Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2012

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NOTE TO THE READER

Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement and Ocean Harvest in 2012 presents important data for the improvement of Central Valley salmon management. Until 2007, only experimental releases of fall-run Chinook salmon from Central Valley hatcheries were marked and coded-wire tagged (low, inconsistent numbers), resulting in a lack of data for harvest management, evaluation of hatchery rearing and release practices, hatchery impacts to natural-origin fish, and the success of habitat improvement programs.

The Central Valley Constant Fractional Marking Program (CFM) was initiated in 2007 to estimate in a statistically valid manner the relative contribution of hatchery production and to evaluate the various release strategies being employed in the Central Valley. Beginning with Brood Year 2006 fall-run Chinook, the program has marked and coded-wire tagged a minimum of 25 percent of releases from the Central Valley hatcheries each year (Buttars 2007, 2008, 2009, and 2010). The program is a cooperative effort of the California Department of Fish and Wildlife (CDFW), the California Department of Water Resources (DWR), the U.S. Bureau of Reclamation, the U.S. Fish and Wildlife Service (FWS), the East Bay Municipal Utilities District (EBMUD), and the Pacific States Marine Fisheries Commission (PSMFC).

In 2012, more than 67,000 Code Wire Tags were recovered from ad-clipped Chinook sampled in Central Valley natural area spawning surveys, at Central Valley hatcheries, Central Valley river creel surveys, and California commercial and recreational ocean fisheries. All of the fall run Chinook Code Wire Tags recovered in the Central Valley were tagged as part of the CFM program.

This report is the third annual evaluation by CDFW's Ocean Salmon Program and evaluates the 2012 Central Valley fall, spring, and late fall runs Chinook Code Wire Tags recovery data in accordance with program objectives.

As with all of its products, CDFW is interested in comments on the utility of this document, particularly regarding its application to monitoring and management decision processes. Therefore, we encourage you to provide us with your comments. Comments should be directed to Brett Kormos, (707) 576-2893, Brett.Kormos@wildlife.ca.gov and Melodie Palmer-Zwahlen, (707) 576-2870, Melodie.Palmer@wildlife.ca.gov, Marine Region, 5355 Skylane Blvd. Suite B, Santa Rosa, CA 95403.

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INTRODUCTION

Each year, approximately 32 million fall-run Chinook salmon (*Oncorhynchus tshawytscha*) are produced at five hatcheries in California's Central Valley (CV): Coleman National Fish Hatchery (CNFH), Feather River Hatchery (FRH), Nimbus Fish Hatchery (NFH), Mokelumne River Hatchery (MOK), and Merced River Hatchery (MER). Production from these hatcheries contributes to sport and commercial fisheries in ocean and inland areas. Prior to 2007, only small experimental releases (generally less than 100,000 fish) of CV fall-run salmon were consistently released with microscopic (≤ 1 mm) coded-wire tags (CWT) inserted in their snouts. Each CWT contains a binary or alpha-numeric code that identifies a specific release group of salmon (e.g., agency, species, run, brood year, hatchery or wild stock, release size, release date(s), release location(s), number tagged and untagged). Any CV salmon containing a CWT is also externally marked with a clipped adipose fin (ad-clipped) to allow for visual identification. Almost all of the fall-run salmon production releases from CV hatcheries were either untagged or tagged at inconsistent and relatively low rates prior to 2007.

In 2004, the CALFED Ecosystem Restoration Program (ERP), under the direction of the Central Valley Salmon Project Work Team (CVSPWT), funded a study to design a constant fractional marking (CFM) and coded-wire tagging program for CV fall-run salmon production at all CV hatcheries. The primary goal of this program was to estimate the relative contribution of hatchery production to harvest and escapement in a statistically valid manner, and to evaluate the various release strategies being employed throughout the CV. The study recommended the implementation of a system-wide marking and tagging program for production releases. Planning studies indicated an optimum marking and tagging rate of 33% for all CV fall-run salmon production releases (Hicks et al. 2005). Following subsequent review of the planning study recommendations, and communication with managers in the Northwest, the CVSPWT recommended a minimum marking and tagging rate of 25% for all fall-run production releases. The CVSPWT is an interagency group tasked with coordinating salmon and steelhead monitoring activities in the CV and it helped develop the CFM program. CVSPWT members included staff from the California Department of Fish and Wildlife (CDFW), California Department of Water Resources (DWR), Central Valley Project Water Association, East Bay Municipal Utility District (EBMUD), Metropolitan Water District, National Marine Fisheries Service (NMFS), Pacific States Marine Fisheries Commission (PSMFC), U.S. Bureau of Reclamation (BOR), and the U.S. Fish and Wildlife Service (FWS) .

Beginning with brood year 2006, at least 25% of fall-run salmon production releases at CNFH (12-13 million), FRH (9-10 million), NFH (5-6 million), and MOK (4-5 million) have been marked and tagged each spring (Buttars 2007, 2008, 2009, 2010, 2011, 2012). However, due to extremely low production numbers, MOK marked and tagged all of its fall-run salmon releases for brood years 2008 and 2009. In addition, all of the experimental fall-run salmon releases (50,000-175,000 fish) at MER, the spring-run salmon releases at FRH (2 million fish), late-fall-run salmon releases at CNFH (1 million fish), and winter-run salmon reared at Livingston Stone National Fish Hatchery (100,000-200,000 fish) have been marked and coded-wire tagged each year.

During 2012, more than 67,000 CWTs were recovered and successfully read from ad-clipped salmon sampled in CV fall-, spring-, and late-fall-run natural area spawning surveys, at CV hatcheries, in CV river angler surveys, and in California ocean commercial and recreational fisheries. All of the fall-run production CWTs recovered in 2012 were tagged as part of the CFM program. This report evaluates the 2012 CV fall-, spring-, winter-, and late-fall-run salmon CWT recovery data in accordance with program objectives. In particular, this report attempts to answer the following questions with this third complete year of recovery data:

- What are the proportions of hatchery- and natural-origin salmon in spawning returns to CV hatcheries and natural areas, in inland harvest, and in ocean harvest? Of the hatchery proportions, what proportions originated from in-basin versus out-of-basin CWT recoveries?

- What are the relative recovery and stray rates for hatchery salmon released in-basin versus salmon trucked to and released into the waters of the Carquinez Strait? The latter includes salmon acclimated in net pens that are pulled by boat for several hours into San Pablo Bay before they are released. In addition, salmon trucked to and held for several days in coastal net pens before release are also evaluated.

- What are the relative recovery rates for salmon acclimated in net pens and released in San Francisco-San Pablo bays or ocean versus salmon released directly into the waters of the Carquinez Strait?

- What are the relative contribution rates of hatchery salmon, by run and release type, to the ocean harvest?

DATA AND METHODS

Inland Escapement Monitoring

During 2012, monitoring of salmon escapement occurred at all five salmon hatcheries and on major rivers and tributaries throughout the CV. In addition, angler surveys were conducted on sport fisheries in the Sacramento, Feather, American, and Mokelumne river basins. Returning salmon were counted and 100% of the ad-clipped salmon were sampled at all CV hatcheries except CNFH where snouts were collected from every fifth ad-clipped salmon observed during most of the fall-run escapement period due to the high volume of salmon returning. Sampling was increased to 100% in late November as the fall-run escapement declined and the late-fall-run escapement began. It should be noted that the late-fall-run escapement at CNFH and in the upper Sacramento River in this report is actually considered the 2013 return year. Although this differs from the reporting scheme used in the 2010 and 2011 CFM reports, it allows direct comparison of CWT recoveries between fall and late-fall escapement. It also aligns sample periods with the upper Sacramento River fall-run and late-fall-run angler surveys. Sample rates and methods (e.g., carcass surveys, weir counts, redd counts) continue to vary among natural spawner surveys throughout the CV (Table 1).

There were 57,908 ad-clipped salmon observed and 41,838 heads collected by various CV projects. Monitoring agencies and projects included CDFW, DWR, EBMUD, FWS, PSMFC, Yuba Accord River Management Team, and the Fisheries Foundation. Most heads were processed by CDFW at their Santa Rosa and Sacramento CWT labs with the exception of 7,147 heads collected from Clear Creek and CNFH that were processed by FWS staff at the Red Bluff FWS office. An additional 2,800 heads were processed by individual projects, most notably at the Red Bluff and La Grange CDFW offices. Their respective data were submitted to the Santa Rosa CWT Lab for inclusion in the 2012 CV CWT recovery database. Almost 97% (40,437) of all heads collected contained a valid CWT, 2.5% of heads had shed their CWTs prior to processing, and less than 1% contained CWTs that were either too damaged to read or lost during processing.

Total escapement estimates and the number of salmon sampled for ad-clips in this report were provided by individual CV projects or hatcheries. All CWT recoveries, along with their respective catch-sample data, were uploaded to the Regional Mark Processing Center (RMPC) with the exception of CWTs processed by FWS, which is responsible for uploading its own data. All California CWT recoveries from 2012 are readily accessible at www.rmpc.org.

Ocean Harvest Monitoring

Since 1962, the CDFW's Ocean Salmon Project (OSP) has monitored California's ocean salmon fisheries at approximately 20 ports between Point Conception and the California-Oregon border. The goal of OSP is to sample at least 20% of all salmon landed in California sport and commercial ocean salmon fisheries to determine average weights, catch-per-unit-of-effort, and other metrics used to estimate the total salmon catch and effort by fishery, port area, and half-month period. In addition, the heads are collected from all ad-clipped salmon observed during sampling to recover CWTs and determine the contribution of specific salmon stocks to these fisheries by time and area.

In 2012, the seasons for California sport and commercial ocean salmon fisheries (Table 2) were less constrained than in recent years due to an increase in the ocean abundance of both Sacramento River and Klamath River fall-run salmon. Field staff sampled 113,760 salmon and collected 28,773 heads that were processed by the Santa Rosa CWT lab. Almost 93% (26,625) of these heads contained a valid CWT, 7% were missing CWTs and less than 1% contained CWTs that were too damaged to read or lost during processing. Although it is generally agreed that CWTs missing from the CV inland head recoveries are most likely the result of salmon "shedding" these tags prior to release, this cannot be assumed for heads recovered from mixed-stock ocean fisheries. Oregon and Washington hatcheries have been "mass-marking" salmon (i.e., ad-clip only without a CWT) to support small mark-selective fisheries in the Pacific Northwest. During the last several years, OSP has noticed a gradual increase in the number of ocean heads processed which do not contain a CWT, especially those collected in California's northern ports. This is most likely due to an increase in the number of mass-marked (i.e., ad-clipped without CWTs) Chinook salmon produced by Oregon and Washington (Nandor et al. 2010), primarily to support their respective mark-selective fisheries.

CWT Data Analysis

A "master" release database of CWT codes was created to determine species, brood year, run, stock origin (hatchery or natural), release site, release date(s), number of salmon CWT tagged, total number of salmon released, and any other pertinent release information (e.g., trucked, net pen acclimation, disease) for all 2012 CWT recoveries. All west-coast CWT release data for broods 2008 through 2011 were downloaded from the RMPC. Approximately 102 million CV salmon were released for these four brood years (BY), of which 37.6 million fish were marked and tagged utilizing 441 unique CWT codes. Although a few natural-origin salmon are trapped, marked, and tagged each year, salmon produced by hatcheries make up more than 98% of all CWT releases. In 2012, there were 297 individual CWT codes recovered in the CV, primarily from age-2, age-3 and age-4 salmon. The CWT master file was updated with any additional information obtained for these CV salmon releases (e.g., number of untagged salmon associated with BY 2008 fall-run CNFH production CWT releases) and the production factor calculated for each CWT code. The production factor, $F_{\text{prod},}$ is the ratio of the total number of salmon released to the total number of salmon marked containing a CWT. Thus it is the total number of salmon (i.e., tagged and untagged) represented by each CWT recovery. F_{prod} was calculated for each CWT code and is defined as,

$$F_{\text{prod}} = (\text{Ad.CWT} + \text{Ad.noCWT} + \text{noAd.CWT} + \text{noAd.noCWT}) \;/\; \text{Ad.CWT}\,,$$

where Ad.CWT is the number of salmon released with ad-clips and CWTs, Ad.noCWT is the number of salmon released with ad-clips but without CWTs (i.e., shed tags prior to release or CWT not correctly inserted), noAd.CWT is the number of salmon released without ad-clips but with CWTs, and noAd.noCWT is the number of salmon released without ad-clips and without CWTs. F_{prod} allows expansion to total hatchery production from observed recoveries of CV CWTs.

For this analysis, each CV CWT release was further classified into "release types" based on the following criteria: run, stock, hatchery or natural, production or experimental, release location, and holding strategy. All CV CWT codes were assigned by brood year into one of 15 fall-run release types (including two "wild" releases), two spring-run release types, one late-fall-run release type, and one winter-run release type:

<u>Sacramento River Basin fall-run Chinook salmon release types</u>

CFHFh	Coleman National Fish Hatchery fall-run in-basin (at hatchery) releases
CFHFn	Coleman National Fish Hatchery fall-run net pen releases
FRHFe	Feather River Hatchery fall-run experimental releases (includes spring x fall hybrid salmon)
FRHFn	Feather River Hatchery fall-run net pen releases
FRHFnc	Feather River Hatchery fall-run net pen coastal releases (Santa Cruz)
FRHFtib	Feather River Hatchery fall-run Tiburon net pen releases (held several months)
FeaFw	Feather River fall-run wild
NIMF	Nimbus Fish Hatchery fall-run in-basin releases
NIMFn	Nimbus Fish Hatchery fall-run net pen releases

<u>San Joaquin River Basin fall-run Chinook salmon release types</u>

MOKF	Mokelumne River Hatchery fall-run in-basin releases
MOKFn	Mokelumne River Hatchery fall-run net pen releases
MOKFt	Mokelumne River Hatchery fall-run trucked releases (no net pen acclimation)
MokFw	Mokelumne River fall-run wild
MERF	Merced River Hatchery in-basin fall-run releases
MERFt	Merced River Hatchery fall-run trucked releases (no net pen acclimation)

Central Valley spring-run Chinook salmon release types

FRHS Feather River Hatchery spring-run in-basin releases
FRHSn Feather River Hatchery spring-run net pen releases

Central Valley Late-Fall-run Chinook salmon release types

CFHLh Coleman National Fish Hatchery late-fall-run in-basin (at hatchery) releases

Sacramento River winter-run Chinook salmon release types

SacW Livingston Stone Hatchery winter-run in-basin releases (Lake Redding Park)

It should be noted that not all release types occur every brood year and that release sites sometimes vary within a given release type (Table 3; Figure 1). There were also a few problem CWT releases where runs were mixed prior to CWT tagging or released utilizing various strategies (e.g., known pairs of FRH fall- and spring-run salmon spawned and identified by CWT subsequently released as experimental “hybrid” salmon for Delta studies; one fourth of Mokelumne “trucked” fall-run salmon were acclimated in net pens prior to release). Thus caution is urged when analyzing or comparing CWT recovery data from these releases.

To facilitate the breakout of the hatchery proportion by stock and release strategy, all release types from the same hatchery/basin were given the same color scheme (Figure 2) in all pie chart figures. All net pen releases, except salmon released from coastal net pens in Santa Cruz and Tiburon, contain black dots. Coastal net pen releases are designated with a criss-cross pattern while Tiburon net pen releases are designated with the same black stripes used for trucked releases in the San Joaquin basin.

To estimate the total escapement (or harvest) associated with each CWT recovery, each tag recovery was expanded by its respective F_{prod} and sample expansion factor, F_{samp}, which is defined as,

$$F_{\mathrm{samp}} = 1 \ / \ (f_e \times f_a \times f_d),$$

where f_e is the fraction of the total salmon escapement sampled and visually examined for an ad-clip, f_a is the fraction of heads from ad-clipped salmon collected and processed, and f_d is the fraction of observed CWTs that were successfully decoded (Tables 4 and 5).

Mohr and Satterthwaite (2013) demonstrated how the potential misidentification of ad-clipped salmon in mark-and-recapture carcass surveys can significantly bias estimations of the total hatchery contribution since survey crews frequently encounter both fresh and non-fresh (decayed) carcasses. Salmon sampled in CV carcass surveys are generally classified as ‘fresh’ or ‘decayed’ based on criteria such as condition of the eyes (clear vs. opaque) or gills (pink vs. grey). Often the ad-clipped (marked) status of a decayed salmon cannot be ascertained due to the deteriorating condition of the carcass. Mohr and Satterthwaite (2013) identified four possible outcomes: 1) certain (all ad-clipped and non-marked salmon are correctly identified), 2) false negatives (ad-clipped salmon identified as not marked), 3) false positives (non-marked salmon identified as ad-clipped) or 4) false negatives/positives (ad-clipped salmon identified as non-marked and non-marked salmon identified as ad-clipped).

While condition criteria are somewhat ambiguous and classification may be inconsistent among surveys, differences in the ad-clip rate between fresh and decayed fish continued to be observed. In the carcass surveys that collected condition criteria for fall-run salmon during 2012 (Appendix 1), 22% of fresh salmon sampled were ad-clipped compared to 9% of the decayed salmon (i.e., false negative). Fresh carcass heads also contained CWTs at a slightly higher rate than heads collected from decayed carcasses (i.e., false positive). Furthermore, the sample sizes between fresh and decayed fish were also different, with the number of decayed salmon sampled (n=15,581) almost five times greater than the number of fresh salmon sampled (n=3,293).

Mohr and Satterthwaite (2013) demonstrated how the differences noted above negatively biased the hatchery contribution estimations for the 2010 upper Sacramento River fall-run and late-fall-run salmon carcass surveys reported in Kormos et al. (2012). They also cautioned that using only fresh CWT data may eliminate the occurrence of rare CWT codes in analyses due to the small sample sizes common with fresh carcasses in these surveys. As in the 2011 CFM report, the following equation developed by Mohr and Satterthwaite (2013) was used to calculate F_{samp} for carcass surveys collecting fish condition data, thus reducing the potential bias associated with these surveys:

$$F_{\mathrm{samp}} = (N \text{ x } p\_{adc|fresh} \text{ x } p\_{cwt|fresh,adc}) / (n_{valid\ cwt}),$$

where N = estimated total escapement, $p\_{adc|fresh}$ = proportion of fresh salmon sampled that were ad-clipped, $p\_{cwt|fresh,adc}$ = proportion of ad-clipped fresh salmon that contained a CWT, and $n_{valid\ cwt}$ = total number of valid CWTs collected from fresh and decayed salmon.

We assume that the calculated hatchery contribution rates for the other carcass mark-and-recapture surveys that did not collecting fish condition in this report are most likely negatively biased due to the issues identified above.

There were 60 CWTs recovered from heads collected opportunistically during redd surveys or other monitoring of the natural escapement in four watersheds (Deer Creek, Mill Creek, Calaveras River, Cosumnes River). Since these CWTs were collected from either a small area of the entire spawning grounds or over a brief temporal period and were not representative of the total escapement, we were unable to calculate their F_{samp} and these CWT recoveries were uploaded to the RMPC with a F_{samp} of 0.00 (i.e., no estimation available). However, instead of disregarding these recoveries in this report, we treated each CWT recovery as a single fish, multiplying each by its respective production factor to estimate the minimum total escapement associated with each CWT recovery.

It should also be noted that there has not been a carcass survey or CWT recovery program conducted in Battle Creek since 2005; thus it was not possible to determine the hatchery contribution, recovery rate, or straying into the natural escapement of this tributary. The total natural area escapement is currently estimated by subtracting the number of salmon returning to CNFH from the total video weir count into Battle Creek. The hatchery contribution to the natural area escapement in Battle Creek is considered equivalent to the hatchery fall-run return sampled at CNFH (R. Null, FWS, pers. comm.).

Another pertinent issue to consider when evaluating the information in this report is the overlap of spring- and fall-run spawners in the Feather and Yuba rivers. Although generally categorized as fall-run surveys, natural escapement estimates in these rivers consist of both runs and should be considered when analyzing hatchery contribution, recovery rates, and straying.

To help delineate between raw CWT recoveries, CWT recoveries expanded for production, CWTs expanded for sampling, and CWTs expanded for production and sampling, the following nomenclature was used:

CWT = Raw count CWT recoveries
CWT_{prod} = CWT recoveries expanded only by their respective production factor, F_{prod}
CWT_{samp} = CWT recoveries expanded only by their respective sample expansion factor, F_{samp}
CWT_{total} = CWT recoveries expanded by both F_{prod} and F_{samp}

Determining hatchery- and natural-origin proportions in CV escapement and harvest
To determine the contribution of hatchery- and natural-origin salmon, all CWT_{total} were summed to estimate the total number of hatchery salmon in each survey. The contribution of natural-origin salmon for each survey was then determined by subtracting the total number of hatchery salmon from the total escapement estimate, as follows:

$$\text{Estimate of natural-origin salmon} = \text{Total escapement estimate} - \sum_{i=1}^{m} CWT_{total,i} \ ,$$

where m = total number of hatchery-origin CWT release groups identified in an escapement survey or hatchery.

Determining recovery rates of various release types in CV escapement and ocean harvest
To determine the relative CV recovery rate, R_{cwt}, of each unique CWT release group (i.e., code), all recoveries were expanded by their location-specific F_{samp}, summed over all recovery locations, and then divided by the total number of salmon tagged and released with this CWT. Since expanded recoveries for several individual CWT groups were less than 0.001% of the total number released, recovery rates are reported in recoveries per 100,000 CWT salmon released, as follows:

$$R_{cwt} = \sum_{j=1}^{l} CWT_{samp,j} \text{ recoveries } / \text{ (CWT release group size / 100,000)} \ ,$$

where j (=1,2,3,,,l) denotes recovery location.

Data from all CWT release groups belonging to the same brood year and release type were combined and an overall release type-specific CV recovery rate, R_{type}, was calculated as:

$$R_{type} = \sum_{j=1}^{l} \sum_{k=1}^{n} CWT_{samp,j,k} \ / \ (\sum_{k=1}^{n} \text{release group size of } CWT_k \ / \ 100{,}000) \ ,$$

where k (= 1,2,3,,,n) denotes release group.

Determining stray proportions of various release groups in CV escapement

To be consistent with the last two reports (Kormos et al. 2012, Palmer-Zwahlen and Kormos, 2013), basin of origin is defined here as the drainage of any major river as it pertains to the geographic region of the CV where a hatchery is located. The CV was segregated into five primary hatchery basins: upper Sacramento River (including Battle Creek), Feather River (including the Yuba River), American River, Mokelumne River, and the Merced River. Hatchery-origin salmon returning to streams not included in these five primary basins were considered to be strays. Any CWTs recovered outside of these defined basins of origin based on their reported stock or hatchery were considered strays.

Further evaluation of these definitions is warranted as future CFM recovery data become available and the definition of straying, as it pertains to sub-basins of the CV, is determined through hatchery program evaluation. To help facilitate this discussion, Appendix 2 presents alternative recovery and stray rates for CNFH and FRH CWT releases based on the assumption that recoveries in the upper Sacramento River and Yuba River, respectively, are strays.

To determine the CV stray proportion, S_{cwt}, for each CWT code, the sum of all CWT_{samp} recoveries collected outside the basin of origin was divided by total CV CWT_{samp} recoveries for that release group, as follows:

$$S_{\mathrm{cwt}} = \sum_{p=1}^{o} CWT_{samp,p} \text{ (out-of-basin locations) } / \sum_{p=1}^{q} CWT_{samp,p} \text{ (all CV locations),}$$

where p denotes recovery location, o denotes the number of out-of-basin recovery locations, and q denotes the total number of recovery locations.

Data from all CWT releases belonging to the same brood year and release type were then combined and release type-specific CV stray proportion, $S_{type,}$ was calculated as:

$$S_{type} = \sum_{p=1}^{o} \sum_{k=1}^{n} CWT_{samp,p,k} \text{ (out-of-basin) } / \sum_{p=1}^{q} \sum_{k=1}^{n} CWT_{samp,p,k} \text{ (all CV locations)}$$

RESULTS

General overview of 2012 CV inland recoveries and California ocean harvest

All except two of the 40,437 valid CWTs recovered in the CV during 2012 were from CV Chinook salmon releases. Most CWTs were brood year 2008 through 2010 releases (Table 6). More than 93% of all CWT_{total} recoveries were fall-run, followed by spring-run (5%), and late-fall-run (1%) salmon releases. Less than 1% of all CWT_{total} recovered were winter-run salmon, all of which were collected in their escapement carcass survey conducted in the upper Sacramento River. The two non-CV salmon were an age-2 fall-run Chinook salmon from Trinity River Hatchery and an age-3 coho salmon (*O. kisutch*); both salmon were recovered during spawning operations at FRH in early October. According to its release data, the coho salmon (Washington stock) was raised at FRH and released into Lake Oroville to provide sport fishing opportunity (the authors assume this fish escaped from Lake Oroville).

The majority of fall-run CWT_{total} recovered in the CV were age-3 (85%), age-2 (13%), and age-4 (2%) fish; a few age-1 and age-5 fish were also recovered (Table 6). Spring-run CWT_{total} recoveries consisted of age-3 (91%), age-2 (6%), and age-4 (3%) fish. Most of the late-fall-run CWT_{total} recovered were age-3 (81%), age-2 (11%), and age-4 (8%) with only two age-5 fish recovered. Almost all (99%) of the winter-run CWT_{total} recovered in the CV were age-3 fish.

Almost 96% of the 26,625 valid CWT recoveries from the California ocean harvest in 2012 were CV salmon releases belonging to brood years 2008 through 2010 (Table 7). Approximately 90% of all CWT_{total} in the ocean harvest were fall-run, followed by spring-run (2%), late-fall-run (1%), and winter-run (0.02%) salmon. The majority of fall-run CWT_{total} were age-3 (95%) and age-2 (3%) fish while age-3 (86%) and age-4 (14%) fish made up most of the late-fall-run catch. Age-3 (88%) and age-2 (12%) fish dominated the spring-run harvest and all winter-run CWT_{total} were age-3. The remaining 7% of ocean CWT recoveries originated from river basins in northern California (e.g., Klamath, Trinity, Smith) or the Pacific Northwest (e.g., Rogue, Chetco, Umpqua, Columbia); most were age-3 (85%) and age-4 (13%) fish.

1. Proportion of hatchery- and natural-origin salmon in CV escapement

The proportion of hatchery-origin salmon on natural area spawning grounds in 2012 varied throughout the CV and by run. The lowest hatchery proportion occurred in the Butte Creek spring-run salmon carcass survey where ad-clipped salmon were not encountered (0%), while the highest proportion (90%) was observed in the Feather River combined fall/spring-run salmon carcass survey (Figure 3).

The hatchery proportion of fall-run salmon returning to CV hatcheries ranged from 79% to 96% (Figure 4). The spring-run return to FRH was 99% hatchery-origin salmon whereas the late-fall-run return to CNFH was almost 100% hatchery-origin salmon. The percentage of hatchery- and natural-origin salmon contribution to the total escapement for all surveys by release type is shown in Table 8.

Upper Sacramento River Basin

Nine escapement surveys were conducted in the Upper Sacramento River Basin that allowed for expansion of CWTs: fall-run and late-fall-run (2013) salmon counts at CNFH; winter-run, fall-run and late-fall-run (2013) salmon mark-recapture carcass surveys in the mainstem Sacramento River; a fall-run salmon mark-recapture carcass survey in Clear Creek; a video count and associated carcass survey in Cottonwood Creek; and spring- and fall-run salmon mark-recapture carcass surveys in Butte Creek.

