International Conference Aral '09

(13-15 October, Saint Petersburg, Russia)

Aral: Past, Present and Future

Two centuries of the Aral Sea investigations

Dynamics of free-living invertebrates fauna of the Aral Sea

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Aral Sea in the beginning of 20th century:

- Area 67499 km^2
  Large Aral 61381 km^2
  Small Aral 6118 km^2
- Volume 1089 km^3
  Large Aral 1007 km^3
  Small Aral 82 km^3
- Level +53.4 m
- Maximal depth 69 m
- Salinity about 10 g/l
- The Aral Sea was inhabited by about 160 species of free-living invertebrates

Changes that occurred in the XX century in the invertebrate fauna of Aral Sea were caused by:

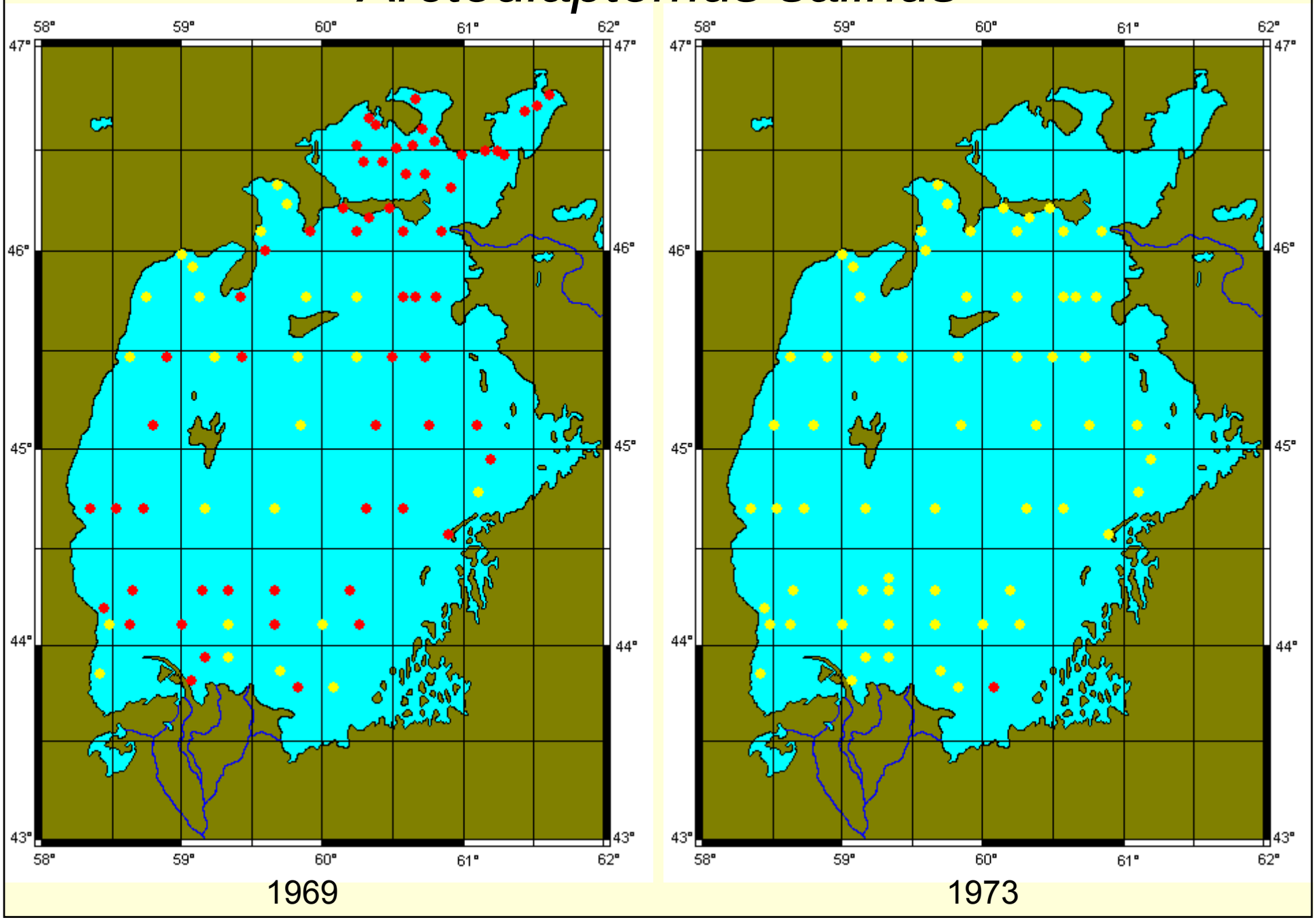
1. Intentional or accidental introduction of alien species of invertebrates and also fishes by man;
2. Changes in hydrological regime of the sea as a result of economic activities.

Introduction of new species of free-living aquatic invertebrates, and also fishes, to the Aral Sea has begun in 1950s.

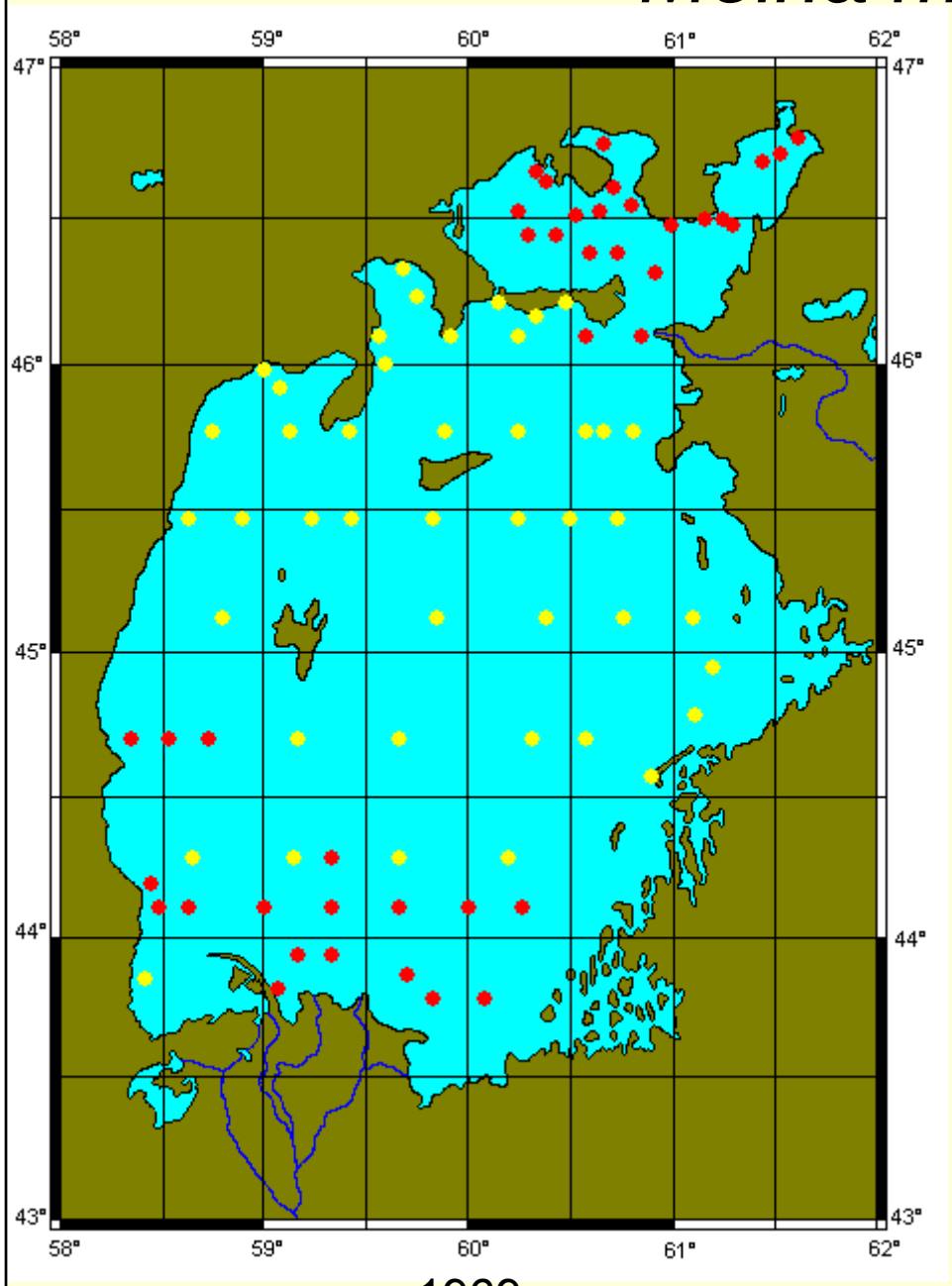
- Fauna of the Aral Sea had low species diversity. Introduction of some invertebrate species being valuable food objects for commercial fishes has been recognized expedient in order to raise fish productivity.
- Planned widening of irrigation in the Aral Sea basin should lead to decrease of river flow and increase in the salinity of Aral and to cause essential changes in the ecosystem.
- Main part of the Aral Sea inhabitants was species of freshwater or brackish-water origin which could not survive forthcoming raise of salinity. Therefore it was proposed to make Aral Sea fauna more euryhaline and resistant to higher salinity in advance by acclimatization of suitable species.
- At development of the plan of Aral Sea fauna reconstruction it was intended subsequent forming of all trophic levels: at first phytoplankton, then zooplankton and zoobenthos, and only after that enriching fish fauna. At that it was specially indicated on the necessity to avoid incidental introductions of undesirable species of aquatic organisms into Aral Sea together.

- Recommended order of aquatic organisms introductions was not observed. Together with the planned acclimatizants in Aral also species which introduction was undesirable got incidentally. Thus possibility of negative consequences was not considered.
- In 1954-1956 plankton-eater Baltic herring *Clupea harengus membras* has been introduced to the Aral Sea. Its number has reached maximum in 1960. Load on zooplankton has increased sharply. Low productivity of zooplankton could not provide food needs of this fish. It fast has exhausted reserve of food and has undermined base of its reproduction. Number of large crustaceans first of all *Arctodiaptomus salinus*, dominated in zooplankton and having low prolificacy and long life cycle, and also cladocerans *Cercopagis pengoi aralensis*, *Moina mongolica*, *Ceriodaphnia reticulata* and cyclops has sharply decreased. Decrease in number and biomass of zooplankton, in turn, has led to the fast fall of Baltic herring number. *A. salinus*, *M. mongolica* and *C. reticulata* have not restored their number and disappeared completely in 1974.
- Incidentally introduced shrimp *Palaemon elegans* apparently became the competitor of indigenous amphipod *Dikerogammarus aralensis*, that has led to its gradual disappearance.

