Feature

The shrinkage of the Aral Sea ranks as one of the world's greatest man-made environmental disasters. While there is some hope for a separated northern part, the main sea is doomed

The demise of the Aral Sea – an environmental disaster

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Tucked away in the geographical heart of Asia, the Aral Sea lies in a sparsely populated desert. It is a closed sea at the low point of a basin that was once all within the USSR but is now split between five new republics, and the Aral itself is shared by Kazakhstan and Uzbekistan (Fig. 1).

Annual rainfall in the desert is less than 90 mm, but water is fed in from mountain ranges around the south-eastern fringe of the basin. There are three great river systems. The Syrdarya rises in the Tien Shan of Kyrgyzstan and flows into the northern end of the Aral Sea. The Amudarya (the Oxus of ancient times) rises in the Pamir Mountains of Tajikistan and Afghanistan and flows into the southern end of the Aral Sea. Terraces on isolated hills around the Aral mark higher water levels in wetter times of the Pleistocene and Holocene. Variations in level relate to global climatic patterns. During four wet phases that existed for about half of the last 5000 years, overflow from the Sea and directly from the Amudarya flowed west along the Uzboi channel into the Caspian. Even though the Caspian is 75 m below the Aral, this route across an empty desert is now dry.

The third and perhaps the most valuable river in the basin is the Zeravshan, which rises in the lesser ranges of the Alau and flows west to water Samarkand and Bukhara. Though a prehistoric tributary of the Amudarya, it no longer reaches that river but dies in a swathe of wetlands – a desert resource which fed the medieval might of the Bukhara khanate, with its capital in their midst.

West of Bukhara, the Aral basin is seriously dry. Temperatures reach over 45 °C in summer and fall far below freezing in winter. The Black Desert (Karakum) and the Red Desert (Kyzylkum) lie either side of a narrow belt of watered land along the Amudarya. A similar belt of usable land follows the Syrdarya, where old ox-bows and meander scrolls identify the floodplain alluvium (Fig. 2), with dry sand, rock and loess just beyond.

As it is a closed body, the level and extent of the Aral Sea has always fluctuated in response to the flows of its only two input rivers, both of which were dominated by huge spring flows of meltwater from the snowfields and glaciers of their headwater mountains. But nature achieved a mean level at about 53 m above sea level, with an area of about

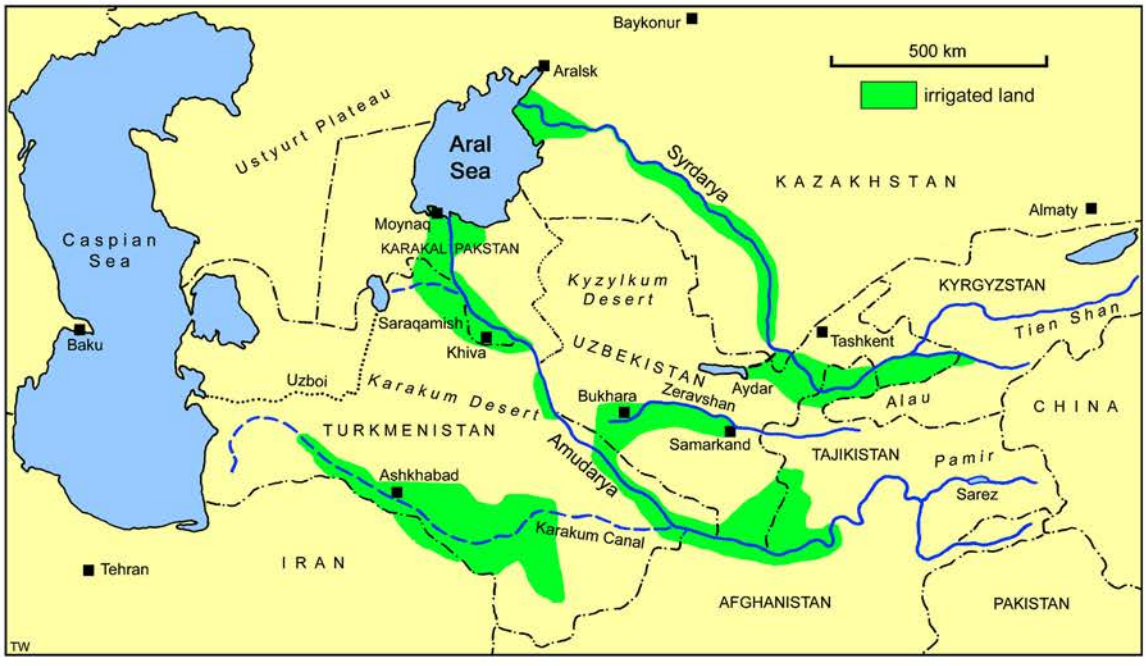

Fig. 1. The geography and politics of the Aral Sea basin. The extent of the irrigated lands is as they are today, but the Aral Sea is drawn at the size it was in 1960. Karakalpakstan is a province within Uzbekistan.

