9 Fish

The problem of fish and fish resources is complex because the aquatic data are incomplete for areas that are of critical importance to fish. We also tend to view the problem too narrowly: we are inclined to concentrate on fish rather than on the ecosystems of which they are part. A species-specific approach is undoubtedly necessary but we must not forget that a broader view of the aquatic ecosystem will lead to more effective identification of problem areas, and development of protective measures.

My principal concern for fish is similar to my principal concern for wildlife: we cannot protect every fish, but we must safeguard those areas where fish concentrate and we must avoid fish populations when they are sensitive to disturbance.

1. To ensure that the fish resources of the Mackenzie Valley and Mackenzie Delta are maintained, measures shall be employed to preserve aquatic habitat and to avoid disturbance of fish during critical life stages.

The evidence I have heard tends to fall into three categories: fish protection, monitoring of the aquatic environment, and fisheries management. I shall deal with each of these topics, but first we need to know the characteristics of northern fish if we are to understand the significance of the measures that are necessary to protect them from the impacts of development.

Characteristics of Northern Fish

Because of their specific life cycles and biological characteristics, the species of fish present in the Mackenzie Valley and the Mackenzie Delta are particularly sensitive to man-made disruptions of their aquatic habitat. Northern fish typically have slow growth rates, are large for their species, and reach sexual maturity at a late stage in their development. These factors mean that in most areas there is a large standing stock of the fish, but a low rate of productivity to maintain that stock.

Most northern fish have specific migration routes and limited spawning, overwintering, nursery and feeding areas. Northern fish can spend their lives entirely in fresh water or in salt water, or move between the two during various stages of their life cycles. Populations of some species, such as the arctic char, spend their lives in fresh water, whereas other populations of the same species migrate to sea. Throughout much of the Arctic, many populations of whitefish and lake trout use productive lakes as substitutes for the sea.

The Mackenzie River, because it originates in warmer latitudes, is more productive and therefore supports more fish species — 34 species have been found there — than most arctic rivers. The Mackenzie Delta and adjacent coastal estuary and lagoons are particularly important to fish: nineteen freshwater and four marine species are known to use these areas extensively.

Fish can be classified as either spring spawners or fall spawners. The eggs of fall spawners have to survive the rigors of the winter environment; they lie in the gravel from October until break-up the following May or June, when the fry hatch and move to nursery areas. Spring spawners deposit their eggs at break-up and the young emerge within a few weeks. Consequently, there is an important difference in the length of time the eggs of the two groups are vulnerable to environmental disruption.

In the Mackenzie River, fall spawners constitute 62 percent of the fish population, and spring spawners constitute 35 percent. The burbot, or freshwater cod, is the winter spawner in the system. Major spring spawning species are arctic grayling, yellow walleye, northern pike, longnose sucker and flathead chub. The arctic grayling, which is distributed throughout the system, is probably the most sensitive species of spring spawner.

Fall spawners in the Mackenzie system are dominated by the Coreonid (whitefish) class, the humpback, broad and round whitefish, arctic and least cisco, and the inconnu. With the exception of the more extensive lakes, these species have larger populations in the north end of the Mackenzie drainage. Well-defined spawning migrations of the whitefish family take place in the Mackenzie Delta channels and the Arctic Red, Peel, Great Bear and Mountain rivers. Arctic and least cisco live in the sea during much of their lives. Populations of all of these species use the Delta channels and brackish Mackenzie estuary as feeding, nursery, and overwintering areas.

Lake trout occur in significant numbers in the deep lakes of the Mackenzie tributaries and the Delta. They do not appear to be a major species in the flowing waters of the system.

Fish Protection

Principles of Protection

The basis of all fish protection is to safeguard critical aquatic habitat and life stages. In Part Three of this report, I deal with many of the specifics of protection as they relate to the pipeline project, but here I want to define biologically appropriate terms and conditions, and emphasize the two fundamental principles.

