HYDROSPHERE

This is a discontinuous water shell of the Earth between atmosphere and solid Earth crust (lithosphere) including oceans, seas and water surface on the land. In broader sense hydrosphere composition includes subsurface waters, ice, and snow of Arctic and Antarctic as well as atmospheric water and water contained in living organisms. The major part of water concentrates in seas and oceans, the second in volume is ground water, the third is ice and snow of Arctic and Antarctic. Surface water, atmospheric and bio-related water amounts percentages of the whole volume of hydrosphere water.

Three quarters of the planet are covered with seas and oceans, the rest are islands

Types of water

Types of water	Name	Volume, mln.km^3	Amount with respect to entire volume of hydrosphere, %
Sea water	Sea	1370	94
Ground (except soil water) water	Ground	61,4	4
Ice and snow (Arctic, Greenland, mountain regions, ice regions)	Ice	24,0	2
Surface water: lakes, reservoirs, rivers, swamps, soil water	Fresh	0,5	0,4
Atmospheric water	Atmospheric	0,015	0,01
Water in living organisms	Bio-related	0,00005	0,0003

Ice distribution on Earth (according to Reymes, 1990)

Ice type	Volume		Square of distribution	
	т	%	mln.km^2	%
Ice caps	$2,4*10^{16}$	98,95	16,1	10,9 of land
Subsurface ice	$2*10^{15}$	0,83	21	14,1 of land
Sea ice	$3,5*10^{13}$	0,14	26	7,2 of ocean
Snow cover	$1*10^{13}$	0,04	7264	14,2 of Earth
Glaciers	$7,6*10^{12}$	0,03	63,5	18,7 of ocean, (sporadically)
Atmospheric ice	$1,7*10^{12}$	0,01	510,1	100 over the Earth

Snow-ice cap of African mountain top of Kilimanjaro melted during 11000 years

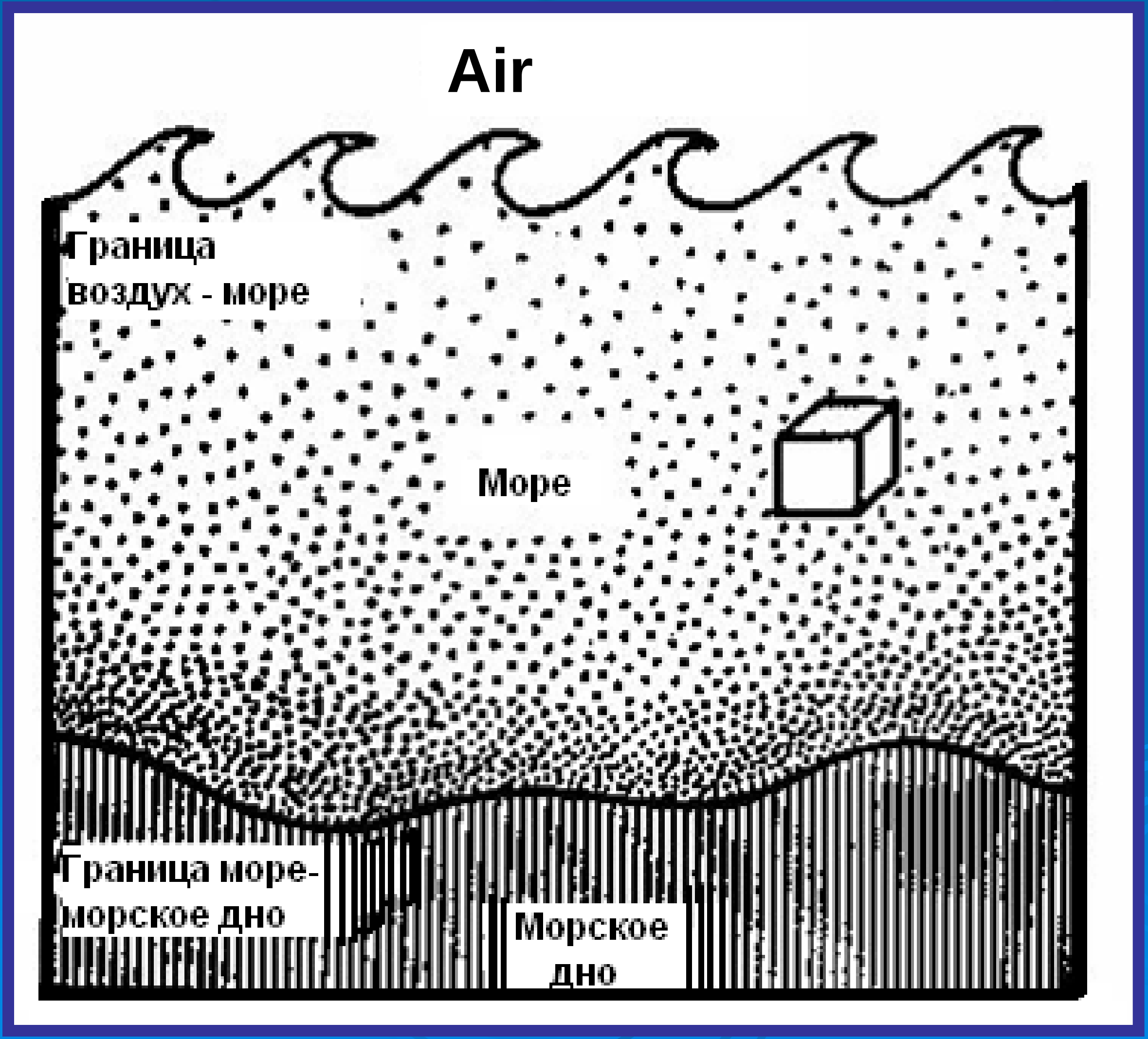
Glaciers are gradually melting

Nearly **94%** of the whole water volume concentrate in oceans and seas; **4 %** are in ground waters; about **2 %** - in ice and snow (mainly in Arctic, Antarctic, and Greenland); **0,4 %** - in surface waters (rivers, lakes, swamps).

Insignificant amount of water is contained in atmosphere and organisms. All types of water are transformed from one form to another in circulation process. Annually the amount of precipitations falling on the ground is equal to that of water evaporated in total from the surface of land and oceans. In general cycle of water the atmospheric water is most movable.

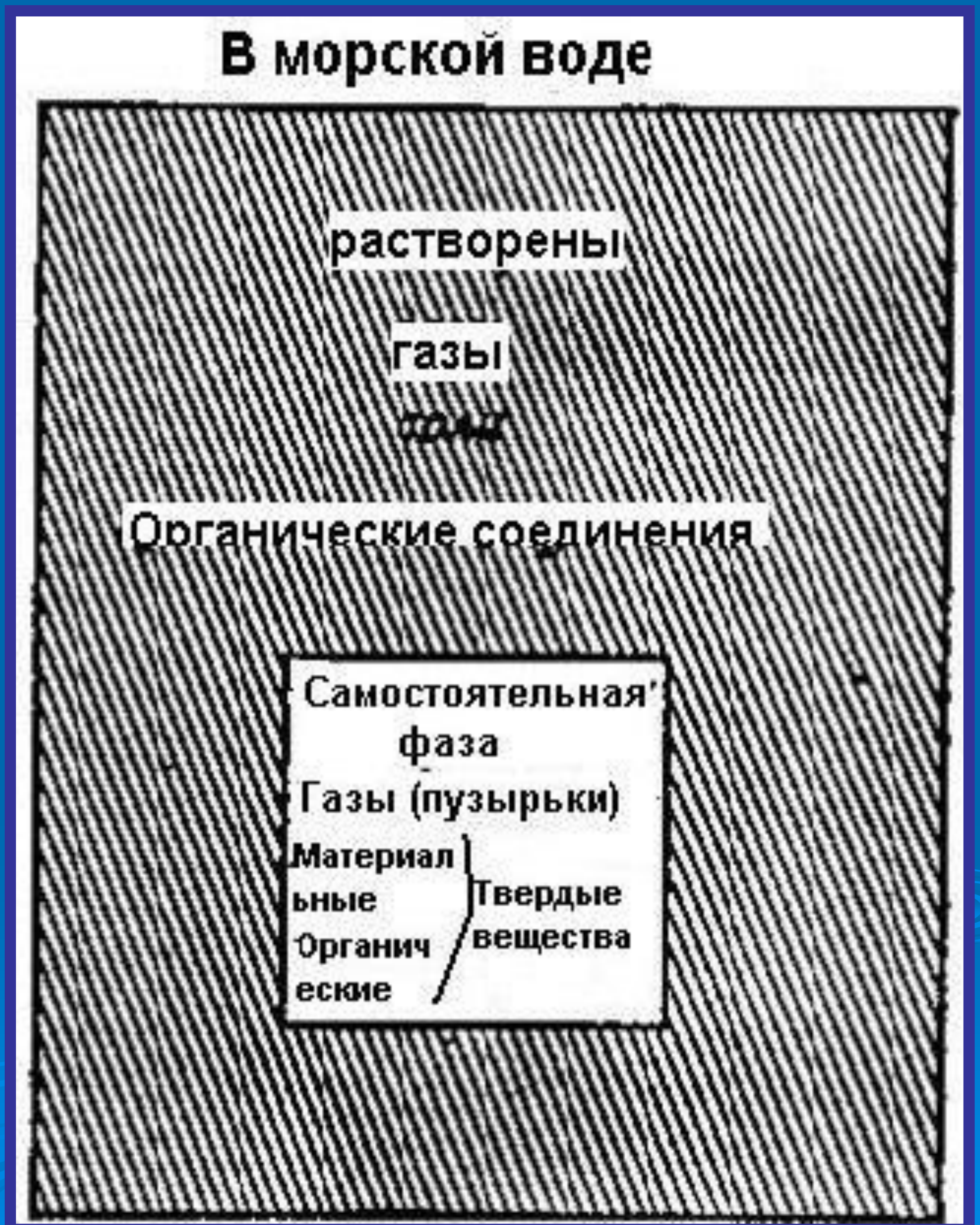
Sea as a system and boundary zones

(according to Horn, 1972)



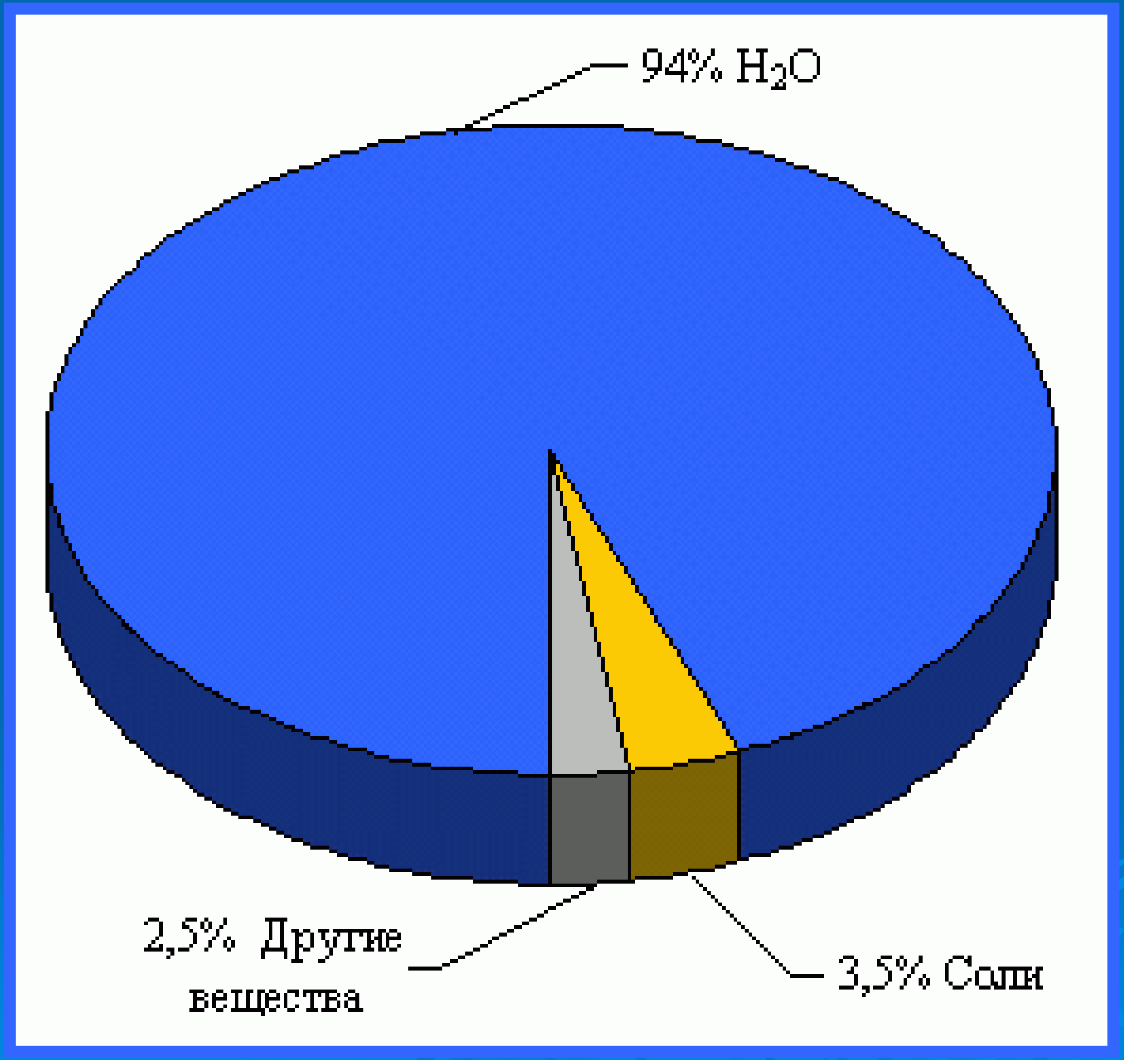
Classification of matter in sea water

(according to Horn, 1972)



