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Nooksack River Juvenile Spring Chinook Salmon Investigations

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INTRODUCTION

Spring chinook salmon historically supported valuable sport, commercial, and treaty Indian fisheries throughout the Pacific Northwest; however, their numbers appear to have dwindled in most Puget Sound river systems to a point where their continued existence is threatened. In northern Puget Sound the Nooksack River spring chinook run, although still viable, is severely depressed. High interception rates, poaching in freshwater, and habitat degradation are important reasons for the decline.

In 1980, the Olympia Fisheries Assistance Office (FAO) drafted an action plan for restoring Puget Sound spring chinook populations. In accordance with the goals of this plan, FAO began a cooperative program with the Washington Department of Fisheries, the Lummi Indian Tribe, and the Nooksack Indian Tribe to restore Nooksack River spring chinook salmon. An integral part of this effort is development of self-sustaining brood runs to the Nooksack River hatcheries for eventual outplanting into suitable habitat in the Nooksack drainage. Coordinating releases from these hatcheries with natural outmigration patterns is important in minimizing competition with wild stocks and maximizing early survival of the hatchery fish. However, little is known about early life history of Puget Sound spring chinook. We therefore initiated a study in January 1981 to determine:

1. the time and size of ocean entry of native Nooksack River spring chinook. With this information, hatchery smolt releases could be programmed to coincide with the peak time and size of wild emigrants.

2. the behavior of hatchery spring chinook after release from Nooksack River hatcheries. If hatchery releases residualize to a significant extent, release timing should be reevaluated.

3. the relationship between spring chinook and other hatchery salmonids released into the Nooksack watershed. Massive releases of other salmonids could interact negatively with the native spring chinook population.

This report addresses progress made towards reaching these objectives during the 1981 field season.

STUDY AREA

The Nooksack River Basin drains roughly 850 square miles in northwestern Washington (Figure 1). Mean annual discharge is approximately 4,000 cfs at Ferndale. In the upper basin, distinctly different streamflow conditions occur in the north and south forks. Glaciers and snowfields in the upper north fork watershed produce higher flows in spring and early summer, well-sustained flows during late summer and early fall, and a lower water period during winter. In contrast, lack of perennial snow and ice in the upper south fork watershed produces higher flows in winter and spring, and lower flows in late summer and fall in accordance with seasonal precipitation. Cooler water temperatures and glacial coloration also occur in the north fork (Division of Water Resources, 1960). In the lower basin, the mainstem Nooksack meanders at a moderate gradient to Bellingham Bay, where tidal influence extends to the general vicinity of the Slater Road bridge shown in Figure 2 (Parker, 1974).

Anadromous fish of the Nooksack basin include all five Pacific salmon, as well as searun cutthroat, steelhead, and dolly varden. Anadromous fish use extends to approximately river mile 60 in both north and south forks, and to the City of Bellingham diversion dam in the lower middle fork. In 1980, observed spawning of radio-tagged spring chinook was concentrated between river miles 40 and 52 in the north fork, and between river miles 46 and 54 in the south fork (Barclay, 1981). No spring chinook spawning is reported in the middle fork. Peak spawning of spring chinook in the south fork was estimated to be 2 to 3 weeks later than north fork spawning (Barclay, 1981).

METHODS AND MATERIALS

Wild Spring Chinook

Movement and size characteristics of wild spring chinook outmigrants were evaluated by marking emergent juveniles in the upper Nooksack drainage and recovering them at marking sites and in downstream areas. As this year's study was approached as a feasibility effort, a variety of sampling locations and gear was used in order to identify techniques most suitable to meet project objectives.

Three sampling stations in the upper north fork (N1, N2 and N3) and three stations in the upper south fork (S1, S2, and S3) were used solely for capturing and marking wild spring chinook fry (Figure 1). Chinook captured at these sites were considered springs because of their proximity to observed spring chinook spawning areas (Barclay, 1981), and the small likelihood of other chinook (i.e., fall chinook) spawning activity at these locations in the drainage.

Juvenile spring chinook were chiefly captured by electrofishing in shallow, rocky river margins and side channels at these upriver sample sites. Portable inclined plane traps were also employed at stations N1 and S3 to capture nocturnal migrants (Figure 3). Trap design was patterned after that used

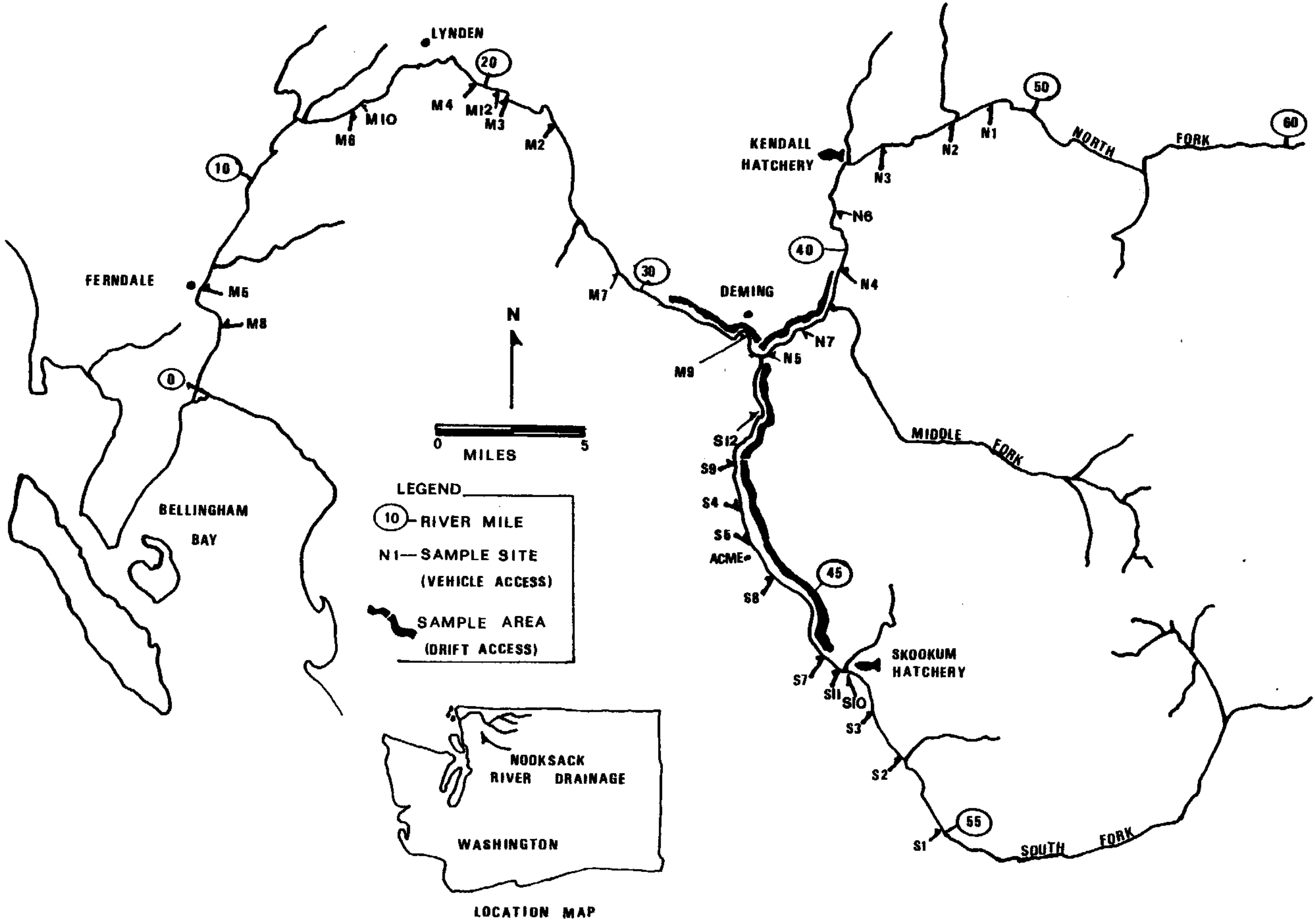

FIGURE 1. LOCATIONS OF UPRIVER SAMPLE STATIONS IN THE NOOKSACK RIVER DRAINAGE

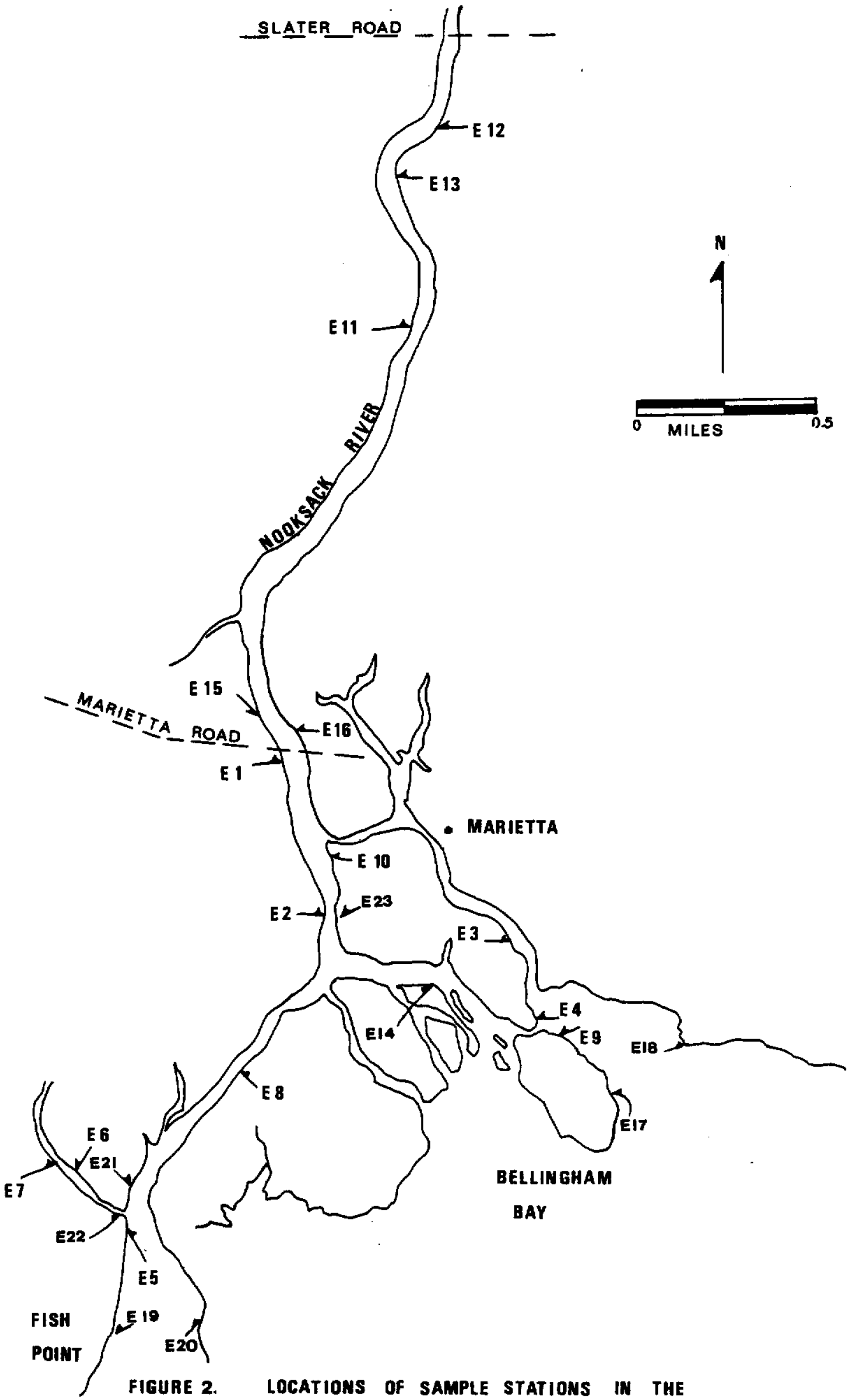

FIGURE 2. LOCATIONS OF SAMPLE STATIONS IN THE NOOKSACK RIVER ESTUARY

Figure 3. Inclined plane trap at station N1, a side channel on the north fork of the Nooksack River.

successfully for juvenile spring chinook trapping on the Queets River of coastal Washington (L. Lestelle, pers. comm.). These traps were fished continually during the periods of greatest fry availability (late February to late April), providing river conditions were suitable for trap operation. Rapid changes in water levels and debris accumulation, particularly at the south fork site, hindered trap operation on a number of occasions, however.

Captured chinook were marked from mid-January to late May of 1981 at upriver stations. Marking was accomplished with a portable CO_2 freeze branding unit using marks unique to each fork and month of capture (Table 1). Fish were anesthetized prior to marking and were allowed to completely recover prior to release below the sampling site.

Efforts to recover marks in downstream waters began in early February, and gradually increased as fry availability in upriver sites decreased. We located approximately 15 sites suitable for beach seining in the lower north and south forks and mainstem which were accessible by vehicle. Additionally, in spring and early summer, five reaches of river were beach seined by rafting to all seinable sites in each reach (Figure 1). Fifteen beach seine sites were also identified in the estuary, 4 to 6 of which were normally fishable at a given tidal height and river flow (Figure 2). Estuary seining was increased from once to twice weekly in late April, and continued until late December, in conjunction with hatchery release monitoring described below. In all, a total of 54 sites were sampled through the total recovery period (Appendix A). Seining was accomplished with a 60' net (1/8" stretch mesh), except for occasional use of a 20' net in areas of limited access.

In an effort to recover nocturnal migrants in the lower river, a floating fyke trap (Davis et al., 1981) was installed at station E15. It was fished intermittently at varying times of day and distances from shore beginning in mid-April. However, we discontinued use of this gear in late May due to high manpower requirements involved in its operation, and the greater effectiveness of beach seining in estuarine areas.

Catch per unit effort (CPUE) and forklength data were noted in all wild chinook marking and recovery work. Forklengths were measured to the nearest mm. Incidental catches of other juvenile salmonids were identified to species, and forklength and catch per effort data noted. In larger catches, only a random subsample of lengths was recorded for each species.

Marking and recovery data were used to make inferences regarding migrational characteristics of juvenile spring chinook in the upper watershed. CPUE and length data gathered during marking were used to infer migrational timing, while recovery data were used to infer spring chinook residence in the upper watershed. In addition to examining age and occurrence of individual mark recoveries, cummulative recoveries were compared to cummulative marks released on successive sampling dates to eliminate sampling variability associated with tracking specific mark groups over the recovery period.

Table 1. Marking sequence for wild juvenile spring chinook in the Nooksack River. All marks were applied to the left side.

Time Period	Mark	
	North Fork	South Fork
January 15 - February 15	Anterior Triple Dot	Anterior Bar
February 16 - February 28	Anterior T	Anterior O
March 1 - March 31	Anterior V	Anterior Double Dot
April 1 - April 30	Posterior Triple Dot	Posterior Bar
May 1 - May 31	Posterior T	Posterior O

Hatchery Spring Chinook

Behavior of hatchery spring chinook was examined by monitoring movement of 75,000 native south fork stock (1980 brood) reared and released at Skookum Hatchery (Figure 1). Two subyearling releases of 64/lb and 9/lb were made by the Lummi Tribe on June 15, 1981, and September 15, 1981, respectively. An estimated 47,600 springs were released on the earlier date, and 26,400 on the latter. Movement and size data were gathered by repetitive beach seining with a 60' net (1/8" stretch mesh) at 12 downstream locations after the June release, and 15 locations after the September release. Seining continued until late December 1981. Several changes in sampling locations were required before the September release, however, due to loss of access to some sites used in the June recovery work.

Skookum Hatchery spring chinook were distinguished from catches of other chinook by the adipose fin clip incurred during microtagging. Of all other chinook releases made in the Nooksack drainage in 1981, only one group of approximately 48,000 Skookum falls (Samish stock) were microtagged (Appendix B). We identified these adipose-clipped fish by applying an "X" freeze-brand to their left side during the microtagging process. These chinook, which were of similar size and number and released the same day as the first group of Skookum spring chinook, were easily recognizable in downstream seine catches by the "X" brand.

CPUE and forklength were noted for all mark recoveries. CPUE was used to compute mean residence time (Healy, 1980) and date of median fish capture (Dawley et al., 1981) for each recovery site. These estimates of the rate of movement were compared between spring chinook releases and the marked group of fall chinook. Forklengths of mark recoveries (measured to the nearest mm) were aggregated by recovery week and by river section (i.e., south fork, mainstem, and estuary) to infer changes in size over the recovery period.

Incidental catches of other juvenile salmonids were identified to species, and total catch and forklength were noted. In larger catches, only random subsamples of forklengths were recorded. Catch data for selected stations are provided in the appendices as a reference. A release of native north fork spring chinook (1980 brood) from Kendall Hatchery was not identifiable in chinook catches as these fish were unmarked, and their size at release was very similar to a concurrent fall chinook release from this hatchery (Appendix B).

RESULTS

Wild Spring Chinook-Marking

We branded a total of 3,856 Nooksack juvenile spring chinook salmon, 3,032 of which were captured at north fork stations and 824 at south fork stations. Station N1 was the primary capture site for north fork juveniles. Electroshocking was the most effective capture method at this side channel location, followed by use of the inclined plane trap. On the south fork, station S3 yielded the greatest number of juvenile chinook. At this main channel sampling site, electroshocking and trapping were equally effective.

Numbers of marks released reflect the greater catch per unit effort for both gear types in the north fork versus south fork stations. Peak catches occurred somewhat sooner at station N1 compared to south fork stations, although juvenile chinook were present in appreciable numbers in both forks over the same general time period, i.e., early February until early May (Figures 4 and 5).

