ARCTIC
VOL. 35, NO. 4 (DECEMBER 1982) P. 524-530

Preliminary Impacts of the James Bay Hydroelectric Project, Quebec, on Estuarine Fish and Fisheries

FIKRET BERKES[1]

ABSTRACT. Flow alterations related to hydroelectric development have affected both the fish stocks and the Cree Indian subsistence fishery in the lower LaGrande River, northern Quebec. Evaluated against several years of baseline data, the initial biological impact of the project on fish populations, mostly whitefish (*Coregonus clupeaformis*) and cisco (*C. artedii*), appeared to be relatively small. Nevertheless, fishing activity in the lower river and the estuary largely ceased from 1979 to 1981, due to physical modifications of traditional fishing areas and other social and economic effects related to the hydro project. Some fishermen modified their methods and continued harvesting in the affected area, but others abandoned the affected area and fished lakes and rivers along the recently constructed road network. It is concluded that earlier impact assessments fell short of predicting these impacts.

Key words: environmental impact, social impact, hydroelectric projects, northern development, James Bay, northern Quebec, subsistence fisheries, native harvesting, *Coregonus clupeaformis, Coregonus artedii*

RÉSUMÉ. Ceci est une étude sur l'effet de l'interruption du débit et d'autres modifications se rapportant au développement hydroélectrique sur la pêche de subsistence (domestique) de l'indien cri dans l'estuaire et la partie inférieure de La Grande Rivière. Se reférant à des données d'avant 1979, l'impact biologique initial sur les populations de poissons, en particulier sur les populations de grand corégone (*Coregonus clupeaformis*) et de cisco de lac (*Coregonus artedii*), semble être relativement petit. Néanmoins, la pêche a cessé de 1979 à 1981 dans la partie inférieure de la rivière et dans l'estuaire, ceci dû en partie à la diminution dans la disponibilité du poisson à ces endroits causée par des modifications physiques dans l'environnement et en partie dû à un nombre de facteurs sociaux et économiques reliés directement ou indirectement au projet hydroélectrique. Certains pêcheurs ont modifié leurs méthodes et ont changé leurs sites de pêche afin de pouvoir continuer leurs activités dans la région affectée. Mais une seconde stratégie d'adaptation s'avère plus importante, notamment celle qui consiste à abandonner la région affectée et à orienter ses efforts de pêche vers les lacs et les rivières le long du réseau routier récemment construit.

Mots clés: impact environnemental, impact social, projets hydroélectriques, développement du nord, Baie James, nord québécois, pêcheries de subsistence, récolte autochtone, *Coregonus clupeaformis, Coregonus artedii*

Traduit par M.-J. Hoja.

INTRODUCTION

Much of the published literature on environmental impact studies is concerned with methodology and probable impact of future environmental alterations, rather than with the actual impact. In the case of the James Bay hydroelectric project in boreal-subarctic Quebec, however, there are sufficient baseline data and post-modification data to permit the assessment of some actual preliminary impacts.

The ecological subsystem examined in this study is the estuary of the LaGrande River, the fish populations therein, and the local fishery, described by Berkes (1981). The biology of the populations of two coregonid species, lake whitefish (*Coregonus clupeaformis*) and cisco (*C. artedii*) in the LaGrande estuary has been studied since 1973 (Morin *et al.*, 1980, 1981.) These studies have substantially documented that the estuarine whitefish and cisco populations are self-sustaining; that they overwinter in the freshwater portion of the lower LaGrande, migrating to the brackish waters of the estuary in spring to feed; and that they return to freshwater in late summer, eventually to spawn there in the fall. The local native subsistence (domestic) fishery, based mainly on these two species, has been monitored since 1975 (Berkes, 1977, 1979). A complete list of all the species caught in the area is given in Morin *et al.* (1980).

The major environmental modification occurred after November 1978 when the flow of the LaGrande into James Bay was interrupted to fill the reservoir of the LG-2 dam, the largest dam in the system and the first to be constructed. As compared to a minimum natural flow of about 340 $m^3 \cdot sec^{-1}$ (Environment Canada, 1975), after interruption the flow was reduced to a few tens of $m^3 \cdot sec^{-1}$ coming into the system mainly from small tributaries downstream of LG-2. In February 1979 the flow trickled down to 2 $m^3 \cdot sec^{-1}$ (Caron and Roy, 1980). The flow was gradually restored between June and November 1979, and LG-2 started to produce power in October, 1979 (Roy, 1981). During this first winter, the diversion channel for the LG-1 dam at km 37 was constructed, taking advantage of the low water levels downstream from LG-2.

