ESTIMATES OF JUVENILE SALMONID ABUNDANCE IN MCGARVEY CREEK, TRIBUTARY TO THE LOWER KLAMATH RIVER, CALIFORNIA SUMMER, 2006

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Estimates of juvenile salmonid abundance in McGarvey Creek, tributary to the Lower Klamath River, California, summer 2006

Abstract.—Knowledge of the status and trends of Lower Klamath River anadromous salmonid population abundance is critical for two reasons: 1) for Endangered Specie Act (ESA) recovery planning for listed species such as coho salmon; and 2) for the Yurok Tribal Fisheries Program (YTFP) to monitor the health of Tribal Trust fish populations over time and to document fisheries responses to completed and ongoing watershed restoration activities in Lower Klamath watersheds. McGarvey Creek is a small, low-gradient coastal stream with approximately 4 miles of anadromous habitats and a confluence with the Klamath River at river mile (rm) 6. Since YTFP has conducted over a decade of sustained fisheries investigations and watershed restoration activities in the McGarvey Creek watershed, it was selected in 2001 to be an index stream to conduct annual summer abundance "Hankin and Reeves" type population estimates for both juvenile coho and trout. 2006 results indicated summer abundance estimates of 850 age 0+ coho +/- 301 fish, 1,033 age 0+ trout +/-248.2, and 979 age 1+ trout +/- 382 fish (95 % confidence intervals) for the entire basin. Estimated abundances for age 0+ coho and age 0+ trout were the lowest of any year between 2001-2004, yet the overall estimated abundance of age 1+ trout remained relatively similar for each of the years studied. Additional studies are needed to monitor and assess the recent general decline of over-summering anadromous salmonids in McGarvey Creek and potential ties to habitat changes in the basin.

Acknowledgments

YTFP wishes to thank the United States Fish and Wildlife Service for providing funding to be able to complete this project. We would also like to express our gratitude to our dedicated and proficient field crews without whom this kind of intensive survey would not be possible.

Background

McGarvey Creek, a small coastal tributary to the Lower Klamath River, has been subjected to intense logging activity, associated road building, and construction of a major highway in its headwaters during the past 60 years (Figure 1). These land management activities have combined with naturally occurring flood events to negatively affect riparian areas and instream fish habitat throughout the watershed. Instream impacts include channel aggradation as a result of chronic sedimentation, siltation of spawning gravels, and loss of habitat diversity (simplification) (Voight and Gale 1998; Gale and Randolph 2000).

In 1997, the Yurok Tribal Fisheries Program (YTFP) initiated a long-term monitoring program to assess salmonid populations and their associated habitat in the McGarvey Creek watershed. Maintaining consistent monitoring efforts has allowed YTFP to establish baseline biological and physical habitat datasets, and the ability to track population trends over time.

Biological objectives of this long-term monitoring program have included:

1) To quantify juvenile rearing abundance, smolt emigration, and adult spawner abundance in McGarvey Creek;
2) To describe life-history strategies of McGarvey Creek salmonid populations;
3) To document annual variation in species distributions; and
4) To collect species/age composition data and tissue samples for genetic analyses.

These monitoring activities have also provided guidance for YTFP's restoration strategy in McGarvey Creek, and provided a means to evaluate ongoing restoration efforts. Since 1997, principal restoration activities implemented in the McGarvey Creek watershed include treatment of potential upslope/road-related erosion sites, modification of anadromous barriers, and the planting of conifers throughout the riparian corridor.

YTFP implemented annual single stream population estimates of juvenile salmonids in McGarvey Creek beginning in 2001 (Figures 1, 2). Juvenile coho (*Oncorhynchus kisutch*) were the primary species of interest in 2001 efforts, but in subsequent years through 2006, juvenile trout abundance was estimated alongside with coho. Anadromous-accessible habitats in the mainstem and West Fork of McGarvey Creek have been divided into multiple survey reaches each year to best reflect the differences between lower and upper watershed (Figure 2).

Site Description

McGarvey Creek is a small, low gradient coastal stream with a drainage area of 8.7 mi^2 on the south-west side of the Lower Klamath River (Figure 1).

