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Central and Arctic Region

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Science Advisory Report 2014/036

ASSESSMENT OF DOLLY VARDEN (*Salvelinus malma*) FROM THE RAT RIVER, NORTHWEST TERRITORIES, 2002-2007

*Dolly Varden (*Salvelinus malma*) from the Rat River: post spawning female (top), post spawning male (middle) and non-spawning adult "silver" (bottom). Photos by Colin Gallagher.*

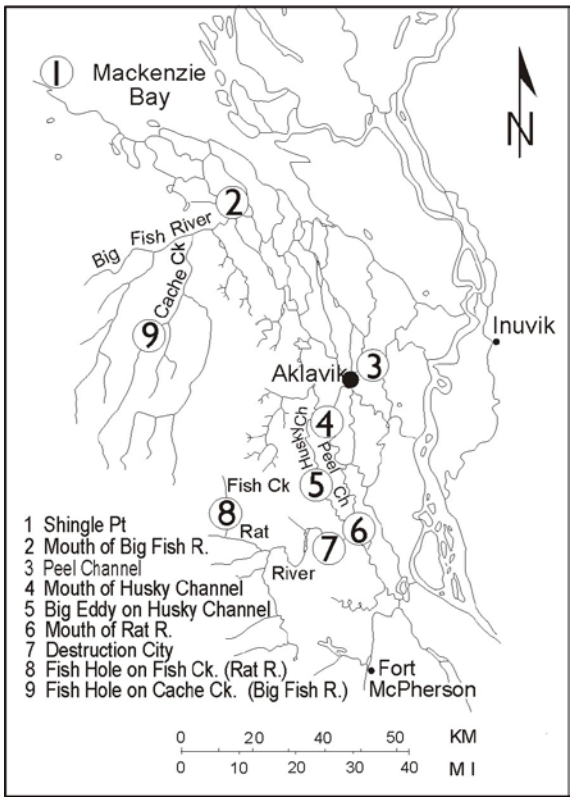

Figure 1. Locations of Dolly Varden fishing, monitoring, spawning and overwintering sites in the Rat River system within the lower Mackenzie River area (from Harwood et al. 2009).

Context

*Fisheries and Oceans Canada (DFO) assessed the status of Dolly Varden (*Salvelinus malma*) in the Rat River, Northwest Territories, in 2001. A sharp decline in the stock was detected by 2004 based on evidence from harvests, catch effort and biological characteristics. Co-management partners decided to close the Rat River fishery on a voluntary basis in 2006 and 2007. DFO Fisheries and Aquaculture Management asked DFO Science to undertake another assessment of the status of the stock.*

All available scientific information relevant to determining the status of the Rat River Dolly Varden stock was peer reviewed during the assessment. Available traditional and local knowledge was also considered. The stock assessment was conducted with the assistance of the Gwich'in Renewable Resource Board (GRRB), Fisheries Joint Management Committee (FJMC), Aklavik Hunters and Trappers Committee (HTC), Aklavik Renewable Resource Council (RRC), Fort McPherson RRC and residents of Aklavik and Fort McPherson.

This Science Advisory Report is from the March 17-19, 2008, Assessment of Rat River Dolly Varden. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Canada

SUMMARY

- Sea-run Dolly Varden, known locally as “char”, inhabits the Rat River and its tributaries.
- Abundance of the mature segment of this stock declined from around 8,500 fish during the period between 1995 and 2001 to around 2,700 in 2004. Following a voluntary closure of the river in 2006 and 2007 by co-management partners, harvest of Dolly Varden was limited to 40 fish by each of three fish monitors (total 120 fish) involved in the community-based sampling program.
- The current status of the stock at the time of this assessment was uncertain as there were no abundance estimates since 2004.
- Future prospects for Rat River Dolly Varden were encouraging with evidence of increases in fork length of spawning fish, improved condition, relatively stable sex and maturity composition and the recent observed pulse of juvenile production in 2007.
- Nevertheless, uncertainties remain including potential changes in Dolly Varden habitat and carrying capacity of the Rat River, low numbers of spawning males and the contribution of Rat River Dolly Varden to the mixed stock coastal fishery.
- Harvesters should be encouraged to release live any Dolly Varden that they think could be a sea-run male as the proportion of spawning males in the stock is very low.
- Harvest levels from all sources, including research activities, mixed stock coastal fisheries and the Rat River directed fishery, are recommended to remain at or below 5% (i.e., 120 fish).
- Examination of approximately 400 fish (>400 mm fork length) is recommended in 2008 to increase precision of the 2007 stock estimate based on mark-recapture analysis.

