

ANNUAL REPORT:  
TERROR LAKE HYDROELECTRIC PROJECT  
1990 SALMON EGG AND FRY SURVIVAL, ESCAPEMENT MAGNITUDE  
AND SPAWNER DISTRIBUTION

By:

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**Appendix A: Commercial Fisheries Division expenditures, Terror River Hydroelectric Project, 1990.**

## ABSTRACT

The record pink and chum salmon escapements occurred in 1989 in the Terror and Kizhuyak Rivers. These escapements were the result of commercial salmon fishery closures from the effects of the Exxon Valdez oil spill. The pre-emergent fry indices from that escapement were only generally fair to good. High water from excessive rainfall in the Fall in 1989 resulted in scouring in both river systems. However, spring climatic conditions were mild which may result in an above average pink return to both systems in 1991. The peak indexed pink salmon escapements in 1990 was 59,600 for the Terror River and 15,400 in the Kizhuyak River. The peak chum escapements in 1990 were 5,000 in the Terror River and 2,300 in the Kizhuyak River. These salmon escapements are near the average escapement for pink salmon and the lowest recorded for chum salmon since this study began.

Key Words: Terror Lake Hydroelectric Project, Salmon, Oncorhynchus, Pre-emergent fry, Spawning distribution, Escapement, Exxon Valdez Oil Spill

## INTRODUCTION

Prior to development of the Terror Lake hydroelectric project potential beneficial and detrimental impacts on the salmon populations of the Terror River and Kizhuyak River were identified (AEIDC, 1981). Changes in stream flow and temperature directly affect salmon spawning and egg survival. In 1981 the Alaska Department of Fish and Game (ADF&G), Commercial Fisheries Division (CFD), entered into an agreement with the Kodiak Electric Association (KEA) to assess the magnitude of change, if any, in the pink salmon (Oncorhynchus gorbuscha) and chum salmon (Oncorhynchus keta) populations in these two rivers. Study began in 1982 to measure pre-project levels of spawning and egg survival and have continued through facility construction and subsequent operations. Specifically, CFD wishes to evaluate (1) salmon egg and fry survival, (2) timing of salmon fry emergence; and (3) trends in salmon escapement magnitude and spawner distribution. The Alaska Energy Authority (AEA) took over the project in 1983.

The Terror and Kizhuyak Rivers are located in north central Kodiak Island (Figure 1). The areas of study encompassed approximately the lower 1.5 miles of each river. The Terror River extends some 7.5 miles, running down from Terror Lake (Figure 2). An earthen and concrete dam was constructed at the lake outlet to increase the lake's volume and control outflow. A 5 mile tunnel was drilled to divert water down to a powerhouse in the Kizhuyak Basin.

It should be noted that data collected during the CFD annual studies may not necessarily be conclusive enough to assess specific changes within the salmon populations in question (Malloy 1981). This report details the efforts of CFD during the 1990 season.

## PRE-EMERGENT FRY SAMPLING

### Methods and Procedures

Pre-emergent fry sampling involved hydraulically excavating sac fry and eggs from spawning habitat. Sampling locations for both rivers are shown in figures 3 and 4. Personnel and equipment were transported to the sites with a Bell Long Ranger helicopter. Ten samples were collected at each pre-selected sampling area. For each sample a circular collection frame, two feet in diameter, was placed on the stream bed circumscribing the area to be excavated. A Homelite XLS pump forced an air/water mixture through a steel probe which was manually worked into the stream bed. All light materials, including eggs and fry, that bubbled up out of the gravel were swept by the current into a tapered net attached to the downstream side of the collection frame. The net

was emptied into a plastic bin and the fry and eggds identified and counted. Fry development, as indicated by the percent absorption of a yolk sac, was noted. A relative index of live fry abundance was developed for each portion of the river sampled.

## Results

### Terror River

Sampling was accomplished on 28 March and 4 April 1990 and is summarized in (Table 1). A comparison of pink salmon fry indexes for the study years (1982-1990) can be seen in (Table 2) and (Figure 7). Sampling sites at Thermograph Creek, Ouzel Creek, Consternation Creek and the ADF&G sites on Terror River all had low pink salmon fry densities. The two intertidal sampling sites in the lower Terror River had average to above average fry densities. High water from heavy rains in the fall of 1989 resulted in scouring of the spawning areas. However, spring climatic conditions were mild and an average to less than average return is expected for 1991.

### Kizhuyak River

Sampling was accomplished between 28 March and 4 April 1990 and is summarized in (Table 3). A comparison of pink salmon fry indexes for the study years (1982-1990) can be seen in (Table 3) and (Figure 48). Generally fry indexes for the Kizhuyak system were average to above average. High water from heavy rains in the fall of 1989 resulted in scouring of the spawning areas. Two sample sites produced no fry and it is suspected that this scouring may have been the cause. Spring climatic conditions were mild which should result in at least an average return for 1991.

## ESCAPEMENT MAGNITUDE AND DISTRIBUTION

### Methods and Procedure

Escapement enumeration and spawner distribution mapping was conducted by aerial survey from a Bell Long Ranger helicopter and small fixed wing aircraft (Cessna 206, Supercub). Surveys were attempted twice weekly through the duration of spawning, as weather permitted. On each flight the observer estimated the number of each salmon species in the bays, intertidal zones, and the river systems. Pink salmon season escapements were figured by adding the highest counts approximately 30 or more days apart. For example, for a particular river a high escapement count of 10 August would be added to a high count of 18 September to arrive

at a total indexed escapement estimate for the season<sup>1</sup>. Chum salmon escapement estimates are made from the peak counts at each system. These counts also serve as a reliable index of total escapements. Both types of escapement estimates are comparable from one year to the next. Spawner distribution was also noted during aerial surveys, and was recorded on a 1:24,000 field map. A foot survey of each river system was to be conducted near the peak of spawning to further document species magnitude and distribution. Unfortunately, because of weather and the extended weir camp operations the foot surveys were not conducted in 1990.

## Results

### Terror River

The indexed pink salmon escapement, estimated by combining high aerial survey counts made on 9 August and 8 September, 1990 was 59,600 (Table 5). The aerial survey data are listed in Table 5. A comparison of even year pink salmon escapements from 1960-1990 can be seen in Figure 5. The 1990 escapement was only slightly below the even year (1960-1990) pink salmon escapement average.

The peak chum salmon escapement count was made 5 August 1990 at 5,000 fish (Table 5). This count is the second lowest since the study began in 1982. a comparison of chum salmon escapements for Terror River 1982-1990 can be seen in Figure 6.

Spawning distribution is shown in Figures 9 and 10. Spawners were observed in the upper Terror sections above Four Mile Creek. Overall spawning distribution shows little change from previous years, with spawners utilizing the entire range of spawning habitat (D. Prokopowich, Alaska Department of Fish and Game, Kodiak, personal communication).

### Kizhuyak River

The indexed pink salmon escapement, estimated by combining high aerial survey counts made on 9 August and 8 September 1990 was 15,400 fish (Table 8). The aerial survey data are listed in Table 8. A comparison of even year (1960-1990) pink salmon escapements can be seen in Figure 5. The 1990 escapement was slightly higher than the even year (1960-1990) pink salmon escapement average.

A peak chum salmon escapement count was made on 17 August 1990 at 2,300 fish (Table 8). This is the lowest chum salmon escapement recorded since this study began in 1982. A comparison of chum salmon escapements for the Kizhuyak River (1982-1990) can be seen in Figure 6).

---

<sup>1</sup>CFD calculated indexed escapements for all major pink salmon systems in a similar manner.

Spawner distribution is shown in Figures 11 and 12. Pink and chum salmon were well distributed throughout the spawning habitat (K. Brennan, Alaska Department of Fish and Game, Kodiak, personal communication).

