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MIGRATION OF SOCKEYE SALMON IN THE KODIAK ARCHIPELAGO, 1981

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ABSTRACT

Maturing sockeye salmon (*Oncorhynchus nerka*) were tagged in the Kodiak archipelago during June 1981 to determine the migration path and degree of mixing of Olga Bay stocks, and in particular of Fraser Lake stock, with other major stocks in the sockeye salmon fishery.

Tag returns indicated Olga Bay stocks composed 23% of catch along the northwest coast, 57% along the southwest coast, 17% in the Red River area, and 96% at Cape Alitak and Moser Peninsula. The principal migration route for Karluk, Red River, Fraser Lake, and Upper Station stocks was south along the west coast of Kodiak Island. Relatively little counter-migration occurred. Relatively little migration occurred along the east coast.

A fishing mortality of 29% was estimated on Fraser Lake sockeye salmon.

Sockeye salmon from Cook Inlet and the Alaska Peninsula were mixed with Kodiak area stocks primarily at the north end and secondarily at the south end of Kodiak Island. The occurrence of outside stocks in the Marmot-Raspberry Island area in experiments at the north end ranged from 27 to 73%.

KEY WORDS: sockeye salmon, *Oncorhynchus nerka*, stock identification, migration, Kodiak Island, Fraser Lake.

INTRODUCTION AND BACKGROUND

Management of the Kodiak area sockeye salmon (*Oncorhynchus nerka*) stocks has always been difficult because of their extensive intermingling in the fisheries. The problem has been further complicated this past decade by rapid proliferation of the Fraser Lake sockeye stock. This stock was introduced artificially into Fraser Lake during 1951-1971 by transplanting eggs, fry, and adults and by construction of a fish ladder in the outlet stream (Russell 1972; Blackett 1979). Sockeye salmon escapements to Fraser Lake were fewer than 30,000 before 1971, increased to 55,000-82,000 during 1971-75, to 120,000-140,000 during 1976-79, and to 400,000 during 1980-82. The stock was largely protected from exploitation by restrictions on the set gillnet fishery¹ in the Moser-Olga section and on purse seine fishing in the Alitak Bay section during the 1960's and 1970's. However, an unknown number of Fraser sockeye salmon were intercepted annually by the gillnet and purse seine fishery along the west coast of Kodiak Island (Figures 1 and 2). Fishing restrictions were eased on the Alitak-Moser-Olga Bay fisheries in the terminal area after 1977 to allow harvest as the run increased. The recent (1977-1981) annual sockeye salmon runs to the Kodiak area have averaged 2,236,000 while annual harvests during 1978-1982 have averaged 970,000 (Blackett 1983). The sockeye harvest since 1947 has averaged 560,000.

The history, management strategy, and present status of the Kodiak area salmon fisheries are elaborated in the 1982 Annual Management Report of the Kodiak office of the Alaska Department of Fish and Game (Manthey et al. 1982).

The report describes a management strategy, instituted in 1971, in which the fishery is directed at healthy stocks and curtailed on depressed stocks by allowing generally single stock fisheries in terminal areas (Figure 3). Limited deference is afforded historic mixed-stock fisheries based on strengths of the stocks intercepted. Mixed-stock fisheries are allowed mainly when all component runs are healthy. At present, the depressed Karluk stocks are protected by a sizable area closure north and south of the mouth while the harvest of healthy runs to minor streams such as Saltery, Afognak, and Little River is encouraged by reducing the size of closed water areas off the stream mouths. The harvest of current surpluses to the major streams (Red River and Fraser Lake) is accomplished by increasing fishing time in the terminal areas. The fishing impact of the highly mobile seine fleet is spread by coinciding the opening of area fishing periods.

Manthey also reports the estimated production capabilities of Kodiak area sockeye salmon streams (Figure 4).

The increased importance of the Fraser Lake stock and changed contributions of other Kodiak area sockeye stocks prompted the need for more current information on the migration routes, timing, and extent of mixing of the stocks. The

¹ A set gillnet is fished from shore at a fixed location and is the only gillnet type used in the Kodiak Management Area.

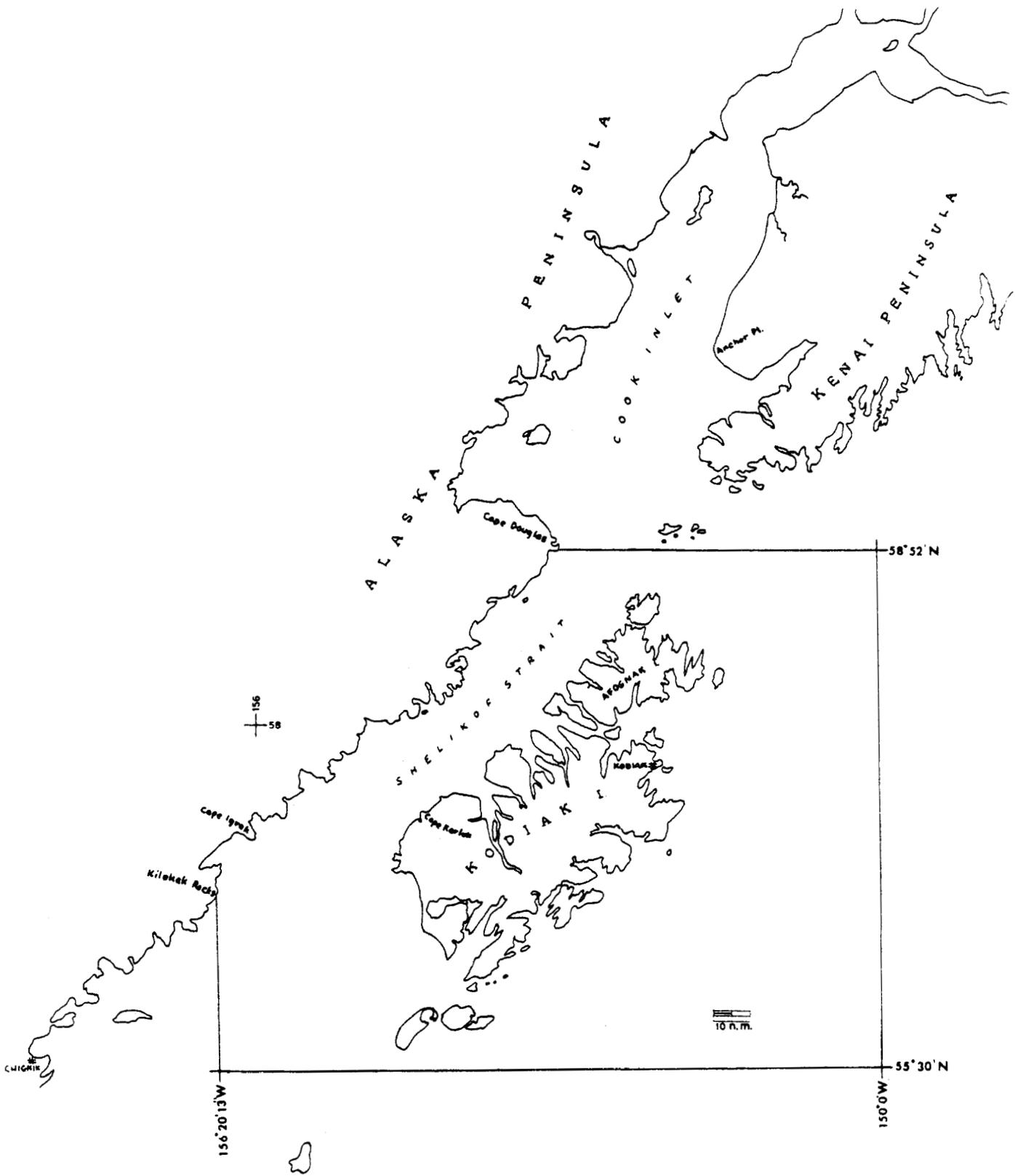


Figure 1. The Kodiak salmon management area (outlined).

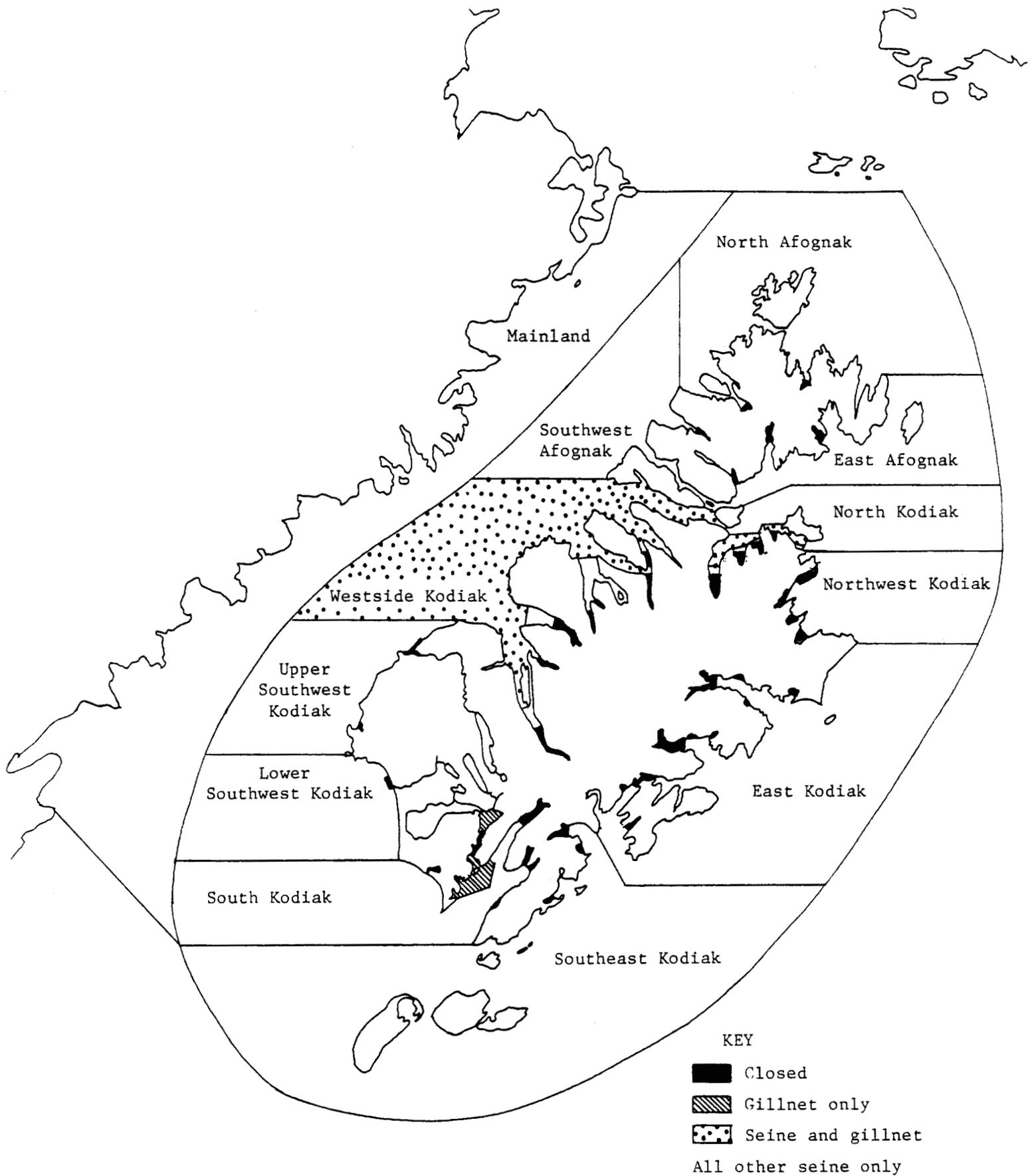


Figure 2. Definition of coastal unit boundaries referenced in this report and areas of commercial fishing restrictions.

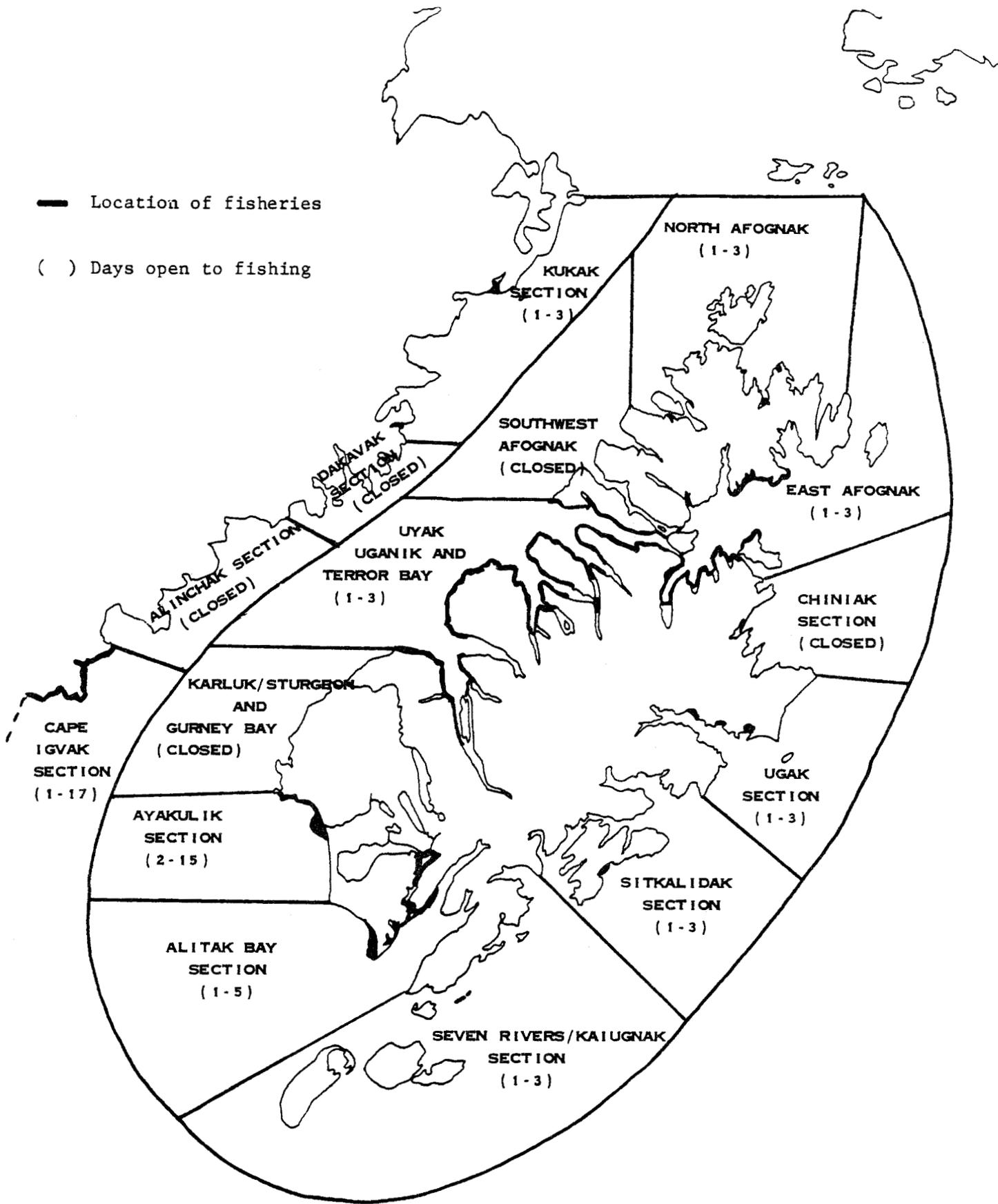


Figure 3. Number of fishing days and location of June sockeye salmon fisheries since 1971.

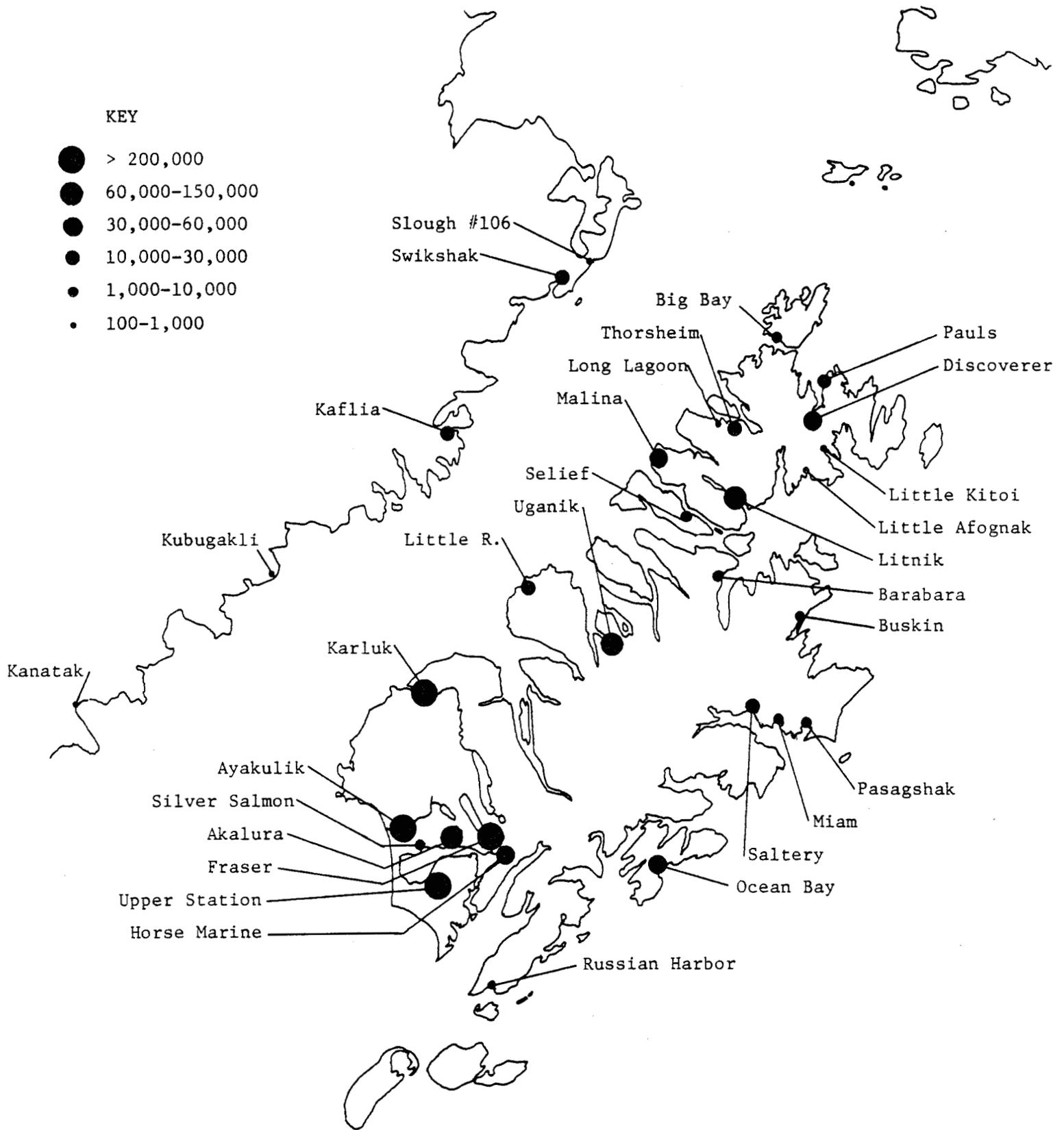


Figure 4. Kodiak area sockeye salmon streams and estimated production capabilities.

extent of stock separation by geographic location or timing at present can be determined by two methods: By mark-recovery experiments and by analysis of scale patterns of sockeye salmon from the fishery.