INTRODUCTION

The northern form of Dolly Varden (*Salvelinus malma*) is distributed in western Alaska north to the continental North Slope and extends eastward to the Mackenzie River system. Dolly Varden is found in the Rat River, located 90 km (55 miles) southwest of Inuvik, Northwest Territories. This river system flows east from its headwaters in the Richardson Mountains (Yukon) along a 130 km (80 miles) course and drains into the Husky Channel of the Mackenzie River (Figure 1). Spawning and overwintering areas for the Dolly Varden are located in spring-fed reaches of Fish Creek, a headwater tributary of the Rat River.

Species Biology

Dolly Varden is a riverine-adapted species and those from the Rat River are considered biologically distinct from the other stocks known from Arctic Canada. Most are anadromous (sea run), residing in a headwater stream for approximately three years before making their first migration to the sea. In the Rat River they travel downstream in spring (May-June) and through channels of the Mackenzie Delta to the coast where they spend the early summer feeding primarily on fishes and benthic organisms. In late July-early August they begin their return migration to their overwintering area in the upper Rat River. Sea-run Dolly Varden undertake these migrations for the rest of their lives. Those that are immature or are mature but not breeding that year are referred to as “silvers”. Most Rat River Dolly Varden mature at five or six years of age and spawn in alternate years although some appear capable of spawning in consecutive years (Harwood et al. 2009). Spawning occurs in Fish Creek, a tributary of the upper Rat River, from late August through to the end of October (Sandstrom et al. 2009). Depending on water temperature, emergence occurs seven to nine months after spawning.

Although Dolly Varden is primarily anadromous, some stocks are isolated by barriers and/or distance, but this does not appear to be the case in the Rat River. Co-occurring resident life history types also occur in some river systems, however residual forms have been rare in the Rat River sampling programs carried out to date. Resident Dolly Varden are almost exclusively males that permanently reside in headwater streams. They typically mature at a smaller size (younger age) than their sea-run counterparts and sneak spawning opportunities with sea-run pairs.

This species is a short-lived *Salvelinus*. Few in the Rat River system live as long as 11 years.

Habitat

Bedrock in the Rat River basin is mostly sandstone, with some limestone in the northern sections, covered by trees in valleys and lower slopes and by tundra vegetation at higher elevations. The accessibility of spawning and overwintering habitat is thought to be the limiting factor for Dolly Varden in the western Arctic where high-gradient rivers freeze completely to the bottom during the winter months over much of their length. The only exception to this is in places where groundwater springs maintain open water throughout the year. In the Rat River, Dolly Varden relies on spring-fed deep pools, in Fish Creek, for spawning and overwintering. There are five main pools which are known locally as “fish holes”. Photographs taken of one pool show an obvious decline in water level since 1995. Water temperatures at the spring discharge sites are in the 4-5°C range. In the Big Fish River, fluctuations in sodium, water and silt levels affect the characteristics of “fish holes” similar to those in the Rat River (Clark et al. 2001).

Downstream of the discharge area, a large field of layered ice (aufeis) forms as the water becomes cooler, dissipates and finally freezes. Most or all of this ice field melts in summer leaving behind a braided gravel plain with shallow flows. Juvenile silvers (< 400 mm fork length (FL)) use this area after finishing their upstream migration to Fish Creek (Sandstrom et al. 2001). They likely do not move to the deep overwintering pools upstream of the aufeis field, which they share with the adults, until sometime in late November after freeze-up.

Specific juvenile rearing areas in Fish Creek are unknown but, based on knowledge from other similar systems, they are most likely located in the spring-fed channels and within the braided gravel plain. Juvenile fish may also make use of habitat in the upper reaches of the Rat River mainstem but if so this would require that they return to the springs to overwinter, unless deeper pools downstream offer overwintering opportunities. The latter has not been documented.

