

ISKUT HOVERCRAFT / FISHERIES SCIENTIFIC REVIEW

PRELIMINARY REPORT

prepared for

**Cominco Ltd.
and
Department of Fisheries and Oceans
Vancouver, British Columbia**

by

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1.0 INTRODUCTION

1.1 Background

Cominco Ltd. has developed the Snip gold mine near the confluence of Bronson Creek and the Iskut River, a major tributary of the Stikine River in northwest British Columbia. In the absence of road access, Cominco has chosen to utilize a hovercraft or air cushion vehicle (ACV) to transport ore concentrate from the mine, and to resupply the minesite with fuel and other materials. The ACV travels along the Iskut River and lower Stikine River on its route between Bronson Creek and the marine port of Wrangell, Alaska (Figure 1).

Potential impacts of the ACV on fish and bird populations of the project area were assessed before the operation commenced in July, 1990 (D.F. Dickins Associates, 1990a and b). The ACV operation was also reviewed by Department of Fisheries and Oceans (DFO) under a federal Environmental Assessment and Review Process (EARP) Guidelines Order. In its screening decision in April, 1991, DFO concluded that potential fish habitat impacts of the ACV were mitigable. Since that decision, however, DFO has expressed concerns regarding the ACV operation, and has concluded that its original EARP review is no longer relevant. Subsequent studies by consultants to Cominco and by others have produced additional information relating to impacts of the ACV on the river environment and fish populations. As a result, Cominco and DFO are undertaking a joint scientific review of existing information on the ACV operation and its potential impact on Iskut River fish habitat.

1.2 Hovercraft Operations

The ACV used by Cominco is a diesel-powered AP.1-88 model that has been modified for freight transport. The vessel is 24 m long, weighs approximately 30 tonnes, and carries cargoes of up to 12 tonnes (Dickins et al. 1992). Cruising speed is typically 20 - 40 knots. The route along the lower Iskut River is approximately 50 km long, including a 40 km section between Bronson Creek and Johnson Creek where the river is highly braided in character. Total route length from Snip Mine to Wrangell is 116 km (Dickins et al. 1992). The craft operates between April and November each year, and generally makes two round trips daily between Snip and Wrangell. During certain periods, ore concentrate shipments are also

