

**Biodiversity loss in a saline lake
ecosystem:
Effects of introduced species and
salinization in the Aral Sea**

N. Aladin, I. Plotnikov, T. Ballatore
in co-operation with P. Micklin

Commonwealth of Independent States - Central Asian States



**Catchment area of the Aral Sea
is about 1500000 km²**

The Aral Sea was the 4th largest lake in the world according to surface in 1960 (comparative areas below in km²)



The Aral Sea map made by materials of A.I. Butakov expedition in 1848-1849

Parameters of the Aral Sea in the beginning of 20th century

- Area 67499 km²
Large Aral 61381 km²
Small Aral 6118 km²
- Volume 1089 km³
Large Aral 1007 km³
Small Aral 82 km³
- Level +53.4 m
- Maximal depth 69 m
- Salinity about 10 g/l
- The Aral Sea was inhabited by about 12 species of fishes and about 150 species of free-living invertebrates excluding Protozoa and small-size Metazoa

Butakov's map, 1848-1849

Intended introductions started in the 1920s of the following number of aboriginal free-living animals:

Fishes – 12

Coelenterata – 1

Turbellaria – 12

Rotatoria – 58

Oligohaeta – 10

Cladocera – 14

Copepoda – 7

Harpacticoida - 15

Ostracoda – 11

Malacostraca – 1

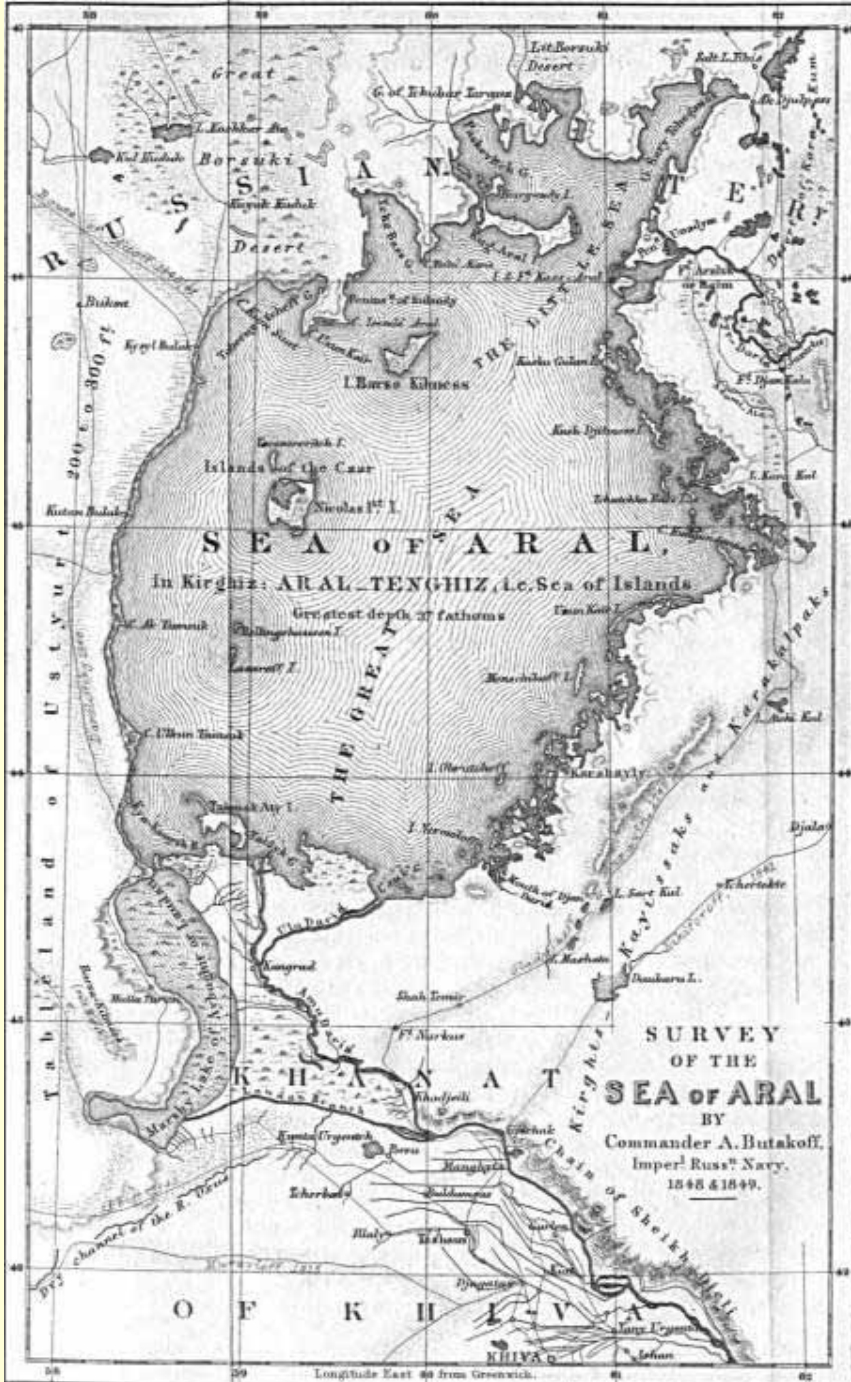
Hydracarina – 7

Bivalvia – 9

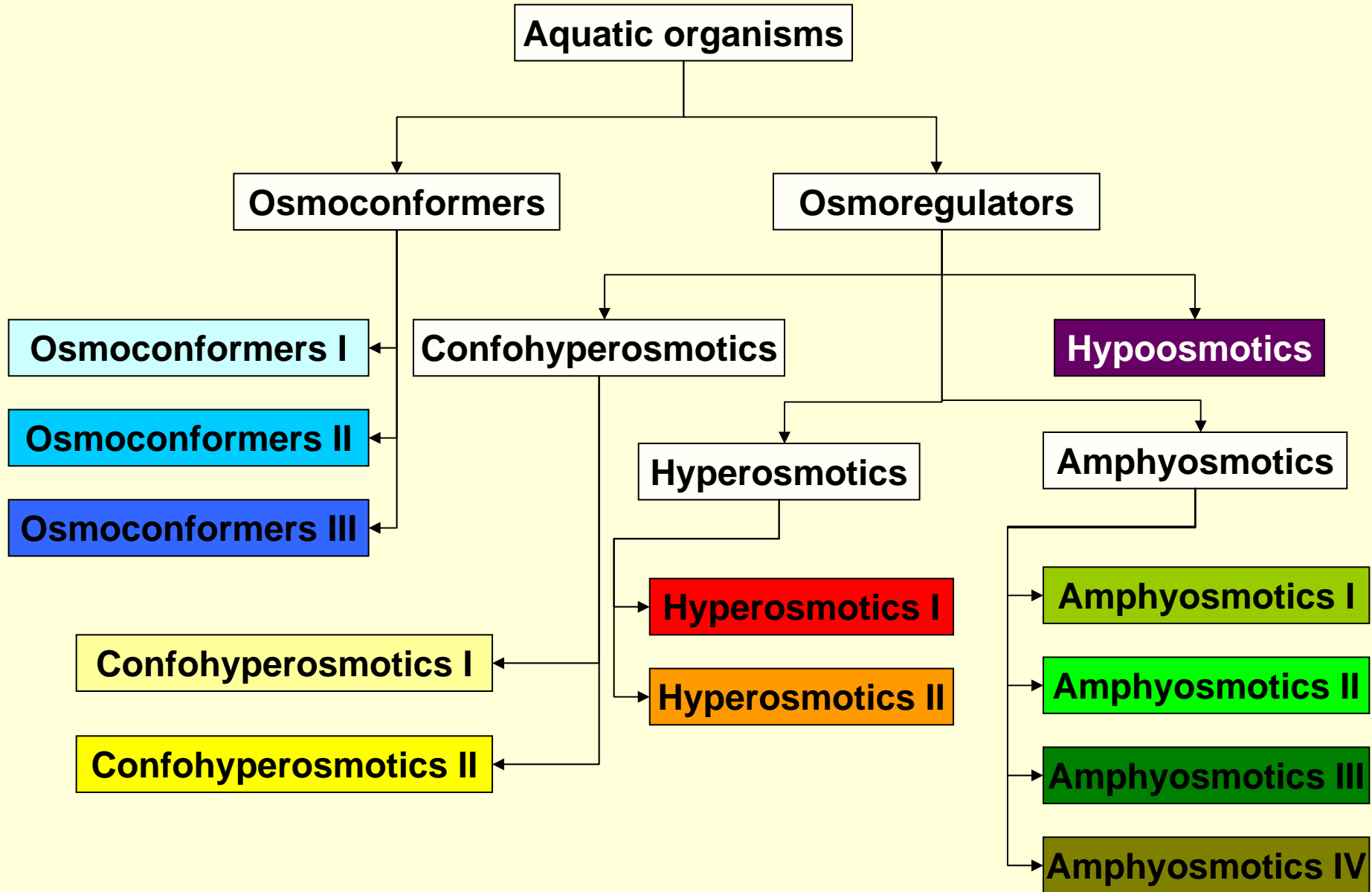
Gastropoda – 3

TOTAL: 160

Protozoa and some other small Metazoa are not included.



Classification of osmoconformers and osmoregulators



Free-living native species in the Aral Sea prior introductions

Species	Type of osmoregulation
Coelenterata	
<i>Protohydra leuckarti</i> Greef, 1970	A3
Turbellaria	
<i>Mecynostomum agile</i> (Beklemischev, 1927)	A3
<i>Macrostomum hystrixinum</i> Beklemischev, 1927	A3
<i>M. minimum</i> (Luther, 1947)	A3
<i>Promonotus orientalis</i> Beklemischev, 1927	A3
<i>Kirgisella forcipata</i> Beklemischev, 1927	A3
<i>Giteystoria bergi</i> (Beklemischev, 1927)	A3
<i>Byrsophlebs geniculata</i> Beklemischev, 1927	A3
<i>Beklemischeviella contorta</i> (Beklemischev, 1927)	A3
<i>Phonorhynchoides flagellatus</i> Beklemischev, 1927	A3
<i>Gyratrix hermaphroditus</i> Ehrenberg, 1831	A3
<i>Pontaralia relicta</i> (Beklemischev, 1927)	A3
<i>Placorhynchus octaculeatus</i> ssp. <i>dimorphis</i> Karling	A3
Nematodes	
<i>Adoncolaimus aralensis</i> Filipjev, 1923	C1
Rotatoria	
<i>Eosphora ehrenbergi</i> Weber, 1918	C1
<i>Trichocerca (Diurella) heterodactyla</i> Tschugunoff, 1921	C1
<i>T. (D.) similis</i> (Wierzejski, 1893)	C1
<i>T. (D.) porcellus</i> (Gosse, 1851)	C1
<i>T. (s. str.) elongata</i> (Gosse, 1896)	C1
<i>T. (s. str.) pusilla</i> (Lauterborn, 1898)	C1
<i>T. (s. str.) longiseta</i> (Schränk, 1802)	C1
<i>T. (s. str.) caspica</i> Tschugunoff, 1921	C1
<i>Synchaeta stylata</i> Wierzejski, 1893	C1
<i>S. vorax</i> Rousselet, 1902	C2
<i>S. tremula</i> (Müller, 1786)	C2
<i>S. pectinata</i> Ehrenberg, 1832	C1
<i>Polyarthra euryptera</i> Wierzejski, 1891	C1
<i>P. luminosa</i> Kutikova, 1962	C1
<i>P. vulgaris</i> Carlin, 1943	C1
<i>P. longiremis</i> Carlin, 1943	C1
<i>Lindia torulosa</i> Dujardin, 1841	C2
<i>Encentrum limicola</i> Otto, 1963	C2
<i>Asplanchna priodonta</i> Gosse, 1850	C1
<i>A. girodi</i> Guerne, 1888	C1
<i>Brachionus angularis</i> Gosse, 1851	C1
<i>B. calyciflorus</i> Pallas, 1776	C1
<i>B. quadridentatus</i> Hermann, 1783	C2
<i>B. plicatilis</i> Müller, 1786	C2
<i>B. rubens</i> Ehrenberg, 1838	C1
<i>B. urceus</i> (Linnaeus, 1758)	C1
<i>Platvias quadricornis</i> (Ehrenberg, 1832)	C1

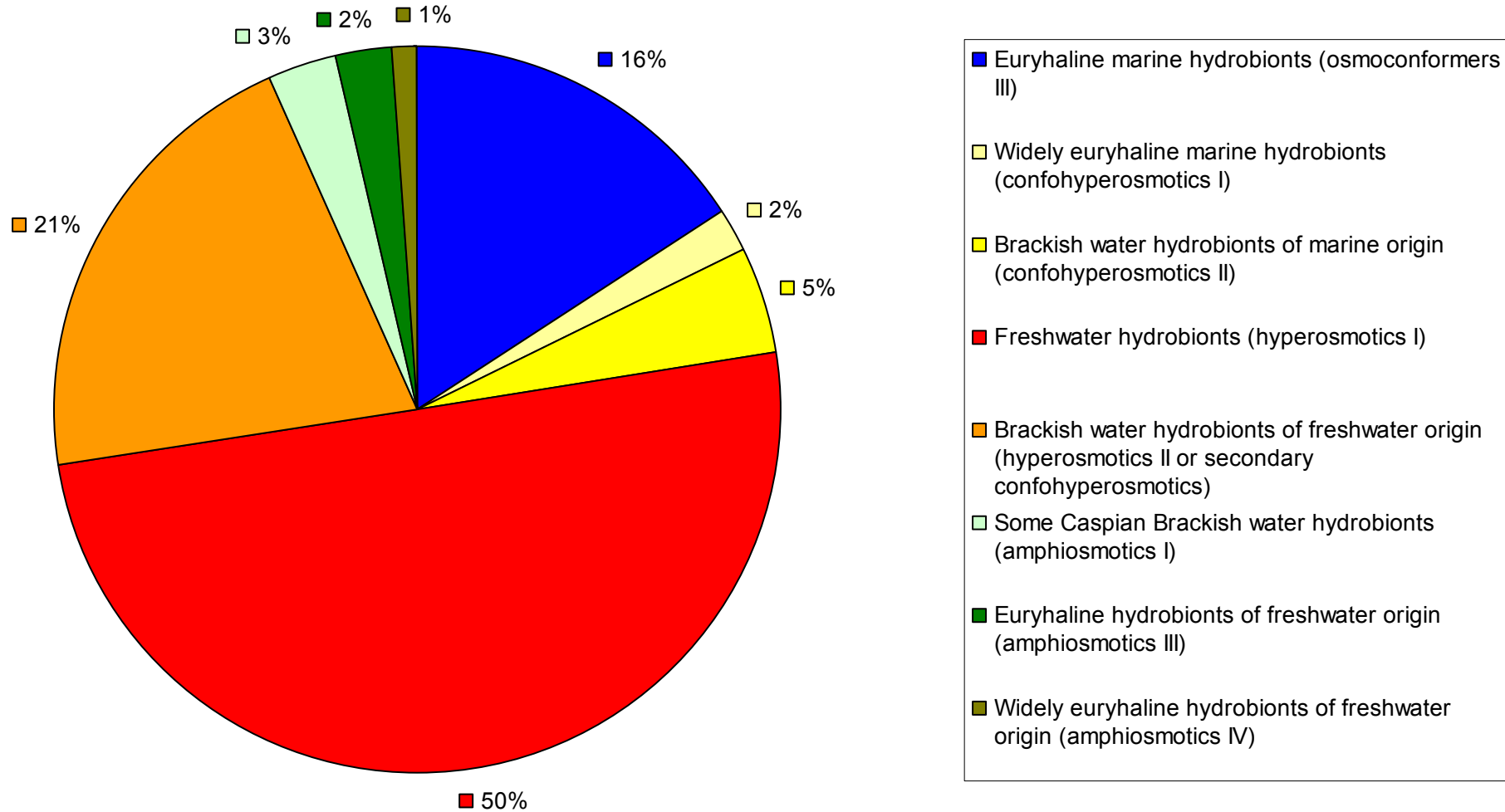
Species	Type of osmoregulation
<i>P. palustris</i> (Müller, 1786)	C1
<i>Keratella cochlearis</i> (Gosse, 1851)	C2
<i>K. tropica</i> (Apstein, 1907)	C2
<i>K. quadrata</i> (Müller, 1786)	C2
<i>K. valga</i> (Ehrenberg, 1834)	C2
<i>Notholca squamula</i> (Müller, 1786)	C2
<i>N. acuminata</i> (Ehrenberg, 1832)	C2
<i>Kellicottia longispina</i> (Kellicott, 1879)	C1
<i>Euchlanis dilatata</i> Ehrenberg, 1832	C1
<i>E. triquetra</i> Ehrenberg, 1838	C1
<i>Trichotria pocillum</i> (Müller, 1776)	C1
<i>T. tetractis</i> (Ehrenberg, 1830)	C1
<i>Mytilina ventralis</i> (Ehrenberg, 1832)	C1
<i>Lecane (Lecane) luna</i> (Müller, 1776)	C1
<i>L. (L.) ungulata</i> (Gosse, 1887)	C1
<i>L. (Monostyla) lamellata</i> (Daday, 1893)	C1
<i>L. (M.) stenroosi</i> (Meissner, 1908)	C1
<i>L. (M.) bulla</i> (Gosse, 1851)	C1
<i>L. (M.) lunaris</i> (Ehrenberg, 1832)	C1
<i>Colurella obtusa</i> (Gosse, 1886)	C1
<i>C. adriatica</i> Ehrenberg, 1831	C2
<i>C. uncinata</i> (Müller, 1773)	C1
<i>C. colurus</i> (Ehrenberg, 1830)	C2
<i>Hexarthra fennica</i> (Levander, 1892)	C2
<i>H. oxyuris</i> (Zernov, 1903)	C2
<i>H. mira</i> (Hudson, 1871)	C1
<i>Testudinella patina</i> (Hermann, 1783)	C2
<i>T. bidentata</i> (Ternetz, 1892)	C1
<i>Filinia longiseta</i> (Ehrenberg, 1834)	C1
<i>Collotheca mutabilis</i> (Hudson, 1885)	C1
Oligochaeta	
<i>Aeolosoma hemprichi</i> Ehrenberg, 1828	C1
<i>Nais elingius</i> Müller, 1773	C1
<i>N. communis</i> Piguet, 1906	C1
<i>Paranais simplex</i> Hrabec, 1936	C1
<i>Amphichaeta sannio</i> Kallstenius, 1892	C1
<i>Chaetogaster</i> sp.	C1
<i>Limnodrilus helveticus</i> Piguet, 1923	C1
<i>Potamothrix bavaricus</i> (Oeschmann, 1913)	C1
<i>Psammorhynchides albicola</i> (Michaelsen, 1901)	C1
<i>Lumbriculus lineatus</i> (Müller, 1771)	C1
Cladocera	
<i>Diaphanosoma brachyurum</i> Lievin, 1848	C1
<i>Chydorus sphaericus</i> (O. F. Müller, 1785)	C2

