Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2019

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INTRODUCTION

Each year, approximately 32 million fall-run Chinook salmon (*Oncorhynchus tshawytscha*) are produced at five hatcheries in California's Central Valley (CV): Coleman National Fish Hatchery (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 tenth annual report on the recovery of CFM CWTs in the CV and ocean fisheries. In 2019, approximately 56,500 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 CFM reports (Kormos et al. 2012, Palmer and Kormos 2013, 2015) for more information and discussion regarding the CFM program, CWT recovery programs, 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., FWS 2020, Kelly and Phillips 2020, Kowalik and Massa 2020).

DATA AND METHODS

Inland Escapement and River Sport Harvest Monitoring

During 2019, 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 2020 return year, however the escapement monitoring period began in late 2019.

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 2019 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 271,100 Chinook salmon that returned to the CV basins analyzed in this report, 114,000 salmon were sampled, 32,600 ad-clipped salmon were observed, and 31,100 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 7,100 heads processed by FWS staff at CFH, 200 heads processed by FWS staff in Lodi, and 1,200 heads 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 2019, California sport and commercial ocean salmon fisheries (Table 2) had increased opportunities compared to the two years prior due to improved abundance forecasts for fall-run Chinook salmon from the Sacramento and Klamath basins. Of the approximately 359,900 salmon harvested in California ocean fisheries during 2019, CDFW field staff sampled 111,600 salmon and collected 20,700 heads that were processed at the Santa Rosa CWT lab. Almost 1,800 heads collected in Oregon sport and commercial ocean fisheries during 2019 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 2019 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 2019 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 2014 through 2017 were downloaded from the RMPC. Approximately 127 million CV salmon were released for these brood years, of which 45 million were marked and tagged utilizing 390 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 2019, there were 250 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 release strategy. All CV CWT codes were assigned by brood year into one of fifteen fall-run, two winter-run, two spring-run, or one late-fall-run release types:

Sacramento River Basin Fall-run Chinook salmon release types

CFHF	Coleman National Fish Hatchery **F**all-run in-basin releases
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
FRHFgg	Feather River Hatchery **F**all-run **G**olden **G**ate releases (no net pen acclimation)
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 (Pillar Point/Santa Cruz)
MOKFgg	Mokelumne River Hatchery **F**all-run **G**olden **G**ate releases (no net pen acclimation)
MOKFb	Mokelumne River Hatchery **F**all-run **b**arge study releases
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)
SacWbat	Sacramento River **W**inter-run **Bat**tle Creek reintroduction 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

CFHL	Coleman National Fish Hatchery **L**ate-fall-run in-basin releases

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 problematic CWT releases where fish were released utilizing more than one strategy (e.g., one out of the fifteen bay/delta net pen MOKFn release groups from the 2017 brood was not actually acclimated in net pens due to traffic delays). Thus, we urge caution when analyzing or comparing CWT recovery data from certain release types. Releases that were part of the Knaggs Ranch rice field study have been excluded from this report, as there was only one inland recovery (an age-4 fish released as part of an in-river control group) and no ocean recoveries in 2019.

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 or harvest 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 2019 was generally higher or similar to the rate observed in non-fresh fish (Appendix 1). Fresh carcass heads also usually contain CWTs at a higher rate than heads collected from non-fresh fish, although that was not the case for most surveys in 2019. 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:

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

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:

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

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:

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

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

Determining stray proportions of various release groups in CV escapement

To be consistent with previous reports (Kormos et al. 2012, Letvin et al. 2020, 2021, 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 2019 CV inland recoveries and California ocean harvest

All of the 34,900 valid CWTs recovered in the CV during 2019 were from CV Chinook salmon releases. Most CWTs were brood year 2015 through 2017 releases (Table 6). About 89% of all CWT_{total} were fall-run, followed by spring-run (7%) and late-fall-run (3%) salmon releases. Only 2% of CWT_{total} were winter-run, some of which were collected from the first cohort of spawners to return to CFH as part of the FWS Battle Creek winter-run Jumpstart program (age-2). The remaining winter-run CWTs were all 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 (76%) and age-2 (21%) fish.

Most of the 20,000 valid CWT recoveries from the 2019 California ocean harvest were CV salmon releases belonging to brood year 2016 (Table 7; one age-7 and five experimental San Joaquin fall-run removed). Approximately 96% of all CWT_{total} in the ocean harvest were CV fall-run, followed by CV spring-run (1%), CV late-fall-run (1%), and CV winter-run (0.2%) salmon. The remaining 2% 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 fish (91%), distantly followed by age-2 (5%) and age-4 (3%) fish.

Over two-thirds of the 1,700 valid CWT recoveries from the 2019 Oregon ocean harvest (south of Cape Falcon) were CV fall-run salmon releases (Table 8; one age-6 removed), which composed 71% of all CWT_{total}. Recoveries of other CV run types were scarce off Oregon. Non-CV stocks made up 29% 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 (79%) and age-4 (18%) fish.

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

During 2019, approximately 146,400 fall-run Chinook salmon returned to spawn in the CV natural areas included in these analyses (Table 9, Fig. 2). There were an additional 4,300 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 (0%), followed by the upper Sacramento River mainstem (5%), Tuolumne River (17%), and Clear Creek (18%). The highest fall-run hatchery proportion occurred in the American River (94%), followed by Battle Creek (90%) and the Mokelumne River (73%). The total CV fall-run hatchery proportion for all natural areas that were adequately sampled during 2019 was 53%.

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 62,100 fall-run salmon returning to the five CV hatcheries ranged from 53% to 90% (Table 9, Fig. 3). The fall-run hatchery proportion for all CV hatcheries combined was 79%. The spring-run return to FRH and the late-fall-run return to CFH were almost entirely hatchery-origin salmon (95% and 98%, 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 in 2019, the fall-run spawning period was considered early October through late November, and the late-fall-run spawning period was considered early December through late February 2020. However, FWS staff ultimately parsed the final escapement into run types based on CWT recoveries and the dominant run type by date. All ad-clipped salmon were sampled during the entire run, and additionally during the late-fall-run period all unmarked salmon were electronically checked for CWTs. An additional 365 late-fall-run salmon were trapped at CFH after spawning operations ended. Also, 2019 was the first year of spawner returns to CFH for winter-run salmon that were spawned at LSH, raised at CFH, and released into North Fork Battle Creek as part of the FWS Jumpstart program.

Winter-, 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 winter-, fall-, and late-fall-run returns to the upper Sacramento River mainstem, Clear Creek, and Mill Creek (Figs. 5, 6). Winter- and late-fall-run spawners collected at KES were primarily hatchery-origin fish. The proportion of hatchery-origin fish (prevalent release type shown in parentheses) at each of the following locations was:

- Winter-run returns CFH: 100% (SacW)
- Fall-run returns CFH: 90% (CFHF)
- Late-fall-run returns CFH: 98% (CFHL)
- Late-fall-run returns CFH (post-spawning): 99% (CFHL)
- Winter-run spawners for broodstock KES: 62% (SacW)
- Late-fall-run supplemental spawners KES: 74% (CFHL)
- Winter-run spawners upper Sacramento River: 35% (SacW)
- Fall-run spawners upper Sacramento River: 5% (CFHF)
- Late-fall-run spawners upper Sacramento River: 14% (CFHL)
- Fall-run spawners Clear Creek: 18% (CFHF)
- Fall-run spawners Battle Creek: 90% (CFHF)
- Fall-run spawners Mill Creek: 40% (CFHF)

Butte Creek and Feather River Basin

In Butte Creek, both spring- and fall-run spawners were entirely of natural-origin. In the Feather Basin, spring- and fall-run returns to FRH and spawners in the Yuba River below Daguerre Point Dam (DPD) were predominantly of hatchery-origin, while spawners in the Feather River and Yuba River above DPD were relatively evenly distributed between hatchery- and natural-origin (Figs. 7, 8). The proportion of hatchery-origin fish (prevalent release type shown in parentheses) at each of the following locations was:

- Spring-run spawners Butte Creek: 0%
- Fall-run spawners Butte Creek: 0%
- Spring-run returns FRH: 95% (FRHS)
- Fall-run returns FRH: 68% (FRHFn)
- Fall/spring-run spawners Feather River: 45% (FRHFn)
- Fall/spring-run spawners Yuba River above DPD: 50% (FRHFn)
- Fall/spring-run spawners Yuba River below DPD: 76% (FRHFn)

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

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 type shown in parentheses) at each of the following locations was:

- Fall-run returns NIM: 87% (NIMFn)
- Fall-run spawners American River: 94% (NIMFn)

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 done because salmon that were encountered upstream of the weir tended to exhibit an earlier run timing (e.g., strays from other hatcheries) 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, beginning in 2018, a single natural area escapement estimate has been reported annually 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 are now merged and the same F_{samp} is applied to CWTS recovered at both the weir and in the downstream carcass survey. This was the second year that fishing was permanently closed upstream of the NIM weir, so there were many 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 2019.

Mokelumne, Stanislaus, and Tuolumne rivers

Fall-run returns to MOK and Mokelumne River natural areas were predominantly hatchery-origin salmon. Spawners in the Stanislaus River were mostly of hatchery-origin by a small margin, while spawners in the Tuolumne River were predominantly of natural-origin (Fig. 10). The proportion of hatchery-origin fish (prevalent release type shown in parentheses) at each of the following locations was:

- Fall-run returns MOK: 89% (MOKFn)
- Fall-run spawners Mokelumne River: 73% (MOKFn)
- Fall-run spawners Stanislaus River: 54% (MOKFn)
- Fall-run spawners Tuolumne River: 17% (MERFn)

Appendix 6 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 and upper San Joaquin rivers

Fall-run returns to MER were relatively evenly distributed between hatchery- and natural-origin salmon, and it was the lowest hatchery contribution observed since the CFM program was fully implemented. Natural area spawners in the Merced River were predominantly of natural-origin. Due to high flows in the San Joaquin River during spring 2019, spring-run spawners could volitionally return to the upper San Joaquin River via the Eastside Bypass. These spring-run spawners were predominantly hatchery-origin salmon (Fig. 11). The proportion of hatchery-origin fish (prevalent release type shown in parentheses) at each of the following locations was:

- Fall-run returns MER: 53% (MERFn)
- Fall-run spawners Merced River: 24% (MERFn)
- Spring-run spawners upper San Joaquin River: 94% (SJOSx)

2. Contribution of CV Release Types to Total Salmon Escapement

In 2019, 57% of the 240,600 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 CFH fall-run in-basin releases (14%) followed by fall-run bay/delta net pen releases from FRH and MOK (9% and 7%, respectively). MOK fall-run bay/delta net pen releases had the highest number of strays, while MOK fall-run coastal net pen and Golden Gate releases had the highest rates of straying (79% and 76%, respectively), closely followed by MER fall-run bay/delta net pen releases (75%). About 14% of all recoveries occurred outside their basin-of-origin and ranged from <1% to 79%, depending on release type:

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

R_{type}	Run	CWT_{total}	% total	# Stray	% stray
CFHF	Fall	34,584	14%	2,173	6%
CFHFn	Fall	0	0%	0	-
FRHF	Fall	3,468	1%	7	<1%
FRHFn	Fall	22,468	9%	2,377	11%
FRHFgg	Fall	14,437	6%	1,881	13%
NIMF	Fall	9,449	4%	41	<1%
NIMFn	Fall	13,853	6%	704	5%
MOKF	Fall	181	<1%	38	21%
MOKFn	Fall	16,285	7%	7,673	47%
MOKFnc	Fall	1,810	1%	1,429	79%
MOKFgg	Fall	1,413	1%	1,079	76%
MERF	Fall	169	<1%	18	11%
MERFn	Fall	2,040	1%	1,536	75%
SacW	Winter	2,922	1%	0	0%
FRHS	Spring	9,864	4%	23	<1%
SJOSx	Spring	153	<1%	7	5%
CFHL	Late-fall	3,873	2%	10	<1%
Non-CV		0	0%	0	
	Total	136,969	57%	18,996	14%

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

In 2019, 60% of the 30,500 salmon harvested in the CV river sport fishery were hatchery-origin fish (Table 9; Figs. 12, 13). The Mokelumne River sport fishery was excluded from these analyses because few fish were sampled (n=11; total harvest=118) and no CWTs were recovered. 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: 55% (CFHF)
- Lower Sacramento River fall-run harvest: 67% (FRHFgg, MOKFn)
- Feather River fall-run harvest: 62% (FRHFn)
- American River fall-run harvest: 64% (MOKFn)
- Upper Sacramento River late-fall-run harvest: 55% (CFHL)

Of all hatchery release types, CFH fall-run in-basin releases contributed the most (21%) to the total CV sport harvest, followed by FRH fall-run Golden Gate and bay/delta net pen releases (12% and 11%, respectively). In-basin releases were primarily 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 and Golden Gate releases were harvested out-of-basin at much higher rates (Tables 9, 10).

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

R_{type}	Run	CWT_{total}	% harvest
CFHF	Fall	6,366	21%
CFHFn	Fall	0	0%
FRHF	Fall	327	1%
FRHFn	Fall	3,376	11%
FRHFgg	Fall	3,766	12%
NIMF	Fall	713	2%
NIMFn	Fall	1,236	4%
MOKF	Fall	0	0%
MOKFn	Fall	1,540	5%
MOKFnc	Fall	94	<1%
MOKFgg	Fall	89	<1%
MERF	Fall	0	0%
MERFn	Fall	60	<1%
SacW	Winter	34	<1%
FRHS	Spring	526	2%
SJOSx	Spring	0	0%
CFHL	Late-fall	309	1%
Non-CV		0	0%
	Total	18,436	60%

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 2015 through 2017 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 very 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 2019. 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
CFHF	2017	Fall	44	3	6%
FRHF	2017	Fall	1	0	0%
FRHFn	2017	Fall	126	1	1%
FRHFgg	2017	Fall	227	19	8%
NIMF	2017	Fall	3	0	0%
NIMFn	2017	Fall	125	5	4%
MOKF	2017	Fall	0.3	0	0%
MOKFn	2017	Fall	30	11	36%
MOKFnc	2017	Fall	159	127	80%
MERFn	2017	Fall	160	120	75%
FRHS	2017	Spring	17	0	0%
SJOSx	2017	Spring	0	0	-
SacW	2017	Winter	63	0	0%
SacWbat	2017	Winter	46	0	0%
CFHL	2018	Late-fall	7	0.2	3%

Age-3 CV Escapement Recovery and Stray Rates

R_{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
CFHF	2016	Fall	259	17	7%
FRHF	2016	Fall	334	1	0.2%
FRHFn	2016	Fall	429	74	17%
FRHFgg	2016	Fall	836	133	16%
NIMF	2016	Fall	396	2	0.4%
NIMFn	2016	Fall	934	51	5%
MOKF	2016	Fall	11	1	11%
MOKFn	2016	Fall	302	146	48%
MOKFnc	2016	Fall	70	55	78%
MOKFgg	2016	Fall	435	327	75%
MOKFb	2016	Fall	172	121	71%
MERF	2016	Fall	13	1	9%
FRHS	2016	Spring	551	1	0.2%
SJOSx	2016	Spring	168	8	5%
SacW	2016	Winter	1,896	0	0%
CFHL	2017	Late-fall	222	1	0.3%

Age-4 CV Escapement Recovery and Stray Rates

R_{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
CFHF	2015	Fall	6	0	0%
FRHF	2015	Fall	0	0	-
FRHFn	2015	Fall	30	2	6%
NIMF	2015	Fall	1	0	0%
NIMFn	2015	Fall	9	0.3	3%
MOKF	2015	Fall	4	0	0%
MOKFn	2015	Fall	9	5	53%
MOKFnc	2015	Fall	8	5	60%
MOKFb	2015	Fall	11	3	27%
MERFn	2015	Fall	3	2	74%
MERFt	2015	Fall	9	9	100%
FRHS	2015	Spring	20	0	0%
SJOSx	2015	Spring	0	0	-
SacW	2015	Winter	2	0	0%
CFHL	2016	Late-fall	136	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 2019 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
CFHF	2017	Fall	24	95%
FRHF	2017	Fall	0	-
FRHFn	2017	Fall	52	99%
FRHFgg	2017	Fall	88	96%
NIMF	2017	Fall	2	100%
NIMFn	2017	Fall	45	97%
MOKF	2017	Fall	0	-
MOKFn	2017	Fall	9	98%
MOKFnc	2017	Fall	157	97%
MERFn	2017	Fall	49	95%
FRHS	2017	Spring	40	100%
SJOSx	2017	Spring	2	100%
CFHL	2018	Late-fall	0	-

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

R_{type}	Brood year	Run	# Recoveries per 100K Released	% sport
CFHF	2016	Fall	489	21%
FRHF	2016	Fall	541	24%
FRHFn	2016	Fall	737	25%
FRHFgg	2016	Fall	1,644	23%
NIMF	2016	Fall	858	20%
NIMFn	2016	Fall	2,175	18%
MOKF	2016	Fall	30	15%
MOKFn	2016	Fall	478	22%
MOKFnc	2016	Fall	760	27%
MOKFgg	2016	Fall	1,774	20%
MOKFb	2016	Fall	329	28%
MERF	2016	Fall	37	18%
FRHS	2016	Spring	122	33%
SJOSx	2016	Spring	54	45%
SacW	2017	Winter	91	89%
SacWbat	2017	Winter	36	94%
CFHL	2017	Late-fall	70	48%

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

R_{type}	Brood year	Run	# Recoveries per 100K Released	% sport
CFHF	2015	Fall	4	21%
FRHF	2015	Fall	0	-
FRHFn	2015	Fall	20	16%
NIMF	2015	Fall	2	0%
NIMFn	2015	Fall	23	6%
MOKF	2015	Fall	0.4	0%
MOKFn	2015	Fall	16	15%
MOKFnc	2015	Fall	34	19%
MOKFb	2015	Fall	20	18%
MERFn	2015	Fall	1	0%
MERFt	2015	Fall	7	0%
FRHS	2015	Spring	0	-
SJOSx	2015	Spring	0	-
SacW	2016	Winter	14	0%
CFHL	2016	Late-fall	144	8%

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

Over half of the 393,600 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 CFH fall-run in-basin releases followed by fall-run bay/delta net pen releases from FRH, NIM, and MOK.

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

R_{type}	Run		CWT_{total}	% harvest
CFHF	Fall		61,303	16%
CFHFn	Fall		24	<1%
FRHF	Fall		5,589	1%
FRHFn	Fall		26,035	7%
FRHFgg	Fall		19,598	5%
NIMF	Fall		20,425	5%
NIMFn	Fall		25,732	7%
MOKF	Fall		266	<1%
MOKFn	Fall		23,570	6%
MOKFnc	Fall		7,788	2%
MOKFgg	Fall		4,907	1%
MERF	Fall		489	<1%
MERFn	Fall		629	<1%
Other CV	Non-fall		4,942	1%
Non-CV			7,293	2%
		Total	208,588	53%

California ocean sport fishery

California anglers harvested approximately 88,500 Chinook salmon in the ocean sport fishery during 2019. The total contribution of hatchery-origin salmon to the California ocean sport fishery was 58%, ranging from 56% to 58% of the total harvest depending on major port area (Fig. 18). Most of the harvest occurred in the San Francisco port area (64%), followed by the Monterey (26%), Eureka/Crescent City (6%), and Fort Bragg (4%) port areas (Table 12).

Of all hatchery release types, CFH fall-run in-basin releases contributed the most (15%) to the total California ocean sport harvest, followed by FRH fall-run bay/delta net pen and Golden Gate releases (10% and 7%, respectively). 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
CFHF	Fall		13,472	15%
CFHFn	Fall		0	0%
FRHF	Fall		1,322	1%
FRHFn	Fall		8,557	10%
FRHFgg	Fall		6,038	7%
NIMF	Fall		3,939	4%
NIMFn	Fall		5,571	6%
MOKF	Fall		66	<1%
MOKFn	Fall		5,295	6%
MOKFnc	Fall		2,776	3%
MOKFgg	Fall		989	1%
MERF	Fall		89	<1%
MERFn	Fall		541	1%
SacW	Winter		247	<1%
FRHS	Spring		883	1%
SJOSx	Spring		26	<1%
CFHL	Late-fall		478	1%
Non-CV			606	1%
		Total	50,895	58%

California ocean commercial fishery

California trollers harvested almost 271,500 Chinook salmon in the commercial ocean fishery during 2019. The total contribution of hatchery-origin salmon to the California commercial ocean fishery was 53%, ranging from 45% to 55% of the total harvest depending on major port area (Fig. 19). Most of the harvest occurred in the San Francisco port area (58%), followed by the Monterey (36%), Fort Bragg (3%), and Eureka/Crescent City (2%) port areas (Table 14).

Of all hatchery release types, CFH fall-run in-basin releases contributed the most (16%) to the total California commercial harvest, followed by fall-run bay/delta net pen releases from NIM, MOK, and FRH (7%, 6%, and 6%, respectively) and NIM fall-run in-basin releases (6%). Non-CV releases contributed 1% to the total commercial harvest (Table 15).

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

R_{type}	Run		CWT_{total}	% harvest
CFHF	Fall		44,290	16%
CFHFn	Fall		14	<1%
FRHF	Fall		3,956	1%
FRHFn	Fall		16,257	6%
FRHFgg	Fall		12,855	5%
NIMF	Fall		15,654	6%
NIMFn	Fall		19,434	7%
MOKF	Fall		191	<1%
MOKFn	Fall		16,886	6%
MOKFnc	Fall		4,532	2%
MOKFgg	Fall		3,620	1%
MERF	Fall		376	<1%
MERFn	Fall		39	<1%
SacW	Winter		46	<1%
FRHS	Spring		1,351	<1%
SJOSx	Spring		21	<1%
CFHL	Late-fall		1,760	1%
Non-CV			2,806	1%
		Total	144,086	53%

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

In 2019, CWTs from many fall-run experimental and net pen release types were recovered in the CV escapement and ocean harvest, and this section will focus on those from brood years 2015 through 2017 (ages 2-4). Experimental releases include barge studies that utilized approximately 600,000 fall-run salmon from MOK, and non-acclimated Golden Gate releases at Fort Baker which utilized approximately 3.5 million and 200,000 fall-run salmon from FRH and MOK, respectively.

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 in Santa Cruz.

The experimental and net pen releases recovered in 2019 are differentiated into the following release types:

- FRHFn   Feather River 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)

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

- 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

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

- 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)

- 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
FRHFn	2017	Fall	126	1	1%
FRHFgg	2017	Fall	227	19	8%
NIMFn	2017	Fall	125	5	4%
MOKFn	2017	Fall	30	11	36%
MOKFnp	2017	Fall	159	127	80%
MERFn	2017	Fall	160	120	75%

Age-3 CV Escapement Recovery and Stray Rates

R_{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
FRHFn	2016	Fall	429	74	17%
FRHFgg	2016	Fall	836	133	16%
NIMFn	2016	Fall	934	51	5%
MOKFn	2016	Fall	302	146	48%
MOKFnp	2016	Fall	80	63	78%
MOKFns	2016	Fall	10	6	66%
MOKFgg	2016	Fall	435	327	75%
MOKFbb	2016	Fall	111	92	82%
MOKFbg	2016	Fall	287	241	84%
MOKFbr	2016	Fall	117	33	28%

Age-4 CV Escapement Recovery and Stray Rates

R_{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
FRHFn	2015	Fall	30	2	6%
NIMFn	2015	Fall	9	0.3	3%
MOKFn	2015	Fall	9	5	53%
MOKFnp	2015	Fall	8	5	60%
MOKFbb	2015	Fall	11	2	17%
MOKFbg	2015	Fall	21	7	32%
MOKFbr	2015	Fall	0	0	-
MERFn	2015	Fall	3	2	74%

Ocean Fishery Harvest

The recovery rate for all fall-run experimental and net pen releases in California and Oregon ocean salmon fisheries, and the percent that occurred in the sport fishery, are shown below to allow direct comparison among these release types (Table 16, Fig. 21).

