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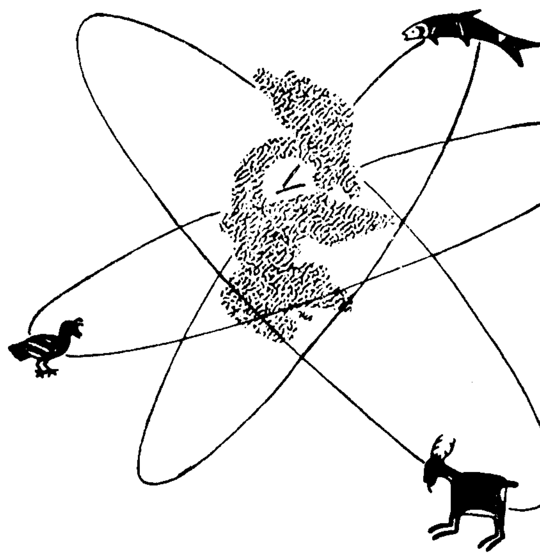

RESEARCH AND DEVELOPMENT SECTION

Oregon Department of Fish and Wildlife

Fish Division

An Evaluation of the Oregon Department of Fish and
Wildlife Standard Spawning Fish Survey System for Coho Salmon

An Evaluation of the Oregon Department of Fish and Wildlife Standard Spawning Fish Survey System for Coho Salmon

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CONTENTS

ABSTRACT

The purpose of this study was to use existing data to : (1) evaluate the four principle assumptions underlying the ODFW standard spawning index; (2) to determine the precision of the present standard index and the sample size needed to achieve the desired level; (3) to determine the effect of hatchery fish on the standard index and (4) to recommend improvements for evaluating coho escapement to Oregon coastal streams. The results of this study indicate that the standard index should be expanded to at least 40 survey units, and the use of the peak count as an index of run size be eliminated and replaced with total fish-days or an estimate of the number of spawners. It was also found that the standard index appears to have been influenced by hatchery production. The use of spawning fish surveys as an absolute measure of abundance is discussed. It is recommended that the standard index be expanded to 40 units which are representative of all the coho habitat on the Oregon coast. It is further recommended that the expanded survey should emphasize streams which have not been heavily stocked with hatchery fish, or that a separate index for wild fish be established.

INTRODUCTION

In Oregon, salmon spawning runs are monitored by the Oregon Department of Fish and Wildlife (ODFW) using a system of standard spawning indexes. The present standard index for coho consists of a set of 11 stream reaches totaling 14.8 mi (23.7 km). ODFW personnel count live and dead fish in these same reaches each year. The average combined count of live and dead fish (converted to fish/mi) is used as an index to determine trends in abundance.

The standard index has changed several times. Standard surveys for coho salmon were first established in the Umpqua River in 1945 by the Fish Commission of Oregon (FCO). By 1949 a system of standard spawning surveys had been established which totaled approximately 58 mi of stream (FCO 1951). The primary purpose of the spawning fish surveys at that time was to evaluate the escapement past the commercial net fishery operating in the lower parts of most larger coastal rivers (Henry 1956; McGie 1980). Spawning fish surveys were also used to evaluate escapement to Columbia River tributaries. After the commercial net fishery in coastal rivers was closed in 1957, the standard spawning surveys were continued as a means of assessing escapement from the rapidly expanding offshore troll and sport fisheries.

In 1971 surveys for coho were reduced to about 39 mi for coastal watersheds (exclusive of Tenmile Lakes surveys) (Skeesick 1972). In 1975, after the merger of the Fish Commission of Oregon and the Oregon Wildlife Commission, the standard index for coho was further reduced to 11 units, totaling 14.8 miles of stream. It was felt that this level of sampling was still sufficient to indicate trends in abundance of salmon.

Although trend data was sufficiently precise to manage the salmon runs in the past, the presently declining runs of coho have precipitated a need for more exact data so that population levels can be established and harvest regulations formulated more precisely. In recent discussions with ODFW personnel who are directly involved with the management of Oregon's salmon resources, we identified two basic objectives for our coho salmon survey system:

1. To measure trends in escapement.

2. To measure the relative abundance of spawners in any given year, especially wild (naturally produced) fish. The desired level of resolution is to within ± 25% so we can compare harvest strategies. Ultimately an absolute (numerical) measure of escapement is desirable.

The purpose of this paper is: (1) to evaluate the four principle assumptions underlying the ODFW standard spawning index, (2) to determine the precision of the present standard index and the sampling effort needed to achieve the desired level, (3) to determine the effect of hatchery fish on the standard index, and (4) to recommend improvements for evaluating coho escapement to coastal Oregon streams.

METHODS

Spawning Survey Data

The spawning survey data used in this paper were obtained from ODFW and FCO reports and from the files of coastal district fishery biologists. Two spawning indexes were constructed from these data to compare with the standard ODFW and FCO indexes. The survey units comprising all the indexes are listed in Appendix 1. The annual values of the indexes (fish/mi) are the grand means of the average value of all the units in each river basin.

Surveys in the Tenmile Lake system are not used in this report because this system has been unusually productive compared to other coastal systems and because a major decline has occurred in the productivity of this system which has not been typical of other coastal systems. The Smith River survey (Beaver Creek) is part of the present ODFW standard coho index but was not used in other indexes because this unit was not surveyed in 1958 and because egg taking and other variable passage conditions at Smith River Falls probably affected the number of fish observed in this unit.

Area Under the Curve (AUC) Population Estimates

To estimate the total number of spawners using a spawning survey area, the observed numbers of live fish were plotted over time. When the first or last observation was not zero, an additional point (of value zero) was added seven days before or after the observation to close the curve. The area under the resulting curve was calculated to estimate the number of fish-days on the area (Fig. 1). Fish-days can be used as an index of abundance or it can be divided by an estimate of the average length of time which coho live on the spawning grounds to estimate the number of fish. Willis (1954) determined that the average spawning ground life for coho in Spring Creek was 11 days for females and 12 days for males. We calculated the average spawning ground life of 181 tagged coho salmon, mostly females, from the Alsea Watershed Study (Moring and Lantz 1975) to be 10.3 days. In this paper, 11 days was used as the average spawning ground life for coho.

