Norwegian-Finnish working group on monitoring and research in Tana

Atlantic salmon monitoring and research in the Tana river system

Outlining a monitoring and research program for the River Tana within the framework of the precautionary approach

Morten Johansen, Jaakko Erkinaro, Eero Niemelä, Tor G. Heggberget, Martin A. Svenning, Sturla Brørs
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Preface

This report concludes the work of a working group put down to draft a monitoring and research program for the Atlantic salmon resource in River Tana, within the framework of the precautionary approach given by The North Atlantic Salmon Concervation Organization (NASCO). The mandate of The Tana Working Group (TWG) was outlined through joint meetings and co-operation between The Directorate for Nature Management (DN) and The Finnish Game and Fisheries Research Institute (FGFRI/RKTL). The report is the responsibility of the Tana Working Group, and is based on both published and unpublished reports and data.

In this report the working group suggests to establish a permanent Norwegian-Finnish monitoring and research group for the Tana river system. At present such a group is under formation. The tasks of the group will be to give annual reports on Atlantic salmon stock status including trends in stock development, evaluate stock status according to NASCO's guidelines to the precautionary approach, identify knowledge gaps related these aspects. The group also can be asked to answer questions posed by the authorities concerning salmon management in Tana River system. Furthermore, tasks of a permanent group task list may be developed in the course of establishing.

The report was firstly released to the Norwegian and Finnish authorities in February 2008. However, to make the report more applicable we found it appropriate to include the extended summary in Norwegian, Finnish and Sami language. We thank Ingrid Nordal for the translation into Sami. We also decided to include some key articles of NASCO, notely the CNL(98)46 *Agreement on Adoption of a Precautionary Approach* and *Decision Structure For Management of North Atlantic Salmon Fisheries*, as these easily can be regarded as the main conditions for the report.

We wish to thank the working group for having presented a well founded knowledge for monitoring the Atlantic salmon in Tana, as well as having identified knowledge gaps that need to be filled the years ahead. Especially we thank (Dr.) Jaakko Erkinaro from RKTL in Oulu, for having chaired the group in an excellent way, and (Dr.) Morten Johansen, from the County Governor of Finnmark, presently at the University of Tromsø, for being the secretary of the group.

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Yngve Svarte, Assistant Director General

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Sammendrag (Extended summary in Norwegian)

1.1 Arbeidsgruppas mandat

Arbeidsgruppas mandat, og dermed målet for denne endelige rapporten, er å foreslå et overvåknings- og forskningsprogram for Tanavassdraget. Programmet skal møte kunnskapsbehovene knesatt i NASCOs *Decision Structure for Management of North Atlantic Salmon Fisheries,* og NASCOs *River Inventory,* og dermed etablere grunnlag for en varig bærekraftig forvaltning av laksebestandene i Tanavassdraget. I tillegg skal gruppa foreslå prosedyrer og rutiner for å kontrollere trusselfaktorer (sykdom og parasitter osv.), og gi råd om hvordan fangststatistikken kan forbedres.

Denne rapporten er det første forsøket på å utforme et overvåknings- og forskningsprogram for Tanavassdraget innenfor rammen gitt av føre var-prinsippet. Arbeidsgruppa står ansvarlig for rapporten som bygger på både publiserte og upubliserte rapporter og data.

1.2 Laksebestandenes status og karaktertrekk

Den subarktiske elva Tana danner grensen mellom Norge og Finland, og benevner egentlig elva fra samløpet mellom Anárjohka (finsk: Inarijoki) og Kárášjohka og ned til utløpet i Tanafjorden. Nedslagsfeltet for hele vassdraget er 16 386 km^2, hvorav nesten 70 % ligger i Norge. Elvesystemet består av uttallige små og store sideelver som sammen gir en tilgjengelig elvestrekning for laks på over 1000 km.

Tanavassdraget danner i dag grunnlaget for den største bestanden av Atlantisk laks i hele verden med en årlig fangst på mellom 70 og 250 tonn, tilsvarende et årlig antall på 50-60 000 laks. I tillegg fanges nesten 200 tonn laks årlig i sjøen i Finnmark, hvorav mer enn 65 % (130 tonn) er tanalaks. Tanavassdraget er også av de få gjenværende større vassdragssystemene som innehar en tallrik laksebestand med liten eller ingen menneskelig påvirkning annet enn selve fisket. Til tross for dokumenterte høye beskatningsrater, særpreges tanalaksen fortsatt av en vesentlig andel gytere som har vært tre, fire og sågar fem år i sjøen. I tillegg utgjør flergangsgytere et viktig bidrag til gytebestanden

Elvefisket i Tanavassdraget inkluderer kommersielle fiskemetoder som stengsel, settegarn, drivgarn og kastenot i tillegg til stangfisket. Garnfisket kan utøves av den delen av lokalbefolkningen som har fiskerett. Hjemmelsgrunnlag og praksis for fiskeretten er ulik i Norge og Finland, generelt kan privat eiendomsbesittelse, jordbruksproduksjon eller arvet rettighet

utløse fiskerett. Stangfisket utgjør 55-65 % av laksefangsten, og andelen har økt noe gjennom de siste 10 årene. Fisket i nedre del av Tana kan karakteriseres som et flerbestandsfiske hele sesongen, mens dette er tilfellet lenger opp i Tana fram til og med i hvert fall andre halvdel av juli. Da har laksen i de ulike sideelvbestandene i hovedsak nådd sine gyteelver. I øvre del av selve Tana er fisket i august rettet mot underbestander som stort sett gyter i hovedelva. I følge to radiomerkingsstudier fra første halvdel av 1990-tallet, kan beskatningsraten i elvefisket komme opp i over 60 %. Et relativt ferskt studium (2004) i den store sideelva Utsjoki antyder beskatningsrater for flersjøvinterslaksen (laks over 3 kg) på mer enn 80 %. Når sjøfisket etter laks innbefattes i tillegg så understreker dette at den effektive beskatningsraten for tanalaksen er svært høy.

Generelt har oppvandringen til lakseelver både i det nordøstre og nordvestre Atlanterhavsområdet gått vesentlig tilbake de siste 50 årene, mens laksebestandene i vassdragene i Øst-Finnmark (inkludert Tana) og Kolahalvøya har vist sykliske svingninger uten noen klar minkende trend. Imidlertid har en i den siste tiden erfart en negativ utvikling for Tanavassdraget, der trenden for storlaks, særlig hunner, er spesielt bekymringsfull. Selv om antallet varierer fra år til år, er det en negativ trend som antyder at oppvandringen av stor laks har gått ned de siste to tiårene. I den samme perioden har trenden vært positiv for en- og tosjøvinterslaks. En har tidligere observert en positiv korrelasjon mellom Tanavassdraget og noen andre vassdrag i Finnmark, denne har endret seg gjennom de siste 10 årene. Gjennom 1970- og -80-tallet var høye fangster i Tana ensbetydende med høye fangster i andre finnmarkselver. De siste årene (etter år 2000) har denne positive korrelasjonen brutt sammen, slik at det i dag ikke er noen sammenheng mellom fangstene i Tana og andre finnmarkselver.

Sammenlikning av totalfangsten i Norge og Finland gjennom de siste tiårene viser at den norske andelen av fisket har minsket i forhold til den finske.

Det er dokumentert at bestandene fra ulike sideelver i Tanavassdraget skiller seg vesentlig fra hverandre genetisk. De minste sideelvene er dominert av smålaks mindre enn 3 kg, der både hann- og hunnlaks har vært ett år i sjøen, i tillegg er det gjerne en liten andel tosjøvinters hunner (3-7 kg). Flersjøvinterslaks (laks som har vært to eller flere vintre i sjøen) finnes i hovedsak i Tana hovedelv, og i de norske sideelvene Máskejohka (munner ut i nedre Tana) samt Kárášjohka og Iešjohka lengst oppe i vassdraget. I disse elvene utgjør to- og tresjøvinters hunnlaks nesten hele gytebestanden.

En skulle forvente at laks som søker tilbake mot de øvre delene av Tanavassdraget (Kárášjohka, Iešjohka og Anárjohka) beskattes relativt seint i sesongen. Data fra skjellprøver viser imidlertid at det meste av flersjøvinterslaksen i både Kárášjohka og Iešjohka er fanget innen slutten av juni. Gjennomsnittlig (dvs. median) fangstdato for disse øvre elvene kan sammenliknes med gjennomsnittlig fangstdato i nedre del av Tana hovedelv, og tidligere enn i den midtre delen av Tanaelva. Dette indikerer at laks som vandrer til Kárášjohka og Iešjohka ankommer Tanaelva svært tidlig i sesongen, og dermed beskattes både i det tidlige sjøfisket langs finnmarkskysten og i det tidlige garnfisket i Tanaelva (hovedsaklig drivgarn fram til 15. juni).

1.3 Utfordringer for forvaltningen

I Tanavassdraget representerer laksebestandenes mangfold og fisket på blanda bestander en stor forvaltningsmessig utfordring. Hovedmålet for bevaring av laksebestandene og fiskeforvaltningen er å utvikle en forvaltningspraksis for hver enkelt bestand. Dette kan oppnås ved å ta i bruk referansepunkt, for eksempel størrelse på gytebestanden og antall gytte egg (eggdeponering). Forvaltningsprinsippet vi har foreslått i denne rapporten er å sette bevaringsgrenser for bestandene som maksimerer eggdeponering. Bevaringsgrensen defineres som det nivået som gytebestanden må nå – dersom færre fisk gyter vil rekrutteringen begynne å avta vesentlig.

For individuelle laksebestander er gytebestanden lik det totale antallet voksne som går opp i elva, minus antall tapt ved beskatning og naturlig dødelighet. Ved å beregne gjennomsnittlig eggproduksjon pr hunnfisk kan en beregne hvor stor gytebestanden må være for å fullrekruttere vassdraget. Slike *gytebestandsmål* kan beregnes på bakgrunn av arealberegninger og spesifikk kunnskap om fiskebestandene både for hele vassdragssystem og for sidevassdrag/tilløpselver.

Et første steg i å etablere gytebestandsmål ble tatt i 2007 av Hindar m.fl. (NINA-rapport 226, http://www.nina.no/archive/nina/PppBasePdf/rapport/2007/226.pdf). Det ble beregnet at 54 756 kg hunnfisk må til for å fullrekruttere hele Tanavassdraget. Dersom en tar utgangspunkt i en beskatningsprosent på 70, ble gytebestandsmålet nådd bare ett år (i 2001) i perioden 1993-2006. Dersom en tar utgangspunkt i en beskatningsprosent på 60, ble gytebestandsmålet nådd i fem år i denne perioden, med 50 % beskatning, er gytebestandsmålet nådd i seks av disse 14 årene.

Gytebestand av hunnfisk som skal til for å kunne nå gytebestandsmålet i Karasjohka er beregnet til 11 501 kg. Gytebestanden beregnes som for liten i forhold til gytebestandsmålet uansett om 40, 50 eller 60 % beskatning legges til grunn. Når en tar utgangspunkt i sideelvene ser situasjonen for gytebestandene ut til å være noe mer positiv etter hvert som en kommer lenger ned i vassdraget.

Både beregning av nødvendig gytebestand (egg/m^2) og areal av produksjonsområder (m^2) som skal til for å nå gytebestandsmålet, inneholder flere usikkerhetsmomenter og forutsetninger. Alle disse kan ha vesentlig innvirkning på hvor mange hunner som er nødvendig for å nå gytebestandsmålet. NASCOs føre var-tilnærming legger imidlertid sterke føringer på forvaltningen om å bruke all tilgjengelig kunnskap med tanke på tiltak. Dette betyr at selv om dagens gytebestandsmål har usikkerheter knyttet til seg, så representerer de uansett den beste kunnskapen vi har i dag og må benyttes ut fra det.

Vi ser den siste tids utvikling i retning av å etablere gytebestandsmål som en lovende og verdifull tilnærming. Vi anbefaler derfor en konsentrert innsats på overvåking og forskning for å videreutvikle dagens gytemål for ulike deler av Tanavassdraget.

Dagens forvaltningssystem, som er basert på en overenskomst mellom Norge og Finland fra 1990, representerer et system som er vanskelig å passe inn med NASCOs føre var-tilnærming. Vi foreslår derfor at framtidige overenskomster baseres på et rammeverk som åpner for at forhåndsavtalte forvaltningstiltak kan iverksettes hurtig hvis forholdet mellom bestandsstatus og forvaltningsmål tilsier det. For å være sikker på at tiltakene er målretta og effektive, bør det iverksettes at forskningsprosjekt som simulerer effektene av ulike forvaltningsstrategier og tiltak.

1.4 Overvåkings og forskningsprogram

Arbeidsgruppa foreslår følgende program med kontinuerlig overvåking av ungfisk og voksenfisk av laks i Tanavassdraget, samt noen grunnleggende forskningsoppgaver som må gjennomføres for å øke den grunnleggende kunnskapen om tanalaksen.

1.4.1 Voksen laks

Overvåking av voksenfisk og smoltutgang med video og/eller hydroakustikk i sideelver. Arbeidsgruppa foreslår at slik årlig overvåking burde inkludere følgende sideelver:

1. Maskejohka (nedre del av Tana)
2. Utsjoki (midtre del av Tana)
3. Karasjohka (øvre del av Tana)

Bruk av indekselver er den mest hensiktsmessige måten å forvalte anadrome fiskebestander på; i disse kan forvaltningsmål utledes, bestandsstatus evalueres, og prognoser om framtidig tilbakevandring beregnes. En overvåkingslokalitet ble opprettet i 2002 ved utløpet av Utsjoki, den største sideelva på finsk side, der totalt antall oppvandrende laks og utvandrende smolt er talt ved hjelp av video hvert år siden 2002. Arbeidsgruppa anbefaler sterkt å utvide overvåkinga av smolt/voksenfisk slik at også nedre og øvre del av vassdraget blir representert. På denne måten kan en koble svingninger i laksebestandene med faktisk overlevelse i ulike deler av vassdraget. Data generert av disse tidsseriene vil danne grunnlaget for biologiske referansepunkter som er nødvendig i forhold til NASCOs *Decision structure*.

Skjellprosjektet. Dette prosjektet har pågått siden starten av 1970-tallet (norsk side inkludert fra 1997), og representerer i dag en svært verdifull kilde med historisk informasjon om utviklingen av laksebestandene i Tana. Prosjektet gir data om flere sider av tanalaksen, for eksempel alders- og størrelsessammensetning, vekst, genetikk, innslag av rømt oppdrettslaks, og relativ beskatning av ulike fiskeredskaper.

Arbeidsgruppa foreslår at prosjektet fortsetter i sin nåværende form, som aktivt involverer både norske og finske lokale fiskere i innsamling av informasjon om tanalaksen. Imidlertid er ikke nåværende dekning av norske sideelver tilstrekkelig, og betydelig innsats må settes inn for å bedre denne situasjonen.

Merke-/telemetri studie. En forvaltningstilnærming basert på bestander og gytebestandsmål som er gjort i denne rapporten tydeliggjør behovet for oppdatert informasjon, både mht tid og rom. Arbeidsgruppa foreslår derfor å iverksette et merke-/telemetristudie så fort som mulig.

I planlegging av et slikt prosjekt bør følgende aspekter tas hensyn til:

1. Antall fisk som merkes må være stort nok til å utvikle beskatnings- og vandringskart for ulike bestander og størrelsesgrupper av laks, ettersom sammensetningen endrer seg i løpet av sesongen og for ulike deler av vassdraget.
2. Merket fisk må identifiseres ved genetiske analyser på en slik måte at den kan lokaliseres til lokal bestand.
3. Flere merkesteder må vurderes, både ute i Tanafjorden og i nedre del av Tanaelva.

Kompleksiteten i vassdragssystemet med mange underbestander av laks og ulike redskapstyper, samt størrelsen av vassdraget setter i seg selv store krav til design og ressursbruk ved et merkestudie. Dette må imidlertid aksepteres av forvaltningen, spesielt på bakgrunn av de prinsippene og kriteriene for bestandsspesifikk kunnskap som er nedfelt i NASCOs Decision Structure (NASCO 2002 CNL31.332).

Total oppvandring av voksenfisk. Det bør startes et prosjekt for å evaluere muligheten av å registrere total oppvandring av voksenfisk til Tana, og hvilken metodikk som eventuelt kan brukes til dette. Ny lovende teknologi har nylig blitt utviklet i form av en *dual-frequency identification sonar* (DIDSON), og potensialet for å kunne bruke denne i overvåkinga bør utredes.

Evaluering av fangststatistikken. Metodene brukt til å beregne fangststatistikken i Tanavassdraget har vært gjenstand for betydelige endringer gjennom årene, og er nå basert på helt ulike metoder på norsk og finsk side. Fangststatistikken er viktig for overvåking og forvaltning, og effekten av å bruke ulike metoder må undersøkes. Metodenes betydning for den endelige fangststatistikken må bli bedre forstått, slik at en lettere kan sammenlikne fangstdata mellom år. Det må understrekes at sjølaksefisket i Finnmark kan ha stor betydning for mengde og sammensetning av spesielt flersjøvinterlaksen i Tanavassdraget. En bør derfor også vurdere en evaluering av fangststatistikkene fra sjøen.

Habitatkartlegging. Eksisterende kunnskap om laksehabitatene i Tanavassdraget bør utvides, spesielt bør det fokuseres på å identifisere gyteområder (areal og fordeling). Dette er viktig for å kartlegge produksjonsområder og for å identifisere habitater som trenger ekstra beskyttelse.

Beskatningsmodell. Arbeidsgruppa foreslår et modelleringsprosjekt som en naturlig oppfølging av et merke-/telemetristudie, der bestandsspesifikk informasjon om romlig og tidsmessig fordeling må bygges inn i en beskatningsmodell.

Fiskeripåvirket evolusjon. I de siste årene har det framkommet vitenskapelig litteratur som viser hvordan menneskeskapt mortalitet kan forårsake storskala og muligens permanente endringer i livshistorietrekk hos fiskebestander. Relativt lite informasjon om dette fins for laks, men de alarmerende endringene sett i andre tungt beskatta fiskebestander antyder at en kan finne tilsvarende endringer også i laksebestander. Dette vil spesielt være tilfelle i fiskerier som på noen som helst måte er selektivt, hvilket en klart kan si om dagens laksefiske med høyere beskatningsrater på tidligvandrende og stor flersjøvinters laks.

1.4.2 Ungfisk av laks

Årlig elektrisk fiske. Arbeidsgruppa foreslår å fortsette den årlige langtidsovervåkninga av ungfisk. Imidlertid vil hovedmålet av en slik overvåkning måtte gjennomgåes for å kunne møte kravene som er lagt til grunn i denne rapporten. Overvåkninga burde minst være i stand til å a) avdekke endringer og trender i tetthet av ungfisk, b) gi romlig informasjon om ungfiskproduksjon, og c) gi informasjon om ungfisktetthet opp mot beregnet bærekapasitet.

Noen grunnleggende endringer til overvåkningsopplegget foreslås:

1. Spesielt fokus bør rettes mot de sideelvene som blir valgt til å overvåke voksenfisk (Maskejohka, Utsjoki and Karasjohka).
2. Når en velger ut lokalisering av el-fiskestasjoner bør det være en blanding av "kjerneområder" (sentrale deler av vassdraget) og "utkantsområder" (de øvre delene av sideelvene). Områder som regnes som gode laksehabitater i den sentrale delen av elva representerer nok de områdene av vassdraget som er minst følsomme for endringer i total tetthet.

Habitatkartlegging. Produksjonsområder for ungfisk (både areal og fordeling) i hele vassdragssystemet, inkludert områder som er for dype for elektrofiske, må identifiseres. Dette vil gi viktig bakgrunnsinformasjon for å øke kvaliteten på forvaltningsmålene.

Habitatmodellering. Den naturlige kapasiteten et vassdrag har til å produsere laksunger varierer fra område til område. Et enhetlig produksjonsmål for hele Tanavassdraget er derfor ikke hensiktsmessig. De ulike måtene habitatene påvirker produksjonen av ungfisk på bør imidlertid modelleres ved å finne sammenhengen mellom populasjons- og habitatvariable (lokale tettheter, habitater i forhold til størrelse og alder på fisken) i hele vassdragssystemet. Slike modeller (f.eks. MesoHABSIM, HABSCORE) har vært brukt i andre områder, men det er tydelig at slike modeller har begrenset overføringsverdi mellom regioner. Arbeidsgruppa foreslår derfor å

initiere et forskningsprosjekt der målsettingen er å spesielt utvikle en habitatmodell for de ulike delene av Tanavassdraget.

1.5 Organisering og samarbeid

Laksefisket i Tanavassdraget har vært regulert siden 1873 av bilaterale overenskomster mellom Finland og Norge. Den generelle overenskomsten vedtas på regjeringsnivå i begge land, og denne regulerer først og fremst det lokale fisket og tilhørende fiskerettigheter. Regionale myndigheter i begge land regulerer turistfisket (fiske for personer som ikke er fast bosatt i elvedalene), og disse reguleringene kan vedtas hvert år. Den siste generelle overenskomsten var signert i 1990.

Denne norsk-finske arbeidsgruppa er midlertidig og avslutter sitt arbeid med denne rapporten. Imidlertid er det store mengder med informasjon som må samles og sammenstilles fra de foreslåtte overvåkings- og forskningsoppgavene. Dette setter store krav til de vitenskapelige rådene som er nødvendige for forvaltningen av vassdraget. For å sikre at denne viktige delen av prosessen ivaretas på en god måte foreslår arbeidsgruppa at det dannes en permanent norsk-finsk overvåknings- og forskningsgruppe for Tanavassdraget. Oppgaver og ansvar en permanent gruppe kan for eksempel innbefatte:

1. Koordinering av overvåkning og forskning.
2. Evaluering og årlig rapportering av bestandsstatus.
3. Evaluering av effektene av forvaltningstiltak.

For å videreutvikle samarbeidet mellom Norge og Finland og lette framtidig sammenstilling og gjennomgang av bestandsdata, foreslår arbeidsgruppa at det etableres en felles database for oppsamlede historiske data samt nye data som kommer ut av overvåknings- og forskningsaktivitetene.

Čoahkkáigeassu (Extended summary in Sami language)

1.1 Bargojoavkku váldi

Bargojoavkku dán raportta váldi lea Deanučázádahkii evttohit bearráigeahččan- ja dutkanprográmma. Prográmma galgá dustet diehtodárbbuid man NASCO *Decision Structure for Management of North Atlantic Salmon Fisheries* ja NASCO *River Inventory* lea dohkkehan, ja mii ásaha vuođu Deanučázádaga luossanáliide bistevaš ja ceavzilis hálddašeami. Lassin lávdegoddi galgá evttohit vuogádagaid ja dábiid rutiinnaid bearráigeahččat uhkádusaid (dávddaid ja parasihtaid jna.), ja erenoamážit buktit ráđiid mo bivdostáhtistihka sáhtášii buoridit.

Dát raporta lea vuosttaš geahččaleapmi hábmet bearráigeahččan- ja dutkanprográmma Deanučázádahkii ovddalgihtii-várrugasprinsihpa vuođul. Bargojoavkkus lea raportta ovddasvástádus man vuođđun leat sihke almmuhuvvon ja almmukeahtes raporttat ja dieđut.

1.2 Luossanáli dilli ja dovdomearkkat

Subárktalaš deatnu Deanučázádat lea Suoma ja Norgga rádjajohka, ja namahuvvo joga vuolgit dakko gokko Anárjohka ja Kárášjohka deaivvadit ja gitta Deanuvuona njálmmi rádjái. Čázádaga olles njuoskkadatguovlu lea 16 386 km2 mas 70 % guovllus gullá Norgga beallái. Čázádagas leat olu smávva ja stuorra oalgejogat mat oktiibuot dahket badjel 1000 km gosa luossa goargŋu.

Deanučázádagas leat máilmmi stuorámus Atlántalaš luossanáli. Jahkásaččat bivdo gaskkal 70 ja 250 tonna, vástideaddji 50-60 000 luosa jahkásaččat. Lassin bivdojuvvo 200 tonna luossa Finnmárkku mearas, gos eambbo go 65 % (130 tonna) lea Deanučázádaga luossa. Deanučázádat lea okta dain moatti báhcán stuorra čázádagain gos leat eatnat luossanálit ja gos lea uhcán olmmošlaš váikkuheapmi earret ieš bivdu. Beroškeahttá duođaštuvvon alla ávkkástallama, de lea čázádaga luosa erenoamášvuohta dat ahte leat olu gođđoguolit mat leat leamaš mearas golbma, njeallje ja maiddái vihtta jagi. Lassin dahket máŋgageardde gođđoguolit dehálaš oasi gođđonáliin.

Deanučázádaga bivdu sisttisdoallá bivdovugiid nugo buođđu, golgadeapmi, nuohttun ja daidda lassin oaggun. Fierpmástallama dahket guovlluolbmot geain lea fierbmevuoigatvuohta. Láhkavuođđu ja guolástanvuoigatvuohta lea earalágán Norgga bealde og Suoma bealde. Oppalaččat sáhttá priváhta oamastanháldu, eanadoallu dahje árbejuvvon vuoigatvuohta addit guolástanvuoigatvuođa. Oaggun dahká 55-65% luossabivddus, ja lea lassánan maŋimuš 10 jagis. Vuolle-deanu bivddu sáhttá dadjat leat máŋganálatbivdu miehtá bivdoáiggi. Badjelis čázádagas fas dat dáhpáhuvvá suoidnemánu maŋimuš vahkuid. Dalle lea oalgejogaid nálit váldoáššálaččat joavdan sin gođđojogaide. Borgemánus Deanučázádaga bajit osiin bivdojit oalgešlájat mat eanaš

gođđet váldočázádahkii. Guokte radiomerkeniskkadeami 1990-logu álggu rájes sáhttá bivddu ávkkástallanhivvodat juksat badjel 60 %. Oalle ođđa dutkan (2004) oalgejogas, Ohcejohka, árvaluvvo ávkkástallanhivvodat máŋgiimearasfitnanvuorro bivdu dahkat (badjel 3 kg luossa) 80 %. Go mearraluossabivdu dasa boahtá lassin, de dat muitala ahte deanuluosa ávkkástallanhivvodat lea oalle allin.

