Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement and Ocean Harvest in 2011

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NOTE TO READERS

Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement and Ocean Harvest in 2011 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 Game (DFG), 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 2011, more than 55,300 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 evaluates the 2011 Central Valley fall, spring, and late fall runs Chinook Code Wire Tags recovery data in accordance with program objectives. In particular, this report attempts to answer the following questions with this second complete year of recovery data:

- What are the proportions of hatchery- and natural-origin fish 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 fish 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 for several hours into San Pablo Bay before fish 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 fish acclimated in net pens and released in the bay versus salmon released directly into the waters of the Carquinez Strait?

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

As with all of its products, Fisheries Branch 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 Dr. Russell J. Bellmer, Fisheries Branch, 830 S Street, Sacramento, CA 95814, (916) 327-8840, Russ.Bellmcr@ wildlife.ca.gov.

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INTRODUCTION

Each year, approximately 32 million fall-run Chinook salmon (salmon) 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 major sport and commercial fisheries in ocean and inland areas. Prior to 2007, only small experimental releases (generally <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 the Constant Fractional Marking (CFM) program.

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 and coded-wire tagging program for CV fall-run salmon production at all CV hatcheries. The primary goal of this program was to estimate in a statistically valid manner the relative contribution of hatchery production 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 marking and tagging rate of 25% of fall-run production releases. The CVSPWT is an interagency group tasked with coordinating salmon and steelhead monitoring activities in the CV and they helped develop the CFM program. CVSPWT members included staff from the California Department of Fish and Wildlife (CDFW), California Department of Water Resources (DWR), East Bay Municipal Utility District (EBMUD), Metropolitan Water District, Central Valley Project Water Association, 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). This CFM program is a cooperative effort of the CDFW, DWR, BOR, FWS, EBMUD, and PSMFC. It should be noted that due to extremely low production numbers, MOK marked and tagged 100% of their fall-run salmon releases for brood years 2008 and 2009. In addition, almost all of the fall-run salmon production at MER (50,000-300,000 fish), spring-run salmon production at FRH (2 million fish), late-fall-run salmon production at CNFH (1 million fish), and winter-run salmon production reared at Livingston Stone National Fish Hatchery (100,000-200,000 fish) have been marked and coded-wire tagged each year.

During 2011, more than 55,300 CWTs were recovered from ad-clipped salmon sampled in CV fall-, spring-, and late-fall-run natural area spawning surveys, at CV hatcheries, in CV river creel surveys, and in California ocean commercial and recreational fisheries. All of the fall-run salmon CWTs recovered in 2011 were tagged as part of the CFM program. This report evaluates the 2011 CV fall-, spring-, 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 second complete year of recovery data:

- What are the proportions of hatchery- and natural-origin fish 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 fish 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 for several hours into San Pablo Bay before fish 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 fish acclimated in net pens and released in the bay versus salmon released directly into the waters of the Carquinez Strait?

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

DATA AND METHODS

Inland Escapement Monitoring

During 2011, monitoring of salmon escapement occurred at all five salmon hatcheries and on major rivers and tributaries throughout the CV. In addition, creel surveys were conducted on sport fisheries in the Feather, American, and Sacramento River basins. Returning salmon were counted and 100% of the ad-clipped salmon sampled at all CV hatcheries except CNFH, which sampled every other ad-clipped salmon (i.e., 50% sample rate) for fall-run escapement and 100% of ad-clipped salmon for the late-fall-run escapement. Similar to 2010, sample rates and methods (e.g., carcass surveys, weir counts, redd counts) varied among natural spawner surveys throughout the CV (Table 1).

Approximately 52,900 ad-clipped salmon were observed and 48,138 heads collected by various CV projects. Monitoring agencies include CDFW, DWR, EBMUD, FWS, and PSMFC. Most heads were processed by CDFW at their Santa Rosa and Sacramento CWT labs with the exception of approximately 9,500 heads collected from Clear Creek and CNFH that were processed by FWS staff at the Red Bluff FWS office. Additionally a few hundred 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 2011 CV CWT recovery database. Almost 97% (46,596) of these heads contained valid CWTs, 2% 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. These data, along with their respective CWT recovery data, were uploaded to the Regional Mark Processing Center (RMPC) and 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 and to collect the heads from all ad-clipped salmon observed during monitoring. In 2011, the seasons for California sport and commercial ocean salmon fisheries were less constrained (Table 2) 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 more than 47,600 salmon and collected 9,768 heads that were processed by the Santa Rosa CWT lab. About 90% (8,717) of these heads contained valid CWTs, 10% were missing CWTs and <1% contained CWTs that were too damaged to read or lost during processing. Although it is generally agreed that CWTs missing from inland head recoveries is 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 northwest. During the last several years, OSP has noticed a gradual increase in the number of ocean heads collected that do not contain CWTs, especially in California's northern ports, and assume that this is due to the increased production of mass-marked salmon in Oregon and Washington.

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 2011 CWT recoveries. All west coast CWT release data for broods 2007 through 2010 were downloaded from the RMPC. Approximately 100.6 million CV salmon were released for these four brood years (BY), of which, 38.5 million fish were marked and tagged utilizing 444 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 2011, there were 310 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, $F_{prod,}$ is the total number of fish released (tagged and untagged) represented by each CWT recovery. F_{prod} was calculated for each CWT code and is defined as,

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

where Ad.CWT is the number of fish released with ad-clips and CWTs, Ad.noCWT is the number of fish 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 fish released without ad-clips but with CWTs, and noAd.noCWT is the number of fish 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 17 fall-run release types, 3 spring-run release types, or 2 late-fall-run release types:

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

CFHFe Coleman National Fish Hatchery fall-run experimental releases
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 fall x spring hybrid salmon)
FRHFn Feather River Hatchery fall-run net pen releases
FRHFnc Feather River Hatchery fall-run net pen coastal releases (Santa Cruz)
FRHFt Feather River Hatchery fall-run trucked releases (no net pen acclimation)
FRHFtib Feather River Hatchery fall-run Tiburon net pen releases (held 2-6 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
NIMFtib Nimbus Fish Hatchery fall-run Tiburon net pen releases (held 3-4 months)

<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 Fish Facility fall-run releases (primarily in-basin)

<u>Central Valley spring-run Chinook salmon release types</u>

FRHS Feather River Hatchery spring-run in-basin releases
FRHSn Feather River Hatchery spring-run net pen releases
ButSw Butte Creek spring-run wild

<u>Central Valley Late-Fall-run Chinook salmon release types</u>

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

It should be noted that not all release types occurred every brood year and release sites sometimes varied within a given release type (Table 3). There were also several problem CWT releases where stock origin did not match hatchery origin (e.g., BY 2007 American River fall-run salmon raised at MOK), stocks or runs were mixed prior to CWT tagging and 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), or a high percentage of the salmon trucked for net pen acclimation actually died prior to release (e.g., 75% mortality reported in truckload of CNFH fall-run salmon being transported to San Pablo Bay net pens).

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,

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

where f_e is the fraction of the total salmon escapement sampled and examined for ad-clipped fish, 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). A few heads were collected opportunistically during redd counts or snorkel surveys; these CWTs were given an F_{samp} of 1.00 (i.e., no expansion) since they were not representative of the total escapement.

After the release of the 2010 report (Kormos et al. 2012), Mohr and Satterthwaite (in press) demonstrated how the potential misidentification of ad-clipped salmon in carcass surveys can significantly bias estimations of the total hatchery contribution since they frequently encounter both fresh and non-fresh (decayed) carcasses.

Salmon sampled in some CV carcass surveys are generally recorded 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 can be uncertain due to the deteriorating condition of the carcass. Mohr and Satterthwaite (in press) 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 have been observed. During the 2010 upper Sacramento River fall-run salmon carcass survey, 21% of the fresh fish sampled were classified as ad-clipped compared to only 6% of decayed fish (i.e., false negative). The fresh carcass heads also contained a CWT more frequently than the heads collected from decayed carcasses (i.e., false positive). Furthermore, the sample sizes for these categories were also significantly different, with the number of decayed fish sampled (n=1,124) nearly four times greater than the fresh fish (n=291). The latter appears to be fairly common among CV carcass surveys currently collecting fish condition data.

Mohr and Satterthwaite (in press) demonstrated how the differences noted above negatively biased the hatchery contribution estimations for the 2010 upper Sacramento River fall-run salmon carcass survey as reported in Kormos et al. (2012). This was also shown to be true for the 2010 upper Sacramento late-fall-run survey. Furthermore, they 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. Since both of these surveys contained false negatives and false positives, and sample sizes for decayed carcasses were much larger than those of fresh carcasses, we have adopted the following equation developed by Mohr and Satterthwaite (in press) to calculate F_{samp} for carcass surveys collecting fish condition data, thus reducing the potential bias associated with these surveys:

$$F_{samp} = (N \times p\_adc|fresh \times p\_cwt|fresh,adc) / n_{valid\ cwt} ,$$

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

Table 6 shows the original and revised F_{samp} for the 2010 upper Sacramento River fall-run and late-fall-run carcass surveys. This new equation was also used to determine F_{samp} for the five CV salmon carcass surveys that collected fish condition sample data in 2011: upper Sacramento River fall-run, upper Sacramento late-fall-run, Clear Creek fall-run, Cottonwood Creek fall-run, and American River fall-run. We are hopeful that other CV carcass surveys will begin to collect fish condition information to reduce the known bias in CWT sample rate calculations and hatchery contribution estimations as demonstrated by Mohr and Satterthwaite (in press). We realize that the calculated hatchery contribution rates of the other carcass surveys in this report are most likely negatively biased.

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 will be 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 fish in each survey. The contribution of natural-origin fish for each survey was then determined by subtracting the total number of hatchery fish 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 fish 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:

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

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

Determining stray proportions of various release groups in CV escapement

To be consistent with Kormos et al. (2012), 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 again 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 1 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 out of the basin of origin was divided by total CV CWT_{samp} recoveries for that release group, as follows:

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

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:

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

RESULTS

General Overview of 2011 CV inland recoveries and California ocean harvest

All but three of the 46,596 valid CWTs recovered in the CV during 2011 were CV salmon releases; most CWTs originated from brood year 2007 through 2009 releases (Table 7). More than 93% of all expanded salmon CWT recoveries were fall-run, followed by spring-run (3%) and late-fall-run (3%) releases. Data from the 2011 escapement survey of Sacramento River winter-run (SacW) salmon is not included in this report (USFWS report); however there were two SacW CWTs recovered at CNFH during fall-run spawning operations.

The majority of fall-run CWTs were age-2 (57%) and age-3 (36%) fish. Three age-1 fall-run CWTs were also sampled. The spring-run CWTs consisted primarily of age-3 (56%), age-2 (24%), and age-4 (20%) fish. Age-4 (51%), age-3 (30%), and age-5 (14%) made up most of the late-fall-run return. Only four age-6 fish were recovered in the CV; all were BY 2006 late-fall-run. It should be noted that there were also eight coho CWTs recovered from BY 2009 Lake Oroville releases; six were recovered during fall-run spawning at FRH while the other two were recovered in the Yuba River carcass survey above the Daguerre Point Dam (DPD) dam. Non-Chinook salmon CWTs were not included in any analyses.

Almost 90% of the 8,717 valid CWT recoveries from the California ocean harvest in 2011 were CV salmon releases; most CWTs were brood year 2007 through 2009 releases (Table 8). Approximately 86% of all expanded CWTs in the ocean harvest were fall-run, followed by late-fall-run (2%), spring-run (1%), and winter-run (<0.4%) salmon. The majority of fall-run salmon CWTs were age-3 (60%) and age-2 (35%) fish. Age-3 (85%) and age-4 (14%) made up most of the late-fall-run salmon catch while age-3 (72%) and age-2 (25%) fish dominated the spring-run salmon harvest. Almost all (99%) of the winter-run salmon were age-3. A few age-6 late-fall-run salmon were also caught. The remaining 10% of ocean CWT recoveries originated from non-CV hatcheries or waters, including the Klamath, Trinity, and Smith rivers in northern California as well as the Rogue, Chetco, Umpqua, Columbia, Snake and other Pacific Northwest rivers; most were age-3 (64%) and age-4 (34%) fish.

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

In 2011, there were 22 individual CWT release types contributing to CV escapement and ocean fisheries. 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 1) in all pie chart figures. All net pen releases, except salmon released from net pens in Santa Cruz and Tiburon, contain black dots. Coastal and Tiburon net pen releases are designated with a crisscross pattern. Trucked and experimental releases are designated by black stripes. The revised hatchery and natural components of the 2010 upper Sacramento River fall-run and late-fall-run carcass surveys from Kormos et al. (2012) are shown in Figure 2.

The proportion of hatchery-origin fish on the natural area spawning grounds in 2011 varied throughout the CV and by run. The lowest hatchery proportion occurred in the Butte Creek spring-run salmon mark-recapture survey where no ad-clipped salmon were encountered (0%)

while the highest proportion (90%) was observed in the Feather River fall/spring-run salmon carcass mark-recapture survey (Figure 3).

It should be noted that since there has not been a carcass survey or CWT recovery program in Battle Creek since 2005, it is not possible to directly determine the hatchery contribution, recovery rate, or stray rate into the natural escapement of this tributary. Total natural escapement is 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 return at CNFH (Robert Null, FWS, pers comm).

The hatchery proportion of fall-run salmon returning to CV hatcheries ranged from 77% to 98% (Figure 4). The spring-run salmon return to FRH was 94% hatchery-origin fish whereas the late-fall-run return to CNFH was almost 100% hatchery-origin fish. The percentage of hatchery and natural-origin contribution to the total escapement for all surveys by release type is shown in Table 9.

Upper Sacramento River Basin

Eight escapement surveys were conducted in the Upper Sacramento River Basin that allow for expansion of CWTs: fall-run and late-fall-run salmon counts at CNFH, fall-run and late-fall-run salmon mark-recapture carcass surveys in the mainstem Sacramento River, a fall-run salmon mark-recapture 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. Four additional escapement surveys were conducted: video counts of fall-run salmon escapement with associated carcass surveys to opportunistically collect CWTs and other bio-data were conducted in Mill and Deer Creeks while redd surveys were conducted in Mill and Deer Creeks to estimate spring-run salmon escapement. Since representative sampling for ad-clipped salmon did not occur in any of these surveys, any CWT recovery in these creeks represents only itself (i.e., F_{samp} = 1.00) and the reported hatchery percentages represent their minimal hatchery contribution. Returns to CNFH were predominantly hatchery-origin fish released from this facility while escapement into natural areas was primarily natural-origin fish (Table 9, Figures 5 and 6):

- Fall-run returns at CNFH were 89% hatchery-origin fish
- Late-fall-run returns at CNFH were 100% hatchery-origin fish
- Fall-run spawners in the upper Sacramento River were 27% hatchery-origin fish
- Late-fall-run spawners in the upper Sacramento River were 44% hatchery-origin fish
- Fall-run spawners in Clear Creek were 8% hatchery-origin fish
- Fall-run spawners in Cottonwood Creek were 58% hatchery-origin fish
- Fall-run spawners in Butte Creek were 7% hatchery-origin fish
- Spring-run spawners in Butte Creek were 0% hatchery-origin fish

Feather River Basin

Five escapement surveys were conducted in the Feather River Basin: spring-run and fall-run salmon counts at FRH, a combined fall/spring-run salmon mark-recapture survey in the Feather River, a combined fall/spring-run salmon mark-recapture survey in the Yuba River below DPD, and a combined fall/spring-run salmon Vaki Riverwatcher count above DPD (with associated bio-sample). The Vaki Riverwatcher count also included the number of ad-clipped salmon entering the system. The 107 heads recovered in the bio-survey above DPD were expanded to the total 1,733 ad-clipped salmon counted at DPD. Hatchery contribution by release type was based on the proportion of valid CWT codes recovered. Spring-run and fall-run salmon returns to FRH and in the natural areas were predominantly of hatchery-origin (Table 9, Figures 7 and 8):

- Spring-run returns at FRH were 94% hatchery-origin
- Fall-run returns at 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 below DPD were 34% hatchery-origin
- Fall/spring-run spawners in the Yuba River above DPD were 65% 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 survey on the American River. In addition, dead salmon were recovered from the NFH weir, which is located just upstream from the hatchery and was installed on September 10th to force returning salmon into NFH. Salmon that migrated upstream beyond the hatchery prior to installation of the weir were trapped in the upstream area. Many of those salmon washed back onto the weir upon death. There is minimal spawning habitat above the weir. Spawner returns to natural areas and those from the NFH were predominantly of hatchery-origin while returns above the NFH weir were predominantly of natural-origin (Table 9, Figure 6):

- Fall-run returns to NFH were 77% hatchery-origin
- Fall-run spawners in the American River were 66% hatchery-origin
- Salmon recovered on the NFH Weir were 26% 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 of all fall-run salmon escapement into the Mokelumne River.

All adult salmon migrating upstream into the Mokelumne River to spawn were counted by the video fish counting device operated by EBMUD at Woodbridge Dam. These counts also included the total number of ad-clipped salmon above the Dam. By subtracting the 15,922 salmon that returned to MOK from the total video count of 18,589 Chinook, it was assumed that the remaining 2,667 salmon remained in the Mokelumne River. Utilizing the same logic, it was also assumed that there were 2,227 ad-clipped salmon remaining in the river since only 14,724 of the 16,951 ad-clipped salmon counted in the video monitoring were recovered at MOK. After reviewing the CWTs recovered from heads collected during sporadic surveys on the Mokelumne River, it was found that the proportions of the CWT codes collected were very similar to the proportion of the same codes recovered at MOK. Because 100% of Chinook salmon observed at MOK were sampled, including seven ad-clipped salmon recovered from the hatchery weir, we felt that the MOK CWT recoveries best represented the entire run and thus expanded the estimated 2,227 ad-clips in the Mokelumne River based on the proportion of valid CWTs recovered. This approach is based on the methodology used by the Klamath River Technical

Team (KRTT) to determine the hatchery composition of fall-run salmon above Willow Creek Weir on the Trinity River (KRTT 2012).

Spawner returns to the Mokelumne River Basin were dominated by hatchery-origin fish (Table 9, Figure 10):

- Fall-run returns at MOK were 98% hatchery-origin
- Fall-run spawners in the Mokelumne River were 88% hatchery-origin

San Joaquin River Basin Tributaries

Four escapement surveys were conducted in tributaries of the San Joaquin River that allow for expansion of CWTs: fall-run salmon counts at MER, as well as fall-run salmon mark-recapture surveys conducted on the Stanislaus, Tuolumne, and Merced rivers. One additional redd survey was conducted on the Calaveras River with an associated carcass survey to opportunistically collect CWTs and other bio-data. Fall-run salmon returns to the Merced, Stanislaus, and Tuolumne Rivers were dominated by hatchery-origin spawners (Table 9, Figure 11):

- Fall-run returns at MER were 88% hatchery-origin
- Fall-run spawners in the Merced River were 89% hatchery-origin
- Fall-run spawners in the Stanislaus River were 83% hatchery-origin
- Fall-run spawners in the Tuolumne River were 73% hatchery-origin

Inland Creel Survey

Five separate creel surveys were conducted in the Sacramento River and its tributaries: upper and lower Sacramento River fall, American River fall, Feather River fall, and a late-fall-run survey on the Sacramento River. The results of these surveys were not shown in 2010 due to extremely high sample expansions that caused hatchery contribution estimates to exceed estimated harvest totals in some cases. Although this over-estimation did not occur in 2011, sample expansions remained high for some of these surveys and thus estimates of hatchery contribution may also be biased high. All inland harvest was dominated by hatchery-origin salmon (Table 9, Figures 12 and 13):

- Upper Sacramento River fall-run harvest was 75% hatchery-origin
- Lower Sacramento River fall-run harvest was 81% hatchery-origin
- Feather River fall-run harvest was 83% hatchery-origin
- American River fall-run harvest was 95% hatchery-origin
- Sacramento River late-fall-run harvest was 68% hatchery-origin

2. Relative recovery and stray rates for hatchery-origin salmon released in-basin versus hatchery-origin salmon trucked and released into the waters of the Carquinez Strait (includes salmon acclimated in net pens and released in San Pablo Bay or Santa Cruz Harbor).

Release strategies vary among hatcheries from year to year. This variability has often been in response to fluctuating abundances of certain stocks or differing policies among mitigating agencies with respect to "best" release practices. Lack of consistency and "problem releases" among CV hatcheries has limited the number of release groups available for direct comparison of differing release strategies. In 2011, there were 11 release groups consisting of 22 individual brood specific release types recovered that allow in-basin releases to be compared directly to trucked/net pen releases.

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 2011. Recovery rates displayed there, 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 the Sacramento River fall-run salmon and other CV stocks, respectively, and include the total number of salmon released with CWTs for each release type. In general, salmon that were trucked and released directly into the waters of Carquinez Strait or acclimated in net pens had higher relative recovery rates than their respective in-basin releases. These releases also had higher stray proportions than their paired in-basin counterparts.

