Potential implications of moving the California Klamath Management Zone/Fort Bragg salmon fishery management line from Horse Mountain north to latitude 40°10'

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Introduction

At their April 2019 meeting, the Pacific Fishery Management Council (Council) requested the Salmon Technical Team (STT) "Conduct the technical analysis needed to inform a change of the salmon management boundary line from latitude 40°05' (Horse Mountain, California) five miles north to latitude 40°10'", with the intention to bring this analysis forward for Methodology Review. Figure 1 displays the California Klamath Management Zone (KC) and Fort Bragg (FB) management areas, the current boundary at Horse Mountain, and the proposed new boundary at latitude 40°10'.

For the past several years, there has been interest, primarily from the commercial salmon fishery sector, for making this change to the existing management line (see, for example, public comment made in March 2016[1] and April 2018[2]). Proponents cite that this change would provide a positive economic impact for the port of Eureka, ease congestion at the port of Fort Bragg, allow for safer fishing conditions, and would simplify management since 40°10' is an existing management line used for groundfish management. Furthermore, proponents of this change have noted that Punta Gorda, Point Delgada, and Cape Vizcaino have at times been used as management line boundaries for fisheries in northern California in the 1980s and early 1990s. Punta Gorda lies approximately 10 nautical miles north of Horse Mountain, Cape Vizcaino lies over 20 nautical miles south of Horse Mountain, and Point Delgada is adjacent to the town of Shelter Cove, approximately four nautical miles south of Horse Mountain.

[1] http://www.pcouncil.org/wp-content/uploads/2016/03/E4c_Sup_PubCom_Helliwell_MAR2016BB.pdf
[2] https://www.pcouncil.org/wp-content/uploads/2018/04/E3b_Supp_PubPresentation1_Helliwell_40-10_APR2018BB.pdf

