NOAA Technical Memorandum NMFS

NOVEMBER 2010

IS THE SEPTEMBER 1 RIVER RETURN DATE APPROXIMATION APPROPRIATE FOR KLAMATH RIVER FALL CHINOOK?

Michael R. O'Farrell
Melodie L. Palmer-Zwahlen
and
Jennifer Simon

NOAA-TM-NMFS-SWFSC-468

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

The National Oceanic and Atmospheric Administration (NOAA), organized in 1970, has evolved into an agency that establishes national policies and manages and conserves our oceanic, coastal, and atmospheric resources. An organizational element within NOAA, the Office of Fisheries is responsible for fisheries policy and the direction of the National Marine Fisheries Service (NMFS).

In addition to its formal publications, the NMFS uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series, however, reflect sound professional work and may be referenced in the formal scientific and technical literature.

NOAA Technical Memorandum NMFS
This TM series is used for documentation and timely communication of preliminary results, interim reports, or special purpose information. The TMs have not received complete formal review, editorial control, or detailed editing.

NOVEMBER 2010

IS THE SEPTEMBER 1 RIVER RETURN DATE APPROXIMATION APPROPRIATE FOR KLAMATH RIVER FALL CHINOOK?

Michael R. O'Farrell[1]
Melodie L. Palmer-Zwahlen[2]
and
Jennifer Simon[2]

[1]Fishery Ecology Division
Southwest Fisheries Science Center
National Marine Fisheries Service
110 Shaffer Road, Santa Cruz, California 95060

[2]California Department of Fish and Game
Marine Region
Ocean Salmon Project
475 Aviation Boulevard, Suite 130
Santa Rosa, California 95403

NOAA-TM-NMFS-SWFSC-468

U.S. DEPARTMENT OF COMMERCE
Gary F. Locke, Secretary
National Oceanic and Atmospheric Administration
Jane Lubchenco, Undersecretary for Oceans and Atmosphere
National Marine Fisheries Service
Eric C. Schwaab, Assistant Administrator for Fisheries

1 Abstract

The cohort reconstruction and harvest model used for the annual assessment of Klamath River fall Chinook (KRFC) salmon make the simplifying approximation that immediately prior to September 1, mature KRFC leave the ocean for the Klamath Basin and immature KRFC remaining in the ocean after September 1 advance one year in age. This approximation has implications for both harvest allocation as well as estimation of population and fishery parameters. In this memo, we investigate KRFC river return timing and evaluate the appropriateness of the current September 1 return date approximation. Analysis of the temporal distribution of catch in the Yurok Tribe's estuary fishery suggests the average midpoint of river return timing for the total KRFC stock is centered around September 1, though some hatchery components regularly exhibit slightly later river return timing. Based on these results, we conclude that the September 1 river return date approximation currently used in KRFC assessment models is appropriate and should be retained.

2 Introduction

The Klamath River fall Chinook (KRFC) cohort analysis and Klamath Ocean Harvest Model (KOHM) both make the simplifying approximation that immediately prior to September 1, mature KRFC leave the ocean for the Klamath Basin and immature KRFC remaining in the ocean after September 1 advance one year in age. The river return date approximation was chosen to be a date when the ocean abundance of KRFC transitions from being a mixture of immature and maturing fish to one of primarily immature fish that will contribute to future fisheries and escapement. The return date approximation is a simplification of the true maturation process in which mature fall Chinook leave the ocean for the Klamath Basin during a reliable, yet more protracted period of time than the models assume.

Age-specific preseason forecasts of KRFC ocean abundance, published annually in the Preseason I report (e.g., PFMC 2009a), are effective on the September 1 return date approximation. The KOHM projects these age-specific September 1 year $(t-1)$ preseason forecasts of ocean abundance through completed, ongoing, and proposed fisheries during the September 1 $(t-1)$ through August 31 (t) period, accounting for both harvest impacts and natural mortality on a monthly basis. After August (t) ocean mortality is deducted from the August (t) ocean abundance, the remaining ocean abundance (age-specific) is multiplied by age-dependent, long-term average maturation rates to forecast the river run size (t), and ultimately escapement (t), of KRFC. The KRFC cohort analysis is based on the same structural relationships as the KOHM, except that individual cohorts are reconstructed from the end of their lifetimes as age-5 spawners backward in time, accounting for harvest impacts, natural mortality, and maturation (Mohr 2006; Goldwasser et al. 2001). The cohort analysis provides the maturation, harvest, contact, and impact rate estimates that are vital to the overall KRFC assessment process. Choice of an appropriate river return date approximation for the KOHM and cohort analysis has implications for both harvest allocation and estimation of, at a minimum, fishery contact, harvest, and impact rates.

With regard to harvest allocation, the September 1 river return date approximation results in impacts for the September 1 $(t-1)$ to August 31 (t) period being applied to the year (t) harvest allocation accounting and conservation objectives. A model river return date set too early relative to the KRFC overall return schedule can result in mature fish destined to spawn in year $(t-1)$ being caught in the ocean after the designated return date. The harvest and impacts of these mature fish caught after the designated river return date will be counted toward year (t) allocation accounting and conservation objectives. Conversely, if the model river return date is set too late relative to the overall return schedule, a large number of immature fish, which would largely contribute to year (t) fisheries and escapement, would instead be counted toward year $(t-1)$ allocation accounting and conservation objectives. Hence, the choice of a model river return date which simultaneously minimizes both of these allocation misclassifications is appropriate.