Table 1. 1990 Terror River Pre-Emergent Fry Sampling Results

Sampling/Location	Number Samples	Sample Dates	Live		Dead		1990 LF/M <sup>2</sup> Index	% Sample W/Fry	Range of Fry Development	H <sub>2</sub> O Temp.	Comments
			Fry	Eggs	Fry	Eggs					
Lower Terror SW Forks-Tidal	10	4/4/90	308 <sup>P</sup>	0	0	165.70	70	70	.50 - .95	3°C	
Lower Terror NE Subtidal	10	4/4/90	1,282 <sup>p</sup>	0	0	2,050	689.72 <sup>P</sup>	90	.50 - .95	5.5°C	
Upper Terror Thermograph	10	4/4/90	25 <sup>p</sup>	0	0	35	13.45 <sup>P</sup>	30	.95	1°C	
Ouzel Creek	10	4/4/90	74 <sup>P</sup>	0	0	340	39.81 <sup>P</sup>	20	.95	3.5°C	Emergent Pink Fry
Consternation Creek	10	4/4/90	2 <sup>P</sup>	0	2	600	1.08 <sup>P</sup>	20	.95	1°C	
ADF&G Sampling Sites Mainstream Terror	50	3/28/90	7 <sup>p</sup>	0	0	2,735	0.75 <sup>p</sup>	8	.95	3°C	

p = pink salmon  
 ch = chum salmon  
 dv = dolly varden

Table 2. Comparison of Pre-Emergent Fry Indexes 1982 - 1990 Terror River: Live Fry/M<sup>2</sup>

<u>Location/Year</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>
Lower Terror S.W. Fork Intertidal	17.75p	240.49p	0	70.42 <sup>P</sup> .54 <sup>ch</sup>	73.17p	573.51p	250.17p	60.26p	165.70 <sup>P</sup>
Lower Terror N.E. Intertidal	569.74 <sup>P</sup> 156.56 <sup>ch</sup>	0	371.71 <sup>P</sup> 415.98 <sup>ch</sup>	185.61 <sup>P</sup>	0	525.63 <sup>P</sup> 278.81 <sup>ch</sup>	263.62 <sup>P</sup> 265.81 <sup>ch</sup>	234.57p 108.14ch	689.72 <sup>P</sup>
Upper Terror Thermograph	0	15.60 <sup>P</sup>	0	501.95 <sup>P</sup>	0	102.22 <sup>P</sup>	0	0	13.45 <sup>P</sup>
Ouzel Creek	8.07 <sup>P</sup> 2.69 <sup>ch</sup>	0	2.15 <sup>P</sup>	32.82 <sup>P</sup>	0	64.02 <sup>P</sup> .54 <sup>ch</sup>	0	232.32p 10.76 <sup>dv</sup>	39.81 <sup>P</sup> 3.77 <sup>dv</sup>
Bear Creek	N/S	.54 <sup>ch</sup>	331.74 <sup>P</sup>	0	230.8 <sup>P</sup>	N/S	N/S	N/S	N/S
Consternation Creek	1.62 <sup>P</sup>	.54 <sup>P</sup>	0	0	0	0	0	.40p	1.08p
ADF&G Sample Sites Mainstream-Terror	25.93p	22.38 <sup>P</sup>	2.04 <sup>P</sup> 5.70 <sup>ch</sup>	107.60 <sup>P</sup>	.22 <sup>P</sup>	71.02 <sup>P</sup>	16.14 <sup>P</sup> 2.69 <sup>ch</sup>	34.54 <sup>P</sup>	0.75p

p = pink salmon  
 ch = chum salmon  
 dv = dolly varden  
 ADF&G Combined  
 N/S = Not Sampled

Table 3. 1990 Kizhuyak River Pre-Emergent Fry Sampling Results

Sampling/Location	Number Samples	Sample Dates	Live		Dead		1988 LF/M <sup>2</sup> Index	% Sample W/Fry	Range of Fry Development	H <sub>2</sub> O Temp.	Comments
			Fry	Eggs	Fry	Eggs					
Kizhuyak-Above Chum Channel	10	4/4/90	237	0	6	18	127.51	40	.80 - .90	3°C	
Kizhuyak 2nd Below Chum Channel	10	4/4/90	0	0	0	0	0	0	-	3°C	
Kizhuyak N.E. Fork-Tidal	10	4/4/90	624	0	0	66	335.71	20	.70 - .95	6°C	
Kizhuyak Above Watchout	10	4/4/90	67	0	0	0	0	0	-	4.5°C	
Kizhuyak Below Watchout	10	4/4/90	172	0	4	24	92.54	70	.90 - .95	4°C	
ADF&G Sample Sites Beaver Pond Creek	40	3/28/90	4,085p	0	142	1,001	549.3	80	.60 - .95	4.5°C	

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Table 4. Comparison of Pre-Emergent Fry Indexes 1982 - 1990 Kizhuyak River: Live Fry/M<sup>2</sup>

<u>Location/Year</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>
Lower Chum Channel	393.82 <sup>P</sup>	0	112.98 <sup>P</sup>	76.39 <sup>P</sup>	23.13 <sup>P</sup>	709.08 <sup>P</sup>	N/S	N/S	N/S
Kizhuyak-Above Chum Channel	22.6 <sup>p</sup>	-	146.87 <sup>P</sup>	1.05 <sup>P</sup>	117.82 <sup>P</sup>	81.78 <sup>P</sup>	0	0	127.51 <sup>P</sup>
Kizhuyak River Below Chum Channel	97.92 <sup>P</sup>	5.92 <sup>P</sup>	N/S	N/S	N/S	232.41 <sup>P</sup>	5.38 <sup>P</sup>	0	0
Kizhuyak River N.E. Fork	0	1.61 <sup>P</sup>	.54 <sup>P</sup>	266.84 <sup>P</sup>	0	0	62.41 <sup>P</sup>	14.53 <sup>p</sup>	325.71 <sup>P</sup>
Kizhuyak River Above Forks/Watchout	0	0	0	N/S	2.69 <sup>P</sup>	38.74 <sup>P</sup>	0	0	0
Kizhuyak River Below Watchout	N/S	N/S	N/S	N/S	N/S	N/S	272.23 <sup>P</sup>	0	92.54 <sup>P</sup>
ADF&G Sample Sites Beaver Pond Creek	1,042.78 <sup>P</sup> 11.23 <sup>ch</sup>	53.8 <sup>P</sup>	493.48 <sup>P</sup>	8.61 <sup>P</sup>	171.22 <sup>P</sup>	1.61 <sup>P</sup>	191.93 <sup>P</sup> 84.33 <sup>ch</sup>	191.39 <sup>p</sup> 39.27 <sup>ch</sup>	549.3 <sup>P</sup>

∞  
p = pink salmon  
ch = chum salmon  
dv = dolly varden  
ADF&G Combined  
N/S = Not Sampled

Table 4A. Footnotes for understanding salmon escapement data.

**Visibility:** Indicates water visibility in the following two categories:  
S=Stream M=Mouth B=Bay A=All three categories or any two categories

**Fish in Stream:**

**-** : Stream not surveyed for this species.

**0** : Stream surveyed for this species, none observed.

**N** : Any numerical designation reflects indexed number of live fish observed; portion of stream surveyed includes 100% of fish in stream for survey date. Any deviations from this are denoted in comments, e.g. carcasses and percentage of system surveyed for that portion of stream expected to contain fish for a specific survey date.

**Categories of Fish Occurrence**

**a/STREAM:** Fish which occur and remain within the spawning area of a stream or which occur in a freshwater portion of a stream during spawning migration; this will also include fish observed in the mouth on the last survey of the year . These fish are not vulnerable to normal illegal fishing methods and means.

=====

**b/MOUTH:** Build-up of fish in saltwater which is normally closed to commercial fishing. These fish generally are not vulnerable to legal fishing, but they may be vulnerable to illegal fishing. This category includes designated lagoons, as described in the closed waters portion of the Commercial Fishing Regulations. These fish are considered to be homing in on the stream for which they are documented and will be counted as fish in the stream on the last survey of the year.

=====

**c/BAY:** Build-up fish, in saltwater which is normally either open to commercial fishing or closed to commercial fishing (closed water sanctuaries), which may be at least partially vulnerable to both legal and illegal fishing. These fish will not be included in the stream count unless special denotation is made in the remarks column and will only apply on the last survey of the year.

Table 5. Terror River aerial survey results, 1990.

