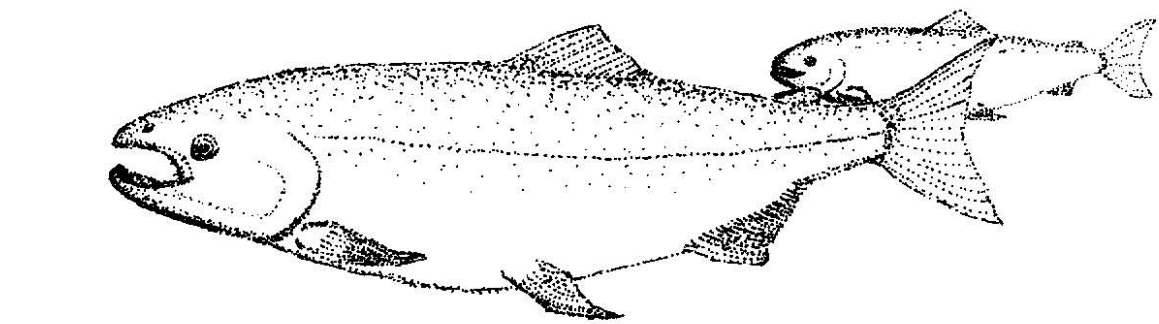
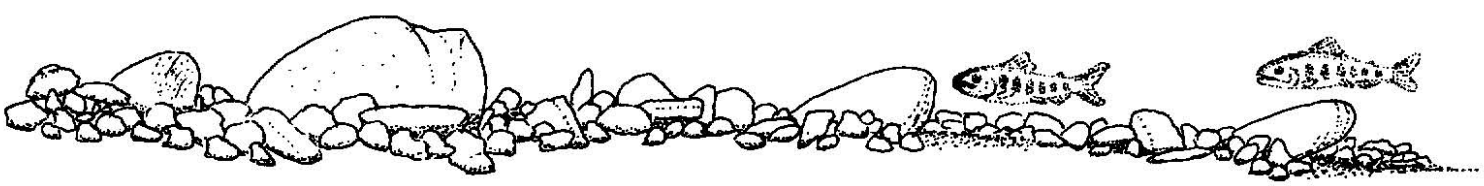
FIELD TESTS OF THE NORTHWEST MARINE TECHNOLOGY MODEL FC-I FISH COUNTER





U.S. FISH AND WILDLIFE SERVICE
FISHERIES ASSISTANCE OFFICE
OLYMPIA, WASHINGTON

FIELD TESTS OF THE NORTHWEST MARINE TECHNOLOGY MODEL FC-1 FISH COUNTER

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by
Stephen Dilley
Fisheries Management Biologist

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INTRODUCTION

The Jefferts binary coded-wire tag (CWT) has been used by fishery managers and scientists for a number of years in estimating hatchery contributions to commercial and sport fisheries as well as assessing specific stocking programs. These estimates and assessments are derived from a statistical analysis of data provided by CWT recovery information and other variables. One of those variables is the number of fish released from the hatchery. This estimate is often inaccurate because of inventory methods and incomplete mortality records. If the number of fish released is inaccurate the tagged to untagged ratio and thus the total survival estimate will be inaccurate. Recent information from the Pacific Marine Fisheries Commission indicates this may be a serious problem. The mark to unmarked ratio of recovered fish show over 66% more marks than at release suggesting overestimation of released unmarked fish.

The number of fish released at Quilcene and Quinault National Fish Hatcheries (NFH) is presently calculated by subtracting observed mortalities from prior inventory estimates. Estimates are calculated by hand counting a random sample of fish and dividing that number by the total weight of the sample. This method provides a fish per pound value which when multiplied by the total pounds of fish gives an estimate of the total number. Error in this method may occur due to the additional weight of water retained by the net and fish, human error in reading the scale, and variability in the fish per pound estimate.

Because of the critical nature of these estimates for both fishery and hatchery managers, it is important to explore alternative approaches to quantifying the numbers of fish at release.

The Olympia Fisheries Assistance Office initiated an assessment of the practicality of using an electronic fish counter to improve the accuracy of the estimated number of fish being released from Quinault and Quilcene NFH's. In addition, the counter was tested for its potential use in obtaining inventory estimates.

METHODS

The electronic fish counter used in this evaluation was a model FC-1 counter developed by Northwest Marine Technology, Inc.* This counter works on a conductivity bridge principle. When a fish passes through one of 16

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* The U.S. Fish and Wildlife Service makes no endorsements of commercial products.

tunnels, three rings of electrodes inside each tunnel sense the change in electrical conductivity and record the passage of a fish. The counter can be described in three parts: the counting head, electronic package, and power supply (Photo 1).

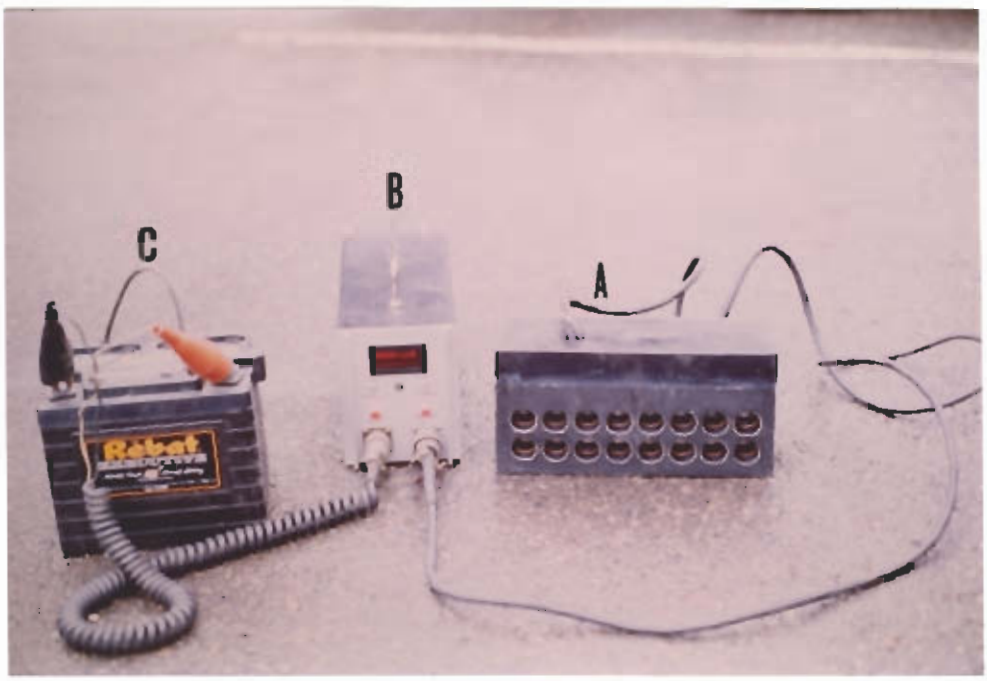

Photo 1. FC-1 counter: A) counting head. B) electronic package. C) power supply.