Fig. 2. Old meander loops of the Syrdarya are overprinted with a square grid of cotton fields 200 km north of Tashkent. The river is in the dark wetlands on the left, and desert encroaches on the right.

67 000 km². This was in equilibrium with rivers that yielded only about half their total resources into the Aral (Table 1). The rest was lost to evaporation and to modest irrigation schemes that the local people had found to be sustainable over the centuries.

The salinity of the Aral was only 1% (about a quarter that of sea water). This was something of an enigma in a closed lake system, where simple inflow of salts in the two rivers would have achieved that level in just 320 years. But the Aral Sea was also losing salt. At times of falling sea level, salt was precipitated in shallow bays and then blown away on the wind as the salt floors were exposed. Then in wetter phases, overflows carried salt out towards the Caspian. The Aral was almost a freshwater lake.

Fig. 3. A cotton field in Uzbekistan. This old postcard dates from the 1932, when the cotton was sustainable and the Aral Sea could survive.

Table 1 The rivers that feed the Aral Sea

River	Length (km)	Catchment (km²)	Total flow (km³/year)	Flow into Aral (km³/year)
Syrdarya	1370	440 000	40	15
Amudarya	1580	1100 000	78	40

Under these conditions, the Aral Sea was a viable part of central Asian life. The Amudarya delta was a splendid wetland with reed beds and beautiful lakes rich in wildlife. On the open sea, fleets of 500-tonne trawlers harvested over 40 000 tonnes of fish every year. Huge ferries took all day to cross the 400 km between Moynaq and Aralsk, the two main fishing ports, which were also beach holiday resorts. But all this is in the past, because mankind has reduced the Aral Sea to a pale shadow of its former self.

Soviet cotton

Central Asia, along with the Aral Sea, was annexed by Tsarist Russia during the 1800s. As far back as 1908, plans were laid for a massive cotton industry in these southern deserts of the empire (Fig. 3). Irrigation water would be taken from the two big rivers – and the Aral Sea was already regarded as expendable.

Soviet central planning moved only slowly and development of the major schemes started in the 1950s, but then the scale was massive. By 1988 there were 700 000 km of irrigation canals, all taking water from the Amudarya and the Syrdarya. There was even a canal into the Bukhara basin. In 1900 there had been 20 000 km² of irrigated land in the region. By 1960 this had crept up to a sustainable 40 000 km², but by 1980 it had exploded to over 70 000 km². All the flatlands were wall-to-wall cotton fields, and cotton is a seriously thirsty crop, so huge amounts of water were spread over the desert. Canals leaked water and more seriously lost far too much water by evaporation from their open channels. The poorly managed and very wasteful schemes grew less and less efficient as poorer land was dragged into irrigation.

The largest single feature is the Karakum Canal. Started in 1954, and still being extended when the money ran out in the 1980s, this reaches 1370 km into the Turkmenistan desert (Fig. 1). It takes 12.9 km³ of water each year to irrigate 9000 km² of cotton fields, with any left over just pouring away into the Caspian. The cotton fields in this scheme are so vast that they need 24-h irrigation to give time for the water to reach their far ends. Efficient night-time irrigation, with minimal evaporation losses, is just not possible. Basic control is barely possible. Some fields are waterlogged, and have reduced crop yields. Others are poisoned with salt or have their soil scoured by erosion. Up to 400 km² of arable land are abandoned each year in the face of rampant soil degradation.

