# ANNUAL BULLETIN OF MONITORING THE CLIMATE STATE AND CHANGE IN THE CASPIAN SEA REGION

# 2021 year

# **1. DATA DECRIPTION**

1.1 For the preparation of the Bulletin, the data observed at the coastal hydrometeorological stations/posts were used on the following characteristics (parameters):

Observation post	Air temperature	Precipitation	Sea level	Seawater
				temperature
		Kazakhstan		
Aktau	+		+	+
Atyrau	+	+		
Ganyushkino	+	+		
Kulaly	+	-	+	+
Kyzan	+	+		
Peshnoy	+	+	+	+
Tushchibek	+	+		
Fort Shevchenko	+	+	+	+

\* Note: The precipitation catalogue has so far been compiled only for the Russian coast

# 2. METEOROLOGICAL CONDITIONS

# 2.1 AIR TEMPERATURE

In 2021, on the Kazakhstan territory, air temperatures in the winter, spring and summer seasons significantly exceeded the norm: in the winter season by 0.4-1.2 °C; in the spring period by 1.6-3.1 °C, and the anomalies exceeded the values of the standard deviation, and in some cases twice; positive anomalies of summer temperatures amounted to 3.1-4.8 °C, which is 3-5 times higher than the standard deviation (table 2.1.1). Temperature anomalies in the autumn season ranged from minus 0.2 to plus 0.9 °C and didn't exceed the standard deviation. The average annual temperatures exceeded the norm by 1.8-3.2 °C, the anomaly values were 2-4 times higher than the standard deviation.

Table 2.1.1 - Characteristics of the average annual and seasonal air temperature according to the data of observation points of the Caspian region in 2021: T – the current value of air temperature; vT – deviations from the long-term average for 1961-1990, C; s – the average square deviation in C for the period 1961-1990

Country/	Year			Winter			Spring			Summer			Autumn		
the observation post	Т	vT	S	Т	vT	S	Т	vT	S	Т	vT	S	Т	vT	S
						Kazak	hstan								

Country/		Ye	ear			Win	nter			Spri	ng		Sur	nme	er		Autum	1
the observation post	Т		vT	s	Т	v	T,	5	Т	v]	Г s	Т	V	νT	S	Т	vT	S
Kazakhstan																		
Aktau	13,8	2,4	$\pm 0,8$	0,	1	0,7	±2,0	1.	3,1	2,2	±1,2	27,3	4,6	5	±1,3	12,7	0,3	±1,1
Atyrau	12,4	3,2	$\pm 0,8$	-5	,7	1,2	±2,4	1.	3,2	3,1	±1,6	29,5	4,8	3	±1,0	9,9	0,9	±1,3
Ganyushkino	11,8	2,4	$\pm 0,8$	-4	,3	1,0	±2,4	12	2,1	2,2	±1,6	27,4	3,0	5	$\pm 0,8$	9,6	0,3	±1,2
Kulaly	12,7	1,8	$\pm 0,8$	-2	,5	0,4	±2,0	1	1,9	1,6	±1,4	27,8	3,1	l	±0,8	11,4	-0,2	±1,1
Kyzan	13,7	2,7	$\pm 0,8$	-3	,3	1,1	±2,4	14	4,9	3,5	±1,3	30,1	4,0	)	±0,9	10,9	0,1	±1,2
Peshnoy	11,0	2,3	$\pm 0,8$	-6	,1	0,7	±2,4	1	1,8	2,5	±1,5	27,1	3,5	5	±0,8	8,6	-0,1	±1,2
Tushchibek	13,5	2,3	±0,7	-2	,0	0,9	±1,9	1.	3,7	2,5	±1,3	29,3	4,0	)	±1,0	11,1	0,0	±1,2
Fort Shevchenko	13,8	2,0	±0,8	-0	,1	0,8	±1,9	1.	3,0	2,0	±1,4	27,5	3,1	l	±0,9	13,1	0,4	±1,2

Table 2.1.2 presents the ranks of the warmest years on the coast of the Caspian Sea and the corresponding anomalies of the mean annual surface air temperature.

