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DO YOUNG COHO SALMON AND STEELHEAD SPRING EMIGRATION ABUNDNACE ESTIMATES OR SUMMER DENSITY AND REARING ESTIMATES REFLECT THE STATUS OR TRENDS OF ADULT POPULATIONS?

PROJECT 2i2

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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There is a need for reliable estimates of threatened adult coho salmon and steelhead abundance in coastal Northern California. However, most monitoring programs in this area are focused on juvenile emigration in spring or summer rearing. Thus it is important to understand the relationship between adult escapement and juvenile abundance. We used four consecutive years data on adult female coho salmon and steelhead escapement, young-of-the-year (YOY) and older age fish abundance estimates from down stream trapping studies, and YOY and juvenile rearing population indices in several coastal streams in Northern California to evaluate if YOY and juvenile trapping programs operated annually from March to June and summer rearing density estimates were correlated with adult escapement (status). We examined these data to determine if YOY and juvenile abundance trends track those of adult populations. Trends were examined by comparing the slopes of adult versus year and juvenile abundance versus year, treating sites as samples, with paired *t*-tests. Steelhead YOY and coho salmon YOY and yearlings (Y+) trapping population estimates and adult female escapement were significantly correlated ($r > 0.52$, $p < 0.02$). Older age steelhead trapping abundance and adult female escapement were not significantly related ($r < 0.17$, $p > 0.44$). Adult female escapement and summer rearing densities were not significantly related for either species ($r < 0.004$ $p > 0.49$). Steelhead YOY summer rearing populations were significantly related to adult female escapement ($r = 0.41$ $p = 0.02$) but coho YOY and older age steelhead were not ($r > 0.05$, $p > 0.21$). YOY and Y+ coho salmon trapping abundance were significantly related to adult returns in subsequent years ($r > 0.42$, $p < 0.03$). With four years data, trends in adult abundance were not significantly different than YOY and older age fish trends for summer rearing and emigrant abundance estimates ($t < 1.44$, $p > 0.21$). However, these trends were not significantly different than zero ($t < 0.96$ $p > 0.08$). Our results suggest that downstream emigrant trapping of YOY steelhead and YOY and Y+ coho were reliable indices of adult abundance. Summer rearing density and population estimates based on electro-fishing were not reliable indices of adult escapement and monitoring programs employing this approach should be undertaken with caution. Summer rearing and downstream emigrant trapping may be reasonable tools for long term trend detection of adult populations. More years' data will be required to fully understand the relationship between these metrics.

INTRODUTION

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Accurate estimates of adult salmon (*Oncorhynchus* spp.) abundance are essential for effective management and conservation (Busby et al. 1996, McElhany et al. 2000). In coastal Northern California, coho salmon (*O. kisutch*) and steelhead (*O. mykiss*) are considered protected species under both state and federal endangered species acts (CDFG 2003, Federal Register 1997, 2000). Conservation criteria will presumably depend on whether important populations have reached escapement thresholds (Shea and Mangel 2001).

However, long-term data on escapement do not exist for most salmonid populations in California (Nehlsen 1996) and the few monitoring efforts begun since 1990 are mainly focused on estimates of juvenile rearing abundance (Prager et al. 1999, Shea and Mangel 2001). Prager et al. (1999) recommends continuing estimation of juvenile abundance coupled with estimation of escapement in selected streams to determine relationships between life stages for monitoring the status (i.e. annual abundance) of coastal populations. Shea and Mangel (2001) present models for coho salmon that suggest increasing time series and reducing observer uncertainty in juvenile estimates will improve statistical power for detecting trends (changes in long term abundance) in adult populations from observations of juvenile abundance. In their models true abundance of adults and juveniles always showed the same trend.

Downstream trapping is commonly used to estimate smolt yield for monitoring salmonid populations (Ward and Slaney 1988, Thedinga et al. 1994, Bradford 2000). Electro-fishing estimates of parr density or abundance in summer also are commonly used for monitoring salmonid populations (Burns 1971, Rodgers et al. 1992, Beland 1996, Mitro et al. 2003) or to predict spring smolt production from fall parr abundance estimates (Bagliniere and Champigneulle 1986). Yet the relationship between these metrics and adult escapement has rarely been evaluated (Ward and Slaney 1988, Lawson et al. 2004). Beland (1996) found a significant linear relationship between age-1 Atlantic salmon parr and redd count two years earlier. Ward and Slaney (1988) found a significant relationship between steelhead emigrant smolts and adult returns. Bradford et al. (2000) found a significant linear relationship between emigrant coho salmon fry and adult parental spawners. However, Lawson et al. (2004) found no relationship between coho salmon spawner abundance and smolt production and Bradford et al. (2000) suggest that smolt production is regulated by density-dependent factors and significant relationships between smolt abundance and parent spawners are only found at very low spawner abundance. We are not aware of any previous attempts to relate coho salmon and steelhead juvenile rearing and smolt abundance to spawner abundance in California.