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

R_{type}	Brood year	Run	# Recoveries per 100K Released	% sport
FRHFn	2017	Fall	52	99%
FRHFgg	2017	Fall	88	96%
NIMFn	2017	Fall	45	97%
MOKFn	2017	Fall	9	98%
MOKFnp	2017	Fall	157	97%
MERFn	2017	Fall	49	95%

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

R_{type}	Brood year	Run	# Recoveries per 100K Released	% sport
FRHFn	2016	Fall	737	25%
FRHFgg	2016	Fall	1,644	23%
NIMFn	2016	Fall	2,175	18%
MOKFn	2016	Fall	478	22%
MOKFnp	2016	Fall	844	26%
MOKFns	2016	Fall	262	29%
MOKFgg	2016	Fall	1,774	20%
MOKFbb	2016	Fall	416	24%
MOKFbg	2016	Fall	431	29%
MOKFbr	2016	Fall	145	32%

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

R_{type}	Brood year	Run	# Recoveries per 100K Released	% sport
FRHFn	2015	Fall	20	16%
NIMFn	2015	Fall	23	6%
MOKFn	2015	Fall	16	15%
MOKFnp	2015	Fall	34	19%
MOKFbb	2015	Fall	31	14%
MOKFbg	2015	Fall	28	22%
MOKFbr	2015	Fall	0	-
MERFn	2015	Fall	1	0%

2019 CFM ANALYSES KEY POINTS

- A majority (57%) of the total 2019 CV salmon escapement (all run-types) was hatchery-origin fish. This was a decrease of 19% in hatchery contribution from the 2018 escapement and was the lowest estimate since the CFM program was fully implemented. Between 2010 and 2018, the hatchery contribution to the total CV escapement averaged 76% and ranged between 65% and 88%. The decrease observed in 2019 suggests continued improvement in natural-origin production following the drought that occurred during 2012-2016. Also, the 2016 fall-run brood, which were age-3 in 2019, hatched during a very wet winter which may have boosted natural-origin juvenile production and survival. CFH fall-run in-basin releases had the highest contribution (14%) to the total 2019 CV escapement, with FRH and MOK fall-run bay/delta releases being the next highest contributors (9% and 7%, respectively).

- The highest stray rates all occurred with offsite MOK and MER releases. MOK fall-run coastal releases strayed the most (79%), followed by MOK fall-run Golden Gate (76%; includes those that were barged to the Golden Gate), MER fall-run offsite (75%; includes bay/delta net pen and non-acclimated), and MOK fall-run bay/delta (47%) releases. Offsite releases from other hatcheries strayed at much lower rates, with the lowest being NIM fall-run bay/delta releases (5%), followed by FRH fall-run bay/delta and Golden Gate releases (11% and 13%, respectively). There were no inland recoveries of offsite CFH releases, although any such recoveries would have been age-5 only.

- 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 38% of the return to MER consisted of fish that were produced there, with the remainder consisting of natural-origin salmon (47%) and stray hatchery-origin salmon (16%). This was the lowest hatchery contribution (53%) observed at MER since the CFM program was fully implemented, as was the hatchery contribution in Merced River natural areas (24%). The out-of-basin hatchery return at NIM was also quite high (28%), with most of those strays originating from MOK.

- Hatchery contributions to natural area escapements were generally much lower than has been observed since the CFM program was fully implemented. For fall-run specifically, the hatchery contribution across all CV natural areas was 53% compared to the 2010-2018 average of 71% (range: 55% - 81%). As mentioned above, this is likely reflective of improved natural-origin production and survival during the wet winter of 2016/17. Most natural area spawning escapements were primarily natural-origin fish. The exceptions were the spring-run escapement to the upper San Joaquin River and the fall-run escapements to Battle Creek and the Yuba, American, Mokelumne, and Stanislaus rivers. In all rivers that contain hatcheries, most of the hatchery-origin components consisted of release types from their respective hatcheries. However, strays from out-of-basin hatcheries made noticeable contributions to the natural area escapements in the American and Merced rivers (37% and 45% of the hatchery-origin

components, respectively), with MOK fall-run bay/delta releases making the most notable contributions (18% and 30% of the hatchery-origin components, respectively).

- Fall-run escapement in the upper Sacramento River mainstem was dominated by natural-origin salmon. The hatchery contribution in 2019 (5%) was the lowest by a wide margin since the CFM program was fully implemented. Between 2010 and 2018, the hatchery contribution in the upper Sacramento River mainstem averaged 39% and ranged between 20% and 68%. 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 mostly natural-origin salmon by a small margin. FRH fall-run bay/delta and Golden Gate releases had the highest contributions of any release type. Spring-run releases from FRH only formed 6% of the escapement but were the next highest contributor. In-basin fall-run releases from FRH composed 4% of the escapement.

- Of the total fall/spring-run escapement in the Yuba River, 80% occurred above DPD and 20% occurred below. The escapement above DPD was evenly distributed between hatchery- and natural-origin salmon, while the escapement below DPD was predominantly hatchery-origin salmon. FRH fall-run bay/delta releases composed the bulk of the hatchery-origin components in both sectors.

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

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

- Fall-run escapement to the Stanislaus River was mostly hatchery-origin salmon by a small margin, with stray MOK bay/delta releases composing the bulk of the hatchery-origin component. Conversely, the fall-run escapement to the Tuolumne River was predominantly natural-origin salmon, with stray MER and MOK bay/delta releases being the highest contributors.

- 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. MER bay/delta releases composed half of the hatchery-origin component.

- For age-2 fall-run salmon, FRH Golden Gate releases had the highest CV escapement recovery rate for their cohort, followed by MER bay/delta, MOK coastal, FRH bay/delta, and NIM bay/delta releases. Offsite releases from MOK and MER had the highest stray rates among this cohort, with MOK coastal and MER bay/delta releases straying at particularly high rates. Releases from other hatcheries and MOK in-basin releases all had substantially lower stray rates.

- For age-3 fall-run salmon, NIM bay/delta and FRH Golden Gate releases had the highest CV escapement recovery rates for their cohort, followed by MOK Golden Gate, FRH bay/delta, NIM in-basin, and FRH in-basin releases. Offsite releases from MOK had the highest stray rates among this cohort, with MOK coastal, Golden Gate, and barge study (excluding the in-river control group) releases straying at particularly high rates. Releases from other hatcheries and MOK in-basin releases all had substantially lower stray rates.

- For age-4 fall-run salmon, FRH bay/delta releases had the highest CV escapement recovery rate for their cohort, followed by MOK barge study releases (excluding the in-river control group). Offsite releases from MOK and MER had the highest stray rates among this cohort, and MER non-acclimated trucked releases returned entirely to non-natal basins (i.e., stray rate of 100%). MER bay/delta, MOK coastal, and MOK bay/delta releases also strayed at very high rates. Releases from other hatcheries and MOK in-basin releases all had substantially lower stray rates.

- While most (60%) of the total CV river sport harvest was comprised of hatchery-origin salmon, it was the lowest hatchery contribution since the CFM program was fully implemented. Between 2010 and 2018, the hatchery contribution to the CV river sport harvest averaged 76% and ranged between 66% and 84%. Similar to the CV escapement, the low hatchery contribution in the inland harvest may be due to improved natural-origin production and survival for the 2016 fall-run brood. The highest-contributing hatchery release types were CFH fall-run in-basin, FRH fall-run Golden Gate, and FRH fall-run bay/delta 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 27% of the catch. Strays from MOK and FRH represented 22% and 15% of the American River sport harvest, respectively.

- Over half of the California ocean sport and commercial harvest was composed of hatchery-origin fish. CFH fall-run in-basin releases had the highest contribution to the total harvest in both fisheries. There were also moderate contributions from FRH, NIM, and MOK fall-run bay/delta releases, as well as FRH Golden Gate and NIM in-basin releases. Non-CV hatchery production contributed moderately to the ocean harvest in the Eureka/Crescent City port area but contributed very little in port areas to the south which combined accounted for 94% and 98% of the total California sport and commercial ocean harvest, respectively.

- Ocean recovery rates for age-3 NIM fall-run releases were much higher than has previously been observed, and the bay/delta releases from that brood had the highest ocean recovery rate of any release type analyzed in this report. The ocean recovery rates for both age-3 NIM bay/delta and in-basin releases were much higher than has been observed in any bay/delta or in-basin release group, respectively, from any CV hatchery since the CFM program was fully implemented.

- Golden Gate fall-run releases from FRH (ages 2 and 3) and MOK (age-3 only) also had very high ocean recovery rates, in addition to the high CV escapement recovery

rates previously mentioned. For the ages at which they were present, both their CV and ocean recovery rates exceeded those of the bay/delta and coastal net pen releases from the same hatchery and brood. The sole Golden Gate release from MOK strayed at a substantially higher rate than those produced at FRH.

- Coastal fall-run releases, all of which were from MOK, also had very high ocean recovery rates at all ages. The age-2 CV escapement recovery rate was also high for coastal fall-run releases, but the age-3 CV recovery rate was quite low. Among the coastal release locations, which in 2019 only co-occurred in age-3 fish, the Pillar Point release had much higher CV and ocean recovery rates than the Santa Cruz release. While the age-3 CV recovery rates were low for both release locations, the Santa Cruz CV recovery rate was noticeably lower. The Santa Cruz release had much lower CV and ocean recovery rates than any other offsite release from that brood.

- This is the third report in the series that has recovery data for non-experimental FRH fall-run in-basin releases, 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 2019 suggest lower survival but less straying for in-basin releases. The differences in survival were stark for the 2017 and 2015 broods (i.e., ages 2 and 4), as there were only 3 CV and no ocean recoveries of age-2 FRH in-basin releases, and no recoveries whatsoever of age-4 FRH in-basin releases. That translates to age-2 CV and ocean recovery rates of 1 and 0 CWTs per 100,000 released, respectively, and age-4 recovery rates of 0 for both. Conversely, FRH bay/delta releases had age-2 CV and ocean recovery rates of 126 and 52 CWTs per 100,000 released, respectively, and age-4 recovery rates of 30 and 20, respectively. Age-2 CV and ocean recovery rates were even higher for FRH Golden Gate releases at 227 and 88 CWTs per 100,000 released, respectively. While offsite FRH releases from those two broods did have higher stray rates than in-basin releases, they were not particularly high ranging between 1% and 8%. There were many more age-3 recoveries of all FRH release types which provides for a more robust comparison, and while the same general pattern was still observed, age-3 recovery rates were much closer between in-basin and bay/delta releases than they were for the other ages. Specifically, age-3 CV and ocean recovery rates for FRH in-basin releases were 334 and 541 CWTs per 100,000 released, respectively, compared to 429 and 737, respectively, for bay/delta releases. This similarity in recovery rates was also observed for this brood in the 2018 report (i.e., as age-2 fish), suggesting adequate in-river conditions during the winter of 2016/17, which as previously stated was a very wet winter. Despite this similarity between age-3 in-basin and bay/delta releases, age-3 Golden Gate releases had much higher CV and ocean recovery rates than either, at 836 and 1,644 CWTs per 100,000 released, respectively. Stray rates for this brood of FRH fall-run were higher than they were for the other broods, at 0.2% for in-basin releases, 17% for bay/delta releases, and 16% for Golden Gate releases.

- The age-3 winter-run CV recovery rate of 1,896 CWTs per 100,000 released was more than four times higher than the next highest recovery rate that has been observed in these reports. Between 2012 and 2018, the age-3 winter-run CV recovery rate

averaged 254 CWTs per 100,000 released and ranged between 72 and 425. This winter-run brood likely benefitted from the wet winter of 2016/17. Additionally, the 2019 winter-run escapement to the upper Sacramento River was the highest escapement observed since 2006 (PFMC 2021).

- 2019 was the first year that winter-run salmon released into North Fork Battle Creek as part of the FWS Jumpstart program began to return as spawners and contribute to ocean harvest (age-2 only). The CV and ocean recovery rates for this release type were both lower than for winter-run released into the upper Sacramento River, although the CV recovery rates were not drastically different. Among the winter-run that returned to the CV in 2019, those that were released into Battle Creek returned entirely to Battle Creek, and those that were released into the upper Sacramento River returned entirely to the upper Sacramento River.

- This is the first report in the series that includes data for the upper San Joaquin River mainstem spring-run escapement. Due to high flows during spring 2019, spring-run spawners could volitionally return to the upper San Joaquin River via the Eastside Bypass. In most years such passage does not exist, and spawners must be trapped further downstream and translocated to the upper San Joaquin River. The spring-run escapement to this sector was overwhelmingly hatchery-origin salmon, although that is expected this early in the reintroduction effort.

- CV and ocean recoveries of winter- and spring-run releases were predominantly age-3 salmon, while recoveries of late-fall-run releases were more evenly distributed between ages 3 and 4. In the CV, approximately two-thirds and one-third of the late-fall-run recoveries were ages 3 and 4, respectively, whereas it was vice versa in the ocean harvest.

- Among the age-3 recoveries of 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 the highest stray rate. Salmon that were trucked to Sausalito and then barged to the Golden Gate had similar but slightly lower stray and ocean recovery rates, and a much lower CV recovery rate, than those that were barged the entire route. Salmon that were released directly into the Mokelumne River as part of the control group had a substantially lower stray rate but also a much lower ocean recovery rate than either of the other treatments, and also a much lower CV recovery rate than those that were barged the entire route.

- Among the age-4 recoveries of barge study releases, salmon that were barged from the Mokelumne River to the Golden Gate had the highest CV recovery rate but also the highest stray rate. Salmon that were trucked to Tiburon and then barged to the Golden Gate had the highest ocean recovery rate, although it was similar to those that were barged the entire route. Both of these treatments exhibited much lower stray rates than the same treatments in the age-3 cohort. There were no recoveries whatsoever of salmon that were released directly into the Mokelumne River as part of the control group for this brood.

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 nine 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 2019. 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. Securing permanent and comprehensive inland and ocean funding for this marking, tagging, monitoring, and evaluation program is critical. 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 using the most recent information, similar to the Klamath Basin fall-run Chinook salmon management process.

ACKNOWLEDGEMENTS

REFERENCES

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

Kelly, B. and J. Phillips. 2020. Lower American River Fall-run Chinook Salmon Escapement Survey, October 2019 – January 2020. California Department of Fish and Wildlife (CDFW) Report. Rancho Cordova, 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. CDFG Fisheries Branch Administrative Report 2012-02. Santa Rosa, CA.

Kowalik, D. and D. Massa. 2020. Lower Yuba River Accord Monitoring and Evaluation Plan: Chinook Salmon Escapement Technical Memorandum, Fall 2019. Pacific States Marine Fisheries Commission (PSMFC) Report. Marysville, 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-PSMFC Report. Santa Rosa, CA.

Letvin, A., M. Palmer-Zwahlen, and B. Kormos. 2021. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2018. Joint CDFW-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. 2021. Review of 2020 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.

United States Fish and Wildlife Service (FWS). 2020. Upper Sacramento River Winter Chinook Salmon Carcass Survey, 2019 Annual Report. FWS Report. Red Bluff, 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
- 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
- TL   Total length
- WD   Woodbridge Dam (Mokelumne River)
- YARMT   Yuba Accord River Management Team

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Table 1a. Estimation and sampling methods used for the 2019 CV Chinook hatchery escapement.

Sampling Location	Estimation and Sampling Methods	Agency
Hatchery Spawners		
Coleman National Fish Hatchery (CFH) Fall and Late-Fall (2020)	Direct count. All fish examined and bio-sampled[a] for fin-clips, tags, marks. All ad-clipped fish sampled and heads collected for CWT recovery. Access upstream of the hatchery closed beginning Aug 1. The fall-run period is considered early Oct through late Nov and the late-fall-run period is considered early Dec through late Feb. However, the final escapement is ultimately parsed into run types based on CWT code recoveries and dominant run type by date. During the late-fall-run period, all unmarked fish are electronically checked for CWTs. Some untagged phenotypic late-fall-run fish are released into Battle Creek above CFH. Grilse cutoff: 650 mm females, 680 mm males fall; 510 mm females, 540 mm males late-fall.	FWS
CFH Winter and Late-Fall (2020) Fish Trap	Direct count of winter-run which are identified by left pelvic fin-clips and CWTs, or late-fall-run that are trapped after CFH spawning operations cease. All fish examined and bio-sampled for fin-clips, tags, marks. All ad-clipped fish sampled and heads collected for CWT recovery, and all unmarked fish are electronically checked for CWTs. Any untagged phenotypic late-fall-run fish are released into Battle Creek above CFH. Any additional fish observed on video after trap removal are examined for fin-clips and added to escapement estimates. Grilse cutoff: 510 mm females, 540 mm males late-fall; all winter-run were grilse in 2019.	FWS
Keswick Fish Trap Winter and Late-Fall (2020)	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, 670 mm males winter; 510 mm females, 540 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 6 - Jun 28 (n~ 5,945) 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 13 and spring spawning began Sep 17. All spring-run fish bio-sampled. Fall spawning occured on Oct 1 for the cold water program and began normally on Oct 9. Fall spawning ceased on Nov 8. Systematic random bio-sample ~20% of all fish for fall-run. 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 4 - Jan 7. 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 15 - Jan 16. 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 17 - Dec 5. 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, 670 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 2019 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 (2020)	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: 610 mm females, 680 mm males winter; 640 mm females, 720 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. Bio-sampling data from CFH used as a surrogate.	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 20 carcasses observed. Bio-sampling data from CFH used as a surrogate.	CDFW
Battle Creek Fall	Video weir count (Aug 19 - Dec 1) 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. Bio-sampling data from CFH used as a surrogate.	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 seven carcasses were observed. Bio-sampling data from CFH 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. All ad-clipped fish (fresh and non-fresh), including "unknown" ad-clipped status, were sampled and heads collected for CWT recovery. Bio-sampling data from CFH used as a surrogate.	CDFW
Butte Creek Spring and Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate for spring-run and fall-run. All fish examined for fin-clips, tags, marks. Systematic random bio-sample of all fish. No ad-clipped fish were observed in either survey. Grilse cutoff: 600 mm spring, 650 mm fall.	CDFW

Table 1b. Estimation and sampling methods used for the 2019 CV Chinook natural escapement. (Page 2 of 2)

Sampling Location	Estimation and Sampling Methods	Agency
Natural Spawners cont.		
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: Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate. 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: 590 mm females, 670 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, 670 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. Grilse cutoff: 610 mm females, 670 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, 670 mm males.	CDFW
Upper San Joaquin River Mainstem Spring	Direct count of carcasses encountered in the upper San Joaquin Restoration Area. All fish examined for fin-clips, tags, marks, condition, and other bio-data. Heads collected for CWT recovery from all fish regardless of ad-clip status. Using various tags and later confirmed with CWTs, all fish classified as either: 1) volitional returns via the Eastside Bypass, 2) translocated from downstream traps, or 3) captive broodstock adult releases. Fish determined to be captive broodstock are removed from the escapement estimate. Fish found dead in downstream traps are bio-sampled in the same manner as other carcasses and are added to the escapement estimate.	FWS, 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 2019 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: 689 mm females, 694 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 31 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.
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 Elliot Road, Jul 16 - Dec 31 from the Elliot Road 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	2 Chinook salmon per day; no minimum size limit.

Table 2. California ocean salmon sport and commercial fishery seasons by major port area, 2019.

Major Port Area	Sport Fishery			Commercial Fishery			
	Season	Size Limit[a]	Days Open	Season	Size Limit[a]	Days Open	Quota[b]
Eureka/Crescent City (Klamath Mgmt Zone)	May 25 - September 2	20" TL	101	June 1 - 30 (Fri - Tue)	27" TL	22	2,500
				July 1 - 30 (Fri - Tue)	27" TL	22	3,997
				Aug. 2 - 5, 12 - 31 (Fri - Tue)	27" TL	<u>18</u>	4,293
						62	
Fort Bragg	April 13 - 30	20" TL	18	June 4 - 30	27" TL	27	
	May 18 - October 31	20" TL	<u>167</u>	July 11 - 31	27" TL	21	
			185	August 1 - 28	27" TL	<u>28</u>	
						76	
San Francisco	April 13 - 30	24" TL	18	May 16 - 31	27" TL	16	
	May 18 - October 31	20" TL	<u>167</u>	June 4 - 30	27" TL	27	
			185	July 11 - 31	27" TL	21	
				August 1 - 28	27" TL	28	
				September 1 - 30	27" TL	30	
				Oct. 1 - 4, 7 - 11, 14 - 15[c]	27" TL	<u>11</u>	
						133	
Monterey[d]	April 6 - August 28	24" TL	145	May 1 - 31	27" TL	31	
				June 4 - 30	27" TL	27	
				July 11 - 31	27" TL	<u>21</u>	
						79	
California Total			616			350	

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

b/ Klamath Management Zone commercial quotas during 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 15 and 50 fish 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 2019 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	2017	LSH	Sac R	Wint	5	216,237	216,746	100%	In-basin	Sacramento River (Lake Redding Park)
SacWbat	2017	LSH	Sac R	Wint	7	212,136	213,546	99%	Reintroduction	North Fork Battle Creek
FRHS	2017	FRH	Fea R	Spr	2	488,223	493,903	99%	In-basin	Feather River (Boyds Pump Ramp)
SJOSx	2017	SJO	San Joa R	Spr	8	209,308	213,526	98%	Reintroduction	San Joaquin River (Fremont Ford Bridge and Friant)
CFHF	2017	CFH	Sac R	Fall	16	1,369,512	5,498,252	25%	In-basin	CFH only
FRHF	2017	FRH	Fea R	Fall	3	250,489	1,007,846	25%	In-basin	Sacramento River (Elkhorn Ramp)
FRHFn	2017	FRH	Fea R	Fall	2	1,496,598	6,005,638	25%	Bay/Delta pens	San Pablo Bay (Mare Island) net pen releases
FRHFgg	2017	FRH	Fea R	Fall	8	609,272	2,460,352	25%	Trucked	Golden Gate releases; trucked to Fort Baker
NIMF	2017	NIM	Ame R	Fall	2	334,047	1,336,727	25%	In-basin	American River (Jibboom Street Bridge and Sunrise Recreation Area)
NIMFn	2017	NIM	Ame R	Fall	4	664,585	2,667,426	25%	Bay/Delta pens	San Pablo Bay (Mare Island and Wickland Oil) net pen releases
MOKF	2017	MOK	Mok R	Fall	2	398,785	400,790	99%	In-basin	Mokelumne River (Hatchery and Woodbridge Dam)
MOKFn	2017	MOK	Mok R	Fall	15	1,649,629	5,383,993	31%	Bay/Delta pens	Western Delta (Sherman Island) net pen releases
MOKFnc	2017	MOK	Mok R	Fall	1	727,344	742,256	98%	Coastal pens	Pillar Point coastal net pen releases
MERFn	2017	MER	Mer R	Fall	3	255,259	1,224,315	21%	Bay/delta pens	Western Delta (Sherman Island) net pen releases
CFHL	2018	CFH	Sac R	Late	14	881,364	901,122	98%	In-basin	CFH (includes spring surrogate releases)
				Total age-2 releases:	92	9,762,788	28,766,438	34%		

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	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 and Gridley)
SJOSx	2016	SJO	San Joa R	Spr	5	90,600	90,600	100%	Reintroduction	San Joaquin River (Eastside Bypass and Hills Ferry)
CFHF	2016	CFH	Sac R	Fall	28	3,020,565	12,184,997	25%	In-basin	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 releases; trucked to Fort Baker
NIMF	2016	NIM	Ame R	Fall	4	591,200	2,367,561	25%	In-basin	American River (Jibboom Street Bridge and 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
MOKFgg	2016	MOK	Mok R	Fall	1	225,243	225,870	100%	Trucked	Golden Gate release; trucked to Fort Baker
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)
MERF	2016	MER	Mer R	Fall	3	245,340	1,334,843	18%	In-basin	MER only
CFHL	2017	CFH	Sac R	Late	14	1,047,211	1,063,413	98%	In-basin	CFH (includes spring surrogate and trap efficiency releases)
				Total age-3 releases:	99	12,037,145	31,413,135	38%		

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	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 and Gridley)
SJOSx	2015	SJO	San Joa R	Spr	3	105,424	105,424	100%	Reintroduction	San Joaquin River (Hills Ferry)
CFHF	2015	CFH	Sac R	Fall	29	3,033,741	12,160,858	25%	In-basin	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 and Wickland Oil) net pen releases
NIMF	2015	NIM	Ame R	Fall	4	692,262	2,770,112	25%	In-basin	American River (Jibboom Street Bridge and 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 coastal net pen releases
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 (Jersey Point)
CFHL	2016	CFH	Sac R	Late	14	1,044,705	1,101,484	95%	In-basin	CFH (includes spring surrogate and small experimental releases)
				Total age-4 releases:	105	12,791,174	36,315,275	35%		

Age-5 CWT releases (with recoveries in 2019)

Release type*	Brood year	Hatchery	Stock origin	Run type	CWT codes	# CWT tagged	Total fish released	% CWT	Release strategy	Release locations / notes
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 and Crockett) net pen releases
NIMFn	2014	NIM	Ame R	Fall	6	979,827	3,932,549	25%	Bay/Delta pens	San Pablo Bay (Mare Island and 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

*CWT release types:

Sacramento River fall Chinook release types (SFC)

CFHF	Coleman National Fish Hatchery fall in-basin 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
FRHFgg	Feather River Hatchery fall Golden Gate releases (no net pens)
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
MOKFgg	Mokelumne River Hatchery fall Golden Gate releases (no net pens)
MOKFb	Mokelumne River Hatchery fall barge study releases
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
SacWbat	Livingston Stone National Fish Hatchery winter Battle Creek reintroduction releases
FRHS	Feather River Hatchery spring in-basin releases
SJOSx	San Joaquin Salmon Conservation and Research Facility spring reintroduction releases
CFHL	Coleman National Fish Hatchery late-fall in-basin releases

Table 4. Central Valley hatchery and natural area escapement estimates, sport harvest, and sample data, 2019.