On the Kazakh coast, the five warmest years included various years of the current century, including 2021, and at some stations also 1995. According to the Atyrau, Kyzan, Peshnoy and Tushchibek weather stations, 2021 was the warmest year, and the average annual temperature anomalies amounted to 2.3-3.2 °C.

Table 2.1.2 – Ranks of the warmest /or coldest / years on Kazakhstan coast of the Caspian Sea and related anomalies of the annual average air temperature ( $^{\circ}C$ ): *R* - the rank of the current values in a series ordered in descending order for positive anomalies and in ascending order for negative ones (only the first 5 ranks are shown); the period for calculating the ranks: whole observation period

R	Year	Averag e annual tempe- rature	Ano- maly	Year	Averag e annual temper ature	Ano- maly	Year	Averag e annual temper ature	Ano- maly	Year	Averag e annual temper ature	Ano- maly
						Kazak	hstan					
M	S Aktau			MS Aty	rau		MS Gan	yushkino		MS Ku	laly	
1	2010	14,0	2,6	2021	12,4	3,2	2021	11,8	2,4	2004	13,1	2,2
2	2021	13,8	2,4	2020	12,0	2,8	2020	11,6	2,2	2010	12,7	1,8
3	2004	13,7	2,3	2010	11,9	2,7	1995	11,6	2,3	2021	12,7	1,8
4	2019	13,6	2,2	2013	11,6	2,4	2010	11,3	2,7	2013	12,7	1,8
5	2018	13,4	2,0	2019	11,5	2,3	2019	11,2	2,3	2007	12,6	1,7
						Kazakh	stan					
M	S Kyzan		М	[S Peshno	у		MS Tushc	hibek	]	MS Fort	Shevchen	ko
1	2021	13,7	2,7	2021	11,0	2,3	2021	13,5	2,3	2004	13,8	2,0
2	2020	13,1	2,1	1995	11,0	2,3	2010	13,3	2,1	2021	13,4	2,0
3	2010	13,1	2,1	2004	10,8	2,1	1995	12,9	1,7	2010	13,4	2,0
4	2019	13,1	2,1	2013	10,7	2,0	2019	12,8	1,6	2020	14,1	1,8
5	1995	13,0	2,0	2010	10,6	1,9	2004	12,8	1,6	2007	13,7	1,8

Table 2.1.3 shows the records of the maximum monthly air temperature (°C) recorded at the observation points of the Caspian region in 2021.

At all stations along the coast of Kazakhstan, the records of the average monthly temperature in August, set earlier in 2016 or 2014, were updated. Atyrau station set a record of average temperature in May, the previous one was recorded in 2014. In this month, daytime temperatures rose to 40.5-44.5 °C, and night temperatures did not fall below 20 °C for 3-4 weeks (so-called tropical nights). At the same time, there was no precipitation during the entire month.

Table 2.1.3 – Absolute maximum/minimum of the monthly average air temperature (°C)recorded in the Caspian Sea region in 2021

Country/	Month	Absolute	Previous	Absolute	Previous
the observation post		maximum of	maximum and	minimum of	minimum and
		2021	a year of its	2021	a year of its
			occurrence		occurrence
Kazakhstan					
Aktau	August	28,7	28,5 (2016)	-	
Atyrau	May	24,6	23,9 (2014)		
Ganyushkino	August	30,4	29,8 (2016)		
Kulaly	August	28,1	26,9 (2014)		
Kyzan	August	28,7	28,4 (2016)	—	
Peshnoy	August	31,4	30,9 (2016)	—	
Tushchibek	August	27,6	26,6 (2016)	-	
Fort Shevchenko	August	31,1	29,9 (2016)		
Aktau	August	29,3	29,2 (2016)		

Table 2.1.4 – Records of monthly maximum air temperature (°C) in the Caspian Sea region in 2021

Not observed in 2021

Country/	Date	Month	Air	Previous	Date of the
the observation			temperature, °C	maximum, °C	previous
post					maximum
Kazakhstan					
Aktau					
Atyrau					
Ganyushkino					
Kulaly					
Kyzan					
Peshnoy					
Tushchibek					
Fort Shevchenko					
Aktau					