Free-living native species in the Aral Sea prior introductions

Species	Type of osmoregulation
<i>Alona rectangula</i> G. Sars, 1861	C2
<i>Bosmina longirostris</i> (O. F. Müller, 1785)	C2
<i>Daphnia longispina</i> (O. F. Müller, 1776)	C2
<i>Ceriodaphnia reticulata</i> (Jurine, 1820)	C2
<i>C. cornuta</i> G. Sars, 1885	C2
<i>C. pulchella</i> G. Sars, 1862	C2
<i>Moina mongolica</i> Daday, 1901	D4
<i>M. micrura</i> Kurz, 1874	C2
<i>Podonevadne camptonyx</i> (G. Sars, 1897)	D3
<i>P. angusta</i> (G. Sars, 1897)	D1
<i>Evadne anonyx</i> G. Sars, 1897	D1
<i>Cercopagis pengoi aralensis</i> M.-Boltovskoi, 1971	C2
Copepoda	
<i>Phyllodiaptomus blanci</i> (Guerne et Richard, 1896)	C1
<i>Arctodiaptomus salinus</i> (Daday, 1885)	B1
<i>Halicyclops rotundipes aralensis</i> Borutzky, 1971	B1
<i>Cyclops vicinus</i> Uljanin, 1875	C1
<i>Acanthocyclops viridis</i> (Jurine, 1820)	C1
<i>Mesocyclops leuckarti</i> (Claus, 1857)	C1
<i>Thermocyclops crassus</i> (Fischer, 1853)	C1
Harpacticoida	
<i>Halectinosoma abrau</i> (Kritchagin, 1873)	B2
<i>Schizopera aralensis</i> Borutzky, 1971	B2
<i>S. jugurtha</i> (Blanchard et Richard, 1891)	B2
<i>S. reducta</i> Borutzky, 1971	B2
<i>Nitocra lacustris</i> (Schmankewitsch, 1875)	A3
<i>N. hibernica</i> (Brady, 1880)	C1
<i>Mesochra aestuarii</i> Gurney, 1921	B2
<i>Onychocamptus mohammed</i> (Blanchard et Richard, 1891)	B2
<i>Cletocamptus retrogressus</i> Schmankewitsch, 1875	A3
<i>C. confluens</i> (Schmeil, 1894)	A3
<i>Limnocletodes behningi</i> Borutzky, 1926	C2
<i>Nannopus palustris</i> Brady, 1880	B2
<i>Enchyrosoma birsteini</i> Borutzky, 1971	A3
<i>Leptocaris brevicornis</i> (Van Douwe, 1905)	B2
<i>Paraleptastacus spinicauda</i> Noodt, 1954	A3
Ostracoda	
<i>Darwinula stevensoni</i> (Brady et Robertson, 1870)	C2
<i>Candona marchica</i> Hartwig, 1899	C1
<i>Cyclocypris laevis</i> (O. F. Müller, 1776)	C2
<i>Plesiocypris newtoni</i> (Brady et Robertson, 1870)	C1
<i>Cyprideis torosa</i> (Jones, 1850)	D4
<i>Amnicythère cymbula</i> (Livental, 1929)	D1
<i>Tyrrhenocythere amnicola donetziensis</i> (Dubowsky, 1926)	D1
<i>Limnocythere (Limnocythere) dubiosa</i> Daday, 1903	
<i>L. (L.) inopinata</i> (Baird, 1850)	C2

Species	Type of osmoregulation
<i>L. (Galolimnocythere) aralensis</i> Schornikov, 1973	D1
<i>L. (Loxocaspia) immodulata</i> (Stepanaitys, 1958)	
Malacostraca	
<i>Dikerogammarus aralensis</i> (Uljanin, 1875)	B1
Hydracarina	
<i>Eylais rimosa</i> Piersig, 1899	C1
<i>Hydriphantes s. str. crassipalpis</i> Köenike, 1914	C1
<i>H. (Polyhydriphantes) flexuosus</i> (Köenike, 1885)	C1
<i>Hydrodroma despiciens</i> (O. Müller)	C1
<i>Limnesia undulata</i> (O. F. Müller)	C1
<i>Arrenurus s. str. tricuspikator</i> (O. F. Müller)	C1
<i>Copidognathus (s. str.) oxianus</i> Viets, 1928	C1
Bivalvia	
<i>D. polymorpha aralensis</i> (Andrusov, 1897)	C2
<i>D. p. obtusicarinata</i> (Andrusov, 1897)	C2
<i>D. caspia caspia</i> Eichwald, 1829	C2
<i>D. c. pallasi</i> (Andrusov, 1897)	C2
<i>Cerastoderma rhomboides rhomboides</i> (Lamarck)	A3
<i>C. isthmicum</i> Issel	A3
<i>H. vitrea bergi</i> Starobogatov, 1971	A3
<i>H. minima sidorovi</i> Starobogatov, 1971	A3
<i>H. m. minima</i> (Ostroumoff, 1907)	A3
Gastropoda	
<i>Theodoxus pallasi</i> Lindholm, 1924	A3
<i>Caspiohydrobia conica</i> (Logvinenko et Starobogatov, 1968)	A3
<i>C. husainovae</i> Starobogatov, 1971	A3
Pisces	
<i>Cyprinus carpio</i> Linnaeus, 1758	C1
<i>Rutilus rutilus aralensis</i> Berg	C1
<i>Abramis brama orientalis</i> Berg	C1
<i>Abramis sapa bergi natio aralensis</i> Tjapkin	C1
<i>Aspius aspius taeniatus</i> (Eichwald)	C1
<i>Barbus brachycephalus brachycephalus</i> Kessler, 1872	C1
<i>Capoetobrama kuschakewitschi</i> (Kessler)	C1
<i>Pelecus cultratus</i> (Linnaeus, 1758)	C1
<i>Scardinius erythrophthalmus</i> (Linnaeus, 1758)	C1
<i>Esox lucius</i> Linnaeus, 1758	C1
<i>Silurus glanis</i> Linnaeus, 1758	C1
<i>Gymnocephalus cernuus</i> (Linnaeus, 1758)	C1
<i>Perca fluviatilis</i> Linnaeus, 1758	C1
<i>Zander lucioperca</i> (Linnaeus, 1758)	C1
<i>Chalcalburnus chalcoides aralensis</i> (Berg)	C1
<i>Salmo trutta aralensis</i>	D3
<i>Pungitius platygaster aralensis</i> (Kessler)	D3
<i>Acipenser nudiventris</i> Lovetzky, 1828	D3

Native aquatic animal species with the different types of osmoconformity and osmoregulation in the Aral Sea



1964



Between the middle of the 19th century and 1961 shape and salinity of the Aral Sea practically didn't change. We must note, however, that due to intended and accidental introductions, that started in the 1920s, the number of free-living animals grew substantially.

In the Aral Sea appeared:

Fishes – 17

Mysidacea – 5

Decapoda – 2

Copepoda – 1

Polychaeta – 1

Bivalvia - 1

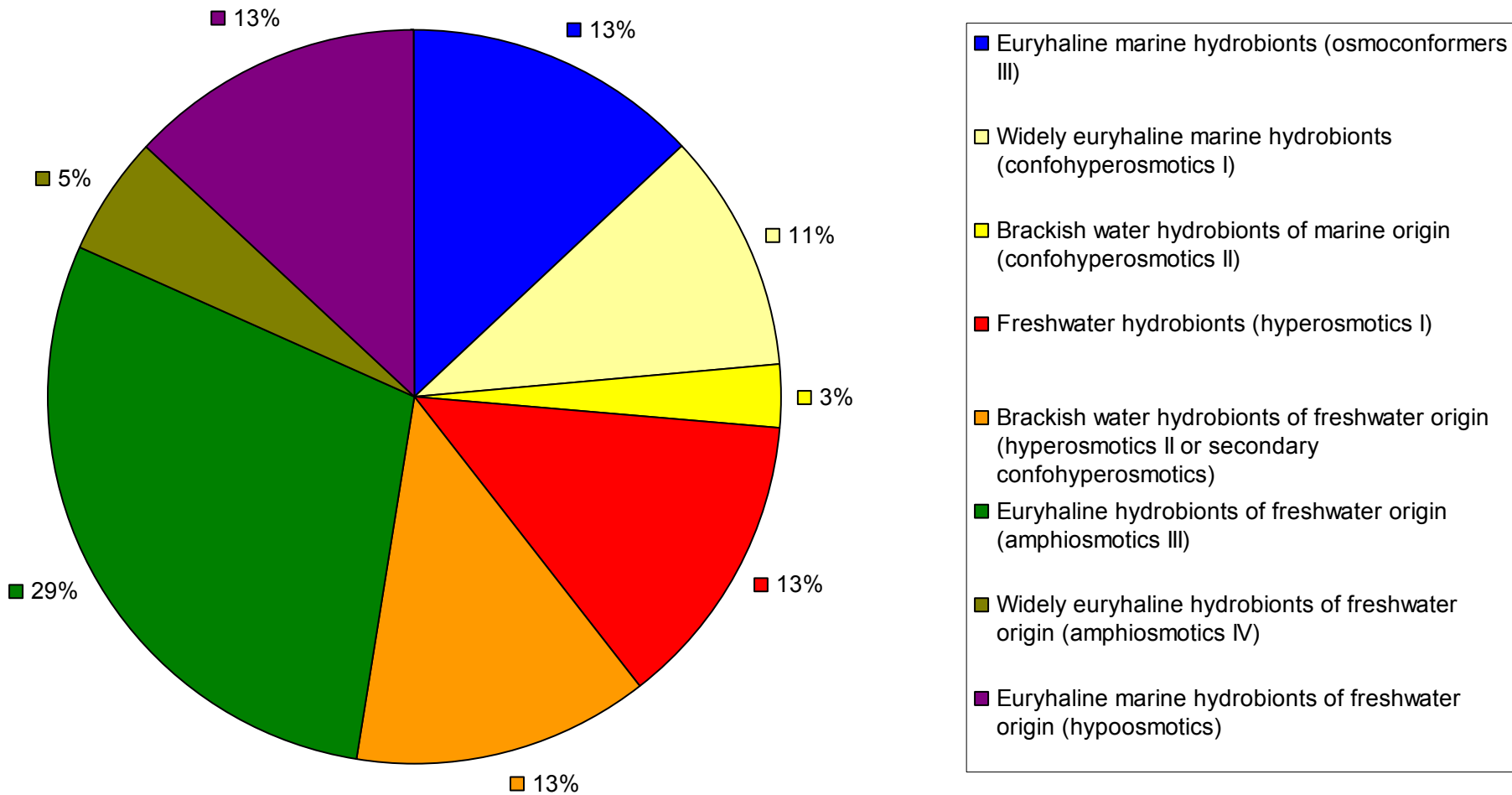
TOTAL: 27

Alien species in the Aral Sea

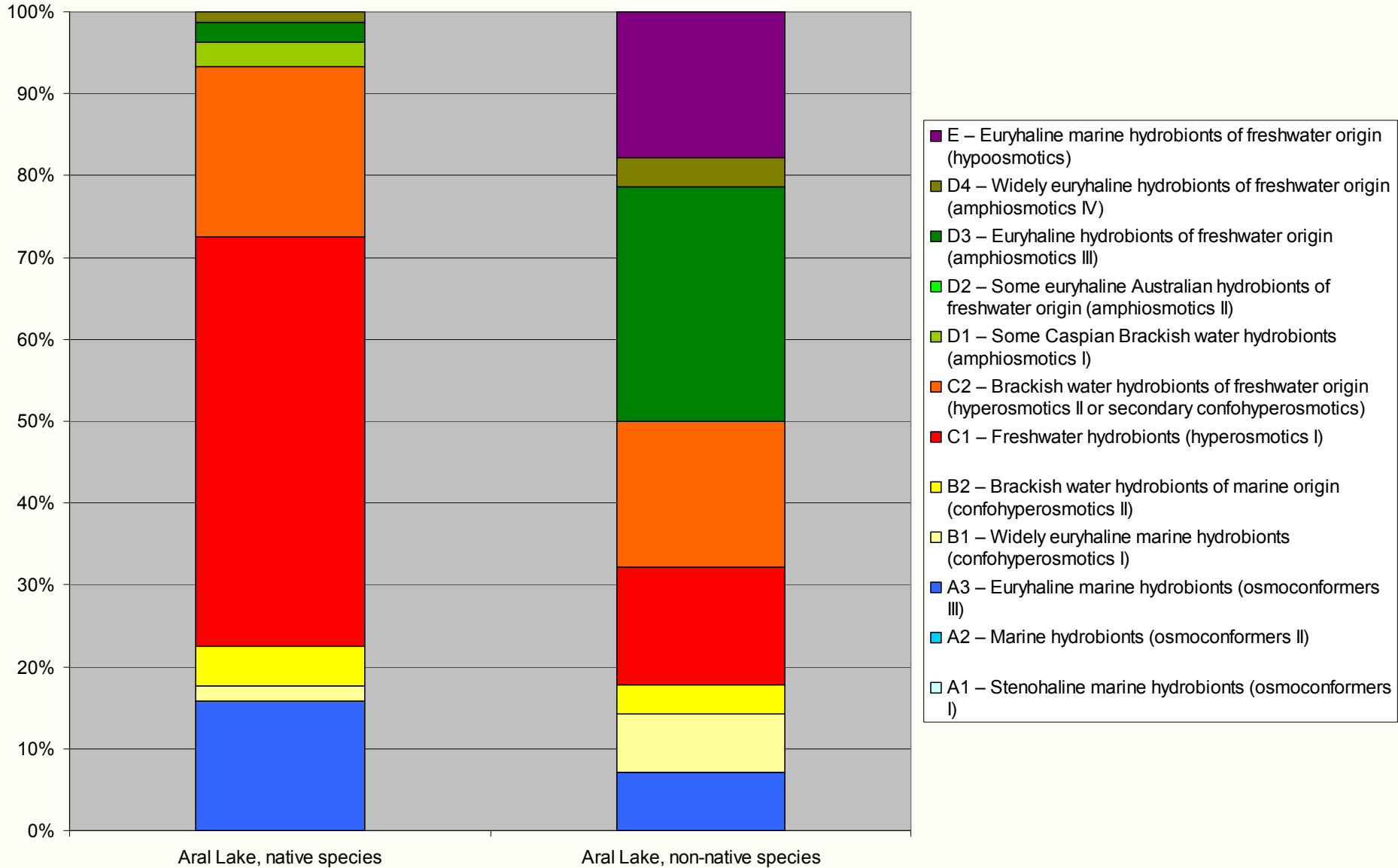
No	Taxon	Source	Year(s) of introduction	Year of first finding	Status after introduction	Status in the 1990s	Ecological status	Way of introduction	Impact	Type of osmoregulation
Pisces										
1	<i>Alosa caspia</i> (Eichwald, 1838)	Caspian	1929—1932	-	-	-	N	A	0	D3
2	<i>Acipenser stellatus</i> Pallas, 1771	Caspian	1927—1934; 1948-1963	1958	-	-	N	A	0	D3
3	<i>Acipenser nudiventris derjavini</i> Borzenko, 1950	Ural River	1958	-	-	-	N	A	-	D3
4	<i>Acipenser guldenstadti</i> Brandt et Ratzeburg, 1833	?	1978-1980	1981	Rare	-	N	A	0	D3
5	<i>Clupea harengus membras</i> (Linnaeus, 1758)	Baltic Sea	1954-1959	1957	Rare	?	N	A	+	E
6	<i>Liza auratus</i> (Risso, 1810)	Caspian	1954-1956	-	-	-	N	A	0	E
7	<i>Liza saliens</i> (Risso, 1810)	Caspian	1954-1956	-	-	-	N	A	0	E
8	<i>Ctenopharyngodon idella</i> (Valenciennes, 1844)	China	1960-1961	1963	Commercial	-	N	A	+	C1
9	<i>Hypophthalmichthys molitrix</i> (Valenciennes, 1844)	China	1960-1961	1963	Commercial	-	N	A	+	C1
10	<i>Aristichthys nobilis</i> (Richardson, 1844)	China	1960-1961	?	Rare	-	N	A	+	C1
11	<i>Platichthys flesus</i> (Linnaeus, 1758)	Sea of Azov	1979-1987	1981	Commercial	Commercial	N	A	+	E
12	<i>Mylopharyngodon piceus</i> (Richardson, 1845)	China	1960—1961	1963	Commercial	-	N	A+	0	C1
13	<i>Syngnatus abaster caspius</i> Eichwald	Caspian	1954—1956	?	Rare	-	N	A+	-	E
14	<i>Atherina boyeri caspia</i> Eichwald, 1838	Caspian	1954—1956	1959	Numerous	Rare	N	A+	-	E
15	<i>Knipowitschia caucasicus</i> (Berg, 1916)	Caspian	1954—1956	1958	Numerous	?	N	A+	-	D3
16	<i>Neogobius fluviatilis</i> (Pallas, 1811)	Caspian	1954—1956	1958	Numerous	?	N	A+	-	D3
17	<i>Neogobius melanostomus</i> (Pallas, 1811)	Caspian	1954—1956	1959	Numerous	-	N	A+	-	D3
18	<i>Neogobius syрман</i> (Nordmann, 1840)	Caspian	1954—1956	1959	Rare	-	N	A+	-	D3
19	<i>Proterorhynchus marmoratus</i> (Pallas, 1811)	Caspian	1954—1966	1959	Rare	?	N	A+	-	D3
20	<i>Neogobius kessleri</i> (Gunter, 1861)	Caspian	1954—1956	1959	Rare	-	N	A+	-	D3
21	<i>Ophicephalus(Channa) argus</i> Cantor, 1842	Kara-Kum canal	1960s	1965	Commercial	Commercial in deltas	N	A+	+	C1
Monogenea										
22	<i>Nitzschia sturionis</i> (Abilgaard, 1794)	Caspian	1927—1934	?	Numerous	-	Pa	A+	-	
Coelenterata										
23	<i>Polypodium hydriforme</i> Ussov, 1885	Caspian	1927—1934	?	Numerous	-	Pa	A+	-	
Mysidacea										
24	<i>Paramysis baeri</i> (Czerniavsky, 1882)	River Don	1958—1960	-	?	-	N-B	A	0	C2
25	<i>Paramysis lacustris</i> (Czerniavsky, 1882)	River Don	1958—1960	1961	Numerous	In deltas	N-B	A	+	C2
26	<i>Paramysis intermedia</i> (Czerniavsky, 1882)	River Don	1958—1960	1961	Numerous	-	N-B	A	+	C2
27	<i>Paramysis ullskyi</i> (Czerniavsky, 1882)	River Don	1958—1960	1963	Rare	-	N-B	AC	+	C2
28	<i>Limnomysis benedeni</i> (Czerniavsky, 1882)	?	?	1975	Rare	-	N-B	AC	+	C2
Decapoda										
29	<i>Palaemon elegans</i> Rathke, 1837	Caspian	1954—1966	1957	Numerous	Numerous	N-B	A+	?	B1
30	<i>P. adspersus</i> Rathke, 1837	Caspian	1954—1966	-	?	-	N-B	A+	?	B1
31	<i>Rhithropanopeus harrisi tridentata</i> (Maitland, 1874)	Sea of Azov	1965, 1966,	1976	Numerous	Numerous	B	A+	+	B2
Copepoda										
32	<i>Calanipeda aquaedulcis</i> Kritschagin, 1873	Sea of Azov	1965, 1966/1970	1970	Numerous	Numerous	P	A	+	B1
33	<i>Heterocope caspia</i> Sars, 1897	?	1971	-	-	-	P	A	0	
34	<i>Acartia clausi</i> Giesbrecht, 1889	?	1985, 1986	-	-	-	P	A	0	B1
Polychaeta										
35	<i>Hediste diversicolor</i> (Müller, 1776)	Sea of Azov	1960—1961	1963	Numerous	Numerous	B	A	+	A3
Bivalvia										
36	<i>Abra ovata</i> (Philippi, 1893)	Sea of Azov	1960, 1961, 1963	1967	Numerous	Numerous	B	A	+	A3
37	<i>Monodacna colorata</i> (Eichwald, 1839)	?	1964, 1965	-	-	-	B	A	0	A3
38	<i>Mytilus galloprovincialis</i> Lamarck, 1819	Sea of Azov	1984-1986	-	-	-	B	A	0	A3
39	<i>Mya arenaria</i> Linnaeus, 1758	Sea of Azov	1984-1986	-	-	-	B	A	0	A3

Way of introduction: A – acclimatization, AC – by accident, A+ - incidentally at planned introduction; Ecological status: N – nekton, B – benthos, N-B – nektobenthos, P – plankton, Pa – parasite; Impact: -, negative, +, positive, 0, no effect, ?, unknown

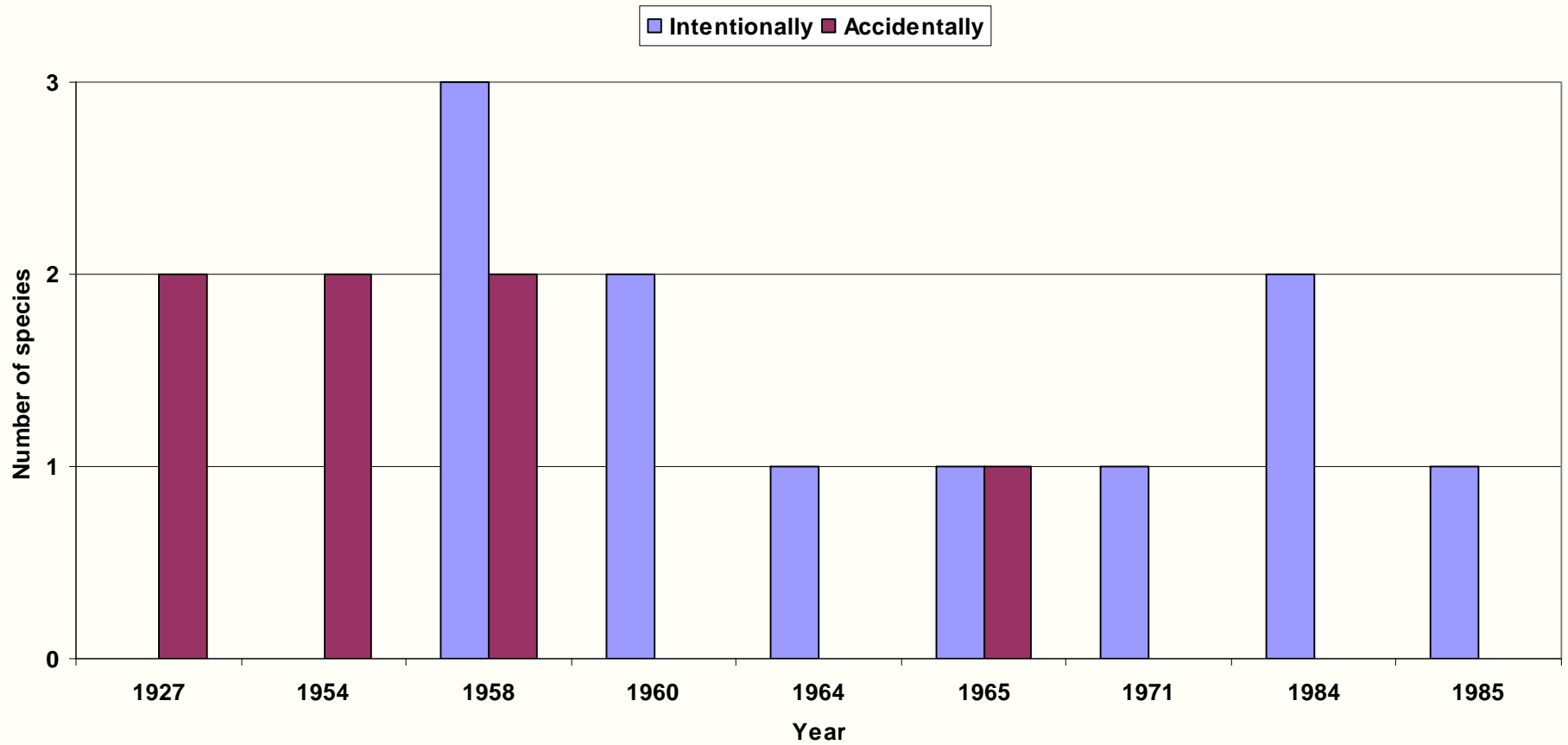
Alien aquatic animal species with the different types of osmoconformity and osmoregulation in the Aral Sea