Previous Sockeye Salmon Tagging in the Kodiak Management Area¹

Previous sockeye salmon tagging studies conducted in the Kodiak archipelago include tagging during two days in August 1928 to determine the origins of sockeye in outer Uganik Bay (Rich and Morton 1929); tagging during one day each in June and July 1938 to determine the travel time of sockeye from upper Alitak Bay to the Cannery Station and Upper Station weirs (Bower 1941); a broad study of sockeye salmon migrations off the south and northwest coastlines in 1948 and an intensive study of the migrations and stock sizes off the northwest coast in 1949 (Bevan 1959); a long series of generally small but geographically comprehensive tagging experiments by the Alaska Department of Fish and Game (ADF&G) during 12 years of the 18-year period from 1961 to 1978 (Roys and Simon 1961; Blackett, Davis, and Russell 1967; Lechner and Eaton 1969; Gwartney 1972; Malloy 1973; Malloy and Manthey 1976; Malloy and Manthey 1977; Nicholson 1978).

The major findings from previous tagging studies are as follows.

Rich and Morton (1929):

Rich tagged 700 sockeye salmon on 19 and 20 August from a trap at Broken Point, Uganik Bay, specifically to determine the interception rate of Karluk stocks by the Uganik Bay fishery. The tag returns indicated the catch from outer Uganik Bay was composed principally of Karluk stocks. Only three of the 317 total tag returns were from Alitak Bay and two were from Cook Inlet. The travel rate for sockeye salmon migrating from Uganik to Karluk River was 10-15 miles per day.

Bower (1941):

Bower reported the work of Joseph Barnaby and Allen DeLacy who tagged 700 sockeye salmon at Bun Point Trap on 28 June and 458 at Miller Island Trap on 29 July 1938. About 5% of the June release was counted at the weirs whereas about 50% of the July release was counted. The difference probably resulted from a fishery closure from 1 to 12 August which allowed greater escapement of the 29 July release. The tagged sockeye from the June release averaged seven days to reach the Cannery Station weir and nine days to reach the Upper Station weir, and from the July release, 17 and 11 days, respectively. No explanation was given for the slower migration rates of the July release.

¹ Hereinafter abbreviated the Kodiak area.

Bevan (1959):

Bevan tagged 3,925 sockeye salmon in 1948 mainly from 20 traps on the northwest coast of the Kodiak archipelago and from Alitak Bay. In 1949 he tagged 7,277 sockeye from four traps along the northwest coast of the Kodiak archipelago. His principal observations relative to migration were "that the northwest coast of Kodiak Island (Cape Karluk to Black Cape) was a distinct unit and that only inconsequential exchanges of fish took place between it and other areas within or outside the Kodiak area." He verified this observation by the data in Table 1.

Bevan further concluded that the populations of sockeye salmon on Kodiak Island could be considered as a separate unit from Cook Inlet, Alaska Peninsula, and Chignik populations. He based this conclusion on the small numbers of tags recovered in those areas as shown in Table 2.

In 1948-49 tagging was comprehensive along the northwest coast and at Cape Alitak, but did not include the southwest coast which has a major sockeye salmon fishery, nor the northeast coast which has a moderate sockeye salmon fishery.

ADF&G (1961-1978):

The principal sockeye tagging and recovery-distribution data from the Kodiak area including those of ADF&G were summarized by Nicholson (1978) in a series of tables and migration maps. A further summary of tagging years, places, and numbers by ADF&G from 1961 to 1978 based on this report is shown in Table 3.

The ADF&G results are generally similar to those reported by Bevan (1959) and Rich and Morton (1929) from tagging at the same locations, i.e., sockeye salmon tagged along the northwest coast originate mainly from that area and predominately from the Karluk River. However, tagging since 1970 shows a greater frequency of Red River and Alitak District stocks mixed in the catch of the northwest coast.

Tagging along the southwest coast shows these stocks are largely of Red River and Alitak Bay origin with a small occurrence of Chignik stocks, a feature also observed by Bevan. Very few tags were recovered north of Cape Karluk.

The ADF&G tagging also encompassed northeast Kodiak Island where no tagging had been done previously. The recoveries, though small in number, showed a highly mixed composition of stocks from all parts of the Kodiak archipelago, Cook Inlet, and Chignik.

Objectives of the 1981 Tagging

This tagging study was undertaken to provide current management information on the timing, routes, and extent of mixing and separation of migration sockeye salmon stocks in the Kodiak area during June, and particularly of the Fraser Lake stock. Scale samples were taken from all tagged sockeye salmon for analysis by the Stock Biology Laboratory of ADF&G.

Table 1. Recoveries made on Kodiak Island from districts other than the northwest coast, 1949.

District	Number of Recoveries	Percent of Tagged	Percent of Recoveries
Red River	43	0.59	1.30
Alitak	23	0.32	0.69
E. Coast	6	0.08	0.18
Marmot Bay	14	0.14	0.42
Total	86	1.18	2.60

Table 2. Recoveries made outside the Kodiak Island area, 1948-1949.

District	Number of Recoveries	Percent of Tagged	Percent of Recoveries
<u>1948</u>			
Cook Inlet	28	0.71	1.89
Chignik	1	0.03	0.07
Alaska Peninsula	2	0.05	0.13
Total 1948	31	0.79	2.09
<u>1949</u>			
Cook Inlet	13	0.18	0.39
Chignik	19	0.26	0.57
Alaska Peninsula	3	0.04	0.09
Bristol Bay	2	0.03	0.06
Total 1949	37	0.51	1.12
Total 1948-1949	68	0.61	1.42

Table 3. Summary of sockeye salmon tagging in the Kodiak archipelago by ADF&G, 1961-1978 (summarized from Nicholson 1978).

Year	Location	Number tagged	Year	Location	Number tagged
1961	Duck B.	25	1970	Miners Pt.	74
61	C. Izhut	26	71	Outlet Cape	20
61	N. Cape	116	71	Broken Pt.	35*
61	Kiliuda B.	28	71	Miners Pt.	194*
61	Sitkalidak St.	11	71	Uyak B.	30
62	C. Izhut	12	71	Halibut B.	304*
62	C. Uganik	7	72	Halibut B.	287
62	N. Cape	14	73	Middle Cape	173
67	C. Alitak	438	76	Old Red River	195
67	Bruin Reef	43	76	Fox I.	53
67	Fox I.	371	76	C. Hepburn	10
67	Splitrock	25	76	C. Alitak	1,284
67	C. Hepburn	20	76	Snug Cove	10
68	Fox I.	109	77	Malina Pt.	37
68	Stockholm Pt.	76	77	Noisy I.	37
68	Splitrock	85	77	E. Uganik I.	17
68	C. Alitak	768	77	Miners Pt.	553
68	Kempff B.	74	77	Spruce I. Narrows	43
68	Bruin Reef	23	78	Karluk,	
69	Miners Pt.	202		Harvester I.,	
70	Kupreanof St.	72		Cape Uyak	<u>237</u>
70	C. Uganik	36			
					6,174

* Approximated number.

MATERIALS AND METHODS

Sockeye salmon were obtained for tagging by chartering purse seine vessels engaged at the time in sockeye fishing at traditional seining locations. Vessels were chartered on the fishing grounds for 1- or 2-day periods usually during weekly closures or during periods of slack fishing.

Netted sockeye salmon were held in the bunt end of the seine and dipnetted aboard individually for tagging, measuring, and scale sampling. The scales were analyzed by the ADF&G Stock Biology Laboratory for identification of patterns specific to individual stocks. Sockeye were tagged with one-inch diameter plastic Peterson disc tags in 31 color combinations denoting specific places and dates of tagging.

The tag discs were either of solid color or of differently colored halves in both the numbered and the unnumbered (blank) discs. The numbered discs were always positioned on the left side of tagged fish, just forward of the dorsal fin. In a few experiments, half-inch diameter blank discs were superimposed outside the one-inch blank discs of contrasting solid color to increase the number of color combinations. The colors consisted of red, yellow, blue, light blue, pink, white, green, plus half-and-half combinations of some of these colors. The tag pins were of nickel alloy 3 inches long by 0.04 inches diameter. Excess length of each pin was cut away after the tag was affixed, leaving about one-half inch for forming the loop knot which secured the tag.

The one-inch disc size was chosen in preference to the 5/8 to 3/4 inch sizes customarily used for salmon tagging because it was more visible. Increased visibility facilitated identification of color combinations by weir watchmen as the sockeye salmon passed counting weirs. Lists of the color combinations were supplied to all weirs. Since weirs are maintained in all five of the major sockeye salmon streams in the Kodiak area, it was possible to identify the tagging locations of escaped sockeye salmon without recapturing them. Sight recovery at the weirs also precluded the necessity of recovering tags from spawning grounds.

The tagging program was advertised in the Kodiak newspapers and on radio news broadcasts, and was probably known to most local Kodiak area fishermen engaged in the sockeye salmon fishery. Rewards of \$2 were paid for tags returned. Most tags from the fishery were returned by individual fishermen to the ADF&G office in Kodiak, but some were collected by ADF&G personnel who contacted seine boats moored at canneries during closed periods. The tagging program probably received greater than usual attention from commercial fishermen at Kodiak Island because of the controversy between seine and gillnet fishermen over the extent of interception of Fraser Lake stocks by the seine fleet.

Tag recovery data were placed on a computer data file for compilation and analysis. Recoveries were compiled by recovery gear and location. The days lapsed between tagging and recovery (days at liberty) were calculated for all recoveries and averaged for each type of recovery gear and for all tagging dates.

RESULTS AND DISCUSSION

A total of 3,109 sockeye salmon was tagged and released during June 1981 at 20 locations along the north, west, and south coastlines of Kodiak Island and from south Afognak Island (Table 4, Figure 5). A recovery rate of 43.9% was realized from all sources which included commercial seine and gillnet fisheries, subsistence fishery, and counting weirs.

The number of recoveries from the seine fishery was relatively small, totaling only 177, while the recoveries from gillnets was 597 and from weirs was 572. Expressed as percentages of total recoveries, these were 13.1, 44.4, and 42.4, respectively. The recovery rate from weirs was high owing to the large tag size and to unusually dry weather which caused the streams to be low and clear during June and July. Weir personnel interviewed post-season believed they had observed virtually all the tagged sockeye passing the weirs and had recorded the tag color combinations accurately. However, some error may have occurred because the white tag discs turned grayish on the outside (side away from the fish) several days after tagging and the red discs darkened. It is likely that recording errors resulted from the large variety of color combinations used and particularly since blue and light blue, red, and pink were used. No attempt was made to test the completeness or accuracy of tag identification at the weirs.

The low recovery rate from the seine fishery was due partly to deliberate non-reporting of recovered tags by Red River seiners. Withholding of tags was detected during attempts by ADF&G biologists to solicit tags from the Red River seine fleet at Lazy Bay. Response indicated that some fishermen possessed tags but were unwilling to return them. The rationale for withholding tags is speculative and probably was done to influence the tagging results; however, the reduced tag return rate biased the results to the disadvantage of the Red River seine fishery in that it tended to show a greater interception of Fraser River and Upper Station stocks in the Red River fishery. Conversely, the return of tags by the Alitak-Moser-Olga Bay gillnet fishermen was probably greater than normal because of their wish to emphasize the terminal nature of their fishery on stocks which they believed to be largely of Olga Bay origin.

Tagging in the Red River and Alitak-Moser-Olga Bay areas was conducted in June just before open fishing periods, which should have resulted in high interception rates of tagged sockeye salmon in the fisheries and high tag return rates. This was true in the Alitak-Moser-Olga Bay area where the gillnet fishery caught 26% of the run but accounted for 42.8% of the tags released in the vicinity. A high rate of return should also have been realized from the Red River fishery which captured 63% of the run but which accounted for only 10% of tags released in the vicinity. The statistics on catch, escapement, tagged:untagged ratios, and tag return rates are shown in Table 5.

The fact that no tags were returned from the canneries indicates that all tags were probably discovered and removed from the catch by fishermen. Low tag return rate from seine fisheries has been reported from other tagging experiments. In Southeastern Alaska during 1938-42 and 1945, seiners took

Table 4. Release and recovery information from sockeye salmon tagging at Kodiak Island during June 1981.

Geographical order	Location	Date	Number released	Number recovered	Number recoveries from known location	Percent recovery by			Average number days at liberty for recoveries by		
						Seine	Gillnet	Stream	Seine	Gillnet	Stream
1	NW Raspberry I.	6/20	120	31	30	6.7	26.7	66.7	9.0	13.1	9.1
2	Raspberry Cape	6/24	147	26	26	23.1	73.1	7.7	10.6	16.0	11.5
3	Noisy Island	6/6	9	8	8	0	0	100	--	--	15.9
4	Miners Point	6/6	92	32	31	29.0	25.8	45.2	8.9	7.7	16.6
		6/7	214	97	97	11.3	13.4	75.3	7.6	9.9	9.5
5	Bear Island	6/26	6	6	6	16.7	16.7	66.7	3.0	4.0	11.7
6	Rocky Point	6/26	15	4	4	0	0	100	--	--	7.0
7	Sturgeon Head	6/26	104	39	39	33.3	59.0	7.7	3.2	4.7	3.3
8	Middle Cape	6/27	107	46	46	17.4	60.9	21.7	4.0	5.1	9.0
9	Cape Ikolik	6/8	100	47	46	23.9	19.6	56.5	5.6	7.0	9.3
10	Bumble Cape	6/8	79	32	32	21.9	6.2	71.9	1.3	8.0	6.9
11	W. Old Red R.	6/6	2	2	2	50.0	0	50.0	10.0	--	7.0
		6/15	47	32	32	6.2	37.5	56.3	0.0	5.3	3.6
12	N. Red R. Marker	6/7	182	113	113	16.8	0.8	82.3	2.8	23.0	3.9
13	S. Red R. Marker	6/7	295	92	92	37.0	0	63.0	2.9	--	5.5
14	S. Old Red River	6/7	87	33	33	42.4	6.1	51.5	3.2	23.0	7.9
		6/16	78	26	26	11.5	50.0	38.5	7.0	5.7	12.9
15	Gold Beach	6/6	14	9	9	11.1	0	88.9	4.0	--	11.6
16	Cape Alitak	6/13	366	245	243	0.8	59.3	39.9	6.0	2.9	9.4
		6/28	345	168	164	4.9	86.0	9.1	2.5	4.0	13.8
17	Moser Peninsula	6/14	303	209	204	0.5	78.4	21.1	--	1.5	10.3
18	North Cape	6/23	25	1	1	0	0	100	--	--	19.0
19	Rubber Boot	6/12	7	1	1	0	100	0	--	6.0	--
		6/23	71	16	16	50.0	18.8	31.2	9.3	8.5	17.0
20	Cape Izhut	6/21	294	49	49	33.3	18.8	47.9	9.4	12.1	13.7
	Total		3,109	1,364	1,350	13.4	45.4	43.8			
	Average								5.5	8.8	10.3

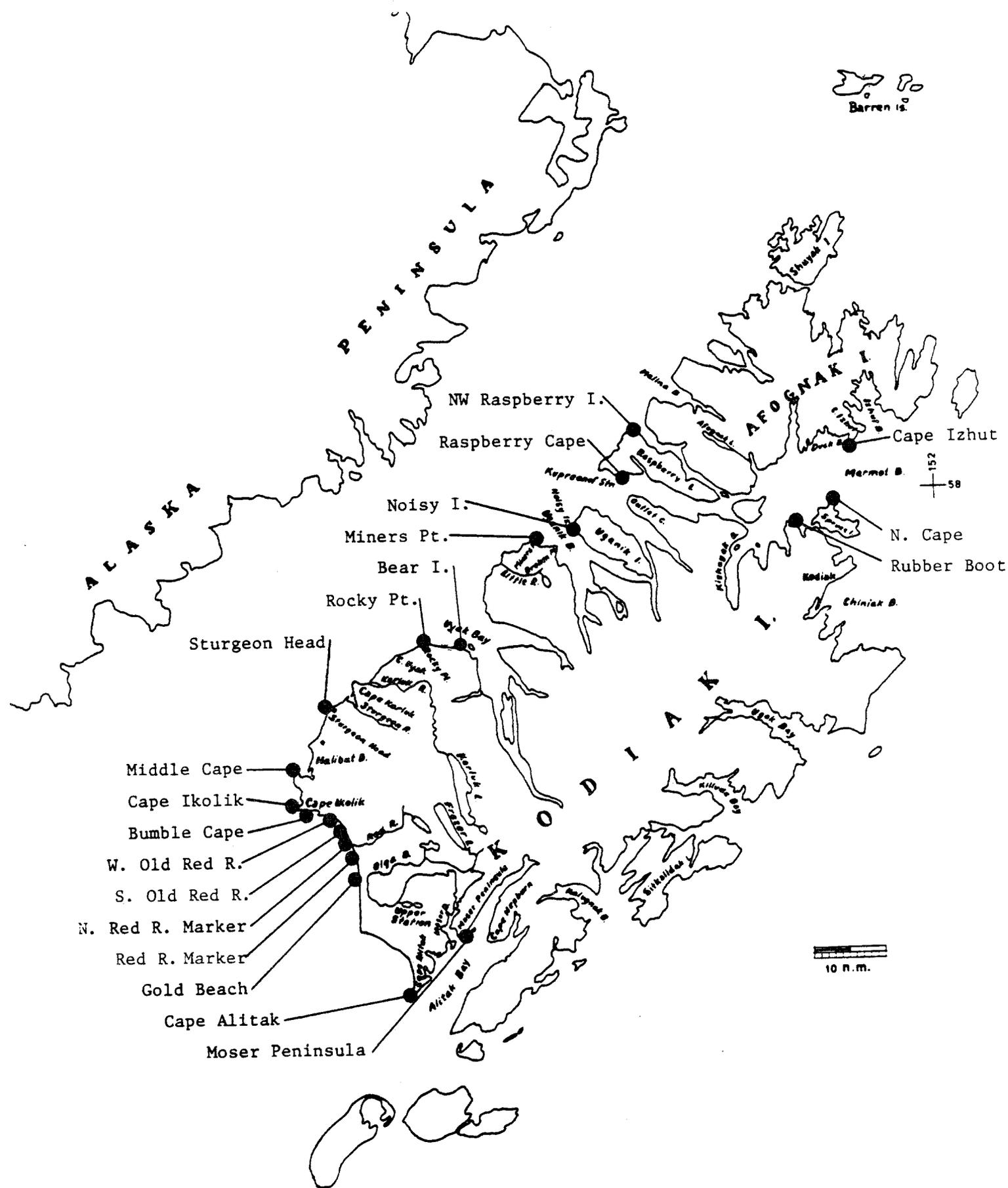


Figure 5. Locations of sockeye salmon tagging during June 1981.

Table 5. Sockeye salmon catch and escapement statistics for June 1981 for the terminal areas of Red River and Olga Bay stocks and tag returns from the terminal fisheries and associated streams.