# Table 2.1.5 – Records of monthly minimum air temperature (°C) in the Caspian Sea region in 2021

Not observed in 2021

Country/	Date	Month	Air	Previous	Date of the
the observation			temperature, °C	maximum, °C	previous maximum
post					
			Kazakhstan		
Aktau					
Atyrau					
Ganyushkino					
Kulaly					

Kyzan			
Peshnoy			
Tushchibek			
Fort			
Shevchenko			

### 2.1.2 Trends in the air temperature

Table 2.1.6 presents estimates of the linear trend of average annual and seasonal air temperatures at observation points in the Caspian region for the period 1976–2021.

According to the data of all meteorological stations of the Kazakhstan coast is observed rising in average seasonal temperatures. The rate of rise varies from 0.23 to 0.92 °C/10 years. Rising in the spring and summer temperatures is statistically significant at all stations, in autumn, with the exception of two stations, and winter temperatures are significant only at three stations, where the share of the trend component in the total variance of the series is about 10 % or above. Average annual temperatures risen by an average of 0.40-0.60 °C every 10 years, rising is statistically significant.

Table 2.1.6 – Estimates of the linear trend of average annual and seasonal air temperatures in the Caspian Sea region for the period 1976-2021: a - the coefficient of the linear trend (°C/10 years); D - the coefficient of determination (%). The trend values that are insignificant at the level of 5% are highlighted

Country/	Ye	ear	Wii	nter	Spr	ing	Sum	mer	Autu	ımn
the observation post	а	D	а	D	а	D	а	D	а	D
Kazakhstan										
Aktau	0,54	56,8	0,43	10,5	0,49	31,4	0,92	62,0	0,31	10,0
Atyrau	0,60	47,1	0,51	7,8	0,61	24,6	0,71	44,9	0,51	20,0
Ganyushkino	0,43	32,6	0,42	6,5	0,46	20,0	0,50	34,1	0,30	9,2
Kulaly	0,40	37,3	0,33	6,4	0,41	19,3	0,47	44,0	0,35	13,8
Kyzan	0,53	51,4	0,43	6,6	0,62	30,0	0,56	35,9	0,36	11,4
Peshnoy	0,40	30,2	0,42	6,0	0,53	22,1	0,37	27,5	0,23	4,8
Tushchibek	0,42	43,3	0,39	9,4	0,44	18,9	0,53	31,5	0,30	8,3
Fort Shevchenko	0,50	52,1	0,42	11,2	0,43	21,5	0,65	51,0	0,45	19,9

# 2.2. PRECIPITATION

# 2.2.1 Precipitation in 2021

Table 2.2.1 presents the characteristics of annual and seasonal precipitation in 2021.

At Kazakhstan coastal stations in 2021, with rare exceptions, significant deficit of seasonal precipitation was recorded. The only exceptions are two cases when the amount of precipitation for the summer season significantly exceeded the norm - at the MS Aktau (306 % of the norm) and at the MS Tushchibek (140 % of the norm). As a result, the annual precipitation ranged from 24 % of the norm (MS Kulaly) to 79 % of the norm (MS Atyrau).

Table 2.2.1 – Characteristics of annual and seasonal precipitation in 2020: R – the amount of precipitation, mm; RR – the ratio of the current value to the norm for 1961-1990, % Table 2.2.1 – Characteristics of annual and seasonal precipitation in 2020: R – the amount of

Страна/название	Г	од	Зи	ма	Bee	сна	Ле	то	Oce	ень
наблюдательного пункта	R	RR	R	RR	R	RR	R	RR	R	RR
Kazakhstan										
Aktau	118,9	73,5	22,3	49,7	9,6	18,9	69,2	306,2	19,3	44,6
Atyrau	125,8	79,1	36,1	108,7	24,2	60,8	10,4	23,3	39,4	95,4
Ganyushkino	117,4	73,3	20,5	65,3	28,2	70,3	19,2	41,0	30,8	73,7
Kulaly	39,0	23,5	4,1	14,3	7,5	13,6	4,8	13,0	17,6	39,0
Kyzan	50,1	29,7	12,2	37,5	16,3	31,0	18,3	43,5	3,0	7,2
Peshnoy	77,1	58,7	21,3	71,7	19,5	58,9	8,1	26,6	18,6	48,8
Tushchibek	94,0	53,1	16,5	51,9	11,7	18,0	53,9	140,4	13,6	32,4
Fort Shevchenko	42,6	29,9	10,7	44,6	5,5	11,8	6,8	19,7	18,3	49,1

