Master's thesis

INVESTIGATING DIFFERENT MIGRATION PATTERNS OF *SALMO TRUTTA* (L.) IN THE TENO RIVER SYSTEM USING STABLE ISOTOPE ANALYSES

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ABSTRACT

The River Teno in Northern Lapland is one of the most important Atlantic salmon (*Salmo salar* L.) rivers and also contains an extensive, but largely unstudied, population of brown trout (*Salmo trutta* L.). Scales from 298 individual trout caught in the river system were analysed for ^{13}C and ^{15}N stable isotopes with the aim of distinguishing between freshwater resident and sea migrating trout and to identify possibly different migration patterns within the system. Trout juveniles and invertebrates were used as freshwater reference material for isotope values and sea trout caught in Tanafjord as sea reference material.

According to the stable isotope analyses, in the main river and in the Inarijoki and Karasjoki tributaries, the major proportion of all the trout analysed were clearly anadromous. In contrast, in the Utsjoki tributary that contains numerous large lakes, freshwater residency seems to be the predominant trout life history pattern. Whereas in the upper river sections and tributaries clearly distinguishable δ^{13}C and δ^{15}N clusters appear, the lower Teno sections show a continuous pattern in δ^{13}C and δ^{15}N signatures with no clustering, probably caused either by repeated migrations between freshwater and marine environments or by feeding in the estuary with intermediate isotope values. In this large, completely free flowing river system, the availability of lakes seems to affect the anadromous migration considerably, but the distance to the sea appears less influential.

JYVÄSKYLÄN YLIOPISTO, Matemaattis-luonnontieteellinen tiedekunta

Bio- ja ympäristötieteiden laitos
Kalabiologia ja kalatalous

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TIIVISTELMÄ

Pohjois-Lapissa sijaitsevassa Tenojoessa elää elinvoimainen mutta pääosin tutkimaton taimenpopulaatio (*Salmo trutta* L.). Jokisysteemistä saatujen 298 taimenen suomuista analysoitiin vakaat isotoopit ^{13}C ja ^{15}N. Tarkoituksena oli erottaa toisistaan makeassa vedessä eläneet ja merivaelluksen tehneet taimenet ja tunnistaa mahdolliset erot niiden vaelluskäyttäytymisessä jokisysteemissä. Makeanveden isotooppiarvojen perustason kuvaajana käytettiin taimenen poikasista ja joen selkärangattomista määritettyjä isotooppisuhteita. Meren perustasona käytettiin Tenovuonosta kalastettujen meritaimenten arvoja.

Isotooppisuhteista voidaan päätellä, että Tenon pääuomassa ja Inarijoessa ja Karasjoessa (Tenon sivujokia) suurin osa tutkituista taimenista oli selvästi käynyt syönnöksellä meressä. Sen sijaan Utsjoessa, johon kuuluu useita suuria järviä, makeassa vedessä pysyminen näyttää olevan yleisin taimenen elintapa. Pääuoman yläjuoksulla ja sivujoissa erottuvat selvät taimenten ^{13}C- ja ^{15}N-arvojen ryhmittymät. Tenojoen alajuoksulla taimenten $\delta^{13}C$- ja $\delta^{15}N$-arvot jakautuivat selvästi kahteen ryhmään. Tämä johtuu todennäköisesti toistuvasta vaelluksesta joen ja meren välillä tai ruokailusta jokisuussa, missä on keskimääräiset isotooppiarvot. Tässä suuressa patoamattomassa jokisysteemissä etäisyys lähellä sijaitseviin järviin tuntuu vaikuttavan selvästi merelle suuntautuvaan vaellukseen mutta meren etäisyyden vaikutus näyttää vähäisemmältä.

Contents

1. INTRODUCTION

1.1. The unexplored brown trout in the Teno River system

The River Teno (Tana in Norwegian) holds one of the most important Atlantic salmon (*Salmo salar* L.) stocks in Europe that has been intensively studied by the Finnish Game and Fisheries Research Institute (FGFRI). However, the river system also contains extensive brown trout (*Salmo trutta* L.) populations, about which rather little is known. In the River Teno and its main tributaries, Inarijoki, Karasjoki and Utsjoki, salmon is the major catch of fishermen and the most valuable species and trout in general only a bycatch, but their importance for the rod and line fisheries might increase in the future. Beside the upper reaches of the tributaries, the main steam and the bigger tributaries are mainly used by salmon parr as nursery areas. Trout juveniles are typically only found in the small tributaries (Erkinaro & Niemelä 1995). Niemelä & McComas (1985) and Jensen et al. (1990) studied ”sea trout“ in the River Teno, but they lacked a powerful tool to confirm that all their analysed fish were indeed sea trout. Trout are known for their polymorphism in life history pattern: residency in the natal stream and migration within freshwater or to the sea are all well documented strategies before fish return to spawn in their natal river (Elliott 1994). In the River Teno some trout certainly migrate to the sea. Others probably make equivalent feeding migrations to lakes within the river system.

1.2. The brown trout (*Salmo trutta* L.)

1.2.1. Different life history patterns

Two major life history patterns are recognized in *Salmo trutta* L., the freshwater resident brown trout (hereafter called “local trout”) and the anadromous, so called “sea trout” (Elliott 1994). The freshwater life cycle can further be subdivided into three different patterns (McCarthy & Waldron 2000). Some fish spend their entire life in their natal stream and never leave it. But fish may also migrate to the parent river or a lake as juveniles and return to their natal stream only for spawning. Although those different migratory patterns are recognized in many trout populations, both freshwater resident and anadromous sea trout often use similar spawning grounds (McCarthy & Waldron 2000) and freely interbreed to some extent (Elliott 1994). Further, Etheridge et al. (2008) emphasized the polymorphism of brown trout migration behaviour, as they found evidence for continuous variation in the pattern of marine vs. freshwater foraging, indicating repeated migration between freshwater and marine environments or estuarine residence.

1.2.2. Sea migration

Migration to the estuary and the sea to access more profitable food resources is one possible life history pattern for freshwater fish. In general, migrating fish grow larger and have an increased reproductive potential, but a lower survival rate than resident fish (Skaala & Nævdal 1989, Jonsson & Jonsson 1993). The cost of migration is an increased risk of marine predation and the energetically costly migration (Berg & Jonsson 1990, Bohlin et al. 2001). Nevertheless, attempts to explain different migrating patterns have revealed rather contrasting results. Genetic differences are reported between anadromous and local trout (Jonsson 1982, Skaala & Nævdal 1989), but the migration pattern might be also induced by environmental conditions, such as food availability (Olsson et al. 2006) or juvenile densities (Bohlin et al. 2001). Several studies have indicated that the anadromous proportion of the stock decreases with migration distance from the sea or with altitude

(Kristoffersen et al. 1994, Wood 1995, Bohlin et al. 2001, Jonsson & Jonsson 2006), whereas other rivers do not support this trend and other factors, such as the composition of the fish community in the river, may influence the trout migration patterns. Jonsson et al. (2006) showed an increase in the mean size of sexually mature sea trout with migratory distance as well as an increased age at sexual maturity. This increased mean size was mainly based on an increase of the smallest anadromous spawners with increasing distance. On the other hand, size-adjusted gonad size in males and the mass at length declined with increasing distance from the sea to the spawning grounds. Females often dominate the migrating proportion, and males among residents (Jonsson & Jonsson 1993). The fitness of females and their reproduction effect increases exponentially as they grow larger, which may explain their predominance.

1.2.3. Smoltification

Much information is available on smolting and smolt migration in sea trout (e.g. Bohlin et al. 1993, Elliott 1994, Sundell et al. 1998, Byrne et al. 2004), but only little on smolting at high latitudes (Finstad & Ugedal 1998, Finstad et al. 2005) and especially in the River Teno (Niemelä & McComas 1985, Jensen et al. 1990). The individual variation of smolting in age and time might be a result of differences in body-size, growth rate and morphology that also seems to induce or inhibit maturation of male parr (Bohlin et al. 1993). During smoltification the sea trout parr undergo several physiological and morphological changes (Finstad & Ugedal 1998), but migration also varies between years, caused by the number of degree-days, change in water level, water temperature and the mean annual fish length (Bohlin et al. 1994). In the River Teno, trout smoltify at an average length of 22 cm at average ages of 5 to 6 years (Niemelä & McComas 1985, Jensen et al. 1990).

1.2.4. Behaviour, duration of the sea sojourn and overwintering

Most researchers assume that large proportions of sea trout mainly stay in the inner fjord system (Jonsson 1985, Knutsen et al. 2001, Finstad et al. 2005). There is little information available on the sea trout behaviour in the sea, but there are some studies about feeding habits. In southern Norway the most abundant prey was fish (mainly clupeids and gobiids), followed by crustaceans, surface insects and polychaetes (Knutsen et al. 2001). In northern Norway fish was a major prey as well, but during the winter time crustaceans dominated the diet and in Ranafjord insects made a large contribution to the diet from July to September (Rikardsen et al. 2006).

In high latitudes, overwintering might occur in freshwater or the sea (Jonsson 1985, Berg & Berg 1989, Berg & Jonsson 1990). In the River Vardnes the sea migration seems to be only a feeding migration, as Berg & Berg (1989) reported a mean duration at sea of 68 days during the summer time. In other rivers the sea trout population may re-enter freshwater without reaching maturity and without obvious reason during the winter. Sea trout might return to freshwater due to osmoregulatory stress in relation to the combination of high salinity and low temperatures (Larsen et al. 2008). On the other hand seawater tolerance and mortalities vary for different sea trout populations. All studies that documented winter residence in freshwater were carried out in watercourses that hold lakes, where fish can remain during the winter (Berg & Berg 1989, Berg & Jonsson 1990, Ugedal et al. 1998). Conditions in rivers of high latitudes might be very harsh during the winter due to difficult ice conditions combined with low water levels. Despite low seawater temperatures and high salinities, sea trout were found feeding extensively on marine crustaceans and polychaetes during early and late winter, leading to stable or increasing condition factor during this time. But decreasing condition factors were reported for sea trout overwintering in freshwater (Berg & Jonsson 1990) and Rikardsen et al. (2006) hypothesized that feeding at sea might outweigh the benefits of staying in freshwater during the winter. This indicates that some sea trout populations are physiologically better adapted to harsh sea winter conditions than others. In the River Teno, previous research suggests that a large proportion of sea trout return to freshwater after only one summer (Niemelä & McComas 1985), but those data do not answer the question of overwintering for 1, 2 or more sea age cohorts in the Teno system. At least Atlantic salmon overwinter in the river after spawning and migrate back to the sea the upcoming spring (Niemelä et al. 2000) suggesting that the River Teno might be large enough to support adequate conditions for freshwater overwintering .

1.2.5. Migration

Niemelä & McComas (1985) analysed a total of 307 adult “sea trout” caught in the Teno river system and reported a bimodal migration timing. They assumed the trout were anadromous, but the samples might also include local trout. In May and at the beginning of June, the cohort was composed of 1, 2 and 3 sea age trout, based on scale reading. A much larger proportion of trout was caught between the end of August and the beginning of October, composed mainly of 0+ (62 %) and 1+ (32 %) sea age cohorts. In this study the samples are caught only between May and the end of August.

1.3. Stable isotope analyses

In fact, it is difficult to distinguish reliably between freshwater resident and anadromous trout forms, since they often overlap in size and body colouration and scale reading hence to be highly subjective and unreliable. Stable isotope analysis (SIA) was used successfully in the past to distinguish between anadromous and resident brown trout (Acolas et al. 2007, McCarthy & Waldron 2000). Stable carbon and nitrogen isotope analysis of trout tissue provide insights into this issue because the isotope ratios can be expected to differ between river, sea and lake habitats.

The δ-Notation is the most common notation used by most researchers for isotope values (Fry 2006): $X = [(R_{Sample} / R_{Standard} - 1)] * 1000$, where X is $\delta^{13}C$ or $\delta^{15}N$ and R describes the ratio of the heavy isotope to the light isotope (e.g. $^{13}C/^{12}C$ or $^{15}N/^{14}N$) of the sample and the standard, respectively. PeeDee Belemnite (PDB) is the reference standard for $^{13}C/^{12}C$ and air for $^{15}N/^{14}N$ respectively (Fry 2006). The standards for the different elements always have a δ value of 0 ‰. The factor 1000 makes the small isotopic difference more visible and the δ unit is therefore as parts per thousand (‰).

Mixing and fractionation of the isotopes, while they are circulating in the biosphere, make them a useful tool for analyses. Large stable pools are the ocean for carbon isotopes or the atmospheric reservoir for $N_{2.}$ Material flow and metabolism in ecosystems lead to characteristic isotopic patterns in the biosphere and “isotopes function as natural dyes or colours, generally tracking the circulation of elements” (Fry 2006).

Freshwater values of $\delta^{13}C$ are generally lower and more variable than those in marine environments with a gradient between the two extremes that correlates with salinity (Riera & Richard 1995). Carbonate rock weathering, mineral springs, atmospheric CO_2 and organic matter respiration as a source for dissolved CO_2 in freshwater directly affects the ^{13}C contents of the components of the carbon cycle. The $\delta^{13}C$ values in freshwater therefore vary widely and due to local physicochemical processes in rivers that may alter $\delta^{13}C$ values at the base of the food webs. Charles et al. (2004) suggested that $\delta^{15}N$ might also be a good tracer for marine feeding in freshwater fish, if the catchments are relatively unimpacted by anthropogenic nitrogen (that might result in high $\delta^{15}N$ values). Nitrogen limitation in contrast to phosphorus limitation might result in big differences in $\delta^{15}N$ values of primary producers (Fry 2006). Strong nitrogen limitation results in little fractionation, whereas sufficient nitrogen favours fractionation during assimilation and thus for lower $\delta^{15}N$ values. If different nitrogen sources are available the stable isotope ^{15}N may function as a tracer for autochthonous or allochthonous organic matter. But $\delta^{15}N$ may also act as an indicator for trophic studies, as it increases in trophic level from plant to herbivore or herbivore to carnivore. Increasing values of 2.2 to 3.4‰ for ^{15}N in the consumer versus its diet are found for aquatic food webs (Vander Zander & Rasmussen 2001, McCutchan et al. 2003, Sweeting et al. 2007). In contrast, the trophic increase of $\delta^{13}C$ values is minor (c. < 1‰) (Hobson 1999).

In summary, the isotopic composition of carbon and nitrogen in fish tissue is controlled by the isotopic composition of primary production at the location occupied by the fish during tissue growth and by the trophic level of the fish (Hutchinson & Trueman, 2006).

Beside different fish tissues such as muscle or adipose fin, scales have also been used for SIA (Perga & Gerdeaux 2003, Syväranta et al. 2008). The use of scales instead of muscle tissue for SIA might be advantageous. Scales might represent an average of the diet during the lifetime of a fish and as the scale volume increases exponentionally with increasing size, even for sea trout the proportion of freshwater residues might be minor as the main growth occurs in marine environment (Satterfield & Finney 2002, Hutchinson & Trueman 2006). Further, many research institutes hold large collections of archived scale samples (e.g. for age and growth rate determination) that could be used for analysis and even historical reconstructions are possible (Gerdeaux & Perga 2006, Syväranta et al. 2008). The Tenojoki Fisheries Research Station in Utsjoki (FGFRI) has gathered a huge archive of salmon and trout scale samples over the last decades from the River Teno system. This extensive archive offers an excellent opportunity to obtain relevant isotope data from large numbers of individual fish.

1.4. Objectives of this study

The aim of this Master's thesis was to use stable isotope analysis to take advantage of the extensive FGFRI trout scale archive and to answer the following questions about the brown trout population of the River Teno in Northern Lapland.

i. To identify the migration patterns of individual fish, classifying them into freshwater resident and anadromous trout.

ii. To analyse the prevalence and importance of anadromy as a life history pattern in trout from different river sections and tributaries.

iii. To test other parameters such as length, sex or scale reading analyses for correlation with the migration strategy.