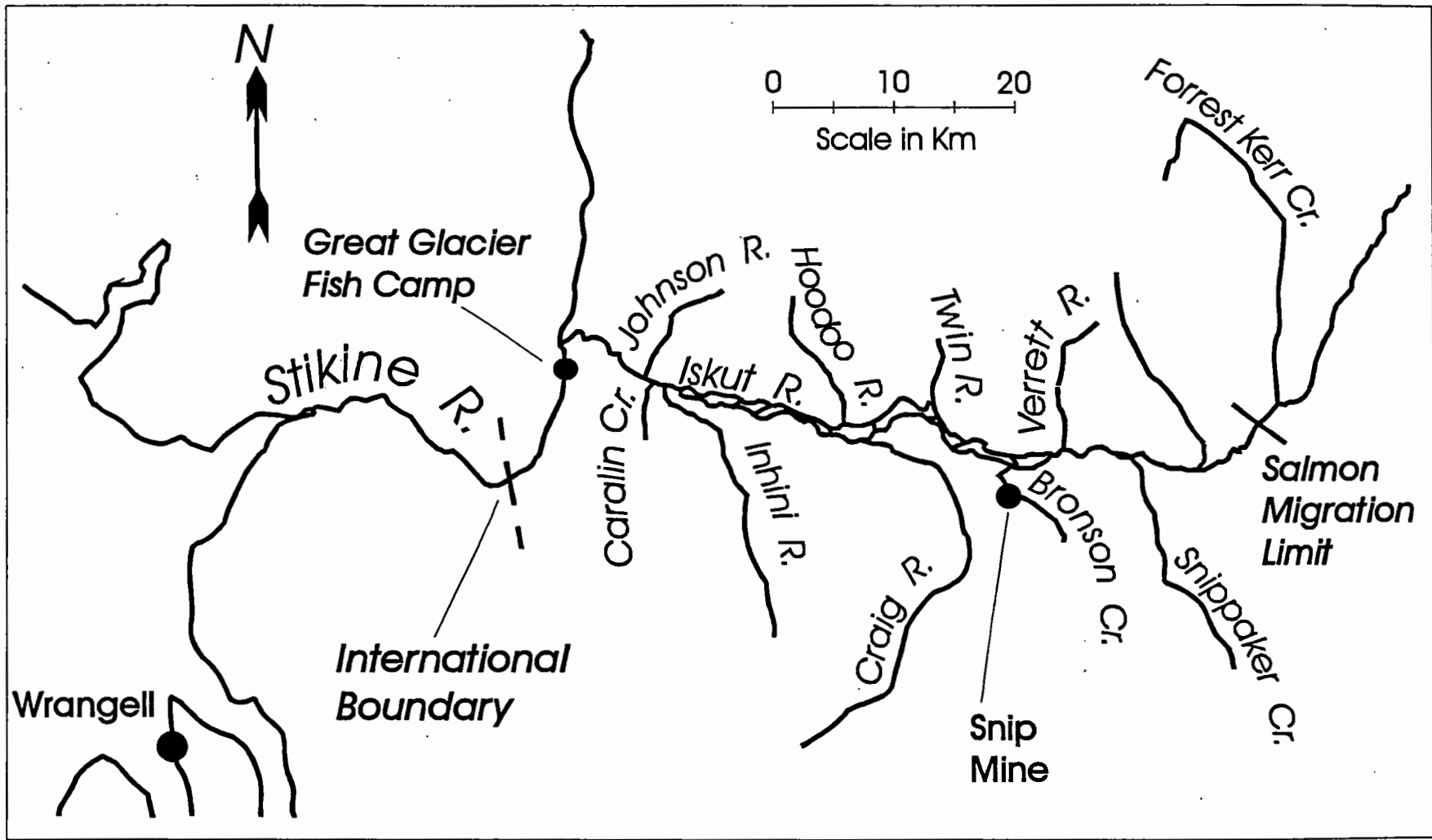


FIGURE 1. Map of the Iskut River study area, showing the Cominco hovercraft route between Snip Mine and Wrangell, Alaska.

unloaded at Great Glacier Fish Camp, just downstream of the Iskut-Stikine confluence, and transported by barge to Wrangell.

An ACV travels over various surfaces (land, water, ice or snow) on a cushion of air between the craft and the surface. The craft's weight is supported by an air cushion contained within a flexible skirt. Air pressure within the skirt is maintained by fans. As the ACV's weight is distributed over the entire air cushion area, downward pressure on the traveling surface is much less than exerted by a wheeled or tracked vehicle of similar weight. At full load, cushion pressure could reach 37 lb/ft^2 , compared to 450 lb/ft^2 for a 190 lb man in street shoes (Nixon, 1993). Forward thrust is provided by two stern-mounted propellers operating in shrouds.

At low to medium river levels on the Iskut, the ACV tends to travel in the main river channel. At high flow the main channel is less defined and the craft may use secondary channels to a greater extent. Over a portion of the route the ACV travels briefly over dry river bars and very shallow water. Detailed documentation in June, 1994, at a moderately high flow ($590 \text{ m}^3/\text{s}$), indicated that the ACV made contact with bars or shallows 9.3% of the travel time between Snip Mine and Great Glacier Fish Camp on the Stikine River (D.F. Dickins Associates, 1994).

1.3 Effects on the River Environment

ACV's have been observed to produce several types of physical impact that could have significance for fisheries resources. Observations at Iskut River have shown that the Cominco ACV generates 20 - 60 cm high waves (Hay & Company, 1995). Though the waves cause some erosion of river banks and bars (Sampson, 1994; Hay & Company, 1995), the principal concern is for erosion of steep, vegetated banks that could offer cover for rearing salmonid juveniles. ACV-generated wave action also results in suspended sediment pulses which could have local effects on rearing juvenile salmon and deposited salmon eggs.

ACV operation at Iskut River also requires periodic removal of log debris that can block or constrict major channels used by the craft. Log debris is removed by chain saw under low water conditions. Some of this debris removal activity has been reported to affect salmon spawning or rearing habitat within the influence of a debris jam (Sampson, 1994).

Passage of the ACV over shallow water on bars or side channels, and the resultant physical impact on rearing salmon juveniles, has also been raised as a concern (HMU-DFO, 1994). In such areas the craft may leave a shallow scar in the gravel bed, due to scarifying action of the skirt and pressurized air escaping from under the skirt. A potential for direct effects on adult salmon and their redds may also exist in relatively shallow areas contacted by the ACV.

1.4 Scientific Review

Continuing operation of an ACV on a river with anadromous salmonid populations is apparently without precedent. The uniqueness of the problem, and the size and glacial character of the Iskut and Stikine rivers, has made it difficult to assess the potential impacts of the ACV.