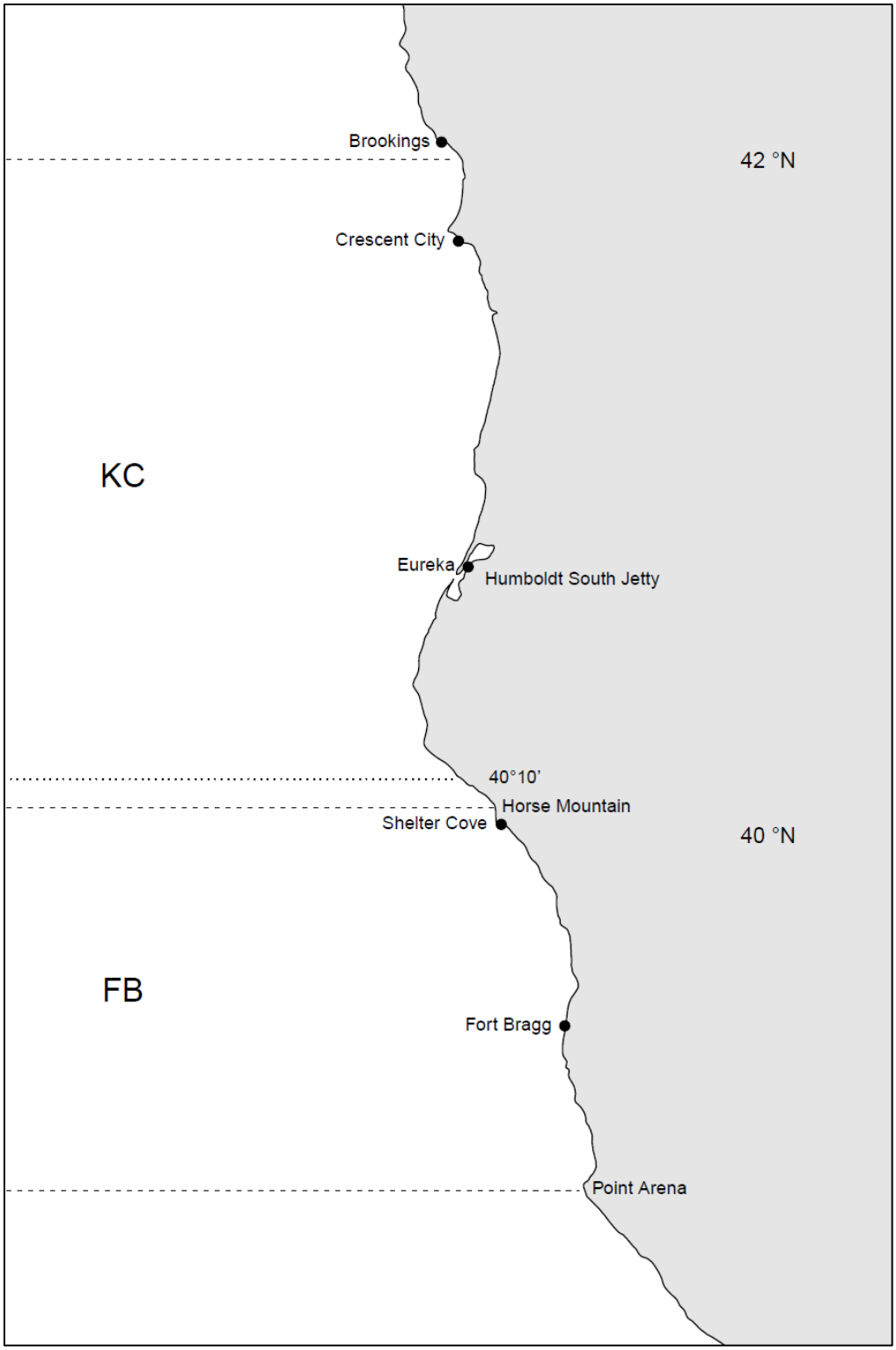

Figure 1. Map of the California Klamath Management Zone (KC) and Fort Bragg (FB) salmon management areas. Dashed lines represent the current boundary between the KC and FB management areas. The proposed action is to move the management boundary north from Horse Mountain to latitude 40°10', which is denoted by the dotted line.

The STT has noted that a change in the management area boundaries could have ramifications for harvest models used for fishery planning. Specifically, the Klamath Ocean Harvest Model (KOHM; Mohr 2006a) and Sacramento Harvest Model (SHM; Mohr and O'Farrell 2014) could be affected because much of the data used to parameterize these models has been collected with the current management line at Horse Mountain. The proposed management line change would essentially transfer approximately five nautical miles from KC to FB. With regard to the commercial fishery, there has been no fishing allowed in the region between Humboldt South Jetty and Horse Mountain since 1992 and thus there are no contemporary data for the region between 40°10' and Horse Mountain. For the recreational fishery, fishing is allowed south to Horse Mountain when the KC area is open. However, effort and coded-wire tag (CWT) data derived from fish caught between 40°10' and Horse Mountain are very likely to be assigned to the FB area as almost all of the fishing activity is based out of Shelter Cove, which lies just south of Horse Mountain.

The analysis described in this report is focused on the technical issues that may arise for the KOHM and SHM if this management line change were to be implemented. We evaluate the potential effects on effort forecasts, forecasts of contact rates per unit effort in the KOHM, forecasts of harvest rates per unit effort in the SHM, and stock proportion forecasts in both the KOHM and SHM. We then examine KOHM and SHM results under recent year fishery structures under one potential way to account for the management line change. We conclude with a discussion of risks posed to key salmon stocks and the assessment process.

Potential Effects on Harvest Models

The KOHM and SHM rely on a variety of model inputs that vary by month, management area, and fishery sector (e.g., commercial, recreational). These inputs are updated on an annual basis with the addition of new data. We identified three model inputs that are potentially affected by the management line change: (1) fishing effort per day open, (2) contact (or harvest) rates per unit effort, and (3) stock proportions.

Fishing effort

Fishing effort forecasts for days-open fisheries (i.e., not quota fisheries) are made on a month, area, and fishery sector basis by multiplying the estimated effort level per open day of fishing, by the number of days expected to be open in the month, area, fishery stratum,

$$f = \beta^{fD} \cdot D, \qquad (1)$$

where f is fishing effort, β^{fD} is the effort per day open, and D is the number of days open. Subscripts for month, area, and fishery sector are suppressed for clarity. A more detailed description of the effort forecasting procedure is presented in Mohr and O'Farrell (2014). Effort forecasts are used within the KOHM and SHM as well as other harvest models south of Cape Falcon, OR.

We discussed the potential for an effect on β^{fD} arising from the proposed change in the management area boundary with commercial and recreational fishermen familiar with the area and the proposal. For the commercial fishery, we considered whether there would be an increase in commercial fishing effort in the FB management area resulting from Eureka area vessels when the KC area was closed since the management area boundary would now be approximately five nautical miles closer to Eureka. Such an effort response was deemed unlikely because the proposed change in distance from Eureka to the northern boundary of FB is relatively small and Eureka-based vessels that typically do not travel outside the KC area to fish would be unlikely to begin doing so. The Shelter Cove commercial salmon fleet currently consists of less than ten active vessels, and they are smaller vessels that typically do not take multiple-day trips. While an effort increase among these vessels is possible, their contribution to the overall salmon fishing effort in the FB area is relatively minor and unlikely to make an appreciable difference. With regard to the recreational fishery, it was deemed very unlikely that Eureka-based vessels would travel below 40°10' to fish for salmon as the travel distance is long, especially for smaller vessels in an area known for rough ocean conditions. For Shelter Cove-based recreational vessels, there could be an increase in effort during times when KC is closed since boats would now be able to traverse further north, however given recent season structures this would only occur during times when local salmon fishing effort and harvest is already low (i.e., early-spring and fall).

