State of Alaska
Department of Fish and Game
Public Review Nomination for Waters
Important to Anadromous Species

83-3384

☒ Addition ☐ Deletion

Name of Waterbody (if known): Atigun River

Location: Arctic

Anadromous Waters Catalog Volume and Number

USGS 1:63,360 Quadrangle Phil Lib. Smith A5, B5, C4, C5, D4 Sag A4, B4, C4, D4 Beechey A4, A3, A4, B3

or 1:250,000 (if 1:63,360 not available)

Species	Date(s) Observed	Stage(s) (Spawning, Rearing, Migration)
Arctic char	Sept or Oct. 1978	rearing

Comments: Please provide any clarifying information in addition to identification on Anadromous Waters Catalog Public Review Maps.

Char probably distributed farther upstream but were observed at road xing.

Name of Observer (please print) Alan K. Townsend

Date: 3-7-83 Signature: Alan K. Townsend

Address: 1300 College Rd
Fairbanks, Ak

Drafted CB 7/5/83

AERIAL 47

USGS, PHILIP SMITH MOUNTAINS A-5, A-4
1" = 2000'

Alyeska pipeline SERVICE COMPANY 1835 SOUTH BRAGAW STREET, ANCHORAGE, ALASKA 99512, TELEPHONE (907) 278 1611, TELEX 090 25 127

June 14, 1983

Letter No. 83- 3384-G

COMMISSIONER'S OFFICE
RECEIVED
JUN 17 1983
DEPARTMENT OF FISH AND GAME

Mr. Don Collingsworth
Commissioner
Alaska Dept. of Fish and Game
Subport Bldg.
Juneau, AK 99801

Re: Anadromous Fish Stream Catalog

Dear Commissioner Collingsworth:

In a review of the proposed 1983 changes to the catalog of Waters Important for the Spawning, Rearing and Migration of Anadromous Fishes we noted that the Atigun River had been added. The catalog indicates that Arctic Char rear in the river well above the Atigun Gorge.

Alyeska Pipeline Service Company wishes to register an objection to the inclusion of the Atigun River to the catalog. While we do not disagree that Arctic Char are found above the Atigun Gorge we do not agree that these are anadromous Char. Alyeska believes that these fish represent a resident population.

To support our claim we are attaching a copy of a telex from Dr. Peter McCart discussing Atigun River Char. Dr. McCart and his associates have many years of experience studying Arctic Char in Northern Alaska and Canada.

Because there is no known data which would support designating the Atigun River as an anadromous fish stream, Alyeska Pipeline Service Company requests that the Atigun River not be included in the 1983 changes to the catalog of Anadromous Fish Streams.

Very truly yours,

B. L. Hilliker
Manager,
Environmental Protection &
Government Reports

BLH/wkk
Attachment

cc: Carl Yanagawa - ADF&G
B. Stafford - DNR

1211

Attn: Dick Mikkelsen

Re: Reclassification of the Atigun River Drainage as an Anadromous Fish Stream

Aquatic Environments Inc. has been conducting fisheries investigations in the Atigun Sagavanirktok Drainage since 1969 and is currently involved in a three year study to assess the long-term effects of the Trans-Alaska Pipeline System on Fish resources of the region. During the course of these studies, we have developed an in-depth understanding of the life history, habitat requirements and distribution of both anadromous and freshwater fish populations in the area. Our early work sponsored by Alyeska Pipeline Service Company (1969-1974) and Alaskan Arctic Gas Study Inc. (1972-1976), included detailed mapping of critical spawning and overwintering areas for anadromous and freshwater populations of Arctic Char. Based on these studies and our most recent investigations in the Atigun River (1981-1983) the following pattern of fish distribution and life history patterns has emerged.

Sampling in the Atigun River Drainage reveals a species compositions of approximately 85% Arctic Grayling, 7% Round Whitefish, 6% Arctic Char, 1% Lake Trout and 1% Burbot. Slimy Sculpin, while abundant throughout the drainage, are not included in this determination.

Lake dwelling populations of eastern form Arctic Char are found in Galbraith Lake and in several small lakes immediately to the south. These isolated populations are non migratory, spawn in lakes, and are not known to interbreed with stream resident fish.

In addition to these lake resident Arctic Char, there is an isolated population of Western form Arctic Char (synonomous with Northern Dolly Varden) inhabiting streams in the Atigun River Drainage. Conditions in the Atigun River Gorge appear to prevent movement of Char from the Sagavanirktok River into the upper Atigun River, effectively isolating this stream resident population.

Stream resident Char in the Atigun River are believed to spawn and overwinter in the vicinity of small groundwater sources located in the mainstream between Pipeline MP 144 and 158. Because the Atigun Gorge is an immpassable barrier to the upstream migration of Char, any fish which migrate downstream into the Sagavanirktok River will be lost to the population, which is reproductively isolated. We are in the process of conducting detailed meristic and morphological studies of stream resident Char from the Atigun River Drainage for comparison with similar data for other North Slope Drainages (McCart 1980), we anticipate these data will be available by October of this year.

In the 15 years during which the Sagavanirktok River system and the Atigun Drainage have been intensively studied (1960 to 1983 inclusive) no one has to our knowledge observed or sampled anadromous Arctic Char spawning in the Atigun River. These are readily distinguishable because they are at least twice as long and weigh at least 10 times as much as stream resident fish. One reason for this absence may be that the accessible reach of the stream downstream of the gorge is very short and appears to have no perennial supply of groundwater. A good Winter supply of groundwater is essential for the incubation of eggs. The only use we can suggest that anadromous Char may make of the Atigun River is a feeding area during the summer when small numbers of juvenile fish from the Sagavanirktok River may enter the lowermost reaches of the stream downstream of the gorge. However the area which such juveniles might utilize is so small and the area of similar habitat elsewhere in the Sagavanirktok System is so large that the Atigun River can be of little significance to the overall well being of anadromous populations in the Sagavanirktok System.

There appears, therefore, to be no justification for considering the Atigun River an anadromous Fish Stream, using any reasonable definition of the term. Many other North Slope streams are also known to support isolated populations of Char populations and in some cases small numbers of rearing juveniles but have not been considered anadromous fish streams.

Sincerely,

Peter McCart, PhD

STATE OF ALASKA

Bill Sheffield, Governor

DEPARTMENT OF FISH AND GAME

OFFICE OF THE COMMISSIONER

P.O. BOX 3-2000
JUNEAU, ALASKA 99802
PHONE: 465-4100

September 16, 1983

Mr. B. L. Hilliker, Manager
Environmental Protection &
Government Reports
Alyeska Pipeline Service Co.
1835 S. Bragaw St.
Anchorage, AK 99512

ALASKA DEPT. OF
FISH & GAME

SEP 23 1983

HABITAT
REGIONAL OFFICE

Dear Mr. Hilliker:

RE: APSC Letter No. 83-3422-G; Atigun River Char.

Thank you for your August 8, 1983, letter regarding the Department's classification of Atigun River char as anadromous fish under the authority of AS 16.05.870. As I understand your concerns, they are as follows:

1. You believe that the Legislature intended us to base anadromous fish designations on the presence of "adult anadromous spawners." You believe that this point is substantiated by our revised Catalog of Waters Important for Spawning, Rearing and Migration of Anadromous Fish (Catalog), because it indicates that "anadromous fish means fish which enter fresh water from the sea for spawning purposes."

2. You believe it highly speculative whether char have ever been able to negotiate the Atigun River gorge.

3. You consider our earlier mention of king salmon in the Susitna to be an inappropriate analogy. You refer to the Department's earlier recognition of king salmon as much stronger swimmers than char and, therefore, not comparable.

4. You disagree with our classification of char as anadromous fish in the Atigun River and desire that we reconsider this designation.

I would like to respond to your concerns in the above order.

1. We are interpreting legislative intent and our catalog definition of anadromous fish to refer to anadromous stocks and not to landlocked populations of otherwise anadromous species. I believe that we are in agreement on this point.

With the above in mind, we do, however, base our classification of anadromous fish waters on the presence of immature fish as well as on the presence of spawners returning from the sea. The fact that AS 16.05.870 provides for the protection of spawning, rearing and migration of anadromous fish means that coverage is not limited to systems identified solely by the presence of adult spawners. Our definition of anadromous fish is a definition of a category of fish that lives through life cycles, all of which are subject to the protection provisions of AS 16.05.870.

The fact that adult and sub-adult char exist throughout the Atigun River is not argued. We concur that anadromous char have not as yet been documented to spawn in the Atigun River. A first issue, then, until such time that spawners may be documented, is whether the Atigun River supports rearing char that will eventually become anadromous and thus is also used for migration by these individuals.

Dr. Hans Nordeng in Norway artificially spawned both resident and anadromous char as separate groups and presented the results of his research at the First International Symposium on Arctic Char in 1981. He demonstrated that both matings between resident adults and matings between anadromous adults produced the same ratio of 40 percent resident offspring and 60 percent anadromous offspring. Such research is of particular importance to the case at hand. Whether this life history pattern exists for the Atigun River char is the proper focus of attention for this first issue.

2. It is the belief of our biologists, familiar with the Atigun River, that char can successfully negotiate both upstream and downstream through the gorge. They base this belief on the following observations:

   a. the presence of many large boulders which break up the laminar flow creating abundant eddies suitable as fish resting areas;

   b. suitable resting areas are close enough together in the gorge to provide ample opportunity for char to negotiate the full length of the gorge; and

   c. there are no falls in the gorge that would create an impassable barrier to fish.

3. I agree that the habits of king salmon in the Susitna River are not directly analagous to those of char on the Atigun River and that king salmon are stronger swimmers than char. The Susitna was mentioned only to emphasize that fish can often accomplish rather surprising feats.

4. We are dealing here with a particular higher order tributary stream. It is our general position that the offspring of resident

char can assume the anadromous lifestyle and migrate to sea. Furthermore, we are not convinced that the Atigun River Gorge is an impassable barrier to char. However, it is worthwhile to delay nomination of the Atigun River for inclusion in the Catalog until we have had a chance to review Dr. McCart's data, which are due in October, and to receive preliminary results from the work of the Sport Fish Division which I directed to be pursued as a consequence of our initial correspondence on this matter. Accordingly, I would appreciate receiving a copy of Dr. McCart's work when it is completed.

Thank you for your attention to our Catalog. I look forward to discussing this matter further after we have had the chance to look at the results of the forthcoming studies.

Sincerely,

Dennis D. Kelso
Deputy Commissioner

cc: Logan
Clark

Record of Telephone Conversation

Person Calling: George Elliott Phone Number: _____

Address: USFWS

Person Called: Phyllis Weber Phone Number: _____

Address: ADF&G/Habitat

Date: 24 August 1983 Time: 1:30

Subject: anadromous char in Atigun River

Comments/discussion:

G. Elliott said that juveniles and residual males overwinter above the gorge. He has found rather large char above the gorge of almost anadromous size, however they did not have anadromous coloration and were found at the wrong time of the year for adult spawning.

Elliott does not believe that the gorge is a barrier to fish passage; grayling appear to move from the Sag River through the gorge to the upper reaches of the Atigun. He cannot substantiate the presence of anadromous char but believes there is a potential for fall spawning.

Elliott is sending a copy of his report pertaining to the Atigun River fish.

MEMORANDUM

State of Alaska

TO: Carl M. Yanagawa
Regional Supervisor
Habitat Division
Anchorage

FROM: Phyllis K. Weber PKW
Habitat Biologist
Habitat Division
Anchorage

DATE: July 6, 1983

FILE NO: LIBRARY – SAG QUAD

TELEPHONE NO: 344-0451

SUBJECT: M. Atigun River
Doc C142

I contacted the Region III Habitat and Sport Fish Divisions regarding documentation of anadromous char in the Atigun River. Al Townsend said that he responded to Mr. Hilliker's objection to the inclusion of the Atigun River in the Anadromous Fish Waters Catalog. Townsend argued that, even though the char may be a resident population, they likely produce anadromous offspring. Townsend referenced published studies which document the genesis of anadromous fish from resident populations. He will also contact Terry Bendock, who nominated the Atigun River, for Bendock's information.

Region III will send us a copy of the response to Mr. Hilliker for our files.

cc: S. Grundy
B. Baker

Solution to the "Char Problem" based on Arctic Char (*Salvelinus alpinus*) in Norway[1]

HANS NORDENG

Zoological Institute, University of Oslo, P.O. Box 1050, Blindern, Oslo 3, Norway

NORDENG, H. 1983. Solution to the "char problem" based on Arctic char (*Salvelinus alpinus*) in Norway. Can. J. Fish. Aquat. Sci. 40: 1372 – 1387.

Rearing and transplantation experiments demonstrate that three coexisting forms of Arctic char *Salvelinus alpinus* (anadromous, small and large freshwater residents) belong to the same gene pool. The parr of each form segregate into all three forms. Single individuals may manifest all three forms during their lifetime, successively attaining the appearance and spawning color of each form. Males mature at a younger age and smaller size than females. Hence, in char populations featuring two or more forms, males dominate in the early maturing form and females in the late maturing form. Char populations that feature only one form (sex ratio 1:1) seem to be established through natural selection for age at sexual maturity. Segregation during the young stage depends upon their genetic constitution and access to food. Offspring of the small resident parents produced more resident individuals and fewer smolts than did offspring of anadromous parents. An increased amount of food increases the resident fraction and reduces the fraction of anadromous char. It is demonstrated that the potential for anadromy exists in populations of char in the southern nonanadromous area, and that one reason for resident behavior in the smolt may be infection of the ureter fluke *Phyllodistomum conostomum* Olsson.

NORDENG, H. 1983. Solution to the "char problem" based on Arctic char (*Salvelinus alpinus*) in Norway. Can. J. Fish. Aquat. Sci. 40: 1372 – 1387.

Des expériences d'élevage et de transplantation ont démontré que trois formes coexistantes de l'omble chevalier *Salvelinus alpinus* (anadrome, petit et gros dulçaquicoles non migrateurs) appartiennent au même effectif de gènes. Les tacons de chaque forme se transforment en l'une ou l'autre des trois formes. Un individu peut prendre les trois formes pendant son cycle vital, adoptant successivement l'apparence et la livrée de fraie de chaque forme. Les mâles atteignent la maturité à un âge et une taille inférieurs aux femelles. Ainsi, dans les populations d'omble qui possèdent deux formes ou plus, les mâles sont plus abondants chez la forme qui mature plus tôt et les femelles, chez la forme qui mature plus tard. La sélection naturelle par l'âge à la maturité sexuelle semble être le facteur déterminant des populations d'une seule forme (rapport des sexes 1:1). Chez les jeunes, la ségrégation dépend de leur constitution génétique et de l'accessibilité de la nourriture. La progéniture de petits parents non migrateurs comporte plus d'individus non migrateurs et moins de saumonneaux que la progéniture de parents anadromes. Une plus grande quantité de nourriture augmente la fraction d'ombles non migrateurs et réduit la fraction d'ombles anadromes. On démontre que le potentiel d'anadromie existe chez les populations d'ombles de la partie méridionale où les poissons ne sont pas anadromes et qu'une infection de l'uretère causée par le trématote *Phyllodistomum conostomum* Olsson peut expliquer la non-migration du saumoneau.

Received July 9, 1982
Accepted May 18, 1983

Reçu le 9 juillet 1982
Accepté le 18 mai 1983

THE "char problem" has long been an unsolved complex of questions concerning the systematics and ecology of Arctic char, *Salvelinus alpinus*. The problem arises from the phenomenon that Arctic char, throughout their circumpolar distribution, frequently occur in two or three coexisting forms of different size. In the southernmost areas of distribution all three forms are freshwater resident, and commonly designated dwarf, normal, and large (predatory) char (Haempel 1924; Neresheimer 1937; Fridriksson 1939; Reisinger 1953; Savvaitova 1969; Nilsson and Filipsson 1971; Dörfel 1974; reviewed in Johnson 1980). Corresponding forms in European river systems of anadromy may be characterized small resident, large resident, and anadromous char (Nordeng 1961; Gullestad 1975).

In principle, char forms differ in (1) age at sexual maturity, (2) sex ratio, (3) spawning color, (4) time and place of spawning, (5) feeding habits, (6) morphometric characters, and (7) migration. The variation in characters between sym-

[1] First presented at the International Symposium on Arctic charr, Winnipeg, May 1981.

Printed in Canada (J7000)
Imprimé au Canada (J7000)

patric forms is typically of the same kind throughout the entire range of distribution, and is often referred to as parallel development (Dörfel 1974) or homologous (parallel) inherited variation in characteristics (Savvaitova 1969).

Nilsson (1855), Reisinger (1953), and Brenner (1980) suggest that the coexisting forms may be regarded as phenotypes of genetically uniform populations, resulting from the influence of differences in environmental factors. However, most authors agree that the coexisting forms of Arctic char are reproductively isolated, although they disagree on the degree of relationship and allocation of taxa. Some consider the forms to be sibling species that were separated allopatrically in preglacial water bodies, and that subsequently invaded their present localities in postglacial times (Svärdson 1961; Nilsson and Filipsson 1971; Henricson and Nyman 1976; Klemetsen and Grotnes 1980). Behnke (1972, 1980) explains the coexisting forms by successive invasions, and considers some of them to be subspecies and even species. Frost (1963, 1965) and Savvaitova (1970, 1973, 1980) suggest that the forms may have developed sympatrically from a common ancestor; at the present time they have reached different stages of evolution and establishment.