Observations of Cominco's ACV operation have led to concerns that it is adversely affecting fish habitat in the Iskut River. Cominco Ltd. and DFO have therefore agreed to conduct a joint scientific review of the ACV operation. The review is being conducted by one individual nominated by each party, and is to utilize available written information. The scope of the assignment includes the Iskut River, as that is the area considered to be most sensitive to the effects of the ACV. The primary objective of this review is to assess the extent, if any, to which operation of the ACV (CH-COM) may (1) constitute harmful alteration, destruction or disruption of fish habitat in the Iskut River, and (2) otherwise adversely affect fish in the Iskut River. Terms of Reference for this scientific review are included in Appendix A. A list of documents examined is presented in Appendix B.

2.0 SYSTEM DESCRIPTION

The Iskut River is a glacial river with a broad flood plain. A narrow bedrock canyon, 14 km upstream of Snip Mine and approximately 80 km from the mouth, acts as a barrier to salmon migration (Figure 1). Upstream from the Twin River confluence, the river has a dominant, relatively stable, main channel. Between Twin River and Johnson River, the Iskut occupies a broad valley with a well braided system of channels, gravel bars, islands and sloughs. Downstream of Johnson River, the Iskut is confined for approximately 5 km before broadening out in the 4 km section upstream of its confluence with the Stikine River.

The alluvial and organic deposits of the Iskut flood plain have created complex habitat for fish and wildlife. These deposits have been shaped by fluvial processes that do not include wave action (Gardiner, 1993; Sampson, 1994). The confluence of the Iskut and Stikine rivers is a particularly active area from the standpoint of river channel morphology (Gardiner, 1993).

The Iskut River is not navigable except by shallow draft jet boats or canoes. Natural variations in seasonal water levels are in the order of 1 - 1.5 m. The Iskut River hydrograph exhibits two annual periods of high flow (Figure 2). River discharge rises in May due to snow melt and stays high until late August. In some years, rain-on-snow events during fall can cause flood peaks that exceed the snow melt freshets.

The Iskut River continually transports sediment either in suspension or as bedload. The majority of the transport occurs during floods (Gardiner, 1993; Hay and Company, 1995). Sand is mainly carried as suspended load while gravels are moved as bedload. It is likely that reaches downstream of the canyon are accumulating sediment rather than being in an erosion/deposition equilibrium (Hay and Company, 1995). The Iskut exhibits dramatic course changes caused by deposited sediment or debris blocking channels on the falling leg of a flood. These changes occur after virtually every flood (Gardiner, 1993). At flood stage, velocity of the Iskut River at the mouth is reduced by Stikine River water levels and by fanning out over the delta. Significant silt deposition occurs at the river confluence during such periods (Sampson 1994).

3.0 FISH POPULATIONS

The Iskut River system supports the five Pacific salmon species, steelhead trout, mountain whitefish and a variety of non-salmonid fish species. Sockeye, coho and chinook are the dominant salmon species in the Iskut system. Pink and chum salmon are relatively rare. Salmon spawning in the Iskut River has been reported to occur mainly in side channels and at the confluences of clear water tributaries. Salmon may spawn along gravel bars or beaches with gentle slopes, but apparently seldom in the main channel where the river is deepest and fast flowing. Salmon juveniles have been observed in a variety of habitats, including the

