A Biological Assessment of the Post-Impoundment Commercial Fishery at Southern Indian Lake, Manitoba, with Historical Comparisons.

by

© Dennis Peristy

A Practicum submitted in partial fulfillment of the Degree of Master of Natural Resources Management.

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ABSTRACT

There have been significant reductions in the catch per unit effort and grade of the commercial whitefish (Coregonus clupeaformis) fishery at Southern Indian Lake (SIL) after lake impoundment and diversion of the Churchill River for hydro-electric development in 1976. It was the purpose of this study to assess biologically the commercial fishery of SIL during the 1987 and 1988 open water seasons. The 1987 whitefish catch per unit effort of 8.44 kg per net night from traditional fishing areas has not recovered to pre-impoundment levels since it was last evaluated in 1981. The geographic distribution of fishing effort has shifted to non-traditional areas of the lake, in response to the lower catches from traditional regions. Fish prices appeared to be the determining factor in the type of species pursued, the quantity of effort expended and the geographic distribution of fishing effort. The quality of whitefish delivered from traditional areas declined from export to continental grade. The age structure of the commercial whitefish catch was similar to that of previous studies with a mean age of 9.7 years. There may be evidence that the whitefish fishery is beginning to return closer to pre-impoundment conditions. Recommendations call for the development of a management plan for the SIL fishery to maximize benefits to the South Indian Lake community.

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INTRODUCTION

1.1 PRELIMINARY INFORMATION

Southern Indian Lake (SIL) was northern Manitoba's largest commercial fishery prior to impoundment of the lake and diversion of the Churchill River by Manitoba Hydro in 1976. There was a general collapse in the lake whitefish (*Coregonus clupeaformis*) portion of the commercial fishery after hydro electric development. The long term effects of the development on the whitefish populations and the commercial fishery of SIL are not fully understood.

The Federal Department of Fisheries and Oceans has been involved as the primary research agency at SIL since its involvement in a federal-provincial study to examine environmental impacts of hydroelectric development (Lake Winnipeg, Churchill and Nelson Rivers Study Board 1975) and has conducted research under the direction of the Northern Flood Agreement (1977). Monitoring and research which occurs on an ongoing basis, is necessary to provide baseline information and data which can describe trends through time.

The purpose of this study is to assess biologically the post-impoundment commercial fishery at SIL, during the 1987 and 1988 open water seasons. Data generated by this research compliments previous work done by the Department of Fisheries and Oceans, and assists in the understanding, management and possible enhancement of the fishery.

1.2 PROBLEM STATEMENT

A commercial fishery can be the largest social and economic activity in a northern community. This continues to be the case at Southern Indian Lake. The commercial fishery at SIL was based on the high quality whitefish fishery which was present before impoundment. The fishery which has continued to evolve since impoundment, has done so in ways which reflect the most feasible opportunities available to the fishermen. The fishermen have reacted to the post-impoundment conditions by changing fishing locations, shifting to other commercial species and increasing fishing effort.

The catch per unit effort for whitefish on historic fishing grounds decreased 68% from 1972 to 1981 (Bodaly et al. 1984b). The market quality of the whitefish catch declined from export (A) grade to continental (B) grade with the concurrent increase in cyst count and a shift to darker colored fish. (Bodaly et al. 1984b). These changes created a condition of lower overall economic returns for the fishermen of Southern Indian Lake (Wagner, 1984).

More information on the status of the SIL fishery is needed to better determine management decisions and objectives. It is important to determine if the lake's fisheries are stabilizing or still in a state of change. What is the commercial availability of whitefish in the historic fishing grounds? Is the downgrading of the lake permanent? Should the commercial fishery be species, location, or seasonally specific? The biological information from the research can be used to assist in determining the type of commercial fishery which should exist on SIL.

1.3 BACKGROUND

Southern Indian Lake is located in Northern Manitoba, within the Canadian Shield region (fig. 1.1). It is intersected by the Boreal Forest and Boreal Forest/Tundra Transition ecological zones, with their respective climatic and biotic types. Permafrost is common in the region. It is part of the Churchill River system and is one of the province's largest lakes. It is a biologically productive lake for northern shield regions, primarily due to the inflow of the Churchill River and its relatively shallow depth. The lake has a high proportion of shoreline length to total area, as a result of the numerous islands, bays and inlets. It is essentially in a riverine condition as a result of its shallow mean depth which does not allow for a normal lake thermostratification.

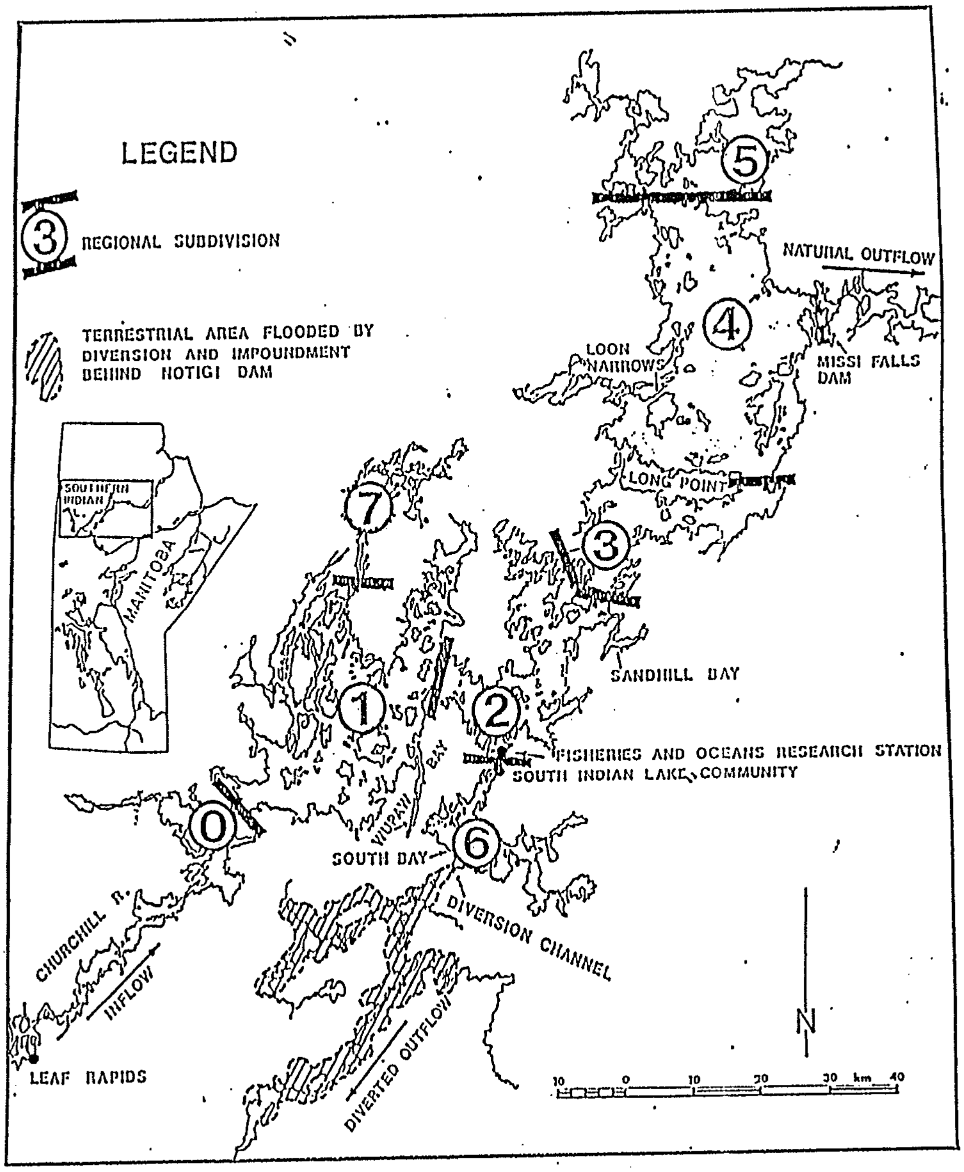

Figure 1.1: Southern Indian Lake (from Newbury et.al. 1984)

The South Indian Lake community is located in the southern portion of the lake and has a population of approximately 600. It is a native-Canadian community and is part of the Nelson House Indian Band. The community does not have direct, year-round road access. It is serviced by a ferry operation in the summer and a winter road for part of that season. Freeze-up and ice-out isolates the community, with the exception of air access.

Commercial and domestic fishing have been and continue to be important social and economic activities for the South Indian Lake community. The SIL commercial fishery was the largest in northern Manitoba, consistently supporting over 100 licensed fishermen, and having an annual quota of 450,000 kilograms, prior to the 1976 impoundment of the lake and diversion of the Churchill River by Manitoba Hydro (Bodaly et al. 1984b). Approximately 85% of the total commercial catch weight was composed of light colored, export (A) grade whitefish, that were only lightly parasitized with the muscle cysts of <u>Triaenaphorus</u> <u>crassus</u> (Bodaly et al. 1984b). Fishing effort was limited to traditional regions (Region 4, Fig. 1.1) of the lake, which produced whitefish of high quality and high value. Those regions which produced whitefish of lower quality and lower value were avoided (Region 5, Fig. 1.1). The exploitation of the export grade whitefish produced considerably higher total returns to the fishermen, as compared to other grades of whitefish or other commercial species.

Since Manitoba Hydro altered the lake's natural level and flow regime, decreases have been documented in the catch per unit effort, market quality, color and cyst count of the catch (Bodaly et al. 1984b). From 1972 to 1981, the catch per unit effort had fallen 68% and cyst counts increased 57% to cause a decrease in the lake's whitefish classification from export (A) grade to continental (B) grade (Bodaly et al. 1983). Effort shifted from traditional (Region 4), to new areas of the lake (Region 5) in an attempt to maintain catch levels. Up to 62% (1979) of the fishing effort occured at new areas after impoundment and regulation (Bodaly et al. 1983).

The market grade of the fish, as related to Triaenaphorus cyst count and color, showed dark colored continental (B) grade fish, making up a higher proportion of the catch. This reached a maximum in 1981, when 81% of the whitefish catch was classified as continental (Bodaly et al. 1983). The amount of cysts in the whitefish flesh is a major determinant of grade. Dark colored whitefish have been noted to have higher cyst levels than light colored whitefish in Southern Indian Lake (Johnston 1984). Color was the basis for grade determination at the local fish packing plant between 1978 and 1980, as an attempt to maintain the lake's grade classification at export. In 1982, the whole whitefish catch of the lake was downgraded to continental grade. Much fishing effort has now shifted to non-flooded, outlying lakes of the SIL fishery, as an attempt to utilize the fisheries of those lakes.

1.4 OBJECTIVES

The purpose of the research is to assess biologically the post-impoundment commercial fishery at Southern Indian Lake, during the 1987 and 1988 open water seasons, with historical comparisons from previous SIL commercial fishing studies. Specifically, the following objectives will be addressed:

1. to quantify and compare the catch per unit effort, the grade, and the age distribution of the lake whitefish catch, among commercially fished regions of SIL;

2. to examine the geographic distribution of fishing effort, the frequency of net relocation, and the commercial fish species composition of the commercial operations, in the various commercially fished regions of SIL;

3. to provide recommendations which would improve the status of the commercial fishery.

1.5 IMPORTANCE OF THE STUDY

The primary importance of the study is to provide data on the biological status of the commercial fishery ten years after the last comparison and twenty years after impoundment. This will allow for a recent update of the condition on the fishery for management purposes and to contribute to the overall study on the effects of impoundment in a northern fishery. The information from the research can be used by the commercial fishermen of SIL to learn more about the biological status of the fishery and to assist in developing their goals and objectives for the fishery. In the past, information from Southern Indian Lake studies have been useful in determining compensation and subsidy rates. If the need for future mitigation occurs due to other Hydro activities, then information from this study may be useful in determining levels of assistance. Additional studies by Baker (in preparation) entitled An Economic Study of the Southern Indian Lake Commercial Fishery and by Barnes (in prep.) regarding whitefish populations and whitefish movements out of the lake are nearing completion. The total information from these studies can be integrated into a more complete knowledge of the fishery.

The main client for this study is the Federal Department of Fisheries and Oceans. Other interested parties could be the Southern Indian Lake Commercial Fishermen's Association, the Manitoba Department of Natural Resources, Manitoba Hydro, the Northern Flood Committee, the Freshwater Fish Marketing Corporation, the Federal Department of Indian Affairs and Northern Development, the Treaty and Aboriginal Rights Research Centre and the international scientific community.

Chapter II

REVIEW OF THE RELATED LITERATURE

There has been extensive study and documentation at Southern Indian Lake by many government agencies, regarding environmental and socio-economic changes which took place after hydro-electric development. More specifically, the Federal Department of Fisheries and Oceans has produced much information on a wide range of biophysical topics, related to the effects of a major hydro development on a large northern lake system. This literature review will synthesize background information which is relevant to the understanding of the changes which occured to the commercial fisheries of Southern Indian Lake.

2.1 BACKGROUND

In 1976, Manitoba Hydro set into working operation on Southern Indian Lake the Churchill River Diversion (fig. 2.1). This was done under licence from the government of Manitoba. The project was developed to transfer water from the Churchill River over to the Nelson River, to increase flows for power generation. This was accomplished by placing a control structure at Missi Falls, the natural outlet of Southern Indian Lake. This served to raise the

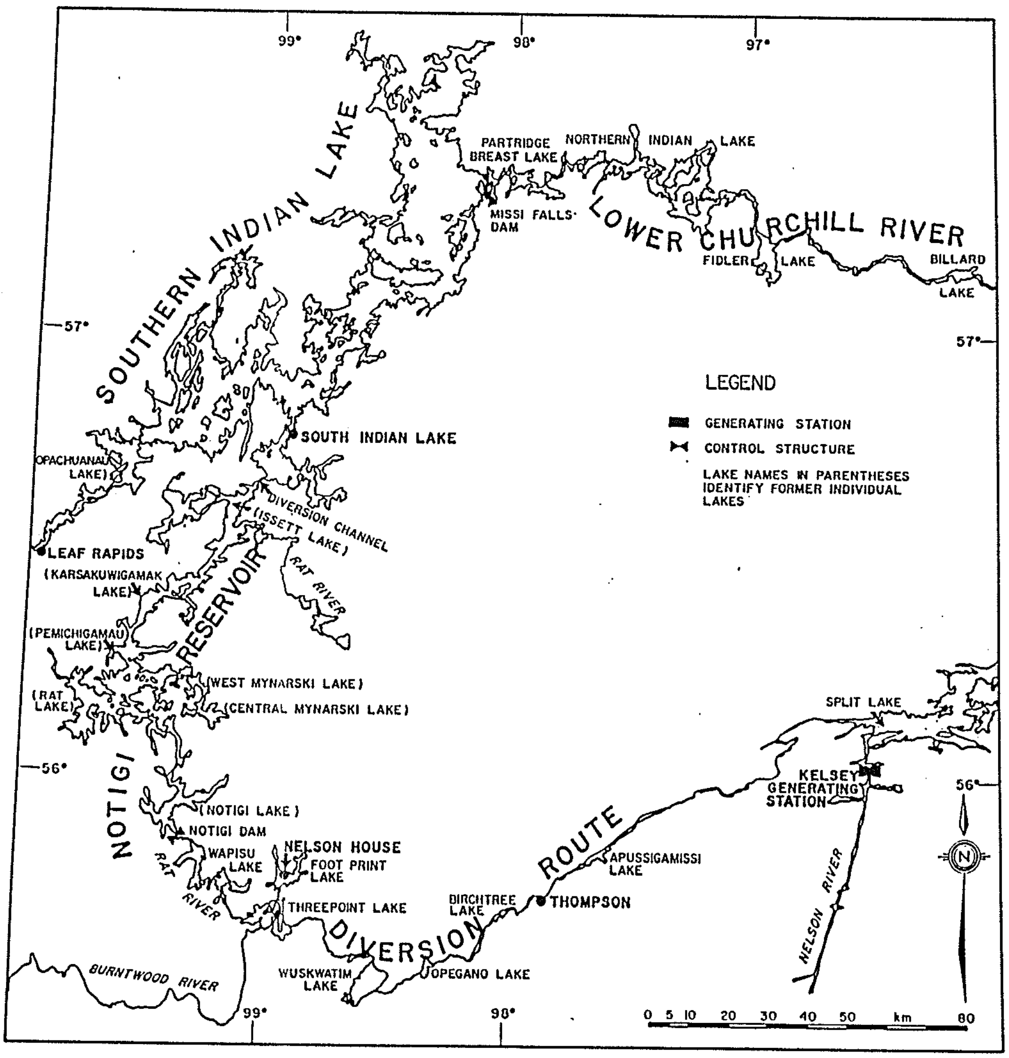

Figure 2.1: Churchill River Diversion (Newbury et al. 1984)

level of the lake by approximately 3 meters (255 m above mean sea level to 258 m above mean sea level) over the mean elevation under historic natural elevations (Newbury et al. 1984). An outlet channel was constructed at the south end of the lake, connecting South Bay to the headwaters of the Rat river. Approximately 75% of the Churchill River flow was diverted southward. The Notigi control structure was built at the outlet of Notigi Lake to control the new downstream flows from SIL (Newbury et al. 1984). Immense environmental alterations took place after diversion and regulation, which affected the people of the South Indian Lake community, the physical, chemical and biological characteristics of the lake, and the two downstream segments of the system.

2.2 POST IMPOUNDMENT PHYSICAL CHANGES

The total area of Southern Indian Lake increased approximately 21%, from 1977 km2 to 2391 km2, and the total volume increased approximately 39%, from 16.84x10 9 m3 to 23.38x10 9 m3 after impoundment (McCullough 1981). The mean depth of the Lake increased 15% to 9.8m, and the net shoreline length increased approximately 3.5% from 3665 km to 3788 km after impoundment (Newbury et al. 1984). The changes in shoreline length, and the water level increases above the natural wave-washed shore zone, caused a change in the type of materials at the eroding face of the shoreline.

Prior to impoundment, bedrock comprised 76% of the lake's shoreline, and after impoundment this was reduced to 14%. The majority of the new shoreline was made up of fine-grained, permafrost overburden materials (Newbury et al. 1984).

The wave energy expended onto the new shoreline types brought about an increase of easily eroded material into the lake, including shoreline vegetation and peat moss. It was estimated that the sediment input from these sources will continue for decades (Hecky and McCullough, 1984). The unconsolidated eroded materials from the unstable shorelines dramatically increased the turbidity of the lake's water. This led directly to decreases in lake temperatures by 1 to 2 degrees celsius, and also to decreases in light available for photosynthesis (Hecky 1984). It was concluded by Patalis and Salki (1984) that these changes brought about decreased productivity and compositional changes in the zooplankton community. Residents of the area have indicated through personal communication that before the project, one could look over 3 meters into the water, and now there are times when one can't even see to a depth of .3 meters. Other problems which have been produced as a result of flooding are the movement of the original Southern Indian Lake community, decreased access by residents to shorelines due to flooded forest areas, and floating debris.

Increased mercury levels in fish species utilized by the domestic and commercial fisheries has also occurred (Bodaly et al. 1984a). The higher mercury levels have been found to be due to a natural process (methylation/demethylation), out of balance, as a result of the flooding adding terrestrial materials to the aquatic environment. An extensive report was produced in 1987 on the mercury situation at Southern Indian Lake, as a result of a Canada-Manitoba agreement (Summary Report, Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion, 1987). Studies included in the report noted that lakes which were the most extensively flooded contained fish with the highest mercury concentrations and that a doubling of peat moss material resulted in a doubling in the amount of mercury which accumulated in the fish. These findings are of considerable importance for the future of the SIL fisheries, the South Indian Lake community and also in the planning of new reservoirs.

