



FINAL REPORT

March 29, 2019

EXECUTIVE SUMMARY

The abundance of spawning Kokanee in the Upper Kootenay River was assessed in September 2018 as part of the yearly Koocanusa Kokanee Enumeration Study that began in 2012.

A total of 100,135 spawning Kokanee were observed at 7 index streams including Sand Creek, Little Sand Creek, Bull River, Norbury Creek, Kootenay River sidechannels, Lussier River, and Findlay Creek. An additional 19,500 to 23,000 Kokanee were observed on the St Mary River, Wildhorse River, and the Kootenay River between Canal Flats and Skookumchuck as part of the extended survey suggesting that streams which historically saw few spawning Kokanee now host a larger proportion of the run.



Although very similar in size to 2017, the 2018 Kokanee run ranks relatively low compared to historical runs over the period of record (i.e., 1996-2018). An overall declining trend has become apparent in the population both in terms of abundance and biomass and it appears that, at comparable density, Koocanusa Kokanee are smaller in recent years than they were prior to 2003.

We recommend to pursue monitoring efforts on a yearly basis and without interruption to ensure data continuity, inform management decisions, and drive management actions should they become necessary to maintain the long-term sustainability of the population.

Kokanee were identified as a species of interest in the Upper Kootenay Ecosystem Enhancement Plan. The objectives of this study are in alignment with the strategic priorities set in the Stream Action Plan in particular Action 13 on the monitoring and evaluation of species of interest.

INTRODUCTION

Kokanee (*Oncorhynchus nerka*) were introduced in Koocanusa Reservoir between 1970 and 1974 by the Kootenay Trout Hatchery near Wardner, BC (Brown, 1993). Donor populations included Chilliwack Lake, Meadow Creek, and Okanagan River (Withler and Cena, 2006). The Koocanusa Kokanee population is now well established with up to 450,000 spawning individuals recorded in the fall of 2002 (Westover, 2002). Spawning occurs in late September in most Upper Kootenay River tributaries as far as 200 km upstream of Koocanusa Reservoir (Westover, 2002). In summer, the species now offers popular angling opportunities.

Between 1996 and 2003, trends in abundance of the Koocanusa Kokanee population were assessed through annual enumeration of spawners on selected Kootenay River tributaries upstream of Koocanusa Reservoir. Monitoring efforts stopped in 2006 due a lack of sufficient funding.

The study was resumed in 2012 thanks to funding provided by the Columbia Basin Trust (2012-2015) and the Fish and Wildlife Compensation Program (2016-2018) as part of the Upper Kootenay Ecosystem Enhancement Plan (UKEEP) in which Kokanee was identified as a species of interest. The objectives of the study are in alignment with the strategic priorities set in the UKEEP Stream Action Plan in particular Action 13 on the monitoring and evaluation of species of interest.

The present report summarizes findings of the study for the 2012-2018 monitoring period and provides an assessment of the current conservation status of the Koocanusa Kokanee population.

METHODS

Study Area

Aerial counts were conducted at seven index streams including Sand Creek, Little Sand Creek, the Bull River, Norbury Creek, side-channels of the Kootenay River between Fort Steele and Wardner, the Lussier River, and Findlay Creek (Figure 1). Index streams were selected at the beginning of the monitoring study in 1996 as they were found to host the majority of Kokanee spawners in the drainage (approx. 80 to 90%), have good water clarity, and have limited overhanging vegetation to facilitate aerial counts. The location of the upstream and downstream limits of enumeration sections on each stream are presented in Table 1.

Additional funding was provided in 2018 to extend the study area to the Lower St Mary River, the Wildhorse River, and the side-channels of the Kootenay River between Canal Flats and Skookumchuck. Streams were assessed from a higher altitude and at higher speed than the regular index sites. The objective of the extended survey was to provide a high-level estimate of the number of Kokanee utilizing these streams for spawning and determine whether the index streams selected over 25 years ago are still those supporting the majority of Kokanee.