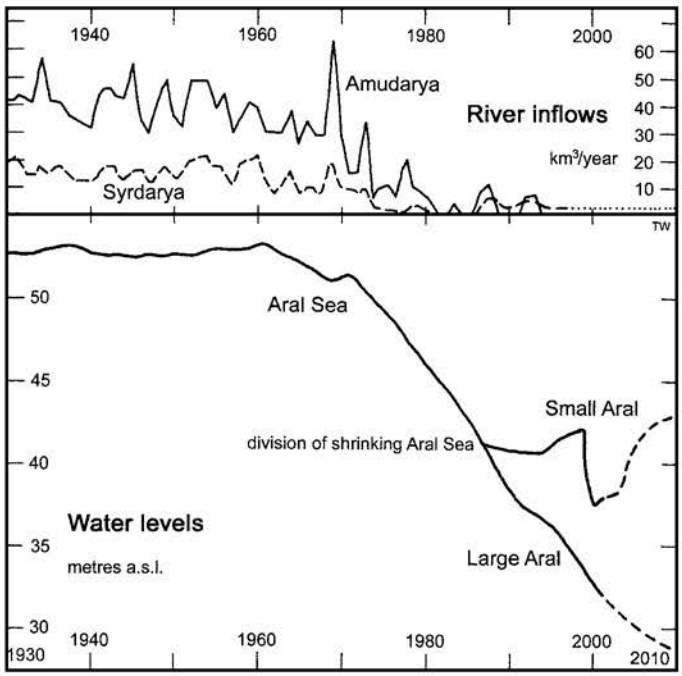

Fig. 4. The fall in water level of the Aral Sea correlated with the falling inflows of its two feeder rivers from 1930 until today, with estimates until 2010. The Aral split into two in 1987. Inflows are approximate after 1990.

Table 2. Dimensions of the Aral Sea over 50 years of decline. The figures for 2010 are the best current estimates, and by then the Large Aral will be in two separate parts.

Year	Sea	Level (m)	Area (km²)	Salinity (%)
1960	Aral Sea	53.4	67 000	1
1971	Aral Sea	51.1	60 000	1
1982	Aral Sea	44.8	51 000	2
1994	Large Aral	36.8	29 000	4
	Small Aral	40.8	3000	3
2001	Large Aral	32.0	20 000	6
	Small Aral	38.0	3000	2
2010?	Large Aral	29.0	7000	8
	Small Aral	43.0	3500	1

All the irrigation water comes from the Amudarya and the Syrdarya. A total of 90 km³/year are now extracted. With natural evaporation losses, both rivers can run dry, and there is often no water left to flow into the Aral Sea. The result is the steady shrinkage of the Aral Sea, entirely due to human interference with a naturally balanced ecosystem. Moscow's politicians and planners carried on expanding the cotton fields until they lost control around 1985. They ignored the Aral Sea's demise, because they were relying on eventual remedy to be provided by diverting water from Siberia's rivers into the Aral basin instead of the Arctic Ocean. Plans for this even greater environmental bombshell were only abandoned in the 1980s. But by then the Aral Sea was doomed, and it was already half-dead.

The shrinking sea

As the irrigation canals were opened up in the 1960s, the flows of the two rivers into the Aral Sea went into major decline. The direct effect was that the Aral Sea went into a matching decline, slowly from 1960 and then more rapidly after 1970 (Fig. 4). In 1960, the two rivers poured 55 km³ of water into the Aral Sea. In 1982 they contributed none; and modest inputs were achieved in only the wetter of subsequent years. Annual flows into the rivers from

