METANOSTRESS CONDITIONS FOR HYDROBIONTS

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Abstract:
When mass degassing of CH_4 is activated, mainly seismogenic, young aerobic commercial fish and zoobenthos die, pelagic fish are thrown ashore, bottom fish float to the surface, rise to the surface and crustaceans go ashore. In surviving fish, reproductive functions are impaired. After mass emission of CH_4, fishing clusters of fish disappear for a while - after information about emission, you should not go to the "affected" waters for fishing. Catches will be significantly lower than predicted and economically unprofitable, you can look for the "edges of affected" waters where the fish migrated, even when the conditions in them are not uncharacteristic for it, for example, in temperature, salinity, depth, feed base. After abnormally seismic years, there is a massive shift in the sexual composition of fish towards fat females with impaired reproductive functions, the non-viability of young fish is an increase in the number of crustaceans.
For administrators, the recognition of seismostress anomalies means the problems of selling regional quotas for the extraction of hydrobionts and obtaining funds for fishing exploration. Hidden information about the seismogenic infertility of maternal herds led to the ruin of Barents, White sea, Caspian artless that bought "blown" quotas.
The conclusions are based on the analysis of retrospective data on fish catches, crustaceans and mollusks in the economic waters of Russia, Taiwan, Peru, Chile, both in marine and fresh waters.

Keywords: *degassing of CH_4, die aerobic fish and zoobenthos die, reproductive functions, fishing clusters, crustaceans*

INTRODUCTION.
Historical notes.
It was noted in the ship's logs of the XVII-XIX centuries that seismic shocks broke masts, guns jumped on their carriages, noises were heard inside the ships as if something rubbed against the ship bottom, thunder was heard on the deck under a clear sky. Sometimes, there was a change in the water color and temperature, boiling sea surface and water fountains, as if caused by the explosion. Here, apparently, gases released during the eruption were a cause. The period of seismic disturbance lasted for 4-10 seconds. Sailors said about the earthquakes effect on fish "fish were trying to hide, and many of them were thrown out of the water. .. Fish, apparently, are thrown out by themselves. Sometimes fishes are injured; their swim bladders were ruptured due to rapid changes in pressure." [11, *p.195*]. The majority of the aforementioned "shocks" were observed near the Earth's crust faults and over volcanoes (Fig. 1).

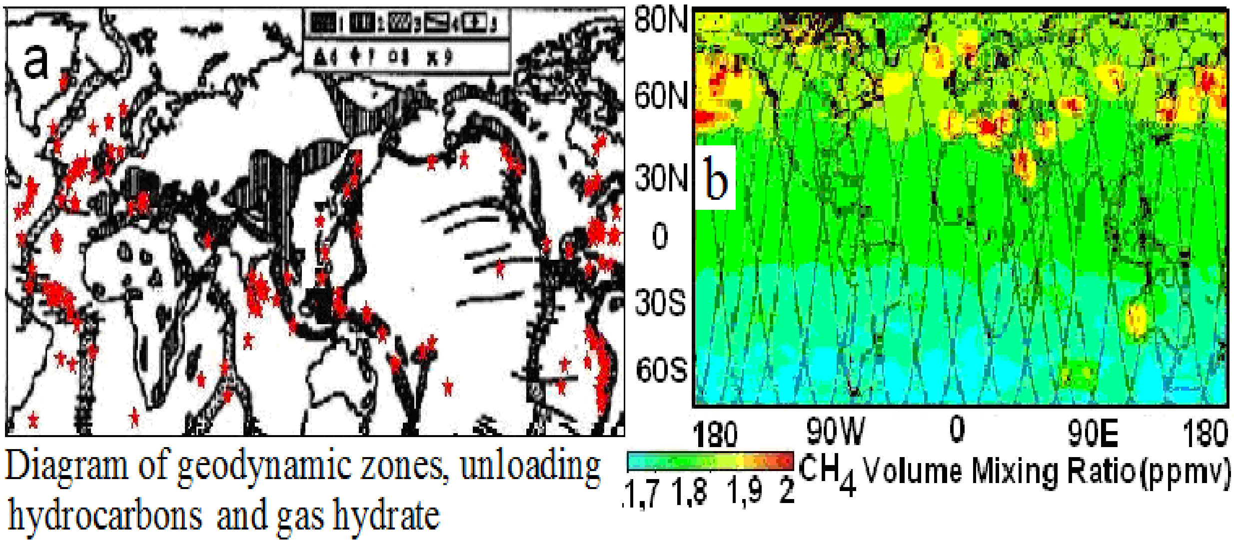

Fig. 1. *Seismic shocks effecting ships and fish suffocation (stars) on the faults diagram (a). Places of local CH_4 content maxima in the atmosphere, at the level of 681 hPa according to AIRS data during the earthquake of 2004-2006 (b) [12].*