With regard to estimation of contact, harvest, and impact rates, a disparity between the timing of the actual river return period and the model river return date can create biases in the reconstructed cohort abundances, that in turn could result in biased estimates of these key rates. If the model river return date is assumed to be a date that is set before or at the beginning of the actual river return period, the reconstructed ocean abundance between the model date and the actual period will be biased low. Viewed from a forward projection perspective, the model assumes that the ocean abundance of a cohort is decreased just prior to the model river return date, owing to maturation, when in fact the true cohort abundance will not be reduced until the actual return period commences at a later time. The result of this bias in the cohort's ocean abundance is that contact, harvest, and impact rates could be biased high for the period between the model river return date and the actual return period since the cohort abundance, the denominator of these rate calculations, is biased low. Conversely, if the model river return date is set later than the actual river return period, the reconstructed abundance between the actual period and the model date will be biased high. Again, from a forward projection perspective, the model population is reduced by maturation at the time immediately preceding the model river return date. However, the true cohort abundance in the ocean is being reduced by maturation well before the model river return date. This high cohort abundance bias would result in the contact, harvest, and impact rates being biased low. All biases described above would be of greater magnitude for cohorts with higher overall maturation rates (e.g., age-4 KRFC relative to age-3 KRFC). To minimize bias in cohort abundance reconstruction, as well as contact, harvest, and impact rates, the model river return date should be chosen to minimize the total temporal distance between the model river return date and the center of the actual river return period.

For KRFC, there is a unique opportunity to evaluate the appropriateness of the September 1 model river return date. Every year, the Yurok Tribe conducts a gillnet fishery in the mainstem Klamath River between the mouth and the confluence with the Trinity River. A substantial portion of the Yurok gillnet fishery occurs in the Klamath River estuary, harvesting Chinook salmon shortly after they exit the ocean. In many years, the fishery operates nearly continuously from early spring, when Klamath River spring Chinook (KRSC) begin entering the river, through the fall when abundance of KRFC in the lower river tapers off. The fishery is monitored by the Yurok Tribe and coded-wire tags (CWTs) are collected, which allows for the evaluation of river entry timing for each run, by hatchery (Iron Gate vs. Trinity) and release type (fingerling vs. yearling). These data can be used to evaluate run timing for the KRFC stock, acknowledging that there is some unknown, but likely short, time lag between when mature KRFC are unavailable to ocean fisheries and their subsequent capture in the Yurok estuary fishery.

Using Yurok catch and CWT recovery data from the Klamath River estuary, we investigate KRFC river return timing and evaluate the appropriateness of the current September 1 return date approximation made in the cohort analysis and KOHM. Section 3 describes the treatment of the Yurok catch and CWT recovery data while section 4 describes the temporal distribution of river return timing inferred from the Yurok data and examines estimated fall ocean fishery impact rates relative to KRFC river return timing. Section 5 evaluates the appropriateness of the September 1 model river return date, given the data and the KRFC assessment structure. Section 6 synthesizes the results and conclusions into recommendations for future KRFC assessment.

3 Data and methods

The Yurok and Hoopa Valley tribes are allotted 50 percent of the total allowable KRFC annual harvest, with the Yurok Tribe generally receiving 80 percent of this tribal allocation. The Yurok gillnet fishery generally begins in late April or early May, depending on when KRSC begin returning to the Klamath Basin. Fishing, and sampling of the catch, typically continues through the summer and fall until the KRFC run is complete in late October or early November. The harvest of KRFC in this fishery is regulated by harvest quotas, and in some years the fishery is closed well before the terminus of the fall run owing to the KRFC quota having been met.

Sampling of the fishery is stratified into three management areas: estuary (mainstem Klamath River from the ocean mouth to the highway 101 bridge), middle Klamath (mainstem Klamath River from the highway 101 bridge to Surpur Creek), and upper Klamath (mainstem Klamath River from Surpur Creek to the Trinity River mouth). Sampling is stratified by management area and week (Sunday through Saturday), with between 20 and 40 percent of the catch sampled per stratum. Samplers attempt to collect the heads from all adipose fin-clipped (i.e., ad-clipped) salmon observed during monitoring. A missing adipose fin indicates the salmon head contains a CWT, which provides brood year, hatchery or river of origin, run, release size, and release location information for that fish. Fishery monitoring data provided by the Yurok Tribe contained information on the number of salmon sampled, the number of ad-clipped salmon observed, the number of heads collected from ad-clipped salmon, as well as the estimated catch by week and river management area stratum. These data were used in conjunction with the CWT recovery data and any discrepancies (e.g., more heads collected than ad-clipped fish observed) were resolved with the Yurok Tribe prior to these analyses.