This paper is primarily concerned with the effects of the flow interruption and LG-1 diversion channel construction on the fisheries of the lower LaGrande. First, some biological parameters of the coregonid populations (distribution, growth and reproduction) are considered. Secondly, the fishery based on these stocks (catch per unit of effort and the activities of fishermen) is analyzed. The first point was addressed in two of the previous impact assessment studies (Federal-Provincial Task Force, 1971; Environment Canada, 1975). But the second point was not addressed in any of the published studies. The material examined in

[1]Institute of Urban and Environmental Studies, Brock University, St. Catharines, Ontario, Canada L2S 3A1

this paper makes it possible to evaluate these previous environmental impact assessment studies.

The approach of the present study is to investigate the effect of the hydro development on the fish populations and their availability for harvesting, as well as that of other considerations affecting the local fishery. The focus of the study is not biological but interdisciplinary, with the hypothesis that the probable impacts are not merely biological but biological *and* socioeconomic in nature.

METHODS

Data on the fish and the fishery were collected between 1975 and 1981 by sampling the catch of the Cree Indian fishermen of Fort George which is located on the LaGrande estuary. (This village was relocated to a new site about 10 km upstream in 1980 and renamed Chisasibi.) The samples were taken with 2½ inch (63.5 mm) stretched mesh gillnets which tend to select for cisco, and 3 and 3½ inch (76.2 and 88.9 mm) mesh gillnets which select for whitefish (Berkes, 1977). A modified version of these gillnets was sometimes used as a seine in the First Rapids area, 37 km from the mouth of the river and the site of the LG-1 dam.

The fish were sorted by species, counted, measured and weighed (accuracy to ±25 g in the field); a smaller sample was checked for sex and maturity, and weighed individually or in small groups (±10 g). Ages were determined by the scale method, assumed to be valid for coregonids of 10 yr or less. Year-to-year changes in individual growth rates were measured by using the growth bands on the scales, under the assumption that the scale gives evidence of not only the age but also the size at the end of each year of the individual's life.

In addition to the field monitoring of fishermen's catches, information was obtained through open-ended interviews on the activity levels of fishermen and on fishing areas utilized by fishermen. Any activities or fishing practices that were unusual compared to the baseline years 1975-1978 were noted and fishermen's own observations were recorded.

RESULTS

The Fish

Changes in the distribution of fish due to the hydro project were evaluated by analyzing the catch per unit of effort of the fall and spring fisheries. The catch per unit of effort in the fall fishery, 1973-78, is summarized in Figure 1. Almost all of the fish captured in this ice fishery on the south branch of the LaGrande were coregonids (95% were cisco). The fishery started after the formation of a firm ice cover in November, and continued until early or mid-December. The catch per unit effort was highly variable year-to-year, consistent with the well-known environmental variability of subarctic regions. The usual trend was toward lower catches in December, but there were exceptions to this trend in 1977.

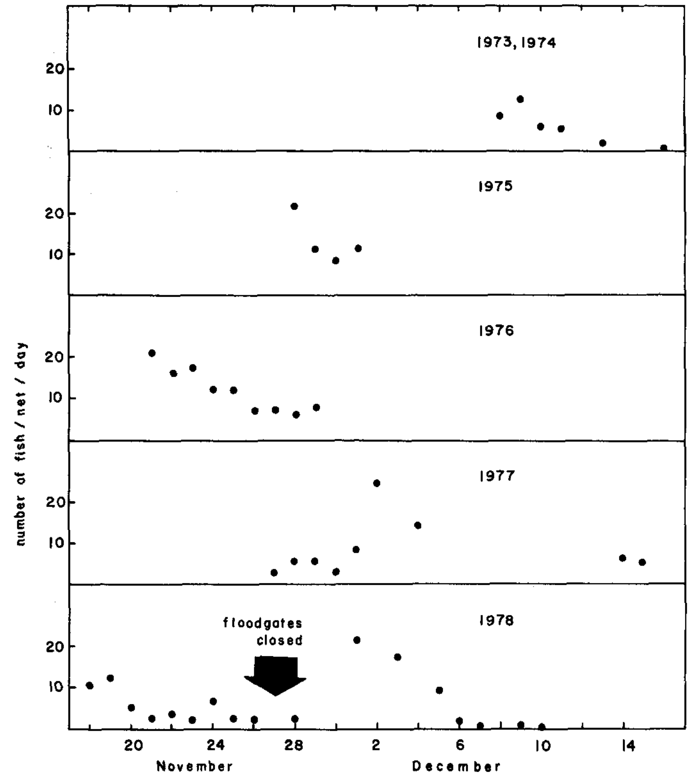

FIG. 1. Ice fishery at the mouth of the south branch of the LaGrande. The number of fish per 50 m gillnet per day in baseline years *vs.* 1978 when the river flow was interrupted to fill the LG-2 reservoir. All 2½ inch gillnets.

In 1978, following the closure of the floodgates on 27 November to fill the reservoir (allowing for a 2-4 day delay for the draining of the system), the catch actually increased before returning to very low levels 6-8 days later. Coregonids caught in early December 1978 were accompanied by an increasing proportion of fourhorn sculpin (*Myoxocephalus quadricornis*) and Greenland cod (*Gadus ogac*), both characteristic of saltwater (Morin *et al.*, 1980). Prior to 1978, cod had never been recorded at sampling stations at the mouth of the LaGrande.

