



## Testing the Winter-run Chinook Model:

### Historical Harvest Rates

#### Introduction:

This is the second in a series of Technical Memorandums that explains how we applied the Winter-run Chinook Integrated Modeling Framework (Winter-run IMF) to historical data as a test of model accuracy. In this memorandum we will discuss data, assumptions, and analysis used to develop marine and freshwater harvest rates used in the simulation of historical conditions.

#### Marine Harvest:

Ocean harvest rates (the percentage of the population at each age harvested in the ocean) are used in the model to account for fish removed by the commercial troll and recreational fisheries. Not all winter Chinook in the ocean are susceptible to harvest. Younger and smaller fish are less likely to be harvested than older and larger fish, because (1) the large lures used are more attractive to larger fish, and (2) fish cannot be retained until they are a minimum size (currently 22 inches in the sport fishery and 26 inches in the commercial fishery).

Winter Chinook enter the ocean as they become one year old. In the summer of the year that the fish enter the ocean, they are too small to be subject to harvest. In their second summer, winter Chinook begin to reach the size where they can be legally harvested, and thus a certain portion of the run is claimed by harvest in their second summer. Fish harvested in this summer are called three year old fish, though in fact they are just over two



years old<sup>1</sup>. In the following winter a majority of winter Chinook return to freshwater to spawn. However, some fish spend an additional year in the ocean and thus are subject to one more season of marine harvest. These fish are harvested as “four year olds.” Since four year olds all exceed minimum lengths for retention by fisherman, they are more susceptible to harvest. The remaining fish that are not harvested return to freshwater to spawn.

Harvest rates are typically estimated by recovery rates of coded-wire tags, but no tagged winter-run Chinook were released during the 1971-1995 broods. Tagged fish were released from the 1969-71 broods and the 1995 to present broods, and harvest recoveries of those fish indicated that the fraction harvested was correlated to the Central Valley Index (CVI), as we will discuss. Tag recoveries of winter run Chinook made it possible to directly estimate their harvest rates at age 3 in 1972, 1973, and 2001. Therefore, we used the CVI to derive harvest rates for winter-run Chinook during most of the 1970’s through the 1990’s.

### What is the Central Valley harvest index and why is it useful?

The CVI is an annual index of the fraction of Chinook harvested in the ocean from all runs of Central Valley Chinook combined (winter, fall, late-fall and spring). The CVI is calculated as the total ocean harvest south of Point Arena divided by Chinook escapement (all stocks) in the Central Valley. The CVI is useful for historical assessment because data have been collected to calculate it for more than 30 years. Cramer (1990) showed that direct estimates of ocean harvest rates based on recoveries from CWT’s of Central Valley Chinook track closely with the CVI. The CVI is a primary measurement used by the Pacific Fishery

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<sup>1</sup> There have been some discrepancies in the past on the age nomenclature of these fish. We refer to these fish as three years old because that is how they are referred to in the CDFG winter Chinook harvest model. Others (including Hallock and Fisher 1985) have referred to these fish as age 2.



Management Council to monitor the effectiveness of their regulations for controlling ocean harvest. Because the CVI harvest index is calculated in the same manner every year, it provides a reliable indicator of trends in ocean harvest of Central Valley Chinook.

### How and why are winter-run Chinook harvest rates different from the CVI harvest index?

The CVI does not distinguish specific runs of Chinook, and it is dominantly composed of fall-run Chinook. Particular runs may be harvested at a lesser or greater rate than the CVI, but because the runs all mix in the same fisheries, it is likely that rates unique to each run will rise and fall together between years.

