Arctic Development

Feasibility Of Creation Of A New Population Of Sea-run Arctic Char Near Inugsuin Fiord, Baffin Island, N.w.t.
Catalogue Number: 3-25-12

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1.) ᖃᐅᔨᓴᐃᐸᓪᓗᑎᒃ ᐃᒪᐅᑉ ᓴᖅᐅᓂᖓᓂᒃ ᑐᓗᖅᑕᕆᑕᐅᔪᓂᒃ ᐊᓪᒪᓗ ᐊᑐᓕᖁᔭᓕᐅᕆᒪᐸᓪᓗᑎᒃ ᐃᖃᓗᐃᑦ ᑐᓗᖅᑕᕆᑎᒥᔪᓐᓃᓐᓂᐊᖅᑕᕆᓐᓂᒃ ᒪᔪᖅᐸᓪᓕᐊᒃᔪᑎᒥᔪᓐᓇᖅᑕᕆᓐᓂᒃ;

2.) ᖃᐅᔨᓴᐃᐸᓪᓗᑎᒃ ᒪᔪᖅᐸᓪᓕᐊᓇᔭᖅᐸᑕ ᑕᒪᓐᓇ ᓈᓪᒪᒃᑯᓯᐊᖅᓱᓂᒃ ᑕᓇᐅᕆᐅᑕᓄᑦ ᐃᖃᓗᖕᓄᑦ.

ᐃᓯᒪᔫᑦ ᓴᖅᐅᓂᐅᔪᑉ ᖃᓂᖓ ᑰᒥ ᑕᐃᑳᓂᓚᐅᕐᐸᑦ, ᑕᓇᐅᕆᐅᑕᐃᑦ ᐃᖃᓗᐃᑦ ᒪᔪᕆᓐᓇᓱᐊᖅᓯᕆᓐᓂᒃ ᐊᓪᒪ ᑯᓪᓗ ᑕᓯᕐᒎᐊᖅᑲᖅᑕᕆᓐᓇᓱᐊᖅᓯᕆᓂᒃ ᐃᓯᒪᒋᔭᐅᔫᑦ. ᒥᑭᖅᑑᑕᐅᔪᑦ ᓴᖅᐅᓃᑦ ᐃᒪᐃᑦ ᑰᐱᓪᔪᐊᖅᐸᖅᑐᓂ ᑰᕐᒥ ᐊᑎᖅᑎᐊᖓᓂ ᖃᔮᑉ ᑕᓯᖓᑕ ᒪᔪᕆᕝᔪᑕᐅᖅᑲᖅᑕᖅᐳᑦ ᒪᔪᕆᓇᖅᓴᖅᑑᓚᓗᐊᓄᑦ.

ᑯᑦᑐᑉ ᑕᓯᖓ, ᐊᕆᓂᖅᑲᖅᑐᖅ 6 ᑭᓛᑕ ᖃᓂᒋᔭᖓᓂ, ᐃᓯᒪᓐᓇᖅᐳᖅ ᓇᔪᖅᑕᐅᔪᓇᖅᑎᐊᓴᐊᒃ-ᓴᖓᓂᒃ ᑕᓇᐅᕆᐅᑕᓄᑦ ᐃᖃᓗᖕᓄᑦ. ᑕᒪᐃᓐᓂᖅᑲᔭᖅ ᑕᓯᖅ ᐃᑎᓂᖓ ᐃᖃᓗᐊᕆᓪᒪᑦ ᐃᖃᓗᖕᓄᑦ ᓇᔪᖅ-ᑕᐅᔪᒥᓇᖅᐳᖅ ᐅᑭᐅᓗᒃᑖᖅ ᐊᓪᒪ ᐃᒪᐅᑉ ᓯᓈ ᑐᐊᐸᖅᑯᖅᑎᐊᖅᐳᓂ ᐅᔭᕋᓯᒃᔪᖃᐅᖅᐳᓂᓗ; ᑕᓯᖅ ᒫᓐᓇ ᑕᓇᐅᕆᐅᑕᐅᕆᖅᑐᓂᒃ ᐃᖃᓗᒃᑲᖅᐳᖅ. ᐃᓐᓇᕈᐊᓂᕆᖅᑐᑦ ᑕᓇᐅᕆᐅᑕᐃᑦ ᐊᒥᓲᓚᐅᖅᐳᑦ ᓯᐅᔭᐅᓂᐅᔪᓂ ᐋᓪᓯ ᐊᑐᓇᐊᓕᒃᓴᖅᑎᖅᑐᒍ 1992.

ᐃᖃᓗᖕᓄᑦ ᒪᔪᕈᑕᐅᔪᓐᓇᕆᓐᓂᐅᔪᖅ ᐃᓄᒃᓯᐃᑦ ᑰᖓᓂ ᖃᓂᒋᔭᖓᓃᖅᐳᖅ 190 m-ᖁᔪᑉ ᓴᖅ-ᐅᓕᓇᐊᖅᐱᖓᓂᑦ ᑯᖁᔪᑉ. ᒪᕐᕈᖕᓂᒃ ᓴᖅᐅᕆᓐᓇᐅᓯᖅᑑᖕᓂᒃ ᐱᑕᖃᖅᒪᑦ. ᐊᖅᑎᖕᓂᖅᓴᐅᔪᒦᖅᑐᖅ ᐊᓪᓗᖅ ᐃᕆᖅᑭᔪᒥᒃ 0.75 m-ᒥᒃ ᖁᖅᑎᖕᓂᖅᓴᐅᔪᖅ ᐳᖅᑐᓂᖃᖅᑎᖅᑐᒍ 3.2 m-ᒥᒃ. ᓴᓂᕋᖃᖅᔪᒃᐳᒃ ᓴᖅᐅᓂᐅᔪᒃ 13.0 m-ᒥᒃ ᐊᕆᓂᖅᑲᖅᑐᒥᒃ. ᓴᖅᐅᓂᐅᔪᑦ ᓴᖅᑭᖅᑕᐅᕚᑉᐳᑦ ᑰᒃ ᐃᕆᖅᑭᕙᕆᐊᖅᑎᖅᑐᒍ ᑯᑉ ᓇᑎᖓᓄᑦ ᑎᑭᐸᖅᐸᓪᓕᐊᓂᐅᔪᒥᑦ.