The counting head consists of a 16-tunnel matrix connected by a cord to the electronic package. Matrices with tunnel diameters of 5/16", 1/2", 3/4", and 1" were used in this study (Photo 2). In addition, two matrices with tunnel diameters of 1-1/2" were constructed of wood and PVC pipe (photo 2) and used to simulate the conditions found in two 1-1/2" model FC-1 counters.

The electronic package (Photo 1) interprets the signal from the counting head and displays the cumulative number of fish passing through the tunnels. The power source was a 35-ampere aircraft battery. For reporting purposes the counting head will be referred to as the "matrix" while the entire unit will simply be called the "counter."

Two funnel shaped crowders were designed to hold the matrices and lead the fish into the counter. Crowder Number 1 was constructed with aluminum screening with the matrix mounted in the constricted end (Photo 3).

Black plastic was placed on the side to help increase the flow of water through the counter. The crowder was not suitable for mounting larger than 1" diameter matrices so crowder number 2 was constructed with a removable end piece (Photo 4 and 5).

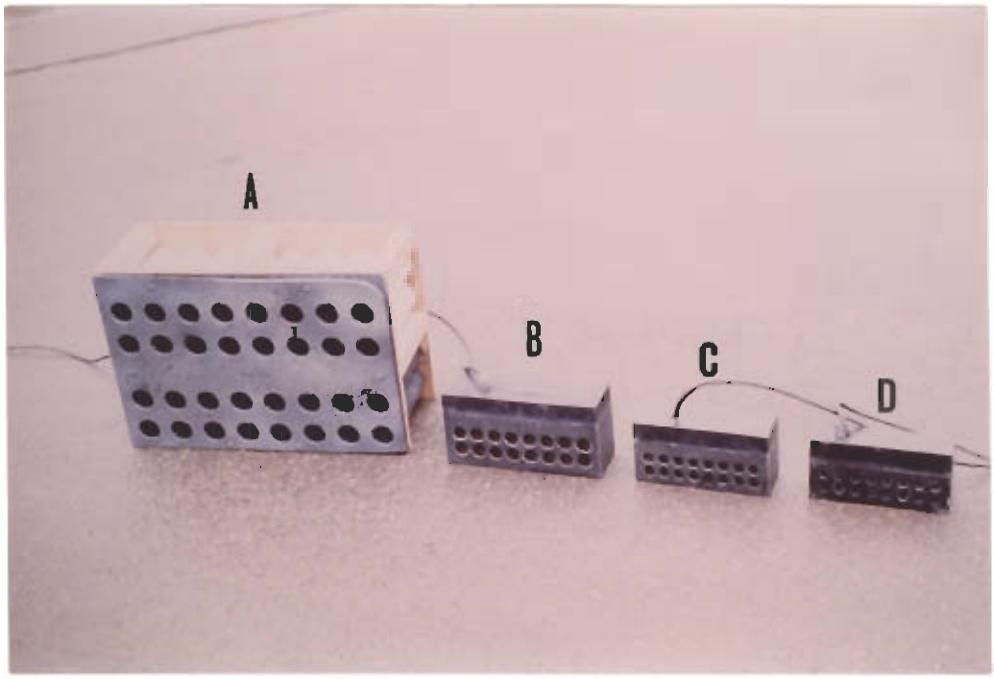

Photo 2. Matrices used in testing, A) mock 1-1/2" diameter matrices, B) 1" diameter matrix, C) 3/4" diameter matrix, D) 1/2" diameter matrix.

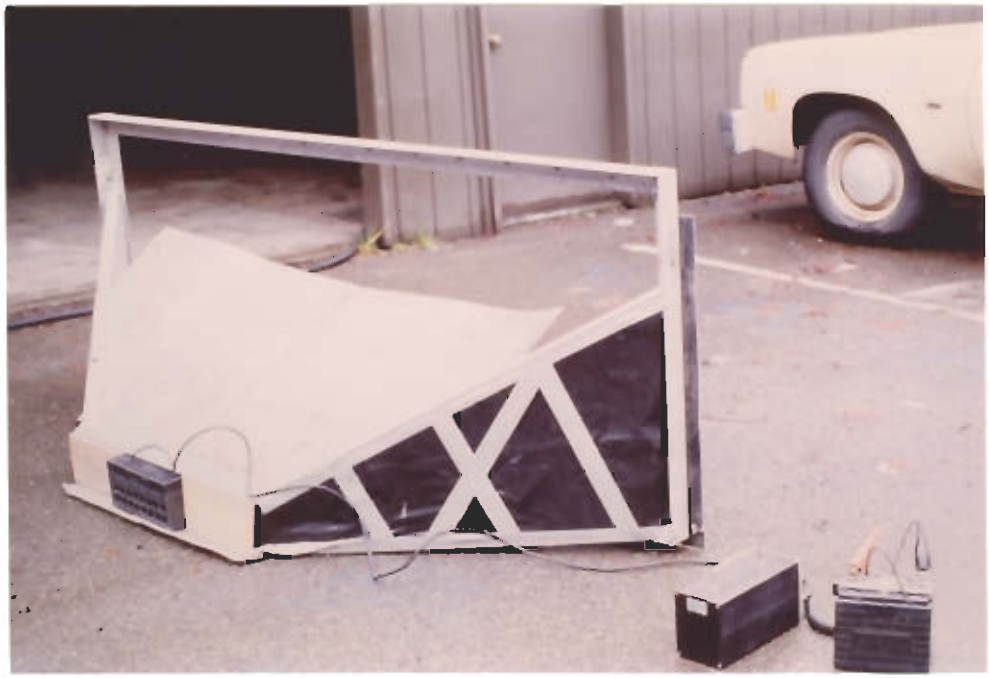

Photo 3. Crowder Number 1 with counting device installed.

