

Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2016

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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 seventh annual report on the recovery of CFM CWTs in the CV and ocean fisheries. In 2016, approximately 31,000 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 ocean salmon commercial and sport fisheries south of Cape Falcon (i.e., California and Oregon).

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

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

Please see earlier annual CFM reports (Kormos et al. 2012, Palmer and Kormos 2013, 2015) for more in-depth information and discussion regarding the CFM program, CWT marking and recovery programs in California, and the methods and analyses used in this report. Additional information on salmon escapement monitoring can be found in the Central Valley Chinook Salmon Escapement Monitoring Plan (Bergman et al. 2012) and other CV salmon population reports (e.g., Killam et al. 2017).

DATA AND METHODS

Inland Escapement and River Sport Harvest Monitoring

During 2016, 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 2017 return year, however the escapement monitoring period began in late 2016.

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 2016 surveys on major rivers and in the hatcheries adequately sampled (sample rate $\geq 20\%$) 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.

There were almost 73,900 salmon sampled, 23,000 ad-clipped salmon observed, and approximately 22,900 heads 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, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service (FWS), and the Yuba Accord River Management Team (YARMT). Most heads were processed by CDFW at their Santa Rosa and Sacramento CWT labs, except for 2,500 heads collected at CFH, which were processed by FWS staff, and several hundred heads collected and processed by CDFW projects in Red Bluff and La Grange.

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 2016, California sport and commercial ocean salmon fisheries (Table 2) were more constrained compared to recent years primarily due to a decrease in the abundance of both Sacramento River winter-run and Klamath River fall-run Chinook salmon. CDFW field staff sampled 25,000 salmon and collected over 6,000 heads that were processed by the Santa Rosa CWT lab. An additional 3,400 heads collected in Oregon ocean sport and commercial fisheries during 2016 are also included in the analyses since Sacramento River fall Chinook is the primary stock harvested in fisheries south of Cape Falcon (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 2016 inland and ocean CWT recoveries are publicly available on the RMPC website at www.rmpec.org.

CWT Data Analysis

A “master” release database of CWT codes recovered in 2016 was created to determine species, brood year, run, stock origin (hatchery or natural), release site, release date(s), number of salmon CWT tagged, total number of salmon released, and any other pertinent release information (e.g., trucked, net pen acclimation, disease issues). Since almost all CV salmon recovered are between the ages of two and five, all CWT release data for Chinook salmon brood years (BY) 2011 through 2014 was downloaded from the RMPC. Approximately 133 million CV salmon were released for these brood years, of which 47 million were marked and tagged utilizing 409 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 2016, there were 244 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,

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

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

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

Sacramento River Basin Fall-run Chinook salmon release types

CFHFh	Coleman National Fish Hatchery F all-run h atchery releases (in-basin)
CFHFn	Coleman National Fish Hatchery F all-run bay/delta n et pen releases
FRHFb	Feather River Hatchery F all-run b arge study releases
FRHFk	Feather River Hatchery F all-run K naggs Ranch e xperimental releases
FRHFn	Feather River Hatchery F all-run bay n et pen releases (San Pablo Bay)
FRHFnc	Feather River Hatchery F all-run c oastal n et pen releases (Santa Cruz, Pillar Point)
FRHFtib	Feather River Hatchery F all-run T iburon net pen releases
NIMF	Nimbus Fish Hatchery F all-run in-basin releases
NIMFn	Nimbus Fish Hatchery F all-run bay n et pen releases (San Pablo Bay)

San Joaquin River Basin Fall-run Chinook salmon release types

MOKF	Mokelumne River Hatchery	Fall-run in-basin releases
MOKFb	Mokelumne River Hatchery	Fall-run barge study releases
MOKFn	Mokelumne River Hatchery	Fall-run bay/delta net pen releases
MOKFnc	Mokelumne River Hatchery	Fall-run coastal net pen releases (Santa Cruz)
MOKFx	Mokelumne River Hatchery	Fall-run experimental releases (raised Merced Hatchery)
MERFt	Merced River Hatchery	Fall-run trucked releases (Jersey Point)

Central Valley Spring-run Chinook salmon release types

FRHS	Feather River Hatchery	Spring-run in-basin releases
FRHSn	Feather River Hatchery	Spring-run bay net pen releases (San Pablo Bay)

Sacramento River Winter-run Chinook salmon release types

SacW	Sacramento River	Winter-run supplementation natural production releases (in-basin)
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Central Valley Late-fall Chinook salmon release types

CFHLh	Coleman National Fish Hatchery	Late-fall-run hatchery releases (in-basin)
CFHLe	Coleman National Fish Hatchery	Late-fall-run emergency releases (Balls Ferry)

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

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

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

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

Salmon sampled in CV carcass surveys are generally classified as ‘fresh’ or ‘non-fresh’ based on criteria such as condition of the eyes (clear vs. opaque) or gills (pink vs. grey). Often the ad-clipped (marked) status of a non-fresh (i.e., decayed) salmon cannot be determined due to the deteriorating condition of the carcass. While condition criteria are somewhat ambiguous and classification may vary among surveys, the ad-clip rate of fresh salmon sampled in 2016 was generally higher than the rate observed in non-fresh fish (Appendix 1). Fresh carcass heads also contained CWTs at a slightly higher rate

than heads collected from non-fresh fish. Furthermore, the sample sizes between fresh and non-fresh fish are usually very different with the number of non-fresh salmon sampled generally much greater than fresh salmon in surveys that collected both conditions.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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, Palmer-Zwahlen and Kormos 2013, 2015, Palmer-Zwahlen et al. 2018, 2019a, 2019b), basin-of-origin is defined as the drainage within which a particular hatchery is located. The CV is divided into five hatchery basins: upper Sacramento River (including Battle Creek), Feather River (including the Yuba River), American River, Mokelumne River, and Merced River. 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:

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

RESULTS

General overview of 2016 CV inland recoveries and California ocean harvest

All of the 22,400 valid CWTs recovered in the CV during 2016 were from CV Chinook salmon releases. Most CWTs were brood year 2012 through 2014 releases (Table 6). A relative few CWT recoveries (n=21) were removed from CFM analyses due to age (i.e., age-1 and age-6), wild fish designation (e.g., MokFw) and “Lake” landlocked releases (e.g., Oroville Lake). About 94% of all CWT_{total} were fall-run, followed by spring-run (4%), and late-fall-run (1%) salmon releases. Less than one percent of CWT_{total} were winter-run, all of which were collected in the upper Sacramento River winter-run carcass survey and the Keswick Dam Fish Trap, where natural winter-run fish are collected for broodstock purposes at Livingston Stone National Fish Hatchery. The majority of fall-run CWT_{total} recovered in the CV were age-3 (58%), age-2 (30%), and age-4 (13%) fish.

Most of the 5,800 valid CWT recoveries (age-6 removed) in the 2016 California ocean harvest were CV salmon releases belonging to brood years 2012 through 2014 (Table 7). Approximately 98% of all CWT_{total} in the ocean harvest were CV fall-run, followed by CV spring-run (1%), CV late-fall-run (0.2%), and CV winter-run (0.1%) salmon. The remaining one percent of California ocean CWT recoveries originated primarily from the Klamath-Trinity Basin and Smith River in northern California, Elk River in Oregon, and the Columbia River Basin. Most of the hatchery-origin fish in the California harvest were age-3 (72%) and age-2 (20%) fish.

Approximately two-thirds of the 3,200 valid CWT recoveries (age-6 removed) in the 2016 Oregon ocean harvest were CV salmon releases (Table 8). Approximately 77% of the CWT_{total} in the ocean harvest were CV fall-run salmon and 1% were CV spring-run. Non-CV stocks made up 23% of the CWT_{total} harvest with most originating from the Columbia River Basin, coastal streams in Oregon, and the Klamath-Trinity Basin. Most of the hatchery fish in the Oregon harvest were age-3 (64%) and age-4 (28%) fish.

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

Approximately 85,000 fall-run Chinook salmon returned to spawn in natural areas during 2016 (Table 9, Fig. 2) and the proportion of hatchery-origin salmon in those areas sampled varied throughout the CV. The lowest hatchery proportion occurred in Butte Creek (14%) while the highest proportion (88%) occurred in the Tuolumne River. It should be noted that the Battle Creek hatchery proportion is estimated using a surrogate since a carcass survey or CWT recovery program has not been conducted in this waterway since 2005. The hatchery contribution and CWT release type composition in the Battle Creek escapement is assumed equivalent to the hatchery fall-run return

sampled at CFH (K. Niemela, FWS, pers. comm.). Surrogate CWTs from MOK were also used for the natural escapement into the Mokelumne River since only a few carcasses were found due to high pulse flow events which occurred weekly from October 4th through December 7th (C. Del Real, EBMUD, pers. comm.). The second highest hatchery proportion occurred in the Feather River (86%). The total fall-run hatchery proportion for all natural areas sampled in the CV during 2016 was 71%.

The hatchery proportion of the 48,700 fall-run salmon returning to the five CV hatcheries and the Keswick Dam fish trap (KES) ranged from 79% to 96% (Table 9, Fig. 3). The fall-run hatchery proportion for all CV hatcheries combined was 91%. The spring-run return to FRH was almost entirely hatchery-origin fish (95%) while the late-fall-return to CFH was 100% hatchery-origin salmon.

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 (FRH) spring-run releases, Yellow = Sacramento River winter-run releases, and Orange = Central Valley (CFH) late-fall-run releases (Fig.4). Additionally, select patterns are used to designate different release types. All bay net pen releases contain black dots while coastal net pen releases are designated with a criss-cross pattern. Experimental barge study and non-acclimated trucked releases are designated with black horizontal stripes.

Upper Sacramento River Basin

At CFH, sampling of the fall-run return began in early October and continued through early December 2016 (Table 10). All ad-clipped salmon were sampled during the entire run. CFH began late-fall sampling three weeks after fall-run sampling ceased and continued through early-March 2017. Based solely on the run-timing above, 8,747 salmon returned to CFH during the “fall” run sampling period, and 1,442 salmon returned during the “late-fall” run period. However, based on the composition of CWT recoveries, FWS staff determined there was some overlap between runs, especially in late November through December. As a result, the final escapement was adjusted to 8,528 fall-run and 1,661 late-fall-run salmon. Due to low counts of fall-run salmon at CFH during early October and to promote genetic integrity, an additional 282 fall-run salmon (200 unmarked) were collected at the KES in the mainstem Sacramento River and transported to CFH as supplemental broodstock. In addition, 13 late-fall salmon (11 unmarked) were collected at the KES and transported to CFH for spawning to promote genetic integrity. An additional 48 late-fall salmon were trapped or counted via video at CFH after spawning operations ended in early-March.

Fall- and late-fall-run returns to CFH, along with fall spawners in Battle Creek, were predominantly hatchery-origin salmon. Natural spawners comprised most of the fall return in all other tributaries (Figs. 5, 6). Winter-run spawners in the upper Sacramento River were primarily natural-origin fish. The proportion of hatchery-origin fish (prevalent release type shown in parentheses) at each of the following locations was:

- Fall-run returns CFH: 83% (CFHFh)
- Late-fall-run returns CFH: 100% (CFHLh)
- Fall-run supplemental spawners KES: 79% (CFHFh)
- Late-fall-run supplemental spawners KES: 15% (CFHLh)
- Fall-run spawners Upper Sacramento River: 39% (CFHFh)
- Fall-run spawners Clear Creek: 26% (CFHFh, FRHFh)
- Fall-run spawners Battle Creek: 83% (CFHFh)
- Winter-run spawners Upper Sacramento River: 26% (SacW)

Butte Creek and Feather River Basin

Spring- and fall-run returns to FRH and spawners in the Feather River were predominantly hatchery-origin (Figs. 7, 8) while escapement to the Yuba River and Butte Creek was mostly natural-origin fish. Unlike previous years, the Yuba River escapement below and above Daguerre Point Dam (DPD) was combined in 2016 due to mechanical issues with the Vaki Riverwatcher (video weir) at DPD. The proportion of hatchery-origin fish (prevalent release type shown in parentheses) at each of the following locations was:

- Fall-run spawners Butte Creek: 14% (FRHFh)
- Spring-run returns FRH: 95% (FRHS, FRHSn)
- Fall-run returns FRH: 96% (FRHFh)
- Fall/spring-run spawners Feather River: 86% (FRHFh)
- Fall/spring-run spawners Yuba River: 39% (CFHFh)

American River Basin

Fall-run returns to NIM and spawners in the American River were predominantly of hatchery-origin (Fig. 9) while “washbacks” collected on the NIM weir were primarily natural-origin salmon. The proportion of hatchery-origin fish (prevalent release type shown in parentheses) at each of the following locations was:

- Fall-run returns NIM: 88% (NIMFh)
- Fall-run spawners American River: 84% (CFHFh, NIMFh)
- Fall-run returns NIM weir: 27% (CFHFh, NIMFh)

Mokelumne River Basin

Hatchery-origin salmon (Fig. 10) dominated fall-run returns to MOK. It should be noted that only a few carcasses were sampled due to weekly high pulse flows and surrogate CWTs from MOK were utilized to determine the composition of the hatchery proportion in the natural escapement (Appendix 4). The proportion of hatchery-origin fish (prevalent release type shown in parentheses) at each of the following locations was:

- Fall-run returns MOK: 90% (NIMFh, MOKFh)
- Fall-run spawners Mokelumne River: 81% (NIMFh, MOKFh)

Merced River and other San Joaquin Basin Tributaries

Hatchery-origin salmon dominated fall-run returns to MER and spawners in the Merced, Stanislaus, and Tuolumne rivers (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: 90% (MOKFn)
- Fall-run spawners Merced River: 77% (MOKFn)
- Fall-run spawners Stanislaus River: 75% (MOKFn)
- Fall-run spawners Tuolumne River: 88% (MOKFn)

2. Contribution of CV Release Types to Total Salmon Escapement

Approximately 77% of the 141,200 total salmon escapement to CV hatcheries and natural areas during 2016-2017 were hatchery-origin fish (Tables 9, 11). Of all hatchery release types, net pen releases contributed the most to total CV escapement: FRHFh (26%), CFHFh (12%), MOKFn (11%) and NIMFn (10%). Net pen CFHFh and MOKFn also had the highest stray numbers. About a third of all recoveries occurred outside their basin-of-origin and ranged from zero to 93 percent, depending on release type:

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

R _{type}	Run	CWT _{total}	% total	# Stray	% stray
CFHFh	Fall	7,899	6%	109	1%
CFHFh	Fall	16,725	12%	15,600	93%
FRHFk	Fall	20	<1%	1	5%
FRHFb	Fall	1,569	1%	13	1%
FRHFh	Fall	36,587	26%	1,470	4%
FRHFnc	Fall	6,153	4%	525	9%
NIMF	Fall	904	1%	0	0%
NIMFn	Fall	13,467	10%	4,194	31%
MOKF	Fall	265	<1%	187	71%
MOKFb	Fall	358	<1%	242	68%
MOKFn	Fall	14,948	11%	11,903	80%
MOKFnc	Fall	232	<1%	144	62%
MERFt	Fall	920	1%	770	84%
FRHS	Spring	2,595	2%	0	0%
FRHSn	Spring	3,470	2%	19	1%
SacW	Winter	472	<1%	0	0%
CFHLh	Late Fall	1,728	1%	20	1%
	Total	108,316	77%	35,201	32%

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

In 2016, approximately 83% of the 36,700 salmon harvested in the CV river sport fishery were hatchery-origin fish (Table 9; Figs. 12, 13). The proportion of hatchery-origin fish (prevalent release type shown in parentheses) in each of the following fisheries was:

- Upper Sacramento River fall-run harvest: 62% (CFHFh)
- Lower Sacramento River fall-run harvest: 79% (FRHF_n, NIMF_n)
- Feather River fall-run harvest: 84% (FRHF_n)
- American River fall-run harvest: 87% (CFHF_n)
- Mokelumne River fall-run harvest: 100% (MOKF_n, NIMF_n)
- Upper Sacramento River late-fall-run harvest: 56% (CFHLh)

It should be noted that the sample expansion factor, F_{samp} , for the Mokelumne River fall-run harvest had to be artificially reduced from 20.12 to 17.58 to prevent the calculated hatchery component from exceeding the total harvest (originally 114%). Of all hatchery release types, CFHF_n contributed the most (35%) to the total CV sport harvest, followed by FRHF_n (17%) and NIMF_n (16%). (Tables 9, 11).

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

R _{type}	Run	CWT _{total}	% harvest
CFHFh	Fall	1,931	5%
CFHF _n	Fall	13,002	35%
FRHFk	Fall	0	0%
FRHFb	Fall	224	1%
FRHF _n	Fall	6,343	17%
FRHF _{nc}	Fall	1,037	3%
NIMF	Fall	127	<1%
NIMF _n	Fall	5,779	16%
MOKF	Fall	0	0%
MOKFb	Fall	65	0%
MOKF _n	Fall	1,450	4%
MOKF _{nc}	Fall	131	<1%
MERFt	Fall	140	<1%
FRHS	Spring	16	0%
FRHS _n	Spring	114	<1%
SacW	Winter	0	0%
CFHLh	Late Fall	73	0%
	Total	30,430	83%

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 2012 through 2014 brood year releases were more consistent than release types analyzed in earlier CFM reports (Kormos et. al. 2012, Palmer-Zwahlen and Kormos 2013, 2015) and only a few “mixed strategy” releases were identified (Table 3).

Table 12 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 2016. 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 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 acclimated in bay and coastal net pens generally had higher CV recovery rates than their respective in-basin or trucked-only releases, but net pen and trucked release types also had higher stray proportions than their in-basin sibling (i.e., same hatchery, run and brood year) in most cases.

Age-2 CV Escapement Recovery and Stray Rates

R_{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
CFHF _n	2014	Fall	45	44	97%
FRHF _k	2014	Fall	22	0	0%
FRHF _n	2014	Fall	189	12	6%
FRHF _{nc}	2014	Fall	475	59	13%
NIMF _n	2014	Fall	128	57	45%
MOKF _n	2014	Fall	153	120	78%
MOKF _{nc}	2014	Fall	60	34	57%
MOKF _x	2014	Fall	45	28	63%
MERF _t	2014	Fall	60	42	70%
FRHS	2014	Spring	1	0	0%
SacW	2014	Winter	52	0	0%
CFHL _h	2015	Late Fall	59	4	7%

Age-3 CV Escapement Recovery and Stray Rates

R _{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
CFHFh	2013	Fall	121	2	2%
CFHFh	2013	Fall	157	144	91%
FRHFk	2013	Fall	14	2	17%
FRHFb	2013	Fall	307	1	<1%
FRHFh	2013	Fall	350	8	2%
FRHFnc	2013	Fall	1,216	86	7%
NIMFh	2013	Fall	218	51	24%
MOKFb	2013	Fall	118	80	68%
MOKFh	2013	Fall	122	102	84%
MOKFnc	2013	Fall	37	27	72%
MERFt	2013	Fall	14	13	94%
FRHS	2013	Spring	145	0	0%
FRHSn	2013	Spring	189	1	<1%
SacW	2013	Winter	73	0	0%
CFHLh	2014	Late Fall	116	0	0%

Age-4 CV Escapement Recovery and Stray Rates

R _{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
CFHFh	2012	Fall	21	1	<1%
FRHFk	2012	Fall	3	0	0%
FRHFb	2012	Fall	216	4	2%
FRHFh	2012	Fall	131	8	6%
FRHFnc	2012	Fall	13	1	11%
NIMF	2012	Fall	27	0	0%
NIMFh	2012	Fall	82	13	16%
MOKF	2012	Fall	13	0	0%
MOKFh	2012	Fall	33	23	70%
MERFt	2012	Fall	34	30	88%
FRHS	2012	Spring	70	0	0%
FRHSn	2012	Spring	151	1	<1%
SacW	2012	Winter	9	0	0%
CFHLh	2013	Late Fall	16	0	0%

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

The total recovery rate of CV hatchery releases in all California and Oregon ocean salmon sport and commercial fisheries varied by age and release type (Table 12). A higher percentage of age-2 CV hatchery salmon were recovered in the ocean sport fishery (Fig. 16), most likely due to the smaller size limits in effect during 2016 compared to those for the commercial fishery (Table 2).

Age-2 Total Ocean Harvest Recovery Rate; percent taken in sport fishery

R _{type}	Brood year	Run	# Recoveries per 100K Released	% sport
CFHF _n	2014	Fall	28	81%
FRHF _k	2014	Fall	0	0%
FRHF _n	2014	Fall	60	88%
FRHF _{nc}	2014	Fall	327	86%
NIMF _n	2014	Fall	52	84%
MOKF _n	2014	Fall	67	83%
MOKF _{nc}	2014	Fall	135	83%
MOKF _x	2014	Fall	15	55%
MERF _t	2014	Fall	9	100%
FRHS	2014	Spring	0	0%
SacW	2015	Winter	0	0%
CFHL _h	2015	Late Fall	1	100%

Age-3 Total Ocean Harvest Recovery Rate; percent taken in sport fishery

R _{type}	Brood year	Run	# Recoveries per 100K Released	% sport
CFHF _h	2013	Fall	62	29%
CFHF _n	2013	Fall	289	30%
FRHF _k	2013	Fall	7	0%
FRHF _b	2013	Fall	152	25%
FRHF _n	2013	Fall	200	28%
FRHF _{nc}	2013	Fall	1,176	32%
NIMF _n	2013	Fall	228	25%
MOKF _b	2013	Fall	299	28%
MOKF _n	2013	Fall	126	26%
MOKF _{nc}	2013	Fall	733	25%
MERF _t	2013	Fall	11	31%
FRHS	2013	Spring	18	58%
FRHS _n	2013	Spring	26	48%
SacW	2014	Winter	9	59%
CFHL _h	2014	Late Fall	8	35%

Age-4 Total Ocean Harvest Recovery Rate; percent taken in sport fishery

R _{type}	Brood year	Run	# Recoveries per 100K Released	% sport
CFHFh	2012	Fall	9	22%
FRHFk	2012	Fall	0	0%
FRHFb	2012	Fall	59	23%
FRHF _n	2012	Fall	57	19%
FRHF _{nc}	2012	Fall	33	18%
NIMF	2012	Fall	17	7%
NIMF _n	2012	Fall	61	18%
MOKF	2012	Fall	6	100%
MOKF _n	2012	Fall	35	14%
MERF _t	2012	Fall	23	15%
FRHS	2012	Spring	7	26%
FRHS _n	2012	Spring	11	52%
SacW	2013	Winter	1	0%
CFHLh	2013	Late Fall	4	17%

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

Almost two-thirds of the 136,500 Chinook salmon harvested in all California and Oregon ocean salmon fisheries were hatchery-origin fish (Fig. 17). Most of the recoveries in both states were net pen releases of fall-run salmon from the CV.

Hatchery-origin contribution by R_{type} to total CA and OR Ocean Harvest

R _{type}	Run	CWT _{total}	% harvest
CFHFh	Fall	3,953	3%
CFHF _n	Fall	24,326	18%
FRHFk	Fall	3	<1%
FRHFb	Fall	636	<1%
FRHF _n	Fall	17,825	13%
FRHF _{nc}	Fall	5,654	4%
NIMF	Fall	559	<1%
NIMF _n	Fall	10,691	8%
MOKF	Fall	86	<1%
MOKFb	Fall	906	1%
MOKF _n	Fall	10,967	8%
MOKF _{nc}	Fall	2,102	2%
MERF _t	Fall	545	<1%
Other CV	Non-fall	884	1%
NonCV		5,544	4%
	Total	84,680	62%

California ocean sport fishery

California anglers harvested over 38,000 Chinook salmon in the ocean sport fishery during 2016. The total contribution of hatchery-origin salmon to the California ocean sport fishery was 75%, ranging from 59% to 80% of the total harvest among major port area (Fig. 18). Most of the harvest occurred in San Francisco (70%), followed by Fort Bragg (13%), Eureka-Crescent City (13%) and Monterey (4%) port areas (Table 13).

Of all hatchery release types, CFHF_n contributed the most (23%) to the total California ocean sport harvest, followed by FRHF_n (16%), MOKF_n (11%), and NIMF_n (10%). Non-CV releases contributed less than one percent to the total harvest (Table 14).

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

R _{type}	Run	CWT _{total}	% harvest
CFHF _h	Fall	1,026	3%
CFHF _n	Fall	8,864	23%
FRHF _k	Fall	0	0%
FRHF _b	Fall	154	<1%
FRHF _n	Fall	6,111	16%
FRHF _{nc}	Fall	2,334	6%
NIMF	Fall	51	<1%
NIMF _n	Fall	3,847	10%
MOKF	Fall	51	<1%
MOKF _b	Fall	252	1%
MOKF _n	Fall	4,303	11%
MOKF _{nc}	Fall	696	2%
MERF _t	Fall	133	<1%
FRHS	Spring	149	<1%
FRHS _n	Spring	183	<1%
SacW	Winter	31	<1%
CFHL _h	Late Fall	45	<1%
NonCV		183	<1%
	Total	28,412	75%

California ocean commercial fishery

California trollers harvested over 55,000 Chinook salmon in the ocean commercial fishery during 2016. The total contribution of hatchery-origin salmon to the California ocean commercial fishery was 63%, ranging from 53% to 74% of the total harvest, depending on major port area (Fig. 19). Most of the harvest occurred in San Francisco (48%), followed by Fort Bragg (28%), Monterey (24%) and Eureka-Crescent City (<1%) port areas (Table 15).

Of all hatchery release types, CFHF_n contributed the most (19%) to the total California commercial harvest, followed by FRHF_n (15%), NIMF_n (8%) and MOKF_n (7%). Non-CV releases contributed about one percent to the total harvest (Table 16).

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

R _{type}	Run	CWT _{total}	% harvest
CFHF _h	Fall	2,137	4%
CFHF _n	Fall	10,632	19%
FRHF _k	Fall	3	<1%
FRHF _b	Fall	301	1%
FRHF _n	Fall	8,008	15%
FRHF _{nc}	Fall	2,544	5%
NIMF	Fall	170	<1%
NIMF _n	Fall	4,681	8%
MOKF	Fall	35	<1%
MOKF _b	Fall	376	1%
MOKF _n	Fall	3,990	7%
MOKF _{nc}	Fall	1,018	2%
MERF _t	Fall	222	<1%
FRHS	Spring	97	<1%
FRHS _n	Spring	143	<1%
SacW	Winter	24	<1%
CFHL _h	Late Fall	92	<1%
NonCV		443	1%
	Total	34,916	63%

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

In 2016, CWTs from several experimental and net pen release types were recovered in the CV escapement, river sport fishery and ocean harvest. These include experimental barge studies that utilized approximately 300,000 fall-run salmon from two different hatcheries (FRH and MOK), rice field releases at Knaggs Ranch, and coastal net pen releases in Pillar Point, operated by Coastside Fishing Club, and Santa Cruz, operated by the Monterey Bay Trout and Salmon Project (MBTSP). However, in 2015, MBTSP moved their net pen operations to Moss Landing due to operational issues with the Santa Cruz Port District. After receiving and releasing their first group of BY 2014 fall-run salmon from MOK (120,000 salmon), it was determined that MBTSP did not have the proper permits to release salmon in the Moss Landing area and thus, the remaining 120,000 fish from MOK with the same CWT code were instead released into bay net pens near Mare Island.

The experimental and net pen releases recovered in 2016 are differentiated into the following release types:

- FRHFbb Feather River Hatchery **F**all-run **b**arge study: trucked and released in SF **b**ay
- FRHFbg Feather River Hatchery **F**all-run **b**arge study: barged to SF Bay and released
- FRHFbr Feather River Hatchery **F**all-run **b**arge study: released in-river (Sac R)

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

- FRHFnp Feather River Hatchery **F**all-run net pen coastal releases – **P**illar Point
- FRHFns Feather River Hatchery **F**all-run net pen coastal releases – **S**anta Cruz

- 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: barged to SF Bay and released
- MOKFbr Mokelumne River Hatchery **F**all-run **b**arge study: released in-river (Mok R)

- MOKFns Mokelumne River Hatchery **F**all-run net pen coastal releases – **S**anta Cruz

- MOKFx Mokelumne River Hatchery **F**all-run **e**xperimental: raised at Merced Hatchery

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 17, Fig. 20).

Age-2 CV Escapement Recovery and Stray Rates

R _{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
CFHFn	2014	Fall	45	44	97%
FRHFkr	2014	Fall	22	0	0%
FRHFn	2014	Fall	189	12	6%
FRHFnp	2014	Fall	474	59	13%
NIMFn	2014	Fall	128	57	45%
MOKFn	2014	Fall	153	120	78%
MOKFns	2014	Fall	60	34	57%
MOKFx	2014	Fall	45	28	63%

Age-3 CV Escapement Recovery and Stray Rates

R _{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
CFHF _n	2013	Fall	157	144	91%
FRHF _{bb}	2013	Fall	340	2	1%
FRHF _{bg}	2013	Fall	298	0	0%
FRHF _{br}	2013	Fall	282	0	0%
FRHF _{kr}	2013	Fall	13	2	17%
FRHF _n	2013	Fall	350	8	2%
FRHF _{np}	2013	Fall	1,216	86	7%
NIMF _n	2013	Fall	218	51	24%
MOKF _{bb}	2013	Fall	97	81	83%
MOKF _{bg}	2013	Fall	255	157	62%
MOKF _{br}	2013	Fall	0	0	-
MOKF _n	2013	Fall	121	102	84%
MOKF _{ns}	2013	Fall	38	27	72%

Age-4 CV Escapement Recovery and Stray Rates

R _{type}	Brood year	Run	# Recoveries per 100K Released	# Strays per 100K Released	% stray
FRHF _{bb}	2012	Fall	351	10	3%
FRHF _{bg}	2012	Fall	291	1	<1%
FRHF _{br}	2012	Fall	1	0	0%
FRHF _{kc}	2012	Fall	6	0	0%
FRHF _{kr}	2012	Fall	1	0	0%
FRHF _n	2012	Fall	131	8	6%
FRHF _{np}	2012	Fall	16	2	14%
FRHF _{ns}	2012	Fall	6	0	0%
NIMF _n	2012	Fall	82	13	16%
MOKF _n	2012	Fall	33	23	70%

Ocean Fishery Harvest

The total recovery rate of fall-run experimental and net pen releases in all California and Oregon ocean salmon sport and commercial fisheries varied by age and release type (Table 17, Fig. 21). A higher percentage of age-2 releases were recovered in the ocean sport fishery, again due to smaller size limits in effect during 2016 compared to the commercial fishery (Table 2).