At CNFH, sampling of the fall-run return began on 2 October 2012 and continued through 5 December 2012. Due to the high number of ad-clipped salmon returning, marked fish were subsampled at a 19% rate through 20 November 2012 and 100% thereafter. After a two week break, CNFH began late-fall sampling (100%) on 20 December 2012 and continued through 28 February 2013. Based solely on the run-timing above, 85,283 salmon returned to CNFH during the “fall” run period, and 2,570 salmon returned during the “late-fall” run period; however, based on composition of CWT recoveries, it was determined that there was significant overlap between runs, especially during the 20 November 2012 through 5 December 2012 time period. To prevent cross-mating of runs, spawning and collection of eggs from fall-run salmon only occurred on or before 2 November 2012 while late-fall egg collection began 29 December 2012. This successfully segregated spawning operations based on CWT recoveries from spawned fish (L. Mahoney, U.S. Fish and Wildlife Service, Red Bluff Office, pers. comm.).

Given the two sampling regimes used during the fall-run return and the overlap between runs, three catch-sample periods were created to calculate the sample expansion factor, F_{samp}, for each CWT collected at CNFH (Table 9). Subsequently, all CNFH late-fall salmon (*n*=998) collected during the fall-run sampling period were moved to late-fall counts and vice-versa for the CNFH fall-run salmon (*n*=4) collected during the late-fall-run sampling period. Non-CNFH recoveries were not moved. Based on this parsing, the final escapement numbers at CNFH were 84,289 fall-run and 3,564 late-fall-run salmon (Table 9).

Returns to CNFH were predominantly hatchery-origin salmon released from this facility, while escapement into natural areas was primarily natural-origin salmon with the exception of fall-run spawners in the upper Sacramento River (Table 8, Figures 5, 6, and 7), with the following composition based on CWT recoveries:

- Fall-run returns to CNFH were 91% hatchery-origin
- Late-fall-run returns to CNFH were 99% hatchery-origin
- Winter-run spawners in the upper Sacramento River were 29% hatchery-origin
- Fall-run spawners in the upper Sacramento River were 67% hatchery-origin
- Late-fall-run spawners in the upper Sacramento River were 4% hatchery-origin
- Fall-run spawners in Clear Creek were 40% hatchery-origin
- Fall-run spawners in Cottonwood Creek were 32% hatchery-origin
- Fall-run spawners in Butte Creek were 12% hatchery-origin
- Spring-run spawners in Butte Creek were 100% natural-origin

Four other escapement surveys in the Upper Sacramento River Basin were also conducted: video counts of fall-run salmon escapement with opportunistic collection of CWTs were conducted in Mill and Deer creeks, while redd surveys were conducted in the same creeks to estimate spring-run salmon escapement.

Feather River Basin

Five escapement surveys were conducted in the Feather River Basin: spring- and fall-run salmon counts at FRH, a combined fall/spring-run salmon mark-recapture carcass survey in the Feather River, a combined fall/spring-run salmon mark-recapture carcass survey in the Yuba River below Daguerre Point Dam (DPD), and a combined fall/spring-run salmon Vaki Riverwatcher video count above DPD with an associated carcass sample to collect CWTs and other bio-data. Since the Vaki Riverwatcher count included the total number of ad-clipped salmon entering the system, CWTs collected in the carcass survey were expanded based on the total ad-clip video count and the proportion of ad-clips containing CWTs above DPD. Spring- and fall-run salmon returns to FRH and in the Feather River were predominantly of hatchery-origin while escapement to the Yuba River had more natural-origin salmon (Table 8, Figures 7 and 8), with the following composition based on CWT recoveries:

- Spring-run returns to FRH were 99% hatchery-origin
- Fall-run returns to FRH were 96% hatchery-origin

- Fall/spring-run spawners in the Feather River were 90% hatchery-origin
- Fall/spring-run spawners in the Yuba River above DPD were 45% hatchery-origin
- Fall/spring-run spawners in the Yuba River below DPD were 27% hatchery-origin

American River Basin

Two escapement surveys were conducted in the American River Basin: fall-run salmon counts at NFH and a fall-run salmon mark-recapture carcass survey on the American River. In addition, salmon carcasses were recovered from the NFH weir, located just upstream of the hatchery. The weir was installed on 8 August 2012 to force returning salmon into NFH, and any salmon that migrated above prior to its installation were trapped between it and Folsom Dam, approximately one-quarter of a mile upstream. Nimbus staff inspected the weir daily and recovered 3,923 carcasses, of which 984 were ad-clipped. Based on the decomposed condition of these fish, it appeared most had died upstream and were "wash-backed" onto the weir by river currents (Paula Hoover, CDFW, pers. comm.). The fall-run salmon returning to NFH, collected on the weir, and spawning in the American River were predominantly of hatchery-origin (Table 8, Figure 9), with the following composition based on CWT recoveries:

- Fall-run returns to NFH were 85% hatchery-origin
- Salmon recovered on the NFH weir were 67% hatchery-origin
- Fall-run spawners in the American River were 73% hatchery-origin

Mokelumne River Basin

Two escapement surveys were conducted in the Mokelumne River Basin: fall-run salmon counts at MOK and a video weir count at Woodbridge Dam (WD) of fall-run salmon escapement to the Mokelumne River. An associated carcass survey was conducted above WD to collect CWTs and other bio-data.

All salmon migrating into the Mokelumne River to spawn were counted by the video fish counting device at WD operated by EBMUD. These counts included the total number of ad-clipped salmon. By subtracting the total number of fall-run salmon that returned to MOK (6,620) from the total video count (12,091) at WD, it was assumed that the remaining 5,471 salmon remained to spawn in natural areas of the Mokelumne River. Subtracting the 4,972 ad-clipped fish sampled at MOK from the 8,808 marked salmon counted in the video monitoring resulted in 3,836 ad-clips remaining in Mokelumne natural areas. In 2012, EBMUD instituted a systematic weekly survey to recover CWTs (639) from all reaches of the river utilized by spawning salmon above WD. Thus, CWTs collected were representative of the natural escapement and expanded based on the calculated total ad-clip count in natural areas and the proportion of ad-clips sampled containing CWTs at MOK. Returns at MOK and spawners in the Mokelumne River Basin were dominated by hatchery-origin salmon (Table 8, Figure 10), with the following composition based on CWT recoveries:

- Fall-run returns to MOK were 96% hatchery-origin
- Fall-run spawners in the Mokelumne River were 78% hatchery-origin

An escapement survey was also conducted on the Cosumnes River, a major tributary to the lower Mokelumne River. Total fall-run escapement was determined utilizing two surveys: redd counts below Granlees Dam (GD) and a Vaki Riverwatcher video count of fish migrating above GD. Although there was no representative sampling for ad-clipped salmon, 38 CWTs were collected opportunistically below GD, primarily during a one-week period in December. Expanding each CWT recovery by its respective F_{prod} provides a minimum estimate of the hatchery contribution in the Cosumnes River (Table 8) by release type and allows inclusion of these recoveries when calculating recovery and stray rates. Thus at least 4% (Table 8) of Cosumnes River fall-run escapement was hatchery-origin salmon, primarily from MOK. Although this is anecdotal information, it seemed a more appropriate approach than disregarding these and other CWTs collected opportunistically.

San Joaquin River Basin Tributaries

Besides the Mokelumne River Basin, four additional escapement surveys were conducted in tributaries of the San Joaquin River Basin that allowed for expansion of CWTs: fall-run salmon counts at MER, as well as fall-run salmon mark-recapture carcass surveys conducted on the Stanislaus, Tuolumne, and Merced rivers. Fall-run salmon returns to the Merced and Stanislaus rivers were dominated by hatchery-origin spawners while a higher proportion of natural-origin salmon was observed in the Tuolumne River (Table 8, Figure 11), with the following composition based on CWT recoveries:

- Fall-run returns at MER were 79% hatchery-origin
- Fall-run spawners in the Merced River were 87% hatchery-origin
- Fall-run spawners in the Stanislaus River were 83% hatchery-origin
- Fall-run spawners in the Tuolumne River were 36% hatchery-origin

One additional redd survey was conducted on the Calaveras River with opportunistic collection of CWTs and other bio-data. There were 12 CWTs collected and expanding each by its respective F_{prod} indicates at least 9% (Table 8) of the fall-run salmon escapement into Calaveras River was of hatchery-origin, primarily from salmon produced at MOK.

Inland Angler Creel Survey

Six separate angler creel surveys were conducted in the Sacramento River and its tributaries: upper and lower Sacramento River fall, American River fall, Feather River fall, Mokelumne River fall, and a late-fall-run survey on the upper Sacramento River. Sport fishing for Chinook salmon was closed in all other areas of the CV. All inland harvest was dominated by hatchery-origin salmon, except for the late-fall fishery in the upper Sacramento River (Table 8; Figures 12 and 13), with the following composition based on CWT recoveries:

- Upper Sacramento River fall-run harvest was 69% hatchery-origin
- Lower Sacramento River fall-run harvest was 84% hatchery-origin
- Feather River fall-run harvest was 79% hatchery-origin
- American River fall-run harvest was 78% hatchery-origin
- Mokelumne River fall-run harvest was 84% hatchery-origin
- Sacramento River late-fall-run harvest was 37% hatchery-origin

2. Relative recovery and stray rates for hatchery salmon released in-basin versus hatchery salmon trucked and released at offsite areas or into acclimation net pens (including Mare Island, Sherman Island, San Pablo Bay, Tiburon, and Santa Cruz Harbor).

Release strategies vary among hatcheries from year to year. This variability has often been in response to annual fluctuations in the abundance of certain stocks or differing policies among mitigating agencies with respect to “best” release practices. Although a few “problem releases” still existed, the 2008 through 2010 brood year releases were more consistent than the release types analyzed in earlier CFM reports (Kormos et. al. 2012, Palmer-Zwahlen and Kormos 2013). In 2012, there were 15 hatchery release groups consisting of 34 individual brood-specific release types recovered that allowed for direct comparison of release strategies or locations.

Table 10 summarizes the recovery rates, $R_{type,}$ (in-basin, stray, and ocean) for all release groups with representative recoveries from the CV and ocean in 2012. Recovery rates displayed here, in the following figures, and discussed below are scaled for comparison at total recoveries per 100,000 salmon released. Figures 14 and 15 provide a graphical representation of R_{type} for Sacramento River fall-run salmon and other CV stocks, respectively, and include the total number of salmon released with CWTs for each release type. With the exception of a few age-2 releases, salmon that were acclimated in net pens had higher relative recovery rates than their respective in-basin or trucked-only releases; however, net pen and trucked release types also had higher stray proportions than their paired in-basin counterparts in most cases.

Coleman National Fish Hatchery - Fall-run salmon brood years 2008, 2009, and 2010
For brood year (BY) 2010 CNFH fall-run salmon releases, the combined age-2 inland and ocean recovery rate for net pen CFHFn releases (99) was 1.3 times greater than in-basin CFHFh releases (76). While the total CV recovery rate was almost equivalent (60 net pen, 65 in-basin), the proportion of CFHFn out-of-basin recoveries was 82% compared to 2% for CFHFh. The CFHFn ocean recovery rate (39) was 3.5 times higher than that of CFHFh (11).

For BY 2009 CNFH fall-run salmon releases, the combined age-3 inland and ocean recovery rate for net pen CFHFn releases (1,684) was 1.4 times greater than in-basin CFHFh releases (1,188). Although the total CV recovery rate for CFHFn releases (616) was slightly less than the rate for CFHFh releases (718), the proportion of CFHFn out-of-basin recoveries was 74% compared to 1% for CFHFh. The CFHFn ocean recovery rate (1,068) was 2.3 times greater than that of CFHFh (470).

For BY 2008 CNFH fall-run salmon releases, the combined age-4 inland and ocean recovery rate for net pen CFHFn releases (33) was 2.8 times greater than in-basin CFHFh releases (12). The total CV recovery rate for CFHFn releases (19) was also double that of CFHFh (9) but most CFHFn recoveries occurred out-of-basin (76%). All CFHFh were recovered in-basin. The CFHFn ocean recovery rate (14) was 4.7 times higher than that of CFHFh (3).

Feather River Hatchery– Spring-run salmon brood years 2008, 2009, and 2010
For BY 2010 FRH spring-run releases, the combined age-2 inland and ocean recovery rate for in-basin FRHS releases (97) was 3.3 times higher than net pen FRHSn releases (29). The total CV recovery rate for FRHS releases (63) was also 3.7 times greater than that of FRHSn (17); all recoveries of both release groups occurred in-basin. The FRHS ocean recovery rate (34) was 2.8 times greater than that of FRHSn (12).

For BY 2009 FRH spring-run salmon releases, the combined age-3 inland and ocean recovery rate for net pen FRHSn releases (1,090) was 1.8 times greater than that of FRHS releases (600). The total CV recovery rate for FRHSn releases (820) was 1.7 times greater than that of FRHS

(492) although 11% of FRHSn were recovered out-of-basin while all FRHS CWTs were recovered in-basin. The FRHSn ocean recovery rate (270) was 2.5 times greater than that of FRHS (108).

For BY 2008 FRH spring-run salmon releases, the combined age-4 inland and ocean recovery rate for net pen FRHSn releases (25) was equivalent to that of FRHS releases (25). The total CV recovery rate for FRHSn releases (23) was essentially equal to that of FRHS (24) with all FRHSn and FRHS CWTs recovered in-basin. The FRHSn ocean recovery rate (1) was slightly less than that of FRHS (2).

Feather River Hatchery – Fall-run salmon brood years 2008, 2009, and 2010
All FRH releases for BY 2008, 2009, and 2010 utilized acclimation net pens with the exception of BY 2008, which included fewer than 500,000 hybrid (FRH spring x FRH fall) salmon released as experimental fish (FRHFe) throughout the lower Sacramento River Basin and Delta. FRH net pen releases were grouped based on the area of final release: San Pablo Bay FRHFn, Santa Cruz coastal net pen FRHFnc, and Tiburon net pen FRHFtib.

For BY 2010 FRH fall-run salmon releases, the combined age-2 inland and ocean recovery rate for San Pablo net pen FRHFn releases (160) was less than that of Tiburon net pen FRHFtib releases (201) but greater than that of coastal net pen FRHFnc releases (149). The CV recovery rate for FRHFn releases (134) was slightly less than that of FRHFtib releases (162) but both rates were an order of magnitude greater than that of FRHFnc releases (10). In addition, 3% and 14% of FRHFn and FRHFtib, respectively, were recovered out-of-basin; no FRHFnc CWTs were recovered out-of-basin. An opposite trend was observed in the ocean fisheries as the recovery rate of FRHFnc releases (139) was 5.3 and 3.6 times greater than the ocean recovery rates of FRHFn releases (26) and FRHFtib releases (39), respectively.

For BY 2009 FRH fall-run salmon releases, the combined age-3 inland and ocean recovery rate was highest for FRHFtib releases (4,303), followed by FRHFnc releases (2,207) and FRHFn releases (1,413). As seen with age-2, the CV recovery rates for FRHFtib releases (1,547) and FRHFn releases (833) were again an order of magnitude greater than that of FRHFnc releases (62) although it should be noted that FRHFnc had the highest proportion (22%) recovered out-of-basin compared to FRHFtib (17%) and FRHFn (13%). The ocean recovery rate was highest for FRHFtib releases (2,756), followed by FRHFnc (2,145) and FRHFn (580) releases. It should be noted that FRHFtib had the highest CV and ocean recovery rates observed among all broods and releases in 2012. Although FRHFnc had the second highest ocean recovery rate in 2012, it also had the lowest total CV recovery rate among age-3 releases.

For BY 2008 FRH fall-run salmon releases, the combined age-4 inland and ocean recovery rate for FRHFn releases (23) was slightly greater than both the experimental FRHFe hybrid release (19) and FRHFtib releases (11). However the CV recovery rates for FRHFe (18) and FRHFn (16) was an order of magnitude greater than that for FRHFtib (1). Approximately 7% of FRHFn were recovered out-of-basin compared to 1% of FRHFe; no FRHFtib were recovered out-of-basin. The ocean recovery rate was highest for FRHFtib releases (10), followed by FRHFn (7) and FRHFe (1) releases.

Nimbus Fish Hatchery – Fall-run salmon brood years 2008, 2009, and 2010
For BY 2010 NFH fall-run salmon releases, the combined age-2 inland and ocean recovery rate for net pen NIMFn releases (44) was 1.8 times lower than that of in-basin NIMF releases (79). The total CV recovery rate for NIMF releases (56) was 1.9 times greater than that of NIMFn (30), with 3% and 6% of NIMF and NIMFn CWTs, respectively, recovered out-of-basin. The NIMF ocean recovery rate (23) was 1.6 times greater than that of NIMFn (14).

For BY 2009 NFH fall-run salmon releases, the combined age-3 inland and ocean recovery rate for NIMFn releases (1,882) was 1.5 times higher than that of NIMF releases (1,236). The total CV recovery rate for NIMFn releases (626) was 1.3 times greater than that of NIMF (499) with approximately 6% of NIMFn recovered out-of-basin compared to 1% of NIMF releases. The NIMFn ocean recovery rate (1,256) was 1.7 times greater than that of NIMF (737).

For BY 2008 NFH fall-run salmon releases, the combined age-4 inland and ocean recovery rate for NIMFn releases (66) was an order of magnitude greater than that of NIMF releases (5). The total CV recovery rate for NIMFn releases (39) was much higher than that of NIMF (1), with 1% of NIMFn recoveries occurring out-of-basin. Only two NIMF releases were recovered in the CV: one at NFH and the other at FRH. The NIMFn ocean recovery rate (27) was 6.8 times greater than that of NIMF (4).

Mokelumne Fish Hatchery – Fall-run salmon brood years 2009 and 2010
All MOK releases for BY 2009 and 2010 were released in-basin (MOKF) or trucked to Sherman Island, where they were either released directly into the San Joaquin River (MOKFt) or placed in acclimation net pens (MOKFn), which were then towed into San Pablo Bay prior to release. It should be noted that three of the five BY 2010 MOKFt releases were actually slated for the net pens but due to unforeseen logistical issues, only a portion (29%-38%) of these fish were actually placed in the acclimation net pens. Overall, approximately 25% of MOKFt releases were acclimated and released from net pens in San Pablo Bay. All MOK BY 2008 were trucked, thus no release strategy comparisons were available.

For BY 2010 MOK fall-run salmon releases, the combined age-2 inland and ocean recovery rate was highest for MOKFn releases (83), followed by MOKFt (23) and MOKF releases (21). The total CV recovery rate for MOKFn releases (67) was 3.2 and 4.2 times greater than that of MOKF (21) and MOKFt (16), respectively; however, 39% of MOKFt and 35% of MOKFn were recovered out-of-basin compared to 5% of MOKF releases. The MOKFn ocean recovery rate (16) was 2.3 times greater than that of MOKFt releases (7); no age-2 MOKF releases were recovered in the 2012 ocean fisheries.

For BY 2009 MOK fall-run salmon releases, the combined age-3 inland and ocean recovery rate for MOKFn releases (1,794) was nearly twice that of MOKF releases (904). The total CV recovery rate for MOKFn releases (768) was 1.5 times higher than that of MOKF (529); however, 53% of MOKFn recoveries were out-of-basin compared to 3% of MOKF recoveries. The ocean recovery rate for MOKFn releases (1,026) was 2.7 times greater than that of MOKF releases (375).

Merced Fish Hatchery – Fall-run salmon brood year 2010
Although all MER fall-run salmon produced for BY 2008 and 2009 were trucked and released directly into the San Joaquin River at Jersey Point, the BY 2010 was split into in-basin MERF released at the hatchery or trucked MERFt released at Hatfield State Park and Mossdale. No Mossdale releases were recovered in 2012.

For BY 2010 MER fall-run salmon releases, the combined age-2 inland and ocean recovery rate for MERF releases (65) was equivalent to MERFt releases (65). The total CV recovery rate for MERFt releases (52) was slightly greater than that of MERF (49), and one fish (MERFt) was recovered out-of-basin. The MERF ocean recovery rate (16) was slightly greater (1.2) than that of MERFt (13).

3. Relative CV recovery and stray rates of bay releases acclimated in net pens and released directly without acclimatization

There was only one release group (BY 2010 MOK fall-run releases) where fish were released both into net pens and directly into the water at the same location; however, due to the issues discussed above regarding 25% of MOKFt releases being acclimated in net pens, it was not possible to differentiate between net pen and trucked releases.

4. Relative recovery rate and contribution of CV release groups to ocean harvest

The relative recovery rate of CV hatchery releases in the 2012 ocean salmon fisheries (sport and commercial combined) varied by age and release type (Figure 16). Of the 76,757 CWT_{samp} recovered in the ocean fisheries, most were age-3 (96%), followed by age-2 (3%) and age-4 (1%) salmon (Table 10). No age-5 CV salmon were recovered in 2012. Almost all age-2 CV salmon were harvested in the sport fishery (Figure 16). Higher age-2 recovery rates in the sport fishery is most likely due to smaller size limits in effect, ranging from 20 to 24 inches total length (TL) in the sport fishery compared to the minimum 27 inches TL requirement in the commercial fishery, and is not a result of differing release strategies among brood years. Net pen releases had the highest recovery rates for age-2 and age-3 CV recoveries while trucked MOK fall-run was highest for age-4.

For all age-2 CV salmon caught in the ocean, FRHFnc (139) had the highest recovery rate, followed by FRHFtib (39), CFHFn (39), FRHS (34), FRHFn (26) and NIMF (23) releases. It should be noted that MOKF and SacW were the only two CV release groups without any age-2 recoveries in the 2012 ocean fisheries.

For all age-3 CV salmon caught in the ocean, FRHFtib (2,756) and FRHFnc (2,145) had the highest recovery rates, followed by MERFt (1,359), NIMFn (1,256), CFHFn (1,068), and MOKFn (1,026). NIMF had the highest ocean recovery rate (737) for in-basin releases.

For all age-4 CV salmon caught in the ocean, MOKFt (33) had the highest recovery rate, followed by NIMFn (27), MERFt (23), CFHLh (15), and CFHFn (14). SacW was the only CV release group without any age-4 ocean recoveries.

Contribution of CV release groups to ocean sport harvest
In 2012, anglers harvested an estimated 123,926 salmon in the California ocean salmon sport fishery. The majority of the harvest occurred in San Francisco (37%) and Eureka-Crescent City (32%) port areas, followed by Monterey (25%) and Fort Bragg (6%) port areas (Table 11). Based on the expanded CWT_{total} collected in the fishery, including non-CV salmon release types, the contribution of hatchery-origin salmon to the California ocean sport fishery was 64%, ranging from 57% to 72% of the total harvest, depending on major port area (Figure 17). Of all CV hatchery release types, FRHFn contributed the most (17.4%) to the total ocean sport harvest, followed by CFHFh (14.0%), NIMF (7.0%), MOKFn (6.0%), NIMFn (4.7%), and CFHFn (4.4%). Non-CV releases (e.g., Klamath-Trinity River Basin, Smith River, Oregon and Washington hatchery stocks) contributed 6.3% to the total harvest (Table 11; Figure 17).

Among all release types, FRHFn contributed the most to the sport fishery in Monterey (24.6%), San Francisco (18.7%), and Fort Bragg (18.5%) port areas while non-CV releases (primarily Klamath River fall-run Chinook and Rogue River hatchery stocks) had the highest contribution (17%) in the Eureka-Crescent City port area, most likely due to its proximity to rivers and salmon hatcheries in northern California and Oregon.

Contribution of CV release groups to ocean commercial harvest
Commercial trollers landed 215,585 salmon in the California ocean salmon fishery, with most salmon landed in the San Francisco (55%) and Monterey (25%) port areas (Table 12). Based on the expanded CWT_{total} collected in the fishery, hatchery-origin salmon made up 64% of the total California commercial harvest, ranging from 46% to 71%, depending on the major port area (Figure 18). Of all CV release types, FRHFn contributed the most (17.1%) to the total commercial harvest, followed by CFHFh (15.0%), NIMF (7.8%), MOKFn (6.5%), NIMFn (6.0%), and CFHFn (4.6%). Non-CV releases contributed 3.4% to the total commercial harvest (Table 12; Figure 18).

Among all release types, FRHFn contributed the most to the commercial fishery in Monterey (23.4%), San Francisco (15.6%), and Fort Bragg (14.7%) port areas while non-CV releases (primarily Klamath River fall-run salmon) had the highest contribution (9.4%) in the Eureka-Crescent City port area (Table 12; Figure 18), again most likely due to the fishery's proximity to rivers and salmon hatcheries in northern California and Oregon.

DISCUSSION

Estimates of hatchery contribution and recovery rate by release type presented in this report should be viewed as the third "single year snapshot" of salmon escapement and harvest in the CV and California ocean fisheries. It should be noted, however, that 2012 is the first "normal" year of escapement and harvest since the collapse of Sacramento River fall-run salmon that began in 2008. During the three years following 2008, annual escapement to the CV was at record low levels and California ocean and river fisheries were closed or heavily constrained.

In 2012, total adult salmon returns to the CV, along with California ocean harvest estimates, were the highest observed since 2005 (PFMC 2013). This was due primarily to the large abundance of brood year 2009 (age-3) CV fall Chinook, which returned in record numbers as age-2 grilse the previous year. Since this large grilse return of fall-run Chinook salmon was used to forecast the available 2012 adult abundance (PFMC 2012a), ocean and CV fisheries were much less constrained than the previous year. Compared to the 2011 season, California's ocean salmon sport fishery was open an additional 43 days among the four major port areas while the commercial fishery added 33 days among the port areas south of Horse Mountain (Fort Bragg, San Francisco and Monterey-south) (PFMC 2012b). The commercial fishery in Eureka-Crescent City (Klamath Management Zone) increased from a quota of 2,280 salmon in 2011 to a quota of 6,000 salmon in 2012. The CV sport fishery added 20 days to the Feather River fishery and 5 days to the fishery in the lower Sacramento River basin. In addition, a new Mokelumne River fishery was developed (open 169 days), expanding the CV sport fishery south of the Sacramento River basin.

Approximately 80% and 86% of the hatchery-origin fish contributing to the total 2012 CV escapement and ocean harvest, respectively, were age-3 CV fall-run Chinook salmon. At this time, neither the year class strength nor age structure of natural-origin salmon in the CV or ocean fisheries is known; however, the Department's scale-aging program in Santa Rosa recently became fully operational and age-specific escapement information on CV stocks from 2006 to the present should be available in the near future. Although all CWT recoveries in 2012 were from CV releases that were representatively marked and tagged at the CFM minimum 25% level, most of the age-3 and age-4 fall-run CWT release groups in this study were produced and released during a time when the populations of CV fall-run salmon were at historically low levels or still in the stages of recovery. Many of the older broods were not exposed to California ocean fisheries during their first one to two years at sea. As a result, their respective recovery rates may be slightly elevated since they were not exposed to hook-and-release mortality prior to being recruited into ocean sport and commercial fisheries.