Occurrence of KRSC and KRFC in the Yurok gillnet fisheries tends to overlap for several weeks in August as the KRSC run wanes and the KRFC run builds. Segregation of the two runs in the catch was accomplished using the proportions of expanded KRSC and KRFC CWTs recovered per week and river management area strata. The total net harvest of KRFC by management area and year was then compared to the total Yurok Tribe KRFC catch reported in Table B-5 of PFMC (2009b) to ensure that the estimates used for this report were consistent with those published in Pacific Fishery Management Council (PFMC) reports.

This report considers catch from the estuary management area only as this represents the first instance of in-river harvest of mature KRFC and is most appropriate for the river return timing analyses. Data from the middle and upper Klamath management areas would be less informative than the estuary since salmon are known to stage in the river as they migrate upstream, which would further complicate the analysis of river return. The estuary, encompassing the lowermost 2.8 river miles, also receives the highest amount of fishing effort of the three management areas.

Yurok catch estimates were available for the period between 1994 and 2008. However, several years (1994, 1995, 2000, and 2006) were omitted from this analysis because quotas closed the estuary fishery prior to the completion of the KRFC run. In addition, data from 2002 were excluded because low river flows and high temperatures resulted in an atypical migratory pattern up the Klamath River. The well publicized "fish kill" in the lower Klamath River occurred in 2002, and this year was characterized by low flows and high temperatures that impeded upstream migration.

3.1 River return timing: composite stock

The estimate of total KRFC catch in the Yurok gillnet fishery by week and management area stratum was provided by the Yurok Tribe for this analysis. These catch estimates are for the composite stock, comprised of natural origin KRFC from both the Klamath and Trinity river basins, as well as hatchery origin fish from the two hatcheries. To evaluate run timing for the composite stock, we examined weekly catch estimates in the Yurok gillnet fishery in the Klamath River estuary.

3.2 River return timing: hatchery stocks

Estimates of hatchery-origin KRFC catch in Yurok gillnet fisheries was determined by coupling CWT information with catch sample data. Successfully decoded CWTs were expanded to an estimate of the catch associated with each tag recovery by accounting for the weekly sampling fraction (f) in the fishery and the hatchery tagging fraction (p) for the particular tag code. The sampling fraction is defined as

$$f = f_c \times f_a \times f_d, \tag{1}$$

where f_c is the fraction of the catch sampled, 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. The tagging fraction is the fraction of the total salmon released (both ad-clipped and non ad-clipped) that contained a particular CWT code. Therefore, the estimated catch per CWT recovery for that particular tag code is equal to $1/(f \times p)$. For this analysis, CWT recoveries were further classified into release types based on hatchery or river of origin, run, or size of fish at release. The four primary KRFC release types include Iron Gate Hatchery fingerlings (IGHF), Iron Gate Hatchery yearlings (IGHY), Trinity River Hatchery fingerlings (TRHF), and Trinity River Hatchery yearlings (TRHY). Both hatcheries also produced small groups of experimental KRFC fingerlings and yearlings and several thousand wild Chinook were captured and tagged each year. The experimental production and wild fish tagging stopped in 1997. For this report, we examine the temporal occurrence of the four primary KRFC release types in the Yurok estuary gillnet fishery and do not consider experimental or wild tag groups further.

3.3 River return timing and estimated ocean fishery impact rates

Concerns have been raised regarding the relationship between the September 1 model river return date and fall (primarily September) ocean fishery impact rates. In particular, if mature fish caught after September 1 ($t-1$) contribute heavily to September ($t-1$) impact rates, fishing opportunity in spring/summer (t) fisheries could be reduced. To evaluate the potential role the September 1 model return date has had on fall fishery impact rates, we plot the cohort analysis-estimated age-3 and age-4 ocean fishery impact rates for all months to determine how fall fishery impact rates compare to winter/spring/summer fishery impact rates. We then examine the correlation between the September age-4 impact rates for IGHF, IGHY, TRHF, and TRHY hatchery release types and the observed "lateness" of the run for those tag groups. The "lateness" metric used for this analysis is defined as the proportion of Yurok estuary catch occurring after September 1. To the extent that a delay in run timing contributes to higher fall fishery nominal impact rates, these two variables should be positively correlated.

4 Results

4.1 River return timing: composite stock

For years when the Yurok estuary fishery was not closed early due to attainment of its quota, we used the weekly estimated catch to infer river return timing of the composite KRFC stock. Figure 1 displays the proportion of the overall KRFC catch from the Yurok estuary fishery by Julian day. This catch includes KRFC of natural and hatchery origin. In general, KRFC harvest in the estuary begins close to August 1 and tapers off toward the end of September. In five of the ten years evaluated, the median date of capture was before September 1. The interannual differences in run timing are relatively small, on the order of days rather than weeks. In general, these data suggest that September 1 is an appropriate midpoint of composite KRFC stock river return timing.