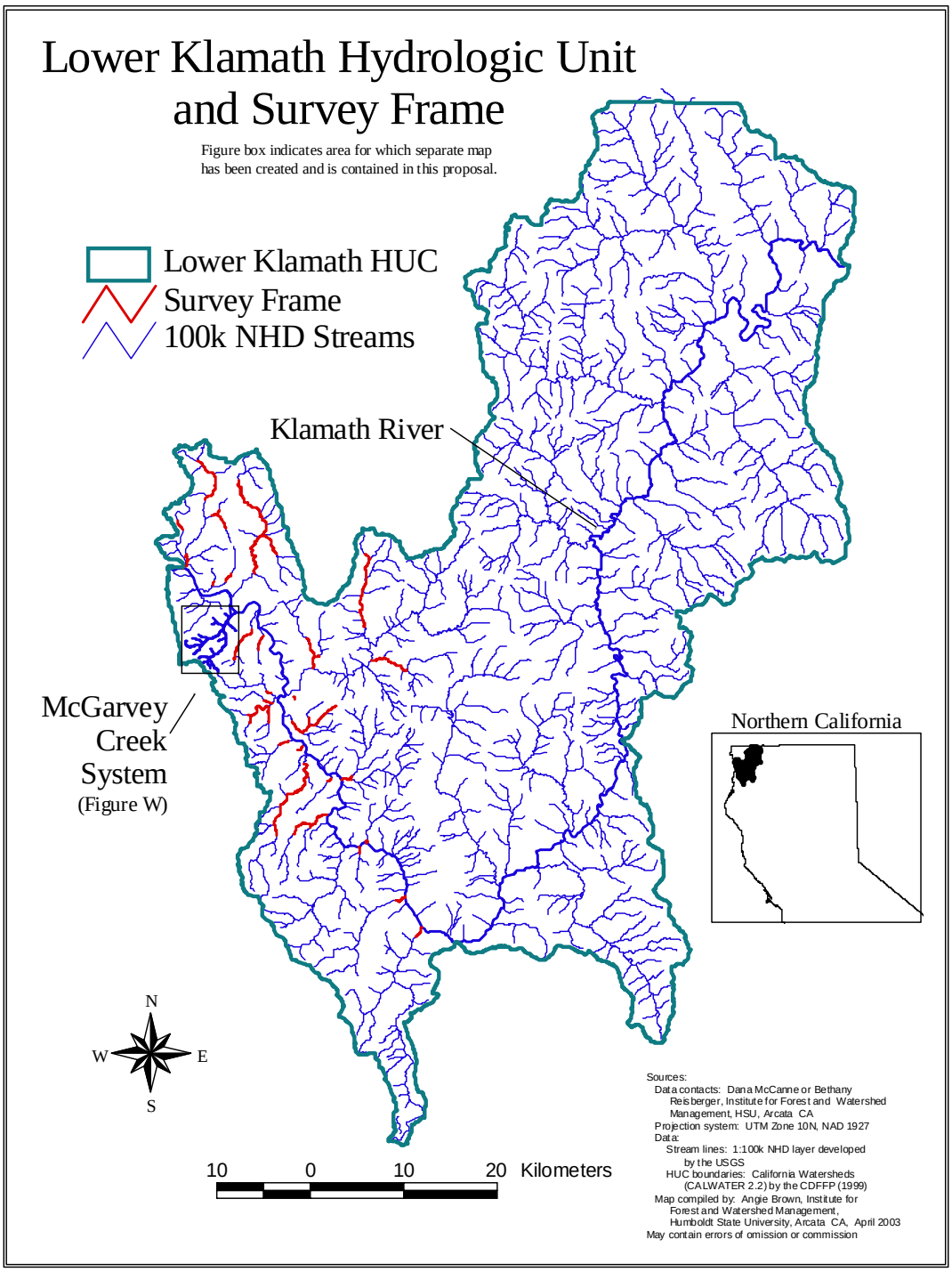

Figure 1. Location of McGarvey Creek within the Lower Klamath River juvenile coho sampling frame, Lower Klamath River, California.

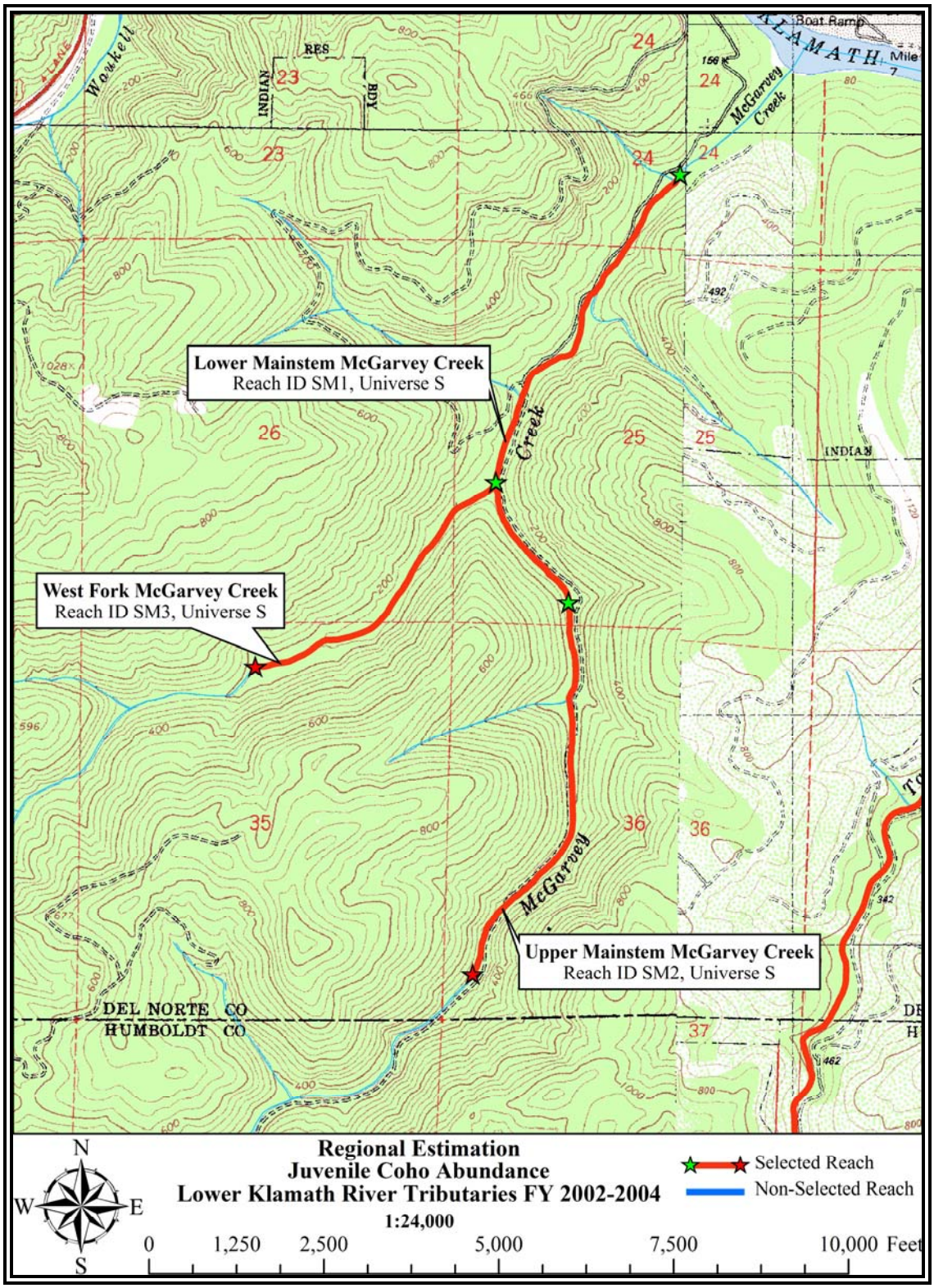

Figure 2. Locations of Lower Mainstem, Upper Mainstem A and West Fork McGarvey Creek single stream abundance reaches, Lower Klamath River, California.

The mouth of McGarvey Creek is located on the Yurok Indian Reservation, and has a confluence with the Klamath River at river mile (rm) 6.4 at T13N, R1E, S24. Upper McGarvey Creek lies outside of the Reservation and is accessible only through Simpson Timber Company land. The outmigrant trapping site is located just downstream of the lower bridge on the Simpson Road # m-10. This site was chosen based on channel characteristics and accessibility. In addition, the Klamath River routinely backs up into lower McGarvey Creek during higher flow conditions, and this trap site is situated upstream of the typical inundation zone.

McGarvey Creek consists of the mainstem and West Fork and some small, unnamed tributaries. These two major forks of McGarvey are low gradient (≤3%) with the exception of one 2,235ft section on the West Fork (YTFP habitat mapping data 1996). The lower section of McGarvey Creek is sinuous, flowing through a broad flood plane as it nears the Klamath. Upper McGarvey Creek is confined, sinuous and contains natural and anthropogenic barriers to anadromous species. The stream substrate of the drainage consists of highly embedded gravel and cobble with approximately 30% of the streambed dominated by silt or sand substrate (YTFP habitat mapping data 1996).