Forklengths of fish marked at all north and south fork stations indicate that, with the exception of only three individuals, all chinook were young-of-the-year. Their mean forklength was 38.8 mm, with over 90% under 43 mm. No significant size difference existed between north and south fork fish, although mean lengths of electroshocker catches were significantly greater at lower stations within the north fork ($t = 9.28$, $P < 0.05$) and the south Fork ($t = 5.63$, $P < 0.05$). These differences were 2.73 mm and 2.17 mm for north and south fork stations, respectively. Figure 6 illustrates size composition of catch by gear type at these stations over the entire marking period.

Weekly size composition of juvenile chinook marked at upriver sites is shown in Figures 7 through 10. At all stations, size was relatively constant in electroshocker catches over the entire 13-week marking period, with means ranging from 38 to 42 mm. However, in trap catches, noticeable increases in mean length were encountered during the final three weeks at the north fork (Figure 7). Nonhomogeneity of sample variances precluded statistical testing of these differences, however. The final week of south fork trapping also yielded an increase in mean length (Figure 10), which was significantly greater than all previous trap catches at that site ($F = 12.89$, $P < 0.05$, Student-Newman-Keuls Procedure*). Gaps in trap data occurred when high water rendered the traps inoperative.

Wild Spring Chinook-Recovery

In all, we recaptured only 109 of the 3,856 chinook marked in the upper north and south forks. With two exceptions, all recaptures were either at or within five river miles of the release site. The two exceptions were south fork marks recovered near Acme and Deming, which were 7.5 and 17.5 river miles, respectively, below the nearest release point on the south fork (station S3).

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*Nie, N., et al., 1975. SPSS: Statistical Package for the Social Sciences. McGraw-Hill, Inc. 675 pp.

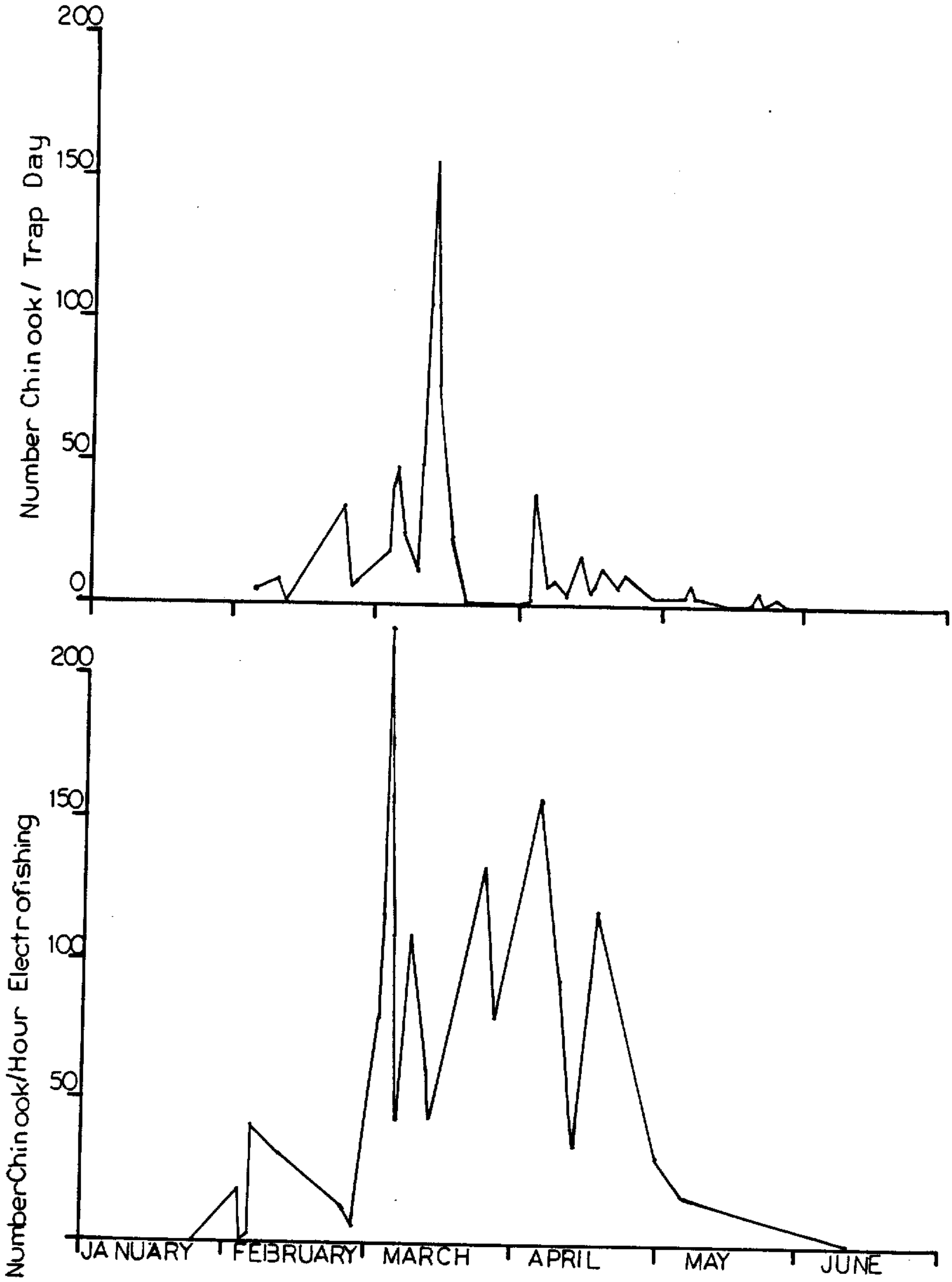

FIGURE 4. Catch per unit effort at station N1, north fork of the Nooksack River.

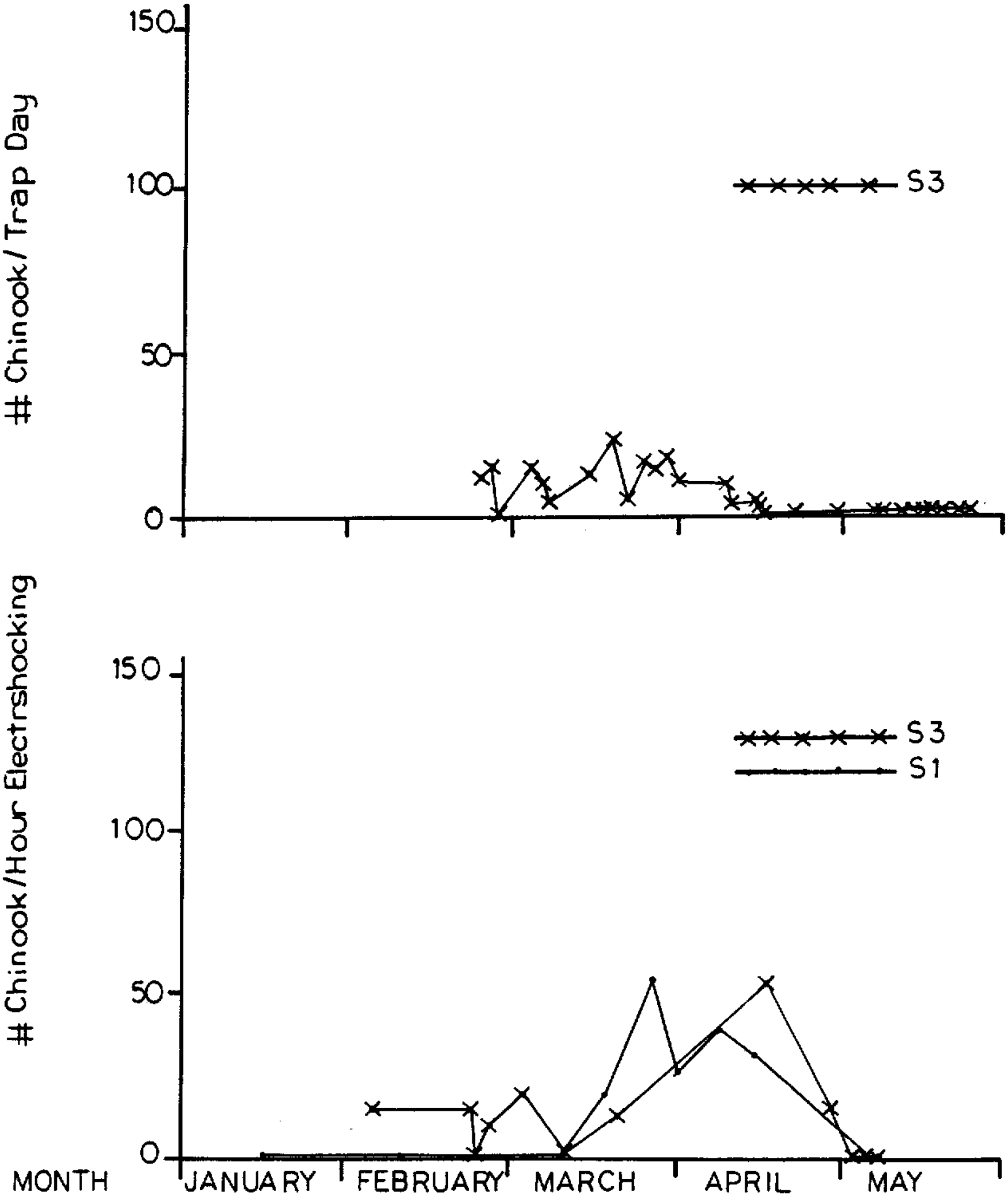

FIGURE 5. Catch per unit effort at stations S1 and S3, south fork of the Nooksack River.

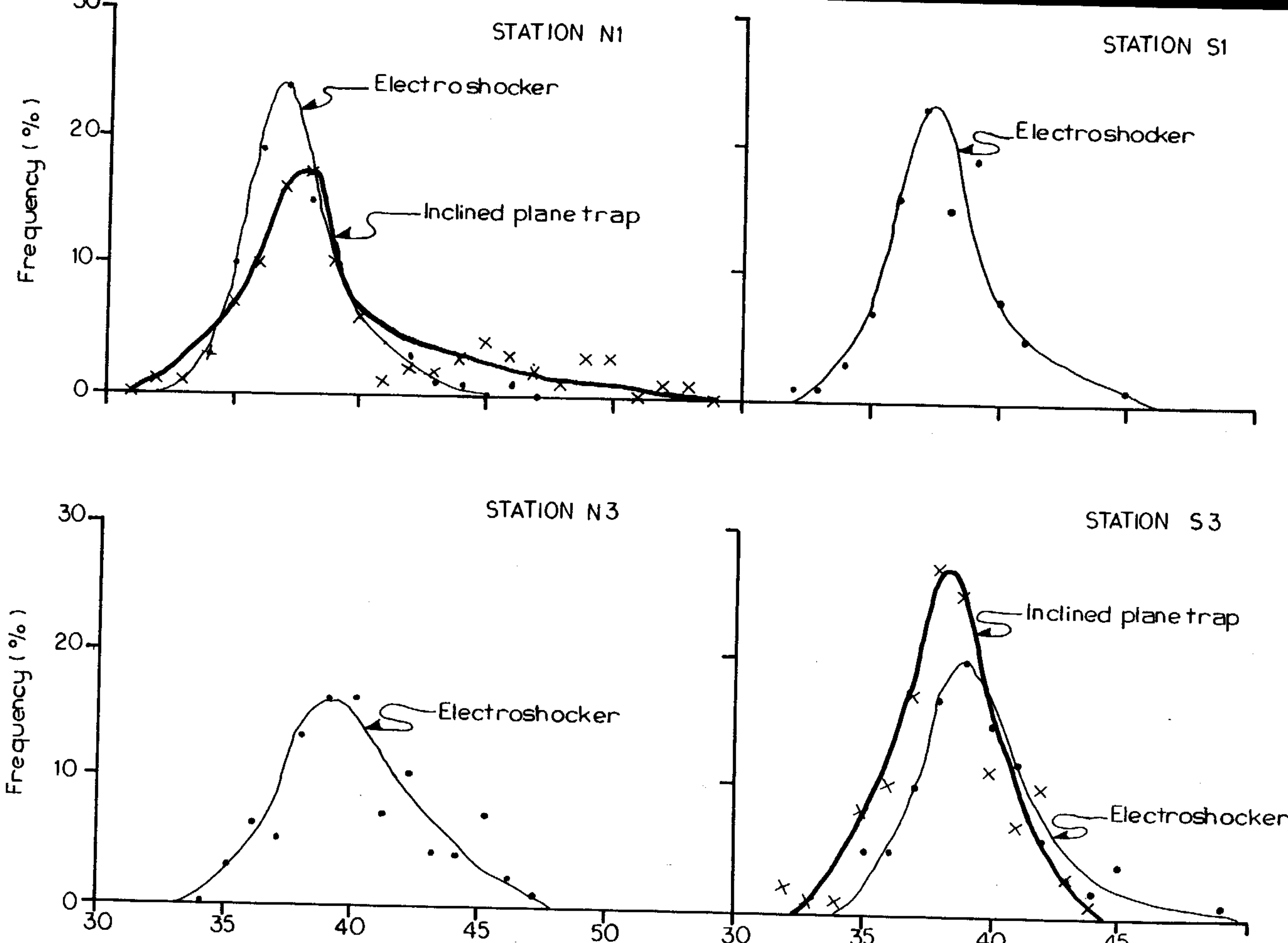

FIGURE 6. Forklength frequencies of juvenile chinook captured by electroshocking and trapping at upper north and south fork stations from January 15 to May 15, 1981.

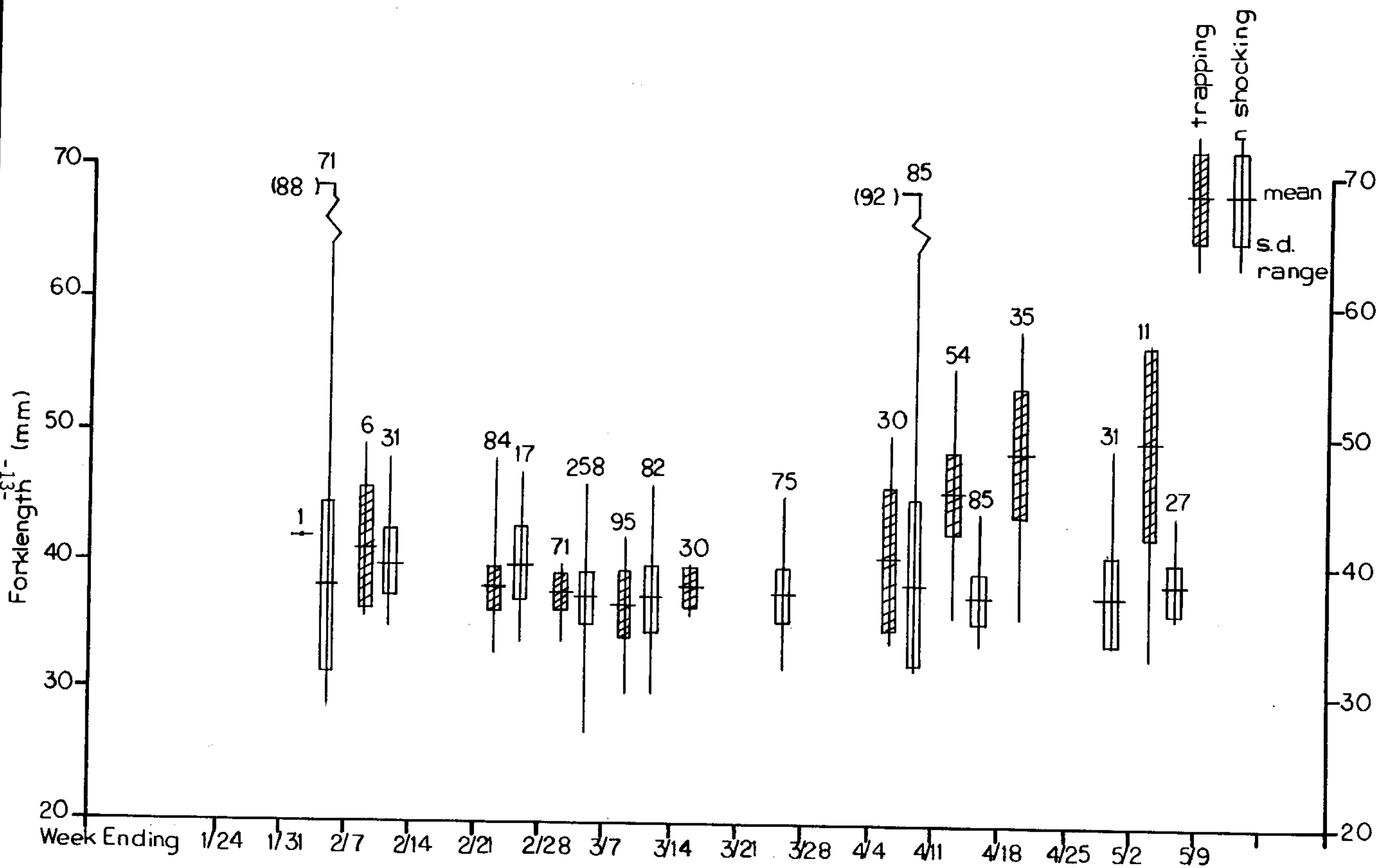

FIGURE 7. Weekly forklength data for unmarked chinook captured by electroshocking and trapping at station N1, north fork of the Nooksack River.