2.3 THE COMMERCIAL FISHERY AT SOUTHERN INDIAN LAKE

Archealogical evidence suggests that fishing was an important way of life for the people in the Southern Indian Lake region as far back as 3000 years ago (Mallory 1975). The commercial fishery began on Southern Indian Lake in the winter of 1941/42 and the summer fishery began in 1950 (Weagle and Baxter 1973). Prior to regulation, the commercial fishery consistently employed over 100 licensed fishermen and their helpers yearly. It was stated by Hecky and Ayles (1974) that prior to impoundment Southern Indian Lake had a higher production of fish then any of the other shield lakes in the region. Ayles (1976) indicated that this was partly due to the flow of the Churchill River having a strong influence on the lake's productivity. Ayles (1976) also stated that pre-impoundment maximum sustained yield of the commercial fishery, was probably significantly in excess of the quota at that time and that there was no reason to believe that the fishery would decline within natural conditions. The annual quota of the lake has been approximately 450,000 kg up to the present. The majority of fish from the lake are delivered by fishermen to the Missi Falls fish station, where the fish are sorted, repacked and then delivered to the Leaf Rapids plant. Transportation of the fish to Leaf Rapids is by the Freshwater Fish Marketing Corporation boat, the Kinoosao.

The commercial fishery at SIL was the largest in northern Manitoba prior to impoundment and diversion, with about 333,500 kg of fish taken yearly (Bodaly et al. 1984b). Approximately 85% of the total commercial catch weight was composed of the lake whitefish, with the rest being made up of pike (Esox lucius) and walleye (Stizostedion vitreum) (Bodaly et al. 1984b). The species composition of the open water commercial catch from 1950 to 1988 is shown in figure

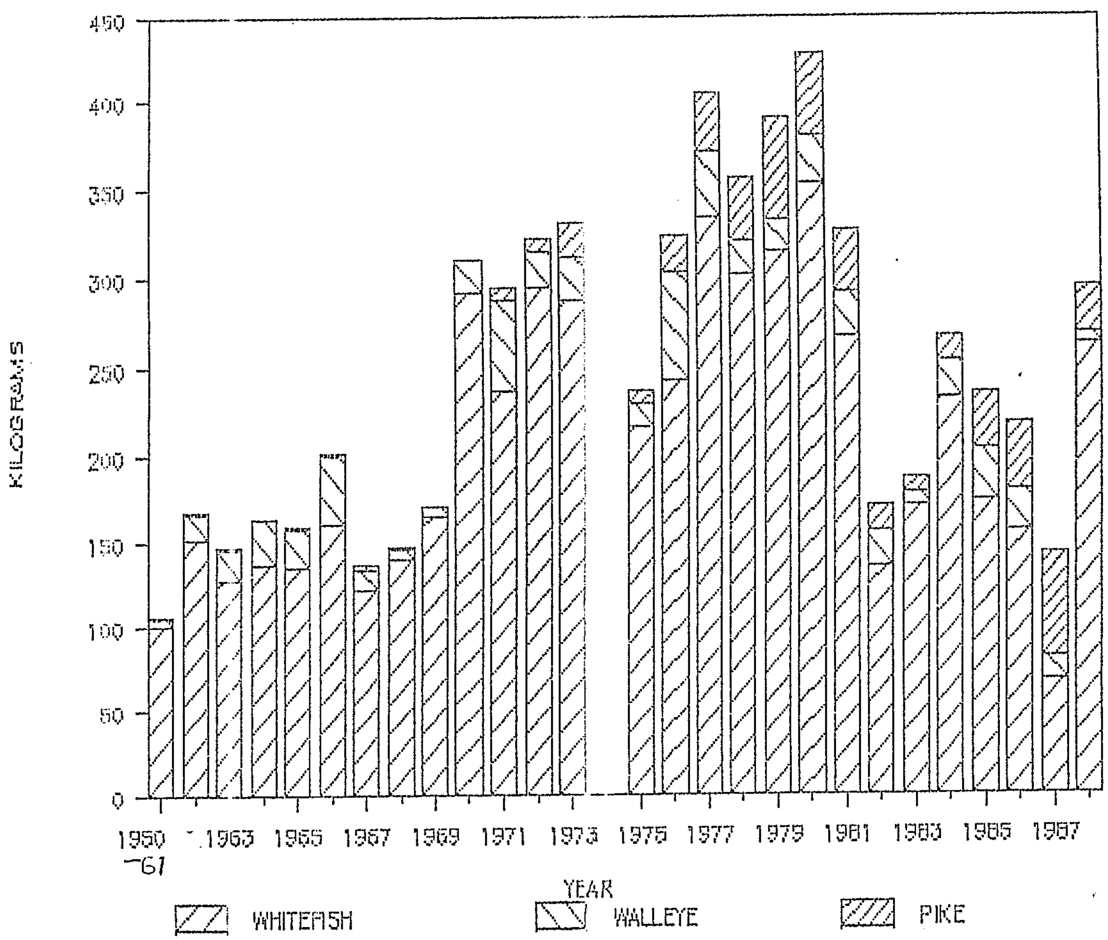

Figure 2.2: Yearly Catch of the Three Main Commercial Species at SIL, 1950-1988 Open Water Seasons From Economics Branch, Department of Fisheries and Oceans, No production 1974.

2.2. The winter fishery was comprised of larger whitefish catch weights than the open water seasons until the mid sixties. The entire whitefish catch was almost entirely made up of light colored, export (A) grade fish, that were only lightly parasitized with the muscle cysts of *Triaenaphorus crassus* (Bodaly et al. 1984b). In order to maximize profit, fishing effort was limited to known traditional regions of the lake, which would produce the higher quality, higher priced whitefish. Those regions which produced whitefish of lower quality were avoided.

Export or A grade whitefish prices can be twice as high as Continental or B grade whitefish prices. Price and profit are deciding factors in influencing the type of fishery which takes place on a lake. With the lower overall returns for whitefish on Southern Indian Lake, significant fishing emphasis has shifted to the exploitation of the other main commercial species of pike and walleye. With this also came the alteration of fishing patterns in terms of regional locations and fishing techniques.

There has been a well documented decline in the Southern Indian Lake commercial fishery, due to reductions in the catch and grade of the whitefish portion of the catch, since Manitoba Hydro altered the lake's natural water level and flow regime (Bodaly et al. 1984b). Decreases have been documented in the catch per unit effort, market quality, color, and cyst count of the catch (Bodaly et al. 1984b).

The selective fishing of certain areas to maintain export quality fish changed after impoundment. This change in geographic distribution of fishing effort was due to sharp declines in catch per unit effort on the traditional fishing grounds. In 1979, 1980 and 1981 the proportion of fishing effort occuring outside of traditional fishing areas was 62%, 30% and 33% respectively (Bodaly et al. 1984b). Figure 2.3 illustrates the regional changes in effort. Lawson (1982) stated that in 1982, 56% of the commercial fishing effort occurred in region 5.

The shift to region 5 from region 4 was due to the fishermen knowing that it was a relatively good whitefish area, although the fish were of poorer quality. Bodaly et. al. (1983a) found that in 1980 and 1981 higher commercial whitefish catches were produced from region 5 than region 4. Region 5 also produced higher catches of pike and walleye.

The amount of fishing effort which occurred in region 5 was affected by compensation agreements between the SIL Fishermen's Association and Manitoba Hydro. In 1979, Manitoba Hydro paid a $.05 per lb. incentive bonus for whitefish caught from historic fishing grounds (region 4) (Manitoba Hydro, 1978). The incentive was not large enough to keep fishermen from pursuing whitefish from region 5 (Wagner, 1984). A system of differential payments was initiated to offset the decreased catch from traditional fishing areas. This payment system increased the price for

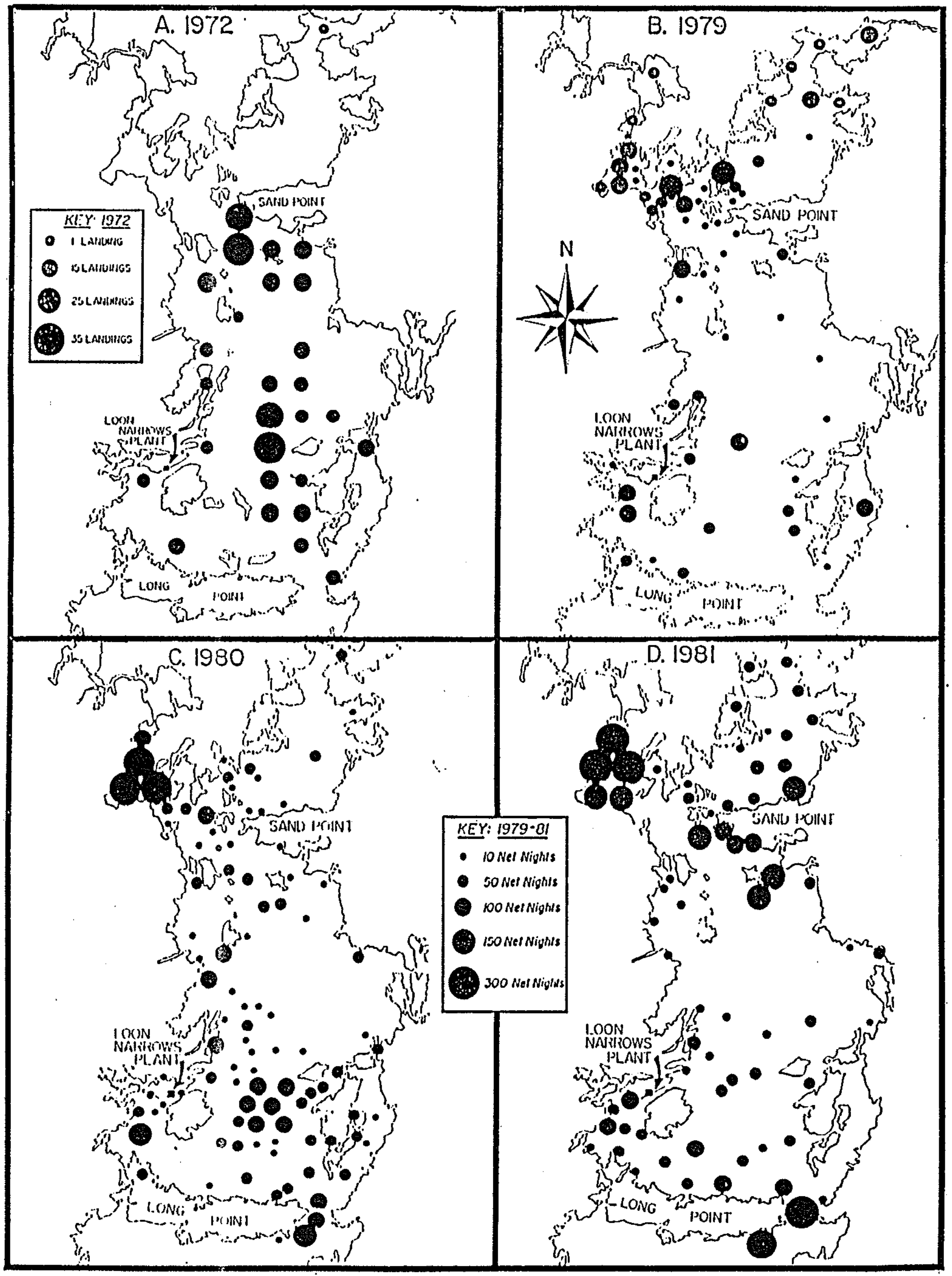

Figure 2.3: Geographic Changes in Commercial Fishing Effort, SIL (from Bodaly et al. 1984b).

dark, continental fish from region 5 to that of export price (MB Hydro, 1978). In 1980, a time restriction was placed on region 5 and in 1981 a voluntary poundage limit was agreed to for region 5. These restrictions decreased the proportion of post-impoundment effort expended in region 5 during those seasons (Bodaly et al. 1983a).

There were declines in the catch per unit effort, on traditional fishing grounds (region 4) (using 13.3 cm mesh) post impoundment. Studies done by the Department of Fisheries and Oceans found that from 1972 to 1981, the catch per unit effort fell 68 % (23 kg per net per 24 hours to 7.5 kg per net per 24 hours) (Bodaly et al. 1984b). It is important to note that there was a declining trend in the catch per unit effort over the 1979, 1980 and 1981 period. Similar declines occured in the winter fishery (table 2.1).

TABLE 2.1

Whitefish Catch Per Unit Effort, SIL Traditional Fishing Areas (region 4), 13.3 cm mesh.

Season	C.P.E.
Summer 1972	23.1
Summer 1979	15.5
Summer 1980	10.3
Summer 1981	7.5
Winter 1972/73	23.4
Winter 1980/81	4.2

From Bodaly et al. 1984b.

Lawson found that in the 1982 summer season, commercial fishermen's catch per unit effort in region 4 using 13.3 cm mesh was 6.5 kg.

The 13.3 cm mesh size was the minimum legal size limit for the traditional fishing grounds (region 4) of SIL. This was reduced to 12.8 cm in 1988. The 10.8 cm mesh is restricted to walleye and pike areas of region 5. The majority of historic whitefish effort was comprised of 13.3 cm mesh (Bodaly et al. 1983a). However Lawson (1982) indicated that the 10.8 cm mesh size comprised 52% of the fishing effort in 1982. In 1987 and 1988 provincial conservation officers found no evidence of 10.8 cm mesh use outside of the pike and walleye areas.

The larger 13.3 cm mesh size places less stress on whitefish populations by selecting larger/older individuals. The use of the 10.8 cm mesh can lower the mean age of the fishery and increase the numbers of fish caught. Both factors can influence whitefish populations. Revenue to fishermen can be enhanced with the use of the 10.8 cm mesh.

The use of 10.8 cm mesh in the whitefish fishery can also increase the rate of cyst infestation in sampled commercial shipments. This is due to whitefish in SIL generally not accumulating <u>Triaenaphorus</u> cysts past the ages of 2 or 3 as a result of a planktonic to benthic dietary change (Johnston, 1984). The 10.8 cm mesh catches smaller individuals which increases the level of cysts as related to the weight of fish in a sample. MacLaren (1978) stated that in SIL the mean cyst count in samples decreased as the mean size of fish increased. The cycle for the <u>Triaenaphorus crassus</u> parasite is discussed in appendix A.

The frequency of net relocation increased and the average time nets were left at the same site decreased post impoundment. The average time nets were left in the water pre-flooding was 18 days and post flooding this declined to 7, 5 and 6 days in 1979,80 and 81, respectively (Bodaly et al. 1983a). Lawson (1982) found that in the 1982 summer season, the frequency of net relocation was 5.2 days for both regions 4 and 5. Net movement was based on the success of catches, avoidance of rough fish species, avoidance of net debris and lifting nets to clean debris. These served to increase the overall effort expended on the fishery. Other variables which increased post-impoundment were the total number of nets fished, travel distances to region 5, and difficulty of landing on flooded shorelines (Bodaly et al. 1983a).

It is common for heavily exploited fish populations to have a lower catch per unit effort. This can increase the total effort expended by commercial fishermen. The low catch per unit effort on SIL did not appear to reflect this situation. It was indicated by Healy (1975) that decreases in the catch per unit effort would not be due to depletion of the stocks by over fishing, if the age structure of the population showed a healthy representation of older individuals. Bodaly et al(1984b) stated that growth rates for the SIL whitefish were within the range of slightly to moderately exploited populations, and the age structure of the commercial catch was geared towards older fish, with overall age structures in 1979 being similar to 1972 (1972-9.1 years, 1979-9.13 years, read from scale samples). Bodaly et al. (1983a) found that between 1979 and 1981, the mean age of commercial whitefish samples was quite stable at 9.95 years and 10.4 years respectively (read from fin ray samples). The modal ages were 11 in 1979 and 1980 and 10 in 1981 (Bodaly et al. 1983a).

The whitefish of SIL appear to have had specific migration patterns. Ayles (1976) suggested that changes in SIL whitefish distribution in early September may have been due to migration to specific spawning locations. Weagle and Baxter (1973) indicated that whitefish movements occured from areas south of Long Point to the area north of Long Point and also that commercial fish landings would increase north of Long Point at that time. Fishermen suggested to Weagle and Baxter that the movements were directly related to spawning migrations and that the area was an important whitefish spawning area. Fishermen were influenced by the migrations and concentrated their efforts for the spawning whitefish off of the small rocky islands and shores of region 4.

Bodaly et al (1984b) also stated that emigration of whitefish from Southern Indian Lake was the likely cause of the post-impoundment decline in the catch per unit effort. It was also indicated that whitefish from region 4 of Southern Indian Lake may have undergone annual migrations downstream into the lower Churchill river (Bodaly et al. 1984b). The return passage of fish is now blocked by the Missi Falls control structure, and large aggregations of whitefish occur at the downstream base of the structure during the summer. Barnes (in prep.) found that in 1986, a significant proportion of the whitefish immediately below the Missi Falls dam morphologically resembled whitefish from region 4, suggesting they may be of the same whitefish stocks. It was also suggested that in 1987 most of the fish below the Missi Falls dam were from downstream locations of the Churchill River. In 1986, there were larger numbers of fish below the dam when higher water flows were leaving SIL. In 1987, shallow water and high summer water temperatures in downstream lakes may have caused movement of fish towards the cooler water stream from SIL (Barnes in prep.).

Emigration of whitefish out of SIL may have been due to the changes in water turbidity after impoundment. Movement of whitefish out of the lake may have been hastened by decreases in light penetration from the increased turbidity now present, and post-impoundment turbidity may have been too high for effective schooling to take place (Hecky 1984).

Bodaly et al.(1980) indicated that light levels can affect feeding, schooling behavior and the depth distribution of whitefish. Bodaly et al.(1984b) also suggested that the increased sediment may also have caused the dispersion of whitefish in Southern Indian Lake. MacLaren (1978) offered the hypothesis that whitefish distribution was disturbed by the drastic change in turbidity, especially in region 4.

Weagle and Baxter (1973) proposed that flooding would cause serious damage on spawning grounds by covering their prefered spawning substrate of boulders and large broken rock. It was suggested by Fudge and Bodaly (1984) that the deposition of sediment on the spawning grounds of whitefish, may have reduced the survival of their eggs.

The evidence suggests that the whitefish populations were significantly affected at Southern Indian Lake. It was stated by Bodaly et al.(1984) that prior to impoundment, there were at least 3 genetically distinct whitefish populations in the SIL area. After impoundment, the genetic differences were absent. It has been recognized that some coregonid species which inhabit large lakes will segregate into separate stocks (Bodaly 1986).

Whitefish in Southern Indian Lake, as in many lakes, can have different color shadings from light, almost silver colored fish to very dark colored fish. The light colored fish from traditional fishing areas were of export quality, due to lower Triaenaphorus cyst levels and also as a result of having a more attractive appearance to the consumer than dark colored whitefish. With the decline in catches from traditional fishing areas, new areas were exploited in the northerly sections of the lake (region 5), where fishermen knew they would get good catches. Figure 2.4 shows the geographic distribution of dark and light colored whitefish from commercial deliveries.

The new fish stocks which were exploited from the non-traditional areas, were composed largely of dark colored, more heavily parasitized fish. From 1972 to 1981, the Triaenaphorus cyst count increased 57% on a per fish basis Bodaly et al. 1983). The market grade of the fish, showed dark colored continental (B) grade whitefish, making up a higher proportion of the catch after impoundment. This is shown in figure 2.5.

Johnston (1984) determined that light and dark whitefish in SIL occupied different habitat types. Her assessment was that "lights occur throughout the lake, are slightly more abundant offshore then inshore and are primarily benthic in habit. Darks are restricted to certain areas of the lake, are more numerous onshore then offshore and are somewhat more pelagic then lights.......whitefish color is correlated with water color and clarity and may be an adaptation for concealment."