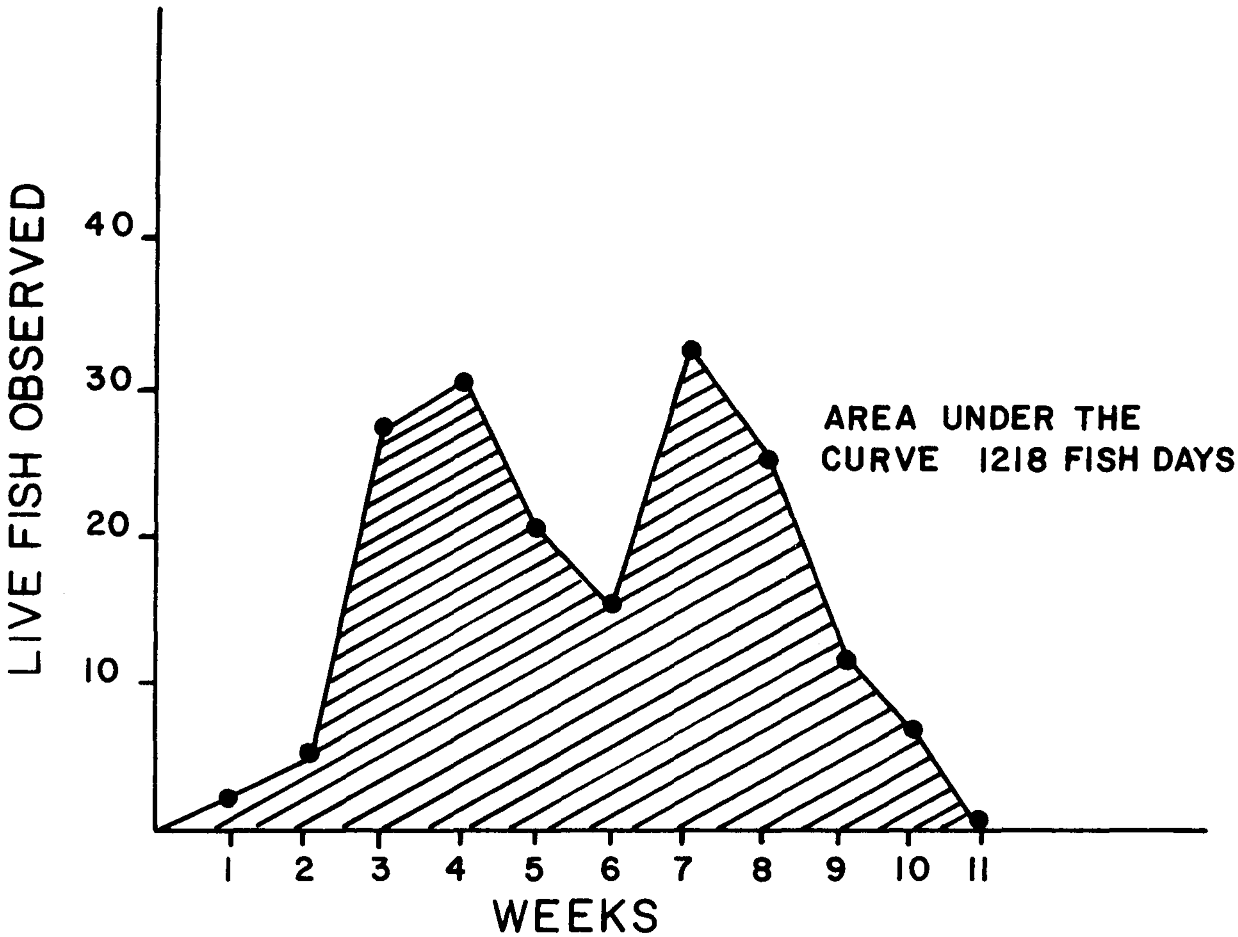

Fig. 1. An example illustrating the area-under-the-curve (AUC) method of estimating the number of fish from spawning survey counts.

RESULTS

Examination of the Assumptions of Spawning Fish Surveys

There are four major assumptions associated with peak-count spawning indexes:

1. The distribution of spawning fish within a watershed is constant, such that a consistent proportion of the run spawns in the index area each year.

2. The peak count is consistently proportional to the total run size.

3. The efficiency of the surveyors is similar between years or between surveys.

4. The probability of a given fish being observed is similar for all levels of abundance.

We have examined these four assumptions and evaluated their validity to the extent possible with the available data. Following is a discussion of each of the assumptions.

Assumption 1. A consistent proportion of the run spawns in the index area each year.

This assumption means that an index area is always populated proportionately to the abundance of fish in the system, and that the variability of the spawning distribution within the system is minor.

Intuitively we would expect this assumption to be violated from time to time because of droughts, logjams, beaver dams, and other phenomena which disrupt the normal distribution of the fish. However, these problems are usually apparent and can be taken into consideration when evaluating the results of the spawning surveys.

A more important question is whether or not this assumption is violated during normal water conditions when there are no access or pollution problems. To answer this question, we analyzed two sets of data from streams where we have both spawning ground counts and an independent measure of the total run into the area for a period of years.

We first compared spawning survey data (carcass counts) from the Rogue River to and an estimate of the number of spring chinook crossing Gold Ray Dam from 1972 to 1978 (unpublished ODFW data). If the assumption that a consistent proportion of the run spawns in a given area each year is true, there should be a significant correlation between the spawning ground counts in that area and the total run. To test this, we regressed the total carcass count from RM 155 to RM 149 against the total population estimate (Gold Ray Dam estimate minus return to Cole Rivers Hatchery). The correlation was significant (R^2=0.87). This indicates that the number of spring chinook spawning in one stretch of the Rogue River is a good indicator of the run size. However, the distribution of spring chinook may not be typical of fall chinook or coho since spring chinook enter the river a long time before spawning and therefore their distribution is not dependent on freshets, as is the case with fall chinook and coho.

We then compared spawning survey data and an independent estimate of total escapement (mark-recapture estimates) for fall chinook in Elk River (unpublished) ODFW data). Chinook were tagged in the Elk River estuary and the tags were recovered in the sport fishery, at Elk River Hatchery and on the spawning grounds. The mark-recapture estimate was adjusted by subtracting the sport catch and the return to Elk River Hatchery to estimate the number of naturally spawning chinook in Elk River. Anvil Creek, a major spawning area for chinook in Elk River, was surveyed approximately weekly each year from 1970 to 1980. A regression of the AUC estimate (of chinook fish-days) for Anvil Creek against the estimated natural spawning population of Elk River was not significant (R^2=0.12). This contradicts the indication from the Rogue River data. However, the correlation could be masked in the Elk River data by additional variance associated with estimates of the sport catch and with the mark-recapture population estimates (as opposed to a dam count estimate on the Rogue). Also, fall chinook (and coho) spawn later than spring chinook when survey conditions are often less than ideal because of higher and more turbid water.

It is unclear from these data whether or not the assumption of consistent distribution holds. Intuitively we might expect salmon to distribute themselves according to the quality of the spawning habitat within the general area to which they return. Since the habitat quality should remain relatively constant from year to year (barring droughts, pollution, etc.) it would seem reasonable to expect that the relative distribution of spawning fish should remain fairly constant from year to year as well. Even if the distribution is constant, spawning ground counts could still be biased estimates of the relative abundance of fish in the system. For example: if the survey unit contained only choice spawning habitat, in a low abundance year that unit could have a disproportionally high portion of the run. Conversely, if the survey had only marginal spawning habitat, on a low abundance year it would have disproportionately few fish. Therefore, spawning survey units should contain both marginal and good spawning habitat.

Assumption 2. <u>The peak count is consistently proportional to the total run size.</u>

ODFW uses the peak count of live and dead fish as an indicator of the size of the spawning population. This method assumes that the peak of the run is relatively constant portion of the total run.

To examine the relationship between the peak and the total run, we examined daily trap records (unpublished) from the Alsea Watershed Study (Moring and Lantz 1975). We divided the spawning seasons into 10 day intervals and examined the relationship between the peak 10 day catch and the total catch for each of 14 years. Table 1 shows the peak 10 day catch, the total catch and the peak/total ratio for each year. The peak/total ratios vary from 0.20 to 0.74, with a mean of 0.34. The mean indicates that, in general, the peak is about one-third of the total run. A regression of the peak count on the total run was significant ($p \leq 0.05$) but the coefficient of determination (R^2=0.54) indicates that only 54% of the variation in the peak count is explained by the size of the run. The remaining 46% was due to year to year variability of the run over time.

Table 1. Peak, total, and peak/total ratios for 10-day trap catches at Deer Creek.

Year	Time of peak (Julian Days)	Peak	Total	Peak/total ratio
1959-60	320-329	47	126	0.37
1960-61	005-014	31	104	0.30
1961-62	350-359	78	172	0.45
1962-63	330-339	19	70	0.27
1963-64	360-004	58	174	0.33
1964-65	330-339	56	204	0.27
1965-66	360-004	71	173	0.41
1966-67	340-349	74	280	0.26
1967-68	330-339	65	185	0.35
1968-69	340-349	40	202	0.20
1969-70	340-349	30	104	0.29
1970-71	360-004	24	99	0.24
1971-72	015-024	34	143	0.24
1972-73	350-359	43	58	0.74

This analysis indicates that there is a rough relationship between the peak count and the total run, but the distribution of the run over time has a major effect on the peak/total ratio.