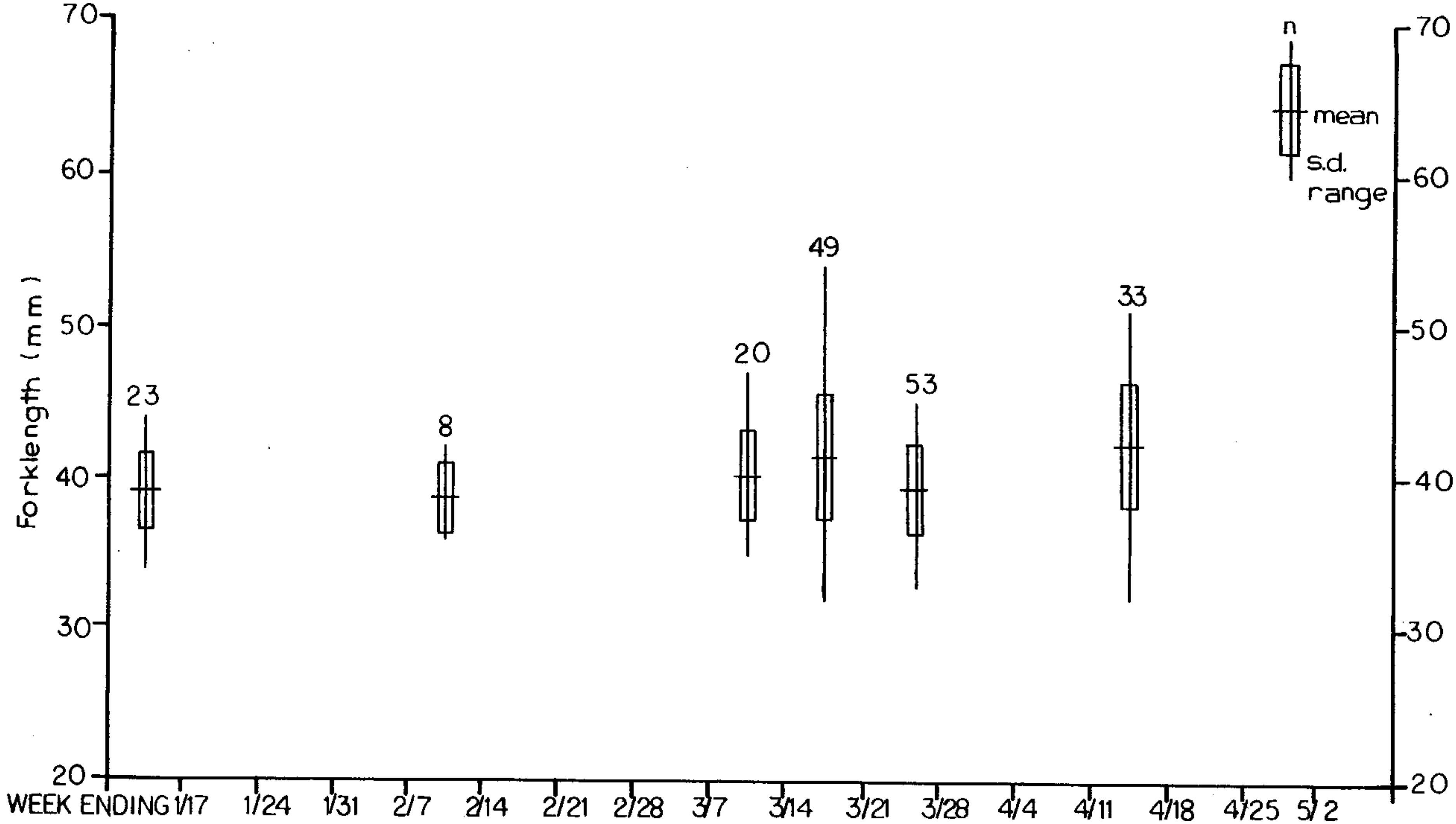

FIGURE 8. Weekly forklength data for unmarked chinook captured by electroshocking at station N 3, north fork of the Nooksack River.

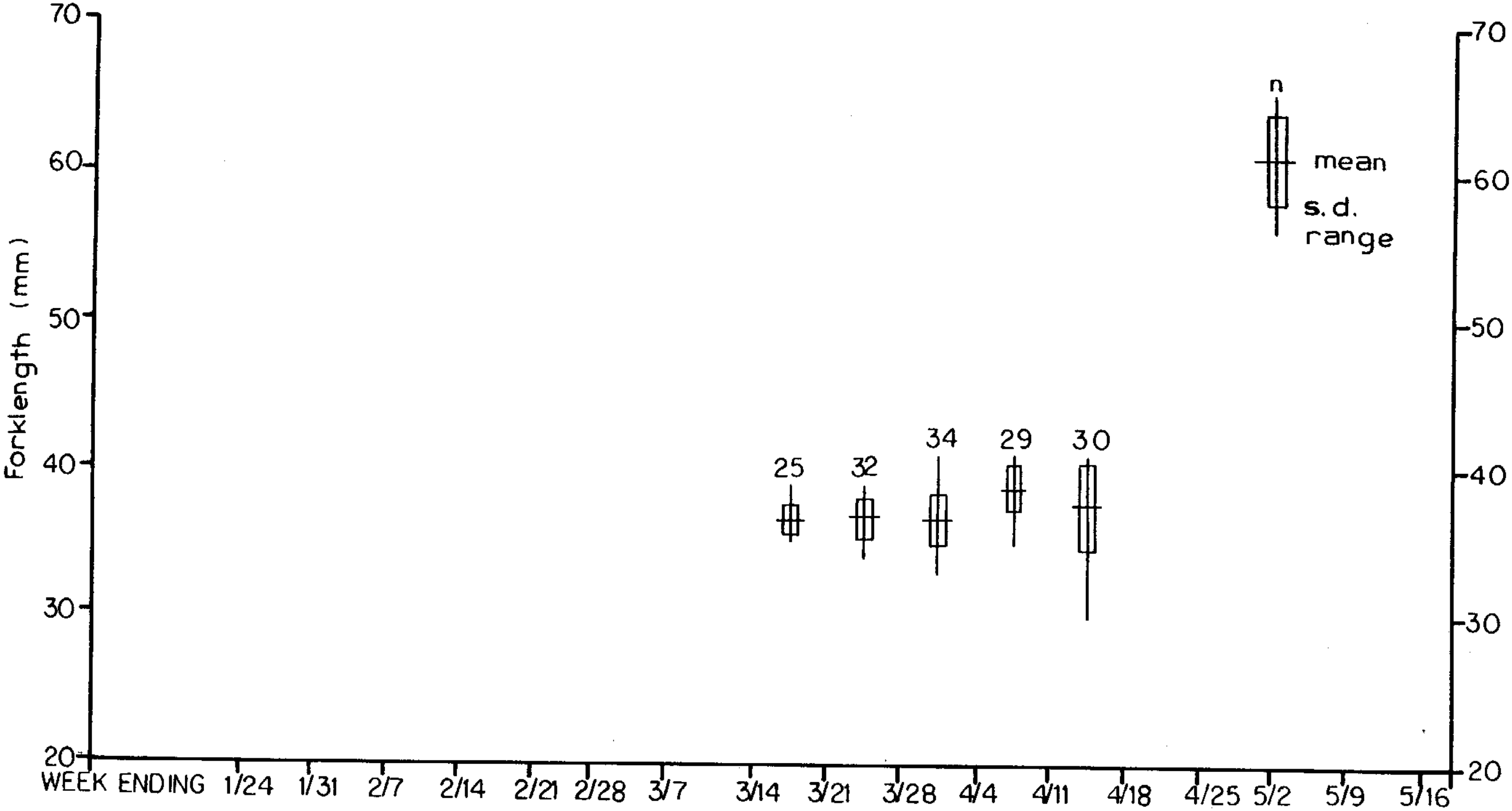

FIGURE 9. Weekly forklength data for unmarked chinook captured by electroshocking at station S1, south fork of the Nooksack River.

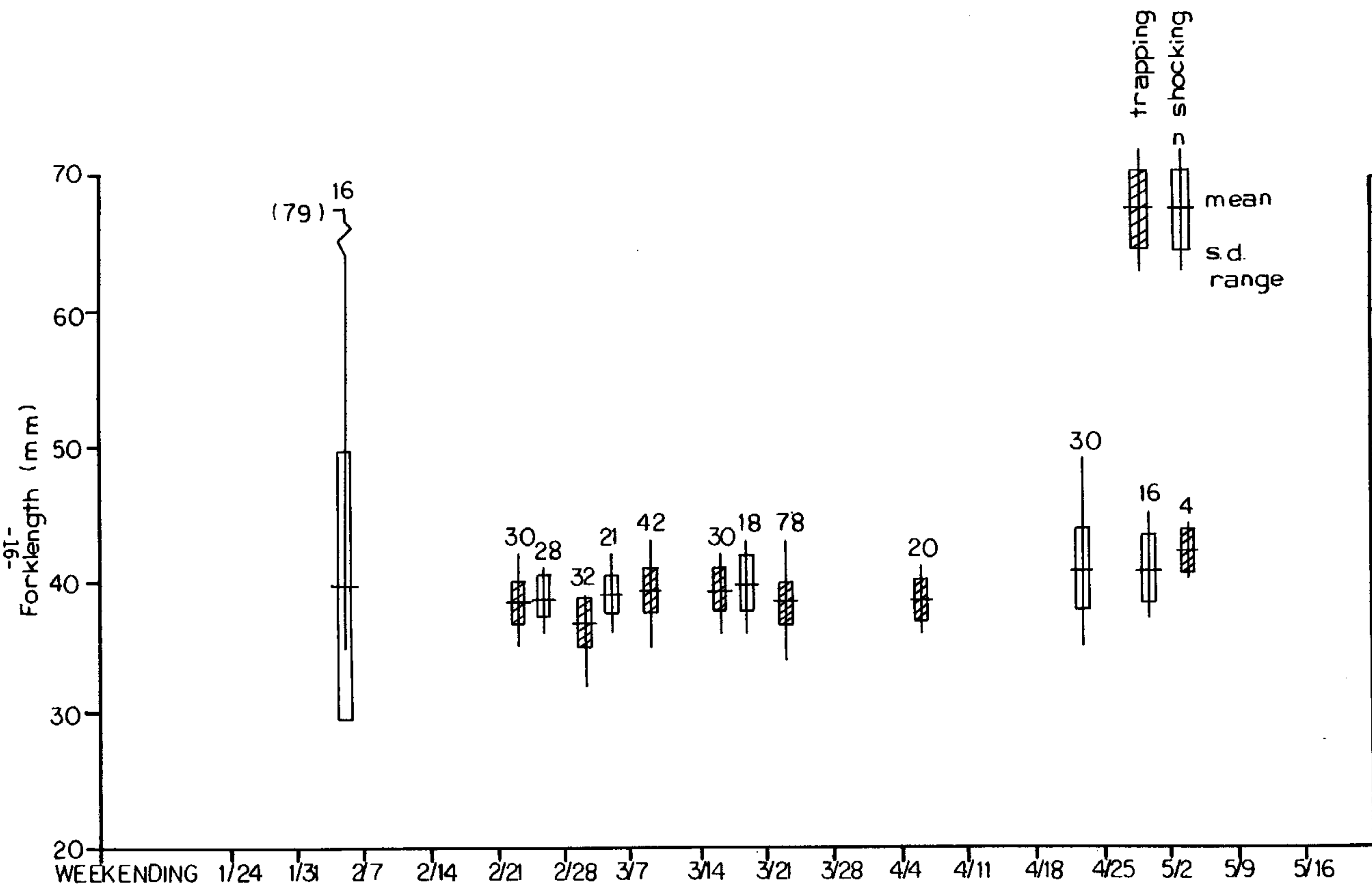

FIGURE 10. Weekly forklength data for unmarked chinook captured by trapping and electroshocking at station S3, south fork of the Nooksack River.

The majority of recoveries were made within four weeks of release (a more exact estimate of age of recoveries was not possible as brands were changed monthly), and were marked during the month of March. Station N1 yielded both the greatest number of mark recoveries and the oldest marks recovered. These recoveries necessarily originiated at this uppermost site. Relatively fewer recoveries were made at the south fork stations. Table 2 summarizes all recovery data by location and by age of mark recovered.

Mean forklengths of fishes recaptured in the first two recovery periods (0-4 and 1-5 weeks, Table 2) were similar to size at marking. Sizes of later recoveries ranged from zero to seven mm larger than mean forklengths of corresponding mark groups, with a generally increasing trend in later recoveries. The limited number of recoveries precluded statistical comparison, however. The largest recaptures (both 46 mm) were the isolated recoveries at station N2 and in the mainstem in the Deming vicinity (Table 2).

Comparison of cumulative marks recovered to cumulative marks released over the entire 16-week marking period indicated that, after the first several weeks, the percentage recovery of marks in each fork was quite constant at approximately 3.1% of marks released in the north fork and 1.8% of marks released in the south fork (Figure 11). A more specific examination of recoveries within each fork was not practical due to the varying effort and gear types used over the sampling period, and the limited numbers of recoveries encountered.

Hatchery Spring Chinook

Recovery patterns for both spring chinook groups and the single group of marked fall chinook released from Skookum Hatchery were measurably different, but differences between June and September releases were most evident.

For June releases of marked spring and fall chinook, CPUE was highest at all stations during the first two weeks following release, with largest catches occurring at upper stations (Figures 12, 13, and 14). Strong parallel fluctuations in catch were also evident for both groups shortly after release. Such fluctuations showed little correlation with river flow, however, based on USGS discharge records for this period.

Peak catches for both June-released groups occurred the day of release at the Saxon Bridge site (S7), the following day in the lower south fork (S9), the third day at most mainstem stations, and the fourth day at most estuarine stations, although peaks in spring chinook catches tended to lag behind fall chinook catches in lower river sampling sites. The total recovery period for springs was substantially longer than falls at nearly all stations, with the last recovery of a June-released spring chinook occurring at Saxon Bridge (S7) 57 days after release. Other stations ranged from 15 to 47 days till final recovery of spring chinook. The last recovery of the fall chinook group also occurred at Saxon Bridge, 36 days after release, and at other stations 11 to 23 days following release.

Table 2. Mark and recovery summary for wild spring chinook.

Location	No. Marked	No. Recovered	No. Recovered by Age (Weeks)						
			0-4	1-5	2-6	3-7	4-8	5-9	6-10
North Fork									
Sta. N1	2,846	74	60	6	4	1	2		1
Sta. N2	0	1						1	
Sta. N3	186	19	15		4				
Total	3,032	94	75	6	8	1	2	1	1
South Fork									
Sta. S1	222	7	3	3	1				
Sta. S2	154	0							
Sta. S3	448	6	5			1			
Acme Vicinity	0	1			1				
Total	824	14	8	3	2	1	0	0	0
Mainstem									
Deming Vicinity	0	1			1				

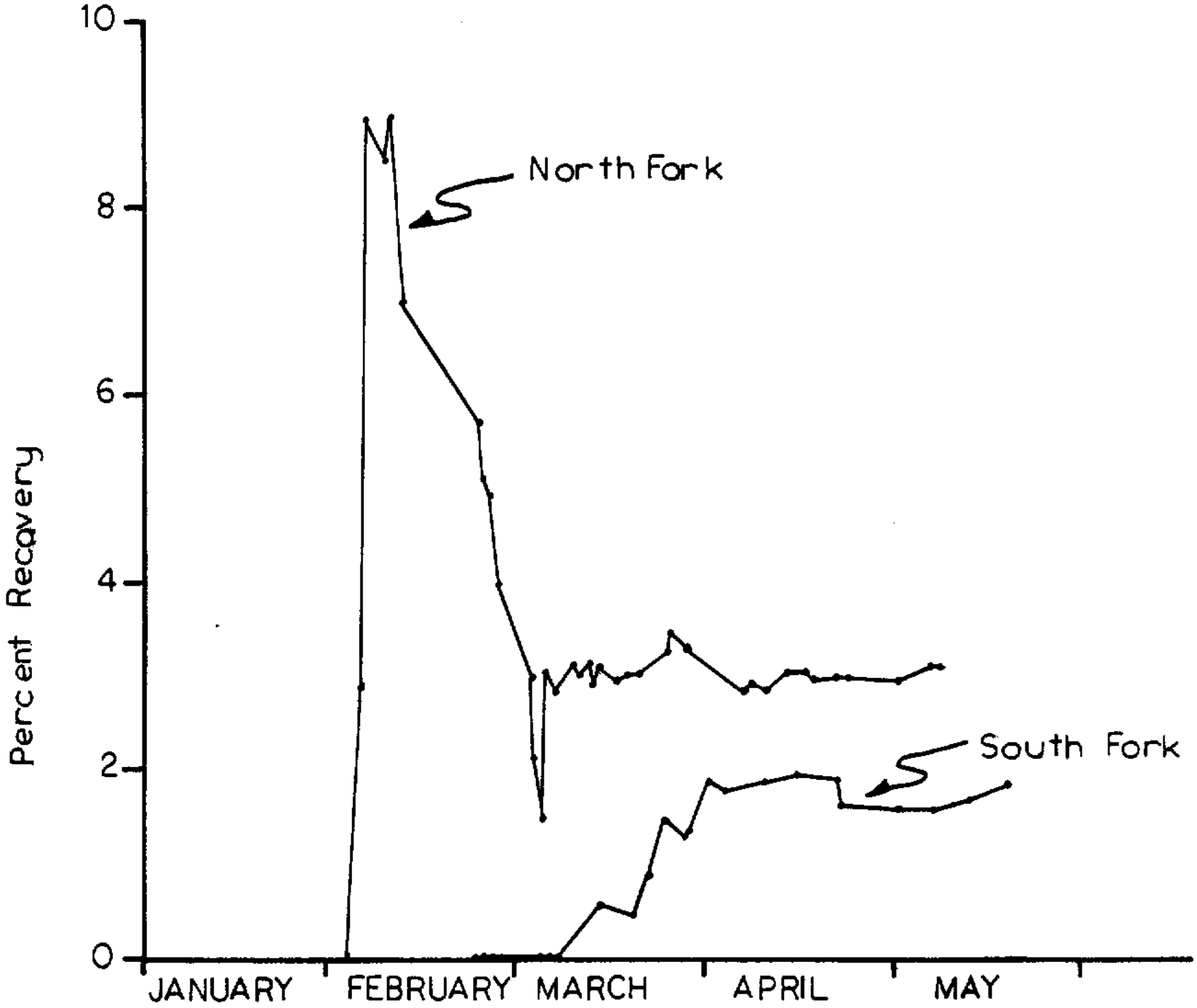

FIGURE 11. Percent recovery [(cumulative recoveries/cumulative marks released) X 100] by date in the north and south forks.