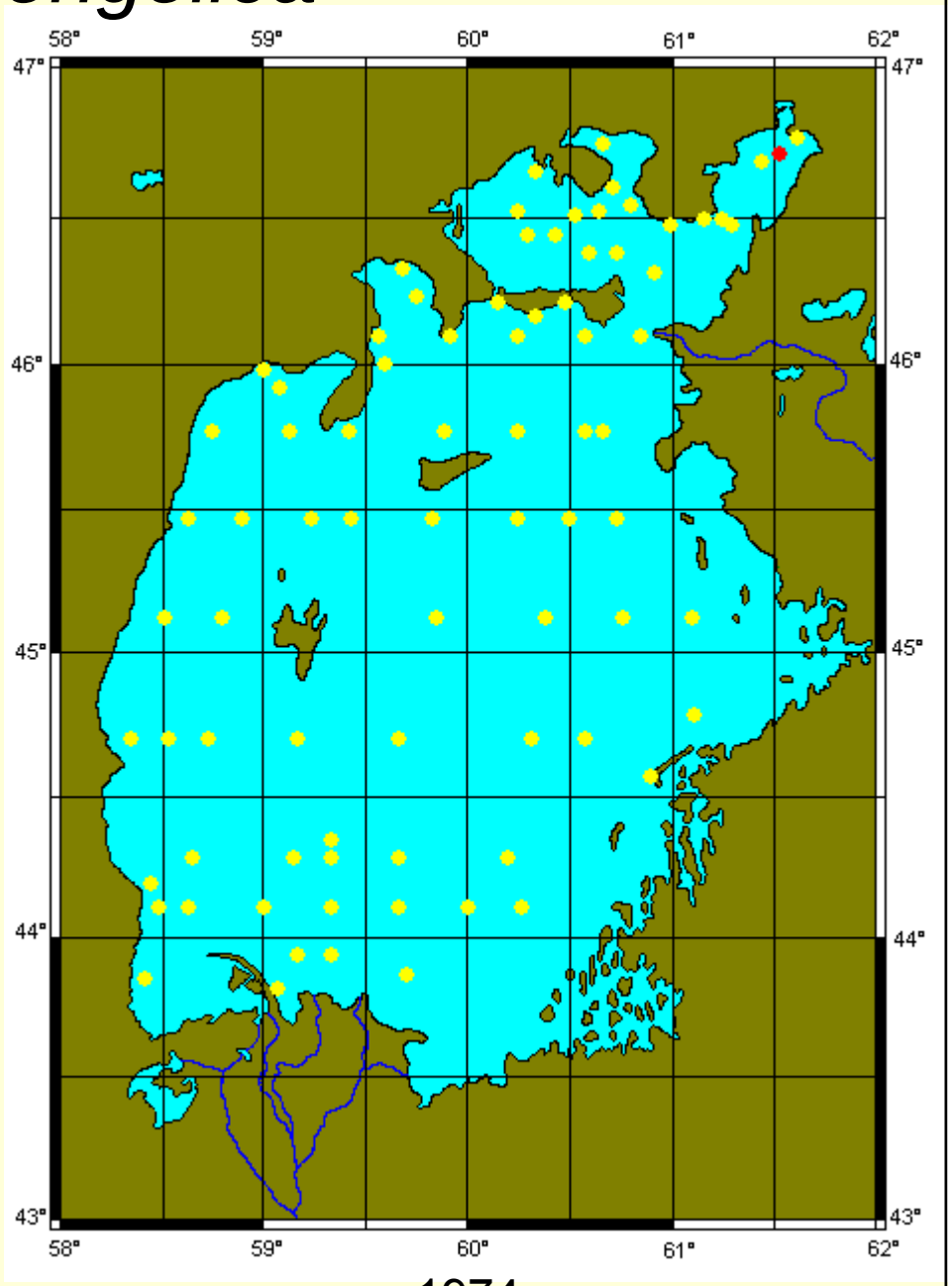
Arctodiaptomus salinus



Moina mongolica

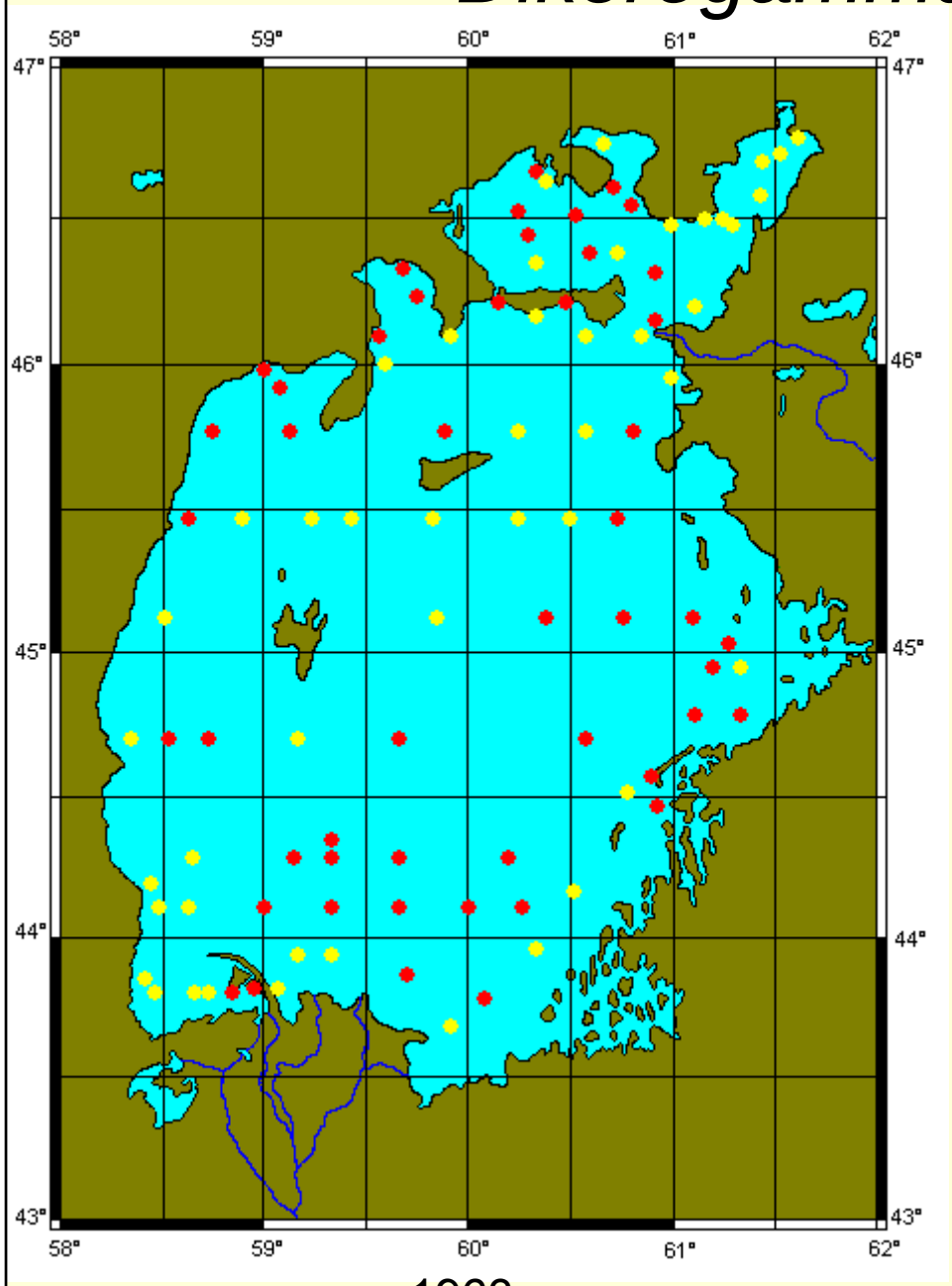


1969

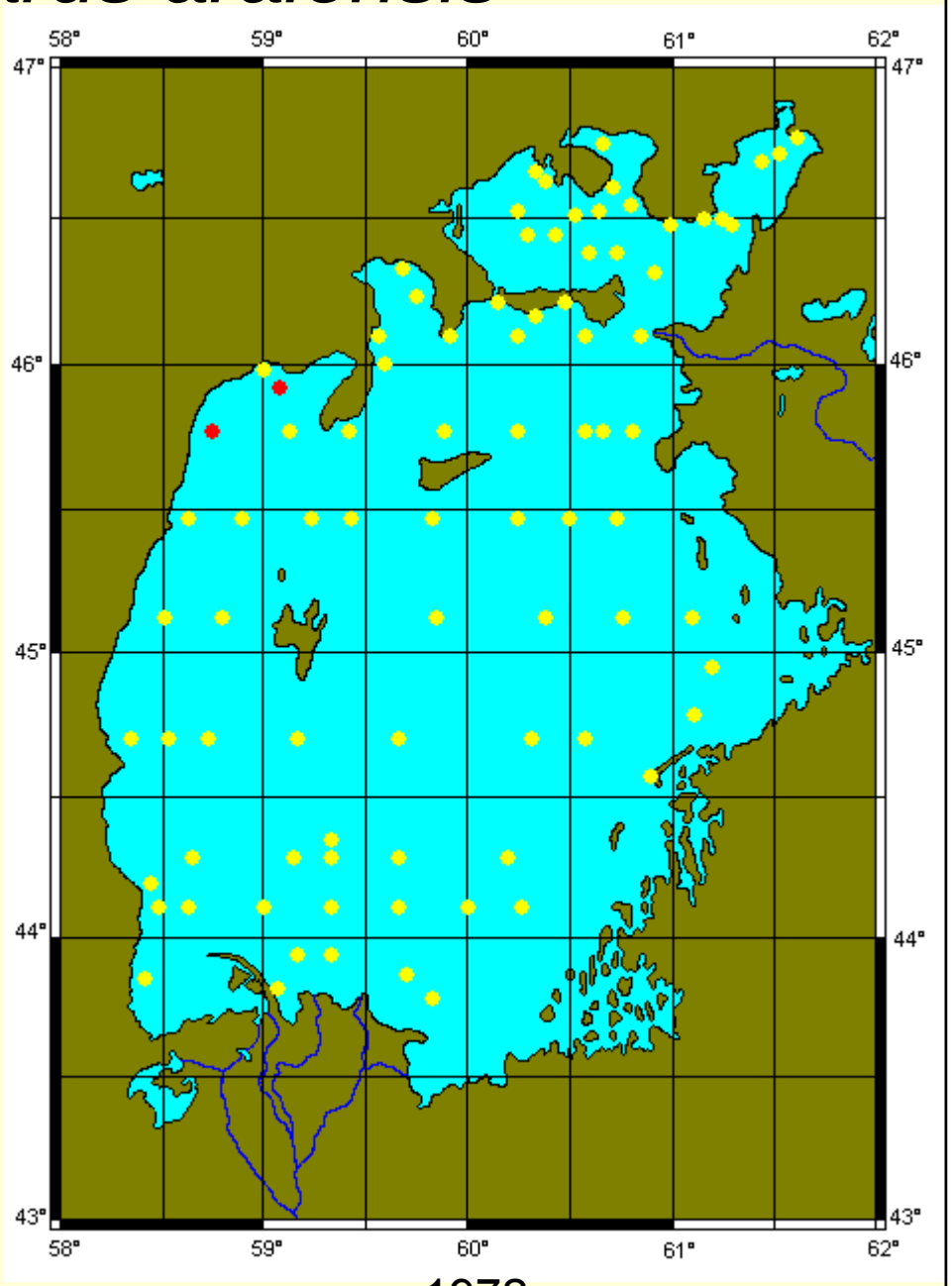


1974

Dikerogammarus aralensis



1963



1972

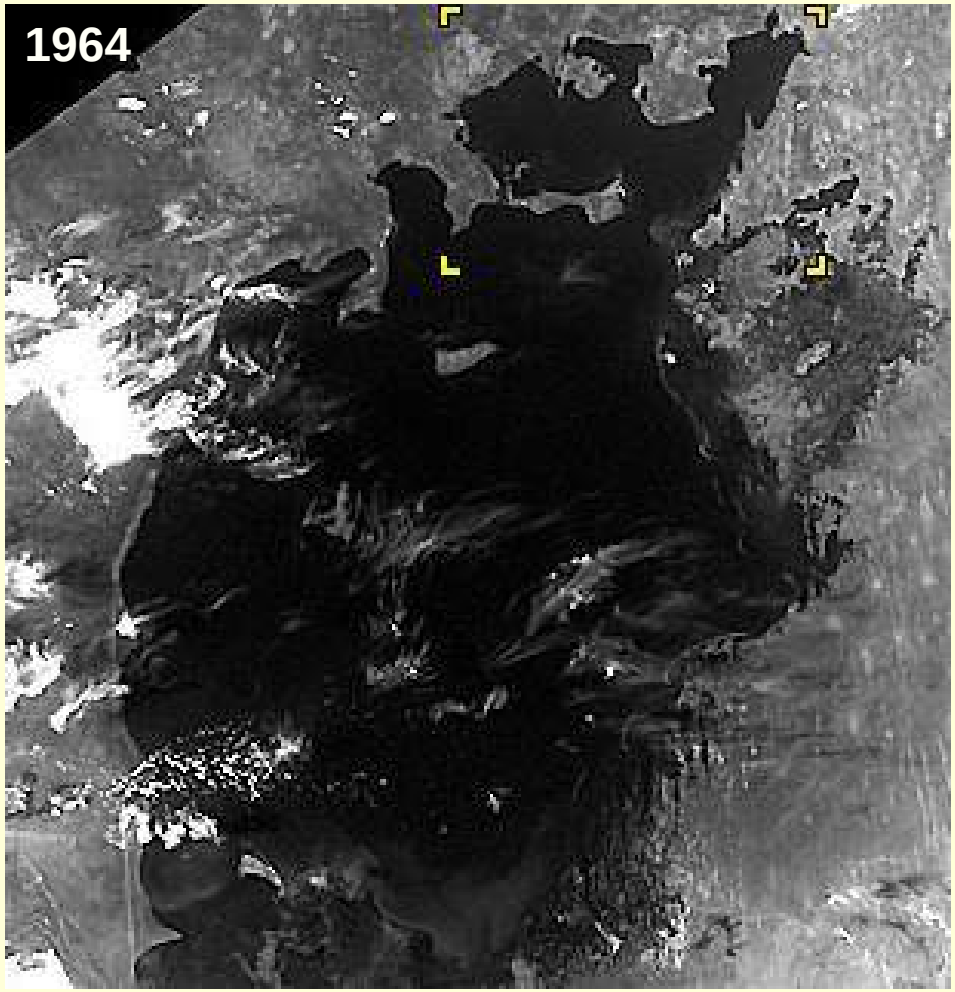
Alien free-living invertebrates in the Aral Sea

Taxon	Source	Year	Status	Way	Impact
Polychaeta					
Hediste diversicolor	Sea of Azov	1960-1961	N	A	+
Bivalvia					
Syndosmya segmentum	Sea of Azov	1960-1963	N	A	+
Monodacna colorata	?	1964, 1965	-	A	0
Mytilus galloprovincialis	Sea of Azov	1984-1986	-	A	0
Mya arenaria	Sea of Azov	1984-1986	-	A	0
Copepoda					
Calanipeda aquaedulcis	Sea of Azov	1965-1970	N	A	+
Heterocope caspia	?	1971	-	A	0
Acartia clausi	?	1985, 1986	-	A	0
Mysidacea					
Paramysis baeri	Don River	1958-1960	?	A	0
P. lacustris	Don River	1958-1960	N	A	+
P.intermedia	Don River	1958-1960	N	A	+
P. ullskyi	Don River	1958-1960	R	AC	+
Limnomysis benedeni	?	?	R	AC	+
Decapoda					
Palaemon elegans	Caspian	1954-1966	N	A+	?
P. adspersus	Caspian	1954-1966	?	A+	?
Rhithropanopeus harrisii tridentata *	Sea of Azov	1965, 1966	N	A+	+

Way of introduction: A – acclimatization, AC – by accident, A+ – incidentally at planned introduction.

