ALASKA DEPARTMENT OF FISH AND GAME

DIVISION OF SPORT FISH

MEMORANDUM

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SUBJECT: Kenai River Chinook salmon inseason assessment in 2015

Assessment of Kenai River Chinook salmon continues to undergo transition. In 2015, sonar operations at river mile 8.6 (rm 9) will be discontinued, and assessment will be based on sonar estimates of abundance at river mile 13.7 (rm 14). The current escapement goals for the early and late runs will not change. This memo summarizes background information and recent sonar-related findings that are relevant to these planned changes.

Note that the numbers presented here are preliminary at this time. Final numbers will be published later this year in a series of FDS reports (Miller et al *In prep a, b, c, d*).

Background

The rm 9 sonar site was chosen in the 1980s because it was downstream of the sport fishery and because the bottom profile was conducive to dual- and split-beam sonar technology.[1] It is not feasible to insonify the entire cross section of the river at rm 9 because the water level fluctuates periodically with the tide, and sonar transducers must be located where they remain submerged at low tide. Sonar-based estimates of abundance at rm 9 apply to a portion of the river cross section, 40-60 m wide, in the deepest water near mid-river. Test gillnetting data have been collected at the rm 9 site in a mid-river corridor corresponding to the insonified zone. Originally, it was believed that few Chinook salmon migrated outside of this midriver corridor.

Multi-beam imaging sonar technology (DIDSON) was developed in the early 2000s, which made it possible to measure fish size from sonar images. Feasibility studies from 2002 to 2009 established that DIDSON could reliably distinguish large from small fish in the Kenai River. Comprehensive (both-bank) DIDSON-based estimates of Chinook salmon abundance at the rm 9 site were obtained beginning in 2010.

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[1] This technology requires a relatively smooth and shallow "V" shaped profile, where the slope is constant from both banks.

DIDSON technology has the additional advantage of being less constrained by bottom profile characteristics.[2] In a 2011 external review of the sonar program, it was recommended that the sonar be moved to a site located upstream of the current site free of tidal influence so that a larger fraction of passing fish could be detected and counted (T Mulligan and M Adkison, unpublished correspondence). In 2011 and 2012, short-term experimental deployments of DIDSON behind the usual transducer placements at rm 9 confirmed that some Chinook salmon migrate near shore, outside of the standard insonified zone.

After the 2012 season, a state space model (SSM) was fitted to sonar, netting, catch-rate, and capture-recapture data; historical abundance was reconstructed; and escapement goals were developed in preparation for the 2013 season (Fleischman and McKinley 2013, McKinley and Fleischman 2013). This modeling exercise, which synthesized information from all applicable data, estimated that the proportion of Chinook salmon migrating mid-river (pMR) and detected by sonar and nets at rm 9 was 0.65 during the early run and 0.78 during the late run. Therefore, since 2013, inriver abundance as estimated by DIDSON has been expanded by (1 / 0.65 =) 1.55 during the early run and (1 / 0.78 =) 1.28 during the late run, to account for incomplete detection at rm 9. In 2013 and 2014, Chinook salmon stocks were managed using projections of escapement based on expanded rm 9 inriver abundance estimates.

The new sonar site at rm 14 was first investigated in 2012. Because it is located upstream of tidal influence and not subject to daily fluctuations of water level, nearly the entire cross section of the river can be insonified at the site. ARIS (next generation DIDSON) sonar was successfully deployed at this site for the entire 2013 and 2014 seasons. Two to five ARIS transducers sampled up to 12 spatial strata for 10 minutes per hour per stratum, and the resulting data were analyzed post-season to produce the preliminary estimates of abundance presented in this memo. Most technical and logistical challenges at the new site have been resolved. The only major change planned for rm-14 operations in 2015 is that abundance estimates will be produced in-season.

The current escapement goals (early-run = 5,300 to 9,000 OEG; late-run = 15,000 to 30,000) will remain in effect in 2015. These goals were designed to be transferable to assessments from the rm 14 sonar site (Fleischman and McKinley 2013, McKinley and Fleischman 2013). The expanded rm 9 estimates were temporary substitutes for the more complete assessments derived from insonifying nearly the entire cross section of the river at the new site.

