# ANNUAL REPORT

# KLAMATH RIVER FISHERIES INVESTIGATIONS

# PROGRESS, PROBLEMS AND PROSPECTS

# 1979

U.S. Fish and Wildlife Service

Arcata Fisheries Assistance Office

Arcata, California

November 21, 1979

TABLE OF CONTENTS

# LIST OF FIGURES

## LIST OF TABLES

# ANNUAL REPORT
# KLAMATH RIVER FISHERIES INVESTIGATIONS
# PROGRESS, PROBLEMS AND PROSPECTS
# 1979

Fisheries investigations conducted in the Klamath River basin and Hoopa Valley Indian Reservation in recent years have failed to provide the kind of reliable data required by decision makers involved in run-size estimation and in-season adjustment processes. Biologists have not succeeded in developing an in-season run-size prediction program or in establishing a dependable spawner escapement estimation program involving fall chinook salmon. We also have not succeeded in collecting adequate data on other important species in the drainage including green and white sturgeon, summer and winter steelhead and spring chinook salmon, all of which comprise portions of annual net harvest. Significant program redirection must take place, including changes in emphases of various components in the fisheries investigation program and involving revisions of federal regulations governing Indian fishing on the reservation, before meaningful progress can occur.

This report addresses the catch-escapement evaluation portion of the investigation program, focusing on progress made and problems encountered in 1979 and on recommended future courses of action for each of the study segments in which we have been involved. The report concludes with an overall study plan.

## I. OCEAN HARVEST EVALUATION

### Description

Biologists will attempt to determine contributions of Klamath River salmon to ocean fisheries through coded-wire tagging programs, offshore harvest monitoring and through a sampling program in the Klamath River to ascertain proportions of hatchery-reared and wild salmon comprising annual production and spawning runs. The California Department of Fish and Game (CDFG) has initiated a coded-wire tagging program at Trinity River and Iron Gate hatcheries and compiles harvest and tag return data through the annual ocean harvest monitoring program. Biologists from CDFG and Arcata FAO participate in river sampling programs.

### Progress and Problems

Data concerning the magnitudes of Klamath River salmon involved in ocean landings and associated hooking mortality rates is very incomplete. Moffett and Smith (1950) estimated that Klamath River salmon contributed about 2.3 million pounds (approximately 230,000 salmon) annually to the offshore commercial catch during the period 1916 to 1943. Hallock, Pelgen and Fisk (1960) estimated that approximately 218,000 Klamath River salmon were harvested offshore annually (circa 1955). Radovich (1967), former Chief of the Marine Resources Branch with the CDFG, estimated that 88 percent of total annual landings of Klamath River salmon were attributable to ocean fisheries which accounted for approximately 308,000 salmon annually.

State and federal biologists have generally agreed that at least two chinook salmon of Klamath River origin are caught in the ocean for each one returning to the river (a 67 percent ocean harvest rate). Data collected from salmon originating in other river systems, however, reveal 3:1 to 6:1 catch-escapement ratios. Fin-clipped 1968-brood spring chinook salmon released from Trinity River Hatchery experienced nearly a 70 percent ocean harvest rate. With the additional summer that fall chinook salmon spend in the ocean, higher ocean harvest rates can be expected. Data from tagged fall chinook salmon of Sacramento River origin indicated ocean harvest rates exceeded 70 percent. Assuming a 3:1 catch-escapement ratio for fall chinook salmon of Klamath River origin and an annual run in the river of 150,000, it follows that approximately 450,000 Klamath River salmon are taken offshore each year.

Young chinook tend to migrate northward after entering the ocean. Consequently, chinook salmon from the Klamath River contribute to the Oregon and southern Washington fisheries before moving back south to California waters as maturing fish. It is generally believed that the California ocean catch of chinook salmon comes mainly from California and Oregon coastal stocks while the Oregon catch is comprised mainly of Oregon coastal stocks, California stocks and fish from the Columbia River. North coastal California stocks also contribute to the Washington catch, especially early in the season. In recent years, according to data accumulated by the Pacific Fishery Management Council, the California offshore commercial and sport fisheries have accounted for an average annual harvest of approximately 744,000 chinook salmon. The average annual harvest off the Oregon coast during the 1971-75 period included approximately 208,000 chinook salmon in the commercial troll fishery and an additional 50,000 chinook salmon in the offshore sport fishery. The average annual harvest off the coast of Washington during the same period included about 280,000 chinook salmon in the commercial troll fishery and an additional 211,000 chinook in the offshore sport fishery.

An historical perspective of salmon landings in California is presented in Figures 1 and 2. Data compiled by the CDFG reveals that under the 1979 offshore fishing regulations, chinook salmon harvest levels off California increased considerably above 1978 levels (Figure 3). Troll fishermen harvested 640,104 chinook salmon (6,600,630 pounds) off California in 1979, 1,364,084 pounds more than the 1978 harvest and considerably more than mean annual harvest levels during the last decade. Troll landings at the three northern California ports (Crescent City, Eureka and Fort Bragg), which presumably comprise greater proportions of Klamath River salmon than do other ports in the state, totaled 4,270,615 pounds (445,552 salmon), approximately 55 percent more than the 2,747,907 pounds landed at north coast ports in 1978 (Figure 4). Coho salmon troll landings in California and the three northern ports (Figures 5 and 6, respectively) were fairly low in 1978 and 1979. Had the troll fishery off California been closed September 15, as requested by Secretary Andrus, approximately 23,200 salmon would have been spared including about 18,700 landed at north coast ports, many of which presumably would have returned to the Klamath River.

Figure 1. California commercial salmon landings from 1915 to 1970.

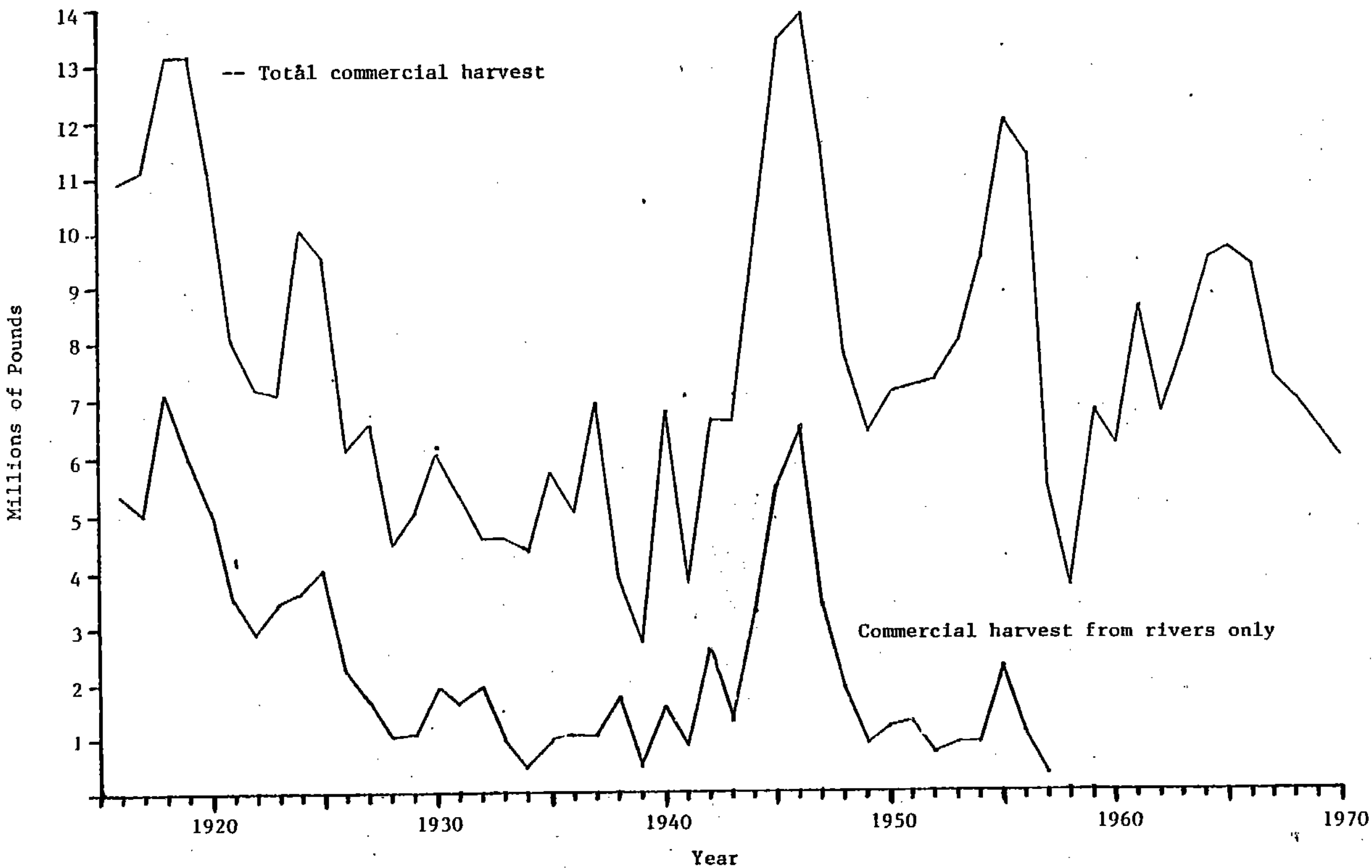


Figure 2. Chinook salmon harvest by the California troll and offshore sport fisheries from 1947 to 1978.

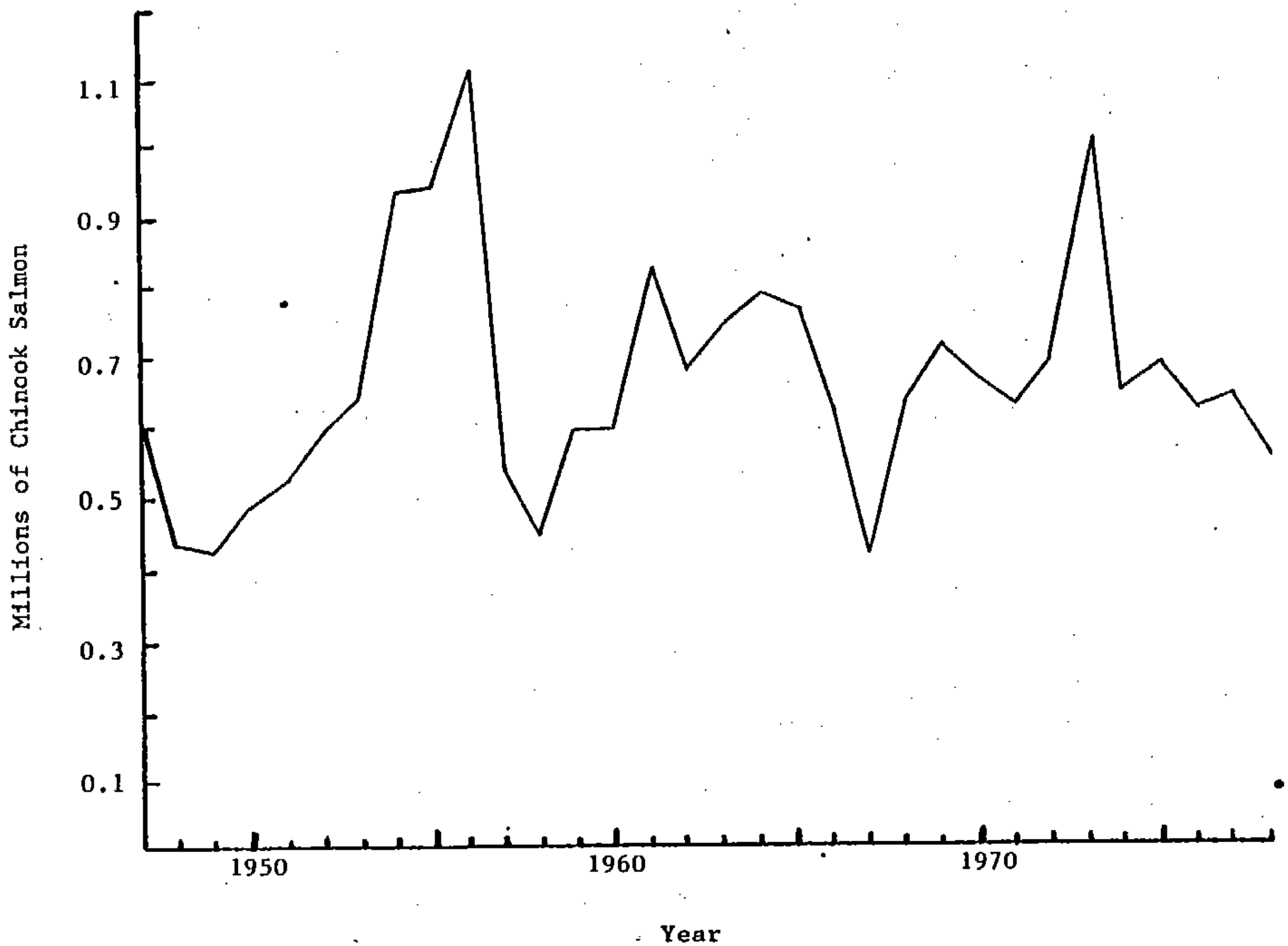


Figure 3. Cumulative troll landings of chinook salmon in California in 1978, 1979 and during the 1971-75 period.

