Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2018

Alex Letvin[1/], Melodie Palmer-Zwahlen[2/], and Brett Kormos[1/]

February 2021

[1/] California Department of Fish and Wildlife
Marine Region
Ocean Salmon Project
3637 Westwind Blvd
Santa Rosa, CA 95403

[2/] Pacific States Marine Fisheries Commission

This report is funded by the U.S. Bureau of Reclamation, East Bay Municipal Utilities District, and the California Department of Water Resources contracts with the Pacific States Marine Fisheries Commission (PSMFC). The work necessary to produce this report was a cooperative effort between the California Department of Fish and Wildlife and the PSMFC. For a copy of this report, please contact Brett Kormos at brett.kormos@wildlife.ca.gov.

INTRODUCTION

Each year, approximately 32 million fall-run Chinook salmon (*Oncorhynchus tshawytscha*) are produced at five hatcheries in California's Central Valley (CV): Coleman National Fish Hatchery (CFH), Feather River Hatchery (FRH), Nimbus Fish Hatchery (NIM), Mokelumne River Hatchery (MOK), and Merced River Hatchery (MER). Production from these hatcheries contributes to CV escapement and sport harvest while also supporting ocean fisheries in California and Oregon. Since 2007, a constant fractional marking (CFM) program has ensured that at least 25% of all CV hatchery production fish are tagged with a microscopic (≤ 1 mm) coded-wire tag (CWT). 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). Each salmon containing a CWT is also externally marked with a clipped adipose fin (ad-clip) to allow for easy visual identification.

This is the ninth annual report on the recovery of CFM CWTs in the CV and ocean fisheries. In 2018, approximately 47,700 CWTs were recovered and successfully read from ad-clipped Chinook salmon sampled in CV fall-, winter-, spring-, and late-fall-run natural area spawning surveys, at CV hatcheries, in the CV angler sport harvest, and in commercial and sport ocean salmon fisheries south of Cape Falcon (i.e., California and most of Oregon).

This report will focus primarily on the results of analyses addressing the following questions:

- What are the proportions of hatchery- and natural-origin salmon in spawner returns to CV hatcheries and natural areas, in inland harvest, and in ocean fisheries? Of the hatchery component, what proportions originated from in-basin versus out-of-basin CWT release strategies?
- What are the relative recovery and stray rates for hatchery-origin salmon released in-basin versus salmon released into the waters of the Sacramento-San Joaquin River Delta, San Francisco-San Pablo bays, or coastal areas? How do recovery and stray rates differ between salmon acclimated in net pens and their siblings released directly into the water? Are these metrics affected by transporting salmon smolts down their natal waterways by vessel and exposing them to river water prior to release in the bay?
- What are the relative recovery and contribution rates of hatchery-origin salmon, by run and release type, to ocean and inland harvests?

Please see earlier annual CFM reports (Kormos et al. 2012, Palmer and Kormos 2013, 2015) for more in-depth information and discussion regarding the CFM program, CWT marking and recovery programs in California, and the methods and analyses used in this report. Additional information on salmon escapement monitoring can be found in the Central Valley Chinook Salmon Escapement Monitoring Plan (Bergman et al. 2012) and other CV salmon population reports (e.g., Del Real and Hunter 2019, Killam 2019).

DATA AND METHODS

Inland Escapement and River Sport Harvest Monitoring

During 2018, monitoring of salmon escapement occurred at all five salmon hatcheries and on major rivers and tributaries throughout the CV. In addition, an angler creel survey was conducted on sport fisheries in the Sacramento, Feather, American, and Mokelumne river basins. It should be noted that the late-fall-run escapement in the upper Sacramento River and at CFH in this report is considered the 2019 return year, however the escapement monitoring period began in late 2018.

Sampling and estimation methods (e.g., carcass surveys, snorkel surveys, weir counts) continue to vary among natural spawner surveys throughout the CV (Table 1); however, most 2018 surveys on major rivers and in the hatcheries adequately sampled (sample rate ≥ 20%) for ad-clipped fish. The sampling rate was generally lower for smaller creeks where biodata was collected over a few days or in limited areas.

Of the approximately 213,800 Chinook salmon that returned to the CV basins analyzed in this report, 110,700 salmon were sampled, 34,500 ad-clipped salmon were observed, and 32,200 heads were collected by various CV projects. Monitoring agencies and projects included the California Department of Fish and Wildlife (CDFW), California Department of Water Resources (DWR), East Bay Municipal Utility District (EBMUD), Pacific States Marine Fisheries Commission (PSMFC), U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service (FWS), and the Yuba Accord River Management Team (YARMT). Most inland heads were processed by CDFW at the Sacramento CWT lab, except for 11,200 heads collected at CFH, which were processed by FWS staff, and 1,100 heads collected and processed by CDFW staff in Red Bluff.

All estimates of CV escapement or harvest and the number of salmon sampled in this report were provided by individual monitoring projects or hatcheries.

Ocean Harvest Monitoring

In 2018, California sport and commercial ocean salmon fisheries (Table 2) off most of the state were highly constrained compared to most years due to a sharp decline in the abundance of Sacramento River Basin fall-run Chinook salmon. Fisheries off far northern California were the sole exception, as much of the available ocean fishing opportunity was placed in that area due to an improved abundance forecast for Klamath River Basin fall-run Chinook salmon. Of the approximately 165,700 salmon harvested in California ocean fisheries during 2018, CDFW field staff sampled 50,000 salmon and collected 12,600 heads that were processed at the Santa Rosa CWT lab. Almost 2,000 heads collected in Oregon sport and commercial ocean fisheries during 2018 are also included in these analyses since Sacramento River fall-run Chinook salmon is the primary stock harvested in fisheries south of Cape Falcon, Oregon (PFMC 2016).

Each year, CDFW validates and uploads all CWT recoveries in California, along with their respective catch-sample data, to the Regional Mark Processing Center (RMPC),

which is the central repository for west coast CWT recoveries. All 2018 inland and ocean CWT recoveries are publicly available on the RMPC website at www.rmpc.org.

CWT Data Analysis

A master release database of CWT codes recovered in 2018 was created to determine species, brood year, run, stock origin (hatchery or natural), release site, release date(s), number of salmon tagged with CWTs, total number of salmon released, and any other pertinent release information (e.g., trucked, net pen acclimation, disease issues). Since almost all CV salmon recovered are between the ages of two and five, all CWT release data for Chinook salmon brood years 2013 through 2016 were downloaded from the RMPC. Approximately 130 million CV salmon were released for these brood years, of which 47 million were marked and tagged utilizing 379 unique CWT codes. Although a few thousand natural-origin salmon are often trapped, marked, and tagged annually, salmon produced by hatcheries make up 99% or greater of all CWT releases. In 2018, there were 240 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 special CV salmon releases (e.g., barge study) and the production factor calculated for each CWT code. The production factor, $F_{prod,}$ is the ratio of the total number of salmon released to the total number of salmon marked containing a CWT. Thus, it is the total number of salmon (i.e., tagged and untagged) represented by each CWT recovery. F_{prod} was calculated for each CWT code and is defined as,

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

where Ad.CWT is the number of salmon released with ad-clips and CWTs, Ad.noCWT is the number of salmon released with ad-clips but without CWTs (i.e., shed tags prior to release or CWT not correctly inserted), noAd.CWT is the number of salmon released without ad-clips but with CWTs, and noAd.noCWT is the number of salmon released without ad-clips and without CWTs. F_{prod} allows expansion to total hatchery production from observed recoveries of CV CWTs. It should be noted that certain release types (e.g., barge study) experienced significant pre-release mortality due to factors related to transport and predation at the release site that went unreported in the RMPC. In some cases, where numbers of mortalities are unavailable in the release information, the resulting calculation for F_{prod} may bias results.

For this analysis, each CV Chinook salmon CWT release was classified into a “release type” based on the following criteria: hatchery or natural stock, run, release location, and holding strategy. All CV CWT codes were assigned by brood year into one of eighteen fall-run release types, one winter-run release type, two spring-run release types, or two late-fall-run release types:

Sacramento River Basin Fall-run Chinook salmon release types

CFHFh	Coleman National Fish Hatchery **F**all-run **h**atchery releases (in-basin)
CFHFn	Coleman National Fish Hatchery **F**all-run bay/delta **n**et pen releases
FRHF	Feather River Hatchery **F**all-run in-basin releases

FRHFn Feather River Hatchery **F**all-run bay/delta **n**et pen releases
FRHFnc Feather River Hatchery **F**all-run **c**oastal **n**et pen releases (Pillar Point)
FRHFtib Feather River Hatchery **F**all-run **Tib**uron net pen releases
FRHFgg Feather River Hatchery **F**all-run **G**olden **G**ate releases (no net pen acclimation)
FRHFk Feather River Hatchery **F**all-run **K**naggs Ranch experimental releases
NIMF Nimbus Fish Hatchery **F**all-run in-basin releases
NIMFn Nimbus Fish Hatchery **F**all-run bay/delta **n**et pen releases

San Joaquin River Basin Fall-run Chinook salmon release types
MOKF Mokelumne River Hatchery **F**all-run in-basin releases
MOKFn Mokelumne River Hatchery **F**all-run bay/delta **n**et pen releases
MOKFnc Mokelumne River Hatchery **F**all-run **c**oastal **n**et pen releases (various sites)
MOKFb Mokelumne River Hatchery **F**all-run **b**arge study releases
MOKFgg Mokelumne River Hatchery **F**all-run **G**olden **G**ate releases (no net pen acclimation)
MERF Merced River Hatchery **F**all-run in-basin releases
MERFn Merced River Hatchery **F**all-run bay/delta **n**et pen releases
MERFt Merced River Hatchery **F**all-run **t**rucked releases (no net pen acclimation)

Sacramento River Winter-run Chinook salmon release types
SacW Sacramento River **W**inter-run supplementation natural production releases (in-basin)

Central Valley Spring-run Chinook salmon release types
FRHS Feather River Hatchery **S**pring-run in-basin releases
SJOSx San Joaquin River **S**pring-run e**x**perimental reintroduction releases (in-basin)

Central Valley Late-fall-run Chinook salmon release types
CFHLh Coleman National Fish Hatchery **L**ate-fall-run **h**atchery releases (in-basin)
CFHLe Coleman National Fish Hatchery **L**ate-fall-run **e**mergency releases (Balls Ferry)

Note that not all release types occur every year and that release sites sometimes vary within a given release type (Table 3; Fig. 1). There were also a few problem CWT releases where fish were released utilizing more than one strategy (e.g., only half of brood year 2014 coastal MOKFnc was released into Moss Landing net pens while the other half was released into bay/delta net pens). Thus, we urge caution when analyzing or comparing CWT recovery data from certain release types.

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 visually examined for an ad-clip, f_a is the fraction of heads from ad-clipped salmon collected and

processed, and f_d is the fraction of observed CWTs that were successfully decoded (Tables 4 and 5).

Salmon sampled in CV carcass surveys are generally classified as 'fresh' or 'non-fresh' 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 non-fresh (i.e., decayed) salmon cannot be determined due to the deteriorating condition of the carcass. While condition criteria are somewhat ambiguous and classification may vary among surveys, the ad-clip rate of fresh salmon sampled in 2018 was generally higher or similar to the rate observed in non-fresh fish (Appendix 1). Fresh carcass heads also contained CWTs at a slightly higher rate than heads collected from non-fresh fish. Furthermore, the sample sizes between fresh and non-fresh fish are usually very different with the number of non-fresh salmon sampled generally much greater than fresh salmon in surveys that collected both conditions.

Mohr and Satterthwaite (2013) demonstrated how the sampling differences noted above could negatively bias the estimates of hatchery contribution. However, they cautioned that using only CWT data from fresh fish could eliminate the occurrence of rare CWT codes in analyses due to the small sample sizes common with fresh carcasses in these surveys. As in previous CFM reports, the following equation developed by Mohr and Satterthwaite (2013) was used to calculate F_{samp} for carcass surveys collecting fish condition data, thus reducing the potential to underestimate hatchery contribution while still incorporating CWT codes from both fresh and non-fresh fish:

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

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

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

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

Determining hatchery- and natural-origin proportions in CV escapement and harvest

To determine the contribution of hatchery- and natural-origin salmon, all CWT_{total} were summed to estimate the total number of hatchery salmon in each survey. The

contribution of natural-origin salmon for each survey was then determined by subtracting the total number of hatchery salmon from the total escapement estimate, as follows:

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

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

Determining recovery rates of various release types in CV escapement and ocean harvest

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

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

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

Data from all CWT release groups belonging to the same brood year and release type (e.g., coastal net pen) were combined and an overall release type-specific CV recovery rate, R_{type}, was calculated as:

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

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

Determining stray proportions of various release groups in CV escapement

To be consistent with previous reports (Kormos et al. 2012, Letvin et al. 2020, Palmer-Zwahlen and Kormos 2013, 2015, 2020, Palmer-Zwahlen et al. 2018, 2019a, 2019b), basin-of-origin is defined as the drainage within which a particular hatchery is located. Given the five hatcheries under consideration in this report, the CV is divided into five hatchery basins (hatchery code in parentheses): (1) upper Sacramento River, including Battle Creek (CFH), (2) Feather River, including the Yuba River (FRH), (3) American River (NIM), (4) Mokelumne River (MOK), and (5) Merced River (MER). Hatchery-origin salmon not returning to their basin-of-origin or to streams and rivers not included in any hatchery basin (e.g., Butte Creek, Stanislaus River, Tuolumne River) are considered strays. Appendices 2 and 3 present alternative recovery and stray rates for CFH and

FRH CWT releases based on the assumption that recoveries in the upper Sacramento River and Yuba River, respectively, are strays.

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

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

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 combined and release type-specific CV stray proportion, S_{type}, was calculated as:

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

RESULTS

General overview of 2018 CV inland recoveries and California ocean harvest

All but two of the 33,600 valid CWTs recovered in the CV during 2018 were from CV Chinook salmon releases. Most CWTs were brood year 2014 through 2016 releases (Table 6). A small number of inland CWT recoveries (n=5) were removed from CFM analyses because they were either age-1 or experimental fall-run releases by the San Joaquin River Restoration Program (SJRRP). About 89% of all CWT_{total} were fall-run, followed by late-fall-run (6%) and spring-run (3%) salmon releases. Only 1% of CWT_{total} were winter-run, all but one of which were collected in the upper Sacramento River, which includes the Keswick Dam Fish Trap (KES) where winter-run are collected for broodstock purposes at Livingston Stone National Fish Hatchery (LSH). The majority of fall-run CWT_{total} recovered in the CV were age-3 (75%) and age-2 (24%) fish.

Most of the 12,200 valid CWT recoveries (experimental SJRRP fall-run removed; n=5) from the 2018 California ocean harvest were CV salmon releases belonging to brood years 2015 and 2016 (Table 7). Approximately 92% of all CWT_{total} in the ocean harvest were CV fall-run, followed by CV late-fall-run (4%), CV spring-run (1%), and CV winter-run (0.4%) salmon. The remaining 3% of California ocean harvest CWT_{total} originated primarily from the Klamath-Trinity Basin and Smith River in northern California, the Rogue and Elk rivers in Oregon, and the Columbia River Basin. Most of the hatchery-origin fish in the California ocean harvest were age-3 (68%) and age-2 (31%) fish.

Over half of the 1,900 valid CWT recoveries (age-6 removed; n=5) from the 2018 Oregon ocean harvest (south of Cape Falcon) were CV fall-run salmon releases (Table

8), which composed 51% of all CWT_{total}. Recoveries of other CV run types were scarce off Oregon. Non-CV stocks made up 49% of the Oregon ocean harvest CWT_{total}, with most originating from the Columbia River Basin, coastal streams in Oregon, and the Klamath-Trinity Basin. Most of the hatchery-origin fish in the Oregon ocean harvest were age-3 (85%) and age-4 (12%) fish.

1. Proportion of Hatchery- and Natural-origin Salmon in CV Escapement

During 2018, approximately 112,300 fall-run Chinook salmon returned to spawn in the CV natural areas included in these analyses (Table 9, Fig. 2). There were an additional 3,200 fall-run salmon that spawned in natural areas of tributaries that are excluded here because sample rates and resultant CWT recoveries were too low to produce reliable results. The proportion of hatchery-origin salmon in those areas sampled varied throughout the CV. The lowest fall-run hatchery proportion occurred in Butte Creek (7%), while the highest (93%) occurred in the Yuba River. The next highest hatchery proportions occurred in the Mokelumne River (87%) and Battle Creek (86%). The total CV fall-run hatchery proportion for all natural areas that were adequately sampled during 2018 was 71%.

One of the upper Sacramento Basin tributaries included in these analyses is Battle Creek, however the hatchery proportion was estimated using a surrogate since a carcass survey or CWT recovery program has not occurred in this waterway since 2005. The hatchery contribution and CWT release type composition in the Battle Creek fall-run escapement is assumed equivalent to the hatchery fall-run return sampled at CFH (K. Niemela, FWS, pers. comm.).

The hatchery proportion of the 57,100 fall-run salmon returning to the five CV hatcheries ranged from 58% to 99% (Table 9, Fig. 3). The fall-run hatchery proportion for all CV hatcheries combined was 87%. The spring-run return to FRH and the late-fall-run return to CFH were almost entirely hatchery-origin salmon (94% and 99%, respectively).

To help differentiate the hatchery composition, all CV release types from the same stock, run, and hatchery use the same shade of color in the pie chart figures: Blue = Sacramento River Basin fall-run releases, Green = San Joaquin Basin fall-run releases, Purple = Central Valley spring-run releases, Yellow = Sacramento River winter-run releases, and Orange = Central Valley late-fall-run releases (Fig. 4). Additionally, select patterns are used to designate different release types. All bay/delta net pen releases contain black dots, while coastal net pen releases are designated with a crisscross pattern. Golden Gate releases are shown with horizontal stripes. In-basin releases do not have any pattern. To present the data in a less complicated manner, several release types have been merged in the pie chart figures and many of the tables. Please refer to footnote b/ in Table 9 for a description of which release types were merged.

Upper Sacramento River Basin

At CFH, fall-run spawning began in early October and continued through early November 2018. All ad-clipped salmon were sampled during the entire run. CFH began

late-fall-run spawning in late December seven weeks after fall-run spawning ceased and continued through early March 2019. For the interim seven weeks, and to a lesser extent during fall-run spawning, there was overlap between runs and FWS staff parsed them out based on CWT recoveries. As a result, the final escapement was 14,198 fall-run and 8,094 late-fall-run salmon. An additional 83 late-fall-run salmon were trapped at CFH after spawning operations ended. Also, to promote genetic integrity, 13 late-fall-run salmon (11 unmarked) were collected at KES in the upper Sacramento River mainstem and transported to CFH as supplemental broodstock.

Fall- and late-fall-run returns to CFH were predominantly hatchery-origin salmon, as were fall-run spawners in Battle Creek where CFH is located. Natural-origin spawners composed most of the fall- and late-fall-run returns to the upper Sacramento River mainstem, Clear Creek, and KES. Winter-run spawners in the upper Sacramento River and those collected at KES were primarily hatchery-origin fish (Figs. 5, 6). The proportion of hatchery-origin fish (prevalent release type shown in parentheses) at each of the following locations was:

- Fall-run returns CFH: 87% (CFHFh)
- Late-fall-run returns CFH: 99% (CFHLh)
- Late-fall-run returns CFH (post-spawning): 100% (CFHLh)
- Winter-run spawners for broodstock KES: 84% (SacW)
- Late-fall-run supplemental spawners KES: 15% (CFHLh)
- Winter-run spawners upper Sacramento River: 82% (SacW)
- Fall-run spawners upper Sacramento River: 22% (CFHFh)
- Late-fall-run spawners upper Sacramento River: 33% (CFHLh)
- Fall-run spawners Clear Creek: 22% (CFHFh)
- Fall-run spawners Battle Creek: 86% (CFHFh)

Butte Creek and Feather River Basin

Spring- and fall-run returns to FRH and spawners in the Feather and Yuba rivers were predominantly of hatchery-origin. In Butte Creek, however, spring- and fall-run spawners were entirely of natural-origin with the exception of one winter-run CWT that was recovered during the fall-run survey (Figs. 7, 8). For the third consecutive year, the Yuba River escapement below and above Daguerre Point Dam (DPD) was combined in 2018 because the estimate below DPD was only 24 fish (D. Kowalik, PSMFC, pers. comm.). The proportion of hatchery-origin fish (prevalent release type[s] shown in parentheses) at each of the following locations was:

- Spring-run spawners Butte Creek: 0%
- Fall-run spawners Butte Creek: 7% (SacW)
- Spring-run returns FRH: 94% (FRHS)
- Fall-run returns FRH: 85% (FRHFn)
- Fall/spring-run spawners Feather River: 80% (FRHFn)
- Fall/spring-run spawners Yuba River: 93% (FRHFn, MOKFn)

American River Basin

Fall-run returns to NIM and spawners in the American River were predominantly of hatchery-origin (Fig. 9). The proportion of hatchery-origin fish (prevalent release types shown in parentheses) at each of the following locations was:

- Fall-run returns NIM: 88% (NIMFn, MOKFn, NIMF)
- Fall-run spawners American River: 76% (MOKFn, NIMFn, NIMF)

In prior versions of this report, CWTs that were collected from fish sampled on the NIM weir (i.e., "washbacks") were analyzed separately from those that were collected during carcass surveys downstream of the weir. This was prudent because salmon that were encountered upstream of the weir tended to exhibit an earlier run timing (e.g., stray FRH spring-run and CFH fall-run) since many of them would have migrated above the weir before it was put in place each year. Additionally, separate escapement estimates have been produced for NIM weir "washbacks" and the carcass survey downstream for almost 40 years. However, in 2018, a single natural area escapement estimate was reported utilizing mark-recapture methods and treating the entire American Basin (i.e., both upstream and downstream of the weir) as one system, so these two escapement sectors have been merged for this report. It was the first year that fishing was permanently closed upstream of the NIM weir, so there were many more carcasses encountered above the weir that would have likely been harvested under prior fishing regulations. Appendix 4 provides a comparison of raw CWT recoveries by release type between fish sampled upstream and downstream of the NIM weir in 2018.

Mokelumne River Basin

Fall-run returns to the Mokelumne River Basin were predominantly hatchery-origin salmon, with the return to MOK being almost entirely of hatchery-origin (Fig. 10). The only two inland recoveries of non-CV CWTs in 2018 occurred at MOK, both of which were yearling releases from Trinity River Hatchery in the Klamath Basin. The proportion of hatchery-origin fish (prevalent release type shown in parentheses) at each of the following locations was:

- Fall-run returns MOK: 99% (MOKFn)
- Fall-run spawners Mokelumne River: 87% (MOKFn)

Appendix 5 provides the F_{samp} calculation for Mokelumne River natural area spawners, which was based on a combination of ad-clips observed via video weir, ad-clips returning to MOK, and CWTs recovered during carcass surveys.

Merced River and other San Joaquin Basin tributaries

Fall-run returns to MER were mostly hatchery-origin salmon, although it was the lowest hatchery contribution observed since the CFM program was fully implemented, and natural area spawners in the Merced River were predominantly of natural-origin. Spawners in the Stanislaus and Tuolumne rivers were primarily hatchery-origin salmon

(Fig. 11). The proportion of hatchery-origin fish (prevalent release type[s] shown in parentheses) at each of the following locations was:

- Fall-run returns MER: 58% (MERF, MOKFn)
- Fall-run spawners Merced River: 34% (MOKFn)
- Fall-run spawners Stanislaus River: 75% (MOKFn)
- Fall-run spawners Tuolumne River: 57% (MOKFn)

2. Contribution of CV Release Types to Total Salmon Escapement

In 2018, 76% of the 187,700 salmon that returned to the CV hatcheries and natural areas included in these analyses were hatchery-origin fish (Tables 9, 10). The hatchery release types that contributed the most to total CV escapement were fall-run bay/delta net pen releases from FRH and MOK (30% and 12%, respectively) and CFH fall-run in-basin releases (13%). MOK fall-run bay/delta net pen releases had the highest number of strays, while fall-run bay/delta net pen releases from CFH and MER had the highest rates of straying at 100% and 93%, respectively. Coastal net pen and non-acclimated Golden Gate releases of fall-run from MOK had the next highest stray rates at 74% and 63%, respectively. About 14% of all recoveries occurred outside their basin-of-origin and ranged from <1% to 100%, depending on release type:

Hatchery-origin contribution by R_{type} to total CV salmon escapement

R_{type}	Run	CWT_{total}	% total	# Stray	% stray
CFHFh	Fall	24,135	13%	1,447	6%
CFHFn	Fall	112	<1%	112	100%
FRHF	Fall	1,336	1%	20	1%
FRHFn	Fall	56,068	30%	1,702	3%
FRHFgg	Fall	2,975	2%	456	15%
NIMF	Fall	4,430	2%	101	2%
NIMFn	Fall	7,216	4%	942	13%
MOKF	Fall	290	<1%	40	14%
MOKFn	Fall	23,377	12%	10,221	44%
MOKFnc	Fall	2,807	1%	2,085	74%
MOKFgg	Fall	2,149	1%	1,349	63%
MERF	Fall	293	<1%	50	17%
MERFn	Fall	909	<1%	848	93%
SacW	Winter	2,158	1%	1	<1%
FRHS	Spring	5,177	3%	2	<1%
SJOSx	Spring	36	<1%	36	NA
CFHLh	Late-fall	9,045	5%	26	<1%
Non-CV		8	<1%	8	
	Total	142,521	76%	19,446	14%

3. Hatchery Proportion and Contribution of CV Release Types to CV Sport Fishery

In 2018, 74% of the 26,100 salmon harvested in the CV river sport fishery were hatchery-origin fish (Table 9; Figs. 12, 13). The proportion of hatchery-origin fish (prevalent release type[s] shown in parentheses) in each of the following fisheries was:

- Upper Sacramento River fall-run harvest: 78% (CFHFh)
- Lower Sacramento River fall-run harvest: 75% (MOKFn, NIMFn, FRHFn)
- Feather River fall-run harvest: 69% (FRHFn)
- American River fall-run harvest: 100% (MOKFn, NIMF)
- Mokelumne River fall-run harvest: 77% (MOKFn)
- Upper Sacramento River late-fall-run harvest: 68% (CFHLh)

Of all hatchery release types, FRH fall-run bay/delta net pen releases contributed the most (31%) to the total CV sport harvest, followed by CFH fall-run in-basin releases (21%). In-basin releases were only harvested in their basin-of-origin or the lower Sacramento River (which all CV stocks must traverse before reaching their basin-of-origin). Conversely, net pen releases were harvested out-of-basin at considerable rates, and it is also worth noting that relatively few of them were harvested in the upper Sacramento River (Tables 9, 10).

Hatchery-origin contribution by R_{type} to total CV river harvest

R_{type}	Run	CWT_{total}	% harvest
CFHFh	Fall	5,524	21%
CFHFn	Fall	0	0%
FRHF	Fall	207	1%
FRHFn	Fall	8,177	31%
FRHFgg	Fall	653	2%
NIMF	Fall	696	3%
NIMFn	Fall	1,102	4%
MOKF	Fall	11	<1%
MOKFn	Fall	1,832	7%
MOKFnc	Fall	155	1%
MOKFgg	Fall	182	1%
MERF	Fall	0	0%
MERFn	Fall	0	0%
SacW	Winter	9	<1%
FRHS	Spring	132	1%
SJOSx	Spring	26	<1%
CFHLh	Late-fall	605	2%
Non-CV		0	0%
	Total	19,311	74%

4a. Relative Recovery and Stray Rates of CV Release Types in Total Escapement

Release strategies vary among hatcheries from year to year. This variability has often been in response to annual fluctuations in the abundance of certain stocks or differing policies among agencies with respect to best release practices. The 2014 through 2016 brood year releases were more consistent than release types analyzed in earlier CFM reports (Kormos et. al. 2012, Palmer-Zwahlen and Kormos 2013, 2015) and only a few "mixed strategy" releases were identified (Table 3).

Table 11 summarizes total CWT_{samp} recoveries and the escapement recovery rate, $R_{type,}$ (in-basin and stray) for all release types collected in the CV escapement and ocean fisheries during 2018. The CWTs collected in the CV river sport fishery are not included since it is not possible to ascertain the location where these fish would have eventually spawned. Recovery rates are standardized utilizing total CWT_{samp} recoveries per 100,000 tagged salmon released. Release types with less than 15,000 total fish released with CWTs are not reported below since just a few recoveries could result in relatively large recovery and stray rate estimates.

Figures 14 and 15 provide a graphical representation of R_{type} for Sacramento River fall-run Chinook salmon and other CV stocks, respectively, and include the total number of salmon released with CWTs for each release type. Fall-run salmon that were released offsite, both those acclimated in net pens and those released directly into the water, had higher CV recovery rates than their respective in-basin releases, but offsite releases also had higher stray rates than their in-basin counterparts.

Age-2 CV Escapement Recovery and Stray Rates

R_{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
CFHFh	2016	Fall	70	4	5%
FRHF	2016	Fall	107	1	1%
FRHFn	2016	Fall	165	24	14%
FRHFgg	2016	Fall	274	42	15%
NIMF	2016	Fall	119	4	3%
NIMFn	2016	Fall	170	23	14%
MOKF	2016	Fall	3	0	0%
MOKFn	2016	Fall	117	57	49%
MOKFnc	2016	Fall	56	47	84%
MOKFb	2016	Fall	143	91	64%
MOKFgg	2016	Fall	177	136	77%
MERF	2016	Fall	22	4	16%
FRHS	2016	Spring	44	0.1	0.2%
SJOSx	2016	Spring	NA	38	NA
SacW	2016	Winter	260	0	0%
CFHLh	2017	Late-fall	122	1	0.4%

Age-3 CV Escapement Recovery and Stray Rates

R_{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
CFHFh	2015	Fall	129	9	7%
FRHF	2015	Fall	21	0	0%
FRHFn	2015	Fall	619	12	2%
FRHFk	2015	Fall	21	13	62%
NIMF	2015	Fall	58	0.1	0.2%
NIMFn	2015	Fall	367	46	13%
MOKF	2015	Fall	29	3	12%
MOKFn	2015	Fall	334	141	42%
MOKFnc	2015	Fall	481	348	72%
MOKFb	2015	Fall	490	262	54%
MERFn	2015	Fall	199	185	93%
MERFt	2015	Fall	130	121	93%
FRHS	2015	Spring	208	0	0%
SJOSx	2015	Spring	NA	2	NA
SacW	2015	Winter	425	0.2	0.1%
CFHLh	2016	Late-fall	707	2	0.3%
CFHLe	2016	Late-fall	726	2	0.2%

Age-4 CV Escapement Recovery and Stray Rates

R_{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
CFHFn	2014	Fall	1	1	100%
FRHFn	2014	Fall	23	2	7%
FRHFnc	2014	Fall	22	3	14%
FRHFk	2014	Fall	2	0	0%
NIMFn	2014	Fall	5	1	22%
MOKFn	2014	Fall	0.2	0.1	50%
MOKFnc	2014	Fall	0.4	0	0%
MERFn	2014	Fall	0	0	-
MERFt	2014	Fall	0	0	-
FRHS	2014	Spring	0.2	0	0%
SJOSx	2014	Spring	NA	0	NA
SacW	2014	Winter	1	0	0%
CFHLh	2015	Late-fall	14	0	0%
CFHLe	2015	Late-fall	0	0	-

4b. Relative Recovery Rate of CV Release Types in the Ocean Harvest

The total recovery rate of CV hatchery releases in California and Oregon (south of Cape Falcon) sport and commercial ocean salmon fisheries varied by age and release type (Table 11). A higher percentage of age-2 CV hatchery salmon were recovered in the ocean sport fishery (Fig. 16) due to the smaller size limits in effect during 2018 compared to those for the commercial fishery (Table 2).

