FRI-UW-8703
January, 1987

Fisheries Research Institute
School of Fisheries
University of Washington
Seattle, Washington 98195

AERIAL SURVEYS OF SOCKEYE SALMON ABUNDANCE ON SPAWNING GROUNDS IN THE LAKE CLARK-TAZIMINA RIVER WATERSHED

by

Steven S. Parker and Greg R. Blair

Funded by

Bristol Bay Salmon Processors

through

Pacific Seafood Processors Association

Date 2-20-87.

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INTRODUCTION

The production of adult sockeye salmon in the upper Newhalen River and Lake Clark watershed (Fig. 1) historically has been of variable importance to the composite Kvichak River stock of sockeye salmon. The system ceased to be a major contributor to Kvichak salmon runs in the late 1930's, probably as the result of severe overfishing of the early-arriving segment of the Kvichak run which differentially impacted escapements to spawning grounds in the upper Newhalen River, Tazimina River, and Lake Clark (Mathisen 1979). In recent years, the trend has reversed (Mathisen and Poe 1981) and salmon runs to the upper Newhalen-Tazimina-Lake Clark system (hereafter referred to as Lake Clark-Tazimina) since 1978 have represented from 15 to 80 percent of the Kvichak system total (mean = 43%), and from 3 to 49 percent (mean = 19%) of the Bristol Bay total (Poe and Rogers 1984). Clearly, the production of sockeye salmon in the Lake Clark-Tazimina system is a valuable component of the Bristol Bay sockeye salmon resource.

Fisheries Research Institute (FRI) has conducted research on the Kvichak sockeye salmon resource since 1948. A major goal of studies has been to formulate optimum escapement sequences for the Kvichak system as a whole and for the component lake systems (Mathisen and Poe 1983). Mapping the distribution of spawners among spawning grounds, based on aerial survey estimation, is of key importance to the evaluation and implementation of an escapement plan for the system. Aerial surveys have been flown throughout the Kvichak watershed sporadically since 1920, and systematic coverage of most spawning grounds was initiated by FRI in 1956. However, coverage of Lake Clark-Tazimina spawning grounds has never been systematic because the peak of spawning generally occurs well after the close of research activities in the autumn.

Aerial surveys seldom account for more than 20% of Kvichak system escapements enumerated at Igiugig (Table 1), thus it is recognized that the counts are useful only to index relative spawner distributions, rather than to actually census the population of spawners in the system. Lake Clark aerial surveys traditionally account for very little of the estimated Lake Clark escapement (0.8-9%), probably because of differences in timing of surveys relative to peak spawning activity at each of the major grounds in the Lake Clark system. Repeated visits to the various spawning areas has been suggested to ensure that maximum numbers of spawners are available to an observer at each location surveyed. Unfortunately, undertaking such a program of surveillance is beyond the time and cost capabilities of FRI. The purpose of this report is to describe FRI aerial survey techniques in sufficient detail to preserve the continuity of Lake Clark surveys, should they be performed by other individuals or agencies.

AERIAL SURVEY TECHNIQUES

The essential ingredients of aerial surveys divide into two parts; flight path characteristics, and visual assessment of fish densities. The first section will describe the details of flight and flightpath employed by FRI in recent years, and the second section will describe counting and recording methods.

Survey Routes

The perimeter of Lake Clark and the major spawning grounds generally are surveyed and reported by sections (Fig. 2). Section boundaries usually coincide with stream mouths or terrain features that are easily or commonly recognized, and may vary from year to year so long as the boundaries are noted on survey reports. Section counts are summarized and reported for Kijik River; Little Kijik River; Kijik Lake and tributaries; Priest Rock Creek and ponds; Lake Clark North Shore; Tlikakila River; Chokotonk River; Currant Creek; Tanalian River; 22 Creek. Provision has not been made in the past for Lake Clark South Shore, although recent surveys indicate that considerable numbers of beach spawners may be counted in some years.

Surveys are best done near mid-day to minimize shadows cast by mountains or overhanging vegetation, and to maximize the depth of light penetration into the water column. The survey route should be planned so that incident sunlight is directly overhead or slightly behind the observer to control surface glare from reflected light. In general, north shore beaches should be inspected with incident sunlight from the south or overhead, Kijik Lake is best with sun directly overhead to avoid shadows cast by Kijik Mountain, and south shore beaches can be flown when sun incidence is overhead or slightly from the north. However, since Lake Clark can be thoroughly surveyed in about 2 hr, there is some flexibility in start time. A generalized survey route, assuming an observer in the right seat of the aircraft, is as follows:

> Beginning at Port Alsworth with the sun slightly below zenith, survey Lake Clark beach to Tommy Creek. Continue along the south shore to Currant Creek, which can be surveyed if fish are present. Examine the next section of beach from Currant Creek into Little Lake Clark to the mouth of Chokotonk River. Beach sections from Port Alsworth to this point are recorded as Lake Clark Southshore. Survey the lower 10 miles of Chokotonk River from the mouth to about Moose Pass. Crossing through Moose Pass, survey Tlikakila River downstream to the delta. Proceed west, surveying northshore beaches to Priest Rock Creek. Priest Rock Creek and ponds should be surveyed and recorded separately, but there may be some difficulty in distinguishing beach spawners from those about to move into the creek. The distinction is simply a judgement call. Continue west, noting any concentrations of salmon off the mouth of Kijik River. West of Kijik Mountain, swing inland to survey Kijik Lake tributaries and the entire perimeter of Kijik Lake. Record separately the counts for lake and tributaries, Little Kijik River to confluence with Kijik River, and Kijik River from confluence to mouth. Several passes may be necessary to include all channels. Sockeye schooled off the mouth in Lake Clark should be included in the Kijik River total. Picking up northshore beaches again, continue west to Chulitna Bay, paying particular attention to beaches in the vicinity of Owl Rock. A

circuit of Chulitna Bay may reveal a few fish on its north shore, but the incidence of spawners from Cape Shuskin west to the outlet of Lake Clark rarely justifies surveying this stretch. Beach spawning between Chokotonk River and Cape Shuskin is designated as Lake Clark Northshore. Cross over to 22 Creek and survey upstream, then fly overland to the outlet of Lake Clark and survey beaches back toward Port Alsworth. The stretch between Sucker Bay and Flat Island is frequently used by beach spawners and should be examined carefully. Tanalian River may be surveyed to the falls, but the abundance of spawners is usually quite low. Tanalian River and 22 Creek are recorded separately, and the beaches are included in Lake Clark Southshore counts.

Flight Characteristics

Surveys have been flown in aircraft ranging from Piper Cubs to Beavers on floats. The aircraft of choice is a Super Cub, Cessna 172 XP, or equivalent, which have superior performance for survey work. A "forgiving" aircraft is desirable, since optimum survey speed frequently is 5-10 knots above stall speed at altitudes of 300-500 feet. The pilot's responsibility is to provide the observer with as clear a view of the spawning grounds as safety allows. For beach spawning areas, straight and level flight may be adequate. Often, however, the aircraft must be slightly rolled or sideslipped to provide an acceptable view for the observer. When multiple passes are needed over a section of braided river or tight meanders, the pilot should fix ground positions to ensure even and uniform survey coverage.

Weather conditions heavily influence aerial survey quality through effects on light intensity, water surface condition, and water clarity. Water clarity in Lake Clark is a problem that cannot be avoided, but surveys can be scheduled to take advantage of favorable conditions of light intensity and surface condition. Clear, calm days provide the best opportunities for counting beach spawners, as even minor ripples or cat's paws may severely distort images below the surface. Weather conditions are somewhat less critical for seeing spawners in shallow streams; however, wind turbulence may limit access to some spawning areas.

Survey Records

The primary responsibility of the observer, aside from actually counting the fish, is to record all information pertinent to the quality and completeness of the survey. Polarized sunglasses are essential to survey quality and must be worn whenever counts are made. We have found that a good quality tape recorder, and a thorough understanding of how it works, are highly desireable for recording information during the survey. Survey data have been lost or not recorded on occasion because of unnoticed in-flight errors in operation of the auto-reverse function or in triggering the microphone.

Information routinely recorded in FRI aerial surveys includes the following:

1. Survey date and times of lift off and touch down.
2. Aircraft type and pilot.
3. Weather conditions, light intensity, and water conditions (visibility).

4. Survey route, location of counts, numbers of spawners schooled, numbers scattered on spawning sites, and numbers of carcasses.
5. Miscellaneous remarks concerning survey effectiveness or events of special interest.

Estimation of Spawner Densities

Although aerial survey techniques have been standardized to the extent that flight characteristics and data records can be duplicated, there is no standard method for estimating numbers of fish on the spawning grounds, thus counting techniques and resultant estimates often vary widely between observers. The problem is minimal at low spawner densities, as nearly each individual can be counted. At higher densities, composite counts may become necessary, i.e. counts in units of 10, 100, or 1,000, for example. The loss of precision in estimates is partially offset by the increase in numbers of fish counted. However, the loss of accuracy in counts at high spawner densities may be substantial, particularly when counts are compared between years or between observers (Bevan 1961). Surprisingly little research effort has addressed the nature of variance in aerial survey counts. A possibility for future studies is the use of photographs to estimate spawner abundance and variance in counts.

Unfortunately, there is little information that can be conveyed on paper to assist in counting spawners from the air. It is extremely difficult to describe the appearance of a school of 2,000 fish, and virtually impossible to describe the appearance of 2,000 spawners scattered on spawning sites. Moreover, a school of 2,000 on lake beaches may have a 3-dimensional configuration, of which only two dimensions are discernable from the air, whereas a school of equal number in a shallow river or stream will be rather more compressed into two dimensions. Estimates of spawner densities ultimately depend on an observer's internal frame of reference. In ideal circumstances, an experienced observer should fly a series of surveys with an inexperienced observer so that this unit of reference can be standardized.

