ANNUAL REPORT

KLAMATH RIVER FISHERIES INVESTIGATION PROGRAM

1980

U.S. Fish and Wildlife Service
Fisheries Assistance Office
Arcata, California

January 23, 1981

TABLE OF CONTENTS

LIST OF FIGURES

Figure | Page

Figure | Page

LIST OF TABLES

LIST OF PLATES

ANNUAL REPORT
KLAMATH RIVER FISHERIES INVESTIGATION PROGRAM
1980

INTRODUCTION

As in other river systems of northern California and the Pacific Northwest, chinook salmon (*Oncorhynchus tshawytscha*) of the Klamath River basin (Figure 1) have experienced the continued effects of habitat degradation and exploitation as reflected by declining runs in recent decades. In 1979 and 1980, considerable attention has been focused on the depressed chinook salmon runs and on related habitat problems and associated fisheries, notably the Indian gill net fishery on the Hoopa Valley Reservation and the ocean troll fishery. The U.S. Fish and Wildlife Service (USFWS) recently ranked anadromous salmonid problems of the Klamath River basin Number 18 of 78 "Important Resource Problems" in the United States in 1980 (USFWS 1980).

The 1976 and 1977 drought, the third driest and driest years, respectively, in recorded California history, undoubtedly contributed to depressed runs in recent years. More significantly, from a long term perspective, societal demands for water and timber resources have resulted and continue to result in large degrees of habitat degradation in the basin. Dams constructed on the Klamath and Trinity rivers have resulted in the loss of considerable anadromous salmonid spawning and rearing habitat located above the project sites, a mean annual diversion of approximately 80 percent of pre-project Trinity River flows into the Sacramento River basin and in significant reductions of habitat availability and quality below the project sites. Appropriation of water for irrigation purposes from the Shasta and Scott river systems, two of the most important anadromous salmonid production areas in the Klamath River basin, has resulted in further reductions of habitat availability and quality. The degree to which logging and associated road building have impacted anadromous salmonids in the drainage appears considerable and the recent acceleration in dredge mining activity for gold creates new concerns.

The ocean-based, Indian net and river sport fisheries impose additional demands on the salmon resource of the Klamath River basin. Net harvest monitoring activities conducted by biologists assigned to the Fisheries Assistance Office (FAO) in Arcata, California reveal that the Indian gill net fishery has accounted for approximately 13,000 to 20,000 chinook salmon annually since 1978. Census work conducted by biologists with the California Department of Fish and Game (CDFG) reveals that sport harvest in the drainage has approximated 2,500 to 14,000 chinook salmon annually since 1976. While total numbers of Klamath River salmon involved in annual ocean landings and lost through hooking or "shaker" mortality remain unquantified, it appears that the ocean fisheries may have accounted for approximately 300,000 of these fish annually in the last decade.

Because of the unsettled nature of the Indian fishing rights issue in northern California, the socio-economic implications of reduced salmon stock abundance on the commercial fishing industry and wide differences of opinion between competing user groups with regard to resource allocation, management entities have experienced considerable frustration in attempting to formulate effective and equitable harvest management policy involving chinook salmon. Through various court decisions, Indians of the Hoopa Valley Reservation have established the right to fish for "subsistence" purposes, but the definition of "subsistence" fishing remains unclear with regard to the sale of fish. In response to perceived inequities regarding current resource allocation trends,

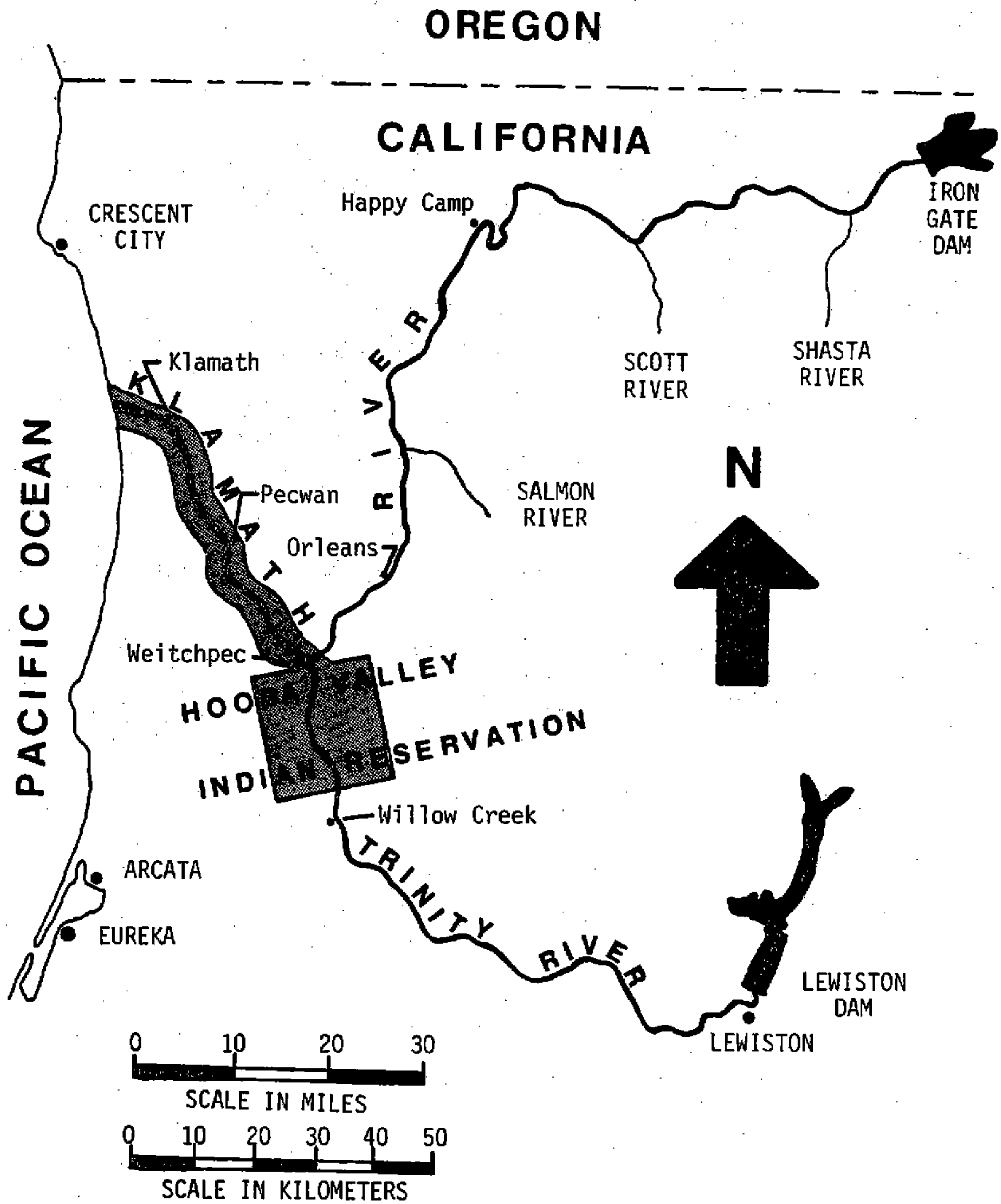


FIGURE 1. The Klamath River drainage and Hoopa Valley Indian Reservation.

Indians of the Hoopa Valley Reservation have displayed wide-spread dissension toward Indian fishing regulations promulgated by the Interior Department in recent years. If attempts by the Indian community to reestablish a legitimate commercial fishery on the reservation succeed, ocean harvest levels would probably have to be reduced substantially to allow for adequate spawner escapement. The complicated questions of Indian fishing on the Hoopa Valley Reservation and of resource allocation will be addressed in an Environmental Impact Statement currently being prepared by the Bureau of Indian Affairs (BIA) in cooperation with the USFWS. Final resolution of the Indian commercial fishing and resource allocation issues may require litigation or congressional action.

In response to increasing demands for the salmon resource in the Pacific Northwest, fishery management agencies have resorted to expansion of artificial propagation programs to increase resource supply and have often adopted harvest management policy which has resulted in the maintenance of high salmon harvest levels. Sustained habitat loss and degradation coupled with continued high harvest rates will adversely affect wild stocks and could easily lead to their demise. It is possible that the Klamath River and other North Coast river systems currently result in the production of more wild chinook salmon than drainages along any other section of the Continental U.S. with the possible exception of the Columbia River basin. Significant program and policy redirection must occur or wild stocks, which cannot withstand the high harvest rates tolerated by hatchery-reared salmon in the mixed stock fisheries, will have increasing difficulty maintaining adequate stock abundance.

In addition to the biological constraints associated with stock resilience and habitat compatability, fisheries managers will continue to face technological, economic and social contraints in attempting to address the complex anadromous salmonid resource problems of the Klamath River drainage. In 1979, the USFWS, working in conjunction with the CDFG and Indians of the Hoopa Valley Reservation, initiated a fisheries investigation program funded by the BIA to assess causes for depressed chinook salmon runs in the Klamath River basin, develop a net harvest monitoring program on the reservation, assist in the development of a run size estimation program, initiate fisheries enhancement measures on the reservation and to collect data on other important species in the drainage. Throughout the course of the investigation program, the Young Adult Conservation Corps (YACC) has provided substantial manpower and material support and YACC enrollees have participated in virtually every aspect of the program. Additional financial support has been forthcoming through the Trinity River Basin Fish and Wildlife Task Force. In conjunction with an Indian training program, Native Americans of the reservation, including four presently involved in fisheries programs at Humboldt State University in Arcata, California, have been hired to assist FAO-Arcata biologists in field studies. This is the second annual report of the investigation program focusing on progress made, problems which remain and prospects for the future.

I. RUN MONITORING AND RUN SIZE ESTIMATION

A. FALL CHINOOK SALMON

1. Introduction

Attempts in recent years to develop a run size estimation program involving fall chinook salmon in the Klamath River drainage through mark-recapture techniques have not succeeded because of problems encountered in tagging adequate numbers of fish and in satisfying various conditions required in the proper utilization of mark-recapture methodology. In hopes of overcoming some of these problems, FAO-Arcata biologists established a beach seining operation within 200 m of the Klamath River mouth (Figure 2) and demonstrated the potential for capturing relatively large numbers of salmon. The strong tidal influence and presence of deep, cold ocean water at the seining site allowed for the tagging of fish with no apparent immediate mortality resulting from handling stress. The great majority of tagged fish released at the site in 1979 and 1980 swam away vigorously and experienced little apparent mortality attributable to harbor seal (*Phoca vitulina*) predation.

In 1980, FAO-Arcata biologists attempted to develop a post-season run size estimation program involving fall chinook salmon utilizing mark-recapture methodology with the Shasta Racks counting facility and Iron Gate and Trinity River hatcheries serving as mark sample sites. We also initiated an in-season run size estimation program utilizing the lower Klamath River gill net fishery (Figure 2) to mark sample fish and through catch/effort evaluations associated with the net fishery and beach seining operation.

FAO-Arcata biologists monitored the fall chinook salmon run in the Klamath River with respect to length and age composition, grilse/adult ratios and incidences of hook-scarred, hatchery-marked and seal-bitten fish. We also explored purse seining as an alternative adult capture technique and initiated a scale reading program to assist in age composition analysis and life history evaluations of the various stocks comprising the run. The scale reading program involving adult chinook salmon was conducted in conjunction with a recently established juvenile sampling program and the in-season run size estimation program involving the Indian net fishery was conducted in conjunction with a general appraisal of the fishery and associated harvest.

2. Adult Capture and Tagging Program

Beach seining methods utilized on the 1980 fall chinook salmon run in the Klamath River were similar to those employed in 1979. Two 7-man crews consisting of biologists and YACC enrollees working alternate 4-day shifts and 10-hour days repeatedly set a 149 m long by 6 m deep (490 ft. by 20 ft.) beach seine with an 8.9 cm (3.5 inch) stretch-mesh size in a semi-circle from the south spit of the Klamath River. The seine was set utilizing a Valco jet sled and retrieved with a 3-horsepower gasoline winch at each end (Plates 1 and 2). Once crowded, fish were netted into live cages for holding prior to tagging.

During the handling and tagging process (Plates 3 and 4), biologists removed the fish from the live cages, placed them into a padded tagging cradle and examined them for tags, fin clips, hook scars, seal bites, gill net marks and other distinguishing features. Fork lengths were recorded in centimeters and a numbered aluminum or monel-metal butt-end band was applied to the lower right mandible of each fish. Seven sizes of bands were utilized ranging from a Number 14 for fish as small as 40 cm to a Number 28 for fish as large as

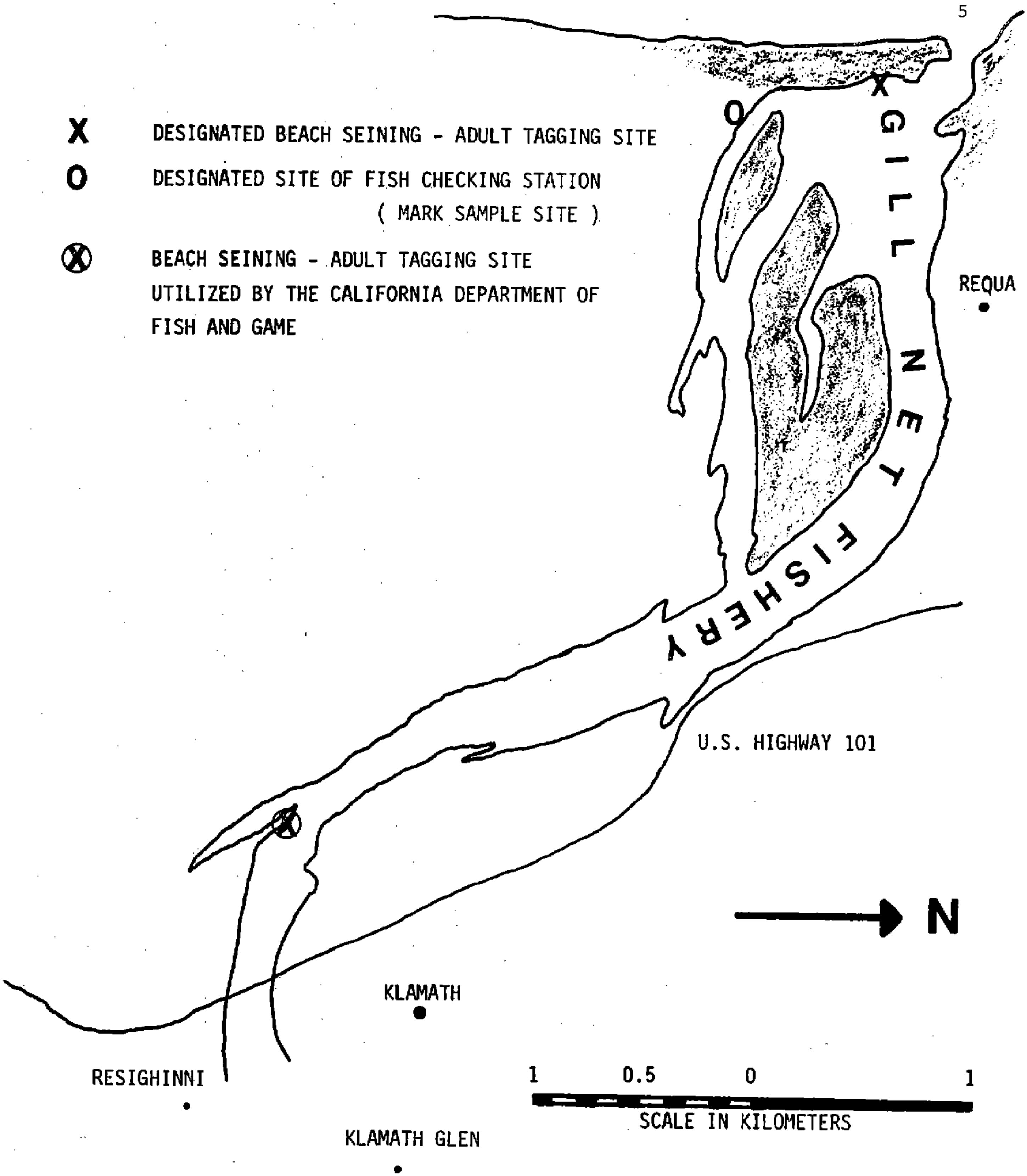
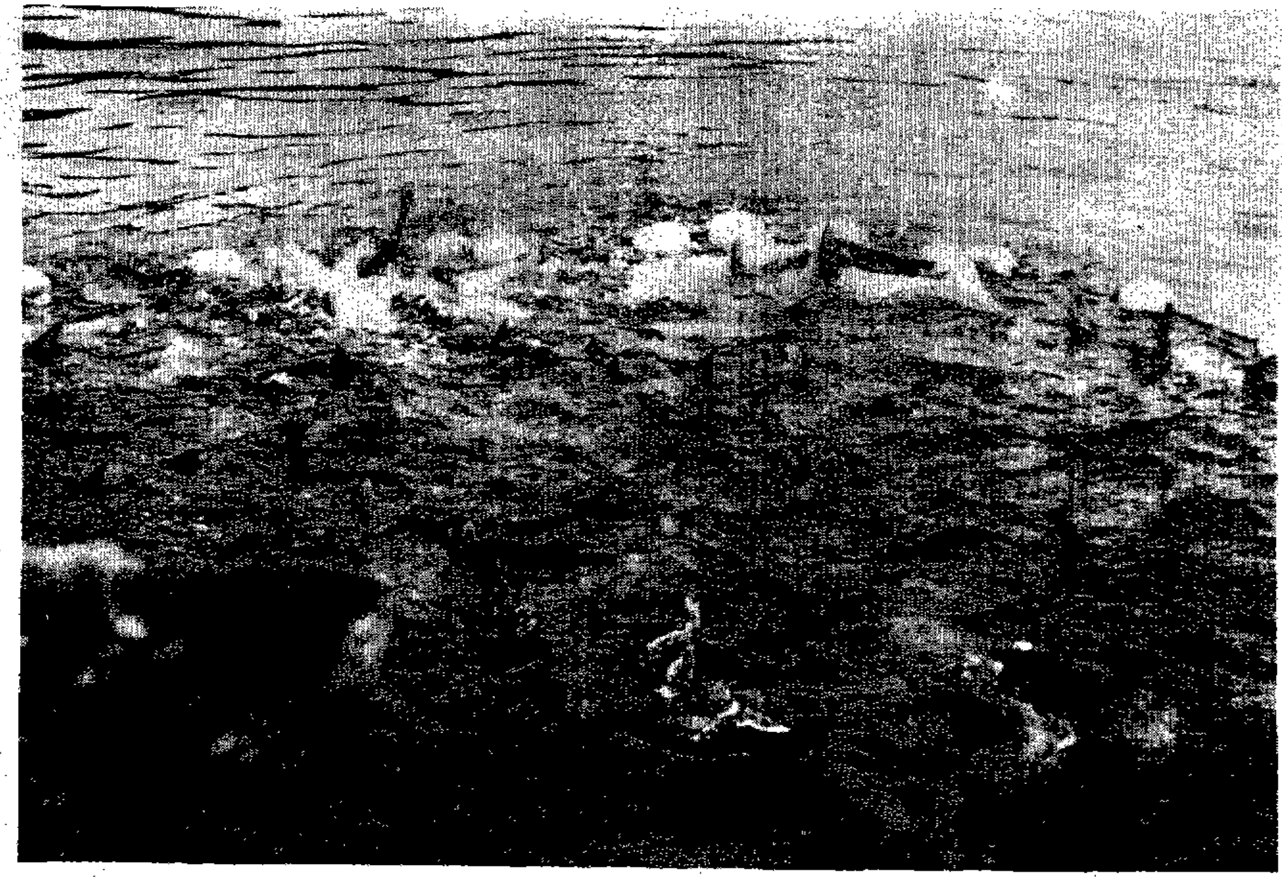
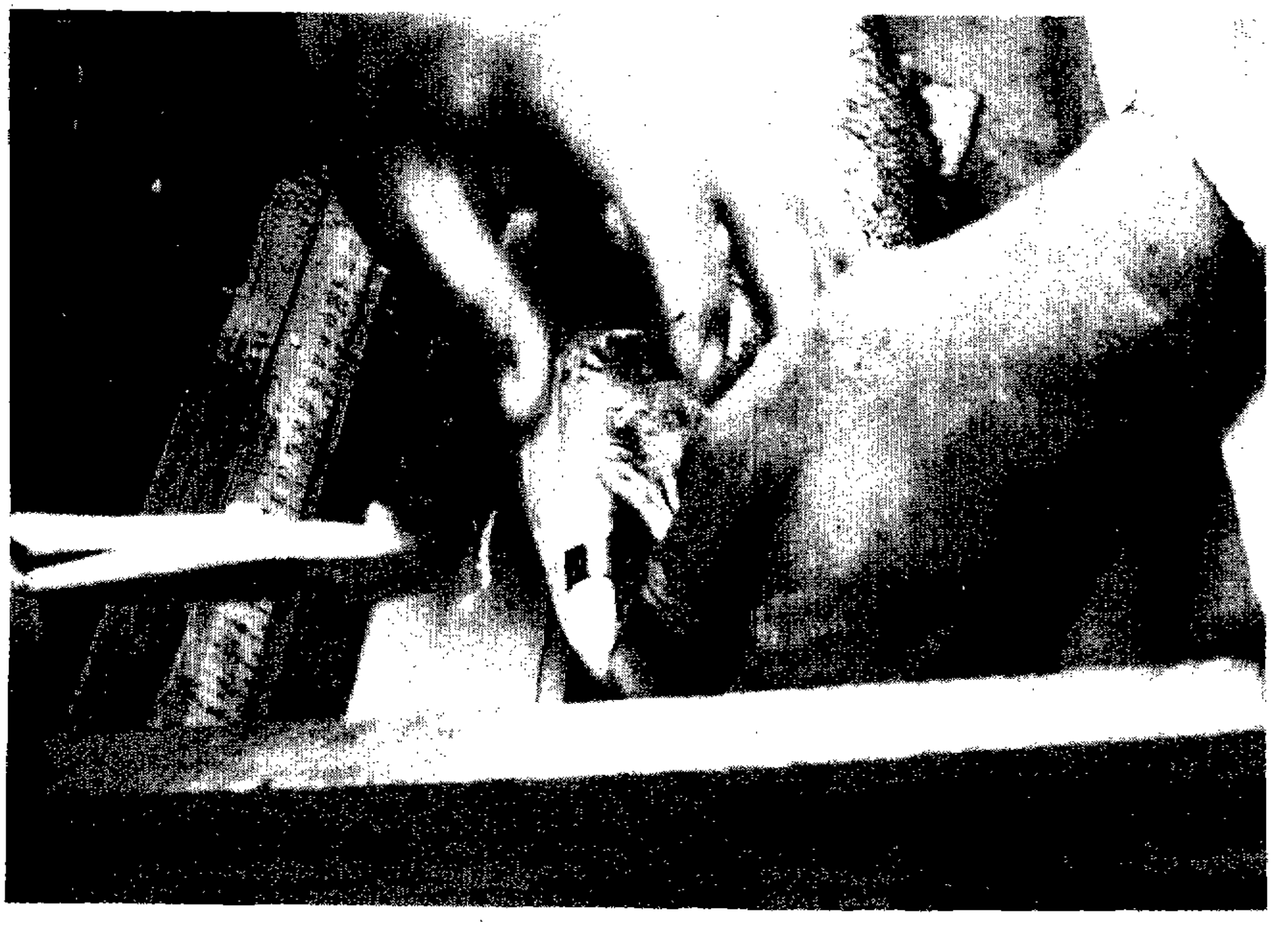


FIGURE 2. The Klamath River estuary with locations of the designated beach seining site, fish checking station and Indian gill net fisheries.

PLATES 1 and 2. The beach seining operation employed to capture adult salmon in the Klamath River estuary in 1979 and 1980.





PLATES 3 and 4. The handling and tagging of adult chinook salmon captured in beach seining operations conducted in the Klamath River estuary in 1979 and 1980.

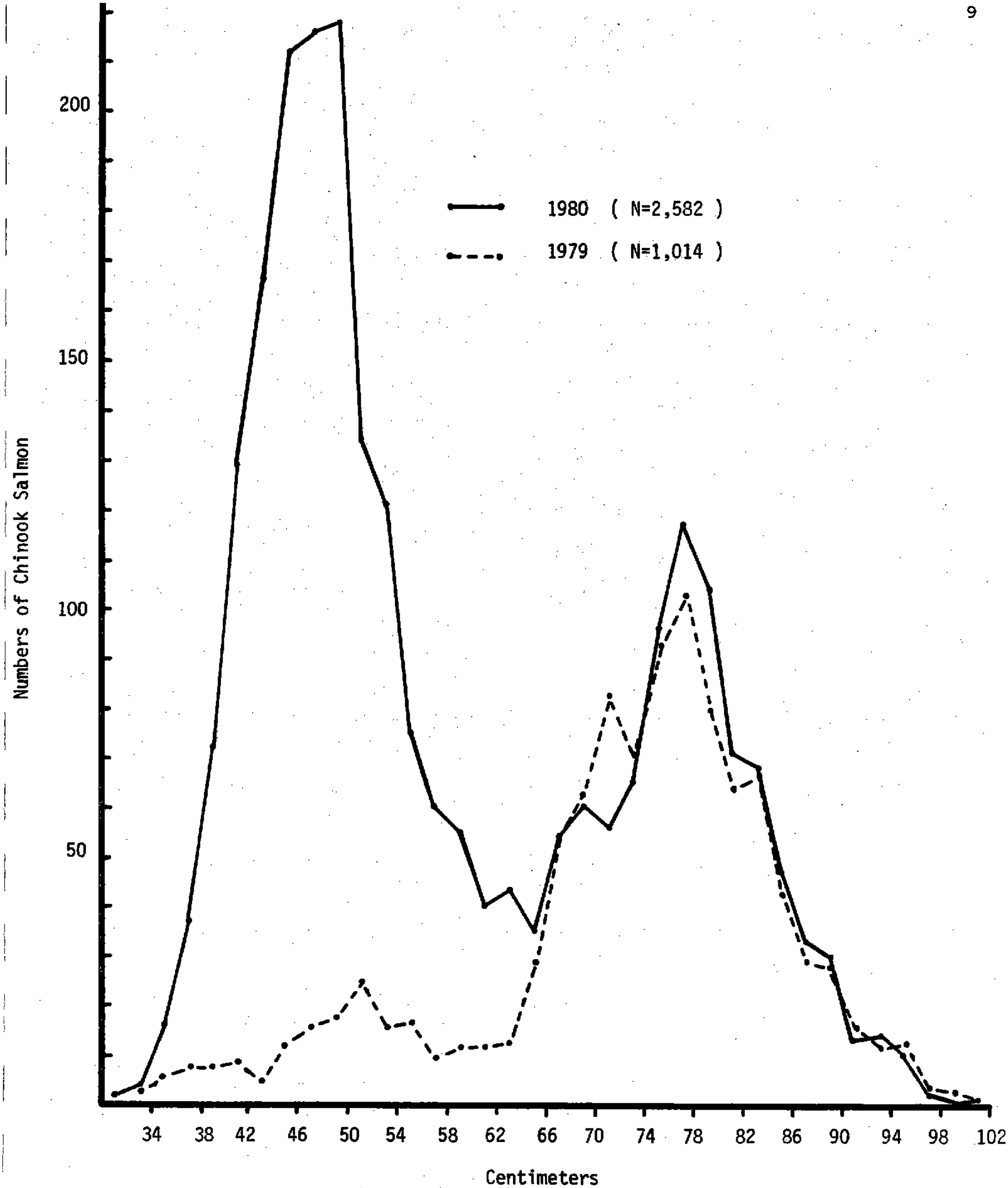


FIGURE 3. Length-frequencies of chinook salmon seined in the Klamath River in 1979 and 1980.

100 cm. A 0.95 cm (3/8 inch) hole punch was applied to the dorsal lobe of the caudal fin of each tagged fish prior to release.

We used jaw tags based on data which reveals that jaw tag utilization results in lower tag shedding rates, reduced tag application time and reduced stress on tagged fish as compared to other tag types. We anticipated using the half-adipose fin clip as the secondary mark to evaluate tag shedding but concerns that such a mark would be confused with returning coded-wire tagged (CWT) fish necessitated the selection of another mark and we decided on the caudal punch. It became clear throughout the course of our study that the caudal punch was not an acceptable secondary mark because of difficulties encountered in detecting the mark when rapidly sampling large numbers of fish and because the punch often became unrecognizable because of fin ray splitting, tissue regeneration and fungus infestation. As a result of these problems, we could not quantify tag shedding rates in 1980. Based on our experiences in 1980 and past experiences of personnel with the Washington Department of Fisheries and USFWS in Washington, which reveal that the half-adipose fin clip is readily distinguished from the healed adipose fin clip of CWT fish, it appears that the half-adipose fin clip is the most appropriate secondary mark to use in conjunction with mark-recapture studies on terminal anadromous salmonid populations and that the jaw tag is the most appropriate tag to utilize in programs of this nature.

Between June 24 and September 28, 1980, FAO-Arcata biologists captured 2,582 chinook salmon in beach seining operations conducted on the south spit of the Klamath River including 1,069 adults (salmon equal to or greater than 58 cm in length) and 1,513 grilse (salmon less than 58 cm in length, which do not count toward the established spawner escapement goal of 115,000 for the drainage). The 1979 beach seining operation, by contrast, resulted in the capture of 1,058 chinook salmon, only 142 of which were grilse. The percentage of grilse observed in the 1980 run (59 percent) was about four times the 13 percent level observed in 1979 beach seining operations (Figure 3) and was considerably higher than grilse ratios observed by CDFG biologists at their beach seining site in recent years. In 1980, the percentage of grilse observed in the lower river was similar to grilse percentages observed by the CDFG at the Shasta Racks (54 percent) and Willow Creek weir (60 percent) but higher than the levels observed at Iron Gate Hatchery (16 percent) and Trinity River Hatchery (31 percent). On a drainage wide basis the CDFG estimated an overall grilse ratio for the year of approximately 32 percent as compared to a 1979 ratio of about 11 percent. It should be noted that grilse cutoff lengths differed somewhat between stations depending on observed length frequency patterns. Grilse ratios observed at the south spit seining site gradually declined from 80 percent in late June and most of July, 1980 to 43 percent during the last week in August before rising to 60 percent in September, 1980.

The significance of the grilse-adult ratio involves its potential utilization in predicting relative sizes of adult runs in subsequent years. While relationships between grilse and subsequent adult returns have been postulated for coho salmon (*Oncorhynchus kisutch*), no clear-cut relationship has been established for chinook salmon. If a relationship exists between chinook salmon grilse returns in one year and returns of three-year-old chinook salmon in the following year, we would expect to see a relatively high return of three-year-old salmon to the Klamath River in 1981.

The peak of the 1980 chinook salmon run entering the Klamath River occurred between August 20 and September 10 when catch per seine haul values frequently exceeded 5 adults and 10 total salmon including grilse (Figure 4). Fish entry from the ocean into the river appeared to be related to tidal stage with most fish entering during the first half of incoming tides (Figure 5).

Of the 2,582 chinook salmon captured at the south spit site in 1980, 22.3 percent of the grilse and 30.5 percent of the adults bore hook scars. Numerous fish displayed missing eyes, maxillaries and mandibles and several trolling hooks found imbedded in the fish were recovered. Data compiled at the Red Bluff Diversion Dam over the last seven years reveals that approximately 33 percent of Sacramento River chinook salmon exhibit hook scars (Reisenbichler pers. comm.).

During the 1980 season, FAO-Arcata biologists tagged 1,325 of the 1,513 chinook salmon grilse seined, 1,038 of the 1,069 adult chinook salmon captured, 18 of 30 coho salmon caught and 217 of 600 adult steelhead trout (*Salmo gairdneri*) seined. As noted earlier, jaw tags were applied to the salmon. At the request of the CDFG, spaghetti tags were applied to the steelhead. Seven coastal cutthroat trout (*Salmo clarki*) and 149 half-pounder steelhead trout were captured during the year but were not tagged. Nine of 12 green sturgeon (*Acipenser medirostris*) seined in 1980 received disc-dangler tags.

Comparisons of catch/effort involving seine hauls of adult chinook salmon during early August and early September in 1979 and 1980 (Figure 6) seem to indicate a reduced run in 1980 versus 1979. Because of a property ownership dispute which prevented us from seining on the south spit during the peak of the 1979 run, however, adequate comparative data from which to draw conclusions is unavailable. In 1981, we plan to continue collecting comparative seining catch/effort data to utilize in conjunction with catch/effort data obtained through the Indian gill net fishery in developing a run size estimation program for the basin.

Of 67 tagged chinook salmon recaptured at our beach seining site in 1980, we recovered 42 on the same days that they were tagged, 5 between 10 to 20 days following tagging and 2 more than 25 days after tagging. Two tagged sturgeon and 11 steelhead trout were also recaptured, most on the same dates that they were tagged. One steelhead tagged in August, 1979 was recaptured in September, 1980.

Because of the unresolved property ownership dispute involving the south spit of the Klamath River which disrupted beach seining operations in 1979, we assessed the applicability of purse seining as an alternative adult capture technique on the Klamath River estuary. During the spring of 1980, we modified our beach seine and two river sleds and conducted experimental purse seining operations in Humboldt Bay, Clair Engle Lake, Stone Lagoon and finally, in the Klamath River estuary (Plates 5 and 6). After extensive testing, we concluded that the purse seining technique could be employed in an adult capture program. Because of the success achieved in conducting our beach seining operation throughout the course of the fall chinook salmon run in 1980, however, we did not have an opportunity to test the purse seining technique while adult chinook salmon were in the estuary.

3. Adult Recapture Program - Net Harvest Monitoring Station

Through the establishment of a net harvest monitoring station on the lower Klamath River in 1980, FAO-Arcata biologists made considerable progress in developing an in-season run size estimation program for chinook salmon utilizing catch rates associated with the lower river gill net fishery and by using the

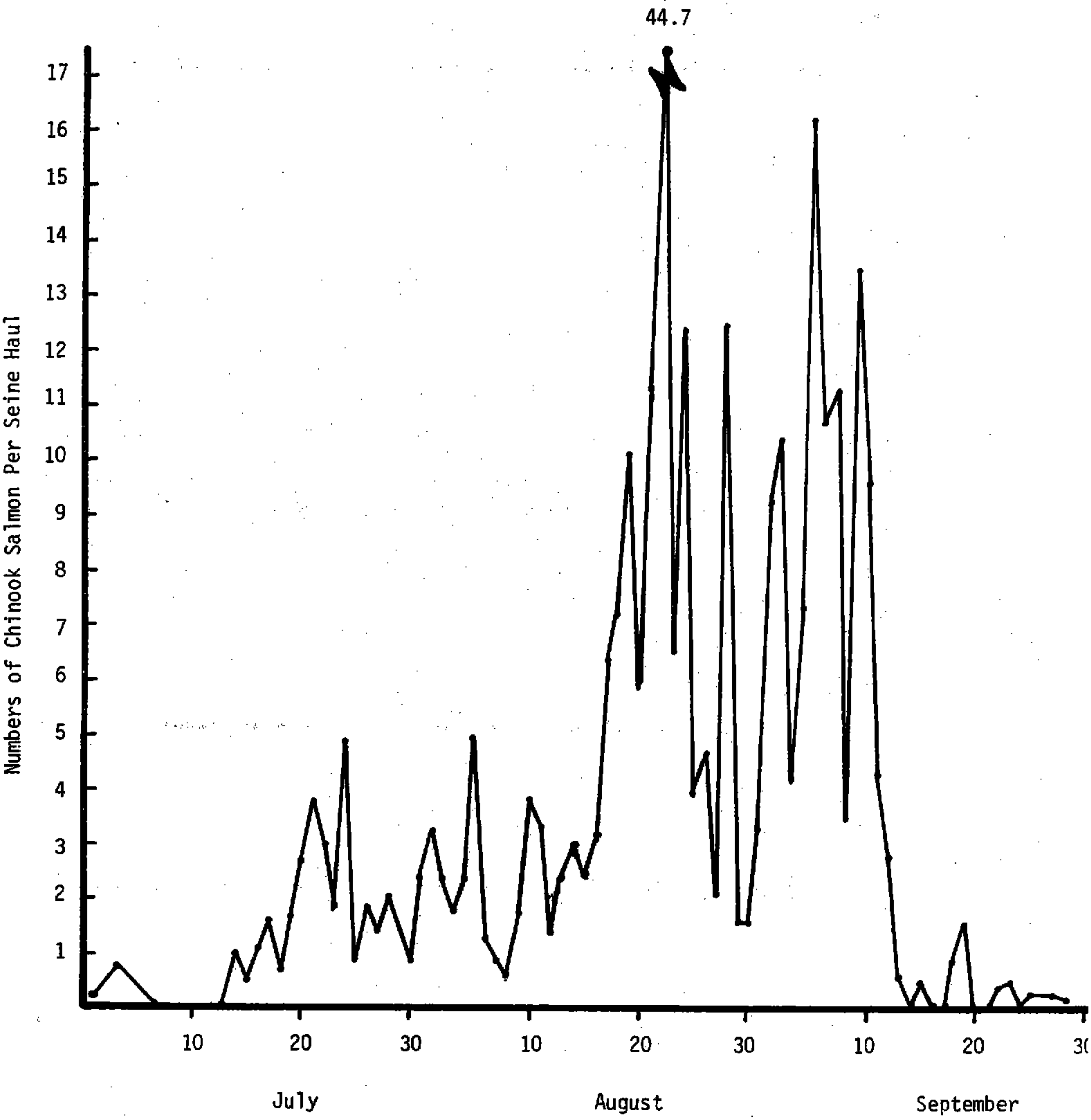


FIGURE 4. Numbers of chinook salmon captured per beach seining haul in the Klamath River in 1980.