Chemical composition of hydrosphere approximates to average composition of sea water, where hydrogen, oxygen, chlorine, and sodium prevail. ***In land water the prevailing are carbonates. Content of mineral substances in land water (salinity) fluctuates greatly depending on local conditions and, first of all, climate. Usually land water is weakly mineralized – fresh (river and fresh lake salinity ranges from 50 to 1000 mg/kg). Average salinity of Oceanic water is around 35 g/kg (35 %), sea water salinity ranges from 1-2 % (Gulf of Finland, Baltic Sea) to 41,5 % (Red Sea). The maximum salt concentration is in salty lakes (Dead Sea up to 260 %)***

Chemical composition of oceans



ELEMENT COMPOSITION OF SEA WATER (Horn, 1972)

Element	Concentration, mg/l	Forms of occurrence	KPre Residence time in environment, years
H	108 000	H_2O	-
He	0,000005	He(r)	-
Li	0,17	U+	$2,0*10^{7}$
Be	0,0000006	-	$1,5*10^{2}$
B	4,6	$B(OH)_2$; $B(OH)_4$	-
C	28	HCO_3^-;H_2CO_3; органические соединения	-
N	0,5	$NO^-{}_3$; $NO^-{}_2$; $NH^-{}_4$; N_2(r); органические соединения	-
O	857 000	H_2Oж; O_2(r); SO^{2-} и другие анионы	-
F	1,3	F^-	-
Ne	0,0001	Ne(r)	-
Na	10 500	Na^+	$2,6*10^{8}$
Mg	1 350	Mg^{2+}; $VgSo_4$	$4,5*10^{7}$
Al	0,01	-	$1,0*10^{2}$
Si	3	$Si(OH)_4$; $Si(OH)_3O^-$	$8,0*10^{3}$
P	0,07	$HPO^{2-}{}_4$; $H_2\ PO_4$; $PO^{3-}{}_4$; $H_3\ PO_4$	-
S	885	$SO^{2-}{}_4$	-
Cl	19 000	Cl^-	-
Ar	0,6	Ar (r)	-
K	380	K^+	$1,1*10^{7}$
Ca	400	Ca^{2+}; $CaSO_4$	$8,0*10^{6}$
Sc	0,00004	-	$5,6*10^{3}$
Ti	0,001	-	$1,6*10^{2}$
V	0,002	$VO_2(OH)^{2-}{}_3$	$1,0*10^{4}$
Cr	0,00005	-	$3,5*10^{2}$
Mn	0,002	Mn^{2+}; $MnSO_4$	$1,4*10^{3}$
Fe	0,01	$Fe(OH)_3$	$1,4*10^{2}$
Co	0,0005	Co^{2+}; $CoSO_4$	$1,8*10^{4}$
Ni	0,002	Ni^{2+}; $NiSO_4$	$1,8*10^{4}$
Cu	0,003	Cu^{2+}; $CuSO_4$	$5,0*10^{4}$
Zn	0,01	Zn^{2+}; $ZnSO_4$	$1,8*10^{5}$
Ga	0,00003	-	$1,4*10^{3}$
Ge	0,00007	$Ge(OH)_4$; $Ge(OH)_3O$	$7,0*10^{3}$
As	0,003	$HAsO^{2-}{}_4$; $H_2\ AsO^-{}_4$; $H_3\ AsO_3$	-
Se	0,004	$SeO^{2+}{}_4$	-
Br	65	Br	-
Kr	0,0003	Kr (r)	-
Rb	0,12	Rb^+	$2,7*10^{5}$
Sr	8	Sr^{2+}; $SrSO_4$	$1,9*10^{7}$
Y	0,0003	-	$7,5*10^{3}$
Zr	-	-	-
Nb	0,00001	-	$3,0*10^{2}$
Mo	0,01	$MoO^{2-}{}_4$	$5,0*10^{5}$

Element	Concentration, mg/l	Forma of occurrence	Residence time in environment, years
Tc	-	-	-
Ru	-	-	-
Rh	-	-	-
Pd	-	-	-
Ag	0,00004	$AgCl^{-}_2$; $AgCl^{2-}_3$	$2,1*10^6$
Cd	0,00011	Cd^{2+}; $CdCl^{2-n}_n$; $Cd(OH)^{2-n}_n$	$5,0*10^5$
In	<0,02	-	-
Sn	0,0008	-	$1,0*10^5$
Sb	0,0005	-	$3,5*10^5$
Te	-	-	-
I	0,06	IO^{-}_3; I^-	-
Xe	0,0001	Xe(r)	-
Cs	0,0005	Cs^+	$4,0*10^4$
Ba	0,03	Ba^{2+}; $BaSO_4$	$8,4*10^4$
La	$1,2*10^{-5}$	-	$4,4*10^2$
Ce	$5,2*10^{-6}$	-	$8,0*10^1$
Pr	$2,6*10^{-6}$	-	$3,2*10^2$
Nd	$9,2*10^{-6}$	-	$2,7*10^2$
Pm	-	-	-
Sm	$1,7*10^{-6}$	-	$1,8*10^2$
Eu	$4,6*10^{-7}$	-	$3,0*10^2$
Gd	$2,4*10^{-6}$	-	$2,6*10^2$
Tb	-	-	-
Dy	$2,9*10^{-6}$	-	$4,6*10^2$
Ho	$8,8*10^{-7}$	-	$5,3*10^2$
Er	$2,4*10^{-6}$	-	$6,9*10^2$
Tm	$5,2*10^{-7}$	-	$1,8*10^3$
Yb	$2,0*10^{-6}$	-	$5,3*10^2$
Lu	$4,8*10^{-7}$	-	$4,5*10^2$
Hf	-	-	-
Ta	-	-	-
W	0,0001	WO^{2-}_4	$1,0*10^3$
Re	-	-	-
Os	-	-	-
Ir	-	-	-
Pt	-	-	-
Au	0,0000004	$AuCl^{-}_2$	$5,6*10^5$
Hg	0,00003	$HgCl^{-}_3$; $HgCl^{2-}_4$	$4,2*10^4$
Tl	<0,00001	Tl^+	-
Pb	0,00003	Pb^{2+}; $PbSO_4$; $PbCl^{2-n}_n$; $Pb(OH)^{2-n}_n$	$2,0*10^3$
Bi	0,00002	-	$4,5*10^5$
Po	-	-	-

Element	Concentration, mg/l	Forms of occurrence	Residence time in environment, years
At	-	-	-
Rn	$0,6*10^{-15}$	Rn(r)	-
Fr	-	-	-
Ra	$1,0*10^{-10}$	Ra^{2+}; $RaSO_4$	-
Ac	-	-	-
Th	0,00005	-	$3,5*10^{2}$
Pa	$2,0*10^{-9}$	-	-
U	0,003	$UO_2(CO_3)^{4-}{}_3$	$5,0*10^{5}$

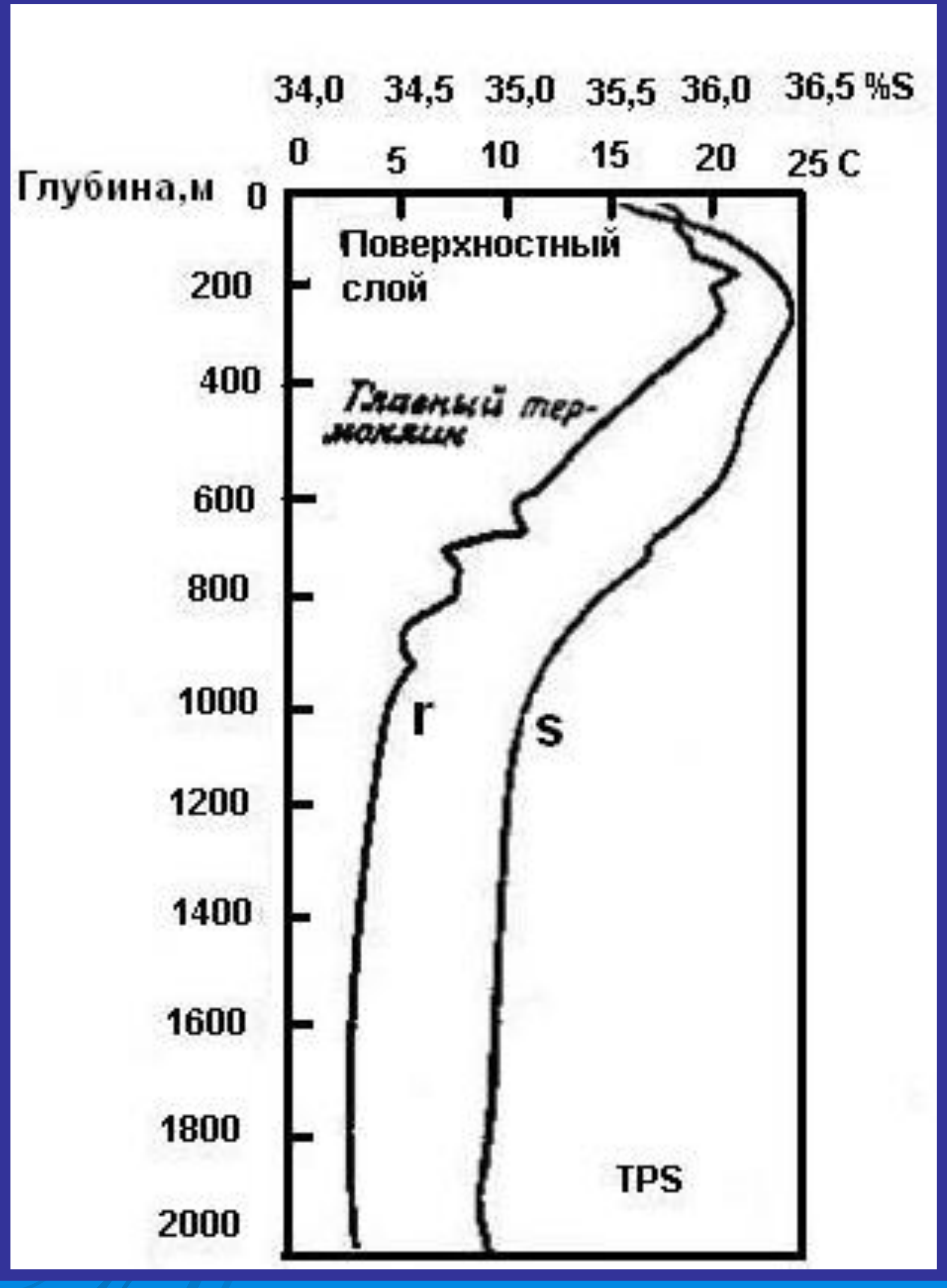
Approximate data on mineral production from natural mineral water (according to Bandarenko S.S. et al., 1986)

