NATURAL FLUCTUATIONS OF ECOSYSTEMS

Marine biology and fishery biology owe much to studies of Russian scientific and fishery institutes. The monograph *Studies of fishery in Russia* in 9 volumes published in Russia back in 1860–1875 is a good example of it. However, the old paradox holds good: the more we learn the less we understand the nature of latent changes in marine ecosystems, including those caused by human activities (**Fig.** 5).

Balanced use of marine bioresources is impossible to imagine without profound understanding of the nature of phenomena and processes developing in marine ecosystems which are complex structures with multiple levels in the thick layers of water including both benthic and pelagic zone. Marine ecosystems extend horizontally from shallow waters of the coastline zone to the bed of the continent through shelf and further include bottom ridges and abyssal areas (Lisytsyn and Vinogradov 1982, Matishov and Pavlova 1990).

Colossal energy and matter fluxes from plankton and benthos to birds, whales, polar bears, walruses via ichthyofauna take place inside marine ecosystems owing to trophic chains and migrations, both active and passive, for hundreds and thousands miles. One should bear in mind, that peak activity of biota is determined by hydrological fronts causing thermo cline, upwelling zones, ice-field edges, estuaries of principal rivers. Hydrothermal areas, open water areas in the ice-fields, underwater ridges are oases of life. All these contribute to a complex structure of ecosystem where mankind plays a role by exploiting valuable commercial species. And to crown it all, ecosystems are exposed to complex natural and anthropogenic influences.

Marine ecosystems develop against the natural background of climatic fluctuations and lifecycles of biota. It is known, that there are big fluctuations in abundance of certain year-classes of some hydrobionts which are closely connected with the natural fluctuations of natural mortality rate of non-commercial marine species.

Bioproductivity of reservoirs and fishery efficiency are influenced greatly by climatic changes on the global scale characterized by recurrent pattern (**Fig.** 6). Marine ecosystems of the shelves of the Azov, Barents, White and some other seas reflect complex geological history related to intermittent glacial and periglacial periods and sea level fluctuations (**Fig.** 7). That is why marine biota is adapted to large scale climatic fluctuations (Matishov and Pavlova 1990).

Sharp climatic anomalies produce specific impact on marine ecosystems cycle. These periods are responsible for breakdowns of trophic and other interrelations within ecosystems. Experts suppose that we are facing the change of the climatic epoch when the prevailing type of the air masses circulation is being modulated causing «cold winters» in the Western Africa and Europe. The latest data show the increasing variation of temperature range in the Northern Hemisphere, which indicates that the climatic system is unstable on the whole.

PHENOMENA	SEA
Long-term fluctuations of climate	BARENTS BALTIC WHITE BLACK AZOV CASPIAN
Anomalous excess of ultraviolet radiation dozes (through “holes” in the ozone layer)	BARENTS
Cyclic advection of warm Atlantic Gulf Stream water	BARENTS BALTIC WHITE
Cyclic advection of cold “fresh” anomaly	BARENTS
Fluctuations of Mediterranean advection water	BLACK AZOV
Expansion of drifting ice-bergs (marine perglacial)	BARENTS
Sea ice dynamics	BARENTS WHITE NORTH CASPIAN
Tidal currents	BARENTS WHITE
Cyclical fluctuations of sea level	CASPIAN
Irregular fluctuations of sea level	AZOV NORTH CASPIAN BALTIC (GULF OF FINLAND)
Cyclic freshening of the basin	BALTIC
Natural fluctuations of river runoff	AZOV BLACK NORTH CASPIAN
Hydrogen sulfide contamination of waters (oxygen deficiency)	BLACK AZOV
Sand storms	AZOV