The McGarvey Creek watershed receives high annual rainfall. Annual rainfall in the Lower Klamath sub-basin frequently averages 100 inches per year. McGarvey stream discharge data is limited but flows have been observed to fluctuate greatly. Stream discharge monitored in McGarvey Creek during 1997-1998 ranged between 3-233 cfs and averaged 19 cfs. McGarvey Creek affords fish access to and from the mainstem Klamath for much of the year with marginal or no access during “summer low-flows”. In most years, streamflow will go “subsurface” for an indeterminate length in late summer. The typical extent of these intermittent streamflows is reflected by the boundaries of the Lower Mainstem reach (Figure 2).

Fish species utilizing McGarvey Creek include, coho salmon, steelhead trout, cutthroat trout, chinook salmon, coastrange sculpin (*C. aleuticus)*, marbled sculpin (*cottis* klamathensis), prickly sculpin (*Cottus asper*), Klamath smallscale sucker (*Catostomus rimiculus)*, speckled dace (*Rhynichthys osculus)*, three spine stickleback (*Gasterosteus aculeatus)*; marbled sculpin, Pacific lamprey (*Lampetra tridentata)*, and brook lamprey (*Lampetra lethophaga*).

Vegetation of the McGarvey Creek watershed was historically comprised of old growth conifer forest, predominantly coastal redwood (*Sequioa sempervirens*) and Douglas fir (*Psuedotsuga menziesii*) with Port Orford cedar (*Chamaecyparis lawsoniana*), western hemlock (*Tsuga heterophylla*) and Sitka Spruce (*Picea sitchensis*). Presently, the McGarvey Creek drainage is dominated by red alder (*Alnus rubra*), big leaf *maple (Acer macrophyllum*), vine maple (*Acer circinatum*) tan oak (*Lithocarpus densiflora*), madrone (*Arbutus menzesii*), California laurel (*Umbellularia californica*), and willow (*Salix* sp.).McGarvey Creek’s hydrology consists of the Mainstem, West Fork and some small, unnamed tributaries. These two major forks of McGarvey are low gradient (≤3%) with the exception of one 2,235ft section on the West Fork (YTFP habitat mapping data 1996).

Methods

Single Stream Population Estimates

YTFP has maintained as consistent an approach as possible each year 2001-2006, using a field (snorkel and electrofishing) methodology based on Hankin and Reeves (1988) and Hankin and Mohr (2008 in press), and statistical analysis methods from Overton and McDonald (1998). Over time, however, reach boundaries have required modifications as our knowledge of fish utilization and environmental conditions in McGarvey Creek has increased. A brief narrative describing the evolution of YTFP's single stream estimate reaches in McGarvey Creek follows:

Two survey reaches were utilized in both 2001 and 2002: one single mainstem reach and a west fork reach. As previously mentioned, the 2001 estimate was generated for juvenile coho only, with side-by-side juvenile trout abundance estimates beginning in 2002.

Steelhead (*O. mykiss*) and coastal cutthroat trout (*O. clarki clarki*) have sympatric distributions in McGarvey Creek. Dive-based surveys investigating either species where the two are sympatric tend to classify all juveniles as generic "trout" because of their similar appearance and behavior (Moyer 2001). In addition recent genetics work have indicated high rated of visual identification errors even by experienced personnel (Baumsteiger 2003, Voight 2008 in progress). Thus abundance estimates were calculated for age 0+ and age 1+ "generic trout" in 2006 due to the lack of funding to analyze genetic samples.

In 2003, the single mainstem McGarvey Creek reach (3.4 miles) was split into two survey reaches (Lower Mainstem & Upper Mainstem A) bringing the total number of single stream estimate reaches to three. This change was made to best document the proportion of fish that presumably perish in sections of creek that become dewatered after surveys are completed (September-October). For the purpose of 2003 surveys, the Lower Mainstem reach's upstream boundary was the confluence with the West Fork.

After an October 2003 survey documented an additional 1600 feet of dry channel extending upstream from the West Fork, the Lower Mainstem reach was extended accordingly for 2004 (YTFP unpublished field notes). Thus, for the years 2004-2006, the Lower Mainstem reach best reflects the approximate length of McGarvey Creek stream channel that loses surface flow each year (Figure 2).

In 2005, surveys indicated coho presence well above the previously known extent of anadromy in the upper mainstem. Therefore, an additional reach (Upper Mainstem B) encompassing the newly found 1925 foot extent of coho utilization extended the collective survey efforts.

Beginning with the 2006 field season, this additional habitat was added to the existing Upper Mainstem reach instead of remaining as a separate reach. This decision was made for two reasons: 1) there were not enough calibration points due to the relative short length of the new Upper B reach, hindering data analyses; and 2) the habitat conditions of

the new Upper B reach were similar in nature to the remainder of the Upper Mainstem reach.

Field Protocols

Surveys utilized modified Hankin-Reeves protocols (Hankin and Mohr, in press 2008; Hankin and Reeves 1988). Survey crews first assigned habitat units to one of five categories: shallow pools, deep pools (>1.1m z_{max}), runs, riffles and "other" (not surveyable due to complexity, water clarity, etc). A stratified systematic sampling (STRATSYS) algorithm was used to select the habitat units that were sampled (one phase electrofishing reaches) and where applicable the sub-sample of units that were calibrated following initial dive counts (two phase survey in Upper Mainstem reach).

Prior to going in the field, STRATSYS was used to generate a numbered list of "yes's" and "no's" corresponding to whether that habitat unit would be selected for sampling or calibration. A separate list was generated for each pertinent habitat strata (runs, shallow pools, riffles) and survey phase. STRATSYS strips were stored in film canisters with slit tops for use in the field. Field personnel have no advance knowledge of STRATSYS outcome until they pull the strip from the canister. This protocol ensures that both the initial identification of primary sampling units and the subsequent calibration selection of a sub-sample of primary units are performed randomly.

Sampling Rates

One phase sampling (4 pass efish depletion) was conducted in the Lower Mainstem and west fork reaches. A two-phase survey modeled after the Hankin and Reeves (1988) methods was conducted on the Upper Mainstem reach.

Riffles (RI) were sampled consistently across all reaches, with 1/12 selected for three-pass electrofishing (Table 1). Deep pools (DP) were sampled at 100% frequency across all reaches using a single dive pass as an index to document the magnitude of fish not enumerated in SP, RU, and RI units.

Table 1. Sampling rates by survey phase/habitat strata, single stream age 0+ coho population estimates, McGarvey Creek, Lower Klamath River, California, 2006.