In another test, we calculated the correlation between the Deer Creek trap count and the peak count on a nearby spawning survey. Deer Creek enters Horse Creek about one half mile upstream from the upper boundary of a FCO standard survey area. Since Deer Creek and Horse Creek are so closely related, we assumed that the factors which govern the abundance of coho in a given year would apply to both streams, therefore the abundance of coho in the two streams would be correlated. If this assumption is valid and peak count is a good indicator of abundance, then there should be a linear correlation between the peak count in Horse Creek and the trap count on Deer Creek. However, a regression of these data shows little correlation (Fig. 2). This could be due to poor correlation between the size of the runs in Deer and Horse creeks, but more likely it is due to the large variation in the peak/total ratios compounded by sampling errors associated with peak counts.

To further examine the assumption that the peak count is consistently proportional to total abundance, we examined the relationship between the peak count and AUC population estimates. The first data set we looked at was spawning survey data collected in the 1978-79 and 1979-80 spawning seasons (Appendix 2). A regression of the AUC population estimate against the peak count of live and dead fish and the 95% prediction intervals is shown in Fig. 3. The peak/total ratios for these data range from 0.17 to 0.85 with a mean of 0.48 and a standard deviation of 0.17.

While there is a strong correlation between the peak and the total over the range of data, the predictive value of this regression for a given peak count is limited. For example: given a peak count of 20 fish per mile, the possible total fish per mile values range from 20 to 85.

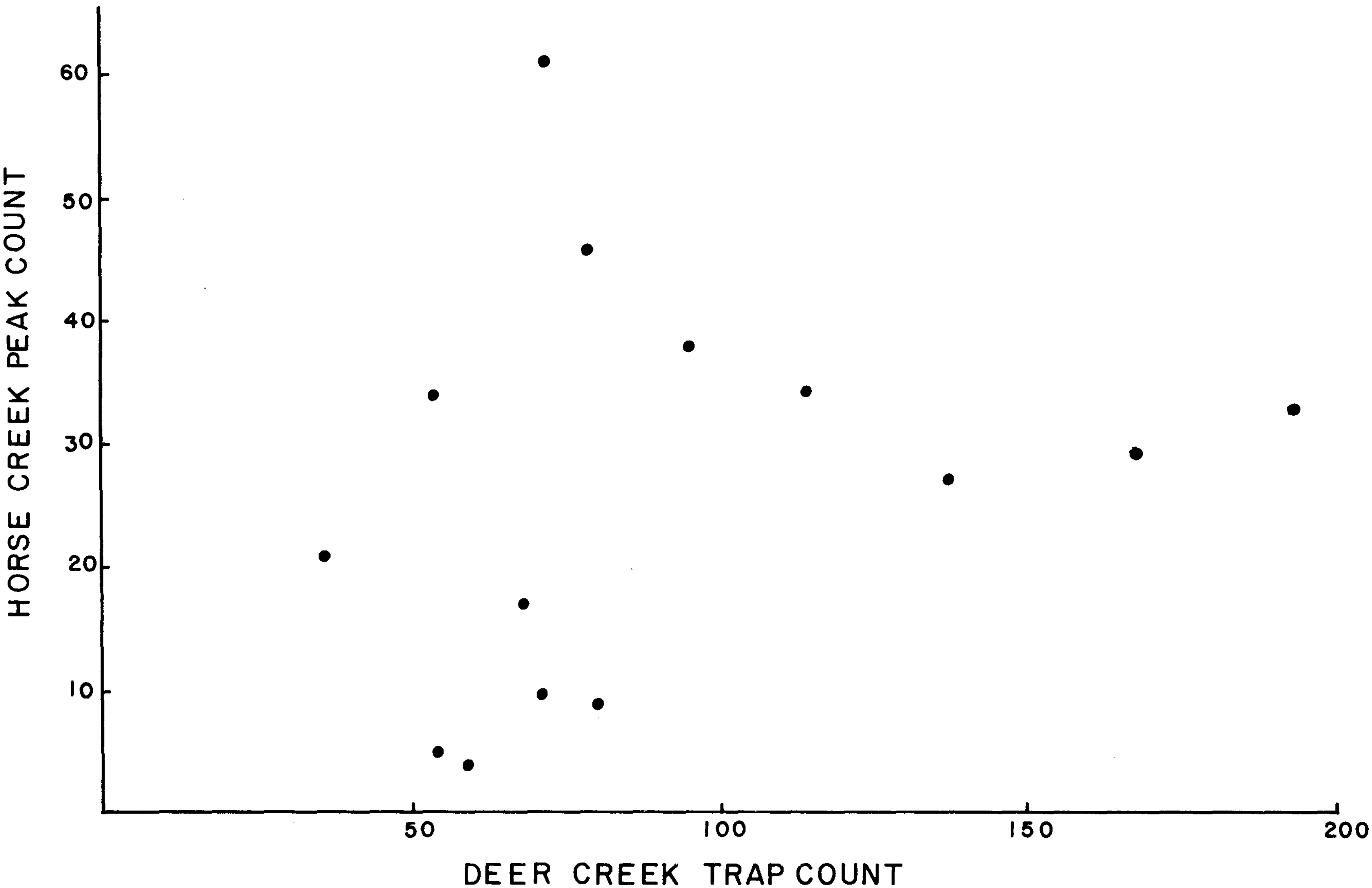

Fig. 2. Relationship between the Deer Creek trap count and the Horse Creek peak count, 1959-72.