As a result of these discussions, we determined that there is unlikely to be a notable effort response from the proposed management boundary change and thus did not further consider modifications to the effort per day open inputs for the KOHM and SHM.

KRFC contact rates per unit effort

The KOHM forecasts ocean contact rates (the proportion of the cohort that encounters fishing gear) for Klamath River fall Chinook (KRFC) by month, management area, fishery sector, and age[3] by multiplying the predicted effort by the estimated contact rate per unit effort,

$$c = \beta^{cf} \cdot f, \qquad (2)$$

where c is the contact rate, β^{cf} is the contact rate per unit of effort, and f is fishing effort as defined in equation (1). Subscripts for age, month, area, and fishery sector are suppressed for clarity. Historical estimates of contact rates and fishing effort are used to estimate β^{cf} as described in Mohr (2006b). A more detailed description of the contact rate forecasting procedure is presented in Mohr (2006a).

Estimates of β^{cf} tend to be higher in KC than FB for both commercial and recreational fisheries (Figure 2). To examine a potential change in contact rates per unit effort in an expanded FB region resulting from the proposed management line boundary change, we computed weighted means of β^{cf} for FB and KC,

$$\beta^{cf}_{FB,adj} = \beta^{cf}_{FB} \cdot w_1 + \beta^{cf}_{KC} \cdot w_2, \qquad (3)$$

[3] Contact rates are age-specific for the commercial fishery. For the recreational fishery, contact rates are not age-specific except for the Oregon and California Klamath Management Zone during the month of August.

with weight w_1 equal to the proportion of the "new" FB management area (denoted by the subscripts FB, adj) that lies between Point Arena and Horse Mountain and with weight w_2 equal to the proportion that lies between Horse Mountain and latitude 40°10'. Weights were computed based on the linear distances between the latitudes associated with Point Arena, Horse Mountain, and 40°10'. This approach yielded weights $w_1 = 0.9312$ and $w_2 = 0.0688$.