Figure 1: Study area map

Table 1: Stream	sections	assessed	in	2018
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Stroom	Downstream Limit		Upstream Limit		Description	
Stream	Easting	Northing	g Easting Northing		Description	
Bull River	612062	5480090	618883	5483682	From confluence ¹ to canyon downstream of	
					Aberfeldie Dam (approx. 11 km)	
Findlay Creek	586868	5549644	583775	5551104	From confluence ¹ to canyon (approx. 5 km)	
Little Sand Creek	623728	5467852	623977	5470884	From confluence ² to Highway 3 bridge	
Lussier River	590735	5528884	597030	5550555	From confluence ¹ to bridge near 10 km mark on	
					Whiteswan FSR (approx. 30 km)	
Norbury Creek	610739	5480867	611352	5480976	From confluence ¹ to CP Rail culvert (approx.	
					750 m)	
Sand Creek	623459	5463166	627793	5470300	From confluence ³ to Highway 3 bridge (approx.	
					13 km)	
Kootenay River	602426	5488614	600312	5494387	Side channels on right downstream bank	
					alongside Cranbrook city fields (approx. 10 km)	

Timing

Weekly ground counts were conducted in early September on Norbury Creek to determine when spawning activity was reaching its peak. Personnel from the nearby Kootenay Trout Hatchery also provided weekly information regarding the number of spawners observed in the creek. Additional ground observations were conducted on Sand Creek at the Jaffray-Baynes Lake Road crossing.

Morphometric data were collected on Norbury Creek on September 27, 2018 with the help of hatchery staff. Ground counts completed on the same day showed that spawning was about to peak. It was decided to initiate the aerial counts the following week.

Sand Creek, Little Sand Creek, and the Bull River were assessed on the first day, September 26, as previous years' observations suggested that peak spawning might occur earlier on streams in the southern part of the study area. Norbury Creek, the side-channels of the Kootenay River, the Wildhorse River, and the St Mary River were assessed on September 27. The Lussier River, Findlay Creek, and the Kootenay River side-channels between Canal Flats and Skookumchuck were assessed on September 28. Weather and stream conditions were optimal for aerial counts (i.e., low turbidity, clear sky, no wind).

Aerial Surveys

Spawning Kokanee were enumerated from a helicopter flying just above tree top level (approx. 20 m) at a speed of 10 to 20 km/h. Two observers sat on the right side of the aircraft where the doors had been removed to improve visibility. During the flights, the helicopter was flown sideways, enabling both observers to see the entire width of the stream. Surveyed streams were divided into 500 m sections that were geo-referenced using a handheld GPS unit. At the end of each section, individual live counts were tallied to derive a mean count that was later compared to video recordings. All fish counts were completed by two observers with over 6 years of experience conducting aerial fish counts. Prior to conducting flights, aerial pictures from previous years were reviewed as a training tool to improve accuracy and precision. Observers wore polarized sunglasses to eliminate water surface glare. Additionally, a digital camera (Sony a6300 with Sigma 19mm f2.8 lens) equipped with a polarized filter and mounted to the helicopter was used to capture videos and still pictures of surveyed reaches within each index stream. The footage was later reviewed on a computer screen to validate and adjust live counts where discrepancies were apparent. These methods follow standard techniques used in aerial Kokanee enumerations in BC (e.g., Westover, 1996-2003; AMEC, 2010). The use of video equipment was an innovation initiated in 2012 which enabled repeatability of aerial counts and enhanced study QA/QC.

Morphometric Data

Length and weight information were collected from 80 Kokanee (40 males, 40 females) captured in Norbury Creek on September 27, 2018 using a seine net. Fish capture followed conditions detailed in Scientific Fish Collection Permit # CB18-380276 (Appendix I). The total number of eggs per female was determined from a random sub-sample of 10 females. Otoliths were collected from a sub-sample of 10 females and 10 males for ageing purposes. Age determination followed methods described in Secor *et al.* (1991).

RESULTS

Peak Counts

The results of the 2018 Koocanusa Kokanee enumeration for each index stream are summarized in Table 2 and Figure 2.

Estimates from each observer were averaged to produce the final estimates reported in Table 2. In 2018, the average coefficient of variation between observers was less than 5%. A comparison between live counts obtained in the field and verification counts using video footage from selected index sites showed a difference of 12% between the two techniques - video counts were higher than live counts. This result is consistent with observations made in previous years of the study.

An estimated 100,135 Kokanee spawned in the study area in 2018. Despite a slight decline compared to 2017 (-2.5%), Kokanee abundance remained relatively constant over the past three years following the sharp increase observed in 2015 which immediately rescinded in 2016.