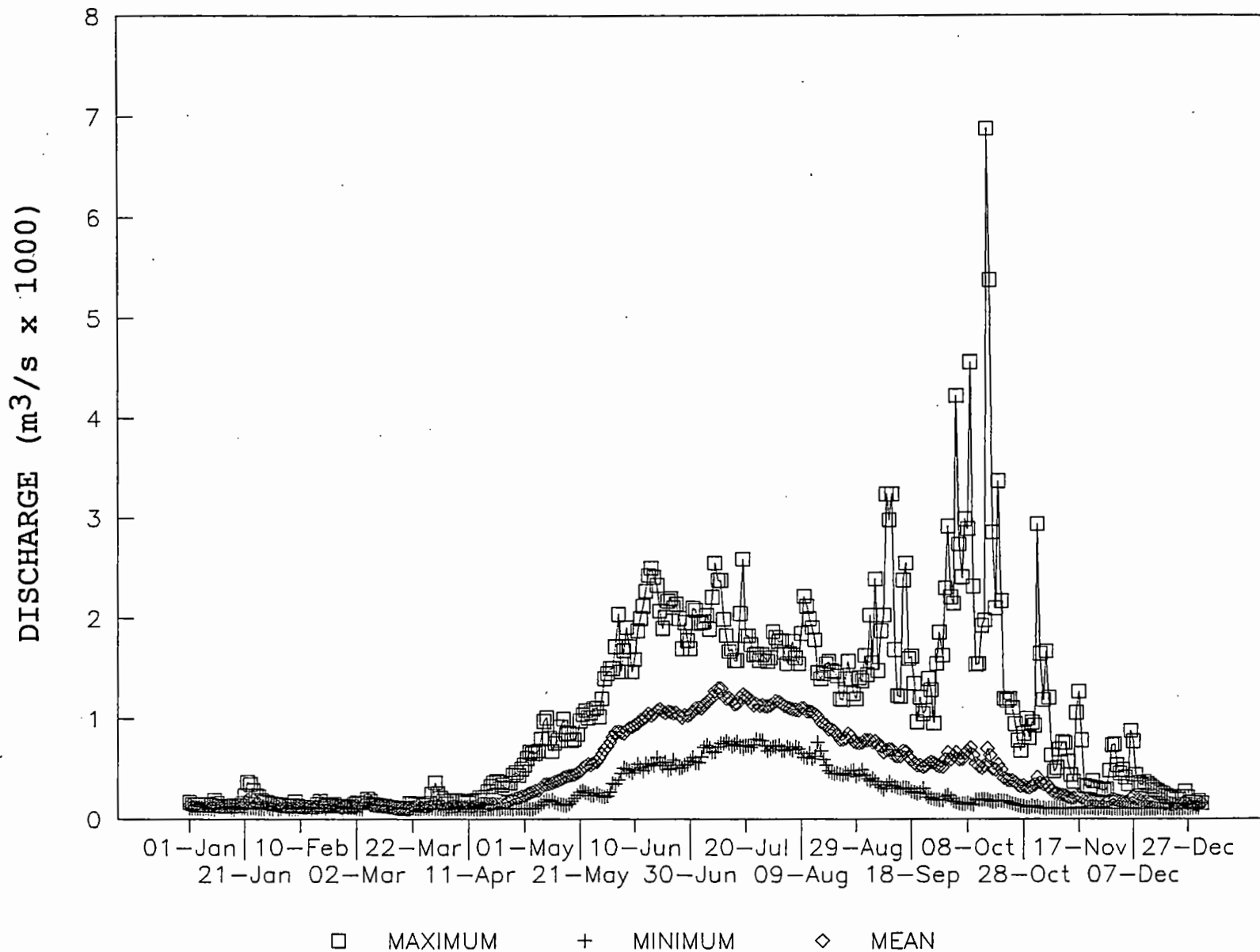


FIGURE 2. Seasonal pattern in Iskut River discharge expressed as the observed daily maximum, minimum and mean during 1959 - 1990. Data are from Water Survey of Canada station number 08CG001 below Johnson River.

main channel, side channels, and off-channel habitat. Brief descriptions of population size and character are presented below for the three principal salmon species in the Iskut River.

3.1 Chinook Salmon

McCart and Walder (1982) reported that chinook salmon are the first to enter the Stikine system. During 1980, adults were first caught in gill nets on May 8 (as this was the first set, the run probably started earlier) and the peak commercial catch occurred June 28 - July 9. McCart and Walder reported that little is known of habitat preferences of spawning chinook salmon in the Stikine and Iskut mainstems, but peak spawning occurs in August. Chinook generally spawn in deeper and faster water than sockeye (Paine, Ledge and Associates, 1994). D.F. Dickins Associates (1990a) indicate that the mouth of Caralin Creek serves as a major spawning area for chinook and chum. In this section, the narrowest point of the Iskut River west of Snip Mine, the river is confined to a single channel less than 200 m wide. McCart and Walder (1982) found chinook fry in the Craig, Inhini and Scud rivers, suggesting that chinook spawning occurs in these drainages as well. Iskut River chinook have a river-type life history which involves juvenile rearing during their first, and sometimes second, summer in the river or its tributaries before seaward migration of smolts the following spring (Paine, Ledge and Associates, 1994). Juvenile chinook tend to prefer slack water, side channels and margins of the mainstem for rearing (McCart and Walder, 1982).

The commercial and native food fisheries in the Stikine River are managed to ensure a target spawning escapement of 5300 chinook to Little Tahltan River, upstream of Telegraph Creek. Management agencies assume that achievement of this target escapement to Little Tahltan River ensures adequate escapements for other stocks in the Stikine-Iskut system. Escapements to the Iskut River and tributaries account for an estimated 10 - 25% of the Stikine River chinook stock (Paine, Ledge and Associates, 1994).