Coleman National Fish Hatchery releases - Fall-run salmon broods 2007, 2008, and 2009
For brood 2009 CNFH fall-run salmon releases, the overall age-2 inland and ocean recovery rate for net pen CNFHn releases (729) was 1.9 times greater than in-basin CFHFh releases (385). While the total CV recovery rate was equivalent (216) between these two release types, the CNFHn ocean recovery rate (513) was 3.0 times higher than that of CNFHh (170). However, the proportion of CNFHh out-of-basin recoveries was only 1%, while the proportion of CFHFn out-of-basin recoveries was very high at 95%.

For brood 2008 CNFH fall-run salmon releases, the overall age-3 inland and ocean recovery rate for net pen CNFHn releases (1,387) was 3.5 times greater than in-basin CFHFh releases (399). The total CV recovery rate for CNFHn releases (296) was also more than double that of CNFHh (120) and the CNFHn ocean recovery rate (1,091) was 3.9 times higher than that of CNFHh (279). However, again the proportion of CNFHh out-of-basin recoveries was only 1%, while the proportion of CFHFn out-of-basin recoveries was very high at 95%.

For brood 2007 CNFH fall-run salmon releases, the overall age-4 inland and ocean recovery rate for net pen CNFHn releases (97) was 3.7 times greater than in-basin CFHFh releases (26). The total CV recovery rate for CNFHn releases (27) was also double that of CNFHh (13) and the CNFHn ocean recovery rate (70) was 5.4 times higher than that of CNFHh (13). However, zero CNFHh recoveries came from out-of-basin, while the proportion of CFHFn out-of-basin recoveries was very high at 98%.

Feather River Hatchery releases – Spring-run salmon broods 2007, 2008, and 2009
For brood 2009 FRH spring-run releases, the overall age-2 inland and ocean recovery rate for net pen FRHSn releases (121) was 1.8 times higher than in-basin FRHS releases (66). The total CV recovery rate for FRHSn releases (110) was also higher than that of FRHS (58) by 1.9 times, and the FRHSn ocean recovery rate (11) was fairly equivalent to that of FRHS (8). Approximately 2% of FRHSn were recovered out-of-basin while all FRHS CWTs were recovered in-basin.

For brood 2008 FRH spring-run salmon releases, the overall age-3 inland and ocean recovery rate for net pen FRHSn releases (238) was slightly lower than that of FRHS releases (249). The total CV recovery rate for FRHSn releases (207) was also slightly lower than that of FRHS (233), and the FRHSn ocean recovery rate (31) was fairly equivalent to that of FRHS (26). Approximately 2% of FRHSn were recovered out-of-basin while all FRHS CWTs were recovered in-basin.

For brood 2007 FRH spring-run salmon releases, the overall age-4 inland and ocean recovery rate for net pen FRHSn releases (67) was slightly higher than that of FRHS releases (50). The total CV recovery rate for FRHSn releases (66) was also slightly higher than that of FRHS (49), and the FRHSn ocean recovery rate (1) was identical to that of FRHS (1). Again, approximately 2% of FRHSn were recovered out-of-basin while all FRHS CWTs were recovered in-basin.

Feather River Hatchery releases – Fall-run salmon broods 2007, 2008, and 2009
Although FRH did not have any in-basin releases for broods 2007, 2008 or 2009, they did have experimental FRHFe, bay net pen FRHFn, coastal net pen FRHFnc, central bay net pen FRHFtib, and trucked direct bay FRHFt releases that can be evaluated.

For brood 2009 FRH fall-run salmon releases, the overall age-2 inland and ocean recovery rate for net pen FRHFn releases (578) was higher than that of central bay net pen FRHFtib releases (301), but lower than that of coastal net pen FRHFnc releases (644). The differences however, in recovery rates for CV and ocean areas are more revealing. The CV recovery rate for net pen FRHFn releases (349) was higher than that of central bay net pen FRHFtib releases (227), and much higher than that of the relatively few coastal net pen FRHFnc releases (60). The ocean recovery rate for net pen FRHFn releases (229) was much higher than that of central bay net pen FRHFtib releases (75), but much lower than that of coastal net pen FRHFnc releases (584). Approximately 4% and 5% of FRHFn and FRHFtib were recovered out-of-basin respectively, while 18% of FRHFnc CWTs were recovered out-of-basin.

For brood 2008 FRH fall-run salmon releases, the overall age-3 inland and ocean recovery rate for net pen FRHFn releases (754) was much higher than that of central bay net pen FRHFtib releases (433) and experimental FRHFe releases (401). The FRHFe releases were actually “hybrid” fish (FRH fall-run x FRH spring-run). The CV recovery rates for net pen FRHFn releases (358), central bay net pen FRHFtib releases (299), and experimental FRHFe releases (332) were fairly equivalent. The ocean recovery rate for net pen FRHFn releases (396) was much higher than that of central bay net pen FRHFtib releases (133) and experimental FRHFe releases (69). Approximately 4% of FRHFn and FRHFe were recovered out-of-basin, while 14% of FRHFtib CWTs were recovered out-of-basin.

For brood 2007 FRH fall-run salmon releases, the overall age-4 inland and ocean recovery rate for net pen FRHFn releases (165) was much higher that experimental FRHFe releases (8). Approximately 2% of FRHFe were recovered out-of-basin. A more in-depth comparison of the net pen FRHFn and trucked direct bay FRHFt releases from this brood are discussed in Section 3 below.

Nimbus Fish Hatchery releases – Fall-run salmon broods 2008 and 2009
For brood 2009 NFH fall-run salmon releases, the CV overall age-2 inland and ocean recovery rate for net pen NIMFn releases (315) was 1.8 times lower than that of NIMF releases (584). The total CV recovery rate for NIMFn releases (129) was 1.5 times lower than that of NIMF (196), and the NIMFn ocean recovery rate (185) was over 2 times lower than that of NIMF (388). Approximately 11% of NIMFn were recovered out-of-basin while only 2% of NIMF CWTs were recovered out-of-basin.

For brood 2008 NFH fall-run salmon releases, the CV overall age-3 inland and ocean recovery rate for net pen NIMFn releases (1,372) was 18.5 times higher than that of NIMF releases (74). The total CV recovery rate for NIMFn releases (247) was 7 times higher than that of NIMF (35), and the NIMFn ocean recovery rate (1,124) was nearly 29 times higher than that of NIMF (39). Approximately 4% of NIMFn were recovered out-of-basin while all NIMF CWTs were recovered in-basin.

Mokelumne Fish Hatchery releases – Fall-run salmon broods 2007 and 2009
For brood 2009 MOK fall-run salmon releases, the CV overall age-2 inland and ocean recovery rate for net pen MOKFn releases (947) was 4.2 times higher than that of MOKF releases (224). The total CV recovery rate for MOKFn releases (811) was 3.6 times higher than that of MOKF (224) The MOKFn ocean recovery rate was 135 while the MOKF ocean recovery rate was zero. Approximately 14% of MOKFn were recovered out-of-basin while only 1% of MOKF CWTs were recovered out-of-basin.

For brood 2007 MOK fall-run salmon releases, the CV overall age-4 inland and ocean recovery rate for net pen MOKFn releases (35) was much higher than that of MOKF releases (1). The total CV recovery rate for MOKFn releases (11) was also much higher than that of MOKF (1), The ocean recovery rate for MOKFn releases was 24 while there were no ocean recoveries for MOKF. Approximately 65% of MOKFn were recovered out-of-basin while the lone MOKF recovery was in-basin.

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

The same issues related to release practices that limited the available recovery comparisons in the previous section also limited the comparison of net pen releases and direct releases in the Carquinez Strait area. As a result there is only one release type comparison possible.

Feather River Hatchery releases – Fall-run salmon brood 2007

For brood 2007 FRH fall-run salmon releases, the overall age-4 recovery rate inland and ocean for net pen FRHFn releases (165) was 3.5 times higher than that of trucked direct bay FRHFt releases (47). The CV recovery rate was 2.7 times higher for net pen FRHFn releases (97) compared to that of trucked direct bay FRHFt releases (36) and the ocean recovery rate for net pen FRHFn releases (68) was 6.8 times higher than that of trucked direct bay FRHFt releases (10). Approximately 11% of FRHFn were recovered out-of-basin while 66% of FRHFt CWTs were recovered out-of-basin.

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

The relative recovery rate of CV hatchery releases in the 2011 ocean salmon fisheries (sport and commercial combined) varied by age and release type (Figure 16). Of the 58,843 CV CWT_{samp} recovered in the fisheries, most were age-3 (60%), followed by age-2 (34%), age-4 (1%) and age-5 (<.01%) fish (Table 10). The majority of age-2 CV salmon were harvested in the sport fishery (Figure 16) due to its lower size limit (24" total length) compared to the commercial fishery (27" total length).

For all age-2 CV releases, coastal net pen FRHFnc (584) had the highest recovery rate, followed by net pen CFHFn (513), in-basin NIMF (388), and San Joaquin basin MERF (372) releases.

Net pen releases also had the highest recovery rates for age-3 CV salmon releases. The recovery rates for net pen NIMFn (1,124) and CFHFn (1,091) releases were similarly high, almost double that of trucked MOKFt releases (573), and nearly three times that of net pen FRHFn releases (396).

Relatively few age-4 or age-5 CWT recoveries were made compared to age-2 and age-3 CV fish. The central bay NIMFtib releases had the highest recovery rate for age-4 (144) and late-fall-run in-basin CFHLh had the highest recovery rate for age-5 (0.6).

Contribution of CV release groups to sport ocean harvest

In 2011, anglers harvested an estimated 49,822 salmon in the California sport ocean salmon fishery. The majority (65%) of the harvest occurred in San Francisco and Monterey port areas (Table 11). Based on the expanded CWT_{total} collected in the fishery, including non-CV salmon release types, hatchery-origin fish contributed 57%-77% of the total harvest, depending on major port area (Figure 17). Of all hatchery release types, fall-run net pen FRHFn contributed the most (18.2%) to the total sport harvest, followed by fall-run in-basin CFHFh (14.4%), net pen NIMFn (8.5%) and in-basin NIMF (7.2%). Non-CV releases contributed 3.2% to the total harvest.

Fall-run net pen FRHFn releases contributed the greatest to the sport harvest in Monterey (23%), San Francisco (20%), and Fort Bragg (16%). In Eureka-Crescent City, the fall-run in-basin CFHFh releases contributed the most (12%) to the hatchery sport catch. Other CV releases contributing to California sport fisheries were net pen NIMFn (6-14%), in-basin CFHFh (12-16%), in-basin NIMF (2-12%), and net pen CFHFn (4-9%). The contribution of non-CV stocks was highest (11%) in the Eureka-Crescent City port area, most likely due to its proximity to rivers and salmon hatcheries in northern California, Oregon and Washington.

Contribution of CV release groups to commercial ocean harvest

Commercial trollers landed an estimated 70,028 salmon in the California commercial ocean salmon fishery; most salmon (56%) were landed in the Fort Bragg port area (Table 11). Based on the expanded CWT_{total} collected in the fishery, hatchery-origin fish contributed 26%-57% of the total harvest, depending on major port area (Figure 18). Of all hatchery-origin release types, fall-run net pen NIMFn contributed the most (11.2%) to the total commercial harvest, followed by fall-run in-basin CFHFh (8.9%), net pen FRHFn (8.8%) and non-CV releases (7.4%).

The Monterey port area catch was dominated by fall-run net pen FRHFn releases (20%), while San Francisco and Fort Bragg port areas were dominated by fall-run net pen NIMFn releases (16% and 10%, respectively). The Eureka-Crescent City port area was dominated by non-CV releases (10%). The other CV release type contributing a relatively high percentage to the California commercial fishery was in-basin CFHFh (4%-13%). The contribution of non-CV stocks was highest (11.1%) in the Fort Bragg area, followed by Eureka-Crescent City (10.3%). Again this is most likely due to the proximity of these port areas to rivers and salmon hatcheries in northern California, Oregon and Washington.

DISCUSSION

Estimates of 2011 hatchery contributions and recovery rates by release type that are presented in this report should be viewed as the second "single year snapshot" of salmon escapement and harvest in the CV and California ocean fisheries. All CWT recoveries in 2011 were from CV releases that were representatively marked and tagged at the CFM minimum 25% level. Although there were definite differences observed in recovery rates and straying proportions among runs, brood years, and CV release groups, this effort 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. Most of the CV CWT release groups in this study were produced, released and recovered during a time when Sacramento River fall-run salmon were at historically low levels or still in the stages of recovery. Although the 2011 ocean and river salmon fisheries were much less constrained than those in 2009-2010, salmon were still not susceptible to the historical levels of effort observed in ocean or river salmon fisheries prior to 2008.

Another critical factor to consider is that 2011 had the highest age-2 escapement of CV fall-run salmon on record. Thus the age-2 recoveries presented in this report are part of a very strong brood, compared to the weaker broods that preceded it. This apparent disparity in year class strength is important to note when comparing the relative recovery rates and hatchery contribution of various release types to harvest and escapement.

Again, the effects of interannual variation on survival and year-class strength for both hatchery- and natural-origin stocks should be considered when evaluating the status of CV salmon stocks. At this time, neither year class strength or age structure of CV natural-original salmon is known.

As noted in Kormos et al. (2012), scale-aging work done on 2006, 2007, and 2008 CV salmon escapement has indicated there may be different maturation rates between hatchery- and natural-origin fish by stock and basin. It remains premature to compare hatchery and natural-origin proportions without having complete brood- and/or stock-specific population estimates. While it may appear that total escapement of hatchery fish in the CV may exceed that of natural-origin fish in any given year, comparing age-specific total escapement (hatchery and natural) after broods complete their life cycle may identify differences in hatchery and natural ratios on a basin- and stock-specific basis. Such analyses may provide the basis for changing hatchery practices to better mimic wild population parameters. They may also further clarify the effects of specific environmental stressors unique to natural-origin fish or specific hatchery CWT release groups.

Strategies for CV fall-run production releases in any given year are often a result of two conflicting objectives. Increasing survival rates to allow for improved escapement and harvest often favors release strategies that bypass the Sacramento-San Joaquin Delta and acclimate salmon prior to release to reduce mortality from predators or other environmental factors. Alternatively, in-basin release practices are aimed at maximizing homing rates back to the hatchery of origin to reduce impacts on natural stocks. It is impossible to make a thorough comparison of hatchery release practices at this time due to the large variability that existed among CWT release types within the same CV hatchery broods examined in this study. Many release types included individual CWT codes that were released at numerous locations at different times and under various conditions (e.g., river water flows and temperatures, different net pen locations, incoming vs. outgoing bay tidal flows). While some individual CWT codes were recovered at a relatively high rate, others within the same release type were recovered at minimal levels if at all. The recovery rate R_{cwt} for individual CWT codes should be examined on a release type basis and the release strategies (e.g., in-basin, net pen acclimation) that produce the greatest resource value (i.e., high recovery rate with low straying) adopted for future release strategy evaluation. Coordinated and paired hatchery release types will allow for direct comparisons to be made between them and will enrich the available data set used for subsequent evaluation of the hatchery program in the future. Only FRH spring-run salmon in-basin and net pen releases have consistently allowed a true comparison during the last several broods.

There has been much debate among salmon biologists and managers on the definition of straying. Although it seems straight-forward to simply define any salmon not returning to the river of its hatchery location as a stray, decades of sharing broodstock and juvenile production among hatcheries, including different run-types, and releasing juvenile salmon at various sites and times throughout the CV have complicated this issue.

Years of sharing broodstock or progeny can confound the straying definitions in any system, especially when salmon return en masse to rivers where the shared broodstock or progeny originated. In addition, juvenile salmon production raised at other rearing facilities or released near the confluences of other rivers or within the delta system appear to exacerbate the problem of salmon straying to other systems. Although many of these practices have been recently terminated, it may take years before the long-term effects of these actions diminish and stray rates can be accurately determined and compared. In addition, preliminary analysis of individual

CWT codes within the same release type indicate that the timing of water releases within the CV during juvenile outmigration and adult escapement may also affect recovery and stray rates.

Another critical issue is 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 are still 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 larger 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 to only the Feather River. This is true despite many factors beyond the control of managers that affect salmon migration patterns such as dam operations, 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), 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 2011 are treated as strays in Appendix 1. It should be noted that differences in stray rates for FRH and CNFH under this alternative stray definition are relatively small as compared to the previous definition. A primary goal of this report is to provide information that will be useful in California salmon management, including the upcoming hatchery review process.

The advent of Santa Cruz coastal bay net pen release recoveries in the CV and ocean fisheries during 2011 also warrants some attention. These “enhancement” releases are intended to provide additional harvest to local ocean fisheries in the Monterey Bay area but they may also pose a potential risk to coastal salmon and steelhead stocks that may suffer from introgression or competition with hatchery stocks. As noted above, this release type should be evaluated after several broods have completed their respective life cycle so that their relative age-specific contribution to ocean fisheries and inland escapement can be determined. However, work is currently underway to monitor central California coastal streams to determine if this release type is straying into these areas. All coastal net pen releases are ad-clipped and contain a unique CWT code so identifying these fish should be relatively simple. If it appears that coastal net pen releases are competing or hybridizing via introgression with ESA-listed coastal salmon or steelhead stocks, then these programs should be seriously evaluated in the near term.

Prior to the creation of the CFM program, the primary purpose of CV salmon escapement monitoring was to provide basic status information (e.g., grilse and adult escapement counts) by individual stocks and major tributaries for California hatchery and ocean harvest management needs. The marking, tagging, or collection of CV CWT fish was not a high priority. CV escapement monitoring has since expanded to provide data for a broad range of management applications, including the recovery planning for ESA-listed salmonid stocks. These applications include assessing recovery efforts, including habitat restoration work, improving ocean and river fisheries management, and evaluating CV salmon hatchery programs to ensure both mitigation and conservation goals are being met. To meet the needs of these various assessment efforts, a review of current methodologies being employed among CV inland escapement monitoring programs was undertaken by CDFW in 2008. The goal of this review was to identify needed changes and/or additions to survey protocols that will ensure both statistically valid estimates of escapement and the collection of biological data, including CWTs and scales, needed for assessment efforts. In 2012, CDFW completed the "Central Valley Chinook Salmon Escapement In-River Monitoring Plan" that recommends methods for estimating escapement and collecting biological data necessary for improved stock assessment in the CV (Bergman et al. 2012). Survey modifications included changes in the current mark-recapture models being utilized, changes in sampling protocols to ensure representative sampling and proper accounting, and the use of counting devices in place of some mark-recapture programs. This monitoring plan is now being implemented among CV surveys to provide the basis for sound CV salmon assessment and subsequent management.

One critical item that was omitted from the recommended CV sampling protocol modifications was the need to account for the fresh versus decayed condition of fish sampled in CV carcass surveys. As identified by Mohr and Satterthwaite (in press) and discussed in this report, this information is needed to minimize the bias in determining the hatchery contribution by release type in natural areas. We know it is incorrect to assume that all sampled carcasses have the same ad-clip detection probability when a large disparity between fresh and decayed fish has been shown. Sample sizes related to these two conditions are also a factor when attempting to recover relatively small CWT releases (e.g., less than 200,000 ESA-listed Sacramento River winter-run salmon CWTs are released annually) or release types with typically low rates of contribution.

Overall, the CV CFM program has been successful in marking and tagging its targeted numbers of salmon each year at the five CV hatcheries. In addition, CWTs are now being recovered throughout the CV in a statistically valid manner. The CDFW CWT laboratories in Santa Rosa and Sacramento have both been expanded and are able to process the 50,000-70,000 heads recovered annually from ad-clipped salmon observed during CV escapement and California ocean and river fisheries monitoring.

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 continue to secure future funding for this program. The results from this program, in conjunction with the creation and 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 enhancement of salmon management in California's Central Valley.

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LIST OF ACRONYMS AND ABBREVIATIONS

Ad-clipped	clipped adipose fin
BOR	U.S. Bureau of Reclamation
CFM	Constant Fractional Marking
CNFH	Coleman National Fish Hatchery
CV	California Central Valley
CWT	coded-wire tag
CDFW	California Department of Fish and Wildlife
DPD	Daguerre Point Dam
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utilities District
ERP	Ecosystem Restoration Program
FRH	Feather River Hatchery
FWS	U.S. Fish and Wildlife Service
MER	Merced River Hatchery
MOK	Mokelumne River Hatchery
NMFS	National Marine Fisheries Service
NFH	Nimbus Fish Hatchery
OSP	Ocean Salmon Project
PSMFC	Pacific States Marine Fisheries Commission
RMPC	Regional Mark Processing Center
YARMT	Yuba Accord River Management Team

Table 1. Estimation and sampling methods used for the 2011 CV Chinook run assessment. (page 1 of 3)

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 the fall and late-fall run spawning periods. Fish that arrive during this 'break' are counted and excised. Those fish that contain a fall CWT code or have their adipose fin present are later counted as a part of the fall run. Fish containing a late-fall CWT code are later counted as late-fall. Systematic random bio-sample[a/] of all fish with adipose fin absent. Grilse cutoff: 700 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 tagged with two uniquely-numbered floytags. All fish marked with floytags returning to FRH during August and September are spawned as spring run. All other fish are spawned as fall run. All spring Chinook are bio-sampled. Systematic random bio-sample ~10% of aggregate fall run fish with adipose fin present and absent. All fall run fish with adipose fin absent are bio-sampled. All spawned fall run 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 and Late-Fall	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. Grilse cutoff: 675 mm females, 755 mm males.	CDFW, FWS

Table 1. Estimation and sampling methods used for the 2011 CV Chinook run assessment. (page 2 of 3)

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: 675 mm females, 755 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: 750 mm.	FWS, CDFW
Butte Creek Spring and Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate for spring run. Peterson mark-recapture estimate for fall run. 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 run 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 in estimate. 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. All fish with adipose fin absent are bio-sampled. Grilse cutoff: 680 mm females, 710 mm males.	EBMUD
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
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

Table 1. Estimation and sampling methods used for the 2011 CV Chinook run assessment. (page 3 of 3)

Sampling Location	Estimation and Sampling Methods	Agency
Recreational Harvest		
Upper Sacramento River Fall	Open July 16th to December 18th 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 August 1st through December 18th.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 July 16th to December 11th from the mouth to 1,000 ft below 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 July 16th to December 31st from the Jiboom Street Bridge to the base of Nimbus Dam with the following reach specific exceptions. The reach from the mouth to the Jiboom Street Bridge was open from July 16th to December 11th. The reach from the SMUD power line crossing to the USGS cable crossing was open from July 16th to October 31st, and the reach from the USGS cable crossing to the Hazel Avenue Bridge was open from July 16th to September 14th. 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
Lower Sacramento River Fall	Open July 16th to December 11th 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 November 1st to December 18th 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. 2011 California ocean sport and commerial salmon fishery seasons by major port area.

