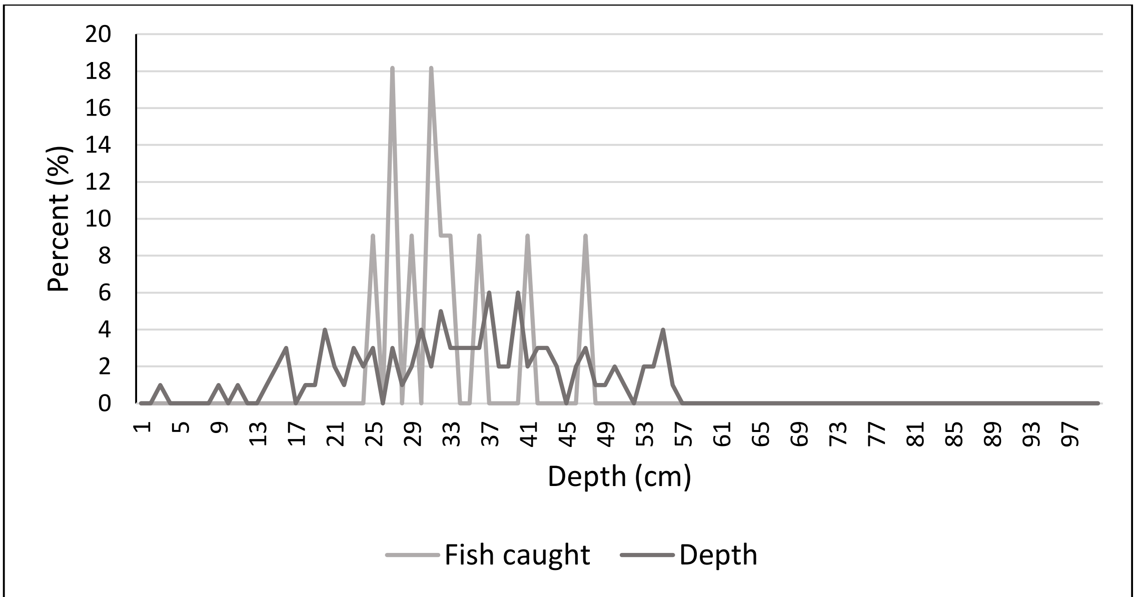

Figure 27: the relationship between depth and fish caught on station 3.

Station 3 had the highest total water velocity of the three stations in the river ranging from 0,04 – 1,44 m/s (avg. 0,54 m/s) (fig. 28). The water was more turbulent than in station 1 and 2. Most of the fish were caught between 0,23 – 0,33 m/s. A p-value at 0.1458 indicates that there is no correlation between water velocity and presence of fish.