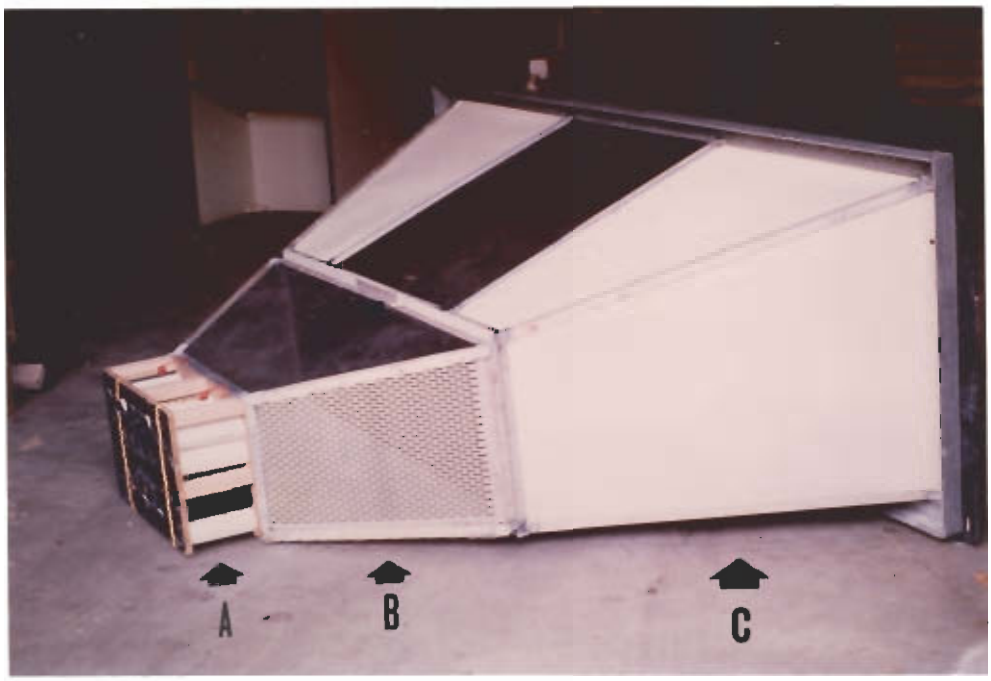

Photo 4. Crowder Number 2: A) 1-1/2" diameter mock matrices; B) Removable end piece; C) main body of crowder.

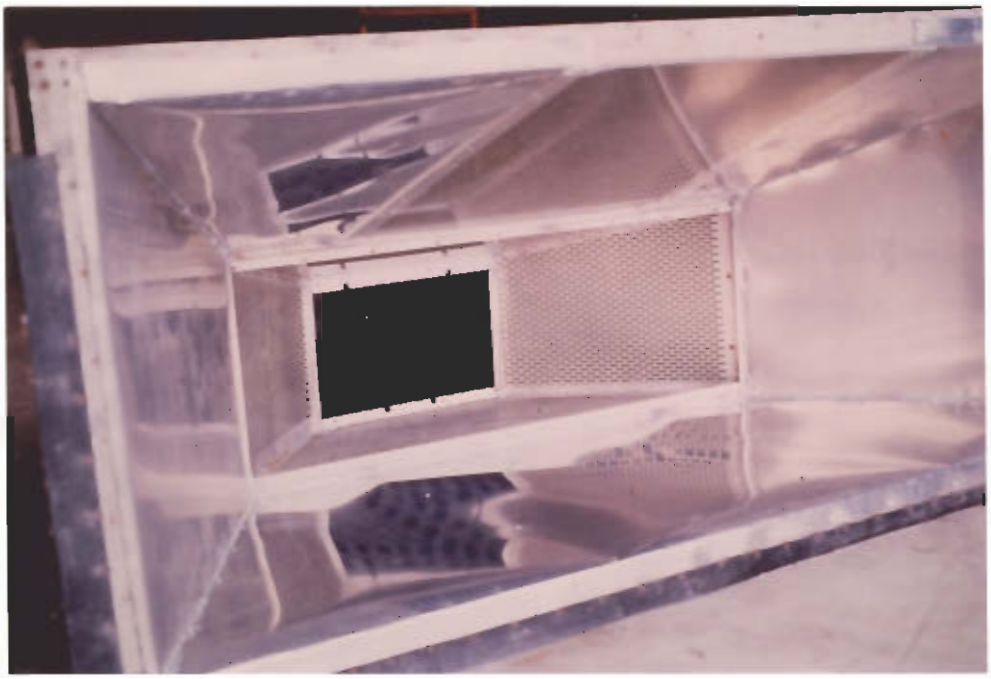

Photo 5. Interior view of crowder Number 2.

The removable end piece provides the flexibility to accommodate any size matrix as well as a number of individual matrices if desired. A clear plexiglass sheet was placed on the top of both sections for observation of fish passage during testing (Photo 4). In addition, during release testing several water level control boards were notched to accommodate the different matrices.

Testing at Release

Two species of salmon (chum and chinook) were used for testing because of their availability and convenient time of release.

The 1/2" diameter matrix was tested at Quinault NFH on an estimated 455,000 chum at 650 fish per pound on April 15, 1982. The matrix was installed in the center of a water level control board and placed into position on the bottom of the outfall of the raceway. An aluminum screen was placed on top of the dam board and the fish were crowded up to the counter. Fish behavior was observed numerous times from 4:30 PM to 8:30 AM. They were left undisturbed until dark (approximately 8:00 PM). At that time an attempt was made to force the fish through the counter by walking along the raceway and flashing lights into the water. This was done periodically throughout the night and early morning. At each observation, whether harassed or not, the number of fish that passed through the counter was recorded.

Crowder Number 1 with a 1" diameter matrix was tested at Quinault NFH on August 19, 1983 with approximately 52,600 chinook at 30 per pound. The matrix was placed in the outfall of the raceway and the fish were then crowded up to the counter and held from 2:30 PM to 9:00 AM the following morning. Because of a past disease problems these fish were left undisturbed with the exception of crowding closer to the counter at 3:00 PM and 6:30 AM. Numerous visual observations of fish behavior were made during this test to detect any signs of stress and reaction to the counter. The number of fish having passed through the counter was recorded at each of these observations.

At Quilcene NFH on May 13, 1982, an estimated 400,000 chum at 612 per pound were used with a 5/16" diameter matrix which was installed in the center of a dam board and placed on the bottom of the outfall of the raceway. An aluminum screen was then attached to the top and the fish were crowded up to the counter. These fish were held from 2:30 PM to 9:00 AM the following morning. Again, numerous visual observations were made during the night and the number of fish having passed through the counter was recorded. During these observations the fish were occasionally crowded closer to the counter as the density of fish decreased. These fish were also periodically harassed to determine whether they would pass through the counter more rapidly.

