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MIGRATIONS OF SALMON IN NORTON SOUND, ALASKA DETERMINED BY TAGGING IN 1978-1979

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ABSTRACT

Chum *(Oncorhynchus keta)*, pink *(O. gorbuscha)*, and chinook *(O. tshawytscha)* salmon were tagged during 1978 and 1979 in Norton Sound to determine stock mixing and migration of salmon in the six commercial fishery subdistricts in the Norton Sound District. A total of 4,406 fish was tagged during the 2 years with 639 recaptured. The direction of travel at time of capture, sex composition of tagging catches, percent recapture by user groups, and the number of days at large after tagging are discussed and used to hypothesize migration routes. The feasibility of separation of stocks by run timing is also investigated. Results show that four of the six subdistricts appeared to harvest stocks indigenous to the subdistrict while two subdistricts harvested mixed stocks, including chum and chinook salmon bound for the Yukon River.

INTRODUCTION

The Norton Sound commercial salmon fishery is composed of six subdistrict fisheries (Figure 1). Each subdistrict is centered around one of the main villages and is usually near a primary salmon producing stream. An exception is the Nome Subdistrict which has no single major spawning stream but rather several streams each with smaller spawning populations. Subdistrict boundaries were established by assuming that the catch in each subdistrict was primarily composed of fish from the streams in that subdistrict. However, since salmon tend to follow the coastline as they return we postulated that the fisheries in the Sound may be intercepting salmon bound for other fisheries both in and outside of the Norton Sound District. Support for this hypothesis comes from catch data that indicates harvests from the other fisheries, particularly the Nome Subdistrict, exceed that which would normally be expected from the local spawning stocks. If true, management must either eliminate these interceptions or account for them in production statistics.

The effectiveness of salmon management depends upon the degree to which the harvest rates on separate salmon stocks can be controlled. A salmon stock, for management purposes, can be considered to be a conspecific spawning population in a single river system or tributary of a river system.

Achieving optimum yield harvests for individual stocks in large coastal fishing districts where many stocks mix on their return to home streams is difficult. Tag and recovery techniques were chosen to study the extent of mixing and fisheries interception of stocks within Norton Sound.

A 2-year tagging program was initiated by the Alaska Department of Fish and Game (ADF&G) in 1978 to identify the amount of stock interception within the six subdistricts of Norton Sound and between the adjacent districts of Kotzebue, Port Clarence, and the Yukon River. This report summarizes results obtained during the 2-year project.

Historical Background of Fisheries

After the inception of statehood for Alaska in 1959, fisheries management responsibilities were shifted from Federal control to the ADF&G in 1960. Surveys conducted by State biologists at the time indicated that there were harvestable surpluses of salmon in Norton Sound that could be used to support a commercial fishery. Prior to this time the principal use of salmon, primarily by the 18,000 Eskimo residents of the area, was for subsistence. Most residents of the area have traditionally utilized, and continue to use, the fish and game resources for subsistence.

Salmon Resources

Five species of Pacific salmon occur in Norton Sound. Pink *(Oncorhynchus gorbuscha)* and chum salmon *(O. keta)* comprise the majority of the returns followed by coho *(O. kisutch)* and chinook salmon *(O. tshawytscha)*. Sockeye salmon *(O. nerka)* are present only in small numbers. Since the start of commercial operations, subsistence usage has declined which has led to an

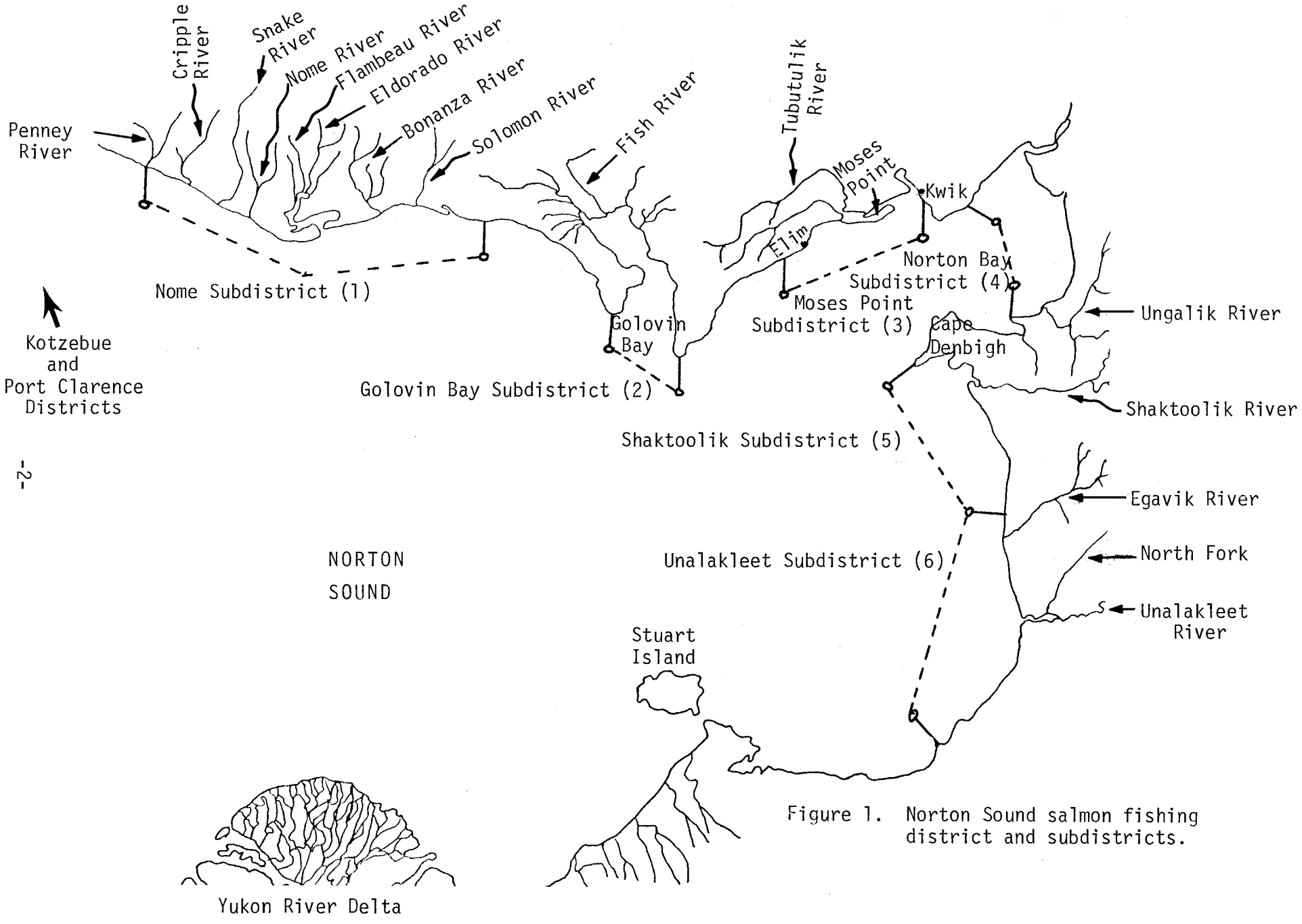


Figure 1. Norton Sound salmon fishing district and subdistricts.

increased commercial utilization in recent years. Early commercial interest was in chinook and coho salmon; chum salmon are now the primary target. It is believed that most chum and chinook salmon populations are fully utilized and increased commercial exploitation in the future will depend upon long-term increases in annual abundance. Pink salmon, while abundant, are not fully utilized at present.

Fisheries Description

Both commercial and subsistence fishermen use set gill nets as the major salmon harvest gear. The commercial fisheries take place in the coastal marine waters, usually within a few hundred meters of shore. Nets can have a maximum aggregate length of 183 m (100 fm) per fishermen. There are no mesh or depth restrictions. A majority of the gill nets fished are 14 mm (5-1/2 in) stretched mesh measure, but 11.5 mm (4-1/2 in) stretch is also used. A net of 21.5 mm (8-1/2 in) stretch measure is commonly used for chinook salmon. Subsistence fishermen will in addition to gill nets, operate beach seines in the main rivers.

The commercial salmon fishing season normally begins after 15 June, although the first commercial landings are not made until late June when fish arrive in harvestable numbers. The season closes by regulation on 31 August. A total of 204 limited entry salmon permits are issued for Norton Sound. Two 48-hour fishing periods normally occur each week in all subdistricts, except in the Moses Point Subdistrict, unless decreased or increased by emergency order.

Management Areas

The Norton Sound Districts is located between the Seward Peninsula and the Yukon-Kuskokwim Delta. It includes all waters from Canal Point Light north to Cape Douglas. The district is divided into six subdistricts: Nome (Subdistrict 1), from Penny River to Topkok Head; Golovin Bay (Subdistrict 2), from Rocky Point to Cape Darby; Moses Point (Subdistrict 3), from Elim Point to Kwik River; Norton Bay (Subdistrict 4), from Kuluktulik River to Island Point; Shaktoolik (Subdistrict 5), from Cape Denbigh to Junction Creek; and Unalakleet (Subdistrict 6), from Junction Creek to Black Point. Each of these subdistricts contain at least one major salmon spawning stream.

METHODS

Tagging Methods

Set gill nets were used to capture salmon for tagging at all sites in 1978 and 1979. Each tagging crew fished a maximum of two 91.5 m (50 fm) shackles of gill net from a 6.4 m (21 ft) skiff depending on weather and their ability to successfully process the salmon. Nets were set perpendicular to the beach, usually just beyond the breaking surf, and in water deep enough to allow most of the net to fish.

The net was worked a minimum of twice per hour to remove, examine, and tag the salmon. During periods of extremely large catches, salmon were removed

from the net and placed in a holding tank. During heavy fishing two tanks were required for each boat; one to hold the fish prior to tagging and one for use as a recovery tank.

A numbered, Peterson-type disk tag with a reward legend was attached slightly below and behind the dorsal fin on one side with a blank disk used as backing on the opposite side. Different colored tags were used at each tagging location. For each fish tagged, the date, location, species, sex, and direction of travel at time of capture were recorded.

Locations and Gear Size

Five tagging locations were used in 1978. Three sites in the Nome Subdistrict: Fort Davis (4.8 km or 3 mi east of Nome), 6-Mile Beach (9.6 km east of Nome), and Hastings Creek (16 km or 10 mi east of Nome). The two other locations were in the Unalakleet Subdistrict 4.8 km (3 mi) south and 4.8 km north of the river entrance. Table 1 gives the fishing times and gear size used.

Four tagging sites were used during 1979. Only the Fort Davis site was used in the Nome Subdistrict and the mesh size was decreased in order to increase the catch of smaller female chum salmon. The same sites were used in the Unalakleet Subdistrict. From 14 June to 27 June, 21.5 mm (8-1/2 in) stretched mesh was used at the north site to capture chinook salmon. From 27 June to 16 July, 15 mm (5-7/8 in) stretched mesh was used. An additional site was established in the Shaktoolik Subdistrict on the north side of the entrance to the Shaktoolik River.

Tag Recovery

The tag legends offered a $1.00 reward for return. Arrangements were made with Norton Sound fish processors to collect the date and location of capture and to pay the reward to commercial fishermen. Several radio announcements were broadcast and posters displayed in the villages to encourage return of the tags from subsistence and sport fishermen. Each major salmon stream in the area was ground surveyed at least once.

Recovery Analysis

Recaptures from the commercial fishery were not used if the fish was captured on the same day of tagging or on the day following tagging. This allowed fish one day to recovery from the effects of tagging and resume their migrational pattern.

However, fish recaptured the same or following day of tagging that had entered rivers or made substantial movements (recaptured in another district) were included in the analysis.

RESULTS

Tagging

A total of 4,406 fish was tagged during 1978 and 1979; 2,446 during 1978 and

Table 1. Gillnet mesh sizes (stretch) used and time fished during both years of the study.

Year		LOCATION					
		NOME SUBDISTRICT			UNALAKLEET SUBDISTRICT		SHAKTOOLIK SUBDISTRICT
		Ft. Davis	6 Mile Beach	Hastings Creek	Unalakleet North	Unalakleet South	Shaktoolik
	1978	15 mm (5-7/8 in) 20 June to 16 July	15 mm (5-7/8 in) 20 June to 16 July	15 mm (5-7/8 in) 20 June to 16 July	15 mm (5-7/8 in) 19 June to 14 July	15 mm (5-7/8 in) 19 June to 14 July	No fishing
	1979	13.5 mm (5-3/8 in) 20 June to 14 July	No fishing	No fishing	21.5 mm (8-1/2 in) 14 June to 27 June 15 mm (5-7/8 in) 28 June to 16 July	15 mm (5-7/8 in) 14 June to 16 July	13.5 mm (5-3/8 in) 14 June to 16 July

1,960 during 1979. This included 2,493 pink salmon, 1,693 chum salmon, 218 chinook salmon, 2 sockeye salmon, and 1 whitefish. The total number of fish tagged by location and species are presented in Table 2 for 1978 and Table 3 for 1979. During both years more pink salmon were tagged than chum salmon (1,305 pink salmon and 1,081 chum salmon in 1978; 1,188 pink salmon and 612 chum salmon in 1979). Of the total 218 chinook salmon, 59 were tagged in 1978 using 15 mm (5-7/8 in) stretched mesh, and 159 in 1979 when 21.5 mm (8-1/2 in) mesh was used part of the time.

During 1978 more salmon were tagged in the Unalakleet Subdistrict (1,526) than in the Nome Subdistrict (920). During 1979 the Unalakleet Subdistrict was again the highest with 1,005 fish captured and tagged with two nets while in the Shaktoolik Subdistrict a total of 763 fish were captured and tagged with one net. In the Nome Subdistrict a total of only 192 fish were captured and tagged.

Daily tagging results and commercial catch per unit effort (CPUE) for 1978 and 1979 by location and species are presented in Appendix Tables 1, 2, and 3 and catches are graphed with the CPUE in Figures 2 to 6. Many sampling days were lost to storms and the catches made on other days were typically not proportional to the abundance in the commercial fishery. During 1978, 8 out of 27 sampling days were lost to storms in the Nome Subdistrict while only 3 out of 27 were lost in the Unalakleet Subdistrict. In 1979, 13 of 25 days were lost in the Nome Subdistrict, 10 out of 32 in the Unalakleet Subdistrict, and 13 out of 26 at the Shaktoolik Subdistrict.

The peak date of tagging in 1978 for all species combined occurred on 11 July in the Nome Subdistrict and 12 July in the Unalakleet Subdistrict. The peak tagging date for chum salmon in the Nome Subdistrict was 25 June and for chum salmon in the Unalakleet Subdistrict, 3 July. The peak tagging date for pink salmon in the Nome Subdistrict was 11 July and for pink salmon in the Unalakleet Subdistrict, 5 July. The peak tagging date for chinook salmon in the Unalakleet Subdistrict was 24 June (none were caught in the Nome Subdistrict).

The peak date of tagging in 1979 for all species combined occurred on 12 July in the Nome Subdistrict, 9 July in the Unalakleet Subdistrict, and 28 June in the Shaktoolik Subdistrict. The peak tagging date for chum salmon was 27 June in the Nome Subdistrict and 9 July in the Unalakleet and Shaktoolik Subdistricts. The peak tagging date for pink salmon was 12 July in the Nome Subdistrict, 9 July in the Unalakleet Subdistrict, and 29 June in the Shaktoolik Subdistrict. The peak tagging date for chinook salmon was 21 June in both the Unalakleet and Shaktoolik Subdistricts (no chinook salmon were tagged in the Nome Subdistrict).

Direction of Travel at Time of Capture

Overall direction of travel at time of capture is tabulated in Table 4 for 1978 and 1979. The results for the Nome Subdistrict in 1978 are shown from the most westerly site (Fort Davis) to the most easterly site (Hastings Creek). Chum salmon in 1978 were primarily heading eastward at the Fort Davis and 6-Mile Beach sites while at the most easterly site (Hastings Creek) they approached the net equally from either side (54% heading east, 46% heading west). The pink salmon followed the same general direction of migration.

Table 2. Total number of fish tagged during 1978 in Norton Sound by species and location.

SPECIES	Nome Subdistrict			Unalakleet Subdistrict		TOTALS
	Ft. Davis	6 Mile Beach	Hastings Cr.	Unalakleet N.	Unalakleet S.	
Pink	156	194	146	351	458	1,305
Chum	143	120	160	303	355	1,081
Chinook	0	0	1	16	42	59
Sockeye	0	0	0	0	1	1
Whitefish	0	0	0	0	0	0
TOTALS	299	314	307	670	856	2,446
	920			1,526		

Table 3. Total number of fish tagged during 1979 in Norton Sound by species and location.