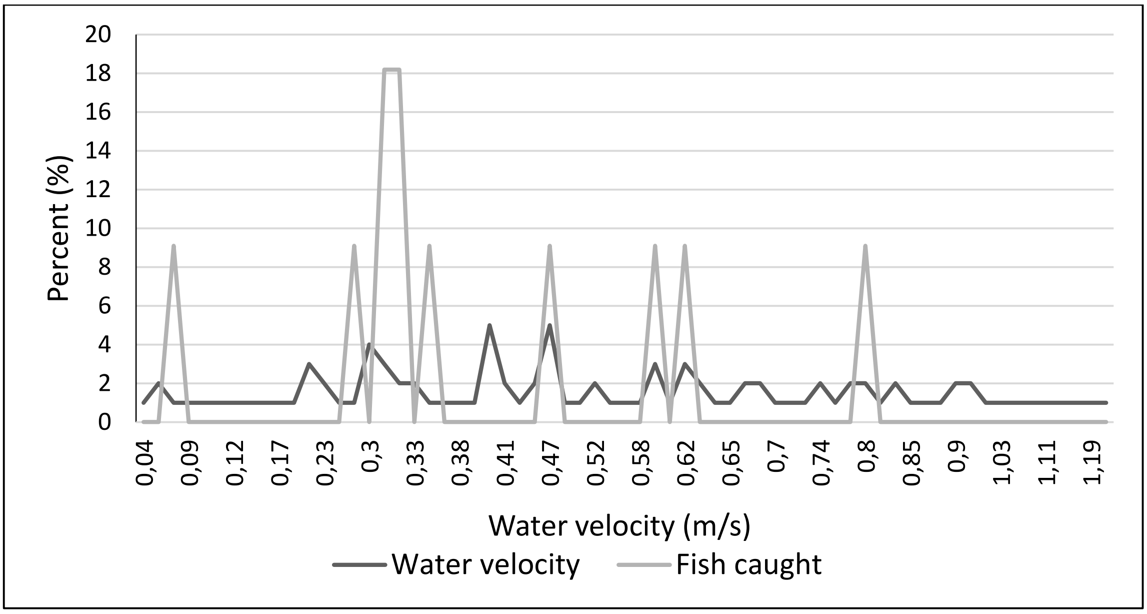

Figure 28: the relationship between water velocity and fish caught on station 3.

The water velocity was lowest closest to the shore, and increased out in the river. Number of fish caught was highest the first two meters from shore, where the water velocity was lowest (fig. 29).

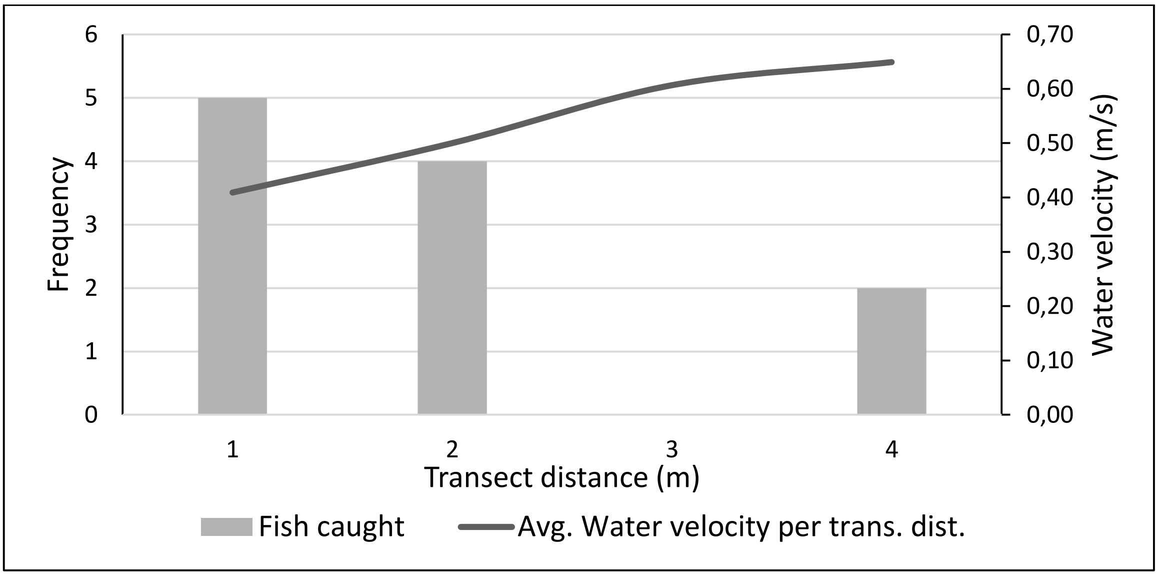

Figure 29: correlation between average water velocity per transect distance, and number of fish caught on each transect distance on station 3.

2.5 Station 4

Date:	30.09.2014
Water temperature:	6,6 ºC
Conductivity:	21,2 µs/cm

Station 4 is located close to the planned development area (fig. 6, fig. 2). The east side of the station has a sufficient amount of vegetation (fig. 30) and organic material, with shallow water. The west side is quite homogenous with less vegetation and organic material, and a steeper depth gradient. On the north side of the station the water velocity is calm, but it gradually increases further south in the station.

Figure 30: station 4 at a low water level. Photo: © Jan Heggenes.

A total of 10 brown trout, 48 european brook lampreys and five three-spined sticklebacks were caught on station 4 (fig. 31). All the brown trout were caught in the first round. Density of brown trout pr. 100 m^2 is 5. The results given by Ecological Methodology (version 7.2) were a catchability of 0,8513 and 95% confidence limits: 10,59-12,80. The catchability is higher than the normal range for electro fishing, which is 0,4-0,6 (Hvidsten 2010). The confidence interval means that the real population size lies within 10,59 and 12,80 for this station.