SUMMARY OF AERIAL SURVEYS OF LAKE CLARK-TAZIMINA

The summary of aerial survey counts on Lake Clark-Tazimina spawning grounds (Table 2) is drawn from the Fisheries Research Institute's Bristol Bay Datafile, Kvichak Data Base Subfile 11, entitled "Spawning Ground Survey Peak Indices 1920 - 1975". The data base for Lake Clark has been updated through 1985. An abbreviated version of Subfile 11 is presented here; additional information on Subfile 11 output concerns type of survey, type of area, extent of survey coverage, quality of survey, estimated date of peak spawning, and observer ID.

Dates of aerial surveys in the Lake Clark-Tazimina system have ranged from July 23 to November 24. July 23 is certainly prior to peak spawning at most locations, and November 24 appears to be too late for most locations. The variance in survey timing reflects the fact that Lake Clark aerial surveys often are done as a matter of opportunity. Surveys performed between late September and mid-October appear most likely to provide best results.

Dates of peak spawning activity at each of the principal spawning grounds are difficult to estimate from survey counts. Date of peak spawning probably varies from year to year and from location to location depending on particular conditions of climate or innate biological timing of a spawning population. The effect of climatic variability is expressed through the maturation, or ripening, of spawners which is partially temperature dependent. Cold summers and cooler water temperatures probably delay time of spawning at all spawning grounds relative to warm summers. Differences in timing between spawning grounds may evolve in response to characteristics of the physical habitat that place time limits on spawning activity. A demonstration of this sort of physical limitation occured in 1980, when uncommonly high Newhalen River discharge created a velocity barrier to the upstream migration of sockeye in late July and August. An estimated 5 million spawners were trapped below the blockage and died unspawned (Poe and Mathisen, unpublished manuscript). Consequently, only the early migrating component of the Newhalen River escapement survived to reproduce. Since migration timing is assumed to be a genetically transmitted characteristic, it seems reasonable to expect that the progeny of the survivors should exhibit a relatively earlier migration timing as adults. Such a mechanism could operate on a local scale to fix the time of peak spawning at individual spawning grounds.

Major concentrations of spawners generally are found in the Tazimina River, the Kijik system, and Priest Rock Creek and ponds. The abundance of sockeye at other locations is variable, but always relatively low. Kijik system spawner counts on average account for about 34% of the Lake Clark-Tazimina total and about 85% of the Lake Clark total. Small streams, such as 22 Creek and Currant Creek, frequently show zero counts and are not usually surveyed from chartered aircraft.

The range in aerial survey counts of spawners in the Lake Clark-Tazimina system suggests that escapements are highly variable. Sums of index counts in years of complete survey coverage range from 1,672 in 1973 to 421,480 in 1975. The abundance of spawners in the Lake Clark-Tazimina system is determined by both the phase of the Kvichak cycle of sockeye salmon production, and by the management of commercial harvests in the Kvichak Bay fishery. The Kvichak cycle determines the harvest policy, i.e. large harvests in years of peak abundance, and little or no harvest in off-peak years. In years of peak abundance, the Lake Clark-Tazimina component of the Kvichak run may be heavily overexploited by a large fleet assembled to harvest the large Lake Iliamna component of the run. In off-peak years, the Lake Clark-Tazimina component may encounter little or no fishing pressure. Therefore, the escapement to Lake Clark-Tazimina spawning grounds in any year depends greatly on the abundance of this component relative to the abundance of the Lake Iliamna component.

A second determinant of Lake Clark-Tazimina escapements derives from the pattern of commercial fishing in the Kvichak District. Evidence from spawning ground recoveries of tags placed on spawners at Igiugig in 1983 indicates that the migratory timing of Tazimina River spawners is earlier, and that of Lake Clark spawners is later, than the average for the composite Kvichak system sockeye salmon migration (Jensen and Mathisen, in press). If fishing pressure is distributed unevenly over the migration of sockeye through the fishing district, then particular substock components may be overfished while others are underfished.

Fisheries Research Institute is attempting to document the relationship between harvest management and subsequent escapements to the upper Newhalen-Lake Clark-Tazimina system. Escapements have been estimated since 1979 from visual counts of sockeye migrating past counting sites at river mile 1 (RM 1) and RM 22 of the Newhalen River. This program has shown that up to 3.0 million spawners may reach spawning grounds in the upper Newhalen-Lake Clark-Tazimina watershed, and it has shed a great deal of light on the migratory behavior of adult sockeye returning to these areas. Unfortunately, the program will most likely be terminated for lack of funding.

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Table 1. Peak aerial estimates of sockeye salmon abundance on spawning grounds in the Kvichak watershed.