Raw material	∑ Production	Из, H_2O,%
Sodium chloride (NaCl)	$2,2*10^8$	30-35
Potassium salts	$2,6*10^7$	5-10
Sodium carbonate	$3,5*10^7$	5-10
Sodium sulfate	$4,6*10^6$	20-30
Calcium chloride	$2,7*10^6$	20-25
Boron(B)	$1*10^6$	20-30
Bromine(Br)	$3,9*10^5$	30-95
Magnesium (Mg)	$1,1*10^5$	25
Lithium (Li)	$5,5*10^4$	15-20
Iodine (I)	$1,3*10^4$	80-85
Iron (Fe)	$4,1*10^6$	+
Copper (Cu)	$6*10^6$	++
Zink (Zn)	$5*10^6$	++
Lead (Pb)	$2,3*10^6$	+
Uranium (U)	$3,8*10^4$	++
Silver (Ag)	$1*10^4$	++

+ - technologies available; ++ - project designed

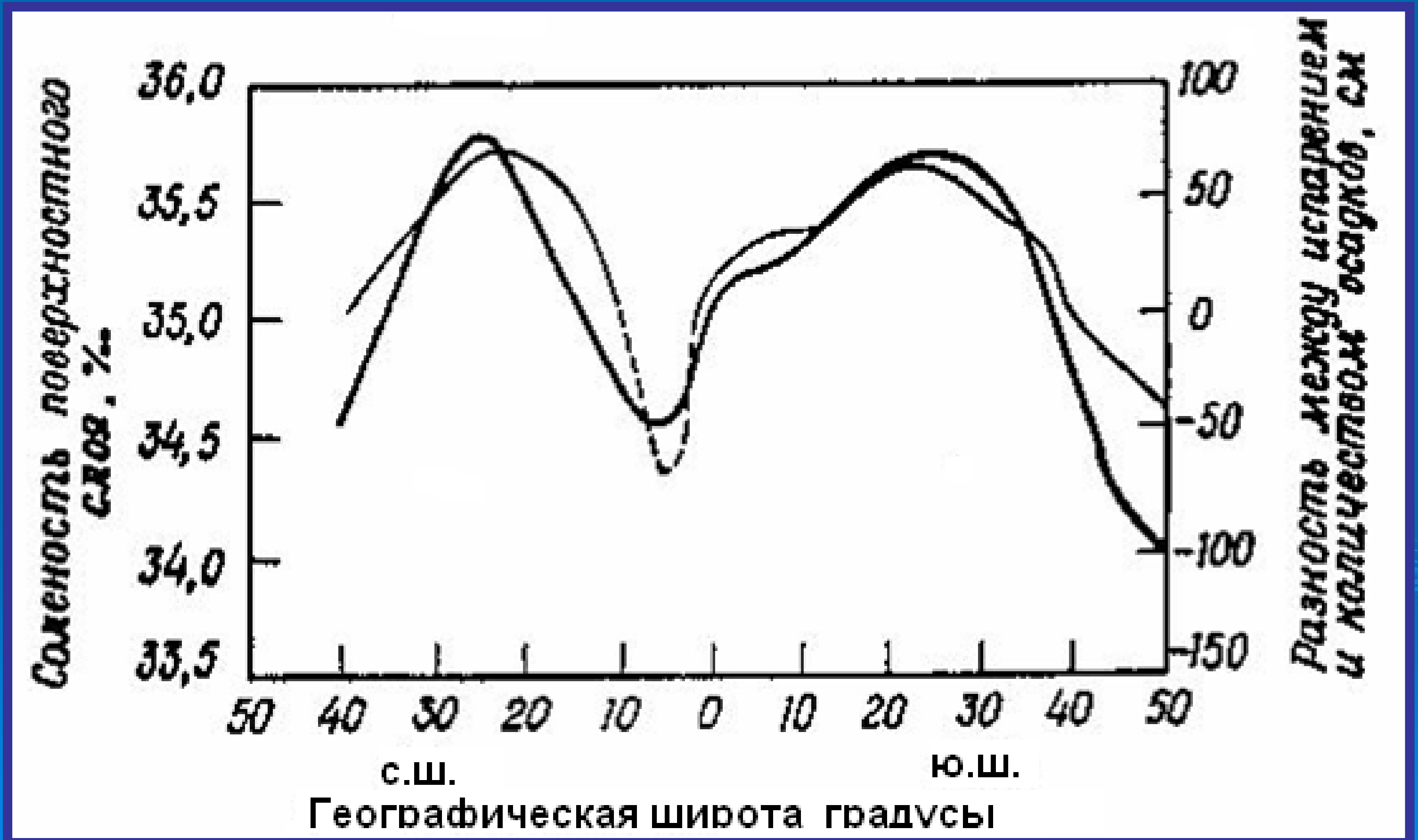
Typical profiles of temperature and salinity

(according to Horn, 1972)



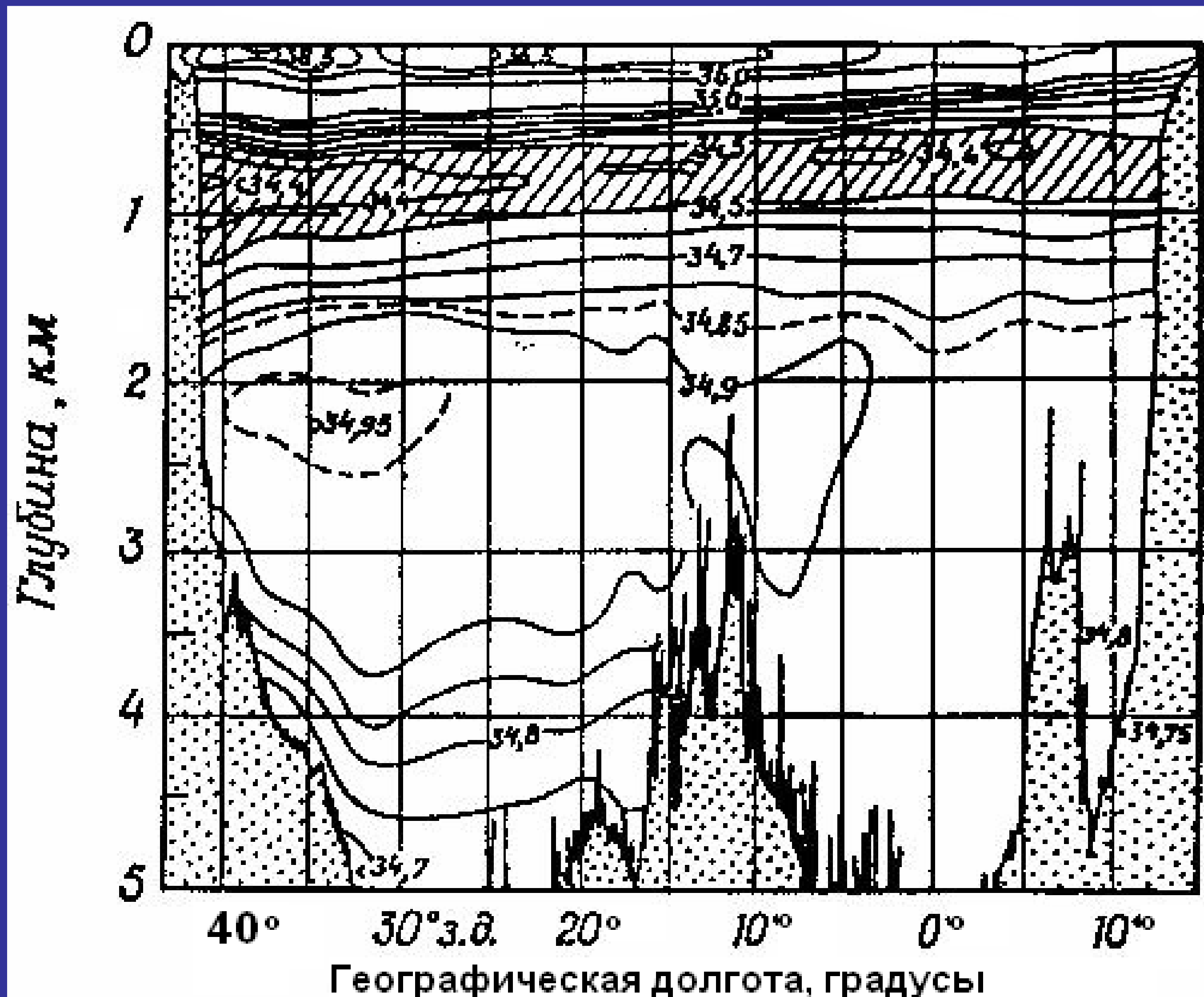
Salinity in the Ocean surface layer as a function of geographic latitude

(according to Horn, 1972)

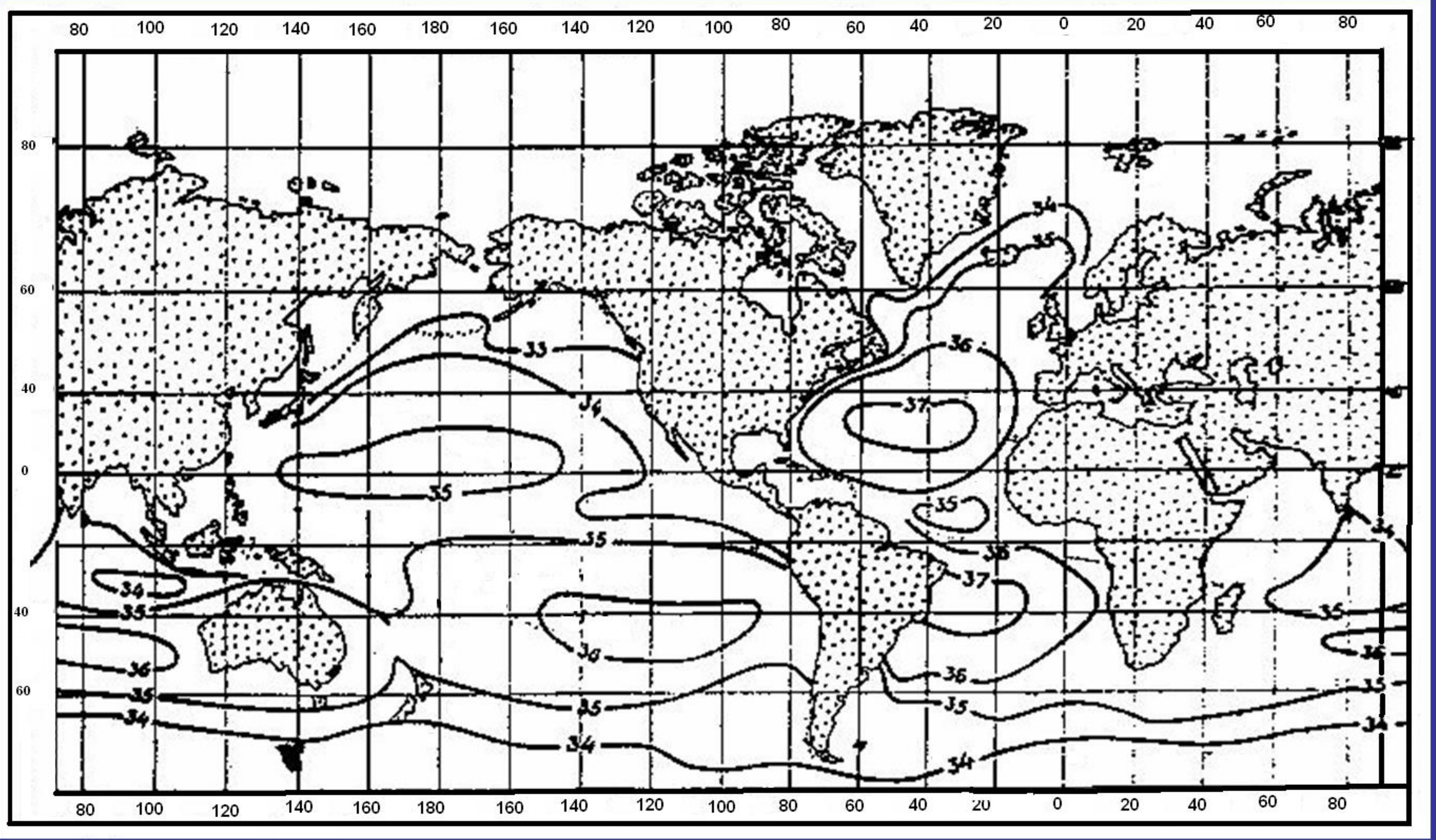


Salinity distribution in vertical cross section of the Atlantic Ocean near 23° S.L.