It is thought that in summer Rat River Dolly Varden feed in highly-productive nearshore lagoons and coastal marine waters along the Beaufort Sea coast. The nature and range of their summer movements is poorly understood. It is presumed they migrate west along the Yukon coast, perhaps to or beyond the Alaskan border (Sandstrom et al. 2009).

Fishery

Until recently, Dolly Varden was harvested along the coastline of the Beaufort Sea by Inuvialuit and Alaskan harvesters (Inupiat) and by beneficiaries in the Inuvialuit Settlement Region (Aklavik) and Gwich’in Settlement Area (Aklavik and Fort McPherson) (Figure 1). A Rat River Working Group was formed in 1995 with membership from the Gwich’in Renewable Resource Board (GRRB), Fisheries Joint Management Committee (FJMC), Aklavik Hunters and Trappers Committee (HTC), Aklavik Renewable Resource Council (RRC), Fort McPherson RRC, and Fisheries and Oceans Canada (DFO) to work towards a Fishing Plan that would support sound management of the fishery to maintain a healthy stock of Dolly Varden in the Rat River. Since then, the fishery has been monitored through a community-based sampling program at three to five sites: the Aklavik town site in Peel channel; mouth of Husky Channel; Big Eddy on Husky Channel; mouth of the Rat River; and Destruction City on the Rat River (Figure 1). Fish monitors typically fished the upstream run of Dolly Varden during August and September. Almost all fish

caught and monitored in the community-based sampling program were caught using 102 mm (4") or 114 mm (4.5") mesh nets.

A sharp decline in the Rat River stock was detected by 2004 based on evidence from harvests (Table 1), catch effort and biological characteristics. In March 2006, following Working Group meetings and with the support of residents of Aklavik and Fort McPherson, a decision was taken by co-management partners to close the Rat River fishery on a voluntary basis. All fisheries (subsistence, domestic, commercial and sport fishing) were closed during the fall migration including the entire migratory route of Dolly Varden, starting from the West Channel, through the Peel and Husky Channels and the Rat River. Fish monitors continued to harvest a small number of Dolly Varden at the fishing sites. A permanent closure of the Rat River fish holes was also implemented. Following review of the monitoring results from 2006, the Working Group recommended a continuance of these management measures for the next two years. The Working Group would re-evaluate the status of Rat River Dolly Varden in fall 2008 when a new stock estimate was available.

ASSESSMENT

Stock size

A program to estimate the number of mature sea-run Dolly Varden in the Rat River was undertaken in the mid-1990s. Dolly Varden greater than 320 mm FL were caught and tagged at the spawning and overwintering site in Fish Creek in 1995, 1997, 2001 and 2004. The ratio of tagged to untagged fish captured during the summer fisheries in the year following tagging was used to estimate the size of the migratory stock (Table 2). The calculations took into account an observed annual tag loss rate of 14%[1].

Spawning Dolly Varden were also tagged at the spawning and overwintering site in fall 2007 to provide a current estimate of abundance. However, results of the mark-recapture study initiated in 2007 required the 2008 summer "recapture" phase in order to complete the analyses. Thus the 2007 abundance estimate was not available for this review.

Stock trends

Abundance of the sea-run segment of Rat River Dolly Varden (>320 mm FL) was relatively stable without trend from 1995 to 2001 (7,400-9,700), however there was a significant decline (p=0.0342) to around 2,700 fish observed in 2004 (Table 2). It is unclear whether that represented a declining trend or simply a temporary downturn in abundance because the 2007 abundance estimate was not available for this review.

[1] Sandstrom et al. (2009) later reported the observed annual tag loss rate was 8% and the abundance estimates were recalculated accordingly.

Table 1. Estimated harvest (number) of Rat River Dolly Varden from 1972 to 2007. Data comes from the Inuvialuit Harvest Study, Gwich'in Harvest Study, and DFO. Harvest in 1972, 1973 and 1975 is thought to include commercial harvests.