Abundance of large Chinook salmon can be directly assessed by the sonar alone,[3] however assessing the abundance of all Chinook salmon (regardless of size) requires sonar data supplemented by additional information from the test gillnetting project. The netting data provide the size information necessary to estimate the number of Chinook salmon that are too small to be distinguished from sockeye, coho, and pink salmon. Such estimates are produced by fitting statistical mixture models to sonar and netting data.[4]

Old (expanded rm-9) and new (unexpanded rm 14) estimates are reported here. Attributes and details of the two estimators are summarized in Table 1. Note that the 2013 rm 14 estimates reported here differ slightly from those in the 2014 FAQ document.[5] In the FAQ, the rm 14 estimates were not decremented by the number of downstream fish.

[2] DIDSON and ARIS technology is better suited to accommodate irregular bottom profiles.
[3] Estimates of Chinook salmon exceeding X cm, as measured by the DIDSON or ARIS, will be produced in the final reports. They are not found in this memo.
[4] A helpful way to illustrate how the sonar and netting data are combined by the mixture model is as follows. If the sonar counts 100 large Chinook salmon, and one half of Chinook salmon sampled in the nets are large, then total Chinook salmon abundance is approximately 200, composed of 100 large and 100 small fish.
[5] http://www.adfg.alaska.gov/static/fishing/pdfs/kenai_king_salmon_faqs_01282014.pdf

Recent Findings

Daily estimates at rm 9 and rm 14 generally tracked one another in 2013 and 2014, although there were multiple periods when the estimates diverged substantially (Figure 1).

Some of the differences could potentially be due to harvest and spawning of fish between the two sites. An inriver creel survey in 2014 estimated that 241 (45%) of 539 harvested Chinook salmon were taken between river miles 9 and 14. Telemetry experiments estimated that 4.2% (2013) and 5.4% (2014) of radio-tagged Chinook salmon spawned between the sites. By adjusting for these factors, inriver run abundance at rm 9 can be reconstructed from the ARIS estimates at rm 14 (Table 2). These reconstructed ARIS estimates ($IR9_A$ in Table 2) compare well, on average, with the expanded DIDSON-based estimate obtained solely from rm 9 data. The average ratio of reconstructed inriver run to DIDSON-based abundance at rm 9 was 0.96 for the early run and 0.98 for the late run (Table 2).

On the other hand, annual ratios of reconstructed inriver run to DIDSON-based abundance at rm 9 differed substantially between years, especially during the early run (1.13 in 2013 vs. 0.79 in 2014), but also during the late run (1.06 in 2013 vs. 0.90 in 2014). This would indicate that the rm-9 DIDSON missed a greater proportion of Chinook salmon in 2013 than in 2014. Findings from an experimental netting project near shore at rm 9 were consistent with these findings: there were relatively more Chinook salmon near shore in 2013 than in 2014.

The median date of early-run passage was four days earlier at rm 14 than at rm 9 in 2013, but no different in 2014 (Figure 2). Median date of late-run passage was four days later at rm 14 than at rm 9 in 2013, and six days later in 2014 (Figure 2). Radio-telemetry results were consistent with these findings: Chinook salmon radio-tagged at rm 9 began to exhibit less consistent upstream migration in late July.

Discussion

During 2013 and 2014 the rm 14 sonar provided abundance assessments that were roughly equivalent, on average, to the expanded rm 9 estimates. The average adjusted ratios of inriver run to DIDSON (Table 2) were slightly less than one (0.96 early run, 0.98 late run), meaning that rm 14 produced estimates of inriver abundance that were slightly smaller, on average, than the expanded rm 9 numbers.

Under the current assessment, the proportion migrating in midriver at rm 9 (pMR) is treated as a constant (although differing between early and late runs). The 2013-2014 findings suggest that pMR can change from one year to the next. Thus the current rm 9-based estimates (which use a constant expansion factor) are prone to error, producing management advice that can either be too restrictive or too lenient.