The strategies for CV fall-run hatchery production releases evaluated in this report continue to be influenced by two primary, and often divergent objectives: 1) maximize homing rates back to the hatchery of origin while minimizing straying to reduce impacts to natural stocks and 2) increase survival rates to improve eventual harvest and escapement. The first objective usually requires releasing fish in-basin, directly into their natal river as close to the hatchery as possible. The second objective generally utilizes release strategies that bypass the Sacramento-San Joaquin Delta and incorporate net pens for acclimation prior to release to reduce mortality from predators and other environmental or habitat related factors. Although the overall approach has differed somewhat among the five CV hatcheries, most have tried since the inception of the CFM program to determine if there are strategies capable of meeting both goals at acceptable limits. While a few hatcheries have found limited success, others have realized that there is no middle ground in meeting both goals. Generally speaking, the trend that has been consistent during the first three years of this CFM analysis is that bay net pen releases generally have higher recovery rates over their in-basin counterparts. This can be analogous to improved survival. These releases have also generally exhibited higher stray rates.

We should emphasize how stray rate calculations can differ depending on the geographic or policy definition for what constitutes a stray for any given stock. From an evaluation standpoint, there is still an issue regarding the definition of straying when a mitigation hatchery is not located on the river being impacted. In 1942, CNFH was built specifically to mitigate for the loss of salmon spawning habitat in the upper Sacramento River basin caused by the construction of Shasta Dam. Because CNFH was built on Battle Creek, approximately 6 miles upstream of its confluence with the Sacramento River, the Keswick Fish Trap was constructed concurrently in the upper Sacramento River specifically to collect salmon broodstock for the hatchery (Black 1999). Historically, salmon taken at the Keswick Fish Trap contributed as much as 50 to 75 percent of the annual fall-run broodstock used at CNFH from the 1940s through the late 1970s (USFWS 2011) and this facility was utilized for fall-run broodstock collection until the late 1980s. Although the collection of fall-run broodstock at Keswick Fish Trap ceased completely in 1987, the introgression of CNFH hatchery- and natural-origin fall-run salmon continues naturally in the upper Sacramento River. Late-fall-run salmon continue to be collected at the trap for CNFH propagation purposes so that a genetically integrated hatchery stock can be maintained and the effects of domestication can be reduced (USFWS 2011). It is for these reasons that some salmon biologists continue to consider CNFH stocks to be analogous to salmon that originate from the mainstem of the upper Sacramento River. Hatchery objectives for CNFH fall-run salmon unambiguously state that CNFH stocks are intended to escape to Battle Creek alone, and all other recoveries outside of that stream are strays.

Tributaries of a large river basin with an existing mitigation hatchery are also not intended to receive hatchery escapement, as is the case with the Yuba River. Hatchery objectives for FRH state that hatchery salmon originating there are intended to escape only to the Feather River. This is true despite many factors beyond the control of managers that affect salmon migration patterns such as dam operations and comparative flow regimes, water temperatures and water diversions. Hatchery release location alone is the tool available to managers to mitigate the straying of hatchery stocks, and it often comes at a cost to the survival of hatchery production. In both the Upper Sacramento River and Feather River basins, the rate of historical and present introgression of natural-origin stocks among their respective tributaries is unknown.

Given the issues identified above and to be consistent with Kormos et al. (2012) and Palmer-Zwahlen and Kormos (2013), the same primary CV basins were used to define stray rates in this report; however to allow further evaluation and discussion of these issues, all CNFH and FRH CWT releases that were recovered in the Upper Sacramento River and Yuba River, respectively, during 2012 are treated as strays in Appendix 2. A primary goal of this report is to provide information that will be useful in California salmon management, including the current hatchery review process.

At CNFH, it has become readily apparent that although the trucked and net pen releases have higher CV and ocean recovery rates than their in-basin sibling releases, they also stray more. The proportion of net pen releases straying outside of Battle Creek in 2012 ranged from 82% (age-2) to 93% (age-4). This is consistent with the high stray proportions observed for CFHFn releases in the 2010 (93%-98%) and 2011 (95%-98%) CFM reports. Stray proportions for in-basin releases in 2012, on the other hand, were much lower, ranging from 5% (age -2) to 13% (age-4), again similar to the proportions reported in the 2010 (1%-19%) and 2011 (4-9%) reports. As a result of this disparity, CNFH adopted a strategy that releases most (90%) of the fall-run salmon production in-basin to reduce the rates of straying and the associated impacts on natural-origin stocks. The remaining fish were trucked and released into San Pablo Bay net pens to increase survival and fishery contribution rates.

At FRH, on the other hand, net pen acclimation in San Pablo Bay has been the release strategy adopted for almost all of its fall-run production. Although CNFH releases several more million fall-run salmon annually than FRH, which is the largest state-run hatchery, their total contribution to California ocean salmon fisheries in 2012 was relatively the same at 19%. Although some of these FRH releases do stray when returning to the CV, this rate has been shown to be relatively small compared to their CV in-basin and ocean harvest recovery rates. Of the 15,900 salmon that strayed throughout the CV in 2012, approximately 17% were FRH fall-run releases which compares closely to CNFH fall releases, which accounted for 13% of all strays. This could be considered a relatively low rate of contribution to the total stray population in the CV given the comparatively large annual production of these two facilities.

Most (58%) of the salmon that strayed in 2012 originated from MOK while just over 8% were trucked releases from MER. Approximately 6% of strays were FRH spring-run releases, which were age-3 net pen releases trapped above and recovered as “wash-back” carcasses at the Nimbus weir on the American River. It should be noted that if Yuba River recoveries of FRH spring-run salmon are included, the spring-run stray contribution increases to 9% with most of these salmon having been released in-basin but below the Yuba and Feather River confluence. There were relatively few stray salmon from NFH or the two “ocean fishery enhancement” programs, with each comprising approximately 1% of all strays.

Aside from the complexities related to straying, there are some additional observations that warrant further discussion, either because they have been identified as a trend consistently seen in all three reports or have the potential to become a subject of interest to managers and salmon biologists.

FRH spring-run recoveries have experienced one of the most consistent and comparable paired release strategies in the CV, with one million fish being planted in both bay net pens and in-river on an annual basis. Although fall-run net pen releases have consistently had higher recovery and stray rates than their in-basin siblings, this has not been the case for spring-run releases at FRH through this third year of analysis. In-basin FRH spring-run releases and their net pen counterparts have almost equivalent recovery rates in ocean fisheries and CV escapement. This is unique among hatchery release types and is useful for management of spring-run as the stray rates for in-basin releases are greatly diminished. This is the only case in the CV where the objectives of fisheries contribution and improved homing rates do not appear to be at odds, facilitating a total in-basin release strategy for this stock which may greatly improve program results. This result and the release conditions that contributed to it should be thoroughly investigated so the mechanism for improved juvenile recruitment through the Delta can be understood and perhaps applied to regular production releases of fall-run. It is important to note that spring-run are not the target of ocean or inland fisheries and contribute minimally to their harvest.

Another repeated observation is the relatively high rate of natural-origin contribution to the escapement into the American River and NFH. The range of contribution from natural-origin stocks in the American River over the last three years has been 27% to 68%. This is exceptional among CV rivers supporting salmon hatcheries where the rate of natural-origin contribution is generally less than 10%. For NFH, the range of natural-origin contribution has been 15% to 23%. This is particularly important because NFH appears to be the only large production hatchery in the CV that has consistently met the minimum percent natural-origin broodstock (also known as pNOB) of 10% as defined and recommended by the California Hatchery Scientific Review Group (CA HSRG). Although MER appears to also meet this criteria, its annual production and escapement is comparatively low. Natural-origin contribution to the escapement above Nimbus weir is also relatively high from one year to the next; however the composition of hatchery-origin salmon trapped above the weir appears to differ greatly to the hatchery composition in the carcass survey below NFH. Further exploration of what may be contributing to the elevated natural production in this basin is warranted.

In addition to their annual production releases, FRH has historically provided approximately 200,000 fall-run salmon each year for programs designed to enhance ocean fisheries. This report includes recoveries from two long-term enhancement programs: 1) Tiburon net pen releases operated by the San Francisco Tyee Club and 2) Santa Cruz coastal net pen releases managed by the Monterey Bay Salmon and Trout Program (MBSTP). Although Tiburon net pen releases have relatively high ocean recovery rates, their stray rates have also been among the highest observed for fall-run releases. This was especially true when earlier broods of Nimbus fall-run fish were utilized as Tiburon releases (Kormos et. al. 2012, Palmer-Zwahlen and Kormos 2013). However this release group is generally divided into two components: 1) fish held for a few weeks and released in May-June as fingerlings and 2) fish held for several months and released as yearlings in October. Based on the few data available, it appears that salmon in the latter group have a higher stray rate and future evaluation of this strategy is warranted.

Although coastal net pen salmon releases in Central California have been occurring for several decades, their analysis is new in this report because the marking and unique tagging of these releases has not been consistent. The MBSTP has been operating their coastal net pen program within Monterey Bay since 1992 but the tagging with a unique CWT code for all their net pen releases did not begin until brood year 2009, with the exception of 1993-1995 broods (Palmer-Zwahlen 2007). Although the ocean recovery rates for both age-2 and age-3 MBSTP coastal net pen releases was among the highest for all CV release groups, few of these fish returned to the CV; in fact, their CV recovery rates were among the lowest for all release types in 2011 and 2012 (Palmer-Zwahlen and Kormos 2013).

Recently, concern has been raised regarding the potential for these coastal net pen Chinook salmon releases to negatively impact natural coho and steelhead populations in central California coastal streams, both of which are listed under the Endangered Species Act (ESA). Although there have been anecdotal reports of Chinook spawning pairs and the collection of a juvenile Chinook in the estuary of the San Lorenzo River by projects not working directly under the auspices of the Department, there has been no systematic survey to date that has shown evidence of interactions with other salmonids that exist in those streams. Furthermore the MBSTP net pen releases have occurred for decades across a wide range of water years and connectivity of those streams to the ocean without Chinook populations becoming established or persistent. The perceived risk of deleterious effects to ESA-listed species may be somewhat ameliorated by the lack of evidence to support such effects after so many years of an established coastal net pen program in this area of the coast. However, the Department has begun a monitoring program of these coastal systems to collect bio-data, including CWTs, from all salmonids in these systems during the fall migration period to ensure listed species are not being impacted. The current monitoring effort may help answer the questions surrounding risk.

The MBSTP coastal net pen program appears to be having its intended effect with high ocean recovery rates and modest contributions to ocean harvest, especially in the Monterey sport and commercial fisheries. This, coupled with very low returns to the CV, suggests this program and those like it may be biologically benign while providing the increased ocean harvest desired for the local fisheries.

Since its inception, the CV CFM program has been successful in marking and tagging its targeted numbers of salmon each year at the five CV salmon hatcheries. The CWT laboratories operated by CDFW in Santa Rosa and Sacramento have both expanded and are able to process the 50,000-70,000 heads expected annually from ad-clipped salmon observed during monitoring of CV escapement and California ocean and river fisheries. Most CV escapement surveys have adopted survey modifications as recommended in the “Central Valley Chinook Salmon Escapement In-River Monitoring Plan” (Bergman et al. 2012) and CWTs are now being recovered throughout most of the CV in a statistically valid manner. This monitoring plan provides the basis for sound CV salmon assessment and subsequent management; however as noted in the 2011 CFM report, one critical item that was omitted was the need to account for the fresh versus decayed condition of fish sampled in CV carcass surveys. As identified by Mohr and Satterthwaite (2013) and discussed in this report, this information is needed to minimize the bias in determining the hatchery contribution by release type in natural areas. The hatchery contribution rates in this report for the carcass mark-and-recapture surveys not collecting fish condition (e.g., Feather River fall-run, Butte Creek fall-run) are most likely negatively biased (Mohr and Satterthwaite 2013). There are also several tributaries (e.g., Mill Creek, Deer Creek, Consumnes River, Calaveras River) where the sampling and collection of heads from ad-clipped salmon continues to occur opportunistically and thus we are only able to estimate the minimum hatchery contribution and straying into these systems. Lastly, the low percentage (3%-7%) of the total salmon harvest sampled in the CV angler survey continues to result in extremely high CWT sample expansion rates (e.g., American River fishery $F_{samp} = 35.41$) that may be biasing the results and producing imprecise estimates of hatchery contribution. Increasing the visual sampling of salmon to at least 20% of the catch, as recommended by the RMPC (Nandor et al. 2010), would improve the analyses of these data.

Looking Forward

One of the primary objectives of the CFM program is to evaluate the relative recovery and stray rates of Chinook released in-basin compared to salmon trucked and released into Carquinez Strait, or other locations beyond the Delta. Over the last three years the trend repeatedly identified in these CWT recovery reports is that offsite release strategies generally increase the rate of straying; however there are additional concepts to explore when reflecting on this trend and the specific estimates of straying for each release type.

In order to evaluate stray rates against hatchery release strategies in an effort to make meaningful management decisions we must define the maximum threshold or acceptable rate of straying for any hatchery stock in the CV. This rate or management target has not yet been identified. Neither the CA HSRG nor any other scientific committee or technical team has provided such a metric for California stocks. It has been hypothesized that the maximum allowable rate of straying should be no more than what occurs naturally; however at this time natural-origin Chinook stray rates are unknown for CV salmon. Determining this rate for hatchery stocks is further complicated by the reduction in and cross-utilization among run types of available spawning habitat due to dams and other barriers. In addition the highly augmented hydrology of the CV and Delta as a whole creates challenges to salmon as they migrate upstream to their final spawning location.

The effects of stray rates cannot be considered alone and wholly as a function of how many hatchery fish from an individual release are present in non-natal streams or areas. This is because the effects of straying are a function of the inter-annual variation in the production of hatchery- versus natural-origin salmon, as well as the variation in production among hatchery stocks themselves. The variability in production, paired with the differing rates of straying, dictates how many hatchery salmon are contributing to spawning populations across the CV, and at what percentage of that total spawning population. Although hatchery production is relatively constant from one year to the next, natural production remains much more variable and easily influenced by environmental or anthropogenic factors. This variation greatly influences the rate of introgression between hatchery- and natural-origin stocks, and during the first three years of the CFM analyses, natural production appears to have been much lower than that of the hatchery programs in the CV.

Hatchery fish spawning amongst natural-origin fish become more of an issue in natural systems with relatively low escapement. The fraction of hatchery fish or out-of-basin hatchery fish integrating on the spawning grounds is increased when 1) natural production is reduced, as is the case in drought years and 2) the spawning habitat or stream normally sees relatively low annual returns of natural-origin fish. This is most common on the smaller tributaries in the CV. For example, while the stray rate of CNFH in-basin releases is relatively low, the straying that does occur is largely relegated to the upper Sacramento River Basin, including small tributaries located above the confluence with Battle Creek. These streams include Clear Creek and Cottonwood Creek and escapement to these streams is relatively low compared to the mainstem upper Sacramento River where CNFH stocks also spawn. Whether or not this rate of introgression there or elsewhere is a significant issue warrants further investigation. We recommend emphasis be put on delineating maximum acceptable thresholds on stray rates and rates of introgression among stocks. We also recommend establishing representative CWT sampling in other natural systems, such as Mill and Deer creeks, as a start to addressing this issue.

It is possible that hydrology is also an influential factor affecting the rates of straying in the CV. It is an evolutionary trait for salmon to seek streams with the appropriate temperature and flow, in addition to seeking out their natal stream. Dam operations and flows among CV streams are often quite variable and present differences in the quality of habitat that is available to spawning salmon. When looking at the composition of hatchery-origin fish trapped each year above the

Nimbus Weir, salmon appear to be explorative during their spawning migration. The proportion of FRH spring-run trapped above the weir is significant, yet they are almost nonexistent in the river section below. This suggests that spring-run salmon, and possibly other stocks, are ascending the American River, and perhaps other tributaries, as they try to find their way to their natal streams. In this case, the installation of the weir prevented these salmon from returning to the mainstem, revealing this potential migratory phenomenon. This behavior could be due to normal migration patterns, or it may be attributable to how water operations among CV streams can affect migratory behavior. The American River is typically the first cold water inflow salmon encounter as they move up the Sacramento River. However, the composition of hatchery fish above the weir suggests that salmon in the CV are exploratory when migrating to spawn (Figure 9). If these fish are allowed time and the opportunity to return to the Sacramento River, they may continue their spawning migration up into the Feather River Basin as their siblings below Nimbus Weir may have done.

As previously stated, FRH spring-run salmon are rarely recovered in the American River carcass survey. As the salmon move up through the system they may be entering and exiting a multitude of tributaries in their search for a final spawning location. Salmon may choose these non-natal tributaries, especially when they have improved water quality over their stream of origin and spawning becomes imperative. A good example of this possible behavior in 2012 is exhibited in the upper Yuba River above DPD. The hatchery component of the spawners in this section of the Yuba River is mostly a homogenous mixture of fish from all five CV hatcheries. Aside from a few CNFH net pen releases taken in the Feather River carcass survey and at FRH, migration of other non-FRH stocks did not occur above the Yuba-Feather River confluence. Since most of these out-of-basin stocks are a long way from their natal streams, it is interesting that they choose to spawn in the Yuba River over the Feather River or the upper Sacramento River. It is recommended that further consideration be given to the role of comparative water operations across the CV when evaluating how to minimize straying and mitigate the effects of hatchery stocks.

There appears to be an interesting dynamic at play between release location, hydrology, and straying. Releasing salmon into the Delta increases their stray rate; this appears to be intensified when the natal stream is small and distant, as is the case with CNFH stocks and Battle Creek. Releasing salmon within their natal river but below the confluence of major tributaries may also increase straying to those tributaries, especially when their water quality is markedly better. Release location alone is an indicator of the propensity of those releases to stray, however water operations may also have a role. An example of this can be found within the Delta. Studies indicate Delta Cross Channel (DCC) Gate operation and pulse flows can influence the rate of straying of Mokelumne River hatchery stocks to the American River. Mokelumne River adult salmon escapement and homing is greatly improved when the DCC gates are closed and extra water is released from Camanche Dam (J. Setka, EBMUD, pers. comm.). This effectively reduces the rate of straying for Mokelumne River stocks to the American River, and possibly to other streams in the Sacramento River basin. The operations of the DCC gates should also be taken into consideration when evaluating how to minimize straying and mitigate the effects of hatchery stocks.

Multi-agency, multi-disciplined Hatchery Coordination Teams (HCTs) have begun the process of looking into solutions to straying and the hatchery- and natural-origin interaction issues identified by the CA HSRG. Mechanisms for a solution include increasing natural production, decreasing hatchery production, changing release strategies, or selective segregation. Each of these mechanisms has costs and benefits to salmon stocks, fisheries management, water operations, and habitat restoration that must be weighed against one another and the responsibilities of agencies as resource managers and conservationists. It is expected that some of this cost benefit analysis will take place within the Hatchery Review Policy Committee (HRPC), an oversight body for the California Hatchery Review process. Ultimately, the synthesis of HCTs solutions and responses to CA HSRG recommendations will be subject to review and implementation by the HRPC. When solutions to issues identified in the HSRG report are considered by the HRPC, it will be important for factors beyond the HSRG recommendations and associated hatchery operations themselves to be taken into account. In many cases as identified above, further study is required to inform such discussions.

This report continues the initial phase of the work needed to statistically analyze the contribution of hatchery- and natural-origin salmon to hatchery and natural areas throughout the CV, evaluate hatchery release strategies, improve California ocean and river salmon fisheries management, and determine if other goals of the CFM program are being met. The CFM program should be continued with the current design for several years to provide comparable, consistent data needed for harvest and hatchery management. Efforts are on-going to secure future permanent funding for this program. The results from this program, in conjunction with the funding of a permanent scale-aging program, should provide the best opportunity to manage CV salmon based on scientifically defensible data. Secure adequate funding will allow both CWT and scale-aging data to be available by February each year in order to manage CV salmon stocks, hatchery production, and California ocean and river fisheries in a real-time manner, similar to Klamath River fall-run salmon management. This work is essential for the continued development of salmon management in California’s CV and fisheries. The authors hope to soon begin analyzing the CV and ocean CWT recoveries of completed broods over their respective life span, thus determining the total contribution to fisheries and escapement and the overall recovery and stray rates associated with various release strategies.

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LIST OF ACRONYMS AND ABBREVIATIONS

Ad-clipped	clipped adipose fin
BOR	U.S. Bureau of Reclamation
BY	Brood year
CA-HSRG	California Hatchery Scientific Review Group
CFM	Constant Fractional Marking
CNFH	Coleman National Fish Hatchery
CV	California Central Valley
CVSPWT	Central Valley Salmon Project Work Team
CWT	coded-wire tag
CDFW	California Department of Fish and Wildlife
DCC	Delta cross channel
DPD	Daguerre Point Dam (Yuba River)
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utilities District
ERP	Ecosystem Restoration Program
FF	Fisheries Foundation
FRH	Feather River Hatchery
FWS	U.S. Fish and Wildlife Service
GD	Granlees Dam (Consumnes River)
HCT	Hatchery Coordination Team
HRPC	Hatchery Review Policy Committee
MER	Merced River Hatchery
MBSTP	Monterey Bay Salmon and Trout Project
MOK	Mokelumne River Hatchery
NMFS	National Marine Fisheries Service
NFH	Nimbus Fish Hatchery
OSP	Ocean Salmon Project
PFMC	Pacific Fishery Management Council
PSMFC	Pacific States Marine Fisheries Commission
RMPC	Regional Mark Processing Center
SJ	San Joaquin
TL	Total length
WD	Woodbridge Dam (Mokelumne River)
YARMT	Yuba Accord River Management Team

Table 1. Estimation and sampling methods used for the 2012 CV Chinook run assessment. (page 1 of 4)

Sampling Location	Estimation and Sampling Methods	Agency
Hatchery Spawners		
Coleman National Fish Hatchery (CNFH) Fall and Late-Fall	Direct count. All fish examined for fin-clips, tags, marks. Hatchery takes a one month break in between fall and late-fall spawning periods. Fish that arrive during this 'break' are counted and excised. Those containing a fall CWT code or have their adipose fin present are later counted as fall. Fish containing a late-fall CWT code are later counted as late-fall. Systematic random bio-sample[a] of all fall fish with adipose fin absent. All late-fall fish with adipose fin absent are bio-sampled. Fall grilse cutoff: 700 mm. Late-fall grilse cutoff: 600 mm.	FWS
Feather River Hatchery (FRH) Spring and Fall	Direct count. All fish examined for fin-clips, tags, marks. All fish arriving at the hatchery April-June are tagged with two uniquely-numbered floytags. All fish marked with floytags returning to FRH during August and September are spawned as spring. All other fish are spawned as fall. All spring Chinook are bio-sampled. Systematic random bio-sample ~10% of aggregate fall fish with adipose fin present and absent. All fall fish with adipose fin absent are bio-sampled. All spawned fall fish are bio-sampled. Grilse cutoff: 650 mm.	CDFW
Nimbus Fish Hatchery (NFH) Fall	Direct count. All fish examined for fin-clips, tags, marks. Systematic random bio-sample ~10% of aggregate fish with adipose fin present and absent. All fish with adipose fin absent are bio-sampled. Grilse cutoff: 685 mm.	CDFW
Nimbus Weir Fall	Direct count. All fish examined for fin-clips, tags, marks. All fish with adipose fin absent are bio-sampled. Grilse cutoff: 685 mm.	CDFW
Mokelumne River Hatchery (MOK) Fall	Direct count. All fish examined for fin-clips, tags, marks. Systematic random bio-sample ~10% of aggregate fish with adipose fin present and absent. All fish with adipose fin absent are bio-sampled. Grilse cutoff: 680 mm females, 710 mm males.	CDFW
Mokelumne Weir Fall	Direct count. All fish examined for fin-clips, tags, marks. All fish with adipose fin absent are bio-sampled. Grilse cutoff: 680 mm females, 710 mm males.	CDFW
Merced River Fish Facility (MER) Fall	Direct count. All fish examined for fin-clips, tags, marks. All fish with adipose fin absent are bio-sampled. Grilse cutoff: 635 mm.	CDFW
Natural Spawners		
Upper Sacramento River Mainstem Fall, Late-Fall, and Winter	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate applied using all females within survey area (Keswick Dam to Balls Ferry). Total female escapement estimate (Keswick Dam to Princeton) is derived using expansions for females spawning outside of the survey area (Balls Ferry to Princeton) through aerial redd surveys. Male Chinook expanded based on the sex ratio at CNFH. Total estimate from Keswick to Princeton is then males and females. All fish examined for fin-clips, tags, marks. Bio-data collected from all fresh fish with adipose fin present and absent. Systematic random bio-sample of aggregate fish with adipose fin present and absent. All fish with adipose fin absent are bio-sampled. Fall grilse cutoff: 610 mm females, 690 mm males. Late-fall grilse cutoff: 610 mm females, 635 mm males. Winter grilse cutoff: 540 mm females, 645 mm males.	CDFW, FWS

Table 1. Estimation and sampling methods used for the 2012 CV Chinook run assessment. (page 2 of 4)

Sampling Location	Estimation and Sampling Methods	Agency
Clear Creek Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate. All fish examined for fin-clips, tags, marks. Bio-data collected from all fresh fish with adipose fin present and absent. Systematic random bio-sample of aggregate fish with adipose fin present and absent. All fish with adipose fin absent are bio-sampled. Grilse cutoff: 610 mm females, 695 mm males.	CDFW, FWS
Cottonwood Creek Fall	Video weir count at mouth of creek to determine total escapement. Systematic carcass survey conducted to collect bio-samples from all fish with adipose fin present and absent. Grilse cutoff: 700 mm.	FWS, CDFW
Butte Creek Spring and Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate for spring. Peterson mark-recapture estimate for fall. All fish examined for fin-clips, tags, marks. Systematic random bio-sample of aggregate fish with adipose fin present and absent. All fish with adipose fin absent are bio-sampled. Grilse cutoff: 610 mm.	CDFW
Feather River Fall	Superpopulation modification of the Cormack-Jolly-Seber mark recapture-estimate. All fish examined for fin-clips, tags, marks. Systematic random bio-sample of aggregate fish with adipose fin present and absent. All fish with adipose fin absent are bio-sampled. Spring Chinook are included. Grilse cutoff: 650 mm.	DWR
Yuba River Fall	Above Daguerre Point Dam: Vaki Riverwatcher direct count. Additionally, systematic random bio-sample of aggregate fish with adipose fin present and absent. All fish with adipose fin absent are bio-sampled. Below Daguerre Point Dam: Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate. All fish examined for fin-clips, tags, marks. Systematic random bio-sample of aggregate fish with adipose fin present and absent. All fish with adipose fin absent are bio-sampled. Spring Chinook are included. Grilse cutoff: 650 mm.	CDFW, YARMT
American River Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate. All fish examined for fin-clips, tags, marks. Systematic random bio-sample of aggregate fish with adipose fin present and absent. All fish with adipose fin absent are bio-sampled. Grilse cutoff: 680 mm.	CDFW
Mokelumne River Fall	Video count at Woodbridge Irrigation District Dam. Additionally, in river survey conducted to collect bio-samples from all fish with adipose fin present and absent. Grilse cutoff: 680 mm females, 710 mm males.	EBMUD
Cosumnes River	Above Granlees Dam: Vaki Riverwatcher direct count. Additionally, opportunistic random bio-sample of aggregate fish with adipose fin absent. Below Granlees dam: Redd count. Additionally, opportunistic random bio-sample of aggregate fish with adipose fin absent. Total grilse and adults apportioned using length frequency analysis. Grilse cutoff: 600 mm.	FF
Calaveras River	Redd count from Bellota Weir to Milton Road. Total escapement equals two times the total redds. Additionally, opportunistic random bio-sample of aggregate fish with adipose fin absent. No grilse estimate was derived.	
Stanislaus River Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate. All fish examined for fin-clips, tags, marks. All fish with adipose fin absent are bio-sampled. Grilse cutoff: 680 mm females, 760 mm males.	CDFW

Table 1. Estimation and sampling methods used for the 2012 CV Chinook run assessment. (page 3 of 4)

Sampling Location	Estimation and Sampling Methods	Agency
Tuolumne River Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate. All fish examined for fin-clips, tags, marks. All fish with adipose fin absent are bio-sampled. Grilse cutoff: 680 mm females, 760 mm males.	CDFW
Merced River Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate. All fish examined for fin-clips, tags, marks. All fish with adipose fin absent are bio-sampled. Grilse cutoff: 680 mm females, 760 mm males.	CDFW
Recreational Harvest		
Upper Sacramento River Fall	Open Jul 16 - Dec 16 from Highway 113 Bridge to the Lower Red Bluff Boat Ramp. An additional river reach from the Red Bluff Diversion Dam to the Deschutes Road Bridge was open Aug 1 - Dec 16. Stratified-random sampling design (one weekday and one weekend sample per week per section during the open season per management zone) that included both roving and access interview components, and the collection of coded-wire tags from adipose fin-clipped salmon for stock identification. Bio-data collected during angler interviews.	CDFW
Feather River Fall	Open Jul 16 - Dec 31 from the mouth to 200 yards above the Live Oak boat ramp, and open Jul 16 - Oct 15 from 200 yards above the Live Oak boat ramp to the unimproved boat ramp above the Thermolito Afterbay Outfall. Stratified-random sampling design (one weekday and one weekend sample per week per section during the open season per management zone) that included both roving and access interview components, and the collection of coded-wire tags from adipose fin-clipped salmon for stock identification. Bio-data collected during angler interviews.	CDFW
American River Fall	Open Jul 16 - Dec 31 from Nimbus dam to the Hazel Avenue Bridge, Jul 16 - Aug 15 from the Hazel Avenue Bridge to the USGS cable crossing, Jul 16 - Oct 31 from the USGS cable crossing to to the SMUD power line crossing, Jul 16 - Dec 31 from the SMUD power line crossing to the Jiboom Street Bridge, and Jul 16 - Dec 16 from the Jiboom Street Bridge to the mouth. Stratified-random sampling design (one weekday and one weekend sample per week per section during the open season per management zone) that included both roving and access interview components, and the collection of coded-wire tags from adipose fin-clipped salmon for stock identification. Bio-data collected during angler interviews.	CDFW
Mokelumne River Fall	Open Jul 16 - Oct 15 from the Comanche Dam to the Highway 99 Bridge, and from Jul 16 - Dec 31 from the Highway 99 Bridge to Woodbridge Dam including Lodi Lake. Stratified-random sampling design (one weekday and one weekend sample per week per section during the open season per management zone) that included both roving and access interview components, and the collection of coded-wire tags from adipose fin-clipped salmon for stock identification. Bio-data collected during angler interviews.	