Reach Type/Location	**Phase 1 SP-RU**	**Phase 2 SP-RU**	**Percent SP-RU calibration**	**Riffles**	**Deep Pools**
Lower McGarvey	Efish 15%		NA	8%	1 pass dive
West Fork McGarvey	Efish 15%		NA	8%	1 pass dive
Upper McGarvey	33% 1 pass dive	25% efish	8.25%	8%	1 pass dive

In the Upper Mainstem reach *phase 1* sampling rates were that 33% of the shallow pools/runs (SP-RU) were selected to undergo an initial dive pass. Divers then flagged 25% of the *phase 1* sampled units to undergo *phase 2* calibration (four pass depletion electrofishing). Thus, the resulting proportion of shallow pool/run units that were calibrated within the Upper Mainstem McGarvey reach was (.33 * .25= .0825), or 8.25% (Table 1).

Data Analysis

Methods for Segment Estimation

Separate population estimates (with 95% confidence intervals) were made for age 0+ coho, age 0+ trout, and age 1+ trout in the *Riffle* and *Shallow Pool/Run* habitat strata in each single stream reach. *Deep Pools* were surveyed using dive counts only (no electrofishing).

Although most *Deep Pool* habitat units had four dive passes per unit, the MBC estimates were only applicable to coho. Since the behavior of trout often violates assumptions required for MBC, estimation of trout numbers in deep pools is unreliable at best. One such assumption is that of equal observation probability between dive passes. Juvenile trout are typically furtive and may seek cover for extended periods of time after first encountering a diver. First-pass dive counts of age 0+ and 1+ trout were reported, not as an estimate of the number of fish in the deep pools, but to provide the magnitude of fish not accounted for in the deep pools.

Since the *Riffle* habitat stratum is not suitable for snorkel surveys, they were sampled using a single-phase electrofishing survey. One-twelfth of all riffle habitat was electrofished. For two reaches, Lower Mainstem McGarvey Creek and West Fork McGarvey Creek, snorkel surveys were not feasible. These reaches were surveyed in the same manner as the *Riffle* habitats, employing a single-phase, multiple pass depletion electrofishing survey. In these two segments, the *Shallow Pool/Run* habitat stratum was sampled at a rate of 8 percent, and 12 percent, respectively.

Where snorkel observation was possible, a sub sample of snorkeled *Shallow Pool* and *Run* habitat types were double sampled (Table 3). In most locations, one-third of all snorkeled units were *calibrated* against electrofishing to develop a statistical relationship between the first-pass dive count and the more reliable electrofishing estimate. Adjustments were made to the total dive count based upon this relationship. The *Other* stratum contained habitat units that were not suitable for snorkeling or electrofishing, and thus no statistical inferences were made.

Incorporation of Reach Length as an Auxiliary Variable

It has been long recognized that habitat surface area is highly correlated with unit fish abundance, but for many single-reach surveys, the reported unit length has a higher correlation than wetted-width surface area. For estimating fish abundance within a reach, habitat unit length was incorporated as an auxiliary variable. If habitat unit information

was incorporated across reaches, then wetted-width surface area would be a more suitable choice.

Electrofishing Jackknife Estimation

Jackknife estimation was used for the electrofishing data where the total number of fish ($\hat{y}_i$) and sampling variance ($\hat{V}(\hat{y}_i)$) in unit *i* were estimated by:

$$\hat{y}_i = \sum_{j=1}^{r_i - 1} c_{i \bullet j} + r_i c_{r_i}$$

$$\hat{V}(\hat{y}_i) = r_i (r_i - 1) c_{r_i}$$

where

r_i = the number of electrofishing passes in the ith habitat unit

c_{r_i} = the number of fish captured in the rth (last) pass in the ith habitat unit

$c_{i \bullet j}$ = the number of fish captured in the jth pass of the ith habitat unit

Two-Phase Estimation for Shallow Pools and Runs in Snorkeled Reaches:

The total number of fish in *Shallow Pools and Runs* ($\hat{T}_{SP/R}$) and sampling variance $\hat{V}(\hat{T}_{SP/R})$ were estimated by:

$$\hat{T}_{SP/R} = N\bar{\hat{y}}_2 \left(\frac{\bar{x}_1}{\bar{x}_2} + \frac{\bar{L} - \bar{l}_1}{\bar{l}_2} \right)$$

$$\hat{V}(\hat{T}_{SP/R}) \approx N^2 \left(1 - \frac{n_1}{N}\right) \left(\frac{\bar{L}}{\bar{l}_1}\right)^2 \frac{s^2_{\hat{y}|l}}{n_1} + N^2 \left(1 - \frac{n_2}{n_1}\right) \left(\frac{\bar{x}_1}{\bar{x}_2}\right)^2 \frac{s^2_{\hat{y}|x}}{n_2}$$

$$s^2_{\hat{y}|l} = \frac{1}{n_2 - 1} \sum_{i=1}^{n_2} \left(\hat{y}_i - \bar{\hat{y}}_2 \frac{l_i}{\bar{l}_2} \right)^2$$

$$s^2_{\hat{y}|x} = \frac{1}{n_2 - 1} \sum_{i=1}^{n_2} \left(\hat{y}_i - \bar{\hat{y}}_2 \frac{x_i}{\bar{x}_2} \right)^2$$

where,

N = total number of *SP/R* habitat units,

$\hat{y}_i$ = the jackknife estimate of the true number of fish in the ith habitat unit

$\bar{\hat{y}}_2$ = the average jackknife estimate of the true number of fish in all Phase II sampled shallow pools and runs.

x_i = the observed number of fish counted during the dive in the ith habitat unit

$\bar{x}_1$ = Phase I mean dive count of fish in shallow pools and runs.

$\bar{x}_2$ = Phase II mean dive count of fish in shallow pools and runs

$\bar{L}$ = average length of all shallow pool and run habitat units

l_i = the length of the ith habitat unit

$\bar{l}_1$ = average length of shallow pools and runs sampled in Phase I

$\bar{l}_2$ = average length of shallow pools and runs sampled in Phase II

n_1 = number of shallow pools and runs sampled in Phase I

n_2 = number of shallow pools and runs sampled in Phase II

Ninety-five percent confidence intervals can be approximated by $2\sqrt{\hat{V}(\hat{T}_{SP/R})}$. Small PhaseII sample sizes might necessitate using $t_{0.025,n-1}\sqrt{\hat{V}(\hat{T}_{SP/R})}$ for the confidence interval.