To evaluate if YOY and juvenile trapping programs operated annually from March to June and summer rearing density estimates were related to adult abundance (status), we used four consecutive years data on female coho salmon and steelhead escapement (Gallagher and Gallagher in press), young-of-the-year (YOY) and smolt abundance estimates, and YOY and juvenile rearing population indices from three coastal streams and eight tributaries in one coastal river. We evaluated these data to determine if YOY and juvenile abundance trends track those of adult populations. We hypothesized that coho salmon and steelhead adult female abundance and YOY and older age fish abundance estimated from downstream migrant trapping (March through June) would be significantly correlated, that summer rearing densities and adult female abundance would be significantly related, and that YOY and older age fish trends would not differ from adult population trends. Our results suggest that Spring trap estimates of coho and steelhead YOY and coho yearlings (Y+) abundance provided useful indices of adult escapement, trap based population estimates of older life stages of steelhead and summer electro-fishing density estimates (coho salmon and steelhead) were not related to adult abundance, that both YOY and Y+ coho abundance from March through June trapping were significantly related to adult returns in subsequent years, and that trends in YOY and juvenile abundance were not different than those of adults. We present linear regression models for prediction of adult coho salmon returns based on YOY and Y+ trap estimates and discuss the implications of our findings for long term monitoring of coastal California salmonids.

MATERIALS AND METHODS

Study Area

The streams studied were Caspar and Hare creeks and the Little and Noyo rivers (Figure 1). These streams range in drainage area from 13 to 260 km^2, flow directly into the ocean, are unregulated, and are groundwater fed with peak flows in winter following heavy rains. Data were colleted in six tributaries to the Noyo River (Hayworth Creek, North Fork, North Fork South Fork, Olds Creek, Redwood Creek, and the South Fork Noyo River above the North Fork South Fork); two sections of the main stem Noyo River above Northspur; and in Caspar and Hare creeks and the Little River (Figure 1).

Emigrant Abundance

Fyke trapping during spring (March to June) was used to enumerate emigrating YOY and juvenile coho salmon and steelhead. Traps were located at the downstream end of each stream study stream (Figure 1). The opening of a 3.0 x 1.2 x 12.2 m fyke net with a 5 mm mesh was set in an area of swift flow and the downstream end was connected to a 3.0 m long 20 cm diameter pipe attached to a 3 mm mesh live car set. Each trap had one to four 2.44 x 1.22 m (6 mm mesh) weir panels set diagonally into the mouth of the net to funnel fish into the traps. Debris screens were set above the opening of each trap and a 0.5 to 1 m section of stream on one side of the trap weir was left unblocked to allow adult fish to bypass the traps.

Traps were fished from early-March to late-June in 2000, 2001, and 2002. Due to high stream flows trapping did not begin until early-April 2003. To determine if fish were moving during late-fall and early-winter one trap was also operated from 15 October 2000 until late-January 2001. All traps were checked daily. All steelhead and coho > 50 mm fork length were measured to the nearest mm and marked with a site and week specific brand following the methods of Everest and Edmundson (1967) or with horizontal and vertical caudal fin clips. All fish <50 mm were counted, but not marked to avoid injuring fry. Fish were assigned age/size class based on fork length frequencies and scale analysis (G. Neillands California Department of Fish and Game, Personal Communication). Steelhead < 50 mm and 51-70 mm were considered YOY, fish between 71 and 120 mm were assumed to be Y+, and fish > 120 mm were treated as Y++ (two years or older). Steelhead < 71 mm captured before fry were first observed in the spring were assumed to be Y+. Coho salmon < 80 mm were considered YOY and fish > 80 mm were assumed to be Y+. Coho salmon were treated as Y+ until YOY were found > 50 mm in spring, after which fork length frequencies were used to separate year classes. At each trap a maximum of thirty fish > 50 mm of each species and size/age class were marked each day. All steelhead and coho >50 mm were examined for marks each day. Unmarked fish were marked and released a minimum of 100 m above the traps. Recaptured fish were measured and released a minimum of 100 m below the traps.

Estimates of the steelhead and coho salmon abundance at each site was estimated by age class using a maximum-likelihood estimator for stratified populations following Darroch (1961) with software developed by Bjorkstedt (2000). Since fish < 50 mm (YOY) were not marked, weekly totals of steelhead and coho <50 mm for each trap were made from the daily catch data and multiplied by weekly capture probabilities for fish between 51 and 70 mm (steelhead) or 51 and 80 mm (coho) captured in late-spring and assumed to be YOY. Standard deviations (SD) for fish <50 mm were calculated using the percentage of SD from 51-70 mm (steelhead) or 51-80 mm (coho) estimates multiplied by the population estimates for fish < 50 mm. The 51-70 mm steelhead and the 51-80 mm coho trap population estimates were combined with < 50 mm estimates for each species to calculate the total YOY population for each trap. In cases where too few YOY, Y+, or Y++ (steelhead only) were marked and recaptured to make separate population estimates, we used the percentage of each life stage captured in a trap over the season multiplied by the population estimate for all fish of each species> 50 mm to calculate these estimates. In these cases, standard deviations were estimated by multiplying the proportion of each age class present by the confidence estimate for fish >50mm.