ᐊᑕᐅᓯᐅᕆᖅᑐᖅ ᐱᓕᕆᐊᖑᓗᓂ ᑕᓇᐅᕆᐅᑕᓄᑦ ᐃᖃᓗᖕᓄᑦ ᐃᕆᖅᑭᒃᔪᑕᐅᔪᓐᓇᖅᐳᖅ ᖄᕆᖅᓯᒃᔪᑕ-ᐅᓗᓂ ᓴᑕᖅᐅᓂᐅᔪᓄᑦ. ᐅᑯᐊ ᐃᓚᐅᔫᑦ:

1.) ᐲᔭᖅᑕᐅᓂᕆᑦ ᓴᖅᐅᓂᐅᔪᑦ ᖄᖅᑐᖅᐃᑦ ᐊᑐᖅᓗᒥᑦ ᐅᕙᓗᖅᓅᑦ ᐃᒪᖅᑯᑦ ᐊᑯᑉᓖᑦ;

2.) ᐃᖃᓗᐃᑦ ᒪᔪᖅᐅᑎᒃᓴᕆᑦ ᐋᖅᑭᒃᓯᖅᑕᐅᓗᑎᒃ ᐃᒪᖅᓂ ᓴᖅᐅᓂᐅᔪᓂ ᐊᓪᒪᓗ;

3.) ᐃᒪᐃᑦ ᓴᖅᐅᓂᐅᔪᑦ ᐃᔾᔪᖃᓂᒃ ᐃᓪᓕᓴᔪᓗᑎᒃ ᑐᐊᐸᕆᓪᓗ ᑭᓐᖓᓂᑦ ᖃᓂᖅᑐᓂᑦ.

ᑭᖁᓪᓕᖅᐸᖁᔪᖅ ᓈᓪᓚᖁᖅᑯᐱᒍᖅ ᖃᐅᔨᒪᔨᐅᔪᓂᒃ ᓇᓗᕆᖅᑐᓪᒪᓇᖕᓂᒃ ᐃᒪᓕᓇᓂᖅᑯᑦ ᐊᑐᕈᑕᐅᒥᐊᖅᑲᕆᓪᒪᑦ, ᓄᓇᖅᑐᑐᖅᑲᐃᑦ ᐱᓕᕆᐊᖅᑲᕈᓇᖅᓴᓪᒪᑕ ᓇᕆᓂᖅ ᐊᓪᒪ ᐋᖅᑭᐊᕈᑕᐅᔪᖅ ᑖᕗᖓᓕᒫᖅ ᐋᖅᑭᒃᑕᐅᓯᒪᓇ-ᔭᖅᐳᓂ ᐊᓯᒃᐸᓇᐊᖅᑲᕈᓐᓃᖅᑐᒍ. ᐃᓯᒪᔫᑦ ᐱᓕᕆᐊᖁᓇᔭᖅᐸᑦ ᑕᒪᓐᓇ ᒪᕈᖕᓂᒃ ᐊᐅᔫᓂᒃ ᐱᓕᓇ-ᐊᖁᓇᔭᖅᓂᖓᓂᒃ ᑲᕆᑐᓚᐱᖕᒥᐅᑕᐃᑦ ᐱᓕᓇᖅᑎᒥᔪᐅᓇᔭᖅᐳᑦ, ᐊᓪᓚᖅᑯᑦ ᓴᓇᕐᕈᑏᑦ ᐊᑐᖅᑕᐅᓗᑎᒃ ᐊᓪᒪ ᐱᖓᓯᓂᒃ ᓯᑕᒪᓂᓪᓗ ᐊᒃᓱᐊᓖᑦ ᓄᓇᓯᐅᑏᑦ. ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᑦ ᖃᓄᖅ ᐊᑭᖃᖅᓱᐊᖅᑎᒥᓇᓱᓇᐊᖅᓴᕆᓐᓂᒃ ᐃᒪᖅ ᐅᔾᔪᖃᓂᒃ ᐃᓪᓕᓯᖅᑕᐅᓇᔭᖅᐸᑦ ᐊᑭᓗᐃᖁᓇᔭᖅᓂᖓᓂᒃ ᖃᐅᔨᒪᔭᐅᓪᓗᐊᖅᑎᖅᑐᒍ.

SUMMARY

This report describes the results of a preliminary study to determine if it Is possible to establish a sea-run population of Arctic char in the Inugsuin River, near the southern tip of Inugsuin Fiord on northeastern Baffin Island. A waterfall is present near the mouth of the stream which prevents upstream movement of fish. If this blockage were not present the system could support a relatively large population of sea-run Arctic char. This would benefit the residents of the community of Clyde River, since populations of sea-run char are scarce in the region. Specific objectives of the study were:

1. to inspect the waterfall barriers and to make preliminary recommendations on ways to permit upstream fish passage; and

2. to survey upstream habitat to determine if it is suitable for sea-run Arctic char,

It was determined that, if the waterfall near the mouth of the river were not present, sea-run Arctic char could easily ascend the river and enter Kudloo Lake. Small waterfalls in the river farther upstream, immediately below Kyak Lake, would prevent further upstream movement.

Kudioo Lake, approximately 6 km^2 in area, appears to offer suitable habitat for sea-run Arctic char. Most of the lake is deep enough to support fish over the winter and shorelines contain large regions of gravel and boulders. The lake presently supports a population of landlocked Arctic char; juveniles were abundant in shoreline areas in early August 1992.

The block to upstream fish movement in the Inugsuin River is about 190 m from the estuaty of the stream. It actually consists of two waterfalls. The lowermost consists of a vertical drop of 0.75 m while the upper is approximately 3.2 m high. The falls are separated by a short shelf of 13.0 m. The falls are created as the river flows over a bedrock shelf.