Age-2 Ocean Harvest Recovery Rate; Percent taken in Sport Harvest

R_{type}	Brood year	Run	# Recoveries per 100K Released	% sport
CFHFh	2016	Fall	54	95%
FRHF	2016	Fall	85	92%
FRHFn	2016	Fall	146	92%
FRHFgg	2016	Fall	383	87%
NIMF	2016	Fall	147	77%
NIMFn	2016	Fall	277	79%
MOKF	2016	Fall	2	100%
MOKFn	2016	Fall	94	82%
MOKFnc	2016	Fall	360	79%
MOKFb	2016	Fall	129	86%
MOKFgg	2016	Fall	516	80%
MERF	2016	Fall	9	88%
FRHS	2016	Spring	65	95%
SJOSx	2016	Spring	130	85%
CFHLh	2017	Late-fall	4	100%

Age-3 Ocean Harvest Recovery Rate; Percent taken in Sport Harvest

R_{type}	Brood year	Run	# Recoveries per 100K Released	% sport
CFHFh	2015	Fall	47	35%
FRHF	2015	Fall	6	26%
FRHFn	2015	Fall	298	32%
FRHFk	2015	Fall	15	23%
NIMF	2015	Fall	60	21%
NIMFn	2015	Fall	479	20%
MOKF	2015	Fall	17	43%
MOKFn	2015	Fall	401	26%
MOKFnc	2015	Fall	1,383	30%
MOKFb	2015	Fall	702	24%
MERFn	2015	Fall	243	17%
MERFt	2015	Fall	189	15%
FRHS	2015	Spring	13	57%
SJOSx	2015	Spring	0	-
SacW	2016	Winter	265	65%
CFHLh	2016	Late-fall	333	25%
CFHLe	2016	Late-fall	376	33%

Age-4 Ocean Harvest Recovery Rate; Percent taken in Sport Harvest

R_{type}	Brood year	Run	# Recoveries per 100K Released	% sport
CFHFn	2014	Fall	1	14%
FRHFn	2014	Fall	12	28%
FRHFnc	2014	Fall	21	19%
FRHFk	2014	Fall	0	-
NIMFn	2014	Fall	2	24%
MOKFn	2014	Fall	2	15%
MOKFnc	2014	Fall	8	13%
MERFn	2014	Fall	0	-
MERFt	2014	Fall	2	0%
FRHS	2014	Spring	0	-
SJOSx	2014	Spring	0	-
SacW	2015	Winter	1	0%
CFHLh	2015	Late-fall	8	50%
CFHLe	2015	Late-fall	0	-

5. Hatchery Proportion and Contribution of CV Release Types to Ocean Salmon Fisheries

Almost two-thirds of the 194,200 Chinook salmon harvested in California and Oregon (south of Cape Falcon) ocean salmon fisheries were hatchery-origin fish (Fig. 17). The most prevalent CV release types recovered off both states were fall-run net pen releases.

Hatchery-origin contribution by R_{type} to CA and OR ocean harvest

R_{type}	Run	CWT_{total}	% harvest
CFHFh	Fall	12,297	6%
CFHFn	Fall	120	<1%
FRHF	Fall	961	<1%
FRHFn	Fall	28,970	15%
FRHFgg	Fall	4,129	2%
NIMF	Fall	5,130	3%
NIMFn	Fall	9,867	5%
MOKF	Fall	182	<1%
MOKFn	Fall	26,043	13%
MOKFnc	Fall	9,789	5%
MOKFgg	Fall	3,570	2%
MERF	Fall	118	<1%
MERFn	Fall	1,209	1%
Other CV	Non-fall	5,846	3%
Non-CV		9,257	5%
	Total	117,486	61%

California ocean sport fishery

California anglers harvested approximately 87,300 Chinook salmon in the ocean sport fishery during 2018. The total contribution of hatchery-origin salmon to the California ocean sport fishery was 57%, ranging from 56% to 71% of the total harvest depending on major port area (Fig. 18). Most of the harvest occurred in the San Francisco port area (83%), followed by the Fort Bragg (7%), Monterey (7%), and Eureka/Crescent City (4%) port areas (Table 12).

Of all hatchery release types, fall-run bay/delta net pen releases from FRH and MOK contributed the most (13% and 10%, respectively) to the total California ocean sport harvest, followed by in-basin fall-run releases from CFH (9%). Non-CV releases composed 1% of the total sport harvest (Table 13).

Hatchery-origin contribution by R_{type} to CA ocean sport harvest

R_{type}	Run	CWT_{total}	% harvest
CFHFh	Fall	8,189	9%
CFHFn	Fall	14	<1%
FRHF	Fall	818	1%
FRHFn	Fall	11,571	13%
FRHFgg	Fall	3,530	4%
NIMF	Fall	2,990	3%
NIMFn	Fall	3,734	4%
MOKF	Fall	99	<1%
MOKFn	Fall	8,841	10%
MOKFnc	Fall	4,270	5%
MOKFgg	Fall	1,652	2%
MERF	Fall	103	<1%
MERFn	Fall	167	<1%
SacW	Winter	241	<1%
FRHS	Spring	1,207	1%
SJOSx	Spring	93	<1%
CFHLh	Late-fall	1,179	1%
Non-CV		1,062	1%
	Total	49,760	57%

California ocean commercial fishery

California trollers harvested over 78,400 Chinook salmon in the commercial ocean fishery during 2018. The total contribution of hatchery-origin salmon to the California commercial ocean fishery was 70%, ranging from 62% to 77% of the total harvest depending on major port area (Fig. 19). Half of the harvest occurred in the San Francisco port area (50%), followed by the Monterey (25%), Fort Bragg (13%), and Eureka/Crescent City (11%) port areas (Table 14).

Of all hatchery release types, fall-run bay/delta net pen releases from FRH and MOK contributed the most (20% and 19%, respectively) to the total California commercial harvest. Non-CV releases contributed 2% to the total commercial harvest (Table 15).

Hatchery-origin contribution by R_{type} to CA ocean commercial harvest

R_{type}	Run	CWT_{total}	% harvest
CFHFh	Fall	3,559	5%
CFHFn	Fall	62	<1%
FRHF	Fall	124	<1%
FRHFn	Fall	15,362	20%
FRHFgg	Fall	579	1%
NIMF	Fall	1,969	3%
NIMFn	Fall	5,818	7%
MOKF	Fall	79	<1%
MOKFn	Fall	15,152	19%
MOKFnc	Fall	4,689	6%
MOKFgg	Fall	1,552	2%
MERF	Fall	14	<1%
MERFn	Fall	888	1%
SacW	Winter	137	<1%
FRHS	Spring	160	<1%
SJOSx	Spring	18	<1%
CFHLh	Late-fall	2,762	4%
Non-CV		1,873	2%
	Total	54,798	70%

6. Relative Recovery and Stray Rates of Fall-run Experimental and Net Pen Release Types

In 2018, CWTs from many fall-run experimental and net pen release types were recovered in the CV escapement, river sport fishery, and ocean harvest, and this section will focus on those from brood years 2014 through 2016 (ages 2-4). Experimental releases include barge studies that utilized approximately 600,000 fall-run salmon from MOK, and rice field studies at Knaggs Ranch in the Yolo Bypass that utilized almost 150,000 fall-run from FRH. Additionally, there was a new release type recovered in 2018 that are referred to as Golden Gate releases in this report. These are non-acclimated fall-run releases at Fort Baker, which is just inside the entrance to San Francisco Bay from the ocean. For brood year 2016, which were recovered as age-2 in 2018, approximately 1 million fall-run from FRH and 200,000 fall-run from MOK were released in this manner.

Net pen releases can be categorized into either bay/delta or coastal releases. Bay/delta net pen releases include those that are released in the western Delta (CFH, MOK, and MER), and those that are released where the Carquinez Strait meets San Pablo Bay (FRH and NIM). Coastal net pen releases include those coordinated by the Coastside

Fishing Club in Pillar Point and those coordinated by the Monterey Bay Trout and Salmon Project (MBTSP) in Santa Cruz and Moss Landing. It should be noted that in 2015, MBTSP moved their net pen operations to Moss Landing due to operational issues with the Santa Cruz Port District. After receiving and releasing their first group of brood year 2014 fall-run salmon from MOK (120,000 salmon), it was determined that MBTSP did not have the proper permits to release salmon in the Moss Landing area so the remaining 120,000 fish with the same CWT code were instead released into bay/delta net pens.

The experimental and net pen releases recovered in 2018 are differentiated into the following release types:

- CFHFn Coleman National Fish Hatchery **F**all-run bay/delta **n**et pens

- FRHFgg Feather River Hatchery **F**all-run **G**olden **G**ate releases (no net pen acclimation)

- FRHFkc Feather River Hatchery **F**all-run rice field study: Elkhorn Boat Ramp (**K**naggs **c**ontrol)
- FRHFkr Feather River Hatchery **F**all-run rice field study: **K**naggs **R**anch (Yolo Bypass)

- FRHFn Feather River Hatchery **F**all-run bay/delta **n**et pens

- FRHFnp Feather River Hatchery **F**all-run coastal **n**et pens – **P**illar Point

- NIMFn Nimbus Fish Hatchery **F**all-run bay/delta **n**et pens

- MOKFbb Mokelumne River Hatchery **F**all-run **b**arge study: trucked and released in SF **B**ay
- MOKFbg Mokelumne River Hatchery **F**all-run **b**arge study: bar**g**ed to SF Bay and released
- MOKFbr Mokelumne River Hatchery **F**all-run **b**arge study: released in-**r**iver (Mok R)

- MOKFgg Mokelumne River Hatchery **F**all-run **G**olden **G**ate releases (no net pen acclimation)

- MOKFn Mokelumne River Hatchery **F**all-run bay/delta **n**et pens

- MOKFnp Mokelumne River Hatchery **F**all-run coastal **n**et pens – **P**illar Point
- MOKFns Mokelumne River Hatchery **F**all-run coastal **n**et pens – **S**anta Cruz/Moss Landing

- MERFn Merced River Hatchery **F**all-run bay/delta **n**et pens

Central Valley Escapement

The CV escapement recovery rate and percent stray for all fall-run experimental and net pen releases are included below to allow direct comparison among these release types (Table 16, Fig. 20).

Age-2 CV Escapement Recovery and Stray Rates

R_{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
FRHFgg	2016	Fall	274	42	15%
FRHFn	2016	Fall	165	24	14%
NIMFn	2016	Fall	170	23	14%
MOKFbb	2016	Fall	80	58	72%
MOKFbg	2016	Fall	256	200	78%
MOKFbr	2016	Fall	92	17	19%
MOKFgg	2016	Fall	177	136	77%
MOKFn	2016	Fall	117	57	49%
MOKFnp	2016	Fall	64	54	84%
MOKFns	2016	Fall	5	2	34%

Age-3 CV Escapement Recovery and Stray Rates

R_{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
FRHFkc	2015	Fall	18	4	20%
FRHFkr	2015	Fall	23	21	92%
FRHFn	2015	Fall	619	12	2%
NIMFn	2015	Fall	367	46	13%
MOKFbb	2015	Fall	441	274	62%
MOKFbg	2015	Fall	963	505	52%
MOKFbr	2015	Fall	67	9	14%
MOKFn	2015	Fall	334	141	42%
MOKFnp	2015	Fall	481	348	72%
MERFn	2015	Fall	199	185	93%

Age-4 CV Escapement Recovery and Stray Rates

R_{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
CFHFn	2014	Fall	1	1	100%
FRHFkr	2014	Fall	2	0	0%
FRHFn	2014	Fall	23	2	7%
FRHFnp	2014	Fall	22	3	14%
NIMFn	2014	Fall	5	1	22%
MOKFn	2014	Fall	0.2	0.1	50%
MOKFns	2014	Fall	0.4	0	0%
MERFn	2014	Fall	0	0	-

Ocean Fishery Harvest

The total recovery rate of fall-run experimental and net pen releases in California and Oregon (south of Cape Falcon) sport and commercial ocean salmon fisheries varied by age and release type (Table 16, Fig. 21). A higher percentage of age-2 releases were recovered in the ocean sport fishery, again due to smaller size limits in effect during 2018 compared to the commercial fishery (Table 2).

Age-2 Ocean Harvest Recovery Rate; Percent taken in Sport Harvest

R_{type}	Brood year	Run	# Recoveries per 100K Released	% sport
FRHFgg	2016	Fall	383	87%
FRHFn	2016	Fall	146	92%
NIMFn	2016	Fall	277	79%
MOKFbb	2016	Fall	134	83%
MOKFbg	2016	Fall	196	86%
MOKFbr	2016	Fall	58	95%
MOKFgg	2016	Fall	516	80%
MOKFn	2016	Fall	94	82%
MOKFnp	2016	Fall	402	79%
MOKFns	2016	Fall	116	73%

Age-3 Ocean Harvest Recovery Rate; Percent taken in Sport Harvest

R_{type}	Brood year	Run	# Recoveries per 100K Released	% sport
FRHFkc	2015	Fall	13	55%
FRHFkr	2015	Fall	16	0%
FRHFn	2015	Fall	298	32%
NIMFn	2015	Fall	479	20%
MOKFbb	2015	Fall	911	27%
MOKFbg	2015	Fall	1,150	22%
MOKFbr	2015	Fall	47	14%
MOKFn	2015	Fall	401	26%
MOKFnp	2015	Fall	1,383	30%
MERFn	2015	Fall	243	17%

Age-4 Ocean Harvest Recovery Rate; Percent taken in Sport Harvest

R_{type}	Brood year	Run	# Recoveries per 100K Released	% sport
CFHFn	2014	Fall	1	14%
FRHFkr	2014	Fall	0	-
FRHFn	2014	Fall	12	28%
FRHFnp	2014	Fall	21	19%
NIMFn	2014	Fall	2	24%
MOKFn	2014	Fall	2	15%
MOKFns	2014	Fall	8	13%
MERFn	2014	Fall	0	-

2018 CFM ANALYSES KEY POINTS

- During 2012 through 2016, California experienced a severe drought, with the 2012 through 2014 period being the driest in the state's history. With the exception of fish that were age-2 in 2018, all other broods covered in this report were affected as juvenile outmigrants during this drought as they were subjected to high temperatures and low flows during their freshwater residency. Dewatering of eggs and/or pre-emergent fry loss were reported by numerous CV projects during this period, especially when minimum flow requirements were reduced in late fall. Pre-spawn mortality rates were also above normal in many rivers and streams. Due to these factors, natural-origin juvenile production was low for the broods that were age-3 and older in 2018 (PFMC 2019).

- The compounding effects of the persistent drought and possibly abnormal ocean conditions resulted in a 2018 adult (i.e., age-3 and older) escapement for Sacramento River Basin fall-run Chinook salmon that was less than the federal conservation

objective for the fourth consecutive year. This was one year after this stock met the federal criteria for overfished status when the 2017 adult escapement was about one-third of the conservation objective (PFMC 2019, PFMC 2020). This resulted in sharply curtailed fishing seasons during 2018. At the time of this report's publication in early 2021, this stock was still overfished. Despite the poor adult escapement in 2018, age-2 returns of Sacramento River Basin fall-run Chinook salmon were the highest since 2011.

- A majority (76%) of the total 2018 CV salmon escapement (all run-types) was hatchery-origin fish. This was a decrease of 12% in hatchery contribution from the 2017 escapement, which was the highest estimate since the CFM program was fully implemented. This reduction suggests an improvement in natural-origin production as the most severe drought effects began to subside, starting with the 2015 brood. Between 2010 and 2018, the hatchery contribution to the total CV escapement has averaged 76% and has ranged between 66% and 88%. FRH fall-run bay/delta releases composed almost one-third of the total 2018 CV escapement, with CFH fall-run in-basin and MOK fall-run bay/delta releases being the next highest contributors.

- The few recoveries of CFH fall-run bay/delta releases (n=17; age-4 only) all occurred out-of-basin in the American River (i.e., stray rate of 100%). MER fall-run offsite releases also strayed at a very high rate (93%), followed by MOK fall-run coastal (74%) and Golden Gate (63%; includes those that were barged to the Golden Gate) releases.

- The stray rate for NIM fall-run bay/delta releases decreased markedly to 13% in 2018 after averaging 33% during 2015-2017. Between 2011 and 2014, stray rates for this release type ranged between 2% and 5%, but then increased sharply in 2015 to 25%, followed by 31% in 2016 and 43% in 2017. During those three years of increased straying, a large majority of those strays returned to the Mokelumne River. It is possible that inter-annual variations in CV water operations, such as pulse flow events and management of the Delta Cross Channel, are influencing the degree to which NIM bay/delta releases stray outside of the American River.

- Salmon escapement into CV hatcheries was predominately hatchery-origin fish. At all CV hatcheries except MER, the majority of their return was composed of their respective releases. But only 26% of the return to MER consisted of fish that were produced there, with the remainder consisting of natural-origin salmon (42%) and stray hatchery-origin salmon (32%). This was the lowest hatchery contribution (58%) observed at MER since the CFM program was fully implemented, as was the hatchery contribution in Merced River natural areas (34%). The out-of-basin hatchery return at NIM was also quite high (36%), with a large majority of those strays originating from MOK.

- Most natural area spawning escapements were dominated by hatchery-origin fish. The exceptions were the Merced River, Butte Creek, Clear Creek, and the upper Sacramento River fall- and late-fall-run escapements. Most of the hatchery-origin

component in the Feather and Mokelumne rivers and Battle Creek consisted of release types from their respective hatcheries, whereas hatchery-origin spawners in natural areas of the American and Merced rivers were predominantly strays from other hatcheries, most notably MOK fall-run bay/delta releases.

- As previously stated, fall-run escapement in the upper Sacramento River mainstem was predominantly natural-origin salmon. The hatchery contribution in 2018 (22%) was the second-lowest since the CFM program was fully implemented and was only slightly higher than 2017 (21%), which was the lowest. Prior to those two years, the hatchery contribution in the upper Sacramento River mainstem between 2010 and 2016 averaged 48% and ranged between 27% and 68%. The low hatchery contribution during 2018 was likely partially due to the absence of any age-4 CFH-origin fish recovered in the upper Sacramento Basin, all of which were released in the western Delta due to drought conditions. As mentioned above, very few age-4 CFH-origin CWTs were observed in the CV during 2018 and they were all recovered out-of-basin. CFH in-basin releases composed the bulk of the hatchery-origin portion of the Sacramento River mainstem fall-run escapement.

- Fall/spring-run escapement to the natural spawning areas of the Feather River was primarily hatchery-origin salmon. FRH fall-run bay/delta releases composed a large majority of the run. Spring-run releases from FRH only formed 3% of the escapement but were the next highest contributor. In-basin fall-run releases from FRH composed 1% of the escapement.

- Fall/spring-run escapement in the Yuba River was predominantly hatchery-origin salmon, a third of which were FRH fall-run bay/delta releases, followed by stray MOK fall-run bay/delta and FRH spring-run in-basin releases.

- Fall-run escapement to the natural spawning areas of the American River was mostly hatchery-origin salmon. Stray MOK bay/delta releases were the highest-contributing release type, followed by NIM bay/delta and NIM in-basin releases.

- Fall-run escapement to the natural spawning areas of the Mokelumne River was predominately hatchery-origin salmon, primarily MOK bay/delta releases.

- The fall-run escapements in the Stanislaus and Tuolumne rivers were mostly hatchery-origin salmon, with stray MOK bay/delta releases being the highest contributor, distantly followed by stray MER bay/delta releases.

- Fall-run escapement to the natural spawning areas of the Merced River was primarily natural-origin salmon. Similar to the return at MER, this was the lowest hatchery contribution observed since the CFM program was fully implemented. Stray MOK bay/delta releases were the highest-contributing release type, distantly followed by MER in-basin and MER bay/delta releases.

- For age-2 fall-run salmon, both FRH and MOK non-acclimated Golden Gate releases had the highest CV escapement recovery rates for their cohort, followed by NIM

bay/delta, FRH bay/delta, and MOK barge study (excluding the in-river control group) releases. The release types with the highest stray rates among this cohort were all produced at MOK, specifically the coastal (Pillar Point), Golden Gate, barge study (excluding the in-river control group), and bay/delta releases. Releases from other hatcheries and MOK in-basin releases all had substantially lower stray rates.

- For age-3 fall-run salmon, FRH bay/delta, MOK barge study (excluding the in-river control group), and MOK coastal (Pillar Point) releases had the highest CV escapement recovery rates for their cohort. Both bay/delta and non-acclimated trucked releases from MER had extremely high stray rates approaching 100%. MOK coastal (Pillar Point), FRH rice field study (excluding the in-river control group), and MOK barge study (excluding the in-river control group) releases also had high stray rates that exceeded 50%.

- For age-4 fall-run salmon, both bay/delta and coastal (Pillar Point) releases from FRH had the highest CV escapement recovery rates for their cohort. CFH bay/delta releases from this brood returned entirely to non-natal basins (i.e., stray rate of 100%). The next highest stray rate was MOK bay/delta releases at 50%, however there were only two inland recoveries of this release type.

- Most (74%) of the total CV river sport harvest was of hatchery origin, with the largest contributors being FRH fall-run bay/delta releases and CFH fall-run in-basin releases. The American River was the only fishery sector where in-basin hatchery fish did not compose a majority of the harvest, as NIM releases only accounted for 45% of the catch. Strays from MOK represented 47% of the American River sport harvest.

- Over half and two-thirds of the California ocean sport and commercial harvest, respectively, was composed of hatchery-origin fish. Bay/delta fall-run releases from FRH and MOK contributed heavily to the total harvest in both fisheries. There were also moderate contributions from CFH fall-run in-basin, NIM fall-run bay/delta, and MOK fall-run coastal releases. Non-CV hatchery production contributed moderately to the ocean harvest in the Eureka/Crescent City and Fort Bragg port areas, but contributed very little in the San Francisco and Monterey port areas which combined accounted for 89% and 75% of the total sport and commercial ocean harvest, respectively.

- Coastal net pen fall-run releases that took place in Pillar Point and non-acclimated Golden Gate fall-run releases (including those that were barged to the Golden Gate), both of which were produced at MOK and FRH, had the highest ocean recovery rates among all release types and broods. In most instances, their ocean recovery rates were several times greater than the rates for bay/delta net pen fall-run releases of the same cohort. Stray rates for these release types were substantially higher among those that were produced at MOK. Pillar Point coastal releases from MOK had stray rates of 84% and 72% at ages 2 and 3, respectively, compared to those produced at FRH (age-4 only) which strayed at 14%. Golden Gate releases from MOK strayed at 77% while those from FRH strayed at 15% (both age-2).

- Among the coastal net pen release locations, Pillar Point releases from MOK (ages 2 and 3) and FRH (age-4) had both the highest CV and ocean recovery rates. The CV recovery rates for Santa Cruz/Moss Landing releases (MOK) were very low. While the ocean recovery rates for Santa Cruz/Moss Landing releases were not necessarily low, they were much lower than Pillar Point releases for cohorts that had both release types (i.e., 2014 and 2016 broods). However, as mentioned above, half of the brood year 2014 (age-4) Moss Landing net pen release group was actually released into bay/delta net pens after encountering permitting issues with Moss Landing fish releases.

- CV recoveries of late-fall- and spring-run releases were primarily age-3 salmon, after being dominated by age-2 salmon in 2017. Since all late-fall-run hatchery production is released in-basin and all spring-run hatchery production has been released in-basin since brood year 2014 (age-4), these results suggest low outmigrant survival for these hatchery run types prior to brood year 2015, likely due to in-river drought conditions.

- Among age-2 barge study releases, salmon that were barged from the Mokelumne River to the Golden Gate had the highest CV and ocean recovery rates but also had the highest stray rate. Salmon that were trucked to Sausalito and then barged to the Golden Gate had the next highest stray and ocean recovery rates but had a CV recovery rate slightly less than the in-river control group. Salmon that were released directly into the Mokelumne River as part of the control group had a substantially lower stray rate than either of the other treatments but also had a much lower ocean recovery rate.

- Among age-3 barge study releases, salmon that were barged from the Mokelumne River to the Golden Gate had the highest CV and ocean recovery rates. Salmon that were trucked to Tiburon and then barged to the Golden Gate had the next highest CV and ocean recovery rates, although the CV recovery rate was less than half of those that were barged the entire distance. Both of these treatments exhibited high stray rates, with those that were trucked to Tiburon being the highest. Salmon that were released directly into the Mokelumne River as part of the control group had a much lower stray rate but also had substantially lower CV and ocean recovery rates than either of the other treatments.

- Due to low river flows caused by drought conditions, there was no barge study conducted for brood year 2014 (age-4).

- This is the second report in the series that has recovery data for non-experimental FRH fall-run in-basin releases (ages 2 and 3), providing another year of recovery and stray rate comparisons between in-basin and out-of-basin FRH fall-run releases from the same brood. Results from 2018 suggest lower survival but less straying for in-basin releases. Among age-2 FRH fall-run, CV and ocean recovery rates for in-basin releases were 107 and 85 CWTs per 100,000 released, respectively, compared to 165 and 146, respectively, for bay/delta releases. The difference was much more drastic among age-3 FRH fall-run, as in-basin releases had CV and ocean recovery rates of

21 and 6 CWTs per 100,000 released, respectively, compared to 619 and 298, respectively, for bay/delta releases. In-basin releases had stray rates of 1% and 0% at ages 2 and 3, respectively, compared to 14% and 2%, respectively, for bay/delta releases.

CONCLUSION

A primary goal of this report is to provide information that will be useful in California salmon management, including CV hatchery assessment. As with each of the previous eight CFM reports, the estimates of hatchery contribution and recovery rate by release type presented in this report should be viewed as a “single year snapshot” of salmon escapement and harvest in the CV and California ocean fisheries during 2018. It is highly probable that all of the age-3 and older release types in this report were affected by one of the most significant droughts in California history. Although no discussion section is included, as in earlier CFM reports covering the 2010, 2011, and 2012 escapement and harvest years, the authors plan to further analyze these data as these and additional tagged broods become complete. This report contains the data and analyses needed to determine the contribution of hatchery- and natural-origin salmon to hatchery and natural areas throughout the CV, evaluate hatchery release strategies and programs, improve California ocean and river salmon fisheries management, evaluate the effectiveness of habitat restoration, and determine if other goals of the CFM program are being met on an annual basis. This information, combined with other tools such as cohort reconstruction and harvest models, will allow resource managers to determine the total contribution of various release strategies to CV escapement and to ocean and inland fisheries by time and area.

The CFM program should be continued with the current design to provide comparable, consistent data needed for hatchery and harvest management. A need still exists to secure permanent and comprehensive inland and ocean funding for this marking, tagging, monitoring, and evaluation program. Such funding is essential to providing complete analyses of recovery and stray rates across release strategies, and will allow critical data to be available by February of each year to manage CV salmon stocks, hatchery production, and California ocean and river fisheries in real-time, similar to the Klamath Basin fall-run Chinook salmon management process.

ACKNOWLEDGEMENTS

We express sincere appreciation to the myriad of staff among many agencies that work tirelessly in the field to gather the necessary data and CWT recoveries that provide the basis for this report. They are too numerous to name individually, but without each of them, this valuable analysis would not be possible. We again thank the following agencies for providing 2018 CV escapement estimates and their respective salmon heads or CWT recoveries: CDFW, DWR, FWS, PSMFC, EBMUD, and YARMT. Special thanks are extended to staff at the following hatcheries for their cooperation in this monitoring effort: Coleman National Fish Hatchery, Feather River Hatchery, Nimbus Fish Hatchery, Mokelumne River Hatchery, Merced River Hatchery, and Livingston Stone National Fish Hatchery.

Special kudos are extended to both CDFW Santa Rosa and Sacramento CWT labs for processing over 32,000 salmon heads and recovering, reading, and validating most of the CWTs used in these analyses. Personal thanks are extended to FWS staff Kevin Offill and Kevin Niemela for providing their agency's catch-sample and CWT data and for answering numerous questions for this report, and to CDFW staff Bill Smith, Jeanine Phillips, Brian Erlandsen, Pat Ferguson, Rob Titus, and Steve Tsao for answering questions and providing additional information pertaining to their CV sectors.

Thanks to the following individuals for providing internal review and text edits for this report: FWS staff Kevin Offill and CDFW staff Audrey Dean, Jeanine Phillips, Chris McKibbin, Hideaki Kubo, Erica Meyers, Vanessa Gusman, Ryon Kurth, Jay Rowan, and others.

We, as always, want to acknowledge Stan Allen (PSMFC) and Alice Low (CDFW retired) for their efforts in developing the CFM program and facilitating its funding, staffing, tagging, and coordination needs. Funding for most of the sampling and CWT processing provided by BOR, CDFW, DWR, EBMUD, SFRA, and YARMT.

REFERENCES

Bergman, J., R. Nielson, and A. Low. 2012. Central Valley Chinook Salmon In-River Escapement Monitoring Plan. California Department of Fish and Game. Fisheries Branch Administrative Report 2012-01. Sacramento, CA.

Del Real, C. and C. Hunter. 2019. Lower Mokelumne River Upstream Fish Migration Monitoring Conducted at Woodbridge Irrigation District Dam August 2018 through June 2019. East Bay Municipal Utility District Report. Lodi, CA.

Killam, D. 2019. Salmonid Populations of the Upper Sacramento River Basin in 2018. California Department of Fish and Wildlife (CDFW). Upper Sacramento River Basin Fisheries Program Technical Report 02-2019. Red Bluff, CA.

Kormos, B., M. Palmer-Zwahlen, and A. Low. 2012. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement and Ocean Harvest in 2010. California Department of Fish and Game. Fisheries Branch Administrative Report 2012-02. Santa Rosa, CA.

Letvin, A., M. Palmer-Zwahlen, and B. Kormos. 2020. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2017. Joint CDFW-Pacific States Marine Fisheries Commission (PSMFC) Report. Santa Rosa, CA.

Mohr, M. and W. Satterthwaite. 2013. Coded-Wire Tag Expansion Factors for Chinook Salmon Carcass Surveys in California: Estimating the Numbers and Proportions of Hatchery-Origin Fish. San Francisco Estuary and Watershed Science 11(4).

Pacific Fishery Management Council (PFMC). 2016. Pacific Coast Salmon Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the Coasts of Washington, Oregon, and California as Amended through Amendment 19. PFMC, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220.

PFMC. 2019. Salmon Rebuilding Plan for Sacramento River Fall Chinook. PFMC, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220.

PFMC. 2020. Review of 2019 Ocean Salmon Fisheries: Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan. PFMC, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220.

Palmer-Zwahlen, M., V. Gusman, and B. Kormos. 2018. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2013. Joint PSMFC-CDFW Report. Santa Rosa, CA.

Palmer-Zwahlen, M., V. Gusman, and B. Kormos. 2019a. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2014. Joint PSMFC-CDFW Report. Santa Rosa, CA.

Palmer-Zwahlen, M., V. Gusman, and B. Kormos. 2019b. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2015. Joint PSMFC-CDFW Report. Santa Rosa, CA.

Palmer-Zwahlen, M. and B. Kormos. 2013. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement and Ocean Harvest in 2011. California Department of Fish and Wildlife. Fisheries Branch Administrative Report 2013-02. Santa Rosa, CA.

Palmer-Zwahlen, M. and B. Kormos. 2015. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2012. California Department of Fish and Wildlife. Fisheries Branch Administrative Report 2015-04. Santa Rosa, CA.

Palmer-Zwahlen, M. and B. Kormos. 2020. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2016. Joint PSMFC-CDFW Report. Santa Rosa, CA.

LIST OF ACRONYMS AND ABBREVIATIONS

- Ad-clipped clipped adipose fin
- BOR U.S. Bureau of Reclamation
- BY Brood year
- CDFW California Department of Fish and Wildlife
- CFH Coleman National Fish Hatchery
- CFM Constant Fractional Marking
- CV California Central Valley
- CWT coded-wire tag
- DPD Daguerre Point Dam (Yuba River)
- DWR California Department of Water Resources
- EBMUD East Bay Municipal Utilities District
- FRH Feather River Hatchery
- FWS U.S. Fish and Wildlife Service
- MBTSP Monterey Bay Trout and Salmon Project
- MER Merced River Hatchery
- MOK Mokelumne River Hatchery
- NMFS National Marine Fisheries Service
- NIM Nimbus Fish Hatchery
- OSP Ocean Salmon Project
- PFMC Pacific Fishery Management Council
- PSMFC Pacific States Marine Fisheries Commission
- RMPC Regional Mark Processing Center
- SFRA Sport Fish Restoration Act
- SJ San Joaquin
- SJRRP San Joaquin River Restoration Program
- TL Total length
- WD Woodbridge Dam (Mokelumne River)
- YARMT Yuba Accord River Management Team

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Table 1a. Estimation and sampling methods used for the 2018 CV Chinook hatchery escapement.