2. *Measures to protect fish should focus on important fish populations rather than on scattered individuals.*

3. *Fish protection should be designed to minimize disturbances where and when fish are most sensitive and most numerous, particularly in spawning grounds and overwintering areas, and along migration routes.*

Spawning and rearing areas, overwintering sites and migration routes are probably the most critical habitats for fish in the North. In addition to the physical sites, suitable water quality and food sources are also essential. Habitat areas and parameters are particularly important in the Arctic because of the generally limited ability of fish populations to recover their original levels after a severe environmental disruption has reduced their numbers.

Most northern fish species need spawning grounds that have the correct substrate – usually gravel or cobble – and suitable water temperatures. The gravel must be free of silt so that water can percolate around deposited fish eggs and permit gas exchange with the surrounding water. Clean gravel also provides good substrate for juvenile fish food, and suitable living space. A pipeline project could disrupt spawning and rearing areas by removing the gravel used for spawning or rearing; by changing the water temperature or chemistry conditions in a way that would be harmful to fish; by causing suspended sediment loads in streams to increase, which would induce silt to settle out on spawning beds and to smother eggs; or by polluting streams with toxic fuels or chemicals.

To survive the severe conditions of the Arctic winter, fish must stay in waters that are sufficiently deep that they will not freeze to the bottom. The flow of water into these areas must be monitored and that water must have tolerable chemistry, dissolved oxygen levels and silt loads and must be free of toxicants. The eggs of fall spawning fish must be in clean, well-oxygenated water during their incubation time. Fish or egg overwintering areas could be damaged by the same pipeline activities that could damage spawning and rearing areas, and by ditching or water removal that could cut off the intragravel flow into the overwintering areas.

Any disturbance of river beds that prevents or delays fish from migrating to normal life cycle areas can affect survival. Some species do not feed en route to spawning areas, and any significant delay in the migrating time might leave them with insufficient body energy to move to these areas. Project activities that could disrupt migration routes by creating barriers in rivers and streams include the installation of culverts, river diversion structures or ice bridges, and the lowering of water levels.

Northern fish also have a limited tolerance to changes in water chemistry – that is, to changes in temperature, in the levels of suspended solids, dissolved oxygen, and pH, and in salt content. They also have a limited tolerance to toxic substances, such as methanol, fuels and pipe-coating materials. Increased levels of suspended solids, for example, could be abrasive to fish gill membranes, and could be toxic to some invertebrate fish food and to fish eggs; and increased water temperatures could make important habitat areas unsuitable. And changes in all of these parameters could result from pipeline activities.

Some changes in aquatic environments may not affect the survival of the fish but they may leave the fish either unpalatable or unsafe to eat. A pipeline project could disrupt sport, commercial and domestic fisheries by introducing persistent materials, such as pesticides, PCB's, or heavy metals, into watercourses, where they could be picked up by fish directly or through the food chains, and accumulate in body tissue.

The ecological balance in a particular aquatic system can also be disrupted by reducing certain species, by removing food sources through chemical contamination or siltation, or by introducing a new species into a watershed in which it is not native. Because there are relatively few species in the North, and because food chains are short and the relationships between species are simple, northern populations are particuarly susceptible to disruptions of this kind.

Different fish species vary in their ability to tolerate disturbance. Arctic grayling, arctic char, pacific salmon, lake trout, inconnu, humpback and broad whitefish, and arctic and least cisco, because of their relatively low tolerance to siltation, particularly during spawning, appear to have the least resistance to disturbance. Slow growth and narrow age classes delay recovery. Economically, however, these are the most important species in the domestic, commercial and sport fisheries. Northern pike, walleyes, longnose and white suckers, flathead, chub and burbot have a broad habitat tolerance and relatively wide distribution, and they are, therefore, probably more resistant to the effects of environmental disturbance. The piscivorous or fish-eating species, such as pike, char, inconnu and burbot, would be most susceptible to chemical contamination because many biological contaminants pass up the food chain and concentrate in such predator species.

4. Pipeline construction and other activities should not be allowed at sensitive times near areas used by fish for spawning, rearing, overwintering and migration.

Spawning and rearing areas should be protected from siltation, gravel removal, fuel spills, and from changes in water temperature, water chemistry, and levels of dissolved oxygen.

During the winter, overwintering areas should be protected from any decrease in water level and flow caused by construction or water intake. They should also be protected from excess siltation, chemical pollution, changes in water temperature and decreases in dissolved oxygen levels.