In river systems along the Norwegian coast resident char occur together with Atlantic salmon *Salmo salar* and brown trout *Salmo trutta*, supplemented with anadromous char north of 65°N (Fig. 1). It is believed that char south of 65°N originated from anadromous ancestors and became nonanadromous during postglacial time. The explanation given is that during late postglacial time, summer temperatures in the Gulf Stream, south of 65°N, gradually became too high for the char. The char thus became marine relicts in their river systems (Huitfeldt-Kaas 1918; Ekman 1922). However, recent continuous measurements (Sætre and Ljöen 1972) indicate that temperatures in coastal waters both south and north of 65°N are 4–11°C during the summer period of sea migration of brown trout and char. The reason for resident behavior during postglacial time may then be due rather to changes in freshwater environmental factors or genetic constitution in the char themselves, than in temperature effects.

In Øvervatn[2], Salangen river system, north Norway (Fig. 1), small resident, large resident, and anadromous char coexist (Nordeng 1961). The three forms generally spawn at separate areas indicating that they may be reproductively isolated (Table 1). On the other hand, young char in the lake exhibit a single phenotype (Nordeng 1961), with a sex ratio of 1:1. Although the sex ratio in the three forms is different, the overall ratio approximates 1:1 as in young char. This indicates that the three forms may belong to the same gene pool (population). To decide whether the three forms in Øvervatn are reproductively isolated or belong to the same population, I studied their progeny in rearing and transplantation experiments. In parallel experiments I studied progeny of Arctic char from south Norway, to decide whether resident behavior results from environmental factors or genetic constitution. The parental stocks were from Bergen and Voss, south Norway (Fig. 1); they resemble the northern anadromous char both in appearance, and age and size at sexual maturity.

[2]The suffix "vatn" means lake.

Environment and Fish Community

Salangen, North Norway

The Salangen river system, situated within the area of anadromy of Arctic char (Fig. 1), is one of the few river systems in Norway in which salmonid species have remained genetically unaffected by human manipulation. Like most river systems in north Norway, the Salangen supports anadromous and resident individuals of Atlantic salmon, brown trout, and Arctic char. The resident salmon consist exclusively of precocious parr males, whereas resident trout and char also include females. Resident char fall into two forms, small and large. In anadromous char and trout the life history and pattern of migration are practically identical (Fig. 2). Each yearly migratory cycle ends with the participating categories (mature and immature veteran migrants and smolts of the year) returning to their freshwater habitats. In salmon, on the other hand, smolts and maturing salmon at sea exchange habitat during the migration period. Atlantic salmon and brown trout spawn in riffles throughout the river system. The various char forms spawn both in the river and in the lake (Øvervatn). Tagging experiments (unpublished) indicate that lake and river anadromous char may be reproductively isolated.

The three forms of Arctic char in Øvervatn exhibit the same kind of variation in characters (Table 1) as in coexisting forms throughout the distribution area (Savvaitova 1969).

Sexual Maturity and Sex Ratio

Among young char (parr) there is only one phenotype (Nordeng 1961), and the sex ratio is 1:1. During a period of 7 yr (the young stage), parr segregate into sexually mature individuals (natural resident males and females) and smolts [Fig. 2(I)]. Sexual maturation is initiated at an age of 2 yr and smoltification at 3 yr. The first to reach sexual maturity are males. During sexual maturation in the subsequent years, mature males exceed females in number, but the proportion declines from year to year. Small resident char maturing at an age of 2–6 yr thus exhibit more males than the large resident char maturing at an age of 3–7 yr; both forms show males in excess (cf. Table 1). Consequently, individuals that do not mature during the young stage, but smoltify and become anadromous char, show an excess of females. Anadromous char attain sexual maturity at an age of 4–8 yr, after their first, second, or third migratory cycle in the sea.

Spawning Areas

In Øvervatn, the spawning areas of anadromous char, large resident, and small resident char are situated close to each other on the northern side of the lake, and will here be called areas I, II, and III, categorized subjectively. Area I (Flåglandet), which is considered the most favorable, is situated at a depth of 2–6 m with a substratum of pebbles and gravel. Area II (Løchola) lies at the same depth, but the substratum consists of pebbles and gravel mixed with a little mud. Area III (Ressestolan), situated between area I and II, must be regarded as the least favorable spawning area as the substratum is composed of rocks and a little sand, with very

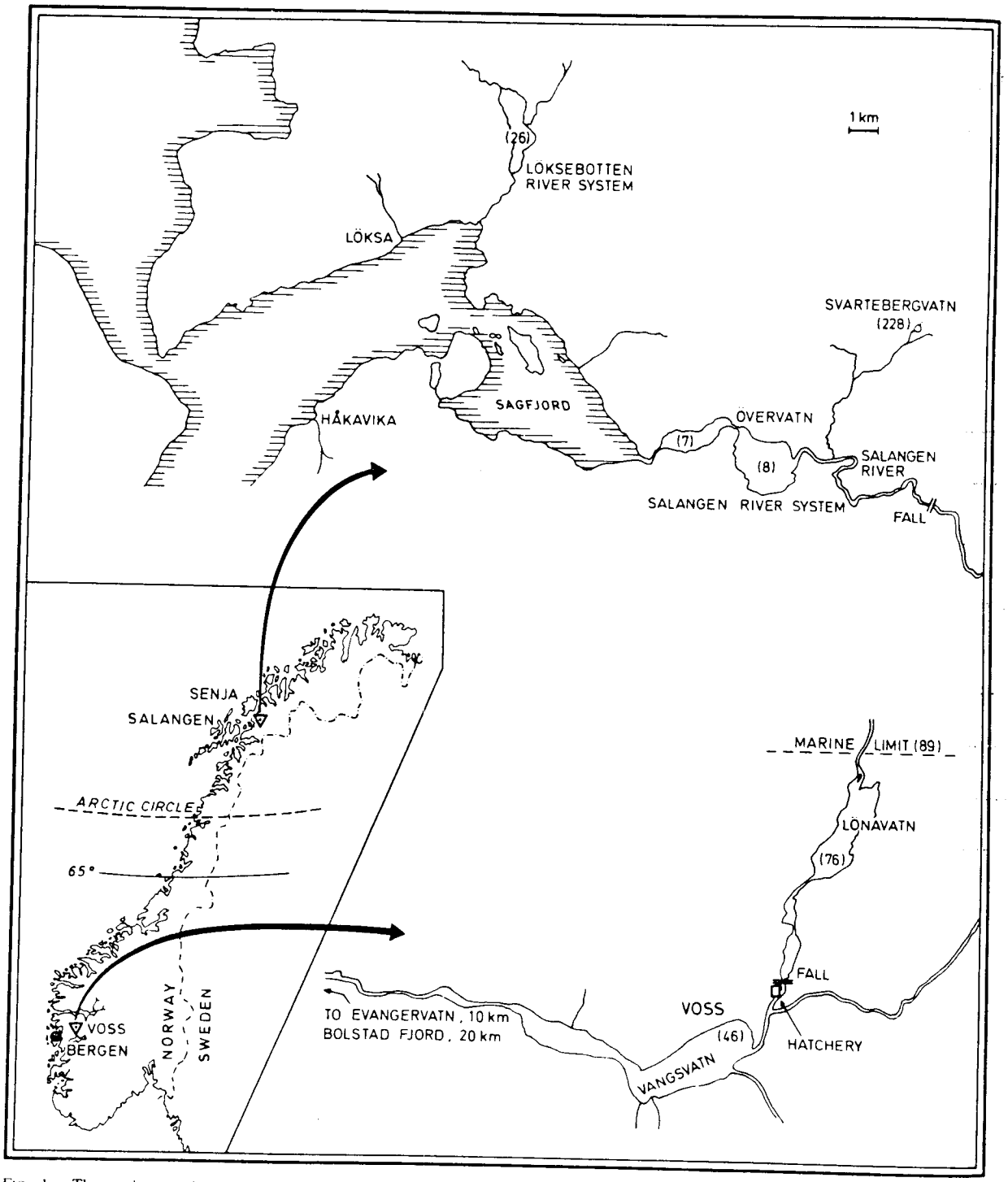

FIG. 1. The study area in south and north Norway and the hatchery below Rognsfossen waterfall at Voss. Number in parentheses = height (m) above sea level.

steep gradients down to 30 m. There seems to be competition for the spawning areas. Anadromous char spawn mainly in area I, large resident char mainly in area II, and small resident char exclusively in area III. Anadromous char and large resi-

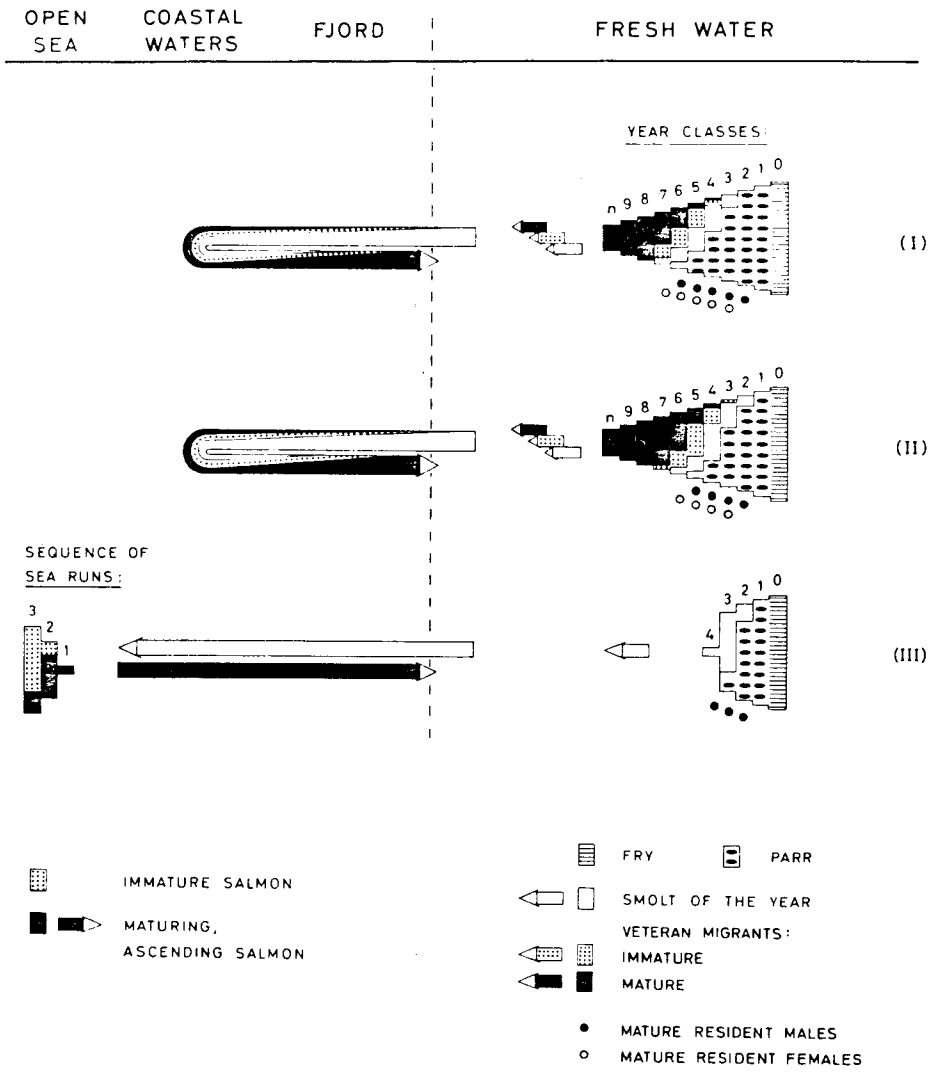

FIG. 2. Life history and migratory pattern in Arctic char *Salvelinus alpinus* (I), brown trout *Salmo trutta* (II), and Atlantic salmon *Salmo salar* (III), Salangen river system, north Norway. The figure is based on the char material in Nordeng (1961) and unpublished data on trout and salmon. The timing of the seasonal migrations is given in Nordeng (1977).

dent char keep their respective areas for themselves, whereas small resident char must share theirs with pairs from both neighboring groups.

FEEDING HABITS

Between annual spawnings resident char feed in freshwater, whereas anadromous char acquire the main part of their food during their stay in coastal waters. After homeward migration, anadromous char also take some food while schooling along the bottom or in the pelagic zone of the lake. Large resident char exhibit both schooling and benthic behavior, whereas small resident char feed on the bottom along the shores and in the inlets and outlets of the lake.

Resident char may change form and feeding habit. According to well-definable spawning zones in otoliths some resident char transform into anadromous char after spawning 1–3 times (Nordeng 1961). This applies to both sexes and accounts for about 9% of anadromous char. After transformation, these previously resident char grow and behave like anadromous char and remature after their second or third period in the sea.

GROWTH RATE AND TOTAL SIZE

Differences in growth rate and total size are often regarded as particularly characteristic of coexisting forms of Arctic char. Extensive annual growth during the immature stage, in the three forms of Salangen char, shows in the otoliths as wide, opaque, summer zones; stagnant growth at the mature

TABLE 1. Life history characteristics of Arctic char *Salvelinus alpinus* in Øvervatn, Salangen river system, north Norway, based on material in Nordeng (1961).

Characteristics	Small resident char	Large resident char	Anadromous char
Age (year)	2–13	3–15	4–14
Length (cm)	14–22	21–38	26–56
Weight (g)	25–90	70–460	160–1650
Sex ratio M:F	4:1	2:1	1:3
Spawning color	Pale grey	Yellow, red	Golden red, red
Spawning season	Autumn	Autumn	Autumn
Spawning frequency	Annual	Annual	Annual
Max. no. of spawning	10	13	7
Spawning areas I, II, III	III	II (III)	I (III)
Feeding habit	Benthic	Benthic–pelagic	Benthic, pelagic
Age at sexual maturity (yr)	2–6	3–7	4–8
Length at sexual maturity (cm)	14–22	21–27	26–48
Average length at sexual maturity (cm)	17.2	26.7	35.8
Average growth rate in mature stage (cm)	0.2	0.3	2.6

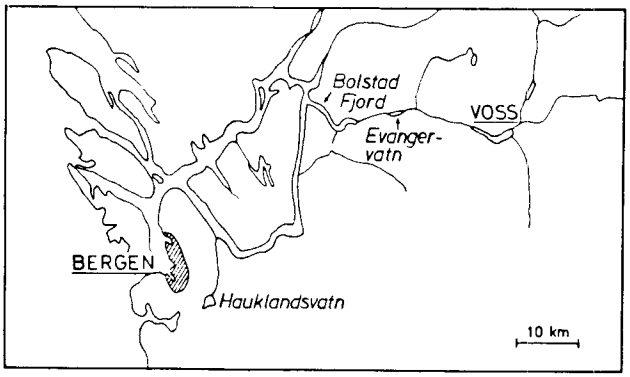

FIG. 3. Study area in south Norway.

stage is manifested as narrow, hyaline, spawning zones, or dense edges in corresponding scales (Nordeng 1961). Annual growth rate during parr stage is similar in all three forms. Growth rate in the mature stage depends on the size of the fish at sexual maturity. This implies different growth rates in the three forms and divergent growth during the mature stage (see Table 1).

BERGEN AND VOSS, SOUTH NORWAY

As in northern Norway, the coastal river systems in south Norway support Atlantic salmon, anadromous brown trout, and resident individuals of each species. Resident char are commonly present in the lakes of the river system, but seagoing char are absent.

During a pilot investigation in south Norway, while searching for suitable populations for our rearing and transplantation experiments, I found small and large resident char corresponding to the natural residents in the Salangen river system, north Norway. These forms were found above impassable waterfalls, together with resident brown trout, and below waterfalls in company with resident and anadromous brown trout and Atlantic salmon. However, in two river systems I found a third form which resembles anadromous char in most characteristics. The localities were Hauklandsvatn, near Bergen, and the Voss river system, both of which drain into the same system of fjords (Fig. 3).

In Hauklandsvatn, situated above a waterfall, 46 m above sea level, small and large resident char were found in addition to the third form which resembles anadromous char in appearance, size of the immature (26–35 cm) and mature (30–42 cm) stages, growth pattern, and age at sexual maturity. The scales of these char showed typical river–sea growth, despite the fact that they had spent their life exclusively in the lake. The change in the growth pattern of the scales occurs at an age of 2, 3, or 4 yr at a body length between 15 and 21 cm. The yearly length increment in the immature "post-smolt" stage was 8–16 cm, at least as high as that of the anadromous char of the Salangen river system (6–11 cm). This form is designated "potential anadromous char," because in all characteristics, except migration, it corresponds to anadromous char. The freshwater resident brown trout in Hauklandsvatn, which use the inlet brooks during parr stage, also showed a marked growth change in their scales.

The Voss river system supports Atlantic salmon, anadromous brown trout, and resident individuals of both species. Potential anadromous char were found both in Vangsvatn below the waterfall (Rognsfossen, 16 m) and in the ~8000-yr-old Lønavatn, situated above the fall, near the limit of former marine inundation (Fig. 1). In Lønavatn I expected to find the early maturing, small and large, resident char typical for such localities. However, I only found the potential anadromous form coexisting with resident brown trout and threespine sticklebacks *Gasterosteus aculeatus*, all obviously originating from anadromous ancestors. In Vangsvatn, the potential anadromous char were found together with small and large resident char. The potential anadromous char in the two lakes differ in body form, being slender in Vangsvatn but having a deep body in Lønavatn. In Lønavatn, char spawn in a restricted area of mediocre quality

TABLE 2. History of Arctic char *Salvelinus alpinus* hatched 1960–71 and used in rearing and transplantation experiments. The parents were small resident (SR), large resident (LR), and anadromous char (A), north Norway, and potential anadromous char (A*), south Norway. The offspring were reared at Voss and studied in the hatchery; some were released in different localities in north and south Norway.

