

## SALMON TECHNICAL TEAM REPORT ON THE TECHNICAL BASIS FOR THE KLAMATH RIVER FALL CHINOOK CONSERVATION OBJECTIVE

This report: (1) Defines the conservation objective for Klamath River fall Chinook, including what is required for it to be modified, (2) Provides a brief history of Klamath River fall Chinook management prior to adoption of the current objective, and (3) Summarizes the basis and findings of the technical work which led to the current objective, as well as the follow-up technical work on the subject completed since the objective was established. This report does not represent an STT evaluation of the technical merits of this work.

### Conservation Objective

The current conservation objective for Klamath River fall Chinook was established in Amendment 9 to the Salmon FMP (PFMC, 1988), and is defined as: “33–34% of potential adult natural spawners, but no fewer than 35,000 naturally spawning adults in any one year. Brood escapement rate must average 33-34% over the long-term, but an individual brood may vary from this range to achieve the required tribal/nontribal annual allocation” (PFMC, 2003, Table 3-1). The objective was designed “to allow a wide range of spawner escapements from which to develop an MSY objective or proxy while protecting the stock during prolonged periods of reduced productivity” (PFMC, 2003, Table 3-1).

A change to the escapement rate portion of the objective “may be made without plan amendment if a comprehensive technical review of the best scientific information available provides conclusive evidence that, in the view of the Salmon Technical Team, Scientific and Statistical Committee, and the Council, justifies a modification” (PFMC, 2003, section 3.1.2). However, the 35,000 natural spawner floor portion of the objective “may only be changed by FMP amendment” (PFMC, 2003, section 3.1.2).

### Brief History

In 1978, the PFMC adopted a spawner escapement goal for Klamath River fall Chinook of 115,00 adults (97,500 natural; 17,500 hatchery) based on observed spawner returns to the basin in the early 1960s (CDFG, 1965). From 1978–1984, overall spawning escapements ranged from 22,700–71,500 (Hubbell and Boydston, 1985). Because the stock abundance was depressed, the PFMC (1985) implemented an interim rebuilding schedule beginning in 1983 which called for an average river run size of 68,900 adults during the 1983–1986 period, to be followed by 20% increases every four years until the long-term spawning escapement goal of 115,00 adults was achieved in the 1994–1998 period. However, for 1983 and 1984, river returns averaged only 50,600 adults. The PFMC responded by closing the KMZ troll fishery in 1985 but the river return that year was only 59,300 adults. Thus, in order to meet even the step 1 interim rebuilding goal of an average return of 68,900 adults over the 1983–1986 period, a river run size of 115,100 adults would have been required in 1986.

Faced with declining run sizes (even with the 1985 KMZ troll closure), there was concern that the production capacity of the basin had significantly decreased since the early 1960s, and if so this would make meeting the interim rebuilding schedule and long-term spawning escapement goal unrealistic (PFMC, 1988). In addition, harvest allocation of the stock among the various ocean and river fishery sectors was an extremely contentious issue. The PFMC responded by calling upon the various state, federal, and tribal management entities and commercial and recreational fishery representatives to meet and begin developing a new long-range management agreement, and this led to the formation of the Klamath River Salmon Management Group (KRSMG), and of its technical team (KRTT) which included fishery consultants selected by the user groups (PFMC, 1988). (The KRSMG and KRTT were the precursors to the soon thereafter permanently established Klamath Fishery Management Council (KFMC) and its technical team (KRTAT).) The KRSMG charged the KRTT with proposing and evaluating alternative management options for Klamath River fall Chinook, and the results of their work (KRTT, 1986) formed the basis of Amendment 9 to the PFMC Salmon FMP (PFMC, 1988).

#### FMP Amendment 9 (PFMC, 1988)

There were four conservation objective alternatives proposed in Amendment 9:

- Alternative 1 (status quo): the interim rebuilding schedule implemented in 1983, leading to the long-term spawning escapement goal of 115,000 adults (97,500 in natural areas) by the 1995–1998 period.
- Alternative 2A was the same as Alternative 1, but with the added requirement of a minimum (floor) spawning escapement to natural areas of 35,000 adults in all years.
- Alternative 2B was the same as Alternative 2A, but with a minimum (floor) spawning escapement to natural areas of 43,000 adults in all years.
- Alternative 3 was (essentially) the current conservation objective: harvest rate management subject to a minimum (floor) spawning escapement to natural areas of 35,000 adults in all years.

The rationale provided for the annual minimum (floor) spawning requirements in Alternatives 2A, 2B, and 3, included (PFMC, 1988): “to prevent extremely low escapements in any one year”, and “to protect against extended periods of depressed natural production and failure to meet hatchery escapement needs.” The floor value of 35,000 was recommended by the KRTT (1986). The floor value of 43,000 was recommended by the PFMC STT (PFMC, 1988).

Alternatives 1, 2A, and 2B were rejected principally because of uncertainty about the basin’s capacity to support natural production, in particular 97,500 adults in natural areas. The California Department of Fish and Game had done an assessment of the basin’s capacity (number of natural area adult spawners needed to produce the maximum number of recruits), on a stream-by-stream basis using a variety of methods, but this resulted in a wide range of estimates for the basin as a whole: 41,000–106,000 (Hubbell and Boydston, 1985). Hubbell and Boydston (1985) concluded: “These varied results point up the dilemma faced in deciding on a

single escapement goal—for Klamath River fall Chinook there is little or no agreement on a preferred number. At best the data provided by the current assessment afford a basis for setting an escapement goal range, or perhaps, the basis for setting a minimum (floor) escapement, below which no fishing would occur.”