*Single-Phase Estimation for Riffles or Shallow Pools/Runs in Non-Snorkeled Reach*es

$$\hat{T}_{hab} = N\bar{\hat{y}}\left(\frac{\bar{L}}{\bar{l}}\right)$$

$$\hat{V}(\hat{T}_{hab}) \approx N^2\left(1-\frac{n}{N}\right)\frac{s^2_{\hat{y}|l}}{n} + \frac{N}{n}\sum_{i=1}^{n}\hat{V}(\hat{y}_i)$$

$$s^2_{\hat{y}|l} = \frac{1}{n-1}\sum_{i=1}^{n}\left(\hat{y}_i - \bar{\hat{y}}\frac{l_i}{\bar{l}}\right)^2$$

where,

hab = habitat unit type, either R*iffles* from all reaches or *Shallow Pools and Runs* from non-snorkeled reaches

N = total number of *hab* habitat units in the reach

n = number of *hab* habitat units sampled

$\hat{y}_i$ = the jackknife estimate of the true number of fish in the ith habitat unit

$\bar{\hat{y}}$ = the average jackknife estimate of the number of fish in all sampled *hab* units

$\bar{L}$ = average length of all *hab* habitat units

l_i = the length of the ith habitat unit

$\bar{l}$ = average length of sampled *hab* units

$2\sqrt{\hat{V}(\hat{T}_{hab})}$

Ninety-five percent confidence intervals can be approximated by . Small sample sizes (<30 individuals) might necessitate using $t_{0.025,n-1}\sqrt{\hat{V}(\hat{T}_{hab})}$ for the confidence interval.

Data entry/QC/QA

Habitat, snorkel, and electrofishing data were entered in a Microsoft Access database organized by reach name. Following completion of data entry, database quality control/assurance checks were accomplished by checking entered records against the field data sheets. 100% of habitat, snorkel and electrofishing data records were checked against the original data sheets; a random group of 10% of all habitat data records were checked for each survey and assessed for accuracy.

Results

While this project is focused on data collected during 2006, the following compares our 2006 findings to results from similar efforts from 2001 – 2004.

Juvenile age 0+ coho abundance

Total estimated abundance of age 0+ coho in McGarvey Creek during late summer 2006 was the lower than any result observed during 2001-2004: 850 age 0+ coho +/-301 fish (95% CI) were collectively estimated for the McGarvey Creek basin (Table 2; Figures 3, 4). This total represented approximately half of the overall 2004 estimate (N= 1,563 +/- 345 coho) (Figure 4).

In 2006, the Lower Mainstem reach held an estimated 353 coho +/- 202 fish (95% CI), the Upper Mainstem reach supported an estimated 293 +/- 204 fish, and the West Fork reach held an estimated 204 +/- 90 fish (95% CI) (Table 2, Figure 3). Estimated abundance decreased in both the West Fork and Upper Mainstem reaches relative to previous years' results, but the number of coho rearing in the Lower Mainstem remained relatively constant to previous findings (Figure 4).

Table 2. Estimated abundances of age 0+ coho, age 0+ trout, and age 1+ trout over-summering in three reaches of McGarvey Creek, Lower Klamath River, California, 2006.

Reach Name	Species	Age	Estimated Abundance (N fish)	Variance	CI	CI upper	CI lower
	COHO	**0+**					
Lower Mainstem			352.9	10205	202.0	554.9	150.9
Upper Mainstem A& B			293.0	10424	204.2	497.2	88.8
West Fork McGarvey			204.1	20234	90.0	294.1	114.1
Grand Total McGarvey			850.0	22653	301.0	1151.0	549.0
	TROUT	**0+**					
Lower Mainstem			72.0	336.2	36.7	108.7	35.3
Upper Mainstem A& B			899.4	13180	229.7	1129.1	669.7
West Fork McGarvey			61.2	1879.5	86.7	147.9	0.0
Grand Total McGarvey			1032.7	15396	248.2	1280.9	784.5
	TROUT	**1+**					
Lower Mainstem			295.3	5121.9	143.1	483.4	152.2
Upper Mainstem A& B			243.4	15222	246.8	490.2	0.0
West Fork McGarvey			211.0	716.1	53.5	264.5	157.5
Grand Total McGarvey			979.2	36394	381.5	1360.7	597.7

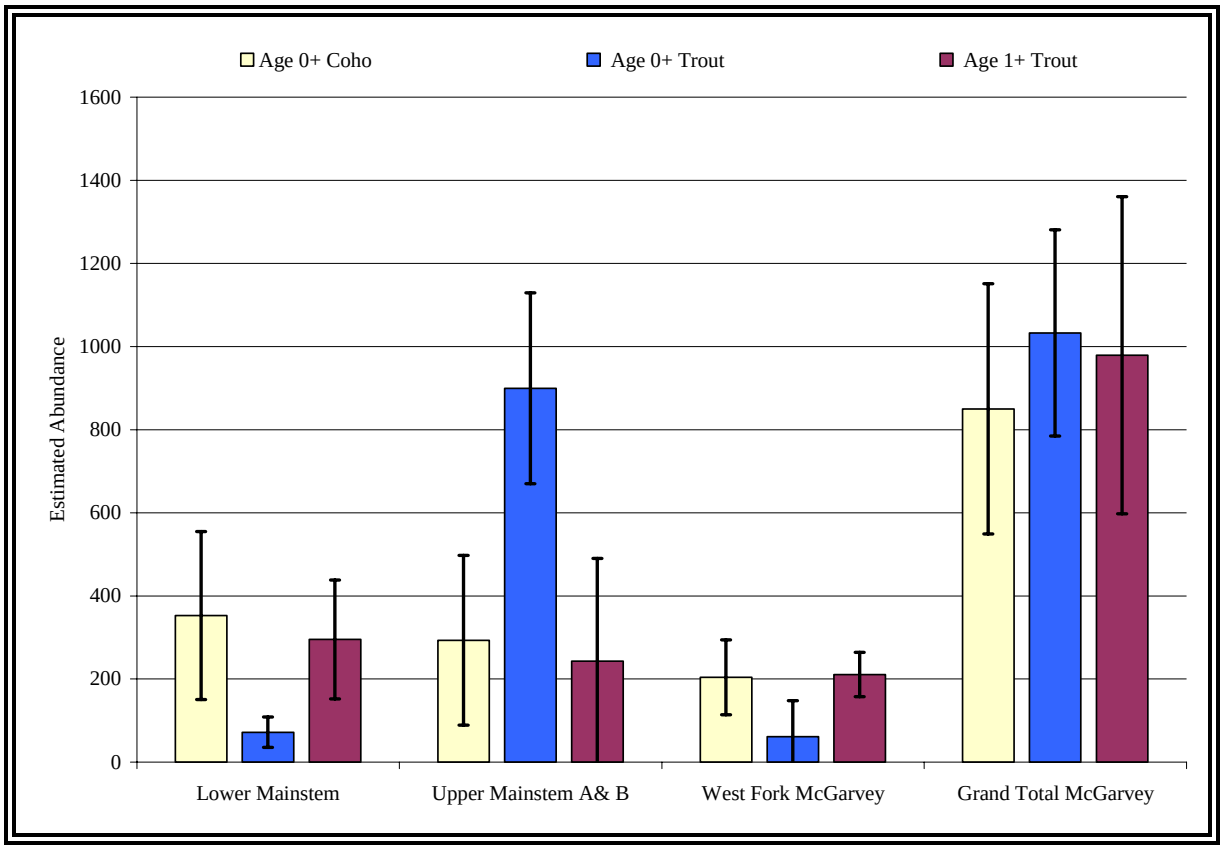

Figure 3. Estimated abundances of age 0+ coho, age 0+ trout, and age 1+ trout over-summering in McGarvey Creek, Lower Klamath River, California, 2006.

