Fish Salvage Activities Related to Diamond Mine Construction in the NWT

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Abstract

Diavik Diamond Mines Inc. (DDMI) is currently developing the Diavik Diamond Mine at Lac de Gras, Northwest Territories. Development of the mine involves the extraction of diamonds from four kimberlite pipes located beneath the substrate of Lac de Gras. The mine requires construction of a system of water retention dikes in Lac de Gras to facilitate open-pit mining under dry conditions. For two successive years, Jacques Whitford has assisted DDMI in working closely with the Department of Fisheries and Oceans to successfully complete the salvage of fish isolated from Lac de Gras by dike construction. The object of fish salvage operations was to remove as many fish as possible from the areas to be dewatered and return them, live, to Lac de Gras. This program offered an excellent opportunity to collect information on fish species, morphology and health in the Lac de Gras area. A variety of capture methods were utilized, including gillnets, trap nets, minnow traps and angling. Captured fish were transported across the dike to a processing area on Lac de Gras, where fish were identified and morphological parameters measured before release. Fraser recovery boxes were utilized for the first time in 2002, resulting in markedly improved survival of cisco (*Coregonus artedii*) and round whitefish (*Prosopium cylindraceum*). The study also demonstrates how environmental protection can be achieved successfully with industry working in collaboration with government agencies.

Introduction

Diavik Diamond Mines Inc. (DDMI) is currently developing the Diavik Diamond Mine (the mine) at Lac de Gras in the Northwest Territories. The project site is located approximately 300 km northeast of Yellowknife, NT (64°31' N, 110°20' W).

Development of the Project will involve the extraction of diamonds from four kimberlite pipes located beneath the substrate of Lac de Gras. The pipes are located directly adjacent to the 20 sq.km. East Island in the east-central portion of Lac de Gras. The Project requires construction of a system of water retention dikes in Lac de Gras to facilitate open-pit mining under dry conditions.

As a condition of the *Fisheries Act* Authorization for the Project, DDMI was required to remove fish from water bodies that were to be permanently altered by mine infrastructure or incorporated into mine operations. Jacques Whitford Environment Limited (Jacques Whitford) was contracted by DDMI to salvage fish from the North Inlet in 2001 and from the area enclosed by the A154 Dike in 2002. The focus of this paper will be on the 2002 salvage project.

Methods

Background

Baseline fishing results determined that fish occur in relatively low densities throughout Lac de Gras, with the majority of fish frequenting shallow areas (<10 m deep) associated with small islands and shoreline areas (Diavik 1998). Prior to beginning salvage efforts, the density of fish in the study area was not known. However, it was assumed to be similar to baseline conditions in the lake. The possibility existed that fish may have avoided the dike area during dredging and construction in 2001 and 2002; however, the extent to which this may have occurred was not known. Based on sampling results from the Diavik Environmental Baseline Study (Diavik 1998) and from the North

Inlet Fish Salvage Project (Jacques Whitford 2002), occurrence of the following fish species were likely present in the study area: lake trout (*Salvelinus namaycush*); cisco (*Coregonus artedii*); round whitefish (*Prosopium cylindraceum*); burbot (*Lota lota*); Arctic grayling (*Thymallus arcticus*); longnose sucker (*Catostomus catostomus*); slimy sculpin (*Cottus cognatus*); and ninespine stickleback *(Pungitius pungitius*).

Fish Salvage Program

The field component of the salvage project was conducted from July 8 to August 16, 2002 inclusive (40 days). Fish capture methods included gillnets, trap nets, angling and Gee-style minnow traps. Recommendations made by the Department of Fisheries and Oceans (DFO) were incorporated into the final methodology for the salvage project.

Gillnets

A variety of gillnets were utilized through the period of the salvage operation. All gillnets were 2.4 m deep, and ranged from 22.9 m to 76.2 m in length. A broad range of mesh sizes were used in order to target a variety of fish sizes. Mesh size ranged from 2.5 cm to 14 cm stretched mesh.

Gillnets were equipped with floats, weights, and adjustable mooring lines to allow nets to be set at variable depths (Hubert 1996; Whittier et al. 1997).