3.2 Sockeye Salmon

Sockeye spawn in the Iskut River system from mid-August to early October, with peak spawning in mid-September (Paine, Ledge and Associates, 1994). The maximum escapement

recorded for the Iskut River in the DFO Stream Information Summary (SIS) is 6000 fish; an additional 2000 - 3000 sockeye are estimated to spawn in Iskut River tributaries. Sockeye spawn in side channels, sloughs and springs of the Iskut mainstem, and in the mouths and lower reaches of tributaries (Craig, Verrett and Inhini rivers). Spawning occurs in gravel at water depths of 20-100 cm. Shallow areas with low flows, not typically used as spawning sites in other systems, are used in the Iskut River if groundwater flow is present (Paine, Ledge and Associates, 1994).

Iskut River sockeye juveniles exhibit both river- and sea-type life history patterns (Wood et al. 1987). Juvenile rearing occurs in the river and estuary rather than in a lake. The young of the sea type migrate to sea in their first summer. The young of the river type spend 1 - 2 summers in the river before migrating to sea. McCart and Walder (1982) indicate that sockeye juveniles have a distinct preference for slack water habitat. The least favoured habitat is the margins of the mainstem. They prefer shallower water and lower velocities than chinook juveniles.

3.3 Coho Salmon

Coho spawn during September - November, later than the other salmon species. Spawning in the Iskut River system occurs mainly off the mainstem, in tributaries and upland ponds and springs (Paine, Ledge and Associates, 1994). Craig River may be the most important coho spawning stream in the entire Stikine watershed. The SIS database indicates a maximum escapement of 2775 to the Iskut mainstem and 10,000 to Craig River. Escapements to isolated sloughs and ponds are likely underestimated and may be important.

Coho juveniles rear for their first, and sometimes second, summer in the Iskut River and its tributaries. Seaward migration of coho smolts peaks in May, at the same time as sockeye smolts. Paine, Ledge and Associates (1994) caught coho juveniles only in off-channel habitat. Coho juveniles prefer small tributaries and quiet water (McCart and Walder, 1982).

4.0 INDIRECT EFFECTS ON FISH POPULATIONS

4.1 Erosion of Steep Banks

Waves produced by the Cominco ACV have been observed to cause, or at least accelerate, the erosion of naturally over-steepened banks along the Iskut River (Sampson, 1994; Hay & Company, 1995). The erosive nature of the wave action results in a more gradual bank slope which apparently has a tendency to protect the eroding bank from subsequent wave action. This self-stabilizing tendency can, however, be offset by the inherent instability of river levels on the Iskut (Sampson, 1994). Changing river levels could lead to additional erosive action at a slightly higher or lower level on the eroding bank.

Steep banks with vegetation and the habitat structure created by fallen trees, wood debris or root wads, can be expected to provide rearing habitat for juvenile salmonids (Bisson et al. 1982). Provided that riparian vegetation and associated features (e.g. fallen trees) remain, accelerated erosion of such banks may not, in itself, cause a change in rearing habitat suitability. Reduction in bank slope, however, could affect habitat values. Studies in non-glacial streams indicate that during the late summer-winter period, rearing salmonids tend to prefer steep bank habitat which provides relatively deep water in association with bank cover (White, 1991). Reduction in near-bank water depth, as observed at certain Iskut River sites, therefore has the potential to reduce the suitability of such steep bank habitat for juvenile salmon rearing. The erosive action appears to move the toe of slope, the holding area for juveniles, further away from vegetative cover along the bank. It may also tend to reduce the natural complexity of the habitat.

Bank erosion also introduces sediment to the stream. Hay & Company (1995) concluded that ACV wave action caused sediment suspension that "--- was limited to a narrow band near the bank, lasted only a few seconds, and had a minimal impact on the fluvial system." Though the limited observations by Hay & Company indicated that these suspended sediment concentrations could be substantial, the short duration of such episodes suggests that stress on rearing salmonid juveniles in the Iskut River would not likely to be significant (Newcombe and MacDonald, 1991).

Under some circumstances, wave induced erosion of steep banks may also affect salmon spawning habitat in the Iskut River. Sampson (1994) reported the use of a side channel in the Hoodoo River fan by the ACV. Wave action apparently caused erosion of a steep bank adjacent to a sockeye salmon spawning area, resulting in gravel deposition on salmon redds. Such an impact could cause smothering of deposited eggs or reduction in suitability of the habitat for spawning and egg incubation.