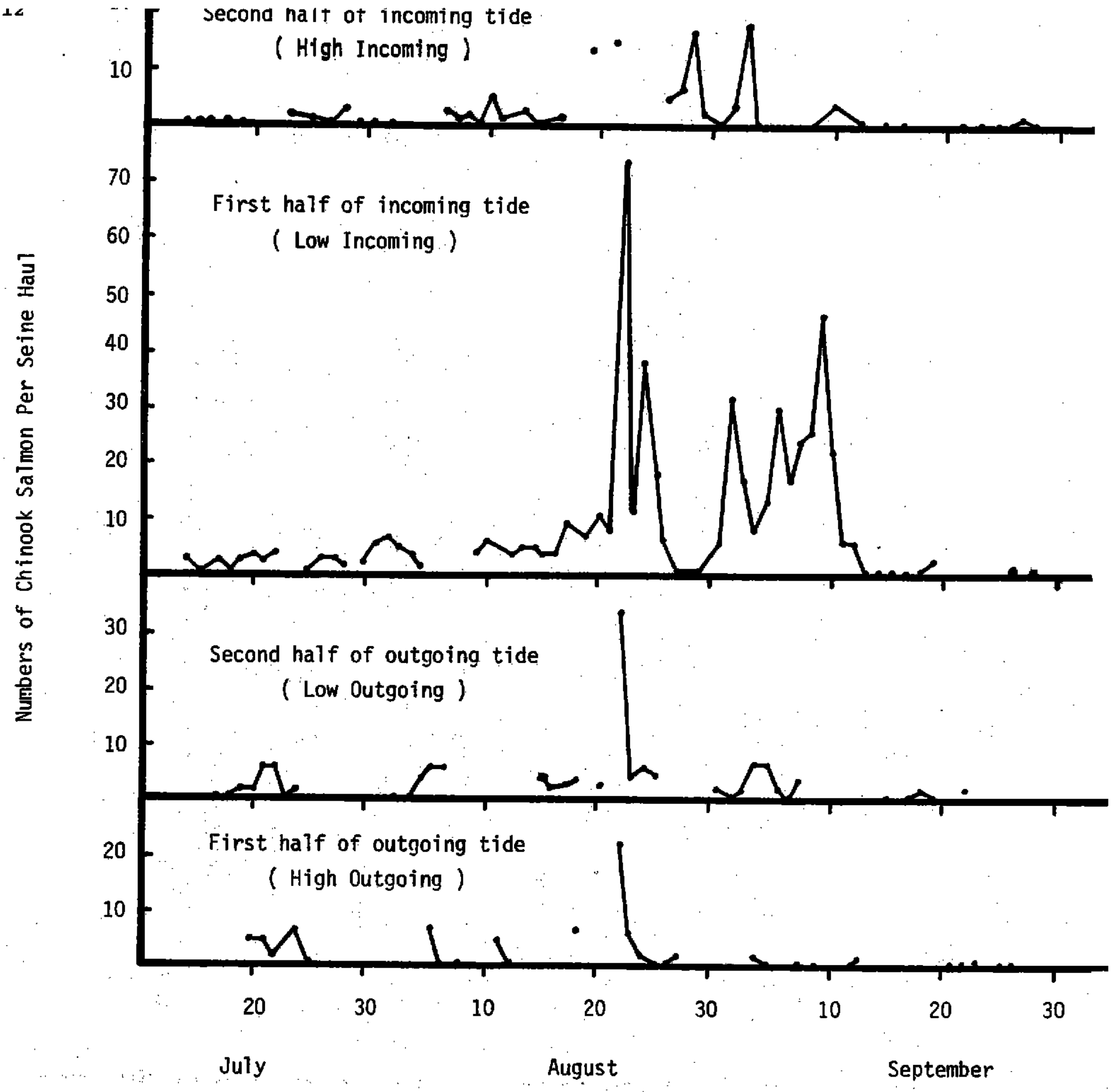


FIGURE 5. Numbers of chinook salmon captured per beach seining haul in the Klamath River at various tidal stages in 1980.

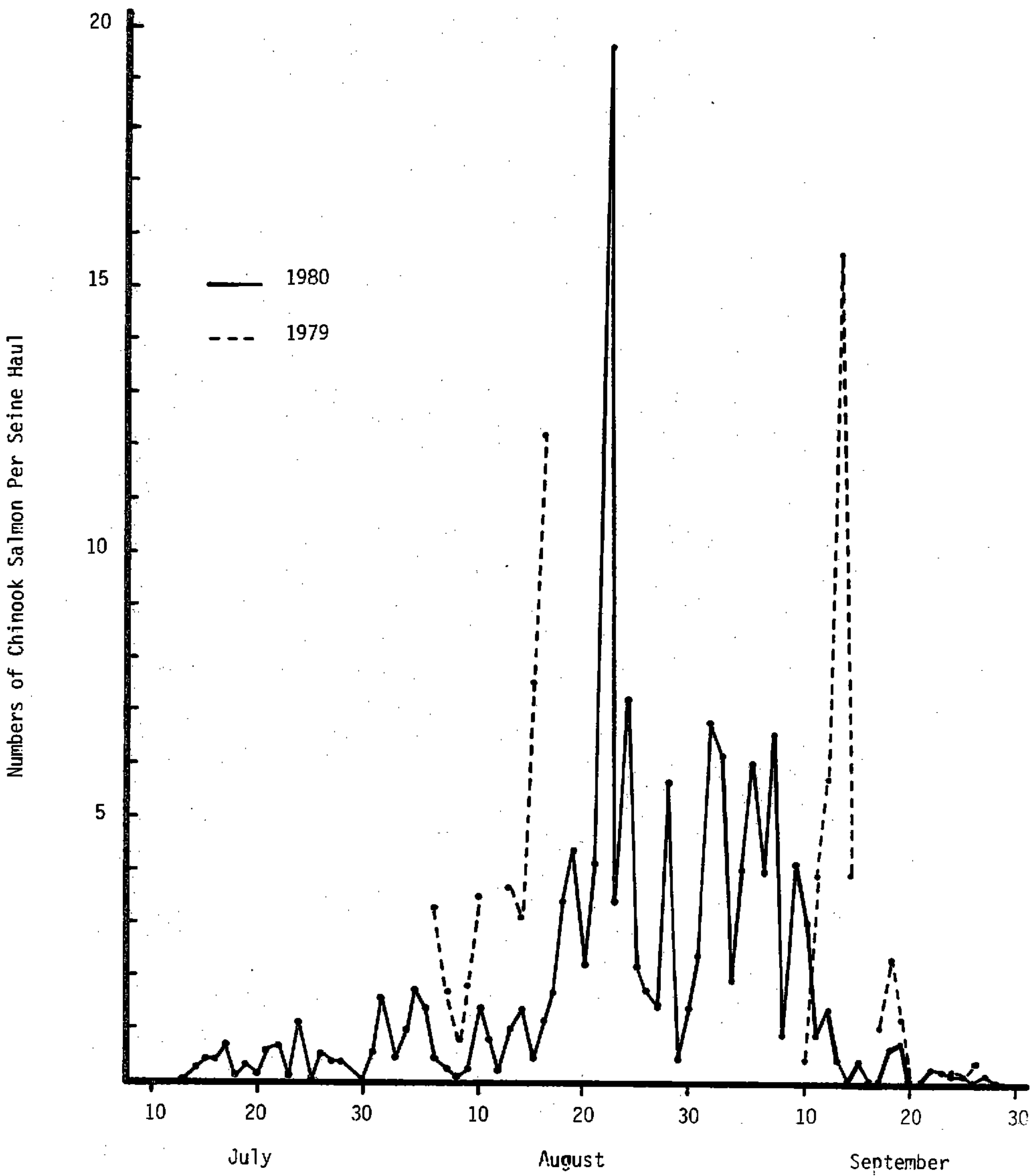
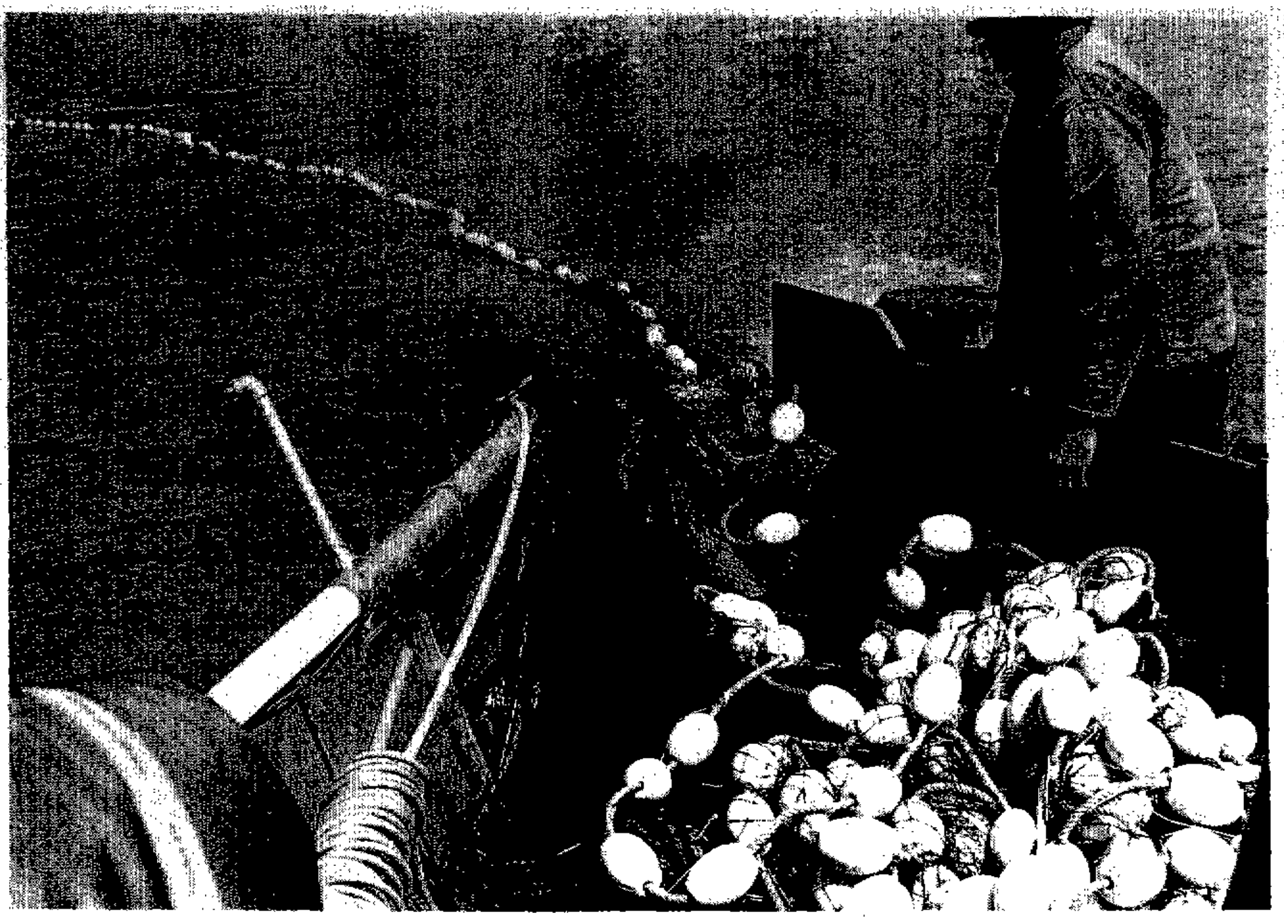


FIGURE 6. Numbers of adult chinook salmon (salmon longer than 58cm) captured per beach seining haul in the Klamath River in 1979 and 1980.



PLATES 5 and 6. Exploratory purse seining operation developed as an alternative adult chinook salmon capture technique for use in the Klamath River estuary.

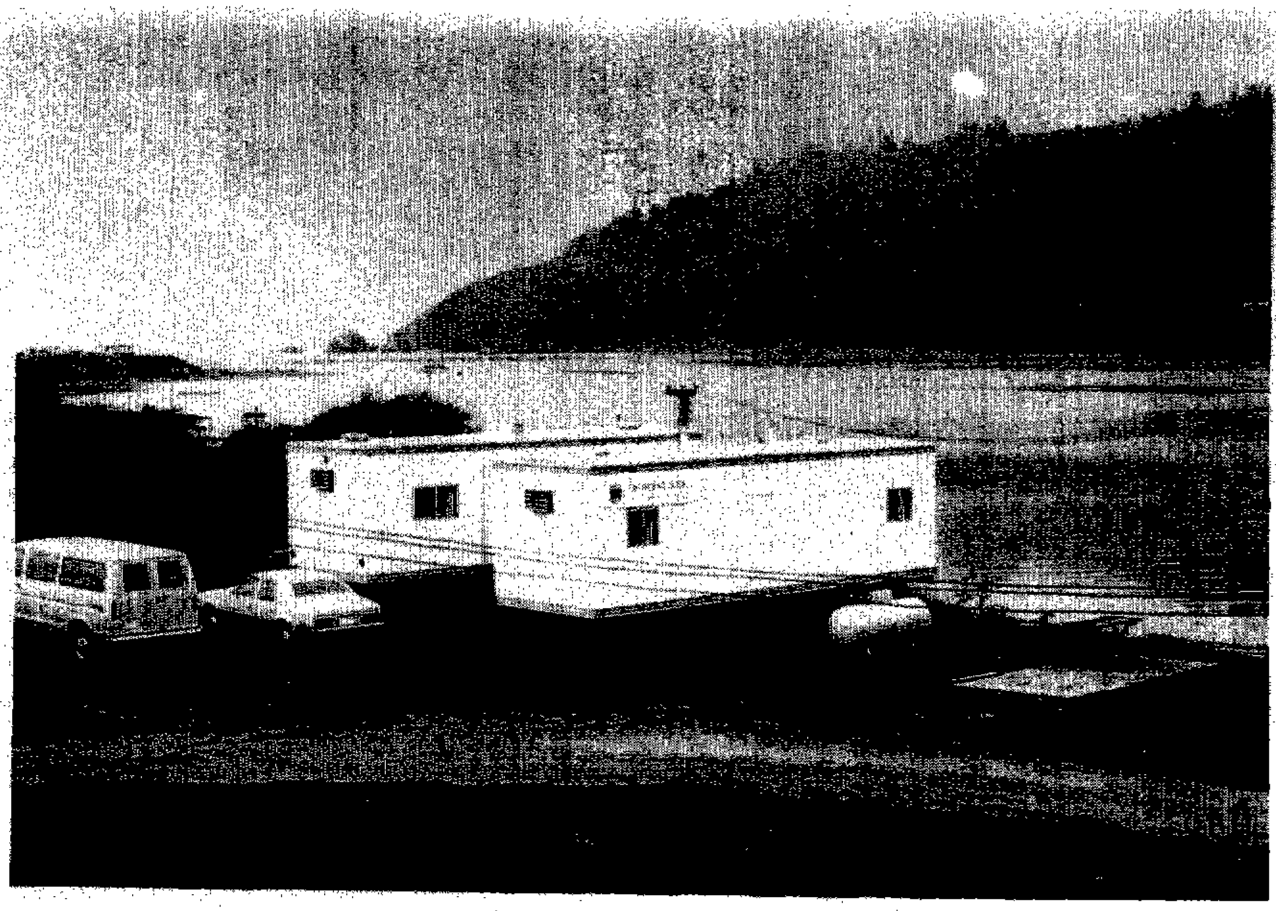
fishery to mark sample tagged fish. The YACC provided two mobile homes which we used to establish a base camp on the lower Klamath River at Chub's Camp (Figure 2, Plate 7). Operating from the base camp, biologists assisted by Indian technicians utilized a river sled to monitor net harvest from the estuary (Plate 8). The mobile homes and river sled were equipped with large signs which read "U.S. Fish and Wildlife Service - Fish Checking Station." Gill net harvest from the lower 9.25 km (5 mile) stretch of the Klamath River (below the Resighinni - Klamath Glen area) was monitored on a daily basis throughout the course of the fall chinook salmon run with effort concentrated at night during hours of greatest harvest. Excellent cooperation was received from the Indian fishers and we estimate having observed approximately 75 percent of the lower river harvest.

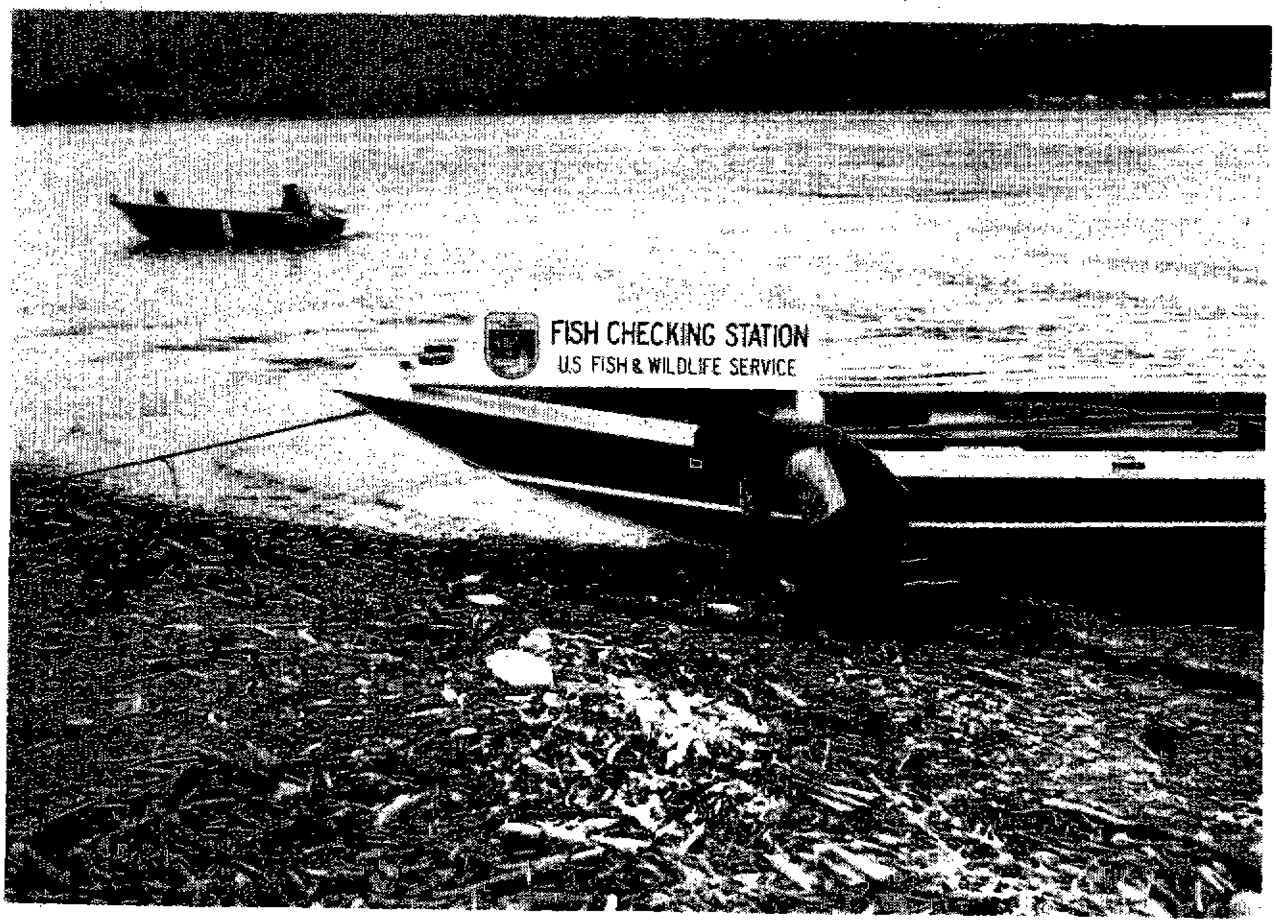
In assessing net harvest from the lower river in 1980, we made approximately 5,400 contacts with individual Indian fishers. Indian people who fished the estuary were contacted approximately twice nightly for a total of about 5,050 contacts. At the Resighinni, about 7 contacts with individual Indian fishers were made daily for a seasonal total of approximately 350 contacts. A total of 7,370 fall chinook salmon were mark sampled during the season.

Based on data collected at the net harvest monitoring station, we estimate that total Indian net harvest from the lower 9.25 km of the Klamath River in 1980 approximated 10,100 fall chinook salmon. A discussion of reservation-wide net harvest for all species is included in Section VI of this report. During the peak of the fall chinook salmon run, which occurred between August 20 and September 10, daily net harvest from the lower river area ranged from approximately 98 to 750 chinook salmon while averaging approximately 311 chinook. Approximately 67 percent of the 1980 lower river net harvest occurred during this 22-day period and approximately 67 percent of total net harvest from the lower 9.25 km stretch of the river occurred in the lower estuary while the remaining 33 percent were caught in the Resighinni - Klamath Glen area (Figure 7). The majority of netted fish ranged from 70 cm to 86 cm (27.5 in. to 34 in.) in length (Figure 8) and weighed between 4.5 kg and 8 kg, or 10 lbs. to 18 lbs. (Figure 9). Chinook salmon of known hatchery origin (adipose fin-clipped fish) observed in net harvest monitoring and beach seining operations displayed length frequency peaks at approximately 60 cm and 74 cm (Figure 10).

Between August 20 and September 10, 9 to 41 gill nets fished the Klamath River estuary on a daily basis resulting in catch per net-night values ranging from 2 to 20.5 chinook salmon and averaging approximately 9 chinook per net-night (Figure 11). Indian fishermen normally set their nets in the deep channel of the estuary off the south spit and in the area below Requa (Figure 12). On the average, approximately 7 gill nets fished the Resighinni - Klamath Glen area during the course of the run.

The lower river net harvest monitoring effort resulted in the recovery of 104 jaw tags, 78 from fish caught in the estuary and 26 from fish caught in the Resighinni area. Mean times between tagging at our beach seining site and recovery in the estuary and Resighinni area were 3 and 13 days, respectively. In the estuary, times between tagging and recovery ranged from 0 to 29 days with 63 percent of the recoveries having occurred on the same dates that the fish were tagged and with 13 percent of the recoveries having occurred 10 or more days after tagging. At Resighinni, times between tagging and recovery ranged from 4 days to 38 days with 58 percent of the recoveries having occurred 10 or more days after tagging and with only 15 percent of the recoveries having occurred within 5 days of tagging.





PLATES 7 and 8. Net harvest monitoring station established on the lower Klamath River in 1980 and biologist operating out of station measuring gill netted salmon.

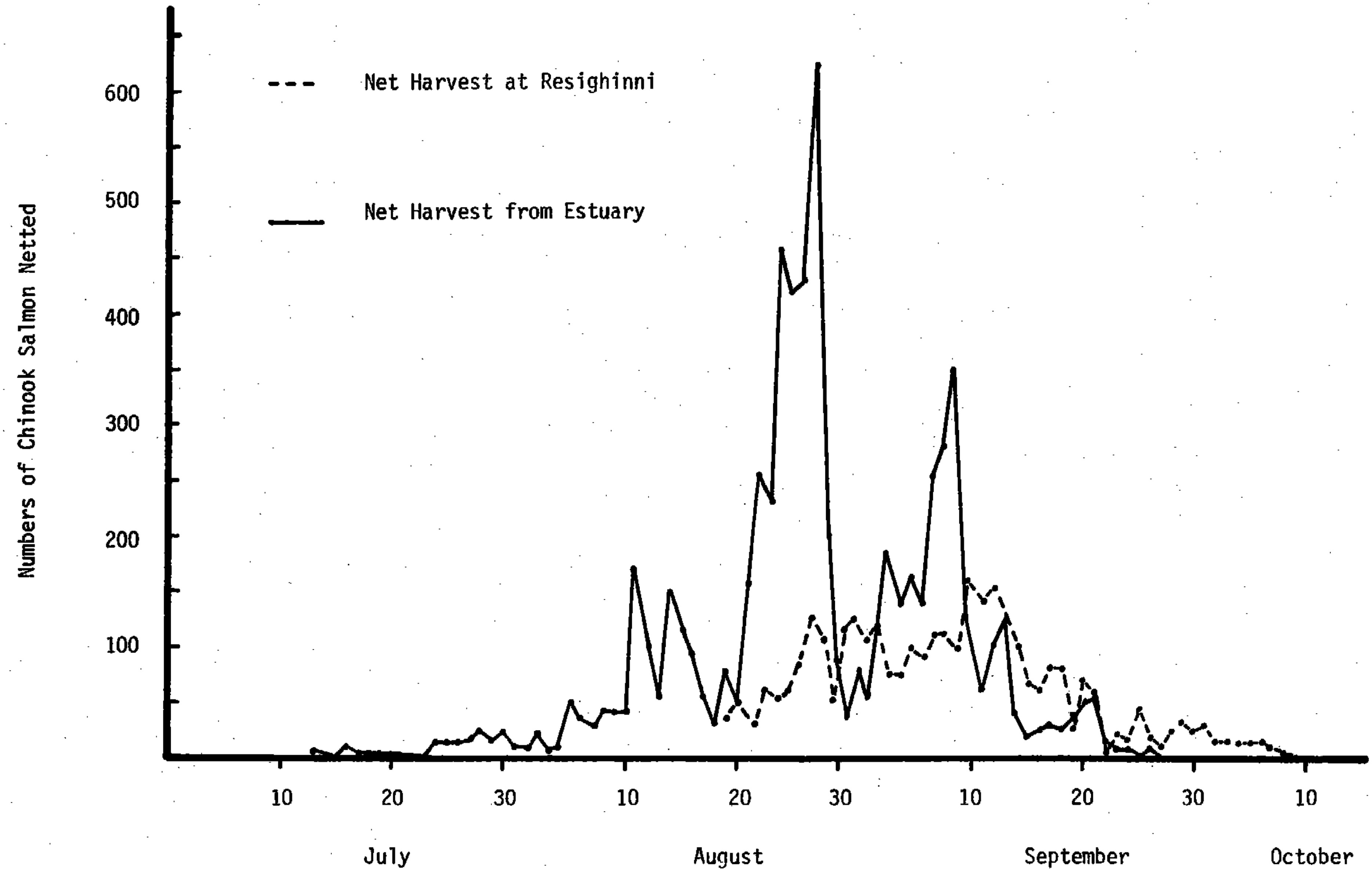


FIGURE 7. Estimated daily Indian gill net harvests of chinook salmon from the lower Klamath River (estuary and Resighinni areas) in 1980.

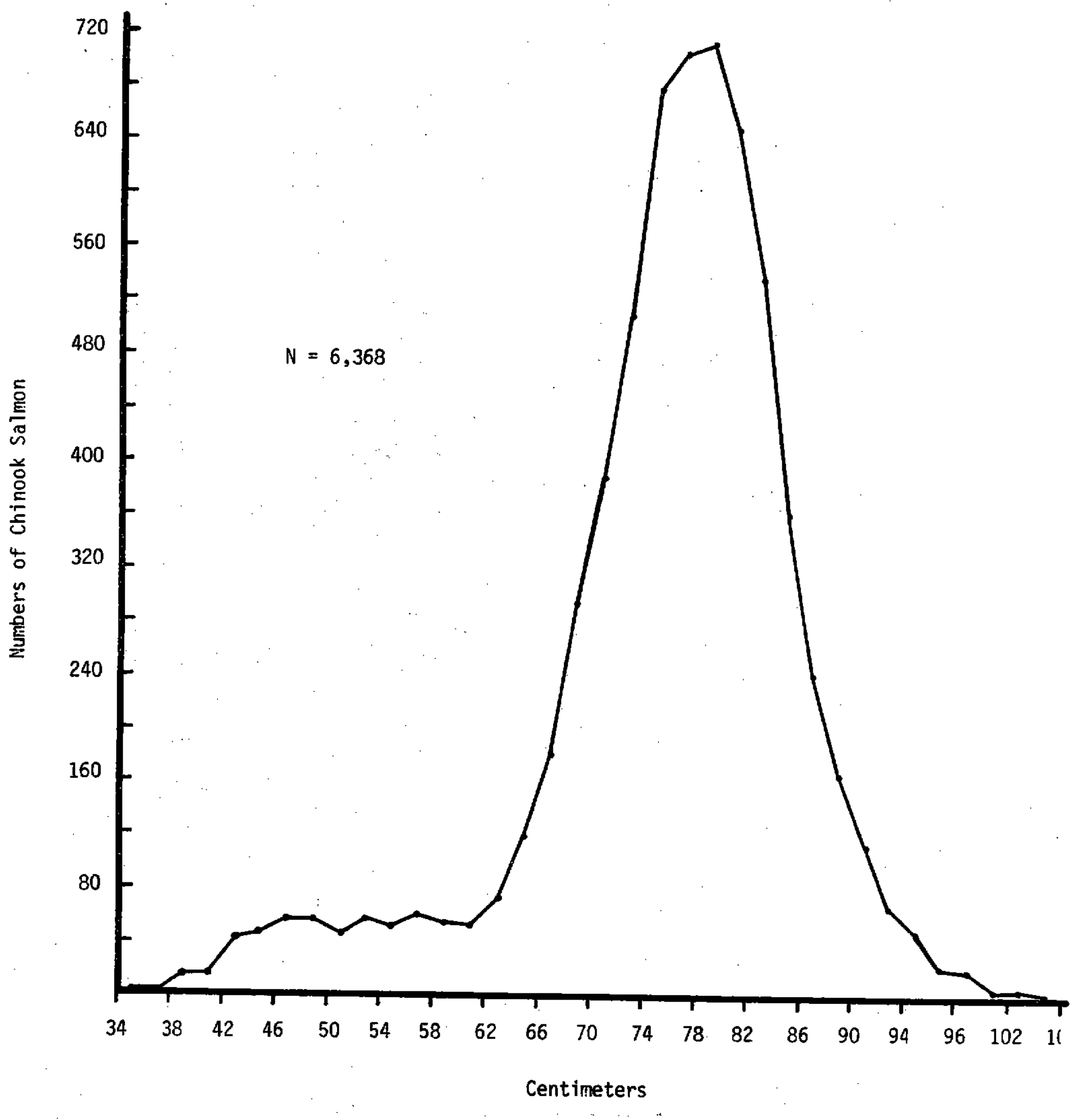


FIGURE 8. Length-frequency of chinook salmon caught by Indian gill netters on the lower Klamath River in 1980.

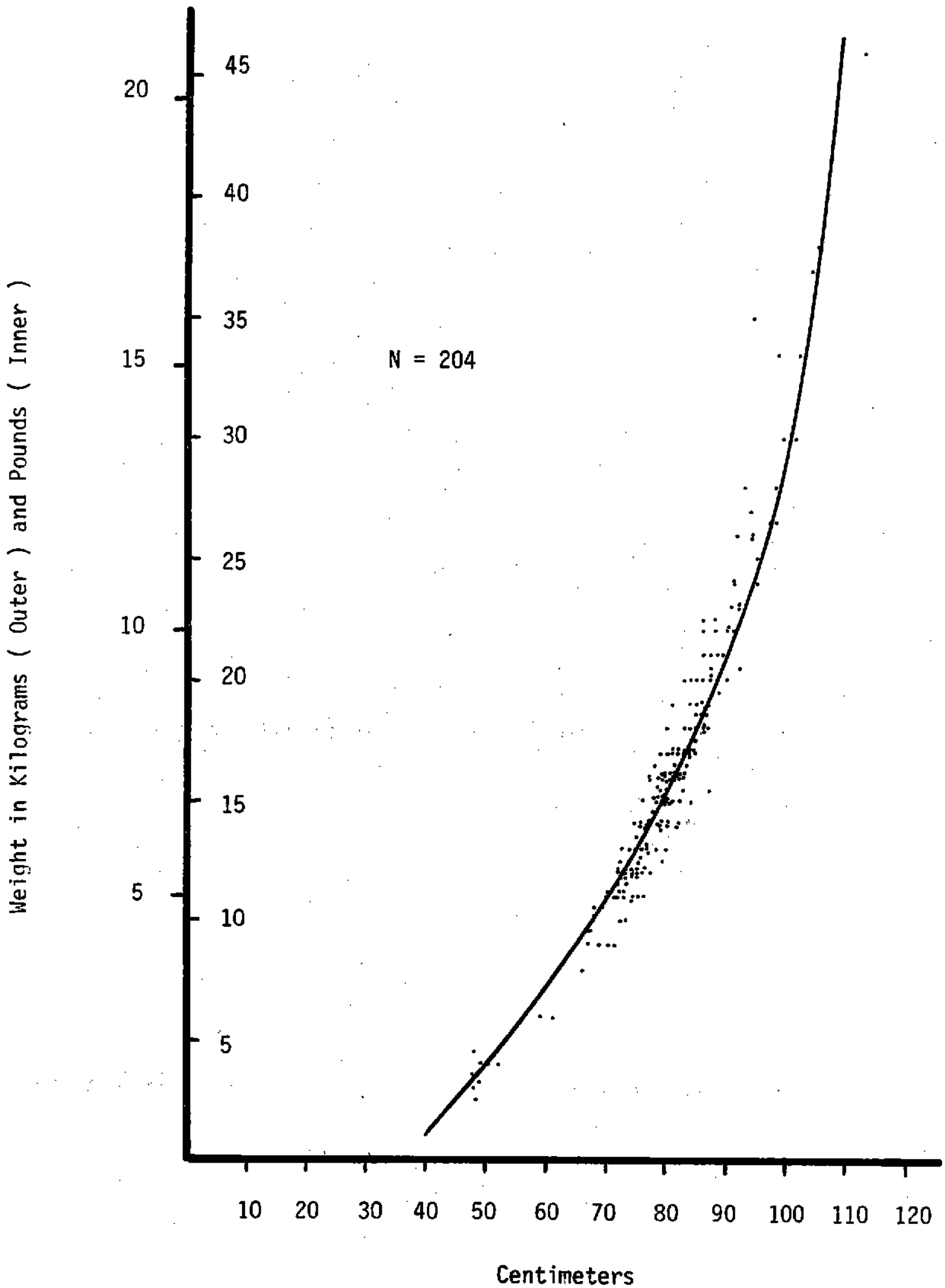


FIGURE 9. Length - weight relationship of chinook salmon caught by Indian gill netters on the lower Klamath River in 1980.

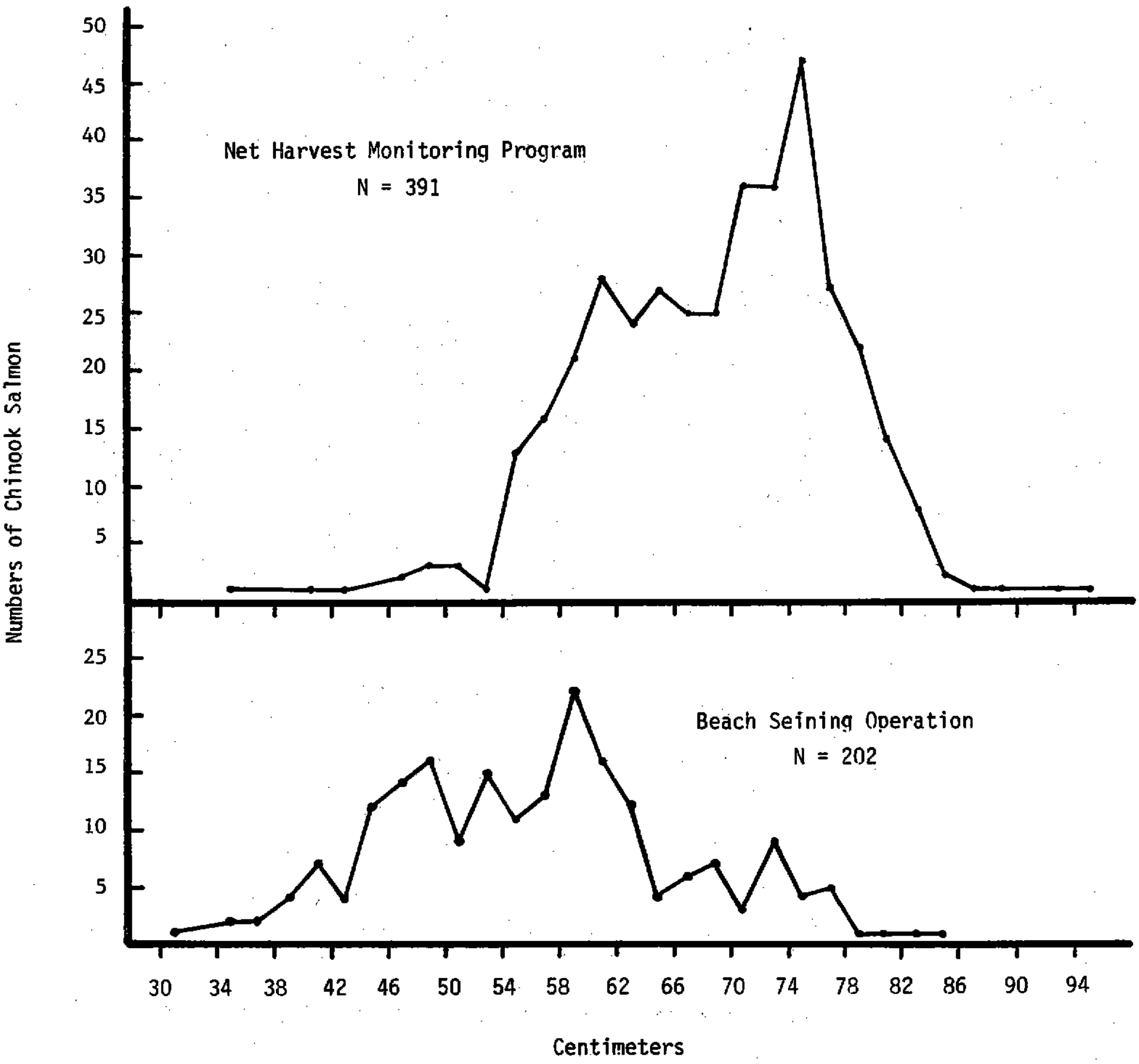


FIGURE 10. Length-frequencies of adipose fin clipped chinook salmon captured in net harvest monitoring and beach seining operations in 1980.

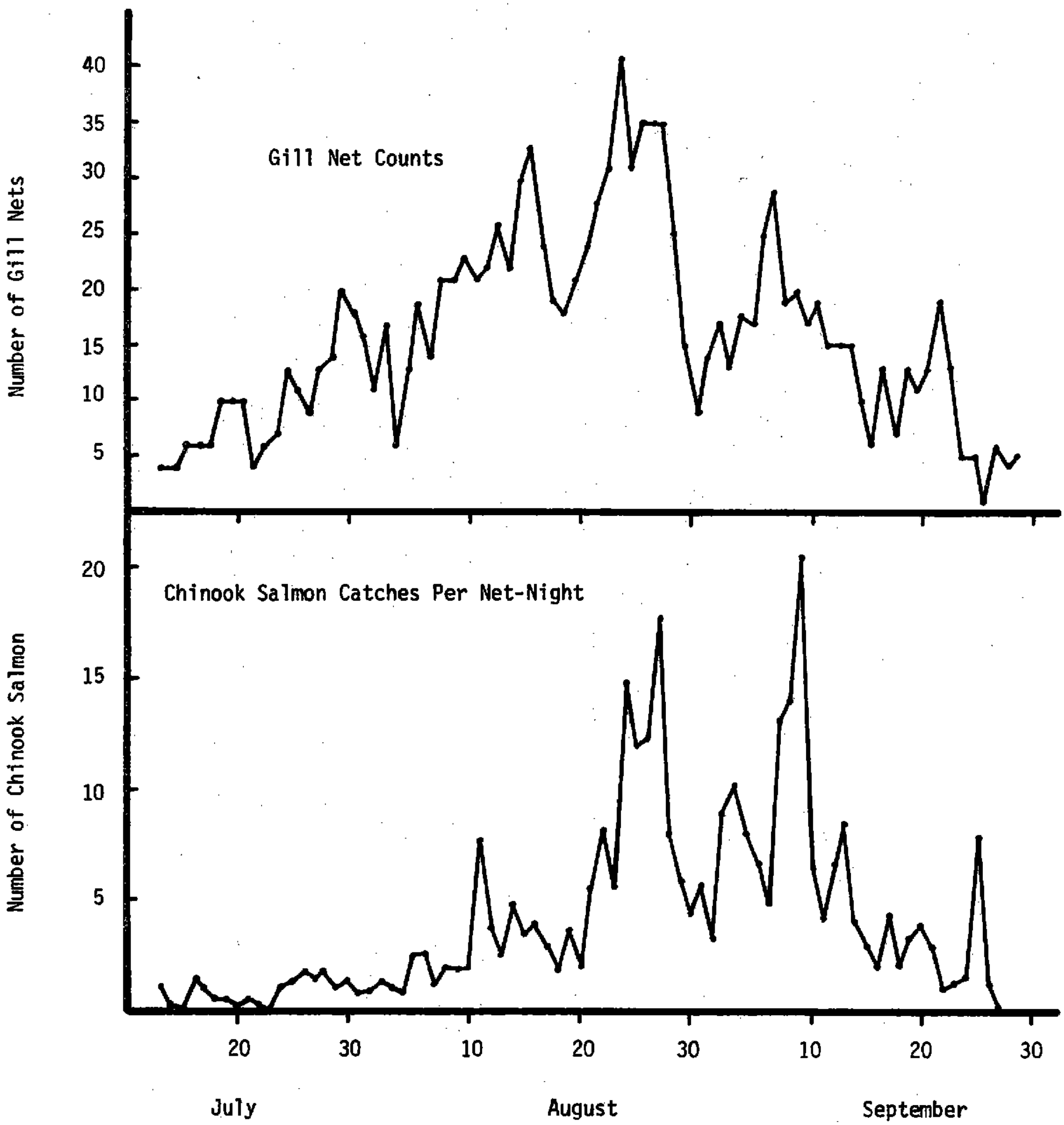


FIGURE 11. Gill net counts in the Klamath River estuary (above) and estimated catches of chinook salmon per net-night of effort in the estuary (below) during the 1980 season.