4.2 River return timing: hatchery stocks

Figure 2 displays the estimated cumulative harvest by day of age-3 and age-4 IGHF, IGHY, TRHF, and TRHY, as well as these four release types combined. Age-3 Iron Gate Hatchery origin KRFC tend to have a slightly earlier river return timing distribution relative to age-3 Trinity River Hatchery origin KRFC. TRHY age-3 have the most variable and latest river return timing of the four release types. The median date of capture for the total age-3 hatchery KRFC ranges from August 30 to September 14, with a mean date of September 5. For age-4, Iron Gate Hatchery origin fish have a median river return date clustered around September 1. Timing of age-4 TRHF is quite variable but also exhibits a median date of capture with a central tendency of September 1. Age-4 TRHY have median dates of capture slightly later than the other release types, ranging from August 26 to September 17. For the total age-4 hatchery catch, median river return timing is clustered fairly tightly, with a mean date of August 31. In general, total hatchery origin age-3 river return timing appears to be slightly later relative to hatchery origin age-4 river return timing.

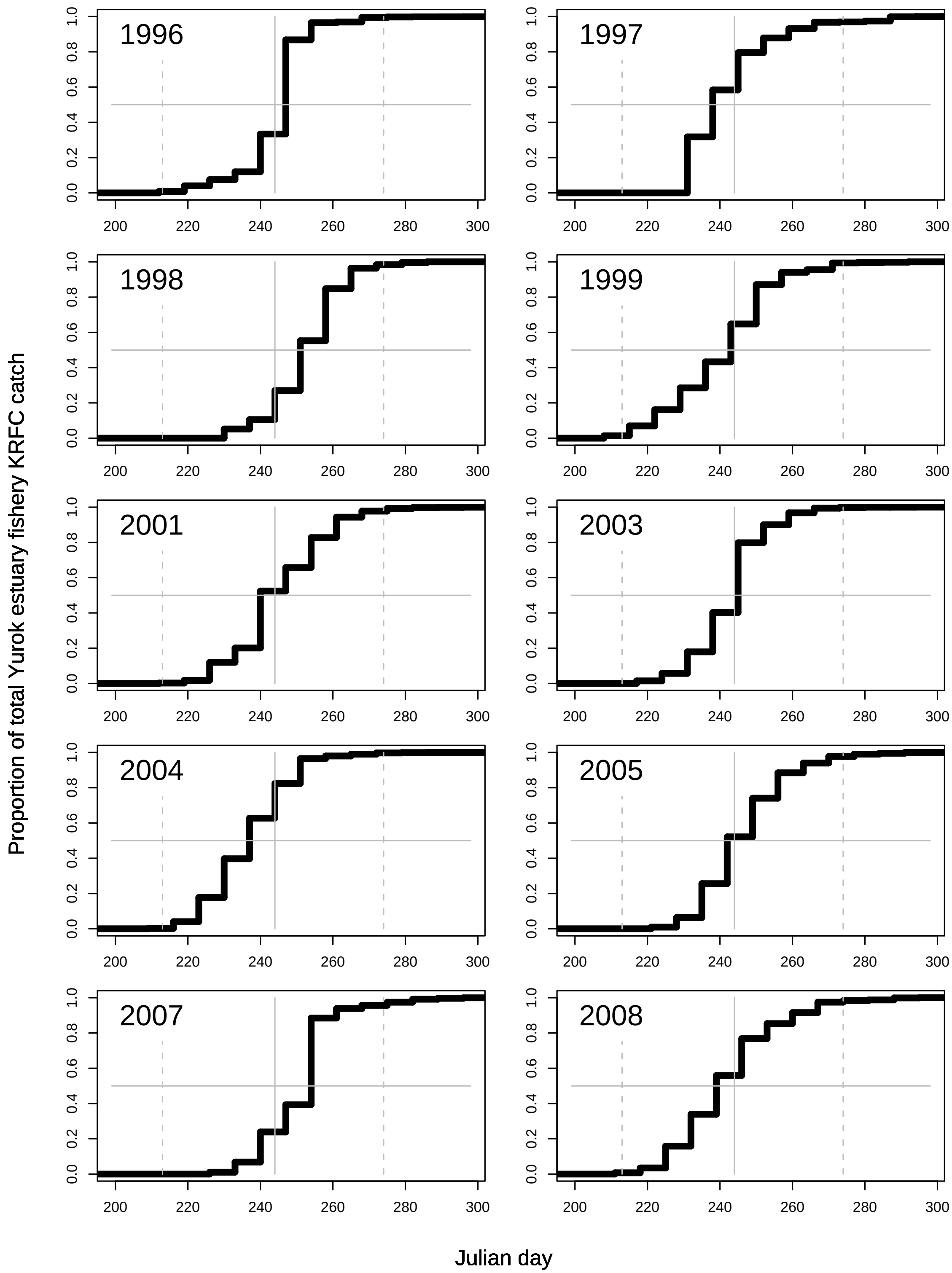

Figure 1. Yurok estuary catch of KRFC by sampling week. The heavy black line is the cumulative catch distribution, plotted at the midpoint of the sampling week. Dashed vertical grey lines represent August 1 and October 1, while the solid vertical grey line represents September 1 (Julian day 244). The horizontal grey line identifies a proportion of 0.50.