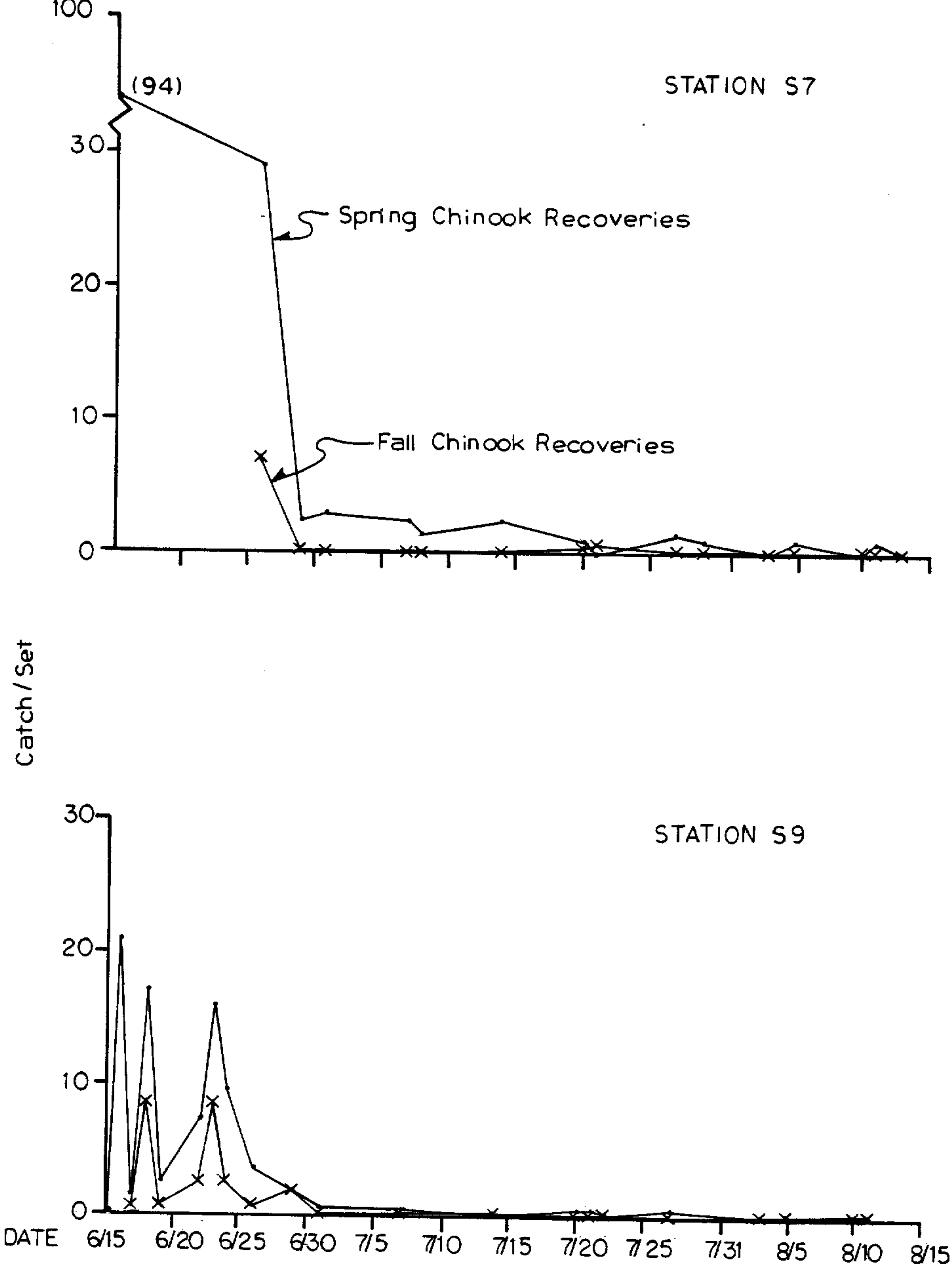

FIGURE 12. Recoveries of Skookum Hatchery spring and fall chinook at South Fork stations S7 and S9 after 6/15/81 release.

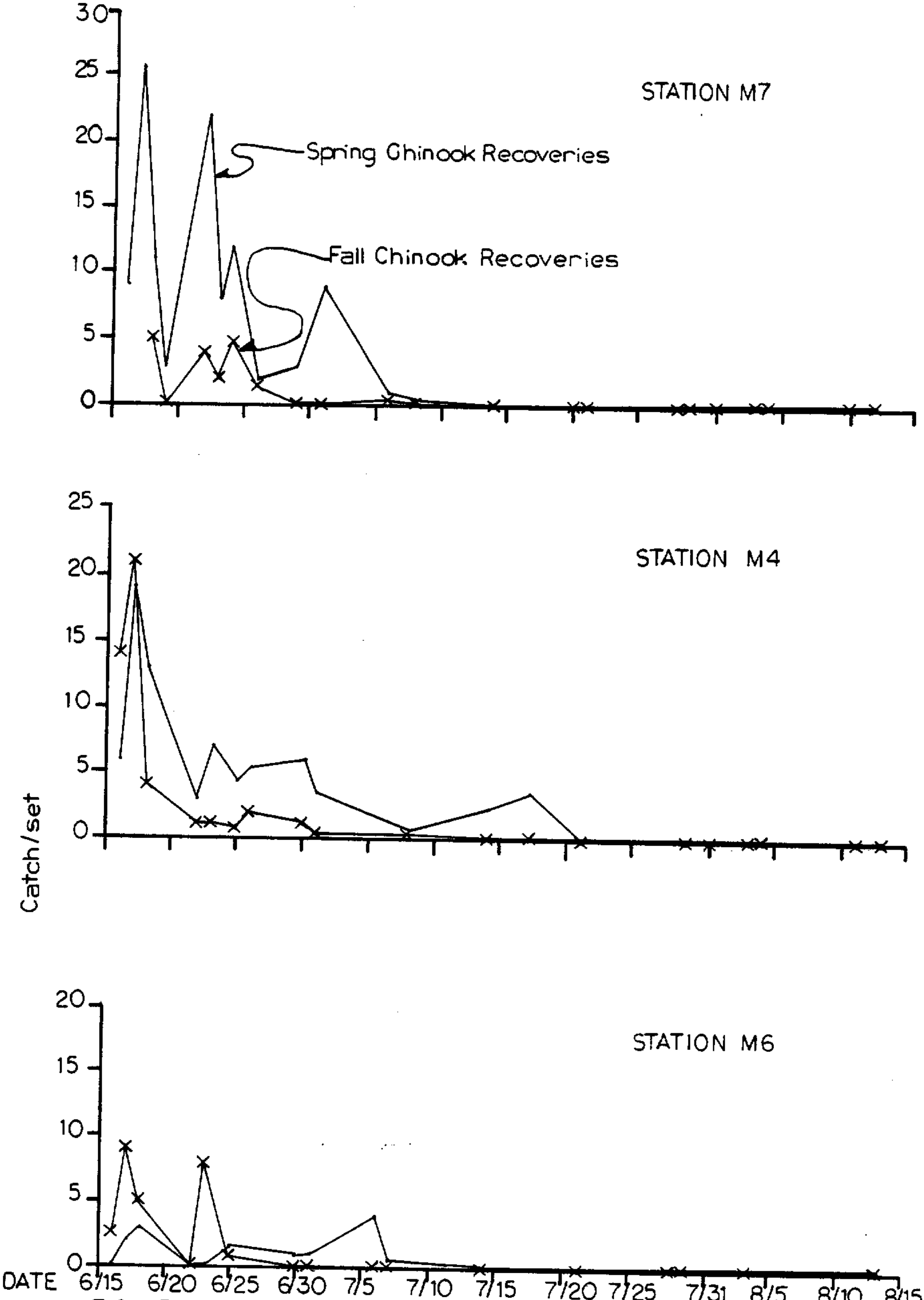

FIGURE13. Recoveries of Skookum Hatchery spring and fall chinook at mainstem stations M7, M4, and M6 after 6/15/81 release. Stations are arranged in downstream order.

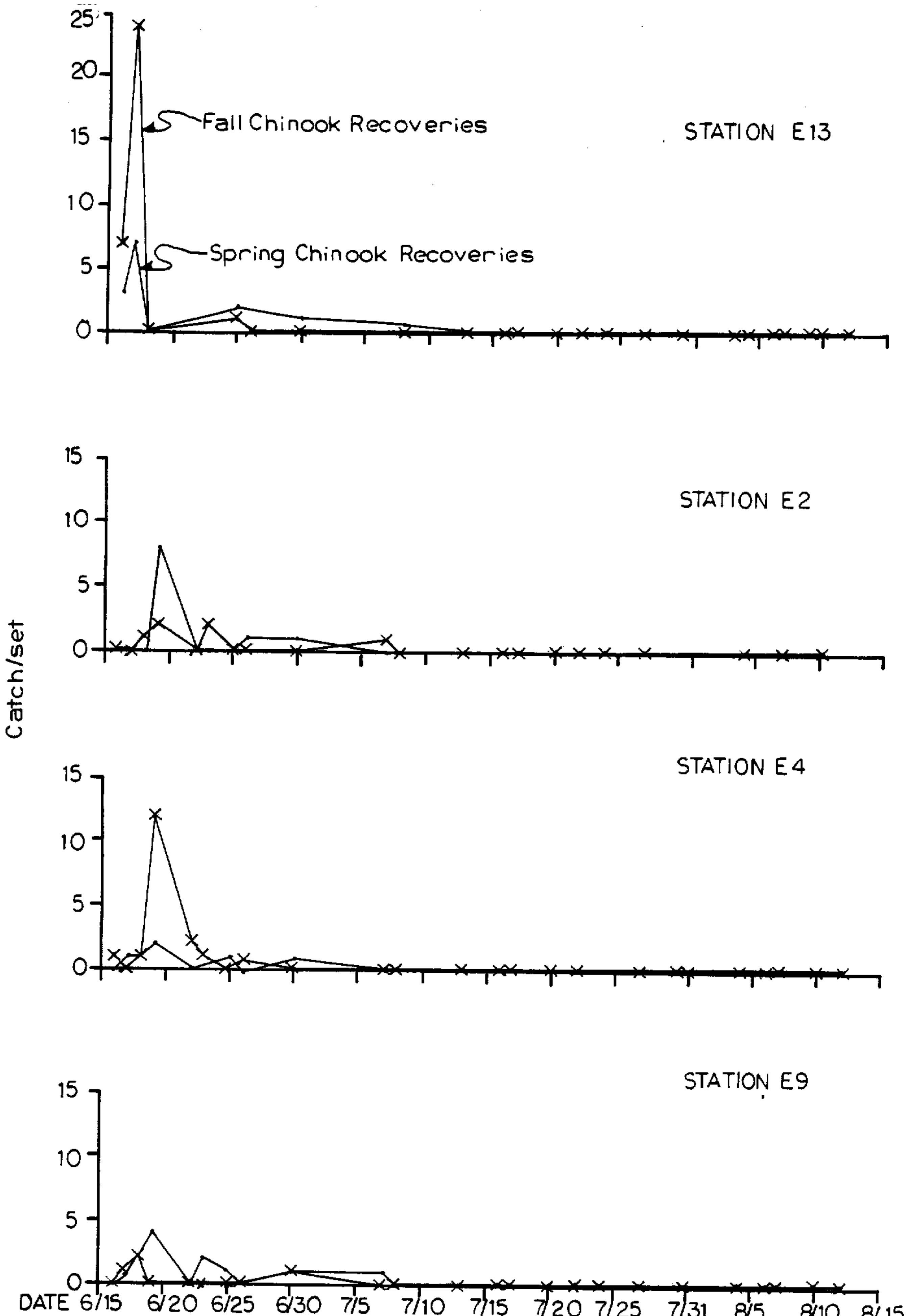

FIGURE 14. Recoveries of Skookum Hatchery spring and fall chinook at estuary stations E13, E2, E4, and E9 after 6/15/81 release. Stations are arranged in downstream order.

Unlike recoveries of June-released spring and fall chinook, the recovery pattern of September-released springs suggested a much slower migration rate. Catch rates were much lower and the recovery period more prolonged compared to either of the June releases (Figures 15 and 16). September catches were initially high only at mainstem stations and the uppermost estuarine station (E13); however, early south fork catches were undoubtedly affected by seasonally low water conditions which reduced gear efficiency. Estuarine catches were generally low and variable during the first weeks of the recovery period as well.

Peak catches of September-released chinook occurred the second and third days following release at mainstem stations and at station E13, although CPUE was considerably less than that of the earlier releases. Peak catches at other stations were much later, with south fork peak catches as late as November 24th. The total recovery period for this release is uncertain, as recoveries continued up to the last week of field activity in late December at the Saxon Bridge site (S7), 93 days after release. Recoveries at this site included precocious males in earlier catches. The recovery period at other stations ranged from 6 to 87 days, with the oldest recoveries reported at upper mainstem sites M7 and M10. Examination of microtags in several of the very late recoveries confirmed they were September-released Skookum spring chinook.

Estimates of movement rates based on mean residence time between release and recapture sites (Healy, 1981), and dates of median fish capture at recovery sites (Dawley et al., 1981) substantiated differences in migrational characteristics among the three releases. Mean residence time estimates, which weight CPUE by julian day of recovery, suggested that the bulk of the fall chinook release reached the upper estuary in approximately three days, with little residualism enroute. This equates to a movement rate of approximately 8 to 9 river miles per day. Corresponding estimates of the two spring chinook releases suggested that residence was 2 to 3 times greater for the June release group, indicating a movement rate of approximately 3 river miles per day. Residence time of the September release was substantially longer yet, with a portion of this group exhibiting strong residualism in the upper south fork. Residence values associated with estuarine sites for all groups tended to follow these trends, but anomalous values were present as well (Table 3).

Dates of median fish capture, or occurrence of the 50th percentile of the release group, closely agreed with the above residence time estimates for both June releases, but differed with residence estimates for mainstem values associated with the September release (Table 4). Median fish capture dates at these locations were less influenced by the presence of later migrants than were residence time estimates, above. Estuarine values were again anomalous.

Length data for weekly catches of June-released chinook are shown in Figures 17 to 19. At release, mean forklength was 81.9 mm (n = 249) for spring chinook and 80.75 mm (n = 8) for fall chinook. No significant differences

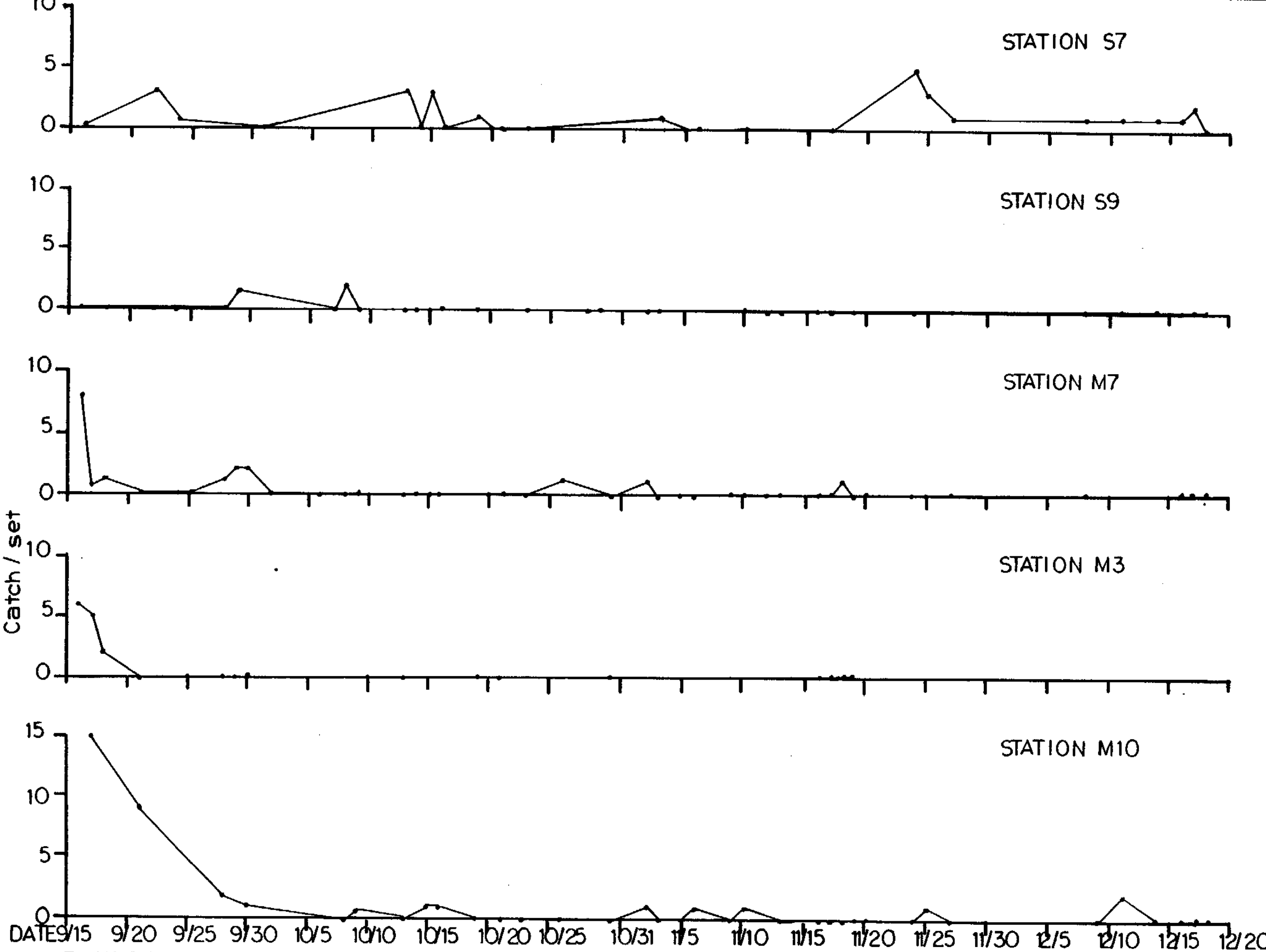

FIGURE 15. Recoveries of Skookum Hatchery spring chinook after 9/15/81 release. Stations are arranged in downstream order in south fork and mainstem.