Figure 2: Estimated numbers of spawning Kokanee in the study area over the period of record 1996-2018

	Sand Creek	L. Sand Creek	Bull River	Norbury Creek	Kootenay River	Lussier River	Findlay Creek	TOTAL
1996	71170	7250	54850	11800	50250	171000	1405	36,7725
1997	17620	3000	10852	11050	18120	49450	2010	112,102
1998	8	488	1782	9340	30195	98217	1120	141,150
1999	16285	9402	26090	7902	32040	145445	9100	246,264
2000	57800	13050	43500	47500	98980	43150	6180	310,160
2001	1432	2450	25325	23300	74510	213460	6475	346,952
2002	81350	37000	19400	19800	83400	177650	9050	427,650
2003	33760	2400	19370	21550	35535	32220	1620	146,455
2004	5755	3580	1987	12270	170	15000	0	38,762
2005	11550	5700	4050	27350	200	52180	2200	103,230
2006-2011				No Da	ita			
2012	21650	5800	7850	17650	30800	51800	11750	147,300
2013	300	500	800	6900	24300	34910	3800	71,510
2014	16700	4200	8600	13675	38600	32700	4700	119,175
2015	24600	3500	14100	8730	46600	182600	15400	295,530
2016	2450	1400	4850	2800	23600	50050	2200	87,350
2017	9000	4500	9550	14620	26000	34750	4250	102,670
2018	7885	3950	7225	9200	11050	57625	3200	100,135

Table 2: Estimated numbers of spawning Kokanee per index sites for the period of record 1996-2005; 2012-2018

Sand Creek and Little Sand Creek

Approximately 7,885 Kokanee were observed in Sand Creek and 3,950 in Little Sand Creek, a result consistent with 2017 estimates for these two streams. A dewatered section of stream was observed between the Baynes Lake Road and the Highway 3 bridges. Although it was not as extensive as in 2017, the dewatered section precluded fish access to upstream spawning habitat.



Figure 3: Kokanee spawning congregation in pool habitat in Sand Creek

Bull River

The 2018 Kokanee run on the Bull River was in decline (-23%) compared to 2017 with an estimated 7,225 fish observed between the Aberfeldie Dam and the Kootenay River confluence. This estimate remains within the 95% confidence interval for the 2012-2017 period of record for this stream. As in previous years, most fish were observed between the confluence and the deep pool immediately upstream of the old Tie Mill Dam. It was noted that the available habitat within this section was not entirely used.



Figure 4: Kokanee redds on the Bull River at the plunge pool below the old Tie Mill Dam

Norbury Creek

An estimated 9,200 Kokanee were observed in Norbury Creek. While in most years the railway culvert below the Kootenay Trout Hatchery precludes any upstream migration, woody debris accumulation below the culvert in 2018 created a backwatering effect allowing Kokanee to access upstream reaches of the creek. Below the culvert, lower numbers of fish were observed than in previous years. Upstream of the culvert, Kokanee were observed spawning all the way to the hatchery dam which prevents any further upstream movement. It should be noted that aerial counting was made difficult by the thick overhanging riparian vegetation upstream of the railway culvert.



Figure 5: Woody debris accumulation at railway culvert on Norbury Creek

Kootenay River Side Channel (near Cranbrook spray irrigation fields)

An estimated 11,050 Kokanee spawned in the side-channel of the Kootenay River adjacent to the Cranbrook spray irrigation fields in 2018. This estimate represents a significant decrease (-57%) compared to the 2017 run and is outside of the 95% confidence interval for the 2012-2017 monitoring period. Active channel migration has been observed on this section of the river in recent years and water flow through the side-channel complex was visibly lower in 2018. Fine sediment deposition appears to have reduced overall habitat suitability and spawning is now only occurring in the upstream reaches of the side-channel.



Figure 6: Spawning Kokanee in the Kootenay River side-channel

Lussier River

Approximately 57,625 Kokanee were observed in the Lussier River in 2018, the second largest return since the monitoring study was restarted in 2012. This estimate represents a 66% increase for this stream compared to the 2017 counts. As in previous years, the Lussier River hosted the largest run in the study area and large groups of Kokanee were still observed beyond the end of the index section approximately 25km upstream of the confluence with Kootenay River.