Crews set gillnets perpendicular to the dike walls and the shoreline of the small islands, throughout the study area. Nets were set for a maximum of one hour at a time, a limit that was chosen based on the 2001 fish salvage project (JWEL 2002) and which presents a reasonable compromise between fish survival and fishing effort. For the majority of the study, overnight sets were avoided to reduce fish mortalities.

Fish were removed from nets and transferred into plastic fish tubs on board each boat. Each tub was labeled with a predetermined code that corresponded to the capture net. This was done to identify fish during transport, measurement and release.

Trap Nets

Two trap nets (one with a box 3.1 m in length and one with a 1.8-m box) were deployed in the study area for the first 25 days. The nets were set in areas where habitat was suitable (i.e., shallow sloping areas, less than 3 m in depth). Traps were oriented perpendicular to the shoreline, with wings and lead extending from the box towards the shore. The trap nets were checked daily to retrieve and process captured fish.

Minnow Traps

Ten Gee-style minnow traps (0.4 m long x 0.25 m diameter) were deployed in the study area for the duration of the fish salvage operation. All traps were baited with dry cat food and set along the shoreline. Minnow traps were checked daily to retrieve and process captured fish.

Angling

On July 20, 12 days after commencement of the salvage program, angling was initiated in an effort to target large lake trout. This continued until the end of the program (total of 28 days).

Processing of Captured Fish

A processing station to record fish data was established adjacent to Lac de Gras on the east side of Dike A154. Fish processing was completed as quickly and carefully as possible to minimize handling mortality. Fish holding tubs were lifted from each boat onto the dock inside the dike and placed in a small, four-wheel drive utility vehicle for transport to the fish processing station. All fish captured were identified to species and measured for forklength (in millimeters). Weight (in grams) was measured for at least 20% of fish captured. All fish were given a cursory external examination for signs of parasitism, injury or other abnormalities. Fish mortalities were examined internally to determine sex, reproductive status, and evidence of parasitism or other abnormalities.

All vigorous fish were released directly to Lac de Gras. Fish that were less than vigorous were placed in Fraser recovery boxes. A total of six Fraser recovery boxes (Farrell et al. 2001) were placed on a dock located on the Lac de Gras side of the A154 Dike. Each box was double-slotted to hold two fish at a time (total of 12 slots), with a lid to shade fish from the sun. Two submersible electric pumps were employed to continuously circulate water from Lac de Gras through the boxes. Valves on the sides of each box were used to control the velocity of water flowing through the boxes. Fish were released from the recovery boxes by means of a sliding door at the end of each compartment, which allowed the fish to move into a holding pen. Specifications for the Fraser recovery boxes can be found at: http://mypage.uniserve.ca/~fraserjake/. Total time spent in the boxes was recorded for each fish. In a further effort to increase survival, fish were released from the Fraser boxes directly into mesh holding pens. This allowed the fish a longer period of recovery while being protected from predators. Fish were released from the holding pen periodically throughout the day.

Fish-out Program

Starting on August 2, twelve days before the conclusion of the fish salvage, increased effort was initiated in an attempt to "fish-out" the study area. Fish salvage continued during the day, as before, however, at the end of the day all available gillnets were set and left overnight. Nets were checked and fish removed the next morning, before resuming normal salvage operations.

Data Analysis

Data collected during the field operations (i.e., for each gillnet that was set) included capture method, deployment and retrieval times, depths, and location information. This information was used to calculate summary statistics such as total number of fish captured, catch-per-unit-effort (CPUE) and the overall species composition. Gillnet catches were entered separately for day and night sampling efforts, except for three nights (August 3-5) when the data was combined.