In the fall of 1979 and 1980, no sampling was possible at this location, as the new temperature and flow regime of the river prevented the formation of a firm ice cover.

Figure 2 shows the distribution of catches in the spring months. Prior to 1979, in most years, gillnetting started in mid- to late May, following breakup. Early catches in the lower river were followed by increased fishing effort in the estuary and the bay. Again, trends are complicated by large year-to-year variations. For example, in 1975, an "early" year, fishermen were setting nets in the bay before the end of May, whereas in 1976, a "late" year, substantial catches were still being obtained in the lower river as late as the first week of June. Fishermen also reported catches from the bay in early June 1976, but the sampling program did not cover these.

Spring 1979 was considered an early year on the basis of early breakup in nearby bays and creeks unaffected by the

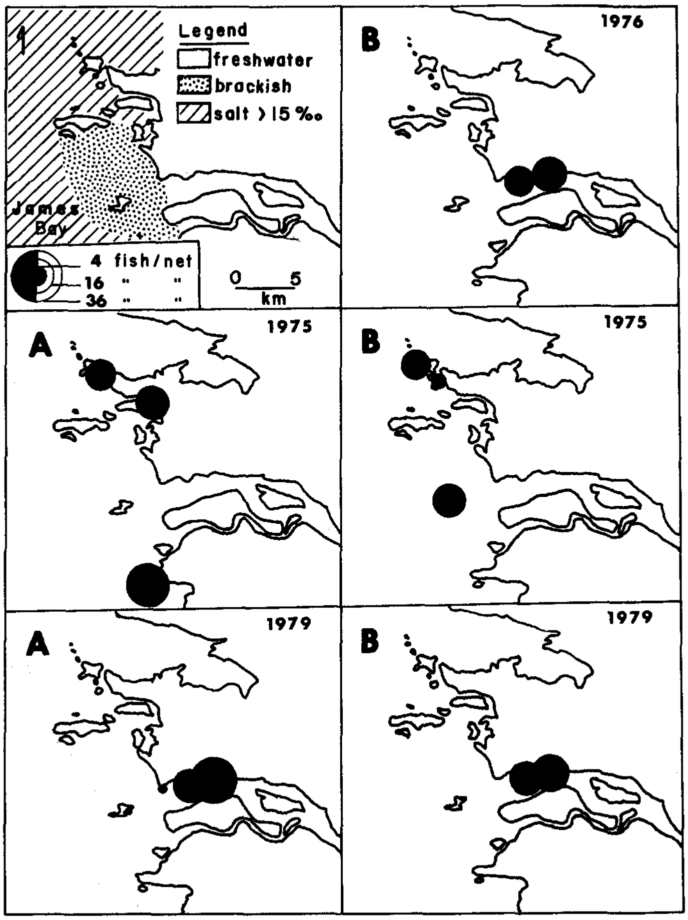

FIG. 2. Spring fishery on the LaGrande River mouth and estuary. The number of fish per 50 m gillnet per day in 1975 (control) *vs.* 1979; 1976 was a year in which the ice breakup was late. Panel A refers to last two weeks in May. Panel B refers to first two weeks in June.

hydro development. On the LaGrande, however, in contrast to 1975, fish were being caught in the lower river but not in the bay until 10 June. There were some small catches in the estuary, but nothing was caught in several other stations in the estuary and the brackish water area. In terms of the dislocation of the fishery, the effect was relatively minor, resulting in a 5-10 km shift in fishing areas.

The clearance of ice from the estuary in 1979 was about two weeks late in comparison to nearby creeks and to other early years. This was correlated with the reduced flow of the river, as the reservoir was still being filled, suggesting that it is the flushing action of the spring flood that normally carries into the bay both the river ice and the fish populations.

Dead fish were not observed either by the investigator or by native fishermen. However, native fishermen indicated in spring 1979 that they considered some of the fish to be thin and inedible. This observation was examined in terms of: (1) the length-frequency of the cisco populations; (2) length-weight relationships of cisco and whitefish populations; and (3) growth of individual cisco and whitefish as judged by the last growth band on scales. To carry out this work, fish sampled in 1979 were compared to fish sampled in one or more of the control years, 1975-78.

The length-frequency relationships of cisco in 1979 were similar to those in other years. The largest fish were caught in August (all years), mostly from the pre-spawning aggregations of mature fish in freshwater. There were no abnormalities in the length-frequency relationships that suggested age-specific mortality among the age-classes (4+ to 8+) normally sampled by gear used in the local fishery (Berkes, 1977).

