

Lake brief Caspian Sea

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Caspian Sea is the largest closed water body on the Earth located between Europe and Asia and named sea because of its size. Geographical coordinates of extreme points of modern water area of the Caspian Sea (without Kara Bogaz Gol): N36°33'–47°07', E46°43'–54°03'. Caspian Sea is on the territory of five countries: Russia, Azerbaijan, Islamic Republic of Iran, Kazakhstan and Turkmenistan. By one of hypotheses Caspian Sea has received the name in honor of ancient tribes of horse-breeder – *Caspians*, lived B.C. at southwest coast of Caspian Sea.



Caspian Sea, though is continental water body, has oceanic origin: it is the rest of Paratethys – a gulf of ancient ocean Tethys. The bed of Caspian Sea it is formed by earth's crust of oceanic type. It is possible to explain salinity of waters by its origin from this ancient ocean. About 6 million years ago the Pontic Lake was divided into Upper Pontic Lake, occupied the Black Sea hollow, and completely isolated Babadjan Lake occupied only South-Caspian hollow. Since this time Caspian Sea exists as isolated basin. In the subsequent time Caspian Sea has gone through a number of transgressions and the regressions, accompanied by significant decrease or increase in its salinity, and about 5–7 thousand years ago modern Caspian Sea (Aladin, Plotnikov, 2000a) was formed.

Morphometric characteristics. Caspian Sea occupies large by area and deep continental depression, its modern level is varying about mark -27 – -28 m a.s.l. (Frolov, 2003; Bolgov, et al., 2007; Rumyantsev, Trapeznikov, 2008). Length of Caspian Sea from the north to the south is 1030 km (along meridian E50°00'), the greatest width reaches 435 km (by parallel N45°30'), the least width is 196 km (by parallel N40°30'). Relief of Caspian Sea coast is defined by character of orographical elements of land: in the north – Near-Caspian lowland, in the south – range Elburs, at the western coast mountains of the Big Caucasus with narrow coastal plain are close to the sea, in southwest – Kura and Lenkoran lowlands and foothills of Talyshs Mountains. East coast is framed by abrupt, low benches, and in its south by aeolian plain with sandy dunes. On the Caspian Sea there are about 50 islands of total area 2049 km². Length of Caspian Sea coastal line is about 6500–6700 km, with the islands – up to 7000 km. By features of morphological structure of hollow and physical-geographical conditions

Caspian Sea is divided to the Northern, Middle and Southern Caspian Sea and isolated gulf Kara Bogaz Gol (Caspian Sea, 1969; Caspian Sea ..., 1986). From these parts Caspian Sea *sensu stricta* are Middle and Southern, the Northern actually is extensive estuary of rivers running into it.

Morphometric characteristics of Caspian Sea considerably change depending on fluctuations of water level (Table 1). At water level -28 m a.s.l. the area is approximately 376300 km², water volume – 78081 km³. The maximal depth (the South-Caspian hollow) is 1025 m. Average depth of Caspian Sea makes 208 m. Northern part of Caspian Sea is shallow, its maximal depth does not exceed 25 m, and average depth is 4 m (Nikolaev, 1971; Caspian Sea ..., 1986). Average depth of Middle Caspian Sea is about 175 m; the greatest depth is 790 m. Average depth of Southern Caspian Sea is 300 m (Zonn, 2000, 2004).

At the east coast there is connected with the main water area by narrow (250–300 m wide) strait (5.5–11 km long) shallow hyperhaline gulf-lagoon Kara Bogaz Gol, which level is by some meters below the level of Caspian Sea. To the gulf there is constant drain, and water in it quickly evaporates. Prior to the beginning of 1930s the drain reached 20–25 km³/year, but to the middle of XX century because of falling level of Caspian Sea it has decreased to 10–15 km³. In 1980, in order to slow down Caspian Sea level fall, the gulf has been separated with a solid dam and for three years has dried up almost completely, having turned to huge saline desert. Closing of drain to Kara Bogaz Gol has led to serious negative consequences. Salt began to be carried by winds, salinizing environment and ground; chemistry of gulf was broken. In 1984 the water-carrying construction with the charge of water 1.5km³/year for restoration and preservations of surface brines, for weakening negative influence on environment and restoration of extraction of mineral salts has been constructed. In 1992, because the Caspian Sea level has begun to increase, the dam has been liquidated. By present time the gulf was completely restored.

