NORTHERN
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FINAL REPORT

BRADLEY RIVER SALMON STUDY PROGRAM

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FINAL REPORT

BRADLEY RIVER SALMON STUDY PROGRAM

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GENERAL INTRODUCTION

The Federal Energy Regulatory Commission (FERC) license granted to the Alaska Power Authority (now Alaska Energy Authority) for the Bradley Lake Hydroelectric Project (Project No. 8221) stipulates that a plan be developed and implemented to monitor the abundance of salmon in the Bradley River. A salmon monitoring plan was submitted to FERC in June of 1986 (Alaska Power Authority 1986a). The intent of this monitoring plan is to provide a yearly index of salmon abundance during both the pre-operational and post-operational periods to allow an appraisal of project impacts to salmon resources of the Bradley River. The salmon escapement monitoring study was scheduled to continue through 1995. The duration of the study program was designed to include a sufficient time period so that pre-project baseline conditions could be compared to post-project conditions. Part I of this report presents the results of the eleventh and last year of studies of salmon escapement to the Bradley River per the scope of work as described in the Salmon Monitoring Plan. Part II of this document consists of a final project report which summarizes the results of all years of the study and addresses whether mitigation measures to protect fish resources have been effective.

Operation of the Bradley Lake Hydroelectric Project began in the fall of 1991, consequently 1992 was the first full year of project operation. However, operational flows were in effect during the summer of 1991 while the reservoir was filling. Therefore, 1995 was the fifth year of the study to examine the salmon resources under the operational flow regime. A separate, but related, study of salmon attraction to the powerhouse discharge channel (tailrace), was instituted in 1992 and completed in 1993 (Alaska Energy Authority 1993). A supplemental study to investigate the use of the Bradley River by rearing salmonids was added in 1994 and reported in the 1994 Annual Report.

The salmon resources of the Bradley River have been documented in considerable detail through a series of studies (USFWS 1982; Woodward-Clyde Consultants 1983, 1984; Northern Technical Services 1985). The Bradley River is a turbid stream of glacial origin, consequently fish cannot normally be visually detected. During the early studies various active and passive sampling techniques were utilized to gain insight into the fish populations. The results of these studies indicated that pink salmon (Oncorhynchus gorbuscha) was the principal salmon species using the river for spawning, although smaller numbers of chum (O. keta), coho (O. kisutch), and chinook (O. tshawytscha) also utilized the river. These studies also indicated that potential spawning habitat was limited to a short segment of the river due to high gradient and coarse substrate at the upstream end and silty tideflats at the lower end.

The 1985 study by Northern Technical Services represented the first year of study for the pre-operational salmon monitoring program. However, the sampling methodology was modified in 1986 per the approved Salmon Monitoring Plan; therefore, data comparable to the 1995 study have only been collected during the 1986 through 1994 field seasons. The 1986-1988 studies were conducted by Dames & Moore (Alaska Power Authority 1986b, 1987, and 1988). The 1989 through 1994 studies (Alaska Energy Authority 1989, 1990, 1991, 1992, 1993 and 1994) as well as the 1995 field studies, which Part I of this report addresses, were conducted by Northern Ecological Services.

The 1986-1994 studies confirmed that pink salmon were the major spawners and that the river also supports small runs of the other salmon species. Considerable information on the abundance, spawning distribution, and other aspects of life history has been collected over the last eleven years.

PART I

BRADLEY RIVER SALMON ESCAPEMENT MONITORING STUDY-1995

OBJECTIVES

The primary objectives of the 1995 field effort were to:

- Continue the sampling methodology for the operational flow regime which was initiated in 1991 in order to allow estimates of salmon abundance to be compared with past years and, at the same time, provide standard catch procedures to be used for catch-per-unit-effort comparisons with 1991-1994.

- Continue the general assessment of the habitat value of the river under the operational flow regime as compared to the pre-operational flow regime

- Maximize the amount of biological information obtained from the study by thoroughly analyzing the data.

METHODS

Study Area

The primary study area was essentially identical to that in the 1986-1994 studies consisting of a 2,011-m (6,600-ft) stream segment extending from the downstream end of Riffle Reach to just above the upstream end of Bear Island Slough (Figure 1). The reduced flow beginning in 1991 allowed access by both fish and study team investigators above Bear Island Slough for a distance of about 300 m, thus the effective study area was lengthened slightly in 1991. The study area encompasses almost all of the known spawning habitat in the Bradley River system.

One study site was located outside of the primary study area.

Fox Farm Creek, a small clear-water tributary to the Bradley River at RM 2.5 was monitored for salmon escapement (Figure 1).

Study Duration

The study was conducted over a 9 week period from July 17 through September 14. The general timing of the study was originally selected to coincide with the duration and timing of the pink salmon run, based on the results of the earlier studies and confirmed in recent years.

Under the normal schedule of sampling, the field crew traveled to the site on Monday evening of each calendar week and intensive sampling took place on every Tuesday, Wednesday and Thursday.

Trap Net Sampling

Trap nets were again used as a primary sampling technique as in the 1986-1994 efforts. The standard project trap nets as redesigned in 1990 (see Alaska Energy Authority 1990) were designed to fish in water as shallow as 0.5 m and proved to work well at selected deeper sites in the river. The redesigned nets are illustrated in Figure 2. These nets were made from 6.35 cm (2.5 inch) stretch mesh nylon. Net wings were attached to the main frame of the net in various configurations depending on the location of the net in the river.

The 6 trap net sites established in 1991 for the operational flow regime were utilized again in 1995 (Figure 3). There was no indication that significant stream channel changes had occurred since the 1991 season, consequently the conditions at each net location effectively duplicated the conditions present during the 1991 through 1994 studies. Some of the nets were accessible by boat and some were only accessible by foot.

During each typical weekly sampling period, the trap nets in

the primary study area were set Tuesday morning and fished until Thursday morning for a total of approximately 48 hours, after which they were removed from the water until the following week. During normal operations, each net was checked every 4 hours during the daytime and then allowed to fish overnight. Some variation in the typical sampling regime occurred because of the difficulty accessing nets during extreme high tides. Sampling times were delayed by 1-2 hours during those days when unusually high tides coincided with scheduled sampling times. In Week 2, weather prevented the crew from reaching the field camp until Tuesday afternoon; consequently, the trap nets were fished from Tuesday afternoon until Thursday afternoon, maintaining the 48 hour schedule.

The fish were removed from the nets at each check, identified to species, measured, and salmon species were tagged using sequentially numbered Floy spaghetti tags. Larger Dolly Varden were marked by punching a hole in the upper lobe of the caudal fin. Sex and spawning condition were recorded for all salmon. Spawning condition codes were as follows:

Code	Condition
1	Fresh, non-spawning coloration, silvery
2	Spawning coloration, not ripe
3	Ripe, eggs or milt readily stripped
4	Spawned out
5	Visible deterioration
6	Dead

Beach Seine Sampling

As a supplemental sampling method, beach seining was conducted during Weeks 3 through 8 of the study period. No seining was conducted in Weeks 1 and 2 because of the large number of spawning chinook salmon in the seine areas. Seine sites are indicated on

Figure 3. Sites S1 and S3 were seined consistently each week and site S7 was seined during Weeks 6 and 7. In most cases two hauls were made at each site. The seine utilized was 100 ft. long by 6 ft. deep, constructed of 2.5 in. stretch mesh netting. Captured fish were processed in a manner similar to that described for the trap net sampling during Weeks 3-4. Because of the large number of pink salmon, fish caught in the seine in Weeks 5-8 were not measured or tagged; the seine catch was enumerated by species and recaptured fish were noted.

Carcass Counts

All salmon carcasses observed within the study area were counted and tags were noted.

Visual Observations

Exceptionally clear water on August 14-16 provided an unusual opportunity for visual observations within the study area. During this time period, visual counts of adult salmon were conducted and spawning areas were documented.

Fox Farm Creek Surveys

Visual surveys of fish present in Fox Farm Creek, a clear tributary to the Bradley River (Figure 1), were conducted once during each sample week. Observers walked the entire habitable length of the creek at lower tide levels and recorded the numbers of fish present for each species of salmon and the numbers of fish showing visible project tags.

Biological Data Management

Data from field data books were entered into a computer spreadsheet (Quattro Pro) using an IBM compatible microcomputer. Printouts from the spreadsheets were checked by field personnel

against the field notebooks. The spreadsheets were edited, correcting any observed errors. Graphs were prepared using the Quattro Pro program.

Population and Escapement Estimation

The principal methods used for estimating populations were the same as those used in past years to assure comparability of data. Population estimates based on trap net catches were calculated for the primary species of salmon present during each sample week using the Peterson model, as modified by Chapman (Ricker 1975). The following assumptions were used in constructing the model:

1. Salmon numbers remained constant during the 3-day sample period.
2. All fish marked during the previous 2 sample weeks were still present in the study area.
3. Fish marked 3 or more weeks prior to the sample week were no longer present in the study area.
4. Marked and unmarked fish were equally susceptible to capture.

In addition, population estimates were calculated based on selected seine catches and carcass counts.

Physical Data Collection

Air temperature, water temperature, turbidity, and stream stage were recorded daily at the field camp (Figure 1) on those days that the study crew was in the field. Turbidity was measured in the field using an HF Instruments Model DRT15 nephelometric turbidity meter. Stream stage was measured using a staff gage. The gage measurements were strictly relative and were not tied to any datum.

Miscellaneous Observations

Wildlife presence and other events of ecological interest were noted as they occurred.

RESULTS

Overall Catch

Overall catch for all methods combined is summarized by week in Table 1. Complete catch records for all measured fish are presented in Appendix A.

As in past years, all five species of Pacific salmon indigenous to Alaska were captured in the Bradley River. Pink salmon again were the most abundant species with a total catch of 4,345 fish. Substantial numbers of chum (220 fish), coho (116 fish), sockeye (53 fish), and chinook (116 fish) salmon also were caught. Small numbers of Dolly Varden (Salvelinus malma) were caught in the trap nets (64 fish).

Trap Net Index Sampling

Trap nets were the primary sampling technique and proved to be effective at catching adult salmon. The sampling effort for the 6 index nets was uniform throughout the study period. Trap net fishing times for each net and week are summarized in Appendix B.

Pink Salmon

Pink salmon catch and catch-per-hour for each week and net are presented in Table 2. The catch-per-hour showed a rapid increase at the beginning of August and remained high throughout the month (Figure 4). The number of pinks caught declined precipitously at the beginning of September with very few fish caught in Week 9. The

maximum catch rate was reached in Week 4 at 2.989 fish per hour (Table 2).

Chum Salmon

Chum salmon were present in the study area during Weeks 1 through 7 (Table 3). The chum salmon catch peaked during late July then declined rapidly with few fish remaining after early August (Figure 5). The maximum catch rate occurred during the second week of the study at 0.283 fish per hour (Table 3).

Coho Salmon

Coho salmon (Table 4 and Figure 6) were first seen in the study area during Week 4 (August 8-10) with catch rate increasing until the end of the study period. The greatest number of fish were caught during Week 9.

Sockeye Salmon

Sockeye salmon were present in the Bradley River during the entire study period (Table 5 and Figure 7) with the highest catch occurring during mid-August.

Chinook Salmon

Chinook salmon were present in moderate numbers during Weeks 1 through 5 with highest numbers occurring during the first week of the study (Table 6 and Figure 8).

Beach Seining

Beach seine catch data are summarized for pink salmon in Table 7. A total of 1,066 pink salmon were caught by the beach seine in 1995, of which 51 were fish that had been tagged previously.

Seine sites S1 and S3 (Figure 3) yielded the greatest number of fish. These sites corresponded with major pink salmon spawning areas. Other salmon species were not caught in significant numbers in the seine.

Carcass Counts

The results of carcass counts are presented in Table 8. During the course of the 1995 study, 1,258 pink salmon carcasses, 13 chum salmon carcasses, 26 chinook salmon carcasses, 1 sockeye salmon carcass, and 2 coho salmon carcasses were observed in the study area.

Fish Condition

Pink Salmon

The condition codes for all measured salmon are presented in Appendix A-1. Condition 3, "ripe", is indicative of spawning condition and was the least subjective of the condition codes since it depended on the actual presence of eggs or milt. Figure 9 shows the percent frequency of occurrence of Condition 3 fish for both male and female pink salmon. As has been the case in past years, males reached spawning condition earlier than females; most males were in spawning condition from Week 3 until Week 7. No ripe females were present during the first week of the study in mid-July. The frequency of females in spawning condition gradually increased during Weeks 2 through 6, reached a peak during Weeks 6-8 and dropped dramatically in Week 9. The peak of spawning apparently occurred in late August.

Chum Salmon

During Weeks 1-3 of the study essentially all the males were ripe. About 25 percent of the females in Week 1 were ripe, 47 percent in Week 2, 42 percent in Week 3, and 25 percent in Week 4.

Most chum salmon spawning probably occurred during late July and early August. Few fish were present in the river after Week 4.

Coho Salmon

Most of the cohos observed prior to Week 9 (Sept. 12-14) were in fresh condition or in the early stages of acquiring their spawning coloration (Appendix A-3). By Week 9, 10 percent of the males had reached spawning condition but no ripe females were observed during the study. The peak of coho spawning likely occurred well after the end of the study period in late September or early October.

Sockeye Salmon

Small numbers of sockeyes were present in the Bradley River throughout the entire study period. Percentages of ripe fish in Weeks 3, 4, 5, 6, and 7 were 20, 50, 67, 57, and 17 percent respectively, suggesting that spawning occurred over a prolonged period with the peak occurring in early to mid-August. While males tended to mature earlier than females, the chronology of maturation to spawning condition for both sexes was less consistent than for the other salmon species. The condition of sockeyes was extremely variable with males and females in pre-spawning condition still present in Week 9.