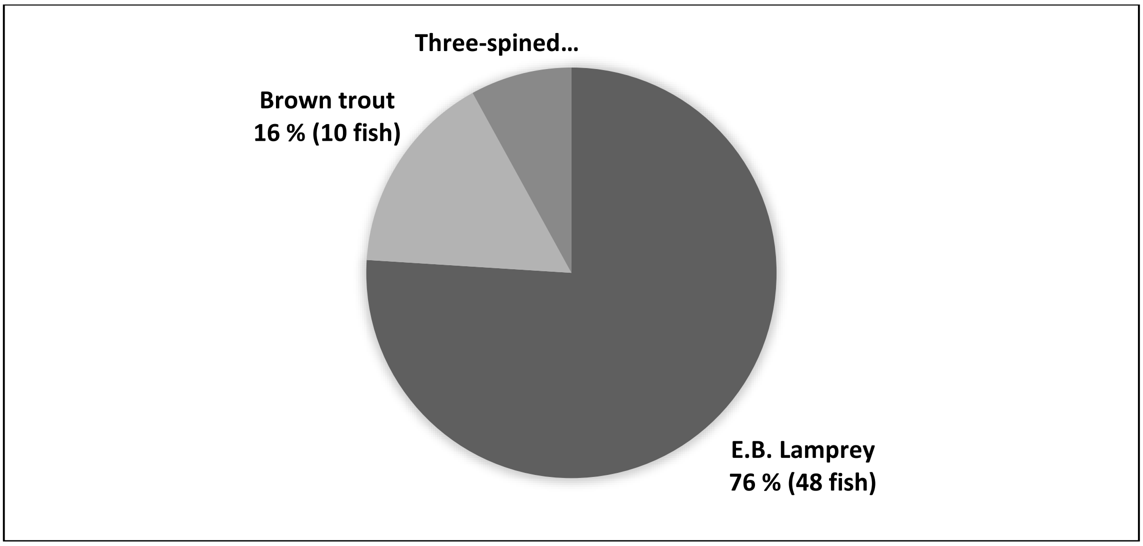

Figure 31: species composition on station 4.

The average length of european brook lampreys was 131,8 mm. The size of the three-spined sticklebacks ranged from 32 – 42 mm, with an average of 36,8 mm. The length distribution of the brown trout was within the interval 50 – 130 mm (avg. 68 mm) (fig. 32).