Percentage of different types of osmoconformers and osmoregulators

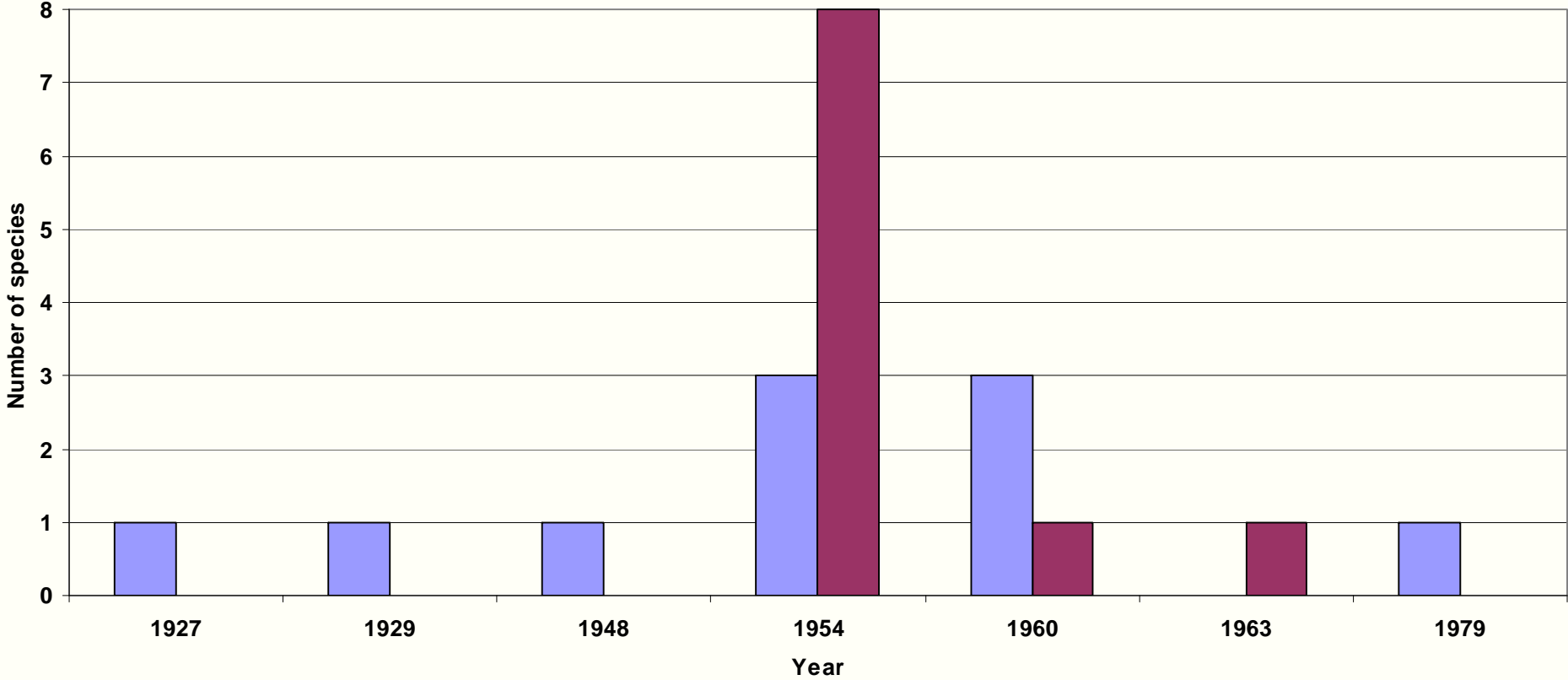


Number of invertebrate species introduced by man



Number of fish species introduced by man

Intentionally Accidentally



Abra ovata



***Abra* and *Nereis* introduced by man are of great importance for flounder nutrition.**

Nereis diversicolor

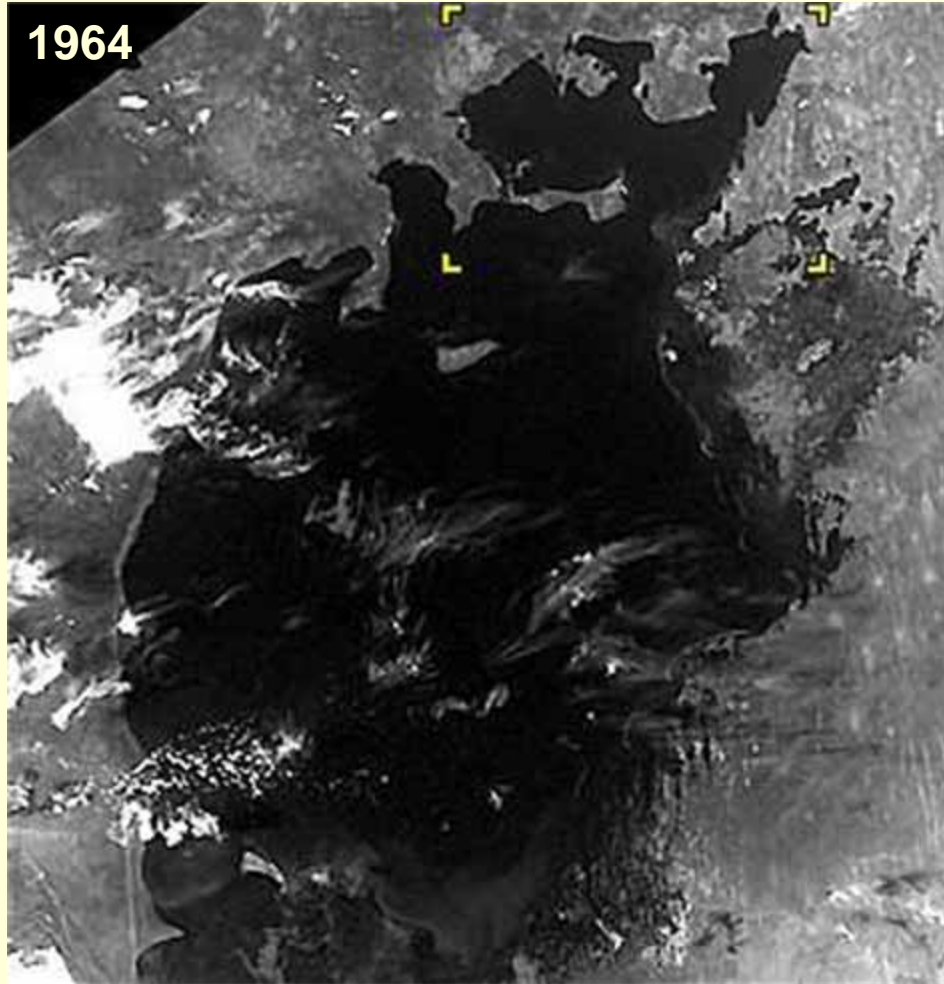


***Rithropanopeus* was introduced accidentally and disturbs lake sediments.**



Rithropanopeus harrisi tridentata

Since 1960 the Aral Sea has steadily shrunk and shallowed owing overwhelmingly to irrigation withdrawals from its influent rivers (Amu Dar'ya and Syr Dar'ya)

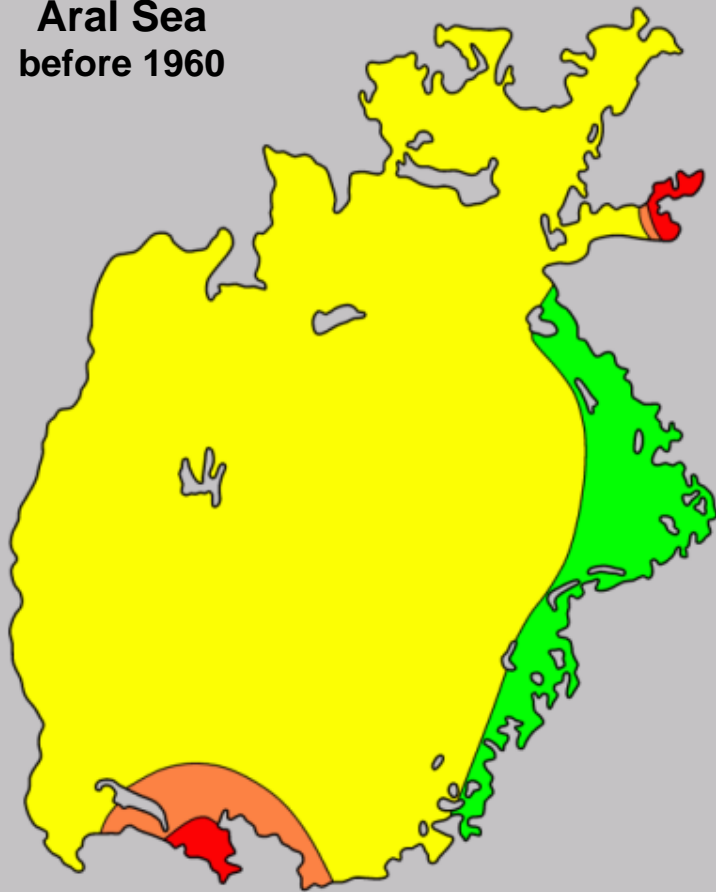


**Jan. 1 2007: Aral area – 14000 km² (21%), volume – 102 km³ (9%);
the Large Aral – 10700 km² (17%), 75 km³ (8%), salinity >90 g/l;
the Small Aral – 3258 km² (53%), 27 km³ (23%), salinity about 13 g/l.**

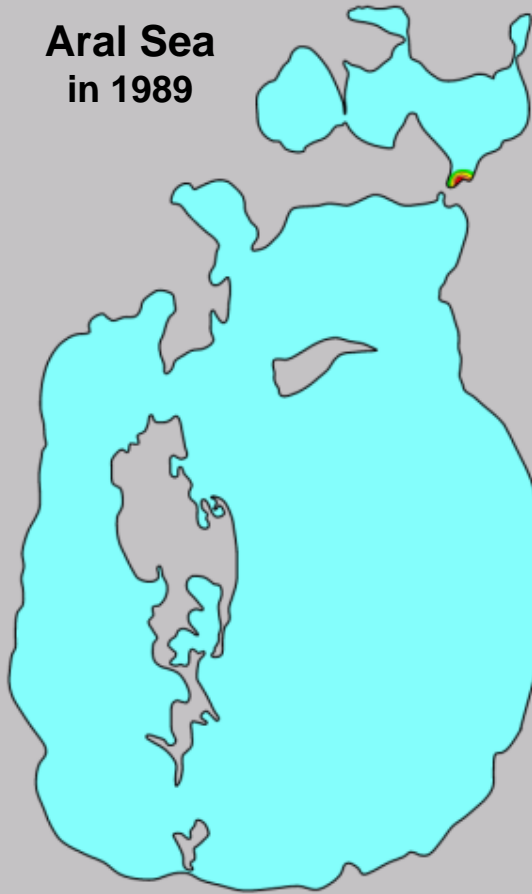
Following main principles of conception of relativity and plurality of salinity barrier zones (Aladin, 1986, 1988; Aladin, Plotnikov, 2007) the following salinity zones were suggested for oceanic, Caspian and Aral waters.

Ecosystems	Salinity range
Basic freshwater	0-3 ‰
Transitional freshwater-brackishwater	3-8 ‰
Basic brackishwater	8-13 ‰
Transitional brackishwater-marine	13-29 ‰
Basic marine	29-42 ‰
Transitional marine-hyperhaline	42-51 ‰
Basic hyperhaline	> 51 ‰

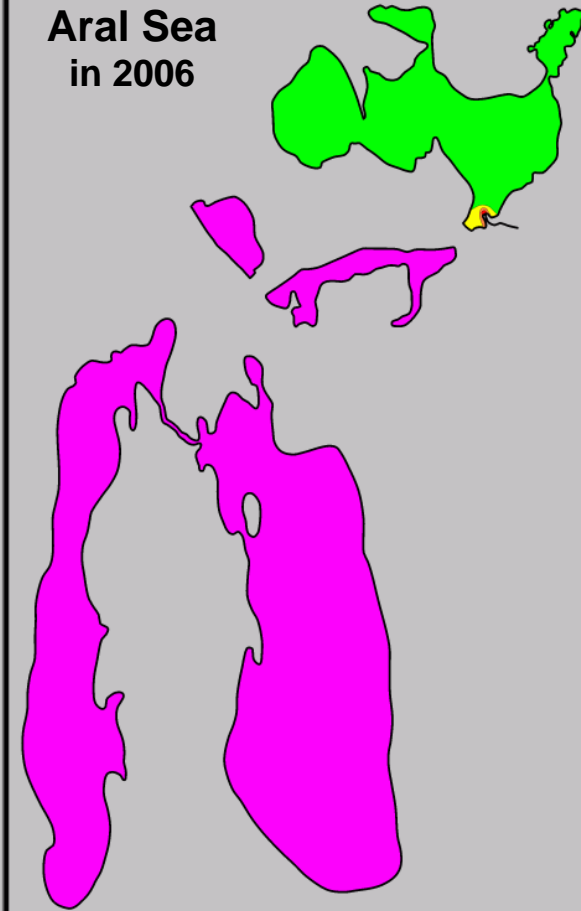
**Aral Sea
before 1960**



**Aral Sea
in 1989**



**Aral Sea
in 2006**



- - Freshwater ecosystems
- - Transitional freshwater-brackishwater ecosystems
- - Brackishwater ecosystems
- - Transitional brackishwater-marine ecosystems
- - Marine ecosystems
- - Hyperhaline ecosystems

Since the end of 1980s, 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 km² (60% from 1960)
Volume 333 km³ (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.

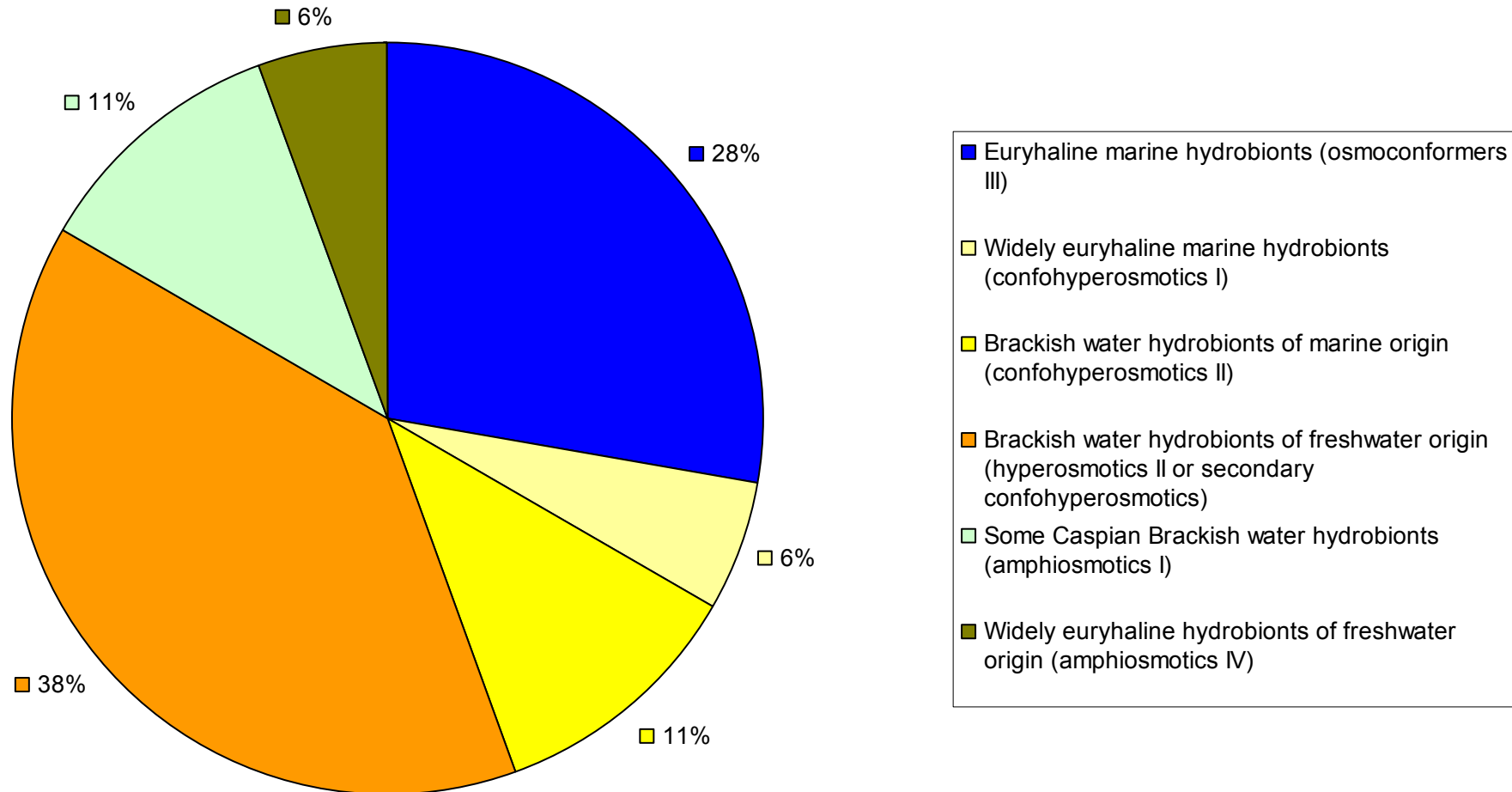
Fishes – 10; Rotatoria – 3;
Cladocera – 2; Copepoda – 2;
Ostracoda – 1; Decapoda – 2;
Bivalvia – 2; Gastropoda - >2;
Polychaeta – 1.