Fig. 5. Natural phenomena affecting the dynamics of marine ecosystems

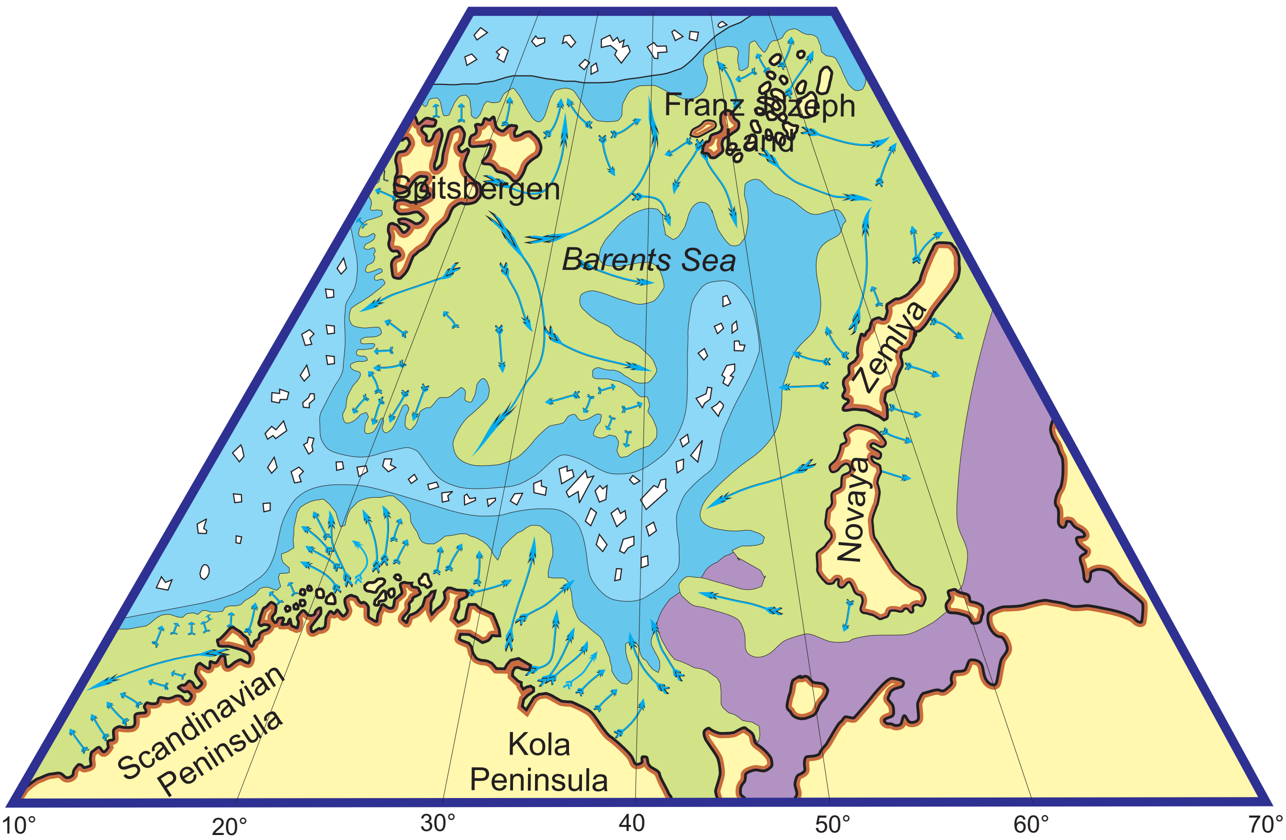


Fig. 6. Probable development of the continental glaciation on the Barents sea shelf during Last Pleistocene (18-20 thousand years ago)

Results of modeling carried out by Prof. Detleff and his group (Potsdam, Germany) proved irregular character of amplitudes and periods of recurrence of natural climatic fluctuations during centuries and millennia. This implies that detected trends (e.g. positive branch of the North-Atlantic Current) may quickly switch to the opposite phase (cooling instead of warming). Coincidence of natural recurrent fluctuations in abundance of fish year-classes and climatic changes in time adds to the complexity of the problem and may produce unpredictable effects.

Every sea is characterized by its own peculiarities of natural changes manifestations on the global scale. In the high latitudes, and especially in the Barents Sea, organisms receive nearly annual dose of solar irradiation during so called Polar day. The anomalous doze of ultraviolet irradiation through the so-called holes in the ozone layer may damage genetic resources of algae and other hydrobionts.

Joint studies of *MMBI* and *the Alfred Wegener Institute of Polar and Marine Studies* (Germany) experimentally proved destructive effects of ultraviolet irradiation exceeding admissible threshold (Dring et al. 1996). The danger of ultraviolet irradiation is in its strong destructive impact on all systems of the biota from impact on the cellular level (DNA and mechanisms of protein synthesis) to ecosystem level (disappearance of less resistant species). Under the influence of high doses of ultraviolet irradiation the growth rate is considerably slowed down, stagnated and plants die off (**Fig.** 8). Ultraviolet irradiation has exceptionally dramatic impact