Table 1. Estimation and sampling methods used for the 2012 CV Chinook run assessment. (page 4 of 4)

Sampling Location	Estimation and Sampling Methods	Agency
Lower Sacramento River Fall	Open Jul 16 - Dec 16 from the Carquinez Bridge to the Highway 113 Bridge. Stratified-random sampling design (one weekday and one weekend sample per week per section during the open season per management zone) that included both roving and access interview components, and the collection of coded-wire tags from adipose fin-clipped salmon for stock identification. Bio-data collected during angler interviews.	CDFW
Upper Sacramento River Late Fall	Open Nov 1 - Dec 16 from Highway 113 Bridge to Deschutes Road Bridge. Stratified-random sampling design (one weekday and one weekend sample per week per section during the open season per management zone) that included both roving and access interview components, and the collection of coded-wire tags from adipose fin-clipped salmon for stock identification. Bio-data collected during angler interviews.	CDFW

a/ Biological samples ("bio-samples" or "bio-data") of live fish or carcasses generally include: sex, fork length, scales, tags or marks, and CWT recovery from ad-clipped fish.

Table 2. California ocean sport and commerial salmon fishery seasons by major port area, 2012.

	Sport Fishery			Commercial Fishery		
Major Port Area	Season	Size Limit[a]	Days Open	Season	Size Limit[a]	Days Open
Eureka/Crescent City	May 1 - Sep 9	20" TL	132	Sep 15-19	27" TL	6000[b]
Fort Bragg	Apr 7 - Nov 11	20" TL	219	Jul 11 - Aug 29	27" TL	50
				Sep 1 - 30	27" TL	30
						80
San Francisco	Apr 7 - Jul 5	24" TL	90	May 1 - Jun 4	27" TL	35
	Jul 6 - Nov 11	20" TL	129	Jun 27 - Aug 29	27" TL	64
			219	Sep 1 - 30	26" TL	30
				Oct 1-5, 8-12[c]	26" TL	10
						139
Monterey[d]	Apr 7 - Jul 5	24" TL	90	May 1 - Jun 4	27" TL	35
	Jul 6 - Oct 7	20" TL	94	Jun 27 - Aug 29	27" TL	64
			184	Sep 1 - 30	26" TL	30
						129
South of Pt Sur[e]				May 1 - Jun 4	27" TL	35
				Jun 5 - Aug 29	26" TL	86
				Sep 1 - 30	26" TL	30
						151
California Total			754			353

a/ Size limit in inches total length (TL).
b/ Quota fishery; open Sep 15-19.
c/ Open only between Pt. Reyes and Pt. San Pedro.
d/ Recreational regulations apply from the Monterey area to the U.S./Mexico border.
e/ Commercial regulations apply from Pt. Sur to the U.S./Mexico border as a subset of Monterey major port area.

Table 3. Central Valley coded-wire tag (CWT) Chinook releases by age, stock, run and release type, brood years 2008-2011. (page 1 of 2)

Age 2 CWT releases

Release type*	Brood year	Hatchery / wild	Stock origin	Run type	CWT codes	Total fish released	# CWT tagged	% CWT	Release strategy	Release locations / notes
FRHS	2010	FRH	Fea R	Spr	2	1,181,710	1,170,340	99%	Basin	Feather River (Boyds Pump Ramp)
FRHSn	2010	FRH	Fea R	Spr	2	1,157,167	1,136,690	98%	Bay pens	Mare Island net pens
CFHFh	2010	CNFH	Sac R	Fall	25	11,369,732	2,835,420	25%	Basin	CNFH
CFHFn	2010	CNFH	Sac R	Fall	3	1,339,659	334,756	25%	Bay pens	Mare Island net pens
FRHFn	2010	FRH	Fea R	Fall	9	10,308,722	2,554,115	25%	Bay pens	San Pablo Bay net pens; Wickland Oil net pens
FRHFnc	2010	FRH	Fea R	Fall	2	187,022	185,985	99%	Coastal pens	Santa Cruz net pens; MBSTE project; held approx 1 week
FRHFtib	2010	FRH	Fea R	Fall	2	56,398	56,030	99%	Tibur. pens	Tiburon net pens, released as fingerlings (May) & yearlings (Oct)
FeaFw	2010	wild	Fea R	Fall	38	194,798	188,791	97%	Basin	Thermalito Bypass
NIMF	2010	NIM	Ame R	Fall	3	3,259,868	1,014,340	31%	Basin	American River (at Sunrise Launch Ramp & Discovery Park)
NIMFn	2010	NIM	Ame R	Fall	3	1,595,731	368,363	23%	Bay pens	Wickland Oil net pens
MOKF	2010	MOK	Mok R	Fall	1	100,467	100,215	100%	Basin	Mokelumne Hatchery (yearlings)
MOKFn	2010	MOK	Mok R	Fall	12	4,548,348	1,126,781	25%	Bay pens	Sherman Island net pens (includes experimental Nimbus spawners)
MOKFt	2010	MOK	Mok R	Fall	5	1,898,828	473,268	25%	Trucked	Sherman Island (approx. 25% released into net pens)
MERF	2010	MER	Mer R	Fall	3	76,971	73,631	96%	Basin	Merced River Hatchery
MERFt	2010	MER	Mer R	Fall	3	58,166	56,011	96%	Trucked	Merced River (Hatfield State Area), San Joaquin River (Mossdale)
SacW	2010	LSH	Sac R	Wint	14	123,859	113,905	92%	Basin	Sacramento River (Lake Redding Park)
CFHLh	2011	CNFH	Sac R	Late	14	1,053,282	1,037,859	99%	Basin	CNFH (includes spring surrogate releases)
			Total age 2 releases:		141	38,510,728	12,826,500	33%	1% wild CWT releases	

Age 3 CWT releases

Release type*	Brood year	Hatchery / wild	Stock origin	Run type	CWT codes	Total fish released	# CWT tagged	% CWT	Release strategy	Release locations / notes
FRHS	2009	FRH	Fea R	Spr	1	1,040,645	1,026,954	99%	Basin	Feather River (Boyds Pump Ramp)
FRHSn	2009	FRH	Fea R	Spr	6	1,085,409	1,058,635	98%	Bay pens	San Pablo Bay net pens
CFHFh	2009	CNFH	Sac R	Fall	25	10,210,921	2,541,142	25%	Basin	CNFH
CFHFn	2009	CNFH	Sac R	Fall	3	1,360,164	337,919	25%	Bay pens	Mare Island net pens
FRHFn	2009	FRH	Fea R	Fall	11	9,536,050	2,367,209	25%	Bay pens	San Pablo Bay net pens; Wickland Oil net pens
FRHFnc	2009	FRH	Fea R	Fall	1	122,334	118,879	97%	Coastal pens	Santa Cruz net pens; MBSTE project; held approx 1 week
FRHFtib	2009	FRH	Fea R	Fall	2	60,739	60,104	99%	Tibur. pens	Tiburon net pens, released as fingerlings (May) & yearlings (Oct)
FeaFw	2009	wild	Fea R	Fall	18	178,063	177,657	100%	Basin	Thermalito Bypass
NIMF	2009	NIM	Ame R	Fall	3	3,221,137	1,000,559	31%	Basin	American River (at Sunrise Launch Ramp & Discovery Park)
NIMFn	2009	NIM	Ame R	Fall	2	1,391,632	347,527	25%	Bay pens	Mare Island net pens
MOKF	2009	MOK	Mok R	Fall	1	99,157	99,048	100%	Basin	Mokelumne Hatchery (yearlings)
MOKFn	2009	MOK	Mok R	Fall	13	2,023,958	2,015,730	100%	Bay pens	Sherman Island net pens
MERFt	2009	MER	Mer R	Fall	6	165,213	154,685	94%	Trucked	San Joaquin River (Jersey Pt)
SacW	2009	LSH	Sac R	Wint	19	198,582	183,644	92%	Basin	Sacramento River (Lake Redding Park)
CFHLh	2010	CNFH	Sac R	Late	13	1,018,422	992,047	97%	Basin	CNFH (includes spring surrogate releases)
			Total age 3 releases:		124	31,712,426	12,481,739	39%	1% wild CWT releases	

Table 3. Central Valley coded-wire tag (CWT) Chinook releases by age, stock, run and release type, brood years 2008-2011. (page 2 of 2)

Age 4 CWT releases

Release type*	Brood year	Hatchery	Stock origin	Run type	CWT codes	Total fish released	# CWT tagged	% CWT	Release strategy	Release locations / notes
FRHS	2008	FRH	Fea R	Spr	5	1,016,835	1,015,717	100%	Basin	Feather River (Boyds Pump Ramp)
FRHSn	2008	FRH	Fea R	Spr	5	1,007,177	1,005,727	100%	Bay pens	San Pablo Bay net pens
CFHFh	2008	CNFH	Sac R	Fall	27	12,529,458	3,128,374	25%	Basin	CNFH
CFHFn	2008	CNFH	Sac R	Fall	3	1,491,668	371,726	25%	Bay pens	Mare Island net pens, San Pablo Bay net pens
FRHFn	2008	FRH	Fea R	Fall	11	7,761,167	2,061,211	27%	Bay pens	Mare Island net pens, San Pablo Bay net pens, Wickland Oil net pens
FRHFe	2008	FRH	Fea R	Hybrid	30	498,341	481,853	97%	CV exper	Spr x Fall hybrid releases: Benicia, Discovery Pk, Elkhorn Boat Launch, Miller Park, Sac River at Garcia Bend and Pittsburg
FRHFtib	2008	FRH	Fea R	Fall	2	91,801	89,859	98%	Tibur. pens	Held 3-4 mos Tiburon net pens, released as yearlings
FeaFw	2008	wild	Fea R	Fall	37	292,423	289,830	99%	Basin	Thermalito Bypass, Feather River
NIMF	2008	NIM	Ame R	Fall	1	270,000	264,006	98%	Basin	American River (Sunrise Launch Ramp)
NIMFn	2008	NIM	Ame R	Fall	4	3,924,887	976,955	25%	Bay pens	Mare Island net pens
MOKFt	2008	MOK	Mok R	Fall	4	250,969	250,300	100%	Trucked	Sherman Island
MokFw	2008	wild	Mok R	Fall	5	21,860	20,680	95%	Basin	Mokelumne River (Woodbridge, Mok R Vino farms)
MERFt	2008	MER	Mer R	Fall	2	34,532	32,978	95%	Trucked	San Joaquin River (Jersey Pt)
SacW	2008	LSH	Sac R	Wint	10	109,785	100,786	92%	Basin	Sacramento River (Lake Redding Park)
CFHLh	2009	CNFH	Sac R	Late	16	1,154,761	1,115,779	97%	Basin	CNFH (includes spring surrogate releases)
			Total age 4 releases:		162	30,455,664	11,205,781	37%	3% wild CWT releases	

Age 5 CWT releases

Release type*	Brood year	Hatchery	Stock origin	Run type	CWT codes	Total fish released	# CWT tagged	% CWT	Release strategy	Release locations / notes
CFHLh	2008	CNFH	Sac R	Late	14	1,108,540	1,074,211	97%	Basin	CNFH (includes spring surrogate releases)

***CV CWT release types:**

Sacramento River Basin Fall Chinook CWT release types

CFHFh	Coleman National Fish Hatchery fall hatchery releases
CFHFn	Coleman National Fish Hatchery fall net pen releases
FRHFe	Feather River Hatchery fall experimental (2008 brdyr includes spring x fall hybrids)
FRHFn	Feather River Hatchery fall bay net pen releases
FRHFnc	Feather River Hatchery fall coastal net pen releases
FRHFtib	Feather River Hatchery fall Tiburon net pen releases
FeaFw	Feather River fall wild
NIMF	Nimbus Fish Hatchery fall basin releases
NIMFn	Nimbus Fish Hatchery fall net pens

Central Valley Spring Chinook CWT release types

FRHS	Feather River Hatchery spring basin releases
FRHSn	Feather River Hatchery spring net pen releases

San Joaquin Basin Fall Chinook CWT release types

MOKF	Mokelumne Hatchery fall hatchery releases
MOKFn	Mokelumne Hatchery fall net pen releases
MOKFt	Mokelumne Hatchery fall trucked releases (no net pens)
MokFw	Mokelumne River fall wild
MERF	Merced River Hatchery fall hatchery releases
MERFt	Merced River Hatchery fall trucked releases (no net pens)

Sacramento River Basin Winter Chinook CWT release types

SacW	Livingston Stone Hatchery winter basin releases

Sacramento River Basin Late Fall Chinook CWT release types

CFHLh	Coleman National Fish Hatchery late fall hatchery releases

Table 4. Escapement estimates and sample data for 2012 CV escapement and harvest.

Escapement Survey	Run	Total Escapement	Chinook Sampled[a]	Observed Ad-Clips	Heads Processed	Valid CWTs	Sample rate (fe)	Ad-clips processed (fa)	Valid CWTs (fd)	CWT Sample Expansion
Hatchery Escapement										
Coleman National Fish Hatchery	Late-fall[b]	3,564	3,564	3,528	3,282	3,240	100%	93.0%	99.7%	1.07 [c]
Feather River Hatchery	Spring	3,738	3,738	3,322	3,321	3,147	100%	100%	98.2%	1.02
Coleman National Fish Hatchery	Fall	84,289	84,289	19,511	3,719	3,627	100%	19.1%	99.3%	5.31 [c]
Feather River Hatchery	Fall	42,161	42,161	14,132	14,126	13,661	100%	100%	99.2%	1.01
Nimbus Fish Hatchery	Fall	9,257	9,257	3,383	3,382	3,279	100%	100%	99.3%	1.01
Nimbus Fish Hatchery Weir	Fall	3,923	3,923	984	984	907	100%	100%	99.6%	1.00
Mokelumne River Hatchery	Fall	6,620	6,620	4,972	4,972	4,875	100%	100%	99.4%	1.01
Merced River Hatchery	Fall	1,000	1,000	658	658	604	100%	100%	97.1%	1.03
Total Hatchery Escapement		**154,552**	**154,552**	**50,490**	**34,444**	**33,340**				
	fall	**147,250**	**147,250**	**43,640**	**27,841**	**26,953**				
Natural Area Escapement										
Butte Creek	Spring	16,140	10,765	0	0	0	67%	-	-	-
Upper Sacramento River (above RBDD)	Late-fall[b]	5,227	74	6	6	5	1%	100%	100%	42.60 [d]
Upper Sacramento River (above RBDD)	Winter	2,671	736	346	346	312	28%	100%	100%	2.27 [d]
Upper Sacramento River (above RBDD)	Fall	22,435	1,183	396	395	383	5%	99.7%	100%	11.86 [d]
Clear Creek	Fall	7,631	580	149	146	141	8%	98.0%	99.3%	5.92 [d]
Battle Creek	Fall	31,360	video	data not collected						- [e]
Cottonwood Creek	Fall	2,556	225	65	65	60	9%	100%	100%	3.43 [d]
Mill Creek	Fall	890	kayak	9	9	9				1.00 [f]
Deer Creek	Fall	873	video	1	1	1				1.00 [f]
Butte Creek	Fall	813	358	32	32	32	44%	100%	100%	2.27
Feather River	Fall	63,649	7,189	2,244	2,240	2,134	11%	99.8%	98.9%	8.97
Yuba River above Daguerre Point Dam (DPD)	Fall	6,649	6,649	1,803	99	95	100%	5.5%	98.9%	18.41 [g]
Yuba River below DPD	Fall	1,082	146	17	17	17	13%	100%	100%	7.41
American River	Fall	34,900	1,305	1,297	1,297	1,284	4%	100%	99.9%	6.33 [d]
Mokelumne River	Fall	5,471	5,471	3,836	639	606	100%	16.7%	96.2%	6.24 [g]
Cosumnes River	Fall	1,071	redd/video	39	39	38				1.00 [f]
Calaveras River	Fall	112	redd	13	13	12				1.00 [f]
Stanislaus River	Fall	4,006	791	608	608	574	20%	100%	96.5%	5.25
Tuolumne River	Fall	783	349	107	107	99	45%	100%	97.1%	2.31
Merced River	Fall	2,257	479	375	375	355	21%	100%	97.5%	4.83
Total Natural Area Escapement		**194,436**	**25,535**	**11,343**	**6,434**	**6,157**				
	fall	**164,103**	**23,542**	**10,595**	**5,687**	**5,457**				
CV Sport Harvest										
Sacramento River (above Feather River)	Fall	25,525	1,913	341	341	330	7%	100%	98.8%	13.50
Sacramento River (below Feather River)	Fall	19,816	632	186	186	185	3%	100%	99.5%	31.52
Feather River	Fall	12,311	642	145	145	142	5%	100%	100%	19.18
American River	Fall	23,563	673	180	180	176	3%	100%	98.9%	35.41
Mokelumne River	Fall	1,210	120	88	88	87	10%	100%	98.9%	10.20
Sacramento River (above Feather River)	Late-fall[b]	720	64	20	20	20	9%	100%	100%	11.25
Total Sport Harvest		**83,145**	**4,044**	**960**	**960**	**940**				
Total		**432,133**	**184,131**	**62,793**	**41,838**	**40,437**				

a/ Number of Chinook salmon sampled and visually checked for an ad-clip; includes one ad-clipped coho salmon (Lake Oroville release) sampled at Feather River Hatchery.

b/ Late-fall hatchery returns, natural escapement, and sport harvest occurred in late fall 2012 (return year 2013).

c/ Average sample expansion factor. CNFH sample expansion factors calculated based on run-timing and sampling protocol; fall and late-fall counts parsed based on CWT codes (see Table 9).

d/ Sample expansion factor calculated based on the ad-clip rate and proportion of ad-clipped fish containing CWTs of fresh fish only and expanded to all CWTs (Mohr and Satterthwaite, 2013).

e/ Battle creek fall Chinook natural escapement not sampled; escapement estimate based on total Battle Creek adult and jack video weir counts minus total return to Coleman National Fish Hatchery.

f/ Escapement estimates based on redd surveys or video counts; CWTs collected opportunistically and are not representative of total escapement.

Table 5. Catch estimates and sample data for 2012 California sport and commercial ocean salmon fisheries by major port area.

Major port	Total Harvest Estimate	Chinook Sampled[a]	Observed Ad-Clips	Heads Processed	Valid CWTS	Sample Rate (fe)	Ad-clips Processed (fa)	CWTs (fd) Valid	CWT Sample Expansion
Sport									
Eureka/Crescent	39,444	10,158	2,339	2,329	1,940	26%	99.6%	99.2%	3.89
Fort Bragg	7,929	2,143	543	540	490	27%	99.4%	98.6%	3.78
San Francisco	46,189	17,157	4,399	4,380	4,183	37%	99.6%	99.1%	2.73
Monterey	30,364	7,675	2,061	2,045	1,967	25%	99.2%	99.2%	4.08
Sport total	**123,926**	**37,133**	**9,342**	**9,294**	**8,580**				
Commercial									
Eureka/Crescent	5,231	3,310	900	900	610	63%	100.0%	98.9%	1.60
Fort Bragg	38,282	12,871	3,513	3,509	3,215	34%	99.9%	99.3%	2.97
San Francisco	119,100	39,562	9,752	9,731	9,099	33%	99.8%	99.1%	3.06
Monterey	52,972	20,884	5,344	5,339	5,121	39%	99.9%	99.3%	2.59
Commercial total	**215,585**	**76,627**	**19,509**	**19,479**	**18,045**				
Ocean total	**339,511**	**113,760**	**28,851**	**28,773**	**26,625**				

a/ Number of salmon visually checked for an ad-clip

Table 6. Raw and expanded CWT recoveries in CV during 2012 by stock & age, brood years 2007-2011

Fall	2011	2010*	2009	2008	2007	Total 2012 CV CWTs	Total CV %
Age	1	2	3	4	5		
Raw CWT Recoveries	4	3,760	24,384	410	4	28,562	71%
	(< 1%)	(13%)	(85%)	(1%)	(< 1%)		
Expanded CWTtotal	**23**	**38,898**	**256,674**	**5,383**	**16**	300,994	93%
	(< 1%)	(13%)	(85%)	(2%)	(< 1%)		

Spring		2010	2009	2008	2007	Total CV CWTs	Total CV %
Age		2	3	4	5		
Raw CWT Recoveries		611	7,501	178		8,290	21%
		(7%)	(90%)	(2%)			
Expanded CWTtotal		**939**	**14,733**	**512**		16,183	5%
		(6%)	(91%)	(3%)			

Late-Fall		2011	2010	2009	2008	Total CV CWTs	Total CV %
Age		2	3	4	5		
Raw CWT Recoveries		366	2,719	186	2	3,273	8%
		(11%)	(83%)	(6%)	(< 1%)		
Expanded CWTtotal		**467**	**3,432**	**324**	**2**	4,226	1%
		(11%)	(81%)	(8%)	(< 1%)		

Winter		2010	2009	2008	2007	Total CV CWTs	Total CV %
Age		2	3	4	5		
Raw CWT Recoveries		1	311			312	1%
		(< 1%)	(100%)				
Expanded CWTtotal		**3**	**765**			767	0.2%
		(< 1%)	(100%)				

All Runs						Total CV CWTs	Total CV %
Age	1	2	3	4	5		
Raw CWT Recoveries	4	4,738	34,915	774	6	40,437	100%
	(< 1%)	(12%)	(86%)	(2%)	(< 1%)		
Expanded CWTtotal	**23**	**40,307**	**275,604**	**6,219**	**18**	322,171	100%
	(< 1%)	(12%)	(86%)	(2%)	(< 1%)		

* - includes brood year 2010 fall-run Chinook released from Trinity River Hatchery.

Table 7. Raw and expanded CWT recoveries in 2012 ocean fisheries by stock and age, brood years 2007-2011.

Fall	2010	2009	2008	2007	Total Ocean CWTs	Total Ocean%
Age	2	3	4	5		
Raw CWT Recoveries	559	22,766	211	1	23,537	88%
	(2%)	(97%)	(1%)	(< 1%)		
Expanded CWTtotal	**6,644**	**187,656**	**2,279**	**10**	196,589	90%
	(3%)	(95%)	(1%)	(< 1%)		

Spring	2010	2009	2008	2007	Total Ocean CWTs	Total Ocean%
Age	2	3	4	5		
Raw CWT Recoveries	153	1,394	9		1,556	6%
	(10%)	(90%)	(1%)			
Expanded CWTtotal	**544**	**4,066**	**27**		4,637	2%
	(12%)	(88%)	(1%)			

Late-Fall	2011	2010	2009	2008	Total Ocean CWTs	Total Ocean%
Age	2	3	4	5		
Raw CWT Recoveries	1	361	53		415	2%
	(< 1%)	(87%)	(13%)			
Expanded CWTtotal	**4**	**1,105**	**171**		1,280	1%
	(< 1%)	(86%)	(14%)			

Winter	2011	2010	2009	2008	Total Ocean CWTs	Total Ocean%
Age	2	3	4	5		
Raw CWT Recoveries		13			13	0.05%
		(100%)				
Expanded CWTtotal		**48**			48	0.02%
		(100%)				

Non CV Rivers	2010	2009	2008	2007	Total Ocean CWTs	Total Ocean%
Age	2	3	4	5		
Raw CWT Recoveries	8	836	237	23	1,104	4%
	(< 1%)	(76%)	(21%)	(2%)		
Expanded CWTtotal	**97**	**12,979**	**2,019**	**122**	15,217	7%
	(< 1%)	(85%)	(13%)	(1%)		

All Runs					Total Ocean CWTs	Total Ocean%
Age	2	3	4	5		
Raw CWT Recoveries	721	25,370	510	24	26,625	100%
	(3%)	(95%)	(2%)	(< 1%)		
Expanded CWTtotal	**7,289**	**205,855**	**4,496**	**132**	217,772	100%
	(3%)	(95%)	(2%)	(< 1%)		

Table 8. Percentage of inland CWT_{total} recoveries by location, run, and release type[a] in hatchery returns, natural escapement and sport harvest during 2012.