Figure 7: Large congregation of Kokanee on the Lussier River

Findlay Creek

An estimated 3,200 Kokanee were observed on Findlay Creek - a 25% decrease compared to the 2017 run. Active channel migration noted in 2017 was confirmed in 2018 resulting in bank erosion and fine sediment deposition in areas that historically provided suitable spawning substrate for Kokanee.



Figure 8: Upper limit of the Kokanee spawning reach on Findlay Creek

St Mary River

Only small groups of Kokanee were observed in the lower reaches of the St Mary River likely due the paucity of suitable spawning habitat. The first significant numbers of fish were observed in the vicinity of Perry Creek. Approximately 1,000-2,000 Kokanee were observed in the mainstem near the confluence with Perry Creek and an additional 2,000-3,000 individuals in Perry Creek itself. A few small groups (approx. 500-1,000 individuals) were spotted near the Mark Creek and Matthew Creek confluences but there was no significant spawning activity on these two tributaries. The largest spawning aggregations were spotted between Matthew Creek and St Mary Lake with approximately 4,000 fish. In total, an estimated 7,500-10,000 spawning Kokanee were observed in The St Mary River downstream of the lake. It should be noted that stream reaches above St Mary lake were not assessed. Kokanee have been observed in the Upper St Mary River at least up to the Redding Creek confluence (Ben Meunier pers. comm.).

Wildhorse River

Approximately 2,000-3,000 Kokanee were observed in the Wildhorse River, half of which were found in the lower 2km of the stream between the railway crossing and the confluence. Habitat availability is limited in the upstream reaches but Kokanee were spotted as far as 15km upstream of the confluence taking advantage of depositional areas with small pockets of suitable spawning gravel.

Kootenay River (between Canal Flats and Skookumchuck)

Large number of Kokanee were observed spawning in the Kootenay River between Canal Flats and Skookumchuck. This section of the river is characterized by low stream gradient and braided channel with abundant gravel bars and side-channels. Fish were spotted both in mainstem habitat and side-channels

utilizing suitable spawning substrate wherever available. Sediment deposition appeared more significant in this area than in other spawning sites. Fish were observed actively excavating fine materials to access the underlying gravel layers. It was also noted that some spawning occurred in side-channels with very low connectivity to the mainstem and these are likely to dewater in the fall and winter months. In total, an estimated 10,000 Kokanee were observed along this 30km section of the Kootenay River.

Morphometric and Biological Data

The morphometric data including mean length, weight, Fulton index, and number of eggs per female captured on Norbury Creek for the 2012-2018 study period are summarized in Table 3.

The average fork length of Kokanee in 2018 was 277.5mm. The mean size of Koocanusa Kokanee has been consistently increasing since the all-time low of 200.7mm recorded in 2015 (Figure 9). Female fecundity has also been increasing although there was a wide range of variation between individuals in 2018. The extrapolated egg production assuming a 1:1 male-female ratio in the population is 18.1 million eggs.

Otolith analysis indicated that the population is dominated by age 2+ fish but age 3+ fish were also present. This result is supported by the length-frequency diagram (Figure 10) which displays a bimodal length distribution with the first age class (2+) centered around 280 mm and the second (3+) around 305mm.

As noted in previous years, the density-growth diagram (Figure 11) displays two distinct distributions between historical data (1993-2003) and data collected since 2012. The 2018 data closely fits the new density-growth relationship further supporting the observation that spawning Kokanee in the study area appear smaller in recent years than they were historically. Interestingly, the 2003 data point corresponding to the year when Kokanee abundance dropped by 66% also fits the new correlation.