1 4010 2.2.1	Character istics	or annuar and	seasonal pree	
nrecinitation	$mm \cdot RR - the ratio$	of the current v	alue to the norm	for 1961-1990 %

Table 2.2.2 – Absolute maximum/minimum	of monthly precipitation (	(mm) recorded in the
Caspian Sea region in 2021		

Country/ the observation	Absolute maximum of 2021		Previous		Absolute minimum of 2021		Previous minimum	
post			1110/111					
	value	date	value	date	значение	value	date	value
Kazakhstan								
Aktau								
Atyrau								
Ganyushkino								
Kulaly								
Kyzan								
Peshnoy								
Tushchibek								
Fort								
Shevchenko								

Not observed in 2021

# 2.2.2 Trends in precipitation

Table 2.2.3 presents estimates of the linear trend of annual and seasonal precipitation in the Caspian Sea region for the period 1976–2021.

On the territory of Kazakhstan is mainly observed decreasing in seasonal precipitation amounts, but statistically insignificant, with the exception of the MS Fort Shevchenko, where the significant decreasing in spring season precipitation was recorded – by 6 mm/10 years. Statistically significant increasing in precipitation was noted in the winter season at Atyrau and Tushchibek stations, and in the spring season – at Atyrau and Peshnoy stations.

Table 2.2.3 – Estimates of the linear trend of annual and seasonal precipitation in the Caspian Sea region for the period 1976-2021: a - linear trend coefficient (mm/10 years); D - determination coefficient (%) The trend values that are insignificant at the level of 5% are highlighted

Country/ Year Winter Spring Summer Autumn	ueler minulion coeffi	cieni <mark>(70).</mark> The tre	ena values inal al	e insignificani a	i the level 0f 5700	ure nigniignieu
	Country/	Year	Winter	Spring	Summer	Autumn

the observation post	а	D	а	D	а	а	D	а	D	а
Kazakhstan										
Aktau	-3,4	0,7	2,0	1,4	-6,4	6,0	3,6	5,1	-0,9	0,3
Atyrau	10,1	7,4	4,6	11,7	8,1	11,2	-1,4	0,7	-1,1	0,5
Ganyushkino	-7,5	4,4	-0,6	0,7	2,8	3,1	-6,6	6,7	-3,4	5,3
Kyzan	-9,0	6,4	-0,1	0,0	-4,2	3,5	-1,6	0,8	-4,1	7,3
Peshnoy	7,3	3,3	2,0	1,8	7,9	11,9	-0,5	0,1	-2,0	1,9
Tushchibek	-2,9	0,4	4,0	9,1	-7,3	5,0	2,8	2,6	-1,7	1,7
Fort Shevchenko	-9,8	7,8	1,8	3,4	-6,4	10,1	-1,5	0,8	-3,4	5,6

#### **3. HYDROLOGICAL CONDITIONS**

# 3.1. RIVER INFLOW TO THE CASPIAN SEA

# 3.1.1 Ural River (Zhaiyk) runoff

The outlet of the Ural River (Zhaiyk) is in the Southern Urals (Uraltau ridge) on the territory of the Russian Federation.

The river flows through Russia (Bashkortostan, Chelyabinsk and Orenburg regions), Kazakhstan (West Kazakhstan and Atyrau regions) into the Caspian Sea. The runoff of the Ural River (Zhaiyk) is characterized by significant interannual and seasonal variability.

At the post of Makhambet village, the average multiyear value of annual runoff amounted to 7.94 km<sup>3</sup> in the period of 1936-2021; it varied from 20.59 km<sup>3</sup> in high-water years to 2.85 km<sup>3</sup> in low-water years. This post closes the river catchment area equal to 230000 km<sup>2</sup>.