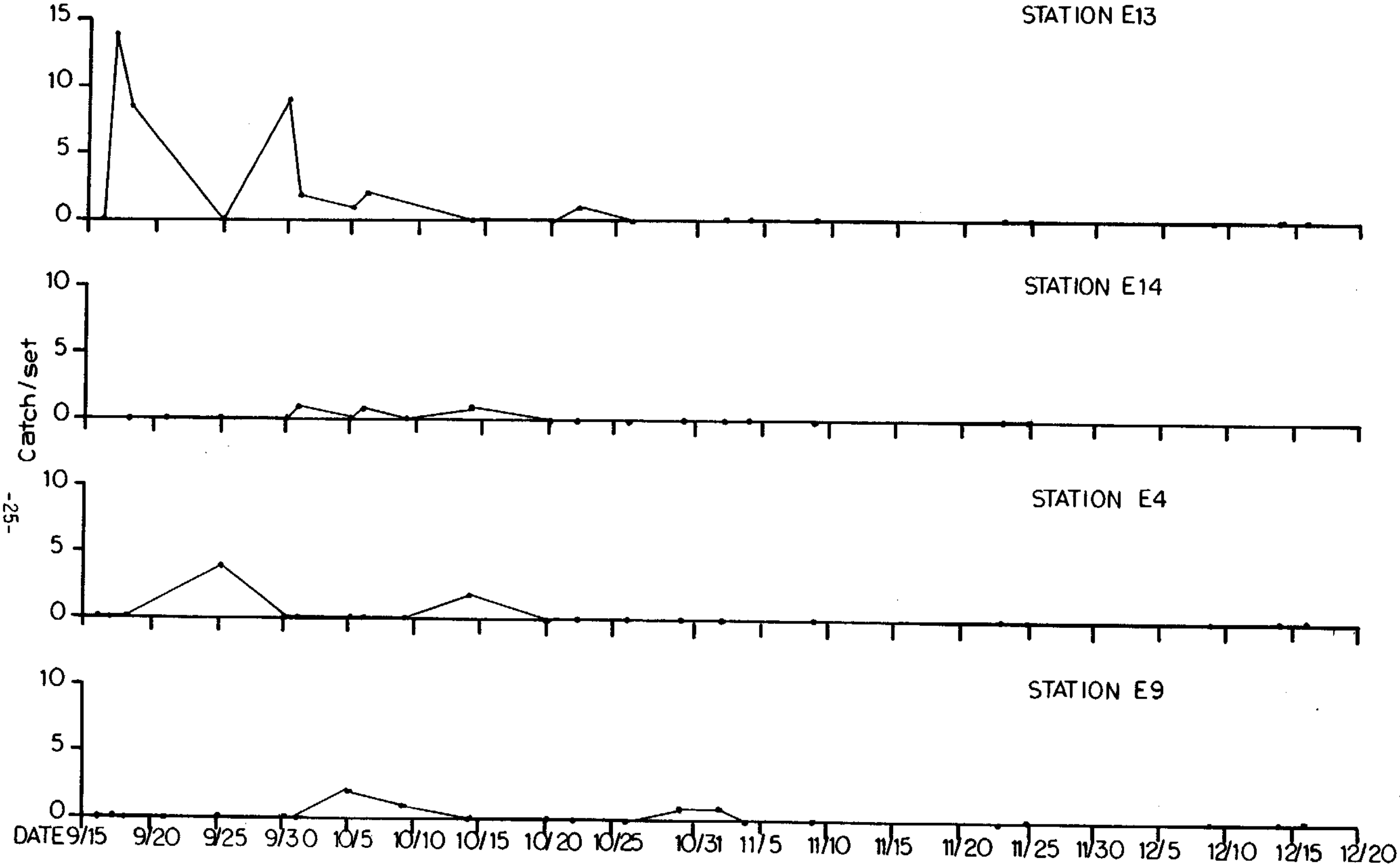

FIGURE 16. Recoveries of Skookum Hatchery spring chinook at estuarine stations after 9/15/81 release. Stations are arranged in downstream order in the Nooksack estuary.

Table 3. Mean residence time in days between Skookum Hatchery and recovery sites for June and September releases.

Recovery Site	Fall Chinook (June Release)	Spring Chinook (June Release)	Spring Chinook (Sept. Release)
South Fork:			
S7	1.2*	5.8	70.0
S9	4.1*	6.0	19.1
Mainstem:			
M7	3.4*	6.3	13.5
M4	3.0	8.1	-
M6	4.2	11.9	-
M10	-	-	16.9
Estuary:			
E13	2.0	4.7	8.5
E2	8.2	5.8	-
E14	-	-	22.0
E4	4.5	6.6	16.3
E9	5.8	7.5	31.4

* CPUE conservatively estimated for first two days of recovery period.

Table 4. Number of days from release to date of median fish capture at recovery sites for June and September releases.

Recovery Site	Fall Chinook (June Release)	Spring Chinook (June Release)	Spring Chinook (Sept. Release)
South Fork:			
S7	0*	0	55
S9	3*	4	23
Mainstem:			
M7	3	7	4
M4	2	3	-
M6	3	10	-
M10	-	-	6
Estuary:			
E13	2	2	3
E2	4	4	-
E14	-	-	21
E4	4	4	10
E9	2	4	24

* CPUE conservatively estimated for first two days of recovery period.

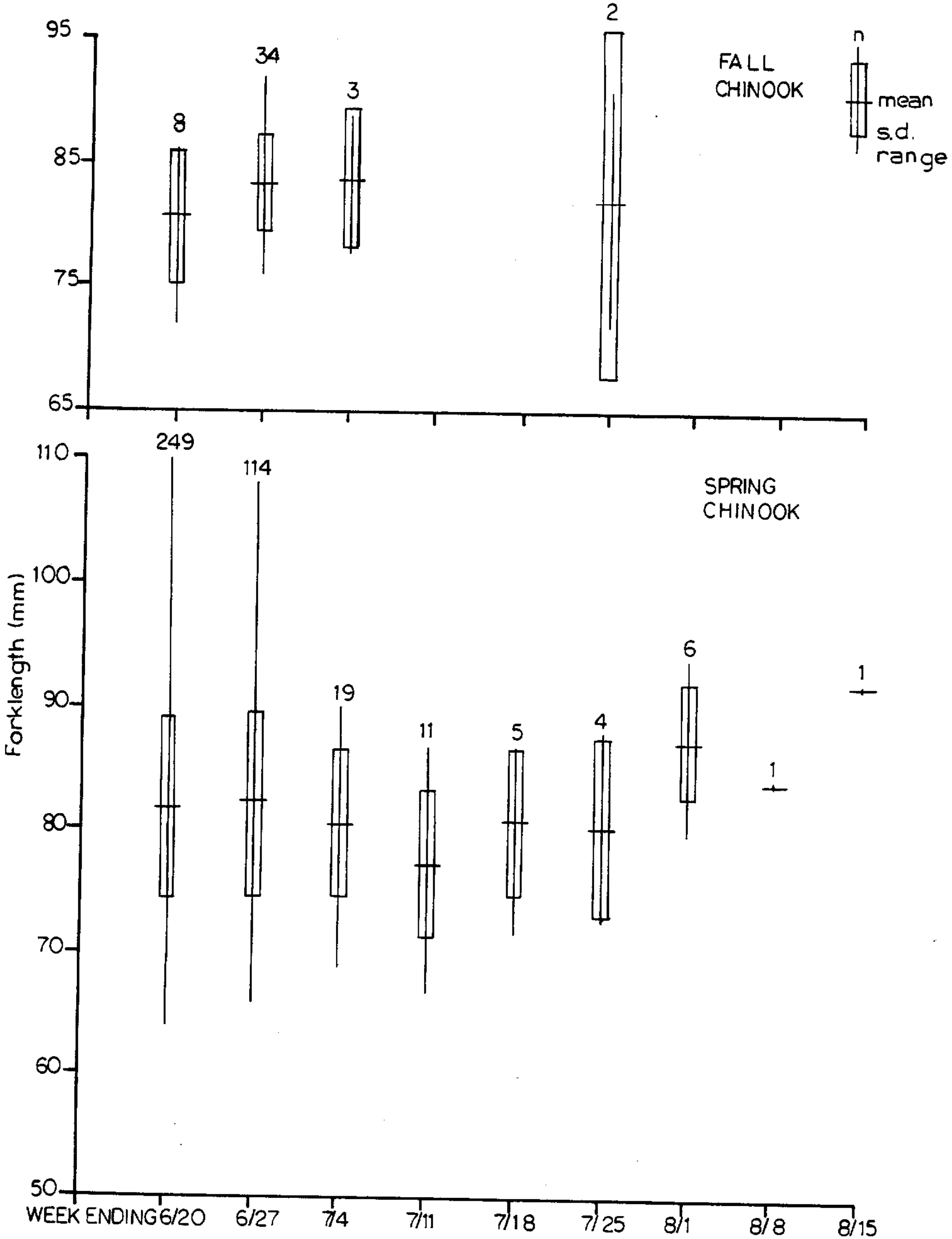

FIGURE 17. Weekly forklength data for recoveries of Skookum hatchery chinook at south fork stations (S6, S7, S8, S9) following 6/15/81 release.

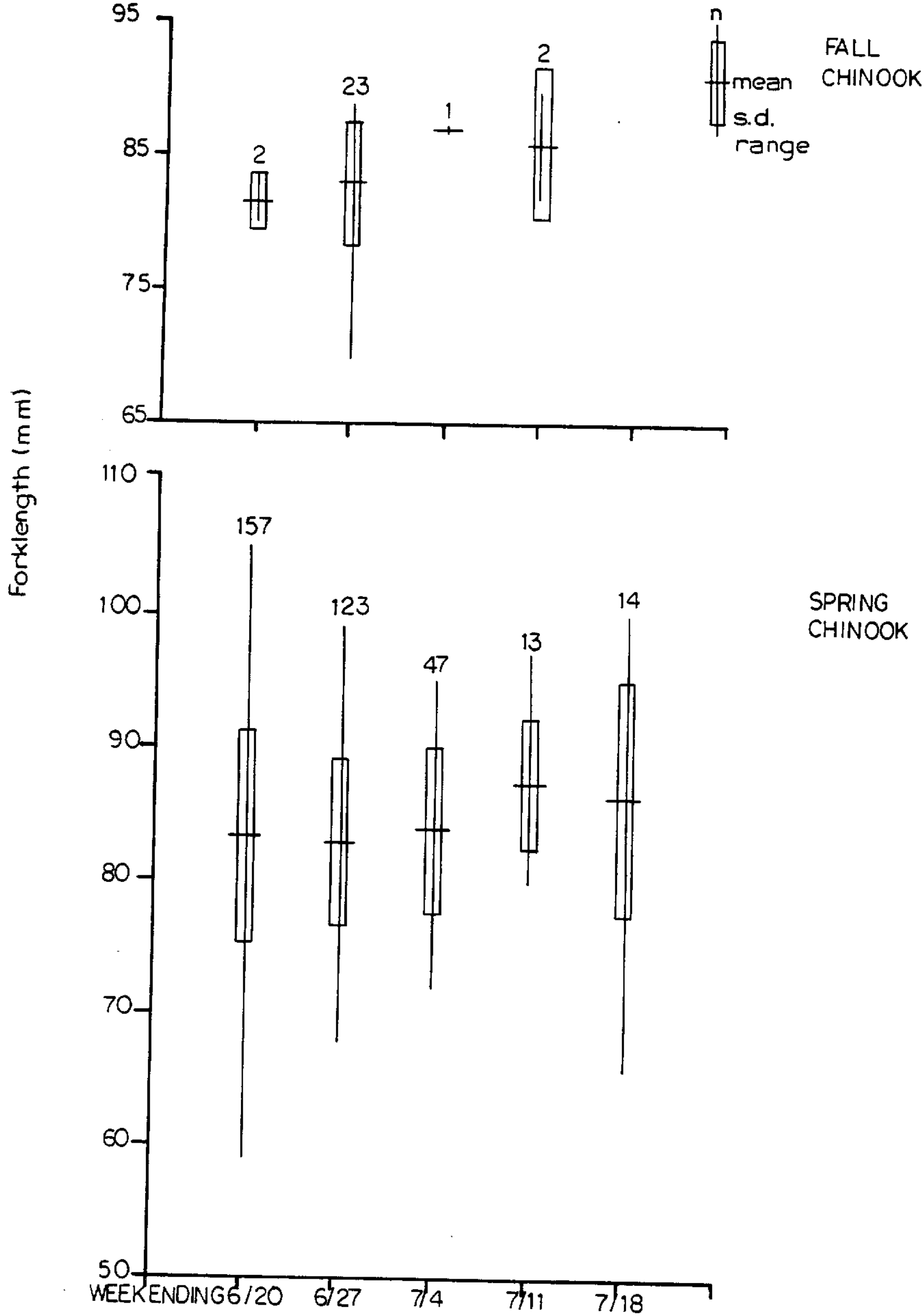

FIGURE 18. Weekly forklength data for recoveries of Skookum Hatchery chinook at mainstem stations (M9, M7, M4, M6) after 6/15/81 release.

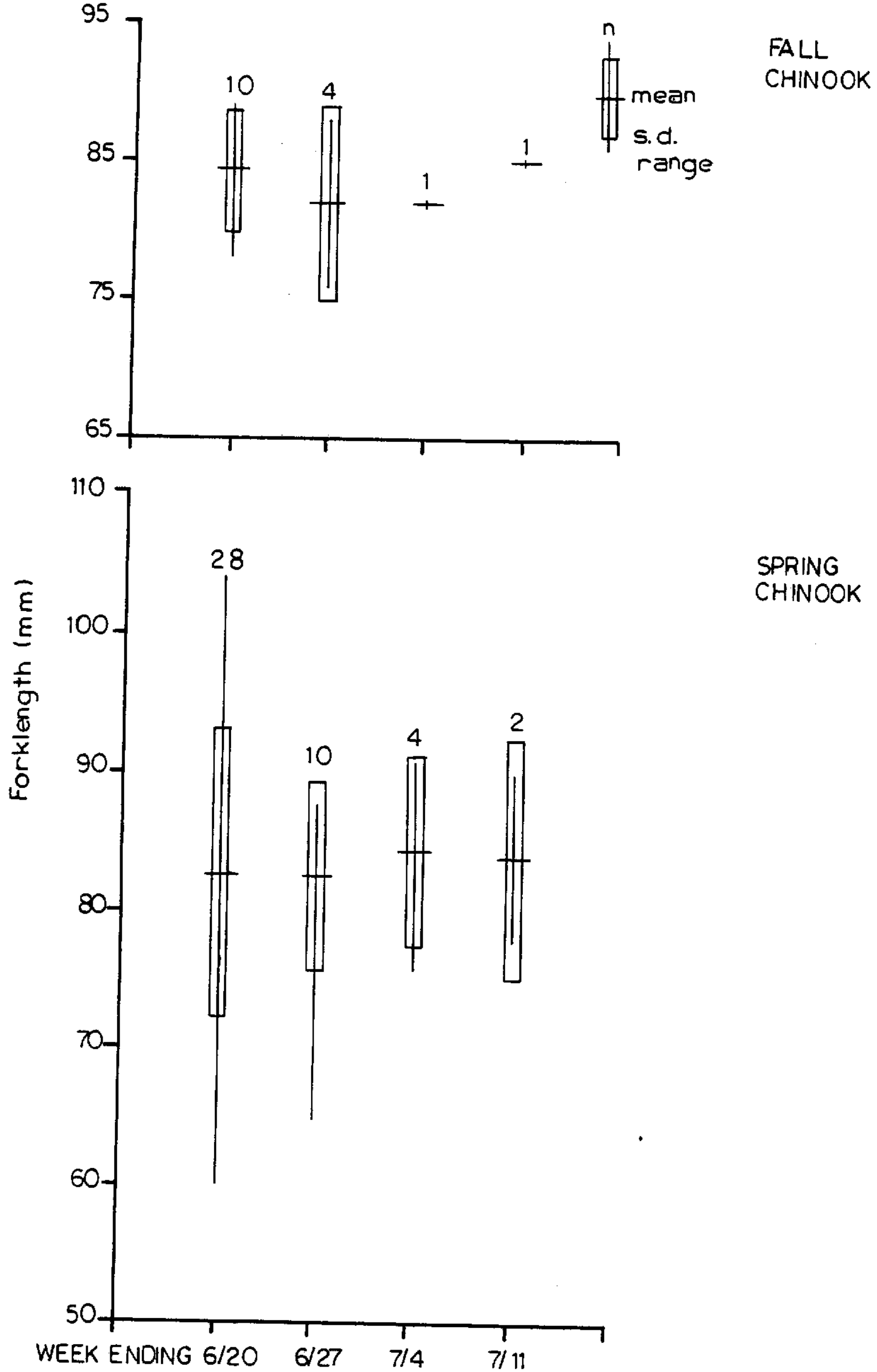

FIGURE 19. Weekly forklength data for recoveries of Skookum Hatchery chinook at estuarine stations (E13, E2, E4, E9) following 6/15/81 release.

in mean forklength were found in spring chinook catches over the recovery period within south fork, mainstem, or estuarine areas. However, comparison between river sections indicated that south fork recoveries as a whole were significantly smaller-sized than either mainstem or estuarine recoveries ($F = 4.226$, $P < 0.05$), although this difference in mean lengths was quite small (< 1.5 mm). In contrast, examination of fall chinook recoveries indicated no significant length differences in recoveries either within or between river sections.