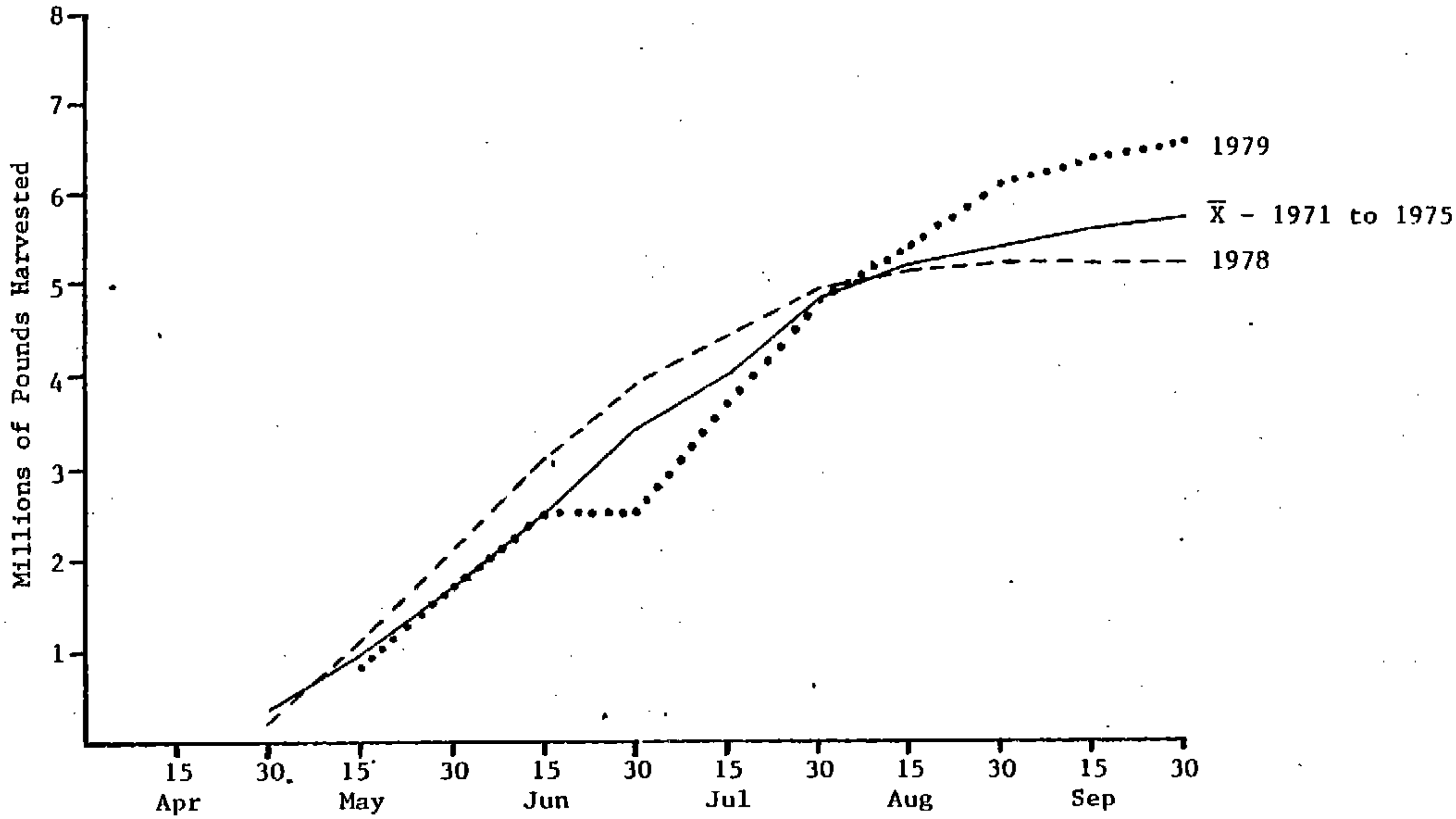


Figure 4. Cumulative troll landings of chinook salmon at the three northern California ports in 1978, 1979 and during the 1971-75 period.

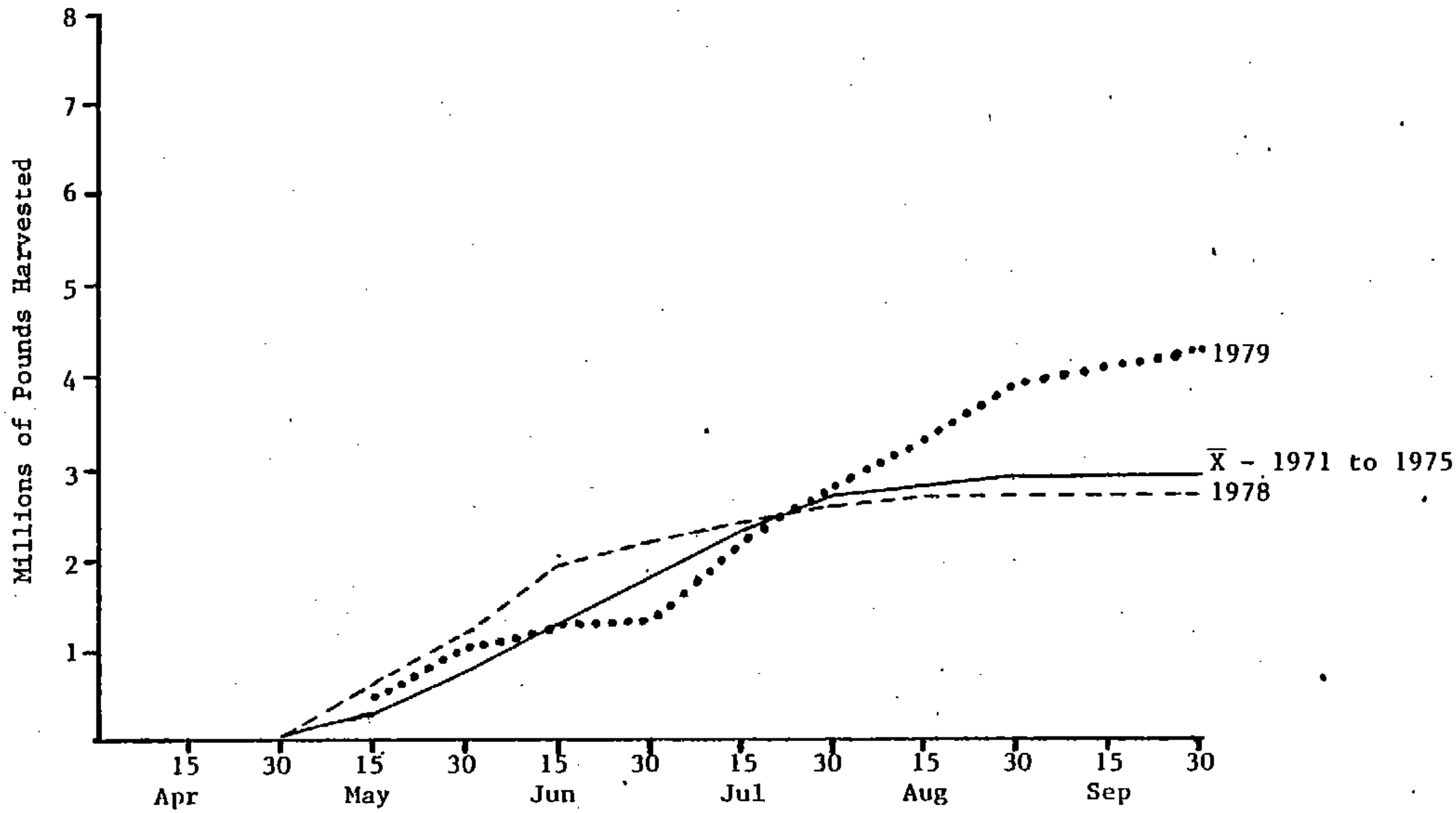


Figure 5. Cumulative troll landings of coho salmon in California in 1978, 1979 and during the 1971-75 period.

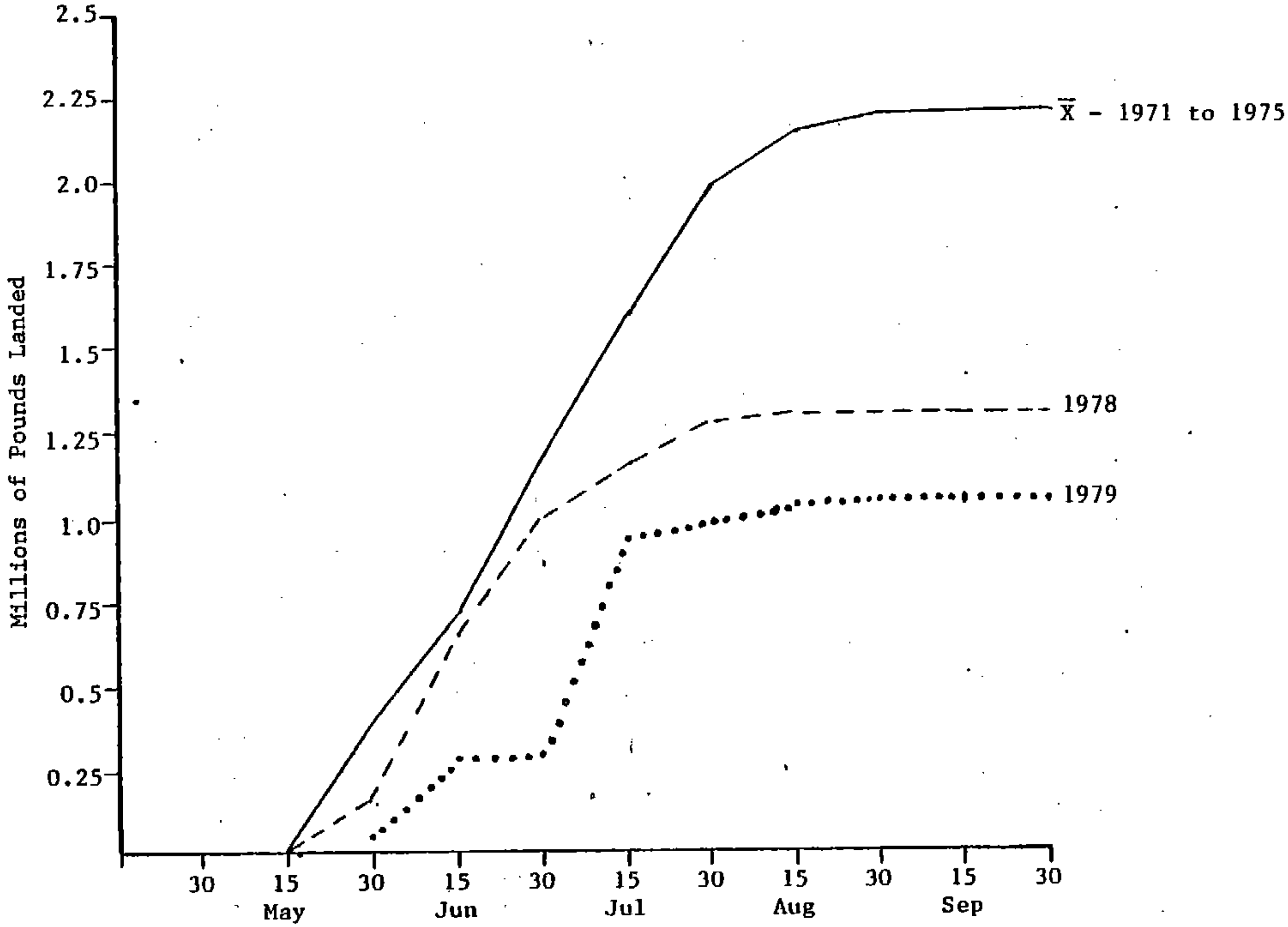
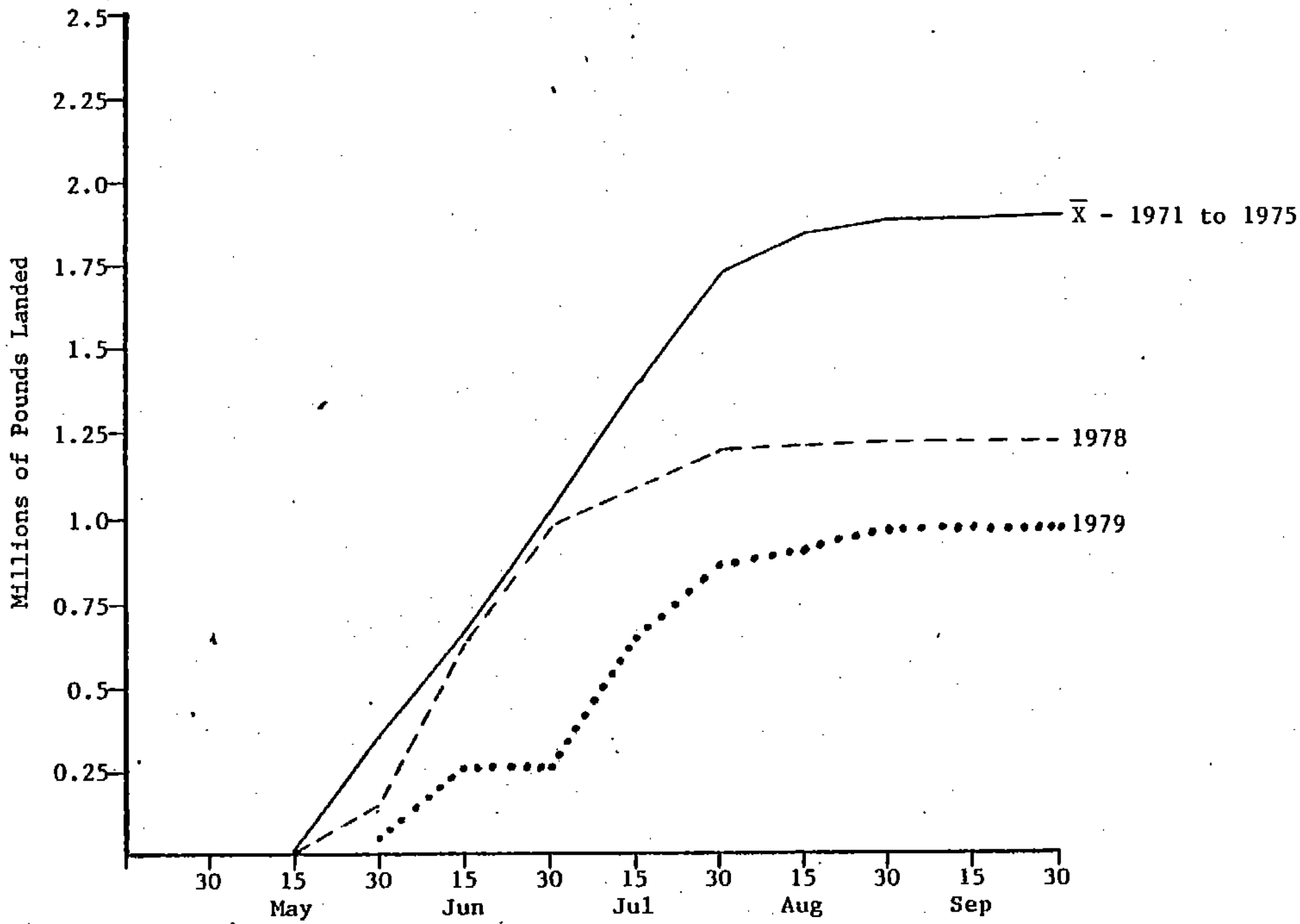


Figure 6. Cumulative troll landings of coho salmon at the three northern California ports in 1978, 1979 and during the 1971-75 period.