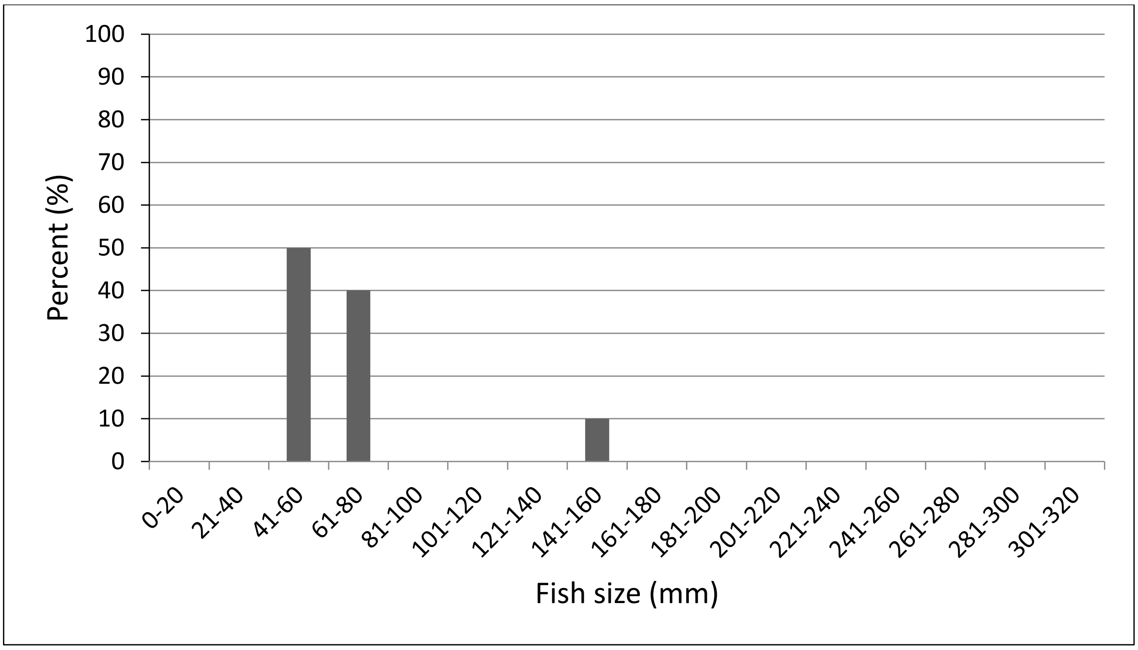

Figure 32: length distribution of brown trout caught on station 4.

The substrate type codes present on station 4 are 2, 6, 7, 8 and 9, dominated by substrate type code 8 (30%) and 2 (27%) (fig. 33). There is a trend which indicates a decreasing substrate size with distance from center of the station line. Overall the depth increased from the center line and further out in the station (avg. depth 73 cm) (appendix 5).

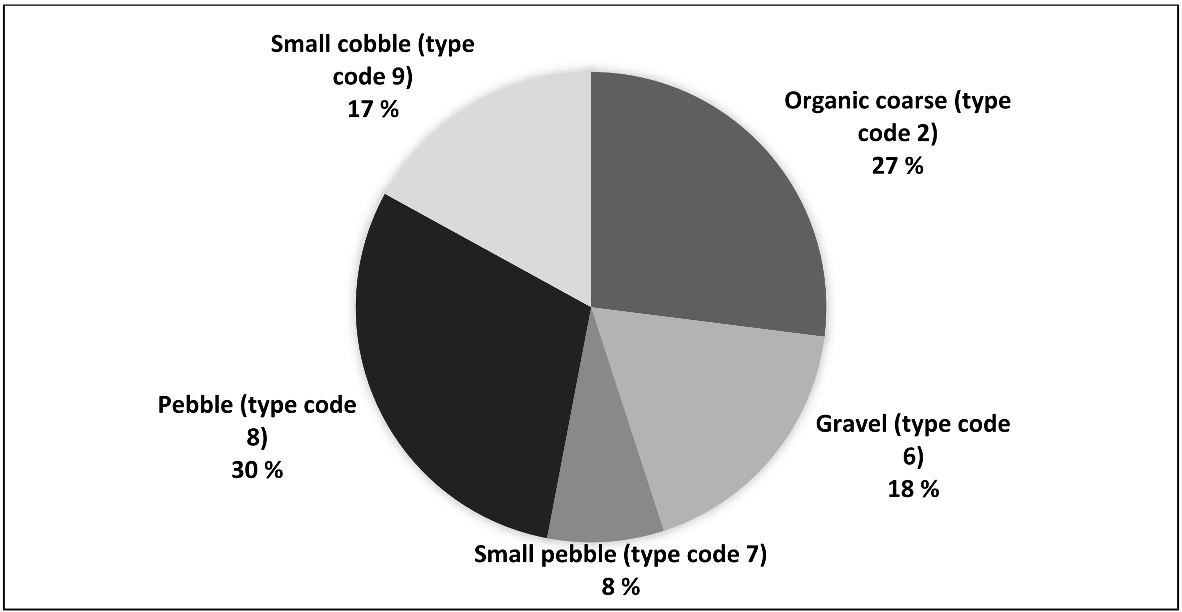

Figure 33: distribution of different substrate types on station 4.

2.6 Station 5

Date:	14.10.2014
Water temprature:	6,1 ºC
Conductivity:	19,3 µs/cm

Station 5 is located on the south side of the pier (fig. 6, fig. 34). The outlet from Bjønndøla comes out on the north side of the pier, creating a higher water velocity in the middle part of the station.

Figure 34: measuring up station 5, at a low water level. Photo: © Jan Heggenes.