Migration routes and times should not be disrupted by any blockage or diversion of flow, lowering of water level, significant increases in suspended sediment, or spills of fuels or toxic chemicals.

THE USE OF NUMERICAL STANDARDS

Much of the evidence I have heard suggests that it is not enough to state the principles of fish protection: it is often difficult to translate them into specific and workable measures. Numerical standards, it seems, are needed as a guide for all who are concerned with the design, review, construction and operation of the pipeline. However, Arctic Gas and, to a lesser extent, Foothills do not agree. They argued that a competent biologist should make site-specific decisions. I agree in principle with their argument, but I do not think it is practicable for a project of this size. Indeed, a protection program founded entirely on such individual judgments may result in unnecessary delays, and unwarranted confusion and, most important, may fail to protect the fish.

It requires a certain academic naïveté to believe that thousands of site-specific design and construction situations can be evaluated satisfactorily by competent biologists. The principle of numerical standards should, therefore, be vigorously promoted. Such standards will inform design engineers of the criteria they must meet; they will show construction personnel the permissible levels for environmental disruption; and they will indicate to operational personnel the operating specifications that must be followed.

I recognize that, in isolated situations, it may be impractical, and perhaps even harmful to the environment, to comply with the numerical standards. If the Company can demonstrate to the Agency that certain numerical standards should not be expected in a particular situation, the Agency may grant an exception. Nevertheless, the principle of numerical standards should, I believe, provide the cornerstone of a sound fish protection program.

Suspended Sediment

The construction of the pipeline will cause increased siltation of waterbodies through the direct disruption of the waterbody, or through increased run-off from adjacent land areas. Although concentrations of suspended solids must be extremely high before they cause direct, short-term damage to fish, finely divided material may settle to the bottom and blanket out normal fish food organisms, or they may spoil spawning beds by decreasing the percolation of water through the substrate. If siltation damage to spawning beds or fish food occurs in only one year, recovery of the stream bed can be expected in successive seasons, and the overall damage to fish populations would probably not be great.

To predict the impact of suspended sediment on the aquatic ecosystem requires an awareness of the seasonal variation of sediment loads: what may be tolerable in spring, when natural sediment loads are high, may be unacceptable in the winter, when most northern rivers are relatively clear. Winter construction of a pipeline may, therefore, cause special suspended sediment problems in watercourses.

5. The construction and operation practices of the Company shall be such as to minimize the release of silt into waterbodies frequented by fish. In areas that are important to fish and where silt loads from project activities can be expected to be significant, the Company shall institute silt control measures before construction activities start.

6. Specific standards shall be established by the Agency to measure the natural silt load in watercourses, and to set upper limits for increased silt loads. If silt loads exceed the upper limits, erosion and silt control measures shall be put in place, or existing ones shall be improved to ensure that the critical habitats and life stages of aquatic resources are protected.

GUIDELINES FOR SUSPENDED SEDIMENT STANDARDS

In his final submission, Commission Counsel proposed a turbidity and macroinvertebrate standard for estimating the increase in finely-divided solids in waterbodies and for assessing the effects of any increase on bottom macroinvertebrates in a stream. These standards and the rationale behind them are given extensive treatment in the submission (Commission Counsel, 1976, "Fish Protection: Suspended Sediment Standards"). I endorse the standards proposed by Commission Counsel and I recommend that experts in the Agency and in the Company refer to that document to appreciate the approach I have adopted below. I must emphasize at the outset that these standards and methods of measurement need further refinement. In particular, they have yet to be tested under winter conditions in the North.

7. The standards for suspended sediment should be tested by the Company and the Agency under field conditions in the *pipeline areas and should be refined so that acceptable and practicable suspended sediment criteria for monitoring the pipeline project can be developed. If other standards are considered, they should have the following characteristics. They should be quantitative and objective; they should be practical enough to be used and to be enforced in the kinds of conditions that will be encountered by the pipeline project; they should be routinely workable by a small staff that is not highly skilled in scientific sediment load assessment practices; and they should measure both short-term and long-term increases in sediment load.*

A standard that sets limits on changes in suspended sediment is necessary to prevent widespread or continued damage to aquatic life. Because it is fairly easy to determine in the field and because the results are known immediately, Commission Counsel recommended that a turbidity standard be adopted.