Parents		Locality	Feeding intensity	Number of offspring at 1+	Number released			
					North Norway		South Norway	
					Salangen	Senja	Voss	Bolstadfjord
			North Norway					
Salangen river system								
1960	SR	Lake	Low	2705			587	72
	LR	"	Low	1629			299	26
	A	"	Low	4046			615	35
1965	A	"	Moderate	1817	519		174	
1970	A_2 of A 1965	Hatchery	"	687				
	SR	Lake	"	3361	1734			
	A	River	"	381		215[a]		
1971	A	River	High	1640	429	85		
			South Norway					
Bergen								
1970	A*	Hauklandsvatn	Moderate	842		442[a]		
Voss river system								
1970	A*	Vangsvatn	Moderate	1000				
	A*	Lønavatn	Moderate	517		306[a]		
1971	A*	Lønavatn	High	3091		356		210
Total				21716	2682	1404	1675	343

[a]Released through a hole in the ice cover of the lake. None were recaptured.

in the middle of the lake (cf. Matzow et al. 1976; Jonsson and Østli 1979).

Resident behavior in the southern potential anadromous char may be congenital or it may be due to environmental factors. The only relevant environmental factor I found was the trematode *Phyllodistomum conostomum* Olsson which infects the ureters of char. This fluke was found regularly in southern char down to a length of 17 cm, except for char in Hauklandsvatn. The ureters could be infested with more than a dozen flukes each. Flukes seem to occlude the ureters and damage the epithelium. In time, the ureters become white and elongated, forming zigzag bands which may be calcified. Infected char are sluggish and do not attempt to leave their lakes either against or with the current.

Among the potential anadromous char of Hauklandsvatn (Bergen), Vangsvatn, and Lønavatn (Voss), char in Lønavatn exhibit the longest span of residency, ~8000 yr. I considered the potential anadromous Løna char and the anadromous Salangen char as particularly useful for comparative rearing and transplantation experiments on resident and anadromous behavior. Therefore, we built a hatchery with a water supply from Lønavatn (Fig. 1). In this way offspring from Løna char would be reared under their natural conditions whereas offspring from Salangen char would be exposed to the environment in which Løna char had been resident for ~8000 yr.

Materials and Methods

Our hatchery at Voss is furnished with 11 troughs measuring 3 × 1 m. To prevent infection of the ureter fluke *Phyllodistomum conostomum*, the water supply was filtered through plankton nets of mesh size 0.5 mm.

In the rearing and transplantation experiments the parents were small resident, large resident, and anadromous char from the Salangen river system, and potential anadromous char from Bergen and Voss. The offspring of each group originated from two to four males and several females. History of the material is given in Table 2. By personal judgment the feeding intensity during the rearing experiments was successively increased (low, moderate, high). In 1960, at low intensity, the offspring were fed by hand four times a day; food was a worm-shaped mixture composed mainly of beef liver and heart. In subsequent experiments the offspring were supplied with pellets 40 times a day (07:00–20:00) from an automatic feeding apparatus. Moderate feeding (1965, 1970) refers to half capacity of the feeding apparatus, and high intensity (1971) to full capacity, resulting in an excess of food in each trough.

During the first autumn, at an age of 0+, char in each trough were counted and a sample was sexed and measured. At this age the number of fry in each trough was around 2000. Owing to natural death and losses during cleaning, numbers decreased to 900–1100 at an age of 1+ when the examination of the fish started. At the end of each growth period in November–December the parr of the year in each trough were counted, measured, and classified. According to their appearance and coloration the immature individuals were

classified into parr and presmolt. The mature individuals were classified into small resident (10.5–21.9 cm) and large resident char (22.0–28.0 cm). The mature char were removed, whereas the presmolts were marked by finclipping and then returned to their respective troughs. During the classification period a few parr escaped and some were killed for sampling of scales, otoliths, and examination of the ureters for the presence of the fluke *P. conostomum*. These unclassified individuals, less than 6% of each form, were omitted from the data analysis. Subsequent examination of the ureters of several thousand char not used in the transplantation experiments revealed that none were infested with the ureter fluke, even after 6 yr in the hatchery.

The offspring used in the transplantation experiments consisted of individuals classified as mature small and large resident char, parr, and smolt. The char were tagged in the hatchery and released at an age of 1+ and 2+ in late autumn or in early spring, just before downstream migration of natural anadromous salmonids. In the Voss river system the char were released in the upper part (Vangsvatn), the lower part (Evangervatn), and the Bolstad fjord outside. Char transplanted to north Norway were transported by air. Offspring of Salangen chars were released in Øvervatn, in their parental river system. At the Isle of Senja, offspring of both anadromous and potential anadromous char were released in Vardnesvatn, situated upstream of a fish trap described by Mathiesen and Berg (1968). Maximum summer temperature in the Voss, Salangen, and Vardnes river systems is about 19, 15, and 19°C, respectively.

Transplanted char were captured by local fishermen and ourselves over a period of 5 yr. Tag returns were accompanied by scales and information on place and time of recapture, total length of fish, and sex. Based on this information and the scale characteristics (Nordeng 1961), I classified the recaptured char as parr, small resident, large resident, and anadromous char. In the Salangen experiment char captured in freshwater before the end of the first natural downstream migration (July 20) were not classified.

In addition to the material presented in Table 3, 150 char from Svartebergvatn were collected in 1981. This lake drains via waterfalls into the Salangen river (Fig. 1), and is populated with landlocked small resident char. They are descendants from the fry of anadromous char released in 1920 by local fishermen. The parents originated from spawning area 1 in Øvervatn (cf. Table 1).

Results

The Rearing Experiments

The aim of the first rearing experiment (1960) was to reveal the relationship between the three forms of Arctic char in Øvervatn (Salangen river system, north Norway). Offspring of small resident, large resident, and anadromous parents were studied during their whole lifetime in the hatchery at Voss, south Norway.

During the rearing period, development in the three groups of offsprings was in principle identical. The sex ratio was 1:1 as in the natural young char. Each offspring segregated into smolts and mature individuals, the latter classified as small and large resident char (Table 3). The successive segregation of parr during the young stage (age 0+ to 4+) is given as total number in Table 4, and as percentage in Fig. 4.

TABLE 3. The total segregation in percent in reared offspring of small resident char (SR), large resident char (LR), and anadromous char (A) *Salvelinus alpinus* during the young stage. The parents were from Øvervatn (Salangen river system, north Norway), and the offspring were reared at Voss (south Norway).

Parents	Offspring			
	Number	SR	LR	A
SR×SR	2705	67.9	10.8	21.3
LR×LR	1629	66.9	11.5	21.6
A×A	4046	62.9	14.2	22.9

Age 0+ — The newly hatched alevins measured 16–18 mm. At a body length of about 10 cm, young char lost their irregular finger or parr marks, and became silvery. Already in June a pronounced group of large individuals developed in each trough and reached a body length of 10–15 cm by the end of the growth period in November–December. At this time faint finger marks reappeared and were present for a few months. None of the young char matured, and all were classified as parr.

Age 1+ — During this growth period the largest parr in each trough developed in two directions, sexual maturation or smoltification. The parr that reached sexual maturity lost their silvery coloring and attained a pale spawning dress. Except for a total of 15 females (0.5%) the maturing individuals were males, measuring 10–22 cm at the end of the growth period. Length interval and spawning dress corresponded to small resident char in the parental river system, and they were classified as such. The nonmaturing large parr retained their silvery dress at the end of the growth period, and exceeded the maturing char in growth. These char were classified as presmolt.

Age 2+ — The largest of the remaining parr from the previous year segregated into (1) presmolts, (2) mature females, and (3) some mature males. The body length of the mature individuals at this season (12–28 cm) had a normal distribution (Fig. 4) and corresponded to the total length interval of the natural small and large resident char at sexual maturity (cf. Table 1). Spawning color of the hatchery char was not very pronounced and could not be used as a definite criterion for classification into small and large resident char. These mature char were therefore artificially divided according to the length interval found in nature, into small resident char (21.9 cm and smaller) and large resident char (22.0 cm and larger).

Age 3+ — As in the previous year the largest parr segregated into presmolts, mature females, and a few males. In this

FIG. 4. The successive segregation (percent) in reared offspring of small resident (SR), large resident (LR), and anadromous char (A) *Salvelinus alpinus* during the young stage. The parents were from Øvervatn (Salangen river system, north Norway) and the offspring reared at Voss, south Norway. The figure includes the offspring in two troughs of each type.

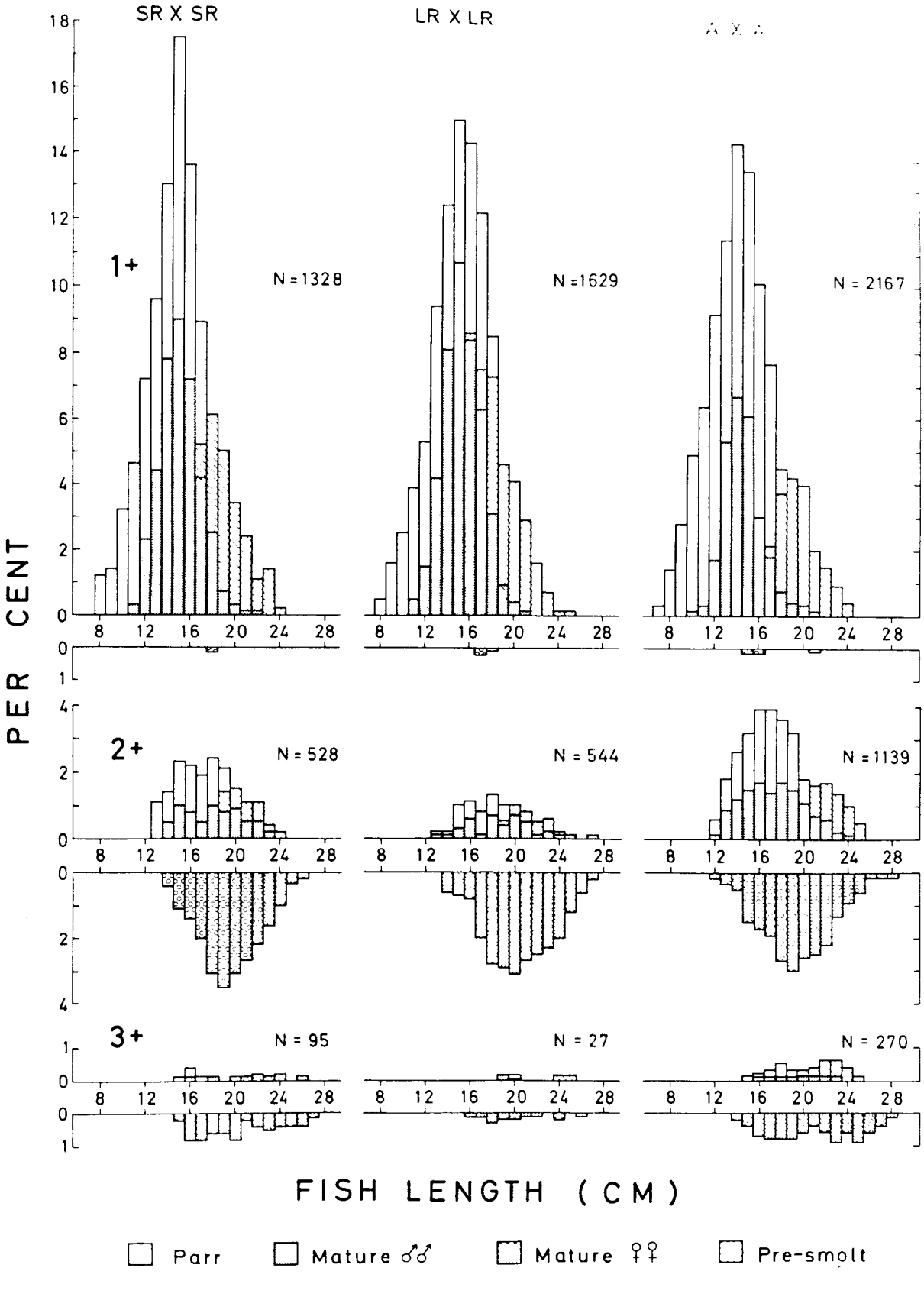
SR X SR
LR X LR
A X A
1+
2+
3+
N = 1328
N = 1629
N = 2167
N = 528
N = 544
N = 1139
N = 95
N = 27
N = 270
PER CENT
FISH LENGTH (CM)
Parr
Mature ♂♂
Mature ♀♀
Pre-smolt

TABLE 4. The successive segregation in total number in reared offspring of small resident char (SR), large resident char (LR), and anadromous char (A) *Salvelinus alpinus* during the young stage. The parents were from Øvervatn (Salangen river system, north Norway), and the offspring were reared at Voss (south Norway). P = parents, F_1 = offspring, M = male, F = female.

	P:	SR × SR				LR × LR				A × A			
Age	F_1:	SR	LR	A	Sum	SR	LR	A	Sum	SR	LR	A	Sum
1+	M	1020	4	472	1502	762	1	318	1085	1239	2	604	1850
	F	6	0			4	0			5	0		
2+	M	210	25	84	989	57	11	29	517	436	60	226	1637
	F	474	196			251	169			651	264		
3+	M	5	2	16	208	2	0	4	27	12	9	76	535
	F	122	63			14	7			202	236		
4+	M	0	1	3	6	—	—	—	—	1	0	19	24
	F	1	1							1	3		
SUM	M	1235	32	575	2705	821	12	351	1629	1688	71	925	4046
	F	603	260			269	176			859	503		

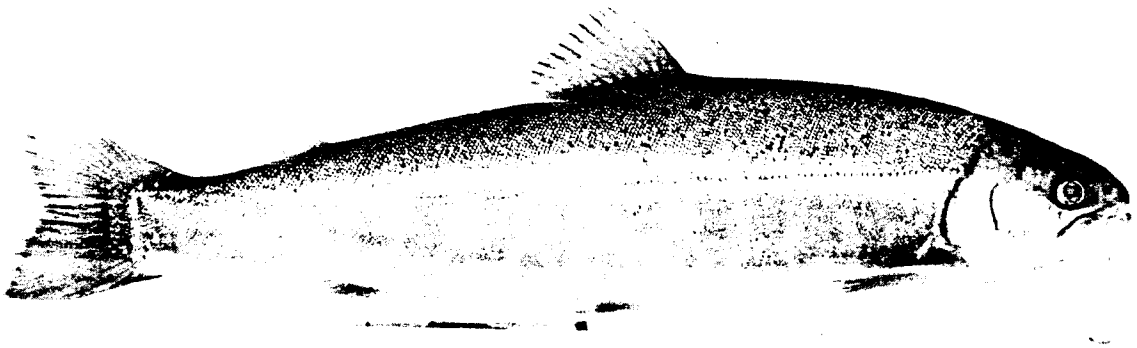

FIG. 5. Immature anadromous char *Salvelinus alpinus*, 35.0 cm, and 3 yr old. The char smoltified at an age of 2 yr (2+) and 22 cm, and is offspring of small resident char from Øvervatn (Salangen river system, north Norway).

season segregation in the offspring of large resident char concluded; i.e. all parr had either become sexually mature resident char or smolt.

Age 4+ — The few remaining parr from the previous year, the offspring of small resident char, and anadromous char segregated into presmolts, mature females, and males, thus concluding the young stage in these offspring (cf. Table 4).

In each type of offspring the males reached sexual maturity at a younger age and smaller length than did females (Fig. 4). This resulted in a dominance of males in the length interval occupied by small resident char, whereas females dominated in the length interval occupied by large resident char.

At the immature stage (Fig. 5) individuals classified as presmolts achieved a yearly length increment of 10 cm or more, corresponding to the natural anadromous char. They reached sexual maturity at an age of 3+ to 6+ with a body length of 26–59 cm.

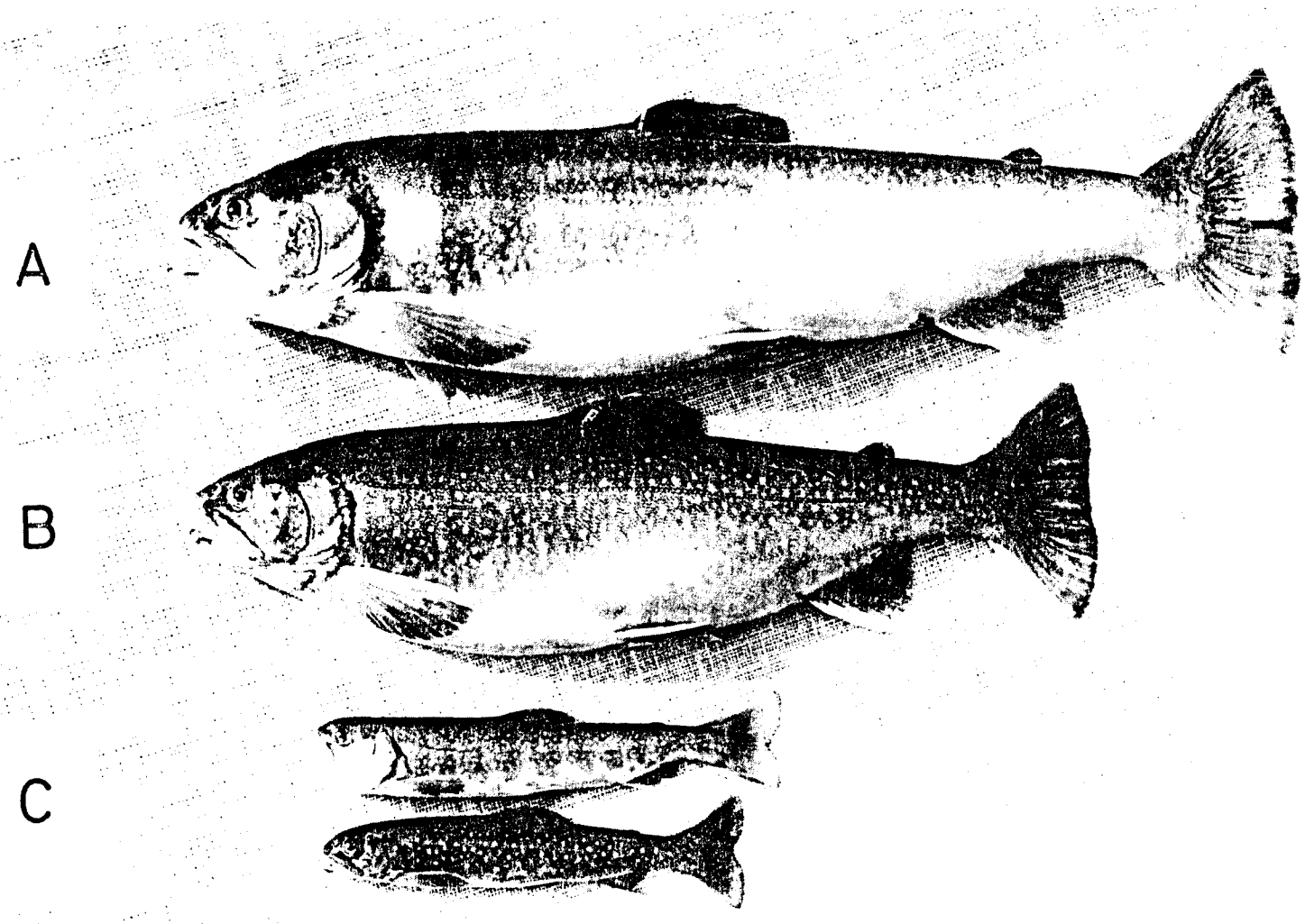

FIG. 6. Individuals of the same brood of small resident char *Salvelinus alpinus* from Øvervatn (Salangen river system, north Norway). The char were reared for 6 yr at Voss, south Norway. (A) Anadromous char, female, 56.5 cm. The char smoltified at an age of 1 yr (1+) and 25.2 cm, and matured at 4+ and 51.5 cm. (B) Large resident char, female, 44.9 cm, which matured at an age of 2 yr (2+) and 27.8 cm. (C) Small resident char, 20–21 cm, matured at an age of 1 yr (1+) and 17.5 cm.