A total of 15 brown trout, 73 european brook lampreys and eight three-spined sticklebacks were caught on station 5 (fig. 35). The number of brown trout caught in the first round of fishing were 11, while four brown trout were caught in round 2. Density of brown trout pr. 100 m^2 is 7,5. The results given by Ecological Methodology (version 7.2) were a catchability of 0,6602 and a 95% confidence limits: 16,02-17,47. The catchability is a bit higher than the normal range for electrofishing, which is 0,4-0,6 (Hvidsten 2010). The confidence interval means that the real population size lies within 16,02 and 17,47 for this station.

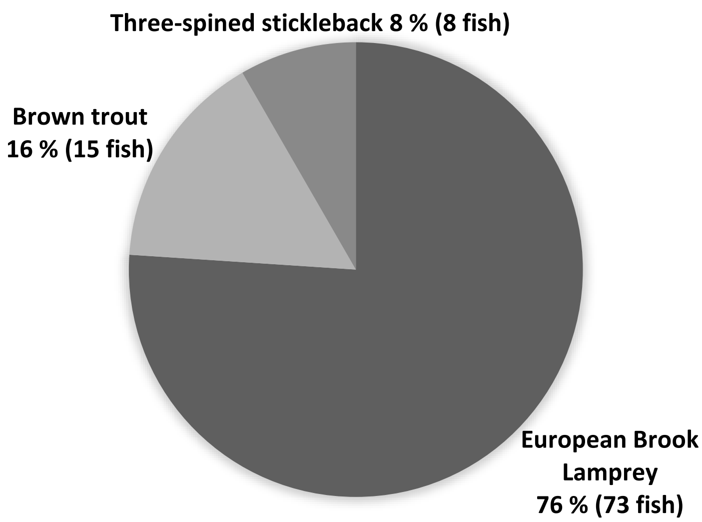

Figure 35: species composition on station 5.

The average length of the 53 european brook lampreys measured was 128,1 mm. The three-spined sticklebacks ranged from 30 – 40 mm (avg. 33,7 mm). The length distribution of the brown trout caught were within the interval 30 – 70 mm (avg. 48,6 mm) (fig. 36).

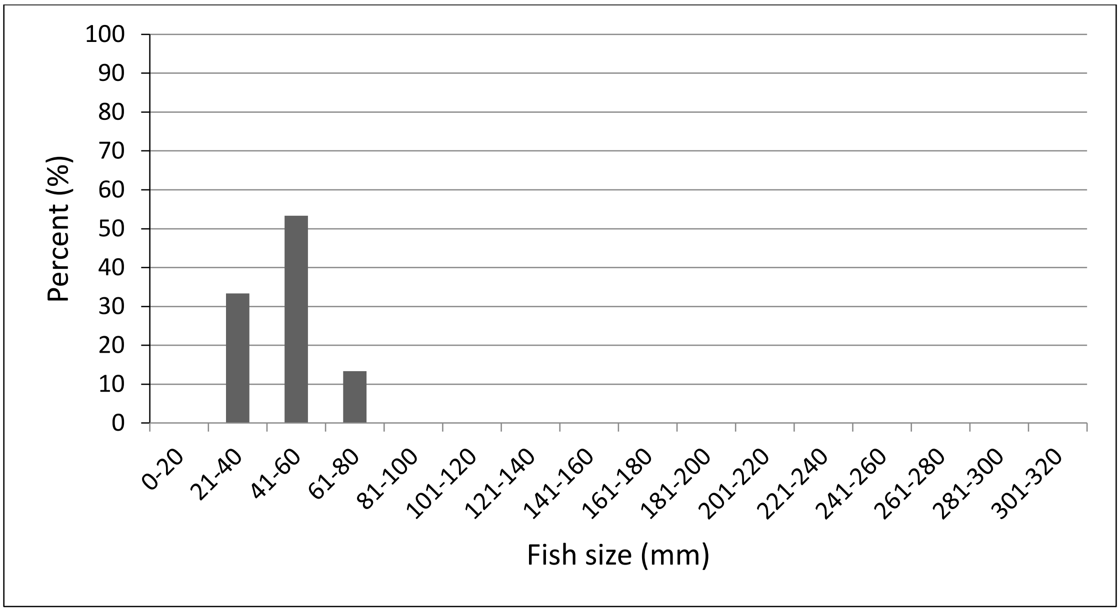

Figure 36: length distribution of brown trout caught on station 5.