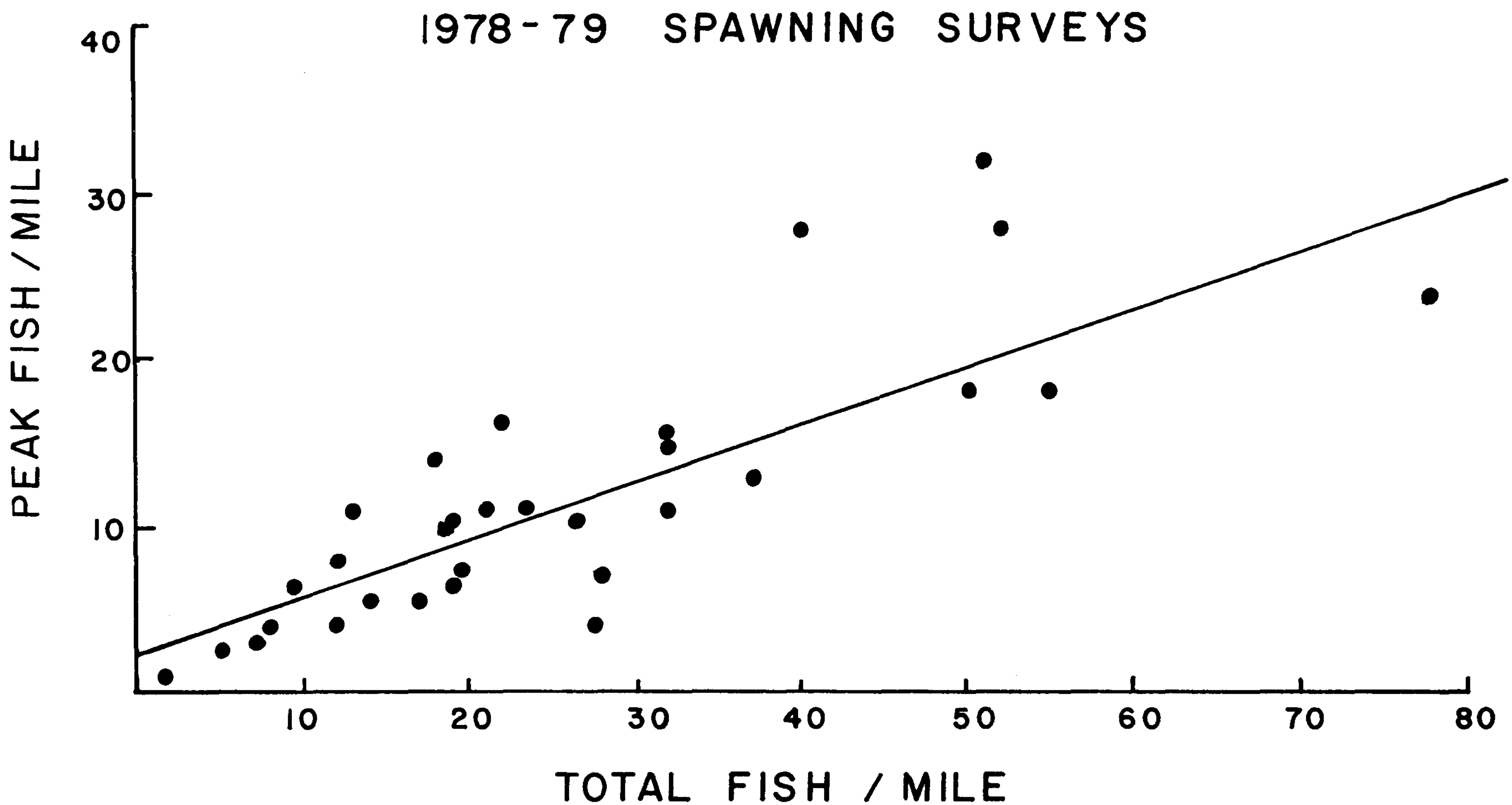

Fig. 3. Relationship between peak count and the total population estimate for coho salmon in 33 spawning survey units in 1978-79 and 1979-80. Two points fall off the graph.

Chinook data from Anvil Creek (unpublished ODFW data) is similar to the above data. The peak/total ratios range from 0.31 to 0.67 with a mean of 0.48 and a standard deviation of 0.11. Again there is an excellent correlation between the peak count and the total over the range of the data (Fig. 4), but the internal variation of the data is too large for the regression to be of value as a predictor. For example: similar numbers of chinook spawned in Anvil Creek in 1978 and 1979 (2,584 and 2,523 spawner-days respectively). However, in 1978 the peak count was nearly double what it was in 1979 (138 and 72 respectively). By using peak count as an indicator of abundance, one would erroneously conclude that spawning fish were only half as abundant in 1979 as in 1978.

The usefulness of peak counts depends on the purpose intended. We have seen that over a period of time or a large number of observations, peak count correlates well with the total run. (Indeed, it would almost have to since we are using the same method to measure both the peak and the total, and thus the peak becomes a major part of both sides of the regression). However, we have also seen that peak count is a poor indicator of abundance on a year to year basis because of large variations in the peak/total ratios. Since one objective of the ODFW spawning index is to detect changes in abundance from year to year, we recommend that the peak count method be replaced by the AUC method.

Because the timing of the peak of the run for coho is so variable, occurring anytime from mid-November through mid-January, spawning surveys must be done frequently to ensure observation of the true peak. If spawning surveys are done frequently enough to ensure observation after true peak, little additional effort would be required to use the AUC method. Adoption of the AUC method would allow continuation of peak count data sets while the AUC data base is being established.

Our recommendation for the use of the AUC method is based on the variability of the distributions of the runs to Deer Creek. Since the peak of the run is variable both in time and with respect to the rest of the run, logic would indicate that the peak is not a good indocator of run size and that the run needs to be sampled frequently. These findings are supported by the lack of correlation between the Horse Creek peak and the Deer Creek trap counts and between the peak counts and AUC estimates. However, we do not have any proof that the AUC method is a better index than the peak count method. Our recommendation is based only on our interpretation of the data. The relative merits of the AUC and the peak count methods is currently being tested by an ODFW research project (Nickelson et al. 1980).

Assumption 3. <u>The efficiency of the various surveyors is similar between surveys and between years.</u>

Willis (1964) compared the results of spawning surveys on three streams by three surveyors on three consecutive days in a Latin-square experimental design. He found no significant differences between the counts of the three surveyors or between the counts grouped by time of day. We have found no other data on differences between the efficiency of surveys.

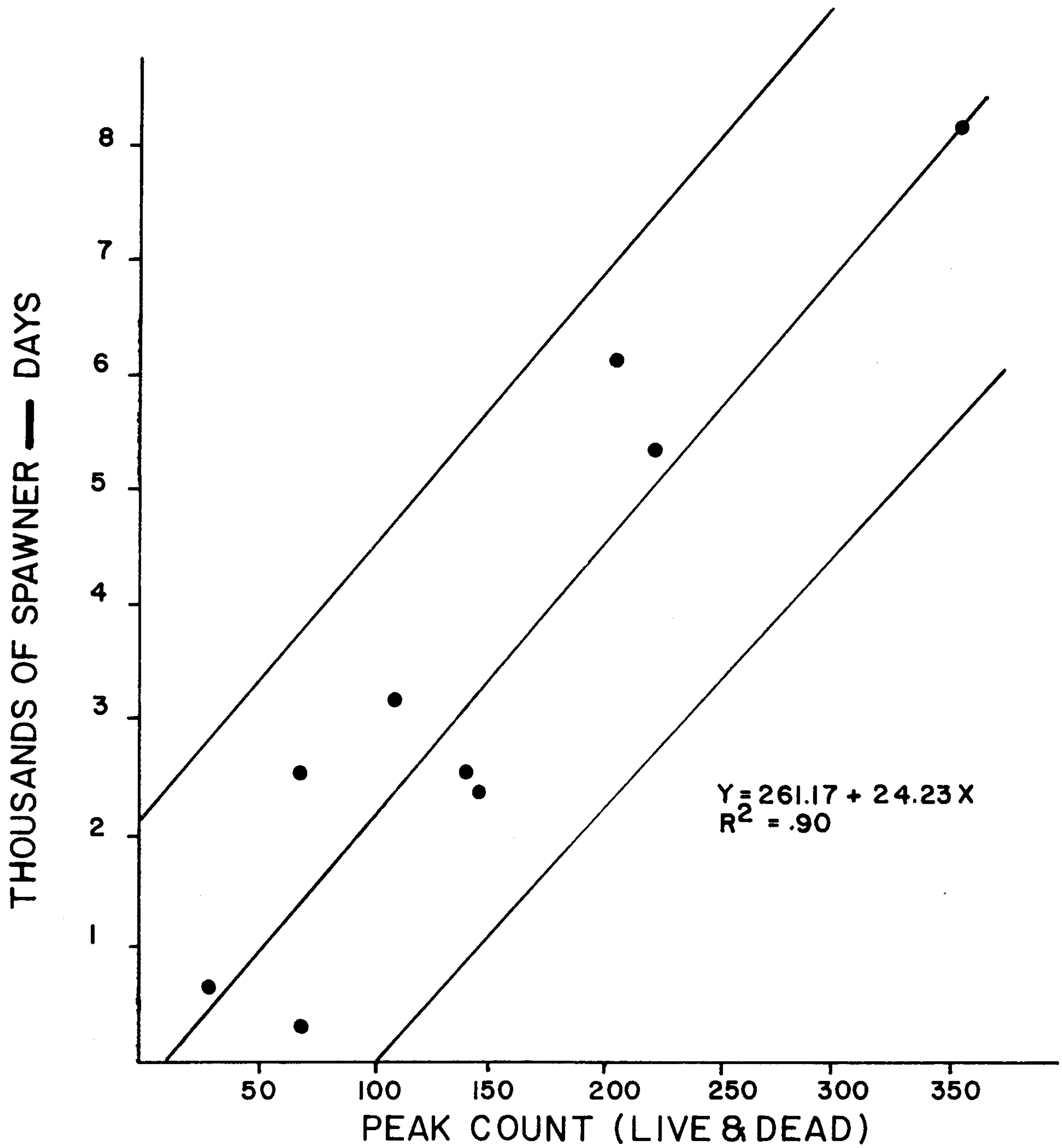

Fig. 4. Relationship between peak count of live and dead chinook and total spawner-days for Anvil Creek, 1970-79.