Catch-per-unit-effort (CPUE) was calculated daily by dividing the total number of fish captured (all species) by the total time gillnets were fishing. While most of the gillnets used were 76.2 m in length, three of the nets were shorter. In order to make CPUE comparable throughout the duration of the salvage project, it was necessary to "standardize" numbers of fish caught by the shorter nets (i.e., to adjust the catch data from these nets as if they were 76.2 m in length). Therefore, catch data from the 22.9-m nets were multiplied by a factor of 3.33 and catch data from the 30.5-m net were multiplied by a factor of 2.5. As well, it was necessary to compensate for decreasing dike volume as the water was pumped out. Volume-weighted CPUE was calculated by multiplying the CPUE (using adjusted catch data) by a factor representing the change in percent volume of the dike as compared to Day 1 of the fish salvage. Daily water volumes in the pit were provided by DDMI. These data are summarized in Table 2 and shown in Figure 1.

In addition to specific information about capture methods, information was also collected and recorded for individual fish. Upon capture, each fish was assigned a unique numerical identifier and, using this identifier, all associated morphological information (e.g., capture method and effort number, species, fork length, weight and external and internal examination results) was compiled in a spreadsheet. This information was used to determine summary statistics such as total fish caught per species, average length and weight by species, general occurrence of internal and external abnormalities, maturity, and sex.

Sampling results were used to estimate the abundance of fish in the study area. Estimates were prepared according to the Leslie and DeLury methods (Everhart and Youngs 1981; Van Den Avyle 1993). The Leslie method uses a least-squares regression approach to develop a linear relationship between CPUE (the y-variable) and the cumulative number of fish captured (the x-variable) for each time increment (days were used in this study). As described above, a daily CPUE value was calculated by dividing the total number of fish caught by the total fishing (gillnetting) time for that day (in hours). Using the slope and x-intercept for the regression line, the estimated

size of the fish population (i.e., abundance) in the study area was determined by extrapolating the regression line until it met the x-axis.

The DeLury population estimate also uses a least-squares regression approach, but the linear relationship is between the natural logarithm (ln) of the CPUE (the y-variable) and cumulative effort (hours fished, the x-variable). Confidence limits (95%) for the slope and x-intercept were used to determine the variability in each population estimate. Separate Leslie and DeLury population estimates were calculated for the total number of fish in the study area and for cisco, which was the most abundant species.

Results

Gillnet Results

As the majority of fish were taken by gillnetting, the analysis of catch data is concentrated on gillnet results. A total of 6,391 gillnet hours of fishing time were expended to capture fish in the study area. Cisco (74%) were the most numerous fish taken in gillnets. Round whitefish and lake trout each represented 10% of the total fish captured, while burbot represented 4%. One Arctic grayling was captured by gillnet. A summary of the morphological data for fish captured by gillnet is presented in Table 1.

In general, a declining trend in CPUE was observed as the fish salvage operation progressed (Figure 1). The effect of compensating for decreasing water volume in the study area became noticeable in the latter stages of fish salvage, as water volume on August 14 was 38% of the volume recorded on July 9 (Table 2). The variability in CPUE is a reflection of the variability in numbers of fish caught given equal amount of effort. For example, over a four-day period (July 17-20) where effort (as represented by fishing time) was virtually identical, CPUE varied from a high of 0.83 fish/hr to a low of 0.22 fish/hr (Table 2). Factors affecting fish catches may include weather conditions, depth of light penetration and placement of nets (Hubert 1996).

Examination of Fish Mortalities

During the fish salvage, all sacrificed fish were subjected to internal examination by dissection. Fish were assessed to determine sex, maturity and for evidence of abnormalities such as parasites or tumours or otherwise abnormal organs (Table 3). The majority of fish examined in this manner were immature individuals (Table 3). The only internal abnormality noted was the presence of cysts of the cestode parasite *Diphyllobothrium* sp. (tapeworm) (Stewart and Bernier 1999). These cysts were observed in 29.5% of lake trout, 25.8% of cisco, 8.8% of round whitefish and 7.1% of burbot. This parasite is commonly observed in salmonid fish in the Northwest Territories (Stewart and Bernier 1999) and does not indicate that fish caught in the study area are in poor health.