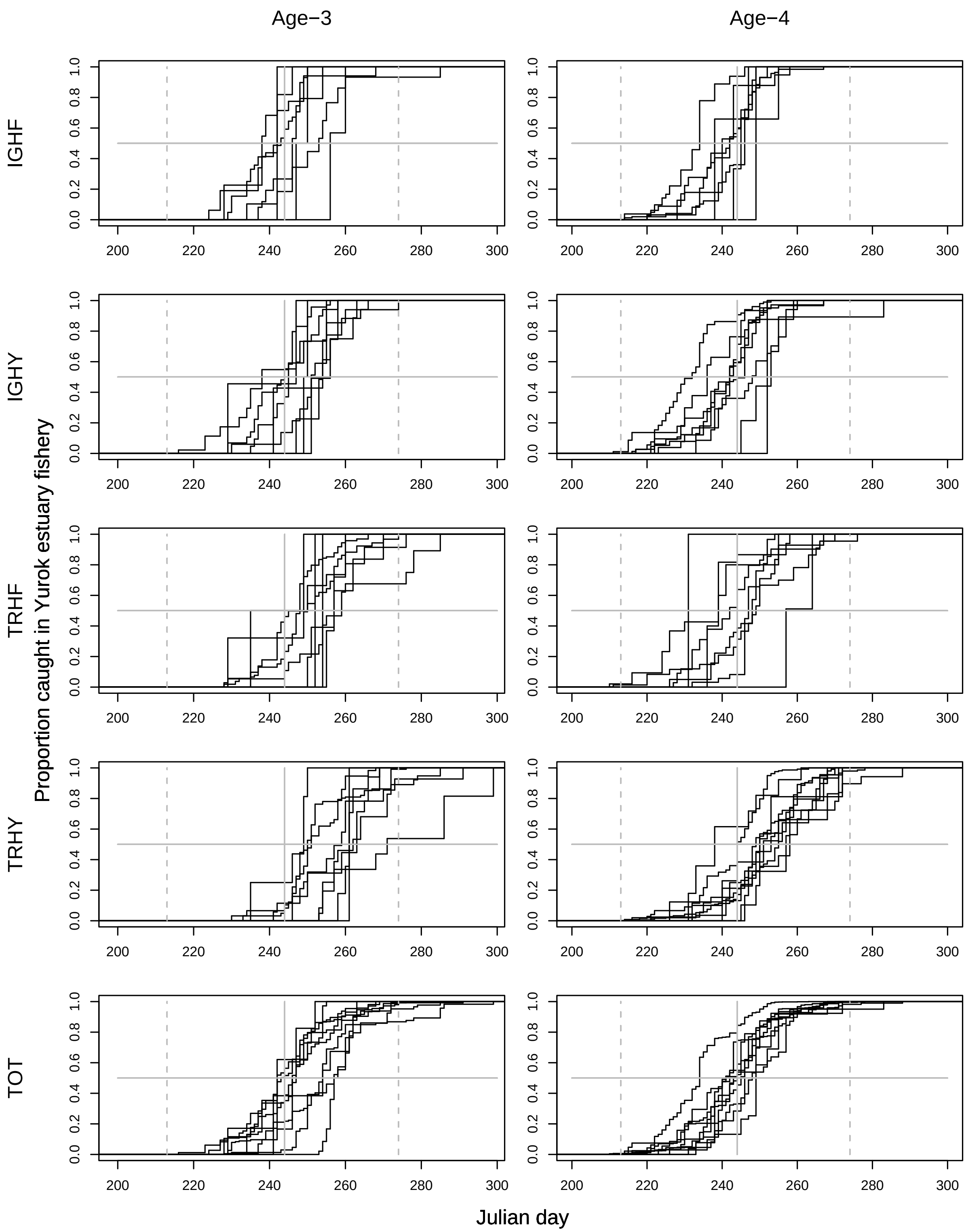

Figure 2. Estimates of cumulative catch of hatchery KRFC by Julian day. IGHF and IGHY are Iron Gate Hatchery fingerlings and yearlings, respectively. TRHF and TRHY are Trinity River Hatchery fingerlings and yearlings. TOT is the total catch of the four hatchery release types combined. Each black line represents an individual year. Grey lines are defined as in Figure 1.