(according to Horn, 1972)

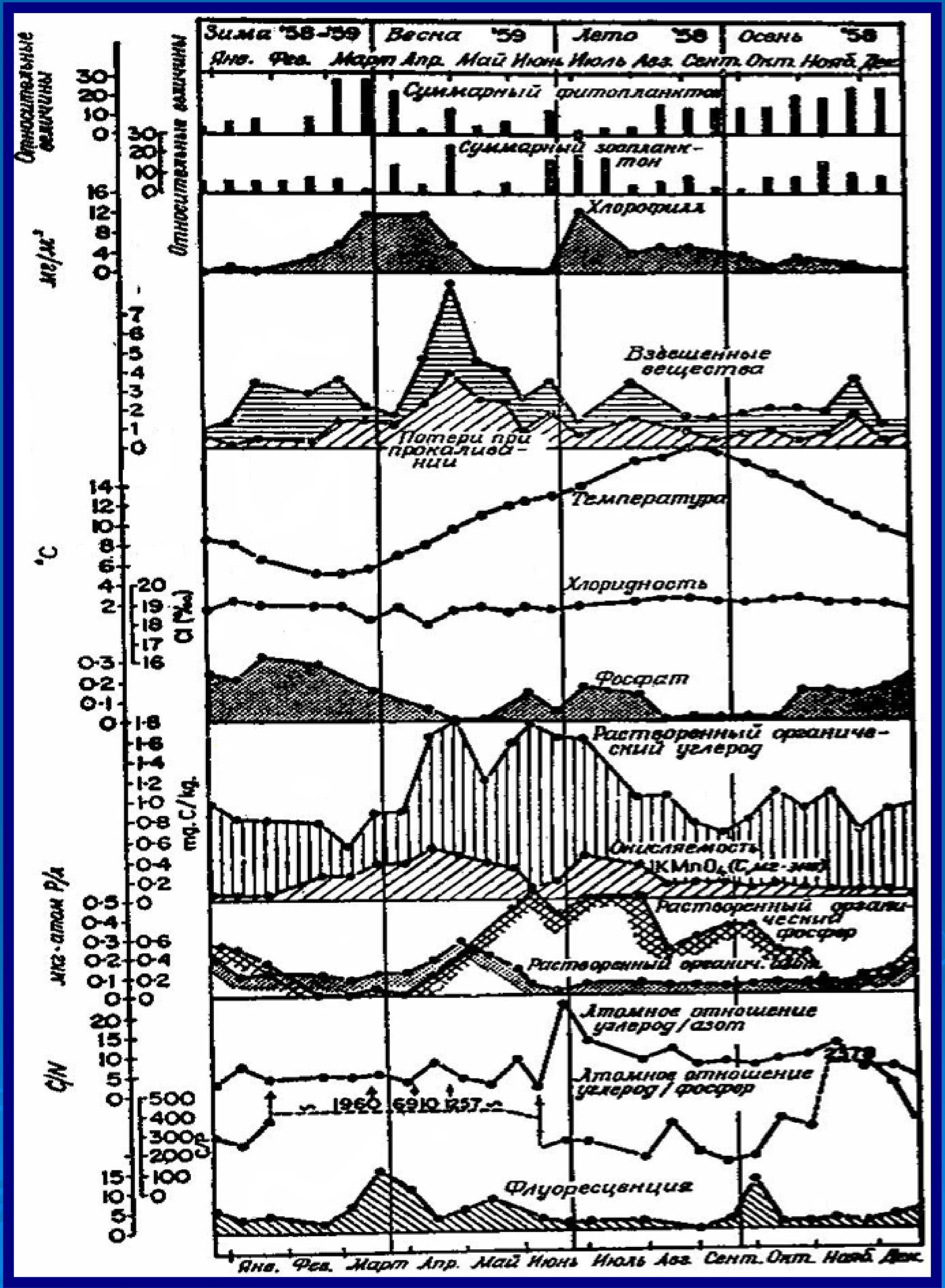


The Ocean surface layer salinity in the North summer
(according to Horn, 1972)

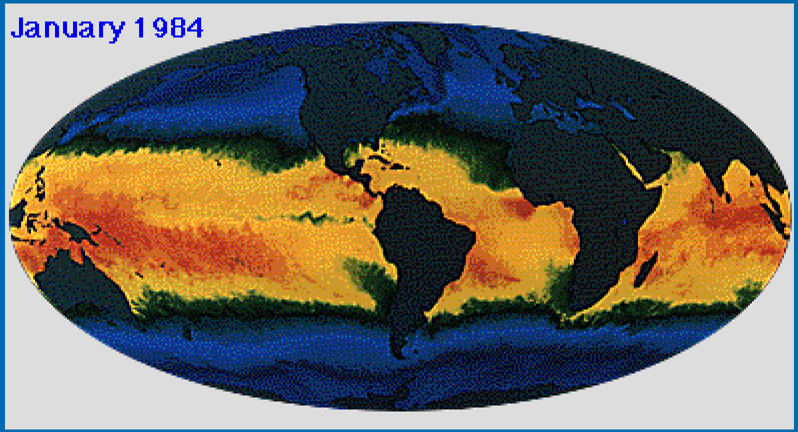


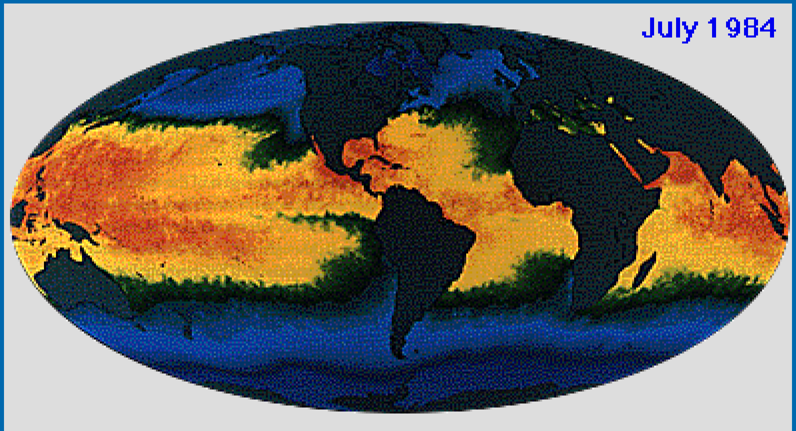
Seasonal changes in oceanic water composition

(according to Horn R.,1972)