The flow of the Ural River (Zhaiyk) is affected by economic activities, the most significant of them is the presence of the Iriklinsky water reservoir, which was built in 1958 and related to reservoirs of long-term regulation. The river regime in the period from the beginning of observations to 1957 is considered to be relatively natural. Since 1958, flow regime started to be regulated, the reservoir began to operate with a constant water discharge, and this made it possible to keep the spring flood in the reservoir (Chibilev, 2008). The flow of the Ural River in Russia is regulated by a cascade of reservoirs built both on the Ural River itself and on its tributaries. The largest of them are: Verkhneuralskoye – the volume of 601 million m<sup>3</sup>, Magnitogorsk – the volume of 189 million m<sup>3</sup>, Iriklinskoye – the volume of 3257 million m<sup>3</sup>. Reservoirs on tributaries: Kumakskoye, Dombarovskoye, Krasnochabanskoye, Sakmarskoye, Chernovskoye (Russia), Aktobe, Karagalinsky (Kazakhstan). Analyzing the flow graph (Fig. 1), it can be concluded that the decreasing trend in annual water runoff of the Ural River (Zhaiyk) at the Makhambet village is observed in 1936-2021. At present, the Ural River regime is facing

low-water phase. In 2021, the runoff of the river at the Makhambet post was 3.69 km<sup>3</sup>, which is 54% less than the multiyear average (1936-2021). This is the minimal runoff, which was recorded in the last 10 years.



Fig. 1. Runoff of the Ural River (Zhaiyk) at Makhambet village for the period 1936-2021

In order to analyze the multi-year variability of the water resources of the Ural River and to identify high-water and low-water phases, the long-term data on average annual water discharge were analyzed with difference-integral curve (DIC), which is expressed by the following formula:

$$DIC = \Sigma(K_i - 1)/C_v,$$

where  $K_i$  - modular coefficient,  $C_v$  - coefficient of variation.



Fig. 2. Difference-integral curve of the Ural (Zhaiyk) at Makhambet village for the period 1936-2021

Figure 2 shows clear presence of the runoff cyclic fluctuations with the high-water and low-water phases, decreasing trend in water runoff is detected, which is especially clearly seen in the last 20 years and induced by climatic factors.

# 3.2. THE LEVEL OF THE CASPIAN SEA

# 3.2.1 The sea level in the Kazakhstan sector in 2021

According to the data of coastal and island stations and posts in 2021, the level of the Caspian Sea in its northeastern shallow part was around -28.43 m abs. and varied from -27.79 m to -29.10 m abs. In the deep-water Kazakh part of the Caspian Sea, according to the data at Fort-Shevchenko, Aktau and Fetisovo posts, the average sea level was -28.52 m abs. with the maximum of -28.05 m and the minimum of -29.07 m abs.

# Wind-driven sea level fluctuations in the Northern part of the Caspian Sea

Sea stations and posts of Kazhydromet recorded 16 cases of upsurges and 71 cases of downsurge in the north-eastern coast of the Caspian Sea during the period from January to December 2021.

The most significant surge phenomena:

- February 14-18, **a critical drop** in the water level by 68 cm was observed at the Peshnoy Isl., caused by a steady north-western wind with a speed of up to 8 m/s.

- July 4-10, **a critical drop** in the water level by 110 cm was observed near the northeastern coast of the Caspian Sea at the Peshnoy post, caused by the steady north wind at a speed of up to 16 m/s.

- July 22-29, a critical drop in the water level by 99 cm was recorded at the Peshnoy post caused by the north wind with a maximum speed of up to 8 m/s.

- July 5-7, there was a decrease in the water level by 30 cm at the Fetisovo post caused by a western wind with a maximum speed of up to 10 m/s.

- September 25-26, a drop in the water level by 32 cm was recorded at Fort-Shevchenko post caused by the north-western wind with a maximum speed of 12 m/s.

- October 20-25, the water level at the Pesnoy post rose to 49 cm, caused by the steady south wind (up to 6 m/s).

- December 27-29, **a critical drop** in the water level by 69 cm was observed near the northeast coast of the Caspian Sea at the Peshnoy post, caused by the steady northeast wind (up to 6 m/s).