Figure 3 shows the length-weight relationships of August cisco and whitefish sampled in 1979 *vs.* some of the control years. For the limited size range of the fish used in the comparisons, the length-weight relationship showed significant ($p<0.01$) linear fit, and the correlation coefficients were $r=0.95$ for cisco and $r=0.95$ and 0.96 for whitefish. When the slopes of the regression lines we compared by F-test, there was a significant difference for cisco, but only at the $p<0.05$ level. For whitefish, there was no significant difference. Similarly, comparisons of May/June samples yielded significant differences at the $p<0.05$ level for both species. When the elevations of the regression lines we compared, there were no significant differences in any of the comparisons for either species in August or May/June.

Growth rates of individual cisco and whitefish in 1979 *vs.* the control years were compared by examining the scales. The fish were matched by length and age but otherwise randomly selected. The fish were taken from samples at the end of the growing season (mostly in October), and all were between 3+ and 6+ years of age (mostly 4+ and 5+). Figure 4 shows that the width of the last growth band, corrected for scale size, indicated no differences between 1979 and the control years for cisco. In the case of whitefish, however, 9 of 22 individuals in the 1979 sample showed a growth band that fell outside the range for the control years. In whitefish sampled in 1979, the distribution of values for the last growth band was not Gaussian but bimodal. Some specimens showed very little growth and in some cases erosion at the edge of the penultimate growth band, but others showed a range of growth rates comparable to the control years.

Fish samples were also analyzed for evidence or lack thereof of reproductive activity. Several specimens of cisco in spawning condition were obtained in October 1979 from the lower LaGrande at km 8. Cisco in pre-spawning aggregations at the end of August 1979 contained ripening eggs with a mean diameter of 1.6 mm ($N=16$). At the same sampling station (37 km from the mouth of the river) in 1978, cisco had 1.5-mm eggs ($N=30$) but the sampling date was a week earlier in 1978. No whitefish in spawning condition or even containing ripening eggs were obtained in 1979, but the sample sizes of mature whitefish were too small to reach a firm conclusion, considering that mature-sized whitefish do not necessarily spawn every year. Cisco in spawning condition (ripe and running)

