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Satbayev University

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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

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STATE OF MICROPHYTE CENOSES AT THE WATER'S EDGE IN THE VICINITY OF THE PORT OF YERSAI AND THE VILLAGE OF KURYK (EASTERN CASPIAN SEA)

Abstract. Microphytic cenoses that develop on coastal rocks in the area of the water's edge can serve as particularly bright indicator biosystems that clearly display any harmful effects on their habitat. Developing, in fact, in the water-land boundary conditions, in the area of direct impact of the surface film of continuously moving water, they are a kind of " sponges " that collect a variety of agents carried by sea currents from sources of pollution. Accumulating in these communities, such agents are able to change the balance of species in the structure of these coenoses in a short time, as well as cause morphological changes in the species themselves. These modifications of the appearance can be caused both by their phenotypic norm of reaction to the presence and high concentrations of the contaminating agent, and by mutations provoked by one or another agent. Based on the obtained results describing the state of microepiphytic and microepilitic cenoses in various locations located at the end of July 2019 in the vicinity of the port of Ersai and the village of Kuryk, it can be concluded that the communities of all three locations were under stress – however, to a significantly different degree.

Key words: the coastal area, water basin, microepiphyton,, macrozoobenthos, biosystem, port Ersai, water area, East of Caspian sea.

Introduction. Communities of microscopic organisms that form in the coastal zone of water bodies are complex, multicomponent systems that are sensitive to various types of anthropogenic impact. The composition, structure, spatial organization of these communities, as well as the morphotypic characteristics of the species that accompany them, look very different - depending on the conditions of the habitat at the current time. Due to the high rate of reproduction of microorganisms, these cenoses react to environmental conditions faster and more clearly than communities of larger organisms. For example, microepiphiton on macroalgae or microepiphiton on coastal rocks reflect changes in the habitat already in the first day or three after the start of events. At the same time, macrozoobenthos developing in the same habitats displays any events that metamorphize the habitat, already indirectly and over longer time intervals.

It should be noted that microphytic cenoses that develop on coastal rocks in the area of the water's edge can serve as particularly bright indicator biosystems that clearly display any harmful effects on their habitat. Developing, in fact, in the water-land boundary conditions, in the area of direct impact of the surface film of continuously moving water, they are a kind of" sponges " that collect a variety of agents carried by sea currents from sources of pollution. Accumulating in these communities, such agents are able to change the balance of species in the structure of these coenoses in a short time, as well as cause morphological changes in the species themselves. These modifications of the appearance can be caused both by their phenotypic norm of reaction to the presence and high concentrations of the contaminating agent, and by mutations provoked by one or another agent.

Objects and methods of research. To study the possible effects of the Kuryk port and the LLP (in the post construction period) of the surrounding coastal waters East of the Caspian sea, in the period 26-28 July 2019 was sampled epilithic benthic communities. The material was taken on the surface of coastal rocks, in the area of the water's edge, at three points.

So, at the point Ep-1, located at a distance of 147 m to the South-West of the beginning of the Western Dam of the port, two samples of macrophytic growth were cut from the surface of flat stone blocks piled under a low coastal chink. The communities from which samples were taken in this location were different in macrophyte balance. In both cases, the growth of up to three centimeters was formed by a dense growth of filamentous scarlet (*Rhodophyta:Ceramiales*). However, in one case, this living red-brown carpet, absorbing the foam of the rolling wave, was formed mainly by thallomas of Ceramium elegans, with a small admixture of *Polysiphonia caspica*. And in another case, *P. caspica* prevailed, with a slight presence of *C. elegans*. In general, such modifications of phytofouling communities are quite typical for habitats at the water's edge in the eastern part of the Central Caspian Sea: both species of scarlet in these biotopes are usually found together [1], but the ratio of their abundance, according to our observations, may be different.

The point Ep-2 was located on a small rock outlet, at a distance of 2807 m to the East of the beginning of the Eastern Dam of the port. Samples of the growth were taken on the surface of calcareous blocks going into the water and from the surf-sanded calcareous rock wall, in the area of the water's edge, in three different communities. In the first case, it was thickets of *Cladophora sericea*, massively developed by a layer of up to 10 cm on blocks, in the shadow of a rock mass; in the second case, a gray fibrous-curd growth on a solid rock formed by colonial diatoms; in the third, also on the rock, there is a scattering of cartilaginous-jelly-like "plaques" of cyanobacteria, the structure-forming basis of which were macrocolonies of Rivularia atra.