Major Port Area	Sport		Commercial		
	Season	size limit[a]	Season	size limit[a]	quota
Eureka/Crescent City	May 14 - Sep 5	24" TL	Jul 2-6, 9-13, 16-20	27" TL	1,400
			Aug 1 - 15	27" TL	1,000
Fort Bragg	Apr 2 - Oct 30	24" TL	Jul 23 - 27	27" TL	
			Jul 29 - Aug 29	27" TL	
			Sep 1 - 30	27" TL	
San Francisco	Apr 2 - Oct 30	24" TL	May 1 - 31	27" TL	
			Jun 25 - Jul 5	27" TL	
			Jul 9-13, 16-20, 23-27	27" TL	
			Jul 29 - Aug 29	27" TL	
			Sep 1 - 30	27" TL	
			Oct 3-7, 10-14[b]	27" TL	
Monterey[c]	Apr 2 - Sep 18	24" TL	May 1 - 31	27" TL	
			Jun 25 - Jul 5	27" TL	
			Jul 9-13, 16-20, 23-27	27" TL	
			Jul 29 - Aug 29	27" TL	
			Sep 1 - 30	27" TL	
South of Pt Sur[d]			May 1 - 31	27" TL	
			Jun 1 - 24	27" TL	
			Jun 25 - Jul 5	27" TL	
			July 9-13, 16-20, 23-27	27" TL	
			Jul 29 - Aug 29	27" TL	

a/ Size limit in inches total length (TL).
b/ Open only between Pt Reyes and San Pedro Pt.
c/ Recreational regulations apply from the Monterey area to the U.S./Mexico border
d/ Separate commercial regulations apply from Pt. Sur to the U.S./Mexico border

Table 3. Central Valley coded-wire tag (CWT) Chinook releases by age, stock, run and release group, brood years 2007-2010. (page 1 of 2)

Age 2 CWT releases

Release group*	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	10,209,934	2,543,157	25%	Basin	CNFH
CFHFn	2009	CNFH	Sac R	Fall	3	1,359,232	339,179	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
MOKFn	2009	MOK	Mok R	Fall	13	2,023,958	2,015,730	100%	Delta pens	Sherman Island net pens
MokFw	2009	wild	Mok R	Fall	2	1,529	1,113	73%	Basin	Mokelumne River (Woodbridge, Mok R Vino farms)
MERF	2009	MER	Mer R	Fall	6	165,213	154,685	94%	Basin	San Joaquin River (Jersey Pt)
CFHLh	2010	CNFH	Sac R	Late	26	2,036,844	1,984,094	97%	Basin	CNFH (includes spring surrogate releases)
			Total age 2 releases:		120	32,531,876	13,294,530	41%	<1% wild releases	

Age 3 CWT releases

Release group*	Brood year	Hatchery / wild	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	12,530,336	3,128,111	25%	Basin	CNFH
CFHFn	2008	CNFH	Sac R	Fall	3	1,427,792	371,685	26%	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	Fall x Spr 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)
MERF	2008	MER	Mer R	Fall	2	34,532	32,978	95%	Basin	San Joaquin River (Jersey Pt)
CFHLh	2009	CNFH	Sac R	Late	16	1,154,761	1,115,378	97%	Basin	CNFH (includes spring surrogate releases)
			Total age 3 releases:		152	30,282,881	11,104,290	37%	1% wild releases	

Table 3. Central Valley coded-wire tag (CWT) Chinook releases by age, stock, run and release group, brood years 2007-2010. (page 2 of 2)

Age 4 CWT releases

Release group*	Brood year	Hatchery	Stock origin	Run type	CWT codes	Total fish released	# CWT tagged	% CWT	Release strategy	Release locations / notes
ButSw	2007	wild	Butte Ck	Spr	33	330,672	323,916	98%	Basin	Butte Creek (Baldwin Construction Yard)
FRHS	2007	FRH	Fea R	Spr	8	1,414,343	1,378,941	97%	Basin	Boyds Pump Ramp (on Feather River)
FRHSn	2007	FRH	Fea R	Spr	2	1,271,761	1,242,480	98%	Bay pens	San Pablo Bay net pens, Wickland Oil net pens
CFHFe	2007	CNFH	Sac R	Fall	8	201,125	196,993	98%	CV exper	Clarksburg, Red Bluff Diversion Dam
CFHFh	2007	CNFH	Sac R	Fall	14	11,232,501	2,801,459	25%	Basin	CNFH
CFHFn	2007	CNFH	Sac R	Fall	3	1,266,949	314,681	25%	Bay pens	San Pablo Bay net pens (Conoco Phillips, Mare Island); 75% truck mortality noted for one release
FRHFe	2007	FRH	Fea R	Fall	19	623,567	619,085	99%	CV exper	Elkhorn Boat Ramp, Isleton, Lighthouse Marina, West Sacramento
FRHFn	2007	FRH	Fea R	Fall	9	9,422,521	2,347,396	25%	Bay pens	Mare Island net pens, San Pablo Bay net pens, Wickland Oil net pens
FRHFt	2007	FRH	Fea R	Fall	4	102,225	101,712	99%	Trucked	Benicia
FeaFw	2007	wild	Fea R	Fall	19	208,717	206,683	99%	Basin	Thermalito Bypass
NIMFn	2007	NIM/MOK	Ame R	Fall	7	6,879,664	1,714,858	25%	Bay pens	Raised at both NIM and MOK; San Pablo Bay net pens
NIMFtib	2007	MOK	Ame R	Fall	1	51,600	51,600	100%	Tiberon pens	Raised at MOK; held 3-4 mos Tiburon net pens, released as yearlings
MOKF	2007	MOK	Mok R	Fall	1	406,593	101,458	25%	Basin	Lower Mokelumne River (New Hope Landing)
MOKFn	2007	MOK	Mok R	Fall	2	2,203,488	550,668	25%	Bay pens	San Pablo Bay net pens
MokFw	2007	wild	Mok R	Fall	1	315	315	100%	Basin	Mokelumne River
CFHLh	2008	CNFH	Sac R	Late	14	1,108,540	1,072,854	97%	Basin	CNFH (includes spring surrogate releases)
				Total age 4 releases:	145	36,724,581	13,025,099	35%	1% wild releases	

Age 5 CWT releases

Release group*	Brood year	Hatchery	Stock origin	Run type	CWT codes	Total fish released	# CWT tagged	% CWT	Release strategy	Release locations / notes
CFHLe	2007	CNFH	Sac R	Late	17	310,099	299,292	97%	CV exper	Sac R (Colusa to RBDD), Georgianna Slough, Port Chicago, Ryde-Koket
CFHLh	2007	CNFH	Sac R	Late	10	751,208	732,952	98%		CNFH (includes spring surrogate releases)
				Total age 5 releases:	27	1,061,307	1,032,244	97%		

***CV CWT release groups:**

Sacramento River Basin Fall Chinook CWT release groups

CFHFe Coleman National Fish Hatchery fall experimental releases
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
FRHFt Feather River Hatchery fall trucked releases (no net pens)
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
NIMFtib Nimbus Fish Hatchery fall Tiburon net pens releases

San Joaquin Basin Fall Chinook CWT release groups

MOKF Mokelumne Hatchery fall basin releases
MOKFn Mokelumne Hatchery fall net pen releases
MOKFt Mokelumne Hatchery fall trucked releases
MokFw Mokelumne River fall wild
MERF Merced Hatchery fall releases

Central Valley Spring Chinook CWT release groups

FRHS Feather River Hatchery spring basin releases
FRHSn Feather River Hatchery spring net pen releases
ButSw Butte Creek spring wild

Sacramento River Basin Late Fall Chinook CWT release groups

CFHLe Coleman National Fish Hatchery late fall experimental releases
CFHLh Coleman National Fish Hatchery late fall hatchery releases

Table 4. Escapement estimates and sample data for 2011 CV escapement.

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]	4,534	4,534	4,445	4,445	4,356	100%	100%	100%	1.00
Feather River Hatchery	Spring	1,969	1,969	1,424	1,424	1,329	100%	100%	99%	1.01
Coleman National Fish Hatchery	Fall	42,380	42,380	9,735	4,999	4,895	100%	51%	99%	1.96
Feather River Hatchery	Fall	32,616	32,616	10,302	10,302	9,983	100%	100%	99%	1.01
Nimbus Fish Hatchery	Fall	12,680	12,680	3,490	3,489	3,377	100%	100%	99%	1.01
Nimbus Fish Hatchery Weir	Fall	3,917	3,917	367	367	335	100%	100%	99%	1.01
Mokelumne River Hatchery	Fall	15,922	15,922	14,724	14,712	14,341	100%	100%	99%	1.01
Merced River Hatchery	Fall	437	437	349	349	337	100%	100%	99%	1.01
Total Hatchery Escapement		**114,455**	**114,455**	**44,836**	**40,087**	**38,953**				
	fall	**107,952**	**107,952**	**38,967**	**34,218**	**33,268**				
Natural Area Escapement										
Upper Sacramento River (above RBDD)	Late-fall[b]	3,725	114	83	81	76	3%	98%	100%	20.21 [c]
Butte Creek	Spring	4,497	2,313	0	0	0	100%	100%	100%	-
Clear Creek	Fall	4,841	647	42	40	36	13%	95%	97%	3.50 [c]
Battle Creek	Fall	12,867	video							[d]
Cottonwood Creek	Fall	2,144	127	62	61	54	19%	98%	98%	5.94 [c]
Upper Sacramento River (above RBDD)	Fall	10,583	378	75	74	67	4%	99%	97%	12.12 [c]
Mill Creek	Fall	1,485	video	29	29	28				1.00 [e]
Deer Creek	Fall	662	video	1	1	1				1.00 [e]
Butte Creek	Fall	419	179	4	4	4	43%	100%	100%	2.34
Feather River	Fall	47,289	5,094	1,632	1,631	1,518	11%	100%	98%	9.48
Yuba River (above Daguerre Point dam)	Fall	7,723	video	1,733	1,733	1,620				1.00 [f]
Yuba River (below Daguerre Point dam)	Fall	1,398	216	27	27	25	15%	100%	96%	6.73
American River	Fall	21,320	921	480	473	440	4%	99%	98%	9.19 [c]
Mokelumne River	Fall	2,667	video	2,234	2,234	2,175				1.00 [f]
Calaveras River	Fall	465	redd	54	54	50				1.00 [e]
Stanislaus River	Fall	1,063	494	305	305	294	46%	100%	99%	2.18
Tuolumne River	Fall	878	444	249	249	241	51%	100%	100%	1.99
Merced River	Fall	1,615	401	284	284	270	25%	100%	98%	4.10
Total Natural Area Escapement		**125,641**	**11,328**	**7,294**	**7,280**	**6,899**				
	fall	**117,419**	**8,901**	**7,211**	**7,199**	**6,823**				
CV Sport Harvest										
Sacramento River (above Feather River)	Fall	19,971	1,389	270	268	257	7%	99%	97%	14.94
Sacramento River (below Feather River)	Fall	14,900	600	170	168	163	4%	99%	99%	25.28
Feather River	Fall	4,218	231	54	52	49	5%	96%	98%	19.35
American River	Fall	21,411	585	165	163	158	3%	99%	99%	37.52
Sacramento River (above Feather River)	Late-fall[b]	1,730	186	123	120	117	11%	98%	99%	9.62
Total Sport Harvest		**62,230**	**2,991**	**782**	**771**	**744**				
Total		**302,326**	**128,774**	**52,912**	**48,138**	**46,596**				

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

b/ Late-fall hatchery and natural escapement occurred in late fall 2010; late-fall sport harvest occurred in late fall 2011.

c/ 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, in press).

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

e/ 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 2011 Ocean Salmon Sport and Commercial Fisheries by major port area.

Port	Total Harvest Estimate	Chinook Sampled[a]	Observed Ad-Clips	Heads Processed	Valid CWTs	Sample Rate (fe)	Ad-clips Processed (fa)	Valid CWTs (fd)	CWT Sample Expansion
Commercial									
Eureka/Crescent	2,391	1,441	164	164	98	60%	100%	99%	1.68
Fort Bragg	39,311	17,087	2,536	2,530	1,943	43%	100%	100%	2.33
San Francisco	21,912	9,207	1,703	1,701	1,598	42%	100%	100%	2.38
Monterey	6,414	2,759	568	568	532	43%	100%	99%	2.35
Commercial total	**70,028**	**30,494**	**4,971**	**4,963**	**4,171**				
Sport									
Eureka/Crescent	9,987	2,510	558	555	472	25%	99%	100%	4.04
Fort Bragg	7,398	2,026	430	429	398	27%	100%	100%	3.70
San Francisco	19,734	9,171	2,716	2,694	2,637	46%	99%	100%	2.20
Monterey	12,703	3,400	1,093	1,072	1,039	27%	98%	100%	3.78
Sport total	**49,822**	**17,107**	**4,797**	**4,750**	**4,546**				
Ocean total	**119,850**	**47,601**	**9,768**	**9,713**	**8,717**				

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

Table 6. Revised CWT sample expansion rate F_{samp} and hatchery proportion of 2010 Upper Sacramento River fall and late-fall carcass surveys.

2010 Upper Sacramento River fall Chinook carcass survey

Original CWT sample expansion rate F_{samp} and hatchery proportion

Fish Condition	Escapement N	Chinook sampled	Observed ad-clips	Heads processed	CWTs recovered	Valid CWTs n	Sample rate	p_{adc}	$p_{adc\text{-}cwt}$	F_{samp}	Total CWT Production	$\sum_{i=1}^{m} CWT_{total,i}$	Hatchery proportion
Combined	16,372	1415	130	129	117	**117**	8.6%	**9.2%**	**91%**	**11.66**	276.71	3,226	**20%**

Revised CWT sample expansion rate F_{samp} and hatchery proportion to reduce bias from false negatives and false positives (Mohr and Satterthwaite, in press)

Fish Condition	Escapement N	Chinook sampled	Observed ad-clips	Heads processed	CWTs recovered	Valid CWTs n	Sample rate	p_{adc}	$p_{adc\text{-}cwt}$	F_{samp}	Total CWT Production	$\sum_{i=1}^{m} CWT_{total,i}$	Hatchery proportion
Fresh		291	60	59	56	56	2%	**21%**	**95%**	57.21			
Decayed		1,124	70	70	61	61	7%	6%	87%				
Combined	16,372	1,415	130	129	117	**117**	9%			**27.38**	276.71	7,578	**46%**

2010 Upper Sacramento River late-fall Chinook carcass survey

Original CWT sample expansion rate F_{samp} and hatchery proportion

Fish Condition	Escapement N	Chinook sampled	Observed ad-clips	Heads processed	CWTs recovered	Valid CWTs n	Sample rate	p_{adc}	$p_{adc\text{-}cwt}$	F_{samp}	Total CWT Production	$\sum_{i=1}^{m} CWT_{total,i}$	Hatchery proportion
Combined	4,282	811	47	46	44	**43**	19%	**6%**	**96%**	**5.52**	45.2	250	**6%**

Revised CWT sample expansion rate F_{samp} and hatchery proportion to reduce bias from false negatives and false positives (Mohr and Satterthwaite, in press)

Fish Condition	Escapement N	Chinook sampled	Observed ad-clips	Heads processed	CWTs recovered	Valid CWTs n	Sample rate	p_{adc}	$p_{adc\text{-}cwt}$	F_{samp}	Total CWT Production	$\sum_{i=1}^{m} CWT_{total,i}$	Hatchery proportion
Fresh		187	28	27	27	27	4%	**15%**	**100%**	23.75			
Decayed		624	19	19	17	16	15%	3%	89%				
Combined	4,282	811	47	46	44	**43**	19%			**14.91**	45.2	674	**16%**

Original $F_{samp} = (N \times p_{\_adc} \times p_{\_cwt|adc}) / n_{valid\ cwt}$,

where N = estimated total escapement, $p_{\_adc}$ = proportion of fish sampled that were ad-clipped, $p_{\_cwt|adc}$ = proportion of ad-clipped fish that contained a CWT, and $n_{valid\ cwt}$ = total number of valid CWTs collected from both fresh and decayed fish.
(Kormos et al. 2012)

New $F_{samp} = (N \times p_{\_adc|fresh}, \times p_{\_cwt|fresh,adc}) / n_{valid\ cwt}$,

where N = estimated total escapement, $p_{\_adc|fresh}$ = proportion of fresh fish sampled that were ad-clipped, $p_{\_cwt|fresh,adc}$ = proportion of ad-clipped fresh fish that contained a CWT, and $n_{valid\ cwt}$ = total number of valid CWTs collected from both fresh and decayed fish.
(Mohr and Satterthwaite, in press)

Table 7. Raw and expanded CV Chinook CWT recoveries by stock and age, brood years 2006-2011.

Fall	2010	2009	2008	2007	2006		Total CV	Total CV
Age	1	2	3	4	5		CWTs	%
Raw CWT Recoveries	3	27,506	9,053	1,381	1		37,944	81%
	(< 1%)	(72%)	(24%)	(4%)	(< 1%)			
Expanded CWT_{total}	**47**	**121,939**	**76,753**	**13,412**	**4**		212,155	93%
	(< 1%)	(57%)	(36%)	(6%)	(< 1%)			
Spring	2010	2009	2008	2007	2006		Total CV	Total CV
Age	1	2	3	4	5		CWTs	%
Raw CWT Recoveries		1,317	2,125	540			3,982	9%
		(33%)	(54%)	(14%)				
Expanded CWT_{total}		**1,880**	**4,421**	**1,541**			7,843	3%
		(24%)	(56%)	(20%)				
Late-Fall	2011	2010	2009	2008	2007	2006	Total CV	Total CV
Age	1	2	3	4	5	6	CWTs	%
Raw CWT Recoveries		102	1,077	2,974	511	4	4,668	10%
		(2%)	(23%)	(64%)	(11%)	(< 1%)		
Expanded CWT_{total}		**375**	**2,273**	**3,941**	**1,104**	**4**	7,698	3%
		(5%)	(30%)	(51%)	(14%)	(< 1%)		
Winter	2011	2010	2009	2008	2007	2006	Total CV	Total CV
Age	1	2	3	4	5	6	CWTs	%
Raw CWT Recoveries		1	1				2	0%
		(50%)	(50%)					
Expanded CWT_{total}		**2**	**2**				4	0%
		(50%)	(50%)					
All Runs							Total CV	Total CV
Age	1	2	3	4	5	6	CWTs	%
Raw CWT Recoveries	3	28,926	12,256	4,895	512	4	46,596	100%
	(< 1%)	(62%)	(26%)	(11%)	(1%)	(< 1%)		
Expanded CWT_{total}	**47**	**124,196**	**83,450**	**18,895**	**1,108**	**4**	227,700	100%
	(< 1%)	(54%)	(37%)	(8%)	(< 1%)	(< 1%)		

Table 8. Raw and expanded Ocean CWT recoveries by stock and age, brood years 2006-2010

Fall	2009	2008	2007	2006	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	3,171	3,815	304	1	7,291	84%
	(43%)	(52%)	(4%)	(< 1%)		
Expanded CWTtotal	**20,055**	**33,975**	**2,825**	**5**	56,860	86%
	(35%)	(60%)	(5%)	(< 1%)		
Spring	2009	2008	2007	2006	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	69	194	8	0	271	3%
	(25%)	(72%)	(3%)			
Expanded CWTtotal	**200**	**573**	**19**	**0**	793	1%
	(25%)	(72%)	(3%)			
Late-Fall	2010	2009	2008	2007	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	0	383	66	3	452	5%
		(85%)	(15%)	(< 1%)		
Expanded CWTtotal	**0**	**1,015**	**168**	7	1,191	2%
		(85%)	(14%)	(< 1%)		
Winter	2010	2009	2008	2007	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	0	71	1	0	72	1%
		(99%)	(< 1%)			
Expanded CWTtotal	**0**	**243**	**3**	**0**	246	0%
		(99%)	(< 1%)			
Non CV Rivers	2009	2008	2007	2006	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	2	358	244	27	631	7%
	(< 1%)	(57%)	(39%)	(4%)		
Expanded CWTtotal	**28**	**4,329**	**2,299**	**103**	6,758	10%
	(< 1%)	(64%)	(34%)	(2%)		
All Runs					Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	3,242	4,821	623	31	8,717	100%
	(37%)	(55%)	(7%)	(< 1%)		
Expanded CWTtotal	**20,283**	**40,136**	**5,314**	**114**	65,848	100%
	(31%)	(61%)	(8%)	(< 1%)		

Table 9. Percentage of inland CWT_{total} recoveries by location, run, and release type[a] in hatchery returns, natural escapement and sport harvest during 2011.