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										
Coleman National Fish Hatchery	Winter	95	95	95	74	74	1.000	0.779	1.000	1.27 [b]
Keswick Dam Fish Trap	Winter	180	180	111	111	106	1.000	1.000	0.964	1.04
Feather River Hatchery	Spring	3,867	3,867	3,664	3,664	3,613	1.000	1.000	0.997	1.00
Coleman National Fish Hatchery	Fall	14,269	14,269	3,218	3,211	3,150	1.000	0.998	0.995	1.01
Feather River Hatchery	Fall	27,103	27,103	7,810	7,810	7,591	1.000	1.000	0.997	1.00
Nimbus Fish Hatchery	Fall	11,296	11,296	2,884	2,883	2,824	1.000	1.000	0.998	1.00
Mokelumne River Hatchery	Fall	8,503	8,503	2,386	2,386	2,355	1.000	1.000	0.998	1.00
Merced River Hatchery	Fall	967	967	132	132	127	1.000	1.000	0.984	1.02
Coleman National Fish Hatchery	Late-fall[c]	3,391	3,391	3,331	3,328	3,268	1.000	0.999	0.998	1.00
Coleman Hatchery Fish Trap	Late-fall[c]	365	365	358	353	340	1.000	0.986	0.977	1.04
Keswick Dam Fish Trap	Late-fall[c]	23	23	16	16	16	1.000	1.000	1.000	1.00
Total Hatchery Escapement		**70,059**	**70,059**	**24,005**	**23,968**	**23,464**				
Natural Area Escapement										
Upper Sacramento River (above Princeton)	Winter	7,853	3,026	958	949	878	0.385	0.991	0.992	3.04 [d]
Butte Creek	Spring	14,860	6,247	0	0	0	0.420	-	-	-
Upper San Joaquin River (above Merced R.)	Spring	155	155	152	150	140	1.000	0.987	0.986	1.04 [d]
Upper Sacramento River (above Princeton)	Fall	24,461	3,089	31	31	28	0.126	1.000	1.000	12.38 [d]
Clear Creek	Fall	5,712	525	30	30	28	0.092	1.000	1.000	9.79 [d]
Battle Creek	Fall	20,875	0	Video - no biodata collected		4,656 [e]	-	-	-	1.00
Cow Creek[f]	Fall	1,817	37	Video - opportunistic CWTs		4	0.020	-	-	-
Cottonwood Creek[f]	Fall	1,317	31	Video - opportunistic CWTs		5	0.024	-	-	-
Mill Creek	Fall	2,523	356	57	57	56	0.141	1.000	1.000	4.51 [d]
Butte Creek	Fall	1,481	171	0	0	0	0.115	-	-	-
Feather River	Fall	51,963	5,192	1,071	1,062	986	0.100	0.992	0.997	10.12 [d]
Yuba River above Daguerre Point Dam (DPD)	Fall	2,691	2,582	501	30	29	0.959	0.060	1.000	17.41 [g]
Yuba River below DPD	Fall	678	92	22	16	15	0.136	0.727	1.000	10.59 [d]
American River[h]	Fall	27,030	14,552	4,208	4,184	3,981	0.538	0.994	0.996	1.88
Mokelumne River	Fall	4,367	4,367	1,039	126	119	1.000	0.121	1.000	8.25 [g]
Stanislaus River	Fall	1,504	186	35	35	33	0.124	1.000	1.000	8.09 [d]
Tuolumne River	Fall	931	619	37	37	27	0.665	1.000	1.000	1.67 [d]
Merced River	Fall	2,211	342	20	20	18	0.155	1.000	1.000	6.46 [d]
Upper Sacramento River (above Princeton)	Late-fall[c]	1,251	356	45	45	42	0.285	1.000	0.977	3.97 [d]
Total Natural Area Escapement		**173,680**	**41,925**	**8,206**	**6,772**	**11,045**				
CV Sport Harvest										
Upper Sacramento River (above Feather R.)	Fall	10,809	861	123	118	113	0.080	0.959	1.000	13.09
Lower Sacramento River (below Feather R.)	Fall	7,426	276	54	54	54	0.037	1.000	1.000	26.91
Feather River	Fall	10,095	830	183	171	167	0.082	0.934	1.000	13.02
American River	Fall	1,828	104	20	20	19	0.057	1.000	1.000	17.58
Mokelumne River[f]	Fall	118	11	0	0	0	0.093	-	-	-
Upper Sacramento River (above Feather R.)	Late-fall	336	57	27	23	23	0.170	0.852	1.000	6.92
Total Sport Harvest		**30,612**	**2,139**	**407**	**386**	**376**				
Total Sampled			**114,123**	**32,618**	**31,126**	**34,885**				

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/ 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%.

c/ Late-fall-run hatchery returns and natural area escapement occurred during late-fall of 2019 through early 2020 (return year 2020).

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 fall natural escapement estimated using video count minus fall return to Coleman National Fish Hatchery (CFH). Surrogate CWTs based on CFH hatchery proportion and CWT recoveries.

f/ Due to the low sample rate and paucity of CWTs collected, this sector has been excluded from further analyses in this report.

g/ Natural area escapement CWTs collected on spawning grounds and expanded based on total ad-clip count observed via video weir (see Appendices 5 and 6).

h/ 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. Beginning in 2018, these two sectors were merged and one natural area escapement estimate is now calculated for the entire American Basin.

Table 5. Total harvest and sample data for 2019 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	4,957	1,273	268	267	256	0.257	0.996	1.000	3.91
Fort Bragg	3,857	1,047	209	206	198	0.271	0.986	1.000	3.74
San Francisco	56,543	17,553	3,649	3,629	3,542	0.310	0.995	0.996	3.26
Monterey	23,103	4,907	976	970	942	0.212	0.994	0.999	4.75
	88,460	**24,780**	**5,102**	**5,072**	**4,938**	**0.280**	**0.994**	**0.997**	**3.60**
California Commercial									
Eureka/Crescent	5,857	3,831	608	608	566	0.654	1.000	0.998	1.53
Fort Bragg	9,281	2,778	507	507	493	0.299	1.000	0.996	3.36
San Francisco	158,392	49,949	9,023	9,003	8,666	0.315	0.998	0.997	3.19
Monterey	97,959	30,288	5,483	5,476	5,306	0.309	0.999	0.994	3.26
	271,489	**86,846**	**15,621**	**15,594**	**15,031**	**0.320**	**0.998**	**0.996**	**3.14**
California Total	**359,949**	**111,626**	**20,723**	**20,666**	**19,969**				
Oregon Sport	**5,311**	**1,596**	**249**	**248**	**232**	**0.301**	**0.996**	**0.979**	**3.41**
Oregon Commercial	**28,375**	**11,129**	**1,530**	**1,521**	**1,453**	**0.392**	**0.994**	**0.990**	**2.59**
Oregon Total	**33,686**	**12,725**	**1,779**	**1,769**	**1,685**				

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 2019[a/].

Fall-run	2017	2016	2015	2014	Total CV CWTs	Total CV %
Age	2	3	4	5		
Raw CWT Recoveries	4,415	18,414	535	1	23,365	67%
	(19%)	(79%)	(2%)	(<1%)		
Expanded CWT total	**29,242**	**104,154**	**4,350**	**4**	137,750	89%
	(21%)	(76%)	(3%)	(<1%)		

Spring-run	2017	2016	2015	2014	Total CV CWTs	Total CV %
Age	2	3	4	5		
Raw CWT Recoveries	56	6,489	220		6,765	19%
	(<1%)	(96%)	(3%)			
Expanded CWT total	**85**	**10,042**	**416**		10,542	7%
	(<1%)	(95%)	(4%)			

Late-fall-run	2018	2017	2016	2015	Total CV CWTs	Total CV %
Age	2	3	4	5		
Raw CWT Recoveries	66	2,302	1,323		3,691	11%
	(2%)	(62%)	(36%)			
Expanded CWT total	**73**	**2,578**	**1,532**		4,182	3%
	(2%)	(62%)	(37%)			

Winter-run	2017	2016	2015	2014	Total CV CWTs	Total CV %
Age	2	3	4	5		
Raw CWT Recoveries	131	929	4		1,064	3%
	(12%)	(87%)	(<1%)			
Expanded CWT total	**270**	**2,676**	**10**		2,957	2%
	(9%)	(91%)	(<1%)			

All Runs					Total CV CWTs	Total CV %
Age	2	3	4	5		
Raw CWT Recoveries	4,668	28,134	2,082	1	34,885	100%
	(13%)	(81%)	(6%)	(<1%)		
Expanded CWT total	**29,670**	**119,450**	**6,308**	**4**	155,432	100%
	(19%)	(77%)	(4%)	(<1%)		

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

Table 7. Raw and expanded Chinook CWT recoveries in 2019 California ocean fisheries by run type and brood year[a].

Fall-run	2017	2016	2015	2014	Total Ocean CWTs	Total Ocean %
Age	2	3	4	5		
Raw CWT Recoveries	983	16,977	280	2	18,242	91%
	(5%)	(93%)	(2%)	(<1%)		
Expanded CWT total	**10,014**	**173,829**	**2,893**	**21**	186,757	96%
	(5%)	(93%)	(2%)	(<1%)		
Spring-run	2017	2016	2015	2014	Total Ocean CWTs	Total Ocean %
Age	2	3	4	5		
Raw CWT Recoveries	58	605			663	3%
	(9%)	(91%)				
Expanded CWT total	**203**	**2,078**			2,280	1%
	(9%)	(91%)				
Late-fall-run	2018	2017	2016	2015	Total Ocean CWTs	Total Ocean %
Age	2	3	4	5		
Raw CWT Recoveries		211	444		655	3%
		(32%)	(68%)			
Expanded CWT total		**748**	**1,490**		2,238	1%
		(33%)	(67%)			
Winter-run	2018	2017	2016	2015	Total Ocean CWTs	Total Ocean %
Age	2	3	4	5		
Raw CWT Recoveries		74	6		80	0.4%
		(93%)	(8%)			
Expanded CWT total		**273**	**20**		293	0.2%
		(93%)	(7%)			
Non-CV stocks	2017	2016	2015	2014	Total Ocean CWTs	Total Ocean %
Age	2	3	4	5		
Raw CWT Recoveries	1	138	183	1	323	2%
	(<1%)	(43%)	(57%)	(<1%)		
Expanded CWT total	**3**	**1,425**	**1,979**	**5**	3,412	2%
	(<1%)	(42%)	(58%)	(<1%)		
All Runs					Total Ocean CWTs	Total Ocean %
Age	2	3	4	5		
Raw CWT Recoveries	1,042	18,005	913	3	19,963	100%
	(5%)	(90%)	(5%)	(<1%)		
Expanded CWT total	**10,220**	**178,353**	**6,383**	**25**	194,981	100%
	(5%)	(91%)	(3%)	(<1%)		
CV Expanded CWT total	10,217	176,927	4,403	21	191,568	98%
(Proportion CV stocks)	(100%)	(99%)	(69%)	(82%)		

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

Table 8. Raw and expanded Chinook CWT recoveries in 2019 Oregon ocean fisheries by run type and brood year[a].

Fall-run	2017	2016	2015	2014	Total Ocean CWTs	Total Ocean %
Age	2	3	4	5		
Raw CWT Recoveries	10	1,132	99	2	1,243	74%
	(<1%)	(91%)	(8%)	(<1%)		
Expanded CWTtotal	**122**	**8,744**	**709**	**21**	9,596	71%
	(1%)	(91%)	(7%)	(<1%)		

Late-fall-run	2018	2017	2016	2015	Total Ocean CWTs	Total Ocean %
Age	2	3	4	5		
Raw CWT Recoveries			40		40	2%
			(100%)			
Expanded CWTtotal			**93**		93	1%
			(100%)			

Spring-run	2017	2016	2015	2014	Total Ocean CWTs	Total Ocean %
Age	2	3	4	5		
Raw CWT Recoveries		15			15	1%
		(100%)				
Expanded CWTtotal		**38**			38	0.3%
		(100%)				

Non-CV stocks	2017	2016	2015	2014	Total Ocean CWTs	Total Ocean %
Age	2	3	4	5		
Raw CWT Recoveries	5	110	233	38	386	23%
	(1%)	(28%)	(60%)	(10%)		
Expanded CWTtotal	**195**	**1,936**	**1,649**	**101**	3,881	29%
	(5%)	(50%)	(42%)	(3%)		

All Runs					Total Ocean CWTs	Total Ocean %
Age	2	3	4	5		
Raw CWT Recoveries	15	1,257	372	40	1,684	100%
	(<1%)	(75%)	(22%)	(2%)		
Expanded CWTtotal	**317**	**10,718**	**2,451**	**123**	13,607	100%
	(2%)	(79%)	(18%)	(<1%)		
CV Expanded CWTtotal	122	8,782	802	21	9,727	71%
(Proportion CV stocks)	(38%)	(82%)	(33%)	(17%)		

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 2019.

Location	Run	SacW	CFHL	CFHF	CFHFn	FRHS	FRHF	FRHFn	FRHFgg	NIMF	NIMFn	MOKF	MOKFn	MOKFnc	MOKFgg	MERF	MERFn	SJOSx	Non-CV	Hatchery	Natural	Total Run
Hatchery Spawners																						
Coleman National Fish Hatchery	Winter	100%																		100%	0%	95
Keswick Dam Fish Trap	Winter	62%																		62%	38%	180
Feather River Hatchery	Spring					94%		0%	0%									0%		95%	5%	3,867
Coleman National Fish Hatchery	Fall			90%			0%	0%	0%					0%						90%	10%	14,269
Feather River Hatchery	Fall		0%	0%		10%	5%	33%	20%		0%		0%	0%	0%		0%	0%		68%	32%	27,103
Nimbus Fish Hatchery	Fall						0%	3%	3%	25%	34%	0%	16%	2%	3%		1%			87%	13%	11,296
Mokelumne River Hatchery	Fall			0%			0%	2%	1%		3%	1%	73%	3%	3%	0%	3%			89%	11%	8,503
Merced River Hatchery	Fall							1%	3%		1%		9%	1%	1%	12%	26%			53%	47%	967
Coleman National Fish Hatchery	Late-fall[c]		98%																	98%	2%	3,391
Coleman Hatchery Fish Trap	Late-fall[c]	1%	98%																	99%	1%	365
Keswick Dam Fish Trap	Late-fall[c]		74%																	74%	26%	23
Total Hatchery Fall-run			*0%*	*21%*		*4%*	*2%*	*15%*	*10%*	*5%*	*7%*	*0%*	*13%*	*1%*	*1%*	*0%*	*1%*	*0%*		*79%*	*21%*	*62,138*
Natural Spawners																						
Upper Sacramento River	Winter	35%																		35%	65%	7,853
Butte Creek	Spring																			0%	100%	14,860
Upper San Joaquin River	Spring																	94%		94%	6%	155
Upper Sacramento River	Fall			4%		0%		1%	1%					0%	0%					5%	95%	24,461
Clear Creek	Fall			15%		0%		1%	2%				1%		0%					18%	82%	5,712
Battle Creek[d]	Fall			90%			0%	0%	0%					0%						90%	10%	20,875
Mill Creek	Fall			40%																40%	60%	2,523
Butte Creek	Fall																			0%	100%	1,481
Feather River	Fall			0%		6%	4%	20%	13%	0%	0%		0%	0%	0%		0%			45%	55%	51,963
Yuba River above DPD	Fall					6%	1%	26%	8%				8%	1%						50%	50%	2,691
Yuba River below DPD	Fall					5%	2%	44%	13%		13%									76%	24%	678
American River	Fall			0%				5%	3%	24%	34%	0%	17%	4%	2%	0%	3%			94%	6%	27,030
Mokelumne River	Fall			1%				2%	2%		6%	1%	55%	2%	3%		2%			73%	27%	4,367
Stanislaus River	Fall	1%						4%	4%		2%		37%	1%	4%		2%			54%	46%	1,504
Tuolumne River	Fall							2%	2%				5%	1%	0%		6%			17%	83%	931
Merced River	Fall								4%				7%			2%	12%			24%	76%	2,211
Upper Sacramento River	Late-fall[c]		14%																	14%	86%	1,251
Total Natural Area Fall-run			*0%*	*15%*		*2%*	*1%*	*9%*	*6%*	*5%*	*7%*	*0%*	*6%*	*1%*	*1%*	*0%*	*1%*			*53%*	*47%*	*146,427*
In-basin CWT$_{total}$	All	1%	2%	15%		4%	2%	9%	6%	4%	6%	0%	4%	0%	0%	0%	0%	0%		53%	47%	221,609
Stray CWT$_{total}$	All		0%	11%		0%	0%	13%	10%	0%	4%	0%	40%	8%	6%	0%	8%	0%		100%		18,996
Total CV Spawners		**1%**	**2%**	**14%**		**4%**	**1%**	**9%**	**6%**	**4%**	**6%**	**0%**	**7%**	**1%**	**1%**	**0%**	**1%**	**0%**		**57%**	**43%**	**240,605**
CV Sport Harvest																						
Upper Sacramento River	Fall			54%		0%		0%	0%											55%	45%	10,809
Lower Sacramento River	Fall	0%	2%	6%			0%	6%	16%	6%	13%		16%		1%					67%	33%	7,426
Feather River	Fall			1%		5%	3%	28%	23%		1%			0%			1%			62%	38%	10,095
American River	Fall							3%	12%	15%	12%		19%	3%						64%	36%	1,828
Upper Sacramento River	Late-fall	2%	42%	8%											2%					55%	45%	336
Total Sport Harvest		**0%**	**1%**	**21%**		**2%**	**1%**	**11%**	**12%**	**2%**	**4%**		**5%**	**0%**	**0%**		**0%**			**60%**	**40%**	**30,494**

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

b/ Release types defined in Table 3; SacWbat recoveries merged with SacW, in-river control releases for MOKFb merged with MOKF, barged and trucked releases for MOKFb merged with MOKFgg, MERFt merged with MERFn.

c/ Late-fall-run hatchery returns and natural area escapement occurred during late-fall of 2019 through early 2020 (return year 2020).

d/ 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 2019.

Location	Run	SacW	CFHL	CFHF	CFHFn	FRHS	FRHF	FRHFn	FRHFgg	NIMF	NIMFn	MOKF	MOKFn	MOKFnc	MOKFgg	MERF	MERFn	SJOSx	Non-CV	Hatchery	Natural	Total Run
Hatchery Spawners																						
Coleman National Fish Hatchery	Winter	95																		95		95
Keswick Dam Fish Trap	Winter	111																		111	69	180
Feather River Hatchery	Spring					3,643		13	4									2		3,662	205	3,867
Coleman National Fish Hatchery	Fall			12,789			2	8	4					2						12,805	1,464	14,269
Feather River Hatchery	Fall		1	32		2,656	1,293	8,842	5,453		20		24	64	7		95	5		18,492	8,611	27,103
Nimbus Fish Hatchery	Fall						1	390	366	2,845	3,826	17	1,806	192	294		86			9,823	1,473	11,296
Mokelumne River Hatchery	Fall		1				1	157	125		253	110	6,220	281	218	6	227			7,599	904	8,503
Merced River Hatchery	Fall							8	29		8		84	14	8	117	248			516	451	967
Coleman National Fish Hatchery	Late-fall[b]		3,315																	3,315	76	3,391
Coleman Hatchery Fish Trap	Late-fall[b]	4	356																	360	5	365
Keswick Dam Fish Trap	Late-fall[b]		17																	17	6	23
Total Hatchery Fall-run			2	12,821		2,656	1,297	9,405	5,977	2,845	4,107	127	8,134	553	527	123	656	5		49,235	12,903	62,138
Natural Spawners																						
Upper Sacramento River	Winter	2,712																		2,712	5,141	7,853
Butte Creek	Spring																				14,860	14,860
Upper San Joaquin River	Spring																	146		146	9	155
Upper Sacramento River	Fall			900		13		193	150					13	12					1,281	23,180	24,461
Clear Creek	Fall			831		10		39	119				39		10					1,048	4,664	5,712
Battle Creek[c]	Fall			18,722			3	12	6					3						18,746	2,129	20,875
Mill Creek	Fall			1,017																1,017	1,506	2,523
Butte Creek	Fall																				1,481	1,481
Feather River	Fall			245		3,352	2,122	10,246	6,805	41	40		122	123	41		46			23,183	28,780	51,963
Yuba River above DPD	Fall					158	35	690	209				210	36						1,338	1,353	2,691
Yuba River below DPD	Fall					32	11	300	85		85									513	165	678
American River	Fall			15				1,421	819	6,563	9,323	21	4,635	957	647	12	918			25,331	1,699	27,030
Mokelumne River	Fall			33				66	100		265	33	2,392	100	116		82			3,187	1,180	4,367
Stanislaus River	Fall		8					64	65		33		551	17	57		23			818	686	1,504
Tuolumne River	Fall							19	20				47	8	3		59			156	775	931
Merced River	Fall								78				155			34	256			523	1,688	2,211
Upper Sacramento River	Late-fall[b]		175																	175	1,076	1,251
Total Natural Area Fall-run			8	21,763		3,565	2,171	13,050	8,456	6,604	9,746	54	8,151	1,257	886	46	1,384			77,141	69,286	146,427
In-basin CWT$_{total}$	All	2,922	3,863	32,411		9,841	3,461	20,091	12,556	9,408	13,149	143	8,612	381	334	151	504	146		117,973	103,636	221,609
Stray CWT$_{total}$	All		10	2,173		23	7	2,377	1,881	41	704	38	7,673	1,429	1,079	18	1,536	7		18,996		18,996
Total CV Spawners		2,922	3,873	34,584		9,864	3,468	22,468	14,437	9,449	13,853	181	16,285	1,810	1,413	169	2,040	153		136,969	103,636	240,605
% stray			0.3%	6%		0.2%	0.2%	11%	13%	0.4%	5%	21%	47%	79%	76%	11%	75%	5%		14%		8%
CV Sport Harvest																						
Upper Sacramento River	Fall			5,801		13		52	52											5,918	4,891	10,809
Lower Sacramento River	Fall	27	167	432			27	430	1,193	431	972		1,186		82					4,947	2,479	7,426
Feather River	Fall			105		513	300	2,831	2,309		52			40			60			6,210	3,885	10,095
American River	Fall							63	212	282	212		354	54						1,177	651	1,828
Upper Sacramento River	Late-fall	7	142	28											7					184	152	336
Total Sport Harvest		34	309	6,366		526	327	3,376	3,766	713	1,236		1,540	94	89		60			18,436	12,058	30,494

a/ Release types defined in Table 3; SacWbat recoveries merged with SacW, in-river control releases for MOKFb merged with MOKF, barged and trucked releases for MOKFb merged with MOKFgg, MERFt merged with MERFn.

b/ Late-fall-run hatchery returns and natural area escapement occurred during late-fall of 2019 through early 2020 (return year 2020).

c/ Battle Creek natural area escapement CWT$_{total}$ based on hatchery proportions at CFH (FWS staff, per. comm).