The few tagging studies with winter-run Chinook indicate they are currently and historically have been harvested at a rate less than that of the CVI. Ocean hook scar rates of winter Chinook examined at RBDD from 1971-1984 averaged 70% of that of fall Chinook and 77% of that of spring Chinook (Hallock and Fisher 1985). These data indicate that fewer winter Chinook were being hooked by harvest gear in the ocean than the other races incorporated into the CVI. Also, CDFG estimated from a fin clip mark-recapture study that winter Chinook harvest was 78% of that averaged for all Chinook stocks combined off of the California coast in 1971 and 1972 (Barraco 1997). Further, in recent years harvest regulations have been specifically designed to reduce harvest of winter-run Chinook. NOAA Fisheries estimated that harvest of age 3 fish of the 1998 brood was only 21%, which we estimated to be approximately 60% of the CVI harvest index.

Winter-run Chinook tend to be harvested at a lower rate, because they are several months younger and smaller at each age during the harvest season than other chinook runs. The CDFG harvest model assigns the birthday of winter Chinook as February 1, while other spring and fall runs are assigned their



“birthday” on the previous September 1. As the result of less growing time in the ocean, mean lengths of winter-run Chinook during the ocean harvest season are several inches shorter than fall Chinook (Figure 1). The length patterns show that most winter-run Chinook do not reach the 26-inch minimum size limit for commercial fisheries until late summer of their age 3 year, so this accounts for their low harvest rate in commercial fisheries.

### Length and Age of Central Valley Chinook

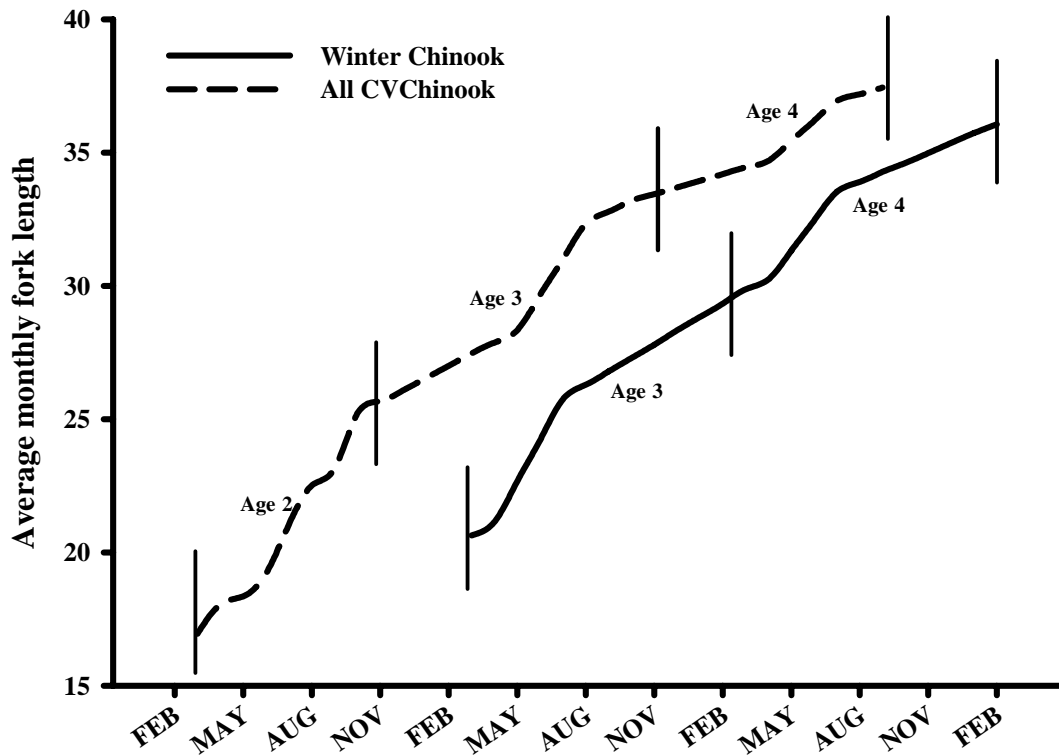


Figure 1. Average fork length and age by month of both winter Chinook and all Central Valley Chinook. Data from Barroco et al. (1989). Lengths derived from marked fish sampled from ocean landings.