Year	Type of Spawning Area: Streams	Ponds	Mainland Beaches	Island Beaches	Total	Kvichak Escapement	Percentage Counted on Spawning Grounds
1955	28,296	357	3,725		32,378	250,546	12.92
1956	1,006,050	17,000	265,030	43,400	1,331,480	9,443,318	14.10
1957	261,237	7,486	79,500	5,200	353,423	2,842,810	12.43
1958	66,972	1,000	26,820	3,770	98,562	534,785	18.43
1959	95,533	3,634	11,147	17,880	128,194	680,000	18.85
1960	1,333,382	28,950	488,500	1,000,000	2,850,832	14,630,000	19.49
1961	392,105	3,120	152,350	106,850	654,425	3,705,849	17.66
1962	220,430	9,918	45,553	10,150	286,051	2,580,884	11.08
1963	36,069	2,598	8,016	5,069	51,752	338,760	15.28
1964	70,444	2,595	7,374	14,791	95,204	957,120	9.95
1965	1,251,896	80,650	387,174	1,957,500	3,677,220	24,325,926	15.12
1966	422,169	14,020	133,939	48,790	618,918	3,775,184	16.39
1967	358,810	6,873	150,490	18,645	534,818	3,216,208	16.63
1968	215,617	8,463	36,355	76,872	337,307	2,557,440	13.19
1969	406,282	27,936	114,345	131,850	680,413	8,394,204	8.11
1970	1,309,313	132,161	546,395	642,790	2,630,659	13,935,306	18.88
1971	315,193	8,615	51,390	61,460	436,658	2,387,392	18.29
1972	145,468	3,828	26,711	10,463	186,470	1,010,000	18.46
1973	57,553	834	9,803	6,662	74,852	226,554	33.04
1974	587,309	48,305	120,590	139,713	895,917	4,433,480	20.21
1975	1,621,925	48,736	423,181	557,276	2,651,118	13,140,450	20.18
1978	677,133	19,080	176,230	6,160	878,603	4,149,288	21.17
1979	2,020,975	50,705	681,179	101,475	2,854,334	11,218,434	25.44

Table 1. Peak aerial estimates of sockeye salmon abundance on spawnin grounds in the Kvichak watershed (continued).

	Type of Spawning Area						Percentage
Year	Streams	Ponds	Mainland Beaches	Island Beaches	Total	Kvichak Escapement	Percentage Counted on Spawning Grounds
1980	1,615,685	15,375	134,750	205,150	1,970,960	22,505,268	8.76
1981	280,640	3,905	28,430	23,065	336,040	1,754,358	19.15
1982	365,834	1,606	42,025	11,325	420,790	1,134,840	37.08
1983	982,644	8,349	9,107	98,983	1,099,083	3,569,982	30.79
1985	925,881	74,326	318,822	293,347	1,612,376	7,211,000	22.36
1986	80,247	2,944	7,823	8,202	99,216	1,200,000	8.27
Peak cycle years							
mean	1,294,876	56,743	366,265	671,352	2,388,549		16.98
s.d.	268,637	42,222	139,740	649,432	805,321		4.62
Non-peak cycle years							
mean	367,728	10,735	87,404	43,208	507,112		18.31
s.d.	438,155	14,153	143,967	46,504	606,452		7.63

Table 2. Aerial survey counts of Lake Clark-Tazimina River spawning grounds, 1920-1986.

			Index of Spawner Abundance			
Location	Year	Date of Survey	Spawning	Dead	Schooled	Total
Tazimina River	1920	9/5				50
	1921					50,000
	1924	8/17				40,000
	1940	7/25				500,000
	1944					550
	1945	9/8				7,500
	1949	9/9	6,000	6,000	0	12,000
	1950					7,500
	1951					4,000
	1952					17,000
	1953					17,000
	1954					3,400
	1955	9/13	50	0	50	100
	1956	9/9	27,300	5,000		32,300
	1957					28,750
	1958	8/28				600
	1959	9/19	150	0	0	150
	1960	8/28	55,000	0	0	55,000
	1961	8/30	30,000	0	0	30,000
	1962	9/3	3,600	400	0	4,000
	1963	9/1	0	0	0	0
	1964	8/29	150	0	0	150
	1965	9/6	27,500	21,600	0	49,100
	1966	8/27	4,800	80	0	4,880
	1967	8/14	1,560	0	1,400	2,960
	1968	9/12	135	115	0	250
	1969	8/11	22,610	0	22,110	44,720
	1970	8/25	85,450	0	42,150	127,600
	1971	9/2	12,870	55	0	12,925
	1972	9/27	0	20	0	20
	1973	9/28	0	12	0	12
	1974	9/5	73,920	30,555	2,325	106,800

Table 2. Aerial survey counts of Lake Clark-Tazimina River spawning grounds, 1920-1986 (continued).

Location	Year	Date of Survey	Index of Spawner Abundance: Spawning	Dead	Schooled	Total
Tazimina River	1975	8/10	149,950	0	149,950	299,900
	1976	8/23	15,580	0	1,210	16,790
	1977	9/1	6,650	255	300	7,205
	1978	8/23	143,475	3,425	84,275	231,175
	1979	8/2	288,000	0	0	288,000
	1980	8/26	157,450	200	63,550	221,200
	1981	9/6	17,860	10,355	0	28,215
	1983	9/8	134,052	78,100	1,650	213,802
	1985	8/27	185,772	0	103,447	289,219
	1986	9/3	5,194	133	437	5,764
		Average	50,175	5,390	16,888	65,728
		Maximum	288,000	78,100	149,950	500,000
		Minimum	0	0	0	0

Table 2. Aerial survey counts of Lake Clark-Tazimina River spawning grounds, 1920-1986 (continued).