Inseason assessment based on the rm 14 sonar, which can insonify nearly the entire cross section of the river, minimizes the uncertainty introduced by the inconsistent detection rates at rm 9. This is the primary advantage of moving the sonar site to rm 14. Other benefits include reduced risk of losing the sonar gear (currently vulnerable during extreme tides), and cost savings due to reduced staffing requirements.

During 2015, inseason run assessment will rely largely on 2013-2014 timing data from the rm 14 sonar. Specifically, the mean of 2013 and 2014 cumulative daily run timing proportions will be used as the basis for projections of end-of-season run size (Figure 3). Run timing curves based on rm 9 DIDSON (n=5 years) and netting CPUE (n=13 years) indicate that 2013 and 2014 runs were not anomalously early or late; and 2013-2014 mean run timing was very similar to mean run timing obtained from those longer datasets (Figure 3). Thus the two years of rm 14 sonar data, though limited, should provide reasonably unbiased point projections of season-ending run size.

While the primary advantage of the rm 14 site is increased accuracy of the final Chinook salmon escapement estimate, a disadvantage is that inseason projections used for management decisions will occur at a time when a smaller fraction of the run has passed the sonar, due to a delay as fish transit the five miles to the upper site. Projections based on smaller fractions require larger expansions and are more uncertain. The information loss due to delayed run timing will offset some of the gain due to monitoring nearly the entire run at rm 14, and the net effect on our ability to accurately assess the run inseason may be positive or negative.

Delayed run timing may be a more important consideration during the late run. In 2013 and 2014, it took up to six days longer for a given proportion of the late run to pass rm 14, compared to rm 9. Decisions based on data through 21 July are currently based on the expectation that approximately 50% of the run has passed rm 9, whereas only 34% of the run had passed the rm 14 sonar by that date in 2013-2014.

We know of few ways to mitigate the delay in management advice. Over the next several years we will investigate the potential for augmenting the information from the rm 14 sonar with catch rates from the rm 9 inriver gillnets. To maximize the extent to which the netting data are representative of all Chinook salmon, it will be important to incorporate data from experimental nearshore drifts. We will also continue to investigate possible environmental predictors of run timing, such as have been found for Yukon River Chinook salmon. We will develop a more complete understanding of the strengths and weaknesses of the new inseason assessment as more years of data accumulate.

Summary

- Inseason assessment based on rm14 sonar is another step in an ongoing transition for Kenai River Chinook salmon management.
- In 2015, inseason run assessment will be based on the rm 14 sonar. The rm 9 sonar will no longer be operated.
- Estimates of total Chinook salmon abundance at the new site will be based on a synthesis of rm 14 sonar data and rm 9 midriver netting data.
- Escapement goals, which were designed to be transferable to the rm 14 sonar, will not change.
- The rm 14 sonar will be able to insonify nearly the entire width of the river, which will result in more accurate assessments of the total run size and an improved understanding of stock dynamics.
- For the late run, run timing at rm 14 may be delayed by several days, requiring staff to make management decisions based upon less accurate projections of total run size. We are actively investigating ways to improve the timeliness and accuracy of late-run management advice, however the best solutions may require that we accumulate several more years of data.

Literature Cited

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Table 1.- Attributes of abundance estimates reported in the memo.

	Sonar-based Estimates		
	"expanded RM 9"	"RM 14"	Comments
Location of Sonar	river mile 8.6	river mile 13.7	
Years Used for Management	2013-2014	2015+	
Sonar Technology	DIDSON	ARIS	Both are multi-beam imaging sonars. ARIS is next generation DIDSON.
Cross-river Spatial Coverage	partial (midriver only)	nearly complete	Nearshore regions not insonified at rm 9
Expansion Factors	1.55 (early run); 1.28 (late run)	none	Rm-9 expansion factors were estimated in 2013 by fitting a state-space model to historical data
Direction of Travel	upstream only	net upstream	Net upstream is upstream fish decremented by downstream fish, to more accurately reflect spawning escapement

Table 2.- Reconstructed annual inriver abundance of Kenai River Chinook salmon at river miles 9 and 14 in 2013 and 2014.