TABLE 5. Segregation in young char *Salvelinus alpinus* originating from small resident (SR) and anadromous (A) parents, Salangen river system, north Norway. The char were reared at Voss, south Norway, and released into their parental river system in spring and autumn 1967, 1971, and 1972. The recaptured char were classified as parr, small resident (SR), large resident (LR), and anadromous (A).

Parents	Released	Recaptured	Classified in %				Not classified, %
			Parr	SR	LR	A	
SR	770	219 (28.4%)	16.9	8.2	11.9	42.9	20.1
A	537	154 (28.7%)	7.8	5.2	13.6	63.6	9.8

In the offspring of each group sexual maturity was initiated at age 1+ in small resident, 2+ in large resident, and 3+ in anadromous char, that is, 1 yr earlier than in the corresponding forms of the parental river system (cf. Table 1). As a whole, maturation extended over a period of 6 yr: from age 1+ in small resident char to age 6+ by the time maturation in anadromous char was completed. The individuals from the same cohort may, thus, reach sexual maturity at body lengths extending from 10 to 59 cm, demonstrating the well-known plasticity in Arctic char (Fig. 6).

The rearing experiment demonstrates that each form of the Salangen char reproduces itself and the other two forms. Thus, the three forms belong to the same population as indicated in the investigation on natural char in the Salangen river system (Nordeng 1961, fig. 19). In the three types of offspring the segregation was significantly different ($\chi^2_4 = 25.69$, $P < 0.01$), depending upon parental form (Table 3).

Development in the offspring of potential anadromous char originating from Hauklandsvatn (Bergen), Vangsvatn, and Lønavatn (Voss river system) was in principle similar to that described for Salangen char. Sex ratio in young char was 1:1. During the young stage each group segregated into individuals which were classified as resident char or smolts, though in different proportions depending upon ancestry (cf. Fig. 7).

Early maturing small resident and late maturing anadromous Salangen char represent the extremes of age at sexual maturity within their gene pool. Offspring of small resident parents produced more resident individuals and fewer smolt than offspring of anadromous parents. This difference (Table 4) was already significant at an age of 1+ ($\chi^2_1 = 34.0$, $P < 0.001$), indicating that the age at sexual maturity of the parents influenced the age at sexual maturity of their offspring.

Transplantation Experiments

Char used in the transplantation experiments were reared at Voss under conditions which prevented infection by the ureter fluke *P. conostomum*.

Release in the Salangen River System

Char released originated from small resident and anadromous char from Øvervatn (Salangen river system) and anadromous char from the Salangen river. The aim of the experiment was to verify the segregation in young char (parr) observed in the hatchery, test the behavior in individuals classified as small and large resident char, and test the capacity for anadromy after rearing in the nonanadromous area at Voss.

Irrespective of parental type (small resident and anadromous) young char (16–23 cm) segregated into small resident, large resident, and anadromous char (Table 5), just as in the hatchery. Offspring of anadromous char produced more smolts than offspring of small resident char. However, the difference is not significant ($\chi^2_2 = 4.01$, $P > 0.05$).

Irrespective of parental type (small resident and anadromous), char classified as small resident and large resident did not migrate to the sea (Table 6) apart from some that transformed into anadromous char after a period as residents. Some of the large resident char transformed into anadromous char, and some small resident transformed into large resident and into anadromous char. Resident char originating from anadromous parents transformed into anadromous char in a significantly higher proportion than in offspring originating from small resident char ($\chi^2_2 = 15.76$, $P < 0.001$). The patterns of transformation described above indicate that single individuals may manifest themselves in all three forms during their lifetime. This is supported by the development seen in the offspring of small resident char (Table 6). In the hatchery all (851 + 114) were classified as small resident char at an age of 1+. When released (2+) 114 had transformed into large resident char. Of these, seven (6.1%) were recaptured as anadromous char (3+).

Further, a control group of 81 young char originating from small resident and anadromous char held in the hatchery segregated and transformed in a manner similar to that of the transplanted char. At an age of 2+ there was a loss of 7, whereas the rest segregated into smolts (17), small resident (15), and large resident char (42). The following year, three of the large resident char transformed into anadromous char. Of the 15 small resident char, 10 became large resident and 3 became anadromous char.

The result of the Salangen transplantation experiment confirmed the rearing results. Young char (parr) segregated into small resident, large resident, and anadromous char (Table 5). Further, the char classified as small and large resident behaved according to their classification, except for some that transformed from one form into another. The transplantation experiment also proved that the anadromous quality in the Salangen char had not been affected by day length or by abiotic factors in the hatchery water when reared in the nonanadromous area at Voss. The anadromous char (Tables 5 and 6) accompanied the natural anadromous char on their seasonal migrations to the sea, and none were recaptured in other river systems.

TABLE 6. Transformation in mature char *Salvelinus alpinus* originating from small resident (SR) and anadromous (A) parents, Salangen river system, north Norway. The char were reared at Voss, south Norway, classified as small resident (SR) and large resident char (LR), and released into their parental river system in spring and autumn 1967 and 1972.

Parents	Offspring	Released	Recaptured	Classified in %			Not classified, %
				SR	LR	A	
SR	SR	851	146 (17.2%)	40.4	24.7	21.9	13.0
	LR	114	24 (21.1%)		70.8	29.2	
A	SR	338	45 (13.3%)	26.7	20.0	46.7	6.6
	LR	72	19 (26.4%)		31.6	57.9	10.5

RELEASE IN VARDNESVATN, SENJA

To test their capacity for anadromy, offspring of potential anadromous char were released in a northern river system containing anadromous char.

Offspring of the potential anadromous char from Lønavatn were released into Vardnesvatn (Senja), accompanied by offspring of anadromous char from the Salangen river as a control. The char originated from the 1971 brood and were released in autumn, 1973, and in early spring, 1974. They were immature and 18–32 cm long, which corresponds to anadromous char in the smolt and postsmolt stage. Downstream migration was monitored by a fish trap situated in the outlet river. During June and July the char accompanied the natural anadromous char on their migration to the sea.

Of the 85 char in the control group, 72 (84.7%) were recorded in the trap. Of the 356 potential anadromous char, 51 (14.3%) were recorded and two were recaptured in other river systems without prior recording in the trap. In contrast to the control group of Salangen anadromous char, the site of the tags in most of the Løna char was infected with *Saprolegnia* sp. After completion of the downstream migration Vardnesvatn was surveyed with gill nets to determine whether Løna char had remained in the lake. Only nine Løna char were recaptured. They were in very poor condition and heavily infected with *Saprolegnia*. This indicates high mortality in the introduced Løna char. Those registered in the trap may thus represent surviving char migrating to the sea.

Of the char registered in the trap only three Salangen and two Løna char returned to the Vardnes river system. Two Salangen char were recaptured in the sea, and six in other river systems.

In spite of high mortality in Løna char, this experiment indicates that the capacity for anadromy exists in southern potential anadromous char.

RELEASE IN THE VOSS RIVER SYSTEM

The aim of this experiment was to test the capacity for anadromy in offspring of Salangen char when released in a southern river system, where natural char are resident and infected with *P. conostomum*.

Offspring of all three Salangen char, classified as smolts (1433) and resident char (242), were released into Vangsvatn and Evangervatn in late autumn (age 1+) and early spring (age 2+), just before commencement of the downstream run of natural brown trout and Atlantic salmon smolts.

TABLE 7. Recaptures of Løna char *Salvelinus alpinus*. The char originates from potential anadromous char from Lønavatn, Voss river system, south Norway. They were reared at Voss, classified as smolt or immature postsmolt, and released (1973) into the Bolstad fjord in a number of 210.

Recaptured		Year of recapture				
Place	Number	1973	1974	1975	1976	Later
Voss river system	13	4	3	2	1	3
Bolstad fjord	30	13	8	2	5	2

Irrespective of parental type, the char behaved in the same manner after release. Of the resident char, 36 (14.9%) were recaptured during the following 6 yr, all in the lakes of release. Of the smolt, 281 (19.6%) were recaptured. As many as 184 were recaptured in their respective lakes immediately after release. Later in the season and in the three following years, 24 were recaptured in the sea and 73 in the river system, of which 6 showed a marked river–sea growth change in their scales.

This experiment shows that smolt of the northern char, reared and released in the southern nonanadromous area, may migrate to the sea.

RELEASE IN THE BOLSTAD FJORD

The aim of this experiment was to test the capacity for anadromy in offspring of the Salangen chars and the native Løna char when released in an environment free from *P. conostomum*. I expected that the char, released directly into the fjord, would feed on marine items in sufficient quantity to make infection of the ureter fluke during the following winter stay in freshwater less likely.

The Salangen chars originated from the 1960 brood and were released in 1963. The Løna char originated from the 1971 brood and were released in 1973. Both groups were immature and 18–32 cm long, which corresponds to anadromous char in the smolt and postsmolt stages. They were released into the Bolstad fjord in June, within the period of downstream migration of the native brown trout.

Of the 133 Salangen char a total of 42 (31.6%) were recaptured during a period of 5 yr, 40 in the sea and only 2 in the Voss river system. Of the 210 Løna char, 43 (20.5%) were

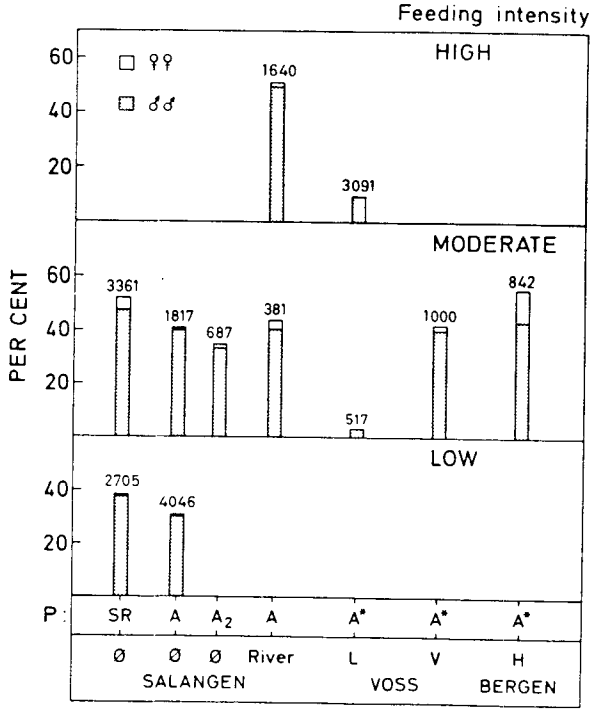

FIG. 7. Fraction of Arctic char *Salvelinus alpinus* maturing at an age of 1+ reared at different feeding intensities. The parents (P) were small resident (SR), anadromous (A), and second generation of anadromous char (A_2), Salangen river system, north Norway (Øvervatn, Ø) and potential anadromous char (A*), Voss river system (Lønavatn, L; Vangsvatn, V), and Bergen (Hauklandsvatn, H), south Norway.

recaptured, 30 in the sea and 13 in the river system (Table 7).

This experiment shows that northern and southern char both in the smolt and postsmolt stage survive a release directly into the sea in the southern nonanadromous area. Further, the recaptures in successive years of the native Løna char indicates that annual migration took place between the home river system and the sea (Table 7).

Genetics and Environment

The rearing experiments (Fig. 7) revealed differences in segregation in offspring from (1) different forms in the same population (Øvervatn, Salangen), (2) the same form from different populations within the same river system (Salangen and Voss), and (3) the same form from different river systems (Salangen, Voss, and Bergen).

Within the same population (Øvervatn, Salangen) a larger percentage of the offspring of the early maturing small resident char (38.1%) reached sexual maturity at an age of 1+ than was the case with the offspring of the late maturing anadromous char (30.8%). This difference was significant at both low ($\chi^2_1 = 38.5$, $P < 0.001$) and moderate feeding intensities ($\chi^2_1 = 63.1$, $P < 0.001$). At moderate feeding the segregation was 52.0 and 40.5% in small resident and anadromous char, respectively.

Offspring of anadromous char from different populations within the same river system (Salangen) segregated slightly differently. The percentage of the offspring of anadromous char from the river reaching sexual maturity at an age of 1+ was slightly higher (43.8%) than for the offspring of anadromous char from the lake (40.5%). The difference, however, was not significant ($\chi^2_1 = 1.5$, $P > 0.2$).

In the offspring of potential anadromous char from different populations in south Norway (Voss, Bergen), the segregation in mature individuals at age 1+ varied considerably. Segregation in offspring of the potential anadromous char from Lønavatn and Vangsvatn (Voss river system) was 3.1 and 42.0%, respectively, the latter corresponding to the segregation in offspring of the Salangen anadromous char. Segregation in the offspring of the potential anadromous char from Hauklandsvatn (Bergen) was somewhat higher, 55.3%, including a comparatively high percentage of females, 12.1%. In the other offspring the proportion of females varied between 0.1 and 4.7%, depending largely on the proportion that reached sexual maturity at age 1+. In the offspring originating from Lønavatn, where only potential anadromous char occur naturally, segregation was particularly low, and none of the females reached sexual maturity at an age of 1+. In all offspring the individuals that matured at an age of 1+ were with few exceptions small resident char measuring 10–22 cm.

The percentage of offspring reaching sexual maturity at an age of 1+ is influenced by feeding intensity. The segregation increased significantly in the offspring of small resident char ($\chi^2_1 = 117.2$, $P < 0.001$) and anadromous char ($\chi^2_1 = 52.3$, $P < 0.001$) from Øvervatn when the feeding intensity increased from low to moderate. A further increase to high feeding intensity, giving an excess of food, increased segregation in the offspring of anadromous char (Salangen river) from 43.8 to 50.5%, and in the offspring of the potential anadromous char (Lønavatn, Voss) from 3.1 to 9.6%. The increase is significant in both anadromous ($\chi^2_1 = 5.7$, $P < 0.05$) and potential anadromous char ($\chi^2_1 = 23.7$, $P < 0.001$).

Increase in feeding intensity also accelerated development in the offspring. At high feeding intensity almost all the males in the offspring of anadromous char (Salangen river) matured at an age of 1+, comprising 49.3% of the total number. The length interval of the males covered the total length interval of both small resident (10.5–21.9 cm) and large resident char (22.0–28.0 cm).

Within their gene pool, the early maturing small resident form and the late maturing anadromous form (Øvervatn) represent the extremes of age at sexual maturity. Offspring of the small resident parents produced significantly more resident individuals and fewer smolts than offspring of anadromous parents, indicating that age at sexual maturity is heritable. The second generation of anadromous parents produced even fewer resident individuals (34.9%), and consequently more smolts than their parents. The difference in segregation was significant ($\chi^2_1 = 6.4$, $P < 0.05$) and indicates a positive effect of selecting for late sexual maturity. On the other hand, a release (1920) of fry of the late maturing anadromous char into Svartebergvatn (Salangen) demonstrates the positive effect of selecting for early sexual maturity, since the

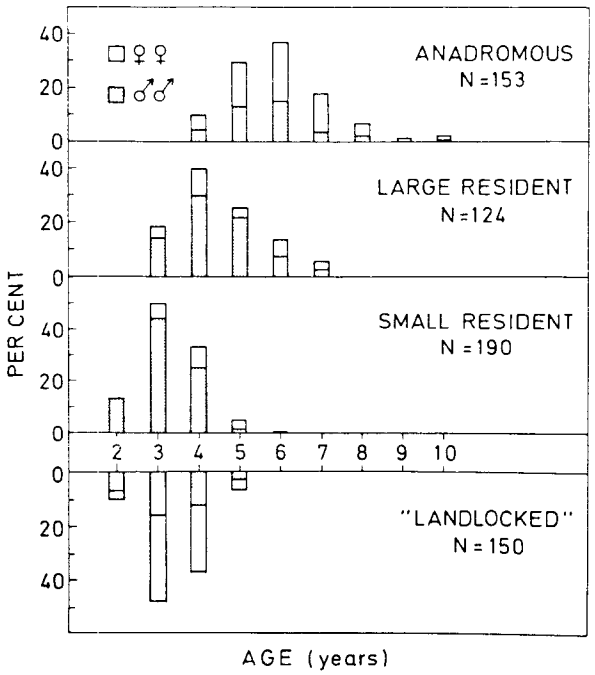

FIG. 8. Age at sexual maturity in the population of Arctic char *Salvelinus alpinus*, Øvervatn (Salangen), consisting of three forms, anadromous, large resident and small resident char, and in "landlocked" char, Svartebergvatn (Salangen). The "landlocked" char are descendants of fry of the anadromous form, released in the lake in 1920.

descendants at the present time (1981) correspond to the early maturing small resident char in age at sexual maturity (Fig. 8). The lake drains via impassable waterfalls into the Salangen river. During the years following the release, smolts were observed to leave the lake and at present only small resident char are left. They mature at a body length of 14–21 cm, and their sex ratio is 1:1.