Chinook salmon

During the first week of the study in mid-July all of the males and 50 percent of the females were ripe. In Weeks 2 and 3 essentially all of the fish were either ripe or spawned out. The number of chinooks present in the river decreased in Weeks 4 and 5 with few fish present after Week 5. Most spawning probably occurred during the last two weeks of July.

Stream Life Duration

Pink Salmon

Table 9 provides information on the tagging history of all pink salmon recaptured in trap nets. As has been the case in past years, most of the prior-weeks recaptures for any given week were fish that had been marked in the previous 2 weeks, suggesting an average stream life duration of 2-3 weeks. However, the 1995 data suggest a somewhat longer average stream life for 1995 fish than observed in prior years. Recaptures caught in Weeks 6 and 7 included significant numbers of fish that had been tagged 3-4 weeks earlier. Some individual fish were present in the river for significantly longer than 2 weeks. One pink salmon recaptured on August 24 was originally tagged on July 19 for a total stream duration of 36 days.

Chum Salmon

The limited number of chum salmon caught in 1995 prevented extensive analysis of stream life duration. Of 45 recaptured fish, only two were recaptured more than two weeks after the marking date.

Chinook Salmon

The timing of the study period did not include the early part of the chinook salmon run; consequently, stream life duration cannot be accurately determined. Sixteen chinook salmon were recaptured in 1995. All of these recaptures were caught within 14 days of the day on which they were originally tagged.

Spawning Area Location

Spawning areas for pink salmon are delineated on Figure 10 and chinook salmon on Figure 11. The unusually clear water during Week

5 coincident with the peak of pink salmon spawning provided an exceptional opportunity for spawning area identification.

Visual Salmon Count

A count of chinook salmon spawners on July 18-19 resulted in observations of 57 fish within the study area, almost all actively spawning. Because of the turbidity, chinooks in deeper areas of the river were not visible.

A count of adult salmon within the study area during clear water conditions on August 15 resulted in estimated numbers as follows: pink salmon - 4,300; chum salmon - 16; sockeye salmon - 1; and chinook salmon - 7. The number of pink salmon is almost certainly an underestimate because of the difficulty counting fish in deep areas of the river and in areas where the fish were in dense aggregations.

Fox Farm Creek Surveys

The weekly visual surveys of Fox Farm Creek (Table 10) indicated that very small numbers of chum salmon utilized the creek for spawning in late July and early August and larger numbers of pink salmon were present from mid-August to early September. Predation by black bears was significant during the chum and pink runs.

Population Estimates

Pink Salmon

Weekly population estimates for pink salmon based on trap net recaptures using the same mark and recapture techniques employed in the 1986-1994 studies are presented in the first part of Table 11. Weekly population estimates ranged from a low of 1,848 in Week 9 to a high of 29,653 in Week 6. Because of the small number of

recaptures in Weeks 3, 8 and 9, the 95 percent confidence limits (Table 11) for the estimates are broad and the statistical reliability of the estimates should be considered poor.

Population estimates also were calculated from selected seine hauls in Weeks 3 through 8 and carcass counts in Weeks 5 through 8 (Table 11). These estimates are based on small numbers of recaptures and, thus, have broad confidence limits.

Chum Salmon

Mark-recapture population estimates for chum salmon in Weeks 2 and 3 are as follows:

Week	Total Catch	Tags Out	Recaps.	Pop. Est.	95% Limits
2	79	55	14	299	191-581
3	64	112	13	524	329-1,064

Chinook Salmon

A single estimate for Week 3 provides some insight into numbers of chinook salmon:

Week	Total Catch	Tags Out	Recaps.	Pop. Est.	95% Limits
3	29	49	4	300	147-1,500

Estimates of Total Escapement

Pink Salmon

An estimate of the total escapement can be calculated from the weekly trap net population estimates for pink salmon using the method of Pirtle and McCurdy (1980). With this method the weekly estimates are summed and divided by a stream life factor of 2.5. Since there is no population estimate for Weeks 1 and 2, these populations were assumed to be equal to 10 times the total catch

for the week, which is a highly conservative estimate of the actual numbers of fish present. Based on the above methodology, total escapement for pink salmon in the Bradley River in 1995 is estimated at about 48,000 fish.

Another approach to escapement estimation is based on a comparison of the overall trap net catch-per-hour in 1995 compared to previous years. The 1995 CPH was 4.46 times higher than the 1994 CPH; multiplying the 1994 escapement estimate by this factor yields a 1995 population estimate of 17,800 fish. Applying the same method to the 1993 results yields a 1995 escapement estimate of 26,500 fish. The relative accuracy of these various escapement estimates is examined below in the Discussion section.

Chum Salmon

The net catch of chum salmon in 1995 was 217 fish of which 20 percent were recaptures of fish caught previously. The mark-recapture estimate for Week 3 indicated that the number of chum salmon present in the river at that time probably fell into the range of 329-1,064 fish. An estimate of around 500 fish is reasonable, based on the 1995 catch statistics.

Coho Salmon

The study ended early in the coho run, therefore escapement cannot be estimated. The total trap net catch was 122 cohos, of which only two were recaptures. It is likely that at least 200 cohos were present in the river at the time of the study.

Sockeye Salmon

A total of 53 sockeye salmon were caught during the study, of which 5 were recaptures. A conservative estimate of the number of sockeyes present in the Bradley River, based on observations during the 1995 season, is 100-300 fish.

Chinook Salmon

Combining untagged captures with untagged carcasses results in a total of 123 individual chinook salmon that were handled during the study period. This represents the minimum number of fish present. More than 80 percent of the trapped fish were males suggesting that the traps were only sampling slightly more than half of the population. The mark-recapture population estimate for Week 3 described above suggested that about 300 chinooks were present in the river at that time.

Tag Returns From Outside the Study Area

One tagged fish was reported to the Alaska Department of Fish and Game in 1995. A coho salmon that was tagged in the Bradley River on August 16 was recovered in a personal use gill net set on the east side of the Homer Spit on August 21.

Physical Data

Air and water temperature, turbidity, and relative water level data are presented in Appendix C. Temperature data were collected at about 9:00 a.m. and, thus, are approximately representative of daily minimums. Water temperature showed relatively little variation, ranging from 7.0 to 10.0 degrees C. Predominantly cloudy weather combined with minimal air temperature extremes contributed to the stable stream water temperature regime. Turbidity was relatively low compared to previous years, ranging from a low of 6 NTU on August 16 to 46 NTU on August 8. High precipitation occurring in mid-August resulted in a high input of water from the clear North Fork portion of the drainage, allowing release of turbid water from the Bradley Lake dam to be reduced and, thus, causing water in the lower Bradley River to be unusually clear. River water level was very stable throughout the study period.

Miscellaneous Observations

The bald eagle nest near Eagle Pool was active again in 1995 with two young observed in the nest at the beginning of the study period in mid-July. The young had successfully fledged by late August. Adult and immature eagles were frequently seen feeding on salmon carcasses within the study area.

Bear signs were observed intermittently throughout the study period. Individual black bears were observed on July 18 and August 14. A small brown bear was seen crossing Riffle Reach on July 19. This bear was the first brown bear seen in the study area since the beginning of the study program in 1986. In spite of these observations and the large number of salmon available in the river, it appeared that bears did not feed extensively along the river.

DISCUSSION

Validity of Abundance Indices and Estimates

The potential difficulties with the use of mark and recapture population estimates under the circumstances in the Bradley River are discussed in detail in the 1986 study report (Alaska Power Authority 1986b). The analysis of marking net vs. recapture net presented in the 1989 study report (Northern Ecological Services 1989) indicates that pink salmon move widely throughout the study area prior to actual spawning and provides some assurance that the assumption that tagged fish are randomly distributed is not grossly violated. It should be noted that all of the "capture" methods were biased in favor of specific components of the pink salmon population. The trap nets sampled fish that were actively moving within the river and tended to catch more males than females. Seining in the latter part of the study period sampled fish that were actively spawning and usually included a more equal sex distribution than the trap net fish. Carcass counts tended to

"sample" fish that had been in the stream for a longer period of time and thus were biased toward fish that had not been recently tagged.

The mark-recapture population estimates for pink salmon in 1995 present several problems. The pink run was very abrupt with most fish entering the river during the high tides of Week 4 (Figure 4). Spawning occurred primarily during Weeks 5-7 followed by a very rapid mortality. It appeared that the run was less prolonged and more synchronized than in previous years. The rapid influx followed by rapid mortality significantly violates the assumption of a closed population which is required for accurate mark-recapture estimates. The inconsistency of the various estimates presented in Table 10 tends to create additional suspicion. The estimates based on carcass counts are considered to be especially unreliable because many of the carcasses were in advanced stages of deterioration and tags may have been lost or tag scars obscured by fungus growth. The visual estimate of pink salmon conducted in Week 5 was much smaller than the mark-recapture estimates of the same time period. Although such an estimate would be expected to be somewhat smaller because it was limited to shallow portions of the study area where the fish were visible, the difference was great enough to cause concern. The impression of the authors is that the mark-recapture estimates overestimated the number of pink salmon, especially in the latter weeks of the study when mortality was rapidly reducing the number of marked fish in the active population. The escapement estimate of 48,000 fish, based on the trap net mark-recapture estimates, probably represents a high estimate. The estimate of 26,500 fish, based on comparing 1995 CPH with 1993 CPH, may be closer to reality. The 1993 mark-recapture population estimates are considered to be more accurate than those conducted in 1995 and the catch-per-unit-effort was similar for 1993 and 1995. It is obvious that, as absolute values, 1995 pink salmon escapement numbers should be viewed with caution.

PART II

BRADLEY RIVER SALMON STUDY PROGRAM - 1986 THROUGH 1995

FINAL SUMMARY REPORT

INTRODUCTION

The 1995 study program represented the final year of a ten-year salmon monitoring plan per the requirements of the FERC license for the Bradley Lake Hydroelectric Project. This brief summary report describes the fish populations during the period of study, discusses apparent project impacts to salmon and their habitats, discusses the pre- and post-project characteristics of the lower Bradley River relative to fish and wildlife habitat values, and evaluates the success of mitigation measures that were incorporated into the project operational plan. Pink salmon were initially identified as the key evaluation species, consequently the discussion will emphasize this species. It should be noted that annual reports were prepared for each year of the study and readers are encouraged to consult these reports for additional detail; this summary should not be considered a substitute for the annual reports.

COMPARISON BETWEEN YEARS

Pink Salmon

Figure 12 compares the estimated escapement and trap net catch per hour for pink salmon for the years 1986 through 1995. Because pink salmon have a two year life cycle, the odd and even year runs are genetically separate and will be discussed separately.

Even year numbers were apparently highest during the first year of the study in 1986. During the fall of 1986, severe flooding occurred on the lower Bradley River significantly changing the course of the river channel in the most heavily used pink salmon spawning area (Tree Bar Reach), undoubtedly destroying most salmon

eggs in the gravel at that time. Even year escapements have been low since 1986. The somewhat larger escapement seen in 1994 was the first return from eggs spawned under the regulated flow regime (in 1992) and provides a preliminary indication that post-impoundment conditions are favorable for survival and that even year runs may be rebounding. Additional years of data will be required to determine whether a trend exists.

Odd year escapements have been significantly larger than even year throughout the study period, with the largest escapement probably occurring in 1989. Pink salmon escapements were generally high throughout Lower Cook Inlet drainages in that year, possibly because the commercial fishery was shut down by the effects of the Exxon Valdez oil spill. The most positive aspect of the escapement data is the high number of pink salmon seen in the Bradley River in 1993 and 1995, both a result of eggs spawned during the regulated flow regime, suggesting favorable post-impoundment incubation conditions. However, high saltwater survival was undoubtedly also a factor; the near record return seen in 1995 mirrored an area-wide trend. Humpy Creek, the closest pink salmon stream to the Bradley River in Kachemak Bay, also experienced high returns in 1995, the highest since 1989 (Hammarstrom, personal communication).

Chum Salmon

Trap net catch per hour data for chum salmon during the years 1986 through 1995 are presented in Figure 13. Chum salmon numbers have been highly variable ranging from an estimated 1600 fish in 1989 to less than 100 fish during low years. Most chum salmon are 3-5 years old with four year old fish usually predominating. It is difficult to draw conclusions from the annual catch data. The three largest escapements occurred during the pre-operational years; however, the survival of progeny from the large 1989 and 1990 runs was apparently poor under pre-operational flows. The somewhat larger numbers in 1995 may suggest improved survival of

fish spawned in 1991 and 1992 under the operational flow regime. Chum salmon runs in Kachemak Bay streams have been generally poor in recent years and the Bradley River numbers may be reflecting area trends.

Coho Salmon

Coho salmon numbers have also been highly variable during the years of the study (Figure 14). Since the timing of the field study did not include the latter part of the coho run, accurate estimation of coho numbers was not possible. Coho salmon have a 3-4 year life cycle suggesting that the progeny from eggs spawned during the early years of flow regulation (1991 and 1992) survived reasonably well to produce the relatively strong returns in 1994 and 1995. More years of data will be needed to establish trends.

Sockeye Salmon

Sockeye salmon were unusual in the Bradley River in 1986 and 1987 with numbers gradually increasing until 1990 when several hundred fish were probably present (Figure 15). Since flow regulation the numbers have been variable. Very small numbers of juvenile sockeyes have been found in the Bradley River suggesting that some natural reproduction has occurred in recent years. The sockeyes in the river have shown wide variation in size and time of maturity suggesting that they may be strays from other systems.

Chinook Salmon

Chinook salmon have demonstrated relatively stable numbers throughout the study years (Figure 16) with the number of fish in the river probably ranging from 50-300. There is no doubt that chinook salmon spawn and rear in the Bradley River. Unusually large returns occurred in 1993 and 1995. The age at maturity for chinook salmon is variable but most returning chinooks are likely to be 4-6 years old. The 1995 spawners may be the first returns

from fish hatched and reared under the regulated flow regime. The relatively large number of fish observed in 1995 may suggest favorable survival under stable, post-operational flows. Again, additional years of data will be required to establish trends.