Age-2 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Bat Cr	Up Sac	Nat crks[a]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	Up SJ	In-basin	Stray	CV total	% CV Stray	Ocean CWT$_{samp}$	In-basin	Stray	CV total	Ocean
SacW[b]	2017	Wint	216,237		137									137	0	137	0%	196	63	0	**63**	**91**
SacWbat[b]	2017	Wint	212,136	98										98	0	98	0%	76	46	0	**46**	**36**
FRHS	2017	Spr	488,223				83							83	0	83	0%	196	17	0	**17**	**40**
SJOSx	2017	Spr	209,308											0	0	0	-	4	0	0	**0**	**2**
CFHF	2017	Fall	1,369,512	547	25	34								572	34	606	6%	334	42	3	**44**	**24**
FRHF	2017	Fall	250,489				3							3	0	3	0%	0	1	0	**1**	**0**
FRHFn	2017	Fall	1,496,598				1,868		17	4				1,868	21	1,890	1%	775	125	1	**126**	**52**
FRHFgg	2017	Fall	609,272	2	12	29	1,264		55	9			9	1,264	117	1,381	8%	536	207	19	**227**	**88**
NIMF	2017	Fall	334,047						11					11	0	11	0%	8	3	0	**3**	**2**
NIMFn	2017	Fall	664,585				2	11	797	20				797	33	830	4%	296	120	5	**125**	**45**
MOKF	2017	Fall	398,785							1				1	0	1	0%	0	0.3	0	**0.3**	**0**
MOKFn	2017	Fall	1,649,629				2		146	318	16	15		318	179	496	36%	143	19	11	**30**	**9**
MOKFnc	2017	Fall	727,344	5		2	142	35	715	228	18	9		228	926	1,154	80%	1,139	31	127	**159**	**157**
MERFn	2017	Fall	255,259				30		202	64	12	102		102	307	409	75%	125	40	120	**160**	**49**
CFHL	2018	Late	881,364	63			1		1					63	2	65	3%	0	7	0.2	**7**	**0**
Total			9,762,788	716	174	65	3,395	45	1,943	644	46		134	5,544	1,619	7,164	23%	3,828				

Age-3 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Bat Cr	Up Sac	Nat crks[a]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	Up SJ	In-basin	Stray	CV total	% CV Stray	Ocean CWT$_{samp}$	In-basin	Stray	CV total	Ocean
SacW[b]	2016	Wint	138,803		2,632									2,632	0	2,632	0%	19	1,896	0	**1,896**	**14**
FRHS	2016	Spr	1,682,317		12	10	9,060	188						9,249	22	9,271	0.2%	2,046	550	1	**551**	**122**
SJOSx	2016	Spr	90,600				7						146	146	7	153	5%	49	161	8	**168**	**54**
CFHF	2016	Fall	3,020,565	7,116	186	431	69		4	8				7,301	512	7,813	7%	14,761	242	17	**259**	**489**
FRHF	2016	Fall	1,029,808	5			3,391	45	1	1				3,436	7	3,443	0.2%	5,571	334	1	**334**	**541**
FRHFn	2016	Fall	733,880	5	25	10	2,372	231	430	52	21		2	2,603	545	3,147	17%	5,405	355	74	**429**	**737**
FRHFgg	2016	Fall	263,611		25		1,781	73	239	47	21		18	1,855	349	2,204	16%	4,333	704	133	**836**	**1,644**
NIMF	2016	Fall	591,200				10		2,329					2,329	10	2,339	0.4%	5,074	394	2	**396**	**858**
NIMFn	2016	Fall	277,532				13	11	2,451	108	8		2	2,451	142	2,592	5%	6,037	883	51	**934**	**2,175**
MOKF	2016	Fall	398,284						5	40				40	5	45	11%	118	10	1	**11**	**30**
MOKFn	2016	Fall	1,155,829			10	23	52	1,448	1,801	117		39	1,801	1,689	3,490	48%	5,521	156	146	**302**	**478**
MOKFnc	2016	Fall	841,802		12		42		394	132	7		3	132	459	591	78%	6,397	16	55	**70**	**760**
MOKFgg	2016	Fall	225,243		12	10	34		628	244	44		8	244	737	981	75%	3,996	108	327	**435**	**1,774**
MOKFb	2016	Fall	295,120				13		329	148	16			148	358	507	71%	971	50	121	**172**	**329**
MERF	2016	Fall	245,340						2	1			29	29	3	32	9%	91	12	1	**13**	**37**
CFHL	2017	Late	1,047,211	2,270	46						8			2,316	8	2,324	0.3%	734	221	1	**222**	**70**
Total			12,037,145	9,396	2,950	470	16,817	601	8,260	2,582	242	101	146	36,712	4,852	41,565	12%	61,124				

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 CWT$_{samp}$	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[a]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	Up SJ	In-basin	Stray	CV total			In-basin	Stray	CV total	Ocean
SacW[b]	2015	Wint	415,865		10									10	0	10	0%	0	2	0	**2**	**0**
FRHS	2015	Spr	2,109,278				412							412	0	412	0%	0	20	0	**20**	**0**
SJOSx	2015	Spr	105,424											0	0	0	-	0	0	0	**0**	**0**
CFHF	2015	Fall	3,033,741	157	12									169	0	169	0%	126	6	0	**6**	**4**
FRHF	2015	Fall	246,501											0	0	0	-	0	0	0	**0**	**0**
FRHFn	2015	Fall	2,019,877		25		545	17	8	1				562	33	596	6%	398	28	2	**30**	**20**
NIMF	2015	Fall	692,262						8					8	0	8	0%	15	1	0	**1**	**2**
NIMFn	2015	Fall	349,016						30	1				30	1	31	3%	82	9	0.3	**9**	**23**
MOKF	2015	Fall	401,194							17				17	0	17	0%	2	4	0	**4**	**0.4**
MOKFn	2015	Fall	1,339,629				11		27	54	16	7		54	61	115	53%	215	4	5	**9**	**16**
MOKFnc	2015	Fall	484,920						21	15		2		15	23	38	60%	167	3	5	**8**	**34**
MOKFb	2015	Fall	302,730						9	24				24	9	32	27%	60	8	3	**11**	**20**
MERFn	2015	Fall	148,804						3			1		1	3	4	74%	2	1	2	**3**	**1**
MERFt	2015	Fall	97,228						1		8			0	9	9	100%	6	0	9	**9**	**7**
CFHL	2016	Late	1,044,705	1,285	137									1,422	0	1,422	0%	1,502	136	0	**136**	**144**
		Total	12,791,174	1,441	184		968	17	105	111	24		11	2,722	139	2,862	5%	2,574				

Age-5 CV recoveries (only release types with recoveries in 2019 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 CWT$_{samp}$	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[a]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	Up SJ	In-basin	Stray	CV total			In-basin	Stray	CV total	Ocean
CFHFn	2014	Fall	2,951,944											0	0	0	-	6	0	0	**0**	**0.2**
FRHFn	2014	Fall	1,047,852				1							1	0	1	0%	0	0.1	0	**0.1**	**0**
NIMFn	2014	Fall	979,827											0	0	0	-	3	0	0	**0**	**0.3**
MOKFn	2014	Fall	1,244,314											0	0	0	-	2	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 and SacWbat are considered one year older than those of the same brood year recovered in the CV (i.e., brood year 2017 = age-3 in the ocean).

Sacramento River fall Chinook release types (SFC)

CFHF	Coleman National Fish Hatchery fall in-basin 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
FRHFgg	Feather River Hatchery fall Golden Gate releases (no net pens)
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
MOKFgg	Mokelumne River Hatchery fall Golden Gate releases (no net pens)
MOKFb	Mokelumne River Hatchery fall barge study releases
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
SacWbat	Livingston Stone National Fish Hatchery winter Battle Creek reintroduction releases
FRHS	Feather River Hatchery spring in-basin releases
SJOSx	San Joaquin Salmon Conservation and Research Facility spring reintroduction releases
CFHL	Coleman National Fish Hatchery late-fall in-basin releases

Table 12. Total CWT$_{total}$ recoveries by port area, month, and release type[a] in the 2019 California ocean salmon sport fishery.

	SacW	CFH CFHL	CFH CFHF	CFH CFHFn	FRH FRHS	FRH FRHF	FRH FRHFn	FRH FRHFgg	NIM NIMF	NIM NIMFn	MOKF	MOK MOKFn	MOK MOKFnc	MOK MOKFgg	MER MERF	MER MERFn	SJO SJOSx	Non-CV	Total CV	Total CWT$_{total}$ Hatchery	Total CWT$_{total}$ Natural	Total Harvest
California Sport Harvest																						
Eureka/Crescent City																						
May			23				11	23	23			56	11	11				23	158	181	135	316
Jun		9	256		26	54	70	88	141	152		296	50	33				59	1,176	1,235	1,071	2,306
Jul		8	352		21	24	80	16	41	33	4	90	21	28				25	717	742	576	1,318
Aug		5	253		5	21	101	63	43	39		91	33	31					685	685	269	954
Sep							6	7				7	2	3					25	25	38	63
Total		**23**	**884**		**51**	**99**	**268**	**197**	**248**	**224**	**4**	**541**	**117**	**106**				**108**	**2,761**	**2,869**	**2,088**	**4,957** (6%)
Fort Bragg																						
Apr			47		3		12	12	12	12		12	3						111	111	95	206
May			14			3												14	17	31	50	81
Jun		25	174			8	15		33	47		139	29	13				32	483	515	432	947
Jul		18	293		17	27	244	112	68	126		126	28	28	16				1,105	1,105	592	1,697
Aug		10	95			14	96	19	38	19		38	24	10					363	363	462	825
Sep							20	10		10		10		3					53	53	48	101
Oct																				-	-	0
Total		**53**	**624**		**20**	**53**	**387**	**153**	**151**	**213**		**325**	**83**	**53**	**16**			**46**	**2,132**	**2,178**	**1,679**	**3,857** (4%)
San Francisco																						
Apr		11	446		69	26	279	148	190	179		222	59	40			5	14	1,674	1,688	1,294	2,982
May	9		341		15	27	176	153	68	85	2	34	36	13		19			977	977	668	1,645
Jun	58	110	2,154		114	260	1,368	958	744	1,004	14	956	431	204			7	108	8,380	8,488	6,971	15,459
Jul	55	49	2,125		115	220	1,984	1,497	566	1,183	6	1,004	751	168		239		103	9,963	10,065	6,493	16,558
Aug	33	109	2,304		131	195	1,848	1,298	458	877	8	878	499	120	44	199		193	9,002	9,195	6,666	15,861
Sep		3	364		13	42	317	299	142	181	6	349	242	58		84			2,101	2,101	1,469	3,570
Oct		10	9		3				40	81		58	121	11					334	334	134	468
Total	**154**	**292**	**7,742**		**460**	**771**	**5,973**	**4,354**	**2,208**	**3,590**	**37**	**3,501**	**2,139**	**614**	**44**	**541**	**12**	**418**	**32,431**	**32,848**	**23,695**	**56,543** (64%)
Monterey																						
Apr	9	38	2,763		323	256	1,174	764	835	705	14	446	178	89			14	20	7,608	7,627	5,965	13,592
May		5	313		4	28	134	91	37	71		69	33	9					794	794	643	1,437
Jun	22	11	460		6	33	177	153	131	153	6	110	66	11	29			6	1,366	1,372	787	2,159
Jul	15	26	460			40	274	80	159	180	5	40	50	45				10	1,374	1,384	1,252	2,636
Aug	47	29	227		19	42	171	247	170	434		264	110	61					1,822	1,822	1,457	3,279
Total	**93**	**110**	**4,223**		**352**	**399**	**1,929**	**1,334**	**1,332**	**1,543**	**25**	**929**	**437**	**216**	**29**		**14**	**35**	**12,964**	**13,000**	**10,103**	**23,103** (26%)
California Total Sport Harvest																						
	247	**478**	**13,472**		**883**	**1,322**	**8,557**	**6,038**	**3,939**	**5,571**	**66**	**5,295**	**2,776**	**989**	**89**	**541**	**26**	**606**	**50,288**	**50,895**	**37,565**	**88,460**
Oregon Total Sport Harvest (South of Cape Falcon)																						
		4	*535*		*7*	*37*	*196*	*77*	*156*	*60*		*155*	*97*	*67*		*40*		*887*	*1,431*	*2,318*	*2,993*	*5,311*

a/ Release types defined in Table 3; SacWbat recoveries merged with SacW, 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 2019 California ocean salmon sport fishery.

		CFH			FRH				NIM		MOK				MER		SJO	Non-CV	Total CV	Total %		Total Harvest
	SacW	CFHL	CFHF	CFHFn	FRHS	FRHF	FRHFn	FRHFgg	NIMF	NIMFn	MOKF	MOKFn	MOKFnc	MOKFgg	MERF	MERFn	SJOSx			Hatchery	Natural	
California Sport Harvest																						
Eureka/Crescent City																						
May			7%				4%	7%	7%			18%	4%	4%				7%	50%	57%	43%	316
Jun		0%	11%		1%	2%	3%	4%	6%	7%		13%	2%	1%				3%	51%	54%	46%	2,306
Jul		1%	27%		2%	2%	6%	1%	3%	2%	0%	7%	2%	2%				2%	54%	56%	44%	1,318
Aug		1%	27%		1%	2%	11%	7%	5%	4%		10%	3%	3%					72%	72%	28%	954
Sep							10%	11%				11%	3%	6%					40%	40%	60%	63
Total		0%	18%		1%	2%	5%	4%	5%	5%	0%	11%	2%	2%				2%	56%	58%	42%	4,957
Fort Bragg																						
Apr			23%		1%		6%	6%	6%	6%		6%	1%						54%	54%	46%	206
May			17%			4%												17%	21%	38%	62%	81
Jun		3%	18%		1%		2%		4%	5%		15%	3%	1%				3%	51%	54%	46%	947
Jul		1%	17%		1%	2%	14%	7%	4%	7%		7%	2%	2%	1%				65%	65%	35%	1,697
Aug		1%	12%			2%	12%	2%	5%	2%		5%	3%	1%					44%	44%	56%	825
Sep							20%	10%		10%		10%		3%					53%	53%	47%	101
Oct																				-	-	0
Total		1%	16%		1%	1%	10%	4%	4%	6%		8%	2%	1%	0%			1%	55%	56%	44%	3,857
San Francisco																						
Apr		0%	15%		2%	1%	9%	5%	6%	6%		7%	2%	1%			0%	0%	56%	57%	43%	2,982
May	1%		21%		1%	2%	11%	9%	4%	5%	0%	2%	2%	1%		1%			59%	59%	41%	1,645
Jun	0%	1%	14%		1%	2%	9%	6%	5%	6%	0%	6%	3%	1%			0%	1%	54%	55%	45%	15,459
Jul	0%	0%	13%		1%	1%	12%	9%	3%	7%	0%	6%	5%	1%		1%		1%	60%	61%	39%	16,558
Aug	0%	1%	15%		1%	1%	12%	8%	3%	6%	0%	6%	3%	1%	0%	1%		1%	57%	58%	42%	15,861
Sep		0%	10%		0%	1%	9%	8%	4%	5%	0%	10%	7%	2%		2%			59%	59%	41%	3,570
Oct		2%	2%		1%				9%	17%		12%	26%	2%					71%	71%	29%	468
Total	0%	1%	14%		1%	1%	11%	8%	4%	6%	0%	6%	4%	1%	0%	1%	0%	1%	57%	58%	42%	56,543
Monterey																						
Apr	0%	0%	20%		2%	2%	9%	6%	6%	5%	0%	3%	1%	1%			0%	0%	56%	56%	44%	13,592
May		0%	22%		0%	2%	9%	6%	3%	5%		5%	2%	1%					55%	55%	45%	1,437
Jun	1%	1%	21%		0%	2%	8%	7%	6%	7%	0%	5%	3%	1%	1%			0%	63%	64%	36%	2,159
Jul	1%	1%	17%			2%	10%	3%	6%	7%	0%	2%	2%	2%				0%	52%	53%	47%	2,636
Aug	1%	1%	7%		1%	1%	5%	8%	5%	13%		8%	3%	2%					56%	56%	44%	3,279
Total	0%	0%	18%		2%	2%	8%	6%	6%	7%	0%	4%	2%	1%	0%		0%	0%	56%	56%	44%	23,103
California Total Sport Harvest																						
	0%	1%	15%		1%	1%	10%	7%	4%	6%	0%	6%	3%	1%	0%	1%	0%	1%	57%	58%	42%	88,460
Oregon Total Sport Harvest (South of Cape Falcon)																						
		0%	10%		0%	1%	4%	1%	3%	1%		3%	2%	1%		1%		17%	27%	44%	56%	5,311

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

b/ Release types defined in Table 3; SacWbat recoveries merged with SacW, 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 2019 California ocean salmon commercial fishery.

| | | CFH | | | FRH | | | | NIM | | | MOK | | | | MER | | SJO | Non- | Total | Total CWT_{total} | | Total |
	SacW	CFHL	CFHF	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																						
Jun		5	142		2	7	8	22	94	42		119	12	8				21	463	484	253	737
Jul		18	261		5	6	74	57	71	49	2	68	21	23				47	654	701	774	1,475
Aug		25	284		9	54	141	138	129	142	3	300	49	46		4		146	1,324	1,471	2,174	3,645
Total		**48**	**688**		**16**	**67**	**223**	**218**	**295**	**234**	**5**	**487**	**82**	**77**		**4**		**214**	**2,442**	**2,655**	**3,202**	**5,857** (2%)
Fort Bragg																						
Jun		41	596		39	56	154	127	341	331		224	62	44			5	15	2,020	2,035	1,546	3,581
Jul		29	628		24	27	171	136	149	190	3	191	41	51	18				1,659	1,659	1,235	2,894
Aug		20	566		11	35	186	94	84	105		194	43	19					1,357	1,357	1,449	2,806
Total		**90**	**1,790**		**74**	**118**	**511**	**357**	**575**	**626**	**3**	**609**	**146**	**114**	**18**		**5**	**15**	**5,036**	**5,051**	**4,230**	**9,281** (3%)
San Francisco																						
May		65	2,594		94	255	1,068	804	1,045	1,265	13	958	312	232	17			77	8,722	8,800	7,276	16,076
Jun	3	252	8,487		181	944	3,330	2,758	3,407	4,572	35	3,933	989	841	77	8	3	755	29,818	30,573	29,286	59,859
Jul		113	3,736		87	427	1,592	1,009	1,349	1,746	17	1,855	443	391	69			271	12,833	13,104	12,037	25,141
Aug	3	480	6,819		315	580	2,408	1,991	2,915	4,167	47	3,618	865	802	138			876	25,147	26,023	24,393	50,416
Sep	4	36	593		13	120	255	306	545	427	3	732	170	164	17	16		23	3,401	3,424	2,675	6,099
Oct	5	2	10			5	10	38	181	134		115	70	36		11			616	616	185	801
Total	**15**	**948**	**22,238**		**690**	**2,330**	**8,662**	**6,906**	**9,442**	**12,311**	**115**	**11,209**	**2,849**	**2,467**	**317**	**35**	**3**	**2,002**	**80,537**	**82,538**	**75,854**	**158,392** (58%)
Monterey																						
May	10	305	12,115		486	776	3,788	2,996	3,128	3,197	36	2,183	749	495			10	292	30,273	30,565	24,360	54,925
Jun	18	247	6,494	14	63	576	2,538	1,827	1,707	2,170	14	1,684	535	334			4	207	18,226	18,432	15,274	33,706
Jul	3	123	965		22	89	534	552	507	895	19	714	171	133	41			76	4,767	4,844	4,484	9,328
Total	**30**	**675**	**19,575**	**14**	**570**	**1,442**	**6,860**	**5,374**	**5,342**	**6,262**	**69**	**4,581**	**1,456**	**962**	**41**		**13**	**576**	**53,266**	**53,841**	**44,118**	**97,959** (36%)
California Total Commercial Harvest																						
	46	1,760	44,290	14	1,351	3,956	16,257	12,855	15,654	19,434	191	16,886	4,532	3,620	376	39	21	2,806	141,280	144,086	127,403	271,489
Oregon Total Commercial Harvest (South of Cape Falcon)																						
		89	3,005	10	25	274	1,025	627	676	668	9	1,234	383	231	24	9	6	2,994	8,295	11,289	17,086	28,375

a/ Release types defined in Table 3; SacWbat recoveries merged with SacW, 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 2019 California ocean salmon commercial fishery.

	SacW	CFH CFHL	CFH CFHF	CFH CFHFn	FRH FRHS	FRH FRHF	FRH FRHFn	FRH FRHFgg	NIM NIMF	NIM NIMFn	MOK MOKF	MOK MOKFn	MOK MOKFnc	MOK MOKFgg	MER MERF	MER MERFn	SJO SJOSx	Non-CV	Total CV	Total % Hatchery	Total % Natural	Total Harvest
California Commercial Harvest																						
Eureka/Crescent City																						
Jun		1%	19%		0%	1%	1%	3%	13%	6%		16%	2%	1%				3%	63%	66%	34%	737
Jul		1%	18%		0%	0%	5%	4%	5%	3%	0%	5%	1%	2%				3%	44%	48%	52%	1,475
Aug		1%	8%		0%	1%	4%	4%	4%	4%	0%	8%	1%	1%		0%		4%	36%	40%	60%	3,645
Total		**1%**	**12%**		**0%**	**1%**	**4%**	**4%**	**5%**	**4%**	**0%**	**8%**	**1%**	**1%**		**0%**		**4%**	**42%**	**45%**	**55%**	**5,857**
Fort Bragg																						
Jun		1%	17%		1%	2%	4%	4%	10%	9%		6%	2%	1%			0%	0%	56%	57%	43%	3,581
Jul		1%	22%		1%	1%	6%	5%	5%	7%	0%	7%	1%	2%	1%				57%	57%	43%	2,894
Aug		1%	20%		0%	1%	7%	3%	3%	4%		7%	2%	1%					48%	48%	52%	2,806
Total		**1%**	**19%**		**1%**	**1%**	**6%**	**4%**	**6%**	**7%**	**0%**	**7%**	**2%**	**1%**	**0%**			**0%**	**54%**	**54%**	**46%**	**9,281**
San Francisco																						
May		0%	16%		1%	2%	7%	5%	7%	8%	0%	6%	2%	1%	0%			0%	54%	55%	45%	16,076
Jun	0%	0%	14%		0%	2%	6%	5%	6%	8%	0%	7%	2%	1%	0%	0%	0%	1%	50%	51%	49%	59,859
Jul		0%	15%		0%	2%	6%	4%	5%	7%	0%	7%	2%	2%	0%			1%	51%	52%	48%	25,141
Aug	0%	1%	14%		1%	1%	5%	4%	6%	8%	0%	7%	2%	2%	0%			2%	50%	52%	48%	50,416
Sep	0%	1%	10%		0%	2%	4%	5%	9%	7%	0%	12%	3%	3%	0%	0%		0%	56%	56%	44%	6,099
Oct	1%	0%	1%			1%	1%	5%	23%	17%		14%	9%	4%		1%			77%	77%	23%	801
Total	**0%**	**1%**	**14%**		**0%**	**1%**	**5%**	**4%**	**6%**	**8%**	**0%**	**7%**	**2%**	**2%**	**0%**	**0%**	**0%**	**1%**	**51%**	**52%**	**48%**	**158,392**
Monterey																						
May	0%	1%	22%		1%	1%	7%	5%	6%	6%	0%	4%	1%	1%			0%	1%	55%	56%	44%	54,925
Jun	0%	1%	19%	0%	0%	2%	8%	5%	5%	6%	0%	5%	2%	1%			0%	1%	54%	55%	45%	33,706
Jul	0%	1%	10%		0%	1%	6%	6%	5%	10%	0%	8%	2%	1%	0%			1%	51%	52%	48%	9,328
Total	**0%**	**1%**	**20%**	**0%**	**1%**	**1%**	**7%**	**5%**	**5%**	**6%**	**0%**	**5%**	**1%**	**1%**	**0%**		**0%**	**1%**	**54%**	**55%**	**45%**	**97,959**
California Total Commercial Harvest																						
	0%	**1%**	**16%**	**0%**	**0%**	**1%**	**6%**	**5%**	**6%**	**7%**	**0%**	**6%**	**2%**	**1%**	**0%**	**0%**	**0%**	**1%**	**52%**	**53%**	**47%**	**271,489**
Oregon Total Commercial Harvest (South of Cape Falcon)																						
		0%	*11%*	*0%*	*0%*	*1%*	*4%*	*2%*	*2%*	*2%*	*0%*	*4%*	*1%*	*1%*	*0%*	*0%*	*0%*	*11%*	*29%*	*40%*	*60%*	*28,375*

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

b/ Release types defined in Table 3; SacWbat recoveries merged with SacW, 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 2019.**

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 CWT$_{samp}$	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[a]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	In-basin	Stray	CV total			In-basin	Stray	CV total	Ocean
FRHFn	2017	Fall	1,496,598				1,868		17	4			1,868	21	**1,890**	1%	**775**	125	1	**126**	**52**
FRHFgg	2017	Fall	609,272	2	12	29	1,264		55	9		9	1,264	117	**1,381**	8%	**536**	207	19	**227**	**88**
NIMFn	2017	Fall	664,585				2	11	797	20			797	33	**830**	4%	**296**	120	5	**125**	**45**
MOKFn	2017	Fall	1,649,629				2		146	318	16	15	318	179	**496**	36%	**143**	19	11	**30**	**9**
MOKFnp	2017	Fall	727,344	5		2	142	35	715	228	18	9	228	926	**1,154**	80%	**1,139**	31	127	**159**	**157**
MERFn	2017	Fall	255,259				30		202	64	12	102	102	307	**409**	75%	**125**	40	120	**160**	**49**

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 CWT$_{samp}$	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[a]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	In-basin	Stray	CV total			In-basin	Stray	CV total	Ocean
FRHFn	2016	Fall	733,880	5	25	10	2,372	231	430	52	21	2	2,603	545	**3,147**	17%	**5,405**	355	74	**429**	**737**
FRHFgg	2016	Fall	263,611		25		1,781	73	239	47	21	18	1,855	349	**2,204**	16%	**4,333**	704	133	**836**	**1,644**
NIMFn	2016	Fall	277,532				13	11	2,451	108	8	2	2,451	142	**2,592**	5%	**6,037**	883	51	**934**	**2,175**
MOKFn	2016	Fall	1,155,829			10	23	52	1,448	1,801	117	39	1,801	1,689	**3,490**	48%	**5,521**	156	146	**302**	**478**
MOKFnp	2016	Fall	720,759		12		42		386	128	7	3	128	451	**579**	78%	**6,081**	18	63	**80**	**844**
MOKFns	2016	Fall	121,043						8	4			4	8	**12**	66%	**317**	3	6	**10**	**262**
MOKFgg	2016	Fall	225,243		12	10	34		628	244	44	8	244	737	**981**	75%	**3,996**	108	327	**435**	**1,774**
MOKFbb	2016	Fall	96,885				11		78	19			19	89	**108**	82%	**403**	20	92	**111**	**416**
MOKFbg	2016	Fall	98,203				2		219	45	16		45	237	**282**	84%	**424**	46	241	**287**	**431**
MOKFbr	2016	Fall	100,032						33	84			84	33	**117**	28%	**145**	84	33	**117**	**145**

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 CWT$_{samp}$	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[a]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	In-basin	Stray	CV total			In-basin	Stray	CV total	Ocean
FRHFn	2015	Fall	2,019,877		25		545	17	8	1			562	33	**596**	6%	**398**	28	2	**30**	**20**
NIMFn	2015	Fall	349,016						30	1			30	1	**31**	3%	**82**	9	0.3	**9**	**23**
MOKFn	2015	Fall	1,339,629				11		27	54	16	7	54	61	**115**	53%	**215**	4	5	**9**	**16**
MOKFnp	2015	Fall	484,920						21	15		2	15	23	**38**	60%	**167**	3	5	**8**	**34**
MOKFbb	2015	Fall	100,982						2	9			9	2	**11**	17%	**32**	9	2	**11**	**31**
MOKFbg	2015	Fall	100,613						7	14			14	7	**21**	32%	**28**	14	7	**21**	**28**
MOKFbr	2015	Fall	101,135										0	0	**0**	-	**0**	0	0	**0**	**0**
MERFn	2015	Fall	148,804						3			1	1	3	**4**	74%	**2**	1	2	**3**	**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.