Year	Source of harvest					Total Estimate
	Aklavik	Shingle Point[1]	Gwich'in	Fish monitors	Unspecified origin	
1972					6,500	6,500
1973					2,600	2,600
1975					2,100	2,100
1980					1,545	1,545
1986		50			1,050	1,100
1987		125			3,000	3,125
1988		74			1,607	1,681
1989	132	53	1,814			1,999
1990	60	107	884			1,051
1991	20	3	353			376
1992	250	9	775			1,034
1993	381	60	968			1,409
1994	842	17	1,296			2,155–2,700
1995	377	32	1,115			1,524–2,251
1996	547	403	1,970			2,920–3,104
1997	643	62	2,688			3,393–3,365
1998	255	386	3,119			3,760–4,234
1999	225	125	1,561			1,911–1,936
2000	8	0	1,485			1,493
2001					1,781	1,781
2002					635	635
2003					1,492	1,492
2004				363	409	772
2005				453	205	658
2006				120	4	124
2007				120		120

[1] 50% of the Inuvialuit catch at Shingle Point.

Table 2. Estimates of abundance for the mature sea-run segment of the Rat River Dolly Varden stock (i.e., fish greater than about 320 mm FL) and the variables used to calculate these estimates. Number of tags available was based on a 14% tag loss estimate. (See Sandstrom et al. 2009 for details.)

Variable description	1995	1997	2001	2004	2007
Number of tags available[1]	334	364	335	239	366
Number of fish examined[2]	1,690	693	420	339	†
Number of recaptures[3]	66	25	18	29	†
Stock Estimate	**8,448**	**9,734**	**7,436**	**2,723**	†
Standard deviation	1,004	1,838	1,625	467	†

[1] Number of tags estimated to still be at large at time of harvest, adjusted for tag loss.
[2] Number of fish captured by the monitors of a size that would have been tagged the previous fall.
[3] Number of tags observed in the harvest.
† Values were available once recapture sampling was conducted in summer 2008. Table 2 in Sandstrom et al. 2009 provides final estimates of abundance for all years.

Biological information

During 1995–2007, silvers were captured in the fishery at a consistent rate of three to one compared to spawners and females outnumbered males by approximately two to one (Harwood et al. 2009). On average, 37.8% (range: 32-46%) were males.

Growth and age

The length distribution of Dolly Varden tagged at the spawning and overwintering site during the mark-recapture study was comparable among years except in 2007 when juvenile silvers (i.e., <400 mm FL) made up a large proportion of the total catch (Sandstrom et al. 2009). Judging by body size they were probably four years of age. Sea-run males and females from North Slope stocks begin to mature at 450 mm and 355 mm, respectively, which corresponds to age 4 (DFO 2001).

The mark-recapture study data showed that the average lengths of male and female spawners were significantly smaller for both sexes before 2000 than after 2000 (Sandstrom et al. 2009). The average length of current-year spawning males pre- and post-2000 was 476 mm (± 58 mm; n=72) and 522 mm (± 65 mm; n=26), respectively. The average length of current-year spawning females pre- and post-2000 was 466 mm (± 42 mm; n=460) and 489 mm (± 48 mm; n=139), respectively. The harvest monitoring data corroborated this finding and demonstrated that the change was due to an increase in size at a given age, not a shift in age structure (Harwood et al. 2009). The trend of increasing growth over time was further supported by the recaptured sample from the 2007 survey which had the highest recorded annual growth rate (Sandstrom et al. 2009). The mark-recapture data also indicated that all size classes were growing at the same rate which suggests that it was the result of an environmental effect rather than density dependence.

Fish in the upstream harvest were also found to be more robust in years when the southeast Beaufort Shelf was completely free of ice earlier than average (Harwood et al. 2009). The timing of break-up influences the timing of the zooplankton bloom. Thus an earlier break-up gives Dolly Varden the opportunity to migrate downstream and access prey earlier in the season. Climate change may also result in an overall increase in the marine pelagic community. These

explanations may account for the documented increases in Dolly Varden growth rates and improved condition in certain years (Harwood et al. 2009).

The mean ages of Dolly Varden caught in the fishery in 2006 and 2007 were lowest for silvers and current-year spawning males and in the lower half of values for current-year spawning females when compared to mean annual ages for the time series between 1995 and 2007 (Harwood et al. 2009). Younger fish can become more vulnerable to the fishery over time when their growth is enhanced or they increase in prevalence within the stock. As previously indicated, there has been a trend of increasing growth over time in recent years. Additionally, older year classes were poorly represented throughout all years of the community-based sampling program while there was an apparent increase in the proportion of four-year-old fish in 2007 (Harwood et al. 2009) (Figure 2).