TAILRACE ATTRACTION

The approved Salmon Monitoring Plan included requirements for a study of salmon attraction to the project tailrace, to be initiated during the first full year of operation and to continue for a minimum of two years. Tailrace attraction studies were conducted in 1992 and 1993 and are reported in detail in the annual reports for those years. The presence of salmon in the tailrace was monitored using trap nets, and the behavior of salmon while in the tailrace area was monitored by tracking selected fish carrying ultrasonic tags. The large pink salmon run in 1993 provided an excellent opportunity for data collection. Most of the information summarized below is the result of the 1993 study.

The results of the trap netting clearly showed that some pink salmon on route to the Bradley River were diverted to the Bradley Lake Hydroelectric Project tailrace discharge. During the peak of the pink salmon run in Week 6 of 1993 there may have been as many as 1,000 pinks in the tailrace area. However, by Week 7 few fish were present in the tailrace while large numbers (up to 20,000) were present in the Bradley River.

The ultrasonic tagging provided substantial insight into the behavior of fish that entered the tailrace area. Of 47 tagged fish, 44 left the tailrace within three days and 21 were ultimately confirmed in the Bradley River. Several fish tagged with Floy tags, plus some fish with ultrasonic tags were recovered in the Bradley River on the day following tagging in the tailrace, suggesting rapid directed movement.

The results of the 1993 tailrace study program suggest that

most pink salmon did not remain in the tailrace area for an extended time. A significant proportion of the fish originally caught in the tailrace were subsequently located in the Bradley River; whereas, there was no indication of movement from the Bradley River to the tailrace. A minor portion of the total pink salmon run on its way to the Bradley River could be delayed by diversion into the tailrace; this delay could have a detrimental effect on the spawning ability of some fish by exhausting energy reserves or causing the fish to arrive too late on the spawning grounds. However, the results of the 1993 tracking studies suggest that most pink salmon that entered the tailrace made a quick correction and left within a few days. Past results of the Bradley River escapement studies have indicated that pink salmon move extensively within the Bradley River prior to actual spawning. From the perspective of the Bradley River, there was no indication that spawning was interrupted in any way. The sum total of these observations suggests that any impacts that occurred as a result of tailrace attraction were negligible relative to the many factors that can affect salmon populations. It is the opinion of the authors that measures to mitigate the attraction of salmon to the tailrace are not needed.

PRE-OPERATIONAL VS. POST-OPERATIONAL HABITAT QUALITY

Pink Salmon Spawning

The greatly reduced volume of water that is present during the open water season under the regulated flow regime has significantly changed the nature of the stream. Depth, width and velocity have been much reduced. Siltation has increased in some areas of the study area, particularly Riffle Reach, which is routinely subjected to tidal flooding. There is some evidence that substrate in upstream areas is shifting to less coarse materials.

Comparing spawning area location between pre-operational and post-operational years suggests an upstream shift. Prior to

reduced flow, Riffle Reach was one of the most important spawning areas with most spawning occurring over a central gravel bar. Under the regulated flow regime this bar became permanently exposed and the channel became split. In recent years less spawning has occurred in Riffle Reach. Gravel substrate within the west channel of lower Riffle Reach has become partly imbedded with silt. However, siltation appeared to be less in 1995 than in 1994, suggesting that some flushing is still occurring under regulated flow.

Under pre-project flow conditions, the portion of the Bradley River study area upstream from the USGS gage station (Figure 1) was deep and fast, with a boulder substrate. It is unlikely that significant spawning by pink salmon occurred in this reach. Under the operational flow regime, depth and velocity were reduced to within the useable range for spawning, and scattered locations within this reach are currently utilized by pink salmon. Patches of suitable substrate have been deposited within the boulder matrix. It is the opinion of the authors that there has been a net increase in the area of useable pink salmon spawning habitat since the advent of regulated flow.

During the large pink salmon escapement in 1995, spawning habitat use appeared to be close to saturation and spawning was observed throughout much of the study area including lower Riffle Reach, which had been abandoned in 1993 and 1994. The Tree Bar Reach complex (Figure 10) continued to be the most heavily used area.

Chinook Salmon Spawning

Chinook salmon spawning occurs in most of the same areas utilized by pink salmon, but there is a higher proportionate use of upstream areas, above Bear Island. The expansion of available spawning habitat to upstream areas following regulation probably has been more significant for chinooks than pinks because they are

better able to utilize the relatively deep and fast water found in the upstream reach.

Chum Salmon

Comparing pre-operational and post-operational spawning area maps for chum salmon suggests that spawning area for chums has decreased under the regulated flow regime. Chums in the Bradley River usually select areas of upwelling water; such areas may be less common under low flow conditions because of generally lower water level.

Coho and Chinook Salmon Rearing

Some information on juvenile coho and chinook salmon was collected during the early pre-licensing studies (U.S. Fish & Wildlife Service 1982 and Woodward-Clyde Consultants 1983) and a limited study of winter rearing in the Bradley River study area was conducted by Northern Ecological Services in 1994 (Alaska Energy Authority 1994). Juvenile cohos have been found in moderate density in a variety of slow water habitats, including sloughs and backwaters both within and above the intertidal area. Juvenile chinook salmon are less common and are usually found along the margins of mainstream areas.

The area of slough and backwater habitats within the salmon escapement study area has been reduced by flow reduction. Most notably, Bear Island Slough has been reduced to two small ponds. Opportunity for coho salmon rearing is likely less than was the case prior to the Bradley Lake Project. However, the habitat areas that remain are more stable seasonally and, thus, may contribute to higher survival of juvenile cohos.

The 1994 winter rearing study indicated that moderate numbers of juvenile chinook salmon utilize mainstream areas adjacent to and upstream from Bear Island. These areas of moderate depth and

velocity were probably not consistently available during unregulated flow when winter discharge often approached zero. Regulated flow has evidently expanded and improved chinook salmon rearing habitat in the Bradley River above the intertidal zone.

The use of intertidal habitats by either coho or chinook has not been adequately studied and effects on these areas by altered Bradley River flow remain unknown.

Wildlife Habitats

Probably the most dramatic change in the ecological characteristics of the Bradley River study area has been the increase in use by wildlife under the reduced flow regime. Use of the river corridor by birds and mammals has been much more evident in recent years. The availability of salmon carcasses in late summer is a major factor in this increase in abundance. Black bear, fox, mink, eagles, gulls, ravens, and magpies commonly feed on salmon. Under the pre-operational flow regime the river was nearly bank full in late summer and most carcasses were washed directly into Kachemak Bay. Shallow water, reduced current velocity, increased area of gravel bars and beaches, and stranding of fish in depressions following extreme tides all contribute to the availability of fish to wildlife. Additionally, the shallow water and shoreline margins present under low flow allow the river to be used as a travel corridor, whereas previously it had been a travel barrier during much of the open water season. Moose and black bear routinely cross the river in contrast to previous years. Stable, moderate winter flow conditions have enhanced habitat for river otter and mink.

Protection From Extreme Flows

Under the natural condition the Bradley River watershed was subject to wide variations in flow. Evidently flooding was common, especially during fall storms, as was seen in the severe conditions

that occurred in the fall of 1986. These extremes affected the habitat suitability for both fish and wildlife. The Bradley Lake reservoir provides a significant buffer against flow extremes. The beneficial impact of this buffer to fish has already been seen. During late September of 1995 heavy precipitation in the Kenai Mountains dramatically raised the level of the Lower Bradley River. If the reservoir had not been able to contain much of the excess water, flooding and scour of salmon spawning areas would probably have occurred, resulting in a loss of salmon eggs.

SUCCESS OF EXISTING MITIGATION MEASURES

The primary mitigation measure relative to fish protection that was established as part of the Bradley Lake Hydroelectric Project licensing was the requirement for mandatory minimum instream flow in the Bradley River. Water has been released into the upper Bradley River via a fish water bypass system since the dam was completed in 1990. The minimum flows required are 100 cfs from mid-April through mid-September, 50 cfs from mid-September through October, and 40 cfs from November through mid-April. These minimum flows were based on recommendations resulting from an instream flow study conducted during project planning (Woodward-Clyde Consultants 1983). The study predicted that pink salmon spawning and incubation habitat would likely be improved under the regulated flow regime while some loss of slough-type rearing habitats might occur.

Since project operation, discharge in the Lower Bradley River fish use area has averaged about 30 percent greater than the mandatory minimums because of the need to maintain a safety margin and, thus, avoid violation of the requirements during unusual climatic conditions. Evidence from the salmon escapement monitoring program suggests that the predictions made during the original instream flow study were essentially correct. Pink salmon appear to be surviving well under the regulated flow regime and there is a preliminary indication that populations are becoming

more stable. A possible bonus that was not predicted is the enhancement of chinook salmon spawning and rearing habitat.

RECOMMENDATIONS FOR FUTURE YEARS

1. Extension of Study Program - It is recommended that salmon escapement monitoring be continued in order to extend the period of record and provide a better indication of trends in salmon reproduction under the regulated flow regime. The Alaska Energy Authority is currently planning to continue the program for an additional 3 years, with the intent of gaining additional insight into the effects on fish populations as flows are fine-tuned closer to allowable minimums.

2. Evidence available to date indicates that special additional measures to mitigate impacts to fish from the Bradley Lake Hydroelectric Project are not necessary. Habitat suitability and survival of pink salmon, the key evaluation species, has probably been enhanced by the existing regulated flow regime. Most other project biological impacts also appear to be beneficial.

3. The number of pink salmon observed in 1995 was probably greater than optimal escapement. Crowding on the limited spawning areas may have adversely affected the spawning process. The presence of these excess fish suggests that additional commercial exploitation during odd years would be a desirable goal. Some exploitation of Bradley River pink salmon undoubtedly occurs in existing lower Cook Inlet fisheries. However, seine fisheries have not specifically targeted Bradley River fish because shallow mud flats make accessing the river mouth area difficult, and turbid water prevents fishermen from directly observing fish schools. In spite of these difficulties, additional fishing effort might be worthwhile.

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TABLE 1. TOTAL CATCH FOR ALL SAMPLE METHODS COMBINED - 1995

WEEK NO.	DATES	PINK SALMON	CHUM SALMON	COHO SALMON	SOCKEYE SALMON	CHINOOK SALMON	DOLLY VARDEN
1	JUL 17-19	63	59	0	2	38	1
2	JUL 25-27	103	79	0	2	31	4
3	AUG 1-3	374	64	0	5	29	6
4	AUG 8-10	1064	11	1	7	8	8
5	AUG 15-17	777	4	7	18	9	7
6	AUG 22-24	905	1	13	7	0	5
7	AUG 29-31	711	2	21	6	0	3
8	SEP 5-7	337	0	33	3	0	6
9	SEP 12-14	11	0	41	3	1	24
	TOTAL	4345	220	116	53	116	64

TABLE 2. TRAP NET CATCH STATISTICS FOR PINK SALMON-1995

	SAMPLING WEEK																			
	1		2		3		4		5		6		7		8		9		TOTAL	
NET	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH
1	2	0.044	1	0.022	2	0.041	34	0.700	11	0.223	67	1.384	79	1.622	31	0.643	4	0.083	231	0.535
3	4	0.088	24	0.516	13	0.267	81	1.650	33	0.671	36	0.739	97	1.996	9	0.186	0	0.000	297	0.686
4	0	0.000	5	0.107	50	1.012	159	3.219	261	5.294	102	2.086	140	2.863	44	0.909	0	0.000	761	1.753
5A	5	0.110	18	0.387	75	1.546	220	4.499	63	1.275	100	2.062	84	1.721	19	0.395	2	0.041	586	1.356
6A	0	0.000	13	0.280	31	0.640	166	3.416	57	1.154	153	3.188	82	1.684	32	0.668	3	0.062	537	1.245
7A	52	1.153	42	0.901	150	3.074	218	4.440	128	2.602	67	1.373	77	1.578	38	0.785	2	0.041	774	1.787
TOTAL	63	0.232	103	0.369	321	1.098	878	2.989	553	1.869	525	1.802	559	1.911	173	0.598	11	0.038	3186	1.227

TABLE 3. TRAP NET CATCH STATISTICS FOR CHUM SALMON-1995

	SAMPLING WEEK																			
	1		2		3		4		5		6		7		8		9		TOTAL	
NET	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH
1	3	0.066	3	0.065	2	0.041	1	0.021	0	0.000	1	0.021	0	0.000	0	0.000	0	0.000	10	0.023
3	1	0.022	15	0.323	5	0.103	2	0.041	0	0.000	0	0.000	1	0.021	0	0.000	0	0.000	24	0.055
4	5	0.112	12	0.258	4	0.081	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	21	0.048
5A	29	0.639	23	0.495	18	0.371	2	0.041	1	0.020	0	0.000	1	0.020	0	0.000	0	0.000	74	0.171
6A	15	0.329	21	0.453	11	0.227	3	0.062	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	50	0.116
7A	6	0.133	5	0.107	11	0.225	1	0.020	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	23	0.053
TOTAL	59	0.217	79	0.283	51	0.174	9	0.031	1	0.003	1	0.003	2	0.007	0	0.000	0	0.000	202	0.078

TABLE 4. TRAP NET CATCH STATISTICS FOR COHO SALMON-1995

	SAMPLING WEEK																			
	1		2		3		4		5		6		7		8		9		TOTAL	
NET	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH
1	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
3	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	1	0.021	3	0.062	1	0.021	5	0.012
4	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	1	0.020	0	0.000	1	0.021	5	0.103	7	0.016
5A	0	0.000	0	0.000	0	0.000	1	0.020	2	0.040	3	0.062	2	0.041	1	0.021	6	0.124	15	0.035
6A	0	0.000	0	0.000	0	0.000	0	0.000	1	0.020	1	0.021	6	0.123	18	0.376	18	0.373	44	0.102
7A	0	0.000	0	0.000	0	0.000	0	0.000	4	0.081	8	0.164	12	0.246	10	0.207	11	0.228	45	0.104
TOTAL	0	0.000	0	0.000	0	0.000	1	0.003	7	0.024	13	0.045	21	0.072	33	0.114	41	0.141	116	0.045