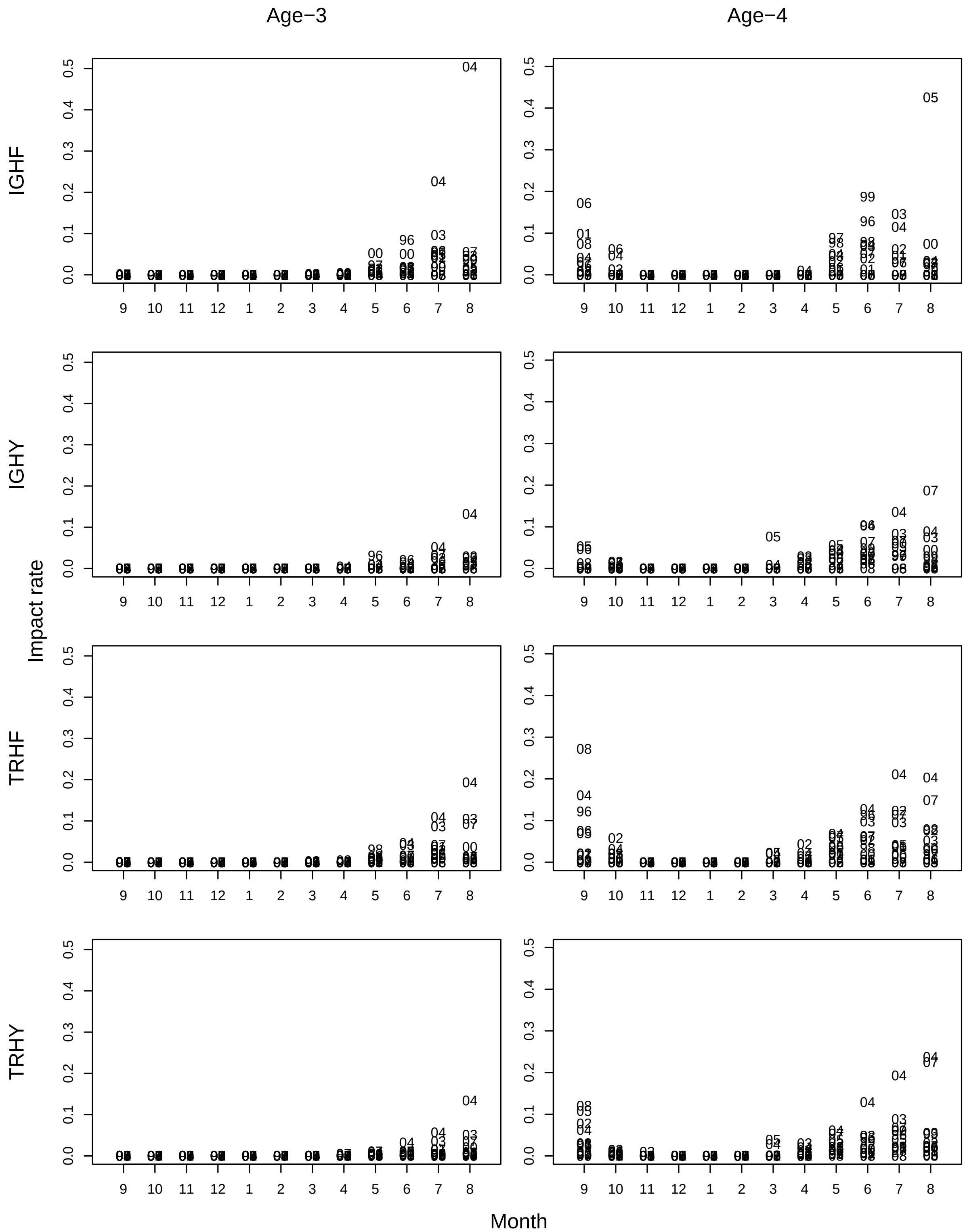

Figure 3. Ocean fishery impact rates for the four major KRFC release types plotted by month. Numbers in the plot denote the year in which the impact rates are applied in forecasting escapement. For example, September–December 2003 and January–August 2004 impact rates are labeled as "04".

4.3 River return timing and estimated ocean fishery impact rates

Figure 3 displays the temporal distribution, and interannual variation in cohort analysis-estimated age-3 and age-4 ocean fishery impact rates for the four major hatchery release types. The years depicted in Figure 3 correspond with the years in Figure 1. For age-3 hatchery KRFC, there are very low levels of fall impacts as only a small proportion of age-3 are vulnerable to harvest because most are smaller than minimum size limits. Age-3 impact rates increase during winter/spring/summer fisheries. Age-4 hatchery KRFC can experience relatively high impact rates from fall fisheries, particularly in September, though they are not appreciably different than August age-3 impact rates. High (greater than 10 percent) impact rates in September have been observed for age-4 IGHF, TRHF, and TRHY.

It can reasonably be assumed that September age-4 ocean impacts are comprised of some mature and some immature KRFC, and the relative proportions of this mixture would have a dependence on river return timing. Table 1 displays the correlation coefficients between the September age-4 ocean impact rates and the "lateness" of the age-3 river return for each of the four hatchery release groups of the same brood. A significantly positive correlation coefficient would indicate a positive association exists between delayed age-3 river return and the age-4 ocean impact rate. The correlation coefficients in Table 1 do not support the hypothesis that age-3 river return timing and September age-4 ocean harvest rates are correlated. Three of the four correlations are negative, while one is positive. None of the correlations are significantly different from zero. It should be noted that the long term average age-3 maturation rate of KRFC is 39 percent. Therefore, even if all maturing age-3 KRFC in a given year had an unrealistically late river return timing (e.g., all KRFC in the cohort returned to the river after September 30), 39 percent of the September age-4 impacts would be expected to be mature fish. In reality, a much smaller, yet variable, proportion of September impacts would be expected to be mature, given the river return timing inferred from Figures 1 and 2 and the particular timing of ocean fisheries in September. Also note that the data and estimates presented here do not allow for direct estimation of the proportion of September impacts that were mature KRFC. It is possible that even the highest September impact rates could be largely the result of immature fish mortality.

Table 1. Pearson correlation coefficients for the September age-4 ocean impact rate and the "lateness" of the age-3 river return timing. Numbers in parentheses are p-values.