	Harvested between sites	Spawned between sites	Observed by ARIS @ rm 14	Reconstructed Inriver Run @ rm 9	Expanded DIDSON @ rm 9		rm14:rm9 Ratio
				$IR9_A$			
	H	S	IR14	$= H + S + IR14$	$IR9_{XD}$		$= IR9_A / IR9_{XD}$
Early Run							
2013	0	0	2,307	2,307	2,037		1.13
2014	0	0	4,211	4,211	5,310		0.79
					mean		0.96
Late Run							
2013	705	761	16,643	18,109	17,011		1.06
2014	241	821	14,134	15,196	16,800		0.90
					mean		0.98

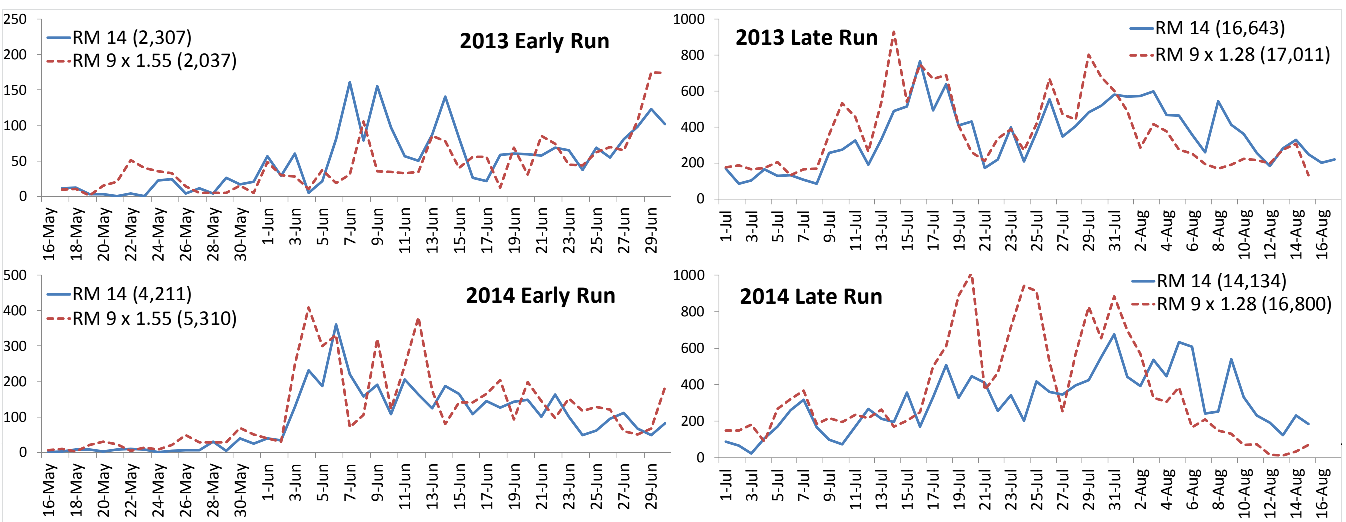

Figure 1.- Daily abundance estimates of Kenai River Chinook salmon as measured by sonar sites at river miles 9 and 14, 2013 and 2014.