Central Valley fall Chinook experimental and net pen release types:

FRHFn   Feather River Hatchery fall bay/delta net pen releases

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

NIMFn   Nimbus Fish Hatchery fall bay/delta net pen releases

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)

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

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.)

MERFn   Merced River Hatchery fall bay/delta net pen releases

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

Figure 1. Map of release sites for CV hatchery release types, brood years 2014-2017.
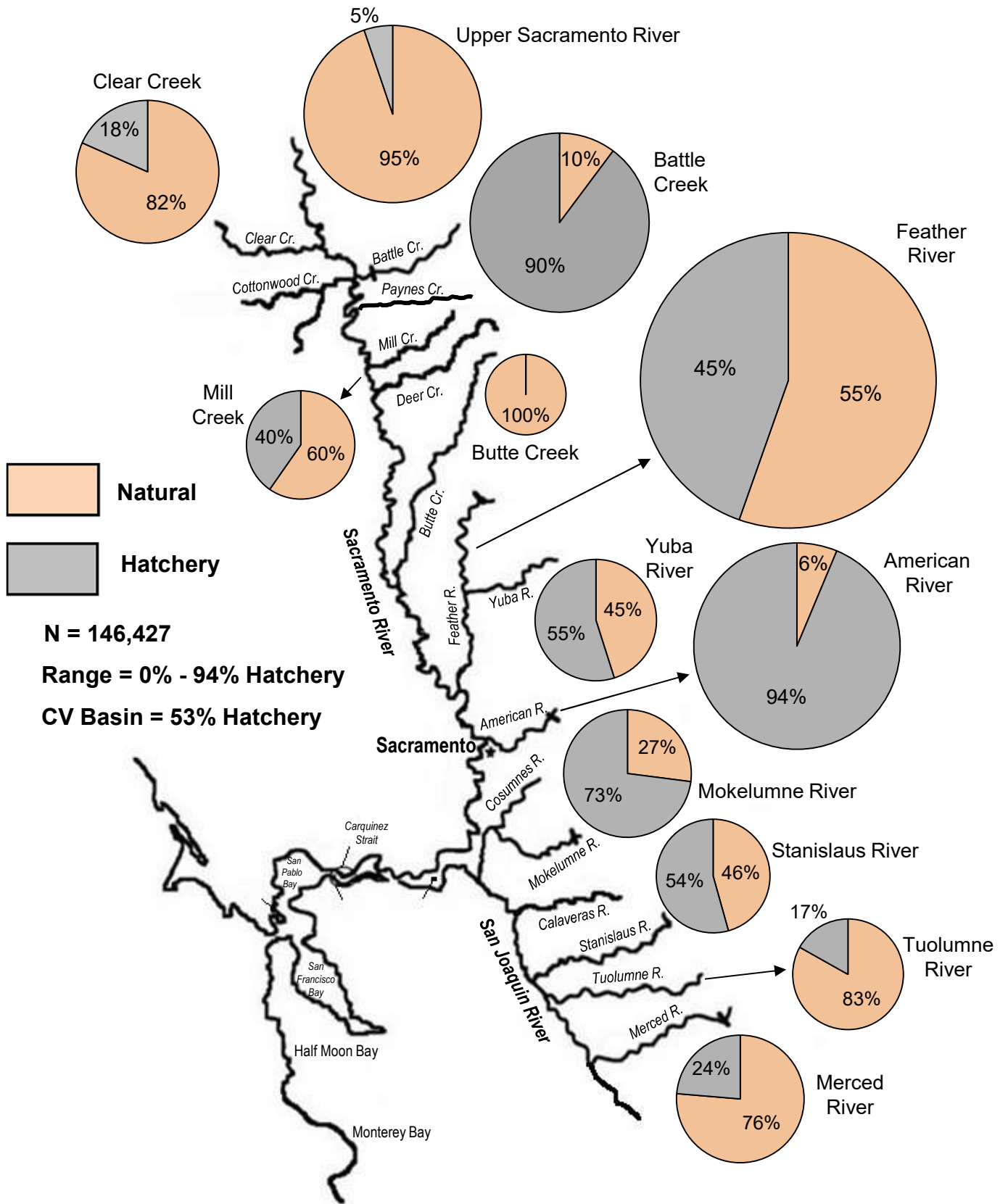
Figure 2. Fall-run CV natural area escapement, hatchery and natural proportions, 2019.
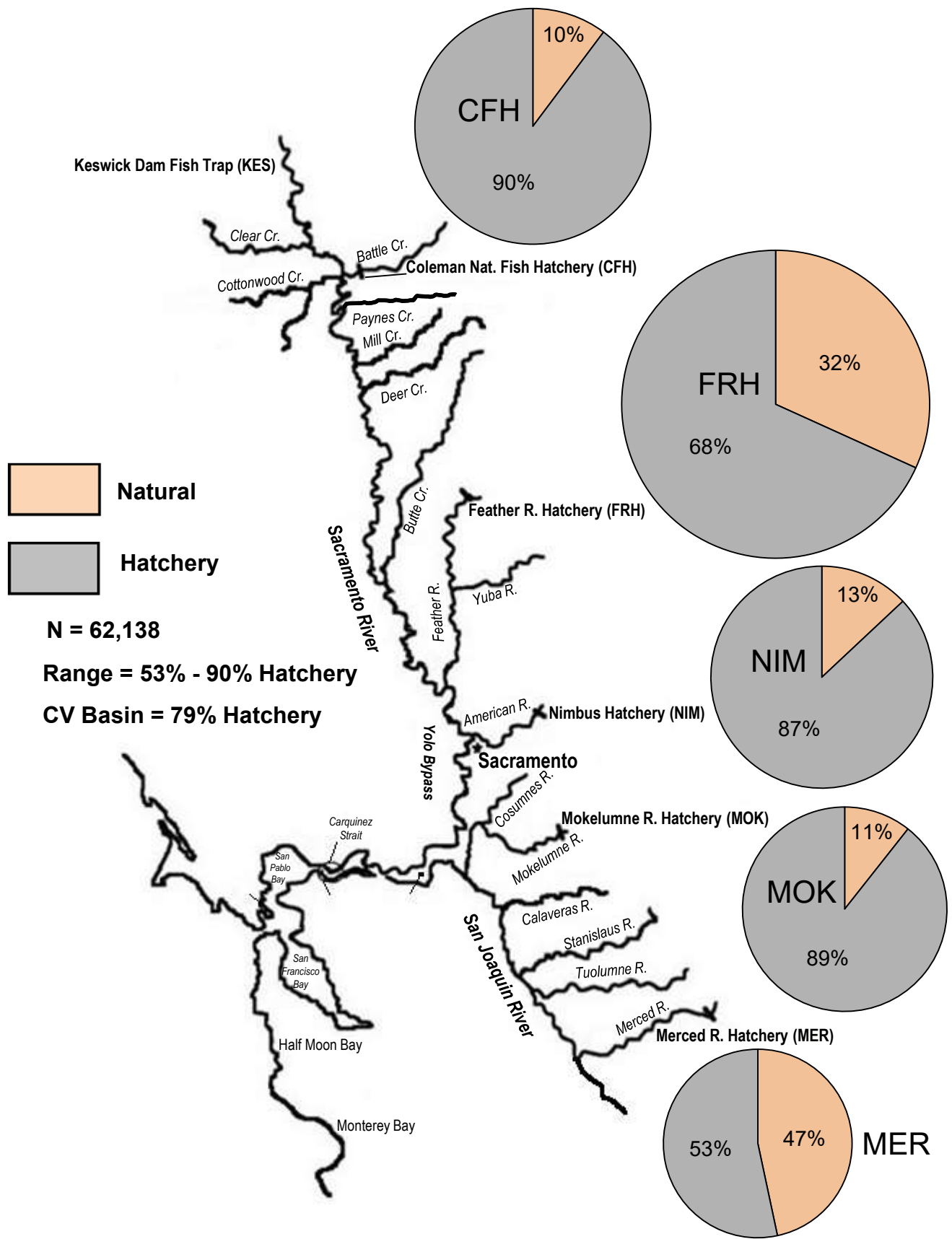
Figure 3. Fall-run CV hatchery escapement, hatchery and natural proportions, 2019.
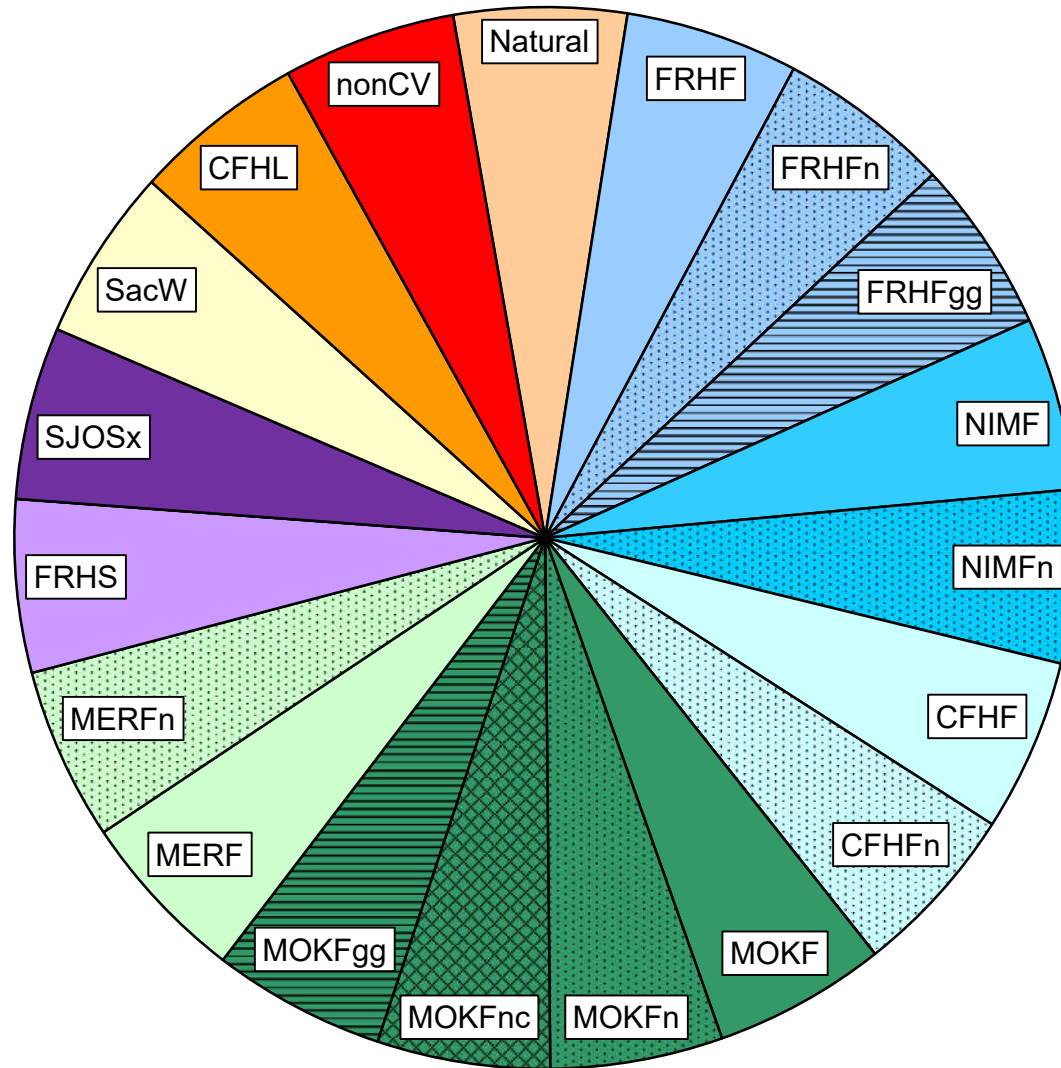
Figure 4. Color and pattern scheme used in all pie chart figures for Central Valley hatchery release types, brood years 2014-2017.
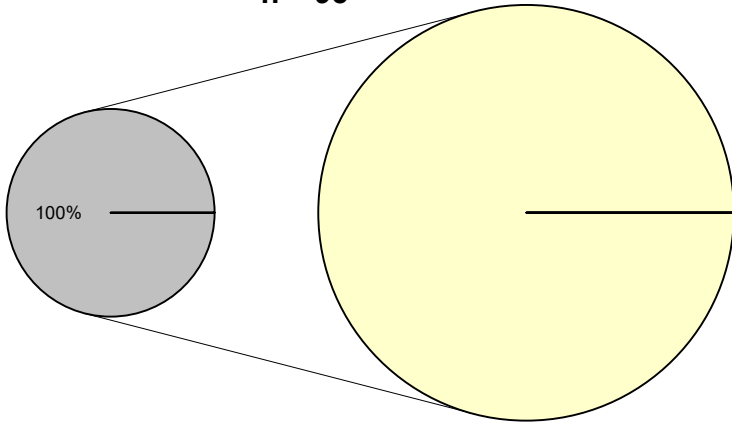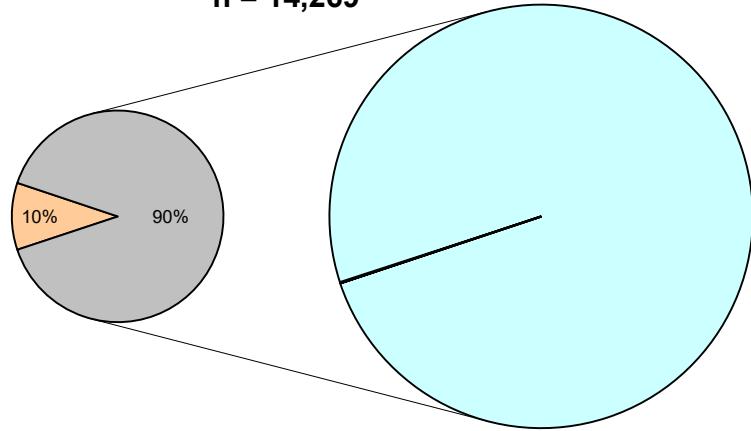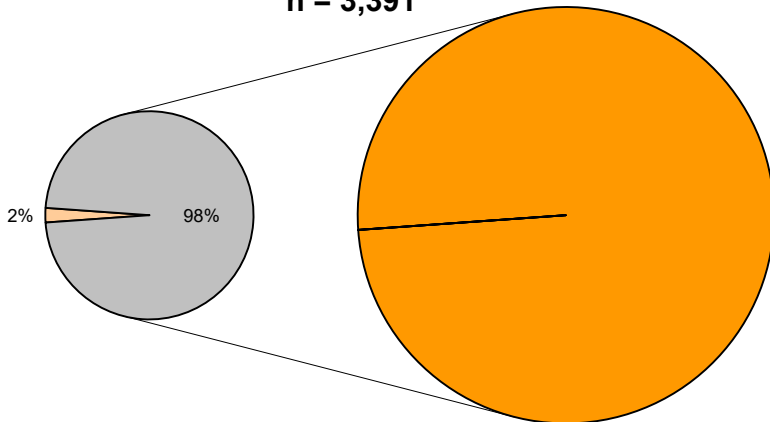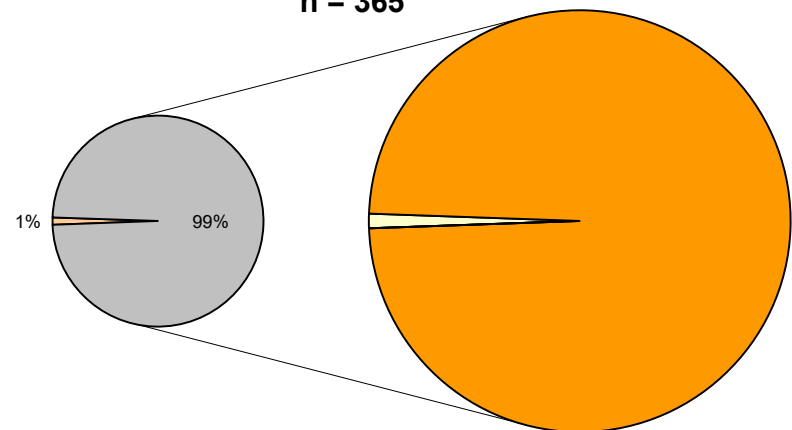
Figure 5. Proportion of hatchery- and natural-origin fish at Coleman National Fish Hatchery, 2019-20.
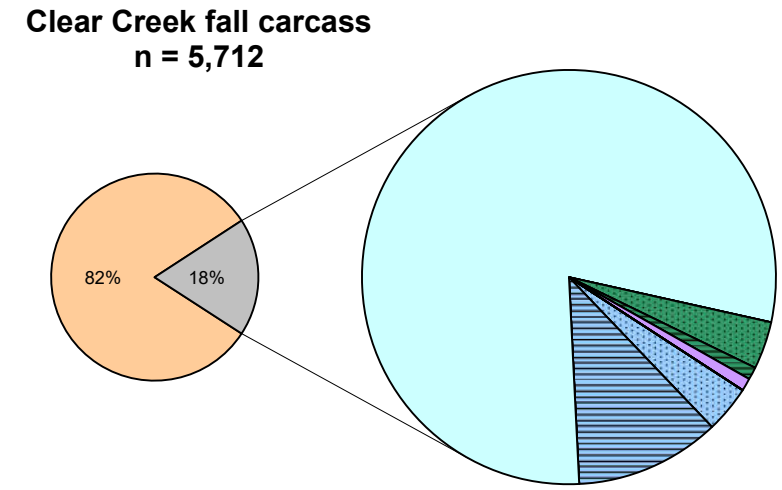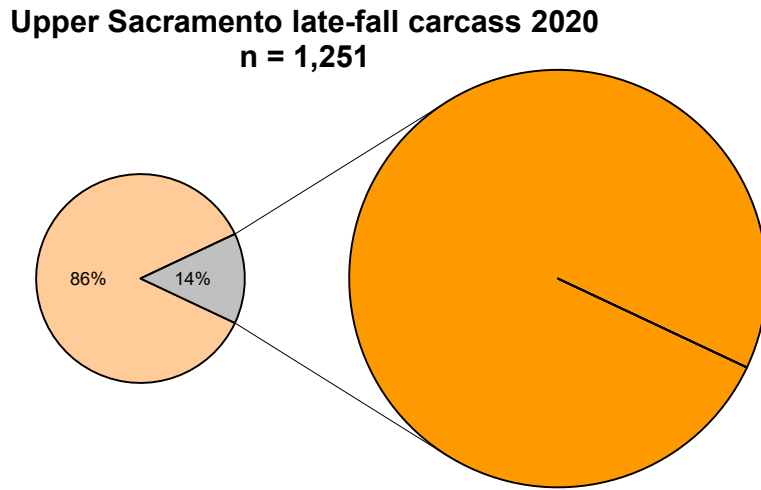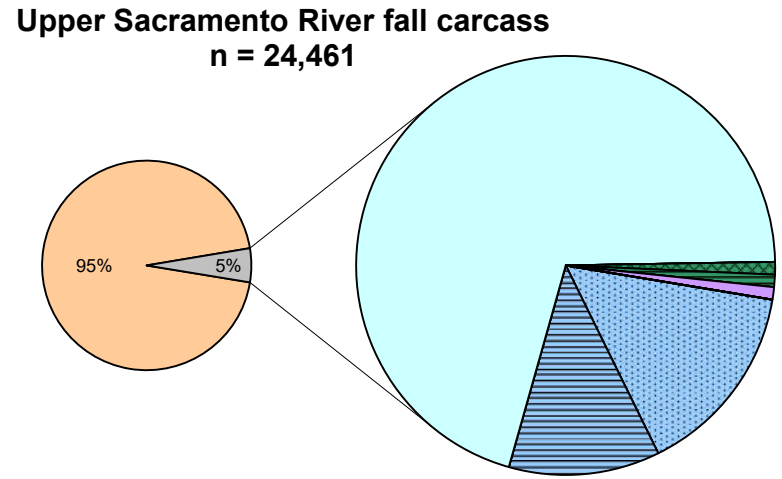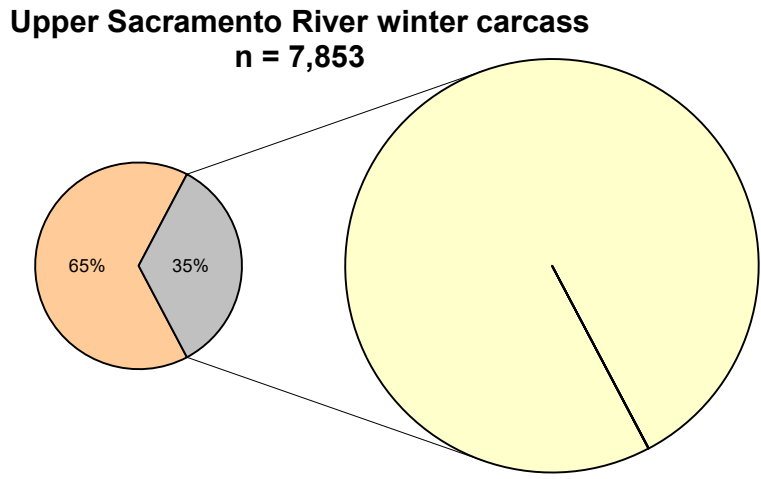
Figure 6. Proportion of hatchery- and natural-origin fish in Upper Sacramento River & tributaries, 2019. (Page 1 of 2)

Battle Creek fall spawners
n = 20,875
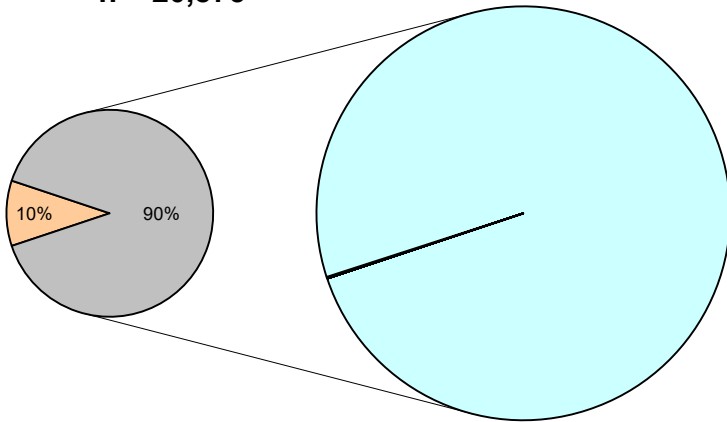
Mill Creek fall carcass
n = 2,523
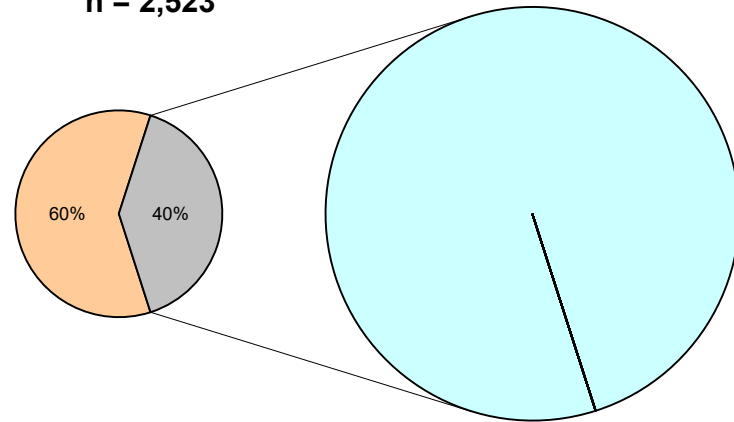
Legend: Natural, FRHF, FRHFn, FRHFgg, NIMF, NIMFn, CFHF, CFHFn, MOKF, MOKFn, MOKFnc, MOKFgg, MERF, MERFn, FRHS, SJOSx, SacW, CFHL, nonCV

Figure 6. Proportion of hatchery- and natural-origin fish in Upper Sacramento River & tributaries, 2019. (Page 2 of 2)

Butte Creek spring carcass
n = 14,860
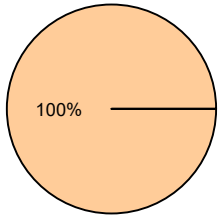
Butte Creek fall carcass
n = 1,481
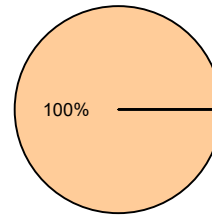
Yuba River fall carcass (above DPD)
n = 2,691
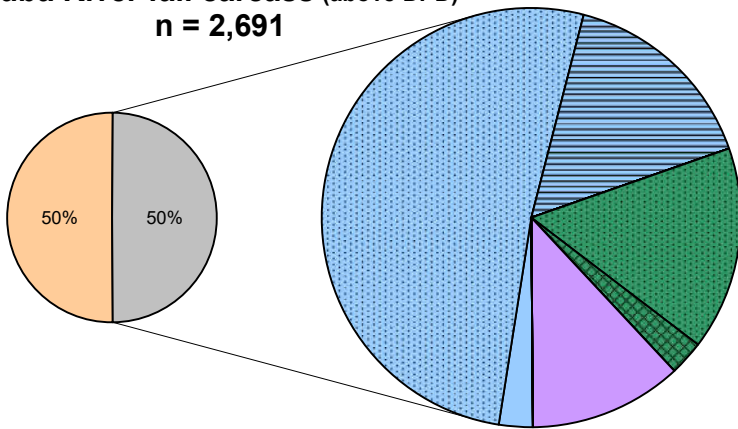
Yuba River fall carcass (below DPD)
n = 678
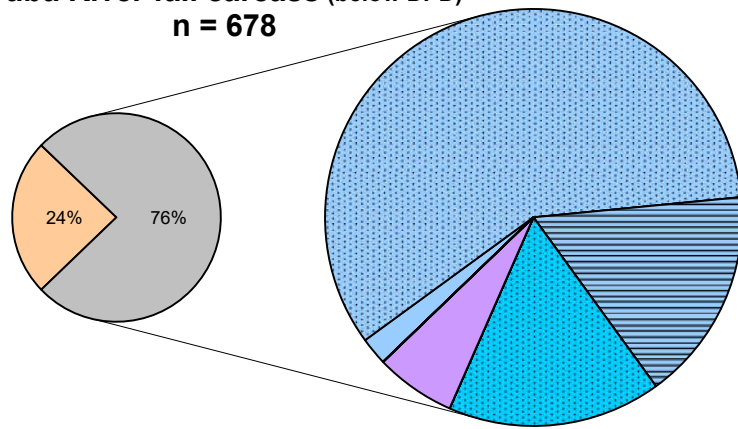
Natural · FRHF · FRHFn · FRHFgg · NIMF · NIMFn · CFHF · CFHFn · MOKF · MOKFn · MOKFnc · MOKFgg · MERF · MERFn · FRHS · SJOSx · SacW · CFHL · nonCV

Figure 7. Proportion of hatchery- and natural-origin fish in Butte Creek & Yuba River, 2019.

