Fisheries Assistance Office
U.S. Fish and Wildlife Service
Olympia, Washington

QUILCENE NATIONAL FISH HATCHERY
OUTMIGRANT EVALUATION STUDY

by

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INTRODUCTION

The Olympia Fisheries Assistance Office (FAO) is currently conducting coded-wire tag (CWT) studies to asses yearling versus subyearling release strategies for increasing total survival of spring chinook reared at the Quilcene National Fish Hatchery (NFH). Emphasis is also being given to the use of smolt indicators as a predictor of smolt functionality and the fish's readiness to emigrate to the marine environment. We initiated this project to develop information to aide in both these types of evaluations. The immediate objectives of this project were to determine the rate of juvenile spring chinook migration, their incidence of residualism, and degree of predation by spring chinook on chum salmon fry which are also released into the Big Quilcene River from the Quilcene NFH. The scope of this project was only concerned with the riverine and estuarine life history of the spring chinook and chum salmon juveniles and examined their migration activity to determine what post release interactions or deviations from normal outmigration patterns occurred that could affect the survival of the emigrating juveniles.

The Big Quilcene River enters Hood Canal at the northwest corner of Quilcene Bay. Quilcene NFH is located at river mile 2.8. Three species of salmon comprised of both yearling and subyearling age classes, are released from the hatchery during the spring. Additionally the Washington Department of Game (WDG) releases steelhead smolts into the Quilcene River during this same time period. Table 1 lists the species, numbers, and size of fish released along with the dates the releases were made during 1984.

METHODS

Residualism

Information relating to residualism of hatchery reared fish in the Big Quilcene River was obtained by electroshocking sample sites at 3 locations in the river. The sample sites were selected below the hatchery at river miles 1.2 (site 1), 1.8 (site 2) and 2.7 (site 3) with the length of each site being 0.05 miles, 0.15 miles and 0.1 miles, respectively. Our choice of sites was constrained by ease of access from both the standpoint of obtaining the land owners permission and the ease of negotiating the terrain in and around the river. However, each site contained both riffles and pools with root wads and undercut banks providing a mixture of habitat representative of the river below the hatchery. Figure 1 shows the sample site locations.

We had to discontinue the use of site three on April 26, because of the presence of spring chinook adults holding in the pools at this site.

We did not develop data to estimate either the number of fish per river mile or total number of fish remaining in the river after release. Our efforts were concerned only with establishing trends of species composition and catch per unit of sampling effort during and after the release.

Table 1. Fish releases in Quilcene River, 1984

Date	Species	Brood Year	Number	Fish/Pound
1/11	Coho	83	80,000	1,500
1/13	Coho	83	85,000	1,500
2/14	Coho	83	29,595	1,000
3/20	Spring Chinook 1/	82	217,833	12.5
3/20	Spring Chinook 2/	82	55,010	9.6
3/21	Spring Chinook 2/	82	54,754	9.6
4/3	Coho	83	64,329	288
4/16	Steelhead 3/	83	5,250	5.2
4/17	Steelhead 3/	83	5,060	4.6
4/23	Chum	83	812,171	700
5/2	Chum	83	406,500	535
5/15	Coho	82	271,035	14.5
5/18	Coho	83	64,000	12.5
6/4	Spring Chinook 1/ 2/	83	201,952	67.5

1/ Cowlitz X South Fork Nooksack
2/ Cowlitz X North Fork Nooksack
3/ Washington Department of Game

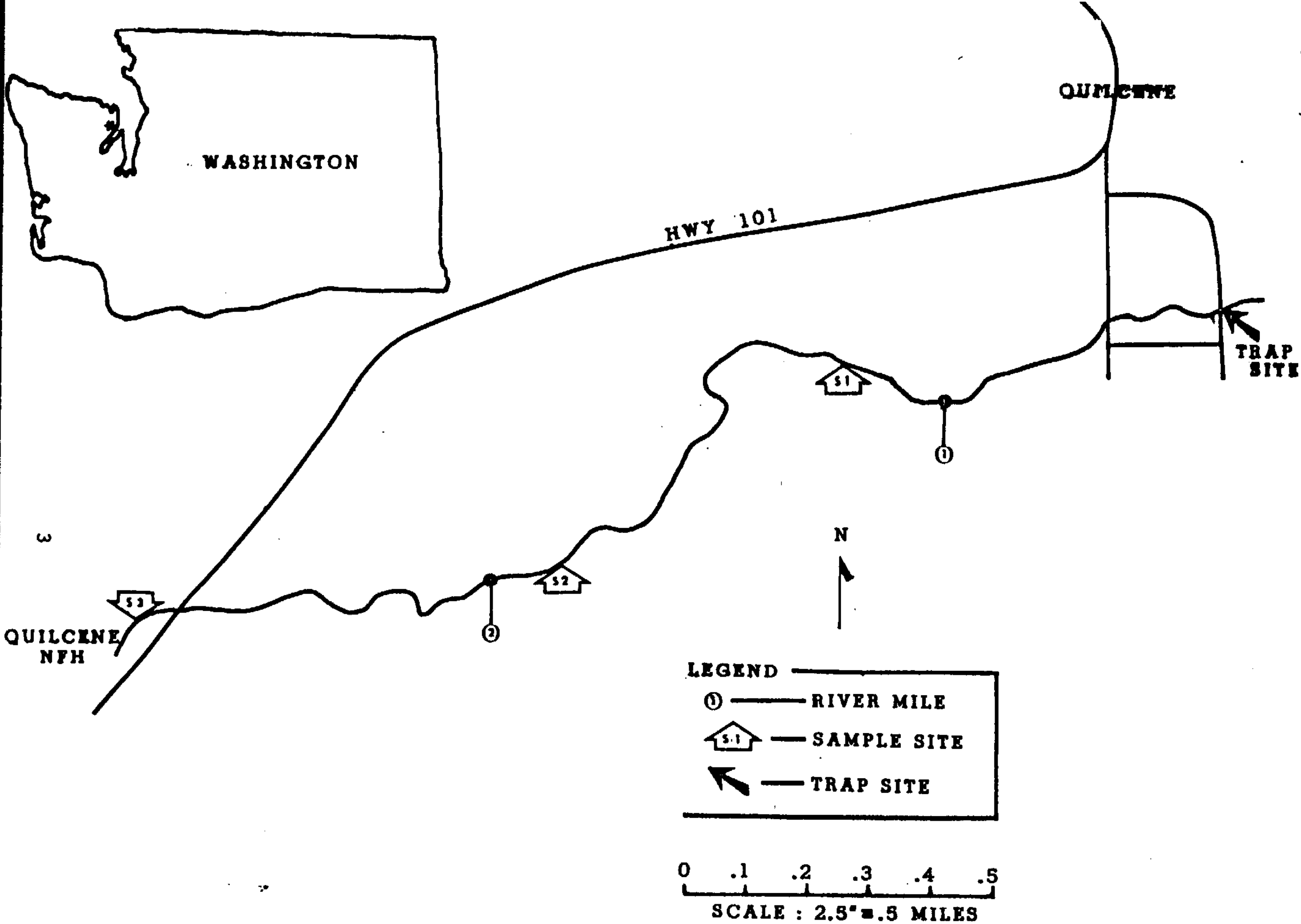

Figure 1. Electroshocking sites located on the Big Quilcene River.

Rate of Migration

Data regarding rate of migration of both yearling and subyearling spring chinook, and chum salmon fry was determined by the operation of a fyke trap at river mile 0.6. The trap was set up under a highway bridge that crossed the river at this location and was held in place by suspending it from a cable drawn taught between the bridge pillings. A weight was placed on the lower crossbar of the trap's mouth to hold it down on the river bottom. The river's width at this site was 60 feet. The trap was situated in the channel 6 feet from the north bank and was operated without wings resulting in only a 4 foot width being fished. The depth of water fished was approximately 2 feet deep but this height varied slighlty with changes in river flow.

Our original plan was to operate the trap for each release group on the day of release until a peak catch was observed followed by a subsequent reduction in catch.

We were able to do this while monitoring the release of the yearling spring chinook. The trap was fished throughout the night on a continuous basis and checked intermittently to ensure the smolts were not being stressed in the trap. It was necessary to adjust the trapping procedures when we began monitoring the release of both chum salmon fry and subyearling spring chinook.

While fishing the trap during the chum release, we stopped its operation upon observing a rapid rise in the number of fish entering the trap. This was necessary because continuous operation of the trap would have resulted in a large number of fry being captured. We would not have been able to hold the fry in the live box prior to counting and measuring without causing stress or injury to them. The trap was placed back into operation when we visually observed a reduction in the numbers of chum fry swimming past the trap area.

During the monitoring of the subyearling spring chinook outmigrants we fished the trap for fifteen minute intervals on a hourly basis until a peak in catch was observed followed by a subsequent reduction in catch. This format for fishing the trap proved to be an effective means of monitoring the outmigration timing without causing injury or stress to the fish caught in the trap.

The trap was also fished during the night on a weekly basis in between release groups.

Trapping efforts started with the first release of yearling chinook March 20 and continued through June.

Predation

The incidence of predation upon chum fry in the river by both yearling chinook and steelhead smolts was determined by analysis of the stomach contents of the smolts. Up to seven fish per river site were randomly selected for stomach analysis during the electroshocking surveys. The