Sampling Location	Estimation and Sampling Methods	Agency
Hatchery Spawners		
Coleman National Fish Hatchery (CFH) Fall and Late-Fall (2019)	Direct count. All fish examined and bio-sampled[a/] for fin-clips, tags, marks. Access upstream of the hatchery closed Aug 1 - Sep 30. Fall-run period: Oct 2 - Nov 8; late-fall-run period: Dec 27 - Mar 1. All ad-clipped fish sampled. Fish returning to CFH from mid-Oct through mid-Dec parsed into run-type based on CWT code recoveries and total run-type proportions by date. Some unmarked phenotypic late-fall-run fish released into Battle Creek above CFH beginning Nov 14. Grilse cutoff: 670 mm females, 770 mm males fall; 570 mm females, 590 mm males late-fall.	FWS
CFH Late-Fall Fish Trap (2019)	Direct count of fish that were trapped Mar 4 - Apr 28 (after CFH spawning operations ceased). All fish examined and bio-sampled for fin-clips, tags, marks. All ad-clipped fish sampled and heads collected for CWT recovery. Any unmarked phenotypic late-fall-run fish are released into Battle Creek above CFH. No additional fish were observed on video in 2018. Grilse cutoff: 570 mm females, 590 mm males.	FWS
Keswick Fish Trap Winter and Late-Fall (2019)	Direct count. All fish examined and bio-sampled for fin-clips, tags, marks. During Feb-Jul, all unmarked fish electronically sampled for presence of CWT and genetically tested to ensure winter-run broodstock. To promote genetic integrity of CFH broodstock, Keswick fish trap was also utilized to collect late-fall-run during Dec-Feb. Grilse cutoff: 610 mm females, 690 mm males winter; 570 mm females, 590 mm males late-fall.	FWS
Feather River Hatchery (FRH) Spring and Fall	Direct count. All fish examined for fin-clips, tags, marks. Fish arriving at the hatchery May 21 - Jun 25 (n~ 3,206) were considered "spring-run" and marked with uniquely-numbered dart tags prior to release back into the Feather River. Only fish marked with dart tags returning to FRH in fall were spawned as spring-run. All remaining fish were considered fall-run. FRH fish ladder opened Sep 14 and spring spawning began Sep 18. All spring-run fish bio-sampled. Fall spawning occured on Oct 1 for the cold water program and began normally on Oct 10. Systematic random bio-sample ~20% of all fish for fall-run until Oct 8, when the rate was reduced to 10%. The rate returned to 20% mid-day on Oct 29 until the following day, when the rate was again reduced to 10% until Dec 12. On Dec 12, the bio-sample rate returned to 20% for the remainder of the season. All ad-clipped fish were sampled and heads collected for CWT recovery. Grilse cutoff: 650 mm spring and fall.	CDFW
Nimbus Fish Hatchery (NIM) Fall	Direct count. NIM ladder open Nov 2 - Jan 8. All fish examined for fin-clips, tags, marks. Systematic random bio-sample of 20% of total fish. All ad-clipped fish sampled and heads collected for CWT recovery. Grilse cutoff: 685 mm.	CDFW
Mokelumne River Hatchery (MOK) Fall	Direct count. MOK open Oct 16 - Jan 31. All fish examined for fin-clips, tags, marks. Systematic random bio-sample 20% of total fish%. All ad-clipped fish sampled and heads collected for CWT recovery. Grilse cutoff: 640 mm females, 680 mm males.	CDFW
Merced River Hatchery (MER) Fall	Direct count. MER open Oct 18 - Dec 13. All fish examined for fin-clips, tags, marks. All ad-clipped fish were sampled and heads processed for CWT recovery. Grilse cutoff: 610 mm females, 710 mm males.	CDFW

[a/] Biological sampling ("bio-samples" or "bio-data") of live fish or carcasses may include observed tags or marks, sex, fork length, scales, carcass condition, spawning condition, and heads collected from ad-clipped fish for CWT recovery.

Table 1b. Estimation and sampling methods used for the 2018 CV Chinook natural escapement. (Page 1 of 2)

Sampling Location	Estimation and Sampling Methods	Agency
Natural Spawners		
Upper Sacramento River Mainstem Winter, Fall, and Late-Fall (2019)	Population estimate for each run produced utilizing five-step process: 1) Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate using all females within carcass survey area (Balls Ferry Bridge to Keswick Dam). 2) Total female escapement estimate in upper Sacramento River is derived using expansions for females spawning outside of the survey area (Princeton to Balls Ferry) through aerial redd surveys. 3) Adult male escapement estimated using adult sex ratio of live fish counts at CFH or Keswick Trap. 4) Grilse escapement estimated using survey ratio of fresh adult males to fresh grilse. 5) Addition of any fish removed for hatchery brood stock purposes. All fish in carcass survey examined for fin-clips, tags, marks, and condition (e.g., fresh, non-fresh, skeleton). Bio-data[a/] collected from all fresh fish. Systematic random bio-sample may occur if carcass counts expected to be high. All ad-clipped fish (fresh and non-fresh), including "unknown" ad-clipped status, were sexed, measured and heads collected for CWT recovery. Grilse cutoff: 620 mm females, 705 mm males winter; 670 mm females, 760 mm males fall; 610 mm females, 620 mm males late-fall.	CDFW, FWS
Clear Creek Fall	Video Station count used to estimate population. Supplemental bio-sampling survey used to estimate biological characteristics of the population (age, sex, hatchery-origin, spawn sucess). All fish in carcass survey examined for fin-clips, tags, marks, and condition (e.g., fresh, non-fresh, skeleton). Bio-data collected from all fresh fish. All ad-clipped fish (fresh and non-fresh), including "unknown" ad-clipped status, were sampled and heads collected for CWT recovery. Grilse cutoff: 660 mm female, 735 mm male.	CDFW, FWS
Cow Creek Fall	Video weir count in lower creek used to determine total escapement. Kayak surveys conducted to collect bio-data from fresh fish. Opportunistic collection of CWTs, however only seven carcasses observed. Due to low sample size, bio-sampling data from Clear Creek used as a surrogate.	CDFW
Battle Creek Fall	Video weir count (Aug 21 - Dec 4) in lower creek used to determine total fall-run escapement. Natural fall-run escapement into Battle Creek calculated by substracting CFH fall-run return from total run. Surrogate CWTs based on hatchery proportion and CWT composition of CFH fall-run return. Grilse cutoff: 670 mm females, 770 mm males.	CDFW
Cottonwood Creek Fall	Video weir count (Sep 24 - Dec 15) in lower creek used to determine total escapement. Kayak surveys conducted to collect bio-data from fresh fish, however only one carcass was observed. Due to low sample size, bio-sampling data from Clear Creek used as a surrogate.	CDFW
Mill Creek Fall	Video counts at Ward Dam in lower Mill Creek plus expanded redd count between Ward Dam and the Sacramento River confluence used to determine total escapement. Bio-sampling surveys conducted to collect bio-data from fresh fish, however only three unmarked carcasses observed. Due to low sample size, bio-sampling data from Clear Creek used as a surrogate.	CDFW
Deer Creek Fall	Video counts at Stanford Vina Ranch Irrigation Company (SVRIC) Dam plus expanded redd count between SVRIC Dam and the Sacramento River confluence used to determine total escapement. Kayak surveys conducted to collect bio-data from fresh fish, however no carcasses were observed. Due to low sample size, bio-sampling data from Clear Creek used as a surrogate.	CDFW

Table 1b. Estimation and sampling methods used for the 2018 CV Chinook natural escapement. (Page 2 of 2)

Sampling Location	Estimation and Sampling Methods	Agency
Natural Spawners cont.		
Butte Creek Spring and Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate for spring-run, however fall-run sampling was limited due to the Camp Fire and too few carcasses (n=14, none recaptured) were handled to utilize this methodology, so the fall-run estimate is the number of carcasses handled. All fish examined for fin-clips, tags, marks. Systematic random bio-sample of all fish. No ad-clipped fish were observed in the spring-run survey. Grilse cutoff: 600 mm spring, 650 mm fall.	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 fresh fish. All ad-clipped fresh fish sampled and heads collected for CWT recovery. Escapement estimate includes spring-run. Grilse cutoff: 650 mm.	DWR
Yuba River Fall	Above Daguerre Point Dam (DPD): Vaki Riverwatcher direct count of escapement and ad-clipped fish. Supplemental carcass survey to collect bio-data and heads from ad-clipped fish (fresh fish only). Below DPD: Mark-recapture estimate not used in 2018 due to a low number of fresh carcasses (n=24) and no recaptures, so estimate derived from number of fresh carcasses observed. All fish examined for fin-clips, tags, marks, and condition. All ad-clipped fresh fish sampled and heads collected for CWT recovery. Escapement estimate includes spring-run. Grilse cutoff: 650 mm.	CDFW, YARMT
American River Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate, including all fish trapped between Nimbus Dam and the Nimbus Fish Hatchery weir, and all dead fish ("washbacks") that were sampled on the weir. All fish examined for fin-clips, tags, marks, and condition. Systematic random bio-sample of all fish. All ad-clipped fish sampled and heads collected for CWT recovery. Grilse cutoff: 680 mm females, 740 mm males.	CDFW
Mokelumne River Fall	Video count at Woodbridge Irrigation District Dam (WIDD) used to determine total escapement and ad-clipped fish above WIDD. Natural spawner escapement estimate and ad-clip rate calculated by subtracting total count and number of ad-clipped fish returning to MOK. Supplemental carcass survey to collect bio-data from fresh fish and heads from all ad-clipped fish. Grilse cutoff: 700 mm.	EBMUD
Stanislaus River Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate. All fresh fish examined for fin-clips, tags, marks. All fresh ad-clipped fish sampled and heads collected for CWT recovery. Grilse cutoff: 610 mm females, 710 mm males.	CDFW
Tuolumne River Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate. All fish examined for fin-clips, tags, marks, and condition. All ad-clipped fish sampled and heads collected for CWT recovery. Opportunistic sampling of ad-clipped fish on Tuolumne Weir (i.e., "washbacks"). Grilse cutoff: 610 mm females, 710 mm males.	CDFW
Merced River Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate. All fresh fish examined for fin-clips, tags, marks. All fresh ad-clipped fish sampled and heads collected for CWT recovery. Grilse cutoff: 610 mm females, 710 mm males.	CDFW

[a/] Biological sampling ("bio-samples" or "bio-data") of live fish or carcasses may include observed tags or marks, sex, fork length, scales, carcass condition, spawning condition, and heads collected from ad-clipped fish for CWT recovery.

Table 1c. Survey design and open dates for the 2018 CV Chinook river sport harvest.

Sampling Location	Survey Design and Open Dates	Agency
Sport Harvest		
	Survey Design	
Central Valley Angler Survey (CVAS)	Stratified-random sampling design (four weekday and four weekend samples per month per section during the open season in each management zone) that included roving counts, roving interviews, access interviews, and sub-sampling of kept salmon. Almost all ad-clipped salmon sampled and heads collected for CWT recovery. Estimates of fishing effort, catch, and harvest of Chinook salmon made monthly for each survey section and then summed for the season total. Grilse cutoff for Sacramento Basin fall-run fishery sectors: 703 mm females, 721 mm males.	CDFW
	Open Dates	
Upper Sacramento River Fall and Late-Fall	Open Aug 1 - Dec 16 from the Deschutes Road Bridge to Red Bluff Diversion Dam and Jul 16 - Dec 16 from Red Bluff Diversion Dam to the Highway 113 bridge near Knights Landing. Nov 1 is used to delineate the cutoff between the fall-run fishery and the late-fall-run fishery.	
Feather River Fall	Open Jul 16 - Oct 15 from the unimproved boat ramp above the Thermalito Afterbay Outfall to 200 yards above the Live Oak boat ramp and Jul 16 - Dec 16 from 200 yards above the Live Oak boat ramp to the Sacramento River confluence.	
American River Fall	Open Jul 16 - Oct 31 from the USGS cable crossing to the SMUD power line crossing, Jul 16 - Dec 31 from the SMUD power line crossing to the Jibboom Street Bridge, and Jul 16 - Dec 16 from the Jibboom Street Bridge to the Sacramento River confluence. Beginning in 2018, closed from Nimbus Dam to the USGS cable crossing.	
Lower Sacramento River Fall	Open Jul 16 - Dec 16 from the Highway 113 bridge near Knights Landing to the Carquinez Bridge.	
Mokelumne River Fall	Open Jul 16 - Oct 15 from Camanche Dam to the Highway 99 Bridge, Jul 16 - Dec 31 from the Highway 99 Bridge to Woodbridge Dam, including Lodi Lake, and Jul 16 - Dec 16 from the Lower Sacramento Road bridge to the San Joaquin River confluence.	
	Bag and Size Limit	
All Areas	1 Chinook salmon per day (decrease from prior years); no minimum size limit.	

Table 2. California ocean salmon sport and commercial fishery seasons by major port area, 2018.

	Sport Fishery			Commercial Fishery			
Major Port Area	Season	Size Limit[a/]	Days Open	Season	Size Limit[a/]	Days Open	Quota[b/]
Eureka/Crescent City (Klamath Mgmt Zone)	June 1 - September 3	20" TL	95	May 1 - 29 (Fri - Tue)	26" TL	21	3,600
				June 1 - 30 (Fri - Tue)	26" TL	22	6,650
				July 1 - 31 (Fri - Tue)	26" TL	23	6,612
				August 3 - 31 (Fri - Tue)	26" TL	21	9,423
						87	
Fort Bragg	June 17 - October 31	20" TL	137	July 26 - 31	26" TL	6	
				August 3 - 29	26" TL	27	
				September 1 - 30	26" TL	30	
						63	
San Francisco	June 17 - October 31	20" TL	137	July 26 - 31	26" TL	6	
				August 3 - 29	26" TL	27	
				September 1 - 30	26" TL	30	
				October 1 - 5, 8 - 12[c/]	26" TL	10	
						73	
Monterey[d/]	April 7 - July 2	24" TL	87	May 1 - 7	26" TL	7	
				June 19 - 30	26" TL	12	
						19	
California Total			456			242	

a/ Size limit in inches total length (TL).

b/ Klamath Management Zone commercial quotas during June, July, and August were increased in-season on an impact neutral basis due to the quota not being attained in the prior month. A daily bag and possession limit ranging between 20 and 50 fish per vessel was in effect during all quota fisheries.

c/ Open Monday through Friday between Pt. Reyes and Pt. San Pedro.

d/ Regulations apply from the Monterey area to the U.S./Mexico border.

Table 3. Central Valley coded-wire tag (CWT) Chinook releases recovered in 2018 by age, run, stock, and release type. (Page 1 of 2)

Age-2 CWT releases

Release type*	Brood year	Hatchery / wild	Stock origin	Run type	CWT codes	# CWT tagged	Total fish released	% CWT	Release strategy	Release locations / notes
SacW	2016	LSH	Sac R	Wint	5	138,803	141,332	98%	In-basin	Sacramento River (Lake Redding Park)
FRHS	2016	FRH	Fea R	Spr	5	1,682,317	1,699,791	99%	In-basin	Feather River (Boyds Pump Ramp & Gridley)
SJOSx	2016	SJO	San Joa R	Spr	5	90,600	90,600	100%	Experimental	In-basin reintroduction releases progeny of captive FRH-origin broodstock
CFHFh	2016	CFH	Sac R	Fall	28	3,020,565	12,184,997	25%	Hatchery	CFH only
FRHF	2016	FRH	Fea R	Fall	5	1,029,808	1,037,894	99%	In-basin	Feather River (Boyds Pump Ramp)
FRHFn	2016	FRH	Fea R	Fall	6	733,880	2,900,225	25%	Bay/Delta pens	San Pablo Bay (Mare Island) net pen releases
FRHFgg	2016	FRH	Fea R	Fall	2	263,611	1,059,692	25%	Trucked	Golden Gate release; trucked to Fort Baker
NIMF	2016	NIM	Ame R	Fall	4	591,200	2,367,561	25%	In-basin	American River (Jibboom Street Bridge & Sunrise Recreation Area)
NIMFn	2016	NIM	Ame R	Fall	2	277,532	1,113,203	25%	Bay/Delta pens	San Pablo Bay (Mare Island) net pen releases
MOKF	2016	MOK	Mok R	Fall	2	398,284	398,784	100%	In-basin	Mokelumne River (Hatchery and Woodbridge Dam)
MOKFn	2016	MOK	Mok R	Fall	12	1,155,829	4,640,819	25%	Bay/Delta pens	Western Delta (Sherman Island) net pen releases
MOKFnc	2016	MOK	Mok R	Fall	2	841,802	852,419	99%	Coastal pens	86% released in Pillar Point; 14% released in Santa Cruz
MOKFb	2016	MOK	Mok R	Fall	3	295,120	301,692	98%	Barge study	3 release sites: Mok R (Miller's Ferry), barged (SF Bay), trucked (Sausalito)
MOKFgg	2016	MOK	Mok R	Fall	1	225,243	225,870	100%	Trucked	Golden Gate release; trucked to Fort Baker
MERF	2016	MER	Mer R	Fall	3	245,340	1,334,843	18%	Hatchery	MER only
CFHLh	2017	CFH	Sac R	Late	14	1,047,211	1,063,413	98%	Hatchery	CFH (includes spring surrogate & small experimental releases)
			Total age-2 releases:		99	12,037,145	31,413,135	38%		

Age-3 CWT releases

Release type*	Brood year	Hatchery / wild	Stock origin	Run type	CWT codes	# CWT tagged	Total fish released	% CWT	Release strategy	Release locations / notes
SacW	2015	LSH	Sac R	Wint	9	415,865	419,690	99%	In-basin	Sacramento River (Lake Redding Park)
FRHS	2015	FRH	Fea R	Spr	5	2,109,278	2,124,688	99%	In-basin	Feather River (Boyds Pump Ramp & Gridley)
SJOSx	2015	SJO	San Joa R	Spr	3	105,424	105,424	100%	Experimental	In-basin reintroduction releases progeny of captive FRH-origin broodstock
CFHFh	2015	CFH	Sac R	Fall	29	3,033,741	12,160,858	25%	Hatchery	CFH only
FRHF	2015	FRH	Fea R	Fall	1	246,501	992,283	25%	In-basin	Feather River (Boyds Pump Ramp)
FRHFn	2015	FRH	Fea R	Fall	14	2,019,877	8,130,003	25%	Bay/Delta pens	San Pablo Bay (Mare Island, Wickland Oil) net pen releases
FRHFk	2015	FRH	Fea R	Fall	3	101,134	101,134	100%	Experimental	Yolo Bypass experimental (Knaggs Ranch rice field study)
NIMF	2015	NIM	Ame R	Fall	4	692,262	2,770,112	25%	In-basin	American River (Jibboom Street Bridge & Sunrise Recreation Area)
NIMFn	2015	NIM	Ame R	Fall	2	349,016	1,397,391	25%	Bay/Delta pens	San Pablo Bay (Mare Island) net pen releases
MOKF	2015	MOK	Mok R	Fall	2	401,194	402,706	100%	In-basin	Mokelumne River (Hatchery and Woodbridge Dam)
MOKFn	2015	MOK	Mok R	Fall	13	1,339,629	5,367,009	25%	Bay/Delta pens	Western Delta (Sherman Island) net pen releases
MOKFnc	2015	MOK	Mok R	Fall	1	484,920	486,138	100%	Coastal pens	Pillar Point net pens; acclimated 1-2 weeks
MOKFb	2015	MOK	Mok R	Fall	3	302,730	303,235	100%	Barge study	3 release sites: Mok R (Miller's Ferry), barged (SF Bay), trucked (Tiburon)
MERFn	2015	MER	Mer R	Fall	3	148,804	273,470	54%	Bay/Delta pens	Western Delta (Sherman Island) net pen releases
MERFt	2015	MER	Mer R	Fall	2	97,228	280,784	35%	Trucked	San Joaquin River at Jersey Point
CFHLh	2016	CFH	Sac R	Late	8	594,043	630,175	94%	Hatchery	CFH (includes spring surrogate & small experimental releases)
CFHLe	2016	CFH	Sac R	Late	6	450,662	471,309	96%	Emergency	Trucked to Balls Ferry
			Total age-3 releases:		108	12,892,308	36,416,409	35%		

Table 3. Central Valley coded-wire tag (CWT) Chinook releases recovered in 2018 by age, run, stock, and release type. (Page 2 of 2)

Age-4 CWT releases

Release type*	Brood year	Hatchery	Stock origin	Run type	CWT codes	# CWT tagged	Total fish released	% CWT	Release strategy	Release locations / notes
SacW	2014	LSH	Sac R	Wint	7	590,623	609,311	97%	In-basin	Sacramento River (Lake Redding Park)
FRHS	2014	FRH	Fea R	Spr	7	1,690,972	1,708,640	99%	In-basin	Feather River (Boyds Pump Ramp & Gridley)
SJOSx	2014	SJO	San Joa R	Spr	1	54,839	54,839	100%	Experimental	In-basin reintroduction releases progeny of captive FRH-origin broodstock
CFHFn	2014	CFH	Sac R	Fall	28	2,951,944	11,846,951	25%	Bay/Delta pens	Western Delta (Rio Vista) net pen releases
FRHFn	2014	FRH	Fea R	Fall	4	1,047,852	4,191,625	25%	Bay/Delta pens	San Pablo Bay (Mare Island, Crockett) net pen releases
FRHFnc	2014	FRH	Fea R	Fall	1	321,527	331,177	97%	Coastal pens	Pillar Point net pens; acclimated 1-2 weeks
FRHFtib	2014	FRH	Fea R	Fall	1	10,336	10,356	100%	Bay/Delta pens	Tiburon net pens; acclimated 1 week
FRHFk	2014	FRH	Fea R	Fall	1	45,200	45,200	100%	Experimental	Yolo Bypass experimental (Knaggs Ranch rice field study)
NIMFn	2014	NIM	Ame R	Fall	6	979,827	3,932,549	25%	Bay/Delta pens	San Pablo Bay (Mare Island, Wickland Oil) net pen releases
MOKFn	2014	MOK	Mok R	Fall	13	1,244,314	4,998,641	25%	Bay/Delta pens	Western Delta (Sherman Island) net pen releases
MOKFnc	2014	MOK	Mok R	Fall	1	241,335	243,164	99%	Mixed pens	50% released in Moss Landing; 50% released in SF Bay
MERFn	2014	MER	Mer R	Fall	1	37,064	144,392	26%	Bay/Delta pens	Western Delta (Sherman Island) net pen releases
MERFt	2014	MER	Mer R	Fall	4	238,408	855,714	28%	Trucked	San Joaquin River at Jersey Point
CFHLh	2015	CFH	Sac R	Late	7	463,924	474,938	98%	Hatchery	CFH (includes spring surrogate & small experimental releases)
CFHLe	2015	CFH	Sac R	Late	6	420,514	433,404	97%	Emergency	Trucked to Balls Ferry
			Total age-4 releases:		88	10,338,679	29,880,901	35%		

Age-5 CWT releases (with recoveries in 2018)

Release type*	Brood year	Hatchery	Stock origin	Run type	CWT codes	# CWT tagged	Total fish released	% CWT	Release strategy	Release locations / notes
CFHFh	2013	CFH	Sac R	Fall	4	1,125,706	4,506,160	25%	Hatchery	CFH only
CFHFn	2013	CFH	Sac R	Fall	11	1,810,972	7,273,847	25%	Bay/Delta pens	Western Delta (Rio Vista) net pen releases
FRHFn	2013	FRH	Fea R	Fall	5	1,459,468	5,906,741	25%	Bay/Delta pens	San Pablo Bay (Wickland Oil) net pen releases
NIMFn	2013	NIM	Ame R	Fall	4	896,419	3,587,565	25%	Bay/Delta pens	San Pablo Bay (Mare Island) net pen releases
MOKFn	2013	MOK	Mok R	Fall	11	1,148,423	4,604,315	25%	Bay/Delta pens	Western Delta (Sherman Island) net pen releases

***CWT release types:**

Sacramento River fall Chinook release types (SFC)

CFHFh	Coleman National Fish Hatchery fall hatchery releases
CFHFn	Coleman National Fish Hatchery fall bay/delta net pen releases
FRHF	Feather River Hatchery fall in-basin releases
FRHFn	Feather River Hatchery fall bay/delta net pen releases
FRHFnc	Feather River Hatchery fall coastal net pen releases
FRHFtib	Feather River Hatchery fall Tiburon net pen releases
FRHFgg	Feather River Hatchery fall Golden Gate releases (no net pens)
FRHFk	Feather River Hatchery fall experimental Knaggs Ranch releases
NIMF	Nimbus Fish Hatchery fall in-basin releases
NIMFn	Nimbus Fish Hatchery fall bay/delta net pen releases

Other CV Chinook release types (OCV)

MOKF	Mokelumne River Hatchery fall in-basin releases
MOKFn	Mokelumne River Hatchery fall bay/delta net pen releases
MOKFnc	Mokelumne River Hatchery fall coastal net pen releases
MOKFb	Mokelumne River Hatchery fall barge study releases
MOKFgg	Mokelumne River Hatchery fall Golden Gate releases (no net pens)
MERF	Merced River Hatchery fall in-basin releases
MERFn	Merced River Hatchery fall bay/delta net pen releases
MERFt	Merced River Hatchery fall trucked releases (no net pens)
SacW	Livingston Stone National Fish Hatchery winter in-basin releases
FRHS	Feather River Hatchery spring in-basin releases
SJOSx	San Joaquin Salmon Conservation and Research Facility spring experimental releases
CFHLh	Coleman National Fish Hatchery late-fall hatchery releases
CFHLe	Coleman National Fish Hatchery late-fall emergency trucked releases (no net pens)

Table 4. Central Valley hatchery and natural area escapement estimates, sport harvest, and sample data, 2018.

Central Valley Survey	Run	Total Escapement or Harvest	Chinook Sampled[a/]	Observed Ad-Clips	Heads Processed	Valid CWTs	Sample rate (fe)	Ad-clips processed (fa)	Valid CWTs (fd)	CWT F_{samp}
Hatchery Escapement										
Keswick Dam Fish Trap	Winter	180	180	154	154	150	1.000	1.000	1.000	1.00
Feather River Hatchery	Spring	2,110	2,110	1,864	1,863	1,843	1.000	0.999	0.998	1.00
Coleman National Fish Hatchery	Fall	14,198	14,198	3,130	3,123	3,074	1.000	0.998	0.997	1.00
Feather River Hatchery	Fall	28,356	28,356	7,969	7,968	7,850	1.000	1.000	0.999	1.00
Nimbus Fish Hatchery	Fall	6,212	6,212	1,818	1,818	1,771	1.000	1.000	0.998	1.00
Mokelumne River Hatchery	Fall	7,420	7,420	2,448	2,448	2,424	1.000	1.000	1.000	1.00
Merced River Hatchery	Fall	903	903	140	140	139	1.000	1.000	1.000	1.00
Coleman National Fish Hatchery	Late-fall[b/]	8,094	8,094	7,884	7,870	7,708	1.000	0.998	0.991	1.01
Coleman Hatchery Fish Trap	Late-fall[b/]	83	83	83	82	81	1.000	0.988	0.988	1.00 [c/]
Keswick Dam Fish Trap	Late-fall[b/]	13	13	2	2	2	1.000	1.000	1.000	1.00
Total Hatchery Escapement		**67,569**	**67,569**	**25,492**	**25,468**	**25,042**				
Natural Area Escapement										
Upper Sacramento River (above Princeton)	Winter	2,458	1,096	901	898	873	0.446	0.997	0.995	2.27 [d/]
Butte Creek	Spring	2,362	1,010	0	0	0	0.428	-	-	-
Upper Sacramento River (above Princeton)	Fall	9,436	2,035	113	113	104	0.216	1.000	0.990	5.59 [d/]
Clear Creek	Fall	8,547	281	16	15	15	0.033	0.938	1.000	32.44
Battle Creek	Fall	9,931	9,931	Video count only		2,148 [e/]	1.000	-	-	1.00
Cow Creek[f/]	Fall	1,165	7	Video - opportunistic CWTs		1	0.006	-	-	1.00
Cottonwood Creek[f/]	Fall	453	1	Video - opportunistic CWTs		1	0.002	-	-	1.00
Mill Creek[f/]	Fall	611	21	Video - opportunistic CWTs		5	0.034	-	-	1.00
Deer Creek[f/]	Fall	124	4	Video - no CWTs observed		0	0.032	-	-	-
Butte Creek	Fall	14	14	1	1	1	1.000	1.000	1.000	1.00
Feather River	Fall	45,826	2,742	660	653	619	0.060	0.989	1.000	16.89 [d/]
Yuba River	Fall	3,073	127	58	58	56	0.041	1.000	1.000	24.20 [d/]
American River[g/]	Fall	21,092	12,238	3,444	3,434	3,270	0.580	0.997	0.998	1.73
Mokelumne River	Fall	10,055	10,055	3,096	803	774	1.000	0.259	0.999	3.86 [h/]
Stanislaus River	Fall	2,377	570	135	135	129	0.240	1.000	1.000	4.17 [d/]
Tuolumne River	Fall	1,077	715	105	102	94	0.664	0.971	1.000	2.05 [d/]
Merced River	Fall	878	136	14	14	12	0.155	1.000	1.000	6.46 [d/]
Upper Sacramento River (above Princeton)	Late-fall[b/]	2,985	403	108	108	103	0.135	1.000	0.990	8.98 [d/]
Total Natural Area Escapement		**122,464**	**41,386**	**8,651**	**6,334**	**8,205**				
CV Sport Harvest										
Upper Sacramento River (above Feather River)	Fall	7,203	417	83	69	68	0.058	0.831	1.000	20.78
Lower Sacramento River (below Feather River)	Fall	5,373	226	60	60	58	0.042	1.000	1.000	23.77
Feather River	Fall	11,387	930	184	173	169	0.082	0.940	1.000	13.02
American River	Fall	1,046	45	17	17	17	0.043	1.000	1.000	19.69 [c/]
Mokelumne River	Fall	648	69	15	13	13	0.106	0.867	1.000	10.84
Upper Sacramento River (above Feather River)	Late-fall	474	57	39	38	36	0.120	0.974	1.000	8.53
Total Sport Harvest		**26,131**	**1,744**	**398**	**370**	**361**				
Total Sampled		**110,699**	**34,541**	**32,172**	**33,608**					

a/ Number of Chinook salmon sampled and visually checked for a clipped adipose fin or electronically scanned to check for the presence of a CWT.

b/ Late-fall-run hatchery returns and natural area escapement occurred during late-fall of 2018 through early 2019 (return year 2019).

c/ As calculated, the value for F_{samp} resulted in a hatchery contribution greater than 100%, so it was adjusted downward until the hatchery contribution equaled 100%.

d/ Carcass survey sample expansion factor based on fresh fish only and expanded to all valid CWT recoveries if collected (see Appendix 1).

e/ Battle Creek natural area escapement estimated using Battle Creek video count minus fall return to CFH. Surrogate CWTs based on CFH hatchery proportion and CWT recoveries.

f/ Due to the low sample rate and paucity of CWTs collected, this creek has been excluded from further analyses in this report. CWTs were collected opportunistically (e.g., kayak survey, snorkel survey) and assigned an F_{samp} of 1.00.

g/ Prior versions of this report have evaluated "washbacks" on the Nimbus Fish Hatchery weir separately from the American River carcass survey downstream of the weir. In 2018, these two sectors were merged and one natural area escapement estimate was calculated for the entire American Basin.

h/ Mokelumne River natural area escapement CWTs collected on spawning grounds and expanded based on total ad-clip count observed via video weir (see Appendix 5).