Before the turbidity standard can be implemented, the following problems may have to be resolved. First, results may vary across the width of a stream river, or from day to day because of wind on lakes. The standards are intended to apply at any point that is the recommended distance from operations. Secondly, the collection of samples will be difficult in winter; it will require well-designed equipment for penetrating the ice and retrieving samples. Finally, if turbidity exceeds the standards, it will be an indication that construction practice is not satisfactory. This situation will be difficult to correct quickly because of the lingering effects of the causes of siltation.

A macroinvertebrate standard assesses the biological effects of an increase in sediment. Because the status of the resident macroinvertebrate community reflects conditions over previous weeks or months, it serves as a continuing, cumulative monitor, and to a large extent it will reflect any problems that are not detected by the infrequent turbidity measurements. Since the diversity of the aquatic community also monitors environmental effects other than siltation, the Agency could use the biological evaluation as an overall check. In questionable cases, findings of the biological survey should take precedence over the physical and chemical surveys.

There are many ways of interpreting ecological data, and Commission Counsel recommended that the Shannon Diversity Index be used because we have experience with it and because it is sensitive, reliable and conducive to use by both professionals and laymen alike. However, two problems may be encountered when implementing the macroinvertebrate standard: it may be difficult to take samples of benthic invertebrates during periods of high discharge in rivers, and it may be difficult to separate benthic invertebrates into individual species.

8. *The frequency and locations for suspended sediment sampling in rivers, streams, lakes and ponds shall be as defined by the Agency. The direction of the sampling site from the construction activity shall be that of maximum effect, depending upon currents and wind. A control sample shall be taken in an unaffected part of the same waterbody or, if that is not possible, in a similar, nearby waterbody.*

Samples shall be taken frequently enough to provide adequate assessments of the amounts of finely-divided solids generated by construction both during the construction phase and immediately afterwards. In particular, turbidity shall be measured at the time of peak activity and during changing discharge.

9. *Turbidity shall be measured in nephelometric turbidity units (NTU), using any reliable, commercially available meter. Procedure for measurement shall follow part 214A of* Standard Methods for the Examination of Water and Wastewater, *prepared by American Public Health Association et al.*

10. *The following standard should be used to determine allowable levels of finely-divided solids in water: at the specified distance from operations, turbidity of the water shall not average more than 27 times the natural level during any 8-hour period, or more than 9 times the natural level during any 96-hour period, or more than 3 times the natural level during any 30-day period.* (For rationale see Commission Counsel, 1976, "Fish Protection: Suspended Sediment Standards.")

11. *Benthic macroinvertebrate samples should be taken in stream riffles using a reliable quantitative device, such as the Surber sampler. The same apparatus shall be used to take both control samples and test samples, and because macroinvertebrate communities may vary seasonally, the samples shall be taken at the same time. The test and control sampling areas must be as similar as possible, particularly with regard to bottom type and velocity of water.*

12. *The following standard should be used to determine ecological damage: at the specified distance from operations, the Shannon Diversity Index for bottom-living aquatic macroinvertebrates shall not be changed more than 25 percent from the natural value as a result of the addition of finely-divided solids.* (For rationale see Commission Counsel, 1976, "Fish Protection: Suspended Sediment Standards.")

13. *The suspended sediment standards shall apply during construction activities, and for two years after they have ceased.*

14. *In the year that starts 12 months after completion of a construction activity, turbidity should not exceed one-half of the levels recommended above and diversity shall not be changed more than the 25 percent recommended above.*

Barriers to Fish

During construction and operation of the pipeline, a variety of structures that could become barriers to the normal movement of fish will be placed in watercourses. There will be culverts beneath temporary and permanent roads, dykes and coffer-dams to divert river flows, and ice bridges, wharves and work pads at river crossing sites. These kinds of installations, which are a vital part of any construction program, could prevent or delay fish migrations by constricting the channel and thereby increasing the water velocity, by altering the river regime, or by physically obstructing the migration routes.