SPECIES	Nome Subdistrict			Unalakleet Subdistrict		Shaktoolik Subdistrict	TOTALS
	Ft. Davis	6 Mi.Beach	Hastings Creek	Unalakleet North	Unala-kleet So.	Shaktoolik	
Pink	119	1	0	318	248	502	1,188
Chum	68	3	0	129	175	237	612
Chinook	1	0	0	107	27	24	159
Sockeye	1	0	0	0	0	0	1
Whitefish	0	0	0	0	1	0	1
TOTALS	189	3	0	554	451	763	1,960
	192			1,005		763	

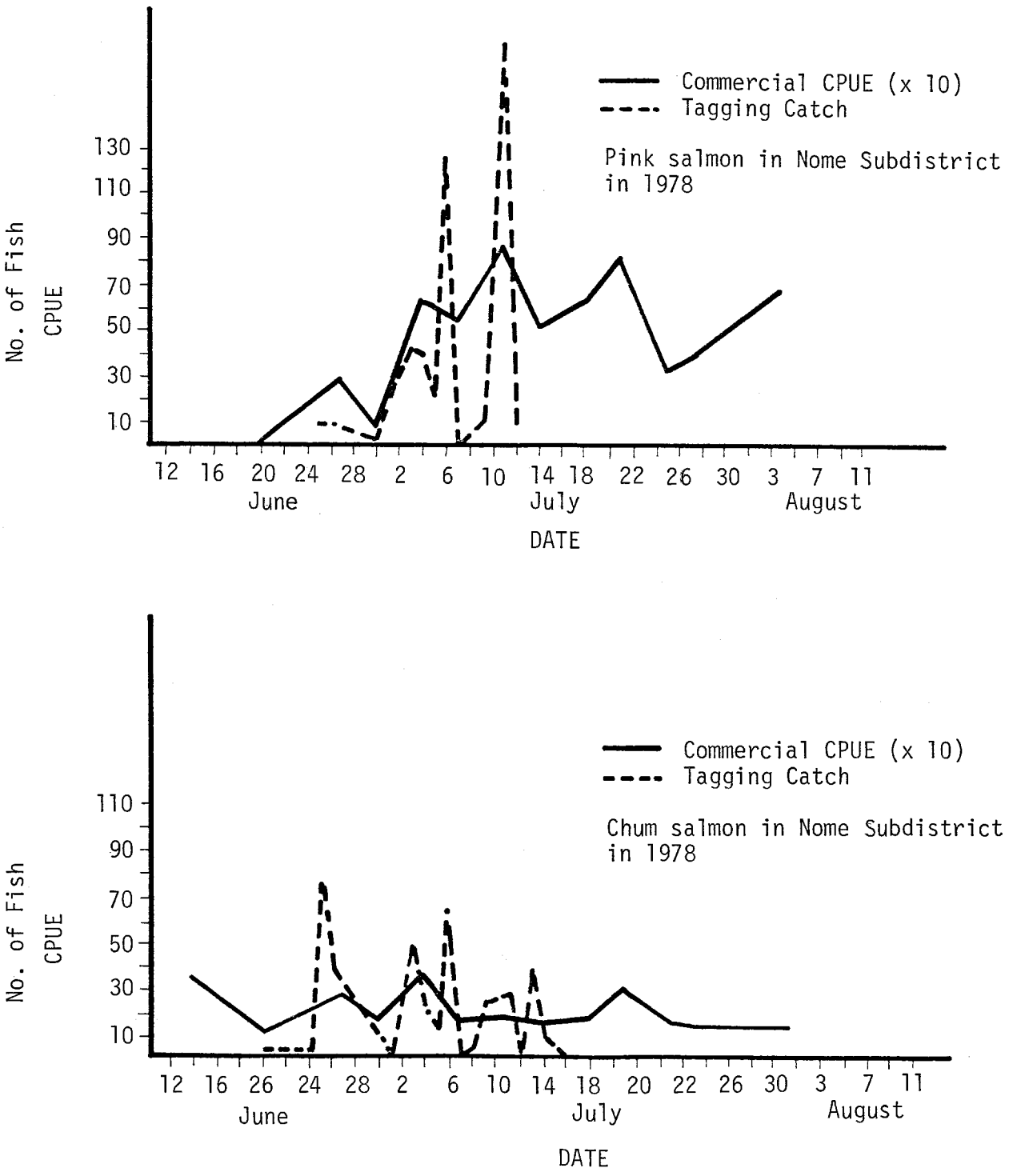


Figure 2. Daily catches at the tagging site and commercial CPUE in the Nome Subdistrict for chum and pink salmon in 1978.

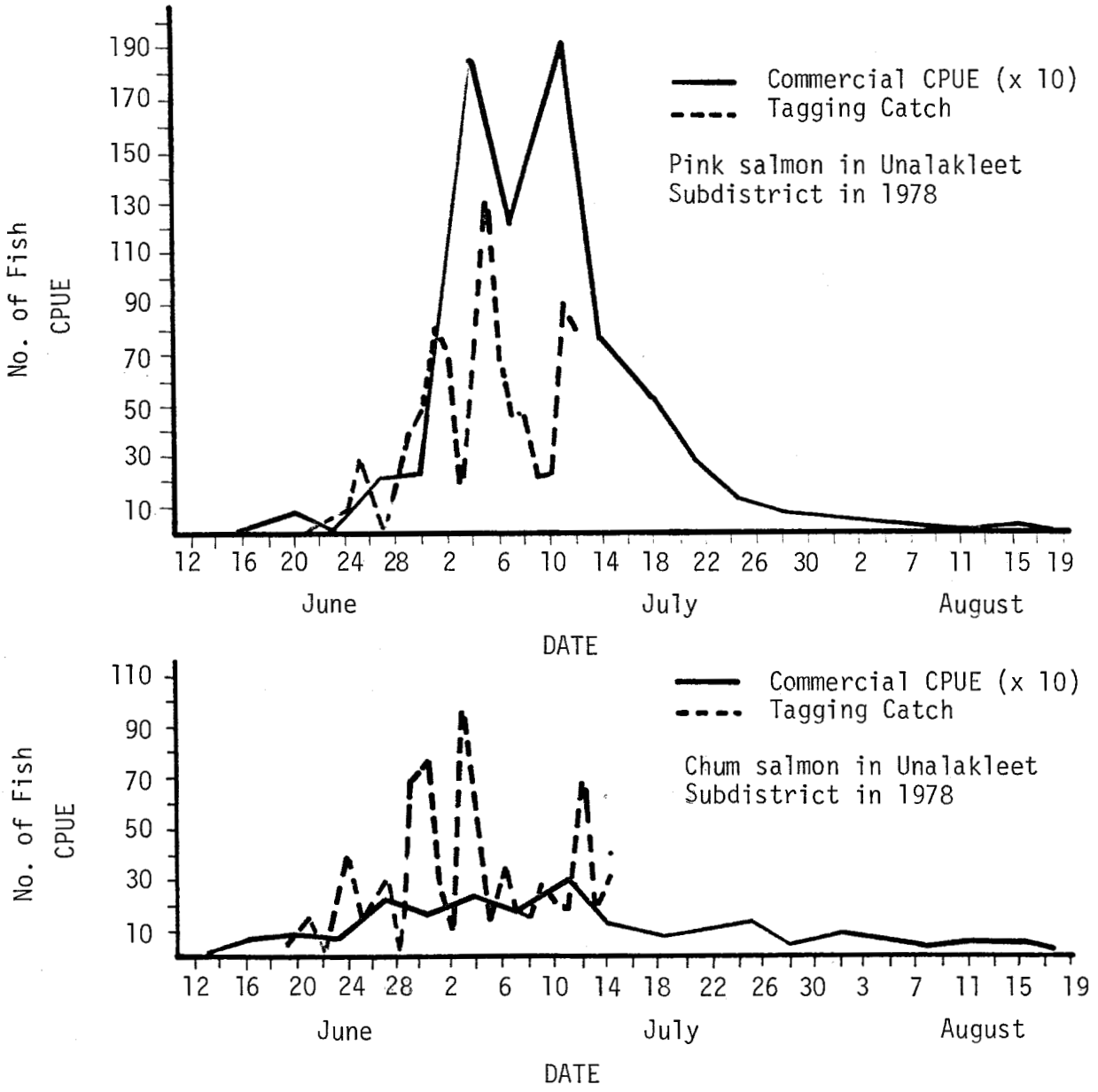


Figure 3. Daily catches at the tagging site and commercial CPUE in the Unalakleet Subdistrict for chum and pink salmon in 1978.

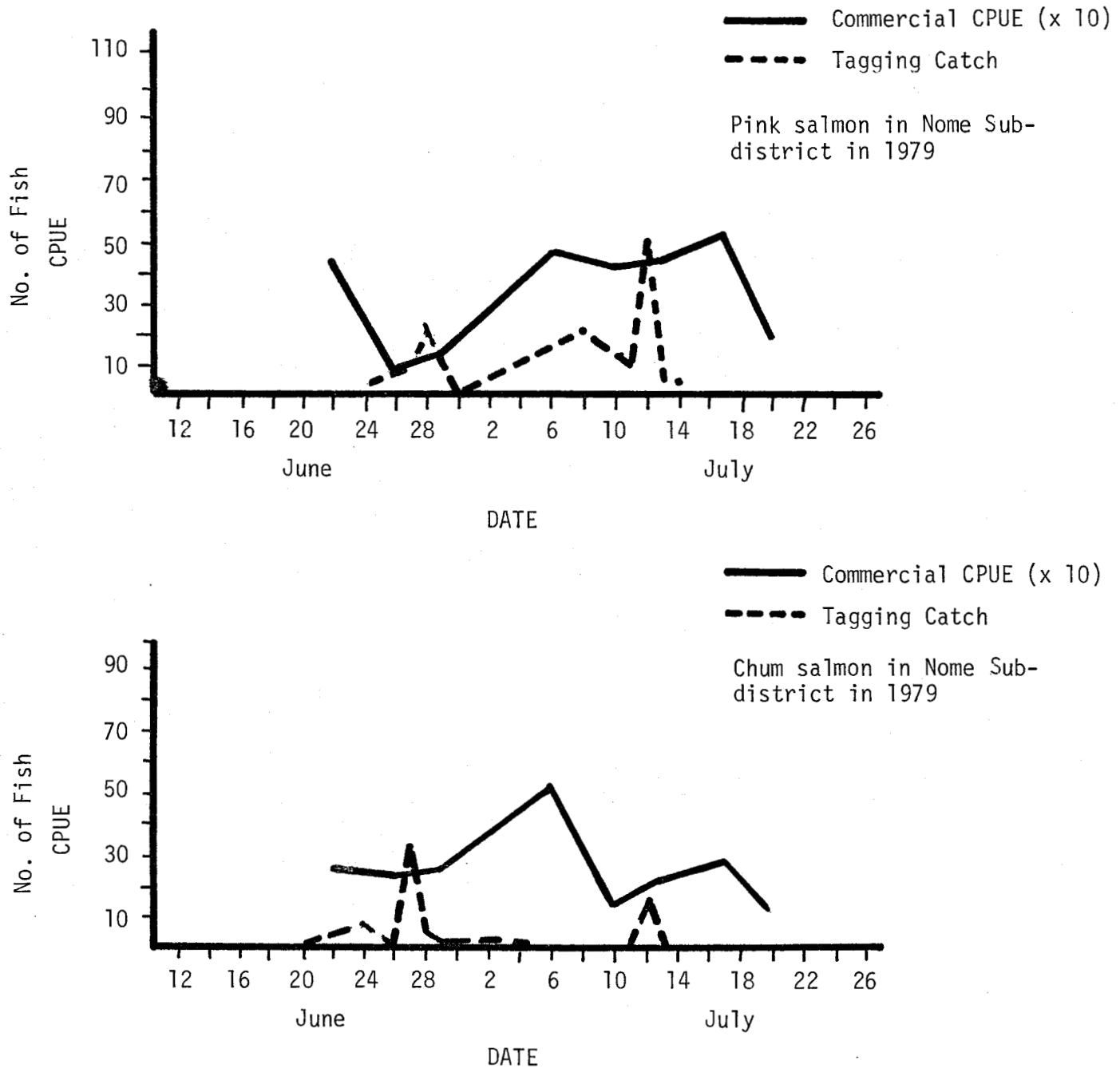


Figure 4. Daily catches at the tagging site and commercial CPUE in the Nome Subdistrict for chum and pink salmon in 1979.

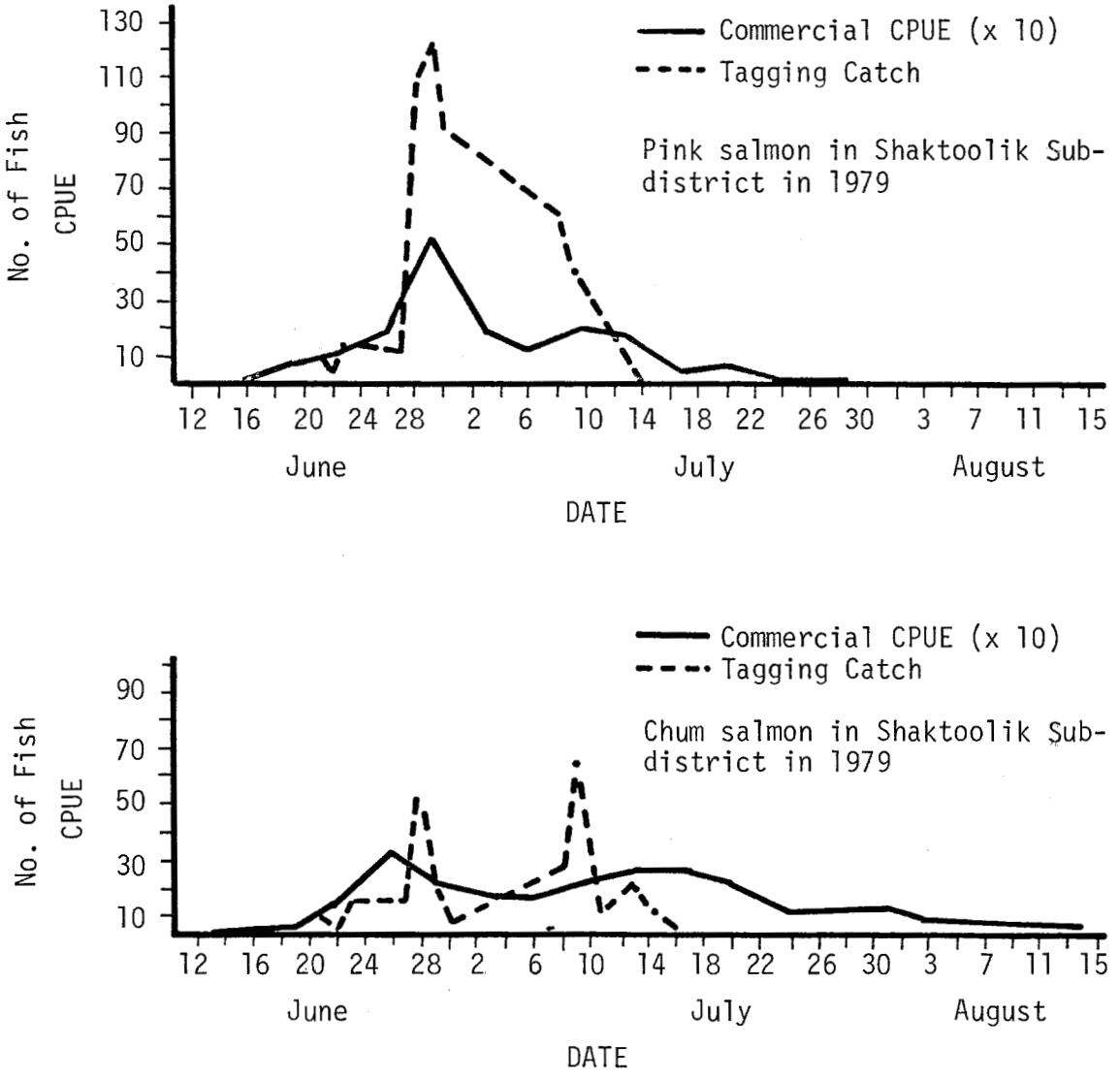
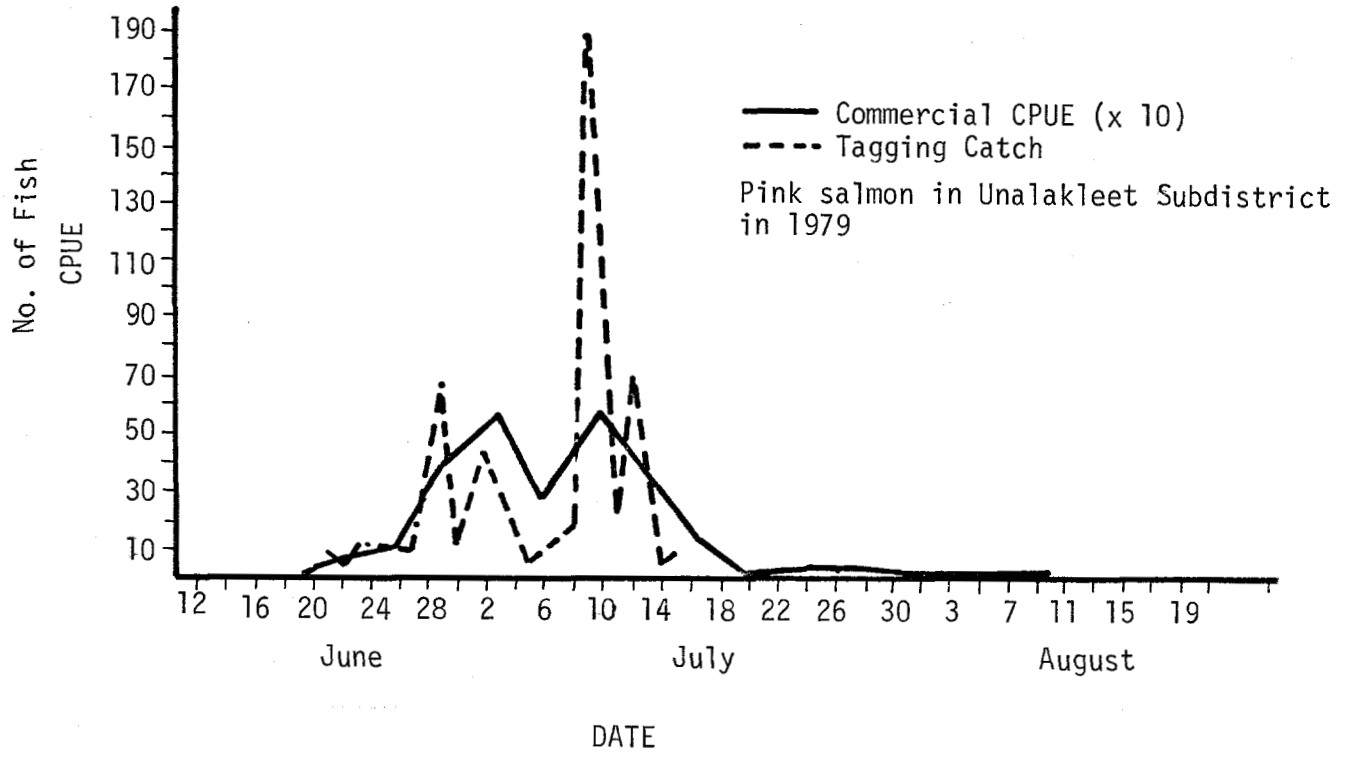


Figure 5. Daily catches at the tagging site and commercial CPUE in the Shaktoolik Subdistrict for chum and pink salmon in 1979.