Table 5. Total harvest and sample data for 2018 ocean salmon sport and commercial fisheries by major port area.

Fishery - Port Area	Ocean Harvest	Chinook Sampled[a/]	Observed Ad-Clips	Heads Processed	Valid CWTs	Sample rate (fe)	Ad-clips processed (fa)	Valid CWTs (fd)	CWT F_{samp}
California Sport									
Eureka/Crescent	3,738	1,006	228	226	195	0.269	0.991	1.000	3.75
Fort Bragg	5,698	1,359	308	306	295	0.239	0.994	1.000	4.21
San Francisco	72,187	20,793	4,780	4,726	4,579	0.288	0.989	0.989	3.55
Monterey	5,691	1,093	278	276	267	0.192	0.993	0.989	5.30
	87,314	**24,251**	**5,594**	**5,534**	**5,336**	**0.278**	**0.989**	**0.990**	**3.68**
California Commercial									
Eureka/Crescent	9,011	3,220	747	747	693	0.357	1.000	0.993	2.82
Fort Bragg	10,551	3,120	748	747	708	0.296	0.999	0.994	3.40
San Francisco	39,429	13,160	4,272	4,268	4,170	0.334	0.999	0.997	3.01
Monterey	19,425	6,287	1,288	1,286	1,244	0.324	0.998	0.995	3.11
	78,416	**25,787**	**7,055**	**7,048**	**6,815**	**0.329**	**0.999**	**0.996**	**3.06**
California Total	**165,730**	**50,038**	**12,649**	**12,582**	**12,151**				
Oregon Sport	**4,301**	**1,711**	**302**	**302**	**286**	**0.398**	**1.000**	**0.997**	**2.52**
Oregon Commercial	**24,128**	**11,182**	**1,675**	**1,675**	**1,633**	**0.463**	**1.000**	**0.995**	**2.17**
Oregon Total	**28,429**	**12,893**	**1,977**	**1,977**	**1,919**				

a/ Number of salmon visually checked for a clipped adipose fin or electronically scanned to check for the presence of a CWT.

Table 6. Raw and expanded Chinook CWT recoveries in the Central Valley by run type and brood year during 2018[a/].

Fall-run	2016	2015	2014	2013	Total CV	
Age	2	3	4	5	CWTs	Total CV %
Raw CWT Recoveries [b/]	6,845 (32%)	14,154 (67%)	193 (<1%)	2 (<1%)	21,194	63%
Expanded CWT_{total}	**34,455** (24%)	**108,767** (75%)	**1,444** (<1%)	**7** (<1%)	144,673	89%

Late-Fall-run	2017	2016	2015	2014	Total CV	
Age	2	3	4	5	CWTs	Total CV %
Raw CWT Recoveries	1,226 (15%)	6,682 (84%)	58 (<1%)		7,966	24%
Expanded CWT_{total}	**1,384** (14%)	**8,167** (85%)	**98** (1%)		9,650	6%

Spring-run	2016	2015	2014	2013	Total CV	
Age	2	3	4	5	CWTs	Total CV %
Raw CWT Recoveries	667 (20%)	2,749 (80%)	3 (<1%)		3,419	10%
Expanded CWT_{total}	**860** (16%)	**4,507** (84%)	**3** (<1%)		5,370	3%

Winter-run	2016	2015	2014	2013	Total CV	
Age	2	3	4	5	CWTs	Total CV %
Raw CWT Recoveries	166 (16%)	857 (84%)	2 (<1%)		1,025	3%
Expanded CWT_{total}	**367** (17%)	**1,796** (83%)	**5** (<1%)		2,167	1%

All Runs					Total CV	
Age	2	3	4	5	CWTs	Total CV %
Raw CWT Recoveries [b/]	8,904 (26%)	24,442 (73%)	256 (<1%)	2 (<1%)	33,604	100%
Expanded CWT_{total}	**37,065** (23%)	**123,237** (76%)	**1,550** (<1%)	**7** (<1%)	161,859	100%

a/ Recoveries of age-1, age-6, and tagged natural-origin fish removed.

b/ Includes one age-2 and one age-3 stray fall-run Chinook that were produced at Trinity River Hatchery.

Table 7. Raw and expanded Chinook CWT recoveries in 2018 California ocean fisheries by run type and brood year[a/].

Fall-run	2016	2015	2014	2013	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	3,433 (34%)	6,706 (66%)	72 (<1%)	1 (<1%)	10,212	84%
Expanded CWT$_{total}$	**31,343** (33%)	**63,752** (67%)	**718** (<1%)	**13** (<1%)	95,826	92%
Late-Fall-run	2017	2016	2015	2014	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	14 (1%)	1,183 (98%)	10 (<1%)		1,207	10%
Expanded CWT$_{total}$	**45** (1%)	**3,858** (98%)	**38** (<1%)		3,941	4%
Spring-run	2016	2015	2014	2013	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	340 (84%)	66 (16%)			406	3%
Expanded CWT$_{total}$	**1,213** (82%)	**265** (18%)			1,478	1%
Winter-run	2017	2016	2015	2014	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries		101 (98%)	2 (2%)		103	1%
Expanded CWT$_{total}$		**373** (98%)	**6** (2%)		379	0.4%
Non-CV stocks	2016	2015	2014	2013	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries		191 (88%)	24 (11%)	3 (1%)	218	2%
Expanded CWT$_{total}$		**2,629** (90%)	**292** (10%)	**12** (<1%)	2,934	3%
All Runs					Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	3,787 (31%)	8,247 (68%)	108 (<1%)	4 (<1%)	12,146	100%
Expanded CWT$_{total}$	**32,601** (31%)	**70,876** (68%)	**1,054** (1%)	**26** (<1%)	104,558	100%
CV Expanded CWT$_{total}$ (Proportion CV stocks)	32,601 (100%)	68,247 (96%)	762 (72%)	13 (52%)	101,623	97%

a/ Recoveries of age-1, age-6, and tagged natural-origin fish removed.

Table 8. Raw and expanded Chinook CWT recoveries in 2018 Oregon ocean fisheries by run type and brood year[a/].

Fall-run	2016	2015	2014	2013	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	16 (1%)	1,152 (96%)	32 (3%)	6 (<1%)	1,206	63%
Expanded CWT$_{total}$	**81** (1%)	**6,263** (96%)	**174** (3%)	**40** (<1%)	6,557	51%

Spring-run	2016	2015	2014	2013	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	5 (33%)	10 (67%)			15	1%
Expanded CWT$_{total}$	**16** (44%)	**21** (56%)			37	0.3%

Late-Fall-run	2017	2016	2015	2014	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries		6 (100%)			6	0.3%
Expanded CWT$_{total}$		**12** (100%)			12	0.1%

Non-CV stocks	2016	2015	2014	2013	Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	3 (<1%)	362 (53%)	257 (37%)	65 (9%)	687	36%
Expanded CWT$_{total}$	**54** (<1%)	**4,699** (74%)	**1,398** (22%)	**172** (3%)	6,323	49%

All Runs					Total Ocean	Total
Age	2	3	4	5	CWTs	Ocean%
Raw CWT Recoveries	24 (1%)	1,530 (80%)	289 (15%)	71 (4%)	1,914	100%
Expanded CWT$_{total}$	**151** (1%)	**10,994** (85%)	**1,572** (12%)	**212** (2%)	12,929	100%
CV Expanded CWT$_{total}$ (Proportion CV stocks)	97 (64%)	6,295 (57%)	174 (11%)	40 (19%)	6,606	51%

a/ Recoveries of age-1, age-6, and tagged natural-origin fish removed.

Table 9. Percentage[a/] of inland CWT_{total} recoveries by location, run, and release type[b/] in hatchery returns, natural escapement and sport harvest during 2018.

			CFH			FRH				NIM		MOK				MER		SJO	Non-	Total %		Total
Location	**Run**	**SacW**	**CFHLh**	**CFHFh**	**CFHFn**	**FRHS**	**FRHF**	**FRHFn**	**FRHFgg**	**NIMF**	**NIMFn**	**MOKF**	**MOKFn**	**MOKFnc**	**MOKFgg**	**MERF**	**MERFn**	**SJOSx[c/]**	**CV**	**Hatchery**	**Natural**	**Run**
Hatchery Spawners																						
Keswick Dam Fish Trap	Winter	84%																		84%	16%	180
Feather River Hatchery	Spring					86%		8%										0%		94%	6%	2,110
Coleman National Fish Hatchery	Fall			86%			0%	0%	0%		0%		0%	0%	0%		0%			87%	13%	14,198
Feather River Hatchery	Fall		0%	0%		5%	3%	68%	8%	0%	0%	0%	1%	0%	0%		0%	0%		85%	15%	28,356
Nimbus Fish Hatchery	Fall		0%		0%			1%	1%	14%	38%	0%	24%	5%	3%	0%	1%			88%	12%	6,212
Mokelumne River Hatchery	Fall		0%				0%	1%	1%		3%	2%	83%	4%	4%		1%	0%	0%	99%	1%	7,420
Merced River Hatchery	Fall		0%					4%	1%		3%		23%	1%	1%	23%	3%			58%	42%	903
Coleman National Fish Hatchery	Late-fall[d/]		99%																	99%	1%	8,094
Coleman Hatchery Fish Trap	Late-fall[d/]		100%																	100%	0%	83
Keswick Dam Fish Trap	Late-fall[d/]		15%																	15%	85%	13
Total Hatchery Fall-run			***0%***	***21%***	***0%***	***3%***	***1%***	***34%***	***4%***	***2%***	***5%***	***0%***	***14%***	***1%***	***1%***	***0%***	***0%***	***0%***	***0%***	***87%***	***13%***	***57,089***
Natural Spawners																						
Upper Sacramento River	Winter	82%																		82%	18%	2,458
Butte Creek	Spring																			0%	100%	2,362
Upper Sacramento River	Fall		0%	20%			0%	1%	0%				0%	0%	0%					22%	78%	9,436
Clear Creek	Fall			17%				4%						0%						22%	78%	8,547
Battle Creek[e/]	Fall			86%			0%	0%	0%		0%		0%	0%	0%		0%			86%	14%	9,931
Butte Creek	Fall	7%																		7%	93%	14
Feather River	Fall					3%	1%	74%	1%		0%		1%	0%	0%					80%	20%	45,826
Yuba River	Fall					16%	2%	33%		3%	3%		25%	7%	4%					93%	7%	3,073
American River	Fall				0%	0%	0%	4%	1%	16%	19%	0%	23%	6%	4%		1%	0%		76%	24%	21,092
Mokelumne River	Fall							1%	0%		5%	1%	70%	4%	5%	0%	1%			87%	13%	10,055
Stanislaus River	Fall							1%			1%	0%	65%	2%	2%		4%			75%	25%	2,377
Tuolumne River	Fall							2%	2%		2%		40%	0%	1%		11%			57%	43%	1,077
Merced River	Fall												27%			4%	4%			34%	66%	878
Upper Sacramento River	Late-fall[d/]		32%										1%		0%					33%	67%	2,985
Total Natural Area Fall-run		***0%***	***0%***	***11%***	***0%***	***2%***	***0%***	***32%***	***1%***	***3%***	***4%***	***0%***	***14%***	***2%***	***1%***	***0%***	***1%***	***0%***		***71%***	***29%***	***112,306***
In-basin CWT_{total}	All	1%	5%	13%		3%	1%	32%	1%	3%	4%	0%	8%	0%	0%	0%	0%	NA		73%	27%	168,234
Stray CWT_{total}	All	0%	0%	7%	1%	0%	0%	9%	2%	1%	5%	0%	53%	11%	7%	0%	4%	0%	0%	100%		19,446
Total CV Spawners		**1%**	**5%**	**13%**	**0%**	**3%**	**1%**	**30%**	**2%**	**2%**	**4%**	**0%**	**12%**	**1%**	**1%**	**0%**	**0%**	**0%**	**0%**	**76%**	**24%**	**187,680**
CV Sport Harvest																						
Upper Sacramento River	Fall		0%	75%				2%												78%	22%	7,203
Lower Sacramento River	Fall		5%	2%			0%	16%	5%	7%	16%		19%	1%	3%					75%	25%	5,373
Feather River	Fall					1%	2%	62%	3%					0%				0%		69%	31%	11,387
American River	Fall							8%		30%	15%		38%	6%	4%					100%	0%	1,046
Mokelumne River	Fall										13%	2%	60%	2%						77%	23%	648
Upper Sacramento River	Late-fall	2%	66%																	68%	32%	474
Total Sport Harvest		**0%**	**2%**	**21%**		**1%**	**1%**	**31%**	**2%**	**3%**	**4%**	**0%**	**7%**	**1%**	**1%**			**0%**		**74%**	**26%**	**26,131**

a/ Any non-zero values less than 0.5% of CWT_{total} are displayed as 0%.

b/ Release types defined in Table 3; CFHLe recoveries merged with CFHLh, FRHFk merged with FRHF, FRHFtib merged with FRHFn, FRHFnc merged with FRHFgg, in-river control releases for MOKFb merged with MOKF, barged and trucked releases for MOKFb merged with MOKFgg, MERFt merged with MERFn.

c/ In-basin CWT recovery data not available for SJOSx releases, therefore only stray SJOSx recoveries are displayed in this table.

d/ Late-fall-run hatchery returns and natural area escapement occurred during late-fall of 2018 through early 2019 (return year 2019).

e/ Battle Creek natural area escapement CWT_{total} based on hatchery proportions at CFH (FWS staff, per. comm).

Table 10. Total inland CWT_{total} recoveries by location, run, and release type[a/] in hatchery returns, natural escapement and sport harvest during 2018.

			CFH			FRH				NIM		MOK				MER		SJO	Non-	Total CWT_{total}		Total
Location	**Run**	**SacW**	**CFHLh**	**CFHFh**	**CFHFn**	**FRHS**	**FRHF**	**FRHFn**	**FRHFgg**	**NIMF**	**NIMFn**	**MOKF**	**MOKFn**	**MOKFnc**	**MOKFgg**	**MERF**	**MERFn**	**SJOSx[b/]**	**CV**	**Hatchery**	**Natural**	**Run**
Hatchery Spawners																						
Keswick Dam Fish Trap	Winter	151																		151	29	180
Feather River Hatchery	Spring					1,817		169										2		1,988	122	2,110
Coleman National Fish Hatchery	Fall			12,233			3	12	4		4		8	4	13		1			12,282	1,916	14,198
Feather River Hatchery	Fall		1	12		1,487	842	19,349	2,144	4	28	3	200	81	39		24	28		24,242	4,114	28,356
Nimbus Fish Hatchery	Fall		2		8			69	79	877	2,339	12	1,499	295	204	6	86			5,476	736	6,212
Mokelumne River Hatchery	Fall		19				1	76	56		196	126	6,152	293	332		76	1	8	7,336	84	7,420
Merced River Hatchery	Fall		4					32	8		24		204	5	9	209	30			525	378	903
Coleman National Fish Hatchery	Late-fall[c/]		7,973																	7,973	121	8,094
Coleman Hatchery Fish Trap	Late-fall[c/]		83																	83		83
Keswick Dam Fish Trap	Late-fall[c/]		2																	2	11	13
Total Hatchery Fall-run			***26***	***12,245***	***8***	***1,487***	***846***	***19,538***	***2,291***	***881***	***2,591***	***141***	***8,063***	***678***	***597***	***215***	***217***	***29***	***8***	***49,861***	***7,228***	***57,089***
Natural Spawners																						
Upper Sacramento River	Winter	2,006																		2,006	452	2,458
Butte Creek	Spring																				2,362	2,362
Upper Sacramento River	Fall		12	1,904			11	88	6				45	39	6					2,111	7,325	9,436
Clear Creek	Fall			1,435				377						32						1,844	6,703	8,547
Battle Creek[d/]	Fall			8,551			2	8	3		3		6	3	9		1			8,586	1,345	9,931
Butte Creek	Fall	1																		1	13	14
Feather River	Fall					1,382	425	33,846	375		68		338	118	17					36,569	9,257	45,826
Yuba River	Fall					489	49	1,002		97	97		775	218	121					2,848	225	3,073
American River	Fall				104	2	3	928	252	3,452	3,935	21	4,911	1,240	868		287	5		16,008	5,084	21,092
Mokelumne River	Fall							78	31		464	124	7,004	429	468	44	150			8,792	1,263	10,055
Stanislaus River	Fall							17			33	4	1,539	46	46		102			1,787	590	2,377
Tuolumne River	Fall							17	17		25		427	4	8		121			619	458	1,077
Merced River	Fall												233			34	31			298	580	878
Upper Sacramento River	Late-fall[c/]		949										36		9					994	1,991	2,985
Total Natural Area Fall-run		***1***	***12***	***11,890***	***104***	***1,873***	***490***	***36,361***	***684***	***3,549***	***4,625***	***149***	***15,278***	***2,129***	***1,543***	***78***	***692***	***5***		***79,463***	***32,843***	***112,306***
In-basin CWT_{total}	All	2,157	9,019	22,688		5,175	1,316	54,366	2,519	4,329	6,274	250	13,156	722	800	243	61	NA		123,075	45,159	168,234
Stray CWT_{total}	All	1	26	1,447	112	2	20	1,702	456	101	942	40	10,221	2,085	1,349	50	848	36	8	19,446		19,446
Total CV Spawners		**2,158**	**9,045**	**24,135**	**112**	**5,177**	**1,336**	**56,068**	**2,975**	**4,430**	**7,216**	**290**	**23,377**	**2,807**	**2,149**	**293**	**909**	**36**	**8**	**142,521**	**45,159**	**187,680**
%stray		0.05%	0.3%	6%	100%	0.04%	1%	3%	15%	2%	13%	14%	44%	74%	63%	17%	93%	NA		14%		10%
CV Sport Harvest																						
Upper Sacramento River	Fall		21	5,428				168												5,617	1,586	7,203
Lower Sacramento River	Fall		271	96			24	850	286	381	857		1,046	72	143					4,026	1,347	5,373
Feather River	Fall					132	183	7,080	367					13				26		7,801	3,586	11,387
American River	Fall							79		315	158		396	59	39					1,046		1,046
Mokelumne River	Fall										87	11	390	11						499	149	648
Upper Sacramento River	Late-fall	9	313																	322	152	474
Total Sport Harvest		**9**	**605**	**5,524**		**132**	**207**	**8,177**	**653**	**696**	**1,102**	**11**	**1,832**	**155**	**182**			**26**		**19,311**	**6,820**	**26,131**

a/ Release types defined in Table 3; CFHLe recoveries merged with CFHLh, FRHFk merged with FRHF, FRHFtib merged with FRHFn, FRHFnc merged with FRHFgg, in-river control releases for MOKFb merged with MOKF, barged and trucked releases for MOKFb merged with MOKFgg, MERFt merged with MERFn.

b/ In-basin CWT recovery data not available for SJOSx releases, therefore only stray SJOSx recoveries are displayed in this table.

c/ Late-fall-run hatchery returns and natural area escapement occurred during late-fall of 2018 through early 2019 (return year 2019).

d/ Battle Creek natural area escapement CWT_{total} based on hatchery proportions at CFH (FWS staff, per. comm).

Table 11. CWT recovery rate (recoveries per 100,000 CWTs released) by release type, brood year and recovery location in 2018. (Page 1 of 2)

Age-2 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT_{samp}) by basin									CV CWT_{samp} totals			% CV Stray	Ocean	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[a/]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	In-basin	Stray	CV total		CWT_{samp}	In-basin	Stray	CV total	Ocean
SacW[b/]	2016	Wint	138,803		360								360	0	360	0%	367	260	0	**260**	**265**
FRHS	2016	Spr	1,682,317				690	48	2				738	2	740	0.2%	1,100	44	0.1	**44**	**65**
SJOSx[c/]	2016	Spr	90,600				28		5	1			NA	34	NA	NA	118	NA	38	**NA**	**130**
CFHFh	2016	Fall	3,020,565	1,967	39	101	3						2,007	104	2,111	5%	1,633	66	4	**70**	**54**
FRHF	2016	Fall	1,029,808	5			1,041	48	2	1			1,090	8	1,097	1%	879	106	1	**107**	**85**
FRHFn	2016	Fall	733,880	2	6	33	914	121	121	11		3	1,035	176	1,211	14%	1,070	141	24	**165**	**146**
FRHFgg	2016	Fall	263,611	2			610		81	22	4	2	610	111	721	15%	1,009	232	42	**274**	**383**
NIMF	2016	Fall	591,200					24	681				681	24	705	3%	868	115	4	**119**	**147**
NIMFn	2016	Fall	277,532	2			20		408	35	4	3	408	64	472	14%	768	147	23	**170**	**277**
MOKF	2016	Fall	398,284							13			13	0	13	0%	7	3	0	**3**	**2**
MOKFn	2016	Fall	1,155,829	3			21	24	568	698	35	6	698	658	1,356	49%	1,092	60	57	**117**	**94**
MOKFnc	2016	Fall	841,802	3	6		22	24	326	76	10	1	76	393	468	84%	3,034	9	47	**56**	**360**
MOKFb	2016	Fall	295,120	2			11	24	227	151	4	1	151	269	420	64%	381	51	91	**143**	**129**
MOKFgg	2016	Fall	225,243	17	9		14	24	221	92	15	6	92	306	398	77%	1,161	41	136	**177**	**516**
MERF	2016	Fall	245,340						1	8		45	45	9	54	16%	22	19	4	**22**	**9**
CFHLh	2017	Late	1,047,211	1,223	45					4		1	1,268	5	1,273	0.4%	45	121	1	**122**	**4**
		Total	12,037,145	3,226	465	135	3,374	339	2,644	1,112	73	68	9,273	2,163	11,401	19%	13,554				

Age-3 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT_{samp}) by basin									CV CWT_{samp} totals			% CV Stray	Ocean	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[a/]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	In-basin	Stray	CV total		CWT_{samp}	In-basin	Stray	CV total	Ocean
SacW[b/]	2015	Wint	415,865		1,767	1							1,767	1	1,768	0.1%	6	425	0.2	**425**	**1**
FRHS	2015	Spr	2,109,278				3,947	436					4,382	0	4,382	0%	283	208	0	**208**	**13**
SJOSx[c/]	2015	Spr	105,424				2						NA	2	NA	NA	0	NA	2	**NA**	**0**
CFHFh	2015	Fall	3,033,741	3,204	436	260							3,640	260	3,900	7%	1,425	120	9	**129**	**47**
FRHF	2015	Fall	246,501				53						53	0	53	0%	16	21	0	**21**	**6**
FRHFn	2015	Fall	2,019,877	3	11	65	12,137	121	125	22	8	5	12,258	239	12,497	2%	6,023	607	12	**619**	**298**
FRHFk	2015	Fall	101,134		11		8		2				8	13	21	62%	15	8	13	**21**	**15**
NIMF	2015	Fall	692,262				1		399				399	1	400	0.2%	413	58	0.1	**58**	**60**
NIMFn	2015	Fall	349,016				4	24	1,121	119	10	3	1,121	160	1,281	13%	1,672	321	46	**367**	**479**
MOKF	2015	Fall	401,194						9	102	4		102	13	116	12%	67	26	3	**29**	**17**
MOKFn	2015	Fall	1,339,629		20	2	113	169	1,029	2,585	455	103	2,585	1,892	4,477	42%	5,379	193	141	**334**	**401**
MOKFnc	2015	Fall	484,920	3	34	32	177	194	1,205	644	40	4	644	1,688	2,332	72%	6,704	133	348	**481**	**1,383**
MOKFb	2015	Fall	302,730	3	6		34	73	642	688	35	2	688	794	1,482	54%	2,125	227	262	**490**	**702**
MERFn	2015	Fall	148,804	2			8		121	73	72	19	19	276	295	93%	362	13	185	**199**	**243**
MERFt	2015	Fall	97,228				3		53	31	31	8	8	118	126	93%	184	9	121	**130**	**189**
CFHLh	2016	Late	594,043	3,686	501		1		2	8		2	4,187	13	4,200	0.3%	1,979	705	2	**707**	**333**
CFHLe	2016	Late	450,662	2,902	365					6		1	3,266	7	3,273	0.2%	1,696	725	2	**726**	**376**
		Total	12,892,308	9,804	3,151	360	16,488	1,016	4,707	4,278	656	148	35,128	5,478	40,605	13%	28,347				

Table 11. CWT recovery rate (recoveries per 100,000 CWTs released) by release type, brood year and recovery location in 2018. (Page 2 of 2)

Age-4 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT_{samp}) by basin									CV CWT_{samp} totals			% CV Stray	Ocean	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[a/]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	In-basin	Stray	CV total		CWT_{samp}	In-basin	Stray	**CV total**	**Ocean**
SacW[b/]	2014	Wint	590,623		5								5	0	5	**0%**	0	1	0	**1**	**0**
FRHS	2014	Spr	1,690,972				3						3	0	3	**0%**	0	0.2	0	**0.2**	**0**
SJOSx[c/]	2014	Spr	54,839										NA	0	NA	**NA**	0	NA	0	**NA**	**0**
CFHFn	2014	Fall	2,951,944						28				0	28	28	**100%**	25	0	1	**1**	**1**
FRHFn	2014	Fall	1,047,852		6		220		4	6			220	16	236	**7%**	122	21	2	**23**	**12**
FRHFnc	2014	Fall	321,527		6		62		5				62	10	72	**14%**	69	19	3	**22**	**21**
FRHFk	2014	Fall	45,200				1						1	0	1	**0%**	0	2	0	**2**	**0**
NIMFn	2014	Fall	979,827						38	11			38	11	49	**22%**	20	4	1	**5**	**2**
MOKFn	2014	Fall	1,244,314						1	1			1	1	2	**50%**	28	0.1	0.1	**0.2**	**2**
MOKFnc	2014	Fall	241,335							1			1	0	1	**0%**	19	0.4	0	**0.4**	**8**
MERFn	2014	Fall	37,064										0	0	0	**-**	0	0	0	**0**	**0**
MERFt	2014	Fall	238,408										0	0	0	**-**	4	0	0	**0**	**2**
CFHLh	2015	Late	463,924	56	9								64	0	64	**0%**	37	14	0	**14**	**8**
CFHLe	2015	Late	420,514										0	0	0	**-**	0	0	0	**0**	**0**
		Total	10,328,343	56	25		286		76	19			395	66	461	**14%**	324				

Age-5 CV recoveries (only release types with recoveries in 2018 are displayed)

Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT_{samp}) by basin									CV CWT_{samp} totals			% CV Stray	Ocean	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[a/]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	In-basin	Stray	CV total		CWT_{samp}	In-basin	Stray	**CV total**	**Ocean**
CFHFh	2013	Fall	1,125,706	2									2	0	2	**0%**	0	0.2	0	**0.2**	**0**
CFHFn	2013	Fall	1,810,972										0	0	0	**-**	5	0	0	**0**	**0.3**
FRHFn	2013	Fall	1,459,468										0	0	0	**-**	3	0	0	**0**	**0.2**
NIMFn	2013	Fall	896,419										0	0	0	**-**	4	0	0	**0**	**0.4**
MOKFn	2013	Fall	1,148,423										0	0	0	**-**	1	0	0	**0**	**0.1**

a/ Natural creeks can include Clear Creek, Cow Creek, Cottonwood Creek, Paynes Creek, Mill Creek, Deer Creek, and Butte Creek, depending on survey year.
b/ Ocean recoveries of SacW are considered one year older than those of the same brood year recovered in the CV (i.e., brood year 2016 = age-3 in the ocean).
c/ In-basin CWT recovery data not available for SJOSx releases, so only ocean and stray inland CWT recovery data are shown.

Sacramento River fall Chinook release types (SFC)

CFHFh	Coleman National Fish Hatchery fall hatchery releases
CFHFn	Coleman National Fish Hatchery fall bay/delta net pen releases
FRHF	Feather River Hatchery fall in-basin releases
FRHFn	Feather River Hatchery fall bay/delta net pen releases
FRHFnc	Feather River Hatchery fall coastal net pen releases
FRHFgg	Feather River Hatchery fall Golden Gate releases (no net pens)
FRHFk	Feather River Hatchery fall experimental Knaggs Ranch releases
NIMF	Nimbus Fish Hatchery fall in-basin releases
NIMFn	Nimbus Fish Hatchery fall bay/delta net pen releases

Other CV Chinook release types (OCV)

MOKF	Mokelumne River Hatchery fall in-basin releases
MOKFn	Mokelumne River Hatchery fall bay/delta net pen releases
MOKFnc	Mokelumne River Hatchery fall coastal net pen releases
MOKFb	Mokelumne River Hatchery fall barge study releases
MOKFgg	Mokelumne River Hatchery fall Golden Gate releases (no net pens)
MERF	Merced River Hatchery fall in-basin releases
MERFn	Merced River Hatchery fall bay/delta net pen releases
MERFt	Merced River Hatchery fall trucked releases (no net pens)
SacW	Livingston Stone National Fish Hatchery winter in-basin releases
FRHS	Feather River Hatchery spring in-basin releases
SJOSx	San Joaquin Salmon Conservation and Research Facility spring experimental rel.
CFHLh	Coleman National Fish Hatchery late-fall hatchery releases

Table 12. Total CWT_{total} recoveries by port area, month, and release type[a/] in the 2018 California ocean salmon sport fishery.

		CFH			FRH				NIM		MOK				MER		SJO	Non-	Total	Total CWT_{total}		Total
	SacW	CFHLh	CFHFh	CFHFn	FRHS	FRHF	FRHFn	FRHFgg	NIMF	NIMFn	MOKF	MOKFn	MOKFnc	MOKFgg	MERF	MERFn	SJOSx	CV	CV	Hatchery	Natural	Harvest
California Sport Harvest																						
Eureka/Crescent City																						
Jun		7	13		8		151			34	3	177	30	18		6		438	447	885	829	1,714
Jul		13	72		14		197	4	31	45	4	196	30	18		7		63	630	693	169	862
Aug		8	125		13	4	139	18	18	51		154	55	9		20	4	74	618	692	443	1,135
Sep																					27	27
Total		**28**	**209**		**35**	**4**	**487**	**22**	**48**	**130**	**7**	**526**	**115**	**45**		**33**	**4**	**575**	**1,696**	**2,271**	**1,467**	**3,738** (4%)
Fort Bragg																						
Jun		14	66		10	7	67		13			67	17	3			3	68	267	335	205	540
Jul		46	234		35	30	434	55	91	52		497	186	37			4	37	1,701	1,738	1,479	3,217
Aug		39	119		19	13	334	30	67	140		261	90	39		7		16	1,158	1,174	672	1,846
Sep			20		10									10					40	40	55	95
Oct																				-	-	0
Total		**99**	**439**		**75**	**49**	**835**	**86**	**171**	**192**		**825**	**293**	**89**		**7**	**7**	**121**	**3,166**	**3,287**	**2,411**	**5,698** (7%)
San Francisco																						
Jun	54	214	921		123	54	1,773	374	372	572	4	958	406	190	19	29	4	196	6,065	6,261	5,100	11,361
Jul	88	264	3,691	14	600	480	4,126	2,087	1,645	1,605	46	3,245	1,651	811	85	28	49	154	20,514	20,668	17,580	38,248
Aug		67	1,343		85	107	1,925	596	406	474	13	1,102	458	218		21	10	15	6,825	6,840	4,877	11,717
Sep	9	63	444		66	69	311	253	250	379	16	1,208	753	187		21	9		4,039	4,039	2,650	6,689
Oct	6	383	465		87	55	119	112	78	231	3	360	373	65		13	8		2,358	2,358	1,814	4,172
Total	**157**	**990**	**6,865**	**14**	**961**	**764**	**8,253**	**3,422**	**2,750**	**3,262**	**81**	**6,874**	**3,640**	**1,471**	**103**	**111**	**81**	**366**	**39,800**	**40,166**	**32,021**	**72,187** (83%)
Monterey																						
Apr	33	44	463		137		1,502		21	126	5	442	115	11		14			2,912	2,912	1,023	3,935
May	27	10	65				104					68	31						305	305	171	476
Jun	18		146				390			24	6	49	54	36					723	723	434	1,157
Jul	7	8										58	22						95	95	28	123
Total	**85**	**62**	**674**		**137**		**1,996**		**21**	**151**	**11**	**617**	**222**	**47**		**14**			**4,036**	**4,036**	**1,655**	**5,691** (7%)
California Total Sport Harvest																						
	241	**1,179**	**8,189**	**14**	**1,207**	**818**	**11,571**	**3,530**	**2,990**	**3,734**	**99**	**8,841**	**4,270**	**1,652**	**103**	**167**	**93**	**1,062**	**48,698**	**49,760**	**37,554**	**87,314**
Oregon Total Sport Harvest																						
		4	***64***		***13***	***10***	***302***	***2***	***24***	***62***		***320***	***159***	***59***		***24***	***7***	***1,133***	***1,053***	***2,186***	***2,115***	***4,301***

a/ Release types defined in Table 3; CFHLe recoveries merged with CFHLh, FRHFk merged with FRHF, FRHFtib merged with FRHFn, FRHFnc merged with FRHFgg, in-river control releases for MOKFb merged with MOKF, barged and trucked releases for MOKFb merged with MOKFgg, MERFt merged with MERFn.

