EFFECTS OF RESERVOIR RELEASES ON ADULT SALMON DURING A DROUGHT YEAR
SUPPLEMENTAL REPORT NUMBER 1
FISH RESEARCH PROJECT
OREGON

PROJECT TITLE: Lost Creek Dam Evaluation Project

PROJECT PERIOD: 1 May 2001 to 31 December 2001

Prepared by: T.D. Satterthwaite

Oregon Department of Fish and Wildlife
2501 S.W. First Avenue
P.O. Box 59
Portland, Oregon 97207

Date submitted: May 2002

This project was funded by the United States Army Corps of Engineers as a cooperative agreement.

CONTENTS

SUMMARY

Objectives for 2001

Project objectives were to: (1) estimate the number of unspawned adult spring chinook salmon that die downstream of Gold Ray Dam, (2) estimate the date that adult spring chinook salmon begin to show signs of disease, (3) estimate the number of unspawned adult fall chinook salmon that die downstream of Gold Ray Dam, and (4) identify the effects of water temperature and flow on the mortality rate of adult spring and fall chinook salmon, and on the timing of disease outbreaks.

Accomplishments in 2001

All objectives were accomplished.

Findings in 2001

Reservoir releases were effective in decreasing the prespawning mortality rates among adult salmonids. Few diseased spring chinook salmon were seen in May and June. Estimated mortality rates were 17% for spring chinook salmon and 11% for fall chinook salmon. Mortality rates of both races of chinook salmon were sharply lower as compared to other drought years, when mortality rates commonly exceeded 50%. Premature deaths were greatest among late-run spring chinook salmon and early-run fall chinook salmon.

Recommendations

1. During the next dry year when reservoir releases in May and June are scaled to predictions of air temperature, the goal for maximum water temperature at Agness should be increased to 66^{O}F. The efficacy of this change should be evaluated by directed sampling.

2. In years when mean flows at Agness during 10 August - 10 September range between 1,900 cfs and 2,200 cfs, mortality rates of fall chinook salmon should be estimated by directed sampling.

3. No additional reservoir storage is needed to decrease mortality among coho salmon. Storage allocated to protect fall chinook salmon also protects early-run coho salmon, and later run fish are not exposed to warm water temperatures.

INTRODUCTION

The Congress of the United States of America authorized construction of Lost Creek Dam on the Rogue River to create a reservoir to be used for multiple purposes, including the enhancement of fishery resources in downstream areas (United States Congress 1962). Benefits to anadromous salmonids in downstream areas were expected to accrue by operating the dam to (1) decrease peak flow in winter, (2) increase flow in summer, and (3) decrease water temperature in summer.

Guidelines for the release of stored water were intended to be flexible, reflecting annual variations in water yield and user demand. When the reservoir fills, 180,000 acre-feet of storage is available for flow augmentation (USACE 1972). Of this total, 125,000 acre-feet were authorized for fishery enhancement (United States Congress 1962). The remaining 55,000 acre-feet of storage was dedicated to other uses: irrigation supply, municipal and industrial supply, and environmental enhancement. Dedicated storage that is not purchased is also available for downstream enhancement of fishery resources (USACE 1972).

The authorizing document also outlined minimum outflow and maximum water temperature to be released from Lost Creek Dam, but clearly stated these guidelines should be modified as additional information became available: "It should also be noted that project operation plans must be sufficiently flexible to permit desirable modifications in scheduled fishery releases, within the limits of storage provided therefore, if experience and further study indicates such action to be desirable for overall project benefits" (United States Congress 1962).

Extensive research conducted before and after the construction of Lost Creek Dam indicated that adult spring and fall chinook salmon died at high rates in the Rogue River during years of low water yield (ODFW 1992, ODFW 2000). In the drought years of 1992 and 1994, mortality estimates of spring chinook salmon in freshwater exceeded 70% (ODFW 2000). Planners projected that mortality rates would also be high in 2001 because pre-season predictions of water yield were near record low levels for the Rogue River Basin (National Resources Conservation Service, unpublished data).

In an effort to protect as many adult chinook salmon as possible with the limited amount of reservoir storage, the United States Army Corps of Engineers (USACE) decided to scale reservoir releases in May and June to predictions of maximum air temperature in the Rogue River Valley. In addition, the USACE decided to release 1,800 cfs from the middle of August through the middle of September. Previous work suggested that these release strategies might be effective in protecting the majority of the spring and fall chinook salmon during their freshwater migration.