Finally, the point of Ep-3 was localized even further to the East, in the area of the village Kuryk, at a distance of 4312 m from the beginning of the Eastern dam of the port, on the sea edge of a rocky promontory that protrudes into the sea almost 900 m from the main contour of the coastline. Here, on flat calcareous rocks, smoothly polished by the surf, only small placers of "plaques" of cyanobacteria based on *R. atra* colonies grew. At the same time, a gray mass of rotting filamentous algae lay in large numbers on the rocks, exuding a strong smell of hydrogen sulfide.

All samples were recorded with a 45% ethanol solution immediately after sampling and delivered to Moscow, to the laboratory of the Institute of Oceanology of the Russian Academy of Sciences, in a dark box. Thus, the material for microscopy of microepiphiton on macrophytes and microepiliton was obtained in the form that best corresponds to the lifetime state of the communities.

The general location of material collection locations in the water area in the vicinity of the port is shown in figure 1.

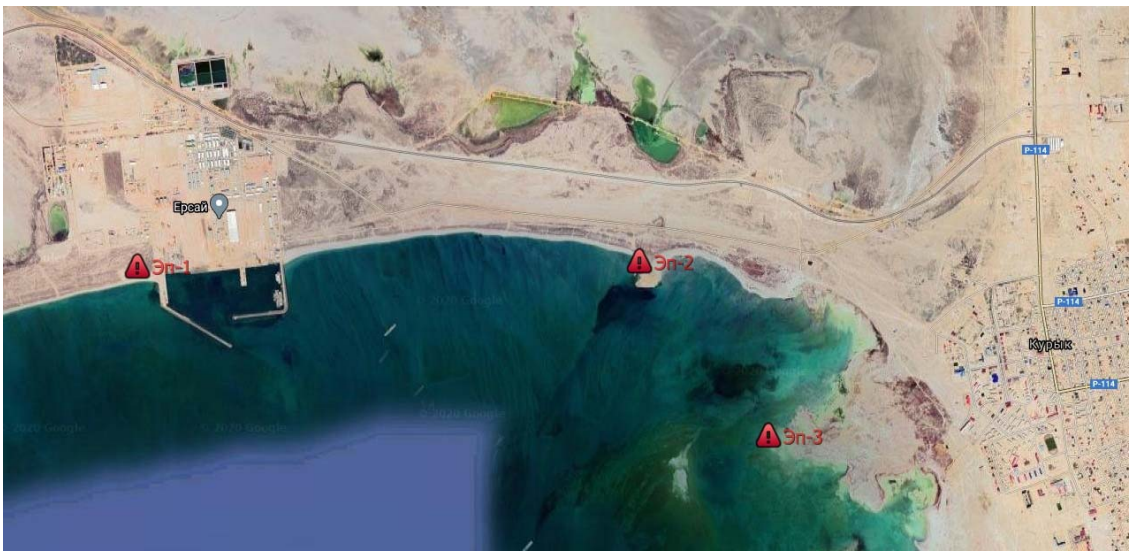

Figure 1 – Location of microepiliton and micro epiphyton sampling points in the waters of the Eastern Caspian Sea in the vicinity of the port of Ersai and the village of Kuryk

Microscopy of the samples was performed on raw material, as well as on permanent preparations made on the basis of the light-refractive medium "Rosin". Observation of fouling in its raw form allowed us to identify tiering in their structure, as well as other features of spatial organization inherent in the studied communities. In addition, the identification of cyanoprokaryotes is possible only in raw form - in the manufacture of permanent preparations, when a concentrated oxidizer is used to clean the shells of diatoms from organic components of cells, many cyanobacteria are dissolved. Working magnifications X400 and X1000 of Leica DMLS and Leica DM2500 light microscopes were used for identification, accounting and photo documentation of microphytes. The determination of the taxonomic affiliation of organisms was established using modern atlases, determinants and taxonomic summaries [2-17].