Table 13. Percentage[a/] of CWT_{total} recoveries by port area, month, and release type[b/] in the 2018 California ocean salmon sport fishery.

		CFH			FRH				NIM		MOK				MER		SJO	Non-CV	Total CV	Total %		Total Harvest
	SacW	CFHLh	CFHFh	CFHFn	FRHS	FRHF	FRHFn	FRHFgg	NIMF	NIMFn	MOKF	MOKFn	MOKFnc	MOKFgg	MERF	MERFn	SJOSx			Hatchery	Natural	
California Sport Harvest																						
Eureka/Crescent City																						
Jun		0%	1%		0%		9%			2%	0%	10%	2%	1%		0%		26%	26%	52%	48%	1,714
Jul		1%	8%		2%		23%	0%	4%	5%	0%	23%	3%	2%		1%		7%	73%	80%	20%	862
Aug		1%	11%		1%	0%	12%	2%	2%	4%		14%	5%	1%		2%	0%	7%	54%	61%	39%	1,135
Sep																					100%	27
Total		**1%**	**6%**		**1%**	**0%**	**13%**	**1%**	**1%**	**3%**	**0%**	**14%**	**3%**	**1%**		**1%**	**0%**	**15%**	**45%**	**61%**	**39%**	**3,738**
Fort Bragg																						
Jun		3%	12%		2%	1%	12%		2%			12%	3%	1%			1%	13%	49%	62%	38%	540
Jul		1%	7%		1%	1%	13%	2%	3%	2%		15%	6%	1%			0%	1%	53%	54%	46%	3,217
Aug		2%	6%		1%	1%	18%	2%	4%	8%		14%	5%	2%		0%		1%	63%	64%	36%	1,846
Sep			21%		11%									11%					42%	42%	58%	95
Oct																				-	-	0
Total		**2%**	**8%**		**1%**	**1%**	**15%**	**2%**	**3%**	**3%**		**14%**	**5%**	**2%**		**0%**	**0%**	**2%**	**56%**	**58%**	**42%**	**5,698**
San Francisco																						
Jun	0%	2%	8%		1%	0%	16%	3%	3%	5%	0%	8%	4%	2%	0%	0%	0%	2%	53%	55%	45%	11,361
Jul	0%	1%	10%	0%	2%	1%	11%	5%	4%	4%	0%	8%	4%	2%	0%	0%	0%	0%	54%	54%	46%	38,248
Aug		1%	11%		1%	1%	16%	5%	3%	4%	0%	9%	4%	2%		0%	0%	0%	58%	58%	42%	11,717
Sep	0%	1%	7%		1%	1%	5%	4%	4%	6%	0%	18%	11%	3%		0%	0%		60%	60%	40%	6,689
Oct	0%	9%	11%		2%	1%	3%	3%	2%	6%	0%	9%	9%	2%		0%	0%		57%	57%	43%	4,172
Total	**0%**	**1%**	**10%**	**0%**	**1%**	**1%**	**11%**	**5%**	**4%**	**5%**	**0%**	**10%**	**5%**	**2%**	**0%**	**0%**	**0%**	**1%**	**55%**	**56%**	**44%**	**72,187**
Monterey																						
Apr	1%	1%	12%		3%		38%		1%	3%	0%	11%	3%	0%		0%			74%	74%	26%	3,935
May	6%	2%	14%				22%					14%	7%						64%	64%	36%	476
Jun	2%		13%				34%			2%	1%	4%	5%	3%					63%	63%	37%	1,157
Jul	6%	6%										47%	18%						77%	77%	23%	123
Total	**1%**	**1%**	**12%**		**2%**		**35%**		**0%**	**3%**	**0%**	**11%**	**4%**	**1%**		**0%**			**71%**	**71%**	**29%**	**5,691**
California Total Sport Harvest																						
	0%	**1%**	**9%**	**0%**	**1%**	**1%**	**13%**	**4%**	**3%**	**4%**	**0%**	**10%**	**5%**	**2%**	**0%**	**0%**	**0%**	**1%**	**56%**	**57%**	**43%**	**87,314**
Oregon Total Sport Harvest																						
		0%	***1%***		***0%***	***0%***	***7%***	***0%***	***1%***	***1%***		***7%***	***4%***	***1%***		***1%***	***0%***	***26%***	***24%***	***51%***	***49%***	***4,301***

a/ Any non-zero values less than 0.5% of CWT_{total} are displayed as 0%.

b/ Release types defined in Table 3; CFHLe recoveries merged with CFHLh, FRHFk merged with FRHF, FRHFtib merged with FRHFn, FRHFnc merged with FRHFgg, in-river control releases for MOKFb merged with MOKF, barged and trucked releases for MOKFb merged with MOKFgg, MERFt merged with MERFn.

Table 14. Total CWT_{total} recoveries by port area, month, and release type[a/] in the 2018 California ocean salmon commercial fishery.

		CFH			FRH				NIM		MOK				MER		SJO	Non-	Total	Total CWT_{total}		Total
	SacW	CFHLh	CFHFh	CFHFn	FRHS	FRHF	FRHFn	FRHFgg	NIMF	NIMFn	MOKF	MOKFn	MOKFnc	MOKFgg	MERF	MERFn	SJOSx	CV	CV	Hatchery	Natural	Harvest
California Commercial Harvest																						
Eureka/Crescent City																						
May			5				82			22		98	26	20		12		102	266	368	569	937
Jun		3	52	13	10		448	3	39	131		523	108	78		33		173	1,440	1,613	864	2,477
Jul		2	56				225	4	28	48		273	108	26		14		150	785	936	884	1,820
Aug		12	116	15			532		37	110		1,168	275	140		89		249	2,493	2,741	1,036	3,777
Total		**17**	**230**	**28**	**10**		**1,287**	**7**	**104**	**310**		**2,062**	**515**	**265**		**148**		**674**	**4,985**	**5,658**	**3,353**	**9,011** (11%)
Fort Bragg																						
Jul	3	65	355	24	6		1,317	9	130	272	6	1,323	378	89		72		168	4,048	4,216	1,865	6,081
Aug		103	36		13	4	675		71	159	9	653	146	49		38		369	1,954	2,324	1,813	4,137
Sep		3					10		10			63	17	8				34	111	145	188	333
Total	**3**	**171**	**390**	**24**	**19**	**4**	**2,002**	**9**	**211**	**431**	**15**	**2,039**	**540**	**145**		**110**		**572**	**6,113**	**6,685**	**3,866**	**10,551** (13%)
San Francisco																						
Jul	11	247	350		19	15	1,937	54	286	530	11	1,694	425	150		144		74	5,873	5,948	1,067	7,015
Aug	42	1,379	836		28	53	4,182	303	540	1,513	22	3,572	1,113	384	14	167	9	357	14,156	14,513	5,277	19,790
Sep	43	507	122		25	24	452	184	498	1,432	18	3,217	1,297	334		149	9		8,312	8,312	2,281	10,593
Oct	3	219			9		12		87	633	3	373	180	93		23			1,636	1,636	395	2,031
Total	**99**	**2,352**	**1,308**		**81**	**92**	**6,584**	**541**	**1,411**	**4,108**	**55**	**8,855**	**3,016**	**960**	**14**	**483**	**18**	**431**	**29,977**	**30,408**	**9,021**	**39,429** (50%)
Monterey																						
May	3	20	520	11	44	8	1,695	8	22	173	3	368	86	32		8		88	3,000	3,088	1,478	4,566
Jun	33	203	1,110		7	20	3,794	13	222	796	7	1,828	532	150		138		108	8,851	8,958	5,901	14,859
Total	**36**	**222**	**1,630**	**11**	**50**	**28**	**5,489**	**21**	**243**	**969**	**9**	**2,196**	**618**	**182**		**146**		**196**	**11,851**	**12,047**	**7,378**	**19,425** (25%)
California Total Commercial Harvest																						
	137	**2,762**	**3,559**	**62**	**160**	**124**	**15,362**	**579**	**1,969**	**5,818**	**79**	**15,152**	**4,689**	**1,552**	**14**	**888**	**18**	**1,873**	**52,925**	**54,798**	**23,618**	**78,416**
Oregon Total Commercial Harvest																						
		8	***486***	***44***	***16***	***8***	***1,734***	***18***	***146***	***253***	***4***	***1,730***	***670***	***307***		***131***		***5,190***	***5,553***	***10,743***	***13,385***	***24,128***

a/ Release types defined in Table 3; CFHLe recoveries merged with CFHLh, FRHFk merged with FRHF, FRHFtib merged with FRHFn, FRHFnc merged with FRHFgg, in-river control releases for MOKFb merged with MOKF, barged and trucked releases for MOKFb merged with MOKFgg, MERFt merged with MERFn.

Table 15. Percentage[a/] of CWT_{total} recoveries by port area, month, and release type[b/] in the 2018 California ocean salmon commercial fishery.

		CFH			FRH				NIM		MOK				MER		SJO	Non-CV	Total CV	Total %		Total Harvest
	SacW	CFHLh	CFHFh	CFHFn	FRHS	FRHF	FRHFn	FRHFgg	NIMF	NIMFn	MOKF	MOKFn	MOKFnc	MOKFgg	MERF	MERFn	SJOSx			Hatchery	Natural	
California Commercial Harvest																						
Eureka/Crescent City																						
May			1%				9%			2%		10%	3%	2%		1%		11%	28%	39%	61%	937
Jun		0%	2%	1%	0%		18%	0%	2%	5%		21%	4%	3%		1%		7%	58%	65%	35%	2,477
Jul		0%	3%				12%	0%	2%	3%		15%	6%	1%		1%		8%	43%	51%	49%	1,820
Aug		0%	3%	0%			14%		1%	3%		31%	7%	4%		2%		7%	66%	73%	27%	3,777
Total		**0%**	**3%**	**0%**	**0%**		**14%**	**0%**	**1%**	**3%**		**23%**	**6%**	**3%**		**2%**		**7%**	**55%**	**63%**	**37%**	**9,011**
Fort Bragg																						
Jul	0%	1%	6%	0%	0%		22%	0%	2%	4%	0%	22%	6%	1%		1%		3%	67%	69%	31%	6,081
Aug		2%	1%		0%	0%	16%		2%	4%	0%	16%	4%	1%		1%		9%	47%	56%	44%	4,137
Sep		1%					3%		3%			19%	5%	2%				10%	33%	44%	56%	333
Total	**0%**	**2%**	**4%**	**0%**	**0%**	**0%**	**19%**	**0%**	**2%**	**4%**	**0%**	**19%**	**5%**	**1%**		**1%**		**5%**	**58%**	**63%**	**37%**	**10,551**
San Francisco																						
Jul	0%	4%	5%		0%	0%	28%	1%	4%	8%	0%	24%	6%	2%		2%		1%	84%	85%	15%	7,015
Aug	0%	7%	4%		0%	0%	21%	2%	3%	8%	0%	18%	6%	2%	0%	1%	0%	2%	72%	73%	27%	19,790
Sep	0%	5%	1%		0%	0%	4%	2%	5%	14%	0%	30%	12%	3%		1%	0%		78%	78%	22%	10,593
Oct	0%	11%			0%		1%		4%	31%	0%	18%	9%	5%		1%			81%	81%	19%	2,031
Total	**0%**	**6%**	**3%**		**0%**	**0%**	**17%**	**1%**	**4%**	**10%**	**0%**	**22%**	**8%**	**2%**	**0%**	**1%**	**0%**	**1%**	**76%**	**77%**	**23%**	**39,429**
Monterey																						
May	0%	0%	11%	0%	1%	0%	37%	0%	0%	4%	0%	8%	2%	1%		0%		2%	66%	68%	32%	4,566
Jun	0%	1%	7%		0%	0%	26%	0%	1%	5%	0%	12%	4%	1%		1%		1%	60%	60%	40%	14,859
Total	**0%**	**1%**	**8%**	**0%**	**0%**	**0%**	**28%**	**0%**	**1%**	**5%**	**0%**	**11%**	**3%**	**1%**		**1%**		**1%**	**61%**	**62%**	**38%**	**19,425**
California Total Commercial Harvest																						
	0%	**4%**	**5%**	**0%**	**0%**	**0%**	**20%**	**1%**	**3%**	**7%**	**0%**	**19%**	**6%**	**2%**	**0%**	**1%**	**0%**	**2%**	**67%**	**70%**	**30%**	**78,416**
Oregon Total Commercial Harvest																						
		0%	***2%***	***0%***	***0%***	***0%***	***7%***	***0%***	***1%***	***1%***	***0%***	***7%***	***3%***	***1%***		***1%***		***22%***	***23%***	***45%***	***55%***	***24,128***

a/ Any non-zero values less than 0.5% of CWT_{total} are displayed as 0%.

b/ Release types defined in Table 3; CFHLe recoveries merged with CFHLh, FRHFk merged with FRHF, FRHFtib merged with FRHFn, FRHFnc merged with FRHFgg, in-river control releases for MOKFb merged with MOKF, barged and trucked releases for MOKFb merged with MOKFgg, MERFt merged with MERFn.

Table 16. CWT recovery rate (recoveries per 100,000 CWTs released) for experimental & net pen release types in 2018. (Page 1 of 2)

Age-2 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT_{samp}) by basin									CV CWT_{samp} totals			% CV Stray	Ocean	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[a/]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	In-basin	Stray	CV total		CWT_{samp}	In-basin	Stray	**CV total**	**Ocean**
FRHFgg	2016	Fall	263,611	2			610		81	22	4	2	610	111	**721**	**15%**	**1,009**	232	42	**274**	**383**
FRHFn	2016	Fall	733,880	2	6	33	914	121	121	11		3	1,035	176	**1,211**	**14%**	**1,070**	141	24	**165**	**146**
NIMFn	2016	Fall	277,532	2			20		408	35	4	3	408	64	**472**	**14%**	**768**	147	23	**170**	**277**
MOKFbb	2016	Fall	96,885				2		49	22	4	1	22	56	**78**	**72%**	**130**	23	58	**80**	**134**
MOKFbg	2016	Fall	98,203	2			6	24	164	55			55	196	**251**	**78%**	**193**	56	200	**256**	**196**
MOKFbr	2016	Fall	100,032				3		14	74			74	17	**92**	**19%**	**58**	74	17	**92**	**58**
MOKFgg	2016	Fall	225,243	17	9		14	24	221	92	15	6	92	306	**398**	**77%**	**1,161**	41	136	**177**	**516**
MOKFn	2016	Fall	1,155,829	3			21	24	568	698	35	6	698	658	**1,356**	**49%**	**1,092**	60	57	**117**	**94**
MOKFnp	2016	Fall	720,759	3	6		21	24	325	72	10	1	72	391	**463**	**84%**	**2,894**	10	54	**64**	**402**
MOKFns	2016	Fall	121,043				1		1	4			4	2	**6**	**34%**	**140**	3	2	**5**	**116**

Age-3 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT_{samp}) by basin									CV CWT_{samp} totals			% CV Stray	Ocean	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[a/]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	In-basin	Stray	CV total		CWT_{samp}	In-basin	Stray	**CV total**	**Ocean**
FRHFkc	2015	Fall	47,661				7		2				7	2	**9**	**20%**	**6**	15	4	**18**	**13**
FRHFkr	2015	Fall	53,473		11		1						1	11	**12**	**92%**	**9**	2	21	**23**	**16**
FRHFn	2015	Fall	2,019,877	3	11	65	12,137	121	125	22	8	5	12,258	239	**12,497**	**2%**	**6,023**	607	12	**619**	**298**
NIMFn	2015	Fall	349,016				4	24	1,121	119	10	3	1,121	160	**1,281**	**13%**	**1,672**	321	46	**367**	**479**
MOKFbb	2015	Fall	100,982	2	6		7		249	169	13	1	169	277	**445**	**62%**	**920**	167	274	**441**	**911**
MOKFbg	2015	Fall	100,613	2			27	73	383	461	23	1	461	508	**969**	**52%**	**1,157**	458	505	**963**	**1,150**
MOKFbr	2015	Fall	101,135						9	59			59	9	**68**	**14%**	**48**	58	9	**67**	**47**
MOKFn	2015	Fall	1,339,629		20	2	113	169	1,029	2,585	455	103	2,585	1,892	**4,477**	**42%**	**5,379**	193	141	**334**	**401**
MOKFnp	2015	Fall	484,920	3	34	32	177	194	1,205	644	40	4	644	1,688	**2,332**	**72%**	**6,704**	133	348	**481**	**1,383**
MERFn	2015	Fall	148,804	2			8		121	73	72	19	19	276	**295**	**93%**	**362**	13	185	**199**	**243**

Table 16. CWT recovery rate (recoveries per 100,000 CWTs released) for experimental & net pen release types in 2018. (Page 2 of 2)

Age-4 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT_{samp}) by basin									CV CWT_{samp} totals			% CV Stray	Ocean	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[a/]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	In-basin	Stray	CV total		CWT_{samp}	In-basin	Stray	**CV total**	**Ocean**
CFHFn	2014	Fall	2,951,944						28				0	28	**28**	**100%**	**25**	0	1	**1**	**1**
FRHFkr	2014	Fall	45,200				1						1	0	**1**	**0%**	**0**	2	0	**2**	**0**
FRHFn	2014	Fall	1,047,852		6		220		4	6			220	16	**236**	**7%**	**122**	21	2	**23**	**12**
FRHFnp	2014	Fall	321,527		6		62		5				62	10	**72**	**14%**	**69**	19	3	**22**	**21**
NIMFn	2014	Fall	979,827						38	11			38	11	**49**	**22%**	**20**	4	1	**5**	**2**
MOKFn	2014	Fall	1,244,314						1	1			1	1	**2**	**50%**	**28**	0.1	0.1	**0.2**	**2**
MOKFns	2014	Fall	241,335							1			1	0	**1**	**0%**	**19**	0.4	0	**0.4**	**8**
MERFn	2014	Fall	37,064										0	0	**0**	**-**	**0**	0	0	**0**	**0**

a/ Natural creeks can include Clear Creek, Cow Creek, Cottonwood Creek, Paynes Creek, Mill Creek, Deer Creek, and Butte Creek, depending on survey year.

Central Valley fall Chinook experimental and net pen release types:

CFHFn Coleman National Fish Hatchery fall bay/delta net pen releases

FRHFgg Feather River Hatchery fall Golden Gate releases (no net pen acclimation)

FRHFkc Feather River Hatchery fall rice field study: Elkhorn boat ramp Sac River (control group)

FRHFkr Feather River Hatchery fall rice field study: Yolo Bypass Knaggs Ranch rice field

FRHFn Feather River Hatchery fall bay/delta net pen releases

FRHFnp Feather River Hatchery fall coastal net pen releases (Pillar Point)

NIMFn Nimbus Fish Hatchery fall bay/delta net pen releases

MOKFbb Mokelumne River Hatchery fall barge study: trucked & released in SF Bay

MOKFbg Mokelumne River Hatchery fall barge study: barged to SF Bay and released

MOKFbr Mokelumne River Hatchery fall barge study: in-river releases (Miller's Ferry, Mok R.)

MOKFgg Mokelumne River Hatchery fall Golden Gate releases (no net pen acclimation)

MOKFn Mokelumne River Hatchery fall bay/delta net pen releases

MOKFnp Mokelumne River Hatchery fall coastal net pen releases (Pillar Point)

MOKFns Mokelumne River Hatchery fall coastal net pen releases (Santa Cruz, Moss Landing)

MERFn Merced River Hatchery fall bay/delta net pen releases

#	Release Type	Release Location
1	SacW	Lake Redding Park (Sac R)
2	CFHLe	Balls Ferry (Sac R)
3	CFHFh, CFHLh	Coleman Fish Hatchery (Bat Cr)
4	FRHS	Gridley (Fea R)
5	FRHS, FRHF	Boyds Pump Boat Ramp (Fea R)
6	FRHFkc	Elkhorn Boat Ramp (Sac R)
7	NIMF	American River
8	FRHFkr	Yolo Bypass - Knaggs Ranch
9	MOKF	Mokelumne River Hatchery
10	MOKF	Woodbridge Dam (Mok R)
11	MOKFbr	Miller's Ferry Bridge (Mok R)
12	MERF	Merced River Hatchery
13	SJOSx	Hills Ferry (San Joaq R)
14	SJOSx	Eastside Bypass (San Joaq R)
15	CFHFn	Rio Vista Net Pens (Delta)
16	MERFt	Jersey Point (Delta)
17	MOKFn, MERFn	Sherman Island Net Pens (Delta)
18	FRHFn, NIMFn	Mare Island Net Pens (Bay)
19	FRHFn, NIMFn	Wickland Oil Net Pens (Bay)
20	FRHFtib	Tiburon Net Pens (Bay)
21	FRHFgg, MOKFgg, MOKFbb, MOKFbg	Trucked (via Fort Baker or Tiburon) or Barged to Golden Gate
22	FRHFnp, MOKFnp	Pillar Point Net Pens (Coastal)
23	MOKFns	Santa Cruz Net Pens (Coastal)
24	MOKFns	Moss Landing Net Pens (Coastal)

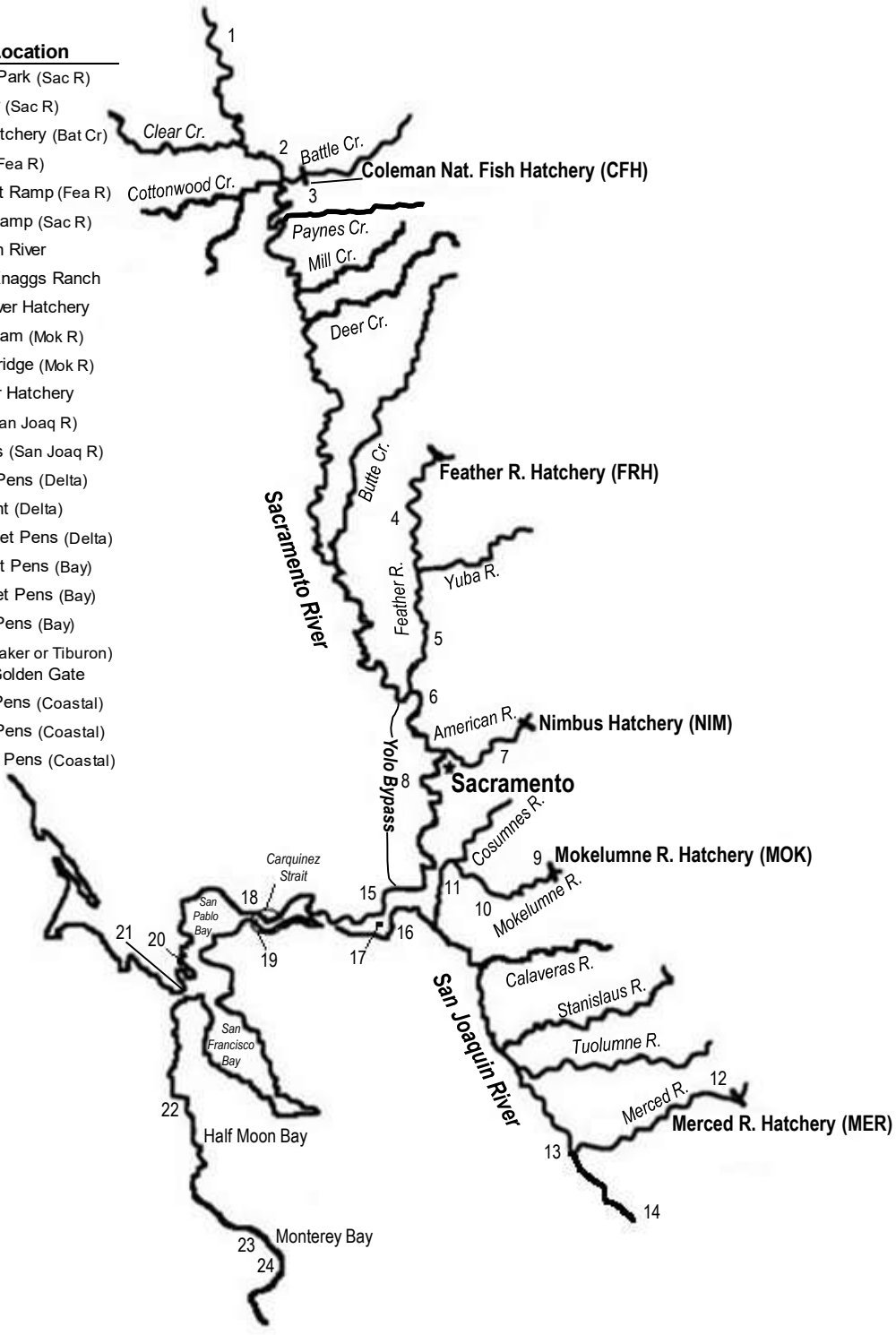


Figure 1. Map of release sites for CV hatchery release types, brood years 2013-2016.

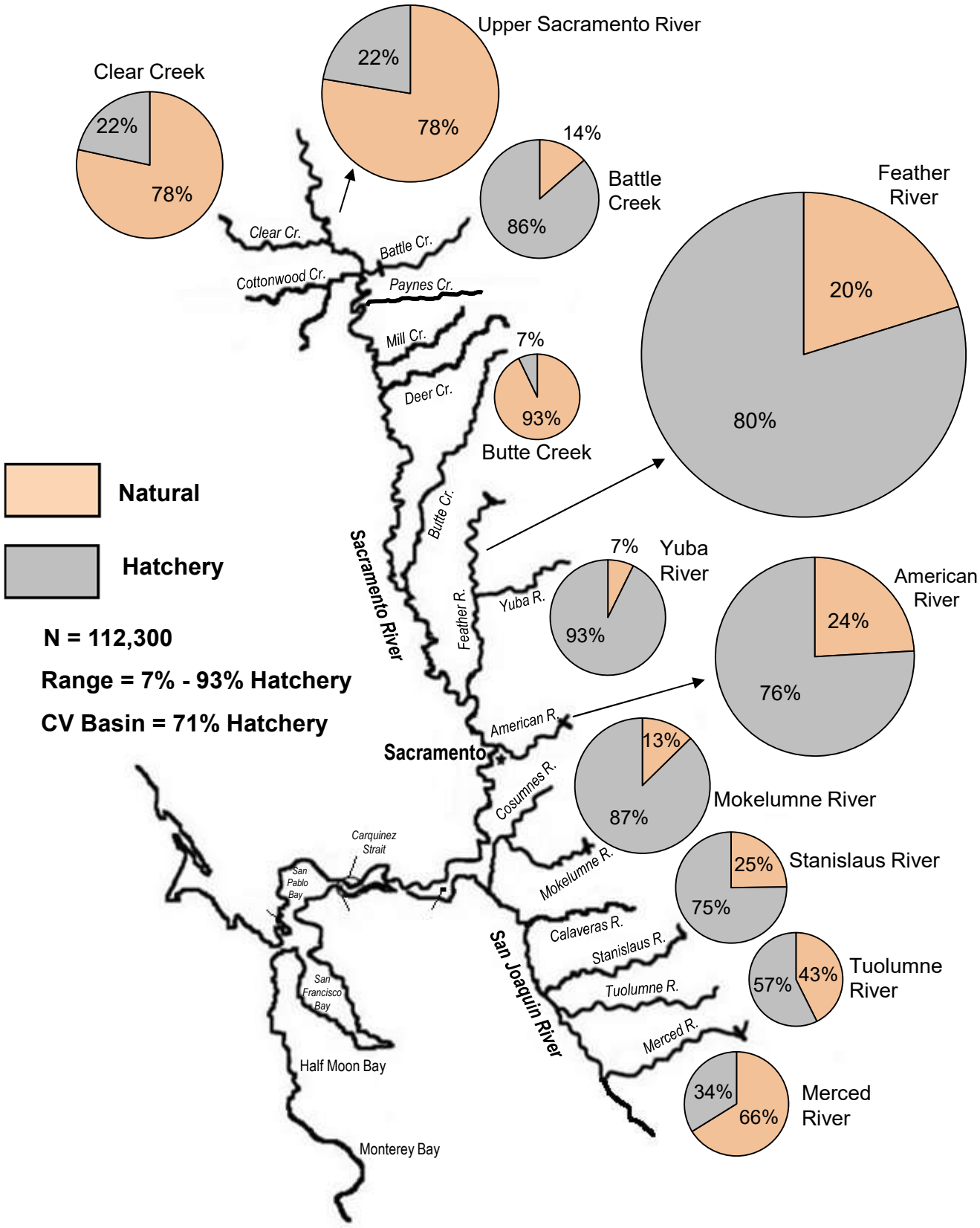


Figure 2. Fall-run CV natural area escapement, hatchery and natural proportions, 2018.

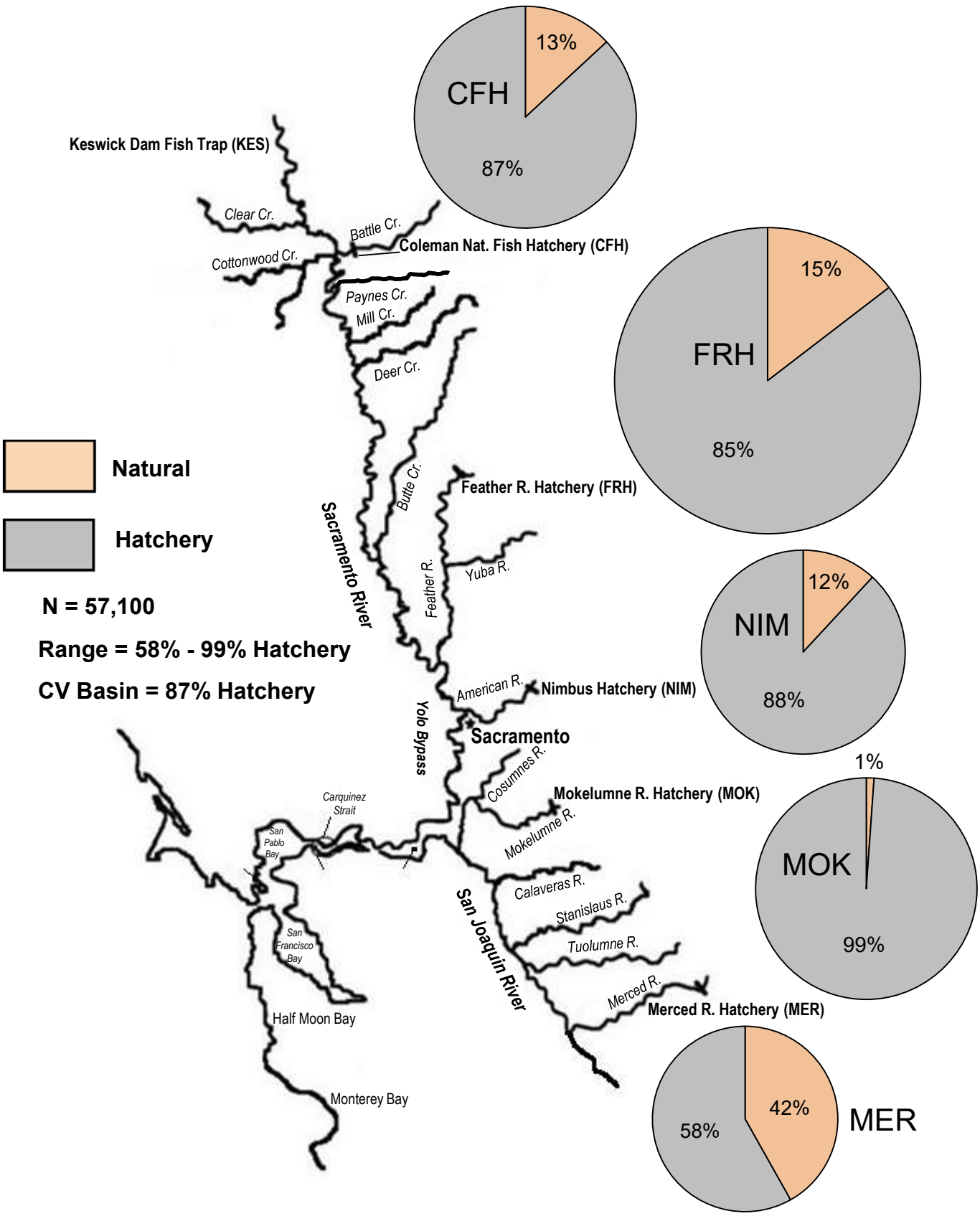


Figure 3. Fall-run CV hatchery escapement, hatchery and natural proportions, 2018.