15. *Installations and activities in waters that are inhabited by fish shall avoid fish-sensitive areas, and shall be designed and scheduled to provide for uninterrupted movement and safe passage of fish. Any structure or stream channel change that may cause blockage to fish, or that may create velocity barriers to fish movements, shall be provided with a fish passage structure or facility approved by the Agency.*

16. *The Company shall submit to the Agency, for design review, complete plans for dredging, trenching, diversion structures, or road crossings of waterbodies. The plans shall include such matters as: schedules for activities; amounts of spoil material to be removed or placed; designs and methods of construction; data on present flow regime or bathymetry of the waterbody in which work will be done; data on the fish resources that are present in the waterbody at all times of the year; information on how flow regimes or bathymetry of the waterbody will be altered by construction; and an assessment of how the fish species that are present in the system will be affected.*

DESIGN GUIDELINES: BARRIERS TO FISH

17. *On fish migration routes, bridges with large spans across watercourses shall be used, wherever practicable, instead of culverts.*

18. *Culverts in watercourses that contain fish shall be of such a size and gradient that the peak water velocity and minimum water depth will not inhibit the passage of migrating fish. The lower ends of culverts in stream beds will be so placed as to eliminate any drop. The applicable standards for fish passage requirements and culvert design shall be as outlined in* Guidelines for the Protection of the Fish Resources of the Northwest Territories During Highway Construction and Operation *by Dryden and Stein.*

19. *Subject to the approval of the Agency, designed fords may be used for temporary stream crossings.*

20. *Winter road ice bridges shall be removed from small watercourses before break-up.*

21. *Construction and use of temporary coffer-dams, berms and diversion dykes in any watercourse that is frequented by fish shall be done in stages or shall be time-staggered to ensure that water velocity does not prevent fish passage. Abandoned water diversion structures shall be plugged and stabilized to avoid trapping or stranding fish.*

22. *If borrow material sites are approved adjacent to or in waterbodies, the Company shall provide levees, berms or other structures to protect fish and fish passage, and to prevent siltation of such waterbodies.*

23. *Water intakes shall be installed and screened in such a way that the intake will not harm fish. (See* Water Withdrawals.)

Underwater Blasting

Some underwater blasting will be necessary in the course of pipeline work. Throughout the hearings, there was frequent comment, particularly in the communities, on the detrimental effects of underwater blasting on fish, muskrat and beaver. Although I am concerned here only with fish, my observations may also apply to aquatic mammals. (I discuss terrestrial blasting operations in the chapter on Terrain Considerations.)

The effects of blasting on fish include direct consequences from the blast, and siltation from the blasted material. Blasting affects the swimbladder, an organ present in most freshwater fish to aid in swimming: the shock waves rupture the bladder, often bursting blood vessels and damaging tissue organs near the bladder. Furthermore, it has been suggested that chemicals present in the water immediately after the explosion may also be detrimental to fish and could disrupt fish migrations.

Factors that determine the extent of damage to fish include water depth, distance from the blast, strength of charge and position, and type of bed. The most serious damage occurs close to a blast site, in gravel-bottom or rock-bottom streams. Silty or muddy stream beds absorb some of the shock waves that are generated by a blast, whereas hard stream beds reflect the shock. Detonations under ice are more damaging to fish than those in open water because ice tends to contain the shock waves.

Blasting could significantly reduce fish populations if it took place in breeding or overwintering areas at times of high fish concentrations. Simultaneous activity in a watercourse could increase the damage to fish populations because it would reduce the number of areas that fish could move to during a blasting operation.

24. *Blasting in waterbodies should be avoided near fish-sensitive areas. Where blasting must be carried out, every effort should be made to schedule the activity so that fish concentrations are avoided, especially at critical stages of their life cycle.*

25. *Blasting shall not be permitted in waterbodies within 1,000 feet of areas in which concentrations of fish eggs are present in the bed, fish are spawning in restricted areas, fish* *are overwintering in restricted areas, or fish are migrating in concentrated schools.*

26. *Where a requirement for blasting in a waterbody is identified during design and planning, the Company shall submit to the Agency an application for permission to blast, together with the information needed to assess the potential impact on fish, and a statement of measures to protect the fish during blasting.*

Where a requirement for blasting in a waterbody is identified during construction activities, the Company's blasting proposal, its potential impact, and fish protection measures shall be subject to approval by the Agency in the field.