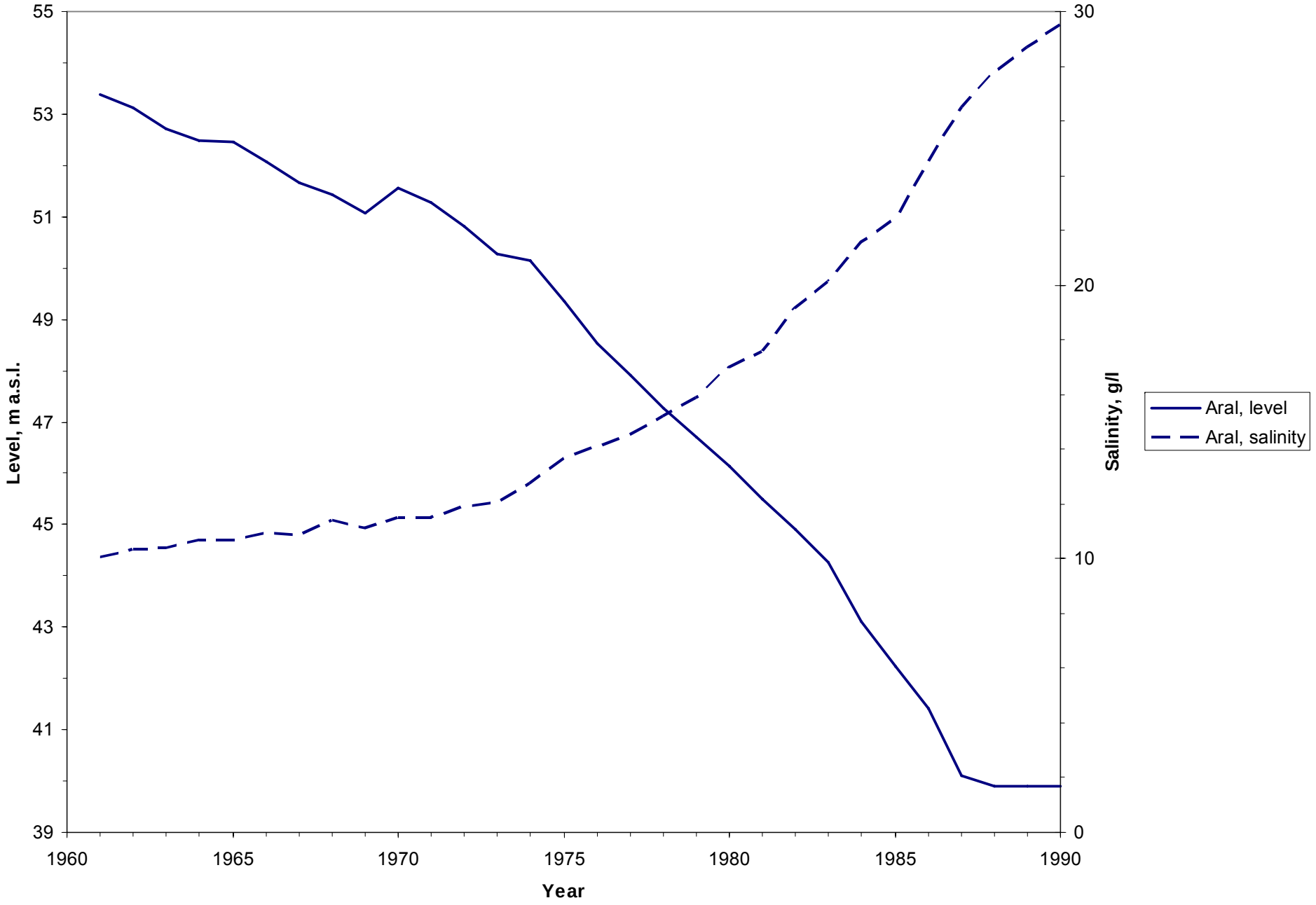
Status: R – rare, N – numerous. Impact: - negative, + positive, 0 no effect, ? unknown. * – only in the Large Aral.

In 1960 because of increased withdrawals of riverine waters for irrigation the Aral Sea regression has begun



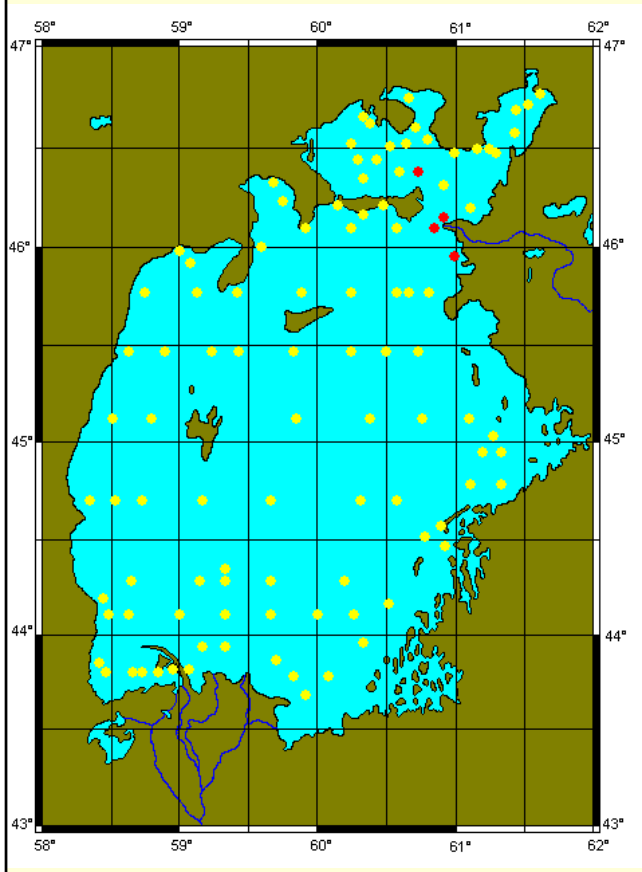
September, 2009: Aral area – 8410 km^2 (13%), volume – 85 km^3 (7.5%);
the Large Aral – 4922 km^2 (8%), 58 km^3 (6%), salinity >100 g/l;
the Small Aral – 3487 km^2 (57%), 27 km^3 (33%), salinity 10-14 g/l.

Aral Sea level and salinity

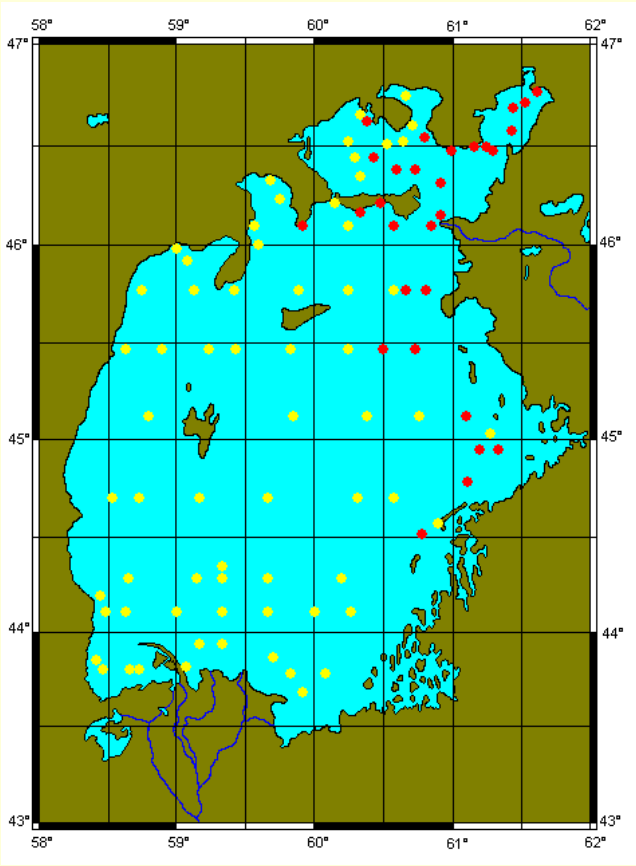


- Already to the beginning of anthropogenic desiccation and caused by it salinization of Aral Sea its ecosystem was changed as a result of planned and incidental introductions of new species.
- Introduced in the beginning of 1960s from the Sea of Azov polychaete Hediste diversicolor and bivalve mollusk Syndosmya segmentum became valuable food for benthofagous fishes. Also introduced from the Sea of Azov copepod Calanipeda aquaedulcis replaced former dominant Arctodiaptomus salinus. Owing to high euryhalinity these species survived further salinization of Aral Sea and remained among predominant species of zoobenthos and zooplankton.