Climate. Climate of Caspian Sea is continental in the northern part, moderated in the middle one and subtropical in the southern. During winter period the monthly average temperature of Caspian Sea changes from -8 – -10°C in the northern part up to +8 – +10°C in the southern part, during summer period – from +24 – +25°C in the northern part up to +26 – +27°C in the southern part. The maximal temperature is fixed at eastern coast – +44°C. The annual course of air humidity repeats annual course of air temperature. The least humidity of air is registered in January–February (in the northern part – 2-3 mm, in the southern – 6-7 mm), and the highest in July-August – 17-20 mm (Caspian Sea ..., 1986; Bolgov, et al., 2007).

Characteristics of thermal and ice regimes. The water temperature of Caspian Sea is subjected to significant latitudinal changes most clearly expressed during the winter period

when the temperature changes from 0–0.5°C at the edge of ice in the north of the sea up to 10–11°C in the south, that is the difference of temperature of water is about 10°C. For shallow areas the annual amplitude can reach 25–26°C. On the average, temperature of water at the western coast is by 1–2°C higher, than at east, and in the open sea water temperature is higher than at coasts by 2–4°C. In the middle of summer average water temperature in the Northern Caspian Sea is 24°C. On the Middle Caspian Sea in winter average temperature of surface water is only 6°C, and in summer it is up to 25°C. In the Southern Caspian Sea water temperature does not fall below 13°C in winter, and rises up to 25–30°C in summer. In shallow gulfs water temperature can reach 35–40°C.

On depth the constant temperature is supported. On depth more than 150 m it is 5–7°C, and on depth below 400–500 m it is 4.5–6°C. In shallow Northern Caspian Sea and gulf Kara Bogaz Gol temperature stratification is not observed.

Caspian Sea is partially freezing water body. Only Northern Caspian Sea freezes in winter. Freezing-over continues from November till March, thickness of ice is 60–90 cm. In the end of December ice covers all space. At this time temperature of subglacial water can fall up to -0.5°C. Squally winds break out ice, forming hummocks up to 12 meters high. In the end of March–April Northern Caspian Sea is entirely cleared from ice. In abnormal warm winters ice cover in Northern Caspian Sea can to be absent practically completely (Bolgov, et al., 2007; Caspian Sea ..., 1986).

In the Middle Caspian Sea circulation of waters caused mainly by river drain and dominating winds dominates is cyclonic. In Southern Caspian Sea cyclonic circulation also is observed, but is less precise expressed, and between Baku and mouth Kura River is complicated by local anticyclonic circulation. In Northern Caspian Sea unstable wind currents of various directions prevail. Here because of the seas shallowness at strong winds there are brightly expressed phenomena of negative and positive water setup. Frequent repeatability of moderate and strong winds causes large number of days with rough sea. The maximal observed height of waves is up to 11 m. From November till March roughness over all water area reaches 6 points. The quietest period is the end of spring and the first half of summer (Caspian Sea, 1969; Kosarev, etc., 2000).

Table 1. Mid-annual components of Caspian Sea water balance (by: Nikonova and Bortnik, 1994).

Period and its length (years)	Average level for period,	Average area for period, thousands	Income part, km ³ /year			Outcome part, km ³ /year		Final balance		Level change for period	
			Riverine	Underground	Precipitations	Evaporation	Ourflow to	km ³ /year	cm/year	Calculated	Observed

	m a.s.l.	km ²	flow	waters			Kara Bogaz Gol			by balance	
1900- 1929 (30)	-26.0	403	332.4	5.5	69.8	389.4	21.8	-3.5	-1.0	-30	-31
1930- 1941 (12)	-26.8	393	268.6	5.5	72.9	394.8	12.4	-60.2	-15.4	-185	-196
1942- 1969 (28)	-28.2	370	285.4	4.0	74.1	356.3	10.6	-3.4	-0.9	-25	-68
1970- 1977 (8)	-28.7	361	240.5	4.0	87.6	374.9	7.1	-49.9	-13.8	-110	-49
1978- 1995 (18)	-27.8	379	315.0	4.0	86.1	348.7	8.6	47.8	13.6	245	235