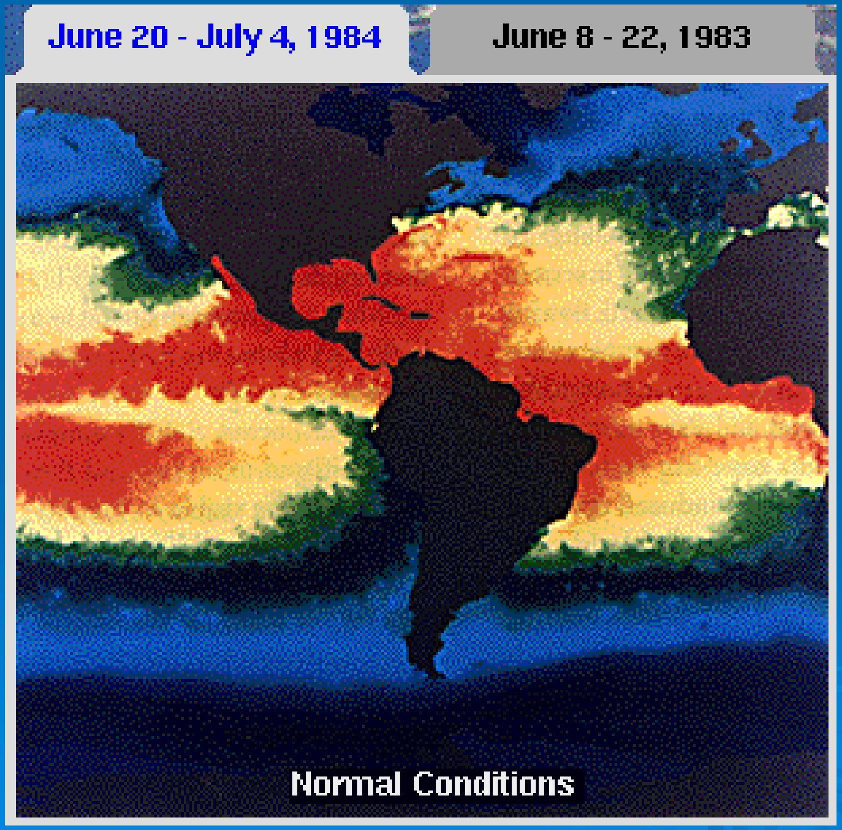
Sea Surface Temperatures

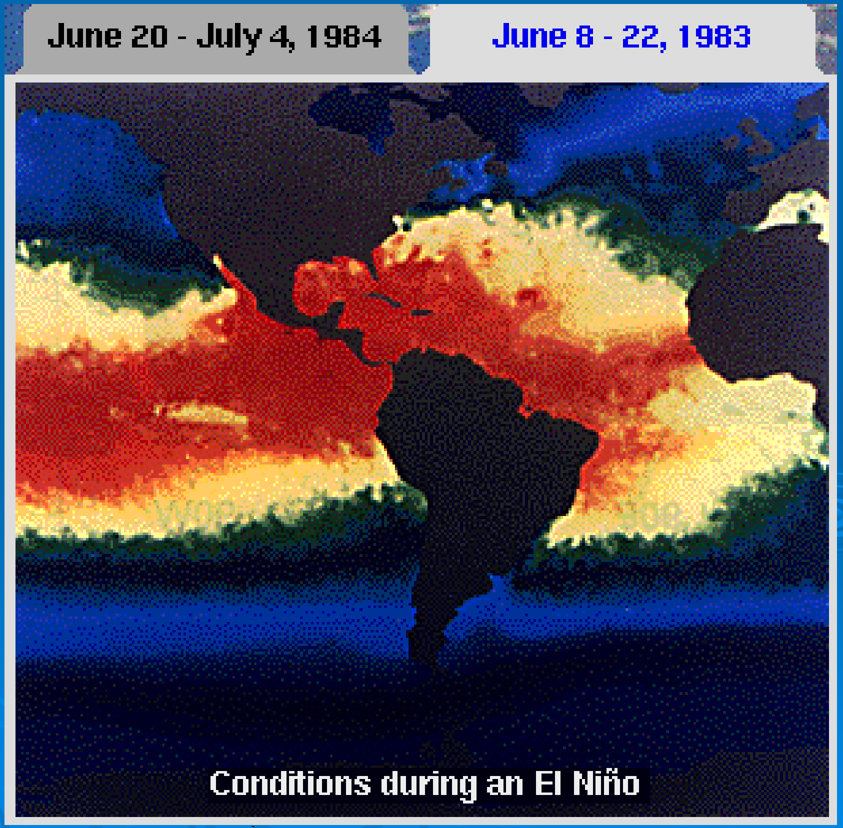


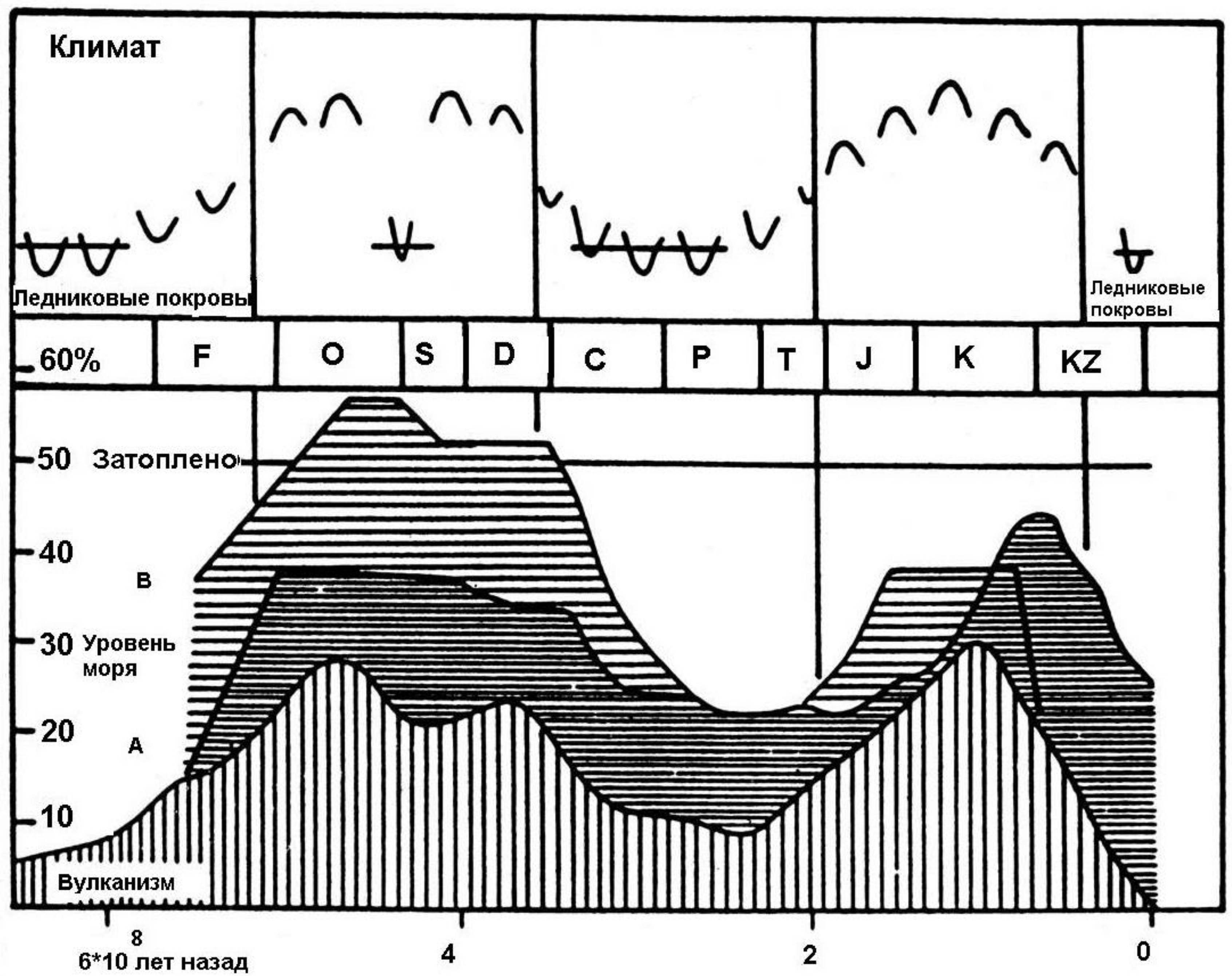


- These global sea surface temperature images of 1984 show normal temperatures within a 6-month cycle. The colors range from blue, which represents 3° C, to dark orange, which represents 30° C.

Anomalies, such as El Niño, may indicate serious global climate changes

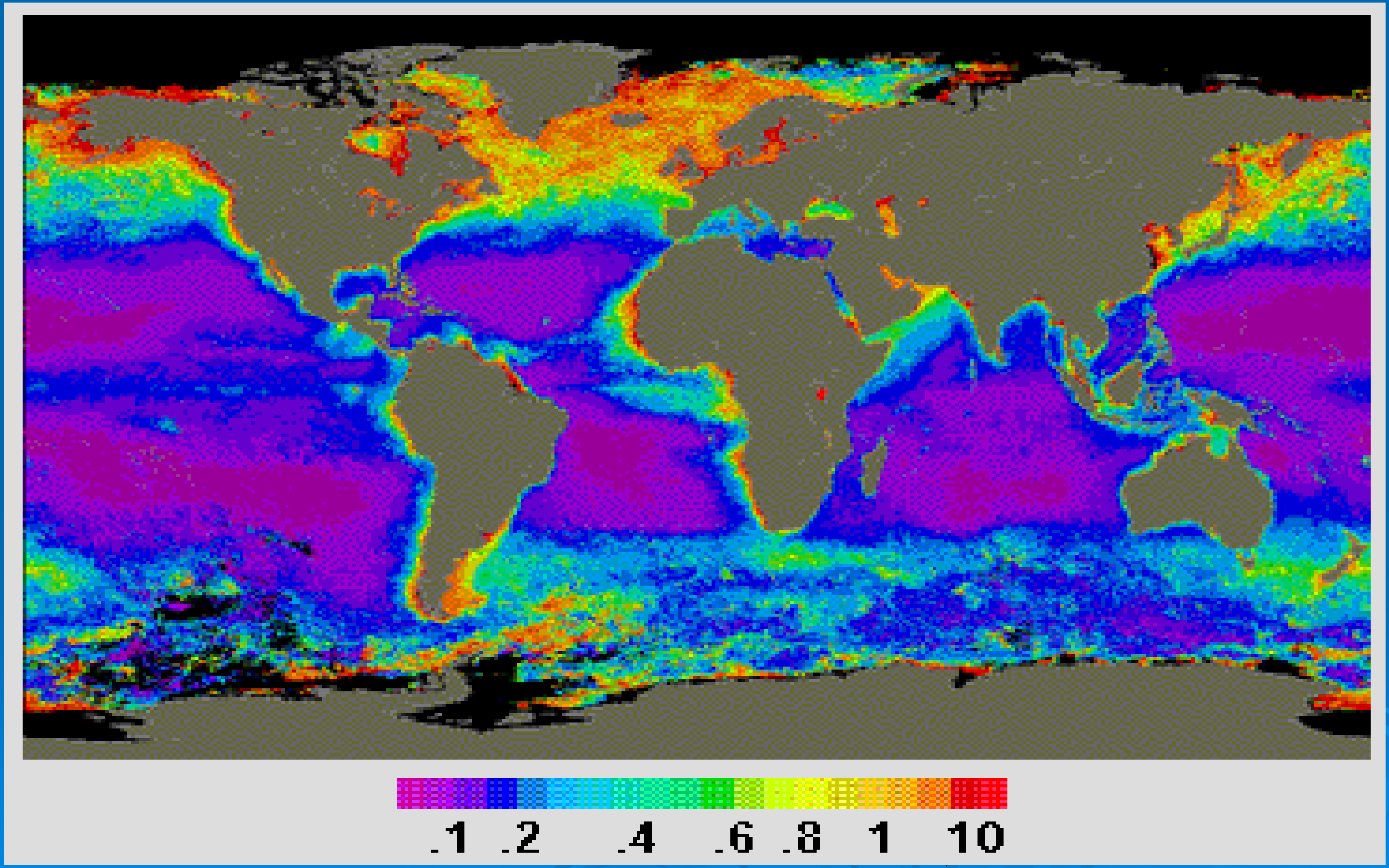


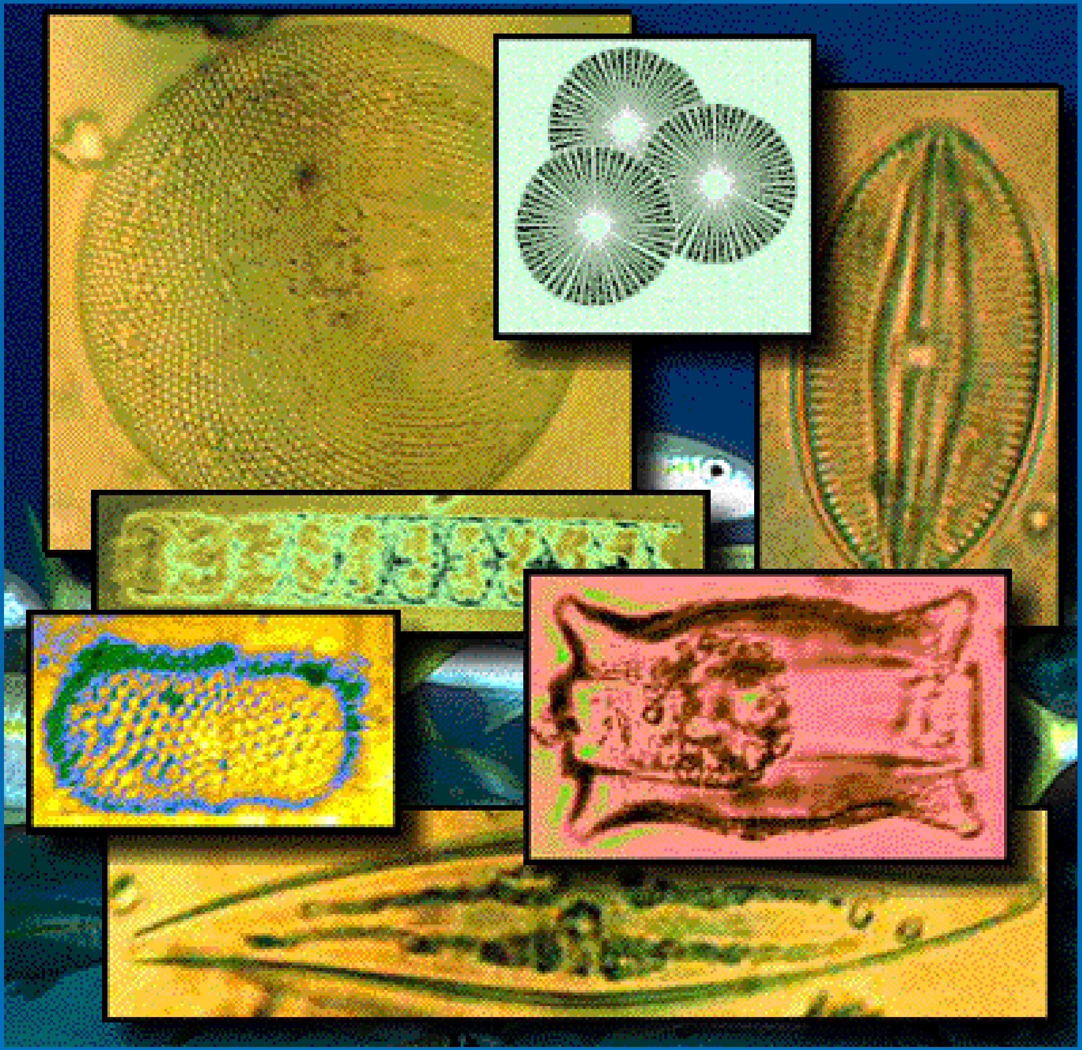




Климат
Ледниковые покровы
Ледниковые покровы
60%
F
O
S
D
C
P
T
J
K
KZ
50
Затоплено
40
B
30
Уровень моря
20
A
10
Вулканизм
8
6*10 лет назад
4
2
0

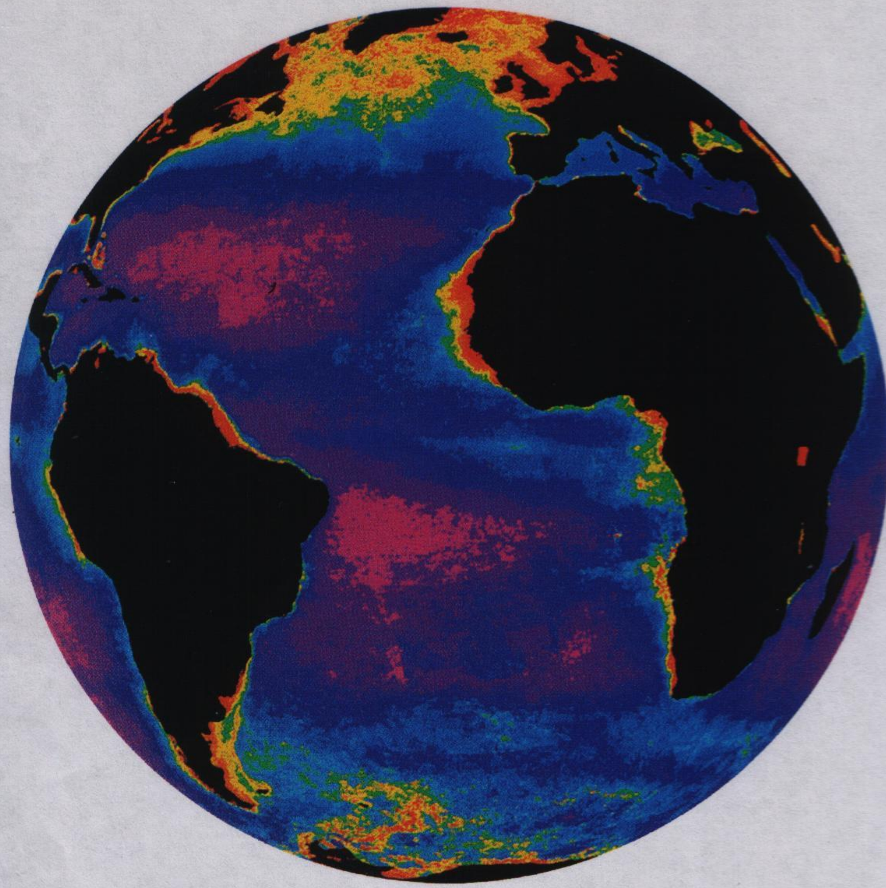
Global distribution of phytoplankton concentration is indicated by ocean color