Discussion and Conclusion

The question whether coexisting forms of Arctic char belong to different populations or to the same gene pool, the "char problem" (Reisinger 1953; Nordeng 1961; Dörfel 1974), is solved by rearing and transplantation experiments. The experiments revealed an identical pattern of segregation in the offspring of northern coexisting small resident, large resident, and anadromous char. During the young stage, parr in each offspring segregated into small resident, large resident, or anadromous char. Each form reproduced itself and the other two forms. Just as in the offspring of northern anadromous char, parr of southern "potential anadromous" parents segregated into coexisting forms present in their respective parental localities. Thus, the coexisting forms of Arctic char belong to the same gene pool as indicated in the investigation on the natural char in the Salangen river system (Nordeng 1961, fig. 19). Reproducing, either in the same or in separate spawning areas, each form gives rise to all three forms as illustrated in Fig. 9.

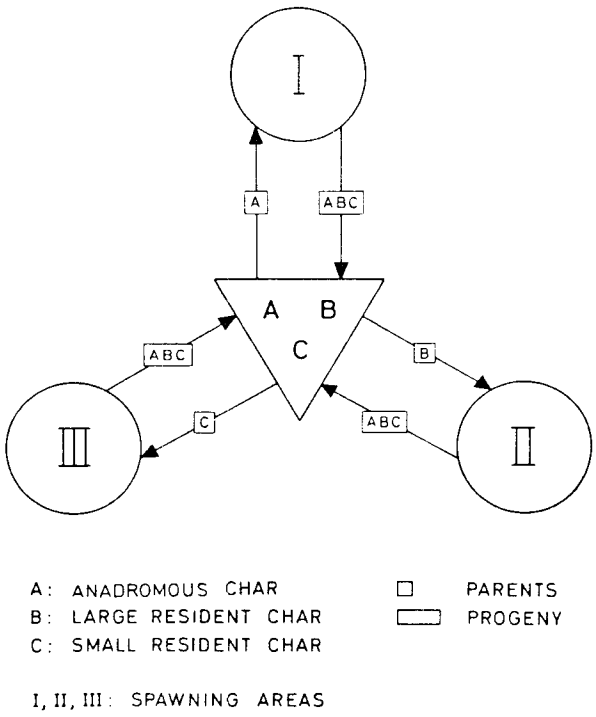

FIG. 9. Reproductive pattern in Arctic char *Salvelinus alpinus* in Øvervatn, Salangen river system, north Norway.

Transplantation experiments confirmed the observed segregation of parr into residents and smolts, and revealed that some resident individuals transformed from one form into another (Fig. 10). Thus single individuals may manifest all three forms during their lifetime, successively attaining the appearance and spawning color of each form. The same phenomenon is observed in natural char (Nordeng 1961, p. 94).

The rearing and transplantation experiments explain the differences in biological characteristics between the coexisting forms of Arctic char (cf. Table 1). In offspring of each form the sex ratio was 1:1. The males reached sexual maturity at a younger age and smaller size than did females. This resulted in a dominance of males in the length interval occupied by the smallest form, and a dominance of females in the length interval occupied by the largest form. The spawning color depended upon body length at sexual maturity.

Within their gene pool, the early maturing small resident form and the late maturing anadromous/potential anadromous form represent the extremes of age at sexual maturity. Offspring of the small resident parents produced significantly more resident individuals and fewer smolts than did offspring of anadromous parents, indicating that age at sexual maturity is heritable. Age at sexual maturity is subjected to rapid selection as the second generation of anadromous parents produced even fewer resident individuals and more smolts than did their parents. This means that a population featuring all three forms incorporates the ability to change into the one or the other extreme form, small resident or anadromous/potential anadromous, respectively. An increase in amount of food

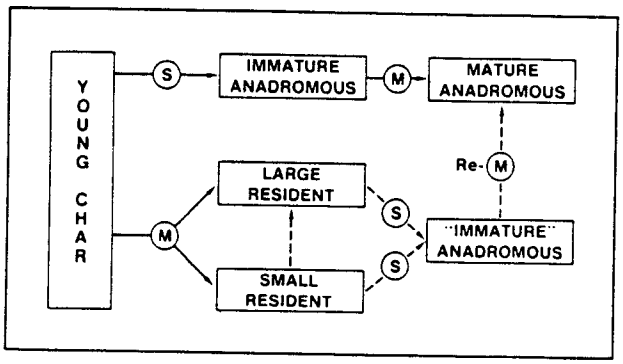

FIG. 10. Segregation (—) and transformation (---) in offspring of small resident, large resident, and anadromous Arctic char *Salvelinus alpinus*, from the Salangen river system, north Norway, revealed by rearing and transplantation experiments. (S) = smoltification, (M) = maturation.

(feeding intensity) accelerates the development in the offspring (shortens the young stage) and increases the proportion of resident individuals. This demonstrates that the pattern of segregation depends both upon genetic constitution and access to food.

In char populations featuring only one form, as in Svartebergvatn (Salangen) and in Lønavatn (Voss), the sex ratio is 1:1. These populations, both originating from anadromous ancestors, seem to be established through natural selection for age at sexual maturity. The two populations exist above waterfalls that prevent upstream migration. In the case of Svartebergvatn, smolts left the lake, so that in the remaining fraction only early maturing small resident char are present. In Lønavatn, smolts do not leave the lake, possibly owing to infection by *P. conostomum*. During the years of isolation intraspecific competition for the restricted spawning area in the lake may have favored the largest individuals, and in the remaining fraction only late maturing potential anadromous char are present.

Transplantation experiments to localities in the northern anadromous area (Salangen and Senja) proved that the capacity for anadromy in northern char had not been affected by water temperature or other abiotic factors during rearing in the nonanadromous area at Voss, and that the fraction of potential anadromous individuals within southern populations exhibit capacity for anadromy when reared under conditions which prevented infection by *P. conostomum*. Transplantation experiments in the southern nonanadromous area (Voss river system and Bolstad fjord outside) revealed that water temperature or other abiotic factors in this area do not prevent anadromous behavior, neither in northern anadromous nor in southern potential anadromous char. In both transplantation experiments the char exhibited annual migration between freshwater and the sea only when released into their respective parental area. This might be explained by orientation towards population-specific pheromones (Nordeng 1977) released from relatives in the parental river system.

The individuals which mature as parr during the young stage may be viewed as the natural resident fraction of anadromous char populations. Anadromous and resident individuals also exist in other salmonids (reviewed by Behnke 1972), for instance in dolly varden char *Salvelinus malma* (Armstrong and Morrow 1980), in masu salmon *Oncorhynchus masou* (Tanaka 1965), and in sockeye salmon *Oncorhynchus nerka* (Ricker 1938; Foerster 1947). In the anadromous fraction of masu and sockeye salmon, females dominate, whereas males dominate in the resident fraction, just as in Arctic char. It is likely that the resident individuals in salmonid populations, comprising either both sexes or males only, represent the same phenomenon. Thus, referring to Salangen salmonids (Fig. 2), the resident individuals, and parr (each of different age) constitute a permanent component of the freshwater bases in their respective migratory systems.

Acknowledgments

First of all I thank my wife, Aase Nordeng. She accepted my devotion to the char, and supported and assisted me throughout this research. I am also indebted to Per Bratland, Institute of Marine Research, Bergen, who assisted me both in the field and in the hatchery. The caretakers at the hatchery, Gunnar Askeland, Bjarne Nedkvitne, and Thoralf Olsen, are also acknowledged for their work. During field work in Salangen, I received valuable help from the Chruickshank family. Ragnvald Andersen and Jostein Skurdal participated in the final preparation of results from rearing and transplantation experiments. I am grateful to Dr Lionel Johnson for critical reading of the manuscript. Financial support was received from the Institute of Marine Research, Bergen; the Norwegian Research Council for Science and the Humanities; the Norwegian Research Council for Agriculture; the Norwegian Fisheries Research Council; and the Directorate for Wildlife and Freshwater Fish. I am indebted to them all.

ARMSTRONG, R. H., AND J. E. MORROW. 1980. The dolly varden charr, *Salvelinus malma*, p. 99–140. *In* E. K. Balon [ed.] Charrs, salmonid fishes of the genus *Salvelinus*. Dr. W. Junk Publishers, The Hague, Netherlands.

BEHNKE, R. J. 1972. The systematics of salmonid fishes of recently glaciated lakes. J. Fish. Res. Board Can. 29: 639–671.

1980. A systematic review of the genus *Salvelinus*, p. 441–480. *In* E. K. Balon [ed.] Charrs, salmonid fishes of the genus *Salvelinus*. Dr. W. Junk Publishers, The Hague, Netherlands.

BRENNER, T. 1980. The arctic charr, *Salvelinus alpinus salvelinus* in the prealpine Attersee, Austria, p. 765–772. *In* E. K. Balon [ed.] Charrs, salmonid fishes of the genus *Salvelinus*. Dr. W. Junk Publishers, The Hague, Netherlands.

DÖRFEL, H.-J. 1974. Untersuchungen zur Problematik der Saiblingspopulationen (*Salvelinus alpinus* L.) im Überlinger See (Bodensee). Arch. Hydrobiol. Suppl. 47: 80–105.

EKMAN, S. 1922. Djurvärldens utbredningshistoria pa Skandinaviska halvön. Bonnier, Stockholm. 614 p. (In Swedish)

FOERSTER, R. E. 1947. Experiment to develop sea-run from landlocked sockeye salmon (*Oncorhynchus nerka kennerlyi*). J. Fish. Res. Board Can. 7: 88–93.

FRIDRIKSSON, Á. 1939. Um murtuna í Thingvallavatni med hlidsjón af ödrum silungsteggundum í vatninu. Náttúrufrædingurinn. 9: 1–30.

FROST, W. E. 1963. The homing of charr *Salvelinus willughbii* (Günther) in Windermere. Anim. Behav. 11: 74–82.

1965. Breeding habits of Windermere charr, *Salvelinus willughbii* (Günther), and their bearing on speciation of these fish. Proc. R. Soc. Edinb. Sect. B (Biol. Sci.) 163: 232–284.

GULLESTAD, N. 1975. On the biology of char (*Salmo alpinus* L.) in

Svalbard. I. Migratory and non-migratory char in Revvatnet, Spitsbergen. Nor. Polarinst. Arbok 1973: 125–140.

HAEMPEL, O. 1924. Studien am Seesaibling mehrerer österreichischer Alpenseen. Verh. Int. Ver. Limnol. 2: 129–135.

HENRICSON, J., AND L. NYMAN. 1976. The ecological and genetical segregation of two sympatric species of dwarfed char (*Salvelinus alpinus* (L.) species complex). Rep. Inst. Freshw. Res. Drottningholm 55: 15–37.

HUITFELDT-KAAS, H. 1918. Ferskvandsfiskenes utbredelse og indvandring i Norge med et tillæg om krebsen. Centraltrykkeriet, Kristiania. 106 p. (In Norwegian)

JOHNSON, L. 1980. The arctic charr, *Salvelinus alpinus*, p. 15–98. *In* E. K. Balon [ed.] Charrs, salmonid fishes of the genus *Salvelinus*. Dr. W. Junk Publishers, The Hague, Netherlands.

JONSSON, B., AND T. ØSTLI. 1979. Demographic strategy in char compared with brown trout in Lake Lone, Western Norway. Rep. Inst. Freshw. Res. Drottningholm 58: 45–54.

KLEMETSEN, A., AND P. GROTNES. 1980. Coexistence and immigration of two sympatric arctic charr, p. 757–763. *In* E. K. Balon [ed.] Charrs, salmonid fishes of the genus *Salvelinus*. Dr. W. Junk Publishers, The Hague, Netherlands.

MATHIESEN, O., AND M. BERG. 1968. Growth rates of the char, *Salvelinus alpinus* (L.), in the Vardnes River, Troms, Northern Norway. Rep. Inst. Freshw. Res. Drottningholm 48: 177–186.

MATZOW, D., H. HURU, B. JONSSON, P. I. KVAMMEN, J. P. NILSSEN, O. T. SANDLUND, AND T. ØSTLI. 1976. Investigations on freshwater biology in Lønavatnet lake and Strandaelva river. Report from the Voss Project, Zoological Institute, University of Oslo 1: 1–235. (In Norwegian, English summary)

NERESHEIMER, E. 1941. Die Lachsartigen (*Salmonidae*), p. 219–370. *In* R. Demoll and H. N. Maier [ed.] Handbuch der Binnenfischerei Mitteleuropas. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.

NILSSON, N.-A., AND O. FILIPSSON. 1971. Characteristics of two discrete populations of arctic char (*Salvelinus alpinus* L.) in a North Swedish lake. Rep. Inst. Freshw. Res. Drottningholm 51: 90–108.

NILSSON, S. 1855. Skandinaviska fauna. Lund. (In Swedish)

NORDENG, H. 1961. On the biology of char (*Salmo alpinus* L.) in Salangen, North Norway. I. Age and spawning frequency determined from scales and otoliths. Nytt Mag. Zool. (Oslo) 10: 67–123.

1977. A pheromone hypothesis for homeward migration in anadromous salmonids. Oikos 28: 155–159.

REISINGER, E. 1953. Zum Saiblingsproblem. Carinthia II 143: 74–102.

RICKER, W. E. 1938. "Residual" and kokanee salmon in Cultus lake. J. Fish. Res. Board Can. 4: 192–218.

SAVVAITOVA, K. A. 1969. Homologous variation in char species of the genera *Salvelinus* (Nilsson) Richardson and *Cristivomer* Gill and Jordan. Probl. Ichthyol. 9: 18–34.

1970. Morphological features and variability of local populations of the lake–river form of the Arctic char (*Salvelinus alpinus* (L.)) from the Kamchatka River Basin. J. Ichthyol. 10: 203–217.

1973. Ecology and systematics of freshwater chars of the genus *Salvelinus* (Nilsson) from some bodies of water in Kamchatka. J. Ichthyol. 13: 58–68.

1980. Taxonomy and biogeography of charrs in the Palearctic, p. 281–294. *In* E. K. Balon [ed.] Charrs, salmonid fishes of the genus *Salvelinus*. Dr. W. Junk Publishers, The Hague, Netherlands.

SVÄRDSON, G. 1961. Rödingen. Fiske 1961: 25–38.(In Swedish)

SÆTRE, R., AND R. LJØEN. 1972. The Norwegian coastal current, p. 514–535. *In* S. Stabell Wetteland and P. Brun [ed.] Proceedings of the first international conference on port and ocean engineering under arctic conditions. 1. Technical University of Norway, Trondheim.

TANAKA, S. 1965. Salmon of the North Pacific Ocean – Part IX Coho, chinook and masu salmon in offshore waters. 3. A review of the biological information of masu salmon (*Oncorhynchus masou*). Bull. Int. North Pac. Fish Comm. 16: 75–135.

July 12, 1983

Mr. B. L. Hilliker
Alyeska Pipeline Service Co.
1835 S. Bragaw St.
Anchorage, AK 99512

Dear Mr. Hilliker:

RE: AS 16.05.870(a) Designation of Atigun River.

Thank you for your letter concerning the life history of Arctic char in the Atigun River. Alyeska's consultant, Dr. McCart, may be correct in his assertion that only resident adult char are found above the Atigun Gorge; the Department has not found spawning anadromous char in that area. However, Dr. McCart's memorandum fails to recognize that the offspring of resident char may assume the anadromous lifestyle and can and do migrate to sea. Conversely, the offspring from anadromous adults can and do remain as freshwater residents. Departmental biologists are also not convinced that the Atigun River Gorge is an impassable barrier to rearing juvenile fish. As you may be aware, both juvenile and adult salmonids can negotiate some very difficult barriers. For example, king salmon have recently been found spawning in a tributary of the Susitna River which enters above the first set of rapids and damsite in Devils Canyon. Because there is currently no way of distinguishing between resident and anadromous juvenile Arctic char, there is no way of determining that at least some of the juvenile Arctic char, which are found throughout the Atigun River drainage, are not anadromous.

The Sagavanirktok River and its tributaries are important char producers. Because of the importance of this stream, and the fact that Department biologists who nominated it for inclusion in the Catalog of Waters Important for Spawning, Rearing and Migration of Anadromous Fishes believe that it is important for spawning and rearing of anadromous fish, we will retain it in this year's catalog. However, you have raised some important issues and I have asked our Sport Fish Division to review Dr. McCart's data and to conduct any field studies necessary to confirm or deny the presence of anadromous char above the Atigun Gorge.