Alaska Department of Fish and Game  
 Salmon Escapement Surveys, 1990  
 (Aerial Surveys Unless Noted in Remarks)

Stream	Date MM-DD	Observer	Visibility			-----Fish in Stream-----				Build Up Fish		Observer Remarks
			Str	Mou	Bay	Reds	Coho	Pink	Chum	Mouth	Bay	
<u>Terror River</u>												
253-331	7-11	Hander				0	0	1500	0	-	-	1420 hours, low incoming tide, pinks were less than 1/4 mile from mouth. Stream flow good.
253-331	7-16	Brennan				0	0	12000	5000	-	-	1900 hours. Only surveyed lower 1 mile of stream...fish all stacked from mouth to 1/2 mile up. Tide high - fish may wash out. Nothing showing on flats. A couple jumpers outside.
253-331	7-19	Blackett	g	g	g	0	0	14300	800	-	50P	-
253-331	7-29	Prokopowic h	g			0	0	20000	5000	-	6000P	-
253-331	8- 5	Prokopowic h	g			0	0	28000	5000	-	-	Very little show in bay.
253-331	8- 9	Prokopowic h	g			0	0	31000	0	-	12000P	Most fish in lower end.
253-331	8-13	Prokopowic h	g			0	0	30000	3000	-	7500P	Bay fish on east side.
253-331	8-14	Hander	g			0	0	33500	1500	-	-	1252 hours. Low tide, scattered fish in flats, good stream flow.
253-331	8-17	Brennan	f	f	f	0	0	7250	1500	1500P 500Ch	-	1240 hours
253-331	8-21	Prokopowic h	g			0	0	21500	0	-	1000P	No build ups, not many new fish in river.
253-331	8-21	Blackett	g	g	g	0	0	10300	200	-	50P	-
253-331	9- 8	Blackett	g	g	g	0	0	28600	200	-	-	300 pink carcasses upstream of Four Mile Creek.
253-331	9-25	Blackett	f	f	f	0	30	3000	0	-	-	-

Salmon Escapement Observations

Report Date 11/06/1990

Table 6. Indexed even-year pink salmon escapements into Terror and Kizhuyak Rivers - 1960-1990.

Year	Terror River	Kizhuyak River
1960	32,000	8,200
1962	50,000	8,000
1964	27,900	-
1966	86,000	8,000
1968	40,000	2,800
1970	40,000	12,000
1972	25,000	10,000
1974	69,000	4,200
1976	46,000	3,200
1978	33,500	1,800
1980	118,000	12,800
1982	39,000	23,650
1984	80,000	36,500
1986	196,500	32,200
1988	124,400	38,910
1990	59,600	15,400
<hr/>		
Average 1960 - 1990	$\bar{X}$ 66,678	$\bar{X}$ 12,804

Table 7. Chum salmon escapements, Terror and Kizhuyak Rivers, 1982-1990.

Year	Terror River Escapement	Kizhuyak River Escapement
1982	12,900	12,000
1983	10,050	3,170
1984	10,000	9,000
1985	3,000	7,000
1986	10,000	55,000
1987	15,000	17,000
1988	15,000	27,500
1989	39,000	55,000
1990	5,000	2,300
Average 1982-1990	$\bar{x}$ 13,328	$\bar{x}$ 20,886

Table 8. Kizhuyak River aerial survey results, 1990.

Alaska Department of Fish and Game  
 Salmon Escapement Surveys, 1990  
 (Aerial Surveys Unless Noted in Remarks)

Stream	Date MM-DD	Observer	Visibility Str Mou Bay	-----Fish in Stream-----				Build Up Fish		Observer Remarks
				Reds	Coho	Pink	Chum	Mouth	Bay	
Kizhuyak River										
259-365	7-16	Brennan	e e f	0	0	0	0	-	-	1930 hours. No fish showing in head of bay or near flats. No stream survey.
259-365	7-19	Blackett	g g g	0	0	1000	130	-	20P	-
259-365	8- 5	Prokopowic h		0	0	5000	200	-	-	No show in bay. 500 pinks were in beaver pond.
259-365	8- 9	Brennan	f f f	0	0	0	0	50P	20P	1800 hrs. Really blank. A few in lower mouth and channels. Zip outside, zip in sloughs. No jumpers. Of which 500 Pinks in beaver pond.
259-365	8- 9	Prokopowic h	g	0	0	7500	0	-	-	
259-365	8-17	Brennan	f f f	0	0	7000	2300	-	1300P	1310 hours. In main stem 6,400 pinks. Most below forks still. 400 pinks up east fork. Only 200 pinks in slough to east. Chums scattered about. Nothing on flats.
259-365	8-21	Blackett	g g g	0	0	5200	525	-	25P	-
259-365	8-23	Brennan	e e e	0	0	3700	0	-	-	1300 hours.
259-365	9- 8	Blackett	g g g	0	0	7900	20	-	-	-
259-365	9-25	Blackett	f f f	0	160	3000	10	-	-	-

Salmon Escapement Observations

Report Date 11/06/1990

Figure 1. Location of Terror River and Kizhuyak River, Kodiak Island, Alaska.

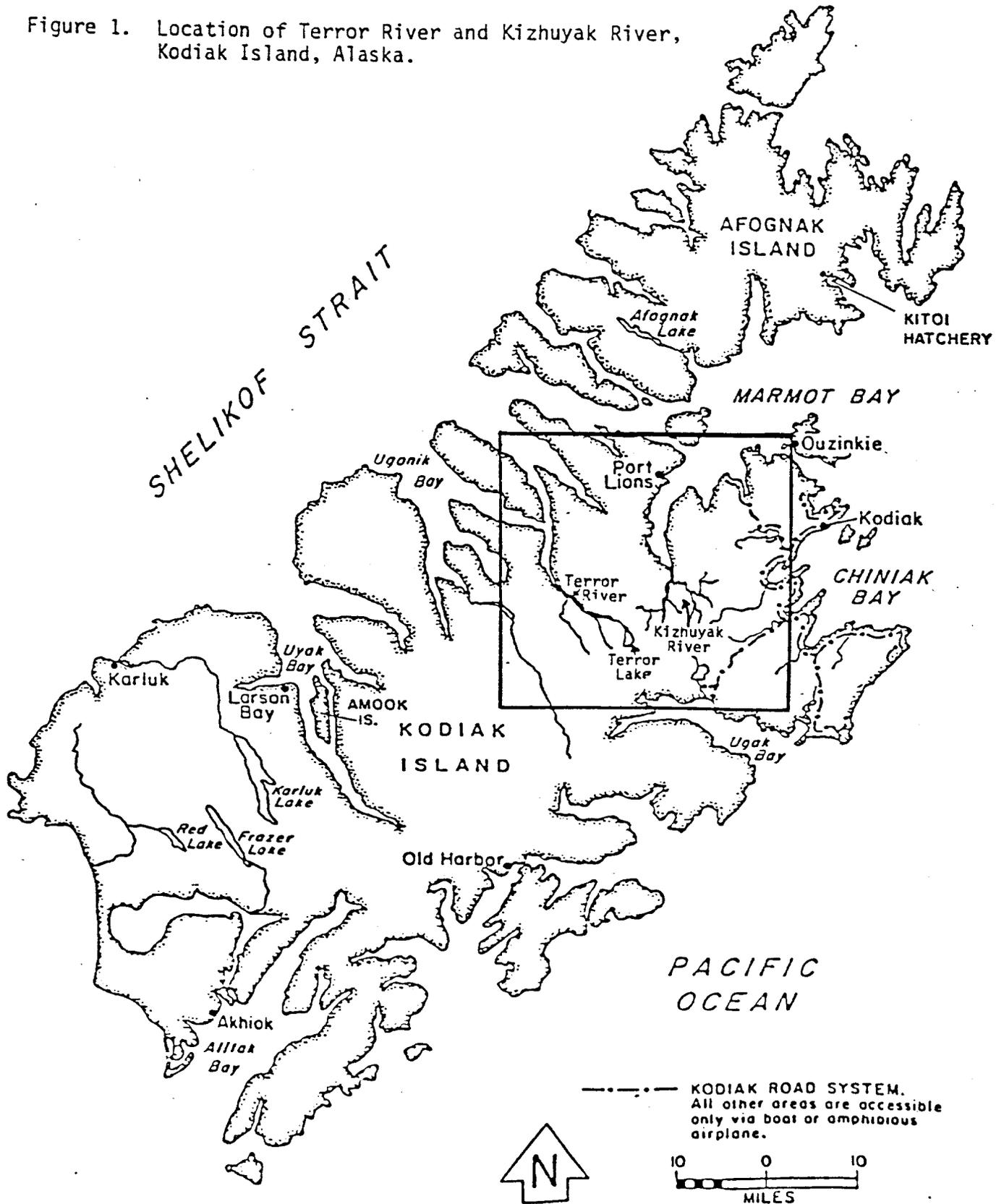


Figure 2. Terror Lake Hydroelectric Project.