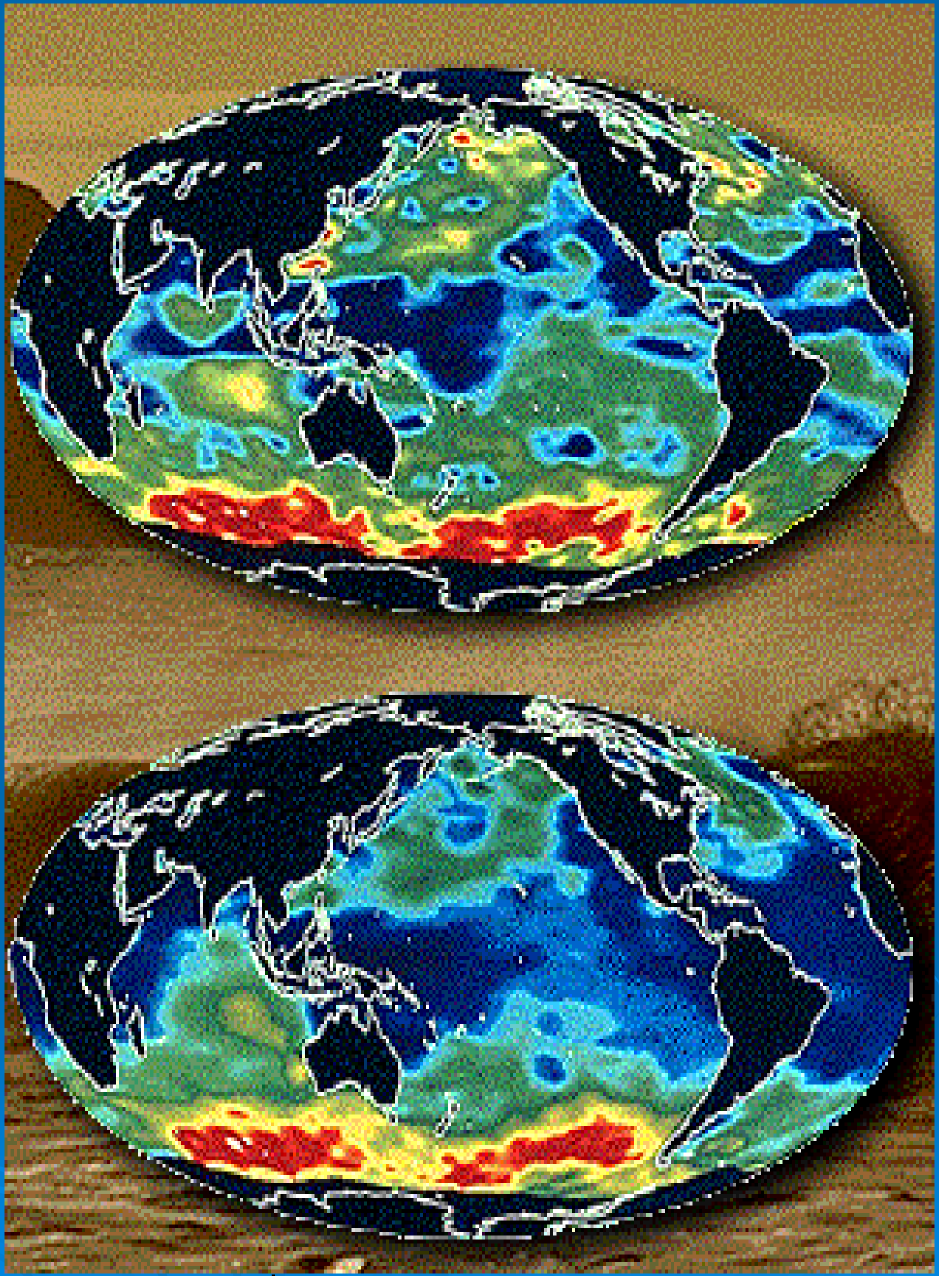
Microscopic green plants, called phytoplankton, form the lowest level of the marine food web and play important roles in many geochemical processes

Plankton productivity in the World Ocean (satellite observation)



Distribution of phytoplankton in the ocean. Produced by scientists at the NASA Goddard Space Flight Center from data taken by the Coastal Zone Color Scanner on the *NIMBUS 7* satellite, the image is an ensemble of data from different seasons. Red, yellow: high concentrations; blue, purple: low concentrations. (*Source:* Courtesy of NASA.)

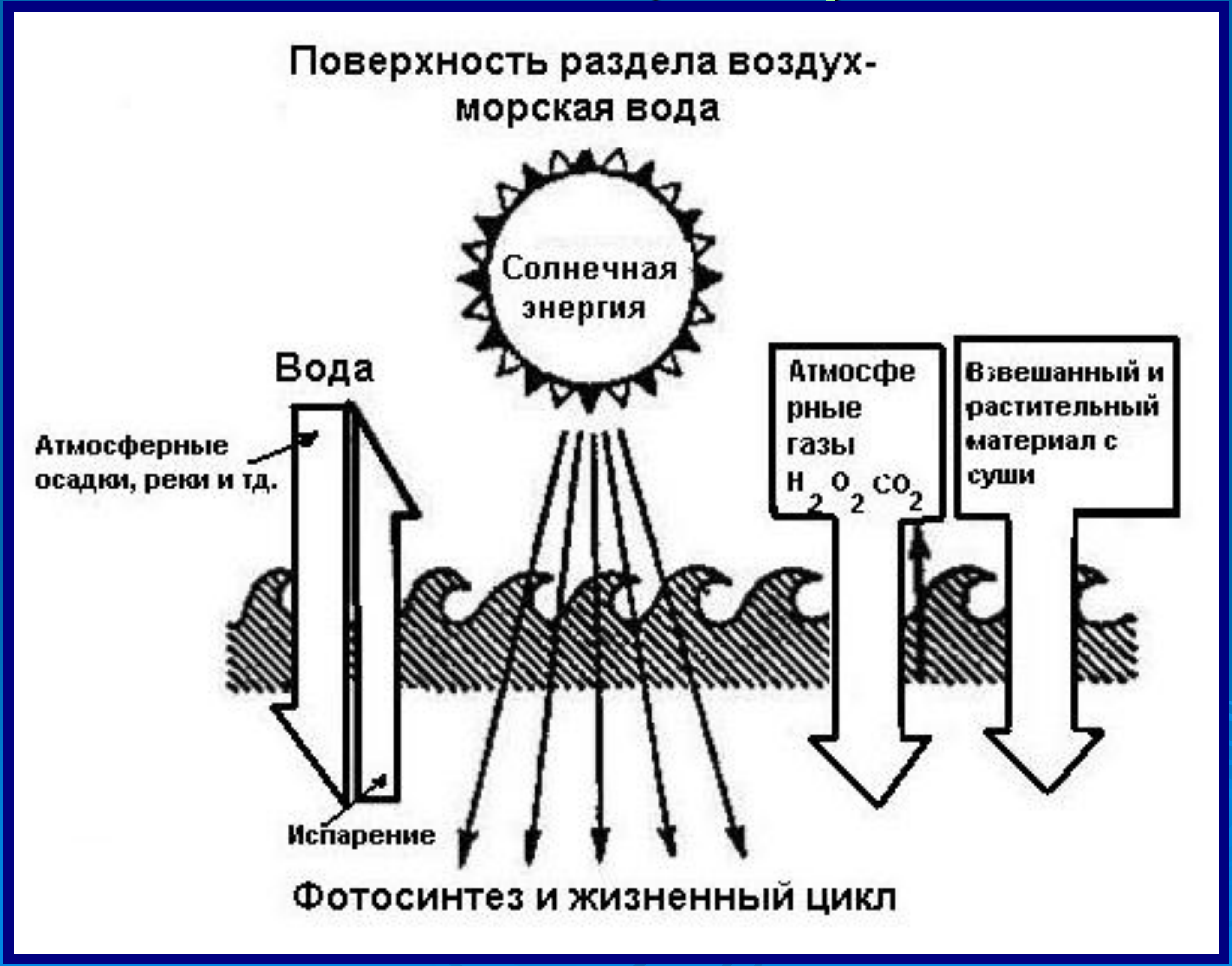
The bottom image indicates the wave heights in the oceans during the same period. Wave height is determined by the shape of the radar pulse returned by the ocean's surface. In this image, the highest waves occur in the Southern Ocean, where waves up to 6 meters high (represented in red) are found. The lowest waves (indicated by dark blue) are found primarily in the tropical and subtropical oceans, where the winds tend to be lighter.

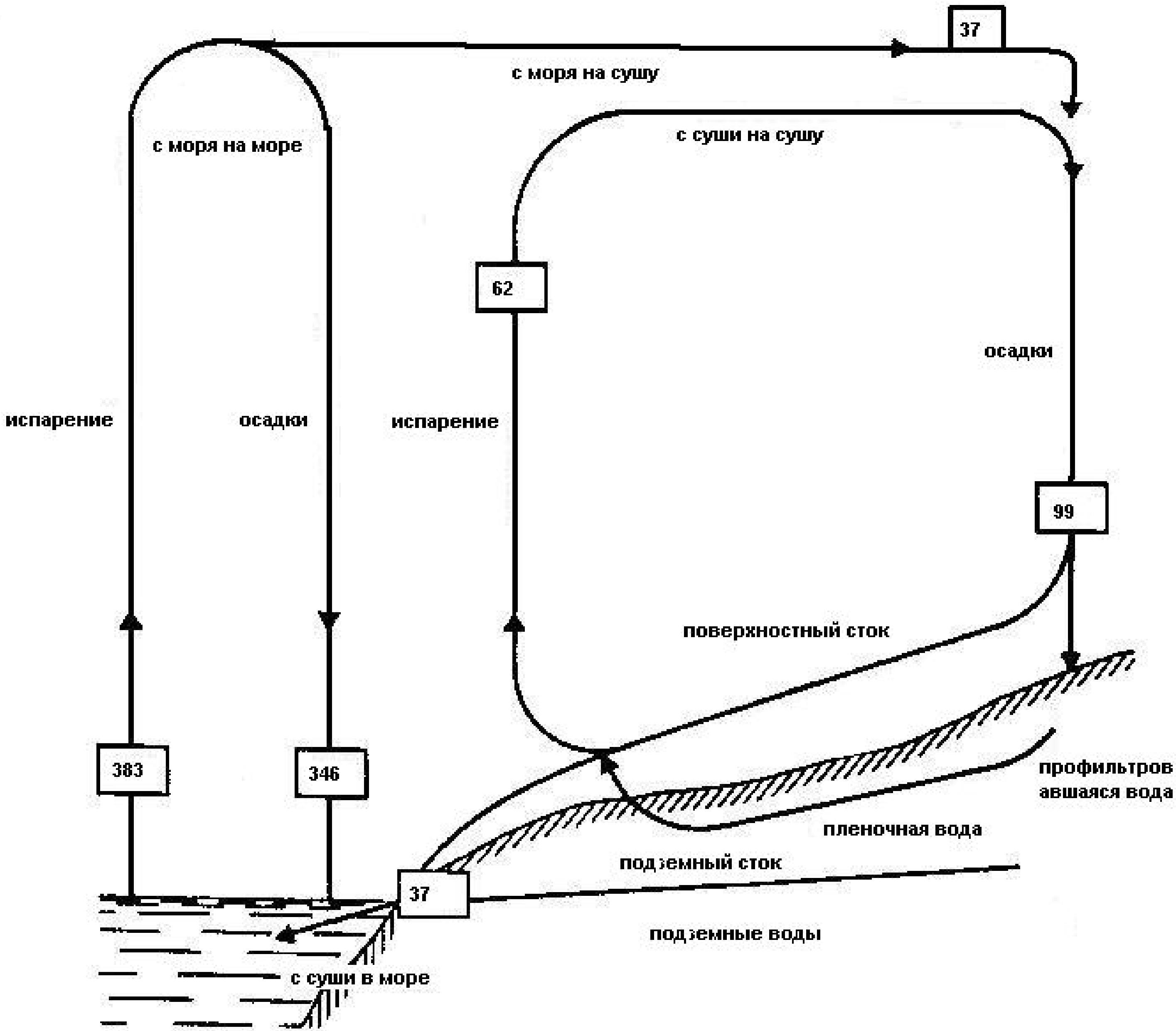


Sea balance
(according to V.I. Vernadskiy, 1960)