Location	Year	Date of Survey	Index of Spawner Abundance: Spawning	Dead	Schooled	Total
Kijik River	1957	9/20	150	0	150	150
	1960	9/12	41,000	0	0	41,000
	1962	9/27	3,200	6	0	3,206
	1964	9/16	0	0	0	0
	1966	9/17	8,215	0	2,500	8,215
	1967	9/14	7,500	0	900	7,500
	1968	9/24	1,765	1	190	1,766
	1969	9/5	0	0	0	0
	1970	9/26	3,925	0	2,900	3,925
	1971	9/22	110	0	50	110
	1972	9/27	1,500	0	325	1,500
	1973	9/28	145	0	45	145
	1974	7/28	2,625	0	2,625	2,625
	1975	9/13	3,160	0	1,425	3,160
	1976	9/30	1,750	0	1,275	3,025
	1978	9/16	8,050	125	6,575	8,175
	1979	10/25	15,500	26,575	1,000	42,075
	1980	8/26	0	0	0	0
	1981	9/6	1,425	0	590	1,425
	1983	9/26	1,650	0	950	1,650
	1985	10/23	551	0	1	551
		Average	4,868	1,272	1,024	6,200
		Maximum	41,000	26,575	6,575	42,075
		Minimum	0	0	0	0

Table 2. Aerial survey counts of Lake Clark-Tazimina River spawning grounds, 1920-1986 (continued).

Location	Year	Date of Survey	Index of Spawner Abundance			
			Spawning	Dead	Schooled	Total
Little Kijik River	1944					500
	1945	9/8				1,000
	1952					500
	1953	9/4	3,000	0		3,000
	1954	9/7	200	0		200
	1955	9/13	500	0		500
	1956	9/28	12,000			12,000
	1957	9/20	6,500	0	3,250	6,500
	1959	9/20	300	0	0	300
	1961	8/30	5,000	0		5,000
	1962	9/27	3,900	100	975	4,000
	1963	9/14	260	0	0	260
	1964	9/16	125	0	0	125
	1965	9/20	8,630	0	3,080	11,710
	1966	9/17	4,770	50	3,170	7,990
	1967	9/14	11,600	0	5,600	17,200
	1968	9/24	1,105	20	250	1,375
	1969	9/5	2,450	0	700	3,150
	1970	8/26	6,000	1,850	200	8,050
	1971	9/22	3,075	0	425	3,500
	1972	9/27	1,625	0	50	1,675
	1973	9/28	240	30	15	285
	1974	7/28	1,775	0	1,775	3,550
	1975	9/13	13,000	130	900	14,030
	1976	9/30	2,100	10	0	2,110
	1978	9/16	30,050	1,800	15,050	46,900
	1979	10/25	15,300	30,500	0	45,800

Table 2. Aerial survey counts of Lake Clark-Tazimina River spawning grounds, 1920-1986 (continued).

Location	Year	Date of Survey	Index of Spawner Abundance: Spawning	Dead	Schooled	Total
Little Kijik River	1980	8/26	3,675	0	1,050	4,725
	1981	9/6	1,705	10	1,155	2,870
	1983	9/26	6,525	200	125	6,850
	1985	10/23	3,650	0	0	3,650
		Average	5,324	1,285	1,642	7,074
		Maximum	30,050	30,500	15,050	46,900
		Minimum	125	0	0	125

Table 2. Aerial survey counts of Lake Clark-Tazimina River spawning grounds, 1920-1986 (continued).

Location	Year	Date of Survey	Index of Spawner Abundance			
			Spawning	Dead	Schooled	Total
Kijik Lake and tribs.	1944					100
	1945	9/8	0	50	0	50
	1957	9/20	850	0	0	850
	1959	10/12	110	0	0	110
	1960	10/1				5,000
	1962	9/27	1,177	5	255	1,437
	1964	9/16	80	0	0	80
	1966	10/7	3,200	300	0	3,500
	1967	9/14	1,300	20	0	1,320
	1968	9/24	450	0	200	650
	1969	9/5	0	0	0	0
	1970	9/26	900	200	0	1,100
	1971	9/22	1,100	0	800	1,900
	1972	9/27	575	0	500	1,075
	1973	9/28	75	0	50	125
	1974	7/23	8,800	0	8,800	17,600
	1975	9/13	83,000	1,420	57,125	141,545
	1976	9/30	2,950	95	5,950	8,995
	1978	9/16	74,650	26,550	31,200	132,400
	1979	10/25	62,100	184,100	13,500	259,700
	1980	8/26	4,700	0	4,700	9,400
	1981	9/6	710	15	125	850
	1983	9/26	12,250	1,057	2,205	15,512
	1985	10/23	1,925	2,850	275	5,050
		Average	11,859	9,848	5,713	25,348
		Maximum	83,000	184,100	57,125	259,700
		Minimum	0	0	0	0

Table 2. Aerial survey counts of Lake Clark-Tazimina River spawning grounds, 1920-1986 (continued).