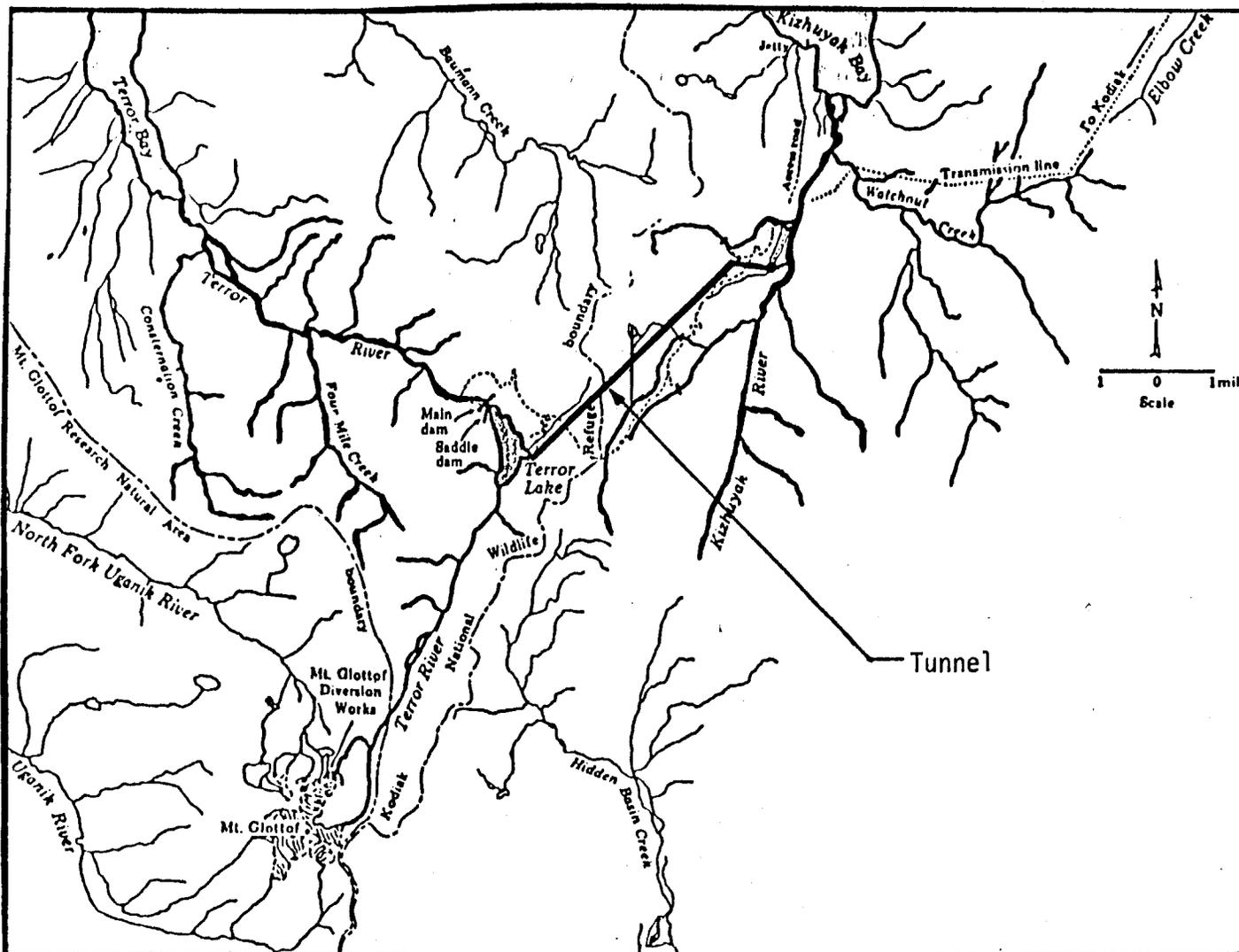


Figure 3. Terror River pink salmon fry indexes 1982-1990.