2. MATERIAL AND METHODS

2.1. Study area

The River Teno (70°22'N, 28°15'E) with its upper tributaries, Inarijoki and Karasjoki, in northern Lapland is one of the most important river systems for Atlantic salmon with a drainage area of 16 000 km^2. For 270 km it forms the border between northern Finland and Norway and the lowest 60 km runs through Norway. The large Teno river system is one of the few remaining, entirely free flowing systems in northern Europe without any damming. In the Utsjoki and the Pulmanki tributaries, different lakes are accessible by trout. Jiesjoki springs out of the large Lake Jiesjärvi, the upper parts of Karasjoki are famous for large lake dwelling trout and Inarijoki forms many large lake-like pools.

The river system also holds grayling (*Thymallus thymallus* L.), whitefish (*Coregonus* spp. L.), minnow (*Phoxinus phoxinus* L.), burbot (*Lota lota* L.), bullhead (*Cottus gobio* L.) and sticklebacks (*Gasterosteus aculeatus* L. and *Pungitius pungitius* L.) (Erkinaro & Niemelä 1995). In the lower Teno, flounder (*Platichtys flesus* L.) migrate upstream up to Lake Pulmankijärvi. Other species in the system are arctic char (*Salvelinus alpinus* L.) and pike (*Esox lucius* L.) (Niemelä et al. 1999).

2.2. Marine and freshwater reference material

The trout stock in the Teno River system might consist out of local and sea trout, hence their $\delta^{13}C$ and $\delta^{15}N$ signatures might vary between the two extremes too. Therefore, reference samples of freshwater and the sea are necessary to classify the results and to verify the differences in stable isotope values between freshwater and marine environments. Trout juveniles are hard to find in the main river and in most parts of the tributaries. Hence invertebrates were used, as in food webs the stable isotope values of the consumer correlates with their diet. Although a trophic enrichment of about 3 ‰ $\delta^{15}N$ and a shift in $\delta^{13}C$ values of the diet towards different tissues of the consumer, invertebrate samples are a possibility to get reliable freshwater reference material from many different locations within the river system.

The invertebrate samples were collected at the end of August 2008 by kick-net sampling in the main stem of the River Teno (n=4) and in different tributaries (n=13) according to Figure 1. The samples are qualitative and represent the most abundant invertebrates in each site. The sampling took place at one location per sampling site with fast flowing current. The invertebrates were not divided into different invertebrate groups, but by subjective analyses the most abundant were Trichoptera larva (caddis fly), Plecoptera larva (stonefly) and Ephemeroptera larva (mayfly). Also Simulidae lava (blackfly), Megaloptera larva and some Annelida were in the samples. The species composition was varying within different river sections and tributaries and it was not possible to find exactly comparable sampling sites with similar habitat.

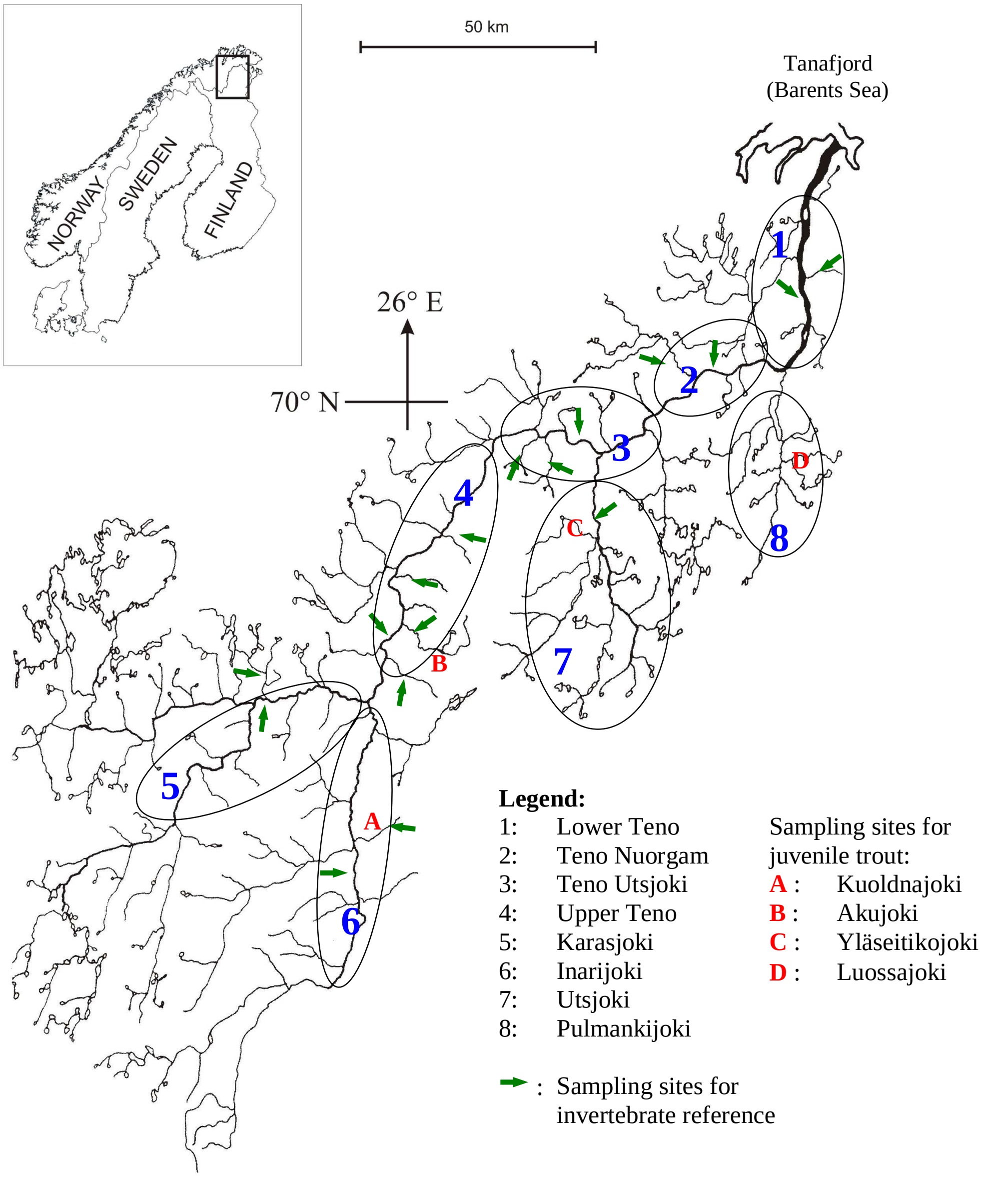

Figure 1. The River Teno system with its tributaries. For this study the main river was divided into four sections (1-4). Additional to the main river, trout scale samples were analysed from the tributaries Karasjoki (5), Inarijok (6) Utsjoki (7) and Pulmankijoki (8). Invertebrate samples were collected in 13 small tributaries and 4 locations in the main river (green arrows). The juvenile trout samples (A – D) where caught in small streams of the tributaries Karasjoki, Akujoki, Utsjoki and Pulmakijoki.

Further freshwater reference material in the form of juvenile trout was obtained by electro fishing in Akujoki (n=11), Kuoldnajoki (Inarijoki tributary) (n=6), Yläseitikkojoki (Utsjoki tributary) (n=6) and Luossajoki (Pulmankijoki tributary) (n=6) by FGFRI. From Kuoldnajoki, Yläseitikojoki and Luossajoki (fish length 14 to 21 cm) only scales were available for analyses and as the sample amount was too small for individual fish analyses, the samples of one location were combined. The juvenile fish from Akujoki (length 3.6 to 13 cm) were stored frozen and freeze-dried before SIA. To compare the stable isotope signatures, for the Akujoki juvenile samples a shift in δ^{13}C values from muscle to scale tissue of 3 ‰ was assumed (Pruell et al. 2003, Satterfield & Finney 2006, Syväranta et al.

2008). Scale samples of 23 individual sea trout, caught by local fishermen in the Tanafjord (Figure 1) in summer 2003 and 2004, were used as marine reference material.

2.3. Scale samples

The Tenojoki Fisheries Research Station (FGFRI) has been collecting salmon and trout scale samples for over 30 years. Scales from a total of 1370 trout were archived between 2000 and 2007. For this study scales from 322 trout individuals (fish length 20 to 80 cm) were selected. The goal was to select a set of samples with uniform fish length distribution for all river section and fish in all size classes. However, as the majority of fish in the archive were in the size class between 40 and 55 cm and trout smaller than 30 to 35 cm were rare, the length distribution varied between the sections to some extent and smaller fish were missing from some locations.

The River Teno was divided into different river section according to Figure 1. Approximately 30 to 60 samples of scale from the year 1998 onwards were collected out of the archive for every section and the tributaries Inarijoki, Karasjoki and Utsjoki. The sample group of Utsjoki (n=48) also includes five samples from other tributaries, such as Pulmankijoki. Because of the low number and the fact that the tributary Pulmankijoki also contains lakes, similar to Utsjoki, those five samples were not analysed individually. No trout samples were available for the river Jiesjoki. Additional, six trout sample (length 27 to 33 cm), caught in the estuary 1986, were analysed.

The fish had been caught during summer by fishermen using rod & line (47 %), gill nets (32 %), weir (16 %) and drift net (5 %). Additional information about the fish was archived with the scales, e.g. length, sex, place of catch. Experienced scale readers at the Tenojoki Fisheries Research Station calculated the age by scale reading of each archived fish. The “freshwater growth” and “sea growth” of each fish were determined by subjective criteria, whereby the “sea growth” period only differs by faster growth rate and could as well take place in freshwater.

2.4. Stable isotope analyses

The scale samples (including the juvenile samples from Kuoldnajoki, Yläseitikojoki and Luossajoki) were acid treated (1.2 N HCl) for 2 min and rinsed 5 times with distilled water according to Perga & Gerdeaux (2003). The invertebrate samples, and for Akujoki the entire juvenile fish, were freeze dried and ground for analyses. For Kuoldnajoki, Yläseitikojoki and Luossajoki the scales of all 6 trout juveniles from each tributary were combined.

Approximately 0.7 mg of scales, ground invertebrates and juveniles were weighed into tin cups. The whole trout scales were analysed. Due to different scales size at different fish length the amount of sample varied between 0.4 to 0.9 mg. SIA was done at the University of Jyväskylä using a FlashEA 1112 elemental analyser coupled to a Thermo Finnigan DELTA^{plus} Advantage isotope ratio mass spectrometer. The samples were processed according to Syväranta et al. (2008) for $\delta^{13}C$ and $\delta^{15}N$ using pike (*Esox lucius* L.) muscle tissue as an internal standard. Replicate standards were run repeatedly in every sequence.

2.5. Data analyses

Different dual isotope graphs with $\delta^{13}C$ and $\delta^{15}N$ values were created. The sea trout caught in Tanafjord and samples that were similar or higher in their stable isotope values were grouped as “sea trout”. On the other hand samples lower in ^{13}C than the highest values of the freshwater reference (juveniles) were grouped as local trout. A two-step cluster analyses was done with statistical software (SPSS) (for all scale samples) including $\delta^{13}C$ and $\delta^{15}N$ values as parameters to check if the assumed seperaration between freshwater resident and anadromous trout was correct and to split samples with intermediate $\delta^{13}C$ and $\delta^{15}N$ values into one of the two clusters. This assumption of local and sea trout was used for the following evaluations. The proportion of local and sea trout was calculated for all section for all analysed fish, but additional also for trout larger than 40 cm to avoid differences in the length distribution between the sections. The frequencies of trout with different $\delta^{13}C$ were created including the results of scale reading to show differences of the separation into local and sea trout by stable isotope cluster analyses and scale reading. SPSS was used to analyse correlation between the stable isotope values and the fish length and to check independence of different fishing methods and the $\delta^{13}C$ signature or the fish length.

3. RESULTS

3.1. Stable isotope analyses

The freshwater reference material of invertebrates from all different sampling sites (mean $\delta^{13}C$ -29.3 ± 1.7 ‰ SD) and the trout juveniles of Kuoldnajoki (-28.4 ‰ $\delta^{13}C$), Yläseitikojoki (-22.8 ‰ $\delta^{13}C$) and Luossajoki (-23.8 ‰ $\delta^{13}C$) scatter over a wide range. To allow for isotope shift between muscle tissue and scales, the $\delta^{13}C$ values of the samples from Akujoki (whole juvenile fish for SIA) were elevated by 3 ‰ (mean $\delta^{13}C$ -25.9 ± 1.3 ‰ SD). With this adjustment, the Akujoki juveniles lay in similar range than the other trout juveniles. All freshwater reference samples were clearly depleted in ^{13}C compared to sea trout caught in the Tanafjord, representing the sea reference (mean $\delta^{13}C$ -17.7 ± 0.9 ‰ SD) (Figure 2). Many of the analysed scales had isotope values that clustered around the sea reference. However, a major group of trout, as well as the juveniles from Yläseitikojoki and Luossajoki, clustered at $\delta^{13}C$ values around -23 to -25 ‰. All trout samples are elevated at least 3 ‰ in $\delta^{15}N$ values, compared to the invertebrate samples. Overall the $\delta^{15}N$ values show a positive correlation with increasing $\delta^{13}C$ values ($R^2 = 0.65$, $p < 0.001$).

3.1.1. Separation into two clusters

SPSS cluster analyses divided the whole data set into two groups: local trout (mean $\delta^{13}C$ -23.5 ‰ ± 1.6 ‰ SD and $\delta^{15}N$ 8.8 ‰ ± 0.9 ‰ SD) and sea trout (mean $\delta^{13}C$ -18.2 ‰ ± 1.1 ‰ SD and $\delta^{15}N$ 11 ‰ ± 0.7 ‰ SD). According to SPSS a $\delta^{13}C$ value of –21 ‰ can be assumed as separation border between the two groups. The separation into local and sea trout is not consistent with growth rate analysis from scale reading (Figure 3). But according to SIA, only very few fish with poor growth rate were in fact sea trout.

A total of 22 trout samples ranged between –21 and –22 ‰ in $\delta^{13}C$ values (Figure 3). The majority of those fish were caught in Teno Nuorgam (n=10) or in the Tributary Utsjoki (n=7). The fish length can be divided into groups of fish smaller than 35 cm (n=11), fish between 37 and 44 cm (n=8) and 3 larger trout (58, 59, 68 cm). Scale reading determined 16 out of 22 trout with only + sea growth (1 summer at sea) or no sea growth at all.

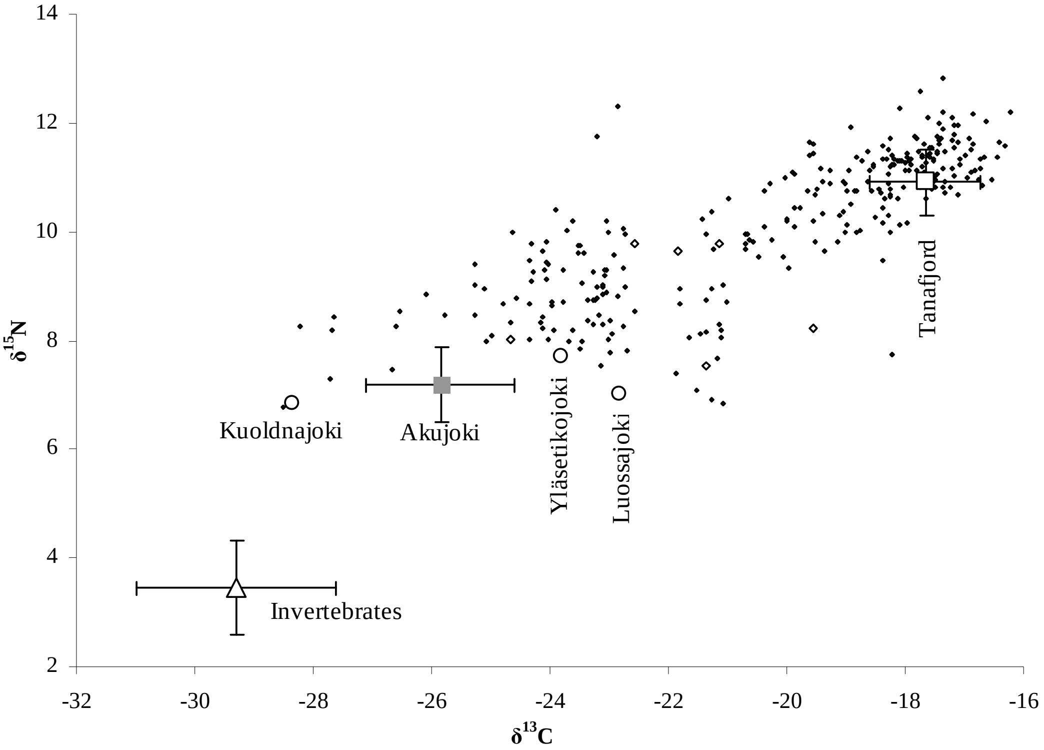

Figure 2. The δ^{13}C and δ^{15}N values for all analysed trout scales (♦), the reference samples (mean value and SD) for invertebrates (Δ) from the Teno River system, sea trout scale samples from the sea (□), trout juveniles from Akujoki (■), Kuoldnajoki, Yläseitikojoki and Luossajoki (mean of 6 juveniles for each location) (○). A small number of 6 individual trout samples were caught in the estuary (◊).