TOTAL: >25

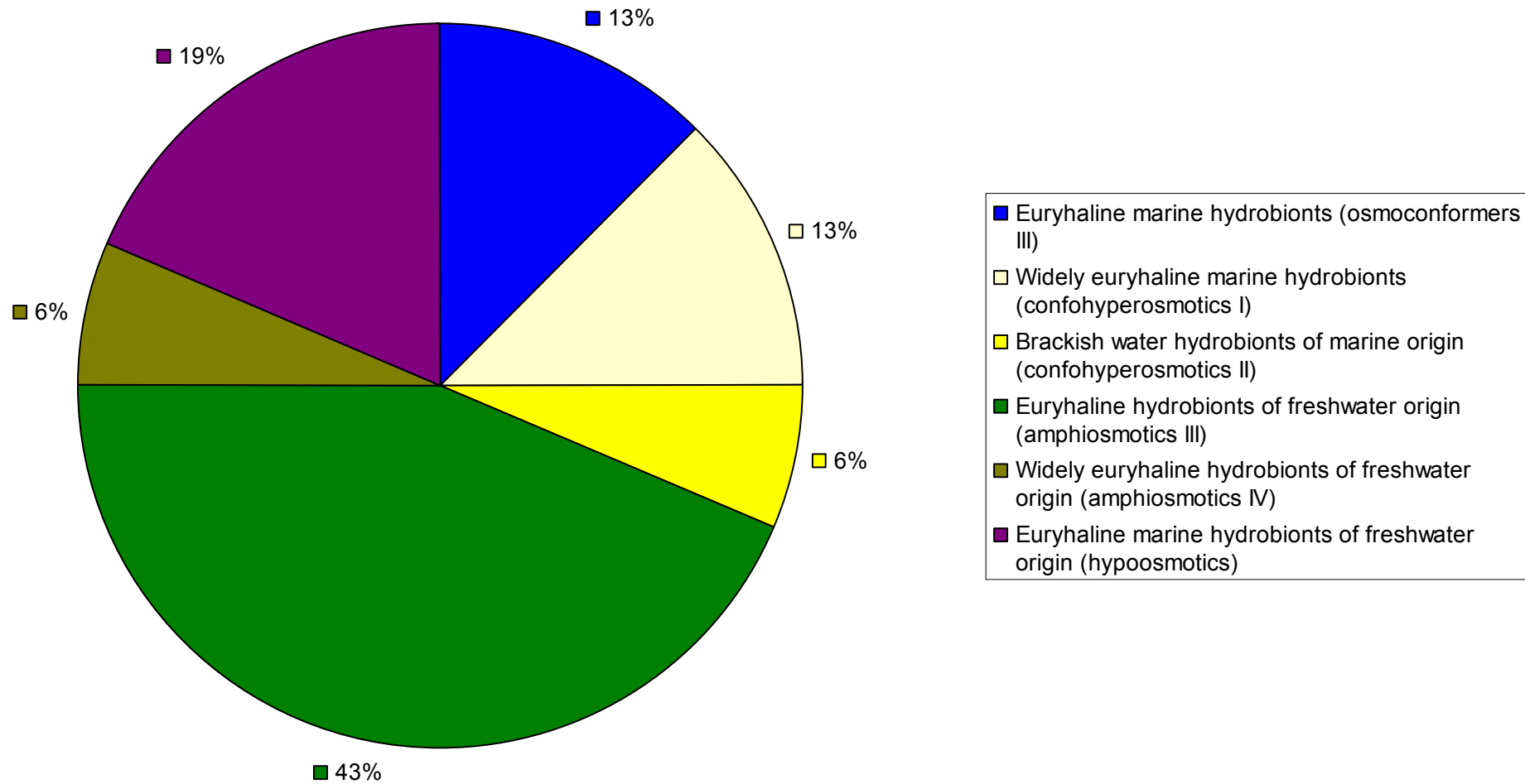
Free-living species in the Aral Sea during separation (both native and introduced)

Species	Type of osmoregulation
Turbellaria	
<i>Mecynostomum agile</i> (Beklemishev, 1927)	A3
Rotatoria	
<i>S. vorax</i> Rousselet, 1902	C2
<i>Synchaeta cecilia</i> Rousselet, 1902	C2
<i>B. quadridentatus</i> Hermann, 1783	C2
<i>B. plicatilis</i> Müller, 1786	C2
<i>K. tropica</i> (Apstein, 1907)	C2
<i>Notholca squamula</i> (Müller, 1786)	C2
<i>N. acuminata</i> (Ehrenberg, 1832)	C2
Polychaeta	
<i>Hediste diversicolor</i> (Müller, 1776)	A3
Cladocera	
<i>Podonevadne camptonyx</i> (G. Sars, 1897)	D3
<i>P. angusta</i> (G. Sars, 1897)	D1
<i>Evadne anonyx</i> G. Sars, 1897	D1
Copepoda	
<i>Calanipeda aquaedulcis</i> Kritschagin, 1873	B1
<i>Halicyclops rotundipes aralensis</i> Borutzky, 1971	B1
Harpacticoida	
<i>Halectinosoma abrau</i> (Kritschagin, 1873)	B2
<i>Schizopera aralensis</i> Borutzky, 1971	B2
<i>Nitocra lacustris</i> (Schmankewitsch, 1875)	A3
Ostracoda	
<i>Cyprideis torosa</i> (Jones, 1850)	D4
<i>Eucypris inflata</i> G.O. Sars, 1903	D4
Malacostraca	
<i>Palaemon elegans</i> Rathke, 1837	B1
<i>Rhithropanopeus harrisi tridentata</i> (Maitland, 1874)	B2
Bivalvia	
<i>C. isthmicum</i> Issel	A3
<i>Abra ovata</i> (Philippi, 1893)	A3
Gastropoda	
<i>Caspiohydrobia conica</i> (Logvinenko et Starobogatov, 1968)	A3
<i>C. husainovae</i> Starobogatov, 1971	A3
Pisces	
<i>Platichthys flesus luscus</i> (Pallas, 1814)	E
<i>Singnatus nigrolineatus caspius</i> Eichwald	E
<i>Atherina boyeri</i> Risso, 1810	E
<i>Clupea harengus membras</i> (Linnaeus, 1758)	D3
<i>Knipowitschia caucasica</i> (Berg, 1916)	D3
<i>Neogobius fluviatilis</i> (Pallas, 1811)	D3
<i>Neogobius melanostomus</i> (Pallas, 1811)	D3
<i>Neogobius syrman</i> (Nordmann, 1840)	D3
<i>Proterorhinus marmoratus</i> (Pallas, 1811)	D3
<i>Neogobius kessleri</i> (Gunter, 1861)	D3

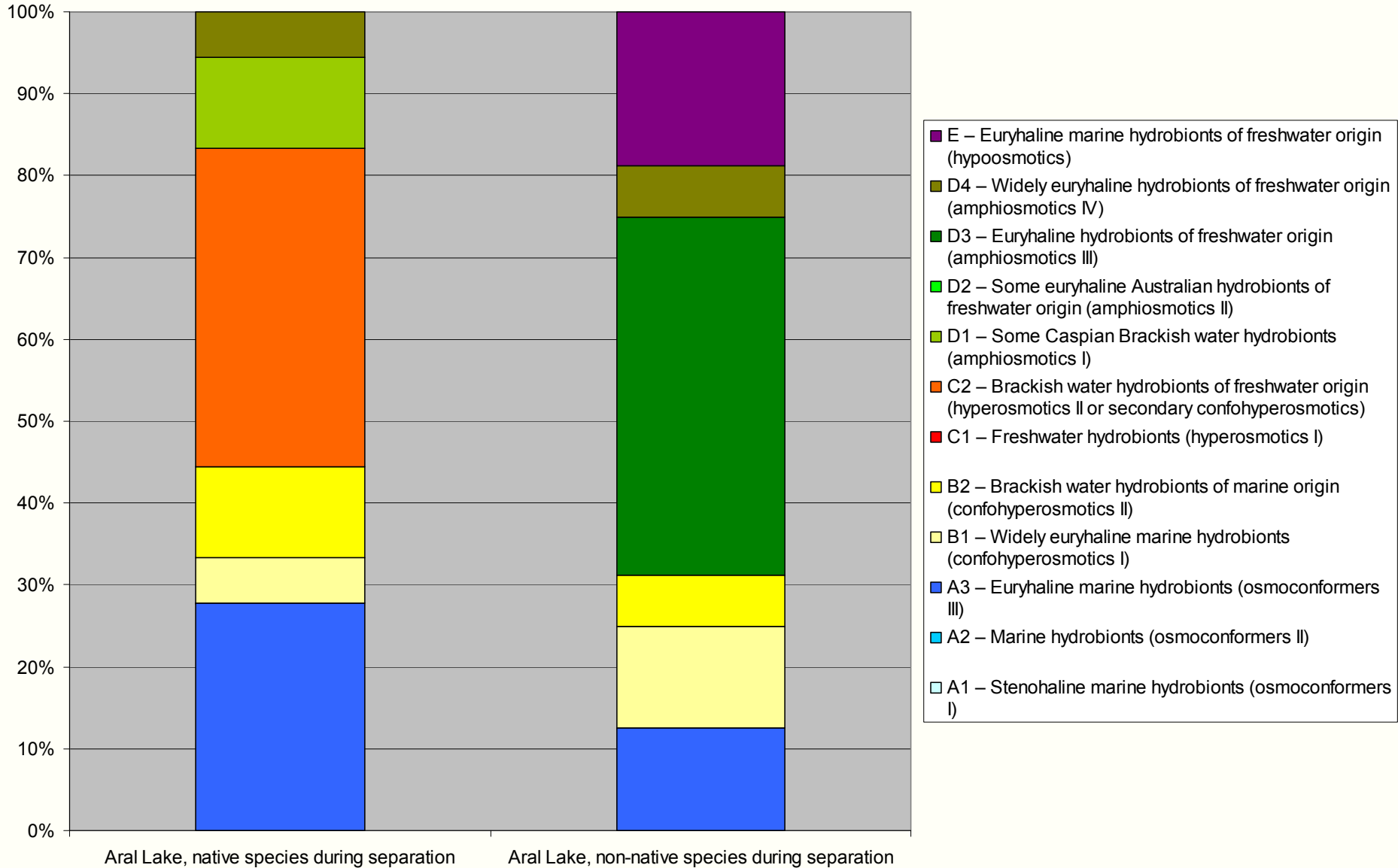
Native aquatic animal species with the different types of osmoconformity and osmoregulation in the Aral Sea during separation



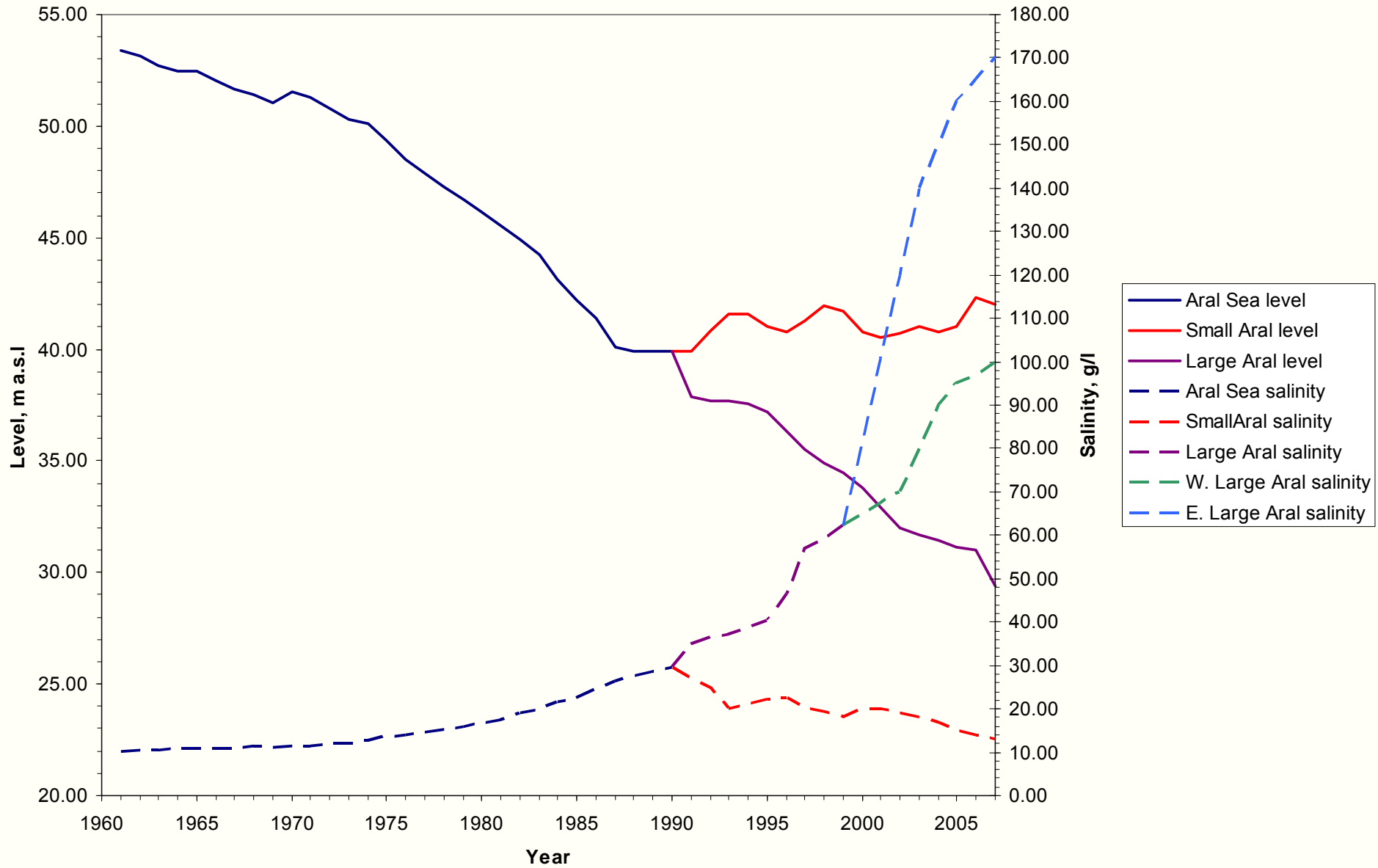
Alien aquatic animal species with the different types of osmoconformity and osmoregulation in the Aral Sea during separation



Percentage of different types of osmoconformers and osmoregulators



Aral Sea level and salinity



Hydrologic and Salinity Characteristics of the Aral Sea

Year (part of Aral Sea)	Level (m asl)	Area (km ²)	% 1960 area	Volume (km ³)	% 1960 volume	Avg. salinity (g/l)	% 1960 salinity
1960 (Whole)^a	53.4	67,499	100	1,089	100	10	100
Large	53.4	61,381	100	1,007	100	10	100
Small	53.4	6,118	100	82	100	10	100
1971 (Whole)	51.1	60,200	89	925	85	12	120
1976 (Whole)	48.3	55,700	83	763	70	14	140
1989 (Whole)		39,734	59	364	33		
Large	39.1	36,930	60	341	34	30	300
Small	40.2	2,804	46	23	28	30	300
2007 (Whole)^b		13,958,	21	102	9		
Large	29.4	10,700	17	75	8	East >100 West 75-85	>1000 750-850
Small	42.0	3,258	53	27	33	12?	120
2025 (Whole)^b		9,658	14	68	6		
Large^c	21-28.3	6,400	10	41	4	> 100 to >200	>1000 to >2000
Small	42.0	3,258	53	27	33	10?	100

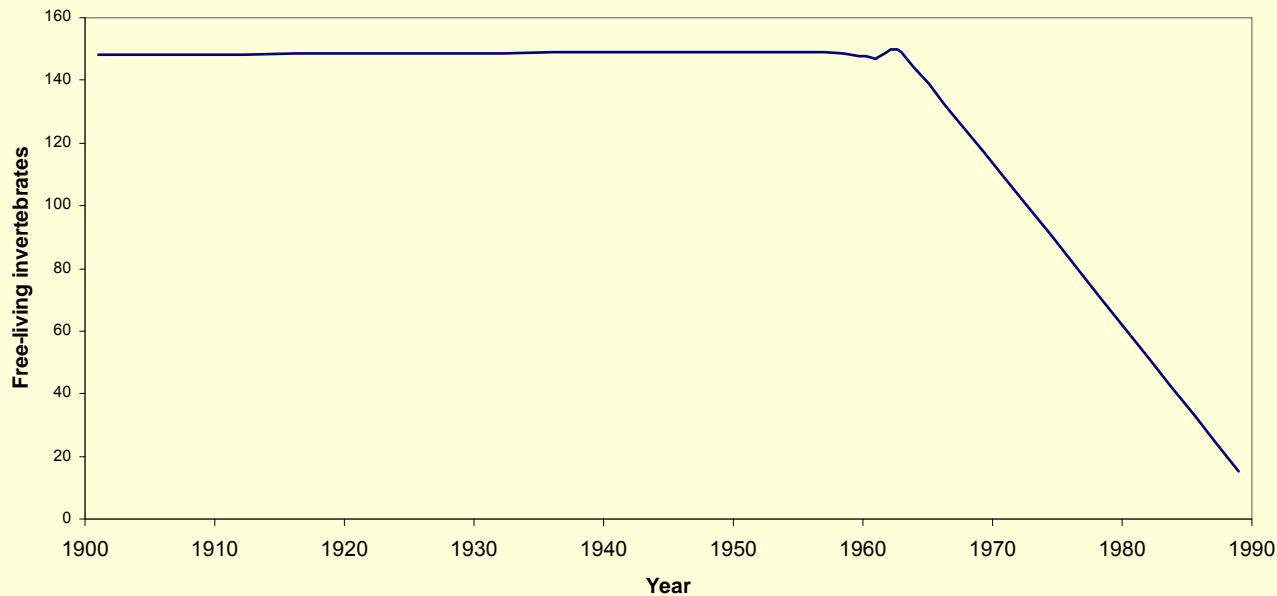
^aAnnual average.