The substrate type codes present on station 5 are 2,6,7,8, 9 and 10 (fig. 37), with type code 9 as the most frequent (36 %). There is a relatively even distribution between the type codes 10 (22%), 2 (20%), and 8 (19%). The distribution of the different type codes are more homogenous than in station 4. Overall the depth increased from the pier and out, with an average depth of 63 cm (appendix 5).

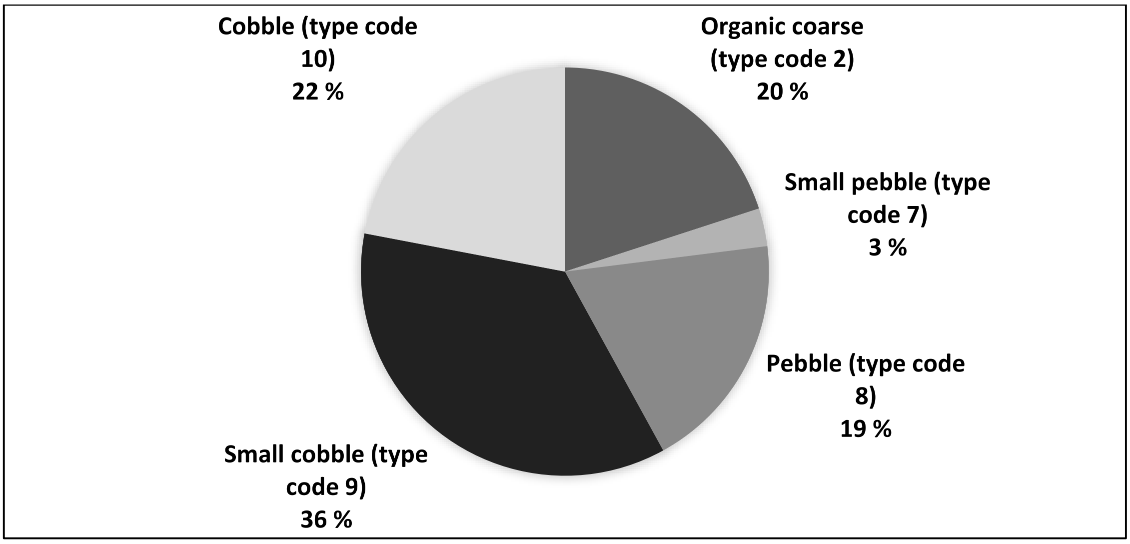

Figure 37: distribution of different substrate types on station 5.

2.7 Spawning fish

Figure 38: areas that were searched for spawning fish. www.norgeskart.no

2.7.1 Pier:

The search for spawning brown trout was done in an approximate 900 m^2 area around the pier (fig. 38). A total of 176 brown trout over 200 mm were observed during six days at both sides (fig. 39); 77,5 % of the fish were seen on the south side of the pier.