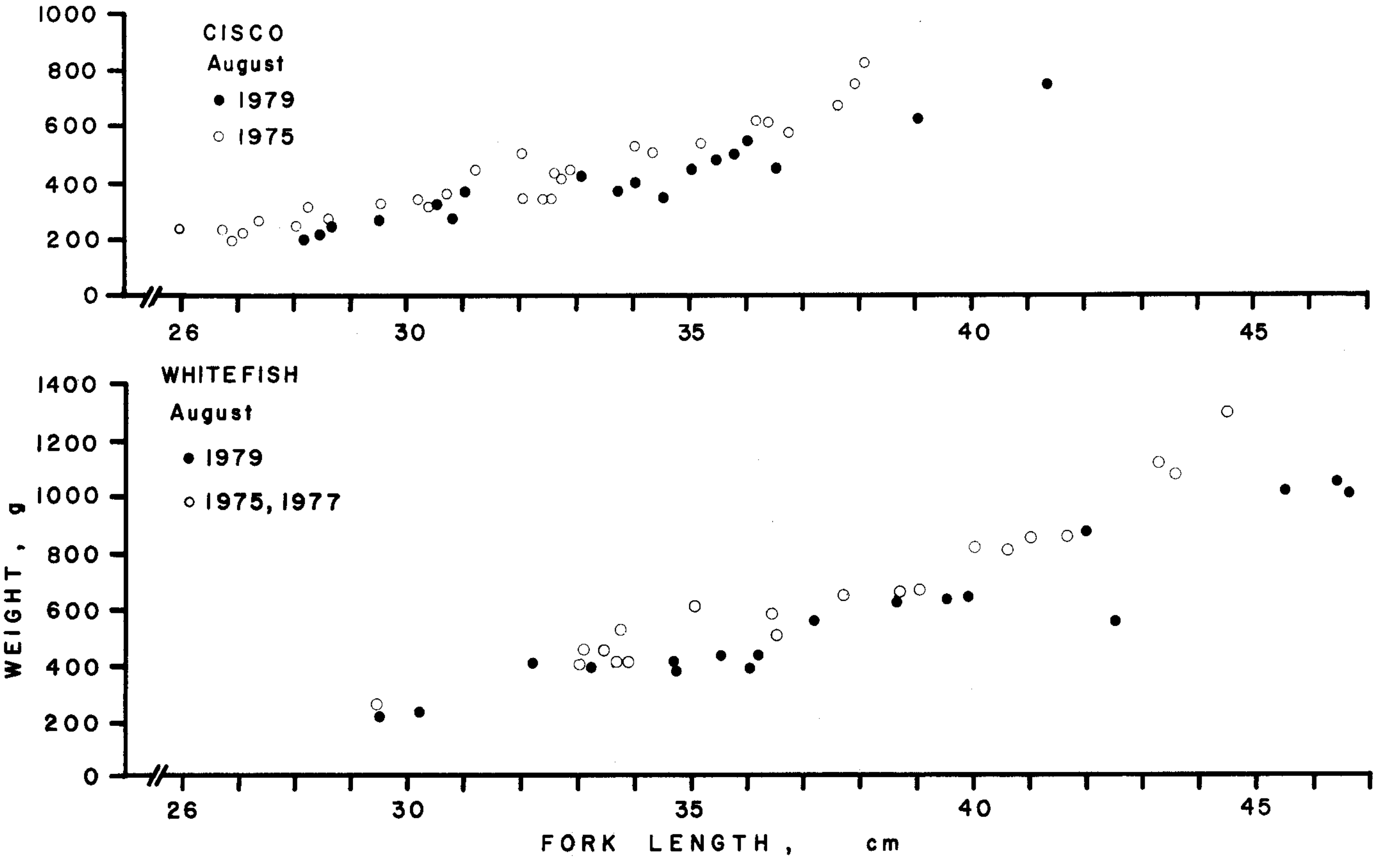

FIG. 3. Length-weight relationships of cisco and whitefish sampled in August, 1975 and 1977 (control) *vs*. 1979. See text.

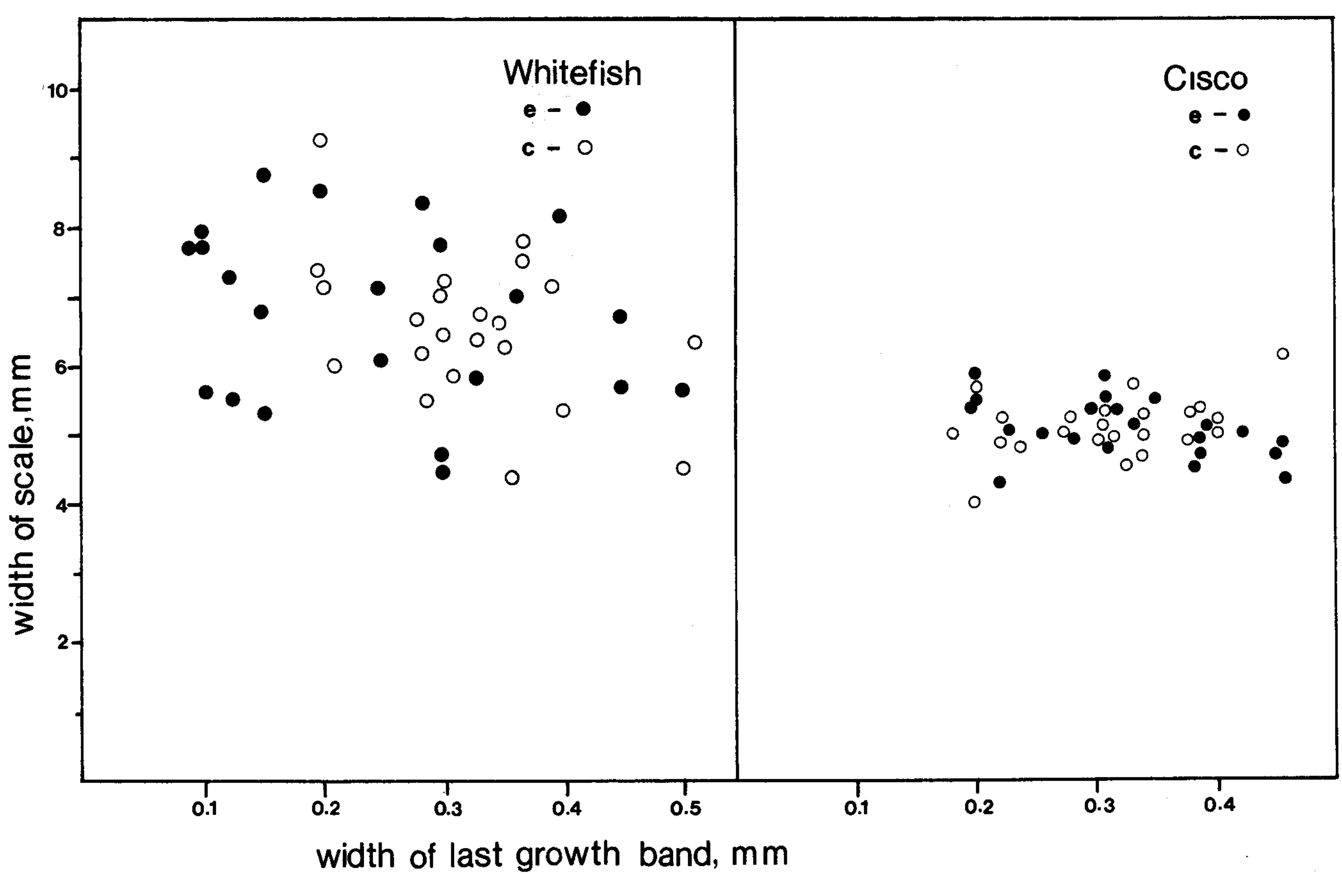

FIG. 4. Growth of whitefish and cisco in the control years 1975, 1977, 1978 (c) *vs*. 1979 (e), as measured by the relative width of the last growth band on scales.

were obtained on 16 October 1981 below LG-1. On 29 October 1981, both cisco and whitefish with ripening eggs (1.6 mm for cisco) were obtained just below the LG-1 area.