Sincerely,

Dennis D. Kelso
Deputy Commissioner

ANS 10

cc: D. Logan
A. Ott
A. Kohl
D. Lowery
J. Brossia

Phillis Smith

Alyeska pipeline SERVICE COMPANY 1835 SOUTH BRAGAW STREET, ANCHORAGE, ALASKA 99512, TELEPHONE (907) 278 1611, TELEX 090 25 127

June 14, 1983 Letter No. 83- 3384-G

COMMISSIONER'S OFFICE
RECEIVED
JUN 17 1983
DEPARTMENT OF FISH AND GAME

Mr. Don Collingsworth
Commissioner
Alaska Dept. of Fish and Game
Subport Bldg.
Juneau, AK 99801

Re: Anadromous Fish Stream Catalog

Dear Commissioner Collingsworth:

In a review of the proposed 1983 changes to the catalog of Waters Important for the Spawning, Rearing and Migration of Anadromous Fishes we noted that the Atigun River had been added. The catalog indicates that Arctic Char rear in the river well above the Atigun Gorge.

Alyeska Pipeline Service Company wishes to register an objection to the inclusion of the Atigun River to the catalog. While we do not disagree that Arctic Char are found above the Atigun Gorge we do not agree that these are anadromous Char. Alyeska believes that these fish represent a resident population.

To support our claim we are attaching a copy of a telex from Dr. Peter McCart discussing Atigun River Char. Dr. McCart and his associates have many years of experience studying Arctic Char in Northern Alaska and Canada.

Because there is no known data which would support designating the Atigun River as an anadromous fish stream, Alyeska Pipeline Service Company requests that the Atigun River not be included in the 1983 changes to the catalog of Anadromous Fish Streams.

Very truly yours,

B. L. Hilliker
Manager,
Environmental Protection &
Government Reports

BLH/wkk
Attachment

cc: Carl Yanagawa - ADF&G
B. Stafford - DNR

1211

In the 15 years during which the Sagavanirktok River system and the Atigun Drainage have been intensively studied (1960 to 1983 inclusive) [redacted]ne has to our knowledge observed or sampled anadromous Arctic Char spawning in the Atigun River. These are readily distinguishable because they are at least twice as long and weigh at least 10 times as much as stream resident fish. One reason for this absence may be that the accessible reach of the stream downstream of the gorge is very short and appears to have no perennial supply of groundwater. A good Winter supply of groundwater is essential for the incubation of eggs. The only use we can suggest that a[redacted]r may make of the Atigun River is a feeding area during the summer when small numbers of juvenile fish from the Sagavanirktok River may enter the lo[redacted]es of the stream downstream of the gorge. However the area which such juveniles might utilize is so small and the area of similar habitat elsewhere in the Sagavanirktok System is so large that the Atigun River can be of little significance to the overall well being of anadromous populations in the Sagavanirktok System.

There appears, therefore, to be no justification for considering the Atigun River an anadromous Fish Stream, using any reasonable definition of the term. Many other North Slope streams are also known to support isolated populations of Char populations and in some cases small numbers of rearing juveniles but have not been considered anadromous fish streams.

Sincerely,

Peter McCart, PhD

Attn: Dick Mikkelsen

Re: Reclassification of the Atigun River Drainage as an Anadromous Fish Stream

Aquatic Environments Inc. has been conducting fisheries investigations in the Atigun Sagavanirktok Drainage since 1969 and is currently involved in a three year study to assess the long-term effects of the Trans-Alaska Pipeline System on Fish resources of the region. During the course of these studies, we have developed an in-depth understanding of the life history, habitat requirements and distribution of both anadromous and freshwater fish populations in the area. Our early work sponsored by Alyeska Pipeline Service Company (1969-1974) and Alaskan Arctic Gas Study Inc. (1972-1976), included detailed mapping of critical spawning and overwintering areas for anadromous and freshwater populations of Arctic Char. Based on these studies and our most recent investigations in the Atigun River (1981-1983) the following pattern of fish distribution and life history patterns has emerged.

Sampling in the Atigun River Drainage reveals a species compositions of approximately 85% Arctic Grayling, 7% Round Whitefish, 6% Arctic Char, 1% Lake Trout and 1% Burbot. Slimy Sculpin, while abundant throughout the drainage, are not included in this determination.

Lake dwelling populations of eastern form Arctic Char are found in Galbraith Lake and in several small lakes immediately to the south. These isolated populations are non migratory, spawn in lakes, and are not known to interbreed with stream resident fish.

In addition to these lake resident Arctic Char, there is an isolated population of Western form Arctic Char (synonomous with Northern Dolly Varden) inhabiting streams in the Atigun River Drainage. Conditions in the Atigun River Gorge [redacted] to prevent movement of Char from the Sagavanirktok River into the upper Atigun River, effectively isolating this stream resident population.

Stream resident Char in the Atigun River are believed to spawn and overwinter in the vicinity of small groundwater sources located in the mainstream between Pipeline MP 144 and 158. Because the Atigun Gorge is an i[redacted] to the upstream migration of Char, any fish which migrate downstream into the Sagavanirktok River will be lost to the population, which is [redacted]. We are in the process of conducting detailed meristic and morphological studies of stream resident Char from the Atigun River Drainage for comparison with similar data for other North Slope Drainages (McCart 1980), we anticipate these data will be available by October of this year.

MEMORANDUM State of Alaska

TO: George Van Wyhe, Reg. Supv.
Sport Fish Division
Fairbanks

DATE: August 3, 1983

FILE NO: 509

TELEPHONE NO: 452-1531

FROM: Terry Bendock, Fishery Biologist
Sport Fish Division
Dept. of Fish & Game, Fairbanks

SUBJECT: Atigun River Char Controversy

This memo outlines the taxonomic confusion of Arctic char and my thoughts on including the Atigun River in the list of anadromous waters. It appears, from reading Dennis Kelso's recent letter to Ben Hilliker that the situation is still quite unclear. This memo will probably not clear up the situation but should point out some of the confusion leading up to the present controversy.

The Anadromous Fish Act (AS 16.05.870) affords protection to habitat utilized by five species (or groups) of Alaskan fish. Included, are both the Dolly Varden (Salvelinus malma) and Arctic char (Salvelinus alpinus). The act affords protection to those habitat not only used for spawning, but also rearing and migration areas. The last published catalog in my possession (March, 1975) included the Atigun River as an anadromous stream. Since that time, there has been an effort by the legislature and the state to remove contiguous protection of fish habitat and replace it with a patch-work system of protected and unprotected reaches that is more conciliatory to the mining and petroleum industries than the fish resources. I have obtained (with difficulty) two recent computer printouts of anadromous streams from Habitat Division (April, 1982 and April, 83) both of which do not include the Atigun River. I do not know when or why the Atigun River was deleted from the list.

Universal agreement on the taxonomy of or classification of Arctic char does not exist. Current opinion is usually divided into two camps. McPhail recognizes two species Salvelinus alpinus in western North America while Behnke would like to see all anadromous char inhabiting coastal streams east to the Mackenzie River, recognized as Salvelinus malma. Regardless of which opinion we agree with, Title 16 affords protection anadromous stocks of either species. The picture is further complicated in that char within a drainage exhibit considerable "placidity" in which sympatric and allopatric forms exist with differing life history patterns. McCart (1980) describes four life history types of char, all of which occur in the Sagavanirktok drainage. Three of these forms, isolated stream residents, anadromous and residual char occupy stream habitats while the fourth type resides in lakes. McCart further concludes that all three stream morphs are the Western Arctic form of the Arctic char and that they cannot be distinguished by meristic characters. The only way to distinguish between what McCart purports to be an entirely non-anadromous stock in the Atigun River and the anadromous counterparts in the Sag. River is to document the life history pattern of the fish in question or examine external

characteristics such as parr-marks and coloration. Anadromous char have not been documented to spawn in the Atigun River. At issue is whether the Atigun River supports rearing char (that will eventually become anadromous) and thus is also used for migration by these individuals. All three forms of char are identical for the first several years of life and are indistinguishable until either a) anadromous char undertake their first sea-ward migration usually at 3 to 5 years of age or b) stream resident and residual char first reach sexual maturity, usually 100% maturity by Age VI. I therefore find it highly improbable that Mr. McCart can tell us that all of the char he has found in the Atigun River - particularly sub-adults are destined to be non-anadromous. Of course we cannot conclude that they are all anadromous either. It is presumptuous to conclude that the Atigun gorge is an impassable barrier to these rearing fish. The gorge has a steep gradient and is choked with large boulders however similar habitats create a great deal of friction with only short runs of fast waters between eddy areas and other suitable resting sites. There are no water falls that would create an impassable barrier to fish.

I attended the first International Symposium on Arctic char in 1981 and a final bit of information to further complicate the issue follows. A paper given by Hans Nordeng from the University of Oslo described a population of Salvelinus alpinus in Norway in which three life history forms occur; 1) small residents 2) large residents and 3) anadromous char. The three types differ in size, age at sexual maturity, sex ratio, spawning color, spawning grounds, growth rate and feeding habits. The sub-adults of the three forms have a uniform phenotype, and while they may belong to separate reproductive units, they are considered to be morphs of the same population. Dr. Nordeng artificially spawned char from each of the three groups and reared the off-spring for seven years. The results of his investigation showed that small resident char produced 30% small residents, 10% large residents and 60% anadromous offspring. Interestingly, each of the other types of char produced a similar ratio of small resident, large resident and anadromous adults. He concluded that small and large resident char correspond to precocious individuals in salmon populations and that the life history pattern that develops may be a function of gene ratio.

Due to the presence of sub-adult char throughout the Atigun River, I recommend that it continues to be included an the list of anadromous waters. Unless Alyeska can demonstrate that 1) the gorges is an impassable barrier, 2) all sub-adult char sampled in the drainage are non-anadromous and 3) resident resident populations of char do not contribute to the gene pool of Salvelinus alpinus, that includes anadromous individuals, than I will continue to consider the Atigun River a integral component of the char habitat within the Sagavanirktok drainage.

McCart, P. J. 1980. A review of the systematics and ecology of Arctic char, Salvelinus alpinus, in the Western Arctic. Can. Tech. Rep. Fish. Aquat. Sci. 935:vii+ 89p.

cc: Fagan

Alyeska pipeline SERVICE COMPANY 1835 SOUTH BRAGAW STREET, AN Backup NE (907) 278 1611 TELEX 090 25 127

August 8, 1983

3422-G

RECEIVED

Mr. Dennis D. Kelso
Deputy Commissioner
Alaska Dept. of Fish and Game
P.O. Box 3-2000
Juneau, AK 99802

Dear Mr. Kelso:

Thank you for your letter of July 12, 1983 regarding the anadromous designation for the Atigun River. However after reviewing your letter I remain unconvinced that the department has sufficient documentation for designating the Atigun River as an anadromous fish stream.

As I recall the legislative intent circumscribing the original statute involved designating anadromous systems based essentially on the presence of adult anadromous spawners. This rationale is substantiated further in the Department of Fish and Game, April 1982 revision of the catalog of waters important for spawning, rearing and migration of anadromous fish. The definition in that catalog states; "anadromous fish means fish which enter fresh water from the sea for spawning purposes." That definition strongly suggests that without the presence of ocean returning adult spawning anadromous species a system does not meet the minimum criteria for anadromous designation.

Your letter also uses the presence of adult King Salmon above the first set of rapids in Devils Canyon on the Susitna River as an example of why the Atigun Canyon gorge may not be an impassable velocity barrier to adult Arctic Char. However in this matter the comparison of King Salmon with Arctic Char is not biologically valid. I have attached a copy of a page taken from the draft habitat regulations proposed by your department in 1981. According to this chart adult King Salmon are classified as high performance swimmers and quite correctly adult and juvenile Arctic Char are classified as slow or low performance swimmers. It's possible that King Salmon, could negotiate the Atigun River gorge but it's highly speculative whether anadromous Arctic Char ever have.

I sincerely hope you will evaluate my comments prior to making the final anadromous fish system designations. I also appreciate your patience in this matter. If I can be of assistance to you do not hesitate to contact me.

Sincerely,

B. L. Hilliker, Manager
Environmental Protection &
Government Reports

cc: John Clark - ADF&G/Juneau
Scott Grundy - ADF&G/Fairbanks
Carl Yanagawa - ADF&G/Anchorage

1211

BLH/wkk
Attachment

(1)

AVERAGE CROSS SECTIONAL VELOCITIES IN FEET/SECOND MEASURED AT THE OUTLET OF THE CULVERT

Length of culvert in feet	Group I Upstream migrant salmon fry and fingerlings when upstream migration takes place at mean annual flood	Group II adult and juvenile slow swimmers: grayling, longnose suckers, whitefish, burbot, sheefish, Northern pike, Dolly Varden/ Arctic Char, upstream migrant salmon fry and fingerlings when migration not at mean annual flood	Group III Adult moderate swimmers: pink salmon, chum salmon, rainbow trout, cutthroat trout	Group IV Adult high performance swimmers: king salmon, coho salmon, sockeye salmon, steelhead
30	1.0	4.6	6.8	9.9
40	1.0	3.8	5.8	8.5
50	1.0	3.2	5.0	7.5
60	0.9	2.8	4.6	6.6
70	0.8	2.6	4.2	6.0
80	0.8	2.3	3.9	5.5
90	0.7	2.1	3.7	5.1
100	0.7	2.0	3.4	4.8
150	0.5	1.8	2.8	3.7
200	0.5	1.8	2.4	3.1
>200	0.5	1.8	2.4	3.0

AWS 1.0

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

OFFICE OF THE COMMISSIONER

Bill Sheffield, Governor

P.O. BOX 3-2000
JUNEAU, ALASKA 99802
PHONE: 465-4100

46 - C180

September 16, 1983

RECEIVED
SEP 2 6 1983
Alaska Dept. of Fish & Game
Habitat – Region III

Mr. B. L. Hilliker, Manager
Environmental Protection &
Government Reports
Alyeska Pipeline Service Co.
1835 S. Bragaw St.
Anchorage, AK 99512

Dear Mr. Hilliker:

RE: APSC Letter No. 83-3422-G; Atigun River Char.

Thank you for your August 8, 1983, letter regarding the Department's classification of Atigun River char as anadromous fish under the authority of AS 16.05.870. As I understand your concerns, they are as follows:

1. You believe that the Legislature intended us to base anadromous fish designations on the presence of "adult anadromous spawners." You believe that this point is substantiated by our revised Catalog of Waters Important for Spawning, Rearing and Migration of Anadromous Fish (Catalog), because it indicates that "anadromous fish means fish which enter fresh water from the sea for spawning purposes."

2. You believe it highly speculative whether char have ever been able to negotiate the Atigun River gorge.

3. You consider our earlier mention of king salmon in the Susitna to be an inappropriate analogy. You refer to the Department's earlier recognition of king salmon as much stronger swimmers than char and, therefore, not comparable.

4. You disagree with our classification of char as anadromous fish in the Atigun River and desire that we reconsider this designation.

I would like to respond to your concerns in the above order.

1. We are interpreting legislative intent and our catalog definition of anadromous fish to refer to anadromous stocks and not to landlocked populations of otherwise anadromous species. I believe that we are in agreement on this point.

With the above in mind, we do, however, base our classification of anadromous fish waters on the presence of immature fish as well as on the presence of spawners returning from the sea. The fact that AS 16.05.870 provides for the protection of spawning, rearing and migration of anadromous fish means that coverage is not limited to systems identified solely by the presence of adult spawners. Our definition of anadromous fish is a definition of a category of fish that lives through life cycles, all of which are subject to the protection provisions of AS 16.05.870.

The fact that adult and sub-adult char exist throughout the Atigun River is not argued. We concur that anadromous char have not as yet been documented to spawn in the Atigun River. A first issue, then, until such time that spawners may be documented, is whether the Atigun River supports rearing char that will eventually become anadromous and thus is also used for migration by these individuals.

Dr. Hans Nordeng in Norway artificially spawned both resident and anadromous char as separate groups and presented the results of his research at the First International Symposium on Arctic Char in 1981. He demonstrated that both matings between resident adults and matings between anadromous adults produced the same ratio of 40 percent resident offspring and 60 percent anadromous offspring. Such research is of particular importance to the case at hand. Whether this life history pattern exists for the Atigun River char is the proper focus of attention for this first issue.

2. It is the belief of our biologists, familiar with the Atigun River, that char can successfully negotiate both upstream and downstream through the gorge. They base this belief on the following observations:

   a. the presence of many large boulders which break up the laminar flow creating abundant eddies suitable as fish resting areas;

   b. suitable resting areas are close enough together in the gorge to provide ample opportunity for char to negotiate the full length of the gorge; and

   c. there are no falls in the gorge that would create an impassable barrier to fish.

3. I agree that the habits of king salmon in the Susitna River are not directly analagous to those of char on the Atigun River and that king salmon are stronger swimmers than char. The Susitna was mentioned only to emphasize that fish can often accomplish rather surprising feats.

4. We are dealing here with a particular higher order tributary stream. It is our general position that the offspring of resident

char can assume the anadromous lifestyle and migrate to sea. Furthermore, we are not convinced that the Atigun River Gorge is an impassable barrier to char. However, it is worthwhile to delay nomination of the Atigun River for inclusion in the Catalog until we have had a chance to review Dr. McCart's data, which are due in October, and to receive preliminary results from the work of the Sport Fish Division which I directed to be pursued as a consequence of our initial correspondence on this matter. Accordingly, I would appreciate receiving a copy of Dr. McCart's work when it is completed.

Thank you for your attention to our Catalog. I look forward to discussing this matter further after we have had the chance to look at the results of the forthcoming studies.

Sincerely,

Dennis D. Kelso
Deputy Commissioner

cc: Logan
Clark

Alyeska pipeline SERVICE COMPANY 1835 SOUTH BRAGAW STREET, ANCHORAGE, ALASKA 99512, TELEPHONE (907) 278-1611, TELEX 090-25-127

August 8, 1983 Letter No. 83-3422-G

Mr. Dennis D. Kelso
Deputy Commissioner
Alaska Dept. of Fish and Game
P.O. Box 3-2000
Juneau, AK 99802

Dear Mr. Kelso:

Thank you for your letter of July 12, 1983 regarding the anadromous designation for the Atigun River. However after reviewing your letter I remain unconvinced that the department has sufficient documentation for designating the Atigun River as an anadromous fish stream.