Characteristics of water regime and water balance. 130 rivers run into Caspian Sea, 9 from them have mouths of deltaic type. The largest rivers are: Volga, Terek, Sulak, Ural, Emba (it now reaches Caspian Sea only in abundance with water years), the Kura, Samur, Atrek and Sefidrud. Catchment area of Caspian Sea (Fig. 12) is about 3.5 million km². The water balance of Caspian Sea is defined mainly by river drain and precipitations (income part), evaporation and outflow of water to Kara Bogaz Gol (outcome part). The drain of ground and underground waters to Caspian Sea is insignificant. Crucial importance in income part of water balance has the drain of Volga giving almost of 80% of inflow of river waters to the sea. Income part is almost completely counterbalanced by evaporation, by 5 times exceeding size of precipitations, the drain to Kara Bogaz Gol makes only 5% (Caspian Sea ..., 1986).

The level of Caspian Sea is changeable. Regular supervision over it are conducted since 1837. The highest for the period of instrumental observations level have been registered in 1896 – about -25 m a.s.l. Up to 1917 relative stability was observed. Since 1917, a level began to fall, and from -25.82 m a.s.l. to 1925 it has lowered up to -26.26 m. To 1930 it has raised a little up to 26.06 m a.s.l. Then slow downturn of level has begun, and from 1933 it became fast. In 1941 level has reached -27.88 m a.s.l. Also it was again stabilized at -27.96 m a.s.l. In 1949 falling of level has renewed and continued up to 1977 having reached mark -29.03 m a.s.l. From 1978 fast rise of level has begun. In 1995 at mark -26.61 m a.s.l. level was stabilized, but further it began to decrease slowly, having lowered to 2002 up to -27.15 m a.s.l. (Mihailov, et al., 1998; Mihailov, Povalishnikova, 1998). Changes of river drain and visible evaporation (Tab. 1) are considered as the principal cause of Caspian Sea level changes, and also geological, climatic and anthropogenous factors (Mihailov, et al., 1998, 2007; Frolov, 2003; Bolgov, et al., 2007).

Fast rise of Caspian Sea level has caused significant damage to economy. In the zone of flooding there were significant territories, especially in the flat part of Dagestan, in Kalmykia and Astrakhan region. The cities of Derbent, Kaspiysk, Makhachkala, Sulak and tens smaller

settlements have suffered. Agricultural lands have been flooded; roads and electric mains, engineering constructions are destroyed. Plenty of polluting substances has got to the sea. Special harm to biodiversity was brought with flooding coastal objects of oil excavation and transportation. Fish rearing station became menaced. Abrasion processes in coastal zone and influence of sea water positive setup have amplified. Last years the damage to flora and fauna of beach and coastal zone of delta of Volga began to be felt. On the other hand, rise of the level has improved conditions fishes pasturing, area spawning grounds has increased, and freshened buffer zone has expanded and promoted increase of potential productivity of Northern Caspian Sea.

Hydrochemistry. Vertical moving of water masses of Caspian Sea is also well expressed, as well as horizontal. Owing to it deep waters are rich with the dissolved oxygen. Even in depths of Southern Caspian Sea concentration of oxygen makes 2 ml/l. On the surface in summer the quantity of oxygen is close to saturation, and in the winter oversaturation is up to 103-105%.

Waters of Caspian Sea have high transparency. In Southern Caspian Sea it reaches 15-20 m. On the average Caspian Sea transparency is little lower – all the year it is about 10 m, and only in summer it can reach 15 m. In Northern Caspian Sea because of shallowness and brought by the rivers suspensions transparency is about 1 m, and up to 7-8 m at significant distance from deltas.

Average salinity of Caspian Sea waters is 12.7-12.8‰, maximal (not including gulf Kara Bogaz Gol) at the east coast is up to 13.2‰, minimal in the northwest – 1-2‰. Fluctuations of salinity over the sea by vertical and by time are insignificant, and only in the north they are more appreciable in connection with fluctuations of drain of Volga. The Caspian Sea water is rather poor with ions of sodium and chlorine and is richer with ions of calcium, magnesium and sulfates owing to old isolation from the World Ocean, and metamorphization under influence of riverine drain (Caspian Sea ..., 1986; Pahomova, Zatuchnaya, 1966).