The Oregon Department of Fish and Wildlife (ODFW), in cooperation with the USACE, developed this project to determine the effects of reservoir releases on the survival of adult spring and fall chinook salmon in the Rogue River during a drought year. Project objectives were to: (1) estimate the number of unspawned adult spring chinook salmon that die downstream of Gold Ray Dam, (2) estimate the date that adult spring chinook salmon begin to show signs of disease, (3) estimate the number of unspawned adult fall chinook salmon that die downstream of Gold Ray Dam, and (4) identify the effects of water temperature and flow on the mortality rate of adult spring and fall chinook salmon, and on the timing of disease outbreaks.

METHODS

Physical Factors

I used provisional data from the United States Geological Survey gage near Agness, river kilometer (RK) 44, to represent water temperature and flow in the Rogue River canyon (RK 55-110).

Timing of Disease Outbreak

Project personnel surveyed the outflows of two tributary streams in the Rogue River canyon twice weekly from the middle of May through the end of June. Surveyors counted the number of live adult salmonids holding at the mouths of Stair Creek (RK 75) and Mule Creek (RK 79) between 0700 and 0800 hours. The tendency for salmon to hold at the mouths of these cold tributary streams was commonly observed in previous years of low water yield when large numbers of chinook salmon died prior to spawning.

Prespawning Mortality

Project personnel surveyed the Rogue River canyon every two weeks from 14 May through 2 October. Surveyors classified chinook salmon carcasses less than 60 cm long as jacks while larger fish were classified as adults. Coho salmon less than 50 cm long were also classified as jacks. Surveyors also examined all salmonid carcasses for tags and fin clips. I used the methods of ODFW (2000) to estimate the number of spring chinook salmon, fall chinook salmon, and coho salmon that died before spawning.

I estimated the rate of prespawning mortality among spring chinook salmon by two methods. First, I divided the estimated number of prespawning mortalities by the number estimated to enter the Rogue River canyon. To estimate the number of live fish that entered the canyon, I added the estimated number of fish that died to estimated number of fish that passed the counting station at Gold Ray Dam (RK 202).

Second, I compared the number that survived to pass Gold Ray Dam with the number that were predicted to pass based on the passage of wild spring chinook salmon at Winchester Dam on the North Umpqua River. I calculated the proportional abundance of spring chinook in each river during 1985-2000. I then assumed that the proportional abundance of spring chinook salmon in the

Rogue River during 2001 was equal to the mean for 1985-2000. Data from the North Umpqua included only wild fish as the number of hatchery fish released varied widely for the North Umpqua, but not for the Rogue River.

I estimated the rate of prespawning mortality among fall chinook salmon by dividing the estimated number of prespawning mortalities by the estimated number that returned to the Rogue River. ODFW estimated the freshwater return of fall chinook salmon in 2001 with methods described by ODFW (1992).

RESULTS AND DISCUSSION

Reservoir Releases

Flow releases under the variable release strategy ranged from about 1,000 cfs to about 3,300 cfs from 1 May through June 6. The USACE managed reservoir releases to try and meet water temperature goals at Agness during this period. The initial goal was a maximum water temperature of 64^{O}F. On 26 May, the goal changed to a maximum water temperature of 65.5^{O}F because field surveys showed that adult spring chinook salmon remained healthy (*see* **Timing of Disease Outbreak**) and because reservoir storage was being depleted quickly. Air temperatures in May were warmer than average and exceeded 100^{O}F twice during the month (Appendix Table 1).

Reservoir outflows during the remainder of conservation release season were 1,400 cfs (7 June - 30 June), 1,200 cfs (1 July - 1 August), 1,800 cfs (2 August - 10 September), and decreased thereafter until 10 October. Outflows during the remainder of October were 800 cfs.

Timing of Disease Outbreak

With the exception of 14 May, surveyors saw no adult spring chinook salmon holding in the outflows of two tributary streams in the Rogue River canyon (Table 1). These findings differed greatly from observations made in 1977, 1992, and 1994, when ODFW staff documented large numbers of adult spring chinook salmon present at these sites. The paucity of fish holding at these sites suggested that adult spring chinook salmon were stressed to a lesser extent by disease in 2001 as compared to other drought years.

Mortality Rates of Adult Salmon

Surveyors found 394 carcasses of adult salmonids in the Rogue River canyon during 2001. Chinook salmon composed almost all of the carcasses, but surveyors also found two coho salmon and one steelhead (Table 2). Five carcasses could not be identified to species, so I assumed that these fish were chinook salmon.