		Coleman National Fish Hatchery					Feather River Hatchery[b]								Nimbus Hatchery			Mokelumne/Merced hatcheries[b]						Total %		Total
Location	Run	CFHLh	CFHLe	CFHFh	CFHFn	CFHFe	FRHS	FRHSn	FRHFe	FRHFn	FRHFnc	FRHFt	FRHFtib	FEAFw	NIMF	NIMFn	NIMFtib	MOKF	MOKFn	MOKFt	MokFw	MERF	nonCV	Hatchery	Natural	Run
Hatchery Spawners																										
Coleman Hatchery	Late	98.4%	-	2.0%	0.1%												-			-				100%	0%	4,534
Feather River Hatchery	Spring						24.2%	29.5%	6.4%	33.1%			0.2%						0.2%					94%	6%	1,969
Coleman Hatchery	Fall	0.6%		86.8%	0.5%	-			-	0.6%			-						-			-		89%	11%	42,380
Feather River Hatchery	Fall			-	2.6%	-	3.3%	4.0%	1.6%	83.6%	0.1%	-	0.4%	-	0.1%	0.1%			0.1%	-		-		96%	4%	32,616
Nimbus Hatchery	Fall				2.0%				-	2.1%	-	-	-		25.9%	37.4%	0.1%		6.3%	0.6%		2.5%		77%	23%	12,680
Nimbus Weir	Fall				3.3%			0.2%	0.1%	3.4%			0.3%		11.3%	5.0%			1.4%	0.1%		0.7%		26%	74%	3,917
Mokelumne Hatchery	Fall	-		-	2.5%		-	0.1%	-	2.0%	-		0.1%		0.1%	3.5%	0.2%	1.2%	77.3%	7.1%	-	3.6%		98%	2%	15,922
Merced Hatchery	Fall	0.2%			3.7%					6.4%			0.2%			0.9%			39.6%	3.9%		33.0%		88%	12%	437
Total Hatchery Fall Run		**0.3%**		**34.1%**	**1.7%**	**-**	**1.0%**	**1.2%**	**0.5%**	**26.2%**	**-**	**-**	**0.1%**	**-**	**3.5%**	**5.1%**	**-**	**0.2%**	**12.4%**	**1.1%**	**-**	**1.0%**		**89%**	**11%**	**107,952**
Natural Spawners																										
Upper Sacramento River	Late	37.2%	4.0%													2.2%	1.1%							44%	56%	3,725
Butte Creek	Spring																							0%	100%	4,497
Clear Creek	Fall			2.3%		0.1%		0.5%	0.1%	5.0%			0.2%											8%	92%	4,841
Cottonwood Creek[c]	Fall			42.2%	6.7%					8.1%	0.3%		0.3%											58%	42%	2,144
Mill Creek[c]	Fall			6.2%	0.8%					0.3%			0.1%											7%	93%	1,485
Battle Creek[d]	Fall	0.6%		86.8%	0.5%	-			-	0.6%			-						-			-		89%	11%	12,867
Butte Creek	Fall				4.1%					2.1%									0.5%					7%	93%	419
Upper Sac River	Fall			12.4%	1.2%	0.2%		0.3%	0.4%	11.7%							0.1%		0.5%			0.1%		27%	73%	10,583
Feather River	Fall				3.1%		4.2%	4.3%	1.8%	75.8%	-	-	0.3%			0.1%	-		-			-		90%	10%	47,289
Yuba River - Above DPD	Fall				8.9%		0.4%	1.7%	1.3%	48.3%			1.5%		0.8%				1.3%			0.2%		65%	35%	7,723
Yuba River - Below DPD	Fall				5.8%		0.5%	1.0%	0.5%	17.4%			0.5%		3.9%	1.9%			1.9%	0.5%				34%	66%	1,398
American River	Fall				11.5%				-	4.6%		0.1%			17.0%	30.6%	0.1%		1.6%	0.4%		0.5%	0.1%	66%	34%	21,320
Mokelumne River	Fall				2.5%			0.1%	-	2.0%			0.1%		0.1%	3.1%	0.1%	1.1%	69.0%	6.4%		3.2%		88%	12%	2,667
Calaveras River[c]	Fall				0.9%											1.7%	0.2%		6.2%	1.9%		2.6%		14%	86%	465
Stanislaus River	Fall				21.4%					3.4%						3.3%	0.2%	0.2%	25.7%	15.6%		12.9%		83%	17%	1,063
Tuolumne River	Fall				8.7%			0.2%	0.5%	13.9%						0.9%	0.2%		21.1%	5.2%		21.9%		73%	27%	878
Merced River	Fall				15.7%					2.0%	0.5%					5.1%	0.2%		25.4%	15.5%		24.6%		89%	11%	1,615
Total Natural Area Fall Run[e]		**0.1%**		**11.2%**	**4.9%**	**-**	**1.8%**	**2.0%**	**0.9%**	**37.8%**	**-**	**-**	**0.2%**		**3.3%**	**6.0%**	**-**	**-**	**2.9%**	**0.6%**		**0.9%**	**-**	**73%**	**27%**	**112,663**
Sport Harvest																										
Inland Creel - Late Fall	Late	65.1%		2.2%				0.6%											0.6%					68%	32%	1,730
Inland Creel - Upper Sac	Fall	0.3%		69.6%	1.5%			0.2%	0.2%	2.8%													0.1%	75%	25%	19,971
Inland Creel - Lower Sac	Fall	1.6%		4.1%	9.0%			0.3%	0.5%	36.4%			0.2%		15.9%	6.1%	0.2%		4.4%	0.8%		1.4%	0.2%	81%	19%	14,900
Inland Creel - Feather	Fall				7.1%		0.5%		0.9%	73.9%			0.9%											83%	17%	4,218
Inland Creel - American	Fall				10.5%			0.2%		7.8%			0.4%		42.4%	29.5%			3.5%	0.2%		0.4%		95%	5%	21,411
Total Sport Fall Harvest		**0.5%**		**24.0%**	**6.9%**		**-**	**0.2%**	**0.2%**	**17.8%**			**0.2%**		**18.9%**	**12.0%**	**-**		**2.3%**	**0.3%**		**0.5%**	**0.1%**	**84%**	**16%**	**60,500**

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/ Natural-origin Feather River (FeaW) and Mokelumne River (Mokw) CWT releases are not included in this table due to minimal recoveries occurring only at the Feather River and Mokelumne hatcheries (contributed 0.02% and 0.01%, respectively).
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 Coleman National Fish Hatchery (FWS staff, per. comm).
e/ Total natural area fall run total only includes surveys with representative sampling of CWTs.

Table 10. 2011 CWT recovery rate (recoveries per 100,000 CWTs released) by release group, brood year, and recovery location (page 1 of 2).

Age 2 CV recoveries

Release group	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	2009	Spr	1,026,954				578	16					594		594	87	58		58	8	0.00
FRHSn	2009	Spr	1,058,635			18	1,033	104	6	4			1,136	28	1,164	113	107	3	110	11	0.02
CFHFh	2009	Fall	2,543,157	5,390	36	212	1			1			5,426	214	5,640	4,321	213	8	222	170	0.04
CFHFn	2009	Fall	339,179	35		35	243	85	215	92	25	28	35	722	757	1,741	10	213	223	513	0.95
FRHFn	2009	Fall	2,367,209	43	97	67	7,492	403	76	73	14	20	7,896	391	8,286	5,421	334	17	350	229	0.05
FRHFnc	2009	Fall	118,879			6	**58**		1	2	8		58	18	76	694	49	15	64	584	0.23
FRHFtib	2009	Fall	60,104				130		1	5	1		130	7	136	45	216	11	227	75	0.05
FeaFw	2009	Fall	177,657				4						4		4	2	2		2	1	0.00
NIMF	2009	Fall	1,000,559				6	30	1,916	6			1,916	42	1,958	3,881	191	4	196	388	0.02
NIMFn	2009	Fall	347,527			1	1		401	38	8		401	49	450	644	115	14	129	185	0.11
MokF	2009	Fall	99,048							220		2	220	2	222		222	2	224		0.01
MokFn	2009	Fall	2,015,730	10		27	33	124	1,145	14,034	534	449	14,034	2,321	16,354	2,730	696	115	811	135	0.14
MokFw	2009	Fall	1,113																		-
MerF	2009	Fall	154,685	2	12	11	28	16	386	605	487	293	487	1,353	1,840	576	315	875	1190	372	0.74
CFHLh	2010	Late	992,047	157						1	1		157	2	159		16	0.2	16		0.01
			Total	5,637	145	376	9,607	778	4,146	15,081	1,078	793	32,494	5,147	37,641	20,255	2,545	1,277	3,822	2,672	

Age 3 CV recoveries

Release group	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				2,237	23		1			2,260	1	2,261	265	223	0.1	223	26	0.00
FRHSn	2008	Spr	1,005,727		24	4	2,006	39	1	10		2	2,045	41	2,086	308	203	4	207	31	0.02
CFHFh	2008	Fall	3,128,111	3,461	267	60							3,727	60	3,788	8,716	119	2	121	279	0.02
CFHFn	2008	Fall	371,685	21	36	8	351	97	472	23	45	51	57	1,048	1,105	4,056	15	282	297	1,091	0.95
FRHFe	2008	Fall	481,853	2	36	4	1,429	104	12	8		4	1,533	66	1,598	334	318	14	332	69	0.04
FRHFn	2008	Fall	2,061,211	20	109	34	6,626	435	135	17	1	24	7,061	340	7,401	8,161	343	17	359	396	0.05
FRHFtib	2008	Fall	89,859	4		17	111	120	11	11			231	43	274	120	257	48	305	133	0.16
FeaFw	2008	Fall	289,830				3						3		3	11	1		1	4	0.00
NIMF	2008	Fall	264,006						92				92		92	104	35		35	39	0.00
NIMFn	2008	Fall	976,955				15	7	2,330	55	9	2	2,330	87	2,417	10,983	238	9	247	1,124	0.04
MokFt	2008	Fall	250,300	2		9	1	7	159	1,305	267	211	1,305	657	1,962	1,433	521	262	784	573	0.33
MokFw	2008	Fall	20,680							2			2		2	4	11		11	21	0.00
MerF	2008	Fall	32,978				1		35	19	27	16	27	70	97	52	81	214	294	157	0.73
CFHLh	2009	Late	1,115,378	1,023	81								1,104		1,104	1,015	99		99	91	0.00
			Total	4,532	554	136	12,779	831	3,249	1,451	349	311	21,777	2,414	24,191	35,563	2,465	851	3,316	4,035	

Table 10. 2011 CWT recovery rate (recoveries per 100,000 CWTs released) by release group, brood year, and recovery location (page 2 of 2).

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[a/]	Fea	Yub	Ame	Mok	Mer	SJ	Basin	Stray	CV total	CWT_{samp}	Basin	Stray	CV total	Ocean	Proportion
ButSw	2007	Spr	323,916																		-
FRHS	2007	Spr	1,378,941				672						672		672	12	49		49	1	0.00
FRHSn	2007	Spr	1,242,480		12		811			1			811	13	824	7	65	1	66	1	0.02
CFHFe	2007	Fall	196,993	12	24	4	1						36	5	41	2	18	2	21	1	0.11
CFHFh	2007	Fall	2,801,459	343	24	6							367	6	373	359	13	0.2	13	13	0.02
CFHFn	2007	Fall	314,681	2		1	9	16	53	3			2	83	85	219	1	26	27	70	0.98
FRHFe	2007	Fall	619,085				43		1				43	1	44	6	7	0.2	7	1	0.02
FRHFn	2007	Fall	2,347,396	2	109	9	1,858	162	138	4		2	2,020	264	2,284	1,595	86	11	97	68	0.12
FRHFt	2007	Fall	101,712				13		24				13	24	37	10	12	24	36	10	0.66
FeaFw	2007	Fall	206,683				1						1		1		0.5		0.5		0.00
NIMFn	2007	Fall	1,714,858		20	1			127	66	4	9	193	34	227	430	11	2	13	25	0.15 [b/]
NIMFtib	2007	Fall	51,600	1	53	1	9		34	30	4	4	64	72	136	74	123	140	264	144	0.53 [b/]
MokF	2007	Fall	101,458							1			1		1		1		1		0.00
MokFn	2007	Fall	550,668		12	1	2		11	22	12	2	22	41	63	129	4	7	11	23	0.65
MokFw	2007	Fall	315																		-
CFHLh	2008	Late	1,072,854	2,932	808								3,740		3,740	168	349		349	16	0.00
			Total	3,292	1,063	23	3,419	178	388	128	21	17	7,984	543	8,527	3,013	740	215	955	372	

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[a/]	Fea	Yub	Ame	Mok	Mer	SJ	Basin	Stray	CV total	CWT_{samp}	Basin	Stray	CV total	Ocean	Proportion
CFHLe	2007	Late	299,292	1	141								142		142		48		48		0.00
CFHLh	2007	Late	732,952	481	445								926		926	5	126		126	0.6	0.00

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

b/ Nimbus Hatchery fall Chinook net pen releases (NIMFn and NIMFtib) brood year 2007 contained salmon from the American River raised at Mokelumne River Fish Hatchery.

Sacramento River fall Chinook releases (SFC)

CFHFe	Coleman Hatchery fall experimental releases
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
FRHFt	Feather River Hatchery fall trucked releases (no net pens)
FRHFtib	Feather River Hatchery fall Tiburon net pen releases (released as yearlings following fall)
FeaFw	Feather River fall wild
NIMF	Nimbus Hatchery fall basin releases
NIMFn	Nimbus Hatchery fall net pens
NIMFtib	Nimbus Hatchery fall Tiburon net pens (released as yearlings following fall)

Other CV releases (OCV)

CFHLe	Coleman Hatchery late fall experimental releases
CFHLh	Coleman Hatchery late fall hatchery releases
FRHS	Feather River Hatchery spring basin releases
FRHSn	Feather River Hatchery spring net pen releases
FRHSt	Feather River Hatchery spring trucked releases
MerF	Merced River fall releases
MokF	Mokelumne Hatchery fall basin releases
MokFn	Mokelumne Hatchery fall net pen releases
MokFt	Mokelumne Hatchery fall trucked releases
MokFw	Mokelumne River fall wild

Wild releases

ButSw	Butte Creek spring wild

Table 11. Percentage of ocean CWT_{total} recoveries by majorport, month and release type[a] in 2011 California sport and commercial fisheries (page 1 of 2).

	Livingston/Coleman Hatcheries						Feather River Hatchery								Nimbus Hatchery			Mokelumne/Merced Hatcheries[b]						Total	Total %		Total
	SacW	CFHLh	CFHLe	CFHFh	CFHFn	CFHFe	FRHS	FRHSn	FRHFe	FRHFn	FRHFnc	FRHFt	FRHFtib	FeaW	NIMF	NIMFn	NIMFtib	MOKF	MOKFn	MOKFt	MokFw	MERF	nonCV	CV	Hatchery	Natural	Harvest
Sport Harvest																											
Eureka/Crescent City																											
May		0.5%		15.4%	5.8%			0.5%	1.0%	20.0%					0.5%	13.5%			1.9%	0.5%		0.5%	4.0%	60.1%	64%	36%	666
Jun				12.8%				0.5%	0.5%	8.0%						8.1%				2.0%			8.3%	31.9%	40%	60%	946
Jul		0.1%		12.7%	6.2%		0.1%	0.1%		11.2%					1.0%	9.8%			0.7%	2.2%		0.1%	9.8%	44.2%	54%	46%	4,384
Aug		0.7%		10.0%	2.2%		0.9%	0.6%		7.8%	0.4%				4.8%	12.4%	0.1%		4.5%	0.6%		0.8%	14.4%	45.8%	60%	40%	3,690
Sep				9.1%	9.2%		1.2%			18.4%	1.2%				4.6%	9.1%			18.3%			6.3%	4.6%	77.4%	82%	18%	301
Total		**0.3%**		**11.8%**	**4.2%**		**0.4%**	**0.3%**	**0.1%**	**10.4%**	**0.2%**				**2.4%**	**10.8%**	**-**		**2.7%**	**1.4%**		**0.6%**	**10.8%**	**45.7%**	**57%**	**43%**	**9,987**
Fort Bragg																											
Apr		0.4%		17.4%	13.2%		1.3%	0.5%	0.4%	23.4%			0.4%			24.4%				3.6%			0.9%	85.0%	86%	14%	880
May				13.2%	1.6%		1.0%	1.9%		17.1%						29.7%				0.9%			2.1%	65.4%	67%	33%	705
Jun		0.9%		6.4%	5.6%		0.3%	0.3%	0.3%	29.2%			0.3%		3.4%	8.1%	0.3%			1.8%			23.1%	57.0%	80%	20%	938
Jul		1.6%		14.1%	3.1%			0.1%	0.1%	12.3%	0.1%		0.1%		0.4%	10.7%	0.1%		1.0%	1.7%		0.3%	1.7%	45.7%	47%	53%	4,043
Aug		1.0%		17.2%	13.5%		0.5%	0.5%		17.2%	1.0%				9.7%	7.6%			4.8%	0.9%				73.8%	74%	26%	510
Sep		1.8%		11.0%						7.2%			0.9%		19.2%	14.6%			7.3%			1.9%		64.0%	64%	36%	204
Oct		4.1%		16.1%				8.2%			4.1%				16.0%				4.0%					52.6%	53%	47%	118
Total		**1.2%**		**13.6%**	**5.1%**		**0.3%**	**0.5%**	**0.2%**	**16.2%**	**0.2%**		**0.2%**		**2.1%**	**13.5%**	**0.1%**		**1.1%**	**1.7%**		**0.2%**	**4.2%**	**56.3%**	**60%**	**40%**	**7,398**
San Francisco																											
Apr		0.9%		13.9%	8.3%		0.9%	1.3%	0.9%	18.2%			1.4%			22.6%				2.6%				70.7%	71%	29%	432
May		2.7%		15.4%	4.2%		1.2%	0.4%	0.6%	11.5%			0.6%			14.6%				2.5%				53.6%	54%	46%	934
Jun	0.7%	2.2%		7.9%	13.1%		2.1%	2.8%	2.8%	33.5%			2.0%		0.8%	8.3%				2.8%			3.0%	79.0%	82%	18%	326
Jul	0.2%	1.1%		18.4%	10.6%		0.2%	0.2%	0.2%	22.8%	1.6%		0.3%	0.1%	6.6%	3.7%			5.8%	0.2%		0.7%	0.1%	72.7%	73%	27%	4,457
Aug	0.2%	0.3%		25.1%	10.5%		-	0.1%		25.1%	1.0%		0.1%		7.2%	2.4%			5.0%	0.2%		1.3%		78.6%	79%	21%	6,531
Sep	0.1%	0.2%		7.4%	2.7%		0.3%	0.2%		16.0%	0.2%		0.1%	-	23.1%	11.9%	0.1%		14.3%	0.7%	-	3.3%		80.6%	81%	19%	5,914
Oct	0.2%	3.7%		3.0%	2.3%			0.6%		3.8%	0.2%	0.2%			13.4%	12.2%	0.4%		15.9%	0.2%		3.6%		59.4%	59%	41%	1,140
Total	**0.2%**	**0.8%**		**16.0%**	**7.4%**		**0.2%**	**0.3%**	**0.1%**	**20.0%**	**0.8%**	**-**	**0.2%**	**-**	**11.6%**	**7.2%**	**-**		**8.2%**	**0.6%**	**-**	**1.8%**	**0.1%**	**75.4%**	**75%**	**25%**	**19,734**
Monterey																											
Apr	0.3%	0.9%		17.2%	12.7%		2.1%	1.7%	2.5%	24.2%			0.3%		0.1%	9.7%	0.1%			1.1%			4.8%	72.8%	78%	22%	4,210
May				8.5%	8.6%			4.3%	2.2%	17.2%						17.0%								57.8%	58%	42%	280
Jun	3.8%	3.4%		11.8%	7.0%				0.5%	21.8%	0.8%		0.4%		1.5%	5.5%	0.4%		0.7%	0.7%		0.4%		58.7%	59%	41%	1,170
Jul	1.1%	0.7%		14.4%	10.4%		0.3%	0.4%		25.5%	3.6%		0.1%		11.0%	3.7%			8.3%	0.1%		2.0%		81.6%	82%	18%	3,998
Aug	3.3%	0.7%		14.2%	2.5%		0.5%	0.9%		19.5%	5.0%		0.3%		14.6%	2.6%			10.5%			2.0%		76.5%	77%	23%	2,369
Sep				6.5%						8.7%	31.7%		1.1%		17.4%				11.3%	1.1%		1.7%		79.5%	79%	21%	676
Total	**1.4%**	**1.0%**		**14.5%**	**8.8%**		**0.9%**	**1.0%**	**0.9%**	**22.5%**	**3.8%**		**0.3%**		**7.3%**	**5.7%**	**0.1%**		**5.2%**	**0.5%**		**1.1%**	**1.6%**	**75.0%**	**77%**	**23%**	**12,703**
Total CA Harvest																											
	0.4%	**0.8%**		**14.4%**	**6.8%**		**0.5%**	**0.5%**	**0.3%**	**18.2%**	**1.3%**	**-**	**0.2%**	**-**	**7.2%**	**8.5%**	**0.1%**		**5.3%**	**0.9%**	**-**	**1.2%**	**3.2%**	**66.5%**	**70%**	**30%**	**49,822**

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.

b/ Mokelumne River natural-origin tagged Chinook recoveries are not included in this table due to very small recovery totals in SF commercial (month 7) and SF sport (month 9), contributing only 0.03% and 0.04% respectively

Table 11. Percentage of ocean CWT_{total} recoveries by majorport, month and release type[a] in 2011 California sport and commercial fisheries (page 2 of 2).