Age-2 Ocean Harvest Recovery Rate; percent taken in sport fishery

R _{type}	Brood year	Run	# Recoveries per 100K Released	% sport
CFHF _n	2014	Fall	28	81%
FRHF _{kr}	2014	Fall	0	-
FRHF _n	2014	Fall	60	88%
FRHF _{np}	2014	Fall	327	86%
NIMF _n	2014	Fall	52	84%
MOKF _n	2014	Fall	67	83%
MOKF _{ns}	2014	Fall	135	83%
MOKF _x	2014	Fall	15	55%

Age-3 Ocean Harvest Recovery Rate; percent taken in sport fishery

R _{type}	Brood year	Run	# Recoveries per 100K Released	% sport
CFHF _n	2013	Fall	289	30%
FRHF _{bb}	2013	Fall	176	19%
FRHF _{bg}	2013	Fall	136	27%
FRHF _{br}	2013	Fall	145	31%
FRHF _{kr}	2013	Fall	7	0%
FRHF _n	2013	Fall	200	28%
FRHF _{np}	2013	Fall	1,177	32%
NIMF _n	2013	Fall	228	25%
MOKF _{bb}	2013	Fall	437	27%
MOKF _{bg}	2013	Fall	457	28%
MOKF _{br}	2013	Fall	0	-
MOKF _n	2013	Fall	126	26%
MOKF _{ns}	2013	Fall	733	25%

Age-4 Ocean Harvest Recovery Rate; percent taken in sport fishery

R _{type}	Brood year	Run	# Recoveries per 100K Released	% sport
FRHFbb	2012	Fall	84	33%
FRHFbg	2012	Fall	88	16%
FRHFbr	2012	Fall	4	0%
FRHFkc	2012	Fall	0	-
FRHFkr	2012	Fall	0	-
FRHFfn	2012	Fall	57	19%
FRHFnp	2012	Fall	28	15%
FRHFns	2012	Fall	43	20%
NIMFn	2012	Fall	61	18%
MOKFn	2012	Fall	35	14%

2016 CFM ANALYSES KEY POINTS

- During 2012 through 2016, California experienced one of its most intense droughts. In fact, the 2012 through 2014 period was the driest in the State's history. On January 17, 2014, California's Governor Brown declared a state of emergency due to the extreme drought which gripped most of the state at the time. As a result, state hatchery managers in the CV began transporting and releasing most of their fall-run salmon production, including brood years 2013 and 2014, into San Pablo Bay and the Delta utilizing net pens to improve survival. Federal hatchery managers at Coleman National Fish Hatchery (CFH), who historically released all of their fall-run production directly into Battle Creek at CFH (approximately 11-12 million salmon annually), also transported and released two-thirds of brood year 2013 and all of their brood year 2014 into Bay/Delta net pens.
- All brood years covered in this report were affected as juvenile outmigrants or returning adult spawners during this drought. Dewatering of eggs and/or preemergent fry loss was reported by numerous CV projects during this period, especially when minimum flow requirements were reduced in late fall. Pre-spawn mortality rates were also above normal in many rivers and streams, combined with reports of adult spawners dying prior to reaching their natal streams. Stray rates may also have been exacerbated by low and differential flows in some cases. Stray rates for some release types were notably higher in 2016 than in previous years.
- In fall 2014, low spawner returns to Merced Fish Hatchery (MER) required the use of supplemental fall-run eggs from Mokelumne Fish Hatchery (MOK) to ensure minimum hatchery production numbers were met. These fish were designated experimental MOKFx and recovery of these age-2 CWTs in either the Mokelumne or Merced river were considered in-basin for this report.

- Approximately three-fourths of the total 2016-2017 CV salmon escapement (all run-types) were hatchery-origin fish. Net pen FRHF_n, CFHF_n, MOKF_n and NIMF_n contributed the most to total CV escapement. Almost all (93%) of the CFHF_n recoveries in the CV were recovered out-of-basin. Trucked MERF_t, along with all in-basin and offsite MOKF releases, strayed more than half the time.
- Salmon escapement into CV hatcheries was predominately hatchery-origin fish. Most of the hatchery-origin fish returning to hatcheries in the Sacramento River Basin were comprised primarily of their respective releases. This was not the case for hatcheries in the San Joaquin River Basin where releases from other hatcheries comprised most of the return at Merced River Hatchery (85%) and Mokelumne River Hatchery (50%).
- Rivers and creeks with hatchery installations generally had the highest proportions of hatchery-origin spawners in natural areas. Most of the hatchery proportion in the Upper Sacramento River and Feather River basins consisted of release types from their respective hatcheries whereas hatchery-origin spawners in the natural escapement of the American, Mokelumne and Merced rivers were predominantly net pen releases from other hatcheries. It should be noted, however, that surrogate CWTs from CFH and MOK were used for both Battle Creek and Mokelumne River natural escapement, respectively.
- Fall-run escapement into the Upper Sacramento River and the few tributaries sampled in this area was predominantly natural-origin salmon; however, many of the natural creeks were not sampled for CWT recovery in 2016 due to drought conditions (e.g., low or non-existent flows). In-basin CFHF_n and net pen CFHF_n and FRHF_n were the hatchery release types most often observed above Red Bluff Diversion Dam.
- Sampling of the fall-run escapement into the Yuba River above and below the Daguerre Point Dam was combined for the first time since 2011 due to mechanical issues with the Vaki Riverwatcher video monitoring system. The return was found to be primarily natural-origin salmon with net pen CFHF_n and FRHF_n the predominant hatchery-origin release type recovered.
- Fall-run escapement in the Feather River was predominantly hatchery-origin salmon, primarily net pen FRHF_n and CFHF_n, along with coastal net pen FRHF_{nc} (Pillar Point) releases.
- Fall-run escapement in the American River was predominantly hatchery-origin salmon, primarily net pen CFHF_n and NIMF_n releases.
- Fall-run escapement in the Mokelumne River was predominately hatchery-origin salmon, primarily net pen NIMF_n and MOKF_n releases; however, it should be noted that CWTs recovered at MOK were used as surrogates for natural escapement.
- All sampled tributaries of the San Joaquin Basin south of the Mokelumne River (Stanislaus, Tuolumne and Merced rivers) were predominantly hatchery-origin salmon

with the vast majority being net pen MOKFn releases. More than a thousand CFHFn were also recovered, along with several hundred NIMFn, MERFt and FRHFn releases.

- For age-2 fall-run salmon, coastal net pen FRHFnc and bay net pen FRHFn, MOKFn and NIMFn releases had the highest CV escapement recovery rates for their cohort. Bay net pen CFHFn and MOKFn, along with trucked MERFt, had the highest stray proportions among age-2 releases.
- For age-3 fall-run salmon, coastal net pen FRHFnc, along with bay net pen FRHFn and all three barge study FRHFb releases, had the highest CV escapement recovery rates for their cohort. Trucked MERFt and net pen CFHFn had the highest stray proportions observed for age-3 release types.
- For age-4 fall-run salmon, barge study FRHFb and net pen FRHFn had the highest CV escapement recovery rates for their cohort. Trucked MERFt and net pen MOKFn had the highest stray proportions observed for age-4 release types.
- Most (83%) of the total CV river sport harvest was hatchery-origin fish predominantly comprised of net pen releases (CFHFn, FRHFn, NIMFn) and in-basin CFHFh. More than three-fourths of CFHFn recoveries occurred in the Feather and American river fisheries. A few hundred CFHFn were also picked up in the Mokelumne River fishery.
- Approximately three-fourths and two-thirds of the California ocean sport and commercial harvest, respectively, was comprised of hatchery-origin fish. Net pen releases, including CFHFn, FRHFn, NIMFn and MOKFn, contributed heavily to the total harvest in both fisheries.
- Coastal net pen FRHFnc and MOKFnc releases had the highest ocean recovery rates among all release types and most broods. Their recovery rates for age-2 and age-3 were several times greater than rates for other net pen releases of the same cohort.
- Pillar Point coastal net pen FRHFnp releases had both the highest CV and ocean recovery rates whereas relatively few Santa Cruz coastal net pen MOKFns releases were recovered in the CV. Most of the FRHFnp recoveries occurred in the Feather River Basin whereas the majority of MOKFns strayed into non-natal basins.
- Among age-3 barge study releases, salmon released as part of the Feather River barge study (FRHFbb, FRHFbg, and FRHFbr) had the highest CV recovery rates with minimal straying. Salmon released as part of the Mokelumne River barge study (MOKFbb, MOKFbg, and MOKFbr) had lower CV recovery rates and strayed more throughout the CV. Barged MOKFbg and bay release MOKFbb had the highest ocean recovery rates for this release strategy but no recoveries of the in-river MOKFbr release occurred in the ocean fisheries or CV, suggesting low outmigrant survival for this release type.
- Among age-4 releases, salmon transported via barge (FRHFbg) or trucked and released (FRHFbb) into San Francisco Bay had the highest CV and ocean recovery

rates for this cohort. Recoveries of age-4 salmon released in-river (FRHFbr) as part of this study were minimal.

- It should be noted that all of the brood year 2014 spring-run production (1.7 million fish) from Feather River Hatchery (FRH) was released in-basin instead of being split between in-basin and net pen releases which had been the standard protocol at FRH since the early 2000s. Past analyses of previous broods have shown comparable recovery rates for in-basin and bay releases. With minimal recoveries of this age-2 release throughout the CV (n=14) and in the ocean fisheries (n=3), low outmigrant survival is suspected at this time.

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 six 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 2016. It is highly probable that all of the release types and broods in this report were affected by one of the most significant droughts in California history. Although no discussion section is included, as in earlier CFM reports covering the 2010, 2011 and 2012 escapement and harvest years, the authors plan to further analyze these data as these and additional tagged broods become complete. This report contains the data and analyses needed to determine the contribution of hatchery- and natural-origin salmon to hatchery and natural areas throughout the CV, evaluate hatchery release strategies and programs, improve California ocean and river salmon fisheries management, evaluate the effectiveness of habitat restoration, and determine if other goals of the CFM program are being met on an annual basis. This information, combined with other tools such as cohort reconstruction and harvest models, will allow resource managers to determine the total contribution of various release strategies to CV escapement and to ocean and inland fisheries by time and area.

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

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LIST OF ACRONYMS AND ABBREVIATIONS

- Ad-clipped clipped adipose fin
- BOR U.S. Bureau of Reclamation
- BY Brood year
- CFM Constant Fractional Marking
- CFH Coleman National Fish Hatchery
- CV California Central Valley
- CWT coded-wire tag
- CDFW California Department of Fish and Wildlife
- 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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Sampling Location	Estimation and Sampling Methods	Agency
Hatchery Spawners		
Coleman National Fish Hatchery (CFH) Fall and Late-Fall (2017)	Direct count. All fish examined and bio-sampled ^{a/} for fin-clips, tags, marks. Access upstream of the hatchery closed Aug 1-Sep 30. Fall-run period: Oct 6-Dec 5, Late-fall-run period: Dec 28 - Mar 8. All fish sampled electronically to check for CWTs. Fish returning to CFH from mid-Nov through early Dec parsed into run-type based on CWT code recoveries and total run-type proportions by date. Grilse cutoff: 700 mm fall, 600 mm late-fall.	FWS
CFH Late-Fall Fish Trap	Direct count. All fish examined and bio-sampled for fin-clips, tags, marks. All unmarked untagged-phenotypic late-fall fish released into Battle Creek above CFH during spawning operations (included in CFH late-fall escapement). All fish sampled electronically at trap Mar 9 - 31 and heads collected for CWT recovery. Late-fall data from video weir counts during Apr-May added. Grilse cutoff: 600mm.	FWS
Keswick Fish Trap (KES) Winter	Direct count. All fish examined and bio-sampled for fin-clips, tags, marks. All unmarked fish electronically sampled for presence of CWT and genetically tested to ensure winter-run broodstock. Grilse cutoff: 580mm.	FWS
Feather River Hatchery (FRH) Spring and Fall	Direct count. All fish examined for fin-clips, tags, marks. Fish arriving at the hatchery May 21-Jul 2 (n~ 5,355) were considered "spring-run" and marked with uniquely-numbered dart tags prior to release back into the Feather River. Only fish marked with dart tags returning to FRH in fall were spawned as spring-run. All remaining fish were considered fall-run. FRH fish ladder opened Sep 14 and spring spawning began Sep 17. All spring-run fish bio-sampled until Sep 28 when the rate was reduced to 50%. Fall spawning occurred on Oct 1 for the cold water program and began normally on Oct 7. 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
FRH Trap Spring	Direct count of salmon that died during early processing of "spring-run" salmon returning to FRH during May-June. All fish examined for fin-clips, tags, marks. All ad-clipped fish were sampled and heads collected for CWT recovery. These fish are not included in FRH spring escapement. Grilse cutoff: 650 mm.	DWR
Nimbus Fish Hatchery (NIM) Fall	Direct count. NIM ladder open Nov 2 - Dec 22. All fish examined for fin-clips, tags, marks. Systematic random bio-sample of 33.3% of total fish returning until November 19th when the rate was reduced to 20%. All ad-clipped fish sampled and heads collected for CWT recovery. Grilse cutoff: 650 mm.	CDFW
Mokelumne River Hatchery (MOK) Fall	Direct count. MOK open Oct 1 - Feb. 28. All fish examined for fin-clips, tags, marks. Systematic random bio-sample ~33% of total fish returning. All ad-clipped fish sampled and heads collected for CWT recovery. Grilse cutoff: 650 mm.	CDFW
Mokelumne Weir Fall	Direct count. All fish examined for fin-clips, tags, marks. All ad-clipped fish were bio-sampled and heads processed for CWT recovery. Grilse cutoff: 650 mm females, 710 mm males.	CDFW
Merced River Hatchery (MER) Fall	Direct count. MER open Nov 5-Dec 24. All fish examined for fin-clips, tags, marks. All ad-clipped fish were sampled and heads processed for CWT recovery. Grilse cutoff: 620 mm females, 700 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 2016 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 (2016)	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 ^{al} 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: 630 mm females, 710 mm males winter; 610 mm females, 650 mm males fall; 610 mm females, 610 mm males late-fall.	CDFW, FWS
Clear Creek Fall	Video weir count used to estimate population. Eleven kayak surveys used to estimate biological characteristics of the population (age, sex, hatchery-origin, spawn success). All fish in survey examined for fin-clips, tags, marks, and condition (e.g., fresh, non-fresh, skeleton). Bio-data collected from all fresh fish. All ad-clipped fish (fresh and non-fresh), including "unknown" ad-clipped status, were sampled and heads collected for CWT recovery. Grilse cutoff: 610 mm female, 650 mm male.	CDFW, FWS
Cow Creek Fall	Video weir count in lower creek used to determine total escapement. Four kayak surveys conducted to collect bio-data from fresh fish. Only four carcasses observed with one ad-clipped. Grilse cutoff: 610 mm females, 670 mm males.	CDFW
Battle Creek Fall	Video weir count (Aug 22 - Dec 2) in lower creek used to determine total fall escapement. Natural fall escapement into Battle Creek calculated by subtracting CFH fall return from total run. Surrogate CWTs based on hatchery proportion and CWT composition of CFH fall return. Grilse cutoff: 700 mm.	CDFW
Cottonwood Creek Fall	Video weir count in lower creek used to determine total escapement. Four kayak surveys conducted to collect bio-data from fresh fish. Only ten carcasses observed with two ad-clipped fish sampled and heads collected for CWT recovery. Grilse cutoff: 610 mm females, 650 mm males.	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. Grilse cutoff: 610 mm females, 650 mm males.	CDFW
Deer Creek Fall	Video counts at Stanford Vina Ranch Irrigation Company (SVRIC) Dam plus expanded redd count between SVRIC Dam and the Sacramento River confluence used to determine total escapement. Kayak surveys conducted to collect bio-data from fresh fish. Approximately 1% of total escapement sampled; opportunistic collection of CWTs. Grilse cutoff: 610 mm females, 650 mm males.	CDFW

Table 1b. Estimation and sampling methods used for the 2016 CV Chinook natural escapement. (page 2 of 2)

Sampling Location	Estimation and Sampling Methods	Agency
Natural Spawners cont.		
Butte Creek Spring and Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate for spring and fall. All fish examined for fin-clips, tags, marks. Systematic random bio-sample of all fish. All ad-clipped fish sampled and heads collected for CWT recovery. Grilse cutoff: 600 mm spring, 650 mm fall.	CDFW
Feather River Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate. All fish examined for fin-clips, tags, marks. Systematic random bio-sample of fresh fish. All ad-clipped fresh fish sampled and heads collected for CWT recovery. Escapement estimate includes spring-run. Grilse cutoff: 650 mm.	DWR
Yuba River Fall	Due to malfunction of Vaki Riverwatcher which usually gives a direct count of escapement and ad-clipped fish above Daquerre Point Dam (DPD), a mark-recapture survey was conducted to determine the salmon abundance above and below DPD. Supplemental carcass survey to collect bio-data and heads from ad-clipped fish (fresh fish only). All ad-clipped fresh fish sampled and heads collected for CWT recovery. CJS escapement estimate includes spring-run. Grilse cutoff: 650 mm.	CDFW, YARMT
American River Fall	Superpopulation modification of the Cormack-Jolly-Seber mark-recapture estimate. All fish examined for fin-clips, tags, marks, and condition. Systematic random bio-sample of all fish. All ad-clipped fish sampled and heads collected for CWT recovery. Grilse cutoff: 650 mm females, 730 mm males.	CDFW
Nimbus Weir Fall	Direct count. Installed Aug 18 to force returning salmon into Nimbus Hatchery; salmon that migrated above prior to installation trapped between Nimbus Dam (located 1/4 mile upstream) and weir. All dead fish that washed back down river ("washbacks") onto weir examined for fin-clips, tags, marks. All ad-clipped fish sampled and heads collected for CWT recovery. Grilse cutoff: 650 mm.	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. Due to ten pulse flow events, only five fresh carcasses sampled. Mokelumne River Hatchery CWTs used as surrogate tags. 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. Opportunistic sampling of ad-clipped fish on Stanislaus Weir (i.e., "washbacks"). Grilse cutoff: 620 mm females, 700 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: 620 mm females, 700 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: 620 mm females, 700 mm males.	CDFW

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

Table 1c. Survey design and open dates for the 2016 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 (one weekday and one weekend sample per week per section during the open season in each management zone) that included both roving counts and access interview components 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.	CDFW
Open Dates		
Upper Sacramento River Fall and Late-Fall	Open Jul 16 - Dec 16 From the Lower Red Bluff Boat Ramp to Highway 113 bridge and Aug 1 - Dec 16 from the Deschutes Road Bridge to the Red Bluff Diversion Dam. Nov 1 is used to delineate the cutoff between the fall-run fishery and the late-fall-run fishery. Grilse cutoff: 700 mm fall.	
Feather River Fall	Open Jul 16 - Oct 15 from the unimproved boat ramp above the Thermolito 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. Grilse cutoff: 680 mm.	
American River Fall	Open Jul 16 - Dec 31 from Nimbus Dam to the Hazel Avenue Bridge, Jul 16 - Aug 15 from the Hazel Avenue Bridge to the USGS cable crossing, Jul 16 - Oct 31 from the USGS cable crossing to 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. Grilse cutoff: 680 mm.	
Lower Sacramento River Fall	Open Jul 16 - Dec 16 from the Highway 113 bridge to the Carquinez Bridge. Grilse cutoff: 700 mm.	
Mokelumne River Fall	Open Jul 16 - Oct 15 from Camanche Dam to the Highway 99 Bridge, Jul 16 - Dec 31 from the Highway 99 Bridge to Woodbridge Dam, including Lodi Lake, and Jul 16 - Dec 16 from the Lower Sacramento Road bridge to the San Joaquin River confluence. Grilse cutoff: 675 mm.	
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, 2016.

Major Port Area	Sport Fishery			Commercial Fishery		
	Season	Size Limit ^{a/}	Days Open	Season	Size Limit ^{a/}	Days Open
Eureka/Crescent City (Klamath Mgmt Zone)	May 16 - 31	20" TL	16	September 9-13, 16-20, 23-27 (1,000 fish quota ^{b/})	28" TL	15
	June 16 - 30	20" TL	15			
	July 16 - August 16	20" TL	32			
	September 1 - 5	20" TL	5			
Fort Bragg	April 2 - November 13	20" TL	226	June 13 - 30	27" TL	18
				August 3 - 27	27" TL	25
				September 1 - 30	27" TL	30
San Francisco	April 2 - 30	24" TL	29	May 6 - 31	27" TL	26
	May 1 - October 31	20" TL	184	June 13 - 30	27" TL	18
				August 1 - 28	27" TL	26
				September 1 - 30	26" TL	30
				October 3 - 7, 10 - 14 ^{c/}	26" TL	10
Monterey - North (Pigeon Pt - Pt Sur)	April 2 - July 15	24" TL	105	May 1 - June 30	27" TL	31
Monterey - South (Pt Sur - US / Mexico)	April 2 - May 31	24" TL	60	May 1 - June 30	27" TL	31
California Total ^{d/}			612			229

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

b/ Klamath Management Zone quota fishery; daily bag and possession limit of 20 salmon per day.

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

d/ California Total does not include days open in Monterey - South (subset of Monterey port area).

e/ Commercial regulations apply from Pt. Sur to the U.S./Mexico border as a subset of Monterey major port area.

Table 3. Central Valley coded-wire tag (CWT) Chinook releases recovered in 2016 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
FRHS	2014	FRH	Fea R	Spr	7	1,690,972	1,708,640	99%	In-basin	Feather River (Boyds Pump Ramp & Gridley)
CFHF _n	2014	CFH	Sac R	Fall	28	2,951,944	11,846,951	25%	Bay pens	San Pablo Bay (Rio Vista) net pen releases
FRHF _k	2014	FRH	Fea R	Fall	1	45,200	45,200	100%	Experimental	Yolo Bypass experimental (Knaggs Ranch rice field study)
FRHF _n	2014	FRH	Fea R	Fall	4	1,047,852	4,191,625	25%	Bay pens	San Pablo Bay (Mare Island, Crockett) net pen releases
FRHF _{nc}	2014	FRH	Fea R	Fall	1	321,527	331,177	97%	Coastal pens	Pillar Point net pens; acclimated 1-2 weeks
FRHF _{tib}	2014	FRH	Fea R	Fall	1	10,336	10,356	100%	Bay pens	Tiburon net pens; acclimated 1 week
NIMF _n	2014	NIM	Ame R	Fall	6	979,827	3,932,549	25%	Bay pens	San Pablo Bay (Mare Island, Wickland Oil) net pen releases
MOKF _n	2014	MOK	Mok R	Fall	13	1,244,314	4,998,641	25%	Bay pens	San Pablo Bay (Sherman Island) net pen releases
MOKF _{nc}	2014	MOK	Mok R	Fall	1	241,335	243,164	99%	Mixed pens	50% released Moss Landing; 50% released in SF Bay
MOKF _x	2014	MOK	Mok R	Fall	2	166,978	573,204	29%	Experimental	MOKF eggs shipped/raised at Merced Hatchery; Jersey Point
MERF _t	2014	MER	Mer R	Fall	3	108,494	426,902	25%	Trucked	San Joaquin River at Jersey Point; 30% released into net pens
SacW	2014	LSH	Sac R	Wint	7	590,623	609,311	97%	In-basin	Sacramento River (Lake Redding Park)
CFHL _h	2015	CFH	Sac R	Late	7	463,924	474,938	98%	Hatchery	Battle Creek at CFH
CFHL _e	2015	CFH	Sac R	Late	6	420,514	433,404	97%	Experimental	Trucked to Balls Ferry (emergency release)
Total age 2 releases:					87	10,283,840	29,826,062	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
FRHS	2013	FRH	Fea R	Spr	4	1,217,640	1,227,476	99%	In-basin	Feather River (Boyds Pump Ramp & Gridley)
FRHS _n	2013	FRH	Fea R	Spr	1	997,962	1,009,198	99%	Bay pens	San Pablo Bay (Mare Island) net pen releases
CFHF _h	2013	CFH	Sac R	Fall	4	1,125,706	4,506,160	25%	Hatchery	Battle Creek at CFH
CFHF _n	2013	CFH	Sac R	Fall	11	1,810,972	7,273,847	25%	Bay pens	San Pablo Bay (Rio Vista) net pen releases
FRHF _k	2013	FRH	Fea R	Fall	1	44,127	44,127	100%	Experimental	Yolo Bypass experimental (Knaggs Ranch rice field study)
FRHF _b	2013	FRH	Fea R	Fall	3	300,145	301,417	100%	Barge study	3 release sites: Sac R (Rio Vista), barged (SF Bay) & trucked (Tiburon)
FRHF _n	2013	FRH	Fea R	Fall	5	1,459,468	5,906,741	25%	Bay pens	San Pablo Bay (Wickland Oil) net pen releases
FRHF _{nc}	2013	FRH	Fea R	Fall	1	366,033	368,458	99%	Coastal pens	Pillar Point net pens; acclimated 1-2 weeks
FRHF _{tib}	2013	FRH	Fea R	Fall	1	11,791	11,791	100%	Bay pens	Tiburon net pens; acclimated 1 week
NIMF _n	2013	NIM	Ame R	Fall	4	896,419	3,587,565	25%	Bay pens	San Pablo Bay (Mare Island) net pen releases
MOKF _b	2013	MOK	Mok R	Fall	3	302,658	303,669	100%	Barge study	3 release sites: Mok R (Miller's Ferry), barged (SF Bay), trucked (Tiburon)
MOKF _n	2013	MOK	Mok R	Fall	11	1,148,423	4,604,315	25%	Bay pens	San Pablo Bay (Sherman Island) net pen releases
MOKF _{nc}	2013	MOK	Mok R	Fall	1	239,294	240,497	99%	Coastal pens	Santa Cruz net pens; 60K released per week, acclimated a few hours
MERF _t	2013	MER	Mer R	Fall	3	393,182	1,501,007	26%	Trucked	Jersey Point emergency releases (high water temp & mortality)
SacW	2013	LSH	Sac R	Wint	4	190,905	193,155	99%	In-basin	Sacramento River (Lake Redding Park)
CFHL _h	2014	CFH	Sac R	Late	14	1,056,322	1,094,719	96%	Hatchery	CFH (includes spring surrogate & small experimental releases)
Total age 3 releases:					71	11,561,047	32,174,142	36%		

Table 3. Central Valley coded-wire tag (CWT) Chinook releases recovered in 2016 by age, run, stock, and release type. (Page 2 of 2)

Age 4 CWT releases

Release type*	Brood year	Hatchery	Stock origin	Run type	CWT codes	# CWT tagged	Total fish released	% CWT	Release strategy	Release locations / notes
FRHS	2012	FRH	Fea R	Spr	2	1,106,679	1,125,897	98%	In-basin	Feather River (Boyds Pump Ramp & Gridley net pens 50%)
FRHSn	2012	FRH	Fea R	Spr	1	1,015,285	1,033,174	98%	Bay pens	San Pablo Bay (Wickland Oil) net pen releases
CFHFh	2012	CFH	Sac R	Fall	14	2,956,873	11,877,921	25%	Hatchery	Battle Creek at CFH
FRHFk	2012	FRH	Fea R	Fall	12	138,888	138,888	100%	Experimental	Yolo Bypass experimental (Knaggs Ranch rice field study)
FRHFb	2012	FRH	Fea R	Fall	3	293,784	299,404	98%	Barge study	3 release sites: Sac R (Broderick), barged (SF Bay), trucked (Ft Baker)
FRHFf	2012	FRH	Fea R	Fall	4	1,453,105	5,848,045	25%	Bay pens	San Pablo Bay net pen releases (various sites)
FRHFnc	2012	FRH	Fea R	Fall	2	649,160	656,564	99%	Coastal pens	Santa Cruz and Pillar Point net pens; acclimated 1-14 days
FRHFtib	2012	FRH	Fea R	Fall	1	9,918	10,028	99%	Bay pens	Tiburon net pens
NIMF	2012	NIM	Ame R	Fall	3	1,026,596	3,277,594	31%	In-basin	American River (Jibboom Street bridge & Howe Ave launch ramp)
NIMFn	2012	NIM	Ame R	Fall	1	182,413	734,906	25%	Bay pens	San Pablo Bay (Mare Island) net pen releases; 19% mortality transport
MOKF	2012	MOK	Mok R	Fall	1	99,548	100,306	99%	In-basin	Mokelumne Hatchery (yearlings)
MOKFn	2012	MOK	Mok R	Fall	13	1,275,158	5,123,986	25%	Bay pens	San Pablo Bay (Sherman Island) net pen releases
MERFt	2012	MER	Mer R	Fall	4	325,953	1,384,973	24%	Trucked	San Joaquin River at Jersey Point and Mossdale
SacW	2012	LSH	Sac R	Wint	16	169,967	181,857	93%	In-basin	Sacramento River (Lake Redding Park)
CFHLh	2013	CFH	Sac R	Late	14	960,075	984,977	97%	Hatchery	CFH (includes spring surrogate & small experimental releases)
Total age 4 releases:					91	11,663,402	32,778,520	36%		

Age 5 CWT releases (with recoveries in 2016)

Release type*	Brood year	Hatchery	Stock origin	Run type	CWT codes	# CWT tagged	Total fish released	% CWT	Release strategy	Release locations / notes
FRHS	2011	FRH	Fea R	Spr	2	1,088,286	1,110,709	98%	In-basin	Feather River (Boyds Pump Ramp & Thermolito Bypass)
FRHSn	2011	FRH	Fea R	Spr	1	1,125,189	1,134,280	99%	Bay pens	San Pablo Bay net pen releases
CFHFh	2011	CFH	Sac R	Fall	28	3,117,042	12,508,161	25%	Hatchery	CFH only
FRHFf	2011	FRH	Fea R	Fall	6	2,293,211	9,265,375	25%	Bay pens	San Pablo Bay net pen releases (approx 15% released directly into bay)
NIMF	2011	NIM	Ame R	Fall	3	1,078,191	3,492,113	31%	In-basin	American River (Howe Ave launch ramp)
NIMFn	2011	NIM	Ame R	Fall	2	328,073	1,312,930	25%	Bay pens	San Pablo Bay (Mare Island) net pen releases
CFHLh	2012	CFH	Sac R	Late	14	1,031,419	1,094,288	94%	Hatchery	CFH (includes spring surrogate & small experimental releases)

***CWT release types:**

Sacramento River fall Chinook release types (SFC)

CFHFh	Coleman National Fish Hatchery fall hatchery releases
CFHFf	Coleman National Fish Hatchery fall net pen releases
FRHFk	Feather River Hatchery fall experimental Knaggs Ranch releases
FRHFb	Feather River Hatchery fall barge study releases
FRHFf	Feather River Hatchery fall bay net pen releases
FRHFnc	Feather River Hatchery fall coastal net pen releases
FRHFtib	Feather River Hatchery fall Tiburon net pen releases
NIMF	Nimbus Fish Hatchery fall in-basin releases
NIMFn	Nimbus Fish Hatchery fall net pens

Other CV Chinook release types (OCV)

MOKF	Mokelumne Hatchery fall in-basin releases
MOKFb	Mokelumne Hatchery fall barge study releases
MOKFn	Mokelumne Hatchery fall net pen releases
MOKFnc	Mokelumne Hatchery fall coastal net pen releases (Santa Cruz)
MOKFx	Mokelumne Hatchery fall experimental (raised in Merced Hatchery)
MERFt	Merced River Hatchery fall trucked releases (no net pens)
FRHS	Feather River Hatchery spring in-basin releases
FRHSn	Feather River Hatchery spring net pen releases
SacW	Livingston Stone Hatchery winter in-basin releases
CFHLh	Coleman National Fish Hatchery late fall hatchery releases
CFHLf	Coleman National Fish Hatchery late fall experimental releases

Table 4. Central Valley hatchery and natural escapement estimates, sport harvest, and sample data, 2016.