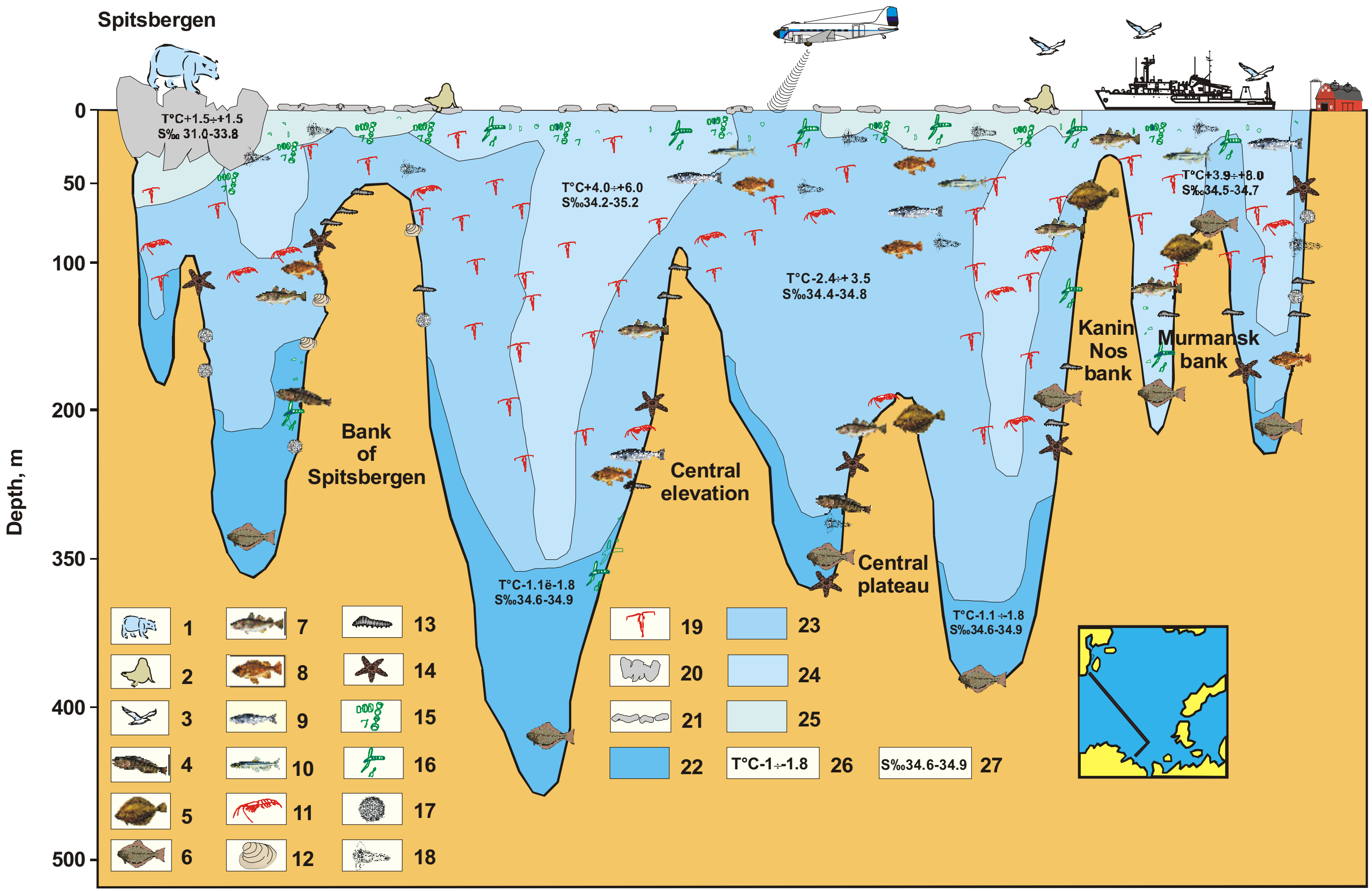


Fig. 7. Structure of the glacial shelf ecosystems (the Barents sea)

The habitat of: 1. polar bear; 2. marine animals; 3. birds; 4. wolffish; 5. plaice; 6. halibut; 7. cod; 8. perch; 9. salmon; 10. capelin; 11. shrimps; 12. scallop; 13. polychaete worms; 14. cushion stars and basket stars; 15-16. diatoms and Mastigophora class; 17. sea urchins; 18. sea butterflies; 19. Calanus and Copepoda subclass

Other symbols: 20. icebergs; 21. sea ice; 22. near bottom waters of Arctic; 23. coastal waters; 24. Atlantic waters; 25. Arctic waters; 26. The Barents Sea waters and water temperature; 27. water salinity

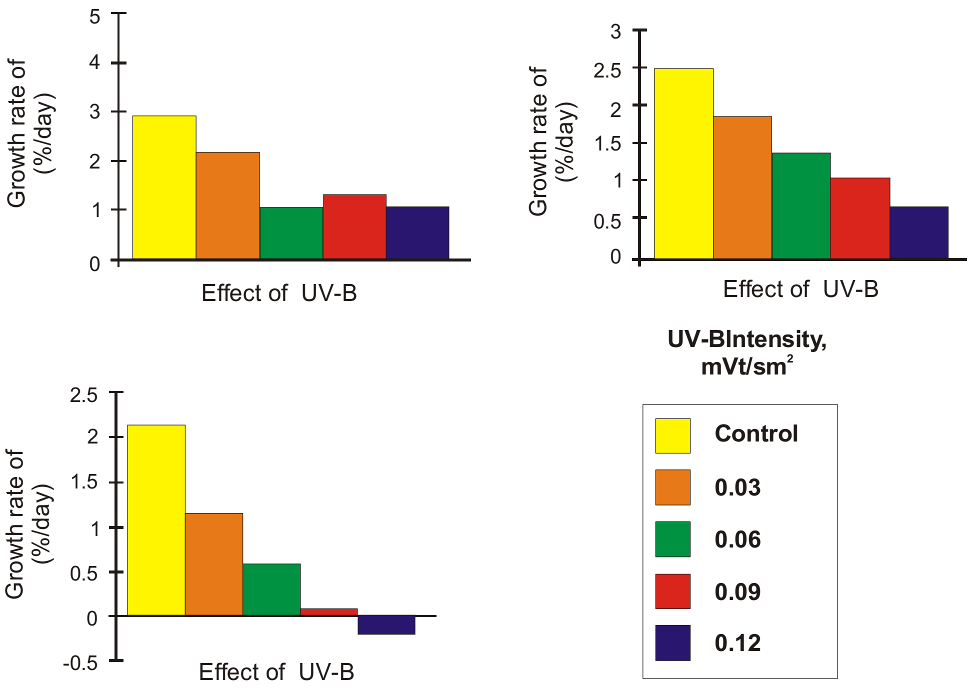


Fig. 8. Ultraviolet radiation impact on the early stages of development of macrophytes

on organisms at the early stages of their life-cycle. Natural level of ultraviolet irradiation that have been observed for last few years significantly (for some species of algae 80%) hinders algae growth rate and reduces natural reproduction capacity of nearly all mass species of algae in the Barents Sea.

The essential role of the Atlantic Ocean for understanding of the processes in the European seas deserves consideration from the geographic viewpoint (**Fig.** 9). One of the crucial factors determining productivity of the Northern seas is temperature and salinity balance in connection with the advection of Atlantic waters. Seasonal and long term dynamics of currents and frontal zones is, in many cases, the crucial factor in marine biota modifications.