Oppalaččat lea luossagoarŋun jogaide sihke davvinuortta ja davvioarji Atlanterábiguovlluin lea mearkkašahtti olu njiedjan maŋimuš 50 jagiid. Muhto luossanálit Nuorta-Finnmárkku čázádagain (maiddá Deanučázádagas) ja Guoládagas čájeha sykliskaláš rievddademiid iige čájet čielga vátnunmearkkaid. Dattege lea maŋimuš áiggiid oaidnán negatiivva ovdáneami Deanučázádagas, gos stuorraluosat, erenoamážit duovit, leat vátnon. Vaikko lohku molsašuddá jagis jahkái, de lea negatiiva vuhttosat das ahte stuorra luosat leat vátnon maŋimuš 20 jagis. Seammá áigodagas leat hui positiivva vuhttosat mii guoska oktii- ja guktiimearasfitnanvuorruid dáfus. Ovdal leat oaidnán positiivva ovttafásttolašvuođa Deanučázádaga ja eará čázádagaid gaskkas Finnmárkkus, muhto dat lea rievdan maŋimuš logi jagi. 1970- ja 80-loguin go ledje buorre luossajagit Deanučázádagas, de lei maiddái eará finnmárkojogain seamma buorre bivdu. Maŋimuš jagiid (maŋŋá 2000) lea dát positiivva ovttafásttolašvuohta nohkan. Dál ii leat šat bivdu seammaláhkai Deanučázádagas ja eará finnmárkkojogain.

Buohtastahtedettiin bivdohivvodaga Norgga bealde ja Suoma bealde maŋimuš logi jagiid čájeha ahte dáža beale oassi bivddus lea vátnon suoma beale ektui.

Lea duođaštuvvon ahte nálit iešguđet Deanučázádaga oalgejogain earránit mealgat genehtalaččat. Uhcimus oalgejogain leat eanáš dittit vuollil 3 kg, ja mat leat leamaš jagi mearas. Lassin leat maiddái veháš 3-7 kilosaš vuorrut. Vuorrut (luosat mat leat leamaš guokte dahje eambbo jagiid mearas) gávdnojit eanáš Deanučázádagas, Máskejogas, Kárášjogas ja Iešjogas čázádaga bajimuš osiin. Dáin jogain dahket duovit mat leat leamaš mearas guokte ja golbma jagi masá visot gođđoguliin.

Galggašii gáddit ahte luossa mii máhccá ruovttoluotta Deanučázádaga bajit osiide (Kárášjohkii, Iešjohkii ja Anárjohkii) ávkkástallo oalle maŋŋit bivdoáiggis. Čuopmaiskosat čájehit ahte eanáš dain luosain mat leat orron máŋga jagi mearas sihke Kárášjogas ja Iešjogas lea bivdon loahpageahčái geassemánus. Gaskamearálaš bivdobeaivi bajit jogain sáhttá buohtastahttit gaskamearálaš bivdobeivviin Deanučázádaga vuolit osiin, ja árat go Deanučázádaga gaska osiin. Dat orru čájeheamen ahte luossa mii goargŋu Kárášjohkii ja Iešjohkii boahtá Deanučázádahkii oalle árrat , ja nu gártá bivdojuvvot sihke árra mearrabivddu áiggi Finnmárkku riddoguovlluin ja árra fierpmástallanáiggis (eanáš golgadatáiggi geassemánu 15.b. rádjái).

1.3 Hálddašeami hástalusat

Deanučázádaga hárrái buktá luossnáliid eatnatvuohta ja bivdin seahkalas šlájain stuorra hálddašanhástalusaid. Váldoulbmilin bisuheames luossanáliid ja guolástanhálddašeami lea

ovdánahttit hálddašanvuogi juohke náli várás. Dan sáhttá juksat go atnui váldá referánsačuoggá, omd. gođđonáliid sturrodaga ja gođđanmaniidlogu (mannedeponeren). Hálddašanprinsihpa man mii leat evttohan dán raporttas lea bidjat seailluhanrájáid náliide mat maksimerejit mannedeponerema. Seailluhanrádjá definerejuvvo dan dássin man gođđonálli ferte juksat – jos uhcán guolit gođđet de unnána gođđohivvodat mealgat.

Individuála luossanáliin leat gođđonáliid lohku oktiibuot seamma logus go dat stuorra luosat mat gorgŋot čázádahkii, earret dat mat bivdojit ja mat jávket lunddolaš jápmimis. Go meroštallá gaskamearálaš mannebuvttadeami juohke duovis, de sáhttá meroštallat man stuoris gođđonálli ferte leat dievasmahttit čázádaga. Dakkár gođđojuksanmeari sáhttá meroštit viidodatmeroštusaid bokte ja guollenáliid spesifihkka dieđuid bokte miehtá čázádatsystema ja oalgejogaid.

Vuosttaš lávki ásahit gođđojuksanmeriid dahkkui 2007:s Hindar ja earát. (NINA-raporta 226, http://www.nina.no/archive/nina/PppBasePdf/rapport/2007/226.pdf. Dalle meroštallui ahte 54 756 kilo duovi fertejit leat jos ollásit galgá sáhttit deavdit čázádaga. Jos bidjá vuođđun ávkkástallanproseantta 70, de juvssai gođđonállejuksanmeari dušše ovtta jagi (2001) 1993-2006 áigodagas. Jos bidjá vuođđun ávkkástallanproseantta 60, de juvssai gođđojuksanmeari 5 jagi dan áigodagas, 50 % ávkkástallan, de lea gođđonállejuksanmeari juksan guhtta dain 14 jagis.

Duviid gođđan mat fertejit ferte leat jos galgá juksat gođđojuksanmeari Kárášjogas lea meroštallon dahkat 11 501 kg. Gođđonálli meroštallo menddo vátnin gođđonállejuksanmeari ektui beroškeahttá das ahte bidjá go 40, 50 dahje 60 % ávkkástallama vuođđun. Go vuolggasadjin váldá oalgejogaid, de orru leamen dilli buoret gođđonáliin čázádaga vuolit osiin.

Sihke gođđonáliid dárbbašlaš meroštallan (manit/m2) ja buvttadanguovllu viidodaga (m2) mii ferte leat juksat gođđonállejuksanmeari, sisttisdoallá máŋga eahpesihkkaris beali ja eavttuid. Buot dát sáhttet leat váikkuheaddjin dasa ahte man olu duviid dárbbaša juksat gođđonállejuksanmeari. NASCO ovddalgihtii-várrugasprinsihppa rávve garrasit ahte hálddašeapmi galgá geavahit buot olahahtti dieđuid doaimmaide. Dat máksá dan ahte vaikko vel dálá gođđonállejuksanmearis leat eahpečielggasvuođat, de dattege dat ovddastit buoremus máhtolašvuođa mii mis otne lea ja man ferte atnit ávkin.

Mii oaidnit ahte daid maŋimuš áiggiid ovdaneami sivaid geažil dárbbu ásahit gođđonállejuksanmeari doaimma hui dehálažžan. Mii danne rávvet guovdilastit bearráigeahččama ja dutkama ovdánahttin dihtii dálá gođđomeari Deanučázádaga iešguđet guovlluide.

Dálá hálddašanvuogádat, mii vuođđuda 1990 soahpamuššii gaskkal Norgga ja Suoma, ovddasta vuogádaga mii lea váttis heivet NASCO ovddalgihtii-váruhanprinsihpii. Mii evttohat danne ahte boahtteáiggi soahpamušat vuođđuduvvojit dakkár rámaid ala mat rahpet vejolašvuođa ahte sohppon hálddašandoaibmabijuid sáhttá jođánit doibmii bidjat jos nállestáhtus ja hálddašeapmi dan oaidná dárbbašlažžan. Sihkkarastit ahte mihttomearit leat beaktilat, de berrešii ásahit dutkanprošeavtta mii stimulere iešguđet hálddašanstrátegiijjaid ja doaimmaid beavttu.

1.4 Bearráigeahčču ja dutkanprográmma

Bargojoavku evttoha čuovvovaš prorámma oktan oktilis bearrágeahčuin veajehiin ja stuorraguliin čázádagas, maiddái vuođđudeaddji dutkandoaimmat mat galget čađahuvvot lasihan dihtii vuođđomáhtolašvuođa deanuluosas.

1.4.1   Stuorraluosat

Stuorraguliid ja veajehiid bearráigeahččan videoid bokte ja/dahje hydroakustihka bokte. Bargojoavku evttoha ahte jahkásaš bearráigeahččan galggašii fátmmastit čuovvovaš oalgejogaid:

1. Máskejohka (vuolledeanus
2. Ohcejohka (gasku čázádaga)
3. Kárášjohka (čázádaga bajit oassi)

Indeksajogaid geavaheapmi lea eanemus ávkkálaš vuohki hálddašit anadroma guollenáliid; daid bokte sáhttá hálddašanjuksanmeriid bidjat vuođđun, sáhttá árvvoštallat nálledili, ja meroštallat boahtteáiggi prognosaid. Bearráigeahččanásahus ásahuvvui 2002 Ohcejotnjálbmái, stuorámus oalgejohka suoma bealde, gos olles lohku gorgŋon luosain ja merriinjiedjan veajehiin leat lohkkon video bokte juohke jagi 2002 rájes. Bargojoavku garrasit neavvu viiddidit stuorraluosaid/veajehiid bearráigeahččama vai maiddái vuolit ja bajit čázádaga oasit ovddastuvvojit. Dakko bokte sáhttá ovttastahttit luossanáli molsašuddamiid duohta seailumiin iešguđet čázádaga osiin. Dieđut mat dain bohtet ovdan dahká vuođđun biologalaš dieđuide mat leat dárbbašlaččat NASCO Decision structure ektui.

Čuopmarošeakta. Rošeakta lea leamaš jođus 1970-logu álggu rájes (Norgga bealde 1997 rájes), ja mii lea hui mávssolaš gáldu mii čájeha historjjálaš ovdáneami čázádaga luossanáliin. Rošeavtta dieđut čájehit máŋga beali deanu luosa birra, omd. agii ja sturrodaga, šattu, genetihka, báhtaran biebmoluosaid, ja iešguđet bivdosiid ávkkástallama.

Bargojoavku evttoha ahte rošeakta jotkojuvvo dálá hámis mii aktiivvalaččat doaimmaha bivdiid sihke Norgga ja Suoma bealde čohkken dihtii dieđuid deanuluosa birra. Dattege ii fátmmas doarvái bures Norgga beale oalgejogaid. Dasa ferte bidjat mealgat searaid buoridit dili.

Merken-/telemetriijja iskan. Dákkár hálddašanvuohki mii dán raporttas ovdanboahtá ja man vuođđun leat nállešlájaid ja gođđanmeriid bearráigeahččan, čalmmustahttá dárbbu gozihit dieđuid, sihke mii guoská áiggi ja viiodoaga dáfus. Bargojoavku evttoha danne álggahit merken-/telemetriijjaiskosa jođáneamosit.

Dákkár rošeavtta plánen berre vuhtiiváldit čuovvovaš deasttaid:

1.   Guliid lohku mat merkejuvvojit fertejit leat dan mađe stuorrát vai sáhttá ovdánahttit ávkkástallan- ja luossajohtolatkártta iešguđet luossanáliin ja daid sturrodagaid, dannego čoahkádus rievdá bivdoáiggi mielde ja iešguđet čázádaga guovllus.

2. Merkejuvvon guliid ferte identifiseret genehtalaš analysaid bokte nu ahte dan sáhttá lokaliseret guovllu náliide.
3. Eambbo merkensajiid ferte árvvoštallat, sihke Deanuvutnii ja Deanučázádaga vuolit osiide.

Čázádatsystema gos leat olu luossaoalgešlájat ja máŋggalágán bivdosat, ja čázádaga stuorrodat gáibida viehka olu merkendutkosa ressursageavaheapmái. Dattege dan ferte hálddašeapmi dohkkehit, erenoamážit daid prinsihpaid ja eavttuid vuođul ja nálledutkandieđut mat leat vuođđun NASCO doaimmaide Decision Structure (NASCO 2002 CNL31.332).

Ollislaš lohku stuorraluosaid goargŋumis. Galggašii álggahuvvot prošeakta evalueren dihtii vejolašvuođaid registreret olles logu gorŋon stuorraluosain čázádagas, ja makkár vuogádaga sáhttá geavahit dán oktavuođas. Ođđa teknologiija lea hutkojuvvon nu gohčoduvvon *dual-freguency idenfication sonar* (DIDSON), ja potensiála sáhttit geavahišgaohtit dan bearráigeahččamis, ferte čielggaduvvot.

Bivdostatistihka evalueren. Vuogádagat mo meroštit bivdostatistihka Deanučázádagas leat sakka rievdan, ja lea dál goappatlágan vuogádat Norgga ja Suoma bealde. Bivdostatistihkka lea dehálaš bearráigeahččamii ja hálddašeapmái, ja váikkuhusaid sierranas vuogádagaid geavaheamis ferte čielggaduvvot. Vuogádagaid loahpalaš bivdostatistihka árvvu ferte buorebut áddet, vai lea álkit buohtastahttit bivddu eará jagiin. Fuopmášahttin veara lea ahte mearraluossabivddus Finnmárkkus sáhttá leat viehka stuorra árvu hivvodaga ja čoahkádusa dáfus, erenoamážit Deanučázádaga máŋgiimearasfitnan vuorrus. Danne fertešii árvvoštallat evalueret mearrabivddu bivdostáhtistihka.

Kártet luosa lunddolaš šaddanbáikkiid (Habitat). Dálá máhttu Deanučázádaga luosa šaddanbáikkiin ferte viiddidit, erenoamážit ferte guovdilastit ja identifiseret gođđansajiid (areála ja juohkima). Dát oassi lea dehálaš kárten dihtii buvttadanguovlluid ja identifiseret luosa lunddolaš šaddanbáikkiid.

Ávkkástallanmálle. Bargojoavku evttoha modellerenprošeavtta mii čuovvolahttá merken-/telemetriijjaiskosa, mas nállái guoski dieđut bohtet ovdan ja ahte fertešiigo viidodaga ja áigái guoski juohkima čatnat ávkkástallanmállii.

Guolástusváikkuheaddji evolušuvdna. Maŋimuš jagiid leat boahtán dieđalaš gáldut mat čájehit mo olbmováikkuheaddji jámolašvuohta sáhttá dagahit stuorra ja veadjá bistevaš rievdademiide guollenáliid eallinhistorjái. Hui uhcán dieđut gávdnojit dan birra, muhto daid sakka rievdausaid man oaidná eará sajis gos guollenáliid garrasit bivdet, dovddahit ahte sáhttá gávdnat vástideaddji rievdamiid maiddái luossanáliid hárrái. Dat dáhpáhuvvá guolástusaid oktavuođas mas lea man nu lágan selektiivvavuohta, man sáhttá dadjat leat dálá luossabivddus mas lea alla ávkkástallanoassi árra luosain ja stuorra vuorruin mat leat máŋgii mearas fitnan.

1.4.2   Luossaveajehat

Jahkásaš elektriska bivdu. Bargojoavku evttoha joatkit veajehiid jahkásaš guhkesáiggi bearrágeahččama. Dattege lea váldomihttomearrin dakkár bearráigeahččamis ahte dan ferte guorahallat dustendihtii dán raportta gáibádusaid. Bearráigeahččan goittoge uhcimusat ferte sáhttit a) čalmmustahttit rievdademiid ja veajehiid valljodaga b) dieđuid veajehiid buvttadeamis, ja buktit dieđuid veajehiidvalljodagain meroštallon ceavzinnávcca ektui.

Muhtun vuođđudeaddji rievdadusat bearráigeahččandoibmii evttohuvvo:

1. Erenoamážit ferte guovdilastit daid oalgejogaid mat leat válljejuvvon bearráigeahččat stuorraluosaid (Máskejohka, Ohcejohka ja Kárášjohka).
2. Go vállje gokko el-guollestášuvnnaid ásaha de fertejit leat sihke "váldoguovllut" (čázádaga guovddáš guovllut) ja "boaittobealguovllut" (čázádaga bajit osiin). Guovllut mat geahččojuvvojit buori lunddolaš šaddanbáikin čázádaga guovddáš guovlluin, leat čázádatguovllut mat eai leat nu hearkkit rievdadusaide valljodaga dáfus.

Habitáhtakárten. Veajehiid buvttadanguovllut (sihke viidodat ja juohkin) miehtá čázádaga, fátmmasta guovlluid mat leat menddo čieknalat elektrobivdui, ferte identifiseret. Dat attášii dehálaš duogášdieđuid lasihan dihtii hálddašanjuksanmeriid kvalitehta.

Habitáhtamodelleren. Lunddolaš kapasitehta mii čázádagas lea buvttadit veajehiid molsašuddá guovllus guvlui. Oktilis buvttadanmearri Deanučázádagas ollislaččat danne ii leat ávkkálaš. Iešguđet vuogit mo habitáhtat váikkuhit veajehiid buvttadeapmái, ferte dattege modellerejuvvot gávdnandihtii oktavuođaid populašuvnna- ja šaddanbáikkiid molsašuddamiin miehtá čázádaga (báikkálašvalljodat, orrunbáikkit stuorrodaga ja guliid agiid ektui. Dakkár modeallat (omd. MesoHABSIN/HABSCORE) lea geavahuvvon eará guovlluin, muhto lea čielggas ahte dakkár modeallain leat unnán sirdinárvu regiuvnnaid gaskkas. Bargojoavko danne evttoha vuolggahit dutkanprošeavtta mas mihttomearrin lea erenoamážit ovdánahttit habitáhtamodeallaid čázádaga iešguđet guovlluide.

1.5 Organiseren ja ovttasbargu

Deanučázádaga luossabivdu lea regulerejuvvon jagi 1873 rájes Suoma ja Norgga gaskasaš soahpamušaid bokte. Oppalaš soahpamuš mearriduvvojit goappat riikkaid ráđđehusaid dásis, ja dat regulere vuosttažettiin guovllu bivddu ja dasa guoski guolástannjuolggadusaid. Guktuid riikkaid regionála eiseválddit regulerejit turistabivddu (geat eai oro fástá leagis), ja daid sqhttq reguleret juohke jagi. Maŋimuš soahpamuš lea vuolláčállon jagi 1990:s.

Atlantic salmon monitoring and research in the Tana river system

Dát norgga-suoma bargojoavku lea gaskaáigásaš ja loahpaha barggus dán raportta bokte. Dattege leat olu dieđut maid ferte čohkket ja buohtastahttit evttohuvvon bearráigeahččamiin ja dutkandoaimmain. Leat garra gáibádusat dieđalaš ráđiide mat leat dárbbašlaččat čázádaga hálddašeamis. Sihkkarastit ahte dát dehálaš oassi proseassas áimmahuššo bures, de evttoha bargojoavku ahte ásahusso fásta norgga-suoma bearrágeahččan- ja dutkanjioavku Deanučázádaga várás. Barggut ja ovddasvástádus dakkár joavku sáhtášii sisttisdoallat:

1.   Bearráigeahččama ja dutkama buohtalastin.
2.   Evalueren ja jahkásaš nálledili raporteren.
3.   Hálddašandoaimmaid váikkuhusaid evalueren.

Ovdánahttin dihtii ovttasbarggu Suoma ja Norgga gaskkas ja álkidahttit boahtteáiggi nálledieđuid buohtalastima, de bargojoavku evttoha ahte ásahuvvo oktasaš dihtorbása mas leat čohkkejuvvon historjjálaš dieđut, ja ođđa dieđut mat ihtet bearráigeahččama- ja dutkandoaimmaid olis.

1 Summary

1.1 Mandate of the Working Group

The mandate of the working group, and thus the goal of this final report, is to draft a stock monitoring and research program for salmon in the Tana river system. The program should meet the data requirements of NASCO *Decision Structure for Management of North Atlantic Salmon Fisheries,* and the *River Inventory,* and thereby establish a basis for long term sustainable management of the Tana salmon stocks*.* In addition, the working group should propose procedures and routines for keeping watch on threatening factors (diseases and parasites etc.), and especially advice on how to improve catch statistics.

The present report is the first attempt at designing a monitoring and research program for Tana salmon, within the framework of the precautionary approach. The report is the responsibility of the Working Group, and is based on both published and unpublished reports and data.

1.2 Stock characterization and status of the Tana Salmon

The subarctic river Tana (Teno in Finnish, Deatnu in Sami) forms the border between northernmost Norway and Finland. The river drains an area of 16 386 km^2, of which almost 70 % is situated in Norway. The river system consists of a multitude of small and large tributaries, constituting more than 1000 km accessible river stretches for ascending Atlantic salmon.

Tana today supports the largest wild stock of Atlantic salmon in the world, with annual river catches fluctuating between 70 and 250 tonnes, equivalent to an annual harvested average of 50-60 000 salmon. In addition, nearly 200 tonnes of salmon is captured annually in the sea fisheries along the Finnmark coast, where more than 65 % (130 t) constitutes Tana salmon. The river Tana is also one of the few remaining large river systems that still support abundant Atlantic salmon stocks with little or no human impact to the system, except for fishing. Despite documented high rates of exploitation, it is still characterized by important contributions of 3, 4, and even some maiden 5SW (sea winter) spawners.

The riverine salmon fisheries in Tana also include commercial fishing methods such as weir, gill net, seine and drift net, in addition to the more traditional use of rod and line. The net fisheries are practiced by local people and it is permitted by fishing rights based on land owning, agriculture production or inherited rights. The rod catch comprises not more than 55-65 % of the catch, although it has increased a little during the last 10 years. Fishing in the lower section is mixed-stock fishery throughout the season, whereas this is true for the upper section until the second half of July, when stocks from the tributaries have mostly ascended into their spawning rivers. In the upper section, fishing in August is directed to sub-stocks reproducing mainly in the main stem. According to two telemetry tagging experiments in the early 1990s, harvest rates in the river fisheries could reach the levels of more than 60 %. A recent study in the large tributary, Utsjoki, even suggested exploitation rates of more than 80 % on multi-sea-winter (MSW)

salmon. It should be emphasised, that by including the sea fishery, the effective exploitation rates for Tana salmon is very high.

In salmon rivers in both the northeast and northwest Atlantic, return rates have decreased significantly the last 50 years, whereas the salmon stocks of eastern Finnmark rivers (including the river Tana) and salmon rivers of the Kola peninsula, have fluctuated in a cyclic manner with no clear declining trend. During the last period, however, some negative developments have experienced in Tana river, in which the trend for large MSW (3- and 4SW) salmon, especially the females, is particularly worrying. Even though the numbers vary from year to year, there is a negative trend indicating that the return of large fish is decreasing within the two last decades. However, during the same period, the trend for 1SW and 2SW fish is increasing. Moreover, earlier observations of positive correlations among Tana and some other western Finnmark rivers seem to have changed during the last 10 years. During the 1970s and 1980s, the catches in Tana and other salmon rivers in Finnmark were positively correlated, with high catches in Tana meaning high catches in other Finnmark rivers. In the last few years (the 2000s), this positive correlation has broken down, and there is presently no relationship between catches in the Finnmark rivers.

Comparison of the total catch in Norway and Finland in the Tana during the last decades shows a trend that the extent of the Norwegian fishery is declining while the Finnish catches make up an increasing proportion

High genetic differentiation among stocks from the different tributaries in the Tana river system has been revealed. The smallest tributaries are dominated by 1SW fish (both males and females) with a small to medium percentage 2SW females. MSW fish are mainly found in Tana main stem, the Norwegian tributary Maskejohka and the uppermost large tributaries Karasjohka and Iesjohka. In these rivers, the female spawning stocks are almost exclusively 2- and 3SW fish.

Salmon migrating to the upper parts of the Tana river system must cover a long distance. It should thus be expected that salmon homing to upper tributaries (e.g. Anarjohka/Inarijoki, Karasjohka and Iesjohka), are harvested relatively late in the season in those areas. Data from scale samples however, show that most of the MSW salmon in both Karasjohka and Iesjohka are caught by the end of June. Median dates of capture in these uppermost areas are comparable to median dates for the lower part of Tana mainstem (and slightly earlier than median dates for the middle part of Tana mainstem), indicating that the salmon ascending to Karasjohka and Iesjohka enter the Tana river very early in the season and are exploited both in the early sea fishery along the Finnmark coast and the drift net fishery in Tana itself.

1.3   Management challenges

The diversity of the salmon stock complex and the mixed stock fisheries represent a major future management challenge in the river Tana. The main objective of salmon conservation and fisheries management in the Tana system is the development of a management practice for individual salmon stocks. This can be achieved through the use of reference points, e.g.

spawning escapement and egg deposition. The management procedure proposed in this report uses the principle of setting conservation limits to maximize egg deposition.

For individual salmon stocks, the total number of adults entering the river, minus the number of fish lost through exploitation and natural mortality, is the spawning escapement. This escapement can be converted into an estimate of total egg production, which may then be compared to stock-specific threshold values for egg production. For the River Tana, we recommend the use of the conservation limit (CL) as recommended by North Atlantic Salmon Conservation Organization (NASCO), which is the stock level that supports maximum yield. The CL is the threshold level below which stocks should not fall, thus the need for a higher management target that managers should aim for.

Although based on preliminary data, a first step in establishing such targets has been taken and targets have been assigned to a total of 180 Norwegian rivers. To meet the spawning target for the whole Tana system, a total spawning escapement of 54 756 kg of females was suggested (Hindar *et al.* 2007). Using an estimated exploitation rate of 70 %, over the period 1993-2006 the spawning target was reached only in 2001. With 60 % exploitation rate, the spawning target is exceeded in 5 years during this period, and with 50 % exploitation rate, the spawning target is exceeded in 6 out of these 14 years.

The spawning escapement (mass of female spawners) required to meet the spawning target for Karasjohka is 11 501 kg. For none of the realistic exploitation rates (between 40 and 60 %), does the estimated spawning stock reach the stock size required to meet the spawning target. Considering tributary-specific numbers, it seems evident that the situation is a bit more positive for the tributaries in the lower part of Tana compared to the upper tributaries.