Testing for Inventory Estimates

Two species of salmon, chum and coho, and steelhead trout were used for inventory testing. These species were chosen because of their availability and the desire to use the counter for inventory estimates of these species.

An esimated 264,400 chum at 409 fish per pound were inventoried (Table 1) on May 27, 1982, at Quilcene NFH. Crowder Number 1 with a 1/2" diameter matrix was placed in the middle of the raceway with the narrow end upstream. These fish were then crowded up to the counter and observed continually for one hour and five minutes. The number of fish having passed through the counter was recorded every five minutes. After 45 minutes, the water level was dropped to 1/2 of the starting level of 1.5 feet. At the end of this time period the crowder was turned to face downstream and the fish crowded to the counter to see if they would be more inclined to go through the counter going with the flow of the water. They were observed for 30 minutes and then the crowders were removed.

Again at Quilcene NFH, coho at 64 fish per pound were used July 7, 1982 (Table 1). On June 29, Crowder number 1, with a 3/4" diameter matrix (Photo 6), was placed in the middle of a raceway with the narrow end upstream.

A standard hatchery crowder was placed approximately 10 feet downstream from the counter. At 8:55 AM, 8,834 fish were placed in this confined area with the only opportunity for exiting through the counter.

Photo 6. Interior view of crowder number 1 with 3/4" diameter matrix installed.

Table 1. Summary of data for groups of fish used in the testing of the FC-1 counter for inventory purposes.

Date	Location	Species	Size Fish/lb	No. of Fish	Length of Test Period
5/27/83	Quilcene NFH	Chum	409	264,400	1 hr. 35 min
7/7/82	Quilcene NFH	Coho	64	8,834	24 hrs.
2/2/83	Quinault NFH	Steelhead	10	42,000	16 hrs.
2/15/83	Quinault NFH	Steelhead	18	22,000	1 hr.

Behavior of these fish was observed periodically during the test period until 9:00 AM the following morning.

On February 2, 1983 Crowder Number 2 with the mock 1-1/2" diameter matrices was used at Quinault NFH (photo 7).

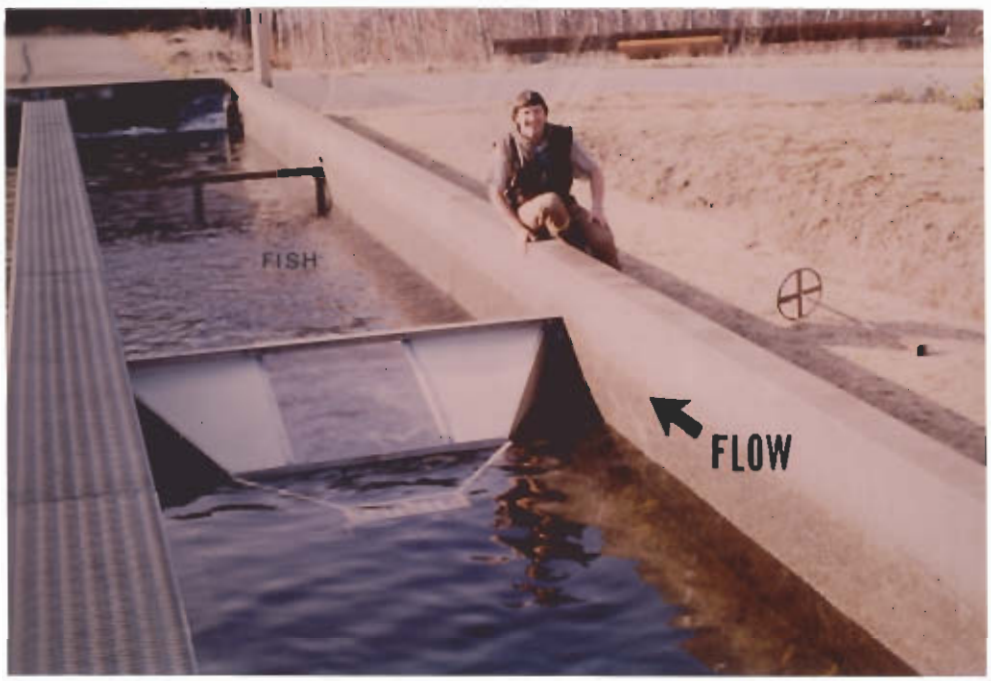

Photo 7. Crowder number 2 installed in a raceway at Quinault NFH during the February 2, 1983 testing.

The raceway contained an estimated 42,000 steelhead at 10 fish per pound (Table 1). Behavior of these fish was observed on numerous occasions during a 16-hour period beginning at 2:20 PM and ending the following morning at 7:30 AM.

The same crowder and mock matrices were tested again on February 15, 1983. However, the crowder was modified by camouflage painting (Photo 8) to cover the bright aluminum finish. The crowder was installed in a raceway at Quinault NFH containing an estimated 22,000 steelhead at 18 fish per pound (Table 1). They were crowded up to the counter very tightly. The hatchery crowder was placed against the front of the counter leaving only the space inside the counter. These fish were held and observed in this situation for a one-hour period.

Photo 8. Interior view of crowder number 2 after camouflage painting of shiny aluminum sheeting.

RESULTS AND DISCUSSION

Testing at Release

A total of 445,200 chum were counted by the FC-1 on the April 15 test at Quinault NFH (Table 2). A visual estimate of 10,000 fish remained in the raceway at the end of the time period. These figures, when added, are within 200 fish of the hatchery estimate of 455,000.

The number of fish passing through the counter between observations (Figure 1) show two peak migrations when the fish were left undisturbed (4:30 PM to 7:00 PM and 3:30 AM to 8:00 AM the following morning). When harassed, large numbers of chum passed through the counter at 8:00 PM, 3:15 AM, and 8:00 AM. Little movement was recorded during the time period from 8:30 PM to 3:00 AM, even with harassment at 8:30 PM, 9:30 PM, and 11:30 PM.

After observation of the fish during the testing it was determined the 1/2" matrix was too large for the fish. Periodically two fish would be seen entering a tunnel at the same time (there was no way to quantify this occurrence). The manufacturer of the FC-1 requires that an appropriate tunnel size be used so that only one fish can pass through a tunnel at a time. This fact may have negatively biased the number obtained from the counter.

During testing it was observed that fish seldom swam head first through the counter and were literally sucked through backwards. In addition, the fish did not move through the counter very fast unless they were forced, either by crowding or harassment.