TABLE 5. TRAP NET CATCH STATISTICS FOR SOCKEYE SALMON-1995

	SAMPLING WEEK																			
	1		2		3		4		5		6		7		8		9		TOTAL	
NET	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH
1	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
3	0	0.000	1	0.022	0	0.000	1	0.020	4	0.081	0	0.000	1	0.021	0	0.000	0	0.000	7	0.016
4	0	0.000	0	0.000	0	0.000	0	0.000	4	0.081	0	0.000	0	0.000	0	0.000	0	0.000	4	0.009
5A	0	0.000	0	0.000	2	0.041	5	0.102	2	0.040	2	0.041	1	0.020	2	0.042	1	0.021	15	0.035
6A	0	0.000	0	0.000	0	0.000	0	0.000	1	0.020	3	0.063	0	0.000	1	0.021	1	0.021	6	0.014
7A	2	0.044	1	0.021	3	0.061	1	0.020	7	0.142	2	0.041	4	0.082	0	0.000	1	0.021	21	0.048
TOTAL	2	0.007	2	0.007	5	0.017	7	0.024	18	0.061	7	0.024	6	0.021	3	0.010	3	0.010	53	0.020

TABLE 6. TRAP NET CATCH STATISTICS FOR CHINOOK SALMON-1995

	SAMPLING WEEK																			
	1		2		3		4		5		6		7		8		9		TOTAL	
NET	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH	CATCH	CPH
1	0	0.000	3	0.065	2	0.041	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	5	0.012
3	6	0.133	2	0.043	1	0.021	3	0.061	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	12	0.028
4	1	0.022	9	0.193	14	0.283	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	1	0.021	25	0.058
5A	3	0.066	2	0.043	1	0.021	1	0.020	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	7	0.016
6A	19	0.417	4	0.086	1	0.021	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	24	0.056
7A	9	0.200	11	0.236	10	0.205	4	0.081	9	0.183	0	0.000	0	0.000	0	0.000	0	0.000	43	0.099
TOTAL	38	0.140	31	0.111	29	0.099	8	0.027	9	0.030	0	0.000	0	0.000	0	0.000	1	0.003	116	0.045

TABLE 7. SEINE CATCH SUMMARY FOR PINK SALMON - 1995

DATE	UNTAGGED	TAGGED	TOTAL
08/02	46	7	53
08/09	83	10	93
08/14	209	15	224
08/21	369	11	380
08/29	150	2	152
09/05	158	6	164
TOTALS	1015	51	1066

TABLE 8. CARCASS COUNT SUMMARY - 1995

SPECIES	DATE	UNTAGGED	TAGGED	TOTAL
PINK SALMON	07/26	0	1	1
	08/01	1	0	1
	08/03	3	1	4
	08/08	4	0	4
	08/09	3	0	3
	08/10	21	1	22
	08/15	23	4	27
	08/16	12	3	15
	08/17	32	6	38
	08/22	37	1	38
	08/23	162	1	163
	08/24	182	10	192
	08/29	70	5	75
	08/30	149	6	155
	08/31	158	4	162
	09/05	137	10	147
	09/06	77	4	81
	09/07	117	0	117
	09/12	1	0	1
	09/13	12	0	12
		1201	57	1258
CHUM SALMON	08/15	5	1	6
	08/16	1	1	2
	08/17	4	0	4
	08/22	1	0	1
		11	2	13
CHINOOK SALMON	07/20	1	0	1
	07/27	0	1	1
	08/01	2	0	2
	08/03	2	0	2
	08/07	2	0	2
	08/08	2	0	2
	08/09	2	0	2
	08/10	1	1	2
	08/15	8	1	9
	08/17	3	0	3
		23	3	26
SOCKEYE SALMON	08/24	0	1	1
		0	1	1
COHO SALMON	09/06	1	0	1
	09/13	0	1	1
		1	1	2

TABLE 9. COMPARISON OF THE WEEK OF MARKING WITH THE WEEK OF RECAPTURE FOR ALL PINK SALMON TRAP NET RECAPTURES-1995

RECAPTURE WEEK	MARKING WEEK									TOTAL
	1	2	3	4	5	6	7	8	9	
1										0
2										0
3		5	5							10
4	2	6	23	17						48
5		1	10	16	11					38
6	1	1	4	12	11	6				35
7			2	4	2	15	5			28
8				1			7	3		11
9							1			1
TOTAL RECAPS.	3	13	44	50	24	21	13	3	0	171
TOTAL TAGS OUT	59	101	338	877	475	373	275	32	0	2530
% RECAPTURED	5	13	13	6	5	6	5	9		

TABLE 10: FOX FARM CREEK VISUAL SURVEYS - 1995

DATE	SPECIES	TOTAL LIVE	LIVE W/ TAGS	TOTAL DEAD	DEAD W/ TAGS
JUL 19	CHUM	1	0	0	0
JUL 26	CHUM	5	0	0	0
AUG 03	CHUM	4	0	1	0
	PINK	0	0	1	0
AUG 08	CHUM	3	0	0	0
AUG 16	PINK	71	0	0	0
AUG 23	PINK	95	0	0	0
AUG 29	PINK	17	0	3	0
SEP 07	PINK	18	0	3	0
SEP 13		NO FISH			

TABLE 11. MARK-RECAPTURE POPULATION ESTIMATES FOR PINK SALMON-1995

WEEK	TOTAL CATCH	TAGS OUT (Past 2-wks)	RECAPS (R)	-95% R	+95% R	POP. EST. (N)	-95% N	+95% N
RECAPTURE VIA TRAP NET								
1	63	0	0	-	-	-	-	-
2	103	59	0	-	-	-	-	-
3	321	160	5	1.6	11.7	8640	32402	4432
4	878	439	29	19.4	41.6	12892	19937	9298
5	553	1215	26	17.0	38.0	24951	39628	17729
6	525	1352	23	14.6	34.4	29653	48746	20689
7	559	848	17	9.9	27.2	26413	48025	17480
8	173	648	7	2.8	14.4	14116	40332	7843
9	11	307	1	0.1	5.6	1848	36961	661
RECAPTURE VIA SEINE								
3	53	328	7	2.8	14.4	2221	6346	1235
4	93	910	10	4.7	18.4	7785	18221	4655
5	224	1215	15	8.4	24.8	17100	32572	11033
6	380	1352	11	5.4	19.7	42958	95463	26168
7	152	848	2	0.2	7.2	43299	649486	18042
8	164	648	6	2.2	13.1	15298	48676	8175
RECAPTURE VIA CARCASS COUNTS								
5 (8/15-8/17)	80	1215	13	6.9	22.3	7035	14276	4418
6 (8/22-8/24)	393	1352	12	6.2	21	41006	85982	25386
7 (8/29-8/31)	392	848	15	8.4	24.8	20854	39722	13455
8 (9/05-9/07)	345	648	14	7.7	23.5	14970	29164	9556

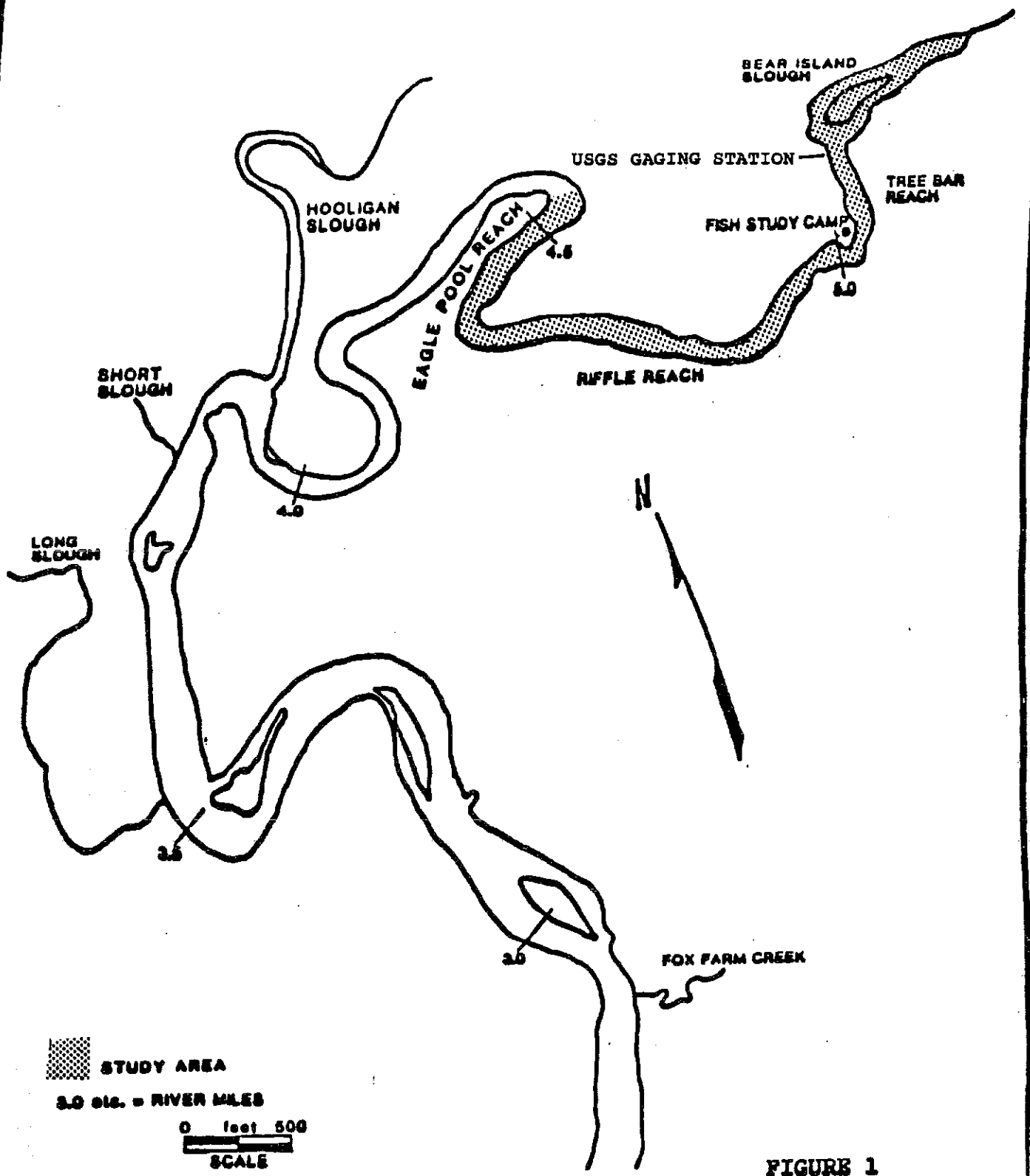
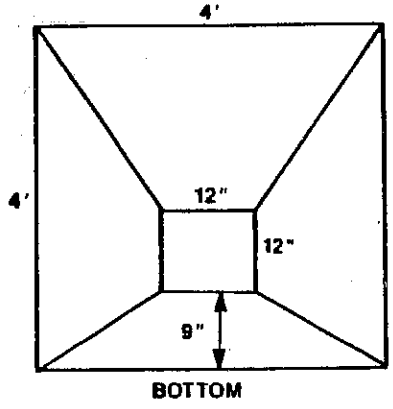
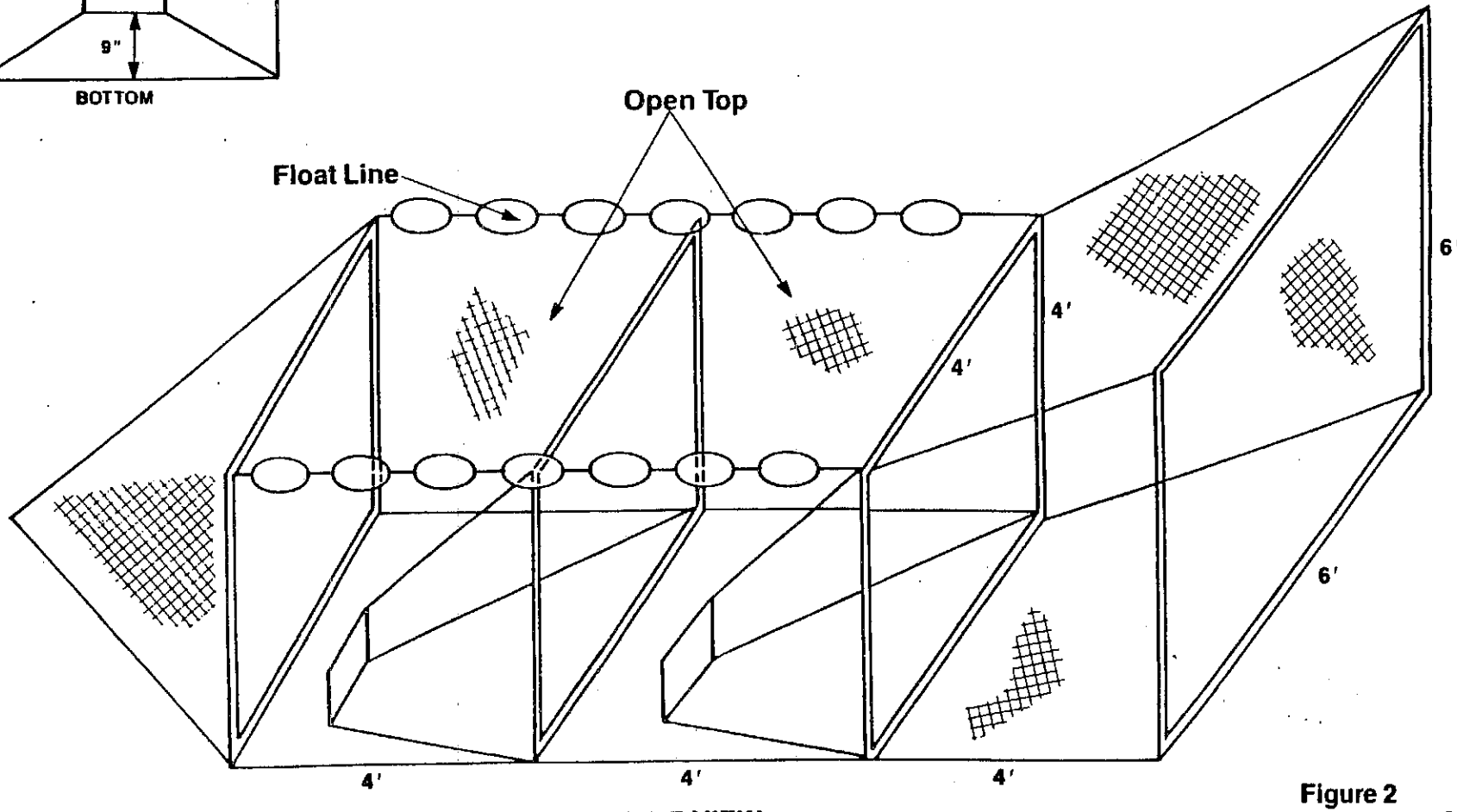