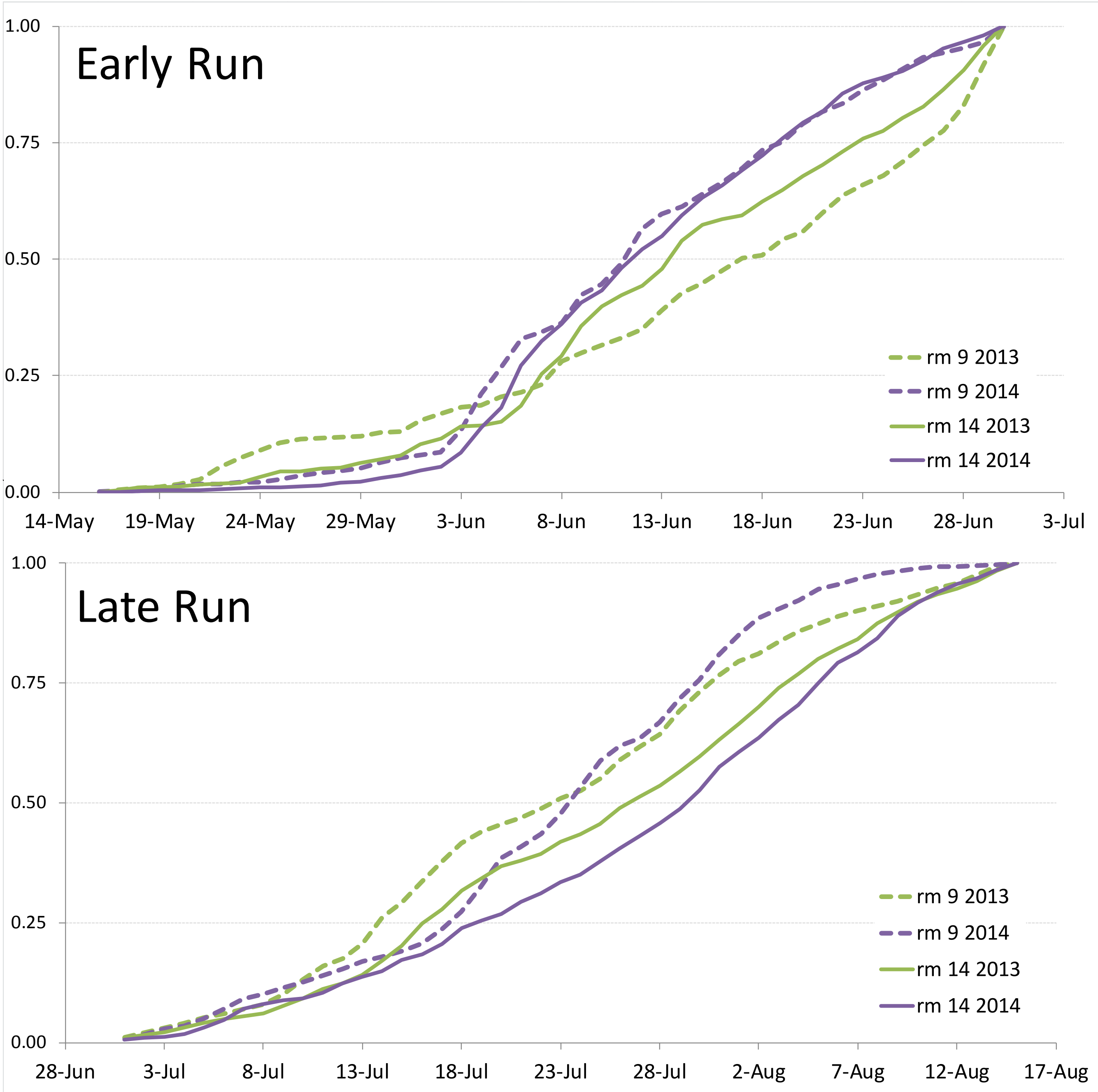

Figure 2.- Cumulative daily proportion of end-of-season abundance (run timing) for Kenai River Chinook salmon as measured by sonar at river miles 9 and 14, 2013 and 2014 early and late runs.