	Fingerling	Yearling
IGH	-0.419 (0.350)	-0.074 (0.862)
TRH	-0.328 (0.428)	0.228 (0.587)

5 Conclusions

The timing of the composite KRFC catch in the Yurok estuary fishery suggests that September 1 is an appropriate river return date approximation for KRFC models. While some hatchery components exhibit slightly later river return timing (e.g., age-3 TRHF and TRHY), this does not have a strong bearing on the river return timing of the composite KRFC stock. As with any salmon stock, various tributaries and hatchery releases might be expected to vary in their timing of river entry. However, as was pointed out in the Introduction, an appropriate model river return date that minimizes allocation and estimation errors should approximate the midpoint of the composite stock river return timing. This balances errors that are inherent in setting the model river return date too late for early returning substocks and too early for late returning substocks.

September age-4 ocean fishery impact rates are not dramatically higher than summer impact rates, which also suggests that the September 1 model river return date is appropriate. Hankin and Logan (2009) constructed a cohort analysis for KRFC using coded-wire tag recoveries from each of the four major release types in the Klamath Basin and observed implausibly high fall impact rates for Trinity River hatchery Chinook when they assumed a September 1 return date. Because of this observation, they explored alternative, later model river return dates, though the result of these modifications to their cohort analysis was not noted in their report. We do not observe these same implausibly high rates with the KRFC cohort analysis used for KRFC assessment. Rather, age-4 September impact rates are of the same general magnitude as impact rates for July and August.

While it is impossible to know, given current data, what proportion of ocean catch in a particular month is comprised of mature fish, one could reasonably assume that high age-4 impact rates in

September could arise if age-3 river return timing was much later than the September 1 model river return date. However, this correlation is not observed for any of the four KRFC hatchery release types. Rather, high (or low) impact rates can occur for cohorts exhibiting either late or early run timing.

High September $(t-1)$ age-4 ocean harvest rates may affect fishing opportunity in spring/summer (t) fisheries owing to the California Coastal Chinook Endangered Species Act consultation standard of a maximum KRFC age-4 ocean harvest rate forecast of 16 percent. The degree to which mature age-3 KRFC contribute to September $(t-1)$ age-4 ocean harvest has periodically been a concern. Examination of age-3 maturation rates and inferred run timing from the Yurok fishery allows for some evaluation of the expected mature fish contribution to age-4 September ocean harvest. The long-term mean maturation rate of age-3 KRFC is 39 percent. Given the age-3 hatchery catch data from the Yurok estuary fishery, one would expect that substantially less than 39 percent of the catch occurring on September 1 would be comprised of mature fish. By September 15, the expected proportion of mature age-4 in the ocean catch would drop to a very low level because most mature fish have exited the ocean to spawn as 3 year old KRFC (see Figure 2). If a goal was to minimize the risk of having mature KRFC impacts in September ocean fisheries, one tactic could be to limit fisheries between September 1 and September 15. Combining this observation based on river return timing with the fall age-4 ocean harvest rate estimates presented by ocean management area in O'Farrell (2009) allows for a more refined approach to decreasing this risk. Limiting fall commercial fisheries during the period between September 1 and September 15 in the California Klamath Management Zone (KC) and the Central Oregon (CO) management area, and to a lesser degree, Northern Oregon (NO), the Oregon Klamath Management Zone (KO), and Fort Bragg (FB), could greatly reduce the risk of harvesting mature KRFC. Commercial fisheries in the Monterey (MO) and the San Francisco (SF) management areas have a very small contribution to the fall age-4 ocean harvest rate, and recreational fisheries in general contribute relatively little to this rate. This tactic may be less effective if substantial effort transfer results from limitation of fisheries in certain ocean management areas. For example, if limitations on commercial fisheries in the CO or KC management area results in a large effort shift to the KO management area, the reduction in mature fish contribution to the age-4 ocean harvest may be lower than expected.

The KRFC conservation objective, specified in the PFMC salmon Fishery Management Plan, applies to the composite stock of fish originating in the Klamath and Trinity rivers, including all hatcheries and tributaries. A previous attempt to perform cohort reconstructions and ocean abundance estimates separately for each stock component (e.g., IGHF, TRHY) performed poorly relative to current methods (KRTAT 1994). Given these results, the choice of an appropriate river return date for models used on the composite stock should reflect the return timing observed for the entire KRFC stock. Based on analysis of harvest in the Yurok estuary fishery, September 1 continues to be a valid approximation for the KRFC river return date used in KRFC fishery assessment models.

6 Recommendations

Given these conclusions, the following recommendations are provided for future KRFC assessment.

1. The current September 1 river return date approximation should be retained in KRFC fishery assessment models. The September 1 date is clearly an appropriate average midpoint date of capture for the composite KRFC stock in the Yurok Tribe estuary fishery, a close proxy for the timing of escapement from ocean fisheries.

2. Limiting commercial fisheries in the KC and CO ocean management areas between September 1 and September 15 could reduce the risk of harvesting mature KRFC that have not yet returned to the river. If there is a desire to decrease the risk of having year $(t-1)$ impacts of mature KRFC apply to year (t) conservation objectives and consultation standards, and thus constraining year (t) fisheries, limiting commercial fisheries during these times and areas would likely be effective in achieving this goal.