	Livingston/Coleman Hatcheries						Feather River Hatchery								Nimbus Hatchery			Mokelumne/Merced Hatcheries[b]						Total	Total %		Total
	SacW	CFHLh	CFHLe	CFHFh	CFHFn	CFHFe	FRHS	FRHSn	FRHFe	FRHFn	FRHFnc	FRHFt	FRHFtib	FeaW	NIMF	NIMFn	NIMFtib	MOKF	MOKFn	MOKFt	MokFw	MERF	nonCV	CV	Hatchery	Natural	Harvest
Commercial Harvest																											
Eureka/Crescent City																											
Jul		0.1%		4.0%	1.9%					6.1%						4.0%				1.0%		0.1%	10.3%	17%	28%	72%	1,584
Aug		0.2%		4.6%						1.9%						3.5%	0.5%			0.5%			10.2%	11%	21%	79%	807
Total		**0.1%**		**4.2%**	**1.2%**					**4.7%**						**3.9%**	**0.2%**			**0.8%**		**0.1%**	**10.3%**	**15%**	**26%**	**74%**	**2,391**
Fort Bragg																											
Jul		0.7%		5.8%	1.7%		0.1%	0.1%	-	5.1%	-	-	-	-	0.1%	7.1%	0.1%		0.1%	0.9%		0.1%	12.7%	22%	34%	66%	21,085
Aug	-	1.5%	-	8.1%	1.8%		0.1%	0.1%	-	5.0%	0.1%	-	-	-	0.5%	12.4%	-		0.4%	1.6%		0.1%	9.4%	32%	41%	59%	17,766
Sep		4.5%		7.4%	2.5%			0.6%	0.7%	7.5%						32.4%			2.5%	3.7%			3.1%	62%	65%	35%	460
Total	**-**	**1.1%**	**-**	**6.9%**	**1.7%**		**0.1%**	**0.1%**	**-**	**5.1%**	**-**	**-**	**-**	**-**	**0.3%**	**9.8%**	**0.1%**		**0.2%**	**1.3%**		**0.1%**	**11.1%**	**27%**	**38%**	**62%**	**39,311**
San Francisco																											
May		0.3%		10.1%	6.0%	-	0.5%	0.7%	0.8%	14.8%			0.4%		0.2%	7.9%	-			1.0%		-	2.2%	43%	45%	55%	7,753
Jun		1.2%		15.5%	6.6%					11.9%			0.2%			17.5%				2.9%			0.2%	56%	56%	44%	2,830
Jul		2.1%		10.6%	5.9%		0.1%	0.1%	0.2%	11.3%		-	0.2%		0.2%	19.3%	0.1%		0.1%	2.8%	-	0.1%	3.3%	53%	56%	44%	8,305
Aug	0.2%	0.9%		26.4%	13.8%					15.1%			0.2%		2.8%	17.3%			0.2%	1.2%				78%	78%	22%	1,395
Sep		0.5%		10.0%	2.0%		0.2%			7.4%					9.4%	34.7%	0.3%		6.0%	2.1%		1.4%		74%	74%	26%	1,312
Oct		3.7%						0.8%							2.9%	23.2%	0.7%		4.3%	0.7%				36%	36%	64%	317
Total	**-**	**1.2%**		**11.9%**	**6.2%**	**-**	**0.2%**	**0.3%**	**0.4%**	**12.5%**		**-**	**0.3%**		**0.9%**	**15.9%**	**0.1%**		**0.5%**	**2.0%**	**-**	**0.1%**	**2.0%**	**52%**	**54%**	**46%**	**21,912**
Monterey																											
May	0.2%	0.3%		10.8%	9.3%		1.4%	2.2%	1.7%	25.1%			0.1%		0.1%	2.2%			0.5%	0.4%			2.4%	54%	57%	43%	3,979
Jun	0.6%	2.5%		17.4%	11.2%				0.6%	14.3%		0.1%		0.1%	0.3%	12.4%				0.7%		0.1%	0.2%	60%	61%	39%	1,359
Jul		1.6%		12.4%	3.6%			0.5%		6.3%					2.1%	10.4%			2.0%	1.6%				41%	41%	59%	695
Aug	2.2%	5.5%		17.3%	8.6%					17.4%	1.1%				14.1%	21.7%			1.1%	1.1%				90%	90%	10%	333
Sep											7.7%													8%	8%	92%	48
Total	**0.4%**	**1.2%**		**12.6%**	**9.0%**		**0.9%**	**1.4%**	**1.2%**	**20.2%**	**0.1%**	**-**	**-**	**-**	**1.1%**	**6.2%**			**0.6%**	**0.6%**		**-**	**1.6%**	**56%**	**57%**	**43%**	**6,414**
Total CA Harvest																											
	-	**1.1%**	**-**	**8.9%**	**3.8%**	**-**	**0.2%**	**0.3%**	**0.2%**	**8.8%**	**-**	**-**	**0.1%**	**-**	**0.5%**	**11.2%**	**0.1%**		**0.3%**	**1.4%**	**-**	**0.1%**	**7.4%**	**37%**	**44%**	**56%**	**70,028**

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.
b/ Mokelumne River natural-origin tagged Chinook recoveries are not included in this table due to very small recovery totals in SF commercial (month 7) and SF sport (month 9), contributing only 0.03% and 0.04% respectively

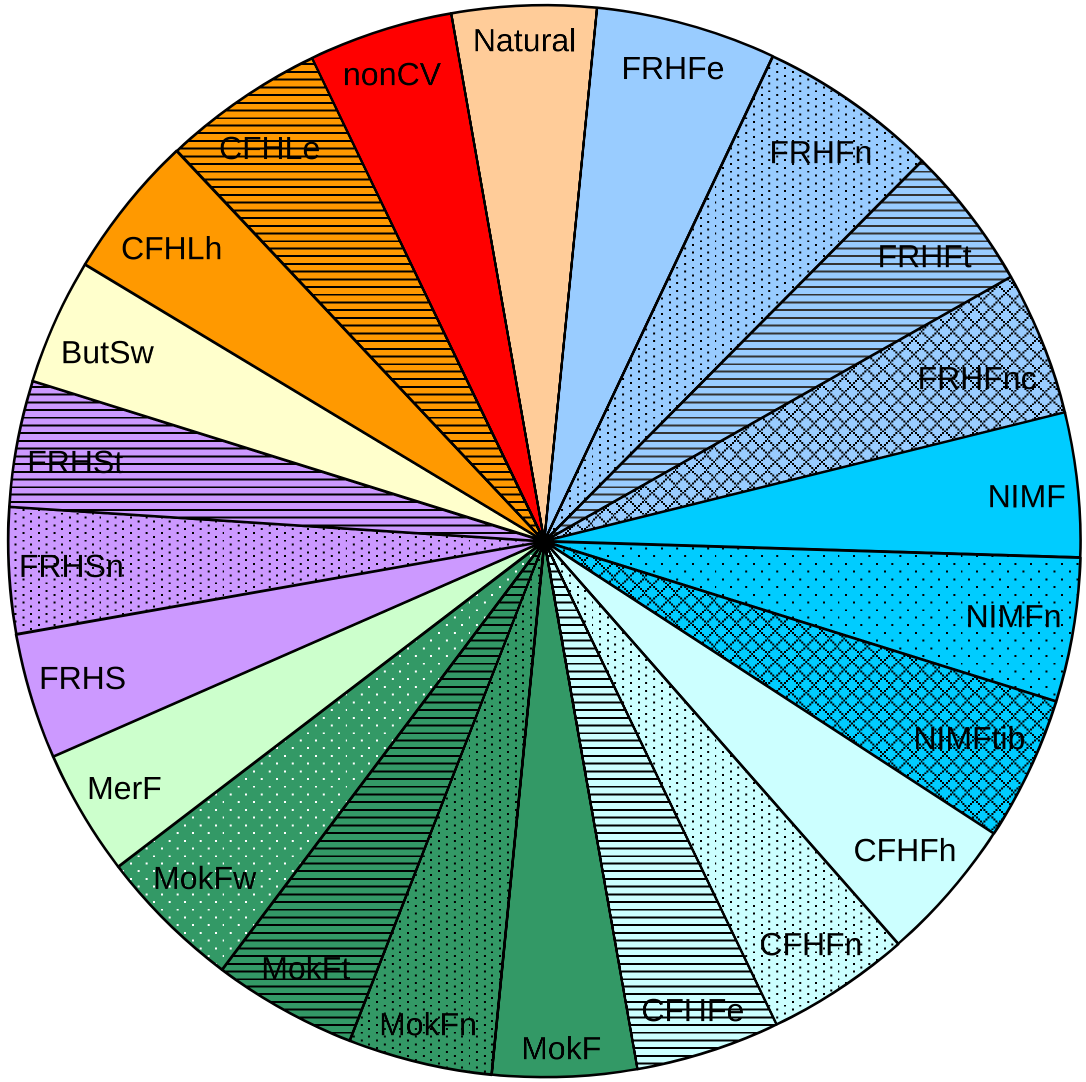


Figure 1. Central Valley hatchery release types color scheme (note: FRHFnc includes FRH fall Tiburon net pen releases).

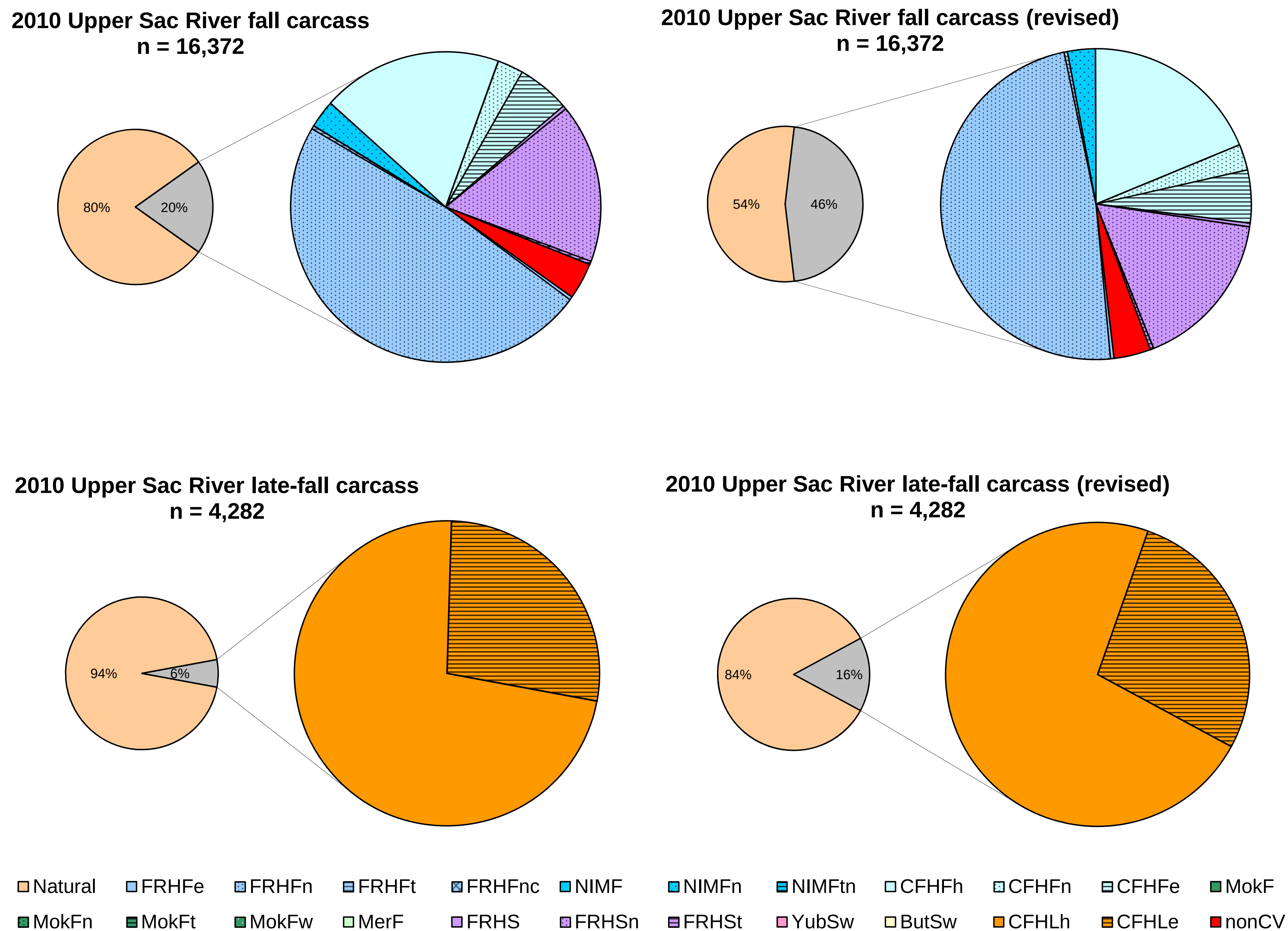


Figure 2. Revised proportion of hatchery and natural-origin fish in 2010 carcass surveys in the Upper Sacramento River Basin.

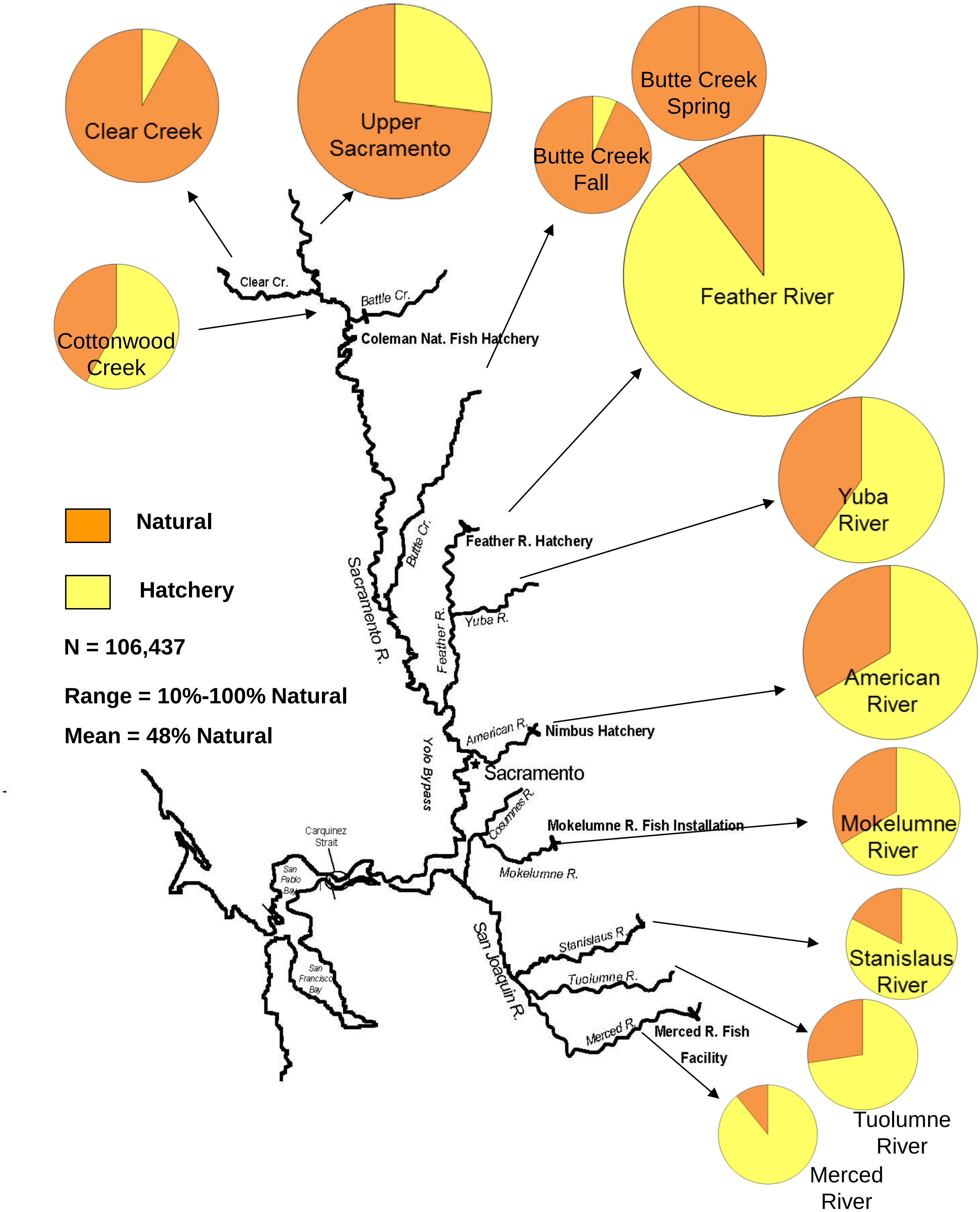


Figure 3. 2011 Chinook Salmon Natural Area Escapement, Hatchery and Natural Proportions.

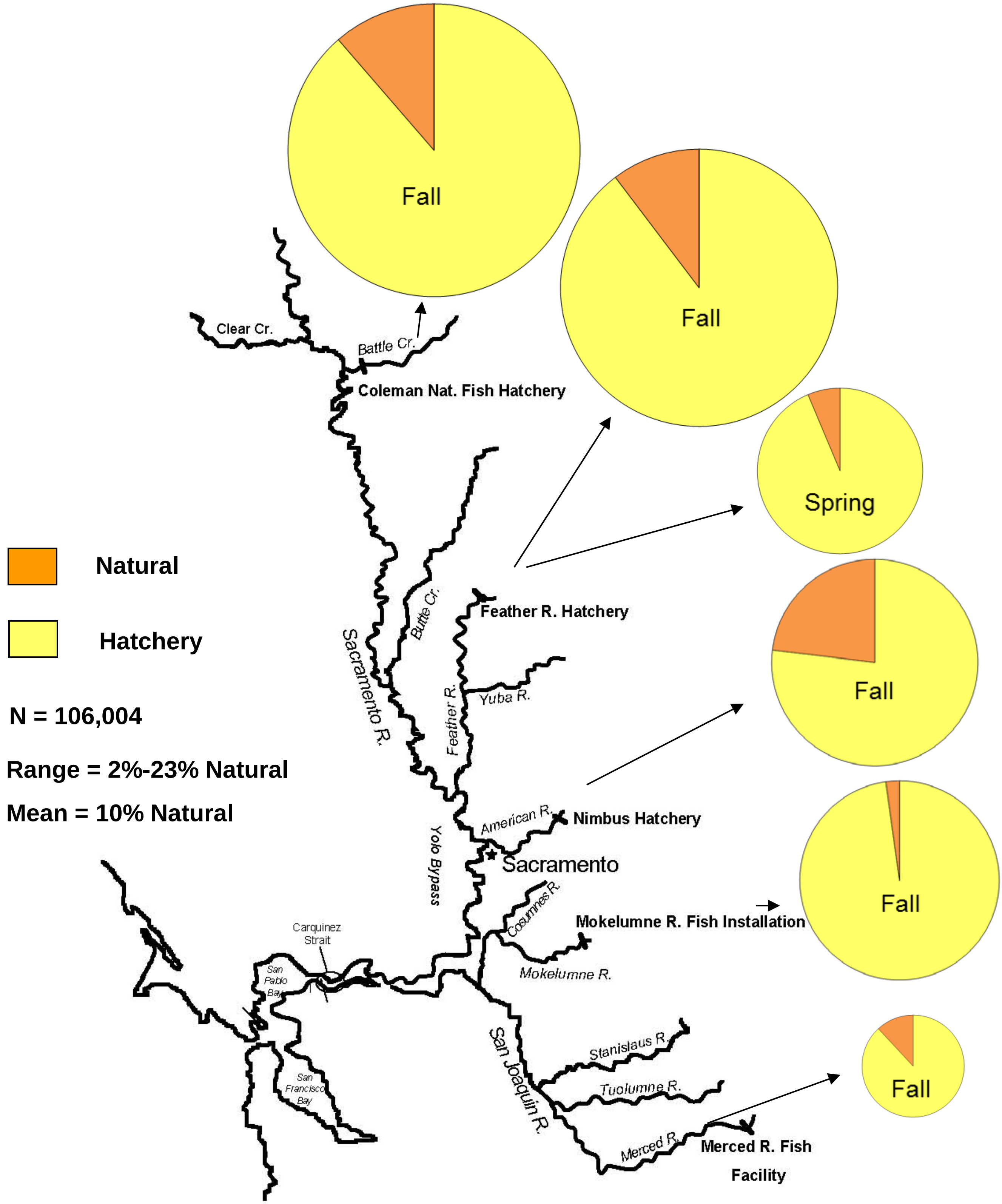


Figure 4. 2011 Chinook Salmon Hatchery Escapement, Hatchery and Natural Proportions.