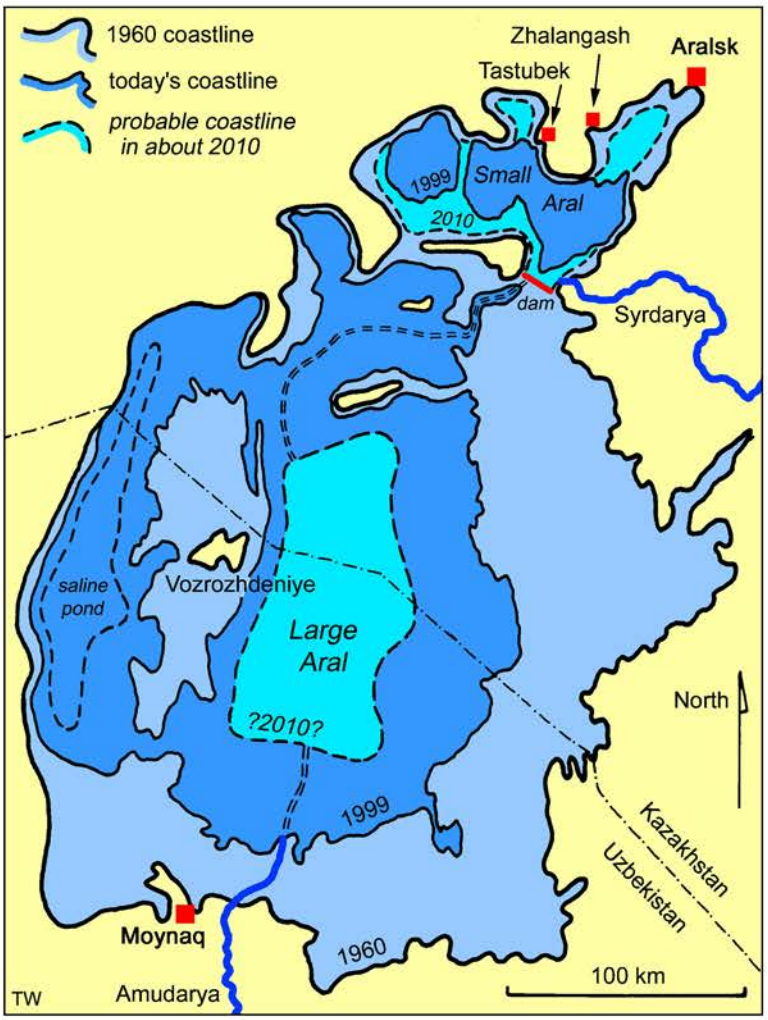

Fig. 5. Map of the Aral Sea, with its original (pre-1960) coastline, its present extent (mapped in 1999) and the likely future extent of its three separate seas.

Fig. 6. Once a ferry route, now a car track across the old floor of the Aral Sea.

their mountain catchments fluctuated with heavy and light winter snowpacks, but there was no overall decline through the period of monitoring, 1920–1990. The reduction of water flows into the Aral Sea was entirely due to the massive abstractions for cotton irrigation.

With its inflow curtailed, the level of the Aral Sea fell by more than 20 m over a period of 40 years (Table 2), while its volume shrank to just one fifth of its natural state. The most visible impact was the shrinkage of the area of the sea (Fig. 5). Most of the sea was only ever shallow, so the falling level created some massive retreats. Parts of the east coast have receded by 75 km. In 1987 the Aral Sea split into two as its falling level exposed new dry land. The Small Aral (Maloe More) took most of the remaining flow from the Syrdarya and has continued to decline at lower rates. But the Large Aral (Bolshoe More) loses more to evaporation, and its level continues to fall unabated. It won temporary respite in 1989 when the Small Aral overflowed into it, and again in the early 1990s when heavy snows in the Pamirs fed some modest inflows through the Amudarya. But sometime in the near future, a shrinking Large Aral will divide yet again.

The scale of water mismanagement in the Aral basin seems to know no bounds. Excess water in the irrigation channels of the Khiva basin flows not back into the Amudarya but into the Daryalyk Canal, which leads into the westbound channel of the old river. In 1963 this poured into the dry Saraqamish depression (Fig. 1). At first, the water cascaded underground to fill up caves in the limestone, but then a new lake was created. With renewed inflows in the 1980s, the lake now has an area of over 2500 km^2, and supports its own fishing industry. This was matched on the Syrdarya in 1969, when spring floodwaters were taken off at a control dam and fed west into the Kyzyylkum desert to create the Aydar Lakes, which now cover 2300 km^2 (Fig. 1). Two new lakes, but at the expense of the Aral Sea.

Not only was the Aral Sea shrinking, it was dying. The Amudarya delta wetlands dried up with the loss of its famous reedbeds. The delta industry of hunting muskrats was decimated. The ferries stopped running in the 1970s with the loss of navigable channels. Fishery catches withered to zero by 1980, and the last indigenous fish species died out around 1985. Perhaps most importantly, the Aral Sea ceased to be a climatic stabilizer. Its open water had underpinned a stable block of moist air. When this was lost, winds from the north swept across unabated, and the southern deserts became hotter in summer and colder in winter.

Where the salinity of the Aral Sea was once a healthy 1%, it is now an almost uninhabitable 6% in the Large Aral. Over 40 000 km^2 of the original sea floor are now exposed. Most is dry mud flats that any geologist would recognize as a playa floor (Fig. 6). This dry mud is heavy with salt, and is also enriched with a cocktail of chemicals, including toxic pesticides that have been washed out of the irrigated soils. Ironically, these were brought into the basin in response to declining crop yields caused by the initial salinization of the soil; and DDT was used widely until 1982. Now this dust–salt–chemical mix is exposed to the wind, and each year more than 20 million tonnes of it are picked up and blown around the basin, with much falling back to contaminate the land further.