Location tagged	Number tagged (t)	June terminal area catch (c)	June escapement (e)	June run (c+e)	Ratio catch to escapement (c÷e)	Ratio tagged to untagged (t:c+e-t)	Tags recovered				
							Red River		Alitak ⁴		
							Seine	Weir	Seine	Gillnet	Weir
Red River	705	157,195 ¹	91,328	248,523	1.72:1	1:350	71	180	1	16	21
Alitak and Moser Pen.	1,014	131,278 ²	375,819 ³	507,097	0.35:1	1:500	6	3	3	434	152

¹ Red River-Ayakulik Section 256-20 which is entirely purse seine.

² Alitak-Moser-Olga Bay gillnet catch (100,082) plus purse seine catch (21,196) from statistical areas 257-20, -30, -40.

³ Fraser Lake and Upper Station weir counts.

⁴ Alitak-Moser-Olga Bay.

30% of the catch but returned 16% of tags (Nakatani, Paulik, and Van Cleve 1975). Withholding of tags by seiners was observed in the fishery at Noyes Island, Southeastern Alaska, in 1958 where interception of Canadian sockeye salmon stocks was at issue (Noerenberg and Tyler 1960).

The high recovery rate by gillnets was due partly to the fact that fish are handled individually and that Peterson disc tags foul readily in gillnet web and hold fish which might otherwise pull free.

The use of large diameter tags undoubtedly resulted in greater than usual predation on tagged sockeye salmon because of their increased visibility. The predation rate was not measured. One tagged sockeye salmon each was observed captured by an eagle and a sea lion shortly after release at Cape Izhut and a large halibut was observed attacking sockeye salmon held in the bunt of the seine during tagging at Moser Peninsula. These predators plus abundant harbor seals undoubtedly preyed more heavily on tagged than on untagged sockeye salmon.

No corrections were made in this report for biases due to varying return rates from the fisheries, increased predation on tagged fish, or tags lost from fish during migration. Loss of Peterson disc tags from sockeye salmon was measured by Bevan (1959) as 10% based on double tagging. Others have reported varying tag losses from salmon and steelhead of 3 to 31% depending on species and maturity stage of the fish monitored (Lister and Harvey 1969; Kruse 1964). Tag loss is greatest among spawning fish and particularly among spawning males. Since our study did not involve spawning ground recovery of tags, the tag loss rate was probably minimal and likely was comparable to all previous tagging studies in the Kodiak archipelago.

Very likely the composition of stocks from areas outside the Kodiak archipelago was underestimated in this report because of tag loss and selective predation on tagged fish. The recovery rate of tags is influenced by the time at liberty. Fish destined for more distant areas such as Cook Inlet, Chignik, and the Shumagin Islands migrate the farthest, are at liberty the longest, and thereafter is subject to tag loss and selective predation for a longer period of time relative to fish destined for local streams.

Tagging at Raspberry Island and in Marmot Bay yielded the greatest numbers of recoveries from outside the Kodiak archipelago and averaged 18.5% return. All other tagging averaged 50.2% return. The return rate for locally recovered fish was unusually high because of numerous sight recoveries at weirs on the major streams. The return rate of locally recovered fish typically has ranged 40-45% in past tagging in the Kodiak archipelago.

It is worth noting the possibility that individual stocks may have been separated in small schools as far as 100 miles from their home streams. This was suggested in the experiment at Noisy Island, Uganik Bay, on 6 June in which all eight returns from nine sockeye salmon tagged were observed at the Fraser Lake weir 14 to 20 days later. The accuracy of the weir observation might be suspect had not the red-green/white color combination been distinct and easily identifiable.

A similar return resulted from tagging six sockeye salmon at Bear Island, Uyak Bay, on 26 June. Five of six returns were identified at the Fraser Lake weir and one at the Karluk weir.

In Uganik and Uyak Bays a summary of past tagging data in which thousands of sockeye salmon were tagged shows a consistent mixture of Karluk River, Red River, and Olga Bay stocks in order of abundance. Daily experiments in which hundreds were tagged have shown variations in which the same three stocks predominate but in which the order of abundance may be reversed. Individual experiments in which fewer than ten were tagged may consist entirely of one of the three principal stocks. This observation emphasizes the variability associated with small tagging experiments and the importance of tagging adequate numbers.

Sockeye Salmon Fishery in 1981

Commercial fishing on the June - early July sockeye salmon runs was permitted generally during three periods after mid-June to July (Table 6). The Red River area fishery, which began on 29 June, was open the longest (249 hours) and accounted for the largest sockeye salmon catch (151,269). The Moser-Olga Bay fishery was open for the second longest period (177 hours) and accounted for the second largest sockeye salmon catch (105,250). The catch rates in Red River and Moser-Olga Bay areas were almost identical, about 600 sockeye salmon per hour.

The approximate units of gear which fished in the Kodiak management area during June 1981 were 150-200 purse seine, 2 beach seine, and 75-100 gillnet.

The area north and south of the Karluk River, from Rocky Point to Cape Ikolik, was closed to fishing to increase the escapement of Karluk sockeye salmon.

The 1981 sockeye salmon catches during the early season are summarized in Table 7.

Sockeye Salmon Escapement in 1981

The escapement curves of runs to the major sockeye salmon streams vary considerably due to varying strengths of sub-stocks or races which make up the run to each stream and due to removal by the fishery (Figure 5). The annual escapement curves since 1975 show fairly consistent early modes during June for all of the major stocks and late but less consistent modes during August or September for Karluk and Upper Station. The shape or magnitude of these curves has of course been modified by the catch.

That the races have distinctive timing traits has been well documented in the Karluk River system and in other major sockeye salmon streams in Alaska and Canada by numerous authors as summarized by Van Cleve and Bevan (1973). The research data leave little doubt that the major sockeye salmon streams in the Kodiak area each are composed of separate races with unique timing differences which affect their time of appearance in the fishery as well as in the rivers. The Karluk River system, which is the largest and most complex in the Kodiak area, appears to have the greatest racial diversity, and Fraser Lake the least,

Table 6. Sockeye salmon fishing periods and catch in the Kodiak area during June 1981.

	June																														Fishing hours	Total catch			
	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	26	27	28	29	30			1		
North Afognak Section														17,508	5,717																	7,703	81	30,928	
East Afognak Section														5,546	5,460																	12,559	81	23,565	
Uganik Bay District														6,547	6,042																	7,957	81	20,546	
Uyak-Karluk District														3,982	3,270																	5,870	81	13,122	
Red River District															79,199	14,667																	63,329	249	157,195
Cape Alitak District														2,886	12,148																	6,162	105	21,196	
Moser-Olga Bay Section														44,529	36,271																	24,450	177	110,080	
Deadman-Portage Section																1,158																	3,990	105	6,550
Kukak Section																																		81	
Ugak Section																																		54	
Kizhuyak Section														892	740																	687	81	2,319	

Table 7. Sockeye salmon catch by statistical area by fishing period during the June early sockeye fishery of the Kodiak area, 1981.

Location	Stat.area	Catch per fishing period ¹			Total catch
		All gears ²			
		Period 1	Period 2	Period 3	
N. Afognak Sec.	251-30	134		228	362
	40		814		814
	50				
	60				
	70				
	81				
	82	17,374	4,903	7,243	29,520
	90			232	232
	252-10				
		<u>17,508</u>	<u>5,717</u>	<u>7,703</u>	<u>30,928</u>
E. Afognak Sec.	252-20			114	114
	30			283	283
	31			856	856
	32	543	1,835	1,197	3,575
	33	1,306		532	1,838
	34	<u>3,697</u>	<u>3,625</u>	<u>9,577</u>	<u>16,899</u>
		5,546	5,460	12,559	23,565
Kizhuyak Sec.	252-36			10	10
	37	79		99	178
	38	813	740	578	2,131
	39				
		<u>892</u>	<u>740</u>	<u>687</u>	<u>2,319</u>
Uganik Bay Dist.	252-35	758	622	824	2,204
	253-11	1,948	2,223	2,152	6,323
	12	1,164	923	1,081	3,168
	31	2,588	2,179	3,689	8,456
	32				
	33	<u>89</u>	<u>95</u>	<u>211</u>	<u>395</u>
		6,547	6,042	7,957	20,546

-Continued-

Table 7. Sockeye salmon catch by statistical area by fishing period during the June early sockeye fishery of the Kodiak area, 1981 (continued).

Location	Stat.area	Catch per fishing period ¹			Total catch
		All gears ²			
		Period 1	Period 2	Period 3	
Uyak Bay,	254-10	3,794	3,153	3,955	10,902
Karluk	20			1,609	1,609
Dists.	30	106	65	171	342
	40	<u>82</u>	<u>52</u>	<u>135</u>	<u>269</u>
		3,982	3,270	5,870	13,122
Red River Dist. (Ayakulik Sec.)	256-20	79,199	14,667	63,329	157,195
<u>Purse seine</u>					
Cape Alitak Sec.	257-20		9,451	5,314	14,765
Deadman- Portage Bay Sec.	257-50 60		1,108 <u>50</u>	4,524 <u>868</u>	5,632 <u>918</u>
			1,158	5,392	6,550
<u>Gillnet</u>					
Moser-Olga B. Sec.	257-20 30 40	2,886 7,831 <u>33,812</u>	2,697 2,355 <u>31,219</u>	848 23,394 <u>5,040</u>	6,431 33,580 <u>70,071</u>
		44,529	36,271	29,282	110,082

¹ Duration of the fishing periods varies by location. Refer to Table 6 for dates and hours of the fishing periods.

² The management districts and sections listed under "Location" all have purse seine and gillnet fisheries except N. Afognak section, Cape Alitak section, Deadman-Portage Bay section, and Red River District which have only a purse seine fishery, and Moser-Olga Bay section which has only a gillnet fishery. The catches by all gears are added together except Alitak Bay District where catch by gear type is significant to this report.

based on its relatively narrow June-July run timing (Figure 6). The Fraser Lake escapement curve is skewed to the left but the catch-plus-escapement curve approximates a normal shape (see Estimation of the Total Fraser Lake Sockeye Salmon Run).

The 1981 Fraser Lake sockeye salmon escapement counted at the weir totaled 377,716. The escapement occurred almost entirely during June and July, peaked sharply in mid-June, and declined gradually during July. Approximately 85% of the total Fraser escapement occurred during June. The timing of the peak weir count was one week later than the early-run peak counts of the other major sockeye salmon runs of the Kodiak area--Karluk River, Red River, Upper Station, and Afognak River--but because the Fraser run probably spent about six days ascending the Dog Salmon River to the weir¹, the actual escapement timing was nearly identical. The Karluk River, Red River, Upper Station, and Afognak River weirs are located 1/4 to 1/2 mile upstream from tidewater and near sea level, whereas the Fraser Lake weir is 7.5 miles upstream at elevation 353 feet². The Fraser Lake run was unimodal, while the other runs had secondary peaks in July or August and the Karluk run had minor peaks in mid- and late August and in mid-September. Because the June runs occur simultaneously, the Fraser Lake run cannot be separated in the fishery by time, and selective harvest is best accomplished based on information about geographical separation of the stocks.

Tag Recovery Locations and Rates

Migration maps based on the tag returns are shown in Figures 6-20. In several instances when small numbers were released, the results of tagging at two adjacent locations on a single day or at two or more locations on consecutive days were combined into one figure. This was done to simplify the presentation and to increase the sample sizes.

The figures show tagging location, most direct migration routes to recovery locations, and numbers and locations of tags recovered. The direct-route lines were drawn as visual aids and are not intended to depict actual migration routes. Actual migration routes are much less direct and often show considerable reverse and lateral movement relative to the destination (Verhoeven 1952; Bevan 1958).

Northwest Raspberry Island, 20 June (Figure 7):

The recoveries of sockeye salmon were widely dispersed along the west and southwest coastline of Kodiak Island to Alitak Bay. Also, five were from Cook Inlet

¹ A six-day time period was approximated based on data presented in a later section of this report, "Migration Rate in the Alitak-Moser-Olga Bay Area".

² In 1983 a weir was established immediately above the river mouth. This weir will be installed annually for management purposes.

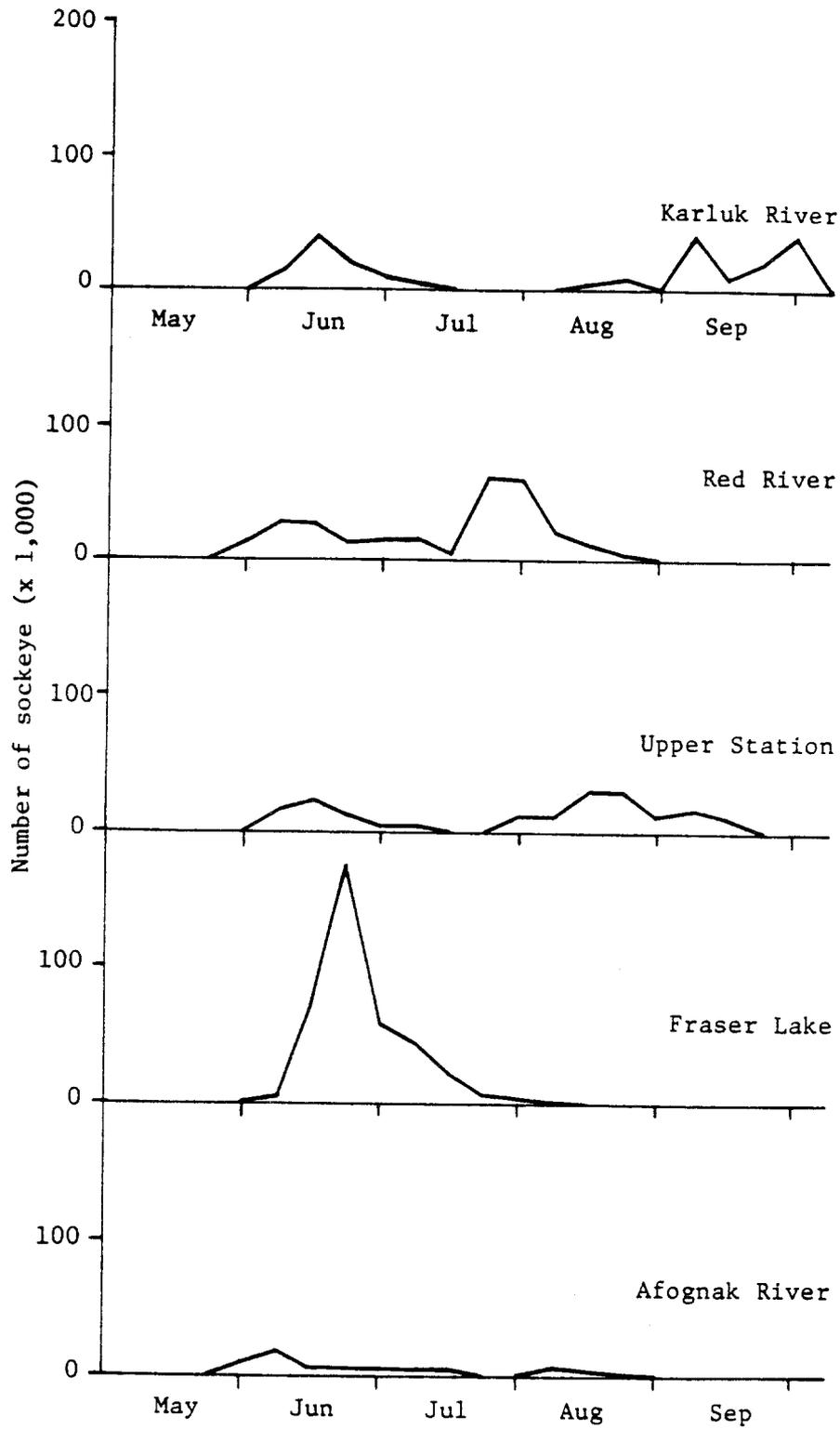


Figure 6. Weekly counts of sockeye salmon at Kodiak area weirs, 1981.

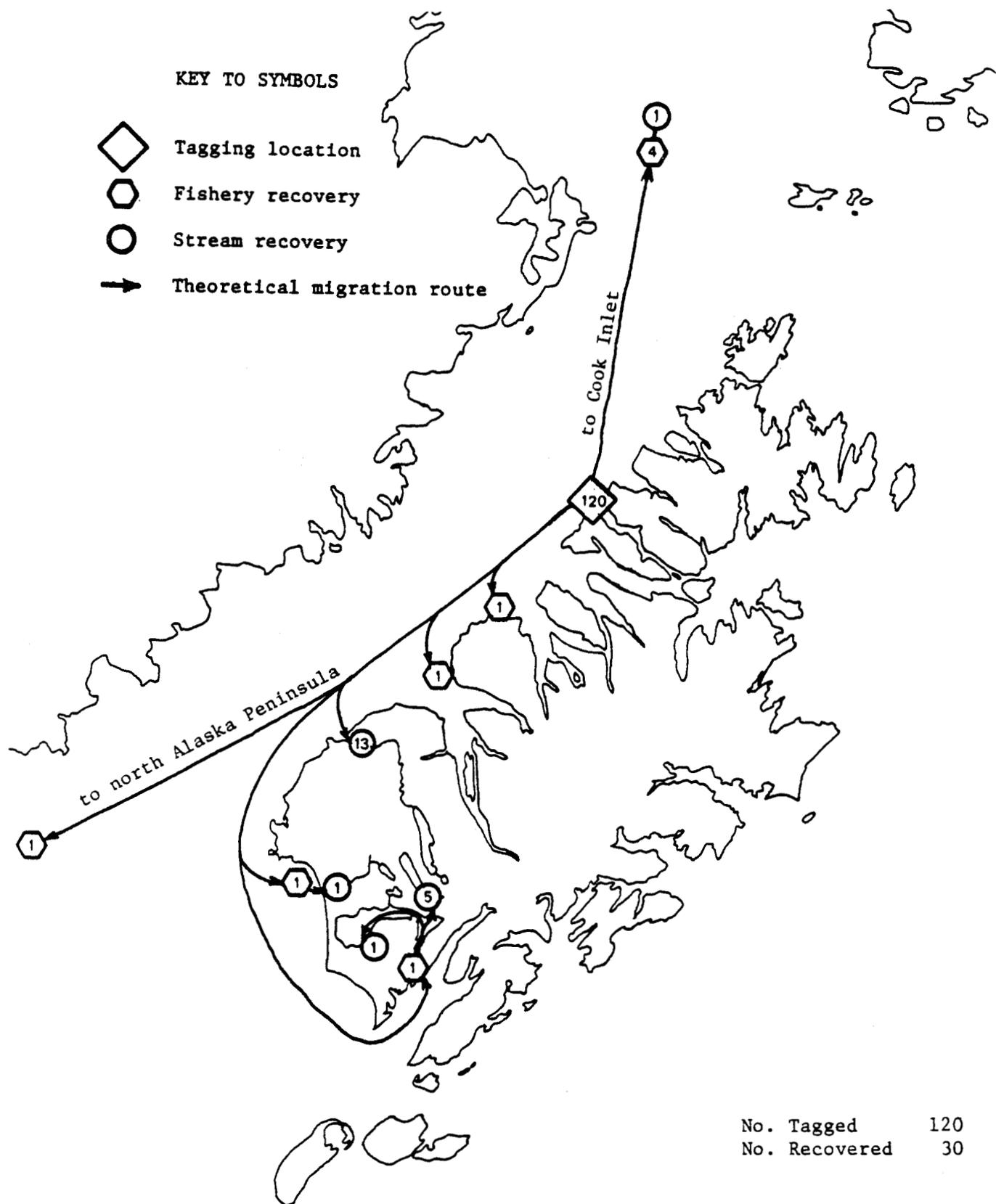


Figure 7. Recovery distribution of sockeye salmon tagged at northwest Raspberry Island on 20 June.

and one was from Bear River on the north side of the Alaska Peninsula. This wide dispersal indicates a highly mixed composition of stocks in the tagging area.