Preliminary data obtained from the Oregon Department of Fish and Wildlife (ODFW) reveals that troll landings of chinook salmon in Oregon increased by about 34 percent in 1979 as compared to 1978 (approximately 2.5 million pounds versus 1.8 million pounds). More noteworthy as far as the Klamath River is concerned is that landings at the five southern ports nearly doubled (approximately 960,000 pounds in 1978 versus over 1.7 million pounds in 1979) and landings at the southernmost port of Brookings, located less than 50 miles from the Klamath River, increased on the order of 3.8 times. Considering the large increases in harvest of chinook salmon off northern California and Oregon in 1979 and taking into account preliminary coded-wire tag returns from chinook salmon released from the Trinity River Hatchery (1976 brood year production) which indicate that the great majority of Klamath River fish are landed at northern California and Oregon ports, it appears that Klamath River salmon comprised a sizeable portion of ocean harvest in these areas.

Ricker (1976), citing several studies, suggested that the Pacific coast catch is comprised of about equal numbers of legal and undersized salmon and that approximately one-half of the undersized salmon released do not survive. Hence, for every two fish harvested, one additional salmon is lost through hooking mortality. Applying this factor to the mean annual harvest of chinook salmon off the coasts of California, Oregon and Washington during the 1971-75 period (approximately 1.5 million salmon), it appears that the offshore fisheries account for approximately 2.25 million chinook salmon annually. Nearly five million coho salmon are also accounted for annually by ocean fisheries off the three states.

Assuming an offshore sport harvest level of 218,000 chinook salmon and applying the "shaker mortality" factor suggested by Ricker (1976) of one salmon lost for every two landed, ocean fisheries off California accounted for approximately 1.3 million chinook salmon in 1979. This figure translates into 8.6 chinook salmon caught or lost for every one returning to the Klamath River (assuming a run size of 150,000) and about 64.4 chinook salmon harvested or lost at sea for each one caught in a gill net on the Hoopa Valley Reservation (assuming a net harvest of 20,000). Table 1 contains a breakdown of ocean harvest and mortality levels at catch-escapement ratios of 2:1, 3:1 and 4:1 assuming run sizes of 150,000 and 200,000 in the Klamath River.

Table 1. Annual chinook salmon losses attributable to ocean fisheries assuming 2:1, 3:1 and 4:1 catch-escapement ratios at two run sizes in the Klamath River.

| Assumed Run Size | Assumed C/E ratios | Ocean Harvest Levels | Hooking Mortality 1/ | Total Number of Salmon Harvested and Lost |
|---|---|---|---|---|
| | 2:1 | 300,000 | 150,000 | 450,000 |
| 150,000 | 3:1 | 450,000 | 225,000 | 675,000 |
| | 4:1 | 600,000 | 300,000 | 900,000 |
| | 2:1 | 400,000 | 200,000 | 600,000 |
| 200,000 | 3:1 | 600,000 | 300,000 | 900,000 |
| | 4:1 | 800,000 | 400,000 | 1,200,000 |

1/ Hooking mortality rate of one fish lost for every two boated (Ricker, 1976).

Unlike most other large river systems in the Pacific Northwest, chinook salmon runs in the Klamath River consist primarily of wild fish which cannot withstand the high harvest rates that hatchery stocks can tolerate. Taking into account the accelerated rate of habitat degradation in recent decades, ocean harvest rates on wild stocks of salmon will probably have to be reduced if these fish are to survive over the long term.

It is important that we work with the CDFG in developing a program which results in reliable estimates of offshore harvest levels pertaining to Klamath River salmon. USFWS involvement should include keeping abreast of the coastwide ocean harvest monitoring program and assisting in fisheries investigations on the Klamath River designed to assess the relative contributions of wild and hatchery-reared salmon to ocean harvest and spawner escapement. Because only hatchery-reared salmon receive coded-wire tags, only hatchery-reared salmon can be identified to origin in the ocean harvest monitoring program. Because the majority of Klamath River salmon are wild, it is important to assess the ratios of wild and hatchery-reared fish so that total harvest figures can be obtained. Such data will be collected through the previously-described adult tagging program and through a smolt sampling program in the Klamath River estuary in which returning adults and out-migrants will be classified according to fin clips. Experiences of the last year indicate that numerous smolts can be sampled with relatively little effort through beach seining operations.

As a result of a request by USFWS, the BIA purchased four coded-wire tagging units and transferred them to CDFG in August 1979. The coded-wire tagging program intitiated by CDFG two years ago should result in preliminary evaluations of the contributions of Klamath River salmon to ocean fisheries beginning this year.

Recently-developed USFWS policies in Region 1 regarding issues dealt with by the Pacific Fishery Management Council will provide guidance in addressing the ocean fishing issue. They include (1) emphasizing the welfare of the resource over special interest user groups, (2) supporting selective stock fisheries over mixed stock fisheries, (3) supporting the harvest of mature fish, (4) encouraging limited entry of commercial and charter boats as a control on fishing pressure, (5) supporting sufficient escapement to provide for the historical Native American fisheries, traditional sport fisheries, and recruitment needs and (6) supporting the preservation and maintenance of all existing races, runs or stocks of ocean fishes.

Recommended Future Course of Action

CDFG should utilize the four new tagging units to expand the coded-wire tagging program at the Trinity River and Iron Gate hatcheries.

USFWS should expand their seining operation and improve their net harvest sampling techniques to better determine relative proportions of wild and hatchery-reared salmon of Klamath River origin contributing to ocean fisheries.

USFWS should keep abreast of the coastwide ocean harvest monitoring program and assist the CDFG in assessing contributions of Klamath River salmon to ocean fisheries.

## II. TERMINAL HARVEST EVALUATION

### A. SPORT HARVEST MONITORING

Description

In an attempt to ascertain the contributions of Klamath River salmon to inland sport fisheries, CDFG has conducted a drainage-wide sport census program in recent years and USFWS has conducted a sport census on the lower Klamath River during 1978 and 1979. The CDFG has also utilized sport census data as a mark sample in their run-size estimation program.

Progress and Problems

In 1978 and 1979, respectively, Arcata FAO employed 12 temporary people (two shifts of six people each) and six temporary persons (two shifts of three people each) to monitor sport harvest from the lower Klamath River. Sport fishermen harvested approximately 700 chinook salmon from the lower river in 1979, approximately 30 percent less than the 1,014 chinook salmon taken by anglers through August 28, 1978 (Figure 7) when CDFG imposed a moratorium on sport salmon harvest from the river. Anglers also caught approximately 1,800 fall-run steelhead from the lower river in 1979. Anglers fishing the Klamath River estuary catch greater numbers of the larger three and four-year salmon as compared to anglers fishing upstream who catch primarily two-year grilse (Figure 8). A length-frequency of chinook salmon captured at the CDFG weir site on the Trinity River is also depicted in Figure 8.

Four Indians of the reservation hired as sport census takers in 1979 experienced no serious conflicts with members of the sport fishing community and the sport census program has proceeded satisfactorily resulting in reliable harvest estimates. Considering the low salmon harvest involved and the high level of effort required to compile the data, however, we should consider a de-emphasis in this study component.

Recommended Future Course of Action

We should de-emphasize the sport census effort from one which involves hired census takers to one which relies on data collection through cooperation of campground owners located on the lower river. The CDFG may wish to census the lower river area as part of their drainage-wide census effort.

Figure 7. Cumulative sport harvest of chinook salmon from the lower Klamath River (below Highway 101 bridge) in 1978 and 1979.

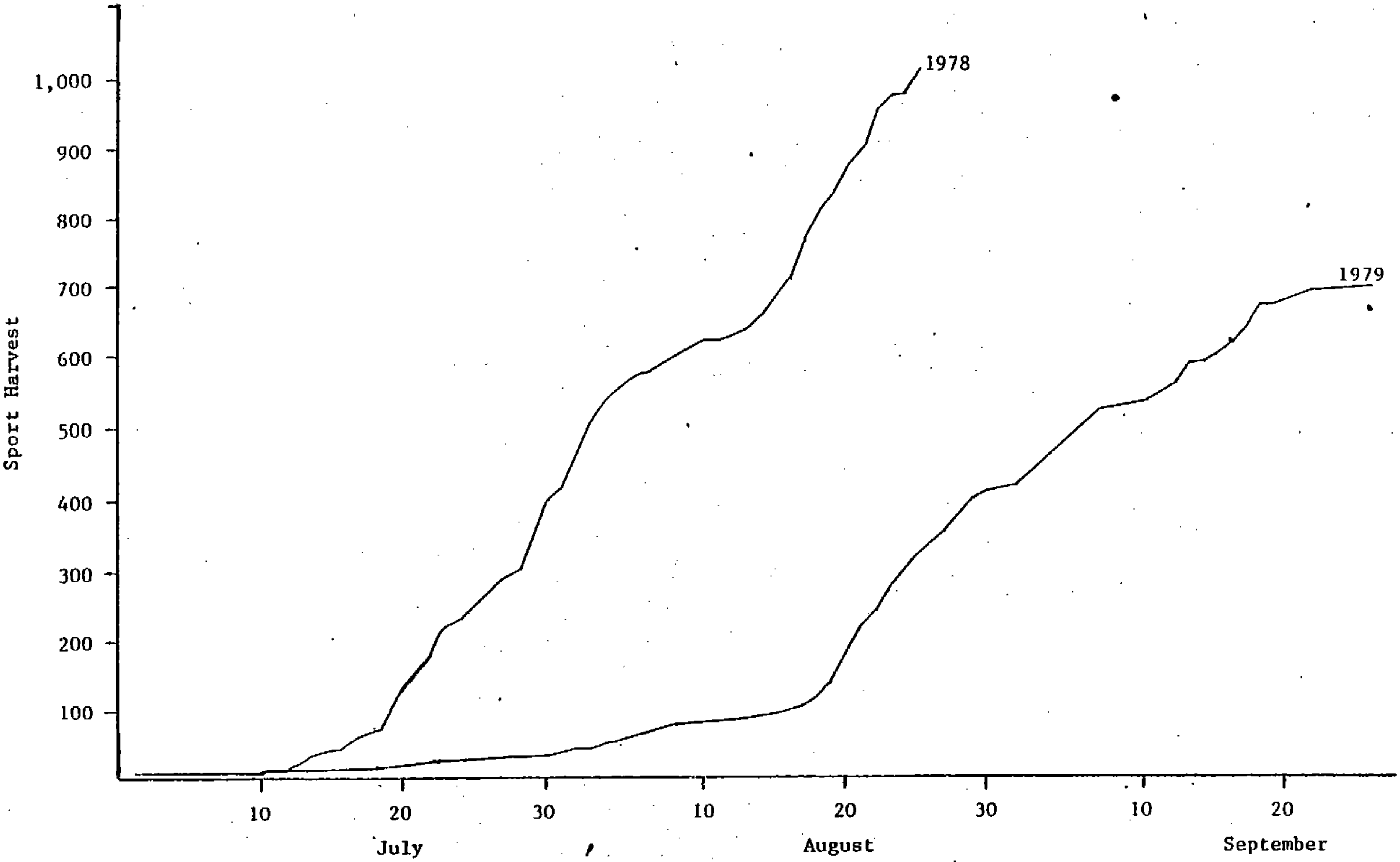
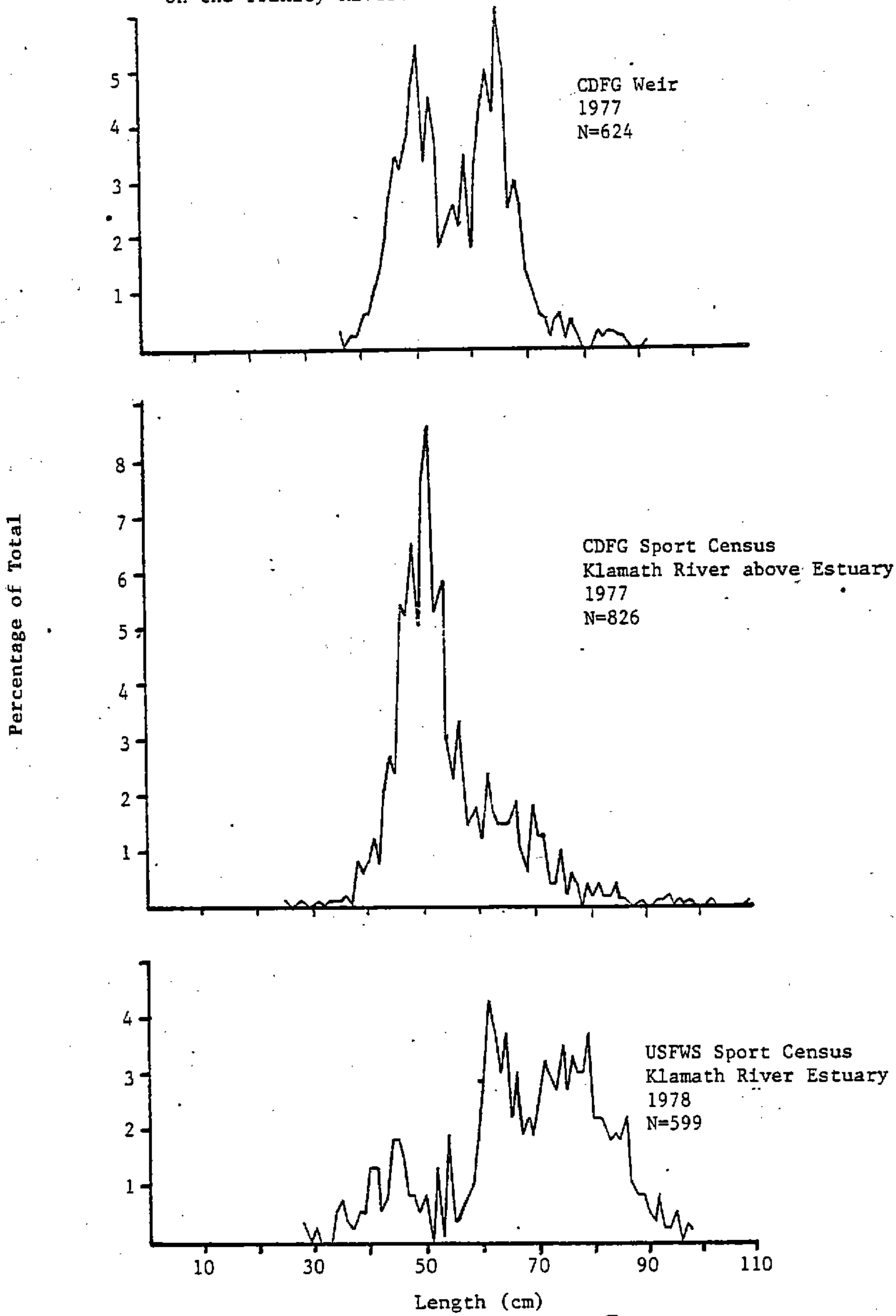


Figure 8. Length-frequencies of chinook salmon harvested by anglers fishing the Klamath River and captured at the CDFG weir on the Trinity River.