Density and rearing abundance

To estimate YOY and juvenile coho salmon and steelhead density and stream resident populations, 100 m sections above and below each trap in the Noyo River were single pass electro-fished weekly for four to six weeks during late-spring and early summer. In general, one person operated an electro-fisher accompanied by two persons with dip nets. All steelhead and coho salmon > 50 mm fork length were measured to the nearest mm, marked with a site and date specific freeze brand, and released as near as possible to the place where they had been captured. All fish <50 mm were counted but not marked. Abundance was estimated using the Jolly-Seber method (Krebs 1989). In cases where there were > 7 recaptures (Krebs 1989) fish of each size class were marked and recaptured, population estimates were made separately for YOY steelhead (51-70 mm) and coho salmon (51-80 mm) and for steelhead Y + and Y++. In cases where too few steelhead of one age class (based on fork length size at sample time) were marked and recaptured, total population estimates were made and multiplied by the percentage of fish in each size class. Total counts of fish < 50 mm were multiplied by the proportion of marked fish from the Jolly-Seber estimates for all life stages combined. The procedure described above for trapping abundance was used to estimate 95% confidence intervals for fish < 50 mm. The length of all electro-fishing reaches were measured and population estimates for each section were divided by the actual length of stream sampled to produce estimates of the number of fish/m. Stream resident populations were estimated by multiplying the number of fish/m for each age class by the total length of stream in which redds were observed (Gallagher and Gallagher in press). Total YOY and juvenile populations were estimated by summing the trap and electro-fishing population estimates for each reach each year.

Coho salmon and steelhead YOY and juvenile density and rearing population estimates for Caspar Creek and Little River were made by multiple pass depletion electro-fishing two 30 m reaches in each stream during September 2000-03. Young-of-the-year and juvenile salmonid populations for each section in each stream were estimated using the Zippin method (Brower and Zar 1984). The resulting densities for each species and age class were averaged for each stream and the resulting fish/m were used to estimate total rearing populations as above. Density and rearing population estimates were not made for the North Fork South Fork Noyo River, the South Fork Noyo River, and Hare Creek.

Relationships among life-stage estimates

We used correlation to determine whether trapping or electro-fishing estimates of juvenile abundance were related to female escapement. Adult female abundance for each stream for 2000-03 was estimated by multiplying the adult populations from Gallagher and Gallagher (in press) by the female to male ratio. Female estimates for 2004 in the North Fork South Fork Noyo, South Fork Noyo, and Little rivers and Caspar Creek were estimated using the methods of Gallagher and Gallagher (in press) from spawning surveys conducted in these streams during 2004. The relationships between coho salmon and steelhead adult female and YOY, Y+, and Y++ (steelhead only) trap populations, densities, and rearing population estimates were examined by correlation, treating each stream or stream segment and year as a sample. The relationship between coho salmon trap Y+ estimates and adult escapement two years later were examined with correlation and predictive relationships developed using linear regression. Similarly, the relationship between coho salmon YOY and adult escapement three years later were examined with correlation and predictive relationships developed using linear regression. The relationship between steelhead females and previous year’s emigration and rearing populations were not examined due to insufficient data. Cohort survival from one life stage to the next was calculated as the proportion estimated at stage n+1 divided by the number of individuals estimated at stage n. Statistical significance was accepted at $p < 0.05$.

Trend detection

Adult female coho salmon and steelhead estimates for each stream reach were regressed against year. For each sample site steelhead and coho salmon YOY, Y+, and Y++ (steelhead only) trapping population estimates were regressed against year and the slopes compared with those of the adult data using paired t-tests. Similarly, YOY, Y+ (steelhead only), and Y++ (steelhead only) density and rearing population estimates were regressed against year for each sample site. The juvenile regression slopes were compared to the adult regression versus year slopes using paired t-tests. Statistical significance was accepted at $p < 0.05$.

RESULTS

Relationships among life-stage estimates

Trap estimated YOY and Y+ coho salmon population estimates were significantly positively correlated with adult female escapement (Figure 2a and 2d, Table 1). Spring and summer coho salmon YOY density estimates were not significantly related to adult female escapement (Figure 2b, Table 1). Coho salmon YOY summer rearing population estimates were not significantly correlated with adult female escapement estimates (Figure 2c, Table 1). Coho salmon YOY density and Y+ trap captures the following spring were not related ($r = 0.24$, $p = 0.40$, $n = 14$). Due to the influence of the trap population estimates, the total (trap plus rearing) YOY coho salmon estimates each year were significantly correlated with adult female escapement (Table 1).

Coho salmon Y+ trap population estimates and adult returns two years later were significantly related ($r^2 = 0.18$, $p = 0.03$, Figure 3a). However Coho salmon YOY trap population estimates and adult returns three years later were significantly related ($r^2 = 0.42$, $p = 0.01$, Figure 3b). We developed models for predicting adult coho salmon returns from Y+ (Equation 1) and YOY (Equation 2) from the trap population estimates.

Equation 1

Adult coho two year later = 51.257 + (0.021 * coho Y+ trap population estimate)

Equation 2

Adult coho three years later = 29.182 + (0.0056 * coho YOY trap population estimate)

Steelhead adult female escapement and YOY trap population estimates were significantly positively correlated (Figure 4a, Table 1). Steelhead YOY density estimates were not significantly related to adult female escapement estimates (Figure 4b, Table 1). However, steelhead YOY rearing population estimates and total population estimates (the sum of trap and rearing estimates) were significantly positively correlated (Figure 4c, Table 1). Rearing YOY steelhead density and Y+ trap population estimates the following spring were not related ($r = -0.06$, $p = 0.82$, $n = 16$). Steelhead Y+ and Y++ estimates were not significantly related to adult female escapement estimates for any estimation method (Figure 4d-i, Table 2). Correlation coefficients for steelhead Y+ and Y++ density estimates, while not significant, show a negative relationship with adult female escapement estimates (Table 1).