There are several uncertainties and assumptions contained in the estimation of the target egg requirement (egg/m^2) and the production area, each of which can have a significant impact on estimate of the total number of females needed to meet the target. However, it should be strongly emphasized that the NASCO precautionary approach clearly puts a strong demand on managers to use all **available** knowledge when deciding on management measures. This means that even though problems can easily be recognized with the presented targets, they still represent the **best** knowledge we have as of today and should be treated as such.

The working group recognizes that the recent development in establishing spawner target levels represent a promising and valuable approach The working group highly recommends a concentrated effort of focused monitoring and research to obtain estimates of higher resolution and refine the current target levels for different parts of the Tana system.

The present management system, based on the agreement between Norway and Finland from 1990, represents a framework that is difficult to fit with the Precautionary Approach. The group therefore suggests that future agreements should be based on an adaptive management framework, allowing for pre-agreed management actions to be implemented depending on stock status in relation to management targets. To make certain that the actions are targeted

and effective, a research project simulating the effects of various management strategies and actions should be implemented.

1.4   Monitoring and research programme

The working group proposes the following programme with continuous monitoring of different aspects of adult and juvenile salmon in the river Tana system, and some basic research tasks that must be performed to improve our basic knowledge about the Tana salmon complex.

1.4.1   Adult salmon

Monitoring of the adult and smolt run through video and/or hydro acoustics in tributaries. The working group proposes that the annual monitoring of the adult and smolt run size should include the following tributaries:

4. Maskejohka (lower part of Tana)
5. Utsjoki (middle part of Tana)
6. Karasjohka (upper part of Tana)

Index rivers are the most useful way to manage anadromous fish stocks whereby management targets can be derived, the status of stocks evaluated, and forecasts made of subsequent adult returns. A monitoring site was established in 2002 at the largest Finnish tributary of the Tana, the River Utsjoki, where the total numbers of smolts descending as well as the numbers of adult salmon ascending have been counted by video monitoring annually from 2002 to 2007. The group highly recommends expanding the smolt-adult monitoring also to the lower as well as the upper part of Tana, in order to better understand and associate fluctuations in abundance with actual trends in survival. Thus, the data produced by these time series will form the basis in establishing biological reference points to complete the information required in relation to the Decision structure.

Scale sampling project. This project has been going on since the beginning of the 1970s, and today represents an immensely valuable source of historical information on the development of salmon stocks in Tana. The project provides data on several aspects of the Tana salmon, e.g. age and size composition, growth, genetics, farmed salmon escapees, and relative exploitation by different fishing gears.

The working group proposes the continuation of the project in its current form, actively involving both Norwegian and Finnish local fishermen in the collection of information about the Tana salmon. However, the present coverage of Norwegian tributaries is not sufficient and considerable effort should be put into improving this situation.

Tagging/telemetry-study. The stock- and target-driven approach to management taken in this report clearly elucidates the need for updated information with a good temporal and spatial resolution. The working group therefore proposes the implementation of a telemetry/tagging-study as soon as possible.

The study design should take into account the following aspects:

4. The number of tagged fish must be sufficient to develop exploitation and migration maps for different stocks and salmon size groups as it changes temporally through the season and spatially through the river system.
5. Tagged fish must be identified through genetical analysis and assigned to local stock.
6. The use of several tagging sites should be considered, both in the Tana fjord and in the lowermost part of the river Tana.

The complexity of the Tana river system with its multitude of stocks, different fishing gears and sheer river size, clearly places high demands on the design and resource use of a tagging study. However, this high level must be accepted by the management institutions, in particular considering the principles and criteria based on actual stock-specific knowledge laid down in the NASCO Decision Structure (NASCO 2002 CNL31.332).

Whole-river adult run size. A project should be initiated with the aim of evaluating the feasibility of monitoring the annual total whole-river adult run size, and the potential methodology to be used. New promising technologies have recently been developed, e.g. dual-frequency identification sonar (DIDSON), and their potential for such monitoring should be explored.

Evaluating catch statistics. The methods involved in calculating catch statistics in Tana have been subject to several changes over the years, and are presently based on rather different methodologies on the Norwegian and Finnish side. Catch statistics are important in monitoring and management, and the impact of different aspects of the methods should be investigated. One important focus should be on understanding the impact of different methods on the final statistics, thus facilitating the comparison of numbers between years. It shoud be emphasized that since the Finnmark sea fishery may influence highly upon the amount and constitution of MSW salmon in Tana river salmon, an evaluation of the sea catch statistics should also be considered.

Habitat mapping. Expand the existing knowledge on salmon habitat in the Tana system, especially focusing on identification of spawning grounds (area and distribution). This is important for mapping of production areas and for identification of habitats and areas in need of extra protection.

Exploitation model. The working group suggests a modelling project as a natural continuation of the tagging/telemetry study, where the spatial and temporal stock-specific information is incorporated.

Fisheries-induced evolution. Recent years have seen a great accumulation of scientific literature demonstrating how human-induced mortality can cause large-scale and potentially permanent changes in life-history traits of fish populations. Relatively little information exists on this for salmon, but the alarming changes seen in other heavily exploited fish populations suggest a high probability that analogous changes can be found within salmon stocks. This will especially be

true for fisheries that in some ways are selective, something that clearly is the case today for the salmon fishery (with its higher exploitation rates on early-running and large multi-seawinter salmon).

1.4.2 Juvenile salmon

Annual electrofishing. The working group highly recommends the continuation of the long-term annual electrofishing survey. However, the basic aim of the survey in future years will have to be reformulated to accommodate the requirements of the target approach adopted in this report. The monitoring should at least be able to a) discover changes and trends in juvenile density, b) provide spatial information on juvenile production, and c) provide information on juvenile density compared with estimated carrying capacity.

Some basic changes to the monitoring design proposed by the working group:

3. Special focus should be given to the tributaries chosen for adult run monitoring (Maskejohka, Utsjoki and Karasjohka).
4. When establishing the distribution of electrofishing stations, a combination of "fringe" and "core" sites should be used. Sites considered to be good salmon habitats in the central part of the river are clearly the parts of the river system that are least sensitive to changes in overall density.

Habitat mapping. Identify juvenile production areas (both area and distribution) in the whole river system, including areas too deep for electrofishing. This will provide important background information for refinement of management targets.

Habitat modelling. The intrinsic capacity of river sections to support juvenile salmon varies from section to section. Therefore a uniform juvenile production target for the entire Tana system is inappropriate. The different ways that habitats affect juvenile production should be approached by modelling the relationship between local densities, sizes and ages of fish and habitat, by correlating population and habitat variables of areas selected from the whole Tana river system (both main stem and tributaries). Such models (e.g. MesoHABSIM, HABSCORE) have been widely used in other areas, but reviews indicate that such models have often limited transferability between regions.

The working group thus proposes the initiation of a research project specifically targeted at developing a habitat model for different parts of the Tana river system.

1.5 Organization and collaboration

Salmon fishing in the River Tana system has been regulated since 1873 by bilateral agreements between Finland and Norway. The general fishery agreement is concluded between the governments of Finland and Norway, and this agreement primarily regulates the local fisheries and the associated fishing rights. Regional authorities in both countries regulate the tourist angling, and these regulations can be amended on a yearly basis. The latest general agreement was signed in 1990.

The present Norwegian-Finnish working group is temporary and concludes its work with the present report. However, vast amount of information needs to be compiled and synthesized from the proposed monitoring and research tasks, setting a high demand on the scientific advice needed for management of the river system. To ensure that this important part of the process is taken care of in an optimal way, the working group suggests the formation of a permanent Norwegian-Finnish monitoring and research group for the Tana river system.

Tasks and responsibilities for a permanent monitoring group may include, e.g.:

4. Coordination of monitoring and research.
5. Evaluation and annual reporting of stock status.
6. Evaluation of the effect of management measures.

To further develop the cooperative process between Norway and Finland, and to ease the future synthesis and review of stock status data, the working group also suggests the establishment of a common database for the accumulated historical and new data resulting from monitoring and research activities.

2   The group and its mandate

Based on the recommendations of joint meetings in 1999 and 2005 between representatives of Norwegian and Finnish authorities, a temporary working group on stock monitoring and research in Tana, referred to as the Group later in this report, was formally established in 2006. The group consists of members from the Directorate for Nature Management (DN; Sturla Brørs), County Governor of Finnmark (Morten Johansen, presently at the University of Tromsø), Norwegian Institute for Nature Research (NINA; Tor G. Heggberget, Martin Svenning) and Finnish Game and Fisheries Research Institute (FGFRI; Eero Niemelä, Jaakko Erkinaro (chair)).

The mandate of the working group was to draft a stock monitoring and research program for salmon in Tana river system. The program should aim to meet the data requirements of NASCO, detailed in the document "Decision Structure for Management of North Atlantic Salmon Fisheries" (CNL31.332) and the River Inventory. In addition, the working group should propose procedures and routines for keeping watch on threatening factors (diseases and parasites etc.), and advice on how to improve catch statistics.

The Decision Structure was developed by NASCO to provide a basis for more consistent approaches to management of the exploitation of salmon throughout the North Atlantic range of the species.

The ultimate management goal is to develop a sustainable management of Tana salmon. Defined management objectives are:

1. Conservation of salmon and their habitats is the highest priority in management decision making.

2. Manage salmon fisheries for sustainable use – to the extent allowed by stock conservation.
3. Monitor and safeguard the genetic diversity of salmon stocks in the Tana river system.
4. Maintain the habitat integrity necessary for long-term salmon production.

3   Introduction

The last 30 years have seen some serious declines in the stock level of various salmonids, especially those for Atlantic salmon (*Salmo salar* L.) (ICES, 2000). The same has been true for many other fish stocks throughout the world, some even facing worse problems than the salmon, and states have therefore been called upon to apply a "precautionary approach" to conservation, management and exploitation of fish stocks (United Nations, 1995). This approach was adopted by the North Atlantic Salmon Conservation Organisation (NASCO) through its "Agreement on the Adoption of a Precautionary Approach" (CNL(98)46) in 1998.

The first NASCO convention required that management should be based upon the "*best available scientific information*" (NASCO 1988), but the Precautionary Approach very clearly changed this into an emphasis on managers and scientists utilizing all available information, regardless of its imperfection, when developing management options. All advice that is given should however account explicitly for the various sources of uncertainty both in the current state of scientific knowledge and in our ability to control fisheries. This approach completely changes the "burden of proof", in that those who challenge the need for restrictions must demonstrate that their intended actions will not have unacceptable effects on the resource.

Atlantic salmon as a fish species occur in more than 2 000 rivers on both sides of the North Atlantic Ocean. On the eastern side the distribution range is from northern Portugal northwards to the White Sea (Russia), while on the western side from Maine to northern Quebec (Crisp 2000). A lot of studies in the last 40 years have looked at the genetical structure of salmon, showing a hierarchically genetically structured species (Ward *et al.* 1994) with a major split between populations from both sides of the Atlantic and a further divergence on the European side between Baltic and Atlantic populations (Ståhl 1987; Verspoor *et al.* 2005). Salmon exhibits a well-known tendency to home to their natal rivers (Stabell 1984), which means restricted gene flow between breeding locations and genetic divergence down to the level of populations within tributaries of river systems (Garant *et al.* 2000) as shown recently for Tana (Vähä *et al.* 2007).

An important separation is given in the Precautionary Approach between single- and mixed-stock fisheries. As will be shown more in detail later in Chapter 4, the fisheries in Tana mostly are mixed-stock fisheries. Mixed-stock fishery of salmon stocks greatly complicates the conservation and management of various aspects of the salmon stocks, and most of all perhaps the conservation of salmon diversity. Unless it is possible to selectively exploit productive populations, the overall exploitation rate must therefore be carefully controlled to ensure conservation of less productive stocks within an area of mixed-stock fishery. Over-exploitation will push the numbers of returning salmon stocks below sustainable levels, and as salmon

abundance declines, diversity and resilience are reduced and risk of extinction is increased. Populations with low diversity are less resilient to environmental stresses such as disease, pollution or changing climate.

In terms of causing mortality, the role of humans can in many ways be compared to the role predators take in natural ecosystems, but there are some very important differences. Predators coexist with their prey, and together they form a dynamic feedback loop. Increased numbers of prey allows for increased numbers of predators. When predator numbers exceed the carrying capacity, prey numbers decline and the predator follows suit. These kinds of feedbacks are unfortunately not present in most situations where modern man exploits natural resources. A further difference lies in the proportion of prey taken by predators. Within natural ecosystems, there seems to be a prevalence of predator-prey exploitation rates of 10 to 20 % (Fowler *et al.* 1999). This prevalence seem to suggest that such proportions have long term sustainability and that higher exploitation rates can have unfortunate and destabilizing effects on both predator and prey. Unfortunately, exploitation rates by humans are rarely this low, and estimates from earlier studies indicate an exploitation rate up to 70 % for Tana. Humans thus represent a superior predator that is causing mortality greatly exceeding any natural causes for adult salmon. No one should be surprised that this causes changes within salmon stocks.

The perspectives found in the last two paragraphs are further discussed in Chapters 5 and 6.2.1. But, after going through such a list of negatives, it is important to emphasize that there exists a clear positive side to all of this. The Tana river system, as it stands today, still retains a large and healthy total stock size and diversity, and the river system as a whole represents a system with an incredibly high total production potential. The most important future role of managers and researchers thus is to find a sustainable framework for the fishery so that all user groups (both tourists and locals) can get their fair share, without negative (and potentially irreversible) long-term effects on stock composition, size and diversity.

4   Salmon in the Tana river system

The subarctic River Tana (Teno in Finnish, Deatnu in Sami) forms the border between northernmost Norway and Finland (70 ° N, 28 ° E). The river drains an area of 16 386 km^2 (of which almost 70 % is in Norway) and the river system consists of a multitude of small and large tributaries (Table 1 and Figure 1), most of which are readily accessible for ascending salmon. Historically, salmon have been found distributed over a total of over 1 200 km, but in the last three decades there are indications that some of the fringe areas are no longer utilized, decreasing the distribution down to under 1 000 km (Table 1). The numbers in Table 1 are gathered from various sources (mainly interviews with local people living in the Tana valley), and therefore do not represent objective scientific facts. The main value of the table, however, lies in its display of the complexity of the system, with the large number of tributaries each potentially supporting distinct and unique salmon stocks.

In addition to the productive main stem, there are more than 30 tributaries supporting distinct spawning stocks (Berg 1964; Moen 1991; Elo *et al.* 1994), and by use of polymorphic microsatellite markers high genetic differentiation among stocks from the different tributaries has been revealed (Vähä *et al.* 2007). DNA microsatellites have indicated pairwise F_{ST}[1] values between inferred populations ranging from 1.5 % to 20.1 % with an average of 9.2 %.
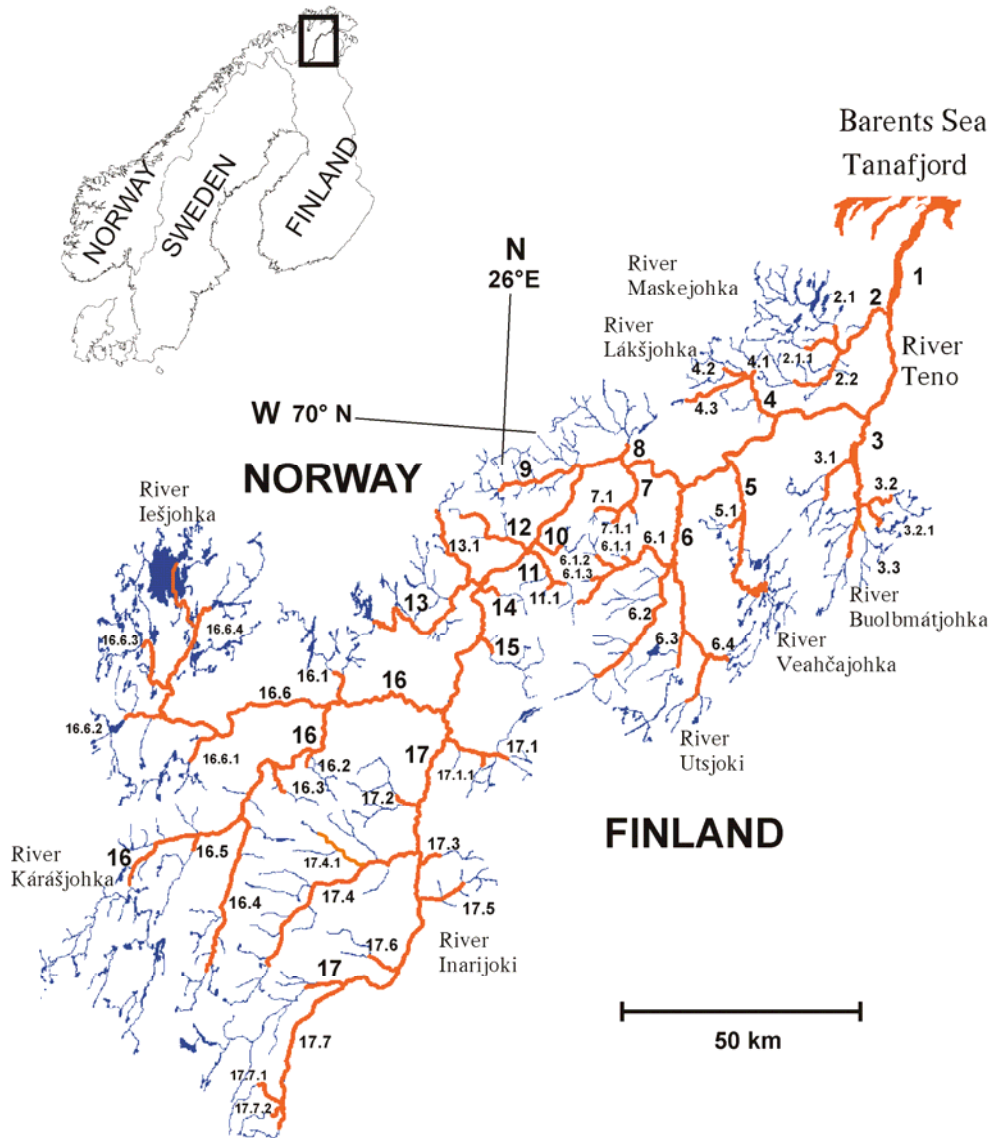
Figure 1: Map of the Tana river system. The orange line indicates the historical distribution of salmon based on historical sources and interviews. The numbers correspond to Table 1. (Map from Eero Niemelä, FGFRI)

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[1] F_{ST} refers to the proportion of the total genetic variance contained in a subpopulation relative to the total genetic variance. Values can range from 0 to 100% (or from 0 to 1). High F_{ST} implies a considerable degree of differentiation among populations.

Table 1: The historical (in 1930-1978) and present (in 1979-2003) distribution of salmon in the Tana river system. + occurs on a regular basis; (+) occurs occasionally; ↑ catches have improved; ↓ catches have declined; − no longer found. (Numbers are collected and systematized by Eero Niemelä, FGFRI, based on various scattered historical sources (unpublished) and several interviews with local people the last two decades.)

River		Historical distribution				Present distribution				
		1930–1978				1979–2003				
		km	1SW	2SW	3SW	4-5SW	km	1SW	2SW	3SW	4-5SW
1	Tana/Teno	211.0	+	+	+	+	211.0	+↑	+↑	+	+↓
2	Maske	30.9	+	+	+		30.9	+	+	+↓	
2.1	Geasis	6.9	+	+	+		6.9	+	+↓	+↓	
2.1.1	Uvjaladnja	6.7	+	+			6.7	+	+↓		
2.2	Ciicujohka	10.9	+				10.9	+			
3	Buolbmát/Pulmanki	39	+	+	(+)		39	+	+	−	
3.1	Gálddaš	13.5	+	+			13.5	+↓	−		
3.2.	Luossa	6.8	+	(+)			5.5	+↓	−		
3.2.1	Skiihpa	6.7	+				6.7	+↓			
3.3	Morešveai	3.4	+				3.4	(+)			
4	Lákš	13.7	+	+	(+)		13.7	+	+↓	+↓	
4.1	Garpe	0.7	+	+			0.7	(+)	(+)		
4.2	Gurte	9.4		(+)	(+)		9.4	+	(+)	(+)	
4.3	Deavkehan	17.5		(+)	(+)		17.5	+	(+)	(+)	
5	Veahća/Vetsi	42.6	+	+	+		42.6	+	+	(+)	
5.1	Váis	5.8	+				5.8	(+)			
6	Utsjoki (lower)	22.2	+	+	+	+	22.2	+	+↓	+↓	+↓
6.1	Ćárse/Tsars	31.2	+	+			31.2	+↓	(+)		
6.1.1	Njiðgu	4.9	+				4.9	(+)			
6.1.2	Liŋkin	5	+	(+)			5	(+)	−		
6.1.3	Uhtsa-Ćárse	3.9	+				3.9	(+)			
6.2	Geavvu/Kevo	35.7	+	+	+		27.5	+↓	(+)	−	−
6	Utsjoki (upper)	36	(+)	+	+	(+)	31.2	+↓	+↓	(+)	−
6.3	Cuoggá	7.6	+	+	(+)		7.6	(+)	−	−	
6.4	Gukće	7.3	+	(+)	(+)		1.7	(+)	−	−	
7	Goahppelaš/Kuoppilas	13.4	+	+	(+)		9.6	+↓	(+)	−	
7.1	Birke	9.7	+	+			1.2	(+)	−		
7.1.1	Koaskim	2.6	+	+			0	−	−		
8	Borse	5	+	+			0.9	(+)	(+)		
9	Leavva	24.1	+	+	+		12	+↓	(+)	−	
10	Nuvvos	7.9	+	+			0	−	−		
11	Njilj	12.7	+	+			12.7	(+)	(+)		
11.1	Mávnnáveai	2.1					2.1	(+)			
12	Báiš	19	+	+	(+)		8.3	+↓	(+)	−	
13	Válj	45.1	+	+	+	(+)	34.6	+↓	(+)	(+)	−
13.1	Áste	18.7	+				3.5	+↓			
14	Jeagelveai	4.3	+				0	−			
15	Áhko	5.1	+	+	(+)		5.1	(+)	(+)	−	
16	Káráš	73.5	+	+	+	+	62.5	+↓	+↓	+↓	+↓
16.1	Geaimme	9.8	+	+			9.8	+	(+)		
16.2	Noaidat	7.9	+				0	−			
16.3	Suolga	3.9	+				1.7	+↓			
16.4	Bavta	44.9	(+)	+	+	+	26.8	+	(+)	+↓	+↓
16.5	Suorbmu	2.7	+	(+)			2.7	+↓			
16.6	Ieš	87.1	+	+	+	+	56.1	+↓	+↓	+↓	+↓
16.6.1	Áste	8.2	+	+			8.2	+↓	(+)		
16.6.2	Vuottaš	15	+	+			0	−	−		
16.6.3	Ráges	14.7	+	+	+		0	−	−	−	
16.6.4	Molleš	4.3	+	+	+		0	−	−	−	
17	Inari	93.2	+	+	+	(+)	93.2	+↓	+↓	(+)	−

Atlantic salmon monitoring and research in the Tana river system

17.1	Gáregas	18.2 +	+	(+)	18.2 +↓	(+)	−	
17.1.1	Vuorgoćearáv	0.9 +			0.3 −			
17.2	Iškoras	5 +			0 −			
17.3	Guoldná	6.1 +			0 −			
17.4	Gorzze	38.1 +	+	+	14.1 +↓	(+)	(+)	
17.4.1	Vuzzul	17.4 +	+		2.9 (+)	−		
17.5	Vuopmaveai	12.9 +			12.9 (+)			
17.6	Casken	8 +	(+)		4 +↓	−		
17.7	Skiehććan	37.1 +	+	+	0 −	−	−	
17.7.1	Njuolas	8 +	+		0 −	−		
17.7.2	Rádjá	2.5 +	+		0 −	−		
	Total km	1 268			963			

The annual salmon catches in the river have fluctuated between 70 and 250 t with an average of 140 t, equivalent to up to 50-60 000 salmon harvested yearly with multi-sea-winter (MSW) fish representing an average of 40 % of the catch. The sea fisheries along the Finnmark coast present nearly 200 tonnes per year of which more than 65 % constitutes Tana salmon. The total salmon production of the River Tana system then including both river and sea catches and the spawning escapement is estimated to be up to 600 tonnes (NOU 1999). Thus, although one of the northernmost Atlantic salmon rivers in the world, the River Tana today most likely supports the largest wild stock of Atlantic salmon in the world, and despite documented high rates of exploitation, it is still characterized by important contributions of 3, 4, and even some maiden 5SW spawners.

Salmon fishing in the River Tana system has been regulated since 1873 by bilateral agreements between Finland and Norway. The general fishery agreement is concluded between the governments of Finland and Norway, and this agreement primarily regulates the local fisheries and their fishing rights. Regional authorities in both countries regulate the tourist angling, and these regulations can be amended on a yearly basis. The latest general agreement, concluded in 1990, states for instance, that the fishing season commences May 20 and terminates August 31. Net fishing is allowed three days per a week and drift net fishing can take place only in the beginning of the season until June 15. All fishing is prohibited for one day in a week.

The salmon fisheries include various fishing methods such as weir, gill net, seine, drift net and rod and line. The net fisheries are practiced by local people and it is permitted by fishing rights based on land owning, agriculture production or inherited rights. The rod catch comprises 55-65 % of the catch. However, in recent years, rod effort has increased whereas the numbers of nets have declined. Fishing in the lower section is mixed-stock fishery throughout the season, whereas this is true for the upper section until the second half of July, when stocks from the tributaries have mostly ascended into their spawning rivers. In the upper section, fishing in August is directed to sub-stocks reproducing mainly in the main stem. According to two telemetry tagging experiments in the early 1990s, harvest rates in the river fisheries can reach the levels of more than 60 % (Erkinaro *et al.* 1999; Karppinen *et al.* 2004).