3.1.2. Differences between river sections and tributaries

According to the SIA results, the proportion of sea trout varied between only 15 % (Tributary Utsjoki) up to 89 % in the lower Teno section for the total data (Table 1), but the length distribution varied between different sections. For trout larger than 40 cm, the proportion of sea trout is much more constant in the different sections of River Teno, Karasjoki and Inarijoki ranging between 70 to 90%. The proportion of sea trout is still significantly lower in the Utsjoki tributary with only 17 % of the trout larger than 40 cm classified as are sea trout by stable isotope results.

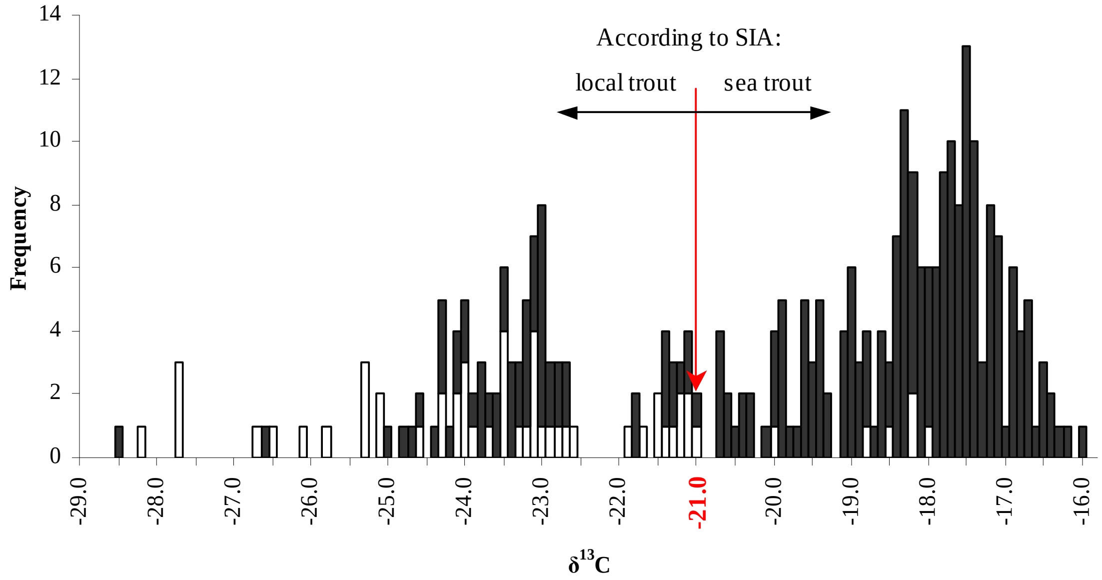

Figure 3. The frequency of trout with different $\delta^{13}C$ signatures. The fish were divided into 0.1‰ $\delta^{13}C$ classes. Cluster analyses (SPSS) determined –21 ‰ as a separation border between local and sea trout. The black and white bars indicate trout with fast and poor growth rate respectively based on scale reading.

Taking into consideration the origin of the analysed trout scales, clearly different distribution patterns of the $\delta^{13}C$ and $\delta^{15}N$ values appear between different river sections (Figure 4 & 5). The Teno Utsjoki, upper Teno and the tributaries form two clearly distinguishable clusters, but the two lower Teno section close to the estuary reveal a continuous pattern in $\delta^{13}C$ and $\delta^{15}N$ signatures. Comparing the signatures of the Utsjoki tributary and the signatures of the Teno Utsjoki river section, the proportion of fish in the two different clusters differs significantly although the distance between the two sampling sections is only some kilometres.

The fish length distribution over all is well balanced in the range of 30 to 54 cm. But in the Teno Utsjoki section, Karasjoki and Inarijoki only very few fish of smaller size classes have been available for analyses (Figures 4 & 5), resulting in differences in the proportion of sea trout between all trout from one location and trout > 40 cm (Table 1).

Table 1. The proportion of sea trout varies with size and within different river section and tributaries. Additional the mean $\delta^{13}C$ values of the local and sea trout clusters and the correlation of the fish length against the $\delta^{13}C$ and $\delta^{15}N$ values are shown.

	proportion of sea trout (all fish)	proportion of sea trout > 40 cm	*Sea trout*		*Local trout*		Correlation of fish length vs. $\delta^{13}C$ (R^2)	Correlation of fish length vs. $\delta^{15}N$ (R^2)
			mean $\delta^{13}C$ of cluster	SD	mean $\delta^{13}C$ of cluster	SD		
Lower Teno (n=46)	89 %	90 % (n=20)	-18.35	1.15	-22.74	0.78	0.23	0.17
Teno Nuorgam (n=55)	71 %	88 % (n=25)	-18.75	1.26	-22.48	1.92	0.44	0.40
Teno Utsjoki (n=39)	79 %	82 % (n=34)	-17.86	0.56	-23.67	0.53	0.16	0.30
Upper Teno (n=45)	47 %	73 % (n=26)	-18.15	1.15	-24.15	0.96	0.55	0.45
Karasjoki (n=31)	71 %	70 % (n=30)	-17.55	0.68	-22.81	1.06	0.13	0.08
Inarijoki (n=30)	73 %	85 % (n=26)	-18.47	1.11	-25.97	1.92	0.33	0.21
Tributaries (Utsjoki) (n=47)	15 %	17 % (n=24)	-18.20	0.58	-23.34	1.42	0.00	0.13

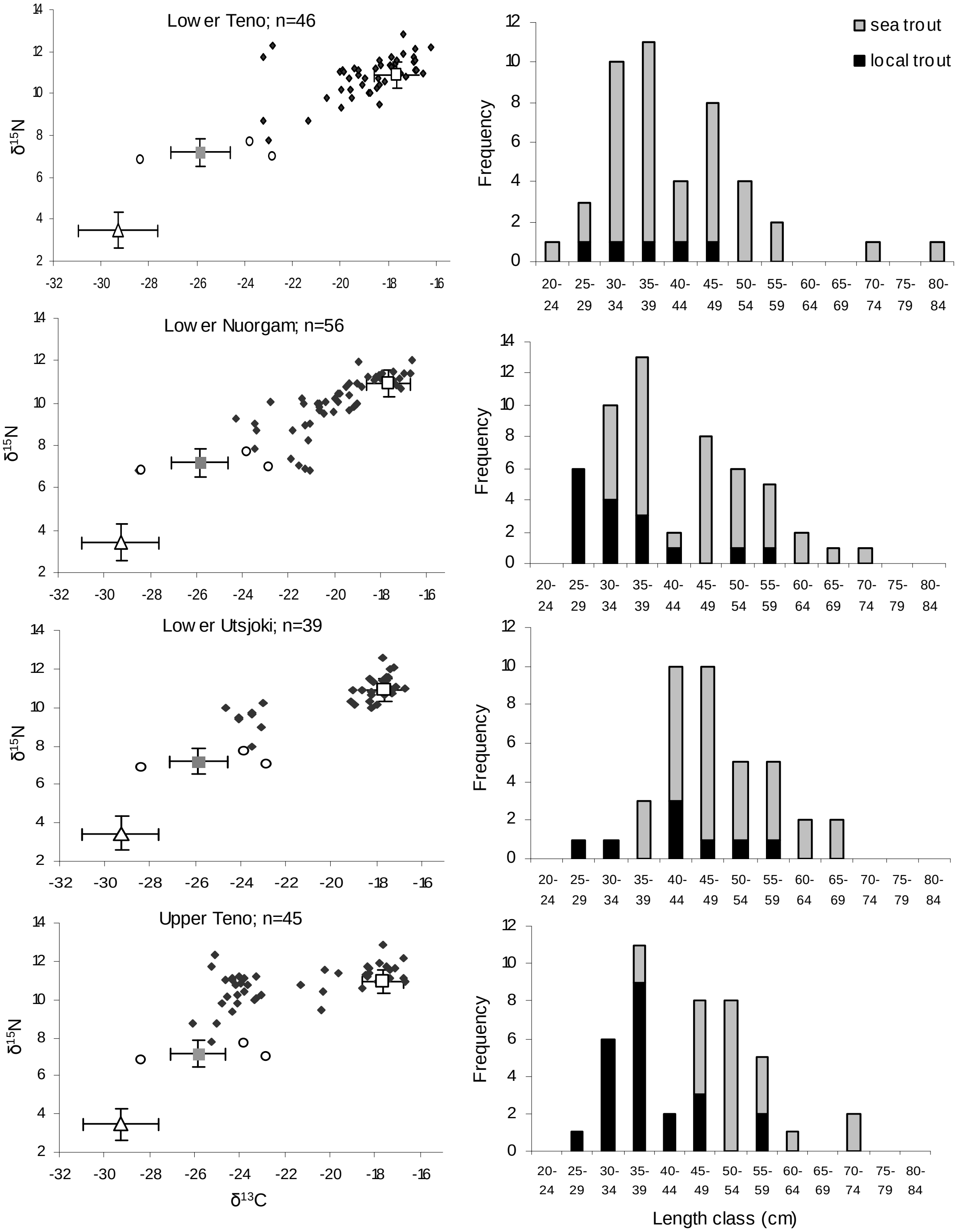

Figure 4. The δ^{13}C and δ^{15}N values of scales (♦) and the length distribution of the analysed trout in River Teno sections.

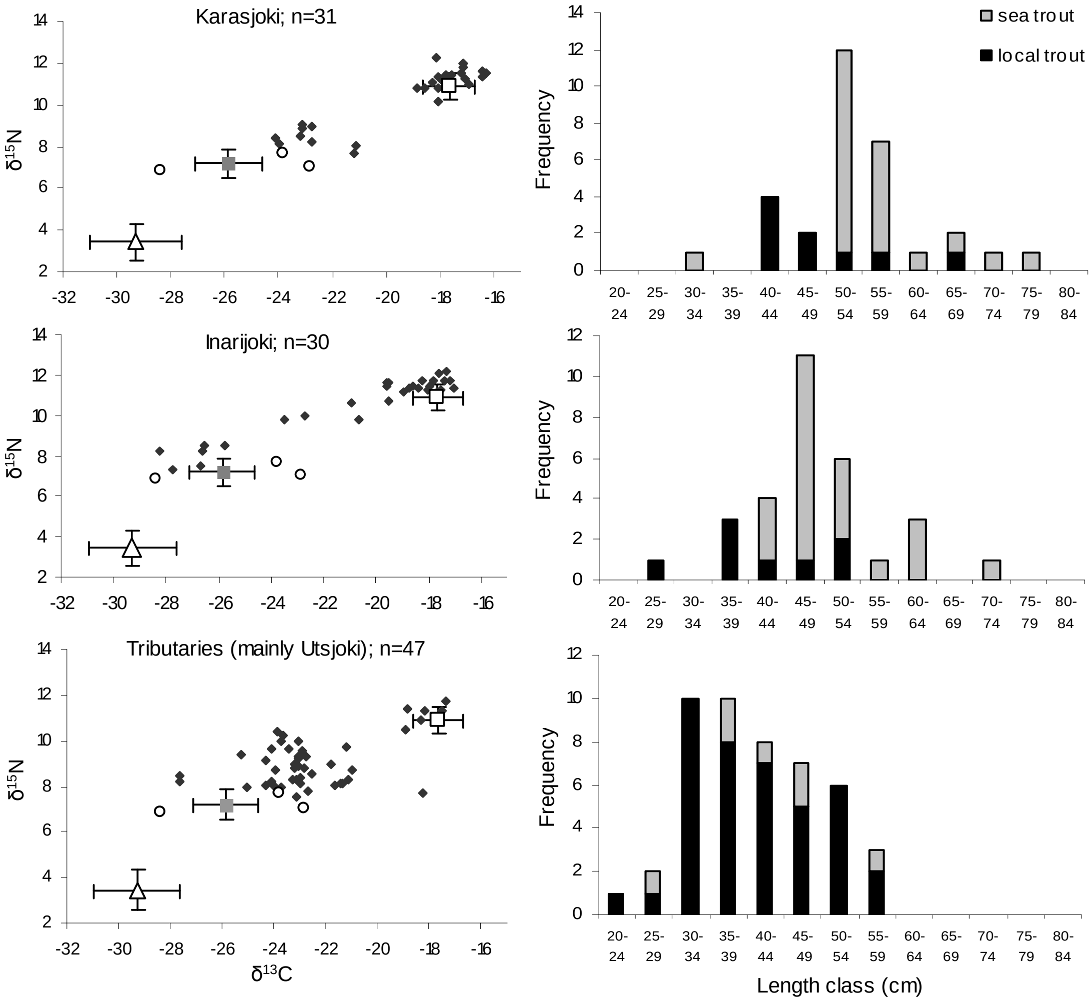

Figure 5. The δ^{13}C and δ^{15}N values of scales (♦) and the length distribution of the analysed trout in different Teno tributaries.

3.2. Further parameters

3.2.1. Influence of fish length

There was a weak but significant correlation between fish length and $\delta^{13}C$ and $\delta^{15}N$ values respectively ($R^2 = 0.21$ and 0.24, $p < 0.001$) (Figure 6). The correlation varied between different river sections (Table 1) and in the Utsjoki tributary the fish length did not correlate with $\delta^{13}C$ at all. For the whole data the proportion of sea trout increased with fish length (Figure 7).

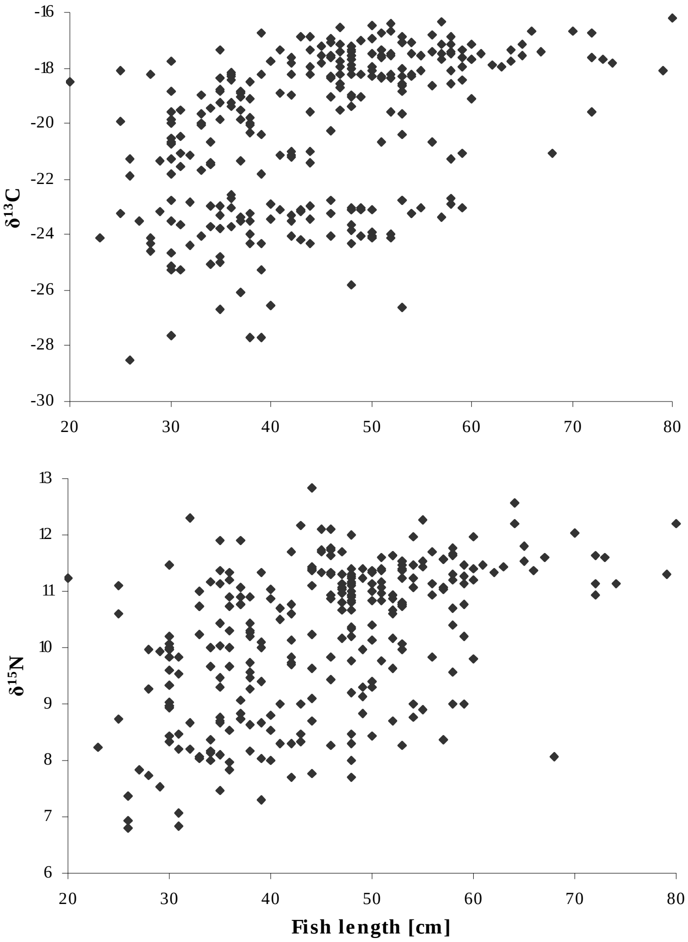

Figure 6. Total fish length and $\delta^{13}C$ and $\delta^{15}N$ values of all analysed trout scale samples (excluding fish caught in the sea and the estuary).