A number of alternatives exist which wouid aiiow sea-run Arctic char to migrate past the faiis. These indude:

1. removal of the waterfalls through the use of explosives or chemicals;
2. construction of a fish iadder around the waterfaiis; and
3. fiiiing in the waterfalls with rinks and gravei from the nearby hillside.

The iast method appears to be the best alternative because it does not require iarge amounts of spedai knowledge, local residents couid perform most of the iabour and it is a permanent soiution. it is beiieved that the projeot oouid be performed over two construction seasons using iabour from Ciyde River, hand toois and AlVs. Aithough detaiied cost mmparisons were not prepared, crude estimates indicate that fiiiing in the waterfalls is by far the most eoonomicai soiution.

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INTRODUCTION

This report desoribes results of a preliminary study of a stream-lake system that enters the sea at the end of Inugsuin Fiord near the mmmunfty of Cfyde River on the northeast coast of Baffin island (Figure 1). A waterfafl is present in the stream which is a oomplete block to upstream movement of fish. Every year residents of Clyde River observe and sometimes harvest small number of sea-run Arctic char at the base of the waterfall where they concentrate. These fish are strays from other systems; sinoe the stream freezes to the bottom every winter, they either perish or move downstream and reenter the sea to searoh for a more suitable location to overwfnter. If the waterfall were not present, it is believed that this freshwater system oould support a healthy population of sea-run Arctic char. This would be extremely valuable to the residents of Clyde River, because sea-run char populations are scarce in the region and they are prized as a food fish.

The objectives of this study were:

1. to inspect the waterfall and to make preliminary recommendations on ways to permit upstream fish passage; and

2. to suwey upstream habitat to determine its suitability for colonizing sea-run Arctic char.

The following report describes results of a brief survey which was performed 9-13 August 1992.

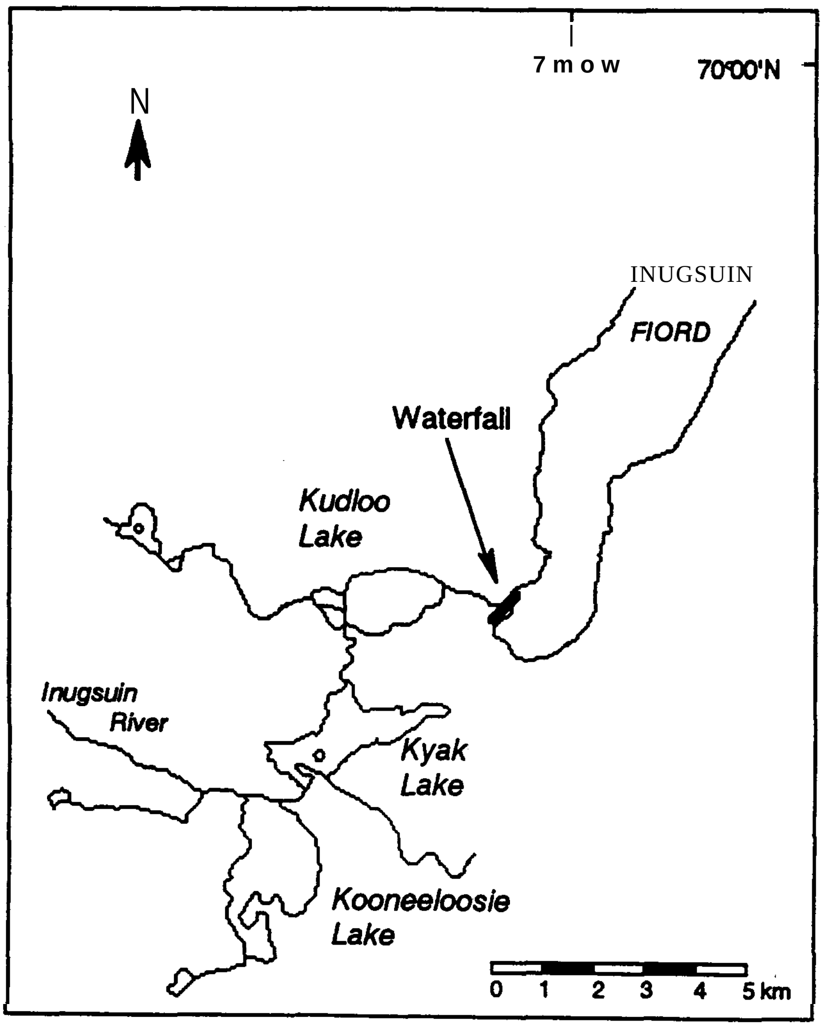

Figure 1. Inugsuin River drainage and location of the waterfall that blocks upstream fish migration.

RESULTS

The drainage under study covers approximately 150 km^2. The main stream draining the region is the inugsuin River which empties four substantial lakes —Kudloo, Kyak, and Kooneeioosie and one iarge unnamed iake in the uppermost part of the drainage (not shown in Figure 1). Fiow in the headwater region is primariiy eastward, then northward through the three iakes and again eastward as the Inugsuin River empties into the southern tip of inugsuin Fiord. Stream and lake habitat was surveyed 10-12 August. At that time Kudioo and Kyak iakes were ice free, but Kooneeioosie Lake was still about 60% ice covered.

Habitat Survevs

Inugsuin River

The iower portions of inugsuin River were divided into nine reaohes (Figure 2) baaed primarily on oharacteristios of fiow and substrate (Tables 1 and 2).

The first reach extends upstream about 180 m from the sea to the base of the iarge pooi immediately beiow a waterfaii (Plates 1 and 2). Fiow within this reach is mostly riffies and rapids over large cobbles and small bouiders.

Reach 2 is a short section composed of two waterfalls with poois at the base of each. This reach is desoribed in more detaii in subsequent sections of this report (see Piates 13-16).