# TERROR RIVER PINK SALMON FRY INDEXES

## COMPARISON 1982-1990

91

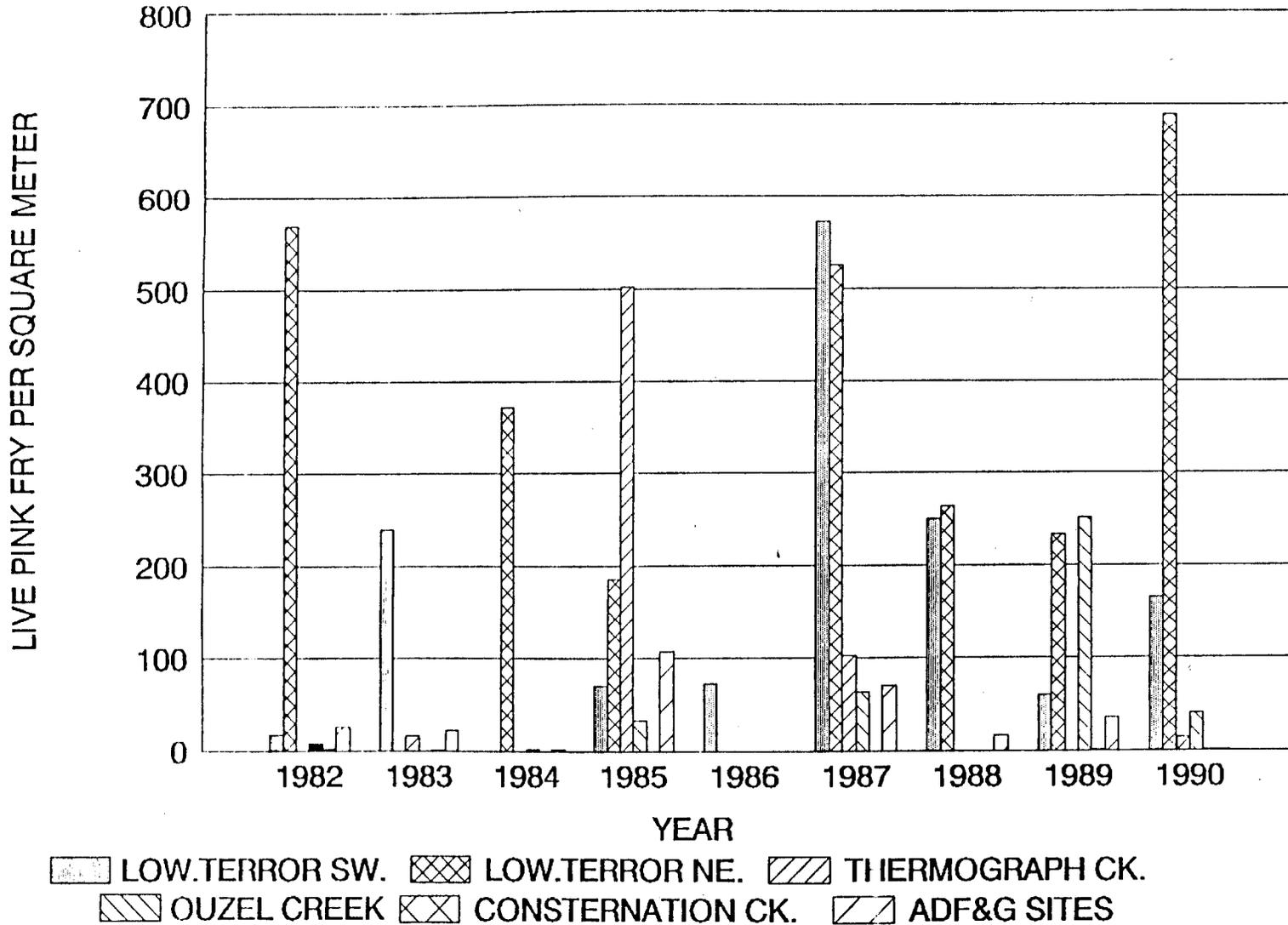


Figure 4. Kizhuyak River pink salmon fry indexes 1982-1990

# KIZHUYAK RIVER PINK SALMON FRY INDEXES

## COMPARISON 1982-1990

17

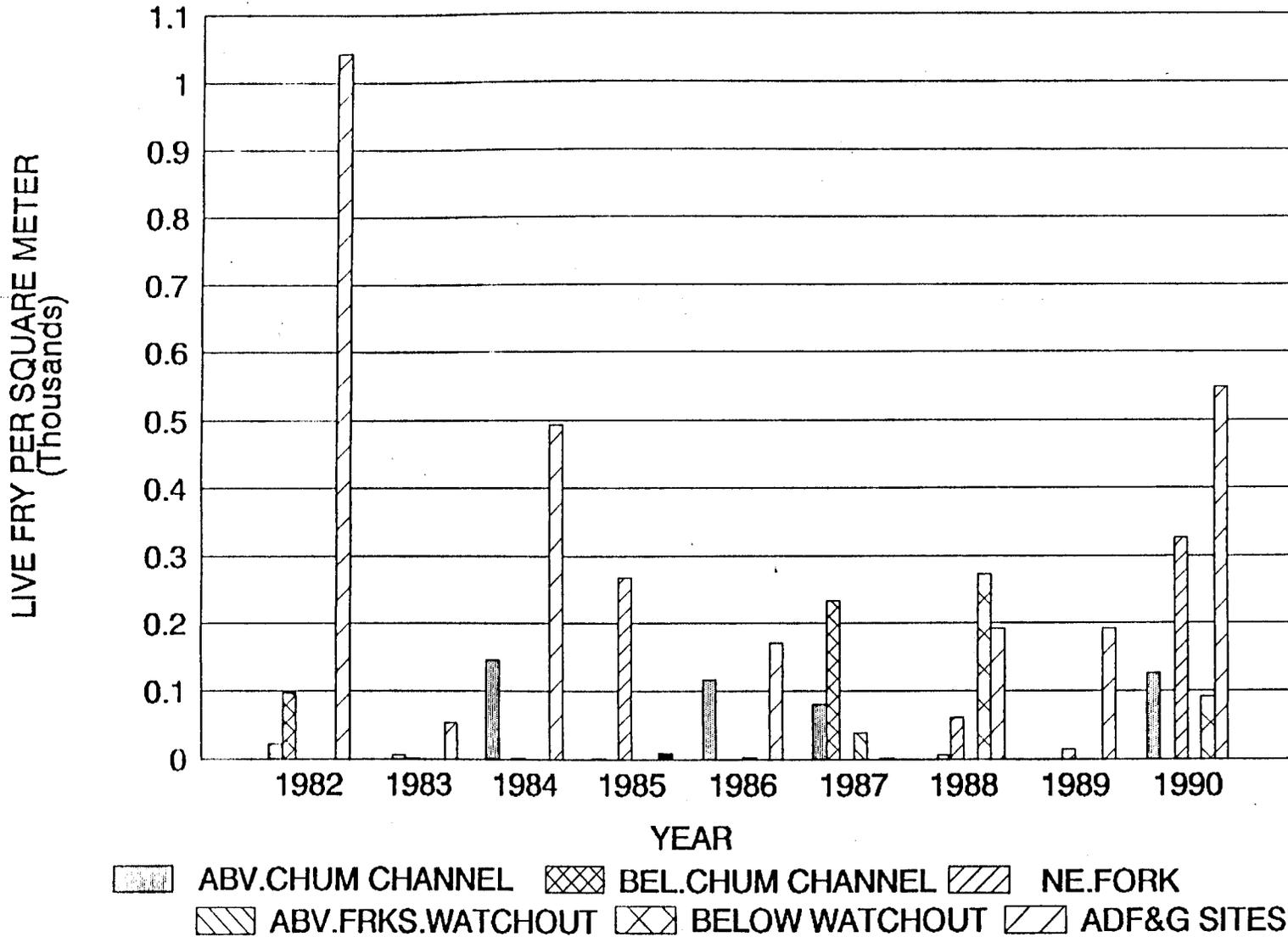


Figure 5. Even year pink salmon escapements, Terror and Kizhuyak Rivers 1960-1990.

# EVEN YEAR PINK SALMON ESCAPEMENTS

TERROR AND KIZHUYAK RIVERS 1960-1990

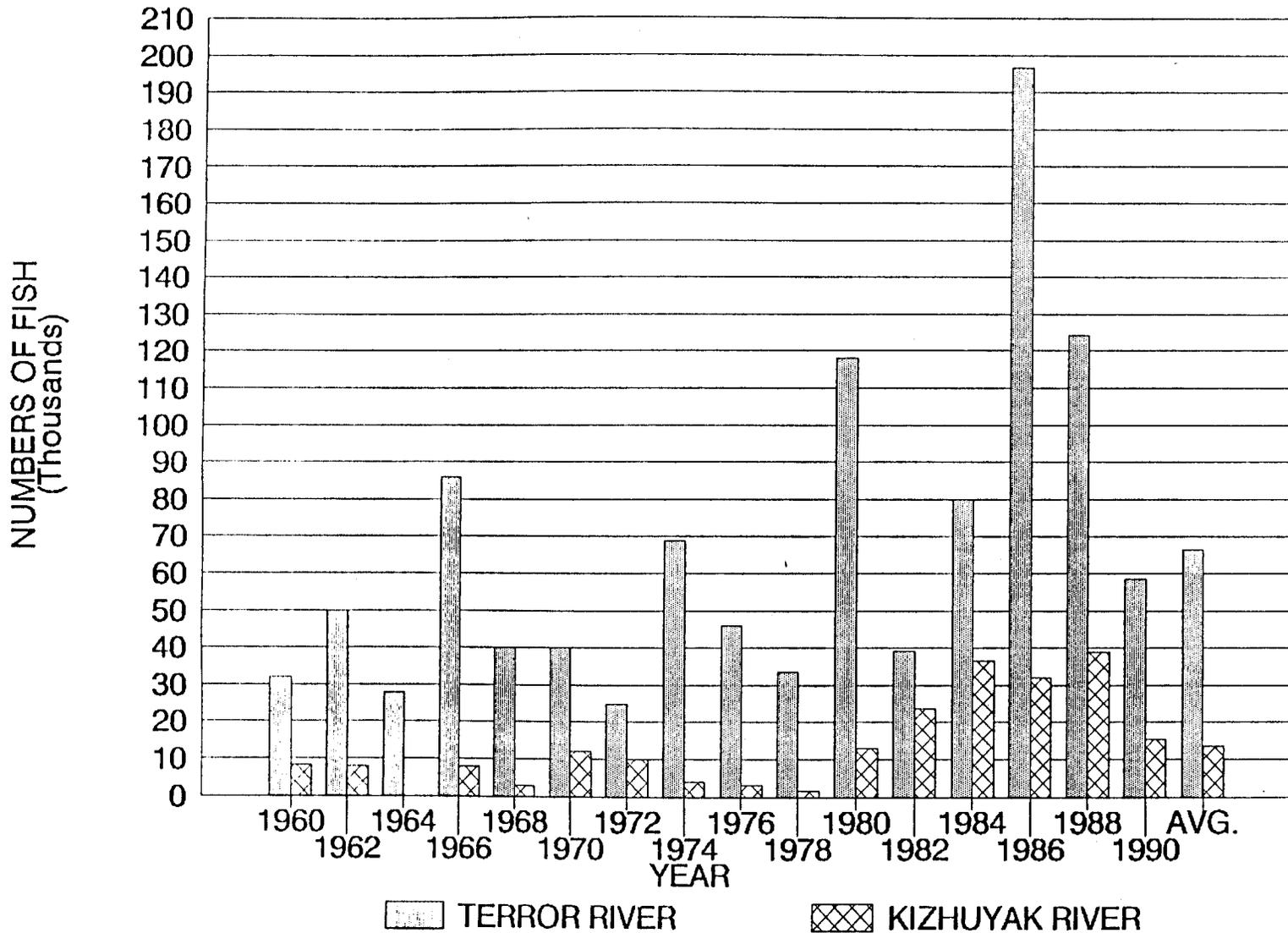


Figure 6. Chum salmon escapements, Terror and Kizhuyak Rivers, 1982-1990.