<table>
<tr><td colspan="2">A.Matter is transported from land and air to the sea</td><td>B.Matter is transported from sea to land or air</td></tr>
<tr><td>Precipitations – rain and snow, wind</td><td>Carry dust; precipitations</td><td>Water evaporation transporting not only water, but also NaCl etc.**</td></tr>
<tr><td colspan="2">Land organisms, matter in solution</td><td>Wind and splashes
Unsolved sea deposits on the bottom</td></tr>
<tr><td colspan="2">Solution by the Ocean</td><td>Gas circulation, Gas escape at temperature and pressure changes.</td></tr>
<tr><td colspan="2">Cosmic dust and gas</td><td rowspan="5">Transition of sea organisms onto land.
Eating sea organisms by land organisms.
Human activity.</td></tr>
<tr><td colspan="2">Rivers carrying large amount of matter into the Ocean in solutions and suspended state</td></tr>
<tr><td colspan="2">Gas absorption by sea water from atmosphere</td></tr>
<tr><td colspan="2">Human activity.</td></tr>
<tr><td colspan="2">Volcanic eruptions (submarine, subaerial)*</td></tr>
</table>

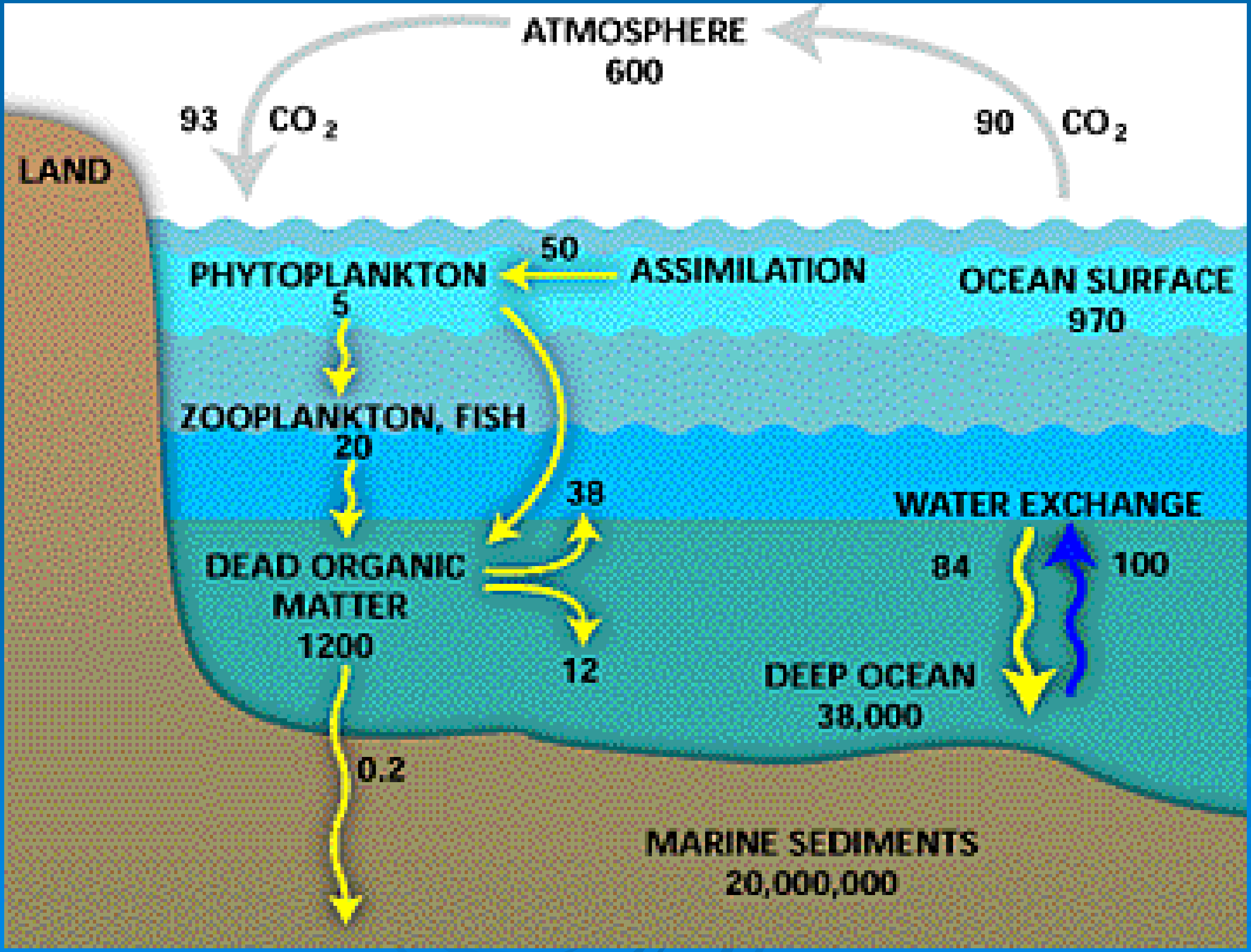
Some transportation processes through the interface of air and sea water (according to Horn R., 1972)





Глобальный круговорот воды (цифры отнесены к суммарному годовому обороту в 10^{15} кг)

This illustration shows the estimate of the carbon exchange between the ocean and the atmosphere. All quantities are in billions of metric tons.



Sea submarine placers

Their role has increased in recent years.

They are, as a rule, delta placers or embedded marginal-marine placers.

They are at different depths and distances from coast.

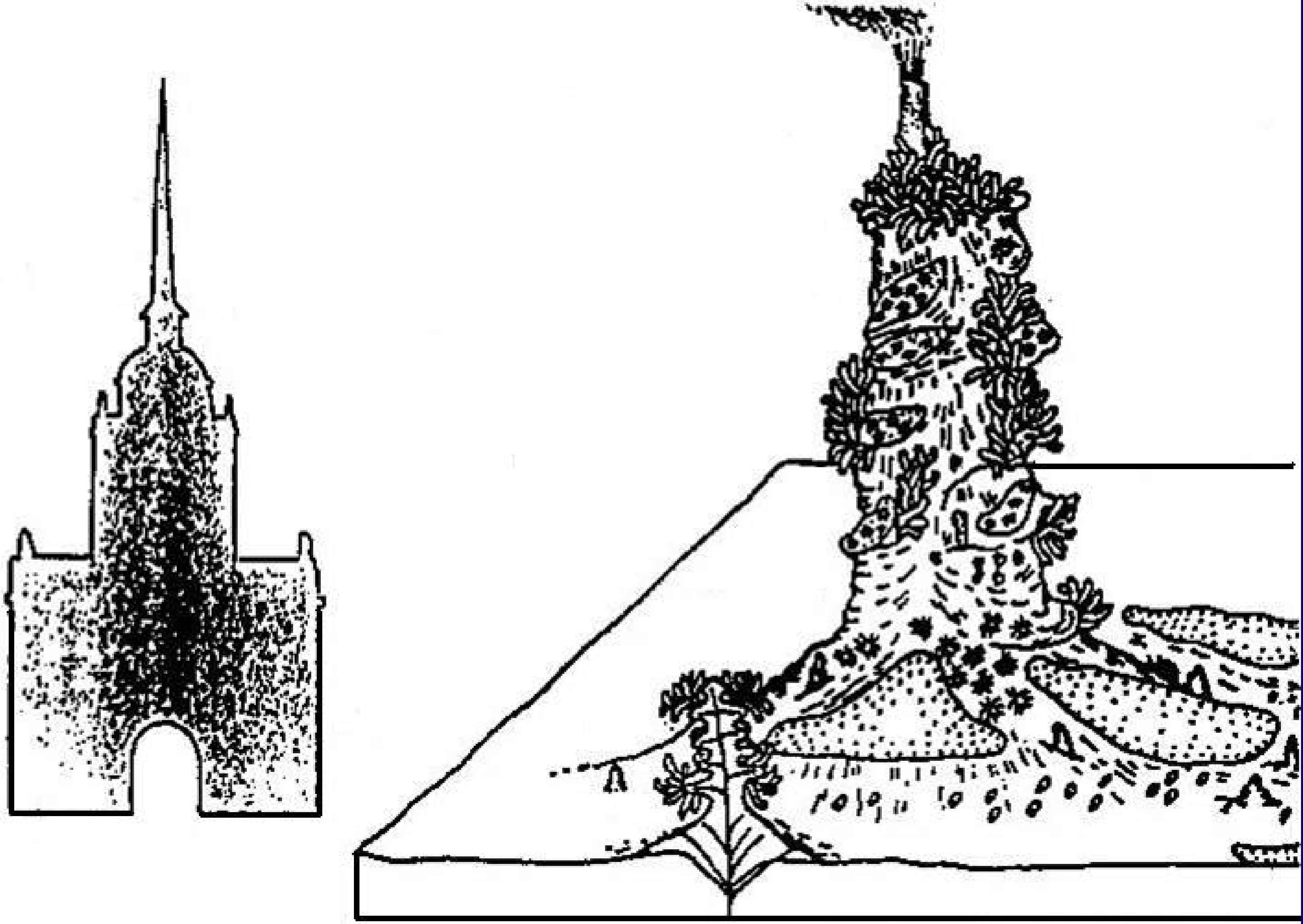
Their length is sometimes up to 1600 km.

Cassiterite – Indonesia
h = 35 m, l from coast – 10-50 km.
Volume – kg/m^3.

Gold – Alaska
h = 5-60 m, l from coast – 5 km.
Sand layer thickness – 6 m.

Diamonds – Western coast of Africa
h to 120 m, l from coast – 5 km.
Length 1200 km
5 carats/1 g. (in original – 0,5 carat m^3)
Production ~ 300 th. carats

There is a problem of international regulation.



"Черный курильщик" , его высота около 120 м.

Current hydrothermal ore-formation on the Ocean bottom

In the SPREADING zones of the Ocean bottom the numerous sites with sources of THERMAL brines forming thick sulfide deposits were revealed:

GALAPAGOS region, the RED SEA (Atlantis depression,
Juan de Fuca range).

Atlantis: Salt thermal deposits reserves^>100 mln. tons.
Content:

Fe>29%	**Ag-60 г/т**	**Sr^{87} /Sr^{86}= 0,7034**
Zn-2-5%	**Au-5 г/т**	
Cu-3-9%		

It is a modern analogue for a number of ancient stratiform depositions (Zhezqazghan, Mount Isa (Australia), Sullivan (Canada) and other deposits of Pb, Zn, Cu)

Deposits are formed by thermal benthic-oceanic.