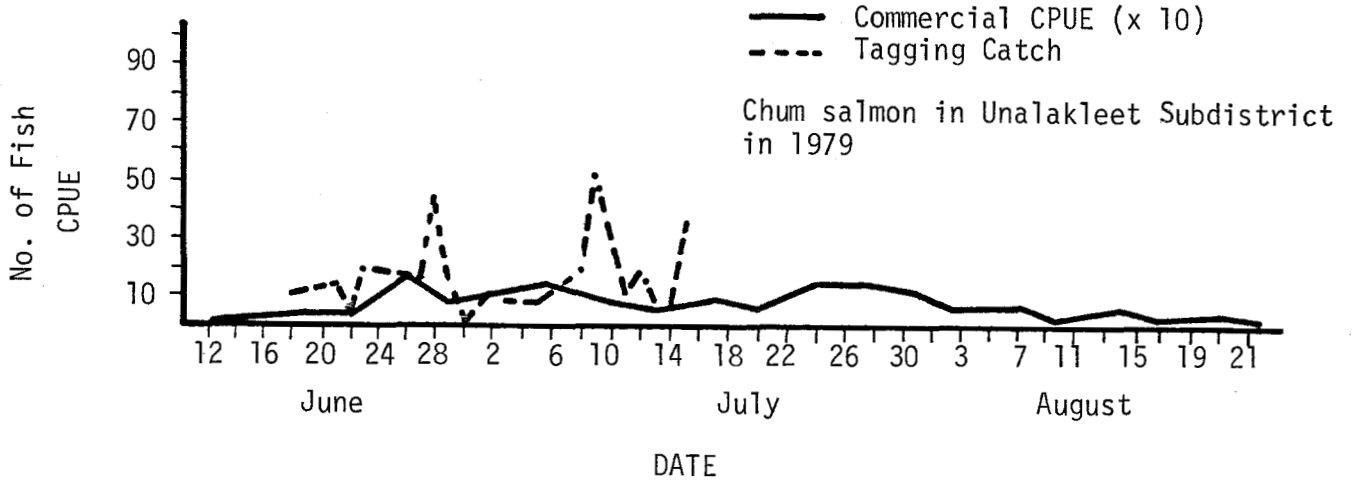


Figure 6. Daily catches at the tagging site and commercial CPUE in the Unalakleet Subdistrict for chum and pink salmon in 1979.

Table 4. Directional movement by site, as indicated from set gillnet catches in percent for chum, pink, and chinook salmon in Norton Sound during 1978 and 1979.

Year	Approaching from	NOME SUBDISTRICT						Approaching from	SHAKTOOLIK SUBDISTRICT			UNALAKLEET SUBDISTRICT					
		Fort Davis		6 Mi Beach		Hastings Cr.			Shaktoolik			Unalakleet North			Unalakleet South		
		Chum	Pink	Chum	Pink	Chum	Pink		Chum	Pink	Chinook	Chum	Pink	Chinook	Chum	Pink	Chinook
1978	East	71	81	70	93	54	44	North				4	8	3	100	100	100
	West	29	19	30	7	46	56	South				96	92	97	0	0	0
1979	East	88	95					North	55	63	58	27	35	12	83	95	81
	West	12	5					South	45	37	42	73	65	88	17	5	19

In the Unalakleet Subdistrict in 1978, the majority of all species captured at the north site were heading in a southerly direction, while at the south site, 100% of all species were captured while heading in a northerly direction.

Tagging occurred at only the most westerly site (Fort Davis) in the Nome Subdistrict in 1979. The majority of the pink and chum salmon were again heading east. In the Unalakleet Subdistrict, fish of both species captured at the north site were again predominantly moving to the south while fish at the south site were again moving predominantly to the north. At the Shaktoolik Subdistrict site, the predominant movement was towards the north for all three species.

Daily directional movement of fish was also plotted in Figures 7 through 11 for all sites and both years. Pink salmon in the Nome Subdistrict (Figure 7) in 1978 were mostly captured while moving to the east at the westernmost tagging locations, but at Hastings Creek approximately equal numbers were captured moving west and east. The majority of the chum salmon in the Nome Subdistrict were captured while moving both to the west and east. They were captured while moving to the west until July at the Fort Davis and 6-Mile Beach locations. Directionality of chum salmon at the Hastings Creek site was difficult to establish. The daily directional movement was predominantly east for both chum salmon and pink salmon at the Fort Davis site (Figure 8) in 1979 (Fort Davis was the only location in the Nome Subdistrict in 1979).

All species at the Unalakleet South site in 1978 were captured while moving in a northerly direction (Figure 9). Movement was southerly at the North site with significant northerly movement on only 1 day at the beginning of the season for chum salmon and virtually no northerly movement for chinook salmon. Pink salmon were also predominantly moving to the south at this location.

Direction of movement in 1979 at the Unalakleet South site (Figure 10) was again predominantly north for all species with chum salmon showing a small southerly component throughout the season. Pink salmon showed little southerly movement while chinook salmon showed a southerly movement on only 2 days. The predominant direction of movement at the Unalakleet North site in 1979 was southerly for chum, pink, and chinook salmon. Chum and chinook salmon showed no preference in direction throughout the 1979 season in the Shaktoolik Subdistrict (Figure 11). Pink salmon tended to move in a more northerly direction at this location.

Sex Composition

The sex composition of fish captured at the tagging sites during 1978 and 1979 is presented in Table 5. Sex composition results are a function of the mesh size used to capture salmon. Almost all pink salmon tagged in both years were males, around 97%. Chum salmon sexes captured were approximately even except in the Nome and Shaktoolik Subdistricts in 1979 when the majority captured were females. Chinook salmon sexes in 1978 were captured at approximately equal rates at the Unalakleet Subdistrict North site but females predominated at the South site. A switch to larger mesh in 1979 for part

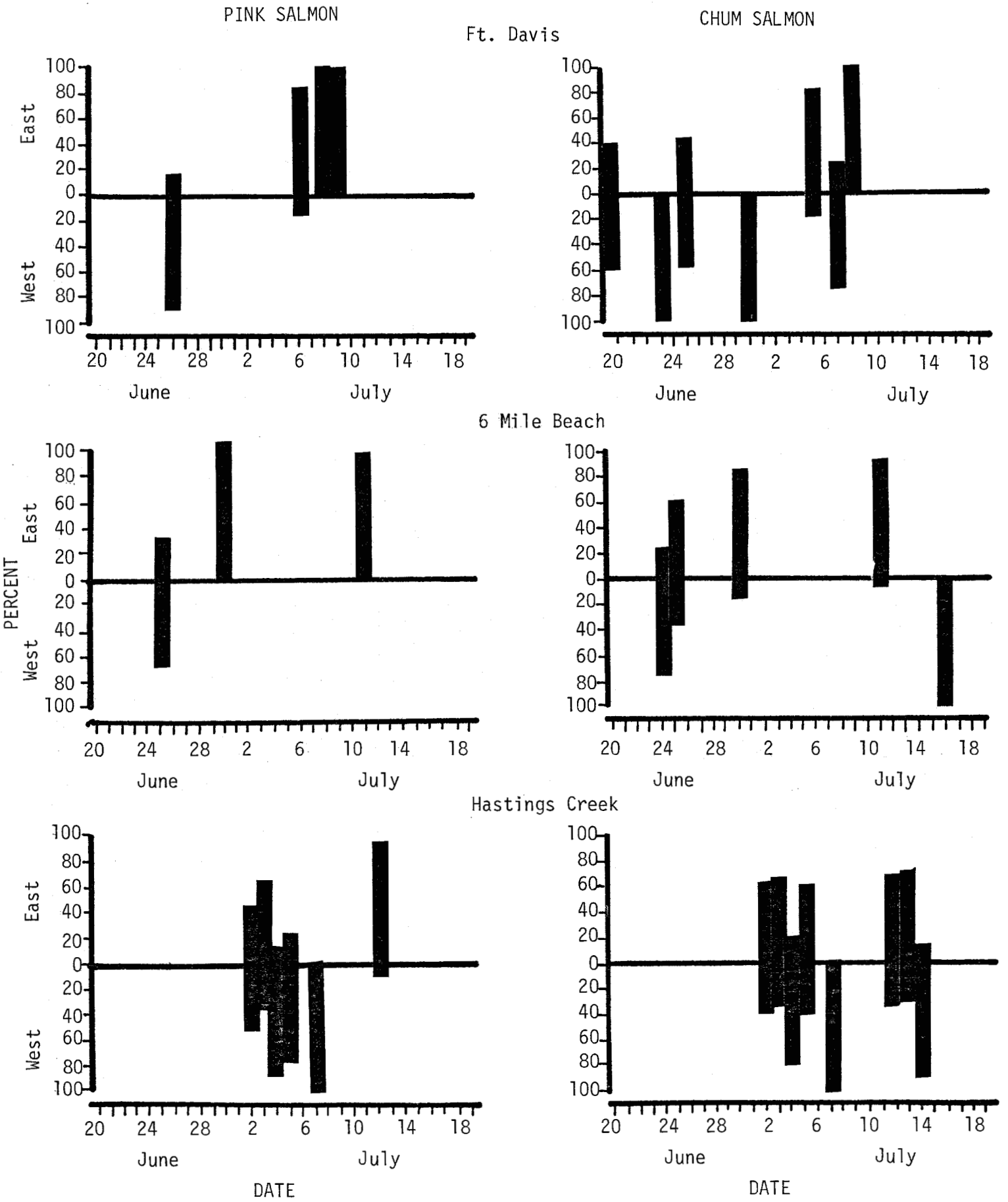


Figure 7. Daily swimming direction of pink and chum salmon in the Nome Subdistrict during 1978.

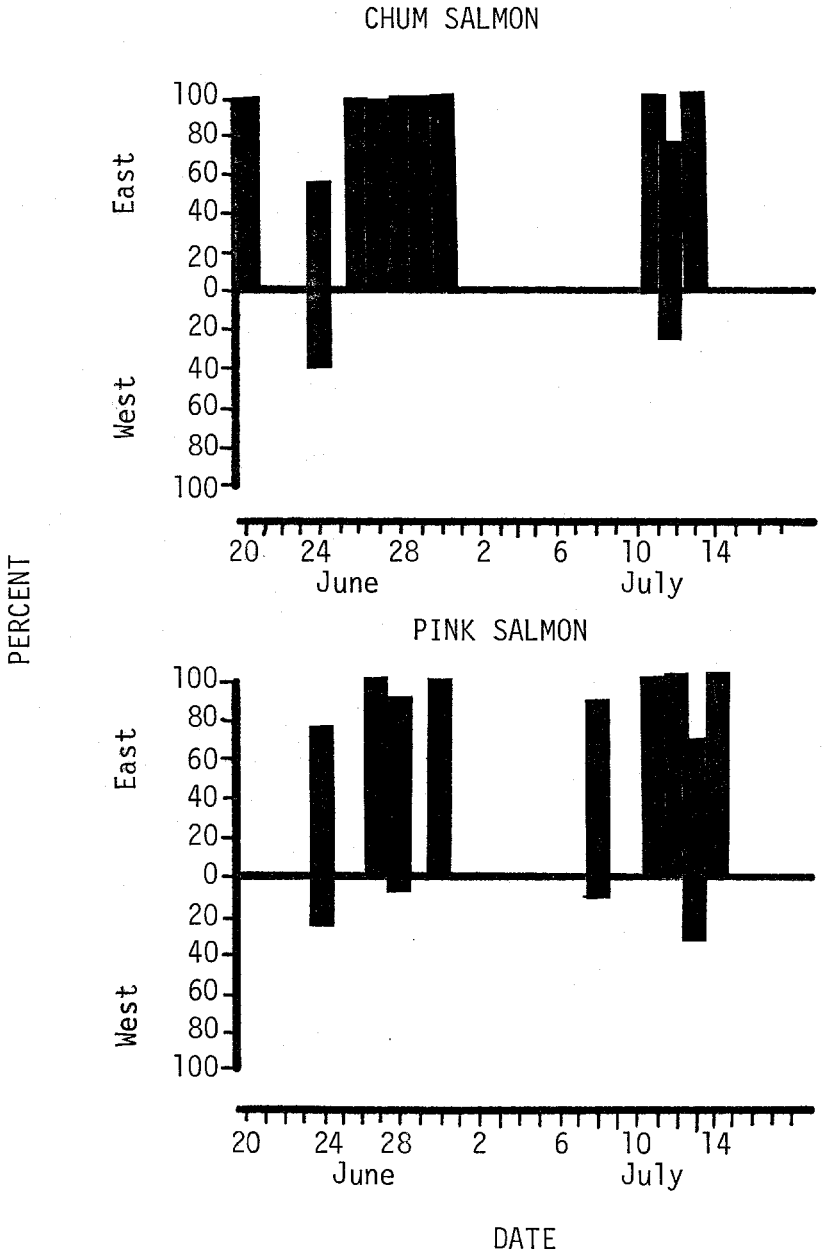


Figure 8. Daily swimming direction of pink and chum salmon in the Nome Subdistrict during 1979.

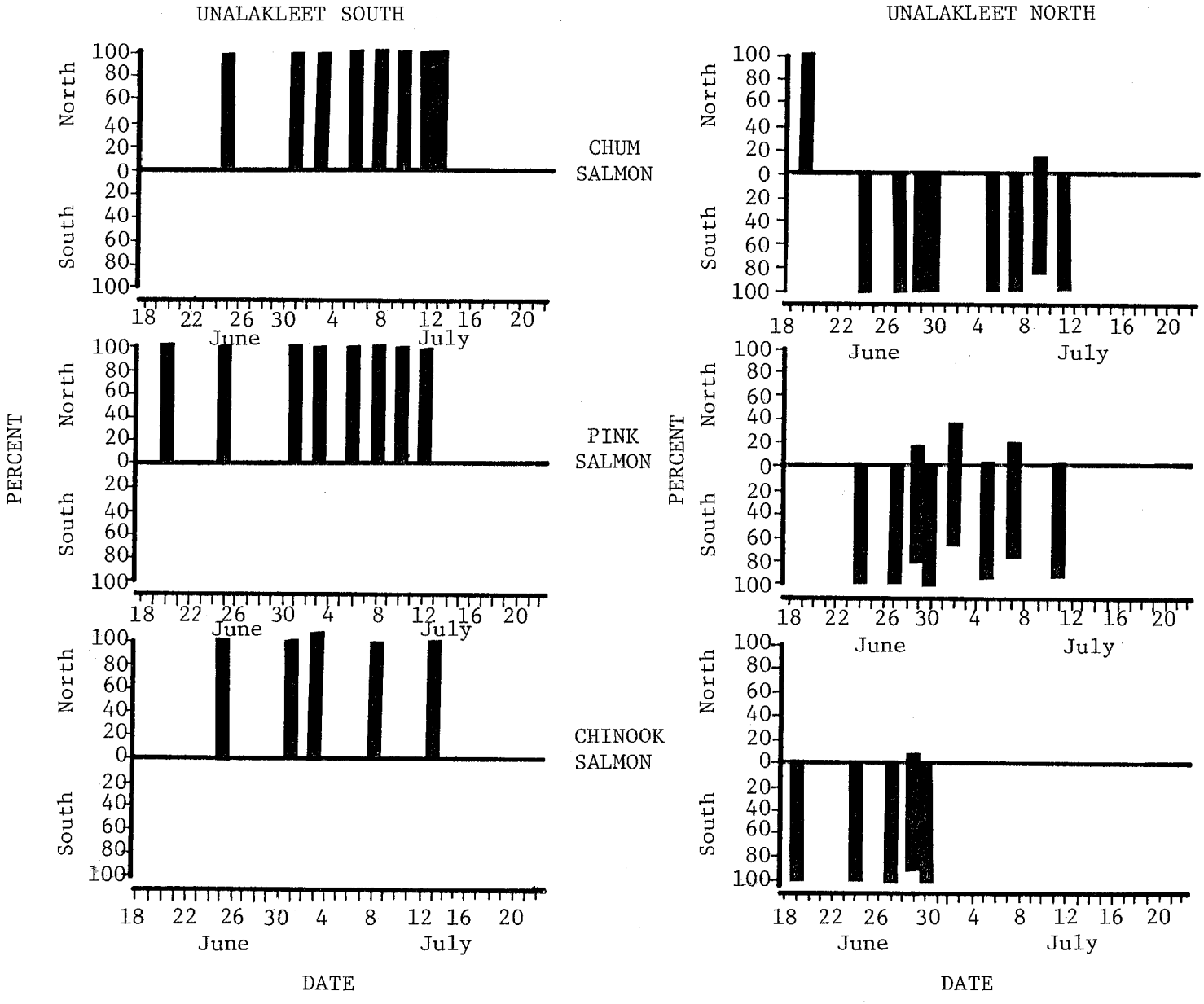


Figure 9. Daily swimming direction of pink, chum, and chinook salmon in the Unalakleet Subdistrict during 1978.