Reach 3 consists of a wide, relatively fiat U-shaped valley with a corresponding wide streambe&about 135 m wetted width at Point Sample Site 2. Fiow in this region is generally riffies, although numerous smaii poois and eddies are created by the iarge cobbie substrate.

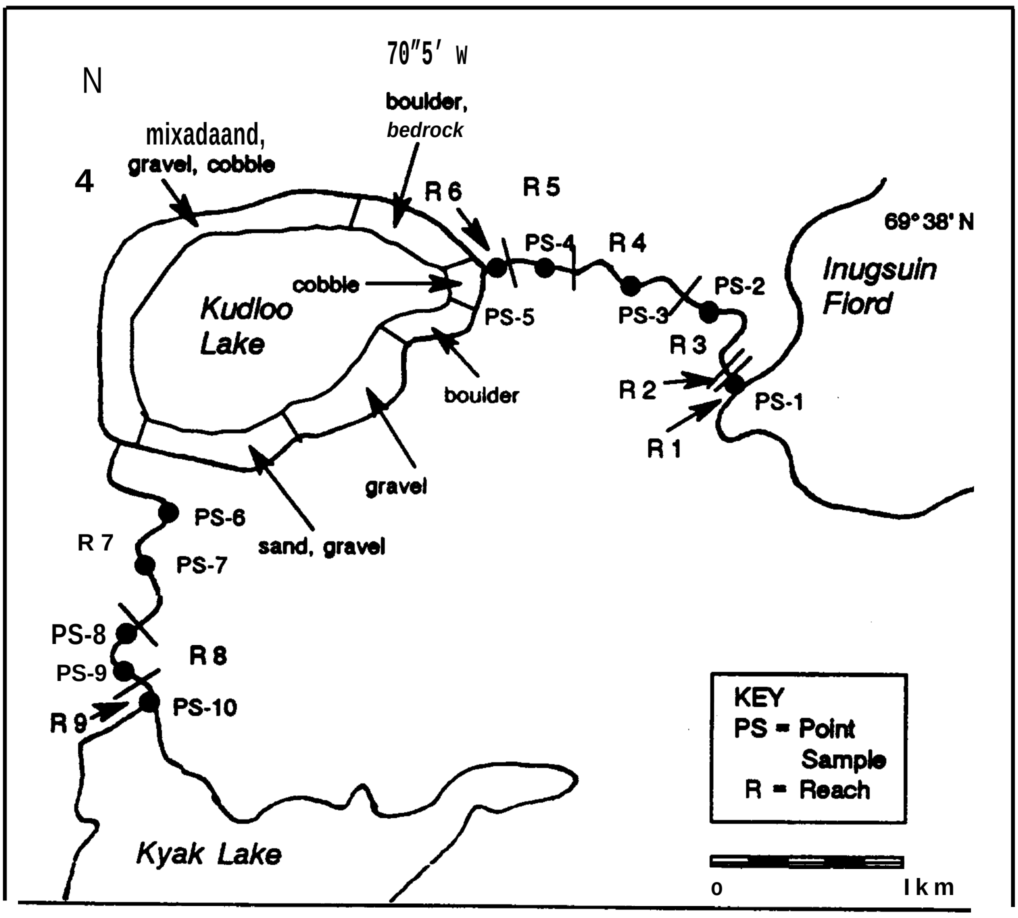

Figure 2. Location of reaches and point sampie sites in the Inugsuin River and composition of the shoreline of Kudloo Lake,

Table 1. Characteristics of Inugsuin River, northeastern Baffin Island, N.W.T., 10-12 August 1992. See Figure 2 for locations of reaches and point sample sites

Reach	**Point Sample Site**	**Stream Width (m)**	**Mean Water Depth (m)**	**Water Clarity**	**Flow Character**	**Substrate**			**Banks**	
						Composition	Shape	Compaction	Composition	Stability
1	1	15	1.0	Clear	Rolling/ broken	Cobble w/some boulder	Rounded	Loose	Cobble and boulder	Unstable
2	-	15	1.0	Clear	Waterfall/ chutes	Bedrock/ boulder	Smooth	Hard	Mostly bedrock	Stable
3	2	135	0.8	Clear	Rolling	Cobble	Rounded	Medium	Boulder-cobble w/some gravel and tundra	Mostly stable
4	3	45	1.2	Clear	Swirling	Cobble/gravel w/some boulder	Rounded	Loose	Glacial till	Unstable
5	4	55	0.8	Clear	Broken riffles	Cobble w/some boulder	Rounded	Loose	Cobble	Unstable
6	5	130	1.5	Clear	Placid	Gravel w/ cobble & fines	Rounded	Loose	Cobble/gravel	Unstable
7	6	35	1.5	Clear	Placid/ swirling	Cobble & gravel	Rounded	Loose	Glacial till	Unstable
7	7	85	0.5	Clear	Pool & riffles	Cobble	Rounded	Loose	Cobble & gravel	Unstable
8	8	35	1.0	Clear	Tumbling	Boulders	Angular	Hard	Boulders/ bedrock	Stable
9	9	15	0.6	Clear	High velocity chutes, waterfalls	Bedrock	Smooth	Hard	Bedrock	Stable
10	10	30	1.0	Clear	Swirling	Cobble	Rounded	Medium	Cobble/ boulder	Stable

Table 2. Summary of reach characteristics of Inugsuin River.

Reach	Percentage Pools	Flow	Stream Channel and Banks	Stream Valley	Fish Blocks
1	< 5	Riffles and rapid	Unstable	Low, nearly absent	Absent
2	10	Waterfalls chutes	Stable bedrock	Bedrock walls	Present - 2 waterfalls
3	10	Riffles and minor rapids	Low, mostly stable	Broad U-shaped	Absent
4	50	Pools and riffles	Mostly unstable	Incised valley	Absent
5	< 5	Riffles	Unstable	U-shaped	Absent
6	90	Placid w/ minor riffles	Unstable	Nearly absent	Absent
7	0	Mostly riffles w/some pools	Unstable	Mostly broad U-shaped	Absent
	< 5	Tumbling with chutes and small falls	Stable bedrock	V-shaped	
		Placid with some riffles	Mostly stable cobble	Nearly absent	

Reach 4 Is characterised by the presence of approximately 6-8 large pools separated by riffles (Plates 3 and 4). These pools would form excelient resting areas for upstream-migrating fish. The region is contained within high valley walls of giaciai till.