Results. The total taxonomic richness of the microphytic flora of the 6 studied microbiotopes located within three locations (points) in the vicinity of the port of Yerasay and the village of Kuryk was 88 species and subspecies. Among them, diatoms significantly prevailed (78 species and subspecies, or 88.64% of the total flora), followed by cyanobacteria (9 species, or 10.23%). One type of microepiphyte is *Acrochaetium* sp. 1, which lived in the status of rare on the surface of filamentous scarlet *C. elegans* and *P. caspica*, also belonged to the scarlet (*Rhodophyta*). In some communities, the number of microphyte species and vvt varied from 6 to 73 (table 4), averaging 26.83.

The richest (in terms of α - diversity, the number of species and vvt) was a community fiber - cheesy oposta on the rocks at location EP-2, East of the port (73 and vvt). Especially poor (with the lowest α-diversity) were the epiphytic community on *S. sericea*, an overgrown block of limestone at the Ep-2 location, and the epiliton of flat rocks at the Ep-z location, represented on the cape to the East of the port by small placers of" plaques " of *R. atra* and 6 accompanying species. For comparison, the" plaques " of *R. atra*, which formed dense placers on the rocks at the location of Ep-2, in the shadow of the southern dam of the port, included, in addition to the matrix-forming species-edifier, 11 more species and vvt. It should be noted that the microepiphyton on *Ceramium* (33 species and vvt) and *Polysiphonia* (30 species and vvt) differed in significant diversity. The average similarity of cenoses in the sample was 29,092% - the communities differed significantly in composition.

Only 3 species were recorded in 5 of the 6 studied cenoses - in different combinations - and, accordingly, can be considered as widespread in the vicinity of the port: These were diatoms *Diatoma moniliformis*, *Licmophora debilis* and *Tabularia affinis-attached*, colony-forming forms. At the same time, 42 species and vvt (47.73% of the total flora found) were observed only at one of the stations, that is, they differed in significant biotope / cenozoic specificity.

Considering the hierarchical roles of species in communities, due to the share of each of them in the total abundance of coenosis, as well as the distribution of species in the sample of coenoses, we can distinguish groups of communities: floristic (by composition) and coenotic (by structure).

Using a sample of 46 species and VVTs recorded in more than one cenosis, we evaluated the similarity of communities by qualitative characteristics using the Sierensen index, and by quantitative characteristics using the Bray-Curtis index.

The mean qualitative similarity of the coenosis on a truncated sample of the types made 35,36% community still differed widely among themselves in composition, which is logical considering only a truncated α - diversity in each of them (6-35 types and VVT, with an average 18,83).

We were able to identify 3 floristic groups differ on sound level (Global R = 1, p=1,7%).

In this floristic group, which included fiber - curdled epilithon location EP-2 and microaspiration of plaques locations EP-1 (group "diatoms + plaques"), described 33 species and vvt. In this case, the floristic similarity of the communities combined with the intragroup similarity at the level of 66.93% led to many common species of diatoms. At the top of the list were *Licmophora debilis, Berkeleya* cf. *rutilans, Epithemia sorex, Navicula* sp. 1, *Amphora hyalina, Cocconeis scutellum var. Parva, Entomoneis gigantea, Grammatophora marina, Grammatophora oceanica, Mastogloia smithii, Pleurosigma strigosum* и *Rhopalodia gibberula*.

The second floristic grouping ("Ep-2 *Cladophora+Rivularia*"), with an intra-group similarity of 55.56%, was formed by coenoses of microepiphytes on *C. sericea* and "plaques" of *R. atra* on the rocks of the Ep-2 location. Here, with an intra-group similarity of 55.56%, the grouping was already characterized by only 5 species and vvt: *Diatoma moniliformis, Licmophora debilis, Tabularia affinis, Heteroleibleinia epiphytica и Tabularia fasciculata.*

Finally, the third group ("Ep-3 *Rivularia*") was represented by a community of *Rivularia*" plaques " on the flat rocks of the Ep-3 location, which grew in small groups among rags of decaying *filamentous algae*. Here, as part of the matrix of *Rivularia* colonies and in the folds of its surface, only 7 species of microphytes lived: *Rivularia atra, Diatoma moniliformis, Tabularia affinis, Berkeleya* cf. *rutilans, Navicula* sp. 1, *Calothrix scopulorum* и *Lyngbya aestuari*i.