Varying efficiency of the surveyors is probably not a major source of error in spawning fish surveys. This sort of assumption is inherent in most sampling schemes which are repeated over a period of time. Careful training of surveyors and making surveys only under clear water conditions will minimize bias caused by violation of this assumption.

Assumption 4. The probability of observing a given fish is constant for all levels of abundance.

This assumption states that there is a direct, straight-line relationship between the number of fish observed in a spawning survey and the actual number of fish there. In other words, the accuracy of the survey is constant for all levels of abundance.

This assumption could be violated at lower levels of abundance if the probability of observing a given coho in the survey unit decreases with overall abundance. Coho are somewhat secretive in freshwater, especially prior to the commencement of the actual spawning activity, and will hide under any available cover. This behavior could bias the spawning index downward at low levels of abundance, since a higher proportion of the population in the index area will be able to find a hiding place where they can't be observed. Although we have no data to substantiate this hypothesis, a number of surveyors have observed that when few live fish are seen, almost no carcasses are found, but when there are many spawners a relatively large portion can be found later as carcasses. This is because at low levels of abundance scavengers remove the carcasses nearly as fast as the fish die. However, at higher levels of abundance there are more carcasses than the scavengers can eat, so the carcasses are left and can be counted. Since carcasses are counted in the peak under the present ODFW survey system, this could cause a downward bias at lower levels of abundance.

Precision of the Standard Index

If we assume that all the assumptions involved in spawning fish surveys are valid, what level of resolution does the present standard index provide? And what sample size is needed to achieve the desired level of resoultion ($\pm$ 25%)?

To examine these questions we calculated power curves for the 90% confidence intervals (CI) of spawning fish surveys for estimating the abundance of coho on the Oregon coast and within a river system. We used the formula:

$$90\%\ CI = \frac{t_{10}\ CV}{N}$$

where: CV = coefficient of variation $\left(\frac{\text{standard deviation}}{\text{sample mean}}\right)$

N = number of survey units (sample size)

t_{10}= Students t value associated with N-1 df.

The CV used in the calculation of the coastwide power curve was calculated by eliminating the highest 10% from the range of CVs for 50 survey units from the years 1950-69. The value 1.25 was used as an estimate of the 90th percentile of the range. Similarly, the CV used for calculating the power curve for within a river system was the estimated 90th percentile of the range of CVs from the Nehalem and Siuslaw systems from 1950-74. These two systems were used because they had the most survey units (eight each) and therefore yielded the best estimates of variance.

The power curves for coastwide and river system surveys are shown in Fig. 5. The top curve in Fig. 5 indicates that the present sample size of 10 units in the standard survey will estimate the average peak fish per mile within ± 72% about 90% of the time. Increasing the sample size to about 40 units would increase the sensitivity of the estimate to 32%, an increase of more than 100%. The slope of the power curve is nearly flat after 40-50 units, indicating that adding more units above that level would not significantly increase the sensitivity of the index. The power curve flattens out at about 30%, indicating that is about the greatest sensitivity we can expect to achieve with a coastwide peak count index.

The lower curve in Fig 5 is a power curve for estimates of the peak fish per mile within a river system. This curve indicates that if we wished to make comparisons between the peak fish per mile figures in two river systems (to compare the effect of a hatchery program, for example), we would need to survey nearly as many units in each system as for the whole coast.

The effect of differences in sample size are demonstrated in Fig. 6. This figure compares the standard ODFW index with a composite index of 50 streams (Appendix 1). Notice that the 50 stream index shows a steady decline between 1964 and 1969, but the standard 10 stream (ODFW) index shows several large fluctuations in the same period which tend to mask the downward trend. The larger sample size of the 50 stream index dampens the large variation between survey units. The greater the sample size the more observations are likely to be near the true mean. This analysis indicates that although the 10 stream index does reflect trends in escapement over the long term, it is not accurate enough to evaluate differences from year to year.

Effects of Hatcheries on the Standard Index

While examining the relationship between the standard and the 50 stream index in Fig. 6, we noticed that starting in 1960 the 50 stream index is consistantly lower than the standard index. Because 1960 is the approximate time when improvements in fish culture technology greatly increased the survival rate of hatchery fish, and since most of the index streams are located on river systems with hatcheries, we hypothesized that after 1960 stray hatchery fish were inflating the standard index counts.

To test this hypothesis, we compared a "wild" index value to the standard index value before and after 1960 (Fig. 7). The wild index is a set of 18 survey units in river systems without hatcheries and with little or no history of hatchery releases as indicated by a review of fish stocking records (Willis 1979). The survey units comprising the index are listed in Appendix 1.

To test the significance of the differences between the two indexes we compared the average difference between the wild and the standard indexes for

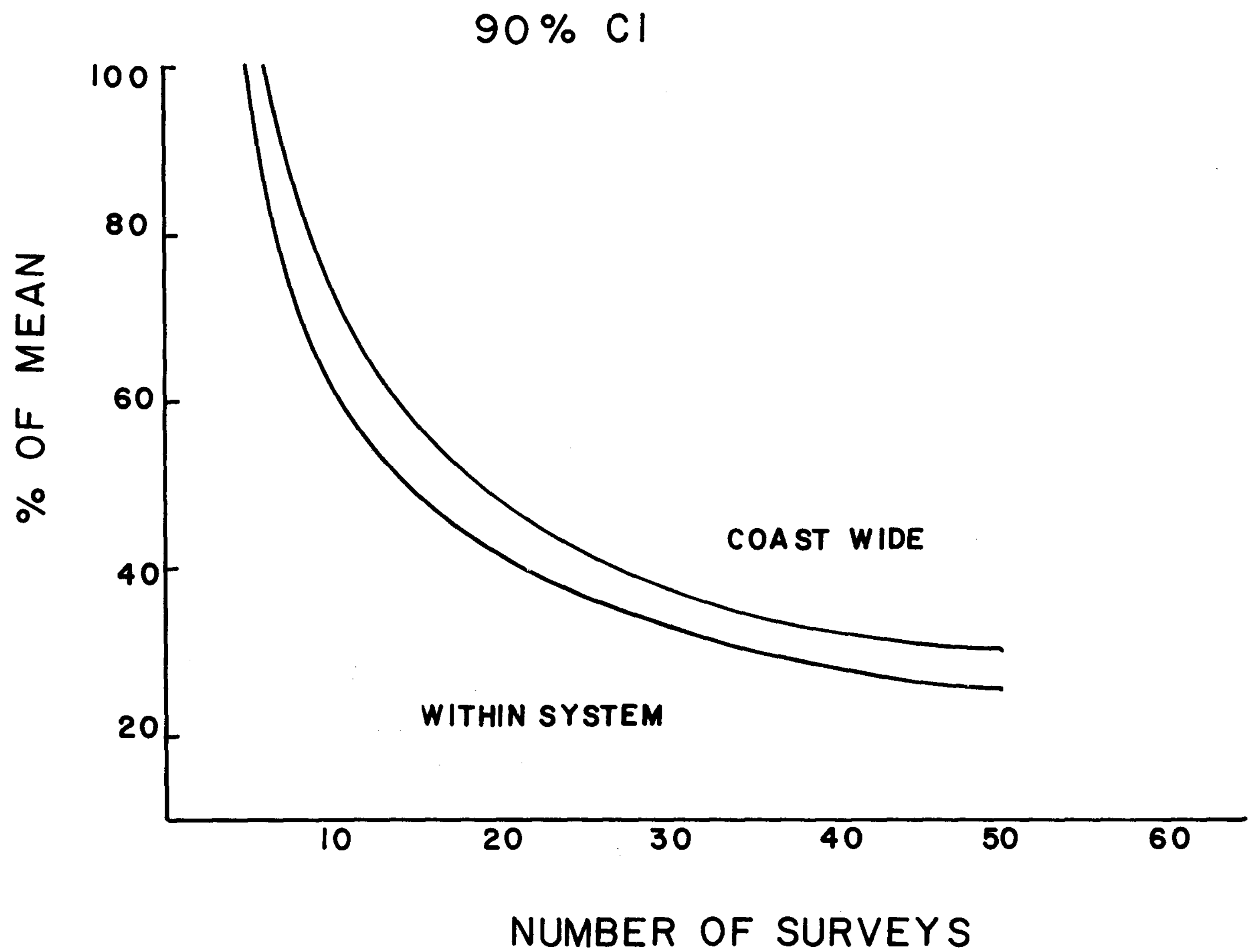

Fig. 5. Relationship between the 90% confidence interval expressed as a percent of the mean and the number of units surveyed for peak-count spawning coho surveys on the Oregon coast.