Central Valley Survey	Run	Total Escapement	Chinook Sampled ^{a/}	Observed Ad-Clips	Heads Processed	Valid CWTs	Sample rate (fe)	Ad-clips processed (fa)	Valid CWTs (fd)	CWT F_{samp}
Hatchery Escapement										
Keswick Dam Fish Trap	Winter	137	137	107	107	107	1.000	1.000	1.000	1.00
Feather River Hatchery	Spring	1,650	1,650	1,551	1,551	1,528	1.000	1.000	0.997	1.00
Keswick Dam Fish Trap	Fall	282	282	82	82	81	1.000	1.000	1.000	1.00
Coleman National Fish Hatchery (CFH)	Fall	8,528	8,528	1,827	1,827	1,801	1.000	1.000	0.999	1.00
Feather River Hatchery	Fall	20,556	20,556	8,770	8,770	8,588	1.000	1.000	0.998	1.00
Nimbus Fish Hatchery	Fall	9,424	9,424	2,269	2,269	2,223	1.000	1.000	1.000	1.00
Mokelumne River Hatchery (MOK)	Fall	6,887	6,887	1,748	1,748	1,709	1.000	1.000	0.996	1.00
Merced River Hatchery	Fall	2,965	2,965	701	701	693	1.000	1.000	0.996	1.00
Coleman National Fish Hatchery	Late-fall ^{b/}	1,661	1,661	1,638	1,635	1,607	1.000	0.998	0.994	1.01
Coleman Hatchery Fish Trap	Late-fall ^{b/}	48	26	25	25	24	0.542	1.000	0.960	1.91
Keswick Dam Fish Trap	Late-fall ^{b/}	13	13	2	2	2	1.000	1.000	1.000	1.00
Total Hatchery Escapement		52,151	52,129	18,720	18,717	18,363				
Natural Area Escapement										
Upper Sacramento River (above RBDD)	Winter	1,409	284	77	76	71	0.202	0.987	1.000	5.05 ^{cl}
Butte Creek	Spring	5,731	672	0	0	0	0.125	-	-	-
Upper Sacramento River (above RBDD)	Fall	4,289	730	62	62	59	0.170	1.000	0.983	9.38 ^{cl}
Clear Creek	Fall	2,481	139	13	13	12	0.056	1.000	0.923	19.34
Battle Creek ^{d/}	Fall	1,021	1,021	218	218	216 ^{d/}	1.000	-	-	1.00
Cow Creek	Fall	821	4	Video - opportunistic CWTs		1	-	-	-	1.00 ^{el}
Cottonwood Creek	Fall	813	10	Video - opportunistic CWTs		2	0.012	-	-	1.00 ^{el}
Mill Creek	Fall	602	11	Video - opportunistic CWTs		3	0.018	-	-	1.00 ^{el}
Deer Creek	Fall	253	19	Video - no CWTs observed		0	0.075	-	-	- ^{el}
Butte Creek	Fall	626	561	31	6	6	0.896	0.194	1.000	5.77 ^{cl}
Feather River	Fall	38,742	3,840	1,378	1,372	1,321	0.099	0.996	1.000	10.13 ^{cl}
Yuba River	Fall	3,565	673	88	87	86	0.189	0.989	1.000	5.36 ^{tr}
American River	Fall	10,484	3,761	722	721	676	0.359	0.999	1.000	3.38 ^{cl}
Nimbus Fish Hatchery Weir	Fall	3,989	3,989	314	314	291	1.000	1.000	0.997	1.00
Mokelumne River ^{g/}	Fall	1,984	1,984	447	447	439 ^{g/}	1.000	-	-	1.00
Cosumnes River	Fall	1,248	25	Video - opportunistic CWTs		6	0.020	1.000	1.000	1.00 ^f
Stanislaus River	Fall	9,192	763	184	184	184	0.083	1.000	1.000	9.69 ^{h/}
Tuolumne River	Fall	1,357	1,145	214	214	199	0.844	1.000	1.000	1.61 ^{cl}
Merced River	Fall	3,331	601	126	125	123	0.180	0.992	1.000	5.59 ^{cl}
Upper Sacramento River (above RBDD)	Late-fall ^{b/}	3,069	73	poor sampling conditions		1	0.024	-	-	1.00
Total Natural Area Escapement		95,007	20,305	3,874	3,839	3,696				
CV Sport Harvest										
Sacramento River (above Feather River)	Fall	2,883	171	29	28	27	0.059	0.966	1.000	17.46
Sacramento River (below Feather River)	Fall	8,410	268	59	59	56	0.032	1.000	0.966	32.50
Feather River	Fall	6,368	406	126	126	123	0.064	1.000	0.992	15.81
American River	Fall	17,859	568	137	136	134	0.032	0.993	1.000	31.67
Mokelumne River	Fall	1,006	50	15	15	15	0.050	1.000	1.000	17.58
Sacramento River (above Feather River)	Late-fall	130	20	11	11	11	0.154	1.000	1.000	6.50
Total Sport Harvest		36,656	1,483	377	375	366				
Total Sampled			73,917	22,971	22,931	22,425				

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

b/ (Late-fall hatchery returns and natural escapement occurred during late fall of 2016 through early 2017 (return year 2017).

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

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

e/ Escapement estimate based on video counts; CWTs collected opportunistically in separate survey (e.g., kayak survey, snorkel survey).

f/ Deviation from normal survey protocols due to failure of Vaki Riverwater (video count) at Daguerre Pt Dam; carcass survey utilizing fresh fish only used to determine escapement for entire Yuba River.

g/ Mokelumne River fall natural escapement estimated using Woodbridge Dam video count minus fall return to MOK. Surrogate CWTs based on MOK CWT recoveries (see Appendix 4).

h/ Stanislaus natural escapement and sample expansion factor based on fresh fish only and expanded to all valid CWTs (36 CWTs recovered from washbacks on Stanislaus Weir).

Table 5. Total harvest and sample data for 2016 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	5,000	1,210	338	338	317	0.242	1.000	0.994	4.16
Fort Bragg	5,031	1,033	267	267	258	0.205	1.000	0.989	4.93
San Francisco	26,646	7,971	2,177	2,174	2,107	0.299	0.999	0.993	3.37
Monterey	<u>1,335</u>	<u>209</u>	<u>51</u>	<u>51</u>	<u>47</u>	<u>0.157</u>	<u>1.000</u>	<u>0.979</u>	<u>6.51</u>
	38,012	10,423	2,833	2,830	2,729	0.274	0.999	0.992	3.68
California Commercial									
Eureka/Crescent	196	126	38	34	34	0.643	0.895	1.000	1.74
Fort Bragg	15,380	4,222	810	801	756	0.275	0.989	0.990	3.71
San Francisco	26,363	6,026	1,602	1,602	1,561	0.229	1.000	0.992	4.40
Monterey	<u>13,246</u>	<u>4,208</u>	<u>779</u>	<u>779</u>	<u>749</u>	<u>0.318</u>	<u>1.000</u>	<u>0.984</u>	<u>3.20</u>
	55,185	14,582	3,229	3,216	3,100	0.264	0.996	0.990	3.84
California Total	93,197	25,005	6,062	6,046	5,829				
Oregon Sport	3,055	954	131	131	118	0.312	1.000	1.000	3.21
Oregon Commercial	40,289	15,522	3,232	3,232	3,121	0.385	1.000	0.990	2.62
Oregon Total	43,344	16,476	3,363	3,363	3,239				

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 2016^a.

<u>Fall-run</u>		2014	2013	2012	2011	Total CV CWTs	Total CV %
Age		2	3	4	5		
Raw CWT Recoveries		5,127 (30%)	9,873 (58%)	2,128 (12%)	19 (<1%)	17,146	77%
Expanded CWT _{total}		38,708 (30%)	75,038 (58%)	16,426 (13%)	109 (<1%)	130,281	94%
<u>Spring-run</u>		2014	2013	2012	2011	Total CV CWTs	Total CV %
Age		2	3	4	5		
Raw CWT Recoveries		11 (<1%)	2,251 (65%)	1,168 (34%)	8 (<1%)	3,438	15%
Expanded CWT _{total}		11 (<1%)	3,820 (62%)	2,355 (38%)	8 (<1%)	6,194	4%
<u>Late-Fall-run</u>		2015	2014	2013	2012	Total CV CWTs	Total CV %
Age		2	3	4	5		
Raw CWT Recoveries		260 (16%)	1,213 (74%)	153 (9%)	18 (1%)	1,644	7%
Expanded CWT _{total}		302 (17%)	1,305 (72%)	172 (10%)	22 (1%)	1,801	1%
<u>Winter-run</u>		2014	2013	2012	2011	Total CV CWTs	Total CV %
Age		2	3	4	5		
Raw CWT Recoveries		144 (82%)	29 (16%)	3 (2%)		176	0.8%
Expanded CWT _{total}		316 (67%)	140 (30%)	16 (3%)		471	0.3%
<u>All Runs</u>		2014	2013	2012	2011	Total CV CWTs	Total CV %
Age		2	3	4	5		
Raw CWT Recoveries		5,542 (25%)	13,366 (60%)	3,452 (15%)	45 (<1%)	22,404	100%
CV Expanded CWT _{total}		39,337 (28%)	80,303 (58%)	18,969 (14%)	139 (<1%)	138,747	100%

a) Recoveries of age-1 and age-6 fish removed.

Table 7. Raw and expanded Chinook CWT recoveries in 2016 California ocean fisheries by run type and brood year^{a)}.

Fall-run		2014	2013	2012	2011	Total Ocean CWTs	Total Ocean%
Age		2	3	4	5		
Raw CWT Recoveries		1,151 (21%)	4,036 (73%)	342 (6%)	2 (<1%)	5,531	95%
Expanded CWT _{total}		12,671 (20%)	44,805 (72%)	4,452 (7%)	30 (<1%)	61,959	98%
Spring-run		2014	2013	2012	2011	Total Ocean CWTs	Total Ocean%
Age		2	3	4	5		
Raw CWT Recoveries		1 (<1%)	126 (77%)	36 (22%)		163	3%
Expanded CWT _{total}		3 (<1%)	432 (76%)	135 (24%)		571	1%
Late-Fall-run		2015	2014	2013	2012	Total Ocean CWTs	Total Ocean%
Age		2	3	4	5		
Raw CWT Recoveries		2 (6%)	21 (62%)	10 (29%)	1 (3%)	34	1%
Expanded CWT _{total}		7 (5%)	90 (66%)	36 (26%)	3 (2%)	137	0.2%
Winter-run		2015	2014	2013	2012	Total Ocean CWTs	Total Ocean%
Age		2	3	4	5		
Raw CWT Recoveries			14 (93%)	1 (7%)		15	0.3%
Expanded CWT _{total}			52 (96%)	2 (4%)		55	0.1%
Non-CV stocks		2014	2013	2012	2011	Total Ocean CWTs	Total Ocean%
Age		2	3	4	5		
Raw CWT Recoveries			15 (18%)	44 (52%)	25 (30%)	84	1%
Expanded CWT _{total}			172 (28%)	356 (57%)	98 (16%)	626	1%
All Runs		2014	2013	2012	2011	Total Ocean CWTs	Total Ocean%
Age		2	3	4	5		
Raw CWT Recoveries		1,154 (20%)	4,212 (72%)	433 (7%)	28 (<1%)	5,827	100%
Expanded CWT _{total}		12,681 (20%)	45,553 (72%)	4,982 (8%)	132 (<1%)	63,347	100%
CV Expanded CWT _{total} proportion CV stocks		12,681 (100%)	45,380 (100%)	4,626 (93%)	34 (26%)	62,721	99%

a) Recoveries of age-1 and age-6 fish removed.

Table 8. Raw and expanded Chinook CWT recoveries in 2016 Oregon ocean fisheries by run type and brood year^{a)}.

Fall-run		2014	2013	2012	2011	Total Ocean CWTs	Total Ocean%
Age		2	3	4	5		
Raw CWT Recoveries		10 (<1%)	1,673 (80%)	398 (19%)	7 (<1%)	2,088	65%
Expanded CWT _{total}		130 (<1%)	12,593 (77%)	3,532 (22%)	58 (<1%)	16,312	76%
Spring-run		2014	2013	2012	2011	Total Ocean CWTs	Total Ocean%
Age		2	3	4	5		
Raw CWT Recoveries			17 (65%)	7 (27%)	2 (8%)	26	1%
Expanded CWT _{total}			48 (42%)	62 (53%)	6 (5%)	116	1%
Late-Fall-run		2015	2014	2013	2012	Total Ocean CWTs	Total Ocean%
Age		2	3	4	5		
Raw CWT Recoveries				2 (67%)	1 (33%)	3	0.1%
Expanded CWT _{total}				3 (45%)	3 (55%)	6	0.0%
Non-CV stocks		2014	2013	2012	2011	Total Ocean CWTs	Total Ocean%
Age		2	3	4	5		
Raw CWT Recoveries		3 (<1%)	89 (8%)	515 (47%)	498 (45%)	1,105	34%
Expanded CWT _{total}		25 (<1%)	1,306 (27%)	2,233 (45%)	1,354 (28%)	4,918	23%
All Runs		2014	2013	2012	2011	Total Ocean CWTs	Total Ocean%
Age		2	3	4	5		
Raw CWT Recoveries		13 (<1%)	1,779 (55%)	922 (29%)	508 (16%)	3,222	100%
Expanded CWT _{total}		155 (<1%)	13,947 (65%)	5,829 (27%)	1,421 (7%)	21,352	100%
CV Expanded CWT _{total} (proportion CV stocks)		130 (84%)	12,641 (91%)	3,596 (62%)	67 (5%)	16,434	77%

a) Recoveries of age-1 and age-6 fish removed.

Table 9. Percentage of inland CWT_{total} recoveries by location, run, and release type^{a/} in hatchery returns, natural escapement and sport harvest during 2016.

Location	Run	SacW	CFH			FRH						NIM		MOK				MER	Total %		Total Run	
			CFHLh	CFHFh	CFHFf	FRHS	FRHSn	FRHFk	FRHFb	FRHFf	FRHFnc	NIMF	NIMFn	MOKF	MOKFb	MOKFn	MOKFnc	MERFt	Hatchery	Natural		
Hatchery Spawners																						
Keswick Dam Fish Trap	Winter	80%																		80%	20%	137
Feather River Hatchery	Spring					47%	46%		<1%	1%										95%	5%	1,650
Keswick Dam Fish Trap	Fall			26%	17%					21%	12%	1%								79%	21%	282
Coleman National Fish Hatchery	Fall			74%	8%					<1%	1%					<1%	<1%	<1%	<1%	83%	17%	8,528
Feather River Hatchery	Fall			<1%	7%	4%	4%	<1%	3%	64%	13%	1%			<1%	<1%	<1%	<1%	<1%	96%	4%	20,556
Nimbus Fish Hatchery	Fall				14%					2%	1%	5%	59%	<1%	<1%	6%	<1%	1%	88%	12%	9,424	
Mokelumne River Hatchery	Fall				10%			<1%		2%	<1%		38%	1%	1%	35%	1%	2%	90%	10%	6,887	
Merced River Hatchery	Fall				11%					1%	<1%		4%	1%	1%	67%	1%	3%	89%	11%	2,965	
Coleman National Fish Hatchery	Late-fall ^{b/}		100%																	100%	0%	1,661
Coleman Hatchery Fish Trap	Late-fall ^{b/}		100%																	100%	0%	48
Keswick Dam Fish Trap	Late-fall ^{b/}		15%																	0%	100%	13
Total Hatchery Fall Run		0%	0%	13%	9%	1%	2%	<1%	1%	28%	6%	1%	17%	<1%	<1%	10%	<1%	1%	91%	9%	48,642	
Natural Spawners																						
Upper Sacramento River	Winter	26%																		26%	74%	1,409
Upper Sacramento River	Fall			15%	8%		<1%		<1%	7%	3%		2%		<1%	2%	<1%	1%	39%	61%	4,289	
Clear Creek	Fall		1%	3%	9%					9%	3%								26%	74%	2,481	
Battle Creek ^{c/}	Fall			74%	8%					<1%	<1%					<1%			83%	17%	1,021	
Butte Creek	Fall									7%	2%					1%	4%		14%	86%	626	
Feather River	Fall				12%	3%	4%	<1%	2%	56%	8%		<1%	<1%	<1%	<1%	<1%	<1%	86%	14%	38,742	
Yuba River	Fall				23%	1%	1%		<1%	8%	1%		1%		<1%	2%	<1%	1%	39%	61%	3,565	
American River	Fall				42%			<1%		2%	<1%	4%	32%	<1%	<1%	3%	<1%	1%	84%	16%	10,484	
Nimbus Fish Hatchery Weir	Fall				11%			<1%		<1%	2%	<1%	<1%	10%	<1%	<1%	2%	<1%	<1%	27%	73%	3,989
Mokelumne River ^{c/}	Fall				8%					2%	<1%		34%	1%	1%	32%	1%	2%	81%	19%	1,984	
Stanislaus River	Fall				7%					1%			2%	<1%	1%	62%		1%	75%	25%	9,192	
Tuolumne River	Fall				22%					1%	<1%		3%	<1%	1%	57%	<1%	3%	88%	12%	1,357	
Merced River	Fall				10%					1%	1%		2%		1%	61%	1%	1%	77%	23%	3,331	
Upper Sacramento River	Late-fall ^{b/}		<1%																	0%	100%	3,069
Total Natural Area Fall-run^{d/}			<1%	2%	15%	1%	2%	<1%	1%	27%	4%	<1%	6%	<1%	<1%	12%	<1%	1%	71%	29%	84,545	
In-basin CWT _{total}	All	<1%	2%	7%	1%	2%	3%	<1%	1%	33%	5%	1%	9%	<1%	<1%	3%	<1%	<1%	69%	31%	105,973	
Stray CWT _{total}	All	<1%	<1%	<1%	44%	<1%	<1%	<1%	<1%	4%	1%	<1%	12%	1%	1%	34%	<1%	2%	100%	0%	35,201	
Total CV Spawners		<1%	1%	6%	12%	2%	2%	<1%	1%	26%	4%	1%	10%	<1%	<1%	11%	<1%	1%	77%	23%	141,174	
CV Sport Harvest																						
Upper Sacramento River	Fall			56%	2%		1%			2%	1%								62%	38%	2,883	
Lower Sacramento River	Fall			3%	33%					14%	1%		22%		<1%	5%	2%		79%	21%	8,410	
Feather River	Fall			1%	17%	<1%	1%			2%	53%	11%							84%	17%	6,368	
American River	Fall				50%			<1%		1%	9%	1%	1%	21%		<1%	4%	1%	88%	13%	17,859	
Mokelumne River	Fall				21%					7%	2%		28%			42%			100%	0%	1,006	
Upper Sacramento River	Late-fall ^{b/}		56%																56%	44%	130	
Total Sport Harvest		<1%	<1%	5%	35%	<1%	<1%	<1%	1%	17%	3%	<1%	16%	<1%	<1%	4%	<1%	<1%	83%	17%	36,656	

a/ Release types defined in Table 3. Note: recoveries of FRHFt_{ib} merged with FRHF_n. MOKFx (age-2 raised at Merced Hatchery) merged into MOKF.

b/ Late-fall hatchery returns, natural escapement, and sport harvest occurred in late fall 2016 (return year 2017).

c/ Battle Creek and Mokelumne River natural escapement CWT_{total} based on hatchery proportions at CFH and MOK, respectively.

d/ Total Natural Area Fall-run includes CWTs collected opportunistically in the Cosumnes River (n=6) and Cottonwood (n=2), Cow (n=1) and Mill (n=3) creeks.

Table 10. Fall- and late-fall-run Chinook salmon escapement at Coleman National Fish Hatchery in 2016 based on run-timing and CWT stock composition.

Calculation of CFH sample expansion factors based on run-timing only

2016 CFH fall-run escapement (October 6, 2016 - December 5, 2016)

Run timing	Escapement N	Chinook sampled (n)	Observed ad-clips	Heads processed	CWTs recovered	Valid CWTs	Sample rate (fe)	Ad-clips processed (fa)	Valid CWTs (fd)	F_{samp}	Avg F_{prod}	$\sum_{i=1}^m CWT_{\text{total},i}$	Hatchery proportion
October 6 - December 5	8,747	8,747	2,025	2,025	1,990	1,988	100%	100.0%	99.9%	1.00	3.632	7,227	82.6%

2017 CFH late-fall-run escapement (December 28, 2016 - March 8, 2017)

Run timing	Escapement N	Chinook sampled	Observed ad-clips	Heads processed	CWTs recovered	Valid CWTs	Sample rate (fe)	Ad-clips processed (fa)	Valid CWTs (fd)	F_{samp}	Avg F_{prod}	$\sum_{i=1}^m CWT_{\text{total},i}$	Hatchery proportion
December 28 - March 8	1,442	1,442	1,440	1,437	1,426	1,420	100%	99.8%	99.6%	1.01	1.064	1,522	>100%

Total CFH count 10,189 10,189 3,465 3,462 3,416 3,408

Final CFH escapement based on CWT stock segregation

2016 CFH fall-run escapement

Run timing	Escapement N	Chinook sampled	Observed ad-clips	Heads processed	CWTs recovered	Fall CWTs	Sample rate (fe)	Ad-clips processed (fa)	Valid CWTs (fd)	F_{samp}	Avg F_{prod}	$\sum_{i=1}^m CWT_{\text{total},i}$	Hatchery proportion
October 6 - January 11	8,528	8,528	1,827	1,827	1,802	1,801	100%	100%	99.9%	1.00	3.871	7,072	82.9%

2017 CFH late-fall-run escapement

Run timing	Escapement N	Chinook sampled	Observed ad-clips	Heads processed	CWTs recovered	Late fall CWTs	Sample rate (fe)	Ad-clips processed (fa)	Valid CWTs (fd)	F_{samp}	Avg F_{prod}	$\sum_{i=1}^m CWT_{\text{total},i}$	Hatchery proportion
November 1 - March 8	1,661	1,661	1,638	1,635	1,614	1,607	100%	99.8%	99.6%	1.01	1.013	1,659	100%

Total CFH count 10,189 10,189 3,465 3,462 3,416 3,408

Table 11. Total inland CWT_{total} recoveries by location, run, and release type^{a/} in hatchery returns, natural escapement and sport harvest during 2016.

Location	Run	SacW	CFH			FRH					NIM		MOK				MER	Total CWT _{total}		Total Run
			CFHLh	CFHFh	CFHFh	FRHS	FRHSn	FRHFk	FRHFb	FRHFh	FRHFnc	NIMF	NIMFn	MOKF	MOKFb	MOKFn	MOKFnc	MERFt	Hatchery	
Hatchery Spawners																				
Keswick Dam Fish Trap	Winter	110																		
Feather River Hatchery	Spring					773	766		4	24										
Keswick Dam Fish Trap	Fall			72	48					58	33		4		8					
Coleman National Fish Hatchery	Fall		6,322	659						12	44			3	1	24	3	4		
Feather River Hatchery	Fall		24	1,417		722	919	9	616	13,066	2,613		204	23	5	80	14	25		
Nimbus Fish Hatchery	Fall			1,307						150	87	497	5,525	7	39	558	40	117		
Mokelumne River Hatchery	Fall			676				1		108	29		2,628	62	92	2,417	70	136		
Merced River Hatchery	Fall			318						36	8		128	30	16	1,999	17	102		
Coleman National Fish Hatchery	Late-fall ^{b/}		1,657																	
Coleman Hatchery Fish Trap	Late-fall ^{b/}		48																	
Keswick Dam Fish Trap	Late-fall ^{b/}		2																	
Total Hatchery Fall Run				6,418	4,425	722	919	10	616	13,430	2,814	497	8,489	125	153	5,086	144	384		
Natural Spawners																				
Upper Sacramento River	Winter	362																		
Upper Sacramento River	Fall			638	339		10		10	302	142		75		19	75	9	41		
Clear Creek	Fall		20	77	233					233	79									
Battle Creek ^{c/}	Fall			758	79					1	5					3				
Butte Creek	Fall									46	12				6	23				
Feather River	Fall				4,550	1,067	1,717	10	931	21,741	2,966		162	63	30	162	10	94		
Yuba River	Fall				817	33	49		5	286	49		43		5	64	5	51		
American River	Fall				4,372		3			258	42	397	3,331	11	14	312	10	78		
Nimbus Fish Hatchery Weir	Fall				442		6		3	61	13	10	417	7	4	84	5	16		
Mokelumne River ^{c/}	Fall				157					38	7		678	16	24	628	18	38		
Stanislaus River	Fall				661					116			156	38	68	5,716		131		
Tuolumne River	Fall				297					19	5		45	5	18	769	3	39		
Merced River	Fall				337					28	17		67		17	2,018	28	48		
Upper Sacramento River	Late-fall ^{b/}		1																	
Total Natural Area Fall-run^{d/}			20	1,481	12,300	1,100	1,785	10	949	23,133	3,339	407	4,978	140	205	9,862	88	536		
In-basin CWT _{total}	All	472	1,708	7,790	1,125	2,595	3,451	19	1,556	35,117	5,628	904	9,273	78	116	3,045	88	150		
Stray CWT _{total}	All	0	20	109	15,600	0	19	1	13	1,470	525	0	4,194	187	242	11,903	144	770		
Total CV Spawners		472	1,728	7,899	16,725	2,595	3,470	20	1,569	36,587	6,153	904	13,467	265	358	14,948	232	920		
	%stray	<1%	1%	1%	93%	<1%	1%	5%	1%	4%	9%	<1%	31%	71%	68%	80%	62%	84%		
CV Sport Harvest																				
Upper Sacramento River	Fall			1,608	70		18			70	18									
Lower Sacramento River	Fall			260	2,741					1,182	67		1,822		33	391	131			
Feather River	Fall			63	1,079	16	32		96	3,356	677									
American River	Fall				8,900		64		128	1,664	257	127	3,676		32	636		140		
Mokelumne River	Fall				212					71	18		281			423				
Upper Sacramento River	Late-fall ^{b/}		73																	
Total Sport Harvest		0	73	1,931	13,002	16	114	0	224	6,343	1,037	127	5,779	0	65	1,450	131	140		

a/ Release types defined in Table 3. Note: recoveries of FRHFt_b merged with FRHFh, MOKF_x (age-2 raised at Merced Hatchery) merged into MOKF.

b/ Late-fall hatchery returns, natural escapement, and sport harvest occurred in late fall 2016 (return year 2017).

c/ Battle Creek and Mokelumne River natural escapement CWT_{total} based on hatchery proportions at CFH and MOK, respectively.

d/ Total Natural Area Fall-run includes CWTs collected opportunistically in the Cosumnes River (n=6) and Cottonwood (n=2), Cow (n=1) and Mill (n=3) creeks.