Reach 5 is entirely riffles fiowing over a bouider-cobble shelf (Piate 4).

Reach 6 is a short, well-deveioped pooi region which contains large areas of calm water (Plate 4), This area is separated from Kudloo Lake by a short section of riffies.

Reach 7 is an approximately 2.0 km iong section of stream immediately above Kudloo Lake. The stream in this area is relatively wide; flow is mainly riffles but a small number of poois are distributed throughout the region.

Reach 8 is a high velocity section of stream which fiows over broken and smooth bedrock and large bouiders. Severai smail waterfalls up to 1.0–1.5 m high are present (Piate 5) and a number of chutes aiso occur in the region (Piate 6). This area is considered as a biock to upstream fish passage.

Reach 9 is a short section of stream which drains Kyak Lake. Flow in this area varies from placid near Kyak Lake to swiriing riffles in iower sections, Substrate is primariiy large cobbies and bouiders,

Kudloo Lake

The lowermost lake in the inugsuin River drainage is Kudloo Lake, with a surface area of approximately 6 km^2 (Plate 7). It is roughly circular in shape with a slightly longer east-west axis (Figure 2). An extensive alluvial fan borders the northwestern shore of the iake whiie bedrock outcrops are common along the eastern shores. Land along the southern shore is moderate in relief, containing areas of broken rock and iow-iying areas of mixed giacial tili.

Common types of substrate in the shallow water margins of Kudioo Lake are shown in Figure 2. Shorelines, in large part, reflect composition of the adjacent lands, as described above. Relatively extensive sandy shorelines are present along the southwestern portion of the lake (Plate 8) with submerged areas being mostly composed of gravel (Plate 9). Rubble is also mmmon in shallow water areas, especially along eastern shores (Plates 10 and 11).

Kudloo Lake appears to offer excellent habitat for Arctic char. Suitable char spawning and overwintering habitats undoubtedly exist, as verified by sightings of numerous juvenile char in shallow water shoreline areas and capture of several char during periods of angling (Plate 12). Char present in Kudloo Lake are a resident, land -locked population typical of numerous lakes in the region.

Kyak Lake and Upstream Areas

Due to the presence of fish blocks in the inugsuin River a short distance below Kyak Lake, detailed habitat surveys were not performed in upper areas of the Inugsuin River drainage. Kyak Lake and Kooneeloosie Lake were briefiy inspected. Fish habitat is present in both lakes, as evidenced by the presence of landlocked populations of Arctic char.

Waterfalls and Fish Blocks

The primary fish blocks under study are located a short distance from the sea-less than 190 m above the mouth of the stream (Figure 3; Plate 13). This region contains two areas which are considered blocks to fish passage (Plates 14 and 15). The lowermost is a small waterfall (vertical drop of approximately 0.75 m) above which is a short (4.0 m) high gradient chute (Plate 15), The upper waterfall is approximately 3.2 m high, Including a shott chute at the top of the fails (Plate 15). The falls are separated by a 13 m low-gradient shelf. A large pool about 35 m long is present immediate-

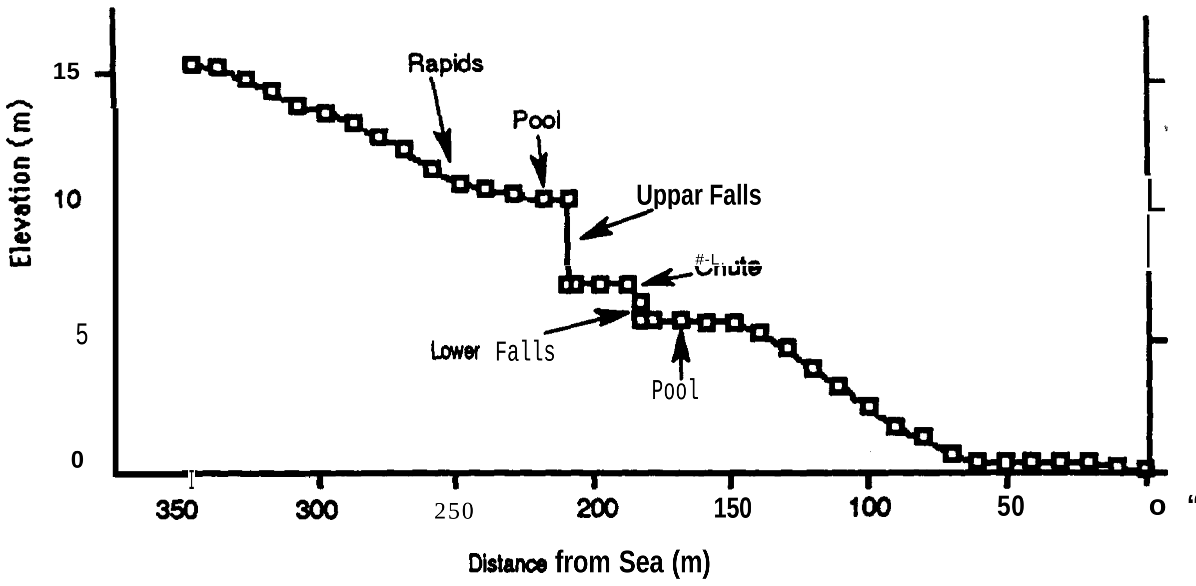

Figure 3. Profiie of the iower 360 m of the Inugsuin River. Measurements were taken with a sight ievei at 10 m intervals. Shorter intervals were used in the region of waterfalls.

iy beiow the iower fails (Piate 14 and 15) and another, relatively cairn-water area about 35 m in iength is present above the upper faiis (Piate 16). immediately above this area is a short region of chutes and rapids which are considered moderate hindrances but not biookages to upstream fish movement (Piate 16).