Year	Length (mm)_	Weight (g)	Egg count	Fulton Index
2012	277.9 ± 10.1	243 ± 33.2	318 ± 104	1.12 ± 0.11
2013	276.8 ± 24	234.1 ± 62.4	527 ± 99	1.09 ± 0.16
2014	230.2 ± 11.2	127 ± 18.6	237 ± 61	1.04 ± 0.1
2015	200.7 ± 14.3	77.7 ± 23.6	171 ± 57	0.94 ± 0.16
2016	239 ± 7.3	154.5 ± 18.9	292 ± 54	1.13 ± 0.12
2017	259.7 ± 12.2	199.8 ± 31.9	304 ± 37	1.14 ± 0.11
2018	277.5 ± 16.3	241.3 ± 54.6	362 ± 142	1.12 ± 0.12

Table 3: Morphometric characteristics of spawning Kokanee sampled in Norbury Creek since 2012. Values indicate sample mean \pm standard deviation



Figure 9: Box-and-Whisker plot of Kokanee fork length (in mm) between 2012 and 2018. (middle bars indicate the sample median, boxes indicate upper and lower quartiles, and whiskers represent the 95% confidence interval; points correspond to outliers)



Figure 10: Length frequency diagram of Kokanee sampled in Norbury Creek in 2018



Figure 11: Mean length vs. abundance of the Koocanusa Kokanee Population (the black lines represent the linear regressions between length and abundance for 1996-2002 and for 2003-2018)

DISCUSSION AND RECOMMENDATIONS

Climate conditions in 2018 were very similar to those in 2017. Winter was characterized by mild temperatures and above normal precipitation. Summer conditions were the driest since 2003 (Environment and Climate Change Canada, 2019) resulting in large forest fires in the region. Despite the lack of summer precipitation, water levels in Koocanusa Reservoir and in streams across the study area remained normal, owing to the significant snowpack accumulated during winter 2017-2018.

There was no notable Kokanee die-off reported in 2018 contrasting with past years when thousands of dead Kokanee were observed in late summer at the surface of the reservoir likely as a result of internal seiche events leading to lethal thermal stress. Vertical temperature profiles collected in August and September 2018 showed weak lake stratification conditions occurring from the Gold Creek confluence to the US/Canada border and likely extending throughout the US portion of the reservoir. The portion from Wardner to Gold Creek was not stratified (Ben Meunier, Pers. Comm.). At the time of the Kokanee run, stream flow and water temperature provided optimal spawning conditions for the species.

The 2018 Koocanusa Kokanee run was relatively similar in size to the runs of recent years (i.e., since 2012) but ranks below the 25th percentile of observations over the entire period of record (i.e., 1996-2018). The detection and interpretation of temporal trends in the Kokanee abundance data since 1996 is made difficult by the large data gap between 2006 and 2011. As such, the following interpretations are speculative in nature.

For the 2012-2018 period, Kokanee abundance have remained relatively stable with more or less 100,000 spawners observed each year in index streams. Only the 2015 run, when 3 times more fish returned, contrasts sharply with other runs in the same period. Although short-lived, the 2015 spike indicates some level of volatility in the dynamics of the population and underlines our poor understanding of the mechanisms driving Kokanee production in Koocanusa Reservoir.

Similarly, in 2003, Kokanee dramatically declined by 66% without any clear explanation and remained low in 2004-2005. Extrapolating over the 2006-2011 data gap, we speculate that the Koocanusa Kokanee population never bounced back to pre-2003 levels suggesting a net loss in Kokanee production over the period of record. This hypothesis is further supported by trends in biomass data estimates showing that at equal density, Koocanusa Kokanee have been consistently smaller since 2003 than they were historically.

Among potential causes of the observed decline, climate change, reservoir ageing, and predator pressure (see Meunier and Oliver, 2018 for a review of the Kokanee vs Bull Trout relationship) are likely factors affecting to some degree biological productivity and Kokanee population dynamics in the reservoir. Frequent changes in Libby Dam operations may also have played a role. For instance, in 2017 and 2018, the reservoir level was drawn well below the typical spring low pool elevation. Riverine conditions occurred from Wardner to Gold Creek resulting in mobilization of benthic sediment and extreme turbidity at the northern end of the reservoir in April, May, June 2017 and 2018. Elevated turbidity affects light penetration and may disrupt phytoplankton photosynthetic activity and overall biological production in the reservoir.