B. NET HARVEST MONITORING

Description

The USFWS has attempted to develop a net harvest monitoring program on the Hoopa Valley Reservation for the purpose of ascertaining the contributions of Klamath River fish to Indian net fisheries and to obtain a mark-sample for the run-size estimation program.

Progress and Problems

By stationing biologists in Indian camps in 1978, we estimated that the net harvest comprised approximately 8,500 salmon through August 28, (Figure 9) when the Department of Interior imposed a moratorium on commercial salmon fishing on the Klamath River. Total net harvest for the year amounted to approximately 12,000 to 15,000 salmon. In 1979, the USFWS hired four Indians of the reservation to collect net harvest data but this approach failed and will probably not succeed in the future because of (1) logistics problems involved in having census people contact a majority of netters on a daily basis considering the number of fishers involved and the remote and widely scattered locations of many nets, (2) logistics problems involved in expecting USFWS biologists to adequately oversee and supervise the activities of census personnel, (3) non-cooperation on the part of many fishers because of concern that data collected would be used to their future disadvantage, and (4) personnel problems involved in finding census people who are at the same time acceptable to the Indian communities and involved agencies.

Because of problems encountered in obtaining net harvest data in 1979, we conducted aerial net-count surveys throughout most of the fishing season and applied rather arbitrary catch figures per net-night of effort to estimate harvest levels (Figure 10). This technique resulted in an approximate net harvest estimate of 20,000 chinook salmon for the year (Figure 9). Assuming an average weight of 13 pounds per salmon, total net harvest amounted to approximately 260,000 pounds (130 tons) of salmon, of which about 16 tons were confiscated in alleged sales transactions by enforcement agents.

A comparison of length-frequencies of gill-netted salmon caught in the Klamath River between the period 1919-1930 and 1978 reveals similar modal peaks but decreased numbers of larger salmon in 1978 (Figures 11 and 12). The reduction in the larger and older individuals could be attributed to the intensified ocean fisheries in conjunction with non-selection for the larger individuals in the current net fishery (most fishers currently utilize 7-inch to 7½-inch stretch mesh gill nets which are selective for three and four-year salmon).

Because of the widespread dissension of Indians of the reservation toward the federal fishing regulations and perceived inequities concerning current resource allocation, it will be difficult to obtain their cooperation in assessing future net harvest levels. The USFWS can no longer be responsible for hiring biologists or Indian people to seek out and make contact with Indian fishers for the purpose of obtaining net harvest data with the intent of utilizing such data to develop a total

Figure 9. Estimated net harvest of chinook salmon on the Hoopa Valley Reservation in 1978 and 1979.

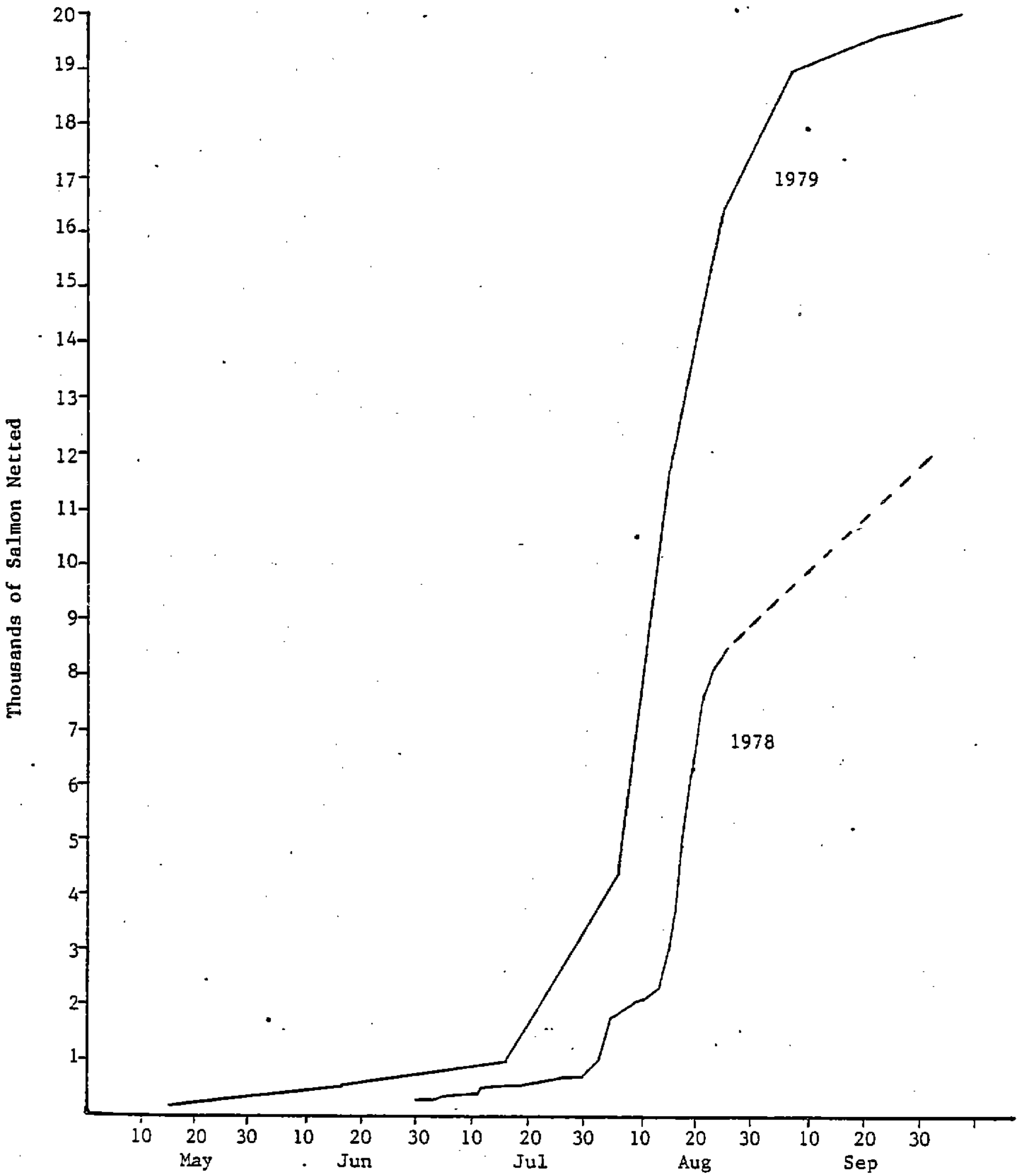


Figure 10. Aerial counts of gill nets fishing various sections of the Hoopa Valley Indian Reservation in 1979.

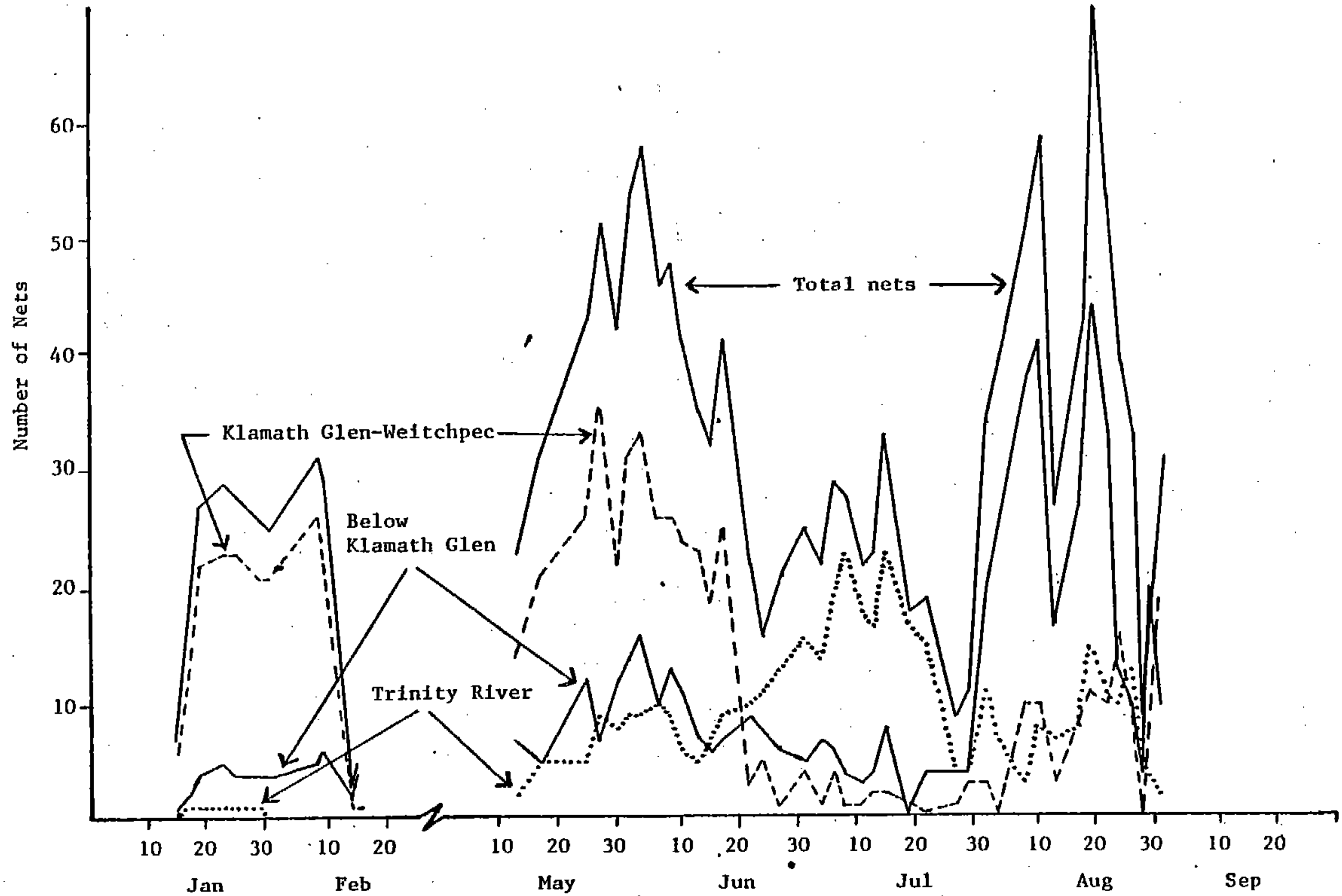


Figure 11. Length frequencies of chinook salmon caught in gill nets on the Klamath River in 1919, 1920 and 1923.