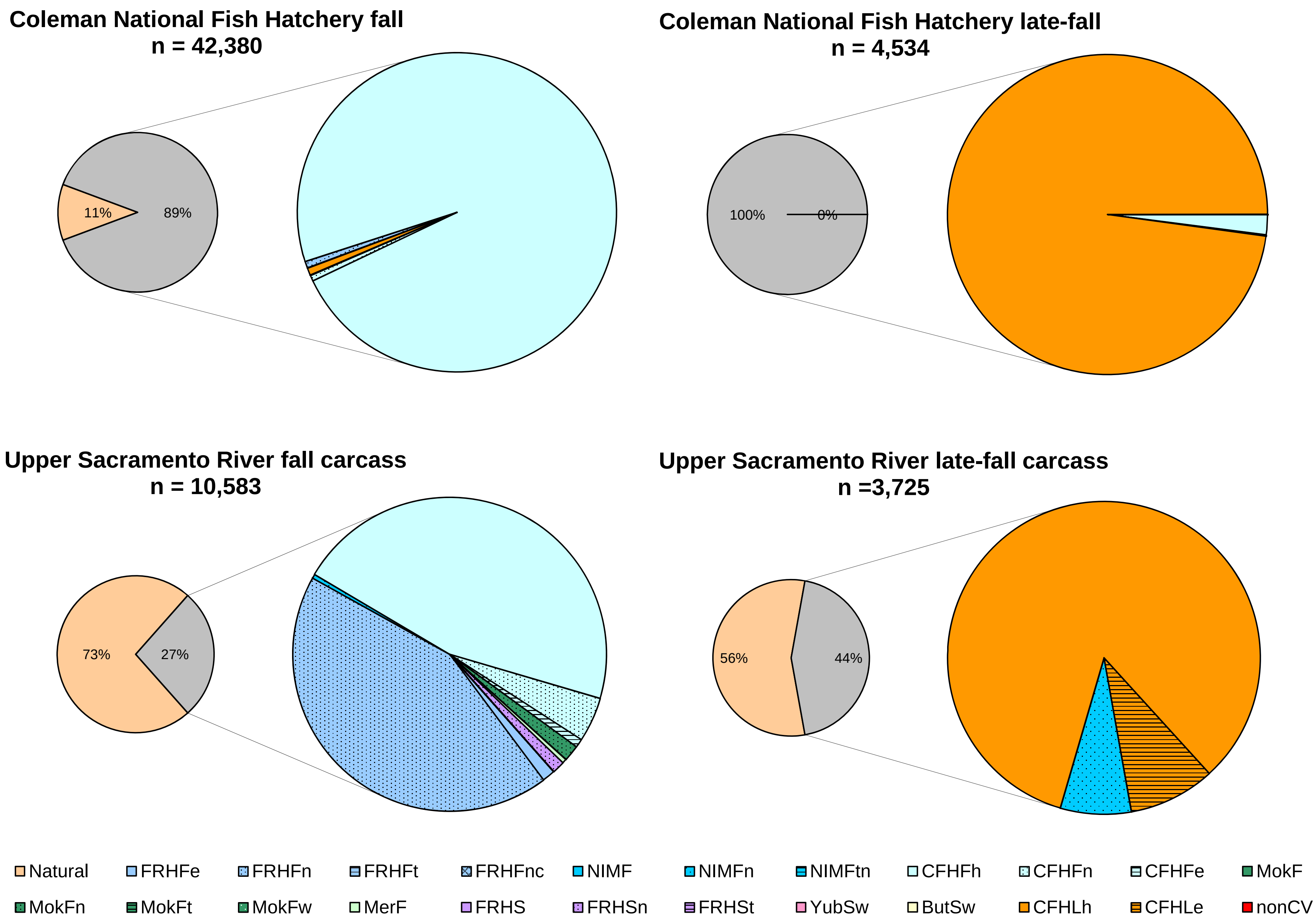


Figure 5. Proportion of hatchery- and natural-origin fish in the Upper Sacramento River Basin.

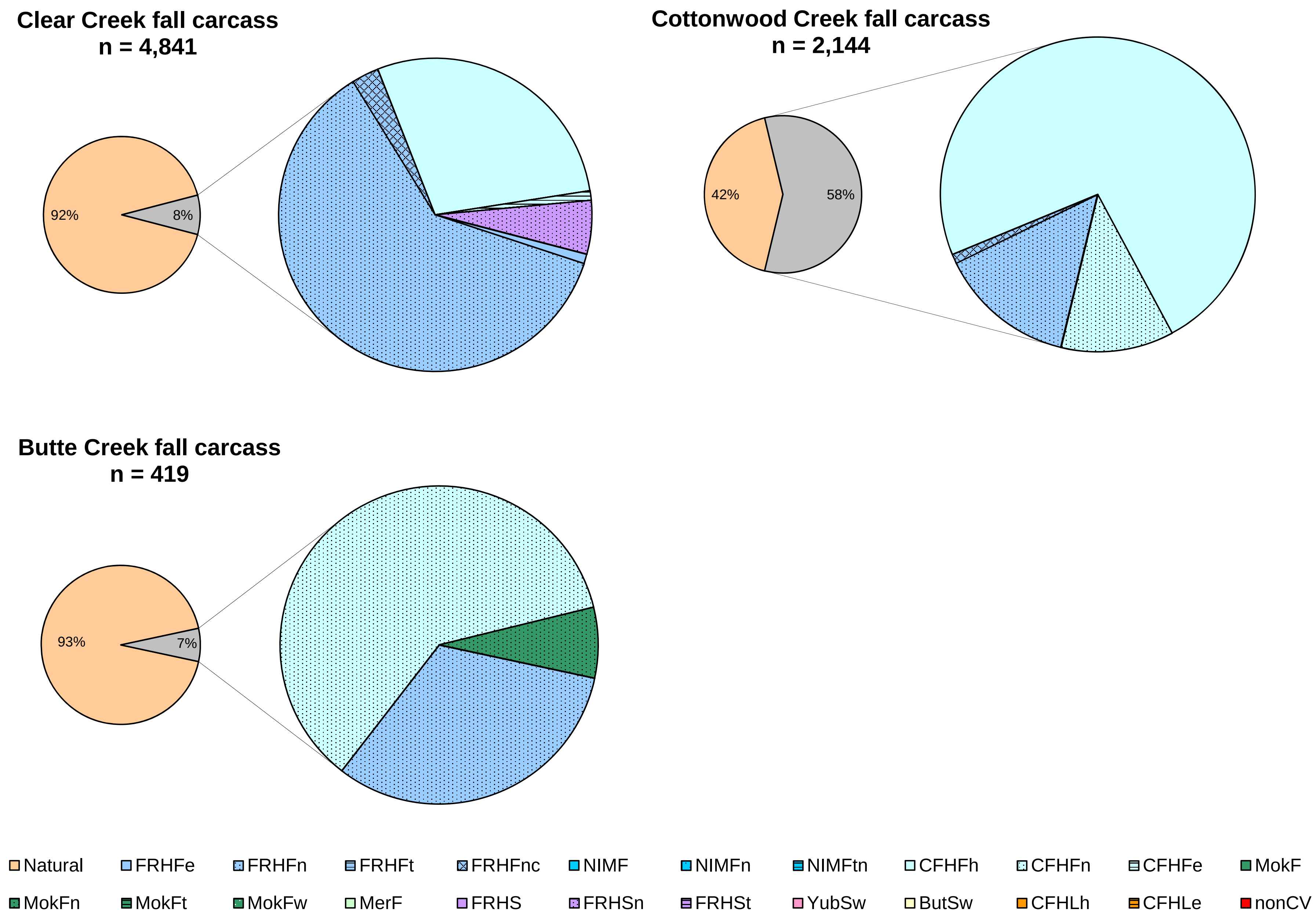


Figure 6. Proportion of hatchery- and natural-origin fish in Clear, Cottonwood, and Butte creeks.

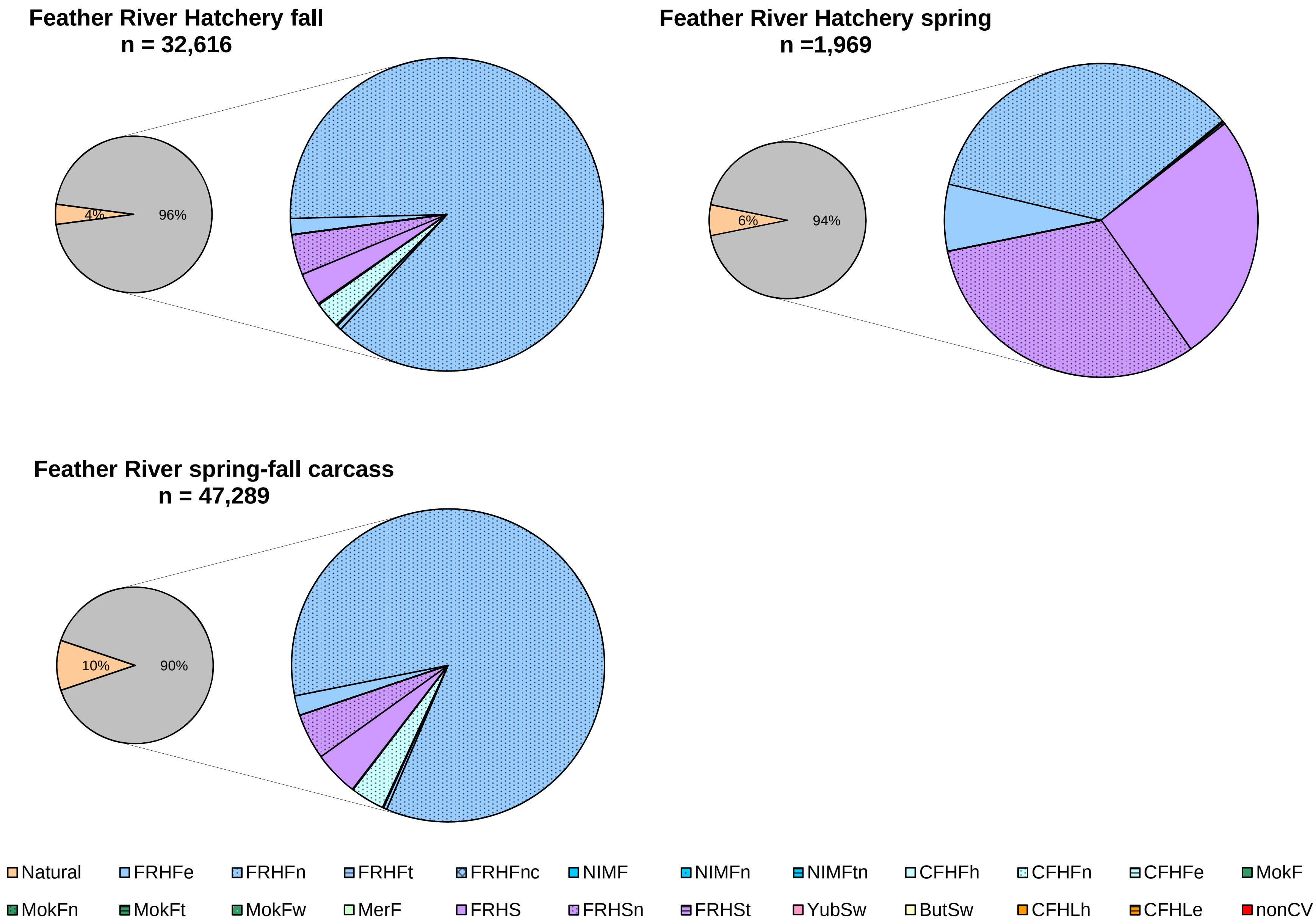


Figure 7. Proportion of hatchery- and natural-origin fish in the Feather River Basin.

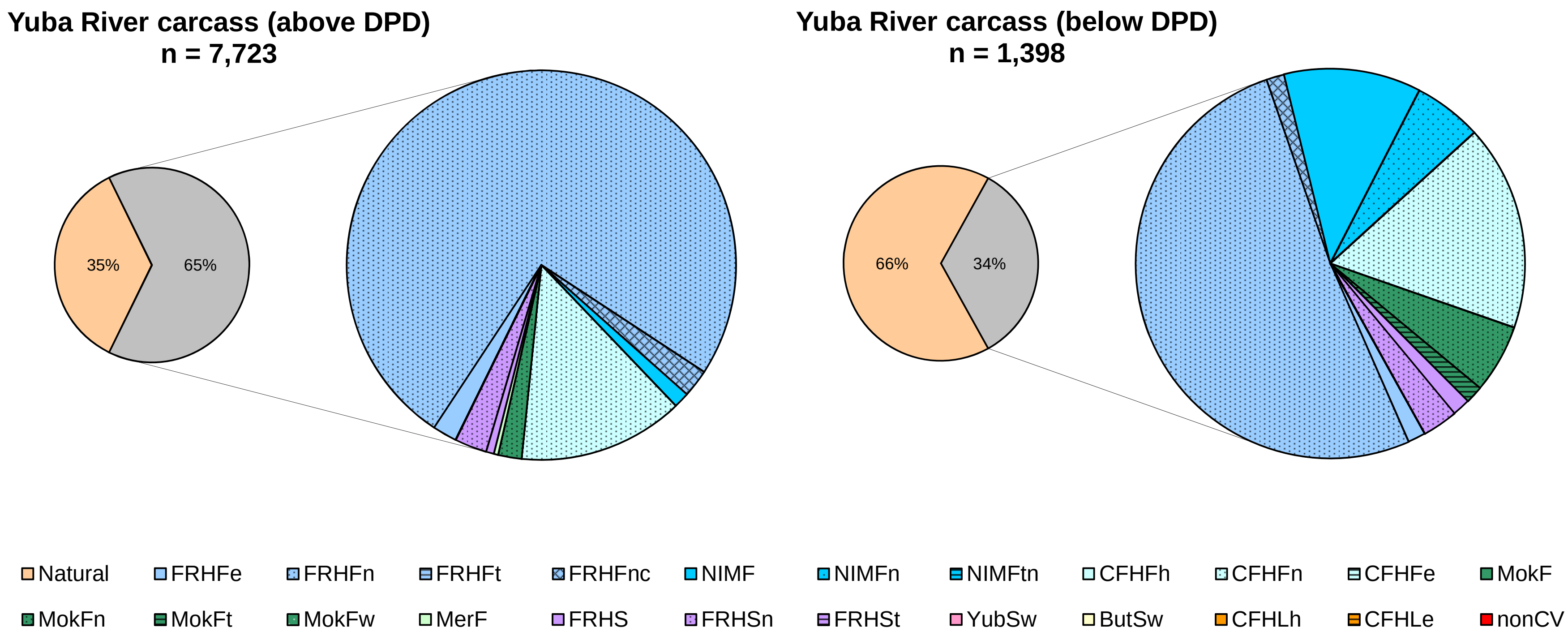


Figure 8. Proportion of hatchery- and natural-origin fish in the Yuba River.

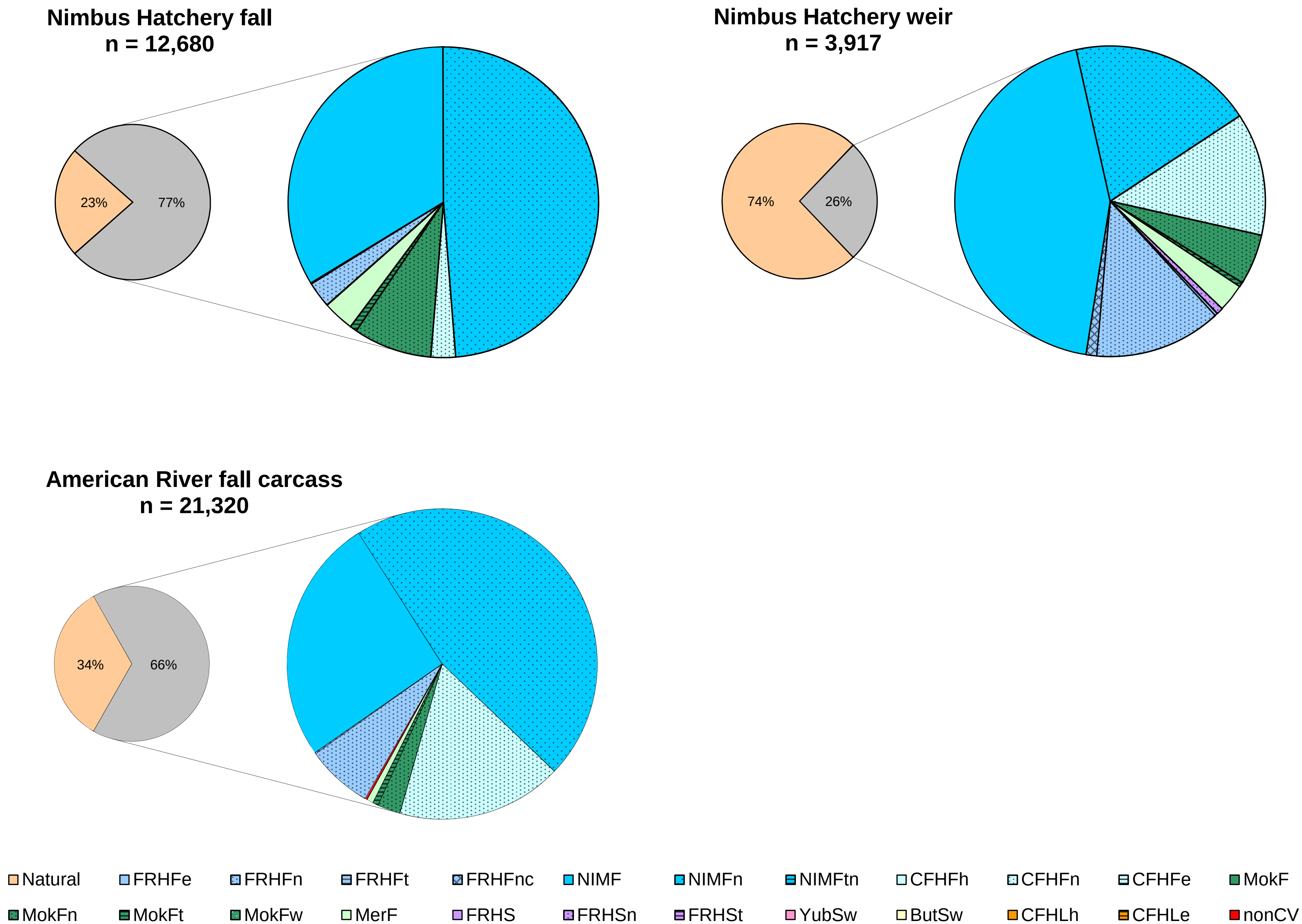


Figure 9. Proportion of hatchery- and natural-origin fish in the American River Basin.

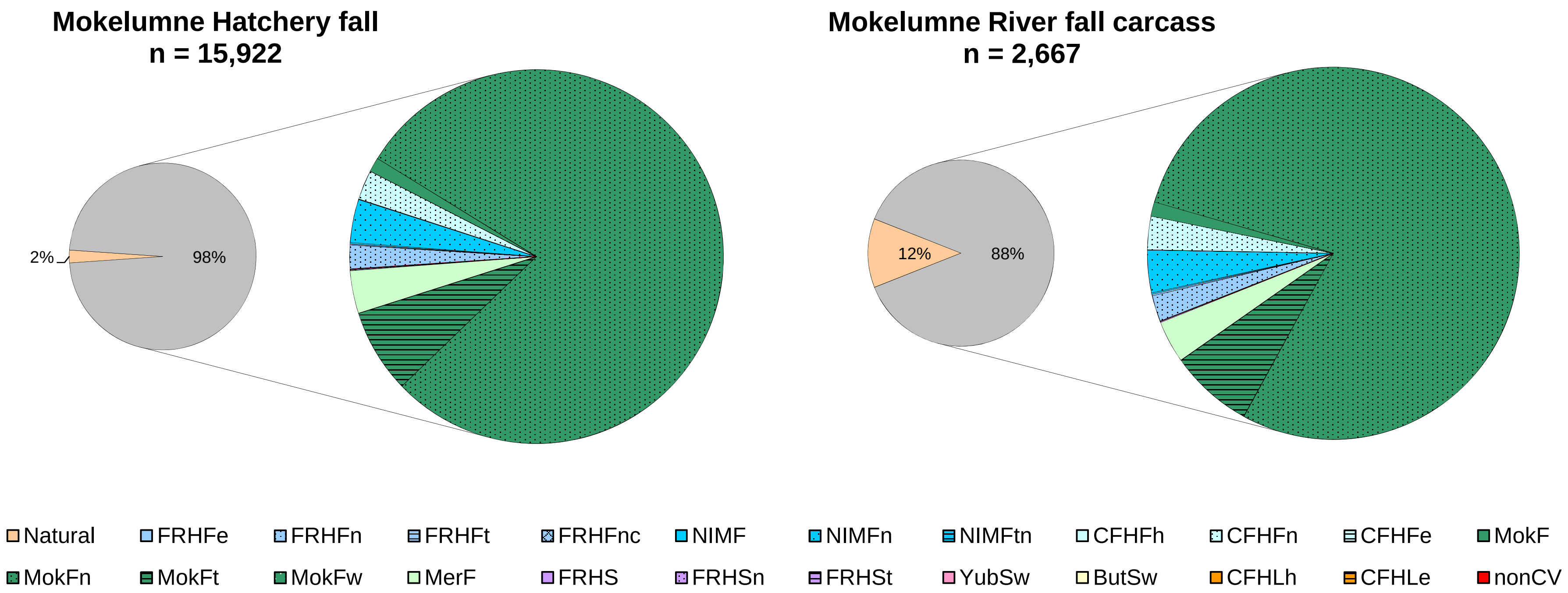


Figure 10. Proportion of hatchery- and natural-origin fish in the Mokelumne River Basin.