Fish Salvage Success

Survival of fish after capture by gillnets varied by fish species (Table 4). Survival data for the salvage component of the project are shown separately from overall survival data (which includes overnight gillnet sets) in the table. The intent of the overnight gillnet sets was to remove the maximum number of remaining fish from the dike as efficiently as possible, as opposed to maximizing release to Lac de Gras. Survival rates during the fish salvage operation were highest for burbot (71.1%), lake trout (63.6%) and round whitefish (52.9%). The lowest survival rate from gillnetting observed during the salvage was for cisco (40.5%). Only one Arctic grayling was captured and it was successfully released.

It was anticipated that use of the Fraser recovery boxes would increase fish survival, by providing cool, oxygenated water in a protective environment. Without rigorous controls, it was not possible to scientifically evaluate the effects of using the boxes, however, field observations indicated that time spent in the boxes was beneficial to some fish. Other fish that had visible damage from being caught in the gillnets (damage to gills in particular) had poor recovery even when the Fraser recovery boxes were used.

Other personal observations noted that, apart from gillnet damage, the fish appeared to be in good condition. Many contained accumulations of

mesenteric fat in the body cavity, indicating that food within the study area was plentiful.

Estimates of Population Size

As described above, the size of the fish community in the study area was estimated using both the Leslie and DeLury methods for calculating population estimates (Everhart and Youngs 1981; Van Den Avyle 1993). This approach was used to estimate both the total number of fish present in the dike and the total number of the most abundant species (cisco). Population estimates and confidence limits surrounding the estimates were compared with the actual number of fish caught during the study (Table 5). Figure 2 depicts the regression relationship between CPUE and cumulative catch (Leslie method) for all species caught. Each point represents one day of gillnet effort. Since they are not included in the gillnet results, juvenile and forage fish (i.e., slimy sculpin) are not included in the population estimates. Similarly, trap net catches of juvenile cisco, burbot and round whitefish are not included in these estimates.

The results of the population estimates should be interpreted with caution. The confidence limits are influenced by the degree of variability around the regression line. This variability is directly related to the variation in daily capture results for all species (i.e., the CPUE) and the patchiness of fish distribution (i.e., some fish school while others may not). In three of four cases, the calculated population estimates were higher than actual numbers of fish caught, and the numbers calculated as the upper 95% confidence limits are extremely high (>10,000). Estimates for cisco were more variable than the estimates for the overall fish population (all species), which may explain why the DeLury population estimate for cisco (4,741) is higher than the estimate for the overall fish population (3,353). The variability in effort (i.e., from as few as five nets per day to a maximum of 20 nets per day, adding overnight gillnet sets and using nets of different lengths) limits the overall utility of the population estimates. Further, the estimates should be interpreted as an indicator only, rather than a definitive figure for the number of fish present. The downward slope of the trend line in Figure 3 is indicative of the decreasing population, however, the actual numerical estimates should not be used as a population range estimate.

Trap Nets

Trap net catches were highly variable, but were successful at capturing juvenile cisco and round whitefish. The larger trap net captured less than 10 fish on most days, but captured over 1000 fish on one date, mostly juvenile cisco (1009 juvenile cisco, 4 juvenile lake trout and 1 juvenile round whitefish). The smaller trap net captured fish on only a single date (81 juvenile cisco and 4 juvenile round whitefish). The value of using these nets is that they target fish that are too small to be caught in even the smallest mesh of the gillnets (Table 6). As well, there was minimal physical damage to fish caught in these nets, and 98.5% of fish captured in trap nets were released alive into Lac de Gras.

Minnow Traps

Although the minnow traps were deployed for the duration of the salvage program, a total of only 19 fish were captured – 18 slimy sculpin and one burbot. All but one of these fish (a slimy sculpin) were released live into Lac de Gras.

Angling

A total of 126.6 rod-hours were spent angling which resulted in the capture of five lake trout (Table 7). Four of the five fish were released live into Lac de Gras. On average, these fish were larger and heavier than the lake trout captured in gillnets (Table 1).

Summary and Discussion

A total of 5,049 fish were captured and removed from the study area over the course of the fish salvage and fish-out operation. The overall survivorship rate during the fish salvage project, using all capture methods, was 50%. This translated to the live release of 2,526 fish from the dike to Lac de Gras (Table 8).