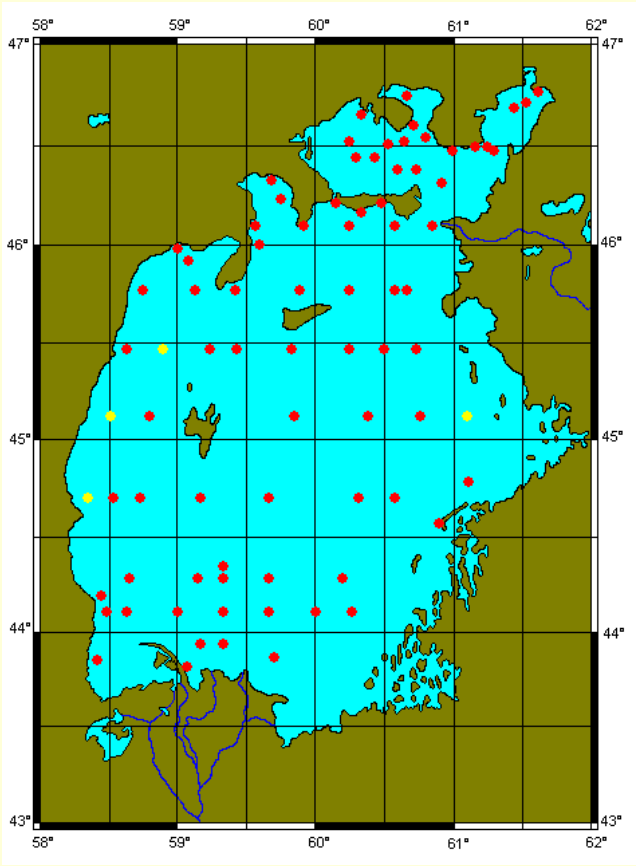
Hediste diversicolor



1964

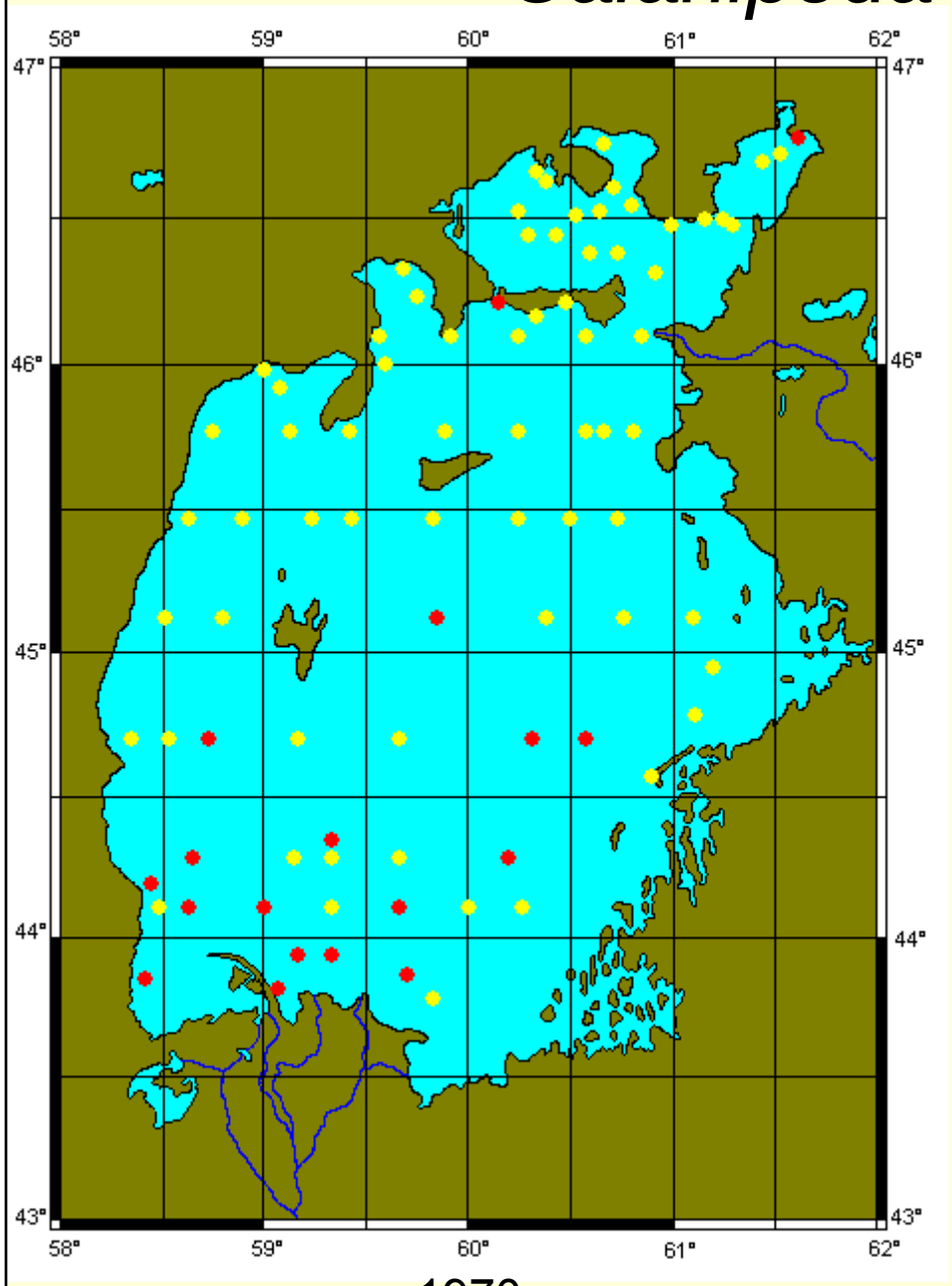


1967

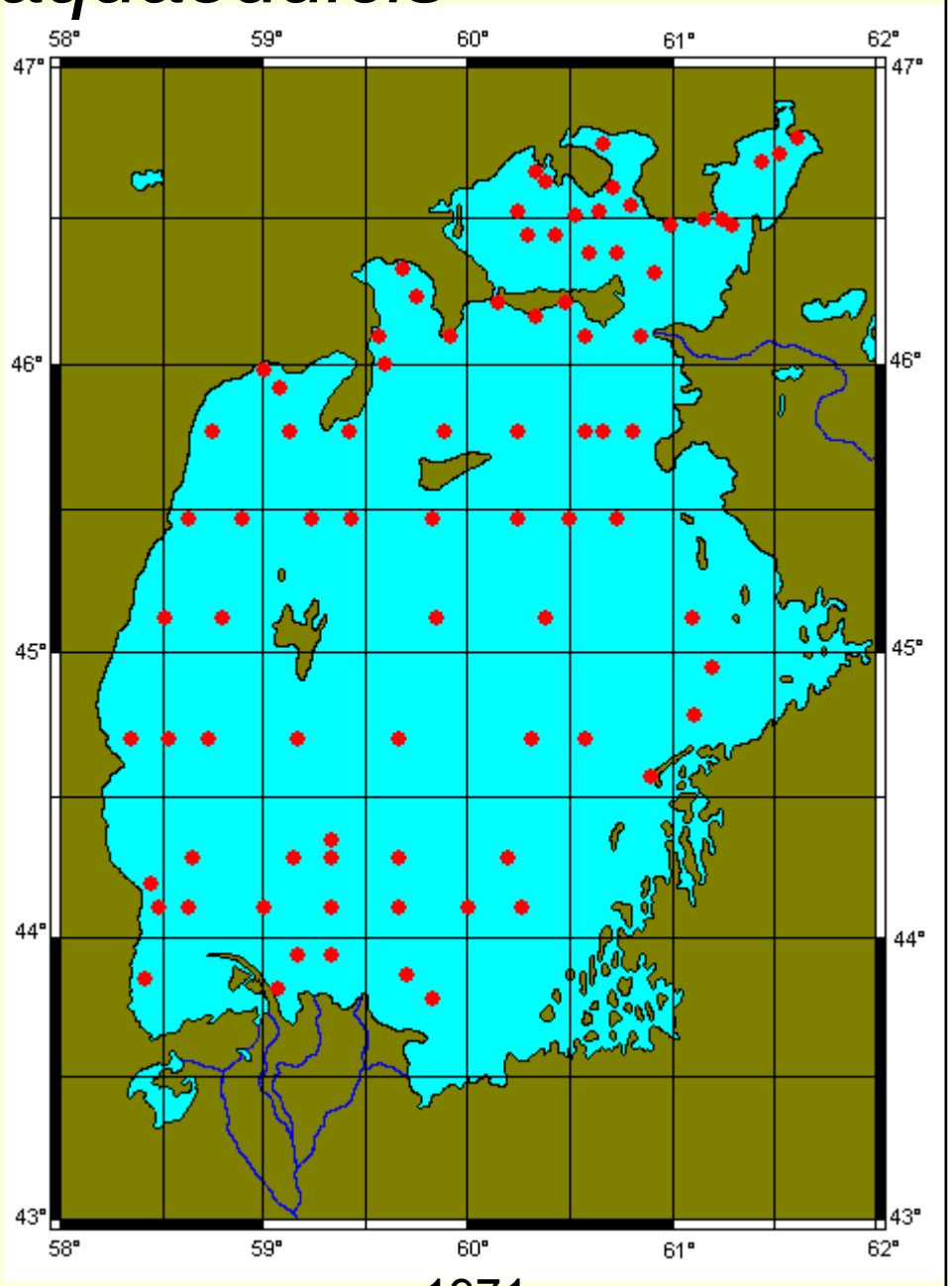


1974

Calanipeda aquaedulcis

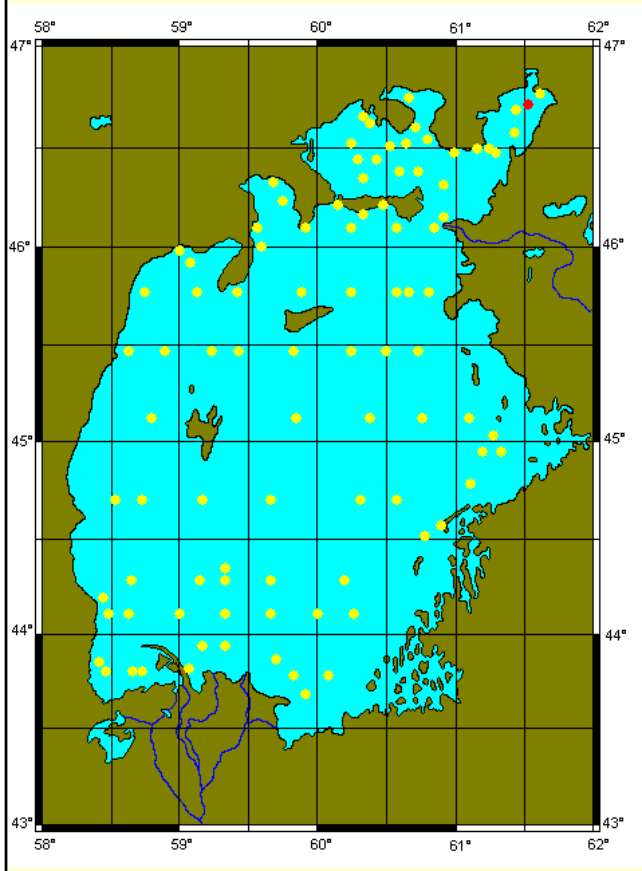


1970

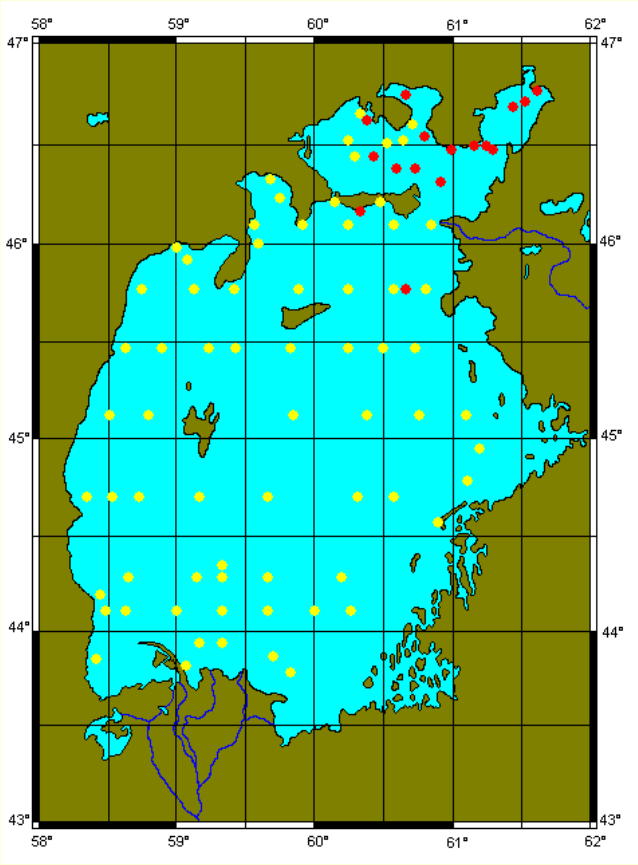


1971

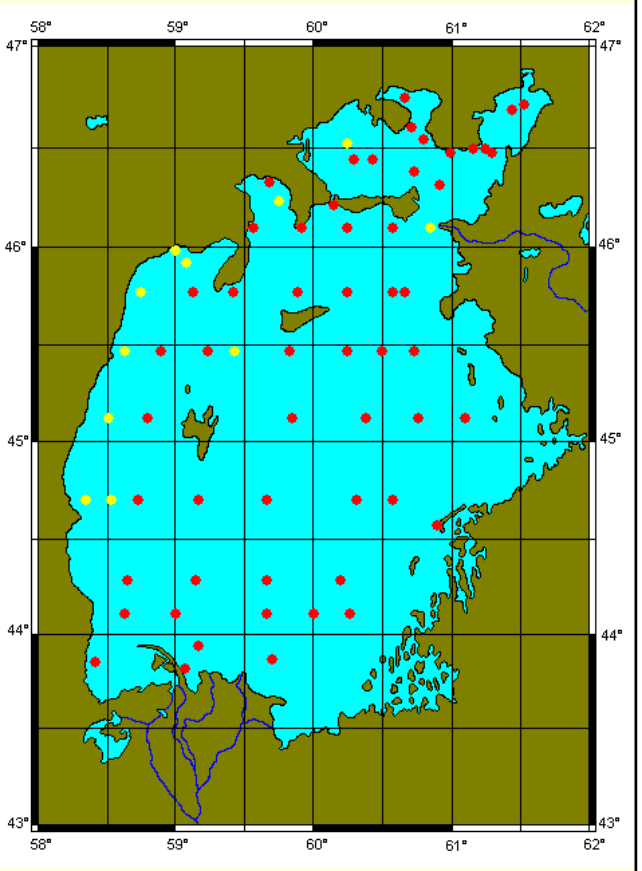
Syndosmya segmentum



1967



1970



1975

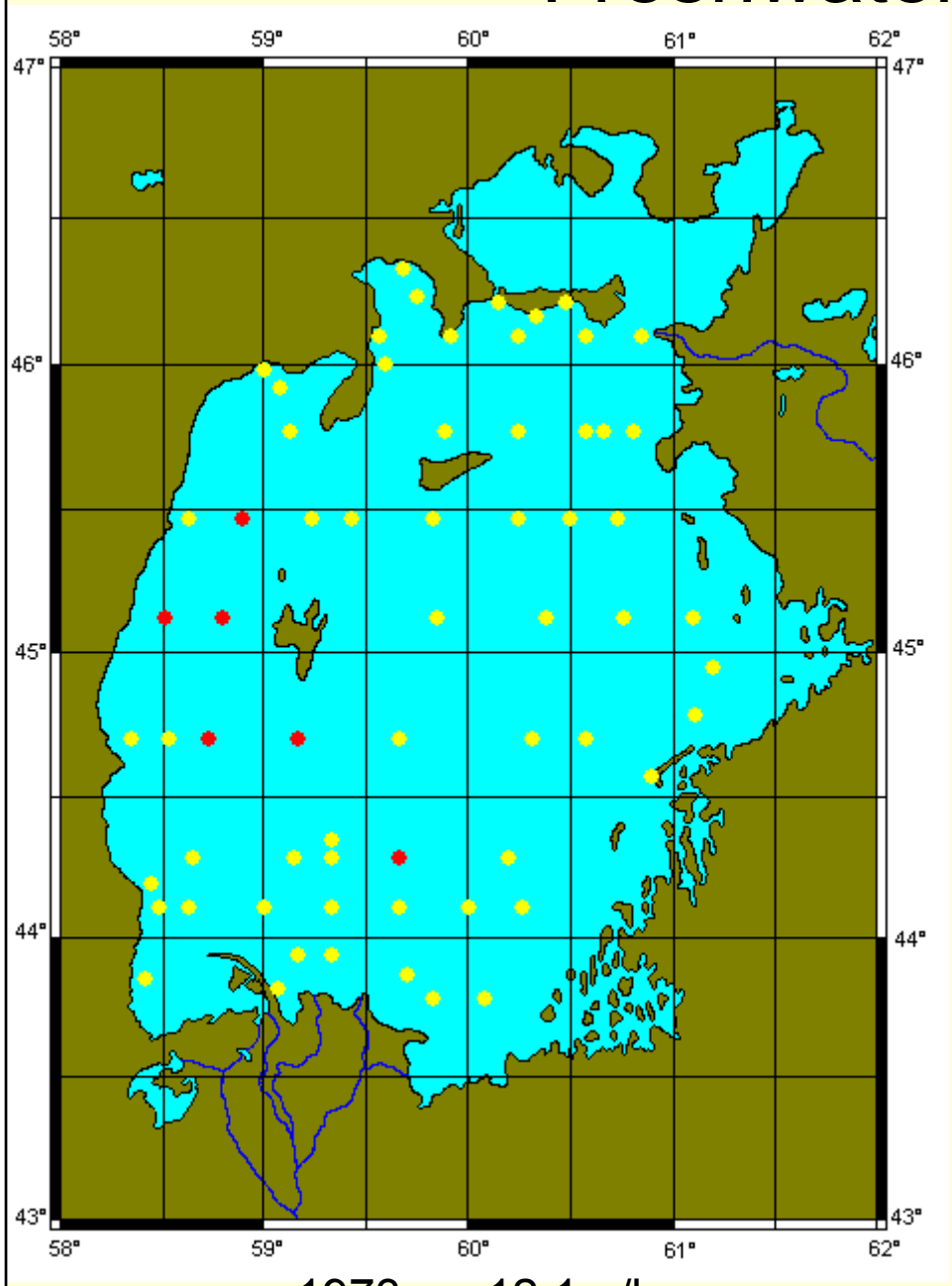
Introductions of alien species into the Aral Sea since 1950's and their negative and positive consequences

- **Negative consequences.**
  Together with valuable alien species introduced advisedly into the Aral Sea some undesirable species were brought accidentally. Some of them caused negative impacts on the fauna.
  The most serious negative consequences were caused by introduction of Baltic herring *Clupea harengus membras*. This plankton-eater exterminated large crustacean species (*Arctodiaptomus salinus, Moina mongolica*, *Alona rectangula*, *Ceriodaphnia reticulata*) predominated in the zooplankton. As a result, average zooplankton biomass decreased by more than 10 times.
  It could be that accidently introduced shrimp *Palaemon elegans* competing with aboriginal amphipod *Dikerogammarus aralensis* step by step caused its extinction.
- **Some positive consequences.**
  Introduced from the Sea of Azov in the beginning 1960's polychaete *Nereis diversicolor* and bivalve *Abra ovata* became valuable food for benthophage fishes. Introduced from the Sea of Azov copepod *Calanipeda aquaedulcis* has replaced former dominant of the Aral Sea zooplankton *Arctodiaptomus salinus* which was exterminated by Baltic herring. Due to their high euryhalinity they survived further Aral Sea salinization and left dominants in zoobenthos and zooplankton.