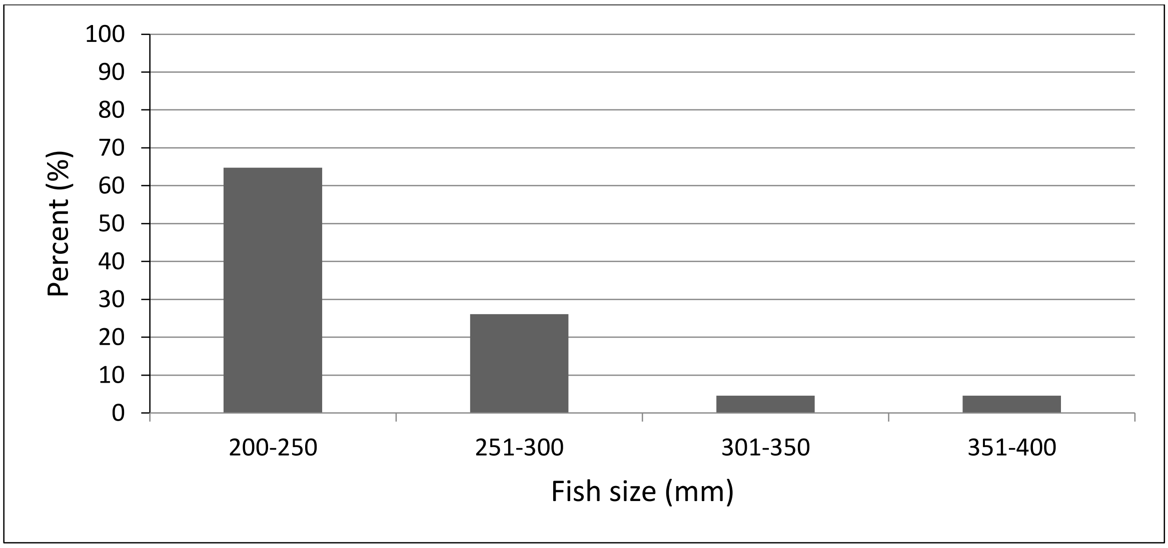

Figure 39: length distribution of spawning fish observed at both sides of the pier.

2.7.2 Delta area:

The search was done from the shore and to the end of station 4, in an approximate 500 m^2 area (fig. 38). A total of 15 brown trout over 20 mm were observed during six days (fig. 40). There were also observed potential spawning beds in the delta area (fig. 41).

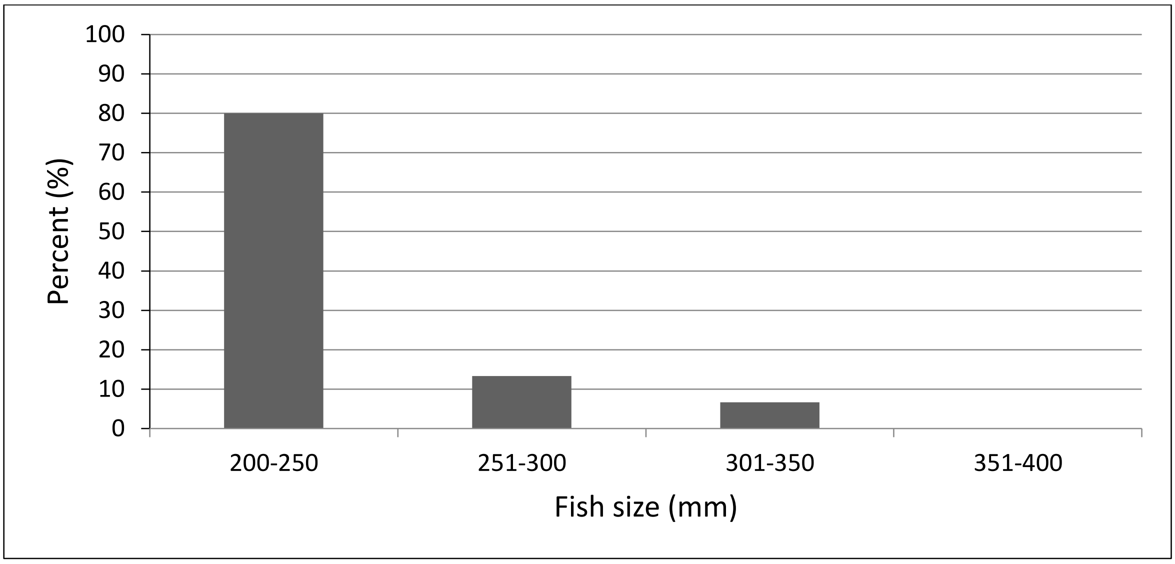

Figure 40: length distribution of spawning fish observed in the delta area.

Figure 41: potential spawning beds in the delta area. Photo: © Jan Heggenes

2.8 Otoliths and shells

Three fish with a size larger than 150 mm were caught; two at station 2 (170 mm and 188 mm), and one at station 3 (305 mm). Otoliths and scales showed an age of 3+ for the fish at 170 mm, and 4 years for the fish at 188 mm. Scales suggested an age at 7+ for the fish at 305 mm.