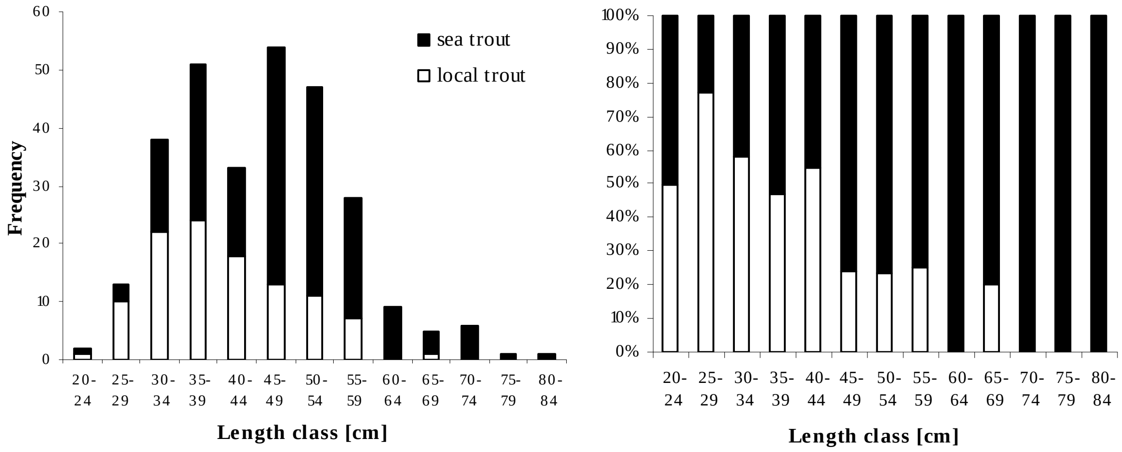

Figure 7. The frequency and proportion of sea trout increased with increasing fish length (total data, excluding fish caught in the estuary and the sea) (n=288).

3.2.2. Sex ratio

A sex ratio female/male of 1.3 for the local trout (n=102) and 1.6 for the sea trout (n=168) respectively was found for the analysed trout samples caught in the river system (Figure 8). In sea trout males seem to dominate in the smaller and bigger length classes, although only few fishes in those classes were included. Taking in consideration the total FGFRI scale archive the sex ratio female/male was 2 for all the archived trout samples in the time period of 1990 to 2007 (n=1548) and 2.9 in the time period of 1980 to 1989 (n=795).

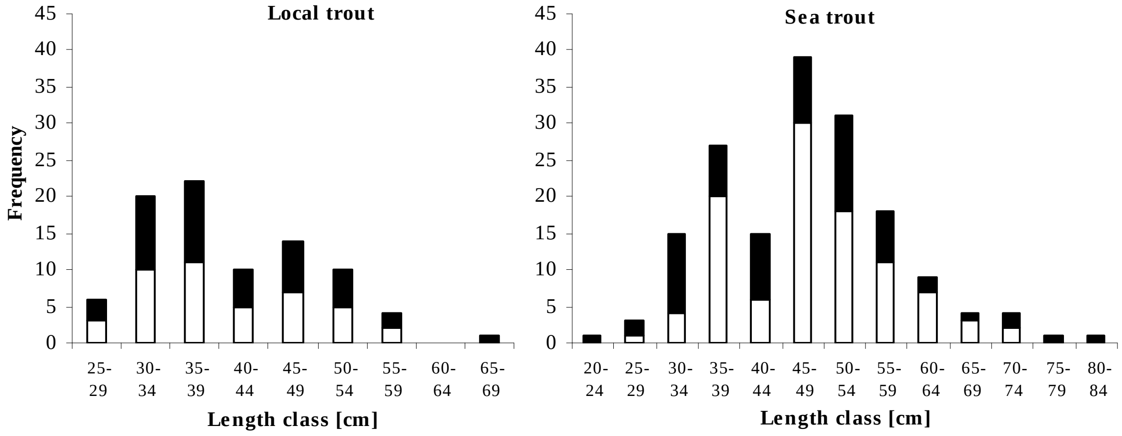

Figure 8. The frequency of males (black) and females (white) in local trout (n=102) and sea trout (n=168) according to SIA caught in the Teno River system.

3.2.3. Sea age and date of catch

The major proportion of sea trout spent 1 or 2 years at the sea, based on scale reading. The proportion of 0+ and more than 3 year sea age fish was low (Figure 9). On the other hand the proportion of local trout in the total weekly catch is highest in the middle of the fishing season in June and July, whereas in the beginning and end of the season the proportion of sea trout is higher and the proportion of 0+ sea trout is increasing in the end of the fishing season (Figure 10).

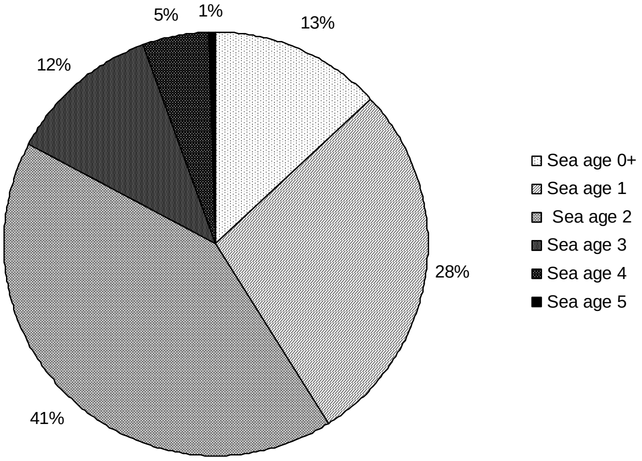

Figure 9. Sea age (0+ = one summer at sea, 1 = one year at sea etc.) distribution in sea trout according to SIA (n=146).

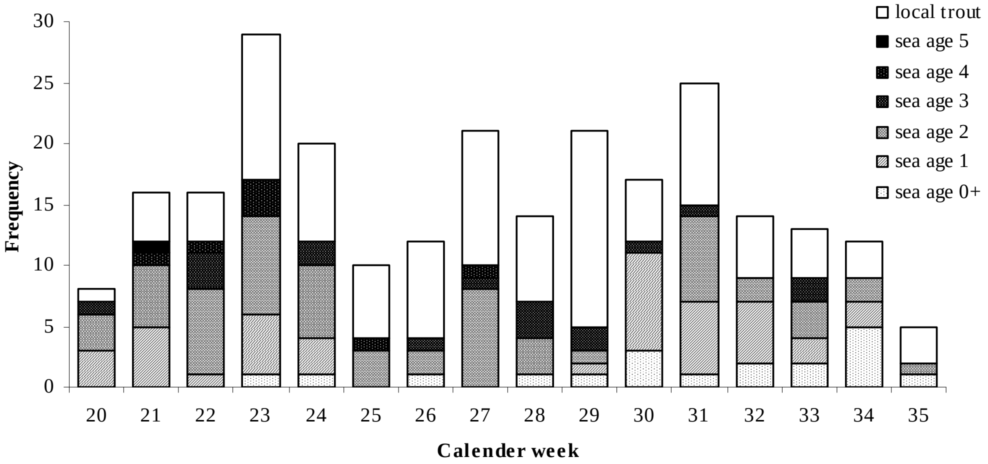

Figure 10. Weekly trout catch frequencies divided into sea age (0+ = one summer at sea, 1 = one year at sea etc) classes for the sea trout and local trout according to SIA for all analysed river sections and tributaries. (34 trout with spawning marks on the scale were excluded).

3.2.4. Fishing method

The $\delta^{13}C$ values were significantly higher in fish caught by weir and drift net, but the fish length is not explaining this difference as weir and drift net are not selective fishing methods for larger fish (Figure 11). However, in the lower Teno section and in Karasjoki more than 50 %, and in Teno Nuorgam and Teno Utsjoki 19 % and 15 % of all trout were caught by drift net and weir respectively. Nevertheless, in most river sections rod & line and gill nets contributed the major proportion of all trout samples (Table 2).

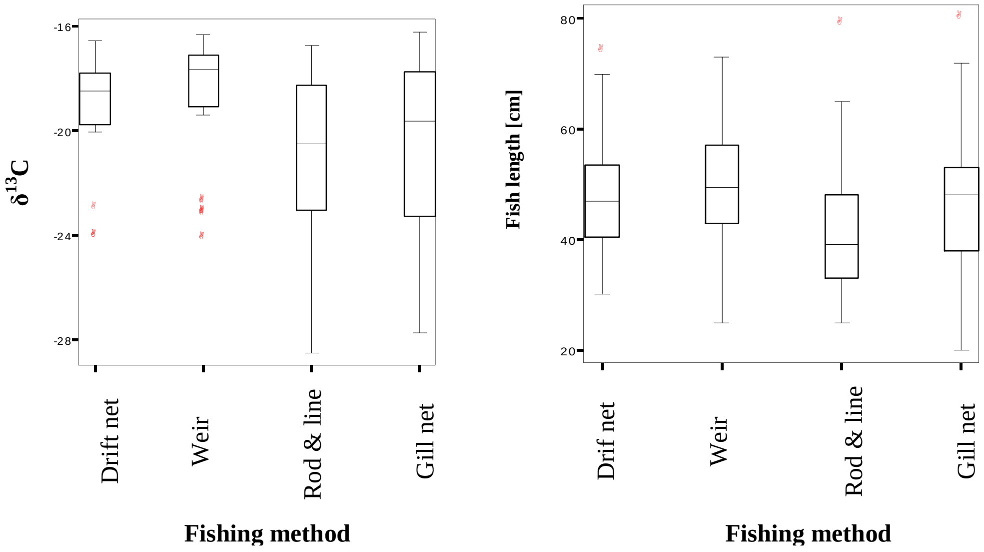

Figure 11. Dependence of δ^{13}C value and the fish length to the fishing method (n=291).

Table 2: The proportion of all analysed trout in the river, obtained by different fishing methods.

	Fishing method				
	Drift net	Weir	Rod & line	Gill net	Unknown
Lower Teno (n=46)	22%	30%	24%	22%	2%
Teno Nuorgam (n=55)	2%	17%	80%	2%	0%
Teno Utsjoki (n=39)	10%	5%	64%	15%	5%
Upper Teno (n=45)	2%	4%	36%	56%	2%
Karasjoki (n=31)	0%	61%	6%	29%	3%
Inarijoki (n=30)	0%	0%	20%	80%	0%
Tributaries (Utsjoki) (n=47)	0%	0%	57%	40%	2%

4. DISCUSSION

4.1. Consistency of the stable isotope data

The large scatter in invertebrate and juvenile trout samples can be explained by differences in sampling sites and in the taxonomic composition of the invertebrate samples. The δ^{15}N signature is widely held to increase by approximately 3 ‰ for every trophic level (Vander Zander & Rasmussen 2001, McCutchan et al. 2003). The δ^{15}N increase from invertebrates to trout juveniles and many trout scale samples is consistent with this trophic increase. In all locations fish length correlated positively with δ^{15}N similar to Etheridge et al. (2008). This may partly reflect a trophic level increase with size due to the piscivorous feeding strategy of larger trout (Vander Zander & Rasmussen 2001), but also by feeding at sea that also results in elevated δ^{15}N values if marine food has higher δ^{15}N than freshwater food. Trout juveniles hatch and grow up in tributaries and therefore represent freshwater signature. As trout grow larger, freshwater residency or sea migration is possible. Trout are accessing better feeding grounds entering the marine environment (with the diet having higher $\delta^{13}C$ values) and thus are expected to grow faster and larger than local trout, hence resulting in a positive correlation of fish length and $\delta^{13}C$ in anadromous trout populations. On the other hand for local trout the $\delta^{13}C$ values are much more constant as trophic enrichment is minor for $\delta^{13}C$ (Hobson 1999), although migration within the river system might still affect the $\delta^{13}C$ signature by accessing different diets.

Of all freshwater reference samples the juvenile samples of Yläseitikkojoki and Luossajoki were most elevated in their $\delta^{13}C$ values. Nevertheless the distance to the sea is more than 115 km and 90 km, respectively and the mean size at smoltification in the Teno system is around 22 cm (Jensen et al. 1990). Thus, the probability that those analysed juveniles (length 14 to 21 cm) had been feeding in the sea and returned must be considered negligible. The stable isotope values of those juveniles are similar to $\delta^{13}C$ values of -25 for grayling and -26 ‰ for brown trout muscle tissue in Lake Pulmanki reported by Mitchell (2007), if a $\delta^{13}C$ shift of 3 ‰ is assumed. In contrast to all other trout samples, for Akujoki the whole juveniles were preceded for SIA instead of scales. To compare them with the scale samples the $\delta^{13}C$ values were elevated by 3 ‰ to consider the stable isotope shift between different tissues. Analysing 5 Pacific salmon species Satterfield & Finney (2002) found for non-lipid-normalized samples scale to muscle $\delta^{13}C$ differences of +2.97 ‰ ± 0.60 SE. On the other hand $\delta^{15}N$ did not fractionate significant between scale and muscle tissue (mean 0.22 ‰ ± 0.50 SE) for those salmon. Also for striped bass an elevation of about 3 ‰ $\delta^{13}C$ was found in scales instead of muscle tissue (Pruell et al. 2003). Syväranta et al. (2008) found elevated $\delta^{13}C$ (mean 2.77 ‰ ± 0.18 SE) and lower $\delta^{15}N$ (mean -0.81 ‰ ± 0.12 SE) values in acid treaded roach scales. Although no study analysed the shift in brown trout, one can assume that the $\delta^{13}C$ shift is in the range of 3 ‰ too. This uncertainty is assumed to be minor in contrast to the much larger difference to the sea reference.

Although only a small number of 23 trout caught in the Tanafjord during two summers were used as sea reference, they were well separated by all freshwater references by elevetated $\delta^{13}C$ and $\delta^{15}N$ values and were satisfying as reference material for this study. Fur further research, also prey sea fish of sea trout might be included for the sea reference.

4.2. Separation into local and sea trout

Separation into the two clusters of local and sea trout was done statistically by cluster analyses, assuming the sea trout caught in the Tanafjord as marine reference and the most depleted trout scales in the range of the juvenile trout as local trout. The test separated the trout into local and sea trout based on their $\delta^{13}C$ and $\delta^{15}N$ values. The separation border of –21 ‰ $\delta^{13}C$ between the two groups might therefore vary to some extend, using different data sets, but might stay in a narrow range. Although the sea trout according to SIA were clearly higher in both $\delta^{13}C$ and $\delta^{15}N$ values than local fish, the $\delta^{13}C$ values seem to be much better for separation as $\delta^{15}N$ values also increase in local trout by piscivorous feeding. Thus, it would be rather difficult to distinguish between local and sea trout only according to the $\delta^{15}N$ values. McCarthy & Waldron (2000) also reported overlapping $\delta^{15}N$ values between local and sea trout.

As the $\delta^{13}C$ values might vary between different geographical locations (Fry 2006) also the final separation border between local and sea trout vary between different river systems and obviously also depends on the analysed tissue. Acolas et al. (2007) reported $\delta^{13}C$ values as low as -21 ‰ in sea trout adipose fin, whereas McCarthy & Waldron (2000) reported $\delta^{13}C$ values in adipose fin of freshwater resident brown trout up to -19.5 ‰. But McCarthy & Waldron (2000) labelled freshwater resident and sea trout first by morphological characteristics and did SIA afterwards. The stable isotope shift between adipose fin and scales is not known in brown trout.

Although the correct boundary setting might be arguable, in the Teno River system for most sections the separation between the local and sea trout clusters was rather obvious (Figures 4 & 5). Only in the two lowest Teno sections was no clear cluster separation apparent and in the upper Teno and Inarijoki four and two fish respectively show critical values and separation into a cluster required statistics.