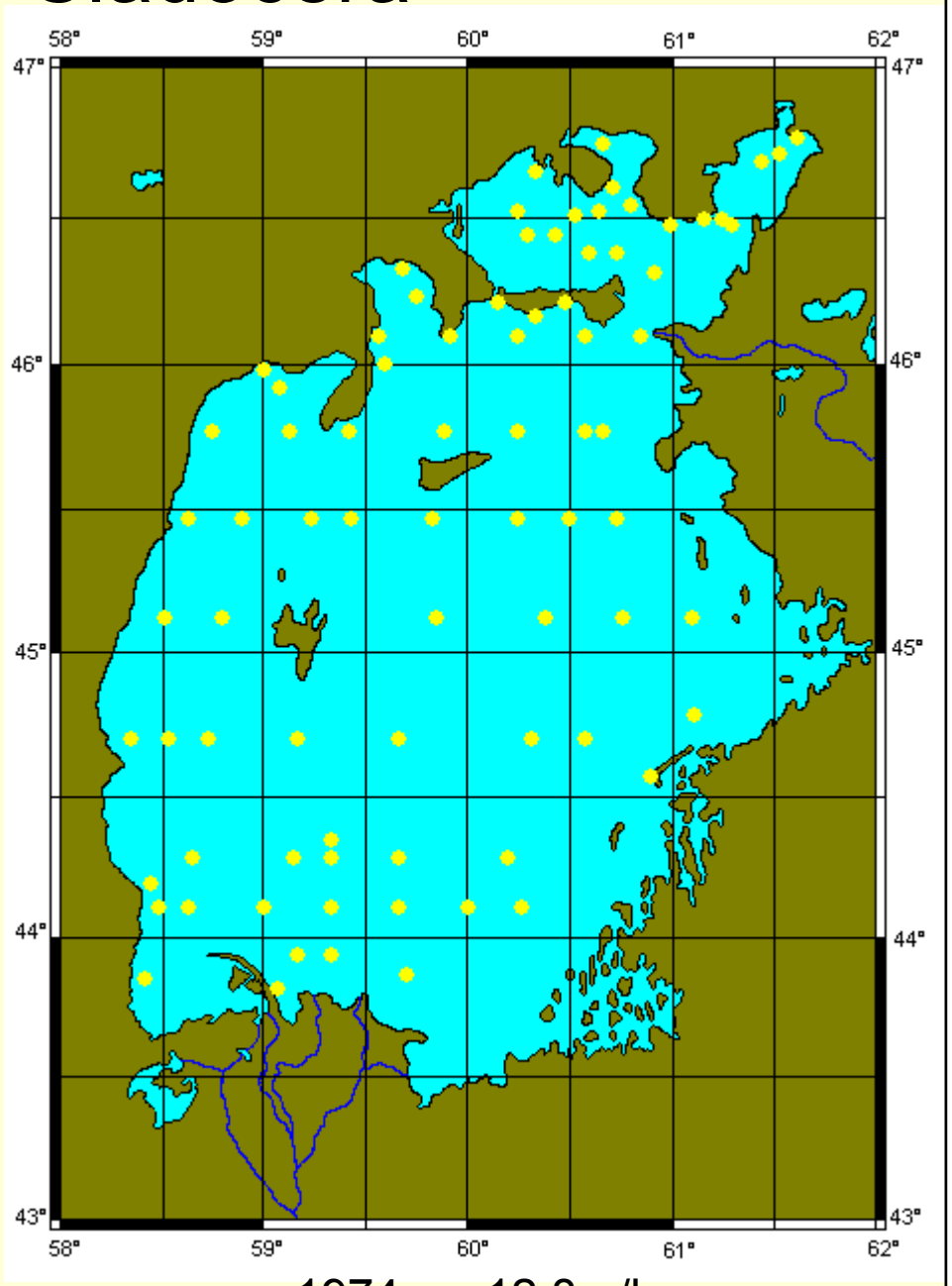
As salinity of the Aral Sea was increasing its biodiversity became lower:

- In 1971-1976, when salinity exceeded 12-14 g/l, brackish-water species of freshwater origin became extinct.
- In 1986-1989, when salinity exceeded 23-25 g/l, Caspian brackishwater species became extinct.