Raspberry Cape, 24 June (Figure 8):

A large number of sockeye salmon in the tagged sample were not Kodiak area stocks (73.1%). The outside recoveries included 16 from Cook Inlet, 2 from the Alaska Peninsula, and one from Sand Point. Recoveries from the Kodiak area were dispersed widely from north Afognak Island to Red River.

The high incidence of Cook Inlet sockeye salmon in the catch indicates that the north Kodiak area was within the migration route of Cook Inlet stocks.

Noisy Island - Miners Point, 6 June (Figure 9):

Recoveries were dispersed widely from Afognak Island to Alitak Bay. The distribution of returns was unexpected in that only one was from the Karluk River and none were from Red River, while 16 were from Fraser Lake, 3 were from Upper Station, and 2 were from the fishery in Moser Bay. The results indicate that the sample catch consisted of diverse stocks from north of the Karluk River plus a high percentage of Fraser Lake stock (41%).

Miners Point, 7 June (Figure 10):

Recoveries ranged from Afognak Island to Alitak Bay and one from the Alaska Peninsula. The composition of the sample catch was substantially different from that of the previous day's tagging at the same location, in that 60 returns were from the Karluk River and 5 returns were from the Red River fishery and weir. This difference indicates a large daily variability in stock composition at Miners Point. This variability is probably typical of short-term tagging experiments conducted at any of the headlands on the west coast of Kodiak Island and indicates that the stocks are at least partially segregated and that the schools may pass headland locations in relatively short time periods.

Rocky Point - Bear Island, 26 June (Figure 11):

The four recoveries from the Rocky Point tagging were all from the Karluk River weir. Of six recoveries from the Bear Island tagging, five were from Fraser Lake weir and one was from the Karluk River weir.

Although the numbers tagged at these adjacent locations are too few to be definitive, the returns tend to confirm the prominence of the Fraser Lake stock on the west coast of Kodiak Island. The returns also demonstrated a highly variable picture of stock composition for short-term sampling.

Sturgeon Head, 26 June (Figure 12):

Recoveries from the Sturgeon Head tagging were principally from the fisheries in Alitak-Moser-Olga Bay and secondarily from the Red River area seine fishery.

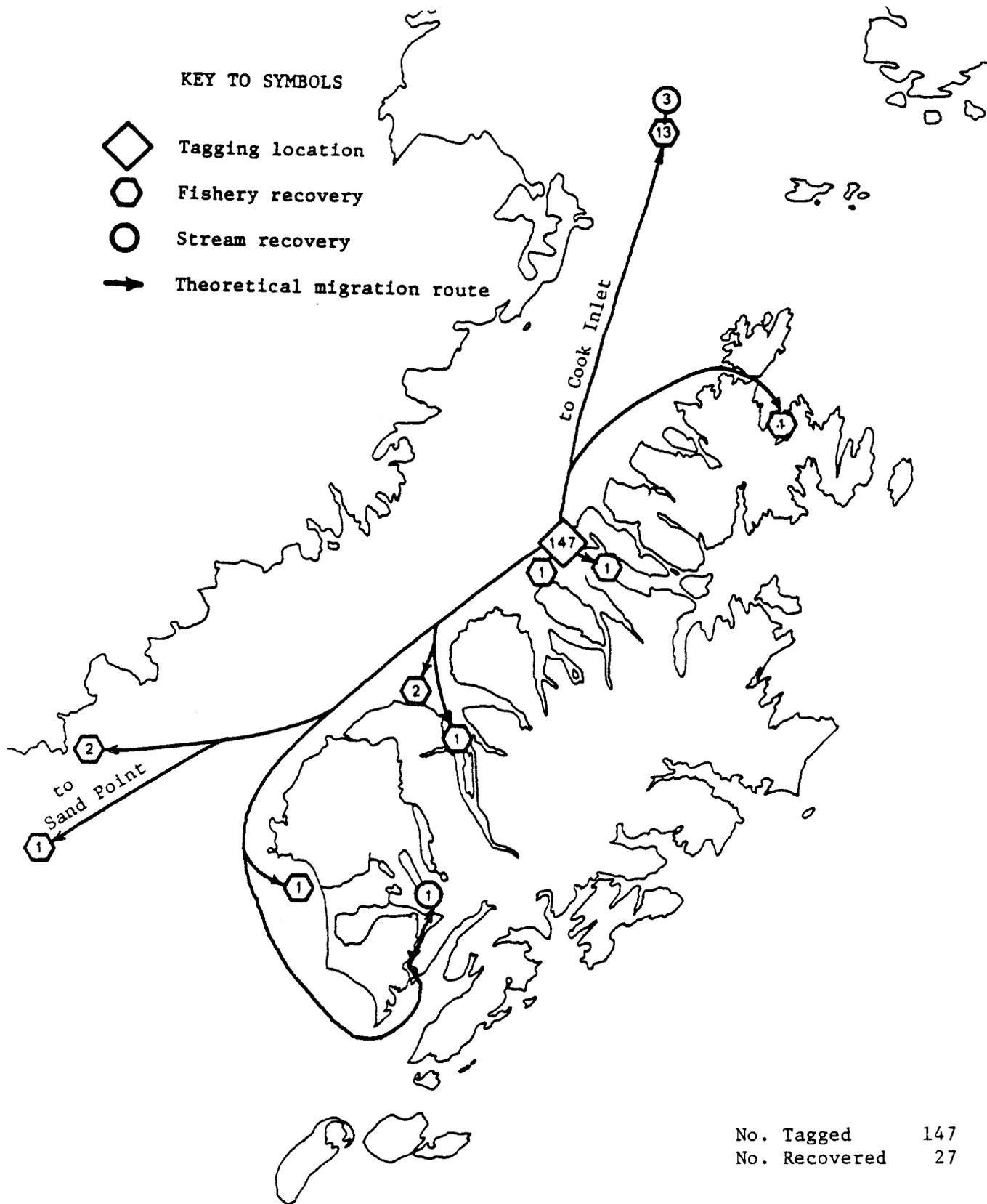


Figure 8. Recovery distribution of sockeye salmon tagged at Raspberry Cape on 24 June.

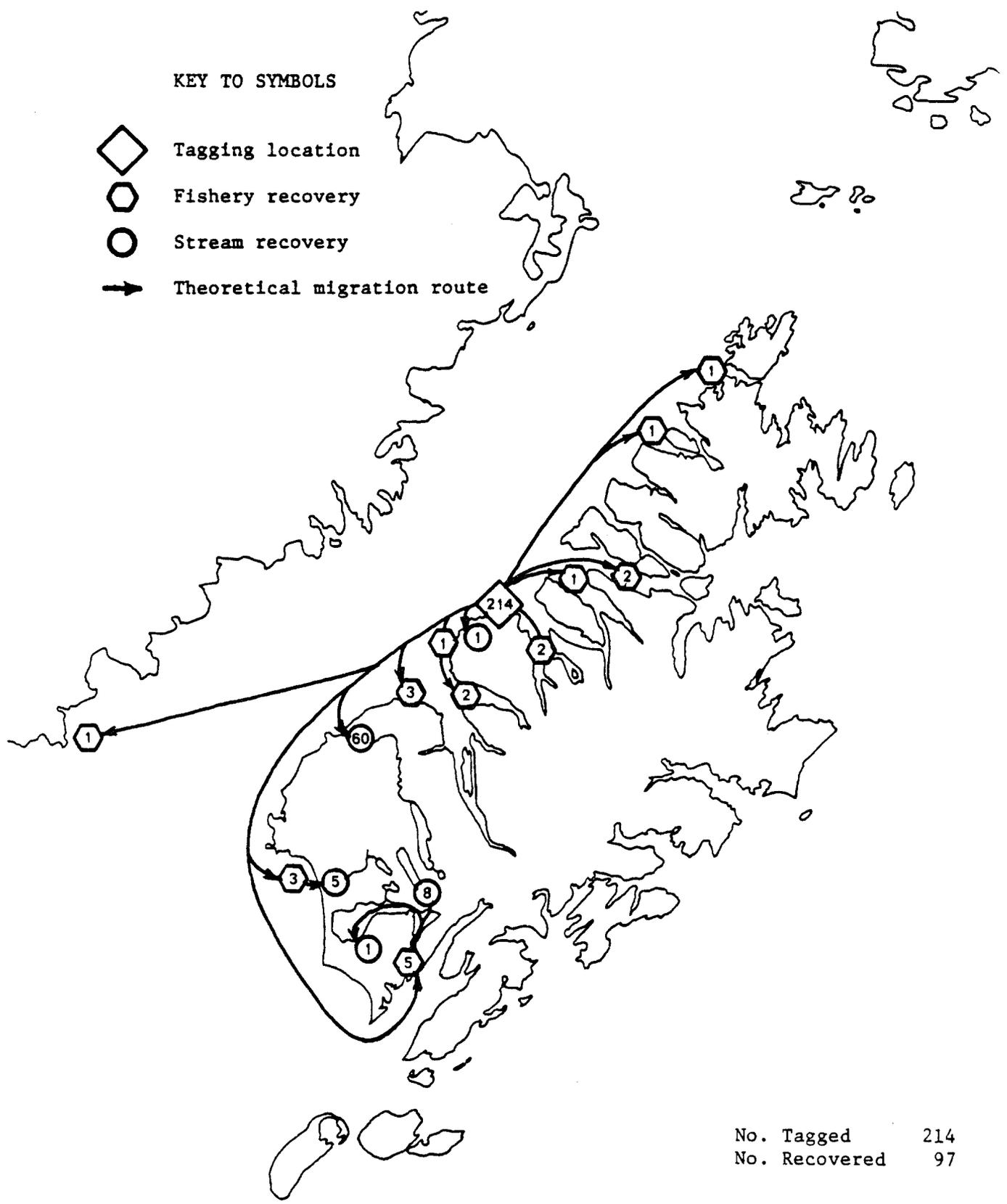


Figure 10. Recovery distribution of sockeye salmon tagged at Miners Point on 7 June.

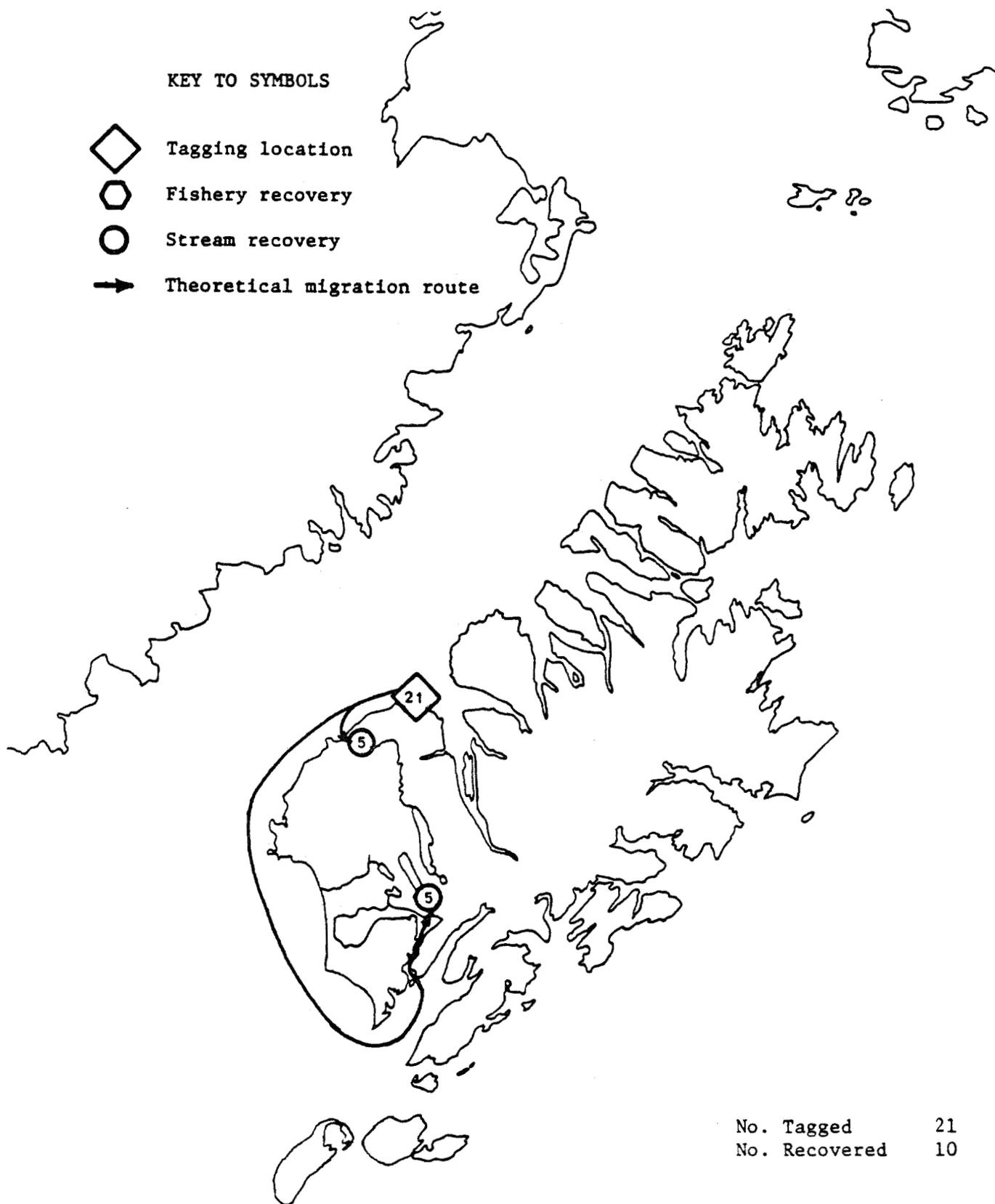


Figure 11. Recovery distribution of sockeye salmon tagged at Rocky Point and Bear Island on 26 June.

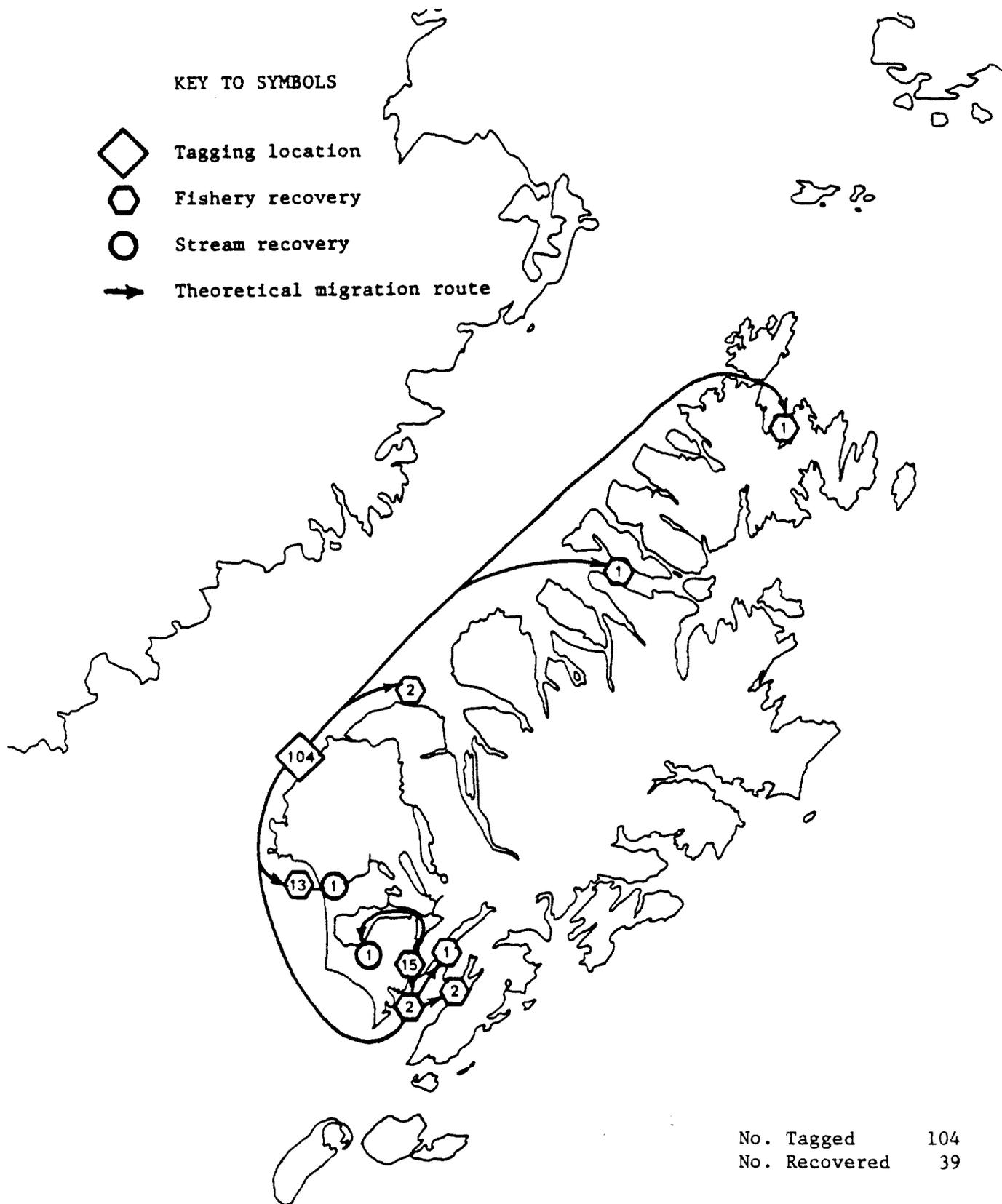


Figure 12. Recovery distribution of sockeye salmon tagged at Sturgeon Head on 26 June.

Interestingly, none were returned from the Karluk River despite its nearby location. Only four recoveries were from locations north of Sturgeon Head, in comparison with 31 recoveries from locations to the south.

This tagging indicates that sockeye salmon in the Sturgeon Head area were largely southbound to Red River and Olga Bay streams.

Middle Cape, 27 June (Figure 13):

Recoveries from the Middle Cape tagging were principally from the fisheries in Alitak-Moser-Olga Bay and secondarily from the Red River weir and area seine fishery.

None were returned from the Karluk weir despite its nearby location. Only three recoveries were from locations north of Middle Cape, in comparison with 43 recoveries from locations south of Middle Cape. This recovery pattern coincides closely with the results obtained from tagging the previous day at nearby Sturgeon Cape and tends to confirm that most sockeye salmon south of Cape Karluk are southbound.

Cape Ikolik, 8 June (Figure 14):

Recoveries from the Cape Ikolik tagging were primarily from the Alitak-Moser-Olga Bay fishery and stream weirs and secondarily from the Red River weir and adjacent fishery.

None were returned from the Karluk weir and only two of the 46 total recoveries were from locations north of Cape Ikolik. This recovery pattern coincides with results obtained from subsequent tagging at adjacent locations along the southwest coast of Kodiak Island.

Bumble Cape, 8 June (Figure 15):

Sockeye salmon tagged at Bumble Cape were destined primarily for Red River and secondarily for Olga Bay streams. There were no recoveries from locations north of Bumble Cape.