Table 1. Numbers of spring chinook salmon observed at the mouths of two tributary streams in the Rogue River canyon.

Survey date	Mule creek	Stair creek	Survey date	Mule creek	Stair creek
05/09	0	0	06/02	0	0
05/14	0	2	06/06	0	0
05/17	0	0	06/10	0	0
05/21	0	0	06/14	0	0
05/24	0	0	06/18	0	0
05/28	0	0	06/22	0	0
05/31	0	0	06/26	0	0

I estimated, by interpolation, that surveyors would have found 778 dead chinook salmon and 3 dead coho salmon if the canyon had been surveyed weekly. I also classified the racial composition of the carcasses based on (1) spring chinook salmon pass Gold Ray Dam through 15 August and (2) these fish migrate at a rate of five kilometers per day (ODFW 2000). The criteria resulted in 482 of the carcasses being classified as spring chinook salmon and 296 of the carcasses being classified as fall chinook salmon.

Table 2. Number of dead adult salmonids found in the Rogue River canyon. Jacks are adult salmon that mature at a relatively young age.

Survey date	Chinook salmon			Coho salmon			Unknown salmon	Steelhead
	Jacks	Adults	Total	Jacks	Adults	Total		
05/14	0	0	0	0	0	0	0	0
05/29	0	0	0	0	0	0	0	0
06/12	2	7	9	0	0	0	0	0
06/26	4	34	38	0	0	0	0	0
07/10	4	179	183	0	0	0	0	0
07/23	1	51	52	0	0	0	0	0
08/07	1	32	33	0	0	0	0	0
08/22	2	49	51	0	0	0	3	1
09/03	0	7	7	0	0	0	0	0
09/18	1	11	12	0	1	1	2	0
10/02	0	1	1	1	0	1	0	0
Totals	15	371	386	1	1	2	5	1

Application of the regressions reported by ODFW (2000) produced total mortality estimates of 8,286 spring chinook salmon, 5,992 fall chinook salmon, and 86 coho salmon. In 2001, ODFW (unpublished data) estimated that 33,273 spring chinook passed Gold Ray Dam, and that 47,836 fall chinook salmon and 40,817 coho salmon returned to the Rogue River. Thus, the estimated mortality rates were 20% for spring chinook salmon and 11% for fall chinook salmon.

In comparison, preseason predictions of mortality rates were 18% for spring chinook salmon and 36% for fall chinook salmon (ODFW unpublished data). These predictions assumed that air temperatures would have been average during the migration periods of chinook salmon. No preseason prediction of mortality rate was made for coho salmon.

Returns of spring chinook salmon to the North Umpqua River also were used to estimate mortality rates of spring chinook in the Rogue River. Numbers of spring chinook salmon that passed Gold Ray Dam accounted for an average of 86.2% (standard error = 1.6%) of total returns of spring chinook to both rivers annually during 1985-2000. Given that an estimated 6,135 wild spring chinook salmon returned to the North Umpqua River in 2001, I predicted that 38,322 spring chinook should have passed Gold Ray Dam on the Rogue River. The actual passage of 33,273 spring chinook salmon at Gold Ray Dam produced an estimated mortality rate of 13% (1-(33,273/38,322)).

Assessment of Reservoir Release Strategies

Spring Chinook Salmon

Reservoir releases were effective through 21 May at keeping water temperatures at Agness below the goal of 64^{O}F (Appendix Table 2). On that day, air temperature reached 96^{O}F at Medford (Appendix Table 1) and the flow at Agness averaged about 4,100 cfs (Appendix Table 2).

Reservoir releases were somewhat effective at keeping water temperatures at Agness below the goal of 65.5^{O}F from 26 May through 6 June. Water temperatures exceeded the goal during three of the days within that period (Appendix Table 2).

Bi-weekly carcass counts showed that spring chinook salmon remained healthy in the Rogue River through the middle of June (Figure 1). Failure to observe large numbers of fish holding at the mouths of cold tributary streams supported this conclusion. Counts of dead fish began to increase only after water temperatures at Agness exceeded 66^{O}F in the middle of June (Figure 1).