The relative abundance of fish species captured during the Dike A154 fish salvage project was identical to that of the North Inlet Fish Salvage Project conducted in 2001. However, mean forklength and weight were lower for fish taken in this study (all species) than those from the North Inlet (Jacques Whitford 2002). This is likely of little significance; during dike construction and dredging, fish were able to freely move in and out of the dike area, and larger fish may have migrated away from the activity. There is no evidence to suggest that the fish taken from either Dike A154 study area or the North Inlet are representative of the overall fish community in Lac de Gras.

The plot of volume-weighted CPUE over time demonstrated a definite downward slope, thus confirming that the salvage operation steadily reduced the size of the fish population within the study area. Calculated population estimates were of limited value, however, as confidence limits around the population estimates were very broad.

Recommendations for future fish salvage operations in the Northwest Territories would be to include all of the methods used in this study with some modifications. Gillnets appear to be the most efficient method of capturing large numbers of fish. The one-hour gillnet set is a reasonable compromise between optimizing fish catches and optimizing survivorship. Setting nets for 30 minutes, while increasing survivorship, would result in the capture of fewer fish per day and necessitate increased field effort to remove the same number of fish.

Trap nets are very effective in a limited range of habitats where shallow, gradual shorelines are available. Therefore, the use of these nets should be based on site-specific availability of suitable habitat. The use of trap nets in the study area was successful in targeting fish that were not as likely to be captured by other methods. Further, traps nets demonstrated a high survival rate for fish captured.

Minnow trap catches were comparatively insignificant, but did capture fish not specifically targeted by other fishing techniques. Future use of minnow traps may not be warranted given their limited effectiveness.

Angling was initiated in order to target larger lake trout suspected of being present in the study area. However, the lengths and weights of lake trout caught by angling were well within the range of the sizes of lake trout caught in the gillnets.

Fraser recovery boxes were used by DDMI for the first time in 2002. Comparison of these results (daytime sets only) with those of the North Inlet project (Jacques Whitford 2002), show higher survival rates for cisco (40.5% in 2002 as compared to 24.4% in 2001) and for round whitefish (52.9% in 2002 as compared to 49.6% in 2001). Survival of lake trout (63.6% vs. 69.3%) and burbot (71.1% vs. 100%) was actually lower in 2002. On a subjective basis, some fish that appeared lethargic but otherwise uninjured seemed to benefit from time spent in the boxes. Personal observations indicate that the boxes were a positive addition to the salvage operation.

It was impossible to scientifically evaluate the effects of using the Fraser recovery boxes, because of the lack of controls (i.e., fish in similar condition that were not placed in the boxes). Given that the Fraser boxes were designed for use in the commercial salmon fishery in salt water, rigorous testing in fresh water would be beneficial. The principle involved in using these boxes is that the fish remain stationary within the boxes, oriented towards the incoming fresh oxygenated water that passes constantly over their gills. It was noted that because the majority of fish caught during the salvage project were relatively small (as compared with salmon caught in a commercial fishing operation), they were able to swim around in the boxes as opposed to being held in a stationary position. If these boxes were to be used in future, it would be useful to have additional lateral dividers, so that width would be adjustable according to the size of fish. Other factors affecting fish in the Fraser boxes include rate of water flow and holding time. It was not possible to evaluate these factors during the salvage operation, given that the primary objective was live release of fish. To properly evaluate these factors, it would be necessary to assess the effects of a range of flow rates and

holding times. This would also necessitate tracking the survival of individual fish for at least 24 hours after release from the boxes.

In order to increase fish survival, it is recommended that the need to handle captured fish be kept to an absolute minimum. This may include elimination of the requirement for length and weight measurements (measurements could be obtained from a subset of fish) thus reducing the holding period and handling prior to release. Omission of this step would obviously result in the loss of this information; however, increased survivorship may justify the resultant trade-off.