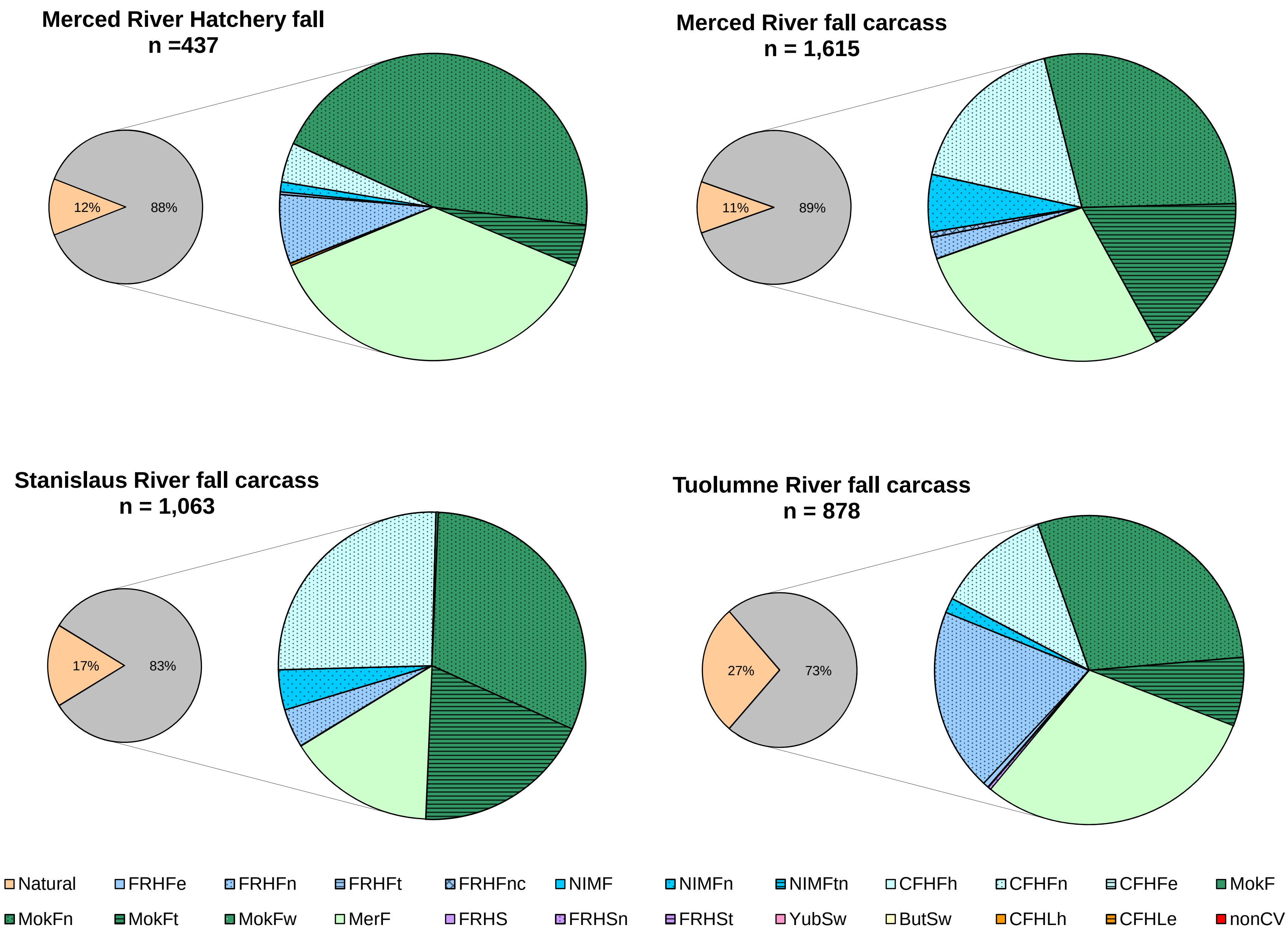


Figure 11. Proportion of hatchery- and natural-origin fish in other San Joaquin River tributaries.

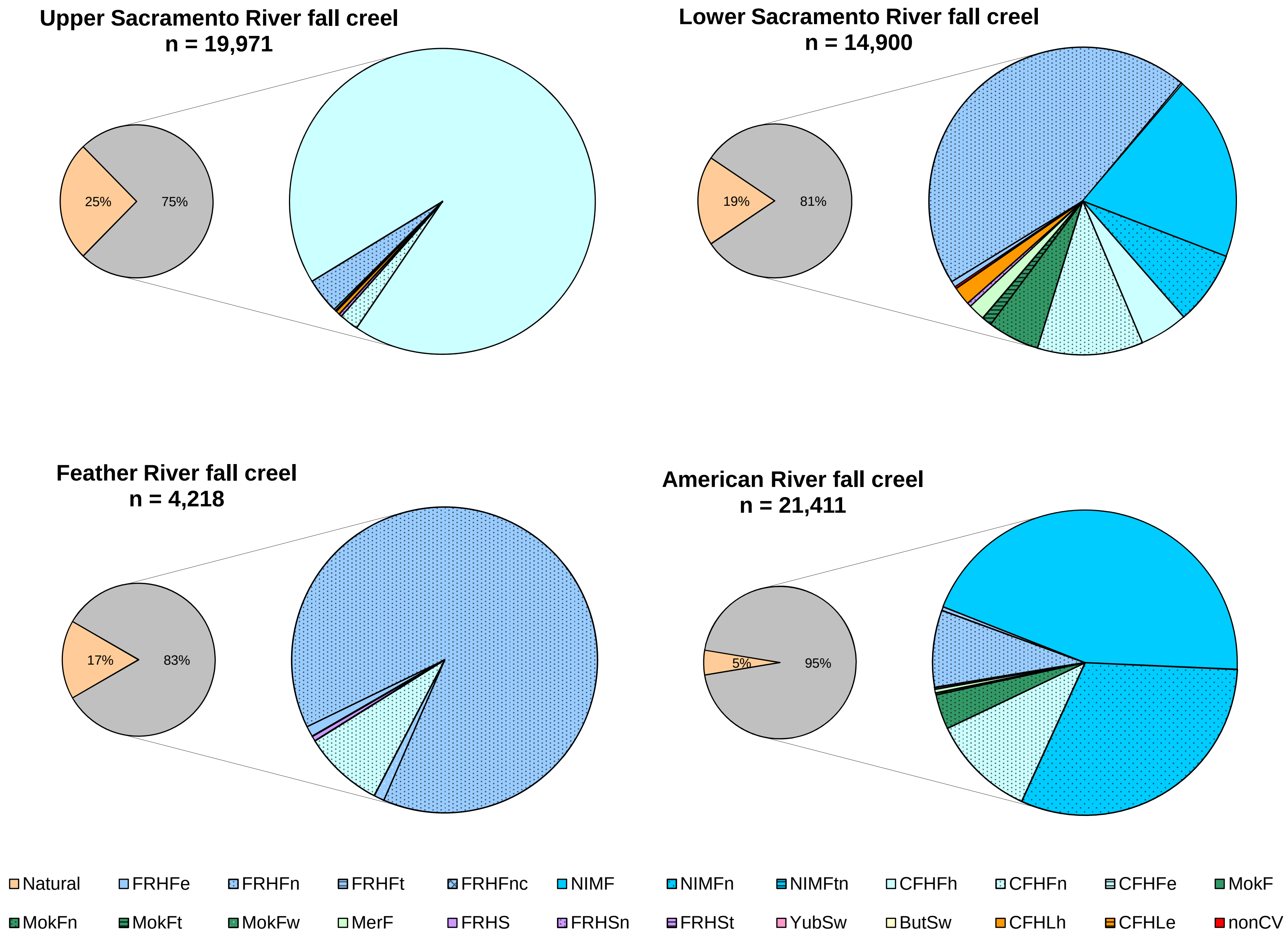


Figure 12. Proportion of hatchery- and natural-origin fish in fall creel surveys on Sacramento, American & Feather rivers.

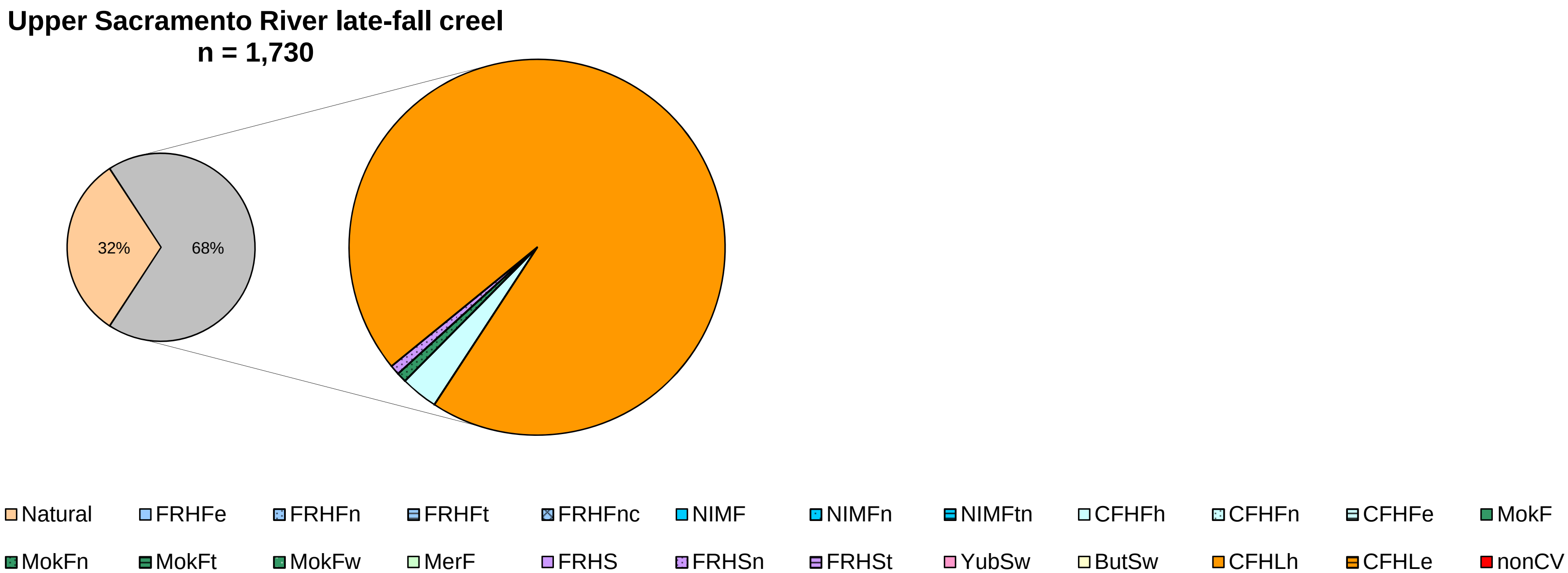


Figure 13. Proportion of hatchery- and natural-origin fish in late-fall creel survey on Upper Sacramento River.

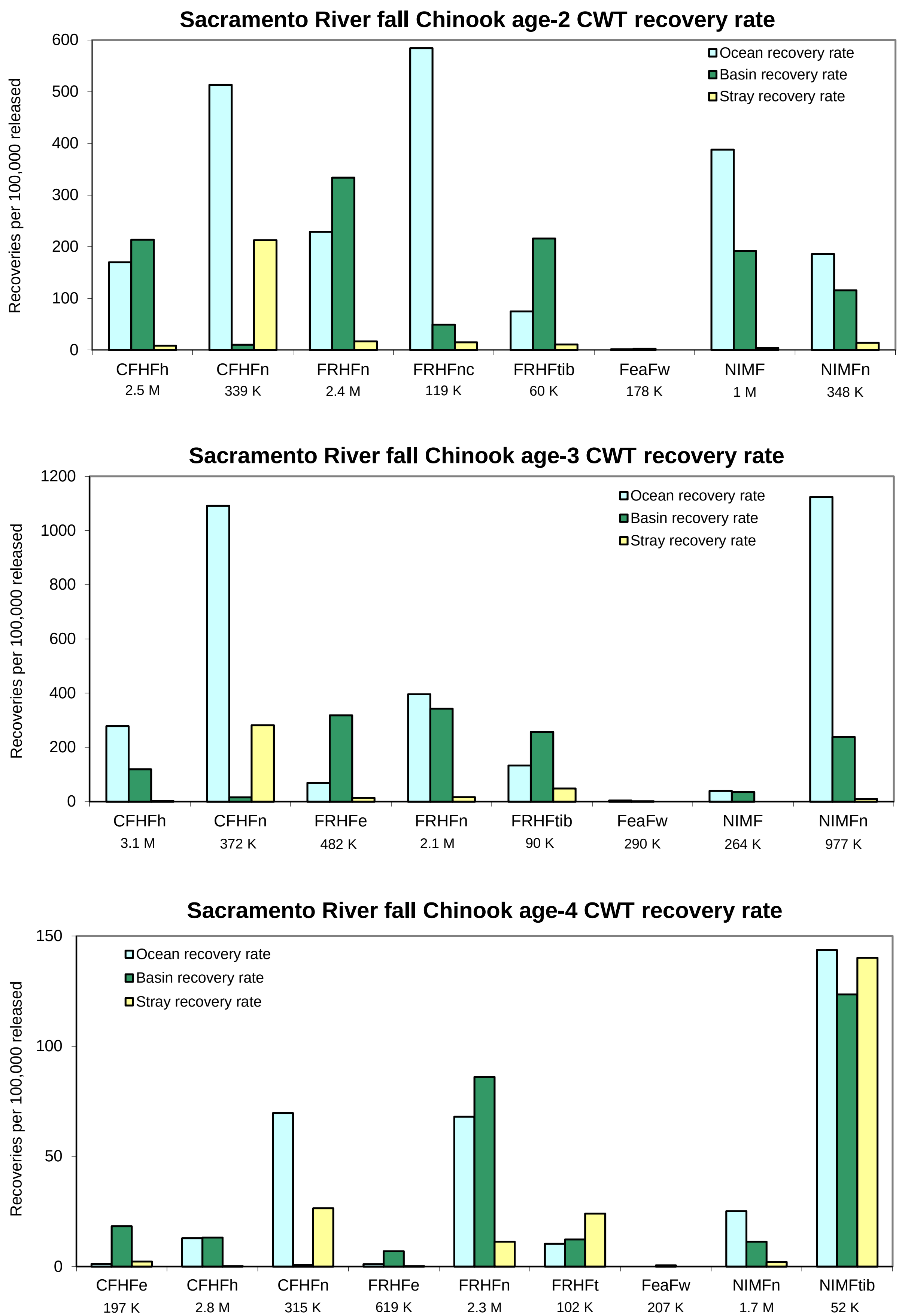


Figure 14. 2011 recovery rates for Sacramento fall Chinook CWT releases by age.

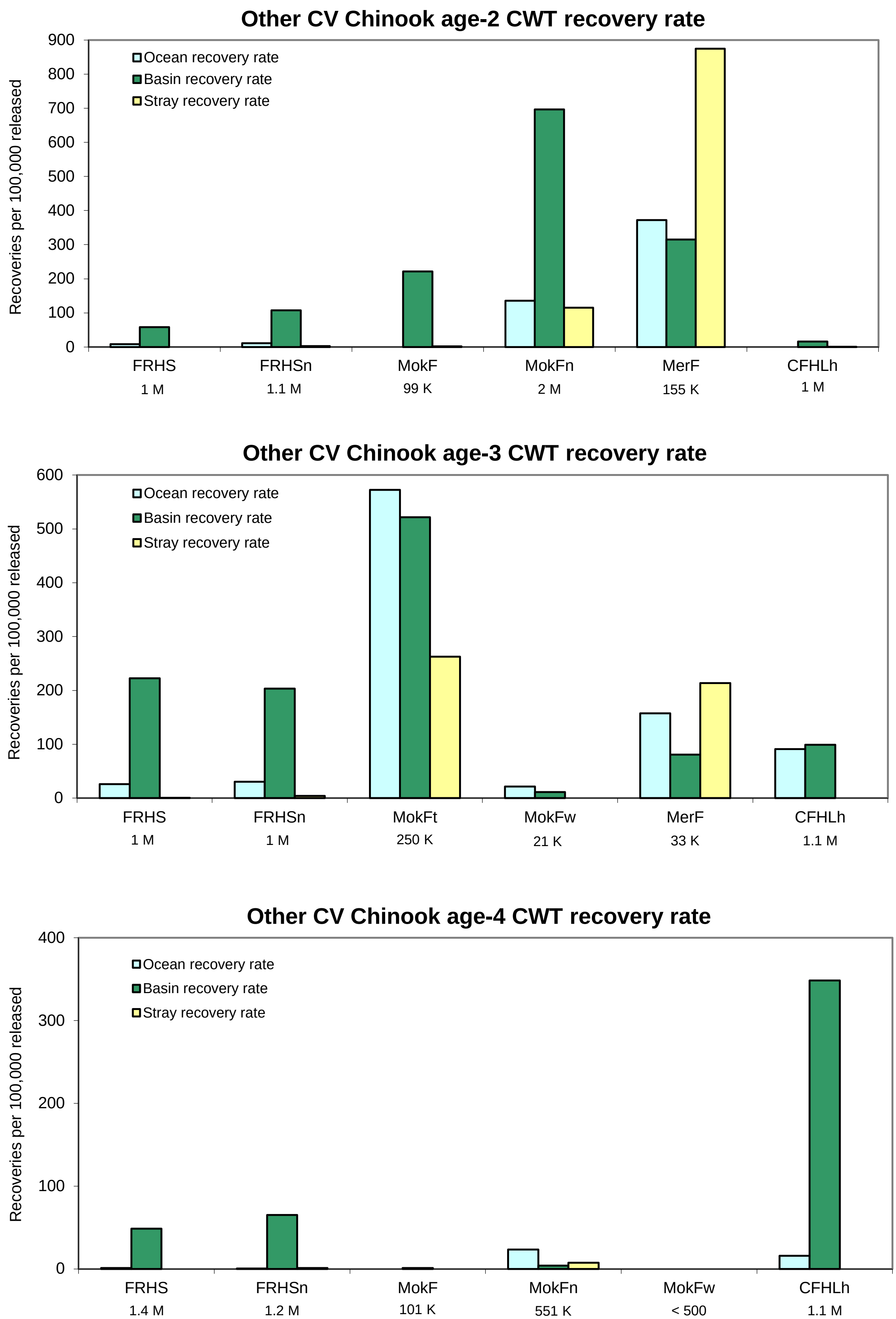


Figure 15. 2011 recovery rates for other CV Chinook CWT releases by age.