Location	Year	Date of Survey	Index of Spawner Abundance: Spawning	Dead	Schooled	Total
Priest Rock Creek and ponds	1966	9/17	1,000	0	1,000	2,000
	1967	9/14	1,000	0	1,000	2,000
	1968	9/24	255	0	250	505
	1969	9/5	0	0	0	0
	1970	9/26	6,950	300	5,000	12,250
	1971	9/22	1,050	0	900	1,950
	1972	9/27	425	0	425	850
	1973	9/28	200	0	200	400
	1975	9/13	17,775	40	16,125	33,940
	1976	9/30	500	0	2,765	3,265
	1978	9/16	3,650	0	3,575	7,225
	1979	10/25	300	900	300	1,500
	1980	8/26	875	0	875	1,750
	1983	9/26	5,625	0	5,625	11,250
		Average	2,829	89	2,717	5,635
		Maximum	17,775	900	16,125	33,940
		Minimum	0	0	0	0

Table 2. Aerial survey counts of Lake Clark-Tazimina River spawning grounds, 1920-1986 (continued).

Location	Year	Date of Survey	Index of Spawner Abundance: Spawning	Dead	Schooled	Total
Tlikakila River	1947	10/16	0	1	0	1
	1959	10/12	0	0	0	0
	1960	9/12	0	0	0	0
	1962	11/24	0	0	0	0
	1968	9/24	2,880	3	350	3,233
	1969	9/5	0	0	0	0
	1970	9/26	3,250	0	250	3,500
	1971	9/22	985	0	360	1,345
	1972	9/27	350	0	0	350
	1973	9/28	970	0	0	970
	1975	9/13	2,760	0	1,260	4,020
	1976	9/30	3,516	0	15	3,531
	1978	9/16	1,160	0	25	1,185
	1979	10/25	8,650	4,590	0	13,240
	1983	9/26	822	0	0	822
	1985	10/23	574	85	0	659
		Average	1,620	292	141	2,054
		Maximum	8,650	4,590	1,260	13,240
		Minimum	0	0	0	0

Table 2. Aerial survey counts of Lake Clark-Tazimina River spawning grounds, 1920-1986 (continued).

Location	Year	Date of Survey	Index of Spawner Abundance: Spawning	Dead	Schooled	Total
Chokotonk River	1947	10/17	175	0	0	175
	1968	9/24	1,730	0	30	1,730
	1969	9/5	0	0	0	0
	1970	9/26	680	0	0	680
	1971	9/22	1,360	0	445	1,805
	1972	9/27	297	0	0	297
	1973	9/28	0	0	0	0
	1975	9/13	35	0	0	35
	1976	9/30	625	0	25	650
	1978	9/16	1,875	0	0	1,875
	1979	10/25	0	60	0	60
	1983	9/26	4	0	0	4
	1985	10/23	50	1	0	51
		Average	525	5	38	566
		Maximum	1,875	60	445	1,875
		Minimum	0	0	0	0

Table 2. Aerial survey counts of Lake Clark-Tazimina River spawning grounds, 1920-1986 (continued).

Location	Year	Date of Survey	Index of Spawner Abundance: Spawning	Dead	Schooled	Total
Currant Creek	1931	9/7	0	0	0	0
	1944					500
	1945	9/8	0	1,200	0	1,200
	1955	9/13	0	0	0	0
	1960	10/1	0	0	0	0
	1963	9/14	0	0	0	0
	1964	9/16	0	0	0	0
	1966	10/7	0	0	0	0
	1968	9/24	10	0	0	10
	1969	9/5	0	0	0	0
	1970	9/26	7	0	0	7
	1971	9/22	15	0	0	15
	1972	9/27	1	0	0	1
	1973	9/28	0	0	0	0
	1975	9/13	0	0	0	0
	1976	9/30	1	0	0	1
	1978	9/16	0	0	0	0
		Average	2	75	0	102
		Maximum	15	1,200	0	1,200
		Minimum	0	0	0	0

Table 2. Aerial survey counts of Lake Clark-Tazimina River spawning grounds, 1920-1986 (continued).