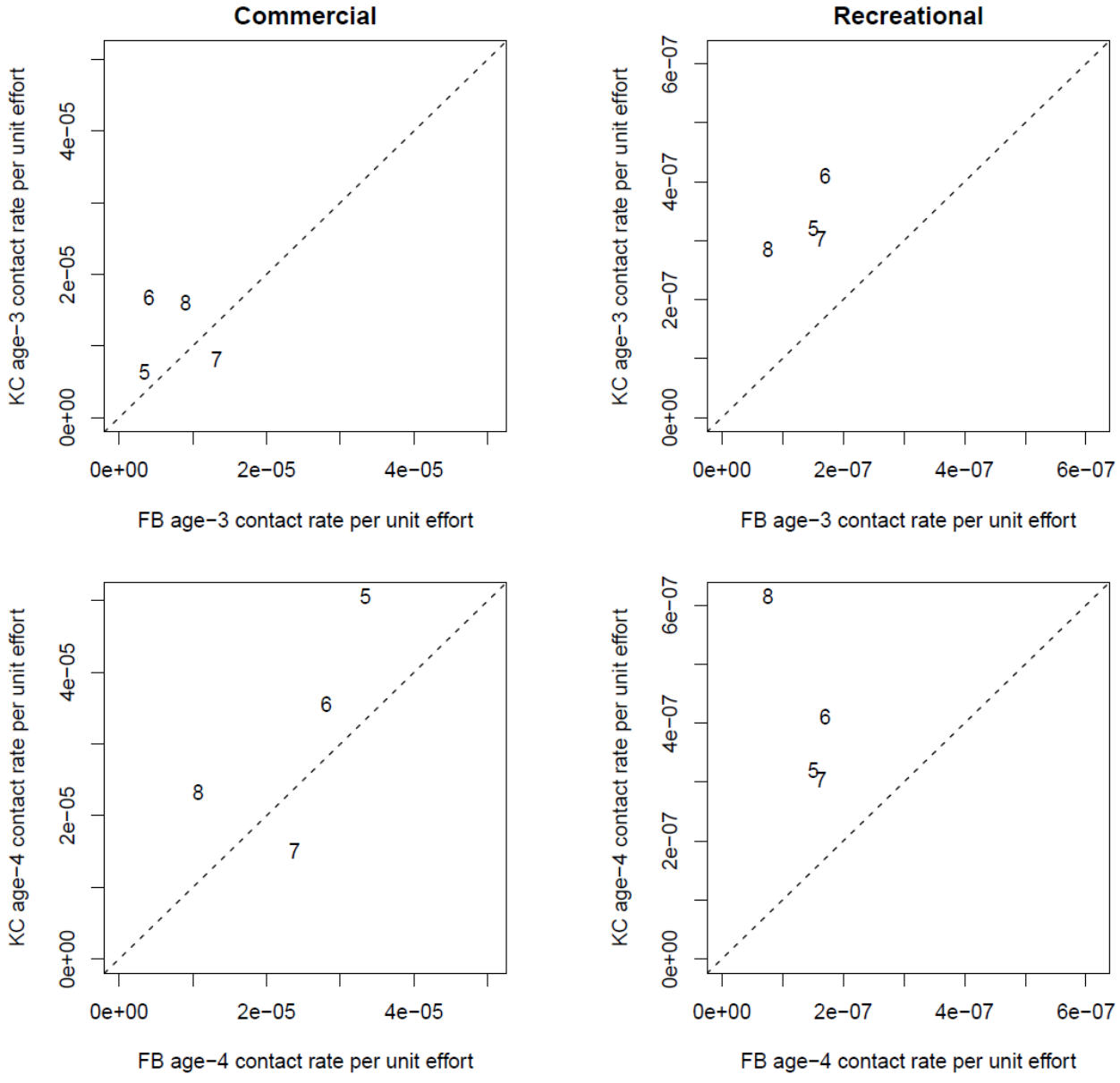

Figure 2. Estimated contact rates per unit effort for age-3 (top part of panel) and age-4 (bottom part of panel) KRFC from the 2019 KOHM. Commercial contact rates per unit effort are displayed on the left hand side of the panel and recreational fishery estimates are on the right hand side of the panel. Numbers denote month.

SRFC harvest rates per unit effort

The SHM forecasts ocean harvest rates for Sacramento River fall Chinook (SRFC) by month, management area, and fishery sector by multiplying the predicted effort by the estimated harvest rate per unit effort,

$$h = \beta^{hf} \cdot f, \tag{4}$$

where h is the harvest rate, β^{hf} is the harvest rate per unit of effort, and f is fishing effort as defined in equation (1). Subscripts for month, area, and fishery sector are suppressed for clarity. Historical estimates of harvest rates and fishing effort are used to estimate β^{hf} as described in Mohr and O'Farrell (2014).

Estimates of β^{hf} tend to be lower in KC than FB for both commercial and recreational fisheries (Figure 3). To examine a potential change in harvest rates per unit effort in an expanded FB region resulting from the proposed management line boundary change, we computed weighted means of β^{hf} for FB and KC in the same manner as previously described for KRFC:

$$\beta^{hf}_{FB,adj} = \beta^{hf}_{FB} \cdot w_1 + \beta^{hf}_{KC} \cdot w_2, \tag{5}$$

with weights estimated and applied as described in the previous section.