			CNFH			FRH							NFH		MOK			MER			Total %		Total
Location	**Run**	**SacW**	**CFHLh**	**CFHFh**	**CFHFn**	**FRHS**	**FRHSn**	**FRHFe**	**FRHFn**	**FRHFnc**	**FRHFtib**	**FeaFw**	**NIMF**	**NIMFn**	**MOKF**	**MOKFn**	**MOKFt**	**MERF**	**MERFt**	**nonCV**	**Hatchery[b]**	**Natural**	**Run**
Hatchery Spawners																							
Feather River Hatchery	Spring				0.1%	39.9%	43.9%	0.1%	14.4%		-		0.1%								99%	1%	3,738
Coleman Hatchery	Late		99.4%													-					99%	1%	3,564
Coleman Hatchery	Fall			89.2%	1.5%		-		0.7%							-			-		91%	9%	84,289
Feather River Hatchery	Fall				2.0%	4.4%	6.4%	0.1%	81.3%	0.1%	0.7%	-	0.1%	0.1%		0.4%	-		0%	-	96%	4%	42,161
Nimbus Hatchery	Fall				0.5%				0.3%				35.1%	32.6%	0.1%	15.0%	0.3%		1.4%		85%	15%	9,257
Nimbus Weir	Fall				5.5%		0.9%	-	3.6%				36.5%	7.9%	-	11.4%	0.3%		0.8%		67%	33%	3,923
Mokelumne Hatchery	Fall				1.5%		-		0.5%	-	-			1.5%	6.6%	81.2%	2.7%		1.9%		96%	4%	6,620
Merced Hatchery	Fall		0.1%		1.6%				0.8%		0.1%		0.4%	3.8%		58.0%	1.4%	2.8%	9.9%		79%	21%	1,000
Total Hatchery Fall Run			**-**	**51.1%**	**1.7%**	**1.3%**	**1.9%**	**-**	**23.8%**	**-**	**0.2%**	**-**	**3.2%**	**2.4%**	**0%**	**5.4%**	**0.2%**	**-**	**0.3%**	**-**	**92%**	**8%**	**147,250**
Natural Spawners																							
Butte Creek	Spring																				0%	100%	16,140
Upper Sacramento River	Winter	28.7%																			29%	71%	2,671
Upper Sacramento River	Late		4.2%																		4%	96%	5,227
Upper Sacramento River	Fall			24.4%	5.1%		4.0%		33.1%	0.1%	0.5%					0.3%					67%	33%	22,435
Clear Creek	Fall			9.3%	4.4%		0.5%		24.4%		0.6%					0.2%			0.2%		40%	60%	7,631
Cottonwood Creek	Fall			10.2%	7.0%				14.7%	0.2%											32%	68%	2,556
Mill Creek[c]	Fall			0.9%	0.4%				0.9%		0.1%					0.3%					3%	97%	890
Battle Creek[d]	Fall			89.2%	1.5%		-		0.7%							-			-		91%	9%	31,360
Butte Creek	Fall								3.3%				1.1%			6.6%	0.2%		0.9%		12%	88%	813
Feather River	Fall			0.1%	3.9%	3.4%	5.9%	0.1%	75.3%	0.1%	0.8%	0.1%	0.1%			0.1%	-		0.2%		90%	10%	63,649
Yuba River above DPD	Fall				8.9%	8.7%	4.0%	0.3%	12.3%		0.6%		1.1%	2.2%		5.5%			1.4%		45%	55%	6,649
Yuba River below DPD	Fall				8.2%				8.2%		0.7%		0.7%	2.8%		4.8%			1.5%		27%	73%	1,082
American River	Fall				5.6%				0.7%				41.2%	19.6%		5.4%	0.2%		0.5%		73%	27%	34,900
Mokelumne River	Fall								0.9%					0.9%	1.7%	70.7%	1.0%		2.3%		78%	22%	5,471
Cosumnes River[c]	Fall													0.4%		3.2%	0.1%		0.2%		4%	96%	1,071
Calaveras River[c]	Fall															7.6%			1.5%		9%	91%	132
Stanislaus River	Fall		0.1%		2.6%				1.6%					1.6%	0.3%	64.6%	0.9%		11.1%		83%	17%	4,006
Tuolumne River	Fall				3.6%				2.4%							21.3%	0.3%		8.4%		36%	64%	783
Merced River	Fall				5.1%				1.7%		0.2%			2.6%		62.4%	0.8%	0.4%	13.9%		87%	13%	2,257
Total Natural Area Fall Run[e]			**-**	**18.0%**	**3.9%**	**1.7%**	**2.5%**	**-**	**32.1%**	**-**	**0.4%**	**0.1%**	**9.0%**	**4.5%**	**0.1%**	**6%**	**0.1%**	**-**	**0.8%**		**80%**	**20%**	**161,157**
Sport Harvest																							
Inland Creel - Late Fall	Late		30.4%		6.3%																37%	63%	720
Inland Creel - Upper Sac	Fall		0.1%	63.9%	1.5%		0.2%		3.4%		0.1%					0.1%					69%	31%	25,525
Inland Creel - Lower Sac	Fall		1.1%	5.1%	5.7%		0.2%		24.3%		0.2%		18.7%	16.2%		10.5%			2.0%		84%	16%	19,816
Inland Creel - Feather	Fall				4.4%	0.9%	1.3%		71.6%		0.8%					0.2%			0.2%		79%	21%	12,311
Inland Creel - American	Fall				9.0%	0.2%	1.4%		3.6%				42.1%	11.4%		10.2%			0.3%		78%	22%	23,563
Inland Creel - Mokelumne	Fall								3.4%						3.4%	72.6%			4.5%		84%	16%	1,210
Total Sport Fall Harvest			**0.3%**	**21.0%**	**5.1%**	**0%**	**0.7%**		**18.7%**		**0.2%**		**16.5%**	**7.2%**	**-**	**6.6%**			**0.7%**		**77%**	**23%**	**82,425**

a/ Any values resulting in less than 0.05% are displayed here as "-". Note: These values represent a small number of recoveries and are not actual zeros.
b/ Recovery of natural-origin Feather River (FeaFw) CWT releases are not included in hatchery proportion totals.
c/ Surveys without representative sampling of CWTs; proportions shown are based only on CWTs collected opportunistically.
d/ No CWT recovery survey or ad-clip count available for Battle Creek natural escapement. CWT release group and total hatchery proportions assumed to be equivalent to fall return at Coleman National Fish Hatchery (FWS staff, per. comm).
e/ Total natural area fall run proportion based only on surveys with representative sampling of CWTs.

Table 9. Coleman National Fish Hatchery 2012 fall- and 2013 late-fall-run Chinook salmon escapement based on run-timing and CWT sample rates.

Calculation of CNFH sample expansion factors based on run-timing and sample rate

2012 CNFH fall-run escapement (Oct 2, 2012 - Dec 5, 2012)

Run timing (CWT sample rate)	Escapement N	Chinook sampled (n)	Observed ad-clips	Heads processed	Valid CWTs	Sample rate (fe)	Ad-clips processed (fa)	Valid CWTs (fd)	F_{samp}	Total CWT Production	$\sum_{i=1}^{m} CWT_{total,i}$	Hatchery proportion
Oct 2- Nov 20 (19%)	84,539	84,539	19,775	3,750	3,658	100%	19.0%	99.3%	**5.32**	14,527	77,283	
Nov 28 - Dec 5 (100%)	744	744	725	722	712	100%	99.6%	98.8%	**1.01**	741	748	
	85,283	**85,283**	**20,500**	**4,472**	**4,370**					**15,268**	**78,031**	**91.5%**

2013 CNFH late-fall-run escapement (Dec 20, 2012 - Feb 28, 2013)

Run timing (CWT sample rate)	Escapement N	Chinook sampled	Observed ad-clips	Heads processed	Valid CWTs	Sample rate (fe)	Ad-clips processed (fa)	Valid CWTs (fd)	F_{samp}	Total CWT Production	$\sum_{i=1}^{m} CWT_{total,i}$	Hatchery proportion
Dec 20 - Feb 28 (100%)	**2,570**	**2,570**	**2,539**	**2,529**	**2,497**	100%	99.6%	99.9%	**1.00**	**2,564**	**2,564**	**99.8%**
Total CNFH count	**87,853**	**87,853**	**23,039**	**7,001**	**6,867**					**17,832**	**80,596**	

Final CNFH escapment based on CWT segregation and sample expansion factors F_{samp} calculated above

2012 CNFH fall-run escapement

Run timing	Escapement N	Chinook sampled	Observed ad-clips	Heads processed	Fall CWTs	Sample rate (fe)	Ad-clips processed (fa)	Valid CWTs (fd)	Average F_{samp}	Total CWT Production	$\sum_{i=1}^{m} CWT_{total,i}$	Hatchery proportion
Oct 2- Dec 5	**84,289**	**84,289**	**19,511**	**3,719**	**3,627**	100%	19.1%	99.3%	**5.31**	**14,519**	**77,052**	**91.4%**

2013 CNFH late-fall-run escapement

Run timing	Escapement N	Chinook sampled	Observed ad-clips	Heads processed	Late fall CWTs	Sample rate (fe)	Ad-clips processed (fa)	Valid CWTs (fd)	Average F_{samp}	Total CWT Production	$\sum_{i=1}^{m} CWT_{total,i}$	Hatchery proportion
Dec 20 - Feb 28	**3,564**	**3,564**	**3,528**	**3,282**	**3,240**	100%	93.0%	99.7%	**1.07**	**3,313**	**3,544**	**99.4%**
Total CNFH count	**87,853**	**87,853**	**23,039**	**7,001**	**6,867**					**17,832**	**80,596**	

Table 10. CWT recovery rate (recoveries per 100,000 CWTs released) by release type, brood year, and recovery location in 2012. (page 1 of 2)

Age 2 CV recoveries

Release	Brood	Run	# CWT	Central Valley CWT_{samp} recoveries by location									CV CWT_{samp} totals			Ocean	Recovery rate per 100,000 released				CV Stray
type	year	type	tagged	Bat Cr	Up Sac	Nat crks[a/]	Fea	Yub	Ame	Mok	Mer	SJ	Basin	Stray	CV total	CWT_{samp}	Basin	Stray	CV total	Ocean	Proportion
FRHS	2010	Spr	1,170,340				659	74					732		732	399	63		63	34	0.00
FRHSn	2010	Spr	1,136,690				195						195		195	137	17		17	12	0.00
CFHFh	2010	Fall	2,835,420	1,738	59	32	9						1,798	41	1,839	309	63	1	65	11	0.02
CFHFn	2010	Fall	334,756	37		8	53	33	51	7	13		37	165	202	129	11	49	60	39	0.82
FRHFn	2010	Fall	2,554,115	27	24	24	3,211	92	28	9	1	5	3,303	118	3,421	668	129	5	134	26	0.03
FRHFnc	2010	Fall	185,985				18						18		18	259	10		10	139	0.00
FRHFtib	2010	Fall	56,030		12		59	18		1			78	13	91	22	139	23	162	39	0.14
NIMF	2010	Fall	1,014,340				1	18	549				549	19	568	231	54	2	56	23	0.03
NIMFn	2010	Fall	368,363				1		104	4	1		104	6	110	52	28	2	30	14	0.06
MOKF	2010	Fall	100,215						1	20			20	1	21		20	1	21		0.05
MOKFn	2010	Fall	1,126,781				14	7	154	486	58	31	486	265	751	177	43	24	67	16	0.35
MOKFt	2010	Fall	473,268				1		21	48	3	5	48	30	78	34	10	6	16	7	0.39
MERF	2010	Fall	73,631								36		36		36	12	49		49	16	0.00
MERFt	2010	Fall	56,011				1				28		28	1	29	7	50	2	52	13	0.03
SacW	2010	Wint	113,905		2								2		2		2		2		0.00
CFHLh	2011	Late	1,037,859	417									417		417	4	40		40	0	0.00
		Total	12,637,709	2,219	97	64	4,223	243	907	575	140	41	7,852	659	8,511	2,441	729	114	844	390	

Age 3 CV recoveries

Release	Brood	Run	# CWT	Central Valley CWT_{samp} recoveries by location									CV CWT_{samp} totals			Ocean	Recovery rate per 100,000 released				CV Stray
type	year	type	tagged	Bat Cr	Up Sac	Nat crks[a/]	Fea	Yub	Ame	Mok	Mer	SJ	Basin	Stray	CV total	CWT_{samp}	Basin	Stray	CV total	Ocean	Proportion
FRHS	2009	Spr	1,026,954				4,577	479					5,055		5,055	1,111	492		492	108	0.00
FRHSn	2009	Spr	1,058,635	16	866	36	7,490	239	35	1			7,729	953	8,682	2,853	730	90	820	270	0.11
CFHFh	2009	Fall	2,541,142	16,757	1,269	212							18,026	212	18,238	11,953	709	8	718	470	0.01
CFHFn	2009	Fall	337,919	266	273	121	740	136	477	17	20	33	539	1,544	2,083	3,609	159	457	616	1,068	0.74
FRHFn	2009	Fall	2,367,209	112	1,791	541	17,024	133	78	11	11	15	17,157	2,559	19,715	13,718	725	108	833	580	0.13
FRHFnc	2009	Fall	118,879		12	3	58			1			58	16	74	2,549	49	14	62	2,145	0.22
FRHFtib	2009	Fall	60,104		107	48	742	26		1	6		768	162	930	1,657	1278	269	1547	2,756	0.17
NIMF	2009	Fall	1,000,559			2	22	7	4,959		1		4,959	33	4,992	7,370	496	3	499	737	0.01
NIMFn	2009	Fall	347,527				10	44	2,051	33	23	16	2,051	125	2,177	4,364	590	36	626	1,256	0.06
MOKF	2009	Fall	99,048						5	509		11	509	16	524	372	514	16	529	375	0.03
MOKFn	2009	Fall	2,015,730	11	59	85	157	390	3,086	7,310	1,752	2,626	7,310	8,166	15,476	20,686	363	405	768	1,026	0.53
MERFt	2009	Fall	154,685	2		21	168	107	313	237	360	477	360	1,325	1,685	2,103	233	856	1089	1,359	0.79
SacW[b]	2009	Wint	183,644		706								706		706	45	384		384	40	0.00
CFHLh	2010	Late	992,047	2,860	85						1	5	2,951	6	2,951	1,079	297	1	298	109	0.00
		Total	12,304,082	20,023	5,168	1,069	30,988	1,562	11,004	8,119	2,174	3,183	68,178	15,118	83,289	73,469	7,019	2,264	9,283	12,298	

Table 10. CWT recovery rate (recoveries per 100,000 CWTs released) by release type, brood year, and recovery location in 2012. (page 2 of 2)

Age 4 CV recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley CWT_{samp} recoveries by location: Bat Cr	Up Sac	Nat crks[a/]	Fea	Yub	Ame	Mok	Mer	SJ	CV CWT_{samp} totals: Basin	Stray	CV total	Ocean CWT_{samp}	Recovery rate per 100,000 released: Basin	Stray	CV total	Ocean	CV Stray Proportion
FRHS	2008	Spr	1,015,717				227	18					245		245	9	24		24	0.8	0.00
FRHSn	2008	Spr	1,005,727				212	18	1				231	1	232	18	23	0	23	2	0.00
CFHFh	2008	Fall	3,128,374	239	36								275		275	81	9		9	3	0.00
CFHFn	2008	Fall	371,726	5	12		29		25				17	54	71	52	5	15	19	14	0.76
FRHFn	2008	Fall	2,061,211		24		301						301	24	325	146	15	1	16	7	0.07
FRHFe	2008	Fall	481,853				66	18	1				85	1	86	6	18	0	18	1	0.01
FRHFtib	2008	Fall	89,859				1						1		1	9	1		1	10	0.00
NIMF	2008	Fall	264,006				1		1				1	1	2	10	0	0	1	4	0.50
NIMFn	2008	Fall	976,955				1		378	1			378	2	381	261	39	0	39	27	0.01
MOKFt	2008	Fall	250,300			2	10		28	46	21	18	74	52	126	81	30	21	50	33	0.41
MERFt	2008	Fall	32,978													8				23	0.00
SacW	2008	Wint	100,786																		
CFHLh	2009	Fall	1,115,779	188	128								316		316	167	28		28	15	0.00
		Total	10,895,271	432	199	2	849	55	435	47	21	18	1,924	134	2,059	847	191	37	228	138	

Age 5 CV recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley CWT_{samp} recoveries by location: Bat Cr	Up Sac	Nat crks[a/]	Fea	Yub	Ame	Mok	Mer	SJ	CV CWT_{samp} totals: Basin	Stray	CV total	Ocean CWT_{samp}	Recovery rate per 100,000 released: Basin	Stray	CV total	Ocean	CV Stray Proportion
CFHLh	2008	Late	1,074,211	2									2		2		0		0		0.00

a/ Natural creeks include Clear Creek, Cottonwood Creek, Mill Creek and Butte Creek.

b/ Age 3 ocean recoveries and recovery rate of SacW are brood year 2010 releases.

Sacramento River fall Chinook release types (SFC)

CFHFh	Coleman Hatchery fall hatchery releases
CFHFn	Coleman Hatchery fall net pen releases
FRHFe	Feather River Hatchery fall experimental (2008 brdyr includes spring x fall hybrids)
FRHFn	Feather River Hatchery fall bay net pen releases
FRHFnc	Feather River Hatchery fall coastal net pen releases
FRHFtib	Feather River Hatchery fall Tiburon net pen releases (released as yearlings following fall)
NIMF	Nimbus Hatchery fall basin releases
NIMFn	Nimbus Hatchery fall net pens releases

Other CV Chinook release types (OCV)

FRHS	Feather River Hatchery spring basin releases
FRHSn	Feather River Hatchery spring net pen releases
MOKF	Mokelumne Hatchery fall hatchery releases
MOKFn	Mokelumne Hatchery fall net pen releases
MOKFt	Mokelumne Hatchery fall trucked releases
MERF	Merced River Hatchery fall hatchery releases
MERFt	Merced River Hatchery fall trucked releases
SacW	Livingston Stone Hatchery winter basin releases
CFHLh	Coleman Hatchery late fall hatchery releases

Table 11. Percentage of CWT_{total} recoveries by majorport, month and release type[a] in 2012 California ocean salmon sport fishery.

			CNFH				FRH				NFH			MOK			MER			Total	Total %		Total
	SacW	CFHLh	CFHFh	CFHFn	FRHS	FRHSn	FRHFe	FRHFn	FRHFnc	FRHFtib	NIMF	NIMFn	MOKF	MOKFn	MOKFt	MERF	MERFt	nonCV	CV	Hatchery	Natural	Harvest
Sport Harvest																						
Eureka/Crescent City																						
May			14.2%	3.3%	0.2%	0.6%	0.1%	15.8%	0.1%	0.2%	10.3%	3.9%		6.6%			1.3%	10%	57%	66%	34%	3,577
Jun		0.1%	9.9%	1.6%	0.2%	0.4%		10.6%	0.2%	0.1%	5.6%	3.8%	-	5.1%			0.5%	20%	38%	58%	42%	10,865
Jul		-	11.7%	3.4%	0.1%	0.3%		12.1%	0.5%	0.1%	6.4%	3.2%	0.1%	4.9%			0.6%	14%	43%	58%	42%	11,810
Aug		0.3%	8.6%	1.4%	0.4%	0.2%		7.0%	0.4%	0.2%	5.7%	4.7%		6.0%	-		0.4%	19%	35%	55%	45%	10,488
Sep		0.2%	2.7%	0.7%	2.1%	1.6%		6.1%	0.7%	0.2%	6.3%	8.1%	0.2%	8.3%			0.9%	15%	38%	53%	47%	2,704
Total		**0.1%**	**10.0%**	**2.2%**	**0.4%**	**0.4%**	**-**	**10.3%**	**0.4%**	**0.2%**	**6.3%**	**4.2%**	**-**	**5.6%**	**-**		**0.6%**	**17%**	**41%**	**57%**	**43%**	**39,444** (32%)
Fort Bragg																						
Apr			29.2%	7.4%		1.9%		22.0%			14.7%	6.5%		8.4%					90%	90%	10%	414
May		0.5%	12.3%	3.8%	0.7%	1.4%		14.7%	1.3%	0.2%	9.8%	6.3%		8.4%				3%	60%	62%	38%	1,530
Jun		1.0%	18.8%	1.2%	0.4%	1.1%		15.5%	0.4%	0.2%	6.5%	3.0%		5.1%			0.6%	9%	54%	62%	38%	1,951
Jul		0.2%	20.9%	7.7%	0.5%	0.4%		20.3%	0.5%	0.2%	3.7%	2.1%		3.5%	0.9%		0.6%	5%	61%	67%	33%	2,300
Aug		0.3%	18.1%	8.2%	1.0%	0.3%		22.6%	1.8%		9.1%	4.1%		5.9%					71%	71%	29%	1,185
Sep			4.3%	3.9%	1.1%	1.0%		24.8%	1.1%		8.2%	16.0%		10.3%					71%	71%	29%	393
Oct			14.9%			4.3%		14.9%		3.8%	14.9%			7.8%					61%	61%	40%	84
Nov			53.4%		6.7%														60%	60%	40%	72
Total		**0.4%**	**18.1%**	**5.0%**	**0.7%**	**0.9%**		**18.5%**	**0.8%**	**0.2%**	**7.3%**	**4.3%**		**5.8%**	**0.3%**		**0.3%**	**4%**	**63%**	**67%**	**33%**	**7,929** (6%)
San Francisco																						
Apr		0.3%	16.9%	4.7%	0.6%	1.6%		20.8%	1.0%	0.9%	7.6%	5.3%	0.1%	7.6%			0.5%	2%	68%	70%	30%	3,837
May		0.8%	16.0%	5.3%	0.8%	2.2%		20.0%	1.1%	1.1%	6.5%	3.5%	0.3%	5.7%			0.7%	3%	64%	67%	33%	5,143
Jun	-	0.8%	15.1%	4.9%	0.2%	1.0%	-	18.7%	0.8%	1.1%	8.5%	7.1%	0.2%	5.5%			0.5%	3%	64%	67%	33%	10,700
Jul	-	0.8%	13.7%	4.9%	1.0%	0.6%		18.6%	1.3%	0.4%	6.4%	5.1%	0.2%	6.0%	0.2%	-	0.5%	1%	60%	61%	39%	15,329
Aug		0.6%	19.0%	4.3%	0.8%	0.3%		28.1%	1.2%	1.1%	4.6%	3.3%	0.1%	5.4%			0.2%	1%	69%	70%	30%	5,340
Sep		0.2%	6.7%	1.0%	0.6%			10.2%	0.1%	0.5%	12.8%	7.5%	0.3%	14.9%	0.9%	0.1%	1.2%		57%	57%	43%	3,871
Oct		2.5%	1.8%		1.1%			1.8%	0.2%	0.7%	15.4%	16.2%	0.7%	16.9%	1.8%		1.7%		61%	61%	39%	1,881
Nov		7.0%		13.8%	7.0%			13.9%				16.9%							59%	59%	41%	88
Total	**-**	**0.7%**	**14.1%**	**4.3%**	**0.7%**	**0.8%**	**-**	**18.7%**	**1.0%**	**0.8%**	**7.7%**	**5.9%**	**0.2%**	**7.1%**	**0.2%**	**-**	**0.6%**	**1%**	**63%**	**64%**	**36%**	**46,189** (37%)
Monterey																						
Apr		0.3%	15.5%	6.1%	1.0%	1.8%		23.2%	1.5%	0.6%	7.4%	3.9%	0.2%	5.2%	-		0.7%	1%	67%	68%	32%	14,535
May		0.4%	14.1%	7.2%	1.2%	3.2%		28.7%	1.3%	0.6%	6.6%	3.6%	0.1%	4.1%			0.6%	1%	72%	73%	27%	4,473
Jun			28.9%	10.0%		0.2%		24.0%	1.3%	0.8%	4.6%	3.0%		3.7%			0.4%	0%	77%	77%	23%	4,376
Jul	0.1%	0.7%	19.0%	7.7%	0.3%	0.3%		26.3%	1.8%	0.5%	7.3%	5.0%	0.1%	6.7%			0.6%	1%	76%	77%	23%	6,268
Aug	1.0%		7.5%	3.8%	3.8%	3.8%		15.1%	6.7%		8.5%	3.8%		0.9%	3.8%				59%	59%	41%	462
Sep						5.4%		42.5%	16.0%										64%	64%	36%	121
Oct			33.6%			4.3%			4.2%										42%	42%	58%	129
Total	**-**	**0.3%**	**17.9%**	**7.1%**	**0.8%**	**1.5%**		**24.6%**	**1.7%**	**0.6%**	**6.8%**	**3.9%**	**0.1%**	**5.1%**	**0.1%**		**0.6%**	**1%**	**71%**	**72%**	**28%**	**30,364** (25%)
Total CA Harvest																						
	-	**0.4%**	**14.0%**	**4.4%**	**0.6%**	**0.9%**	**-**	**17.4%**	**0.9%**	**0.5%**	**7.0%**	**4.7%**	**0.1%**	**6.0%**	**0.1%**	**-**	**0.6%**	**6%**	**58%**	**64%**	**36%**	**123,926**

a/ Any values resulting in less than 0.05% are displayed here as "-". Note: These values represent some small number of recoveries and are not actual zeros.

Table 12. Percentage of CWT_{total} recoveries by majorport, month and release type[a] in 2012 California ocean salmon commercial fishery.