# 3.3. SEAWATER TEMPERATURE

3.3.1 Seawater temperature in the Kazakhstan sector of the Caspian Sea in 2021 Methodology: The average annual value of water temperature for the period 1981-2010 is adopted in the Bulletin as a norm. This was recommended by the 16th session of the WMO Commission on Climatology as a standard norm.

Water temperature anomalies are defined as deviations of the observed value from the norm.

The obser-	Year,						Mo	onth						Vaar
vation post	period	1	2	3	4	5	6	7	8	9	10	11	12	rear
Kazakhstan														
Aktau	Average in 2021	2,0	3,6	4,2	11,5	16,2	17,3	16,8	22,0	17,5	12,9	8,4	5,7	11,5
	Max.	4,8	5,9	8,3	16,2	21,2	23,7	24,0	27,3	22,7	23,4	12,4	9,5	27,3
	Min.	0,2	-0,3	0,1	0,2	11,0	12,0	13,0	14,1	13,7	9,6	6,2	-2,0	-2,0
	Average in 1981- 2010	2,7	2,4	5,5	11,0	15,4	17,6	17,8	19,1	18,1	14,3	8,9	4,5	11,4
	Anomali es	-0,7	1,2	-1,3	0,5	0,8	-0,3	-1,0	2,9	-0,6	-1,4	-0,5	1,2	0,1
Fort Shevchen- ko	Average in 2021	0,5	1,1	1,3	10,6	17,9	23,3	25,0	23,0	18,2	10,9	6,3	4,3	11,9
	Max.	1,5	4,1	5,9	15,0	23,3	26,0	28,4	29,8	24,2	16,5	10,7	8,5	29,8
	Min.	0,1	-0,6	-0,5	2,7	14,6	20,8	21,3	19,3	9,5	7,2	3,0	0,5	-0,6
	Average in 1981- 2010	1,0	0,7	2,9	9,3	16,0	22,0	24,5	22,6	18,6	13,4	7,5	2,6	11,7
	Anomali es	-0,5	0,4	-1,6	1,3	1,9	1,3	0,5	0,4	-0,4	-2,5	-1,2	1,7	0,1
Kulaly Isl.	Average in 2021	0,5	0,4	2,0	15,6	21,2	26,5	27,9	27,7	17,6	11,6	5,9	2,9	13,3
	Max.	2,4	3,9	9,7	19,9	26,2	29,3	30,2	30,1	28,1	15,9	11,2	6,8	30,2
	Min.	-0,9	-1,8	-1,2	9,1	16,7	23,1	17,3	25	12,2	8,1	1,1	0,3	-1,8
	Average in 1981- 2010	0,3	0,5	3,6	11,8	18,6	24,3	26,5	25,2	19,8	12,8	6,3	1,7	12,7
	Anomali es	0,2	-0,1	-1,6	3,8	2,6	2,2	1,4	2,5	-2,2	-1,2	-0,4	1,2	0,7
Peshnoy	Average in 2021	2,3	1,8	1,6	8,0	17,4	22,6	22,7	22,1	12,7	6,7	3,1	2,1	10,3
	Max.	3,6	3,8	5,6	15,4	27,8	29,9	29,4	29,8	23,3	14,6	9,8	4,8	29,9
	Min.	0,9	0,2	0,5	1,2	4,2	12,2	10,2	7,2	2,3	1,4	1,7	0,8	0,2
	Average in 1981- 2010	0,8	0,9	1,9	9,2	16,9	22,5	24,7	23,1	17,1	9,8	3,6	1,2	11,0
	Anomali es	1,5	0,9	-0,3	-1,2	0,5	0,1	-2,0	-1,0	-4,4	-3,1	-0,5	0,9	-0,7

Table 3.3.1 – Average values, anomalies from the standard norm, maximum and minimum in the seawater temperature (°C) recorded in data on the Caspian Sea coasts in 2021

Table 3.3.2 – Absolute maximum/minimum of the monthly average seawater temperature (°C) recorded in the Caspian Sea region in 2021