The relative proportions of each reaches' coho estimate to the overall McGarvey estimate, however, show year-to year shifts in localized densities (Figure 4). In 2006, 41.5% of the overall McGarvey coho estimate was rearing in the intermittent flow reach (Lower Mainstem) as opposed to 2004 results when this reach held approximately 20% of the overall coho estimate. Concomitant decreases in relative abundance were observed for both the Upper Mainstem and West Fork single stream reaches in 2006. The Upper Mainstem proportion of the overall estimate decreased from 42% in 2004 to 34.5% in 2006, while coho producton in the West Fork reach decreased from 37% in 2004 to only 24% of the total basin estimate ion 2006.

An examination of year to year differences (Figure 4) between reaches since 2002 indicates a longer study period is needed to discern any trends. The majority of coho rearing in the Lower Mainstem likely perished since this reach becomes dewatered by late summer in most years (including 2006). In addition to higher mortality rates, the increased proportion of fish present in this lower intermittent reach could indicate a recent worsening of instream habitat quality in the Upper Mainstem and West Fork reaches. Other potential factors such as annual variability in adult returns and nonnatal rearing, however, could just as likely account for the year to year differences between reaches, and a longer time period of study is required before drawing conclusions.

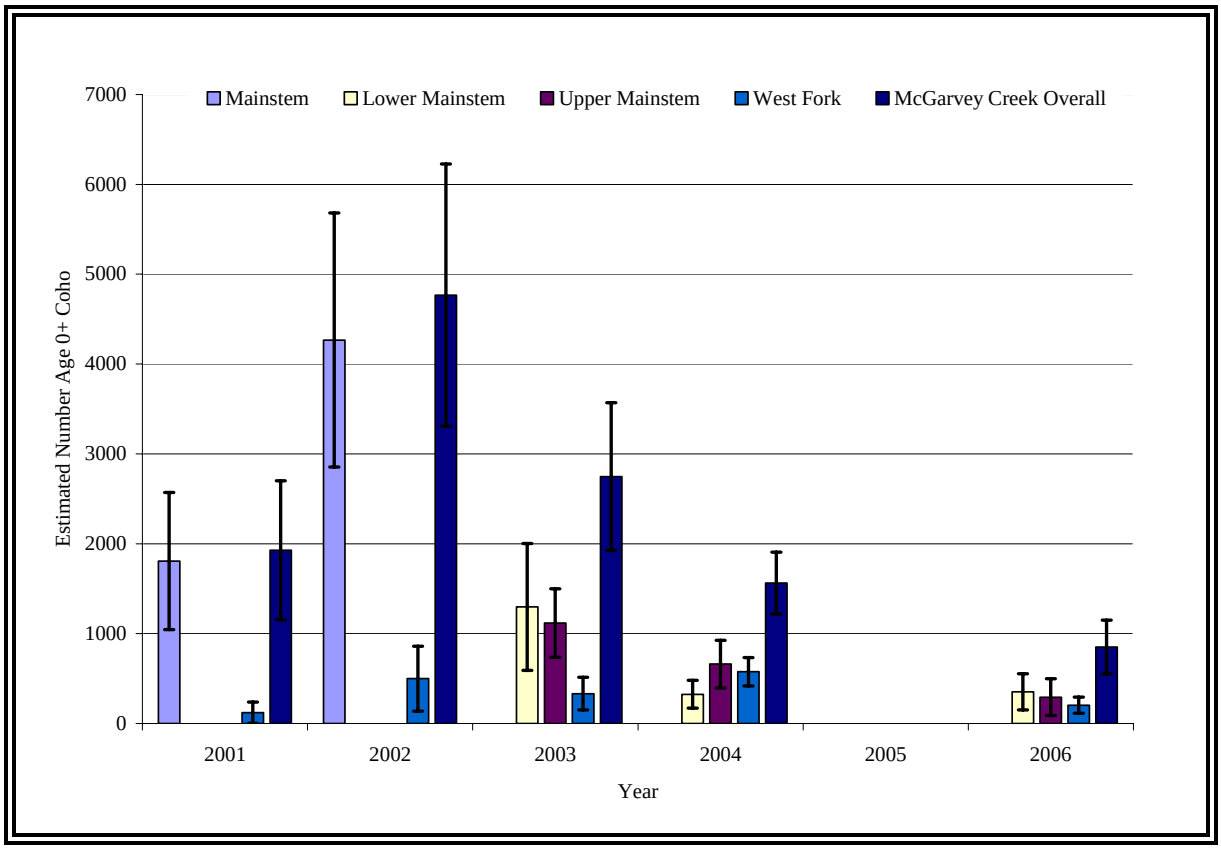

Figure 4. Estimated abundance of age 0+ coho over-summering in McGarvey Creek, Lower Klamath River, California, 2001-2004, and 2006.

The overall downward trend of juvenile coho summer abundance since 2002 is apparent. The abundance of coho present in 2005, however, is unknown pending further analysis (Figure 4), and as previously mentioned, 5-6 years is too short a time period to draw solid trend conclusions from. Qualitative knowledge of 2005 survey results confirmed that '05 abundance was more similar in magnitude to the 2002 results than any other year since. Therefore, it appears that one of the three independent year classes of coho (2002 & 2005) is relatively much stronger than the other two in McGarvey Creek. The weaker year classes of 2003 & 2006 are linked as well, and show an approximate decline from ~2850 juvenile fish to 850 fish in just one generation, an alarming observation when placed in the further context of population viability. Again, a longer time period, of study along with the finalization of 2005 data analyses is needed to further confirm these apparent patterns.