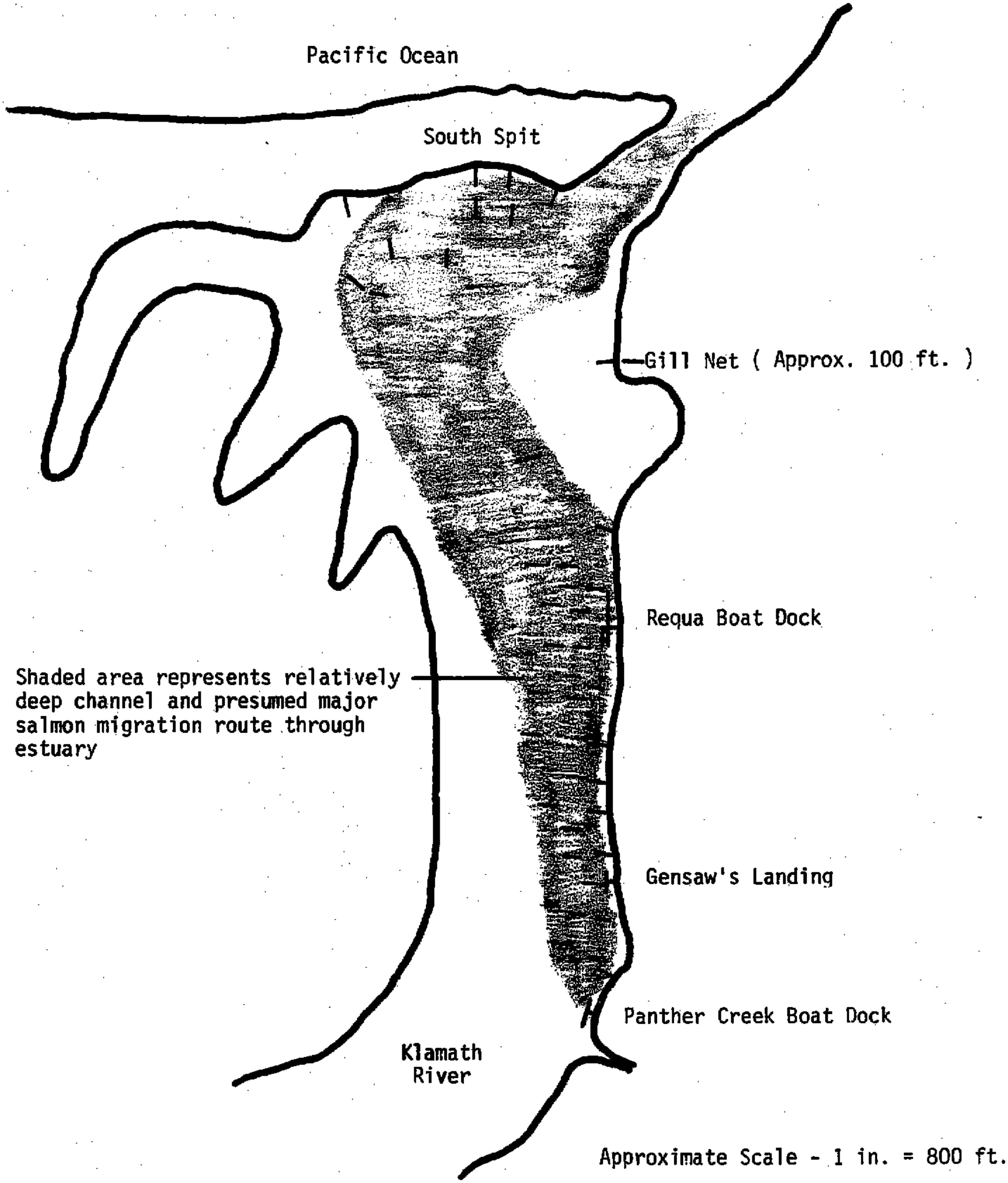


FIGURE 12. Approximate net placement pattern on a typical heavy netting night in 1980 during the peak of the chinook salmon run in the Klamath River estuary.

As elaborated on in Section VI of this report, we believe, based on our experiences this year, that we probably over-estimated net harvest on the reservation last year. In estimating net harvest last year, we applied rather arbitrary catch per net-night values to total numbers of nets counted in the river. With the expanded effort in 1980, we observed large differences in catch-effort between nets with the majority of fishers catching far fewer fish than the minority. In light of this, we expect that the values applied last year were high because they were largely based on reports and observations of catches by the more successful fishers. We now believe that net harvest last year approximated 15,000 and was slightly greater than the net harvest this year. We also anticipated during the course of the run that 1980 run size was fairly comparable with the 1979 run considering that netting effort in the two years appeared to be comparable and assuming that a relationship exists between numbers of fish in the river and net harvest.

In addition to the 67 tag recoveries at our beach seining site and 104 tag recoveries from the lower river net fishery, we received 7 tag returns from the upriver gill net fishery, 2 returns from the ocean fisheries and 43 returns from the river sport fishery (Table 1). Biologists of the CDFG reported the recovery of 11 jaw-tagged fish at their lower river seining site, 8 tagged fish at their Trinity River weir sites, 32 tagged fish at the Trinity River Hatchery, 14 tagged fish at the Iron Gate Hatchery, 21 tagged fish at the Shasta Racks and 25 tagged fish recovered on the spawning grounds (Table 1). Known recoveries of tagged chinook salmon totaled 332 for an overall recovery rate of 14 percent. It is believed that considerable numbers of our tagged fish went unnoticed at the Shasta Racks and that many others caught in upriver net and sport fisheries were not reported.

TABLE 1. Recoveries of chinook salmon tagged by the U.S. Fish and Wildlife Service on the Klamath River in 1980.

Recovery Site	Numbers Recovered[1/]
Gill Net Fishery	111
USFWS Seine Site	67
Sport Fishery	43
Trinity River Hatchery	32
CDFG Spawning Ground Surveys	25
Shasta Racks	21
Iron Gate Hatchery	14
CDFG Seine Site	11
CDFG Weirs	8
TOTAL	332

Overall Recovery Rate - 0.14

1/ Tag return data are preliminary and subject to minor revision.

4. Spawner Escapement and Run Size Estimation

In 1978, the CDFG established a spawner escapement goal of 115,000 adult fall chinook salmon in the Klamath River basin. When the chinook salmon run into the river that year appeared inadequate to satisfy the goal, the Department of the Interior promulgated an in-season adjustment to the federal Indian fishing regulations which placed a moratorium on commercial fishing by Indians of the Hoopa Valley Reservation. Despite this action, chinook salmon spawner escapement for the year numbered approximately 71,500, about 62 percent of the goal. In light of an anticipated low chinook salmon run in 1979, the Department of the Interior issued Indian fishing regulations which extended the commercial fishing moratorium and prohibited the use of drift gill nets (the most efficient netting technique) on the Klamath River below the Highway 101 bridge. When it again became apparent that the spawning run would not satisfy the 115,000 goal, the Interior Secretary requested a closure of the ocean troll fishery off California during the latter half of September. Following denial of the request, trollers landed an additional 23,200 chinook salmon in California, many of which possibly would have returned to the Klamath River, and spawner escapement in the river system dropped to 38,000, or 33 percent of the spawner escapement goal.

In 1980, another anticipated low run year, the Interior Department extended the commercial fishing moratorium and drift netting prohibition on the Hoopa Valley Reservation and the Department of Commerce, acting on recommendations of the Pacific Fishery Management Council (PFMC), promulgated offshore fishing regulations based on a spawner escapement goal of 86,000 chinook salmon in the Klamath River basin. The 25 percent reduction in the spawner escapement goal was deemed necessary to prevent severe disruption of the California ocean fisheries. The PFMC now considers the 115,000 figure as a "long term goal" scheduled to be reached over two complete cycles (eight years) given average environmental conditions. Despite the imposition of a six-week seasonal closure in the Fishery Conservation Zone off California and numerous days of bad weather, California chinook salmon landings in 1980 were above the 1971-75 average and spawner escapement in the Klamath River basin, based on preliminary reports of the CDFG, plummeted to perhaps the lowest level ever, 33,400, or 29 percent of the escapement goal.

In a series of three in-season status reports concerning the 1980 fall chinook salmon run in the Klamath River, we expressed our concern that the run appeared to be well below the spawner escapement goal and could approximate the low level of 1979. These assessments were made, as noted previously, based on comparisons of net harvest levels and beach seining catch/effort values observed during the two years. We anticipate continuing to develop the in-season run size estimation program in future years.

5. Recommended Future Run Size Estimation Program

Since 1976 and 1978, respectively, the CDFG and USFWS have attempted to develop a run size estimation program involving chinook salmon in the Klamath River drainage utilizing mark-recapture methodology. Because of problems encountered by CDFG biologists with their tagging program in the lower Klamath River, they decided in 1980 to abandon mark-recapture methodology as a means to estimate run sizes of chinook salmon in the drainage (Boydstun 1980) although they still continue to tag salmon at their lower river beach seining site and continue to utilize mark-recapture techniques in estimating run sizes in the Trinity River. As a result of experiences by FAO-Arcata biologists in 1980, we have concluded that mark-recapture techniques cannot be utilized to develop an in-season run size estimation program in the basin and probably cannot be employed to develop a sufficiently reliable post-season run size estimation program.

The difficulties associated with the proper utilization of mark-recapture methodology in run size estimation basically relate to inabilities in satisfying sample size requirements and mark-recapture conditions. Because of concerns that the handling and tagging of fish in conjunction with mark-recapture investigations might result in differential mortality between tagged and untagged fish, we attempted to evaluate the impact of the handling and tagging processes on fish released at the south spit seining site. In an attempt to evaluate the behavior of released jaw-tagged fish, a graduate student with the California Cooperative Fishery Research Unit at Humboldt State University applied radio tags to six jaw-tagged chinook salmon captured in our beach seining operation. Unfortunately, however, signals from the radio tags could not be picked up, probably because the liberated fish chose to stay in the saltwater wedge of the estuary which resulted in signal transmission problems.

Because elevated surface water temperatures in the Klamath River estuary during the summer of 1980, which frequently exceeded 70°F and occasionally approached 80°F, appeared to adversely affect the recovery rate of chinook salmon handled in our beach seining operation, we recorded temperature profiles in the estuary to assess how deep the high temperature water extended. We discovered that at our south spit seining site during the period of August 1 to September 10, cool water (55°F to 61°F) was always available to recovering fish at depths below 2 to 3 m (Figure 13). Tagged fish appeared to recover rapidly in surface waters which measured no higher than 69°F but recovery rates slowed noticeably as surface water temperatures exceeded 70°F.

Because of the availability of cold water at the south spit seining site, it appeared that fish could be handled safely in relatively warm surface water providing they could be returned quickly to the deeper water. For the great majority of seine hauls, our crews experienced no problem in expediting the fish handling process. On a few occasions, however, when relatively large numbers of salmon were captured per seine haul, fish had to be released without additional handling because of the stress incurred as a result of prolonged exposure to high temperature surface water. Because of this situation, it would be extremely difficult to tag adequate numbers of fish in a year when the run is relatively large and when surface water temperatures commonly exceed 69°F. In order to achieve 95 percent confidence that adult run size estimates would fall within 10 percent of true values, we would have to tag approximately 4 to 5 percent of the non-grilse component of the run assuming run sizes ranging from 100,000 to 150,000 (Figure 14). In 1980, we succeeded in tagging 1,038 adult chinook, only about 2 percent of a very low run.

Temperature profiles taken directly in the Klamath River mouth during incoming, high slack and outgoing tidal stages in August, 1980 revealed the expected gradation between warmer surface and cooler bottom water, while profiles taken at low slack tide revealed relatively warm water throughout the water column (Figure 15). This warm water "curtain," which may form twice daily, possibly delayed the entry of chinook salmon and other species into the river until lifted by the following incoming tide, possibly explaining why catch/effort values associated with our beach seining operation were consistently higher during the early phases of incoming tides (Figure 5). We plan to investigate this relationship further in 1981 and coordinate future seining operations taking into account tidal stages.

Problems involved in developing an in-season run-size estimation program in 1980 utilizing mark-recapture methodology were compounded by large differences between length-frequency distributions of fish tagged at the south spit seining

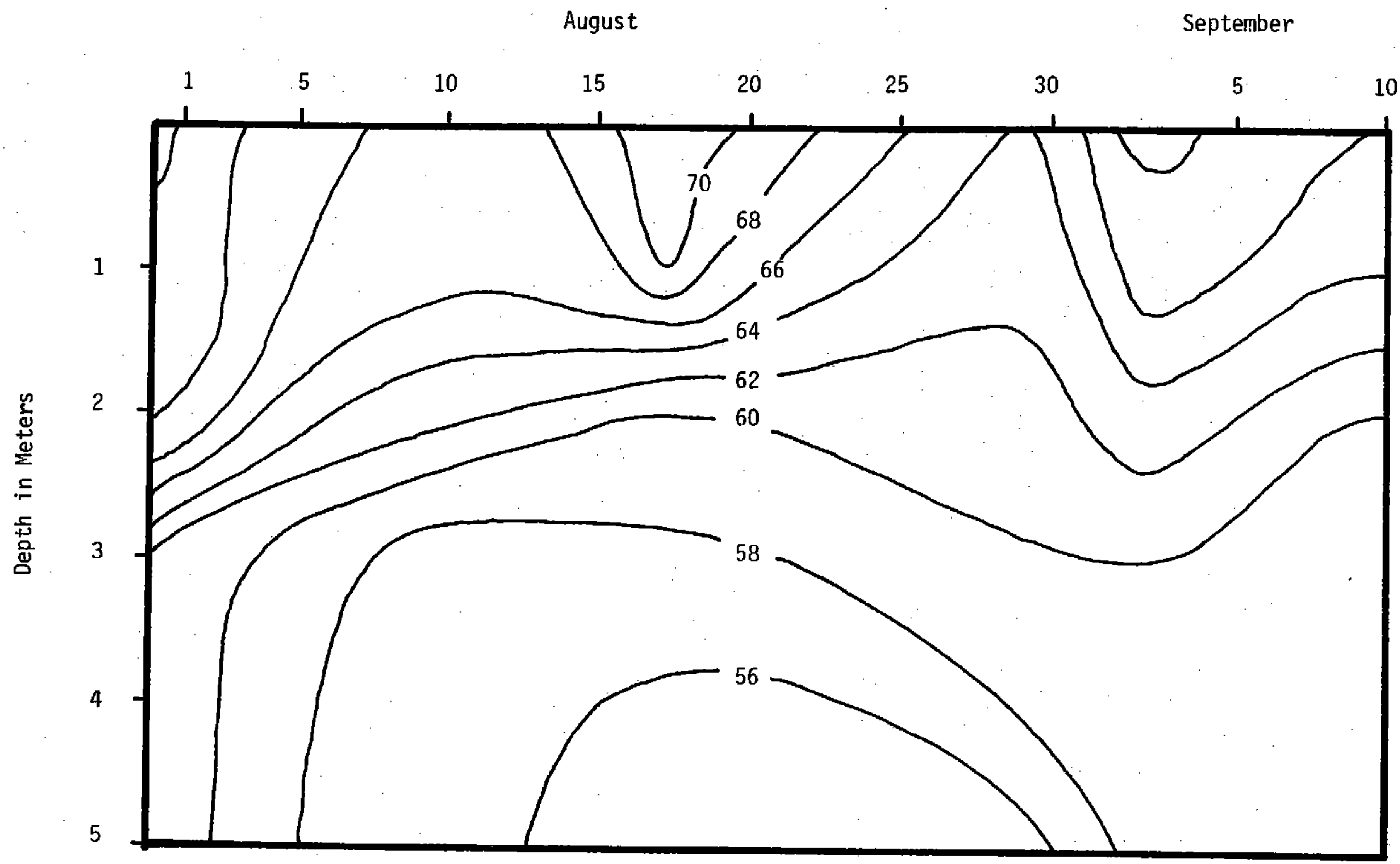


FIGURE 13. Temperature profile (^{o}F) at the south spit seining site, Klamath River estuary during the period from August 1 to September 10, 1980.

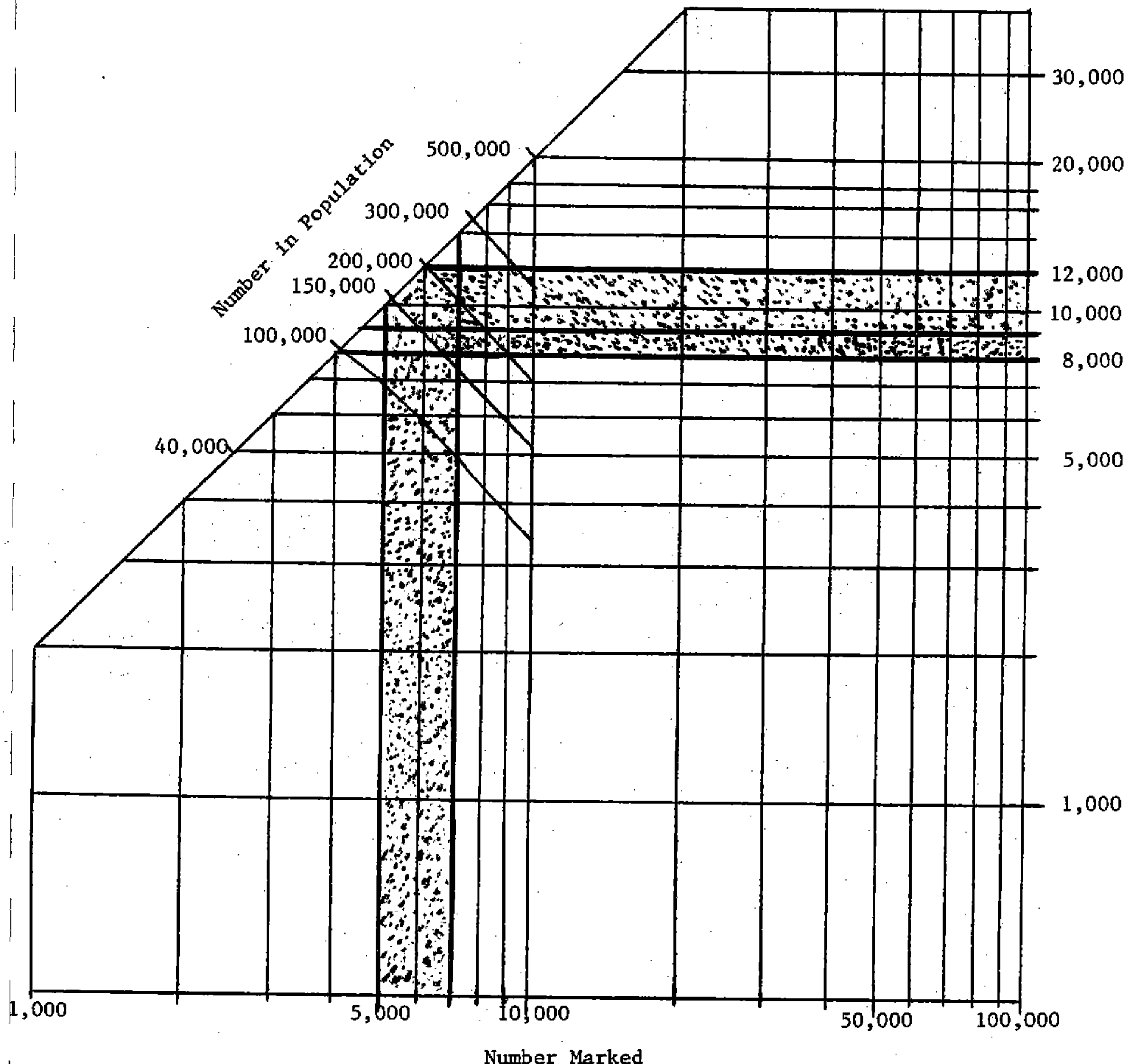


FIGURE 14. Sample size combinations required for population estimation programs involving mark-recapture methodology in order for estimates to fall within 10 percent of true values at the 95 percent confidence level (modified from Ricker 1958).

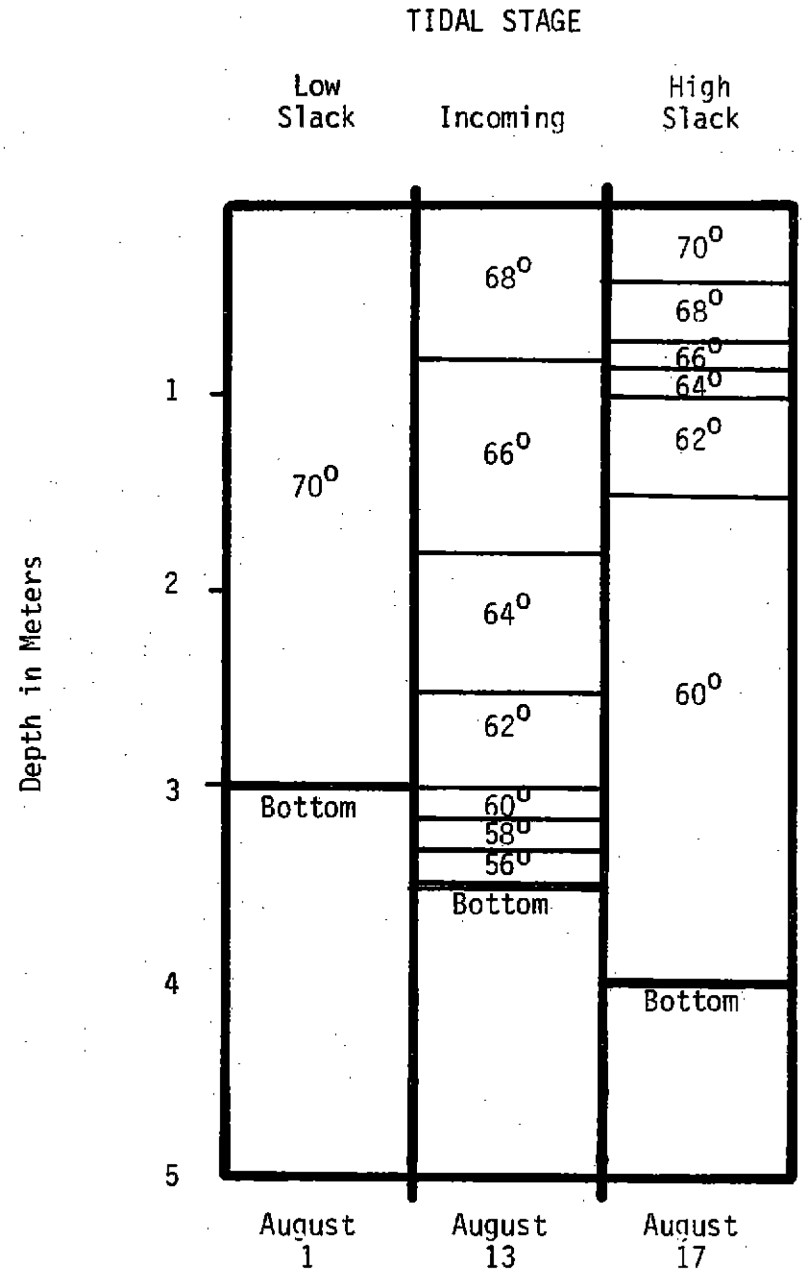


FIGURE 15. Representative temperature profiles (°F) of the Klamath River mouth recorded at low slack, incoming and high slack tides during the summer of 1980.

site and observed in the lower river net harvest. Applying the methodology employed by Ricker (1958) in adjusting for differences between length frequency distributions of tagged and recovered populations of lemon sole (*Parophrys vetulus*), it appears that only about 49 percent of the tagged salmon we released may have been considered "effectively" tagged for the net fishery (Figure 16), an inadequate number to use in estimating run size within desired accuracy ranges and confidence levels. For all practical purposes, it was not worth the effort to tag salmon which measured less than 62 cm in length.

As noted previously, run size estimation through mark-recapture methodology was further complicated because of lack of agreement for use of a suitable secondary mark. We, therefore, were not able to evaluate tag shedding rates or rapidly sample large numbers of fish in the net fishery. Another complicating factor involved the inadequate sampling of jaw-tagged fish at the Shasta Racks counting facility because of concerns that such sampling would slow the run in the Shasta River and result in additional stress to the fish. It appears that we would not be able to utilize the racks in future years to sample tagged fish and consequently, would not be able to obtain a large, reliable mark sample of wild salmon in the drainage. Because of problems associated with the adequacy of the secondary mark, we do not believe that mark samples of wild salmon obtained through spawning ground surveys would be reliable.

An important condition of using mark-recapture techniques in estimating run size is that the marked fish randomly mix with the unmarked fish prior to recapture. Because of the close proximity of the lower river net fishery to our tagging site (Figure 2), it appears that we will be unable to satisfy this condition in utilizing the lower river net fishery as a mark sample to estimate run size on an in-season basis. It became obvious during the 1980 season that numerous salmon entered the estuary at night and were immediately caught in gill nets prior to having had an opportunity to be seined and tagged. This problem possibly could be resolved by using an upriver net fishery as a mark-sample but net harvest in upriver areas is so small as compared to the estuary harvest that adequate mark samples probably could not be obtained to estimate run size within desired accuracy ranges or confidence levels.

An additional source of error in utilizing mark-recapture methodology may result from differential mortality between tagged and untagged fish through harbor seal predation. During the 1980 season, we noted considerable activity by harbor seals in the vicinity of our south spit seining site. While it appeared that harbor seal predation was not a big problem, water conditions at the south spit site render an evaluation of differential mortality nearly impossible. A further complicating factor involves the potential tagging of salmon which enter the Klamath River only to return to the ocean before migrating to their natal streams. We observed considerable numbers of chinook salmon of Rogue River origin in the 1980 Indian net harvest and at least two chinook salmon tagged by our crews in 1980 were caught by fishermen in the ocean.

Assuming, for the reasons outlined above, that mark-recapture methodology cannot be utilized to develop an in-season run size estimation program involving chinook salmon in the Klamath River drainage and that it would not be possible to utilize the methodology in attempting to develop a post-season program, it appears that only three options are available in pursuing an in-season run size estimation program in the basin. The first method, as described earlier, involves the development of a relationship between run size and catch/effort rates experienced in beach seining operations and in the lower river net fishery.

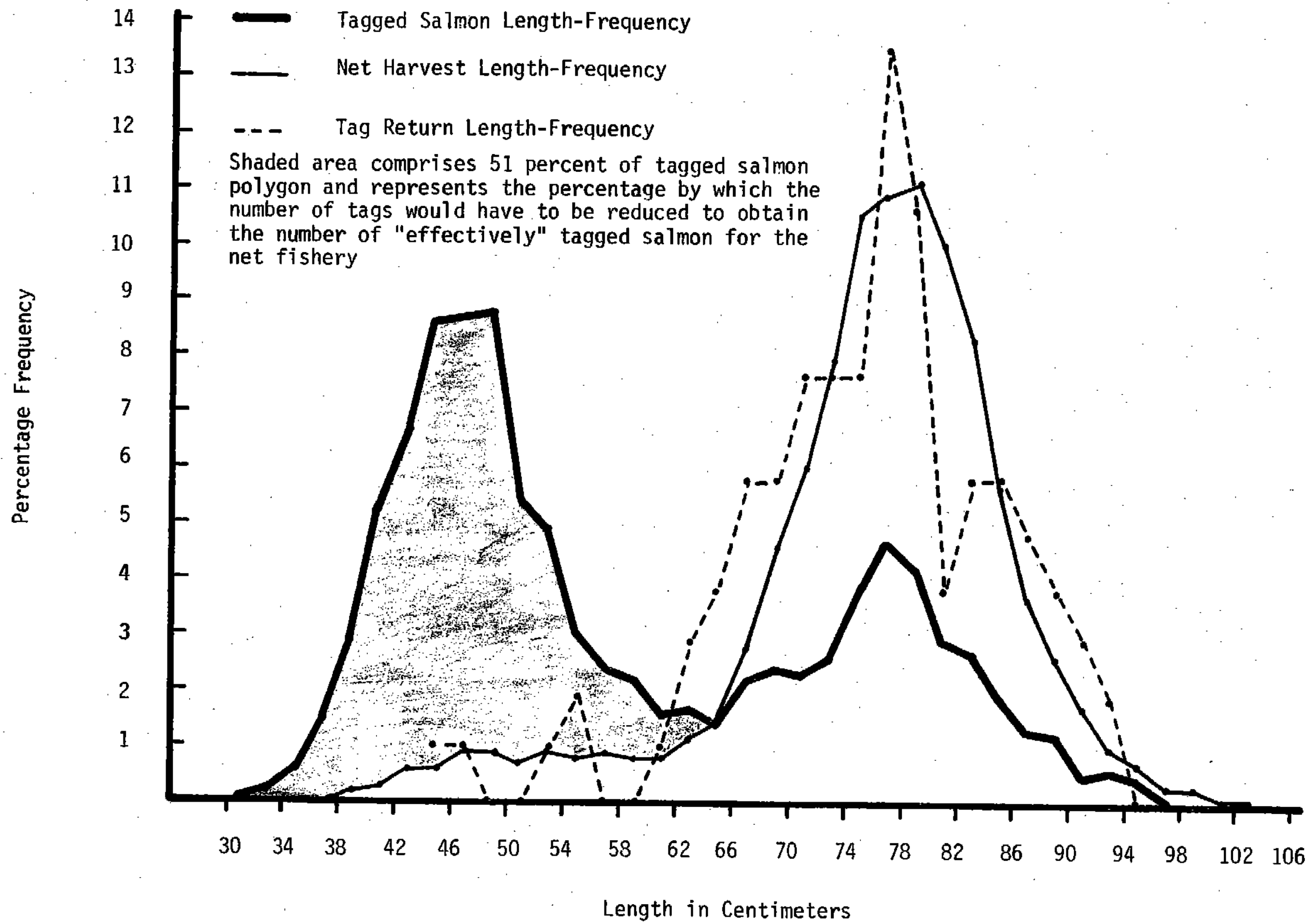


FIGURE 16. Percentage length-frequency distributions of chinook salmon in the Klamath River as tagged in beach seining operations and sampled in the lower river net harvest and tag returns.

Assuming that a relationship exists between these catch rates and the number of fish in the river and that post-season run size estimates derived by the CDFG are reasonably accurate, it should be possible to develop such a program and we plan to investigate that possibility further in 1981. Based on our experiences in 1980, we should be able to sample approximately 15 to 20 percent of the adult run through beach seining and net harvest monitoring programs.

The second alternative involves the employment of one or more of the newly improved electronic fish counting devices currently being investigated. Because of species differentiation limitations associated with the devices and the presence of large numbers of individuals of a variety of species in the Klamath River at the same time, the use of these devices would probably have to be coordinated with an extensive adult sampling program.

The third method to evaluate run size in the Klamath River drainage is through the establishment of a fish counting weir across the river. We have discussed this possibility several times in the past and experimented with a fish counting tower in 1979 (Plate 9). Of all possible run size estimation procedures, it appears that a properly designed weir may offer the best prospect for obtaining very reliable in-season and post-season run size estimates of fall chinook salmon on a continuing basis. In addition, such a structure could provide the opportunity to obtain run size estimates for other races and species including spring chinook salmon, green and white sturgeon, coho salmon and fall steelhead, all of which comprise portions of annual net harvest on the Hoopa Valley Reservation.

The Alaska Department of Fish and Game routinely utilizes relatively inexpensive temporary counting weirs to enumerate salmon escapement on a number of river systems (Pedersen pers. comm.). It appears that a similar structure might be used on the Klamath River to gather escapement data on fall chinook salmon, fall steelhead and coho salmon. A more costly structure would probably be required if escapement data on sturgeon and spring chinook salmon was also desired because of the higher flows associated with those runs. Considering the combined annual costs of run size estimation programs conducted by the USFWS and CDFG, it appears that even a relatively costly structure could pay for itself in a few years and be available to evaluate spawner escapement in the drainage for decades. Because reliable run size estimates will probably be required on a continuing basis, it seems imprudent from economic and biological standpoints to continue funding relatively imprecise annual run size estimation programs when better data could be collected at a lower cost over the long term through the use of a properly designed fish counting weir. The California Resources Agency and many Indian people of the Hoopa Valley Reservation have expressed support for the fish counting weir concept.

In exploring the possibility of a fish counting weir on the Klamath River, navigability laws and wild and scenic river designations would have to be taken into account. Debris accumulation problems and the potential impacts of flooding would also have to be considered. An appropriate fish counting structure would also probably have to be designed and constructed so as not to result in excessive delays of normal fish migration patterns.

B. SPRING CHINOOK SALMON

The spring chinook salmon run in the lower Klamath River began in March, peaked in late May and was generally over by mid-June although some spring-run CWT chinook were observed during July. With the help of several Indian fishers, we sampled 176 spring-run salmon in the net fishery ranging in fork length from 46 cm to 97 cm (Figure 17) and averaging 75.2 cm in length and 5.9 kg dressed weight. No size difference was noted between the sexes and we detected

PLATE 9. Fish observation tower tested on the lower Klamath River in 1979.

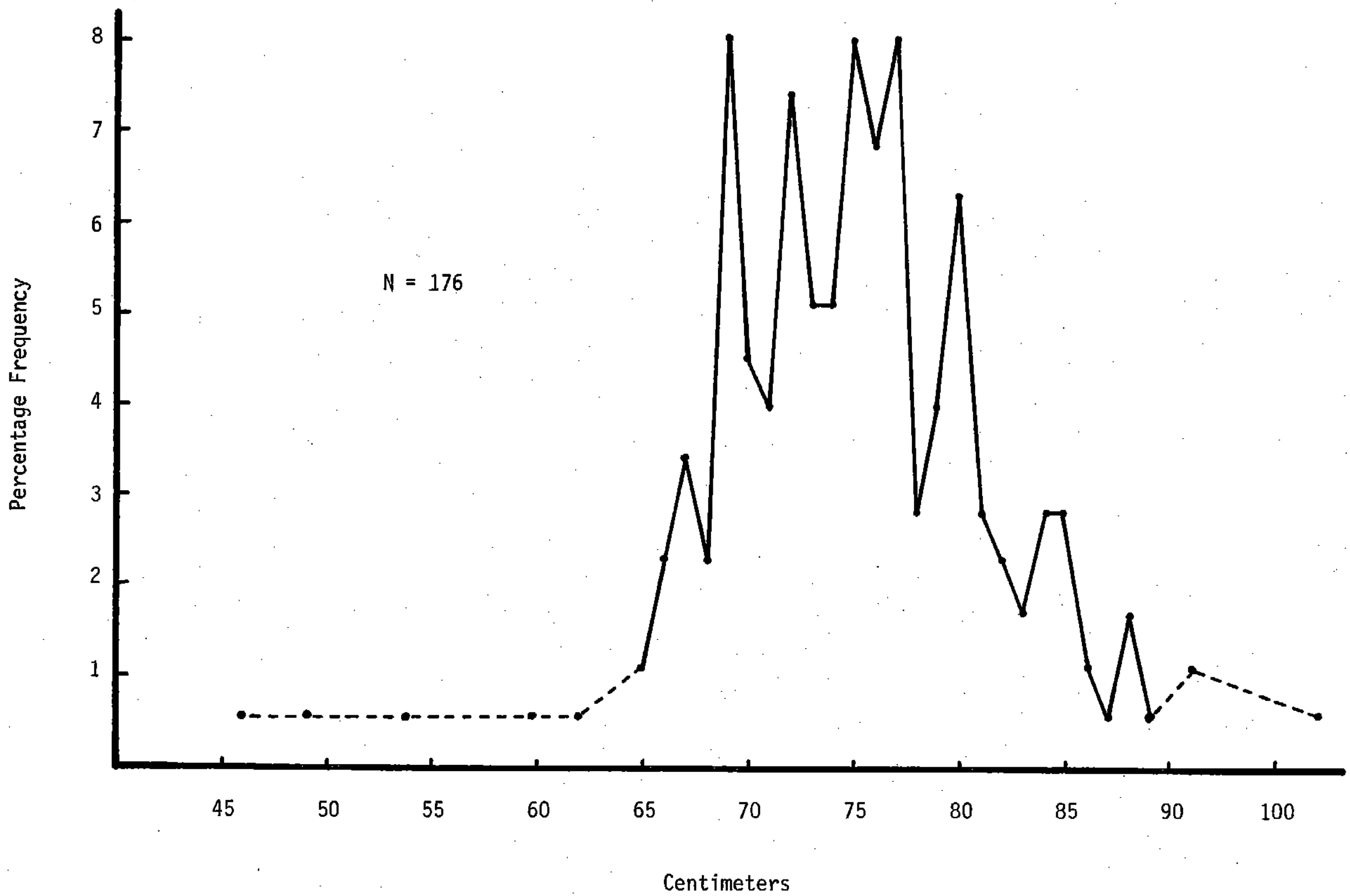


FIGURE 17. Length-frequency distribution of spring chinook salmon caught in gill nets on the Klamath River in 1980.

no difference in sex or age composition between early or late arrivals and the run in general.

The data that we collected in 1980 appears to support the generally held view that the spring chinook salmon run in the Klamath River basin consists largely of hatchery fish. Adipose fin-clipped fish represented 41 percent of the observed net harvest (47 percent of the May harvest and 33 percent of the June harvest). Of 48 coded-wire tags recovered, approximately 64 percent were from fish released from Trinity River Hatchery and surprisingly, about 36 percent were from Rogue River fish released from the Cole Rivers Hatchery. It is not clear whether Rogue River fish spawn in the Klamath River drainage or return to the ocean but several were captured upriver as far as 48 km above the mouth. Based on marked/unmarked ratios of the respective CWT release groups, it appears that well over half of the spring chinook salmon run consisted of hatchery fish.

Largely because of high flow conditions and large quantities of debris in the river, relatively few Indian people fish the spring run as compared to the fall chinook run. Based on over 50 contacts with Indian fishers during the spring months, we estimate that the Indian net fishery resulted in a harvest of approximately 1,000 spring chinook salmon in 1980 with the majority of the catch having occurred in the lower 26 km of the Klamath River. Indian fishers generally captured most spring salmon with set nets fished during daylight or twilight hours. Drift netting techniques were not generally effective on spring-run fish. Because of the concurrent run of large sturgeon, Indian fishers generally utilized heavy-gauged nylon nets ranging from 18.4 cm to 24.1 cm (7.25-inch to 9.5-inch) stretched mesh.

C. STEELHEAD TROUT

Largely because of the concurrent run of fall chinook salmon, Indian fishers do not target on the smaller fall steelhead and the few fish netted can be considered as incidental to the chinook salmon harvest. Biologists operating the net harvest monitoring station observed only 81 steelhead trout caught by Indian fishers in 1980. These fish ranged in length from 31 cm to 76 cm and averaged approximately 53.7 cm, far below the length-frequency distribution observed for net caught chinook salmon (Figure 8). Observations by FAO-Arcata biologists and reports by Indian fishers in upriver areas also point to a low steelhead harvest in the fall. Reservation-wide net harvest of fall-run steelhead trout in 1980 is estimated at 300 fish.

In the absence of significant concurrent runs of other species, some Indian fishers targeted on winter steelhead (and possibly spring steelhead) from November, 1979 through April, 1980. Because of the high water conditions and relatively poor netting success during this period, relatively few Indian fishers participated in this fishery. The majority of winter steelhead caught in the lower 26 km of the Klamath River in January and February were harvested during daylight or twilight hours through the use of set nets which were generally of single strand monofilament ranging in mesh size from 10.2 cm to 16.5 cm (4 in. to 6.5 in.), stretched. Based on observations of FAO-Arcata biologists and reports from Indian fishers, we estimate that approximately 1,000 winter steelhead were caught on the reservation during the 1979-80 season.