As I recall the legislative intent circumscribing the original statute involved designating anadromous systems based essentially on the presence of adult anadromous spawners. This rationale is substantiated further in the Department of Fish and Game, April 1982 revision of the catalog of waters important for spawning, rearing and migration of anadromous fish. The definition in that catalog states; "anadromous fish means fish which enter fresh water from the sea for spawning purposes." That definition strongly suggests that without the presence of ocean returning adult spawning anadromous species a system does not meet the minimum criteria for anadromous designation.

Your letter also uses the presence of adult King Salmon above the first set of rapids in Devils Canyon on the Susitna River as an example of why the Atigun Canyon gorge may not be an impassable velocity barrier to adult Arctic Char. However in this matter the comparison of King Salmon with Arctic Char is not biologically valid. I have attached a copy of a page taken from the draft habitat regulations proposed by your department in 1981. According to this chart adult King Salmon are classified as high performance swimmers and quite correctly adult and juvenile Arctic Char are classified as slow or low performance swimmers. It's possible that King Salmon, could negotiate the Atigun River gorge but it's highly speculative whether anadromous Arctic Char ever have.

I sincerely hope you will evaluate my comments prior to making the final anadromous fish system designations. I also appreciate your patience in this matter. If I can be of assistance to you do not hesitate to contact me.

Sincerely,

B. L. Hilliker, Manager
Environmental Protection &
Government Reports

cc: John Clark - ADF&G/Juneau
Scott Grundy - ADF&G/Fairbanks
Carl Yanagawa - ADF&G/Anchorage

1211

BLH/wkk
Attachment

(1)

AVERAGE CROSS SECTIONAL VELOCITIES IN FEET/SECOND MEASURED AT THE OUTLET OF THE CULVERT

Length of culvert in feet	Group I Upstream migrant salmon fry and fingerlings when upstream migration takes place at mean annual flood	Group II adult and juvenile slow swimmers: grayling, longnose suckers, whitefish, burbot, sheefish, Northern pike, Dolly Varden/ Arctic Char, upstream migrant salmon fry and fingerlings when migration not at mean annual flood	Group III Adult moderate swimmers: pink salmon, chum salmon, rainbow trout, cutthroat trout	Group IV Adult high performance swimmers: king salmon, coho salmon, sockeye salmon, steelhead
30	1.0	4.6	6.8	9.9
40	1.0	3.8	5.8	8.5
50	1.0	3.2	5.0	7.5
60	0.9	2.8	4.6	6.6
70	0.8	2.6	4.2	6.0
80	0.8	2.3	3.9	5.5
90	0.7	2.1	3.7	5.1
100	0.7	2.0	3.4	4.8
150	0.5	1.8	2.8	3.7
200	0.5	1.8	2.4	3.1
>200	0.5	1.8	2.4	3.0

SOLUTION OF THE "CHARR PROBLEM" BASED ON CHARR, *SALVELINUS ALPINUS*, IN NORWAY, *Hans Nordeng, University of Oslo, Oslo, Norway.*

Atlantic salmon, *Salmo salar*, brown trout, *Salmo trutta*, and arctic charr, *Salvelinus alpinus*, coexist in most river systems in Norway. Charr occur as three types: small resident charr, large resident charr and anadromous charr. Anadromous charr are found only in North Norway. The three types differ in size, age at sexual maturity, sex ratio, spawning color, spawning grounds, growth rate and feeding habits.

The young charr of the Salangen river system in North Norway have a uniform phenotype. During the young stage (the first 7 years) they become either small resident charr (30%), large resident charr (10%) or smolts (60%). The sex ratios of the three types (M:F) are 5:1, 4:1 and 1:3, respectively, giving an overall ratio of 1:1, as in the young. This indicates that the three types of the Salangen charr are morphs of the same population. However, their separate spawning grounds suggest that they may belong to different reproductive units.

Offspring of the three types were reared at Voss in the southern, non-anadromous region. During the young stage, offspring of each type developed into the parent type and into the two other types. Transplanted to the parent river system the fish behaved according to type. In parallel rearing experiments, offspring of resident charr from southern Norway produced the two resident types only, but no smolts. However, offspring from two exceptional southern resident populations produced smolts as well as resident charr; these smolts behaved as anadromous charr when transplanted to a northern locality. Transplanted to their parental southern locality the smolts did not migrate to the sea, probably owing to general infection of the urethra by the fluke, *Phyllodistomum conostomum* Olsson.

These rearing experiments show that the three types of charr in the Salangen river system are morphs of the same population. The small and large resident morphs, maturing during the comparatively long juvenile stage, correspond to the precocious individuals in salmon and anadromous trout. Most populations of southern resident charr correspond wholly to the precocious morphs of an anadromous charr population.

STATE OF ALASKA

Bill Sheffield, Governor

DEPARTMENT OF FISH AND GAME

OFFICE OF THE COMMISSIONER

P.O. BOX 3-2000
JUNEAU, ALASKA 99802
PHONE: 465-4100

Philip Smith

Bruce B

Grundy S

Yamaguchi

September 16, 1983

RECEIVED
SEP 21 1983
Alaska Dept. of Fish & Game
Habitat – Region III

Mr. B. L. Hilliker, Manager
Environmental Protection &
Government Reports
Alyeska Pipeline Service Co.
1835 S. Bragaw St.
Anchorage, AK 99512

Dear Mr. Hilliker:

RE: APSC Letter No. 83-3422-G; Atigun River Char.

Thank you for your August 8, 1983, letter regarding the Department's classification of Atigun River char as anadromous fish under the authority of AS 16.05.870. As I understand your concerns, they are as follows:

1. You believe that the Legislature intended us to base anadromous fish designations on the presence of "adult anadromous spawners." You believe that this point is substantiated by our revised Catalog of Waters Important for Spawning, Rearing and Migration of Anadromous Fish (Catalog), because it indicates that "anadromous fish means fish which enter fresh water from the sea for spawning purposes."

2. You believe it highly speculative whether char have ever been able to negotiate the Atigun River gorge.

3. You consider our earlier mention of king salmon in the Susitna to be an inappropriate analogy. You refer to the Department's earlier recognition of king salmon as much stronger swimmers than char and, therefore, not comparable.

4. You disagree with our classification of char as anadromous fish in the Atigun River and desire that we reconsider this designation.

I would like to respond to your concerns in the above order.

1. We are interpreting legislative intent and our catalog definition of anadromous fish to refer to anadromous stocks and not to landlocked populations of otherwise anadromous species. I believe that we are in agreement on this point.

With the above in mind, we do, however, base our classification of anadromous fish waters on the presence of immature fish as well as on the presence of spawners returning from the sea. The fact that AS 16.05.870 provides for the protection of spawning, rearing and migration of anadromous fish means that coverage is not limited to systems identified solely by the presence of adult spawners. Our definition of anadromous fish is a definition of a category of fish that lives through life cycles, all of which are subject to the protection provisions of AS 16.05.870.

The fact that adult and sub-adult char exist throughout the Atigun River is not argued. We concur that anadromous char have not as yet been documented to spawn in the Atigun River. A first issue, then, until such time that spawners may be documented, is whether the Atigun River supports rearing char that will eventually become anadromous and thus is also used for migration by these individuals.

Dr. Hans Nordeng in Norway artificially spawned both resident and anadromous char as separate groups and presented the results of his research at the First International Symposium on Arctic Char in 1981. He demonstrated that both matings between resident adults and matings between anadromous adults produced the same ratio of 40 percent resident offspring and 60 percent anadromous offspring. Such research is of particular importance to the case at hand. Whether this life history pattern exists for the Atigun River char is the proper focus of attention for this first issue.

2. It is the belief of our biologists, familiar with the Atigun River, that char can successfully negotiate both upstream and downstream through the gorge. They base this belief on the following observations:

   a. the presence of many large boulders which break up the laminar flow creating abundant eddies suitable as fish resting areas;

   b. suitable resting areas are close enough together in the gorge to provide ample opportunity for char to negotiate the full length of the gorge; and

   c. there are no falls in the gorge that would create an impassable barrier to fish.

3. I agree that the habits of king salmon in the Susitna River are not directly analagous to those of char on the Atigun River and that king salmon are stronger swimmers than char. The Susitna was mentioned only to emphasize that fish can often accomplish rather surprising feats.

4. We are dealing here with a particular higher order tributary stream. It is our general position that the offspring of resident

char can assume the anadromous lifestyle and migrate to sea. Furthermore, we are not convinced that the Atigun River Gorge is an impassable barrier to char. However, it is worthwhile to delay nomination of the Atigun River for inclusion in the Catalog until we have had a chance to review Dr. McCart's data, which are due in October, and to receive preliminary results from the work of the Sport Fish Division which I directed to be pursued as a consequence of our initial correspondence on this matter. Accordingly, I would appreciate receiving a copy of Dr. McCart's work when it is completed.

Thank you for your attention to our Catalog. I look forward to discussing this matter further after we have had the chance to look at the results of the forthcoming studies.

Sincerely,

Dennis D. Kelso
Deputy Commissioner

cc: Logan
Clark

[redacted]

Philip Smith

ALASKA DEPT. OF
FISH & GAME

SEP 2 1983

HABITAT
REGIONAL OFFICE

July 12, 1983

Mr. B. L. Hilliker
Alyeska Pipeline Service Co.
1835 S. Bragaw St.
Anchorage, AK 99512

Dear Mr. Hilliker:

RE: AS 16.05.870(a) Designation of Atigun River.

Thank you for your letter concerning the life history of Arctic char in the Atigun River. Alyeska's consultant, Dr. McCart, may be correct in his assertion that only resident adult char are found above the Atigun Gorge; the Department has not found spawning anadromous char in that area. However, Dr. McCart's memorandum fails to recognize that the offspring of resident char may assume the anadromous lifestyle and can and do migrate to sea. Conversely, the offspring from anadromous adults can and do remain as freshwater residents. Departmental biologists are also not convinced that the Atigun River Gorge is an impassable barrier to rearing juvenile fish. As you may be aware, both juvenile and adult salmonids can negotiate some very difficult barriers. For example, king salmon have recently been found spawning in a tributary of the Susitna River which enters above the first set of rapids and damsite in Devils Canyon. Because there is currently no way of distinguishing between resident and anadromous juvenile Arctic char, there is no way of determining that at least some of the juvenile Arctic char, which are found throughout the Atigun River drainage, are not anadromous.

The Sagavanirktok River and its tributaries are important char producers. Because of the importance of this stream, and the fact that Department biologists who nominated it for inclusion in the Catalog of Waters Important for Spawning, Rearing and Migration of Anadromous Fishes believe that it is important for spawning and rearing of anadromous fish, we will retain it in this year's catalog. However, you have raised some important issues and I have asked our Sport Fish Division to review Dr. McCart's data and to conduct any field studies necessary to confirm or deny the presence of anadromous char above the Atigun Gorge.

Sincerely,

Dennis D. Kelso
Deputy Commissioner

ANS 2.0

cc: D. Logan
A. Ott
A. Kohl
D. Lowery
J. Brossia

Alyeska pipeline SERVICE COMPANY 1835 SOUTH BRAGAW STREET, ANCHORAGE, ALASKA 99512, TELEPHONE (907) 278-1611, TELEX 090-25-127

June 14, 1983 Letter No. 83- 3384-G

COMMISSIONER'S OFFICE
RECEIVED
JUN 17 1983
DEPARTMENT OF FISH AND GAME

Mr. Don Collingsworth
Commissioner
Alaska Dept. of Fish and Game
Subport Bldg.
Juneau, AK 99801

Re: Anadromous Fish Stream Catalog

Dear Commissioner Collingsworth:

In a review of the proposed 1983 changes to the catalog of Waters Important for the Spawning, Rearing and Migration of Anadromous Fishes we noted that the Atigun River had been added. The catalog indicates that Arctic Char rear in the river well above the Atigun Gorge.

Alyeska Pipeline Service Company wishes to register an objection to the inclusion of the Atigun River to the catalog. While we do not disagree that Arctic Char are found above the Atigun Gorge we do not agree that these are anadromous Char. Alyeska believes that these fish represent a resident population.

To support our claim we are attaching a copy of a telex from Dr. Peter McCart discussing Atigun River Char. Dr. McCart and his associates have many years of experience studying Arctic Char in Northern Alaska and Canada.

Because there is no known data which would support designating the Atigun River as an anadromous fish stream, Alyeska Pipeline Service Company requests that the Atigun River not be included in the 1983 changes to the catalog of Anadromous Fish Streams.

Very truly yours,

B. L. Hilliker
Manager,
Environmental Protection &
Government Reports

BLH/wkk
Attachment

cc: Carl Yanagawa - ADF&G
B. Stafford - DNR

1211

Attn: Dick Mikkelsen

Re: Reclassification of the Atigun River Drainage as an Anadromous Fish Stream

Aquatic Environments Inc. has been conducting fisheries investigations in the Atigun Sagavanirktok Drainage since 1969 and is currently involved in a three year study to assess the long-term effects of the Trans-Alaska Pipeline System on Fish resources of the region. During the course of these studies, we have developed an in-depth understanding of the life history, habitat requirements and distribution of both anadromous and freshwater fish populations in the area. Our early work sponsored by Alyeska Pipeline Service Company (1969-1974) and Alaskan Arctic Gas Study Inc. (1972-1976), included detailed mapping of critical spawning and overwintering areas for anadromous and freshwater populations of Arctic Char. Based on these studies and our most recent investigations in the Atigun River (1981-1983) the following pattern of fish distribution and life history patterns has emerged.

Sampling in the Atigun River Drainage reveals a species compositions of approximately 85% Arctic Grayling, 7% Round Whitefish, 6% Arctic Char, 1% Lake Trout and 1% Burbot. Slimy Sculpin, while abundant throughout the drainage, are not included in this determination.

Lake dwelling populations of eastern form Arctic Char are found in Galbraith Lake and in several small lakes immediately to the south. These isolated populations are non migratory, spawn in lakes, and are not known to interbreed with stream resident fish.

In addition to these lake resident Arctic Char, there is an isolated population of Western form Arctic Char (synonomous with Northern Dolly Varden) inhabiting streams in the Atigun River Drainage. Conditions in the Atigun River Gorge [redacted] to prevent movement of Char from the Sagavanirktok River into the upper Atigun River, effectively isolating this stream resident population.

Stream resident Char in the Atigun River are believed to spawn and overwinter in the vicinity of small groundwater sources located in the mainstream between Pipeline MP 144 and 158. Because the Atigun Gorge is an i[redacted] to the upstream migration of Char, any fish which migrate downstream into the Sagavanirktok River will be lost to the population, which is [redacted]. We are in the process of conducting detailed meristic and morphological studies of stream resident Char from the Atigun River Drainage for comparison with similar data for other North Slope Drainages (McCart 1980), we anticipate these data will be available by October of this year.

In the 15 years during which the Sagavanirktok River system and the Atigun Drainage have been intensively studied (1960 to 1983 inclusive) [redacted]e has to our knowledge observed or sampled anadromous Arctic Char spawning in the Atigun River. These are readily distinguishable because they are at least twice as long and weigh at least 10 times as much as stream resident fish. One reason for this absence may be that the accessible reach of the stream downstream of the gorge is very short and appears to have no perennial supply of groundwater. A good Winter supply of groundwater is essential for the incubation of eggs. The only use we can suggest that a[redacted]r may make of the Atigun River is a feeding area during the summer when small numbers of juvenile fish from the Sagavanirktok River may enter the lo[redacted]es of the stream downstream of the gorge. However the area which such juveniles might utilize is so small and the area of similar habitat elsewhere in the Sagavanirktok System is so large that the Atigun River can be of little significance to the overall well being of anadromous populations in the Sagavanirktok System.

There appears, therefore, to be no justification for considering the Atigun River an anadromous Fish Stream, using any reasonable definition of the term. Many other North Slope streams are also known to support isolated populations of Char populations and in some cases small numbers of rearing juveniles but have not been considered anadromous fish streams.

Sincerely,

Peter McCart, PhD

Alyeska pipeline SERVICE COMPANY 1835 SOUTH BRAGAW STREET, ANCHORAGE, ALASKA 99512, TELEPHONE (907) 278-1611, TELEX 090-25-127

June 14, 1983 Letter No. 83- 3384-G

Mr. Don Collingsworth
Commissioner
Alaska Dept. of Fish and Game
Subport Bldg.
Juneau, AK 99801

Re: Anadromous Fish Stream Catalog

Dear Commissioner Collingsworth:

In a review of the proposed 1983 changes to the catalog of Waters Important for the Spawning, Rearing and Migration of Anadromous Fishes we noted that the Atigun River had been added. The catalog indicates that Arctic Char rear in the river well above the Atigun Gorge.

Alyeska Pipeline Service Company wishes to register an objection to the inclusion of the Atigun River to the catalog. While we do not disagree that Arctic Char are found above the Atigun Gorge we do not agree that these are anadromous Char. Alyeska believes that these fish represent a resident population.

To support our claim we are attaching a copy of a telex from Dr. Peter McCart discussing Atigun River Char. Dr. McCart and his associates have many years of experience studying Arctic Char in Northern Alaska and Canada.

Because there is no known data which would support designating the Atigun River as an anadromous fish stream, Alyeska Pipeline Service Company requests that the Atigun River not be included in the 1983 changes to the catalog of Anadromous Fish Streams.