Freshwater Cladocera

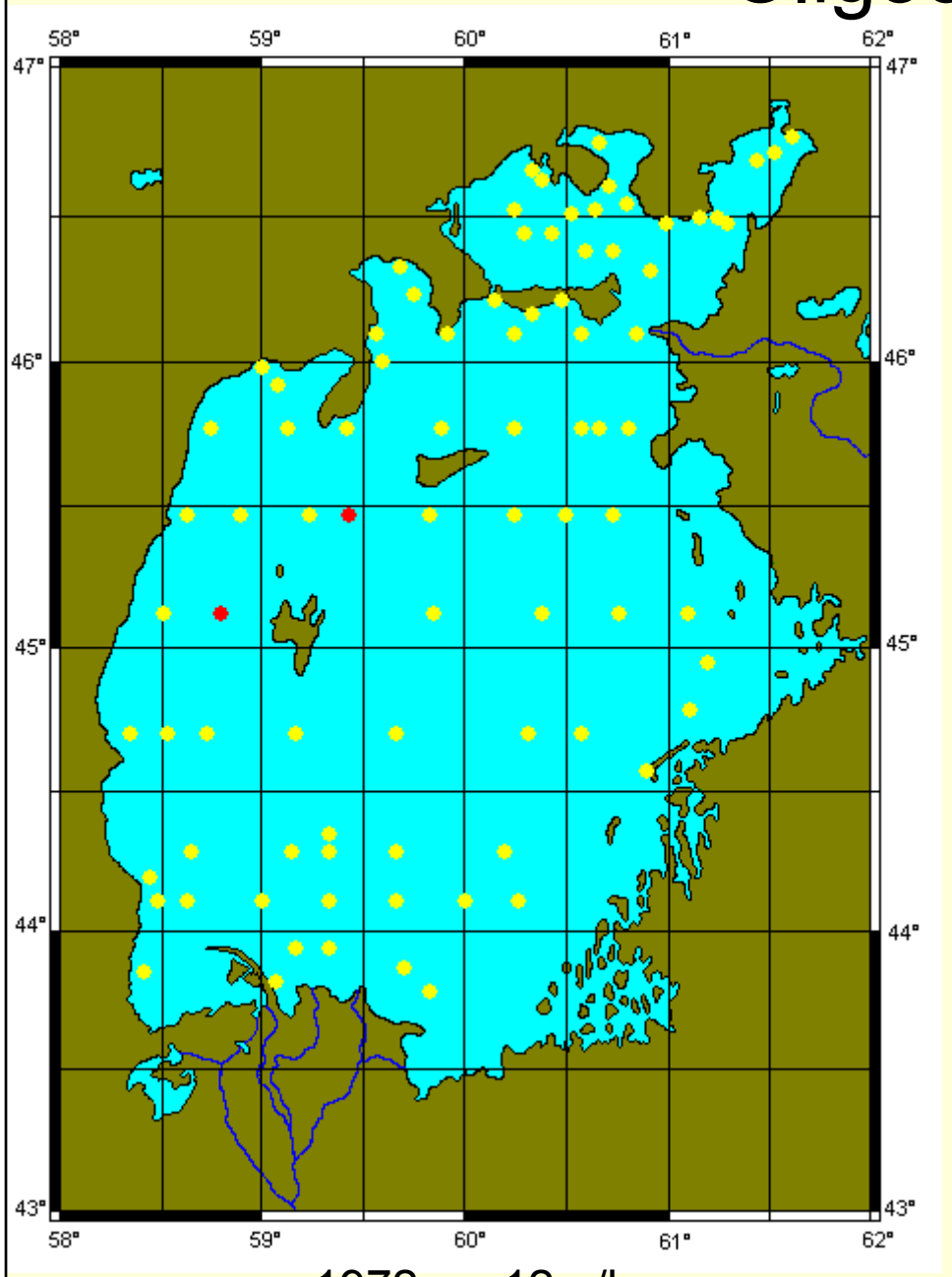


1973 12.1 g/l

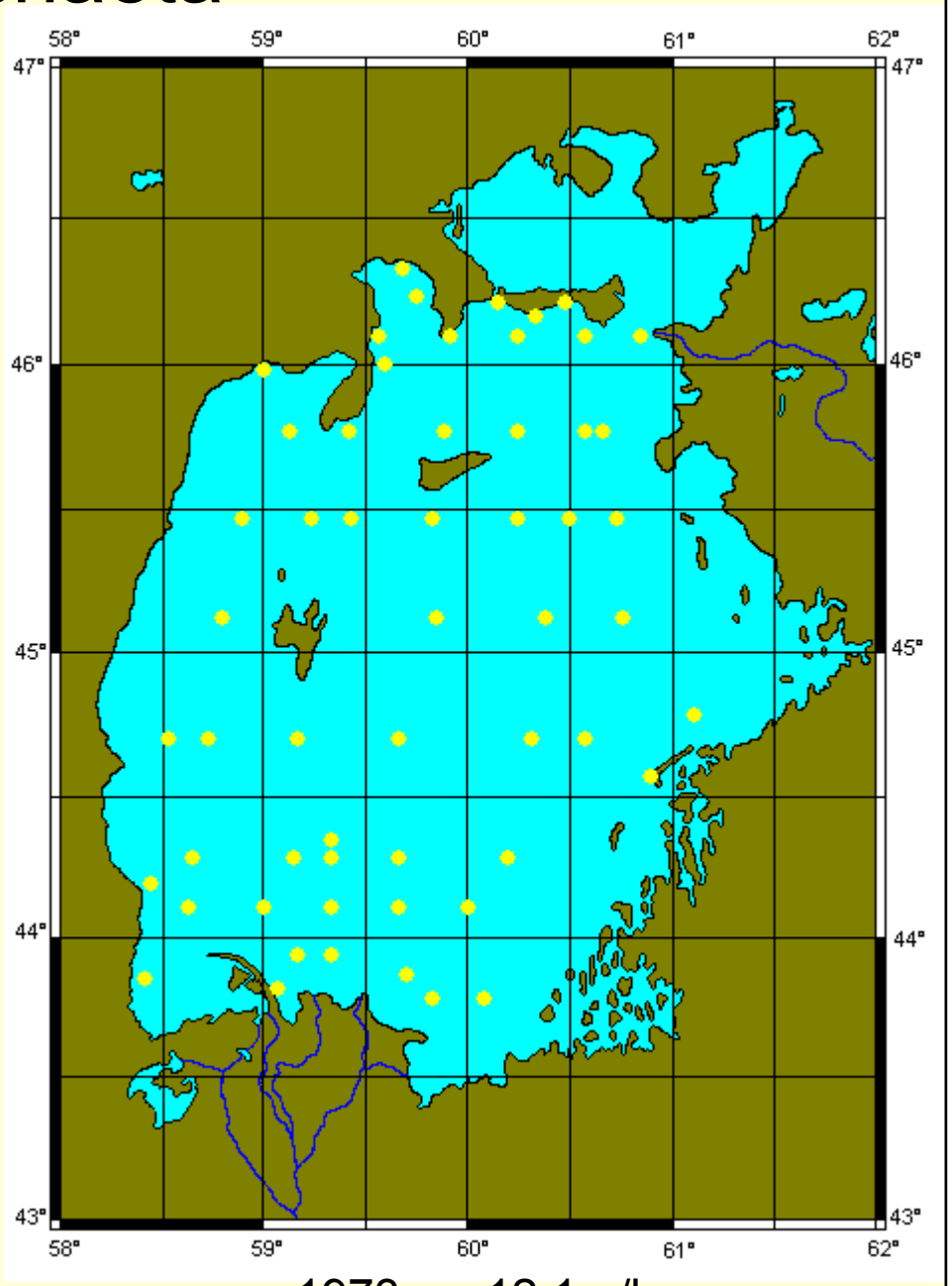


1974 12.8 g/l

Oligochaeta

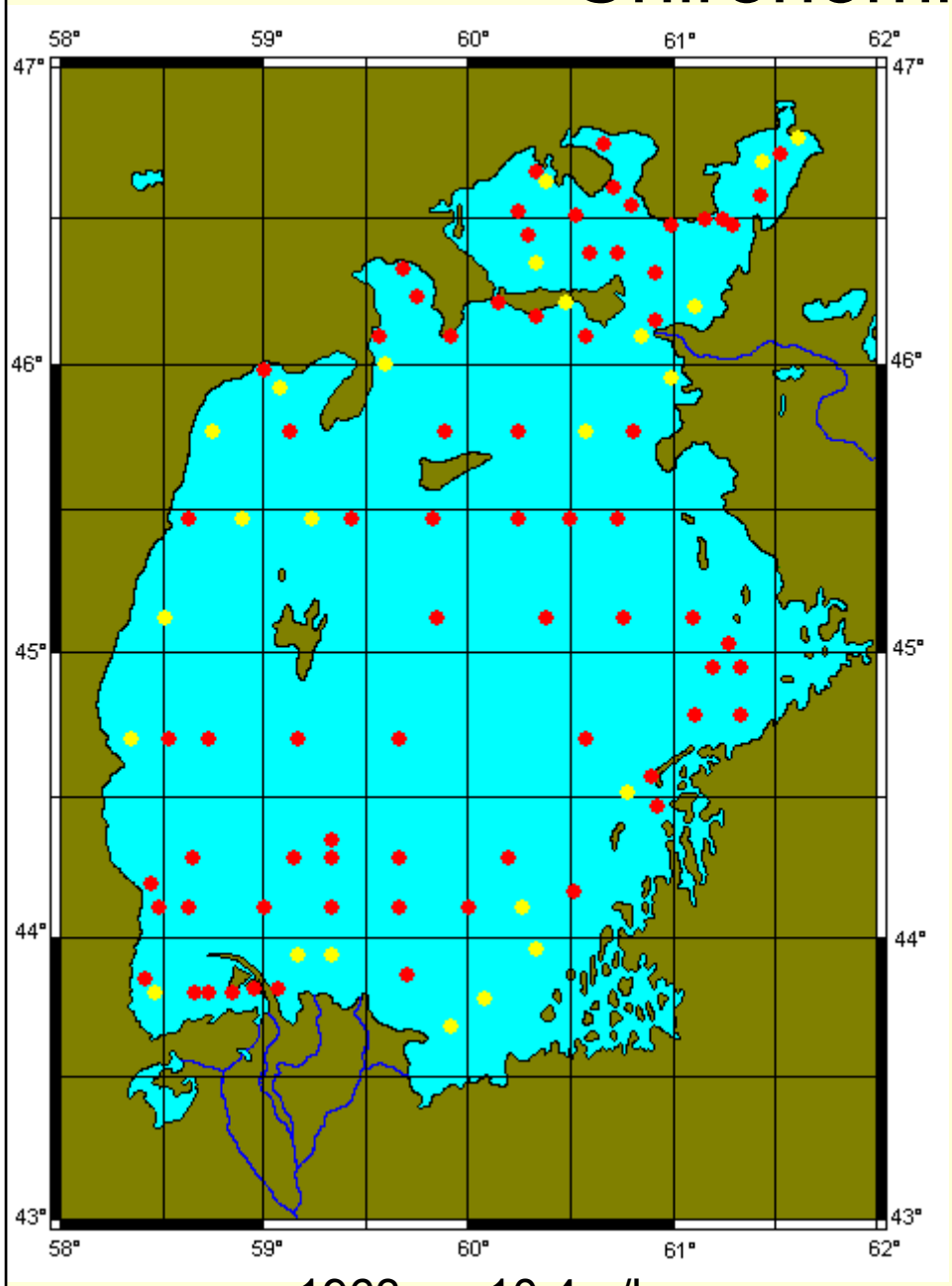


1972 12 g/l

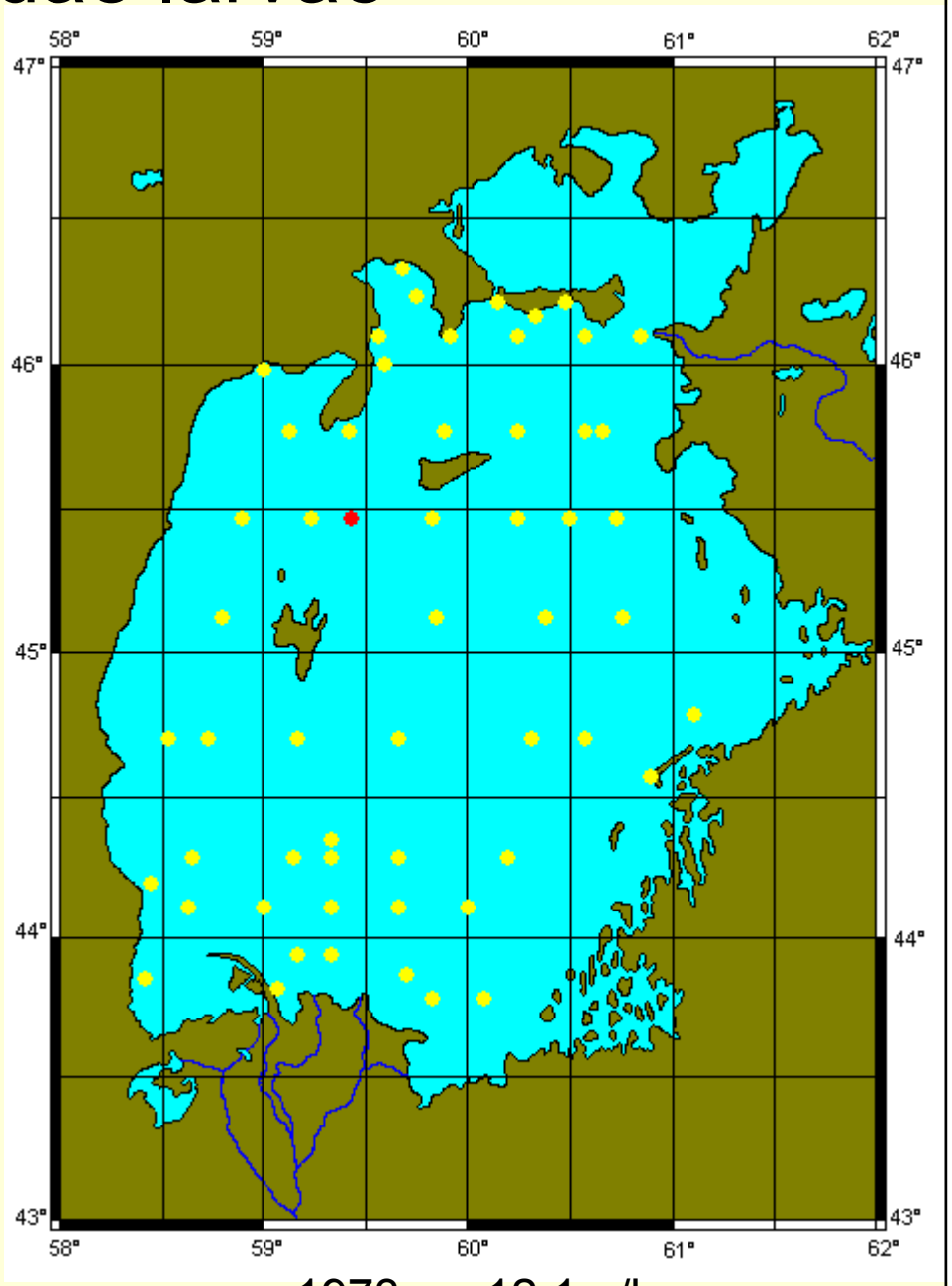


1973 12.1 g/l

Chironomidae larvae

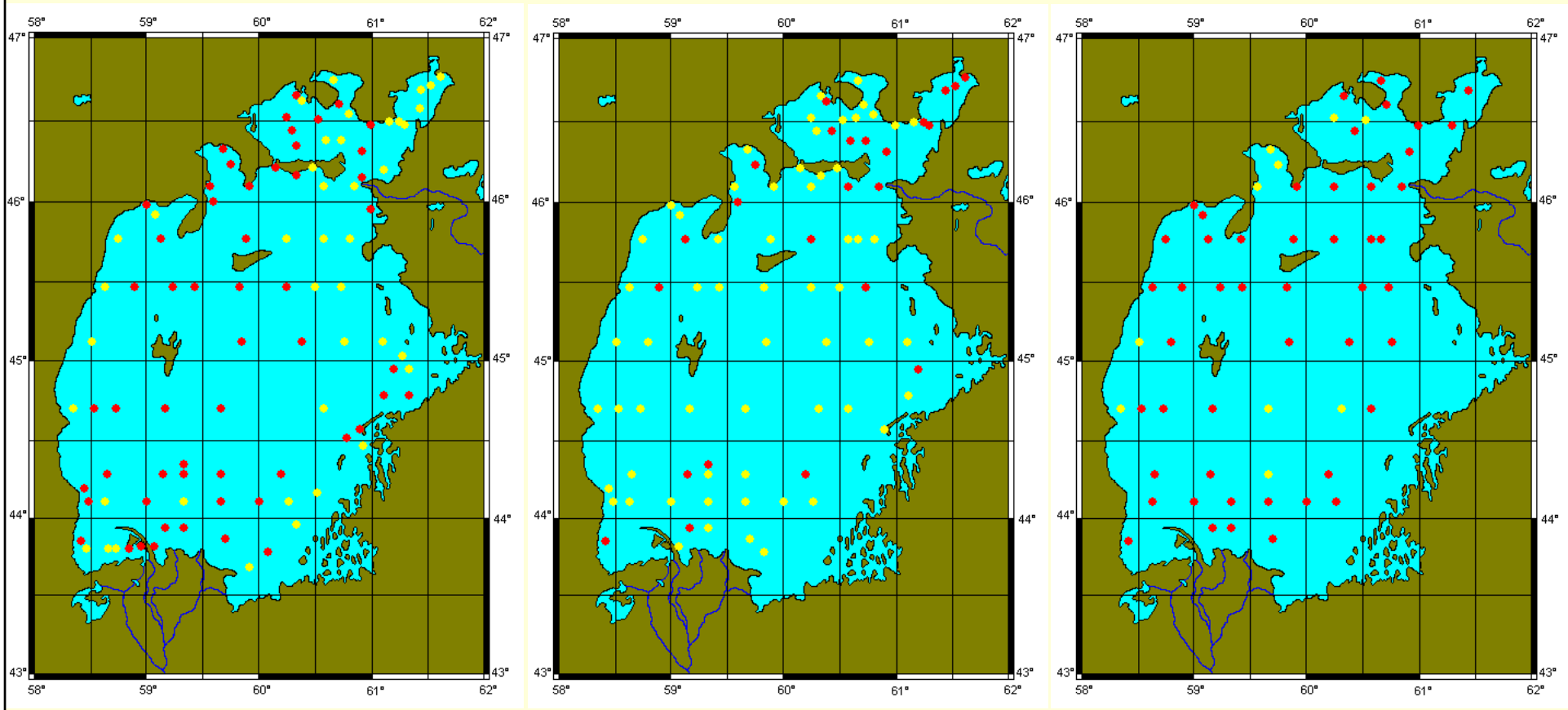


1963 10.4 g/l



1973 12.1 g/l

Cerastoderma spp.



1963 10.4 g/l

1970 11.5 g/l

1977 14.5 g/l

Cerastoderma isthmicum* substituted *C. rhomboides rhomboides

Since the end of 1980's, when the level dropped by about 13 m and reached about +40 m, the Aral Sea divided into the Large and Small Aral

Area 40000 km^2 (60% from 1960)
Volume 333 km^3 (33% from 1960)
Salinity 30 g/l (10 g/l in 1960)

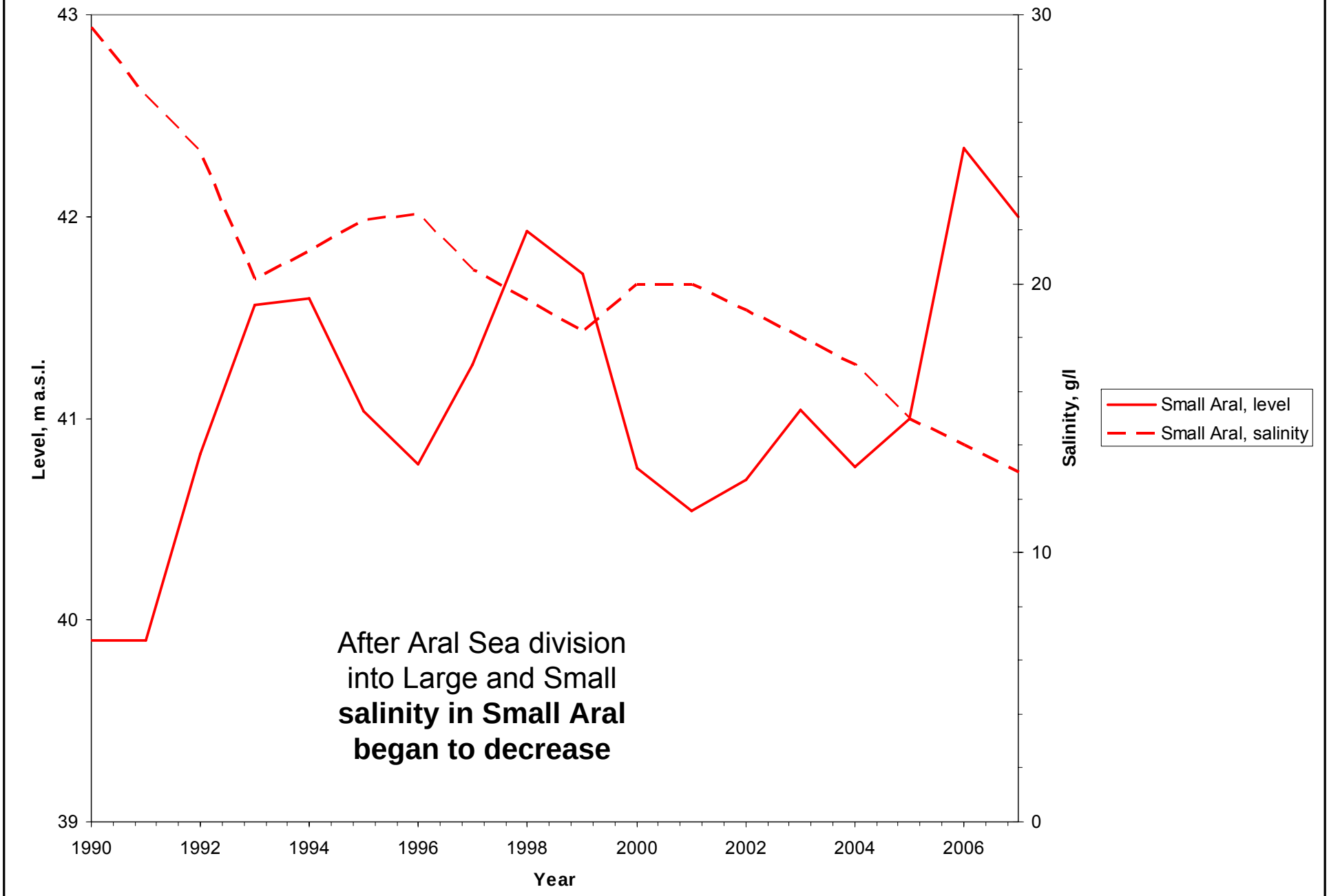
In autumn 1987 – spring 1989 Aral Sea divided into 2 lakes: Small (Northern) Aral and Large (Southern) Aral. In both lakes salinity increased and could survive practically the same number of free-living animals.