In salmon rivers in both the northeast and northwest Atlantic, return rates has decreased significantly the last 50 years, whereas the salmon stocks of the river Tana fluctuate in a cyclic manner with no clear declining trend. The same tendency has been seen in the salmon rivers of the Kola Peninsula, suggesting that the Tana River together with the other salmon rivers in the Barents Sea areas constitute the most important production area of wild Atlantic salmon in the world. However, with the potential for overexploitation (included within-river mixed exploitation) of the Tana salmon stocks, impacts from salmonid aquaculture, the expanding oil industry in the Barents Sea, and uncertain consequences resulting from global climate change (Bigg 2000; Drinkwater 2000), it is important to monitor the dynamics of salmon populations in one of the few remaining large river systems that still support abundant salmon stocks with little or no human impact to the system, except for fishing. Attention should be focused specially on monitoring of the size and composition of the spawning stocks, recruitment, smolt production, survival rates and exploitation.

The catch statistics for the Tana river system have historically been divided into two separate parts, the Norwegian catch and the Finnish catch. Responsible for calculating the Norwegian catch have been the County Governor of Finnmark, while the Finnish Game and Fisheries Research Institute (FGFRI) have calculated the catch on the Finnish side.

From 1973 until 2007, the Norwegian catch have varied greatly, from a high of nearly 180 000 kg in 1975 down to a low of 32-33 000 kg in 2004 and 2005 (Figure 2). There is thus considerable variation in the catches, with peaks seemingly every 8-9 years. Worth noting from the figure is that the catch in the last 4 years represent a transition period in which a large number of changes have been introduced to the Norwegian methodology, culminating in the numbers from 2007 being based exclusively on reported catch. All earlier numbers have had some degree of estimation of total catch based on a varying percentage reported catch.
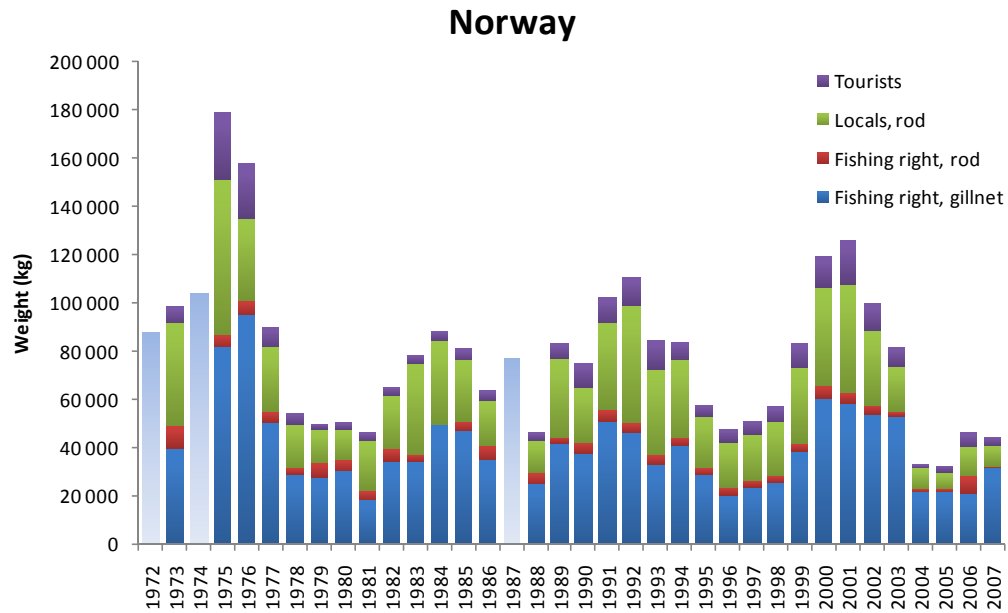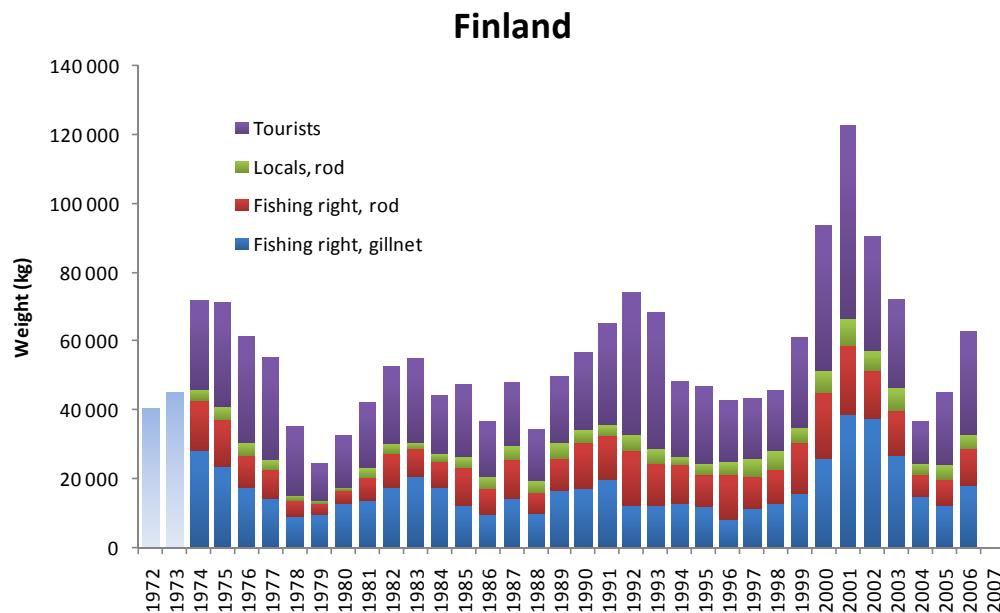
Figure 2: Norwegian catch (weight in kg) of salmon in the Tana river in the period 1972-2007. Lightly shaded years (1972, 1974 and 1987) represents seasons in which the available catch data is without fishing gear. (Data provided by the County Governor of Finnmark)

The Finnish catches from Tana also show variation from year to year (Figure 3), and the general pattern of good and bad periods coincide well. The highest year was seen in 2001 with an estimated catch of nearly 123 000 kg. The lowest year was 1980 with an estimated catch just above 32 000 kg.

Finland

Figure 3: Finnish catch (weight in kg) of salmon in the Tana river in the period 1972-2006. Lightly shaded years (1972 and 1973) represents seasons in which the available catch data is without fishing gear. (Data provided by FGFRI)

When the total catch is compared between Norway and Finland, a trend emerges showing that the extent of the Norwegian fishery is declining while the Finnish catches make up a larger and larger proportion (Figure 4). During the 1970s and 1980s, the Norwegian catch was responsible for 60-70 % of the total catch. During the 1990s, this proportion gradually declined towards 50 %, and in the last three seasons (2004-2006) the Finnish catch has made up over 50 % of the total.
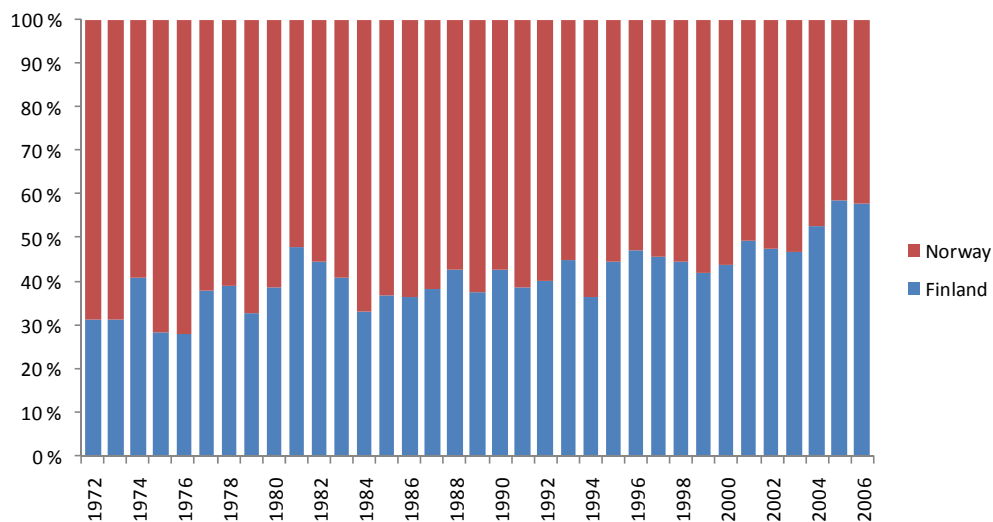

Figure 4: Relative distribution of catch (weight) between Norway and Finland in the period 1972 to 2006. (Data provided by the County Governor of Finnmark and FGFRI)
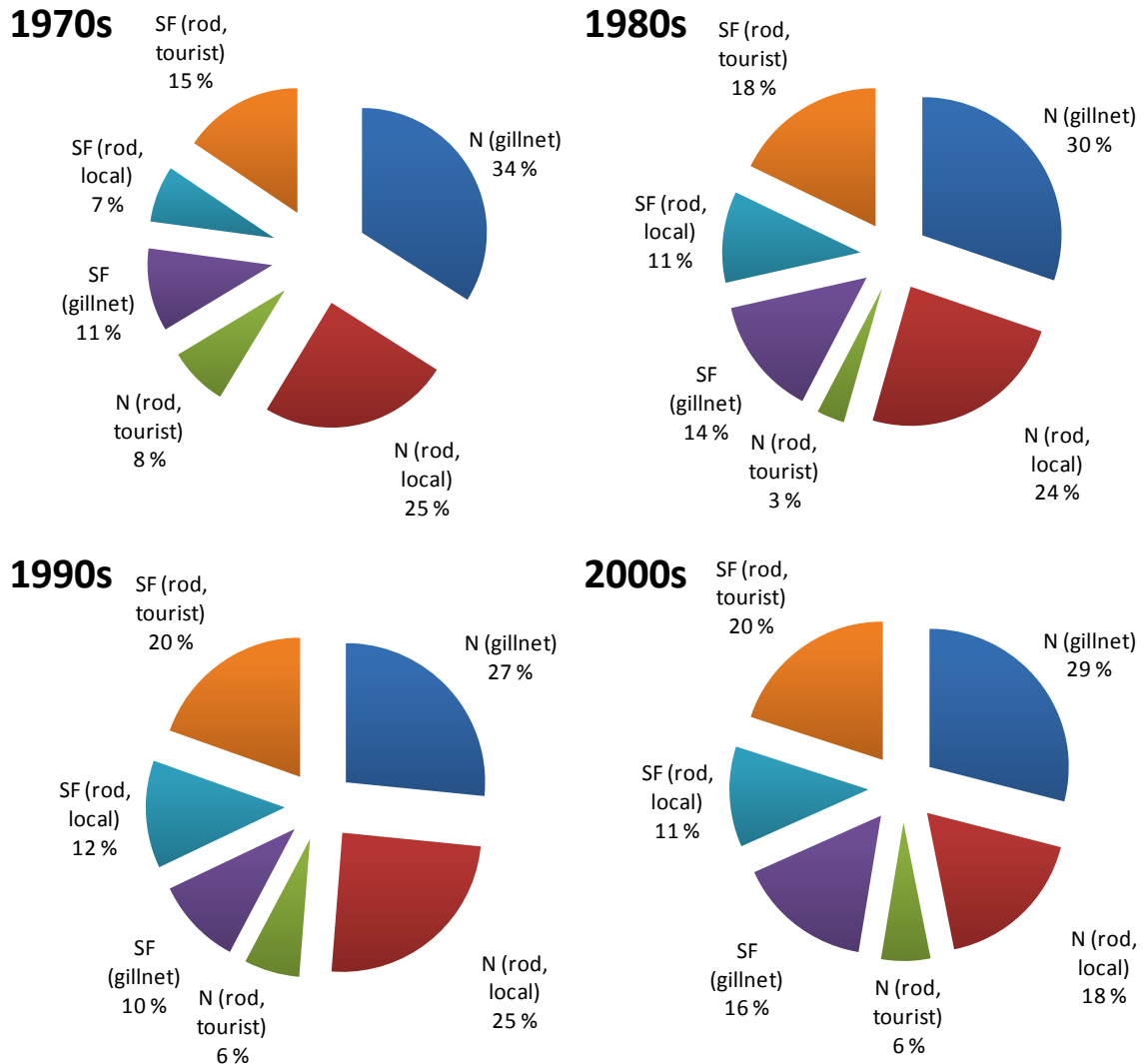
1970s

1980s

1990s

2000s

Figure 5: Total catch of salmon (weight) in Tana distributed into different fishermen categories. (Data provided by the County Governor of Finnmark and FGFRI)

Looking at the total catch divided into fisherman categories, we see that in the last three decades the relative contribution of local traditional gillnet-based methods have been relatively stable, varying between 37 % (1990s) and 45 % (2000s) (Figure 5). The Norwegian rod catches have declined slightly in contribution in the period, down from 32 % in the 1970s to 24 % in the 2000s. The Finnish rod catch have increased in relative contribution from 22 % in the 1970s up to 31-32 % in the 1990s and 2000s.

Looking more into detail on the Norwegian catch from the 1970s up until today, we see that gillnet-based methods most of the time accounts for more than 50 % of the catch. The exception is the 1990s, where gillnets, weirs and drift nets together contributed 46 % of the catch (as opposed to 51-55 % in the other decades) (Figure 6). Most of the gillnet catch is taken in drift nets and weirs, but there seems to be an increasing amount of fish being taken in standard

gillnets (up from 4 % in the 1970s to 10 % in the 2000s). Local rod catch is varying between 34 % (2000s) and 43 % (1990s). The highest contribution from tourists was seen in the 1970s, where tourists accounted for a total of 12 % of the Norwegian catch, while the lowest contribution was in the 1980s with 6 %.
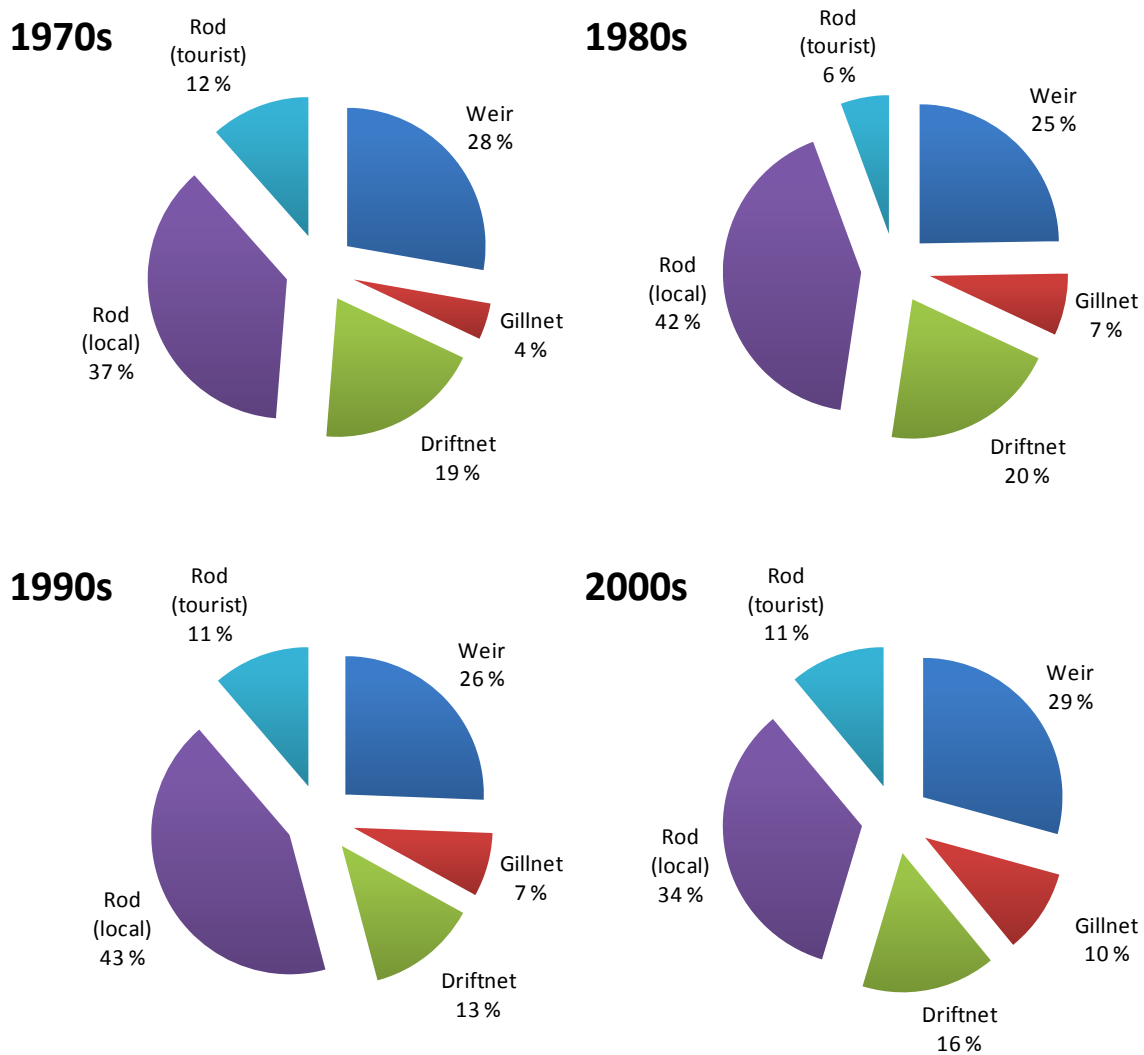

Figure 6: Norwegian catch (weight) in Tana divided into different fishing gears. Note that in addition to the gears shown, seine is also allowed. It is however omitted from the figure due to very low percentages each decade. (Data provided by the County Governor of Finnmark)
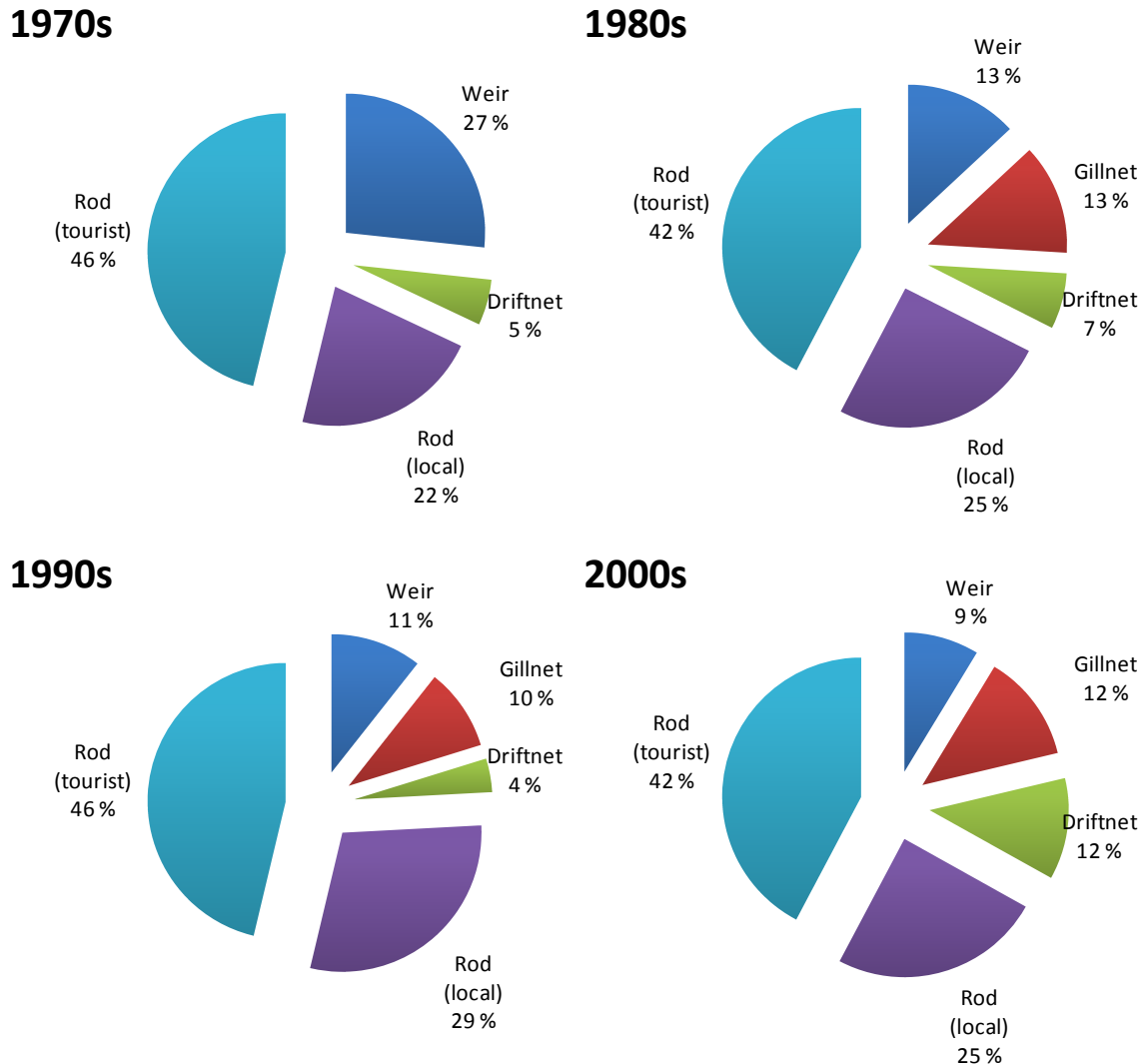
Figure 7: Finnish catch (weight) in Tana divided into different fishing gears. Note that in addition to the gears shown, seine is also allowed. It is however omitted from the figure due to very low percentages each decade. (Data provided by FGFRI)

The Finnish catch shows a different pattern from the Norwegian. In Finland, a much higher percentage of the fish is caught using rod, with gillnet based methods accounting for between 25 % (1990s) up to 33 % (1980s and 2000s) (Figure 7). Correspondingly, rod accounts for 67-75 % of the Finnish catch. Tourist fishermen have a much larger impact on the total catch in Finland than in Norway. While in Norway the tourists varies between 6-12 %, the tourists in Finland accounts for 42-46 % of the catch.

An interesting picture emerges when a comparison is made between the Norwegian catch statistics from Tana and other rivers in Finnmark (Figure 8). During the 1970s and 1980s, the cathes were positively correlated, with high catches in Tana meaning high catches in other Finnmark rivers. The slope of this regression is 2.33, and the R^2 is 0.61. In the 1990s, the correlation is still significant and positive. The slope however is down to 1.33 and the R^2 equals

0.54. In the last few years (the 2000s), the earlier positive relation has broken down, and as shown in Figure 8 (right), there is no relationship between catches (R^2=0.04). This is one indication that the salmon in the Tana river system have had a negative development relative to what other rivers in Finnmark have experienced.

However, in the evaluation of Figure 8, it is important also to be aware that most other Finnmark rivers historically have used other methods of gathering catch statistics than Tana. Whereas the numbers from Tana represent an *estimation* of the total catch based on extrapolation from those few that have reported, the numbers from most other rivers are based on *actually reported* numbers based on very low catch report percentages in the 1970s-1990s. In the later years (2000s), the introduction of deposits in these other Finnmark rivers have caused reporting rates to increase, thus probably also causing a relative increase when compared with Tana.
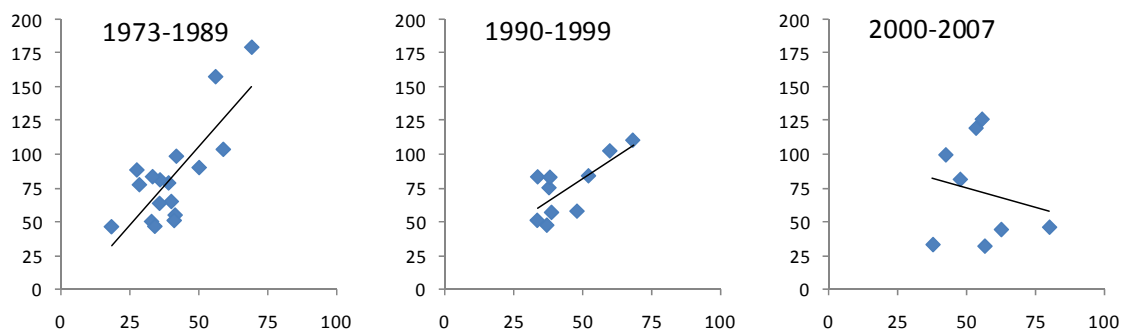

Figure 8: Regressions comparing the Norwegian catch of salmon in Tana (vertical axis) with other rivers in Finnmark (horizontal axis). Both axes represent weight in tonnes. Figure to the left shows the time period 1973-1989 (equation y=2.33x-11.03, R^2=0.61), figure in the middle shows 1990-1999 (equation y=1.33x+15.64, R^2=0.54) and figure to the right shows 2000-2007 (equation y=-0.59+105, R^2=0.04). (Data provided by the County Governor of Finnmark)

Through the scale sampling project (further described in section 6.2.2), a hugely valuable time series dating back to the early 1970s have been collected containing data describing various parameters of the stock diversity complex in the Tana river system. Based on the scales, it is possible to estimate the relative abundance of different sea age classes captured throughout the fishing season and by different gear types.

The available data from 1973 to 2006 is shown in Figure 9. Several of the autocorrected regressions are statistically significant, but most notably and worrying is the trend for large MSW (3- and 4SW) salmon, especially the females. Even though the numbers cycle up and down, there is a clear negative trend showing that the return of large fish is diminishing within the time series period. At the same time, the plots for 1- and 2SW fish give the impression of a more positive trend.