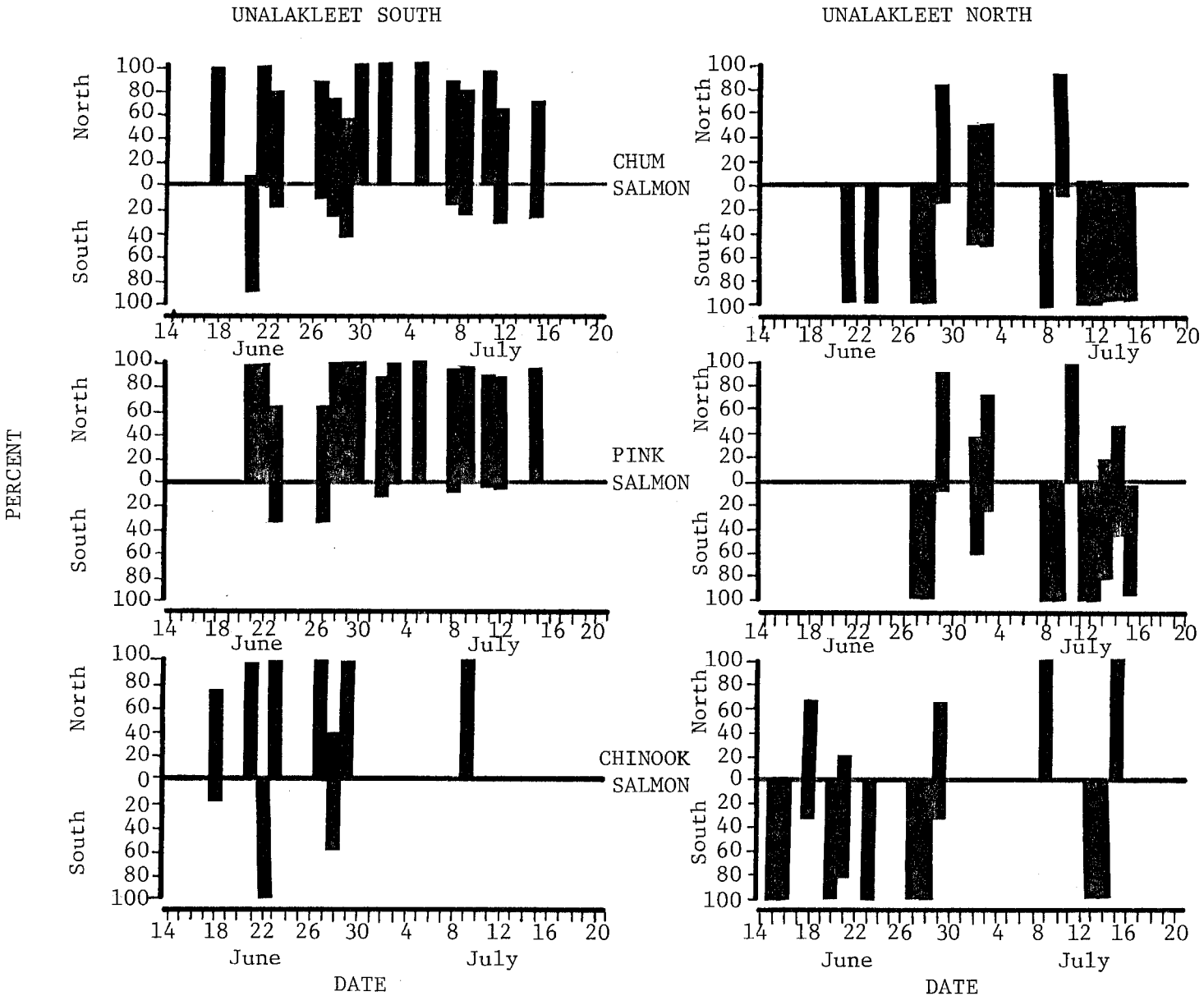


Figure 10. Daily swimming direction of pink, chum, and chinook salmon in the Unalakleet Subdistrict during 1979.

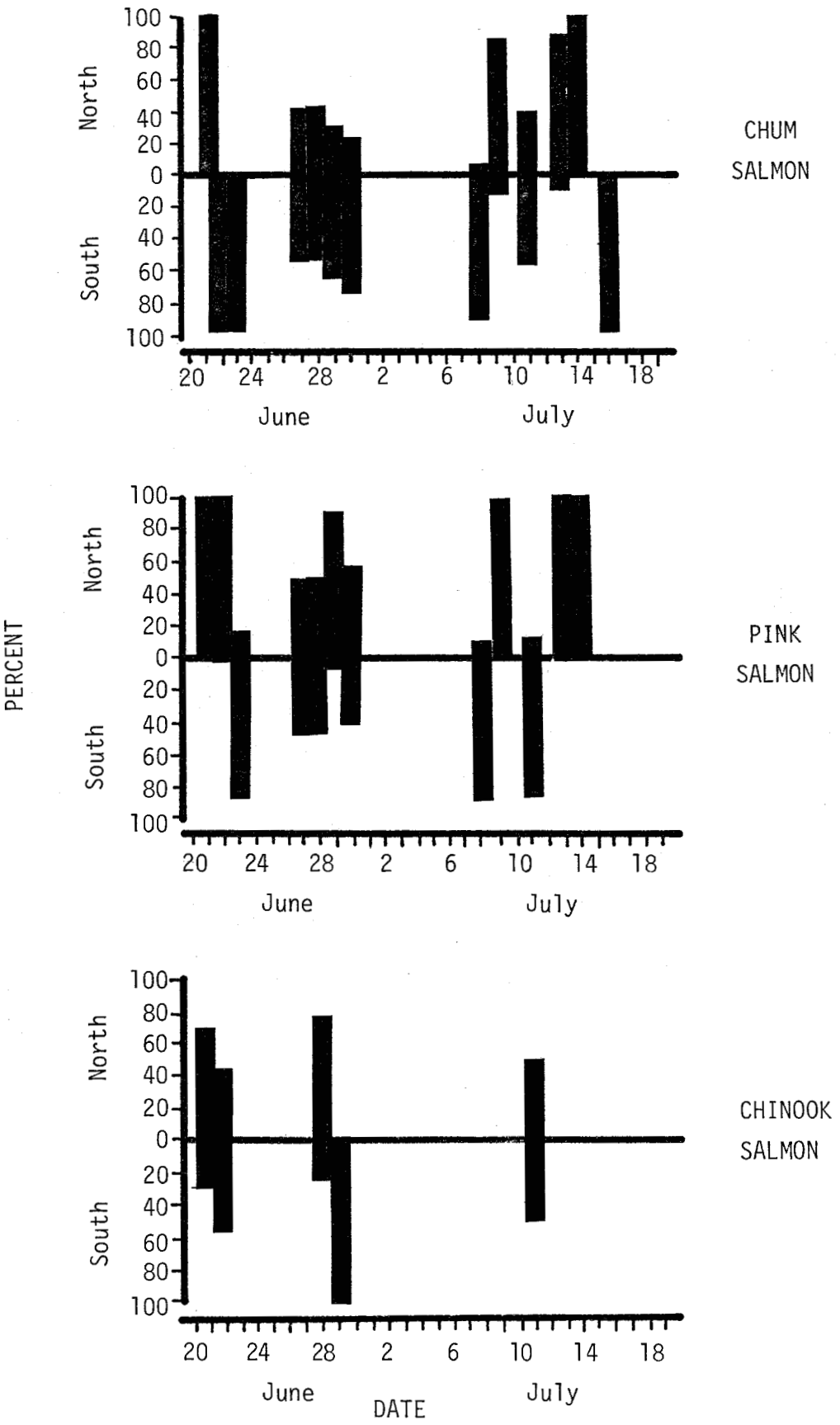


Figure 11. Daily swimming direction of pink, chum, and chinook salmon in the Shaktoolik Subdistrict during 1979.

Table 5. Sex composition (%) of tagging catches by site and species, 1978 and 1979.

		NOME SUBDISTRICT						UNALAKLEET SUBDISTRICT						SHAKTOOLIK SUBDISTRICT		
		Fort Davis		6 Mi Beach		Hastings Cr.		Unalakleet North			Unalakleet South			Shaktoolik		
Year	Sex	Chum	Pink	Chum	Pink	Chum	Pink	Chum	Pink	Chinook	Chum	Pink	Chinook	Chum	Pink	Chinook
1978	Male	55	97	60	94	53	98	54	98	54	56	98	31			
	Female	45	3	40	6	47	2	46	2	46	44	2	69			
1979	Male	13	99					53	96	70	64	98	81	35	99	79
	Female	87	1					47	4	30	36	2	19	65	1	21

of the season, tended to favor the capture of males.

Recapture Method

The major recapture locations during 1978 and 1979 are listed in Table 6. The percentage recovery of the salmon tagged at each site by year is given in Table 7. The highest recovery rate was for chinook salmon tagged at the Unalakleet North site (67%) in 1979. A higher percentage of chinook salmon was recovered than any other species, overall 19% of all chinook salmon tagged were recovered; overall pink salmon returns numbered 15% and overall chum salmon returns were 16%.

Fish tagged at the Unalakleet South site were recovered at a lower rate than at any of the other areas (range 6 to 17%, $\bar{x}$ = 12%). Tags applied at the Unalakleet North site were recovered at the highest mean rate of 19% (range 13 to 67%). Fish tagged at the Nome and Shaktoolik sites were returned at mean rates of 16% (range 14 to 20%) and 17% (range 13 to 22%), respectively.

The number and percentage of recoveries of tagged salmon by user group is presented in Table 8. Most of the returns were from the commercial fishery which accounted for 90% of the chinook salmon, 60% of the pink salmon, and 65% of the chum salmon returns. The subsistence fishery returned 7% of the chinook salmon, 20% of the pink salmon, and 25% of the chum salmon. Spawning ground recaptures contributed 0% of the chinook, 12% of the pink, and 7% of the chum recoveries.

Migration

Migration patterns were assembled from tag recovery data by districts for 1978 and 1979.

Chum Salmon:

Chum salmon tagged in the Nome Subdistrict on the north side of Norton Sound were recaptured in the Nome Subdistrict at rates of 88% and 92% in 1978 and 1979, respectively. Ten percent of the recoveries from the Nome Subdistrict tag releases in 1978 were from the Kotzebue District 200 miles to the north (Figure 12). Only small percentages (2% to 8%) were recovered in subdistricts to the east.

Only 31% of chum salmon tagged in the Unalakleet Subdistrict in 1978 were recaptured in the subdistrict. A considerable number of recaptures of chum salmon tagged in the Unalakleet Subdistrict were made in the Yukon River District and in the Shaktoolik Subdistrict (26% and 21%, respectively). Small percentages were recaptured in Norton Bay and Moses Point Subdistricts (2% in each). The percentage of fish tagged and recaptured in the Unalakleet Subdistrict was much greater (66%) in 1979 (Figure 13). Fifteen percent were recaptured in the Yukon River District and 12% in the Shaktoolik Subdistrict. A small percentage (2%) were recaptured in the Norton Bay Subdistrict.

Chum salmon tagged in 1979 in the Shaktoolik Subdistrict were recaptured in four Norton Sound subdistricts and in the Yukon River (Figure 13). Ten percent of those tagged in the Shaktoolik Subdistrict were recaptured in the

Table 6. Recovery locations of salmon tagged in 1978 and 1979.

1978	1979
Kotzebue District	Port Clarence District
Port Clarence District	Norton Sound District
Norton Sound District	Nome Subdistrict (1)
Nome Subdistrict (1)	Fort Davis
Safety Sound	Buckland
Nome River	Nome River
Eldorado River	Snake River
Flambeau River	Golovin Bay Subdistrict (2)
Snake River	Golovin Bay
Salmon Lake	Moses Point Subdistrict (3)
Cripple River	Elim - Moses Point
Bonanza River	Norton Bay Subdistrict (4)
Penny River	Ungalik River
Golovin Bay Subdistrict (2)	Shaktoolik Subdistrict (5)
Fish River	Cape Denbigh
Golovin Bay	Shaktoolik River
Moses Point Subdistrict (3)	Within 3 miles of the Shaktoolik River
Kuluktulik River	4 to 15 miles south of the Shaktoolik River
Elim - Kwik	Unalakleet Subdistrict (6)
Norton Bay Subdistrict (4)	4 to 10 miles north of the Unalakleet River
Ungalik River	Within 3 miles of the Unalakleet River
Shaktoolik Subdistrict (5)	Unalakleet River
Cape Denbigh	3 or more miles south of the Unalakleet River
Shaktoolik River	Egavik River
Unalakleet Subdistrict (6)	Yukon River Districts
More than 3 miles north of the Unalakleet River	
Within 3 miles of the Unalakleet River	
Unalakleet River	
More than 3 miles south of the Unalakleet River	
Egavik River	
Yukon River Districts	

Table 7. Percent of tags recovered by species, location, and year.

1978	Chinook Salmon			Pink Salmon			Chum Salmon		
	Number tagged	Number recovered	Percent recovery	Number tagged	Number recovered	Percent recovery	Number tagged	Number recovered	Percent recovery
Nome				496	68	14%	423	70	17%
Unalakleet North	42	9	21%	143	39	27%	355	46	13%
Unalakleet South	16	2	13%	351	20	6%	303	47	16%
TOTAL	58	11	19%	990	127	13%	1,081	163	15%

1979	Chinook Salmon			Pink Salmon			Chum Salmon		
	Number tagged	Number recovered	Percent recovery	Number tagged	Number recovered	Percent recovery	Number tagged	Number recovered	Percent recovery
Nome				120	24	20%	71	12	17%
Shaktoolik	24	3	13%	502	76	15%	237	53	22%
Unalakleet North	27	18	67%	318	56	18%	129	22	17%
Unalakleet South	107	9	8%	248	41	17%	175	27	15%
TOTAL	158	30	19%	1,188	197	17%	612	114	19%

Table 8. Number and percentage of pink, chum, and chinook salmon recoveries by user group during 1978 and 1979.