After sails and oars recede into the past at the end of the XIX, the sailors, trusting their instruments, ceased to "hear" and "see" much of events around. Lack of expenditure for hydrobiology survey about natural phenomena among local population, including behavior of fish, did not contribute to systematization of collected data on unusual behavior of aquatic organisms before [14]. This led to the attempt to explain reason for the sharp declines in reproduction or reason for fish suffocation, inexplicable from the point of view of the thesis based on the replenishment of the stock, by contamination, unaccounted fishing, poor statistics, foreign species devouring food base of the natives, possible genetically determined periodicities in the aquatic organism behavior patterns. The one was periodicity replaced by another, "genetically" caused post-spawning death of fish was not confirmed by the control series.

In the *Fiji Islands*, where a kind of mackerel lives in Salt Lake, the Melanesians simulate harmful to fishes natural phenomena. According to a strict ritual, on a certain day all the villagers enter the lake and muddy the bottom silt. Natural gas with hydrogen sulfide is released from the silt. Half poisoned fish float to the surface where they are caught. The ritual is associated with the requirements of ichthyology - occurs after spawning. Then the oxygen returns to the water and water stirred the silt gives the young first feed [31].

Below, typical situations of the hydrobionts clusters development in seismic stress conditions in rivers, lakes, seas and oceans are analyzed.

In this article role of hydrogen sulfide for aquatic organisms is not considered separately from methane. Its destructive effect on hydrobionts is known, but for it there are no maximum permissible concentrations in contrast to CH_4 and to *O2*, Also, as a rule, clusters of non-target aquatic organism using chemosynthesis products located near methane seeps are not considered.

During over 40 years, where were attempts to explain large-scale episodic near-bottom hypoxia in the *Azov* and *Caspian Seas* by changes in river flow, ice cover and other hydrometeorological phenomena. Stable dependencies were not found, as well as a stable correlation of these characteristics with the benthos and benthophages development was not obtained [16]. CH_4 concentration was not taken into account, since its content in water, as a rule, does not exceed 10^{-4} mg/l, and in soft soils - does not reach maximum permissible concentration (10^{-2} mg/l), that is not critical for hydrobionts. In the soils of wetlands, over hydrocarbon deposits, near the centers of earthquakes and active faults, CH_4

concentration reaches 0.1÷10 mg/l, for example, over a gas field in the center of the Volga homos and in the soils of the main *Bakhtemi*r branch after spring flood. It is these places that hypoxia foci and low biomass of zoobenthos are confined to (Fig. ***2.a-c***) [6]. Sharp decline in the benthos biomass is due to increased concentrations of harmful to benthic CH_4 (Fig. ***2.d***) [13,29].