Coho salmon survival from one life stage to the next ranged from 0.004 to 0.42 (Table 2). Steelhead survival based on trapping and summer rearing population estimates ranged from 0.03 to 0.61 (Table 2).

Trend detection

Trends in coho salmon adult escapement over four years were not significantly different than trends in any other life stage or estimation method (Table 3). The power of these tests was low ($\beta < 0.13$). The slopes of these regressions were not significantly different than zero ($t < 0.96$, $p > 0.08$, d. f. = 9). The power of these tests was low ($\beta < 0.35$). Trends in steelhead adult escapement over four years were not significantly different than trends in YOY and Y+ population estimates from trapping and summer rearing studies (Table 4). Trends in adult female steelhead escapement were marginally significantly different than the trends in YOY density (Table 4). The power of these tests was low ($\beta < 0.45$). The slopes of these regressions were not significantly different from zero ($t < 1.60$, $p > 0.08$, d. f. = 9). However, the power of these tests was low ($\beta < 0.20$).

DISCUSSION

Relationships among life-stage estimates

Fyke trapping coho salmon YOY and Y+ and steelhead YOY from March to June in unregulated coastal streams in Mendocino County, California appears to be a useful tool for monitoring adult population status. Using a maximum-likelihood estimator for a stratified capture-recapture effort resulted in YOY (steelhead and coho) and Y+ (coho only) population estimates that were significantly correlated with adult female escapement. Thus these trapping population estimates appear to be a reliable index of adult escapement. Shea and Mangel (2001) found that true adult and true juvenile numbers were always related and that observer uncertainty in juvenile counts decreased the statistical reliability of these relationships. Our results suggest that the error in the YOY and Y+ trapping abundance estimates did not obscure their relationship with adult escapement. Although, our estimates of YOY trap populations were largely based on capture efficiency for larger fish (a large fraction of the YOY were < 50 mm and were therefore not marked) and larger fish may be able to avoid traps, we none the less found a significant relationship between YOY and adults. Bradford et al. (2000) found a significant linear relationship between emigrant coho salmon fry and parental female spawners. They did not investigate the relationship between Y+ and parental spawners and state that 60 to 90% of fry emigrated in their first spring. Lawson et al. (2004) did not find a relationship between coho salmon spawner abundance and smolt production in Washington and Oregon coastal streams. However, Lawson et al. (2004) derived their estimates of smolt production from estimates of adult returns and ocean survival while in this study we used actual estimates of emigration from downstream traps. The significant relationships we observed between coho salmon and steelhead YOY and coho Y+ may be because populations in the streams we studied are at very low abundance levels. Barrowman and Myers (2000) and Bradford (1999) suggest that spawner abundance and smolt production are only related at very low abundance levels.

Our results suggest that trapping steelhead Y+ and Y++ from March to June is not an effective method for monitoring adult parental spawner population status. Ward and Slaney (1988) found significant relationships between steelhead smolt production and spawner abundance in subsequent years in British Columbia but did not examine the relationship between smolts and their parental spawners. Movement of steelhead Y+ and Y++ during winter is likely the reason we did not find a significant relationship between adult females and their progeny by trapping March to June. About 50% of the total number of steelhead Y+ and Y++ moved past a trap on the Noyo River between November 2000 and January 2001, a period which was not sampled in other streams or during other years due to difficulties operating the traps in high stream flows. However, less than 2% of coho were captured at this trap during this period. Movement or delayed migration of these age classes within streams may also explain the lack of significant relationships with adult female escapement. Kahler et al. (2001) found that both upstream and downstream movement of steelhead and coho salmon was common and Everest (1973) found that steelhead moved out of ephemeral streams in summer and back into these streams following winter rains. Leider et al. (1986) found that many presmolt steelhead in a Washington river moved from tributaries into the main stem, some later moved back to the tributaries, and many remained in the main stem and smolted the following year. Seamons et al. (2004) observed considerable dispersal of Y+ steelhead. Trap avoidance by larger steelhead might also explain the lack of significance we observed. Large steelhead can avoid downstream migrant traps and were observed swimming around a trap on the Bear River in California (S. Ricker California Department of Fish and Game, personal communication). High mortality between life stages and variability in mortality could also result in a lack of significant relationship between older life stages and adults. However, survival estimates observed in this study (Table 2) were not different from those reported for steelhead in other streams (Kahler et al. 2001). Misclassification of steelhead age class based on fork length size could also explain the lack of relationship between older age parr and adult parental spawners. Ward and Slaney (1988) found that smolt size was directly related to age. They found the mean size of two year and older steelhead smolts to be > 150 mm. In an Idaho stream, Chrisp and Bjorn (1978) found that 140-160 mm (total length) as the minimum size of steelhead at smoltification. We used > 120 mm as the separation point between one and two year and greater age steelhead and thus may have counted some one year old fish as two year olds and included fish older than two years in the Y++ category. Shapovalov and Taft (1954) found steelhead < 70 mm in May to be YOY and fish between 71 and 125 mm to be age two and older in Waddell Creek, California. Examination of the fork length frequencies from our trap capture data and scale reading from trapped fish (G. Neillands California Department of Fish and Game, personal communication) suggested that our size/age class separations were reasonable for coastal streams in Mendocino County. The inclusion of non-smolts in our data sets, emigration of parr that smolt downstream of our traps, and the inability to trap during the winter months are likely explanations as to why there was no relationship between adult female steelhead escapement and their progeny estimated from March to June by fyke trapping.