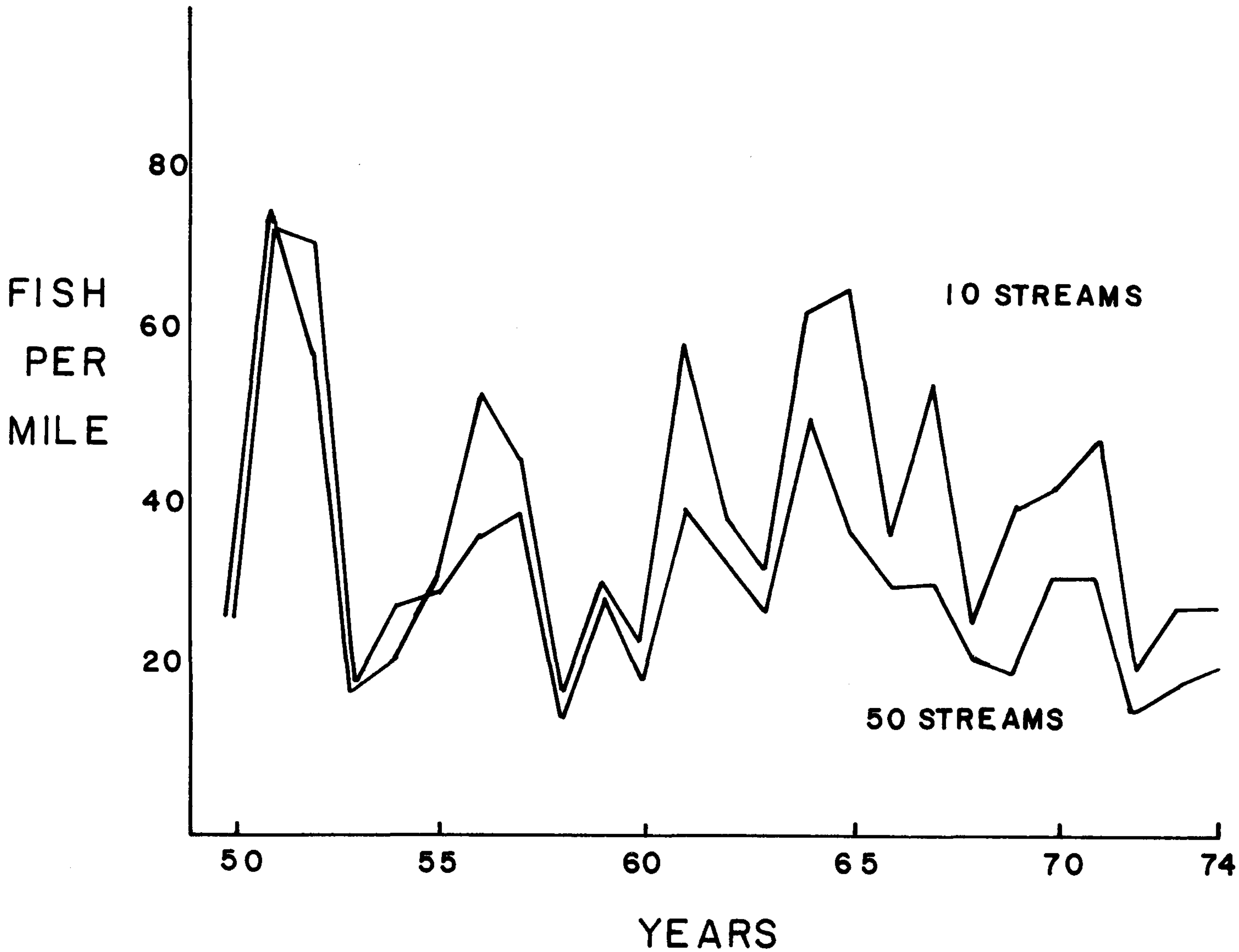

Fig. 6. A comparison of the peak fish per mile counts of coho salmon in the 50 and 10 stream indexes from 1950-1974.

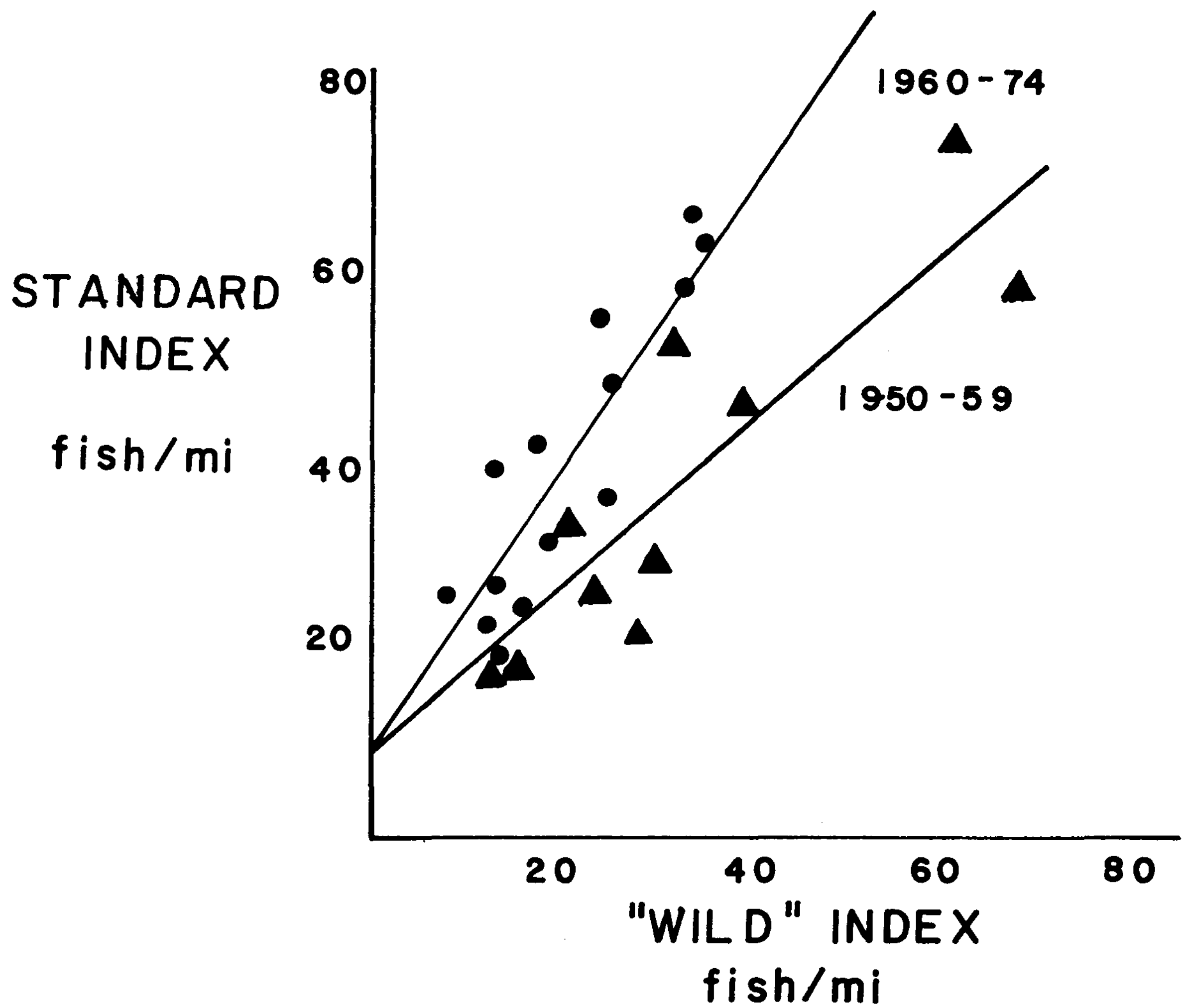

Fig. 7. Relationship between the "wild" index and the standard index peak fish per mile counts.