The extended survey completed in 2018 on the St Mary River, Wildhorse River, and Kootenay River between Canal Flats and Skookumchuck found larger numbers of Kokanee than expected. Approximately 19,500 to 23,000 spawners were observed in these streams representing 16.2% to 18.7% of the total 2018

count. At the inception of the monitoring program in 1996, it was estimated that the seven index streams host approximately 90% of the entire run (Westover, 1997). Results from the 2018 extended survey indicate that this estimate is no longer accurate and that streams which historically saw few spawning Kokanee now host a larger proportion of the run. Already in 2002, it was noted that groups of Kokanee started spawning in pockets of suitable habitat along the Kootenay River mainstem as far as 200 km upstream of Koocanusa Reservoir, a behaviour that the population did not exhibit earlier. As a result of the apparent fluctuation in spawner distribution, and until a detailed basin-wide survey is completed, we do not have enough information to produce reliable estimates of the total number of spawners in the study area and must continue relying on relative abundance estimates as a proxy for true population abundance.

Hydro-acoustic surveys, used in conjunction with a target calibration netting campaign, are effective tools to assess true abundance of aquatic organisms in lakes. A Kokanee hydro-acoustic survey has been conducted by Montana Fish Wildlife and Parks on the US portion of Koocanusa Reservoir yearly since 2012. Implementing a similar program on the Canadian portion of the reservoir would constitute a significant improvement over the method currently used to monitor Kokanee abundance as presented in this report (i.e., aerial counts of spawners). Such a program would allow the monitoring of multiple age classes in the population and would provide us with a better understanding of recruitment and population dynamics. Until suitable funding is identified to support such program, we highly recommend that the aerial enumeration of spawning Kokanee continues on a yearly basis and without interruption. Data gaps should be avoided at all cost as they hinder the interpretation of population trends and the ability of fisheries managers to implement timely conservation actions should they become necessary to maintain the population's long-term sustainability.

ACKNOWLEDGEMENTS

VAST would like to thank the staff of the Kootenay Trout Hatchery for their help with collecting Kokanee in Norbury Creek, and Wildlife Capture Management Ltd. who provided helicopter services for this project.

This Project is funded by the Columbia Basin Trust and the Fish and Wildlife Compensation Program (FWCP). The FWCP is a partnership between BC Hydro, the Province of B.C., Fisheries and Oceans Canada, First Nations and public stakeholders to conserve and enhance fish and wildlife in watersheds impacted by BC Hydro dams.

CLOSURE

VAST trusts that the information provided in this report is accurate and meets your current requirements. Should you have any questions, or require further information, please do not hesitate to contact us.

Ben Meunier, MSc **Fisheries Biologist**

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Reviewed by: Leigh Anne Isaac, PhD, RPBio Sr Wildlife Biologist

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APPENDIX I

Ministry of Forests, Lands, Natural Resource Operations and Rural Development

> FISH COLLECTION PERMIT Research

File: 34770-20

Permit No.: CB18-380276

Permit Holder: Ben Meunier 304 Industrial Road G Cranbrook BC V1C 7J4.

Authorized Persons: Ben Meunier, Gerry Oliver, Andy Wight, Aden Stewart

Pursuant to section 19 of the Wildlife Act, RSBC 1996, Chap. 488, and section 18 of the Angling and Scientific Regulations, BC Reg. 125/90, the above named persons are hereby authorized to collect fish for scientific purposes from non-tidal waters subject to the conditions set forth in this Permit: Permitted Sampling Period: September 21, 2018 - October 31, 2018 Permitted Waterbodies: Kootenay/ Boundary Region - Norbury Creek (349-345600) Permitted Sampling Techniques: DN, SN (subject to permit terms and conditions) Targeted Species: KO (subject to permit terms and conditions) Permitted Lethal Sampling: Up to 20 in Kootenay/ Boundary Region - Kootenay/ Boundary Region - Norbury Creek (349-345600)(subject to permit terms and conditions) Provincial Conditions: (Permit holders must be aware of all terms and conditions): See Appendix A. **Region Specific Conditions:** See Appendix A.

Authorized by:

avient

Albert Chirico, Regional Information Specialist/Fisheries As authorized by the Regional Manager Recreational Fisheries & Wildlife Programs Kootenay-Boundary Region

Date: September 20, 2018 Permit Fee \$25 Any contravention or failure to comply with the terms and conditions of this permit is an offense under the *Wildlife Act*, RSBC 1996, Chap. 488 and B.C. Reg. 125/90.

Ministry of Forests, Lands, Natural Resource Operations & Rural Development	Fish and Aquatic Habitat Branch PO Box 9391 Stn Prov Gov Victoria BC V8W 9M3	•
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