Juvenile age 0+ trout abundance

Similar to juvenile coho, total estimated abundance of age 0+ trout in McGarvey Creek during late summer 2006 was lower than any result observed during 2002-2004: 1033 age 0+ trout +/- 248 fish (95% CI) were collectively estimated for the McGarvey Creek basin (Table 2; Figures 3, 5). This total represented approximately 37% of the overall 2004 estimate (N=2,757 +/- 464 trout) (Figure 5).

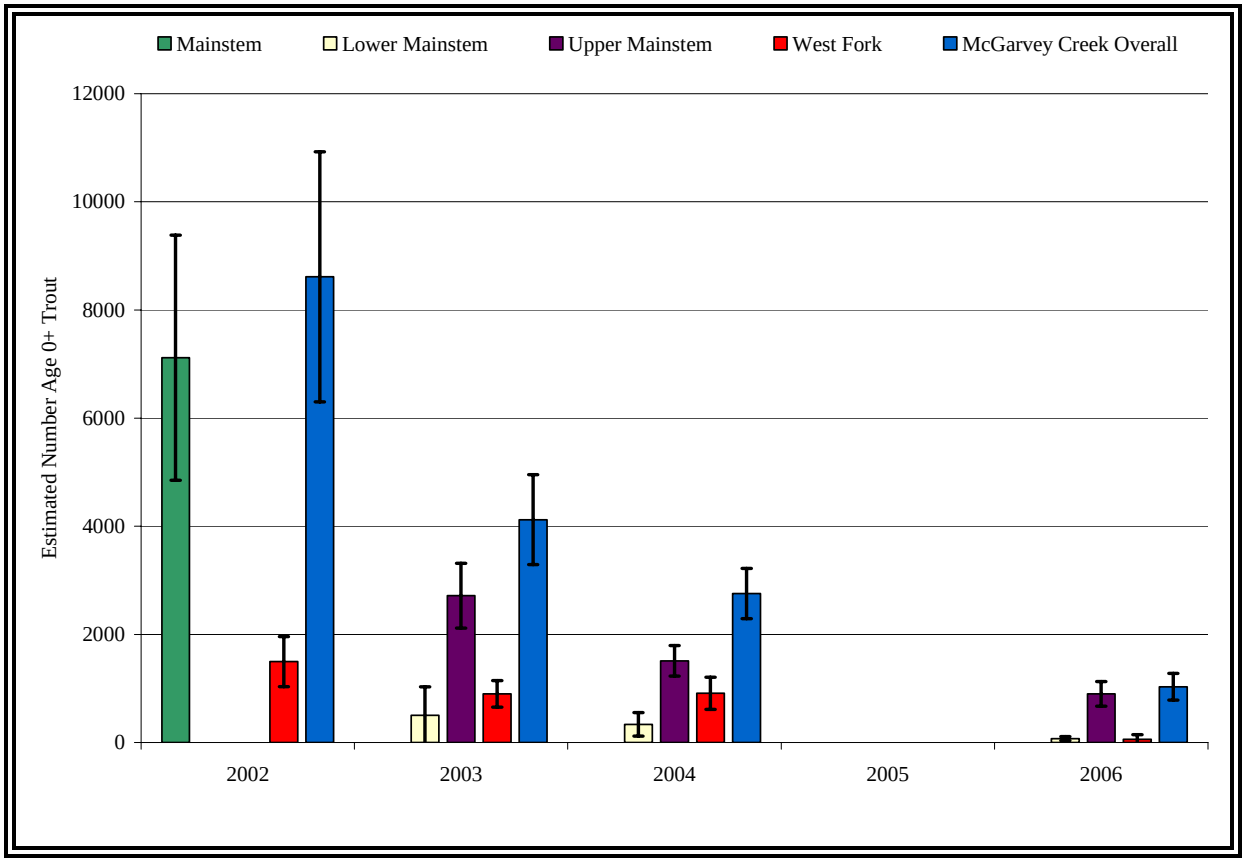

Figure 5. Estimated abundance of age 0+ trout over-summering in McGarvey Creek, Lower Klamath River, California, 2002-2004, and 2006.

In 2006, the Lower Mainstem reach held an estimated 72 age 0+ trout +/- 37 fish (95% CI), the Upper Mainstem reach supported an estimated 899 +/- 230 age 0+ trout, and the West Fork reach held an estimated 61 +/- 87 trout (95% CI) (Table 2, Figure 3). Estimated abundance of age 0+ trout decreased in all three McGarvey Creek reaches relative to 2004 results, and continues a downward trend of observed abundance since 2002. Estimated age 0+ trout abundance declined most dramatically in the Lower Mainstem and West Fork reaches versus 2002-2004 results (Figure 5).

Although abundance declined across the watershed, one finding was consistent with previous survey results: the relative majority of age 0+ trout summer production occurs in the upper mainstem McGarvey Creek reach (Figure 5).

In 2006, approximately 87% of the overall age 0+ trout estimate were rearing in the Upper Mainstem reach versus approximately 54 % in 2004. The relative proportion of age 0+ trout found in the upper mainstem between 2004 and 2006 increased dramatically, and is of concern because of the implications that suitable spawning habitats are limiting in the West Fork and Lower Mainstem reaches. The overall downward trend of age 0+ trout summer abundance across the watershed since 2002 is irrefutable (lacking 2005

data), and mirrors somewhat the observed trends of age 0+ coho abundance (Figures 4, 5).

Juvenile age 1+ trout abundance

Total estimated abundance of age 1+ trout in the McGarvey Creek watershed during late summer 2006 was calculated to be 979 trout +/-382 fish (95% CI) (Table 2; Figures 3, 6). Unlike results for juvenile coho and age 0+ trout, these findings represented a small increase to observed overall 1+ trout abundance in 2004 (=851 age 1+ fish +/- 218 trout) (Figure 6).

In 2006, the Lower Mainstem reach held an estimated 295 age 1+ trout +/- 143 fish (95% CI), the Upper Mainstem reach supported an estimated 243 +/- 247 age 1+ trout, and the West Fork reach held an estimated 211 +/- 54 trout (95% CI) (Table 2, Figure 3). Relatively high variance and wide confidence bounds in the Upper Mainstem Reach contributed greatly to the higher than expected uncertainty with the overall estimate (Table 2, Figure 6). Estimated abundance of age 1+ trout represented an increase in the Lower Mainstem reach, and small decreases in the West Fork and Upper Mainstem reaches relative to 2004 results (Figure 6).

Overall estimated abundance of age 1+ trout appears to vary year to year, but has remained fairly consistent within the McGarvey Creek watershed with no clear-cut trends evident since 2002. This pattern is also quite different than observed findings for age 0+ coho and age 0+ trout which have shown overall abundance declines each year (Figure 6).