FIGURE 1

LOWER BRADLEY RIVER WITH SALMON ESCAPEMENT STUDY AREA



END VIEW
Showing offset throat



SIDE VIEW

Figure 2
Bradley River Trap Net Design
(As Modified in 1990)

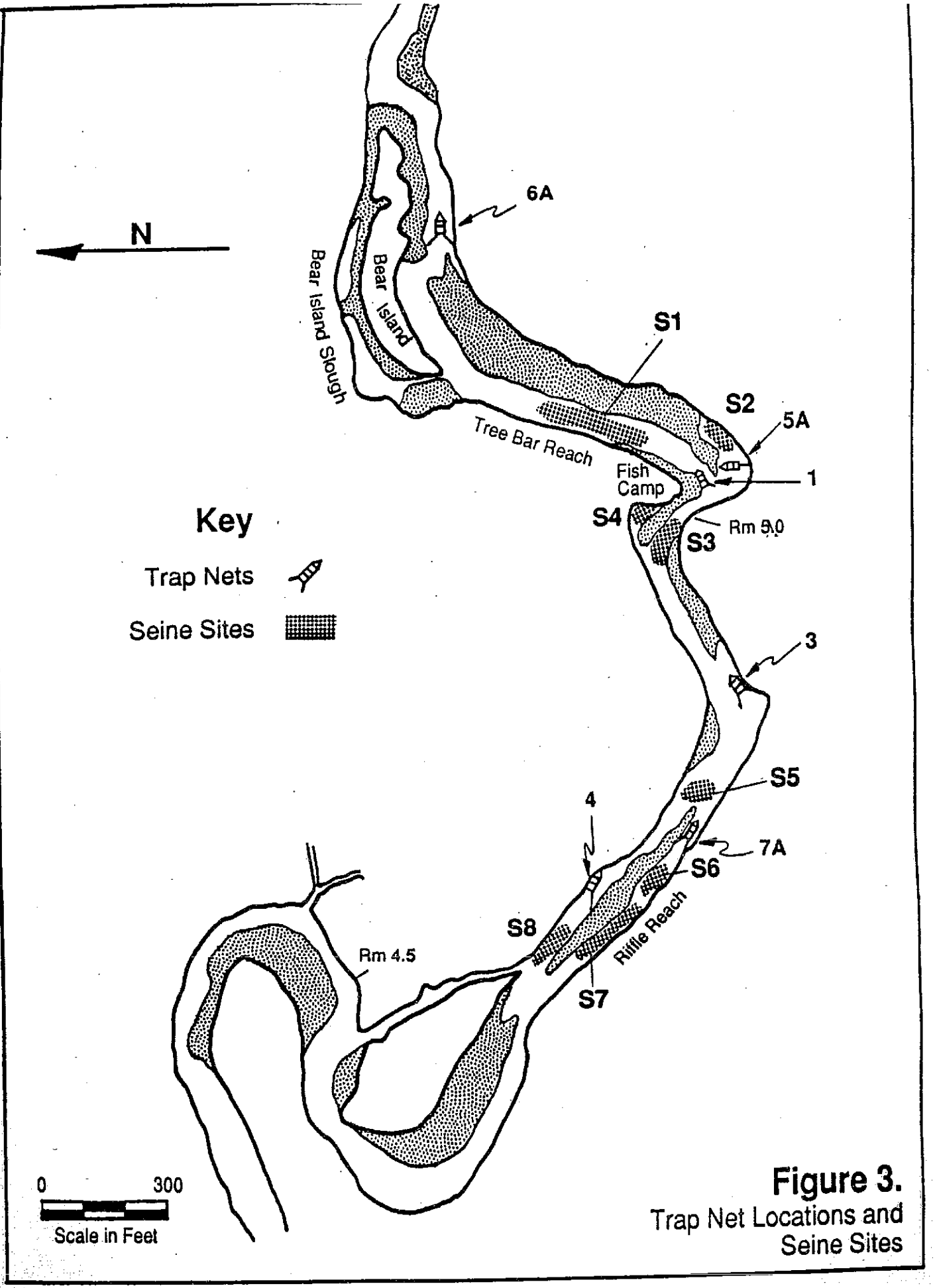


Figure 3.
Trap Net Locations and Seine Sites

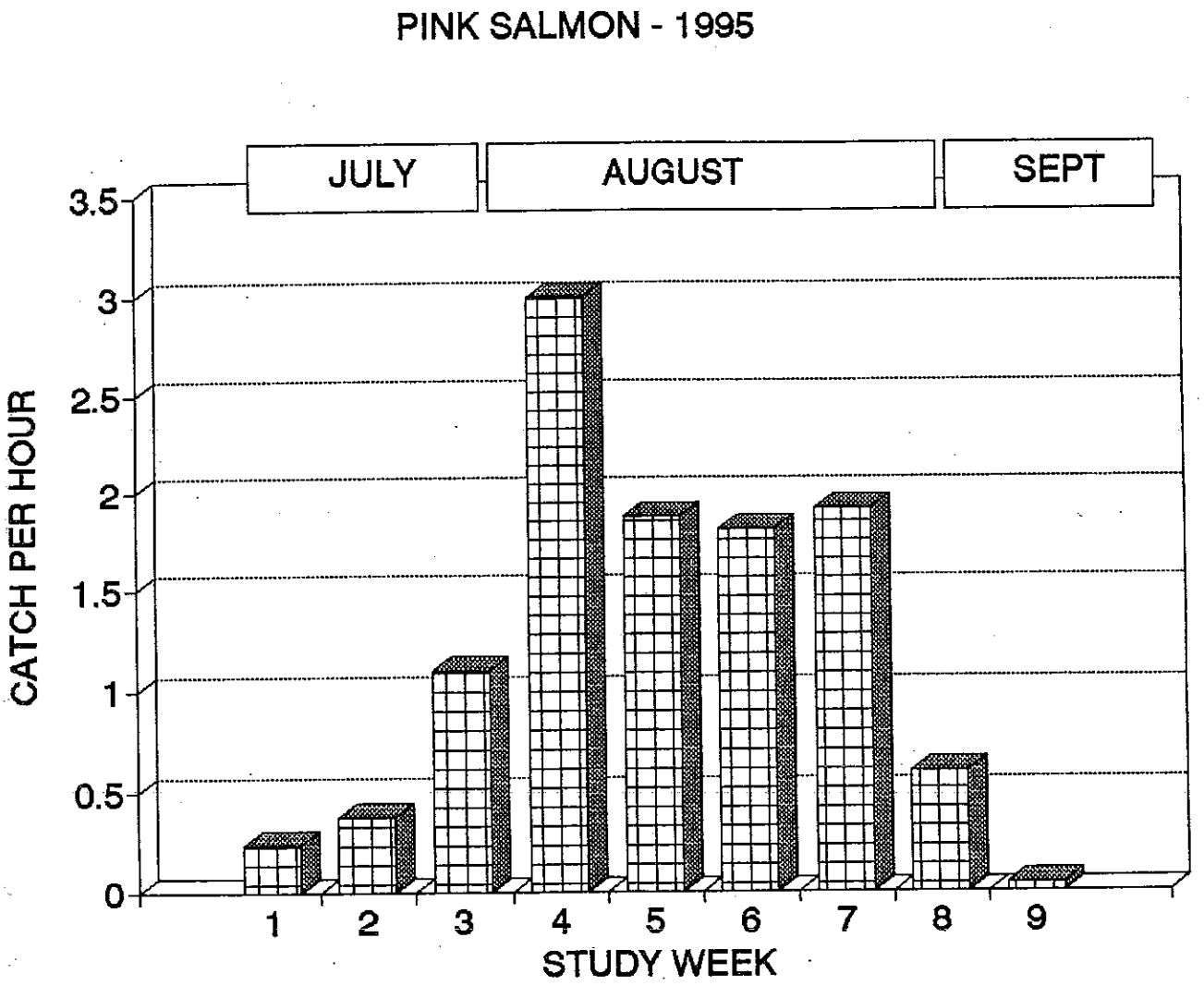


Figure 4. Catch-per-unit-effort for pink salmon by study week.

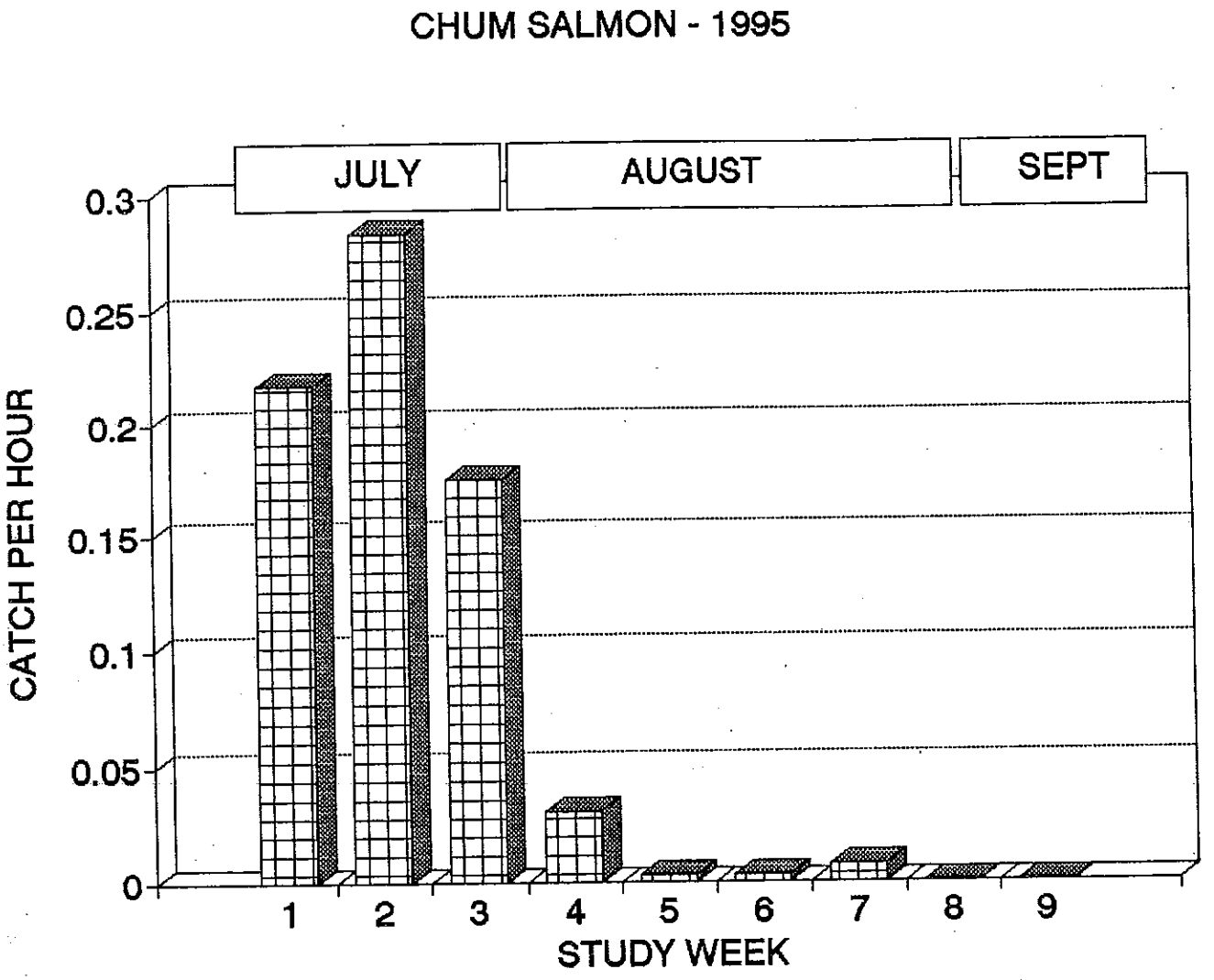


Figure 5. Catch-per-unit-effort for chum salmon by study week.