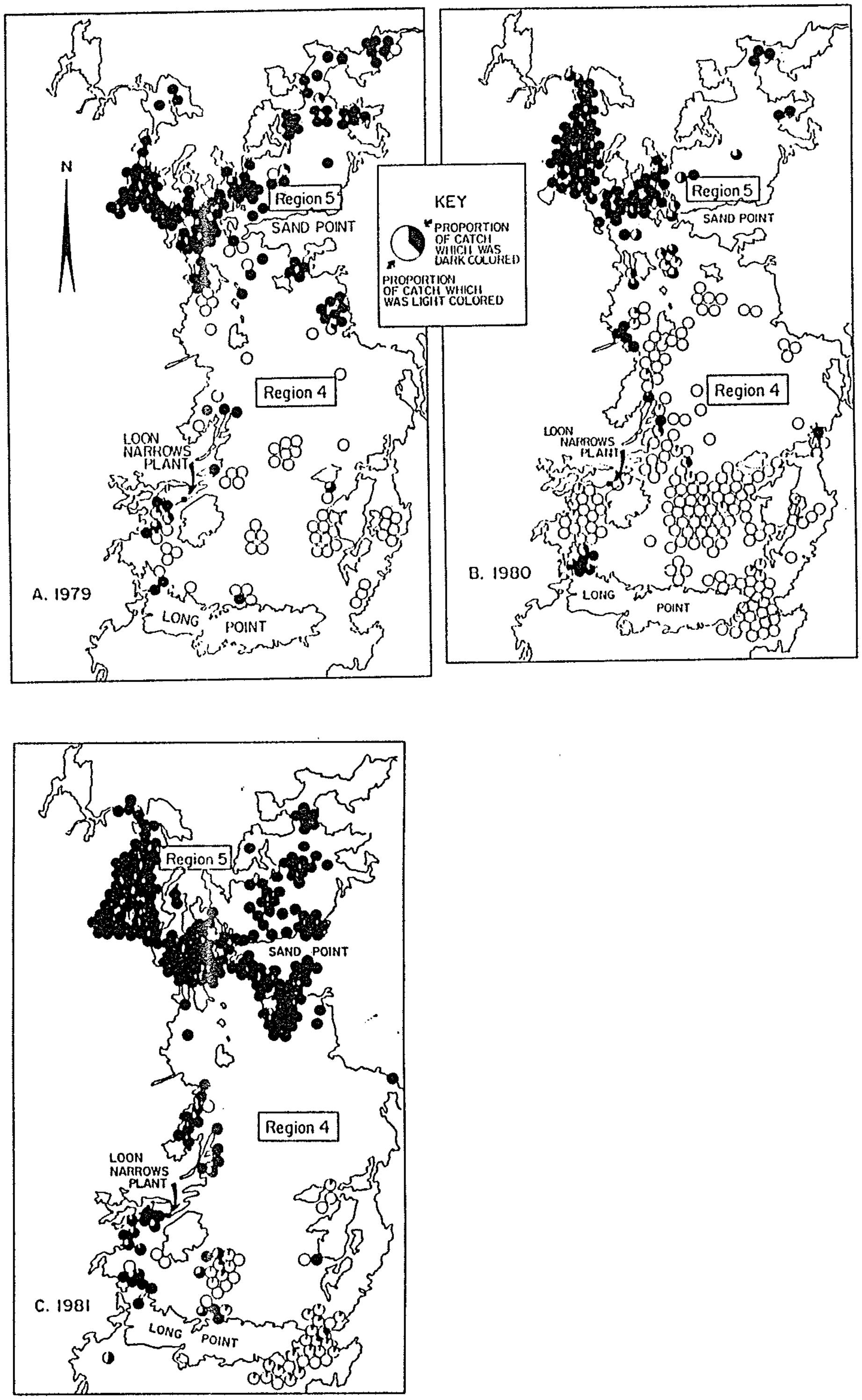

Figure 2.4: Geographic Distribution of Light and Dark Whitefish, SIL (from Bodaly et al. 1984b).

Figure 2.5: Yearly Whitefish Catch & Grade, Open Water Seasons, SIL.
Export = A, Continental = B, Cutter = C.

KG	50-72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
400						A											
390						A			A								
380						A		A	A								
370						A		A	A								
360						A		A	A								
350						A		A	A								
340						A		A	A								
330						A		A	A								
320						A		A	A								
310					A	A		A	A								
300					A	A	A	A	A								
290					A	A	A	A	A	A							
280		A			A	A	A	A	A	A							
270		A		A	A	A	A	A	A	A							
260		A		A	A	A	A	A	B	A							
250		A		A	A	A	A	A	B	A							
240		A		A	A	A	A	A	B	A			A				B
230		A		A	A	A	A	A	B	A			A				B
220		A		A	A	A	A	A	B	A			A				B
210		A		A	A	A	B	A	B	A			A				B
200		A		A	A	A	B	A	B	A			A				B
190		A		A	A	A	B	A	B	A			A	A			B
180		A		A	A	A	B	A	B	A			A	A			B
170		A		A	A	A	B	A	B	A		B	A	A	A		B
160	A	A		A	A	A	B	A	B	A		B	A	A	A		B
150	A	A		A	A	A	B	A	B	A		B	A	A	A		B
140	A	A		A	A	A	B	A	B	A		B	A	A	A		B
130	A	A		A	A	A	B	A	B	A		B	A	A	A		B
120	A	A		A	A	A	B	A	B	A	B	B	A	B	A		B
110	A	A		A	A	A	B	B	B	A	B	B	B	B	A		B
100	A	A		A	A	A	B	B	B	A	B	B	B	B	A		B
90	A	A		A	A	A	B	B	B	A	B	B	B	B	A		B
80	A	A		A	A	A	B	B	B	A	B	B	B	B	A		B
70	A	A		A	A	A	B	B	B	A	B	B	B	B	B	B	B
60	A	A		A	A	A	B	B	B	A	B	B	B	B	B	B	B
50	A	A		A	A	A	B	B	B	B	B	B	B	B	B	B	B
40	A	A		A	A	A	B	B	B	B	B	B	B	B	B	B	B
30	A	A		A	A	A	B	B	B	B	B	B	B	B	B	B	B
20	A	A		A	A	A	B	B	B	B	B	B	B	B	B	C	C
10	A	A		A	A	A	B	B	B	B	B	B	B	B	C	C	C
<5	B	A		A	A	A	B	B	B	B	B	C	B	B	C	C	C

Kilograms round weight, rounded to nearest 10,000 kg.
From Economics Branch, Dept. Fisheries and Oceans.

Dark colored whitefish have been noted to have higher Triaenaphorus cyst levels than light colored whitefish in Southern Indian Lake. Johnston (1984) indicated that the level of infestation is on average higher in darks than in lights, but that there is no causal connection between cyst count and color. Johnston (1984) also indicated that the higher cyst count of darks may be related to diet and distribution. Darks tend to occupy pelagic habitats and feed on pelagic food items. The water color of their habitat (clear and dark) can promote dark colored fish. Imhoff (1977) noted that some other North American lakes have dark whitefish populations that also have higher Triaenaphorus cyst counts. Baxter and Glaude (1980) discussed that populations of fish parasites may be increased as a result of impoundment, through changes in feeding habits. Kelly (1977) stated that reservoir conditions generally are more suitable for Triaenaphorus crassus then river conditions. Peterson (1971) suggested that the impoundment of a Swedish river into a lake increased the occurance of Triaenaphorus crassus in whitefish populations. Kelly (1977) explained that zooplankton and the intermediate host of the parasite, the copepod increases, the feeding habits of whitefish follow this change, utilizing the food source, and the final host, pike also increases. In contrast, Bodaly et al.(1984) indicated that in Southern Indian Lake, the observed increases in cyst counts were likely due to the exploitation of existing, more highly infected stocks from region 5.

Variation in color of whitefish was the basis for grade determination at the local fish packing plant from 1978 to 1981, as an attempt to maintain the lake's grade classification at export. It also allowed for a quick, relatively easy method of on-site grade classification by sorting personnel. Due to the reduction in fish quality at Southern Indian Lake, the entire whitefish catch of the lake was downgraded to continental grade in 1982. This produced a lower price for the fish and less income for the fishermen. The lake has consistently sampled below export grade since 1976. The yearly mean cysts per commercial shipment sampled by Freshwater Fish Marketing Corporation inspectors is shown in table 2.2.

TABLE 2.2

Mean Cyst Levels of Sampled Commercial Shipments, Open Water Seasons, SIL.

Year	Cysts/45 KG	Year	Cysts/45 KG
1988	60	1979	79
1987	73	1978	55
1986	61	1977	42
1985	--	1976	47
1984	89	1975	28
1983	55	1974	--
1982	73	1973	30
1981	57	1972	23
1980	54	1971	23

From Freshwater Fish Marketing Corporation

The lower price and reduced catch per unit effort, led directly to a collapse of the commercial fishery (Bodaly et al. 1984b). Due to the collapse, the fishery became subsidized by Manitoba Hydro to maintain its viability (Wagner, 1984). Between 1977 and 1982, compensation of approximately $1 million was made to the fishermen. In 1983, a one-time settlement of $2.5 million was made as compensation for all past, present and future losses to the fishery. It was found by Wagner (1981) that without subsidies in 1980, only 33% of the fishing enterprises would achieve long run viability, and that in the same year, the total amount of subsidies allowed for 92% of the enterprises to be financially viable in the long run. Thornton in 1986 determined that only 10 of 28 sampled fishing enterprises could achieve long run viability with program subsidies set up from the Southern Indian Lake Commercial Fishermen's Association capital fund. The fund was created from the compensation settlement. Thornton (1986) also found that without the subsidies, only 5 of the enterprises would have been viable in the long run.

A large portion of the fishing effort shifted to outlying lakes not affected by flooding in an attempt to exploit their fish populations. This was highly influenced by various agencies of the public sector in the form of freight subsidies, differential payments, subsidized interest rates on loans for boats and motors, and in some cases, fishermen received boats and motors through special grants (Wagner, 1981). Berkes (1982) presented a similar situation, where fishermen of the Lower Grande River in Quebec changed locations due to the alteration of traditional fishing areas by hydro development. Thornton (1986) found that without the inclusion of subsidies from the capital fund, only 2 of the 34 inland lakes would have achieved long run viability. With the inclusion of the fund 7 of the lakes would be viable.

The importance of fish prices to a fishery cannot be overstated. They can affect the overall effort expended into a fishery. In 1987, the Freshwater Fish Marketing Corporation initiated a situation where higher prices would be paid for whitefish, if reductions were made in the total catch. For continental (B grade) whitefish, a 50% reduction in the previous three years average catch increased the price from $.27 to $.60 per kg (appendix B). Basically, fishermen were paid not to catch fish. This type of pricing scheme can affect the amount of effort expended. The 1988 prices for whitefish were higher and the pricing scheme was not in effect. Continental were at $.41 per kg and even cutter (C grade) had a price of $.37 per kg (appendix B). These prices could initiate more effort in the whitefish fishery and possibly excellent returns to the fishermen.

The literature presented indicates the widespread post-impoundment changes at Southern Indian Lake which influenced the commercial fisheries. Fishing in the north as a whole has a variety of intrinsic problems, such as distance to market and accessibility. The impoundment and diversion have greatly added to these problems at SIL. Fishing was historically the main economic and social activity of the South Indian Lake community, and has now been severely disrupted.

Chapter III

METHODS

3.1 DATA COLLECTION

The field activities for the study occured during the 1987 and 1988 open water commercial fishing seasons. Quantitative data collection occured during the 1987 season, while the 1988 season was restricted to the collection of qualitative data. Data generated from this study were compared to historic information collected by the Department of Fisheries and Oceans.

The majority of the data was limited to the fishing operations which delivered fish to the Missi Falls fish packing plant. Most of the commercial fish catch was received at that point. The marketable species composition and catch weights of the commercial catch were taken from Freshwater Fish Marketing Corporation daily catch records and end of season records. Related influencing factors such as rough fishing weather and alternative employment opportunities were assessed subjectively from field information gathered on-site.

Information on the commercial fishing operations were obtained from interviews with commercial fishermen at the

Missi Falls fish packing plant and on the fishing grounds on a daily basis. The questionnaire used was similar to that utilized in previous studies on the SIL commercial fishery (Bodaly et al. 1980, Bodaly et al. 1983a) (appendix C.). The attempt was made to interview as many fishermen as possible.

Fishermen were asked;

- the number of nets set in the water,
- the number of gangs used,
- nets per gang,
- nets run that day,
- time since nets last checked,
- number of new sets,
- number of nets pulled that day,
- number of nets moved that day,
- open or shore type set,
- net mesh size,
- regional and specific locations of all sets,
- number of fishermen in the operation.

Data were recorded for each fishing operation (per yawl). Each fishing operation included the number of fishermen on board, whether they were licenced or helpers. The information was calculated and analyzed to assess the daily fishing patterns of the commercial fishermen.

3.2 CATCH PER UNIT EFFORT

The catch per unit effort was analyzed on a regional, mesh size and seasonal basis. It was calculated by dividing the total sampled commercial catch weight for whitefish by the total number of sampled nets run, for each particular analysis. A single commercial gill net, set for 24 hours, was regarded as one unit. The standard sizes for commercial gill nets used in the 1987 Southern Indian Lake commercial fishery are 13.3 centimeters and 10.8 centimeters stretched mesh and 91.4 meters in length. In 1988, 12.7 cm mesh was included in the fishery, and its possible effects were discussed.

For adequate comparison with historical data, the whitefish catch per unit effort data was calculated by using only the commercial deliveries which had higher quantities of whitefish than all of the other commercial species combined. This was to attempt to duplicate the historic situation where whitefish was the targeted species. Much of the fishing effort in 1987 was geared towards pike and walleye, and this screening process attempted to delete that fishing effort. To have included whitefish from the pike and walleye effort would cause the whitefish catch per unit effort to be unfairly reduced.

3.3 WHITEFISH GRADE, CYST COUNT AND COLOR

Whitefish grade classification samples were selected randomly from the commercial deliveries. Sample size was dependent on the availability of whitefish in the commercial deliveries. Cyst infestations were determined by the standard method used by Federal Fisheries Inspectors. Grade classifications were determined by cutting for *Triaenaphorus crassus* cysts by slicing the fish's musculature into approximately 1 cm transverse strips to expose all cysts. The grade classifications are based on the number of cysts present per 45 kg of whitefish (dressed weight).

Grade Classifications:

0 to 40 cysts per 45 kg = export (A) grade

41 to 80 cysts per 45 kg = continental (B) grade

over 80 cysts per 45 kg = cutter (C) grade

The formula for grade calculation is:

cysts X 45 / kg fish in sample = cysts per 45 kg.

The field data form is shown in appendix C.

Other grade data recorded on a per sample basis was;

- -regional and specific location,
- -number of fish in the sample,
- -single and cumulative fish weights,
- -cyst numbers,
- -external color of the whitefish.

Cyst counts were calculated as cysts per total kilogram, cysts per fish, percent occurrence of grade, mean cyst count per sample, and cyst count for light whitefish over 1 kg (dressed) from region 4 (to determine if larger individuals had lower cyst counts).

External coloration of samples and the commercial catch was visually estimated into light, intermediate and dark categories. In determining the color, emphasis was placed on the shading of the back and top of the head. There was also a recognition of external variables, which can affect the recording of color. These are different light conditions between sample times, discrepancies between sampling personnel and the characteristic of whitefish changing external color over time, after removal from the water.

3.4 WHITEFISH AGING

Lake whitefish aging samples were collected randomly from as many of the whitefish samples as possible. The pelvic fin from the left side of the whitefish, was collected for aging purposes. Determination of age was made from anulli ring counts from pelvic fin sections. The fin ray method was chosen because it appears to be a more accurate method of age determination for whitefish than the scale aging method (Mills and Beamish, 1980). This is especially important because the aging of fish is a difficult undertaking, and has much room for error. The sectioning and aging method used was described in Deelder and Willeimse (1973). The aging samples were analyzed by the author after a 75% consistency was achieved in the reading of a 1982 subsample from SIL. The age distribution of the commercial catch was calculated and used in determining the state of exploitation, and health of the whitefish stocks.

3.5 OTHER INFORMATION

Fork length and dressed weight for all whitefish age samples and some whitefish grade samples, were recorded to the nearest centimeter and 10 grams, respectively.

Seasonal analysis was categorized according to time period during the fishing season. The first half of the season until the summer shutdown, the summer portion of the second half of the season and the fall portion of the second half of the season were considered separately or in combinations, to determine if differences existed in the analyses.

The regional breakdown of the lake was that which is used by the Department of Fisheries and Oceans (fig. 1.1). Certain analyses further segmented region 4 into three subregions to determine if differences existed (fig. 3.1).

Information for the 1988 season was collected through conversations with commercial fishermen and also through

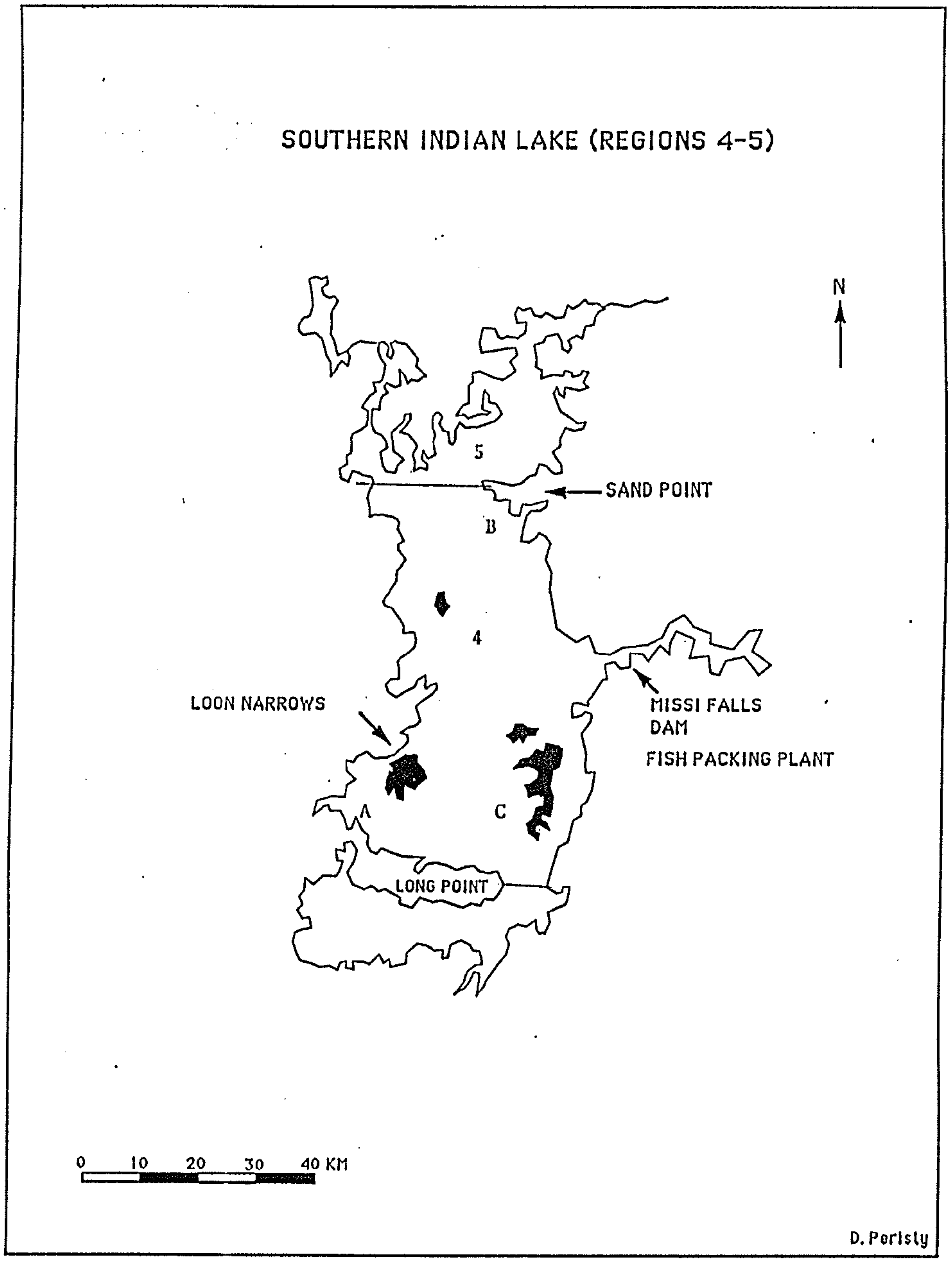

Figure 3.1: Southern Indian Lake, Regions 4 & 5, Subregions A,B & C.

actual gill netting done by the author on Southern Indian Lake for the Department of Fisheries and Oceans. Additional information on the fishery was received from conversations with Department of Fisheries and Oceans and Freshwater Fish Marketing Board personnel.