Very truly yours,

B. L. Hilliker
Manager,
Environmental Protection &
Government Reports

BLH/wkk
Attachment

cc: Carl Yanagawa - ADF&G
B. Stafford - DNR

1211

Attn: Dick Mikkelsen

Re: Reclassification of the Atigun River Drainage as an Anadromous Fish Stream

Aquatic Environments Inc. has been conducting fisheries investigations in the Atigun Sagavanirktok Drainage since 1969 and is currently involved in a three year study to assess the long-term effects of the Trans-Alaska Pipeline System on Fish resources of the region. During the course of these studies, we have developed an in-depth understanding of the life history, habitat requirements and distribution of both anadromous and freshwater fish populations in the area. Our early work sponsored by Alyeska Pipeline Service Company (1969-1974) and Alaskan Arctic Gas Study Inc. (1972-1976), included detailed mapping of critical spawning and overwintering areas for anadromous and freshwater populations of Arctic Char. Based on these studies and our most recent investigations in the Atigun River (1981-1983) the following pattern of fish distribution and life history patterns has emerged.

Sampling in the Atigun River Drainage reveals a species compositions of approximately 85% Arctic Grayling, 7% Round Whitefish, 6% Arctic Char, 1% Lake Trout and 1% Burbot. Slimy Sculpin, while abundant throughout the drainage, are not included in this determination.

Lake dwelling populations of eastern form Arctic Char are found in Galbraith Lake and in several small lakes immediately to the south. These isolated populations are non migratory, spawn in lakes, and are not known to interbreed with stream resident fish.

In addition to these lake resident Arctic Char, there is an isolated population of Western form Arctic Char (synonomous with Northern Dolly Varden) inhabiting streams in the Atigun River Drainage. Conditions in the Atigun River Gorge appear to prevent movement of Char from the Sagavanirktok River into the upper Atigun River, effectively isolating this stream resident population.

Stream resident Char in the Atigun River are believed to spawn and overwinter in the vicinity of small groundwater sources located in the mainstream between Pipeline MP 144 and 158. Because the Atigun Gorge is an immpassable barrier to the upstream migration of Char, any fish which migrate downstream into the Sagavanirktok River will be lost to the population, which is reproductively isolated. We are in the process of conducting detailed meristic and morphological studies of stream resident Char from the Atigun River Drainage for comparison with similar data for other North Slope Drainages (McCart 1980), we anticipate these data will be available by October of this year.

In the 15 years during which the Sagavanirktok River system and the Atigun Drainage have been intensively studied (1960 to 1983 inclusive) no one has to our knowledge observed or sampled anadromous Arctic Char spawning in the Atigun River. These are readily distinguishable because they are at least twice as long and weigh at least 10 times as much as stream resident fish. One reason for this absence may be that the accessible reach of the stream downstream of the gorge is very short and appears to have no perennial supply of groundwater. A good Winter supply of groundwater is essential for the incubation of eggs. The only use we can suggest that anadromous Char may make of the Atigun River is a feeding area during the summer when small numbers of juvenile fish from the Sagavanirktok River may enter the lowermost reaches of the stream downstream of the gorge. However the area which such juveniles might utilize is so small and the area of similar habitat elsewhere in the Sagavanirktok System is so large that the Atigun River can be of little significance to the overall well being of anadromous populations in the Sagavanirktok System.

There appears, therefore, to be no justification for considering the Atigun River an anadromous Fish Stream, using any reasonable definition of the term. Many other North Slope streams are also known to support isolated populations of Char populations and in some cases small numbers of rearing juveniles but have not been considered anadromous fish streams.

Sincerely,

Peter McCart, PhD

MEMORANDUM State of Alaska

TO: See Distribution List

DATE: October 10, 1983

FILE NO:

TELEPHONE NO: 465-4105

SUBJECT: Atigun River

FROM: for John A. Clark, Director
Department of Fish and Game
Habitat Division

Inclusion of the Atigun River into the 1983 revision of the Anadromous Fish Waters Catalog was contested by Alyeska Pipeline. The Introduction to the Catalog defines anadromous fish as "fish which enter fresh water from the sea for spawning purposes..." We did not have sufficient data to show that the char in the Atigun River are anadromous by this definition. Therefore, the Atigun River is being deleted from the 1983 revision to the Catalog.

Please replace the maps for Quadrangle 131, Philip Smith Mountains B5 and C-4 with the enclosed revised maps and discard Quadrangle 131, Philip Smith Mountains A-5 and B-4. Thank you.

Enclosures (maps)

Distribution:

Alaska State Legislature
Attorney General's Office, Dept. of Law
Scott Grundy
John Trent
Rick Reed
Len Schwarz
Brian Biglar

ALASKA DEPT. OF
FISH & GAME
OCT 1983
RECEIVED

JACK/Atig. v

DRAFT BY. D Cary

AS SENT TO [illegible]

FOR REVIEW AND SIGNATURE.

See Distribution List

DATE sent 9/21/83

DRAFTED BY: P. Weber 9/23/83

Reviewed By: _____

Approved By: _____ 465-4105

John A. Clark, Director
Department of Fish and Game
Habitat Division

Atigun River

Inclusion of the Atigun River into the 1983 revision of the Anadromous Fish Waters Catalog was contested by Alyeska Pipeline. The Introduction to the Catalog defines anadromous fish as "fish which enter fresh water from the sea for spawning purposes..." We did not have sufficient data to show that the char in the Atigun River are anadromous by this definition. Therefore, the Atigun River is being deleted from the 1983 revision to the Catalog.

Please replace the maps for Quadrangle 131, Philip Smith Mountains B5 and C-4 with the enclosed revised maps and discard Quadrangle 131, Philip Smith Mountains A-5 and B-4. Thank you.

Enclosures (maps)

Distribution:

Ron Larson, House Resources Committee, Juneau
Attorney General's Office, Dept. of Law
Scott Grundy
John Trent
Rick Reed
Len Schwarz
Brian Biglar

ALASKA DEPT. OF FISH & GAME
SEP 23 1983
HABITAT
REGIONAL OFFICE

file: ANS 2.0

MEMORANDUM State of Alaska

TO: Bruce Baker, Deputy Director
Habitat Division
Department of Fish and Game

DATE:

FILE NO: BB

TELEPHONE NO: 344-0541

FROM: Phyllis Weber PW
Habitat Biologist
Habitat Division
Anchorage

SUBJECT: Memo Pertaining to Deletion of Atigun River

The distribution list for the memo pertaining to the deletion of the Atigun River includes all offices which have copies of the 1983 volume of the Atlas to The Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes (AWC, Volume V, Arctic Region) which contains the maps for the Atigun River (Philip Smith quadrangle, A5, B4, B5 and C4). The 1982 version of Volume V of the AWC did not designate the Atigun River as an anadromous fish stream. Therefore, persons having the 1982 version of Volume V or the 1983 version of the AWC will have the Atigun River represented correctly in their copies of the AWC.

Other State and Federal agencies and the private sector are not able to obtain copies of the AWC until its adoption in October. Our cartographic staff revised the composite for the maps containing the Atigun River and gave them to the reproduction company responsible for printing the Atlas. Therefore, when these other offices purchase the Atlas from our vendor, they will receive revised maps which do not designate the Atigun River as an anadromous fish stream.

As stated above, the enclosed memo will be sent to everyone who already has copies of the 1983 version of Volume V of the AWC which shows the Atigun River as an anadromous fish stream. Our cartographer has printed copies of the revised maps and has them packaged for mailing. The subject memo will be mailed with the maps so that all recipients will understand why we are sending the new maps, that the old maps for Philip Smith B5 and C4 must be replaced with the new maps and that the old maps for Philip Smith A5 and B4 must be discarded. Therefore, we need the subject memo signed and returned to us so that we can include it with the revised maps and mail it to all persons currently possessing the 1983 version of Volume V of the AWC.

BILL SHEFFIELD, GOVERNOR

DEPARTMENT OF FISH AND GAME

P.O.BOX 3-2000
JUNEAU, ALASKA 99802
PHONE: (907) 465-4100

OFFICE OF THE COMMISSIONER

July 12, 1983

Mr. B. L. Hilliker
Alyeska Pipeline Service Co.
1835 S. Bragaw St.
Anchorage, AK 99512

Dear Mr. Hilliker:

RE: AS 16.05.870(a) Designation of Atigun River.

Thank you for your letter concerning the life history of Arctic char in the Atigun River. Alyeska's consultant, Dr. McCart, may be correct in his assertion that only resident adult char are found above the Atigun Gorge; the Department has not found spawning anadromous char in that area. However, Dr. McCart's memorandum fails to recognize that the offspring of resident char may assume the anadromous lifestyle and can and do migrate to sea. Conversely, the offspring from anadromous adults can and do remain as freshwater residents. Departmental biologists are also not convinced that the Atigun River Gorge is an impassable barrier to rearing juvenile fish. As you may be aware, both juvenile and adult salmonids can negotiate some very difficult barriers. For example, king salmon have recently been found spawning in a tributary of the Susitna River which enters above the first set of rapids and damsite in Devils Canyon. Because there is currently no way of distinguishing between resident and anadromous juvenile Arctic char, there is no way of determining that at least some of the juvenile Arctic char, which are found throughout the Atigun River drainage, are not anadromous.

The Sagavanirktok River and its tributaries are important char producers. Because of the importance of this stream, and the fact that Department biologists who nominated it for inclusion in the Catalog of Waters Important for Spawning, Rearing and Migration of Anadromous Fishes believe that it is important for spawning and rearing of anadromous fish, we will retain it in this year's catalog. However, you have raised some important issues and I have asked our Sport Fish Division to review Dr. McCart's data and to conduct any field studies necessary to confirm or deny the presence of anadromous char above the Atigun Gorge.

Sincerely,

Dennis D. Kelso
Deputy Commissioner

cc: D. Logan
A. Ott
A. Kohl
D. Lowery
J. Brossia

RECEIVED
JUL
Alaska Dept. of Fish & Game
Habitat -- Region III

MEMORANDUM State of Alaska

TO: Carl M. Yanagawa
Regional Supervisor
Habitat Division
Anchorage

DATE: July 6, 1983

FILE NO: Sag

TELEPHONE NO: 344-0451

FROM: Phyllis K. Weber
Habitat Biologist
Habitat Division
Anchorage

SUBJECT: M. Atigun River
Doc C142

I contacted the Region III Habitat and Sport Fish Divisions regarding documentation of anadromous char in the Atigun River. Al Townsend said that he responded to Mr. Hilliker's objection to the inclusion of the Atigun River in the Anadromous Fish Waters Catalog. Townsend argued that, even though the char may be a resident population, they likely produce anadromous offspring. Townsend referenced published studies which document the genesis of anadromous fish from resident populations. He will also contact Terry Bendock, who nominated the Atigun River, for Bendock's information.

Region III will send us a copy of the response to Mr. Hilliker for our files.

cc: S. Grundy
B. Baker

[illegible]

re: [illegible] River

Carl –

I contacted K III [illegible]

K III [illegible]

[illegible] River. Al Townsend wrote a response based upon the argument that even though the char may be a resident population, they likely are producing anadromous offspring. He referenced published studies to substantiate this. He will also contact Terry [illegible] who nominated the [illegible] River for his information. K III will send us a copy of their response for our files.

– [illegible]

GOLDENROD INSTRUCTIONS

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

DATE: 6/20/83 DOCUMENT NO. C142

☐ Region I ☐ Region IV

☐ Region II ☐ Data Mgmt.

☒ Region III ☐ _____

___ Prepare draft comments for Director's signature.

✓ Prepare draft comments for Commissioner's signature.
Acting Deputy

Response due in Habitat 6/24

Comments:

✓cc: Carl Yanagawa

DEPARTMENT OF FISH AND GAME
HEADQUARTERS

FROM: Commissioners Office DATE 6/17/83

REMARKS Habitat to prepare response for RC 150's sign by 06-27-83

Routing	Sign Off
COMMISSIONER	
1 Commissioner	
___ Deputy/Resource	
2 Deputy/Program	
___ Spec. Projects	
___ Planning	
___ Ext. Affairs	
Log	
___ Library	
___ Habitat	
___ Subsistence	
___ F & G Boards	
___ Public Comm.	
___ Vessels	
GAME	
___ Director	
___ Dep. Director	
___ Admin. Ass't	
___ Research Chief	
___ _____	
SPORT FISH	
___ Director	
___ Dep. Director	
___ Admin. Ass't	
___ Research Chief	
___ _____	

Routing	Sign Off
COMM FISH	
___ Director	
___ Dep. Director	
___ Admin. Ass't	
___ Research	
___ Computer Serv.	
___ Ext. Juris.	
___ CFEC	
___ _____	
ADMINISTRATION	
___ Director	
___ Dep. Director	
___ Fiscal Officer	
___ Accounting	
___ Supply	
___ Personnel/Pay	
___ Contracts	
FRED	
___ Director	
___ Chief T & D	
___ Chief Operation	
___ Admin. Officer	
___ Admin. Ass't	
___ PNP Hatcheries	
___ _____	
___ _____	

11-77 (3/82)

State of Alaska
Department of Fish and Ga
Public Review Nomination for Waters
Important to Anadromous Species

☒ Addition ☐ Deletion

131 Name of Waterbody (if known): Atigun River

Location:

Arctic
ALASKA DEPT. OF
FISH & GAME
HABITAT
REGIONAL OFFICE

Anadromous Waters Catalog Volume and Number

USGS 1:63,360 Quadrangle Phillip Smith A5,B5,C4,C5,D4 Sag A4,B4,C4,D4 Beechey Pt. A3,A4,B3

or 1:250,000 (if 1:63,360 not available)

Species	Date(s) Observed	Stage(s) (Spawning, Rearing, Migration)
Arctic char	Sept a Oct. 1978	rearing

Comments: Please provide any clarifying information in addition to identification on Anadromous Waters Catalog Public Review Maps.

Char probably distributed farther upstream but were observed at road xing.

Name of Observer (please print) Alan H Townsend

Date: 3-7-83 Signature: Alan H. Townsend

Address: 1300 College Rd
Fairbanks, Ak

Drawn 3-8-83

drafted CB 3/31/83

Sagavanirktok River — all the 1st leg to Sag R

AERIAL 47

USGS, PHILIP SMITH MOUNTAINS A-5, A-4

1" = 2000'

Department of Fish and Game
Public Review Nomination for Waters
Important to Anadromous pecies

[X] Addition [ ] Deletion

Name of Waterbody (if known): Atigun River ~~Gorge / Sagavanirktok~~

Location:

Anadromous Waters Catalog Volume and Number _____

USGS 1:63,360 Quadrangle Philip Smith C-4

or 1:250,000 (if 1:63,360 not available) _____

Species	Date(s) Observed	Stage(s) (Spawning, Rearing, Migration)
AC		Migration/Rearing

Comments: Please provide any clarifying information in addition to identification on Anadromous Waters Catalog Public Review Maps.

Name of Observer (please print) _____

Date: 3/30/83 Signature: Terry Bendock

Address: ADF&G FBKS

Department of Fish and Game
ublic Review Nomination f Waters
Important to Anadromous Species

[X] Addition [ ] Deletion

Name of Waterbody (if known): Atigun River ~~Gorge / Sagavanirktok~~

Location:

Anadromous Waters Catalog Volume and Number _____

USGS 1:63,360 Quadrangle Philip Smith C-4

or 1:250,000 (if 1:63,360 not available) _____

Species	Date(s) Observed	Stage(s) (Spawning, Rearing, Migration)
AC		Migration/Rearing

Comments: Please provide any clarifying information in addition to identification on Anadromous Waters Catalog Public Review Maps.

Name of Observer (please print) _____

Date: 3/30/83 Signature: Terry Bendock

Address: ADF&G FBKS

MEMORANDUM (Brief Communications)

State of Alaska

TO:	Name: Carl Yanagawa	Dept./Div./Sect.: Habitat ADF&G	Mail Stop:
FROM:	Name: Rob Armstrong	Dept./Div./Sect.: Coop. Fish Unit	Telephone: 474-7661
SUBJ.:	Solution to the Char Problem		Date: 12/6/83

I'm afraid Nordeng's solution may create problems for your evaluation of anadromous fish streams. Fascinating "critters".

Bob

02 [illegible]

Form 02-005

REPLY MEMO

State of Alaska

MESSAGE	REPLY
TO PHYLLIS WEBER DATE 7/18/83	TO _____ DATE _____
HABITAT — ANCHORAGE	
ATTACHED is A COPY,	inquires by Alyeska
OF HEADQUARTERS	to Headquarter's.
RESPONSE TO	
ALYESKA PIPELINE	Bob McLean
REGARDING AS 16.05.870(a)	FBX.
Designation of the	
Atigun River.	
As I indicated verbally,	
the preferred reactive	
course of action would	
be to refer all future	

1. KEEP YELLOW COPY. 2. SEND WHITE AND PINK COPIES WITH CARBON INTACT.

1. WRITE REPLY. 2. DETACH STUB, KEEP PINK COPY. RETURN WHITE COPY TO SENDER.

MEMORANDUM (Brief Communications) **State of Alaska**

TO: Name: Phyllis Wieber	Dept./Div./Sect.: Habitat	Mail Stop:	
FROM: Name: Durand	Dept./Div./Sect.:	Telephone: 295	
SUBJ.: Antigan River		Date: 7-18-83	

Dick Michaelson with Alyeska Pipeline submitted to Don Collinsworth a request to have the Antigan River removed from the Anadromous Waters Catalog. Time is drawing near the adoption of the AWC. Dick wanted a call today telling of the status and/or decision on Antigan River.

Dick Michaelson 265-8437

7/19 Called Dick Michaelson [illegible]

02-001C(12/80)

MEMORANDUM (Brief Communications)

State of Alaska

TO:	Name	Dept./Div./Sect.	Mail Stop
FROM:	Name	Dept./Div./Sect.	Telephone
SUBJ.:			Date 1/31/85

02-001C(12/80)