# CHUM SALMON ESCAPEMENTS

## TERROR AND KIZHUYAK RIVERS 1982-1990

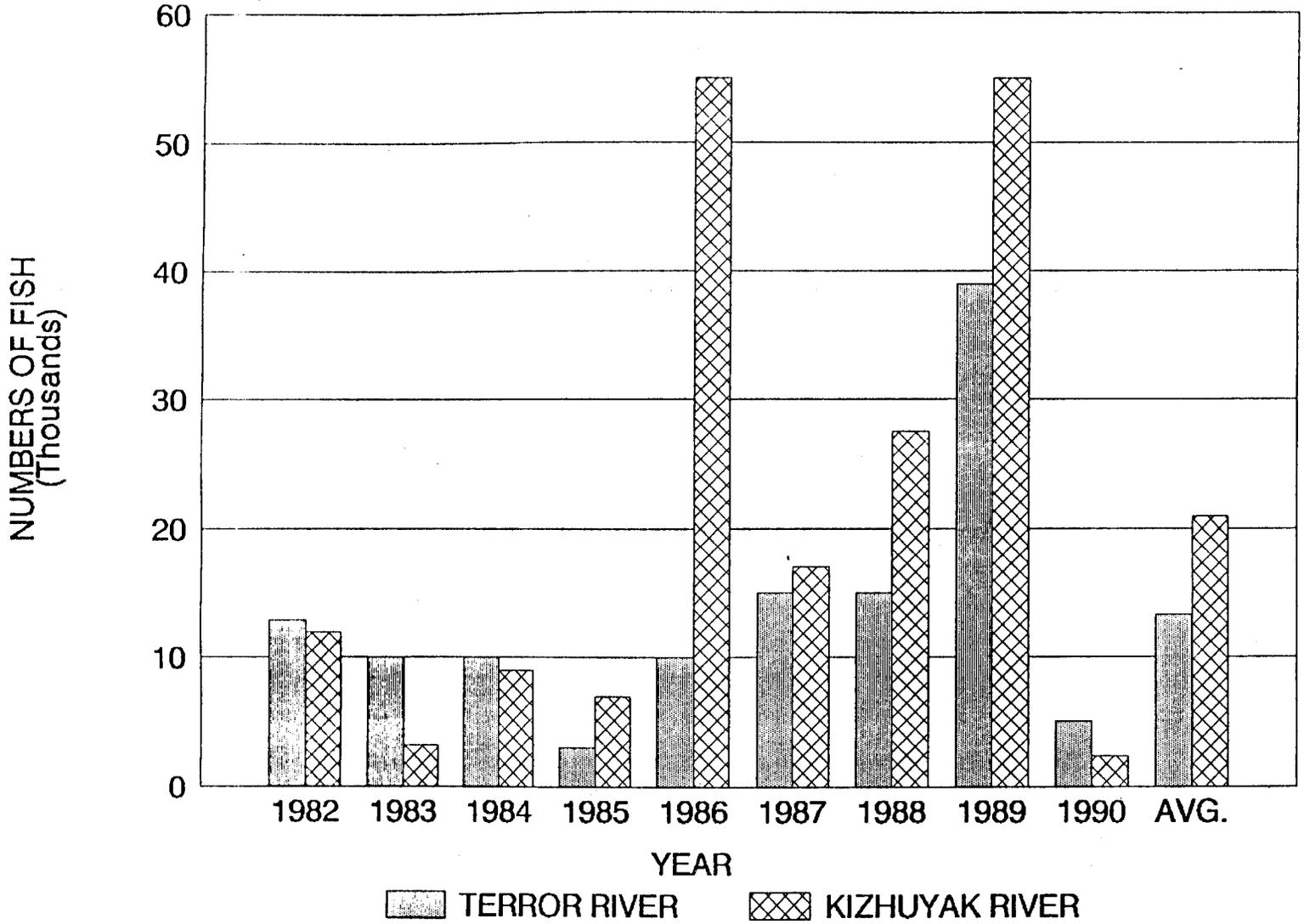


Figure 7. Terror River pre-emergent fry sampling sites, 1990

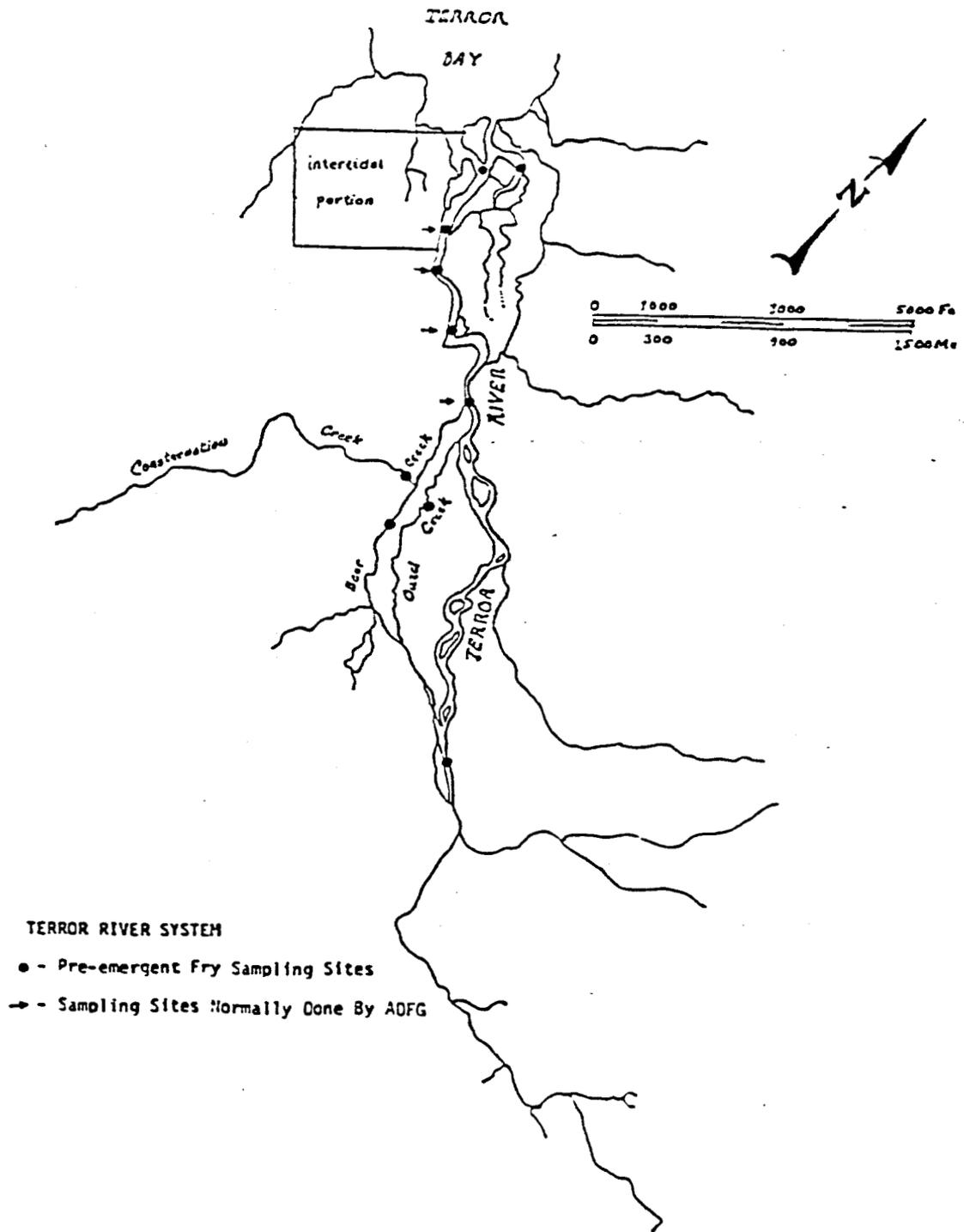




Figure 29. Terror River pink salmon distribution, 1990

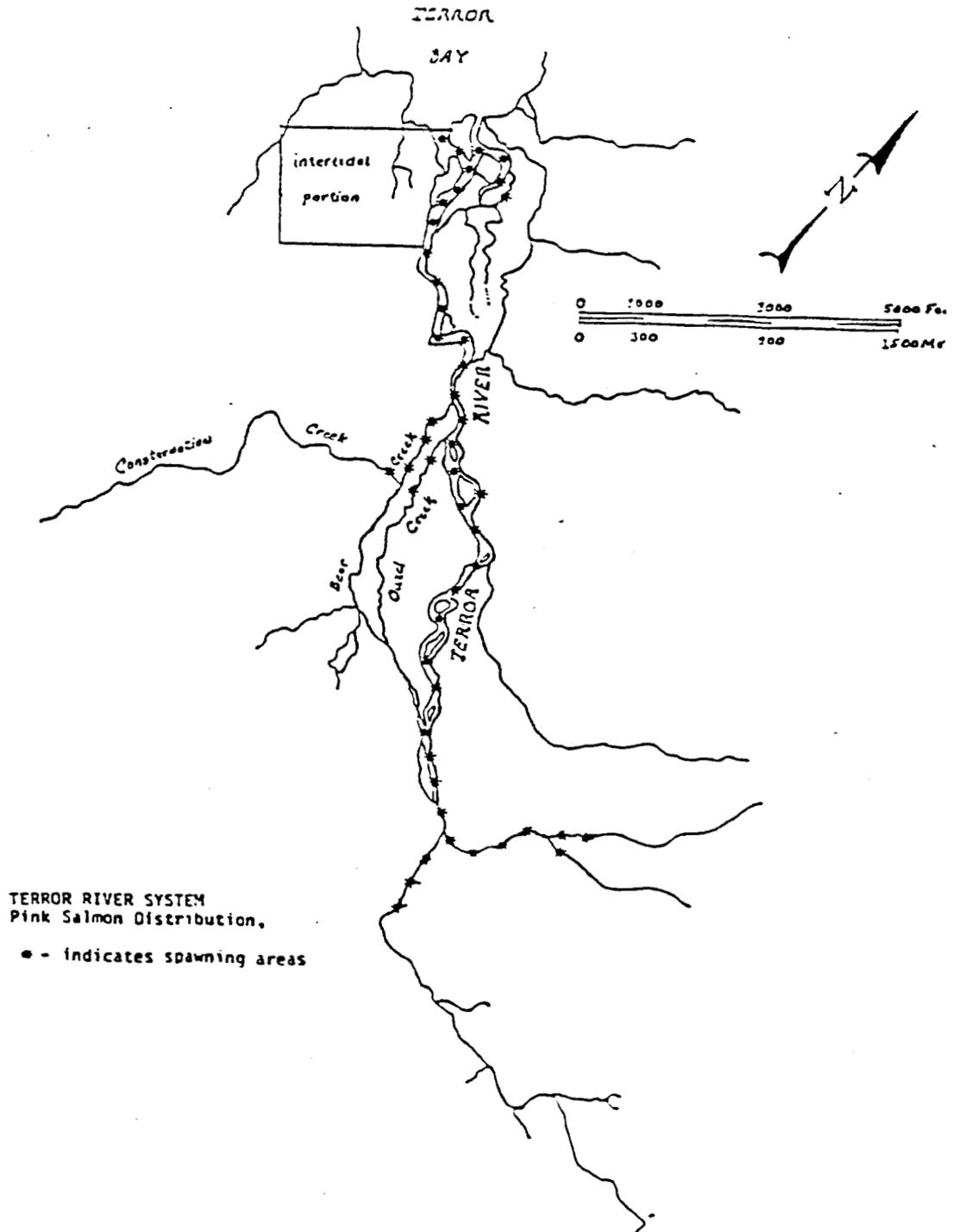


Figure 10. Terror River chum salmon distribution, 1990

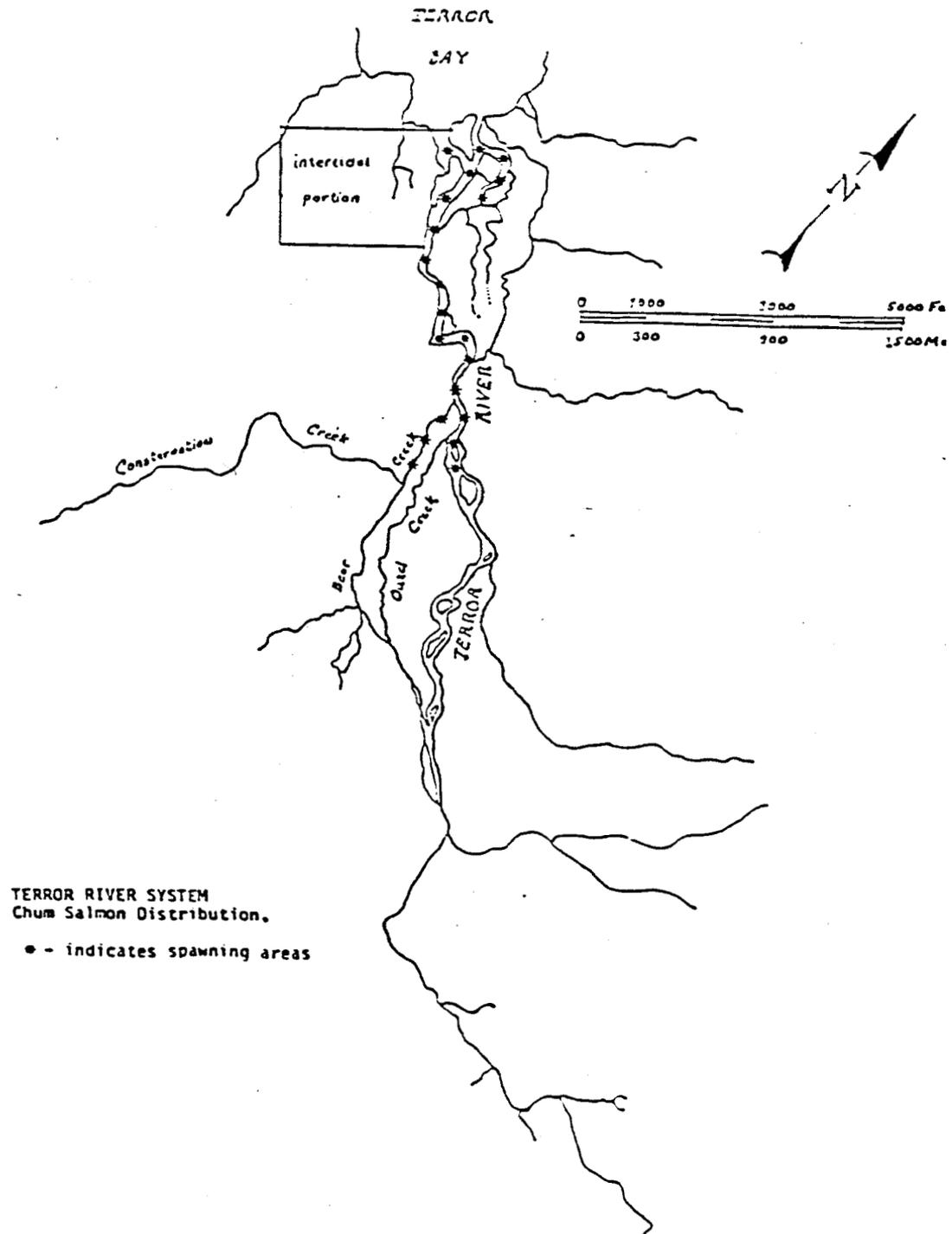


Figure 11. Kizhuyak River pink salmon distribution, 1990

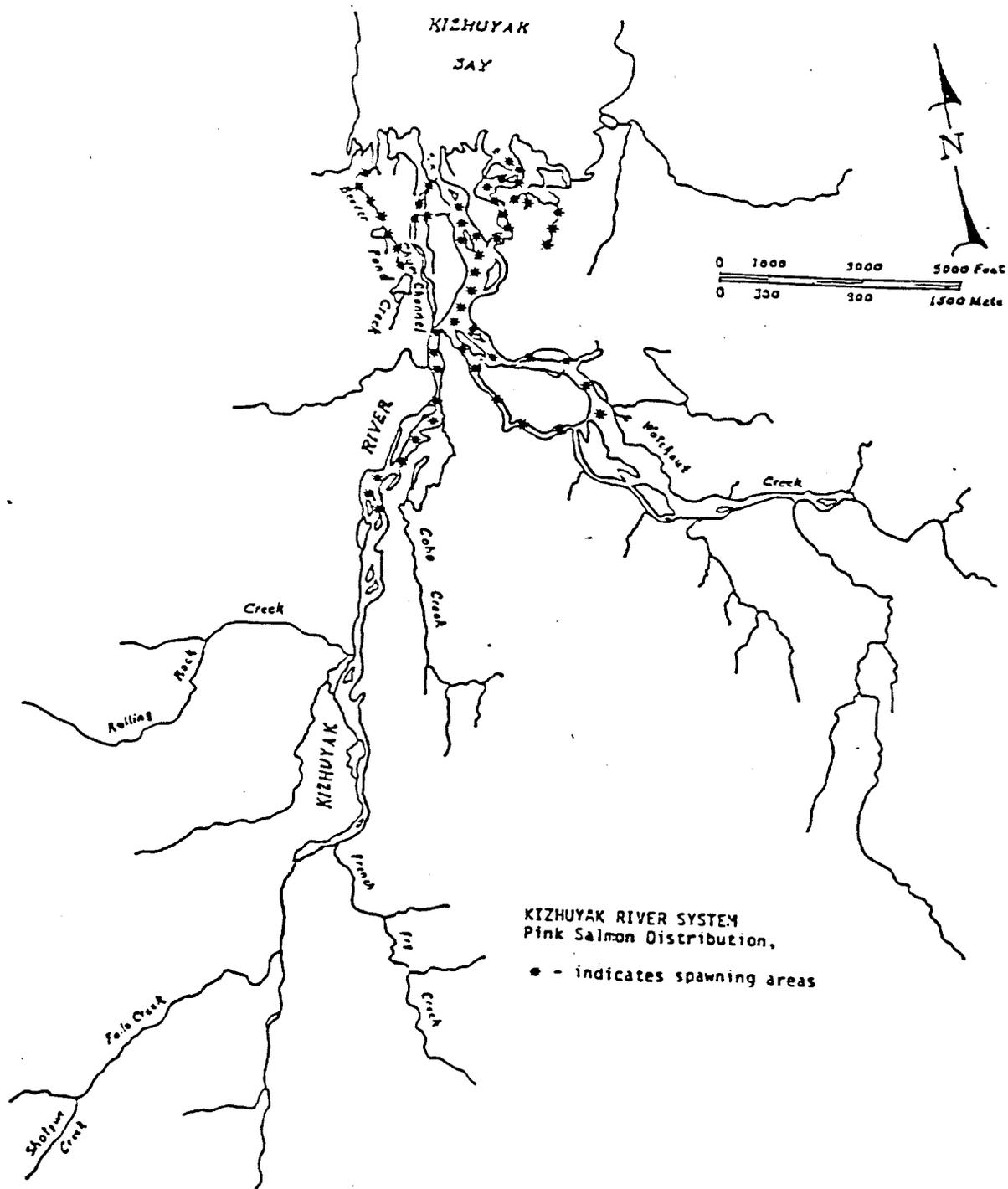
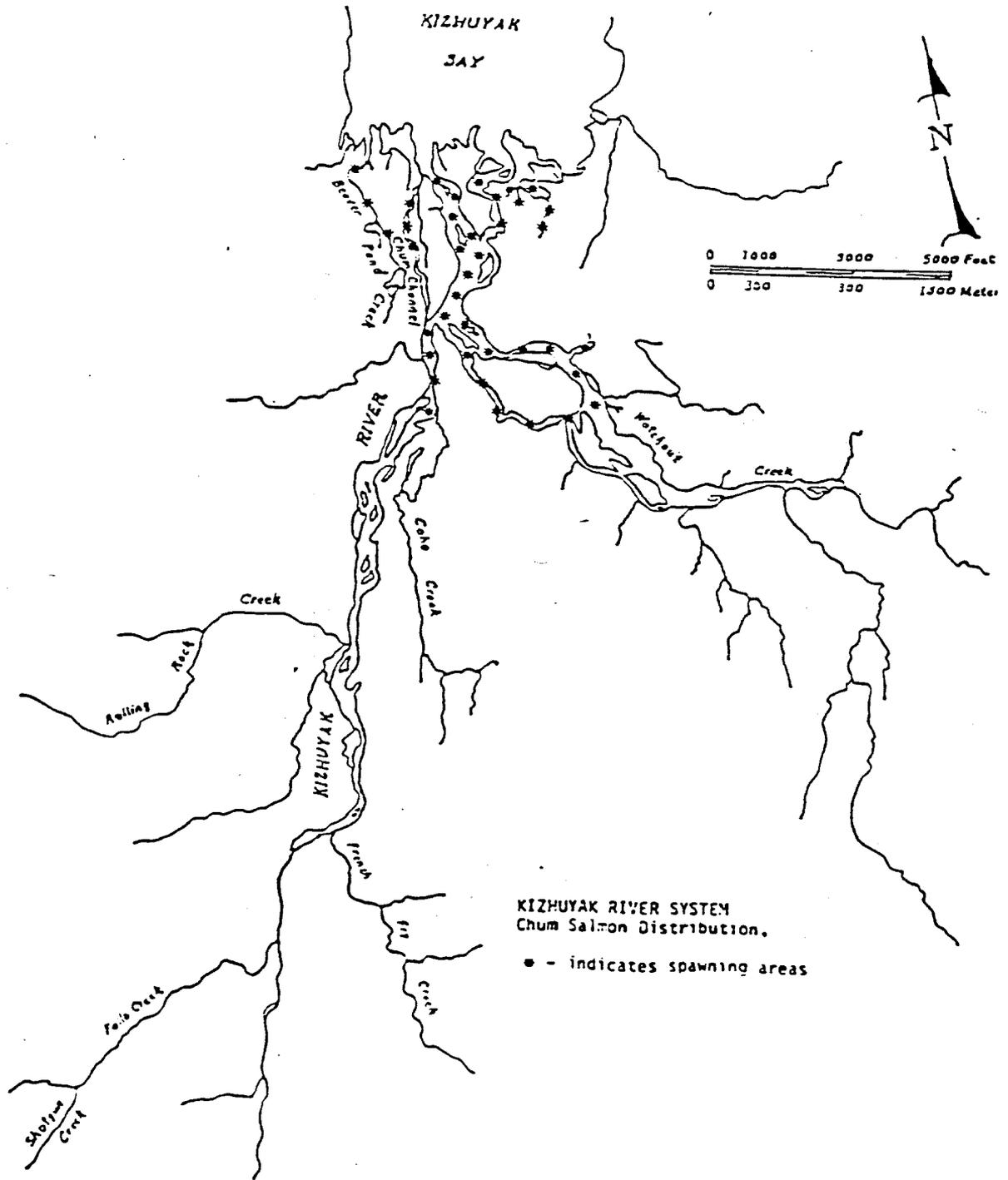


Figure 12. Kizhuyak River chum salmon distribution, 1990