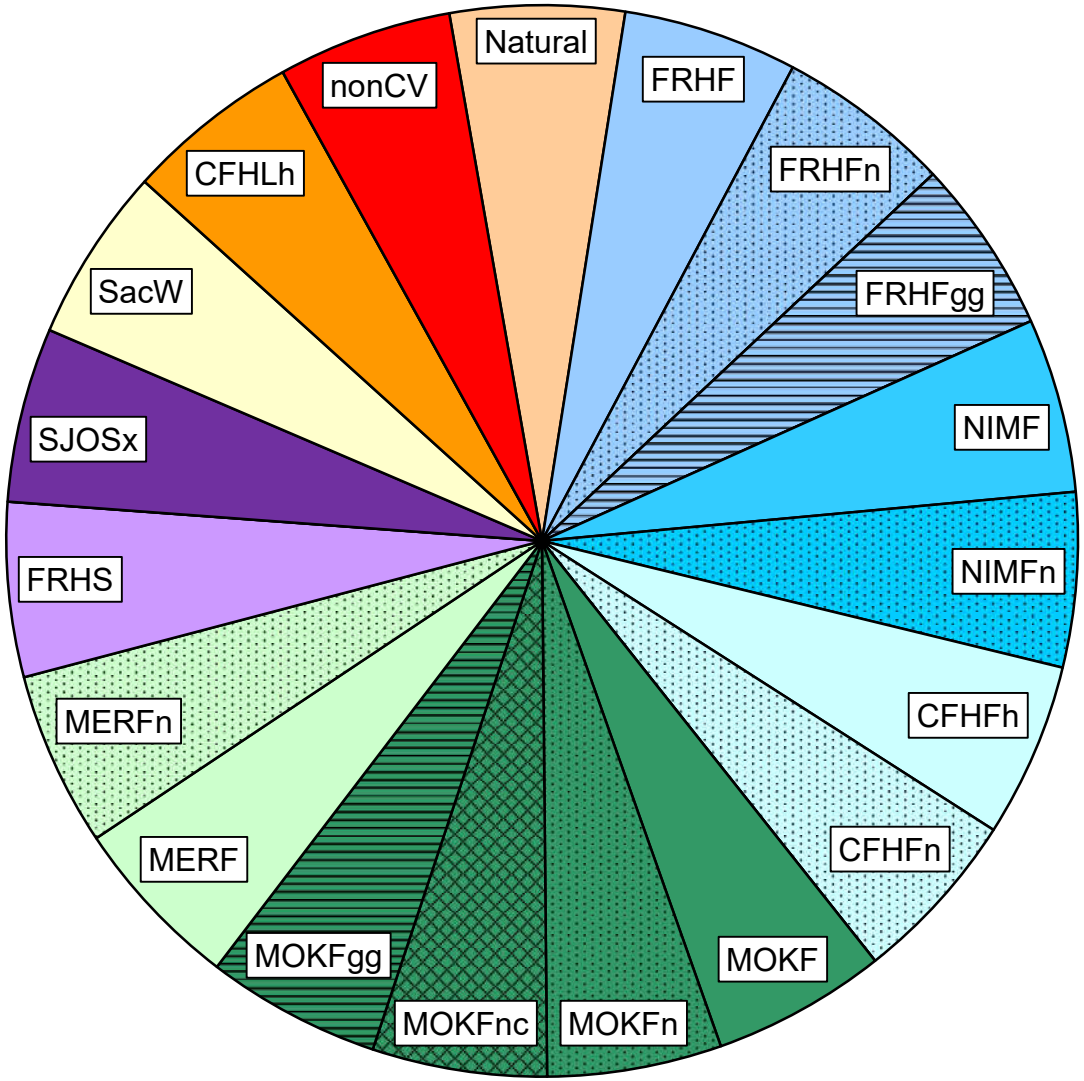


Figure 4. Color and pattern scheme used in all pie chart figures for Central Valley hatchery release types, brood years 2013-2016.

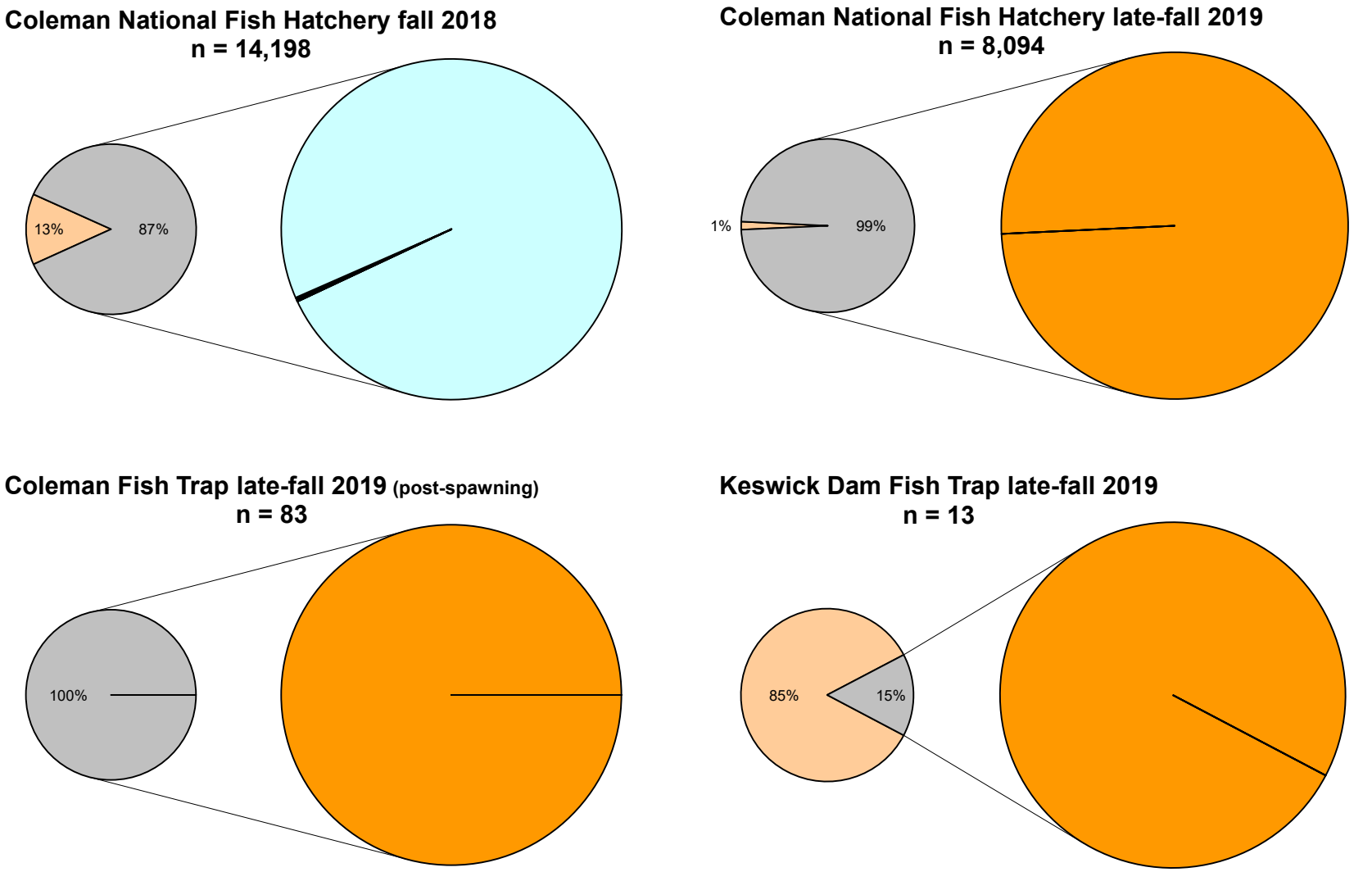


Figure 5. Proportion of hatchery- and natural-origin fish at Coleman National Fish Hatchery, 2018-19.

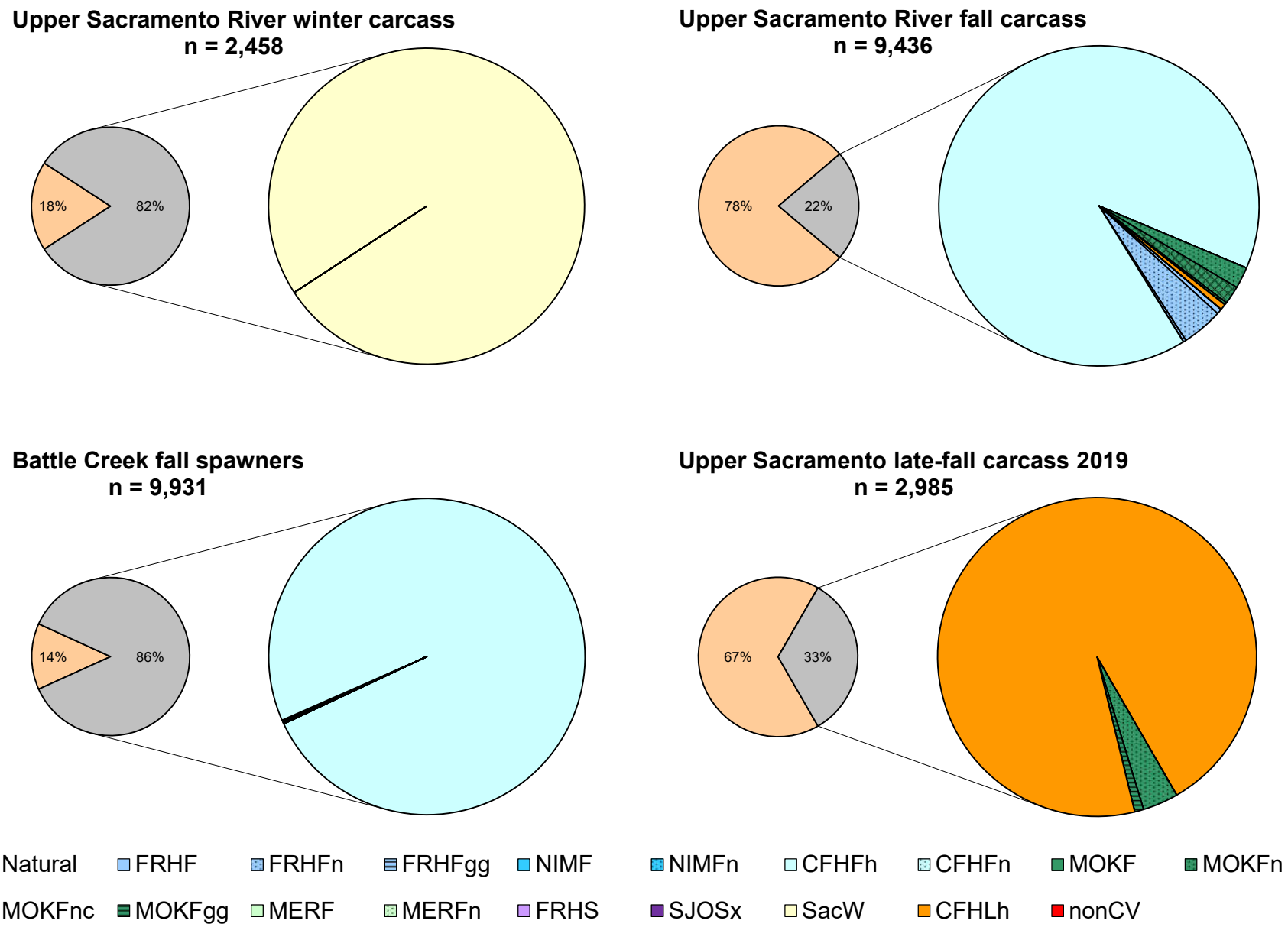


Figure 6. Proportion of hatchery- and natural-origin fish in Upper Sacramento River & tributaries, 2018. (Page 1 of 2)

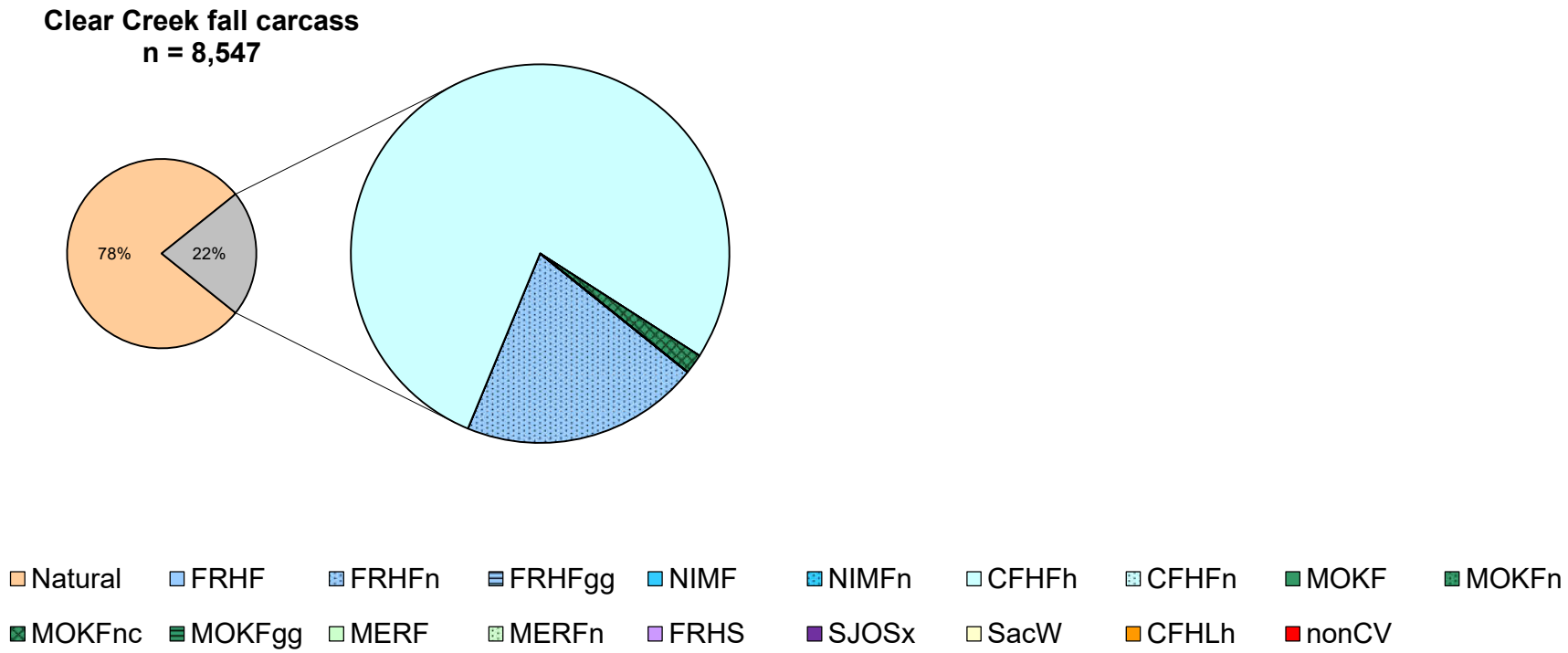


Figure 6. Proportion of hatchery- and natural-origin fish in Upper Sacramento River & tributaries, 2018. (Page 2 of 2)

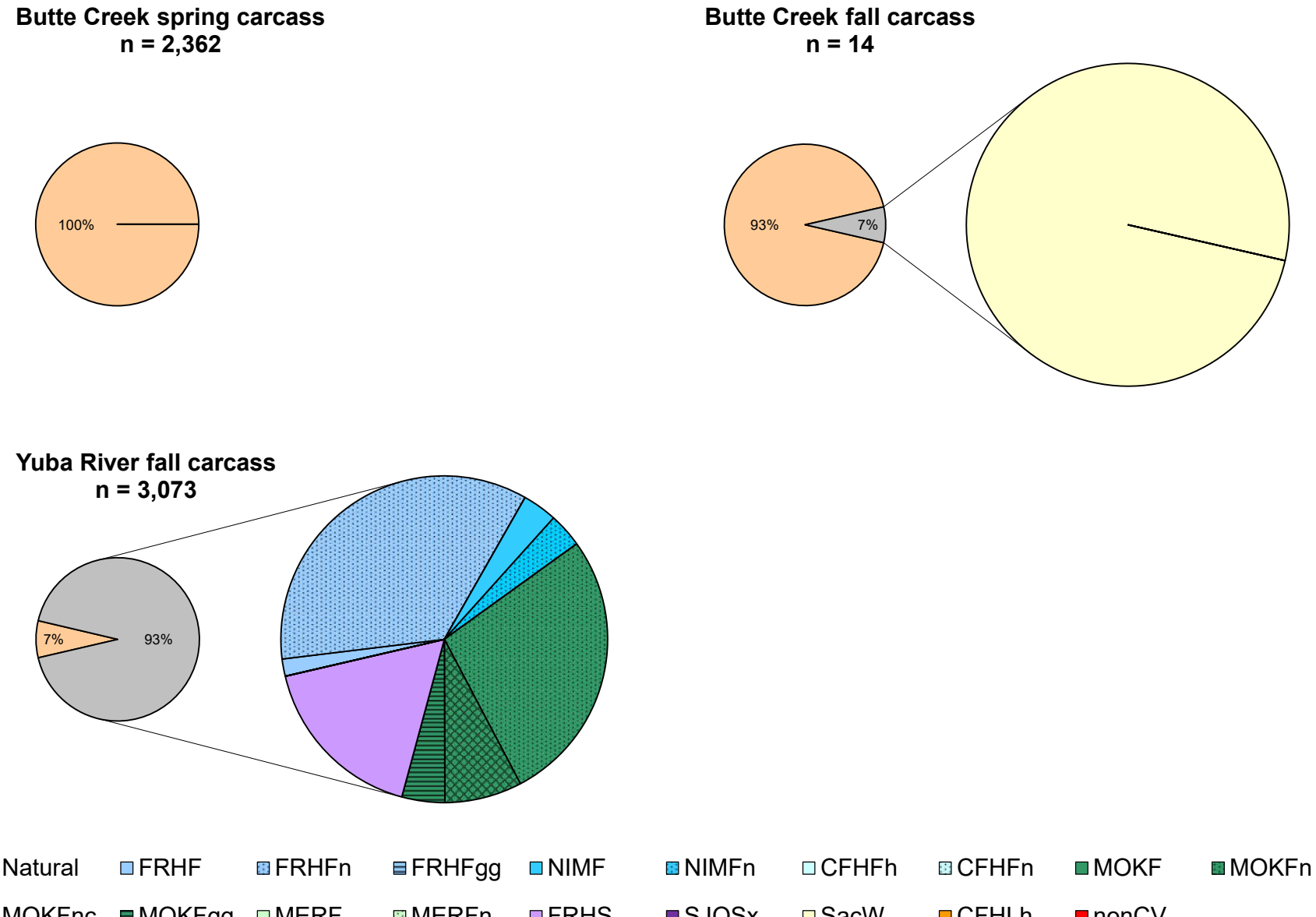


Figure 7. Proportion of hatchery- and natural-origin fish in Butte Creek & Yuba River, 2018.

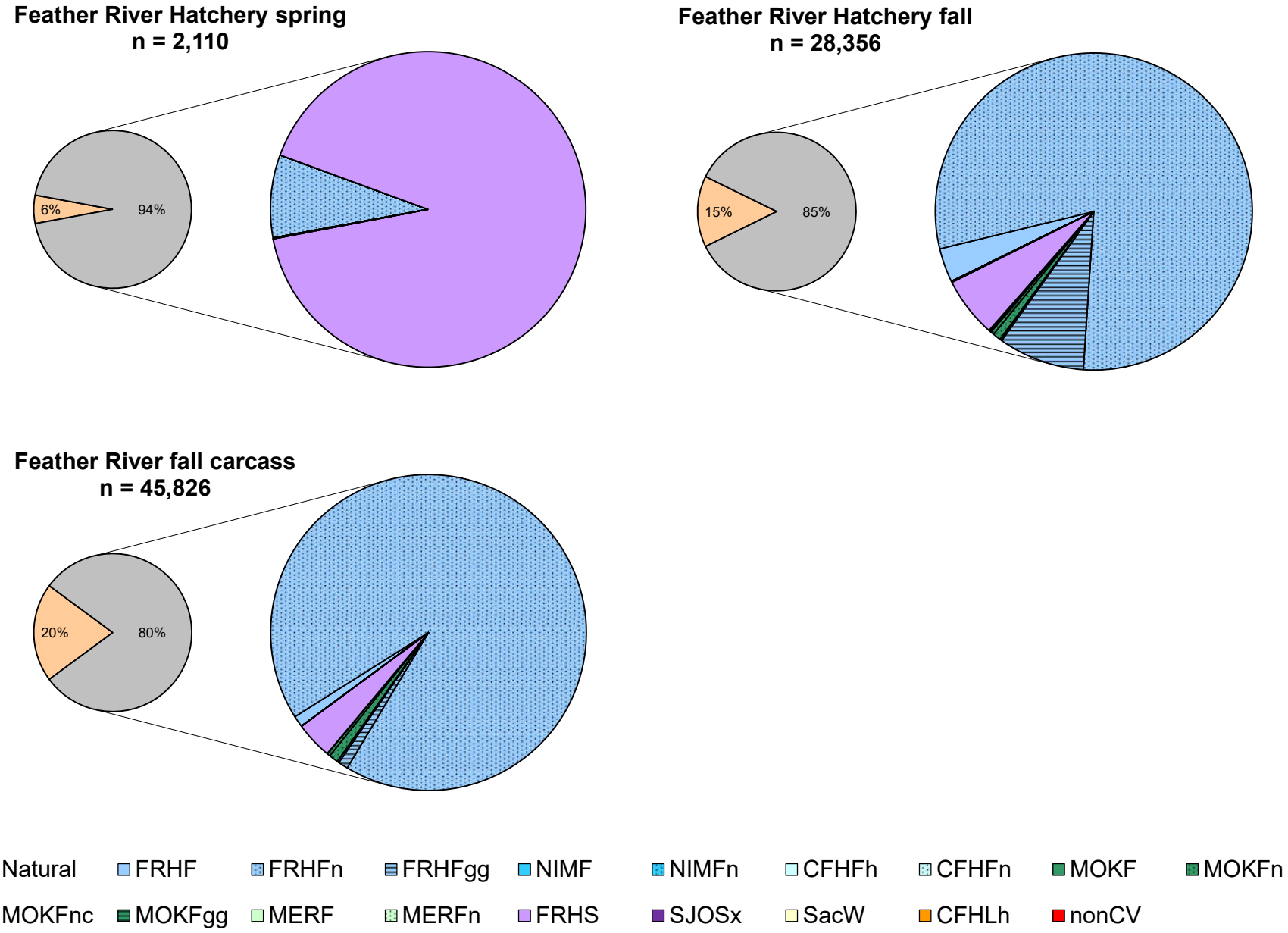


Figure 8. Proportion of hatchery- and natural-origin fish in the Feather River, 2018.

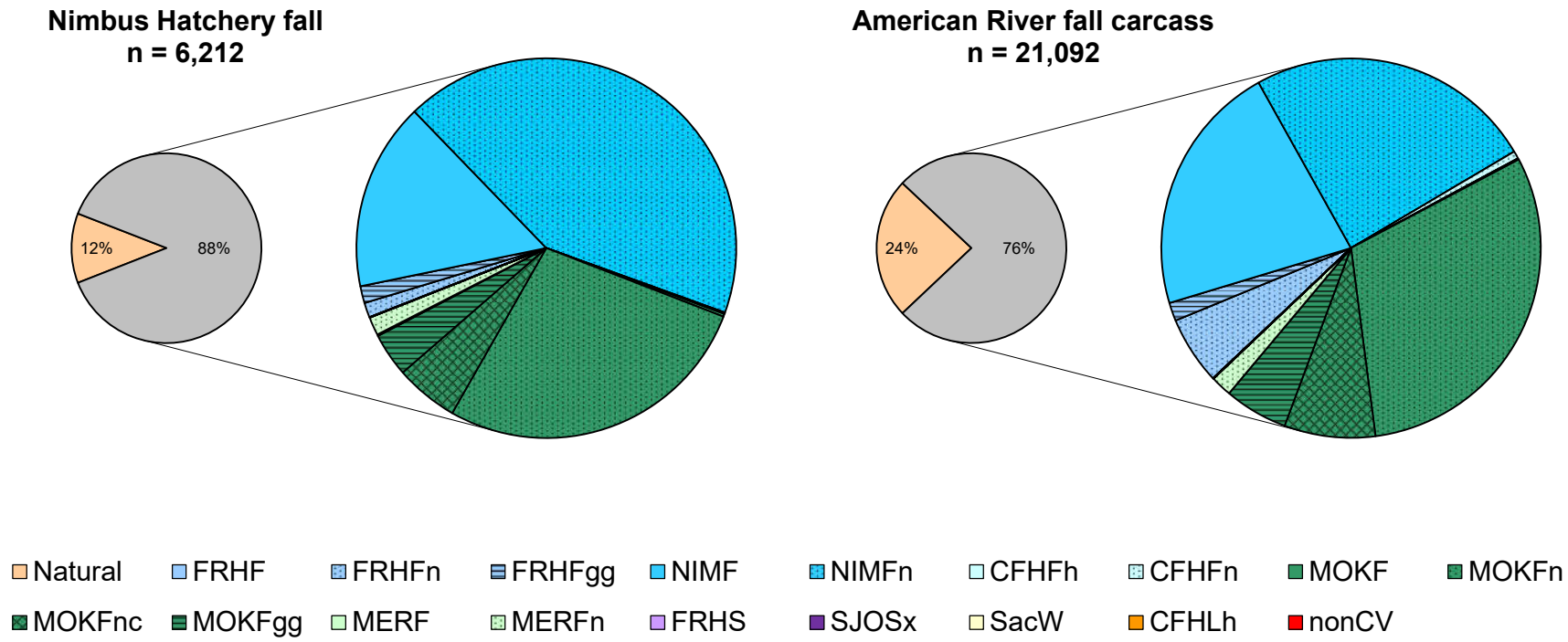


Figure 9. Proportion of hatchery- and natural-origin fish in the American River, 2018.

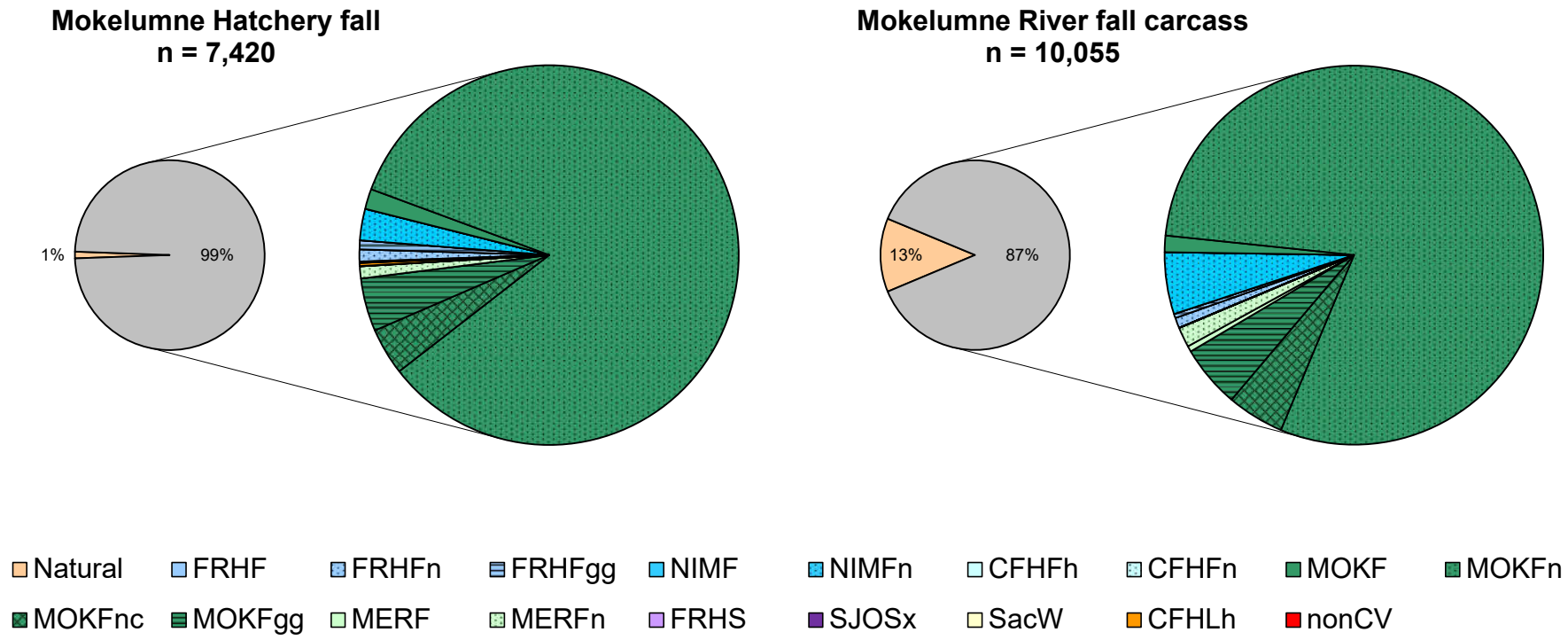


Figure 10. Proportion of hatchery- and natural-origin fish in the Mokelumne River, 2018.