Of course, the qualitative composition of communities and their quantitative structure, determined by the hierarchy of contributions of individual species to the total abundance, often determine the similarities and differences of communities in different ways.

The average similarity of coenoses (in the truncated composition) in the quantitative structure was 24.03% - the communities, as a whole, differed greatly among themselves in the hierarchy of the species that form them. We were able to distinguish three cenotic groups with a general reliable level of differences (Global R = 1, p=1,7%).

The first group ("diatoms") was formed by communities of fibrous-curd growth on the rocks of the Ep-2 location, formed on the basis of macrocolonies of diatoms. These cenoses were characterized by a set of 23 species and vvt (table 1). Here, the main structure-forming role was played by branched colonies of *Diatoma moniliformis*. They served as a kind of spongy substance, inside which branched tubular colonies of *Berkeleya cf. rutilans* and *Berkeleya scopulorum*, long branching trichomes of the cyanobacterium *Diphothrix sp*. 1, small polymer sacs of *Gloeocapsa alpina* colonies, and 68 other diatomaceous species living a mobile and attached lifestyle. It should be noted that *Mastogloia species* in communities of this type lived without capsules, which they usually form when settling on solid substrates - here, among dense colonies of *D. moniliformis*, they retained mobility.

Table 1 – Set of species that characterized the coenotic grouping of "diatoms" at the Ep-2 location, East of the port of Ersai

Species and subspecies	Contribution to the overall abundance of cenosis, %
Diatoma moniliformis	27,24
Epithemia sorex	6,43
Amphora hyalina	5,71
Craticula subhalophila	5,49
Mastogloia smithii	5,15
Rhopalodia gibberula	4,93
Amphora lineolata	4,52
Berkeleya scopulorum	4,27
Cylindrotheca closterium	3,66

In the structure of the communities of this group, we noted the presence of mutant (aberrant) cell forms of some diatoms. Most often, these were *Epithemia turgida* and *Phopalodia gibba*, whose shells were significantly deformed, and their ornamentation was characterized by violations of the ornament.

The second coenotic group ("filaments"), with an intragroup similarity of 49.54%, was formed by communities of microepiphyton of filaments: both on the surface of scarlet in the Ep-1 location and on *C. sericea* in the Ep-2 location. These coenoses were characterized by a set of 5 species (table 2), and the main structure-forming role among them was played by the epiphytic thin-trichomal cyanobacteria *Heteroleibleinia epiphytica*. *Mastogloia* species included in the structure of the magenta microepiphyton in the Ep-1 location lived on their surface in an encapsulated state. Note also that in the cenosis on *C. sericea* the role of the second dominant was played by branched colonies of *D. moniliformis*, and already they were followed by *Tabularia affinis* and *T. fasciculata* in the status of mass.

The third group ("*Rivularia*"), with an intragroup similarity of 84.67%, was formed by cenoses based on the matrix of *Rivularia* macrocolonies that lived on rocks in the locations of Ep-2 and Ep-3. Trichomes played a major role in their structure *R. atra* (table 3).

Table 2 – Set of species that characterize the coenotic grouping of "filaments" formed by microepiphytic communities on the surface of filamentous macroalgae in the vicinity of the port of Ersai

Species and subspecies	Av.Abund	Av.Sim	Sim/SD	Contrib, %	Cum., %
Heteroleibleinia epiphytica	0,42	38,82	51,45	78,35	78,35
Licmophora debilis	0,03	1,8	6,32	3,63	81,99
Pteroncola inane	0,1	1,66	0,58	3,35	85,34
Cocconeis scutellum var. *scutellum*	0,03	1,64	0,58	3,3	88,64
Tabularia affinis	0,04	1,58	0,58	3,19	91,83

Table 3 – A set of species that characterize the coenotic group "Rivularia" formed by microepiphytic communities on the surface of filamentous macroalgae in the vicinity of the village of Kuryk

Species and subspecies	Av.Abund	Av.Sim	Contrib, %	Cum., %
Rivularia atra	0,87	80,21	94,74	94,74