Table 12. CWT recovery rate (recoveries per 100,000 CWTs released) by release type, brood year and recovery location in 2016. (page 1 of 2)

Age 2 CWT recoveries																						
Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT _{samp}) by basin									CV CWT _{samp} totals			% CV Stray	Ocean CWT _{samp}	Recovery rate per 100K released				
				Bat	Cr	Up	Sac	Nat crks ^{al}	Fea	Yub	Ame	Mok	Mer	SJ	In-basin			Stray	CV total	In-basin	Stray	CV total
FRHS	2014	Spr	1,690,972					11						11	0	11	0%	3	1	0	1	1
CFHFn	2014	Fall	2,951,944	35		3		212	32	619	127	115	179	38	1,285	1,323	97%	826	1	44	45	28
FRHFk	2014	Fall	45,200					10						10	0	10	0%	0	22	0	22	0
FRHFn	2014	Fall	1,047,852	3		6	19	1,841	11	44	22	6	23	1,852	124	1,976	6%	625	177	12	189	60
FRHFnc	2014	Fall	321,527	27		33	32	1,314	21	58	21	18	2	1,336	191	1,527	13%	1,052	415	59	475	327
FRHftib	2014	Fall	10,336					62		1		6		62	7	69	10%	26	604	64	667	255
NIMFn	2014	Fall	979,827					21		692	492	26	24	692	563	1,254	45%	511	71	57	128	52
MOKFn	2014	Fall	1,244,314	6		11	6	31	5	86	411	465	881	411	1,492	1,903	78%	836	33	120	153	67
MOKFnc	2014	Fall	241,335	3				17		40	62	18	3	62	82	144	57%	327	26	34	60	135
MOKFx	2014	Fall	166,978	1				27		7	19	9	11	28	47	75	63%	25	17	28	45	15
MERFt	2014	Fall	108,494	1						10	31	20	3	20	45	65	70%	10	18	42	60	9
SacW ^{bl}	2014	Wint	590,623					306						306	0	306	0%	51	52	0	52	9
CFHLh	2015	Late	463,924	254		2	19							256	19	275	7%	7	55	4	59	2
CFHLe	2015	Late	420,514											0	0	0	50%	0	0	0	0	0
Total			10,283,840	330	361	76	3,548	70	1,559	1,185	683	1,127	5,082	3,855	8,938	43%	4,299					
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 ^{al}	Fea	Yub	Ame	Mok	Mer	SJ	In-basin			Stray	CV total	In-basin	Stray	CV total
FRHS	2013	Spr	1,217,640					1,758	11					1,769	0	1,769	0%	218	145	0	145	18
FRHSn	2013	Spr	997,962					1,864	16	6				1,880	6	1,886	<1%	258	188	1	189	26
CFHFh	2013	Fall	1,125,706	1,233	98	19	6							1,332	25	1,357	2%	700	118	2	121	62
CFHFn	2013	Fall	1,810,972	149	93	60	1,275	172	904	82	48	60		242	2,600	2,842	91%	5,228	13	144	157	289
FRHFk	2013	Fall	44,127					5		1				5	1	6	17%	3	11	2	14	7
FRHFb	2013	Fall	300,145					913	5	2				918	2	920	<1%	457	306	1	307	152
FRHFn	2013	Fall	1,459,468			53	1	4,958	32	39	10	9	11	4,990	123	5,113	2%	2,921	342	8	350	200
FRHFnc	2013	Fall	366,033	21	131	58	4,109	27	81	15	7	3		4,136	316	4,452	7%	4,306	1130	86	1216	1177
FRHftib	2013	Fall	11,791			2	141							141	2	143	1%	109	1196	17	1213	922
NIMFn	2013	Fall	896,419			20	59	11	1,496	322	23	26		1,496	461	1,956	24%	2,045	167	51	218	228
MOKFb	2013	Fall	302,658	1	19	6	35	5	57	116	33	86		116	241	357	68%	906	38	80	118	299
MOKFn	2013	Fall	1,148,423	1				26	11	61	222	484	592	222	1,176	1,399	84%	1,446	19	102	122	126
MOKFnc	2013	Fall	239,294			9	7	5	15	25	27			25	64	89	72%	1,755	11	27	37	733
MERFt	2013	Fall	393,182					12		6	8	3	24	3	51	54	94%	44	1	13	14	11
SacW ^{bl}	2013	Wint	190,905			138								138	0	138	0%	2	72	0	72	1
CFHLh	2014	Late	1,056,322	1,221	1									1,222	0	1,222	0%	87	116	0	116	8
Total			11,561,047	2,627	565	144	15,170	295	2,667	801	633	802	18,636	5,067	23,703	21%	20,484					

Table 12. CWT recovery rate (recoveries per 100,000 CWTs released) by release type, brood year and recovery location in 2016. (page 2 of 2)

Age 4 CWT recoveries				Central Valley total recoveries (CWT _{samp}) by basin									CV CWT _{samp} totals			% CV	Ocean	Recovery rate per 100K released			
Release type	Brood year	Run type	# CWT tagged	Bat Cr	Up Sac	Nat crks ^{a/}	Fea	Yub	Ame	Mok	Mer	SJ	In-basin	Stray	CV total	Stray	CWT _{samp}	In-basin	Stray	CV total	Ocean
FRHS	2012	Spr	1,106,679				754	21					776	0	776	0%	77	70	0	70	7
FRHSn	2012	Spr	1,015,285		9		1,488	32	3				1,520	13	1,533	1%	117	150	1	151	12
CFHFh	2012	Fall	2,956,873	526	78	2							604	2	606	<1%	274	20	1	21	9
FRHFk	2012	Fall	138,888				4						4	0	4	0%	0	3	0	3	0
FRHFb	2012	Fall	293,784		9		623		1				623	10	633	2%	174	212	4	216	59
FRHFfn	2012	Fall	1,453,105		30	50	1,755	27	33	4			1,782	117	1,899	6%	832	123	8	131	57
FRHFnc	2012	Fall	649,160		9		74						74	9	83	11%	217	11	1	13	33
FRHFtib	2012	Fall	9,918				20	5					26	0	26	0%	0	258	0	258	0
NIMF	2012	Fall	1,026,596						280				280	0	280	0%	178	27	0	27	17
NIMFn	2012	Fall	182,413				11		125	13			125	24	149	16%	110	69	13	82	61
MOKF	2012	Fall	99,548							13			13	0	13	0%	6	13	0	13	6
MOKFn	2012	Fall	1,275,158		9		3		91	127	52	142	127	297	424	70%	449	10	23	33	35
MERFt	2012	Fall	325,953		9		14	11	35	6	14	23	14	97	111	88%	75	4	30	34	23
SacW ^{b/}	2012	Wint	169,967		15								15	0	15	0%	0	9	0	9	0
CFHLh	2013	Late	960,075	155									155	0	155	0%	38	16	0	16	4
Total			11,663,402	681	170	52	4,747	96	568	162	65	165	6,138	569	6,707	8%	2,545				

Age 5 CV recoveries

Age 5 CV recoveries				Central Valley total recoveries (CWT _{samp}) by basin									CV CWT _{samp} totals			% CV	Ocean	Recovery rate per 100K released			
Release type	Brood year	Run type	# CWT tagged	Bat Cr	Up Sac	Nat crks ^{a/}	Fea	Yub	Ame	Mok	Mer	SJ	In-basin	Stray	CV total	Stray	CWT _{samp}	In-basin	Stray	CV total	Ocean
FRHS	2011	Spr	1,088,286				6						6	0	6	0%	6	1	0	1	1
FRHSn	2011	Spr	1,125,189				2						2	0	2	0%	0	1	0	1	0
CFHFh	2011	Fall	3,117,042	9	1								10	0	10	0%	13	1	0	1	1
FRHFfn	2011	Fall	2,293,211				14						14	0	14	0%	2	1	0	1	1
NIMF	2011	Fall	1,078,191						3				3	0	3	0%	0	1	0	1	0
NIMFn	2011	Fall	328,073						2				2	0	2	0%	3	1	0	1	1
CFHLh	2012	Late	1,031,419	21									21	0	21	0%	6	2	0	2	1

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

b/ Ocean recoveries of SacW are considered one year older than those of the same brood year recovered in CV (i.e., brood year 2014 = age-3 ocean).

Sacramento River fall Chinook release types (SFC)

CFHFh	Coleman National Fish Hatchery fall hatchery releases
CFHFfn	Coleman National Fish Hatchery fall bay net pen releases
FRHFk	Feather River Hatchery fall Knaggs Ranch experimental releases
FRHFb	Feather River Hatchery fall barge study releases
FRHFfn	Feather River Hatchery fall bay net pen releases
FRHFnc	Feather River Hatchery fall coastal net pen releases (Pillar Point)
FRHFtib	Feather River Hatchery fall Tiburon net pen releases
NIMF	Nimbus Hatchery fall in-basin releases
NIMFn	Nimbus Hatchery fall bay net pens releases

Other CV Chinook release types (OCV)

FRHS	Feather River Hatchery spring in-basin releases
FRHSn	Feather River Hatchery spring bay net pen releases
MOKF	Mokelumne River Hatchery fall in-basin releases
MOKFb	Mokelumne River Hatchery fall barge study releases
MOKFfn	Mokelumne River Hatchery fall bay net pen releases
MOKFnc	Mokelumne River Hatchery fall coastal net pen releases (Santa Cruz)
MOKFx	Mokelumne River Hatchery fall experimental releases
MERF	Merced River Hatchery fall in-basin releases
MERFt	Merced River Hatchery fall trucked releases
SacW	Livingston Stone Hatchery winter in-basin releases
CFHLh	Coleman National Fish Hatchery late fall hatchery releases

Table 13. Total CWT_{total} recoveries by port area, month and release type^{a/} in 2016 California ocean salmon sport fishery.

	<u>CFH</u>				<u>FRH</u>				<u>NFH</u>		<u>MOK</u>				<u>MER</u>	Non CV	Total CV	Total CWT _{total}		Total Harvest		
	SacW	CFHLh	CFHFh	CFHFh	FRHS	FRHSn	FRHFk	FRHFb	FRHFh	FRHFnc	NIMF	NIMFn	MOKF	MOKFb	MOKFn			MOKFnc	MERFt		Hatchery	Natural
California Sport Harvest																						
Eureka/Crescent City																						
May		18	331		5	19	388	65		92		18	147	14	22	26	1,119	1,144	310	1,454		
Jun		17	174			4	140	52		121		13	173	22		9	717	726	217	943		
Jul		33	357		4	8	206	58		181		29	82	29			987	987	447	1,434		
Aug		17	70				105	48		122		17	139	35			554	554	92	646		
Sep			50					75	22	99		3	74	19		25	341	366	16	523		
Total		86	981		9	31	914	245		614		80	616	118	22	59	3,717	3,776	1,083	5,000 (13%)		
Fort Bragg																						
Apr		8			4	4	16	4									35	35	73	108		
May								19	9	19			18				65	65	39	104		
Jun			19		5	5	55	14					18	9		5	125	130	92	222		
Jul	5	161	867	10		20	628	102	20	384		35	467	51	22	51	2,773	2,824	700	3,524		
Aug		37	233				163	52	18	190	6		253	22			973	973	17	990		
Sep													23				23	23	52	75		
Oct																			8	8		
Total	5	205	1,119	10	9	29	881	181	38	593	6	35	778	82	22	56	3,994	4,050	973	5,031 (13%)		
San Francisco																						
Apr	6		100	380	54	54	7	230	50	13			24	14		6	933	939	267	1,206		
May	7	3	232	1,028	68	91	43	559	188	144		10	98	28	12	10	2,511	2,521	1,042	3,563		
Jun		5	40	382	2		13	279	66	99		6	90	3		7	985	992	261	1,253		
Jul	12	11	175	2,042		4	14	1,493	442	885	12	42	783	185		35	6,099	6,134	1,891	8,025		
Aug	6	7	112	1,702		4	17	1,067	413	559	21	15	634	111	12	3	4,681	4,684	1,427	6,111		
Sep		4		822				511	651	13	674		46	1,210	141	52	4,122	4,122	1,736	5,858		
Oct		10		38					19	266	12	3	49	6			403	403	227	630		
Total	31	39	660	6,394	124	153	93	4,140	1,828	13	2,640	45	121	2,889	489	76	19,735	19,796	6,850	26,646 (70%)		
Monterey																						
Apr			52	211	8	5		43	32			16			13		380	380	336	716		
May			24	159	7	7		112	48					6		7	362	369	203	572		
Jun								20					20				40	40	7	47		
Total			76	370	15	13		176	80			16	20	6	13	7	783	790	545	1,335 (4%)		
California Total Sport Harvest																						
	31	45	1,026	8,864	149	183	0	154	6,111	2,334	51	3,847	51	252	4,303	696	133	183	28,229	28,412	9,451	38,012
Oregon Total Sport Harvest																						
	0	0	37	141	0	3	0	3	57	20	0	32	0	0	246	15	0	559	555	1,114	1,941	3,055

a/ Release types defined in Table 3. Note: recoveries of FRHFt merged with FRHFh, MOKF (age-2 raised at Merced Hatchery) merged into MOKF.

Table 14. Percentage of CWT_{total} recoveries by port area, month and release type^{a/} in 2016 California ocean salmon sport fishery.

	<u>CFH</u>			<u>FRH</u>					<u>NFH</u>		<u>MOK</u>				<u>MER</u>	<u>Non</u>	<u>Total</u>	<u>Total %</u>		<u>Total</u>		
	SacW	CFHh	CFHf	CFHFn	FRHS	FRHSn	FRHFk	FRHFb	FRHFf	FRHFnc	NIMF	NIMFn	MOKF	MOKFb	MOKFn	MOKFnc	MERf	CV	CV	Hatchery	Natural	Harvest
California Sport Harvest																						
Eureka/Crescent City																						
May		1%	23%		<1%		1%	27%	4%		6%		1%	10%	1%	2%	2%	77%	79%	21%	1,454	
Jun		2%	18%				<1%	15%	6%		13%		1%	18%	2%		1%	76%	77%	23%	943	
Jul		2%	25%		<1%		1%	14%	4%		13%		2%	6%	2%			69%	69%	31%	1,434	
Aug		3%	11%					16%	7%		19%		3%	22%	5%			86%	86%	14%	646	
Sep			10%						14%	4%	19%		1%	14%	4%		5%	65%	70%	30%	523	
Total	0%	0%	2%	20%	0%	<1%	0%	1%	18%	5%	0%	12%	0%	2%	12%	2%	<1%	1%	74%	76%	24%	5,000
Fort Bragg																						
Apr			7%				4%		4%	14%	4%								32%	32%	68%	108
May										18%	9%			19%					63%	63%	37%	104
Jun				9%		2%	2%	25%	6%						8%	4%	2%	56%	59%	41%	222	
Jul	<1%	5%	25%	<1%			1%	18%	3%	1%	11%		1%	13%	1%	1%	1%	79%	80%	20%	3,524	
Aug		4%	24%						17%	5%	2%	19%	1%		26%	2%		98%	98%	2%	990	
Sep															30%			30%	30%	70%	75	
Total	0%	<1%	4%	22%	<1%	<1%	0%	1%	18%	4%	1%	12%	<1%	1%	15%	2%	<1%	1%	79%	80%	20%	5,031
San Francisco																						
Apr	1%		8%	32%	4%	5%	1%	19%	4%		1%			2%	1%		<1%	77%	78%	22%	1,206	
May	<1%	<1%	7%	29%	2%	3%	1%	16%	5%		4%		<1%	3%	1%	<1%	<1%	70%	71%	29%	3,563	
Jun		<1%	3%	30%	<1%		1%	22%	5%		8%		<1%	7%	<1%		1%	79%	79%	21%	1,253	
Jul	<1%	<1%	2%	25%	<1%	<1%	<1%	19%	6%		11%	<1%	1%	10%	2%		<1%	76%	76%	24%	8,025	
Aug	<1%	<1%	2%	28%	<1%	<1%	<1%	17%	7%		9%	<1%	<1%	10%	2%	<1%	<1%	77%	77%	23%	6,111	
Sep		<1%		14%					9%	11%	<1%	12%		1%	21%	2%	1%	70%	70%	30%	5,858	
Oct		2%		6%					3%		42%		2%	<1%	8%	1%		64%	64%	36%	630	
Total	<1%	<1%	2%	24%	<1%	1%	0%	<1%	16%	7%	<1%	10%	<1%	<1%	11%	2%	<1%	<1%	74%	74%	26%	26,646
Monterey																						
Apr			7%	29%	1%	1%		6%	4%				2%			2%		53%	53%	47%	716	
May			4%	28%	1%	1%		20%	8%							1%	1%	63%	65%	35%	572	
Jun								44%						43%				86%	86%	14%	47	
Total	0%	0%	6%	28%	1%	1%	0%	0%	13%	6%	0%	0%	0%	1%	1%	<1%	1%	59%	59%	41%	1,335	
California Total Sport Harvest																						
	<1%	<1%	3%	23%	<1%	<1%	0%	<1%	16%	6%	<1%	10%	<1%	1%	11%	2%	<1%	<1%	74%	75%	25%	38,012
Oregon Total Sport Harvest																						
	0%	0%	1%	5%	0%	<1%	0%	<1%	2%	1%	0%	1%	0%	0%	8%	<1%	0%	18%	18%	36%	64%	3,055

a/ Release types defined in Table 3. Note: recoveries of FRHFt merged with FRHFf, MOKf (age-2 raised at Merced Hatchery) merged into MOKF.

Table 15. Total CWT_{total} recoveries by port area, month and release type^{a/} in 2016 California ocean salmon commercial fishery.

	<u>CFH</u>				<u>FRH</u>				<u>NFH</u>		<u>MOK</u>				<u>MER</u>	<u>Non</u>	<u>Total</u>	<u>Total CWT_{total}</u>		<u>Total</u>	
	<u>SacW</u>	<u>CFHLh</u>	<u>CFHFh</u>	<u>CFHFh</u>	<u>FRHS</u>	<u>FRHSn</u>	<u>FRHFk</u>	<u>FRHFb</u>	<u>FRHFh</u>	<u>FRHFnc</u>	<u>NIMF</u>	<u>NIMFn</u>	<u>MOKF</u>	<u>MOKFb</u>	<u>MOKFn</u>	<u>MOKFnc</u>	<u>MERFt</u>	<u>CV</u>	<u>CV</u>	<u>Hatchery</u>	<u>Natural</u>
California Commercial Harvest																					
Eureka/Crescent City																					
Sep			14		2			28	22		27		2	21	9		2	124	126	70	196
																					(<1%)
Fort Bragg																					
Jun	10	243	1,256		16	51	1,118	322	67	753		57	691	164	8	165	4,757	4,922	5,034	9,956	
Jul																					
Aug	7	114	619		5		531	198	19	542	20	41	483	91	31		2,701	2,701	1,814	4,515	
Sep	4		98				82	61		132		16	82	16			490	490	419	909	
Total	21	357	1,972		21	51	1,730	582	87	1,427		20	114	1,255	271	38	165	7,947	8,113	7,267	15,380
																					(28%)
San Francisco																					
May	3	401	1,183	63	72	41	844	139	26	162		20	52	58		42	3,064	3,106	41	3,147	
Jun		21	21											5			48	48	398	446	
Aug	13	18	675	3,315		5	74	2,590	737	17	1,166		85	910	354	121	21	10,080	10,101	3,718	13,819
Sep	5	28	115	1,288	5	5	5	821	677	5	1,094	16	79	1,338	219	38		5,738	5,738	2,624	8,362
Oct			32				16	28	16	302		12	64	8				478	478	111	589
Total	19	49	1,212	5,839	68	82	119	4,270	1,581	64	2,724	16	196	2,364	644	159	63	19,407	19,470	6,893	26,363
																					(48%)
Monterey																					
May	6	402	1,897	29	38	3	86	1,379	274	6	365		35	215	57	25	193	4,819	5,012	5,208	10,220
Jun	5	15	166	909			44	600	86	12	136		29	136	37		20	2,176	2,196	830	3,026
Jul																					
Aug																					
Total	5	21	568	2,807	29	38	3	130	1,980	360	18	502		64	351	94	25	6,995	7,208	6,038	13,246
																					(24%)
California Total Commercial Harvest																					
24	92	2,137	10,632	97	143	3	301	8,008	2,544	170	4,681	35	376	3,990	1,018	222	443	34,473	34,916	20,269	55,185
Oregon Total Commercial Harvest																					
0	6	752	4,688	62	50	0	178	3,649	756	338	2,131	0	277	2,428	373	190	4,360	15,878	20,238	20,051	40,289

a/ Release types defined in Table 3. Note: recoveries of FRHFt_b merged with FRHF_n, MOKF_x (age-2 raised at Merced Hatchery) merged into MOKF.

Table 16. Percentage of CWT_{total} recoveries by port area, month and release type^{a/} in 2016 California ocean salmon commercial fishery.

	<u>CFH</u>			<u>FRH</u>					<u>NFH</u>		<u>MOK</u>				<u>MER</u>	<u>Non CV</u>	<u>Total CV</u>	<u>Total %</u>		<u>Total Harvest</u>		
	<u>SacW</u>	<u>CFHLh</u>	<u>CFHFh</u>	<u>CFHFn</u>	<u>FRHS</u>	<u>FRHSn</u>	<u>FRHFk</u>	<u>FRHFb</u>	<u>FRHFh</u>	<u>FRHFnc</u>	<u>NIMF</u>	<u>NIMFn</u>	<u>MOKF</u>	<u>MOKFb</u>	<u>MOKFn</u>	<u>MOKFnc</u>	<u>MERFt</u>			<u>Hatchery</u>	<u>Natural</u>	
California Commercial Harvest																						
Eureka/Crescent City																						
Sep			7%		1%			14%	11%		14%		1%	10%	4%		1%	63%	64%	36%	196	
Fort Bragg																						
Jun		<1%	2%	13%		<1%	1%	11%	3%	1%	8%		1%	7%	2%	<1%	2%	48%	49%	51%	9,956	
Aug		<1%	3%	14%		<1%		12%	4%	<1%	12%	<1%	1%	11%	2%	1%		60%	60%	40%	4,515	
Sep		<1%		11%				9%	7%		15%			2%	9%	2%		54%	54%	46%	909	
Total	0%	<1%	2%	13%	0%	<1%	0%	<1%	11%	4%	1%	9%	<1%	1%	8%	2%	<1%	1.1%	52%	53%	47%	15,380
San Francisco																						
May		<1%	13%	38%	2%	2%		1%	27%	4%	1%	5%		1%	2%	2%		1%	97%	99%	1%	3,147
Jun			5%	5%											1%				11%	11%	89%	446
Aug	<1%	<1%	5%	24%		<1%	1%	19%	5%	<1%	8%		1%	7%	3%	1%	<1%	73%	73%	27%	13,819	
Sep	<1%	<1%	1%	15%	<1%	<1%	<1%	10%	8%	<1%	13%	<1%	1%	16%	3%	<1%		69%	69%	31%	8,362	
Oct				5%				3%	5%	3%	51%		2%	11%	1%			81%	81%	19%	589	
Total	<1%	<1%	5%	22%	<1%	<1%	0%	<1%	16%	6%	<1%	10%	<1%	1%	9%	2%	1%	<1%	74%	74%	26%	26,363
Monterey																						
May		<1%	4%	19%	<1%	<1%	<1%	1%	13%	3%	<1%	4%		<1%	2%	1%	<1%	2%	47%	49%	51%	10,220
Jun	<1%	<1%	5%	30%				1%	20%	3%	<1%	5%		1%	5%	1%		1%	72%	73%	27%	3,026
Total	<1%	<1%	4%	21%	<1%	<1%	<1%	1%	15%	3%	<1%	4%	0%	<1%	3%	1%	<1%	2%	53%	54%	46%	13,246
California Total Commercial Harvest																						
	<1%	<1%	4%	19%	<1%	<1%	<1%	1%	15%	5%	<1%	8%	<1%	1%	7%	2%	<1%	1%	62%	63%	37%	55,185
Oregon Total Commercial Harvest																						
	0%	<1%	2%	12%	<1%	<1%	0%	<1%	9%	2%	1%	5%	0%	1%	6%	1%	<1%	11%	39%	50%	50%	40,289

a/ Release types defined in Table 3. Note: recoveries of FRHFtib merged with FRHFh, MOKFx (age-2 raised at Merced Hatchery) merged into MOKF.

Table 17. CWT recovery rate (recoveries per 100,000 CWTs released) for Experimental & Net Pen release types in 2016. (page 1 of 2)

Age 2 CWT recoveries				Central Valley total recoveries (CWT_{sample}) by basin										CV CWT_{sample} totals			% CV Stray	Ocean CWT_{sample}	Recovery rate per 100K released			
Release type	Brood year	Run type	# CWT tagged	Bat Cr	Up Sac	Nat crks ^{al}	Fea	Yub	Ame	Mok	Mer	SJ	In-basin	Stray	CV total			In-basin	Stray	CV total	Ocean	
CFHFn	2014	Fall	2,951,944	35	3		212	32	619	127	115	179	38	1,285	1,323	97%	826	1	44	45	28	
FRHFkr	2014	Fall	45,200				10						10	0	10	0%	0	22	0	22	0	
FRHFn	2014	Fall	1,047,852	3	6	19	1,841	11	44	22	6	23	1,852	124	1,976	6%	625	177	12	189	60	
FRHFnp	2014	Fall	321,527	27	33	32	1,314	21	58	21	18	2	1,336	191	1,527	13%	1,052	415	59	475	327	
NIMFn	2014	Fall	979,827				21		692	492	26	24	692	563	1,254	45%	511	71	57	128	52	
MOKFn	2014	Fall	1,244,314	6	11	6	31	5	86	411	465	881	411	1,492	1,903	78%	836	33	120	153	67	
MOKFns	2014	Fall	241,335	3			17		40	62	18	3	62	82	144	57%	327	26	34	60	135	
MOKFx	2014	Fall	166,978	1			27		7	19	9	11	19	56	75	75%	25	11	34	45	15	
Age 3 CWT recoveries				Central Valley total recoveries (CWT_{sample}) by basin										CV CWT_{sample} totals			% CV Stray	Ocean CWT_{sample}	Recovery rate per 100K released			
Release type	Brood year	Run type	# CWT tagged	Bat Cr	Up Sac	Nat crks ^{al}	Fea	Yub	Ame	Mok	Mer	SJ	In-basin	Stray	CV total			In-basin	Stray	CV total	Ocean	
CFHFn	2013	Fall	1,810,972	149	93	60	1,275	172	904	82	48	60	242	2,600	2,842	91%	5,228	13	144	157	289	
FRHFbb	2013	Fall	100,227				333	5	2				339	2	341	1%	176	338	2	340	176	
FRHFbg	2013	Fall	100,564				299						299	0	299	0%	137	298	0	298	136	
FRHFbr	2013	Fall	99,354				280						280	0	280	0%	144	282	0	282	145	
FRHFkr	2013	Fall	44,127				5			1			5	1	6	17%	3	11	2	14	7	
FRHFn	2013	Fall	1,459,468		53	1	4,958	32	39	10	9	11	4,990	123	5,113	2%	2,921	342	8	350	200	
FRHFnp	2013	Fall	366,033	21	131	58	4,109	27	81	15	7	3	4,136	316	4,452	7%	4,306	1130	86	1216	1177	
NIMFn	2013	Fall	896,419		20		59	11	1,496	322	23	26	1,496	461	1,956	24%	2,045	167	51	218	228	
MOKFbb	2013	Fall	101,051		9		11	5	20	16	15	21	16	82	98	83%	442	16	81	97	437	
MOKFbg	2013	Fall	101,426	1	9	6	24		37	99	18	65	99	159	259	62%	464	98	157	255	457	
MOKFbr	2013	Fall	100,181										0	0	0		0	0	0	1	0	
MOKFn	2013	Fall	1,148,423	1			26	11	61	222	484	592	222	1,176	1,399	84%	1,446	19	102	122	126	
MOKFns	2013	Fall	239,294		9		7	5	15	25	27		25	64	89	72%	1,755	11	27	37	733	

Table 17. CWT recovery rate (recoveries per 100,000 CWTs released) for Experimental & Net Pen release types in 2016. (page 2 of 2)

Age 4 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT _{sample}) by basin								CV CWT _{sample} totals			% CV Stray	Ocean CWT _{sample}	Recovery rate per 100K released					
				Bat Cr	Up Sac	Nat crks ^{a/}	Fea	Yub	Ame	Mok	Mer	SJ	In-basin	Stray			CV total	In-basin	Stray	CV total	Ocean	
FRHFbb	2012	Fall	97,760		9		334							334	9	343	3%	82	341	10	351	84
FRHFbg	2012	Fall	99,192				288			1				288	1	289	<1%	88	290	1	291	88
FRHFbr	2012	Fall	96,832				1							1	0	1	0%	3	1	0	1	4
FRHFkc	2012	Fall	46,492				3							3	0	3	0%	0	6	0	6	0
FRHFkr	2012	Fall	92,396				1							1	0	1	0%	0	1	0	1	0
FRHFfn	2012	Fall	1,453,105		30	50	1,755	27	33	4				1,782	117	1,899	6%	832	123	8	131	57
FRHFnp	2012	Fall	412,360		9		59							59	9	68	14%	116	14	2	16	28
FRHFns	2012	Fall	236,800				15							15	0	15	0%	101	6	0	6	43
NIMFn	2012	Fall	182,413				11		125	13				125	24	149	16%	110	69	13	82	61
MOKFn	2012	Fall	1,275,158		9		3		91	127	52	142		127	297	424	70%	449	10	23	33	35

^{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 Chinook Experimental and Net Pen release types

CFHFn	Coleman National Fish Hatchery fall bay net pen releases	NIMFn	Nimbus Hatchery fall bay net pens releases
FRHFbb	Feather River Hatchery fall barge study: trucked & released in SF Bay (Ft Baker, Tiburon)	MOKFbb	Mokelumne River Hatchery fall barge study: trucked & released in SF Bay (Tiburon)
FRHFbg	Feather River Hatchery fall barge study: barged to SF Bay and released	MOKFbg	Mokelumne River Hatchery fall barge study: barged to SF Bay and released
FRHFbr	Feather River Hatchery fall barge study: in-river releases (numerous sites Sac R.)	MOKFbr	Mokelumne River Hatchery fall barge study: in-river releases (Miller's Ferry, Mok R.)
FRHFkc	Feather River Hatchery fall rice field study: Elkhorn boat ramp Sac River (control grp)		
FRHFkr	Feather River Hatchery fall rice field study: Yolo Bypass Knaggs Ranch rice field	MOKFx	Mokelumne River Hatchery fall experimental releases (raised at MER)
FRHFfn	Feather River Hatchery fall bay net pen releases	MOKFn	Mokelumne River Hatchery fall bay net pen releases
FRHFnp	Feather River Hatchery fall coastal net pen releases - Pillar Point		
FRHFns	Feather River Hatchery fall coastal net pen releases - Santa Cruz	MOKFns	Mokelumne River Hatchery fall coastal net pen releases - Santa Cruz

#	Release Type	Release Location
1	SacW	Lake Redding Park (Sac R)
1a	CFHLe	Balls Ferry (Sac R)
2	CFHFh,CFHLh	Coleman Fish Hatchery
3	FRHS	Gridley (Fea R)
4	FRHS	Boyd's Pump Boat Ramp (Fea R)
5	FRHFbr, FRHFkc	Elkhorn Boat Ramp (Sac R)
6	NIMF	American River
7	FRHFbr	Broderick Boat Ramp (Sac R)
8	FRHFkr	Yolo Bypass - Knaggs Ranch
9	MOKF	Mokelumne River Hatchery
10	MOKFbr	Miller's Ferry Bridge (Mok R)
11	FRHFbr	Rio Vista (Sac R)
12	MOKFx (raised)	Merced River Hatchery
13	MERF	Hatfield State Area (Mer R)
14	MERFt	Mossdale (San Joaq R)
15	MERFt, MOKFx	Jersey Point (San Joaq R)
16	MOKFn, MOKFt	Sherman Island
17	FRHSn, NIMFn	Mare Island Net Pens
18	FRHFkn, NIMFn	Wickland Oil Net Pens
17-18	CFHFkn, FRHFkn	San Pablo Bay Net Pens
19	FRHFtib	Tiburon Net Pens
20	FRHFbb, MOKFbb	Trucked to SF Bay (Fort Baker, Tiburon)
20	FRHFbg, MOKFbg	Barged to SF Bay (Golden Gate mouth)
21	FRHFnp	Pillar Point Net Pens
22	FRHFns, MOKFns	Santa Cruz Net Pens

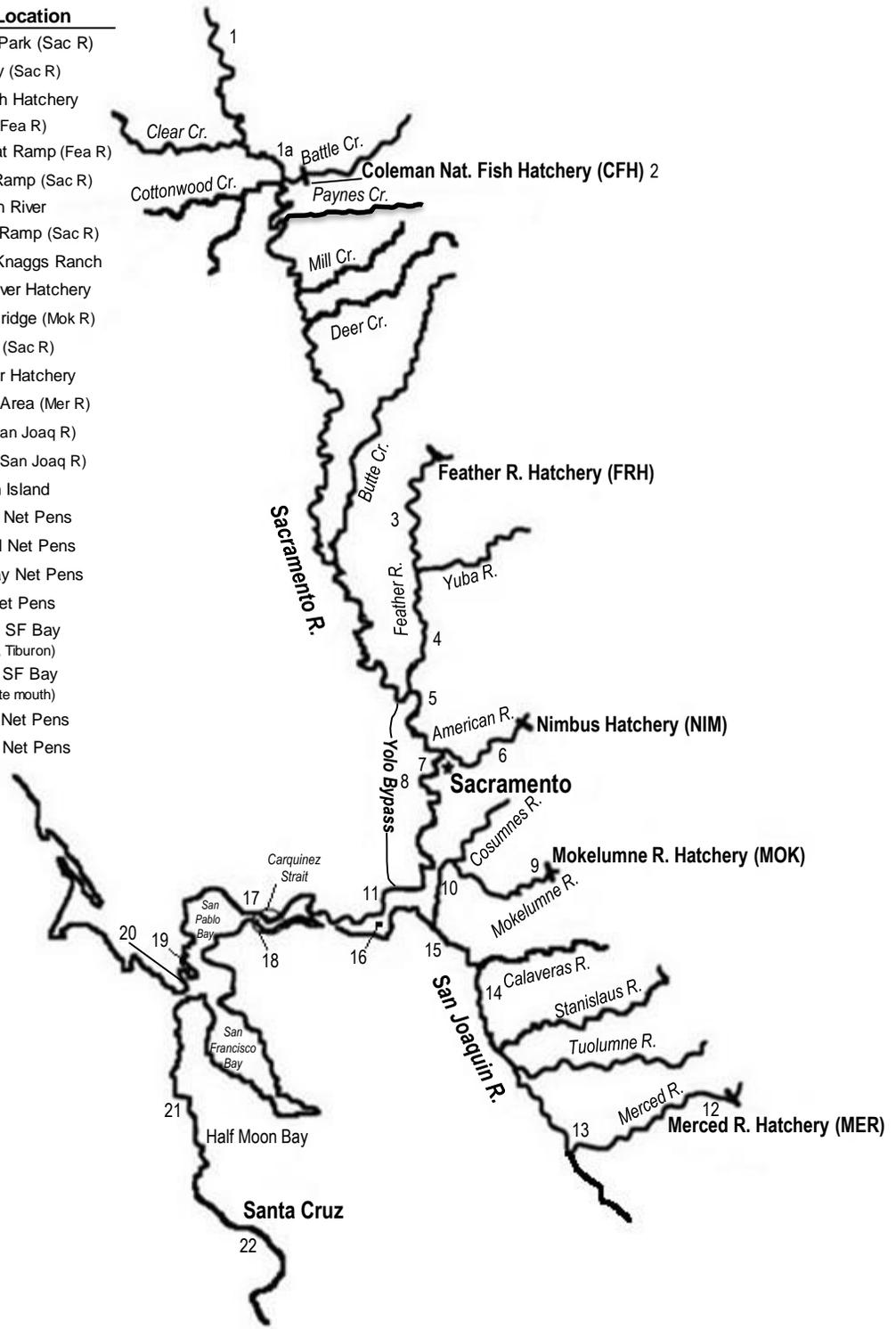


Figure 1. Map of release locations for CV hatchery release types, brood years 2011-2014.