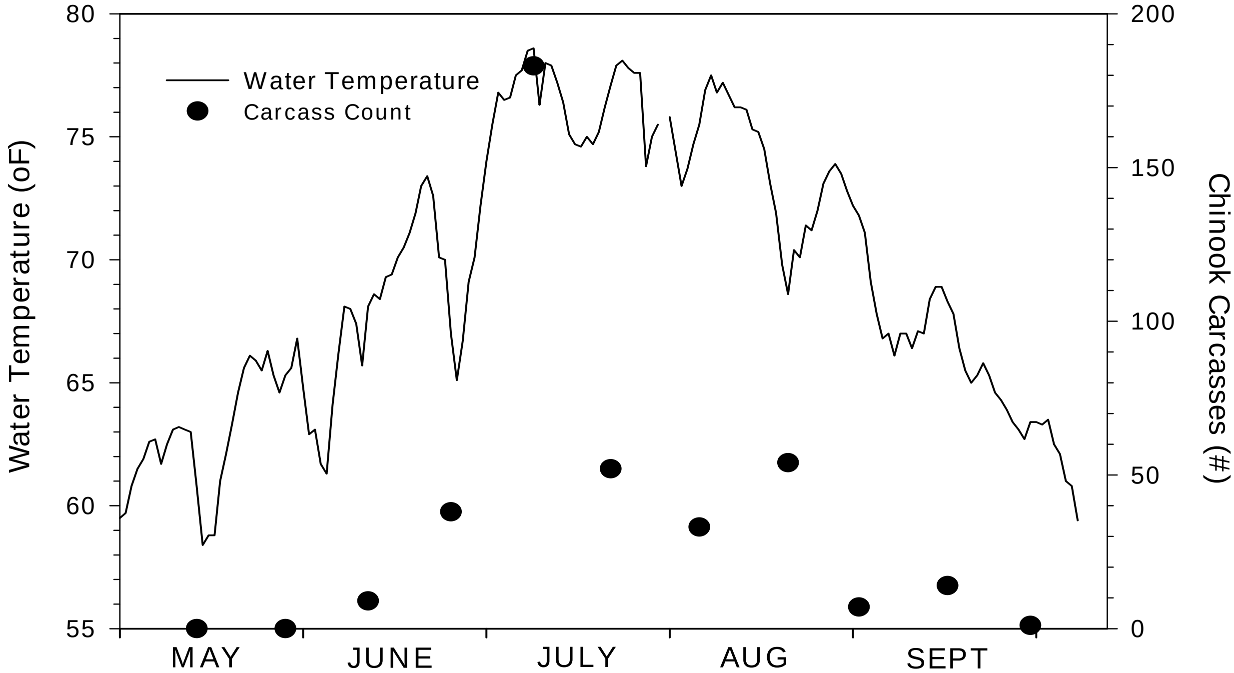

Figure 1. Relationship between maximum water temperature at Agness and the number of chinook salmon carcasses seen in the Rogue River canyon, 2001.

I estimated that 17% (mean of the two independent estimates) of the spring chinook salmon died in the area downstream of Gold Ray Dam in 2001. In contrast, rates of prespawning mortality in this area ranged from 34% to 70% in 1977, 1992, and 1994 (ODFW 2000), when there were roughly comparable water yields in the Rogue River Basin. The release of about 90,000 acre-feet of reservoir storage helped cool river temperatures and was probably the primary factor that delayed the onset of prespawning mortality among spring chinook salmon in 2001.

Although mortality rates of spring chinook salmon were low in comparison to other years of very low water yields, prespawning mortality among the later portion of the run remains of concern to fishery managers. Wild fish return later than hatchery fish, and returns of wild fish in the 1990s were the lowest of any decade going back to the 1940s (ODFW unpublished data).

ODFW (2000) recommended that reservoir releases be managed so that the daily maximum water temperature at Agness does not exceed 65^{O}F. Findings from sampling in 2001 indicate that this recommendation does not need to be modified for years of average, or above average, water yield. Findings from sampling in 2001 also suggested that a maximum water temperature goal of 66^{O}F at

Agness in May and June should be implemented and evaluated during the next year of extreme low water yield.

The increase in the recommended temperature goal will conserve reservoir storage for later use during drought years. The predictive relationship used by the USACE to manage for water temperature goals calls for the release of an additional 445 cfs (about 900 acre-feet per day) of reservoir storage to decrease water temperature at Agness by 1°F during May and June. Savings in reservoir storage could then be used to afford more protection to wild spring chinook salmon, which return later than counterparts of hatchery origin.

Fall Chinook Salmon

Reservoir releases were effective in maintaining a minimum flow of 1,800 cfs at Agness from through 6 August through 12 September (Appendix Table 2). With the exception of one week, water temperatures at Agness exceeded 73°F each day during August (Appendix Table 2).