Length data for September-released springs are shown in Figure 20. These fish averaged 144.9 mm ($n = 58$) at time of release. During recovery, significantly smaller-sized springs were encountered in the latter weeks of sampling in the south fork ($F = 9.56$, $P < 0.05$). Specifically, south fork catches made the weeks of 10/17, 11/28, and 12/19 (Figure 20) were significantly smaller in length than initial catches (Student-Newman-Keuls Procedure, $P < 0.05$). Chinook in this size range (≤ 130.5 mm) comprised less than 12% of pre-release length samples, however. Similar comparisons in mainstem and estuarine catches were not significant. Comparison between river sections, however, again indicated a significantly smaller mean forklength for south fork versus mainstem and estuarine beach seine catches ($F = 29.54$, $P < 0.01$). This difference in mean forklengths was approximately 19 mm.

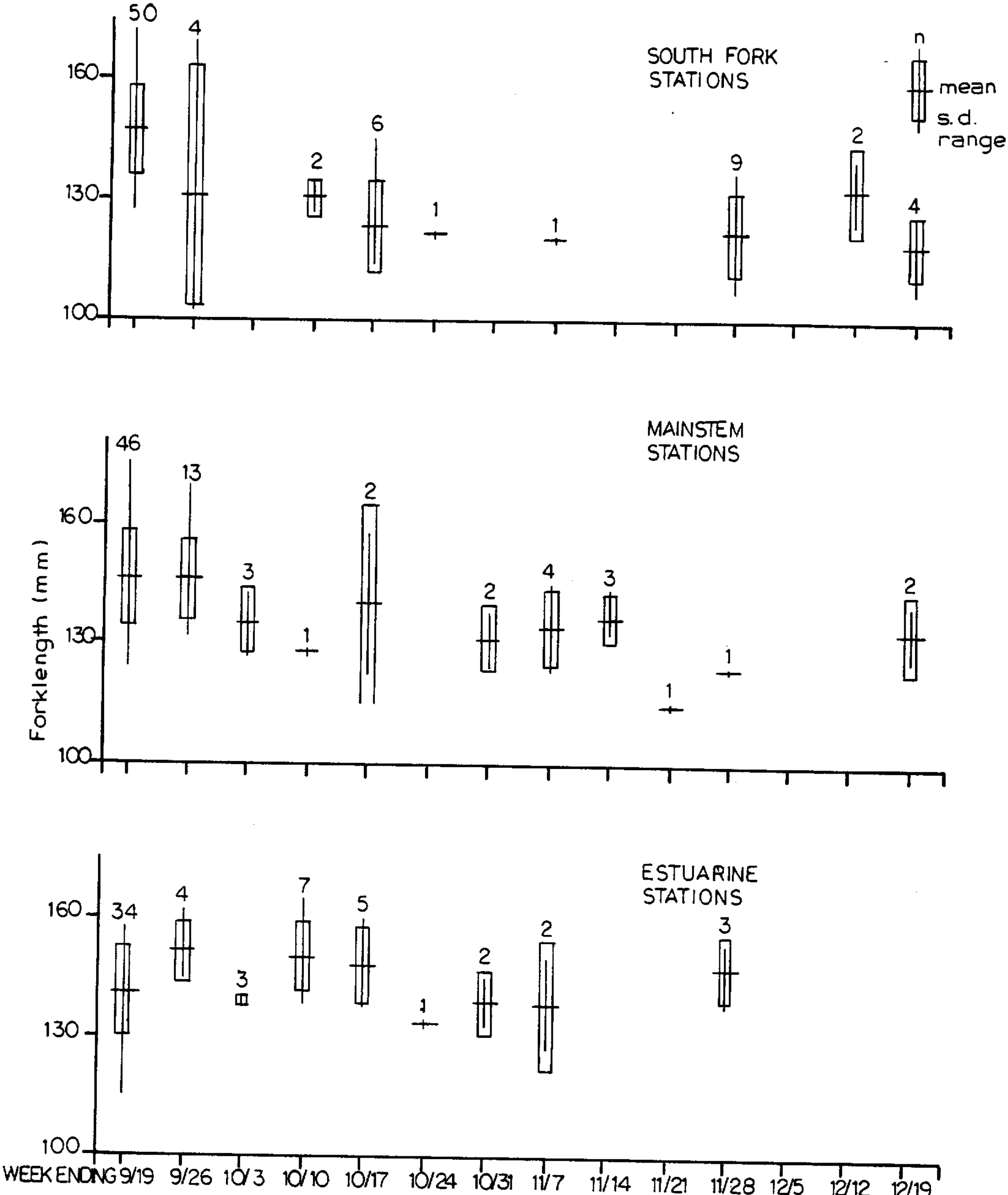

FIGURE 20. Weekly forklength data for recoveries of Skookum Hatchery spring chinook after 9/15/81 release.

DISCUSSION

The concept of a one-year juvenile freshwater residency for spring chinook salmon is well established, although variations in early life history have been noted in the Columbia Basin and in coastal investigations (Table 5). Reimers (1979), Reimers and Loeffel (1967), Levy et al. (1979) and others have documented multiple life-history types both among and within stocks of fall chinook salmon as well.

Examination of marking and recovery data collected in this investigation of wild juvenile spring chinook does not establish whether outmigrants were predominately subyearlings, yearlings, or some combination of the two. The data do suggest, however, that residency in the upper watershed of each fork was relatively brief, and that a strong subyearling outmigration was possible. Evidence supporting such a movement pattern in the upper river includes the low, but constant recovery percentages over the majority of the recovery period in each fork, despite intensive sampling in a range of habitats using a variety of gear. Additionally, age and location of recoveries suggest limited upriver residence. The presence of only recently emergent fry in nearly all upriver catches also indicates limited residence, although size increases of chinook in later trap catches and in lower river shocker catches suggest some limited rearing occurred in upriver areas following emergence. We do not believe, however, that our gear selected only for smaller chinook, as other yearling-sized salmonids were frequently encountered, particularly in trap catches at these sites.

The lack of wild mark recoveries in lower river areas may be due to a strong subyearling outmigration, but this cannot be confirmed with existing data. In conjunction with hatchery release monitoring, lower river areas were intensively sampled with negative results for seven months after completion of the wild marking phase in May. A total of 770 beach seine hauls alone were made during this period, with subyearling chinook of comparable size in many catches. It seems likely that some recoveries would have occurred if the native population remained in freshwater for any appreciable time. Post-marking mortality is not believed to be a significant factor in lack of recoveries; preliminary results from an ongoing experiment at Quilcene National Fish Hatchery show high survival in juvenile spring chinook (36-39 mm forklength) subjected to similar capture and handling stresses. Scale analysis of returning spawners (1980 and 1981 broods) also indicated a predominance of subyearling outmigrants (Sneva, 1981).

A factor associated with the lack of wild recoveries in lower river areas could have been the relatively low numbers of fish marked and the relatively long period of time over which marking occurred. Less than 4,000 wild chinook were marked and released over a four-month period. In comparison, total recovery of the June 15th release of 48,000 Skookum hatchery spring chinook was only 1% in all mainstem and estuarine sites, and the majority of this catch was made in the first weeks after release. These fish, of course, were larger than their wild equivalents at time of release, and their rate of movement and susceptibility to capture may have differed.

Table 5. Reported outmigration patterns of wild spring chinook salmon.

Location	Outmigration Pattern	Comment	Source
Columbia Drainage			
Wenatchee R.	Subyearling and yearling emigrations in spring and throughout summer and fall months.		French and Wahle (1959)
Willamette R.	Subyearling emigration in spring and fall, yearling emigration in spring.	Predominant returns were from either subyearling fall or yearling spring emigrants, based on scale analysis.	Mattson (1962, 1963)
Yakima R.	Yearling emigration during spring months.		Major and Mighell (1969)
John Day R.	Yearling emigration during spring months.		Burck et al. (1979, 1980)
Warm Springs R.	Subyearling emigration in summer and fall, yearling emigration in spring.	Most spawner returns showed 1+ freshwater residence based on scale analysis.	Diggs (undated)
Coastal Oregon			
Rogue R.	Subyearling emigration in spring and fall months	Scale analysis indicated most returning spawners were fall emigrants.	Cramer (1979)
Coastal Washington			
Queets R.	Presumed subyearling emigration in late summer.	Studies not yet completed.	Lestelle (1980)

Estimates of movement rates for the Skookum Hatchery chinook suggested residualism occurred in the spring chinook releases, with the most pronounced residualism in the September group. In this latter group, the presence of precocious males would account for a portion of the high degree of residualism observed immediately below Skookum Hatchery. Gebhards (1960) noted that precocious sexual maturity in male chinook is established in many hatchery populations and has been recognized since at least the turn of the century. Moveover, Royal (1972) noted that as the size of spring chinook released increases, the number of residual jacks increases. However, the significantly smaller-sized individiuals encountered in south fork sampling, particularly in the September release group, would suggest that the observed differences in movement rate are not solely related to the occurrence of precocious males, as these individuals tend to be larger than their normal counterparts (Gebhards, 1960).

Movement rate estimates for Skookum hatchery chinook appear reasonable and probably reflect actual differences in migrational characteristics of the respective release groups. The estimated rate of 8 to 9 river miles per day to the estuary for Skookum fall chinook is close to the 3-year average value of 11.2 river miles per day for riverine movement of Columbia River "subyearling chinook" (Dawley, 1981). Movement rates of other Nooksack hatchery fall chinook also appear comparable to the above, based on comparison of catch data in lower stations (Appendix C) and hatchery release information (Appendix B). The lesser rates for spring chinook releases are, therefore, probably indicative of migrational delay.

CONCLUSIONS

Wild Spring Chinook

Studies conducted in 1981 did not establish time and size of ocean entry of Nooksack River wild spring chinook. The limited number of wild mark recoveries precluded any definitive evaluation of the native outmigration, including interaction with other hatchery salmonids. Available mark and recovery data did suggest, however, that juvenile spring chinook residence in the upper watershed was relatively brief, and that a strong subyearling outmigration could have occurred. Evidence supporting such a movement pattern included number, age, and location of mark recoveries, and length data collected at time of initial capture.

Marking a substantially larger number of wild fish in a shorter time period, immediately followed by an intensive downstream recovery effort, would likely yield sufficient recoveries to establish time and size of ocean entry of Nooksack River spring chinook. In view of the above, the scope of our efforts in 1982 will be reduced to investigation of only north fork juveniles, in conjunction with field microtagging of these fish to help define marine contribution and interception of wild Nooksack spring chinook.

Hatchery Spring Chinook

Examination of subyearling spring chinook behavior after release from Skookum Hatchery indicated that a greater degree of residualism occurred in September-released fish (9/lb) than in June-released fish (64/lb). In both release groups, significantly smaller-sized individuals comprised upper river catches, but these differences were most pronounced in the September group. Average rate of movement to the estuary of the June release group, estimated to be approximately 3 river miles per day, was probably much greater than that of the September group. By way of comparison, a June release of Skookum Hatchery fall chinook (79/lb) exhibited no significant size differences in downstream catches, and moved to the estuary at an estimated rate of 8 to 9 river miles per day.

The above suggests that, of the two release times examined, June is preferrable for rapid emigration of Skookum spring chinook from the Nooksack River. Rapid movement of Skookum Hatchery springs from the system should minimize competition with the wild stock, and improve early survival of the hatchery fish. An additional examination of a yearling Nooksack spring chinook release would provide a useful comparison to these estimated rates of movement of subyearling spring chinook.

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Appendix A. Sampling station locations in the Nooksack drainage.

Station	Location
N1	Side channel right bank north fork.
N2	Mouth Maple Creek north fork.
N3	Right bank access above Kendall Hatchery north fork.
N4	Welcome Bridge north fork.
N5	Backwater SR9 Bridge north fork.
N6	Nork fork road access.
N7	Dirt road access east of Highway 9 junction.
S0	Skookum Hatchery
S1	Larson Bridge vicinity south fork.
S2	Cavanaugh Creek confluence south fork.
S3	River Mile 15 vicinity south fork.
S4	Sand bar SR9 below Acme south fork.
S5	Acme Bridge.
S6	Riprap site just below hatchery.
S7	Saxon Bridge.
S8	Rothenbuhler access.
S9	Strand Road.
S10	Bar 600 yards above Skookum Hatchery.
S11	Raft access eighth mile above S6.
S12	Junk car site below Strand Road S9.
M2	Nolte Road access main stem.
M3	Abbott Road access main stem.
M4	Thiel Road access main stem.
M5	Ferndale site main stem.
M6	Guide Meridian Bridge access.
M7	Goshen Road access.
M8	Hovander Park access.
M9	Darlea property access.
M10	River road access just below M6.
M11	Just downstream of Everson Bridge on north bank.
M12	Directly across from M3.
E1	Marietta Bridge.
E2	Naked Lady fishing hut.
E3	Opposite Marietta launch.
E4	Channel confluence.
E5	Fish Point.
E6	Above Lummi launch.
E7	Above Station E6.
E8	Couch site.
E9	Opposite Station E4.
E10	Bar east side of second drift.
E11	West side above Marietta.
E12	Bar below Slater Road bridge.
E13	Bar below Slater Road bridge River Mile 3.1.
E14	Middle reach of east arm.
E15	Fyke trap site.
E16	Broken dike site.
E17	Sawdust south.
E18	Treaty Rock.

Appendix A. (Continued)

Station	Location
E19	Fish Point south.
E20	Opposite Fish Point south.
E21	Other side of channel from E22.
E22	Just north of E5.
E23	Shallow bar above Naked Lady hut E2.
ACL	Skookum Hatchery - Acme Bridge - lower (drift).
ACL	Skookum Hatchery - Acme Bridge - upper (drift).
ACL	Skookum Hatchery - Acme Bridge - middle (drift).
CD	Acme Bridge - Strand Road access (drift).
EF	Welcome Bridge - State Route 9 bridge (drift).
DF	Strand Road access - State Route 9 bridge (drift).
FG	State Route 9 Bridge - Mt. Baker Highway bridge (drift).
GH	Mt. Baker Highway bridge - Goshen Road access (drift).

Appendix B. Hatchery plantings in the Nooksack River drainage during 1981.

Species	Brood Year	Source	Stock	Class	Planting Date	Fish/lb.	Numbers Planted	Location	Tag/ Mark
Spring chinook	80	WDF - Kendall Hatchery	Nooksack No. Fk.	Fingerling	Apr. 6 (Mar. 25 - voluntary release)	110.0	134,900	North Fork Kendall Cr.	
Spring chinook	80	Lummi-Skookum Hatchery	Nooksack So. Fk.	Fingerling	June 15	64.0	47,600	South Fork Skookum Cr.	Ad. clip (CWT 5-8-37)
Spring chinook	80	Lummi-Skookum Hatchery	Nooksack So. Fk.	Fingerling	Sept. 15	9.0	26,400	South Fork Skookum Cr.	Ad. clip (CWT 5-8-33)
Fall chinook	80	WDF - Kendall Hatchery	Nooksack	Fingerling	Apr. 6 (Mar. 25 - voluntary release)	150.0	846,500	North Fork Kendall Cr.	
Fall chinook	80	WDF - Kendall Hatchery	Samish	Fingerling	May 29	115.0	798,400	North Fork Kendall Cr.	
Fall chinook	80	WDF - Kendall Hatchery	Green River	Fingerling	May 29	115.0	1,251,000	North Fork Kendall Cr.	
Fall chinook	80	WDF - Kendall Hatchery	Green River	Fingerling	June 4	55.0	1,637,000	North Fork Kendall Cr.	
Fall chinook	80	WDF - Kendall Hatchery	Samish	Fingerling	June 12	90.0	1,399,000	North Fork Kendall Cr.	
Fall chinook	80	WDF - Kendall Hatchery	Samish	Fingerling	June 12	105.0	2,551,600	North Fork Kendall Cr.	
Fall chinook	80	WDF - Kendall Hatchery	Green River	Fingerling	June 12	90.0	1,099,600	North Fork Kendall Cr.	