The Fishery

This section attempts to summarize, in chronological order, how the fishery was affected by the hydro development and related changes. Fort George Cree subsistence fisheries on the lower LaGrande consisted of four component fisheries in 1975-78: the October pre-freeze-up fishery, November/December ice fishery, spring fishery, and the August First Rapids fishery (Table 1).

TABLE 1. Annual catch per unit of effort in the four major seasonal fisheries of the Fort George Cree people

Fisheries	Years	No. of samples	Catch per unit of effort[1] mean ± SD, kg
Pre-freeze-up fishery,	1975	14	4.3 ± 2.2
estuary of north	1976	13	10.2 ± 5.0
channel of the La	1977	30	4.1 ± 2.1
Grande, October	1978	40	8.3 ± 5.7
	1979	59	2.8 ± 2.1
	1980	3	5.6 ± 1.0
Ice fishery, estuary	1975	11	5.8 ± 2.4
of south channel of	1976	42	5.1 ± 2.6
the La Grande,	1977	23	5.0 ± 3.6
November/December	1978	32	3.4 ± 3.3
	1979	(none possible)	—
	1980	(none possible)	—
Spring fishery,	1975	23	4.5 ± 2.8
estuary of north	1976	23	4.2 ± 2.7
channel of the La	1978	6	5.6 ± 0.9
Grande, May/June	1979	26	4.4 ± 3.3
	1980	6	8.3 ± 1.2
		No. days fishing[2]	Catch per day
First Rapids seining,	1975	1	54.0
37 km upriver on the	1977	1	89.8
La Grande, mid- to late	1978	1	91.4
August	1979	3	10.3

[1]Defined as catch of all fish (except sculpins), round weights, per check of a 50 m net. Nets were usually checked once a day.

[2]One day of fishing per group may be five to ten hauls of a seine. Only the 1979 samples were taken with gillnets at this site.

Starting with November 1978 when the river flow was first interrupted, each of these component fisheries was followed up, with the following results:

1. November/December 1978 ice fishery was not affected by the interruption of flow, which did not occur until after the fishery was almost over (Fig. 1). At that time, fishing was curtailed and small-game hunting began, as both hare and ptarmigan were at a peak in their population cycles in 1979.
2. May/June 1979 fishery was affected by late breakup; ice stayed in the lower river, moving back and forth with the tides, rather than being cleared rapidly as in most years. Some nets were damaged by ice and others were quickly fouled by dead aquatic weeds and debris, much more so than in previous years. Most fishermen pulled out their nets but some persisted, altering their fishing locations and setting nets parallel to the direction of tidal flow, rather than at right angles to it as is usually done.
3. August 1979 fishery in the lower river and at the First Rapids was almost nonexistent, partly because of river conditions, debris, and the destruction of the seining site in the construction of the diversion channel of LG-1. Another factor was a remedial program set up under the James Bay Agreement to provide gasoline subsidies to cover the cost of travelling to alternate fishing locations on other rivers and lakes.
4. October 1979 fishery was conducted under near-normal conditions, as the flow of the river had been restored and much of the debris swept away. However, fewer fishermen participated and the mean catch per unit of effort was less than half those of the previous years (but statistically not significant by t-test).
5. November/December 1979 ice fishery was nonexistent because freeze-up was delayed by the relatively warm water from the reservoir and an unusually mild early winter.
6. May/June 1980 fishery was almost nonexistent largely because the relocation of the community commenced that spring. Breakup was early as a result of early warming, and yet catches were poor in the estuary. Better-than-average harvests were obtained in the lower river, but this was not sufficient to attract fishermen.
7. August 1980 fishery, with the community relocation activity at its peak, was nonexistent, even though a few families attempted, without much success, to seine at the First Rapids. Since about three-quarters of the total labour force of the village were employed by the relocation project, most fishing activity took place on the weekends, along the roads towards LG-2 and LG-3 dams.
8. October 1980 fishery was almost nonexistent again, though a small number of samples indicated that fish were available in the river. Only half of the total labour force remained on the relocation project, but those interested in fishing were mostly travelling to inland lakes along the hydro roads.

Subsequent field trips showed that hardly anyone fished in the river in November/December 1980 and in spring 1981. Many fishermen and hunters traveled by road to LG-2 and LG-3 areas, and by October 1981, to the LG-4 area. There were occasionally nets in the LaGrande during spring, summer and fall months, but the focus of fishing activity had clearly shifted to inland lakes accessible by truck. By fall 1981, fishermen were also beginning to set nets in the LG-2 reservoir and reportedly obtaining good harvests.