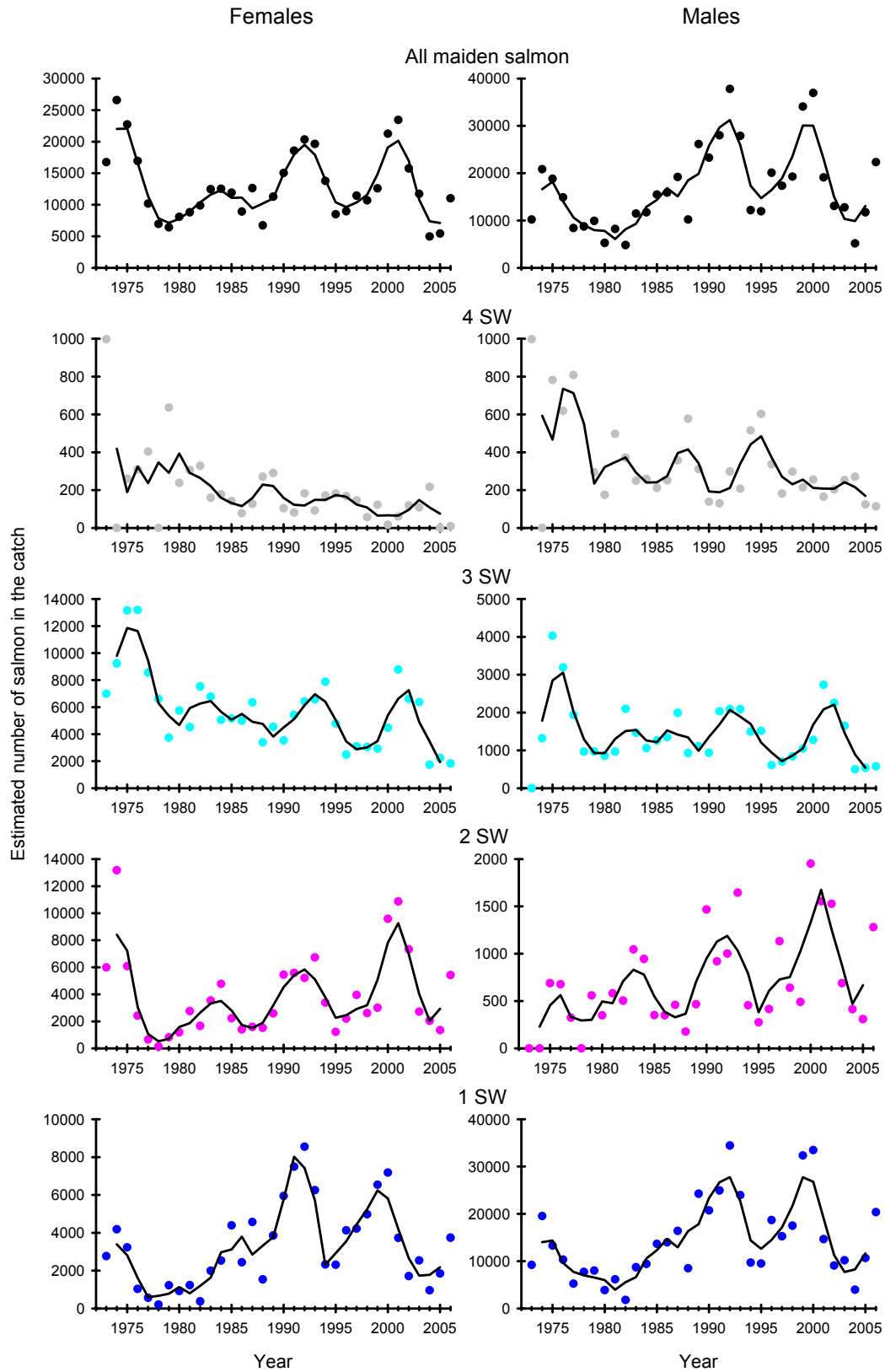Atlantic salmon monitoring and research in the Tana river system

Figure 9: The estimated number of captured salmon in the Tana river system with autocorrected regression analyses for the period 1973-2006. (Modified after Niemelä *et al.* 2006)

The same worrying and negative trend for larger salmon that was observed in estimated numbers can be seen when the estimated stock situation is plotted as percentages (Figure 10). First of all, the figure readily illustrates how most of the males are 1SW fish, while historically most of the females have been MSW fish. In the last couple of decades, however, the relative percentage of MSW females has decreased and the proportions of females returning as 1SW and 2SW fish have increased. Also noticeable in Figure 10 is the relatively high proportion of previous spawners that have been seen in the Tana river system during the later years (especially the years 2001-2004).
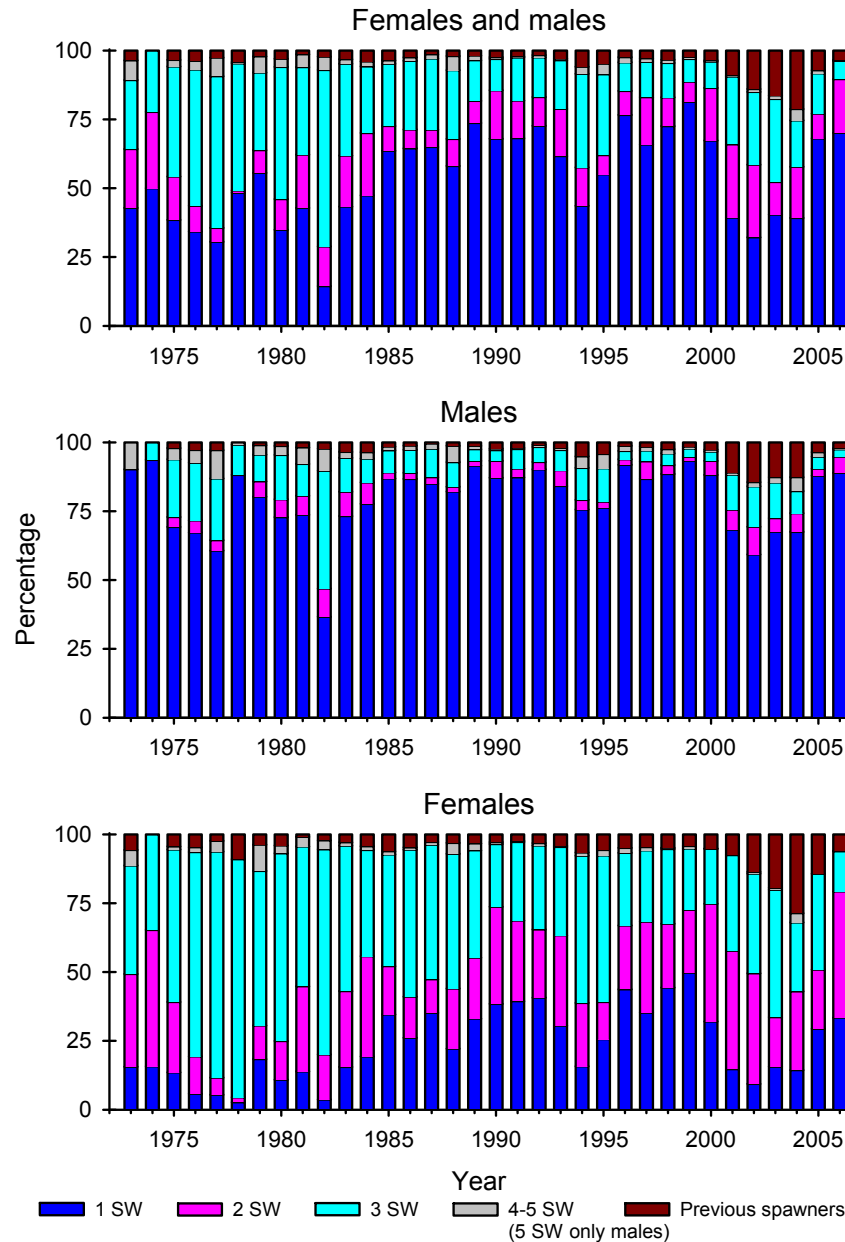
Figure 10: The estimated sea-age distribution based on number of salmon captured in the Tana river system during the period 1973-2006. (Modified after Niemelä 2004)

Atlantic salmon monitoring and research in the Tana river system

The scale samples are gathered from different parts of the Tana river system, and we can thus get a picture of the salmon size composition in different areas (Figure 11). The smallest tributaries are dominated by 1SW fish (both males and females) with a small to medium percentage 2SW females. MSW fish are mainly found in Tana main stem, the Norwegian tributary Maskejohka and the uppermost large tributaries Karasjohka and Iesjohka. In the latter two rivers, the female spawning stocks are almost exclusively 2- and 3SW fish.
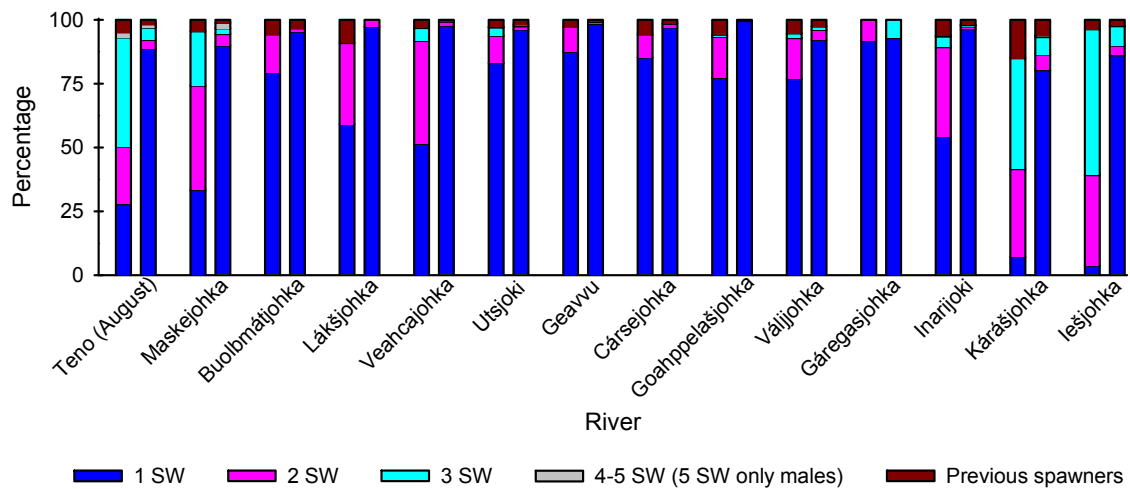

Figure 11: The estimated percentage sea-age distribution of fish caught in different areas of the Tana river system. (Figure from Niemelä 2004)
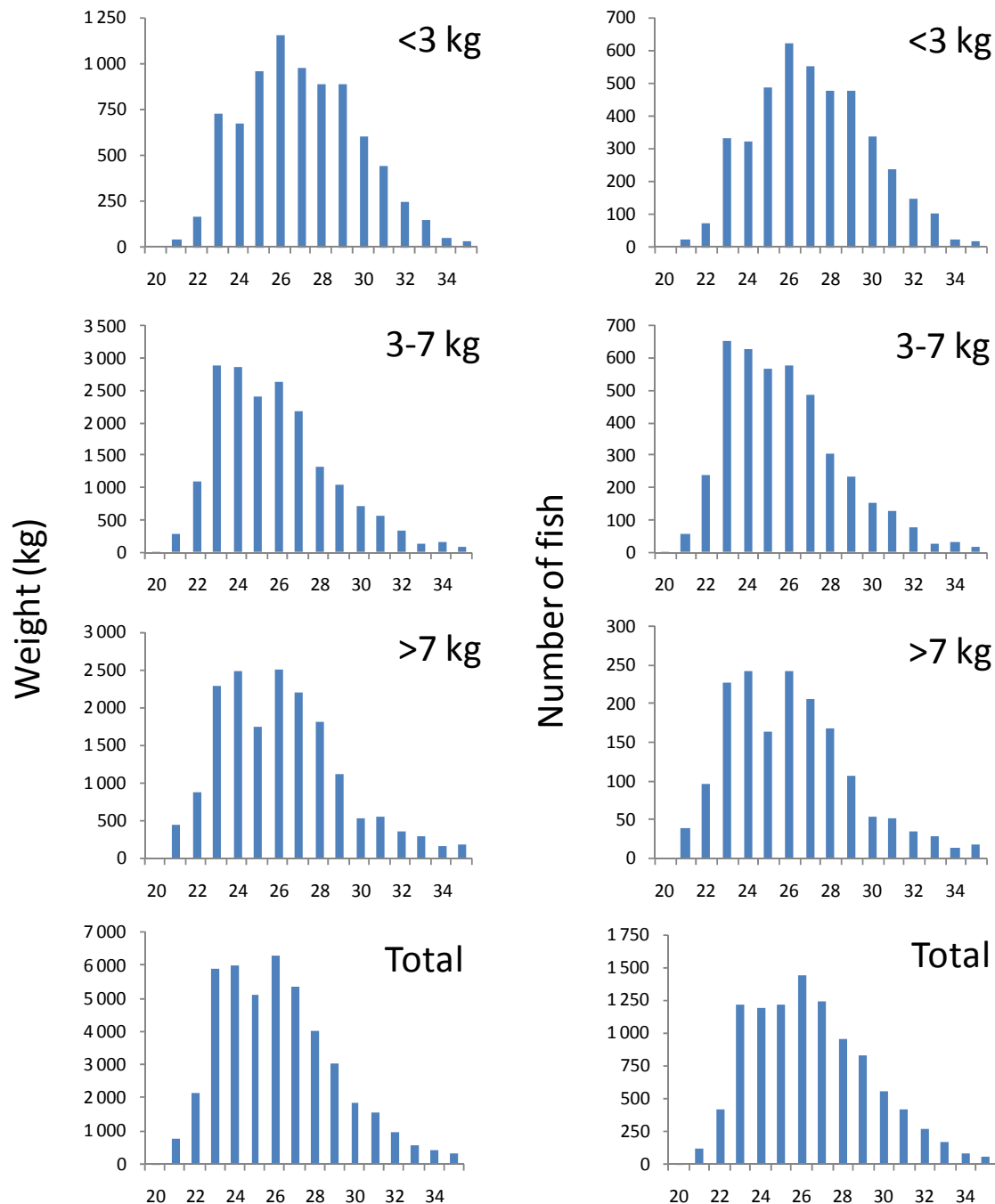
Figure 12: Norwegian catch of salmon in the Tana water course in 2007 separated into weeks (20-35). Weights are given to the left while numbers are given to the right. Size classes correspond roughly to sea ages: <3 kg as 1SW, 3-7 kg as 2SW and >7 kg as MSW. (Data provided by the County Governor of Finnmark)

The resolution of the Norwegian catch allows the plotting of the catch of different size groups within each week of the season, as shown with the data from 2007 in Figure 12. Most of the larger salmon comes early and is taken by the end of June, while the peak catch of smaller salmon is from late June/early July. Very few salmon are taken in August.

The salmon ascending towards the upper parts of the river system must cover long distances, thus it is expected that salmon originating from the upper tributaries such as Anarjohka/Inarijoki, Karasjohka and Iesjohka, were captured relatively late in the season. Data from scale samples show some surprising results, with most of the MSW salmon in Karasjohka and Iesjohka being caught as early as the middle to the end of June (Figure 13). Median dates of capture in these uppermost areas are comparable to median dates for the lower part of Tana mainstem (and slightly earlier than median dates for the middle part of Tana mainstem), indicating that the salmon ascending to Karasjohka and Iesjohka (about 240 km from the Tana estuary) is entering the Tana river very early in the season.
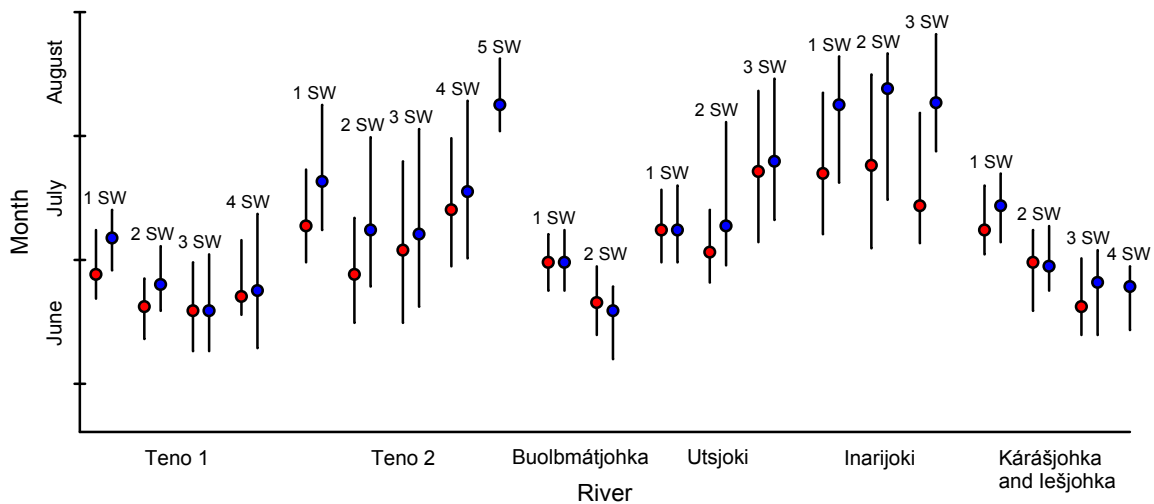

Figure 13: Median dates (SD) of 1-4SW (sea winter) salmon captured in the Tana river system in the period 1997-2005. (Data from Eero Niemelä, FGFRI)

5   Reference points and management targets

The management of salmon has increasingly become target-focused following initiatives from NASCO, starting with the agreement of the contracting parties in 1998 to adopt and apply a Precautionary Approach to the conservation, management and exploitation of Atlantic salmon. A procedure for this management regime is further detailed and formalized in the document "*Decision structure for the management of North Atlantic salmon fisheries*" (CNL31.332 2002).

The basis for the Decision Structure is to provide a consistent basis and approach for the management and exploitation of salmon throughout the North Atlantic distribution area. Emphasis is put on establishing reference points such as conservation limits and management targets, and management actions that are triggered when the stock status fail to meet the designated targets.

The development of biological reference points should thus provide managers and scientists an ability to assess the fish stock status and evaluate exploitation. The reference points take two

forms: *limits* and *targets* (United Nations 1995). The *limit* is a boundary which ideally should not be crossed, and *limit reference points* thus demarcate undesirable stock or fishery levels. The *target* is, on the other hand, a point to aim at, and a *target reference point* thus is the basis for optimizing a particular outcome. Uncertainties and variations will make it virtually impossible to hit a target every year, but the stock level should be fluctuating around the designated target level.

In management these reference points are usually called "*conservation limits*" and "*management targets*". The conservation limit is the stock level below which recruitment would increasingly and significantly fail. The management target is the stock level over which management can be certain that the stock is above the undesired conservation limit. The Precautionary Approach requires "that conservation limits and management targets be set for each river and combined as appropriate for the management of different stock groupings defined by managers" and "that stocks be maintained above conservation limits by means of management targets".

There are no clear rules about how conservation requirements should be defined, and as a consequence a large number of different types of reference points have been developed for use in the management of different fish stocks (e.g. ICES 1997). The definitions do for instance not determine where the limit and target levels should be set, and the choice here obviously depends upon several factors (e.g. harvest strategy, degree of uncertainty, level of risk that managers are willing to take etc.).

One possible approach is to set the conservation limit very low. A low level might still protect the stock from being fished into extinction, but it would not ensure optimum use of available habitat and therefore also not provide optimized catch rates. Such an approach would also need a very high probability that the limit was not crossed, as crossing a very low limit could have severe consequences for the stock. Conversely, for a more conservative set limit, it could be acceptable for the stock to fall below the limit more frequently.

A particular problem that managers of salmon face is the complex life cycle of salmon. Throughout its life cycle, the salmon migrates between different habitats (freshwater and seawater) over large areas (rivers, coastal areas, open water). Also, around the North Atlantic, there are at least 2 000 separate and unique river stocks, most of which are exploited in common oceanic and coastal mixed stock fisheries in addition to more stock-specific river fisheries. This complexity ensures the need for a consistent and objective approach for setting the reference points, and ICES therefore have proposed that the first step in setting biological reference points for salmon should be to base them upon established stock-recruitment relationships.

There is a growing concern among researchers about an apparent connection between exploitation through fisheries and evolution. Fisheries represent a human-induced selection pressure acting on top of natural selection, and some studies show that this pressure can cause

rapid evolution, mainly since fishing has become the main source of mortality in most fish stocks, often exceeding natural mortality by several hundred percent (Jørgensen *et al.* 2007).

Fisheries-induced mortality may have important consequences for several life-history traits. Life-history theory predicts that increased mortality should favour evolution towards earlier sexual maturation at smaller size and elevated reproductive effort. Several studies on different fish species have been published recently showing that fishing leads to:

- Maturation at a lower age
- Maturation at a smaller size
- Reduced annual growth
- Increased fecundity
- Loss of genetic diversity

These negative effects are especially conspicuous when the fishing is selective with respect to size, maturity, behaviour or morphology. This have been documented for several species, and the question is no longer related to whether or not such evolution occurs but more focused on how fast the fisheries bring about evolutionary changes (Jørgensen *et al.* 2007). Documentation is presently lacking for salmon, but potential selectivity issues with the fisheries in Tana make it probable that these issues exist and might cause increasingly negative developments in the future.

All of the above listed changes are negative from the perspective of the fisheries. All over the distribution range of salmon, there has been a general tendency the last decades for the average size to become smaller and smaller. This also seems to be true for the Tana salmon, where the MSW component of the stock clearly have been declining the last decades.

A further consequence of changing basic life history traits through fisheries is the consequence these changes has for the production level and yield of each stock. The direction of the changing traits will consequently lead to lowered yield, lowered potential production, and thus also change the conservation limits. This means that the management targets no longer are fixed, but rather moving in step with the fishing regime.

Evidence of local adaptations in salmon is still indirect and comes mostly from ecological correlates in fitness-related traits. The scale and extent of adaptive variation is still poorly understood, but it probably varies with habitat heterogeneity, environmental stability, selection and drift. It is argued that acting as if stocks are not locally adapted carries a great risk of mismanagement (García de Leániz *et al.* 2007).

The loss in genetic diversity might lead to a situation in which the genetical basis for variation in a life-history trait disappears. As a consequence of this, a change in fishing regime through stronger regulations might potentially not result in the salmon stock moving back towards pre-fishery conditions. This bleak view illustrates the importance of the precautionary approach and the real need for establishing a sustainable, adaptive and evolutionary enlightened management

of Tana as soon as possible. The evolutionary approach means aiming to maintain the conditions necessary for natural selection to operate unhindered, minimising alterations to native genotypes and habitats, and allowing for stock sizes above carrying capacities so that competition and other sources of natural mortality are encouraged.

5.1   Spawning targets

A major objective for salmon conservation and fisheries management is to develop a practical basis for managing individual salmon stocks and the environment in which they live in order to optimise sustainable yield. One way of achieving this, is to specify stock-specific targets for reproduction (e.g. egg deposition). For a salmon stock, the number of adults estimated to be lost through exploitation and natural mortality subtracted from the total run size, is called the spawning escapement. This escapement can be converted to a total egg production for the stock and then compared to a stock-specific threshold value for egg production. This threshold is the conservation limit (CL) (or Minimum Biologically Acceptable Limit) recommended by NASCO, and is the stock level that supports maximum yield and thus maximises potential yield under the life-cycle characteristics applying to the stock.

The CL is the threshold level below which stocks should not fall, and it is recommended that managers should aim to hold escapement at a higher (unspecified) level termed the management target. A first step in establishing such targets for different parts of the Tana river system has already been taken through the work of Hindar et al. (2007) (Table 2), and further details on the model and process behind the suggested targets can be found in their report.

Below the suggested spawning targets are summarized and compared to the present stock situation in the Tana river system. It is important to emphasize here that these numbers are the result of a first attempt at estimating a target. The numbers are therefore untried and as such should not be interpreted as exact threshold limits, even though they are presented as such in Table 2 and Figure 14-Figure 18.

There are several uncertainties and assumptions contained in the estimation of target (egg/m^2) and area, each of which can have a significant impact on the total number of females needed to meet the target. For some parts of the system (e.g. Tana main stem, Anarjohka and Utsjoki), the given area are an estimated production area, while for other parts (e.g. Karasjohka and Iesjohka) the areas are calculated using a GIS approach on existing maps. These two methods are hardly comparable. The latter method will result in a very high area (as it will represent the wetted area during floods), while the former method will result in a relatively low area. A 50 % reduction in area will result in a 50 % in total number of eggs (if the target in eggs / m^2 is kept constant). However, this situation is not as bad as it might sound immediately, as the choice of method for area calculation also have had an impact on the choice of target (eggs / m^2) with the target being regulated down with the GIS calculated areas.

But, even given this disclaimer, it should also be strongly emphasized that the NASCO precautionary approach clearly puts a strong demand on managers to use all **available**

knowledge when deciding on management measures. This means that even though problems can easily be recognized with the presented targets, they still represent the **best** knowledge we have as of today and should be treated as such. This is especially urgent given the negative indications seen in various parts of the Tana river system (see Figure 9 for the negative trend in large multiseawinter salmon, and Figure 15 and Figure 16 for the huge discrepancy between spawning target and estimated spawning stock in the upper part of the system).

Table 2: Estimated spawning targets for different parts of the Tana river system (table from Hindar *et al.* 2007).

River	Target (eggs/m²)	Area (m²)	#eggs to meet target	Total weight adult females (kg)	Average weight (kg)	#adult females needed
Tana (main stem)	2	19 060 000	38 120 000	21 178	5	4 236
Anárjohka	2	8 300 000	16 600 000	9 222	4	2 306
Utsjoki	6	600 000	3 600 000	2 000	2.25	889
Kárásjohka	2	10 351 020	20 702 040	11 501	6	1917
Iešjohka	2	5 175 610	10 351 220	5 751	6	958
Láksjohka	4	745 365	2 981 460	1 656	1.5	1 104
Máskejohka	4	1 069 238	4 276 950	2 376	4	594
Leavvajohka	1	502 680	502 680	279	2	140
Valljohka	1	618 090	618 090	343	2	172
Other tributaries	1	808 130	808 130	449	2	224
Tana (total)		47 230 133	98 560 570	54 756		12 539

A major point of notice here is the presence in Table 2 of some tributary-specific management targets. As such we are not presently at the point where we can talk about stock-specific targets for the stock complex of the whole Tana river system (especially the main stem), as we are lacking spatial boundaries of the different stocks.