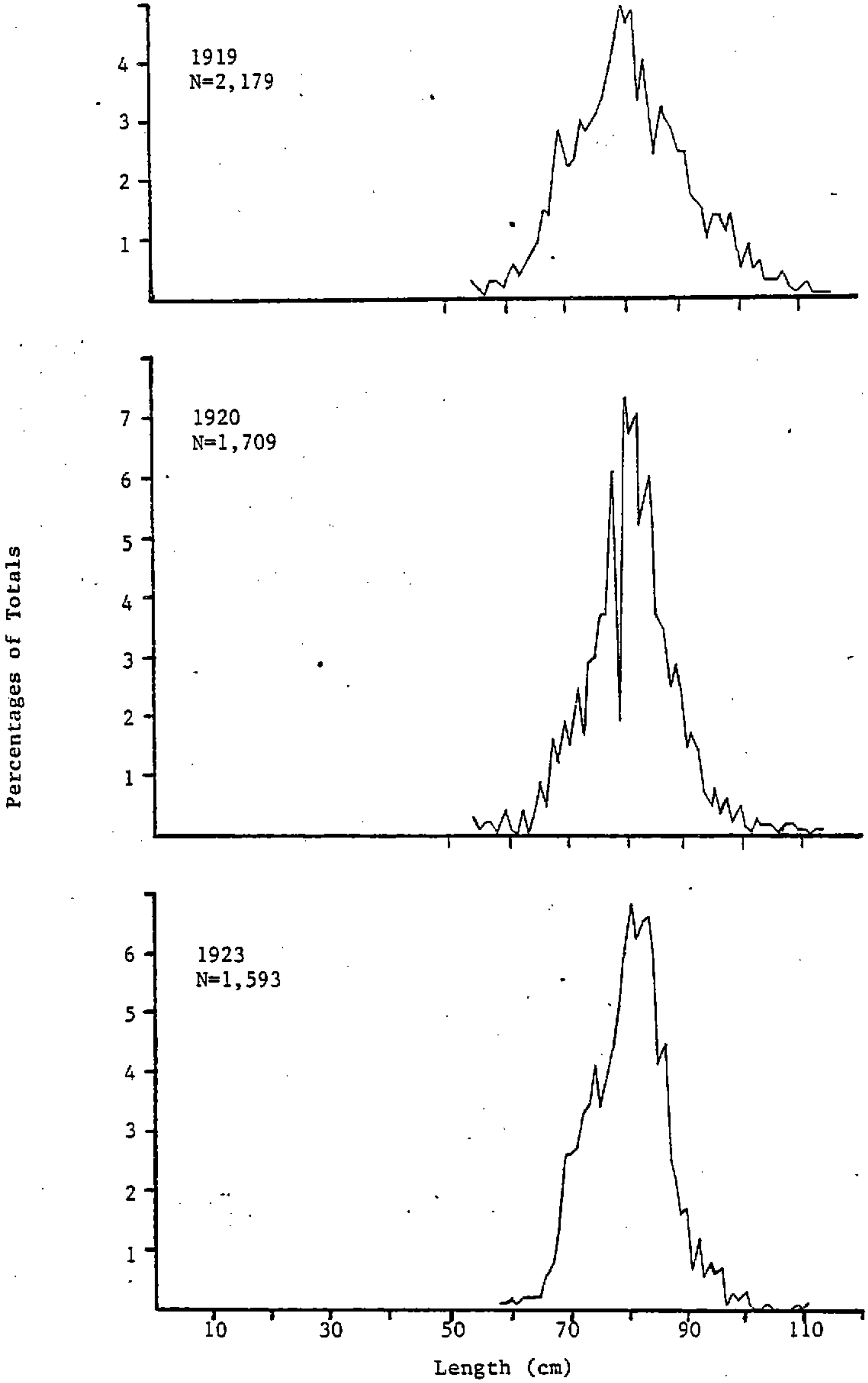
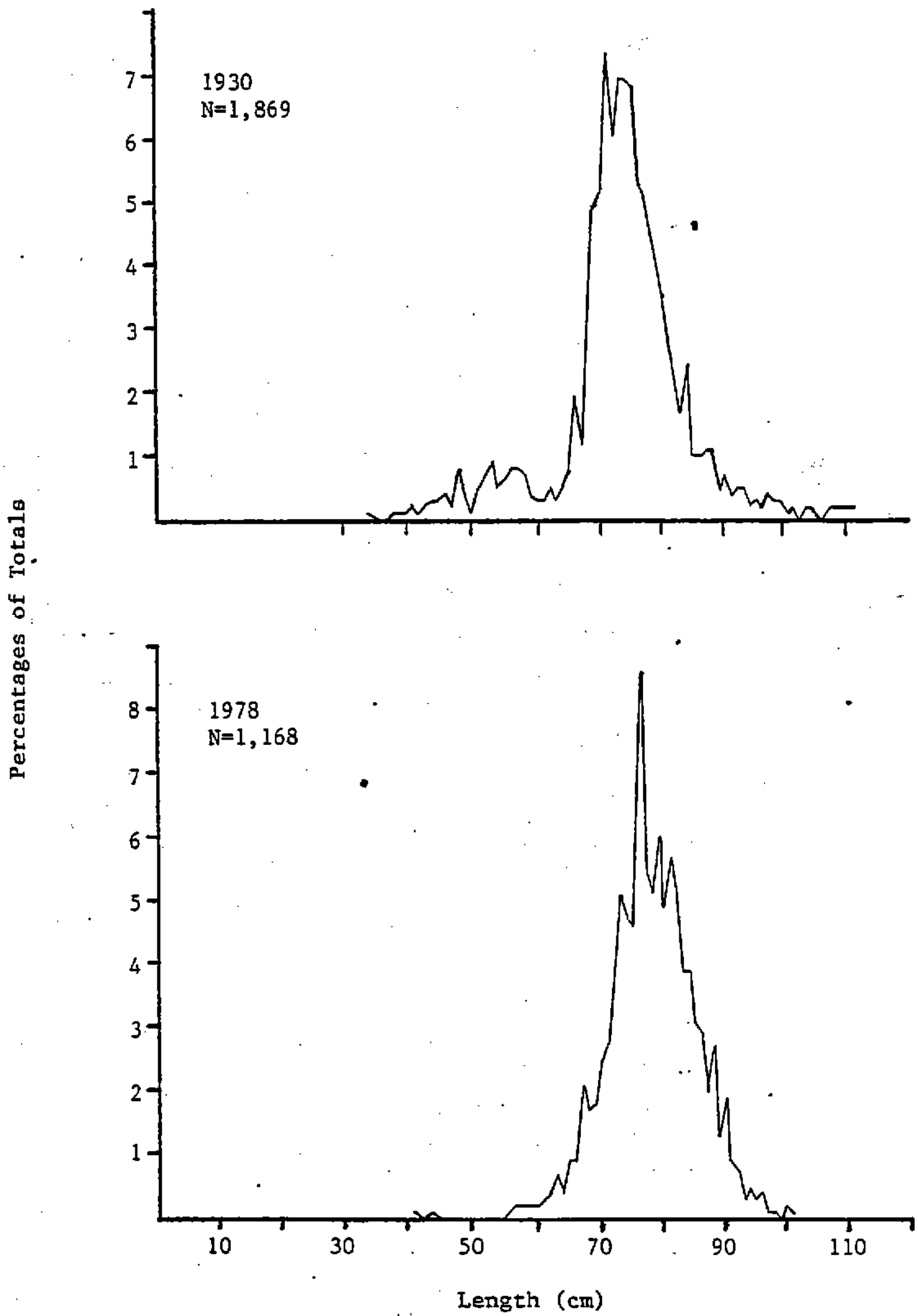


Figure 12. Length-frequencies of chinook salmon caught in gill nets on the Klamath River in 1930 and 1978.



annual net harvest estimate for the reservation. It is imperative, however, that our biologists examine a large portion of net harvest from the Klamath River estuary to acquire the necessary mark sample required in the proposed in-season run-size estimation program described in a subsequent section. The mark sample obtained could be incorporated into an overall net harvest evaluation program.

Recommended Future Course of Action

Dispense with the unreliable, ineffective and costly aerial net-count surveys and discontinue utilizing biologists or Indian people to seek out and contact Indian fishers for the purpose of obtaining net harvest data with the intent of utilizing such data in an annual net harvest evaluation program.

The recommended mark sampling program involving net-caught fish outlined in a subsequent section should be incorporated into an overall net harvest evaluation program.

## III. RUN-SIZE AND SPAWNER ESCAPEMENT EVALUATIONS

### A. TAGGING PROGRAM

Description

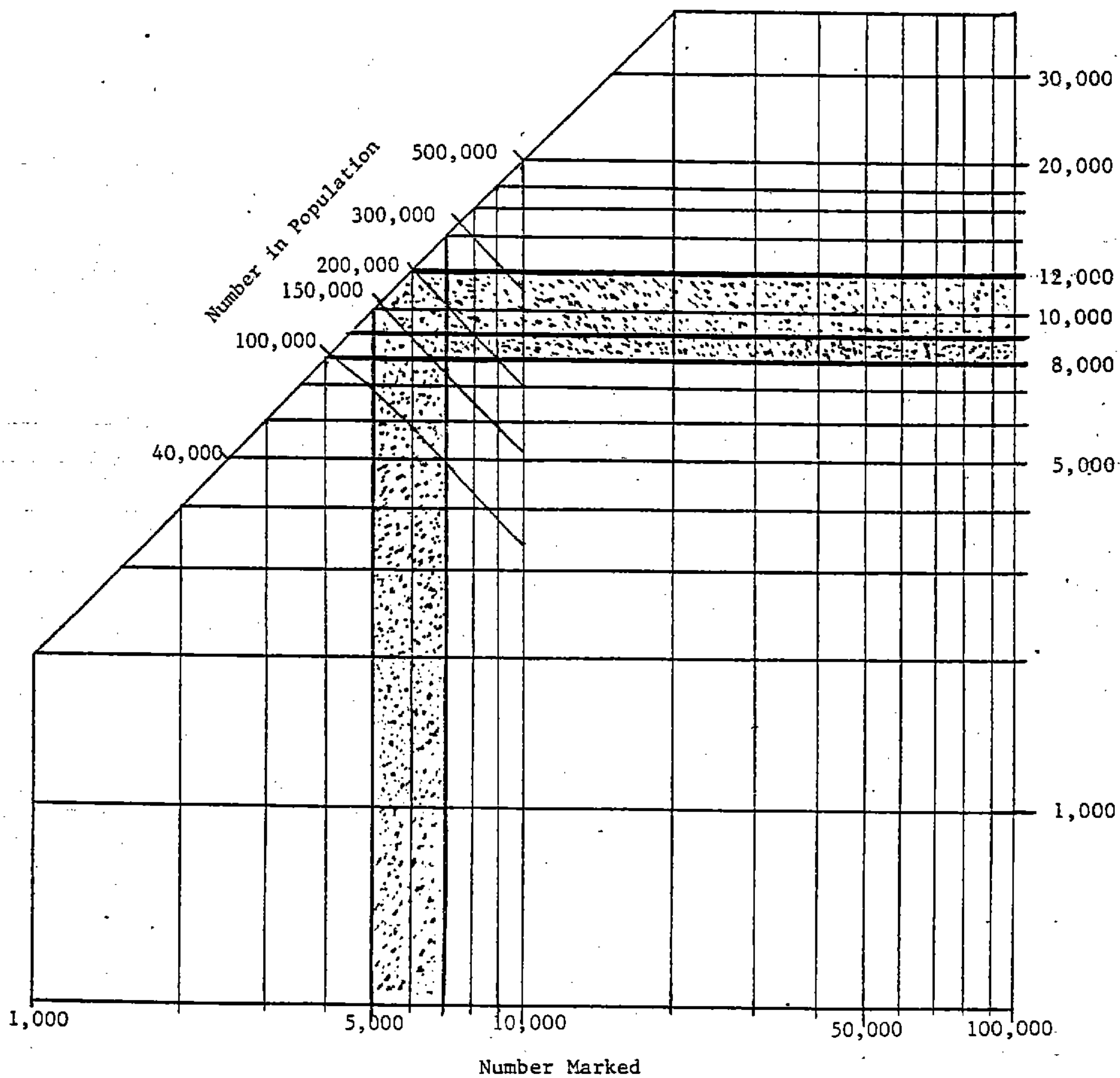
Adequate numbers of salmon must be tagged before reliable run-size and spawner escapement estimates can be made through mark-recapture techniques. We would like to be 95 percent confident that our estimates fall within 10 percent of true values. To achieve this degree of reliability, we must tag 5,000 to 7,000 chinook salmon while examining about 8,000 to 12,000 salmon, depending on run size, for tags (Figure 13). Tagging programs conducted by CDFG and USFWS have fallen far short of attaining the required tagged fish levels.

Progress and Problems

A beach seining operation conducted by CDFG biologists below the Highway 101 bridge resulted in the tagging of approximately 1,200 to 1,600 chinook salmon during the years 1976 through 1978 and 648 chinook in 1979. Because of the relatively low numbers of salmon captured there and considering that the site is located above the area where the majority of net harvest occurs, we cannot expect that this operation could be utilized in conjunction with an in-season run-size estimation program or in a post-season program involving estimates which fall within 10 percent of true values.

Arcata FAO biologists explored gillnetting as a means to capture fish for tagging in 1978 and 1979 but rejected the technique for a number of reasons including inefficiency, stressed fish conditions and competition for suitable netting sites. This year we established

Figure 13. Sample size combinations required for population estimation programs involving mark-recapture techniques in order for estimates to fall within 10 percent of true values at the 95 percent confidence level (modified from Ricker, 1968).



a beach seining operation at the mouth of the Klamath River and demonstrated its potential for tagging relatively large numbers of salmon. We also believe that a purse seining operation conducted in the Klamath River estuary would result in large numbers of tagged salmon.

We established a beach seining operation on the north spit of the Klamath River about 200 yards above the mouth on July 10, and operated there through August 5, during which time we tagged only 37 chinook salmon. On August 6, we moved the operation to the south spit and continued seining there through August 16, during which time we captured 517 chinook salmon including daily totals of 115 and 138 on August 15, and 16, respectively. As a result of a property ownership dispute involving the south spit, we moved the operation back to the north spit on August 17, and continued seining there through September 7, during which time we tagged only 193 chinook salmon. We resumed operations on the south spit on September 10, well after the run had peaked, and captured 309 chinook salmon and 106 coho salmon before the run ended including a daily high of 198 salmon (142 chinook salmon and 56 coho salmon) on September 13. Season totals include 1,016 chinook salmon tagged out of 1,058 captured and 123 coho salmon tagged out of 124 captured. CDFG, by comparison, tagged 648 chinook salmon and 111 coho salmon at their seining site. During the last four days that we operated on the south spit (August 13-16), prior to moving back to the north spit, we captured 356 chinook salmon (6.85 per seine haul). Our highest daily catch rate was 28.3 salmon per haul on September 13. During the entire season (July 15 through October 12) at all sites combined, we captured and tagged 2.54 and 2.44 chinook salmon per seine haul, respectively. CDFG, by contrast, captured 0.83 chinook salmon per seine haul at their site during the same period. Considering that our catch rate was three times that of CDFG despite the undesirable conditions under which we had to operate in 1979 and taking into account that CDFG has seined on the order of 1,500 chinook salmon in previous years, we have good reason to believe that our seining operation could result in the tagging of adequate numbers of salmon in future years.

A length-frequency of chinook salmon captured at the USFWS sites (Figure 14) reveals that approximately 142 (14 percent) were grilse (Age I+ salmon less than 59 cm in length). Approximately 21 percent of chinook salmon captured at the CDFG site were considered grilse. These compare to grilse percentages of 23, 33 and 32 percent in 1976, 1977 and 1978, respectively (Figure 15). Approximately 4.7 percent of chinook salmon captured had adipose fin clips (fish of hatchery origin) including about 21 percent of the grilse and 1.5 percent of the adults. Approximately 18 percent of the salmon had hook scars (presumably a result of offshore fishing), three individuals had seal bites and 12 individuals had gill net marks. Of the coho salmon seined, 39.7 percent had adipose fin clips, about 20 percent had hook scars and none had seal bites or net marks.

Figure 14. Length-frequency of chinook salmon seined at the mouth of the Klamath River in 1979.