West Old Red River, North Red River Marker, South Red River Marker, South Old Red River, Gold Beach. 6, 7 June (Figure 16):

Of 249 total recoveries from these five experiments, 226, or 91%, were from the Red River weir and fishery. Only 18, or 7%, were from the Alitak-Moser-Olga Bay area.

The high return rate from Red River weir indicates that stocks in the area curing early June were largely Red River.

West Old Red River, South Old Red River, 15, 16 June (Figure 17):

Of 58 recoveries, 26 were from the Red River weir and fishery and 19 were from the Alitak-Moser-Olga Bay area.

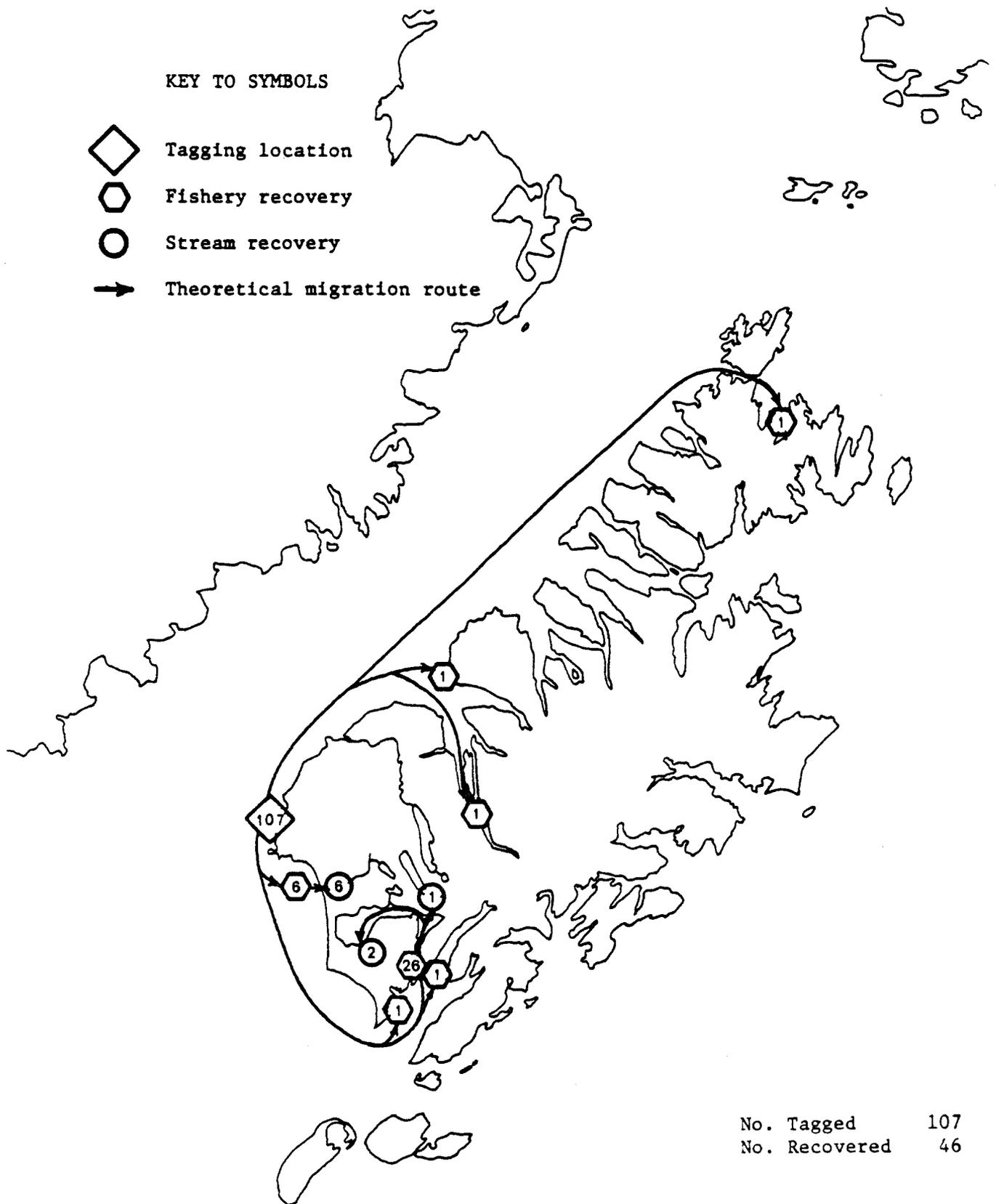


Figure 13. Recovery distribution of sockeye salmon tagged at Middle Cape on 27 June.

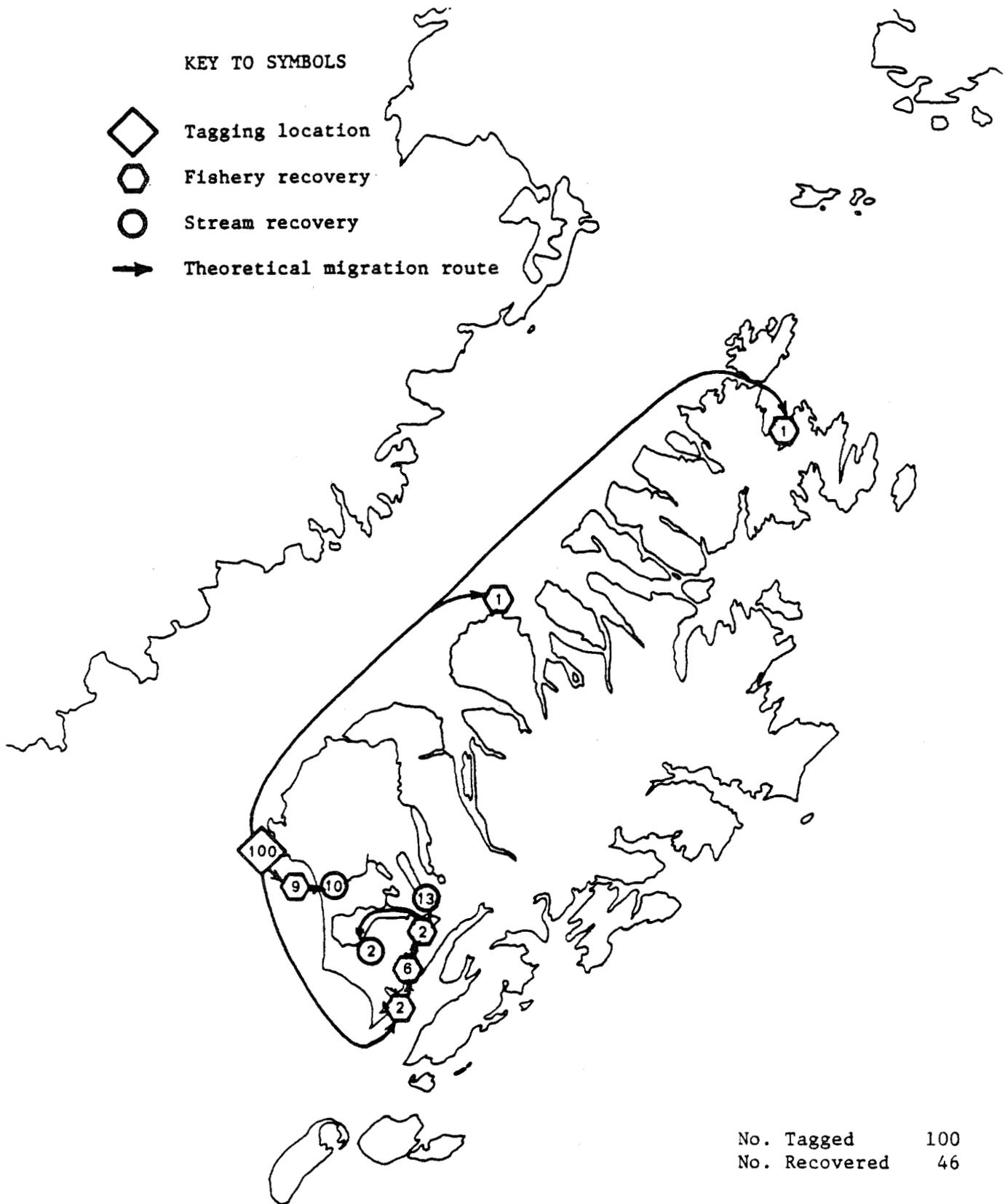


Figure 14. Recovery distribution of sockeye salmon tagged at Cape Ikolik on 8 June.

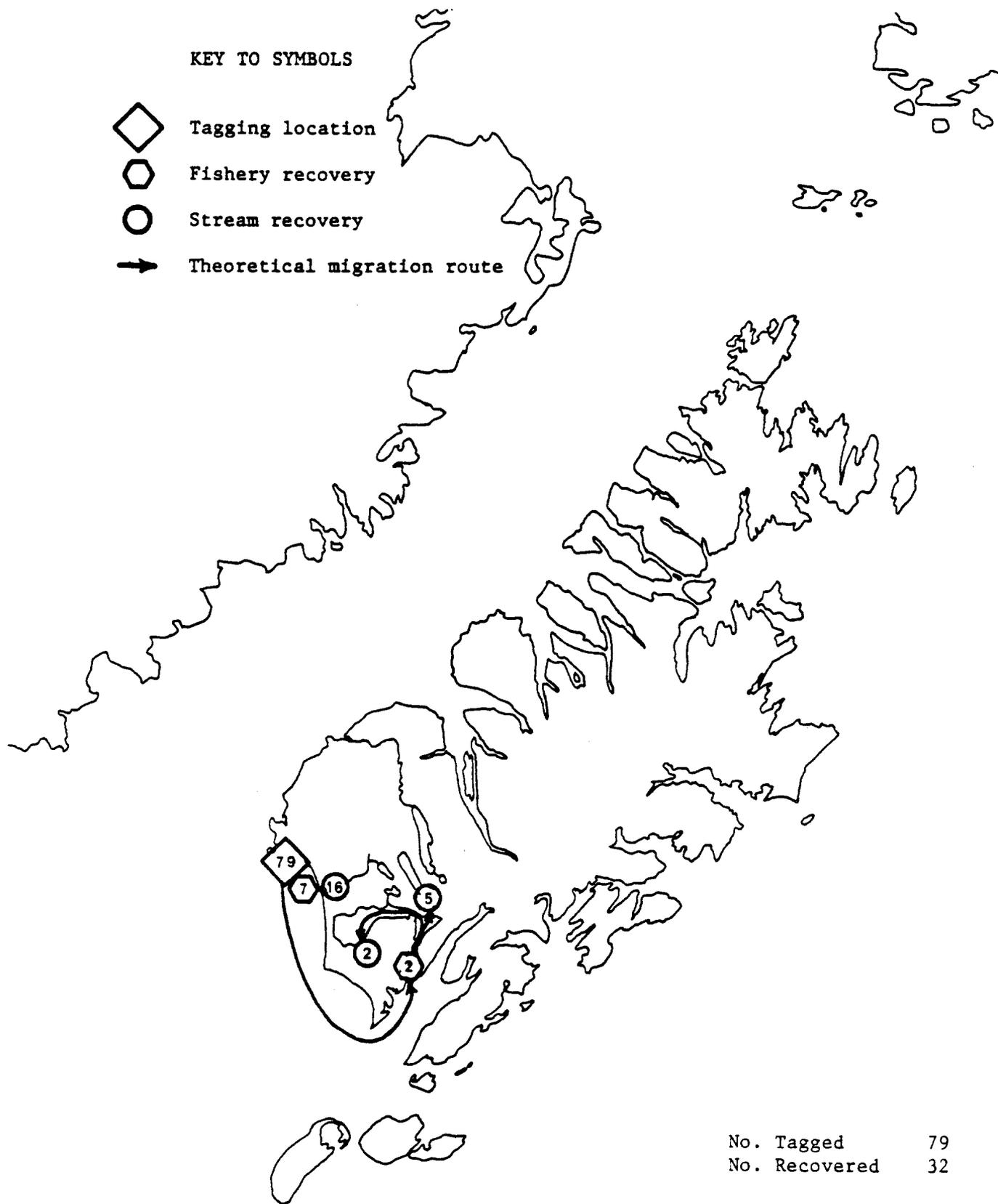


Figure 15. Recovery distribution of sockeye salmon tagged at Bumble Cape on 8 June.

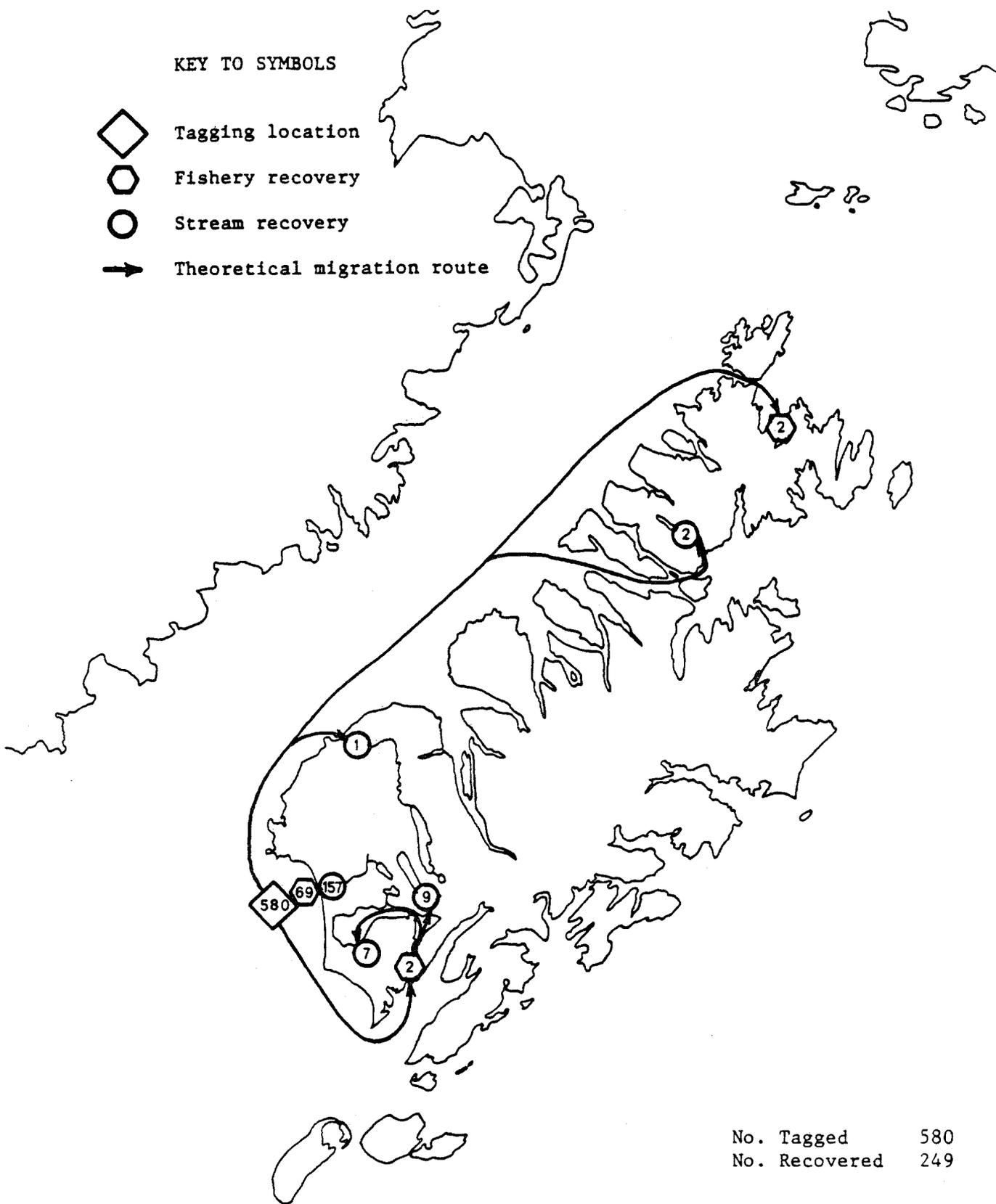


Figure 16. Recovery distribution of sockeye salmon tagged at West Old Red River, North Red River Marker, South Red River Marker, South Old Red River, and Gold Beach on 6-7 June.

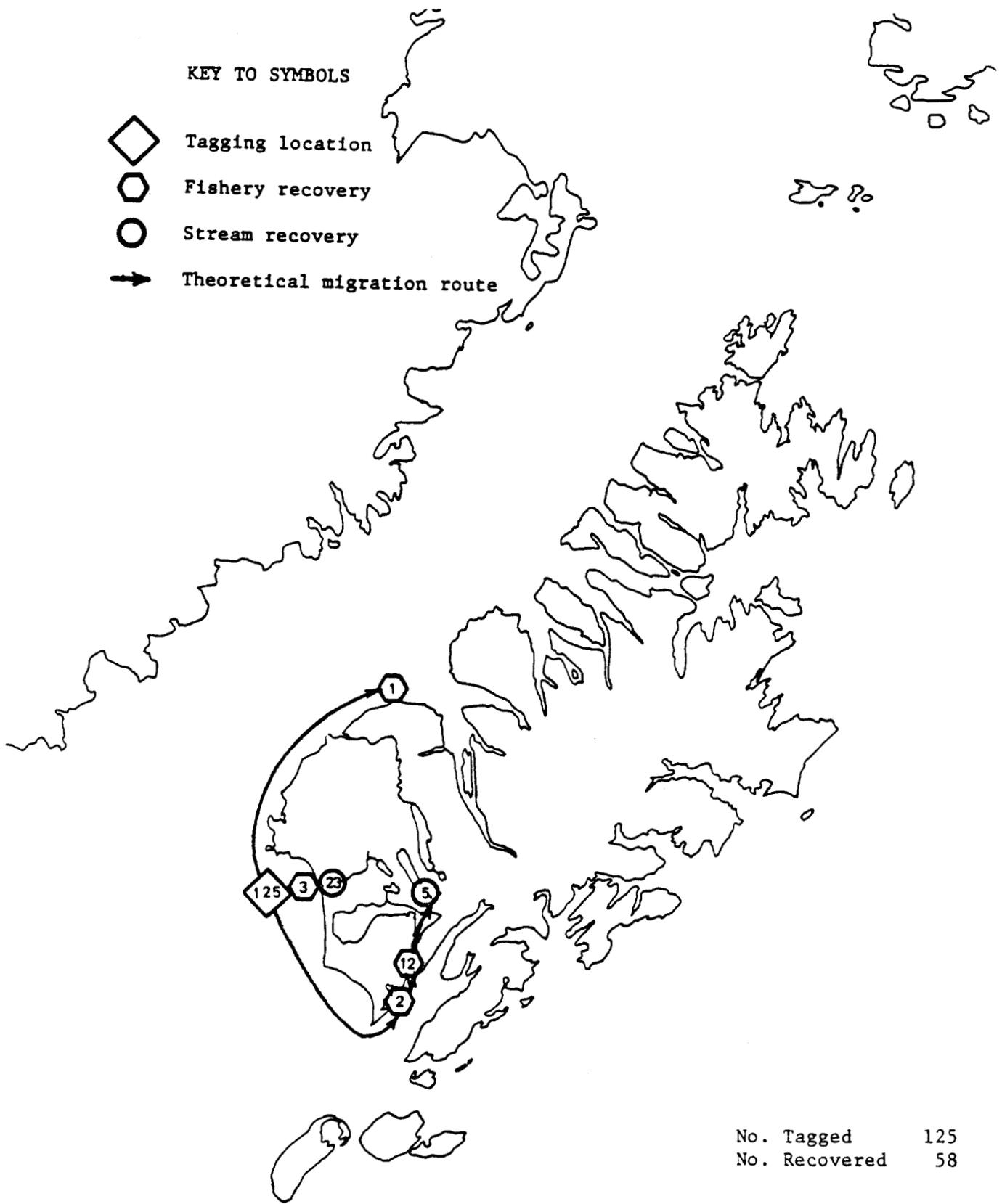


Figure 17. Recovery distribution of sockeye salmon tagged at West Old Red River and South Old Red River on 15-16 June.