The lowest concentration of salts is observed in Northern Caspian Sea – on the average 5-10‰. Near to deltas of Volga, Ural and Terek, salinity is up to 2-4‰. Directly in avandeltas of these rivers salinity is less than 0.5‰. In shallow water areas of east coast of Northern Caspian Sea water salinity be above the average. In shallow gulfs water salinity can reach 30‰ and higher. Salinity of Middle Caspian Sea is 12.7‰. It is lowered at Sulak delta, and at the east coast salinity of surface water can raise up to 13.0-13.2‰. Salinity of Southern Caspian Sea is 13‰. Near mouths of rivers it is lowered. At the eastern and southern coasts it can be observed salinity a little above the average. Salinity increases with depth a little in the open parts of Caspian Sea.

The highest salinity is in gulf Kara Bogaz Gol. Vaporability from its surface is 1500 mm/year, at quantity of precipitations up to 70 mm/year. It is the huge evaporator, and salinity of its waters is 300-350‰ and more. The Caspian Sea water brings in the gulf about 130-150 million tons of salts, that is by 10 times more, than all Caspian Sea receives them. It is possible to tell that Kara Bogaz Gol plays a role of a desalter. At the bottom of gulf owing to evaporation and natural sedimentation the huge amount of salts is being accumulated.

Main biological features. Biodiversity of Caspian Sea is by 2.5 times poorer than biodiversity of Black Sea or by 5 times is poorer than in Barents Sea (Zenkevich, 1963). For true fresh-water fauna and flora salinity is too high, and for true marine species it is low. By origin modern fauna is mainly of Neogene age. The recent biodiversity of Caspian Sea reflects complex history of paleocaspian transgressions and regressions and connected with their refreshing and salinization.

In Caspian Sea there are living more than 500 species of plants and 854 species of fishes and animals, various by origin. Speciation in the Caspian Sea has created the general high level of endemism (approximately 42-46%).

Phytoplankton of Northern Caspian Sea is qualified as estuary, and in phytoplankton of Middle and Southern Caspian Sea euryhaline marine neretic and brackish-water species prevail. From plants in Caspian Sea cyanobacteria and diatoms (*Chaetoceros wighamii* and *Rhizosolenia calcar-avis*) prevail. Among recent invaders there are many red and brown algae. From phanerogams *Zostera* and *Ruppia* are the most widespread. Charophytes give the largest biomass. Production of phytoplankton in the shallow areas of Northern Caspian Sea does not depend on size of drain of phosphates and is oppressed during great high waters. In deeper parts of Northern Caspian Sea primary production of phytoplankton depends on the phosphates coming during high water with drain of Volga. Primary production of phytoplankton in the Middle and Southern Caspian Sea is expressed by close sizes and is commensurable with production in Northern Caspian Sea. Bacterial flora of water and ground has the greatest development in areas of sea and riverine waters meeting.

The species structure of zooplankton of Caspian Sea proper without strongly freshened water areas near deltas is poor. In total 18 species of copepods and 24 species of cladocerans, 32 species of rotifers and 5 species of infusorians are described. Among copepods *Eurytemora grimmeri*, *E. minor*, *Acartia tonsa*, *Calanipeda aquaedulcis*, *Limnocalanus grimaldii* dominate. The greatest number of species is among cladocerans presented by endemic for Caspian fauna families Podonidae and Cercopagidae. Among them *Podon polyphemoides*, *Podonevadne trigona*, *P. camptonyx*, *Evadne anonyx*, etc are met more often. During period of reproduction

meroplankton, presented mainly by larvae of bivalve mollusks and crustaceans, brings contribution to the biodiversity.