On the other hand, life histories of brown trout can be very diverse and the assumption of only two groups might be too simplified as differences in the migration pattern of sea trout might occur and feeding in lakes of local trout might result in elevated δ^{13}C values. Grey (2001) reported in muscle tissue of brown trout of the littoral zone and the open water area δ^{13}C values from -27.9 up to –21.2 ‰. Assuming a ^{13}C isotope shift of approximately 3 ‰ towards scales (Satterfield & Finney 2002) a significant proportion of those trout would be labelled in this study as sea trout. Unfortunately no reference samples from lakes within the Teno system were available for this study. Within the study area, lakes mainly occur in the tributary Utsjoki, whereas certain tributaries have lakes in their headwaters where no samples were analysed. But the tributary Inarijoki contains several big, lake like pools and also River Teno contains sections with low current. Additional reference material from invertebrates and prey fish in those section could answer the question how fare those areas vary in their stable isotope values from normal river sections. But one can assume that this problem of elevated isotope values might be most relevant for the samples from Utsjoki tributary in this study.

4.2.1 Intermediate δ^{13}C signatures

Beside trout that might have been mislabelled as sea trout according to their δ^{13}C values, although their were local trout, a small number of 22 fish were labelled as local trout although they would also fit very well in the sea trout group according to the frequency distribution. Between the two most extreme stable isotope values of clear local and sea trout, different explanations are possible for the intermediate δ^{13}C and δ^{15}N values:

(1) Short sojourn in marine environment and stable isotope signature consists of a mixture of marine and freshwater origin, e.g. 0+ sea winter trout.

(2) Short sojourn in marine environment during the summer combined with feeding on terrestrial insects during that time.

(3) Feeding in the estuary, with diet isotope values intermediate between freshwater and marine.

(4) Last time feeding at sea the previous year and residency in freshwater the following year.

(5) Different diet source, such as lakes, with elevated δ^{13}C values.

A total of 11 fish with intermediate δ^{13}C values of –22 to –21 ‰ we caught in Teno Nuorgam and lower Teno section, where trout have access to the sea by a relative short and easy migration (no severe rapids or waterfalls) This might support repeated migration between freshwater and marine environments (1) as reported by Etheridge et al. (2008). Many fish with intermediate values are smaller than 35 cm and their scale reading interpretation supports explanation (1) or (2) as only one of those small trout was labelled with 1 year at the sea, but the remaining fish were labelled with only freshwater growth. The main growth in freshwater in combination with a short sea sojourn might therefore result in intermediate stable isotope values. Rikardson et al. (2006) reported sea trout feeding extensively on terrestrial insects during the summer time in northern Norway and this feeding pattern might also appear in the River Teno sea trout population and might be considered as explanation (2). Hypothesis (3) cannot be rebutted or verified with these data as no SIA was done on possible trout diet in the estuary. Eero Niemela (personal note, 2008) posted that within the estuary area sea trout are eating mainly *Ammodytes* species or sometime descending salmon smolts. *Ammodytes* is totally a salt waters species, nevertheless they might show intermediate δ^{13}C and δ^{15}N values depending on their diet. The 6 analysed trout caught in the estuary scattered over a wide range and those fish also might be only passing the estuary towards the sea or they are caught during their up migration. The 7 trout in this group from Utsjoki tributary separate well from the sea trout cluster (Figure 5) and are much closer to the local trout cluster. Utsjoki tributary consists of many lake systems that are possible feeding grounds for trout. Different feeding strategies (littoral, pelagic) within a lake might result in different δ^{13}C signatures that might explain those high δ^{13}C values for local trout (5) as Grey (2001) also reported surprisingly high δ^{13}C values in lake dwelling trout. Sea trout smoltify in the Teno at average lengths of 22 cm (Niemelä & McComas 1985, Jensen et al. 1990). For larger trout with intermediate δ^{13}C values hypothesis (1) is therefore unlikely but hypothesis (5) is more likely. No publications supporting hypothesis (4) have been found and no information is available about overwintering of the trout. Further the δ^{13}C and δ^{15}N values and the date of catch seem not to correlate. Even if sea trout might overwinter in freshwater and are caught while descending the river their scales should be still representing the sea signature as the architecture of fish scales suggests, that it represents an average of the diet during the life time (Hutchinson & Trueman 2006). Berg & Jonsson (1990) documented decreasing condition factors for sea trout overwintering in freshwater. Obviously although low temperatures and thus low metabolism the trout are not able to fulfil their nutrient requirements. One can therefore assume that the marine signature will not dilute dramatically in that time period.

4.3. Sea trout proportion in different locations

According to the stable isotope analysis, in Utsjoki tributary only a minor proportion of the trout stock is anadromous, but most trout are freshwater resident fish. On the other hand in River Teno, Inarijoki and Karasjoki anadromy is the major life history pattern of brown trout. The dual isotope plots of δ^{13}C and δ^{15}N (Figures 4 & 5) in the Teno River system reveals three completely different patterns.

In contrast to all other section, in the lower two River Teno sections a continuum of increasing δ^{13}C and δ^{15}N values over a wide range and no clustering appears. Although only a very minor proportion of trout are labelled as local trout, a significant proportion of fish show stable isotope values clearly lower than the sea trout in upriver sections. This might be partly explained by the large number of fish in the length classes of 30 to 39 cm, but also supports the idea of a different life history strategy. Etheridge et al. (2008) reported similar stable isotope results, concluding continuous migration between freshwater and marine environments or feeding in the estuary. Already relatively small trout between 20 and 30 cm caught in those lower Teno sections show a clear sea signature might support continuing variation between the environments. The first rapid at Alaköngäs in the Nuorgam section might act as a border for this continuing migration pattern as below this rapid distances to the sea are short and no serious migration obstacle occurs and in the upper Teno sections a clear separation between local and sea trout appears. In the lowest river section only 5 local trout (10 %) were detected, but it also stays unclear witch proportion of sea trout where actually on their up migration. But as the fish were not caught in the main migration season in the end of August and September (Niemelä & McComas 1985) one can assume that this proportion is reasonable.

In all the upriver sections a clear separation between the local and sea trout is shown in the dual isotope plots. In the Utsjoki Teno, upper Teno section, Inarijoki and Karasjoki the sea trout from the major proportion, that supports the idea of earlier theories that trout caught in the main steam are mainly migrating sea trout (Erkinaro & Niemelä 1995). But in all those sections also a few local trout over 50 cm are caught that might feed or even spawn in the main steam. Unfortunately, only very few trout samples smaller than 40 cm were available from some sections (Utsjoki Teno, Inarijoki and Karasjoki). The stable isotope results from upper Teno for example indicate that large proportions of trout in the length classes below 40 cm might in fact be local fish. This lays contrast with Jensen et al. (1990) that reported a length distribution of anadromous brown trout caught in river Teno in the period of 1985 to 1987 that peaked around 30 cm. However it stays unclear if those trout have been actually feeding in the sea or also include a unidentified number of local trout. In comparison of the lower and upper river sections one could assume that sea trout increase in mean size, with increasing distance to the sea as reported by Jonsson et al. (2006). At least for trout larger than 40 cm the proportion of sea trout in those sections is varying in the narrow range of 70 to 85 % and can be assumed to be constant. Despite the fact of poor length distribution, the constant proportion of sea trout in all section (excluding Utsjoki) upwards of Alaköngäs would support the idea that trout use the main river and tributaries mainly as migration route to access their breeding areas in the upper tributaries as suggested by Erkinaro & Niemelä (1995). Otherwise one would expect decreasing sea trout proportions with increasing distance from the sea as reported in many other rivers (Kristoffersen et al. 1994, Wood 1995, Bohlin et al. 2001, Jonsson & Jonsson 2006). But without having a representative sample amount of all length classes in each section this can not be evaluated terminally.

The Utsjoki tributary is unique in its trout grouping and has to be analysed individually. The length distribution is well balanced in the range of 30 to 55 cm and clearly local trout are predominant in that tributary. In contrast to all other locations, the River Utsjoki is haltered by numerous big lakes that offer various feeding opportunities for trout. Depending on the diet and feeding strategy, feeding in the pelagic or littoral zone of the lake might alter the $\delta^{13}C$ signatures in trout (Eloranta 2007). Grey (2001) reported even $\delta^{13}C$ values that might be higher than the separation border for sea trout in this study. Nevertheless, this would even increase the proportion of local trout in Utsjoki. The low proportion of sea trout in Utsjoki is remarkably especially in direct comparison with Karasjoki or Inarijoki that need a much longer migration distance to the sea. Obviously, the anadromy is the less favourable life history strategy if lakes offer possible feeding grounds and reduce the costs for migration and the risk of predation.

4.4. Other aspects

4.4.1. Correlation of fast growth rate and sea migration

All sea trout performed well with a fast growth rate identified by scale reading (only 6 exceptions). Also a major proportion of the local trout show fast growth rates, but the local trout also includes a numerous individuals with slow growth rate. This data suggest that scale reading might be an appropriate tool to identify the slow growing local trout, but is not possible to distinguish between fast growing local trout and sea trout. Obviously trout perform well also within freshwater in the Teno system resulting and good feeding grounds must be available. Probably the growth rate increases as soon trout turn to piscivorous and can access better diet, but it stays unclear what larger freshwater resident trout feed predominantly.

4.4.2. Sex ratio

The sex ratio was very low with a female/male ratio of 1.6 for all identified sea trout (according to SIA) and 2 for all the collected scale samples from the years of 1990 to 2007. However, it was 2.9 in the time period 1980 to 1989. In contrast Niemelä & McComas (1985) reported a female/male ratio of 4. It stays unclear if the low female proportion in this study is based on changes in the anadromous trout population in the previous decade or is only by chance. If further studies also report low sex ratios in the same range, further investigation to find the reason for this would be needed. The sex ratio for the local trout (according to SIA) in this study was low with 1.3 and as local trout mature much earlier than sea trout it might be even lower for the total spawning population as this study mainly includes large trout (Dellefors & Faremo 1988). Nevertheless the sex ratio favours female for sea trout supporting the suggestion by Jonsson & Gravem (1985) that the female ratio will be higher in high-food but high risk habitats such as the marine environment.

4.4.3. Weekly trout catch frequencies

This study supports the findings by Niemelä & McComas (1985) of a bimodal catch of sea trout, whereas in the middle of the fishing season the proportion of local trout was increasing. Nevertheless for this study only trout sampled during the fishing season were available, whereas Niemelä & McComas (1985) reported the most important migration timing for sea trout from the end of August until the beginning of October. They reported that the late run consisted mainly of 0+ (62 %) and 1 (32 %) sea age cohorts, similar to this study where most of the 0+ sea age fish were caught in the very end of the fishing season (Figure 10). But this study also contains mainly fish in the length category of 40 to 55 cm that might also explain the large proportion of 1 and 2 sea age trout in the analysed samples.

4.4.3. Reliability of the data

Although weir and drift net statistically favour sea trout, the sample gathered by those methods should not affect the final results and conclusions of this study as those techniques were mainly used in the lowest Teno section and in Karasjoki. Whereas in the lowest section the proportion of sea trout anyway can be assumed to be highest due to the short migration distance to the sea, in Karasjoki mainly fish over 40 were caught and the $\delta^{13}C$ values also depends on the size (Figure 6). All in all the majority of fish were caught by rod & line and gill net that can be assumed to be nonselective.

The trout scales were gathered during the fishing season by local fishermen and might therefore represent the catch of trout in the Teno system. Sampling intensity might vary during the season and might favour large fish or those with special features resulting in a distorted picture of the trout stock. Further, the accuracy of length or weight of the samples might be doubtful in some cases as length and weight do no not correlate for some fish, or scale bags might have been mixed up before they were labelled. Nevertheless, the opportunities offered by the extensive scale archive clearly outweigh these uncertainties.

4.5. Future prospects

Although this study in combination with those of Niemelä & McComas (1985) and Jensen et al. (1990) brings some light into the issue of the unexplored brown trout population of the River Teno system, many questions are still open to answer, and research on the Teno trout is still far behind the research of the economically much more important salmon. By analysing trout scales from Jiesjoki tributary, where large lakes are accessible by trout, the hypothesis that a large proportion of trout stock are freshwater resident, if lakes offer good feeding grounds, could be tested. Further, in the future additional reference data might increase the reliability, especially by including more juvenile samples and samples from the lakes within the system. Also salmon parr could be used as freshwater reference material, as they are easier to collect than trout juveniles and they should represent similar stable isotope values. Considering possibly intersecting of $\delta^{13}C$ values of sea trout and lake dwelling trout additional isotopes could be included.

At this point, most researchers suggest that the reproduction of the Teno trout population is mainly restricted to the small and upper tributaries of the system as in the main steam and the larger tributaries Atlantic salmon is the predominant fish species. Salmon, and especially salmon parr, seem to be the more competitive at utilising those habitats and salmon parr are using extensively small tributaries (where no salmon are spawning) as nursery areas (Erkinaro 1995). It is still unclear which tributaries are the main contributor to the anadromous and local trout that are caught in the main steam and tributaries and/or how far trout also use the main steam and tributaries as spawning and nursery areas.. The question rises why trout are able to compete in those small streams against salmon. In quantitative electro fishing for salmon parr densities in River Teno and tributaries trout juveniles are in general not found in the main steam but only in small tributaries (Erkinaro & Niemelä 1995). To find breeding areas, radio telemetry of ascending sea trout could be one technique that would also answer questions about migration speed and distance in the River Teno.

Another important aspect that might explain differences in migration pattern and the stable isotope signature might be the genetic variability between different trout populations within the Teno River system. As trout juveniles in the Teno system are mainly restricted to the small and upper parts of the tributaries, the population might not be interbreeding and gene flow might be restricted.

The contribution of anadromous trout to the total recruitment remains unclear. SIA on lately hatched, individual trout fry would reveal the maternal origin of the emerging fry and thus the contribution of anadromous female trout in the total spawning stock (assuming similar survival and hatching rate of the eggs in the gravel) (McCarthy & Waldron 2000, Charles et al. 2004). Different migration patterns might influence the reproductive strategies, so that at similar fork length sea trout seem to invest more energy in higher fecundity, whereas resident brown trout invest more energy in bigger eggs (Elliott 1994, Acolas et al. 2007). That approach could not reveal the contribution of freshwater resident males in fertilization and differences in the surviving rate of trout parr. Nevertheless on important problem in this approach is the uncertainty about breeding and nursery areas of trout contribution to the sea trout stock.

The large FGFRI scale archive would offer opportunities to identify changes in life-histories or migration pattern back in time. Fishermen have reported reduced catches in the sea trout in the Tanafjord in the past years. SIA could answer the question if the proportion of sea trout has changed over the last decades. The archived scales already suggest a decreasing sex ratio female/male in the last two decades.

Additional, similar stable isotope analysis on trout in the neighbouring Näätämö River system could be done. The Näätämö River (on the Norwegian site River Neiden) also contains several lake-like and large lakes in the headwaters that offer feeding grounds for local trout although migration to the sea is possible. Based on the findings from Utsjoki tributary, one would expect a higher number of local trout than in the main steam of River Teno. Although the River Näätämö is smaller than the Teno system, a comparison of the migration pattern of two northern latitude rivers could support the findings of this study.

4.6. Wider context of this study

This study is one of the first ones that used brown trout scales for SIA on a large scale to identify life histories and migration pattern in a large river system. In contrast to other studies where scale reading or morphological characteristics were used, SIA distinguishes between local and sea trout with a high certainty. In the past, most brown trout studies were limited to rather small river systems or rivers were migration was limited by obstacles. In Europe and in the native distribution area of the brown trout most of all large river systems are to some extend dammed for hydro power or otherwise modified. Hence, the River Teno as a large and versatile free flowing river might offer some insights into the migration dynamics of the brown trout.