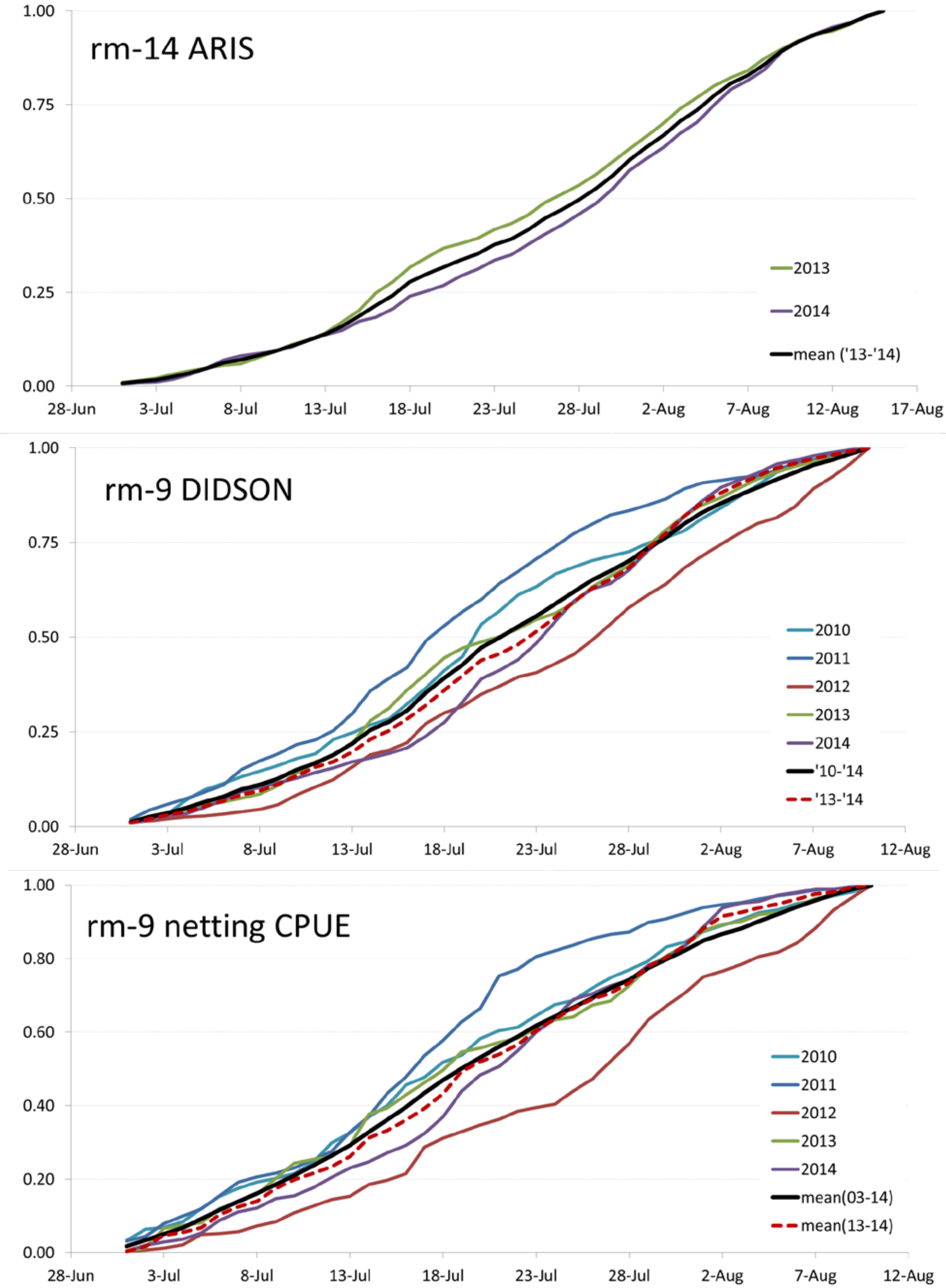

Figure 3.- Cumulative daily relative abundance of late-run Kenai River Chinook salmon as measured by sonar at river mile 14 (2013 and 2014), at river mile 9 (2010-2014, mean of 2010-2014, mean of 2013-2014); and cumulative daily netting CPUE at river mile 9 (2003-2014, mean of 2003-2014, mean of 2013-2014). Run timing during years 2013 and 2014 was not atypical, and mean 2013-2014 run timing is very similar to mean run timing during 2010-2014 and 2003-2014.