Approximately 500 fish were killed in the screen above the counter. This screen was composed of slots that measure 15 mm x 2 mm. When fish were forced up to the counter by crowding or harassment, a number of them would get sucked through the screen tail first. Since the slots were not large enough for the entire fish to pass through they became gilled in the screen making it impossible to remove them without injury. By the end of the test period almost every available slot had a fish gilled in it.

The FC-1 counted 327,644 chum on the May 13 testing at Quilcene NFH. Fish that remained in the raceway after the test were weighed and released. It was estimated, using the hatchery fish per pound figure, that 62,271 fish did not pass through the counter. A small slot was observed under the dam board and by a visual estimate, 10,000 fish passed through undetected by the counter. In addition, approximately 200 fish were lost due to gilling in the screen. The above figures give a total release estimate of 400,115 fish (Table 2). The hatchery estimate of 400,000 fish was obtained by the number of fish ponded minus the daily mortalities. As with the Quinault chum estimate, those two figures are very close. Since a smaller size matrix (5/8") was used at Quilcene, the counter estimate was probably not negatively biased. However, the estimated 10,000 fish that escaped under the dam board is speculative at best.

Table 2. Results of testing the FC-1 counter on three groups of fish at time of release from the hatchery.

Date	Location	Species	Size Fish/lb	Length of Testing	Counter Estimate	Hatchery Estimate [A]
4/15/82	Quinault NFH	Chum	650	16 hrs.	455,200	455,000
5/13/82	Quilcene NFH	Chum	612	24 hrs.	400,115	400,000
8/19/82	Quinault NFH	Chinook	30	18.5 hrs.	B	52,600

A/ Based on number of fish ponded minus the daily mortalities.

B/ Insufficient number of fish passed through counter for estimate.

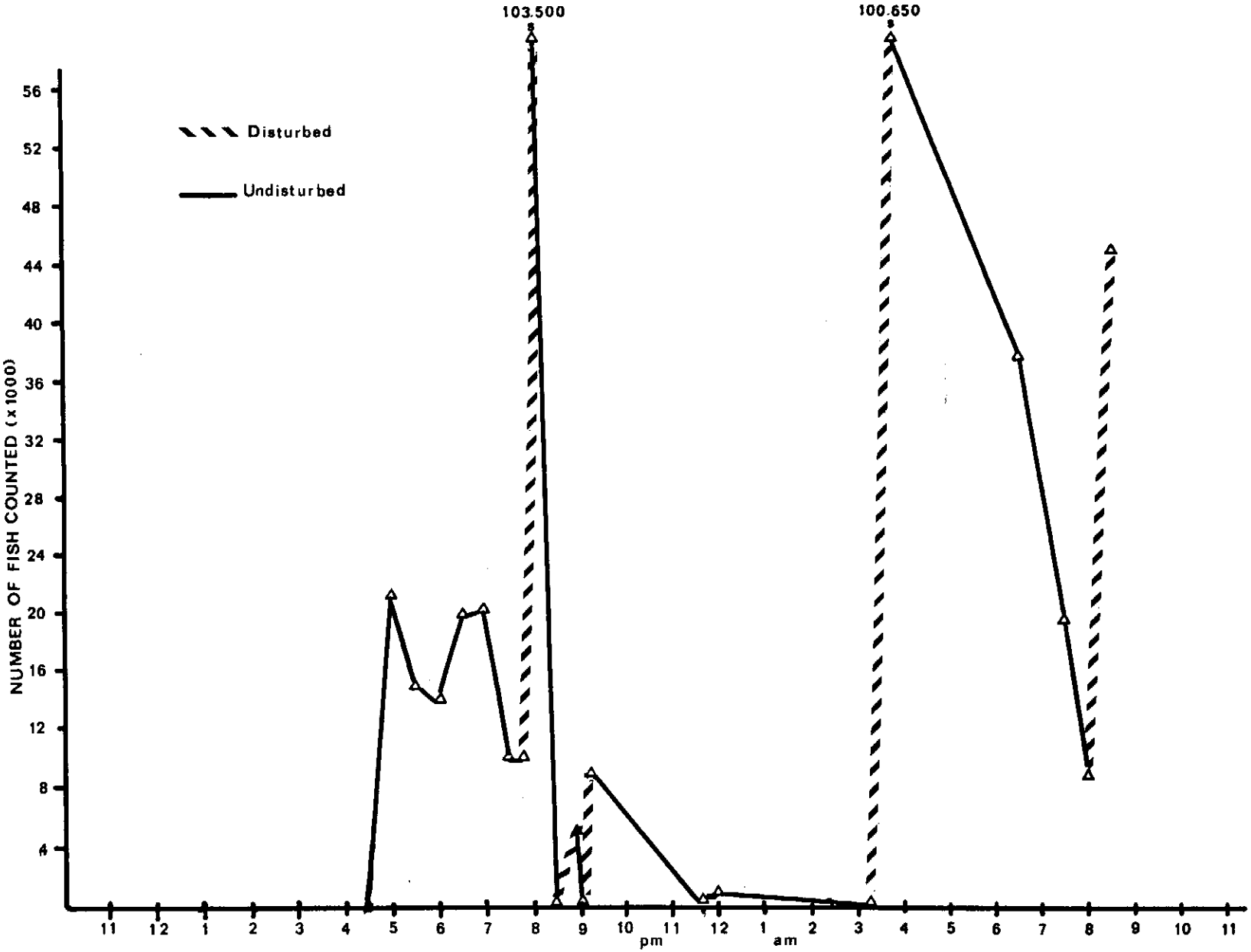

Figure 1. Number of chum salmon passing through the FC-1 counter between each time period during testing on april 15, 1982 at Quinault NFH.

Quilcene chum exhibited a slightly different behavior then chum tested at Quinault NFH. Figures 2 demonstrates three peaks of migration when the fish were not distrubed. These peaks occurred at 5:00 PM, 10:00 PM, and between 6:00 and 7:30 AM the following morning. Little movement occurred in the early morning hours similar to that exhibited by Quinault chum. Quilcene chum displayed their largest undisturbed movement between 8:00 PM and midnight while the Quinault chum showed virtually no movement during this same period, even when harassed (Figure 1). These differences in behavior could be related to variation in size of the fish between groups, timing of migration, overhead lighting, or densities at the time the fish were crowded up to the counter.