Fishing activity in the lower LaGrande and the estuary remained at low levels throughout 1981 and 1982 although many of the regular fishermen tried the First Rapids area in both years, and reportedly obtained small to medium harvests. Some obtained good catches in 1982. Prior to 1979, the mean harvest per fishing group per day was 58.8 kg (N = 4). In 1982, the mean harvest per fishing group per day was 24.2 kg (N = 5). In terms of the number of participants, the First Rapids fishery returned to pre-1979 levels only in 1982. However, relatively more fishing took place inland, especially along the roads.

DISCUSSION

These findings may be analyzed at several levels: (1) the impact of the development project on the fish populations; (2) the effect of physical environmental modifications on the availability of the fish for harvesting; (3) the socioeconomic impact of a constellation of development-related changes on the native fishery.

Biological impacts of the hydroelectric development on the fish stocks of the LaGrande have been relatively small, based on the documentation possible in the first two years following the interruption of flow. A major stress on the fish was no doubt the encroachment of saltwater into the overwintering habitat of the fish below km 37. The maintenance of some flow in the river assured that a freshwater refuge was always maintained during the winter (Caron and Roy, 1980).

The length-weight relationships indicated that both the cisco and whitefish stocks underwent some loss of condition. But the near-normal growth of cisco as shown by growth bands on scales (Fig. 4) indicated that the cisco subsequently compensated, presumably by growing more rapidly over the summer months when they fed in the estuary. Reduced growth in many of the individual whitefish in 1979 may be related to the benthic feeding habits of this species and the probable destruction of freshwater fauna and flora of the lower LaGrande by saltwater encroachment during the winter of 1978-79. There is evidence of reduced population numbers of benthic invertebrates in the lower river in the August and October 1979 samples taken by the SEBJ (1981: Table A-III and A-IV).

In terms of the direct effect of the saltwater encroachment on fish, the data of Caron and Roy (1980) and Roy (1981) show that the coregonids stayed just ahead of the moving saltwater front during the encroachment, consistent with the November/December 1978 data presented in this study. Since the post-modification seasonal flow and temperature conditions on the LaGrande will be considerably different from the natural conditions (Berkes, 1981), a complete understanding of the biological impact is yet to come. It is not known if the major species have been reproducing successfully since 1979, but this may be possible to test when the 1979 year-class and the subsequent year-classes of cisco and whitefish are recruited into the local fishery five or more years later. One complication is that relatively large numbers of whitefish and cisco have been escaping unharmed through the turbines, from the LG-2 reservoir to the lower river (D. Roy, pers. comm.). It is not known if the lower river populations of coregonids can be maintained by this upstream recruitment if reproductive success in the lower river is impaired.

The second level of analysis concerns the effect of physical modifications on the availability of the fish for harvesting. Changes in distribution of fish in fall 1978 and spring 1979 have been documented for the year of the flow interruption, and changes in distribution of the stocks in subsequent years are also likely. Data are admittedly few on this, but the elimination of the spring flood in the LaGrande would probably mean a delay in the movement of the stocks from the lower river to the estuary. Conversely, greater post-modification flows in the fall and winter may mean that the fish have more freshwater habitat available to them in those months.

From the point of view of the local fishermen, such changes appear to be relatively easy to adapt to. Cree fishermen were observed to be frequently testing new areas and modifying their methods, as in the adjustment of the gillnetting methods in the face of debris fouling the nets (presumably freshwater flora killed by saltwater in the winter of 1978-79). However, it should be noted that while some fishermen were able or willing to adjust their methods (as in setting nets parallel, rather than perpendicular, to the shore) other fishermen simply dropped out of the fishery, even when fishing was physically possible and the fish were considered desirable.

Fishermen had relatively more difficulty adapting to changes when it became physically difficult to carry out the usual methods. For example, in 1979 and 1980 there was no successful response to the delay in freeze-up, probably because there was still enough ice in November/December to prevent the usual use of gillnets but not enough to use as a platform. In the case of the First Rapids seining area which was partly destroyed by construction, the fishermen tried several tactics to make harvesting possible. They used different areas for seining on both sides of the river and also set gillnets below the rapids. By August 1982 some of the fishermen were obtaining good catches in one seining area rehabilitated by communal effort in summer 1982, but the harvest was not as good as before 1979 when two seining areas were used.

The third level of analysis concerns other factors, mostly socioeconomic in nature, that seemed to affect the fishery. One factor was the gas subsidy program which encouraged fishermen to move from the river to other areas. A second factor was the relocation of the community which tied up much of the labour force of the village from spring 1980 to fall/winter 1980.