Carcass counts showed that some fall chinook salmon died during upstream migration in late July and August, but that few died in September (Figure 1). This indicated that more early-run fish died as compared to late-run fish. Previous tagging studies documented that early-run fall chinook salmon spawn primarily in the Rogue River, while late-run fish spawn in tributary streams (ODFW 1992). The greater risk of early-run fall chinook salmon to prespawning mortality was also documented by ODFW (1992).

I estimated that 11% of the fall chinook salmon died during their upstream migration in 2001. In contrast, rates of prespawning mortality exceeded 50% during 1979 and 1980, when flow in the river was lower during August and early September (ODFW 1992). The release of about 100,000 acre-feet of reservoir storage helped cool river temperatures and was probably the primary factor that limited prespawning mortality among fall chinook salmon in 2001.

ODFW (1992) recommended that reservoir releases be managed so that the daily maximum water temperature at Agness average less than 68°F during August-September. To attain this goal, ODFW (1992) recommended that reservoir releases be managed to maintain a minimum flow at Agness of 2,300 cfs from 10 August through 10 September.

Daily flows at Agness remained below 2,000 cfs from 10 August through 10 September in 2001 (Appendix Table 2). The estimated loss of 11% of the fall chinook salmon run in 2001 shows that a flow of 1,800 cfs at Agness during this period is insufficient to preclude prespawning mortality among fall chinook salmon. Given that 2,300 cfs results in effective prevention of losses, it appears that some flow between 1,900 cfs and 2,300 cfs would result in minimal prespawning mortality among fall chinook salmon. Continued assessments during years of low water yield may help to better identify the volume and timing of reservoir releases needed to protect fall chinook salmon.

Coho Salmon

Reservoir releases were effective in minimizing prespawning mortality among coho salmon that entered the Rogue River in August and September.

In 1980-86, few coho salmon entered the Rogue River before the middle of September, and none entered the river during August (ODFW 1990). In 2001, an estimated 400 fish entered the river in August. Despite an early return by a small portion of the run, no dead coho salmon were found in the Rogue River canyon until the middle of September. Reservoir storage released during August and September probably afforded additional protection for coho salmon, as well as for fall chinook salmon.

The main portion of the coho salmon run in 2001 entered freshwater in October, a comparable time to previous years (ODFW 1990). Maximum water temperatures at Agness in early October did not exceed 64°F even though the flow decreased to about 1,000 cfs (Appendix Table 2). These findings suggest that reservoir storage does not need to be released in October to protect coho salmon, even though the wild fish are listed as threatened under the Endangered Species Act of the United States.

ACKNOWLEDGMENTS

David Haight and Christopher Volpe assisted with sampling multiple times during the field season.

REFERENCES

ODFW (Oregon Department of Fish and Wildlife). 1990. Effects of Lost Creek Dam on coho salmon in the Rogue River. Phase II completion report. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Completion Report, Portland.

ODFW (Oregon Department of Fish and Wildlife). 1992. Effects of Lost Creek Dam on fall chinook salmon in the Rogue River. Phase II completion report. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Completion Report, Portland.

ODFW (Oregon Department of Fish and Wildlife). 2000. Effects of Lost Creek Dam on spring chinook salmon in the Rogue River. Phase II completion report. Volume I. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Completion Report, Portland.

United States Congress. 1962. Rogue River basin, Oregon and California. Public Law 87-874, 87th Congress, 2nd Session, House Document 566.

USACE (United States Army Corps of Engineers). 1972. Final Environmental statement. Lost Creek Lake Project, Rogue River, Oregon. Portland District, Portland, Oregon.

Appendix Table 1. Air temperatures recorded at the Medford airport, May through 10 October, 2001.

Day of month	Maximum temperature (°F)					
	May	Jun	Jul	Aug	Sep	Oct
1	60	77	89	92	88	94
2	66	68	97	92	90	90
3	77	67	100	84	91	87
4	83	73	97	80	89	90
5	71	65	88	92	72	84
6	79	78	92	96	81	75
7	91	85	94	99	87	71
8	88	85	98	104	94	67
9	81	80	102	105	96	68
10	87	74	96	101	91	68
11	95	73	82	99	83	--
12	86	73	92	97	86	--
13	78	81	92	97	85	--
14	60	84	88	96	92	--
15	61	84	83	99	88	--
16	68	83	76	95	88	--
17	75	81	81	93	90	--
18	79	85	85	78	88	--
19	85	89	86	88	86	--
20	86	93	81	85	90	--
21	96	96	86	82	89	--
22	100	94	90	74	93	--
23	95	83	95	74	95	--
24	92	70	94	83	93	--
25	92	73	97	93	69	--
26	91	64	96	94	64	--
27	76	80	92	93	69	--
28	74	79	86	91	73	--
29	77	84	79	93	83	--
30	92	85	78	92	93	--
31	100	--	86	90	--	--

Appendix Table 2. Provisional estimates of water temperature and flow at the USGS gage near Agness, May through 10 October, 2001.