5. CONCLUSIONS

For this Master's thesis a large number of archived scale samples from different river sections and tributaries in the Teno River system were analysed for stable isotope to distinguish successfully between freshwater resident and anadromous trout:

- In the lower Teno section the proportion of sea trout was up to 90 % with stable isotope values indicating continuous migration between freshwater and the sea or feeding in the estuary.
- In the middle and upper Teno sections and in the tributaries Inarijoki and Karasjoki the proportion of sea trout was high, in the range of 70 to 80 % for trout larger than 40 cm.
- In contrast in tributary Utsjoki only a minor proportion of 15 % were sea trout, but the majority were local trout, probably feeding in the numerous lakes within the Utsjoki tributary.
- In the Teno River system and probably also in other large river systems, the proportion of sea trout is not only depending on the migration distance to the sea, but also on the availability of lakes as possible feeding grounds.

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APPENDIX I

AI Table 1. Trout with intermediate stable isotope values ($\delta^{13}C < -21‰$) labelled as local trout according to SIA.

Identifier	River section	$\delta^{13}C$	$\delta^{15}N$	Date of catch	length	weight	weight gutted	Fishing method	Maturity level	Sex	scale reading			
		[‰]	[‰]		[cm]	[g]	[g]	1 drift net 2 weir 3 rod&line 4 gill net	0 to 1	0: not determined 1: male 2: female	freshwater growth	freshwater + growth	sea growth	sea + growth
N 771	Teno Nuorgam	-21.9	7.38	11.06.2006	26	130		3	0.25	2	6	0	0	0
N 557	Teno Nuorgam	-21.8	8.67	15.08.2005	39		400	3	0.25	2	5	0	0	1
T 252	Utsjoki	-21.8	8.96	12.06.2003	30	200		3		1	7	0	1	0
T 749	Utsjoki	-21.7	8.05	18.07.2006	33	310	280	3	0.25	1	8	1	0	0
N 774	Teno Nuorgam	-21.5	7.07	22.05.2006	31	250		3	0.25	2	7	0	0	0
T 751	Utsjoki	-21.5	8.12	18.07.2006	34	310	280	3	0.25	2	7	1	0	0
LT 322	Lower Teno	-21.4	8.74	11.07.2007	37			3		1	8	0	0	1
N 602	Teno Nuorgam	-21.4	10.22	08.06.2005	44	800		3	0.5	2	6	0	1	0
N 631	Teno Nuorgam	-21.4	9.95	28.08.2005	29	200		3	0.25	2	6	0	0	1
T 751	Utsjoki	-21.4	8.15	18.07.2006	34	310	280	3	0.25	2	7	1	0	0
N 771	Teno Nuorgam	-21.3	6.92	11.06.2006	26	130		3	0.25	2	6	0	0	0
N 787	Teno Nuorgam	-21.3	8.97	04.08.2006	30	250		3	0.25	1	5	0	0	1
O 706	Upper Teno	-21.3	10.39	03.07.2006	58	1800	1400	3	0.25	2	8	0	4	0
NOR 202	Karasjoki	-21.2	7.69	2005	42			4		2	5	0	2	1
T 755	Utsjoki	-21.2	8.30	20.07.2006	41	570	480	3	0.75	2	9	1	0	0
T 899	Utsjoki	-21.2	9.69	20.07.2007	42		530	3	0.5	2	7	1	0	0
N 544	Teno Nuorgam	-21.1	9.01	07.08.2005	59	1700		3	0.5	2	3	0	2	1
N 649	Teno Nuorgam	-21.1	8.20	18.08.2005	32		250	3		0	7	0	0	1
N 774	Teno Nuorgam	-21.1	6.83	22.05.2006	31	250		3	0.25	2	7	0	0	0
NOR 244	Karasjoki	-21.1	8.06	28.06.2005	68	3700		4		1	11	1	0	0
I 571	Inarijoki	-21.0	10.60	08.06.2005	42	600		4	0.75	1	6	0	2	0
T 684	Utsjoki	-21.0	8.69	20.06.2005	44	930	790	3	0.25	1	8	0	0	0

AI Table 2. Raw data of all reference samples.

Identifier		$\delta^{13}C$ [‰]	$\delta^{15}N$ [‰]	Date of catch	Length [cm]	Weight [g]	Fishing method	Maturity level	Sex	Spawned	Freshwater growth [years]	Freshwater "+" growth	Sea growth [years]	Sea "+" growth
S 053	Sea reference - trout caught in Tanafjord	-16.49	11.64	08.07.2004	63	2500	1		♂	X	5	0	3	1
S 119		-18.99	10.91	09.07.2003	47		Krokgarn		♀		6	0	1	1
S 120		-16.03	11.68	09.07.2003	47		Kilenot		♀		7	0	2	1
S 121		-17.41	10.46	30.07.2003	48		Kilenot				6	0	2	1
S 122		-17.69	10.89	29.07.2003	51		Kilenot							
S 123		-17.86	11.04	25.07.2003	52		Kilenot							
S 124		-17.86	10.88	24.07.2003	49		Kilenot		♀		6	1	2	1
S 125		-19.92	10.14	24.07.2003	47		Kilenot				4	0	2	1

S 126		-18.35	10.27	24.07.2003	49		Kilenot	♀	6	1	2	1
S 127		-17.48	10.66	24.07.2003	49		Kilenot	♀	5	0	2	1
S 128		-17.07	11.20	24.07.2003	52		Kilenot	♀	6	0	2	1
S 129		-16.72	11.20	23.07.2003	53		Kilenot	♀	6	0	2	1
S 130		-17.78	11.11	23.07.2003	54		Kilenot	♀	6	0	3	1
S 131		-17.71	10.71	23.07.2003	44		Kilenot	♀	7	0	1	1
S 132		-17.84	10.52	23.07.2003	49		Kilenot		6	0	2	1
S 133		-16.54	11.58	23.07.2003	49		Kilenot		6	0	2	1
S 134		-16.82	11.61	23.07.2003	68		Kilenot		5	0	4	1
S 135		-18.24	10.22	23.07.2003	48		Kilenot	♀	5	0	2	1
S 136		-17.85	10.12	23.07.2003	51		Kilenot	♀	7	1	2	1
S 137		-17.06	11.31	23.07.2003	52		Kilenot		6	0	2	1
S 138		-19.37	9.40	23.07.2003	54		Kilenot		7	1	2	1
S 139		-18.29	11.49	22.07.2003	52		Kilenot	♀	6	0	3	1
S 140		-16.82	11.78	22.07.2003	50		Kilenot		5	0	3	1
X A4	Trout juveniles	-31.42	6.80	19.08.2008	6	trout	whole juvenile					
X A5		-29.43	6.48	19.08.2008	7	trout	whole juvenile					
X A6		-28.36	8.73	19.08.2008	4	trout	whole juvenile					
XA 1		-27.64	6.98	19.08.2008	13	trout	whole juvenile					
XA 2		-27.06	7.28	19.08.2008	9	trout	whole juvenile					
XA 3		-27.27	6.78	19.08.2008	10	trout	whole juvenile					
XA 7		-29.08	8.11	19.08.2008	4	trout	whole juvenile					
XB 1		-29.65	6.89	19.08.2008	8	trout	whole juvenile					
XB 2		-29.25	7.06	19.08.2008	9	char	whole juvenile					
XB 3		-29.50	7.44	19.08.2008	11	trout	whole juvenile					
XB 4		-28.72	6.52	19.08.2008	4	trout	whole juvenile					
XTT1		-22.84	7.01	2004		Scales of 6 trout juveniles between 10 and 21cm						
XTT2		-23.80	7.72	2004		Scales of 6 trout juveniles between 10 and 21cm						
XTT3		-28.36	6.85	2004		Scales of 6 trout juveniles between 10 and 21cm						
XX 01	Invertebrates	-28.47	3.89	25.08.2008		Luftijoki						
XX 01		-29.63	3.94	25.08.2008		Teno Tana bru						
XX 03		-29.02	5.17	25.08.2008		Teno Alaköngäs						
XX 04		-27.26	2.25	25.08.2008		Laksjohka						
XX 05		-32.02	3.44	27.08.2008		Utsjoki						
XX 06		-31.50	4.05	27.08.2008		Teno Utsjoki						
XX 07		-26.84	2.96	27.08.2008		Kuoppilasjoki						
XX 08		-27.72	2.88	27.08.2008		Badda						
XX 09		-28.90	4.08	27.08.2008		Nuvvosjohka						
XX 10		-26.62	2.81	27.08.2008		Nilijoki						
XX 11		-29.44	3.45	27.08.2008		Kaivojoki						
XX 12		-29.54	2.16	27.08.2008								
XX 13		-31.39	2.62	27.08.2008		Palggakjoki						
XX 14		-30.68	4.04	27.08.2008		Inarijoki						
XX 15		-27.98	3.61	27.08.2008		Karasjoki						
XX 16		-31.20	4.76	27.08.2008		Teno Akukoski						
XX 17		-29.79	2.52	19.08.2008		Akujoki						

AI Table 3. Raw data of all scale samples.

Identifier	Location	$\delta^{13}C$ [‰]	$\delta^{15}N$ [‰]	Date of catch	Length [cm]	Weight [g]	Weight gutted [g]	Fishing method	Maturity level	Sex	Spawned	Freshwater growth [years]	Freshwater "+" growth	Sea growth [years]	Sea "+" growth
E 002	Esturary	-21.38	7.54	16.08.1986	31		250	3		♂		6	0	0	1
E 005		-21.13	9.79	16.08.1986	33		290	3		♀		6	0	0	1
E 010		-24.67	8.02	18.08.1986	28		150	3		♀		6	1	0	0
E 011		-19.57	8.21	18.08.1986	27		120	3		♀		7	1	0	0
E 016		-22.58	9.78	17.08.1986	29		230	3		♀		6	0	0	1
E 017		-21.83	9.66	17.08.1986	31		260	3		♀		5	0	0	1
I 564	Inarijoki	-17.70	11.19	31.05.2005	60	2400		4	0.75	♀	X	6	0	1S1	0
I 565		-25.79	8.47	01.07.2005	48	1000		3	0.75	♂		7	1	0	0
I 566		-18.63	11.46	02.08.2005	53	1500		3				5	0	3	0
I 567		-19.61	11.65	31.05.2005	52	1200		4	0.5	♂	X	5	0	2S	0
I 568		-18.39	11.35	02.06.2005	46	1600		4		♀		6	0	4	0
I 569		-18.26	11.70	07.06.2005	47		850	4	0.75	♀	X	5	0	2S1	0
I 570		-19.57	11.43	08.06.2005	44	720		4	0.75	♂		5	0	2	0
I 571		-20.98	10.60	08.06.2005	42	600		4	0.75	♂		6	0	2	0
I 572		-17.82	11.71	24.06.2005	42	1000		3	0.5	♀	X	5	0	S1	0
I 573		-17.35	12.19	21.06.2005	64	2400		4	0.75	♂		6	1	4	0
I 574		-19.54	10.67	29.06.2005	47	1100		4		♀		6	0	2	1
I 575		-28.21	8.27	2005		600		3		♀		9	1	0	0
I 576		-26.67	7.47	07.06.2005	35	500		4	0.75	♀		6	0	0	0
I 577		-27.72	7.31	31.05.2005	39	500		4		♂		8	0	0	0
I 695		-20.70	9.77	04.07.2006	51	1300	1130	4	0.25	♀		5	0	3	1
I 696		-26.54	8.53	22.07.2006	40	800		3		♂		8	1	0	0
I 697		-18.74	11.30	08.06.2006	47	700		4	0.5	♀		7	0	2	1
I 698		-17.76	10.81	13.06.2006	47	1200		4	0.5	♂		6	0	2	0
I 699		-23.53	9.74	08.06.2006	38	500		4	0.5	♂		10	0	0	0
I 700		-19.56	11.62	19.07.2006	72	3800	3100	4	1	♀	X	7	0	2S1S	1
I 701		-17.44	11.68	27.06.2006	58	2300	2000	4	0.5	♀	X	4	0	3S	1
I 702		-17.52	11.29	13.06.2006	46		1120	4		♀		5	0	2	0
I 703		-18.01	11.25	21.06.2006	48	940	720	4	0.25	♀		5	0	2	1
I 704		-17.07	11.35	20.06.2006	53	2100		4	0.75	♀	X	4	0	1SS1	0
I 763		-22.74	9.97	28.06.2006	53	1700	1450	4	0.75	♀		6	0	3	0
I 764		-26.60	8.27	27.06.2006	53	1550	1350	4	0.5	♂	X	4	0	2S1	0
I 932		-18.96	11.12	11.07.2007	48	1000	900	4	0.5	♂		7	0	2	0
I 935		-17.95	11.44	05.07.2007	63	1600	1400	4	0.25	♂	X	7	0	S1	0
I 937		-17.63	12.11	11.07.2007	46	950	800	3		♂		6	1	2	1
I 942		-17.22	11.69	28.08.2007	45	920	760	4	0.75	♀		6	1	1	1
K 057	Teno Utsjoki	-23.51	9.61	21.06.2001	30	400		3	0.25	♀		6	0	1	0
K 266		-24.62	9.98	17.07.2003	28	350		4		♂		7	1	0	0
K 285		-23.47	8.00	30.07.2003	40	350		3	0.5	♀		8	1	0	0
K 551		-18.98	10.13	17.08.2005	42	1200			0.5	♀		8	0	1	1
K 552		-17.55	11.54	18.08.2005	65	2600		3	0.75	♂		5	0	3	1
K 561		-17.96	10.17	09.08.2005	47	1100		3	0.25	♀		5	0	1	1
K 562		-17.76	10.86	14.08.2005	40	800		3	0.25	♂		5	0	1	1
K 711		-23.10	8.99	29.06.2006	43	680	600	3	0.25	♂		8	1	0	0
K 723		-17.71	11.38	28.06.2006	60		3400	2	0.75	♀	X	6	0	1SS1	0
K 724		-18.12	11.30	27.05.2006	58	1700		3	0.25	♂	X	6	0	2S	0
K 737		-16.77	10.97	07.06.2006	51	1900	1600	4	0.25	♀		7	0	2	0
K 740		-17.34	10.71	09.08.2006	41	800		2	0.25	♀		6	0	1	1
K 741		-18.28	11.52	09.08.2006	53	1500		4	0.25	♀	X	5	0	1S1	1
K 742		-18.24	9.99	04.08.2006	39	600		3	0.25	♀		5	0	1	1
K 743		-19.10	10.31	01.08.2006	38	800	650	3	0.25	♀		6	0	1	1
K 760		-17.58	11.54	08.06.2006	55	2000		1	0.25	♀		5	0	4	0
K 777		-17.33	10.92	12.08.2006	48	1300		3	0.25	♀		7	0	1	1