Turning to the topic of diversity and equiobility of the species structure of coenoses, we evaluated these parameters using the Shannon-Weaver indices (diversity, H`), Pielow (J`) and the interspecific Encounter Probability Index (EPI). The highest diversity in H` was distinguished by the coenosis of fibrous-curd fouling on rocks (location Ep-2) (table 4). Here, the highest value of EPI and one of the highest values of J` were noted - the cenosis was most diverse, rich in species and balanced. Nevertheless, the value of J` at a level below 0.8 still indicates a strong influence of the first dominant on the structure of the cenosis, which was actually expressed in the structure-forming role *Diatoma moniliformis*.

Table 4 – Values of diversity indices (H`) and equalization of species structure (J`, EPI) for communities of different locations in the vicinity of the port of Ersai and the village of Kuryk. In accordance with the selection of indices for each cenosis, its α - diversity (species richness) is given

Locations and communities	α- diversity	J`	H`	EPI
Ep -1 *Ceramium elegans*	33	0.597	2.088	0.785
Ep -1 *Polysiphonia caspica*	30	0.722	2.455	0.832
Ep -2 Волокнисто-твор. оброст	70	0.708	3.008	0.899
Ep -2 *Cladophora sericea*	6	0.640	1.146	0.615
Ep -2 *Rivularia atra*	12	0.351	0.872	0.350
Ep -3 *Rivularia atra*	7	0.141	0.274	0.113

Microepiphyton on the surface of filamentous scarlet was characterized by medium-low (for *Polysiphonia*) and low (for *Ceramium*) indicators of diversity and equalization. However, in the conditions of the Caspian Sea, it is difficult to count on particularly high indicators of these indices for microepiphyton. For example, in the northern part of the sea-lake, only 2-3 species of microepiphytes can be found on *Polysiphonia species*, with a significant dominance of one of them. Given the high number of microepiphyton species in the coenoses we studied in the port area, we can say that the relatively low values of H`, J` and EPI are due to the significant roles of the dominant species (*Heteroleibleinia epiphytica* and, on *Ceramium,* also *Pteroncola inane*) in their structure.

The microepiphyton of *S. sericea*, represented by a small number of species, was characterized by the lowest indices of all indices among the coenotic group of "filaments". However, this is generally characteristic of epiphytic communities on *Cladophora*, which are forced to live on a well-washed, rarely branching cylindrical substrate with a fibrous-cellulose cell surface. Nevertheless, it should be noted that a certain stress was manifested for this cenosis through low diversity indicators and significant roles of dominants.

In turn, the lowest indicators of diversity and equalization against the background of a small number of species were characterized by cenoses based on *Rivularia* "plaques". Nevertheless, a significant difference in all 4 indicators was clearly noted between the cenoses of this type that lived within the Ep-2

and Ep-3 locations – in favor of the cenosis at the Ep-2 location. *Rivularia*-based communities at the Ep-3 location grew under the most severe stress.

Based on the obtained results describing the state of microepiphytic and microepilitic cenoses in various locations located at the end of July 2019 in the vicinity of the port of Ersai and the village of Kuryk, it can be concluded that the communities of all three locations were under stress – however, to a significantly different degree.

Thus, the least stressful effect was observed in the location of Ep-1, at a distance of about 150 m to the South-West of the port. Here, only abundant organic pollution of the coastal water area affected. In turn, the cenoses of the Ep-2 location bore, first, the imprints of organic pollution, which stimulated the violent development of "garbage" species, such as *Diatoma moniliformis, Tabularia affinis, T. fasciculata* and-on *Cladophora – Heteroleibleinia epiphytica*. Secondly, the coenosis of the fibrous-curd-like growth of rocks, which takes on, like a sponge, the effect of all the agents dissolved in the surface film of water, was clearly affected by a certain toxic pollution, clearly manifested in the presence of aberrant forms of diatoms from the genera, albeit insignificant *Epithemia, Mastogloia* and *Rhopalodia*.

Finally, the flat rocks of the Ep-3 location were already located, in fact, on the distribution line along the coast of those agents that can go to the water area of the coastal zone with the sewage of the village of Kuryk. The communities here were actually knocked out and slowly rotted away. The same microepilitic coenoses based on the dense polysaccharide matrix of *Rivularia* macrocolonies that survived here were in an extremely depressed state.