4.2 Erosion of Sand/Gravel Bars

The physical effects of ACV waves on gradually sloping sand and gravel bars have also been assessed in the Iskut River (Hay & Company, 1995). Though wave induced erosion of bars does occur, the physical impact does not appear to be of significance to fish habitat. At steeper sloping sites, the erosion apparently tends to be self-limiting, while along more gradually sloping sites wave energy is insufficient to cause measurable erosion. The self-limiting erosion process at steeper sites involves redeposition of eroded material along the bar face, causing subsequent waves to break further away from the water's edge, thereby dissipating the wave's energy some distance from shore. Habitat suitability for rearing salmon juveniles would not appear to be substantially altered by these processes.

Wave induced erosion does cause local elevation of suspended sediment levels. As noted in Section 4.1, the short duration of such events is not likely to result in measurable stress to rearing juvenile salmonids.

4.3 Log Debris Removal

A Cominco crew removed part of the White Snag log jam, near the Inhini River confluence, in the fall of 1993. This allowed ACV access to a new area and into a sockeye spawning area downstream of the log jam (Sampson, 1994). The log jam in the Hoodoo River fan was also partially removed. The sheltered channels behind the jams were reported to be used by spawning salmon (Sampson, 1994) and would also likely provide juvenile salmon rearing and overwintering habitat (Etherton, 1994).

5.0 DIRECT EFFECTS ON FISH POPULATIONS

5.1 Underwater Noise and Adult/Juvenile Salmonids

D.F. Dickins Associates (1990a) conclude that the ACV air cushion provides sound insulation that results in very little propeller and engine noise being transmitted into the water. They reported investigations which measured underwater sound levels from an ACV (AP.1-88 model) at a level of 147 dB at 1 m, 124 dB at 15 m, and 118 dB at 30 m away from the craft. At a distance of 15 m, underwater noise generated by the ACV was actually lower than produced by an aluminum punt powered by a 15 hp outboard motor (139 dB). For perspective, it should be noted that the ambient noise of a fast flowing river would exceed 106 dB (D.F. Dickins Associates, 1990 a).

Salmon react to underwater noise by diving or avoidance activity. The effect of noise on salmon spawning activity is considered likely to be transitory (D.F. Dickins Associates, 1990a). It is not uncommon to have substantial motor boat activity around salmon spawning areas in British Columbia. To the knowledge of the writers, there are no regulations that restrict use of power boats in relation to salmon spawning in British Columbia. Based on this information, underwater noise created by the ACV does not appear to be a concern.

5.2 Disturbance of Salmon Redds

ACV waves can cause erosion and sediment mobilization along river banks and bars. Where this occurs in proximity to salmon spawn, sediment mobilization and subsequent deposition could cover salmon redds and adversely affect embryo survival. The ACV's tendency to create marks or scars in the river gravel as it crosses exposed bars or shallow water could also affect salmon redds.

An ACV traverse of the Hoodoo River fan in fall, 1993, was reported by Sampson (1994) to affect salmon redds in a similar manner to that noted above.

5.3 Effects on Juvenile Salmonids in Shallow Water

Even at a moderately high flow in the Iskut River (590 m³/s), the ACV has been observed to travel over shallow water or on gravel bars for approximately 10% of the travel time (D.F. Dickins Associates, 1994). At lower flows the ACV route can involve movement through relatively shallow channels (B. Sampson video). The presence of juvenile salmon in such areas has been documented by several investigators (McCart and Walder, 1982; Paine, Ledge and Associates, 1994; HMU-DFO, 1994; Etherton, 1994). Although air cushion pressure within the ACV skirt is low (Nixon, 1993), the craft does create turbulence and can displace sand and gravel substrates in shallow water (HMU-DFO, 1994). ACV effects on juvenile salmon in shallow water were briefly examined (HMU-DFO, 1994), but the study results were inconclusive. The potential for the ACV to affect fish in shallow water remains undetermined.