Winter steelhead caught in the net fishery generally ranged from 52 cm to 83 cm in fork length (Figure 18) and averaged approximately 66.7 cm with males having averaged approximately 2 cm longer than females. The steelhead generally ranged from 2 kg to 7 kg in weight while averaging about 3.5 kg.

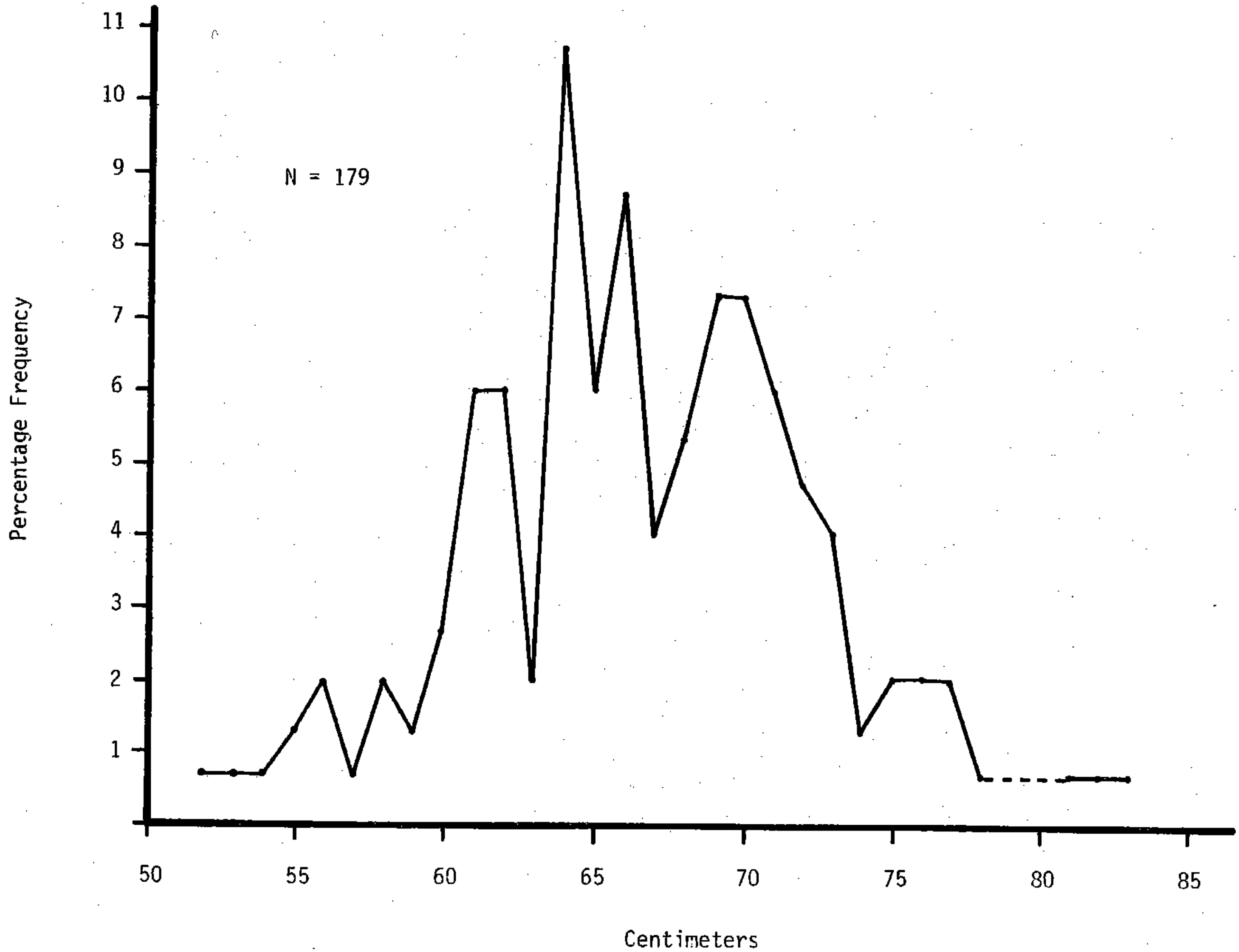


FIGURE 18. Length-frequency distribution of winter steelhead caught in gill nets on the Klamath River in 1980.

D. COHO SALMON

In conjunction with the net harvest monitoring station operation, we observed 143 coho caught from the lower Klamath River between September 17 and October 9, when we terminated the harvest monitoring program. The fish ranged in length from 35 cm to 84 cm and averaged 70.1 cm. Little netting effort was directed toward coho in the estuary and the majority of fish were harvested in the Resighinni - Klamath Glen area. A number of upriver Indian people reported fishing for coho salmon in September and October. Based on scattered reports and observations, our estimate of coho salmon harvest by Indian fishers is 1,500 fish.

E. STURGEON

Virtually no information has been available concerning the life history, abundance and harvest of green sturgeon and white sturgeon (*Acipenser transmontanus*) of the Klamath River basin. A sturgeon investigation program initiated by FAO-Arcata biologists in 1979 was expanded in 1980 in an attempt to gather baseline data. Data available at this writing is presented in Section V of this report.

II. AGE COMPOSITION OF CHINOOK SALMON RUNS

A. INTRODUCTION

To assess the age composition of chinook salmon runs in the Klamath River basin, we initiated a scale collection and interpretation program and collected approximately 230 juvenile and 1,000 adult scales. Preliminary study results are presented herein and a detailed report on our findings will be forthcoming in 1981.

Attempts to accurately interpret adult scales in evaluating the age structure of chinook salmon spawning runs in the Klamath and Trinity river basins are complicated by the occurrence of a variety of juvenile life history patterns. The proper aging of adult salmon through scale interpretation requires that the appropriate juvenile life history pattern be recognized so that the first annulus can be properly designated. Interpretation of adult scales can be greatly facilitated if growth between the focus and first annulus can be recognized as having occurred in the stream, river, estuary or ocean. Based on preliminary scale reading efforts and following discussions with personnel of the CDFG, USFWS and Oregon Department of Fish and Wildlife, it became evident that the best way to understand and interpret growth phases and checks found on adult scales was to collect juvenile salmon at various points in the drainage throughout their freshwater life history phase and relate respective growth patterns observed on scales to the time of year and habitat type in which they were collected.

Juvenile life history patterns, as reflected on scales, vary considerably depending on whether salmon are of the spring of fall race, whether they are of wild or hatchery origin and, if of hatchery origin, whether they were released as yearlings or fingerlings. While the number of freshwater circuli on scales from Klamath River and Sacramento River chinook salmon are similar, Klamath River fish often display a freshwater check and intermediate growth area not normally present in Sacramento River chinook. Scale characteristics of Klamath River chinook salmon appear to closely resemble those of Rogue River chinook.

The proper interpretation of juvenile life history patterns on adult scales will allow biologists to assess the relative contributions of the various races to returning spawning runs. Through beach seining and net harvest monitoring activities in future years, we plan to routinely take scales for age analysis. The State of California has proposed the annual release of two million pond-reared yearling chinook salmon in the Klamath River drainage. Proportionate returns of these fish as well as fish released from hatcheries as fingerlings and returns of wild races would best be evaluated through scale interpretation based on random samples collected from the lower river.

Cursory observations of juvenile salmon in the Klamath River estuary in 1979 and sampling in 1980 revealed that large numbers of juvenile salmon may utilize this area for rearing during portions of the summer. An influx of additional large numbers of salmon resulting from pond rearing programs or other proposed hatcheries could result in competitive disadvantages for wild stocks. The larger yearling chinook salmon released may have a competitive edge over their smaller wild counterparts. Prolonged residence by hatchery fish in areas where summer rearing is important to wild juveniles can have a detrimental effect on the wild stocks as observed in the Sixes River estuary, Oregon where juvenile chinook salmon growth rates were retarded for a three-month period during high population densities (Reimers 1973). The rate of freshwater growth has been shown to influence age at maturity (Chapman 1953; Parker and Larkin 1959; Schluchter and

Lichatowich 1977) with fast growth normally associated with early maturation and slow growth associated with late maturation. The age at maturity has important management implications in that it influences the time which chinook salmon remain in the ocean where they are susceptible to the ocean fisheries.

B. METHODS

Juvenile chinook salmon scales were collected through the juvenile sampling program described in Section IV of this report and adult scales were obtained through beach seining and net harvest monitoring programs described in Section I. Numerous scales were collected from CWT fish with known ages and juvenile life history patterns. Cellulose acetate impressions of the scales were made utilizing a Carver Model C laboratory press and viewed on a Bell and Howell ABR-1020 dual lens projector. Scale impressions were analyzed independently by two interpreters and a third reading by both interpreters was made if the first two interpretations differed. Scales which could not be aged with confidence after the third reading were excluded from the age analysis.

C. RESULTS AND DISCUSSION

The typical scale pattern of wild fall-run chinook salmon reveals a short freshwater growth period followed by intermediate estuarine and rapid ocean growth. Deposition of the first annulus normally occurs during ocean growth after approximately 30 circuli have been formed and ocean annuli generally consist of bands of 8 to 14 narrowly-spaced circuli followed by wide bands of spring growth (Plates 10 and 11). Most scales examined from returning chinook salmon in 1980 reflect an unusually fast growth rate in the ocean during the spring of 1979 (Plate 12), possibly in response to favorable ocean conditions resulting from unusually high upwelling activity reported for that time period. It appears that few wild fall chinook salmon which migrated from the system as yearlings were represented in the 1980 spawning run but hatchery-released yearlings, which were characterized by uniform freshwater growth (Plate 13), did return in considerable numbers.

Many of the adult scales examined to date exhibit a check reflecting an interruption in ocean growth during the rapid spring-summer growth period. The incidence of salmon with scales exhibiting this type of growth check appears to be highly correlated with known hook-scarred fish. We plan to investigate the apparent relationship between the hooking process and retarded growth rates more thoroughly in 1981.

A preliminary analysis of 66 adult fall chinook salmon scales collected in 1980 reveals that the run consisted of at least 5 age classes ranging from 2 to 6 years (Figure 19). Relating Figure 19 to the length-frequency distributions of chinook salmon caught in the Indian net fishery (Figure 8) and beach seining operation (Figure 3), it appears that the adult run was dominated by 3 and 4 year fish and consisted of few 5 and 6 year fish and that the run included a large grilse component.

Analysis of scales from 159 spring chinook salmon reveals that the fish ranged from 3 to 5 years of age with considerable overlapping of lengths between the age classes (Figure 20). Salmon in their fourth year dominated the sample catch (83 percent) while spring salmon in their third and fifth years comprised 6.3 and 10.7 percent of the sample net harvest, respectively. Because gill nets do not effectively harvest grilse, we cannot evaluate that component of the run.

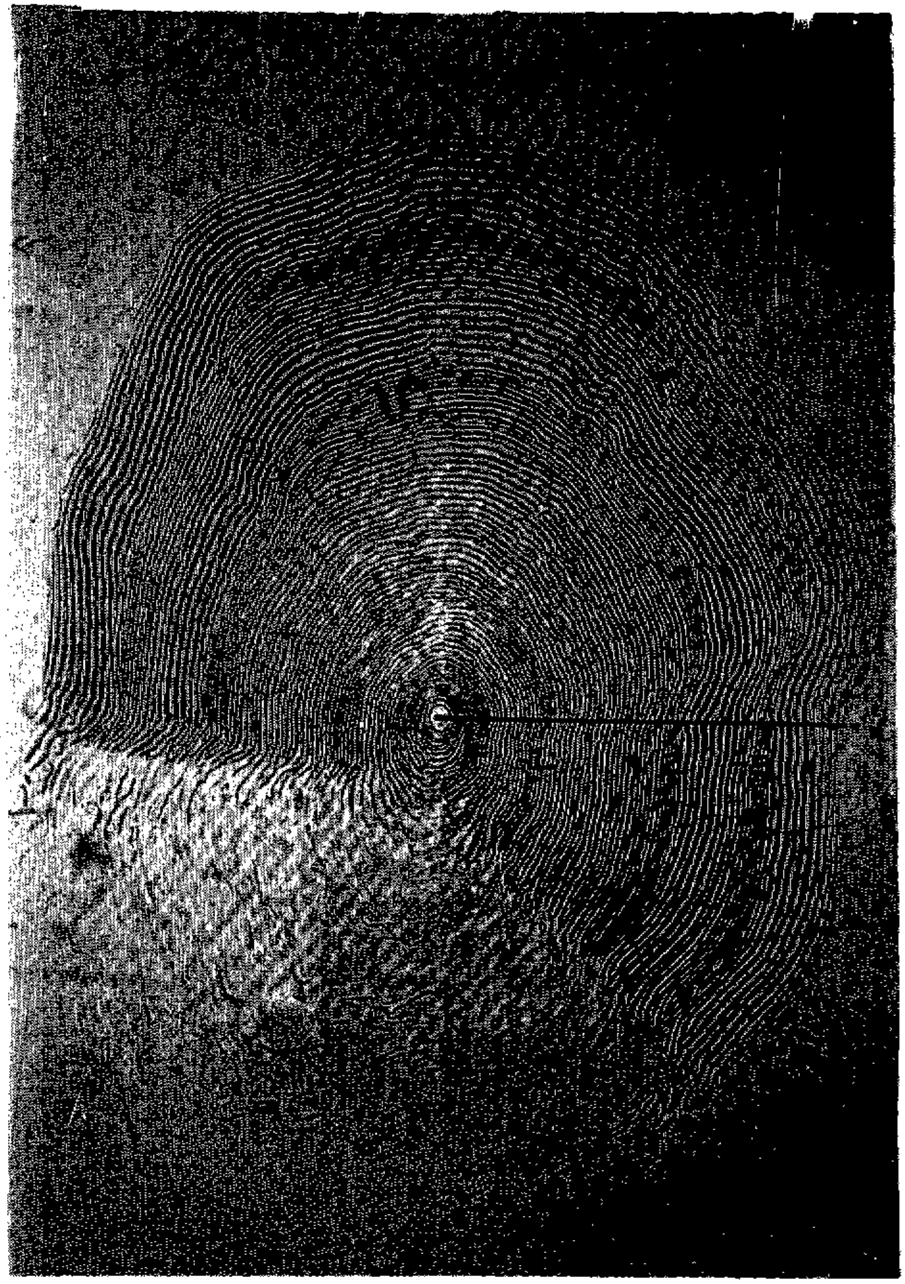


PLATE 10. Scale impression reproduction from a 79 cm chinook salmon in its fourth year depicting the end of freshwater growth (F) and three annuli.

PLATE 11. Scale impression reproduction from a 94 cm chinook salmon in its fifth year depicting the end of apparent hatchery growth, the end of apparent estuarine growth and four annuli.

PLATE 12. Scale impression reproduction from a 76 cm chinook salmon in its fourth year depicting the end of apparent hatchery growth, three annuli and unusually rapid growth in the ocean during the spring of 1979.

PLATE 13. Scale impression reproduction from a 56 cm chinook salmon reared in a hatchery to yearling stage depicting hatchery growth and two annuli.

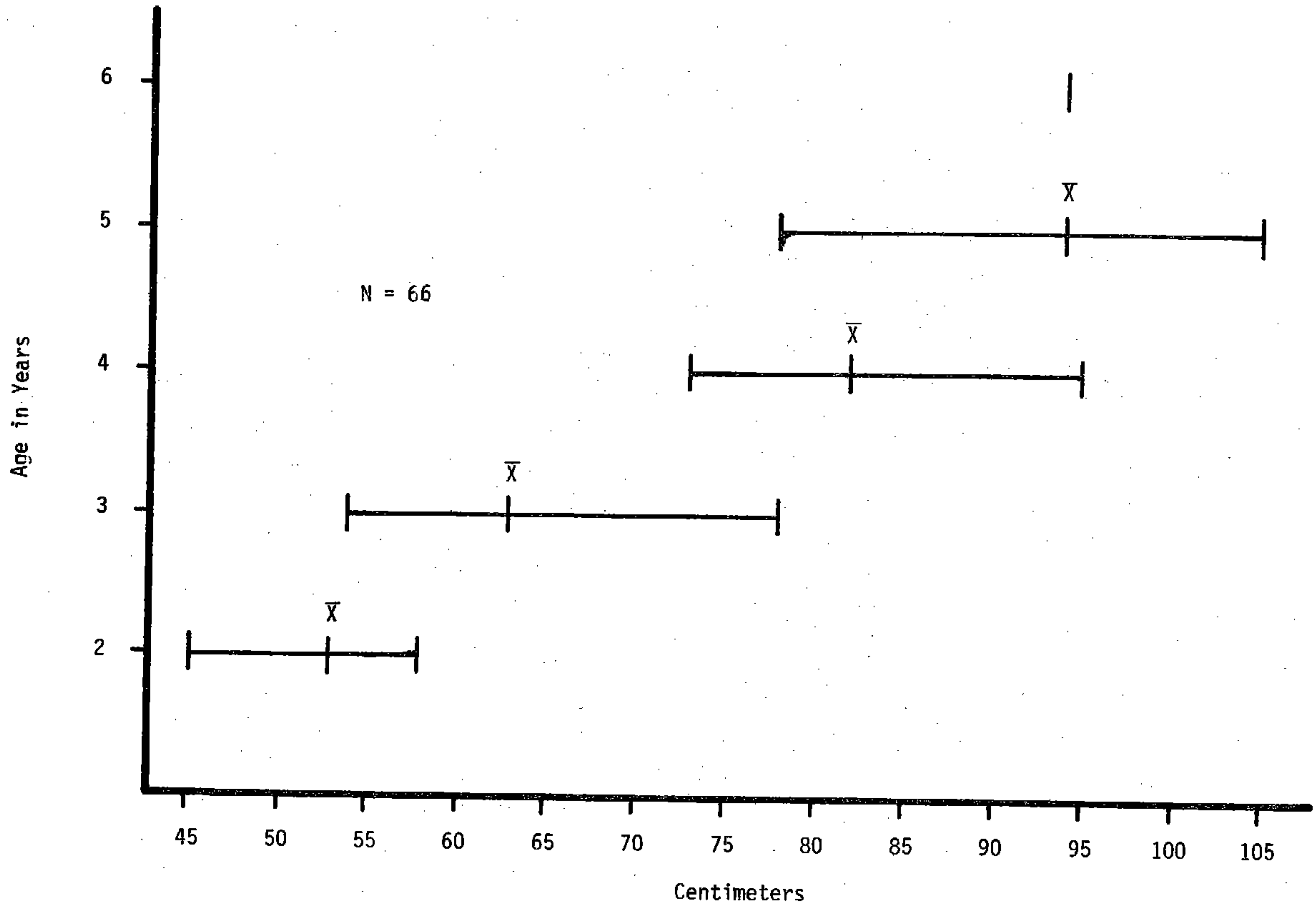


FIGURE 19. Length ranges and mean fork lengths of each age class of fall chinook salmon caught by gill nets in the Klamath River during 1980.

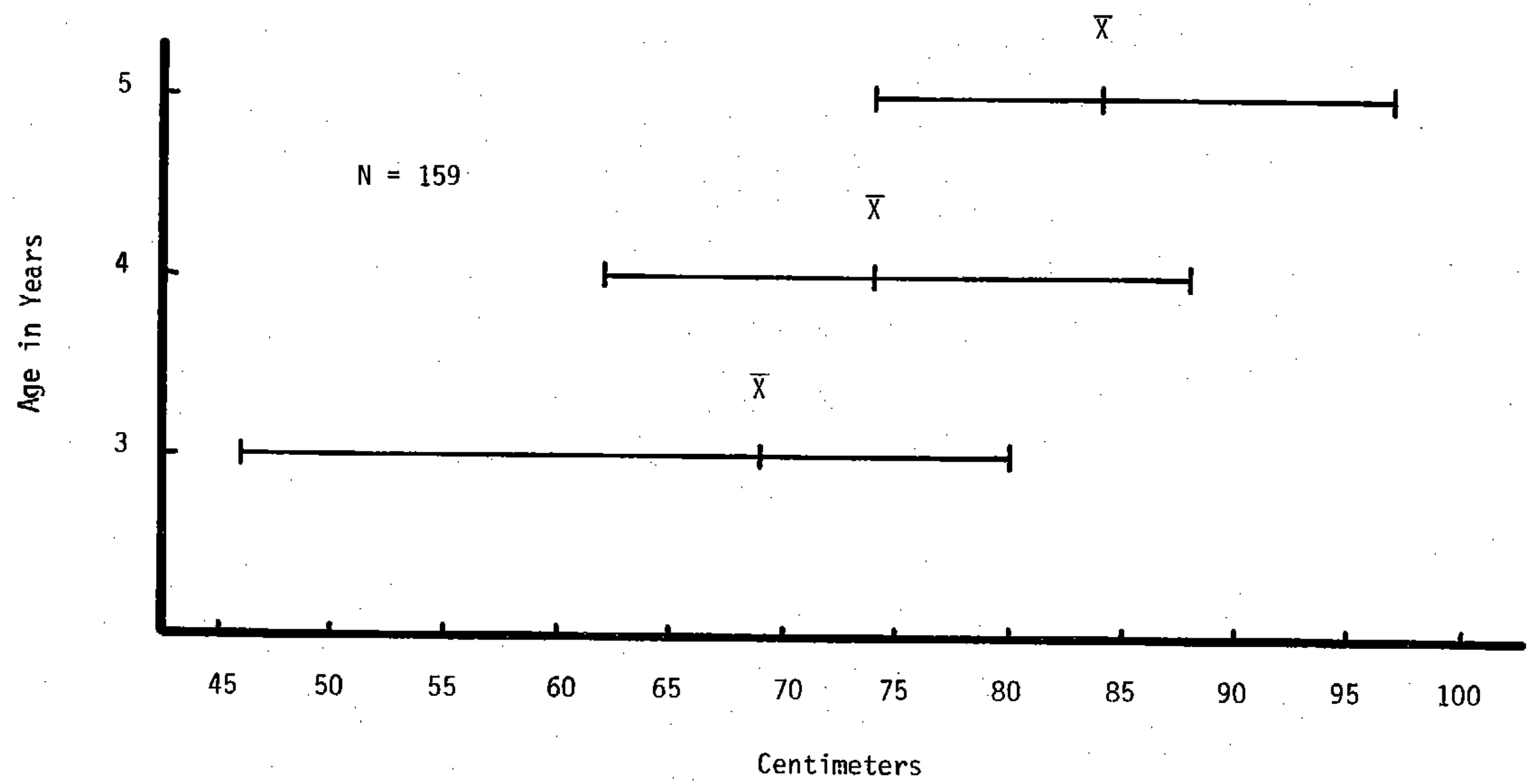


FIGURE 20. Length ranges and mean fork lengths of each age class of spring chinook salmon caught by gill nets in the Klamath River during 1980.

III. CODED WIRE-TAG RECOVERIES IN THE SPAWNING RUN

A. INTRODUCTION

With the expanded tagging programs at Trinity River and Iron Gate hatcheries in recent years, CWT returns have become increasingly available to provide information on the life history and harvest of hatchery-reared salmon originating in the Klamath River system. Preliminary CWT returns from 1976-brood fall chinook salmon (CWT group 06-61-01) released from the Trinity River Hatchery indicated a 3:1 catch-escapement ratio (Hankin pers. comm.) and revealed that ocean fishermen harvested the great majority of salmon from this CWT group off the northern California and southern Oregon coast.

In response to a request by the USFWS, the BIA purchased four coded-wire tagging units and transferred them to the CDFG in 1979 to assist in the CWT program. In 1980, FAO-Arcata biologists expanded their CWT recovery program involving the Indian net fishery on the Hoopa Valley Reservation and the results of that effort are presented herein. As part of a coastwide ocean harvest monitoring program, the CDFG is compiling CWT return data for a number of Klamath River release groups harvested in 1980. As it becomes available, this data will be analyzed in conjunction with in-river returns to further evaluate the contributions of Klamath River stocks to the respective fisheries.

B. METHODS

Spring chinook salmon CWT recoveries were obtained through periodic mark sampling of net harvest from the Klamath River and through voluntary returns provided by a number of Indian fishers. Most fall chinook and coho salmon CWT returns were collected through the net harvest monitoring station operation described in Section I of this report. All adipose fin-clipped fish were noted as such and measured and of 489 adipose fin-clipped fish observed, we recovered 263 tags. Tags were dissected from heads with the aid of a magnetic field detector and read using a Nikon 104 dissecting scope.

For each major CWT group of fall chinook salmon recovered, return data was expanded to the total estimated net harvest to allow for preliminary assessments of harvest rates, preliminary evaluations of the contributions of the groups to the Indian fishery and to chart the timing of entry of the various CWT groups into the river. The first expansion involved the assignment of each adipose fin-clipped fish for which CWT data was lacking to a most likely CWT group based on length-frequency patterns, relative abundance and timing of entry into the river of known CWT groups. Secondly, daily numbers of known and likely CWT groups in our sample were divided by the estimated percentage of Indian harvest on the lower Klamath River observed by our biologists. Finally, reservation-wide net harvests of each CWT group were estimated by dividing the respective lower river figures by 0.75, our estimated percentage of Indian harvest which occurred in the lower river area. For each major CWT group of spring chinook and coho salmon recovered. return data was expanded by total seasonal harvest estimates (1,000 spring chinook salmon and 1,500 coho salmon).

Using the 06-61-01 tag group as an example, 90 percent of all 06-61-01 tags recovered after August 1 were from fish which measured at least 72 cm, so all adipose fin-clipped fish larger than 72 cm for which tags were not recovered were assigned to this group. The inclusion of younger fish of other CWT groups into the 06-61-01 group was probably nearly balanced by the omission of 06-61-01 fish which measured less than 72 cm. Each daily number of known and likely

06-61-01 tags was then divided by respective estimated percentages of Indian harvest from the lower river observed by our biologists resulting in daily catch expansions (Figure 21) and an estimated lower river harvest of this group of 248. This figure was then divided by 0.75 to obtain an estimate of total net harvest on the reservation for this CWT group of 329.

C. RESULTS AND DISCUSSION

Of 7,370 fall chinook salmon mark-sampled, we observed 400 adipose fin-clipped fish and recovered 222 coded-wire tags, including 103 of the 06-61-01 group (Table 2). Based on data expansion, we estimate that Indian fishers harvested 329 of the 4-year-old 06-61-01 group and 321 3-year-old fall chinook represented by 4 CWT groups. Because of small sample sizes, catch expansions of four grilse CWT groups could not be accomplished. Since gill nets are not selective for grilse salmon (Figure 8), we believe that total net harvest of these CWT groups was very small.

Of 107 spring chinook salmon mark sampled, we observed 42 adipose fin-clipped fish and recovered 25 coded-wire tags (an additional 23 tags were recovered through voluntary returns). Half of the 48 tags recovered were from the 06-61-06 CWT group released from the Trinity River Hatchery. Rogue River salmon released from Cole Rivers Hatchery, represented by 5 CWT groups, contributed 17 recoveries (Table 2). As in the case of fall chinook salmon, we could not evaluate the grilse CWT groups and we believe that total net harvest of these groups was very small.

One summer chinook salmon of Columbia River origin was recovered in the Indian net fishery. This 4-year-old fish of CWT group 63-16-08 was released from Klickitat Hatchery. Of 149 coho salmon mark-sampled, we observed 47 adipose fin-clipped fish and recovered 11 tags, 6 from the 06-59-40 CWT group released from Iron Gate Hatchery and 5 from 3 CWT groups released from Trinity River Hatchery (Table 2).

The timing of entry into the Klamath River estuary of 3-year-old versus 4-year-old CWT groups of fall chinook salmon reveals notable differences. While the 4-year-old fish, represented by CWT group 06-61-01, were relatively evenly distributed over the course of the run (Figure 21), the combined returns of CWT groups of 3-year-old fall chinook salmon released from Trinity River Hatchery (CWT groups 06-61-02, 06-61-03, 06-61-05 and 06-61-07) revealed that disproportionately large numbers of fish entered the river between September 7 and 10 (Figure 22). Based on fish sampled in the net fishery, sport fishery and beach seining operation in 1979 and 1980, it appears that nearly 50 percent of all hatchery marked 3-year-old fall salmon entered the river within a 4-day period in early September.

Of the 4 3-year-old CWT groups released from Trinity River Hatchery, groups 06-61-02 and 06-61-03 were early summer releases of approximately 38/pound fish while the 06-61-05 and 06-61-07 groups were yearling releases of 11/pound and 7/pound fish, respectively. While the numbers of tagged fish in the 4 release groups were similar (tagged groups ranged from 166,000 to 194,000), we observed about 5 times as many tags from the yearling groups (Table 2).

Another comparison of the 4 3-year-old CWT groups released from Trinity River Hatchery reveals that the longer the fish were held before release, the smaller they were when they returned to the river. Fish from the 06-61-02 and 06-61-03 groups, which were released in early summer, returned at a mean size of approximately 67.15 cm while fish of the 06-61-05 CWT group which were

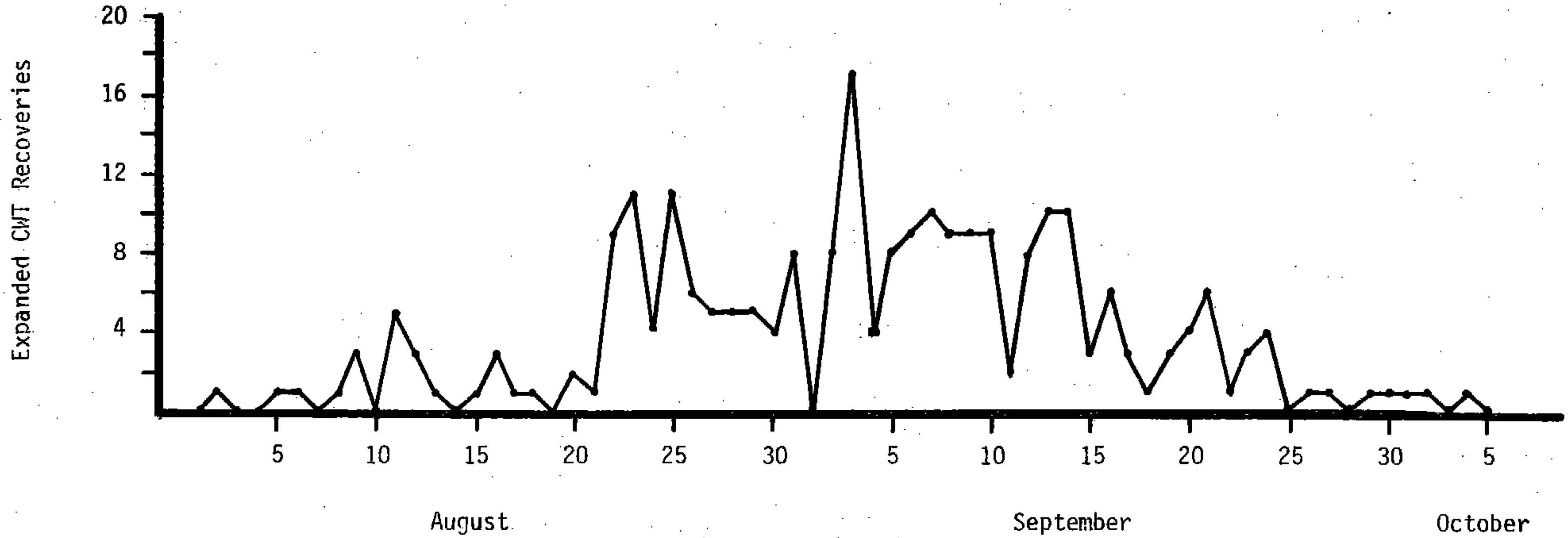


FIGURE 21. Catch expansions by date in the 1980 lower Klamath River gill net fishery of CWT group 06-61-01 (1976 brood year fall chinook salmon released from the Trinity River Hatchery).

TABLE 2. Recoveries and expanded harvest estimates of coded-wire tagged groups of salmon harvested in the Indian gill net fishery on the Hoopa Valley Reservation in 1980.

Species and Race	Tag Code	Brood Year	Hatchery of Origin	Mean[5] Length	No. Tags[6] Recovered	Expanded No.[7] Harvested
Fall Chinook Salmon	06-61-01	1976	TRH[1]	75.9	103	329
	06-61-07	1977	TRH	61.4	55	160
	06-61-05	1977	TRH	64.0	41	109
	06-61-03	1977	TRH	67.1	11	27
	06-61-02	1977	TRH	67.2	8	25
	06-61-08	1978	TRH	--	1	-
	06-61-10	1978	TRH	47.0	1	-
	06-61-15	1978	TRH	36.0	1	-
	06-59-01	1978	IGH[2]	47.0	1	-
Spring Chinook Salmon	06-61-06	1976	TRH	71.3	24	206
	09-16-17	1976	CRH[3]	78.2	6	93
	09-16-19	1976	CRH	75.7	4	47
	09-16-18	1976	CRH	77.3	3	28
	09-16-20	1976	CRH	71.5	2	20
	09-16-16	1976	CRH	79.0	2	19
	06-61-04	1977	TRH	60.0	2	19
	06-61-11	1978	TRH	53.0	4	-
	06-61-12	1978	TRH	--	1	-
Summer Chinook	63-16-08	1976	KH[4]	--	1	-
Coho Salmon	06-59-40	1977	IGH	71.8	6	260
	06-61-51	1977	TRH	73.0	2	90
	06-61-54	1978	TRH	43.5	2	80
	06-61-52	1977	TRH	58.0	1	40

1/ TRH - Trinity River Hatchery

2/ IGH - Iron Gate Hatchery

3/ CRH - Cole Rivers Hatchery (Rogue River system)

4/ KH - Klickitat Hatchery (Columbia River system)

5/ Mean fork length in centimeters

6/ Includes all tags recovered through mark sampling and volunteer returns

7/ Harvest expansions obtained using tag recoveries in mark sampling program only

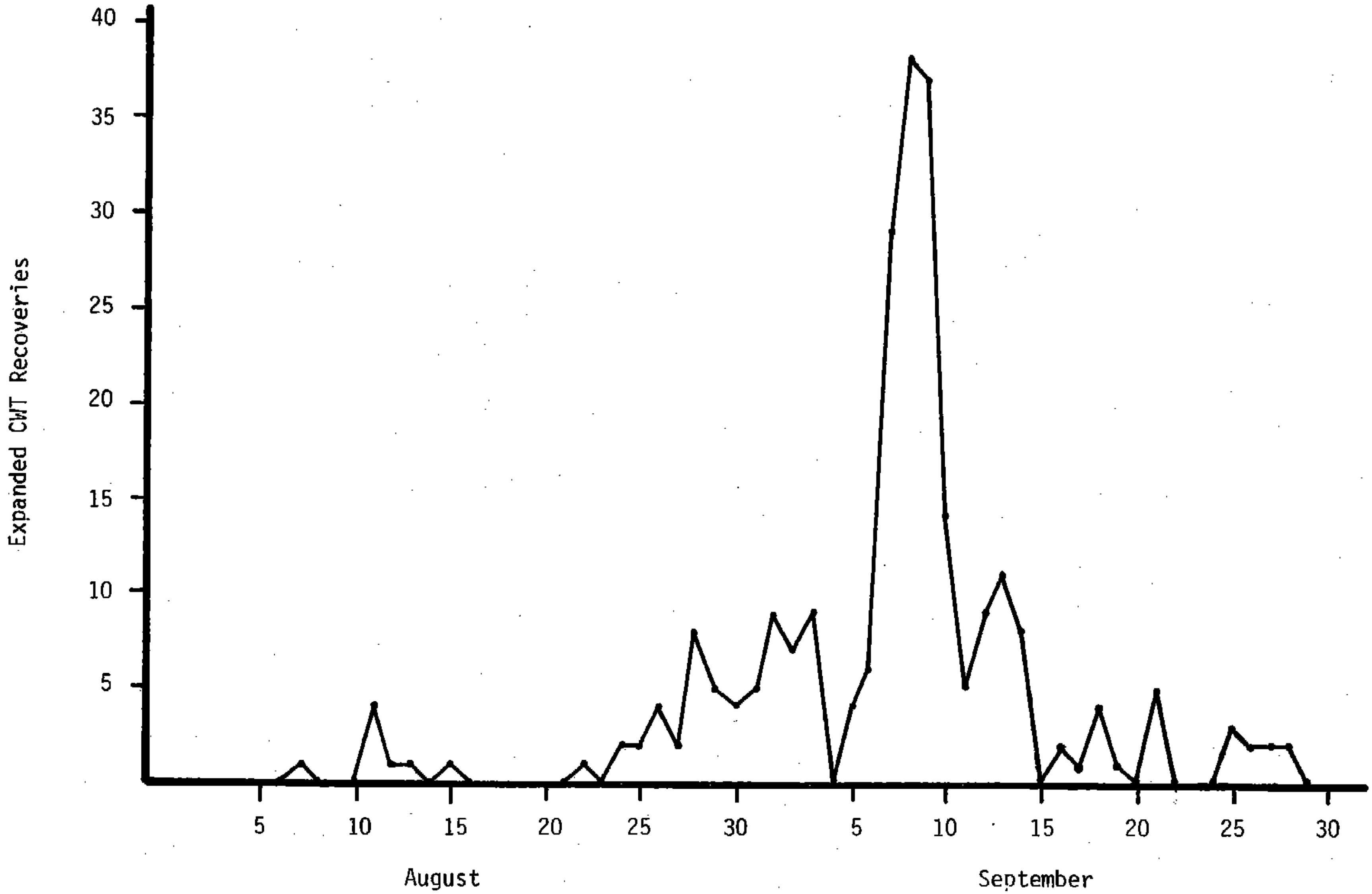


FIGURE 22. Catch expansions by date in the 1980 lower Klamath River gill net fishery of all 1977 brood year fall chinook salmon CWT groups released from the Trinity River Hatchery.

released in October and fish of the 06-61-07 group which were held until the following March, returned at mean sizes of 64.0 cm and 61.4 cm, respectively (Table 2). A chi-square analysis of length-frequency distributions of recovered fish belonging to the 4 CWT groups revealed significant differences in length at the 99 percent level between the three release times. Considering size selectivity associated with the gill net fishery, which should result in a more efficient harvest of 67 cm fish versus 64 cm or 61 cm fish, we suspect that the true rate of return of CWT group 06-61-05 and 06-61-07 fish versus 06-61-02 and 06-61-03 fish may have been greater than observed.

Preliminary data compiled by the Pacific Fishery Management Council (PFMC 1980) reveals that the ocean fisheries landed 2,502 chinook salmon of the 06-61-01 CWT group and 779 chinook salmon of the 06-61-05 CWT group in 1980. Respective contributions of these CWT groups to the 1980 net fishery were estimated at 329 and 109 (Table 2) resulting in respective harvest ratios of 7.6:1 and 7.1:1. Ocean recovery data for three CWT groups of 1977 brood Trinity River fish (06-61-07, 06-61-03 and 06-61-02) were not included in the PFMC (1980) report.