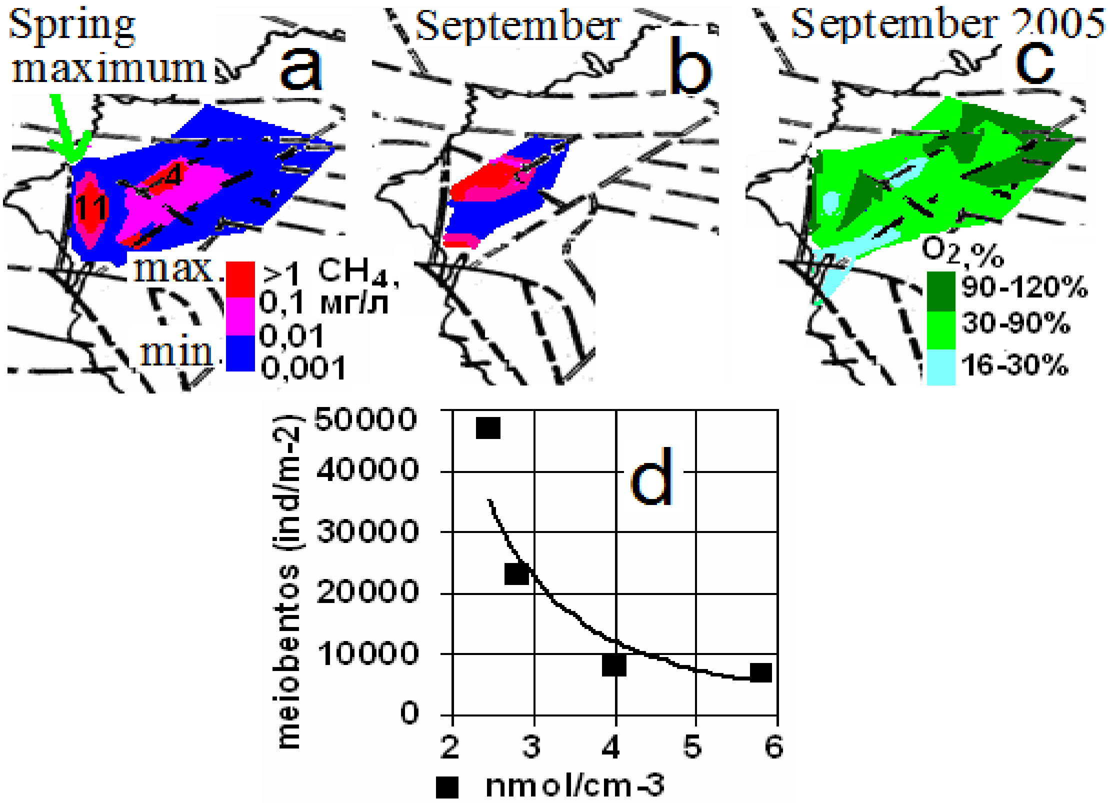

Fig. 2. *CH_4 content in precipitation in the northern part of the Caspian Sea on the faults scheme, in spring (a) and in September (b), relative O_2 content at the bottom in September 2005 (c). Ratio between meiobenthic (0.1÷1 mm) abundance in the top 5-cm layer of sediments and methane content in the top 25-cm layer of sediments in paleo bed of the Dnieper Canyon (beam of the Donuzlav Bay) (d).*

After regional earthquakes, bottom hypoxia is typical in the non-tidal seas. There is no clear relationship between number of earthquakes, their magnitudes and oxygen concentrations (Fig. 3). This is due to the seasonal warming (methane-producing bacteria activate at increasing temperature of the environment), specificity of regional magmatism (hot or cold, prevalence of CO_2 or CH_4 at degassing, respectively), degassing intensity, foreshocks that make "stored" CH_4 leave silt, clay traps and gas hydrates. In seismic years, biomass of zoobenthos decreases without connection with traditional abiotic and biotic factors.