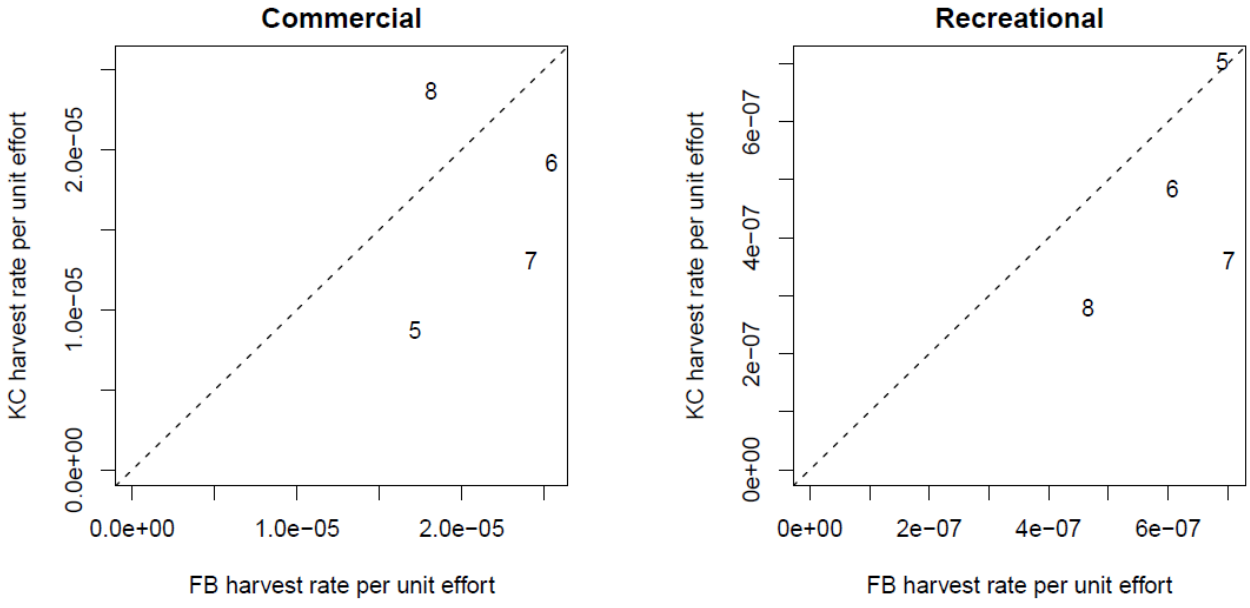

Figure 3. Estimated SRFC harvest rates per unit effort from the 2019 SHM. Commercial fishery harvest rates per unit effort are displayed on the left hand side of the panel and recreational fishery estimates are on the right hand side of the panel. Numbers denote month.

Proportion KRFC

The KOHM forecasts KRFC harvest (H^K) in quota fisheries by multiplying the month, management area, and fishery-specific quota (Q) by the proportion of harvest expected to be KRFC (p^K), $H^K = Qp^K$. Estimates of p^K tend to be higher in KC than FB for both the commercial and recreational fisheries (Figure 4). Quota fisheries are common for the commercial sector in KC, but occur only rarely in FB. Recreational quota fisheries have not occurred in these management areas for many years.

To examine a potential change in p^K that could be expected in an expanded FB region resulting from the proposed management line boundary change, we computed weighted means of p^K for FB and KC,

$$p^K_{FB,adj} = p^K_{FB} \cdot w_1 + p^K_{KC} \cdot w_2, \qquad (6)$$

with weight w_1 equal to the proportion of the "new" FB management area (denoted by the subscripts FB, adj) that lies between Point Arena and Horse Mountain and with weight w_2 equal to the proportion that lies between Horse Mountain and latitude 40°10'. As previously noted, weights $w_1 = 0.9312$ and $w_2 = 0.0688$.

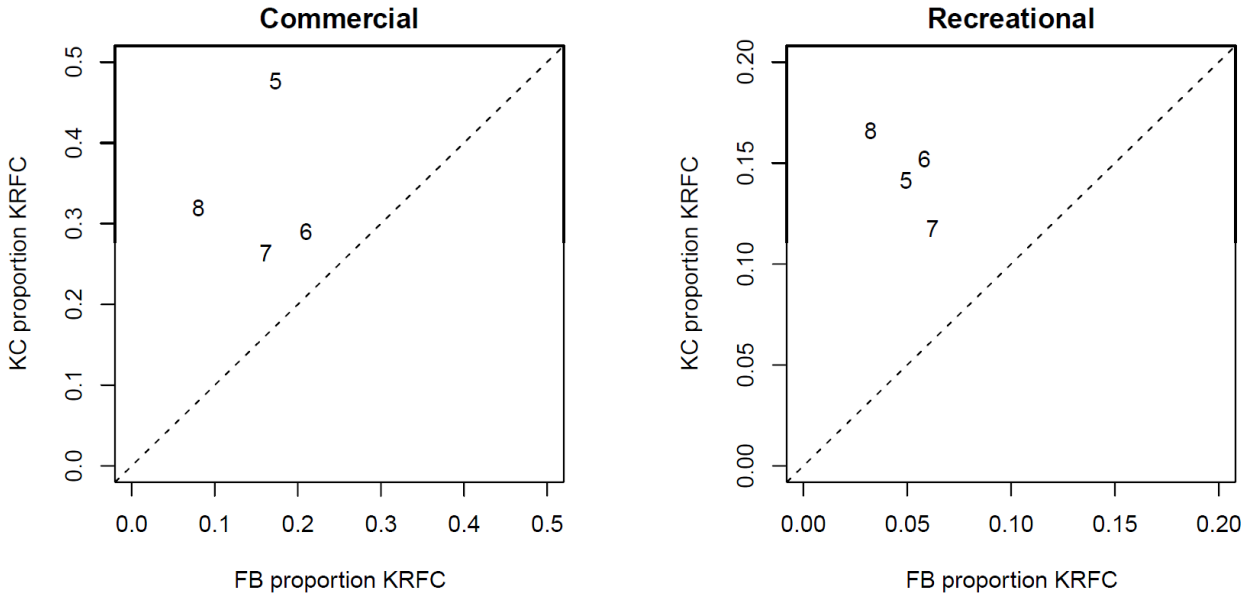

Figure 4. Estimated proportion of harvest that are KRFC from the 2019 KOHM. Estimates for the commercial fishery are displayed on the left panel and recreational fishery estimates are on the right panel. Numbers denote month.

Proportion SRFC

The SHM forecasts SRFC harvest in quota fisheries in the same manner as described for KRFC: $H^S = Qp^S$. Estimates of p^S tend to be lower in KC than FB for both the commercial and recreational fisheries

(Figure 5). Quota fisheries are common for the commercial sector in KC, but occur only rarely in FB. Recreational quota fisheries have not occurred in these management areas for many years.