A preliminary estimate of the percentage of hatchery fish which comprised the 3-year-old and 4-year-old components of the 1980 fall chinook salmon run in the Klamath River was arrived at by comparing numbers of known and likely CWT group fish observed in the Indian net fishery to marked and unmarked hatchery releases of 1976 and 1977 brood year fish. Between August 1 and September 30, harvest estimates of presumed 3 year salmon (ranging in length from 56 cm to 71 cm) and 4 year salmon (ranging in length from 72 cm to 86 cm) were 1,552 and 6,535, respectively, and CWT expansions for the respective groups were 246 and 243. As nearly as can be determined from preliminary data provided by CDFG biologists and hatchery personnel, it appears that combined releases of chinook salmon from Trinity River and Iron Gate hatcheries approximated 156,000 pounds of 1976-brood fish of which about 24,000 pounds were marked (approximately 15 percent) and 89,000 pounds of 1977-brood fish, approximately 62,000 pounds of which were marked (about 70 percent). Assuming that fish returned at a rate proportional to the total weight released (to correct for differing return rates of fingerling and yearling releases) it appears that the 1980 lower river net harvest consisted of about 350 3-year-old and 1,600 4-year-old hatchery fish which represent approximately 23 percent and 24 percent of the total harvest of 3-year-old and 4-year-old fish, respectively. It appears, therefore, that the 1980 fall chinook salmon run in the Klamath River consisted of about a 3:1 ratio of wild to hatchery-reared fish.

IV. JUVENILE CHINOOK SALMON INVESTIGATIONS

A. INTRODUCTION

As noted in previous sections, biologists have expended considerable effort in recent years sampling adult chinook salmon to evaluate run size and spawner escapement levels in the Klamath River basin and to assess net harvest levels and contributions of hatchery-marked Klamath River salmon to the ocean fisheries. Through the establishment of a juvenile sampling program on the Hoopa Valley Reservation in 1980, we initiated investigations to assess the migration patterns, distribution, growth and racial composition of chinook salmon smolts in the drainage and to explore the potential for developing annual smolt abundance indices to utilize in predicting future run sizes. An operational plan which addresses future juvenile chinook salmon investigations in the basin will be forthcoming in 1981.

B. METHODS

We established 11 beach seining stations on the Klamath River, 5 located below the Highway 101 bridge (estuary stations) and 6 upriver stations located between Tarup and Roach creeks (between River Kilometers 12.6 and 50.2) and sampled them on a weekly basis throughout most of 1980. Beach seining operations were conducted with a 30.5 m long by 1.8 m deep seine having a mesh size of 0.6 cm which was set with the aid of a jet sled during most of the year and by a swimmer late in the year (Plate 14). The 6 upriver stations consisted of riffle and pool areas and the 5 estuary stations, which generally consisted of water less than 2 m deep, were sampled at various tidal stages.

To sample the pelagic portion of the Klamath River estuary, we employed a midwater trawling technique (Plates 15 and 16) from late June to mid-August when engine problems resulted in a suspension of sampling until late September. The trawl had an effective net mouth area of 6.7 m^2 and we utilized a 6.4 m jet sled, 115 hp outboard motor and 2 3-horsepower gasoline powered winches with a 31 m length of 4.8 mm cable to set and retrieve it. A General Oceanic Flowmeter was used to measure the distance of the tows at the designated trawling station (located between the Requa boat dock and Panther Creek resort) which had a mean depth at low tide of approximately 6.1 m. Tows varied from 7 to 12 minutes depending on current velocity and trawling was generally conducted at night. Tows were made sampling the upper 2 m of the water column.

Sampling efficiency, especially at the upriver sites, appeared to be related to river flow, which generally ranged from 75,000 cfs in February to 4,000 cfs in August (Figure 23). Depressed catch rates in late July and early August at upriver stations coincided with decreased flow and increased water temperature (Figure 23). While the beach seining effort at the upriver stations remained relatively consistent, debris and gravel bar movements during high flow periods necessitated changing station locations occasionally. Replication of sampling the trawl station was also consistent but competition for space with the Indian net fishery required occasional rescheduling of the timing of tows. Catch rates at the trawling site appeared to be related to time of day, tidal stage and water turbidity.

All fish collected were identified to species, measured to the nearest millimeter and examined for fin clips before being released. Scale samples were taken from various marked and unmarked individuals to evaluate life history patterns and to assist in aging adult salmon. Samples of adipose fin-clipped fish were sacrificed for CWT identification.

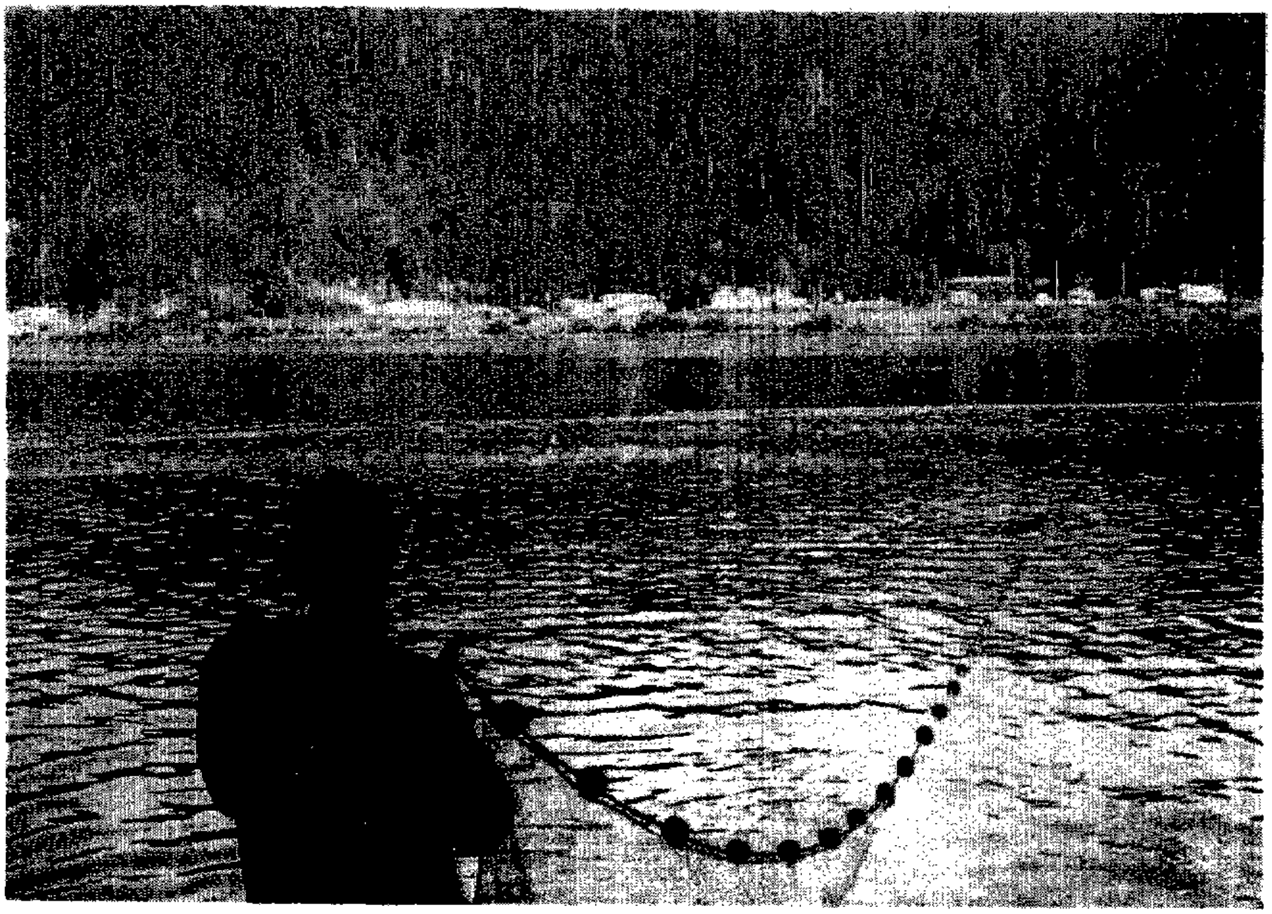


PLATE 14. Juvenile beach seining operation conducted on the lower Klamath River in 1980.

PLATES 15 and 16. Trawling technique employed in the Klamath River estuary in 1980 to sample juvenile chinook salmon.

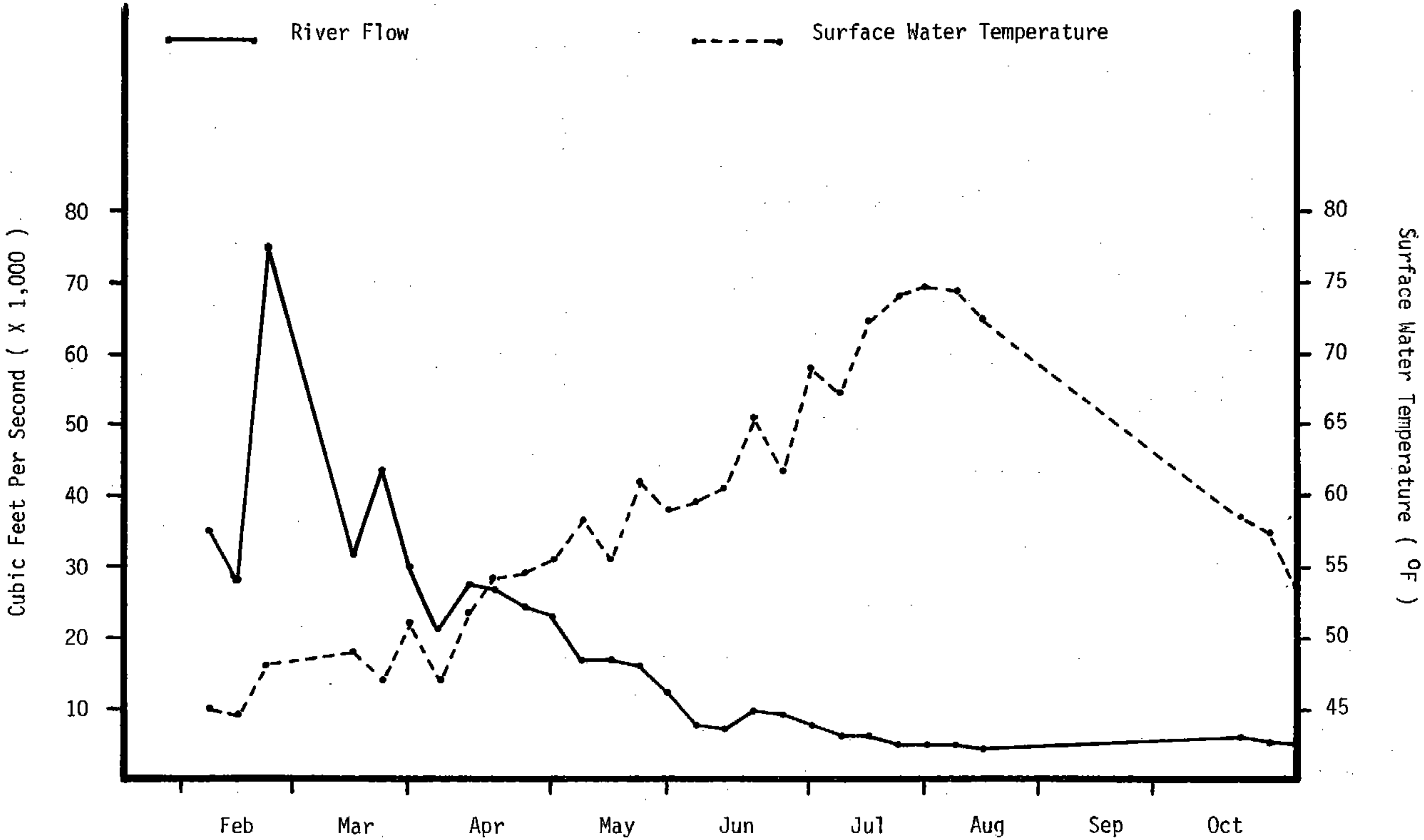


FIGURE 23. Klamath River flows at Terwer Creek and mean surface water temperature of the Klamath River as recorded at six upriver sampling stations located between River Kilometers 12.6 and 50.2 in 1980.

C. RESULTS AND DISCUSSION

1. Catch Rates and Length-Frequency Distributions

During the period extending from January through October, 1980, we captured 927 juvenile chinook salmon at the upriver stations and 896 juveniles at the estuary sites (544 through beach seining and 352 through trawling). Highest catch rates at all stations occurred in July, corresponding to influxes of hatchery released fish. Catch rates associated with the midwater trawl (Figure 24) generally exceeded those associated with beach seining at the estuary and upriver stations (Figures 25 and 26, respectively).

Length-frequency distributions of juvenile chinook salmon captured at the upriver stations in 1980 (Figure 26) reveal that the fish represented progeny of the 1978 and 1979 brood years. Length-frequency distributions in February were bi-modal with respective mean lengths of approximately 90 mm and 166 mm. In late March and April, sampled chinook salmon exhibited three apparently distinct length ranges with respective means of 40 mm, 92 mm and 178 mm which probably represented a cross section of wild and hatchery-reared spring and fall chinook salmon moving through the system. Some of the salmon of the largest size group may have represented late migrants of 1978-brood production released from Iron Gate Hatchery in November, 1979 and some individuals of the two largest size groups possibly represented yearling and young-of-the-year spring chinook salmon. Analysis of scales collected from these fish may shed more light on racial composition. A large percentage of juveniles captured at upriver sites in May and June probably were wild young-of-the-year fish and approximately 35 percent of the chinook juveniles captured in early July were part of marked release groups from Trinity River and Iron Gate hatcheries.

Length-frequency distributions of juvenile chinook salmon captured in the estuary through trawling (Figure 24) and beach seining (Figure 25) were generally uni-modal except for a small group of relatively large fish seined in April, all of which were marked fish released from Trinity River Hatchery. Approximately 35 percent of the juvenile chinook salmon captured in July were part of marked hatchery release groups. Comparisons of length distribution and catch rate curves for the estuary stations indicate that the majority of chinook salmon juveniles entered the ocean at a mean length of approximately 91 mm.

During the period extending from April through October, 1980, young-of-the-year chinook salmon captured through beach seining at the estuary and upriver stations increased in length from approximately 38 mm to 138 mm (Figures 25 and 26). Mean lengths of fish sampled during June and the first half of July increased by about 5 mm per week at upriver stations and 6 mm per week at the estuary sites. Mean lengths of salmon captured in the estuary from mid-July through October increased by about 3 mm per week. Mean lengths of salmon captured in the trawl ranged about 5 mm larger than fish sampled through beach seining during corresponding time periods.

2. CWT Recoveries

Through October, 1980, adipose fin-clipped chinook salmon from the various hatchery release groups (Table 3) comprised approximately 22, 18 and 20 percent of the juvenile chinook salmon catches at the trawling station and estuary and upriver seining sites, respectively (Figures 27, 28 and 29). Of 158 coded-wire tags read, 44 were from fish of the 06-61-33 group, 37 were from fisn of

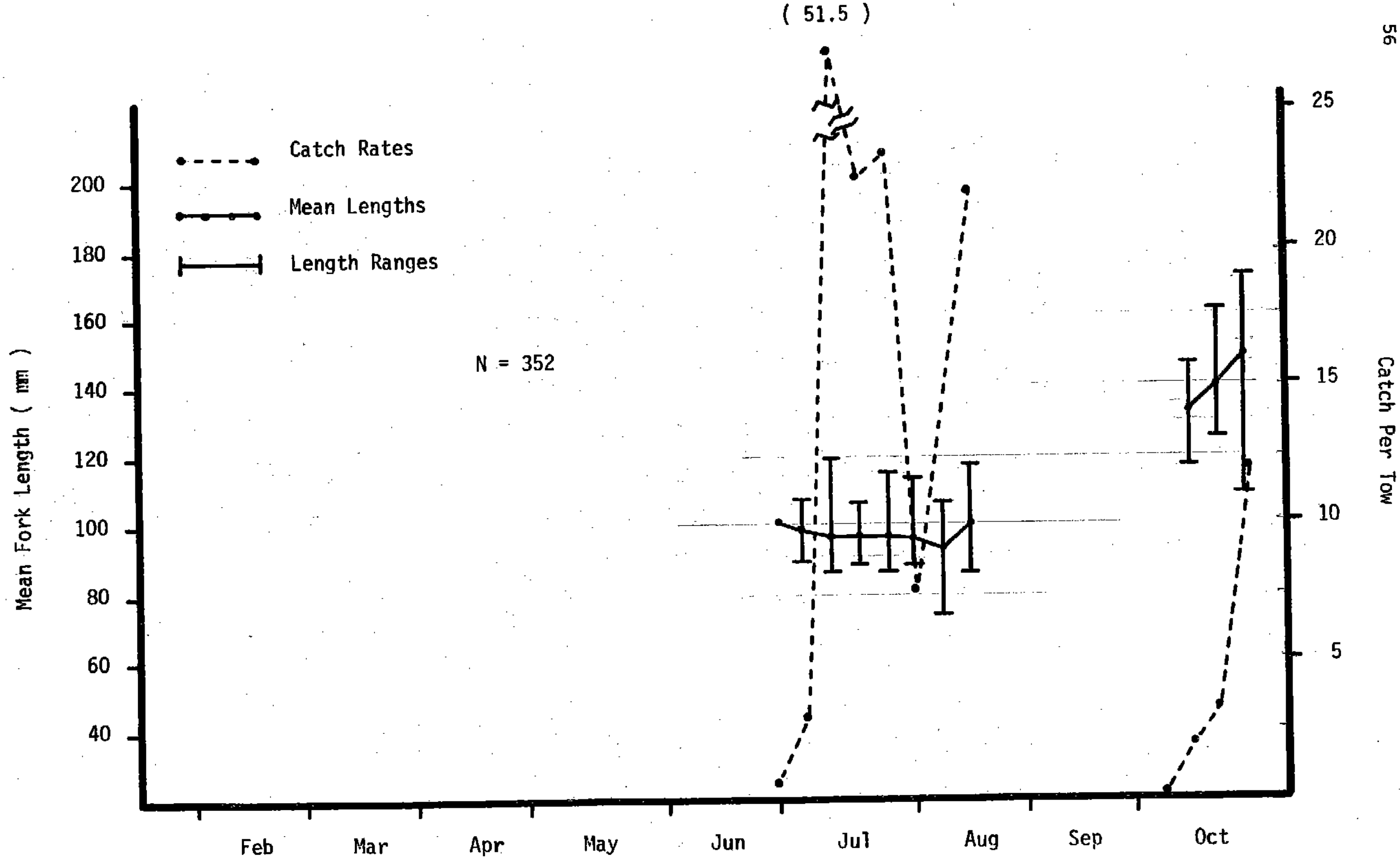


FIGURE 24. Mean catch rates, mean lengths and length ranges of juvenile chinook salmon captured through trawling in the lower Klamath River estuary in 1980.

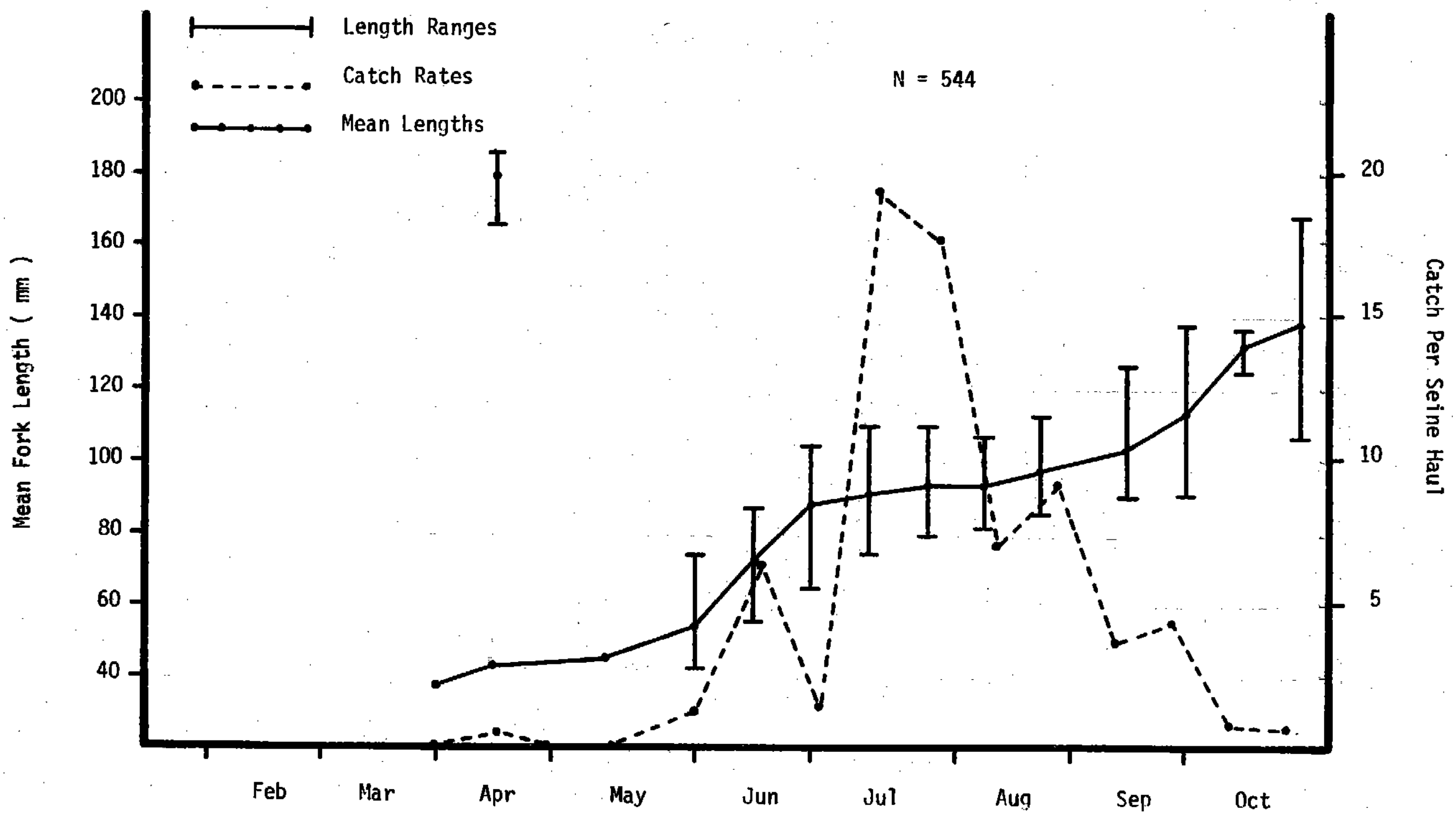


FIGURE 25. Mean catch rates, mean lengths and length ranges of juvenile chinook salmon captured at five beach seining stations located in the Klamath River estuary in 1980.

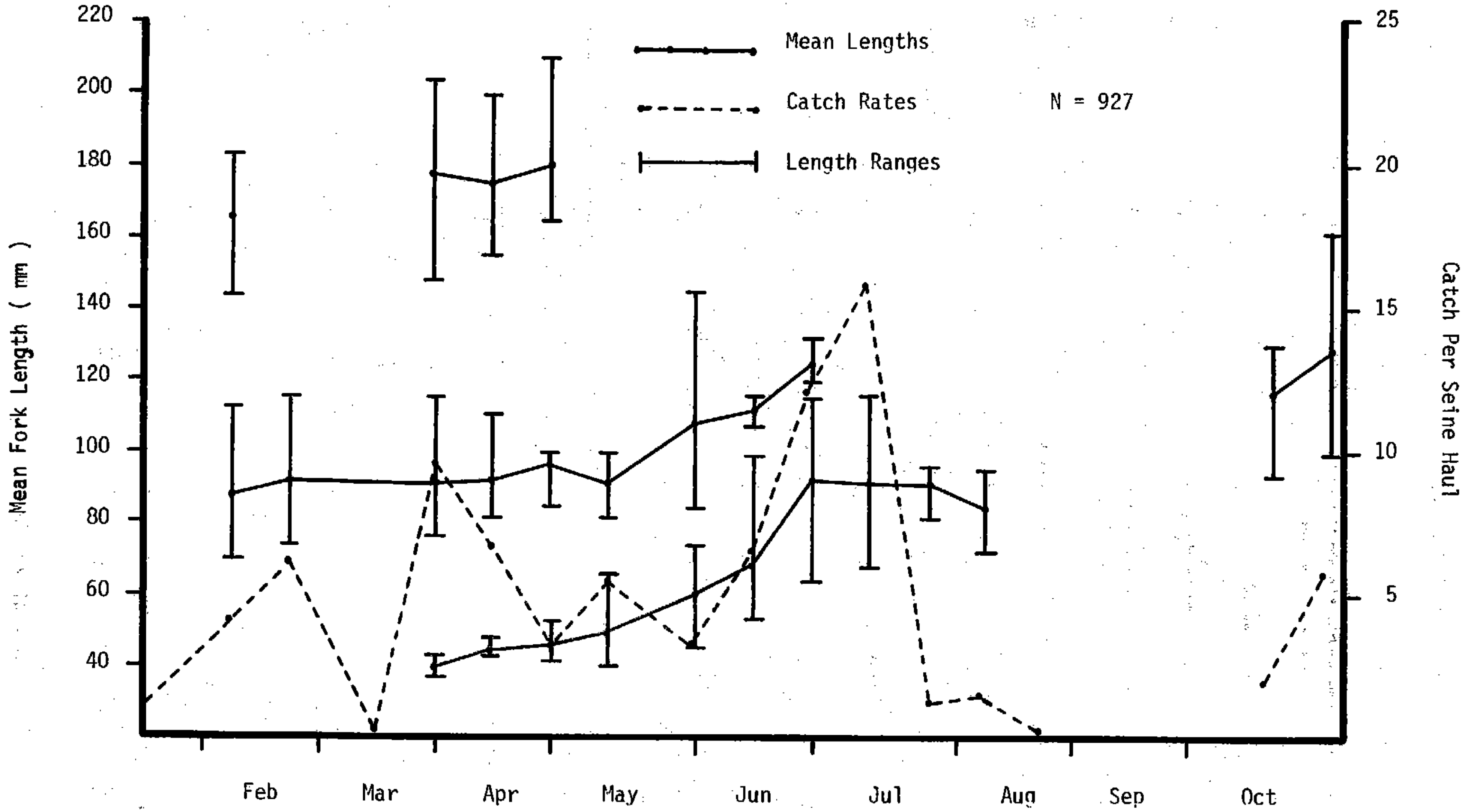


FIGURE 26. Mean catch rates, mean lengths and length ranges of juvenile chinook salmon captured at six upriver beach seining stations on the Klamath River (between River Kilometer 12.6 and 50.2) in 1980.

TABLE 3. Coded-wire tagged groups of chinook salmon released from the Trinity River and Iron Gate hatcheries between November, 1979 and October, 1980.

CWT Code	Hatchery	Fish Strain	Brood Year	Month & Year of Release	Fish Size at Release (No. per Kg)	Number Released	Number Released Not Marked
06-61-30	TRH[1/]	SR[3/]	1978	11-79	20	191,916	28,000
06-61-14	TRH	FR[4/]	1978	11-79	31	207,279	54,000
06-61-31	TRH	SR	1978	03-80	17	134,948	24,864
06-61-15	TRH	FR	1978	03-80	20	156,020	3,152
06-61-16	TRH	FR	1979	06-80	231	199,500	10,733
06-61-32	TRH	SR	1979	06-80	149	187,894	12,206
06-61-17	TRH	FR	1979	06-80	191	193,897	6,203
06-61-33	TRH	SR	1979	06-80	152	181,134	7,154
06-61-09	TRH	FR	1979	10-80	34	90,995	1,013
06-61-34	TRH	SR	1979	10-80	30	86,594	174
06-59-01	IGH[2/]	FR	1978	11-79	20	191,071	18,929
06-59-03	IGH	FR	1979	06-80	169	189,420	17,977

1/ Trinity River Hatchery

2/ Iron Gate Hatchery

3/ Spring-Run

4/ Fall-Run

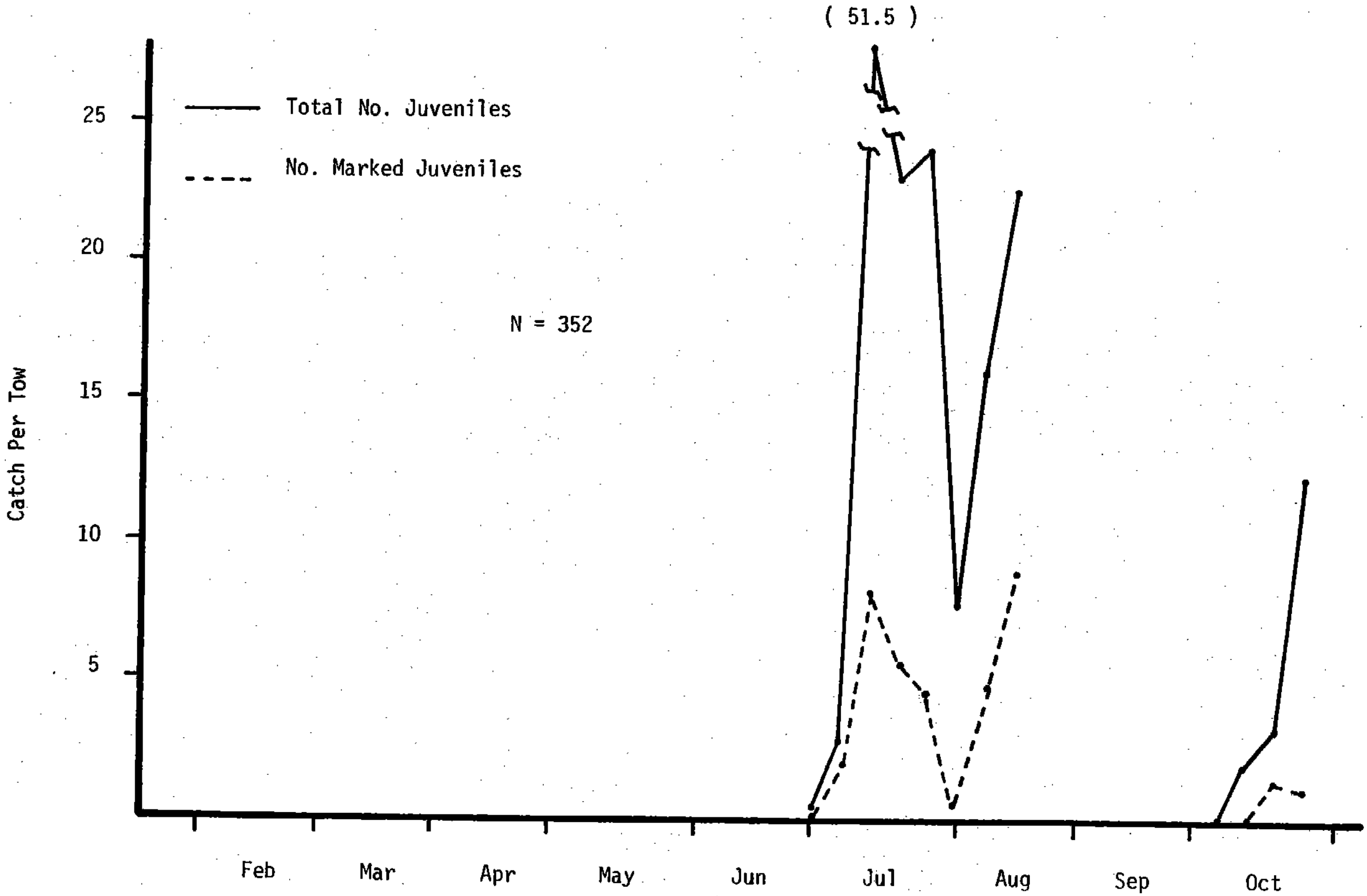


FIGURE 27. Mean catch rates of juvenile chinook salmon and hatchery marked juvenile chinook salmon captured by trawling in the lower Klamath River estuary in 1980.

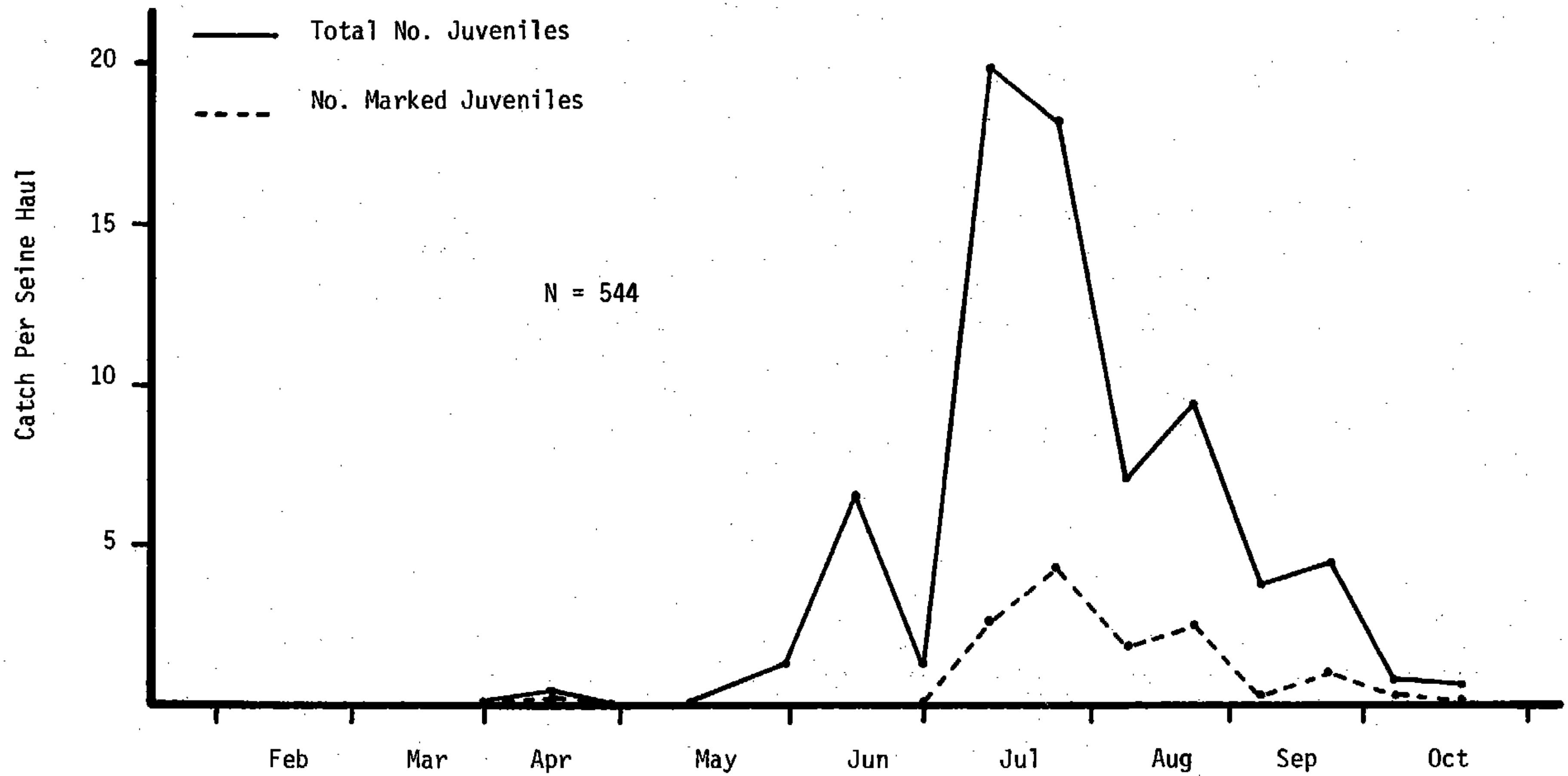


FIGURE 28. Mean catch rates of juvenile chinook salmon and hatchery marked juvenile chinook salmon captured at five beach seining stations located in the Klamath River estuary in 1980.

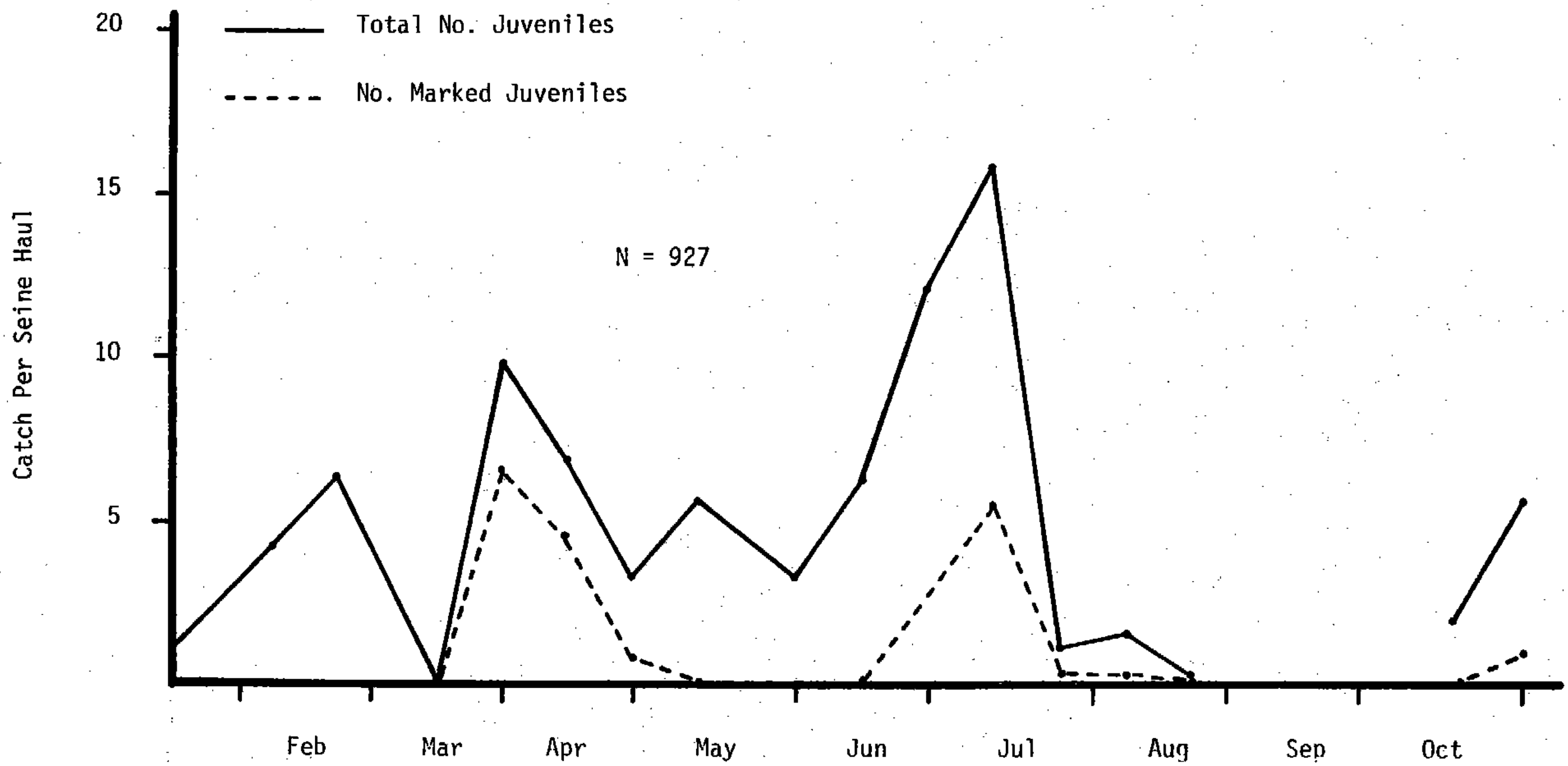


FIGURE 29. Mean catch rates of juvenile chinook salmon and hatchery marked juvenile chinook salmon captured at six upriver beach seining stations on the Klamath River (between River Kilometer 12.6 and 50.2) in 1980.

the 06-61-17 group, 25 were from fish of the 06-59-33 group, 15 were from fish of the 06-61-09 group, 14 were from fish of the 06-61-15 group, 13 were from fish of the 06-61-31 group and 10 were from fish of the 06-61-34 group. We also recovered 35 right ventral fin-clipped chinook out of a group of 168,344 clipped fish released from Trinity River Hatchery in mid-October, 1980.