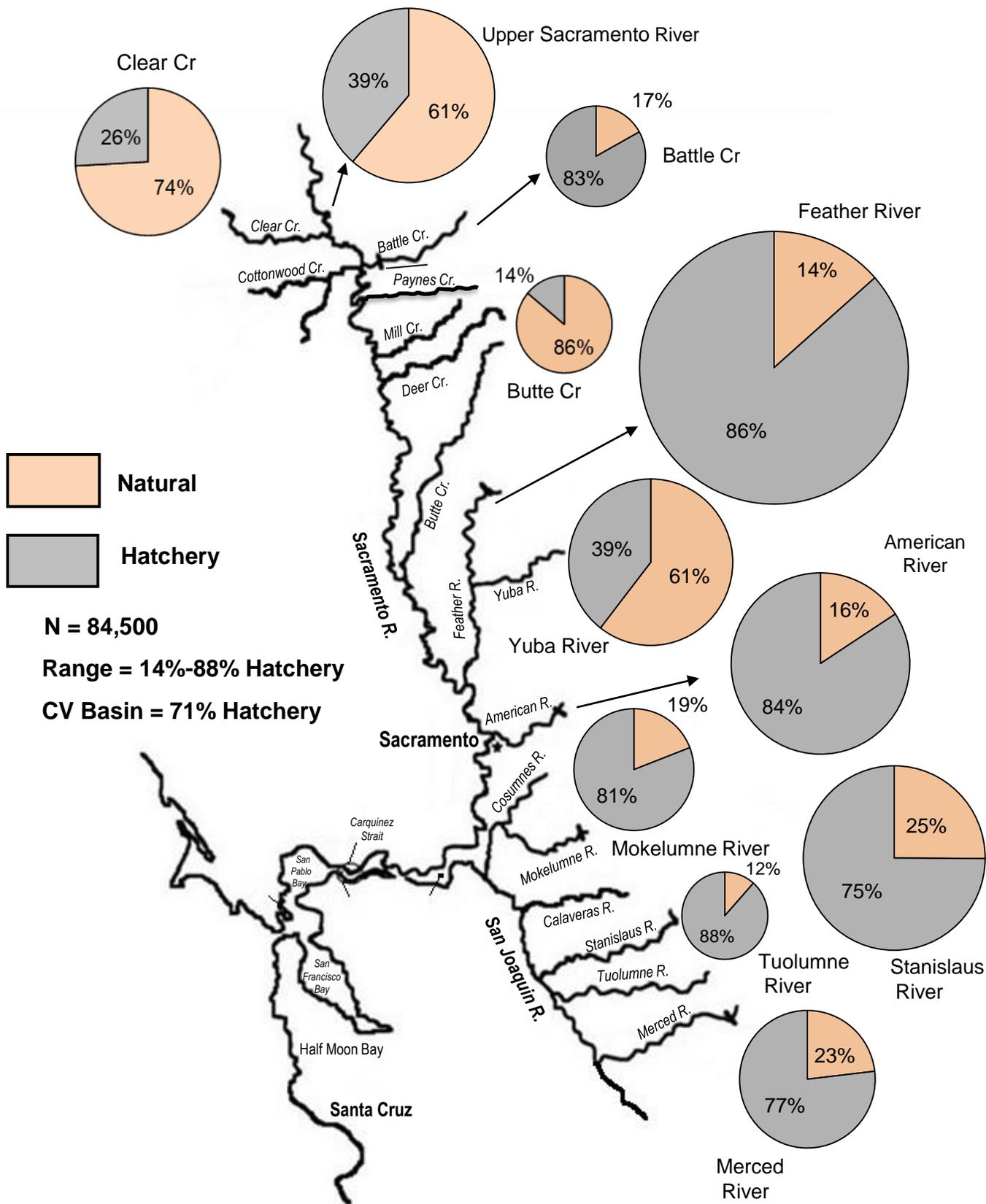


Figure 2. Fall-run CV Natural Area Escapement, Hatchery and Natural Proportions, 2016.

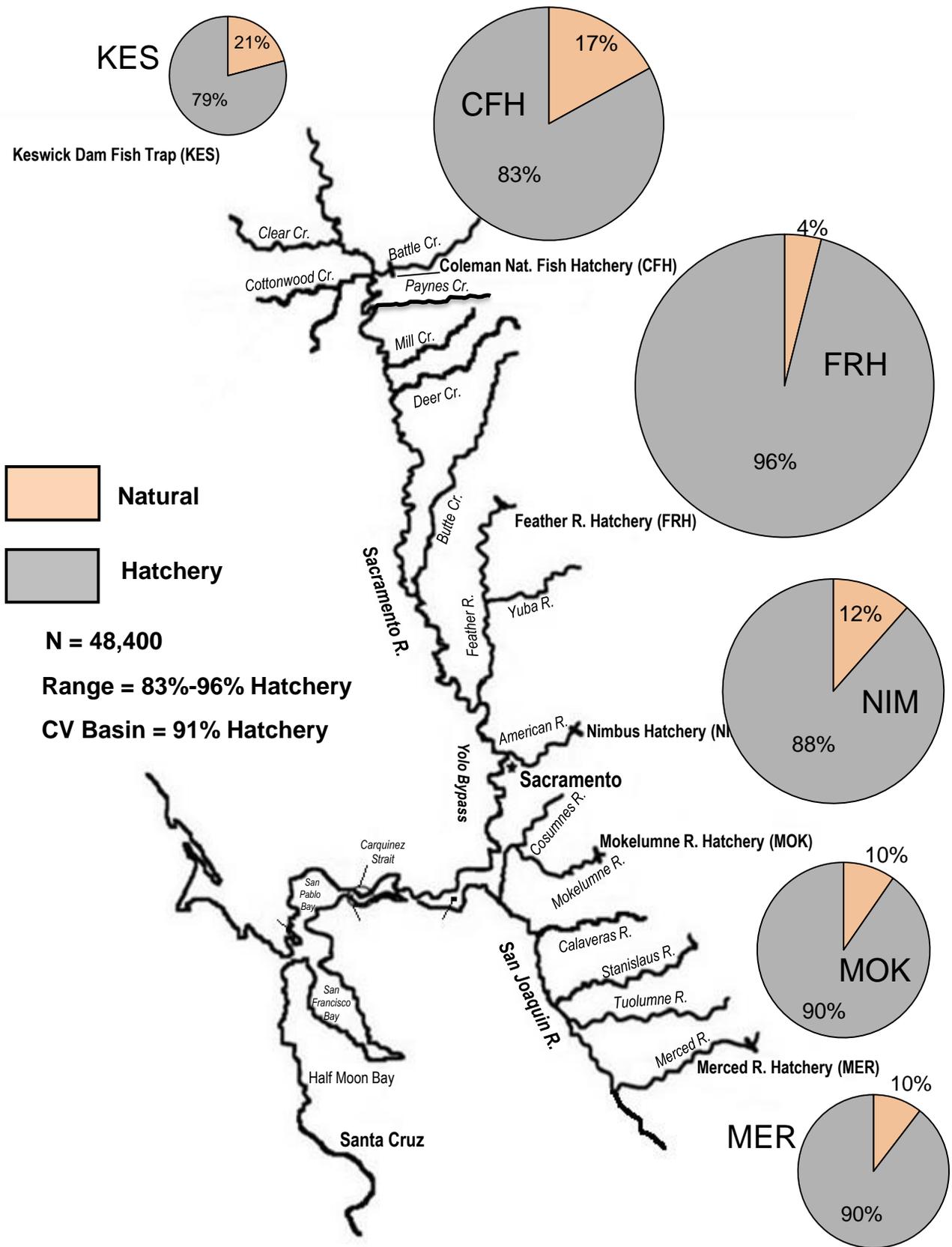


Figure 3. Fall-run CV Hatchery Escapement, Hatchery and Natural Proportions, 2016.

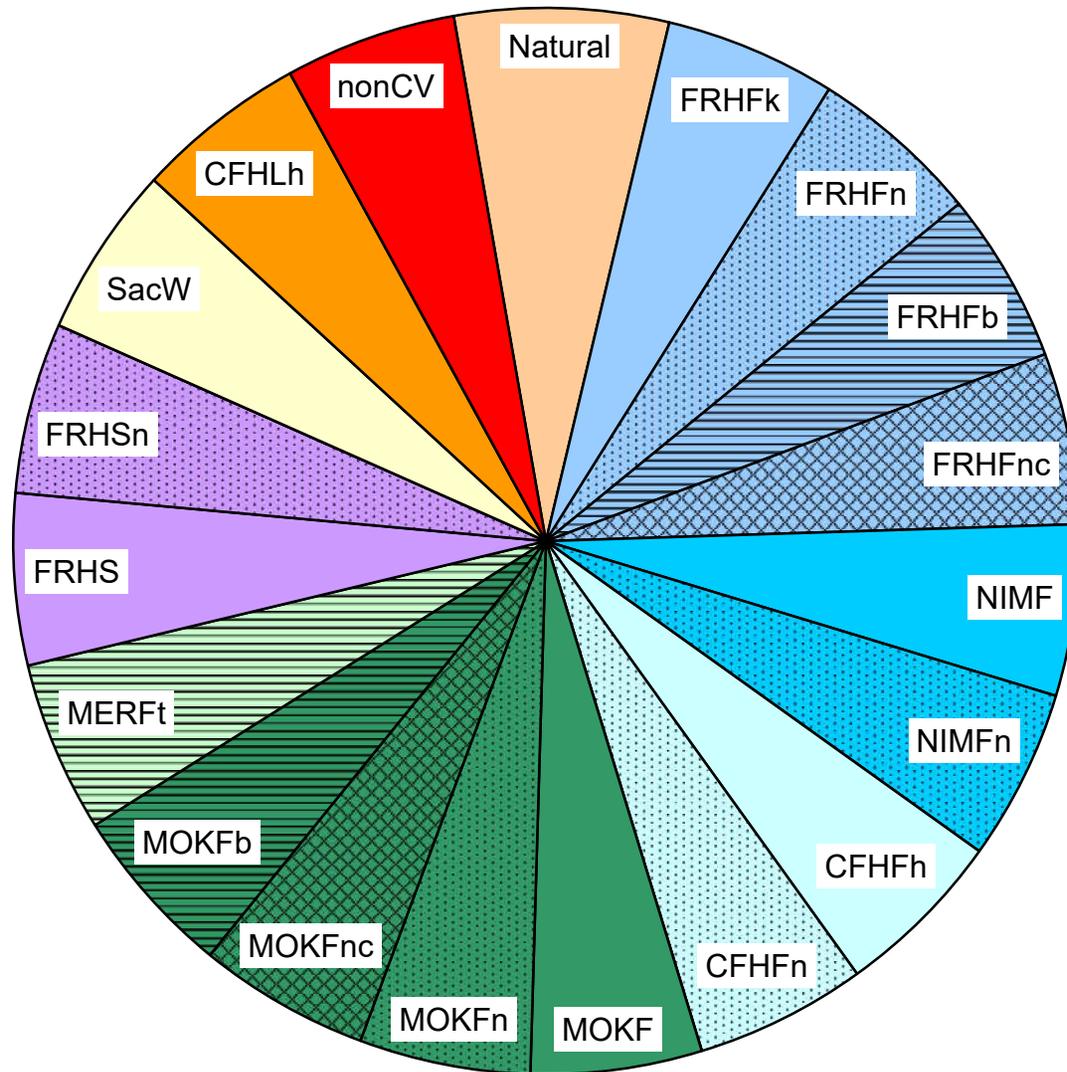
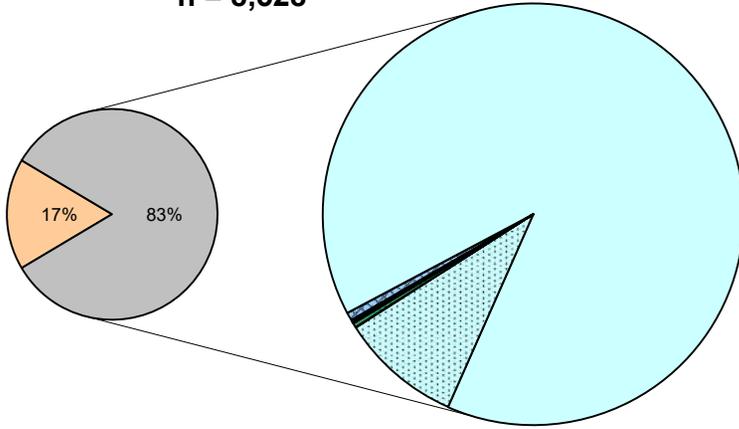
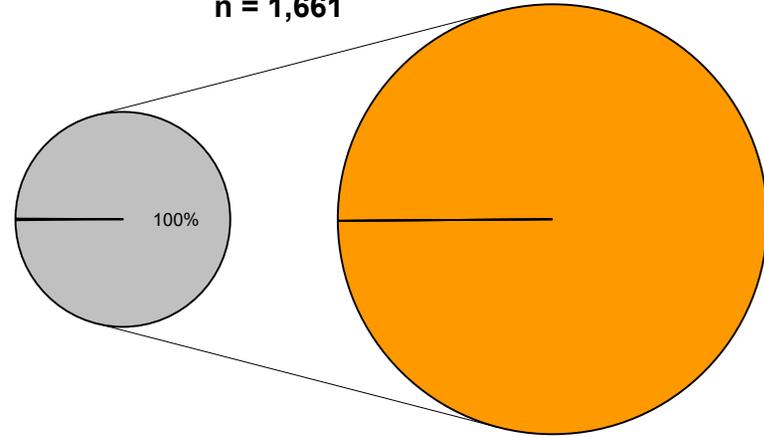


Figure 4. Color and pattern scheme used in all pie chart figures for Central Valley hatchery release types, brood years 2010-2013.

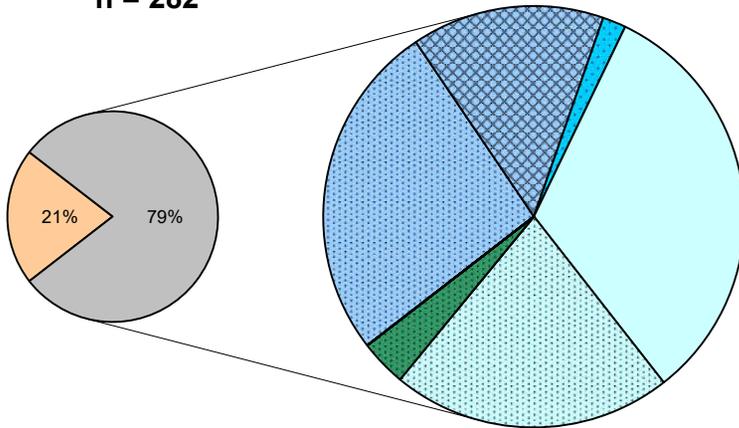
Coleman National Fish Hatchery fall 2016
n = 8,528



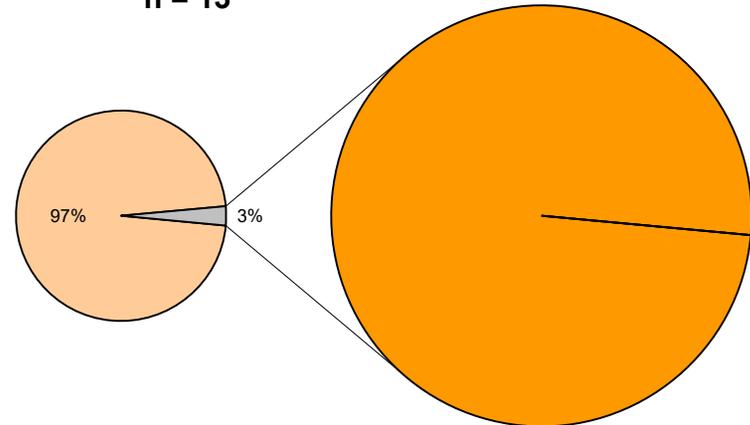
Coleman National Fish Hatchery late-fall 2017
n = 1,661



Keswick Dam Trap fall 2016
n = 282



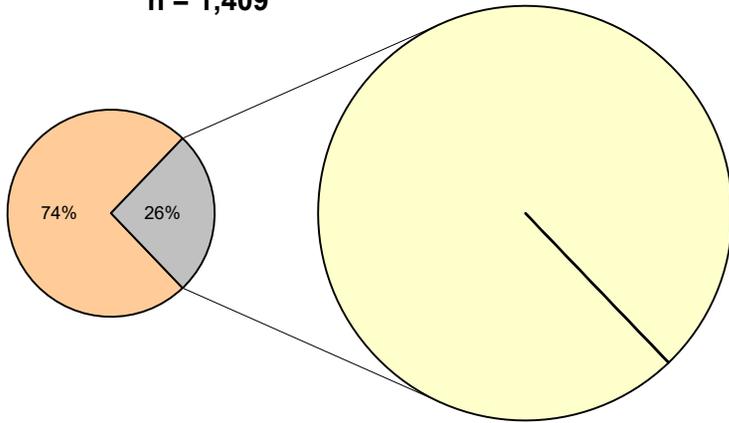
Keswick Dam Trap late-fall 2017
n = 13



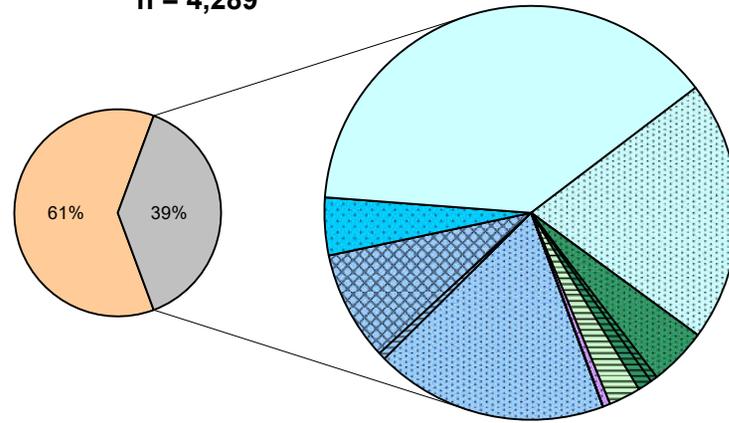
- Natural
 FRHFk
 FRHFf
 FRHFb
 FRHFnc
 NIMF
 NIMFn
 CFHFh
 CFHFf
 MOKF
 MOKFn
 MOKFb
 MERFt
 FRHS
 FRHSn
 SacW
 CFHLh
 nonCV

Figure 5. Proportion of hatchery- and natural-origin fish at Coleman National Fish Hatchery, 2016-17.

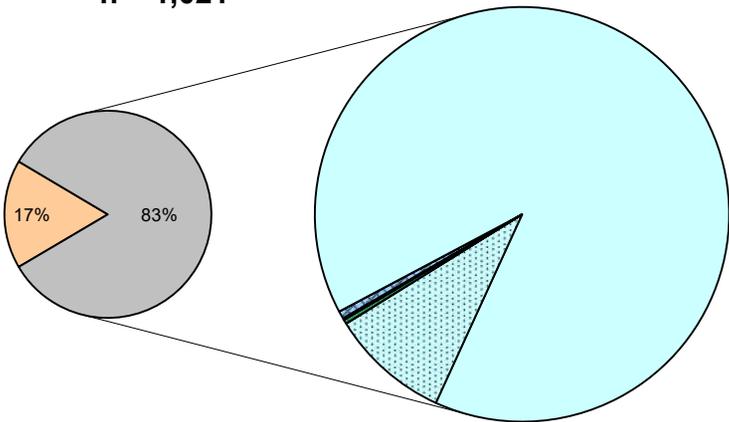
Upper Sacramento River winter carcass
n = 1,409



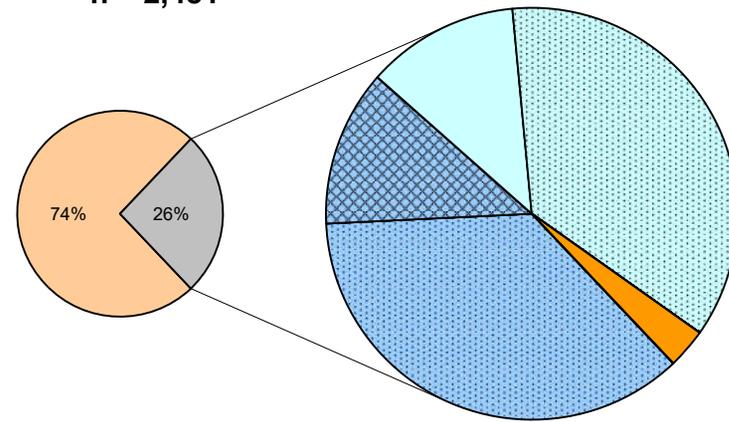
Upper Sacramento River fall carcass
n = 4,289



Battle Creek fall spawners
n = 1,021



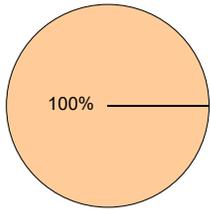
Clear Creek fall carcass
n = 2,481



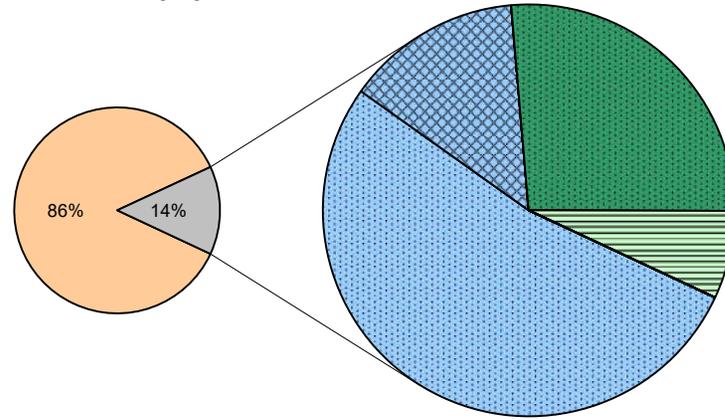
- Natural
- FRHFk
- FRHFh
- FRHFb
- FRHFnc
- NIMF
- NIMFn
- CFHFh
- CFHFh
- MOKF
- MOKFn
- MOKFnc
- MOKFb
- MERFt
- FRHS
- FRHSn
- SacW
- CFHLh
- nonCV

Figure 6. Proportion of hatchery- and natural-origin fish in Upper Sacramento River & tributaries, 2016.

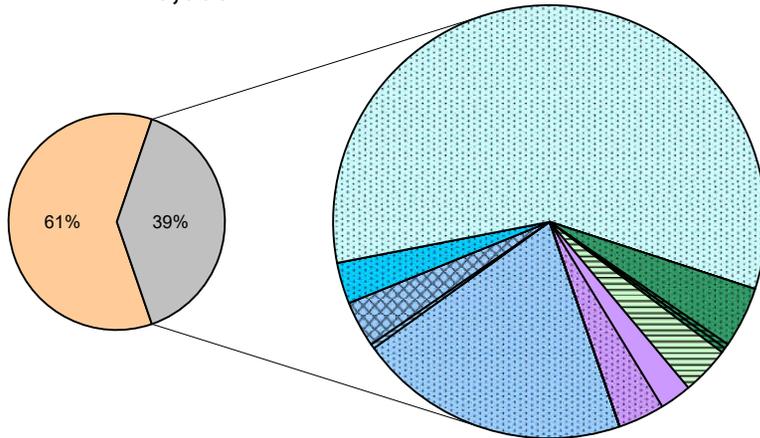
Butte Creek spring carcass
n = 5,731



Butte Creek fall carcass
n = 626



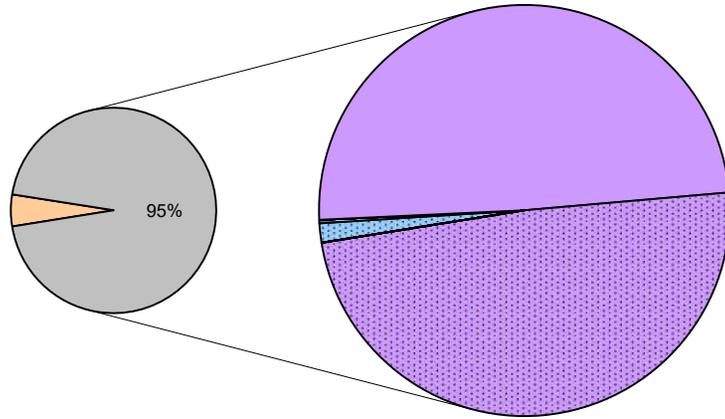
Yuba River fall carcass
n = 3,565



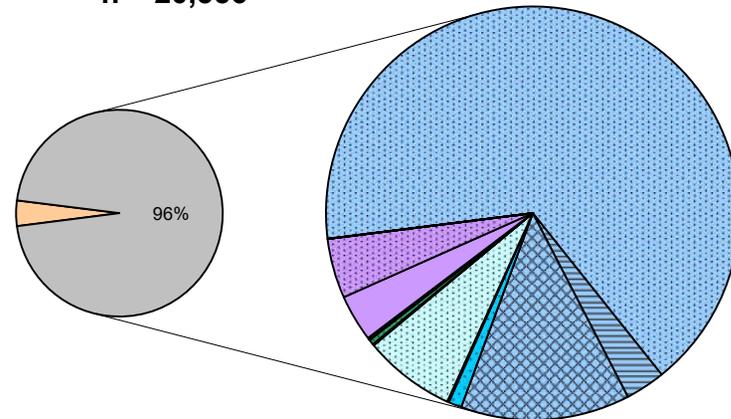
- Natural
- FRHFk
- FRHFfn
- FRHFfb
- FRHFnc
- NIMF
- NIMFn
- CFHFh
- CFHFfn
- MOKF
- MOKFn
- MOKFnc
- MOKFfb
- MERFt
- FRHS
- FRHSn
- SacW
- CFHLh
- nonCV

Figure 7. Proportion of hatchery- and natural-origin fish in Butte Creek & Yuba River, 2016.