This study was limited to collecting biological data, however external factors which affected fishing patterns, such as socio-economics and the environment, are included in the discussion.

Chapter IV

RESULTS

4.1 SAMPLING DISTRIBUTION

A total of 62% (322 of 516) of the 1987 seasonal deliveries to the Missi Falls fish packing plant were sampled over the entire commercial season. Seventy-four percent of the total deliveries in the first half of the season were sampled and 53% of the total deliveries in the second half of the season were sampled. Of the total sampled effort in net nights, 52.8% occurred in the first half of the season and 47.2% occurred in the second half of the season (appendix D, table 1). Refusals to be interviewed were essentially nil, however not all information was received from each respondent or sample.

4.2 GEOGRAPHIC DISTRIBUTION OF FISHING EFFORT

Of the sampled effort for the entire 1987 season, the distribution of fishing effort in net nights showed that region 4 received somewhat more effort than region 5 (58.3%, region 4 and 41.7%, region 5) (appendix D, table 2). Historic fishing areas (region 4) showed increased effort in the second half of the season (Total 2nd half - 73.3%, Fall portion - 95.3%). Region 5 received more effort in the summer portions of the season (1st half - 52.8% and 2nd half summer 64.2%).

Figure 4.1 shows the geographic fishing distribution of the sampled effort (2777 net nights). The distribution indicates that a significant (58.3%), but smaller then historic (pre-impoundment) amount of fishing effort occured in traditional regions which are south of Sand Point (region 4). The major fishing areas were around Long Point, Jam Island (largest island on figure), Sand Point and the small bays and shorelines of region 5.

For the first part of the season (1421 net nights) the majority of the total effort occurred in region 5, while a significant proportion of secondary effort occured around Jam Island and Long Point (figure 1, appendix E). Effort for the summer portion of the second half of the season (500 net nights total effort) was largely limited to certain regions. The major emphasis occured just north of Sand Point (figure 2, appendix E). In the fall portion of the second half of the season (856 net nights total effort) the areas of main effort were north and east of Long Point, north of Jam Island, and just south of Sand Point (figure 3, appendix E).

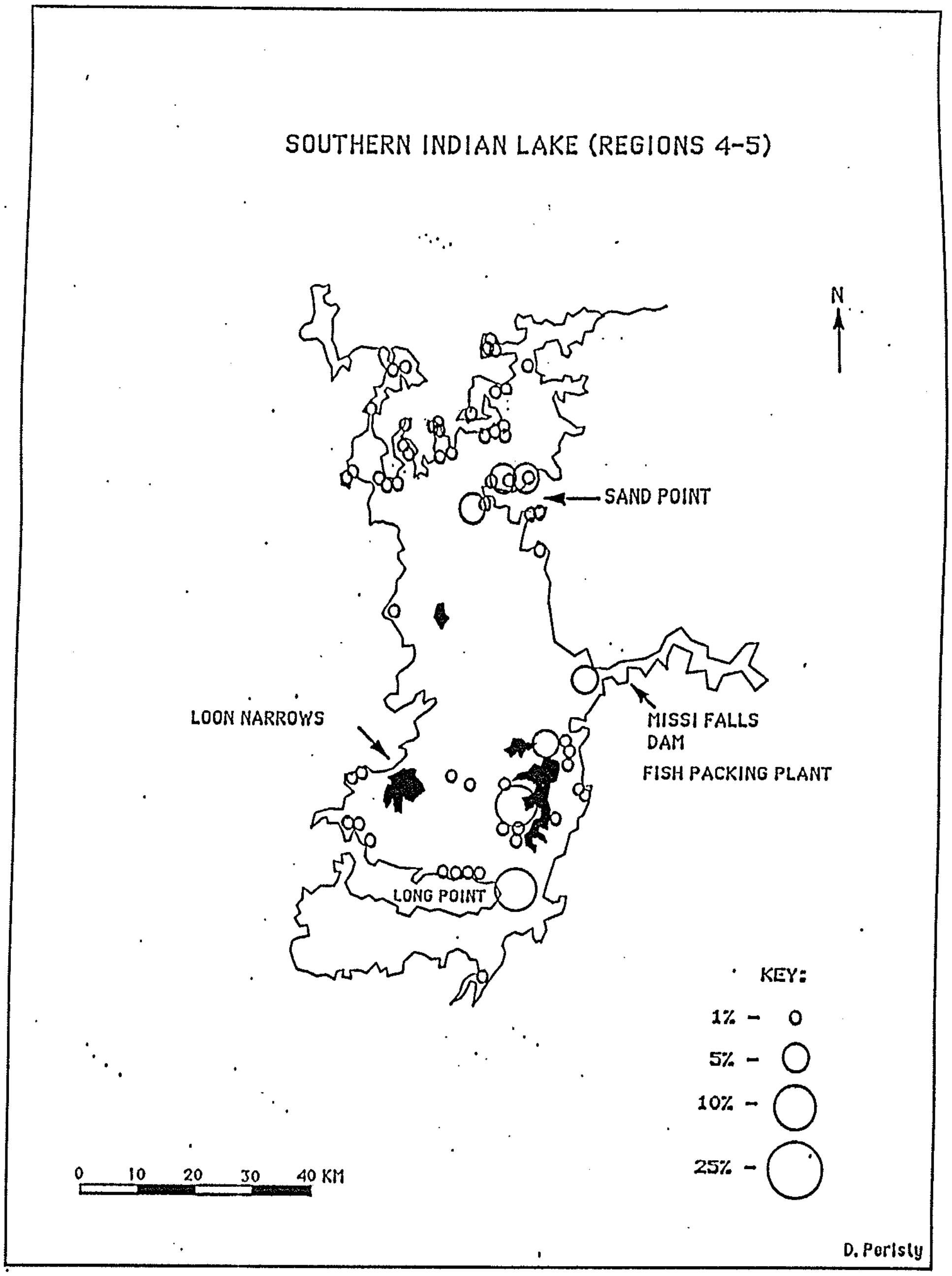

Figure 4.1: Geographic Distribution of Fishing Effort, SIL, 1987.

4.3 SPECIES COMPOSITION OF THE COMMERCIAL CATCH

Whitefish comprised the majority of the sampled catch (52%) over the 1987 season (table 4.1). Pike and walleye comprised 38% and 10% respectively. The importance of the regions to the catch success of specific species and to the commercial fishery as a whole, is shown in the data. Whitefish from region 4 comprised 71% of the sampled whitefish catch. Walleye and pike from region 5 comprised 78 % (pike - 56%, walleye - 22%) of the total sampled catch. The commercial catch species composition from Freshwater Fish Marketing Corporation catch records is shown in table 3, appendix D.

TABLE 4.1

Percent Sampled Species Composition of Fish Landed at Missi Falls, SIL, 1987, Regional Breakdown.

Region	Pike	Walleye	Whitefish	Kilograms
Region 4	26	3	71	15990.5
Region 5	56	22	22	9670
Total	38	10	52	25660.5

Dual region samples (respondents from both regions) consisted of an additional 2302.5 kg for a total sample size of 27963 kg. The inclusion of the dual region samples did not alter the total percent species composition.

Table 4.2 indicates the percent species composition of each seasonal portion of the commercial catch. The importance of pike during the early part of the overall season (spring) can be seen, as it made up 61% of the catch. Conversely, it had very poor representation in the fall catch (4%). This can be contrasted with whitefish, which occurred as the greatest proportion of the catch in the fall (93%). Walleye showed a slight decline in the seasonal proportions of the commercial catch throughout the overall season.

TABLE 4.2

Percent Sampled Species Composition of Fish Landed at Missi Falls, SIL, 1987, Seasonal Breakdown.

Season	Pike	Walleye	Whitefish	Kilograms
1st Half	61	8	31	11589
2nd Half Summer only	34	4	62	6364.5
Fall	4	3	93	7706

The differences in seasonality in the fishery can also be shown in terms of the proportion of a species caught during each portion of the season, as shown in table 4.3. The majority of the total pike catch was taken in the first half of the season (74%). The fall catch of pike was drastically reduced and it was likely an incidental species, as both whitefish and walleye occurred in their greatest total proportions at that time (whitefish: 63%, walleye: 61%). Both whitefish and walleye occurred in significant proportions during the first half of the season. The summer portion of the second half of the season was quite a slow period, with only pike occurring in any significant amount.

TABLE 4.3

Percent Species Composition of Sampled Fish Landed at Missi Falls, SIL, 1987, Seasonal Proportion.

Season	Pike	Walleye	Whitefish
1st Half	74	31	26
2nd Half Summer only	23	8	7
Fall	3	61	63
Kilograms	9635.5	2605	13420

The importance of regionality and seasonality to the catch success of the various species is further represented in the region specific analysis shown in appendix E, tables 4 through 7.

4.4 WHITEFISH CATCH PER UNIT EFFORT

The 1987 whitefish catch per unit effort (corrected for historic comparison as discussed in the methods) on traditional fishing grounds (region 4), with the use of the historic (legal) mesh size of 13.3 cm was 8.44 kg per net night (table 4.4). This figure is the most important of the calculated catch per unit effort data, because of its comparability to the data collected by previous studies. The catch per unit effort for region 5 using the same analysis and mesh size, was 11.18 kg per net night (table 8, appendix D). This figure may not be fully representative, due to the relatively smaller sample size. When comparing the average catch per unit effort including both mesh sizes between the two regions, the catch per unit effort was found to be similar (region 4: 9.05 kg, region 5: 10.08).

The difference in the effectiveness between the two mesh sizes utilized in the fishery can be seen in table 4.4 and tables 8, 9 and 10 in appendix D. The 10.8 cm mesh size generally exhibited larger catches, due to the selection of smaller sized individuals (13.12 kg per net night for the season, table 9, appendix D). This can be compared to the 13.3 cm mesh, catch per unit effort for the season, which was 9.5 kg (table 10, appendix D).

TABLE 4.4

Whitefish Catch Per Unit Effort, Region 4, SIL, 1987.

Mesh Size	Kilograms	Net Nights	Catch Per Unit Effort
10.8 cm	4275.5	336	12.72
13.3 cm	7475	886	8.44
Total	11750.5	1222	9.62
Combined*	14360.5	1586	9.05

*Includes samples with combined mesh sizes in sets.

The catch per unit effort for mesh sizes and regions combined, showed some difference during the season. While the first half of the season and the fall catches were approximately the same (1st half: 10.01 kg, 2nd half, fall: 10.52 kg), the 2nd half summer portion of the season was considerably less (7.73 kg) (table 11, appendix D).

4.5 WHITEFISH GRADE

The majority of 1987 grade samples for the regions were analyzed as continental (41-80 cysts per 45 kg). This is consistent with the lake's present market classification. Table 4.5 illustrates the percent occurrence of the grades in the sampled regions. The total lake classification had approximately one half (51%) of the sampled deliveries graded as continental. Of the 41 samples analyzed from the historic fishing areas of region 4, 56% were continental, 37% were export and 7% were cutter. The further breakdown of region 4 into 3 subregions, showed very little difference in the percent occurrence of grades. Region 5 showed the largest incidence of cutter grade (>80 cysts per 45 kg) whitefish (38%) and the smallest incidence of export grade (<40 cysts per 45 kg) whitefish (24%).

TABLE 4.5

Percent Occurance, Area Grade by Sample, SIL, 1987.

Area	Export	Continental	Cutter	Samples
Region 4*	37	56	7	41
Region 4A**	36	64	-	11
Region 4B**	40	60	-	5
Region 4C**	40	50	10	20
Region 5	24	38	38	16
Total	33	51	16	57

*Includes isolated regions not counted in subregions.
**Included in Region 4.

4.5.1 Cyst Count Differences by Region

The 1987 average whitefish cyst count per 45 kg was found to be in the continental grade category for all areas (except area 4B, which was export, although the sample size was much smaller) (table 4.6). Region 4 had an average cyst count per 45 kg of 51.9 which was less than region 5 (74.1) or fish that were delivered directly to the community (81.1) (caught from southern areas of the lake).

TABLE 4.6

Average Total Cyst Count of Sampled Areas, SIL, 1987.

Dressed Weight

Area	Cysts	Kilograms	Cysts Per 45 Kilograms
Region 4	443	384.3	51.9
Region 4A*	160	120.2	59.9
Region 4B*	13	27.5	21.3
Region 4C*	263	184.7	64.1
Region 5	174	104.5	74.9
Post**	203	112.7	81.1
Total	820	601.5	61.4

*Included in Region 4.
**Deliveries made to community

The trend continues for continental grade fish and higher cyst counts for region 5 and community deliveries when the mean cyst count is determined for each 45 kg grade sample calculation (table 12, appendix D). The subregional analysis of region 4 showed different cyst counts (region 4A: 62.5/45 kg, region 4B: 41.8/45 kg, region 4C: 44/45 kg), but all were in the continental grade range (40-80 cysts per 45 kg).

The mean cyst count per kg sample also indicated a difference in the numbers of cysts in whitefish between regions. As in the other analysis, the mean cyst count per sample showed that less cysts occured in region 4 samples (1.04) than in region 5 (1.36) or community deliveries (1.46) (table 13, appendix D).

On a per fish basis, the same trend was evident (table 14, appendix D). Sampled whitefish from region 4 had a mean of 1.07 cysts per fish, while region 5 and community delivered fish had means of 1.6 and 1.51, respectively. The modal cyst count for fish from all areas was 0.

4.6 WHITEFISH COLOR

There were 13,932.8 kilograms of whitefish visually estimated for external color in the 1987 commercial catch. Light whitefish made up 59% of the catch. Grey colored whitefish were estimated at 29% and dark whitefish occured in 12% of the catch. Table 4.7 shows that region 4 had a higher incidence of light colored whitefish in the sampled commercial catch, than did region 5 (region 4: 66%, region 5: 35.5%). Grey whitefish were represented in 58.6% of the catch from region 5, while in region 4, they only occurred in 24.5% of the sampled catch. Dark whitefish showed a low representation from both regions.

TABLE 4.7

Percent Whitefish Color of Sampled Catch, SIL, 1987, Regional Breakdown.

	Light	Grey	Dark
Region 4	66	24.5	9.5
Region 5	35.5	58.4	6.1
Total	61	30	9
Kilograms	7443	3674	1092

Figure 4.2 shows the geographic distribution of colored whitefish from the major areas sampled in the commercial catch. The larger proportion of light whitefish were delivered from the traditional fishing area, region 4. Proportionately more grey and dark whitefish were delivered from region 5.

Table 15 in appendix D shows that in the first half of the season, light whitefish made up the majority of the sampled commercial catch (77.6%). In the second half of the season when more whitefish were delivered, there was a higher incidence of grey whitefish then in the first half of the season (16%: 1st half, 35.7%: 2nd half).

There was a relationship between the color of whitefish and the type of net set (open vs shore). Table 16 in appendix D indicates that open lake sets produce more light colored whitefish than do shore sets. A total of 67.9% of sampled light whitefish were caught from open sets during the entire season. Shore sets produced a more even distribution, where 35.8% were light, 36.4% were grey and 27.8% were dark.

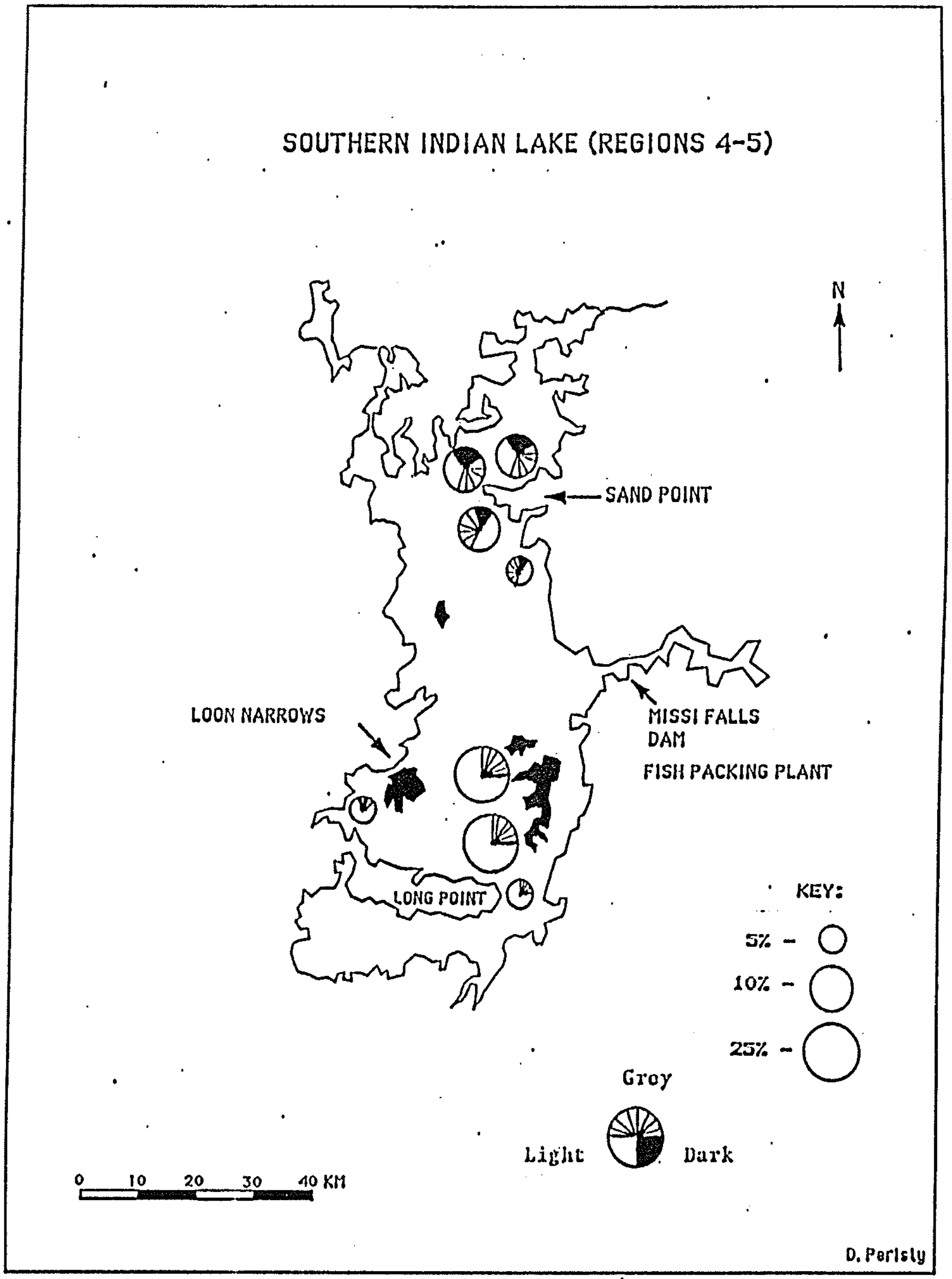

Figure 4.2: Geographic Distribution of Colored Whitefish, Percent of the Sampled Catch, SIL, 1987.

4.6.1 Color and Grade

Table 17 in appendix D shows that a large proportion of export grade whitefish are light colored. For all sampled areas, 65% of the export whitefish were light colored (grey: 17%, dark: 18%). While light colored whitefish made up the largest portion of the continental grade (48%), it was not as large for export, with the other colors occurring more often (grey: 29%, dark: 23%) (table 18, appendix D). Table 19 in appendix D shows that for cutter whitefish, dark colored fish were the most evident. For the total sampled areas, dark whitefish made up 39%, grey whitefish made up 38% and light whitefish made up 23%. The chance of a light whitefish being export was 49% (65% occurrence light export/136% total samples light whitefish). The chances for grey and dark whitefish being export were much lower (grey : 20%, 17/84, dark : 20%, 18/80) (tables 17, 18, 19, appendix D).