Juveniles of the 06-61-31 CWT group released from Trinity River Hatchery on March 5 and 6, 1980, first appeared in our estuary catches on March 16, 1980. Ten of these fish were also captured at our upriver stations in late March and early April and none were recovered after April 20, 1980, indicating that these fish moved into the ocean by May, 1980.

Thirteen juveniles of the 06-61-15 CWT group released from the Trinity River Hatchery on March 11 and 12, 1980 were recovered at estuary and upriver stations in early April and only 1 fish from this group was sampled after April 20, also indicating that most of these fish had entered the ocean by May, 1980. Juveniles of the 06-59-03 CWT group released from Iron Gate Hatchery in mid-June, 1980 first appeared at upriver sampling stations on July 2 and none were sampled after the second week in July at these sites. Juveniles from this group first appeared in estuary catches during the second week of July and most were sampled during mid-July. One individual each from this group was recovered in the estuary in mid-August and during the second week in October.

Two CWT groups, 06-61-33 (fingerling release of spring chinook) and 06-61-17 (fingerling release of fall chinook), from the Trinity River Hatchery were released into the Trinity River above the Hoopa Valley Reservation near Willow Creek on June 25 and 26, 1980. While overall catch rates of these groups for the year were similar, about 6 times as many spring fish were sampled at upriver stations in July. Juveniles from both groups first were captured at the upriver and estuary stations during the first week of July and of 81 combined recoveries (44 of the 06-61-33 group and 37 of the 06-61-17 group), 14 were recovered after October 1, 7 each at upriver and estuary sites. Approximately 58 percent (47 fish) of the recoveries occurred in July.

Juveniles of 2 CWT yearling groups, 06-61-34 and 06-61-09, released from the Trinity River Hatchery on October 15 and 16, 1980, were recovered at upriver and estuary stations during the latter part of October. Catch rates and movement patterns of the 2 groups of fish were similar.

While few conclusions can be drawn about the movement patterns of the respective CWT release groups, it appears that the yearling groups released from Trinity River Hatchery in March (CWT groups 06-61-15 and 06-61-31) moved out of the system into the ocean most quickly and fingerling chinook salmon of the two Trinity River Hatchery groups released near Willow Creek in June, 1980 (CWT groups 06-61-17 and 06-61-33) appeared to spend the most time in the river system. To minimize competition with wild juveniles in the river system, it may be advisable to discourage further off-site releases of hatchery-reared fish.

3. Production Estimates

By comparing known ratios of marked and unmarked hatchery releases of chinook salmon produced in the 1979 brood year at Trinity River and Iron Gate hatcheries with ratios of marked and unmarked juveniles observed in our sampling program, we were able to generate a rough estimate of total chinook salmon production in the Klamath River basin from 1979 brood year fish. Preliminary data obtained from CDFG biologists (Hopelain and Maria pers. comm.) indicate that approximately 1.3 million of 2.8 million chinook salmon released from the hatcheries through October 30, 1980 were marked (46 percent). Thirteen percent of the chinook salmon sampled which were presumed to represent progeny of 1979 brood year fish, were also marked. By multiplying the percentage of marked fish sampled by the unmarked percentage of hatchery fish released and dividing the result by the marked percentage of hatchery fish released, we estimate that approximately 15 percent of the unmarked portion of our sample presumed to represent 1979 brood year production consisted of hatchery-released fish and that approximately 27 percent of our sample consisted of hatchery-reared fish. Assuming that our sample was representative of the population and applying a 2.7:1 ratio of wild to hatchery-reared chinook in the drainage to the hatchery release, it appears that wild chinook salmon production in the basin for the year approximated 7.7 million smolts.

4. Juveniles of Other Species Captured

Of 30 coho salmon captured, approximately 37 percent were marked fish of hatchery origin. Of the marked samples identified, 5 were of the 06-61-54 CWT group released from the Trinity River Hatchery, 4 were of the 06-61-53 CWT group released from Trinity River Hatchery and 2 were of the 06-59-41 CWT group released from the Iron Gate Hatchery. Ten of the 11 marked coho captured which were released at the hatcheries between March 11 and April 9, 1980, were recaptured in April and May and the other was caught on June 17 in the estuary.

We captured 406 steelhead trout which probably represented at least 3 age classes based on length patterns observed (Figure 30). None of the fish exhibited hatchery marks. All 46 cutthroat trout sampled were collected at the estuary stations.

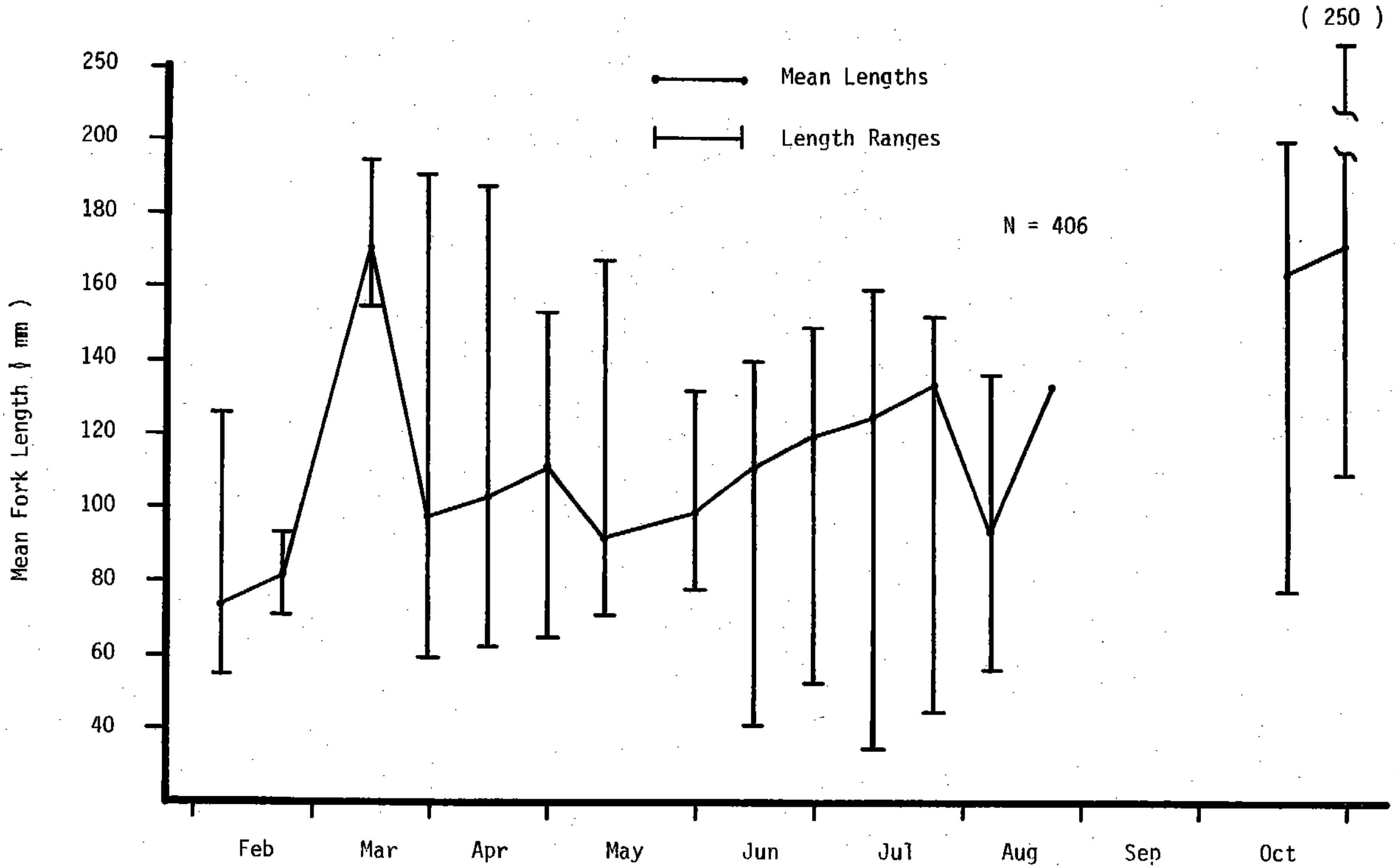


FIGURE 30. Mean lengths and length ranges of juvenile steelhead trout captured at six upriver beach seining stations on the Klamath River (between River Kilometer 12.6 and 50.2) in 1980.

V. STURGEON INVESTIGATIONS

A. INTRODUCTION

Virtually no information has been available concerning the abundance, harvest and life history of green sturgeon (*Acipenser medirostris*) and white sturgeon (*Acipenser transmontanus*) of the Klamath River basin. A sturgeon investigation program initiated by FAO-Arcata biologists in 1979 was expanded in 1980 in an attempt to gather baseline data. Data available at this writing is presented herein and a more detailed report of our findings will be forthcoming in 1981.

While past and present sizes of green and white sturgeon spawning runs are not known, it is clear that the magnitudes of recent green sturgeon runs have far exceeded white sturgeon runs in the basin and virtually all of the data collected to date has concerned green sturgeon. In the absence of a fish counting weir across the Klamath River, it will probably by difficult to estimate sturgeon run sizes in the future. Through comparisons of catch/effort in the fisheries or of "jumper" counts at designated areas of restricted flow, however, we may be able to develop relative abundance indices.

Although spawning habits of green sturgeon in the Klamath River drainage are poorly understood, individuals have been observed well inland in the Klamath and Trinity rivers with Happy Camp (River Kilometer 171) considered near the upstream limit of their distribution. A "sturgeon hole" located upstream from Orleans (River Kilometer 96) may be a major spawning ground on the Klamath River as leaping and other frantic behavior indicative of spawning or courtship is frequently observed there in the spring and early summer (Moyle 1976). Other streams utilized by sturgeon are the Salmon and South Fork-Trinity rivers (CDFG 1978). One 178 cm long individual tagged by CDFG biologists on May 18, 1977 at River Kilometer 4.5 was recovered near Orleans on June 30, 1977 (L.B. Boydstun pers. comm.).

The life history of green sturgeon in the marine environment is not well understood. Individuals tagged in San Pablo Bay, California have been recaptured in coastal waters as far as 650 miles away (Fry 1973) and bottom fishermen occasionally catch sturgeon.

B. METHODS

FAO-Arcata biologists attempted to capture sturgeon through beach seining, set lining, gill netting and trawling techniques while the great majority of adults sampled occurred through the monitoring of the Indian net and Indian and non-Indian hook and line fisheries (Plates 17 and 18). Sturgeon sampled were identified to species based on lateral scute counts, measured, weighed and examined for any distinguishing marks or tags (Plates 19 and 20). Sex and sexual maturity condition were also recorded whenever possible. A section from the proximal end of the lead ray of one pectoral fin was excised for age analysis, stomach contents were examined and percent body weight of gonadal tissue was calculated from subsamples of harvested fish. Juvenile sturgeon sampled in 1979 received spaghetti tags applied immediately posterior to the dorsal fin and juveniles and adults captured in 1980 received disc-dangler tags applied immediately anterior to the dorsal fin.

In monitoring net harvest of sturgeon, we regularly contacted approximately 15 Indian fishers who were involved in the fishery resulting in a total of approximately 100 individual contacts on 31 dates between Match 25 and July 2,

PLATE 17. Gill netting activity conducted on the Klamath River below "Coon Creek falls" in 1980 to capture adult sturgeon.

PLATE 18. Snagging activity conducted on the Klamath River below "Coon Creek falls" in 1980 to capture adult sturgeon.

PLATE 19. Adult green sturgeon caught on the Klamath River in 1980.

PLATE 20. Weighing an adult green sturgeon caught on the Klamath River in 1980.

1980. The harvest of post-spawning adults was also monitored through the net harvest monitoring station. The gill net fishery operated under federal regulations governing Indian fishing on the Hoopa Valley Reservation, while the great majority of hook and line harvest apparently occurred through illegal snagging activity by Indians and non-Indians in a number of isolated pools along the Klamath River. Observations of snagging activity occurred on 22 dates between April and July, 1980.

C. RESULTS AND DISCUSSION

Mature green sturgeon of the 1980 spawning run began entering the Klamath River in March. Although near-ripe females were observed in the lower river as late as July, the harvest monitoring program revealed that the bulk of the run occurred between mid-April and mid-June and peaked in May (Figure 31). Downstream movement of spawned-out fish began in May and continued through November with peak movement apparently having occurred between late August and mid-September. Disc-dangler tags were applied to 4 adults captured, none of which have as yet been recovered.

A combined length-frequency distribution of 159 green sturgeon sampled in 1979 and 1980 reveals juvenile and spawner components of the population and a general absence of fish in the 90 cm to 145 cm range (Figure 32). Apparently, green sturgeon in this size range rarely enter the freshwater environment. Females harvested in the net and hook and line fisheries were generally larger than males (Table 4, Figure 33) and this difference was found significant by chi-square analysis at the 99 percent level.

Based on numerous observations by FAO-Arcata biologists and frequent contacts with fishers who targeted on sturgeon, we estimate that Indian gill net and combined Indian and non-Indian hook and line fisheries accounted for approximately 300 and 400 adult green sturgeon, respectively, during 1980. Small numbers of downstream migrant spawned out sturgeon were caught in the summer and fall net fisheries and additional small numbers of juvenile green sturgeon generally ranging between 70 cm and 90 cm in length, were harvested by gill nets incidentally to fisheries which were targeting on other species. Total harvest of white sturgeon probably did not exceed 25 during the year.

As was the case in 1978 and 1979, it appears that the majority of the snag harvest of sturgeon from the Klamath River occurred from a pool located below the mouth of Coon Creek at River Kilometer 58. In 1977, heavy rainfall caused a debris slide in Coon Creek resulting in a constriction of the Klamath River and the formation of "Coon Creek falls" which, while not posing a migration barrier to spawners, does retard the rate of migration to the extent that large numbers of sturgeon become congregated below the falls during the peak of the run. Observations of snagging activity at the "Coon Creek pool" on 22 dates between April 17 and July 2, resulted in an estimated harvest of 300 green sturgeon by mid-May. We estimated that an additional 50 fish were caught at other locations by mid-May and that another 50 green sturgeon were taken in the hook and line fisheries on the Klamath River after mid-May, including some in late summer and fall.

Gill net harvest of green sturgeon spawners occurred primarily from mid-April to mid-June and peaked during the week of May 11. The monitoring of 6 gill nets, which fished between Notchko Flats (River Kilometer 48) and Coon Creek on a regular basis between April 14 and June 12, resulted in a catch of 130 green sturgeon. These nets, all of which were 24.1 cm (9.5-inch) stretched mesh heavy twine, fished exclusively for sturgeon.

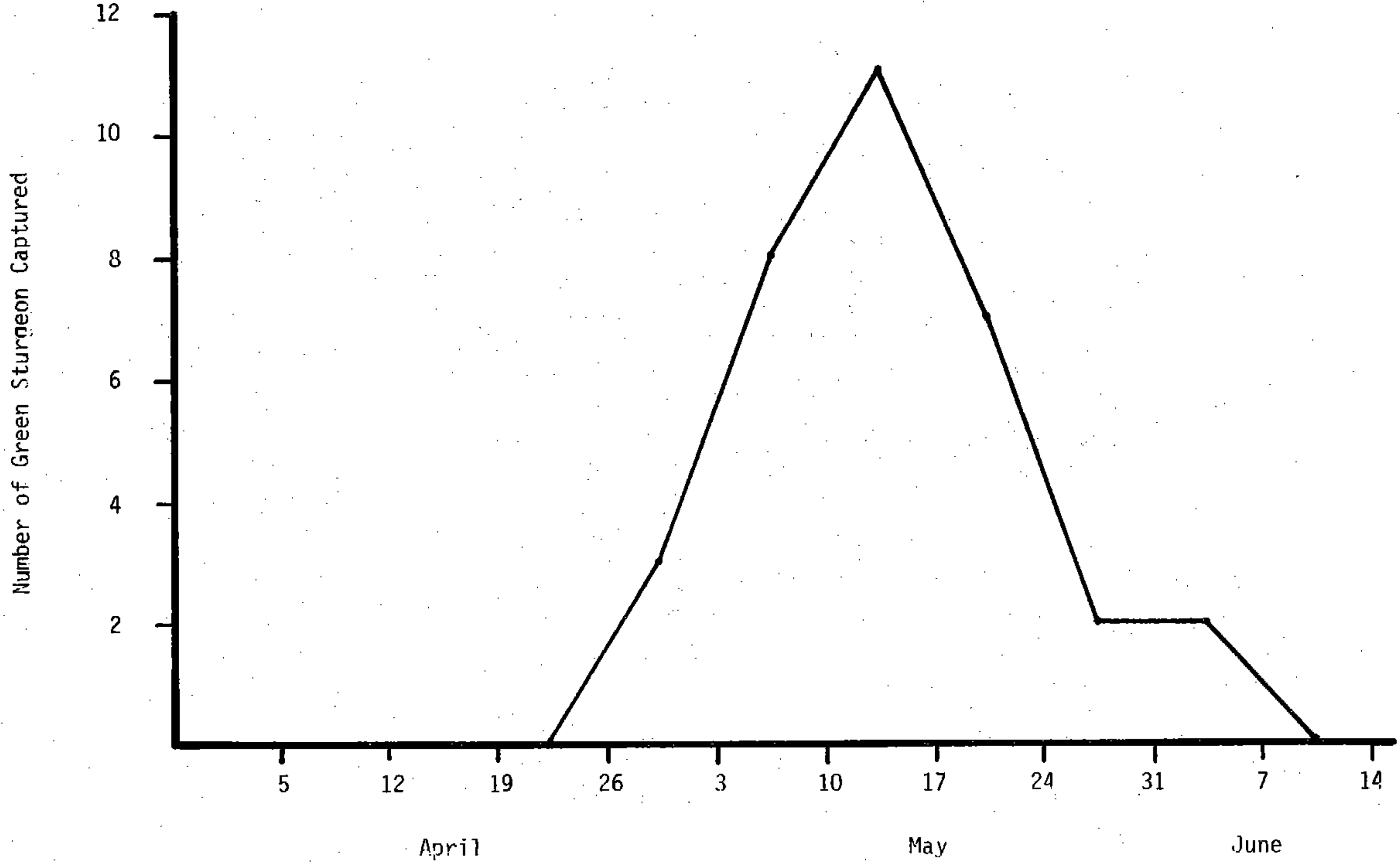


FIGURE 31. Estimated weekly catches of upstream migrant spawning condition green sturgeon in four gill nets fished on a regular basis from April 14 to June 10, 1980 in the Notchko Flat area (River Kilometer 48).

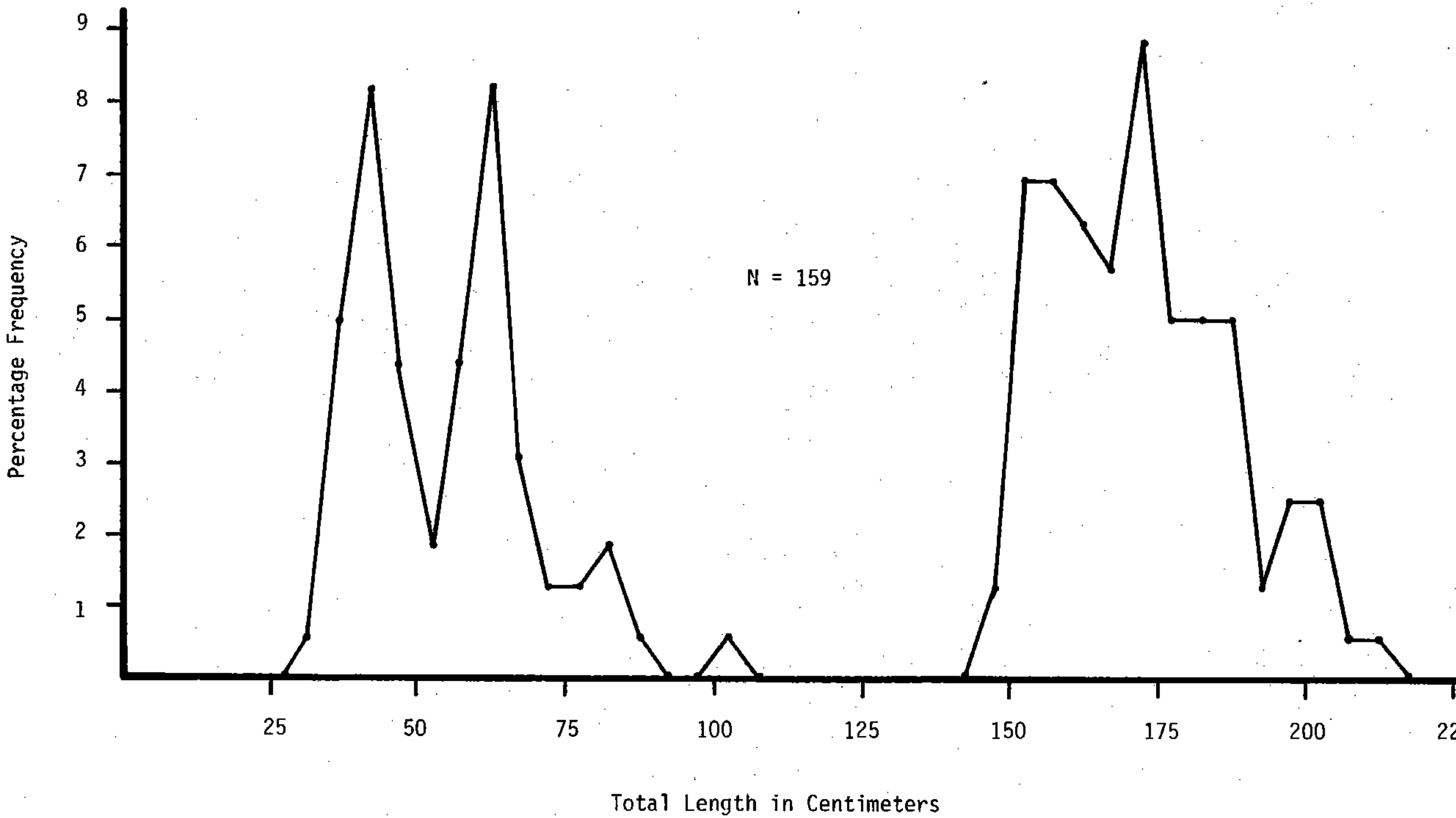


FIGURE 32. Combined length-frequency distribution of 159 green sturgeon sampled in 1979 and 1980 through beach seining and harvest monitoring programs.

TABLE 4. Lengths, weights and ratios of occurrence of male and female green sturgeon captured through gill net and hook and line fisheries on the Klamath River during the spawning migration of 1980.

Parameter	Fishery	Sex	
		Male	Female
Total Length Range (cm)	Hook and Line	149-183	170-205
	Gill Net	148-195	160-211
	Combined	148-195	160-211
Mean Total Length (cm)	Hook and Line	167.8	188.6
	Gill Net	165.3	187.0
	Combined	166.1	187.3
Percent of Sample Larger than 175 cm	Hook and Line	20.0	80.0
	Gill Net	14.8	83.1
	Combined	16.5	82.5
Mean Weight (kg)	Hook and Line	30.6	45.8
	Gill Net	24.1	44.6
	Combined	27.1	45.0
Sample Size	Hook and Line	15	5
	Gill Net	31	25
	Combined	46	30
Sex Ratio of Sampled Fish (Male/Female)	Hook and Line	3:1	
	Gill Net	1.2:1	
	Combined	1.5:1	

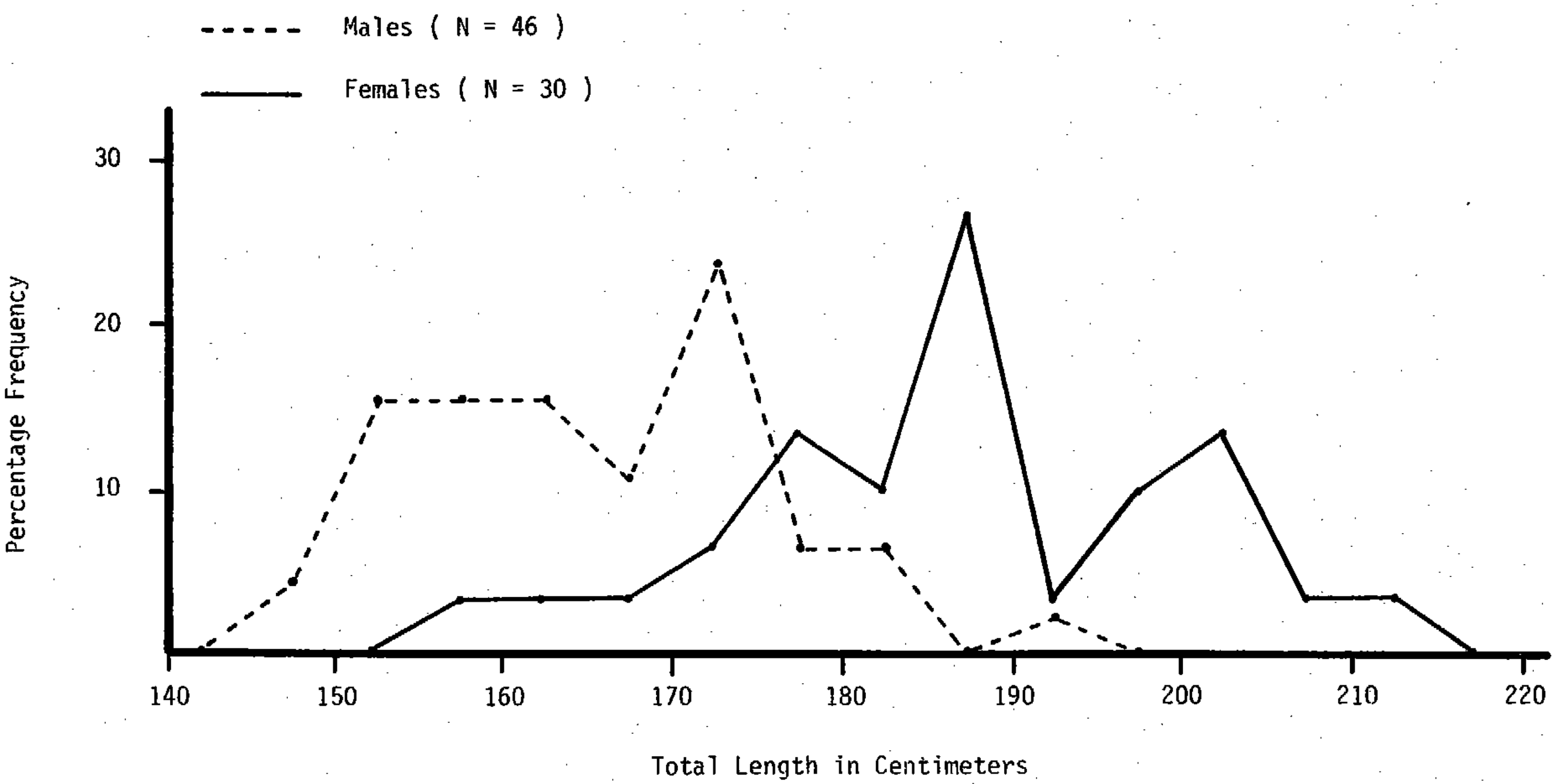


FIGURE 33. Length-frequency distributions of 46 male and 30 female green sturgeon sampled in the 1980 gill net and hook and line fisheries on the Hoopa Valley Indian Reservation.

The sampling program revealed that 3 males were harvested for every female in the snag fishery while 1.2 males were harvested for every female in the gill net fishery (Table 4). Perhaps the high ratio of males in the snag fishery is a result of selectivity in this fishery for smaller individuals which were generally males (Table 4) and that the true sex ratio of the run might be better represented by the gill net harvest.

It appears that the elimination of the illegal snag fishery would be a desirable step in helping to protect the sturgeon resource. Although increased enforcement efforts would assist towards this end, we recommend that the in-river obstruction at Coon Creek be removed, thereby eliminating the opportunity to catch large numbers of sturgeon. FAO-Arcata biologists have discussed this possibility with the BIA and CDFG.

Young-of-the-year green sturgeon, ranging from about 7 cm to 15 cm in length, are often seen in upriver pools in late summer. CDFG biologists captured 211 sturgeon ranging between 7 cm and 29 cm in length in the Trinity River near Willow Creek in July, August and September of 1968 in conjunction with salmonid emigration studies (Healey 1970). Of these, 206 measured less than 19 cm and probably represented young-of-the-year fish while the remaining 5 may have been holdovers from the 1967 brood. Between 1976 and 1980, CDFG biologists captured numerous juvenile green sturgeon ranging from approximately 10 cm to 15 cm in length at their lower Klamath River seining site (Figure 2) in late August and September (Hopelain pers. comm.). It appears, therefore, that young-of-the-year green sturgeon begin their annual outmigration in July and are far down-stream by late August and September. The fact that we did not encounter young-of-the-year green sturgeon in our beach seining operations conducted in the Klamath River estuary in 1979 and 1980 may suggest that these fish spend little time in the estuary. Fyke net sampling by CDFG biologists in the lower Klamath River during the spring and early summer of 1971 resulted in the capture of only 3 small green sturgeon (Healey 1970).

FAO-Arcata biologists captured numerous juvenile green sturgeon ranging in length from 31 cm to 85 cm in beach seining operations conducted in the Klamath River estuary in 1979 and 1980. Of 32 juveniles tagged and released in 1979, 14 were recaptured within 38 days of tagging and 5 individuals were recaptured twice. None of eight juvenile sturgeon tagged in 1980 were recaptured. Since no evidence exists documenting the presence of green sturgeon greater than 29 cm in length in upriver portions of the drainage, it appears that some juveniles which migrated from the system as young-of-the-year fish occasionally reenter the estuary for brief periods during the following summer and fall. Length-frequency distributions of juvenile green sturgeon captured during beach seining operations conducted between July and December, 1979 and mark-recapture data indicate that one group of fish, ranging between 45 cm and 80 cm, entered the estuary in late July and returned to the sea in late September and that another group, ranging between 31 cm and 48 cm, entered the estuary in late October and returned to the ocean in mid-November (Figure 34). Relatively few green sturgeon juveniles were captured in the estuary in 1980. In both 1979 and 1980, many more sturgeon were caught off the north spit of the Klamath River in shallow water with a slow current and muddy substrate as compared to the south spit site with its fast current, relatively deep water and sandy substrate.

Pectoral fin ray sections have been collected from 71 adult and 14 juvenile green sturgeon to data for age analysis. One section analyzed from a 37 cm fish revealed it to be in its second year. Stomachs from 9 male and 8 female

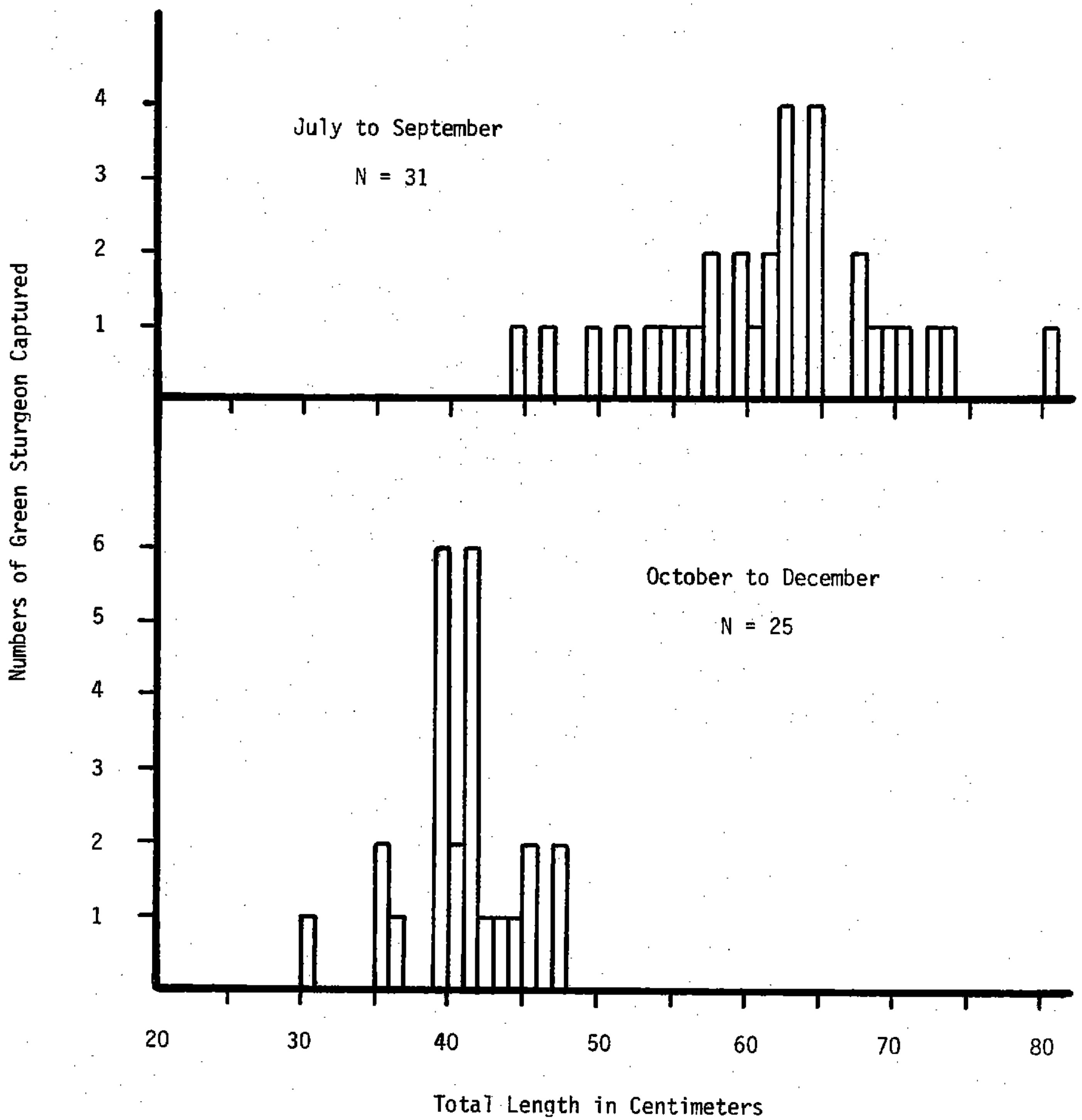


FIGURE 34. Length-frequency distributions of juvenile green sturgeon seined in the Klamath River estuary from July to September and October to December, 1979.

green sturgeon harvested were found to be empty indicating little or no feeding activity during the spawning migration. Females and males averaged 10.3 percent and 4.3 percent gonadal tissue by body weight, respectively.

VI. HARVEST MONITORING PROGRAM

A. THE INDIAN FISHERIES

1. Historical Perspective

Generations of Indians have utilized fishing grounds in the Klamath River drainage and their fisheries for salmon, steelhead and sturgeon have historically provided the mainstay of Indian economy in the area. Well established trade routes existed from the interior to the sea resulting in a lively commerce in dried fish and shells (Moffett and Smith 1950). Indians historically constructed fish weirs of logs, poles and brush across the rivers and speared or netted upstream migrants. Salmon runs were so large that Indian fishers had to frequently remove the weirs to prevent them from being broken by the dense concentrations of fish (Hoptowit 1980). Hoptowit (1980) noted that the Hupa, Yurok and Karok people consumed in excess of two million pounds of salmon (more that 150,000 salmon) annually. After the arrival of non-Indians in the area, salmon runs apparently declined in response to large-scale mining activity in the basin and Indians were compelled to open their weirs more frequently so that non-Indians could harvest more salmon (Hoptowit 1980).

A commercial non-Indian administered gill net fishery for salmon developed on the lower Klamath River during the latter quarter of the nineteenth century and continued until 1933 when state legislation was passed prohibiting that activity. Annual salmon landings in this fishery during the years 1915 to 1928 averaged approximately 329,000 kg (about 52,000 salmon) and the average number of boats employed in the taking of salmon during these years approximated 82 (Snyder 1931). Boydstun and Hopelain (1978), citing a study conducted by E.C. Scofield in 1926, referred to a gill net catch of approximately 31,000 chinook salmon from the lower Klamath River out of an estimated run for that year of about 435,000. Indian people were primarily employed to harvest the fish and they also performed most of the work in conjunction with associated cannery operations.

Following the state imposed commercial fishing prohibition on the Klamath and Trinity rivers in 1933, Indians of the reservation continued to fish for consumptive and ceremonial purposes relying almost exclusively on the more convenient introduced gill net (Plates 21 and 22) instead of their more effective traditional fish weirs. Indian harvest levels in the succeeding decades apparently declined to small fractions of what they had been. Radovich (1967) and Young (1969) estimated annual Indian harvest levels on the reservation during the 1960's ranging from approximately 3,000 to 20,000 salmon.

2. Indian Fisheries of the 1970's

The State of California regulated Indian fishing activity on the Hoopa Valley Reservation for over a century but a number of recent court decisions upheld the Indian right to fish on the reservation free from state regulation. Following resolution of the *Mattz v. Arnett* case in 1973, which held that the lower 20-mile portion of the reservation still retained its status as an Indian reservation, and the *Arnett v. Five Gill Nets* case in 1976, which held that the State of California lacked jurisdiction to regulate Indian fishing on the reservation, netting activity apparently increased as numerous Indian fishers began to assert their perceived right to sell fish which had been denied them in previous decades.

PLATES 21 and 22. Indian gill netting on the Klamath River, Hoopa Valley Reservation (top photo courtesy of Nick Allen).

Since 1977, the Interior Department has promulgated regulations governing Indian fishing on the Hoopa Valley Reservation. Enforcement and fisheries investigation programs conducted by the USFWS and BIA have evolved in conjunction with the regulations. While the Interior Department recognizes the right of Indians of the reservation to sell fish and allowed for the sale of fish in 1977 and 1978, it placed a moratorium on commercial fishing in August, 1978 which has been extended through 1980 in an attempt to satisfy spawner escapement goals in the Klamath River drainage in anticipated low run years.

Through a number of court decisions, Indians of the Hoopa Valley Reservation have established their right to fish for subsistence purposes but the definition of subsistence remains unclear with regard to the sale of fish. While both state law and current federal regulations prohibit the sale of fish caught on the reservation, differences exist between state and federal agencies concerning the future exercise of the commercial Indian fishing right. Because the reservation was created pursuant to federal legislation and not by treaty, appropriate interpretations of Indian fishing rights issues can probably occur only through interpretations of Indian purposes for which the reservation was established. The absence of an organized tribe on the Klamath River portion of the reservation and questions concerning the nature and extent of the individual fishing right further complicate the entire Indian fishing rights issue, the resolution of which may require congressional action or further litigation.

In attempting to resolve the Indian commercial fishing rights question on the Hoopa Valley Reservation, the California Attorney General has recently filed suit against the Secretary of the Interior and the federal government, on behalf of the Indian people, has contemplated court action. A number of elected representatives of government are also attempting to resolve the issue through congressional action.

The Department of the Interior, through the BIA as lead agency and USFWS as cooperating agency, has initiated an Environmental Impact Statement concerning regulation of the Indian fishery on the Hoopa Valley Reservation which will focus on the issue of commercial fishing. Preliminary scoping sessions held on the reservation in October, 1980 resulted in overwhelming expressions of support for preserving the Indian right to sell fish and for the establishment of an equitable harvest allocation scheme between ocean-based and Indian fisheries as a means of ensuring adequate runs of salmon in the river so that the commercial right could be exercised without jeopardizing needed spawner escapement. Most Indian people agreed that the commercial right could be exercised provided that spawner escapement requirements were satisfied, that a fair on-reservation allocation scheme was implemented and that consumptive and ceremonial fishing activity was not curtailed.