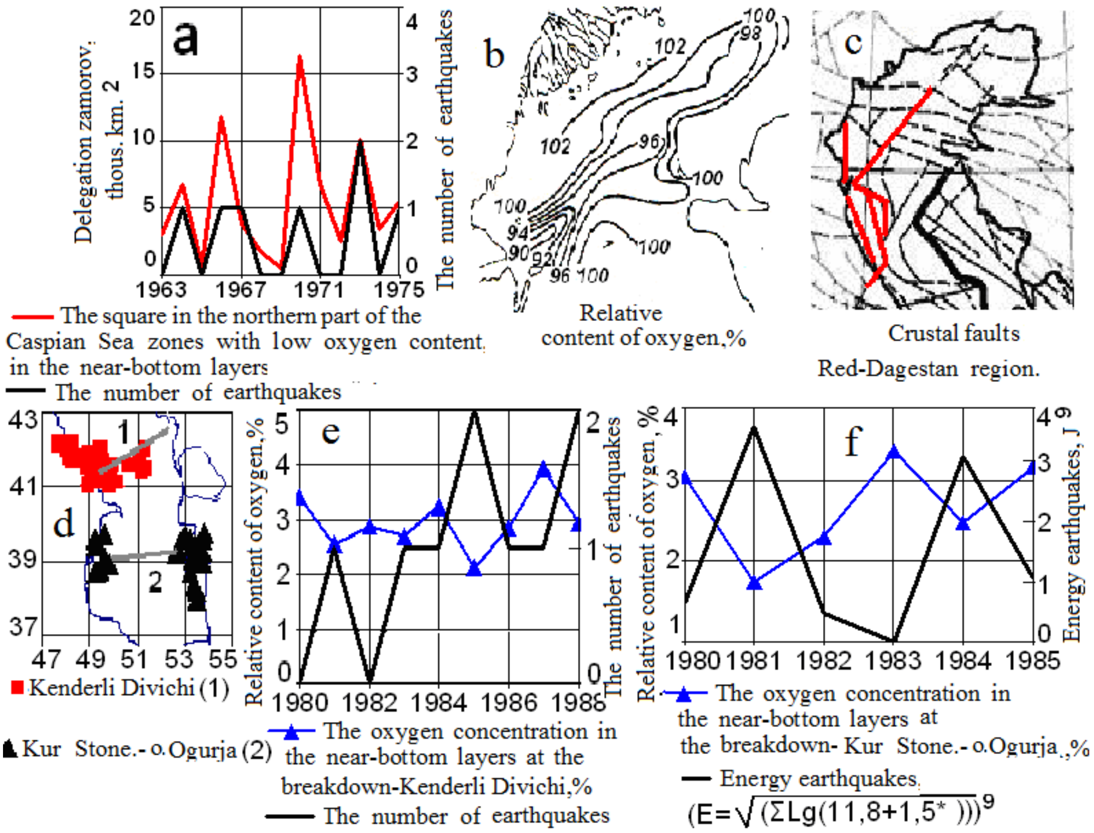

Fig. 3. Seismic activity, area of fish suffocation, O_2 content at the bottom of the Caspian Sea (a-f). Regional faults (c).

Since 50's of XX century, a trend of the benthos biomass variation in northern marine part of the *Caspian Sea* (over the faults stretching from seismically active Terek coastal regions to the *Ural Borozdina* (Fig. 4)) was antiphase with the number and energy of Terek earthquakes. In seismically active years, year-to-year reduction in the biomass of mollusks reached 90%, worms and nereis - up to 30-70%. In the years of sharp declines in the biomass of food benthos due to seismic stresses, food animosity among benthophages grew, pace of growth reduced. In the seismic 1954÷1956, there were up to 15÷20% of plants and soil in stomachs of sturgeon and roach, in seismically quiet years - 2-3 times less; near-bottom hypoxia was observed as well. In 1957-1958, the benthos load decreased; this was not due to reduction of benthophagus, but due to calming of seismic situations [16]. Catastrophic for the biota in northern marine part of the *Caspian Sea* were consequences of almost two dozen Dagestan earthquakes in May 1988, when water saturation with oxygen near the bottom decreased to 9% (Fig. 4.б). Less than 2% of the animals survived at depths above 10 m, compared to previous and subsequent years. This was not due to the benthophagus - sturgeon, as this year their main feed bases remained in the south part of the sea. In the next seismically active year, in condition of good bottom aeration, biomass of all groups of invertebrate benthos rose to the level of previous years; sturgeon returned to the north part of the *Caspian Sea*, concentration of starred sturgeon was the highest in the last 6 years. Massive reproduction problems among the lower Volga fish are observed in the benthophagus roach, which is more resistant to salinity than bream, perch and carp, and feeds over the marine active faults.

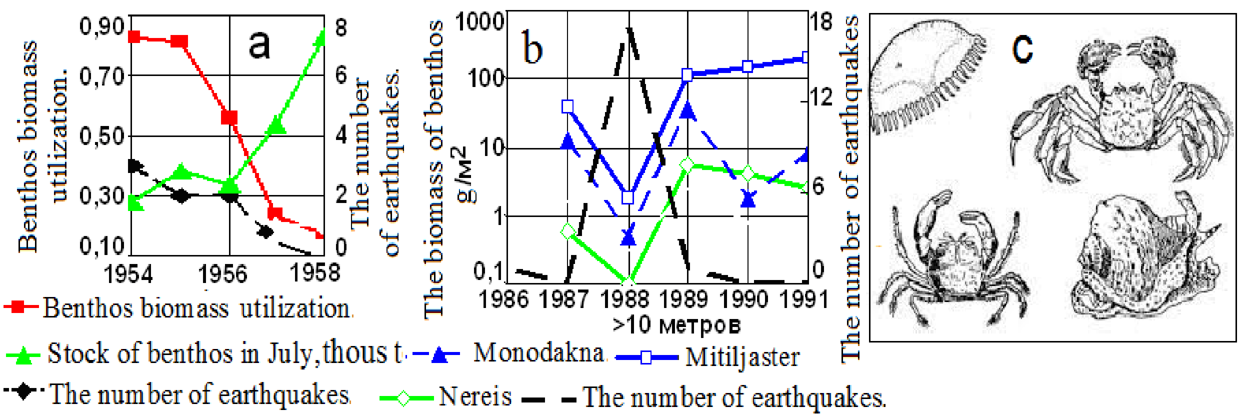

Fig. 4. *Utilization rate and benthic reserve, number of earthquakes (a). Comparison of the number of Terek earthquakes with the biomass of mollusks, nereis and crustaceans at depths of more than 10 m in the northern part of the Caspian (b).*