3. Discussion

The catchability at station 1 was 0,4177, just within the normal range for electro fishing (Hvidsten 2010). The catchability was lower on station 2 (0.3996), and higher on station 3 (0,5322). There are many different factors that can affect the catchability in these stations. At a water temperature lower or just around 5°C, which is the case in station 1-3, the fish changes behavior and become more inactive. They hide further down in the substrate, which can lead to a lower catchability. This may cause an underestimated population density (Standard Norge 2003). Ideally the electro fishing should have been done a couple of weeks earlier, when the water temperature was above 5°C.

Our results from station 1(1) might indicate that the most essential factor affecting the catchability is water flow. When station 1 was electro fished the first time the water flow was significant lower than the second time, which resulted in higher catch (141,6 %) that was somewhat smaller in size (5 %). We assume the water flow would have had the same effect on station 2 and 3. Another factor that affects the catchability estimate is the use of Ecological Methodology. The program cannot deal with the value 0, so at station 3 where round three was not carried out value 1 was used. This can lead to a slight overestimation of the population. In general a small sample results in bigger uncertainty (Whitlock and Schluter 2014). Based on the results from the river stations it seems like this area is an important nursery habitat for fish, with a dominance of juvenile brown trout.

Number of brown trout caught on station 4 and 5 were smaller than on the other stations. The catchability was 0,8513 on station 4 and 0,6602 on station 5, which can be a slight overestimation because we did not catch brown trout at each round. The low number of fish can be a result of more organic substrate, and lack of hiding places. Organic substrate was also the reason for the high number of european brook lampreys caught. The water depth was overall greater than in the river, which can lead to lower catch.

The average fish density in the examined river area per 100 m^2 was 18. Similar regional studies has been done for Vallaråi in 2011 with an estimated average population density between 32-65, Bøelva (1992) 70,1, Bøelva (2009) 19,2, Heddøla (1992) 8,8, Heddøla (2009) 44,1 (Hvidsten 2010) and Tinnåa (2001-2005) with a density between 40-80 (Heggenes 2008). All estimations are per 100m^2. Comparisons between different studies must be interpreted with caution because of different methodology and calculation methods. We saw that by using a formula described by Bohlin et.al. (1989) the estimates of fish density pr. 100 m^2 became a bit higher. The polulation desity in Bjønndøla seems to be lower than most of the other studied rivers in the county. That can possibly be explained with the fact that Bjønndøla is a smaller river, and receives cold water directly from Lifjell mountain area. Cold water in the growth season will inhibit growth rate for juvenile brown trout, which has an optimal growth rate between 13-14 ^oC (Heggenes, Bergan et al. 2011). Despite the fact that the population density is lower than in the other mentioned rivers, Bjønndøla seems to be an important recruitment area for brown trout.

Observations of potential spawning beds (fig. 40) and number of spawning fish gives an indication that the pier and delta area (fig. 38) are spawning locations for brown trout. A lower number of fish observed in the delta area may have several reasons. The disturbance in the water caused by vading may scare away some of the fish. In addition the water is calm in large parts of the area, which is less preferred by spawning brown trout (Barlaup, Gabrielsen et al. 2008) The water level was high in the observation period, with an average depth of 73 cm on station 4. Spawning brown trout prefers water depth between 15- 45 cm (Louhi, Mäki-Petäys et al. 2008). The area surrounding the pier is less homogenous and has deep, but also shallow areas that are suitable for spawning. This can explain the higher number of observed spawning brown trout.

The development of the proposed campground will require large amounts of fill material to level up the ground. This has to be done to an extent that can keep the constructions and pluming unaffected by the highest regulated water level. The shallow delta areas at station 4 seem to be less important for spawning according to our observations, but if the fill material is going to be collected from this area the hiding places, nursery and feeding grounds for brown trout in all sizes might be reduced significantly. Shallow vegetation is likely represented at many locations in Lake Seljordsvatn, but the area around station 4 might be especially important because it is located close to the spawning activity at station 5. Potential interests in motorized boat traffic from the planned pond and into the lake will in addition have a negative effect on these habitats.

Based on the observations of spawning activity and related important key habitats, the construction and subsequent land use will likely have a negative effect on the biotic and abiotic factors for a healthy and sustainable population of brown trout in the south-east part of Lake Seljordsvatn and in River Bjønndøla. In addition an impact assessment for **the** construction area is recommended regarding potential elimination of nesting grounds for birds, if any endangered or prioritized spices are represented in the region.

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