			RECAPTURE METHOD									
			Commercial		Subsistence		Sport		Spawning Ground		Other	
Species	Year	Area	No.	%	No.	%	No.	%	No.	%	No.	%
Chinook	1978	Unalakleet N	9	100	0	0	0	0	0	0	0	0
		Unalakleet S	2	100	0	0	0	0	0	0	0	0
Chinook	1979	Unalakleet N	15	83	2	11	1	6	0	0	0	0
		Unalakleet S	9	100	0	0	0	0	0	0	0	0
		Shaktoolik	2	66	1	33	0	0	0	0	0	0
		TOTALS	37	90	3	7	1	3				
Pink	1978	Nome	23	34	17	25	0	0	21	31	7	10
		Unalakleet N	19	49	6	15	0	0	7	18	7	18
		Unalakleet S	11	55	4	20	0	0	3	15	2	10
Pink	1979	Nome	10	42	13	54	0		1	4	0	
		Unalakleet N	49	88	4	7	0		0		3	5
		Unalakleet S	33	80	5	12	0		0		3	8
		Shaktoolik	51	67	16	21	0		7	9	2	3
		TOTALS	196	60	65	20			39	12	24	7
Chum	1978	Nome	18	26	36	51	0		11	16	5	7
		Unalakleet N	41	89	3	7	0		1	2	1	2
		Unalakleet S	33	72	10	22	0		2	4	1	2
Chum	1979	Nome	2	20	7	70	0		0		1	10
		Unalakleet N	21	95	0		1	5	0		0	
		Unalakleet S	23	85	3	11	0		1	4	0	
		Shaktoolik	39	74	10	19	0		3	6	1	1
		TOTAL	177	65	69	25	1	<1	18	7	9	3

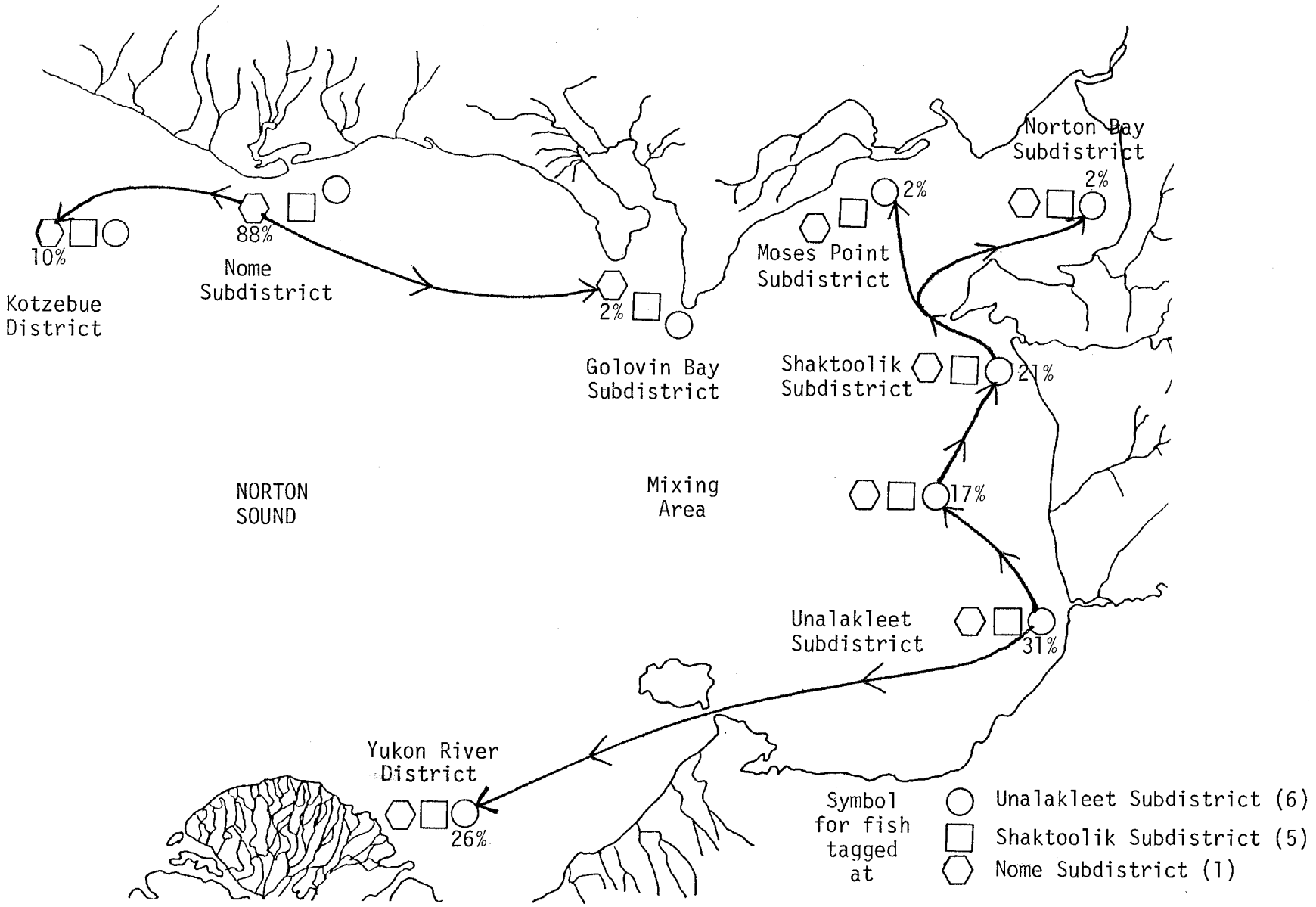


Figure 12. Tagged chum salmon migrations in Norton Sound during 1978.

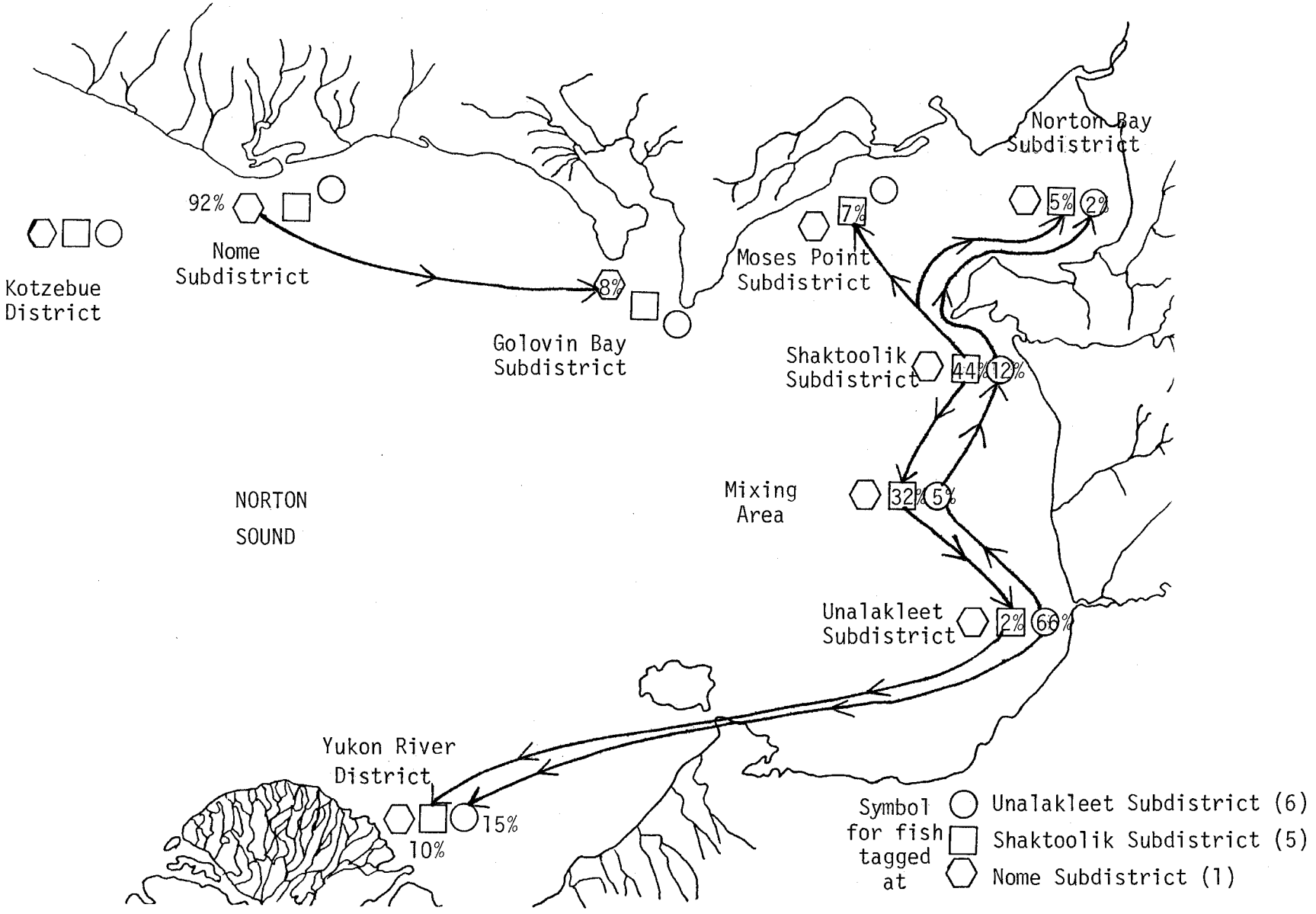


Figure 13. Tagged chum salmon migrations in Norton Sound during 1979.

Yukon River District and 44% were recaptured in the Shaktoolik Subdistrict. A large percentage of the recaptures was in the mixing area 3 mi south of the entrance of the Shaktoolik River to 4 mi north of the Unalakleet River (32%). A total of 12% of the recoveries came from the northern Moses Point and Norton Bay Subdistricts.

Pink Salmon:

The majority of pink salmon tagged in the Nome Subdistrict was recaptured in the same subdistrict in both 1978 and 1979, 86 and 92%, respectively (Figures 14 and 15). Only 4% were recaptured to the north in the Kotzebue District in 1979, 0% in 1978. The eastward migration of pink salmon from the Nome Subdistrict was minimal, in 1978, 15% were recaptured in subdistricts to the east, and, in 1979, only 4%.

Recaptures on the eastern side of Norton Sound (Unalakleet and Shaktoolik Subdistricts) indicated that pink salmon remained in the local area of tagging more than chum salmon. Recoveries in the Yukon District occurred only in 1978, with 2% from the Unalakleet Subdistrict. A large majority of those tagged in the Unalakleet Subdistrict in 1978 were recaptured in the same subdistrict (76%). Seventeen percent were recaptured in the mixing area 4 mi north of the Unalakleet River to 3 mi south of the Shaktoolik River. Only 5% were recaptured in the Shaktoolik Subdistrict in 1978.

Recaptures from fish tagged in the Unalakleet Subdistrict in 1979 were much the same as those in 1978 with the exception being that no pink salmon were recaptured in the Yukon District. However, the majority of pink salmon tagged in the Shaktoolik Subdistrict in 1979 were recaptured outside that subdistrict. Ten percent were recovered in the northern Moses Point and Norton Bay Subdistricts. The largest percentage of recaptures of fish tagged at Shaktoolik (39%) were in the mixing district between Shaktoolik and Unalakleet. Sixteen percent were recaptured at the mouth of the Unalakleet River.

Chinook Salmon:

No recaptures of chinook salmon were made in the Nome Subdistrict in either year (Figures 16 and 17). In 1978, chinook salmon tagged at the Unalakleet Subdistrict sites were recaptured in the Unalakleet Subdistrict (57%), Yukon River District (29%), and the Shaktoolik Subdistrict (14%). No chinook salmon were recaptured in the mixing district (between Shaktoolik and Unalakleet). During 1979, chinook salmon tagged in the Unalakleet Subdistrict were mainly recaptured in the same subdistrict (71%) with only 10% recaptured in the Yukon River District. Returns from areas north of the Unalakleet Subdistrict were 14% in the mixing area and 5% in the Shaktoolik Subdistrict. All recoveries of chinook salmon tagged in the Shaktoolik Subdistrict were recovered in the same subdistrict.

Days at Large

The mean number of days at large (days between initial tagging and eventual recapture), standard deviation, and sample size for chum, pink, and chinook salmon recaptured in 1978 and 1979 are presented in Appendix Tables 4 through 9. Data are grouped by the subdistrict of tagging, method, and location of

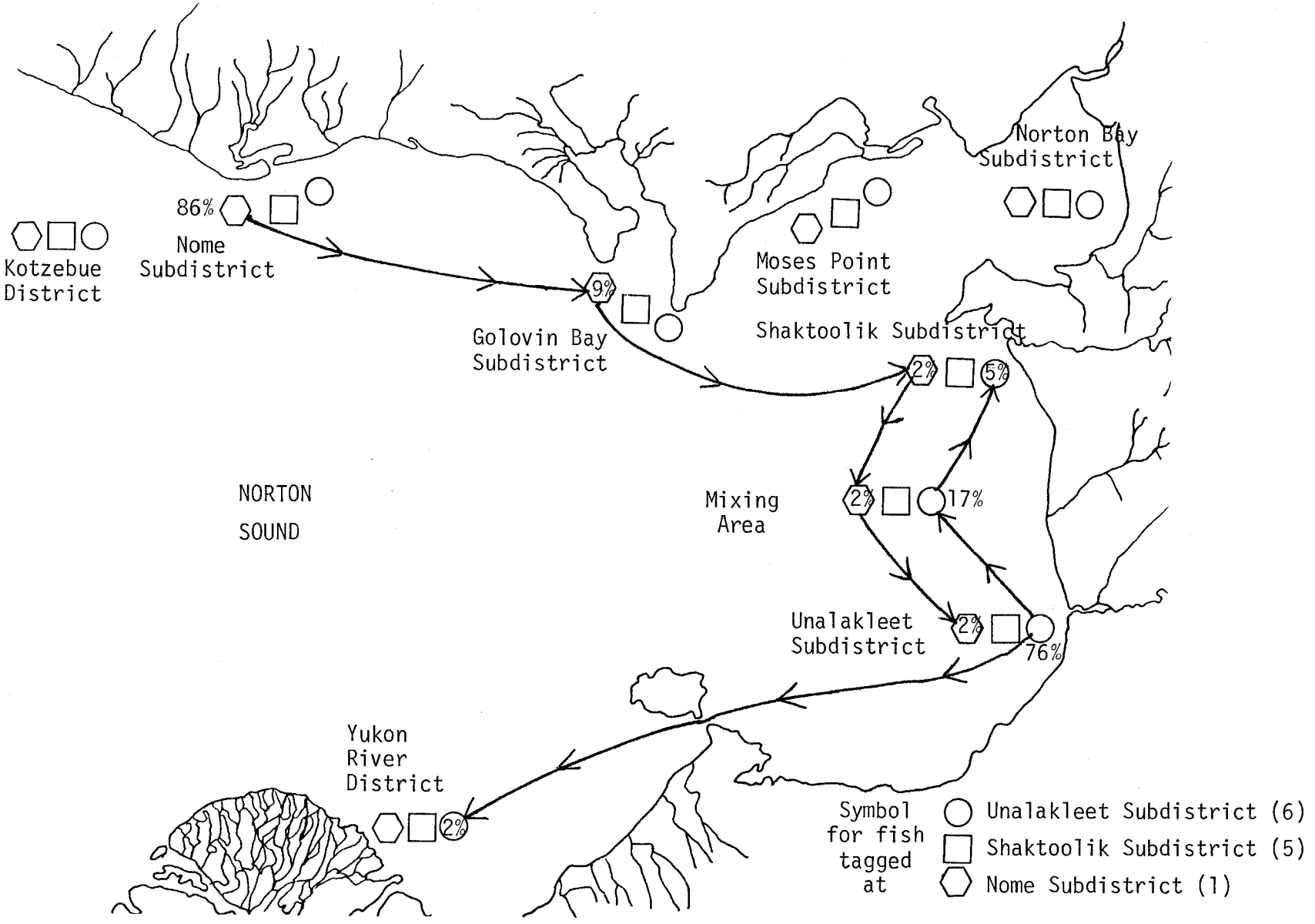


Figure 14. Tagged pink salmon migrations in Norton Sound during 1978.

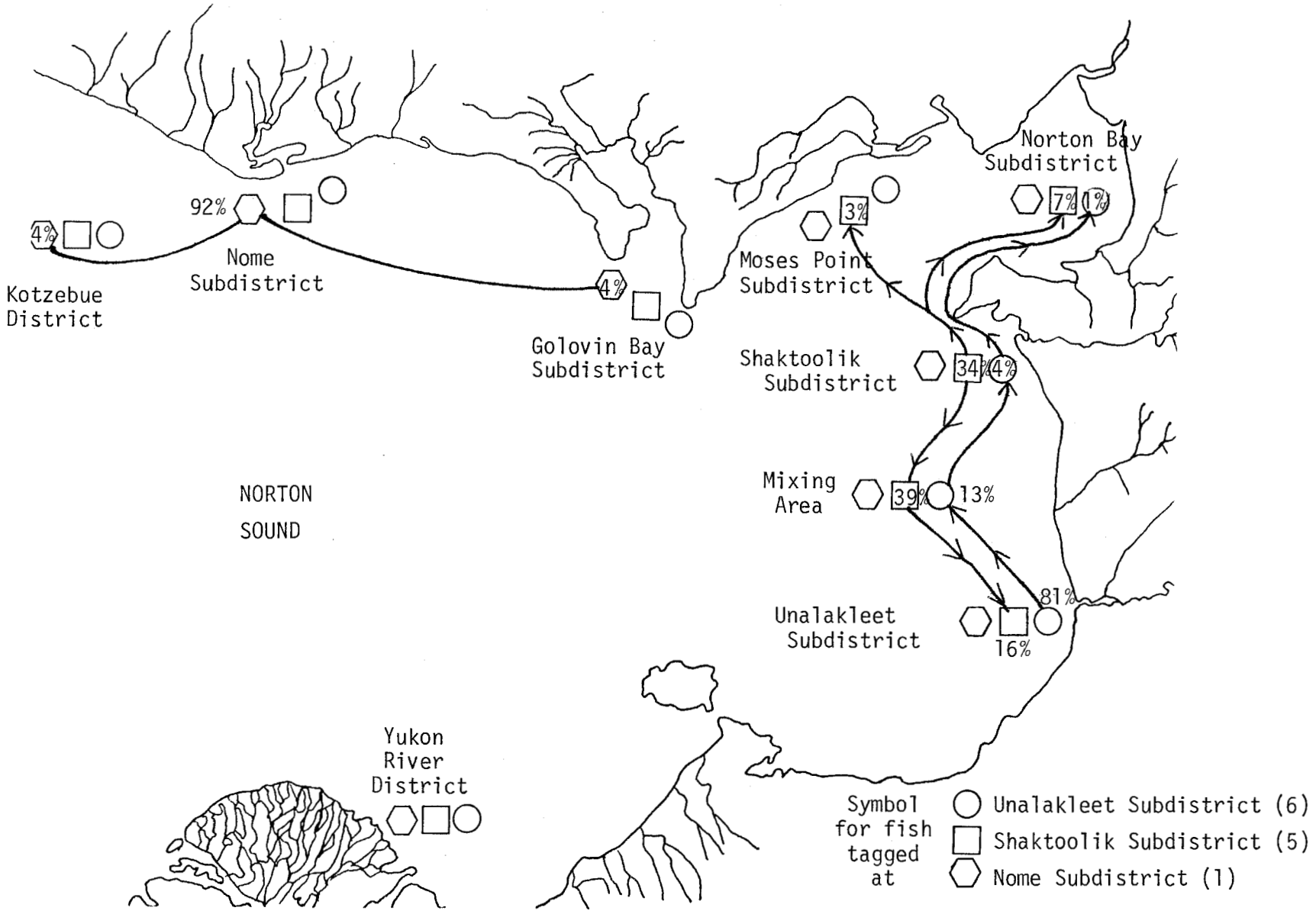


Figure 15. Tagged pink salmon migrations in Norton Sound during 1979.