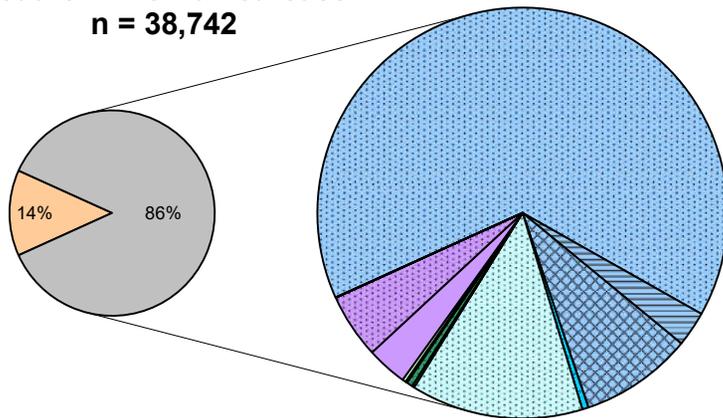
Feather River Hatchery spring
n = 1,650



Feather River Hatchery fall
n = 20,556



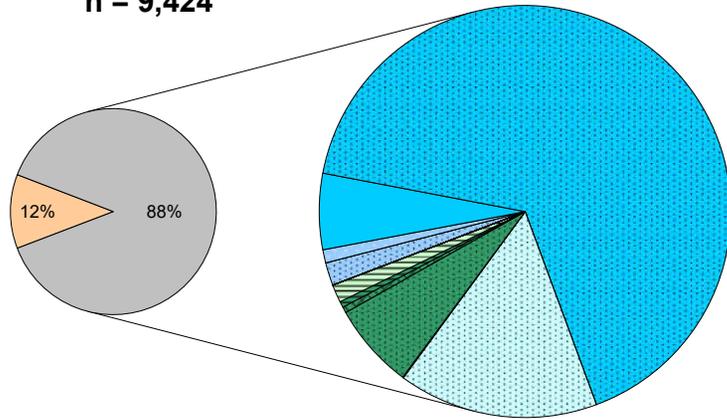
Feather River fall carcass
n = 38,742



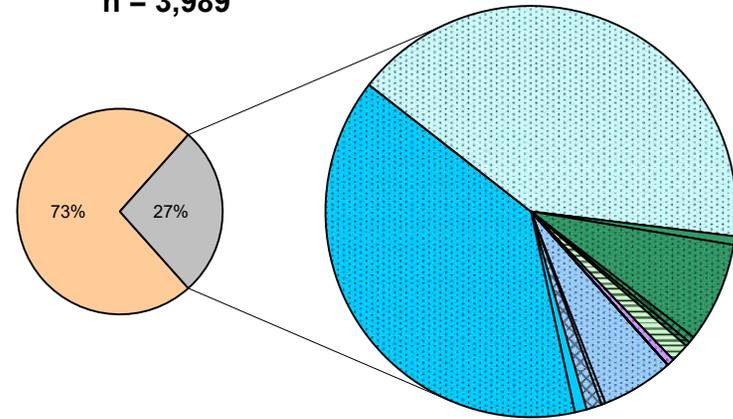
- Natural
 FRHFk
 FRHFfn
 FRHFb
 FRHFnc
 NIMF
 NIMFn
 CFHFh
 CFHFfn
 MOKF
- MOKFn
 MOKFnc
 MOKFb
 MERFt
 FRHS
 FRHSn
 SacW
 CFHLh
 nonCV

Figure 8. Proportion of hatchery- and natural-origin fish in the Feather River Basin, 2016.

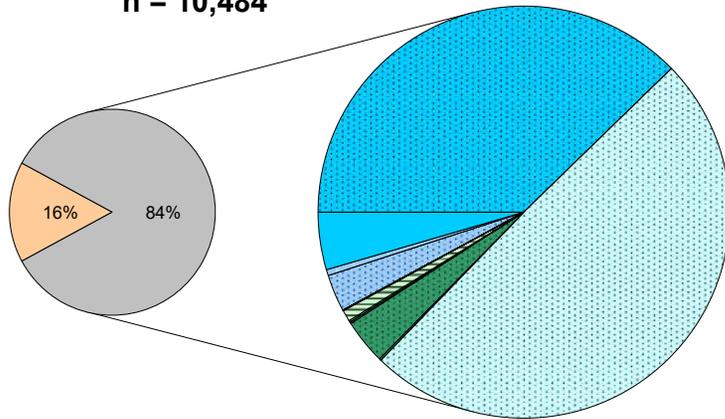
Nimbus Hatchery fall
n = 9,424



Nimbus Hatchery Weir
n = 3,989



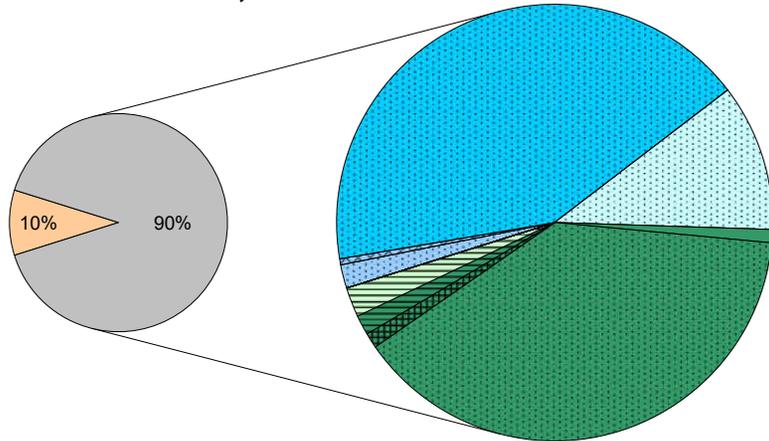
American River fall carcass
n = 10,484



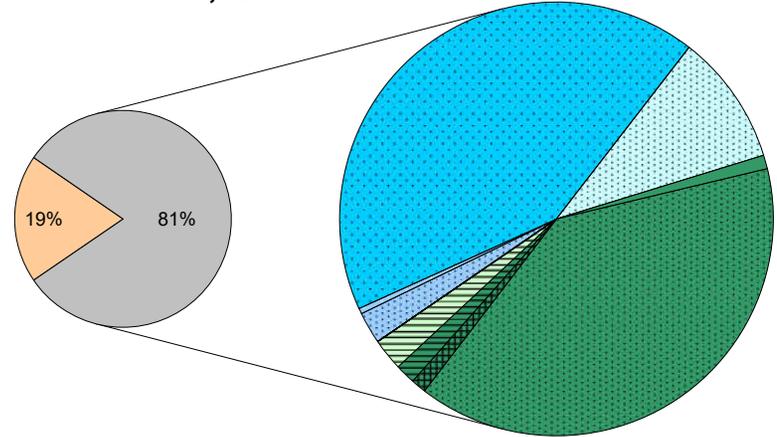
- Natural
 FRHFk
 FRHFfn
 FRHFfb
 FRHFfnc
 NIMF
 NIMFn
 CFHFh
 CFHFfn
 MOKF
- MOKFn
 MOKFnc
 MOKFb
 MERFt
 FRHS
 FRHSn
 SacW
 CFHLh
 nonCV

Figure 9. Proportion of hatchery- and natural-origin fish in the American River Basin, 2016.

Mokelumne Hatchery (MOK) fall
n = 6,887



Mokelumne River fall carcass^{a/}
n = 1,984

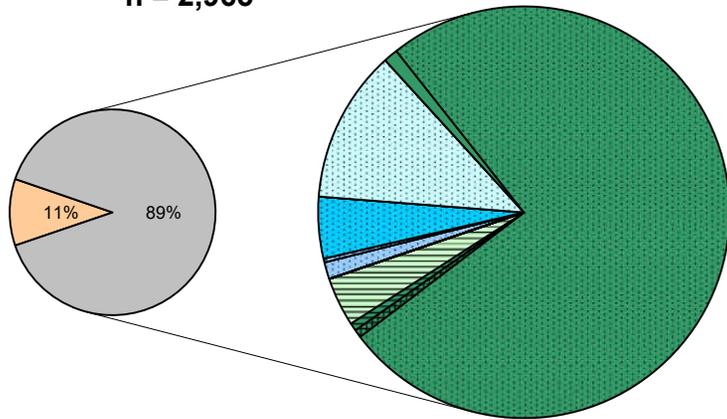


- Natural
 FRHFk
 FRHFfn
 FRHFfb
 FRHFfnc
 NIMF
 NIMFn
 CFHFh
 CFHFfn
 MOKF
- MOKFn
 MOKFnc
 MOKFb
 MERFt
 FRHS
 FRHSn
 SacW
 CFHLh
 nonCV

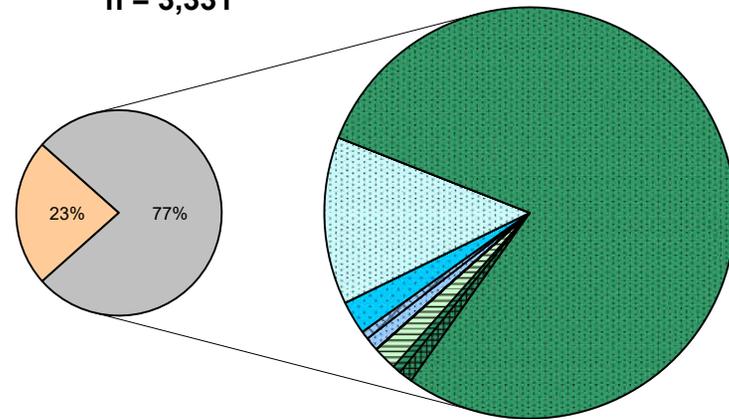
Figure 10. Proportion of hatchery- and natural-origin fish in the Mokelumne River Basin, 2016.

^{a/} Surrogates CWTs from MOK were used to determine the composition of the hatchery proportion in the Mokelumne River (see Appendix 4).

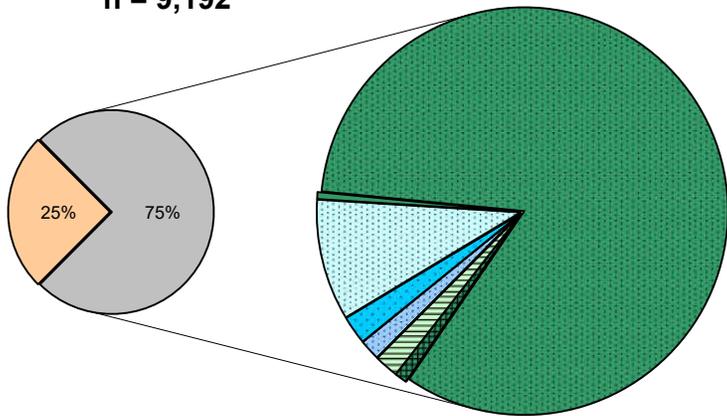
Merced River Hatchery fall
n = 2,965



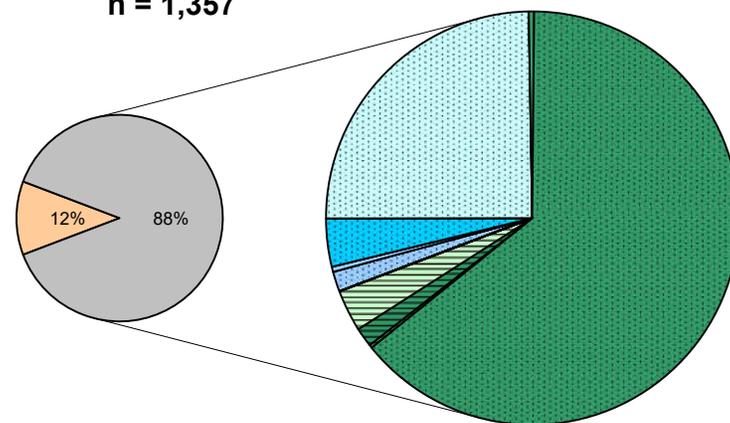
Merced River fall carcass
n = 3,331



Stanislaus River fall carcass
n = 9,192



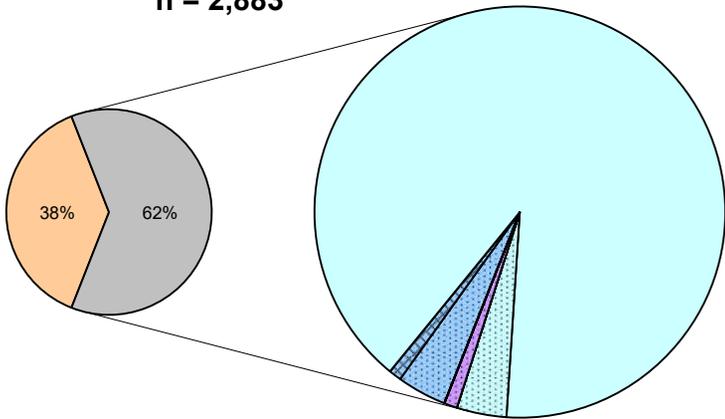
Tuolumne River fall carcass
n = 1,357



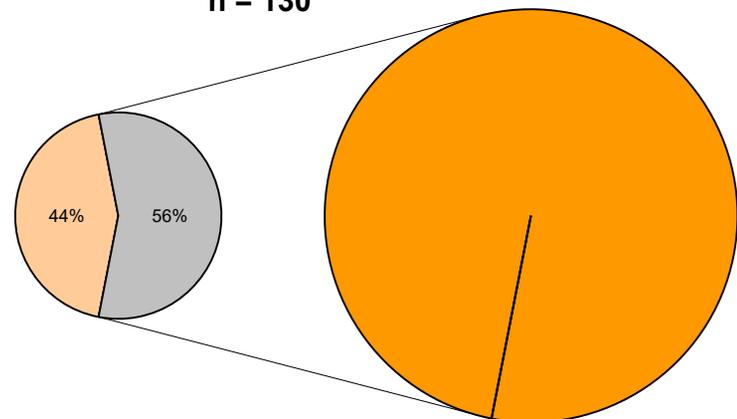
- Natural
- FRHFk
- FRHFfn
- FRHFb
- FRHFnc
- NIMF
- NIMFn
- CFHFh
- CFHFfn
- MOKF
- MOKFn
- MOKFnc
- MOKFb
- MERFt
- FRHS
- FRHSn
- SacW
- CFHLh
- nonCV

Figure 11. Proportion of hatchery- and natural-origin fish in Merced River & San Joaquin Basin tributaries, 2016.

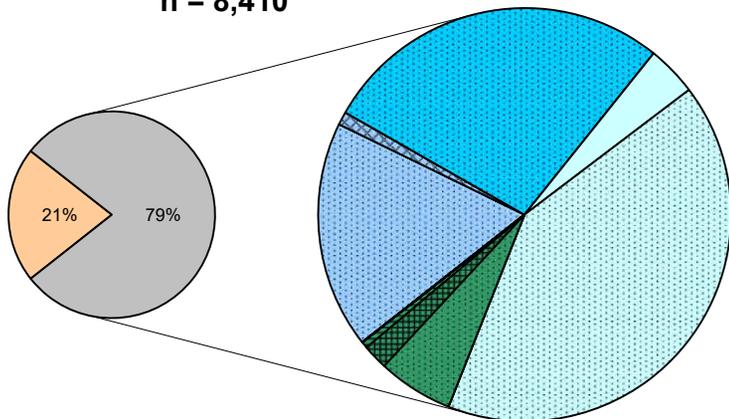
Upper Sacramento River fall creel
n = 2,883



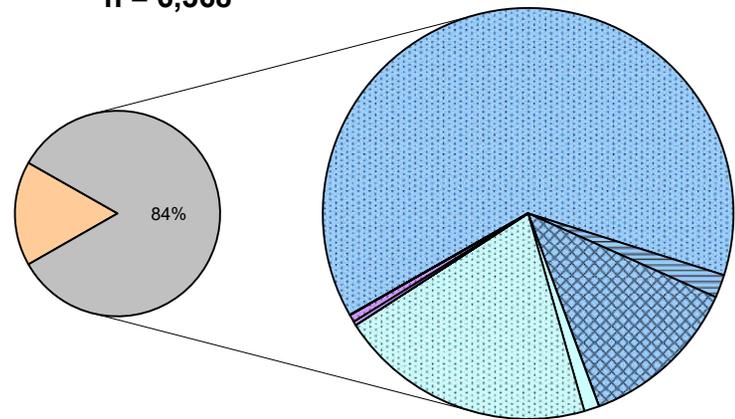
Upper Sacramento River late-fall creel 2017
n = 130



Lower Sacramento River fall creel
n = 8,410



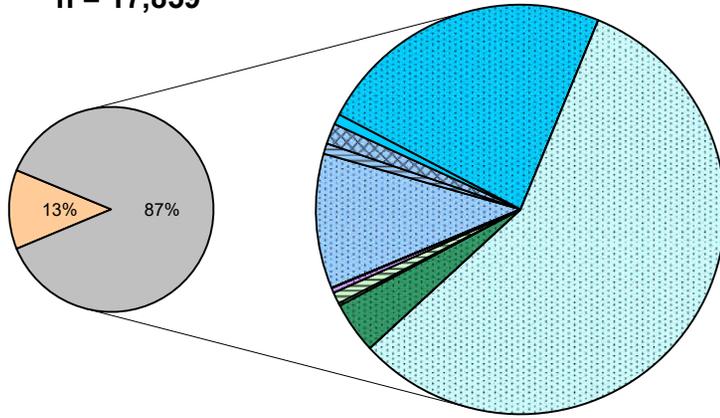
Feather River fall creel
n = 6,368



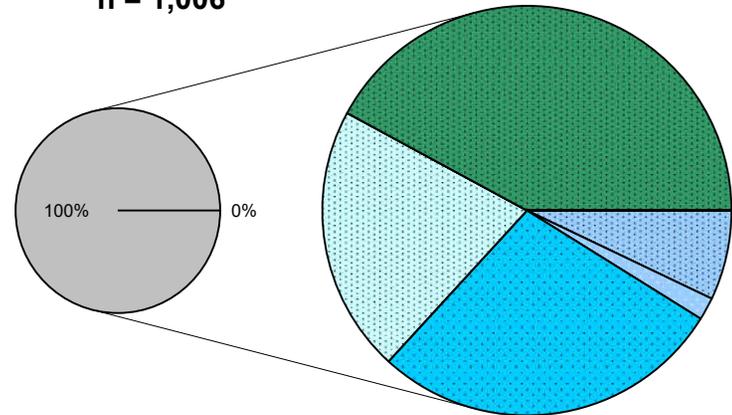
- Natural
 FRHFk
 FRHFfn
 FRHFfb
 FRHFfnc
 NIMF
 NIMFn
 CFHFh
 CFHFfn
 MOKF
- MOKFn
 MOKFnc
 MOKFb
 MERFt
 FRHS
 FRHSn
 SacW
 CFHLh
 nonCV

Figure 12. Proportion of hatchery- and natural-origin fish in sport harvest on Sacramento & Feather rivers, 2016.

American River fall creel
n = 17,859



Mokelumne River fall creel
n = 1,006



- Natural
- FRHFk
- FRHFfn
- FRHFb
- FRHFnc
- NIMF
- NIMFn
- CFHFh
- CFHFfn
- MOKF
- MOKFn
- MOKFnc
- MOKFb
- MERFt
- FRHS
- FRHSn
- SacW
- CFHLh
- nonCV

Figure 13. Proportion of hatchery- and natural-origin fish in sport harvest on American & Mokelumne rivers, 2016.

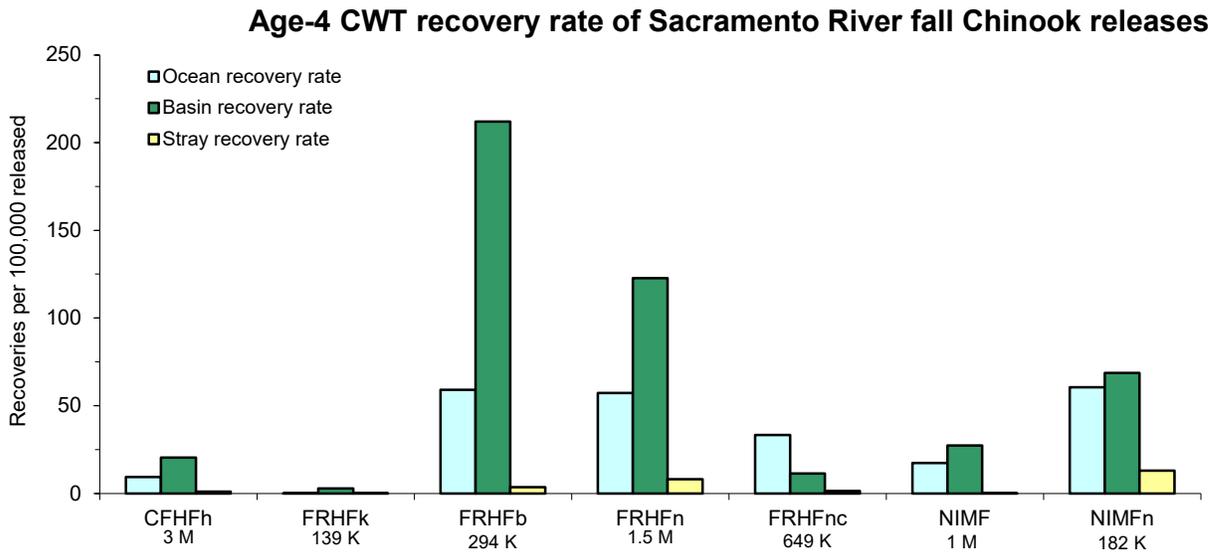
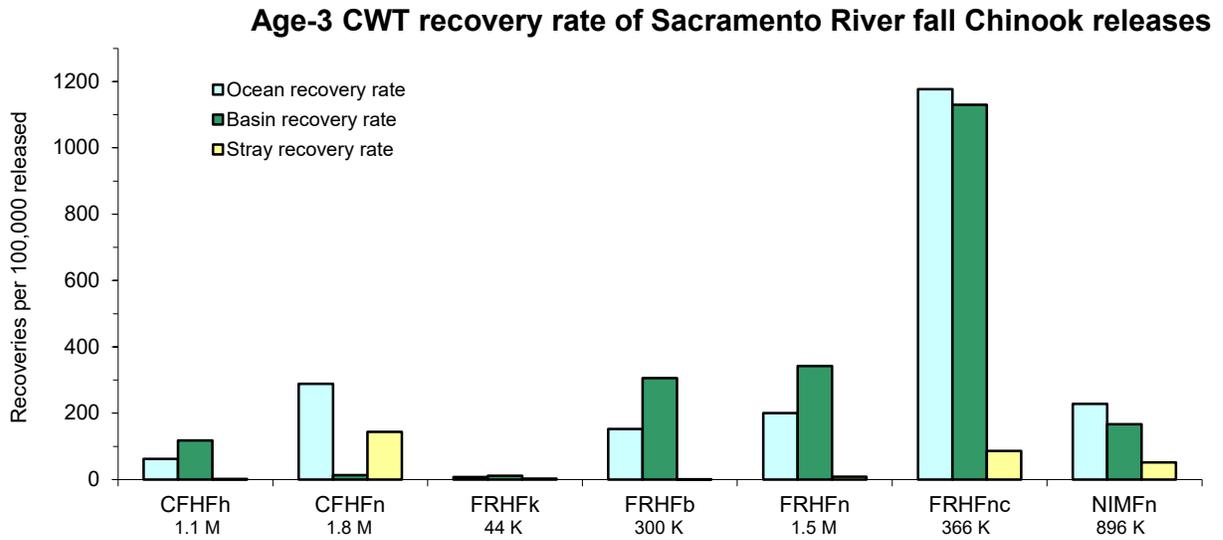
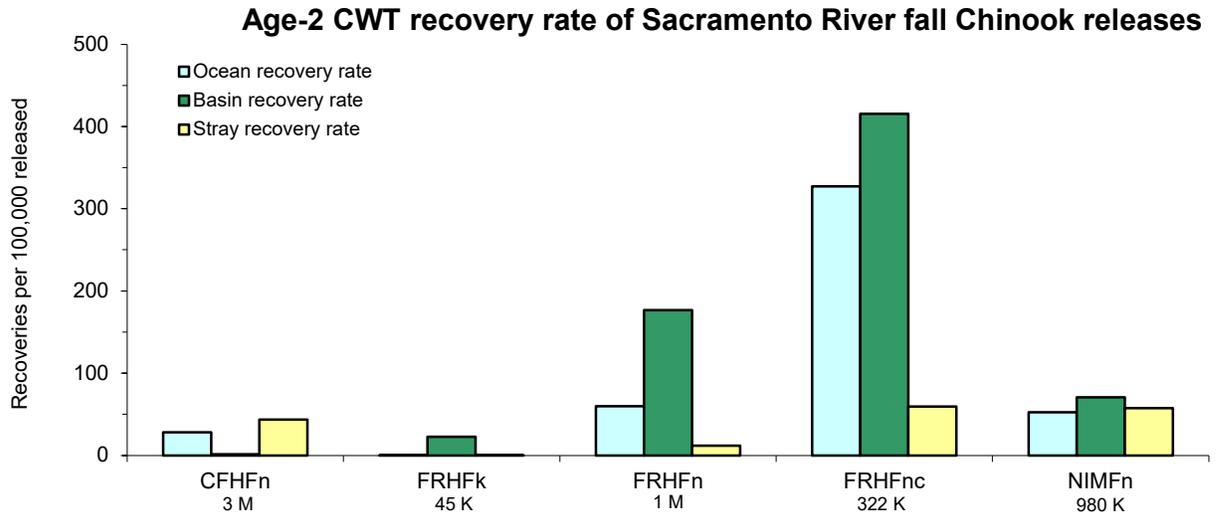


Figure 14. CWT recovery rates of Sacramento River fall Chinook releases by age in 2016.

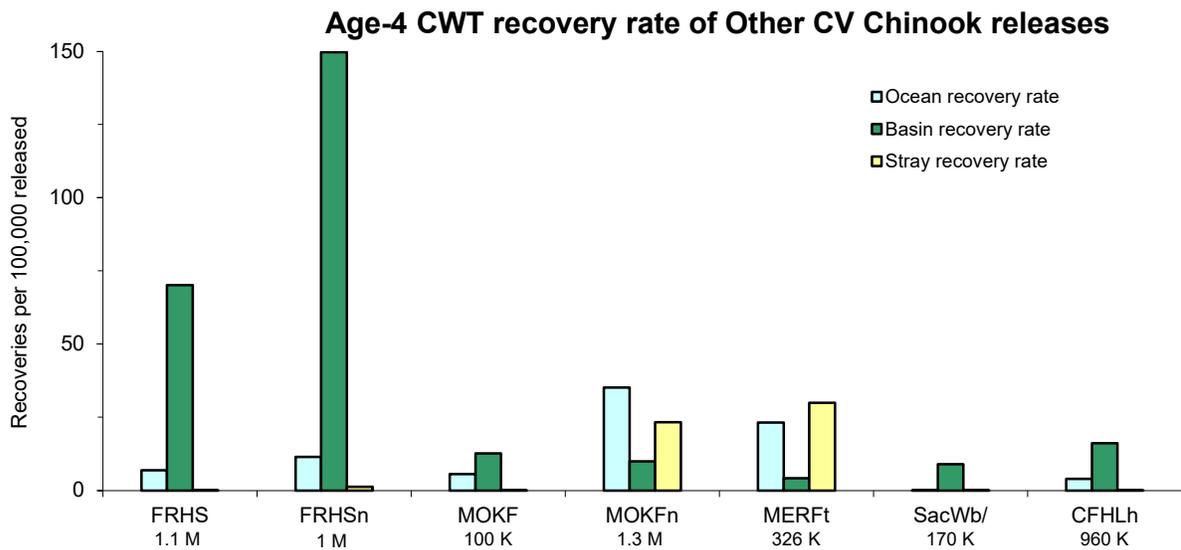
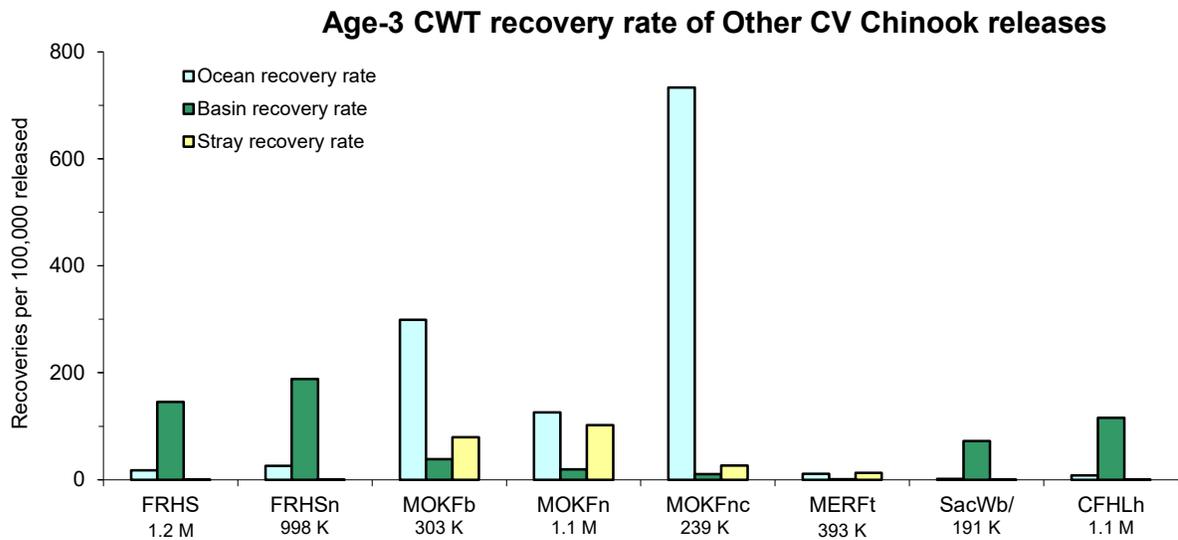
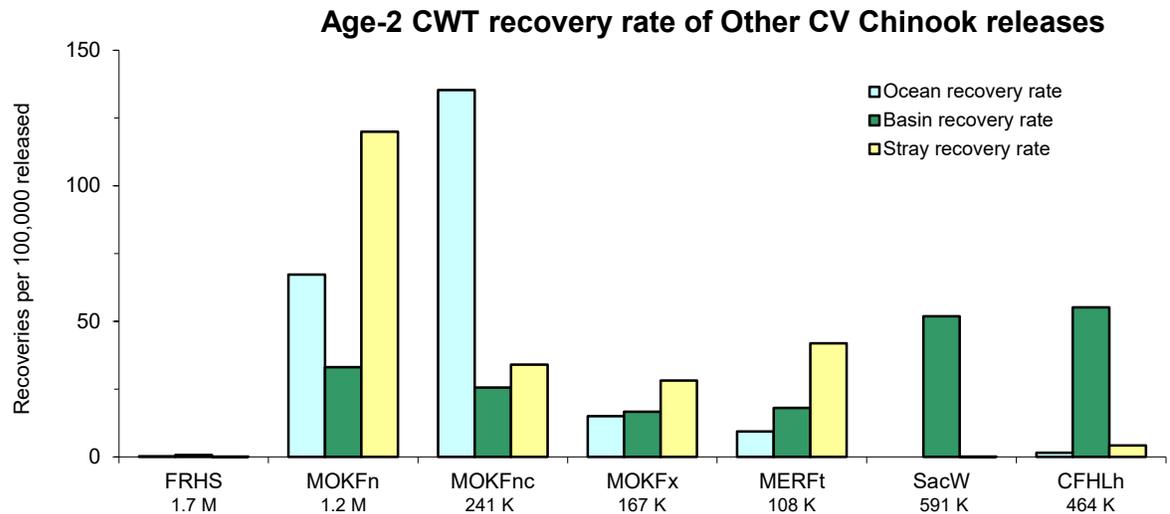
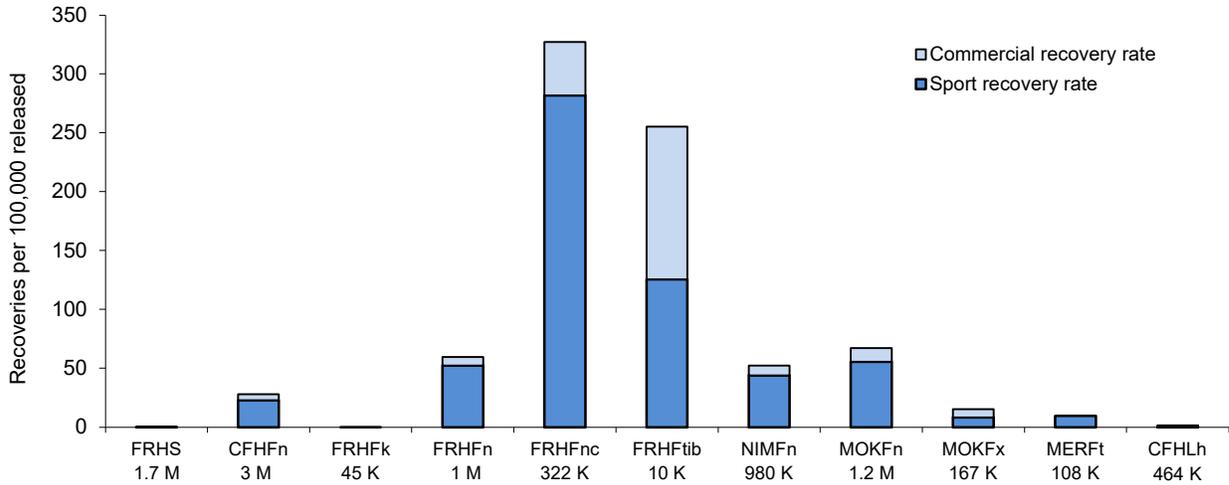
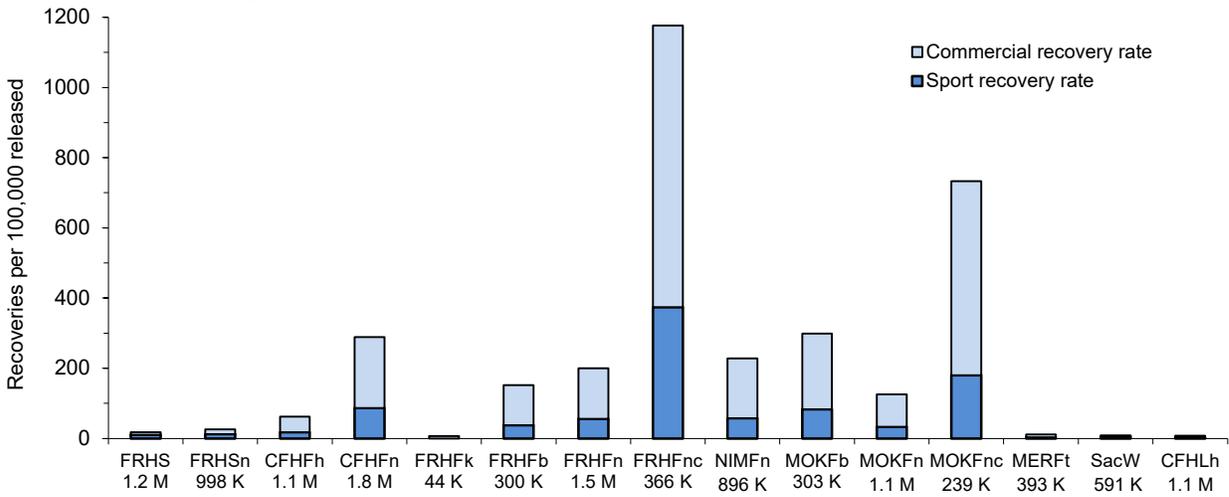


Figure 15. CWT recovery rates of Other CV Chinook releases by age in 2016.