6.0 CONCLUSIONS

1. **The definitiveness of conclusions regarding ACV impacts on fisheries resources of the Iskut River has been limited by the fact that most biological studies of Iskut River anadromous salmonids were not designed with a view to assessing ACV impacts.** For example, juvenile salmon sampling techniques have not been suited to documenting fish use of the full range of fish rearing habitats influenced by ACV operations. There is also a lack of current and detailed information on salmon spawning timing and distribution relative to ACV routes. In some reaches, river character and channel location have likely changed since salmon spawning distribution was last documented in 1979 and 1980.
2. **ACV generated wave action, in conjunction with natural processes, has been shown to cause stream bank erosion along the Iskut River.** Though investigators differ on the extent and significance of the bank erosion, there is agreement that the erosive action tends to result in a more gradual bank slope than would naturally occur. Steep banks, particularly those with vegetation and related cover features, can provide habitat for juvenile salmon rearing. **Along such vegetated steep banks, reduced bank slope has the potential to adversely affect habitat suitability for juvenile salmon through reduced water depth adjacent to bank cover features, possible alteration of**

nearbank hydraulic complexity, and increased distance between riparian vegetation and the river's edge.

3. Underwater noise generated by an ACV is apparently comparable to or less than other surface craft in a riverine environment. While noise from the ACV may cause fish, particularly spawning salmon, to exhibit avoidance behavior, the short duration of the noise event would likely cause only temporary displacement from a holding or spawning area. **Underwater noise from the ACV is not considered likely to affect adult or juvenile salmonids.**
4. Log debris which restricts or obstructs ACV access to certain channels of the Iskut River is normally removed by chain saw at low river flow. At some sites a log debris jam may shelter a side channel from the main river flow. Such side channels can be important spawning and juvenile rearing or overwintering sites. **It is therefore important that log debris removal be conducted in a manner compatible with protection of significant side channel habitats.**
5. **The ACV could affect salmon redds by (1) direct physical disturbance, or (2) sediment deposition resulting from wave action.** The likelihood and magnitude of such impacts is difficult to assess because of the absence of current, site specific information on salmon spawning distribution in relation to the ACV route.
6. Juvenile salmon are known to rear in shallow water areas crossed by the ACV, and may therefore be vulnerable to the ACV in these areas. **The potential for ACV impact on juvenile salmon in shallow water has not been adequately assessed.**

7.0 REFERENCES CITED

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- ETHERTON, P. 1994. Results of fish capture activities at two sites within the flood plain of the Iskut River, June 1-2, 1994. Dept. of Fisheries and Oceans, Whitehorse, Y.T. 29 p.
- GARDINER, S.R.M. 1993. Stikine/Iskut River Study. Letter report for Cominco Ltd., Smithers, B.C. by Hay & Company Consultants Inc., Vancouver. 7 p. + figures and photographs.
- HAY & COMPANY. 1995. Natural and vessel-induced bank erosion, sediment transport and bed pressures of lower Iskut River. Prepared for Cominco Ltd. by Hay & Company Consultants Inc., Vancouver, B.C. 33 p. + figures and photographs.

- HMU-DFO. 1994. Summary report. Department of Fisheries and Oceans, Pacific Region, May 31-June 2, 1994 field inspection of Cominco Ltd., Snip Mine hovercraft operation on the Iskut and Stikine rivers. Prepared by Habitat Management Unit, New Westminster, B.C. 5 p. + table and figures.
- McCART, P., AND G. WALDER. 1982. Fish populations associated with proposed hydroelectric dams on the Stikine and Iskut rivers. Volume 1: Baseline studies. Preliminary report for BC Hydro and Power Authority by Aquatic Environments Ltd., Calgary, Alberta. 101 p. + tables and figures.
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- WOOD, C.C., B.E. RIDDELL, and D.T. RUTHERFORD. 1987. Alternative life histories of sockeye salmon (*Oncorhynchus nerka*) and their contribution to production in the Stikine River, northern British Columbia. p. 12-24. In H.D. Smith, L. Margolis, and C.C. Wood [ed.] Sockeye salmon population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

APPENDIX A

OUTLINE OF FISHERIES SCIENTIFIC REVIEW SNIP HOVERCRAFT OPERATION

1. Objectives

The primary objective of this review is to assess the extent, if any, to which the operation of the hovercraft CH-COM may

- (a) constitute harmful alteration, destruction or disruption of fish habitat in the Iskut River, B.C., having regard to the definition of "fish habitat" set out in the Fisheries Act; and
- (b) otherwise adversely affect fish in the Iskut River.

If the review concludes that a material risk to fish or fish habitat may exist, but the risk cannot be adequately assessed using the available information, the review panel will recommend any further studies which could help determine the extent of the risk.

2. Scope

The review will encompass all of the available written information on

- the fisheries resources of the Iskut River;
- the physical effects of the hovercraft on the river environment;
- the applicable hydrological information on the sections of the river in question; and
- any other relevant data.