Appendix B. (Continued)

Species	Brood Year	Source	Stock	Class	Planting Date	Fish/lb.	Numbers Planted	Location	Tag/ Mark
Fall chinook	80	WDF - Skagit	Green River	Fingerling	July 28	62.0	400,000	North Fork Kendall Cr.	
Fall chinook	80	Lummi-Skookum Hatchery	Samish	Fingerling	June 15	79.0	47,779	South Fork Skookum Cr.	Ad. clip (CWT 5-4-47) "X"-branded on left side
Fall chinook	80	Lummi-Skookum Hatchery	Samish	Fingerling	June 15	79.0	1,253,121	South Fork Skookum Cr.	
Coho	80	WDF - Skagit	Skagit	Fingerling	Mar. 10	1646.0	166,246	North Fork	
Coho	80	WDF - Skagit	Skagit	Fingerling	Mar. 10	1646.0	506,968	Middle Fork	
Coho	80	WDF - Skagit	Skagit	Fingerling	Mar. 10	1646.0	506,968	South Fork	
Coho	79	WDF - Skagit	Skagit	Yearling	May 5	20.0	102,660	North Fork	
Coho	79	WDF - Skagit	Skagit	Yearling	May 6	20.0	70,640	North Fork	
Coho	79	WDF - Skagit	Skagit	Yearling	May 7	20.0	47,740	North Fork	
Coho	79	WDF - Skagit	Skagit	Yearling	May 4	20.0	30,000	South Fork	
Coho	79	WDF - Skagit	Skagit	Yearling	May 5	20.0	102,800	South Fork	
Coho	79	Lummi-Skookum Hatchery	Skykomish	Yearling	May 15	17.0	900,000	South Fork Skookum Cr.	
Coho	79	Lummi-Skookum Hatchery	Skookum	Yearling	May 15	25.0	20,463	South Fork Skookum Cr.	Ad. clip (CWT 5-7-60)

Appendix B. (Continued)

Species	Brood Year	Source	Stock	Class	Planting Date	Fish/lb.	Numbers Planted	Location	Tag/ Mark
Coho	79	Lummi-Skookum Hatchery	Skookum	Yearling	May 15	25.0	624,537	South Fork Skookum Cr.	
Coho	79	WDF - Skagit	Skagit	Yearling	June 5	19.0	5,784	South Fork	Ad. clip (CWT 632222)
Coho	79	WDF - Skagit	Skagit	Yearling	June 5	19.0	109,694	South Fork	
Chum	80			Fingerling	May 11	600.0	60,000	North Fork Rutsatz Sl.	
Chum	80			Fingerling	May 20	500.0	40,000	North Fork Rutsatz Sl.	
Winter steelhead		WDG - Barnaby Slough		Yearling	April	8.6-8.9	5,300	North Fork	Rv. clip
Winter steelhead		WDG - Barnaby Slough		Yearling	April	8.6-8.9	5,940	North Fork	
Winter steelhead		WDG - Bellingham Hatchery		Yearling	April	8.0	12,500	North Fork	
Winter steelhead		WDG - Bellingham Hatchery		Yearling	April	7.2	20,596	Mainstem	
Winter steelhead				Yearling	April	7.9	9,091	Mainstem	
Winter steelhead		WDG - White Horse rearing pond		Yearling	April	6-6.3	6,000	Mainstem	Ad. clip

Appendix B. (Continued)

Species	Brood Year	Source	Stock	Class	Planting Date	Fish/lb.	Numbers Planted	Location	Tag/ Mark
Winter steelhead		WDG - White Horse rearing pond		Yearling	April		11,043	Mainstem	
Summer steelhead		WDG - Barnaby Slough		Yearling	April	8.6-8.9	10,818	North Fork	

Appendix C. Chinook salmon catch data (unmarked specimens) at selected stations during 1981 sampling.

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan. Dev.	n
M7	6/16	356.5	77.2	87	54	7.8	31
	6/17	548.0	77.1	86	67	4.7	23
	6/18	199.0	79.8	95	68	6.5	20
	6/19	61.0	81.1	94	50	8.8	40
	6/22	436.0	74.4	88	53	10.3	40
	6/23	122.0	80.3	125	50	13.5	42
	6/24	208.0	80.3	129	52	13.5	20
	6/26	36.7	79.8	94	61	7.8	19
	6/29	40.0	69.0	83	53	9.9	17
	7/1	22.0	78.6	91	60	8.7	20
	7/6	17.0	69.4	83	58	6.8	20
	7/8	10.0	70.3	85	54	10.2	20
	7/14	13.0	73.0	87	59	9.1	13
	7/20	1.0	62.0	-	-	-	1
	7/21	33.0	70.6	95	60	7.8	20
	7/28	77.0	82.8	98	64	10.6	20
	7/29	68.0	81.1	111	53	13.7	22
	7/31	85.0	85.2	112	64	12.1	20
	8/3	26.0	77.0	101	57	12.3	20
	8/4	23.0	76.8	99	55	10.2	20
	8/10	1.0	57.0	-	-	-	1
	8/12	11.0	66.2	84	52	8.4	11
	8/17	5.0	64.2	72	54	6.6	5
	8/19	9.0	69.3	87	52	11.1	9
	8/21	4.0	68.5	86	55	13.4	4
	8/24	4.0	64.5	70	50	9.7	4
	8/27	4.0	69.2	77	61	7.1	4
	9/9	1.5	73.0	79	65	7.2	3
	9/16	7.5	79.7	141	61	20.6	13
	9/17	2.5	75.4	80	72	3.6	5
	9/18	3.0	77.0	84	73	6.1	3
	9/21	2.0	78.0	89	67	15.6	2

Appendix C (continued)

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan. Dev.	n
M7	9/28	3.0	84.3	86	83	1.5	3
	9/29	2.0	-	-	-	-	-
	9/30	2.0	-	-	-	-	-
	10/2	1.0	84.0	-	-	-	1
	10/6	1.0	75.0	-	-	-	1
	10/8	6.0	85.0	95	75	7.3	6
	10/9	3.0	76.3	79	75	2.3	3
	10/13	10.0	78.1	84	68	5.6	10
	10/15	4.0	71.8	77	67	4.1	4
	10/16	10.0	78.4	86	70	5.5	10
	10/20	0.0	-	-	-	-	-
	10/21	0.0	-	-	-	-	-
	10/23	7.0	80.6	100	73	8.9	7
	10/26	9.0	84.0	98	73	7.5	9
	10/30	9.0	82.6	95	70	7.8	9
	11/2	7.0	79.8	90	69	7.6	7
	11/3	6.0	80.2	93	74	6.9	6
	11/6	0	-	-	-	-	-
	11/9	0	-	-	-	-	-
	11/10	0	-	-	-	-	-
	11/12	1.0	76.0	-	-	-	1
	11/13	4.0	87.0	93	83	4.3	4
	11/16	2.0	78.0	80	76	2.8	2
	11/17	11.0	83.4	100	73	7.5	11
	11/18	5.0	83.2	92	71	7.6	5
	11/19	2.0	75.0	77	73	2.8	2
	11/20	5.0	83.2	87	78	3.3	5
	11/27	0	-	-	-	-	-
	12/8	2.0	81.0	-	-	-	2
	12/16	0	-	-	-	-	-
	12/17	1.0	86.0	-	-	-	1
	12/18	4.0	83.8	86	81	2.2	4
M4	3/12	8.3	-	-	-	-	-
	3/25	4.0	51.5	63	44	6.9	12
	4/2	112.0	53.5	112	33	10.0	336
	4/8	44.8	52.6	94	39	9.0	118
	4/15	39.0	55.3	98	36	10.2	59
	4/22	61.2	60.3	160	40	15.4	137
	4/28	37.3	60.2	144	42	15.3	96
	5/7	27.2	57.7	78	36	8.5	90
	5/13	97.4	60.5	77	49	7.7	30
	5/15	13.7	59.0	75	47	7.5	30
	5/20	77.0	63.9	217	45	21.0	64
	5/26	27.0	65.9	83	44	8.8	35

Appendix C (continued)

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan Dev.	n
M4	5/29	169.0	66.4	76	53	6.1	20
	6/2	68.2	62.4	74	46	7.6	20
	6/16	557.0	79.3	86	73	4.5	22
	6/17	505.0	81.4	94	59	9.3	21
	6/18	245.0	80.2	94	73	6.2	19
	6/22	59.0	78.6	86	64	7.1	38
	6/23	45.0	79.2	85	69	5.0	40
	6/25	31.7	81.7	84	66	6.7	19
	6/26	13.3	80.3	91	62	8.0	15
	6/30	27.3	79.2	89	52	9.2	20
	7/1	20.0	77.4	93	49	13.0	23
	7/8	20.3	77.4	89	65	6.3	19
	7/14	23.0	77.6	89	56	8.8	20
	7/17	30.5	76.9	93	59	9.9	20
	7/21	8.7	79.8	93	67	7.6	20
	7/29	55.5	88.7	105	73	9.4	20
	7/31	16.3	87.4	108	63	11.1	20
	8/3	13.7	86.1	108	72	9.5	20
	8/4	19.3	83.5	106	70	9.1	20
	8/13	0.5	79.0	-	-	-	1
	8/17	1.5	70.3	-	-	-	3
	8/19	0.5	75.0	-	-	-	1
	8/21	1.0	73.0	-	-	-	2
M6	5/15	13.0	55.7	70	41	6.7	31
	5/26	34.0	61.1	73	52	6.5	20
	6/16	163.0	78.6	94	61	7.1	20
	6/17	419.0	80.4	97	63	9.1	20
	6/18	269.0	79.2	89	70	5.3	19
	6/22	66.0	77.7	92	46	10.5	42
	6/23	62.0	81.6	135	55	16.4	38
	6/25	33.0	78.5	88	56	8.5	18
	6/30	10.0	76.8	86	68	5.5	10
	7/1	9.0	72.2	83	55	10.9	9
	7/6	29.5	67.5	82	53	9.0	20
	7/7	2.5	70.6	85	53	14.4	5
	7/14	2.0	79.0	90	68	15.6	2
	7/22	16.0	82.6	102	69	10.1	16
	7/28	4.0	67.2	83	57	11.1	4
	7/29	9.0	91.9	103	72	10.8	9
	8/3	2.0	87.3	93	75	8.3	4
	8/21	2.0	73.0	78	68	7.1	2

Appendix C (continued)

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan Dev.	n
E13	3/20	14.0	43.7	55	37	4.3	14
	3/26	8.0	46.2	51	40	3.8	8
	4/2	19.0	48.2	70	40	8.5	19
	5/7	120.0	66.4	95	53	8.7	31
	5/14	21.0	56.9	70	35	9.1	21
	6/16	480.0	80.5	88	71	4.9	20
	6/17	769.0	84.2	148	69	16.3	21
	6/18	9.5	79.2	91	61	8.2	19
	6/25	62.0	80.7	203	50	29.9	20
	6/26	36.0	78.5	86	63	7.1	20
	6/30	37.0	80.5	93	58	7.9	20
	7/8	1.5	73.0	83	66	8.9	3
	7/13	0	-	-	-	-	-
	7/16	2.0	81.5	91	72	13.4	2
	7/20	12.0	81.7	100	74	7.2	12
	7/22	13.0	84.5	102	69	11.2	13
	7/24	24.0	88.7	113	72	9.8	20
	7/27	7.0	91.4	108	74	12.0	7
	7/30	21.0	92.9	113	74	12.2	20
	7/31	18.0	88.0	110	72	9.8	18
	8/4	2.0	85.0	87	83	2.8	2
	8/6	3.0	79.7	80	79	0.6	3
	8/7	5.0	85.8	94	81	5.1	5
	8/10	0	-	-	-	-	-
	8/12	0	-	-	-	-	-
	8/17	0	-	-	-	-	-
	8/20	0	-	-	-	-	-
	8/24	2.0	94.0	-	-	-	2
	8/31	0	-	-	-	-	-
	9/4	0	-	-	-	-	-
	9/9	0	-	-	-	-	-
	9/16	0	-	-	-	-	-
	9/17	0	-	-	-	-	-
	9/18	2.0	113.5	-	-	-	2
	9/25	0	-	-	-	-	-
	9/30	3.0	-	-	-	-	-
	10/1	0	-	-	-	-	-
	10/5	0	-	-	-	-	-
	10/6	0	-	-	-	-	-
	10/14	0	-	-	-	-	-
	10/20	0	-	-	-	-	-
	10/26	0	-	-	-	-	-
	11/2	0	-	-	-	-	-
	11/4	0	-	-	-	-	-

Appendix C (continued)

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan Dev.	n
E2	2/11	0.0	-	-	-	-	-
	3/20	4.0	42.5	50	38	5.3	4
	4/2	2.0	53.5	57	50	4.9	2
	5/1	10.0	57.0	71	39	10.8	10
	5/7	2.0	57.5	63	52	7.8	2
	5/14	9.0	66.0	73	57	5.1	9
	5/21	9.0	67.0	75	55	6.0	9
	6/4	25.0	69.8	94	56	8.3	20
	6/16	79.0	76.4	87	58	8.8	20
	6/17	53.0	76.5	88	63	6.8	20
	6/18	63.0	74.1	88	57	9.3	20
	6/19	304.0	79.8	88	66	6.6	40
	6/22	6.0	72.0	88	50	15.3	12
	6/23	22.0	77.9	88	52	9.2	22
	6/25	2.5	63.2	70	59	4.3	5
	6/26	4.0	78.1	87	72	5.3	8
	6/30	5.0	79.6	85	67	7.3	5
	7/7	5.0	74.8	81	70	4.7	5
	7/8	3.0	75.7	79	73	3.0	3
	7/13	2.0	70.0	75	65	7.1	2
	7/16	5.0	78.2	82	76	2.3	5
	7/17	7.0	76.0	82	72	3.5	7
	7/20	3.0	80.3	82	77	2.9	3
	7/22	2.0	79.5	81	78	2.1	2
	7/24	7.0	86.0	95	78	7.0	7
	7/27	3.0	83.3	87	81	3.2	3
	8/4	4.0	89.7	95	87	3.6	4
	8/7	1.0	77.0	-	-	-	1
	8/10	1.0	77.0	-	-	-	1
	8/31	0	-	-	-	-	-
E9	2/11	1.0	50.0	-	-	-	1
	3/20	0	-	-	-	-	-
	3/26	8.0	51.1	60	41	6.3	8
	4/2	1.0	42.0	-	-	-	1
	5/7	16.0	62.1	72	39	8.0	16
	5/14	18.0	59.3	77	46	7.4	18
	5/21	45.0	63.9	72	54	5.0	20
	6/4	49.0	75.5	93	62	9.1	20
	6/16	466.0	78.8	90	70	5.4	20
	6/17	111.0	81.6	99	57	9.0	19
	6/18	163.0	82.9	140	63	15.1	21
	6/19	80.0	78.4	90	66	7.3	40
	6/22	50.0	75.6	85	55	8.3	40
	6/25	30.0	80.0	94	65	7.5	20
	6/26	28.0	79.5	98	67	7.9	18

Appendix C (continued)

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan Dev.	n
E9 (cont.)	6/30	9.0	71.8	84	56	9.6	9
	7/7	12.5	72.5	83	56	8.5	11
	7/8	1.0	-	-	-	-	1
	7/13	10.0	72.3	79	66	4.3	10
	7/16	4.0	75.6	81	71	4.6	4
	7/17	3.0	76.3	79	73	3.1	3
	7/20	4.0	75.0	82	62	9.0	4
	7/22	2.0	76.5	77	76	0.71	2
	7/24	25.0	92.6	106	70	9.3	20
	7/27	4.0	83.0	95	76	8.5	4
	7/31	19.0	94.6	109	73	9.5	19
	8/4	6.0	82.7	99	76	8.3	6
	8/6	3.0	83.3	90	75	7.6	3
	8/7	2.0	92.5	108	77	21.9	2
	8/27	0	-	-	-	-	-
	8/31	0	-	-	-	-	-
	9/21	0	-	-	-	-	-
	9/25	2.0	89.5	91	88	2.1	2
	9/30	0	-	-	-	-	-
	10/1	0	-	-	-	-	-
	10/9	1.0	97.0	-	-	-	1
	10/20	0	-	-	-	-	-
	10/22	0	-	-	-	-	-
	10/26	0	-	-	-	-	-
	10/30	1.0	-	-	-	-	-
	11/9	0	-	-	-	-	-
	11/23	0	-	-	-	-	-
	11/25	0	-	-	-	-	-
	12/9	0	-	-	-	-	-
	12/14	0	-	-	-	-	-
	12/16	0	-	-	-	-	-

Appendix D. Coho catch data for selected stations during 1981 sampling.