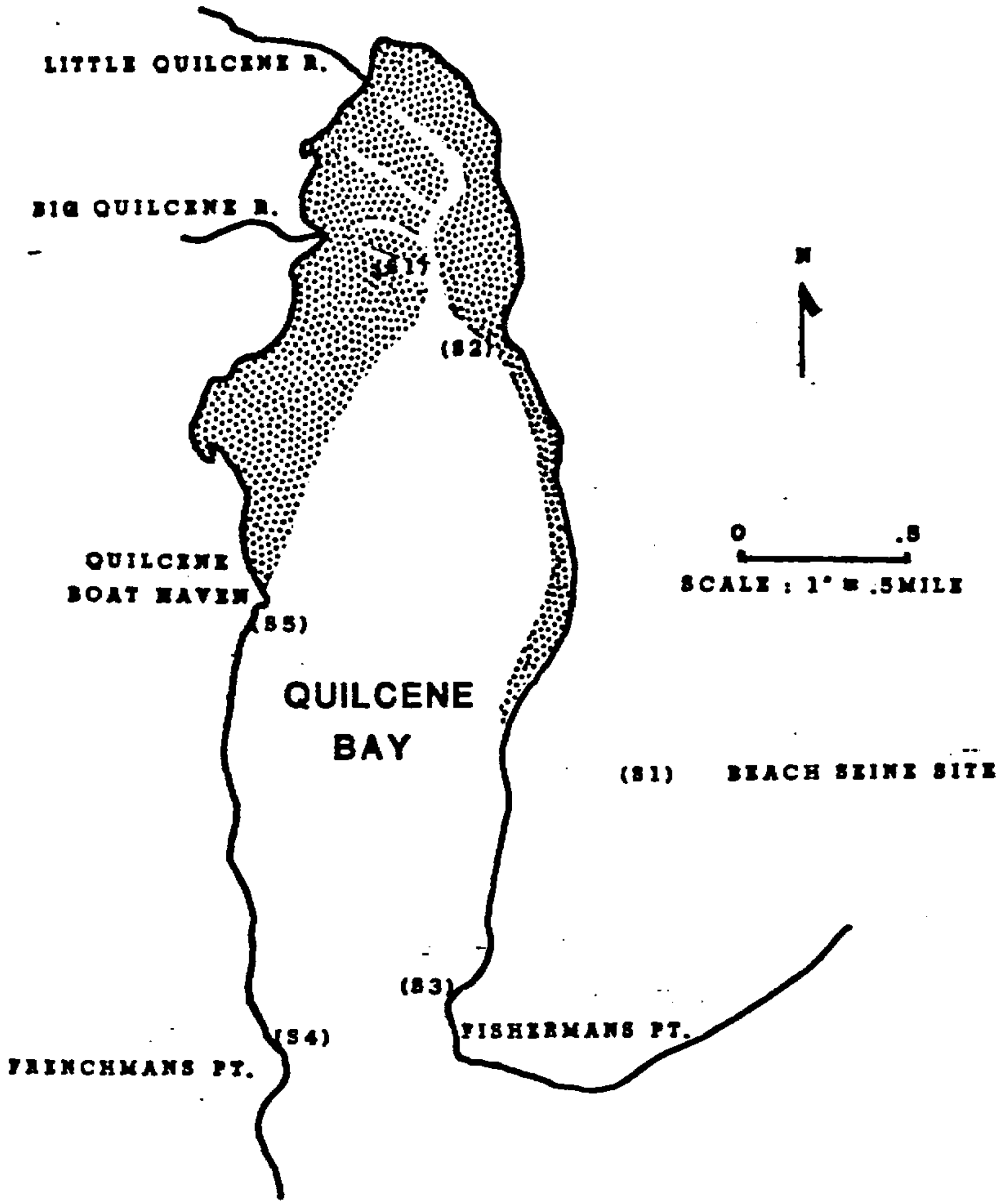

Figure 2. Beach seine sites located in Quilcene Bay.

stomachs were removed from the fish at the end of the survey day and placed in a 10% formalin solution. The stomach contents were examined within two weeks of capture.

Seven beach seine sites were selected within Quilcene Bay to capture yearling chinook for stomach content analysis to determine the incidence of spring chinook predation upon chum salmon in the estuary (Figure 2). A 100' X 6' seine (3/16" in mesh) was used for this purpose. We did not schedule any beach seining of Quilcene Bay to asses the incidence of steelhead predation upon chum salmon in the estuary.

RESULTS AND DISCUSSION

Species Composition Prior To Hatchery Releases

The Quilcene River is not used by naturally spawning spring chinook. Chum, coho, steelhead and a small number of fall chinook are known to spawn in the watershed. A preliminary electroshocking survey was conducted on March 6 to determine what salmonid species were located at the survey sites. No yearling chinook or chum fry were captured during this survey One subyearling chinook was captured at S1 and three steelhead yearlings and two trout were captured at S2. Although no chum fry were captured during this survey, their occurrence in the river was confirmed when we began fishing the fyke trap on a weekly basis.

Numerous coho subyearlings were observed and captured during this electroshocking survey. Several groups of coho subyearlings had been released during the year prior to beginning our study (Table 1). However, no plans were made to evaluate these releases and therefore we made no attempt to enumerate any coho subyearlings during any subsequent electroshocking surveys.

Yearling Spring Chinook

The evaluation of outmigration patterns began March 20 with a release of yearling spring chinook (Table 1). We had originally scheduled the yearling chinook release for mid May, but these plans were changed when an epizootic of kidney disease (KD) developed in this group of fish. In order to avoid further increase in the incidence of this disease and the total loss of all the fish a decision was made to release them as soon as possible.

A release of yearling fish this early in the spring however, had the potential to adversely impact wild chum fry in the river and the estuary. The chum fry would be a source of prey for these yearlings. Additionally, if the effect of the KD epizootic resulted in a significant number of yearlings losing their ability to migrate, those yearlings that residualized would be a source of predation upon later releases of hatchery reared chum fry.

We are unable to address the issue of predation in the estuary because no chinook yearlings were captured for stomach analysis during any beach seine sets made in the estuary. Strong southerly winds delayed beach seining of the estuary until March 29, eight days after the release. Additional beach seine sets occurred on April 4 and 5. We discontinued the beach seining after April 5.

Data was collected, however, to assess the degree of predation in the river. Apparently predation by the yearling spring chinook upon chum salmon in the river was insignificant. The data obtained from the stomach analysis of fish captured during the electroshocking surveys indicates a low incidence of predation and no conclusive evidence that yearling chinook preyed upon chum salmon. A total of 97 yearling chinook were captured in the river during four weekly electrofishing surveys (Table 2) that followed the release; 33 of these were sacrificed for stomach analysis. Evidence of predation was recorded in only two stomachs. The combined analysis of the two stomachs resulted in a count of five fish; three coho fry and two unidentified fry. On the other hand, nineteen stomachs were observed to be empty of food organisms. Most of these stomachs contained a light green colored fluid.

A low incidence of residualism by spring chinook was observed. The catch data collected during the weekly electrofishing surveys shows that not all the yearling chinook outmigrated to the estuary immediately upon release from the hatchery on March 20 (Figure 3). Thirteen days after the release, we were still catching yearling chinook at the index sites. During this same time, however, we were observing a significant reduction in the number of outmigrants being captured in the fyke trap. The rate of catch per hour had dropped to 1 within two weeks of the second release of yearlings (Figure 4). The decline in trap catches while fish were still caught by electrofishing indicates a majority of the fish moved out of the river immediately but some did remain up to two weeks.

Our weekly electroshocking surveys and fyke trapping operations were interrupted during the third week of the study by a spring freshet. We resumed trapping the following week on April 18, one day after two consecutive WDG steelhead releases (Table 1). During subsequent electroshocking surveys no spring chinook yearling were captured (Table 2). We did, however, capture a relatively small number of steelhead smolts and observed many more steelhead in the deep pools of the survey sites that we could not effectively electroshock. No yearling spring chinook outmigrants were captured in the fyke trap either. We assume the previous weeks freshet forced most of the remaining yearlings out of the river.

Table 2. Yearling spring chinook captured during electrofishing surveys

Site	1	2	3	Total
Date				
3/6	0	0	0	0
3/28	10	40	3	53
4/4	2	35	7	44
4/18	0	0	0	0
4/26	0	0	no sample	0

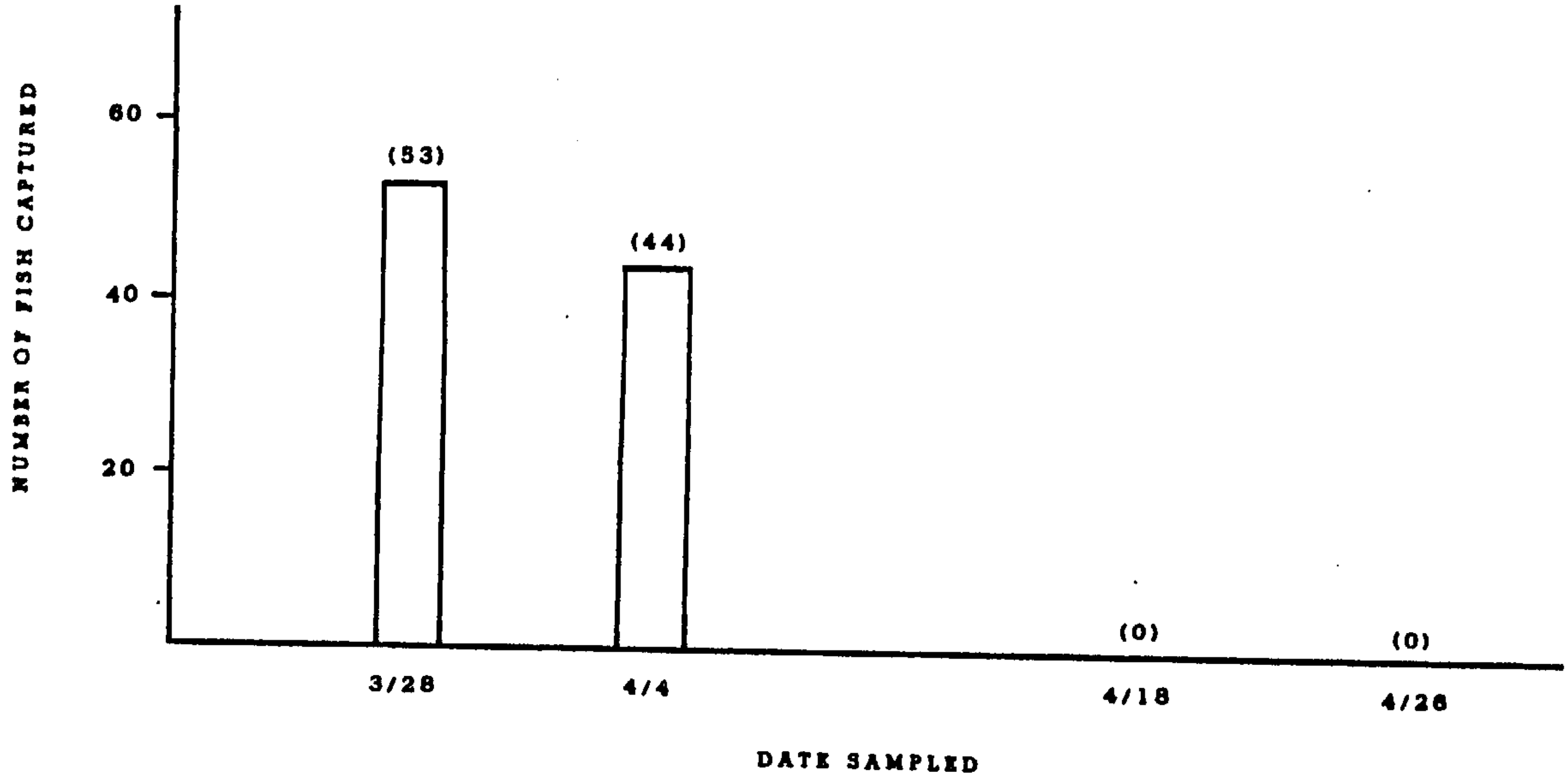

Figure 3. Total catch by electrofishing at all sites, yearling chinook.