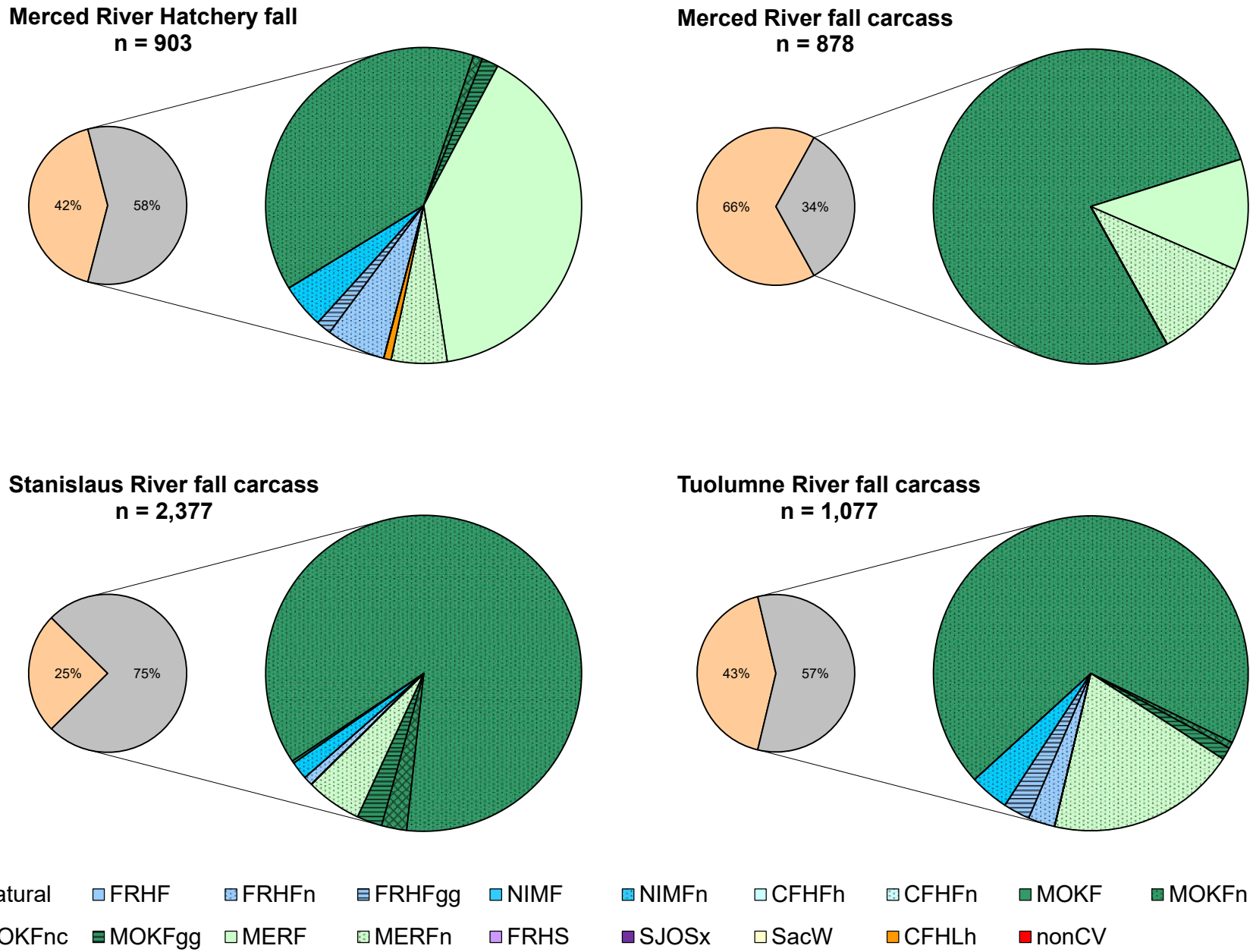


Figure 11. Proportion of hatchery- and natural-origin fish in the Merced River & San Joaquin Basin tributaries, 2018.

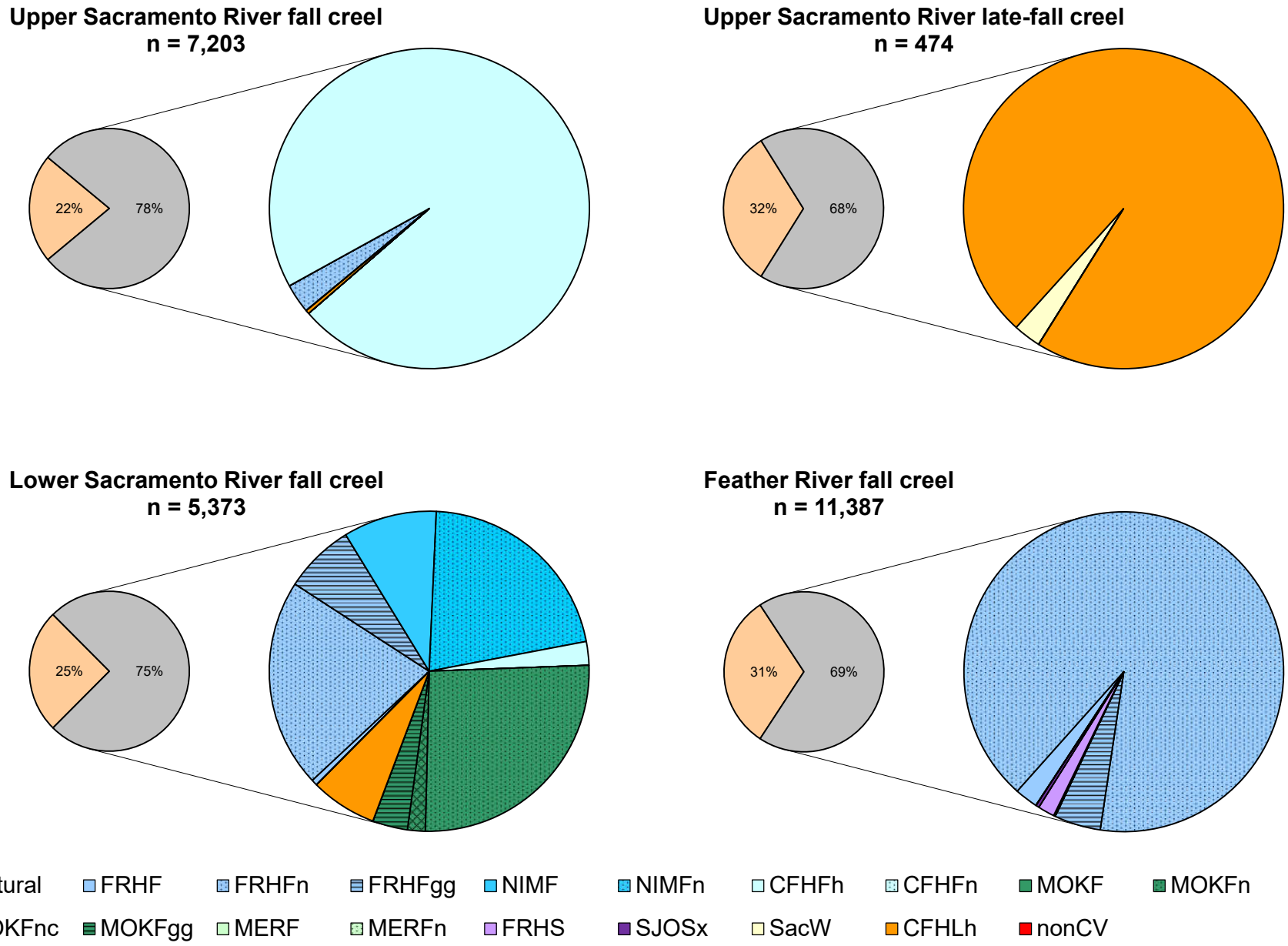


Figure 12. Proportion of hatchery- and natural-origin fish in sport harvest on Sacramento & Feather rivers, 2018.

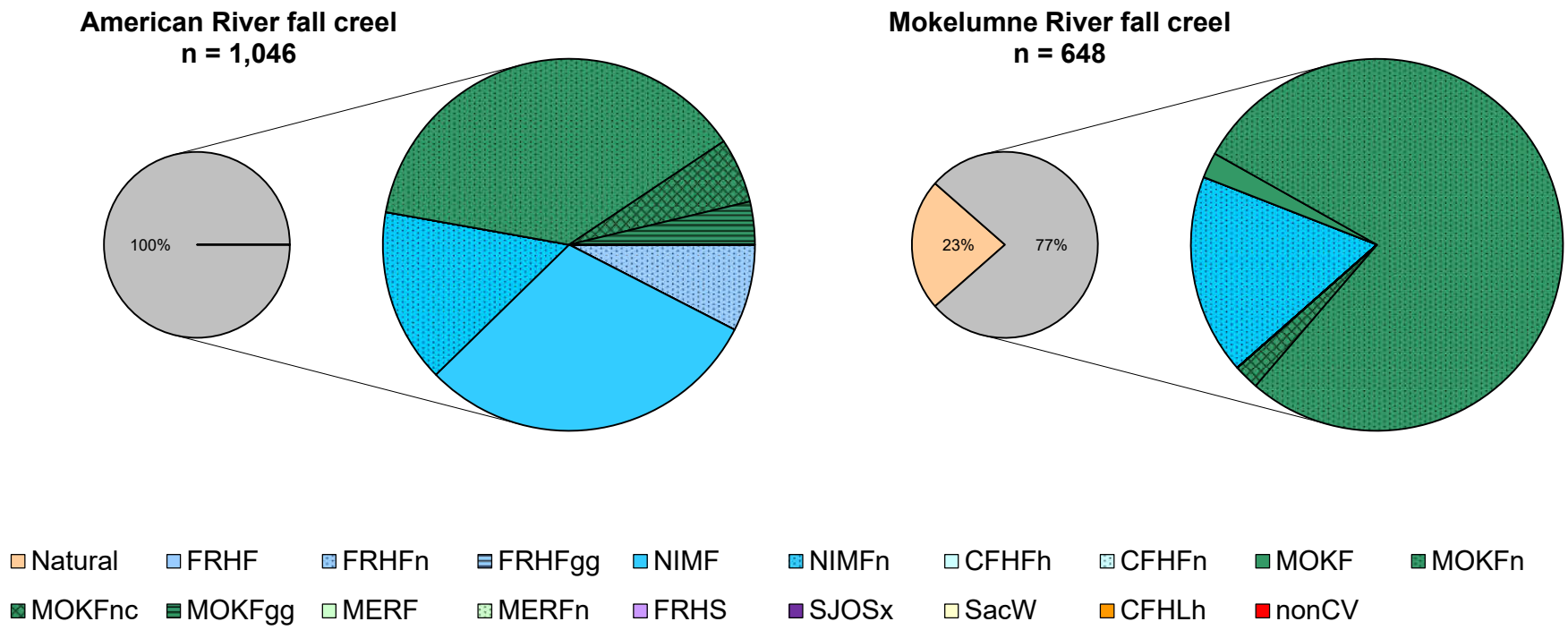
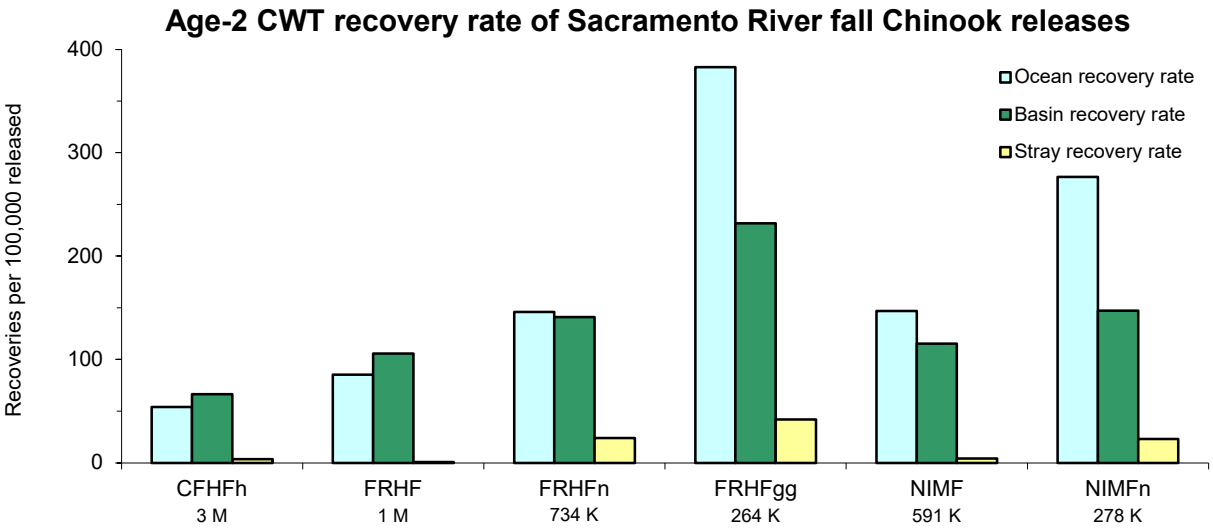
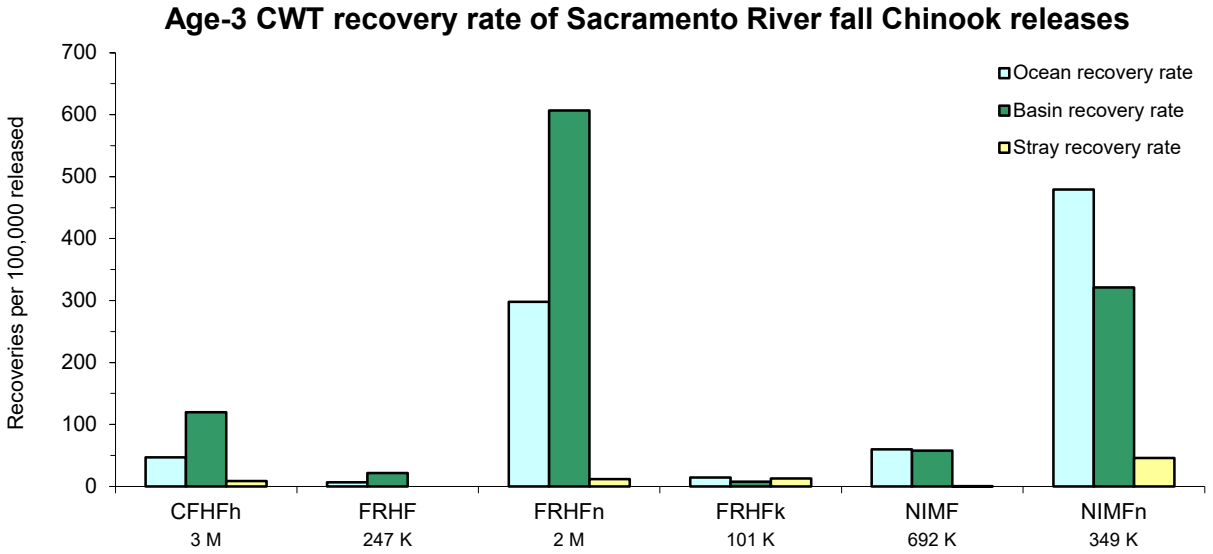


Figure 13. Proportion of hatchery- and natural-origin fish in sport harvest on American & Mokelumne rivers, 2018.





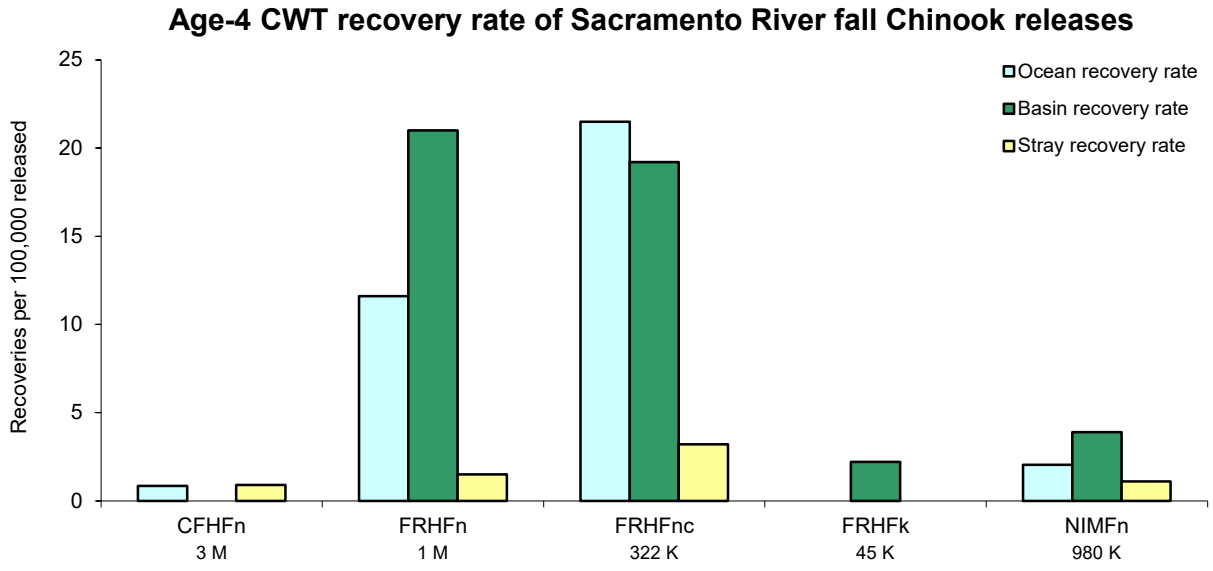


Figure 14. CWT recovery rates of Sacramento River fall Chinook releases by age in 2018.

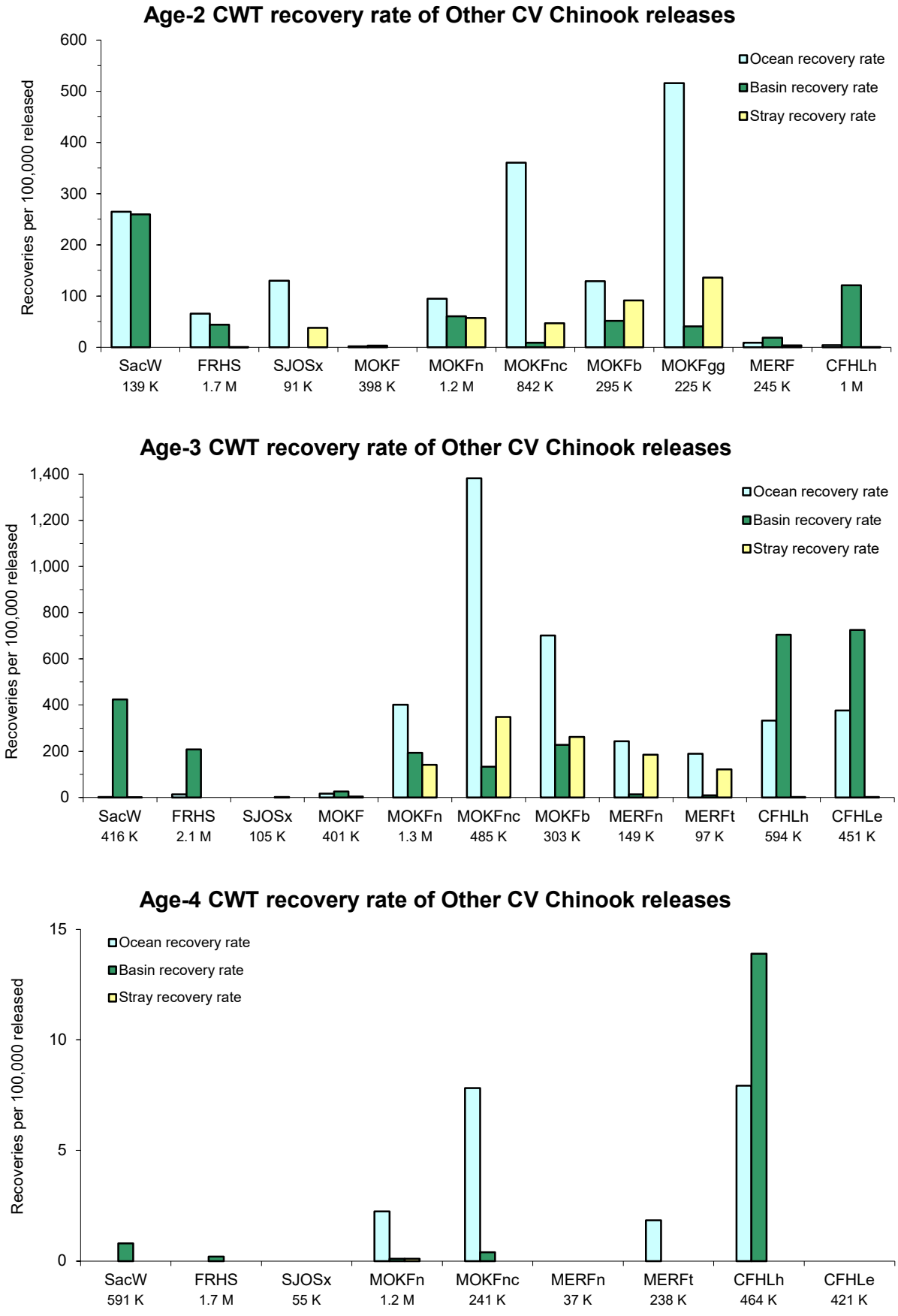


Figure 15. CWT recovery rates of Other CV Chinook releases by age in 2018.

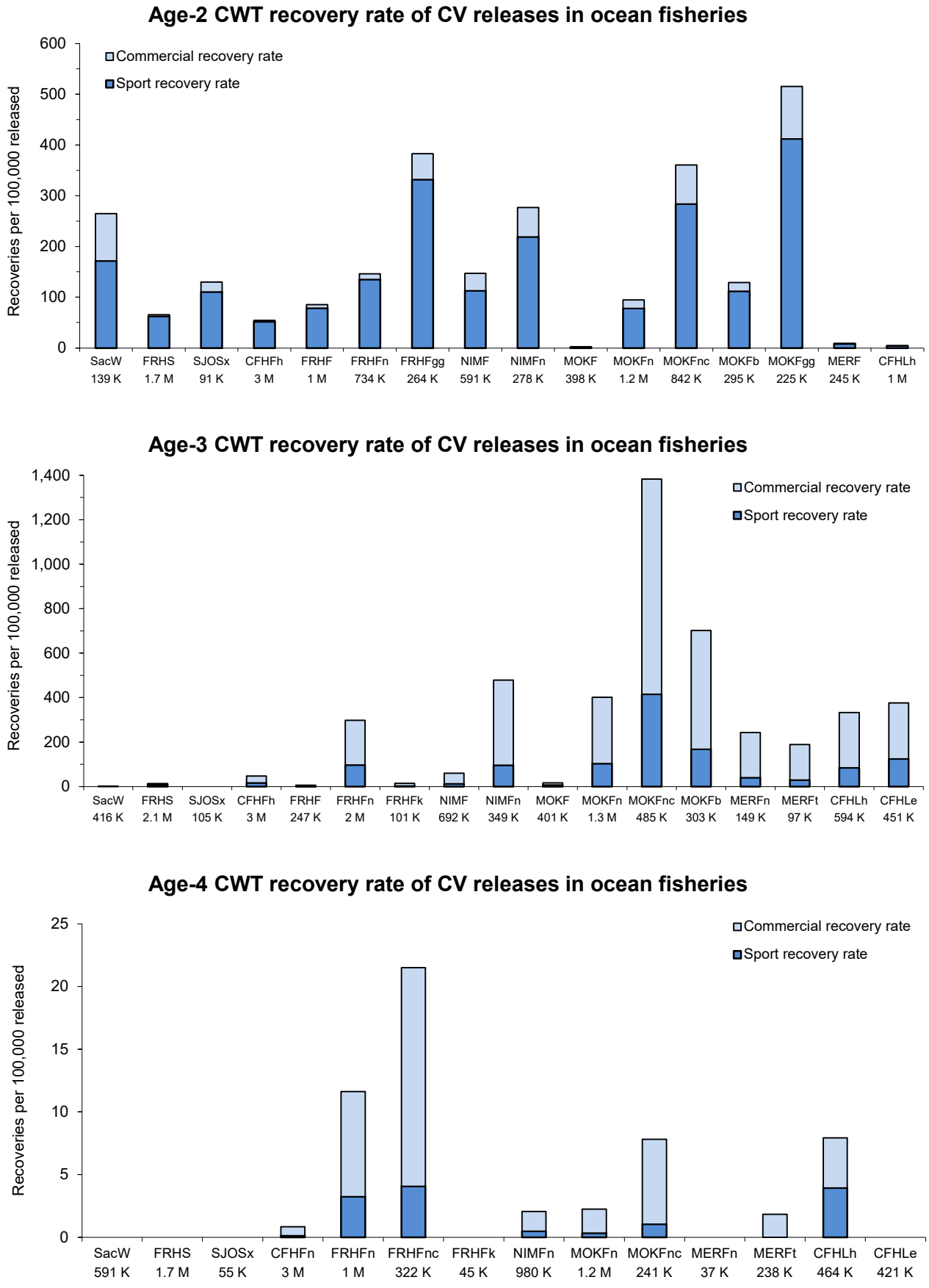


Figure 16. CWT recovery rates by release type in 2018 ocean salmon fisheries.

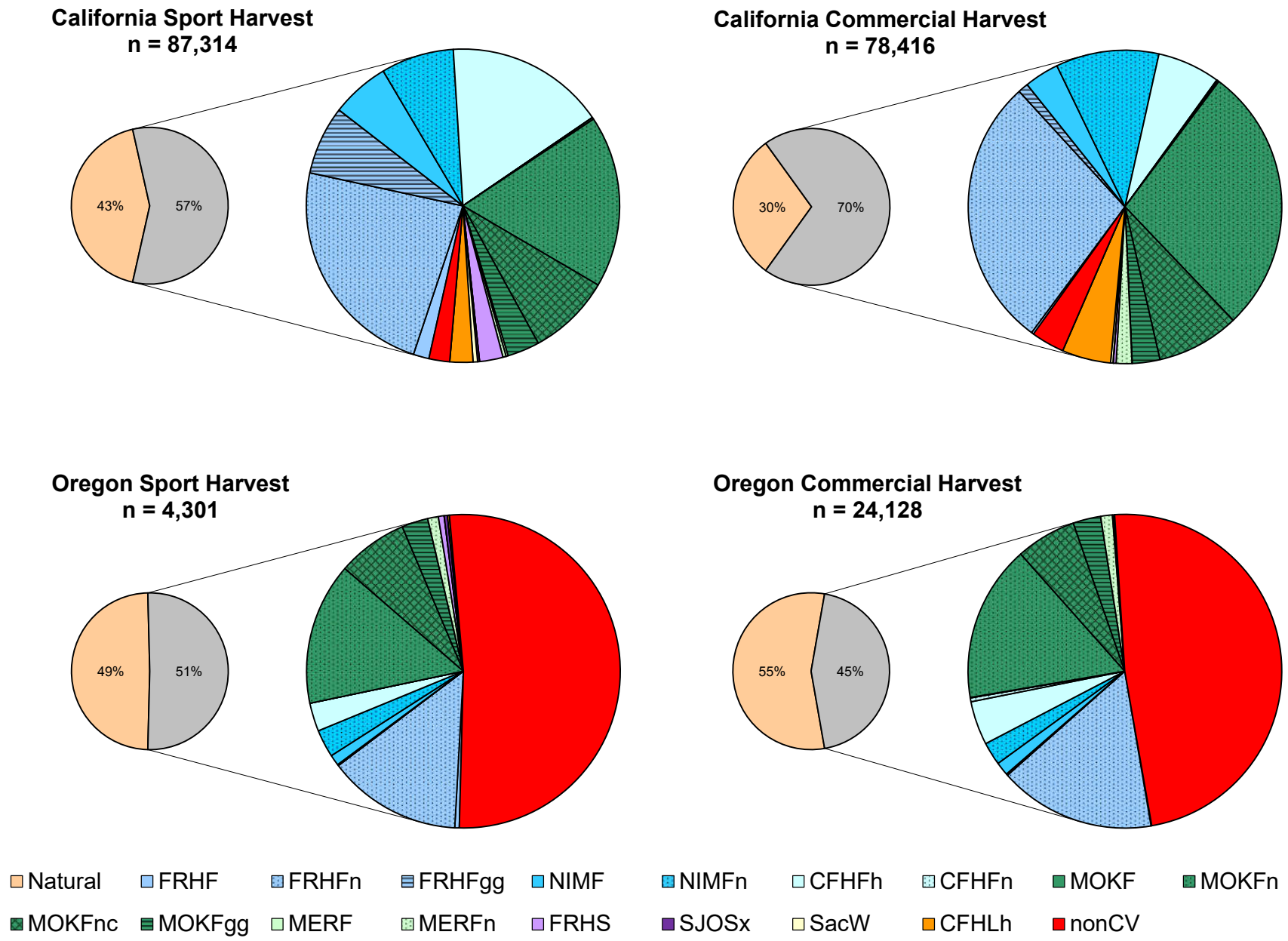


Figure 17. Proportion of hatchery- and natural-origin salmon in 2018 California and Oregon ocean fisheries.

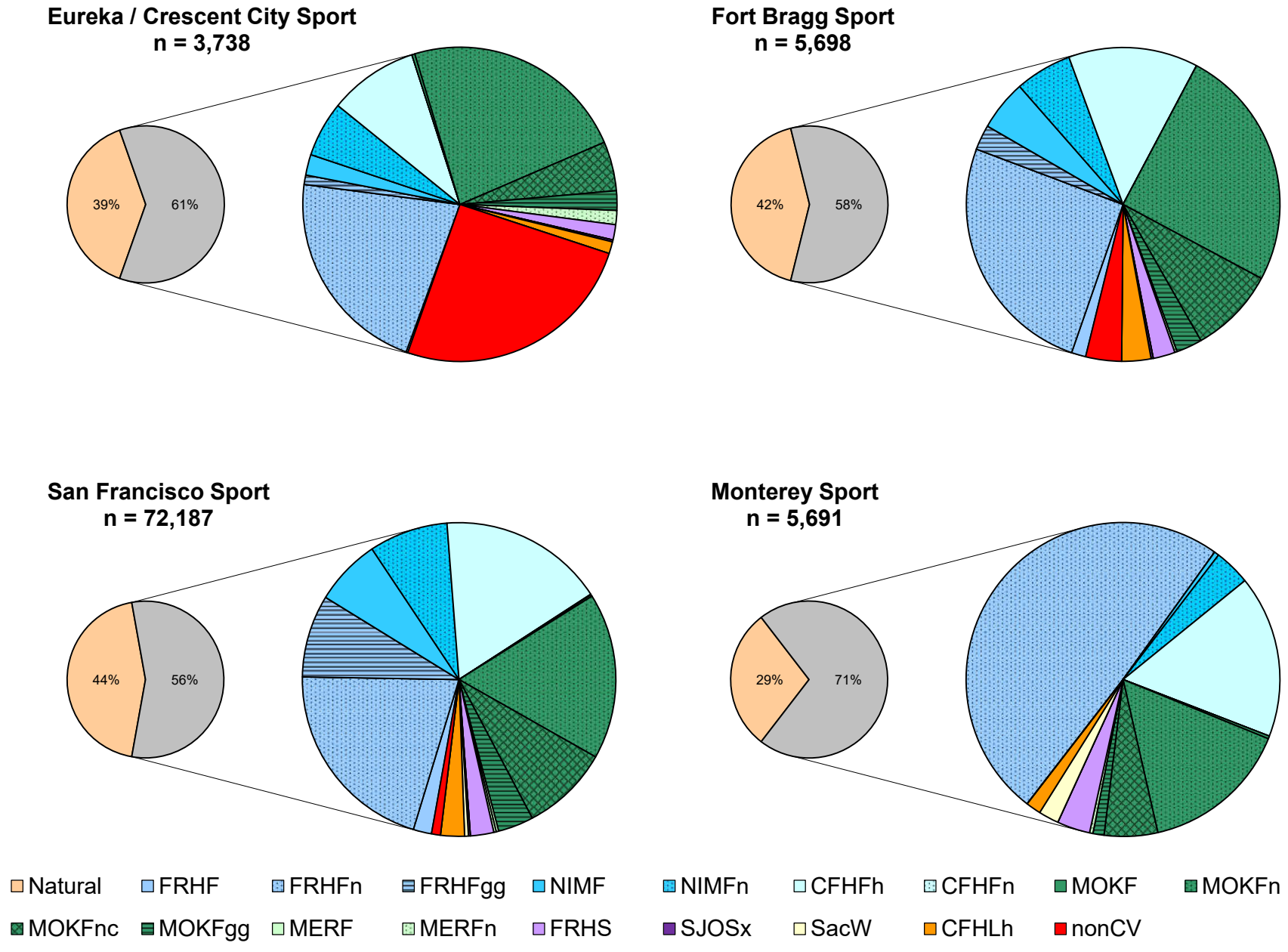


Figure 18. Proportion of hatchery- and natural-origin salmon in the 2018 California ocean sport fishery.