The longshore current in this area moves from East to West. The dams of the port, in fact, play the role of cut-offs, thanks to which the flow carrying the bulk of the sewage of the village Kuryk, partly turns towards the open sea. As a result, coastal communities to the west of the port are significantly less polluted than those to the East. Bottom microphyte communities of the surf strip were studied for this area of the Caspian coast for the first time.

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ЕРСАЙ ПОРТЫ МЕН ҚҰРЫҚ АУЫЛЫНЫҢ (ШЫҒЫС КАСПИЙ) МАҢЫНДАҒЫ СУ КЕМЕРІНДЕГІ МИКРОФИТТІК ЦЕНОЗДАРДЫҢ ЖАЙ-КҮЙІ

Аннотация. Су кемері аймағындағы жағалаудың жартастарында пайда болатын микрофиттік ценоздар, тіршілік ету ортасына қандай да бір зиянды әсерлерді айқын көрсететін ерекше жарқын индикаторлық биожүйелер болып табылады. Су-құрлықтық шекаралық жағдайында, үздіксіз қозғалатын судың беткі қабатының тікелей әсер ету аймағында дамып, олар ластану көздерінен теңіз ағындарымен тасымалданатын әртүрлі агенттерді жинайтын "сіңіргіштер" болып табылады. Осындай қауымдастықтарда жинақтала отырып, мұндай агенттер қысқа мерзімде осы ценоздардың құрылымындағы түрлердің тепе-теңдігін өзгерте алады, сонымен қатар түрлердің морфологиялық өзгерістерін тудырады. Сыртқы көріністің бұл модификациясы олардың ластаушы заттың болуына және жоғары концентрациясына фенотиптік реакция нормасына, сондай-ақ белгілі бір агент қоздыратын мутацияға байланысты болуы мүмкін. 2019 жылғы шілде айының соңында Ерсай порты мен Құрық ауылының маңында орналасқан түрлі локациялардағы микроэпифиттік және микроэпилиттік ценоздардың жай-күйін сипаттайтын алынған нәтижелер негізінде барлық үш жердегі қауымдастықтар күйзеліске ұшырады деген қорытынды жасауға болады, дегенмен, көрсеткіштер әртүрлі дәрежеде болды.

Түйін сөздер: жағалау аймағы, су айдыны, микроэпифитон, макрозообентос, биожүйе, Ерсай порты, акватория, Шығыс Каспий.

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СОСТОЯНИЕ МИКРОФИТНЫХ ЦЕНОЗОВ НА УРЕЗЕ ВОДЫ В ОКРЕСТНОСТЯХ ПОРТА ЕРСАЙ И ПОС. КУРЫК (ВОСТОЧНЫЙ КАСПИЙ)

Аннотация. Микрофитные ценозы, развивающиеся на береговых скалах в области уреза воды, могут служить особенно яркими индикаторными биосистемами, наглядно отображающими какие-либо вредоносные воздействия на среду их обитания. Развиваясь, по сути, в граничных условиях вода-суша, в области прямого воздействия поверхностной плёнки непрерывно движущейся воды, они являются своего рода «губками», собирающими в себя самые разные агенты, разносимые морскими течениями от источников загрязнения. Накапливаясь в этих сообществах, такие агенты способны в короткие сроки изменять баланс видов в структуре этих ценозов, а также вызывать морфологические изменения самих видов. Эти модификации облика могут быть обусловлены как их фенотипической нормой реакции на присутствие и высокие концентрации загрязняющего агента, так и мутациями, провоцируемыми тем или иным агентом. На основании полученных результатов, описывающих состояние микроэпифитных и микроэпилитных ценозов в различных локациях, располагавшихся в конце июля 2019 года в окрестностях порта Ерсай и пос. Курык, можно сделать заключение, что сообщества всех трёх локаций находились в состоянии стресса – однако в существенно разной степени.

Ключевые слова: прибрежная зона, водоём, микроэпифитон, макрозообентос, биосистема, порт Ерсай, акватория, Восточный Каспий.

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