Recreational harvest of Central Valley Chinook is primarily between April and November, and commercial harvest is in May to September. Since winter Chinook enter freshwater in the winter and early spring, they avoid all of the commercial season and most of the recreational season in their year of maturity. As a result of the earlier season opening and smaller legal size limit in sport fisheries, about 70% of the ocean harvest of winter-run



Chinook occurs in the sport fisheries. The small size at age and early entry to freshwater combine to cause a lower harvest rate at each age on winter-run Chinook than for other Central Valley stocks. Age 2 fish are too small to be harvested, and their harvest rate is assumed to be 0%.

#### How did we estimate annual harvest rates for winter-run Chinook?

In years for which ocean harvest rates could not be estimated directly from tag recoveries of winter-run Chinook, we assumed that harvest rate of winter-run was a constant fraction of the CVI harvest rate index. We estimated this fraction based on the fin-clip study reported by Hallock and Fisher (1985), which showed the ocean harvest rate of age 3 fish averaged 35.4% in 1972 and 1973 (Barrocco et al 1989). That rate was 50% of the CVI harvest index for 1972 and 1973. Thus, we assumed the harvest of age 3 winter-run Chinook from 1970 to 1999 was half of the CVI harvest index.

The relative harvest rate at age 4 for winter-run Chinook was similarly based on harvest rates estimated by Barrocco et al. (1989) from the data of Hallock and Fisher (1985). The ratio of harvest rates for age 4 to age 3 winter-run Chinook was 1.54:1. We applied this ratio to each year, and estimated the annual harvest rate of age 4 winter Chinook to be 1.54 times that of age 3 winter Chinook. The assumption that winter-run harvest rates remained a constant fraction of the CVI seems reasonable, because there was little significant change in commercial or recreational harvest regulations until the mid-1990's.

#### How have changes in harvest regulations affected harvest rates?

Most of the ocean harvest of winter Chinook is in the recreational fishery. In an effort to protect the endangered winter Chinook, managers began to change recreational harvest



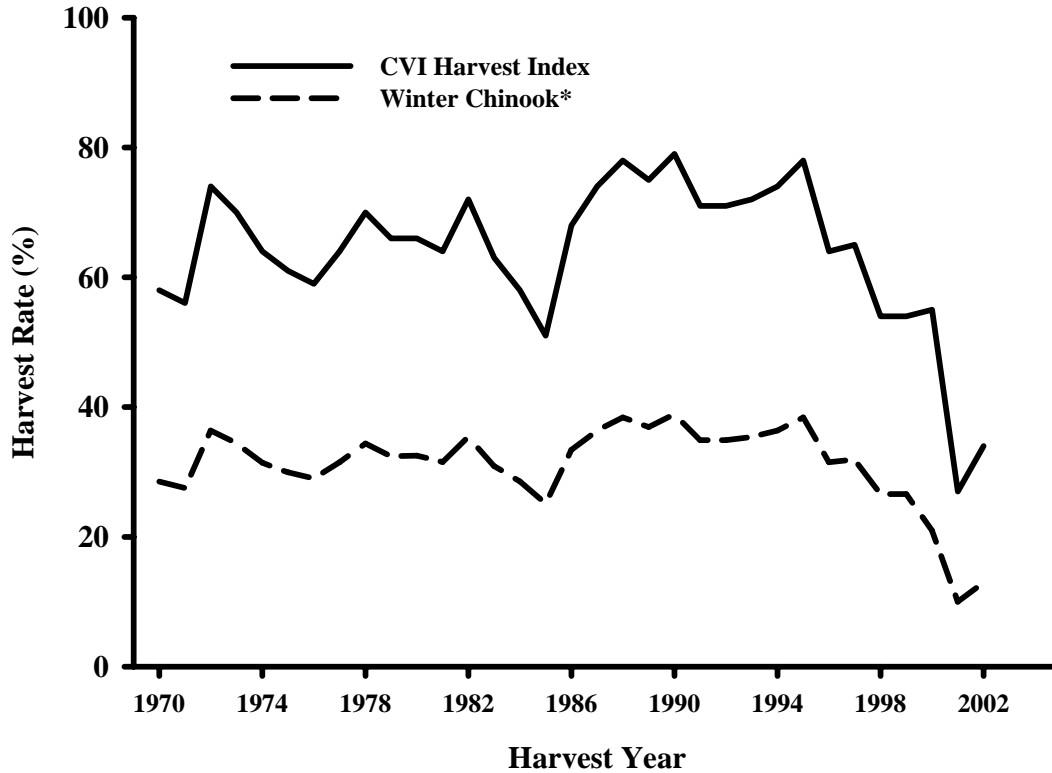
regulations in 1995. The recreational harvest season began in mid February before 1995, but was delayed until mid April in 1995 and thereafter. Also, the minimum size limit was increased from 20 inches to 24 inches to reduce retention of winter-run Chinook. These changes impacted the relationship between winter Chinook harvest rates and the CVI harvest index.