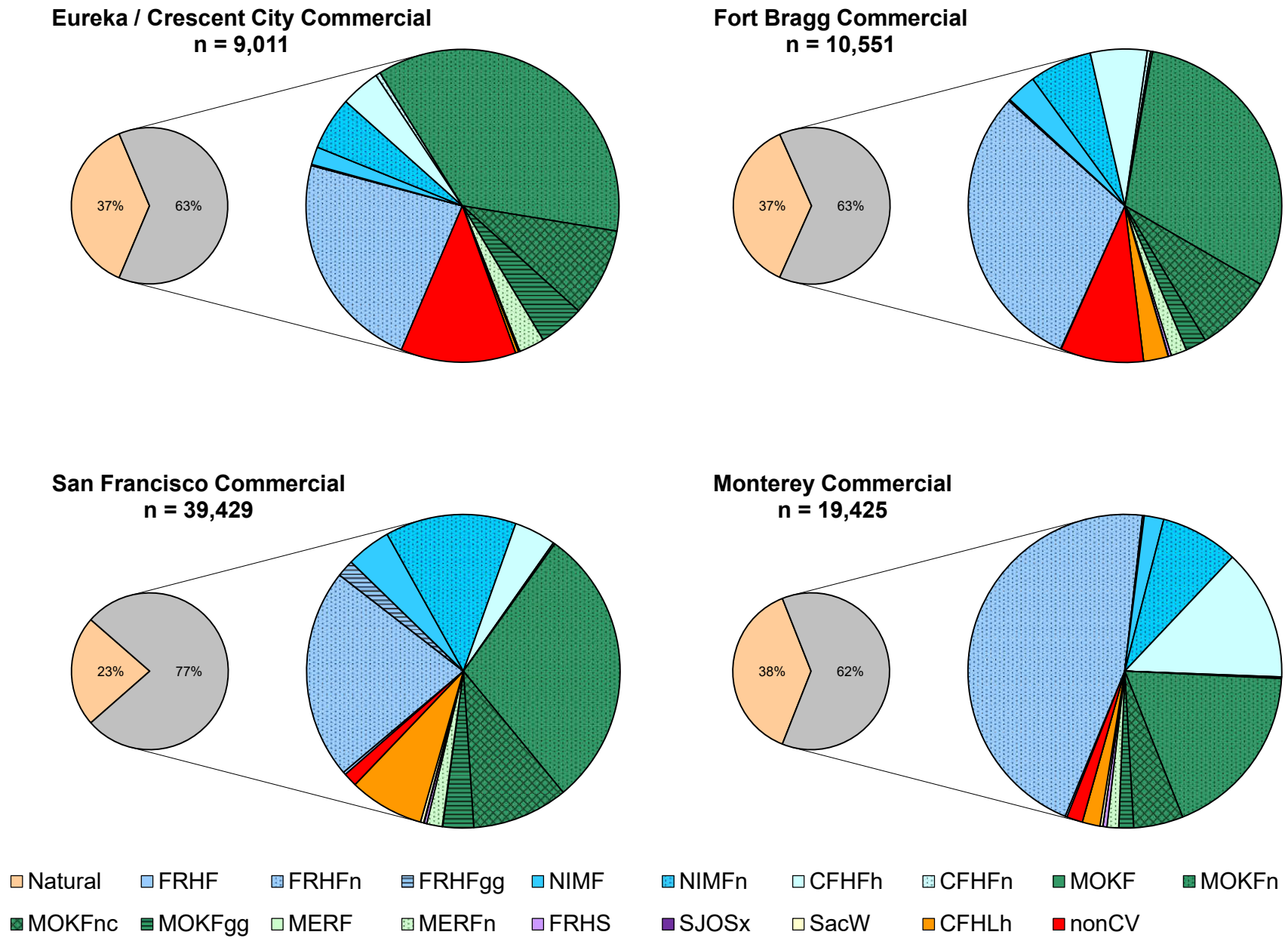
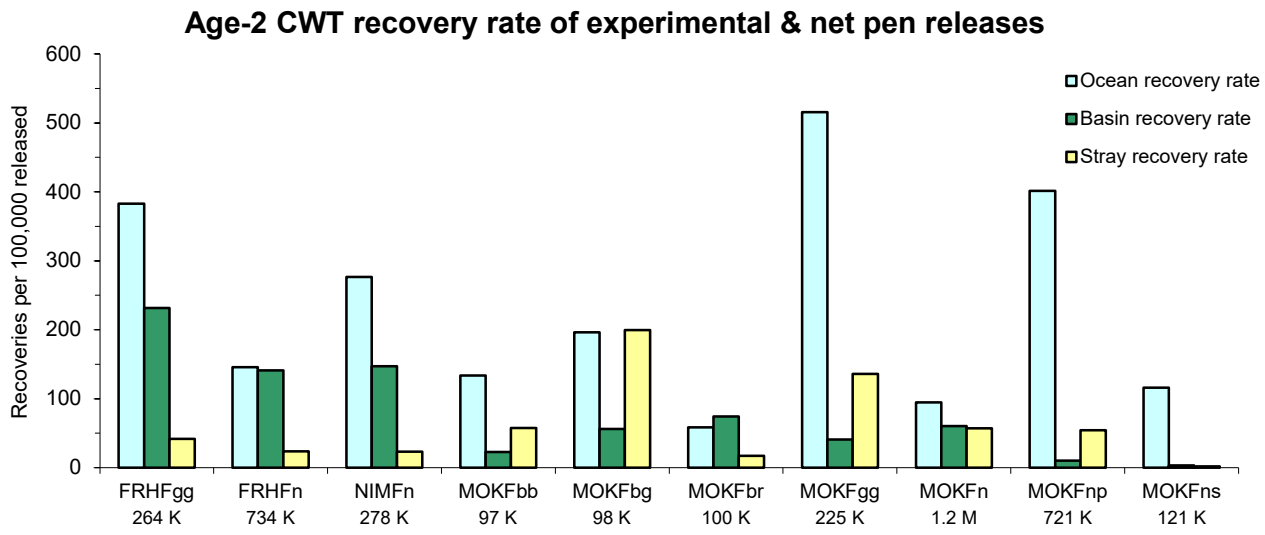
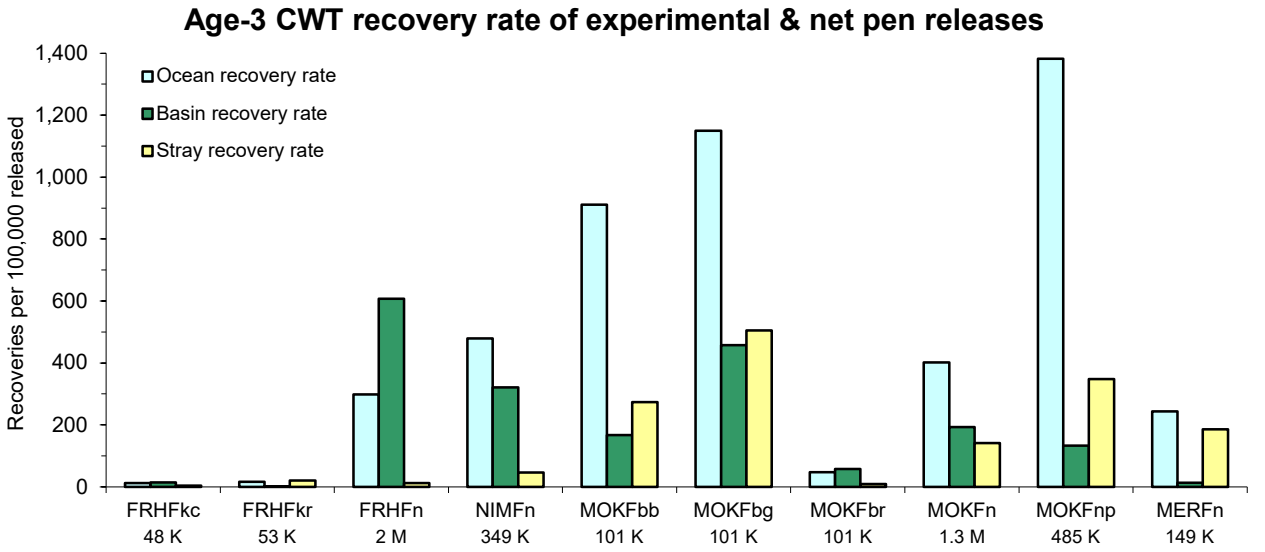


Figure 19. Proportion of hatchery- and natural-origin salmon in the 2018 California ocean commercial fishery.





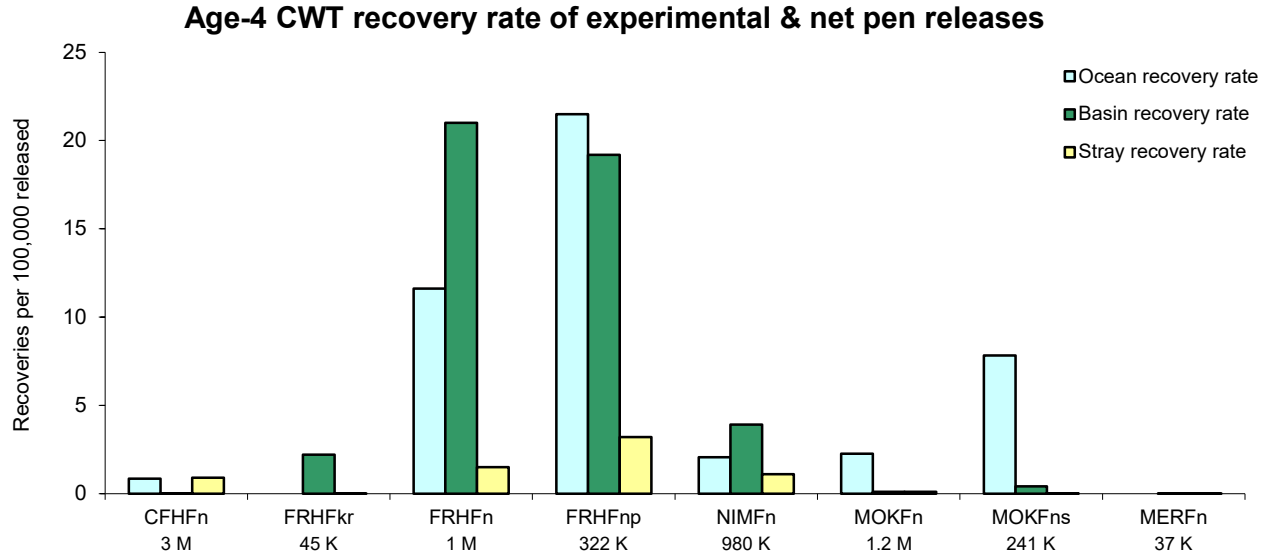


Figure 20. CWT recovery rates of experimental and net pen releases by age in 2018.

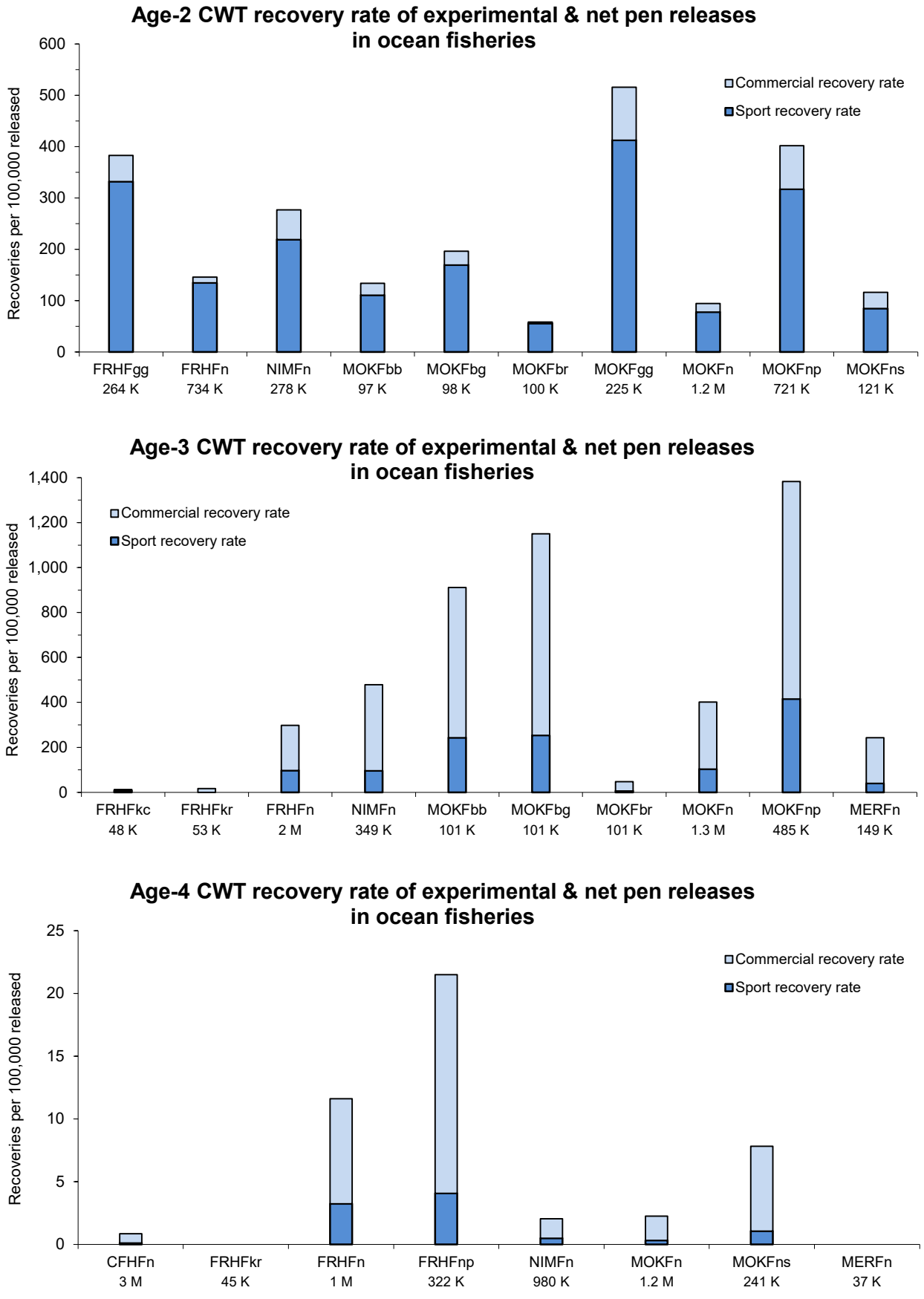


Figure 21. CWT recovery rates of experimental and net pen releases in 2018 ocean sport and commercial fisheries.

Appendix 1. Sample expansion factors for Central Valley salmon carcass surveys collecting fish condition in 2018.

Upper Sacramento River fall-run Chinook salmon carcass survey

Condition	Escapement N		Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	Valid CWTs	*p_adc*	*p_cwt|adc*	F_{samp}	Avg F_{prod}	$\sum_{i=1}^{m} CWT_{total,i}$	% hatchery
fresh	32%		649	6.9%	41	41	40	40	**0.06**	**0.98**	14.54	3.63	2,110	22.4%
non-fresh	68%		1,386	14.7%	72	72	65	64	0.05	0.90				
total		**9,436**	2,035	21.6%	113	113	105	**104**			**5.59**	**3.63**	2,110	**22.4%**

Feather River fall-run Chinook salmon carcass survey (fresh only)

Condition	Escapement N		Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	Valid CWTs	*p_adc*	*p_cwt|adc*	F_{samp}	Avg F_{prod}	$\sum_{i=1}^{m} CWT_{total,i}$	% hatchery
fresh	100%		2,742	6.0%	660	653	619	619	**0.24**	**0.95**	16.89	3.50	36,568	79.8%
non-fresh														
total		**45,826**	2,742	6.0%	660	653	619	**619**			**16.89**	**3.50**	**36,568**	**79.8%**

Yuba River (above and below DPD) fall-run Chinook salmon carcass survey (fresh only)

Condition	Escapement N		Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	Valid CWTs	*p_adc*	*p_cwt|adc*	F_{samp}	Avg F_{prod}	$\sum_{i=1}^{m} CWT_{total,i}$	% hatchery
fresh	100%		127	4.1%	58	58	56	56	**0.46**	**0.97**	24.20	2.10	2,849	92.7%
non-fresh														
total		**3,073**	127	4.1%	58	58	56	**56**			**24.20**	**2.10**	**2,849**	**92.7%**

Stanislaus River fall-run Chinook salmon carcass survey (fresh only)

Condition	Escapement N		Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	Valid CWTs	*p_adc*	*p_cwt|adc*	F_{samp}	Avg F_{prod}	$\sum_{i=1}^{m} CWT_{total,i}$	% hatchery
fresh	100%		570	24.0%	135	135	129	129	**0.24**	**0.96**	4.17	3.32	1,787	75.2%
non-fresh														
total		**2,377**	570	24.0%	135	135	129	**129**			**4.17**	**3.32**	**1,787**	**75.2%**

Tuolumne River fall-run Chinook salmon carcass survey (includes decayed weir recoveries)

Condition	Escapement N		Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	Valid CWTs	*p_adc*	*p_cwt|adc*	F_{samp}	Avg F_{prod}	$\sum_{i=1}^{m} CWT_{total,i}$	% hatchery
fresh	44%		313	29.1%	58	58	56	56	**0.19**	**0.97**	3.44	3.22	620	57.6%
non-fresh	56%		402	37.3%	47	44	38	38	0.12	0.86				
total		**1,077**	715	66.4%	105	102	94	**94**			**2.05**	**3.22**	**620**	**57.6%**

Merced River fall-run Chinook salmon carcass survey (fresh only)

Condition	Escapement N		Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	Valid CWTs	*p_adc*	*p_cwt|adc*	F_{samp}	Avg F_{prod}	$\sum_{i=1}^{m} CWT_{total,i}$	% hatchery
fresh	100%		136	15.5%	14	14	12	12	**0.10**	**0.86**	6.46	3.84	297	33.8%
non-fresh														
total		**878**	136	15.5%	14	14	12	**12**			**6.46**	**3.84**	**297**	**33.8%**

Upper Sacramento River winter-run Chinook salmon carcass survey

Condition	Escapement N		Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	Valid CWTs	*p_adc*	*p_cwt|adc*	F_{samp}	Avg F_{prod}	$\sum_{i=1}^{m} CWT_{total,i}$	% hatchery
fresh	53%		578	23.5%	473	473	466	465	**0.82**	**0.99**	4.26	1.01	2,006	81.6%
non-fresh	47%		518	21.1%	428	425	411	408	0.83	0.97				
total		**2,458**	1,096	44.6%	901	898	877	**873**			**2.27**	**1.01**	**2,006**	**81.6%**

Upper Sacramento River late-fall-run Chinook salmon carcass survey 2019

Condition	Escapement N		Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	Valid CWTs	*p_adc*	*p_cwt|adc*	F_{samp}	Avg F_{prod}	$\sum_{i=1}^{m} CWT_{total,i}$	% hatchery
fresh	46%		184	6.2%	60	60	57	56	**0.33**	**0.95**	16.51	1.07	994	33.3%
non-fresh	54%		219	7.3%	48	48	47	47	0.22	0.98				
total		**2,985**	403	13.5%	108	108	104	**103**			**8.98**	**1.07**	**994**	**33.3%**

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

Appendix 2. Alternative 2018 CWT recovery and stray rates (recoveries per 100,000 CWTs released) of CFH and FRH releases.[a/]

Age 2 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT_{samp}) by basin									CV CWT_{samp} totals			% CV Stray	Ocean	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[b/]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	In-basin	Stray	CV total		CWT_{samp}	In-basin	Stray	**CV total**	**Ocean**
CFHFh	2016	Fall	3,020,565	1,967	39	101	3						1,967	143	2,111	7%	1,633	65	5	70	54
CFHLh	2017	Late	1,047,211	1,223	45					4		1	1,223	50	1,273	4%	45	117	5	122	4
FRHF	2016	Fall	1,029,808	5			1,041	48	2	1			1,041	56	1,097	5%	879	101	5	107	85
FRHFn	2016	Fall	733,880	2	6	33	914	121	121	11		3	914	297	1,211	24%	1,070	125	40	165	146
FRHFgg	2016	Fall	263,611	2			610		81	22	4	2	610	111	721	15%	1,009	232	42	274	383
FRHS	2016	Spr	1,682,317				690	48	2				690	50	740	7%	1,100	41	3	44	65

Age 3 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT_{samp}) by basin									CV CWT_{samp} totals			% CV Stray	Ocean	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[b/]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	In-basin	Stray	CV total		CWT_{samp}	In-basin	Stray	**CV total**	**Ocean**
CFHFh	2015	Fall	3,033,741	3,204	436	260							3,204	696	3,900	18%	1,425	106	23	129	47
CFHLh	2016	Late	594,043	3,686	501		1		2	8		2	3,686	514	4,200	12%	1,979	620	87	707	333
CFHLe	2016	Late	450,662	2,902	365					6		1	2,902	372	3,273	11%	1,696	644	82	726	376
FRHF	2015	Fall	246,501				53						53	0	53	0%	16	21	0	21	6
FRHFn	2015	Fall	2,019,877	3	11	65	12,137	121	125	22	8	5	12,137	360	12,497	3%	6,023	601	18	619	298
FRHFk	2015	Fall	101,134		11		8		2				8	13	21	62%	15	8	13	21	15
FRHS	2015	Spr	2,109,278				3,947	436					3,947	436	4,382	10%	283	187	21	208	13

Age 4 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT_{samp}) by basin									CV CWT_{samp} totals			% CV Stray	Ocean	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[b/]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	In-basin	Stray	CV total		CWT_{samp}	In-basin	Stray	**CV total**	**Ocean**
CFHFn	2014	Fall	2,951,944						28				0	28	28	100%	25	0	1	1	1
CFHLh	2015	Late	463,924	56	9								56	9	64	14%	37	12	2	14	8
CFHLe	2015	Late	420,514										0	0	0	-	0	0	0	0	0
FRHFn	2014	Fall	1,047,852		6		220		4	6			220	16	236	7%	122	21	2	23	12
FRHFnc	2014	Fall	321,527		6		62		5				62	10	72	14%	69	19	3	22	21
FRHFk	2014	Fall	45,200				1						1	0	1	0%	0	2	0	2	0
FRHS	2014	Spr	1,690,972				3						3	0	3	0%	0	0.2	0	0.2	0

a/ CFH and FRH releases recovered in the Upper Sacramento River and Yuba River, respectively, are considered stray recoveries in this table.

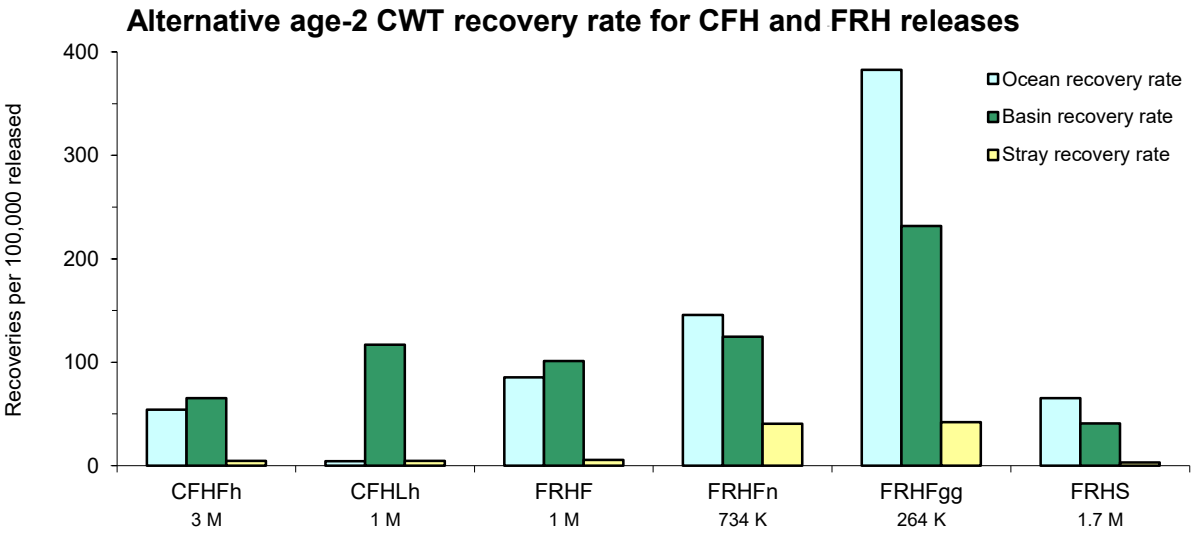
b/ Natural creeks can include Clear Creek, Cow Creek, Cottonwood Creek, Paynes Creek, Mill Creek, Deer Creek, and Butte Creek, depending on survey year.

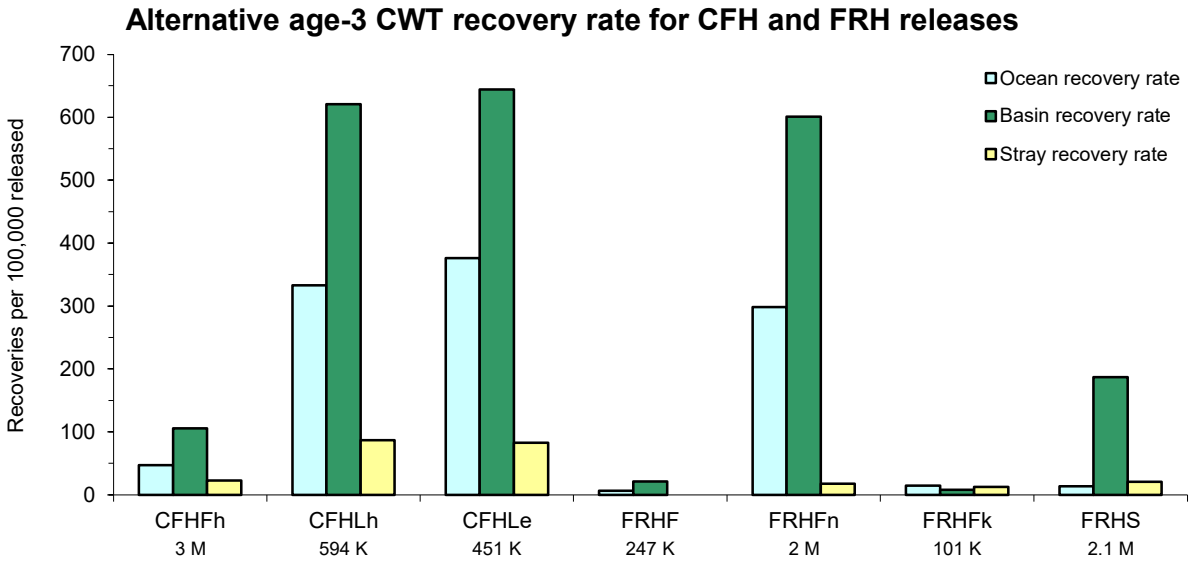
Sacramento River fall Chinook release types (SFC)

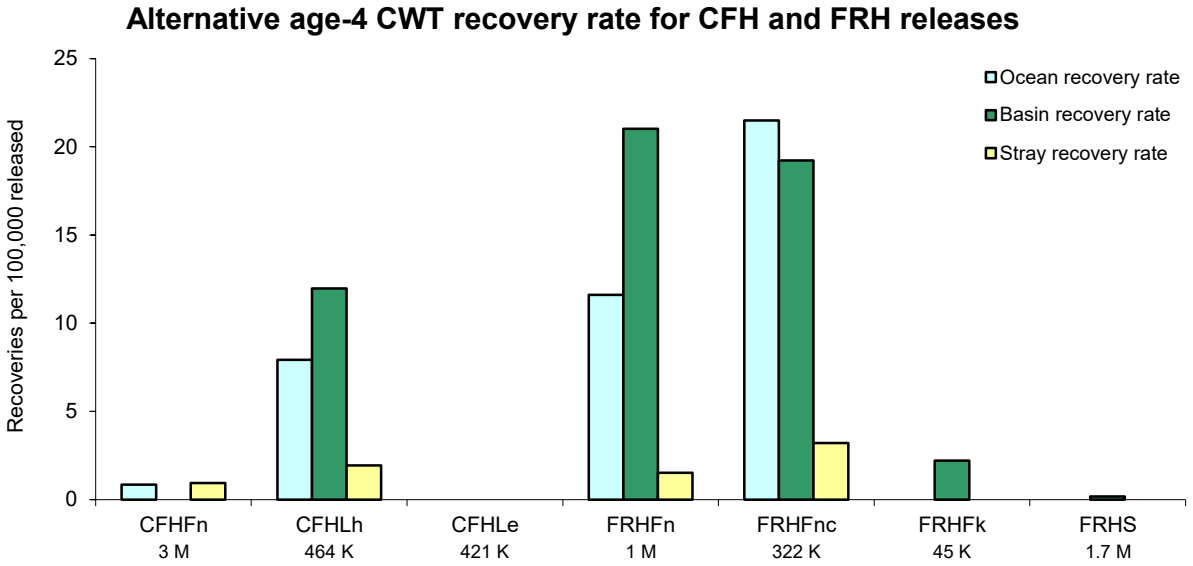
CFHFh Coleman National Fish Hatchery fall hatchery releases
CFHFn Coleman National Fish Hatchery fall bay/delta net pen releases
FRHF Feather River Hatchery fall in-basin releases
FRHFn Feather River Hatchery fall bay/delta net pen releases
FRHFnc Feather River Hatchery fall coastal net pen releases
FRHFgg Feather River Hatchery fall Golden Gate releases (no net pens)
FRHFk Feather River Hatchery fall experimental Knaggs Ranch releases

Other CV Chinook release types (OCV)

CFHLh Coleman National Fish Hatchery late-fall hatchery releases
CFHLe Coleman National Fish Hatchery late-fall emergency trucked releases (no net pens)
FRHS Feather River Hatchery spring in-basin releases







Appendix 3. Alternative CWT recovery rates for CFH and FRH releases by age in 2018.

Appendix 4. Comparison of raw CWT recoveries by release type between fish sampled in natural areas above and below the NIM weir in 2018.

Release type	Run type	# CWT recoveries above NIM weir	% of total above NIM weir	# CWT recoveries below NIM weir	% of total below NIM weir
FRHS	Spring	1	<1%	0	-
SJOSx	Spring	2	<1%	1	<1%
CFHFh	Fall	0	-	0	-
CFHFn	Fall	15	1%	0	-
FRHF	Fall	1	<1%	0	-
FRHFn	Fall	121	5%	14	1%
FRHFnc	Fall	1	<1%	0	-
FRHFtib	Fall	0	-	0	-
FRHFgg	Fall	23	1%	13	1%
FRHFk	Fall	1	<1%	0	-
NIMF	Fall	341	15%	157	15%
NIMFn	Fall	307	14%	261	26%
MOKF	Fall	2	<1%	1	<1%
MOKFn	Fall	470	21%	238	23%
MOKFnc	Fall	551	25%	164	16%
MOKFb	Fall	313	14%	111	11%
MOKFgg	Fall	40	2%	44	4%
MERF	Fall	0	-	0	-
MERFn	Fall	41	2%	12	1%
MERFt	Fall	18	1%	6	1%
	Total	2,248		1,022	

Appendix 5. Sample expansion for CWTs recovered in the Mokelumne River above Woodbridge Dam (WD) in 2018.

	Total count	Total ad-clips	% ad-clip
Woodbridge Dam video	17,475	5,544	31.7%
Mokelumne River Hatchery return	7,420	2,448	33.0%
Natural Escapement Mokelume River	**10,055**	**3,096**	30.8%

Mokelume River natural area escapement above WD: Total video count minus hatchery return with supplemental carcass survey CWT data

Escapement N	Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	Valid CWTs	*p_adc*	*p_cwt|adc*	F_{samp}	Avg F_{prod}	$\sum_{i=1}^{m} CWT_{total,i}$	% hatchery
10,055	10,055	100%	**3,096**	**803**	**775**	**774**	**0.308**	**0.965**	**3.86**	**2.94**	**8,792**	**87.4%**
Video count			Video count		Carcass survey							