Age-2 CWT recovery rate of CV releases in Ocean Fisheries



Age-3 CWT recovery rate of CV releases in Ocean Fisheries



Age-4 CWT recovery rate of CV releases in Ocean Fisheries

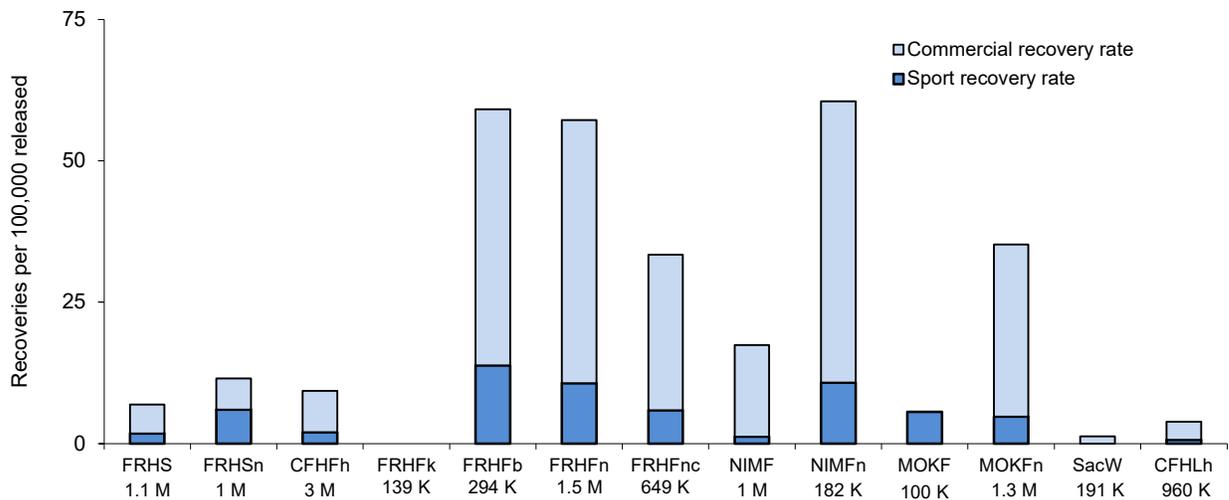
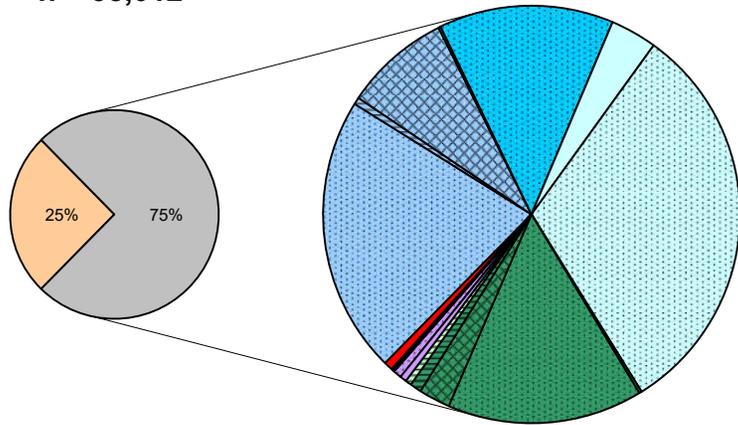
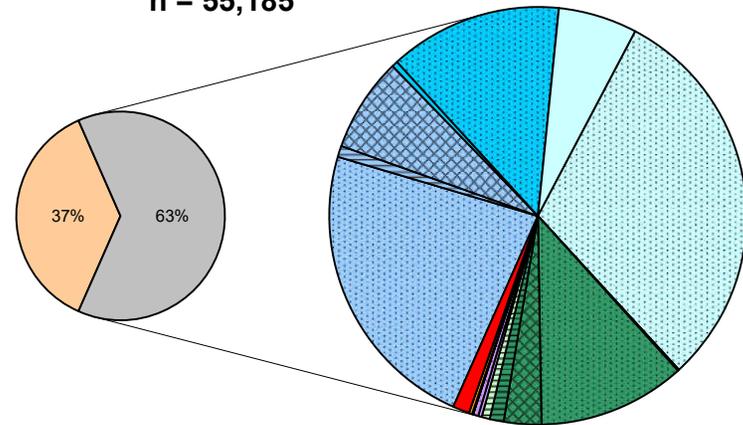


Figure 16. CWT recovery rates by release type in 2016 Ocean Salmon Fisheries.

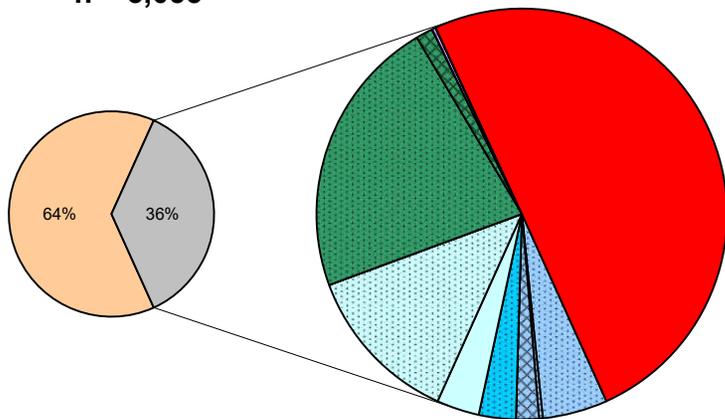
California Sport Harvest
n = 38,012



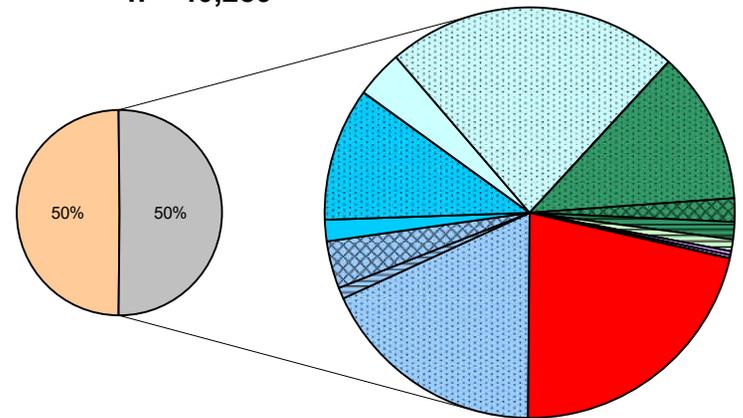
California Commercial Harvest
n = 55,185



Oregon Sport Harvest
n = 3,055



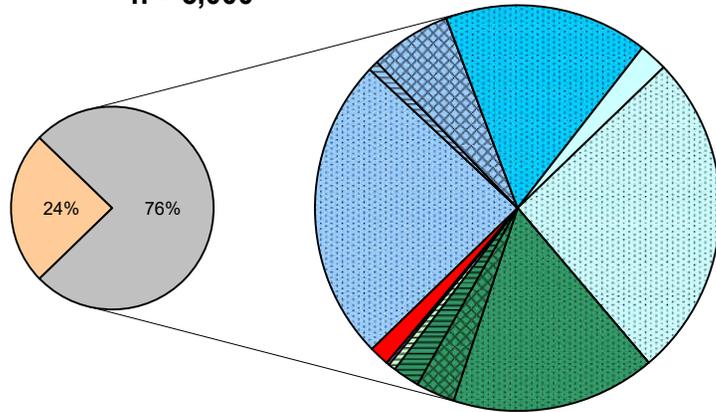
Oregon Commercial Harvest
n = 40,289



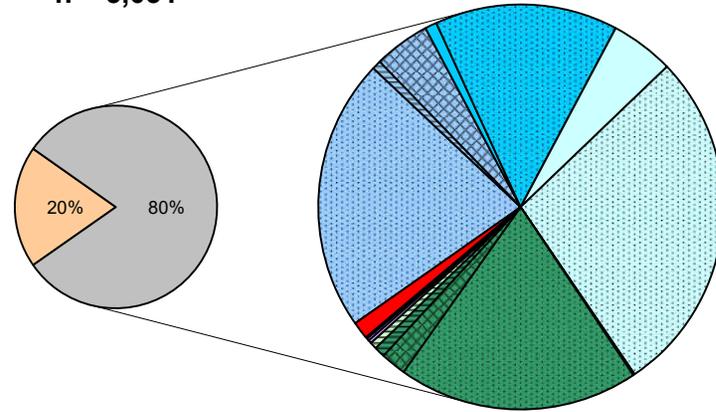
Natural
 FRHFk
 FRHFfn
 FRHFfb
 FRHFfc
 NIMF
 NIMFn
 CFHFh
 CFHFfn
 MOKF
 MOKFn
 MOKFnc
 MERFt
 FRHS
 FRHSn
 SacW
 CFHLh
 nonCV

Figure 17. Proportion of hatchery- and natural-origin salmon in 2016 California and Oregon ocean fisheries.

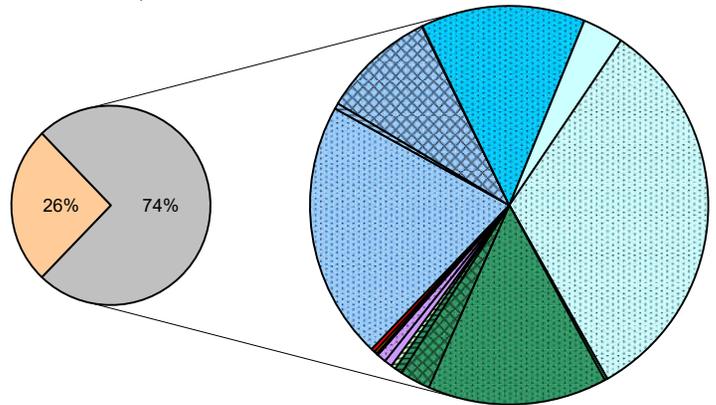
Eureka / Crescent City Sport
n = 5,000



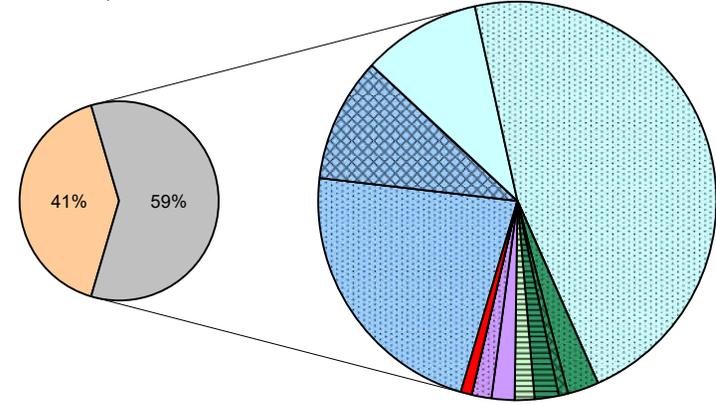
Fort Bragg Sport
n = 5,031



San Francisco Sport
n = 26,646



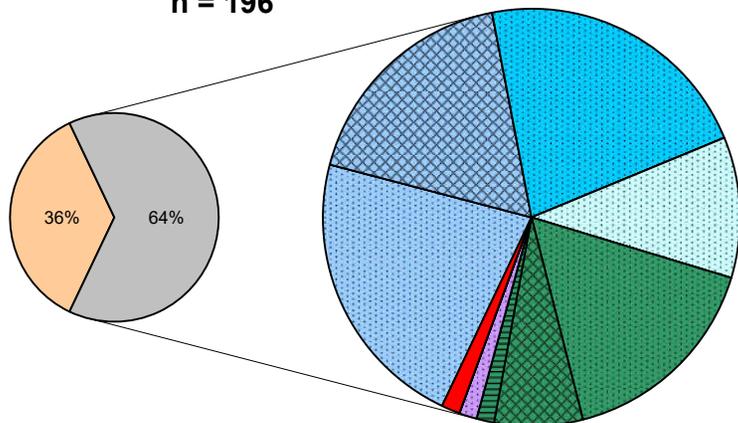
Monterey Sport
n = 1,335



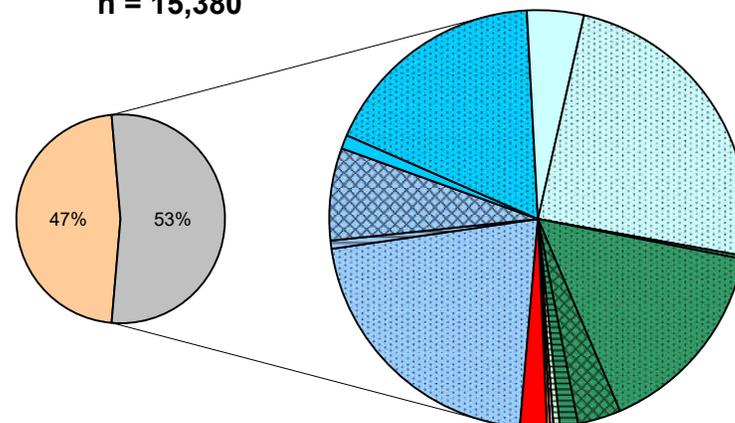
- Natural
 FRHFk
 FRHFfn
 FRHFfb
 FRHFfnc
 NIMF
 NIMFfn
 CFHFh
 CFHFfn
 MOKF
- MOKFfn
 MOKFfb
 MERFt
 FRHS
 FRHSn
 SacW
 CFHLh
 nonCV

Figure 18. Proportion of hatchery- and natural-origin salmon in the 2016 California ocean sport fishery.

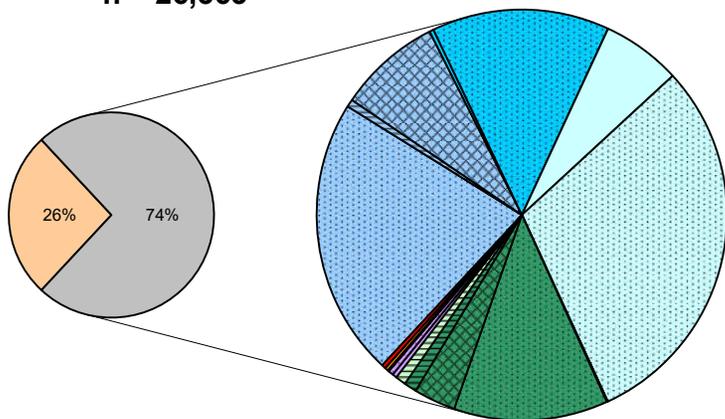
Eureka / Crescent City Commercial
n = 196



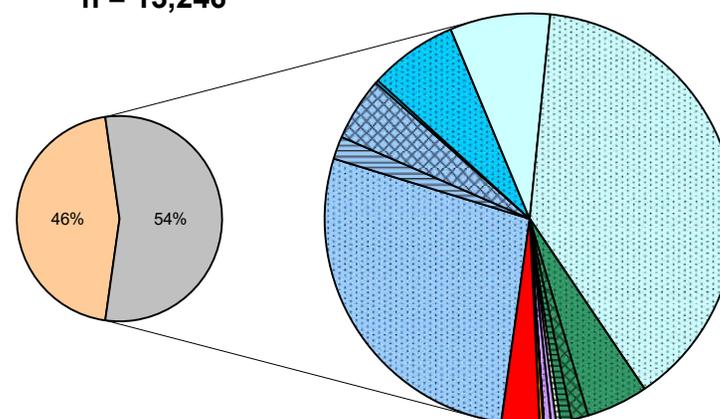
Fort Bragg Commercial
n = 15,380



San Francisco Commercial
n = 26,363



Monterey Commercial
n = 13,246



- Natural
 FRHFk
 FRHFfn
 FRHFfb
 FRHFfc
 NIMF
 NIMFn
 CFHFh
 CFHFfn
 MOKF
- MOKFn
 MOKFnc
 MOKFb
 MERFt
 FRHS
 FRHSn
 SacW
 CFHLh
 nonCV

Figure 19. Proportion of hatchery- and natural-origin salmon in the 2016 California ocean commercial fishery.

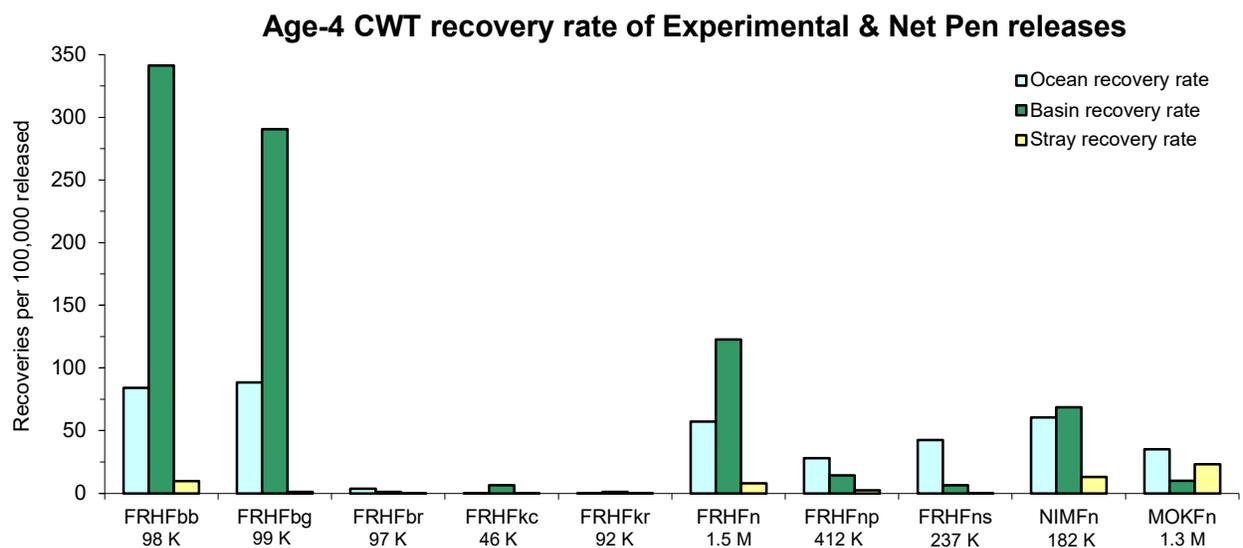
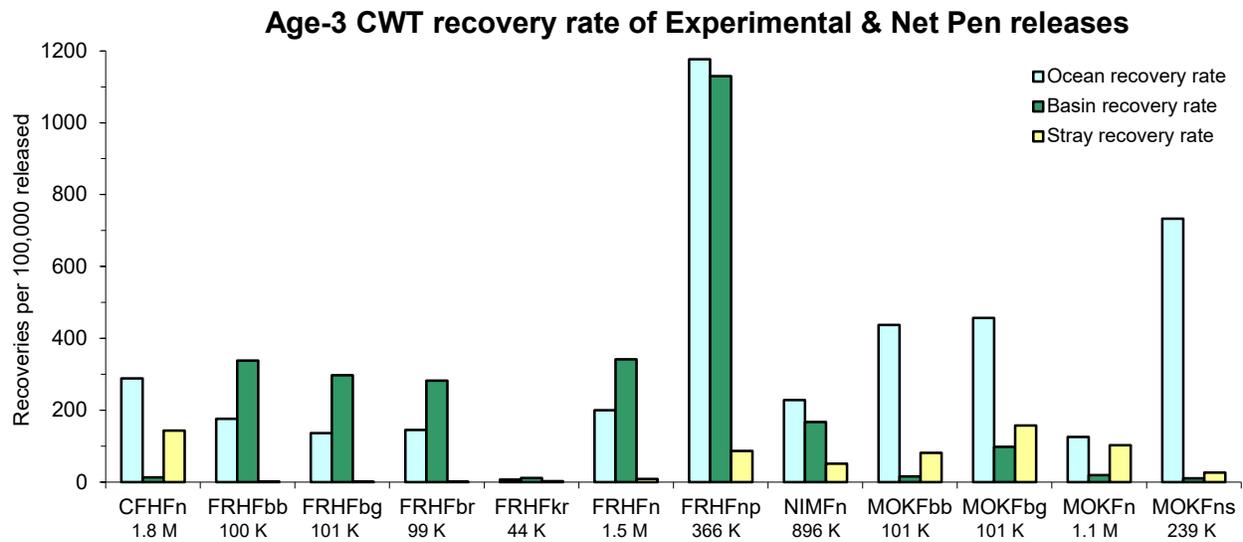
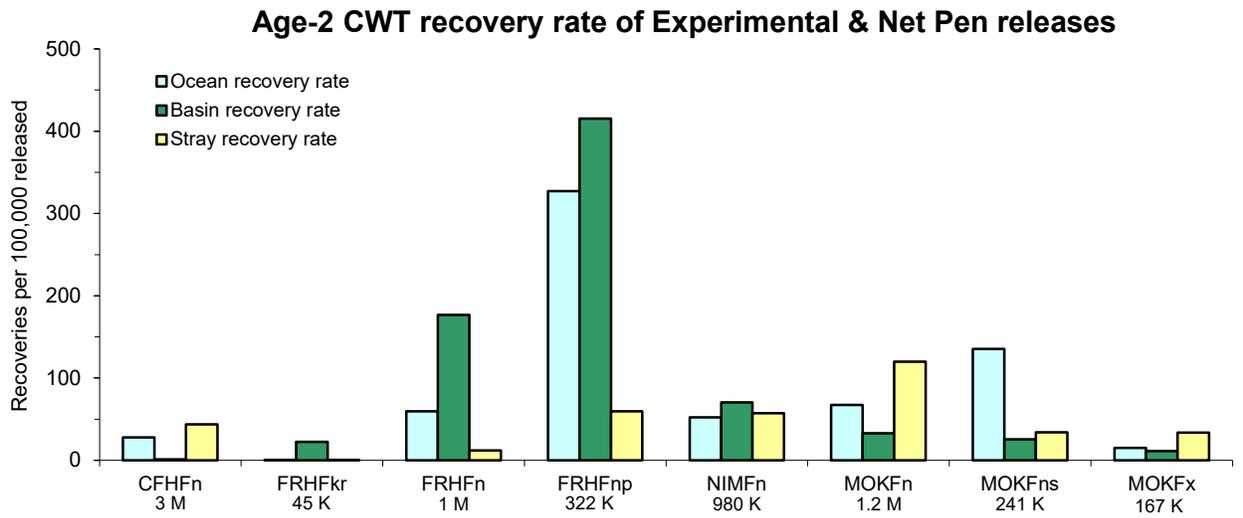


Figure 20. CWT recovery rates of Experimental and Net Pen releases by age in 2016.