The PFMC implemented Alternative 3, as developed and recommended by the KRTT (1986). The rational and technical basis for their recommendation follows.

### KRTT (1986)

Because of the uncertainty of the basin’s spawner capacity, the KRTT favored a fixed harvest rate (fixed escapement rate) objective, subject to a minimum (floor) number of spawners. Hankin and Healy (1986) had shown that the MSY harvest rate for Chinook salmon depends on the stock productivity (Ricker  $\alpha$ ) and maturation schedule, but not on basin capacity (Ricker  $1/\beta$ ). Therefore, MSY could be achieved without knowing the capacity, as long as the productivity and maturation schedule could be estimated. It was also argued by the KRTT that a fixed harvest rate objective would lead to interannual variation in the number of spawners, which over time would help to identify the stock-recruitment relationship.

To evaluate this approach, the KRTT constructed a fishery stock dynamics model, which coupled a Ricker stock-recruitment function (Ricker, 1975) to a cohort life-cycle model that included ocean and river fishery mortality. The model was used to simulate stock dynamics and resulting fishery harvests over a 40-year period at various combinations of ocean and river harvest rates. The results indicated that a brood escapement rate of about 35% would maximize the long-term average annual harvest of the stock.

The results of the KRTT modeling work depend on a number of parameters, but are most sensitive to the stock productivity (Ricker  $\alpha$ ) parameter. The KRTT assumed that  $\alpha=7$  for recruitment at age 3, based on a review of the literature and of the available data for the Klamath basin. Variation in the survival rate prior to recruitment at age-3 was simulated by multiplying the Ricker expected recruitment times a normally distributed random variable with mean 1 and standard deviation 0.3, based on the variation observed in ocean salmon landings in the KMZ from 1952–1984. Other fishery- and age-specific parameters included vulnerability, fraction legal size, release mortality rate, dropoff rate, maturity rate, and natural mortality. The values used by the KRTT for these other parameters are similar to those currently used by the STT. The simulation results also assume that the brood escapement rates are achieved precisely, and that the underlying model structure is appropriate.

The rationale of the KRTT for the annual minimum (floor) spawning requirement was “to protect the production potential of the resource in the event of several consecutive years of adverse environmental conditions.” This rationale was based on the results of modeling 3 consecutive years of poor recruitment (20% of expected) followed by 7 years of expected (Ricker) recruitment. The average catch over the 10 year period was 17% greater with the spawner floor in place. In addition, the KRTT noted that “a minimum spawning escapement of 35,000 natural spawners would be higher than any natural escapement since 1978, [escapement] levels that have been widely regarded as too low for the basin.”

## KRTAT (1999)

More recently, the Klamath Fishery Management Council charged its technical team with conducting a modeling study of the spawner floor and its relationship to MSY. The study also evaluated the effects of de minimus fisheries, but that will not be reviewed here. The modeling approach used by the KRTAT (1999) for the study was similar to that of the KRTT (1986), but included the following improvements: (1) the Ricker stock-recruitment model was based on a direct fit of Klamath River basin natural area spawner-recruit data, brood years 1979–1993.<sup>1/</sup> The stochastic component of recruitment for simulations was assumed log-normally distributed with parameters estimated from the observed data. (2) “Pre-season” stock abundance estimates were used to determine the allowable harvest under the conservation objective. Age-specific abundance estimates were assumed to be median-unbiased and log-normally distributed. (3) Fishery harvests and related mortalities were determined using a harvest model (Prager and Mohr, 2001) similar to the PFMC Klamath Ocean Harvest Model, except that ocean fisheries were aggregated over time and space. Given the “pre-season” abundance estimates, the model determined the allowable harvest such that the customary fishery sector allocations were achieved, and the projected escapement met the 33% rate subject to the floor value. Floor values of 15,000–50,000 adults were examined in increments of 5,000 adults, and abundance predictor coefficients of variation of 0–75% were examined in increments of 25%. For each combination of these variables, the simulation was run for 3,000 years to achieve precision in the simulation statistics.

The principal results were: (1) The spawner-recruit data-based estimates of the Ricker function parameters,  $\hat{\alpha}=8.2$  and  $\hat{\beta}=0.0233$ , were remarkably similar to the low-capacity curve parameter values used by the KRTT (1986) in their modeling work:  $\alpha=7.0$  and  $\beta=0.0244$ . (2) Stock abundance estimator imprecision strongly affected simulated average catch: realistic coefficients of variation of 50–75% decreased the catch by up to 30%. (3) Average catch increased as the spawner floor was raised from 15,000 to 30,000 or 35,000; it decreased markedly with higher floor values.

The KRTAT (1999) concluded that “The results of this study suggest that the present spawner floor of 35,000 is prudent. Decreasing it seems unlikely to bring substantial increases in yield. Sissenwine et al. (1988) found that persistence of a stock (at exploitable levels) under strong environmental variation requires higher escapements than simple models may predict. The KRTT (1986) report [did explore recovery after a series of three poor years, and found] that recovery was quicker, more complete, and led to higher yields with the spawner floor of 35,000 fish in place. The Team therefore recommends that the current spawner floor of 35,000 be retained.”

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1/ The model was fit with spawning stock units as numbers of fish, and as biomass of fish. The fitted models were not markedly different, but biomass provided the best fit and was used for the simulation.

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