Contaminated soil and water have now produced a massive health problem among the people condemned to remain in the dying towns and villages. Two-thirds of the people now suffer ill health. Hepatitis is rampant in Khiva, Moynak is afflicted with anaemia and birth deformities, Aralsk has an

epidemic of TB. This environmental disaster knows no bounds.

The Large Aral today

Although it sits astride the border, the Large Aral is largely the problem of Uzbekistan, which has the Amudarya that should feed it and also has the populated old delta lands around the southern end. Few people live on the Kazakh shores of the Large Aral.

Yet the largest single take from the Amudarya is by Turkmenistan, into its own Karakum Canal. This water has to be kept flowing, because more than two million people live in and depend on the land irrigated by it. The canal infrastructure is simply falling apart through lack of maintenance and control since the collapse of the Soviet economy. Distribution canals leak, crops are swamped, yields fall, water is wasted. The canal is so long that it takes 30 days for water to travel down it. This would demand efficient planning and control to ensure water was supplied only when it was needed. But there is no overall monitoring and far too few control gates. So the canal is always at full capacity. The workforce finds that the easiest way to eliminate periodic shortages, and they have no concern for the water that is wasted by over-irrigation or as spare runoff to the Caspian.

Research on the Aral Sea has been ongoing since 1986. Two years later, Moscow resolved to halt the decline of the Sea (but not reverse it), but even these plans were not realized through the Soviet collapse. Uzbekistan inherited the problem in 1991 and brought it to international recognition. There have been scientific conferences and political good words, but very little action.

Cotton is among the world's most thirsty crops; it uses twice the amount of water for an equal cash value of wheat or rice, and 10 times the amount for potatoes or sugar. But Uzbekistan cannot afford to change its main cash crop when there is no practicable means for mass export of perishable food crops. Cotton is easier, and the current plans are to expand the cotton fields! The irrigation is inefficient, but there is no real incentive to clean up and control the disintegrating canals (Fig. 7). Meanwhile, the largest water user is the Karakum Canal – owned by Turkmenistan, which has no interest in the Aral Sea. Sadly, the political problems run deeper. The Aral Sea wetlands, which are suffering the most, are in Karakalpakstan, a subdivision of Uzbekistan with a different indigenous population. and the controlling Uzbeks have far more concern for their own cotton industry than they have for the entire existence of the Karakalpaks.

Positive change appears as only chinks of enlightenment. The World Bank has an expensive scheme to clean up the Amudarya delta wetlands, but the wildlife has already disappeared. A UNESCO–German-funded project aims to increase farming and irrigation efficiency in the Khiva basin (Fig. 1), but this only starts in 2002 and affects only a tiny part of the region. Prospects for the Large Aral do not look good.

Fig. 8. Ships in the desert – the view from the seafront at Aralsk.

Fig. 7. A new destination for the Aral water – an old inefficient canal in the Amudarya basin.

Fig. 9. A street in Aralsk swept by dust from the exposed floor of the Aral Sea.

Fig. 10. The ships' graveyard at Zhalangash.

The Small Aral today

Lying entirely in Kazakhstan, along with most of its Syrdarya feeder, the Small Aral Sea at least avoids some of the political problems of its larger neighbour. But it too has suffered.

Aralsk is the old fishing port and coast resort. Once a thriving town served by the Moscow–Almaty railway, it is now a ghostly relic. Where the Aral Sea once stood there is now only desert, littered with the hulks of abandoned fishing boats (Fig. 8). On what was once a holiday beach, the local children swim in a pool held up by scaffolding and a plastic sheet. Commercial fishing, mainly for sturgeon and catfish, stopped in 1980. Ten years later, land-based industries were depleted by the Soviet economic collapse. Between the derelict docks and the derelict factories, Aralsk's houses and apartments look across desolate windswept streets (Fig. 9). Dust storms rage on 65 days a year; most are just on the north wind, but there's usually an extra one a couple of days after a rocket launch at Baykonur (Russia's equivalent of Cape Kennedy, just out to the east). Now lost in a desert of mankind's own making, Aralsk is a very sad place, and its inhabitants struggle merely to survive.

Fig. 11. Today's fishing boat on the Aral Sea at Tastubek.

Even more depressing is Zhalangash. A dusty main street reaches from empty desert to where the Aral Sea once was – now replaced by more empty desert. Dust has replaced spray. Eagles have replaced seagulls. The village men who once worked the trawlers now tend camels, goats and sheep, which struggle for feed on the thin dust-smothered grass, and their children play on the ships' graveyard (Fig. 10), a scatter of eight ships that lie rusting in a desert that was once a sheltered bay.