The stock composition in these two experiments was 45% Red River and 33% Olga Bay.

Cape Alitak, 13 June (Figure 18):

Tags were returned almost exclusively from the Alitak-Moser-Olga Bay fishery and streams (97.9% of all returns) which shows that the catch was composed almost entirely of Fraser Lake and Upper Station stocks.

The three returns from the Cape Igvak-Chignik area indicate the presence of small numbers of Chignik stocks at Cape Alitak (1.2% of returns). That only one tag each was recovered from Red River and Uyak Bay indicates little representation of stocks from more northerly locations. The low return rate of tags from the Red River seine fishery may have influenced the results but the lack of recoveries from the Red River weir tends to confirm the conclusion.

The exploitation rate by the Alitak-Moser-Olga Bay gillnet fishery was high on tagged sockeye salmon bound for Fraser Lake and Upper Station streams. Of 238 recoveries from fishery and streams in the area, 141, or 59.2%, were from the fishery.

These results were similar to those of the 28 June tagging at Cape Alitak.

Cape Alitak, 28 June (Figure 19):

The returns were mainly from the Alitak-Moser-Olga Bay fishery and from Fraser Lake (90%). Five percent were recovered each from Red River area and Chignik and none were recovered north of the Red River area.

The exploitation rate by the Alitak-Moser-Olga Bay gillnet fishery was high on tagged sockeye salmon bound for Olga Bay streams. Of 148 recoveries from fishery and streams in the area, 126, or 85.1%, were from the fishery.

These results were similar to those of the 13 June tagging at Cape Alitak.

Moser Peninsula, 14 June (Figure 20):

With the exception of one sockeye salmon recovered from Chignik, all recoveries from this tagging were from the Alitak-Moser-Olga Bay fishery and streams.

The Moser Bay fishery in particular accounted for a major portion of the local returns (72.3%). The exploitation rate by the Alitak-Moser-Olga Bay gillnet fishery was 78.8% of all returns from the area.

North Cape - Rubber Boot, 23 June (Figure 21):

Recoveries from tagging at these adjacent locations were dispersed widely from Cook Inlet, Chignik, and various locations in the lengths of Afognak and Kodiak Islands. Clearly, these sockeye salmon were highly mixed and transitory.

The recovery rate was low (22.5%) as is typical of tagging experiments in which the fish are tagged at substantial distances from their home streams.

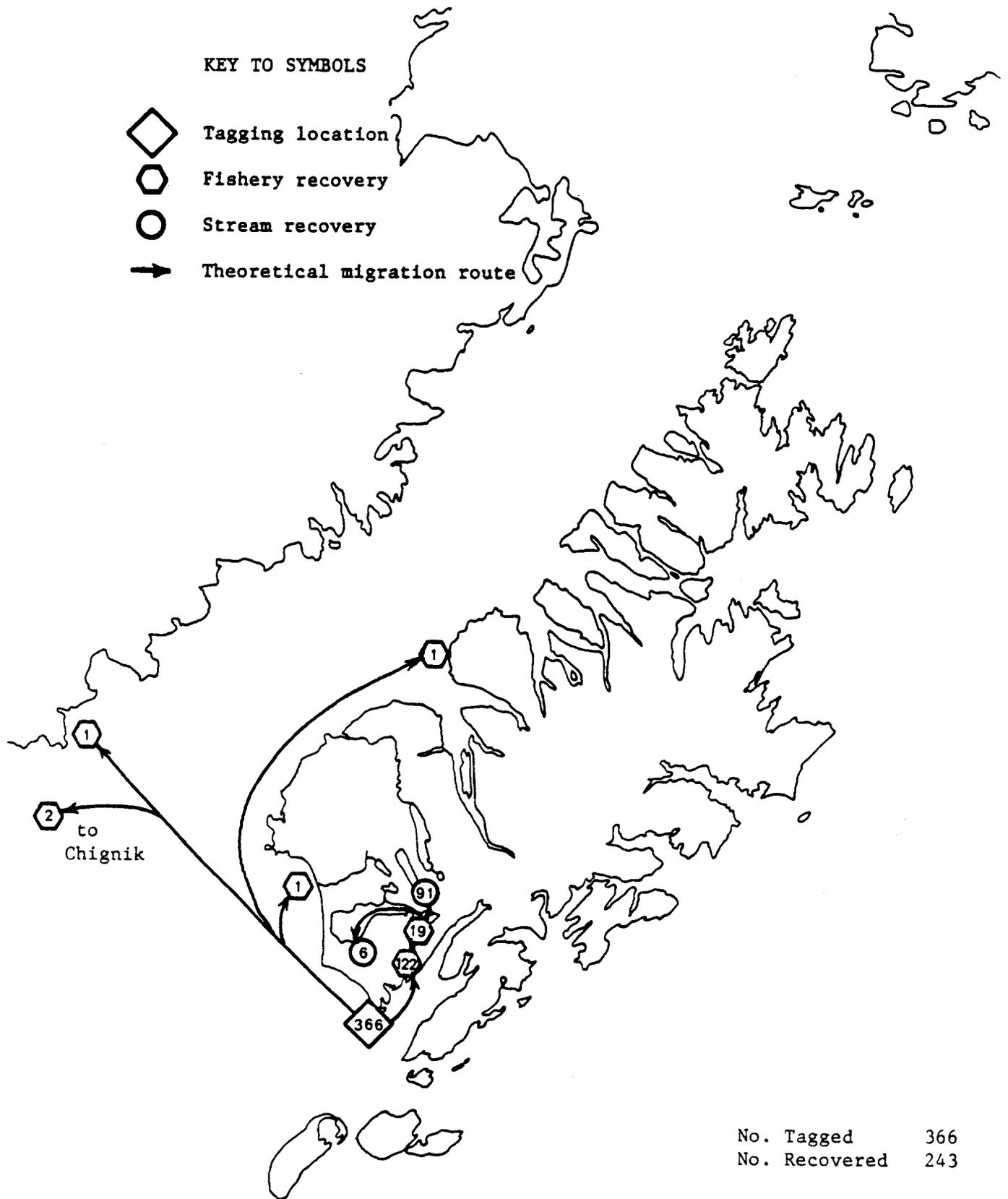


Figure 18. Recovery distribution of sockeye salmon tagged at Cape Alitak on 13 June.

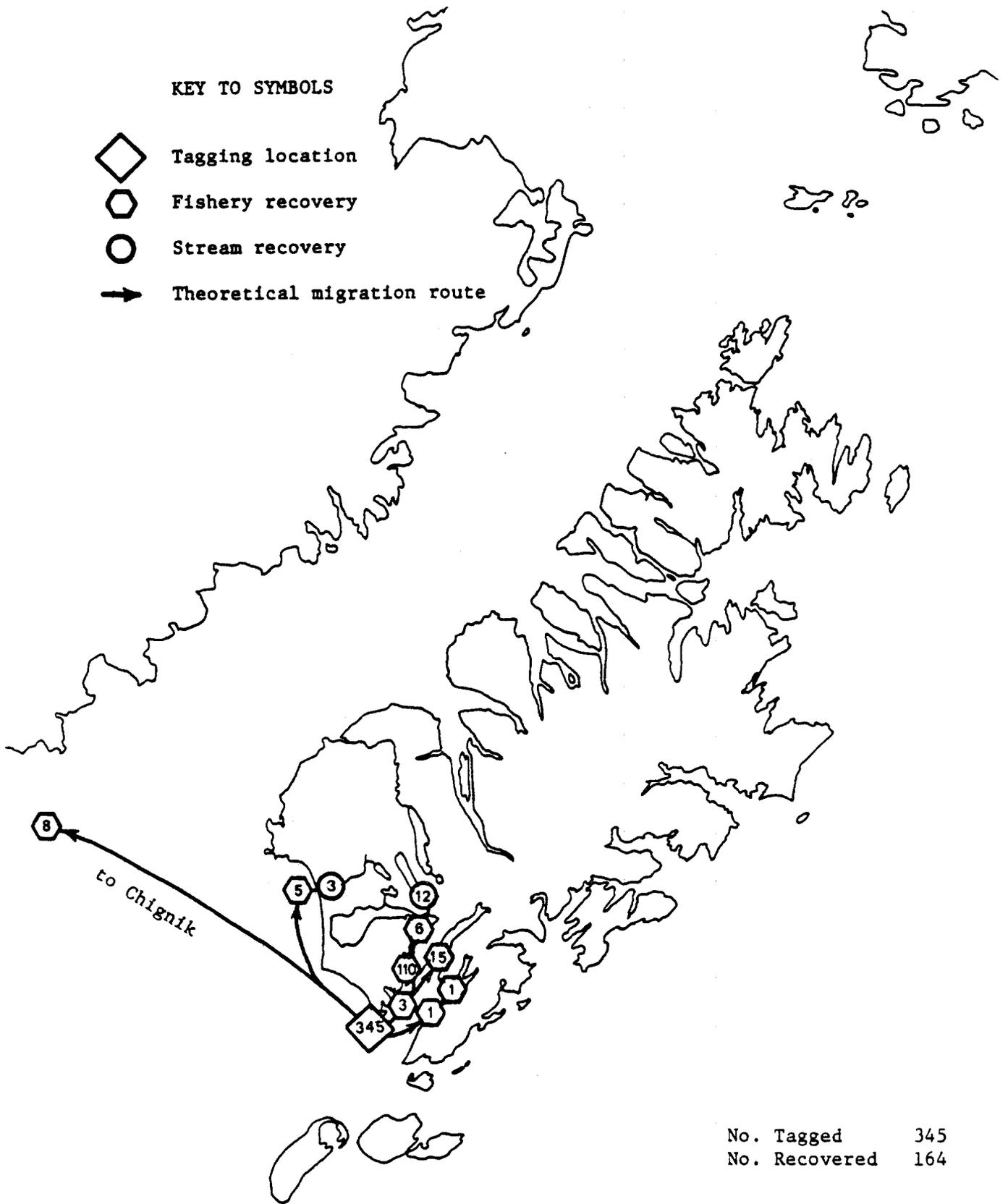


Figure 19. Recovery distribution of sockeye salmon tagged at Cape Alitak on 28 June.

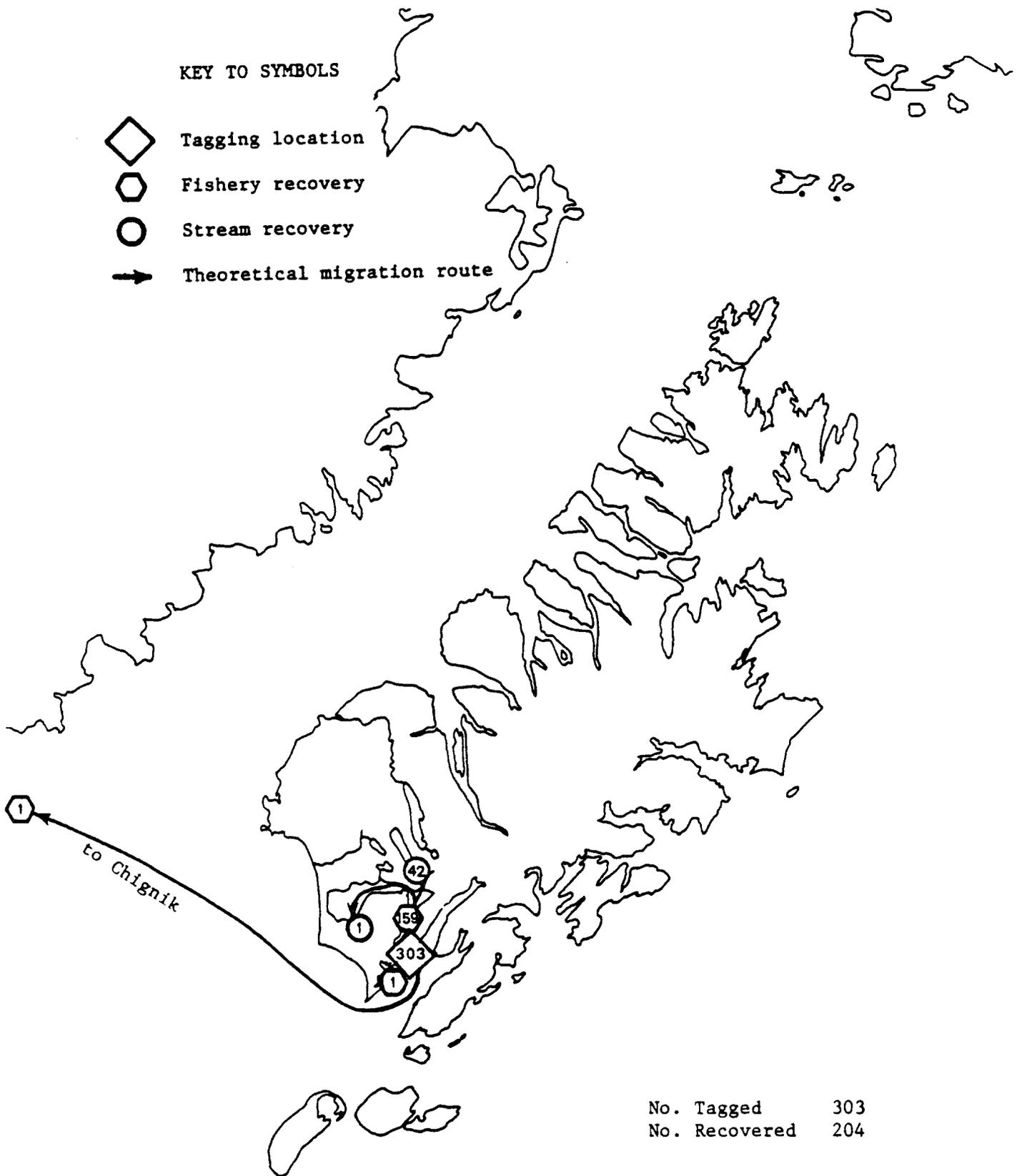


Figure 20. Recovery distribution of sockeye salmon tagged at Moser Peninsula on 14 June.

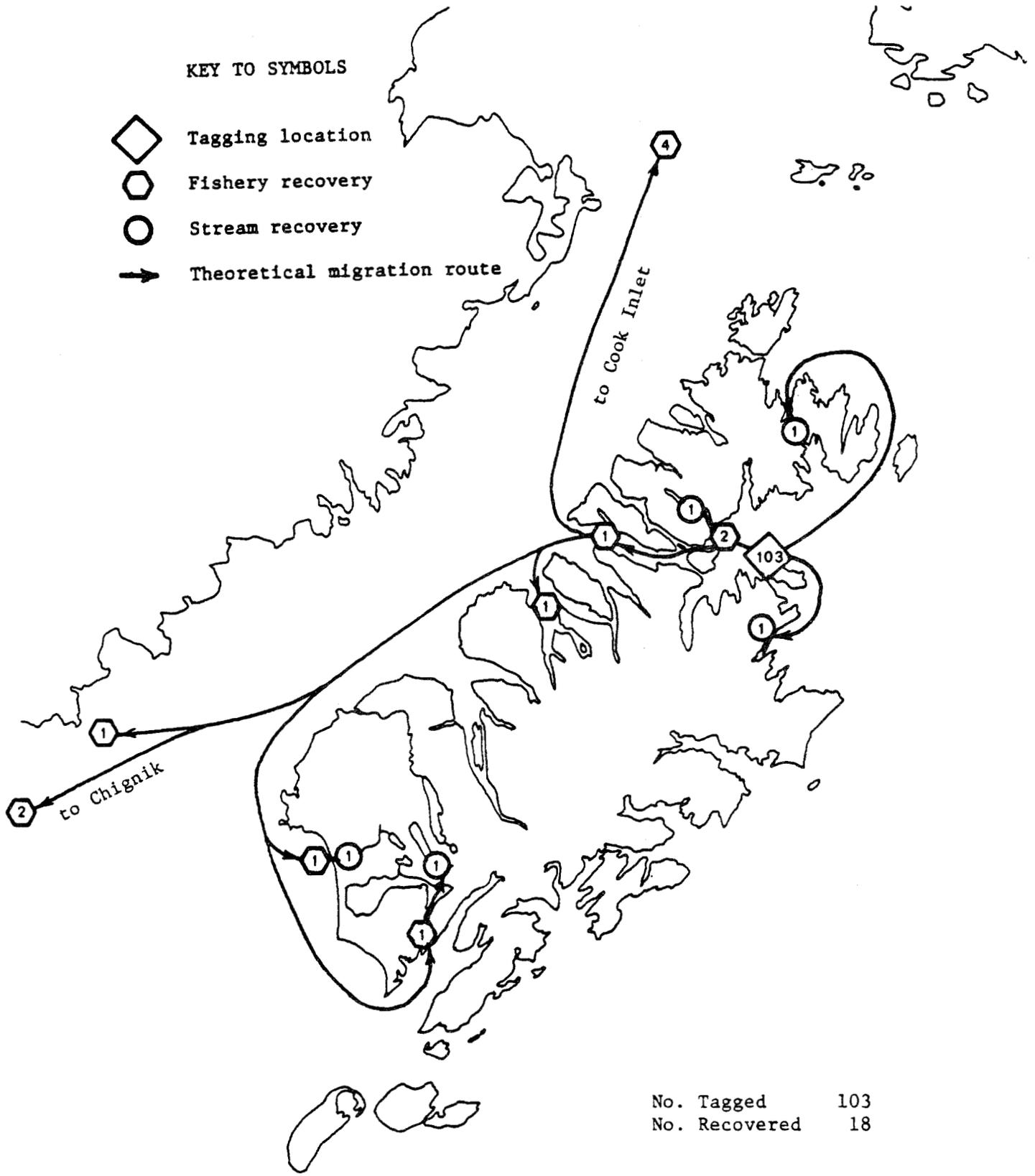


Figure 21. Recovery distribution of sockeye salmon tagged at Rubber Boot on 12 and 13 June, and at North Cape on 23 June.

Cape Izhut, 21 June (Figure 22):

Returns from this experiment were dispersed widely, similar to the results from tagging at nearby North Cape and Rubber Boot.

The Cook Inlet recoveries accounted for 10.2% of all recoveries, and the Cape Igvak-Chignik-Sand Point recoveries accounted for 16.3%.

Many recoveries were from Afognak Island sockeye salmon streams. Single recoveries each were from Buskin and Saltery Cove streams on the east side of Kodiak Island as well as one from the terminal fishery south of Sitkalidak Island in the vicinity of the small sockeye salmon system at Ocean Beach.

The overall recovery rate of 16.7% was well below the total rate for all tagging in this series (43.9), but was typical of experiments in which the recoveries are widely dispersed.