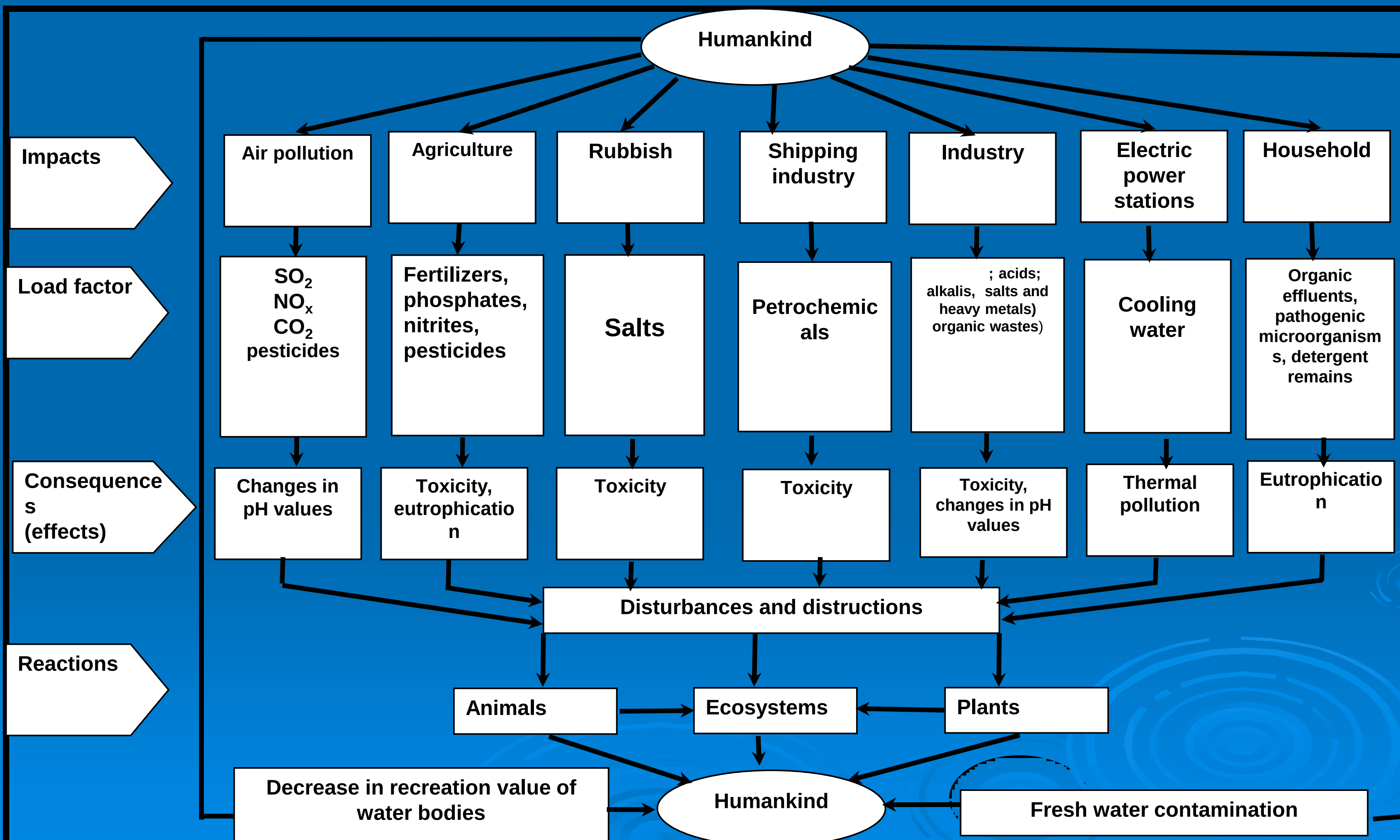
Composition of Sulfide ore in the World Ocean

Elements	Mid-Atlantic ridge	East-Pacific Rise	Juan-de-Fuca	Galapagos ridge
Fe, %	17,6-30,2	23,1-28,7	5-24,7	
Cu, %	2,01-16,25	0,61-1,89	0,06-0,61	
Zn, %	1,39-4,06	2,80-5,93	11,48-28,84	
Ba, %	0,05-0,09	0,07	0,03-1,37	
Pb г/т	260-460	230-1160	1920-2150	
Co	15,9-103,8	44-62,1	5,4-10,5	
Ni	38-45	2,7-56,5	25,8	
As	62-67	431-480	421-711	
Cd	52	122-493	134-550	
Ag	42,7-48,6	121,3-172,6	63,1-165,2	
Au	1-12,85 (до 70 г/т)	0,18	0,13-4,42	
Mn	< 0,1	< 0,1	< 0,1	< 0,1

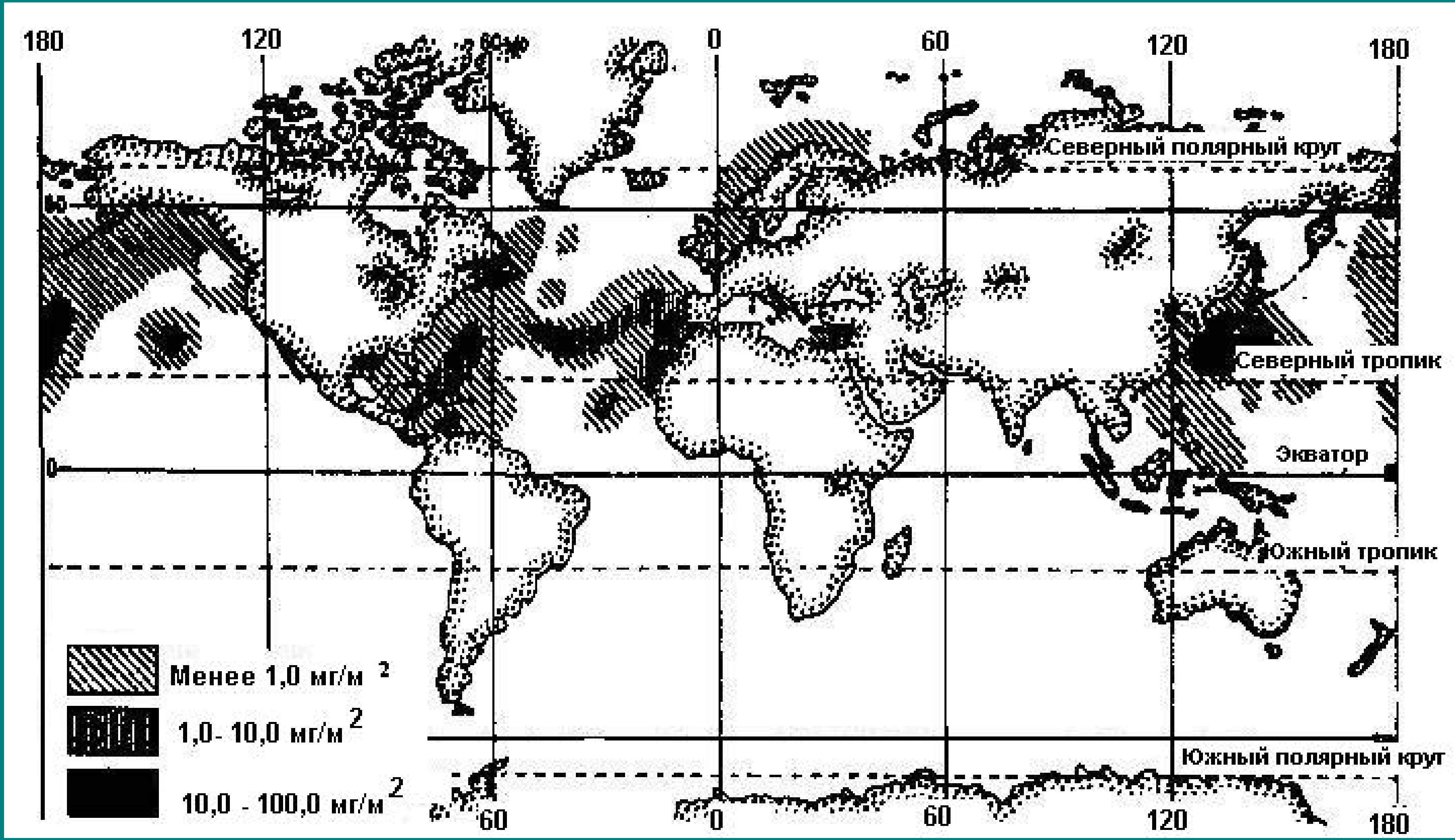
HYDROSPHERE **Balance disturbance:**			
Irreversible water consumption	**-**	**9**	**Mainly due to irrigation and reservoirs**
Irreversible outflow into the ocean	**430-570 km^3/year**	**-**	**Mostly due to water pumping from wells.** **Data of different authors differ.**
Oil pollution		**3560 times**	**Oil film covers up to ¼ of the World Ocean surface.**
Heavy metal pollution	**$2135x10^6$ t/year** **-**	**since the 19-th century 10-15 times on average**	**Sometimes geochemical abnormalities differ from catastrophic level by one of values**

Anthropogenic disturbances in functional cycle by the example of water ecosystem

(«Environment», 1993)

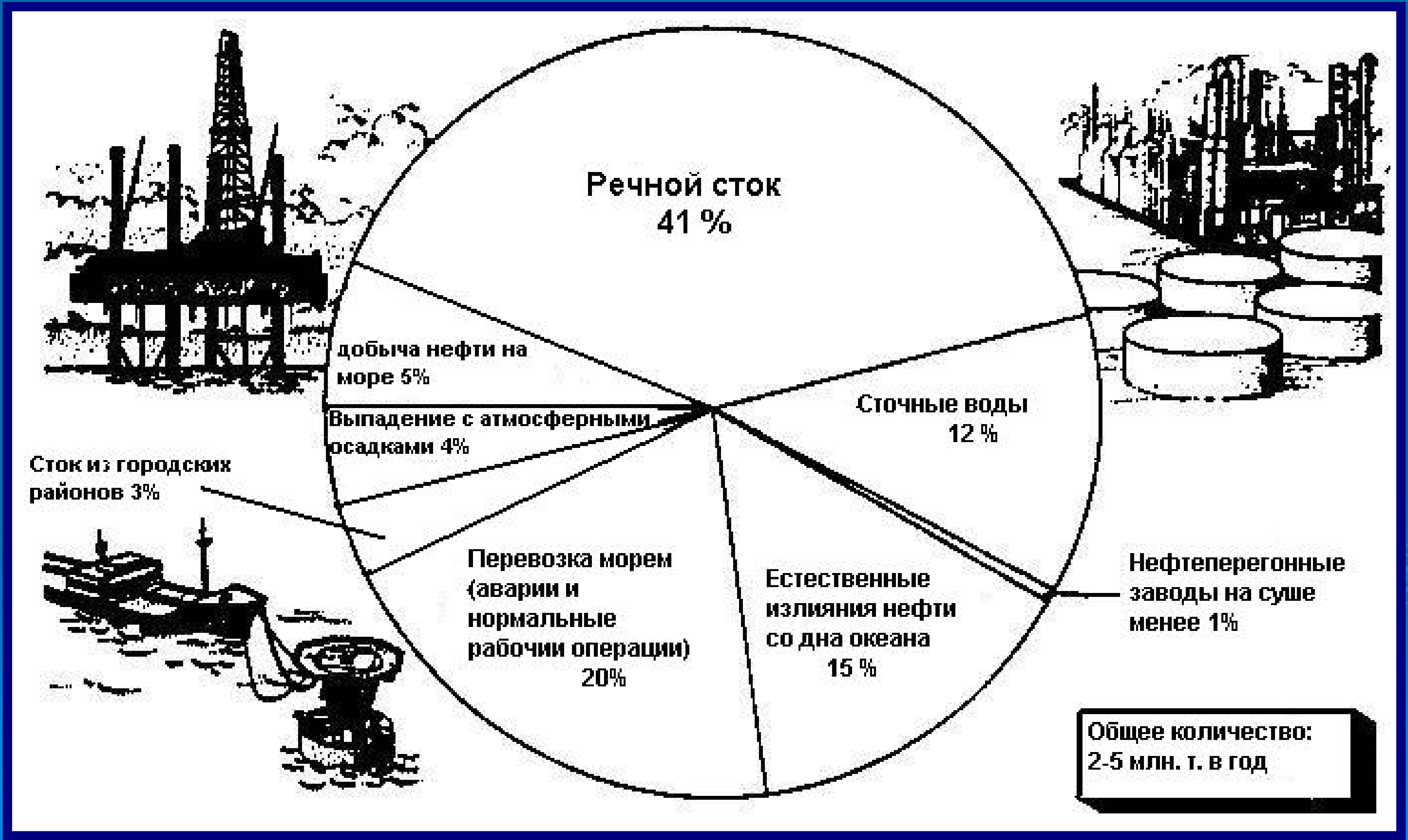


Oil Spillages Concentrations on the World Ocean Surface
(according to N.F. Reimes,1990)



Oil pollution sources of world reservoirs at the beginning of the 1980's

(According to P. Revel et al., 1995)



The photo was taken from the space satellite on September 7, 1985, showing waters of the Mahajamba Bay on Madagascar Island. The sedimentation, seen on the left of the bay, is the result of extreme erosion due to deforestation.

Silting rates in some reservoirs

Country	Reservoir	Annual silting rates (t)	Period of complete silting (years)
Egypt	Aswan High Dam	139 000 000	100
Pakistan	Mangla Dam	3 700 000	75
Philippines	Ambuclao	5 800	32
Tanzania	Matumbulu	19 800	30
Tanzania	Xisongo	3 400	15

Source: S.A. El-Swiafy, E.W.Dangler, "Rainfall Erosion in the Tropics: A State of the Art", American Society of Agronomy, Soil Erosion and Conservation in the Tropics (Madison, Wisc.: 1982