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Table 1: Summary Morphological Statistics for Fish Captured by Gillnet (One-Hour and Overnight Sets)								
	N	Fork length (mm)			N	Weight (g)		
		Mean	Maximum	Minimum		Mean	Maximum	Minimum
Cisco	2662	198.7	377	25	2499	124.7	1900	10
Round Whitefish	364	199.3	464	125	333	136.2	1525	20
Lake Trout	382	229.7	650	75	379	201.1	3300	10
Burbot	143	271.3	650	117	143	245.6	2320	25
Arctic Grayling	1	-	278	278	1	-	250	250

N = number of observations

Table 2: Catch-Per-Unit-Effort (CPUE) Data From Gillnets (One-Hour and Overnight Sets)						
Date	**Total Fish Caught (all species)**	**Adjusted Catch (all species)**	**Total Time (hours)**	**CPUE (fish caught/hr)**	**Dike Volume (%)**	**Volume-Weighted CPUE**
July 9-02	36	36	22.5	1.60	1.000	1.60
July 10-02	115	115	49.7	2.31	1.001	2.32
July 11-02	72	72	42.6	1.69	1.000	1.69
July 12-02	86	86	47.0	1.83	1.003	1.84
July 13-02	57	57	45.8	1.24	1.004	1.25
July 14-02	60	60	51.7	1.16	1.005	1.17
July 16-02	79	79	51.6	1.53	1.005	1.54
July 17-02	60	60	92.2	0.65	1.005	0.65
July 18-02	83	83	99.7	0.83	1.005	0.84
July 19-02	20	20	90.5	0.22	1.005	0.22
July 20-02	37	37	89.7	0.41	1.004	0.41
July 21-02	18	18	101.2	0.18	1.002	0.18
July 22-02	81	81	100.9	0.80	0.999	0.80
July 23-02	22	22	100.2	0.22	0.997	0.22
July 24-02	11	18	126.4	0.14	0.992	0.14
July 25-02	104	325	131.1	2.48	1.003	2.49
July 26-02	16	18	82.1	0.22	1.003	0.22
July 29-02	5	7	13.4	0.52	0.916	0.48
Aug 2-02	282	289	126.4	2.29	0.766	1.75
*Aug 3-02	498	624	359.4	1.74	0.714	1.24
Aug 4-02	283	399	415.9	0.96	0.673	0.65
Aug 5-02	171	220	389.8	0.56	0.622	0.35
Aug 6-02	122	150	394.2	0.38	0.569	0.22
Aug 7-02	122	194	478.6	0.41	0.569	0.23
Aug 8-02	111	122	481.6	0.25	0.520	0.13
Aug 9-02	145	279	469.2	0.59	0.488	0.29
Aug 11-02	324	394	945.4	0.42	0.434	0.18
Aug 12-02	147	214	406.6	0.53	0.411	0.22
Aug 13-03	324	594	403.9	1.47	0.401	0.59
Aug 14-02	90	170	182.0	0.93	0.379	0.35
TOTAL	**3581**	**4843**	**6391**			

* - denotes start date of overnight gillnet sets.
CPUE – catch-per-unit-effort – calculated as adjusted catch divided by the amount of time gillnets were in the water

Table 3: Detailed Examination of Mortalities (Day and Overnight Gillnet Catches)								
		Sex			Maturity		Abnormalities	
	N	Female	Male	Unknown	Immature	Mature	None	[1]Parasite
Cisco	1935	666	851	418	1266	669	1436	499
Round Whitefish	194	31	121	42	168	26	177	17
Lake Trout	193	22	145	26	176	17	136	57
Burbot	56	13	22	21	50	6	52	4

[1] – parasitic tapeworm *Diphyllobothrium* sp. (Stewart and Bernier 1999)
N = No. of observations

Table 4: Survival by Species for Fish Captured by Gillnets												
	Cisco		Round Whitefish		Lake Trout		Burbot		Arctic Grayling		TOTAL	%
	n	%	n	%	n	%	n	%	n	%		
[1]Daytime Sets Only	536	40.5	110	52.9	77	63.6	27	71.1	1	100	**751**	**44.4**
Overall	671	25.0	139	38.3	184	49.1	87	60.8	1	100	**1082**	**30.2**

[1] – Data from August 3-5 was excluded because catch data from daytime and overnight sets was not separated.
Note: n – number of fish captured in the study area and released live to Lac de Gras. Percentages represent the proportion of total fish captured that was released.