Salinity anomaly in the North Atlantic waters and in the Norwegian-Greenland basin in 1970–1980s stands out against the background of the other natural phenomena influencing ecosystem dynamics (Belkin et al. 1997). The North-Atlantic Current salinity anomaly reached the Barents Sea in 7 years after entering the scene (**Fig.**10). The advection of cold fresh water is to be blamed for annual minimum and maximum salinity and temperature on the sea shelf.

Climatic fluctuations occurring during one century or stretching over a number of centuries play an important part in the cycle of biota (**Fig.**11, 12). Some unfavorable climatic changes (cold hydrological years) are known for their particular pattern of occurrence (11, 21, 33, 90 years and longer periods). For instance, normally ice free Kola Bay froze 5 times during the 20th century (1902,1933,1965,1998,1999) and anomalous icebergs deviations up to 1000 km off the habitual drifting route in the Barents Sea took place (**Fig.** 12). 1977–1980 cooling caused reduction of the main Barents Sea fish species stock abundance and decline in fisheries (Yaragina et al. 1996). This cooling is confirmed by Arctic species expansion (Arctic cod) further to the west of the Barents Sea.

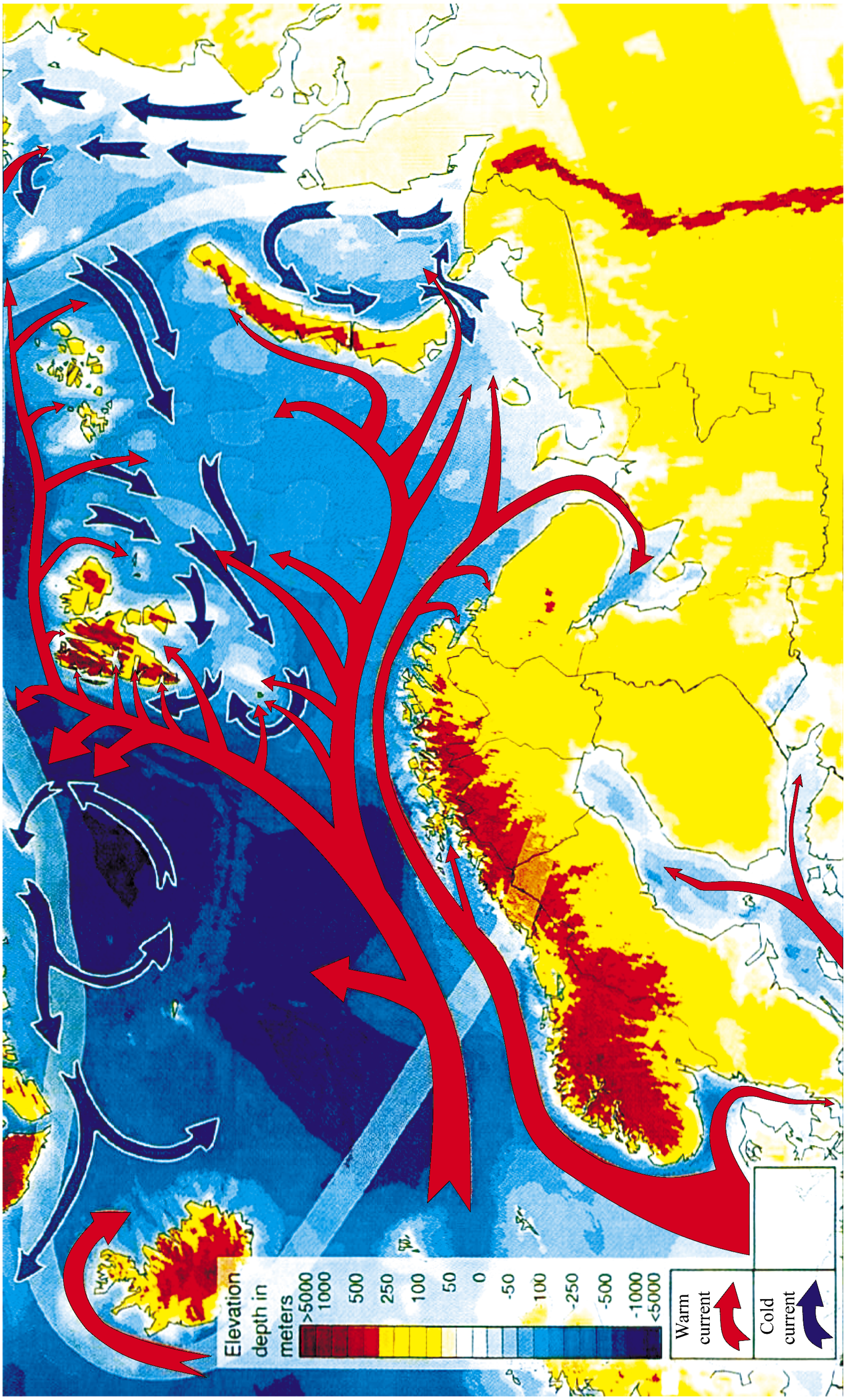


Fig. 9. Advection of warm Atlantic water of the Gulf Stream system

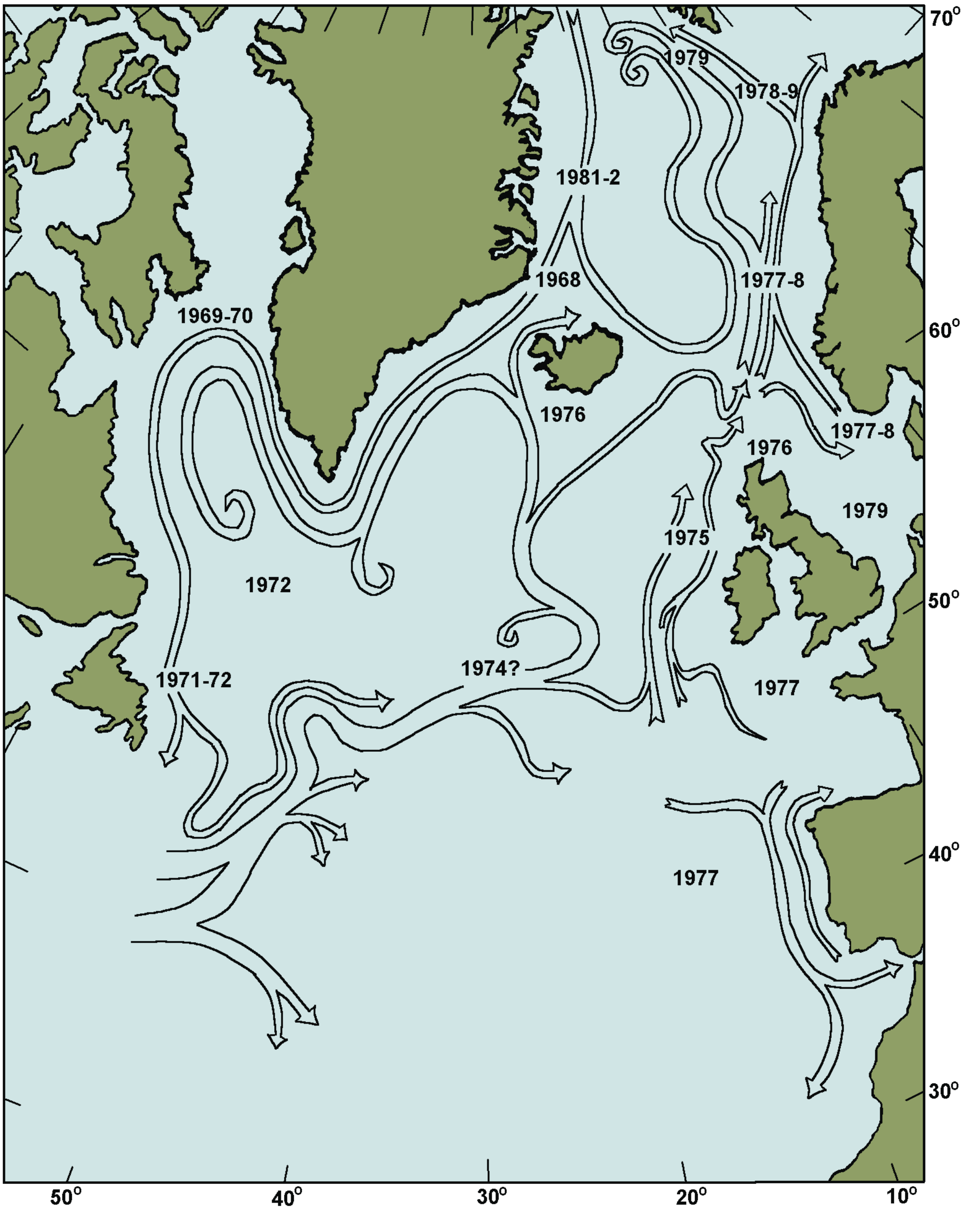


Fig. 10. Shifts of the salinity anomaly in the Atlantic in the 1970s (by Belkin et al., 1997)

Hydrochemical balance, especially salinity, plays an important part in the isolated Southern seas and in the Baltic Sea. The Caspian Sea and the Azov Sea represent brackish reservoirs with salinity 10–13‰ which is 3 times less than ocean water salinity (35‰). The Black Sea typical salinity is 15–19‰. The Baltic Sea basin waters salinity varies from 5–9‰ during the periods of freshening to 10–14‰ during the periods of salinization.

On the whole, water salinity of the above mentioned seas is 2 to 4 times less than in the Barents Sea and any variation of salinity brings drastic changes into the life cycle of local biota. The Azov Sea deficiency of fresh water outflow resulting from rivers run-off regulation, caused 3‰ increase in average salinity (**Fig.**13). This is only one decimal fraction of ocean waters regular salinity, but for the brackish sea it is one third of the normal value. This resulted in outburst of jellyfish biomass in the Black Sea. This is not an isolated event. Advection from the Atlantic ocean and related to it balance of salinity is one of the most important natural factors determining the Baltic Sea ecosystem productivity. In the periods of freshening, as it happened at the late 1970s, production of marine fauna, especially of cod, goes down (Antonov 1998).