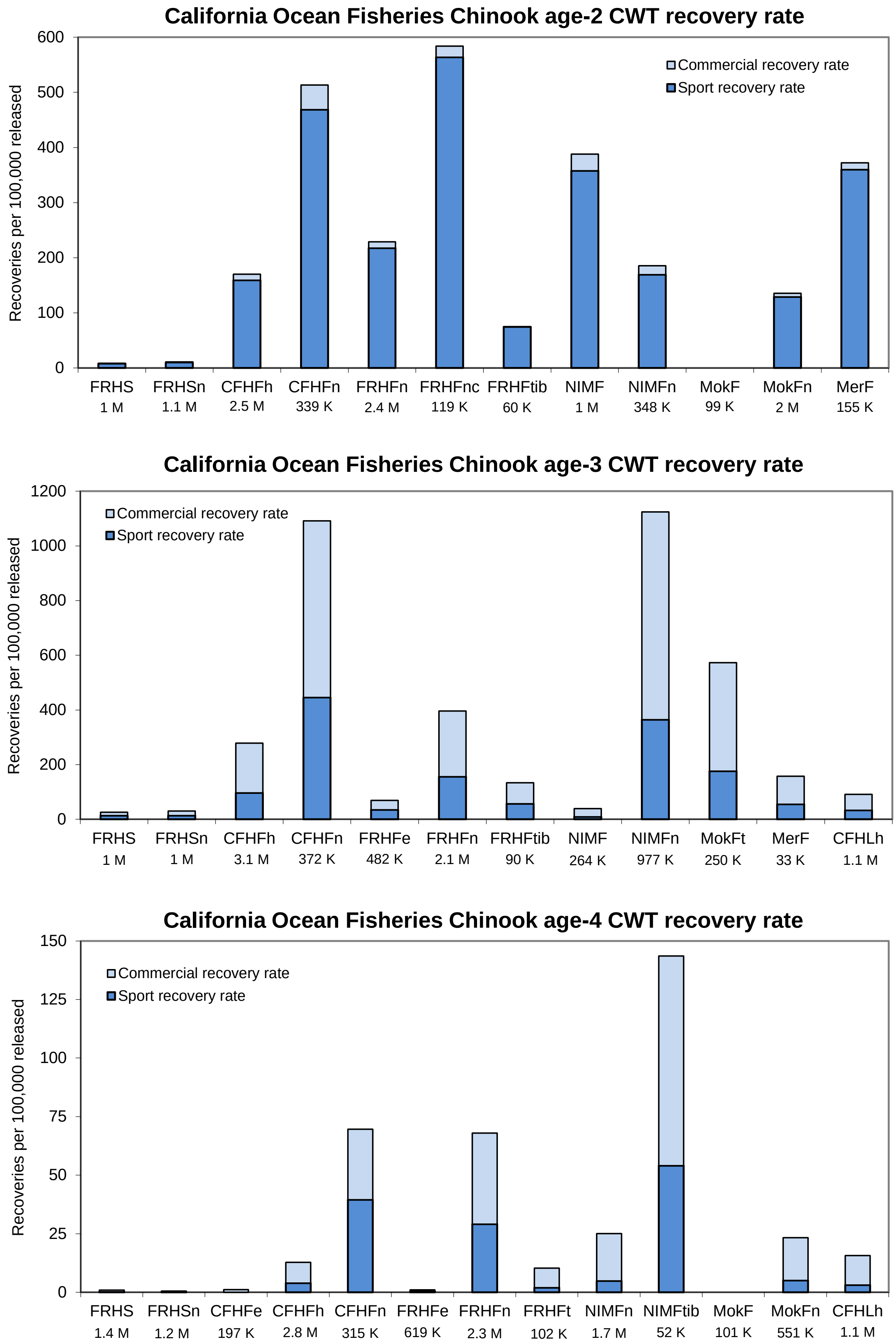


Figure 16. 2011 CV Chinook recovery rates in ocean sport and commercial fisheries.

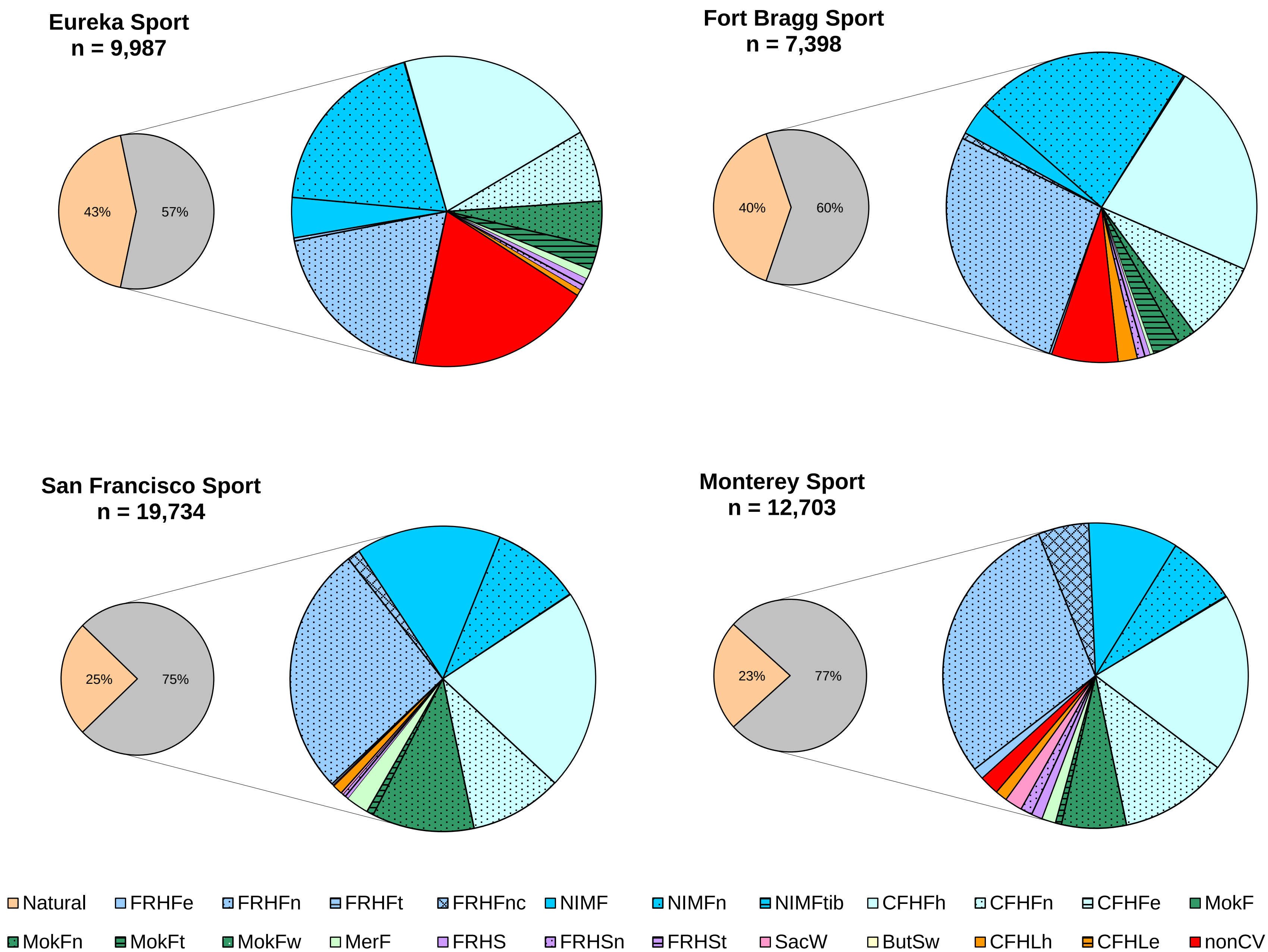


Figure 17. Proportion of hatchery- and natural-origin salmon in the 2011 California ocean sport fishery.

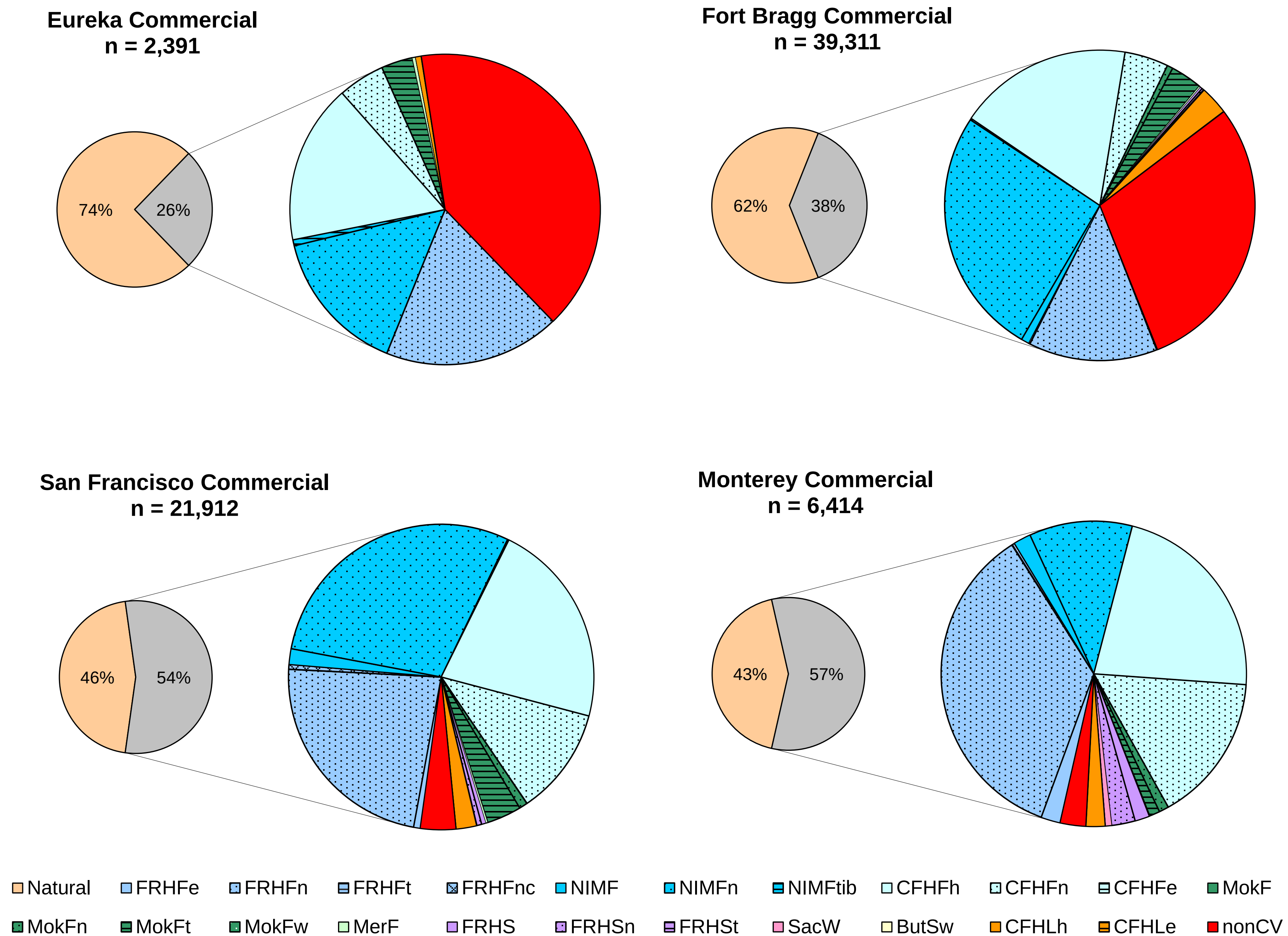


Figure 18. Proportion of hatchery- and natural-origin salmon in the 2011 California ocean commercial fishery.

Appendix 1a. Alternative 2011 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	2009	Fall	2,543,157	5,390	36	212	1			1			5,390	250	5,640	4,321	212	10	222	170	0.04
CFHFn	2009	Fall	339,179	35		35	243	85	215	92	25	28	35	722	757	1,741	10	213	223	513	0.95
CFHLh	2010	Late	992,047	157						1	1		157	2	159		16	0.2	16		0.01
FRHFn	2009	Fall	2,367,209	43	97	67	7,492	403	76	73	14	20	7,492	794	8,286	5,421	317	34	350	229	0.10
FRHFnc	2009	Fall	118,879			6	58		1	2	8		58	18	76	694	49	15	64	584	0.23
FRHFtib	2009	Fall	60,104				130		1	5	1		130	7	136	45	216	11	227	75	0.05
FRHS	2009	Spr	1,026,954				578	16					578	16	594	87	56	2	58	8	0.03
FRHSn	2009	Spr	1,058,635			18	1,033	104	6	4			1,033	132	1,164	113	98	12	110	11	0.11

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	2008	Fall	3,128,111	3,461	267	60							3,461	327	3,788	8,716	111	10	121	279	0.09
CFHFn	2008	Fall	371,685	21	36	8	351	97	472	23	45	51	21	1,084	1,105	4,056	6	292	297	1,091	0.98
CFHLh	2009	Late	1,115,378	1,023	81								1,023	81	1,104	1,015	92	7	99	91	0.07
FRHFe	2008	Fall	481,853	2	36	4	1,429	104	12	8		4	1,429	170	1,598	334	296	35	332	69	0.11
FRHFn	2008	Fall	2,061,211	20	109	34	6,626	435	135	17	1	24	6,626	775	7,401	8,161	321	38	359	396	0.10
FRHFtib	2008	Fall	89,859	4		17	111	120	11	11			111	163	274	120	123	182	305	133	0.60
FRHS	2008	Spr	1,015,717				2,237	23		1			2,237	24	2,261	265	220	2.4	223	26	0.01
FRHSn	2008	Spr	1,005,727		24	4	2,006	39	1	10		2	2,006	80	2,086	308	199	8	207	31	0.04

Age 4 CV recoveries

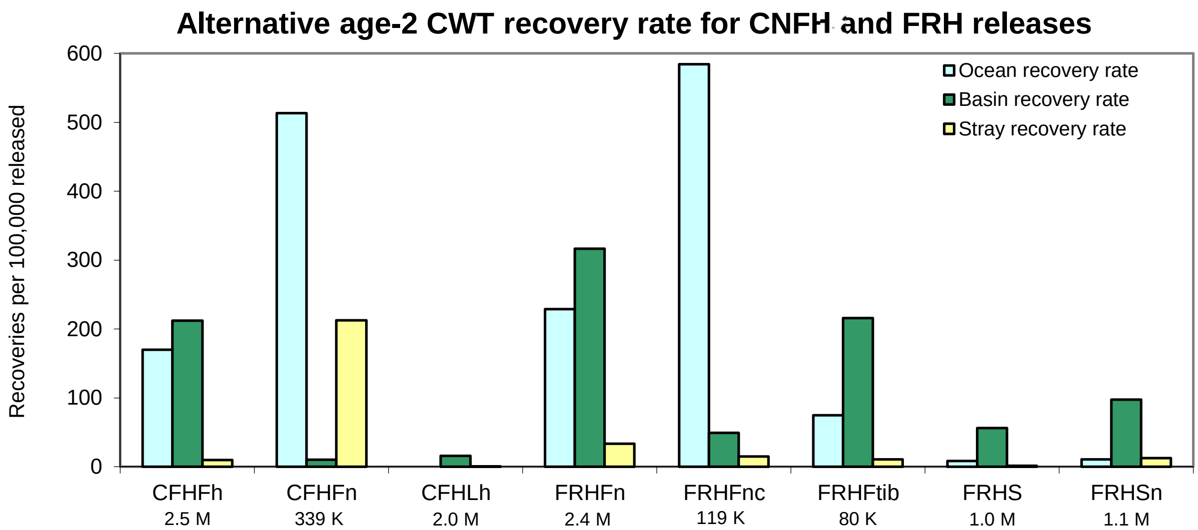
Release	Brood	Run	# CWT	Central Valley CWT_{samp} recoveries by location									CV CWT_{samp} totals			Ocean	Recovery rate per 100,000 released				CV Stray
group	year	type	tagged	Bat Cr	Up Sac	Nat crks[b]	Fea	Yub	Ame	Mok	Mer	SJ	Basin	Stray	CV total	CWT_{samp}	Basin	Stray	CV total	Ocean	Proportion
CFHFe	2007	Fall	196,993	12	24	4	1						12	29	41	2	6	15	21	1	0.71
CFHFh	2007	Fall	2,801,459	343	24	6							343	30	373	359	12	1.1	13	13	0.08
CFHFn	2007	Fall	314,681	2		1	9	16	53	3			2	83	85	219	1	26	27	70	0.98
CFHLh	2008	Late	1,072,854	2,932	808								2,932	808	3,740	168	273	75	349	16	0.22
FRHFe	2007	Fall	619,085				43		1				43	1	44	6	7	0.2	7	1	0.02
FRHFn	2007	Fall	2,347,396	2	109	9	1,858	162	138	4		2	1,858	426	2,284	1,595	79	18	97	68	0.19
FRHFt	2007	Fall	101,712				13		24				13	24	37	10	12	24	36	10	0.66
FRHS	2007	Spr	1,378,941				672						672		672	12	49		49	1	0.00
FRHSn	2007	Spr	1,242,480		12		811			1			811	13	824	7	65	1	66	1	0.02

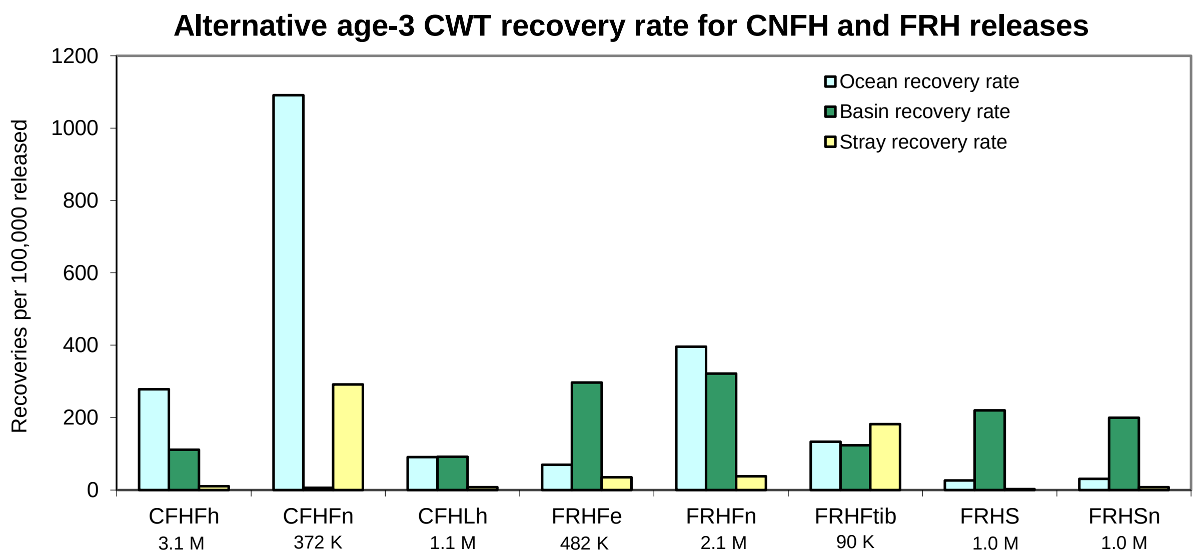
Age 5 CV recoveries

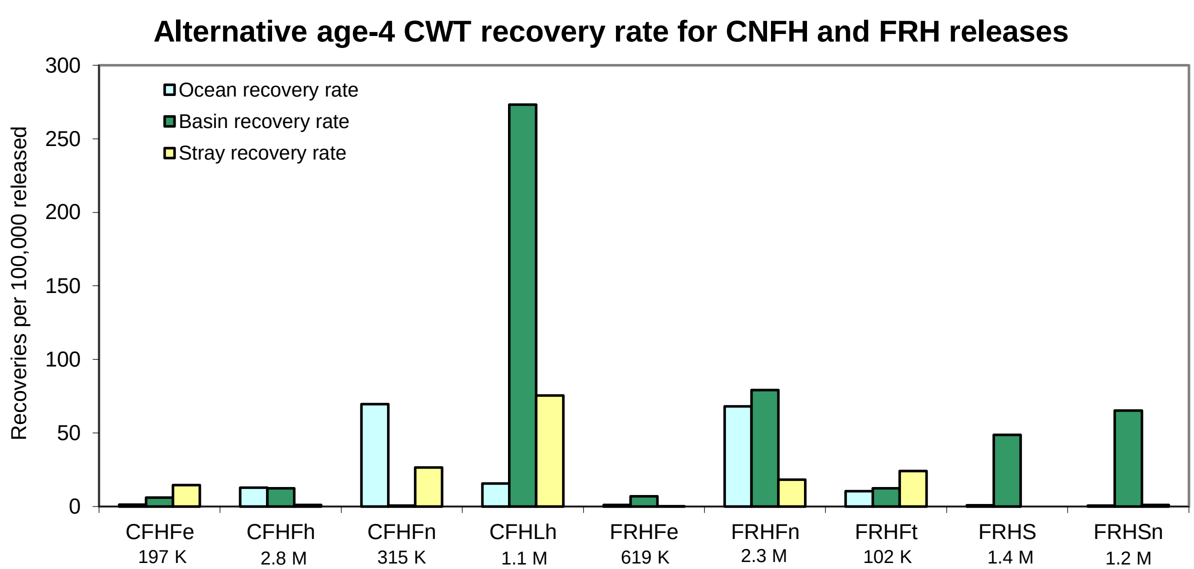
Release	Brood	Run	# CWT	Central Valley CWT_{samp} recoveries by location									CV CWT_{samp} totals			Ocean	Recovery rate per 100,000 released				CV Stray
group	year	type	tagged	Bat Cr	Up Sac	Nat crks[b]	Fea	Yub	Ame	Mok	Mer	SJ	Basin	Stray	CV total	CWT_{samp}	Basin	Stray	CV total	Ocean	Proportion
CFHLe	2007	Late	299,292	1	141								1	141	142		0	47	48		0.99
CFHLh	2007	Late	732,952	481	445								481	445	926	5	66	61	126	0.6	0.48

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, Butte Creek and Mill Creek.







Appendix 1b. Graphs of alternative 2011 recovery rates for CNFH and FRH releases.