To examine a potential change in p^S that could be expected in an expanded FB region resulting from the proposed management line boundary change, we computed $p^S_{FB,adj}$ in the same manner as described for KRFC:

$$p^S_{FB,adj} = p^S_{FB} \cdot w_1 + p^S_{KC} \cdot w_2. \qquad (7)$$

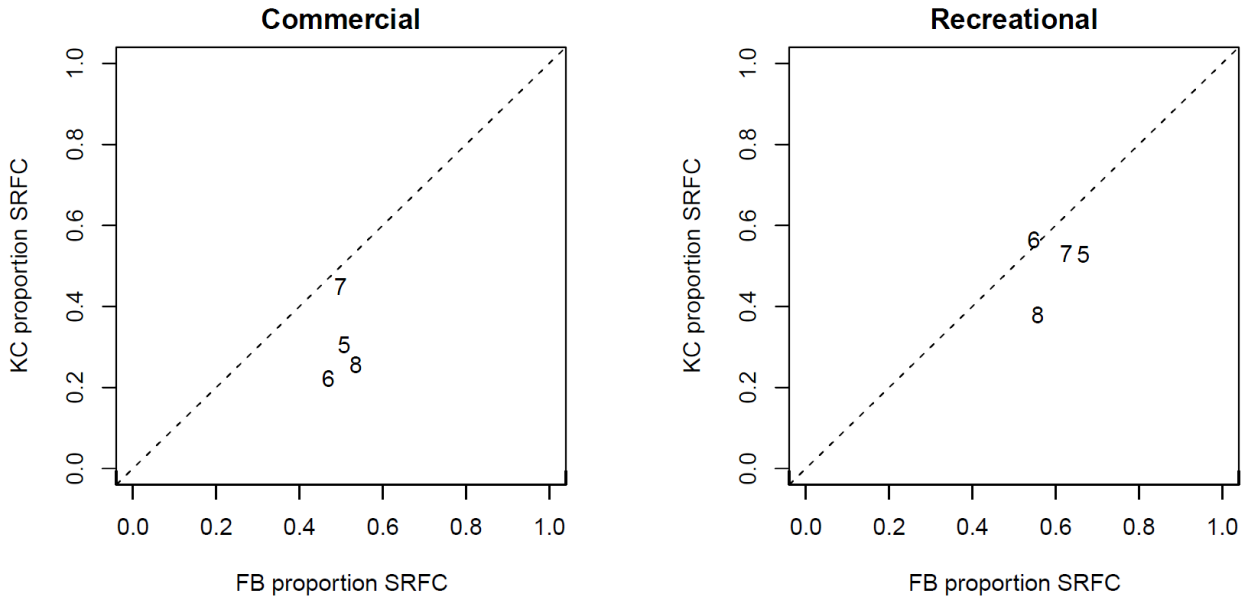

Figure 5. Estimated proportion of harvest that are SRFC from the 2019 SHM. Estimates for the commercial fishery are displayed on the left panel and recreational fishery estimates are on the right panel. Numbers denote month.

Retrospective Analysis

We ran the KOHM and SHM under the status quo management line boundaries and under the scenario where the northern boundary of the FB management area was moved northward from Horse Mountain to 40°10'. For the 40°10' scenario in the KOHM, $\beta^{cf}_{FB,adj}$ and $p^K_{FB,adj}$ were assumed for the FB management area as defined in equations (3) and (6), respectively, for both the commercial and recreational fisheries. For the recreational fishery in FB for the month of August, the $\beta^{cf}_{FB,adj}$ were assumed to be age-specific, following the convention for the KC area in that month and fishery sector. For the 40°10' scenario in the SHM, $\beta^{hf}_{FB,adj}$ and $p^S_{FB,adj}$ were assumed for the FB management area as defined in equations (5) and (7), respectively, in both the commercial and recreational fisheries.

The status quo and 40°10' scenarios were evaluated in the KOHM and SHM for years 2014-2019, but excluding 2017. Year 2017 was omitted because there were no pre-September commercial fisheries in the KC or FB management areas, no recreational fishery in the KC area, and a heavily restricted recreational fishery in the FB area.

The status quo harvest model results were identical to those found in Preseason Report III for those years. For the 40°10' scenario, the only modifications to the KOHM and SHM were those described two paragraphs above for the FB management area; all other model inputs used at the time (years 2014-2019, excluding 2017) were preserved.

To evaluate the potential effect of the proposed management line change, we focused on evaluation of results for fishery metrics (harvest and harvest rates) and projected river mouth returns. The percent difference, $\left(\frac{y-x}{x} \times 100\right)$, between the status quo scenario (x) and the 40°10' scenario (y) was computed for each of these metrics.