Indian harvest levels from the Klamath and Trinity rivers during the 1970's and the impact of those harvests on the resource have been subject to considerable debate in recent years. A review of records compiled by the Oregon Department of Fish and Wildlife revealed that Oregon processors purchased approximately 118,000 kg of Klamath River salmon (about 20,300 fish) in 1977, the first year in which federal regulations allowed for the sale of fish by Indians of the reservation. While no direct monitoring of the catch occurred in 1977, Indian fishers were relatively open in the transporting and selling of fish and it appears reasonable to assume that total commercial net harvest for the year probably did not greatly exceed the 20,300 figure. Taking into account fish caught for consumptive purposes, total net harvest in 1977 may have approximated 30,000 chinook salmon.

The 1977 Indian fishery on the Hoopa Valley Reservation resulted in numerous conflicts between various resource user groups and federal and state agencies regarding the exercise of the Indian commercial fishing right and the impact of an expanded Indian fishery on the resource. Representatives of a variety of interest groups and elected representatives of local, state and federal government deplored the "illegal" fishery and numerous front page articles appeared in northern California newspapers which referred to the tons of salmon commercially harvested from the Klamath River and the implications of such a harvest on the resource.

FAO-Arcata biologists first attempted to directly monitor net harvest on the Hoopa Valley Reservation in 1978. Past experiences revealed that most salmon caught on the reservation and most salmon caught for commercial purposes were harvested from the Klamath River estuary. Consequently, we stationed biologists in the Indian fish processing camps on the lower river and with the cooperation of the Indian fishers, counted fish as they were cleared through the camps prior to being transported for sale. We continued this operation through August 28, when the Interior Department, through an in-season adjustment to the federal fishing regulations, imposed a commercial fishing moratorium on the reservation because of an apparent low run of salmon in the Klamath River that year. Indian people were very upset over the moratorium and over the presence of large numbers of federal agents which were brought in to enforce the Indian fishing regulations.

Through August 28, we had estimated that approximately 8,500 salmon had been harvested by Indians from the lower Klamath River. Based on a number of reports from upriver and downriver Indian fishers, we speculated that total net harvest for the year approximated 15,000. Utilizing mark-recapture data generated through studies conducted by the CDFG, another net harvest estimate of 25,000 salmon was arrived at. Based on our experiences in 1979 and 1980 relating net catch rates to run timing and run size, it appears that a reasonable net harvest estimate for 1978 is 20,000 chinook salmon.

In 1977 and 1978, more than 140 Indian fishers sold Klamath River salmon. Considering that many of these fishers acknowledge having sold fish caught by other Indians of the reservation, the number of Indian people who directly profited from such sales was considerably greater and may have approximated 300. Following the imposition of the commercial fishing moratorium in August, 1978 and continuing through 1980, a relatively small number of Indian fishers have continued to sell fish, claiming that the commercial fishing moratorium infringes upon their subsistence fishing rights and results in unfair and inequitable resource allocation between ocean-based and Indian fisheries.

In an attempt to develop a net harvest monitoring program in 1979, we hired four Indians of the reservation to contact individual Indian fishers and collect net harvest data. This approach did not succeed because of logistics problems in contacting a majority of Indian netters on a daily basis considering the remote and widely scattered locations of many nets, logistics problems in adequately supervising census personnel and because of a considerable amount of non-cooperation from many Indian fishers. Because of these problems, we attempted to estimate net harvest by applying rather arbitrary catch per net-night values obtained through contacts with a number of Indian fishers to total numbers of nets observed in the rivers arrived at through systematic aerial surveys. Utilizing this technique, we arrived at a total net harvest estimate of approximately 20,000 chinook salmon for the year (Table 5). Based on catch per net-night values observed in our net harvest monitoring program in 1980

TABLE 5. Gill net counts and estimated Indian net harvest of chinook salmon on the Hoopa Valley Reservation (HVR) in 1979 as reported in 1979.

Time Period	Mean Net Count Per Day on the HVR	Mean Net Count Per Day in the Klamath River Estuary	Estimated Mean Daily Catch per Net in the Klamath River Estuary	Estimated Mean Daily Catch From the Klamath River Estuary	Estimated Total Catch from the Klamath River Estuary	Estimated Total Catch on the Reservation
May	38	<1	--	---	-----	150
June	38	<1	--	---	-----	350
July	23	1	2	2	60	500
Aug. 1-10	45 1/	32 1/	10	320	3,200	3,400
Aug. 11-20	52 1/	28 1/	25	700	7,000	7,400
Aug. 21-31	38 1/	18 1/	20	360	3,600	4,600
Sept. 1-15	--	7	15	105	1,575	2,575
Sept. 16-30	--	7	1	7	105	605
October	--	--	--	---	-----	400
Entire Season					15,540	19,980

1/ Net count figures in August were expanded by five in an attempt to account for nets not observed.

(Figure 11), it appears that we overestimated net harvest from the Klamath River estuary in August and early September, 1979 when we assigned an overall average catch of approximately 17.5 fish per net-night to the total numbers of nets in the water, a figure arrived at through contacts with the more successful fishers. In 1980, we observed that a relatively small number of fishers caught disproportionately larger numbers of fish and that only twice during the year did daily catch per net-night values exceed 15 (Figure 11). Based on our experiences in 1980 and the knowledge that netting effort and run size were roughly comparable in 1979 and 1980, our estimate of Indian net harvest in 1979 is revised downward to 15,000 chinook salmon.

Summing up, our best estimates of Indian net harvest on the Hoopa Valley Reservation in 1977, 1978 and 1979 are 30,000, 20,000 and 15,000 chinook salmon, respectively. Assuming relatively comparable netting effort in the three years, it appears that the declining annual net harvest levels have been closely related to declining spawning runs in the river as reported by the CDFG. As noted in the next subsection, the same pattern appears to apply in 1980. On numerous occasions, a number of individuals have claimed that Indians of the Hoopa Valley Reservation have harvested on the order of 50,000 to 100,000 chinook salmon annually since 1978. It should be noted that run size estimates for these years have generally ranged between 50,000 and 100,000. It should also be noted that during the period of 1915 to 1928, when a legitimate commercial fishery operated on the Klamath River, when nearly 100 boats were engaged in the capture of fish, when the lengths of gill nets employed greatly exceeded those utilized in recent years and when salmon runs exceeded those of recent years by a factor of four of five, that an average of 52,000 salmon were caught annually (Snyder 1931).

3. The 1980 Indian Fishery

As elaborated on in Section IA3 of this report, we established a net harvest monitoring station on the lower Klamath River in 1980 and monitored lower river net harvest on a daily basis throughout the course of the run. We estimate having made approximately 5,400 contacts with individual fishers and believe that we observed about 75 percent of the Indian net harvest from the lower 9.25 km stretch of the Klamath River (below the Resighinni - Klamath Glen area). We received excellent cooperation from the Indian community and estimate that Indian net harvest from the lower river area in 1980 totaled 10,100 fall chinook salmon.

Upriver estimates of net harvest were made through periodic contacts with Indian fishers and by observing numbers of fish caught by various individuals on given days. Based on approximately 20 contacts with five Indian fishers who regularly fished the Klamath River between Klamath Glen and Pecwan, we estimate that approximately 1,000 fall chinook salmon were caught in this area. Based on approximatley 25 contacts with 10 Indian fishers who regularly fished the Klamath River between Pecwan and Weitchpec, we estimate that approximately 800 fall chinook salmon were harvested in this area. We observed that only about 15 fishers regularly fished the upper Klamath River area and it appears that these individuals accounted for the great majority of the harvest. Because of dense algal concentrations in the river, which quickly fouled up nets and greatly reduced their efficiency, many Indian people decided not to expend the time and effort required to operate and maintain gill nets in the area.

Little monitoring of the harvest from the Trinity River occurred in 1980 and our catch estimate should be viewed as more speculative than estimates derived for the Klamath River. Based on scattered sampling and reports, we estimate that net harvest from the Trinity River approximated 1,100 fall chinook salmon in 1980 leading to a reservation-wide harvest estimate of 13,000 fall chinook salmon for the year. A summary of net harvest estimates involving all species caught on the Hoopa Valley Reservation in 1980 is presented in Table 6. Unknown numbers of lamprey (*Lampetra tridentata*) and eulachon (*Thaleichthys pacificus*) were also harvested by Indian people during the year.

Indian people who fished for fall chinook salmon generally used a 30.5 m (100 ft.) net consisting of 18.4 cm (7.25 in.) stretched single-strand monofilament mesh. Other nets used in the fishery included nylon and multi-strand monofilament ranging in mesh size from 18.4 cm to 20.3 cm (8 in.) stretched.

B. THE OCEAN FISHERIES

The ocean troll fishery in California has evolved into one of the state's largest industries having accounted for landings of approximately 1.3 to 4.7 million kilograms (1,433 to 5,179 tons) of salmon annually since 1916. Since 1947, the ocean-based fisheries off California have harvested approximately one-half million to one million chinook salmon annually with the sport fisheries having accounted for relatively small percentages of the total harvests (Figure 35). Prior to 1963, chinook salmon formed the great majority of California troll landings but between 1963 and 1973, coho salmon landings increased to 25 percent of the total, an increase which coincided with expanded artificial propagation programs in Oregon and Washington. Frey (1971) noted that the intense troll fishery has selectively reduced the numbers of chinook salmon which survived to the end of their fourth or fifth years and Ricker (1980) associates, in large measure, the troll fishery with a 50 percent reduction in the mean weight of chinook salmon harvested over the last 50 years and with a decrease of one year in the average age of chinook salmon spawners.

Expansion of the troll fishery has continued as evidenced by the number of registered California commercial fishing vessels having nearly doubled between the late 1960s and 1975 (PFMC 1979) and continued increases in the number of registered vessels since 1975. Despite greater seasonal restrictions placed on the commercial troll fishery in 1979, chinook salmon landings in California increased appreciably over levels of recent years and landings at the three northern California ports, which presumably comprise relatively large proportions of Klamath River salmon, increased by approximately 55 percent over the 1978 level (Figure 36).

In conjunction with its program to manage the salmon fisheries off the coast of California, Oregon and Washington in 1980, the PFMC placed a six-week seasonal closure on the commercial troll fishery in the Fishery Conservation Zone off of northern California and southern Oregon (Figure 37). Despite this closure and relatively many days of bad ocean fishing conditions, preliminary data compiled by the CDFG reveal that California chinook salmon landings in 1980 exceeded the mean annual landing during the 1971-75 period (approximately 575,000 versus 563,000 chinook salmon). Landings at the three northern California ports approximated 299,000 chinook salmon in 1980 and during the 1971-75 period. Preliminary data compiled by the Oregon Department of Fish and Wildlife reveal that chinook salmon landings at the southern Oregon ports (Coos Bay - Brookings area) totaled about 150,000 in 1980, slightly less than the mean 1971-75 level.

TABLE 6. Estimated 1980 harvest levels of fish caught from the Klamath and Trinity rivers by Indians of the Hoopa Valley Reservation.

Species / Race	Estimated Harvest
Fall chinook salmon	13,000
Spring chinook salmon	1,000
Coho salmon	1,500
Fall steelhead	300
Winter steelhead	1,000
Green sturgeon	700 1/
White sturgeon	< 25

1/ Includes a hook and line harvest of 400 sturgeon, many of which were caught by non-Indians.

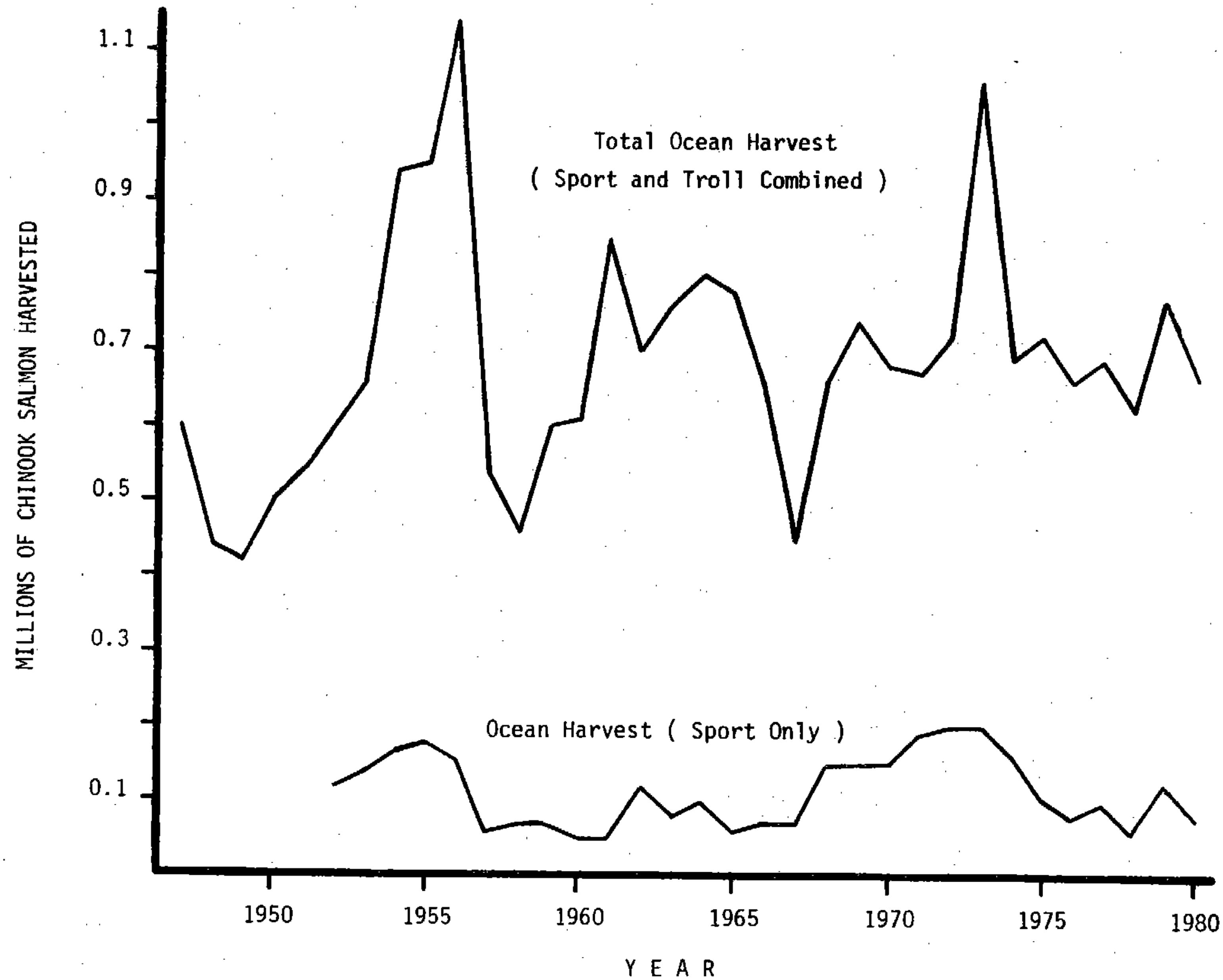


FIGURE 35. The California ocean troll and ocean sport harvest of chinook salmon from 1947 to 1980.

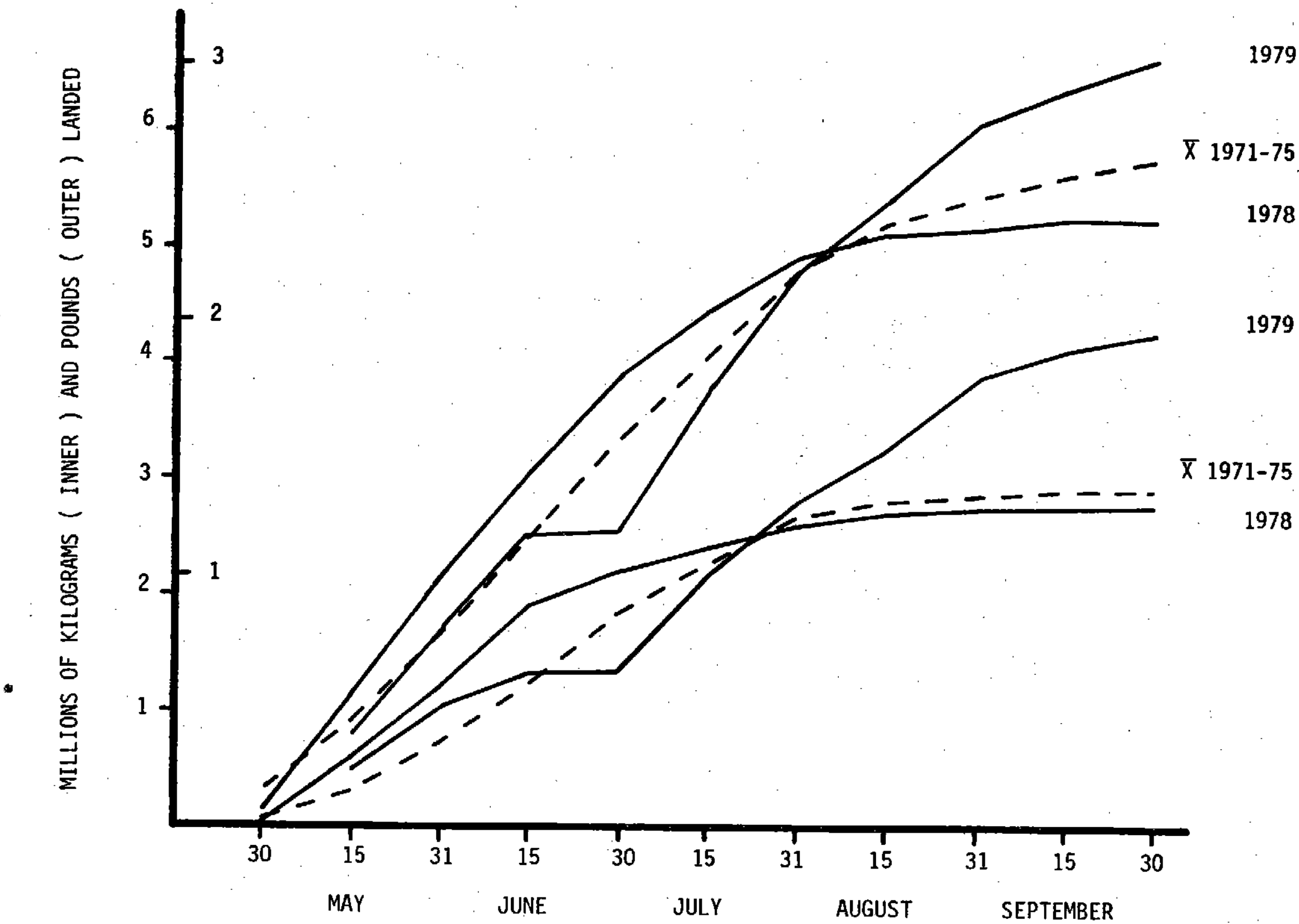


FIGURE 36. Commercial ocean landings of chinook salmon in California (upper three lines) and at the three northern California ports (lower three lines) during the 1971-75 period and 1978 and 1979 seasons.

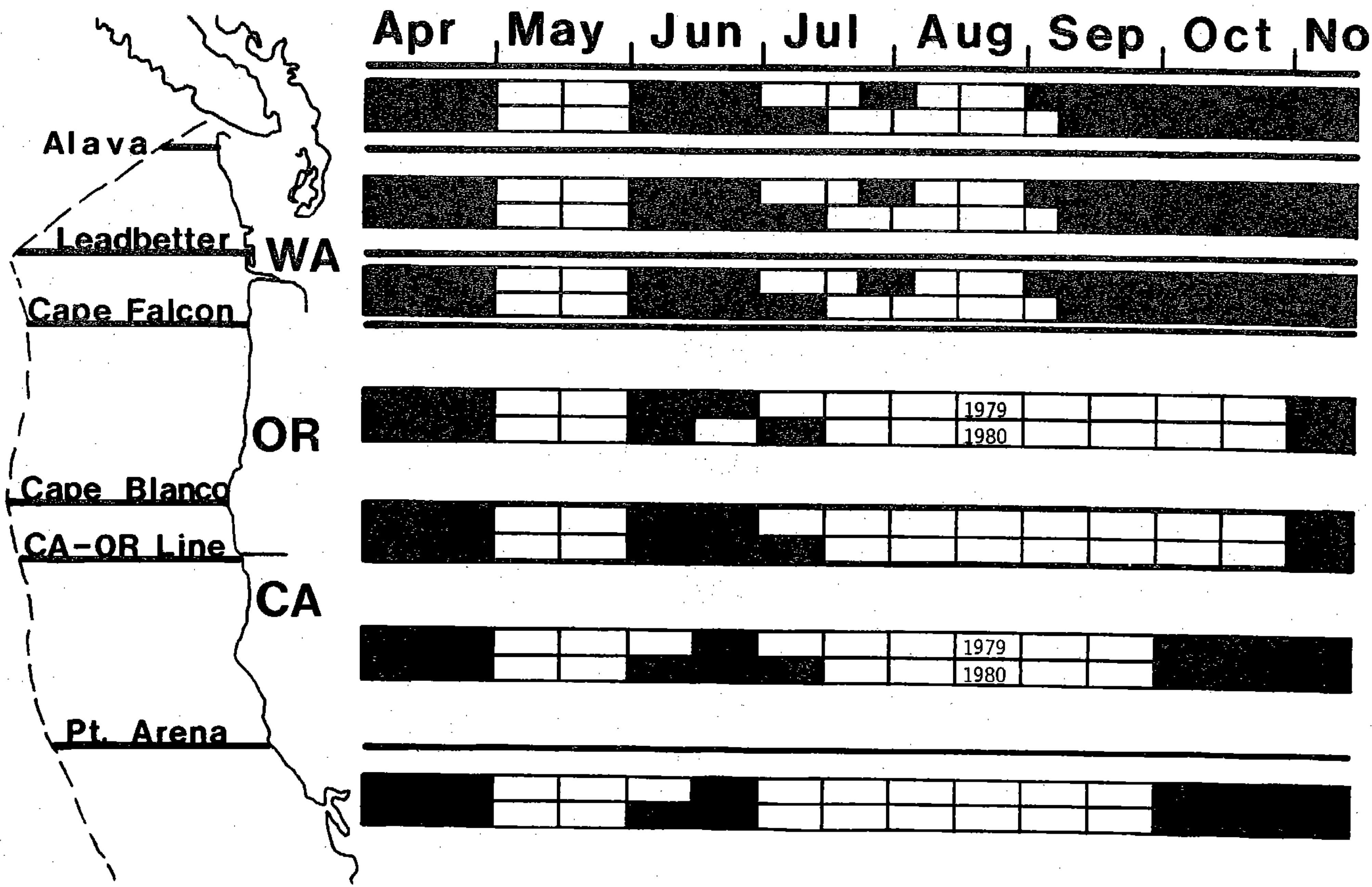


FIGURE 37. Seasonal closures (black areas) imposed on the commercial troll fishery in the various management areas of the Fishery Conservation Zone in 1979 (top halves of bar graphs) and 1980 (bottom halves of bar graphs)

Representatives of the commercial fishing industry have repeatedly asserted that the ocean fisheries account for relatively few Klamath River salmon. In beach seining operations conducted by the U.S. Fish and Wildlife Service on the Klamath River in 1980, nearly one in three adult chinook salmon captured bore hook scars. Numerous fish exhibited missing eyes, maxillaries and mandibles and several trolliing hooks were found imbedded in the fish. Nearly one in four of the grilse captured, which had been exposed to the ocean fisheries for only about one year, also displayed hook scars. Data compiled at Red Bluff Diversion Dam in the last seven years reveals that approximately one in three returning Sacramento River chinook salmon exhibit hook scars.

Ocean fisheries, in addition to accounting for large annual landings of salmon, result in the loss of large numbers of sublegal salmon each year. O'Brien, Taylor and Jensen (1972) reported that sublegal or "shaker" salmon (chinook and coho salmon less than 66 cm and 63.5 cm, respectively) comprised 71 percent (629,966 salmon) and 65 percent (485,193 salmon) of the California ocean catch in 1968 and 1969, respectively. They concluded, as did Ricker (1976), that approximately equal numbers of legal and undersized salmon comprised the Pacific coast catch. Van Hyning (1968) and Milne and Ball (1956) felt that hooking mortality rates approximated 40 percent and 50 percent, respectively. Parker and Black (1959) reported a delayed hooking mortality rate for chinook salmon of 71 percent and Jensen (1969), as reported by Wright (1972), believed that the "shaker" mortality rate for coho salmon exceeded 60 percent. Wright (1972) reviewed several hooking mortality studies and suggested a "probable hooking mortality" range of 15 to 45 percent. In a more recent analysis of "shaker" mortality studies, Ricker (1976) estimated a rate of 50 percent and concluded that one salmon dies as a result of hooking for every two legal salmon landed in the ocean fisheries.

With regard to northern California, Denega (1973) noted that waters off Eureka, Trinidad and Fort Bragg yielded a particular abundance of "shakers" consisting primarily of 2-year-old chinook salmon. During a 10-day sampling of the troll catch off Eureka and Fort Bragg in late April and early May, 1969, Boydstun (1972) observed about equal numbers of legal and sublegal chinook salmon and only 9 legal coho salmon out of 247 caught. Assuming a 30 percent hooking mortality rate, he estimated that nearly 1 salmon died through hooking for every 2 legal salmon landed.

In 1967, John Radovich, former Chief of the Marine Resources Division of the CDFG, estimated that ocean fisheries harvested approximately 308,000 Klamath River salmon per year, 88 percent of estimated total annual harvest. Applying a 40 percent shaker mortality rate, it is estimated that the ocean fisheries accounted for 431,000 Klamath River salmon annually.

Preliminary CWT returns from 1976-brood Trinity River Hatchery salmon reveal that trollers harvested these fish at a high rate in the area between Fort Bragg, California and Cape Blanco, Oregon. In exploring a rationale for determining the contribution of Klamath River salmon to northern California and southern Oregon coastal fisheries, CDFG biologists have recently estimated that Klamath River salmon comprise 40 percent of the total ocean harvest of chinook salmon between Fort Bragg and Cape Blanco, a harvest which has averaged approximately 400,000 per year over the last decade. Again applying a 40 percent shaker mortality rate, it is estimated that the northern California and southern Oregon ocean fisheries have accounted for 224,000 Klamath River salmon annually. It is widely recognized that additional Klamath River salmon are harvested in the ocean south of Fort Bragg and north of Cape Blanco.

C. THE INLAND SPORT FISHERY

Popular sport fisheries for chinook salmon and steelhead trout have developed along the Klamath and Trinity rivers with densest concentrations of anglers normally found fishing the fall chinook salmon and fall steelhead runs in the Klamath River estuary during August (Plates 23 and 24). In a statewide inventory of fish and wildlife resources (CDFG 1965), the CDFG estimated that sport fishing accounted for approximately 28,000 adult salmon per year from the Klamath River basin. A survey conducted by Department personnel indicated that sport fishermen harvested approximately 95,000 salmon in the Klamath River drainage in 1955 (Hallock, Pelgen and Fisk 1960). Census work conducted by the CDFG in recent years, assisted by the USFWS in 1978 and 1979, resulted in sport harvest estimates in the basin of approximately 10,000, 14,000, 4,000, 2,500 and 8,000 chinook salmon in 1976, 1977, 1978, 1979 and 1980, respectively.

D. HARVEST OVERVIEW

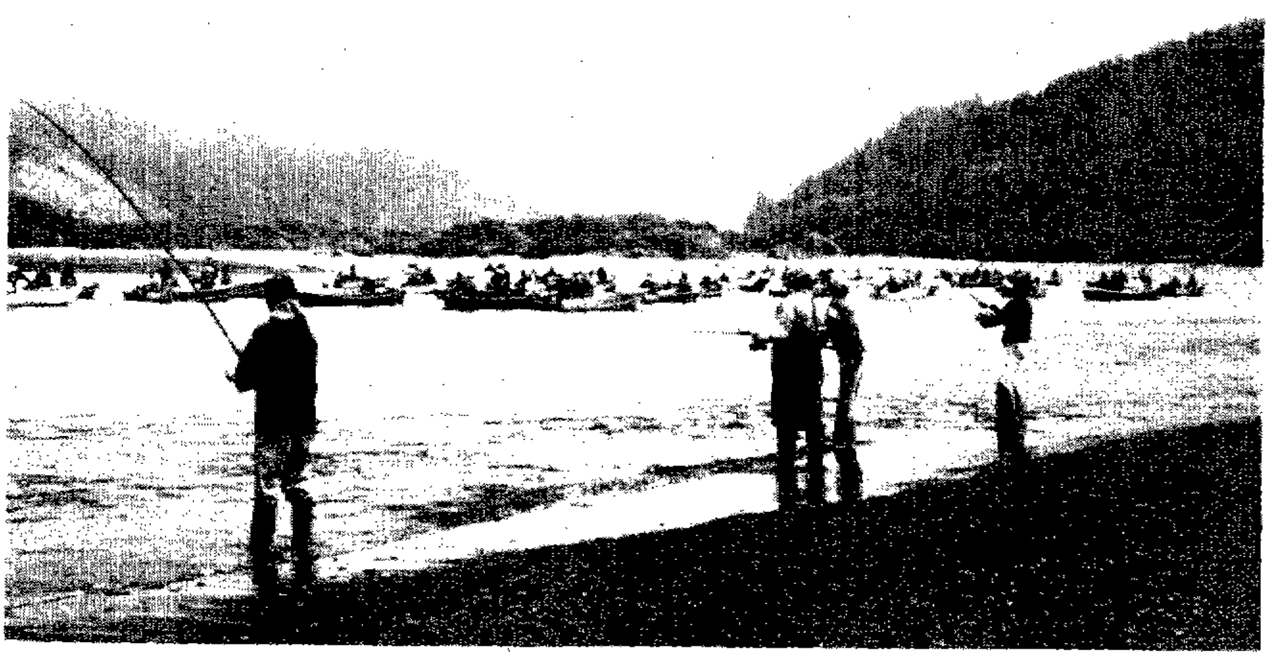
Fisheries operating off the coast of Washington, British Columbia and Alaska probably account for relatively few Klamath River salmon. Of the California and Oregon ocean fisheries, the California troll fishery has accounted for the largest numbers of chinook salmon caught offshore in recent years followed by the Oregon troll fishery, California ocean sport fishery and the Oregon ocean sport fishery (Figure 38). Hooking mortality associated with these fisheries possibly accounts for another 40 to 50 percent of the numbers of chinook landed annually.

Assuming that 40 percent of the ocean harvest of chinook salmon between Fort Bragg and Cape Blanco consists of Klamath River salmon, that this harvest represents 80 percent of the total ocean harvest of Klamath River salmon and that a 40 percent hooking mortality rate applies, it is estimated that the ocean fisheries have accounted for approximately 280,000 Klamath River salmon annually over the last decade. Approximately 95 percent of these fish were harvested in the troll fisheries and the remaining five percent were caught in the recreational fisheries. While data is unavailable for a number of years, it appears that mean annual Indian net and inland sport harvest during the last decade approximated 20,000 and 10,000 Klamath River salmon, respectively (Figure 38), approximately 7 percent and 3 percent, respectively, of total annual mortality attributable to fishing (Table 7).

TABLE 7. Estimated annual contributions of Klamath River chinook salmon to the various fisheries during the 1970's.

Fishery	Estimated Annual Harvest	Estimated Percentage of Total
Ocean Troll	266,000 1/	85.8
Indian Net	20,000	6.5
Ocean Sport	14,000 1/	4.5
Inland Sport	10,000	3.2
TOTAL	310,000	100.0

1/ Includes "shaker" mortality estimated at 40 percent of landings.



PLATES 23 and 24. Sport fishing activity in the Klamath River estuary in 1980.

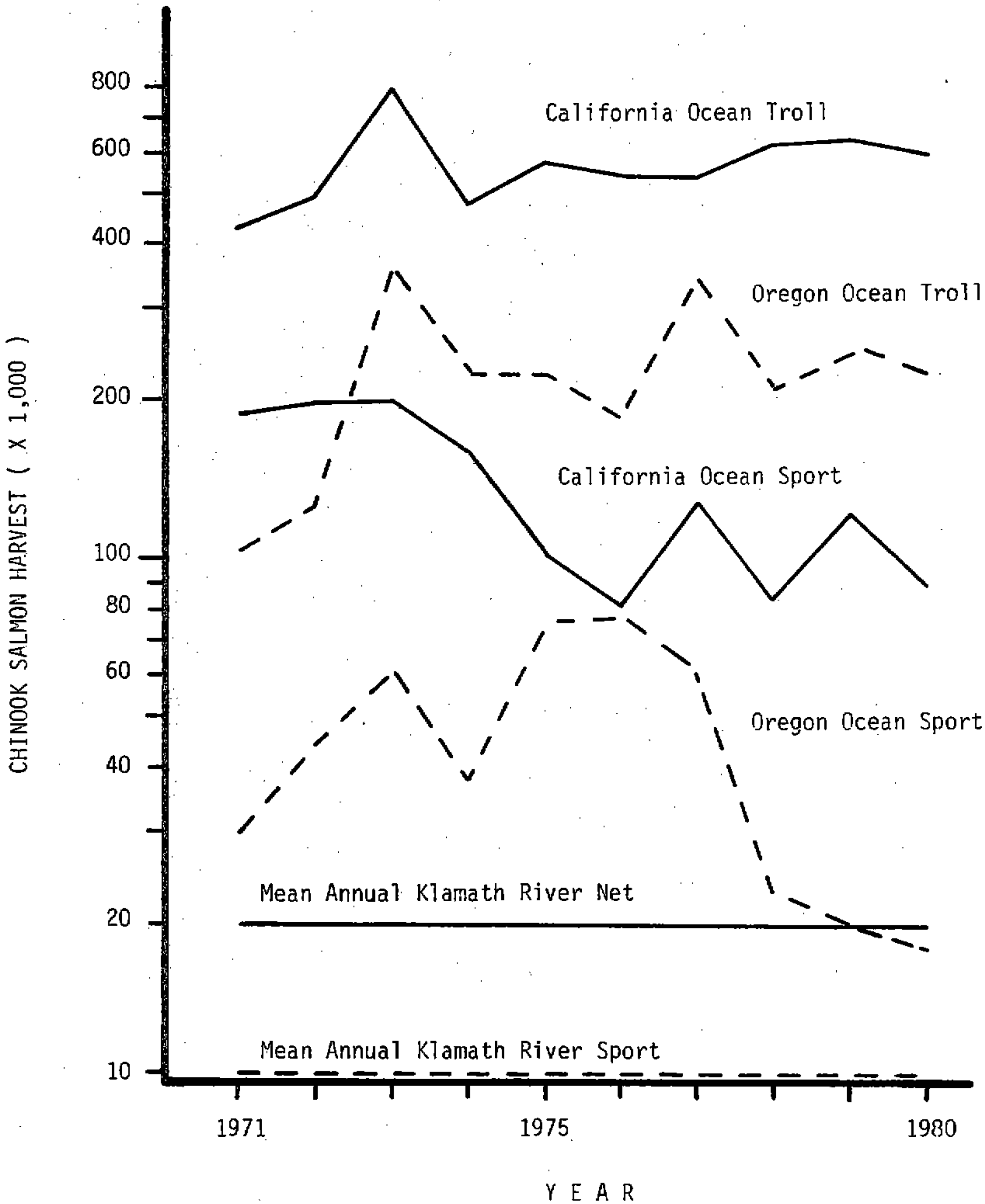


FIGURE 38. An overview of recent harvest levels associated with fisheries which account for considerable numbers of Klamath River chinook salmon (because of a lack of annual data for the net and river sport fisheries, estimated mean values for the decade are provided).

VII. WILD STOCK MANAGEMENT

As in other river systems of the Pacific Northwest, natural stocks of chinook salmon in the Klamath River drainage have experienced the continued effects of exploitation and habitat loss and degradation as reflected by declining run strengths in recent decades (Figures 39 and 40). Despite these trends, it appears that approximately 75 percent of Klamath River chinook salmon are of wild origin (see Sections III and IV). It is possible that the Klamath River and other North Coast California river systems currently result in the production of more wild chinook salmon than drainages along any other section of the Continental U.S. with the possible exception of the Columbia River basin. Clearly, the option to preserve native gene pools still exists but without significant redirection in watershed management and harvest management policy, that option may not be available in the not too distant future. Regional anadromous fish management policy of the USFWS (USFWS 1979a) favors wild fish over hatchery fish strains with emphasis placed on maintaining and restoring naturally occurring runs.

As human population continues to expand, competing resource user groups will undoubtedly place additional demands on water and timber resources of the Klamath River basin to the continued detriment of wild stocks. Doubters of this supposition need only look at the Columbia and Sacramento - San Joaquin river systems. As biologists, we can do little more than direct attention to resource costs associated with these demands and accompanying activities, remain vigilant to associated fisheries impacts and take whatever action we can to provide for appropriate resource protection and mitigation in the context of other societal demands. In conjunction with these duties, FAO-Arcata staff provided input into the 1980 Environmental Impact Statements concerning the proposed inclusion of five California rivers, including the Klamath and Trinity rivers, in the National Wild and Scenic Rivers System and regarding the management of flows in the Trinity River for fisheries mitigation purposes. In follow-up efforts to a completed field survey of reservation waters (USFWS 1979b) and a watershed condition inventory of the Hoopa Valley Reservation (Mayer and Fox 1979), completed through the assistance of the National Aeronautics and Space Administration, we continued to assist the BIA in a stream clearance program on the reservation (Plates 25 and 26). We also continued to work with the BIA in developing appropriate logging guidelines and in reviewing and commenting on timber harvest plans for the reservation.

Working through the Trinity River Basin Fish and Wildlife Task Force, we continued to implement a chinook salmon reseeding program in three tributary streams (Pine, Mill and Supply creeks) on the Hoopa Square portion of the reservation. Utilizing a fish rearing station constructed in Hoopa in 1978 (Plates 27 and 28) with the help of the Hoopa Valley Tribe and eggs and fish obtained from the CDFG, we reared 116,000 chinook salmon in 1979 and 1980 and stocked these fish into the three streams (Plate 29) after fish migration barriers had been removed. A fish weir and trapping facility constructed on Supply Creek was utilized to monitor out-migrant levels and spawner returns (Plates 30 and 31). Because of funding problems, this program will be terminated in 1981 but the fish rearing station and Supply Creek weir and trapping facility may be incorporated into a rearing pond program on the reservation currently being considered by the BIA.