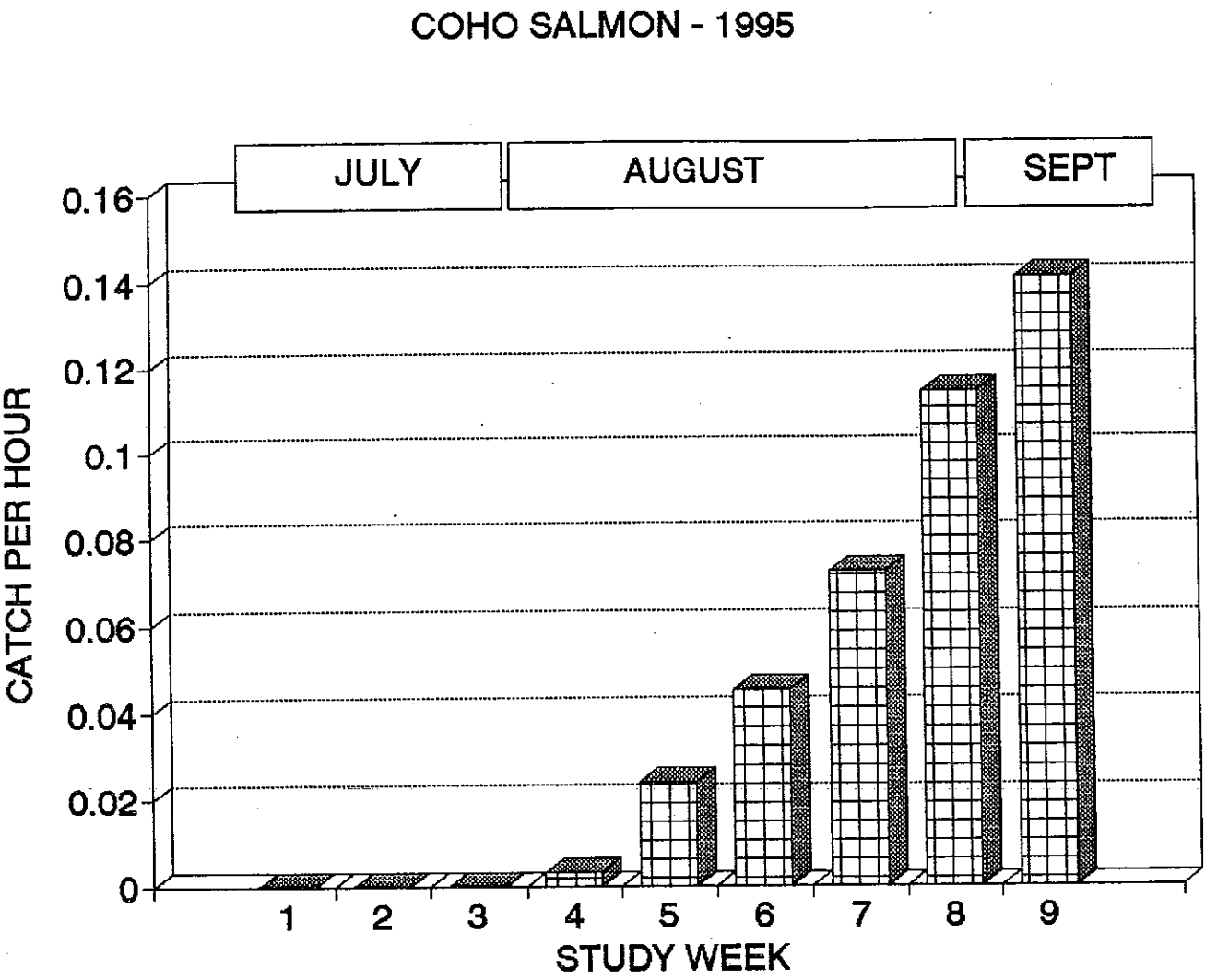


Figure 6. Catch-per-unit-effort for coho salmon by study week.

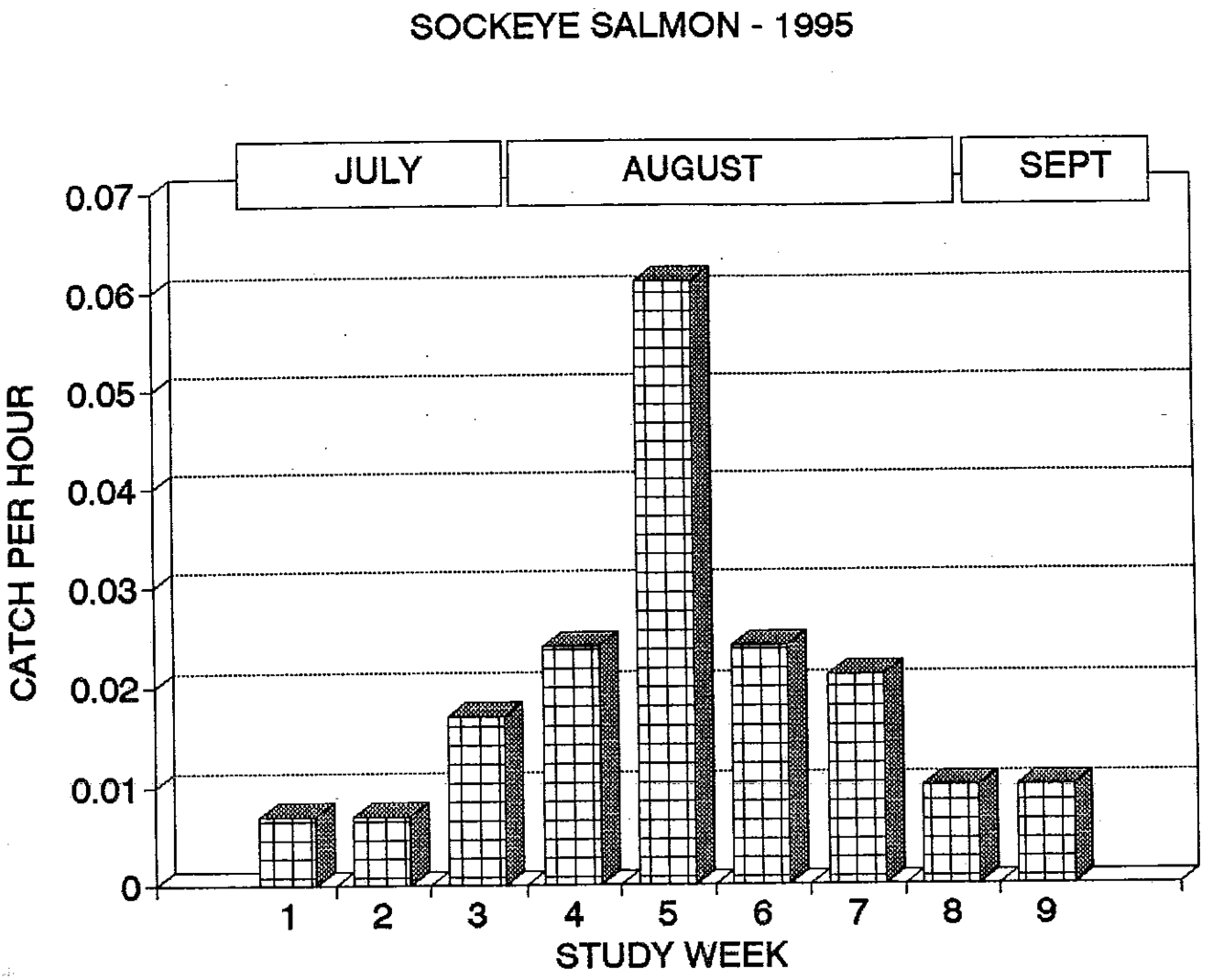


Figure 7. Catch-per-unit-effort for sockeye salmon by study week.

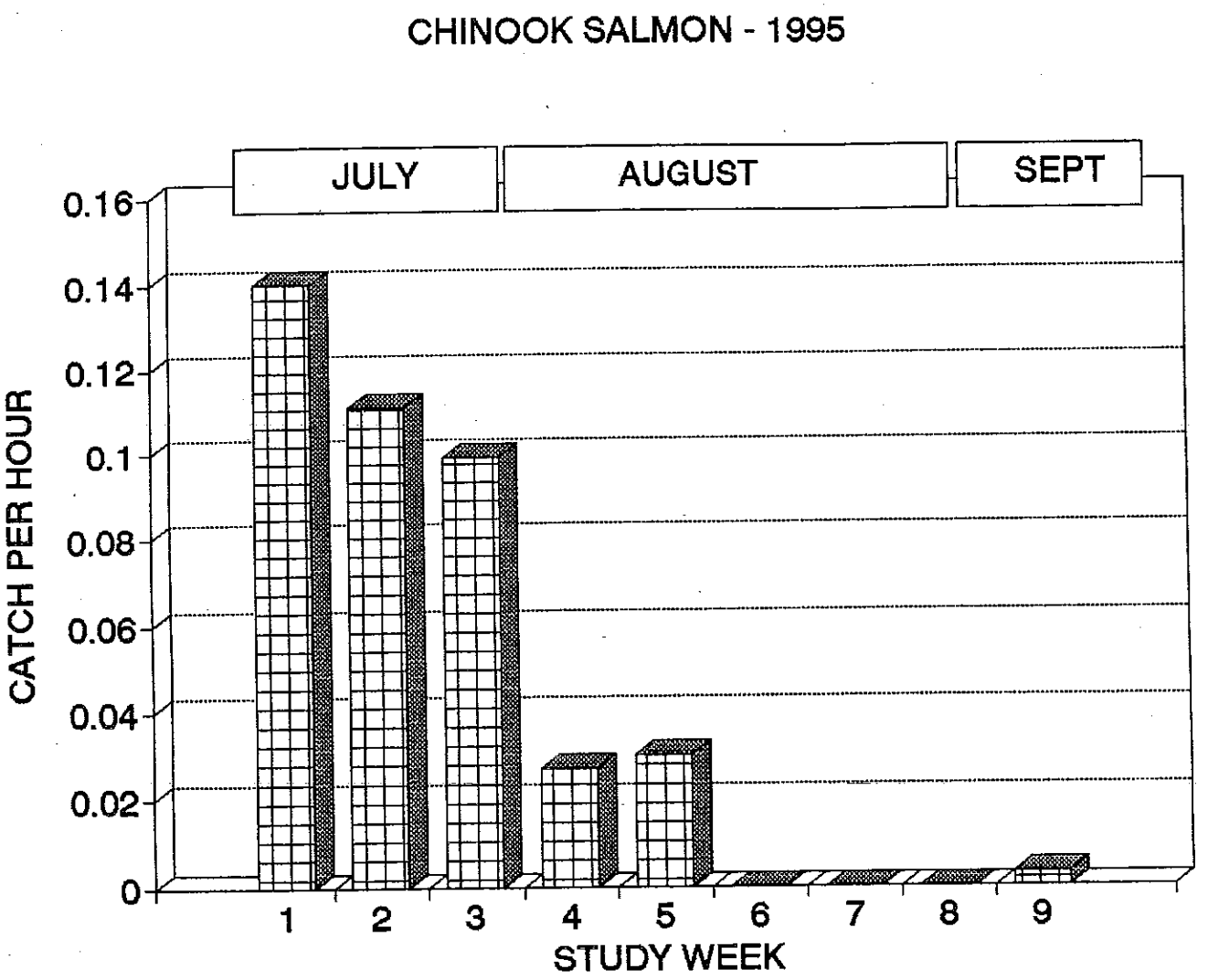


Figure 8. Catch-per-unit-effort for chinook salmon by study week.

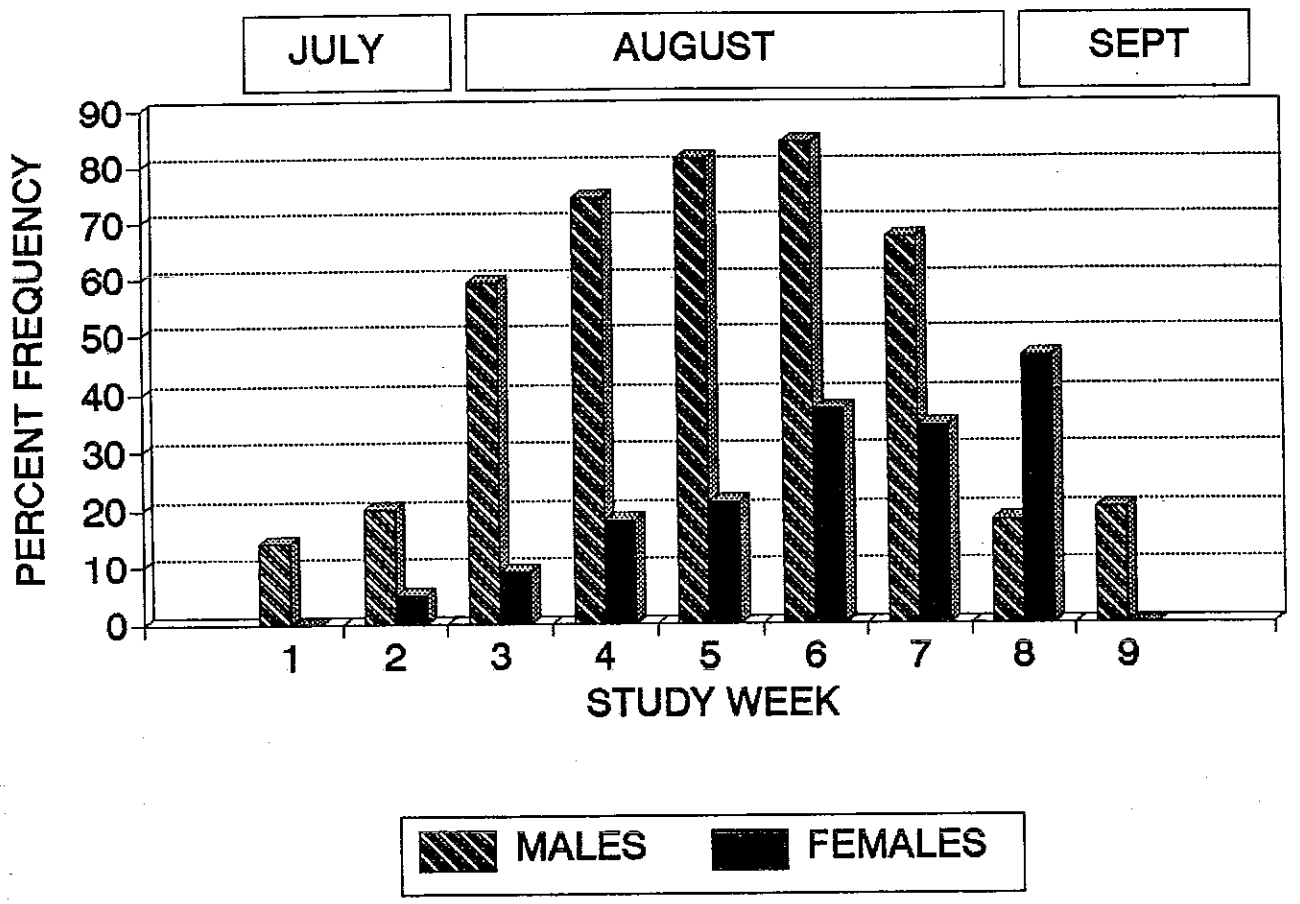


Figure 9. Percent frequency of occurrence of ripe pink salmon by study week.