K 778		-18.27	10.28	24.05.2006	36	460		3	0.25	♂		5	1	1	0
K 779		-17.55	10.79	21.05.2006	48	1020		3	0.25	♀		5	0	2	0
K 780		-18.63	10.92	03.06.2006	56		1570	3	0.25	♂		5	0	3	0
K 796		-17.65	10.61	08.06.2006	42		900	3	0.5	♂		6	0	1	1
K 797		-17.73	11.03	03.08.2006	40		900	3	0.5	♂		5	0	1	1
K 798		-17.50	11.03	27.07.2006	57	1800		3	0.5	♀	X	6	0	1S	1
K 799		-17.42	11.99	10.08.2006	48	1500		3	0.25	♀		6	0	2	1
K 802		-17.18	11.04	18.08.2006	47	800		3	0.25	♂		5	0	1	1
K 803		-18.26	10.77	01.08.2006	42	850		3	0.25	♀		6	0	1	1
K 821		-17.57	11.38	23.08.2006	51	1100		3				6	0	2	1
K 837		-24.05	9.40	14.06.2006	50	1100	800	1	0.25	♀		6	0	3	0
K 843		-23.05	10.18	20.05.2007	59	2200		3	0.25	♂		6	0	3	0
K 845		-17.44	11.60	24.05.2007	67	3000		4	0.5	♀		5	0	5	0
K 849		-17.53	10.92	02.06.2007	48	1300		3	0.25	♀	X	4	0	1S1	0
K 850		-19.06	10.94	03.06.2007	46	1100		3	0.25	♀		5	0	2	0
K 853		-24.05	9.43	12.06.2007	46	800		1	0.25	♀		7	0	0	0
K 854		-17.76	12.57	12.06.2007	64	3000		1	0.75	♀	X	5	0	1S2	0
K 858		-17.69	11.10	01.06.2007	48	1400		3	0.25	♀		5	0	2	0
K 859		-17.21	12.09	01.06.2007	45	1060		3	0.25	♂	X	6	0	S1	0
K 910		-23.49	9.75	14.06.2007	42		700	4	0.5	♀		8	0	2	1
K 911		-18.25	10.68	15.06.2007	52		1200	4	0.25	♀	X	11	0	1S1	0
K 947		-18.21	11.40	07.06.2007	44		800		0.5	♀		6	0	2	0
LT 01	Lower Teno	-18.31	11.33	05.06.2000	50	1500		1		♀		8	0	2	0
LT 022		-17.24	10.82	18.07.2001	48	1500		2		♀		5	0	2	1
LT 025		-17.93	11.32	13.06.2001		1000		1		♂		5	0	3	1
LT 031		-20.04	11.01	23.05.2001	33	500		1		♀		6	0	2	0
LT 064		-16.90	11.52	29.06.2004	53	2160		2		♂		7	0	4	0
LT 065		-19.06	10.38	01.07.2004	48	1000		2		♀		7	0	2	0
LT 067		-17.70	11.40	29.07.2004	48	800		2		♂		5	0	2	1
LT 072		-16.82	11.14	11.08.2004	56	2200		2		♀	X	4	0	2	1
LT 074		-17.85	11.74	04.06.2004	45			3		♂		6	0	1	1
LT 075		-19.43	11.18	25.05.2004	34	350		1		♂		5	0	1	0
LT 076		-18.81	9.99	07.06.2004	30	300		1		♂		5	0	1	0
LT 08		-16.53	10.96	15.06.2000	47	1200		1		♀		5	0	2	1
LT 085		-18.38	9.47	29.08.2002	35			4		♂					
LT 110		-16.86	12.17	30.07.2003	43			2		♂		8	0	2	0
LT 114		-23.00	7.78	03.06.2003	44	800		1		♀	X	5	0	1S1	0
LT 15		-18.41	10.73	21.05.2001	36	400		1		♂		5	0	1	
LT 16		-16.92	11.73	24.07.2001	46	1300		2		♂		4	0	3	1
LT 17		-16.89	11.10	01.08.2001	44	800		2		♂		5	0	1	1
LT 18		-17.48	10.94	08.08.2001	52	1700		2		♂		6	0	2	1
LT 187		-20.56	9.82	09.08.2005	30			3		♂		5	0	0	1
LT 203		-17.67	11.60	24.08.2005	73	5600		2		♀	X	5	1	3S2	1
LT 206		-17.35	12.83	25.08.2005	44	1100		2		♂		6	0	1	1
LT 207		-17.89	11.24	24.05.2005	48	1100		2		♀		6	0	2	0
LT 210		-16.86	11.62	31.08.2005	58	2800		4		♂		5	1	2	1
LT 214		-19.87	11.06	14.06.2005	37	600		4		♀		7	0	1	0
LT 215		-18.98	10.75	15.06.2005	33	400		4		♂		6	1	1	0
LT 220		-18.37	11.59	05.07.2005	51	1800		2		♀		8	0	2	0
LT 227		-19.97	9.34	23.08.2005	30			4		♂		4	1	0	0
LT 248		-23.22	11.76	06.07.2005	46	1200		2		♂		5	0	3	1
LT 253		-19.51	9.82	22.05.2006	31	300		1		♂		7	0	1	0
LT 255		-19.66	10.75	23.05.2006	33	300		4		♀		6	0	1	0
LT 263		-18.38	10.45	24.07.2006	35			3		♀		5	0	1	1
LT 289		-18.50	10.25	15.06.2006	38			1		♂		7	0	0	1
LT 318		-23.23	8.73	02.08.2007	25			4		♀		6	0	0	1
LT 322		-21.37	8.74	11.07.2007	37			3		♂		8	0	0	1
LT 353		-19.91	11.09	23.07.2007	25			3		♂		6	0	1	1
LT 356		-18.12	10.60	23.07.2007	25			3		♂		6	0	1	1
LT 360		-18.76	10.02	24.07.2007	35			3		♀		8	0	1	1
LT 365		-16.23	12.22	24.07.2007	80			4		♂	X	6	0	2SS1	1
LT 366		-17.36	11.90	24.07.2007	35			4		♀		8	0	1	1
LT 369		-22.85	12.31	27.07.2007	32			3		♀		6	0	1	1
LT 370		-19.26	11.13	25.07.2007	35			3		♀		4	0	1	1
LT 373		-19.56	10.21	26.07.2007	30			3		♀		6	0	1	1
LT 375		-18.53	11.22	26.07.2007	20			3		♂		6	1	0	0

LT 386		-19.28	10.89	25.07.2007	36					♀		7	0	0	1
LT 400		-19.99	10.19	19.09.2004	38	380		4		♀		5	0	0	1
N 075	Teno Nuorgam	-18.94	11.91	20.05.2001	37	450		3	0	♀		7	0	1	0
N 091		-23.49	7.83	12.06.2001	27	140		3	0	♀		6	0	0	0
N 139		-23.37	8.74	18.06.2002	37	350	300	3	0	♂		5	0	1	0
N 213		-20.37	10.09	16.08.2002	39	500	450	3	0.25	♀		4	0	0	1
N 214		-19.76	10.45	06.08.2002	38	550	500	3	0.25	♀		7	0	0	1
N 266		-24.30	9.27	17.07.2003	28	350		4		♂		7	1	0	0
N 410		-19.03	10.89	20.05.2003	37	400		3	0.25	♀		6	1	1	0
N 425		-20.05	9.56	23.05.2003	38	470		3	0.25	♀		7	0	2	0
N 432		-23.48	9.06	27.05.2003	37	400		3	0.25	♀		7	0	0	0
N 516		-19.86	10.44	06.06.2000	35	400	300	3	0.25	♀		5	0	1	0
N 541		-18.55	11.21	05.06.2005	58	1200		3				6	1	3	0
N 544		-21.09	9.01	07.08.2005	59	1700		3	0.5	♀		3	0	2	1
N 556		-18.20	11.24	07.08.2005	54		1200	3	0.25	♀		6	0	2	1
N 557		-21.82	8.67	15.08.2005	39		400	3	0.25	♀		5	0	0	1
N 600		-18.06	11.29	05.06.2005	48	1000		3	0.25	♀		5	1	2	0
N 602		-21.44	10.22	08.06.2005	44	800		3	0.5	♀		6	0	1	0
N 603		-20.63	9.84	09.06.2005	56		1460	3	0.25	♂	X	7	0	2S1	0
N 604		-17.99	11.14	09.06.2005	59		1600	3	0.25	♂		9	0	0	0
N 605		-22.76	10.07	10.06.2005	53	1700		3	0.25	♂	X	7	0	1S1	0
N 630		-20.71	9.97	15.08.2005	30	350		3		♂		5	0	0	1
N 631		-21.37	9.95	28.08.2005	29	200		3	0.25	♀		6	0	0	1
N 632		-19.99	10.23	28.08.2005	33	400		3	0.25	♂		6	0	0	1
N 636		-28.50	6.78	20.08.2005	26			3				6	0	0	1
N 638		-19.88	10.08	30.07.2005	30	300		3	0.25	♂		7	0	0	1
N 639		-18.24	11.19	30.07.2005	36	500		3	0.25	♀		4	0	1	1
N 641		-20.46	9.52	23.08.2005	31			3				4	0	0	1
N 647		-17.12	10.69	18.08.2005	58	2200		2	0.25	♂		5	0	2	1
N 649		-21.12	8.20	18.08.2005	32		250	3				7	0	0	1
N 650		-17.59	11.00	23.08.2005	48	1400		2				4	0	2	1
N 652		-19.36	9.65	24.08.2005	36	600		2	0.25	♀		7	0	0	1
N 658		-20.70	9.68	31.08.2005	34	400		3	0.25	♀		7	0	0	1
N 735		-19.40	10.91	20.05.2006	48	850		3	0.25	♂		6	0	3	0
N 736		-17.22	11.16	20.05.2006	48	950		3	0.25	♀		6	0	2	0
N 745		-17.45	11.08	26.05.2006	47	1100		3	0.25	♀	X	6	0	S1	0
N 756		-16.99	11.41	03.08.2006	49			2	0.75	♀		4	1	2	1
N 758		-19.14	9.81	31.07.2006	60		1400	2	0.25	♀		6	0	2	1
N 759		-19.40	10.34	03.08.2006	48		1250	2	0.25	♀		6	0	1	1
N 771		-21.88	7.38	11.06.2006	26	130		3	0.25	♀		6	0	0	0
N 771		-21.26	6.92	11.06.2006	26	130		3	0.25	♀		6	0	0	0
N 773		-17.50	10.82	25.05.2006	50	1240		3	0.25	♀		5	0	2	0
N 774		-21.54	7.07	22.05.2006	31	250		3	0.25	♀		7	0	0	0
N 774		-21.07	6.83	22.05.2006	31	250		3	0.25	♀		7	0	0	0
N 775		-17.35	10.82	21.05.2006	51	1450		3	0.25	♂		6	0	2	0
N 776		-19.50	10.78	20.05.2006	37	430		3	0.25	♀		6	0	1	0
N 776		-18.86	10.75	20.05.2006	37	430		3	0.25	♀		6	0	1	0
N 787		-21.26	8.97	04.08.2006	30	250		3	0.25	♂		5	0	0	1
N 787		-20.68	9.97	04.08.2006	30	250		3	0.25	♂		5	0	0	1
N 788		-18.28	11.05	04.08.2006	51	1400		3	0.25	♂		8	0	2	1
N 794		-19.03	9.98	30.08.2006	49	1550		2	0.25	♀	X	6	0	1S	1
N 795		-16.67	11.38	22.08.2006	66	4100	3450	2	0.25	♀	X	5	0	1S2	1
N 842		-17.46	11.45	12.06.2006	61	1900		3	0.75	♀	X	6	0	2S1	0
N 860		-16.64	12.03	29.05.2007	70		2700	1			X	5	0	1SS1	0
N 881		-17.96	11.37	01.06.2007	44		650	3	0.25	♂		5	1	2	0
N 900		-17.46	11.46	18.07.2007	54		1650	2	0.5	♀		6	0	3	1
NOR 006	Karasjoki	-23.12	9.01		41	1100		2		♂		6	0	2	1
NOR 011		-23.16	8.47	31.07.2001	43	1100		2				7	1		
NOR 013		-16.42	11.64	16.08.2001	52	2000		2		♂		6	0	2	1
NOR 020		-17.17	11.79	06.06.2001	65	3000		2		♀		6	0	4	0
NOR 023		-18.10	12.27	06.06.2001	55	2000		2		♀		6	0	4	0
NOR 032		-17.11	11.97	03.06.2003	54	1500		4		♂		6	0	1	1
NOR 033		-17.06	11.24	05.06.2003	53	1500		4		♀		5	0	1	1
NOR 034		-17.58	11.43	11.06.2003	55	1900		2		♀		5	0	2	1
NOR 059		-24.14	8.43	27.07.2004	50	1800		2		♀		5	0	3	1
NOR 060		-22.77	8.27	01.07.2004	46	1100		2		♀		6	1		

NOR 061		-23.12	8.84	01.07.2004	49	1500		2		♂		9			
NOR 062		-18.29	11.06	09.06.2004	54	1800		2				6	0	2	1
NOR 063		-17.16	11.96	23.06.2004	60	2000				♀		5	0	3	1
NOR 095		-17.65	10.93	13.08.1998	72	3900		4		♂		5	0	3	1
NOR 112		-18.08	10.12	10.08.1999	50	700		4		♂		5	0	1	1
NOR 168		-22.72	8.99	01.07.2003	58			2		♀		5	0	3	1
NOR 169		-17.66	11.06	01.07.2003	57			2		♀		6	0	2	1
NOR 170		-16.95	11.00	02.07.2003	50	1200		2		♀		6	0	2	0
NOR 171		-18.56	10.76	08.07.2003	53	1600		2		♀	X	5	0	2S1	0
NOR 172		-17.17	11.56	07.07.2003	57	1600		2		♂		5	0	3	1
NOR 173		-17.65	11.25	08.07.2003	59	2200		2		♀		5	0	3	0
NOR 174		-16.30	11.57	10.07.2003	57	1800		2		♀		6	1	3	0
NOR 182		-16.45	11.37	25.06.2002	50	1400		2		♂		6	0	2	0
NOR 183		-18.03	10.81	06.06.2002	53	700		2		♀	X	5	0	1S1	0
NOR 184		-18.09	11.31	12.06.2002	79	3200		3		♂	X	5	0	2S1S1	0
NOR 201		-17.93	11.12	24.06.2005	50			4		♀		7	0	2	0
NOR 202		-21.17	7.69	01.01.2005	42			4		♀		5	0	2	1
NOR 244		-21.10	8.06	28.06.2005	68	3700		4		♂		11	1	0	0
NOR 246		-23.95	8.18	25.06.2005		300		3		♂		9	0	0	0
NOR 247		-18.83	10.77	15.06.2005	53	1500		4				5	0	3	0
NOR 333		-17.78	11.48	20.06.2007	30			4		♂		4	0	2	0
O 099	Upper Teno	-23.62	8.19	16.08.2001	31	300		4	0.5	♂		6	0	0	1
O 100		-24.66	8.34	28.08.2001	30	227		4	0.5	♂		6	0	0	1
O 218		-20.30	10.90	21.07.2002	38	600		3	0.25	♀		5	0	1	1
O 219		-24.09	9.28	23.05.2002	28	190		4	0.5	♂		5	0	0	0
O 220		-23.28	8.75	23.05.2002	35	380		4	0.5	♀		5	0	1	0
O 224		-25.26	9.03	06.08.2002	30	300		3	0.5	♀		8	1	0	0
O 224		-25.12	8.95	06.08.2002	30	300		3	0.5	♀		8	1	0	0
O 225		-23.78	9.30	12.07.2002	35	400		3	0.5	♂		5	0	1	1
O 225		-23.77	8.70	12.07.2002	35	400		3	0.5	♂		5	0	1	1
O 272		-24.79	8.68	07.08.2003	35	450		3	0.5	♀		7	0	0	1
O 272		-24.99	8.09	07.08.2003	35	450		3	0.5	♀		7	0	0	1
O 436		-23.98	8.63	24.06.2003	38	580		4	0.25	♂		8	1	0	0
O 468		-23.26	9.28	01.06.2000	38	600	500	4	0.25	♀		6	0	3	0
O 470		-24.57	8.78	19.06.2000		1500	1350	3	0.5	♂		5	0	3	0
O 472		-16.73	11.34	04.07.2000	39	830	760	3	0.25	♂		6	1	2	0
O 512		-24.36	8.67	01.08.2000	32	200	180	4	0.25	♂		4	0	1	1
O 536		-26.10	8.84	22.08.2000	37	800	600	4	1	♀		7	1	0	0
O 629		-25.28	8.48	26.07.2005	31	350		4	0.75	♂		5	1	0	0
O 706		-21.28	10.39	03.07.2006	58	1800	1400	3	0.25	♀		8	0	4	0
O 713		-23.38	8.36	05.07.2006	57	2000	1800	4	0.25	♀		5	0	4	1
O 716		-16.74	11.15	23.05.2006	72	5400		4		♂		6	0	4	0
O 765		-18.33	10.61	15.06.2006	52	1200	1000	4	0.5	♂		5	0	2	0
O 766		-24.32	9.77	15.06.2006	48	1200	1000	4	0.75	♂	X	5	0	S1	0
O 767		-18.43	10.78	20.06.2006	59	2200	1800	4	0.75	♀	X	6	0	1S1	0
O 768		-18.59	11.12	16.04.2006	47	1000	800	4	0.5	♀		6	0	2	0
O 769		-16.70	10.85	07.06.2006	52	1400	1300	4	0.25	♂		5	0	2	0
O 770		-19.63	11.40	22.05.2006	53	1300	1100	4	0.25	♀		4	0	2	0
O 781		-24.07	9.14	29.06.2006	49	1450	1250	3			X	6	0	1S1	1
O 800		-20.37	10.74	18.07.2006	53	1800		3		♀	X	5	0	1S1	0
O 813		-17.59	10.94	16.07.2006	52	1300		3	0.5	♀		7	1	2	1
O 815		-20.27	9.85	31.05.2006	46	1010		3	0.25	♀		6	0	2	0
O 871		-17.80	11.13	31.05.2007	74	3800		1			X	4	0	2S2	0
O 872		-17.11	11.64	31.05.2007	46	1000		4				5	0	2	0
O 873		-17.32	11.48	31.05.2007	59	2000		4				5	0	3	0
O 874		-17.36	11.17	05.06.2007	51	1400		4				7	1	2	0
O 875		-17.47	11.75	06.06.2007	58	2000		4			X	4	0	1S1	0
O 884		-18.26	10.66	03.07.2007	48	1300			0.5	♀		5	0	2	0
O 885		-24.06	9.83	29.05.2007	42	950	800	4	0.75	♂		8	0	0	0
O 889		-17.89	11.32	14.06.2007	62	2100	1900	4	0.25	♀	X	6	0	2S1	0
O 903		-23.01	8.01	21.07.2007	48	700		3	0.75	♀		6	0	1	1
O 928		-18.37	10.15	18.07.2007	52	1200		4		♂	X	6	0	1S1	0
O 948		-24.35	9.46	22.07.2007	38	500		3	0.25	♂		7	0	1	1
O 949		-18.23	11.24	03.07.2007	49		1100	2	0.25	♀		5	1	2	0
O 951		-24.16	8.34	01.08.2007	43	800		2	0.25	♀		6	0	1	1
O 960		-17.63	11.39	29.05.2007	51	1500		4	0.25	♂		5	0	2	0