the years 1950-59 and 1960-74. The test showed significant difference at the 0.05 level (t = 3.81, 23 df) in the latter period. This result was verified by analysis of covariance of the two regressions in Fig. 7. There was a significant diffence in elevation ($p \leq 0.05$), although the slopes were not significantly different with this sample size.

To test whether this difference was the result of hatchery programs, we did a multiple regression of the standard index, and the coastal hatchery returns against the wild index. The coefficients of determination (R^2) for the regressions are shown in Table 2.

Table 2. Coefficients of determination (R^2) for the multiple regression analysis of standard index counts, wild index counts, and coastal hatchery returns.

	1950-59	1960-74	1950-74
Standard index vs. wild index	0.77	0.74	0.54
add coastal hatchery returns	0.75[a]	0.82[b]	0.75[b]

[a] *diffference not significant, P>0.05*
[b] *a significant difference,* $P \leq 0.05$.

There was a good correlation between the standard and wild indexes for the years 1950-59 (R^2=0.77). Adding hatchery returns did not significantly increase the correlation (R^2=0.79). The correlation between the two indexes for the period in 1960-74 was not as good initially (R^2=0.74), but adding hatchery returns added significantly ($P<0.05$) to the correlation (R^2=0.82). The overall regression of 1950-74 indicates that 21% of the variation between the wild and the standard index can be accounted for by hatchery returns.

DISCUSSION

The present index system reflects trends in escapement over the long run. This was the primary objective for which the system was designed. However, because of the small sample size, it is of questionable value in making comparisons from one year to the next. The 90% confidence interval of the observed mean is plus or minus about 72%, which is too large an interval at normal peak-count levels to compare individual years.

Expanding the standard index to at least 40 units will more than double the precision of the index, reducing the confidence interval from about 72% to around 32%. Our calculations (Fig. 5) show that 40 units approaches the point of diminishing return for peak-count surveys, and that adding more survey units above this level would not substantially increase the precision of the index. Forty units in the standard index does not seem unreasonable since the FCO included 47 units until 1975. Assuming the index were expanded to 40 units, the resulting 32% confidence interval still falls short of the desired 25%.

However, eliminating the use of the peak count as an indicator of abundance may improve the sensitivity of the index. The use of the peak count is a major source of variation in the standard index method. The peak of the run is only roughly related to the run size, and the timing of the peak of the run is highly variable as well, occurring from mid-November to mid-January. Therefore, the entire run needs to be accounted for by making surveys at regular intervals during the spawning season. We recommend that AUC population estimates be used as the index of abundance to replace peak counts. The AUC method will still provide peak counts to continue the long sets of trend data already established.

If the standard index is expanded, the index units should be distributed as evenly as possible among the miles of coho spawning streams such that the index is representative of the whole coast to the maximum degree possible. Table 3 lists estimates of the number of miles of coho spawning streams in each drainage. These figures should be used as a guide for distributing the surveys among the total miles of streams. Wherever feasible, existing survey units should be used in the expanded index, especially those listed in the wild index (Appendix 1).

Table 3. Estimated miles of spawning habitat in Oregon coastal watersheds.

Drainage	Miles of coho spawning habitat
Necanicum R.	62
Elk Cr.	5
Nehalem Bay	360
Tillamook Bay	276
Sand Lake	11
Nestucca Bay	197
Salmon R.	40
Siletz Bay	203
Yaquina Bay	156
Beaver Cr.	33
Alsea Bay	322
Yachats R.	44
Tenmile Cr.	21
Big Cr.	14
Mercer Lake	10
Siuslaw Bay	706
Siltcoos Lake	50
Tahkenitch Lake	20
Umpqua Bay	972
Tenmile Lakes	62
Coos Bay	268
Coquille R.	390
New R./Floras Lake	23
Sixes R.	14
Elk R.	6
Rogue R.	354
Chetco	5
Misc. ocean tribs.	137
Total	4,764

Spawning Fish Surveys as a Measure of Absolute Abundance

Spawning fish surveys can be used to estimate the actual abundance of spawners over extended area by three methods: (1) the spawning surveys are located randomly throughout the entire area of interest, (2) the area under consideration is stratified to represent the spawning distribution of the population and sampled accordingly, or (3) a spawning survey index is calibrated to an indepedent method of population estimation.

Totally random sampling (method 1) is both statistically inefficient and logistically impractical. Method 2 would require extensive stream surveys to stratify the distribution. Since distribution is probably related to habitat quality, some of the needed information may already be on hand in the form of physical stream survey data. Method 3 would require extensive tagging programs such as those described by Morgan and Cleaver (1954), Henry (1964), Morgan (1964), and Morgan and Henry (1959).

Probably the most viable alternative would be a combination of method 2 and method 3 using a mark-recapture population estimate. Since the mark-recapture estimate would require extensive stream surveys to recover tags, the information gained by these surveys could be used to describe the distribution of the spawning population. Area-under-the-curve population estimates from selected sites could then be expanded into a total population estimate which could serve as a check for the mark recapture estimate.

Although the AUC method gives an estimate of the total number of fish in a survey unit, the method has an inherent downward bias due to the fact that the efficiency of observation in spawning surveys changes with water conditions and the maturity of the fish (i.e. "green" fish tend to be more secretive than actively spawning fish). We know of no good estimates of the general efficiency of spawning fish surveys of the type made for coastal coho. A current ODFW research project is investigating this subject (Nickelson et al. 1980). The results of this research should be useful in adjusting AUC population estimates.

RECOMMENDATIONS

1. The standard index for coho should be expanded to at least 40 survey units.

2. The distribution of the index survey units should reflect the distribution of miles of spawning streams on the Oregon coast.

3. Existing survey units should be used where feasible. When new units are chosen, they should be representative of the spawning habitat in that system.

4. The expanded index should emphasize surveys on systems which are not strongly influenced by hatchery programs and which can be managed for wild fish, or a separate index should be established for wild fish.

5. Index units should be surveyed approximately weekly throughout the spawning season. Index data should be reported as fish-days or estimated numbers of spawners.

REFERENCES CITED

Fish Commission of Oregon. 1951. Spawning ground surveys, coastal streams in Oregon. Unpublished report. Mimeo 37 p.

Henry, K. A. 1956. Summary of spawning ground surveys for adult silver salmon in some coastal streams of Oregon showing percent increase or decrease over the parent run. Fish Comm. Ore. Unpublished Report. 3 p.

Henry, K. A. 1964. Oregon coastal salmon and steelhead tagging programs, Part I. Tillamook Bay, 1953. Fish. Comm. Oreg. Contribution No. 28. p. 5-42.

McGie, A. M. 1980. Spawning chinook, coho, and chum salmon surveys in coastal watersheds of Oregon, 1979. Ore. Dep. Fish Wildl., Res. & Develop. Sect. Mimeo. 13 p.

Morgan, A. R. and F. C. Cleaver. 1954. The 1951 Alsea River silver salmon tagging program. Fish Comm. Ore., Contribution No. 21. 30 p.