4.6.2 Cyst Count and Color

The number of cysts per 45 kg as they relate to color of whitefish is shown in table 4.8. The pre-impoundment norm of light colored export fish from region 4, is not borne out by this data. The light whitefish from region 4 had a cyst count of 46.6 per 45 kg, which translates to continental grade. When region 4 was further analyzed by sub region, the possibility for light export fish from 2 of the 3 subregions was shown. Regions 4A (Loon Narrows) and 4B (south of Sand Point) had 22.9 and 37.1 cysts per 45 kg respectively. This may be due to a smaller sample size, when compared to the other areas (table 20, appendix D). This is also the case for grey whitefish in region 4B (6.4 cysts per 45 kg) (table 21, appendix D). It can be seen that region 4 as a whole, had lower cyst counts than the other sampled regions. It also can be generally seen that the lighter colored fish had lower cyst counts than the darker colored fish. Sample size for dark colored whitefish is shown in table 22, appendix D.

TABLE 4.8

Average Cysts Per 45 Kilograms, Color & Area, SIL, 1987.

Area	Dark	Grey	Light
Region 4	57.4	54	46.6
Region 4A*	61	67.3	22.9
Region 4B*	-	6.4	37.1
Region 4C*	50.9	61.9	48.2
Region 5	106.8	82.3	53.6
Post**	117.9	78.5	52.9
Total	75.1	65.6	48.9

*Included in Region 4.
Calculated per each fish from all samples.

On a cyst per fish basis, similar trends were evident. Region 4 and light colored fish, had less cysts in the commercial samples. The figures ranged from .92 cysts per fish in light colored samples from region 4, to 2.67 cysts per fish in dark colored samples from region 5 (tables 23 through 25, appendix D). The modal cyst count for all areas was 0. The cyst count for light whitefish over 1 kg dressed weight from region 4 was found to be 45.6 per 45 kg (continental grade) (52.25 kg 53 cysts).

4.7 WHITEFISH AGE DISTRIBUTION

The percent age distribution for the total sampled commercial whitefish catch is shown in figure 4.3. The dominant age class was 9 years (26%). The majority of the individuals were between 8 and 11 years (82%, range: 6-15 years). There was very little difference between regions 4 and 5 in the overall age structure of the sampled catch (figures 4 and 5, appendix D). Nine was the dominant age class (region 4: 27%, region 5: 25%) and the majority of individuals sampled were between 8 and 11 years (region 4: 80%, range: 6-15 years and region 5: 83%, range: 6-14 years). The mean age of whitefish samples from both region 4 and region 5 was 9.7 years. The mean ages before rounding are shown in table 26, appendix D.

Figure 4.3: Percent Age Composition of Sampled Commercial Catch, SIL, 1987.

```
 %
30
29
28
27
26              XXX
25              XXX
24              XXX
23              XXX
22              XXX XXX
21              XXX XXX
20              XXX XXX
19              XXX XXX
18          XXX XXX XXX
17          XXX XXX XXX
16          XXX XXX XXX XXX
15          XXX XXX XXX XXX
14          XXX XXX XXX XXX
13          XXX XXX XXX XXX
12          XXX XXX XXX XXX
11          XXX XXX XXX XXX
10          XXX XXX XXX XXX
 9          XXX XXX XXX XXX
 8          XXX XXX XXX XXX XXX
 7          XXX XXX XXX XXX XXX
 6          XXX XXX XXX XXX XXX
 5          XXX XXX XXX XXX XXX
 4      XXX XXX XXX XXX XXX XXX XXX
 3      XXX XXX XXX XXX XXX XXX XXX
 2      XXX XXX XXX XXX XXX XXX XXX
 1  XXX XXX XXX XXX XXX XXX XXX XXX XXX XXX
     6   7   8   9  10  11  12  13  14  15   age/years
```

4.8 FISHING PROCEDURES

Each enterprise used approximately 15 nets per night, which is the legal limit on a per license basis (range: 5-32) (table 1, appendix D). There were on average 4.2 nets in each open set gang (range: 1-6) and 1.1 nets in each shore set gang (range: 1-3) (27, appendix D).

For the whole season, for regions 4 and 5, there was an even proportion of use between the 10.8 and 13.3 cm mesh sizes (10.8: 50.8%, 13.3: 49.2%) (table 28, appendix D). The season in itself showed variation temporally and spatially. Region 4 had fairly high use of 10.8 cm mesh, even though it is legally restricted to 13.3 cm mesh (season total; 10.8 mesh: 32.2%). The second half of the season showed a higher use of 13.3 cm mesh in region 4, likely as a result of the additional whitefish fishing effort (75.2%). Region 5 was fished more intensively with 10.8 cm mesh directed at the pike and walleye fishery (77.1%). The total use in the first half of the season was 10.8 mesh: 65.6% and 13.3 mesh: 34.4%. The total use in the second half of the season was 10.8 mesh: 36.3% and 13.3 mesh: 63.7%.

Table 29, appendix D shows that for the season, there was an emphasis on shore sets (64.4%). Open sets became more prevalent in the second half of the season (55.1%) with the fishermen looking for fish in deeper waters (especially during the summer portion). Shore sets were used most during the first half of the season (77.9%).

The average amount of nights a net was left at a single location is shown in table 4.9. The total for the sampled areas was 5 nights in one location (range 5-10). Locations in region 4 appear to have been left in the same spot longer than those in region 5, although this may be due to the smaller sample size for region 5 (region 4: 6.3 days, region

5: 2.9 days). Region 4 showed little difference of net movement on a seasonal basis. Region 5 had a higher incidence of net movement, possibly due to it allowing for increased success in walleye and pike catches.

TABLE 4.9

Mean Number of Nights Nets Were Left In One Location, SIL, 1987.

Seasonal and Regional Breakdown

Season	Region	Data Points	Nights	Mean	Range
1st Half	4	28	163	5.8	1-10
2nd Half	4	44	281	6.4	1-10
Fall*	4	30	198	6.6	1-10
Total	4	102	642	6.3	1-10
1st Half	5	33	86	2.6	1- 9
2nd Half	5	7	30	4.3	1- 7
Total	5	40	116	2.9	1- 9
Total	4/5	112	560	5.0	1- 10

*Included in 2nd half

4.9 SUMMARY AND HISTORIC COMPARISON OF MAJOR RESULTS

This section presents and compares the major findings of this study to previously collected data (table 4.10). The most valid comparisons are with the 1987 region 4 data due to the majority of historic information being from that region. The region 4/5 data is to compare the status of the overall 1987 data with historic information.

The catch per unit effort is higher in 1987 (region 4, 8.44 kg per net night) than 1981 (7.5 kg per net night) but is lower than 1980 (10.3 kg per net night). The percent of export samples (37%) has increased since 1981 (19%) but is less than 1980 (66%). The mean cyst count per kg from region 4 has decreased to its lowest level of the post impoundment data (1.04), but for both regions combined (1.20) it is at its highest level since 1982 (1.22). The mean cyst count per shipment from region 4 is at its lowest postimpoundment level (51.9/45 kg) but for regions 4 and 5 combined it is at its second highest post-impoundment level (61.4/45 kg). Cyst count evidence should be compared region 4/5 data because the commercial fisheries in 1979, 80 and 81 had a high exploitation rate of region 5 fish. This would then show a continued increase in the rate of cyst infestation and the grade reduction of region 4 fish to continental. The proportion of light colored whitefish in the 1987 commercial catch (71%) has shown a distinct

TABLE 4.10

Summary of Major Results in the SIL 1987 Open Water Commercial Fishery, With Historical Comparisons.

	1987 R.4	1987 R.4/5	1981	1980	1979	1972
Catch per unit effort (kg/n.n)	8.44	9.75	7.5	10.3	15.5	23.1
% Whitefish export grade	37	33	19	66	28	100
Mean cyst count, per kg dressed wt.	1.04	1.20	1.16	1.09	1.22	0.53
Mean cyst count, per shipment.	51.9	61.4	57.2	54.2	79.1	23.1
% Light colored whitefish.	66	59	14	65	28	100
% Whitefish in commercial catch.*	71	46	79	89	81	91
% Total effort.	58	--	67	70	38	100
Days nets left at one location.	6.3	5.0	5.6	5.0	7.0	18.0**
Whitefish mean age.***	9.8	9.7	10.2	10.4	9.95	9.1

Data from Bodaly, 1984b, Bodaly, 1983.
*Data from Freshwater Fish Marketing Corp. except 1987, region 4 from this study.
**Pre flood average.
***From fin ray sections except 1972, from scale analysis.

increase since the 1981 low of 46%. The proportion of whitefish in the 1987 commercial catch was low in comparison to all sampled years. The 1987 geographic effort in region 4 (58%) continued to show post-impoundment variation. There was an increase in the amount of time nets were left at a region 4 location in 1987 (6.3 days) as compared to 1981 (5.6 days) and 1980 (5 days) but this is much less than before impoundment (18 days, 1972). The whitefish mean age from the 1987 commercial catch is similar to previous information (region 4: 9.8 years, region 4/5: 9.7 years).

Chapter V

DISCUSSION

The results of this study demonstrate that the SIL whitefish fishery has not significantly recovered from post-impoundment reductions in catch per unit effort and grade. The catch per unit effort of whitefish on historic fishing grounds is similar to the levels monitored by the Department of Fisheries and Oceans, in their most recent studies of 1980 and 1981. The quality of whitefish from traditional fishing areas actually declined from export to continental grade. The geographic distribution of fishing effort appears to follow the price received for a species, that is, fishermen will fish in areas where they feel the catches will be representative of the species, that will allow for the highest rate of return for the effort. There may be evidence that the whitefish fishery is showing some signs of a return closer to pre-impoundment levels. A movement to more favorable conditions is evident in the catch per unit effort, the overall quality of whitefish from regions 4 and 5 combined and the number days nets were left in one location.

5.1 GEOGRAPHIC DISTRIBUTION OF FISHING EFFORT

During the 1987 season, there was significant variation in the locations fished. The first half of the season and the summer portion of the second half of the season had a majority of effort occuring in region 5 (1st half: 52.8%, 2nd half summer: 64.2%). This coincided with the higher catches of pike and walleye (1st half, pike: 61%, walleye: 8%). The prices for whitefish in 1987 were relatively low, shifting the commercial emphasis to walleye and especially pike. Fishing effort in region 5 during the early part of the season, was to take advantage of the better pike and walleye catches available in the small shallow bays and inlets, that are more common in that region. Region 5 is an important pike and walleye fishery, especially when whitefish prices are low. It also can produce large quantities of lower grade whitefish, which is important when their prices are relatively high. Bodaly et al. (1983a) indicated that fishing in region 5 was more attractive to commercial fishermen than region 4 after impoundment due to higher catches of whitefish. Also, nets were easier to set and run due to shallower water and shorter wind fetches.

The effort during the fall portion of the season shifted to the traditional region 4 area (95.3%). This is the time of the year when whitefish migrate to spawning areas and are the easiest to catch. Therefore, fishermen can obtain more whitefish with the least amount of effort (93% of total sampled fall catch). Rick Hay (Regional Manager, Fresh Water Fish Marketing Corporation, The Pas, pers. comm.) indicated that the bulk of the fishing effort for the 1988 season occured in the fall and over 60% of the total whitefish catch was from regions 4 and 5. While fish from region 5 are now a major component of the fishery, region 4 is still an important area, even though the catches are not as quantitatively or qualitatively successful as they were historically.

In 1988, good whitefish catches and increased effort were evident from fishermen which delivered directly to the Southern Indian Lake Community (R. Hay, pers. comm.). This portion of the fishery had significant characteristics which were different from regions 4 and 5. Some of these included a less intensive per man fishing approach and a poor fish receiving facility. Although there were exceptions, fishing operations would fish for shorter periods of time, and trips back to the community were far more frequent and for longer periods of time, than operations which fished in regions 4 and 5. The community fish station for the two sampled seasons, was a small unrefrigerated shed. Fish were shipped to the Leaf Rapids fish plant by truck, usually on a daily basis. This situation will change, as a year round fish packing plant is scheduled to open for the 1989 season. A new more efficient fish plant will likely shift more effort away from regions 4 and 5, to the south end of the lake.

Studies done by the Department of Fisheries and Oceans in 1972, 1979, 1980 and 1981 have shown the geographic distribution of fishing effort for those seasons. Movement of fishing effort was quite variable after impoundment, but the overall shift to region 5 from region 4 is quite evident. The change was not as much to exploit walleye and pike as it was to obtain better catches of whitefish, while they could still fetch export prices. When prices decreased for whitefish, significant effort in region 5 was to exploit the walleye and pike of the area. Price, subsidies and catch size appear to have been major factors in determining the geographic fishing distribution. Bodaly et al. (1984b) indicated that the differences in the proportion of geographic distribution were largely due to the compensation agreements between the SIL Fishermen's Association and Manitoba Hydro. The low prices for whitefish during 1987 caused fishermen to expend seasonal and geographical effort so they would obtain the best catches of walleye and especially pike. This caused fishermen to expend a higher then historic amount of effort in region 5 during earlier portions of the season.

In conversations with fishermen during the 1988 season, it was found that a considerable amount of the 1988 effort occurred in region 5, to exploit the whitefish stocks of that area. This was confirmed by Rick Hay (pers. comm.). One fisherman noted that whitefish catches were so good in that region, that he could only lift about eight nets per day, even though he had eighteen nets in the water. Region 5 is an important component of the commercial fishery since impoundment.

5.2 SPECIES COMPOSITION OF THE COMMERCIAL CATCH

There was a definite decrease in the proportion and amount of whitefish delivered in 1987, when compared to pre-impoundment information. The 1987 open water season had one of the lowest total catch weights of the last 25 commercial open water seasons (140000 kg). This was also the case for whitefish (68500 kg). Historic pre-impoundment seasonal catches of whitefish comprised approximately 85% of the total catch. The commercial whitefish catch of 46% for the 1987 season is considerably less, especially when the total kg delivered are far below historic figures. Pike comprised a significant 42% of the total 1987 commercial catch and walleye comprised 12% of the total commercial catch. This is much higher than average pre-impoundment levels for pike and walleye. Weagle and Baxter (1973) indicated that in the first 23 years of the fishery (from 1950), pike made up less than 1% of the total catch. The commercial catch weight for pike in 1987 was the largest for all open water seasons (61,100 kg).

The 1988 fishery was more comparable to the pre-impoundment fishery in species composition and total catch weight. Approximately 300,000 kg of whitefish, walleye, and pike were caught during the open water season. Whitefish comprised approximately 85% of the catch. This was due to the higher whitefish prices in the 1988 season as compared to 1987. All whitefish were paid as continental, regardless of the actual grade (Rick Hay, pers. comm.). Another factor which would have influenced the higher catches, would have been the implementation of 12.7 cm mesh nets into the whitefish fishery. The slightly smaller mesh size would have increased the catch by selecting more individuals.

There was a distinct seasonal shift evident in the species composition of the commercial catch in 1987. Pike was the favored species in the early portion of the season (1st half: 61%). Pike is easiest to catch at this time, due to higher movement as a result of postspawning activities and cooler water temperatures. Whitefish was the favored species during the fall season. Whitefish accounted for 93% of the sampled catch during the fall portion of the season and this made up 63% of the total whitefish catch. Whitefish undergo seasonal migrations to spawning areas in the fall, making them easier to catch at that time.

The species changes indicate a dual type of fishery which operated during that season. The pricing scheme and low whitefish prices promoted the dichotomy of the fishery. SIL is generally not noted as a good pike or walleye fishery. The shift of effort to these species (especially pike) appeared to reflect an opportunistic attempt by the fishermen to be able to continue fishing, by exploiting those species with the best chance of large economic returns.

The exploitation of pike and walleye causes additional wear and tear on the nets when compared to whitefish, due to spines and teeth getting caught in the nets. Also, more time is spent removing the fish. Pike also have a tendency to tangle in the nets to a greater degree than the other marketable species. This is especially evident in the smaller 10.8 mesh size. The areas where pike are fished for also have a greater incidence of debris which can get caught in the nets, due to the pike's preferred near shore habitat. Conversly, whitefish are a much easier species to fish for and work with. The habitat is in areas with far less debris and the whitefish are relatively simple to remove from the nets, especially in the case of the large 13.3 mesh size.

Certain areas of region 4 and much of region 5 also produce large quantities of rough fish species, which make the picking of nets more difficult. Historic fishing patterns, when whitefish were the targeted species, allowed for selective fishing in areas where rough fish species could be avoided. The shift to near shore fishing for pike generally increases the catch of rough fish. Some fishermen indicated that over 400 suckers (Catostomus spp.) could be caught in just one net, causing it to take over three hours to pick. This adds considerably to the time and effort expended into picking the nets. It also creates extra wear and tear on nets and the filling up of net space, that could be used by marketable species.

5.3 CATCH PER UNIT EFFORT

The catch per unit effort for light colored, export whitefish on historic fishing grounds may have leveled off (1987: 8.44 kg per net night, 1981: 10.3, 1980: 7.5), or may in fact be on the increase. The similarity in the catch per unit effort between 1980, 1981 and 1987 shows that it is very likely the catches have levelled off. Trend data for the seasons following 1987 would be necessary to determine if the catch is increasing. The catch per unit effort levels do demonstrate that the whitefish fishery has not recovered to pre-impoundment status. The low catch per unit effort figures are coupled with lake's continental classification, which in total, exhibits the lack of a high quality whitefish fishery on the lake.

There have been several explanations for the observed decrease in the whitefish catch per unit on historic fishing grounds. Increased suspended sediment levels in SIL after impoundment could alter whitefish distribution patterns. This would make whitefish more difficult to catch if distribution was to new areas, especially out of the lake itself. They would also be more difficult to catch if schooling behavior was reduced or diluted. Bodaly et al. (1980) stated that suspended sediments can directly affect the distribution and schooling behavior of whitefish in SIL.

Bodaly et al. (1984b) indicated that emigration of whitefish out of the lake was the probable cause for the decline in catch per unit effort on historic fishing grounds. Local residents observed pre-impoundment movements of whitefish upstream and downstream over two smaller sets of rapids at Missi Falls. The passage of fish to SIL from downstream locations is now blocked by the Missi Falls control structure. Large quantities of whitefish have been observed after impoundment at the base of the Missi Falls control structure. Barnes (in prep.) estimated that 88,764 whitefish were present below the Missi Falls control structure in the fall of 1986. This was over 60% of the total number of whitefish caught during that summer. Barnes (in prep.) also suggested that the Missi Falls whitefish population is a heterogeneous mix of fish from both upstream (region 4) and downstream locations. The relative proportions are determined by environmental conditions. The Missi Falls control structure has effectively blocked the passage of any possible whitefish migrations into SIL. The exclusion of such migrations, especially on an annual basis, would reduce the numbers of whitefish in SIL. This would result in lower commercial whitefish catches (lower catch per unit effort values) from traditional fishing areas (region 4).

The catch per unit effort increases approximately 25% in region 4, when the smaller 10.8 cm mesh size is used. Healy (1975) has indicated that the 10.8 cm mesh will produce larger commercial whitefish catches than the 13.3 cm mesh. This is as a result of the additional smaller individuals which are caught in the smaller mesh. This can have the effect of reducing whitefish quality, through an increased number of cysts occuring per kg. Whitefish in SIL do not take on more parasites as they increase in age, thus if more smaller individuals are taken, the cumulative cyst levels will be higher. The 12.7 cm mesh used in 1988 may also create a similar condition, although likely to a lesser extent.

Region 5 had higher catch per unit effort levels, but this is likely not indicative of the potential of the region, due to a smaller sample size, and the fact that the region was used more as a pike fishery with many whitefish being discarded. The pricing scheme of the 1987 fishery and the low price for cutters would limit the effort for whitefish in the region. In comparison, 1988 season with its better whitefish prices, had large quantities of lower grade whitefish being delivered from region 5.

Fishermen have always known that they are able to get good whitefish catches from the north end. Bodaly et al. (1983a) found that the whitefish catch per unit effort in 1980/81 was was significantly higher in region 5 than region

4. Ayles (1976) stated that a combination of no fishing pressure and good light conditions which allowed for the maximum use of available nutrients, created reasonable growth conditions for whitefish in region 5. The problem is that region 5 fish are of a lower commercial quality (high cyst counts). The 1988 season's higher price for continental and cutter whitefish, allowed fishermen to exploit the fish in areas where large catches could be obtained. These whitefish populations would generally have been less intensively exploited and the potential for extremely successful catches was high. The large catches exhibited by fishermen over the season supports this hypothesis. High incomes to fishermen, would reinforce it. Although not quantified for the 1988 season, discussions with fishermen and the Missi Falls fish plant manager, revealed that a major proportion of the lake's fishing effort occurred in region 5. This was to take advantage of the good catches of lower quality whitefish, so returns from the fishery would be enhanced.