^bAs of January 1.

^cThe sea will consist of a western and eastern part with the west basin at 21 meters with and the east at 28.3.

Sources: Compiled by Philip Micklin from Asarin and Bortnik, 1987 and Bortnik and Chistyayeva, 1990, Table 8.4, p. 72 (for 1960, 1971, and 1976); Glavgidromet, 1994–2003; Water Balance, 1990–2006; Final Report, 2004; Ptichnikov, 2000, 2002; and Expedition, 2005 (for 1989, 2006, 2011).

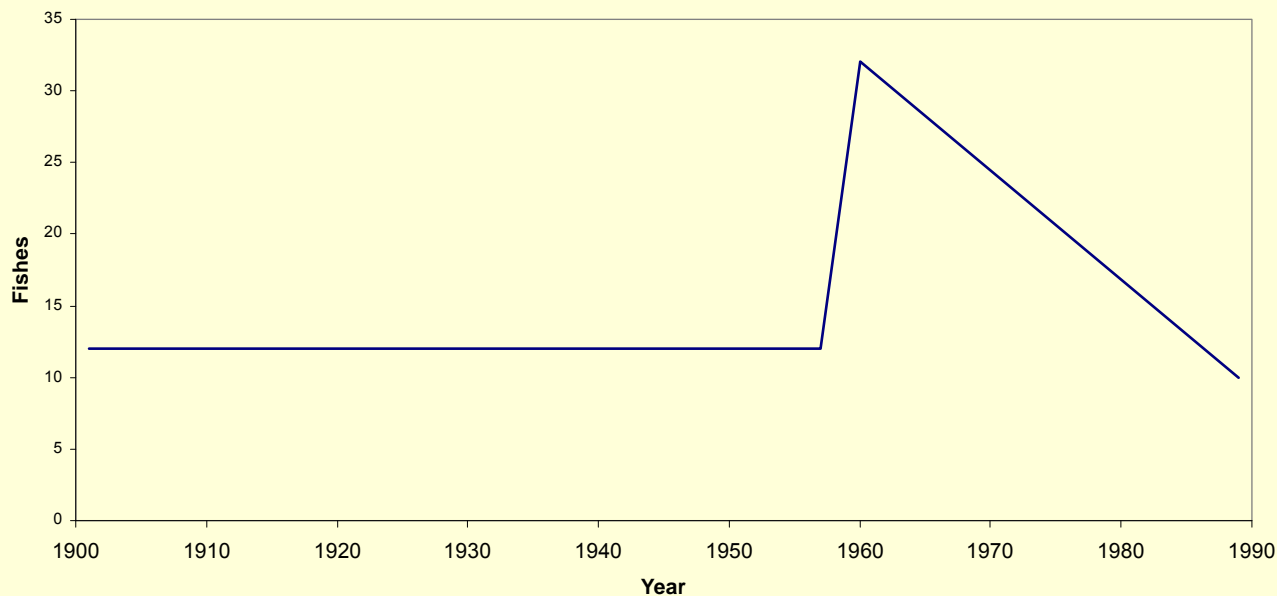
ARAL SEA



Change of species number in the Aral Sea.

Top: free-living invertebrates excluding Protozoa and micro-Metazoa

ARAL SEA



Bottom: fishes

Zooplankton and zoobenthos of the Aral Sea just after its separation (1989)

Average salinity about 30 g/l

ZOOPLANKTON

Rotatoria

Synchaeta vorax

Synchaeta gyrina

Synchaeta cecilia

Cladocera

Podonevadne camptonyx

Evadne anonyx

Copepoda

* *Calanipeda aquaedulcis*

Halicyclops rotundipes aralensis

Larvae Bivalvia

* *Abra ovata*

Cerastoderma isthmicum

ZOOBENTHOS

Bivalvia

* *Abra ovata*

Cerastoderma isthmicum

Gastropoda

Caspiohydrobia spp.

Polychaeta

* *Nereis diversicolor*

Ostracoda

Cyprideis torosa

Decapoda

* *Palaemon elegans*

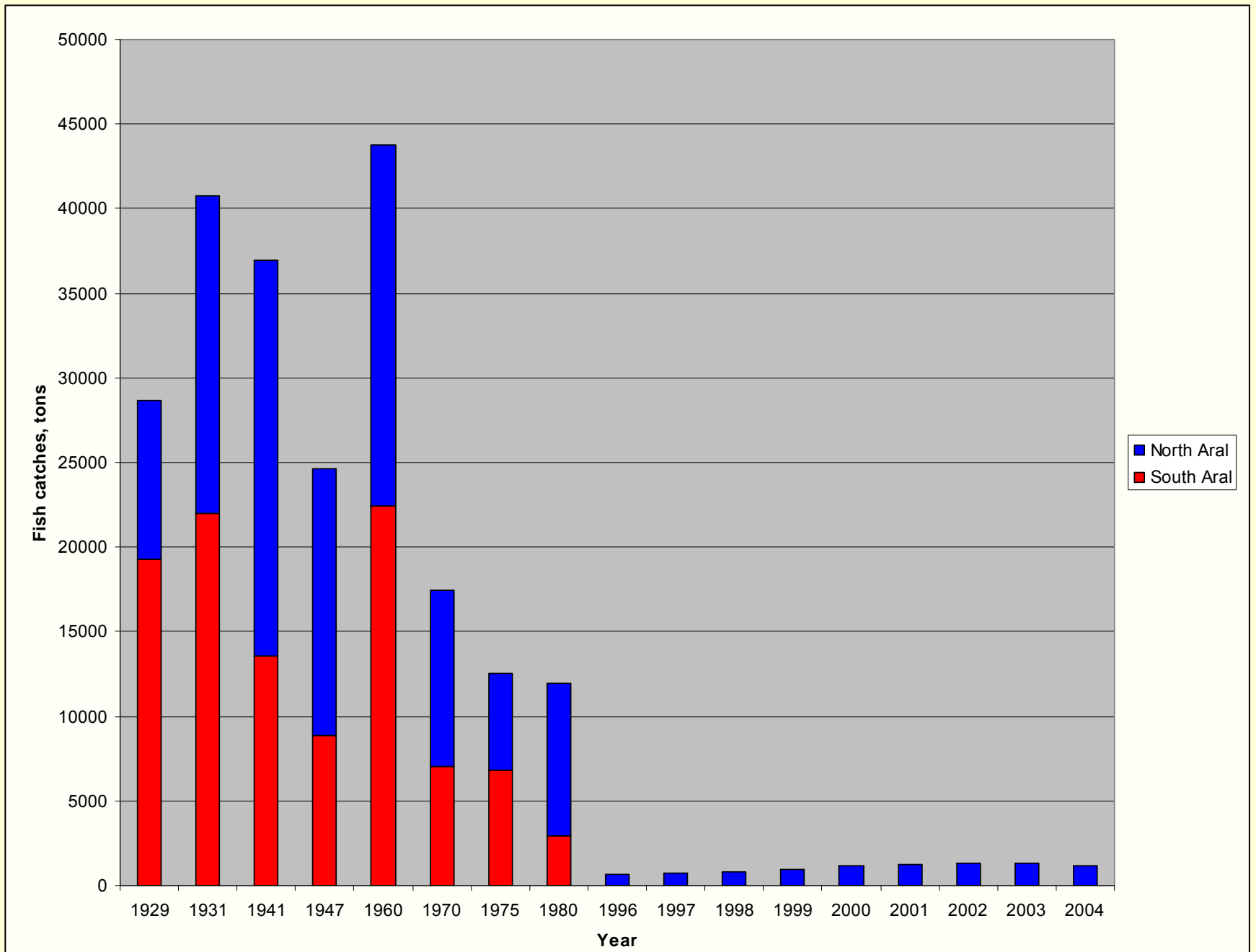
* *Rhithropanopeus harrisi tridentatus*

Fishes of the Aral Sea just after its separation (1989)

Average salinity about 30 g/l

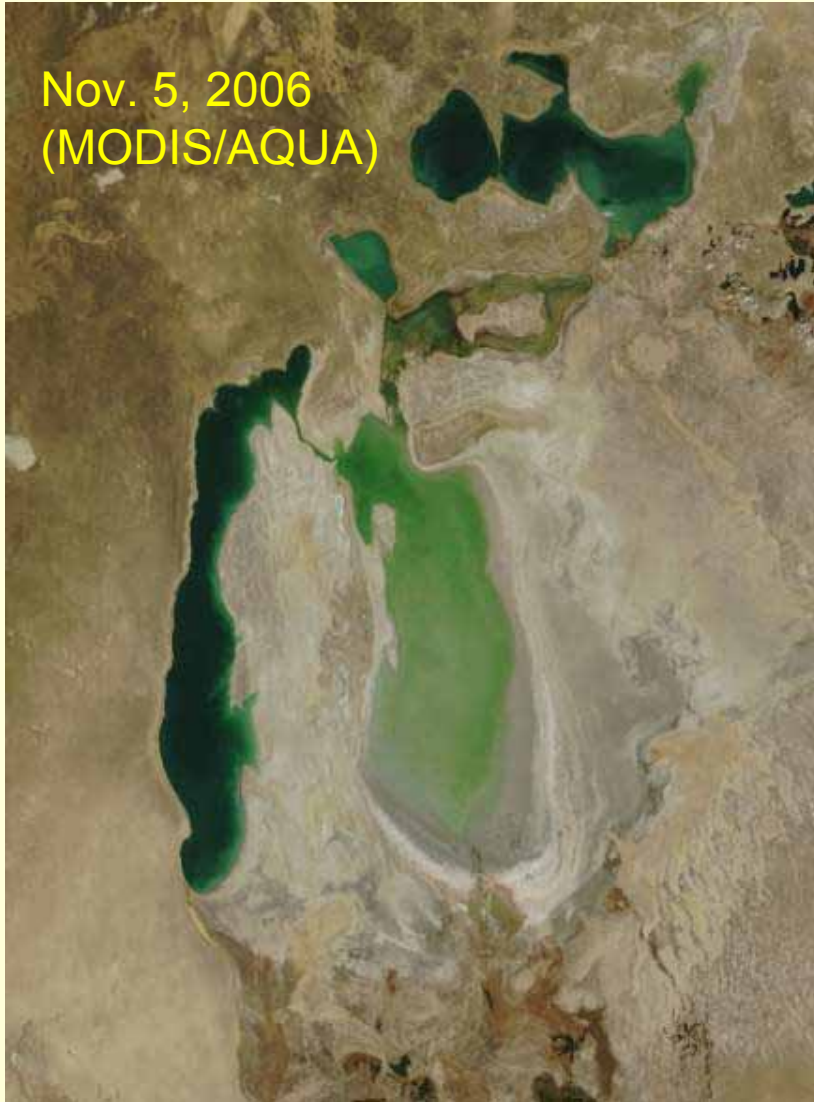
1. Stickleback - *Pungitius platygaster* (Kessler, 1859)
2. Baltic herring - *Clupea harengus membras* (Linnaeus, 1758)
3. Flounder - *Platichthys flesus* (Linnaeus, 1758)
4. Silverside - *Atherina boyeri caspia* Eichwald, 1838
5. Bubyr goby - *Knipowitschia caucasicus* (Berg, 1916)
6. Sand goby - *Neogobius fluviatilis* (Pallas, 1811)
7. Round goby - *Neogobius melanostomus* (Pallas, 1811)
8. Syrman goby - *Neogobius syrman* (Nordmann, 1840)
9. Tubenose goby - *Proterorichinus marmoratus* (Pallas, 1811)
10. Bighead goby - *Neogobius kessleri* (Gunter, 1861)

Dynamics of fish catches in the North and South Aral Sea



Since beginning of 2003, when the level in the Large Aral Sea dropped by 22 m and reached about +31 m, the Large Aral Sea is practically divided into the Eastern Large and Western Large Aral

Nov. 5, 2006
(MODIS/AQUA)



January 2004

Jan. 1, 2007: Area 14000 km² (21% from 1960)

Volume 85 km³ (8% from 1960)

Salinity: Western part – 80-90 g/l,
Eastern part – 150-160 g/l (excluding Tsche-Bas bay where salinity is 80-90 g/l)

In both lakes salinity increased so high that practically all fishes gone and only few free-living invertebrates could survive.

Fishes – 4?; Infusoria – 2; Rotatoria – 3;
Cladocera – 2; Copepoda – 2; Ostracoda – 2;
Branchiopoda – 1; Decapoda – 2;
Bivalvia – 2; Gastropoda - >2;
Polychaeta – 1?.

TOTAL: >29?

Since separation of the Small Aral Sea from Large Aral at the end of 1980s number of free-living animals increased because salinity in this lake became nearly twice lower and in 2005 reached about 17 g/l.

