Introduction

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Abstract This book presents a systematization and description of the knowledge accumulated to date on the physical oceanography, marine chemistry, and marine biology of the Aral Sea. A special attention is paid to satellite monitoring of the state and different natural parameters of the Aral Sea and its surroundings. Reasons for the progressing environmental crisis and present socio-economic problems in the Aral Sea region are highlighted. The publication is based on numerous observational data, collected by the authors of the chapters during sea and shore expeditions, on the archive data of Moscow State University, P.P. Shirshov Institute of Oceanology, and the Hydropject Institute (Moscow, Russia), as well as on a wide scientific literature mainly published in Russian editions. These data are complemented by the results of a series of Russian national and international projects, where an extensive research of the Aral Sea was carried out over the past decade. This book is addressed to the specialists working in various fields of physical oceanography, marine chemistry, biology, and environmental problems.

Keywords Amudarya, Aral Sea, Environmental crisis, Syrdarya

Before 1960 the Aral Sea (Fig. 1) was a water-abundant sea-lake that was fourth largest in the world list of lakes after the Caspian Sea (USSR, Iran), Great Lakes (USA, Canada), and Victoria Lake in Africa. This was a real “pearl” among the sands of the largest deserts – Karakums and Kyzylkums. Navigation between the...
sea ports Muinak and Aralsk and the fishery – the famous Aral bream, barbell, sturgeon, *Chalkalburnus* and others – were developed here. One could find beautiful recreational zones and beaches here. The deltas of the Amudarya, the major river of Central Asia, and Syrdarya bringing their waters into the Aral Sea were famous for their biodiversity, fishery, muskrat rearing, and reed production. The local population found occupation in the spheres related to the water infrastructure.

This was a natural and stable period of the Aral Sea evolution that since 1960 was followed by the anthropogenic one, which continues till the present day. This land-locked water body existed almost thanks to runoff from the two main rivers of Central Asia – Amudarya and Syrdarya. But since 1960 riverine water resources have been irrationally used for increasing irrigation of agricultural lands and creation of artificial water reservoirs. As a result the Aral Sea water balance was disrupted and irreversible alterations in the sea regime appeared that later escalated into one of the “largest ecological disasters of the twentieth century.” During the last 50 years we have observed a progressive degradation of the Aral Sea and its environment. During this time period the sea shrunk in size from 66,100 km$^2$ (in 1961) to 10,400 km$^2$ (in 2008), its volume decreased from 1,066 to 110 km$^3$. 

![Fig. 1 A map of Central Asia](http://www.lib.utexas.edu/maps/commonwealth/cis_central_asia_pol_95.jpg)
the sea level dropped by 24 m, and its salinity (mineralization) rose from 10 to 116 ppt and about 160 ppt in the western and eastern Large Aral Sea, respectively. The decrease in area of the Large Sea occurred mainly through its shallow eastern part, the area of which in 2008 (3,200 km²) became for the first time less than that of the western part (4,000 km²) (Fig. 2). The ongoing desiccation, shallowing, and salinization of the Aral Sea have resulted in profound changes in its physical, chemical, and biological regime.

Today at the location of the former Aral Sea there are three remnant water bodies: the Small Aral Sea, Western Large Aral Sea, and Eastern Large Aral Sea (see Fig. 2). In June 2009 the Western and Eastern Large Aral Sea were still connected by a small, shallow, and narrow channel in the northern part of both basins (Fig. 3). The Aral Sea lost its economic importance, and the aftermath of its degradation represents a serious threat to the local population due to a lack of fresh water, water quality loss, salinization of soils, dust and salt storms, climate deterioration, various diseases, etc.

By the mid-1980s the Aral crisis had been acknowledged by the whole world and became one of the most significant environment protection issues. The Aral problem is not global, but nevertheless it stirs global interest. For many years it was used by the scientific and civil societies to stress how quickly man’s activities may cause degradation of vast expanses on our planet.