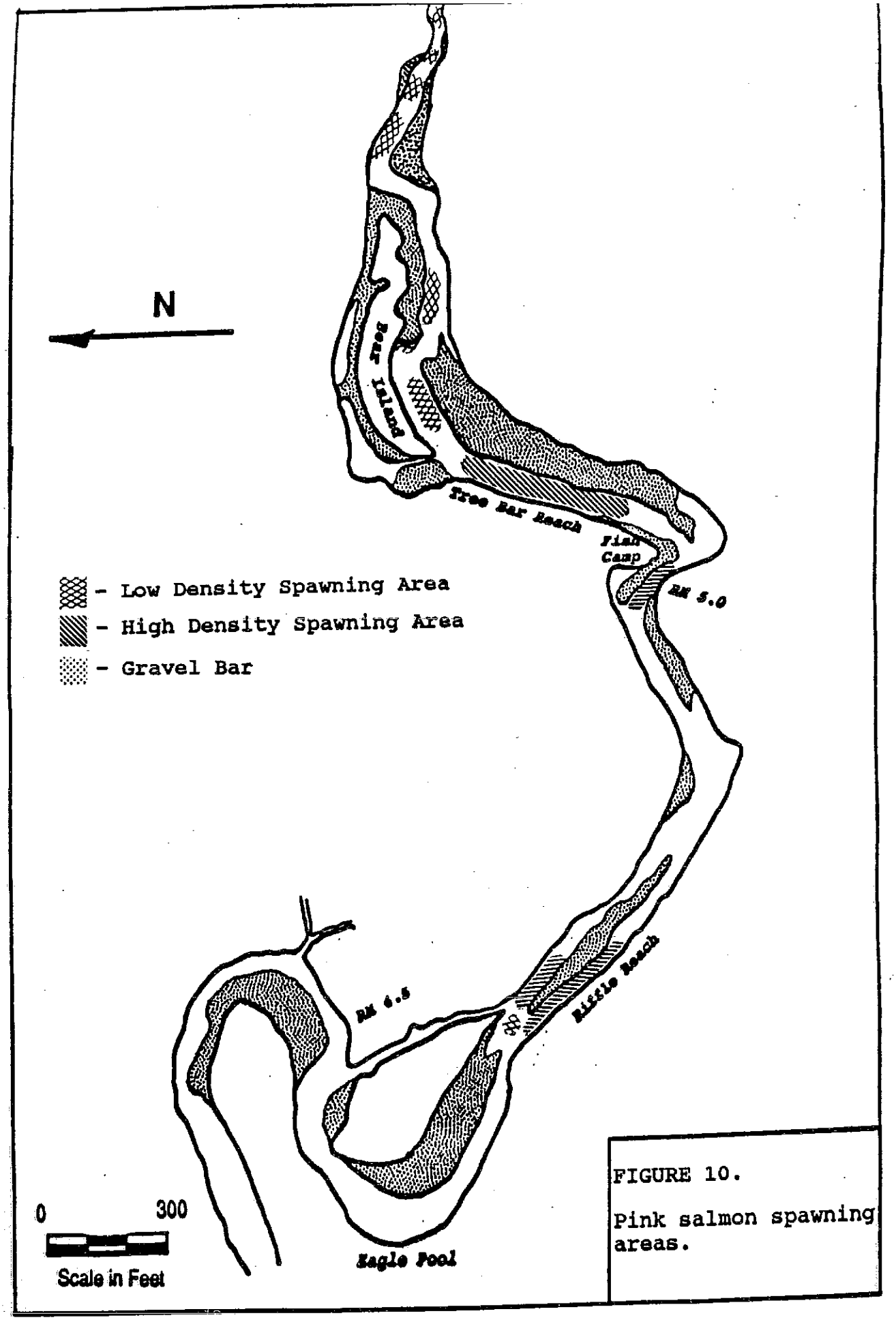


FIGURE 10.

Pink salmon spawning areas.

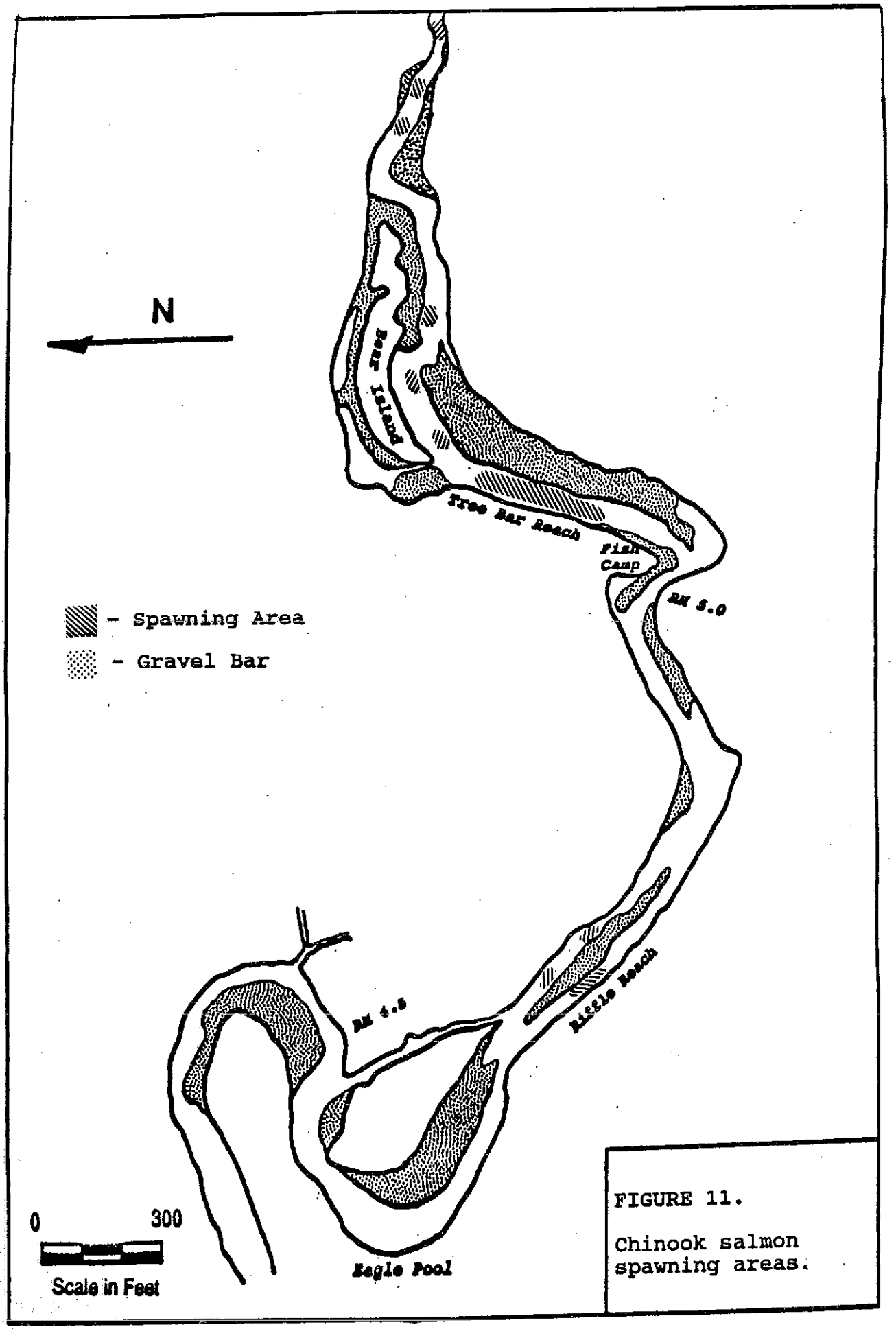


FIGURE 11.

Chinook salmon spawning areas.

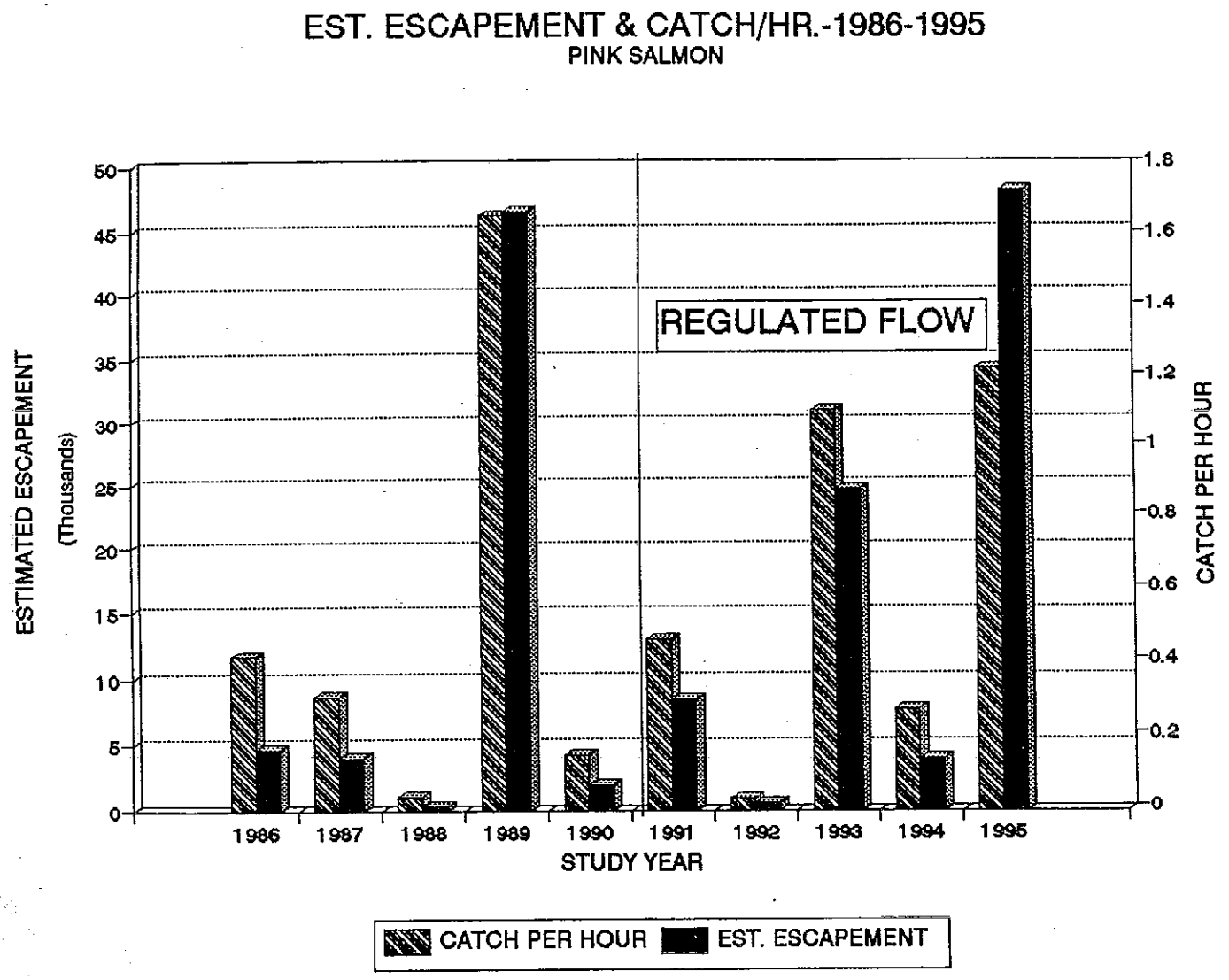


Figure 12. Estimated escapement and trap net catch per hour for pink salmon - 1986 through 1995.