A preliminary list of the written materials to be examined during the review is attached as Appendix "A".

3. Review Panel

The review will be conducted by a review panel made up of two recognized authorities in fisheries science. One individual will be nominated by Cominco Ltd., and the other by the Department of Fisheries and Oceans.

Appendix A (cont.)

4. Review Process and Presentation of Results

The review process will be conducted on an informal basis in order to proceed toward realization of the study objectives and presentation of the results at the earliest practicable date.

However, it is generally envisaged that the process will follow this sequence of steps:

- (a) an initial meeting of the review panel with representatives of Cominco Ltd. and the Department of Fisheries and Oceans to clarify the objectives of the review, to identify any further information requirements, and to establish a date by which the review will be finally completed;
- (b) submission of a final written outline of the review process by the panel members and approval by Cominco Ltd. and the Department of Fisheries and Oceans;
- (c) a series of informal meetings between the two panel members only, to discuss the data, formulate initial conclusions, and identify the most appropriate methods for presentation of the results;
- (d) a site visit by the panel members to view the hovercraft operation in situ;
- (e) an interim presentation by the review panel to representatives of Cominco Ltd. and the Department of Fisheries and Oceans, once the panel members have formulated their preliminary results;
- (f) an informal consultation forum to be attended by representatives of other government agencies, interested members of the public and public interest groups;
- (g) presentation by the panel members of their final results and conclusions to Cominco Ltd. and the Department of Fisheries and Oceans; and
- (h) distribution of the final results and conclusions to other government departments, interested members of the public and public interest groups.

APPENDIX B

LIST OF DOCUMENTS TO BE EXAMINED DURING THE FISHERIES SCIENTIFIC REVIEW - SNIP HOVERCRAFT OPERATIONS

1. D.F. Dickins Associates Ltd. Jan. 25, 1990. Snip Project, Preliminary ACV Environmental Assessment.
2. D.F. Dickins Associates Ltd. June 14, 1990. Stikine/Iskut River Hovercraft Operations: Environmental Summary.
3. D. Dickins, M. Royea and P. Morrison. June, 1992. Cominco's AP.1-88 Operation: A Successful Application of Hovercraft in the Mining Industry. Presented at the Intersociety High Performance Marine Vehicles Conference and Exhibit, Washington, D.C., June 24-27, 1992.
4. D.F. Dickins Associates Ltd. June 29, 1994. Cominco ACV Operations: Field Notes from June, 1994 observations during DFO's visit to Snip.
5. S. R. M. Gardiner, Hay & Company Consultants Inc. Oct. 18, 1993. Stikine/Iskut River Study.
6. Paine, Ledge and Associates and Aquatic Resources Ltd. August, 1994. Iskut River Spring Fish Survey, 1994.
7. Hay & Company Consultants Inc. January, 1995. Natural and Vessel-induced Bank Erosion, Sediment Transport and Bed Pressures of the Lower Iskut River.
8. Habitat Management Unit, Fraser River Division, DFO. June 29, 1994. Summary Report, Department of Fisheries and Oceans, Pacific Region - May 31 to June 2, 1994. Field Inspection of Cominco Ltd., Snip Mine Hovercraft Operation on the Iskut and Stikine Rivers.
9. D.F. Dickins Associates Ltd. February 10, 1992. Snip Operations - Hovercraft Spill Contingency Plan.
10. Ministry of Forests - Prince Rupert Forest Region. May, 1989. Lower Stikine Management Plan. Approved by the Environment and Land Use Committee.
11. A. Nixon. April 21, 1993. Science and Technology Division, Library of Parliament, Research Branch. Impact of Downwash Pressure from Air Cushion Vehicles.
12. B. G. Dane, Technical Officer. Habitat Management Unit, Fraser River, NBC and Yukon Division, Dec. 17, 1991. Snip Mine Hovercraft Operation.
13. Department of Fisheries and Oceans. November 15, 1990. EARP Screening Summary.

Appendix B (cont.)

14. B. Sampson. April 26, 1994. Charlie Oscar Mike - The Industrial Destruction of the Mainstem Iskut River Ecosystem.
15. B. Chilibeck, Environmental Engineer, Habitat Conservation Unit, DFO. June 29, 1994. Site Investigation - Data Report, Cominco Hovercraft CH-COM on the Iskut River, May 31 - June 2, 1994.
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Appendix B (cont.)

28. **W. T. Sampson. May 27, 1994. Induced Incremental Erosion of the Iskut River Caused By The Wake From An AP.1-88 Hovercraft.**
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