Location	Year	Date of Survey	Index of Spawner Abundance: Spawning	Dead	Schooled	Total
Tanalian River	1945	9/8				250
	1955	9/13	0	0	0	0
	1960	10/1	0	0	0	0
	1961	8/30	0	0	0	0
	1963	9/14	0	0	0	0
	1964	9/16	0	0	0	0
	1965	9/26	255	70	200	525
	1966	9/17	300	4	300	604
	1967	9/14	0	0	1,600	1600
	1968	9/24	8	0	0	8
	1969	9/5	150	0	150	300
	1970	9/25	325	0	300	625
	1971	9/22	0	0	175	175
	1972	9/27	10	0	0	10
	1973	9/28	0	0	0	0
	1975	9/13	250	0	250	500
	1976	9/30	0	0	75	75
	1978	9/16	0	0	0	0
	1981	9/6	275	0	275	550
		Average	87	4	185	185
		Maximum	325	70	1,600	1,600
		Minimum	0	0	0	0

Table 2. Aerial survey counts of Lake Clark-Tazimina River spawning grounds, 1920-1986 (continued).

Location	Year	Date of Survey	Index of Spawner Abundance: Spawning	Dead	Schooled	Total
22 Creek	1963	9/14	0	0	0	0
	1964	9/16	0	0	0	0
	1965	9/6	0	0	0	0
	1966	10/7	0	10	0	10
	1967	9/14	0	0	0	0
	1968	9/24	0	0	0	0
	1969	9/5	0	0	0	0
	1972	9/27	0	0	0	0
	1973	9/28	0	0	0	0
	1975	9/13	0	10	0	10
	1976	9/30	0	0	0	0
	1981	9/6	0	0	0	0
		Average	0	2	0	0
		Maximum	0	10	0	0
		Minimum	0	0	0	0