#### How did we model the effects of changes in regulations on winter Chinook harvest rates?

We estimated the effect of these regulatory changes on the harvest rate of winter-run Chinook relative to other runs by using direct estimates of winter-run harvest rates from CWT recoveries of the 1998 brood. This was the first brood since the Hallock and Fisher (1989) studies for which tag recoveries were sufficient to obtain a reliable estimate of harvest rates. NOAA Fisheries has estimated from CWT recoveries in the 2000 ocean fisheries that the harvest rate of age 3 winter-run Chinook was 21%. This is only slightly less the 27% we would have estimated by taking half of the 54% CVI rate for that year. Based on this new estimate of age 3 harvest rate in 2000, we assumed the winter-run harvest rate at age 3 was 39% of the CVI during 2000 and thereafter. The final harvest rates that we used in the hindcast simulation are listed in Table 1, and shown with the CVI in Figure 2. .



### Harvest Rate Indices



\*Age 3 Winter Chinook rates used in the hindcast model.

Figure 2. Central Valley Index (CVI) and estimated harvest rates of age 3 winter-run Chinook, 1970-2002.

Table 1. Annual estimates of ocean harvest rates used in the hindcast simulation for winter-run Chinook.

Year	Ocean Harvest Rate		
	Age 2	Age 3	Age 4
1970	0	0.29	0.44
1971	0	0.28	0.42
1972	0	0.36	0.56
1973	0	0.34	0.53
1974	0	0.31	0.48
1975	0	0.30	0.46
1976	0	0.29	0.45
1977	0	0.31	0.48
1978	0	0.34	0.53



1979	0	0.32	0.50
1980	0	0.32	0.50
1981	0	0.31	0.48
1982	0	0.35	0.55
1983	0	0.31	0.48
1984	0	0.29	0.44
1985	0	0.25	0.39
1986	0	0.33	0.51
1987	0	0.36	0.56
1988	0	0.38	0.59
1989	0	0.37	0.57
1990	0	0.39	0.60
1991	0	0.35	0.54
1992	0	0.35	0.54
1993	0	0.35	0.55
1994	0	0.36	0.56
1995	0	0.30	0.45
1996	0	0.24	0.37
1997	0	0.24	0.38
1998	0	0.21	0.32
1999	0	0.21	0.32
2000	0	0.21	0.32
2001	0	0.10	0.15
2002	0	0.13	0.34

### Freshwater Harvest:

A portion of the winter-run Chinook that return to freshwater are caught by anglers in the Sacramento River, so the model must account for removals of these fish. Current regulations protect winter run Chinook from in-river harvest, but this has not always been the case. In 1990, the California Fish and Game Commission adopted regulations prohibiting the harvest of adult salmon during the period that winter Chinook are in the river. These regulations were thought to virtually have eliminated the impacts of freshwater harvest on winter Chinook returns (NMFS 1997). During the 1968-1975, harvest rates were estimated from



angler surveys, and ranged between 4% and 18%, with an average of 10% (Hallock and Fisher 1988). Angler surveys during 1983-1986 indicated that freshwater harvest rate averaged 8.7% in those years (NMFS 1997). Starting in 1987, the angling season was reduced, and harvest rate was estimated at 1.3%, followed by 4.2% in 1988, and 3.1% in 1989 (NMFS 1997).