Summary of Migration Characteristics in 1981 and Comparison with Characteristics Observed in Past Tagging

Westside Area:

The 1981 tagging in the westside area between Noisy Island and Cape Karluk showed a strong southward movement to the Karluk River, Red River, Fraser Lake, and Upper Station. Most returns were from the local Karluk District; however, in some experiments more than half the recoveries were from the Red River and Alitak Districts. The occurrence of Red River and Alitak stocks was much greater than that found before 1950 by Rich and Morton (1929), and by Bevan (1959), and was similar to that reported by ADF&G during the period 1969-1978 (Nicholson 1978).

Bevan reported that only 2.5% of sockeye salmon tagged on the northwest coast were recovered from other districts. More recent tagging by ADF&G on the northwest coast (Westside Kodiak) resulted in 15.8 and 26.5% recovery rates from Red River and Alitak Bay, respectively. In 1981, 30.8% of all weir recoveries of sockeye salmon tagged on westside Kodiak were recovered from Alitak Bay weirs (Table 8). The difference between the early and recent tagging results undoubtedly reflects changed stock sizes, i.e., smaller in the Karluk River, and increased in the Red River, Fraser Lake, and Upper Station.

Southwest Kodiak:

The principal direction of migration of sockeye salmon on the southwest coast between Sturgeon Head and Cape Ikolik was south to Red River and Olga Bay. Relatively few tags were returned from locations north of tagging.

Olga Bay stocks were abundant, and at times predominant, in experiments in the southwest Kodiak area in which returns from Alitak Bay averaged 57.3% of total returns (Table 9).

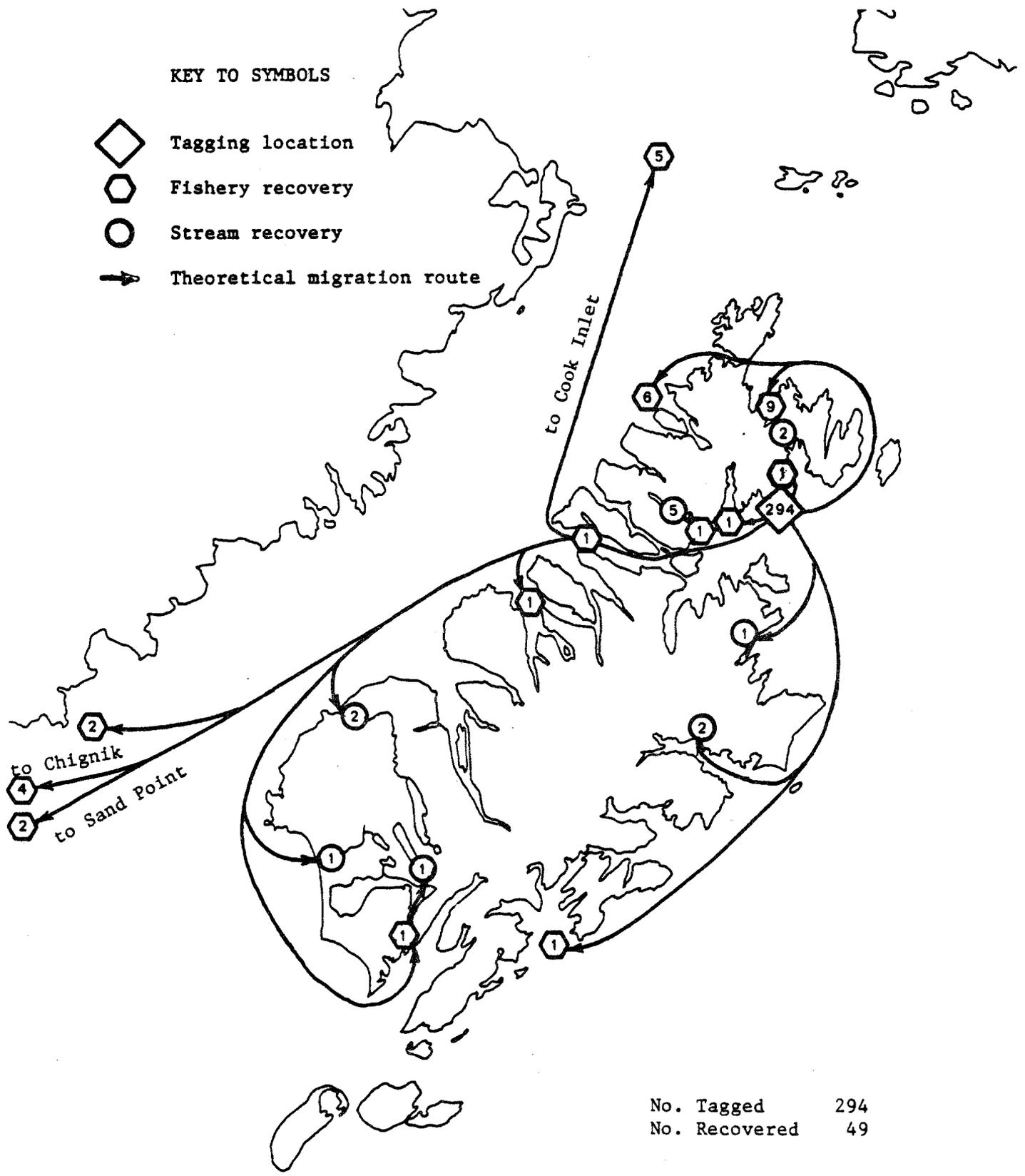


Figure 22. Recovery distribution of sockeye salmon tagged at Cape Izhut on 21 June.

Table 8. Distribution of tags recovered at stream weirs from tagging within six general areas of the Kodiak archipelago, 1981.

Area of tagging	Number tagged	Total weir recoveries	Recoveries from weirs (% of total)				
			Karluk R.	Red River	Fraser L.	Upper Station	Afognak R.
Southwest Afognak	267	21	13 (61.9)	1 (4.8)	6 (28.6)	1 (4.8)	0 (0)
Westside Kodiak	336	107	65 (60.7)	5 (4.7)	29 (27.1)	4 (3.7)	3 (2.8)
Sturgeon R.-Gurney B.	311	36	0 (0)	17 (4.7)	14 (38.9)	5 (13.9)	0 (0)
Red River Beach	784	227	1 (0.4)	196 (86.3)	19 (8.4)	9 (4.0)	2 (1.0)
Alitak Bay	1,014	155	0 (0)	3 (1.9)	145 (93.5)	7 (4.5)	0 (0)
N. Kodiak-S.E. Afognak	397	11	2 (18.2)	1 (9.1)	2 (18.2)	0 (0)	6 (54.5)

Table 9. Percentage of Alitak-Moser-Olga Bay recoveries among total recoveries from tagging along the northwest, west, and south coasts of the Kodiak archipelago in 1981.

Tagging area	Tagging date	Total recoveries from known locations (A)	Recoveries from Alitak-Moser-Olga Bay	
			Number (B)	Percent of total [(B/A) x 100]
<u>Southwest Afognak and Westside Kodiak</u>				
NW Raspberry I.	6/20	30	7	23.3
Raspberry Cape	6/24	27	1	3.7
Noisy Island				
Miners Point	6/6	39	19	48.7
Miners Point	6/7	97	14	14.4
Bear Island	6/26	6	5	83.3
Rocky Point	6/26	4	0	0
Total		203	46	22.7
<u>Southwest Kodiak</u>				
Sturgeon Head	6/26	39	21	53.8
Middle Cape	6/27	46	31	67.4
Cape Ikolik	6/8	46	23	50.0
Total		131	75	57.3
<u>Red River District</u>				
Bumble Cape	6/8	32	5	15.6
W. Old Red R.	6/6	2	1	50.0
W. Old Red R.	6/15	32	12	37.5
S. Old Red R.	6/7	33	6	18.2
S. Old Red R.	6/16	26	19	73.1
N. Red R. Marker	6/7	113	4	3.5
S. Red R. Marker	6/7	92	5	5.4
Gold Beach	6/6	9	2	22.2
Total		339	54	15.9
<u>Alitak Bay District</u>				
Cape Alitak	6/13	243	238	97.9
Cape Alitak	6/28	164	148	90.2
Moser Peninsula	6/14	204	203	99.5
Total		611	589	96.4

The percentage of Alitak returns among total returns in the Red River area between Bumble Cape and Gold Beach averaged 15.9%, but the percentage varied by distance tagged from the river mouth; the lowest percentage occurred in experiments less than two miles from the river mouth (4.4%) and the highest percentage at locations ranging from 2 to 15 miles from the river mouth (33.6%).

South Kodiak:

Olga Bay stocks were predominant at Cape Alitak and Moser Peninsula. Returns from Alitak Bay averaged 96.4% of total returns. This rate is about the same as in all previous tagging.

The relatively high composition of Olga Bay stocks in sample catches along the west coast of the Kodiak archipelago, and the fact that no sockeye salmon fishery has developed along the east coast, particularly the southeast coast, indicate that the west coast is by far the most important migration route for Olga Bay stocks.

Of 131 total sockeye salmon recovered from the 1981 tagging along the southwest coast between Sturgeon Head and Cape Ikolik, none were recovered at Karluk despite the nearness of tagging locations to the Karluk River. Tagging by ADF&G in the same area (Halibut Bay) in June 1971-73 yielded a high percentage of returns from Karluk (58% of returns) in 1971 and low percentages in 1972 and 1973 (3% and 7% of returns, respectively). A review of escapement to Karluk, Red, Fraser Lake, and Upper Station streams for June 1971-73 and 1981 indicates that the large return of tags from Karluk River in 1971 did not result from a preponderance of Karluk sockeye salmon stocks in 1971. While the return of tags from Red River and Fraser Lake-Upper Station streams was roughly proportional to the June escapements, the return from Karluk was not (Figure 23).

In summary, tagging has indicated that during June, Karluk stocks composed small or negligible portions of total stocks in Halibut Bay during three or four years and a high portion in the fourth year. Karluk stocks have not occurred in appreciable numbers south of Halibut Bay and appear to approach Karluk River mainly from the north.

Sockeye salmon stocks from Cook Inlet, Chignik, and other places on the Alaska Peninsula were mixed with Kodiak area stocks at the north and south ends of Kodiak Island. The percentage of outside stocks among total recoveries from all experiments were minor: Cook Inlet, 2.2; Alaska Peninsula, 0.5; Chignik, 1.3; Shumagin Islands, 0.2; north Alaska Peninsula, 0.1 (Table 10). These rates are higher than those reported by Bevan from the 1948-49 tagging (Table 1) but Bevan did not tag in northeast Kodiak Island (Marmot Bay) where outside stocks are more prevalent. The percentage of outside stocks and particularly of Cook Inlet stocks among recoveries from individual experiments was substantial at some of the northern locations such as Rubber Boot, Cape Izhut, and Raspberry Island (Table 11). The Cook Inlet returns were mainly from the fishery but also from Tustumena Lake, Kenai River, Susitna River, and Big River Lake.

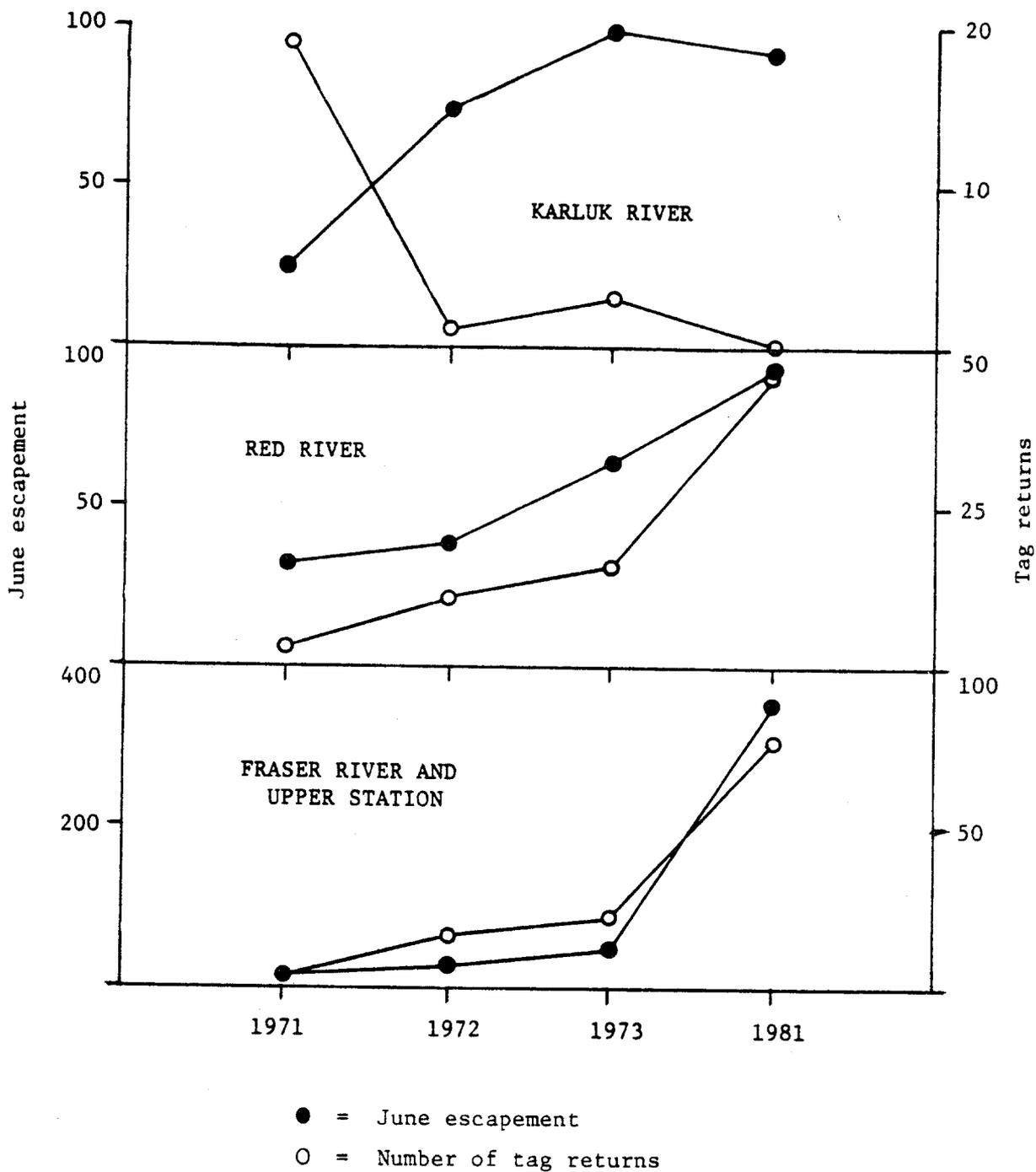


Figure 23. June escapements and numbers of tags recovered at Karluk River, Red River, Fraser Lake-Upper Station weirs from tagging during 1971, 1972, 1973, and 1981.

Table 10. Occurrence of Cook Inlet - Alaska Peninsula stocks among total recoveries.

District	Number of recoveries	Percent of tagged	Percent of recoveries
Cook Inlet	30	0.96	2.22
Chignik	17	0.55	1.30
S. Alaska Peninsula	7	0.23	0.52
N. Alaska Peninsula	1	0.10	0.07
Shumagin Islands	<u>3</u>	<u>0.03</u>	<u>0.22</u>
	58	1.87	4.29

Table 11. Occurrence of Cook Inlet - Alaska Peninsula stocks in individual experiments.

Location tagged	Number of recoveries from known locations	% of Recoveries from outside the Kodiak area					
		Cook Inlet	Alaska Pen.	Chignik	Sand Point	N. Alaska Pen.	Total
North Cape	1						
Rubber Boot	17	23.5	5.8	11.8			41.1
Cape Izhut	49	10.2	4.1	8.2	4.1		26.6
NW Raspberry I.	30	16.7				3.3	20.0
Raspberry Cape	26	61.5	7.7		3.8		73.0
Noisy I.	8						
Miners Pt.	128		0.8				0.8
Bear I.	6						
Rocky Pt.	4						
Sturgeon Head	39						
Middle Cape	46						
Cape Ikolik	46						
Bumble Cape	32						
W. Old Red R.	34						
N. Red R. Marker	113						
S. Red R. Marker	92						
S. Old Red R.	59						
Gold Beach	9						
Moser Peninsula	204			0.5			0.5
Cape Alitak	407		0.2	2.5			2.7
Total	1,350	2.2	0.5	1.3	0.2	0.1	4.3

That the return rates from Cook Inlet were greatest among the northerly tagging locations might be expected from their proximity to Cook Inlet, but it is interesting that northerly tagging locations also yielded the highest rates for sockeye salmon headed southwest to locations along the Alaska Peninsula.

Tagging at the northerly locations also yielded a more widespread distribution of returns from the Kodiak area than did tagging at all other locations.

These results and the results from previous ADF&G tagging demonstrate that the stock composition in the Marmot Bay - Raspberry Island area during June is composed of a highly varied mixture from nearly all sockeye salmon streams in the Kodiak archipelago, from many streams in Cook Inlet, and the Alaska Peninsula.

The migration of Cook Inlet sockeye salmon past the northern Kodiak archipelago is probably countered by a similar movement of Kodiak area sockeye salmon through outer Cook Inlet. This was indicated in tagging experiment conducted in Seldovia Bay in 1959 (Tyler and Noerenberg 1961) in which 7.5% of sockeye salmon, 12.2% of pink salmon (*Oncorhynchus gorbuscha*) and 5.0% of chum salmon (*O. keta*) returns were from the Kodiak archipelago.

Migration Rate in the Red River Area

The days required for sockeye salmon tagged at various locations in the Red River area to reach the Red River weir are shown in Figure 24. The tagging locations ranged from Middle Cape, 15 miles north of Red River to Gold Beach, 4 miles south of Red River. The average time for all sockeye salmon tagged in this area to reach the weir, which is 0.2 miles above the river mouth, was 4.1 days. Peak frequencies ranged from one day from north and south Red River markers, which are less than two miles away, to 3-5 days from more distant locations. Interestingly, two sockeye salmon tagged at Bumble Cape 6 miles north and two sockeye salmon tagged at north Red River marker 2 miles north passed the weir on the day of tagging, which involved an unusually rapid transition to a riverine environment.

Migration Rate in the Alitak-Moser-Olga Bay Area

The tagging at Cape Alitak and Moser Peninsula provided information on the travel time to the Fraser Lake and Upper Station weirs. Tagging at Cape Alitak on 13 and 28 June resulted in 106 sockeye salmon passing the Fraser Lake weir in an average time of 9.5 days, and in six sockeye salmon passing the Upper Station weir in 4.7 days¹. Since the mouth of Upper Station is 12 miles farther up Olga Bay than the mouth of the Fraser Lake outlet stream (Dog Salmon River), or an estimated 1.0-1.5 days' migration, the travel time to the Dog Salmon River mouth was probably about 3.2-3.7 days. By subtracting this period from the 9.5 days required to reach the weir, a period of roughly 5.8-6.3 days appears to have been spent by sockeye salmon in ascending the Dog Salmon River to the Fraser Lake weir, a distance of 7.5 miles from tidewater and an elevation of 353 ft above sea level.

¹ Upper Station weir is 0.5 miles above tidewater.