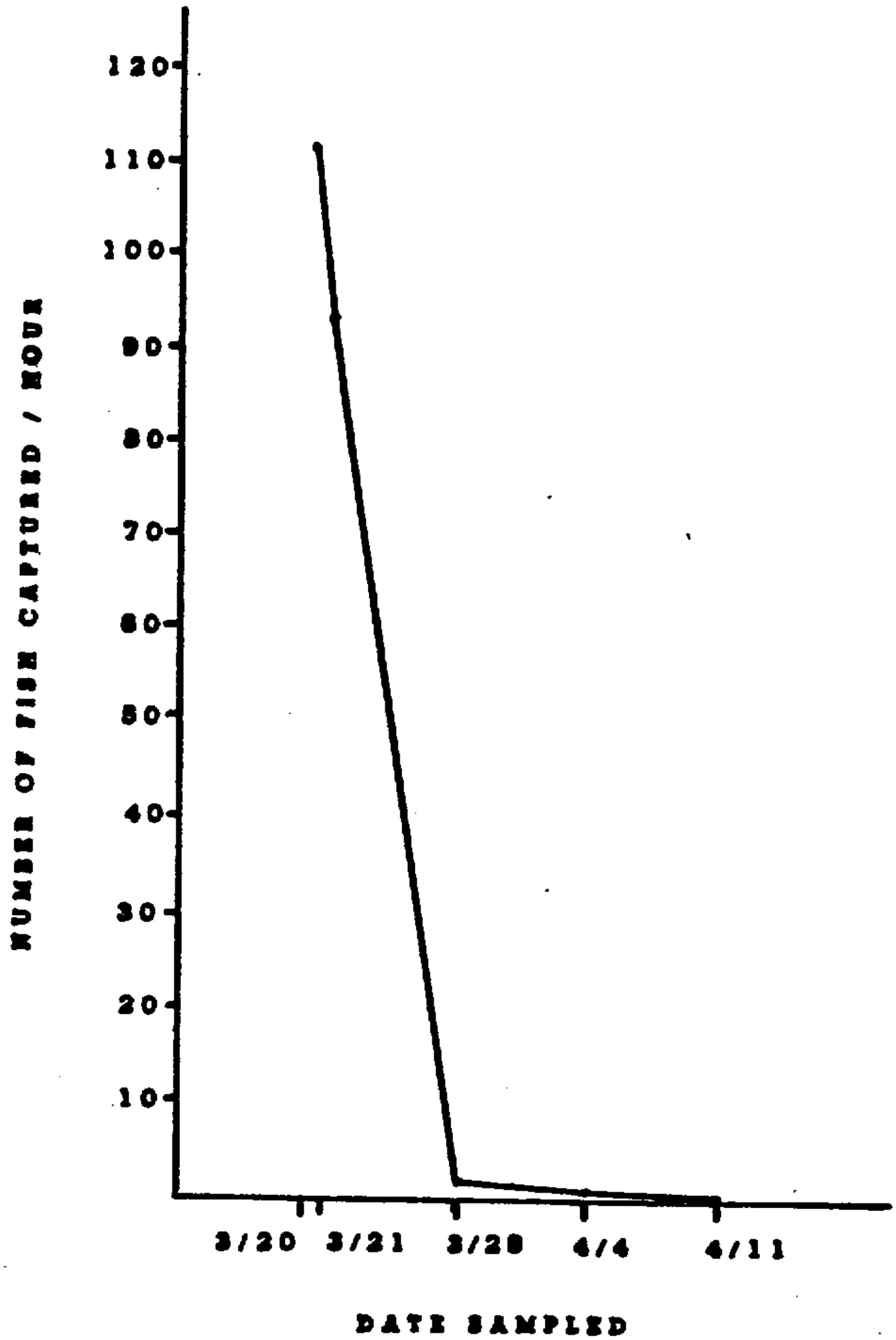

Figure 4. Yearling chinook outmigrants captured during weekly Fyke trapping.

A follow up electroshocking survey conducted on April 26 recovered neither yearling spring chinook nor steelhead smolts. We discontinued the electrofishing surveys for the yearling chinook at this time.

We suspect that the residualism and the low incidence of predation recorded for the yearling chinook that remained in the river may have been related to their poor health at release. The number of stomachs devoid of food organisms and the "greenish" fluid we observed in many of these empty stomachs indicates that these fish were not actively preying upon any food organisms in the river. Although we made no attempt to make a definitive assessment of their pathological status after release, several of the yearling chinook sacrificed for stomach analysis were observed to have gross lesions on their kidneys.

The overall condition of the yearling chinook when released was extremely poor. Many of the fish were moribund and it was evident that they would not survive the rigors of the natural environment. Prior to release, the hatchery staff recorded mortalities as high as 0.5 percent per day for the North Fork Nooksack stock and 0.175 percent per day for the South Fork Nooksack stock. The yearling chinook were slow to recover from the handling involved with the fyke trapping and electroshocking compared to other species released into the river and handled in the same manner.

Further evidence of high post release mortality was obtained on March 20, the day of release. At approximately 1:30 p.m., four hours after the fish were released, we walked down to the mouth of the Quilcene River in Quilcene Bay. The tidelands, where the river enters the bay, were dewatered with the Quilcene River flowing through the area in many shallow braided streams. An estimated 5,000 dead and dying smolts were observed on the tidelands trapped in tide pools and laying at the edges of the braided streams. We observed numerous seagulls actively feeding on the smolts in the area. Nearly all of the fish carcasses had marks indicative of bird predation.

Since the location of the fyke trap at river mile 0.6 is just above the tidal influence of the bay, the timing of fish at the trap closely coincides with their arrival in Quilcene Bay. Our trapping data indicates the fish released on March 20 reached the bay on the ebbing tide just prior to low tide (Figure 5). The Seattle low tide corrected for Zelatched Point, Dabob Bay occurred at 1:08 p.m. and was a 0.1 foot tide. We believe their arrival in the bay during the ebbing tide made them highly vulnerable to predation.

We notified the hatchery of the situation occurring at the bay and it was decided to postpone releasing the rest of the yearlings on that day. There is no way to accurately estimate the impact of the bird predation that occurred during this release. During the several days that followed the release, large numbers of gulls were observed actively feeding at the mouth of the river.

We can not attribute the presence of gulls and their feeding activity solely to the release of the yearling chinook. In addition to the seagulls, large flocks of scooters and scaups, two species of seabirds that feed on herring spawn, were observed. We believe that the sea bird population

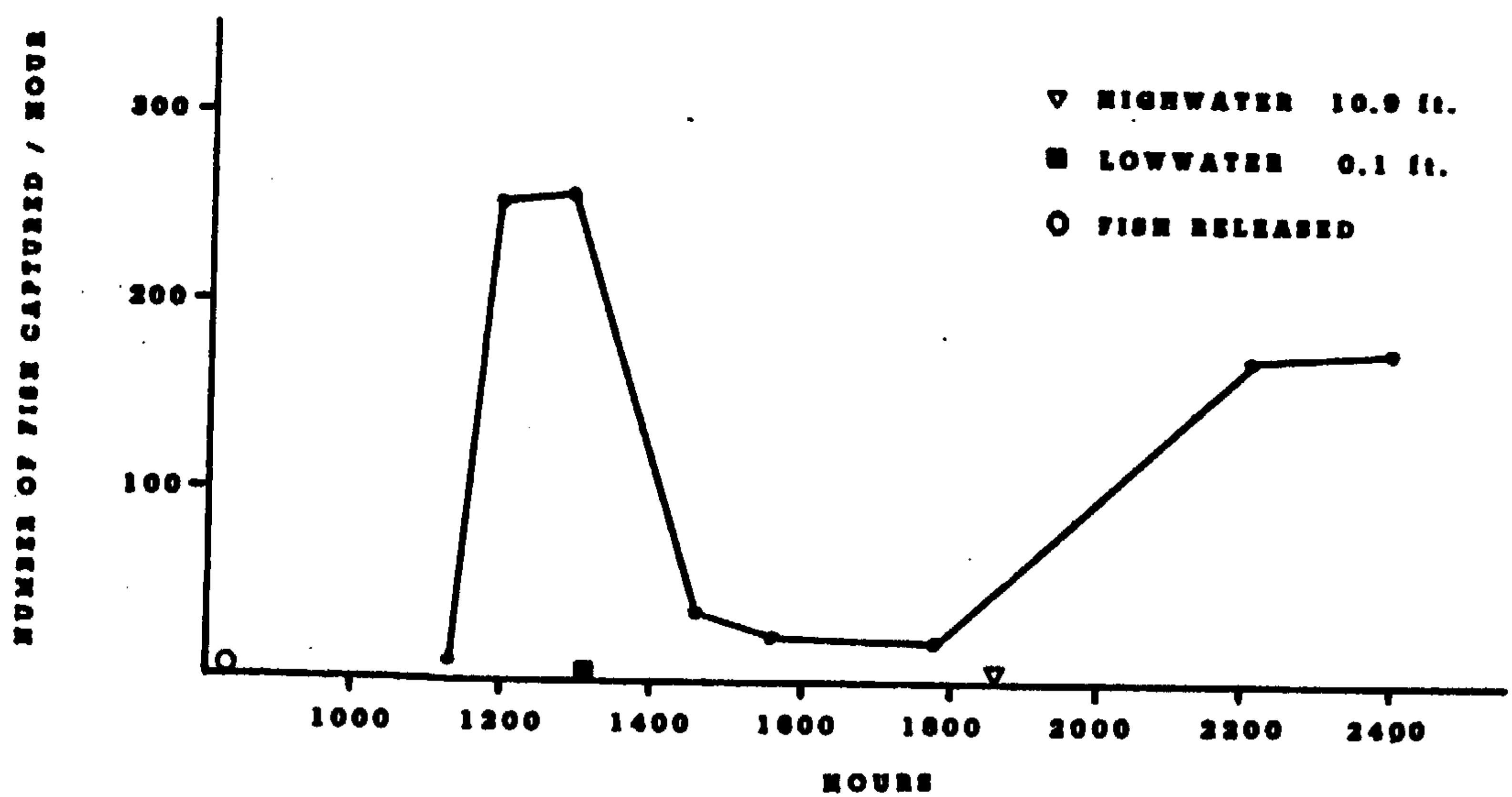

Figure 5. Yearling spring chinook Fyke trap catches and outmigration pattern on May 20, 1984.

was temporarily increased during this time of year due to the herring spawning that was occurring in the bay. Historically, Quilcene Bay has been an area used by spawning herring, and we confirmed its use this year by observing the presence of spawn on the eel grass in the bay.

The remaining yearling chinook (all North Fork Nooksack stock) were released at 6:00 p.m. on March 21. This time was chosen to avoid having the fish arrive at the bay during low tide. A 10.6 foot tide at 8:42 p.m. was predicted for this evening (Figure 6). We walked down to the mouth of the river at 1:30 a.m. to observe the bay during the low tide that followed this release of fish. Although it was dark, approximately 20 dead yearlings were observed on the tidelands. We are unable to determine, however, if these fish were part of the March 20 night's release or originated from the release of March 21.

Steelhead

No evidence of steelhead predation upon chum salmon fry was recorded. During the electroshocking survey, conducted one day after their release twenty-two steelhead were captured (Table 3). Fifteen steelhead were randomly selected and sacrificed for stomach content analysis. Thirteen of these fish had empty stomachs with the remaining two containing insects. No steelhead were captured during any subsequent electroshocking surveys. Additionally steelhead were only recovered in the fyke trap on the night of April 18. Both of these observations indicate that the steelhead readily outmigrated upon release.