Table 5: Population Estimate Results for Study Area							
	Total Fish Caught	Leslie Population Estimate			DeLury Population Estimate		
			95% Confidence Limits			95% Confidence Limits	
		Estimate	Lower	Upper	Estimate	Lower	Upper
All Species	3570	4403	1997	14015	3353	1295	16595
Cisco	2688	3167	1384	10490	4741	595	25559

Table 6: Summary Morphological Statistics for Fish Captured by Trap Nets								
	N	Fork length (mm)			N	Weight (g)		
		Mean	Maximum	Minimum		Mean	Maximum	Minimum
Cisco	1378	84.2	238	75	1378	35.3	100	20
Round Whitefish	56	163.1	253	120	27	61.9	125	25
Lake Trout	15	143.7	295	71	7	67.1	300	10
Burbot	1	-	262	262	1	-	100	100
Slimy Sculpin	3	47.0	51	42	3	25	25	25

N= number of observations

Table 7: Summary Morphological Statistics for Fish Captured by Angling							
	N	Fork Length (mm)			Weight (g)		
		Mean	Maximum	Minimum	Mean	Maximum	Minimum
LKTR	5	290.6	353	212	340.0	525	125

Table 8: Overall Fish Survival by Capture Method				
	Total Captured	**# Live**	**# Dead**	**% Survival**
[1]Gillnets (day)	1679	748	931	44.6
Gillnets (overall)	3581	1082	2499	30.2
Trap Nets	1444	1422	22	98.5
Minnow Traps	19	18	1	94.7
Angling	5	4	1	80.0
TOTAL	**5049**	**2526**	**2523**	**50.0**