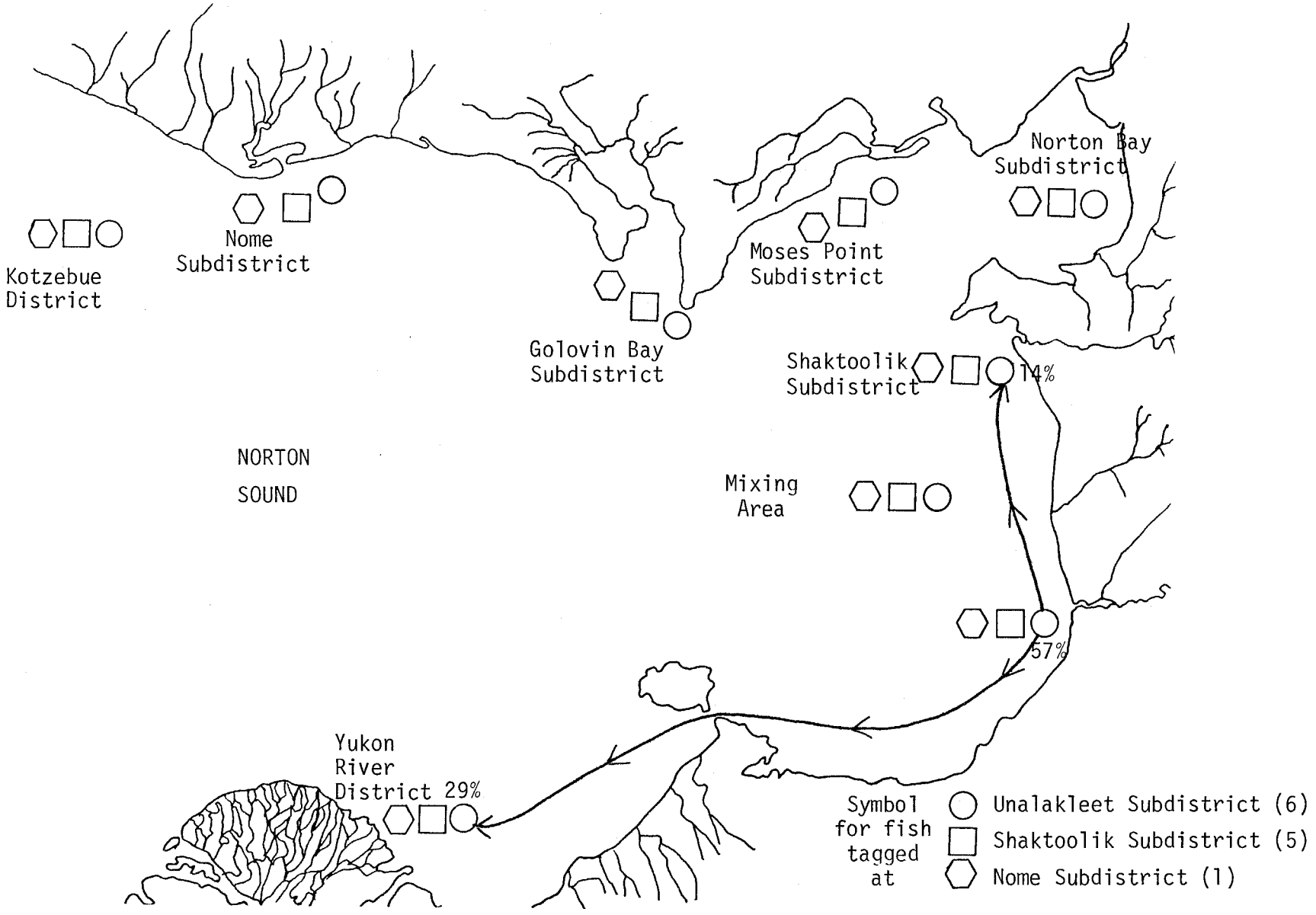


Figure 16. Tagged chinook salmon migrations in Norton Sound during 1978.

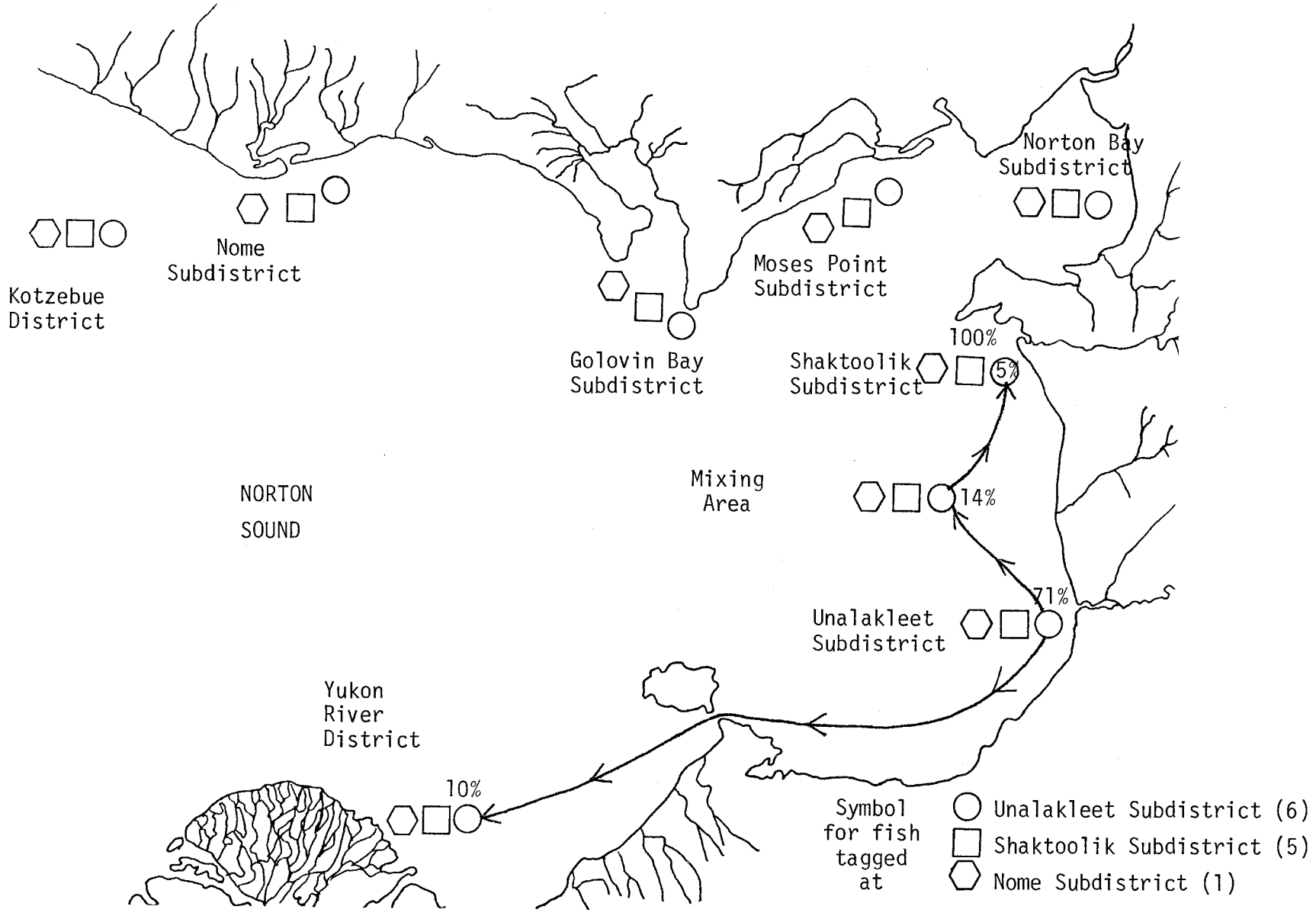


Figure 17. Tagged chinook salmon migrations in Norton Sound during 1979.

recapture. Distance (days at large) is related to recapture method since the commercial fishery is the closest proximity to tagging, followed by the subsistence fishery, and finally spawning ground.

Chum Salmon:

Chum salmon recaptured commercially in the district in which they were tagged were generally at large from 2 to 7 days (Appendix Tables 4 and 5). Those recaptured in the subsistence fishery were at large generally from 3 to 20 days while chum salmon recaptured in the Yukon River were at large from 10 to 13 days.

Pink Salmon:

Pink salmon recaptured in the subdistrict in which they were tagged ranged from 3 to 10 days at large in the commercial fishery. Pink salmon captured outside the subdistrict in which they were tagged remained at large for 6 to 10 days. Recaptures in the subsistence fishery were at large from 8 to 28 days (Appendix Tables 6 and 7).

Chinook Salmon:

Chinook salmon recaptured in the subdistrict in which they were tagged were at large from 2 to 8 days. Recaptures made in the Yukon River averaged 22 days later (Appendix Tables 8 and 9).

Separation of Stocks by Timing

Data were stratified by time of tagging to identify differences in timing for salmon stocks in Norton Sound. Intervals were chosen according to blocks of days when tagging could have occurred because of weather and the results are given in Tables 9 and 10.

Chum Salmon:

In 1978, chum salmon tagged at Unalakleet were recaptured near the Unalakleet River (South site) only 18% to 38% of the time (Table 9). During the first week (18 June to 24 June) chum salmon tagged at the Unalakleet North site were recovered primarily in the Unalakleet River (75%). Chum salmon were also recaptured in the northerly Moses Point Subdistrict (13%) during this period. During the following 2 weeks (27 June to 3 July and 5 July to 9 July), chum salmon tagged at both Unalakleet sites were recovered fairly evenly in the Shaktoolik and Unalakleet Subdistricts, the mixing area between, and in the Yukon River. The only documented recoveries in the Norton Bay Subdistrict occurred during these periods. During the last week of the period, 11 July to 15 July, chum salmon were recovered fairly evenly in the Shaktoolik and Unalakleet Subdistricts and the mixing district. A small percentage (13%) was also recovered in the Yukon River.

The pattern of recovery in 1979 differed from 1978. Few chum salmon tagged at the North site of the Unalakleet Subdistrict were recaptured. Those that were recaptured occurred mainly in the Unalakleet Subdistrict (Table 9). None of the chum tagged at the north site were recovered in the Yukon River.

Table 9. Temporal patterns of return by district for chum salmon tagged at Unalakleet in 1978, 1979, and Shaktoolik in 1979.

UNALAKLEET 1978

Date				Moses Point Subdistrict		Norton Bay Subdistrict		Shaktoolik Subdistrict		Mixing Area		Unalakleet Subdistrict		Yukon River	
		North	South	North	South	North	South	North	South	North	South	North	South	North	South
6-18 to 6-24	# tags out	58	19	13%	0%	0%	0%	0%	0%	0%	33%	75%	33%	13%	33%
	# tags returned	8	6												
6-27 to 7-3	# tags out	186	124	0%	0%	4%	6%	13%	29%	22%	18%	26%	18%	35%	29%
	# tags returned	23	17												
7-5 to 7-9	# tags out	60	72	0%	0%	10%	0%	30%	18%	30%	9%	20%	36%	10%	36%
	# tags returned	10	11												
7-11 to 7-15	# tags out	51	88	0%	0%	0%	0%	33%	38%	33%	13%	33%	38%	0%	13%
	# tags returned	3	8												

UNALAKLEET 1979

Date				Norton Bay Subdistrict		Shaktoolik Subdistrict		Mixing Area		Unalakleet Subdistrict		Yukon River	
		North	South	North	South	North	South	North	South	North	South	North	South
6-18 to 6-24	# tags out	2	45	0%	0%	0%	11%	0%	0%	0%	33%	0%	56%
	# tags returned	0	9										
6-27 to 7-3	# tags out	42	53	33%	0%	0%	25%	0%	0%	67%	50%	0%	25%
	# tags returned	3	4										
7-5 to 7-9	# tags out	28	52	0%	0%	0%	33%	0%	0%	100%	67%	0%	0%
	# tags returned	2	6										
7-11 to 7-15	# tags out	57	25	0%	0%	7%	0%	7%	25%	86%	75%	0%	0%
	# tags returned	14	4										

-Continued-

Table 9. Temporal pattern of return by district for chum salmon tagged at Unalakleet in 1978, 1979, and Shaktoolik in 1979 (continued).

SHAKTOOLIK 1979

Date			Moses Point Subdistrict	Norton Bay Subdistrict	Shaktoolik Subdistrict	Mixing Area	Unalakleet Subdistrict	Yukon River
6-21 to 6-23	# tags out	20	0%	0%	100%	0%	0%	0%
	# tags returned	1						
6-27 to 6-30	# tags out	88	17%	11%	11%	44%	6%	11%
	# tags returned	18						
7-8 to 7-9	# tags out	86	0%	0%	65%	29%	0%	6%
	# tags returned	17						
7-11 to 7-14	# tags out	43	0%	0%	66%	17%	0%	17%
	# tags returned	6						

Table 10. Temporal patterns of return by district for pink salmon tagged at Unalakleet in 1978, 1979, and Shaktoolik in 1979.

UNALAKLEET 1978

Date		North	South	Norton Bay Subdistrict North	Norton Bay Subdistrict South	Shaktoolik Subdistrict North	Shaktoolik Subdistrict South	Mixing Area North	Mixing Area South	Unalakleet Subdistrict North	Unalakleet Subdistrict South	Yukon River North	Yukon River South
6-21 to 6-25	# tags out	12	32	0%	0%	7%	20%	7%	20%	80%	60%	7%	0%
	# tags returned	5	5										
6-27 to 7-3	# tags out	159	99	0%	0%	0%	0%	29%	33%	71%	67%	0%	0%
	# tags returned	17	6										
7-5 to 7-9	# tags out	197	117	17%	0%	0%	25%	0%	0%	83%	75%	0%	0%
	# tags returned	6	4										
7-10 to 7-15	# tags out	90	103	0%	0%	0%	0%	0%	20%	0%	80%	0%	0%
	# tags returned	0	5										

UNALAKLEET 1979

Date		North	South	Norton Bay Subdistrict North	Norton Bay Subdistrict South	Shaktoolik Subdistrict North	Shaktoolik Subdistrict South	Mixing Area North	Mixing Area South	Unalakleet Subdistrict North	Unalakleet Subdistrict South	Yukon River North	Yukon River South
6-21 to 6-25	# tags out	0	22	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
	# tags returned	0	3										
6-27 to 7-3	# tags out	108	85	9%	0%	9%	17%	18%	0%	64%	83%	0%	0%
	# tags returned	11	6										
7-5 to 7-9	# tags out	104	106	0%	0%	0%	0%	19%	9%	81%	91%	0%	0%
	# tags returned	16	11										
7-11 to 7-15	# tags out	106	35	0%	0%	6%	0%	28%	13%	67%	87%	0%	0%
	# tags returned	18	8										

-Continued-

Table 10. Temporal patterns of return by district for pink salmon tagged at Unalakleet in 1978, 1979, and Shaktoolik in 1979 (continued).

			SHAKTOOLIK 1979					
Date			Moses Point Subdistrict	Norton Bay Subdistrict	Shaktoolik Subdistrict	Mixing Area	Unalakleet Subdistrict	Yukon River
6-21 to 6-23	# tags out	28	13%	13%	25%	50%	0%	0%
	# tags returned	8						
6-27 to 6-30	# tags out	333	3%	3%	26%	45%	23%	0%
	# tags returned	31						
7-8 to 7-9	# tags out	106	0%	0%	58%	33%	8%	0%
	# tags returned	12						
7-10 to 7-14	# tags out	35	0%	17%	33%	33%	17%	0%
	# tags returned	6						

Chum salmon tagged at the south site were recovered mainly in or near the Shaktoolik and Unalakleet Rivers. Only during the first 2 weeks (18 June to 24 June and 27 June to 3 July) were chum salmon that were tagged at Unalakleet South recovered in the Yukon River (56 and 25%, respectively). Only during the second week (27 June to 3 July) did chum salmon show significantly in other subdistricts. Small percentages of chum salmon tagged at the Shaktoolik Subdistrict appeared in the Yukon River.

Pink Salmon:

Pink salmon in Norton Sound appeared not to stray as much as chum salmon. Those salmon tagged at the Unalakleet site in 1978 appeared to do the majority of their wandering during the early part of the season from 21 June to 3 July (Table 10). Only one pink salmon (7%) was recovered in the Yukon River in 1978 and only one fish was recovered outside the Unalakleet and Shaktoolik Subdistricts (17%) during the entire period.