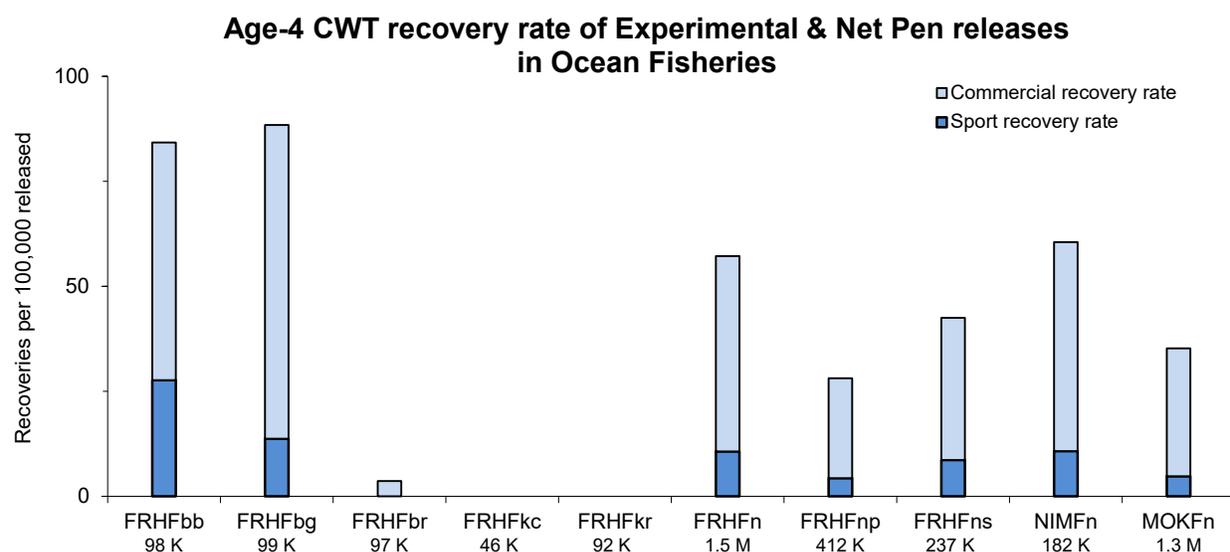
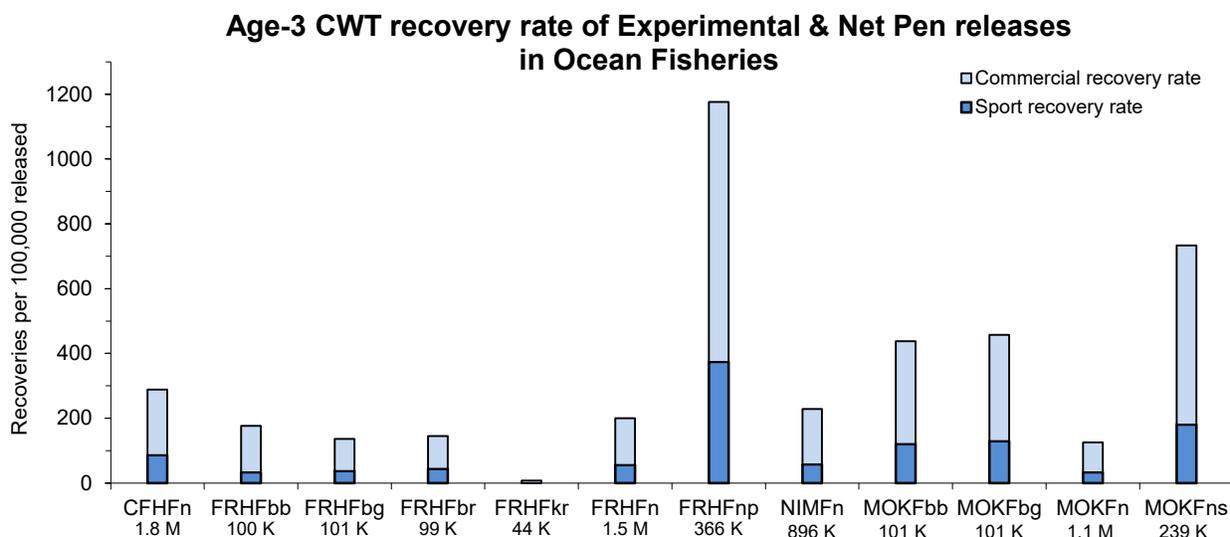
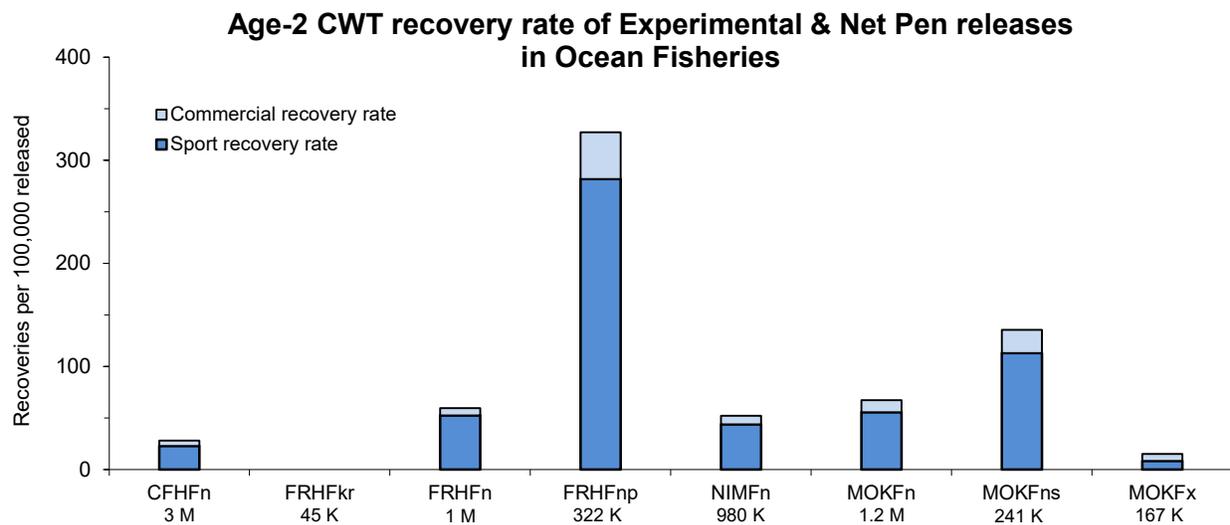


Figure 21. CWT recovery rates of Experimental and Net Pen releases in 2016 ocean sport and commercial fisheries

Appendix 1. Sample expansion factors for Central Valley salmon carcass surveys collecting fish condition in 2016. (page 1 of 2)

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 30%		217	5.1%	29	29	28	28	0.13	0.97	19.76	3.00	1,660	38.7%
nonfresh 70%		513	12.0%	33	33	32	31	0.06	0.97				
total	4,289	730	17.0%	62	62	60	59			9.38	3.00	1,660	38.7%

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 100%		139	5.6%	13	13	13	12	0.09	1.00	19.34	2.77	642	25.9%
nonfresh													
total	2,481	139	5.6%	13	13	13	12			19.34	2.77	642	25.9%

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

Condition	Escapement N	Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	Valid CWTs	p_{adc}	$p_{cwt adc}$	F_{samp}	Avg F_{prod}	$\sum_{i=1}^m CWT_{total,i}$	% hatchery
fresh 100%		3,840	9.9%	1,378	1,372	1,321	1321	0.36	0.96	10.13	2.50	33,507	86.5%
nonfresh													
total	38,742	3,840	9.9%	1,378	1,372	1,321	1,321			10.13	2.50	33,507	86.5%

Yuba River (above and below DPD) 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 100%		673	18.9%	88	87	86	86	0.13	0.99	5.36	3.05	1,408	39.5%
random													
total	3,565	673	18.9%	88	87	86	86			5.36	3.05	1,408	39.5%

Lower American River fall-run Chinook salmon carcass survey

Condition	Escapement N	Chinook sampled (n)	Sample rate	Observed ad-clips	Ad-clips processed	CWTs recovered	Valid CWTs	p_{adc}	$p_{cwt adc}$	F_{samp}	Avg F_{prod}	$\sum_{i=1}^m CWT_{total,i}$	% hatchery
fresh 18%		683	6.5%	156	156	149	149	0.23	0.96	15.35	3.86	8,827	84.2%
nonfresh 82%		3,078	29.4%	566	565	527	527	0.18	0.93				
total	10,484	3,761	35.9%	722	721	676	676			3.38	3.86	8,827	84.2%

Appendix 1. Sample expansion factors for Central Valley salmon carcass surveys collecting fish condition in 2016. (page 2 of 2)

Merced 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	100%	601	18.0%	126	125	123	123	0.21	0.98	5.59	3.72	2,560	76.9%
nonfresh													
total	3,331	601	18.0%	126	125	123	123			5.59	3.72	2,560	76.9%

Stanislaus 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	100%	763	8.3%	148	148	148	148	0.19	1.00	12.05	3.87	6,898	75.0%
weir CWTs				51	51	36	36						
total	9,192	763				184	184			9.69	3.87	6,898	75.0%

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	52%	594	43.8%	147	147	140	140	0.25	0.95	2.28	3.75	1,200	88.4%
nonfresh	48%	551	40.6%	67	67	59	59	0.12	0.88				
total	1,357	1,145	84.4%	214	214	199	199			1.61	3.75	1,200	88.4%

Upper Sacramento River winter-run Chinook salmon carcass survey 2017

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	57%	161	11.4%	42	41	40	40	0.26	0.98	8.97	1.02	367	26.0%
nonfresh	43%	123	8.7%	35	35	31	31	0.28	0.89				
total	1,409	284	20.2%	77	76	71	71			5.05	1.02	367	26.0%

p_{adc} = proportion of sampled fish that were ad-clipped; $p_{cwt|adc}$ = proportion of ad-clipped fish containing CWTs

Appendix 2. Alternative 2016 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 _{sample}) by basin										CV CWT _{sample} totals			% CV Stray	Ocean CWT _{sample}	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks ^{b/}	Fea	Yub	Ame	Mok	Mer	SJ	In-basin	Stray	CV total	In-basin			Stray	CV total	Ocean	
CFHFf	2014	Fall	2,951,944	35	3		212	32	619	127	115	179	35	1,288	1,323	97%	826	1	44	45	28	
CFHLh	2015	Late	463,924	254	2	19							254	21	275	8%	7	55	5	59	1	
FRHFf	2014	Fall	45,200				10						10	0	10	0%	0	22	0	22	0	
FRHFf	2014	Fall	1,047,852	3	6	19	1,841	11	44	22	6	23	1,841	135	1,976	7%	625	176	13	189	60	
FRHFnc	2014	Fall	321,527	27	33	32	1,314	21	58	21	18	2	1,314	213	1,527	14%	1,052	409	66	475	327	
FRHFtib	2014	Fall	10,336				62		1		6		62	7	69	10%	26	604	64	667	255	
FRHS	2014	Spr	1,690,972				11						11	0	11	0%	3	1	0	1	0	

Age 3 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT _{sample}) by basin										CV CWT _{sample} totals			% CV Stray	Ocean CWT _{sample}	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks ^{b/}	Fea	Yub	Ame	Mok	Mer	SJ	In-basin	Stray	CV total	In-basin			Stray	CV total	Ocean	
CFHFf	2013	Fall	1,125,706	1,233	98	19	6						1,233	124	1,357	9%	700	110	11	121	62	
CFHFf	2013	Fall	1,810,972	149	93	60	1,275	172	904	82	48	60	149	2,693	2,842	95%	5,228	8	149	157	289	
CFHLh	2014	Late	1,056,322	1,221	1								1,221	1	1,222	<1%	87	116	0	116	8	
FRHFf	2013	Fall	44,127				5						5	1	6	17%	3	11	2	14	7	
FRHFb	2013	Fall	300,145				913	5	2				913	7	920	1%	457	304	2	307	152	
FRHFf	2013	Fall	1,459,468		53	1	4,958	32	39	10	9	11	4,958	155	5,113	3%	2,921	340	11	350	200	
FRHFnc	2013	Fall	366,033	21	131	58	4,109	27	81	15	7	3	4,109	342	4,452	8%	4,306	1123	94	1216	1,176	
FRHFtib	2013	Fall	11,791		2		141						141	2	143	1%	109	1196	17	1213	922	
FRHS	2013	Spr	1,217,640				1,758	11					1,758	11	1,769	1%	218	144	1	145	18	
FRHSn	2013	Spr	997,962				1,864	16	6				1,864	22	1,886	1%	258	187	2	189	26	

0.001

Age 4 CWT recoveries

Release type	Brood year	Run type	# CWT tagged	Central Valley total recoveries (CWT _{sample}) by basin										CV CWT _{sample} totals			% CV Stray	Ocean CWT _{sample}	Recovery rate per 100K released			
				Bat Cr	Up Sac	Nat crks ^{b/}	Fea	Yub	Ame	Mok	Mer	SJ	In-basin	Stray	CV total	In-basin			Stray	CV total	Ocean	
CFHFf	2012	Fall	2,956,873	526	78	2							526	80	606	13%	274	18	3	21	9	
CFHFf	2013	Fall	1,810,972	149	93	60	1,275	172	904	82	48	60	149	2,693	2,842	95%	5,228	8	149	157	289	
CFHLh	2013	Late	960,075	155									155	0	155	0%	38	16	0	16	4	
FRHFf	2012	Fall	138,888				4						4	0	4	0%	0	3	0	3	0	
FRHFb	2012	Fall	293,784		9		623		1				623	10	633	2%	174	212	4	216	59	
FRHFf	2012	Fall	1,453,105		30	50	1,755	27	33	4			1,755	144	1,899	8%	832	121	10	131	57	
FRHFnc	2012	Fall	649,160		9		74						74	9	83	11%	217	11	1	13	33	
FRHFtib	2012	Fall	9,918				20	5					20	5	26	21%	0	204	54	258	0	
FRHS	2012	Spr	1,106,679				754	21					754	21	776	3%	77	68	2	70	7	
FRHSn	2012	Spr	1,015,285		9		1,488	32	3				1,488	45	1,533	3%	117	147	4	151	11	

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

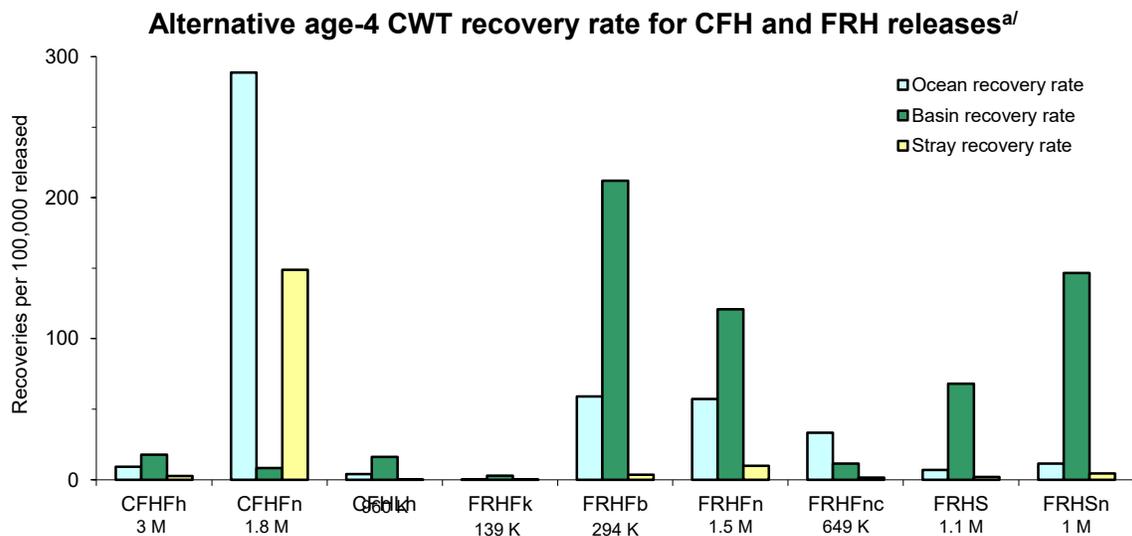
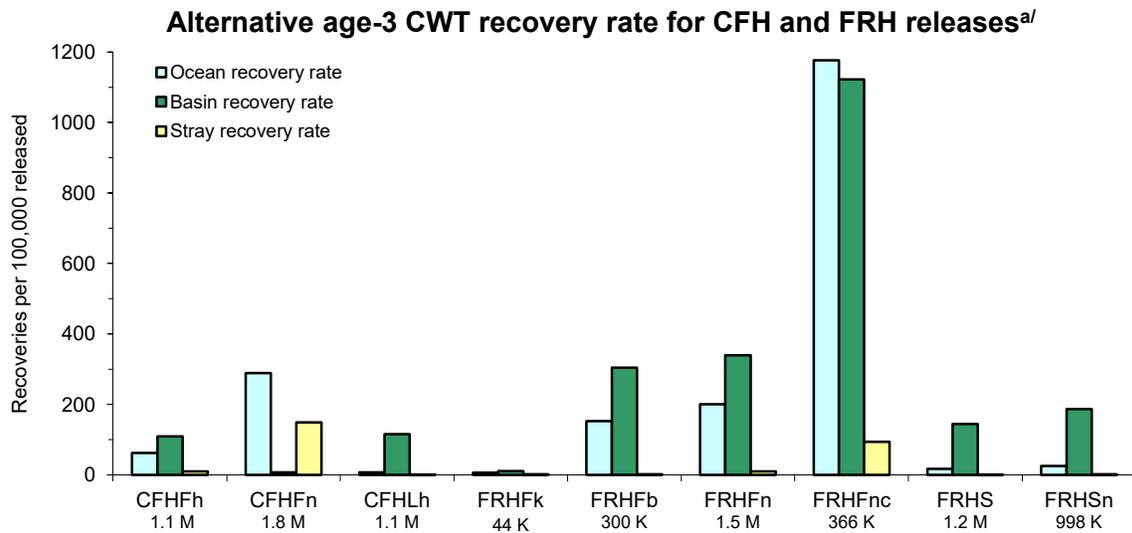
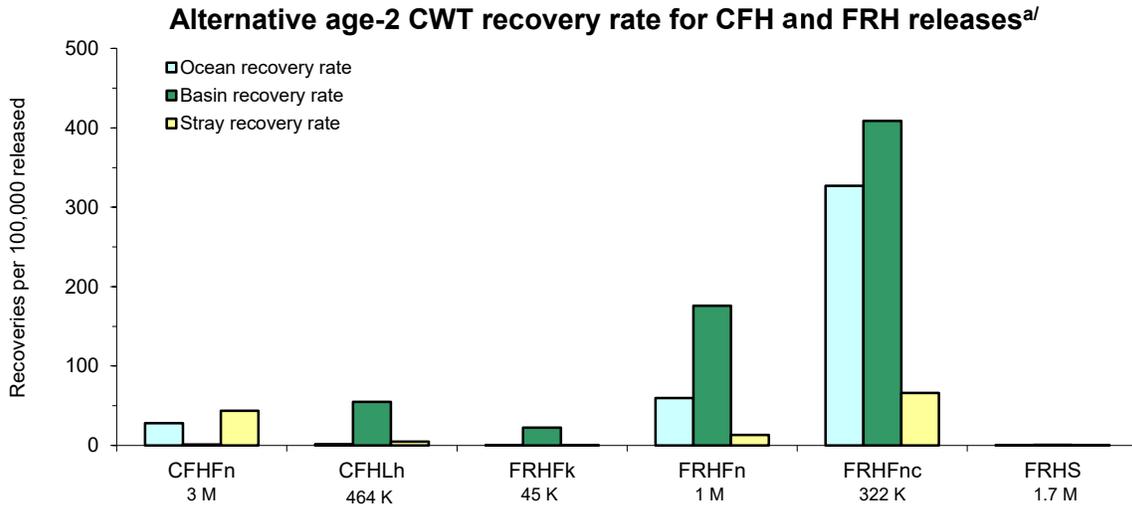
b/ Natural creeks can include Clear Creek, Cow Creek, Cottonwood Creek, Paynes Creek, Mill Creek, Deer Creek and Butte Creek, depending on survey year.

Sacramento River fall Chinook release types (SFC)

CFHFf	Coleman National Fish Hatchery fall hatchery releases
CFHFf	Coleman National Fish Hatchery fall bay net pen releases
FRHFf	Feather River Hatchery fall Knaggs Ranch experimental releases
FRHFb	Feather River Hatchery fall barge study releases
FRHFf	Feather River Hatchery fall bay net pen releases
FRHFnc	Feather River Hatchery fall coastal net pen releases (Pillar Point)
FRHFtib	Feather River Hatchery fall Tiburon net pen releases

Other CV Chinook release types (OCV)

FRHS	Feather River Hatchery spring in-basin releases
FRHSn	Feather River Hatchery spring bay net pen releases
CFHLh	Coleman National Fish Hatchery late fall hatchery releases



Appendix 3. Alternative CWT recovery rates for CFH and FRH releases by age in 2016.
 a/ CFH and FRH releases recovered in the Upper Sacramento River and Yuba River, respectively, considered stray recoveries.

Appendix 4. Sample expansion for surrogate CWTs in Mokelumne River above Woodbridge Dam (WD) based on video data, 2016.(page 1 of 2)

	Known ad status		% adclip		tot_val
	Total				
Woodbridge Dam video	8,871	2,197	24.8%		
MRFI return	6,887	1,748	25.4%	1748	1709
Natural Escapement Mokelumne R	1,984	449	22.6%	1,000	0.978

Mokelumne River natural escapement above WD: Total video count minus MRFI with supplemental carcass survey CWT data

Escapement	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	$\sum_{i=1}^n CWT_{total,i}$	% hatchery
N	1,984	100%	449	449	439	439	0.226	0.978	1.00	3.66	1,604	81%

Surrogate Mokelumne Hatchery (MOK) CWTs

catchy	cs_id	brdyr	age	relgroup	hatch_grp	cwtcode	prodfct	estnum	CWT_total	MOK_prop
2016	54MOK316	2014	2	OCV	MERFt	60715	3.85	3.34	12.86	0.8%
2016	54MOK316	2014	2	OCV	MERFt	60716	3.90	2.31	9.01	0.5%
2016	54MOK316	2014	2	OCV	MERFt	60717	4.11	0.51	2.10	0.1%
2016	54MOK316	2014	2	OCV	MOKFn	60674	4.02	6.16	24.76	1.4%
2016	54MOK316	2014	2	OCV	MOKFn	60553	4.00	4.62	18.48	1.1%
2016	54MOK316	2014	2	OCV	MOKFn	60669	4.02	6.16	24.76	1.4%
2016	54MOK316	2014	2	OCV	MOKFn	60670	4.01	4.37	17.52	1.0%
2016	54MOK316	2014	2	OCV	MOKFn	60671	4.02	9.25	37.19	2.1%
2016	54MOK316	2014	2	OCV	MOKFn	60672	4.02	11.82	47.52	2.7%
2016	54MOK316	2014	2	OCV	MOKFn	60673	4.02	10.28	41.33	2.3%
2016	54MOK316	2014	2	OCV	MOKFn	60675	4.04	4.37	17.65	1.0%
2016	54MOK316	2014	2	OCV	MOKFn	60676	4.01	15.41	61.79	3.5%
2016	54MOK316	2014	2	OCV	MOKFn	60677	4.01	7.96	31.92	1.8%
2016	54MOK316	2014	2	OCV	MOKFn	60678	4.01	2.05	8.22	0.5%
2016	54MOK316	2014	2	OCV	MOKFn	60710	4.00	0.26	1.04	0.1%
2016	54MOK316	2014	2	OCV	MOKFn	68737	4.01	1.03	4.13	0.2%
2016	54MOK316	2014	2	OCV	MOKFnc	60661	1.01	12.59	12.72	2.9%
2016	54MOK316	2014	2	OCV	MokFw	60370	1.00	0.26	0.26	0.1%
2016	54MOK316	2014	2	OCV	MokFw	60371	1.00	0.26	0.26	0.1%
2016	54MOK316	2014	2	OCV	MokFw	69204	1.00	0.26	0.26	0.1%
2016	54MOK316	2014	2	OCV	MOKFx	60718	3.95	1.54	6.08	0.4%
2016	54MOK316	2014	2	OCV	MOKFx	60719	3.11	2.31	7.18	0.5%
2016	54MOK316	2014	2	SFC	CFHFn	55811	4.03	4.11	16.56	0.9%
2016	54MOK316	2014	2	SFC	CFHFn	55780	4.01	1.03	4.13	0.2%
2016	54MOK316	2014	2	SFC	CFHFn	55781	4.00	0.26	1.04	0.1%
2016	54MOK316	2014	2	SFC	CFHFn	55782	4.00	1.03	4.12	0.2%
2016	54MOK316	2014	2	SFC	CFHFn	55783	4.00	0.51	2.04	0.1%
2016	54MOK316	2014	2	SFC	CFHFn	55784	4.00	0.26	1.04	0.1%
2016	54MOK316	2014	2	SFC	CFHFn	55785	4.00	1.03	4.12	0.2%
2016	54MOK316	2014	2	SFC	CFHFn	55787	4.01	0.51	2.05	0.1%
2016	54MOK316	2014	2	SFC	CFHFn	55788	4.01	0.26	1.04	0.1%
2016	54MOK316	2014	2	SFC	CFHFn	55790	4.00	1.29	5.16	0.3%
2016	54MOK316	2014	2	SFC	CFHFn	55791	4.00	0.51	2.04	0.1%
2016	54MOK316	2014	2	SFC	CFHFn	55793	4.00	0.26	1.04	0.1%
2016	54MOK316	2014	2	SFC	CFHFn	55794	4.00	0.51	2.04	0.1%
2016	54MOK316	2014	2	SFC	CFHFn	55795	4.00	0.77	3.08	0.2%
2016	54MOK316	2014	2	SFC	CFHFn	55796	4.00	0.51	2.04	0.1%
2016	54MOK316	2014	2	SFC	CFHFn	55797	4.01	0.26	1.04	0.1%
2016	54MOK316	2014	2	SFC	CFHFn	55804	4.01	0.26	1.04	0.1%
2016	54MOK316	2014	2	SFC	CFHFn	55805	4.06	2.83	11.49	0.6%
2016	54MOK316	2014	2	SFC	CFHFn	55806	4.01	1.03	4.13	0.2%
2016	54MOK316	2014	2	SFC	CFHFn	55807	4.03	1.03	4.15	0.2%
2016	54MOK316	2014	2	SFC	CFHFn	55808	4.04	1.03	4.16	0.2%
2016	54MOK316	2014	2	SFC	CFHFn	55809	4.02	1.29	5.19	0.3%
2016	54MOK316	2014	2	SFC	CFHFn	55810	4.05	6.16	24.95	1.4%
2016	54MOK316	2014	2	SFC	FRHFn	60656	4.04	0.51	2.06	0.1%
2016	54MOK316	2014	2	SFC	FRHFn	60657	3.96	0.51	2.02	0.1%
2016	54MOK316	2014	2	SFC	FRHFn	60658	4.00	3.34	13.36	0.8%
2016	54MOK316	2014	2	SFC	FRHFn	60662	1.03	4.37	4.50	1.0%
2016	54MOK316	2014	2	SFC	NIMFn	60663	4.00	18.24	72.96	4.2%
2016	54MOK316	2014	2	SFC	NIMFn	60664	4.01	18.24	73.14	4.2%
2016	54MOK316	2014	2	SFC	NIMFn	60665	4.01	22.09	88.58	5.0%
2016	54MOK316	2014	2	SFC	NIMFn	60666	4.00	28.26	113.04	6.4%
2016	54MOK316	2014	2	SFC	NIMFn	60667	4.04	8.73	35.27	2.0%
2016	54MOK316	2014	2	SFC	NIMFn	60668	4.03	4.88	19.67	1.1%
2016	54MOK316	2013	3	OCV	MERFt	60629	4.85	0.77	3.73	0.2%
2016	54MOK316	2013	3	OCV	MERFt	60630	2.37	0.77	1.82	0.2%
2016	54MOK316	2013	3	OCV	MOKFbb	60570	1.00	3.34	3.34	0.8%

Surrogate Mokelumne Hatchery (MOK) CWTs continue

catchy	cs_id	brdyr	age	relgroup	hatch_grp	cwtcode	profct	estnum	CWT _{total}	MOK_prop
2016	54MOK316	2013	3	OCV	MOKFbg	60593	1.00	20.29	20.29	4.6%
2016	54MOK316	2013	3	OCV	MOKFn	60595	4.03	1.54	6.21	0.4%
2016	54MOK316	2013	3	OCV	MOKFn	60526	4.00	0.26	1.04	0.1%
2016	54MOK316	2013	3	OCV	MOKFn	60584	4.00	3.60	14.40	0.8%
2016	54MOK316	2013	3	OCV	MOKFn	60585	4.01	8.73	35.01	2.0%
2016	54MOK316	2013	3	OCV	MOKFn	60586	4.01	6.42	25.74	1.5%
2016	54MOK316	2013	3	OCV	MOKFn	60587	4.01	6.16	24.70	1.4%
2016	54MOK316	2013	3	OCV	MOKFn	60588	4.00	6.16	24.64	1.4%
2016	54MOK316	2013	3	OCV	MOKFn	60589	4.00	8.22	32.88	1.9%
2016	54MOK316	2013	3	OCV	MOKFn	60590	4.01	2.83	11.35	0.6%
2016	54MOK316	2013	3	OCV	MOKFn	60591	4.01	0.51	2.05	0.1%
2016	54MOK316	2013	3	OCV	MOKFn	60596	4.01	0.77	3.09	0.2%
2016	54MOK316	2013	3	OCV	MOKFnc	60617	1.01	5.14	5.19	1.2%
2016	54MOK316	2013	3	SFC	CFHFn	55691	4.01	1.80	7.22	0.4%
2016	54MOK316	2013	3	SFC	CFHFn	55692	4.01	1.03	4.13	0.2%
2016	54MOK316	2013	3	SFC	CFHFn	55693	4.00	2.31	9.24	0.5%
2016	54MOK316	2013	3	SFC	CFHFn	55694	4.01	1.29	5.17	0.3%
2016	54MOK316	2013	3	SFC	CFHFn	55695	4.01	0.51	2.05	0.1%
2016	54MOK316	2013	3	SFC	CFHFn	55696	4.03	1.03	4.15	0.2%
2016	54MOK316	2013	3	SFC	CFHFn	55697	4.00	0.77	3.08	0.2%
2016	54MOK316	2013	3	SFC	CFHFn	55704	4.00	1.29	5.16	0.3%
2016	54MOK316	2013	3	SFC	CFHFn	55705	4.06	1.29	5.24	0.3%
2016	54MOK316	2013	3	SFC	CFHFn	55706	4.03	1.29	5.20	0.3%
2016	54MOK316	2013	3	SFC	CFHFn	55707	4.00	3.85	15.40	0.9%
2016	54MOK316	2013	3	SFC	FRHFkr	601020808	1.00	0.26	0.26	0.1%
2016	54MOK316	2013	3	SFC	FRHFfn	60564	4.00	0.51	2.04	0.1%
2016	54MOK316	2013	3	SFC	FRHFfn	60565	4.08	0.51	2.08	0.1%
2016	54MOK316	2013	3	SFC	FRHFfn	60566	4.09	0.51	2.09	0.1%
2016	54MOK316	2013	3	SFC	FRHFfn	68042	4.04	0.26	1.05	0.1%
2016	54MOK316	2013	3	SFC	FRHFfnp	60618	1.01	2.83	2.86	0.6%
2016	54MOK316	2013	3	SFC	NIMFn	60575	4.00	4.62	18.48	1.1%
2016	54MOK316	2013	3	SFC	NIMFn	60579	4.01	16.95	67.97	3.9%
2016	54MOK316	2013	3	SFC	NIMFn	60580	4.00	26.46	105.84	6.0%
2016	54MOK316	2013	3	SFC	NIMFn	60581	4.00	17.47	69.88	4.0%
2016	54MOK316	2012	4	OCV	MERFt	60435	3.13	0.26	0.81	0.1%
2016	54MOK316	2012	4	OCV	MERFt	60436	4.41	1.03	4.54	0.2%
2016	54MOK316	2012	4	OCV	MOKF	60438	1.01	2.57	2.60	0.6%
2016	54MOK316	2012	4	OCV	MOKFn	60455	4.01	1.03	4.13	0.2%
2016	54MOK316	2012	4	OCV	MOKFn	60457	4.04	1.80	7.27	0.4%
2016	54MOK316	2012	4	OCV	MOKFn	60480	4.03	1.54	6.21	0.4%
2016	54MOK316	2012	4	OCV	MOKFn	60481	4.01	0.77	3.09	0.2%
2016	54MOK316	2012	4	OCV	MOKFn	60482	4.01	1.03	4.13	0.2%
2016	54MOK316	2012	4	OCV	MOKFn	60483	4.02	0.77	3.10	0.2%
2016	54MOK316	2012	4	OCV	MOKFn	60484	4.01	2.31	9.26	0.5%
2016	54MOK316	2012	4	OCV	MOKFn	60485	4.03	3.08	12.41	0.7%
2016	54MOK316	2012	4	OCV	MOKFn	60486	4.00	2.05	8.20	0.5%
2016	54MOK316	2012	4	OCV	MOKFn	60487	4.00	2.05	8.20	0.5%
2016	54MOK316	2012	4	OCV	MOKFn	60488	4.01	2.31	9.26	0.5%
2016	54MOK316	2012	4	OCV	MOKFn	60489	4.05	5.14	20.82	1.2%
2016	54MOK316	2012	4	OCV	MOKFn	68633	4.01	1.80	7.22	0.4%
2016	54MOK316	2012	4	SFC	FRHFfn	60466	4.01	1.00	4.01	0.2%
2016	54MOK316	2012	4	SFC	FRHFfn	60465	4.02	0.26	1.05	0.1%
2016	54MOK316	2012	4	SFC	NIMFn	60372	4.03	<u>2.57</u>	<u>10.36</u>	<u>0.6%</u>
								439	1604	100%
									3.66 avg prod	