Capture-recapture and depletion electro-fishing to estimate coho salmon and steelhead rearing density from small sections (30 to 100 m reaches) and extrapolating the density estimates to reach population abundance estimates were not effective tools for monitoring adult salmonid status in the streams we studied. Except for YOY steelhead rearing populations there was no relationship between rearing density or rearing population estimates and adult parental spawners (Figs. 3-4, Table 1-2) or between rearing YOY density and Y+ emigrant abundance the following spring. Density estimates in this study were not different from those obtained following a Hankin and Reeves (1988) approach in three of our study streams during 2002 (G. Neillands California Department of Fish and Game, personal communication), suggesting that an increased effort in obtaining density estimates would not improve relationships between rearing density and adult escapement. Atlantic salmon parr densities and redd counts are significantly related (Beland 1996, Semple et al. 1994, Beard and Carline 1991). Beland (1996) attributed the significant relationship between redd counts and parr density of Atlantic salmon to limited parr dispersal from spawning areas. We did not sample areas in close proximity to heavily used spawning areas and compared our density estimates to total estimates of escapement for spawning reaches which the density estimation sites were assumed to represent. We assumed that density in each reach would reflect adult escapement in these reaches and that annual and spatial variability in the escapement would be reflected in our density estimates. Dispersal and movement of coho salmon and steelhead (Bradford et al. 2000, Kahler et al. 2001, Seamons et al. 2004) might account for the lack of a relationship between rearing density and parental spawner abundance. Bradford et al. (2000) found that coho salmon streams can be fully seeded with juveniles at relatively low spawner abundance and that a large proportion of fish emigrated as fry. Approximately one quarter of our rearing sampling was conducted in early-fall while the bulk of the sampling was done in late-spring. Mitro et al. (2003) found rearing steelhead abundance in spring and fall to be highly correlated such that the difference in sampling time was not likely a big influence on our results. We found that YOY steelhead rearing population estimates were significantly associated with adult escapement which may be because most of our sampling was conducted in spring, relatively soon after fry emergence. Bias in the depletion electro-fishing removal estimates (Petersen et al. 2004) may have influenced our density estimates. Misclassification of fish age based on fork length and mortality between life stages, as discussed above, might also have influenced our results for comparisons of density to adult escapement. Due to lack of data we were unable to examine relationships between rearing density and subsequent adult returns. Rearing density and or rearing population estimates may be related to subsequent year's spawner escapement; we recommend this receive further study.

Trend detection

While trends in adult escapement were not significantly different from those of YOY and juvenile coho salmon and steelhead among estimation methods the trends were also not significantly different than zero. The power of the paired t-tests for all comparisons of adult and juvenile time series was low such that there could be differences in trends, especially for YOY steelhead density. Lack of a difference in trends may be because most samples came from the Noyo River and the other streams studied are within 20 km of each other such that they represent a metapopulation (Isaak et al. 2003). It may also be because the populations are at very low abundance levels. Isaak et al. (2003) found that adult Chinook salmon populations became highly synchronous as abundance decreased over time. Bradford (1999) states that smolt abundance and adult abundance are only related at very low population levels. The lack of trends in our data may also be due to only having four years of data. Because coho salmon generally have a rigid three year life cycle we might not observe trends with only four years data. We suspect that trend detection would be more appropriate with more year's data and annual estimates examined by three-year cohorts. Larsen et al. (2004) found that trend detection increased markedly with increased time series and Shea and Mangel (2001) state that statistical uncertainty in trend detection for modeled coho salmon populations increased with shorter time series. There is increasing evidence that Pacific salmonid populations follow a decadal cycle in abundance which is related to large scale climate (Smith and Ward 2000, Smith et al. 2000). If salmonid population abundance fluctuate on decadal or longer time frames, the four years data we examined could be too short to detect these long term trends. However, Bradford et al. (2000) suggest their results and results of other works they refer to argue against the idea that regional effects of climate affect freshwater survival in coho salmon.

In conclusion, we found that YOY and Y+ (coho only) emigrant trapping annually from March to June in coastal Mendocino County streams appears to be an effective tool for monitoring adult steelhead and coho salmon status and trends. Summer density does not reflect adult or juvenile emigrant populations, and status and trend monitoring that relies on summer density should be approached with caution, especially considering that most salmonid monitoring in California is focused on estimates of juvenile rearing abundance (Prager et al. 1999, Shea and Mangel 2001). However, these data may be of use for evaluating habitat conditions or evaluating restoration activities. We recommend that electro-fishing and downstream trapping coupled with spawner escapement monitoring be continued and the relationships between these data be further evaluated with more years' data. Trap design and placement should be modified to increase the likelihood of capturing older age steelhead.