Chum Salmon

The pattern of outmigration for both groups of chum fry released from the hatchery was similar. The data collected on the night of release (April 23 and May 2) shows a sharp rise in catch within three hours after release (Figure 7 and 8). It appears, however, that not all of the hatchery chum outmigrated on the night of release. Trapping data collected on the night following each release resulted in relatively high catch rates following a pattern similar to what was observed on the night of release (Figure 9 and 10). Subtle changes in trap efficiency were minimized by similiar conditions during fyke trapping on the night of release and the night that followed each release; the sky was overcast and the river was running low and clear.

We continued monitoring chum outmigration on a weekly basis after the hatchery releases. During five successive weeks of fyke trapping we observed evidence of continued chum outmigration (Figure 11). However we attribute these later outmigrating chum fry to hatchery fish that spawned naturally in the river and not due to residualism of the fry released by the hatchery. Several observations support this. First, a distinct size difference was observed between the fry captured on the night of release and those that were caught in the trap during the weeks that followed. On the nights of April 23 and May 2, when the two releases of hatchery chum occurred, the mean size of chum caught in the trap was 45 mm. However on May 9, seven days after the second release, the mean size was 38 mm.

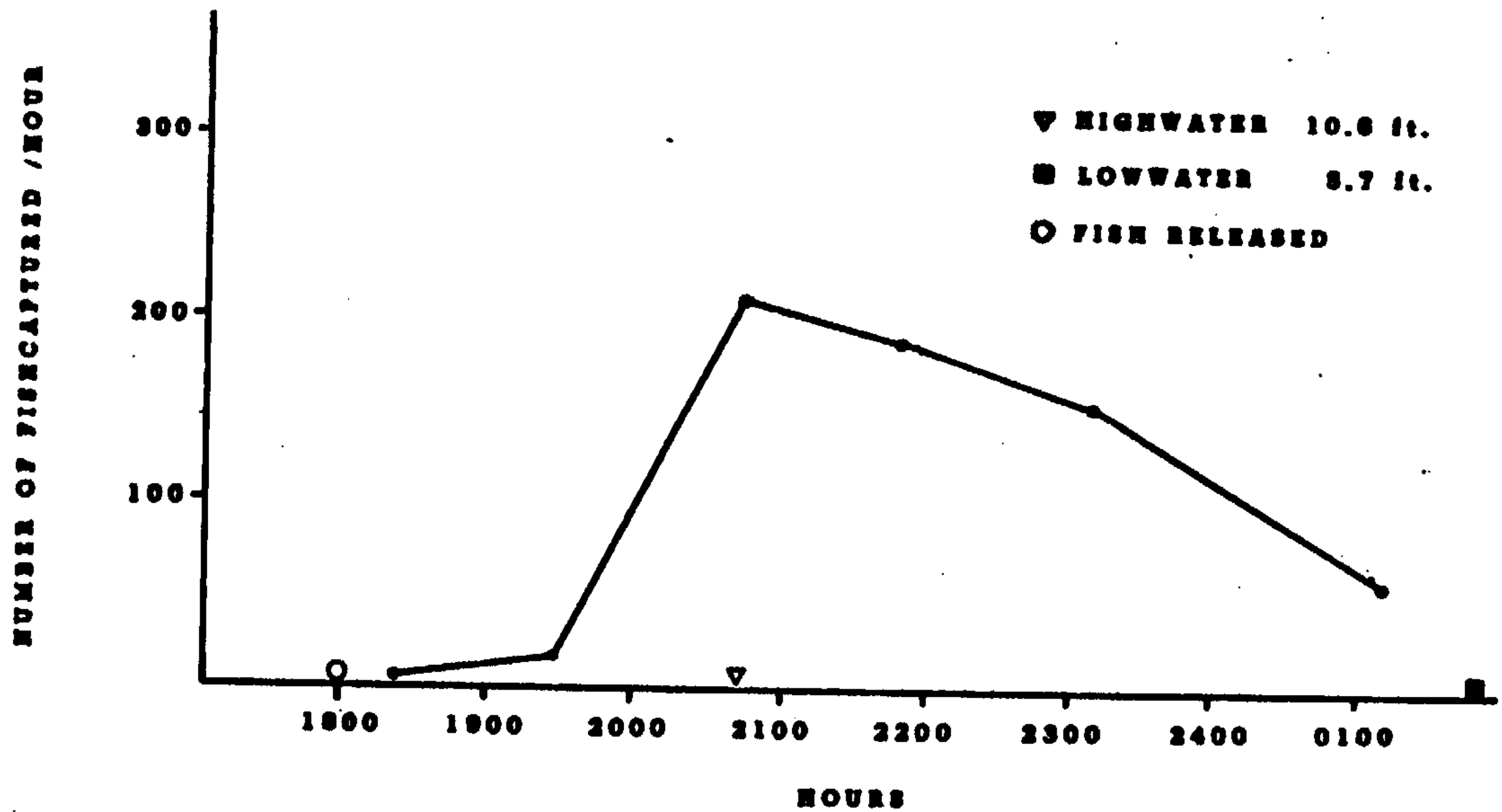

Figure 6. Yearling spring chinook Fyke trap catches and outmigration pattern of second release on May 21, 1984.

Table 3. Record of WDG steelhead smolts captured during electrofishing surveys that occurred after their release into the Big Quilcene River.

Site	1	2	3
4/18	1	10	11
4/26	0	0	no sample

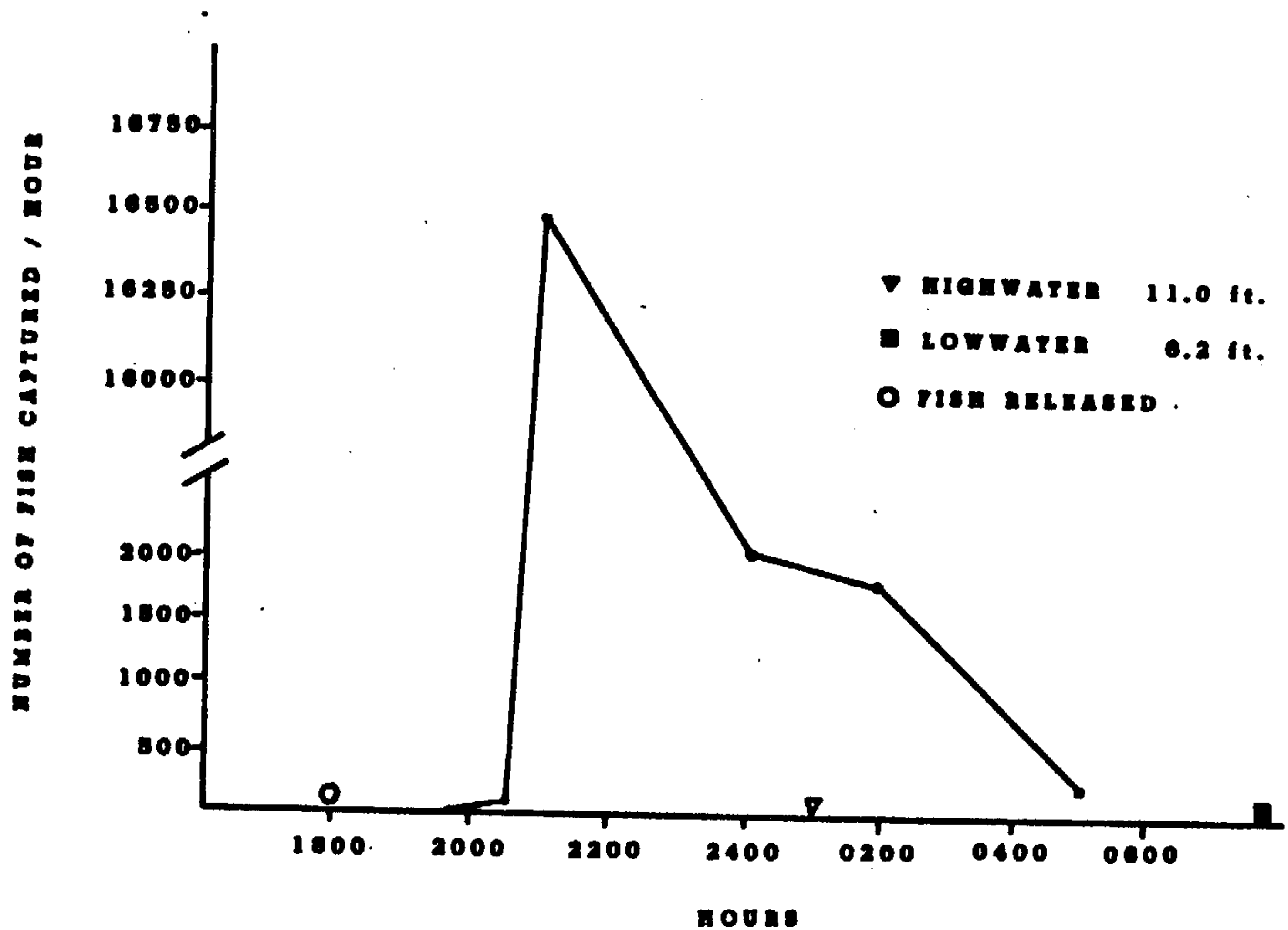

Figure 7. Chum salmon Fyke trap catches and outmigration pattern on April 23, 1984.