The above fish biooks are oreated as the river fiows over bedrock ledges. These have been exposed in the immediate area by stream fiow over a iong period of time. Deposits of giadai tiii overlay the bedrock in the immediate vicinity of the water-falls and form high banks on the north side of the stream above the faiis (Piate 16).

The other major fish biock in the inugsuin River drainage are a short distance beiow Kyak Lake (Piates 5 and 6). This area of about 0.5 km contains numerous smaii waterfalls and high-velocity chutes. The waterfalls, although small, are thought to be complete blocks to upstream movement of Arctic char, In addition to these problems, flow in the Inugsuin River in one area of this region is entirely beneath the surface of a cobble field during periods of low flow (Qillaq, personal observations). Extensive work , would have to be performed at several sites in order to permit fish passage through this region. Such works are considered beyond the scope of present consideration.

Conclusions

1. Waterfalls in the lower portion of the Inugsuin River are complete blocks to fish movement.

2. Fish habitat in Kudloo Lake is believed to be excellent for Arctic char as evidenced by the presence of numerous land-locked char inhabiting the lake, its depth and substrate characteristics.

3. If the fish blocks in the lower portion of Inugsuin River were removed or bypassed, Kudloo Lake would be available for colonization by sea-run Arctic char; further upstream movement would be limited by fish blocks a short distance below Kyak Lake,

5. Since sea-run char are present at the base of the waterfall every year in late summer, colonization of Kudloo Lake would be quite rapid.

6. It is realised that, if sea-run char successfully colonized Kudloo Lake, it would be several years before a substantial population developed, because of the slow growth rates and late maturation of char in the Arctic.

METHODS FOR BARRIER REMOVAL

Several methods exist for removal or bypass of the fish blocks in the lower Inugsuin Riven These are briefiy discussed in the foiiowingmateriai.

Removal of Bedrock Ledges

The bedrock iedges that create thewaterfaiis might be removed with expiosive charges ormoresiowiy with Expan-DEX. Both of these methods require driiiing into soiid bedrook and removai of iarge amounts of rock. Hydroiogy of the stream wouid be affected, iikeiy produoing more sever rapids and chutes immediately above the major waterfaii. (The iatter region is presentiy an area of high water veioocities.) A number of biasts wouid probabiy be necessary to ensure fish passage.

Use of expanding chemicais wouid be much siower and might not be feasibie, due to the iarge amount of rock that must be moved, as weii as the unknown efficiency of the method in this partiouiar type of rock and environment. Use of Expan-DEX requires driiiing hoies in the bedrock and filling them with the ohemioai. Under ideai conditions, the ohemioai expands and fractures the rock within severai hours. This method was tried but found to be unsuitable in NWT soapstone quarries, possibiy due to ooid temperatures.

Fishwavs

Based on preliminary conversations with Department of Fisheries and Ooeans personnei, a fishway couid be buiit around the waterfalls. Severai alternative designs for fishways exist, and various construction materiais couid be used, inciuding ooncrete, steei, aiuminum, wood, naturai substrates or combinations of such materiais.

Because of the diffiouity of working in bedrock, it was suggested that a "flume" type of fishway would be most easiiy constructed. Suoh a fishway wouid oonsist of a series of raised connected troughs mounted on steei supports which are anohored into the bedrock. Entranoes and exits of the fishway would have to be carefully plaoed to facilitate fish movement, and to ensure proper water flow through the passage. The entire structure would have to be drained in early winter to prevent damage by ice. Entrance and exit areas would also have to have protection from ioe damage. A , considerable amount of knowledge of seasonal fluctuations in water level would also have to be obtained to ensure proper flows in the fishways.

Filling

Another method which would eliminate the waterfalls is to simply fill in the streambed with material from adjaoent banks. This remedy might be feasible because large amounts of unconsolidated sand, gravel, cobble and larger boulders are available from the northern bank of the stream immediately adjacent to and above the major waterfall.

RECOMMENDATIONS

Table 3 lists known advantages and disadvantages of each method that oould be used to eliminate the fish block(s) on the lower Inugsuin River. It is apparent that a number of potential solutions exist, but it appears that filling in the waterfall is the preferable alternative, because:

1, it relies on relatively little technicai expertise;

2. it is a permanent solution;

3. little, if any, mafntenanoe would be required;

4. it is an acceptable method to the community; and

5, it would offer more employment opportunities for local residents than most other alternatives,

Based on measurements obtained in this study, fill would have to be placed over a horizontal distanoe of about 60 m in a wedge-shaped configuration. The upstream base of the wedge would be siightly over 3.0 m thick. Thickness would graduafly deorease until the region of the lower falls was encountered, when fill would have to be approximately 2.0 m thick. Fill would extend into the lower pool for about 20 m. This configuration would maintain a moderate gradient of about 8% over the iength of the filled area. The actual surface of the filled area would have to be oomposed of iarge rooks and boulders, carefuily placed in order to oreate a series of Pod/rapid areas which ohar could easily ascend. The surface wouid in effeot be a fishway composed of natural rock piaced in a zig-zag fashion over the naturai waterfall.

Width of the chasm that requires filling averages approximately 10 m. Estimates of the total amount of fill necessary vary from 950 m^3 to 1330 m^3, depending on exaot depth of fill required at specific locations. This volume of material oould be deiivered by, for example:

Table 3. Advantages and disadvantages of alternative methods to eliminate fish blocks in the lower Inugsuin River.