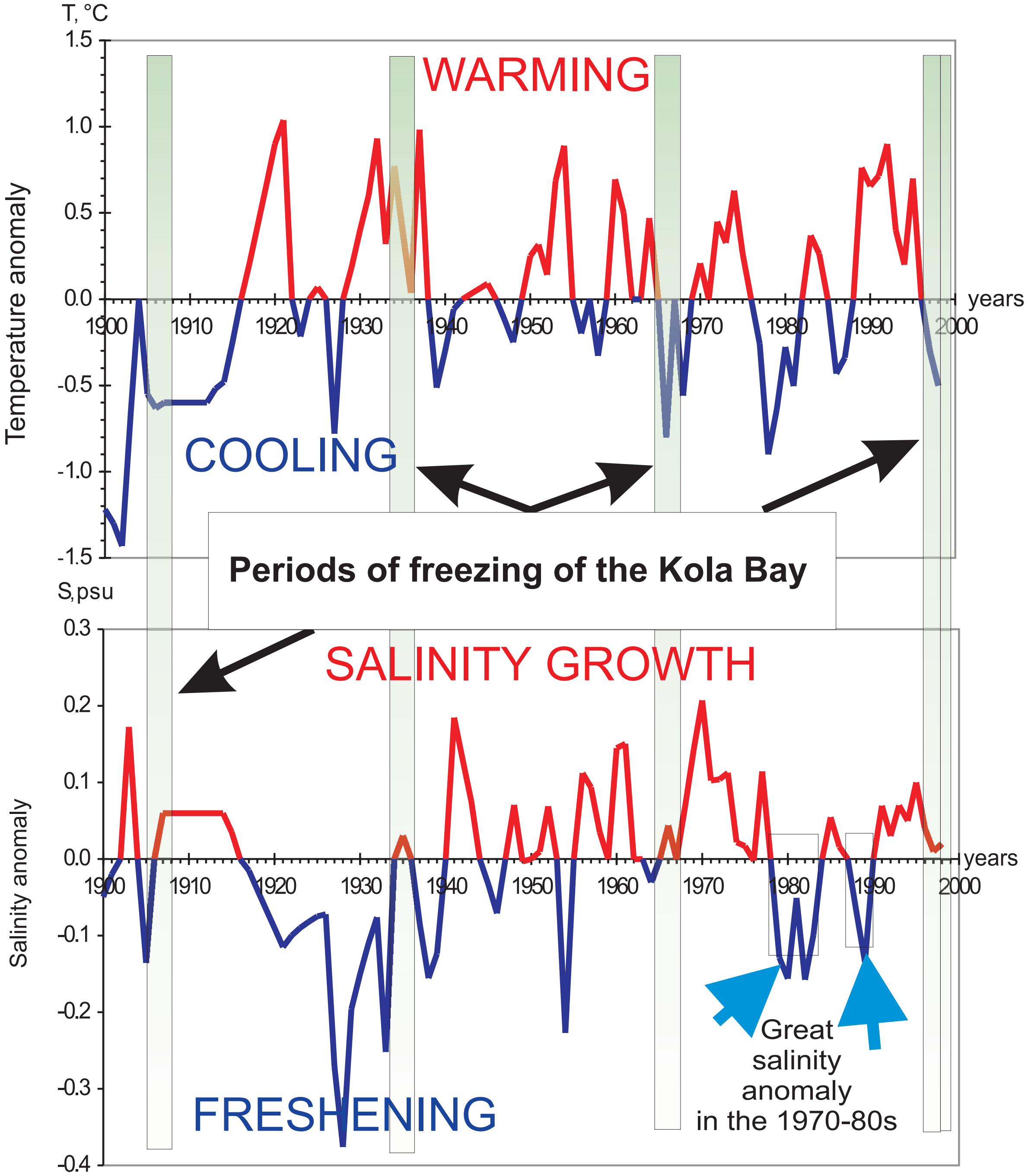


Fig. 11. Long-term changes of temperature and salinity in the Barents sea. 0 to 50 m depth