Results

Table 1 displays KOHM sector-specific ocean harvest, age-specific harvest rates, and river return projections for the status quo and 40°10' scenarios. Percent difference for each of these metrics was small, less than 3.1 percent (much less, in most cases) over each year and metric. With the exception of 2014, all harvest-related measures for KRFC were higher for the 40°10' scenario relative to status quo. As a result, river return projections were slightly lower under the 40°10' scenario relative to status quo. For 2014, the difference between the two scenarios was small with the percent difference falling on both sides of zero for the harvest metrics and near zero for the river return.

Table 2 displays SHM sector-specific ocean harvest, ocean harvest rates, and river return projections for the status quo and 40°10' scenarios. Across all metrics, the percent differences were less than one percent. In contrast to the results for KRFC, harvest-related metrics were lower, and river returns higher, under the 40°10' scenario relative to the status quo.

The differences between the status quo and 40°10' scenario results are entirely due to changes in β_{FB}^{cf} and β_{FB}^{hf}, and not p_{FB}^{K} and p_{FB}^{S}, because there were no FB quota fisheries for the years considered. Quota fisheries in the FB management area are rare for the commercial fishery and have not occurred for the recreational fishery.

Table 1. Klamath Ocean Harvest Model (KOHM) projections under the status quo and 40°10' scenarios.

Year	Metric	KOHM: status quo	KOHM: 40°10'	% Difference
2014	Commercial harvest	19,646	19,583	-0.32%
	Recreational harvest	3,521	3,573	1.48%
	Age-3 ocean harvest rate	0.046	0.046	-0.28%
	Age-4 ocean harvest rate	0.160	0.160	0.15%
	River return	92,827	92,824	0.00%
2015	Commercial harvest	24,566	24,754	0.77%
	Recreational harvest	4,882	4,951	1.41%
	Age-3 ocean harvest rate	0.047	0.048	0.74%
	Age-4 ocean harvest rate	0.160	0.162	1.04%
	River return	119,753	119,578	-0.15%
2016	Commercial harvest	5,056	5,157	2.00%
	Recreational harvest	1,237	1,262	2.02%
	Age-3 ocean harvest rate	0.022	0.023	3.07%
	Age-4 ocean harvest rate	0.084	0.085	1.56%
	River return	52,138	52,052	-0.16%
2018	Commercial harvest	11,818	11,867	0.41%
	Recreational harvest	2,813	2,857	1.56%
	Age-3 ocean harvest rate	0.034	0.034	0.67%
	Age-4 ocean harvest rate	0.115	0.116	0.48%
	River return	91,873	91,825	-0.05%
2019	Commercial harvest	21,884	21,989	0.48%
	Recreational harvest	2,879	2,923	1.53%
	Age-3 ocean harvest rate	0.045	0.046	1.23%
	Age-4 ocean harvest rate	0.160	0.161	0.32%
	River return	97,912	97,820	-0.09%

Table 2. Sacramento Harvest Model (SHM) projections under the status quo and 40°10' scenarios.

Year	Metric	SHM: status quo	SHM: 40°10'	% Difference
2014	Commercial harvest	191,237	190,450	-0.41%
	Recreational harvest	77,466	77,298	-0.22%
	Ocean harvest rate	0.423	0.422	-0.24%
	River return	365,948	366,903	0.26%
2015	Commercial harvest	169,853	168,559	-0.76%
	Recreational harvest	85,601	85,445	-0.18%
	Ocean harvest rate	0.392	0.390	-0.51%
	River return	396,531	397,982	0.37%
2016	Commercial harvest	83,749	83,510	-0.29%
	Recreational harvest	40,130	40,057	-0.18%
	Ocean harvest rate	0.413	0.412	-0.24%
	River return	175,731	176,042	0.18%
2018	Commercial harvest	44,763	44,634	-0.29%
	Recreational harvest	21,895	21,840	-0.25%
	Ocean harvest rate	0.291	0.290	-0.34%
	River return	162,774	162,958	0.11%
2019	Commercial harvest	142,288	141,719	-0.40%
	Recreational harvest	48,921	48,824	-0.20%
	Ocean harvest rate	0.504	0.502	-0.40%
	River return	188,423	189,089	0.35%

Discussion

Our analysis of potential effects on the KOHM and SHM suggests that moving the current KC/FB management line boundary five nautical miles north to latitude 40°10' would likely have very small effects on projected harvest, harvest rates, and river mouth returns for both Klamath and Sacramento River fall Chinook salmon. If the management area boundary line was changed to 40°10', the modifications to the KOHM and SHM described could be implemented for fishery planning in the first year. However, subsequent data collected from the "new" KC and FB management areas would complicate calculation of the weighted mean estimates used for contact rates per unit effort, harvest rates per unit effort, and stock proportions described in this report. We view the analysis presented here as an evaluation of the potential effect of the management line change rather than a new method that would be incorporated into the harvest models should the management line shift northward to 40°10'.