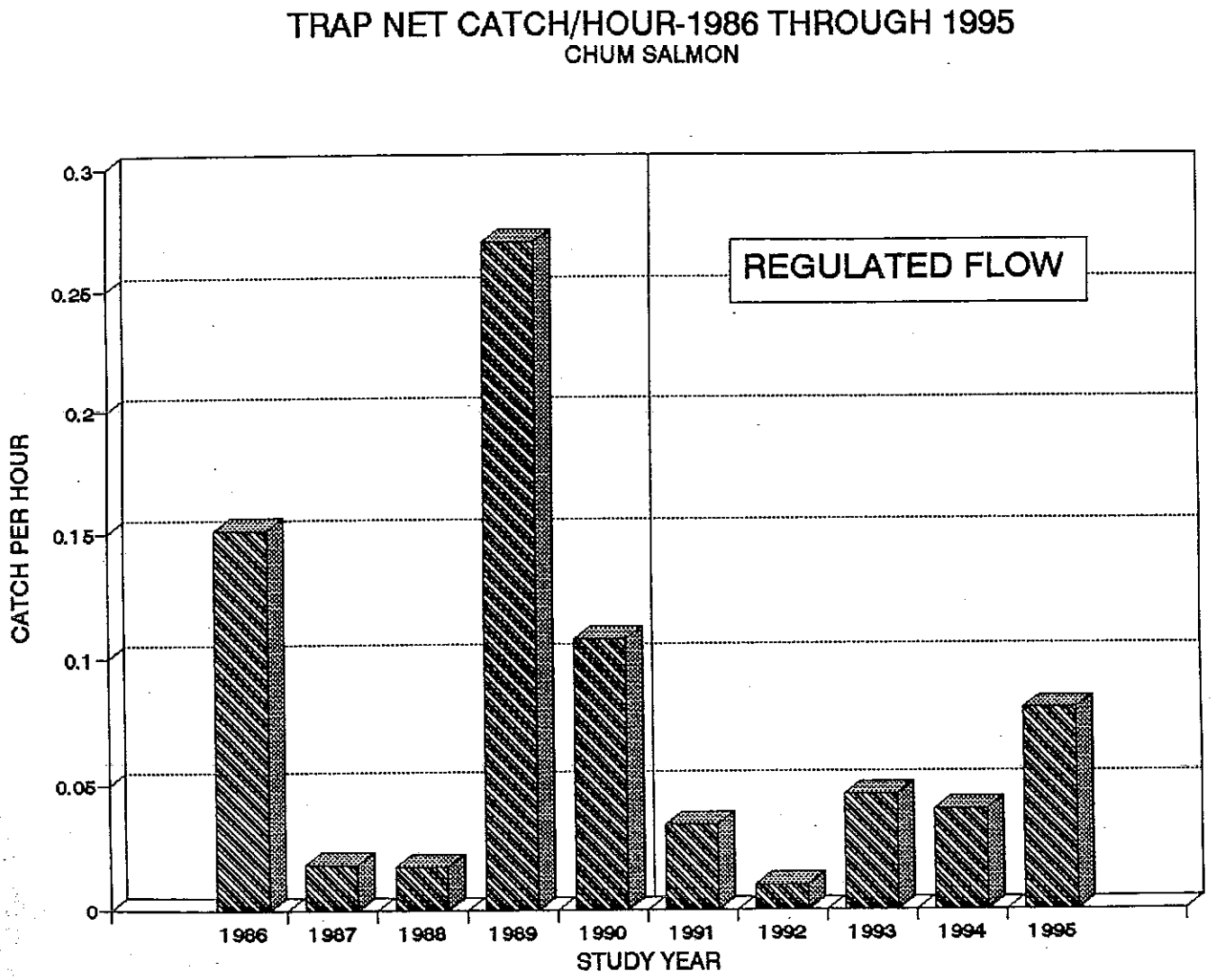


Figure 13. Trap net catch per hour for chum salmon - 1986 through 1995.

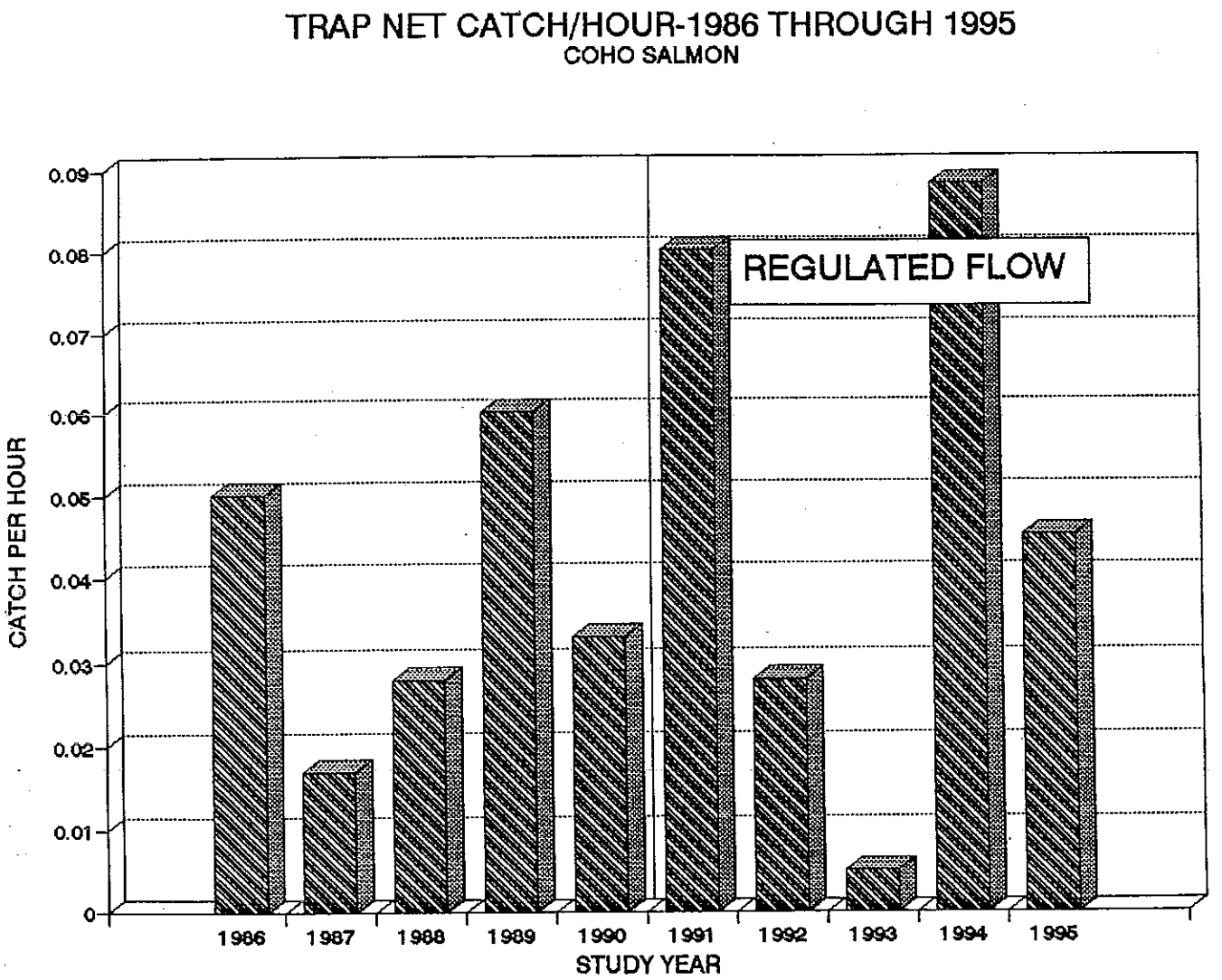


Figure 14. Trap net catch per hour for coho salmon - 1986 through 1995.

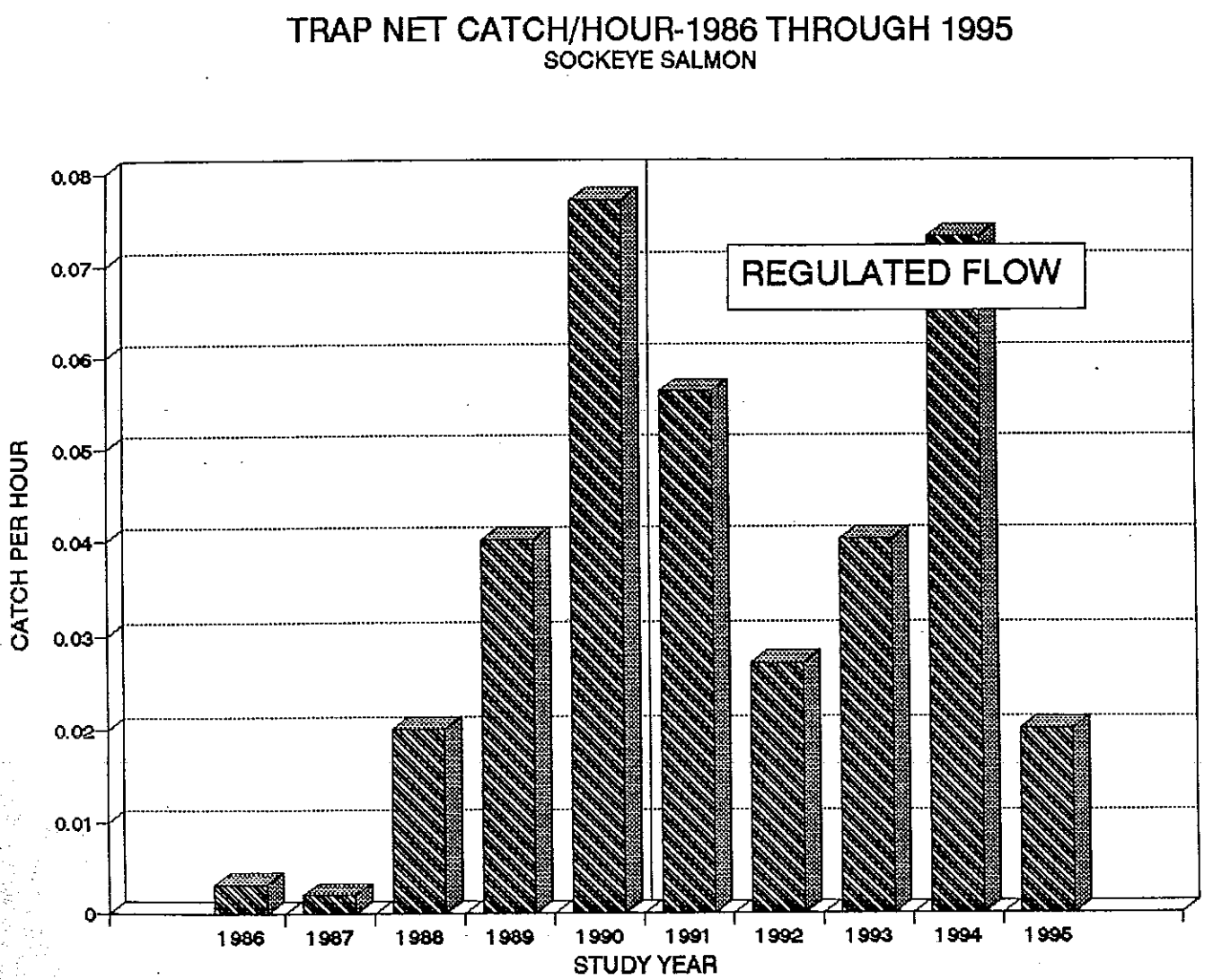


Figure 15. Trap net catch per hour for sockeye salmon - 1986 through 1995.

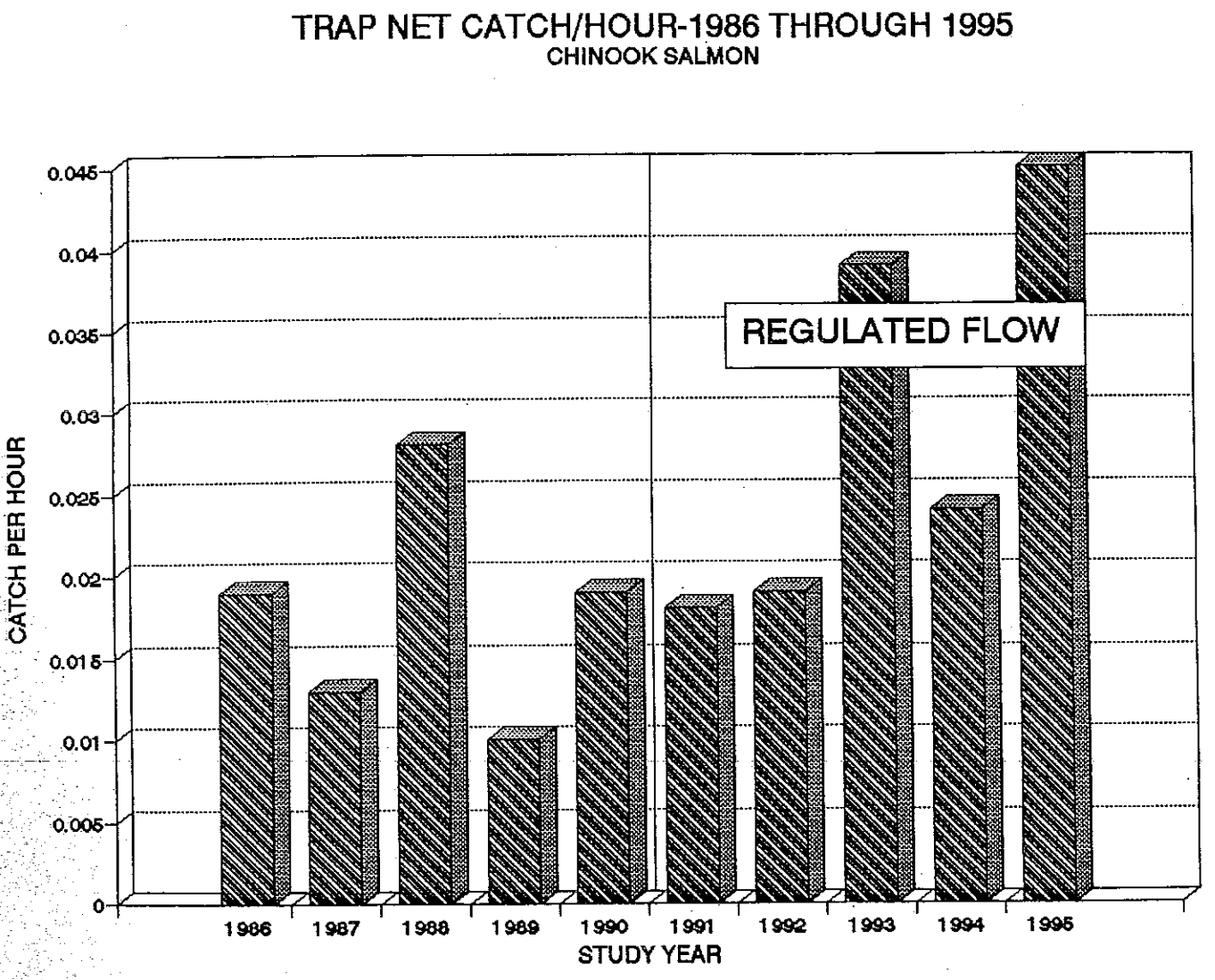


Figure 16. Trap net catch per hour for chinook salmon - 1986 through 1995.