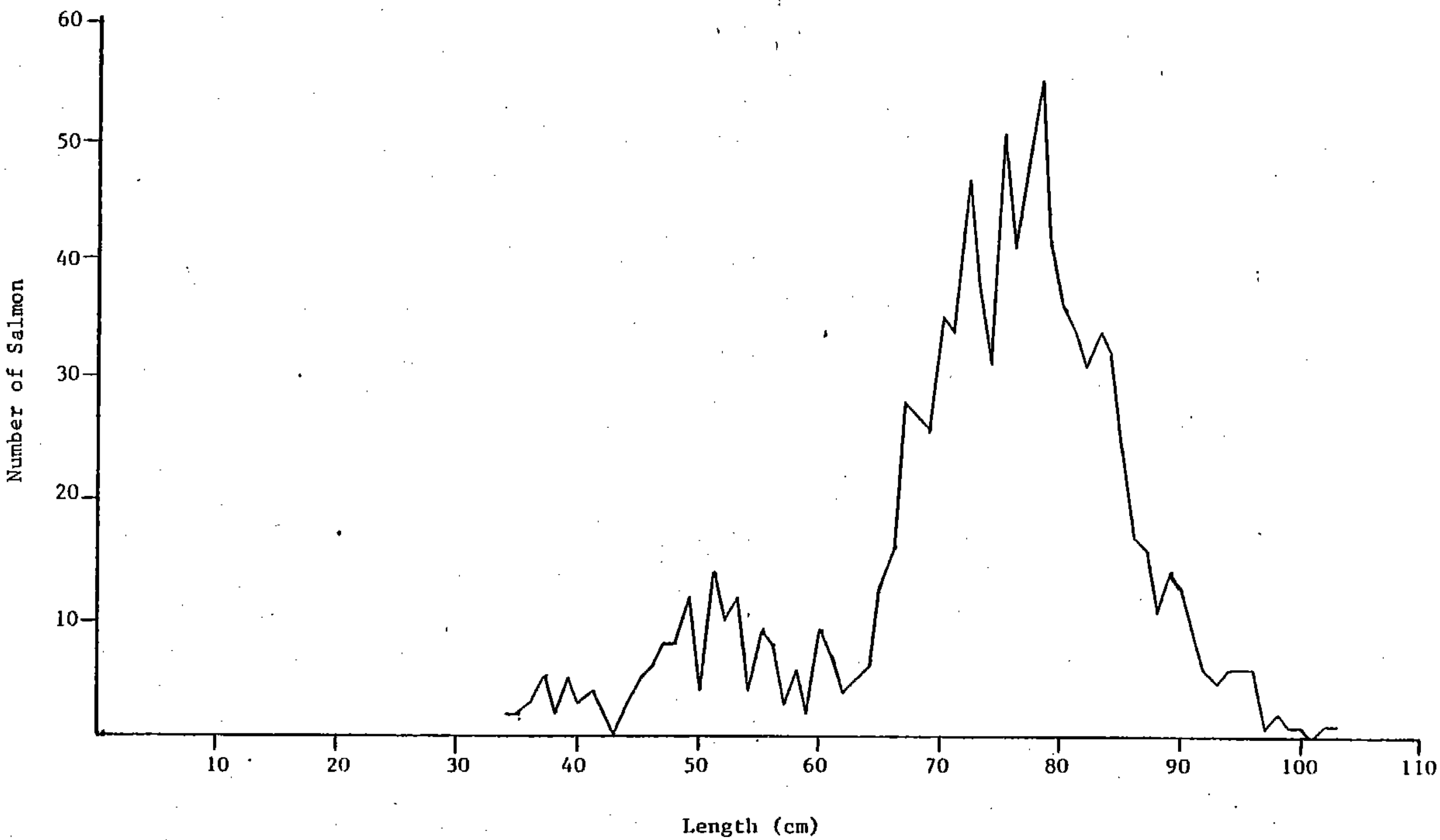
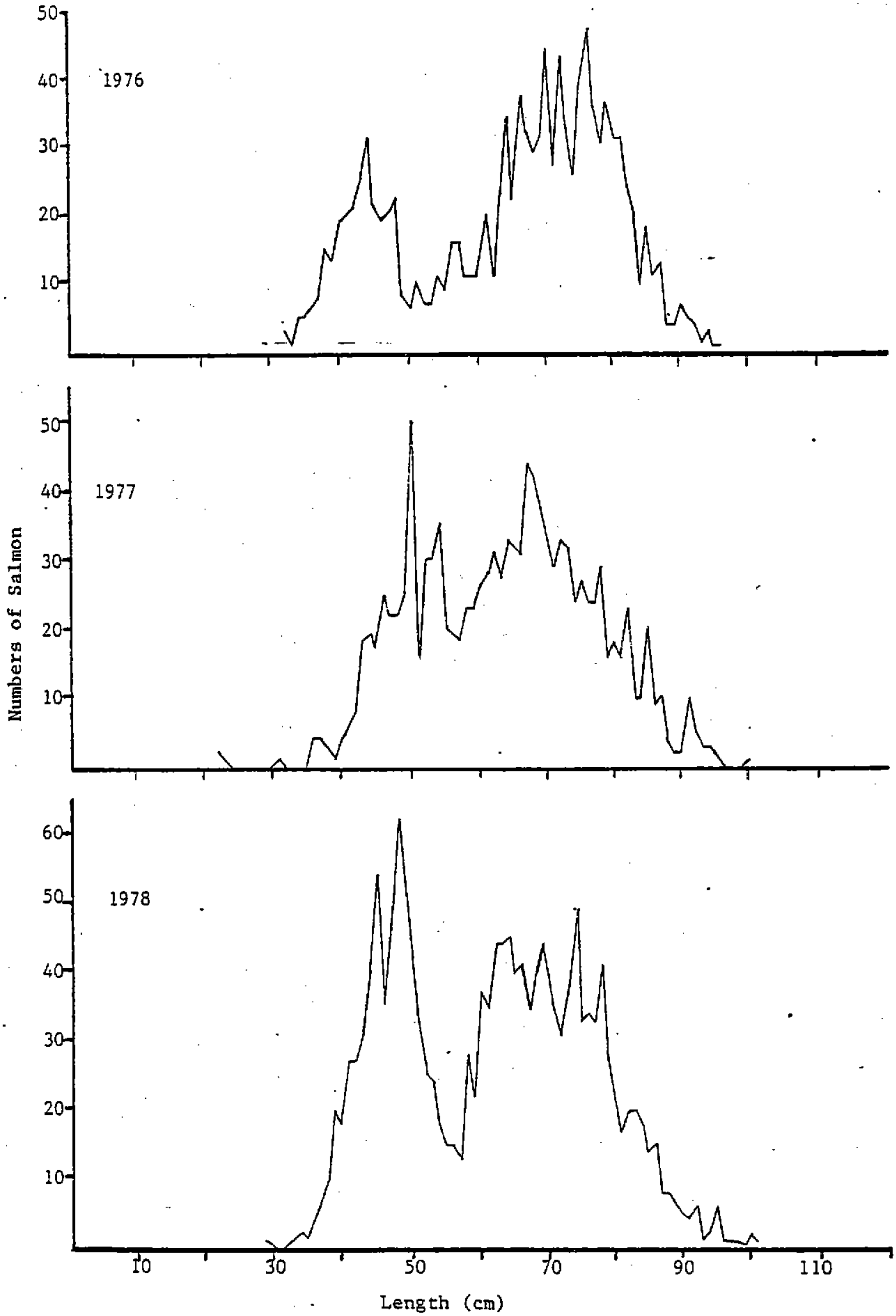


Figure 15. Length-frequencies of chinook salmon captured at the CDFG seining site in 1976, 1977 and 1978.



The south spit site is situated so that salmon could be captured from the deep channel leading to the ocean which parallels the spit (Figure 16). It appears that salmon congregate in the deeper channel and do not frequently move into the shallower areas of the estuary during daylight hours. Other seining sites in the area tested proved unsuitable because of low catch rates, strong tidal currents, debris problems, warm water and/or competition for space with sport fishermen.

The strong tidal influence at our site generally kept water temperatures in the mid-60s, allowing us to tag fish with minimum stress and no apparent mortality. Temperatures at the CDFG site have measured considerably higher, periodically having ranged into the mid to high 70s. The great majority of tagged fish released from our site swam away vigorously and, unlike fish released from the CDFG site, experienced no apparent mortality attributable to harbor seal predation.

Our seining operation took up approximately 60 yards out of a total of 460 yards available for sport fishing on the south spit. Anglers typically chose to fish along the 340-yard stretch of beach located between the seining site and mouth of the Klamath River with the densest concentrations most always occurring within 100 yards of the mouth. Reaction to our seining operation by the sport fishing community was, by and large, most favorable. Scores of anglers regularly congregated around our crews filming the operation and asking numerous questions. The operation evolved into a major attraction on the lower river and was most positive from a public relations standpoint.

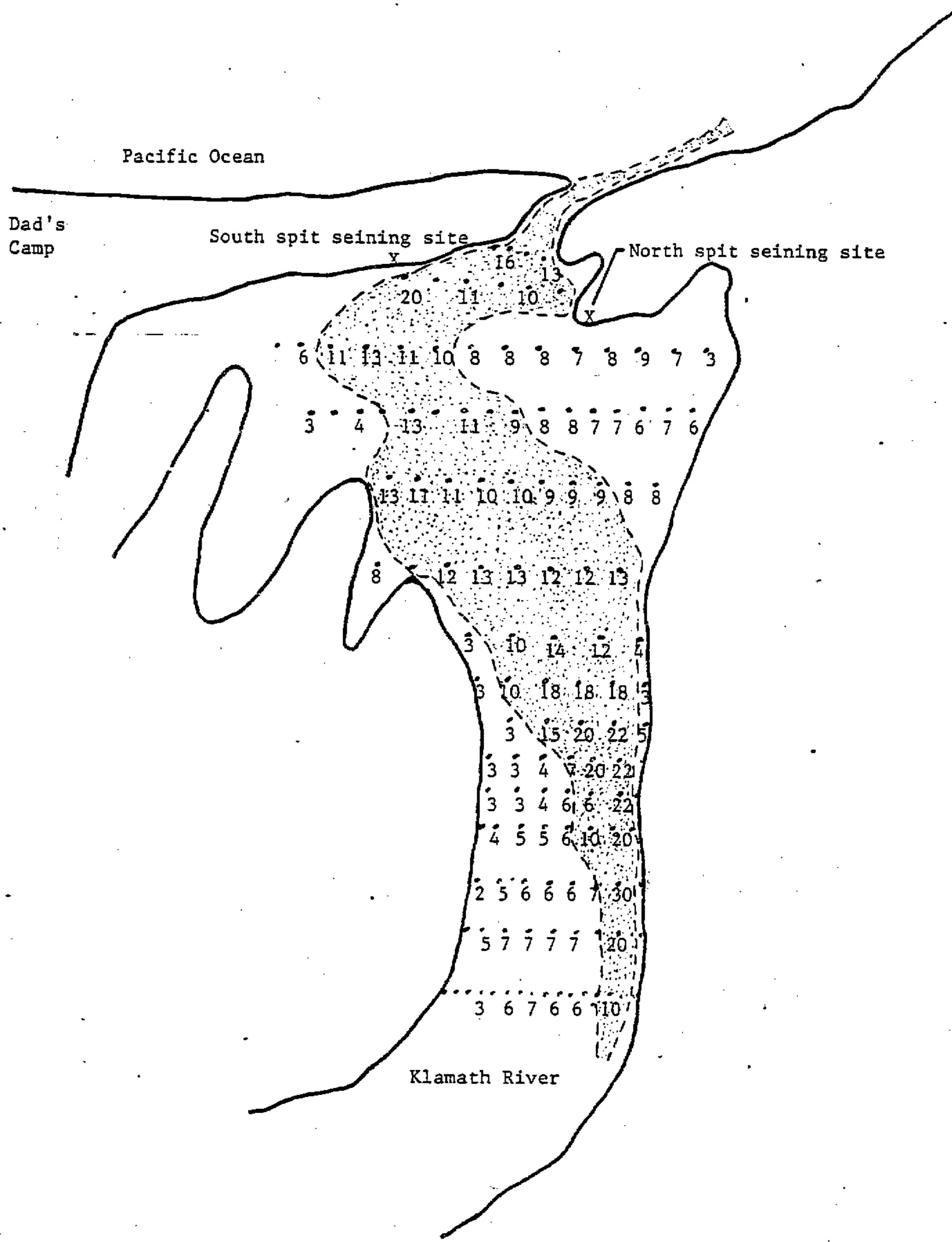
On a number of occasions, Indian fishers set gill nets in the vicinity of our seining operation. While only one tagged fish was observed caught in these nets, steps must be taken in the future to insure that released fish have an adequate opportunity to randomly mix with the untagged population before being exposed to harvest.

<u>Recommended Future Course of Action</u>

The tagging program should be continued utilizing the beach seining technique near the mouth of the Klamath River as the primary means to capture fish. In the event that property ownership disputes disrupt beach seining efforts in the future, we will require the support and assistance of the Solicitor's Office, BIA and Assistant U.S. Attorney's Office to resolve them as quickly as possible. If such disputes result in a lengthy delay of the beach seining operation, we may wish to attempt to acquire the purse-seining vessel, Great Blue Heron, from our Olympia FAO. In preparation for that occurrence, two of our staff will be sent to Olympia, Washington this winter to become familiar with the operation of the vessel.

Beach seining operations should be extended throughout much of the year, flows permitting, so that badly needed data on spring chinook salmon, coho salmon, green and white sturgeon and winter and summer steelhead can be collected. Such a program should be accompanied by extensive age-growth analyses.

Figure 16. Depth profile of the Klamath River estuary with locations of seining sites.



To minimize the occurrence of tagged fish being caught in gill nets on a disproportionate basis, the federal fishing regulations should be revised to include a provision prohibiting gill netting within a 100-yard radius of any ongoing beach seining or purse seining operation.

Considerable thought was given to the type of tag and secondary mark which should be employed in future tagging operations. Recent studies conducted by CDFG which indicated that jaw tags experience a higher shedding rate than spaghetti tags, are in conflict with results of similar studies conducted through our Olympia Fisheries Assistance Office. In an attempt to resolve some of these uncertainties and considering the large sample size that we expect to be dealing with next year, we plan to tag every fifth fish with a jaw tag and the remaining fish with spaghetti tags. Secondary marks will include posterior and anterior dorsal fin clips for the two tag types, respectively, in accordance with CDFG recommendations.