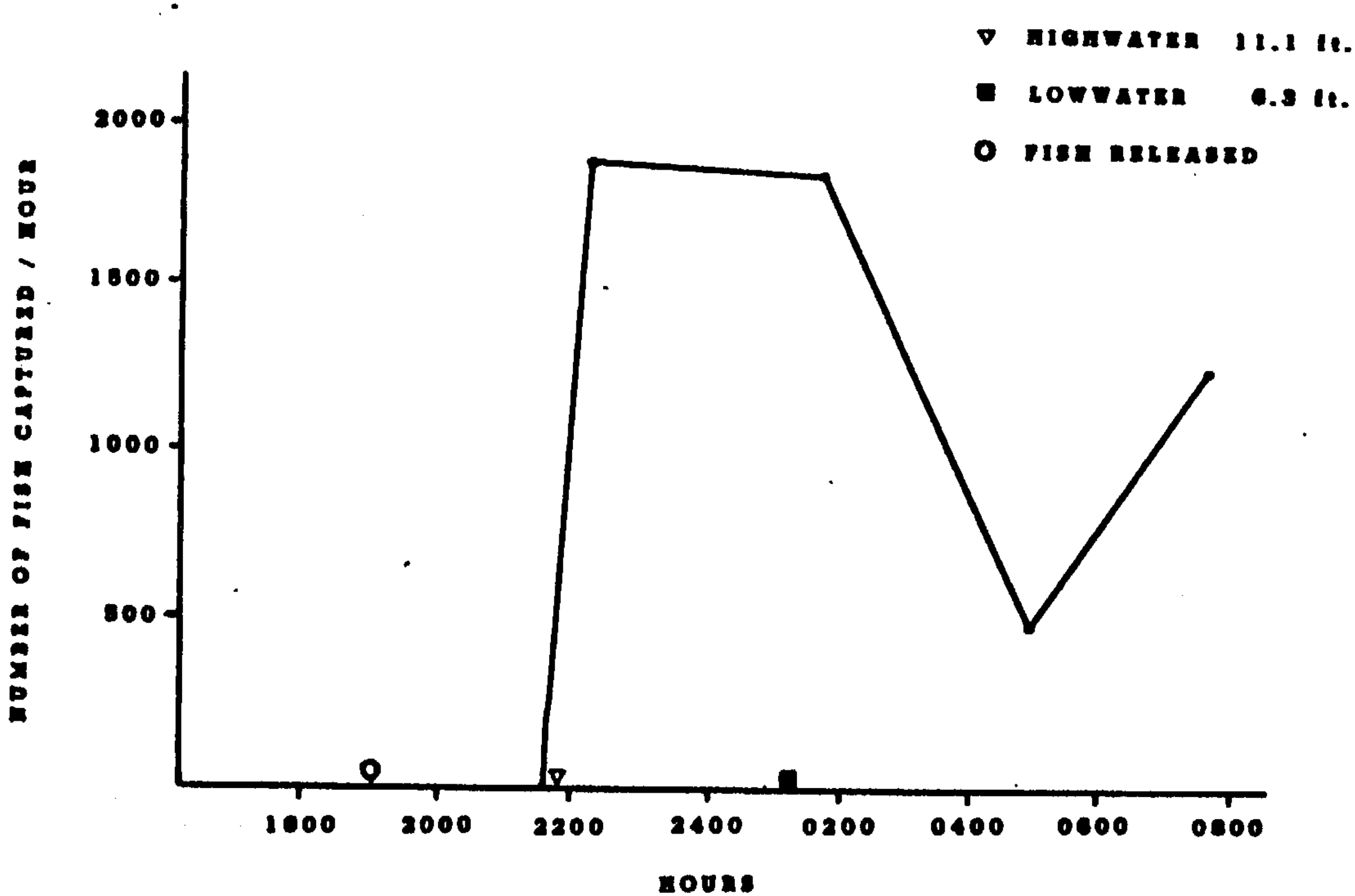

Figure 8. Chum salmon Fyke trap catches and outmigration pattern on May 2, 1984.

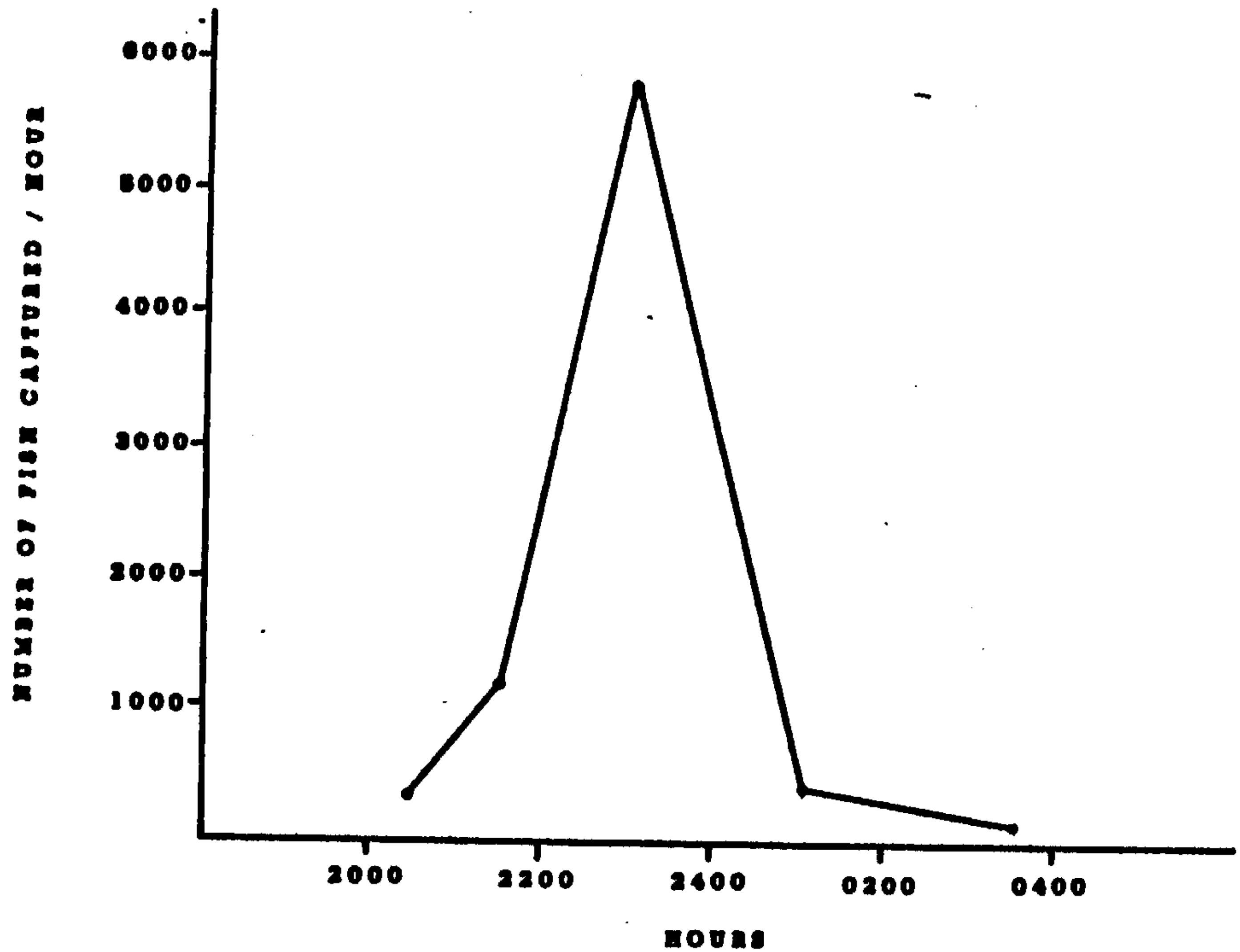

Figure 9. Chum salmon Fyke tran catches and outmigration pattern on April 24, 1984.

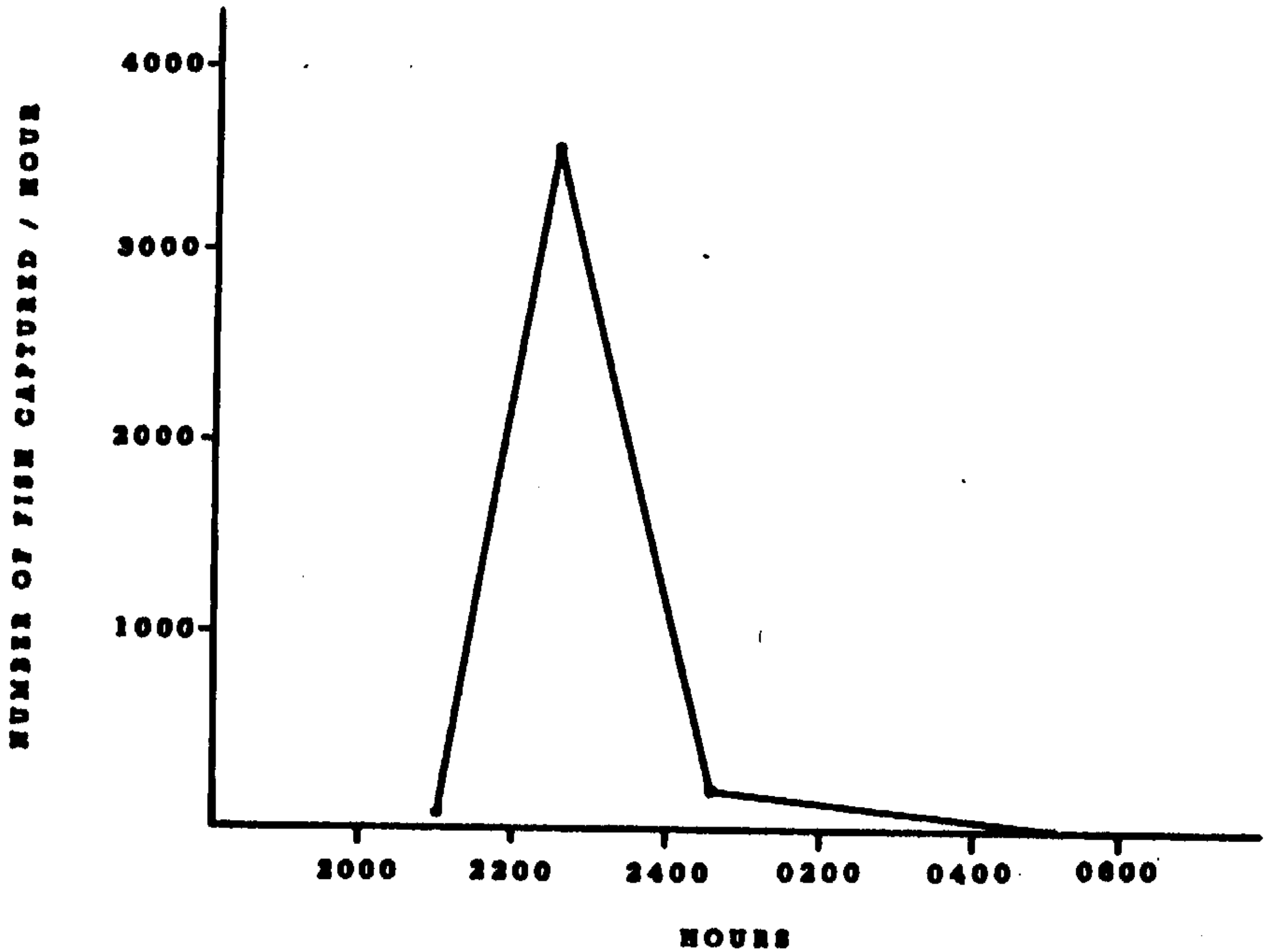

Figure 10. Chum salmon Fyke trap catches and outmigration pattern on May 3, 1984.