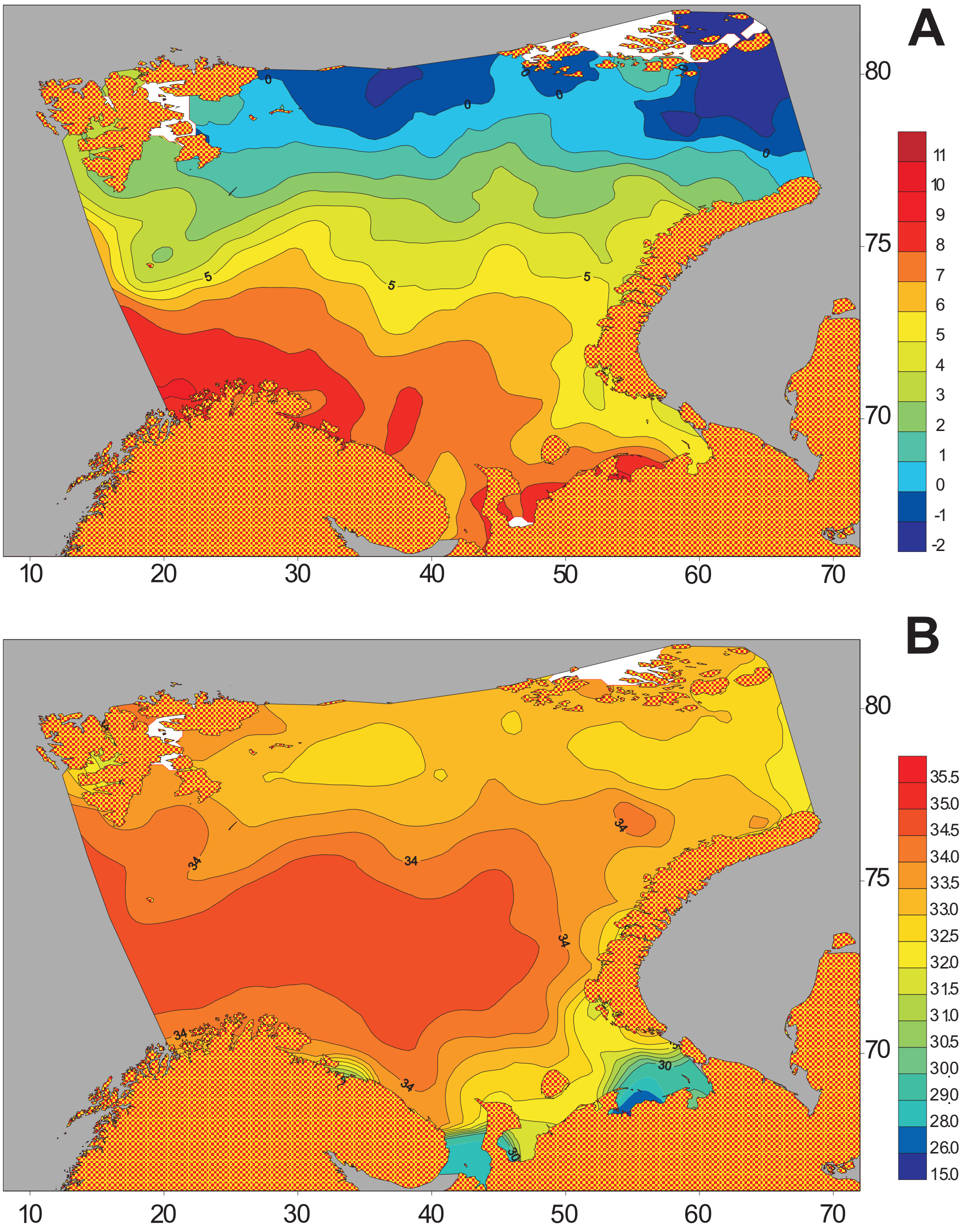


Fig. 12. Long-term average temperature (A) *and salinity* (B) *in the Barents Sea. September. Surface horizon 0 meters (Climatic Atlas of the Barents sea 1998)*

There are some other hazardous natural phenomena in the Southern seas. The Azov Sea shallow water is most exposed to sandstorms and extreme fluctuations of sea level. Sea level fluctuations of the isolated Caspian Sea are even more remarkable (**Fig.**14). Observations during 1830–1997 show that sea level fluctuations range reaches 3 m with annual changes of up to 15 cm. This sea level decrease was well known and publicly discussed in the 1960–70s. This was followed by stable increase of sea level in 1978. In 1997, another (now 30 cm) decrease followed.

Such large scale changes in regime of the Caspian Sea, resulting from climatic changes, alter the ecosystem. Fish yield in the North of the Caspian Sea and Volga River delta has changed considerably (**Fig.**14). Relative sea level increase naturally fosters bioproductivity of the given reservoir.