27. *Blasting shall be permitted in water that is frequented by fish only if effective measures are taken to protect the fish. Such measures could include adjusting the time of the blast, moving fish and keeping them out of the blast area by means of nets, using blast deflectors (sand bags) or absorbers (air curtains), using charges of minimum size, and detonating charges in sequence with sufficient delay between firings to permit dissipation of the shock wave.*

28. *Underwater blasting shall conform to the same siltation standards as other in-water pipeline activities.* (See Fish: Suspended Sediment.)

29. *Underwater blasting shall be prohibited within one mile of fishing sites that are being used by local people and local fishermen.*

Monitoring of the Aquatic Environment

In the chapter on Wildlife, I stated that a monitoring program is essential to ensure both the maintenance of populations and the effectiveness of any protective measures that may be adopted as part of a pipeline project. Monitoring of the aquatic environment is particularly important: the aquatic environment is less accessible to observation, and problems are often not evident until they reach intolerable levels. In some cases, postconstruction monitoring will be particularly important. The monitoring of siltation levels, for example, is probably more important after construction than at any other time. Such monitoring may be necessary for several years after construction ends.

30. *During the construction and operation of the pipeline the aquatic environment shall be monitored. The Agency, in cooperation with the government agencies responsible for ongoing fish protection, should develop the monitoring program and establish what the responsibilities of the Company will be before, during and after construction.*

I recognize that the development of a monitoring program will require a detailed knowledge of local conditions and project activities. Although I cannot say what form such a program would take, I can suggest aspects of monitoring that may be necessary and appropriate. I have based my guidelines on those contained in Commission Counsel's final submission (Commission Counsel, 1976, "Fish Protection: Monitoring of Aquatic Environment").

Monitoring Guidelines

31. *An aquatic environment monitoring program should be divided into three phases – preconstruction, construction and postconstruction – and should incorporate the following observations and factors:*

Turbidity should be used to compare postconstruction levels of suspended sediment with preconstruction levels. During construction, turbidity levels downstream from construction should be compared with turbidity levels upstream.

Dissolved oxygen levels should be monitored to ensure adequate oxygen levels in water where fish resources are present. These levels, which are most critical in winter, should be measured in waters that may be disturbed by construction or operation of the project.

Water levels and flows should be monitored where and when water quantities are limited, to ensure that adequate quantities are maintained for fish.

Nutrient levels should be monitored in waste disposal areas to prevent overenrichment of fish habitat or high biological oxygen demand.

Fish and bottom sediment contaminant levels should be monitored as a baseline measure that will warn of any contamination of a fishery resource.

Water temperature should be monitored to ensure that tolerable limits for aquatic resources are maintained, and that water temperature is low enough to maintain adequate oxygen levels.

Gravel removal sites should be inspected before, during and after construction to determine the suitability of the site for removal of material, and to assess conformity with extraction plans, adequacy of restoration of site, and return of site to a stable state.

Chemical water quality parameters should be monitored in locations where pipeline-related activity might create chemical changes in water quality that could adversely affect fish.

Water velocities through culverts and some diversion structures should be monitored to ensure that velocities do not exceed the capabilities of fish migrating upstream.

Use of explosives in water should be checked visually to ensure that local fish populations are not affected by shock waves from blasts.

Pipeline crossing site inspections should involve visual *checks to ensure that erosion control devices are working, and that disturbed areas do return to a stable state.*

In addition to general monitoring, a few comprehensive studies may be necessary in certain aquatic environments that are sensitive to environmental disruption, or to the extensive use of resources by man. For example, it may be necessary to establish parameters such as benthos productivity and diversity, and the population dynamics of a domestic fishery resource, and to monitor the abundance of rare species.

Fisheries Management

Man's Use of Fish

In the North, the domestic, commercial and sport fisheries overlap in some areas as each fishery competes for the same species. This overlap will probably increase in the future.

The government's management programs are, for the most part, directed towards the benefit of native people. Accordingly, the harvesting of fish for domestic purposes has precedence over commercial or sport fishery development.