Morgan, A. R. 1964. Oregon coastal salmon and steelhead tagging programs, Part II. Siletz River, 1954. Fish Comm. Ore., Contribution No. 28. p. 43-62.

Morgan, A. R. and K. A. Henry. 1959. The 1955-56 silver salmon run into the Tenmile Lakes system. Fish Comm. Ore., Res. Briefs 7(1):57-77.

Moring, J. A. and R. L. Lantz. 1975. The Alsea watershed study: effects of logging on the aquatic resources of three headwater streams of the Alsea River, Oregon. Part 1 - Biological studies. Ore. Dep. Fish Wildl., Fish. Res. Rep. No. 9. 66 p.

Nickelson, T. E., J. W. Nicholas, and W. M. Beidler. 1980. Coastal coho production factors. Ore. Dep. Fish Wildl. Federal Aid Project AFS-74-1. Job final rep. 24 pp.

Skeesick, D. G. 1972. Spawning fish surveys in coastal watersheds, 1971. Fish Comm. Ore., Mgt. Res. Div. Mimeo 54 p.

Willis, M. J. 1979. Out-system transfers of coho salmon stocks in coastal river systems. Ore. Dep. Fish Wildl., Res. & Develop. Sect. Info. Rep. Fish. No. 79-9. 12 p.

Willis, R. A. 1954. The length of time that silver salmon spent before death on the spawning grounds at Spring Creek, Wilson River, in 1951-52. Fish. Comm. Ore., Res. Briefs 5(1):27-31.

Willis, R. A. 1964. Experiments with repeated spawning ground counts of coho salmon in three Oregon streams. Fish Comm. Ore., Res. Briefs 10(1):41-45.

APPENDIX

Appendix 1. Spawning surveys composing the 50 stream index, ODFW standard index and the wild index. Tenmile Lake surveys not included.

Watershed	Survey unit	Miles of survey	50 Stream index	FCO standard index	ODFW standard index	"Wild" index
Nehalem	Cow Cr.	0.5	X	X		X
	N. Fk. Cromin Cr.	0.5	X	X		X
	Fishhawk Cr. #2	1.0	X	X		X
	Hamilton Cr.	1.0	X	X		X
	W. Humbug Cr.	1.1	X	X		X
	N. Fk. Wolf Cr.	1.1	X	X	X	X
	Northwest Cr.	0.5	X	X		X
	Oak Ranch Cr.	1.0	X	X		X
Wilson	Cedar Cr. & trib.	2.9	X	X	X	
	Devil's Lk. Fk. (lower)	0.5	X	X		
	Devil's Lk. Fk. (upper)	0.5	X	X		
Nestucca	Bear Cr.	1.5	X	X		
	Clear Cr.	0.8	X	X	X	
	East Cr.	1.3	X	X		
	Moon Cr.	0.8	X	X		
	Niagra Cr.	0.4	X	X		
Yaquina	Grant Cr.	1.5	X	X		
	Salmon Cr.	0.5	X	X		
	Simpson Cr.	1.5	X	X		
	Yaquina R.	2.0	X	X	X	
Beaver Cr.	N. Fk.	1.0	X	X		X
	N. Fk. of N. Fk.	0.5	X	X		X
	S. Fk. of N. Fk.	0.8	X	X		X

Appendix 1 (continued)

Watershed	Survey unit	Miles of survey	50 Stream index	FCO standard index	ODFW standard index	"Wild" index
Alsea	Bummer Cr.	1.0	X	X		
	Horse Cr.	1.0	X	X		X
	Lobster Cr.	1.0	X	X	X	
	Wilson Cr.	1.3	X	X		
	Cherry Cr.	0.8	X	X		
Yachats	School Fk.	0.5				X
	Williamson Cr.	1.25				X
Siuslaw	Panther Cr.	0.75	X		X	
	Billie Cr.	1.25	X			X
	Fish Cr.	1.0	X			
	Rogers Cr.	1.25	X			
	Haynes Cr.	0.75	X			
	McLeod Cr.	1.5	X			X
	Misery Cr.	1.0	X			
	Taylor Cr.	0.75	X			
Umpqua	Schofield Cr.	2.0	X		X	
	Miller Cr.	0.5	X			
	Dean Cr.	1.0	X			
	Buck Cr.	1.5	X			
	Johnson Cr.	1.0	X			
Coos	Larson Cr.	1.3	X	X	X	
	Morgan Cr.	1.0	X	X		
	Marlow Cr.	1.0	X	X		
Coquille	Cherry Cr.	1.8	X	X		X
	Middle Cr.	1.0	X	X		X
	N. Fk.	1.0	X	X		X
	Steele Cr.	1.0	X	X	X	
	Big Cr.	1.0	X	X	X	
	Salmon Cr.	1.0	X	X		

Appendix 2. Spawning coho data collected by ODFW research personnel in 1978-79 and 1979-80 spawning seasons.

			1978-79 SPAWNING SEASON				
System	Stream	Survey length	Estimated spawning population (AUC method)	Peak count[a] (live and dead)	Peak fish/mi	Total fish/mi	Peak / total
Nehalem	Cronin Cr.	2.7	20	8 (1)	3.0	7.4	0.40
Wilson	Devils Lake Fk.	3.1	68	34 (3)	11.0	22.0	0.50
Nestucca	Farmser Cr.	2.2	31	13 (1)	5.9	14.1	0.42
Alsea	Horse/Deer Cr.	2.5	43	18 (1)	5.5	17.2	0.42
Siuslaw	Green Cr.	1.8	9	5	2.8	5.0	0.55
Coos	Marlow Cr.	1.25	38	12 (7)	9.6	30.4	0.32
Coquille	Alder Cr.	1.0	185	53	53	185	0.29
	Moon Cr.	1.5	40	16	10.7	26.7	0.40

[a] *jacks in parentheses*

Appendix 2 (continued)

1979-80 SPAWNING SEASON							
System	Stream	Survey length	Estimated spawning population (AUC method)	Peak count (live and dead)	Peak fish/mi	Total fish/mi	Peak/total
Necanicum	Hawley Cr.	0.25	3	2 (1)	8	12	0.67
	Volmer Cr.	0.25	3	1	4	12	0.33
	Mail Cr.	0.25	10	7	28	40	0.70
	Bergsvik Cr.	1.0	32	15	15	32	0.47
	Necanicum R.	1.5	56	20	13.3	37.3	0.36
Nehalem	Cronin Cr.	1.5	41	7	4.7	27.3	0.17
	W. Humbug Cr.	1.1	35	12	10.9	31.8	0.34
	Hamilton Cr.	1.0	8	4	4	8	0.50
	Rock Cr.	0.5	1	1	2	2.86	0.70
	N. F. Wolf	1.1	21	7	6.4	19.1	0.33
Nestucca	Elk Cr.	1.0	52	28	28	52	0.54
	Bear Cr.	0.7	130	83	58	91	0.64
	Bays Cr.	1.0	18	14	14	18	0.78
	Testament Cr.	0.5	39	12	24	78	0.31
	Wolfe Cr.	0.75	13	4	5.3	17.3	0.31
	Farmer Cr.	1.0	51	32	32	51	0.63
	Three R.	1.0	22	17	17	22	0.77
	Alder Cr.	0.5	92	29	58	184	0.32
Little Nestucca	S. Fork	1.0	13	11	11	13	0.85
	Bear Cr.	0.75	14	8	10.7	18.7	0.57
	Sourgrass Cr.	1.0	32	16	16	32	0.50
	Louie/Baxter Cr.	0.5	25	9	18	50	0.36
Alsea	Cascade Cr.	2.4	51	27	11.25	21.25	0.53
	Horse Cr.	1.0	55	18	18	55	0.33
	Drift Cr.	1.4	13	9	6.4	9.3	0.69