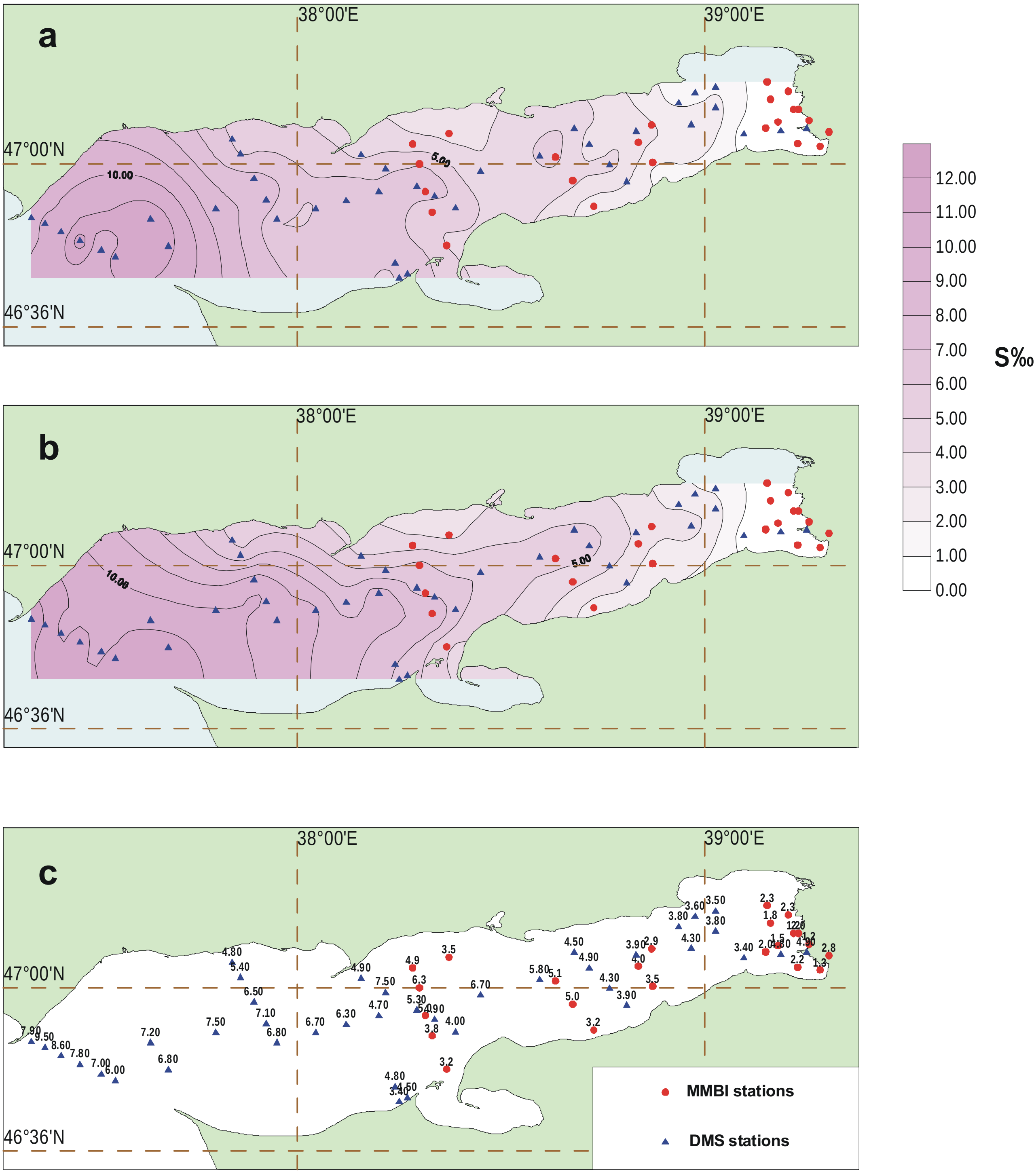
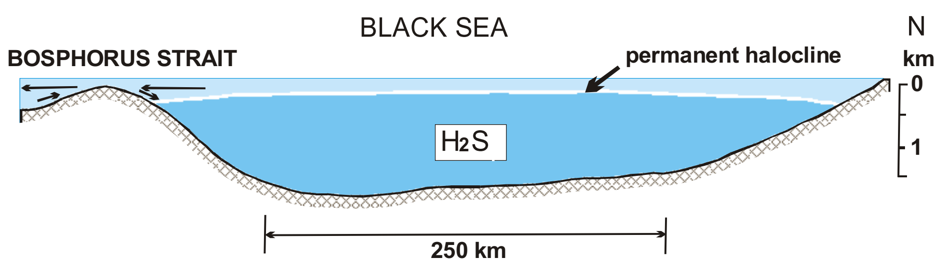


Fig. 13. Distribution of water salinity on (a) surface, (b) near the bottom and depth in meters at the stations in the Taganrog Bay of the Azov Sea (by summarized data of the MMBI expeditions and the Don River mouth stations (DMS), June 1998)

The scheme of anoxic environment in the Black Sea



Long-term changes of the Caspian Sea level
by instrumental observations (1),
average sea level (2)
and its forecast with 50% precision (3)

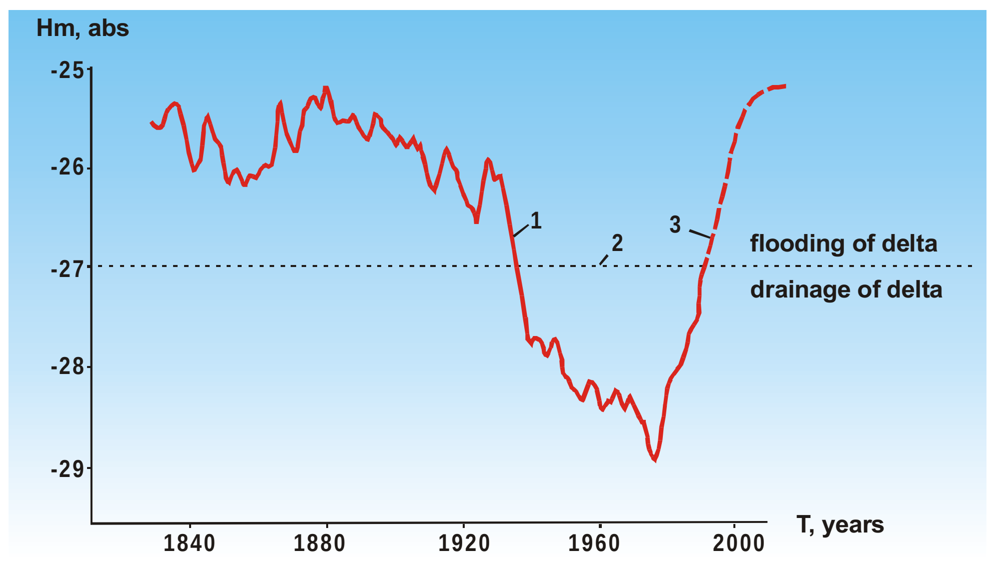


Fig. 14. Natural anomalous phenomena (by Demaison and Moore 1980, R K. Klige 1984)

It is noteworthy that the Black Sea is one of the biggest containers of hydrogen sulphide which saturates its waters at depths below 70–150 meters (**Fig.** 14). This is the reason for absence of rich benthos, characteristic of other seas, beyond these depths.

The complete answer to the question «What parameters cause changes in species dynamics even for one given species?» will require data on physical and chemical parameters of the species environment, efficiency of food supply, competitors, predator and parasites influence on its life cycle. Also information on how all the variables influence reproduction, mortality and migration will be needed.