The cash income from this employment made it possible for many families to buy pickup trucks or vans and to travel relatively long distances along recently opened roads, from LG-2 to LG-4 and south to Matagami, without much regard to cost. Thus, a third factor was the availability of new roads. But it should be added that trucks had come into common use earlier, around 1976-77, when much of the road network in the LaGrande hydroelectric complex area became usable (Berkes, 1981:maps). It was not until 1980, however, that much of the fishing activity of the whole community had shifted to lakes and rivers along these roads, from the lower LaGrande and the adjacent James Bay coast. The magnitude of this shift has yet to be documented, and its significance to the local subsistence economy has yet to be evaluated.

In conclusion, the analysis of biological parameters alone indicates that the fish stocks of the lower LaGrande have undergone relatively little change as a result of the hydro development. But the analysis of the community fishery shows that fishing activity in the lower LaGrande and the estuary nearly ceased from 1979 to 1981, partly because of physical environmental modifications and partly as a result of social and economic effects directly and indirectly related to the hydro project.

This is the first long-term study, to my knowledge, on the response of native fishermen to changing environmental conditions associated with a hydro project. How fishermen respond to changes has significance also with respect to many development projects across the north which may affect areas utilized by native communities and the viability of subsistence economies in these areas. The findings indicate that short-term responses, such as changes in fishing methods and fishing sites in the same general area, may be overshadowed by much larger-scale and longer-term shifts in fishing/hunting areas. The preference for this latter strategy was undoubtedly influenced by social and economic changes that accompanied the hydro project.

From an impact-assessment point of view, the major conclusion is that what actually happened to the fish and the fishery in the period 1979-81 had little resemblance to what had been predicted in earlier impact assessments. There had been three such reports (Federal-Provincial Task Force, 1971; Environment Canada, 1975; SEBJ, 1977), all of which received relatively wide circulation. The Task Force report had predicted the unavoidable loss of anadromous (sea-run) fish. Environment Canada (1975) distinguished between short-term and long-term impacts of the project on these fish and stated the conditions under which the survival probability of the populations would be enhanced. SEBJ (1977) provided a highly technical analysis of the environmental implications of the two construction alternatives, but defined its mandate to avoid the relevant questions of whether the fish populations and the fishery could remain viable.

While these three studies differed considerably from one another in their approaches and conclusions, they were similar in omitting those considerations which, in retrospect, affected the native fishery most profoundly: the physical environmental changes that limited the harvestability of the fish, and social and economic changes that facilitated a switch of the major harvest area.

ACKNOWLEDGEMENTS

I thank the Band Council of Fort George (Chisasibi) and fishermen who cooperated with the study, and D. Roy for his criticisms and suggestions. I am grateful to R. Baxter, J. Bobbish, L. Bobbish, S. Herodier, G. Melvin, M. Orr and R. Polson who assisted with data collection and analysis. The study was supported by the Natural Sciences and Engineering Research Council of Canada (in the earlier years) and by the Social Sciences and Humanities Research Council of Canada.

REFERENCES

BERKES, F. 1977. Fishery resource use in a subarctic Indian community. Human Ecology 5:289-307.

———. 1979. An investigation of Cree Indian domestic fisheries in northern Quebec. Arctic 32:46-70.

———. 1981. Some environmental and social impacts of the James Bay hydroelectric project, Canada. Journal of Environmental Management 12:157-172.

CARON, O. et ROY, D. 1980. Coupure de La Grande Rivière: Période critique pour la faune aquatique en aval du barrage de LG-2. Eau du Québec 13(1):23-28.

ENVIRONMENT CANADA. 1975. A Statement of Environmental Concerns and Recommendations for Protection and Enhancement Measures. James Bay Hydro-Electric Project. Ottawa: Environment Canada, Lands Directorate. 45 p.

FEDERAL-PROVINCIAL TASK FORCE. 1971. A Preliminary Study of the Environmental Impacts of the James Bay Development Project, Quebec. Report of the Joint Federal-Provincial Task Force. 56 p.

MORIN, R., DODSON, J. and POWER, G. 1980. Estuarine fish communities of the eastern James-Hudson Bay coast. Environmental Biology of Fishes 5:135-141.

———. 1981. The migrations of anadromous cisco (*Coregonus artedii*) and lake whitefish (*C. clupeaformis*) in estuaries of eastern James Bay. Canadian Journal of Zoology 59:1600-1607.

ROY, D. 1981. Répercussions de la coupure de La Grande Rivière à l'aval de LG-2. Hudson/James Bay Symposium, University of Guelph, Guelph, Ontario. 15 p.

SEBJ. 1977. Rapport d'Environnement LG-1. Etude des Variantes d'Aménagement Mille 23 vs. 44. Montréal: Société d'Energie de la Baie James. 233 p.

———. 1981. Réseau de Surveillance Écologique de Complexe la Grande 1979. Zooplancton et Benthos. Montréal: Société d'Energie de la Baie James.