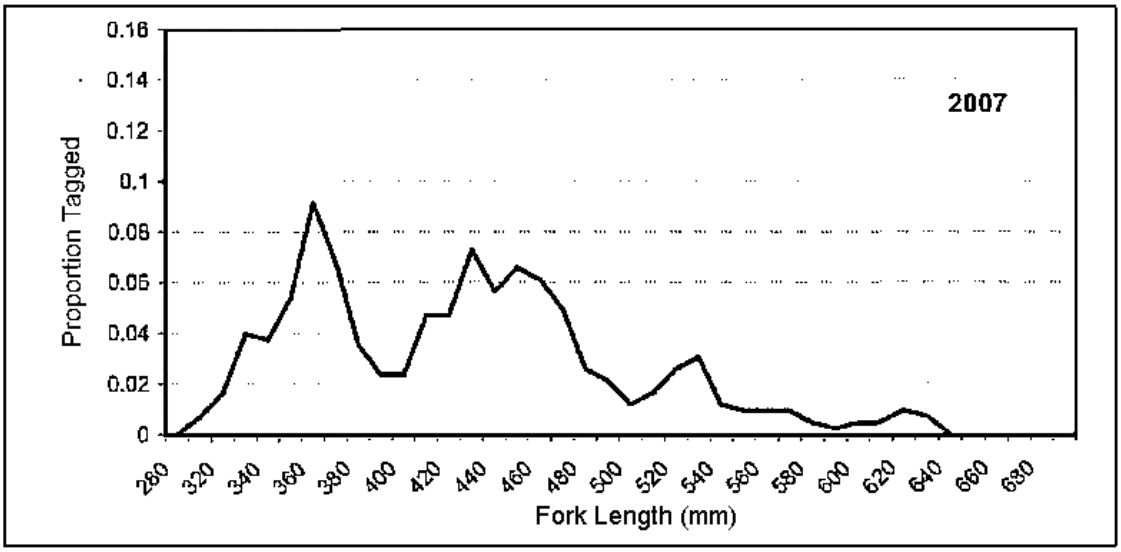

Figure 2. Fork length (FL) and number of char tagged in 2007 at the spawning and overwintering site on Fish Creek, Rat River, NT (from Figure 8 in Sandstrom et al. 2009).The spike in abundance at about 360 mm FL represents four-year-old Dolly Varden.

Reproduction

At the spawning and overwintering site the proportion of female to male spawners tagged remained relatively constant over the mark-recapture study period (1995–2007). Females accounted for 80-98% of the annual spawning stock, resulting in a sex ratio of 9.5:1 (Sandstrom et al. 2009). These results are comparable to the small proportion of sea-run males (about 6%) caught in the fishery over the same time period, although in 1999 the percentage of spawning males reached almost 20% (Harwood et al. 2009). This highly-skewed sex ratio means there may be too few sea-run males to successfully mate with all the available females. During the five years of tagging in the Rat River only one resident male Dolly Varden was caught (in 2004) (Sandstrom et al. 2009) although current sampling methods are not appropriate for catching these small fish. If resident males are rare then the potential for any supplementary input from them attempting to sneak spawning opportunities with sea-run pairs is unlikely. What impact these conditions may have on the annual reproductive capacity of this stock is unknown but is a source of concern. However, the apparent increase in the proportion of four-year-old fish in 2007 provides some evidence for improved recruitment.

During the 1995–2007 mark-recapture study, 106 Dolly Varden were identified as spawners when captured in the fall and then recaptured the following summer. Of these, 17% (1 of 6) males and 56% (56 of 100) females were identified as sequential spawners (Sandstrom et al. 2009).

Comparison of the incidence of sequential spawning during the study was limited for females and not possible for males because of the small number of recaptures. Nevertheless, the incidence of sequential spawning was relatively consistent (approximately 60%) for females at either end of the time series.