It should however be recognised that there is a clear need to focus on conservation of each discrete stock component, as exchange of individuals among populations appears to be low, at least in the short term, neighbouring populations do not necessarily compensate for local shortfalls in production elsewhere (Youngson *et al.* 2003). The main problem here is, of course, that current resource limitations make it impossible to obtain total coverage for assessments of any refinement on any geographical scale within the system, and in practice, compromise approaches have to be taken. Such compromises will however involve using inter-population numbers, and will probably not be able to catch population specific factors.

Using numbers from catch statistics, it is possible to give some crude estimates on the spawning stock levels both for Tana in total and for some of the tributaries. To be able to do this, some assumptions have to be made about the exploitation rate in the system. Here we have

calculated the estimations using three different exploitation rates for the total estimation in the Tana main stem: 70, 60 and 50 %. For the tributaries, we have used lower exploitation rates: 60, 50 and 40 %. There exist some estimates on the exploitation rate in the Tana river from telemetry studies, showing that the rate can be up to 70 % (Erkinaro *et al.* 1999; Karppinen *et al.* 2004). This is supported by estimated catch rates for MSW Utsjoki salmon in 2004, reaching 80 % (M.-A. Svenning, unpublished data).

To meet the spawning target for the whole Tana river, a total spawning escapement of 54 756 kg females is needed (Table 2). Using an estimated exploitation rate of 70 %, the spawning target is reached only for the year 2001 in the period 1993-2006 (Figure 14). Using 60 % exploitation rate, the spawning target is exceeded in 5 years in the period (1993 and 2000-2003). Using 50 % exploitation rate, the spawning target is exceeded in 6 years (1993, 1994 and 2000-2003).
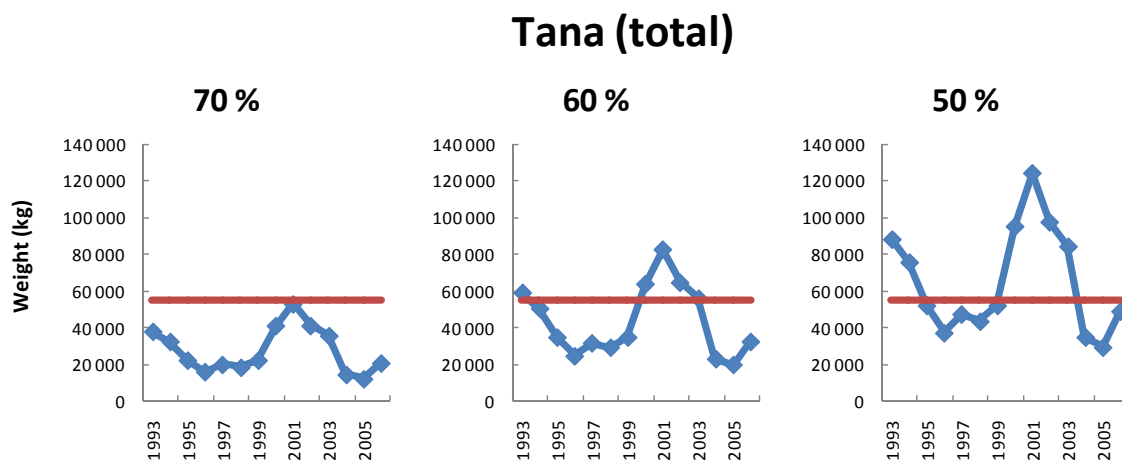

Figure 14: Estimated spawning stock for the whole Tana river system from 1993-2006, based on three different exploitation rates: 70, 60 and 50 %. Spawning target is plotted as a horizontal red line, while estimated spawning stock (females) is plotted as a blue dotted line. (Data provided by the County Governor of Finnmark)

Looking more in detail, we should be able to provide spawning stock size estimates for the different tributaries in the Tana system. One requirement is the existence of tributary-specific catch statistics. The available data is unfortunately very limited in this regard. We have however such tributary specific numbers for the Norwegian tributaries from the year 2004 and onwards. In the evaluation here, it is important to remember also that the catch statistics from 2004-2006 are only reported numbers, while the official total statistic from those years are estimated numbers. For instance in 2006, the estimated total catch is approximately 30 % higher than the reported total catch. It is however methodologically difficult to do tributary-specific estimations, making comparisons a bit difficult from year to year in the below figures.

The spawning escapement (females) needed for Karasjohka to meet its spawning target is 11 501 kg (Table 2). Regardless of the chosen exploitation rate, the estimated spawning stock is far below the stock size needed to meet the spawning target (Figure 15). With the current stock

size, Karasjohka would not be able to meet its spawning target even if the fishery in the area were closed off.

Even given the obvious limitations in the current spawning targets, the discrepancy between estimated spawning stock size and the spawning target is so large that it is a definite cause of concern.
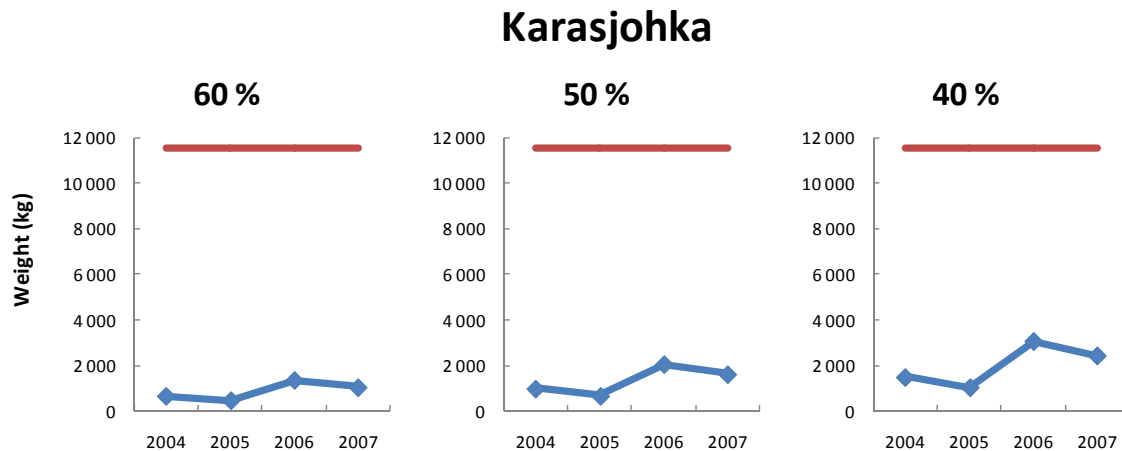
Karasjohka

Figure 15: Estimated spawning stock for the tributary Karasjohka from 2004-2007, based on three different exploitation rates: 60, 50 and 40 %. Spawning target is plotted as a horizontal red line, while estimated spawning stock (females) is plotted as a blue dotted line. (Data provided by the County Governor of Finnmark)

A similar situation as that found in Karasjohka is observed in the neighbouring river Iešjohka. The spawning escapement (females) needed to meet the spawning target here is 5 751 kg (Table 2). Regardless of the chosen exploitation rate, the estimated spawning stock is far below the stock size needed to meet the spawning target (Figure 16). With the current stock size, Iešjohka would not be able to meet its spawning target even if the fishery in the area were closed off.
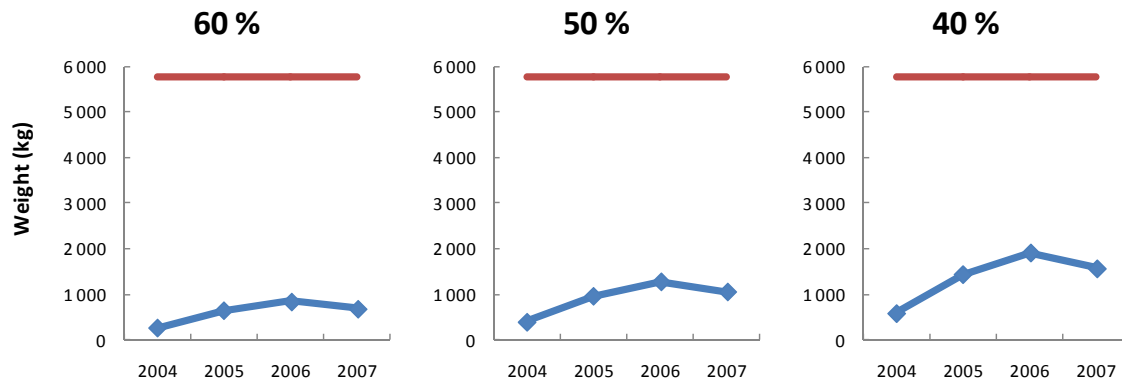
Iesjohka

60 %

50 %

40 %

Figure 16: Estimated spawning stock for the tributary Iešjohka from 2004-2007, based on three different exploitation rates: 60, 50 and 40 %. Spawning target is plotted as a horizontal red line, while estimated spawning stock (females) is plotted as a blue dotted line. (Data provided by the County Governor of Finnmark)

Laksjohka is a small river flowing into the Tana in the lower part of the border area between Norway and Finland. The spawning escapement (females) needed for the river to meet its spawning target is estimated at 1 656 kg (Table 2). Regardless of the chosen exploitation rate, the estimated spawning stock is far below the stock size needed to meet the spawning target (Figure 17).

Laksjohka

60 %

50 %

40 %

Figure 17: Estimated spawning stock for the tributary Laksjohka from 2004-2007, based on three different exploitation rates: 60, 50 and 40 %. Spawning target is plotted as a horizontal red line, while estimated spawning stock (females) is plotted as a blue dotted line. (Data provided by the County Governor of Finnmark)

Maskejohka is a medium sized tributary flowing into the Tana in the lower part of the river. The spawning escapement (females) needed for the river to meet its spawning target is estimated at 2 376 kg (Table 2). Regardless of the chosen exploitation rate, the estimated spawning stock is far below the stock size needed to meet the spawning target (Figure 17).
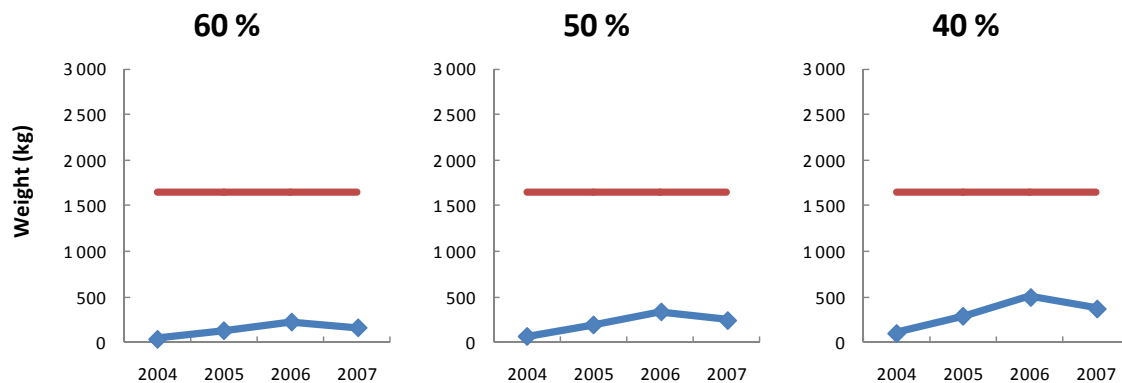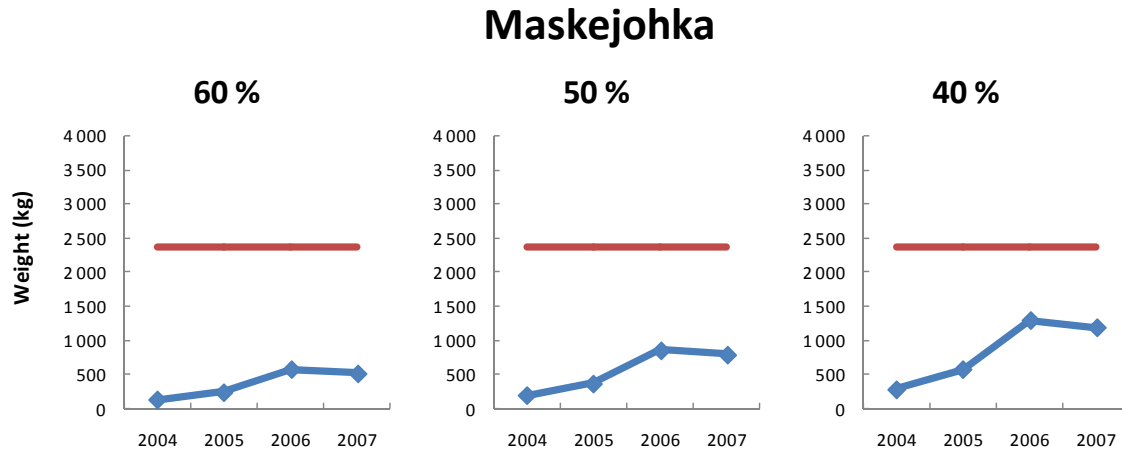
Maskejohka

Figure 18: Estimated spawning stock for the tributary Maskejohka from 2004-2007, based on three different exploitation rates: 60, 50 and 40 %. Spawning target is plotted as a horizontal red line, while estimated spawning stock (females) is plotted as a blue dotted line. (Data provided by the County Governor of Finnmark)

Looking at the tributary-specific numbers, it seems evident that the situation becomes a bit more positive for the tributaries in the lower part of Tana compared to the upper tributaries. While both Maskejohka and Laksjohka are not reaching the spawning targets in any of the years 2004-2007, both tributaries seem to be closer to their designated targets than the uppermost rivers Karasjohka and Iesjohka.

The existing spawning target estimates for the Tana system are mainly derived from general models based on data in a few Norwegian rivers (Hindar *et al.* 2007), and there are obviously a need to refine these estimates. An important target for the monitoring should therefore be to gather data suitable for building future stock-recruitment models specifically for the different parts of the Tana river system.

Basic data is needed on several aspects of the life cycle of salmon to be able to further refine and recalculate the spawning targets. What is needed is basic stock-recruitment data over time, where accurate estimations of spawning stock need to be related to recruitment of juveniles and smolt. The approach taken with the video monitoring in Utsjoki is a good step in this regard. However, additional data is needed in a highly complex river system as Tana, and therefore the monitoring design of adults, juveniles and smolts suggested in chapters 6.1.1-6.1.4 is tailored to meet this demand in addition to fulfilling the need for accurate annual monitoring of the stock situation.

5.2   Juvenile production

Looking at a river, it is obvious that habitat characteristics change spatially within sections of the river. The salmon (both juveniles and adults) have preferences within the habitat range of water depth, velocity, riverbed substratum and cover, meaning that some sections of the river are of a better quality for salmon spawning and juvenile production than others. Distribution of salmon will therefore potentially be inherently patchy, at least on the local scale, because egg

deposition is clumped. The availability of suitable freshwater habitat for spawning and juvenile rearing is therefore important, and it is generally believed that the juvenile freshwater stage forms a bottleneck in production where density-dependent processes occur whereas the numbers of adults returning from sea are more proportional to numbers of salmon leaving freshwater (Jonsson & Jonsson 2004).

The range of hydrological conditions and grain-size composition in spawning gravels quoted in the literature vary considerably (Jones 1959; Beland *et al.* 1982; Mills 1989; Gibson 1993; Elliott *et al.* 1998; Bardonnet & Baglinière 2000; Kondolf 2000), but the typical spawning sites seem to be the transitional areas between pool and riffle where flow is accelerating and depth decreasing, where gravel of suitable coarseness is present and interstices are kept clean by up-welling flow.

Newly hatched alevins remain within the redd, drawing nutrition from the yolk sac until they emerge to feed as fry. Due to the properties of the habitat that salmon choose to spawn in, salmon fry emerge in habitat conditions that correspond to their preferences. But at the time of emergence, a large part of the fry population disperses and settles at different distances from the redd, mostly within 300 m downstream (Beall *et al.* 1994; Webb *et al.* 2001). Later in the first season, there seem to be a new phase of dispersal that could be related to increased territory size (Gustafson-Greenwood & Moring 1990). Due to limited swimming ability, almost all fry dispersal happens in a downstream direction, although there are observations indicating a limited dispersal also upstream (Einum & Nislow 2005). The dispersal distance depends on factors such as number of recruits, habitat heterogeneity and the production capacity of the area. There can also be some among-individual differences in the propensity to disperse that is related to body size, in that fish that are initially largest remain closest to the redd. Fish near the redd can then suffer reduced growth due to high density, but still retain a size advantage (Webb *et al.* 2001; Bujold *et al.* 2004).

Salmon juveniles (both fry and parr) are territorial and will defend areas of the stream associated with feeding stations on or just above the substratum, from where they intercept drifting particles and forage the surrounding benthos (Stradmeyer & Thorpe 1987). Fry and parr densities vary considerably in natural streams and rivers, and the limiting factor is often the availability of suitable habitat. Throughout the life cycle, each developmental stage utilizes different habitats, and habitat availability will determine recruitment levels to the smolt stage. Taking a generally simplified view, juvenile survival can be said to be depent upon food availability and space, for which individuals compete (Kalleberg 1958). The availability of space is defined by the habitat types within the river system, this tends to limit population size and is often termed the "carrying capacity" (Egglishaw & Shackley 1982). Interactions with other fish species such as trout also affect utilization of habitat by juvenile salmon.

As a result of the density dependence of salmon in the juvenile phase, a self-thinning relationship between mass and number can be inferred. Under controlled conditions the slope of the thinning line can be consistent with allometry of territory size or metabolic rate or both,

and a gradient of -1.12 appears to give a good fit (Steingrímsson & Grant 1999). The slope of the thinning line will be related to the quality of the habitat. In practice, there are a lot of complicating factors, e.g. in that habitat quality definitely is dependent on fish size. Small juveniles require relatively low current velocities while larger juveniles prefer deeper water (Heggenes *et al.* 1999). The availability of shelter also will have an impact, and a bottleneck will exist if there is an insufficiency of deep areas or rough substratum (Armstrong & Griffiths 2001).

Perhaps even more illustrative of the complex dynamics that exist, is the observed relationship between juvenile production and genetic diversity (Griffiths & Armstrong 2001). It is possible that different types of individuals may use the habitat in different ways, as seen for instance in brook charr (McLaughlin *et al.* 1999), and this usage might have a genetic basis. Some fish might be pool specialists, others most effective at using riffles, others again best at using streams. As such, the total carrying capacity for a mixture of types may be higher than for one type alone because the different types can spread out and get the most out of the environment. This idea has been confirmed experimentally, where it was found that a mixture of six families resulted in juvenile densities two-fold higher than when single families were present, with no difference in mean growth (Griffiths & Armstrong 2001). The slope of the thinning line will in other words vary with genetic diversity.

The different ways habitat affects production of salmon can be approached by modelling the relationship between local densities, sizes and ages of fish and habitat, by correlating population and habitat variables within the whole river system or within parts of the system (Milner *et al.* 1998). Reviews of the applicability of such habitat models (Barnard & Wyatt 1995) show that although such models work in that the habitat explains variation in salmon abundance, the models hardly have transferability between regions, and the best models incorporate both local- and catchment-scale variables. The basic methodology of using habitat models on juvenile salmon abundance and distribution in Tana is therefore not possible today, but with some careful designing of the annual juvenile monitoring (see page 60), data can be accumulated for parameters needed to implement habitat model for different parts of the Tana river system.

Even without a habitat model, some basic targets need to be met for the river system. First and foremost here is the inherent assumption of the spawning targets that spawners are distributed throughout the system. In practice, this is hardly possible both because of the patchy distribution of spawning locations and because the probability of using different places differ with differing spawning stock sizes. Following up the spawning targets with mapping of juvenile densities would allow us to get a picture of how the production potential in the river system is utilized, and how the actual production is spaced out at different spawning stock sizes. Secondly, this mapping should at least be compared to minimum threshold levels of juvenile densities (reflecting estimations of carrying capacities).

6   Stock characterisation and monitoring

The life cycle of the salmon pose a complex challenge for managers and researchers. Salmon utilize rivers for reproductive and nursery phases, and the marine environment for adult development and rapid growth (Mills 1989). Each life stage has its own unique habitat requirements, and monitoring should thus be targeted at several stages to ensure adequate assessment of the status of each stock.

6.1   Abundance criteria

6.1.1   Adult run size

Data on salmon run size are essential in several regards: to estimate spawning escapements, exploitation rates, and to investigate the relationships between stock and catch, and between stock and recruitment. Under an adaptive, active management regime, being able to monitor the amount of ascending fish would be very valuable.

There are various means of measuring the run-size of migratory fish; some of the methods most potential for the Tana system are described below.

6.1.1.1 Direct counting

Data from upstream trapping are perhaps the most direct and least biased form of annual run measurement. A trap provides basic numbers and biological data (species, age, size, sex). However, traps are labour-intensive, the capital costs of structures and installation are high, and the trap represents an invasive method that requires man-handling of the fish. Also, unless full-width traps are used, mark-recapture techniques are necessary to estimate population size. The size and scale of the Tana river system means that using upstream trapping can never be a practical way of estimating adult run size.

Various automatic fish counters (such as resistivity, optical and hydro acoustic counters) have been developed to provide direct measures of run size. The various counter technologies have greatly improved in accuracy and cost efficiency in recent years, and today can provide a significant value in supplying information on the size and timing of salmon runs.

The various counter technologies are suitable for different conditions, with resistivity and optical counters require some form of in-river man-made structures (e.g. fish ladder, Crump weir) that narrows the fish passage and forces the fish to swim through an observation zone. Although not as invasive as a trap, structures like this may still alter the behaviour of salmon.

Hydro acoustic counters have a higher range and have the potential to be used without any man-made in-river structures, thus having the advantage of being a non-invasive, non-destructive technique for monitoring the abundance if fish populations. This methodology has already been tried out in the Tana river in the late 1990s with mixed results. However, single- and split-beam acoustic techniques have been used since 1977 to estimate gross escapement of salmon stocks into the Fraser River (British Columbia) (Xie *et al.* 2002), and results from Fraser River also show that a dual-frequency identification sonar (DIDSON) can provide very accurate

species-specific countings of the adult run of Pacific salmon (Holmes *et al.* 2006). The technology has thus progressed far from the first attempt that was made in Tana.

A large-lens DIDSON have the potential to give good estimates of the gross adult run size entering the Tana. There are challenges in terms of software, but good advances have been made in this area recently through the work of Simrad (Norway) and Ceitatech (Sweden). The hydro acoustical systems unfortunately needs a high level of technical competence which, coupled with the high costs of equipment and software, adds up to a methodology needing a considerable level of funding.

A video monitoring site has been in operation since 2002 at the outlet of the river Utsjoki, a large tributary of the Tana. Video monitoring has several clear advantages: information is provided on for instance species and sex, and the monitoring can be used to count both adult and smolt runs. The number of descending smolts out of and ascending adults in to Utsjoki has thus been counted annually from 2002 to 2007, and funding is available at least until 2010 through the research project "Laks i Nord" (funded by the Norwegian Research Council).

In addition to providing good and detailed numbers, the video monitoring has the advantage that its technical costs are reasonably low. However, the actual counting of the video tapes is time consuming as it has proven difficult to automate this process through the use of computer software. Also, to be able to cover the width of the river, several cameras must be employed, and this limits the river width that can practically be covered. For this reason, this method is most suitable for monitoring the salmon moving into and out of Tana tributaries.

6.1.1.2 Estimation from tagging

Mark-recapture programs can be used to estimate the escapement of returning salmon stocks. In these kinds of programs, salmon are captured and tagged when entering the river. At the end of the season, salmon are checked at or close to spawning areas, and the amount of tagged vs non-tagged fish are counted. This ratio can then be used to calculate the total size of the adult salmon run.

The main problem with mark-recapture programs is that they are labour-intensive and costly to operate. Indications from British Columbia where such programs are extensively used shows that mark-recapture programs quickly become more costly than other methods of estimating run size.

6.1.1.3 Estimation from catch statistics

Catch statistics are a central part of the monitoring of all salmon rivers. The catch reports given by the fishermen provide important information:

- An estimate of yield from the fishery
- An estimate of run size (based on assumptions about the relationship between catch, effort and stock)

For Tana, catch statistics are currently the only indicator of total gross run size. There are, however, several potential weaknesses in both the historical statistical data and present day statistics. The first and foremost problem comes from the sheer complexity of the river system and the different fisheries therein. With several fishing methods and several groups of fishermen in two separate countries, it is obvious that differing methodologies (with intrinsic different vulnerabilities for problems) of calculating catch between countries potentially creates a problem when inferences are made from the statistical data.

Other potential weaknesses:

- Inaccurate reporting
- Absence of a rigorous means of assessing fishing effort and exploitation rate (especially the influence of environmental factors)
- Uncertainties in the link between stock variables and catchability
- Relationships between run size and catch reports seemingly become more and more variable with lower stock levels (Peterman & Steer 1981)

Both Norway and Finland are in a process of improving the methodology and accuracy of the catch statistic. A large step was taken in Norway in 2004 with the introduction of an electronic internet-based system for license sale and catch reporting. Combined with the extensive use of deposits, this has greatly increased the number of catch reports that are returned. In 2007 deposits were increased, and cooperation was started between the management and the administration of the fishing right owners to ensure that reports from local fishermen fishing with traditional net-based methods were as accurate as possible. The experiences from the first year have been very good, and 2007 is the first year that the Norwegian catch can be given purely as reported numbers without any additional estimates.

An important progress also from 2004 and onwards, was the increased resolution in the reported numbers. Today, the Norwegian catch reports are combining fishing equipment, date, size of the fish and location. This is particularly important as shifts in stock composition in relation to time of ascent and location of spawning in the catchment are important criteria for the conservation of stock structure (especially for large spring-run salmon).

An obvious question about catch statistics is whether or not it contains information that can be used to explore the causes of changes in fisheries, the biological mechanisms that drive these variations, and to prompt appropriate management regulations. A comprehensive catch statistic definitely has a great potential value in this respect. However, in order to generate direct signals that relate to the abundance of adult salmon, the imperfections must be clearly defined. This is obviously difficult due to a general lack of fishery-independent data, so knowledge must be further sought through an inferential approach as the most appropriate way of establishing the utility of both present-day and historical data.