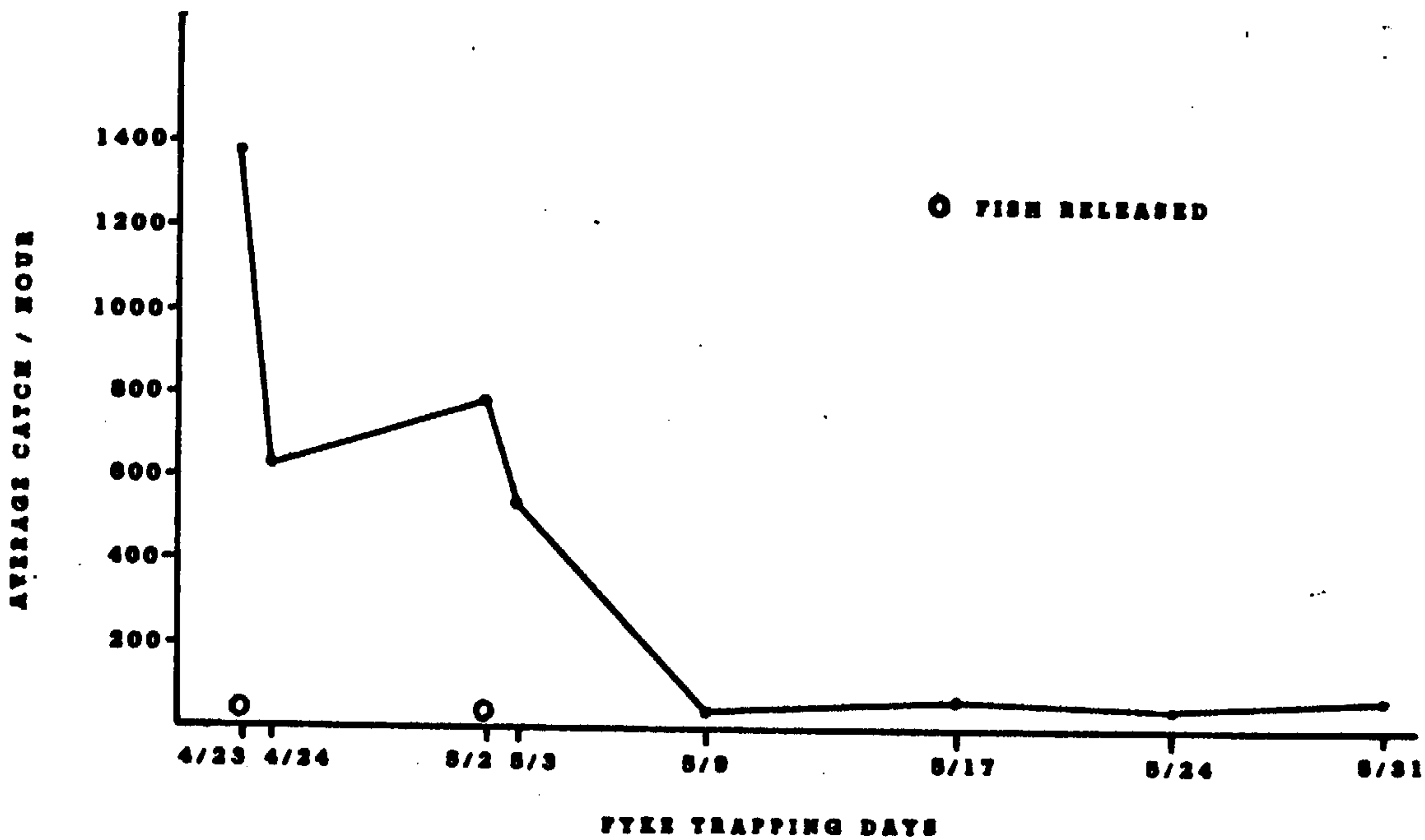

Figure 11. Chum Fyke trap catches and outmigration pattern for the period May 23 through June 31.

Second, we observed distinct ventral slits on many of the fry caught in the trap during the weeks that followed, indicating that many of these fry had not completely absorbed their yolk sacs. The occurrence of ventral slits on newly emergent chum fry has been reported by others studying the outmigration patterns of naturally spawned chum fry (Kurt Fresh, Washington Department of Fisheries, personal communication). The hatchery reared chum had absorbed their yolk sac and were fed briefly before release.

It appears from the fyke trapping data that the chum, occurring naturally in the river, outmigrated over a considerable period of time. Our study was not specifically designed to monitor their outmigration timing and, therefore, sufficient data was not collected to determine when the peak of outmigration occurred.

Subyearling Spring Chinook

Our evaluation of the subyearling spring chinook indicates that they exhibited a strong tendency to outmigrate upon release. The pattern of outmigration on the night of release is presented in Figure 12. We observed a sharp rise in catch per hour within three and one half hours after release. The number of fish captured on the night following the release was considerably lower (Figure 13). A downward trend in fyke trap catch per effort data continued until June 19 (Figure 14). Trapping was discontinued at this time because the catch rate dropped below one fish per hour.

The low catch per site data collected during the electroshocking surveys indicates that a relatively few subyearling chinook residualized in the river (Figure 15).

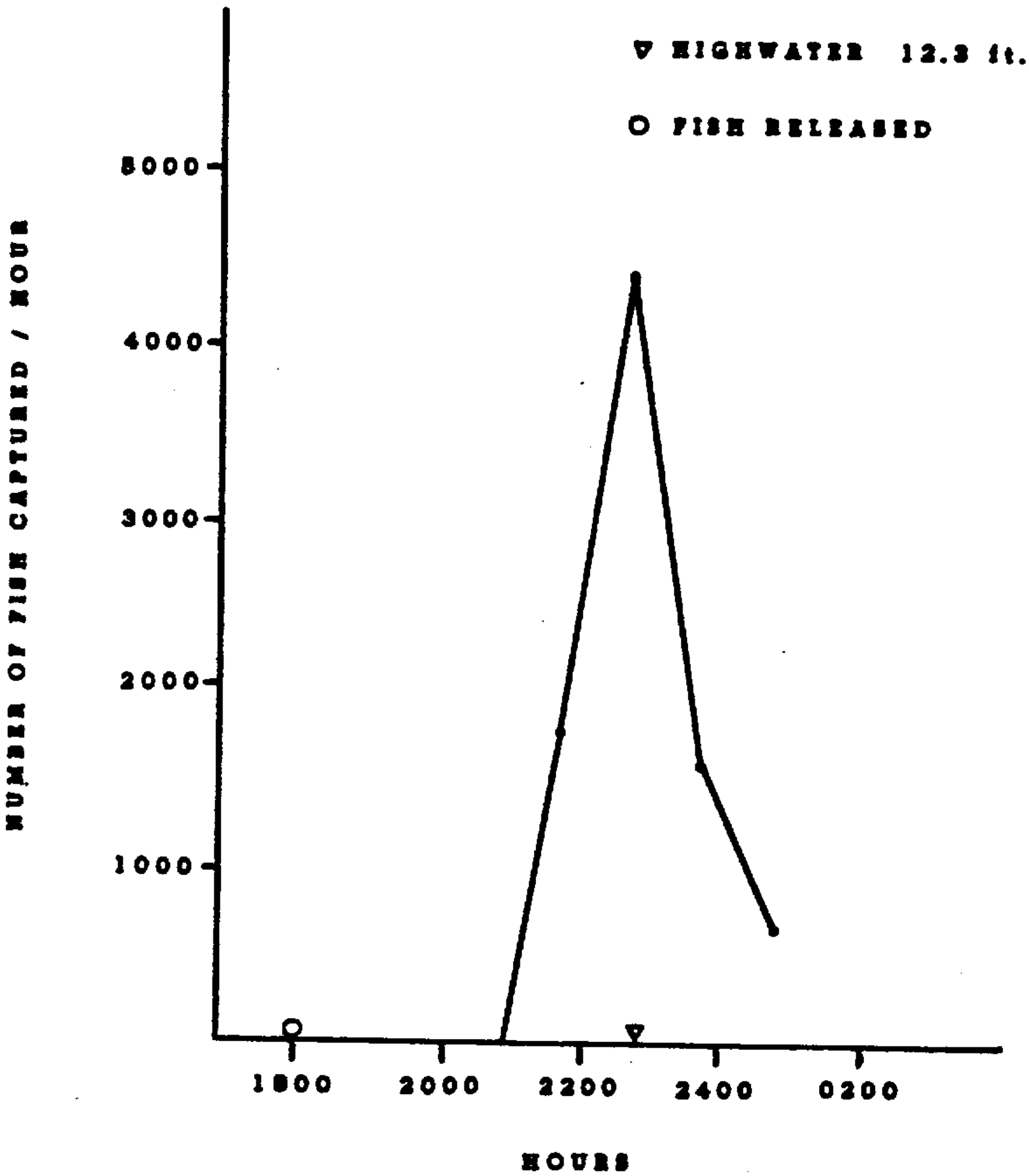

Figure 12. Subyearling spring chinook Fyke trap catches and outmigration pattern on June 4, 1984.

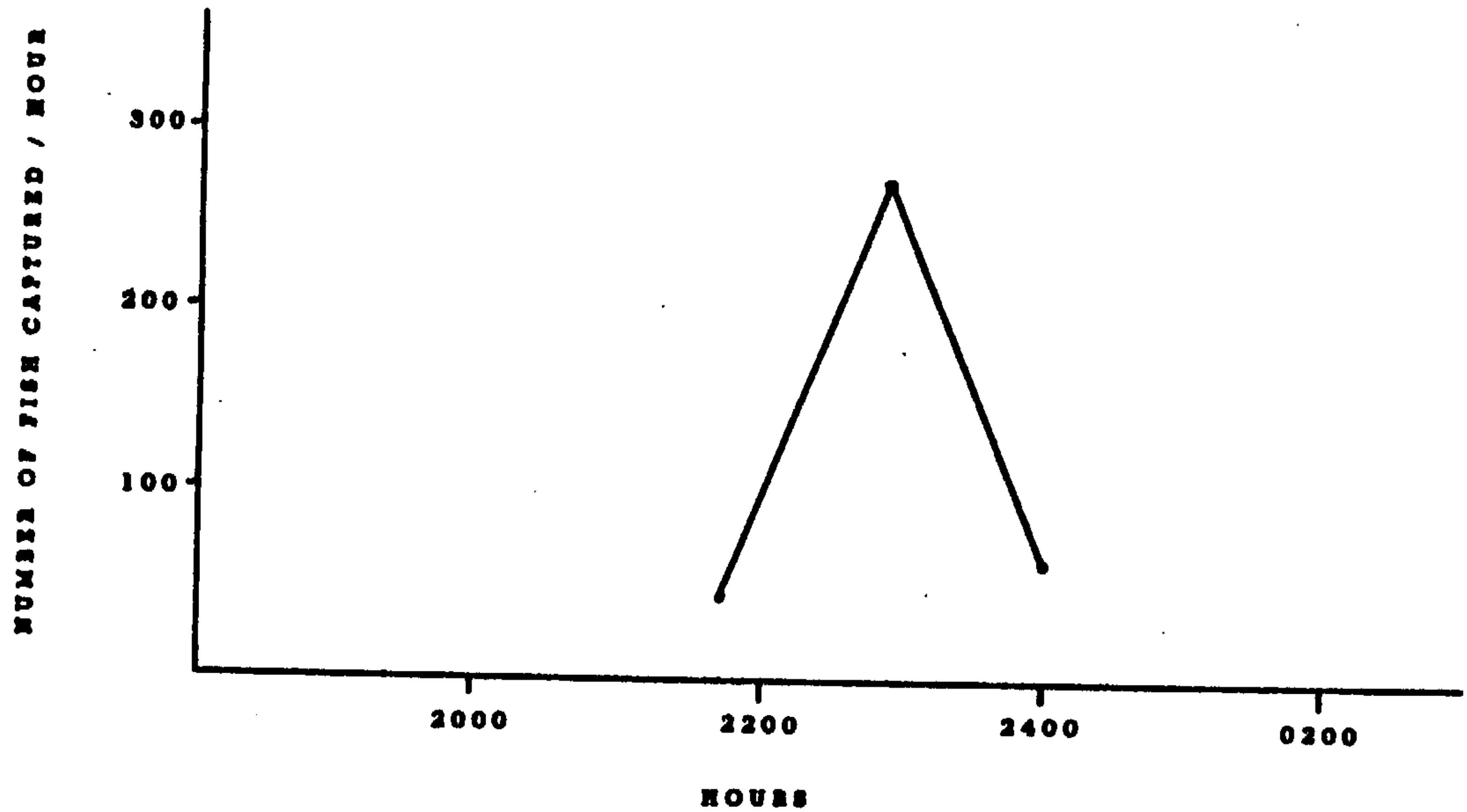

Figure 13. Subyearling spring chinook Fyke trap catches and outmigration pattern on June 5, 1984.