Method	Advantages	Disadvantages
Explosives	- Permanent sdutbn - Project possibly accomplished in one season - Short-term funding requirements	- Size of waterfalls necesattatea "major" btasts ' - Signifbarrt redudbn in height of upper ledge could affect stream hydrology and create additional fish blocks immediately upstream - Work could proceed "in the dry" oniy in the late winter/ earty aprtng period, mid-Aprti to mid-May - Use of rock driifa in remote regions - Moderate level of experience required - Fish movements after completion of prqect moderately difficuit to monitor - Method not favoured by community residents
Expansion chemicals	- Permanent solution - No community resistance to concept - Large community involvement - Relatively short teim funding require-ments if method proves efficient	- Effiaency of technique difficult to assess - Most suited to smaiier projects - Couid affect stream hydrology - Use of rock drills in remote region - Fish movements after completion of projed moderately difficult to monitor
Ffshways	- Effectiveness easily monitored - No effect on upstream hydrdogy - No community resistance to concept	- Relatively high level of expertise required—hydrology, engineering, fisheries biology - Woukt require annual maintenance and placement of sane components - System constructed of numerous units, ali of which must be property waridng for whole to be effective; chanoee of system faiiure great without oonstant monitoring - Constant expense due to instaiiatfon requirements, ioss, breakdown, of components etc. - Extreme difficulty in obtaining iong-term funding commitments
Fill	- Permanent solution - Favoured by community residents - Woutd not negatively affect upstream hydrdogy, could be beneficial - Relatively bw amounts of expertise " required - Large employment possibilities for comm-unity residents - Mechanical equipment requirements min-imal; afi equipment on site regularly repair-ed by residents - Large amounts of fiii available in adjacent afiuvfai rktga - Work could proceed in the open-water period Juiy-September - Short-term funding requirements	- May require 2 seasons of work - Effectiveness moderately diffbuif to monitor - Surfece of fiii would have to be composed of large rocks to prevent erosbn

1. 100 loads from a large dump truck;
2. 650 loads from a large front-end loader; or
3. about 2,000 loads from a small trailer pulled by an ATV.

Since it may not be possible to get heavy equipment to the study site, hand tools, ATVS and small trailers might be the most efficient method of moving materials, It is believed that the majority of the material could be moved in one season of about 50 working days. This would entail moving about 20 m^3 of material per day for which a relatively large work foroe would be required. Fine material would have to be placed in sandbags to prevent erosion, and sandbags would have to be proteoted with cobbles and boulders.

A seoond season of work would be necessary to allow for settling of material over one annual oycle and careful placement of the final surface material to ensure fish passage.

Although formal cost comparisons have not been prepared, crude estimates indicate that filling in the waterfall is by far the most economioai solution.

PLATEs

ᐊᔾᔩᑦ

Plate 1. Rapids and riffles **in Reach 1.**

ᐊᒃᔨ 1 . ᑰᒐᓛᖅᓃᑦ ᐊᒻᒪ ᐃᒃᒋᖅᓴᓂᐅᔪᑦ ᓈᑦ 1 -ᒥ.

Plate 2. Lower seotlon of Reach 1 as it empties into Inugsuin Fiord.

ᐊᒃᔨ 2. ᐊᑎᖖᖕᒍ ᓈᑦ 1 ᐃᒪᐃᔮᖅᐸᖕᓂᐊᑎᖕᓄᒍ ᐃᓄᒃᓯᐃᑦ ᕕᔪᐊᑦᔪᑦ.

Plate 3. A pool, riffle area **in Reach 4.**

ᐊᔾᔨ **3.** ᐃᒪᕐᓯᒃ , **A** ᓯᑦᕋᓂᐅᔪᒥ ᓈᑦ **4-ᒥ.**

Plate 4. Upstream **end of Reach 4 (foreground) with Reach 5 in centre of picture, Kudloo Lake is in background and** Reach 6 is Immediately below Kudloo Lake.

ᐊᔾᔨ 4. ᒪᔪᕐᕋᑉᐱᐅᓂᐅᔪᑦ ᐃᓱᖓ ᓈᑦ 4-ᒥ (ᓯᕗᓂᐊᓂ) ᓈᑦ 5 ᕿᑎᐊᓂ ᐊᔾᔨᐅᑉ. ᑯᓪᓗᒃ ᑕᓯᖅ ᑐᓄᐊᓃᑉᐳᖅ ᐊᒻᒪ ᓈᑦ 6 ᐊᑎᑦᑎᐊᖑᓃᑦᑐᖅ ᑯᓪᓘᑉ ᑕᓯᐅᑉ.

Plate5. Waterfalls in Reach 8.

ᐊᒃᕿ 5. ᐃᒪᖅ ᓴᕐᕿᐅᓂᐅᔪᖅ ᐲᑉ 8-ᒥ.

Plate 6. Bedrock and rapids in Reach 8 with a high velocity chute in background.

ᐊᒃᕿ 6, ᐃᒪᐅᑉ ᐱ ᒃᓂ ᒃᑲ ᓇ ᑎ ᒃᑲ ᑰᕙᓛᒃᑐᒥ ᐲᑉ 8-ᒥ ᑐᓄᐊᓂ ᑕ ᑯᖅᐅᐳᖅ ᓯᑲᔪᒥᒃ ᐃ ᕐᕿᕆᓂ ᐅ ᔪᖅ.

Plate7. Southwestern portion of Kudloo Lake.

ᐊᔾᔨ 7. ᓂᒡᒋᖅᐸᓯᖕᖓ ᑯᖅᓗ ᑕᓯᐅᖅ.

Plate8. Low-lying southwestern shore of Kudloo Lake.

ᐊᔾᔨ 8. ᖁᓪᓕᓯᕐᒋᓐᓂᓇᕐᖓ ᓂᒡᒋᖅᐸᓯᖕᖓᓂ ᓯᒡᔭᒥ ᑯᖅᓗ ᑕᓯᖕᖓᑕ .