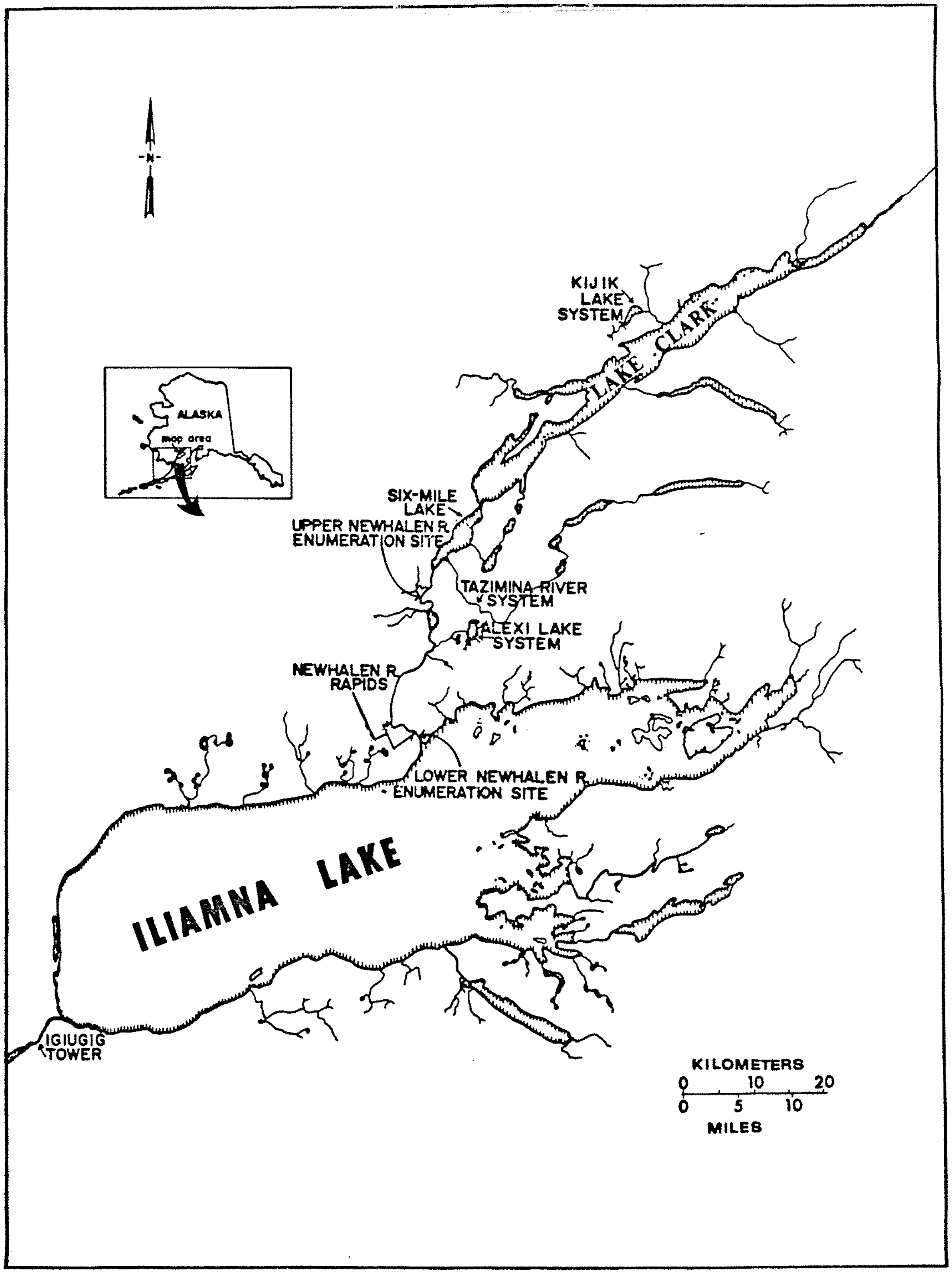
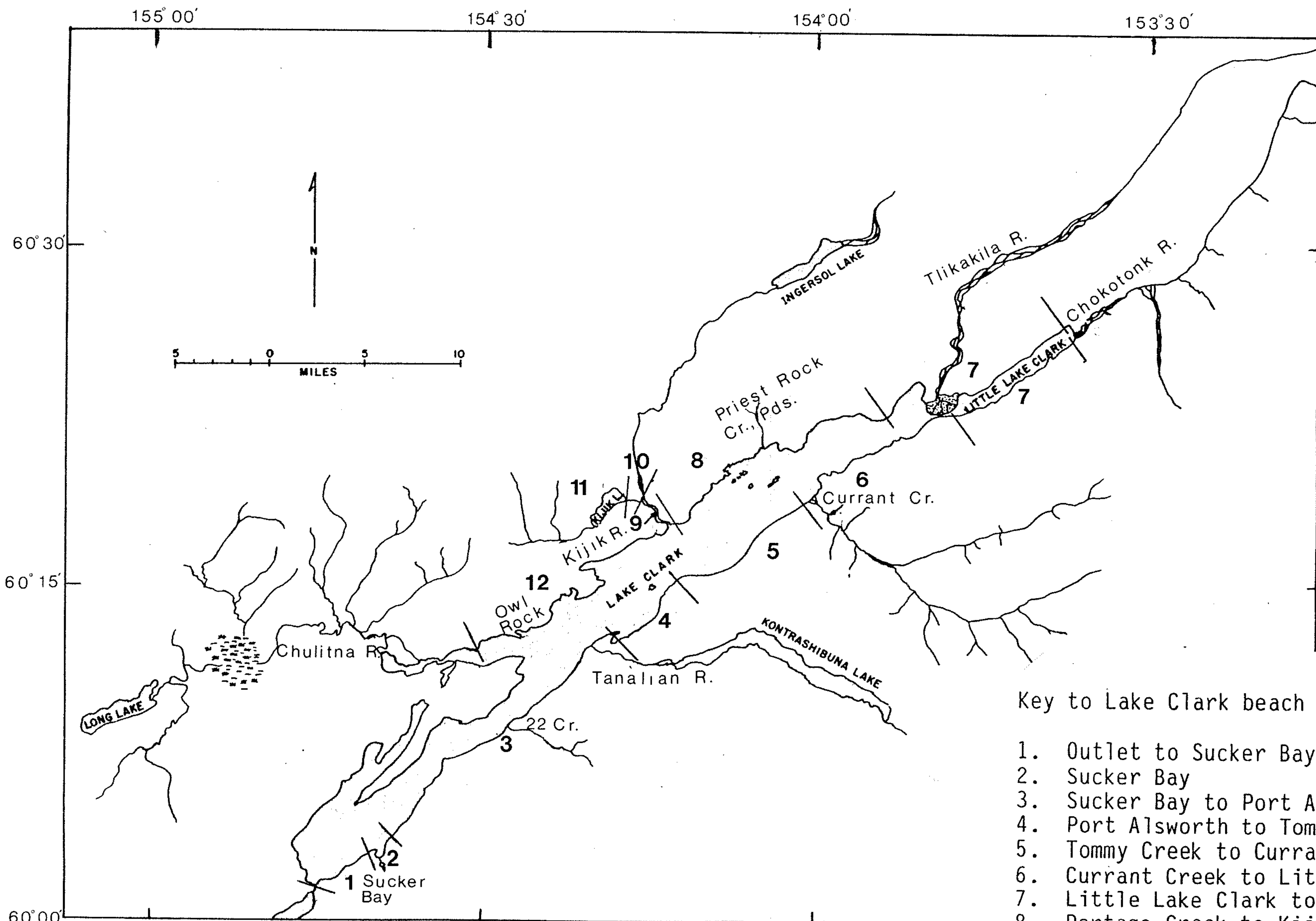


Fig. 1. Kvichak River system showing the location of the ADF&G Igiugig enumeration station, the FRI Newhalen River counting stations at RM 1 and RM 22, and the major sockeye salmon spawning units of the Newhalen River-Lake Clark system.



Key to Lake Clark beach sections:

1. Outlet to Sucker Bay
2. Sucker Bay
3. Sucker Bay to Port Alsworth
4. Port Alsworth to Tommy Creek
5. Tommy Creek to Currant Creek
6. Currant Creek to Little Lake Clark
7. Little Lake Clark to Portage Creek
8. Portage Creek to Kijik
9. Kijik River
10. Little Kijik River
11. Kijik Lake and tributaries
12. Kijik to Chulitna Bay

Figure 2. Lake Clark sockeye salmon aerial survey sections.