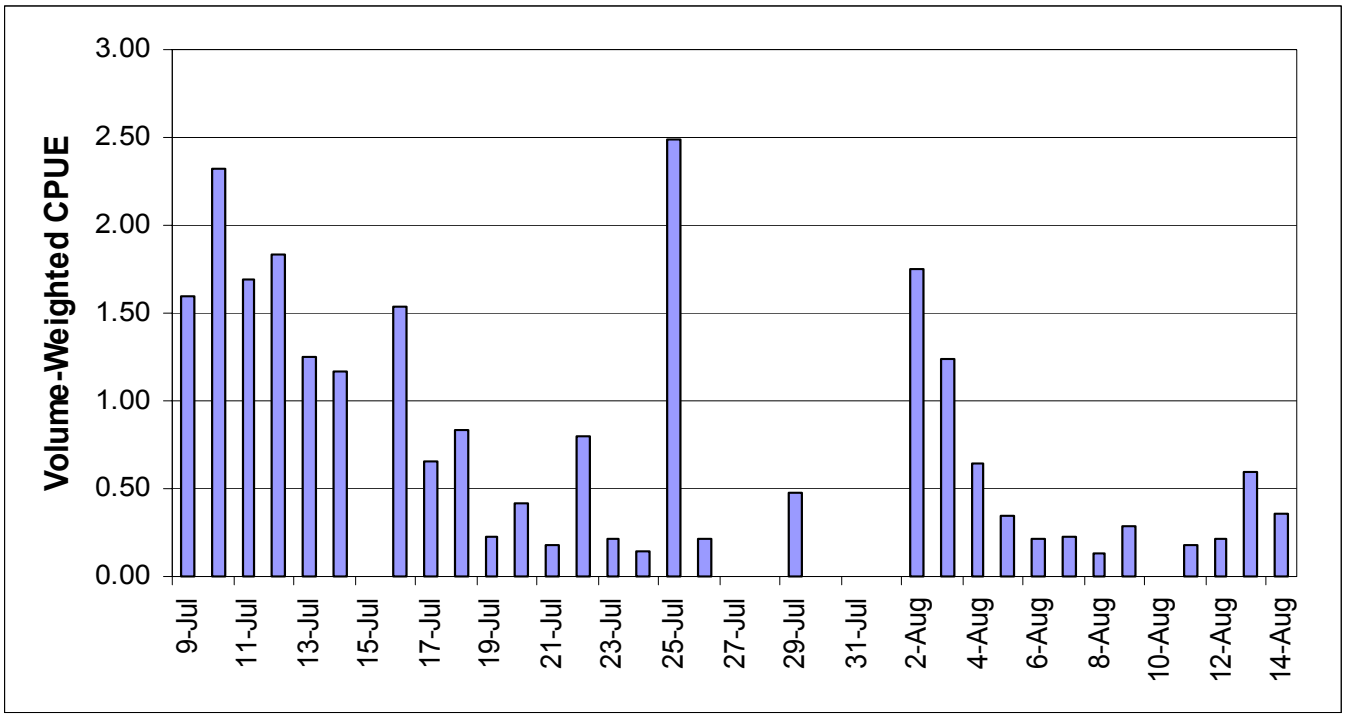

Figure 1: Volume-Weighted CPUE Results from Day and Night Gillnet Sets

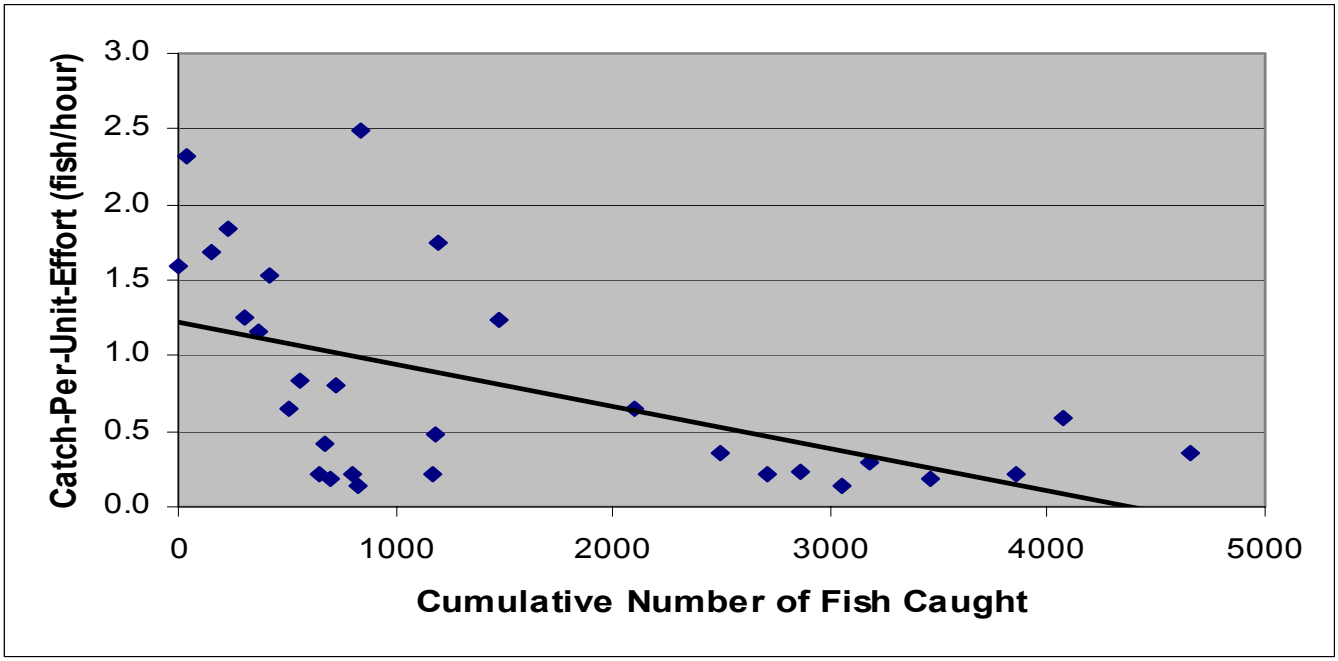

Figure 2: Regression Results Showing Estimated Fish Population in Study Area (Leslie Method