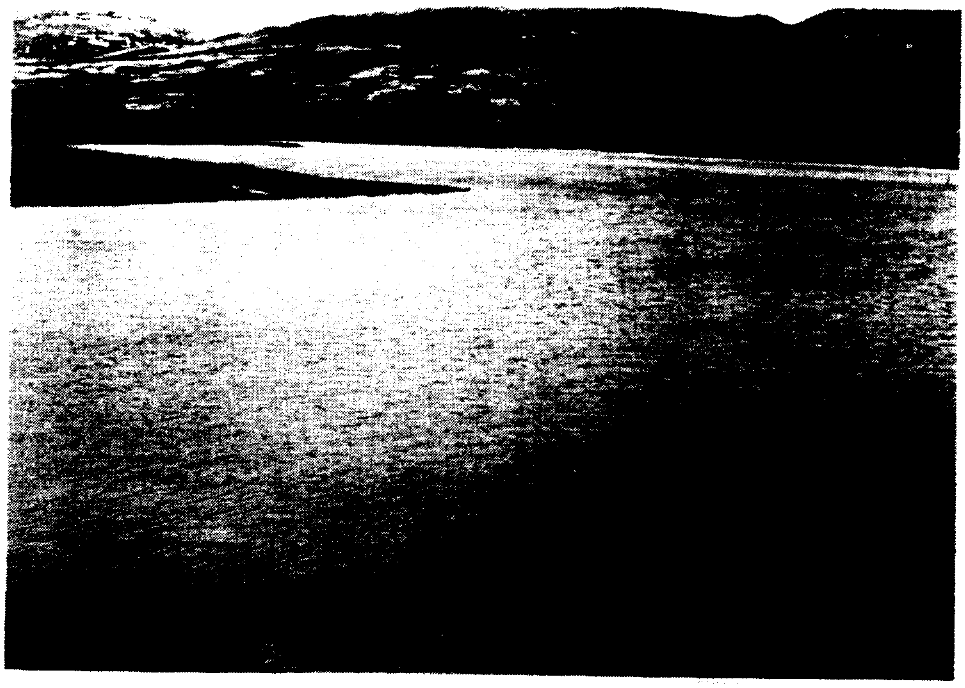

Plate 9. Gravel substrates of Kudloo Lake,

ᐊᔾᔨ 9. ᑐᐊᐸᔮᖓ ᑯᑦᓗ ᑕᓯᖓᑕ .

Plate IO. Rubble substrates of Kudloo Lake.

ᐊᔾᔨ 10. B+ ᕿᖃᐅᖅᓂᖓ ᑲᑎᒪᐅᖅᑐᓂᒃ ᑯᑦᓗ ᑕᓯᖓᑕ .

Plate 11. Broken bedrook along the southeastern shore of Kudloo Lake. Outlet of the lake is in background.

ᐊᔾᔨ 11. ᓯᖁᑉᑎᖅᓯᒪᓂᐅᔪᖅ ᐃᒡᓕᖓ ᓂᒡᒋᖅᐸᓯᖓᓂ ᑯᑦᓗ ᑕᓯᐅᑉ. ᐊᓂᕚᓪᓚᐊᖅᐱᖓ ᑕᑯᒃᓴᐅᕗᖅ ᐊᑭᐊᓂ ᑕᓯᐅᑉ.

Plate 12. Typical landlocked Arctic char from Kudloo Lake,

ᐊᔾᔨ 12. ᑕᓇᐅᕐᒥᐅᑕᐅᖏᑦᑐᑦ ᐃᖃᓗᐃᑦ ᑯᑦᓗ ᑕᓯᖓᓂᑦ .

Plate 13. Lowermost portion oflnugsuin River. inugsuin Fiord isin background and the waterfalls area is in the foreground.

ᐊᔾᔨ 13. ᐊᑦᑎᖕᓂᖅᐸᓯᖓ ᐃᓄᒃᓯᐃᑦ ᑰᖓᑕ. ᐃᓄᒃᓯᐃᑦ ᐱᔪᐊᑦ ᐊᑭᐊᓃᑉᐳᖅ ᐊᒻᒪ ᐃᒪᐅᑉ ᓴᑉᕙᐅᓂᖓ ᓯᕗᓂᐊᓃᑉᐳᖅ.

Plate 14. Waterfalls in Reach 2 of the inugsuin River. Note the iarge pooi at the base of the lower falls. Sea-run char collect in this region every autumn oniy to be stopped from further upstream movement by the waterfalls.

ᐊᔾᔨ 14. ᐃᒪᐅᑉ ᓴᑉᕙᐅᓂᖓ ᓵᑦ 2-ᒥ ᐃᓄᒃᓯᐃᑦ ᑰᖓᓂ. ᖃᐅᔨᓗᒍ ᐃᒪᕐᔪᓂᐅᔪᖅ ᐃᒪᐅᑉ ᓴᑉᕙ-ᐅᓂᐅᑉ ᐊᑎᒃᐸᓯᖕᓂᖓ. ᑕᓇᐅᕙᒥᐅᑕᐃᑦ ᐃᖃᓗᐃᑦ ᑕᒃᑲᓂ ᐅᑭᐊᒃᓵᑕᒪᑦ ᑕᒃᑯᖓ ᑲᑎᓯᖑᔪᑦ ᐅᖓᑎᒃᑲᓂᐊᓄᑦ ᒪᔪᕆᓇᐃᖅᑲᖅᑐᑎᒃ ᐃᒪᐅᑉ ᓴᑉᕙᐅᕙᖅᑲᐊᓂᖓᓄᑦ ᓄᕐᑲᑎᑕᐅᖅᑐᑎᒃ.

Plate 15. Close-up ofwaterfalls in Reaoh20f theInugsuin River.

ᐊᒃᐱ 15. ᐅᒃᑯᐊᕐᑕᐅᓂᖓ ᐃᒪᐅᑉ ᓴᕐᕙᐅᓂᖓᑕ ᕿᒃ 2-ᒥ ᐃᓄᒃᓯᐃᕐ ᑰᖓᓂ.

Plate 16. Pool and rapids above the major waterfall in Reaoh 2 of the Inugsuin River.

ᐊᒃᐱ 16. ᐃᒪᕐᓯᒃ ᑰᓚᓛᕐᓗ ᐃᒪᒥ ᓴᕐᕙᐅᓂᐅᔪᒥ ᕿᕐ z-r ᐃᓄᒃᓯᐃᕐ ᑰᖓᓂ.