Even more desperate is Tastubek. There are perhaps 30 houses, and some of those are abandoned. The surviving families eke out a survival on the edge of nowhere. On a section of coast where the seabed was steeper, the Aral Sea has retreated only a kilometre with its falling level. So the villagers can still manage some subsistence fishing in small boats, which they launch from the ever-changing beach (Fig. 11). They catch flatfish, which were introduced by the Soviets to replace the sturgeon when salinity started to rise. But they are not popular as food, so it's not worth the fishermen hauling their meagre catches over the 80 km of rough dirt road to Aralsk. They just eat the fish themselves, waiting isolated in their forlorn little village, waiting for a better future – which could be on the horizon.

When the Aral split into two seas in 1987, much of the remnant Syrdarya flowed into the Small Sea. In 1994 an embankment dam of sand was built to divert all the Syrdarya into the Small Aral and also prevent any overflow into the Large Aral (Fig. 5). The level of the Small Aral actually rose, until the frail dam succumbed to wave erosion and was broken through in April 1999. The idea of splitting the Aral Sea into sustainable fragments had first been mooted in Moscow in the 1970s. Now it was seen to be feasible. A new dam will be stronger and will be 16 km long. The World Bank has recently allocated £45 million to the project, and construction should start in 2002. Eventually it will allow the Small Sea to reach a level of 43 m, when excess water will be allowed to overflow through a channel in the west into the Large Aral (Fig. 5).

This does rely on a maintained inflow from the Syrdarya; but it will require only about 3 km^3/year, and that is considered achievable with a modest review of irrigation in the cotton fields up-valley. The Sea will never again reach Aralsk, but it will reach a stable level, and it should be a lake of almost fresh water with its permanent outflow. Then new coastal settlements and renewed fishing should be possible. A Danish-funded project is already determining the best species for restocking the waters – and this is the glimmer of hope that could give the people of Tastubek a second chance.

The future

While the Small Aral does appear to have a sustainable future, the prospects for the Large Aral remain bleak. A sustainable Large Aral Sea needs an annual inflow of 28 km^3 from the Amudarya, but any hope for this is unreal. An inflow of 11 km^3/year could maintain some form of shrunken sea, but even this is doubtful. Massive reductions of the irrigated areas and major improvements of irrigation technology are just not foreseeable. Turkmenistan's cotton could be maintained with just half the water in the Karakum Canal, and that would put 6 km^3/year back into the Aral Sea. Far more likely is the total failure of the canal, when even more water will then be lost into the Caspian catchment.

Both Tajikistan and Afghanistan are likely to take more water from the Amudarya when their present wars are over and they start to industrialize. A one-off bonus could come from Tajikistan, where 17 km^3 of water are held in Lake Sarez behind a dam of landslide debris that blocked the valley in an earthquake in 1911. Another earthquake could trigger failure of the debris dam, releasing a flood pulse that would raise a shrunken Large Aral by nearly a metre in one go (if all the water reached the Aral after causing massive destruction on its way down the Amudarya valley).

The most likely future for the Large Aral is further shrinkage. It will then divide into two again. The eastern sea should become sustainable with modest inflows from the Amudarya and also overflow water from the Small Aral (Fig. 5). Meanwhile, the western half will continue to shrink and will ultimately become a saline pond or a salt flat.

There is one final twist to the Aral story. Vozrozhdeniye Island was originally a tiny speck of land in the middle of the sea, the ideal place for a Soviet biological weapons research centre. In the 1980s a weapons inspection programme forced the Russians to hide their arsenal, and numerous drums of anthrax spores were buried on the island. They have since been forgotten, and since 1992 the new republics have ceased to guard the site (which straddles their border). With the shrinkage of the Aral Sea, the island is now much larger and will soon be joined to the mainland. Accessible to anyone who digs them up, or exposed when the drums rot away, this anthrax dump is just another nail in the Aral Sea's coffin.

Fig. 12 Fresh shells in the desert of Zhalangash Bay are a reminder that the Aral Sea covered this sand less than 40 years ago.

With or without the anthrax, the demise of the Aral Sea has been an environmental disaster on a massive scale (Fig. 12). The fact that it has occurred entirely due to human interference is both distressing and depressing, but at the same time instructive. It should never be repeated.

Suggestions for further reading

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