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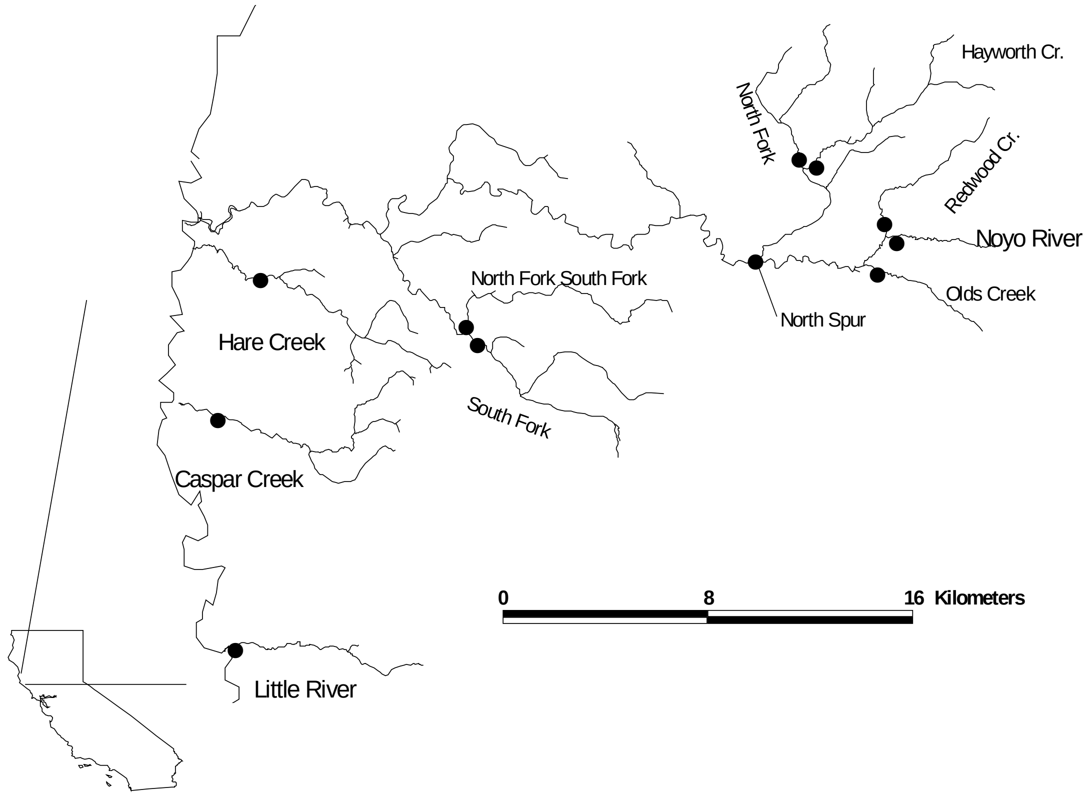

Figure 1. Location of study streams and trap locations in Mendocino County California. Dark circles indicate trap locations.