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan. Dev.	n
M7	6/16	1.0	113.2	179	53	65.5	4
	6/17	0	-	-	-	-	-
	6/18	0	-	-	-	-	-
	6/19	0	-	-	-	-	-
	6/22	8.0	80.2	143	55	38.9	8
	6/23	0	-	-	-	-	-
	6/24	1.0	51.0	-	-	-	1
	6/26	0	-	-	-	-	-
	6/29	0	-	-	-	-	-
	7/1	0	-	-	-	-	-
	7/6	0	-	-	-	-	-
	7/8	3.5	48.0	56	43	4.5	7
	7/14	0	-	-	-	-	-
	7/20	0	-	-	-	-	-
	7/21	1.0	51.0	-	-	-	1
	7/28	5.0	57.8	67	46	8.0	5
	7/29	1.0	62.0	-	-	-	1
	7/31	1.0	53.0	-	-	-	1
	8/3	2.0	48.5	49	48	0.7	2
	8/4	3.0	64.7	78	49	14.6	3
	8/10	1.0	49.0	-	-	-	1
	8/12	4.0	59.0	63	53	4.6	4
	8/17	0	-	-	-	-	-
	8/19	3.0	65	67	64	1.7	3
	8/21	4.0	58.5	65	40	12.3	4
	8/24	1.0	63.0	-	-	-	1
	8/27	0	-	-	-	-	-
	9/3	0	-	-	-	-	-
	9/9	2.0	94.5	190	62	63.7	4
	9/14	0	-	-	-	-	-
	9/16	1.0	62.0	-	-	-	1
	9/17	1.5	61.3	68	54	7.0	3
	9/18	0	-	-	-	-	-
	9/21	2.0	59.0	73	45	19.8	2
	9/24	0	-	-	-	-	-
	9/25	0	-	-	-	-	-
	9/28	1.0	66.0	-	-	-	1
	9/29	0	-	-	-	-	-
	9/30	0	-	-	-	-	-
	10/2	5.0	71.0	83	57	9.7	5

Appendix D (continued)

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan. Dev.	n
M7	10/6	0	-	-	-	-	-
	10/8	0	-	-	-	-	-
	10/9	1.0	80.0	-	-	-	1
	10/13	0	-	-	-	-	-
	10/14	0	-	-	-	-	-
	10/15	0	-	-	-	-	-
	10/16	0	-	-	-	-	-
	10/20	0	-	-	-	-	-
	10/21	0	-	-	-	-	-
	10/23	0	-	-	-	-	-
	10/26	1.0	64.0	-	-	-	1
	10/30	3.0	74.7	95	63	17.7	3
	11/2	2.0	64.0	71	57	9.9	2
	11/3	1.0	116.0	-	-	-	1
	11/5	0	-	-	-	-	-
	11/6	0	-	-	-	-	-
	11/9	0	-	-	-	-	-
	11/10	0	-	-	-	-	-
	11/12	3.0	358.3	482	292	107.2	3
	11/16	0	-	-	-	-	-
	11/17	0	-	-	-	-	-
	11/18	0	-	-	-	-	-
	11/19	1.0	82.0	-	-	-	1
	11/20	1.0	60.0	-	-	-	1
M4	3/12	0	-	-	-	-	-
	3/25	0	-	-	-	-	-
	4/2	0.3	134.0	-	-	-	1
	4/8	0	-	-	-	-	-
	4/15	1.0	136.7	140	132	4.1	3
	4/22	2.8	137.3	195	105	21.8	14
	4/28	3.8	121.0	155	34	36.8	15
	5/7	3.2	120.4	134	110	8.2	13
	5/13	3.4	40.3	85	33	10.1	24
	5/15	3.5	131.0	150	115	7.9	20
	5/20	26.5	117.0	160	32	22.5	53
	5/26	14.0	115.5	154	29	24.1	21
	5/29	5.7	108.1	135	33	28.9	16
	6/2	2.6	60.9	128	33	36.5	13
	6/16	3.0	127.3	135	120	7.5	3
	6/17	7.0	127.9	155	39	40.0	7
	6/18	2.0	91.0	137	45	65.0	2
	6/22	0	-	-	-	-	-
	6/23	0	-	-	-	-	-
	6/25	0	-	-	-	-	-
	6/26	0.6	86.0	131	41	63.6	2

Appendix D (continued)

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan. Dev.	n
M4 (cont.)	6/30	2.7	46.5	52	40	4.0	8
	7/1	0.8	49.7	59	44	8.1	3
	7/8	0.7	48.5	52	45	5.0	2
	7/14	0	-	-	-	-	-
	7/17	0	-	-	-	-	-
	7/21	0.3	65.0	-	-	-	1
	7/29	0	-	-	-	-	-
	7/31	0.3	56.0	-	-	-	1
	8/3	0	-	-	-	-	-
	8/4	0	-	-	-	-	-
	8/11	0	-	-	-	-	-
	8/13	0	-	-	-	-	-
	8/17	0	-	-	-	-	-
	8/18	0	-	-	-	-	-
	8/21	0	-	-	-	-	-
	8/27	0	-	-	-	-	-
	9/3	0	-	-	-	-	-
E13	3/20	0	-	-	-	-	-
	3/26	0	-	-	-	-	-
	4/2	0	-	-	-	-	-
	5/7	32.0	126.4	150	72	15.5	20
	5/14	11.0	131.3	153	82	18.6	11
	6/16	2.0	142.5	148	137	7.8	2
	6/17	6.0	133.7	148	123	8.2	6
	6/18	0	-	-	-	-	-
	6/25	1.0	99.0	-	-	-	-
	6/26	0	-	-	-	-	1
	6/30	0	-	-	-	-	-
	7/8	0	-	-	-	-	-
	7/13	0	-	-	-	-	-
	7/16	0	-	-	-	-	-
	7/17	0	-	-	-	-	-
	7/20	0	-	-	-	-	-
	7/22	0	-	-	-	-	-
	7/24	0	-	-	-	-	-
	7/27	0	-	-	-	-	-
	7/30	0	-	-	-	-	-
	7/31	0	-	-	-	-	-
	8/4	0	-	-	-	-	-
	8/6	0	-	-	-	-	-
	8/7	0	-	-	-	-	-
	8/10	0	-	-	-	-	-
	8/12	0	-	-	-	-	-

Appendix D (continued)

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan. Dev.	n
E13 (cont.)	8/12	0	-	-	-	-	-
	8/17	0	-	-	-	-	-
	8/20	0	-	-	-	-	-
	8/24	0	-	-	-	-	-
	8/31	0	-	-	-	-	-
	9/4	0	-	-	-	-	-
	9/9	0	-	-	-	-	-
	9/17	1.0	118.0	-	-	-	1
	9/18	0	-	-	-	-	-
	9/25	0	-	-	-	-	-
	10/1	2.0	288.0	318	258	42.4	2
	10/5	4.0	292.0	315	263	25.2	4
	10/6	2.0	480.0	490	470	14.4	2
	10/20	0	-	-	-	-	-
	10/22	0	-	-	-	-	-
	10/26	0	-	-	-	-	-
	11/2	0	-	-	-	-	-
	11/4	0	-	-	-	-	-
	11/9	0	-	-	-	-	-
E9	2/11	0	-	-	-	-	-
	3/20	0	-	-	-	-	-
	3/26	0	-	-	-	-	-
	4/2	0	-	-	-	-	-
	4/20	0	-	-	-	-	-
	5/7	1.0	128.0	-	-	-	1
	5/14	1.0	130.0	-	-	-	1
	5/21	111.0	129.2	148	112	9.4	20
	5/4	2.0	126.0	126	126	-	2
	6/16	4.0	138.5	145	138	6.2	4
	6/17	1.5	124.7	150	106	22.7	3
	6/18	0	-	-	-	-	-
	6/19	2.0	139.0	139	139	-	2
	6/22	0	-	-	-	-	-
	6/23	0	-	-	-	-	-
	6/25	0	-	-	-	-	-
	6/26	0	-	-	-	-	-
	6/30	0	-	-	-	-	-
	7/7	0	-	-	-	-	-
	7/8	0	-	-	-	-	-
	7/13	0	-	-	-	-	-
	7/16	0	-	-	-	-	-
	7/17	0	-	-	-	-	-
	7/20	0	-	-	-	-	-
	7/22	0	-	-	-	-	-
	7/24	0	-	-	-	-	-
	7/27	0	-	-	-	-	-

Appendix D (continued)

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan Dev.	n
E9 (cont.)	7/31	0	-	-	-	-	-
	8/4	0	-	-	-	-	-
	8/6	0	-	-	-	-	-
	8/7	0	-	-	-	-	-
	8/10	0	-	-	-	-	-
	8/12	0	-	-	-	-	-
	8/17	0	-	-	-	-	-
	8/20	0	-	-	-	-	-
	8/24	0	-	-	-	-	-
	8/27	0	-	-	-	-	-
	8/31	0	-	-	-	-	-
	9/4	0	-	-	-	-	-
	9/9	1.0	540.0	-	-	-	1
	9/16	1.0	475.0	-	-	-	1
	9/17	1.0	87.0	-	-	-	1
	9/18	0	-	-	-	-	-
	9/21	0	-	-	-	-	-
	9/25	0	-	-	-	-	-
	9/30	0	-	-	-	-	-
	10/1	0	-	-	-	-	-
	10/5	0	-	-	-	-	-
	10/9	0	-	-	-	-	-
	10/14	0	-	-	-	-	-
	10/20	0	-	-	-	-	-
	10/22	0	-	-	-	-	-
	10/26	0	-	-	-	-	-
	10/30	0	-	-	-	-	-
	11/2	1.0	275.0	-	-	-	1
	11/4	0	-	-	-	-	-
	11/9	0	-	-	-	-	-

Appendix E. Chum salmon catch data for selected stations during 1981 sampling.

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan. Dev.	n
M3	3/12	0.0	-	-	-	-	-
	4/2	0.0	-	-	-	-	-
	4/8	1.8	36.8	40	33	2.8	9
	4/15	1.7	36.4	38	32	2.5	5
	4/29	0.0	-	-	-	-	-
	5/1	0.2	37.0	-	-	-	1
	5/20	2.5	37.2	39	36	1.3	5
	6/2	0.0	-	-	-	-	-
M4	3/12	0.0	-	-	-	-	-
	3/25	0.0	-	-	-	-	-
	4/2	0.6	37.0	39	35	2.8	2
	4/8	2.0	38.4	41	36	1.8	8
	4/15	4.0	38.1	39	36	0.9	12
	4/22	1.2	37.3	41	34	3.0	6
	4/28	1.8	35.3	37	34	1.1	7
	5/7	3.2	36.7	38	35	1.2	13
	5/13	1.1	41.1	44	36	3.1	8
	5/15	0.5	37.0	39	33	3.5	3
	5/20	8.5	42.5	82	31	13.9	17
	5/26	0.0	-	-	-	-	-
	5/29	0.0	-	-	-	-	-
	6/2	0.2	40.0	-	-	-	1
	6/16	0.0	-	-	-	-	-
E13	3/20	0.0	-	-	-	-	-
	3/26	0.0	-	-	-	-	-
	4/2	0.0	-	-	-	-	-
	5/7	27.0	37.4	39	36	1.4	9
	5/14	6.0	36.7	38	33	2.0	6
	6/16	0.0	-	-	-	-	-
E2	3/20	0.0	-	-	-	-	-
	4/2	0.0	-	-	-	-	-
	4/7	0.0	-	-	-	-	-
	4/8	0.0	-	-	-	-	-
	4/20	0.0	-	-	-	-	-
	5/1	0.0	-	-	-	-	-
	5/7	2.0	36.5	38	35	2.1	2
	5/14	1.0	36.0	-	-	-	1
	5/21	10.0	38.0	42	36	1.6	10
	6/4	0.0	-	-	-	-	-

Appendix E (continued)

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan Dev.	n
E14	3/26	0.0	-	-	-	-	-
	4/2	0.0	-	-	-	-	-
	4/20	0.0	-	-	-	-	-
	5/1	0.0	-	-	-	-	-
	5/7	2.0	36.5	38	35	2.1	2
	5/21	15.0	38.1	40	36	1.4	15
	6/4	0.0	-	-	-	-	-
E9	3/20	0.0	-	-	-	-	-
	3/26	0.0	-	-	-	-	-
	4/2	0.0	-	-	-	-	-
	4/20	8.0	34.8	37	33	1.4	8
	5/7	10.0	38.7	58	34	6.9	10
	5/14	9.0	38.4	41	36	1.7	9
	5/21	38.0	43.3	88	35	15.1	20
	6/4	0.0	-	-	-	-	-

Appendix F. Steelhead catch data (forklength $\geq$70mm) at selected stations during 1981 sampling.

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan. Dev.	n
M4	3/12	0.0					
	3/25	0.3	180.0	-	-	-	1
	4/2	0.6	158.0	240	76	115.0	2
	4/8	0.25	149.0	-	-	-	1
	4/15	3.3	181.5	345	78	71.8	9
	4/22	6.4	165.6	360	76	56.7	32
	4/28	4.8	180.2	220	94	37.6	18
	5/7	0.25	205.0	-	-	-	1
	5/13	0.0	-	-	-	-	-
	5/15	0.2	83.0	-	-	-	1
	5/20	1.0	129.0	178	80	69.3	2
	5/26	4.0	99.2	148	73	25.8	8
	5/29	4.0	116.2	205	76	36.4	12
	6/2	2.2	102.7	183	74	30.6	11
	6/16	0.0	-	-	-	-	-
	6/17	3.0	86.0	90	80	5.3	3
	6/18	5.0	104.2	123	79	16.2	5
	6/22	8.0	94.2	116	76	12.6	16
	6/23	11.0	98.3	136	76	16.5	22
	6/25	2.0	78.3	82	74	3.4	6
	6/26	2.0	96.5	137	80	21.4	6
	6/30	1.3	88.5	105	72	16.9	4
	7/1	2.5	88.6	145	70	21.3	10
	7/8	0.3	85.0	-	-	-	1
	7/14	1.0	113.0	132	95	18.5	3
	7/17	3.5	94.2	115	86	9.9	7
	7/21	3.0	96.7	112	86	9.0	9
	7/29	2.0	99.2	112	87	13.1	4
	7/31	0.6	93.0	98	88	7.1	2
	8/3	0.3	98.0	-	-	-	1
	8/4	1.0	85.3	98	72	13.1	3
	8/11	5.7	135.6	390	72	75.1	17
	8/13	13.5	122.2	250	97	37.5	15
	8/17	8.0	101.4	148	72	20.3	16
	8/19	7.0	110.1	280	71	50.8	14
	8/21	9.0	112.3	270	70	42.3	18
	8/27	0	-	310	82	98.4	4
E9	2/11	0.0	-	-	-	-	-
	3/20	0.0	-	-	-	-	-
	3/26	0.0	-	-	-	-	-

Appendix F. (continued)

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan. Dev.	n
E9	4/2	0.0	-	-	-	-	-
	4/20	0.0	-	-	-	-	-
	5/7	0.0	-	-	-	-	-
	5/14	3.0	220.0	270	188	43.9	3
	5/21	0.0	-	-	-	-	-
	6/4	1.0	187.0	-	-	-	1
	6/16	1.0	148.0	-	-	-	1
	6/17	0.0	-	-	-	-	-
	6/18	0.0	-	-	-	-	-
	6/19	0.0	-	-	-	-	-
	6/22	0.0	-	-	-	-	-
	6/23	0.0	-	-	-	-	-
	6/25	0.0	-	-	-	-	-
	6/26	1.0	133.0	-	-	-	1
	6/30	0.0	-	-	-	-	-
	7/7	0.0	-	-	-	-	-
	7/8	0.0	-	-	-	-	-
	7/13	2.0	130.5	178	63	67.2	2
	7/16	0.0	-	-	-	-	-
	7/17	1.0	240.0	-	-	-	1
	7/20	1.0	157.0	-	-	-	1
	7/22	0	-	-	-	-	-
	7/24	0	-	-	-	-	-
	7/27	0	-	-	-	-	-
	7/31	0	-	-	-	-	-
	8/4	0	-	-	-	-	-
	8/6	0	-	-	-	-	-
	8/7	0	-	-	-	-	-
	8/10	1.0	115.0	-	-	-	1
	8/11	1.0	225.0	-	-	-	1
	8/17	0	-	-	-	-	-
	8/20	0	-	-	-	-	-
	8/24	1.0	128.0	-	-	-	1
	8/27	0	-	-	-	-	-
	8/31	0	-	-	-	-	-
	9/4	1.0	230.0	-	-	-	1
	9/9	0	-	-	-	-	-
	9/16	0	-	-	-	-	-
	9/17	0	-	-	-	-	-
	9/18	1.0	125.0	-	-	-	1

Appendix F (continued)

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan. Dev.	n
E9 (cont.)	9/21	0	-	-	-	-	-
	9/25	0	-	-	-	-	-
	9/30	0	-	-	-	-	-
	10/1	0	-	-	-	-	-
	10/5	1.0	138.0	-	-	-	1
	10/9	0	-	-	-	-	-
	10/14	0	-	-	-	-	-
	10/20	0	-	-	-	-	-
	10/22	0	-	-	-	-	-
	10/26	0	-	-	-	-	-
	10/30	0	-	-	-	-	-
	11/2	1.0	75.0	-	-	-	1
	11/4	1.0	76.0	-	-	-	1
	11/9	0	-	-	-	-	-

Appendix G. Trout catch data (forklength < 70mm) at Station M4 during 1981 sampling.

Station	Date	Catch/set	Mean Forklength (mm)	Max.	Min.	Stan. Dev.	n
M4	3/12	0.0	-	-	-	-	-
	3/25	0.3	65.0	-	-	-	1
	4/2	0	0	-	-	-	-
	4/8	0	-	-	-	-	-
	4/15	0.3	58.0	-	-	-	-
	4/22	0	-	-	-	-	-
	4/28	0.25	62.0	-	-	-	1
	5/7	0	-	-	-	-	-
	5/13	0	-	-	-	-	-
	5/15	0	-	-	-	-	-
	5/20	0.5	41.0	-	-	-	1
	5/26	0	-	-	-	-	-
	5/29	0.3	43.0	-	-	-	1
	6/2	0.2	48.0	-	-	-	1
	6/16	0.0	-	-	-	-	-
	6/17	1.0	34.0	-	-	-	-
	6/18	0	-	-	-	-	-
	6/22	2.0	37.5	39	36	1.7	2
	6/23	2.0	41.5	42	41	0.6	2
	6/25	1.0	50.0	67	40	14.8	3
	6/26	1.7	42.8	48	38	3.7	5
	6/30	2.3	46.0	48	43	1.7	7
	7/1	4.2	45.8	49	41	2.5	17
	7/8	1.3	50.5	52	49	1.7	4
	7/14	2.0	47.5	57	41	6.5	6
	7/17	4.0	52.0	66	40	8.2	8
	7/21	2.3	53.0	62	38	9.0	7
	7/29	2.5	56.2	66	44	7.8	5
	7/31	1.0	52.7	56	49	3.5	3
	8/3	2.0	55.2	65	41	10.1	6
	8/4	4.7	54.7	68	39	9.2	14
	8/11	1.0	58.0	68	40	15.6	3
	8/13	5.5	50.1	65	40	8.2	11
	8/17	8.0	52.0	68	35	8.5	16
	8/19	4.5	54.1	69	41	10.6	9
	8/21	4.0	57.9	68	48	7.5	8
	8/27	5.0	54.6	58	49	3.4	10
	9/3	2.0	58.7	62	54	3.6	4