Feather River Hatchery spring
n = 3,867
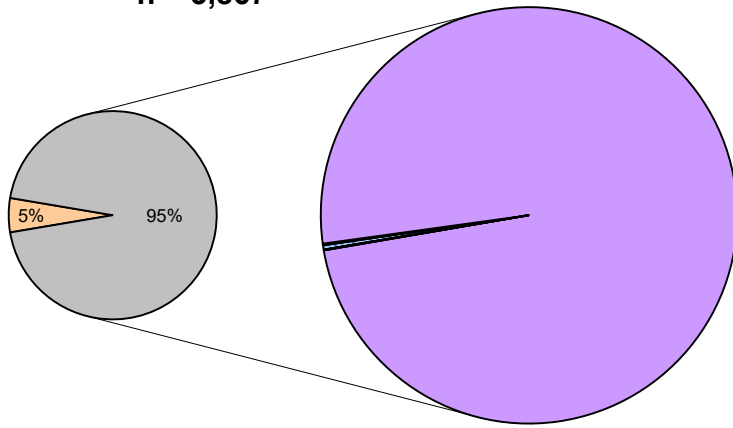
Feather River Hatchery fall
n = 27,103
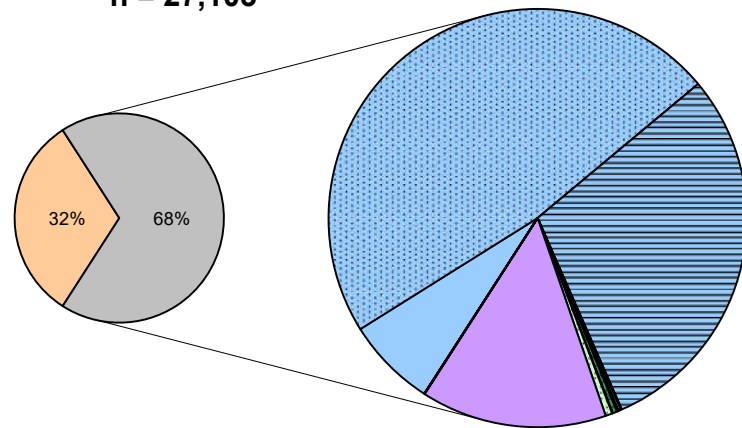
Feather River fall carcass
n = 51,963

Legend: □ Natural □ FRHF ⊞ FRHFn ⊞ FRHFgg □ NIMF ⊞ NIMFn □ CFHF ⊞ CFHFn ■ MOKF ■ MOKFn ■ MOKFnc ■ MOKFgg □ MERF ⊞ MERFn □ FRHS ■ SJOSx □ SacW □ CFHL ■ nonCV
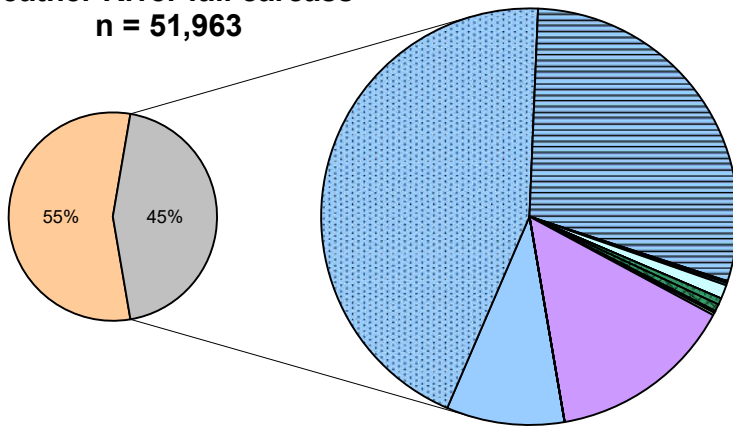
Figure 8. Proportion of hatchery- and natural-origin fish in the Feather River, 2019.
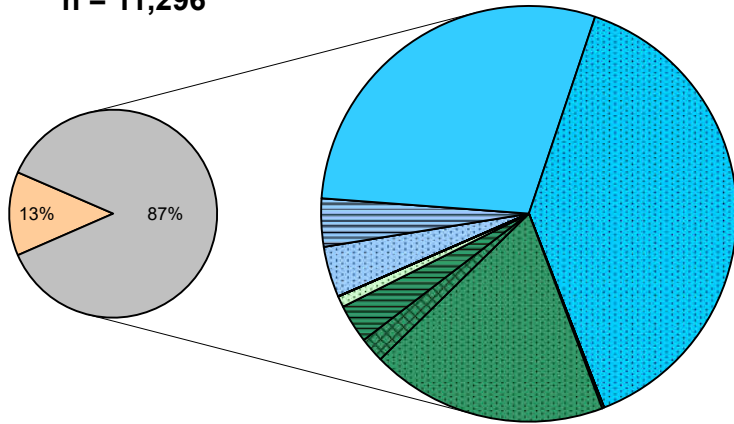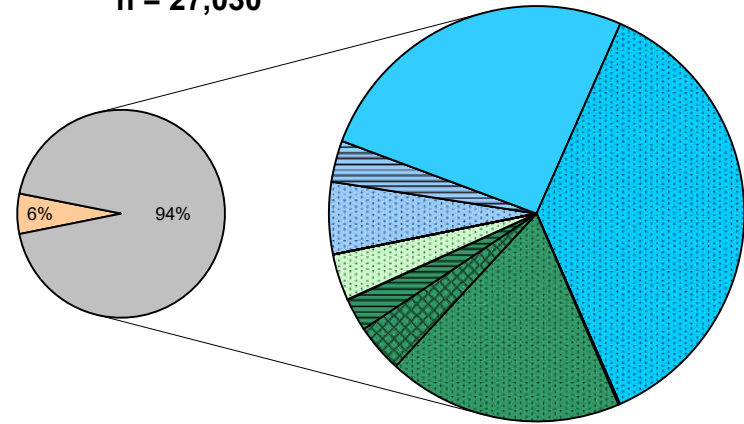
Figure 9. Proportion of hatchery- and natural-origin fish in the American River, 2019.
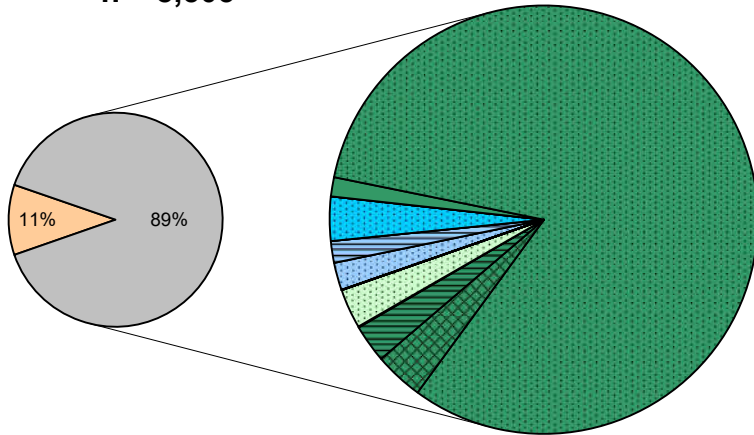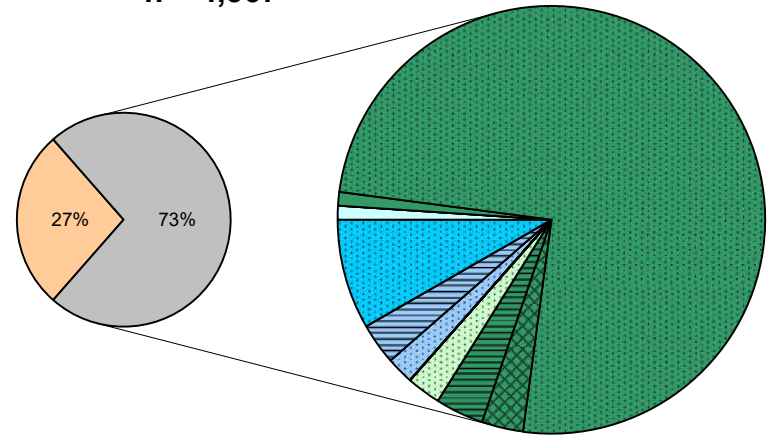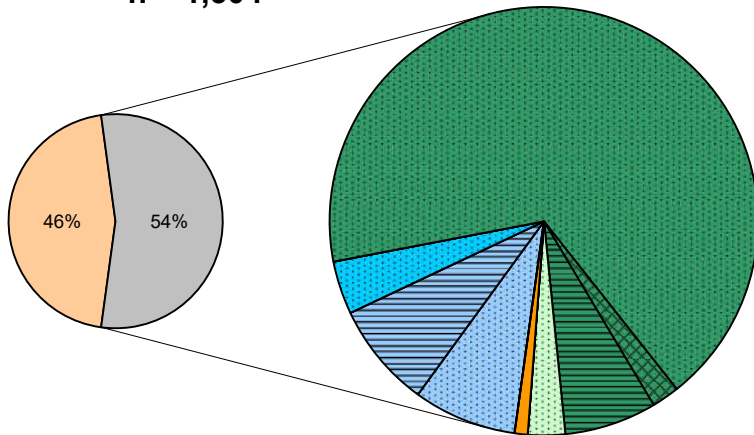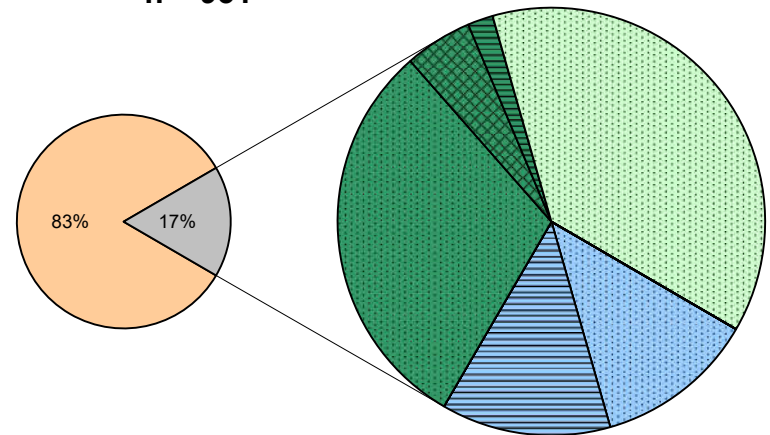
Figure 10. Proportion of hatchery- and natural-origin fish in the Mokelumne, Stanislaus, & Tuolumne rivers, 2019.

Merced River Hatchery fall
n = 967

47% 53%
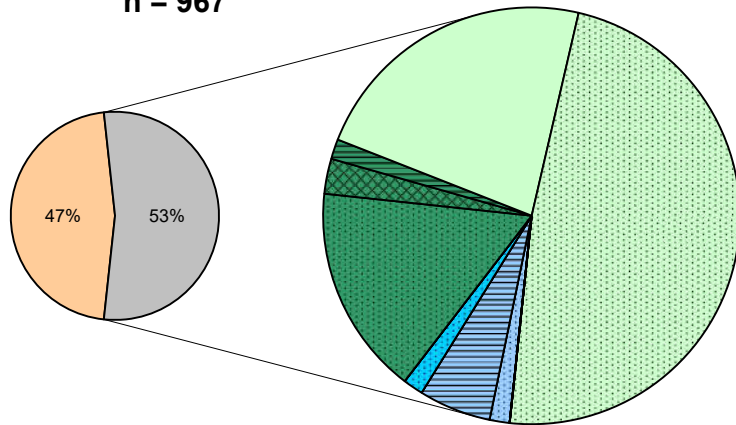
Merced River fall carcass
n = 2,211

76% 24%
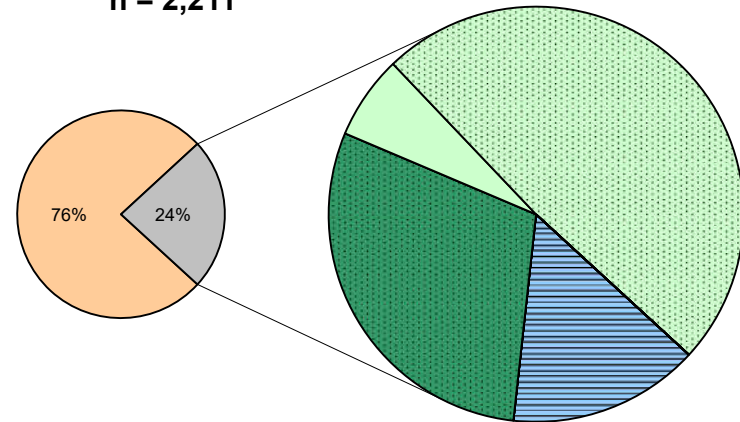
Upper San Joaquin River spring carcass
n = 155
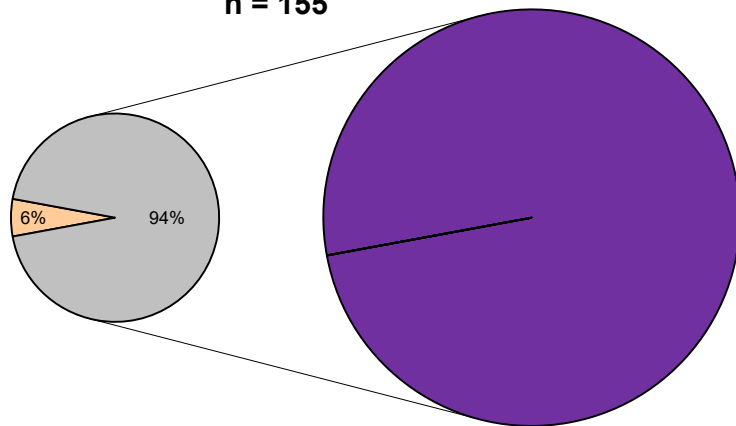
6% 94%

☐ Natural ☐ FRHF ☐ FRHFn ☐ FRHFgg ☐ NIMF ☐ NIMFn ☐ CFHF ☐ CFHFn ■ MOKF ■ MOKFn
■ MOKFnc ■ MOKFgg ☐ MERF ☐ MERFn ☐ FRHS ■ SJOSx ☐ SacW ☐ CFHL ■ nonCV

Figure 11. Proportion of hatchery- and natural-origin fish in the Merced & Upper San Joaquin rivers, 2019.
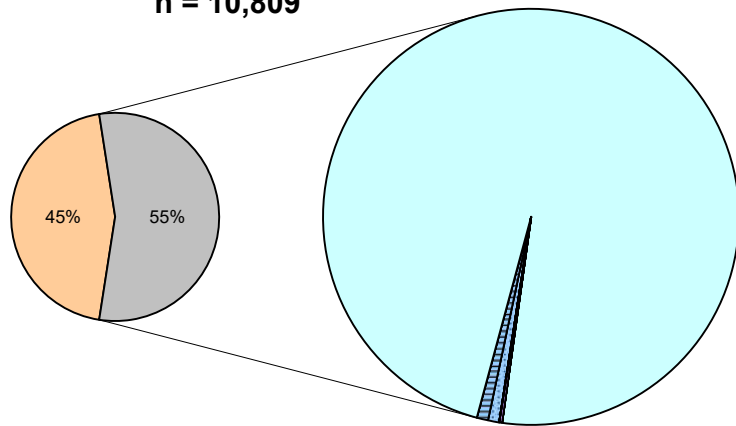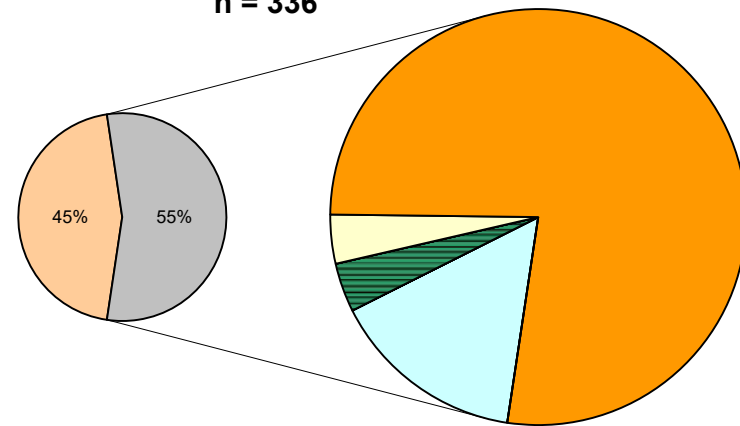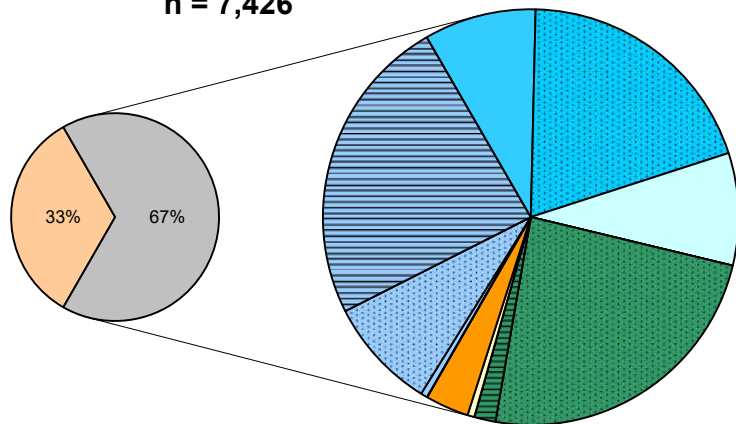
Figure 12. Proportion of hatchery- and natural-origin fish in sport harvest on the Sacramento & Feather rivers, 2019.

American River fall creel
n = 1,828
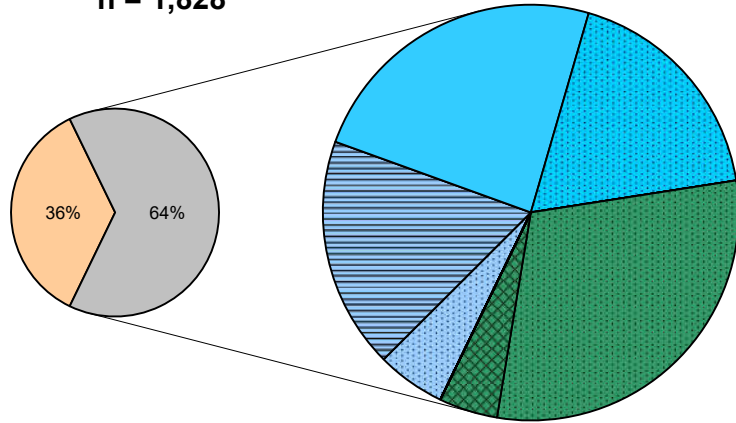
Natural · FRHF · FRHFn · FRHFgg · NIMF · NIMFn · CFHF · CFHFn · MOKF · MOKFn
MOKFnc · MOKFgg · MERF · MERFn · FRHS · SJOSx · SacW · CFHL · nonCV