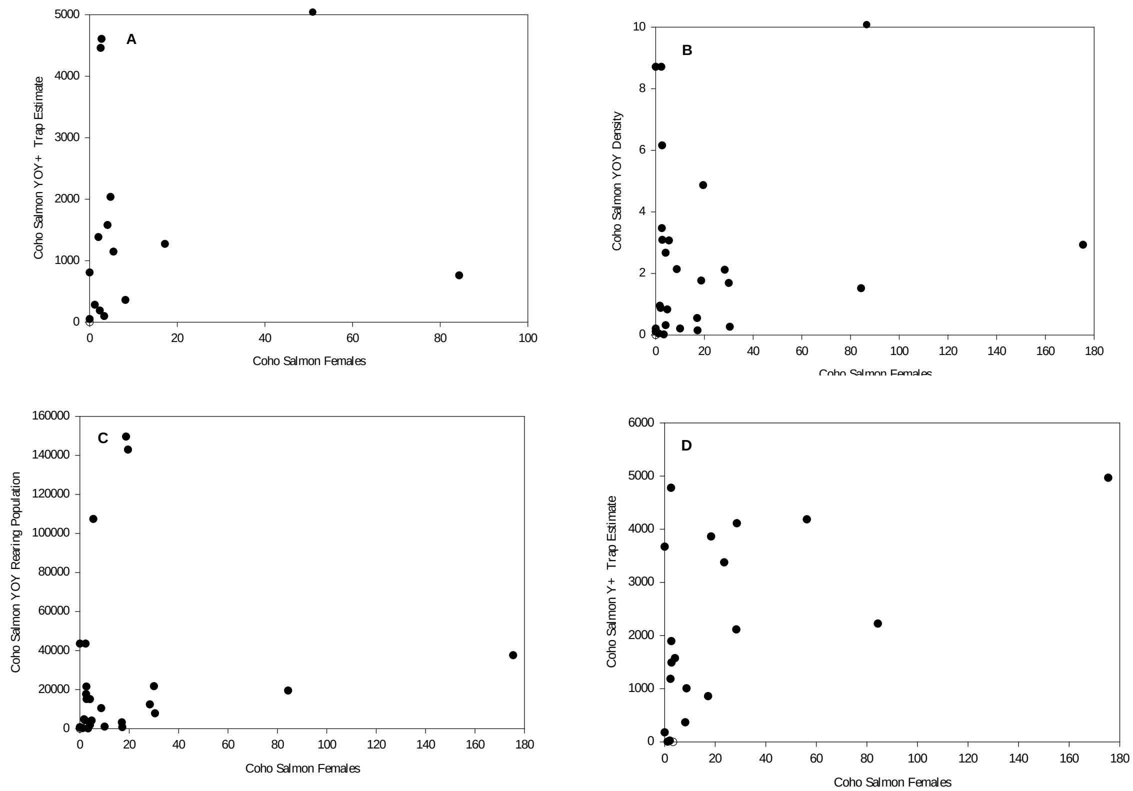

Figure 2. Scatter plots of adult coho salmon females against young-of-the-year (YOY) and juveniles by estimation method. A. YOY trap estimates. B. YOY density (number/m). C. YOY rearing population estimates. D. Y+ trap estimates.

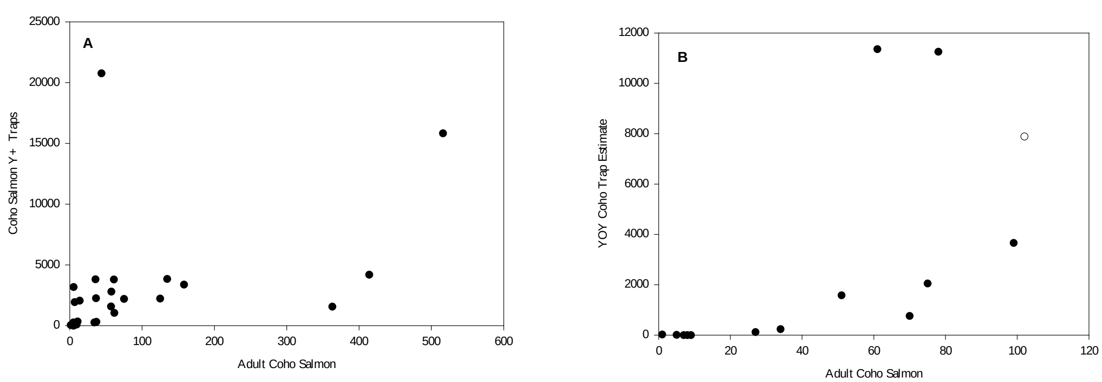

Figure 3. Scatter plots of coho salmon adults versus the previous years juvenile and YOY trap population estimates. A. Adults versus two years previous Y+ trap estimates. B. Adults versus three years previous YOY trap estimates.