It was not surprising to find the hatchery estimates of chum at both facilities to be close to the estimate obtained from these tests. Fairly accurate counts of live eggs are made prior to hatching and since chum are reared for a short period of time (two to three months) relatively few mortalities are undetected.

The FC-1 counted 23,730 Quinault chinook on the August 18 test date (Table 2). At the end of the test period, based on a visual estimate, approximately half of the fish remained in the raceway. No attempt was made to obtain a weight from these fish for estimating the number remaining in the raceway because of a past disease problem. It was felt that weighing would stress the fish to the point of causing a reappearance of the disease.

Two peaks in undisturbed migration occurred for Quinault chinook during the test period (Figure 3). The first took place from 3:30 to 5:00 PM and the second from 8:30 PM to 6:30 AM the following morning. The largest migration of fish took place between 9:00 PM and 12:30 AM.

Chinook behavior was compared to the two groups of chum. The first peak in migration coincided for both chinook and chum (Figure 1, 2, 3). This may be a function of initial crowding up to the counter and not volitional migration. The second peak for chinook started from a low point just before 8:00 PM and continued to increase through the night and tapered off by 8:00 AM. Chum migration also increased at 8:00 PM but by 3:00 AM little movement was observed. No chinook were gilled on the screen, in contrast to the chum. This was a result of their larger size, swimming ability, and the lack of crowding and harassment.

Testing for Inventory Estimates

The results of the inventory testing on May 27, 1983 at Quilcene NFH can be found in Figure 4. The peak rate of chum movement through the counter in a five minute period was 2,220. If the fish moved through the counter at this rate, approximately 9 hours would be needed to inventory the raceway. A small increase in the number of fish moving through the counter was observed when the water level in the raceway was lowered by one-half (Figure 4). However, this effect appeared to disappear fairly quickly. When the crowder was reversed, virtually no fish moved through the counter even when harassed. This testing was done at midday and these results could have been influenced by this variable. Based on our earlier tests

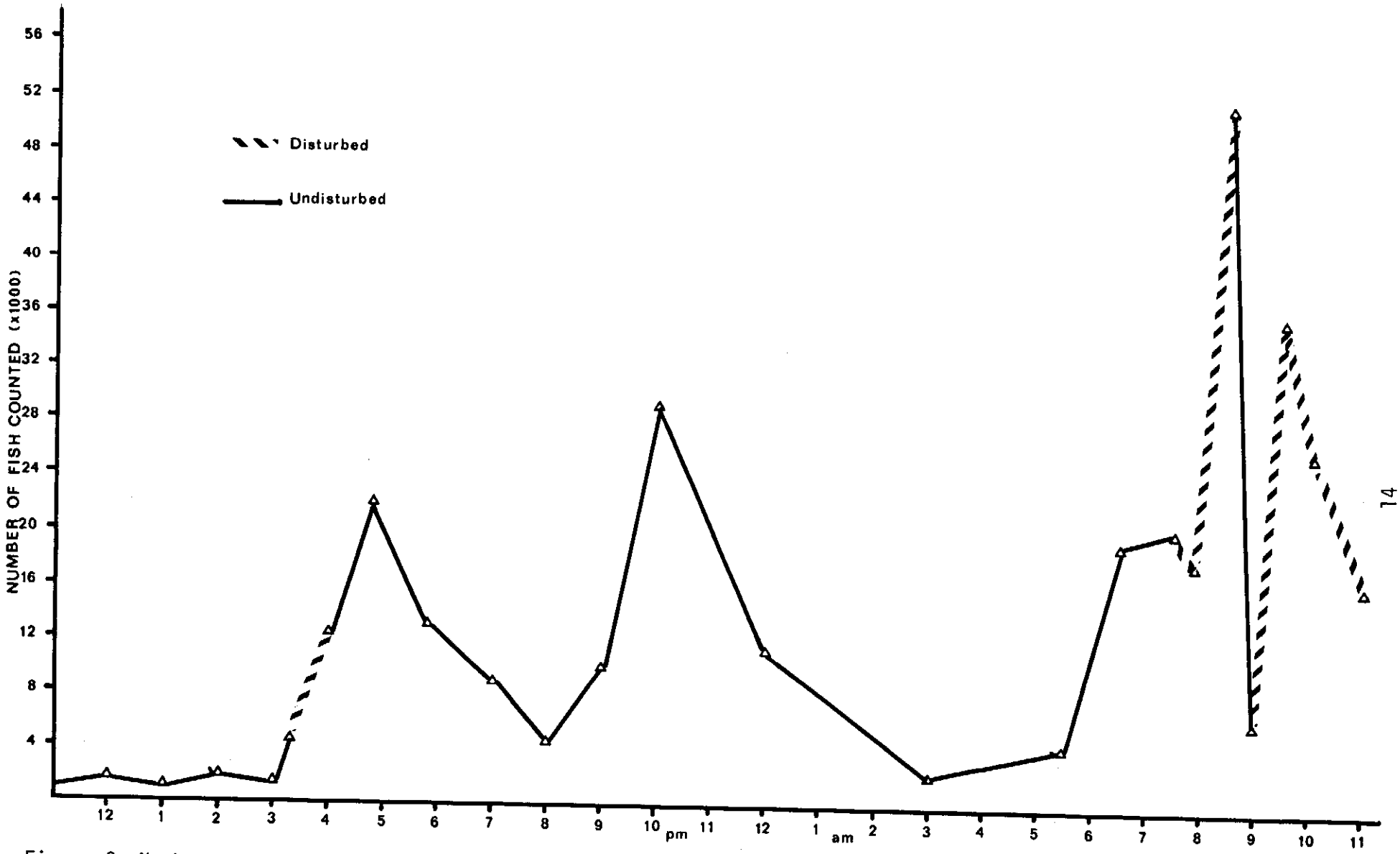

Figure 2. Numbers of chum salmon passing through the FC-1 counter between each time interval during testing on May 13, 1982 at Quilcene NFH.