			CNFH				FRH				NFH			MOK			MER		Total	Total %		Total
	SacW	CFHLh	CFHFh	CFHFn	FRHS	FRHSn	FRHFe	FRHFn	FRHFnc	FRHFtib	NIMF	NIMFn	MOKF	MOKFn	MOKFt	MERF	MERFt	nonCV	CV	Hatchery	Natural	Harvest
Commercial Harvest																						
Eureka/Crescent City																						
Sept		**0.7%**	**3.6%**	**1.6%**	**0.4%**	**1.0%**		**6.9%**	**0.2%**	**0.3%**	**5.5%**	**8.7%**	**0.2%**	**6.4%**			**0.8%**	**9.4%**	**36%**	**46%**	**54%**	**5,231**
Fort Bragg																						**(2%)**
Jul		0.4%	12.3%	3.9%	0.2%	0.9%		14.1%	0.5%	0.5%	6.9%	6.0%	0.1%	6.5%	-		0.6%	7.7%	53%	61%	39%	24,324
Aug		1.0%	12.8%	3.4%	0.1%	0.6%		16.5%	0.6%	0.4%	12.6%	8.7%	0.2%	9.2%	0.1%	-	0.9%	3.3%	67%	70%	30%	12,304
Sep		2.3%	4.6%	1.8%	0.2%	0.5%		10.2%	0.7%	0.5%	10.0%	14.8%	0.5%	15.3%			2.0%		63%	63%	37%	1,654
Total		**0.7%**	**12.1%**	**3.7%**	**0.2%**	**0.8%**		**14.7%**	**0.6%**	**0.5%**	**8.9%**	**7.2%**	**0.2%**	**7.8%**	**0.1%**	**-**	**0.8%**	**6.0%**	**58%**	**64%**	**36%**	**38,282**
San Francisco																						**(18%)**
May		0.1%	14.9%	4.1%	0.6%	1.5%		16.8%	0.9%	0.5%	5.3%	3.3%	-	3.9%	-	-	0.4%	3.1%	52%	55%	45%	34,005
Jun		0.1%	14.1%	4.7%	0.3%	0.6%		19.3%	0.9%	0.8%	7.4%	6.9%	-	5.6%			0.6%	4.4%	61%	65%	35%	10,090
Jul	-	0.4%	14.3%	4.2%	0.2%	0.4%		15.8%	0.7%	0.6%	7.9%	6.2%	0.1%	6.7%	-		0.8%	4.4%	58%	63%	37%	51,592
Aug		0.6%	17.9%	6.0%	0.1%	0.3%		16.2%	0.8%	0.8%	8.8%	8.4%	0.1%	7.4%	0.1%		0.8%	1.3%	68%	69%	31%	14,292
Sep		0.2%	3.6%		0.1%	0.2%		8.0%	0.1%	0.4%	19.0%	11.6%	0.2%	16.3%			2.0%	0.2%	62%	62%	38%	5,808
Oct		1.3%	1.2%					1.2%		0.3%	13.3%	33.4%	0.6%	23.8%	0.3%		4.2%		79%	79%	21%	3,313
Total	**-**	**0.3%**	**14.0%**	**4.1%**	**0.3%**	**0.7%**		**15.6%**	**0.7%**	**0.6%**	**7.9%**	**6.7%**	**0.1%**	**6.8%**	**-**	**-**	**0.8%**	**3.3%**	**59%**	**62%**	**38%**	**119,100**
Monterey																						**(55%)**
May		0.1%	20.8%	6.8%	1.1%	2.7%		22.6%	1.0%	0.4%	5.3%	2.8%	-	3.4%	-		0.4%	1.5%	67%	69%	31%	24,852
Jun		0.1%	21.8%	6.9%	0.3%	0.5%		25.4%	1.2%	0.5%	7.6%	2.4%		4.3%			0.5%	0.9%	72%	72%	28%	9,295
Jul		0.2%	19.9%	6.4%	0.1%	0.3%		24.4%	1.4%	0.6%	9.0%	3.8%	0.1%	6.3%	-		0.5%	1.0%	73%	74%	26%	16,926
Aug	1.1%	2.4%	9.8%	3.8%		1.7%		15.9%	1.8%	0.1%	10.3%	4.2%		10.0%			0.6%	0.5%	62%	62%	38%	1,670
Sep	2.3%					4.4%		8.7%						4.3%					20%	20%	80%	229
Total	**-**	**0.2%**	**20.3%**	**6.6%**	**0.6%**	**1.5%**		**23.4%**	**1.2%**	**0.4%**	**7.0%**	**3.1%**	**-**	**4.7%**	**-**		**0.4%**	**1.2%**	**70%**	**71%**	**29%**	**52,972**
Total CA Harvest																						**(25%)**
	-	**0.3%**	**15.0%**	**4.6%**	**0.4%**	**0.9%**		**17.1%**	**0.8%**	**0.5%**	**7.8%**	**6.0%**	**0.1%**	**6.5%**	**-**	**-**	**0.7%**	**3.4%**	**61%**	**64%**	**36%**	**215,585**

a/ Any values resulting in less than 0.05% are displayed here as "-". Note: These values represent some small number of recoveries and are not actual zeros.

Appendix 1. Central Valley fall-run Chinook salmon carcass surveys collecting fish condition in 2012

Upper Sacramento River fall-run Chinook salmon carcass survey

Condition		Escapement N	Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	*p_adc*	*p_cwt|adc*
fresh	26%		1,183	5.3%	256	255	243	0.22	0.95
nonfresh	74%		3,421	15.2%	155	152	143	0.05	0.94
total		22,435	4,604	20.5%	411	407	386		

Clear Creek fall-run Chinook salmon carcass survey

Condition		Escapement N	Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	*p_adc*	*p_cwt|adc*
fresh	20%		580	7.6%	71	68	64	0.12	0.94
nonfresh	80%		2,380	31.2%	87	87	78	0.04	0.90
total		7,631	2,960	38.8%	158	155	142		

Cottonwood Creek fall-run Chinook salmon carcass survey

Condition		Escapement N	Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	*p_adc*	*p_cwt|adc*
fresh	23%		225	8.8%	23	23	18	0.10	0.78
nonfresh	77%		758	29.7%	57	57	42	0.08	0.74
total		2556	983	38.5%	80	80	60		

Lower American River fall-run Chinook salmon carcass survey

Condition		Escapement N	Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	*p_adc*	*p_cwt|adc*
fresh	12%		1,305	3.7%	312	312	300	0.24	0.96
nonfresh	88%		9,249	26.5%	1,053	1,053	993	0.11	0.94
total		34,900	10,554	30.2%	1,365	1,365	1,293		

Sacramento fall-run Chinook salmon carcass surveys combined

Condition		Escapement N	Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	*p_adc*	*p_cwt|adc*
fresh	17%		3,293	4.9%	662	658	625	0.20	0.95
nonfresh	83%		15,808	23.4%	1,352	1,349	1,256	0.09	0.93
total		67,522	19,101	28.3%	2,014	2,007	1,881		

p-adc = proportion of sampled fish that were ad-clipped; *p_cwt|adc* = proportion of ad-clipped fish containing CWTs

Appendix 2. Alternative 2012 CWT recovery and stray rates (recoveries per 100,000 CWTs released) of CNFH and FRH releases.[a/]

Age 2 CV recoveries

Release	Brood	Run	# CWT	Central Valley CWT_{samp} recoveries by location									CV CWT_{samp} totals			Ocean	Recovery rate per 100,000 released				CV Stray
group	year	type	tagged	Bat Cr	Up Sac	Nat crks[b/]	Fea	Yub	Ame	Mok	Mer	SJ	Basin	Stray	CV total	CWT_{samp}	Basin	Stray	CV total	Ocean	Proportion
CFHFh	2010	Fall	2,835,420	1,738	59	32	9						1,738	101	1,839	309	61	4	65	11	0.05
CFHFn	2010	Fall	334,756	37		8	53	33	51	7	13		37	165	202	129	11	49	60	39	0.82
CFHLh	2011	Late	1,037,859	417									417		417	4	40		40	0	
FRHFn	2010	Fall	2,554,115	27	24	24	3,211	92	28	9	1	5	3,211	210	3,421	668	126	8	134	26	0.06
FRHFnc	2010	Fall	185,985				18						18		18	259	10		10	139	
FRHFtib	2010	Fall	56,030		12		59	18		1			59	31	91	22	106	56	162	39	0.35
FRHS	2010	Spr	1,170,340				659	74					659	74	732	399	56	6	63	34	0.10
FRHSn	2010	Spr	1,136,690				195						195		195	137	17		17	12	

Age 3 CV recoveries

Release	Brood	Run	# CWT	Central Valley CWT_{samp} recoveries by location									CV CWT_{samp} totals			Ocean	Recovery rate per 100,000 released				CV Stray
group	year	type	tagged	Bat Cr	Up Sac	Nat crks[b/]	Fea	Yub	Ame	Mok	Mer	SJ	Basin	Stray	CV total	CWT_{samp}	Basin	Stray	CV total	Ocean	Proportion
CFHFh	2009	Fall	2,541,142	16,757	1,269	212							16,757	1,481	18,238	11,953	659	58	718	470	0.08
CFHFn	2009	Fall	337,919	266	273	121	740	136	477	17	20	33	266	1,817	2,083	3,609	79	538	616	1,068	0.87
CFHLh	2010	Late	992,047	2,860	85						1	5	2,860	91	2,951	1,079	288	9	297	109	0.03
FRHFn	2009	Fall	2,367,209	112	1,791	541	17,024	133	78	11	11	15	17,024	2,691	19,715	13,718	719	114	833	580	0.14
FRHFnc	2009	Fall	118,879		12	3	58			1			58	16	74	2,549	49	14	62	2,145	0.22
FRHFtib	2009	Fall	60,104		107	48	742	26		1	6		742	188	930	1,657	1235	312	1547	2,756	0.20
FRHS	2009	Spr	1,026,954				4,577	479					4,577	479	5,055	1,111	446	46.6	492	108	0.09
FRHSn	2009	Spr	1,058,635	16	866	36	7,490	239	35	1			7,490	1,193	8,682	2,853	707	113	820	270	0.14

Age 4 CV recoveries

Release	Brood	Run	# CWT	Central Valley CWT_{samp} recoveries by location									CV CWT_{samp} totals			Ocean	Recovery rate per 100,000 released				CV Stray
group	year	type	tagged	Bat Cr	Up Sac	Nat crks[b/]	Fea	Yub	Ame	Mok	Mer	SJ	Basin	Stray	CV total	CWT_{samp}	Basin	Stray	CV total	Ocean	Proportion
CFHFh	2008	Fall	3,128,374	239	36								239	36	275	81	8	1.1	9	3	0.13
CFHFn	2008	Fall	371,726	5	12		29		25				5	66	71	52	1	18	19	14	0.93
CFHLh	2009	Late	1,115,779	188	128								188	128	316	167	17	11	28	15	0.41
FRHFe	2008	Fall	481,853				66	18	1				66	19	86	6	14	4.0	18	1	0.23
FRHFn	2008	Fall	2,061,211		24		301						301	24	325	146	15	1	16	7	0.07
FRHFtib	2008	Fall	89,859				1						1		1	9	1		1	10	
FRHS	2008	Spr	1,015,717				227	18					227	18	245	9	22	2	24	1	0.00
FRHSn	2008	Spr	1,005,727				212	18	1				212	19	232	18	21	2	23	2	0.08

Age 5 CV recoveries

Release	Brood	Run	# CWT	Central Valley CWT_{samp} recoveries by location									CV CWT_{samp} totals			Ocean	Recovery rate per 100,000 released				CV Stray
group	year	type	tagged	Bat Cr	Up Sac	Nat crks[b/]	Fea	Yub	Ame	Mok	Mer	SJ	Basin	Stray	CV total	CWT_{samp}	Basin	Stray	CV total	Ocean	Proportion
CFHLh	2008	Late	1,074,211	2									2		2		0		0		

a/ CNFH and FRH releases recovered in upper Sacramento River and Yuba River, respectively, considered as stray recoveries.

b/ Natural creeks include Clear Creek, Cottonwood Creek, Mill Creek and Butte Creek.

	Release Type	Release Location
1	SacW	Lake Redding Park
2	CFHFh,CFHLh	CNFH
3	FeaFw	Thermalito Bypass
4	FRHS	Boyds Pump Ramp (FRH)
5	FRHFe	Elkhorn Boat Launch
6	NIMF	Sunrise Launch Ramp (NFH)
7	FRHFe, NIMF	Discovery Park (NFH)
8	FRHFe	Miller Park, Garcia Bend
9	MOKF	MOK
10	MokFw	Mok R Vino Farms
11	MokFw	Woodbridge
12	MERF	MER
13	MERFt	Hatfield State Area
14	MERFt	Mossdale
15	MERFt	Jersey Point
16	MOKFn, MOKFt	Sherman Island
17	FRHFe	Benicia, Pittsburg
18	CFHFn, FRHSn, FRHFn, NIMFn	Mare Island Net Pens
19	FRHFn,NIMFn	Wickland Oil Net Pens (Conoco Phillips Refinery)
20	CFHFn,FRHSn FRHFn	San Pablo Bay Net Pens (Wickland Oil + Mare Island)
21	FRHFtib	Tiburon Net Pens
22	FRHFnc	Santa Cruz Net Pens

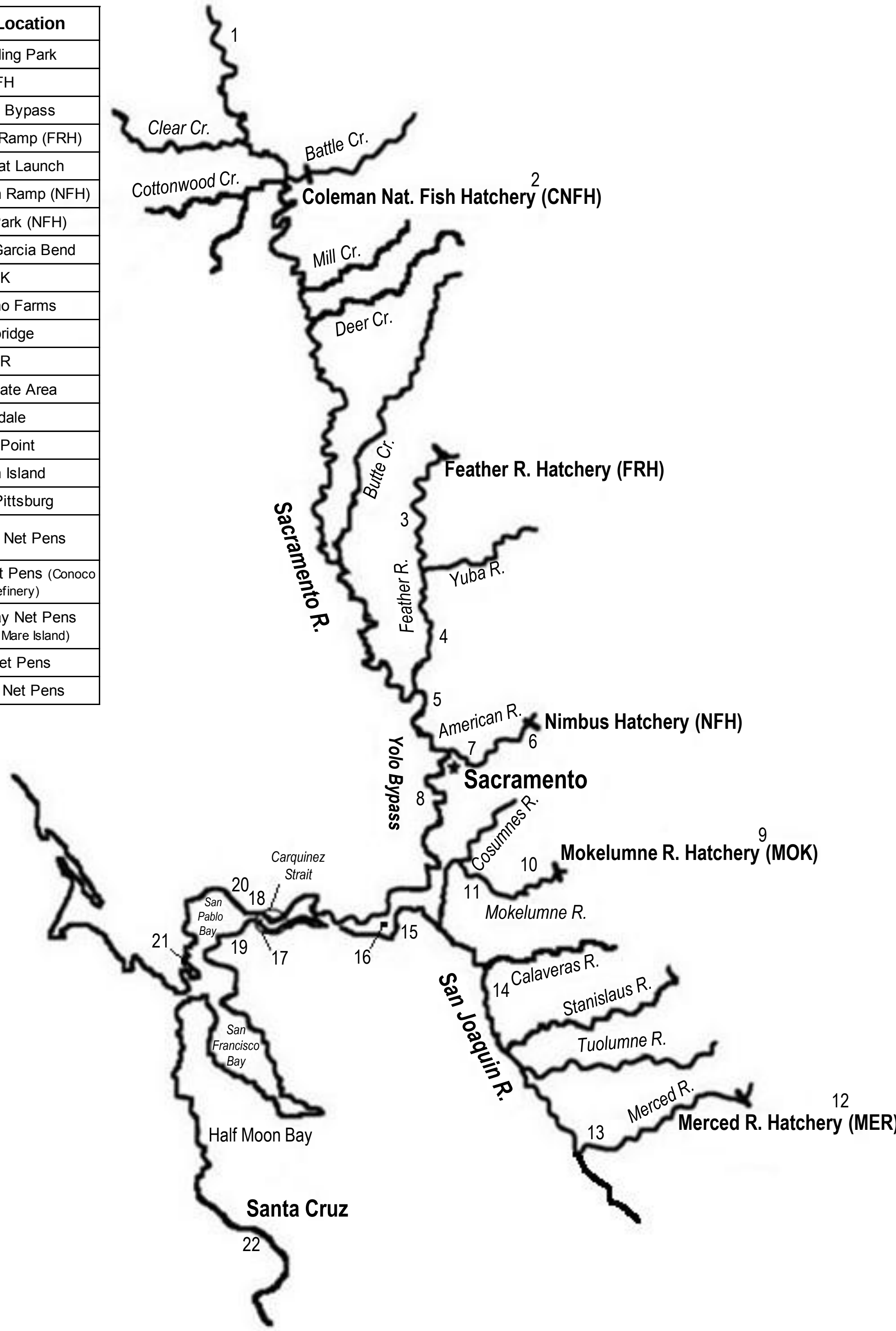


Figure 1. Map of release sites for CV Chinook salmon hatchery release types, brood years 2008-2011.

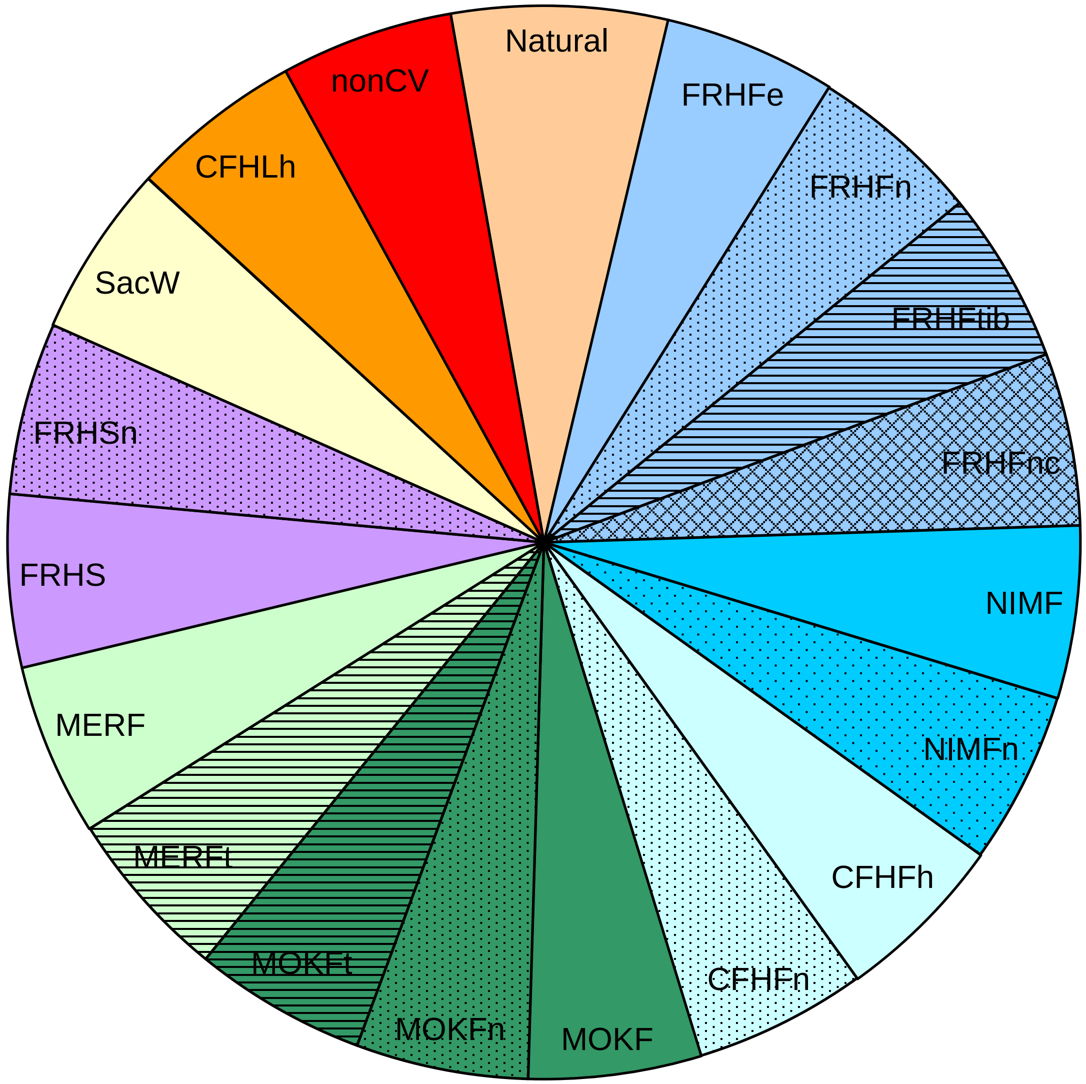


Figure 2. Color scheme for Central Valley hatchery release types.

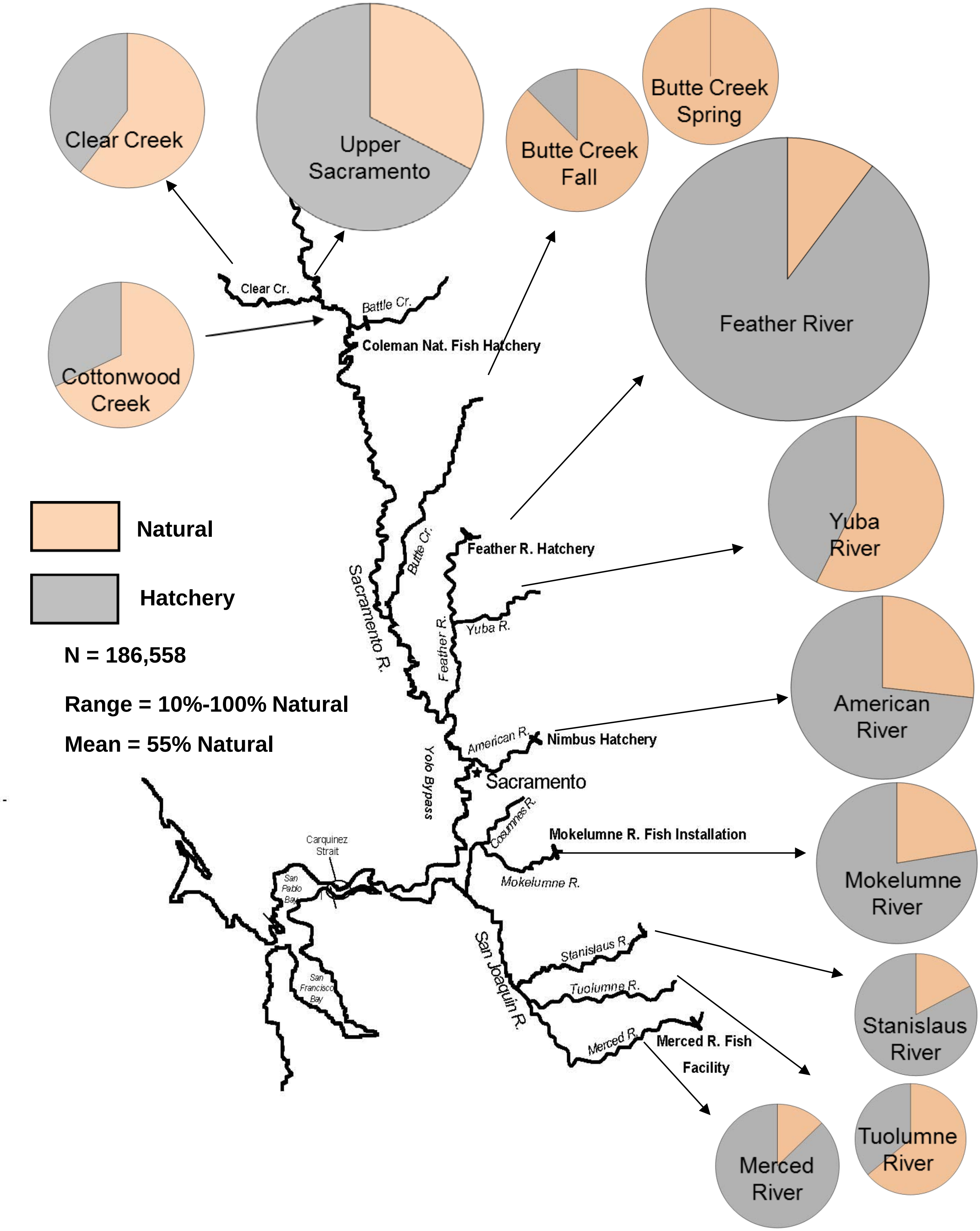


Figure 3. 2012 Fall Chinook Natural Area Escapement, Hatchery and Natural Proportions.

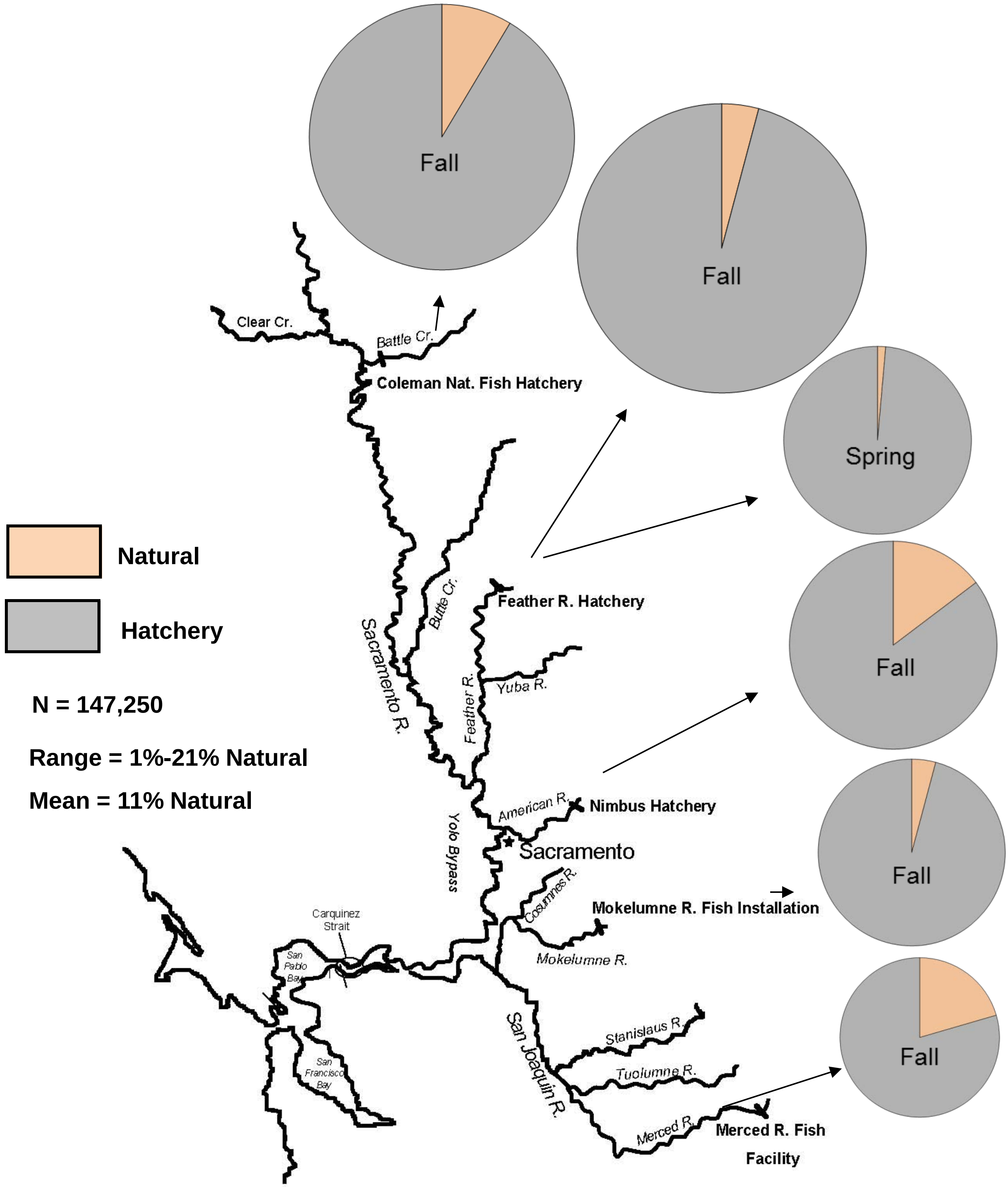


Figure 4. 2012 Fall Chinook Hatchery Escapement, Hatchery and Natural Proportions.