#### LITERATURE CITED

- AEIDC (Arctic Environmental Information and Data Center). 1981. An assessment of environmental effects of construction and operation of the proposed Terror Lake hydroelectric facility, Kodiak, Alaska. Final Report, University of Alaska, Anchorage.
- Malloy, L. 1981. Project Proposal: Kizhuyak River and Terror River salmon studies. Unpublished Report; Alaska Department of Fish and Game, Kodiak.

APPENDIX A. Commercial Fisheries Division Expenditures,  
Terror River Hydroelectric Project, 1990.

DATE 09/20/90  
PROGRAM ID ETSLEBAL  
VERSION 3.0

ALASKA DEPARTMENT OF FISH AND GAME

LEDGER BALANCE SUMMARY FOR: 11039991 TERROR LAKE

LINE ITEM	ALLOCATION	EXPENDITURES	ENCUMBRANCES	ENCUMBRANCES		CREDITS	BALANCE
				PAID	OBLIGATED		
100 - PERSONNEL	16,000.00	11,405.95	.00	.00	11,405.95	.00	4,594.05
200 - TRAVEL	300.00	.00	.00	.00	.00	.00	300.00
300 - CONTRACTUAL	5,000.00	.00	.00	.00	.00	.00	5,000.00
400 - COMMODITIES	7,500.00	.00	.00	.00	.00	.00	7,500.00
500 - EQUIPMENT	.00	.00	.00	.00	.00	.00	.00
LINES 200 - 500	12,800.00	.00	.00	.00	.00	.00	12,800.00
ALL LINES	28,800.00	11,405.95	.00	.00	11,405.95	.00	17,394.05

DOCUMENT TYPE MAP

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FPO - 0	PR - 0	TA - 0	

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