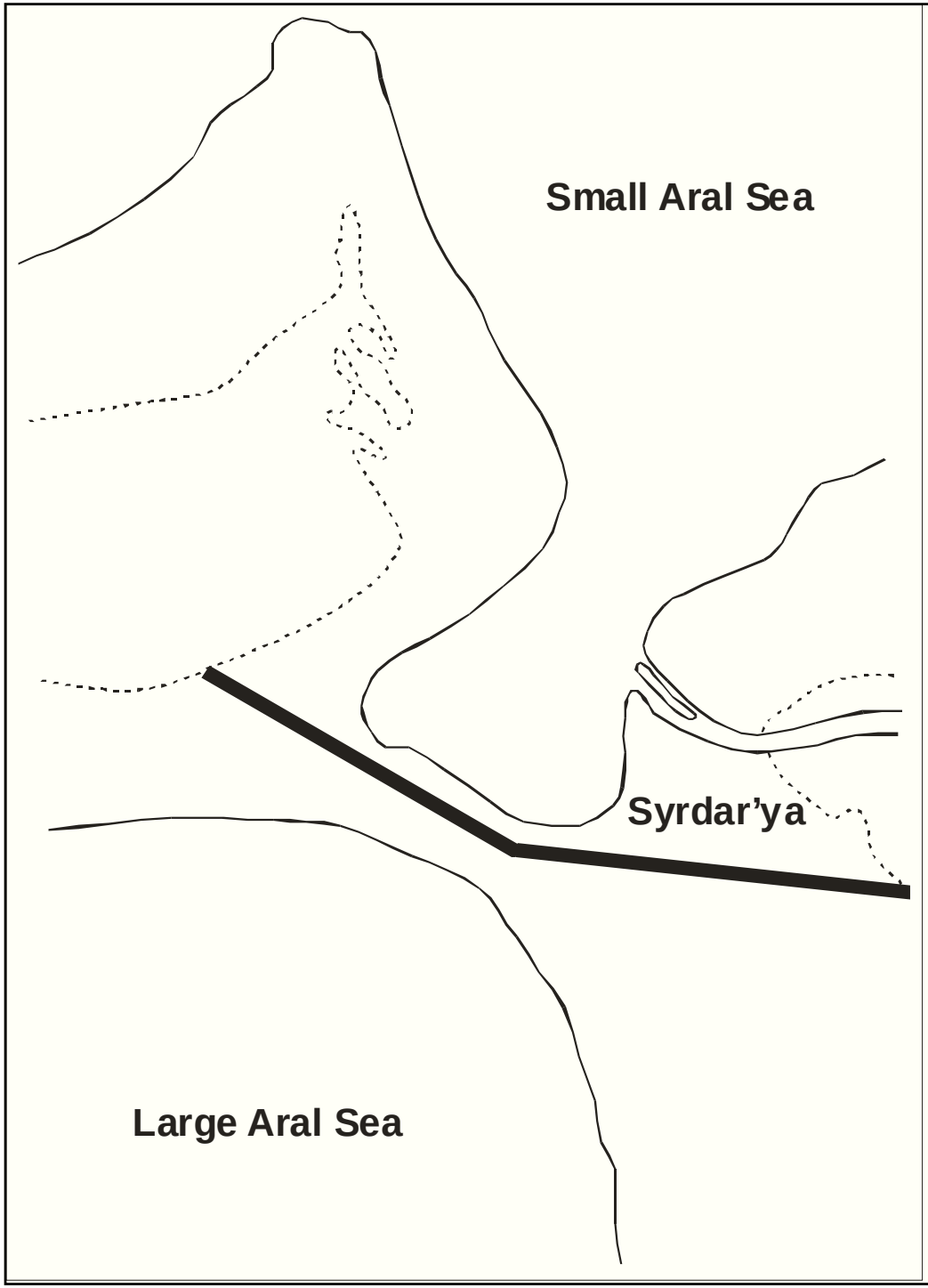
Fishes – 10; Rotatoria – 3; Cladocera – 2; Copepoda – 2; Ostracoda – 1; Decapoda – 2; Bivalvia – 2; Gastropoda - 20; Polychaeta – 1.

Small Aral Sea

Small Aral where Syr Darya inflows has positive water balance. Because of this after Aral Sea division into two water bodies water salinity in Small Aral began to decrease.

Level and salinity of Small Aral Sea

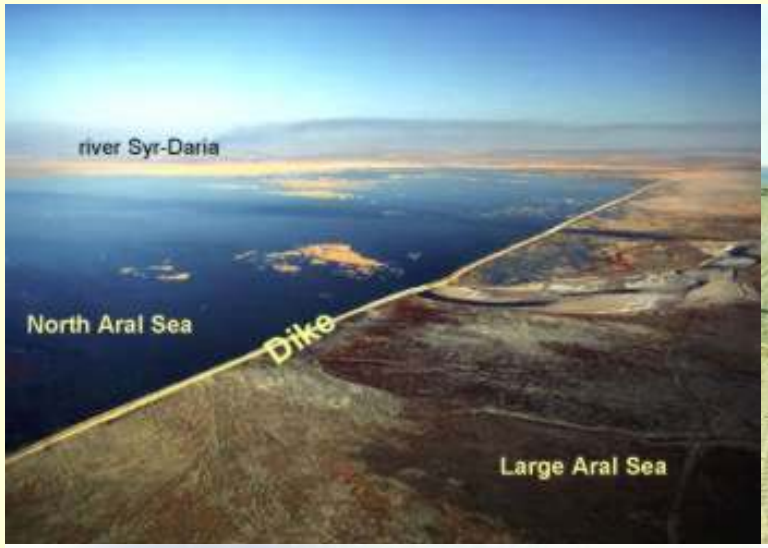




Dike in Berg strait is preserving Small (Northern) Aral and rehabilitating its biodiversity.

By: Aladin N.V., Plotnikov I.S., Potts W.T.W., 1995. The Aral Sea desiccation and possible ways of rehabilitation and conservation of its North part // Int. J. Environmetrics. Vol. 6: 17-29.

The first dike in Berg's strait was built in August 1992

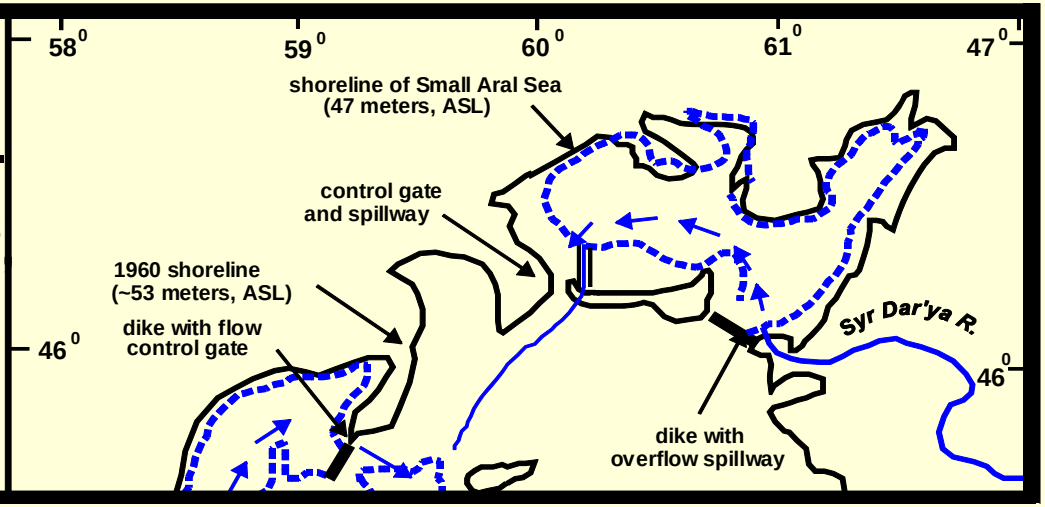


April 20, 1999, when level of Small Aral Sea increased by more than 3 m and reached +43.5 m, storm destroyed the dike.

Russian company “Zarubezhvodstroy” made new dike in Berg strait. It was completed in autumn 2005.

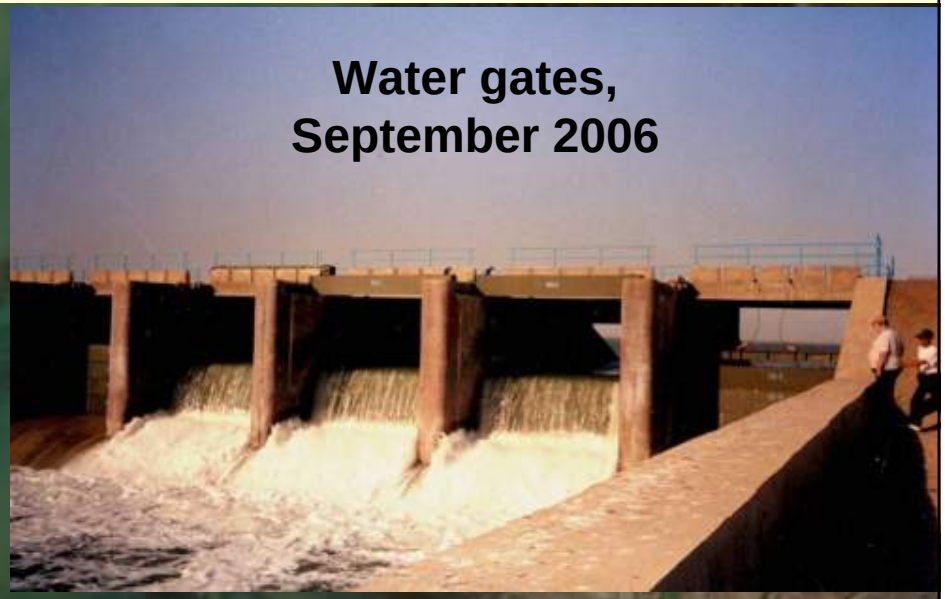
Small Aral Sea

level 47 m, area 4310 km^2, vol. 46.5 km^3, river inflow 4.5 km^3, outflow toward L. Aral 1.4 km^3, salinity 7.6 g/l (?), start date for project - 2004



Unfortunately level of Small Aral reached only +42.5 m, and not 47 m as it is shown above. Discharge from Small Aral to Large Aral will be not through former Auzy-Kokaral strait, but via former Berg strait. Small Aral area will be 3382 km^2, volume 29.5 km^3, inflow from Syr Darya 3.5 km^3/year, outflow via Berg strait 1.15 km^3.

New dike built by Russian company “Zarubezhvodstroy”



Water gates,
September 2006

Kok-Aral
Dam

Zooplankton of Small Aral Sea after its separation and now

(only common species)

1989

Rotatoria

Synchaeta vorax

S. cecilia

Copepoda

Calanipeda aquaedulcis

Halicyclops rotundipes aralensis

Bivalvia Larvae

Syndosmya segmentum

Cerastoderma isthmicum

2007

Rotatoria

Synchaeta vorax

S. cecilia

Cladocera

Podonevadne camptonyx

Evadne anonyx

Copepoda

Calanipeda aquaedulcis

Halicyclops rotundipes aralensis

Bivalvia Larvae

Syndosmya segmentum

Cerastoderma isthmicum

Zoobenthos of Small Aral Sea after its separation and now

(only common species)

1989

Bivalvia

Syndosmya segmentum

Cerastoderma isthmicum

Gastropoda

***Caspiohydrobia* spp.**

Polychaeta

Hediste diversicolor

Ostracoda

Cyprideis torosa

Decapoda

Palaemon elegans

2007

Bivalvia

Syndosmya segmentum

Cerastoderma isthmicum

Gastropoda

***Caspiohydrobia* spp.**

Theodoxus pallasi ?

Polychaeta

Hediste diversicolor

Ostracoda

Cyprideis torosa

Eucypris inflata

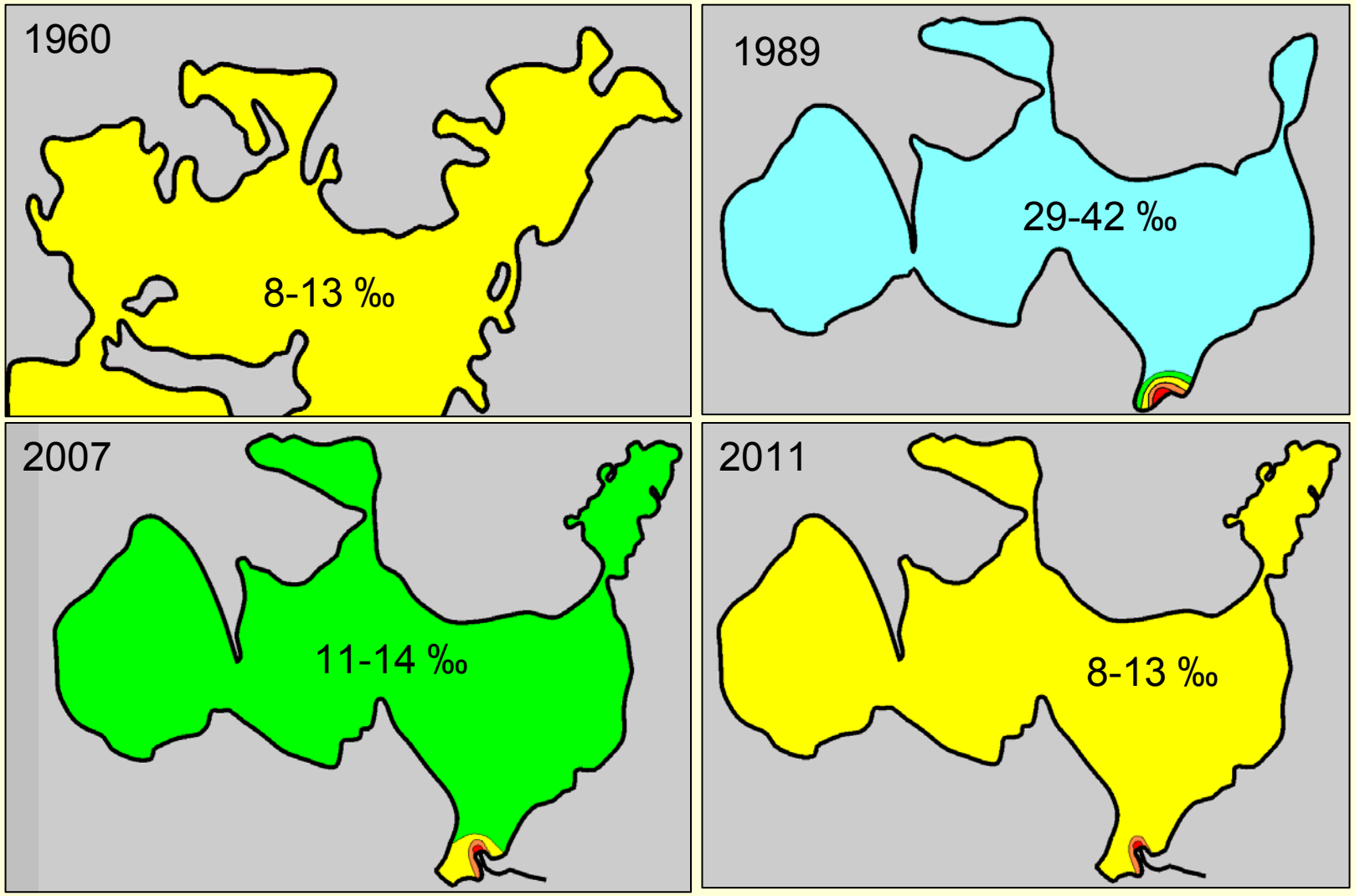
Decapoda

Palaemon elegans

Insecta

***Chironomidae* larvae**

Dike in Berg's strait funded by GEF and Kazakhstan government allowed to improve brackish water environment of Small (Northern) Aral Sea