Tag shedding rates should be evaluated by examining returns from the net fishery, Iron Gate Hatchery, Trinity River Hatchery and the Shasta Racks. To utilize the racks, it will be necessary to handle and examine each fish for tags and secondary marks. Such efforts will require close coordination with the CDFG which operates the facilities in question and we must be prepared to provide the additional manpower required to conduct these investigations at the racks and, if necessary, at the hatcheries.

Investigations on green and white sturgeon will be initiated utilizing beach seining and setlining as principal capture techniques. Setlines will consist of lengths of one-quarter-inch nylon rope to which are attached short lengths of braided nylon twine and large hooks at approximately 10-foot intervals. Attempts to capture sturgeon will begin this winter and intensify during the spawning migration period. Disc tags will be applied under the anterior edge of the dorsal fin of each sturgeon captured and a fin-ray section will be excised from the lead edge of the pectoral fin for age determination and to serve as a secondary mark. The total length and weight of each individual captured will also be recorded.

B. MARK-SAMPLE PROGRAM

Description

In conjunction with the tagging program, adequate numbers of fish must be examined for tags before reliable run-size and spawner escapement estimates can be made. We would like to be 95 percent confident that our estimates fall within 10 percent of true values. To achieve this degree of reliability, we must examine about 8,000 to 12,000 salmon for tags, depending on run size, in conjunction with a tagging program involving 5,000 to 7,000 salmon (Figure 13). Mark sample programs conducted by USFWS and CDFG biologists have fallen far short of these levels on an in-season basis. Because of the importance attached to predicting run-size as early as possible in the season, it is essential that the tagging program be conducted close to the mouth and that the net fishery be utilized to the maximum extent in the mark sampling program. Changes in the federal fishing regulations will be required before such a program can succeed.

Progress and Problems

During the last two years, we have attempted to develop a mark-sampling program utilizing the net fishery, sport fishery and CDFG seining operation. In 1978, the CDFG attempted to estimate run-size on an in-season basis through the placement of a weir and counting chamber in the Klamath River at the Highway 101 bridge. All attempts failed to provide the kind of reliable data needed.

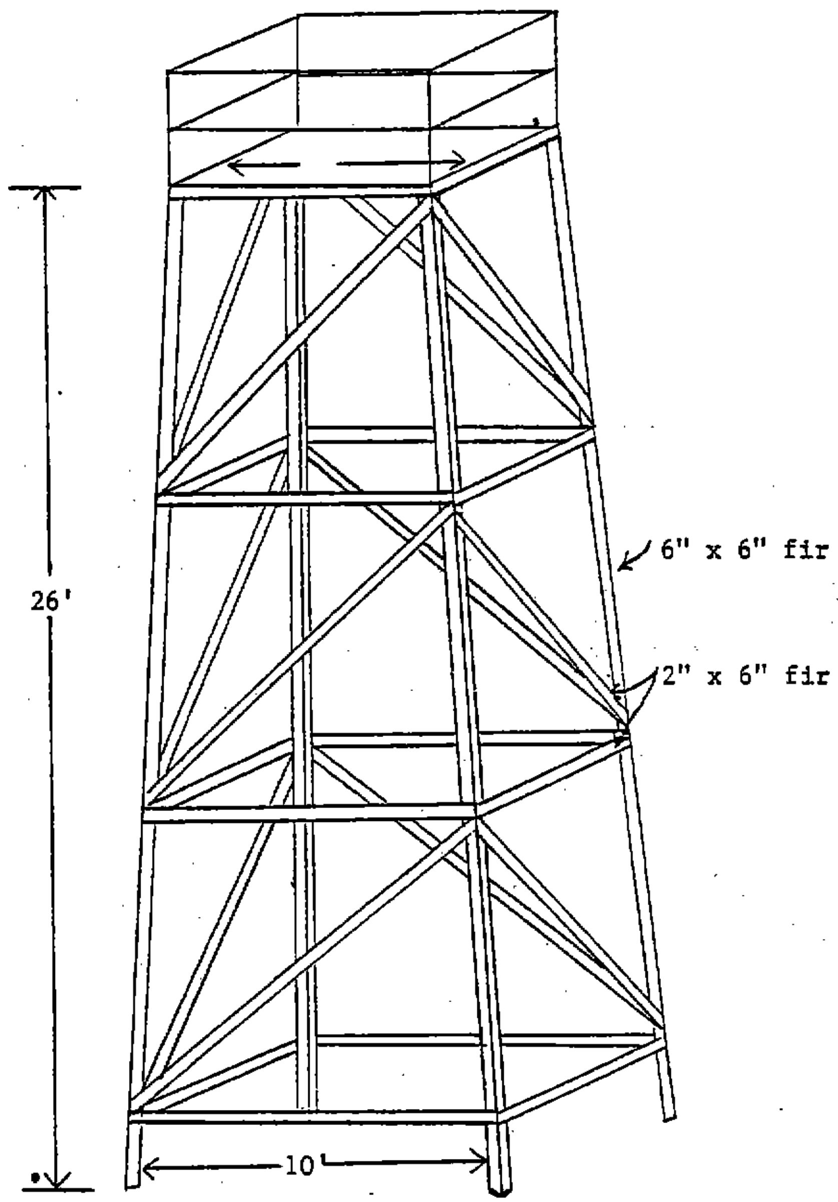
Mark samples obtained through the sport fishery and CDFG seining operation are too small. While an adequate mark-sample could be obtained through the net fishery, problems encountered in observing the net harvest, as discussed in a previous section, have frustrated attempts to develop this program. Experiences with the CDFG weir, which had to be removed from the river within 12 hours after installation because of clogging problems, demonstrated the futility of such techniques in run-size estimation.

Because of problems encountered in developing a mark sampling program, a new technique, namely, direct observation of runs through the use of a a counting tower, was explored this year. A U.S. Army Corps of Engineers Section 10 permit was obtained which permitted the placement of a 26-foot high wooden tower (Figure 17) in the Klamath River at Blake's Riffle near Klamath Glen during the week of September 16. Surface water chop at the site hampered observation so the tower was disassembled and re-installed at a site located a few hundred yards upstream where viewing conditions were improved. While numerous fish were observed from the tower, most of which were probably catostomids, time did not permit the installation of viewing panels on the river bottom or a lighting system for night viewing. While few chinook salmon were seen, it appears safe to conclude that this technique could not be successfully employed to obtain reliable mark samples in the future even if fish were to be marked with brightly-colored spaghetti tags.

For a variety of reasons, it is doubtful that tower methodology could result in reliable run-size estimates involving chinook salmon, coho salmon and steelhead trout. Two or more towers used in conjunction with bank-to-bank silhouette panels and an effective night lighting system could be employed to collect run-timing information and, assuming good weather and water conditions throughout the season, some run-size data on adult chinook salmon and sturgeon. The costs involved in such a study, however, would probably not justify the effort.

Experiences of the last two years associated with the attempted development of an in-season run-size estimation program leave two courses of

Figure 17. Fish observation tower tested on the Klamath River in 1979.



action for future consideration: (1) the construction of an elaborate fish counting facility across the Klamath River at the probable expense of several million dollars or (2) the development of a comprehensive mark-recapture program on the lower river utilizing the net fishery as the principal means to obtain the mark sample. Practical considerations render the former alternative most unlikely.

Of the 1,016 chinook salmon, 123 coho salmon, 337 steelhead trout and 31 sturgeon tagged by our crews in 1979, 188 tags have been recovered including 150 tags (15 percent) from chinook salmon (Table 2). At our seining site, most of the chinook salmon recaptures occurred on the same days that they were tagged while sturgeon were frequently recaptured several weeks after release. Our crews also recovered six fish which had been tagged at the CDFG site located about three miles upstream. At their site, CDFG crews recovered four of our tagged chinook salmon (0.4 percent) and four of our tagged steelhead (1.2 percent). Times between tagging and recapture for the eight fish were 1, 3, 8 and 15 days for the chinook salmon and 2, 2, 9 and 38 days for the steelhead trout. At their trapping facility on the Trinity River located approximately 60 miles above our tagging site, CDFG crews recovered five of our tagged chinook salmon which had been released 7 to 21 days earlier. We believe that several hundred of our tags may have been recovered in the net fishery but only 14 were returned to date, all from chinook salmon. Fourteen chinook salmon tags were also returned by sportsmen along with four from coho salmon and 12 tags from steelhead trout.

Preliminary data provided by the CDFG reveals that 50, 23 and 18 of our tags from chinook salmon were recovered or observed at the Shasta Racks, Iron Gate Hatchery and Trinity River Hatchery, respectively.[3] Fish arrived at the Shasta Racks within 27 to 70 days, at the Iron Gate Hatchery within 39 to 68 days and at the Trinity River Hatchery within 27 to 78 days subsequent to tagging. Because of the low visibility of the tags that we used (the tags were brown and blended in with the color of the dorsal surfaces), it is possible that a number of tags were not recognized at the Shasta Racks. It is anticipated that additional tags will be recovered in conjunction with ongoing spawning ground surveys and the sport census program conducted by the CDFG.

Recommended Future Course of Action

Federal fishing regulations must be changed to provide for the establishment of a fish checking station at Requa through which all fish caught from the lower river area must be cleared. The station would have to be manned by a biologist and Indian enforcement agent during permissible hours of fishing.

In light of the recommended tagging program involving spaghetti tags, jaw tags and secondary marks, mark sampling efforts at the hatcheries, Shasta Racks and on the spawning grounds will have to be expanded to allow for proper indentification. Permission to become involved in such efforts must be obtained from the CDFG. An additional person will probably be needed at the racks so that each salmon can be examined

Table 2. Recoveries of fish tagged by USFWS on the Klamath River in 1979.

| Species | No. Tagged | Numbers of Recoveries by Source: USFWS Seine Site | CDFG Seine Site | CDFG Weir | Net Fishery | Sport Fishery | Shasta Racks | Trinity River Hatchery | Iron Gate Hatchery | Spawning Grounds | Total | Recovery Rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chinook Salmon | 1,016 | 22 | 4 | 5 | 14 2/ | 14 3/ | 50 4/ 1/ | 18 1/ | 23 1/ | — 3/ | 150 | 0.148 |
| Coho Salmon | 123 | 0 | 0 | 1 | 0 | 4 | 0 | 1 | 0 | — | 6 | 0.049 |
| Steelhead Trout | 337 | 4 | 4 | 0 | 0 | 12 | 0 | 0 | 0 | — | 20 | 0.059 |
| Sturgeon | 31 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 12 | 0.387 |
| Total | | 38 | 8 | 6 | 14 | 30 | 50 | 19 | 23 | | 188 | |

1/ Preliminary data provided by the CDFG and subject to revision.

2/ Net returns assumed to be a small portion of total recoveries.

3/ Returns from CDFG not yet available.

4/ Returns may be considerably below actual level because of incomplete tag recognition.

utilizing the live box in place. We must be prepared to furnish the additional manpower required to accomplish these efforts.

Mark sampling of sturgeon will occur through contacts with Indian fishers and by means of set-line sampling in known sturgeon resting areas. Beginning in FY 1981, it is planned to radio-tag a number of adult sturgeon to ascertain migration patterns and spawning areas.

C. SPAWNER ESCAPEMENT EVALUATION

Description

In-season and post-season spawner escapement levels will be estimated through the implementation of the tagging and mark sampling methodologies described in the two previous sections. In-season estimates will occur through the stratified Schaefer population estimation method utilizing the lower river net harvest as the primary mark sample. Run prediction will occur through the development of a regression relationship between calculated in-season indices and final run-size estimates. Post-season estimates would occur through hatchery returns, spawning ground surveys and Shasta River counts utilizing mark-recapture techniques. In-season estimation and run prediction programs would be patterned after those developed at the Olympia Fisheries Assistance Office involving chum salmon in the Nisqually River.

Progress and Problems

Attempts to develop a useful and accurate run-size estimation program involving chinook salmon in the Klamath River system utilizing mark-recapture techniques have been frustrated by failures to tag adequate numbers of fish and by inabilities to satisfy many of the conditions required in the proper utilization of mark-recapture formulae. A preliminary CDFG estimate of chinook salmon run-size in the Klamath River in 1976 was 260,000 with a 95 percent confidence interval of 211,000 to 321,000 and the 1977 preliminary estimate was 203,000 with a 95 percent confidence interval ranging from 154,000 to 279,000 salmon (Jensen, 1977). The large confidence intervals, which approximate the spawner escapement goal level of 115,000, are largely a result of the relatively few salmon which have been tagged on an annual basis. With the additional tagging effort that we hope to provide in future years, there is good reason to believe that enough salmon can be tagged so that we can be 95 percent confident that post-season estimates will fall within 10 percent of true values (plus or minus approximately 20,000 salmon).

Problems encountered in attempting to satisfy the conditions required for the proper utilization of mark-recapture formulae have led some biologists to question the advisability of using mark-recapture techniques in estimating run sizes on large river systems. Conditions which must be met or accounted for include (1) marked fish suffer the same natural mortality as unmarked fish, (2) marked fish are as vulnerable to fishing being carried on as are unmarked fish, (3) marked fish do not lose their marks,

(4) marked fish become randomly mixed with the unmarked fish prior to subsequent sampling, (5) all marks are recognized and reported on recovery and (6) that there is a negligible amount of recruitment to the catchable population during the time that recoveries are made.

The typical result of differential mortality, differential vulnerability, tag shedding and incomplete tag recognition, all of which have occurred in varying degrees in Klamath River population studies, is overestimation. With this in mind, six Petersen estimates of run size can be arrived at utilizing salmon tagged at USFWS and CDFG sites (1,016 and 648, respectively) and the Shasta Racks, Iron Gate Hatchery and Trinity River Hatchery as mark-sample points. Preliminary data obtained from CDFG reveals that 50 USFWS and 38 CDFG tags were recovered at the Shasta Racks from a mark-sample of 8,144 chinook salmon. Inserting this data into the Petersen formula (N=M(C+1)/R+1) results in run-size estimates of 162,261 and 135,332, respectively. At the Iron Gate Hatchery, preliminary returns include 23 USFWS and 9 CDFG tags from a mark-sample of 2,558 chinook salmon resulting in estimates of 108,331 and 165,823, respectively. At Trinity River Hatchery, preliminary returns include 18 USFWS and 4 CDFG tags from a mark-sample of 5,073 chinook salmon resulting in estimates of 271,325 and 657,590 respectively. The apparent large sizes of the point estimates coupled with the large differences between them, reflect the problems currently involved in mark-recapture programs.