While this analysis suggests only small effects on projected harvest rates and river returns, a change in the KC/FB management line is not without risk. We lack data specific to the area in question between Horse Mountain and 40°10' that could be used for a more detailed analysis. Commercial fishing in that area has been closed since 1992. Data in the form of CWTs collected from the commercial fishery in KC prior to 1992 could have come from the area between Horse Mountain and 40°10', but this cannot be verified. This uncertainty may be particularly problematic for KRFC, a stock that frequently constrains ocean fisheries in FB and KC, because they have relatively high impacts from the commercial fishery and their distribution is centered in KC and adjacent areas. However, the KRFC contact rates and stock proportions that were used in these analyses to represent the area between Horse Mountain and 40°10' (i.e., from the entire KC area) may be higher than the "true" values. Almost all of the commercial data used to inform those estimates was collected from vessels fishing from Eureka north, an area that likely has higher KRFC contributions to catch during most of the year than the area in question.

There is less of a concern surrounding the recreational fishery because most, if not all, of the vessels fishing between Horse Mountain and 40°10' that were sampled by field staff were encountered in Shelter Cove, which lies within the current FB area. Thus, for practical purposes, stock-specific harvest proportions and contact/harvest rates per unit of effort in the area between Horse Mountain and 40°10' are already being incorporated into the FB area in the KOHM and SHM. Moving the boundary north might benefit management of the recreational fishery, since it would "correct" the assignment of that five-mile stretch into the management area for which its data is already being assigned.

In discussions with stakeholders, it was determined that an appreciable effort response to the proposed boundary change would be unlikely. However it is possible that there would be new interest in fishing an area that has been closed to commercial salmon fishing for nearly 30 years. The realized effort response among the commercial fleet may therefore be greater than expected. A notable increase in recreational effort seems highly unlikely due to the reasons described above.

A further concern is the potential effect on Endangered Species Act-listed stocks such as California coastal Chinook and Southern Oregon/Northern California coast (SONCC) coho salmon. The nearby Mattole River watershed, which flows into the ocean at latitude 40°18', is considered a critical component of the California coastal Chinook evolutionarily significant unit (ESU) and is the southernmost coastal extent for the SONCC coho ESU. Fishery contacts with salmon from other watersheds within these ESUs would also be expected between Horse Mountain and 40°10'. There is currently no hatchery component for California coastal Chinook, meaning we are unable to assess fishery impacts on this ESU. Genetic Stock Identification data suggest that California coastal Chinook and KRFC exhibit similar distributions in spring and early summer, but by August catch per unit effort for California coastal Chinook was increased in the FB area while KRFC catch per unit effort shifted to the northern portion of KC, near the Klamath River mouth (Satterthwaite et al. 2014). Retention of coho salmon is illegal throughout California, so any fishery mortality incurred by SONCC coho between Horse Mountain and 40°10' would be limited to hook-and-release mortality, dropoff mortality, and misidentified harvest.

Given the results presented herein, we find that there are small anticipated effects on the KOHM and SHM imparted by the proposed management boundary change. With regard to the Chinook Fishery Regulation Assessment Model (FRAM), the STT expects that the proposed change to the salmon

management boundary would have a negligible effect, given that the anticipated changes to total catch are small. Stock compositions of the KMZ and Southern California FRAM fisheries (currently delineated by Horse Mountain) are similar. For both commercial and recreational fisheries in these areas, greater than 90 percent of the catch comes from stocks that originate south of Cape Falcon, for which Chinook FRAM is not used to forecast fishery impacts. For each of these harvest models, there are limitations to accurately estimating the effect of small-scale changes to ocean salmon fisheries.

Given the small anticipated effect on KOHM, SHM, and Chinook FRAM results, we suggest that no changes be made to these harvest models if the Council chooses to adopt the proposed change in the management area boundary. Therefore the decision is largely one of policy, weighing the benefits to the fishery and the potential costs due to uncertainty in the effects on salmon stocks in the area of interest.

Conclusions

1. Data do not exist on a fine enough scale to directly evaluate potential changes to stock-specific fishery impacts resulting from the proposed change to the KC/FB management area boundary.

2. Such a change may increase the uncertainty in harvest model projections, primarily in terms of commercial impacts.

3. The evaluation of potential changes to harvest, harvest rates, and river return projections for KRFC and SRFC resulting from this management line adjustment suggested that effects could be small.

4. The STT recommends no changes to existing harvest models if the Council were to adopt this change to the KC/FB management area boundary line.

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