The domestic fishery is traditionally an important source of protein in the Mackenzie Valley and Mackenzie Delta. Native people depend on fish for part of their dietary requirements, and as food for their dogs. The domestic fishery has declined somewhat since the snowmobile replaced dogs in many areas, but the catch is still important as a supplement to other wildlife sources of food.

Since its start in 1945 on Great Slave Lake, commercial fishing has continued uninterrupted in the Mackenzie drainage. Whitefish is the most important species harvested. At the present time the only other commercial operation outside the southern lakes of the system is a small, experimental commercial fishery on the East Channel of the Mackenzie Delta.

Sport fishery for arctic grayling throughout the Mackenzie drainage, and for char and lake trout in the Mackenzie Delta, represents a great tourist potential.

Fisheries and the Pipeline Project

Pipeline construction will make accessible many domestic, commercial and sport fishing locations that were previously isolated. Access will be provided by new roads, the location of construction and operating personnel in remote areas, and an increase in air and water traffic along the route. The increase in sport and commercial fishing activity could affect the ongoing domestic harvest. River traffic, fishing by construction personnel, spills, the location of facilities such as stockpile sites and wharf sites, and the general consequences of constructing the project on fish biology will all have a significant effect on fishing activities.

As I explained earlier, northern fish populations have a limited capacity to recover from unnatural losses. If fishing by pipeline personnel is not regulated, short-term reductions in fish populations along the route may occur. Long-term reductions could result if permanent access routes are opened up, and if fishing is not adequately controlled.

32. *Construction and operation of the pipeline and associated activities shall not interfere with ongoing domestic, commercial or sport fishing activities of the region. Pipeline activities shall not disturb fishing areas or cause changes to water, with the result that fish avoid certain fishing areas. Protection shall be afforded first and foremost to domestic fishing activities and domestic fish resources.*

33. *Unless otherwise approved by the Agency, pipeline-related facilities and activities shall be located at least 1,000 yards from any existing, well-defined domestic, sport or commercial fishery. Where pipeline activities or facilities are within one mile of such a site, the Company shall provide the local people with a description of its planned activities in the area. Any modifications requested by the local people shall be worked out in consultation with representatives from the local people, the Company, and the Agency.*

34. *Where local people and government authorities agree that project access roads are beneficial to local fisheries, they should be left intact when pipeline construction is completed. All other project access shall be blocked and the disturbed areas shall be restored when pipeline use of the access route has ended.*

Throughout the Inquiry, biologists told me that there are insufficient data on fish, particularly the domestic fishery, to develop a comprehensive management program. In my opinion, both the proponent of a major frontier development and the government have an obligation to ensure the continuation of fisheries in the region. The pipeline company has an obligation to show that it has properly researched the impacts of its project on resource harvesting activities.

In order to draw up workable and detailed plans for protecting fishing activities during pipeline construction, specific information is necessary.

35. *To plan for the protection of fisheries, the Company, in cooperation with all agencies responsible for fisheries management and the native organizations, shall compile a catalogue of fishing areas and fishing activities along the route.* (See Renewable Resources.) *This catalogue should provide a complete listing of all fish species caught in the domestic, commercial and sport fisheries, as well as information on the numbers of fish caught, the time of year and location of catches, the fishing methods used, an approximate estimate of catch per unit of fishing effort, the way fish are used after being caught, and the numbers of people involved in each fishery and the locations of fishing camps.*

36. *Before pipeline activity begins, the Agency shall establish regulations to control the level of fishing activity by Company* *personnel during construction, and shall develop programs to monitor changes in fishing activity that result directly or indirectly from the pipeline project.*

37. *During the pipeline construction period, no sport fishing shall be permitted from pipeline structures or within the pipeline right-of-way. Personnel engaged in pipeline construction, operation or maintenance shall not fish within 1,000 yards of any domestic or commercial fishery, or any area, such as a well-defined fish overwintering region, that is vulnerable to overfishing. Maps and descriptions of prohibited areas shall be posted in pipeline camps, and explained to personnel in worker-orientation programs.*

38. *The Company shall ensure that all fishery regulations are observed by all persons working on the pipeline project.*