The lake's fishery is now more dependent on price for its success. The prices for continental and cutter grades of whitefish must be higher in order for their exploitation to be successful in the fishery. If a harvestable export producing area exists on the lake, the continued exploitation of poor quality fish could continue to keep the lake downgraded, just to keep the large catches of poor quality fish. This may be acceptable only in short run situations as long as adequate prices are available for the lower grades. The option for a return to a high grade fishery is possibly lost. Some fishermen have indicated that it was the exploitation of low grade whitefish in the several years following impoundment that caused the downgrading of the lake to a continental classification.

The Freshwater Fish Marketing Corporation is attempting to allow only export fish to be delivered from SIL during the 1988 winter fishery by limiting the fishing effort to region 4 (Rick Hay (pers. comm.). This will be achieved by putting in a winter road only as far as region 4, thus excluding fish from region 5. This would likely be very difficult to regulate during the open water season in a fishery of this size.

5.4 WHITEFISH GRADE, COLOR AND CYST INFESTATION

An important part of the study is the possible movement of region 4 to a continental fishery. Historically it produced export grade whitefish (Sunde, 1963) (Bodaly et al. 1984). The data from this study indicates that the fish being delivered from region 4 have cyst counts which are high enough to be of continental grade. However, certain evidence points to the possibilities of; the region still having export fish in significant quantities; certain areas within the region may be export; and that the region still produces the highest quality fish of the sampled regions. On a per shipment basis in 1987, continental grade occurred with the highest incidence (56%), but export shipments comprised a significant portion of the commercial catch at 37%. Region 5 shipments were of a lower quality when compared to region 4. This is consistent with the historic evidence. Field sampling by federal inspectors of commercial fishermen from region 4 during the winter of 1988 had only three of 11 samples classified as export (Freshwater Fish Marketing Corporation, Thompson, unpublished data). Test netting done by the Manitoba Department of Natural Resources in 1986, using commercial nets, found that region 4 whitefish samples were of export quality (Cook, 1986). Dick (1981) found that region 4 light whitefish were of export quality but lights and darks combined from region 4 were continental grade. Experimental data from Bodaly et al. (1983b) indicated that light whitefish caught in 10.8 and 13.3 cm mesh from region 4 had increasing cyst levels over the years 1978 (export), 1979 (continental) and 1982 (continental) (table 5.1).

As indicated earlier, increasing the size of whitefish individuals in the commercial catch can reduce the rate of cyst infestation. Data from Bodaly et al.(1983b) considering larger (>1kg dressed) light whitefish from region 4 showed export grade occuring in 1978 and 1979

TABLE 5.1

Cyst Infestations in Experimentally Caught Light Whitefish, SIL.

Corrected for dressed weight, 10.8/13.3 cm mesh combined

	1978	1979	1982
number	69	108	70
kilograms	46.9	90.1	64
cysts	29	77	62
cysts/45 kg	27.8	46.1	52.3

From Bodaly et al. 1983b.

(Table 5.2). In 1980 the grade was borderline export/continental. The cyst count appeared to be increasing over the studied years, although sample size was likely a factor. The 1987 data from this study had light whitefish >1 kg grading at continental. The current analysis of this study indicates that selective fishing for larger light whitefish from region 4 will not improve the grade of the fishery to export. The mean cyst count for all sampled light whitefish from region 4 was 44.6/45 kg(table 20, appendix D). The similar rates of cyst infestation found in this study between sizes may indicate a change in food habits of larger fish toward that of younger individuals, although there are many considerations involved in this hypothesis.

TABLE 5.2

Cyst Infestations of Experimentally Caught Light Whitefish > 1 kg, SIL.

Corrected to dressed weight

	1978	1979	1982	1987
kilograms	10	8.2	20.1	52.3
cysts	0	3	18	53
cysts/45 kg	0	16.5	40.3	45.6

From Bodaly et al. (1983b) except 1987 from this study.

Deliveries of whitefish from the 1987 commercial catch were graded at 91% continental and 9% cutter. Deliveries of whitefish from the 1988 commercial catch were graded at 92% continental and 8% cutter (Rick Hay, pers. comm.). All open water commercial seasons after 1976 have had mean cyst counts in the continental range (Department of Fisheries and Oceans, unpublished data). Data from this study had the mean cyst count of 1987 being less than the commercial samples of the Freshwater Fish Marketing Corporation (this study: 61/45 kg, FFMC: 73/45 kg, Department of Fisheries and Oceans, unpublished data). The varying background information makes it difficult to assess the actual grade of region 4.

This study's region 4 information of increasing cyst levels in whitefish indicates that the region may now be a continental fishery (the exception may be region 4B which exhibited an export classification in this analysis). However, region 4 still had the lowest cyst count levels of the sampled regions. This is consistent with pre-impoundment conditions. Historically, fishermen selectively fished region 4 rather than region 5 for the higher quality fish. Early post-impoundment increases in continental fish deliveries, were largely due to the exploitation of fish which were of lower quality from region 5 (Bodaly et al. 1984b). Johnston (1984) noted that conditions favorable for higher cyst levels are more prevalent in region 5 than in region 4. This is due to the shallower mean water depth and the larger numbers of pike (final host in cycle). Bodaly et al. (1980) indicated that the decreased light penetration after flooding could have caused whitefish to spend more time in shallow water. This would bring whitefish from region 4 into a situation where there is an increased probability of cyst infestation. This is as a result of co-inhabiting with pike in shallow water areas where pike are more prevalent. Dick (1981) suggested that cyst levels would continue to increase to a new equilibrium in SIL whitefish which are associated with shallow, inshore areas of the lake. Rawson (1947) discussed that cyst infestations of whitefish were higher in the shallow near-shore water areas of Great Slave Lake and Lake Athabasca. Lawler (1970) stated that whitefish from shallow water have higher cyst levels than whitefish from deep water. Deliveries made to the South Indian Lake community, also had a lower grade of whitefish evident.

5.4.1 Whitefish Color

The estimation of external color in whitefish is very difficult. Light whitefish made up the majority of the catch in 1987. This was especially the case in region 4. Grey whitefish occurred in their greatest quantity in the region 5 samples. Dark whitefish had a low representation from both regions. The low incidence of dark whitefish in the commercial catch was due to fishermen discarding those fish. This was as a result of low prices for whitefish as a whole, the knowledge of the fishermen that the fish were of lower quality and the chance that dark whitefish would be more readily downgraded to cutter.

If greys are considered more similar to darks than lights, the geographic distribution of color in the 1987 commercial catch, is similar to what Bodaly et al (1984b), Johnston (1984), and MacLaren (1978) have indicated, that dark colored fish occur in greater numbers in region 5. Some fishermen have stated that light whitefish are occurring more often in catches from region 5, even near shore.

The second half of the season had a higher incidence of darker fish in the shipments than did the first half of the season. This was likely as a result of all whitefish caught in the fall being delivered, due to the higher prices for whitefish at that time (1987 pricing scheme). Many whitefish would have been discarded by fishermen in the early season, to keep the total catch to under one half of the previous three year average. Whitefish would have been more readily fished for and kept in the fall, when they are more easily caught. Less overall effort would have been expended, and more successful catches would have occurred. Cursory observations during the 1988 season indicated a somewhat even representation of all colors, but greys were the most evident.

The data indicates that the open water sets produced more light colored fish, and that the shore sets produced larger catches of dark colored whitefish. This has also been found by other researchers on Southern Indian Lake. Bodaly et al. (1984b) and Johnston (1984) stated that lights and darks occupy different habitat types, that darks occur more onshore than offshore and that lights are a deeper water fish.

Light colored whitefish occurred in significant quantities for all grades, but export and continental comprised the highest proportions. More light colored fish are export but it was found that this was not an exclusive trait as some darks were export as well. Light whitefish had lower overall cyst levels, but most sampled areas still produced the lower quality grades of cutter and continental. The exceptions were 4A and 4B, but this may be due to a smaller sample size. Region 4 as a whole had the lowest cyst counts of the sampled regions, but the average grade for fish caught in this region was continental. The grey and dark colored whitefish were found to have had the highest levels of cysts. Johnston (1984) stated that dark whitefish had higher mean cyst levels than light whitefish due to being more susceptible to cyst infestation as a result of their their diet (pelagic) and distribution (near shore). Rawson (1947) noted that dark whitefish were caught near shore in Lake Athabasca. Johnston (1984) provided extensive information on the color of whitefish in SIL.

Overall, the data indicates that region 4 may now be an actual continental grade fishery, and if so, impoundment may be the cause. There is a possibility that subregions 4A and 4B may have a chance at being export grade for only light colored whitefish, but sample size of this study must be considered. Peterson (1971) and Kelly (1977) have found that conditions have become more favorable for *Triaenaphorus crassus* parasites after impoundment of river systems. It must be remembered that the impoundment schemes in those studies may not have been regulated in a similar manner (eg. drawdowns as opposed to flooding) and may not have had similar effects. In Southern Indian Lake, lower quality whitefish are correlated with large numbers of pike and shallower water depth (Johnston 1984). Region 4 does not have these conditions to the same extent as does region 5. It is possible that a combination of certain mechanisms may be at work in influencing the increased cyst levels in region 4. These could be the mixing of whitefish stocks a result of the flooding, different feeding habits or the inhabiting of fish into shallower waters thus causing an overlap into pike habitat.

5.5 AGE OF THE COMMERCIAL CATCH

The mean age of the 1987 commercial catch (9.72) is quite similar to that of post-impoundment studies done in 1979, 80 and 81 (9.95 - 10.40) (Bodaly et al. 1984b). Earlier studies done, using scale analysis rather than fin ray analysis found similar mean ages (Ayles, 1976), (Bodaly et al. 1983a). The modal age was 9 for this study, which is lower than those of the years 1979-81 (1979/80: 11, 1981: 10) (Bodaly et al. 1984b). Differences between this study and others, are likely due to the difficulty in achieving consistency in aging fish by different researchers. The age distribution of the commercial catch appears similar to that of previous studies. However, it may represent a lightly exploited commercial whitefish fishery where the effects of exploitation on age structure are relatively slight (Healy, 1975). The whitefish populations of Southern Indian Lake have historically been thought of as light to moderately exploited by Bodaly et al.(1984b) and Ayles (1976). The low level of commercial exploitation in SIL would eliminate any hypothesis which would consider over fishing as a causal factor in the decreased levels of catch per unit effort on traditional fishing grounds. Great Slave Lake whitefish were described by Healy (1975) as lightly exploited, with the bulk of the commercial catch being between the ages of 9-12 years. Data from this study indicates that the 1987 SIL commercial whitefish catch was comprised 95% of individuals over 8 years and 52% over 10 years. A situation of an under-utilized whitefish population could allow for a higher level of commercial harvest. Healy (1980) indicated that increased exploitation of under-utilized whitefish stocks would be accompanied by increased growth rates and recruitment within the stocks. This is thought to be due to the removal of adult suppression from the younger fish. It must be noted that other important factors such as mortality, growth and maturity of the stock are important in determining a whitefish stock's state of exploitation.

There was very little difference in this study between the age structures of region 4 and region 5 even with the difference in percent use of mesh size This may show an indication that the whitefish populations are becoming more homogeneous or that the rate of exploitation between the regions is similar. Bodaly et al. (1984b) has indicated that differences in allele frequencies between whitefish stocks that existed pre-impoundment, are no longer evident. The mixing of whitefish stocks may provide a possible explanation into the reduced grade of region 4.

5.6 FISHING PROCEDURES

The fishing procedures of the 1987 season appear to indicate a a less stable fishery, than that which existed pre-impoundment. Studies done post-impoundment by Bodaly et al. (1984b), have documented similar situations as those found in this study.

Gang size (4.2 nets per gang, range: 1-6) was comparably less in this study than preimpoundment (up to 10 nets per gang) (Weagle and Baxter, 1973). The smaller gang size could be due to having more nets spread out over the lake in order to search for fish. The increase in emphasis to a pike fishery would also reduce gang size, as the pike technique for shore sets is generally limited to single net sets.

The amount of time nets were left in a single location, has stayed approximately the same as other post-impoundment data (5 days). Bodaly et al. (1983) indicated that before impoundment, nets were left in a single location for an average of 18 days and this was reduced to 5 days in 1980 and 6 days in 1981. Weagle and Baxter (1973) indicated that nets are left in a location basically as long as they continue to catch fish. Observations have revealed that fishermen will not continue to fish at a location if they are not successful. Region 5 had a higher incidence of net movement, likely related to pike fishing and shore sets. The specific shore areas may be more easily fished out, and this would cause increased movement to other areas.

The shore set vs. the open set gives some indication into the species being fished. The pike/walleye fishery had a very high amount of shore sets in the first half of the season (77.9%). This fishing effort was directed into the shallower water areas which pike inhabit, especially during that time of year. The summer portion of the second half of the season, had the highest amount of open sets (55.1%). This was not as species specific, as much as it was to find fish which migrate to deeper, cooler waters at that time of the year. The fall portion of the season was directed toward a shore set (63%). This was likely due to being able to catch the migrating/spawning whitefish which congregate off of rocky islands. The tendency towards shore sets for the majority of the season (64.4%), may also be due to the fact that it is easier to fish. Shore sets can be in sheltered areas, away from the long wind fetches and rough waters which are a hazard on the lake. As discussed earlier, it may be important to consider that whitefish caught in near shore areas could be darker and have higher cyst counts.

An aspect of the fishery which exhibits the dual fishery characteristic of the 1987 season is the mesh size. The higher incidence of the smaller 10.8 cm mesh size, indicates the emphasis on pike and walleye in the early portions of the season and in region 5. Opposite trends are noted when whitefish was fished for in region 4 in the fall, as the 13.3 mesh size was more often used. The inclusion of the 12.8 cm mesh in the 1988 season was to increase the chances of successful whitefish catches.

Mesh size can have considerable implications on the age, size and rate of cyst infestation of whitefish. As discussed earlier, larger whitefish can have lower rates of cyst infestation. The use of the smaller 10.8 and 12.7 cm mesh nets would catch smaller sized individuals. This could then lower the grade of whitefish caught by increasing the cyst count per kilogram. Healy (1975) stated that the 10.8 cm mesh would produce larger numbers of whitefish in a commercial catch than the 13.3 cm mesh due to the additional selection of smaller individuals. Cook (1986) noted that SIL whitefish caught from 10.8 cm mesh had significantly higher rates of infestation then whitefish from the 13.3 cm mesh (although all samples were of export quality). Data from Bodaly et al. (1983b) indicated a similar trend for the years 1978 and 1982 (table 5.3).

TABLE 5.3

Cyst Infestation in Experimentally Caught Light Whitefish, Region 4, SIL, 10.8 cm mesh and 13.3 cm mesh.

Corrected for dressed weight.

Mesh	1978	1979	1982
10.8	28.6	49.9	48.4
13.3	15.4	59.5	19.1

From Bodaly et al. (1983b).

The illegal use of 10.8 cm mesh in the SIL whitefish fishery is significant enough in that it may continue to keep the grade of the lake at continental (if an export quality fishery exists). This is a serious but delicate problem considering that fishermen are attempting to make a living, and 10.8 cm mesh will produce better catches then 13.3 cm mesh. The recent implementation of 12.8 cm mesh into the fishery may also contribute to the addition of smaller individuals to the catch. However, the extent of this if any is unknown at this time.

5.7 QUALITATIVE FISHING INFORMATION

The 1987 season did not have as high a total effort expended as the 1988 season. This was likely the result of many reasons, such as poor catches for favored (high priced) species, low prices for whitefish, and alternative employment at the Big Sand Lodge, at local construction sites and at fire fighting. Many fishermen did not fish during certain times of the season so they could pursue other traditional activities, such as moose and geese hunting. Commercial fishing is a very difficult activity. It is very expensive to get started, is very hard work and is not stable (eg. price and environmental fluctuations). These were indicated as reasons some men chose to engage in other forms of employment. Many fishermen waited until fall before they started fishing, to take advantage of the whitefish spawning run, which increased economic returns from effort. Fishermen who did fish throughout most of the season, did so because of the overall limited employment opportunities and their feeling that there was nothing else to do.

Fishing as a traditional activity appears to have changed post-impoundment. It was said to be a family activity, but many operations now approach it on a different level. Although not analyzed in this study, the Missi Falls operations appeared to be as often as not, a non-family effort. Fishing operations which delivered to the Southern

Indian Lake community, were generally less intensive than the Missi Falls operations. Fishing in Southern Indian Lake is quite difficult (especially region 4). This is due to its size (a high incidence of rough water which can keep fishermen off of the lake, and the difficulty in finding fish) and the relatively new problems caused by hydro-electric development.

Many fishermen now fish inland lakes, either exclusively or on an alternating basis with Southern Indian Lake. The smaller inland lakes are easier to fish due to less rough water, the ease of filling the lake's quota (better catches) bonus incentives (for air shipment), reduced mesh sizes, and being able to fish with no competition from other enterprises. A common complaint of fishermen in SIL was that if they would get good catches in an area, other fishermen would move in to also get the good catches. Observed deliveries were larger for inland lakes than for Southern Indian lake in 1987. Conversely, 1988 was not as good a season for the inland lakes. These lakes have been intensively fished in the recent past and this may be reflected in the 1988 season's catches. The good catches in Southern Indian Lake may have also removed some of pressure from the inland lakes.

5.8 SUMMARY OF RESULTS AND COMPARISONS

The results of this study when compared to historic results demonstrate that the SIL whitefish fishery has not shown significant recovery from post-impoundment reductions in the catch per unit effort and grade from historic fishing grounds. The data may indicate several different situations. The fishery may have stabilized at the levels exhibited during the 1980s, or a marginal trend returning closer to post impoundment levels may be evident. If the latter is the case, the early to mid 1980s would have been the bottom end of the decline. However there is a lack of successive seasons of data on which to confidently base the assumptions (especially the latter view).

Chapter VI

CONCLUSIONS AND RECOMMENDATIONS

This study further documents the changes in the commercial fishery of Southern Indian Lake since diversion of the Churchill River and lake impoundment in 1976. The data generated by this study demonstrate that the whitefish fishery has not significantly recovered from post-impoundment reductions in catch per unit effort and grade. There are significant differences in the commercial fishery before and after impoundment.

6.1 CONCLUSIONS

1) The catch per unit effort for whitefish on the traditional fishing grounds (region 4, 8.44 kg/net night), was approximately the same as previous post-impoundment data (1979: 7.5 kg net/night, 1980: 10.3 kg net/night) and was much less then pre-impoundment data (23.1 kg net/night, 1972). It was also less than data from region 5 (11.18 kg net/night). There may be some indication of a return closer to pre-impoundment levels.

2) The grade of light whitefish from region 4 has shown a decline to continental grade from export. The mean cyst count per shipment for light whitefish from region 4 was

51.9 (continental) and continental was the most common grade in region 4 and region 5. It may be that the option of returning to an export quality fishery is no longer possible. Region 4 still produced the highest quality whitefish of the studied regions. Contrary to the literature, larger light whitefish (>1 kg) from SIL (region 4) did not have lower cyst levels than the total sampled catch of light whitefish from region 4.

3) The geographic distribution of fishing effort has shifted from region 4 to region 5 in response to high catches of preferred species (pre-impoundment, region 4: 100%, 1987, region 4: 58%). When whitefish prices were low in 1987, pike made up a proportionately larger than historic amount of the commercial catch. The majority of these were caught from region 5. In 1988, prices for lower grade whitefish increased, and their representation in the commercial catch increased. Region 5 was an important area for good catches of lower grade whitefish in 1988 and pike in 1987. Fish prices and economic returns influenced the overall physical, temporal and spatial fishing effort.

4) The age structure of whitefish was similar to that of past studies, and any variation may be due to differences in fish aging results by sampling personnel.