The methodology behind the Norwegian catch statistics have been gradually developed in the later years, temporarily culminating with close to 100 % reporting rate among all fishermen in the 2007 season. In earlier years, it has been necessary to do an estimation of the total catch based on the reported numbers. The high reporting rate in 2007 has however eliminated this necessity, meaning that the numbers from 2007 for the first time are based exclusively on reported catch.

This gives a unique possibility to further investigate the historical numbers, e.g. through the use of a randomization process like Monte-Carlo functions. Various scenarios can be simulated through this, thus providing a picture of the reliability and accuracy of the historically estimated numbers. For example, the historical estimation of catch is basically based on the assumption that the reported catch is representative of the non-reported catch. This is only true if the probability of delivering a catch report is independent of the actual catch. If the probability of delivering a catch report is lower for fishermen without catch, then the estimation process will give an overestimation of the total catch. The Monte-Carlo simulation should provide further information on the consequences of these kinds of scenarios, at the very least providing an estimate of the error variance of earlier numbers.

The same procedure can be performed for the Finnish catch statistics. Presently, Finland and Norway use very different methodologies. Whereas Norway base all the reporting on deposits with fishermen filling out and delivering catch reports straight after fishing (for daily licences) or filling out a catch diary (for seasonal licenses), Finland use a system in which all fishermen are contacted after the season closes. All fishermen are first contacted by a letter in which they are asked to fill out a supplemented catch report. If they fail to answer, they are contacted a second time with a new letter. If they still fail to answer, they are then contacted through a phone call. This approach can also be evaluated through the use of the same Monte-Carlo simulation outlined for the Norwegian numbers.

The work on developing the catch statistics methodology should get continued focus, and a natural extension of the current developments would be to look further into how the fishermen themselves view the changes that have been made. As such, the monitoring group strongly suggests the implementation of an interview study, focusing on how the fishermen do their reporting in light of the changes that have been made in recent years.

6.1.1.4 Concluding advice for Tana

1) Continuing the video monitoring in Utsjoki should be a very high priority. The time series of data on ascending and descending fish is highly relevant both in direct management and in establishing future stock/recruitment-relationships for the salmon stocks in Tana.

2) Additional sites should be included in the direct monitoring of ascending/descending fish, and the monitoring group suggests the establishment of at least an additional site in the upper part (e.g. at the bridge in the Anarjohka or Karasjohka) and in the lower part (e.g. the river Maskejohka) of the Tana river system. Methods used for monitoring can be either video or hydro acoustics.

3) The possibility of establishing a hydro acoustic counting system at the lower end of the main Tana river should be reviewed further in detail.
4) The system for calculating catch statistic have recently been improved, but this should be further investigated through research looking into the impact of different report percentages and different methodologies (e.g. through the Monte Carlo-approach outlined in Chapter 6.1.1.3 above).
5) An interview study should be done, looking into how the fishermen view the changes that have been made to the reporting system.

6.1.2   Spawning stock size and activity

Having a reasonably accurate assessment of the stock specific spawning escapement is a necessary prerequisite in the evaluation of stock status in relation to spawning targets. In a river system such as Tana, with its complex interacting system of separate stocks and different fishing methods, finding the actual spawning escapement for different stocks is at best a difficult task.

There are at least two available methods for estimating aspects of spawning:

1) Estimation of spawning stock size from catch statistics
2) Counting spawners and redds by snorkelling

Each of these is reviewed in more detail below.

6.1.2.1 Estimation from catch statistics

Most of the issues pertaining to the use of catch statistics in the estimation of spawning stock size are already summarized under the adult run size heading above (chapter 6.1.1.3), and are therefore not necessary to repeat here. A topic that should be covered in the discussion in this section, however, is the issues caused by parts of the reported catch coming from multi-stock fishery areas of the river system. This fact will, for instance, make it very difficult for us now to estimate the actual spawning stock size for the Tana main stem, as the reported catch within the Tana main stem consists both of salmon belonging to tributaries and salmon belonging to the main stem.

Basically what is needed to solve this is more information about the relative catch rates within different parts of the system. We need some kind of exploitation map of the river system, with at least both spatial and temporal resolution, and ideally, with resolution also pertaining to fishing gear. That has the potential of providing a way to designate parts of the catch in the mixed stock areas into separate stocks.

With the improvements that have been made (and will be made) with the catch statistics, we are having a good picture of the catch of salmon in different parts of the system at different times of the year. However, the main parameter we are missing to get an accurate picture of the exploitation for each stock is the stock-specific exploitation rate. For this reason, the discussion of spawning targets (in chapter 5.1) is presenting estimated spawning stock sizes for different

exploitation rates. The data we have available suggest an exploitation rate of up to 70 %, and for that reason Figure 14 is presenting estimated spawning stock for up to 70 % exploitation rate.

Some further details on the estimation of spawning stock from catch are given in the following. The total number of spawning fish (S_T) can be calculated from the proportion of females (P_{fem}) in the spawning population:

$$S_T = \frac{S_{T,fem}}{P_{fem}}$$

By rearranging this equation, the number of spawning females ($S_{T,fem}$) can easily be derived.

To calculate the catch equivalent to the total female spawning size requires knowledge about the relationship between total catch (C_T) and escapement. First of all, an estimate of river annual run size (R) is provided by:

$$R = \frac{C_T}{U}$$

where U is the catch exploitation rate expressed as a proportion of the total annual run.

From this, total spawners can be calculated as:

$$S_T = (R - C_T) \cdot s = C_T \left(\frac{1}{U} - 1 \right) \cdot s$$

where s is the proportion of fish surviving the in-river phase.

These equations then provide an estimate of the catch equivalent to the stock achieving its management target:

$$C_T = \frac{S_T / s}{1/U - 1}$$

Depending on the accuracy of the catch statistics, some adjustments might be needed for C_T. For instance, to account for under-reporting of catch, an equation like this must be used:

$$C_{adjusted} = \frac{C_{reported}}{r}$$

where r is the estimated catch reporting rate.

Several of the above parameters are presently not known, and data must therefore be gathered so that reasonable estimates can be given. To solve the issue of the exploitation rate (U) and survival (s), a combined telemetry/tagging-study is proposed, the details of which are provided

in Chapter 7. Issues concerning the quality of catch statistics are further discussed above (heading 6.1.1.3).

6.1.2.2 Estimation from snorkelling

A recently published study has looked into the reliability of snorkelling as a method for assessing spawning stock in five tributaries of the Tana: Akujoki, Nilijoki, Baisjohka, Utsjoki and Pulmankijoki (Orell & Erkinaro 2007). In the small rivers (width 5-20 m) snorkelling was found to be reasonably precise while in the medium-sized river (width 20-40 m) the precision of the counting method was considerably lower. The high observation efficiency and precision, favourable behaviour of salmon and congruence between snorkel counts and catch statistics in small rivers suggest that reliable data on salmon spawning stocks can be collected by snorkelling. Direct counting of spawners through snorkelling can also play an important role as a supportive index for the estimation of spawning stock from catch statistics.

There is presently an assumption in the calculation of spawning targets that the spawners actually are distributed more or less evenly throughout the river system. The juveniles are not able to do long-range migrations up- and downstream from the spawning grounds to compensate if spawners for example are clumped in the lower part of a river. Estimation of spawning stock from catch statistics will not be able to cover this assumption, and here snorkelling (together with registration and counting of redds) can provide an important extra source of monitoring information.

6.1.2.3 Spawning activity

Redd counting is one possible measure of spawning activity. It involves mapping and counting of the streambed disturbance that is created by spawning fish. This method has been widely used in several areas of the world with the view that there is a relationship between female numbers and the number of redds. From the nearby Alta, there is evidence of a relationship between number of large salmons in the catch and subsequent number of redds (Ugedal *et al.* 2007). Other data from Scotland however implies that there is not a strong correlation between redd counts, female numbers and subsequent juvenile production (Youngson *et al.* 2007). This obviously needs further studies, but until the situation is adequately clarified, redd counting may only be validly used to indicate the presence of spawning fish and to a certain degree the number of spawning fish present. Too little information exists right now on how to reliably scale redd numbers into more accurate adult estimates, and especially how to scale redd numbers into estimates of subsequent juvenile production. Time series of redd counts are however definitely well suited to make estimates of the relative abundance of spawners within areas, and maps of redd locations will be useful to indicate regions which adults are not reaching in particular years.

6.1.2.4 Concluding advice for Tana

1) An accurate catch statistic is an important tool when estimating spawning stock size, and as such, a detailed and accurate statistic with resolution broken down into numbers and

weights of fish and place of capture is necessary. High effort should be put into using catch statistics methods that ensure this.

2) Exploitation rates are not established on a stock-specific level, and an extensive tagging/telemetry-study should be undertaken to provide such estimates.

3) Continued effort should be put into counting spawners (and eventually redds) to establish the actual extent and distribution of spawning.

6.1.3 Juvenile monitoring

Juvenile assessments using electrofishing is a cost-effective monitoring method that has been used in the Tana river system since 1979 with a total of 57 sites being annually monitored (spaced out in the Tana main stem, the river Inarijoki/Anárjohka and the river Utsjoki/Ohcejohka). This program has provided data on changes in juvenile salmon production (densities), occurrence and densities of other fish species, and long-term growth variations of juveniles.

Surveys like this are potentially highly informative for assessments of spawning and territory saturation and juvenile monitoring elides the problems involved in projecting catch data onto smaller sub-catchment scales. Juvenile monitoring thus directly provides data at the localised scales that are most appropriate and useful for managers, giving accurate and precise spatial and temporal information about fish stocks in different parts of the river system.

However, care must be taken to avoid some pitfalls in acquisition and interpretation of data. Firstly, density estimates are very much dependent on quality controlling multi-pass fishing to solve potential problems between operators and methods. This can be partly remediated by standardizing a sampling protocol.

Secondly, the sampling design need to be put through a power analysis to ensure that intensity of sampling is sufficient to detect levels of change in juvenile density at least down to a certain pre-specified precision level. This is especially important for a system like Tana where a gross, single-stock recruitment model is inappropriate.

Thirdly, the chosen monitoring stations should be placed into a context of habitat quality (related for instance to density capacity) and access from spawning areas. This is necessary to be able to generalise from local density estimates up to larger spatial scales.

Fourthly, care should be taken to ensure that data is gathered on the full age-structure of the juvenile populations. This is important when tracing annual variations in abundance.

Fifthly, the spatial variability in the relationship between spawner number and juvenile density is mostly unknown, especially how this changes with differing numbers of spawners. At low spawner levels, density-dependent mortality is expected to be reduced. Some knowledge on the cumulative effects of annual variations in spawner numbers, the strength of year classes and the resulting smolt output would from a management target perspective be very useful.

Sixthly, electrofishing does not catch all fish present. Using single-pass fishing would thus not provide an estimate of the true number of juveniles present. However, there are key assumptions that need to be met also when doing multiple successive passes to ensure that an estimate of the true numbers can be given. Especially important is maintaining a constant efficiency of capture between passes.

Seventhly, electrofishing is inherently size-dependent in catchability. This unavoidably leads to potential errors, especially when comparing density estimates from single-pass fishing.

Eightly, for a river system like Tana, there will unavoidably be large-scale differences in temperature and benthic production that makes inter-site comparisons difficult. This goes both for the habitat difference between small and large rivers, and for differences between smaller rivers.

Ninthly, and lastly, some rigour should be put into the selection of electrofishing sites. An important issue here is that sites judged to be good salmon habitats are clearly the parts of the river system that are least sensitive to changes in overall density.

This last issue is perhaps the most serious problem with the existing juvenile monitoring program in Tana today. Most of the existing sampling stations are in the central parts of the river system, areas that are likely to be saturated with juveniles coming from both local spawning and from migrations (potentially over large distances). The allocation of resources into sampling different areas should therefore be revised to enhance both the management and research value of the monitoring.

Keeping track of juvenile densities through yearly monitoring is important and can provide managers with an early warning about developing problems with different stocks and within different areas. This was exemplified in the River Alta, where juvenile production was declining in the upper part of the river in the years following the regulation (Ugedal *et al.* 2007). For this reason, it is important to define a clear *aim* for the monitoring. If the aim is defined so that monitoring is supposed to provide accurate density estimates that is to be put into a production potential framework and a monitoring density time series, a much more rigorous and resource-demanding approach needs to taken compared to what is needed merely for getting samples of the juveniles (for diversity criteria), getting some density estimates and establishing areas of production.

The NASCO Decision Structure puts a high emphasis on having sufficient knowledge and control on the status of all unique stocks within a system, and the monitoring group highly recommends going for a continuation of an annual electrofishing survey. The basic aims of this survey needs to be reformulated however to accommodate the requirements of the target approach adopted in this report. The monitoring should thus at least be able to a) discover changes and trends in juvenile density, b) provide spatial information on juvenile production, and c) provide information on juvenile densities and how they compare to estimated carrying capacities.

It is outside the scope of this report to pinpoint in detail the number of sites etc. needed for surveys fulfilling these requirements. We therefore suggest a transitional startup period in which data relevant for the design of a new program is gathered and systematized, while the previous annual monitoring program is continued.

Some basic changes to the future juvenile monitoring program proposed by the working group:

1) Special focus should be given to the rivers chosen for adult run monitoring (Maskejohka, Utsjoki and Karasjohka).
2) When establishing the distribution of electrofishing stations within the whole river system, a combination of "fringe" and "core" sites should be used. Sites considered to be good salmon habitats in the central part of the river are clearly the parts of the river system that are least sensitive to changes in overall density.

At the very least, the juvenile monitoring should be able to provide a classification of the density of juvenile salmon in order to establish the relative condition of stocks within the river system. However, appropriate absolute classification values corresponding to favourable conditions must be developed. To accomplish this, an extensive habitat mapping and subsequent habitat modelling must be performed.

In the habitat mapping, juvenile production areas within the river system must be identified (with size/area, absolute placement, and placement relative to spawning grounds). This provides important background information for refinement of management targets, as for instance production areas without nearby spawning grounds must be populated by migrating juveniles, and thus are expected to contribute less to the smolt production than production areas close to spawning grounds.

A habitat within the river system that has received comparatively little attention is deeper areas of the river. Tana has a large proportion of deep areas, with water depths exceeding those that can be monitored using conventional methods such as electrofishing. This characteristic river morphology implies a challenge both for fish managers and researchers. The vast majority of river studies on Atlantic salmon are conducted in shallow areas during the summer period (Bremset 1999). Although there is a common tendency to extrapolate from small scales to large scales, large spatial and temporal differences in fish abundance can easily lead to erroneous conclusions.

The limited number of studies from deeper areas of rivers has showed that fish abundance, habitat use and behaviour can be fundamentally different from that recorded in the shallow areas. Firstly, there is evidence of other social organization of juveniles than the traditional view of a rigid territory structure (Klemetsen *et al.* 2003), as juvenile salmon in pools seem to be organised in a looser interspecific dominance-hierarchy (Gibson 1993; Bremset & Berg 1999). Secondly, the traditional view of deeper parts of rivers as low-productive for juvenile salmonids is not universal true. Gibson (1988) recorded large numbers of juvenile salmon and brook trout foraging in deep pools of a Canadian river. Similarly, Bremset & Berg (1997) recorded

significantly higher abundances of young salmon and brown trout in deep pools compared to shallow riffles in three Norwegian rivers.

There is thus insufficient information on the production of young salmonids in a large river system like the Tana. Findings in shallow areas close to river banks are not representative of the conditions in other habitats, and conclusions on population status and trends are consequently error prone. There are alternative methods available for studies of juvenile fish abundance, such as video recording and direct underwater observations, and as a starting point, the monitoring group recommend pilot studies using these methods as a part of the juvenile monitoring program in Tana.

The intrinsic capacity of river sections to support juvenile salmon varies from section to section, and as such a uniform juvenile production target for the entire Tana system is inappropriate. The different ways that habitats affect juvenile production should be approached by modelling the relationship between local densities, sizes and ages of fish and habitat, by correlating population and habitat variables within both the whole Tana river system and separate parts of the system. Such models (e.g. MesoHABSIM, HABSCORE) have been used extensively in other areas, but reviews show that such models have very little transferability between regions. The working group thus propose the initiation of a research project specifically targeted at developing a habitat model for different parts of the Tana river system.

6.1.3.1 Concluding advice for Tana
1. The comprehensive annual long-term electrofishing survey for juveniles should be continued. However, the aim of the survey should be refocused, and the survey must be redesigned so that it can a) discover changes and trends in juvenile density, b) provide spatial information on juvenile production, and c) provide information on juvenile density compared with estimated carrying capacity.
2. Areas of juvenile production (both area and distribution) needs to be mapped, including areas too deep for electrofishing.
3. A research project specifically targeted at developing a habitat model for different parts of the Tana river system should be initiated.

6.1.4   Smolt production
Smolt output is an important reference point as it represents the outcome of freshwater production. As such it is one of the most valuable information points from the early life stages of salmon populations. Smolt output estimates thus provide a direct measure of the freshwater status of the stock, and combined with adult return estimates allows calculation of sea survival. In effect, this is a critically important piece of information that bridges how the relative contributions of environmental conditions in freshwater versus the sea impacts the different stocks.

There are at least two methodologies that can provide estimates of smolt output:

1) **Direct counting through video monitoring**. This is probably the most accurate method, but it quickly becomes difficult to use with increasing size of the river. The counting of fish from the video tapes is also time-consuming. Presently, the smolt output is monitored with this method at two sites in the Tana river system:
   a. The long-term video monitoring site at the Utsjoki river mouth which have been in operation since 2002.
   b. In 2007 a video monitoring site was operated at the mouth of the small river Akujoki. The continuation of this site is however open.

2) **Estimation through mark-recapture**. This is probably the most common way of solving this, and basically consists of the following two stages:
   a. A marking stage where a number of (pre-)smolts are marked (either through fin clipping or other methods that allow the smolts to be identified).
   b. A recapture stage where smolt are captured (usually a smolt trap). From this stage, the total number of smolts can be calculated from the ratio of marked to unmarked smolt.

The marking stage could either be performed by electrofishing and marking pre-smolts in various areas of the river system before the smolt migration starts, or by directly calculating the smolt trap efficiency by taking a number of trapped smolts, tagging them, and moving them upstream so that they subsequently can be trapped again. Of these two approaches to marking, the latter is in some ways greatly preferable, as it decreases the number of assumptions needed in the estimation. Either way, the ratio of marked to unmarked smolts will form the basis of smolt output estimation. The mark-recapture method have been shown to work in several river systems, including the large River Tornionjoki flowing into the northern end of the Baltic Sea and forming a 500 km long border between Finland and Sweden (Mäntyniemi & Romakkaniemi 2002).

There are no published results comparing estimates of smolt run size from video monitoring and mark-recapture methods within the same river, and as such we have little basis here for evaluating the accuracy of both methods. There are some unpublished data from Norway showing however that the discrepancy between the methods can be considerable. This illustrates the need to do methodological testing of the methods that are chosen to assess the accuracy and precision of the respective estimates.

6.1.4.1 Concluding advice for Tana
Given the monitoring effort that is suggested in different parts of the system, the monitoring group suggest the following outline for smolt production monitoring:

1) The three main monitoring tributaries (Maskejohka, Utsjoki and Karasjohka) should be included, depending on the method chosen for monitoring of adults (e.g. video monitoring versus hydro acoustics). Video monitoring is already in place at Utsjoki, and this long-term time series should be given a very high priority in a future monitoring program.

2) Total smolt output for the Tana river system should be estimated through a mark-recapture study. This might not be necessary to do on a long-term annual basis, but at least effort should be put into a study long enough to provide correlations between smolt numbers from tributaries and the Tana total smolt output.

6.2 Diversity criteria

6.2.1 Stock identification and within-river diversity

From Figure 1 and Table 1, found early in chapter 4, an impression can be gotten of the potential stock complexity of the Tana river system. In addition to salmon in the Tana main stem, a multitude of differently sized tributaries also support spawning salmon. Tributary sizes and their respective spawning stock sizes vary considerably, with some small tributaries supporting spawning stocks down to barely a hundred fish, while some of the larger tributaries have several thousand spawners.

The strong homing capability of salmon is the basis for the formation and maintenance of local breeding groups (populations or stocks) of salmon, both between rivers and within rivers. Each stock is susceptible to the effects of natural selection, so stocks from a given area are expected to exhibit heritable adaptations to the local environment. For the Tana river system, this has resulted in the presence of a multitude of genetically unique stocks within the river system (Vähä *et al.* 2007).

From a management perspective, this genetic diversity represents a practical problem of scale. The genetically unique populations are spatially aggregated and discrete only during spawning (and possibly in the juvenile phase). The rest of the time, especially in the pre-reproductive phase during which fisheries are active, the salmon from different populations are dispersed and mixed. To make matters even more complicated, the spatial boundaries of each population in the spawning and juvenile phase might not be practically possible to define precisely. How then should management initiatives be taken for each population?

An obvious solution to the dilemma could be to combine several closely related single genetic populations into larger groups and let these groups be the management units. This approach is flexible in that it through the use of nested or otherwise interchangeable groupings can be related specifically to particular management targets and fisheries.

How then to decide upon these groupings? Three different themes emphasizing different aspects of a population structure is recognised being based on either ecology, systematics or evolution (Bowen 1999). The first theme is the concept of Management Units which focuses on the ecological context of the populations (Moritz 1994). The systematics theme is stressed in the concept of Evolutionary Significant Units (Moritz 1994). The third theme, the Geminate Evolutionary Unit, takes an evolutionary perspective (Bowen 1999). All three themes are originally based on genetical analyses, but there are arguments for a more pragmatic approach that are using more general insights to supplement or even replace genetical data in some situations (Crandall *et al.* 2000).

Regardless of the chosen scale of the groupings, a framework encompassing the groups and their relatedness is needed. This is provided by metapopulation theory; with its emphasis on the hierarchical way populations (or other defined units) interrelate in a spatial and temporal scaled context.

But in the end, regardless of the choice of themes and theoretical frameworks, the most important perspective is still that the management should focus on identifying rational fisheries-based groupings consistent with the conservation of the genetic populations on which the fisheries are based. This is perhaps especially important for a river system like Tana, with its multitude of fishing gears that potentially can cause differential exploitation rates on differing stocks.

It is here also worth emphasizing the important connection between stock identification and catch statistics. The fishery in several areas within the river system is clearly exploiting mixed stocks, while the fishing in other areas is more based on single stocks. Having identified the extent of the distribution areas of each unique stock should allow for a better reporting system, where each catch report can be separated into areas with single stocks and areas with mixed stocks.

6.2.1.1 Concluding advice for Tana
Stock identification through genetical analyses of scale samples (both adults and juveniles) and fish from tagging studies should be continued.

6.2.2 Within-stock diversity
Within each salmon stock, a varying diversity of life history traits can be found. Examples of such traits are freshwater residence time, juvenile habitat choice, age at maturity, and length of the marine phase. Looking only at smolt age and sea age, there are at least 28 known smolt age (2-8) and sea age (1-5) combinations for virgin salmon and 68 known combinations for previous spawning salmon (Niemelä 2004). If this is extended to include for example juvenile habitat choice and juvenile migration pattern, the number of life history combinations would increase greatly.

The wide life cycle variation exhibited in smolt and sea ages complicates the interpretation of relationships both within and between stocks, e.g. the relationship between juvenile abundance and subsequent run sizes of various sea-age groups, data that are needed for further development and refinement of stock-specific spawning targets.

Depending on the nature of the fisheries, the different life history combinations within a stock might be exploited differently, with some combinations meeting a higher mortality than other. This will cause what is termed fisheries-induced evolution (or fisheries-induced selection), where the frequency distribution with which different life history combinations is expressed within a stock gradually changing. Life histories that are more vulnerable will decrease at the expense of other life histories.

The existence of a size-selection within the salmon fisheries, with large salmon being more vulnerable than small salmon, is a possible explanation for the declining trend seen in number of ascending multi-seawinter salmon in Tana (Figure 9).

The trouble with evolutionary changes like these is that there is a genetical basis to the different life history combinations. When a certain life history expression starts to decline, the frequency of the associated genotype coding for this particular life history also declines. This can, if no attempts are made to alter the fishing regime causing the selection, ultimately mean that the genetic diversity within a stock becomes reduced.

Having a thorough monitoring of the distribution of different life history combinations in the river system is for this reason of the utmost importance. This has for a long period of time now been accomplished in the Tana river system through the scale sampling project. From its start in the early 1970s, this project have accumulated a times series of data that today represents an immensely valuable source of historical information on the development of salmon stocks in Tana. The project provides data on several aspects of the Tana salmon, e.g. age and size composition, growth, genetics, farmed salmon escapees, and also (at least to a certain degree) relative exploitation of different fishing gears.

The working group propose to continue the project in its current form, and here emphasize the important work that the project has committed when it comes to actively involving both Norwegian and Finnish local fishermen in the gathering of information about the Tana salmon. However, the group also recognize the need for some adjustments to the project. Specifically, the present coverage of Norwegian tributaries is not good enough and considerable effort should be put into getting better coverage there. Several of the tributaries are mainly fished by tourist anglers, so an approach involving this group should be promising.

There are aspects of the juveniles that are also important for monitoring. Production and density of juvenile salmon in running water are limited by what is called the carrying capacity. This is mainly caused by the behaviour of the juveniles, as they have a territorial way of living that limits how dense the fish can stay in comparison to each others. Experimental studies however indicate that the carrying capacity changes with the level of genetic diversity within the area. A high level of diversity causes considerably heightened carrying capacity compared with a low genetic diversity situation.

Monitoring of juvenile within-stock diversity is partly covered within the annual juvenile monitoring program (see chapter 6.1.3). There are some aspects to the diversity that are not covered, such as juvenile migration patterns. A lot of basic data have been gathered on this topic already (Erkinaro 1997), and it continues to be the focus (e.g. through a current research project at the University of Tromsø).

6.2.2.1 Concluding advice for Tana

Data from the juvenile monitoring and adult scale sampling should provide the necessary information to establish the extent and composition of different life history strategies in various

parts of the Tana river system. Effort should be put into discovering stock-specific trends and changes in the diversity of life history traits.