During 1979, pink salmon tagged in the Unalakleet Subdistrict also tended to be recaptured in the Unalakleet Subdistrict. The lowest percentage recaptured was 64% during the second week (27 June to 3 July) when fish were recaptured in areas to the North in the Moses Point and Norton Bay Subdistricts (Table 10).

Pink salmon tagged in the Shaktoolik Subdistrict in 1979 tended to wander more than those tagged in the Unalakleet Subdistrict. The highest recapture in the Shaktoolik Subdistrict occurred during the third period (8 July to 9 July) when 58% were tagged and recaptured there. Small percentages of pink salmon were recaptured to the north but the primary recapture area for those salmon tagged in the Shaktoolik Subdistrict was in the mixing area. The fish were perhaps heading for the Egavik River. No pink salmon tagged in the Shaktoolik Subdistrict were recaptured in the Yukon River.

Chinook Salmon:

Not enough chinook salmon were tagged to be able to stratify over time.

Circulation Patterns in Norton Sound

Temperature, salinity, and current patterns have been used by oceanographers to describe the circulation patterns in Norton Sound. Reproduction of a figure by Muensh (1980) shows a schematic of the net circulation in Norton Sound as determined from temperature, salinity, and current measurements (Figure 18). It is assumed that fish are influenced by these patterns on their entrance into the sound and their migration to rivers.

Inflow into the Sound occurs in the middle of the Sound. From here it moves north and exists along the northern edge. Temperature is highest inshore and along with low salinities inshore, indicates the flow of fresh water from the rivers entering the Sound, primarily the Yukon.

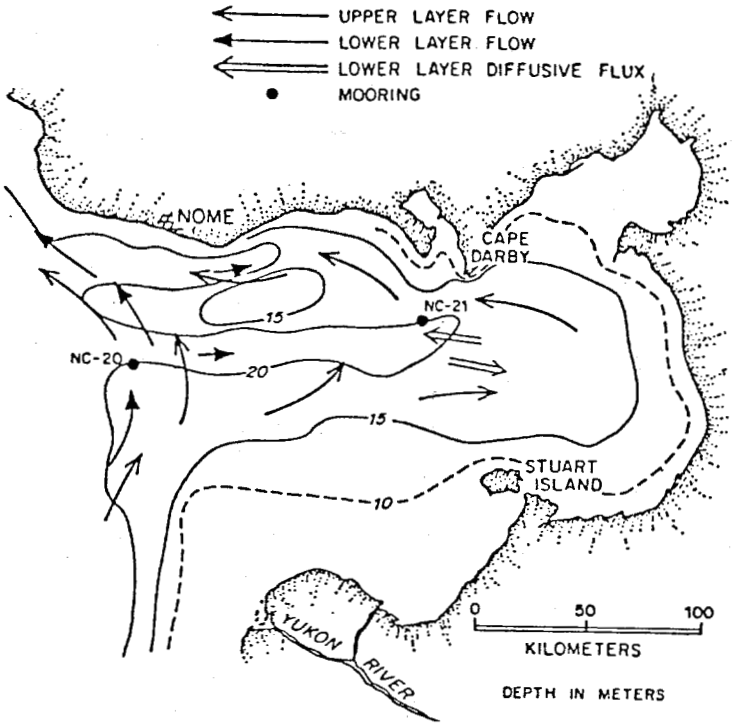


Figure 18. Circulation patterns in Norton Sound as determined from temperature and salinity measurements in July 1977, from Muensh (1980).

Yukon River Recaptures

Of particular interest to management is the interception of salmon stocks from other districts, in the case of Norton Sound, primarily the Yukon River. Table 11 gives the dates on which chum, chinook, and pink salmon were tagged that were eventually recovered in the Yukon River. A total of 31 chum salmon tagged in Eastern Norton Sound was recaptured in the Yukon River. The majority of these chum were tagged between 29 June and 6 July in 1978 and 21 June and 29 June in 1979, mostly from the Unalakleet Subdistrict. Four chinook salmon tagged at Unalakleet were recaptured in the Yukon River. All four had been tagged in June. Only one pink salmon tagged in Norton Sound was recaptured in the Yukon River.

DISCUSSION

The study attempted to answer the following question: does fishing in the subdistricts of Norton Sound intercept salmon bound for other subdistricts in Norton Sound and/or districts outside of Norton Sound?

The majority of the tag recoveries came from commercial salmon catches. Unfortunately commercial catch recoveries do not necessarily define the river of origin. Because a fish is tagged in Subdistrict A and recaptured in Subdistrict B does not mean that Subdistrict B was its final destination. The main value of this type of data is to define a general migration route and identify the areas and the amount of milling by these fish. Recoveries made in the escapement provide a conclusive stream of origin, but generally are not quantitative because of the few recoveries made. Recoveries in both the commercial catch and the escapement are biased by the inability to tag fish in proportion to the run size and to tag each stock in proportion to the river population. The commercial catch recovery is also biased by unequal and often unknown distribution of effort of the harvesters. Escapement recoveries are biased by lack of coverage on some streams, different degrees of water clarity, depth of the water where fish are holding, and stacking and burying of tagged carcasses. Despite all the biases, a general picture of salmon migration (Figure 19) in Norton Sound is emerging.

Results of the tagging suggest that there are both interception and non-interception subdistricts in Norton Sound depending on the species of salmon. During both years of tagging, high percentages of pink and chum salmon tagged in the Nome Subdistrict were also recaptured there. The only significant outmigration from the Nome Subdistrict was when 10% of the tagged chum salmon were recaptured in the Kotzebue District. This would suggest that the Nome Subdistrict is basically a non-interception fishery. Although no fish were tagged in the Golovin Bay Subdistrict, recoveries of fish tagged at Nome (less than 10%) were made in that subdistrict. This would suggest that fish returning to Golovin Bay returned without passing through the other subdistricts. Also, no fish were tagged in the Moses Point Subdistrict, however, the small amount of fish that were recovered there were tagged in the Shaktoolik and Unalakleet Subdistricts. Salmon returning to Norton Bay probably avoid the other subdistricts.

Table 11. Tagging dates and locations of salmon recaptured in the Yukon River.

Species	CHUM SALMON				CHINOOK SALMON			PINK SALMON
Year	1978		1979		1978		1979	1978
Location	Unalakleet North	Unalakleet South	Unalakleet South	Shaktoolik	Unalakleet North	Unalakleet South	Unalakleet South	Unalakleet North
Tagging date								
June 18			1				1	
19								
20								
21			2					
22		1						
23			2					
24	1							
25		1				1		
26								
27	1		1					
28				1			1	
29	4			1				
30	3				1			
July 1		1						
2								1
3		4						
4								
5								
6		3						
7	1							
8		1		1				
9								
10								
11								
12								
13				1				
14								
TOTALS	10	11	6	4	1	1	2	1
	31				4			1

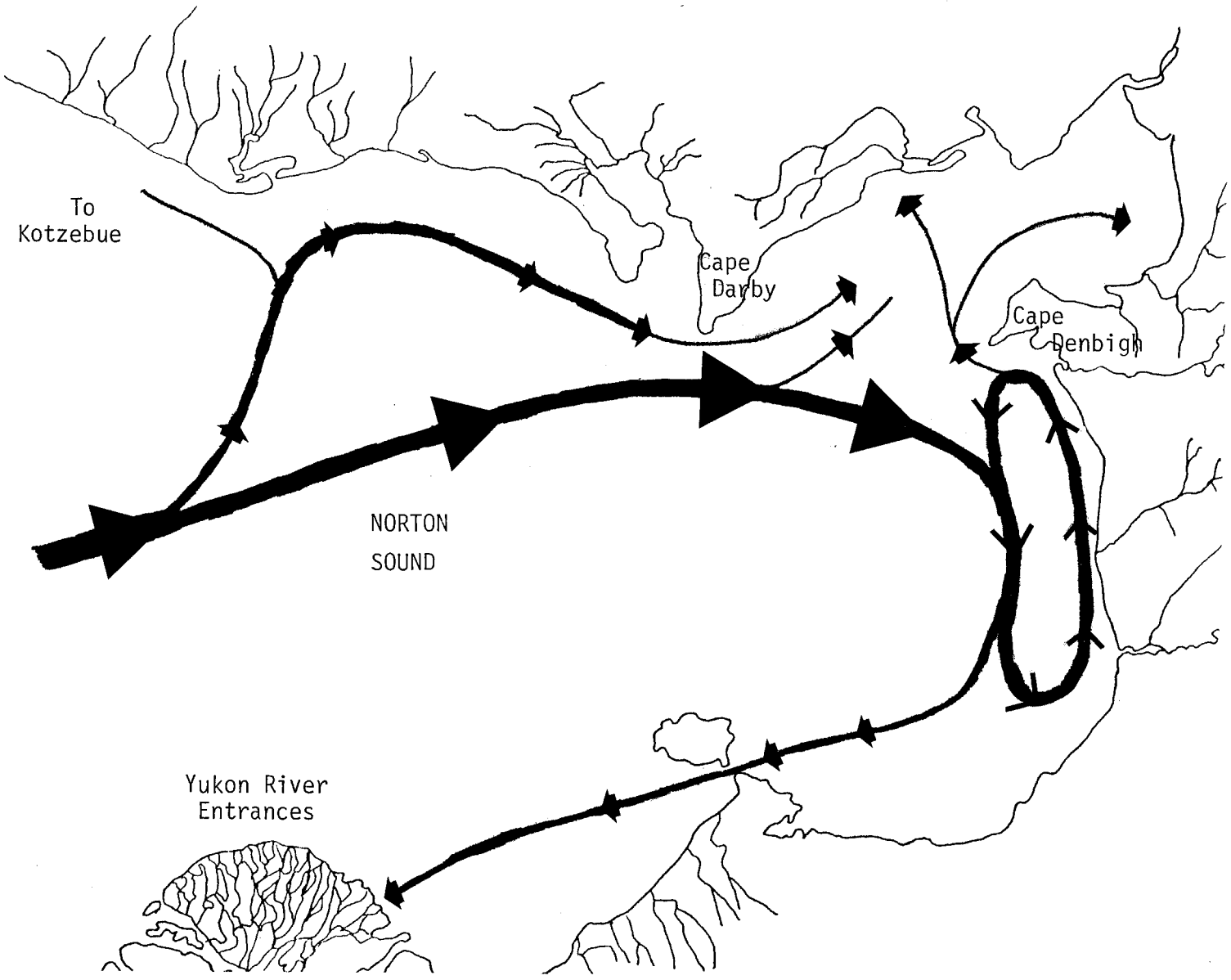


Figure 19. Composite migrational patterns of salmon in Norton Sound.

Fish tagged in the Shaktoolik and Unalakleet Subdistricts were caught in substantial numbers in the commercial fisheries of the other subdistrict. One problem with these subdistricts is that the Egavik River lies close to the border of the two subdistricts. Many of these fish may be homing for the Egavik River but few recaptures were actually made in the river. Yukon River returns also come mainly from these areas. No fish from either of these subdistricts were caught in the Nome or Golovin Bay subdistricts.

As seen from the circulation pattern in Figure 18, the main inflow current in Norton Sound is in the middle. This would seem to lend support to the main migration path hypothesized in Figure 19. Fish heading for the Nome, Golovin Bay, Moses Point, and Norton Bay Subdistricts seem to be able to follow a fairly direct course to the areas and subdistrict fisheries are performed on discrete stocks. However, salmon returning to streams in the Shaktoolik and Unalakleet Subdistricts may be mislead because of the large proportion of Yukon River water flowing up the coast. This could also explain why the fish eventually captured in the Yukon River are found in this area.

Separation of runs by timing does not appear to be feasible. Although only four periods were chosen to evaluate this possibility, no definite trends were apparent.

CONCLUSIONS

The hypotheses that the subdistrict fisheries in Norton Sound are interception fisheries was confirmed for the Shaktoolik and Unalakleet Subdistricts but appears to be false for the Nome, Golovin Bay, Moses Point, and Norton Sound Subdistricts.

No conclusions could be made from information gained from examining daily or overall direction of movement at time of capture.

The majority of recoveries were made by the commercial fishery within 2-7 days after tagging.

Salmon migration into Norton Sound probably takes place in the middle of the Sound with runs to the northern subdistricts being separated but runs to the eastern subdistricts mixed.

Up to 29% of chum salmon tagged at Unalakleet were recaptured in the Yukon River.

There is no separation of runs by timing.

LITERATURE CITED

Muench, R.D. 1980. Physical oceanography and circulation in Norton Sound. Norton Sound Synthesis Meeting, Anchorage, Alaska, 28-30 October 1980. Alaska Outer Continental Shelf Environmental Assessment Program.

APPENDICES

Appendix Table 1. Daily catches of pink, chum, and chinook salmon by location, 1978.

	PINK					CHUM					KING					TOTALS					
Dates	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Total
6-19	-	-	-	0	0	-	-	-	0	5	-	-	-	0	3	-	-	-	0	9	8
20	0	0	0	1	0	5	0	0	0	0	0	0	0	0	0	5	0	0	1	0	6
21	*	*	*	0	3	*	*	*	0	16	*	*	*	0	0	*	*	*	0	19	19
22	*	*	*	3	0	*	*	*	3	0	*	*	*	1	0	*	*	*	7	0	7
23	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
24	0	0	0	0	9	1	4	0	0	37	0	0	0	0	17	1	4	0	0	63	68
25	0	10	0	28	0	0	76	0	16	0	0	0	0	8	0	0	86	0	52	0	138
26	10	0	0	*	*	39	0	0	*	*	0	0	0	*	*	49	0	0	*	*	49
27	*	*	*	0	2	*	*	*	0	31	*	*	*	0	2	*	*	*	0	35	35
28	*	*	*	0	0	*	*	*	1	0	*	*	*	0	0	*	*	*	1	0	1
29	*	*	*	0	37	*	*	*	0	67	*	*	*	0	13	*	*	*	0	117	117
30	0	3	0	0	49	0	12	0	0	78	0	0	0	0	6	0	15	0	0	133	148
7- 1	0	0	0	81	0	1	0	0	27	0	0	0	0	3	0	1	0	0	111	0	112
2	0	0	31	0	71	0	0	23	0	10	0	0	0	0	1	0	0	54	0	22	136
3	0	0	43	18	0	0	0	50	96	0	0	0	0	2	0	0	0	93	116	0	209
4	0	0	40	*	*	0	0	25	*	*	0	0	0	*	*	0	0	65	*	*	65
5	0	0	21	0	130	0	0	13	0	14	0	0	0	0	0	0	0	34	0	144	178
6	125	0	0	70	0	70	0	0	35	0	0	0	0	0	0	195	0	0	105	0	300
7	0	0	1	0	46	0	0	1	0	19	0	0	0	0	0	0	0	2	0	65	67
8	3	0	0	47	0	4	0	0	15	0	0	0	0	1	0	7	0	0	63	0	70
9	18	0	0	0	21	23	0	0	0	27	0	0	0	0	0	41	0	0	0	48	89
10	*	*	*	24	0	*	*	*	22	0	*	*	*	0	0	*	*	*	46	0	46
11	0	181	0	0	90	0	27	0	0	18	0	0	0	0	0	0	208	0		108	316
12	0	0	10	79	0	0	0	3	70	0	0	0	0	0	0	0	0	13	149	0	162
13	0	0	0	0	0	0	0	37	18	0	0	0	0	1	0	0	0	37	19	0	56
14	0	0	0	0	0	0	0	8	0	33	0	0	1	0	0	0	0	9	0	33	42
15	*	*	*	-	-	*	*	*	-	-	*	*	*	-	-	*	*	*	-	-	
16	0	0	0	-	-	0	1	0	-	-	0	0	0	-	-	0	1	0	-	-	1
	156	194	146	351	458	143	120	160	303	355	0	0	1	16	42	299	314	307	670	855	2,445

LEGEND:

1 = Ft. Davis
2 = 6 Mile Beach
3 = Hastings Creek
4 = Unalakleet S.
5 = Unalakleet N.
* are days missed due to storms
- are days not fished

Appendix Table 2. Daily catches of pink, chum, and chinook salmon by location, 1979.