36% · 64%

Figure 13. Proportion of hatchery- and natural-origin fish in sport harvest on the American River, 2019.
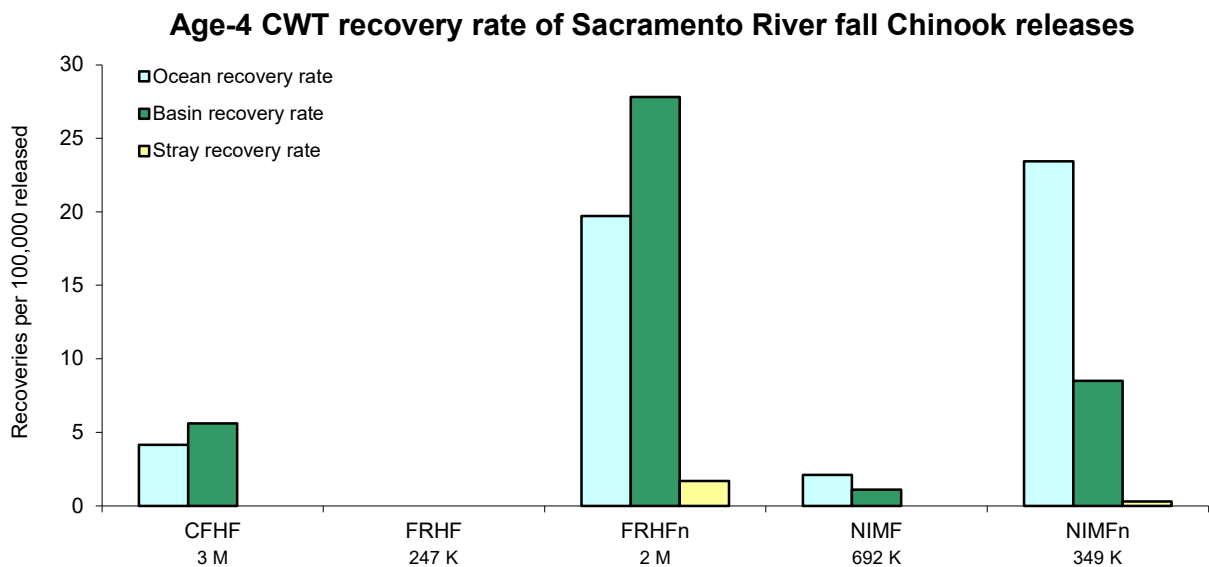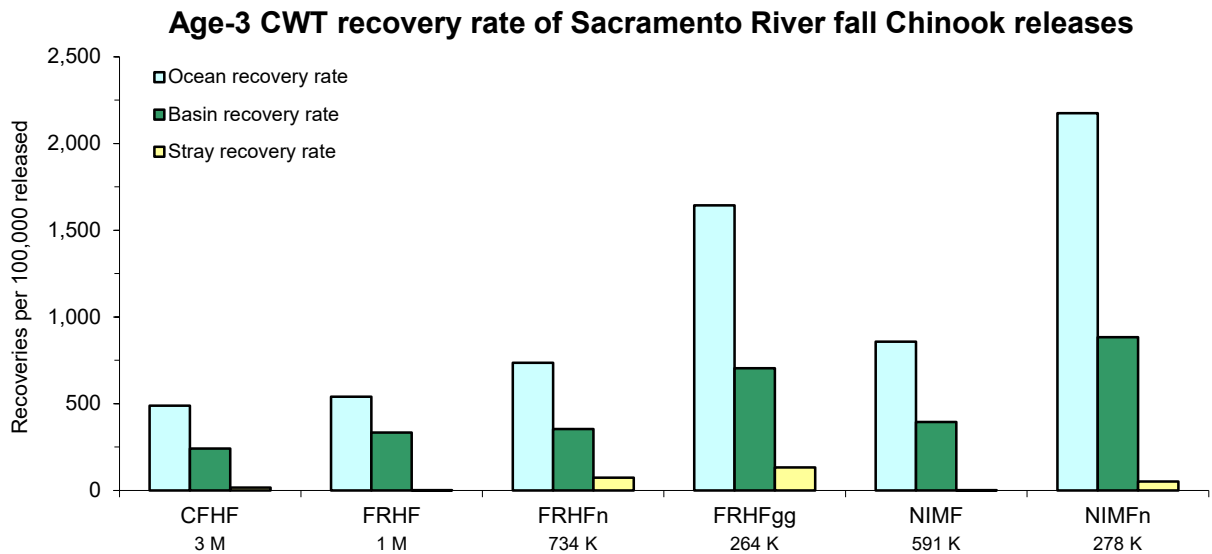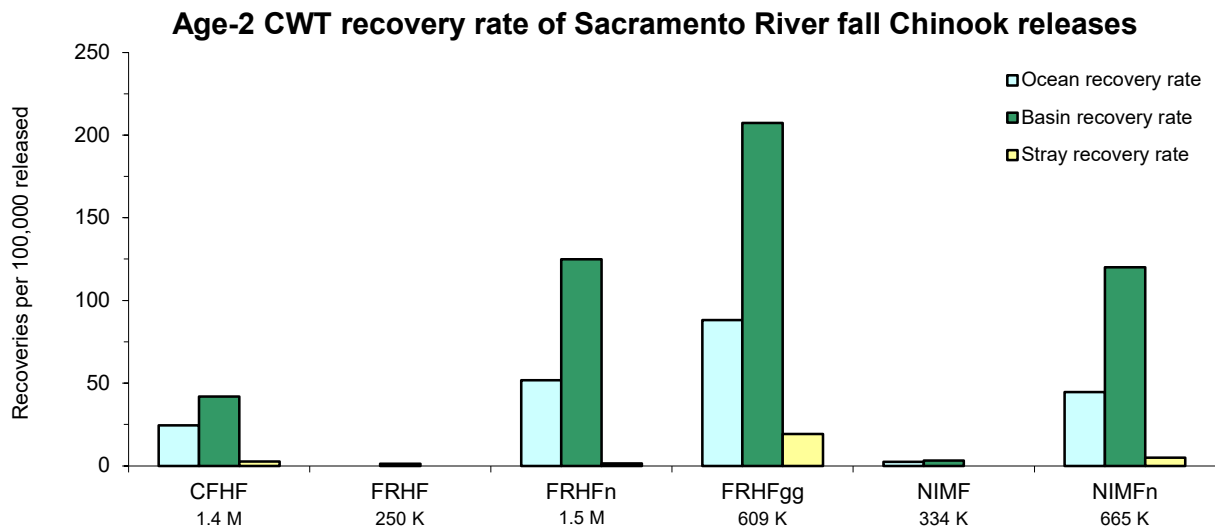
Figure 14. CWT recovery rates of Sacramento River fall Chinook releases by age in 2019.

Figure 15. CWT recovery rates of Other CV Chinook releases by age in 2019.
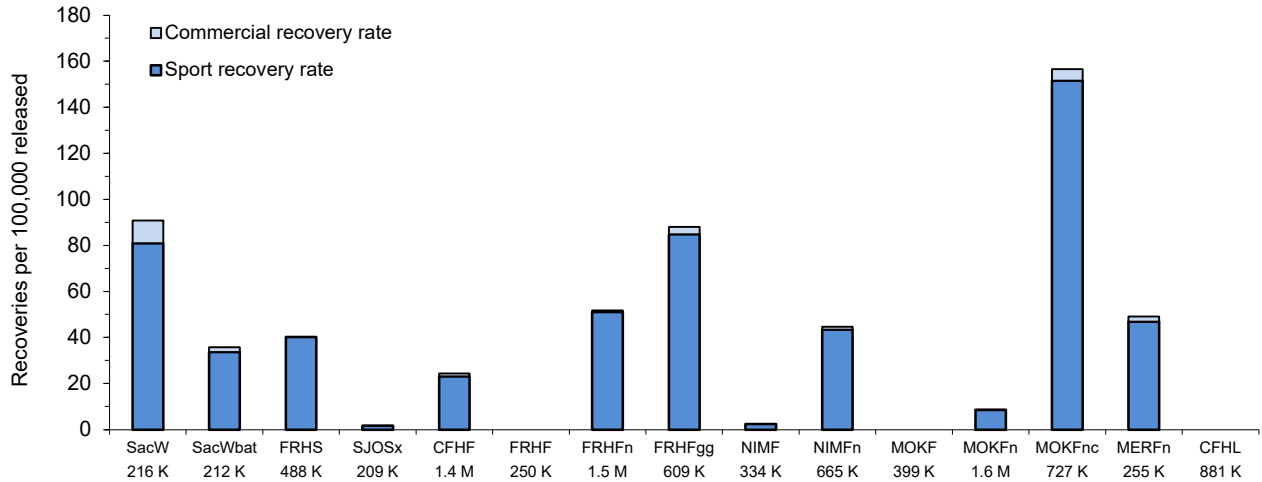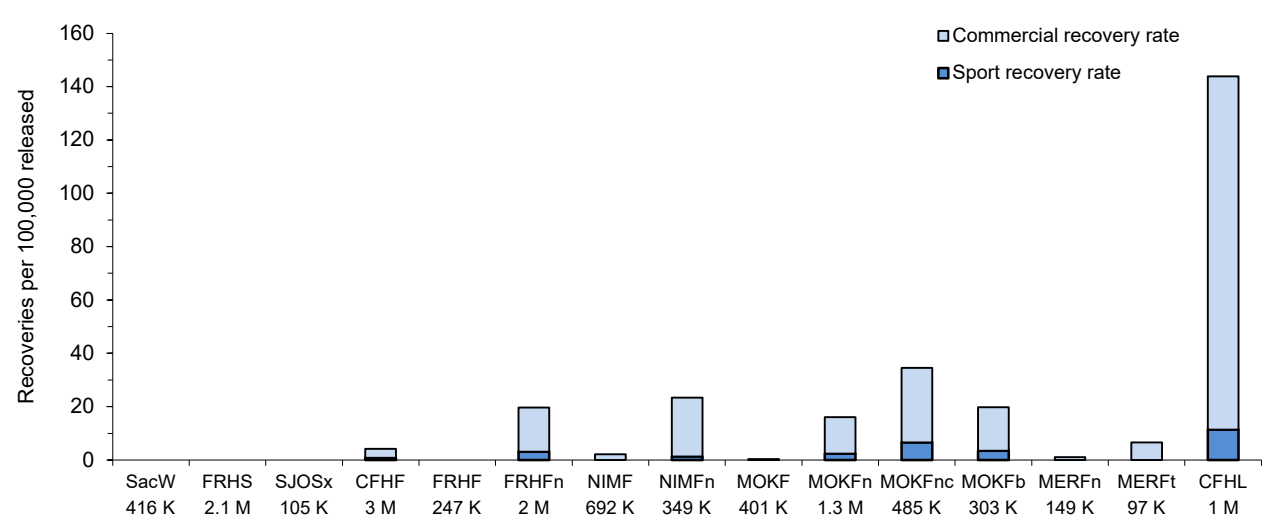
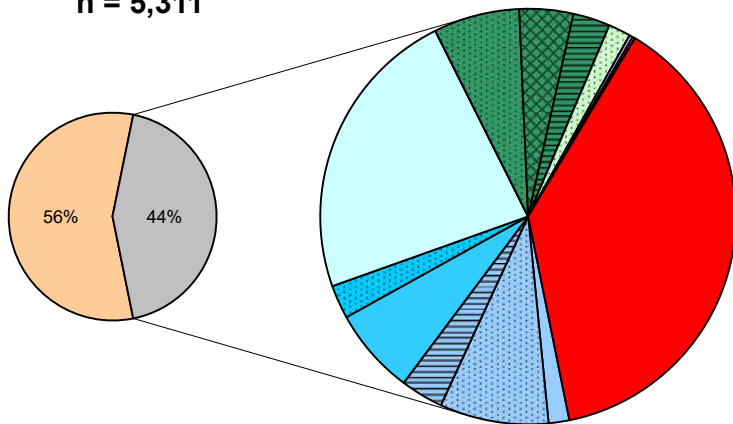Figure 16. CWT recovery rates by release type in 2019 ocean salmon fisheries.

California Sport Harvest
n = 88,460

42% 58%
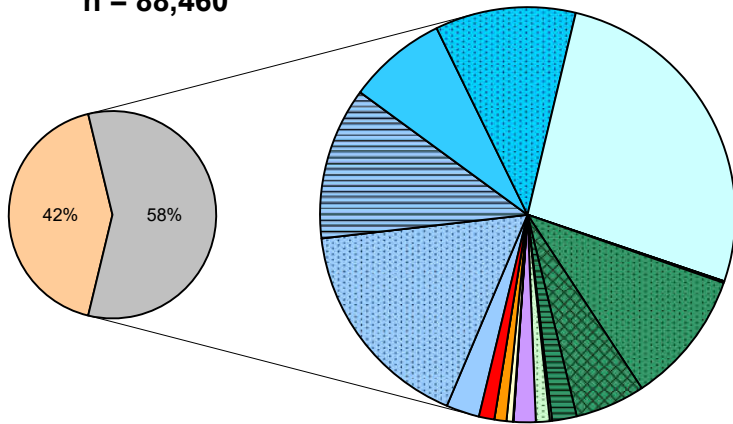
California Commercial Harvest
n = 271,489

47% 53%
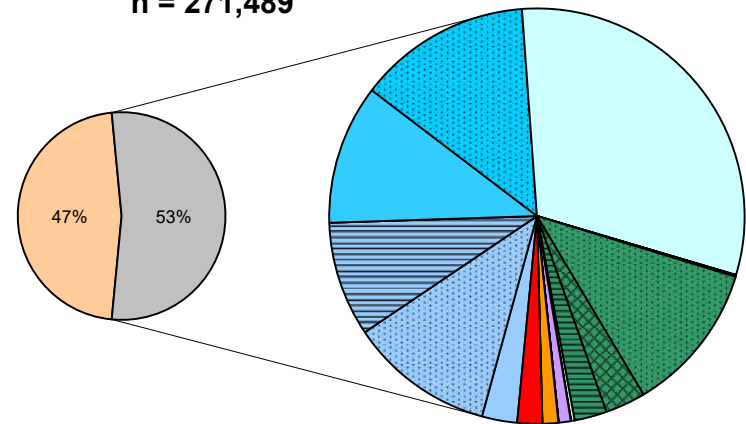
Oregon Sport Harvest
n = 5,311

56% 44%

Oregon Commercial Harvest
n = 28,375

60% 40%

Natural | FRHF | FRHFn | FRHFgg | NIMF | NIMFn | CFHF | CFHFn | MOKF | MOKFn
MOKFnc | MOKFgg | MERF | MERFn | FRHS | SJOSx | SacW | CFHL | nonCV
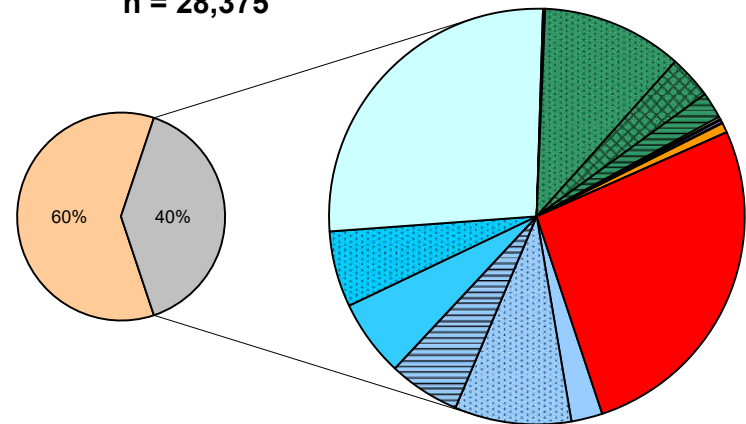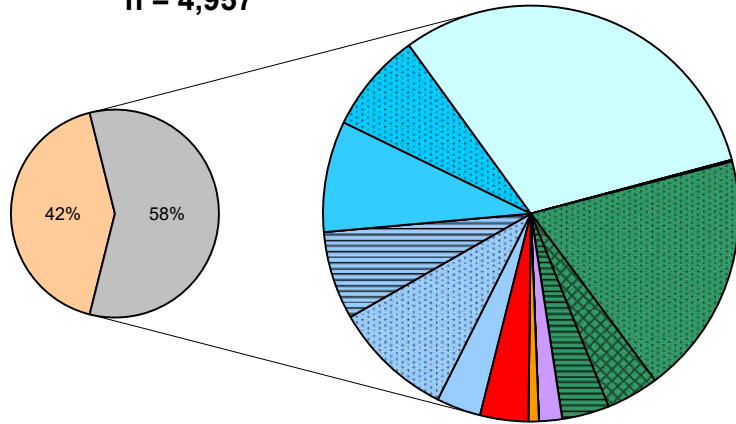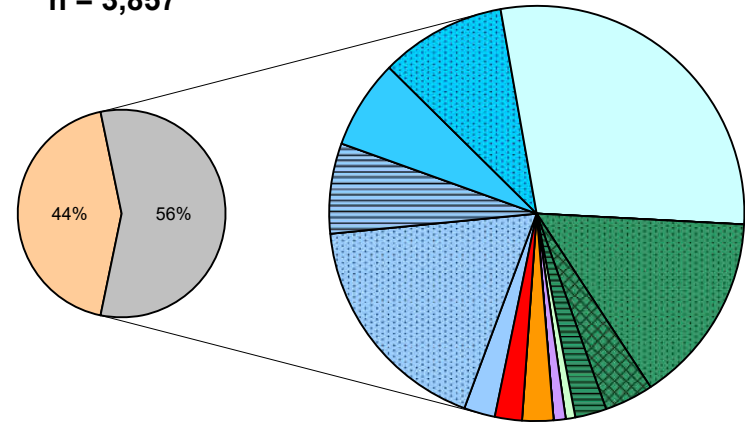
Figure 17. Proportion of hatchery- and natural-origin salmon in 2019 California and Oregon ocean fisheries.
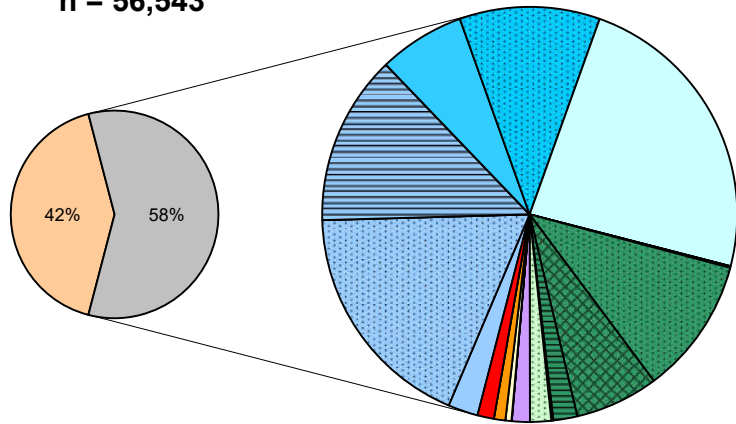
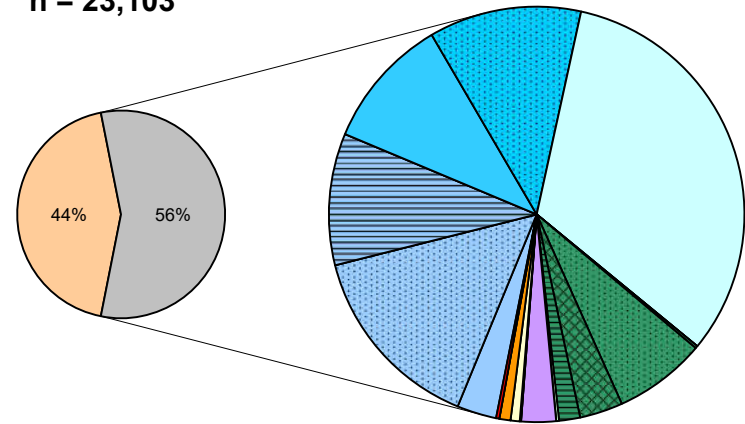Figure 18. Proportion of hatchery- and natural-origin salmon in the 2019 California ocean sport fishery.

Eureka / Crescent City Commercial
n = 5,857
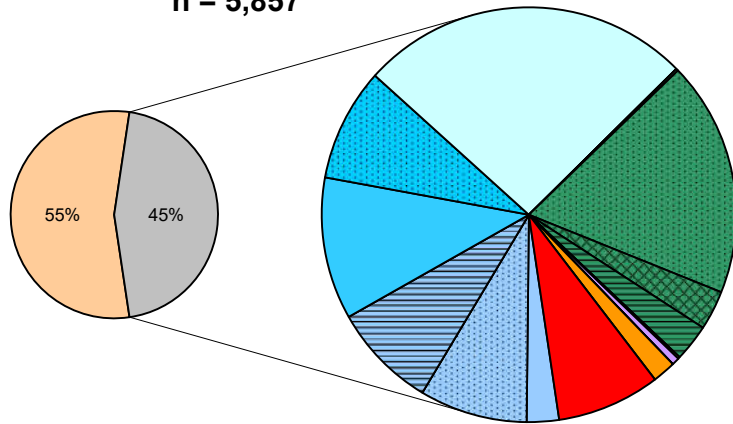
Fort Bragg Commercial
n = 9,281
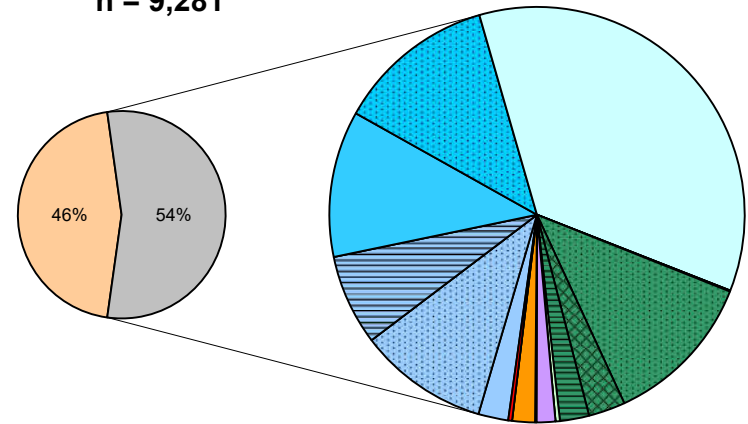
San Francisco Commercial
n = 158,392

Monterey Commercial
n = 97,959
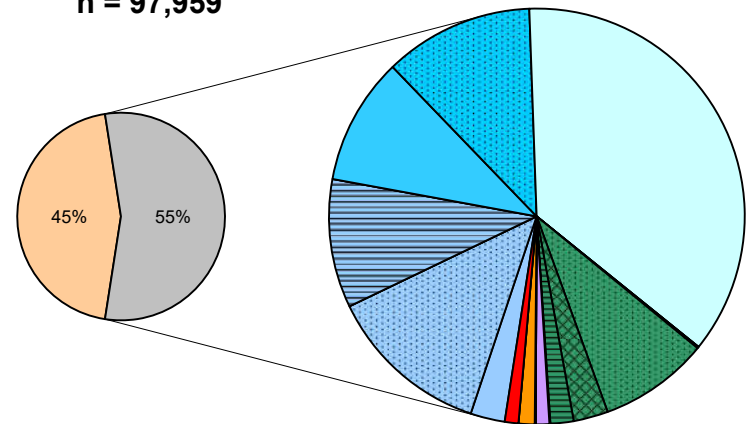
Legend: Natural, FRHF, FRHFn, FRHFgg, NIMF, NIMFn, CFHF, CFHFn, MOKF, MOKFn, MOKFnc, MOKFgg, MERF, MERFn, FRHS, SJOSx, SacW, CFHL, nonCV