Country/		Absolute	Previous	Absolute	Previous
the observation	Month	maximum of	maximum and	minimum of	minimum and
post	Different	2021	a year of its	2021	a year of its
	months		occurrence		occurrence

	for max and min!				
		Kaza	khstan		
Aktau		22,0 August	24,5	2,0 January	-0,7 (February
			(August 2006)		2012)
Fort Shevchenko		25,0 July	27,2 (July	0,5 January	-0,7 (January
			1998)		1977)
Kulaly Isl.		27,9 July	28,5 (July	0,4 February	-1,2 (January
			2018, 2019)		1999)
Peshnoy		22,7 July	27,3 (July	1,6 March	-0,2 (March
			1996)		1976)

Table 3.3.3 – Records of monthly maximum	m seawater temperature	(°C) in the Caspian Sea
region in 2021		

Country/	Date	Month	Seawater	Previous	Date of the					
the observation			temperature,	maximum, °C	previous maximum					
post			°C							
Kazakhstan										
Aktau	21	August	27,3	28,8	30.07.2000					
Fort Shevchenko	03	August	29,8	33,6	07.2005					
Kulaly Isl.	22	July	30,2	33,7	08.1977					
Peshnoy	17	June	29,9	35,5	03.08.2000					

Table 3.3.4 – Records of monthly	minimum seawater temp	perature (°C) in	the Caspian Sea
region in 2021			

Country/	Date	Month	Seawater	Previous	Date of the					
the observation			temperature,	maximum, °C	previous					
post			°C		maximum					
Kazakhstan										
Aktau	23	December	-2,0	-1,7	18.02.2012					
Fort Shevchenko	26	February	-0,6	-1,2	14.01.2003					
Kulaly Isl.	24	February	-1,8	-2,3	02.12.2002					
Peshnoy	24	February	0,2	-1,8	20.12.1990					

# **4. ICE CONDITIONS**

The winter of 2020-2021 in the Caspian Sea was moderate according to the sum of negative air temperatures in the cold half of the year and the spread of the ice edge. The stable ice cover was observed in the northern shallow part of the Caspian Sea.

According to the Peshnoy post data, the first ice was observed near the northern coast of the Caspian Sea since 20 November 2020, and the first ice fringe was formed, which was evenly distributed over the entire coast. A 3-ball ice foot was also formed in the area of the Kuryk post. On November 29, primary types of ice appeared (Figure 3, 4). The ice foot along the entire north-eastern coast of the sea was established in early December 2020. (Figure 5).

On 10 December 2020, drifting ice appeared in the middle part of the Caspian Sea, near Aktau post. On December 22, the ice thickness of 4 cm was recorded at the post. The maximum ice thickness was recorded off the north-eastern coast of the Northern Caspian Sea in January 2021: 36 cm at the Peshnoy post, and 43 cm at the Zhanbai post (Figure 6).

On February 2, 2021, gradual spring ice melting began in the Caspian Sea (Figure 7, 8). On March 25, 2021, the ice foot completely melted in the area around the Peshnoy post (Figure 9), and on March 30, 2021, the entire northern coastal area of the Caspian Sea was completely cleared from ice.



Fig. 3. The first ice near the northern coast of the Caspian Sea, November 20, 2020 (image by the "World View NASA" project)



Fig. 4. The beginning of the ice formation off the coast of the Northern Caspian. Satellite image of the Caspian Sea, November 29, 2020 (by the "World View NASA" project)



Fig. 5. Ice cover setting in the Northern Caspian, December 13, 2020 (Image by the "World View NASA" project)



Fig. 6. Ice situation in the Northern Caspian, December 25, 2020 (Image by the "World View NASA" project)



Fig. 7. The beginning of the spring melted ice cover of the Northern Caspian. Satellite image of the northern part of the Caspian Sea, February 2, 2021 (by the "World View NASA" project)



Fig. 8. Melted spring ice cover of the Northern Caspian. Satellite image of the northern part of the Caspian Sea, March 08, 2021 (by the "World View NASA" project)



Fig. 9. Complete purification of the Caspian Sea from ice. Satellite image of the northern part of the Caspian Sea, March 28, 2021 (by the "World View NASA" project)