	PINK				CHUM				CHINOOK				TOTALS				GRAND TOTALS
	Nome	Unalakleet South	Unalakleet North	Shaktoolik	Nome	Unalakleet South	Unalakleet North	Shaktoolik	Nome	Unalakleet South	Unalakleet North	Shaktoolik	Nome	Unalakleet South	Unalakleet North	Shaktoolik	
6/14	-	0	0	-	-	0	0	-	-	0	18	-	-	0	18	-	18
15	-	0	0	-	-	0	0	-	-	0	17	-	-	0	17	-	17
16	-	0	0	-	-	0	0	-	-	0	13	-	-	0	13	-	13
17	-	*	*	-	-	*	*	-	-	*	*	-	-	*	*	-	
18	-	0	0	-	-	10	0	-	-	5	6	-	-	15	6	-	21
19	-	*	*	-	-	*	*	-	-	*	*	-	-	*	*	-	
20	0	0	0	-	1	0	0	-	0	0	10	-	1	0	10	-	11
21	*	8	0	11	*	13	1	5	*	8	22	12	*	29	23	29	81
22	*	5	0	4	*	4	0	2	*	1	0	5	*	10	0	10	20
23	*	9	0	13	*	18	1	13	*	3	4	0	*	30	5	26	61
24	4	*	*	*	7	*	*	*	0	*	*	*	11	*	*	*	11
25	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
26	0	*	*	*	1	*	*	*	0	*	*	*	1	*	*	*	1
27	8	3	6	12	34	9	7	13	1	2	1	0	43	14	14	25	96
28	20	21	8	106	5	32	12	50	0	5	8	4	25	58	28	160	271
29	0	13	56	123	1	5	9	21	0	1	3	1	1	19	68	145	233
30	1	12	0	92	2	1	0	4	0	0	0	0	3	13	0	96	112
7/ 1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
2	*	30	13	*	*	6	6	*	*	0	0	*	*	36	19	*	55
3	*	6	25	*	*	0	8	*	*	0	0	*	*	6	33	*	39
4	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
5	*	5	0	*	*	8	0	*	*	0	0	*	*	13	0	*	13
6	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
7	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
8	22	15	2	62	0	13	6	24	0	0	0	0	22	28	8	86	144
7/ 9	*	86	102	44	*	31	22	62	*	2	2	0	*	119	126	106	351
10	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
11	9	11	12	24	2	4	7	12	0	0	0	2	11	15	19	38	83
12	50	21	49	*	16	9	13	*	0	0	1	*	66	30	63	*	159
13	3	0	35	9	2	0	7	18	0	0	1	0	5	0	43	27	75
14	3	0	4	1	0	0	6	11	0	0	1	0	3	0	11	12	26
15	-	3	6	*	-	12	24	*	-	0	0	*	-	15	30	*	45
16	-	-	-	1	-	-	-	2	-	-	-	0	-	-	-	3	3
TOTAL	120	248	318	502	71	175	129	237	1	27	107	24	192	450	554	763	1,949

Appendix Table 3. Catch and effort for pink, chum, and chinook salmon in the subsistence and commercial catches by subdistrict in 1978 and 1979.

	1978							1979					
	Subdistrict 1	Subdistrict 2	Subdistrict 3	Subdistrict 4	Subdistrict 5	Subdistrict 6		Subdistrict 1	Subdistrict 2	Subdistrict 3	Subdistrict 4	Subdistrict 5	Subdistrict 6
	Nome	White Mountain	Elim	Koyuk	Shaktoolik	Unalakleet		Nome	White Mountain	Elim	Koyuk	Shaktoolik	Unalakleet
EFFORT	134	8	18	11	18	55		108	22	17	12	16	36
Chinook catch	35	1	38	12	81	1,044		17	0	16	12	62	640
Pink catch	13,063	2,470	1,995	1,210	3,275	13,268	Subsistence	6,353	2,546	6,078	735	2,575	6,960
Chum catch	4,295	1,061	1,229	1,060	1,170	3,442		3,273	2,840	1,195	1,400	1,670	1,597
Chinook CPUE	.26	.13	2.11	1.09	4.50	18.98		.16	0	.94	1.00	3.88	17.78
Pink CPUE	97.49	308.95	110.83	110.00	181.94	241.24		58.82	115.73	357.53	61.25	160.94	193.33
Chum CPUE	32.05	132.63	68.28	96.36	65.00	62.58		30.31	129.09	70.29	116.67	104.38	44.36
EFFORT	4,368	10,056	18,912	9,888	15,456	30,576		2,406	10,224	12,768	10,512	15,240	39,918
Chinook catch	19	22	444	470	1,339	7,507		9	75	1,035	856	2,376	6,354
Pink catch	22,869	71,533	39,694	8,471	46,236	134,925	Commercial	5,862	45,948	40,811	6,201	18,944	48,020
Chum catch	8,782	41,377	44,595	21,973	35,388	37,059		5,391	30,201	37,123	15,579	21,960	30,445
Chinook CPUE	.0044	.0022	.02	.05	.09	.25		.0037	.01	.08	.08	.16	.16
Pink CPUE	5.24	7.11	2.10	.86	2.99	4.41		2.44	4.49	3.20	.59	1.24	1.20
Chum CPUE	2.01	4.11	2.36	2.22	2.29	1.21		2.24	2.95	2.91	1.48	1.44	.76
Chinook escapement	2	57	76	528	519	1,222		0	184	176	1,017	167	789
Pink escapement	108,619	236,836	71,512	58,694	203,303	757,380		1,349	35,372	193,776	29,880	40,450	11,200
Chum escapement	37,969	43,817	16,914	25,133	19,972	40,523		842	11,847	18,722	10,114	4,350	1,700
Total run Chinook	56	80	558	1,010	1,939	9,773		26	259	1,227	1,885	2,605	7,783
Total run Pink	144,551	310,839	113,201	68,375	252,814	905,573		13,564	83,866	240,665	36,816	61,969	66,180
Total run Chum	51,046	86,255	62,738	48,166	56,530	81,024		9,506	44,888	57,040	27,093	27,980	33,742

Appendix Table 4. Recovery areas and days at large for chum salmon tagged in the Nome and Unalakleet Subdistricts, 1978.

	Nome Subdistrict (1)			Unalakleet Subdistrict (6)					
				Unalakleet North			Unalakleet South		
Commercial	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Nome Subdistrict (1)									
Safety Sound	12	5.2	5.3						
Golovin Bay Subdistrict (2)									
Golovin Bay	1	4.0	---						
Moses Point Subdistrict (3)									
Elim-Kwik				1	3.0	---			
Norton Bay Subdistrict (4)									
Ungalik River				1	4.0	---	1	4.0	---
Shaktoolik Subdistrict (5)									
Shaktoolik River							2	1.5	0.7
Cape Denbigh				7	7.0	3.9	5	9.6	10.1
Unalakleet Subdistrict (6)									
Within 3 miles of the Unalakleet River				10	5.2	5.1	5	5.2	5.4
3 or more miles south of the Unalakleet River				3	6.3	1.2	1	14.0	---
3 or more miles north of the Unalakleet River				9	2.7	1.4	8	2.8	1.6
Kotzebue District									
Kotzebue	4	7.8	2.1						
Yukon District									
Yukon River				10	13.7	12.2	10	10.0	12.5
Subsistence									
Nome Subdistrict (1)									
Nome River	17	10.4	7.3						
Safety Sound	5	8.2	3.2						
Eldorado River	3	8.7	3.1						
Fish River	3	34.3	16.7						
Flambeau River	2	7.5	1.4						
Snake River	1	9.0	---						

-Continued-

Appendix Table 4. Recovery areas and days at large for chum salmon in the Nome and Unalakleet Subdistricts, 1978 (continued).

	Nome Subdistrict (1)			Unalakleet Subdistrict (6) Unalakleet North			Unalakleet Subdistrict (6) Unalakleet South		
Subsistence	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Cripple River	1	3.0	---						
Bonanza River	1	14.0	---						
Moses Point Subdistrict (3)									
Kuluktulik River				1	4.0	---			
Shaktoolik Subdistrict (5)									
Shaktoolik River				1	23.0	---	1	1.0	---
Cape Denbigh							2	20.0	25.5
Unalakleet Subdistrict (6)									
Within 3 miles of the Unalakleet River							1	5.0	---
3 or more miles south of the Unalakleet River							1	15.0	---
3 or more miles north of the Unalakleet River				1	28.0	---			
Unalakleet River				1	19.0	---	3	20.3	10.0
Port Clarence District	3	5.3	2.1						
Yukon District									
Yukon River							1	4.0	---
Spawning Ground									
Nome Subdistrict (1)									
Nome River	3	32.0	6.2						
Snake River	6	29.5	3.1						
Eldorado River	2	20.5	4.9						
Unalakleet Subdistrict (6)									
Unalakleet River				1	31.0	---	2	18.0	0.7
Other									
Nome Subdistrict (1)									
Nome River	2	46.0	0.0						
Bonanza River	1	54.0	---						
Unalakleet Subdistrict (6)									
Unalakleet River				1	2.0	---	1	2.0	---

Appendix Table 5. Recovery areas and days at large for chum salmon in the Nome, Shaktoolik, and Unalakleet Subdistricts, 1979.

Commercial	Nome Subdistrict (1)			Shaktoolik Subdistrict 5			Unalakleet Subdistrict (6) Unalakleet North			Unalakleet Subdistrict (6) Unalakleet South		
	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Nome Subdistrict (1)												
Fort Davis	3	6.7	8.1									
Golovin Bay Subdistrict (2)												
Golovin Bay	1	23.0	---									
Moses Point Subdistrict (3)												
Moses Point												
Norton Bay Subdistrict (4)												
Ungalik River				2	3.0	1.4						
Shaktoolik Subdistrict (5)												
Within 3 miles of the Shaktoolik River				6	4.5	2.8						
Cape Denbigh				1	3.0	---						
4 to 15 miles south of the Shaktoolik River				2	2.0	---						
Unalakleet Subdistrict (6)												
Within 3 miles of the Unalakleet River							14	4.5	3.9	7	4.6	3.1
3 or more miles south of the Unalakleet River				1	6.0	---				2	12.5	6.4
4 to 10 miles north of the Unalalkleet River				11	5.6	3.9				1	4.0	---
Yukon District												
Yukon River										6	9.3	5.8
Subsistence												
Nome Subdistrict (1)												
Buckland	1	19.0	---									
Fort Davis	2	21.5	29.0									
Nome River	4	20.7	31.5									
Moses Point Subdistrict (3)												
Moses Point				2	12.0	1.4						

-Continued-

Appendix Table 5. Recovery areas and days at large for chum salmon tagged in the Nome, Shaktoolik, and Unalakleet Subdistricts, 1979 (continued).

Subsistence	Nome Subdistrict (1)			Shaktoolik Subdistrict (5)			Unalakleet Subdistrict (6) Unalakleet North			Unalakleet Subdistrict (6) Unalakleet South		
	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Shaktoolik Subdistrict (5)												
Shaktoolik River				8	6.6	2.8				1	13.0	---
Unalakleet Subdistrict (6)												
Unalakleet River										1	18.0	---
Spawning Ground												
Shaktoolik Subdistrict (5)												
Shaktoolik River				3	21.3	1.5						
Unalakleet Subdistrict (6)												
Unalakleet River										1	30.0	---
Sport Fish												
Unalakleet Subdistrict (6)												
Unalakleet River										1	13.0	---
Other												
Nome Subdistrict (1)												
Snake River	1	3.0	---									
Moses Point Subdistrict (3)												
Moses Point				1	6.0	---						

Appendix Table 6. Recovery areas and days at large for pink salmon tagged in the Nome and Unalakleet Subdistricts, 1978.

	Nome Subdistrict (1)			Unalakleet Subdistrict (6)					
				Unalakleet North			Unalakleet South		
Commercial	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Nome Subdistrict (1)									
Safety Sound	12	4.8	2.5						
Golovin Bay Subdistrict (2)									
Golovin Bay	6	3.8	3.5						
Shaktoolik Subdistrict (5)									
Shaktoolik River				2	5.0	4.2	1	2.0	---
Cape Denbigh							1	4.0	---
Unalakleet Subdistrict (6)									
Within 3 miles of the Unalakleet River	1	3.0	---	11	7.3	5.1	5	6.0	5.7
3 miles north of the Unalakleet River	1	31.0	---	7	3.4	1.5	3	10.7	15.0
Egavik River				1	3.0	---			
Yukon District									
Yukon River				1	12.0	---			
Subsistence									
Nome Subdistrict (1)									
Nome River	11	8.5	8.0						
Safety Sound	4	10.3	5.3						
Kuiuktulik River	1	6.0	---						
Snake River	1	28.0	---						
Unalakleet Subdistrict (6)									
Within 3 miles of the Unalakleet River				2	5.0	1.4	1	9.0	---
Egavik River				1	11.0	---	3	12.7	11.5
Unalakleet River				3	10.1	9.8			
Spawning Ground									
Nome Subdistrict (1)									
Nome River	13	24.8	3.2						
Snake River	6	30.2	3.8						
Penny River	1	14.0	---						

-continued-

Appendix Table 6. Recovery areas and days at large for pink salmon tagged in the Nome and Unalakleet Subdistricts, 1978 (continued).

Spawning Ground	Nome Subdistrict (1)			Unalakleet Subdistrict (6)					
				Unalakleet North			Unalakleet South		
	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Shaktoolik Subdistrict (5)									
Shaktoolik River	1	36.0	---						
Unalakleet Subdistrict (6)									
Unalakleet River				7	18.7	3.6	3	19.7	8.6
Other									
Nome Subdistrict (1)									
Nome River	7	25.0	3.8						
Unalakleet Subdistrict (6)									
Unalakleet River				6	8.8	7.5	2	10.5	12.0
Within 3 miles of the Unalakleet River				1	3.0	---			

Appendix Table 7. Recovery areas and days at large for pink salmon tagged in the Nome, Shaktoolik, and Unalakleet Subdistricts, 1979 (continued).

	Nome Subdistrict (1)			Shaktoolik Subdistrict (5)			Unalakleet Subdistrict (6)					
							Unalakleet North			Unalakleet South		
Subsistence	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Nome Subdistrict (1)												
Snake River	1	3.0	---									
Nome River	7	23.6	20.7									
Fort Davis	2	28.5	0.7									
Moses Point Subdistrict (3)												
Elim-Moses Point				1	10.0	---						
Shaktoolik Subdistrict (5)												
Shaktoolik River				9	17.4	7.6	1	16.0	---	1	27.0	---
Unalakleet Subdistrict (6)												
Within 3 miles of the Unalakleet River										1	13.0	---
Unalakleet River				6	10.8	7.2	3	8.3	3.2	3	12.7	16.1
Spawning Grounds												
Nome Subdistrict (1)												
Nome River	1	44.0	---									
Shaktoolik Subdistrict (5)												
Shaktoolik River				6	20.7	6.0						
Unalakleet Subdistrict (6)												
Unalakleet River				1	55.0	---						
Other												
Unalakleet Subdistrict (6)												
3 or more miles south of the Unalakleet River							2	15.5	9.2	3	6.3	8.4
Unalakleet River				2	9.5	7.8	1	3.0	---			

Appendix Table 7. Recovery areas and days at large for pink salmon tagged in the Nome, Shaktoolik, and Unalakleet Subdistricts, 1979.

Commercial	Nome Subdistrict (1)			Shaktoolik Subdistrict (5)			Unalakleet Subdistrict (6) Unalakleet North			Unalakleet Subdistrict (6) Unalakleet South		
	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Nome Subdistrict (1)												
Fort Davis	7	6.7	7.1									
Golovin Bay Subdistrict (2)												
Golovin Bay	1	14.0	---									
Moses Point Subdistrict (3)												
Elim-Moses Point				1	3.0	---						
Norton Bay Subdistrict (4)												
Ungalik River				4	9.2	9.6	1.	4.0	---			
Shaktoolik Subdistrict (5)												
Within 3 miles of the Shaktoolik River				3	5.0	5.2						
Cape Denbigh				3	4.3	.6	1	6.0	---			
4 to 15 miles south of the Shaktoolik River				8	5.5	4.7	3	15.7	12.0	1	15.0	---
Unalakleet Subdistrict (6)												
Within 3 miles of the Unalakleet River				1	9.0	---						
4 to 10 miles north of the Unalakleet River				15	9.5	9.8	3	4.0	1.7	1	2.0	---
3 or more miles south of the Unalakleet River							3	3.0	1.7	2	10.0	14.1
Yukon District												
Yukon River												
Port Clarence District												
Port Clarence	1	3.0	---									

-continued-

Appendix Table 8. Recovery areas and days at large for chinook salmon tagged in the Unalakleet Subdistrict in 1978.

		Tagged at					
		Unalakleet North			Unalakleet South		
	Commercial	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Recovered at	Unalakleet Subdistrict (6) Within 3 mile of the Unalakleet River	3	3.7	2.1	1	2.0	---
	Shaktoolik Subdistrict (5) Shaktoolik River	1	6.0	---			
	Yukon District Yukon River	1	6.0	---	1	8.0	---

Appendix Table 9. Recovery areas and days at large for chinook salmon tagged in the Shaktoolik and Unalakleet Subdistricts in 1979.[1]

Recovered at	Commercial	Tagged at Unalakleet North N	$\bar{X}$	SD	Unalakleet South N	$\bar{X}$	SD	Shaktoolik N	$\bar{X}$	SD
	Unalakleet Subdistrict (6)									
	Within 3 miles of the Unalakleet River	7	4.7	1.6	6	3.5	1.4			
	4 to 10 miles north of the Unalakleet River	2	8.0	1.4	1	2.0	---			
	Shaktoolik Subdistrict (5)									
	Within 3 miles of the Shaktoolik River							1	5.0	---
	4 to 15 miles south of the Shaktoolik River							1	1.0	---
	Cape Denbigh	1	1.0	---						
	Yukon District									
	Yukon River				2	22.0	21.2			
	Subsistence									
	Unalakleet Subdistrict (6)									
	Unalakleet River	2	6.0	7.1						
	Shaktoolik Subdistrict (5)									
	Shaktoolik River							1	25.0	---
	Sport Fish									
	Unalakleet River	1	3.0	---						

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