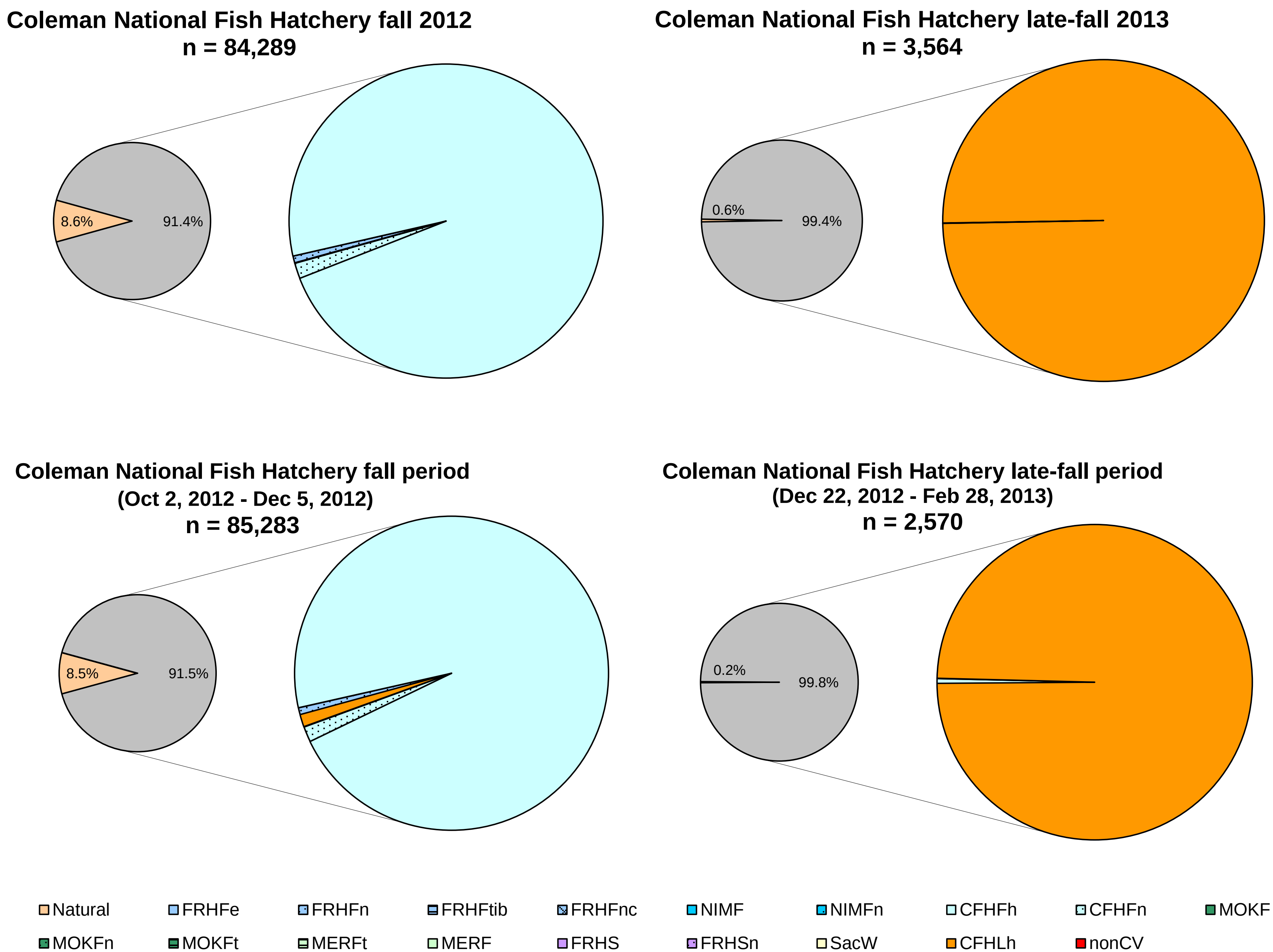


Figure 5. Proportion of hatchery- and natural-origin fish at Coleman National Fish Hatchery, 2012.

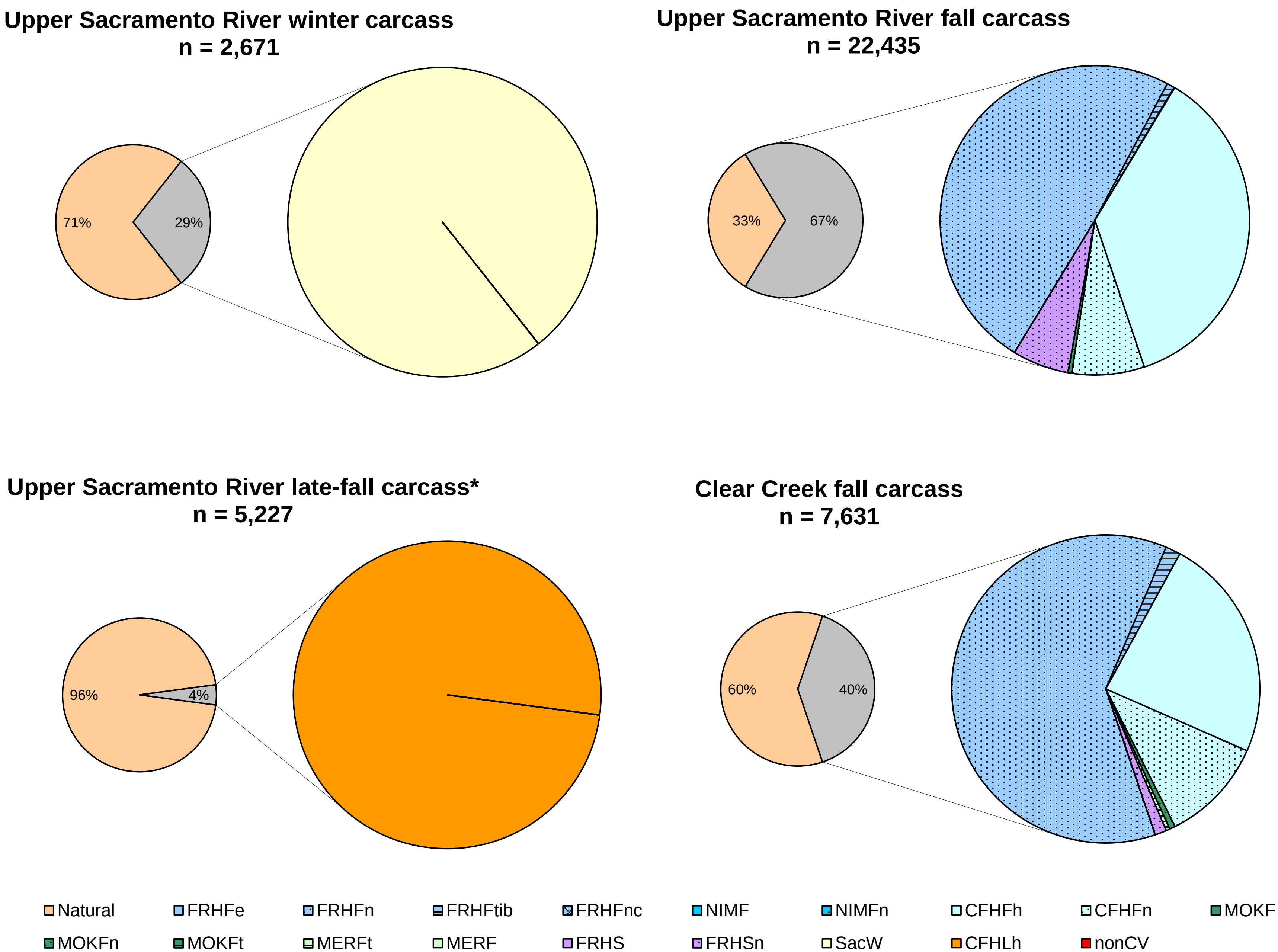


Figure 6. Proportion of hatchery- and natural-origin fish in Upper Sacramento River and Clear Creek, 2012.

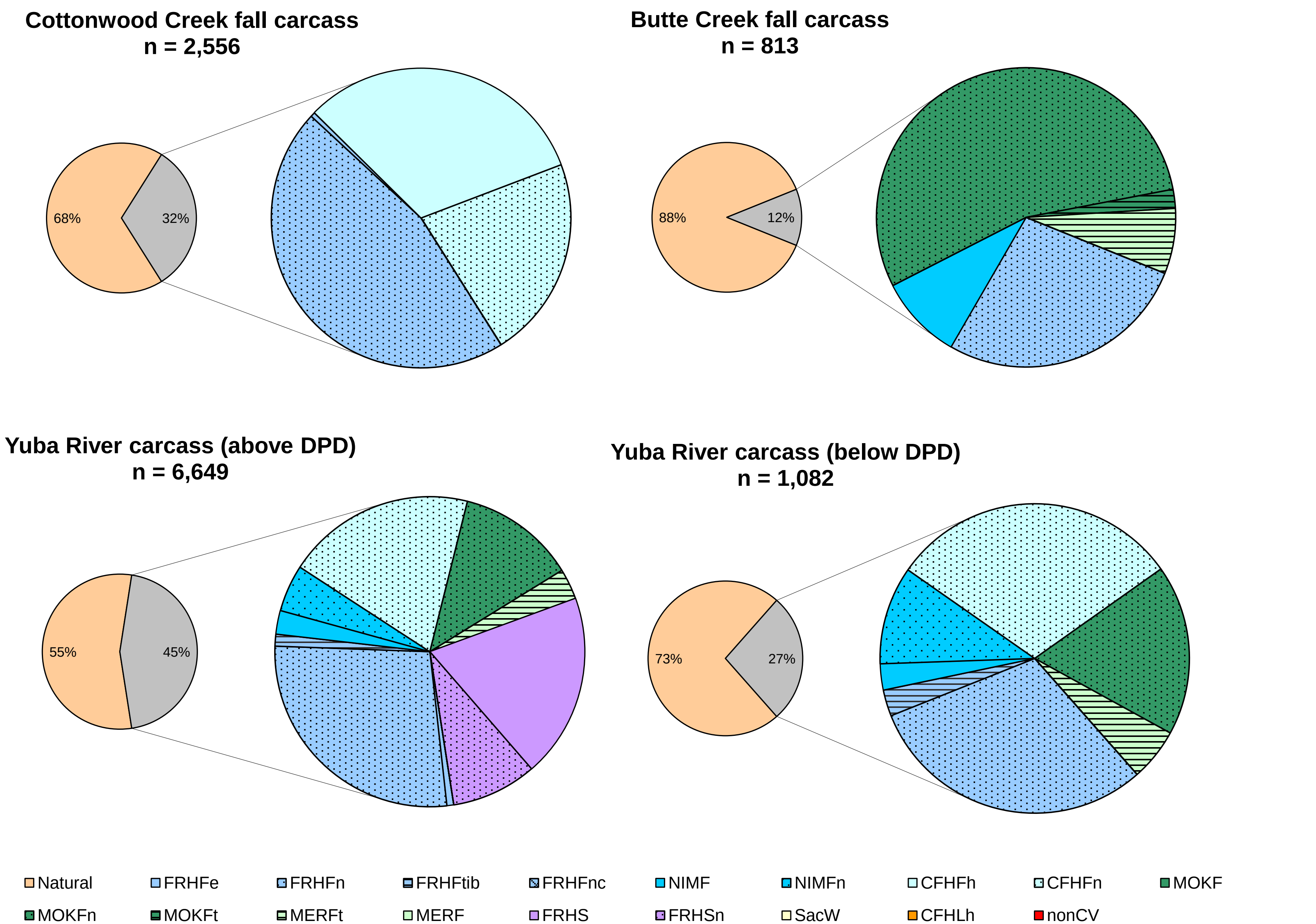


Figure 7. Proportion of hatchery- and natural-origin fish in Cottonwood Creek, Butte Creek & Yuba River, 2012.

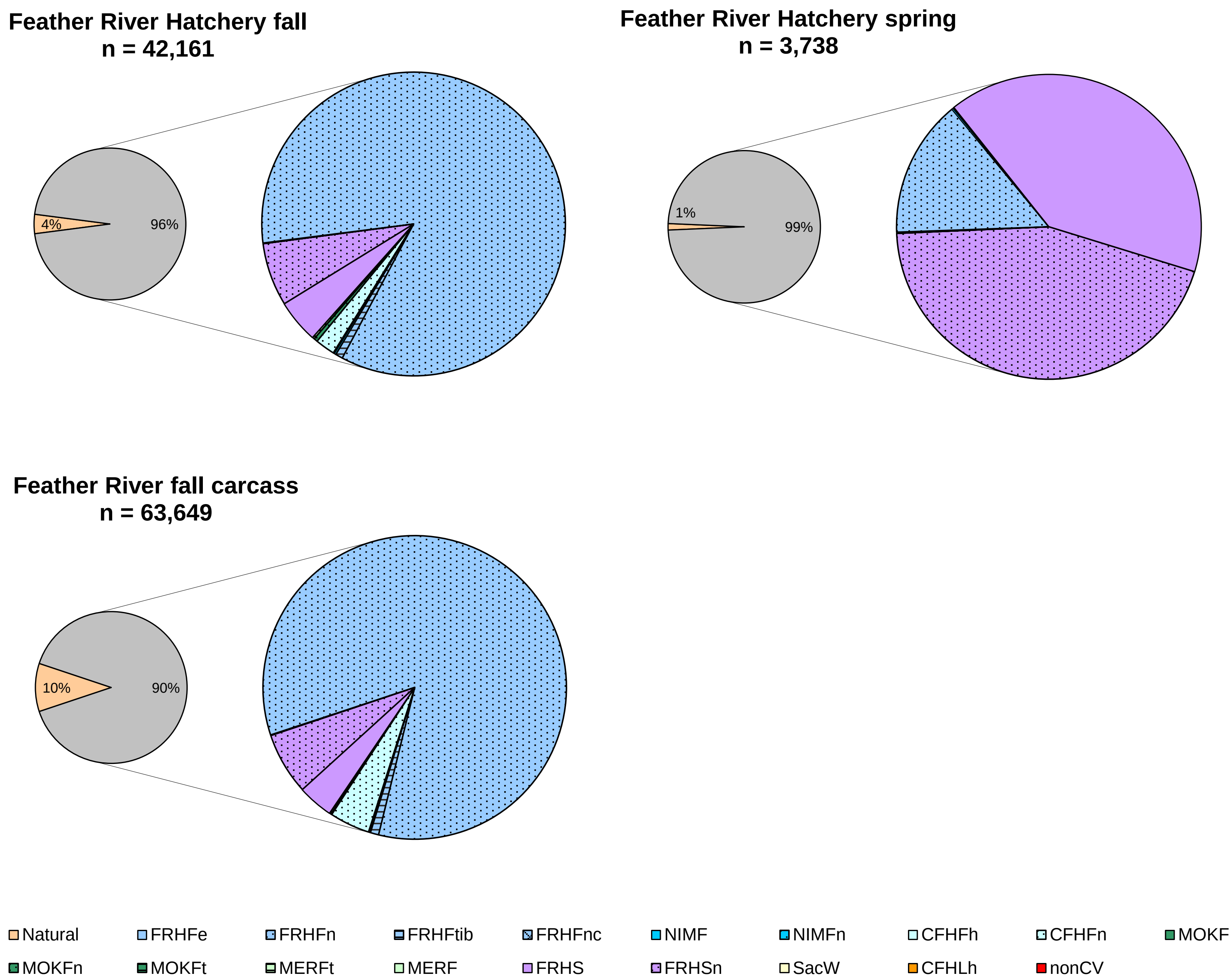


Figure 8. Proportion of hatchery- and natural-origin fish in the Feather River Basin, 2012.

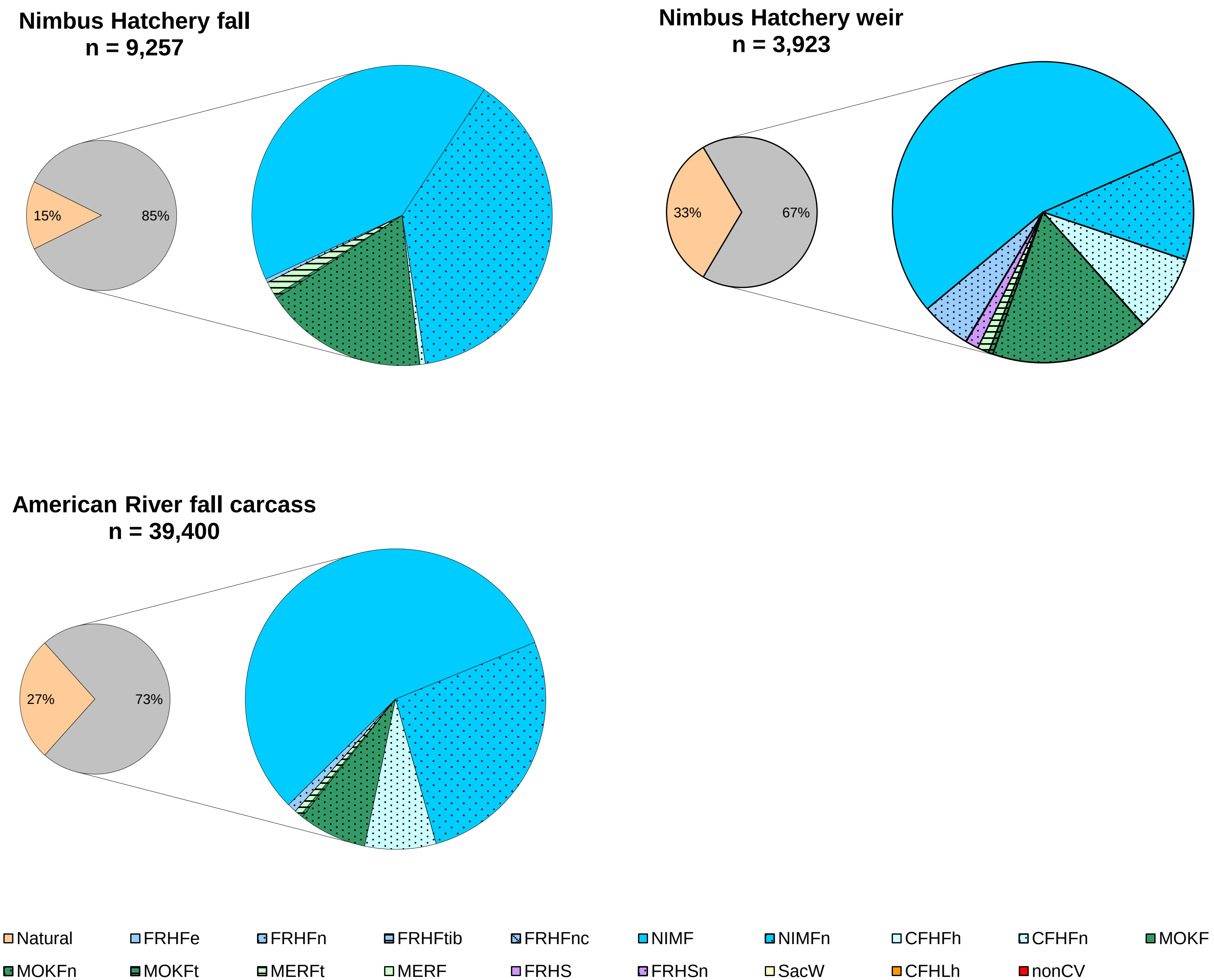


Figure 9. Proportion of hatchery- and natural-origin fish in the American River Basin, 2012.

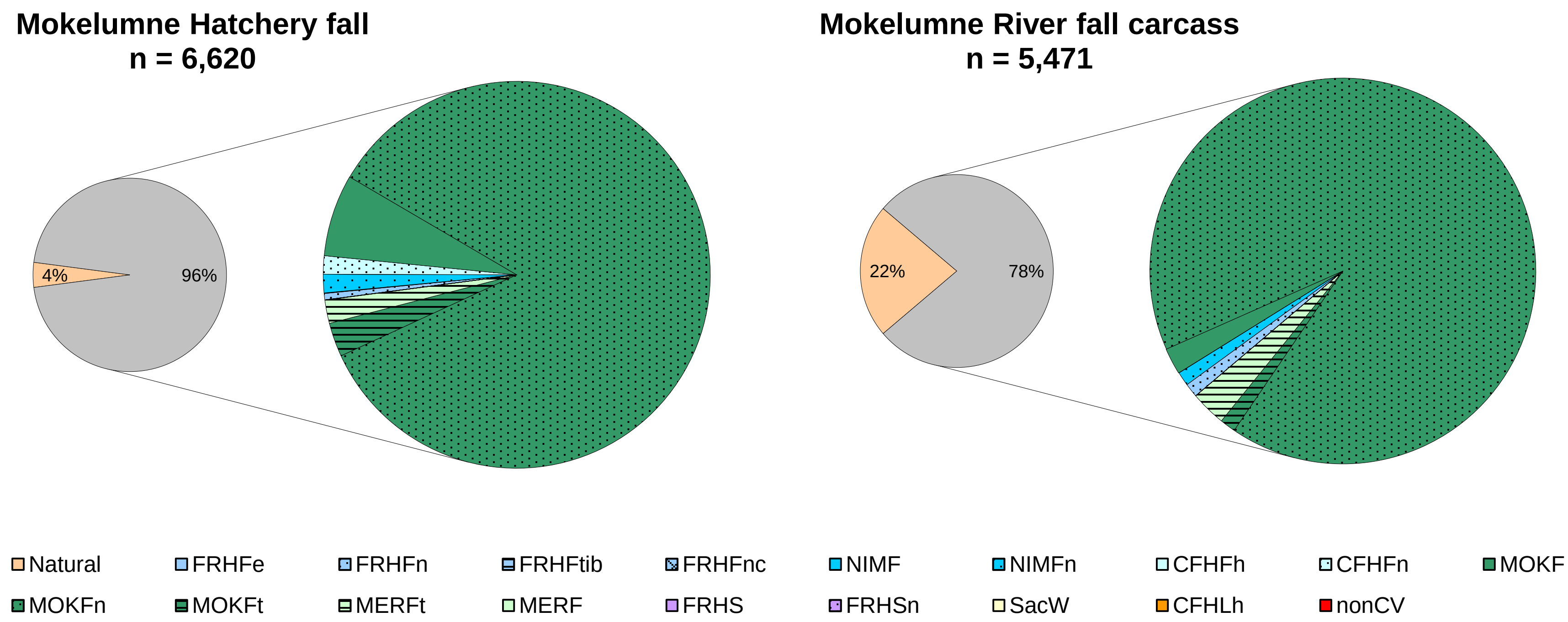


Figure 10. Proportion of hatchery- and natural-origin fish in the Mokelumne River Basin, 2012.

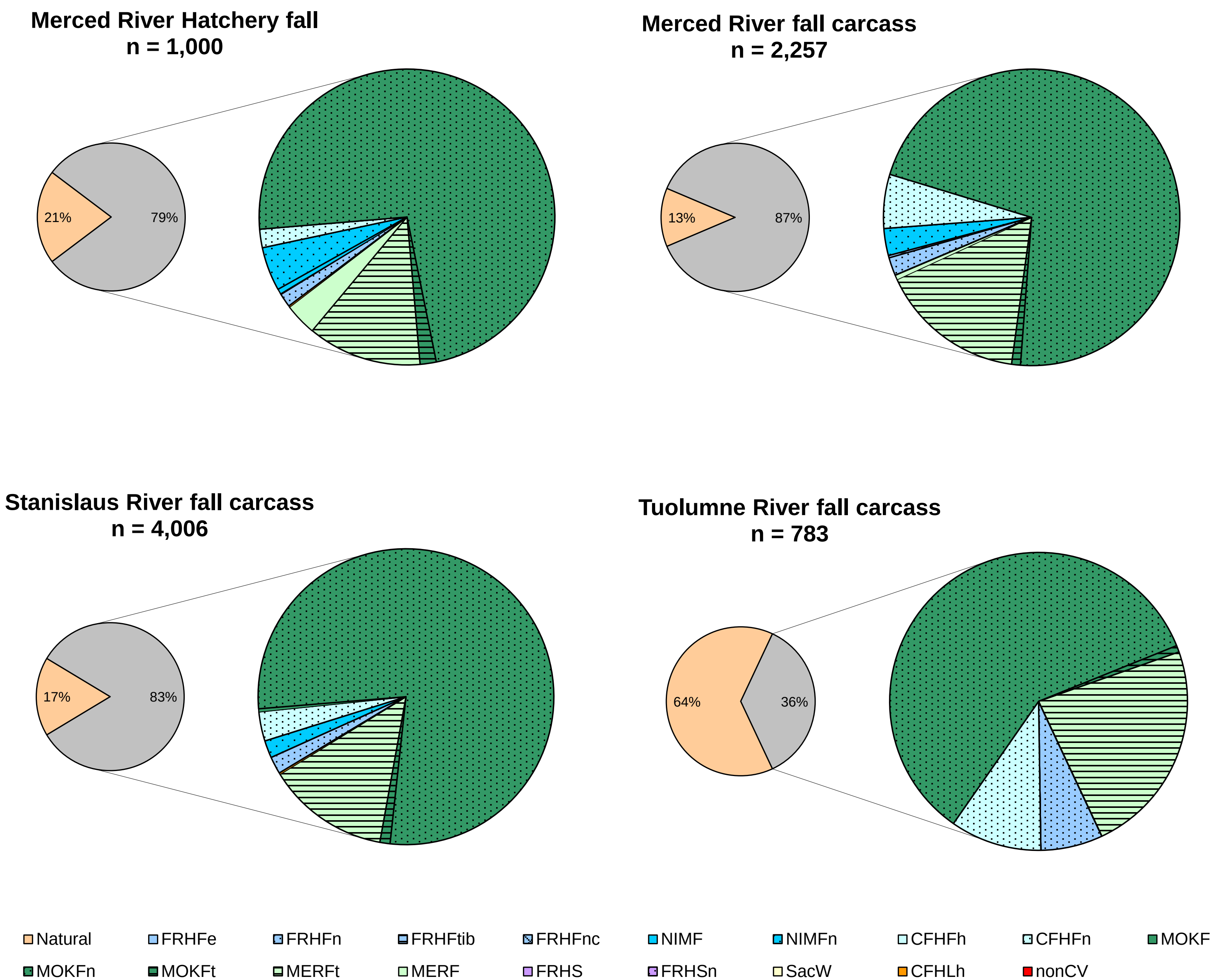


Figure 11. Proportion of hatchery- and natural-origin fish in other San Joaquin River tributaries, 2012.