In the interest of wild stocks, habitat problems of the Klamath River basin will continue to be addressed by the USFWS, CDFG, U.S. Forest Service and other concerned agencies. It must be recognized, however, that decades would be required before significant habitat improvement measures (e.g., increased Trinity River flows or improved logging practices) would be reflected by large, sustained

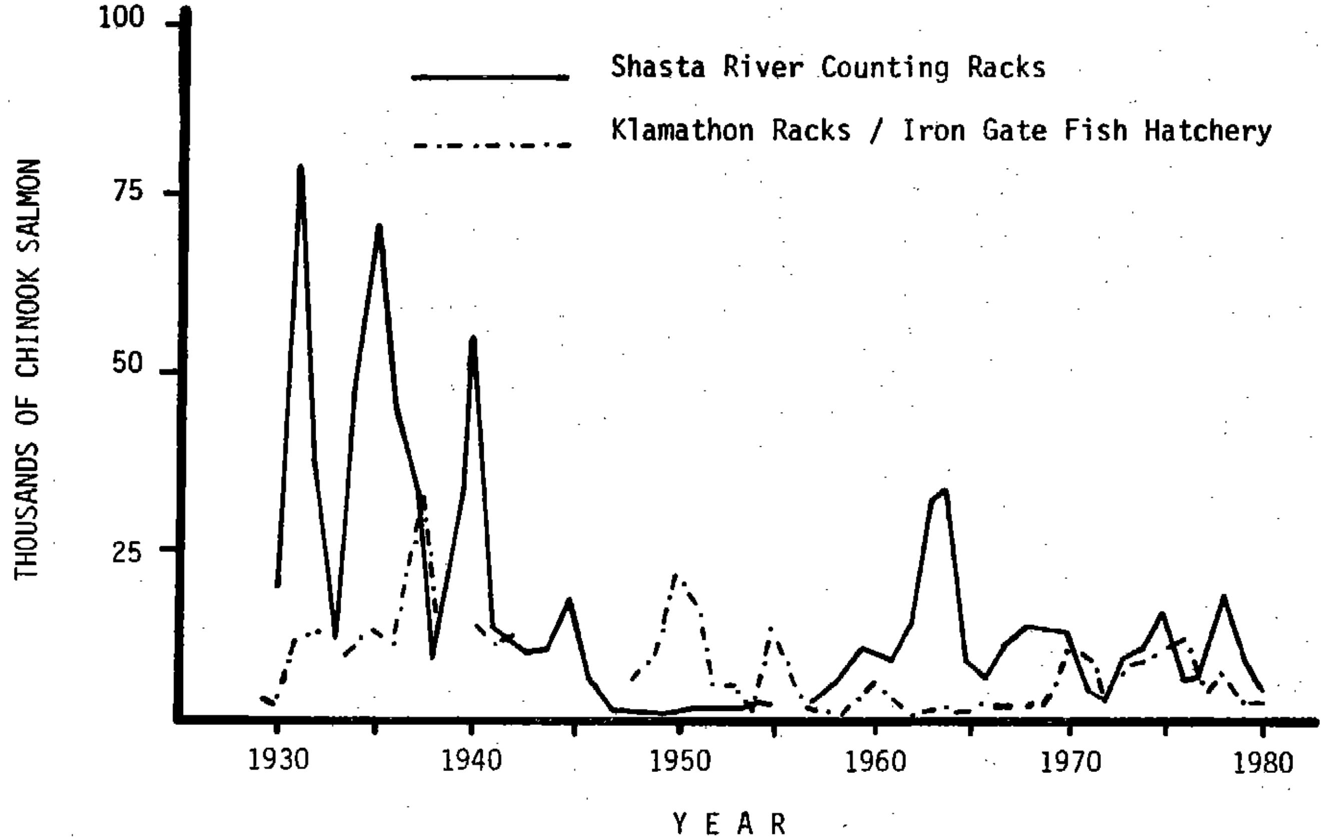


FIGURE 39. Chinook salmon spawner returns to the Shasta River Counting Racks and Klamathon Counting Racks / Iron Gate Hatchery from 1930 to 1980.

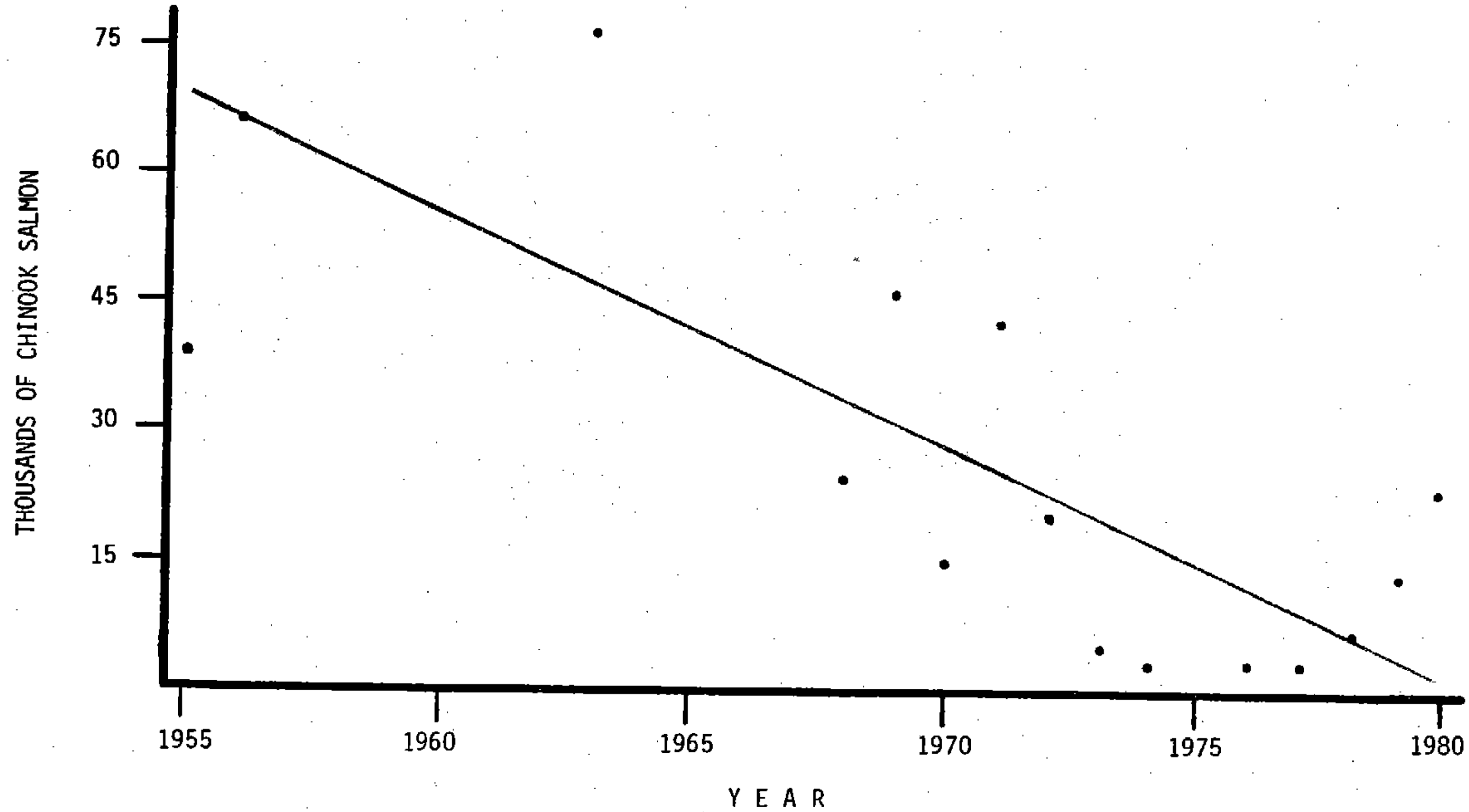
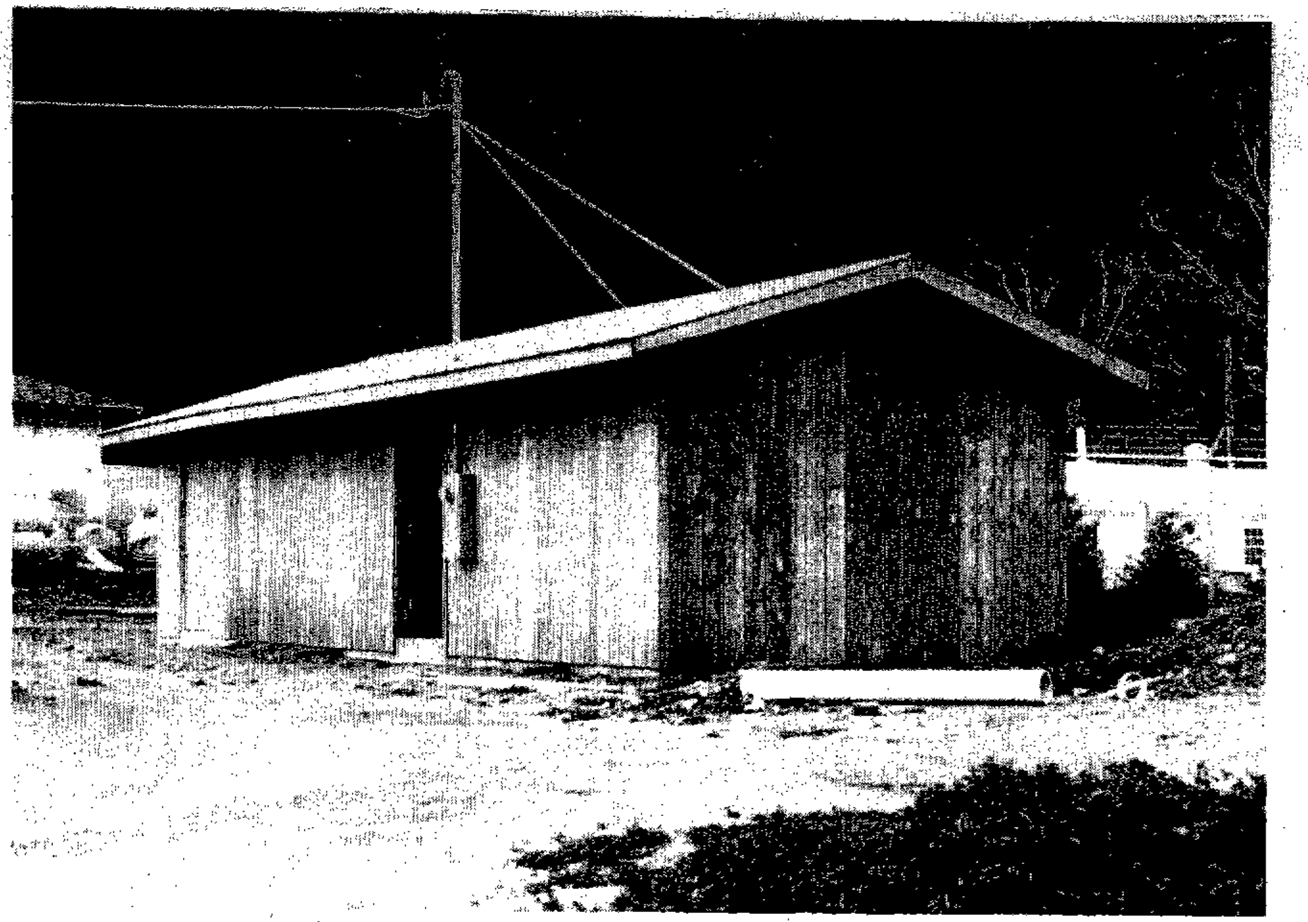


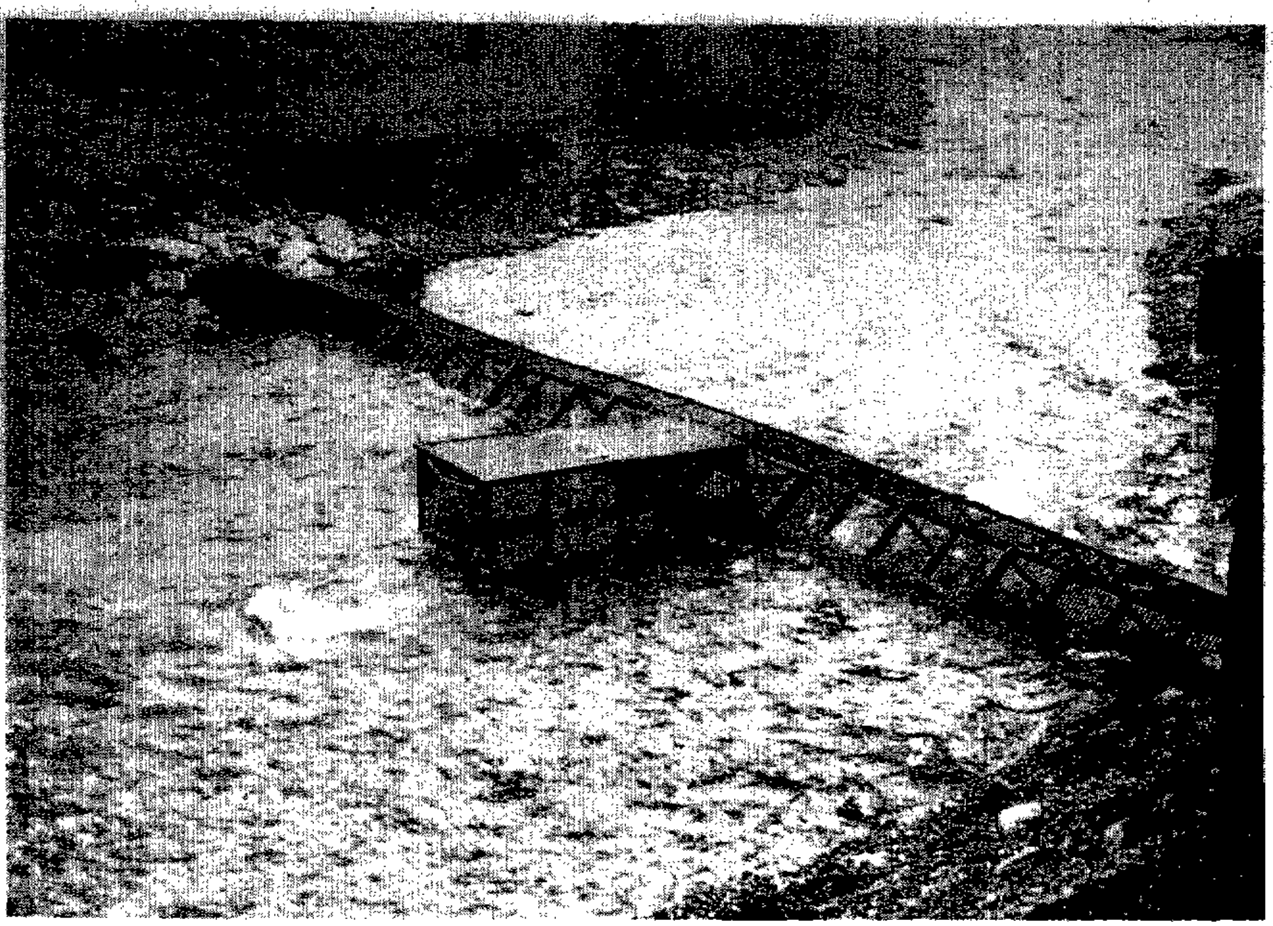
FIGURE 40. Spawner escapement estimates of chinook salmon in the Trinity River from 1955 to 1980 (point estimates for years 1955 to 1978 from Frederiksen, Kamine and Associates, Inc. 1979; point estimates for 1979 and 1980 from Pacific Fishery Management Council 1980).

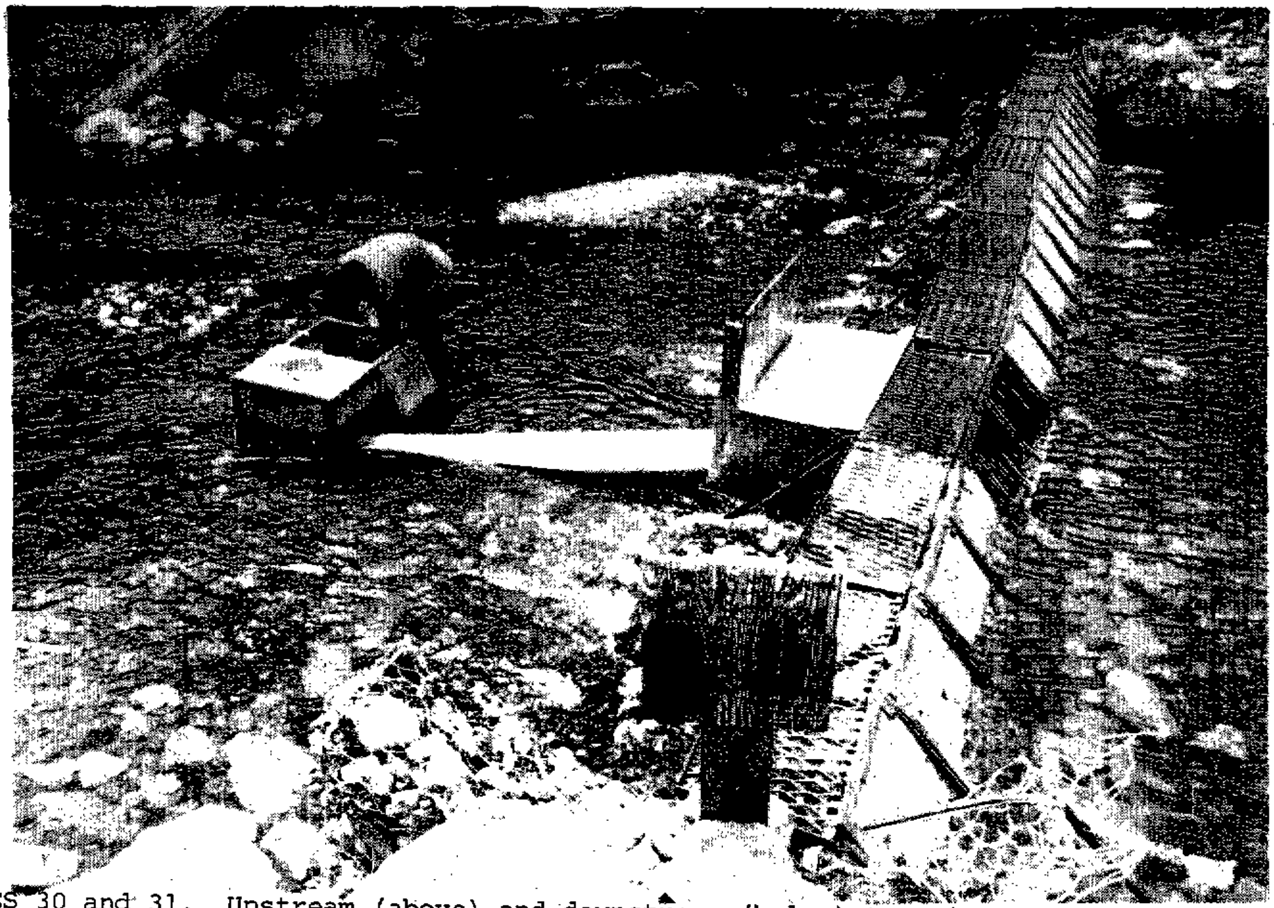
PLATES 25 and 26. Stream clearance work conducted by enrollees of the Young Adult Conservation Corps on the Hoopa Valley Reservation.



PLATES 27 and 28. The Hoopa Valley Fish Rearing Station constructed in Hoopa, California in 1978.

PLATE 29. Juvenile chinook salmon reared at the Hoopa Valley Fish Rearing Station being stocked into Supply Creek.





PLATES 30 and 31. Upstream (above) and downstream (below) trapping functions of the Supply Creek weir and fish trapping facility.

increases in spawner escapement levels. It must also be realized that habitat improvement measures alone will not greatly improve the status of overexploited wild stocks.

The U.S. Forest Service, Bureau of Land Management and a variety of other agencies spend millions of dollars annually to restore chinook salmon habitat. Management personnel may have difficulty justifying such expenditures in the name of wild stock enhancement if niches created remain unfilled and as artificial propagation programs expand to keep pace with demands imposed by commercial, recreational and subsistence fishing interests. A large pond rearing program proposed for the Klamath River basin and the proposed construction of the third hatchery in the drainage may result in increased salmon availability to the user groups at the expense of wild stocks in the system. Reisenbichler and McIntyre (1977) noted significant differences in survival between wild steelhead and a hatchery stock only two generations removed from the wild and they concluded that interbreeding among wild and hatchery stocks on natural spawning grounds can result in a significant depression of adult returns. Recent investigations by the CDFG revealed that the straying of hatchery-reared chinook salmon occurs to a large degree in the Trinity River basin, possibly in response to past releases of hatchery-reared salmon at sites located far below the Trinity River Hatchery. Larkin (1974) stated: "The problem of harvesting the new production from enhancement programs is essentially an extension of existing problems of joint harvesting of natural stocks. It has been increasingly apparent in recent years that the intense fishery is slowly but irrevocably eliminating less productive natural runs. It seems difficult to imagine how this trend can be reversed. With so many individual stocks, it is technically impossible to manage each separately . . . . It thus seems an inevitable long-term consequence of a heavy fishery that the least productive stocks will have to be sacrificed if the most productive are to be utilized, and that salmon-enhancement programs, if they are successful, will accelerate the process." In reviewing the history of artificial propagation as a means of salmon enhancement, Larkin (1979) noted that " . . . enthusiasms for a quick doubling of the numbers of salmon had to be quenched by the appreciation that hyperefficient hatchery practices would have major potentials for creating many kinds of mischief. In addition to the biological questions concerning the impact of cultured fish on the genetics and disease risks of wild fish, there were the more immediately troublesome questions centered on how to harvest the fruits of enhancement without damaging natural production."

McIntyre (1979) stated that harvest rates in excess of 60 percent would prevent escapements required to maintain maximum sustained yield levels and recommended that the harvest rate of Klamath River chinook salmon stocks should not exceed 60 percent. Gunsolus (1978) stated that the percentage of available coho salmon caught by the troll fishery in the Oregon index area increased from 55 to 65 percent since the 1960's resulting in escapement levels considered inadequate to sustain wild stocks and he recommended a 10 percent reduction in the ocean catch to return wild stocks to satisfactory levels. Referring to an allowable harvest rate of 62 percent for wild stocks as compared to the likely prevailing rate of 70 to 80 percent, Frederiksen, Kamine and Associates, Inc. (1979) stated that the harvest of Trinity River chinook salmon exceeds the capability of wild stocks from sustaining themselves and noted that recent ocean harvest rates have reached levels sufficient to reduce wild stock levels regardless of habitat conditions in the Trinity River basin. Denega (1973), citing L.B. Boydstun and P.T. Jensen of the CDFG, stated that wild fish comprised 90 percent of California chinook salmon landings and that the commercial harvest exceeded maximum sustained levels. During the period from 1930 to 1960, when

California ocean landings consisted primarily of wild salmon, there appears to have existed a generally inverse relationship between ocean harvest levels and spawner escapement levels of wild chinook salmon in the Shasta River (Figure 41). Gunsolus (1978) reported a similar relationship for coho salmon of Columbia River origin.

As noted by Larkin (1979), fishery regulation must be geared to achieving spawner escapement levels that are adequate both quantitatively and qualitatively rather than on the economic or social circumstances of the fisheries. While the establishment of the 115,000 spawner escapement goal for the Klamath River basin in 1978 represented a step forward, the goal does not discriminate between naturally produced and artificially propagated fish and consequently, does not afford adequate protection for wild stocks. Because of differences which exist between the survival of fish reared in a hatchery versus the natural environment (Figure 42), it would appear appropriate to establish separate goals taking into account wild stock requirements. It would also appear appropriate not to reduce the established goal in years of anticipated low runs to prevent economic disruption in a fishery as was done by the PFMC in 1980 with regard to the commercial troll fishery, unless such a reduction can be supported on a biological basis. The PFMC now considers the original 115,000 figure as a "long term goal" not scheduled to be reached for 2 complete cycles (8 years) given average environmental conditions. In 1979, the PFMC stated that the exploitation level which could be sustained for regional aggregates of important wild stocks would be used by the Council in establishing maximum fishing rates (PFMC 1979).

It appears that management entities simply cannot effectively deal with the problems presented by roughly equal fishing pressure on mixed stocks within an area. The PFMC (1979) stated: "Naturally and artificially produced salmon stocks of varying run strengths cannot be harvested at an equal rate without adversely impacting one or the other. Fisheries which operate in areas where both naturally and artificially produced stocks are present will either overfish natural stocks or underfish hatchery stocks." Perhaps the question of where we go from here hinges upon society's perception of wild stock protection in the context of increasing demands for the salmon resource. Should society opt for management policy which basically favors continued maximum yields of salmon at the possible expense of less productive wild stocks, management agencies could conceivably divert funds earmarked for habitat restoration and stock assessment to a variety of artificial propagation programs, e.g., hatcheries, rearing ponds and sea ranching, and produce enough fish to satiate demand and allow for a large mixed-stock commercial fishery. Should society, on the other hand, place priority on maintaining and restoring wild stocks, management agencies may have to reexamine the way in which they implement "optimum" policy, especially as it relates to the nature and extent of relatively unmanageable mixed stock commercial fisheries as opposed to selective stock fisheries. In the absence of some form of societal expression, management agencies will probably continue to establish policy influenced to a disproportionate degree by the desires of the user groups involved in harvesting the resource and the individual biases of biologists and administrators involved in the implementation of "optimum" fishery management policy. Larkin (1979) noted that "The only realistic prognosis for salmon is a long and slow decline in abundance, tempered by the amelioration of some of the effects of environmental attrition and the fisheries by an array of enhancement techniques. To make it otherwise will require outspoken recognition of the present situation and a commitment to experimental management coupled with long-term research. To achieve doubling of present levels of abundance with our current attitudes doesn't look all that likely: Maybe we can't get there from here."

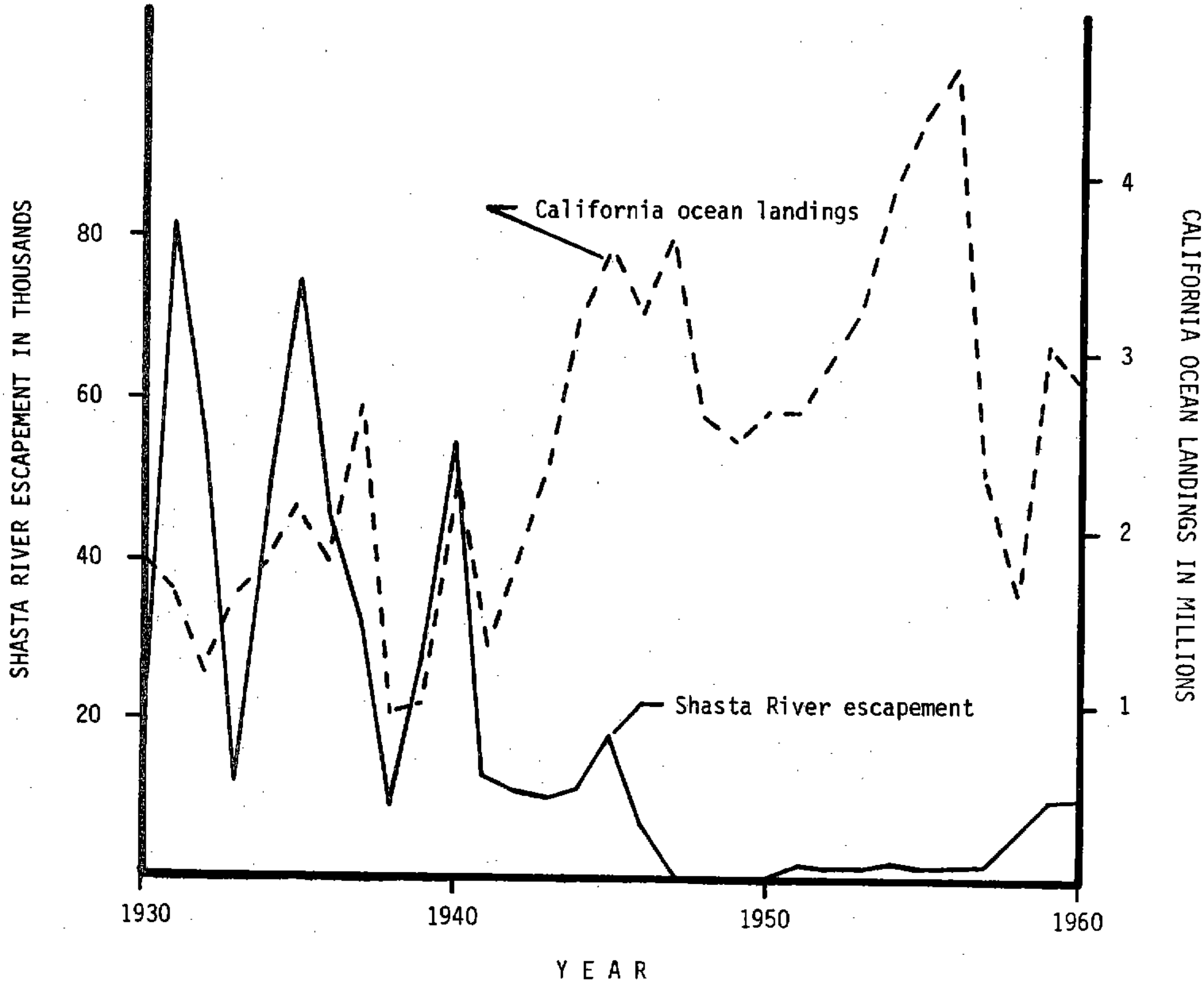


FIGURE 41. Ocean landings of primarily wild chinook salmon in California as compared to spawner returns of wild chinook salmon in the Shasta River, Klamath River basin, during the years 1930 to 1960.

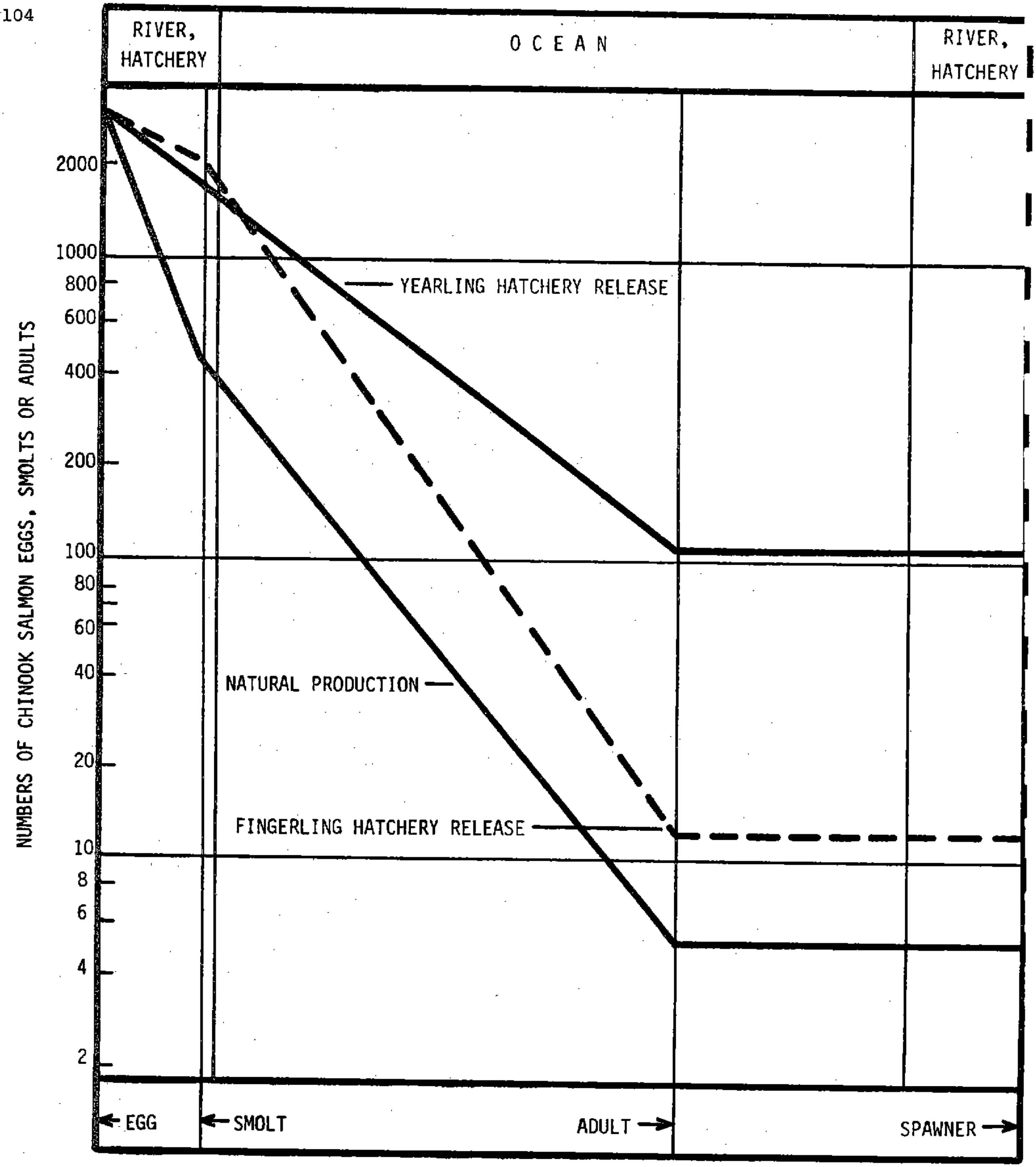


FIGURE 42. Estimated survival of wild versus hatchery reared chinook salmon in the Trinity River drainage during various life history stages under a no harvest scenario (redrawn from Frederiksen, Kamine and Associates, Inc. 1979).

VIII. REFERENCES

Boydstun, L.B. 1972. The ages and lengths of king salmon (*Oncorhynchus tshawytscha*) and silver salmon (*Oncorhynchus kisutch*) in a troll catch made off northern California during 1969. California Department of Fish and Game. Administrative Report Number 72-13. 14pp.

____. 1980. Problems in determining fall king salmon run size in the Klamath River by tagging in the lower river. Draft report. California Department of Fish and Game. Rancho Cordova, California. 17pp.

____ and J.S. Hopelain. 1978. Fall runs of king salmon and silver salmon in the Klamath River in 1976. Preliminary draft. California Department of Fish and Game. 19pp.

California Department of Fish and Game. 1965. California Fish and Wildlife Plan. Vol III: 323-679.

____. 1978. Letter from Director, California Department of Fish and Game to Regional Director, U.S. Fish and Wildlife Service dated March 24, 1978. Sacramento, California. 10pp.

Chapman, D.W. 1953. Studies on the life history of Alsea River steelhead. Journal of Wildlife Management 22 (2): 123-134.

Denega, M.M. 1973. Age composition and growth rates of chinook salmon from northern California's salmon troll fishery. M.S. Thesis. Humboldt State University. Arcata, California. 56pp.

Frederiksen, Kamine and Associates, Inc. 1979. Trinity River basin fish and wildlife management program - Draft report. Sacramento, California. 6 Volumes.

Frey, H.W. 1971. California's living marine resources and their utilization. California Department of Fish and Game. Sacramento, California. 148pp.

Fry, D.H. 1973. Anadromous fishes of California. California Department of Fish and Game. 111pp.

Gunsolus, R.T. 1978. The status of Oregon coho and recommendations for managing the production, harvest and escapement of wild and hatchery-reared stocks. Oregon Department of Fish and Wildlife. Clackamas, Oregon. 59pp.

Hallock, R.J., D.E. Pelgen and L.O. Fisk. 1960. Fish, game and recreation in the Klamath River basin of California. California Department of Water Resources. Bulletin No. 83: 149-165.

Healey, T.P., Jr. 1970. Studies of steelhead and salmon emigration in the Trinity River. California Department of Fish and Game. Anadromous Fisheries Branch Administrative Report 73-1. 37pp.

Hoptowit, D.R. 1980. Klamath - Trinity salmon restoration project - final report. California Resources Agency. Sacramento, California. 92pp.

Jensen, P.T. 1969. A review of the sublegal salmon situation in California's commercial troll fishery. California Department of Fish and Game. Sacramento, California. 5pp.

Larkin, P.A. 1974 Play it again Sam - an essay on salmon enhancement. Journal of the Fisheries Research Board of Canada 31:1433-1456.

____. 1979. Maybe you can't get there from here: a foreshortened history of research in relation to management of Pacific salmon. Journal of the Fisheries Research Board of Canada 36:98-106.

Mayer, K.E. and L. Fox III. 1979. Watershed condition inventory of the Hoopa Valley Indian Reservation utilizing Landsat digital data. Fisheries Assistance Office and Humboldt State University. Arcata, California. 46pp.

McIntyre, John D. 1979. The Service's Fisheries Assistance Program in California. U.S. Fish and Wildlife Service - Internal Report. Red Bluff, California. 18pp.

Milne, D.J. and E.A. Ball. 1956. The mortality of small salmon when caught by trolling and tagged or released untagged. Fisheries Research Board of Canada. Pacific Coast Station. Progress Report Number 106:10-13.

Moffett, J.W. and S.H. Smith. 1950. Biological investigations of the fishery resources of Trinity River, Calif. Special Scientific Report: Fisheries Number 12. U.S. Fish and Wildlife Service. Washington, D.C. 71pp.

Moyle, P.B. 1976. Inland fishes of California. University of California Press. Berkeley, California. 405pp.

O'Brien P., S.N. Taylor and P.T. Jensen. 1972. A review of chinook and coho shaker catches in the Pacific coast troll fishery. Pacific Marine Fisheries Commission. Annual Report - 1972:75-84.

Pacific Fishery Management Council. 1979. Comprehensive plan for the management of the commercial and recreational salmon fisheries off the coasts of California, Oregon and Washington - Preliminary review draft. Portland, Oregon. 315pp.

____. 1980. Proposed plan for managing the 1980 salmon fisheries off the coast of California, Oregon and Washington - Draft. Portland, Oregon. 125pp.

Parker, R.R. and E.C. Black. 1959. Muscular fatigue and mortality in troll-caught chinook salmon (*Oncorhynchus tshawytscha*). Journal of the Fisheries Research Board of Canada 16:95-106.

Parker, R.R. and P.A. Larkin. 1959. A concept of growth in fishes. Journal of the Fisheries Research Board of Canada 16:721-745.

Radovich, J. 1967. Salmon resource of the Klamath River system. California Department of Fish and Game Memorandum. 2pp.

Reimers, P.E. 1973. The length of residence of juvenile fall chinook salmon in Sixes River, Oregon. Oregon Fish Commission, Research Report - 4(2):1-43.

Reisenbichler, R.R. and J.D. McIntyre. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, Salmo gairdneri, Journal of the Fisheries Research Board of Canada 34:123-128.

Ricker, W.E. 1958. Handbook of computations for biological statistics of fish populations. Fisheries Research Board of Canada. Bulletin 119. Ottawa, Canada. 300pp.

_____. 1976. Review of the rate of growth and mortality of Pacific salmon in salt water, and noncatch mortality caused by fishing. Journal of the Fisheries Research Board of Canada 33:1483-1524.

_____. 1980. Causes of the decrease in age and size of chinook salmon (*Oncorhynchus tshawytscha*). Canadian Technical Report of Fisheries and Aquatic Sciences No. 944. Nanaimo, British Columbia. 25pp.

Schluchter, M.D. and J.A. Lichatowich. 1977. Juvenile life histories of Rogue River spring chinook salmon, *Oncorhynchus tshawytscha* (Walbaum) as determined by scale analysis. Oregon Department of Fish and Wildlife. Information Report Series - Fisheries 77-5. 24pp.

Snyder, J.O. 1931. Salmon of the Klamath River. California Division of Fish and Game. Fisheries Bulletin No. 34. 129pp.

U.S. Fish and Wildlife Service. 1979a. Regional policy book. Sections on anadromous fish management and fisheries problems dealt with by the Pacific Fishery Management Council. Portland, Oregon. 3pp.

_____. 1979b. Final report - Hoopa Valley Indian Reservation - inventory of reservation waters, fish rearing feasibility study and a review of the history and status of anadromous fishery resources of the Klamath River basin. Fisheries Assistance Office, Arcata, California. 134pp.

_____. 1980. Important resource problem source document. Washington, D.C. 6pp.

Van Hyning, J.M. 1968. Factors affecting the abundance of fall chinook salmon in the Columbia River. PhD. Thesis. Oregon State University. 424pp.

Wright, S. 1972. A review of the subject of hooking mortalities in Pacific salmon (*Oncorhynchus*). Pacific Marine Fisheries Commission. Annual Report - 1970:47-65.

Young, J. 1969. Indian fishery - lower Trinity River Division, North Coast project. U.S. Fish and Wildlife Service. Internal memorandum dated January 16, 1969. 1p.