7 Acknowledgements

We wish to thank the Yurok Tribe, particularly Desma Williams, for providing historical data and estimates from their Klamath River gillnet fishery. The analysis could not have been completed without this information. The contents of this memo were presented at the 2009 salmon methodology review meeting held on October 6, 2009 in Portland, Oregon. We thank the members of the PFMC Science and Statistical Committee Salmon Subcommittee and the Salmon Technical Team who evaluated and commented on this work at the methodology review. We also thank Michael Mohr for his thoughtful comments.

References

Goldwasser, L., M. S. Mohr, A. M. Grover, and M. L. Palmer-Zwahlen (2001). The supporting databases and biological analyses for the revision of the Klamath Ocean Harvest Model. Unpublished report. National Marine Fisheries Service, Santa Cruz, CA.

Hankin, D. G. and E. Logan (2009). Review draft: A preliminary analysis of Chinook salmon coded-wire tag recovery data from Iron Gate, Trinity River and Cole Rivers hatcheries, brood years 1978–2001. Contract report prepared for the Hoopa Tribal Council.

KRTAT (1994). Comparison of Klamath fall Chinook stock projection methods with post-season stock estimates for years 1985 through 1993. Unpublished report. Klamath Fishery Management Council, Yreka, CA.

Mohr, M. S. (2006). The cohort reconstruction model for Klamath River fall Chinook salmon. Unpublished report. National Marine Fisheries Service, Santa Cruz, CA.

O'Farrell, M. R. (2009). Assessment of fall ocean Chinook salmon fisheries south of Cape Falcon, OR. Unpublished report. National Marine Fisheries Service, Santa Cruz, CA.

PFMC (2009a). Preseason report I: Stock abundance analysis for 2009 ocean salmon fisheries. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

PFMC (2009b). Review of 2008 ocean salmon fisheries. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

RECENT TECHNICAL MEMORANDUMS

SWFSC Technical Memorandums are accessible online at the SWFSC web site (http://swfsc.noaa.gov). Copies are also available form the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (http://www.ntis.gov). Recent issues of NOAA Technical Memorandums from the NMFS Southwest Fisheries Science Center are listed below:

NOAA-TM-NMFS-SWFSC-458 Evidence of genetic differentiation for Hawai'i insular false killer whales *(Pseudorca crassidens)*.
S.J. CHIVERS, R.W. BAIRD, K.K. MARTIEN, B.L. TAYLOR, F.I. ARCHER, A.M. GORGONE, B.L HANCOCK, N.M. HEDRICK, D. MATILLA, D.J. McSWEENEY, E.M. OLESON, C.L. PALMER, V. PEASE, K.M. ROBERTSON, J. ROBBINS, J.C. SALINAS, G.S. SCHORR, M. SCHULTZ, J.L. THIELEKING, and D.L. WEBSTER
(May 2010)

459 Assessing trends in abundance for vaquita using acoustic monitoring: within refuge plan and outside refuge research needs.
L. ROJAS-BRANCHO, A. JARAMILLO-LEGORETTA, G. CARDENAS, E. NIETO, P. LADRON DE GUEVARA, B.L. TAYLOR, J. BARLOW, T. GERRODETTE, A. HENRY, N. TREGENZA, R. SWIFT, and T. AKAMATSU
(June 2010)

460 Estimates of sustainable yield for 50 data-poor stocks in the Pacific Coast groundfish fishery management plan.
E.J. DICK, and A.D. MacCALL
(June 2010)

461 Documentation of the California catch reconstruction project.
S. RALSTON, D.E. PEARSON, J.C. FIELD, and M. KEY
(July 2010)

462 Serious injury determinations for cetaceans caught in Hawaii longline fisheries during 1994-2008.
K.A. FORNEY
(October 2010)

463 Spawning biomass of Pacific sardine *(Sardinops sagax)* off the U.S. in 2010.
N.C.H. LO, B.J. MACEWICZ, and D.A. GRIFFITH
(October 2010)

464 Ecosystem survey of *Delphinus* species cruise report.
S.J. CHIVERS, W.L. PERRYMAN, N.M. KELLAR, J.V. CARRETTA, F.I. ARCHER, J.V. REDFERN, A.E. HENRY, M.S. LYNN, C. HALL A. JACKSON, G. SERRA-VALENTE, T.J. MOORE, C. SURREY-MARSDEN, and L.T. BALLANCE
(October 2010)

465 Oregon, California and Washington line-transect and ecosystem (ORCAWALE) 2008 cruise report.
J. BARLOW, A.E. HENRY, J.V. REDFERN, T. YACK, A. JACKSON, C. HALL, E. ARCHER, and L.T. BALLANCE
(October 2010)

466 A forward-looking scientific frame of reference for steelhead recovery on the south-central and southern California coast.
D.A. BOUGHTON
(October 2010)

467 Some research questions on recovery of steelhead on the south-central and southern California coast.
D.A. BOUGHTON
(October 2010)