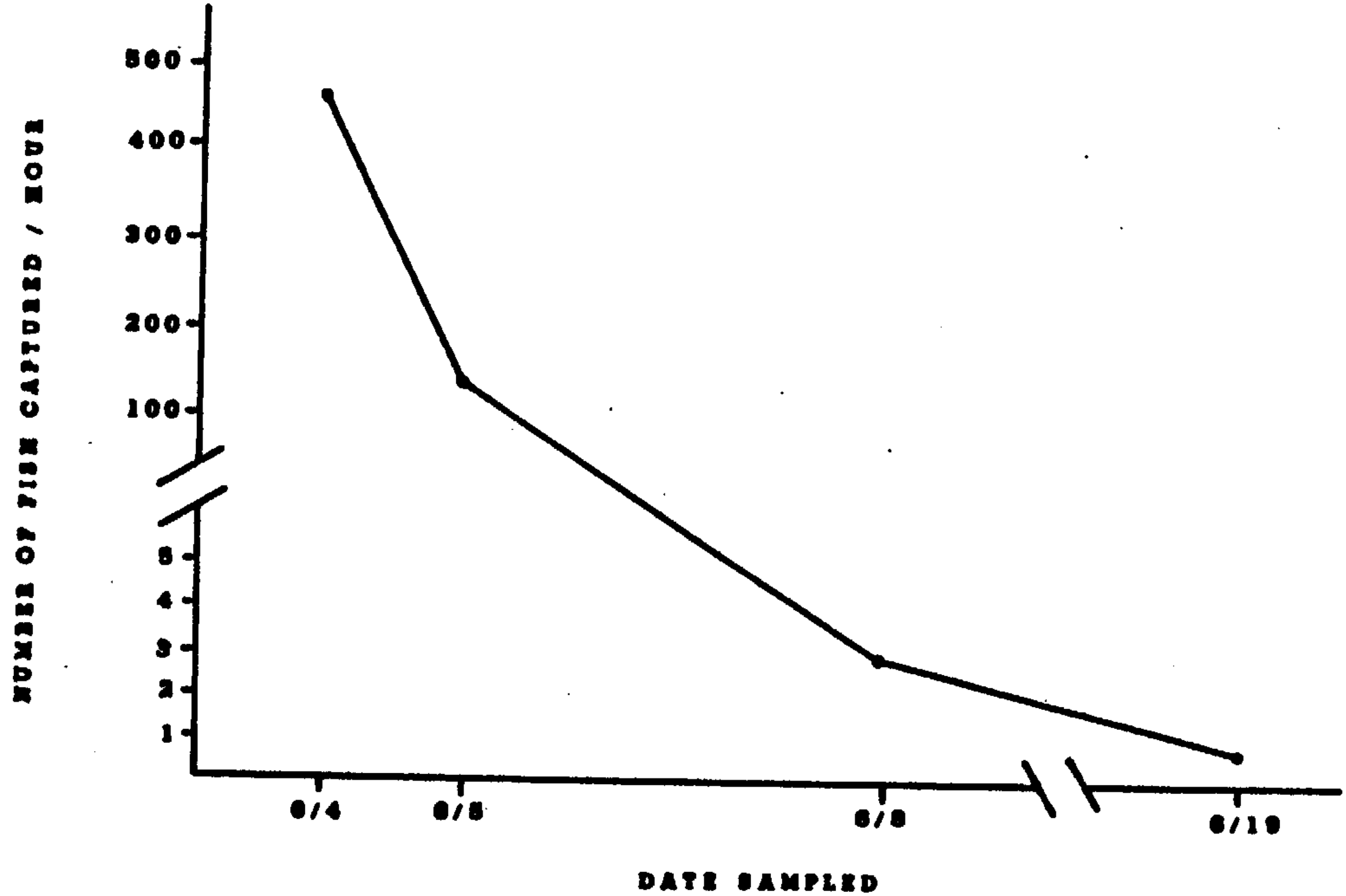

Figure 14. Subyearling spring chinook outmigrants captured during weekly fyke trap operation.

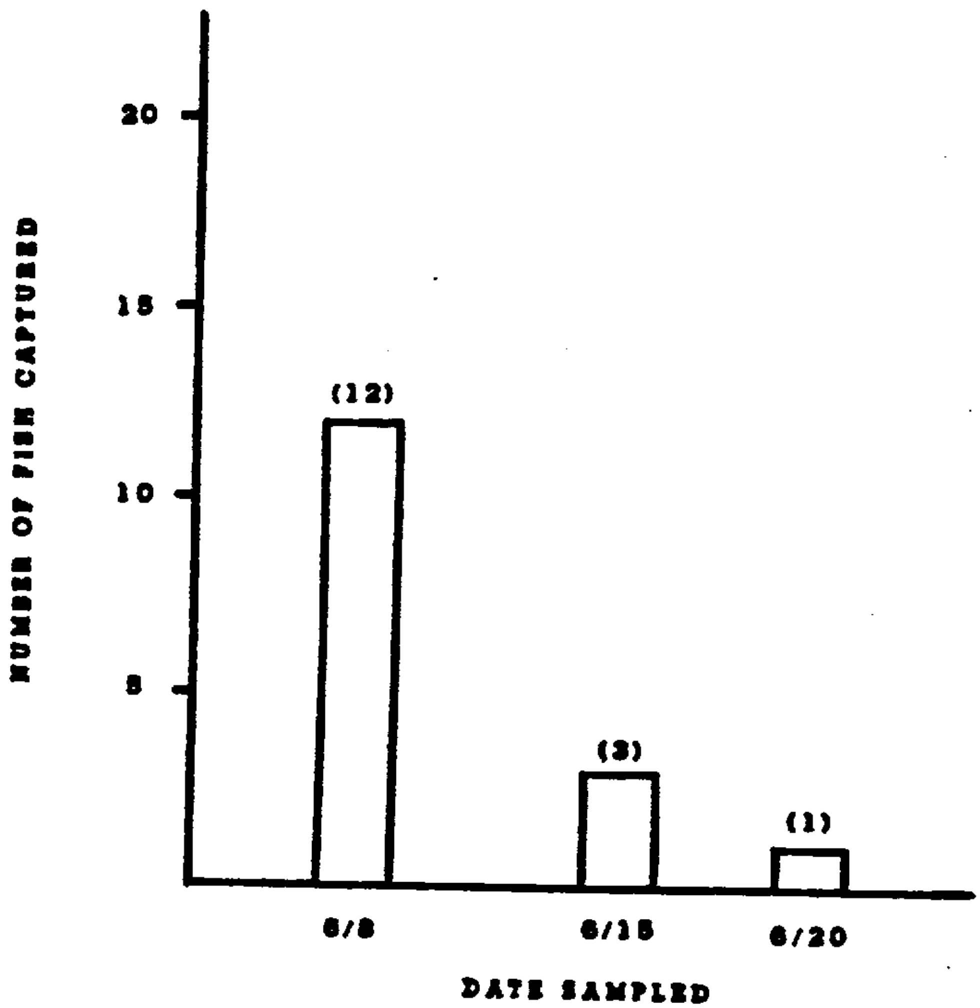

Figure 15. Total catch of subyearling spring chinook by electrofishing at all sites.

RECOMMENDATIONS

We recommend that manipulation of incubation rearing and release strategies be considered that will reduce species interactions. The poor performance of many hatchery programs (Fresh, 1984) has been linked to an unclear understanding of species interactions occurring in the freshwater and marine evironment. Fresh and Cardwell (1982) reviewed the literature regarding the impacts of species interactions upon both wild and hatchery produced salmonids. From their literature review they developed recommended hatchery practices to reduce species interaction i.e., competition and predation. Their recommendations involve manipulations of the predator-prey relationship and are applicable to the programs at Quilcene NFH. Their findings are incorporated into the following recommended release strategies.

Predator Manipulation

We recommend that yearling smolt releases be avoided during March because of the increased population of fish eating birds at Quilcene Bay during this time of year. However, if releases must be made at this time or whenever the potential for bird predation is high, aerial exploding devices such as cracker shells, discharged from a shotgun, could be used to haze predatory birds.

Student volunteers from the Peninsula College Fisheries Program reported that hazing efforts on the mornings following the chum salmon fry releases were effective in disrupting the feeding activity of the gulls at the mouth of the river.

Prey Manipulations

Optimize Environmental Conditions During Outmigration

As recommended by Fresh and Cardwell (1982), the hatchery can take advantage of environmental conditions as a means of reducing the effectiveness of predators. We suggest fish releases be made at dusk. This technique takes advantage of both allowing the fish to migrate under the cover of dark and the fish's natural tendency to outmigrate at night. To further reduce the effectiveness of predators it is also recommended that when possible, releases be made on overcast nights and when stream flows are high.

Our observations during this study indicate that particular consideration be given to both tide height and direction of tide flow prior to scheduling any fish releases at Quilcene. We suggest that fish be released on the rising tide (approximately three hours prior to high tide)to avoid the chance of their becoming trapped in tide pools during the ebbing tide. Although we did not determine what tide height completely covers the tidelands at the mouth of the Quilcene River, we recommend that releases be made during the higher high water that occurs during the tide cycle and if possible, on nights when the difference between the high and low tide is at a minimum.

Reduce Risk of Predation

We must recognize the potential impact hatchery programs may have on each other and on wild stocks. The transfer of the Walcott chum fry program to the Big Quilcene River compounds the factors that influence the success of this program. The Big Quilcene River is intensely used for other hatchery smolt releases and the potential for interspecies predation is high. Temporal separation of yearling smolt releases in relation to both hatchery releases of chum fry and to the timing of wild juvenile chum outmigration will reduce the potential for adverse interaction.

Our study did not observe any significant level of predation by spring chinook upon chum salmon fry within the river. We attribute this primarily to the poor health of the yearling chinook and to the 33 day separation between release of the yearling chinook and chum fry. The potential for species interaction, however is not limited to the river. It also extends out to the estuary.