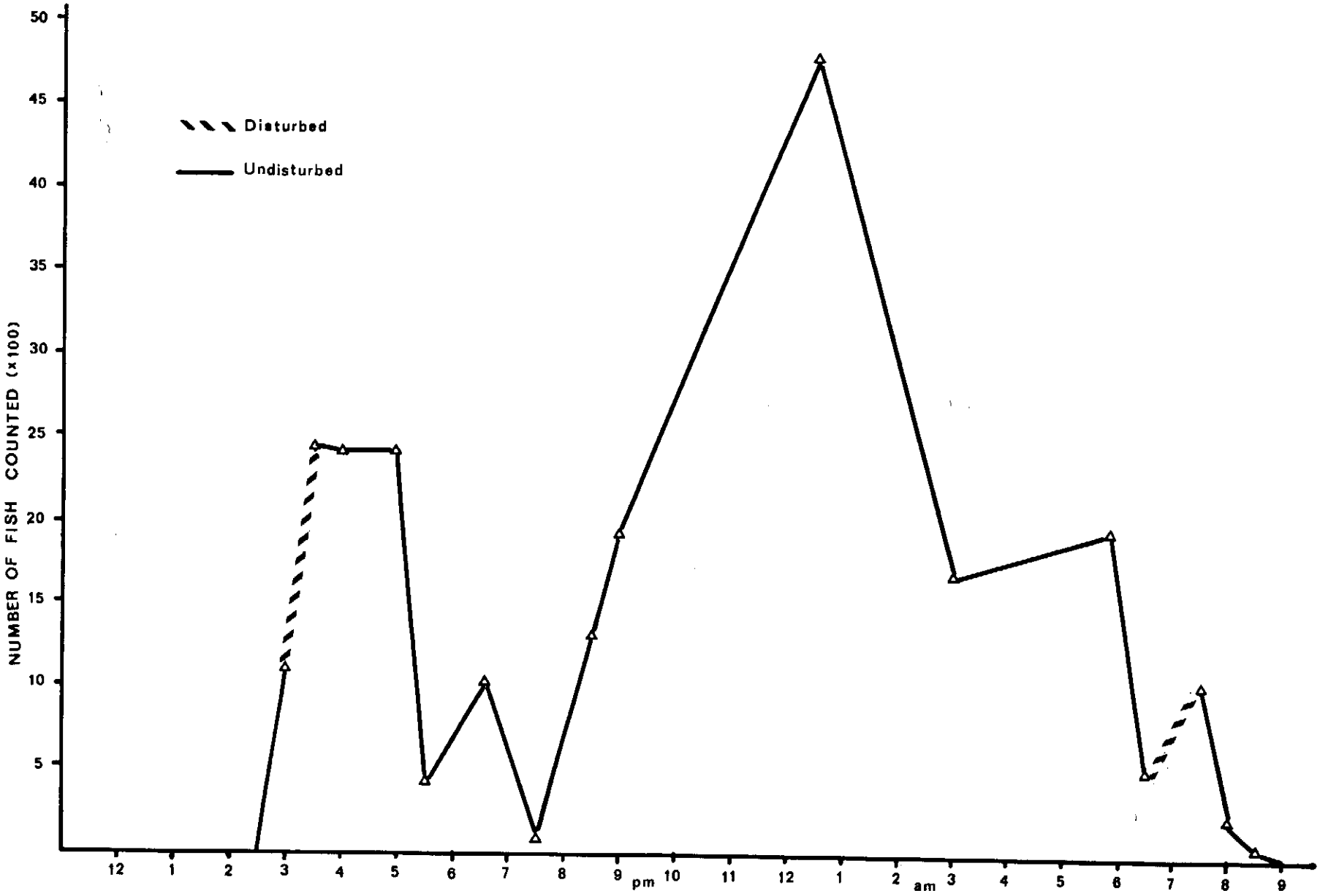

Figure 3. Numbers of chinook salmon passing through the FC-1 counter between each time interval during testing on August 18, 1983 at Quinault NFH.

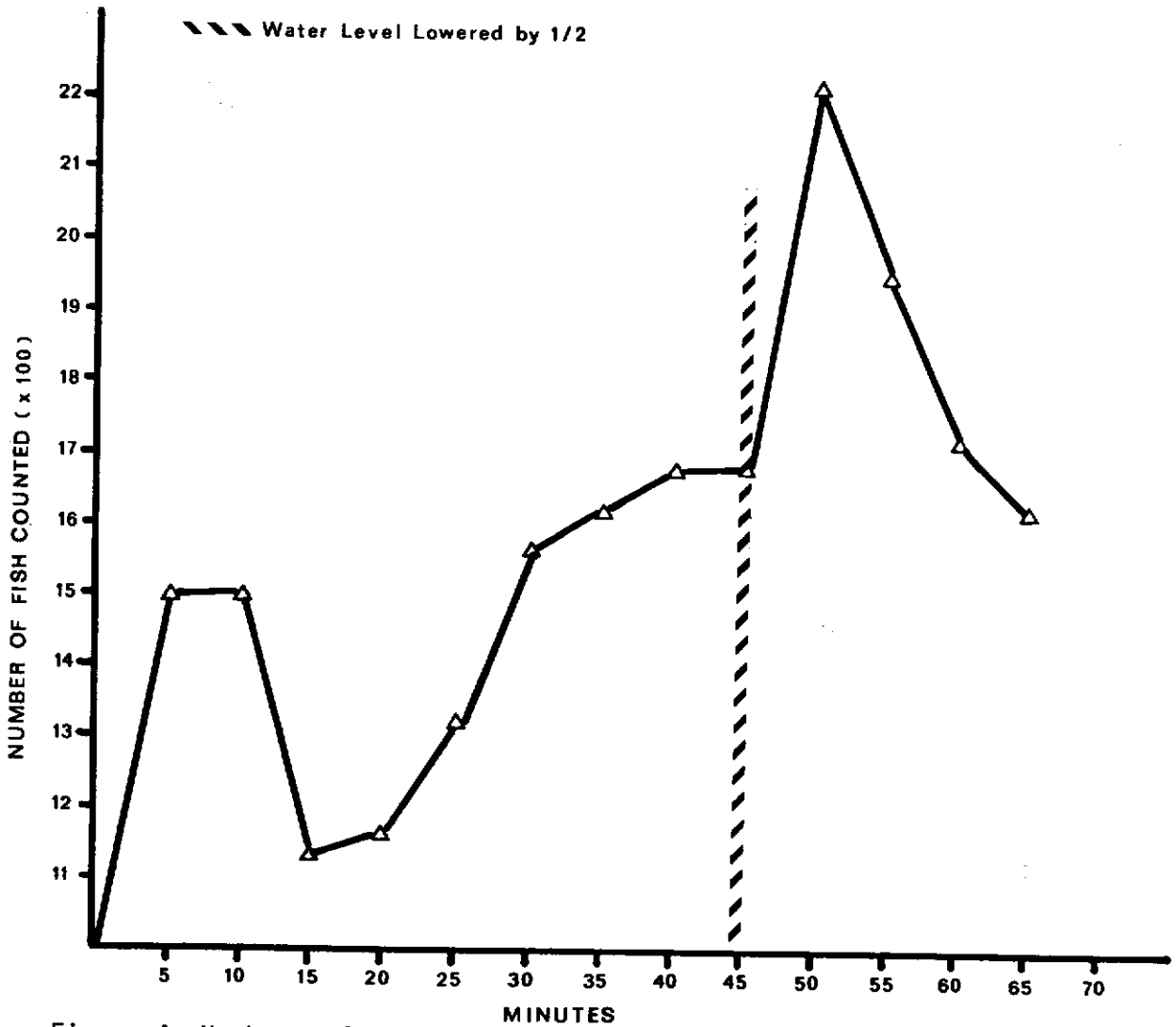

Figure 4. Numbers of chum salmon passing through the FC-1 counter between each time interval during the May 27, 1982 testing.

with chum behavior at release, the fish may be more apt to move through the counter at dusk or early evening.