Sources of uncertainty

A number of uncertainties remain about the Dolly Varden Rat River stock. These include the size of the summer spawning stock, especially males; abundance of juveniles and residents; and age and length of fish at smoltification. Given the low proportion of spawning males, live sampling for biological data has been limited for that segment of the stock. Habitat use outside the fall spawning period has not been investigated. Uncertainties about potential changes in Dolly Varden habitat and carrying capacity of the Rat River also remain. A better understanding is also needed of the proportion of Rat River Dolly Varden in the mixed-stock coastal fishery. It is assumed that 50% of the coastal fishery is from the Rat River stock but that is likely an overestimate (DFO 2001).

Outlook

Estimates of abundance derived from the mark-recapture study showed a decline between 2001 and 2004. The stock-size estimate for 2007 was not available at the time of this report. Declines in Catch Per Unit Effort (CPUE) which had been apparent in 2000-2002 remained at a low level through to 2006 and then showed a slight improvement in 2007. Instantaneous mortality rates, both natural and from the fishery combined, increased from 0.3-0.5 in 1989 to 1.0 in 1999 but had declined to 0.54 in 2007. These data corroborate other favourable signs recorded during recent years of the mark-recapture study and community-based sampling program time series.

Changes have been observed in weather patterns in the western Arctic in recent years. One effect of this has been an increase in the condition of Rat River Dolly Varden in years of early break-up of sea ice over the Beaufort Shelf. However, environmental changes within the Rat River, such as declining water levels, may have negative effects on the stock by dropping it to a lower equilibrium or reducing the quality of habitat, but this is currently unknown.

Based on the data available at the time of the assessment, the overall outlook for the stock appeared to be cautiously optimistic.

CONCLUSIONS AND ADVICE

The estimated numbers of mature (320 mm FL) sea-run Dolly Varden from the Rat River was about 8,500 fish during 1995–2001 and then declined to around 2,700 in 2004. Current status of the stock was uncertain at the time of this assessment as there were no abundance estimates since 2004.[2] Future prospects for Rat River Dolly Varden were encouraging with evidence of increases in fork length of spawning fish, improved condition, relatively stable sex and maturity composition and an observed pulse of juvenile production in 2007. The increased growth of individual fish raises biomass to the fishery and, to some extent, may offset the pressure of the fishery on reproductive potential of the stock.

In spite of these positive signs, there are still low numbers of spawning males which means the effective population size is very low. Weak representation of older age classes throughout all years of the community-based sampling program is also a concern. A number of uncertainties

[2] Sandstrom et al. (2009) used mark-recapture analysis to calculate a stock estimate for 2007 based on recaptures during the summer 2008 harvest. They reported that abundance of Dolly Varden (>320 mm fork length) in the Rat River stock remained relatively stable between 1995 and 2007 in spite of the temporary decline detected in 2004.

remain including size of the summer spawning stock, especially males; abundance of juveniles and residents; age and length of fish at smoltification; potential changes in Dolly Varden habitat and carrying capacity of the Rat River; and the contribution of Rat River Dolly Varden to the mixed stock coastal fishery.

For these reasons, three measures are recommended for future management and research. Harvesters should be encouraged to release live any Dolly Varden that could be a sea-run male. Harvest levels from all sources, including research activities, mixed stock coastal fisheries and the Rat River directed fishery, are recommended to remain at or below 5% (i.e., 120 fish). Examination of approximately 400 fish (>400 mm fork length) is recommended in 2008 to increase precision of the 2007 stock estimate based on mark-recapture analysis.

OTHER CONSIDERATIONS

Infectious pancreatic necrosis virus, which can cause high mortality in young fish, is endemic in Rat River Dolly Varden (DFO 2001). Survivors can become lifelong carriers and infect other individuals in the population. The potential impacts of contaminants and parasite loads on Dolly Varden have not been studied. Arctic Grayling (*Thymallus arcticus*) occupy the same spawning and overwintering pools in Fish Creek as Dolly Varden which may present competition for available habitat and food sources, particularly when habitat is reduced by low water levels. Arctic lamprey and seals may be a significant source of mortality for juvenile sea-run Dolly Varden (primarily smolts) (DFO 2001). While in freshwater, congregations of Dolly Varden in spawning and overwintering habitat may be vulnerable to piscivorous fishes, mammals and birds.

SOURCES OF INFORMATION

This Science Advisory Report is from the March 17-19, 2008, Assessment of Rat River Dolly Varden. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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