In total for today zoobenthos of Caspian Sea is presented by 379 species. The greatest number of species belongs to foraminiferans (13), turbellarians (25), nematode (52), ostracods (23), mysids (20), cumaceans (18), amphipods (73), bivalves (25) and gastropods (81). Characteristic feature of bottom fauna is its high endemism and prevalence of species of autochthonic Caspian complex. Mollusks *Dreissena* spp., *Pyrguila* spp., aboriginal polychaetes, cumaceans, etc. belong to them. Number of Mediterranean species has got independently or has been introduced by men: mollusks *Mytilaster lineatus*, *Cerastoderma* sp., *Syndosmia segmentum*, polychaete *Hediste diversicolor*, crustaceans – shrimps (Palaemonidae), crab *Rhithropanopeus harrisi*, sea acorn (*Balanus* sp.), 2 species of bryozoans and others. A number of generatively fresh-water species has got into periods of Caspian Sea freshening also. In postglacial time a number of the Arctic species penetrated from northern seas.

In the Caspian Sea 101 species of fishes are registered. Among fishes 5 species of sturgeons, shads, sprats, gobies and tadpole-gobies are autochthones. Also there are Mediterranean and Arctic invaders. There is a lot of species of fishes of fresh-water origin. Some of them have been introduced by man intentionally.

From sea mammals endemic Caspian Seal *Phoca caspica* lives in Caspian Sea.

As a result of falling sea level, regulation of drain of rivers Volga, Kura and Araks, conditions for reproduction of diadromous and semi-anadromous fishes have worsened, and their number and catches were reduced.

In XX century invaders has got into Caspian Sea from other seas as intentionally or in passing as a result of deliberate acclimatization of economic valuable species of fishes, and casually: with ballast waters or from biofouling on the bottoms of vessels. It creates a problem of such invasive species which are capable to break seriously biological balance which has developed in the ecosystem of water body. So, *Mytilaster* has superseded *Dreissena*. Recently to Caspian Sea has been brought ctenophore *Mnemiopsis leidyi*. This invader actively eats away zooplankton and dooms on starvation plankton-eating fishes from whom the sprat not only itself is object of fishery, but plays important role as food object of predatory fishes and seal (Aladin, Plotnikov, 2000b, 2004).

Economic characteristics of anthropogenous activity in the basin. Economy of Caspian Sea is connected with oil and gas recovery, navigation, fishery, extraction of seafoods, and also various salts and minerals (having filled in Kara Bogaz Gol) and use of recreational resources.

In Caspian Sea in escalating volumes oil and gas recovery is carried out. The proved resources of oil in Caspian Sea make about 10 billion tons; the general resources of oil and gas condensate are estimated as 18-20 billion tons.

Fish stocks of Caspian Sea are estimated very highly. Caspian Sea is capable to give annually up to 500-550 thousand tons of a fish if not to ally overfishing.

Recreational resources of the Caspian coast are presented by sandy beaches, mineral waters and medical dirts.

Main problems connected with anthropogenous activity. Now ecological state of Caspian Sea is in very complex condition.

The rivers bring to Caspian Sea pollution from the huge catchment is subjected to strong anthropogenous influence. For example, according to last data, by means of the rivers to Caspian Sea 75 million tons of mineral oil annually income, from them 95% is from Volga. Isolation makes ecosystem of Caspian Sea as closed lake especially vulnerable to various kinds of pollutants, remaining in its boundaries. Thus, Caspian Sea accumulates in itself all harmful substances coming into it. Such pollutants as oil hydrocarbons, which average concentration here exceeds norm for used for fishery water bodies by 1.5-2 times, are in the lead. In some water areas, first of all in the places of extraction and transportation of oil, pollution can be catastrophic. So, coastal water area from Sumgait up to Kura has completely lost value for fishery. Despite of catastrophic local pollution, waters of Caspian Sea as a whole are polluted while poorly, owing to high speed of processes of autopurification (Aladin, Plotnikov, 2000b).

Because of absence of the uniform agreement on protection of the sea among the near-Caspian countries, catastrophic growth of poaching takes place. Injurious catching of sturgeons has led to impossibility to provide fish-breeding factories with necessary number of spawners necessary for artificial reproduction of sturgeon fishes, now unable to support the number. If in 1984 in Caspian Sea 25.7 thousand tons of sturgeon fishes were got, already to 1994 their catching was reduced up to 6.8 thousand tons, and it continues to decrease. Now existence of herds of sturgeon fishes in Caspian Sea is under threat (Aladin, Plotnikov, 2000b).