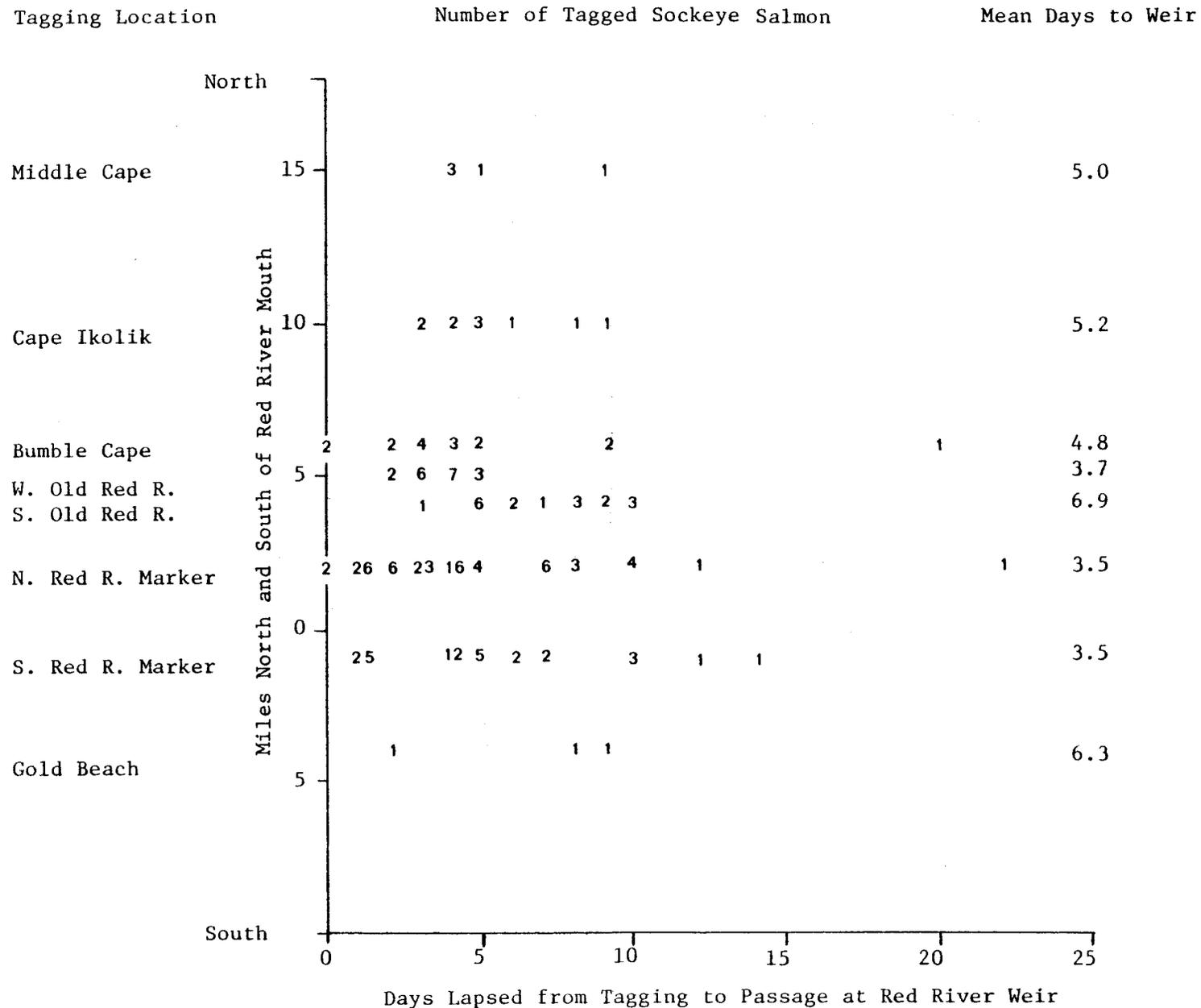


Figure 24. Daily frequency of sockeye salmon observed passing Red River weir following tagging in the vicinity of Red River, 1981.

Sockeye salmon tagged at Moser Peninsula on 14 June averaged about one day longer to reach the Fraser Lake weir than did those tagged at Cape Alitak, even though the Moser Peninsula site is 12 miles nearer; 41 averaged 10.3 days to Fraser Lake weir; and one passed Upper Station weir three days after tagging.

These migration times are about half those reported by Bower (1941) from the 1938 tagging at nearby Bun Point and Miller Island traps.

In experiments near the Red River and Olga Bay terminal areas, travel rates to the fishery and weirs were determined to the nearest day. The tagged sockeye salmon did not appear to manifest the 48-hr migrational delay due to effects of tagging, as was observed by Bevan in 1948-49. It may be that such delay is less for sockeye salmon tagged within a few miles of their home stream, or the difference may be due simply to handling, as might occur between trap and seine capture gear.

Estimation of the Fraser Lake Sockeye Salmon Run during June

The Fraser Lake run size was estimated from tag returns and catch and escapement data. Tag recovery rates were used as estimates of the occurrence rate of Olga Bay sockeye salmon stocks in each of the major fishing areas of the Kodiak archipelago (Table 12). These estimates ranged from 6.0% in East Afognak and Kizhuyak sections to 96.4% at Alitak Bay. The catch of Olga Bay stocks during June-July was estimated by multiplying the tag recovery rates by catches at each fishery location during each of the three fishing periods. The relative proportions of Upper Station and Fraser stocks in the catch during each fishing period were estimated from the escapements to both streams. The proportions averaged 5.9 : 94.1 and were nearly constant during the three periods. The estimated June catches of Upper Station and Fraser Lake stocks are 9,281 and 151,571, respectively. The timing and magnitude of the total Fraser Lake run were approximated by combining catch and escapement data (Figure 25). The catch timing was adjusted to compensate for migrational delay between each fishing location and the Fraser Lake weir using mean days required by tagged fish to travel those distances (Table 13).

The catch, escapement, and total June run estimates are 151,571, 377,716, and 529,287, respectively. The estimated catch is 28.6% of the total run.

Observation of Sockeye Salmon Movement in the Red River Fishery

The Red River purse seine fishery is intensive and competitive along a sand-gravel beach approximately six miles north and south of the Red River mouth. Many of the nets are constructed to conform to the shallow, gradual slope of the bottom, and are set with the lead line on the bottom. These nets are set perpendicular to the beach with a slight belly in the direction of Red River mouth. The offshore end is set with a pronounced hook to intercept and turn back fish which lead outward along the net¹. The skiff-end of the seine is

¹ These observations were made during moderate weather. Fishing techniques may vary with the individual fisherman, weather, tide, and fish abundance.

Table 12. Estimated catch during June of Upper Station and Fraser Lake sockeye salmon stocks in the major fishing areas of the Kodiak archipelago based on escapements, tag returns, and area catches.

Percentage distribution of escapement to Upper Station and Fraser Lake:										
1st fishing period, Jun 9-15:		(A) Upper Station, 5.6								
		(B) Fraser Lake, 94.4								
2nd fishing period, Jun 17-20:		(C) Upper Station, 5.4								
		(D) Fraser Lake, 94.6								
3rd fishing period, Jun 28-Jul 1:		(E) Upper Station, 6.7								
		(F) Fraser Lake, 93.3								
Fishery area	% of total tags returned that were returned from Upper Station and Fraser weirs (G)	Apportionment of June catch								
		June catch			1st period		2nd period		3rd period	
		1st period (H)	2nd period (I)	3rd period (J)	Upper Station (AxGxH)	Fraser Lake (BxGxH)	Upper Station (CxGxI)	Fraser Lake (DxGxI)	Upper Station (ExGxJ)	Fraser Lake (FxGxJ)
E. Afognak Sec. and Kizhuyak Sec.	6.0	6,438	5,534	13,246	22	364	18	314	5	742
Uganik B. Dist. and Uyak-Karluk Dist.	22.7	10,529	9,312	13,827	134	2,256	11	2,000	210	2,928
Red River Dist.	15.9	79,199	14,662	63,329	705	11,887	126	2,705	675	9,395
Cape Alitak Dist.										
Moser-Olga B. Sec.										
Deadman-Portage Sec.	96.4	47,415	49,577	34,602	2,560	43,148	2,581	45,211	2,235	31,121
Apportioned catch of Upper Station and Fraser Lake stocks:					3,421	57,655	2,735	49,730	3,125	44,186
Estimated total catch of Upper Station stocks = 9,281										
Estimated total catch of Fraser Lake stocks = 151,571										

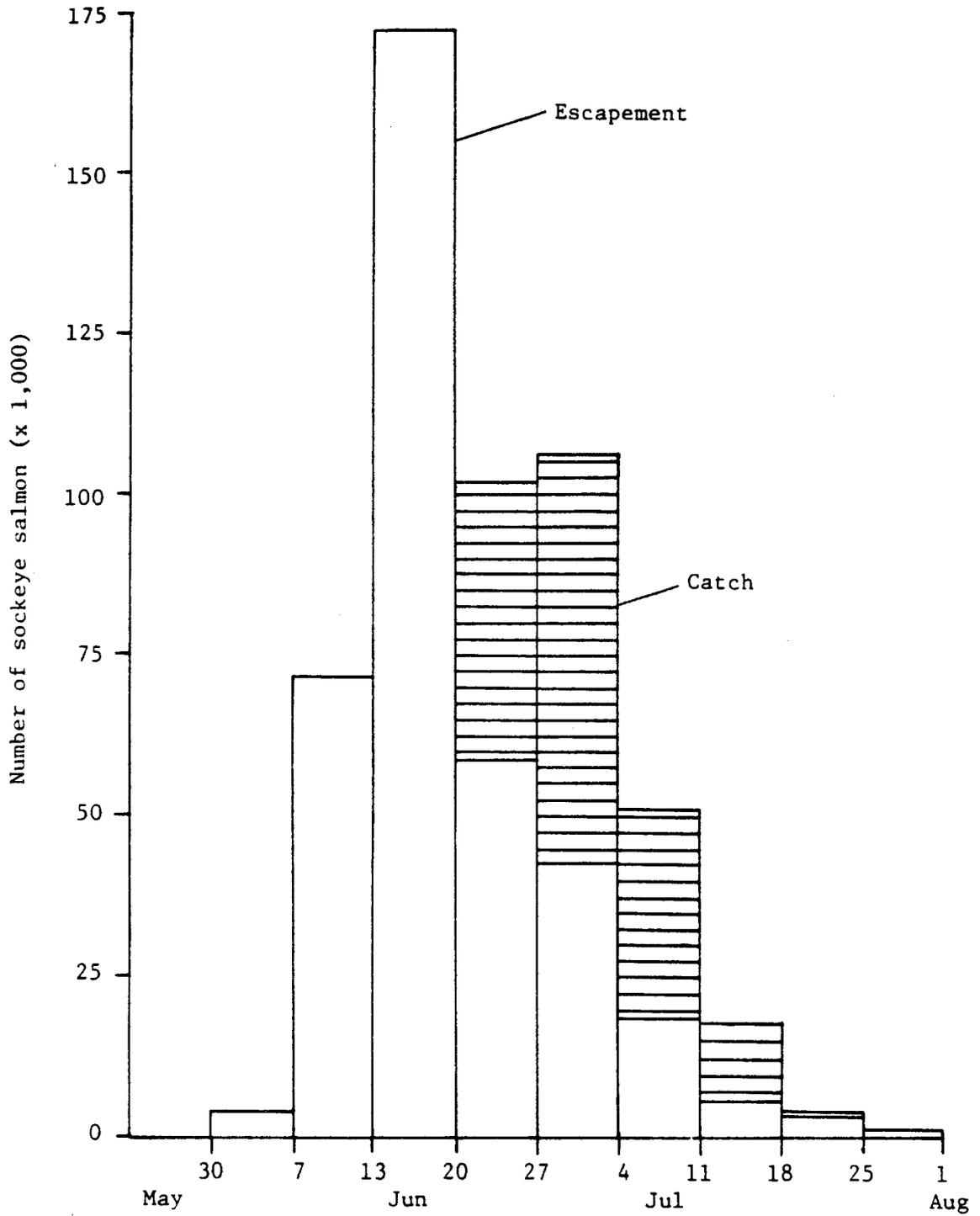


Figure 25. Relative timing and magnitude of Fraser Lake sockeye salmon escapement and catch. Escapement recorded at Fraser weir. Catch timing was adjusted to include estimated migration time from fishery to weir.

Table 13. Number of days required by tagged Fraser Lake sockeye salmon to migrate from major fisheries of the Kodiak archipelago to the Fraser Lake weir.

Fishery area	Days to migrate from fishing area to weir	
	\bar{X}	n
E. Afognak Section Kizhuyak Section	21.0	3
Uganik Bay District and Ugak-Karluk District	15.7	23
Red River District	13.9	32
Cape Alitak District and Moser-Olga Bay Section and Deadman-Portage Section	11.3	145

positioned as close to the beach as possible. In moderate weather the skiff rides the crest of breaking waves within a few yards of the beach. Under these conditions it is doubtful that any sockeye salmon pass the shore end.

Nets are set about every quarter mile along the entire beach. Because the number of boats engaged in the fishery exceeds the beach space available, many wait in turn at favored sites to begin setting as soon as the preceding boat begins closing its net. Consequently, nets are in place continuously at quarter-mile intervals during the entire daylight period when weather permits.

Regulations allow the nets to be held open indefinitely for intercepting and accumulating fish, but by convention among the fishermen, holding time is limited to one hour when boats are waiting to set. The area from just south of the river mouth to 1.5 miles north is closed to fishing.

With the seines at such close intervals, any sockeye salmon traveling along the beach would soon encounter a net and be caught. If this were the case, the first seine in line would catch fish and the others would not, but because all seining sites are productive, sockeye salmon must continuously recruit to the beach throughout its length.

Our tagging was done from seine boats engaged in this fishery. The fish were dipnetted from the closed bunt of the seine, tagged, and released on the spot where the seine haul was completed. If these fish had traveled along the beach after release, they would have probably all been caught by the next seine; however, the data showed that the tagged fish escaped the fishery and passed the Red River weir at nearly the same rate as did fish tagged well north of the Red River fishery. Clearly, many of the tagged sockeye salmon did not travel along the beach but moved offshore.

This apparent onshore-offshore movement along the Red River beach is well known to fishermen of the area. During interviews, several expressed the belief that sockeye salmon travel toward Red River primarily through offshore waters but periodically move to the beach at a steep angle and then return offshore with little travel along the beach. Whether this apparent behavior is a reaction to the nets is not known, but it seems to be an effective means for sockeye salmon to avoid the fishery and yet maintain orientation to the shoreline on final approach to the river mouth.

Comparison of Tagging Results with Scale Pattern Analysis

Scales were collected from most sockeye salmon tagged in this study. The scale circulus patterns were analyzed and compared with scale samples collected from the major sockeye salmon systems in the Kodiak, Cook Inlet, and Chignik areas (Conrad 1984).

The scale pattern analysis agreed generally with tagging results. Both methods were handicapped by the small sample sizes, which, in most experiments, limited the conclusions to listing the stocks present in the samples. In a few experiments where a single stock dominated the sample, the comparison was stated more confidently. This was true for the Cape Alitak experiments in which most of

the tagged sample was of Fraser Lake origin. Fraser Lake stock also dominated the sample at Moser Peninsula on 14 June. Even though many of the fish tagged in these experiments were intercepted by the Moser-Olga Bay gillnet fishery, their destination can be inferred reliably because of the highly terminal nature of the Moser-Olga Bay fishery on Olga Bay stocks. Tag returns from a terminal fishery such as this have nearly the same conclusive value as do stream recoveries in identifying the destinations of the fish.

Scale pattern analysis appears to offer the best potential for determining stock composition in the Kodiak area fishery because the results can be quantified and are not influenced by tag loss and selective predation, as are the results from tagging. This is potentially advantageous in evaluating the extent of interception by the fishery of stocks originating from distant areas such as Cook Inlet and Chignik.

Some of the results of the scale pattern analysis were questionable, such as the identification of the 1.3 age class¹ samples from Uyak Bay as consisting of 80% Afognak River stock and the identification of more than 50% of the samples from Ugak Bay (Saltery Cove), as consisting of Chignik stocks. These apparent anomalies may be clarified once the minor Kodiak stocks are included in the classification model (Conrad 1984).

If information about migration rates is important to any future investigations, then tagging or other means of marking will be necessary. Only by tagging may individual fish be tracked throughout the experiment.

SUMMARY AND CONCLUSIONS

1. During June 1981, 3,109 maturing sockeye salmon were tagged at 20 locations along the northeast, west, and south coastlines of Kodiak Island and from southeast and southwest Afognak Island with one-inch diameter Peterson disc tags in various color combinations, each specific to a date and place of tagging. In all, 177 tags were recovered from the seine fishery, 597 from the gillnet fishery, and 576 were identified as they passed the counting weirs at the five major sockeye salmon streams in the Kodiak area. The large number of sight recoveries from the weirs resulted from the use of highly visible, large-diameter tags and from low, clear water conditions which added visibility.
2. The relatively small number of returns from the seine fishery was partly due to withholding of tags by fishermen, possibly in order to influence the results. The large number of returns from the gillnet fishery may also represent an effort to influence the results.
3. Sockeye salmon tagged along the northwest and west coasts showed strong southward movement to the systems supporting the largest sockeye salmon runs which were the Karluk, Red, Fraser, and Upper Station Lakes. The

¹ One year in freshwater, three-plus years in salt water.

occurrence of Red River stocks along the northwest coast was considerably greater than reported from tagging before 1950. This difference probably reflects changed stock sizes, i.e., smaller in Karluk River and larger in Red River, Fraser Lake, and Upper Station.

4. The recovery of tagged sockeye salmon in Olga Bay from tagging along the southwest coast between Sturgeon Head and Cape Ikolik averaged 57%. The recovery of Olga Bay stocks from tagging in the Red River area between Bumble Bay and Gold Beach averaged 16%. Recoveries in Olga Bay represented only 5% of tagged samples within two miles of Red River and 37% of samples 2-15 miles from Red River. The Olga Bay percentages would have been reduced for the Red River area if seiners had not purposefully retained tags.
5. Olga Bay stocks composed 96% of sockeye salmon tagged at Cape Alitak and Moser Peninsula, which is about the same rate reported from all previous tagging.
6. Olga Bay stocks migrated principally down the west coast of Kodiak Island.
7. The estimated catch of Fraser Lake sockeye salmon during June was 151,571. The catch composed 29% of the total Fraser run of 529,287.
8. Karluk River stocks approached mainly from the north and did not occur in appreciable numbers south of Halibut Bay.
9. Sockeye salmon stocks from Cook Inlet and Chignik were mixed with Kodiak area stocks primarily at the north end and secondarily at the south end of Kodiak Island. The percentage of outside stocks in recoveries from all sockeye salmon tagged in 1981 was low, but from individual experiments in the Marmot Bay - Raspberry Island area the percentage was substantial, 27-73%.

RECOMMENDATION FOR FURTHER SOCKEYE SALMON TAGGING

The composition of Alitak stocks should continue to be monitored by tagging and scale pattern analysis if the stocks increase appreciably or if commercial fishing is allowed in the lower southwest Kodiak or southwest Afognak management units.

Additional tagging and scale pattern analysis should be done to determine the composition of stocks in the east Afognak management unit as it is likely that Cook Inlet and Chignik stocks would be abundant there during June-July. It should be noted that in the east Afognak unit a June fishery has not been allowed since 1970 and the incidental harvest of sockeye salmon during the June-August pink salmon fishery has averaged 8,360 in the past decade.

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