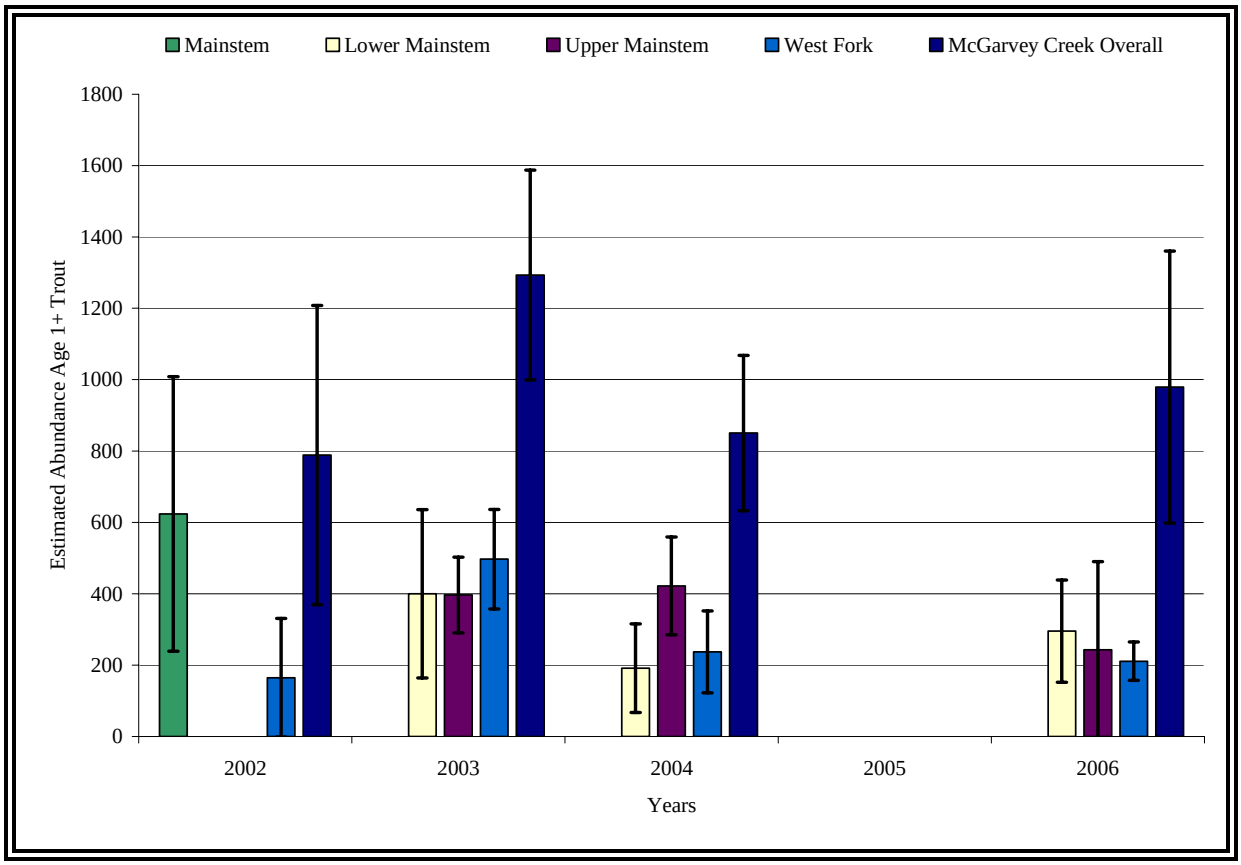

Figure 6. Estimated abundance of age 1+ trout over-summering in McGarvey Creek, Lower Klamath River, California, 2002-2004, and 2006.

Summary and Conclusions

Estimated overall abundance of age 0+ coho and age 0+ trout in 2006 decreased relative to findings between 2001 and 2004 for the McGarvey Creek basin. Relative proportions of estimated species abundance between reaches appears to vary more annually for age 0+ coho and age 1+ trout than for age 0+ trout. Since both juvenile coho and presmolt trout have been frequently documented as making extensive upstream and downstream movements, the varying proportional use of the three McGarvey reaches between years for these fish is not surprising (Nickelson et al. 1992; Leider et al 1986). In addition (Bramblett et al. 2002) found that steelhead abundance was higher in mainstem river habitats than tributaries during summer months versus the situation where coho were found in tributaries year round. The apparent importance of the Upper Mainstem Mcgarvey Creek reach for age 0+ trout can likely be tied to the existence of the best remaining spawning habitat in the basin, as well as contributions from resident populations above anadromous barriers.

Annual spring outmigrant smolt estimates for the McGarvey Creek basin have frequently indicated much higher estimates of salmonid production than would be predicted from the previous late summer population estimate (YTFP unpublished data 1996-2007). Recent YTFP studies investigating fall and winter non-natal movements of salmonids out

of the mainstem Klamath River into lower river tributaries such as McGarvey Creek have shown consistent and widespread upstream and downstream movements of salmonids throughout the fall and winter months, complicating the formulation of a "native" smolt production estimates for streams such as McGarvey Creek. In fall 2007 large numbers of presmolt coho and juvenile steelhead and cutthroat were documented upstream from the river (YTFP unpublished data 2007). YTFP's current ongoing study is employing PIT tags in both coho and trout as a means to track individual fish residency, growth, and attain an approximation of the magnitude of non-natal rearing that occurs in McGarvey Creek.

The importance of this low gradient stream with abundant cover during fall and winter months, however, appears to be much greater for nonnatal rearing opportunities than previously understood (YTFP unpublished data 2006-2008). Preliminary genetics results from summers 2002-03 have shown an almost complete lack of homozygous (pure) age 0+ steelhead residing in McGarvey Creek during summer months (Voight 2008 in progress). Thus it is possible that a large proportion of steelhead enumerated each spring at YTFP's outmigrant trap are not native to the McGarvey basin (i.e.: had entered sometime during fall-winter months).

YTFP continued the annual late summer single stream estimation of juvenile salmonids in the McGarvey Creek during 2007 and preliminary qualitative results indicate similar findings as 2006 efforts. Continuing this valuable baseline data set will not only provide crucial data for ESA recovery planning but also provide a means to track the relative response over time of fish populations to the extensive watershed restoration work the Yurok Tribe has already completed in the basin.

The decreases of abundance for both age 0+ coho and age 0+ trout over the past five years is troubling from a biological perspective as there is no obvious single causal agent can be readily identified besides the large amounts of fine sediments found throughout the basin. The amount of quality spawning habitat in McGarvey Creek appears to becoming a limiting factor for young of the year production and merits further investigation.

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