5) The time nets were left at one location in region 4 has shown an increase over the years 1980 (5 days), 1981

(5.6 days) and 1987 (6.3 days). The time nets were left in a location in 1987 is still much less then before impoundment (18 days, 1972).

6.2 RECOMMENDATIONS

There is an ongoing need in environmental research for the post-impact monitoring and assessment of development projects. This system of environmental auditing can enhance the information base of the scientific community which assists in the decision making process of management and future development. It is this type of information which can allow for the successful implementation of future projects into the sustainable economic development concept.

Southern Indian Lake is still an important commercial fishery in northern Manitoba. The fact that people gain their livelihood from the Lake, necessitates the need for some continued action in the form of ongoing monitoring and specific management techniques, all to enhance the fishery. In determining recommendations one must consider the importance of the fishery and develop valid suggestions from the biological information received.

It is important that Government and the SIL Fishermen's Association determine the goals and objectives of the fishery. These can be used in developing a long term management strategy for the Lake. The whitefish fishery does not show a significant return to pre-impoundment conditions, thus negating the issue of an export quality fishery in the near future. The management strategy should reflect this situation and attempt to develop the fishery towards maximum social benefits for the SIL community. This could mean concentrating effort on continental grade whitefish, other fish species or new areas of the Lake.

There were significant negative impacts to the commercial fishery after impoundment for hydro-electric development. Additional factors such as fish prices, subsidy agreements and compensation payments have continued to keep the fishery in a state of change since impoundment. The present management of the fishery does not utilize its full potential. The time has come to develop a management plan for the fishery which will maximize benefits to the SIL community.

Specifically, I recommend;

1) The development of long term goals and objectives and the creation of an overall management plan for the SIL fishery by the community and government.

2) Reducing the mesh size regulations to 10.8 cm for the whole lake. This would have to occur in conjunction with keeping the lake graded at continental. The quantity of whitefish caught would increase, thus increasing economic revenues to the fishermen. At present the whitefish stocks

are under-exploited and could withstand extra fishing pressure. The whitefish caught could be limited to light colored to ensure a higher quality fishery. The smaller mesh size would also increase the harvest of the other commercial species. More intensive utilization of pike may decrease the cyst levels in whitefish.

3) Monitoring and analysis of the whitefish stocks and the commercial fishery by the Manitoba Department of Natural Resources or Federal Department of Fisheries and Oceans, to determine any trends in the whitefish catch and grade and to assess the health of stocks in response to increased exploitation. Statistical analysis should occur on the information for more complete reliability. This could occur every three years. An expanded information base may be able to identify a possible export whitefish fishery on SIL for exploitation in the future. The Freshwater Fish Marketing Corporation should monitor the grade of whitefish from SIL on a regular basis.

4) The Department of Natural Resources should undertake an intensive monitoring program on the effects of smaller mesh sizes on the age structure, state of exploitation and grade of the commercial whitefish catch from SIL.

Chapter VII

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Appendix A

WHITEFISH PARASITE CYCLE

The following discussion of the Triaenaphorus crassus parasite is taken directly from Scott and Crossman (1973).

"The cestode parasite Triaenaphorus crassus is of particular interest because of the marketing problem caused by the presence of its repulsive cysts in whitefish flesh. Although the cysts are unsightly, they are not harmful to man.

T. crassus Forel is a pseudophyllidean cestode found typically in the circumpolar subregion of the Holarctic. The northern pike, is the definitive or final host. The parasite attains sexual maturity in the gut of the pike, produces eggs at the time the pike spawns, and then dies. The embryo parasite develops in the egg, becomes a coracidium, and leaves the egg shell. This free-swimming form must be eaten by the first intermediate host, a copepod, for further development. In North America, Cyclops bicuspidatus is the most important copepod. In this host the parasite is transformed into a procercoid larva and the duration of this stage may last approximately one month. When an infected copepod is eaten by whitefish, ciscoes, or other members of the family Salmonidae, the plerocercoid burrows through the gut wall and becomes transformed into a plerocercoid larva which usually encysts in the musculature. This plerocercoid stage may remain viable for 4-5 years and if the infected fish is eaten by a pike during this period the life cycle begins again. It has been found that the degree of infection can be significantly lowered by fishing pike intensively."

Appendix B

FISH PRICES

FRESHWATER FISH MARKETING CORP.

Fresh Summer Price List

Summer 1987

F.O.B. STATION - Leaf Rapids

		1986 $/Lb.	1987 $/Lb.	Kg			Kg	
WHITEFISH	Sm.	.19	.19		or	.26)		With 25% Reduction
EXPORT	Med.	.34	.34	.75	or	.46	1.01	in 3 yr. average
DSD.	Lge.	.35	.35	.77	or	.47	1.03	Production
	Jbo.	.36	.36	.80	or	.48	1.06	
WHITEFISH	Sm.	.14	.09		or	.19)		With 50% Reduction
CONT."	Med.	.19	.12		or	.27)		in 3 yr. average
DSD.	Lge.	.19	.12	.27	or	.27	.60)	Production
	Jbo.	.19	.12		or	.27)		
WHITEFISH	All Sizes	.12	.08	.18	or	.19)	.42	With 50% Reduction
CUTTERS								in 3 yr. average
HDLS.								Production
PICKEREL	Sm.	.76	.87					
DSD.	Med.	.87	1.04	2.30				
JACKFISH								
Dsd. 4-9		.34	.54	1.19				
Hdls.		.24	.39	.86				
GOLDEYE		.26	.54					
PERCH		.74	.74					
STURGEON		[illegible].54	3.54					
TULLIBEE	Exp.	.24	.24					
Dsd.	Cont.	.12	.12					

SOUTH INDIAN LAKE AREA DEDUCTIONS:

Boat Frt.	9¢ per lb.	(Fish Hauled by Kinoosao)
Ice	4¢ per lb.	

FRESHWATER FISH MARKETING CORPORATION

****** FRESH SUMMER 1988 PRICE LIST ****** NORTHERN MANITOBA

EFFECTIVE: 26-June-88

FOB STATION: LEAF RAPIDS

FREIGHT BACKOFF FROM TRANSCONA .138

AGENT : F.F.M.C. N.M.A.

THE ONLY SPECIES AND GRADES THAT WILL BE ACCEPTED AT THIS DELIVERY POINT ARE THOSE INDICATED BELOW

SPECIES	GRADE	$/KG.
WHITEFISH EXPORT DRESSED	SML (.45 - .7)	.412
	MED (.7 - 1.4)	.792
	LGE (1.4 - 1.8)	.812
	JBO (OVER 1.8)	.832
WHITEFISH CONTINENTAL DRESSED	SML (.45 - .7)	.302
	MED (.7 - 1.4)	.412
	LGE (1.4 - 1.8)	.412
	JBO (OVER 1.8)	.412
WHITEFISH CUTTERS/HDLS.	ALL SIZES	.372
PICKEREL ROUND	SML (.35 - .6)	1.732
	MED (.6 - 1.6)	1.952
	LGE (OVER 1.6)	1.622
PICKEREL BELLY-SPLIT	SML (.30 - .55)	1.912
PICKEREL DRESSED	MED (.55 - 1.4)	2.512
	LGE (OVER 1.4)	2.132
SAUGER ROUND	MED (25 - 30cm)	1.292
	LGE (30 - 35cm)	1.402
	JBO (OVER 35cm)	1.512
SAUGER BELLY-SPLIT	MED (25 - 30cm)	1.362
	LGE (30 - 35cm)	1.492
	JBO (OVER 35cm)	1.602
Nlls Whites Continental	Lake Run	.522

SPECIES	GRADE	$/KG.
NORTHERN PIKE DSD (GILLS OUT)	MED (NOT ACPTD)	
	LGE (1.8 - 4.1)	.962
NORTHERN PIKE HEADLESS	SML (.35 - .9)	.632
	OTHER (OVER .9)	.632
LAKE TROUT DRESSED	SML (.9 - 1.8)	1.182
	MED (1.8 - 3.6)	1.402
LAKE TROUT HEADLESS	LGE (OVER 3.6)	1.072
PERCH ROUND	20cm & OVER	1.622
GOLDEYE DRESSED	MED (.35 - .45)	1.402
	LGE (OVER .45)	1.402
STURGEON HEADLESS	MED (3.6 - 5.5)	6.472
	LGE (OVER 5.5)	7.802
TULLIBEE EXPORT DSD.	MED (.35 - .7)	.522
	LGE (OVER .7)	.522
TULLIBEE CONT. DSD.	MED (.35 - .7)	.262
	LGE (OVER .7)	.262
MULLET		***
CARP		***

*** Special order only. Prices will be issued at time of sale.

ABOVE PRICES ARE TO BE SHOWN ON FISH PURCHASE TICKETS BEFORE DEDUCTIONS. SCHEDULE "C" OUTLINES DEDUCTIONS FOR # 2 QUALITY FISH. CULLS ARE NOT ACCEPTED.

Appendix C

FIELD DATA FORMS

CONFIDENTIAL

S.I.L. 1987 SUMMER COMMERCIAL FISHERY

DATE: June ________ FISHERMAN ____________________________
July ________ ____________________________
August ______ LOCATION ____________________________

NUMBER OF NETS ________ SET __________ PULLED __________

MESH SIZE NET DEPTH ____________________________
4½ __________
5½ __________ DAYS AT LOCATION __________________

OPEN SET ___________ SHORE SET ____________________________

WHITEFISH WALLEYE

LIGHT		DARK
_____	Small	_____
_____	Medium	_____
_____	Large	_____
_____	Jumbo	_____

WALLEYE

SMALL _________
MEDIUM _________
LARGE _________

PIKE

2/4 (HEADLESS) _____
4/9 (DRESSED) _____

TULLUBEE

MEDIUM _________
LARGE _________

COMMENTS:

____
____
____
____
____

S.I.L. CYST COUNT 1987

DATE: JUNE ____ FISHERMAN ____________________

JULY ____ ____________________

AUGUST ____ LOCATION ____________________

SEPT. ____

# FISH	WEIGHT	# CYSTS	LIGHT	DARK
1	____	____	____	____
2	____	____	____	____
3	____	____	____	____
4	____	____	____	____
5	____	____	____	____
6	____	____	____	____
7	____	____	____	____
8	____	____	____	____
9	____	____	____	____
10	____	____	____	____
11	____	____	____	____
12	____	____	____	____
13	____	____	____	____
14	____	____	____	____
15	____	____	____	____
16	____	____	____	____
17	____	____	____	____
18	____	____	____	____
19	____	____	____	____
20	____	____	____	____
21	____	____	____	____
22	____	____	____	____
23	____	____	____	____
24	____	____	____	____
25	____	____	____	____
TOTAL	____	____		

$$\text{CYSTS/100 LBS.} = \frac{\text{TOTAL CYSTS} \times 100}{\text{LBS FISH SAMPLED}}$$

Appendix D

TABLES

TABLE D.1

Percent Seasonal Effort, Mean Nets Per Night, SIL, 1987.

	Total Nets	Data Pts.	Nets Per Night	% Effort
1st Half	1626	107	15.2	52.8
2nd Half	1451	97	15	47.2
Fall*	954	62	15.4	31
Total	3077	204	15.1	100

Range : 5-32 nets per night
*Included in 2nd half

TABLE D.2

Relative Proportion of Effort in Regions 4 and 5 for Various Times of the 1987 Fishing Season, SIL.

Season	Region 4	Region 5	Data Pts.
1st Half	47.2	52.8	1421
2nd Half	73.3	26.7	1356
Summer*	35.8	64.2	500
Fall*	95.3	4.7	856
Total Season	58.3	41.7	2777

*Included in 2nd half

TABLE D.3

1987 Commercial Catch Species Composition, SIL.

Species	Percent	Kilograms
Whitefish	48	68500
Pike	43	61100
Walleye	9	14100

From Economics Branch, Department of Fisheries and Oceans, Wpg. and Freshwater Fish Marketing Corporation, Wpg.

TABLE D.4

Percent Species Composition of the Sampled Commercial Catch, Seasonal Breakdown, Region 4, SIL, 1987.

Season	Pike	Walleye	Whitefish	Kilograms
1st Half	39	1	59	5937.5
2nd Half Summer only	63	9	28	2614
Fall	3	2	95	7438
Total	26	3	71	15990.5

TABLE D.5

Percent Species Composition of the Sampled Commercial Catch, 1987 Seasonal Breakdown, Region 5, SIL.

Season	Pike	Walleye	Whitefish	Kilograms
1st Half	84	16	-	5651.5
2nd Half Summer only	14	33	53	3750.5
Fall	36	2	62	268
Total	56	22	22	9670

Percent may not add to 100 due to rounding.

TABLE D.6

Percent Species Composition of Sampled Commercial Catch, Seasonal Proportion, Region 4, SIL, 1987.

Season	Pike	Walleye	Whitefish
1st Half	55	18	31
2nd Half Summer only	39	47	6
Fall	6	35	63
Kilograms	4224.5	493.5	11272.5

TABLE D.7

Percent Species Composition of Sampled Commercial Catch, 1987 Seasonal Proportion, Region 5, SIL.

Season	Pike	Walleye	Whitefish
1st Half	88	42	-
2nd Half Summer only	10	58	8
Fall	2	<1	92
Kilograms	5411	2111.5	2147.5

TABLE D.8

Whitefish Catch Per Unit Effort, Region 5, SIL, 1987.

Mesh Size	Kilograms	Net Nights	Catch Per Unit Effort
10.8 cm	699	88	7.94
13.3 cm	1017.5	91	11.18
Total	1716.5	179	9.59
Combined*	2147.5	213	10.08

*Includes samples with combined mesh sizes in sets.

TABLE D.9

Whitefish Catch Per Unit Effort, 10.8 cm Mesh Size, 1987 Seasonal Breakdown, SIL.

Season	Kilograms	Net Nights	Catch Per Unit Effort
1st Half	651.5	44	14.81
2nd Half Summer	468	53	8.83
2nd Half Fall	1464	100	14.64
2nd Half Total	1932	153	12.63
Season	2583.5	197	13.12

TABLE D.10

Whitefish Catch Per Unit Effort, 13.3 cm Mesh Size, 1987 Seasonal Breakdown, SIL.

Season	Kilograms	Net Nights	Catch Per Unit Effort
1st Half	1949.5	208	9.37
2nd Half Summer	2050.5	205	10.00
2nd Half Fall	4344	465	9.34
2nd Half Total	6394.5	670	9.54
Season	8344	878	9.50

TABLE D.11

Whitefish Catch Per Unit Effort, 1987 Seasonal Breakdown, Regions and Mesh Sizes Combined, SIL.

Season	Kilograms	Net Nights	Catch Per Unit Effort
1st Half	3373	337	10.01
2nd Half Summer	2528	327	7.73
2nd Half Fall	7869	748	10.52
2nd Half Total	10397	1075	9.67
Season	13770	1412	9.75

TABLE D.12

Mean Cysts per 45 kg Sample by Area, SIL, 1987.

Area	Cyst Count	Range
Region 4*	48.9	0-188
Region 4A**	62.5	9-133
Region 4B**	41.8	9-133
Region 4C**	44	27- 68
Region 5	59.7	16-118
Post***	77.3	42-280

*Includes isolated regions not counted in subregions.
**Included in Region 4.
***Deliveries made to community.

TABLE D.13

Regional Mean Cyst Count Per Sample, SIL, 1987.

Region	Mean Count	Range	Samples	Mean Weight Per Sample (kilograms)
Region 4	1.04	0 -3	39	8.9
Region 5	1.36	.4-2.83	15	7.9
Post*	1.46	.8-4.2	14	7.4
Total	1.2	0 -4.2	68	8.4

*Deliveries made to the community.

TABLE D.14

Mean Cysts Per Fish By Region, Sampled From Commercial Catch, SIL, 1987.

Area	Cysts Per Fish	Fish Sampled	Total Cysts
Region 4	1.07	413	443
Region 5	1.6	109	174
Post*	1.51	134	203
Total	1.21	676	820

*Deliveries made to community.
Modal cyst count = 0

TABLE D.15

Percent Whitefish Color, 1987 Seasonal Variation, SIL.

Season	Light	Grey	Dark	Kilograms Sampled
1st Half	77.6	16	6.4	3389.5
2nd Half	54.7	35.7	9.6	8882.7
Fall*	57.8	30.1	12.1	6057.1
Total	60.7	30.2	9	12272.2

*Included in 2nd half.

TABLE D.16

Percent Occurrence Whitefish Color as Related to Set Type, SIL, 1987.

Season	Light	Grey	Dark	Kilograms
Open Set				
Summer	65.8	31.3	2.9	5464.9
Fall	74.4	9	16.6	1758.9
Total	67.9	25.9	6.2	7223.8
Shore Set				
Summer	1.3	15.7	83	593
Fall	44.5	41.6	13.9	2362
Total	35.8	36.4	27.8	2955

TABLE D.17

Percent Occurrence of Color in Export Grade Whitefish, SIL, 1987.

Region	Dark	Grey	Light
Region 4	20	16	64
Samples	22		
Region 5	10	20	70
Samples	4		
Post*	-	-	-
Samples	-		
Total	18	17	65
Samples	26		

*Deliveries made to the community.

TABLE D.18

Percent Occurrence of Color in Continental Grade Whitefish, SIL, 1987.

Region	Dark	Grey	Light
Region 4	27	25	48
Samples	14		
Region 5	18	33	49
Samples	6		
Post*	20	32	48
Samples	10		
Total	23	29	48
Samples	30		

*Deliveries made to the community.

TABLE D.19

Percent Occurrence of Color in Cutter Grade Whitefish, SIL, 1987.

Region	Dark	Grey	Light
Region 4	33	26	41
Samples	3		
Region 5	46	54	-
Samples	5		
Post*	35	28	37
Samples	4		
Total	39	38	23
Samples	12		

*Deliveries made to the community.

TABLE D.20

Average Light Whitefish Cyst Count By Area, SIL, 1987.

Area	Cysts	Kilograms	Cysts Per 45 Kilograms
Region 4	177	171	44.6
Region 4A*	4	7.9	22.9
Region 4B*	11	13.4	37.1
Region 4C*	155	144.7**	48.2
Region 5	57	47.9	53.6
Post***	52	44.3	52.9
Lake	286	263.2	48.9

*Included in Region 4.
**Isolated sets not counted.
Calculated per each fish from all samples.
***Deliveries made to the community.

TABLE D.21

Average Grey Whitefish Cyst Count By Area, SIL, 1987.

Area	Cysts	Kilograms	Cysts Per 45 Kilograms
Region 4	97	80.9	54
Region 4A*	40	26.8	67.3
Region 4B*	2	14.1	6.4
Region 4C*	55	40	61.9
Region 5	58	31.7	82.3
Post**	56	32.1	78.5
Lake	211	144.7	65.6

*Included in Region 4.
**Deliveries made to the community.
Calculated per each fish from all samples.

TABLE D.22

Average Dark Whitefish Cyst Count By Area, SIL, 1987.

Area	Cysts	Kilograms	Cysts Per 45 Kilograms
Region 4	169	132.4	57.4
Region 4A*	116	85.5	61
Region 4B*	-	-	-
Region 4C*	53	46.9	50.9
Region 5	59	24.9	106.8
Post**	95	36.3	117.9
Lake	323	193.6	75.1

*Included in Region 4.
**Deliveries made to the community.
Calculated per each fish from all samples.

TABLE D.23

Cysts Per Light Colored Whitefish by Area, SIL, 1987.

Area	Cysts Per Fish	Fish Sampled	Total Cysts
Region 4	.92	192	177
Region 5	1.16	49	57
Post*	.96	54	52
Lake	.97	295	286

*Deliveries made to community.
Modal cyst count = 0.

TABLE D.24

Cysts Per Grey Colored Whitefish by Area, SIL, 1987.

Area	Cysts Per Fish	Fish Sampled	Total Cysts
Region 4	1.15	84	97
Region 5	1.71	34	58
Post*	1.44	39	56
Lake	1.19	177	211

*Deliveries made to community.
Modal cyst count = 0.