Day of month	Maximum water temperature (°F)						Mean flow (cfs)					
	May	Jun	Jul	Aug	Sep	Oct	May	Jun	Jul	Aug	Sep	Oct
1	59.5	64.8	72.2	--	72.8	62.7	2,446	3,781	1,544	x,xxx	1,851	1,326
2	59.7	62.9	74.0	75.8	72.2	63.4	1,945	3,227	1,465	1,077	1,851	1,365
3	60.8	63.1	75.5	74.4	71.8	63.4	1,919	2,776	1,312	1,067	1,891	1,274
4	61.5	61.7	76.8	73.0	71.1	63.3	2,387	2,477	1,227	1,784	1,905	1,067
5	61.9	61.3	76.5	73.7	69.1	63.5	2,401	2,289	1,176	1,757	1,878	1,057
6	62.6	64.1	76.6	74.7	67.8	62.5	3,040	2,101	1,176	1,824	1,891	1,089
7	62.7	66.2	77.5	75.5	66.8	62.1	3,600	1,907	1,186	1,811	1,905	1,028
8	61.7	68.1	77.7	76.9	67.0	61.0	3,454	1,673	1,176	1,824	1,891	1,028
9	62.5	68.0	78.5	77.5	66.1	60.8	3,473	1,556	1,166	1,837	1,932	1,028
10	63.1	67.4	78.6	76.8	67.0	59.4	3,438	1,533	1,186	1,864	1,891	1,077
11	63.2	65.7	76.3	77.2	67.0	--	3,563	1,544	1,077	1,824	1,878	--
12	63.1	68.1	78.0	76.7	66.4	--	3,545	1,567	1,355	1,824	1,811	--
13	63.0	68.6	77.9	76.2	67.1	--	3,262	1,579	1,280	1,837	1,641	--
14	60.8	68.4	77.2	76.2	67.0	--	3,090	1,533	1,376	1,851	1,584	--
15	58.4	69.3	76.4	76.1	68.4	--	3,456	1,499	1,301	1,837	1,584	--
16	58.8	69.4	75.1	75.3	68.9	--	3,654	1,487	1,238	1,811	1,641	--
17	58.8	70.1	74.7	75.2	68.9	--	3,764	1,420	1,238	1,811	1,699	--
18	61.0	70.5	74.6	74.5	68.3	--	3,938	1,442	1,227	1,797	1,699	--
19	62.1	71.1	75.0	73.1	67.8	--	3,781	1,454	1,207	1,837	1,728	--
20	63.3	71.9	74.7	71.9	66.4	--	3,885	1,442	1,207	1,891	1,612	--
21	64.6	73.0	75.2	69.8	65.5	--	4,080	1,420	1,217	1,878	1,612	--
22	65.6	73.4	76.2	68.6	65.0	--	4,026	1,398	1,217	1,878	1,570	--
23	66.1	72.6	77.1	70.4	65.3	--	3,920	1,376	1,207	1,974	1,352	--
24	65.9	70.1	77.9	70.1	65.8	--	3,868	1,365	1,217	1,988	1,101	--
25	65.5	70.0	78.1	71.4	65.3	--	3,833	1,398	1,186	1,974	1,125	--
26	66.3	67.0	77.8	71.2	64.6	--	3,402	1,454	1,156	1,932	1,473	--
27	65.3	65.1	77.6	72.0	64.3	--	2,841	1,709	990	2,129	1,405	--
28	64.6	66.7	77.6	73.1	63.9	--	2,776	1,661	1,009	1,864	1,326	--
29	65.3	69.1	73.8	73.6	63.4	--	2,776	1,661	1,009	1,864	1,365	--
30	65.6	70.1	75.0	73.9	63.1	--	3,040	1,649	1,038	1,851	1,339	--
31	66.8	--	75.5	73.5	--	--	3,709	--	1,077	1,837	--	--