Figure 19. Proportion of hatchery- and natural-origin salmon in the 2019 California ocean commercial fishery.
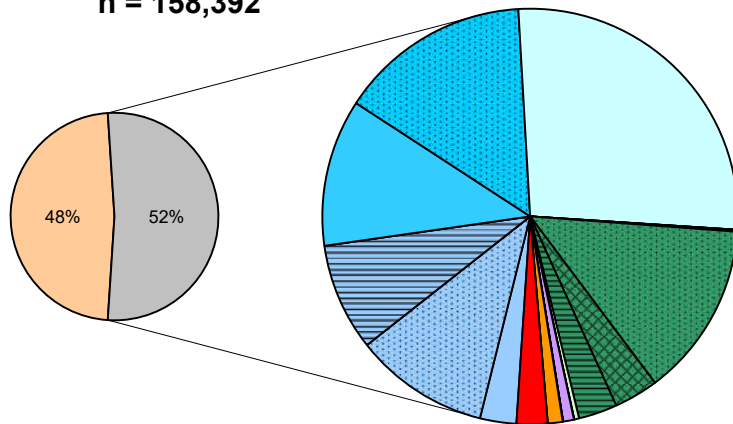
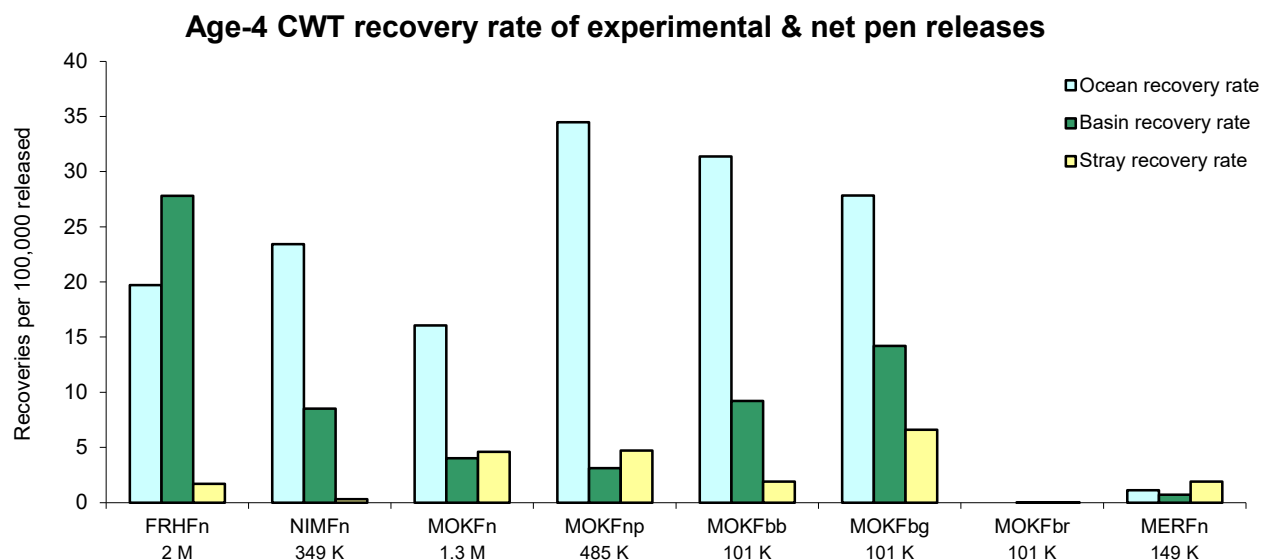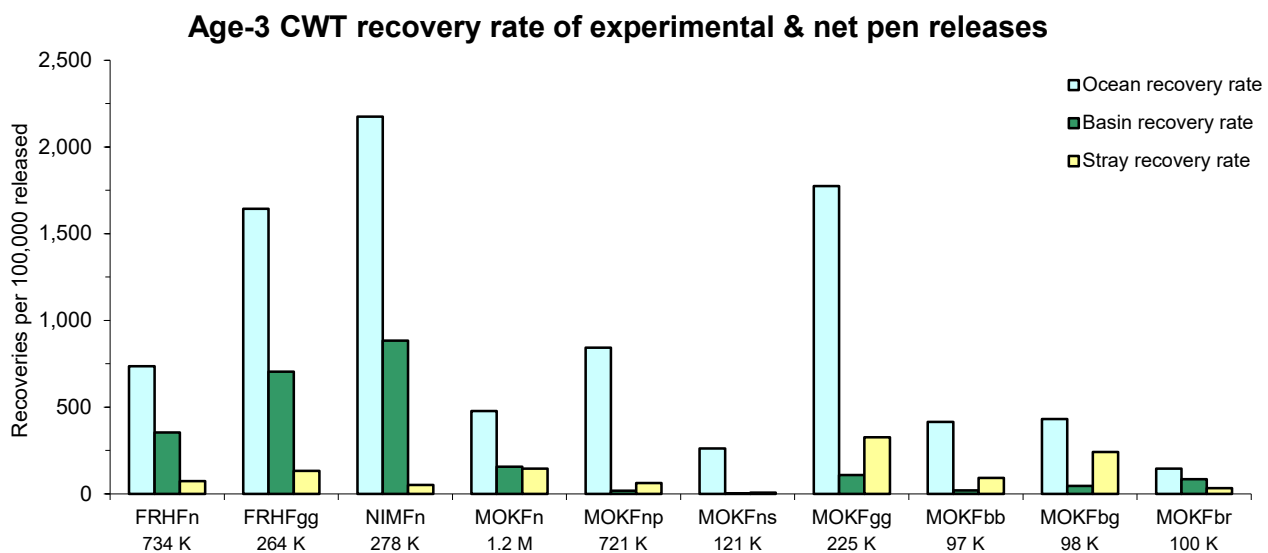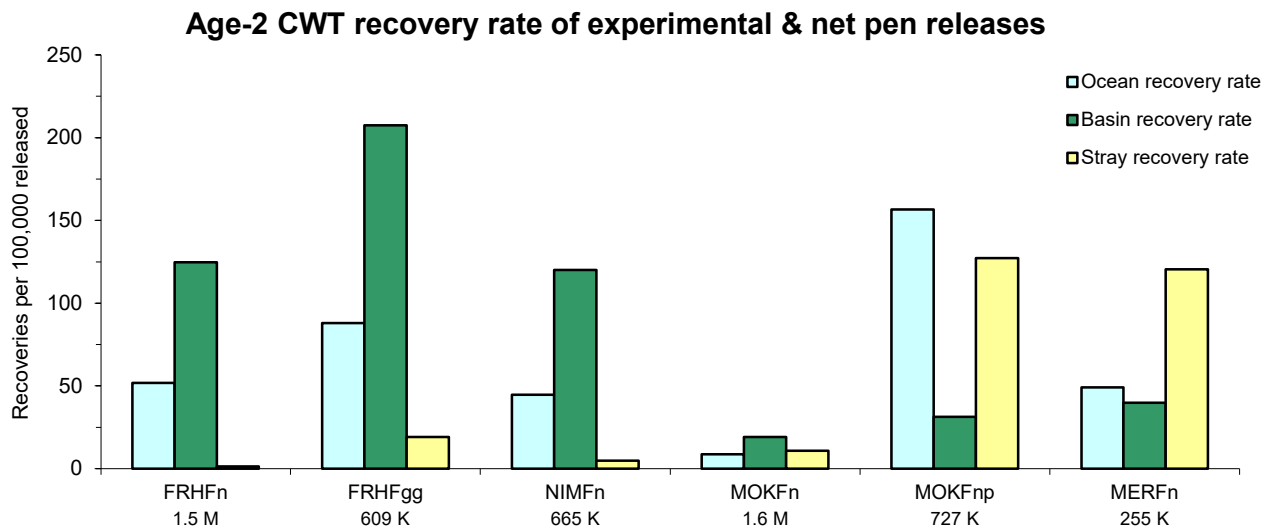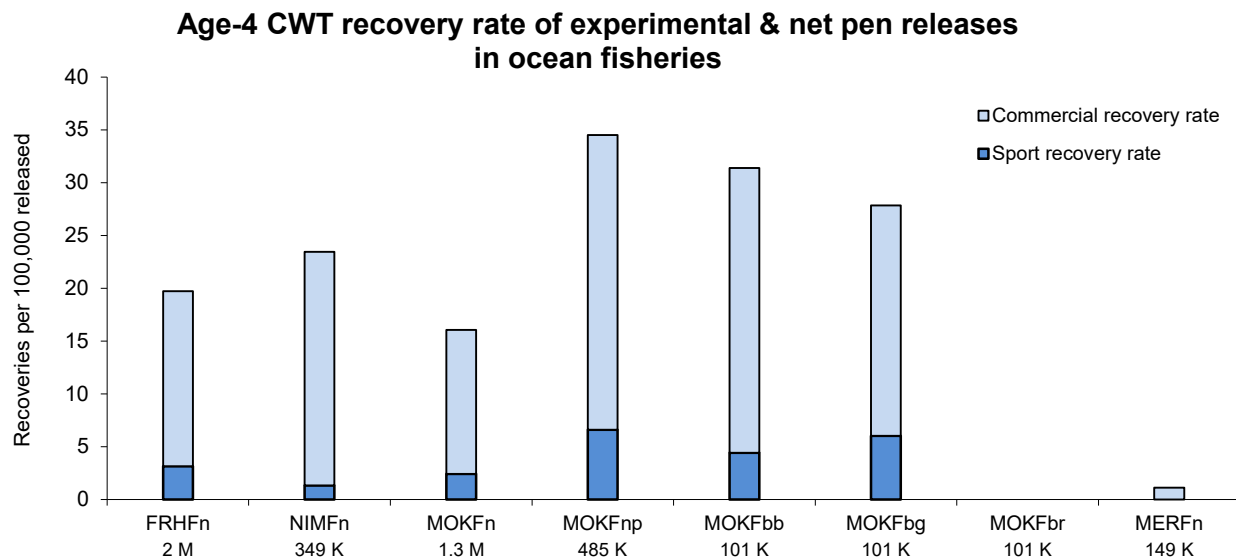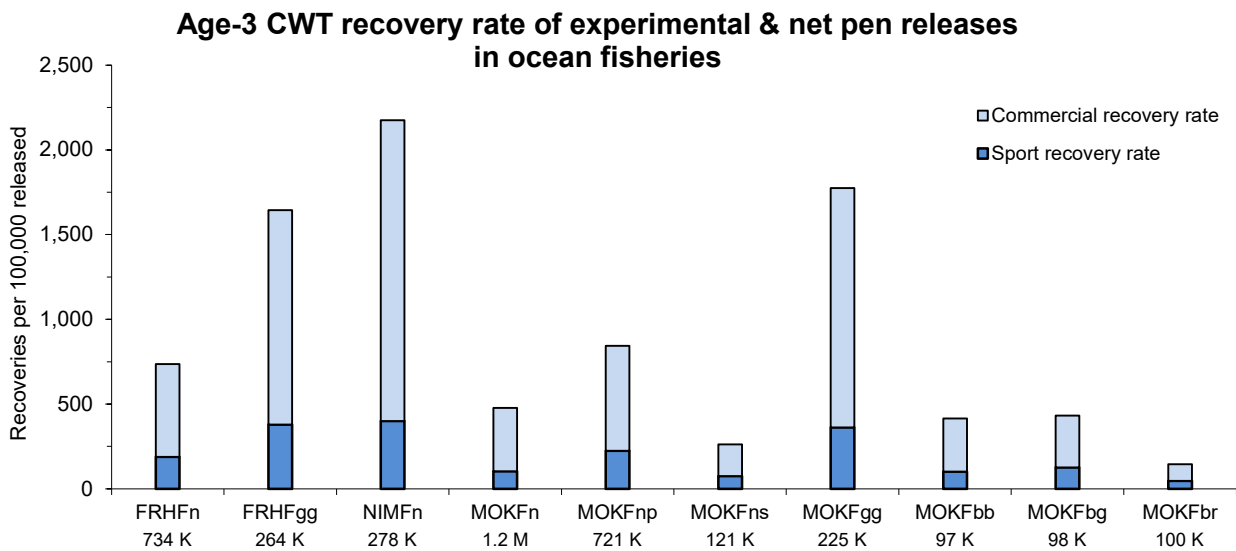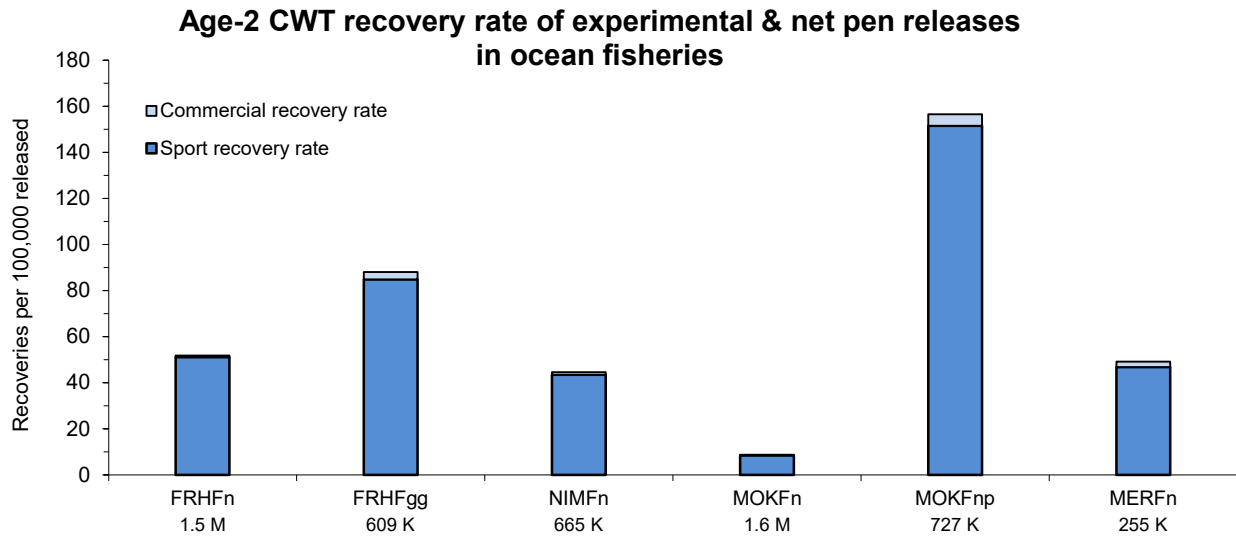Figure 20. CWT recovery rates of experimental and net pen releases by age in 2019.

Figure 21. CWT recovery rates of experimental and net pen releases in 2019 ocean sport and commercial fisheries.

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%		988	4.0%	17	17	14	14	**0.02**	**0.82**	24.76	3.69	1,281	5%
non-fresh 68%		2,101	8.6%	14	14	14	14	0.01	1.00				
total	**24,461**	3,089	12.6%	31	31	28	**28**			**12.38**	**3.69**	**1,281**	**5%**

Clear Creek 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 99%		521	9.1%	27	27	25	25	**0.05**	**0.93**	10.96	3.82	1,048	18%
non-fresh 1%		4	0.1%	3	3	3	3	0.75	1.00				
total	**5,712**	525	9.2%	30	30	28	28			**9.79**	**3.82**	**1,048**	**18%**

Mill Creek 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 93%		330	13.1%	34	34	33	33	**0.10**	**0.97**	7.65	4.03	1,017	40%
non-fresh 7%		26	1.0%	23	23	23	23	0.88	1.00				
total	**2,523**	356	14.1%	57	57	56	56			**4.51**	**4.03**	**1,017**	**40%**

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

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%		5,192	10.0%	1,071	1,062	989	986	**0.21**	**0.93**	10.12	2.32	23,183	45%
non-fresh													
total	**51,963**	5,192	10.0%	1,071	1,062	989	**986**			**10.12**	**2.32**	**23,183**	**45%**

Yuba River below Daguerre Point Dam fall-run Chinook salmon carcass survey (only fresh fish processed)

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 70%		64	9.4%	16	16	15	15	**0.25**	**0.94**	10.59	3.23	513	76%
non-fresh 30%		28		6									
total	**678**	92	13.6%	22	16	15	**15**			**10.59**	**3.23**	**513**	**76%**

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

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%		186	12.4%	35	35	33	33	**0.19**	**0.94**	8.09	3.06	818	54%
non-fresh													
total	**1,504**	186	12.4%	35	35	33	**33**			**8.09**	**3.06**	**818**	**54%**

Tuolumne 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 53%		331	35.6%	25	25	16	16	**0.08**	**0.64**	2.81	3.47	156	17%
non-fresh 47%		288	30.9%	12	12	11	11	0.04	0.92				
total	**931**	619	66.5%	37	37	27	**27**			**1.67**	**3.47**	**156**	**17%**

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

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%		342	15.5%	20	20	18	18	**0.06**	**0.90**	6.46	4.50	523	24%
non-fresh													
total	**2,211**	342	15.5%	20	20	18	**18**			**6.46**	**4.50**	**523**	**24%**

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 48%		1,461	18.6%	528	526	495	492	**0.36**	**0.94**	5.43	1.02	2,712	35%
non-fresh 52%		1,565	19.9%	430	423	390	386	0.27	0.92				
total	**7,853**	3,026	38.5%	958	949	885	**878**			**3.04**	**1.02**	**2,712**	**35%**

Upper San Joaquin River spring-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 11%		17	11.0%	16	16	16	15	**0.94**	**1.00**	9.73	1.00	146	94%
non-fresh 89%		138	89.0%	136	134	126	125	0.99	0.94				
total	**155**	155	100.0%	152	150	142	**140**			**1.04**	**1.00**	**146**	**94%**

Upper Sacramento River late-fall-run Chinook salmon carcass survey 2020

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 38%		135	10.8%	19	19	18	17	**0.14**	**0.95**	9.81	1.05	175	14%
non-fresh 62%		221	17.7%	26	26	25	25	0.12	0.96				
total	**1,251**	356	28.5%	45	45	43	**42**			**3.97**	**1.05**	**175**	**14%**

p_adc = proportion of sampled fish that were ad-clipped; $p\_cwt\|adc$ = proportion of ad-clipped fish containing CWTs

Appendix 2. Alternative 2019 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 CWT$_{samp}$	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[b]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	Up SJ	In-basin	Stray	CV total			In-basin	Stray	CV total	Ocean
CFHF	2017	Fall	1,369,512	547	25	34								547	59	606	10%	334	40	4	44	24
CFHL	2018	Late	881,364	63			1			1				63	2	65	3%	0	7	0.2	7	0
FRHF	2017	Fall	250,489				3							3	0	3	0%	0	1	0	1	0
FRHFn	2017	Fall	1,496,598				1,868		17	4				1,868	21	1,890	1%	775	125	1	126	52
FRHFgg	2017	Fall	609,272	2	12	29	1,264		55	9			9	1,264	117	1,381	8%	536	207	19	227	88
FRHS	2017	Spr	488,223				83							83	0	83	0%	196	17	0	17	40

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 CWT$_{samp}$	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[b]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	Up SJ	In-basin	Stray	CV total			In-basin	Stray	CV total	Ocean
CFHF	2016	Fall	3,020,565	7,116	186	431	69		4	8				7,116	697	7,813	9%	14,761	236	23	259	489
CFHL	2017	Late	1,047,211	2,270	46						8			2,270	54	2,324	2%	734	217	5	222	70
FRHF	2016	Fall	1,029,808	5			3,391	45	1	1				3,391	52	3,443	2%	5,571	329	5	334	541
FRHFn	2016	Fall	733,880	5	25	10	2,372	231	430	52	21		2	2,372	775	3,147	25%	5,405	323	106	429	737
FRHFgg	2016	Fall	263,611		25		1,781	73	239	47	21		18	1,781	423	2,204	19%	4,333	676	160	836	1,644
FRHS	2016	Spr	1,682,317		12	10	9,060	188						9,060	211	9,271	2%	2,046	539	13	551	122

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 CWT$_{samp}$	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks[b]	Fea	Yub	Ame	Mok	Sta/Tuo	Mer	Up SJ	In-basin	Stray	CV total			In-basin	Stray	CV total	Ocean
CFHF	2015	Fall	3,033,741	157	12									157	12	169	7%	126	5	0.4	6	4
CFHL	2016	Late	1,044,705	1,285	137									1,285	137	1,422	10%	1,502	123	13	136	144
FRHF	2015	Fall	246,501											0	0	0	-	0	0	0	0	0
FRHFn	2015	Fall	2,019,877		25		545	17	8	1				545	51	596	9%	398	27	3	30	20
FRHS	2015	Spr	2,109,278				412							412	0	412	0%	0	20	0	20	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.
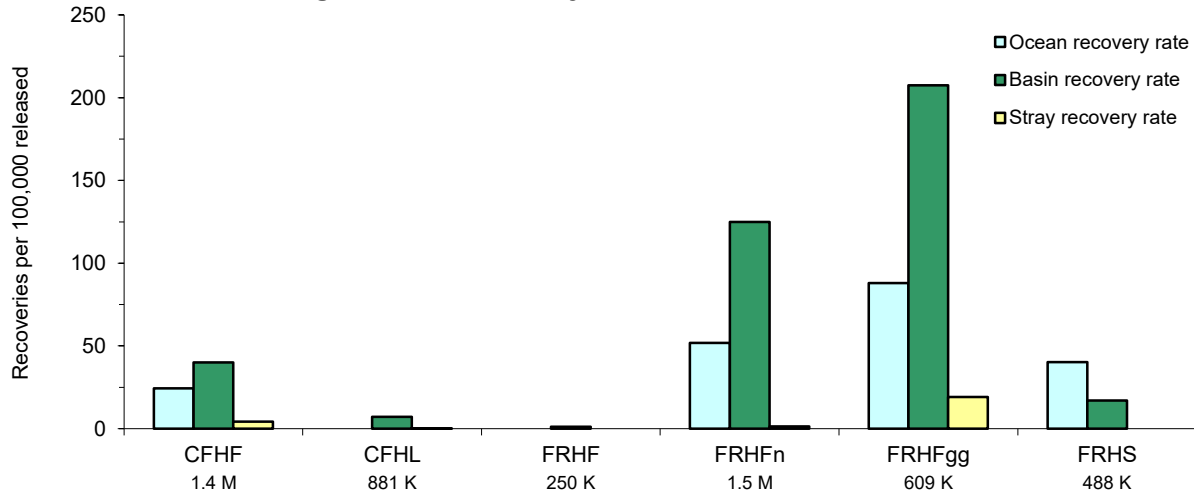
Sacramento River fall Chinook release types (SFC)
CFHF   Coleman National Fish Hatchery fall in-basin releases
FRHF   Feather River Hatchery fall in-basin releases
FRHFn   Feather River Hatchery fall bay/delta net pen releases
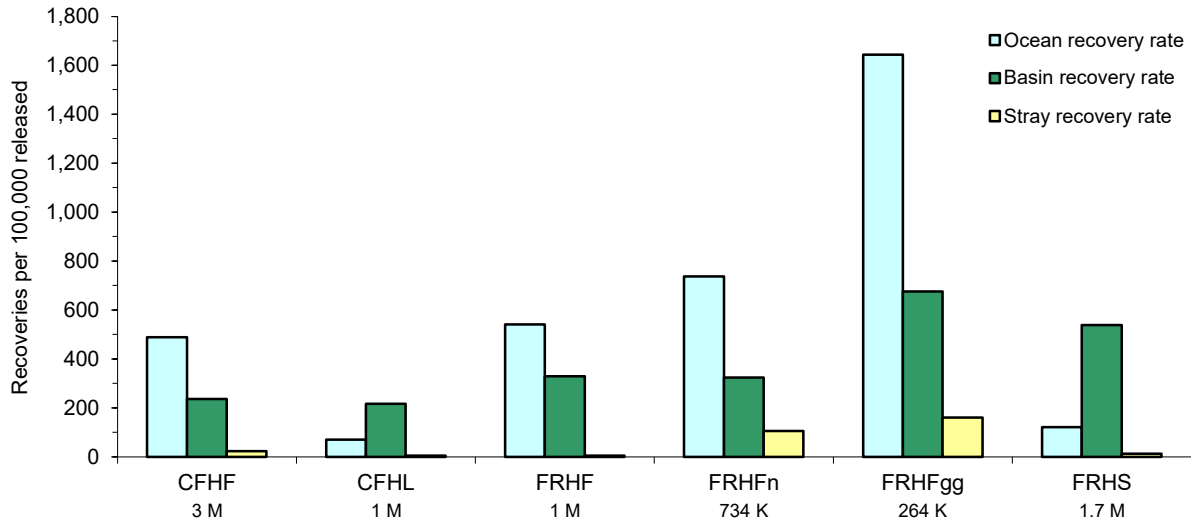FRHFgg   Feather River Hatchery fall Golden Gate releases (no net pens)

Other CV Chinook release types (OCV)
CFHL   Coleman National Fish Hatchery late-fall in-basin releases
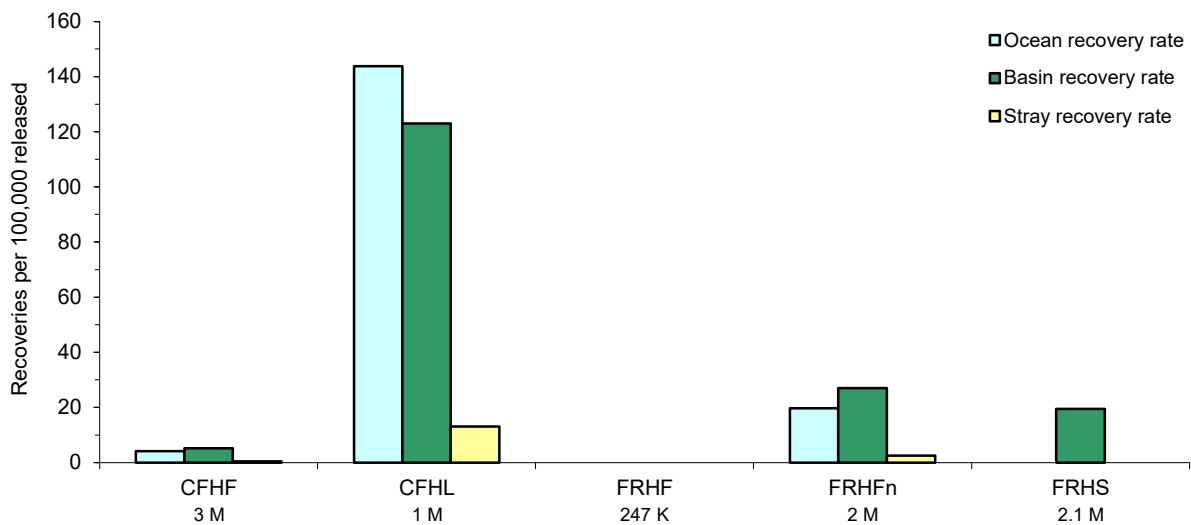FRHS   Feather River Hatchery spring in-basin releases

Appendix 3. Alternative CWT recovery rates for CFH and FRH releases by age in 2019.

Appendix 4. Comparison of raw CWT recoveries by release type between fish sampled in natural areas above and below the NIM weir in 2019.

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	0	-	0	-
SJOSx	Spring	0	-	0	-
CFHF	Fall	0	-	2	<1%
CFHFn	Fall	0	-	0	-
FRHF	Fall	0	-	0	-
FRHFn	Fall	158	8%	32	2%
FRHFgg	Fall	74	4%	34	2%
NIMF	Fall	316	15%	555	29%
NIMFn	Fall	481	23%	755	40%
MOKF	Fall	1	<1%	1	<1%
MOKFn	Fall	345	17%	276	14%
MOKFnc	Fall	406	20%	94	5%
MOKFgg	Fall	112	5%	110	6%
MOKFb	Fall	100	5%	28	1%
MERF	Fall	1	<1%	0	-
MERFn	Fall	81	4%	19	1%
MERFt	Fall	0	-	0	-
	Total	2,075		1,906	

Appendix 5. Sample expansion for CWTs recovered in the Yuba River above Daguerre Point Dam (DPD) in 2019.

Yuba River natural area escapement above DPD: Total video count 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
2,691	**2,582**	**96%**	**501**	**30**	**29**	**29**	0.194	0.967	17.41	2.65	1,338	50%
Video count			Video count		Carcass survey							

DPD video count	Total	% ad-clip
No clip	2,081	
Ad-clip	501	19.4%
Unknown clip	109	
Total	**2,691**	

Appendix 6. Sample expansion for CWTs recovered in the Mokelumne River above Woodbridge Dam (WD) in 2019.

	Total count	Total ad-clips	% ad-clip
Woodbridge Dam video	12,870	3,425	26.6%
Mokelumne River Hatchery return	8,503	2,386	28.1%
Mokelume River natural escapement	**4,367**	**1,039**	23.8%

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
4,367	4,367	100%	**1,039**	**126**	**119**	**119**	0.238	0.944	8.25	3.25	3,187	73%
Video count			Video count		Carcass survey							