T 251	Utsjoki	-22.56	8.54	31.08.2003	36	380		3		♀		7	1	0	0
T 251	Utsjoki	-22.69	7.82	31.08.2003	36	380		3		♀		7	1	0	0
T 252	Utsjoki	-21.82	8.96	12.06.2003	30	200		3		♂		7	0	1	0
T 252	Utsjoki	-22.77	9.34	12.06.2003	30	200		3		♂		7	0	1	0
T 253	Utsjoki	-27.67	8.17	12.06.2003	38	410		3		♀		7	1	0	0
T 277	Utsjoki	-25.26	9.38	17.07.2003	39	540	480	3	0.25	♀		7	1	0	0
T 287		-18.91	10.51	01.08.2003	41		650	3	0.75	♀		6	0	2	1
T 381	Utsjoki	-22.87	8.81	14.07.2004	40		610	4	0.75	♀		4	0	1	0
T 382	Utsjoki	-23.72	10.01	15.07.2004	34		340	4	0.75	♀		5	0	1	0
T 383	Utsjoki	-23.62	10.19	27.07.2004	48	1500		4	0.25	♂		4	0	2	1
T 384	Utsjoki	-23.04	9.29	30.06.2004	49	1280	1140	4	0.25	♂		9	1	0	0
T 390	Pulmanki	-24.03	8.02	24.06.2004	33	420	380	4	0.25	♂		5	0	1	0
T 451	Utsjoki	-23.21	8.99	23.07.2003	54		1500	3		♀		6	0	5	1
T 452	Pulmanki	-17.53	11.33	17.07.2003	45	900		4	0.75	♀		5	0	3	1
T 476		-18.30	10.88	04.07.2000	46	800		3	0.25	♀		7	1	2	0
T 477	Utsjoki	-23.09	9.19	06.07.2000	48	1300	1200	4	0.5	♀		7	0	0	0
T 478	Utsjoki	-23.07	9.29	12.07.2000	50	1440	1290	4	0.25	♀		5	0	3	0
T 479	Utsjoki	-23.21	8.77	10.08.2000	54	2080	1900	4	0.25	♂		5	0	2	1
T 486	Utsjoki	-23.28	8.30	04.07.2000	42	760		3	0.5	♀		9	1	0	0
T 539	Utsjoki	-27.65	8.44	28.07.2004	30			3	0.75	♂		6	1	0	0
T 563	Utsjoki	-23.04	8.89	06.07.2005	55	2250	2050	4	0.25	♂		5	0	2	1
T 601	Pulmanki	-23.44	9.62	08.06.2005	44	900		4	0.25	♀		6	0	1	1
T 606	Utsjoki	-23.90	10.39	27.07.2005	50	1510	1310	4	0.75	♂		4	0	2	1
T 611	Utsjoki	-17.39	11.71	15.06.2005	56	1650		4	0.25	♀	X	5	0	1S1	0
T 684	Utsjoki	-21.01	8.69	20.06.2005	44	930	790	3	0.25	♂		8	0	0	0
T 689	Utsjoki	-18.23	7.74	03.07.2005	28	210		3	0.25	♀		5	1	0	0
T 728	Utsjoki	-23.69	7.97	11.07.2006	36	410	360	3	0.25	♂		7	1	0	0
T 732	Utsjoki	-18.19	11.34	11.07.2006	36	410	360	3	0.25	♂		7	1	0	0
T 744	Utsjoki	-23.84	7.68	15.07.2006	48		1000	3	0.5	♀		6	0	2	0
T 746	Utsjoki	-18.83	11.38	19.07.2006	35	285	260	3	0.5	♂		8	1	0	0
T 747	Utsjoki	-25.07	7.99	18.07.2006	34	330	300	3	0.25	♀		7	1	0	0
T 748	Utsjoki	-23.15	7.53	18.07.2006	29	210	180	3	0.25	♀		7	1	0	0
T 749	Utsjoki	-21.66	8.05	18.07.2006	33	310	280	3	0.25	♂		8	1	0	0
T 751	Utsjoki	-21.38	8.15	18.07.2006	34	310	280	3	0.25	♀		7	1	0	0
T 751	Utsjoki	-21.45	8.12	18.07.2006	34	310	280	3	0.25	♀		7	1	0	0
T 752	Utsjoki	-22.92	9.57	04.07.2006	58	2300	1900	4	0.75	♀		13	1	0	0
T 755	Utsjoki	-21.15	8.30	20.07.2006	41	570	480	3	0.75	♀		9	1	0	0
T 822	Utsjoki	-23.10	8.29	22.06.2006	48	1500	1310	4	0.25	♂		.	.	1	1
T 896	Utsjoki	-24.33	9.10	10.06.2007	44		780	3	0.25	♀		7	0	1	0
T 898	Utsjoki	-24.34	8.02	12.07.2007	39		620	3	0.5	♂		10	1	0	0
T 899	Utsjoki	-21.24	9.69	20.07.2007	42		530	3	0.5	♀		7	1	0	0
T 909	Utsjoki	-23.97	8.70	19.07.2007	52	1950	1550	3	0.75	♀		7	1	0	0
T 952	Utsjoki	-22.99	8.35	06.06.2007	34	400		4	0.25	♀		5	0	1	0
T 953	Utsjoki	-22.96	8.12	06.06.2007	35	500		4	0.25	♂		7	0	1	0
T 954	Utsjoki	-23.03	10.00	07.06.2007	36	400		4	0.25	♀		8	0	1	0
TX 1	Utsjoki	-24.12	9.65	22.07.2008	52	1200				♂					
TX 2	Akujoki	-24.12	8.22	19.08.2008	23										

* Fishing method: 1 = drift net, 2 = weir, 3 = rod & line, 4 = gill net.

APPENDIX II: THE MISTERY OF LARGE BROWN TROUT IN RIVER NUORTI - STABLE ISOTOPE ANALYSES REVEALS ANADROMY IN THE SPAWNING STOCK

AII 1. Introduction

River Näätämöjoki is another important Salmon river that rises from Lake Iijärvi in Finland and runs to the Varangerfjord in Norway where it is called Neidenelva. Although the river is significantly smaller than the River Teno, it also holds important stocks of Atlantic salmon (*Salmo salar* L.) and sea trout (*Salmo trutta* L.). River Nuortijoki is a small tributary that runs into Neidenelva. Every year in the spawning season in September numerous large brown trout are observed in the stream. Rather contrasting opinions exist on the origin of those trout. In the lower section of the stream a possible migration barrier consists out of several waterfall cascades combined with very low water levels. Salmon have never been observed in Nuortijoki. Upstream, several lakes offer possible feeding grounds for trout. The number and size of the fish might indicate sea migrating trout, whereas the presumed impassable migration obstacle in the lower section support the theory of down-migrating, lake dwelling trout. The trout size and density in Nuortijoki indicate that most of the fish are certainly not stream resident individuals.

The aim of this small project was to answer the question if those spawning brown trout are anadromous trout or local trout that has been up for discussion for years, stable isotope analyses was used according to the approach in River Teno.

AII 2. Material and methods

AII 2.1. Sample sites

The stream Nuortijoki (69°41’N, 29°12’E) is a small tributary (width 2 to 5 m and in most parts very shallow) of Neidenelva at the Finnish-Norwegian border. In the upper region several lakes are accessible by the trout. The stream holds a good stock of juvenile trout and in the spawning season numerous large trout are observed by locals.

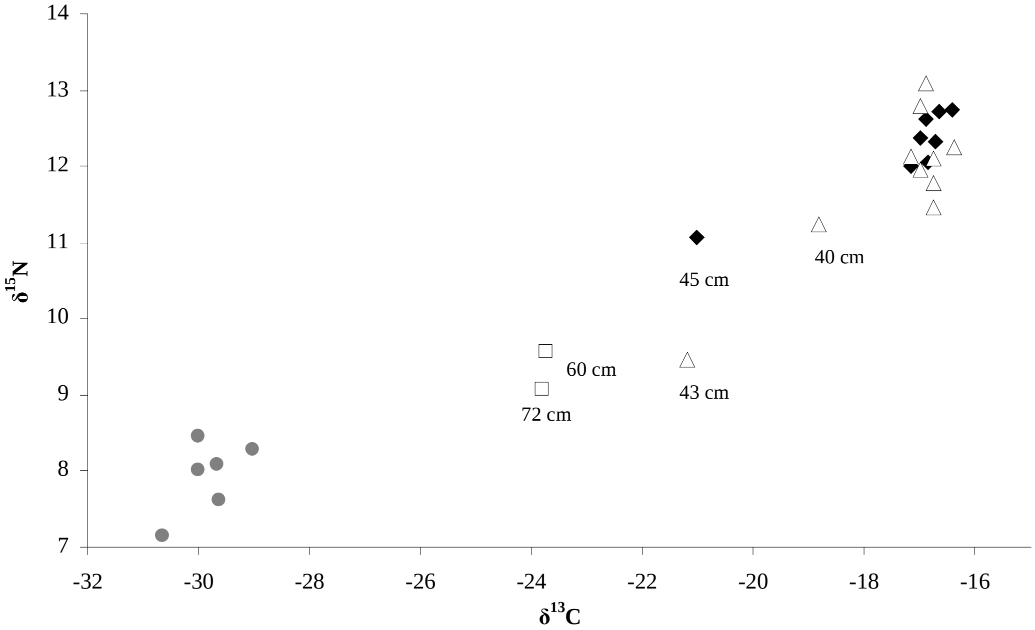
During the spawning season, on 12th September 2008, 8 adult trout (length 45 to 62 cm) were caught by nets in Nuortijoki. A small number of scales were removed by forceps between the adipose fin and the lateral line. The fish were released immediately into the stream. Another 6 trout juveniles (length 4 to 13 cm) were caught by electro fishing. Due to the small scale size all juvenile fish were freeze dried, ground and used for SIA. An additional 10 scale samples of trout caught in Neidenelva (40 to 79 cm) and 2 scale samples of trout caught in Näätämöjoki (60 & 72 cm) were selected for SIA. Those samples were collected by rod and line fishermen during the fishing season 2008.

AII 2.2. Stable Isotope Analyses

The samples were processed and analysed like the River Teno samples.

AII 3. Results

The trout juveniles of Nuortijoki had clearly low $\delta^{13}C$ and $\delta^{15}N$ values in the same range as the freshwater reference material in the Teno River system (AII Figure 1). In contrast the scale samples are enriched in ^{13}C and ^{15}N and the majority of trout of Neidenelva and Nuortijoki range around $\delta^{13}C$ -17 ‰. Of all the scale samples, the two samples from River Näätämö are most depleted.



AII Figure 1. The $\delta^{13}C$ and $\delta^{15}N$ values of the adult brown trout scale samples from Nuortijoki (♦), Neidenelva (Δ), River Näätämö (□) and of the juvenile samples from Nuortijoki (●).

AII 4. Discussion

The majority of Nuortijoki and Neidenelva trout have similar $\delta^{13}C$ and $\delta^{15}N$ values, indicating similar feeding and thus migration pattern. One can assume that a large proportion of trout in Neidenelva are sea trout. The stable isotope values correspond very well to the reference trout caught in Tanafjord ($\delta^{13}C$ mean -17.7 ± 0.9 ‰ SD) and the trout identified as anadromous trout in the River Teno system. Therefore, in Nuortijoki 7 out of 8 analysed trout have been definitely feeding at the sea. Evidently the presumed migration obstacle is actually passable by sea trout, but salmon do not populate this small stream.

One fish from each of Neidenelva and Nuortijoki show $\delta^{13}C$ signatures around –21 ‰ which in the Teno River system was exactly the separation border between the freshwater resident and the anadromous group. Different explanations for those intermediate stable isotope values are discussed in the thesis.

The two River Näätämo trout with their clearly depleted values compared to the anadromous trout might have been feeding in the numerous lakes or large lake-like pools in Näätämo. The FGFRI assumes that a proportion of the brown trout stock in Näätämö is feeding in lakes. Further investigations using stable isotope analyses could answer this question, similar to this study in the Teno system.

AII Table 1. Total data of all analysed Nuortijoki, Neiden and Näätämö trout samples.

Location	**$\delta^{13}C$ [‰]**	**$\delta^{15}N$ [‰]**	**Date of catch**	**Length [cm]**	**Weight [g]**	**Sex**	**Freshwater growth [years]**	**Sea growth [years]**	**Sea "+" growth**
Nuortijoki	-16.42	12.75	12.09.2006	48		♀			
Nuortijoki	-16.66	12.71	12.09.2008	62		♀	4-5	5	
Nuortijoki	-16.74	12.32	12.09.2008	58		♀	4	4+	
Nuortijoki	-16.86	12.06	12.09.2008	55		♀	4-5	3	
Nuortijoki	-16.89	12.62	12.09.2008	55		♂	4	3+	
Nuortijoki	-17.01	12.38	12.09.2008	55		♂	4	3+/4+	
Nuortijoki	-17.17	12.00	12.09.2008	46		♂	4	3+	
Nuortijoki	-21.02	11.07	12.09.2008	45		♂	?		
Näätämö	-23.73	9.56	01.08.2008	60	2614	♀			
Näätämö	-23.80	9.07	29.07.2008	72	4265	♀			
Neiden	-16.40	12.24	09.08.2005	57	1700		4+	2+	1
Neiden	-16.76	11.78	19.08.2002	52	1500	♂	6	1+	
Neiden	-16.76	12.11	10.08.2004	62	2850	♂	4	3+	
Neiden	-16.77	11.45	17.08.2005	44	700	♂	5	1+	
Neiden	-16.91	13.09	05.06.2005	50	1400	♀	4	3	
Neiden	-17.00	12.78	24.07.2002	79	5300	♂	5	6+	
Neiden	-17.01	11.96	2004	50	1000	♂	5	1+	
Neiden	-17.16	12.13	28.07.2005	53	1500	♀	6	2+	1
Neiden	-18.84	11.24	01.08.2005	40	600	♂	5	1+	
Neiden	-21.20	9.47	04.07.2005	43	1000	♀	6	3	
Nuortijoki	-30.02	8.45	12.09.2008	13					
Nuortijoki	-29.99	8.02	12.09.2008	8.8					
Nuortijoki	-29.68	8.08	12.09.2008	6.9					
Nuortijoki	-30.65	7.14	12.09.2008	3.8					
Nuortijoki	-29.01	8.27	12.09.2008	4.1					
Nuortijoki	-29.63	7.62	12.09.2008	4.3					