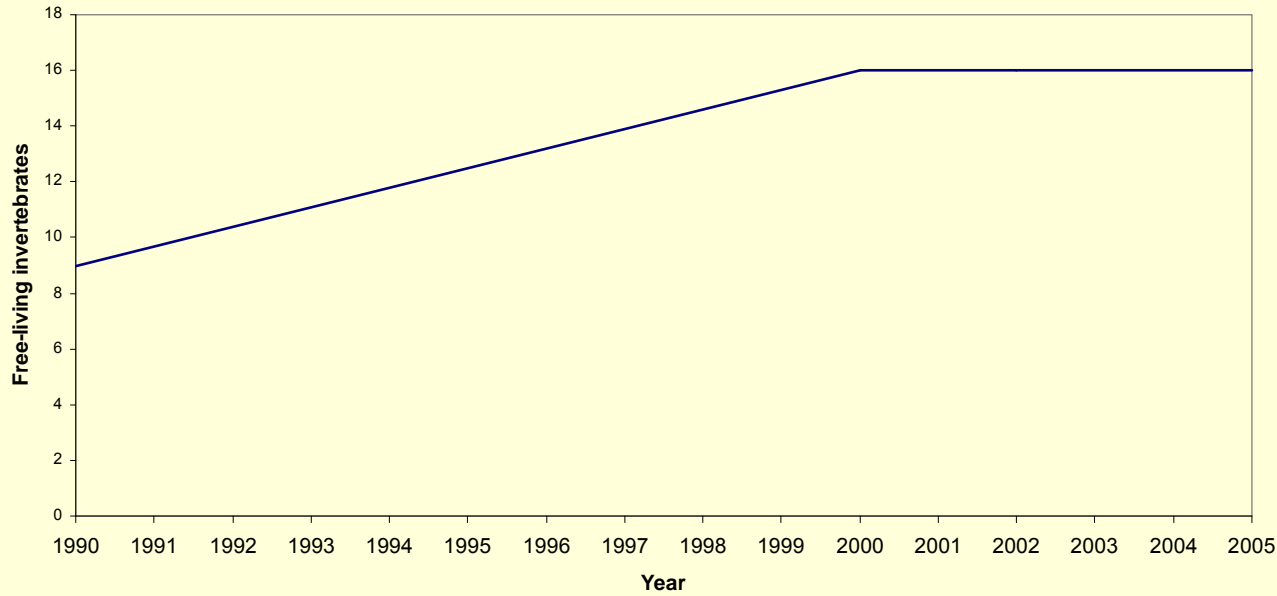
Area 2865 km² (47% from 1960), Volume 23 km³ (28% from 1960), Level +40.4 asl



**Fishes – 12?;
Rotatoria – 3;
Cladocera – 2;
Copepoda – 2;
Ostracoda – 2;
Decapoda – 2;
Bivalvia – 2;
Gastropoda -
>1;
Polychaeta – 1.
TOTAL: >27?**

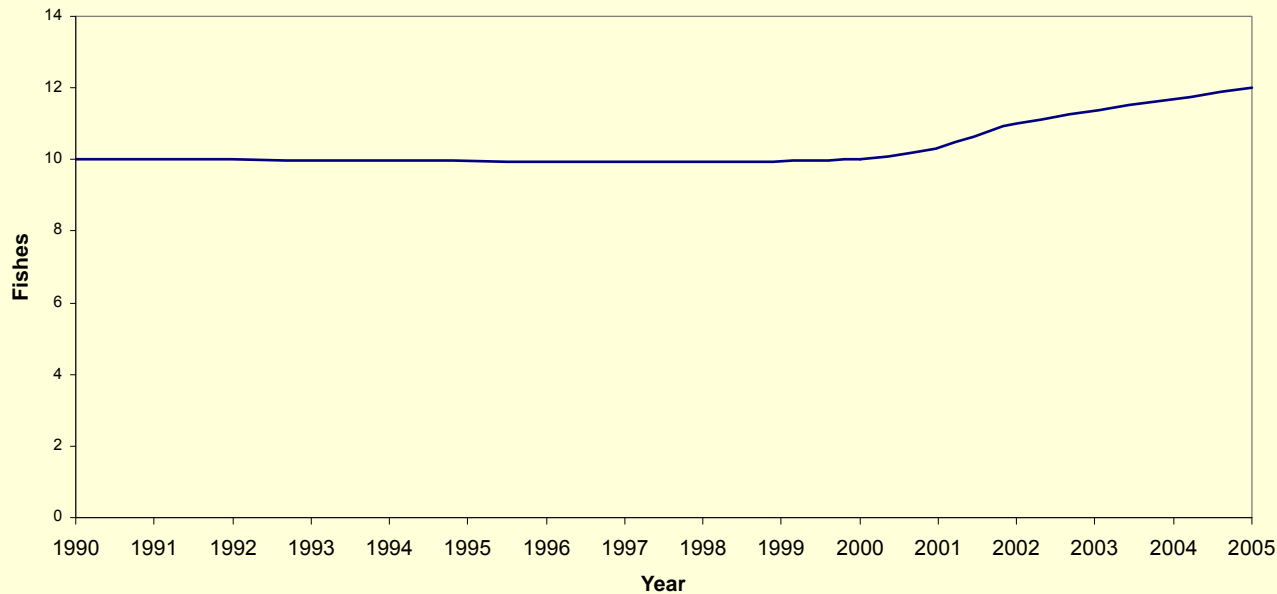
The
Jan

SMALL ARAL SEA



Change of species number in the Small Aral Sea.

SMALL ARAL SEA



Top: free-living invertebrates excluding Protozoa and micro-Metazoa

Bottom: fishes

Zooplankton and zoobenthos of the Small Aral Sea (2005-2007)

Average salinity about 11-17 g/l

ZOOPLANKTON

Rotatoria

Synchaeta vorax

Synchaeta gyrina

Synchaeta cecilia

Cladocera

Podonevadne camptonyx

Evadne anonyx

Copepoda

* *Calanipeda aquaedulcis*

Halicyclops rotundipes aralensis

Larvae Bivalvia

* *Abra ovata*

Cerastoderma isthmicum

ZOOBENTHOS

Bivalvia

* *Abra ovata*

Cerastoderma isthmicum

Gastropoda

Caspiohydrobia spp.

Polychaeta

* *Nereis diversicolor*

Ostracoda

Cyprideis torosa

Eucypris inflata

Decapoda

* *Palaemon elegans*

Fishes of the Small Aral Sea (2005-2007)

Average salinity about 11-17 g/l

1. Stickleback - *Pungitius platygaster* (Kessler, 1859)
2. Baltic herring - *Clupea harengus membras* (Linnaeus, 1758)
3. Flounder - *Platichthys flesus* (Linnaeus, 1758)
4. Silverside - *Atherina boyeri caspia* Eichwald, 1838
5. Bubyr goby - *Knipowitschia caucasicus* (Berg, 1916)
6. Sand goby - *Neogobius fluviatilis* (Pallas, 1811)
7. Round goby - *Neogobius melanostomus* (Pallas, 1811)
8. Syrman goby - *Neogobius syrman* (Nordmann, 1840)
9. Tubenose goby - *Proterorichinus marmoratus* (Pallas, 1811)
10. Bighead goby - *Neogobius kessleri* (Gunter, 1861)
11. Grass carp - *Ctenopharyngodon idella* (Val., 1844)
12. Pike perch - *Sander lucioperca* (Linnaeus, 1758)

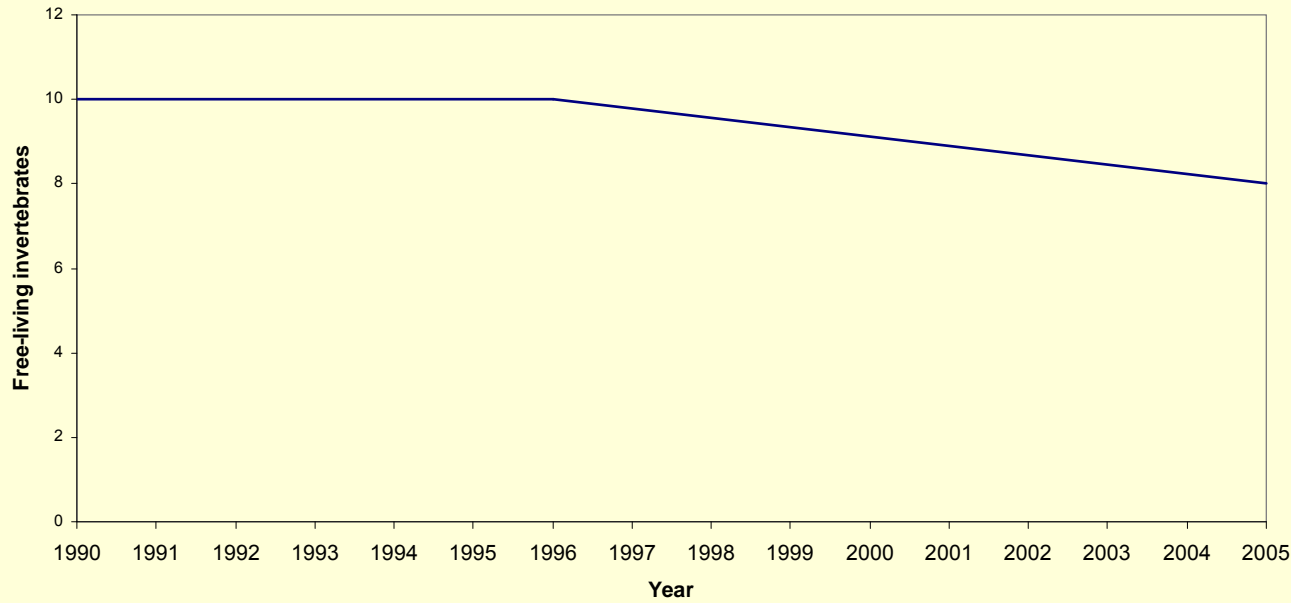
When in 1992 a dike in Berg strait was built, fishing on the Small Aral was recommenced. According reports of fishermen in 2004 **silver carp** (*Ctenopharyngodon idella*) reappeared in Small Aral



Flounder (*Platichthys flesus*) is about to disappear from the Large Aral Sea because of rising salinity.

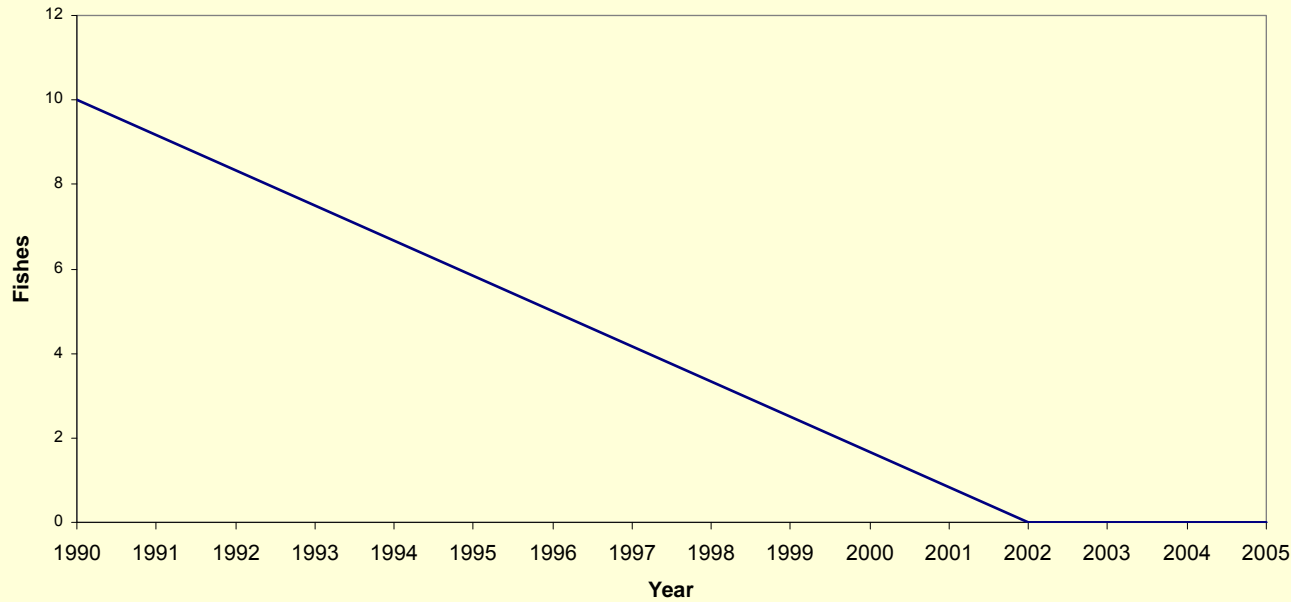


LARGE ARAL SEA



Change of species number in the Large Aral Sea.

LARGE ARAL SEA



Top: free-living invertebrates excluding Protozoa and micro-Metazoa

Bottom: fishes

Zooplankton and zoobenthos of the Western Large Aral Sea (2005)

Average salinity 80-90 g/l

ZOOPLANKTON

Infusoria

Fabraea salina

Hexarthra fennica

Rotatoria

Brachionus plicatilis

Cladocera

Moina mongolica ?

Copepoda

Halicyclops rotundipes aralensis

Branchiopoda

Artemia salina

ZOOBENTHOS

Infusoria

Frontonia sp.

Turbellaria

Mecynostomum agile ?

Gastropoda

Caspiohydrobia spp.

Bivalvia

* *Abra ovata*

Polychaeta

* *Nereis diversicolor*

Ostracoda

Cyprideis torosa

Eucypris inflata

Zooplankton and zoobenthos of the Eastern Aral Sea (2005)

Average salinity 150-160 g/l

Zooplankton

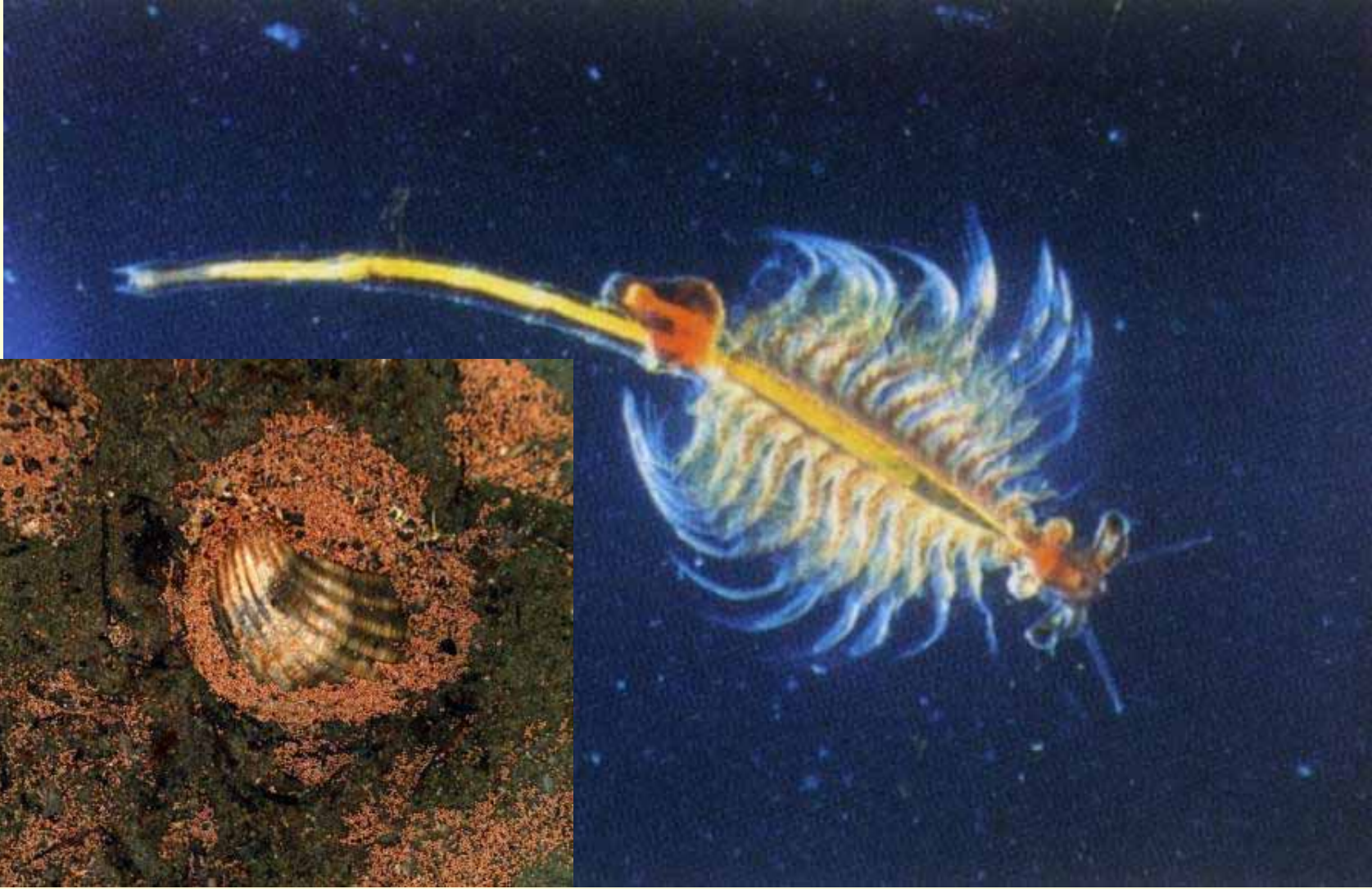
Artemia salina

Zoobenthos

Alive macro- and mezo- Metazoa are not available

Only in Tsche-Bas bay due to much lower salinity (80-90 g/l) zooplankton and zoobenthos resembles those of the Western Large Aral Sea

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



Nowadays industrial harvesting under aegis of international company INVE Aquaculture is being considered, but in 2005 the company postponed activities until salinity increase to levels more favorable for brine shrimp.