In years that were not sampled, we assumed harvest rate was 9% prior to 1983 and 5% after 1990 (Figure 3; Table 2). The pre-1983 assumption was based on estimate harvest rates in the late 60's, early 70's, and mid-80's all averaging between 8-10% harvest. The assumed 5% harvest rate after 1990 allows for incidental retention of winter-run Chinook before the season closed January 15. Recoveries of winter-run Chinook CWTs in 2001 revealed the angler take of winter-run Chinook before January 15 accounted for up to 24% of the run (West Coast BRT 2003). This estimate was derived from nine CWTs recovered from the river fishery prior to January 15. Subsequently, the season closed January 1, which would have reduced the observed harvest rate in 2001 to less than 5% (West Coast BRT 2003).

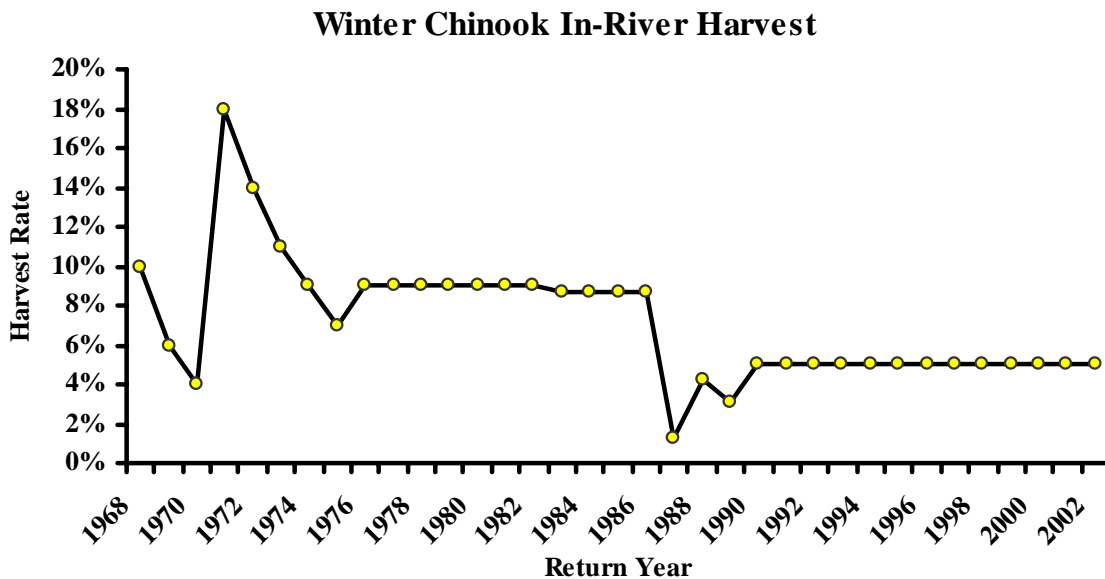


Figure 3. Modeled winter Chinook in-river harvest rates, 1968-2002.



Table 2. Values used to simulate annual in-river harvest of winter Chinook in the Sacramento River.

Run Year	Freshwater Harvest (%)
1968	10.0
1969	6.0
1970	4.0
1971	18.0
1972	14.0
1973	11.0
1974	9.0
1975	7.0
1976	9.0
1977	9.0
1978	9.0
1979	9.0
1980	9.0
1981	9.0
1982	9.0
1983	8.7
1984	8.7
1985	8.7
1986	8.7
1987	1.3
1988	4.2
1989	3.1
1990	5.0
1991	5.0
1992	5.0
1993	5.0



1994	5.0
1995	5.0
1996	5.0
1997	5.0
1998	5.0
1999	5.0
2000	5.0
2001	5.0
2002	5.0

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