The results of inventory testing with 8,834 hand counted coho on July 7, demonstrated that the counter overestimated the number of fish passing through by 232 percent. An estimate of 3,012 uncounted fish was obtained by the weight of the fish remaining in the crowded area at the end of the test. While the counter estimated that 13,515 fish had passed through, infact, only 5,822 had actually migrated through the counter. Subsequent observations revealed the error in counting was attributable to fish remaining in the counter tunnels. These fish moved back and forth and undoubtedly were counted a number of times. This behavior accounted for the biased estimate given by the counter.

Inventory testing with steelhead took place on February 2 and 15 at Quinault NFH. It was estimated that after 2 hours of testing, on February 2, 10,000 fish had moved through the counter at a slower but continual rate until it was removed at 7:30 AM. Of the 42,000 fish used in this test, an estimated 35,000 fish moved through the counter during the 16 hour test period (2:20 PM to 7:30 AM). Photos 9 and 10 show typical densities of fish in the crowder on February 2.

Fish were observed holding in the counting tubes similiar to the coho observed at Quilcene NFH, but to a lesser degree. In addition, the fish seemed to shy away from the crowder during the daylight hours. The bright shiny surface of the crowder (Photo 5) may have been the reason for this behavior. This problem was addressed by painting with camouflage paint (Photo 8). In the February 15 test, all but about 1,500 fish of an estimated 22,000 moved through the crowder during a one-hour period.

The results of the two tests in February strongly suggest that movement of fish through the mock counters was positively correlated with density.

Photo 9. Looking through plexiglass top of crowder number 1 during testing with steelhead at Quinault NFH on February 2, 1983. Arrow indicates direction of water flow.

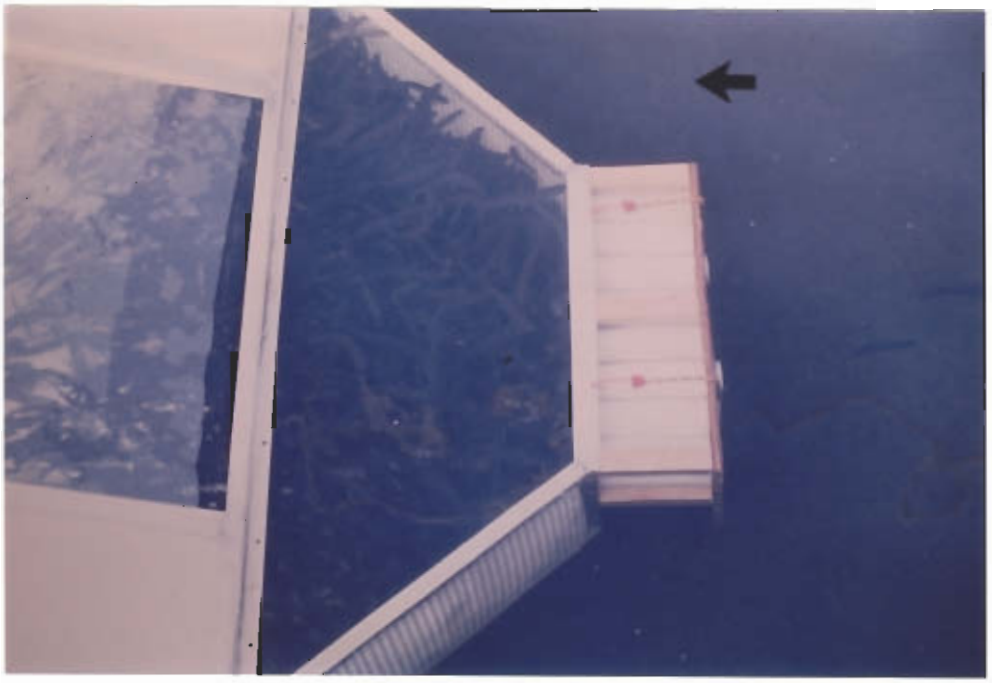

Photo 10. Densely crowded steelhead in crowder number 2 during testing at Quinault NFH on February 2, 1983. Arrow indicates direction of water flow.

CONCLUSIONS

Release Estimates

The results of our experiments with the FC-1 fish counter suggest that it can be an effective means of obtaining accurate estimates of fish released from hatcheries. However, two important points should be considered before using this device.

1. The counter may adversely affect smolting fish at the time of release. Salmonid smolts are especially susceptible to stress and scale loss. Both of these factors could precipitate a disease outbreak and eventual poor survival upon entry into salt water. Special care would have to be taken so that the densities of fish crowded to the counter are kept relatively low and the fish disturbed as little as possible. The ideal situation would be a volitional release without crowding the fish.

2. Two or more matrices per raceway would provide more area for migration, reduce stress, and allow more rapid migration from the raceway. Some hatchery strategies call for a large release of fish over a short period of time, particularly in the case of chum. This goal could be achieved by placing a number of counters in each raceway. However, this is probably cost prohibitive. Two counting units would cost over $9,000. In addition, crowding the fish to very high densities may still be required. If volitional releases are desired, it appears that a long period of time (days) may be required for complete outmigration from each raceway. Further testing with a number of matrices is recommended to determine whether outmigration time could be reduced with an additional counter.

Inventory Estimates

The counter did not function satisfactorily for inventory purposes because of the problem of fish remaining in the tunnels and being counted numerous times. A new model has been recently developed by NMT that will eliminate this problem. With this new system accurate counts of fish could be obtained throughout the rearing period which would eliminate the necessity of counting the fish at release, and thus reduce stress related problems caused by crowding.