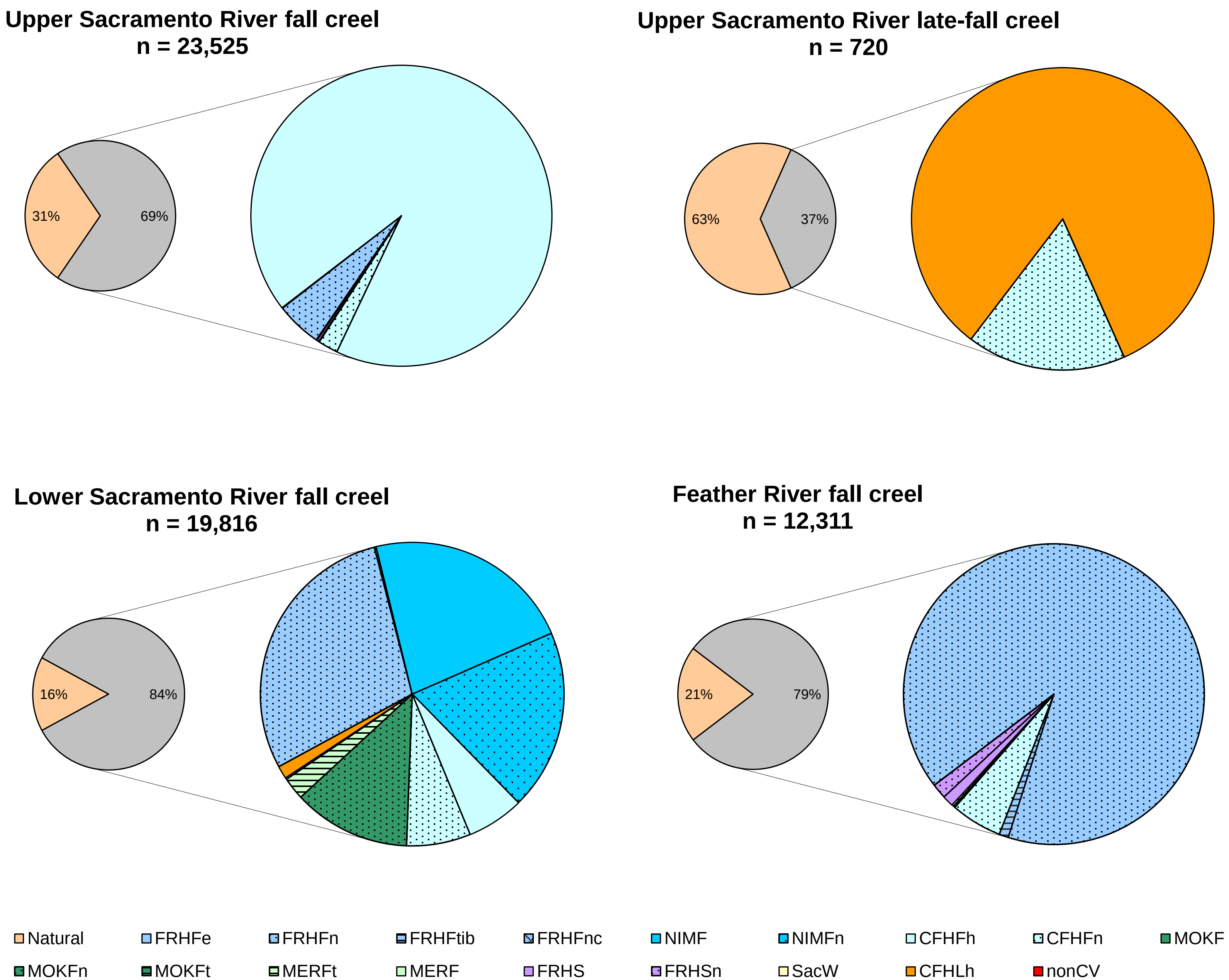


Figure 12. Proportion of hatchery- and natural-origin fish in angler creel surveys on Sacramento and Feather rivers, 2012.

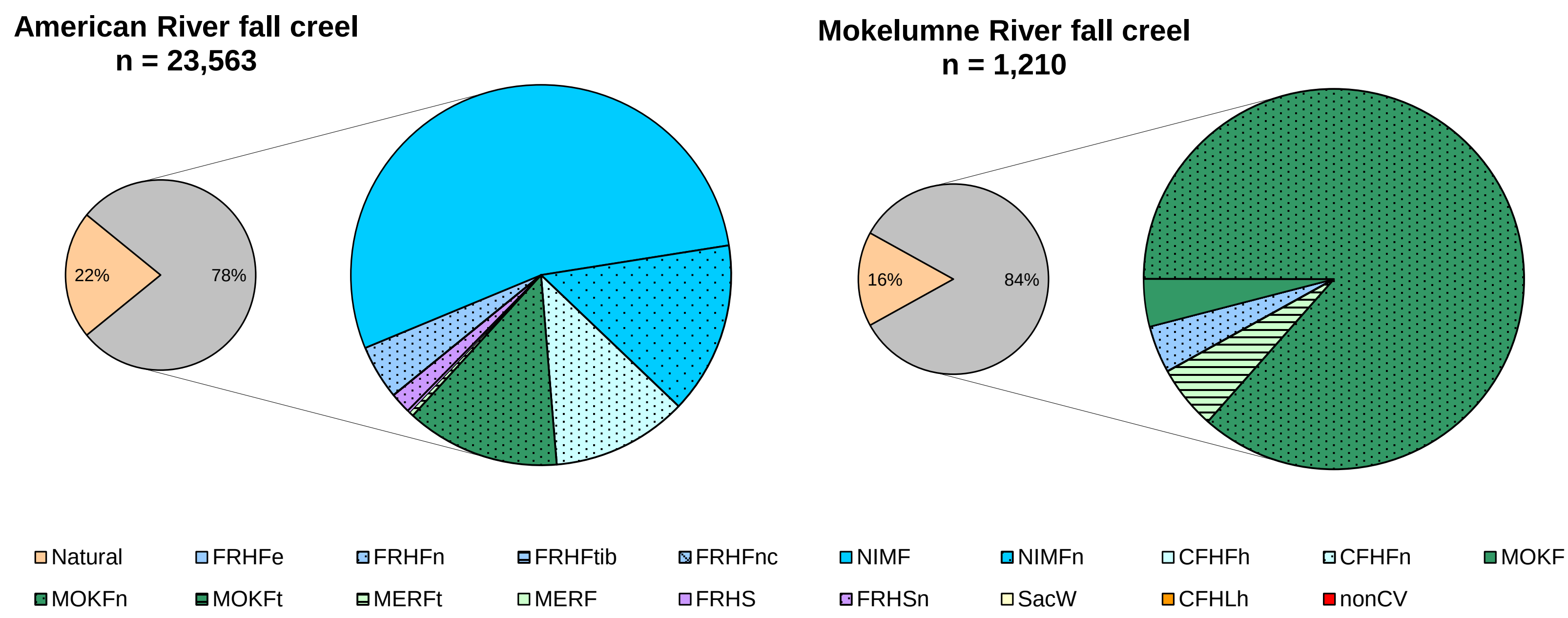


Figure 13. Proportion of hatchery- and natural-origin fish in angler surveys on American and Mokelumne rivers, 2012.

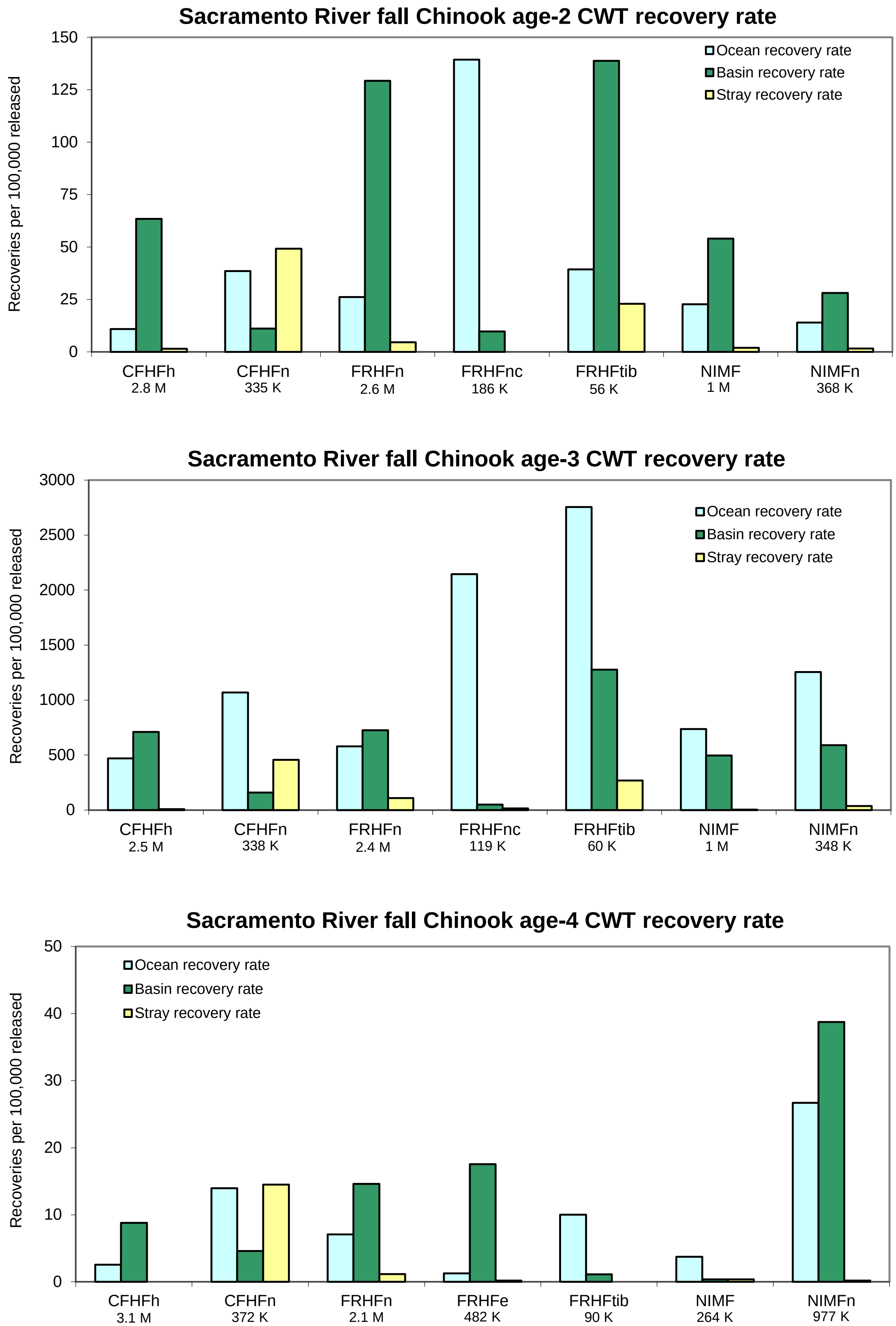
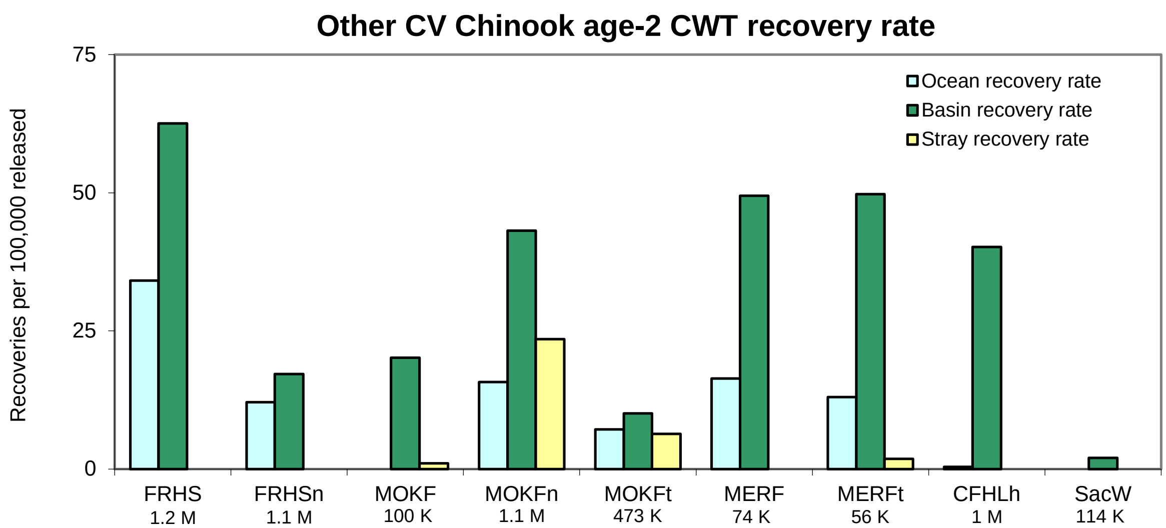
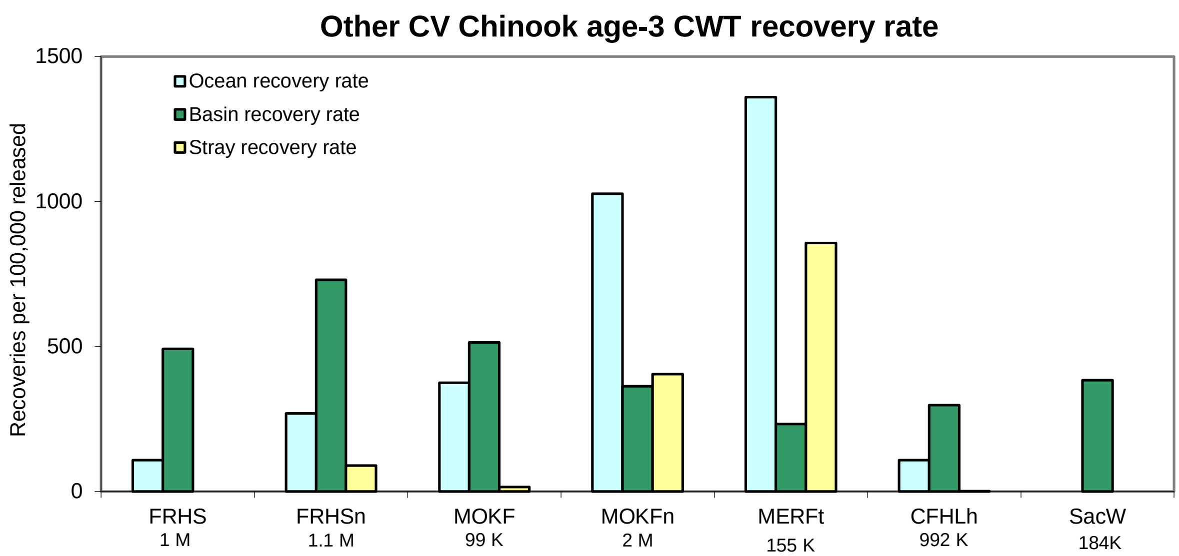


Figure 14. Recovery rates for Sacramento fall Chinook CWT releases by age in 2012.





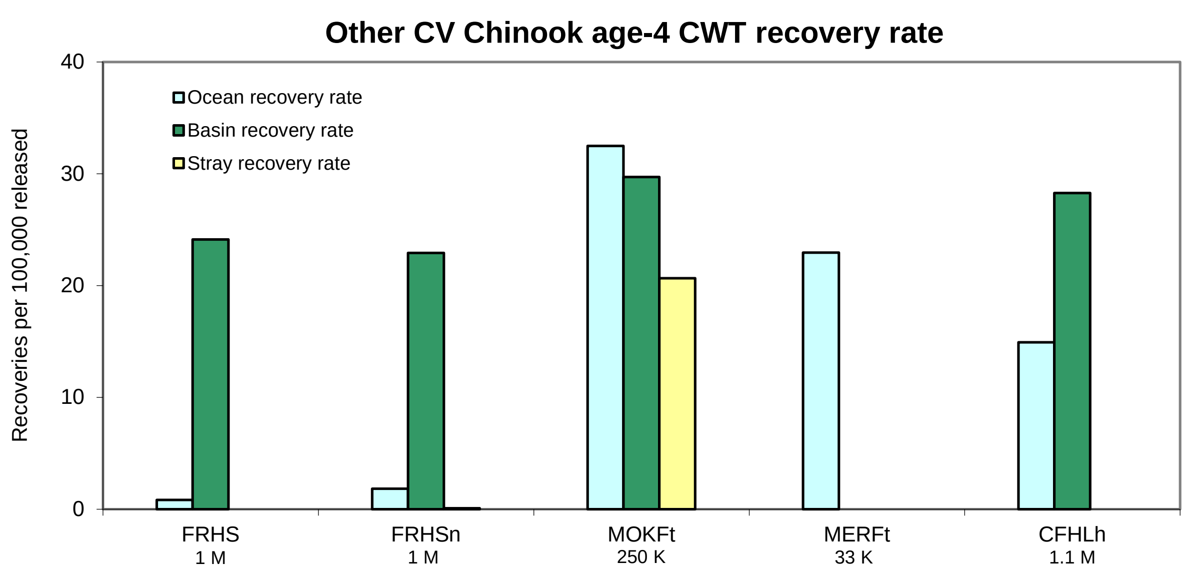


Figure 15. Recovery rates for other CV Chinook CWT releases by age in 2012.

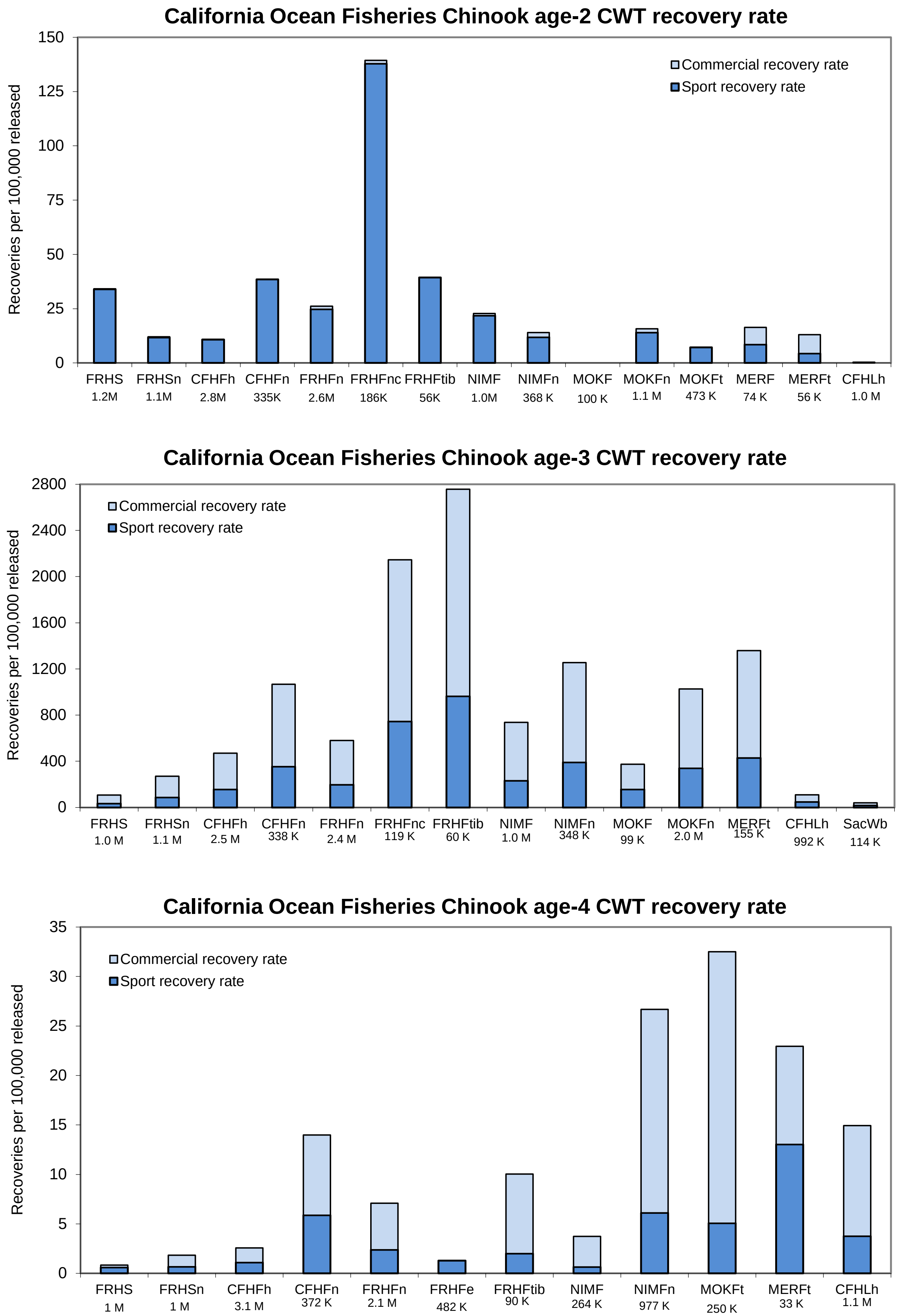


Figure 16. CV Chinook recovery rates in 2012 CA ocean sport and commercial fisheries.

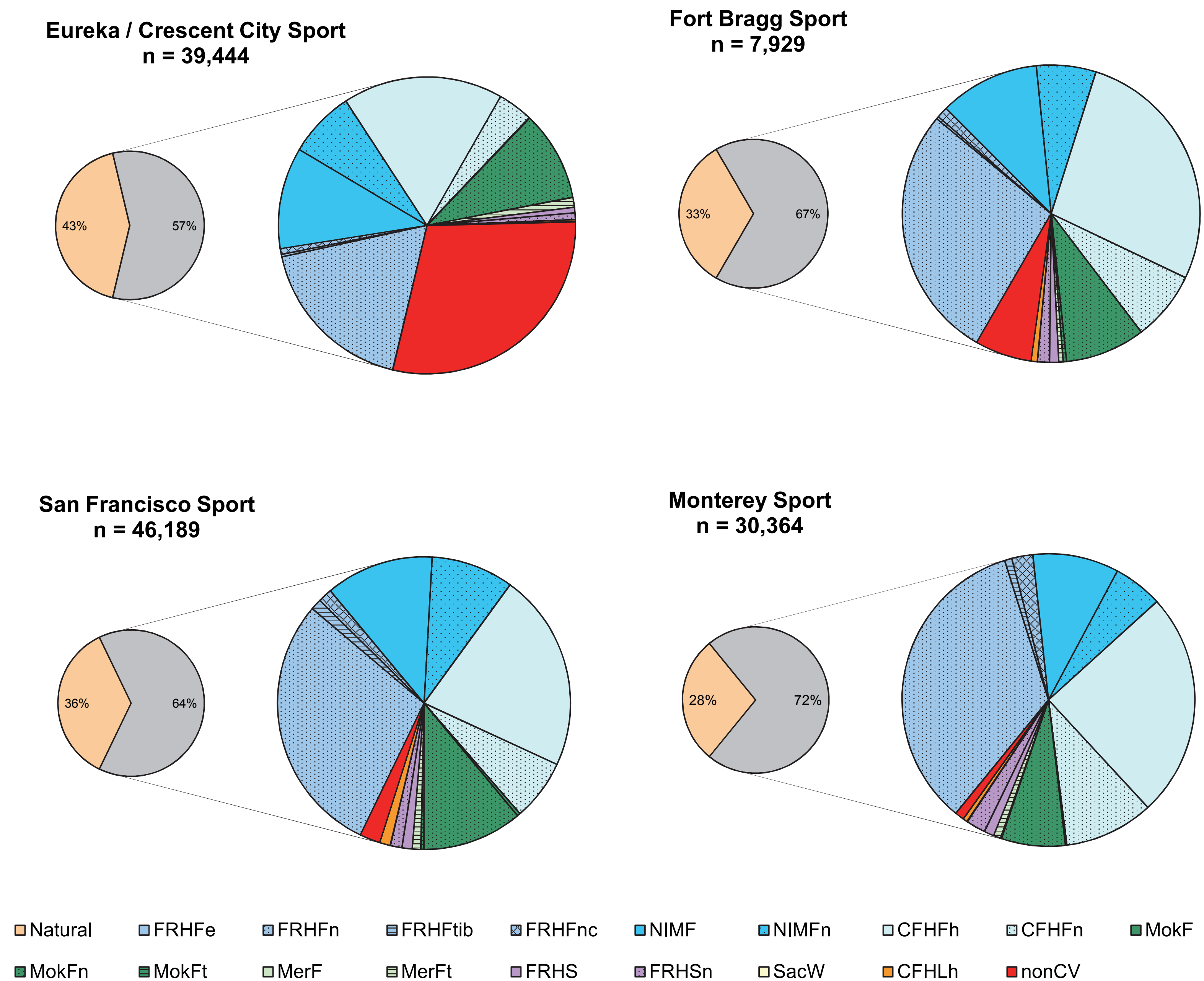


Figure 17. Proportion of hatchery- and natural-origin salmon in the 2012 California ocean sport fishery.

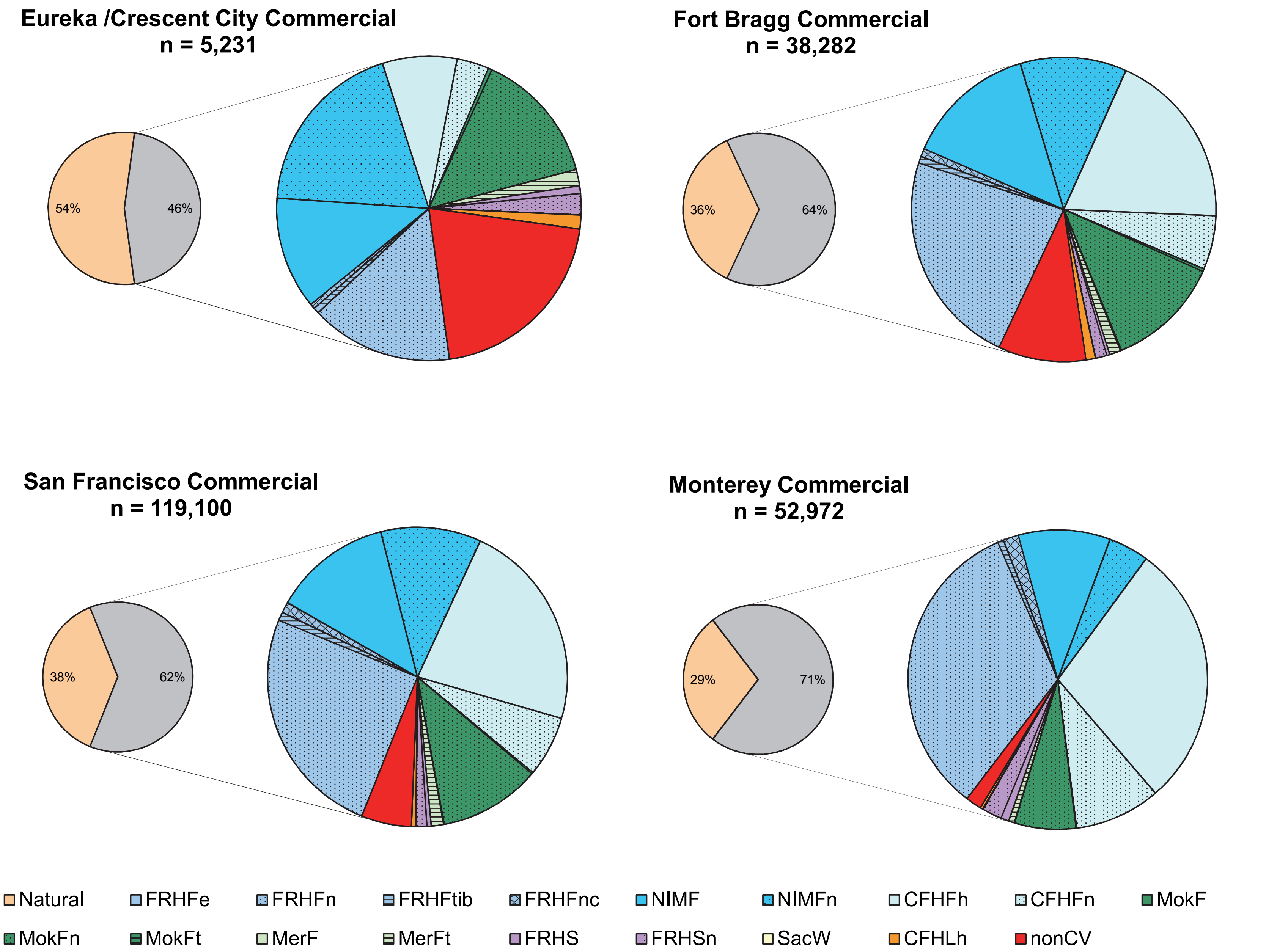


Figure 18. Proportion of hatchery- and natural-origin salmon in the 2012 California ocean commercial fishery.