The impact that the March release of yearling chinook had upon juvenile chum salmon in the estuary is unknown. We were unable to collect any data to make an assessment in that regard. We do know, however, that through early March and late April, a peak period of feeding activity occurs within Hood Canal by both hatchery and wild stocks of juvenile chum salmon. As we stated earlier in the discussion, a group of yearlings released during this time of year may prey upon these juvenile chum.

The hatchery staff has a degree of latitude in controlling the releases of chum, coho, and spring chinook because they are U.S. Fish and Wildlife Service (FWS) programs. The steelhead smolts however, are released by the Washington Department of Game (WDG). We contacted Jim Nielson, WDG District Biologist, prior to the steelhead releases, to express our concern for the potential of steelhead smolts preying upon hatchery chum. Mr. Nielson stated that WDG's long running steelhead program in the Quilcene River takes precedence over any new FWS fry planting programs. He did say, however, he would cooperate to minimize the conflicts. Our coordination with WDG resulted in a six day separation between release of steelhead yearlings and chum fry. We suggest that this cooperation between the two agencies be continued to reduce the risk of overlapping releases.

Although residualism of steelhead did not appear to occur to any degree and the fyke trapping data indicated a tendency for them to readily outmigrate, a more favorable scenario would have the Quilcene chum fry released prior to the yearling smolts. This would allow the chum fry to clear the river system and seek out the protection of the nearshore area of the estuary prior to the release of the steelhead smolts. The difficulty in achieving this, however is due to both the late timing of the Walcott broodstock and the need to provide early rearing for the chum fry prior to release. The combined effect of both these factors often results in releases of smaller than desired chum fry at the end of April or the first week of May which coincides with the time WDG considers to be optimum for release of their steelhead smolts.

We therefore recommend that investigations be initiated to study the effects of manipulating incubation and rearing strategies on the resulting quality of chum fry produced at the hatchery. Particular consideration should be given to the use of artificial substrate during incubation. An abundance of evidence exists in the literature that indicates larger and better quality fry are produced when artificial substrate is used during incubation. We presume that utilizing this technique on chum fry at Quilcene NFH would result in a stronger fry that will withstand the rigors of the natural environment.

Time and Size at Release

In an effort to reduce species interaction during the fresh water life stages we recommend that the hatchery release fish that will migrate to the marine environment upon release. Any fish released from the hatchery that residualize in the river have the potential of becoming predators and/or competitors of both newly emerging fry of salmonids that spawn naturally in the river and upon chum fry that are released by the hatchery.

Our data regarding the subyearling spring chinook indicates that residualism did not occur. On the other hand, a relatively large number of hatchery reared coho subyearlings were observed in the river during the weekly electroshocking surveys. Unfortunately our study was not designed to collect any data regarding either the post release behavior patterns of these fish or the incidence of their predation upon other salmonids. We do suggest, though, that in order to reduce the incidence of adverse species interaction, releases of coho subyearlings should be restricted to fed fry and preferably of a size less than 800 fish per pound.

To tie together the concept of predator-prey manipulation within a proper release window we suggest that both coho and spring chinook yearling smolts be released during mid to late May. We believe that such timing of yearling releases would avoid adverse species interactions and provide the maximum survival for these fish. Johnson (1973) assessed the impacts of WDF hatchery coho programs on pink and chum salmon production. From his assessment he recommended that hatchery releases of coho smolts be made after May 1. He suggests releases after this date would assure reduced predation upon pink and chum salmon and that this release timing would coincide with the natural outmigration timing recorded for coho salmon. He postulated that utilizing the natural outmigration timing would increase survival.

Other investigators have reported on the effects of manipulating rearing and release strategies. Reimers (1979) reported that increased survival of fall chinook was achieved at the Elk River Oregon Fish Hatchery by adopting the native Elk River outmigration patterns to the hatchery reared stock. Hopley (1977) and Westgate et al, (1983) reported that extending the hatchery rearing period of coho to late May and June increased survival above that recorded for releases made in April and early May.

There is little information available to describe an optimum release strategy for spring chinook in Puget Sound. The need exists to develop information that will maximize survival of spring chinook reared at Quilcene NFH. Data regarding outmigration of wild chinook in the Elwha River was collected in the spring of 1984 (Wunderlich and Dilley, 1985). Catches of yearling chinook were recorded in late May and June. The chinook were incidentally caught during an assessment of hatchery produced juvenile coho passage through the Elwha River dams.

We intend to continue evaluation of time and size at release strategies for spring chinook reared at Quilcene NFH. Subsequent analysis of our data may require an adjustment of the current release strategy.

Monitor Indicators of Smolt Functionality

Past experience with rearing spring chinook and coho salmon at Quilcene NFH has shown that these fish exhibit signs of apparent smolting during the first summer of rearing. This observation prompted the hatchery staff to collect fish samples for analysis of gill Na^+ K^+ ATPase enzyme activity. These samples are sents to Wally Zaug at the National Marine Fisheries Service, Cook Field Station located in Cook Washington. The data from Mr. Zaug's analysis shows a peak in enzyme activity for the 1983 brood spring chinook occurring in mid June (Figure 16). The subyearlings were released during the peak of ATPase enzyme activity.

We recommend that data regarding gill Na^+, K^+ ATPase continue to be collected for both yearling and subyearling chinook to develop a better understanding of its relationship to smolt functionality and the fish's ability to survive. We further recommend that salt water challenge tests be conducted to supplement the ATPase data. However, as Wedemeyer et al. (1980) state "...in evaluating smoltification indices and hatchery performance, the major criterion should be the summation of hatchery returns and contribution to the fishery." The evidence obtained during this study indicates that the subyearling chinook were ready to migrate. Their ability to survive the marine environment as age-zero smolts, however will be determined after the analysis of their CWT recovery data.

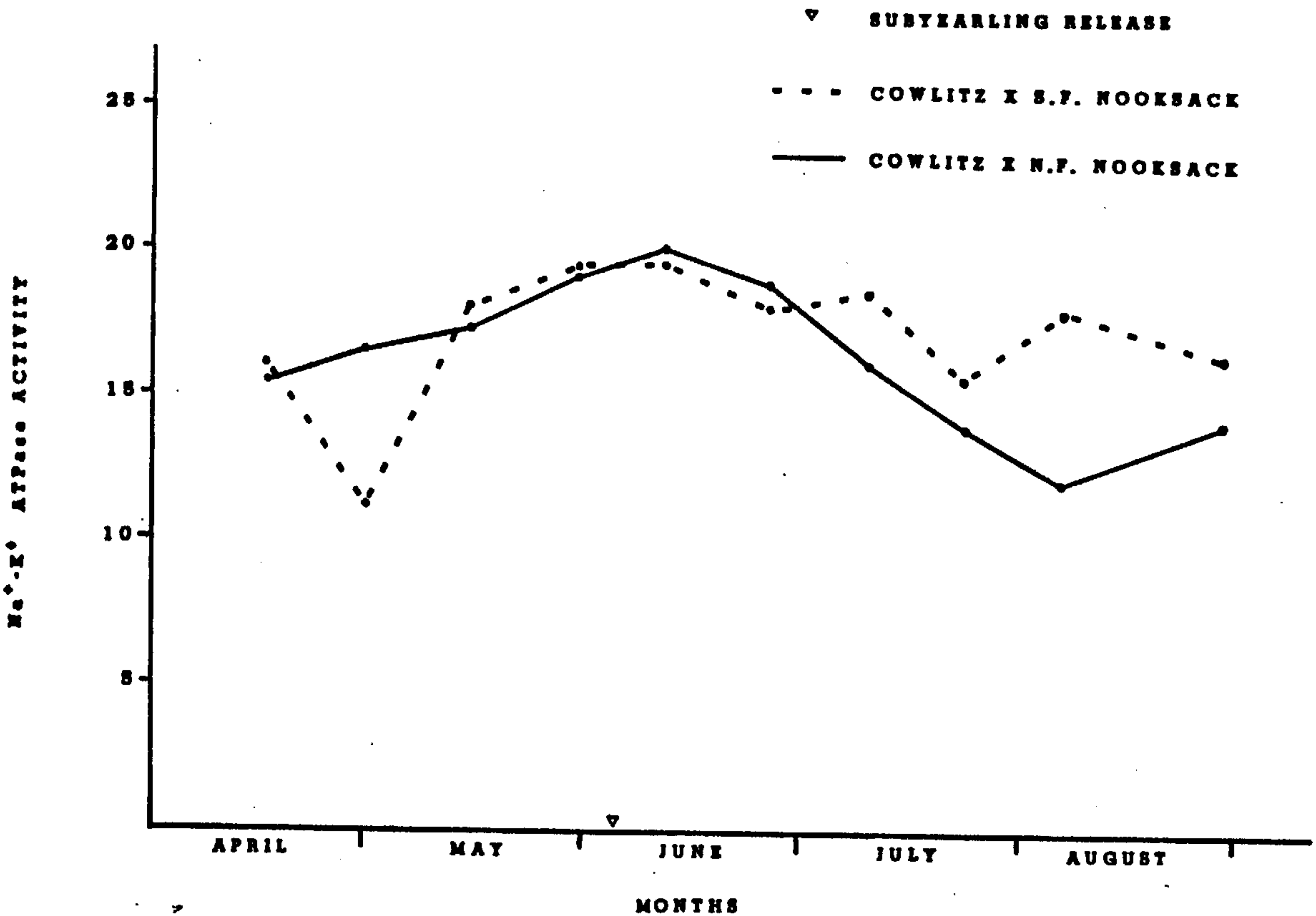

Figure 16. Na^{+}/K^{+} - ATPase activity (uM Pi/mg protein · hour) observed in brood year 1983 spring chinook at Quilcene NFH.

SUMMARY LIST OF RECOMMENDATIONS

Predator Manipulation

1. Avoid releases of outmigrants during early spring when predatory bird population is high.

2. Employ bird hazing techniques if needed to deter excessive predatory bird activity.

3. Avoid releases of yearling smolts in March and April to reduce the potential of their predation upon chum salmon fry.

Prey Manipulation

Optimize environmental conditions during outmigration.

1. Liberate, fish at dusk or during the night, on high water if possible, to provide cover for the fish during outmigration to the estuary.

2. Adjust time of hatchery release to coincide with the rising tide in Quilcene bay.

Reduce Risk of Predation

1. Ensure temporal separation between yearling releases and releases of chum fry.

2. Coordinate hatchery chum fry releases with WDG yearling steelhead releases.

3. Investigate the effects of manipulating incubation and rearing regimes upon the quality of hatchery produced chum fry.

Time and size at release

1. Avoid releasing subyearlings that do not show obvious signs of migrating activity.

2. Release yearling chinook and coho in mid to late May to reduce the potential for their predation upon wild chum salmon in the estuary and to ensure maximum survival.

3. Continually monitor indicator of smolt functionality and correlate them with release strategies that provide maximum survival.

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