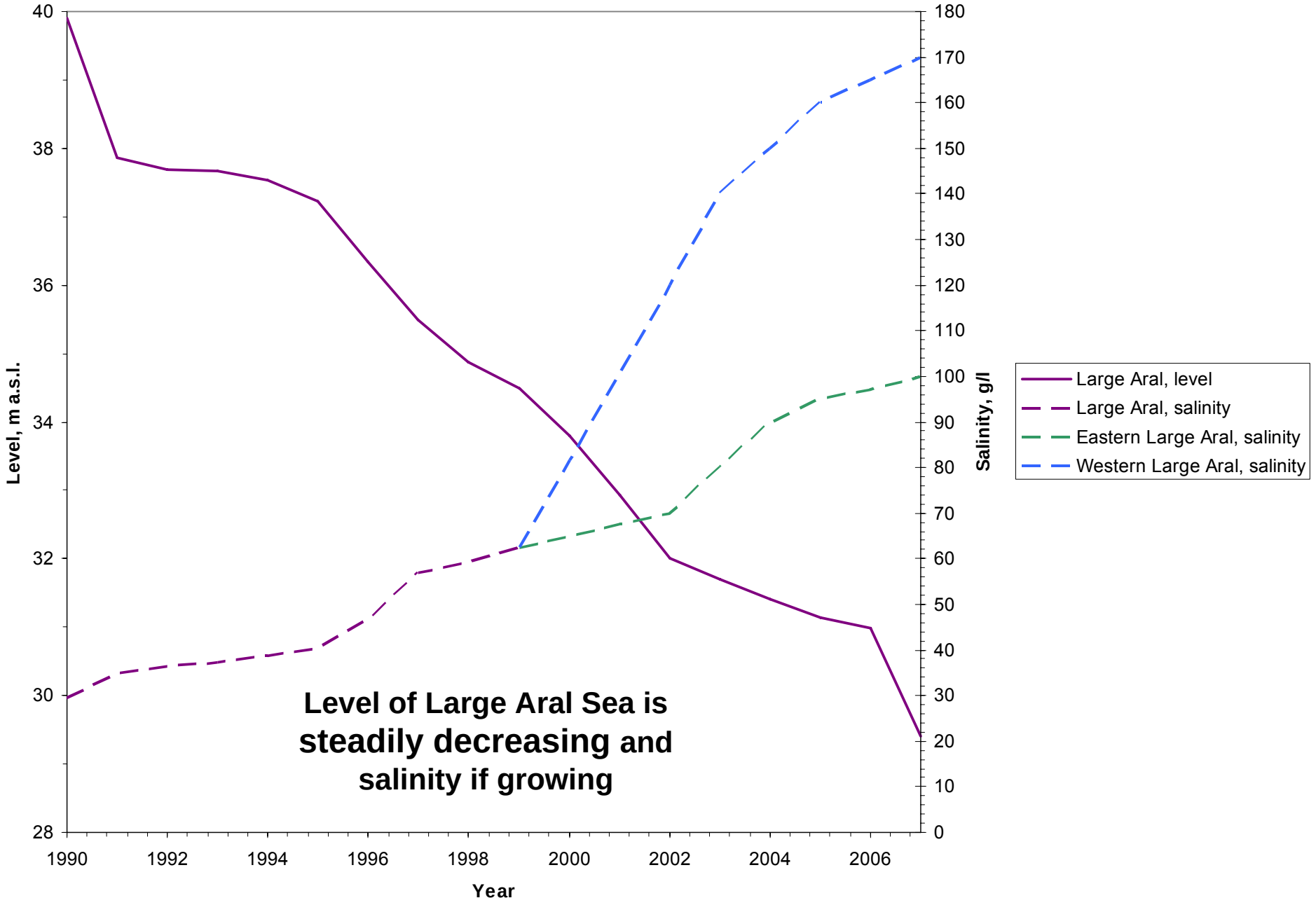


- Dike in Berg's strait allowed increase of level in Small (Northern) Aral Sea to +42 m a.s.l. with "forcing" to 42.5 m.
- Present average salinity in Small (Northern) Aral Sea is about 16-17 g/l. In the nearest future it will reach 8-13 g/l.
- For further improvement of situation there are needed improvements in irrigation efficiency to raise inflow from Syr Dar'ya.
- It is possible to make the present dike a bit higher and raise the level to +45 m a.s.l. This will allow to enlarge the volume and area of Small (Northern) Aral Sea.

Large Aral Sea

- After Aral Sea division in 1989 the water balance of Large Aral, into which Amu Darya inflows but which runoff practically does not reach this part of earlier single water body, is negative, level is quickly decreasing and water salinity continues to grow. By the end of 1990s separated Large Aral Sea turned into hyperhaline water body.
- In 1999 due to its level fall Large Aral has divided into deep-water Western Large Aral and shallow and more fast salinizing Eastern Large Aral.
- After 2005 Tschebas Bay separated from Large Aral Sea.
- Eastern Large Aral possibly will be desiccated completely in 2010.

Level and salinity of Large Aral Sea



Zooplankton of Large Aral Sea after its separation and now

(only common species)

1989

Rotatoria

Synchaeta vorax

S. cecilia

Copepoda

Calanipeda aquaedulcis

Halicyclops rotundipes aralensis

Larvae Bivalvia

Syndosmya segmentum

Cerastoderma isthmicum

2007

Only Western Large Aral:

Infusoria

Fabrea salina

Rotatoria

Brachionus plicatilis

Hexarthra fennica

Cladocera

Moina mongolica

Copepoda

Apocyclops dengizicus

Branchiopoda

Artemia parthenogenetica

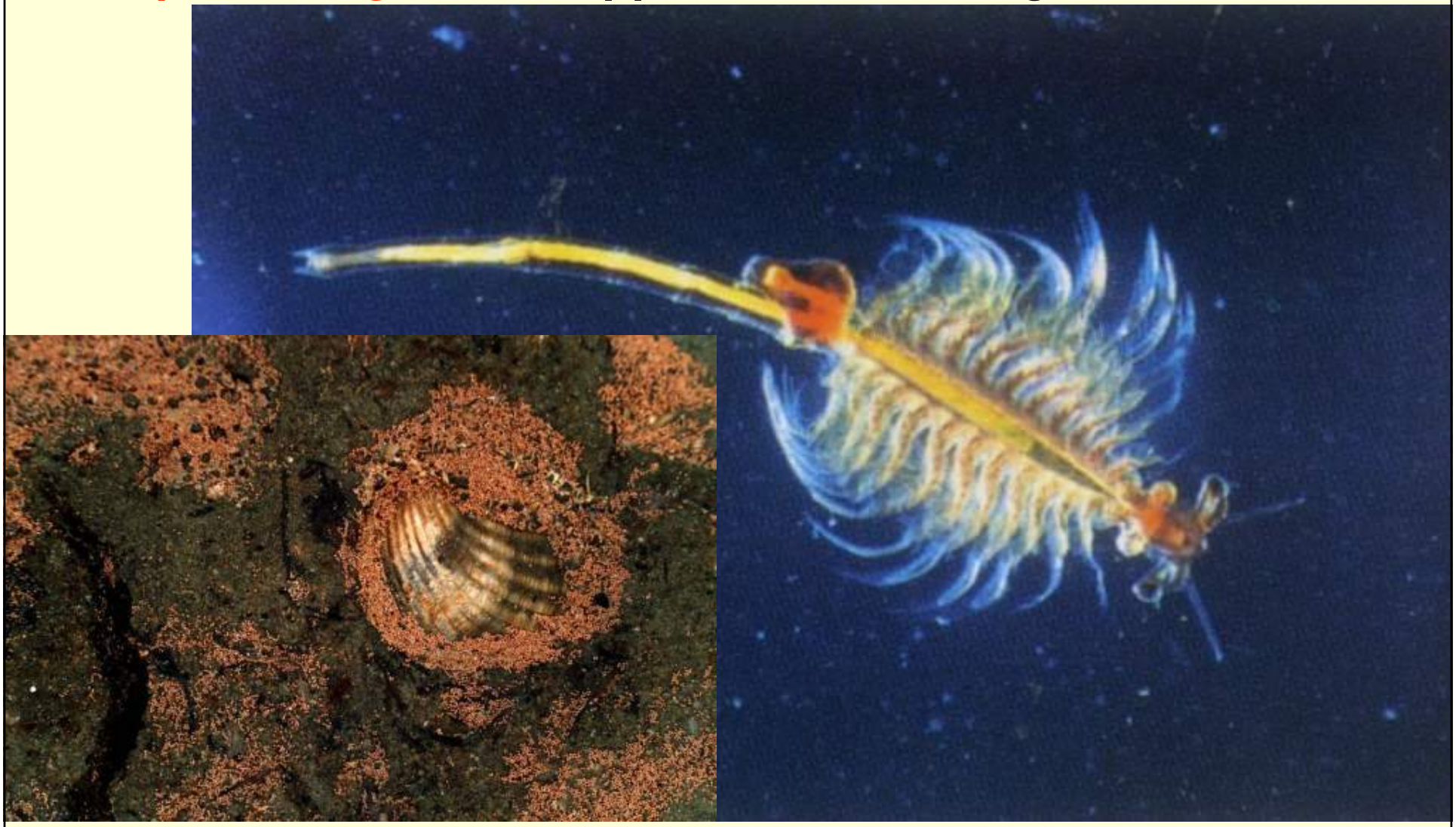
Western Large Aral:

Branchiopoda

Artemia parthenogenetica

In Tsche-Bas Bay zoobenthos resembles that of the Western Large Aral Sea

At the end of 20th century brine shrimp *Artemia parthenogenetica* appeared in the Large Aral Sea.



In 2002-2005 there was preparation to industrial harvesting of cysts under aegis of international company INVE Aquaculture, but in 2005 the company postponed activities.

Zoobenthos of Large Aral Sea after its separation and now

(only common species)

1989

Bivalvia

Syndosmya segmentum

Cerastoderma isthmicum

Gastropoda

Caspiohydrobia spp.

Polychaeta

Hediste diversicolor

Ostracoda

Cyprideis torosa

Decapoda

Palaemon elegans

Rhithropanopeus harrisii tridentata

2007

Only Western Large Aral:

Infusoria

Frontonia marina ?

Turbellaria

Mecynostomum agile ?

Gastropoda

Caspiohydrobia spp.

Ostracoda

Cyprideis torosa

Eucypris inflata

Insecta

Chironomidae gen. sp.

In Tsche-Bas Bay zoobenthos resembles that of the Western Large Aral Sea

Changes in the invertebrates fauna of the Large Aral Sea due to its transformation into hyperhaline water body

- *Synchaeta* spp.
  – is extinct since1997
- *Calanipeda aquaedulcis*
  – is extinct since1997
- *Nereis diversicolor*
  – is extinct since 2001
- *Cerastoderma isthmicum*
  – is extinct since 2001
- *Abra ovata*
  – is extinct since 2002
- *Artemia parthenogenetica*
  – appeared in 1998
- *Moina mongolica*
  – reappeared in 1996
- *Apocyclops dengizicus*
  – appeared in 2004
- *Hexarthra fennica*
  – became common species
- *Brachionus plicatilis*
  – became common species

- Together with transformation of Large Aral Sea into hyperhaline water body after its separation from Small Aral Sea its biodiversity has decreased due to disappearance of marine origin species in the end of 1990s and beginning of 2000s. This has occured, when salinity has reached 80-100 g/l.
- Into the Large Aral Sea from saline water bodies of Priaralye there were introduced by natural way some representatives hyperhaline fauna.

Conclusions

- Still prior to the beginning of anthropogenic regression and salinization of the Aral Sea its ecosystem has survived consequences of new species introductions.
- It is possible to distinguish 3 main stages of Aral Sea biodiversity decrease process in owing to its salinization:
  - in 1971-1976 when salinity has exceeded 12-14 g/l, brackish-water species of freshwater origin have disappeared;
  - in 1986-1989 when salinity has exceeded 23-25 g/l, brackish-water species of Caspian origin have disappeared;
  - in the end of 1990s and beginning of 2000s in the Large Aral Sea when its salinity has exceeded 80-100 g/l, species of marine origin have disappeared.
- After division Aral Sea in 1989 Small Aral has positive water balance and its salinity began to decrease. After construction of a new dike in Berg's strait there is possible recovering of biodiversity.
- Large Aral Sea having negative water balance continues to dry up and salinity is increasing; it has turned to the end of 1990s into hyperhaline water body. Recovering of its biodiversity is not a real possibility.


Thank you for your attention

- Разбить текстовые слайды где текст мелкий на несколько
- Заменить картинку на последнем
- Проверить язык
- Посмотреть и подумать, чем еще можно дополнить: картинки/диаграммы, текст.