Fig. 2 Satellite image of the Aral Sea from MODIS-Terra on 18 August 2008 adapted from http://earthobservatory.nasa.gov/Features/WorldOfChange/aral_sea.php
In Soviet times the Aral Sea was regularly monitored and investigated: about ten hydrometeorological stations operated on the coasts and islands of the sea, there were regular hydrological and biological observations in the sea in different seasons, as well as geological and geophysical research in the Aral Sea region. A huge data set on the environmental conditions of the sea was collected.

The number of investigations and publications devoted to the Aral Sea problem is enormous. Some of the monographs are listed in the references in chronological order [1–54]. Only in the 1980–1990s it was about 1,000 scientific papers and books, and more than two-thirds of them were published in the late 1990s. Their greater part was collected by J.C.J. Nihoul, A.N. Kosarev, A.G. Kostianoy, and I.S. Zonn and included into the book “The Aral Sea: Selected Bibliography” (2002) [44]. Most of these papers were published in Russian.

Fig. 3 Satellite image of the Aral Sea from MODIS-Aqua on 23 June 2009. Image courtesy of D.M. Soloviev, Marine Hydrophysical Institute, Sevastopol, Ukraine
The Aral Sea crisis redoubled when after disintegration of the USSR in 1990–1991 the investigations and monitoring of the sea practically ceased. Almost all hydrometeorological stations have been closed, sea expeditions stopped, and assessment of ongoing quick changes in the Aral Sea environment have ceased. At the same time the interest in the Aral Sea problem has risen sharply on the international level. Under the auspices of a number of international organizations and funds a set of important projects on different aspects of the Aral Sea problem have been funded [53, 54].

Many UN organizations (UN University, UNDP, UNESCO, UNEP, UNIDO, FAO, WMO, UN High Commissioner for Refugees, and the International Labor Organization); financial organizations (World Bank, Asian Development Bank, European Bank for Reconstruction and Development, International Monetary Fund, Global Environment Facility); European Union Programs (TACIS, INTAS, INCO-Copernicus, OSCE, TEMPUS); international nongovernmental organizations (“Doctors Without Borders”); regional organizations (International Fund for Saving of the Aral Sea, Interstate Coordination Water Commission, Commission on Sustainable Development, Central Asian Economic Community); and bilateral organizations (US Agency for International Development, Soros Foundation (USA), Konrad Adenauer Foundation, Friedrich Ebert Foundation, Germany Agency for Technical Cooperation (Germany), NOVIB (the Netherlands), NATO Program “Science for Peace,” JAIKA, Global Infrastructure Fund Research Foundation (Japan), and others) were involved in the implementation of many hundreds of projects. Apart from these organizations, experts, consultants, scientists, academicians, and others from more than 30 countries took part in the study and preparation of project proposals on the Aral problems. Needless to say, from 2000 more than 30 international projects devoted to various aspects of problems in the Aral Region were elaborated within the framework of the International Programs INTAS and INCO-Copernicus. Dozens of Eastern-European, Russian, and Central Asian institutions and laboratories were also involved in comprehensive investigations. And, of course, ministries, local authorities, institutes of the Academy of Sciences, and national nongovernmental organizations of all Central Asian countries participated in this international cooperation.

The International Fund for Saving the Aral Sea (IFAS) plays a very important role in the international cooperation. IFAS is an interstate organization established in 1993 by the heads of Central Asian states – Uzbekistan, Turkmenistan, Tajikistan, Kazakhstan, and Kyrgyzstan. In 1997, after merging with the Interstate Council for the Aral Sea, the final organizational structure of IFAS was shaped. The main tasks of IFAS are raising funds in the five Central Asian states and through international donors to financially support the Aral Basin Program; implementing joint environmental and research-practical projects on saving the sea and on environmental improvements in the regions affected by the Aral disaster; financing joint fundamental and applied investigations and research-technical developments on restoration of the environment balance; and rational management of natural resources and environmental protection. In December 2008 IFAS received observer
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