7 Selectivity of fishery

Within the Tana river system, there is still a high diversity in fishing gear, with several traditional fishing methods still being widely used today. The different methods represent a further complication of an already complex mixed-stock fishery. Each method potentially has its own selectivity in terms of exploitation rate on different parts of the stock complex, making it very challenging to get any control of the actual exploitation rates of each stock.

This is however only a part of what really makes selectivity an important issue to control. Selective fishery will cause differential mortality within stocks. Some life history strategies will be punished with higher mortality than other life history strategies. Theoretical investigations into the adaptive dynamics of these situations show that size-selective fishery will lead to evolutionary responses within stocks even under relatively low rates of size-selective exploitation (Ratner & Lande 2001). These responses invariably go towards lowered maturing ages and lowered maturing size, and because the responses are coupled with reduced genetic diversity, the responses very easily become irreversible. The reason for this is simple. Compared with the intense evolutionary pressure that human exploitation is causing, natural selection puts a relatively weak pressure on fish stocks in the other direction.

There exist some reasonably easily understood examples to this. The most obvious is the negative effects of having a minimum-size limit in the fishery. This principle is for instance commonly used in fish management in Norway. The logic behind the principle is perfectly reasonable at first look: by disallowing fishery on small fish, the fish is allowed to breed before they reach a catchable size. This keeps the stocks from collapsing, which seems sound. However, this strategy of course also selects for smaller individuals. Small fish have larger chances of reproduction and therefore gets favoured. As a result, the body sizes of the population as a whole also becomes smaller (Haugen & Vøllestad 2001).

The potential negative evolutionary effects of fisheries have until now generally not been taken into account in fish management both for marine species and anadromous salmonids, simply because it has proven difficult to convince authorities that observed changes have a genetic basis and thus can be serious long-term negatives (Stockwell *et al.* 2003). This puts an extra need on having a rigorous monitoring and research effort that can provide solid evidence for genetic shifts within the stocks.

For the Tana river system then, concentrated effort is needed on at least two different stages. First of all, more basic knowledge is clearly needed and must be gathered and systematized. Secondly, a monitoring approach must be found so that unwanted fishery-induced evolutionary changes can be detected early and compensated for with adjusted management strategies.

An excellent starting point for studying this problems lies within the scale-sampling project that have been active now since the middle of the 1970s. Within this project, samples are taken of salmon caught on all the different fishing gears throughout the fishing season. We thus have a time series covering over 30 years describing different aspects of stocks within the system (e.g. size composition, growth, time and place of catch, fishing gear). In addition, genetical analyses can be performed on the scale samples, thus correlating observed phenotypical changes to possible genetical changes.

A second source of information is clearly needed however, as the stock- and target-driven approach to management taken in this report clearly elucidates the need for updated information with a good temporal and spatial resolution. The working group for this reason strongly suggests that a large-scale tagging and radio telemetry study should be carried out in the river system. There has been a couple of earlier tagging (1977-1980) and telemetry (1992-1996) studies in Tana that have provided some information about exploitation patterns and rates in the river system, but there is a clear need for updated information from a rigidly designed new study.

Some aspects that the study design should take into account:

1. Number of tagged fish must be sufficient to develop exploitation and migration maps for different stocks and salmon size groups as it changes temporally through the season and spatially through the river system.
2. Tagged fish must be stock identified (through genetical analysis).
3. The use of several tagging sites should be considered, both in the Tana fjord and in the lowermost part of the River Tana.

The complexity of the Tana river system with its multitude of stocks, different fishing gears and sheer river size, clearly places high demands on the design and resource use of a tagging study. However, this high level is something the management should be ready to accept, especially when considering the criteria of actual stock-specific knowledge found in the NASCO Decision Structure.

7.1   Concluding advice for Tana

1. The long-term scale sampling project is providing important information and should be continued in its present form. Some changes must be done so that scale samples from all Norwegian tributaries are included in the future.
2. A comprehensive tagging/telemetry-study must be undertaken. The study should have a scale sufficient to provide temporal and spatial stock-specific data on migration and exploitation.

8   Threatening factors

8.1   *Gyrodactylus salaris*

The parasite *G. salaris* is not yet found in Finnmark. The nearest Norwegian localities with *G. salaris* are the rivers Skibotnelva and Signaldalselva in Troms. In Finland and Sweden the parasite is found in several rivers flowing into Bottenvika. The parasite belongs to the natural fauna of the large River Tornionjoki/Torneälv, and through fish farming have also been introduced to the Enare lake (which forms the source of the River Paatsjoki/Pasvik). Some of the headwaters of both these systems are situated very close to the source areas of the Tana river.

As of now, we have only a couple of options available with regards to the parasite: Preventative measures and monitoring.

Anglers visiting the river are receiving information about the parasite, and on the Norwegian side they are also required to disinfect their fishing equipment before they are allowed to buy a fishing license. This is unfortunately still not a requirement on the Finnish side, but the responsibility of each angler having clean/dry equipment has been strongly emphasized in the new (2003) Finnish veterinary regulation.

Tana is part of the Norwegian national monitoring of *G. salaris*, and samples of juvenile salmon are taken each year and checked for presence of the parasite. As of now, however, no plan of actions exists for what to do in case the parasite in the future is discovered in the river system. Also, to ensure early discovery of an infection, the monitoring needs to be redesigned and extended to give a better coverage of different areas within the system.

8.2   Proliferative kidney disease

Highly reduced catches and significant juvenile mortality in some Norwegian salmon rivers such as Åbjøra (Nordland) and Jølstra (Sogn & Fjordane) were in 2006 suspected and recently found to be associated with proliferative kidney disease (PKD) (Forseth *et al.* 2007, T. Forseth and T. A. Mo, personal comm.).

There have been plans to accomplish a pilot screening in Tana, but this has not been carried out so far. We suggest that this pilot should be accomplished as far as possible, associated with other monitoring (e.g. that of *G. salaris*), to confirm the potential of PKD as a threatening factor for Tana salmon.

8.3   Cottus gobio

The bullhead (*Cottus gobio*) is a newly introduced fish species in the Tana river system. It was first observed in Utsjoki in 1979, and has increased its distribution in that tributary since. It has been recently observed in the main river at some places between the river mouth of Utsjoki and the Storfossen/Alaköngäs area.

There have been some studies of the potential interactions between bullheads and juvenile salmonids. It is found to be frequent in areas with low salmon density but is seldom found in high abundance in areas with a high salmon density (Gabler 2000), but decisive answers about its impact on salmon are still lacking. Focus should be kept on the bullhead in the annual

juvenile monitoring, especially to see if the observations from Storfossen/Alaköngäs represent a new establishment.

8.4 Escaped farmed salmon

The production levels of the aquaculture industry have increased tremendously since its infancy in the early 1970s, and today the natural production of wild salmon is vanishingly small compared to the production of farmed salmon. Approximately 800 000 tonnes farmed salmon is produced annually around the Atlantic, most of which is produced in Norway. The annual catch of wild salmon is in comparison only 2-3 000 tonnes, of which approximately 5 % is taken in the River Tana.

Farmed salmon used in Norway can originally be traced back to around 40 Norwegian wild salmon stocks. Through intensive selection in 8-9 generations, the salmon now is very much adapted to a life in fish farms (Gjøen & Bentsen 1997) and genetically very different from wild stocks.

Farmed salmon can potentially escape from fish farms throughout their life cycle, and today escaped farmed salmons are caught in fisheries both out in the open sea, along the coast, within the fjords and in the rivers. It is documented that farmed salmon can spawn successfully in rivers (Lura & Sægrov 1991).

The hybridisation between escaped farmed salmon and locally adapted wild stocks is a major cause of concern, as it will cause potentially detrimental genetical changes to the wild stocks that can reduce viability of the stocks. A high proportion of escaped salmon in the catches can also hide the real population size of the wild salmon, a problem that can complicate the fish management of rivers.

Autumn registrations of the amount of farmed salmon present in rivers have been conducted in Norway since 1985, and in several rivers high proportions have been recorded. In Tana, registrations of farmed salmon have come from two sources: 1) the regular scale samples taken from fishermen during the summer, and 2) monitoring fishing close to the river mouth during the autumn (90/91, 96/97 and 03/04). The proportion of farmed salmon in the catches during the summer has been very low, well below 1 %. In the autumns of 1990 and 1991, the proportions were at their highest with 43-47 %. However, the numbers of fish caught in the samples were only 19 and 7, respectively. The proportions of farmed salmon in the other autumn investigations was 0-13 %, but still with low total numbers of fish (8-21).

With the formal ratification of the Tana fjord as a national salmon fjord in Norway, all aquaculture in the fjord is closed.

The Group recommends the continuation of the monitoring through the scale samples. In addition, extra post-season sampling should be conducted at regular time intervals, e.g. every 5th year.

8.5   Water quality

The Tana River valley has settlements on both sides, with extensive agricultural activity both in the lower and upper areas. The human activity can potentially cause pollution and eutrophication, making it necessary to keep a focus on water quality. This aspect will be taken care of through the implementation of the European Water Framework Directive, the work of which started in Tana in 2007.

8.6   Overexploitation

Human exploitation have for a long time now been the most important cause of mortality for adult salmon during their spawning migration. Historically, an increasing number of examples have shown us that it is possible draw too heavily on salmon stocks through exploitation. However, history also teaches us that it is possible to have a sustainable and at the same time extensive fishery for salmon. The only caution in this comes from the problems that potentially can arise from fisheries induced evolution; a topic described several places elsewhere in this report that should receive more attention also in Tana.

One of the things that make exploitation a complex issue in Tana is the number of fishing gears that are still used within the river system. In addition to angling, traditional fishing methods with different types of gillnet is still widely employed in the Tana river and the Tana fjord. The combined exploitation rate both in the fjord and within the river is thus potentially very high, thus creating a need for accurate monitoring.

The monitoring and research program outlined in this report is tailored towards providing accurate information through which early warnings about stock changes and declines that can be traced back to overexploitation. The program should further provide the necessary information so that management actions can be tailored towards counteracting the elements of the fisheries that are causing problems.

8.7   *Paralithodes camchaticus*

The red king crab (*P. camchaticus*) was introduced artificially into the Murmansk fjord (Russia) from the Pacific in the 1960s, and has since this introduction spread rapidly and extensively west along the Norwegian coast. The first crab was caught in Norway in the Varanger fjord in 1976, and since then the crab densities have increased greatly with population sizes today estimated to be close to 1 million.

The crab is an omnivore, digesting everything from cod larvae to other crabs. This, combined with the high densities, is causing some alarming large-scale changes in the benthos species composition, changes that might ripple out through large parts of the marine ecosystem. Presently we have no knowledge about potential effects of this invasive species on the marine phase of Atlantic salmon, but the sheer scale of the changes makes it important to keep an eye on this in the future.

9 Management regime

A central tenet that follows from the NASCO Precautionary Approach and Decision Structure is that salmon rivers should be managed within a flexible framework in which targets are formulated and research and monitoring data are explicitly used to follow the relation between stock status and targets. Depending on stock status, pre-agreed management actions should be selected and implemented.

It is highly important to focus management actions in such a way that they rely clearly on available scientific knowledge. This should enable the management actions to be pinpointed towards the actual goals (or targets) the management wants to reach. The factual suggestions for management actions thus depend on:

1. The specific goals that are formulated for each stock and each fishery.
2. Results from the monitoring and scientific programs (e.g. the telemetry study should ideally provide some kind of exploitation map detailing when, where and how much the different stocks are exploited, allowing the management to derive actions targeted specifically towards the goals).

Monitoring data must play a central role in informing the decisions of those charged with managing the river. An active adaptive management presupposes a monitoring regime that is capable of detecting environmental trends in spite of the levels of process and observation uncertainty inherent in the system. In other words, it implies that analysis of monitoring data must achieve sufficient statistical power to enable informed decision-making. This is the basis of the monitoring program proposed in this report.

The present management system in Tana (detailed in the agreement between Norway and Finland dating back to 1990) is unusable within a framework that puts high demands on flexibility. The process of changing and implementing regulations in the river system today requires a total renegotiation of the agreement, a process that is both rigid and time-consuming.

Adaptive environmental assessment and management, frequently just called adaptive management, is a management procedure that considers management alternatives as experimental treatments (Walters 1986). Management actions are implemented within a well-defined framework for setting goals, monitoring and evaluation of outcomes (Walters 1986). Consequently, adaptive management facilitates the methodical collection of information on how stocks and management interact.

Models should thus play an important role in adaptive management. Models provide a representation of the system itself and will aid the development of quantitative approaches to management. Models can also be used to investigate the quantitative understanding of key components, relationships, assumptions and uncertainties. Perhaps most importantly, models present a method for exploring components of the management system, including decision rules, targets, contingencies and alternate management strategies.

The methodological collection of research and monitoring data that is proposed with this report, will allow for future simulations of various management actions and strategies. Various effects and outcomes of proposed actions can thus be predicted, increasing the probability of choosing and implementing management actions that will actually work towards the wanted target.

9.1 Concluding advice for Tana

1. Future agreements between Norway and Finland need to be formulated to allow for a flexible adaptive management.
2. A research project should be started to model the stock specific effects of various potential future regulations of the fishery. This will strengthen the basic foundation of the management, and allow for predefined management options to be targeted specifically at the negative effects that counteraction.

10 River inventory

In 1990, NASCO approved the establishment of a database of salmon rivers containing information on habitat-related parameters of the river (detailed in the Plan of Action to protect and restore Atlantic salmon habitat (CNL(01)51)). Each Party of NASCO has an obligation to keep the information contained in the river database updated as new knowledge and new developments are taking place.

Most of the basic research tasks and the monitoring proposed in this report will yield information valuable for the River inventory. Additional information will come from the implementation of the European Water Framework Directive.

The Group suggest that the responsibility of keeping the River inventory updated is given to the County Governor of Finnmark and FGFRI.

11 Future collaboration

The present Norwegian-Finnish working group is temporary and as such concludes its work with the present report. However, the amount of information that needs to be correlated and synthesized from the proposed monitoring and research tasks is huge and will place a high demand on the scientific advice for the management of the river system. To ensure that this important part of the process is sufficiently taken care of, the working group suggest the formation of a permanent Norwegian-Finnish monitoring and research group for the Tana river system.

Some suggested tasks for a permanent monitoring group:

1) Coordination of monitoring and research.
2) Evaluation and annual reporting of stock status.
3) Evaluation of the effect of management measures.

To further the cooperative process between Norway and Finland, and to ease the future synthesis and review of stock status data, the working group also suggests the formation of a common database that the accumulated new and historical monitoring and research data are put into.

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Appendices

1. CNL(98)46 *Agreement on Adoption of a Precautionary Approach*

2. CNL31.332CNL31.33 Decision Structure For Management of North Atlantic Salmon Fisheries

Agreement on Adoption of a Precautionary Approach

1.   NASCO and its Contracting Parties agree to adopt and apply a Precautionary Approach to the conservation, management and exploitation of salmon in order to protect the resource and preserve the environments in which it lives. Accordingly, NASCO and its Contracting Parties should be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures.

2.   The Precautionary Approach requires, *inter alia*:

    a)   consideration of the needs of future generations and avoidance of changes that are not potentially reversible;

    b)   prior identification of undesirable outcomes and of measures that will avoid them or correct them;

    c)   initiation of corrective measures without delay, and these should achieve their purpose promptly;

    d)   priority to be given to conserving the productive capacity of the resource where the likely impact of resource use is uncertain;

e)   appropriate placement of the burden of proof by adhering to the above requirements.

3.   The application of a Precautionary Approach should involve all parties concerned with salmon conservation, management and exploitation.

4.   The Precautionary Approach will be applied by NASCO and by its Contracting Parties to the entire range of their salmon conservation and management activities. Initially the application will be to the following three areas:

-        Management of North Atlantic salmon fisheries

-        The formulation of management advice and associated scientific research

-        The area of introductions and transfers including aquaculture impacts and possible use of transgenic salmon.

5.   Both NASCO and its Contracting Parties should as the next step address application of the Precautionary Approach to freshwater habitat issues and the by-catch of salmon in other fisheries.

Management of North Atlantic salmon fisheries

6.   An objective for the management of salmon fisheries for NASCO and its Contracting Parties is to promote the diversity and abundance of salmon stocks. For this purpose, management measures, taking account of uncertainty, should be aimed at maintaining all salmon stocks in the NASCO Convention area above

their conservation limit (currently defined by NASCO as the spawning stock level that produces maximum sustainable yield), taking into account the best available information, and socio-economic factors including the interests of communities which are particularly dependent on salmon fisheries and the other factors identified in Article 9 of the Convention. In order to achieve this, a Precautionary Approach will be applied to the management both of fisheries regulated by NASCO and those in homewaters.

7. The application of the Precautionary Approach to salmon fishery management is an integrated process which requires at least the following:

a) that stocks be maintained above the conservation limits by the use of management targets;

b) that conservation limits and management targets be set for each river and combined as appropriate for the management of different stock groupings defined by managers;

c) the prior identification of undesirable outcomes including the failure to achieve conservation limits (biological factors) and instability in the catches (socio-economic factors);

d) that account be taken at each stage of the risks of not achieving the fisheries management objectives by considering uncertainty in the current state of the stocks, in biological reference points and fishery management capabilities;

e) the formulation of pre-agreed management actions in the form of procedures to be applied over a range of stock conditions;

f) assessment of the effectiveness of management actions in all salmon fisheries;

g) stock rebuilding programmes (including, as appropriate, habitat improvement, stock enhancement and fishery management actions) be developed for stocks that are below their conservation limits.

8. The management procedures for all salmon fisheries could include the following elements:

      a)   definition of target spawning stock levels in the relevant rivers;

      b)   definition of pre-fishery abundance of individual salmon stocks or groups of stocks occurring in the relevant fishery;

      c)   utilisation only of the surplus according to a) and b) above;

      d)   socio-economic factors.

9.   New fisheries targeted on salmon or which could result in a by-catch of salmon should be subject to cautious conservation and management measures. In accordance with Article 2, paragraph 3 of the Convention, the Parties shall invite the attention of non-Contracting Parties to any significant by-catch of salmon by its vessels.

10.   Efforts to minimise unreported catches, and to improve estimates of them, are consistent with the Precautionary Approach. NASCO and its Contracting Parties agree to evaluate and report on progress in this area.

The formulation of management advice and associated scientific research

11.   ICES or other scientific advisors should be requested, *inter alia*, to:

a)   provide stock conservation limits and management targets for all river stocks;

b)   advise on the risks of not achieving the objectives of NASCO or its Contracting Parties by considering uncertainty in the current state of the stocks, in biological reference points related to specific management objectives and in fishery management capabilities;

c)   provide catch options or alternative management advice with associated risk assessments for the fisheries regulated by NASCO and homewater fisheries for all salmon stocks;

d)   advise, in the light of current conditions in the freshwater and marine environment, on stock rebuilding programmes including, where appropriate, habitat improvement, stock enhancement, disease prevention and fishery management actions;

e)   identify the monitoring and data collection required to better achieve the objectives of NASCO and its Contracting Parties;

f)   advise on the impacts on salmon stocks of existing and new fisheries for other species, and of salmon fisheries on non-target species.

The area of introductions and transfers including aquaculture impacts and possible use of transgenic salmon

12.   Implementation of the measures contained in the following agreements is essential in the light of the Precautionary Approach:

- North American Commission Protocols on Introductions and Transfers, NAC(92)24

- Amendments to the North American Commission Protocols on Introductions and Transfers, NAC(94)14

- Resolution by the Parties to the Convention for the Conservation of Salmon in the North Atlantic Ocean to Minimise Impacts from Salmon Aquaculture on the Wild Salmon Stocks, CNL(94)53

- NASCO Guidelines for Action on Transgenic Salmon, CNL(97)48

- Resolution by the North-East Atlantic Commission of the North Atlantic Salmon Conservation Organization to Protect Wild Salmon Stocks from Introductions and Transfers, NEA(97)12.

The Parties therefore agree to report to the Council or to the appropriate Commission of NASCO on the steps taken to achieve the measures described in

the above agreements. The Contracting Parties should ensure full implementation of these agreements and will consider whether the agreements need to be re-examined and complemented by additional steps.

The North Atlantic Salmon Conservation Organization

Decision Structure

For Management of

North Atlantic Salmon Fisheries

Decision Structure to Aid the Council and Commissions of NASCO and the Relevant Authorities in Implementing the Precautionary Approach to Management of North Atlantic Salmon Fisheries

Introduction

In response to concern about the status of Atlantic salmon stocks, NASCO and its Contracting Parties have agreed to adopt and apply a Precautionary Approach to the conservation, management and exploitation of salmon in order to protect the resource and preserve the environments in which it lives. Accordingly, NASCO and its Contracting Parties should be more cautious when information is uncertain, unreliable or inadequate and the absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures.

To assist in applying the Precautionary Approach to the management of North Atlantic salmon fisheries, the Council of NASCO has developed this Decision Structure which was adopted in 2002. The Decision Structure provides a basis for more consistent approaches to the management of exploitation throughout the North Atlantic range of the species. It proposes the use of reference points such as conservation limits (i.e. the number of spawning salmon below which the stock would decline markedly) and management targets, or other indicators of stock status, to trigger management actions to address any failure in abundance or diversity. It is intended that the Decision Structure be widely applied by managers with stakeholders on salmon rivers. In applying the Decision Structure, management decisions should be taken in accordance with an assessment of risk, such that, in the face of uncertainty, there is a low risk to abundance and diversity of the stock(s). The probability of achieving the management goals should be high. The results of using the Decision Structure should be monitored and evaluated to ensure that the actions taken in managing salmon fisheries are consistent with the Precautionary Approach. The Contracting Parties have agreed to report annually to NASCO on their experiences in applying the Decision Structure and on the extent of its implementation.

Secretary
Edinburgh
14 November, 2002

A.   *Brief Description of the Fishery(ies):*

Date of review:	
Fishery location:	
Gear types:	
Magnitude of fishery (e.g. catch or effort):	
Current management restrictions:	
Outline pre-agreed procedures (or provide references):	
Principal river stock(s) exploited:	
Other fisheries exploiting stock(s):	
Other information:	

**If fishery primarily exploits salmon from only one river answer all questions in Section B;
If fishery exploits salmon from more than one river answer all questions in section C.**

B. *Single River Stock Fishery(ies)*

B1. Specify the reference points (Conservation Limit and/or Management Target) or alternative measures used to define adequate abundance of the stock.

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B2. Describe the status of the stock relative to the abundance criteria in B1.
- Include trends and forecasts of abundance.

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B3. Is the stock meeting other diversity criteria (e.g. age structure, run-timing, fecundity)?
- Describe criteria assessed;
- Identify possible reasons for any failure.

Yes/No

B4. Is the fishery(ies) selective for certain stock components (e.g. age groups, size groups, populations)?
- If yes, describe reasons.

Yes/No

B5. Is the stock threatened by factors other than fisheries (e.g. habitat degradation, disease/parasites, predators)?
- If yes, describe threat and management action that will be taken (e.g. establish gene bank; habitat mitigation).

Yes/No

B6. Describe management actions that will be employed to control harvest, including measures that will be used to address any failure or trend in abundance or diversity, taking account of pre-agreed procedures.
- Decisions should take account of: uncertainty in the assessments; abundance of the stock (q. B2); diversity of the stock (q. B3); selectivity of the fishery (q. B4); any non-fishery factors affecting the stock (q. B5); and socio-economic factors; and other fisheries exploiting the stock;
- Describe the expected extent and timescale of effects.

B7. Outline programmes (including in-season programmes) that will be used to monitor the effect of the management measures and identify information deficiencies and timeframe for resolution.

C. *Mixed River Stock Fishery*

C1. Specify the reference points (Conservation Limits and/or Management Targets) or alternative measures used to define adequate abundance of the exploited stocks.

C2. Describe the status of all stocks relative to the abundance criteria in C1.
-   Include trends and forecasts of abundance.

C3. Are all the stocks meeting other diversity criteria (e.g. age structure, run-timing, fecundity)?
-   Describe criteria assessed;
-   Identify possible reasons for any failures.

Yes/No

C4. Is the fishery selective for certain stock components (e.g. age groups, size, populations, river stocks)?
-   If yes, describe reasons.

Yes/No

C5. Are any of the stocks threatened by factors other than fisheries (e.g. habitat degradation, disease/parasites, predators?
-   If yes, describe threat and management action that will be taken (e.g. establish gene bank; habitat mitigation).

Yes/No

C6. Describe management actions that will be employed to control harvest, including measures that will be used to address any failure or trend in abundance or diversity, taking account of pre-agreed procedures.

- Decisions should take account of: uncertainty in the assessments; abundance of the stock (q. C2); diversity of the stock (q. C3); selectivity of the fishery (q. C4); any non-fishery factors affecting the stock (q. C5); and socio-economic factors; and other fisheries exploiting the stock;
- Describe the expected extent and timescale of effects.

C7. Outline programmes (including in-season programmes) that will be used to monitor the effects of the management measures, and identify information deficiencies and the timeframe for their resolution.

Definitions

Population: A group of salmon, members of which breed freely with each other, but not with others outside the group. The smallest group that can be usefully managed.

Stock: A management unit comprising one or more salmon populations. This would be established by managers, in part, for the purpose of regulating fisheries. (The term may be used to describe those salmon either originating from or occurring in a particular area. Thus, for example, salmon from separate rivers are referred to as "river stocks" and salmon occurring at West Greenland may be referred to as the "West Greenland stock").

Mixed stock fishery: A fishery exploiting a significant number of salmon from two or more river stocks.

Conservation Limits: Conservation limits demarcate the undesirable spawning stock level at which recruitment would begin to decline significantly. The level cannot be used in management without also defining the acceptable probability (e.g. proportion of years) when the stock may be permitted to fall below the conservation limit.

Currently NASCO and ICES define the conservation limit as the spawning stock level that produces maximum sustainable yield. Formerly referred to as Minimum Biologically Acceptable Level (MBAL) or a Spawning Target.

Management Target: The management target is the stock level employed by managers/scientists to aim at in order to achieve the objective of exceeding the conservation limit for the desired proportion of years and for achieving other management objectives. The management target will therefore be greater than the conservation limit with the margin between them at least reflecting the risks, decided by managers, of stocks falling below the conservation limit.