Fishes of the Western Large Aral Sea (2005)

Salinity 80-90 g/l

1. Stickleback - *Pungitius platygaster* (Kessler, 1859) - ?
2. Flounder - *Platichthys flesus* (Linnaeus, 1758) - ?
3. Silverside - *Atherina boyeri caspia* Eichwald, 1838 - ?
4. Round goby - *Neogobius melanostomus* (Pallas, 1811) - ?

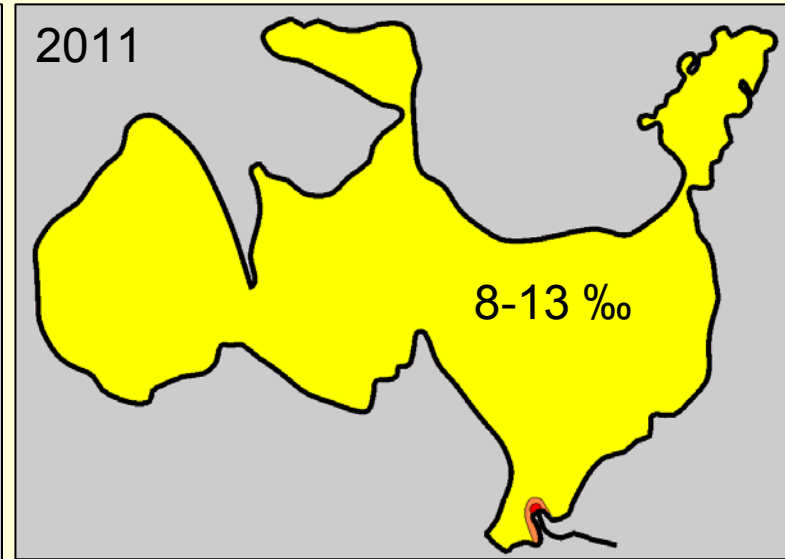
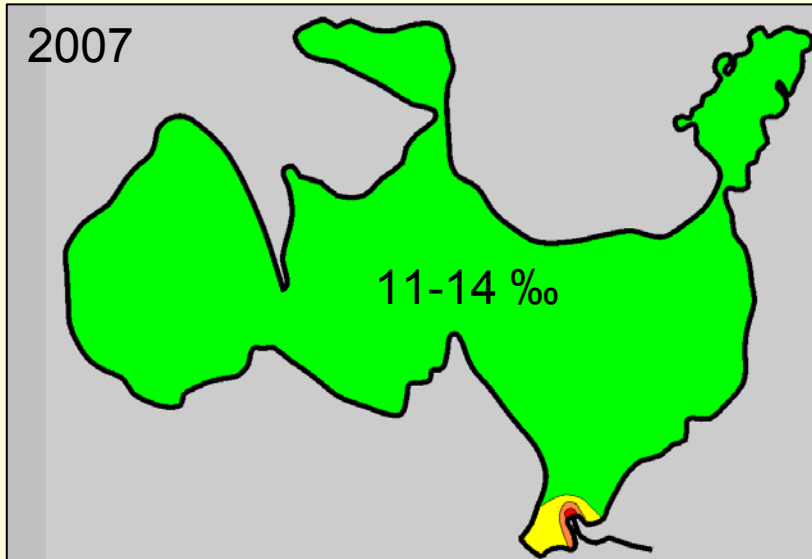
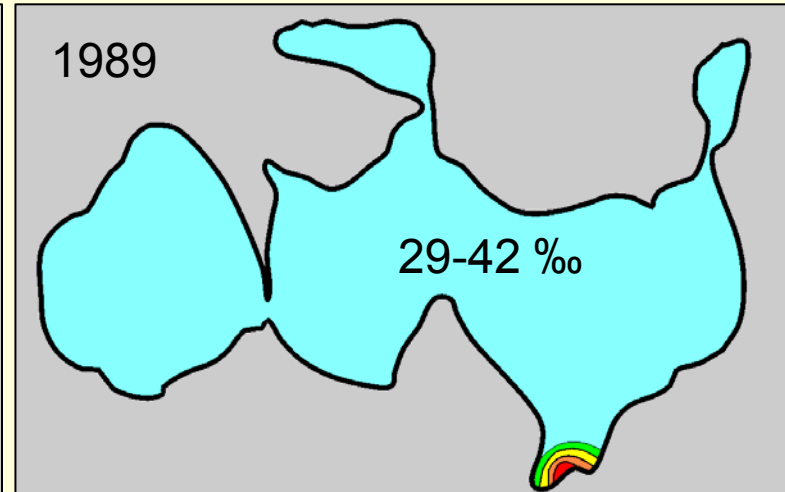
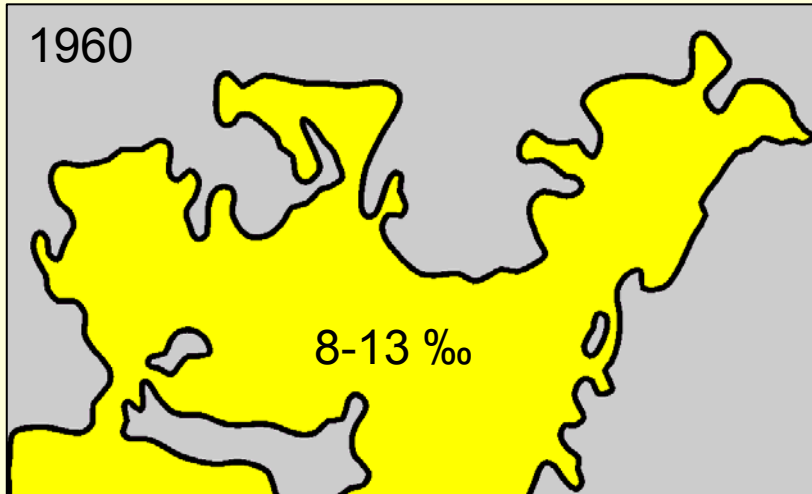
Fishes of the Eastern Large Aral Sea (2005)

Salinity 150-160 g/l

Fishes in the Eastern Large Aral are not registered.

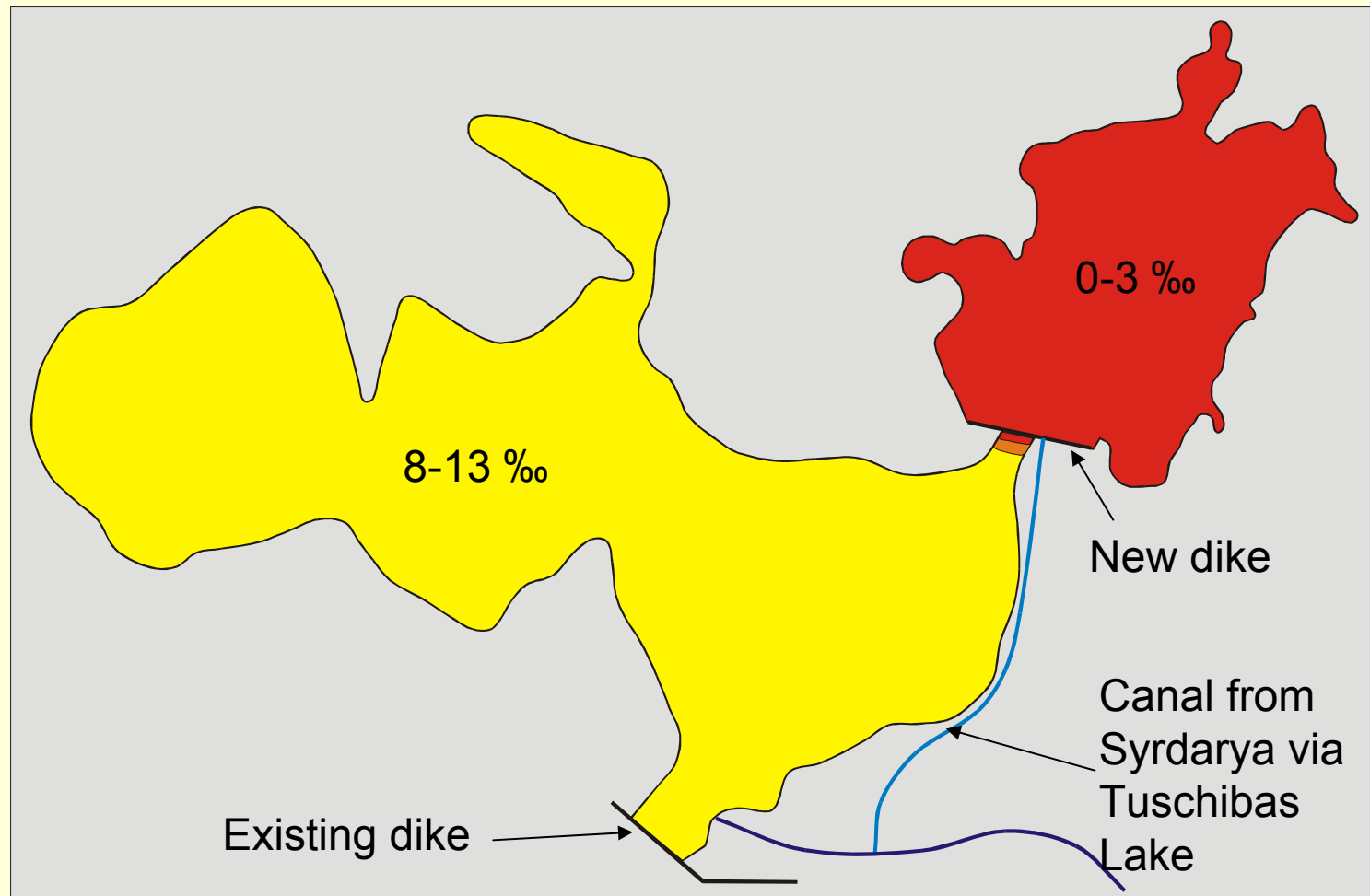
Only in Tsche-Bas bay flounder (*Platichthys flesus*) was observed in water with salinity 80-90 g/l. In the remnants of the strait between Small and Eastern Large Aral silverside (*Atherina boyeri caspia*) was found in water with salinity 60-80 g/l.

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 11-14 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.

Alternative 2nd phase of the Small Aral rehabilitation project



- **Alternative 2nd phase of the project would raise level only of Saryshaganak Gulf.**
- **Second phase would allow further improvement of the health of the local people, to decrease unemployment and increase living standards as well as income to the local families.**
- **The local economy also will be improved (fishery, shipping, etc.).**
- **Local microclimate around Small (Northern) Aral Sea will be much better than now.**

Second dike to be built
in the nearest future
Level 46-47 m a.s.l.

Аральск

Canal to Aralsk
(≈10 km)

Canal from Tuschibas Lake to
Sarycheganak Bay (≈50 km)

Жаланаш

Платина САМ

Бугуны

оз. Тусшыбар

оз. Карашалак

Жанакурылыс

озера Ақсатпау

озера Ақсатпау

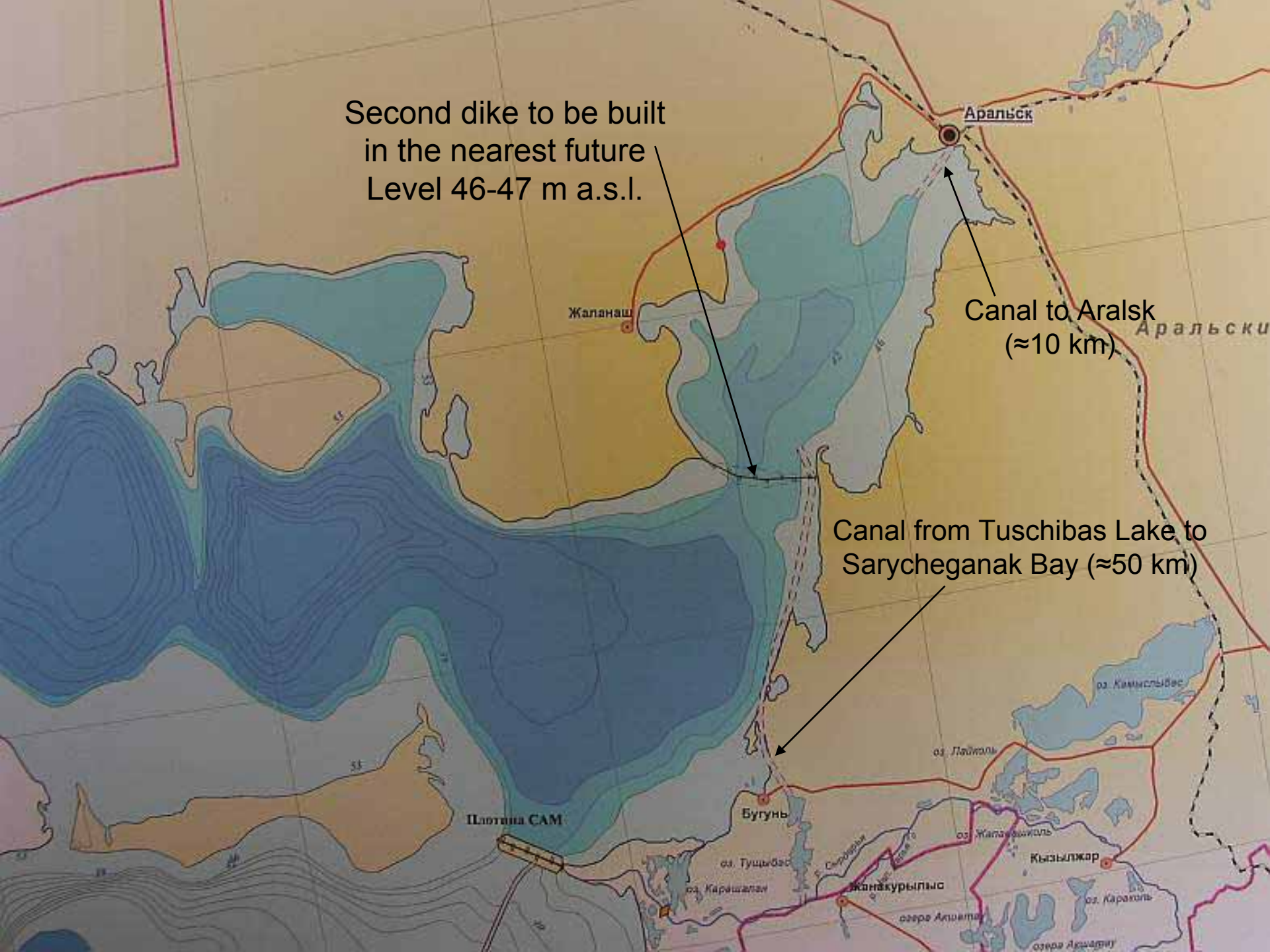
оз. Камыслыбас

оз. Лайкөл

оз. Жапауылкөл

Кызылжар

оз. Караколь





**MODIS image of Aral Sea from
18 Aug, 2006**

- 1. Small (Northern) Aral Sea –
“Kazal Sea”**
- 2. Western Large (Southern)
Aral Sea – “Western Uzaral”**
- 3. Eastern Large (Southern)
Aral Sea – “Eastern Uzaral”**
- 4. Former Tschebas Bay –
“Tschebas-Kul”**
- 5. Strait between Eastern and
Western Large Aral**
- 6. Remnants of strait from
Small Aral to Large Aral**



Thank you for your attention.

Aral Sea has the future!