Following the completion of spawning ground surveys, the CDFG will present final run size and spawner escapement estimates. Preliminary returns to the Iron Gate Hatchery (2,558 in 1979 versus 7,840 in 1978) and Shasta Racks (8,144 in 1979 versus 18,731 in 1978), as depicted in Figure 18, as well as returns to the Trinity River Hatchery (5,073 in 1979 versus 8,755 in 1978) would seem to indicate that the 1979 spawner escapement level may be even lower than the 110,000 estimate of last year (87,000 adults plus 23,000 grilse). A review of returns to the Iron Gate Hatchery, Trinity River Hatchery and Shasta Racks since 1976, however, when compared to run-size estimates for those years, reveals no clear relationship (Table 3).

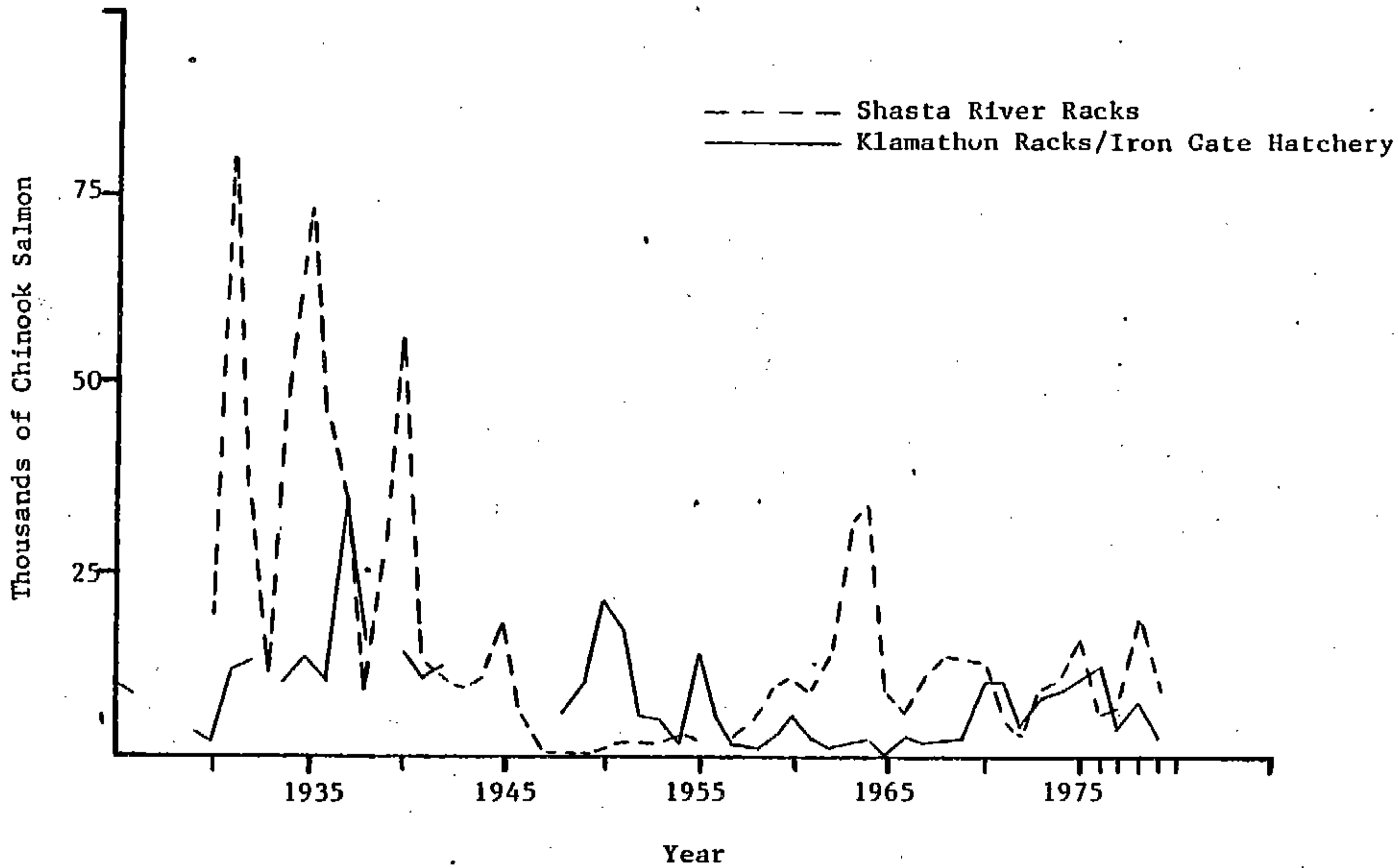
Table 3. Chinook salmon returns to the Iron Gate Hatchery, Trinity River Hatchery and Shasta Racks since 1976 along with run-size estimates for 1976, 1977 and 1978.

| Year | Chinook Salmon Returns | | | | Run-Size |
|---|---|---|---|---|---|
| | Iron Gate H. | Trinity River H. | Shasta Racks | Total | Estimates |
| 1976 | 13,726 | 7,624 | 6,073 | 27,423 | 209,702 1/ |
| 1977 | 4,833 | 5,721 | 7,447 | 18,001 | 195,602 1/ |
| 1978 | 7,840 | 8,755 | 18,731 | 35,326 | 139,000 2/ |
| 1979 | 2,558 | 5,073 | 8,144 | 15,775 | |

1/ Presented in McIntyre (1979) utilizing CDFG mark-recapture data.

2/ Presented by CDFG utilizing techniques other than mark-recapture.

Figure 18. Chinook salmon counts at the Shasta River Racks and Klamathon Racks/Iron Gate Hatchery through 1979.



It is believed that some of the problems encountered in conducting mark-recapture investigations in the Klamath River drainage in recent years can be alleviated by conducting the tagging operation at the mouth of the Klamath River (to reduce stress-induced mortality and harbor seal predation), by applying secondary marks to salmon receiving jaw and spaghetti tags (to ascertain respective tag shedding rates) and by stationing adequate numbers of personnel at the hatcheries and Shasta Racks (to allow for a thorough evaluation of returns). Since the bulk of the tagging effort must occur below the net fishery in order to use that fishery in conjunction with an in-season estimation and run prediction program, it seems reasonable to incorporate such efforts into the post-season estimation program.

The in-season run-size estimation program developed at Olympia FAO has involved purse seining and jaw tagging techniques and has relied on Indian net harvest for the mark sample. The stratified Schaefer model employed to estimate run size, in which marking periods are designated by i and recovery periods are designated by j, is described as:

$$N = \sum Nij = \sum (Rij \cdot \frac{Mi}{Ri} \cdot \frac{Cj}{Rj})$$

where,

N = estimated run size

Mi = the number of fish marked in the ith period of marking

Cj = the number of fish caught and examined for marks in the jth period of recovery

Ri = total recaptures of fish marked in the ith period

Rj = total recaptures during the jth period

Rij = the number of fish marked in the ith marking period which are recaptured in the jth recovery period.

The Petersen model, which will be used as an alternative run-size estimation method, is described as:

$$N = \frac{m(c+1)}{r+1}$$

where,

N = the total run size

m = the toal number of fish marked

c = the number of fish examined for marks in the fishery

r = the number of marked fish recovered in the sample (c).

Olympia FAO personnel developed a run prediction program utilizing four years of mark-recapture data to establish a regression relationship between a calculated in-season index and a final run-size estimate based on the first three weeks of mark-recapture data:

$$\text{Run size} = 2306.2 + 1.491\ (\text{index})\ (r^2 = .99,\ d.f. = 2,\ p\ 0.01)$$

As the run progresses, more reliable updated run-size forecasts are possible.

Recommended Future Course of Action

It is proposed to develop in-season run-size estimation and run prediction programs involving fall chinook salmon on the Klamath River utilizing beach seining as the principal capture technique and obtaining the mark sample through an examination of net harvest at the proposed fish checking station. With three or four years of data, it should be possible to develop a run-size prediction program which would provide for reliable estimates of final run size before the run has passed its peak. Such a program would provide decision-makers involved in the in-season adjustment process with reliable information on which to base decisions.

Through the tagging of adequate numbers of salmon, it is proposed to refine the post-season run-size estimation program so that estimates will fall within 10 percent of true values at the 95 percent confidence level.

## IV. STUDY PLAN

### A. OBJECTIVES

Objectives of the proposed fisheries investigation program include:

(1) Development of reliable in-season run-size estimation and run prediction programs involving fall chinook salmon in the Klamath River drainage.

(2) Refinement of the post-season run-size estimation program involving fall chinook salmon in the Klamath River drainage to within 10 percent of true values,

(3) Establishment of a program to collect life history, abundance and net harvest information on other important anadromous fishes in the Klamath River basin including green and white sturgeon,

(4) Refinement of the program to assess the contributions of wild and hatchery-reared Klamath River salmon to ocean fisheries, and

(5) Training of designated Indians of the reservation in all phases of the fisheries investigation program.

### B. TIME FRAMES, STAFFING NEEDS AND FUNDING REQUIREMENTS

Fisheries investigations will be conducted by a staff of four fishery biologists serving as field crew supervisors to six YACC enrollees and a number of fisheries technicians and Indian trainees under the overall supervision of the Biologist-in-Charge, Arcata FAO and Project Leader, Red Bluff FAO. It is proposed that two position ceilings be transferred from the BIA to USFWS - Fisheries Assistance Office, Arcata, California to implement the program. A four-year program is recommended during which time it is anticipated that project objectives can be accomplished. Involvement by USFWS in and beyond FY 1984 will depend upon the degree of accuracy required in run-size estimates for those years and on the extent to which Indian beiologists can assume management responsibilities. Detailed staffing and funding requirements to implement the program, as presented in the Revised Study and Budget Proposal dated November 1, 1979, are outlined in Tables 4 and 5.

Table 4. Staffing and associated funding requirements for the proposed FY 1980 anadromous fisheries program on the Hoopa Valley Indian Reservation.

| Position | GS Level | Number Required | Total Man-Months | Cost (x $1,000)1/ |
|---|---|---|---|---|
| Project Leader | 13 | 1 | 2 | 5.4 |
| Biologist-in-Charge | 12 | 1 | 9 | 20.4 |
| Fishery Biologist | 11 | 1 | 9 | 17.0 |
| Fishery Biologist | 9 | 3 | 24 | 37.5 |
| Biol. Technician | 5 | 15 | 60 | 61.8 |
| Clerk-Typist | 3 | 1 | 12 | 9.8 |
| YACC | -- | 6 | 72 | --- |
| Total | | | | 151.9 |

1/ Salaries include ten percent employee benefits

Table 5. Budget projections for the proposed fisheries investigation program on the Hoopa Valley Indian Reservation.

| Funding Element | Funding Requirements (x $1,000) in FY 1980 | 1981 | 1982 | 1983 | 1984 and beyond |
|---|---|---|---|---|---|
| Salaries1/ | 151.9 | 167.1 | 183.8 | 202.2 | 2/ |
| Vehicle rentals | 9.0 | 9.0 | 10.0 | 10.0 | |
| Travel, per diem | 10.0 | 10.0 | 10.0 | 10.0 | |
| Office supplies, services | 5.0 | 5.0 | 5.0 | 5.0 | |
| Storage space | 1.6 | 1.6 | 2.0 | 2.0 | |
| Equipment, maintenance | 14.0 | 10.0 | 10.0 | 5.0 | |
| Sub-Total | 191.5 | 202.7 | 220.8 | 234.2 | |
| Grand Total (including 17.5% admin. costs) | 232.1 | 245.7 | 267.6 | 283.9 | |

1/ Salaries in future years adjusted to take into account anticipated step and cost-of-living increases.

2/ Involvement in and beyond FY 1984 will depend upon the degree of accuracy required in run-size estimates for those years.

The successful development of the proposed program hinges upon successful beach seining operations in which our crews remain unimpeded from accomplishing their tasks and the successful development and operation of the proposed fish checking station on the lower river through which the examination of all fish caught by Indian netters in the estuary can be accomplished. The support and cooperation, as well as considerable assistance, will be required from the BIA in order for these operations to succeed. Indications are that the lower river Indian community is more receptive to the fish checking concept than they have been in the past.

The cooperation of the CDFG will be required to obtain post-season mark-samples from the hatcheries, Shasta Racks and spawning grounds. We must be prepared to furnish whatever manpower is required to assist CDFG in this effort.

## LITERATURE CITED

Hallock, R.J., D.E. Pelgen and L.O. Fisk. 1960. Fish, game and recreation in the Klamath River basin of California. Cal. Dep. of Water Res. Bull. No. 83. 149-165 p.

Jensen, Paul T. 1977. Letter from Chief, Anadromous Fish. Branch, Cal. Dep. of Fish and Game, December 19, 1977. 2 p.

McIntyre, John D. 1979. The 1978 fall chinook salmon run in the Klamath River. U.S. Fish and Wildl. Serv. - Internal Rep. 12 p.

Moffett, J.W. and S.H. Smith. 1950. Biological investigation of the fishery resources of Trinity River, California, U.S. Fish and Wildlife Service - Spec. Sci. Rep. - Fisheries No. 12. Wash., D.C. 71 p.

Radovich, John. 1967. Salmon resource of the Klamath River system. Cal. Dep. of Fish and Game Memorandum, May 24, 1967. 2 p.

Ricker, W.E. 1968. Methods for assessment of fish production in fresh waters. Blackwell Scientific Publications. Oxford and Edinburgh. 313 p.

Ricker, W.E. 1976. Review of the rate of growth and mortality of Pacific salmon in salt water, and noncatch mortality caused by fishing. J. Fish. Res. Board Can. 33:1483-1524