TABLE D.25

Cysts Per Dark Colored Whitefish by Area, SIL, 1987.

Area	Cysts Per Fish	Fish Sampled	Total Cysts
Region 4	1.23	137	169
Region 5	2.67	26	59
Post*	2.3	41	95
Lake	1.58	204	323

*Deliveries made to community.
Modal cyst count = 0.

TABLE D.26

Mean Age of the Sampled Commercial Whitefish Catch by Region, SIL, 1987.

	Samples	Mean Age	Mode	Range
Region 4	159	9.786	9	6-15
Region 5	265	9.706	9	6-14
Combined	424	9.722	9	6-15

TABLE D.27

Average Nets Per Gang, Open vs. Shore Set, SIL, 1987.

	Open	Shore
Nets Per Gang	4.2	1.1
Range	1-6	1-3
Data Pts	87	443

TABLE D.28

Percent Use Mesh Size, Seasonal and Regional Breakdown, SIL, 1987.

Season	Region 4		Region 5		Totals	
	10.8	13.3	10.8	13.3	10.8	13.3
1st Half	41.5	58.5	84.6	15.4	65.6	34.4
pts.	528		670		1198	
2nd Half	26.7	73.3	62.1	37.9	36.3	63.7
pts.	881		332		1213	
Fall*	24.8	75.2	99.1	.9	25.8	74.2
pts.	702		11		713	
Totals	32.2	67.8	77.1	22.9	50.8	49.2
pts.	1409		1002		2411	

*Included in 2nd half

TABLE D.29

Percent Open vs. Shore Sets, Seasonal Basis, SIL, 1987.

	Open	Shore	Data Points
1st Half	22.1	77.9	1436
2nd Half	55.1	44.9	992
Fall*	37	63	592
Total	35.6	64.4	2428

*Included in 2nd half

TABLE D.30

Seasonal Proportion of Total Commercial Catch, SIL, 1987.

Season	Region 4 only	Region 4 total	Region 5 only	Region 5 total
1st Half	37	27	58	22
2nd Half Summer only	16	10	39	15
Fall	47	30	3	1
Total		62		38

Percent may not add to 100 due to rounding.

TABLE D.31

Percent Whitefish Sampled in the 1987 SIL Commercial Catch.

Season	Region 4	Region 5	Total
1st Half	31.1	-	26.5
2nd Half	67.9	100.	73.5
Fall*	62.4	7.7	53.6
Total Kilograms	11172.5	2147.5	13420
Percent	83.3	16.7	

*Included in 2nd half
Overall Total = 14408 kg. Whitefish not counted due to dual region locations = 988 kg.

TABLE D.32

Percent Grade by Sampled Delivery by set type, SIL, 1987.

Grade	Open	Shore	Samples
Export	86.7	13.3	15
Continental	63.6	36.4	22
Cutter	75	25	8

TABLE D.33

Percent Whitefish Color, Seasonal Breakdown, SIL, 1987.

Season	Light	Grey	Dark	Total
1st Half	34.9	14.6	22.6	27.7
2nd Half	65.1	85.4	77.4	72.3
Fall*	47	49.1	66.3	49.4
Total Kilograms	7452.9	3709.9	1109.4	12272.2
Percent	60.7	30.2	9	

*Included in 2nd half.

TABLE D.34

Percent Whitefish Color, Seasonal Breakdown, Region 4, SIL, 1987.

Season	Light	Grey	Dark	Total
1st Half	38.6	21.7	25.7	33.3
2nd Half	61.4	78.3	74.3	66.7
Fall*	51.9	71.5	74.3	58.8
Kilograms	6724	2496.2	973.4	10193.6

*Included in 2nd Half

TABLE D.35

Percent Whitefish Color, Seasonal Breakdown, Region 5, SIL, 1987.

Seasonal Breakdown

Season	Light	Grey	Dark	Total
1st Half*	-	-	-	-
2nd Half	100	100	100	100
Fall**	98.3	96.9	90.7	97
Kilograms	728.9	1213.7	136	2078.6

*Not sampled due to lack of whitefish deliveries from Region 5.
**Included in 2nd half.

TABLE D.36

Percent Whitefish Color, Seasonal Composition, Region 4, SIL, 1987.

Seasonal Composition

Season	Light	Grey	Dark	Kilograms Sampled
1st Half	77.6	16	6.4	3389.5
2nd Half	60.6	28.8	10.6	6804.1
Fall*	58.2	29.8	12	5994.1
Total	66	24.5	9.5	10193.6

*Included in 2nd Half.

TABLE D.37

Percent Whitefish Color, Seasonal Composition, Region 5, SIL, 1987.

Seasonal Composition

Season	Light	Grey	Dark	Kilograms Sampled
1st Half*	-	-	-	-
2nd Half	35.5	58.4	6.1	2015.6
Fall**	35	58.4	6.6	63
Total	35.5	58.4	6.1	2015.6

*Not sampled due to lack of whitefish deliveries from Region 5.
**Included in 2nd half.

TABLE D.38

Cyst Count, Dark Whitefish, Set Type, Region 4, SIL, 1987.

Set/ Season	Cysts Per 45 Kilograms	Kilograms	Cysts
Open			
Summer	78.6	5.2	9
Fall	63.4	3.6	5
Total	72.4	8.7	14
Shore			
Summer	50.3	91.2	102
Fall	118	3.1	8
Total	52.5	94.3	110

TABLE D.39

Cyst Count, Grey Whitefish, Set Type, Region 4, SIL, 1987.

Set/ Season	Cysts Per 45 Kilograms	Kilograms	Cysts
Open			
Summer	37.7	10.8	9
Fall	46.1	10.8	11
Total	41.9	21.9	20
Shore			
Summer	49.1	8.3	9
Fall	60.1	8.9	12
Total	55	17.2	21

TABLE D.40

Cyst Count, Light Whitefish, Set Type, Region 4, SIL, 1987.

Set/ Season	Cysts Per 45 Kilograms	Kilograms	Cysts
Open			
Summer	43	78.5	75
Fall	47.2	33.4	35
Total	45	111.9	112
Shore			
Summer	0	9.7	0
Fall	254.1	4.3	24
Total	77.4	14	24

Appendix E

FIGURES

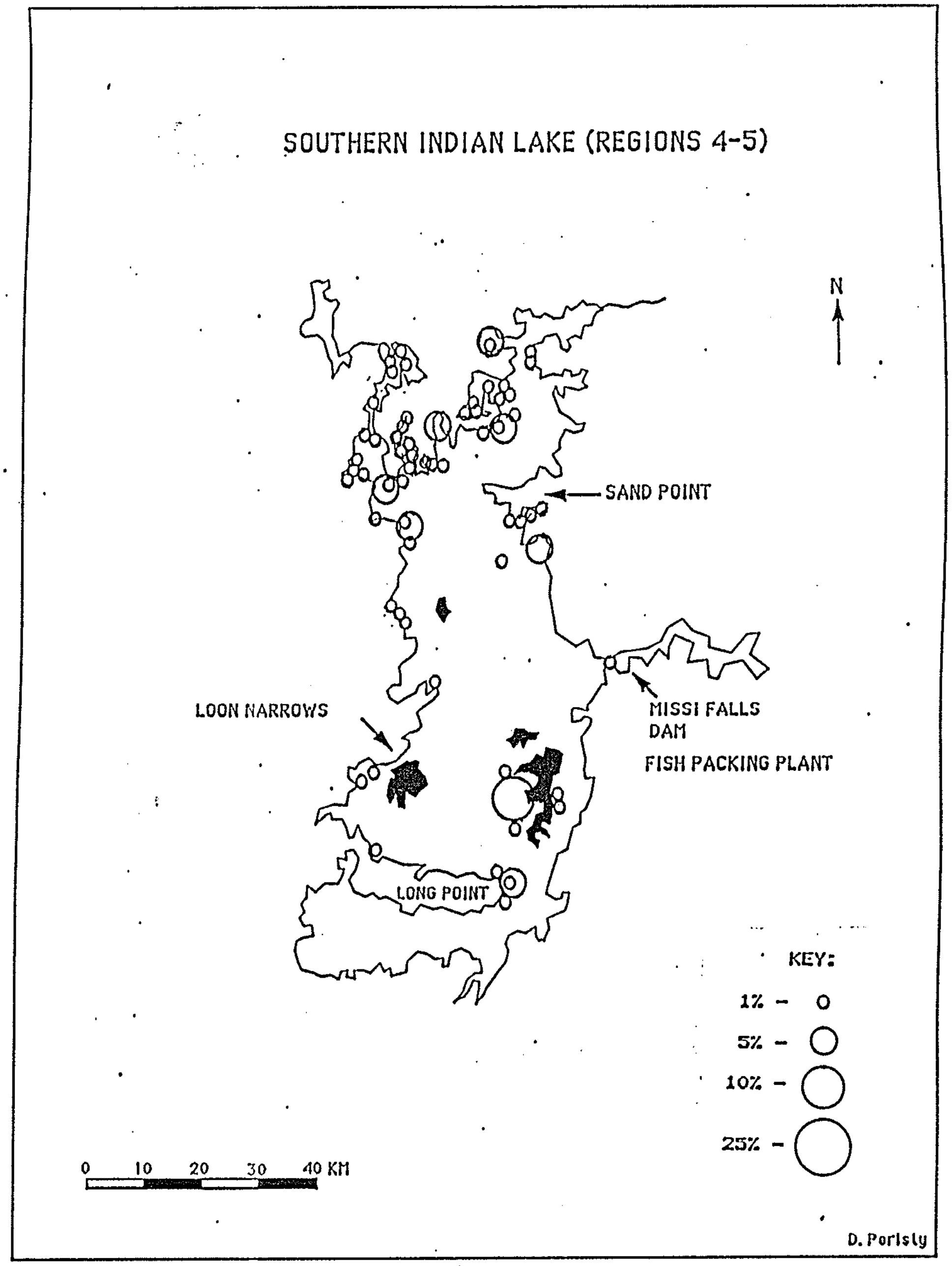

Figure E.1: Geographic Distribution of Fishing Effort, First Half of Season, SIL, 1987.

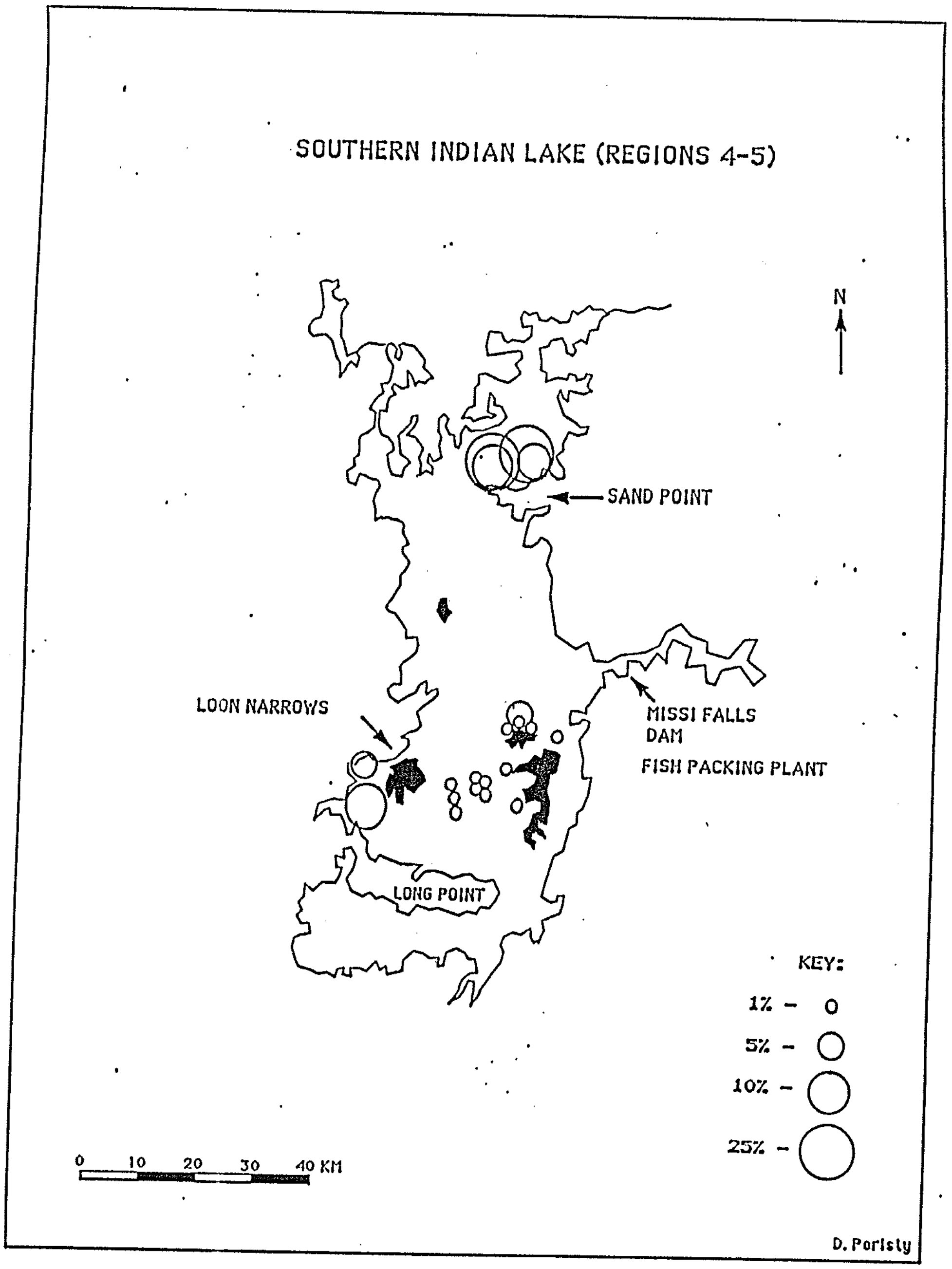

Figure E.2: Geographic Distribution of Fishing Effort, Second Half, Summer Portion, SIL, 1987.

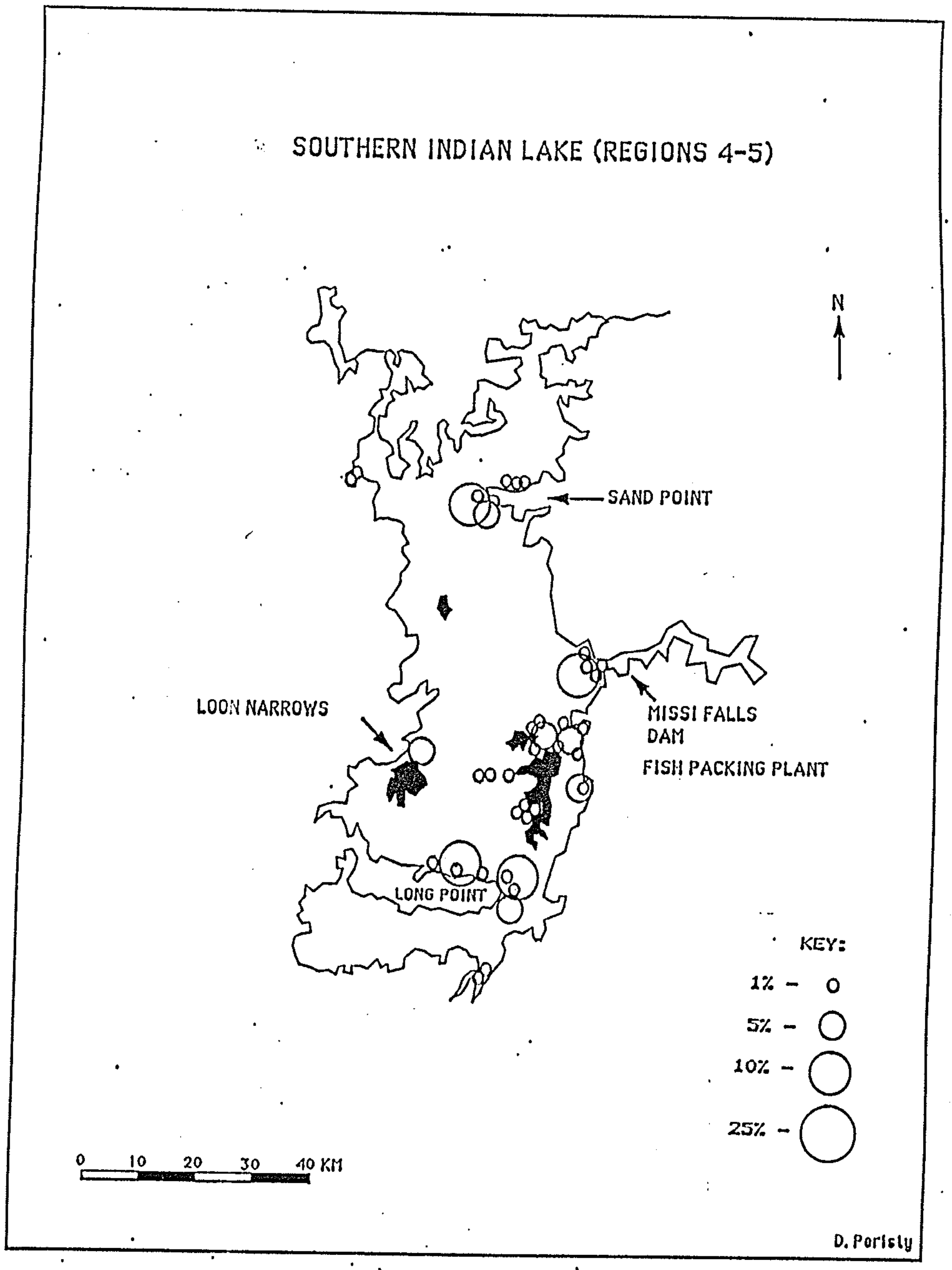

Figure E.3: Geographic Distribution of Fishing Effort, Second Half, Summer Portion, SIL, 1987.

Figure E.4: Percent Age Distribution of Sampled Commercial Catch, Region 4, SIL, 1987.

```
 %
30
29
28
27             XXX
26             XXX
25             XXX
24             XXX
23             XXX
22             XXX XXX
21             XXX XXX
20             XXX XXX
19             XXX XXX
18         XXX XXX XXX
17         XXX XXX XXX
16         XXX XXX XXX
15         XXX XXX XXX
14         XXX XXX XXX
13         XXX XXX XXX XXX
12         XXX XXX XXX XXX
11         XXX XXX XXX XXX
10         XXX XXX XXX XXX
 9         XXX XXX XXX XXX
 8         XXX XXX XXX XXX XXX
 7         XXX XXX XXX XXX XXX
 6         XXX XXX XXX XXX XXX
 5         XXX XXX XXX XXX XXX
 4     XXX XXX XXX XXX XXX XXX
 3     XXX XXX XXX XXX XXX XXX XXX XXX
 2     XXX XXX XXX XXX XXX XXX XXX XXX
 1 XXX XXX XXX XXX XXX XXX XXX XXX XXX XXX
    6   7   8   9  10  11  12  13  14  15  Age
```

Figure E.5: Percent Age Distribution of Sampled Commercial Catch, Region 5, SIL, 1987.

```
 %
30
29
28
27
26
25              XXX
24              XXX
23              XXX XXX
22              XXX XXX
21              XXX XXX
20              XXX XXX
19              XXX XXX
18          XXX XXX XXX
17          XXX XXX XXX XXX
16          XXX XXX XXX XXX
15          XXX XXX XXX XXX
14          XXX XXX XXX XXX
13          XXX XXX XXX XXX
12          XXX XXX XXX XXX
11          XXX XXX XXX XXX
10          XXX XXX XXX XXX
 9          XXX XXX XXX XXX
 8          XXX XXX XXX XXX XXX
 7          XXX XXX XXX XXX XXX
 6          XXX XXX XXX XXX XXX
 5          XXX XXX XXX XXX XXX
 4      XXX XXX XXX XXX XXX XXX
 3      XXX XXX XXX XXX XXX XXX XXX
 2      XXX XXX XXX XXX XXX XXX XXX
 1  XXX XXX XXX XXX XXX XXX XXX XXX XXX
     6   7   8   9  10  11  12  13  14  15  Age
```