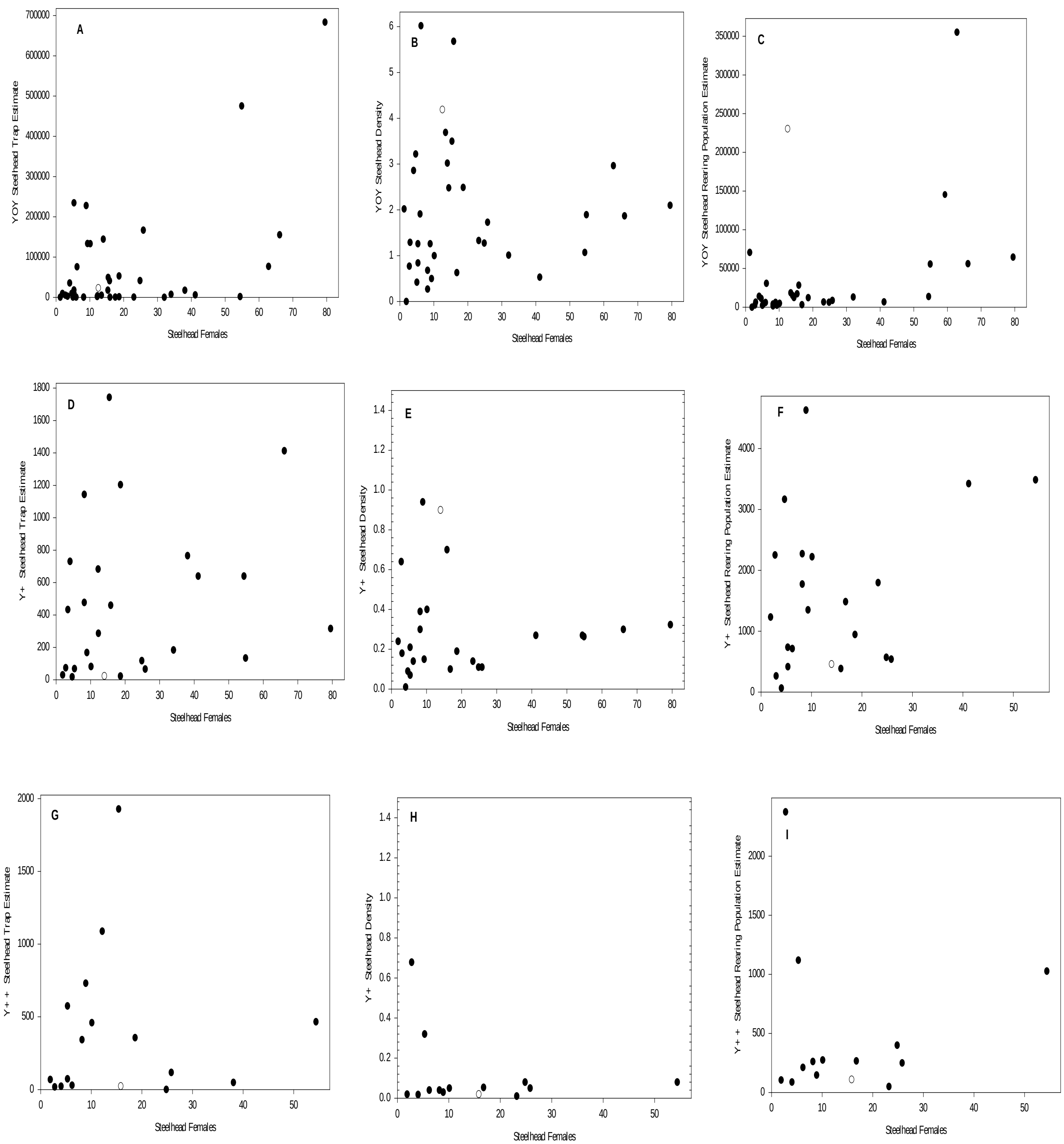

Figure 4. Scatter plots of adult steelhead females against young-of-the-year (YOY) and juveniles by estimation method. A. YOY trap estimates. B. YOY density (number/m). C. YOY rearing population estimates. D. Y+ trap estimates. E. Y+ density. F. Y+ rearing population estimates. G. Y++ trap estimates. H. Y++ density. I. Y++ rearing population estimates.

Table 1. Results of correlation analysis between coho salmon or steelhead adult female escapement and fyke trap abundance estimates, electro-fishing density, and rearing young-of-the-year and older offspring populations in Mendocino County, California. Total populations are the sum of the trapping and electro-fishing estimates.

Metric	Coho Salmon YOY			Coho Salmon Y+			Steelhead YOY			Steelhead Y+			Steelhead Y+ +		
	R	*P*-Value	N	R	*P*-Value	N	R	*P*-Value	N	R	*P*-Value	N	R	*P*-Value	N
Trap Estimate	0.83	< 0.001	28	0.52	0.02	20	0.54	0.0002	41	0.17	0.44	23	0.01	0.95	17
Density Estimate	-0.001	0.99	27	-	-	-	0.004	0.98	34	-0.06	0.82	19	-0.22	0.49	12
Rearing Population	0.10	0.60	27	-	-	-	0.41	0.02	34	0.30	0.21	19	0.05	0.88	12
Total Population	0.50	0.01	25	-	-	-	0.66	< 0.0001	34	0.21	0.40	18	0.14	0.66	12

Table 2. Average coho salmon and steelhead survival estimates from one life stage to the next for eleven streams in coastal Mendocino County, California.

Species	Life-Stage	Proportion Surviving Average	N	S.E.	Range
Steelhead	YOY-Y+	0.09	23	0.03	0.003-0.47
Steelhead	YOY-Y+ +	0.06	12	0.03	0.002-0.30
Steelhead	Y+ -Y+ +	0.35	12	0.05	0.14-0.61
Coho Salmon	YOY-Y+	0.12	12	0.04	0.004-0.42
Coho Salmon	YOY-Adult	0.01	2	0.005	0.006-0.017
Coho Salmon	Y+ -Adult	0.06	25	0.01	0.002-0.29

Table 3. Results of paired t-tests between the slope of adult coho salmon female escapement versus year regressions and the slope of young-of-the-year and Y+ trapping estimated abundance and electro-fishing density and rearing population regressions versus year for four years data in eleven streams in coastal Mendocino County, California. None of the slopes were significantly different than zero.

Life Stage	Metric	Average Slope	SE	N	*t*-Value	*P*-Value
Adult Females	-	0.063	0.07	10	-	-
YOY	Trap Estimate	-0.00061	0.00069	10	0.97	0.40
	Density Estimate	0.292	0.13	6	-1.20	0.40
	Rearing Population	0.00005	0.00007	6	1.44	0.21
	Total Population	0.00004	0.00002	7	1.44	0.21
Y+	Trap Estimate	0.002	0.003	10	1.02	0.33

Table 4. Results of paired t-tests between the slope of adult steelhead female escapement versus year regressions and the slope of young-of-the-year and Y+ trapping estimated abundance and electro-fishing density and rearing population regressions versus year for four years data in eleven streams in coastal Mendocino County, California. None of the slopes were significantly different than zero.

Life Stage	Metric	Average Slope	SE	N	*t*-Value	*P*-Value
Adult Females	-	-0.038	0.061	10	-	-
YOY	Trap Estimate	-0.00013	0.00008	10	0.61	0.55
	Density Estimate	0.38	0.18	7	-2.41	0.05
	Rearing Population	0.000032	0.000043	7	-0.62	0.56
	Total Population	-0.00003	0.0001	7	0.62	0.56
Y+	Trap Estimate	0.015	0.01	10	-0.89	0.40
	Density Estimate	5.25	5.84	7	-0.91	0.40
	Rearing Population	0.00034	0.0005	7	-0.62	0.56
	Total Population	0.00023	0.0004	7	-0.62	0.56