There are usually attempts are trying to explain sharp reductions of zoobenthos biomass in the *Azov Sea* by temperature and salinity of water, river flow and wind mixing. When it does not work, connections with bottom hypoxia (which develops at weakened mixing, often in combination with increase in temperature) are looked for, although it is experimentally proved that many zoobenthos species survive after prolonged hypoxia. This approach is traditional in the analysis of short series, when biomass reductions sometimes coincide with the large-scale hypoxia. However, when the series are lengthening, it turns out that the coincidence of inter-annual and inter-seasonal changes in biomass with river flow and temperature are generally accidental. The hypoxia occurrence is not always associated with the weakening of mixing and heating [19,22,23]. Contradictions are eliminated when seismic data are used to analyze development of benthic and hypoxic biomass (Fig. 5). In seismically quiet years in the Kerch-Taman region, the biomass of zoobenthos in the *Azov Sea* increases by 10-20% from April to July. By October, the increase reaches 70÷100%. After seismically active winter-spring months, benthos biomass falls by ≈20% from April to July due to eating by benthophagus. In October, the biomass of the benthos is gradually restored to the April level [16].

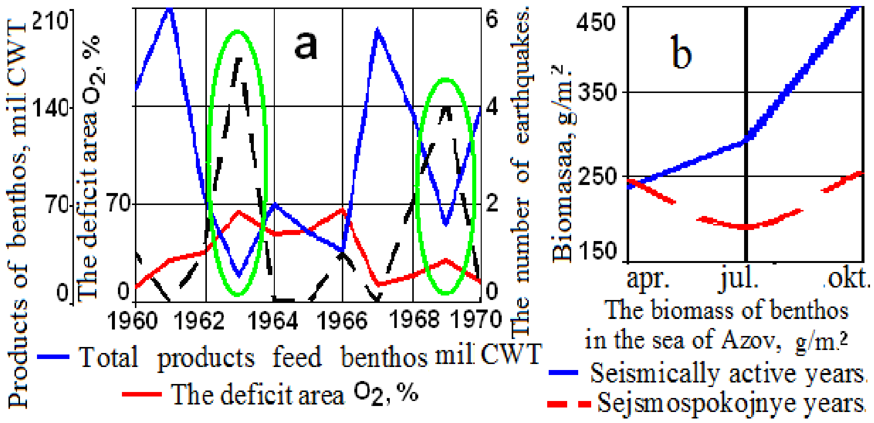

Fig. 5. *Area of hypoxia zones, benthos biomass in the Azov Sea and earthquake (a). Benthos biomass in seismically quiet and seismically active years in the Azov Sea (b).*

Finally, let us focus on the paper [27] in which a team of marine geologists and hydrobiologist discusses a problem of hydrobionts development on active faults of the Earth's crust in tidal waters. The paper states that the nature creates abnormal conditions in the fault zones to which biological subjects are not adapted evolutionarily. Living in such geopathogenic zones (*GPZ*) causes a state of stable stress in living organisms, which leads to functional disorders, reduces resistance to various diseases, can cause behavioral disorders and even mutations. In the areas of active faults in the *Kandalaksha* bay of the *White Sea*, biomass and the number of bivalve mollusks, especially *Bivalvia*, are 2 to 3 times more outside the *GPZ* than in the immediate vicinity "which may be considered an evidence of *GPZ* negative impact on development of the benthos associated with active faults". The reasons for the identified laws are not discussed by the authors.

3. Commercial oceanology.

Reproduction of the most widespread Caspian fish - anchovy pilchard - is also limited by seismic stresses (Fig. 6). Females are more active after seismically active years самки [2,28]. In seismically active years, fat content in sprats falls from the usual in seismic years' value (1995) 0.7% to 0.6% [8]. A year after significant winter-spring seismic stresses (2000-2001), the sprat fatness increases to 0.8%, size and weight go beyond the Smith's L→15.9 cm [7,24]. Where the fodder shortages due to increased consumption of zooplankton by the foreigner comb jelly? In the Soviet period, correlation coefficient between number of fingerlings and number of earthquakes reached -0.8 (June and subsequent earthquakes were included into the following year). General information that the survey was conducted from June to July is not enough; some earthquakes could be mistakenly included into the following year, but not to the current one. Using more recent data is difficult; area of responsibility of Russian hydrobiologists and seismologists reduced after collapse of the Soviet Union.

The interrelation, perhaps, would be closer if reproductive function disturbances would be taken into account. They were noticed long time ago, but they were not taken into account in the unpromising (according to the authors) long-term forecasts of catches depending on the temperature of water and air, wind conditions, food supply, etc. [20,21,26]. No one linked the dynamics of fish population to seismic activity (partly due to departmental information about earthquakes).

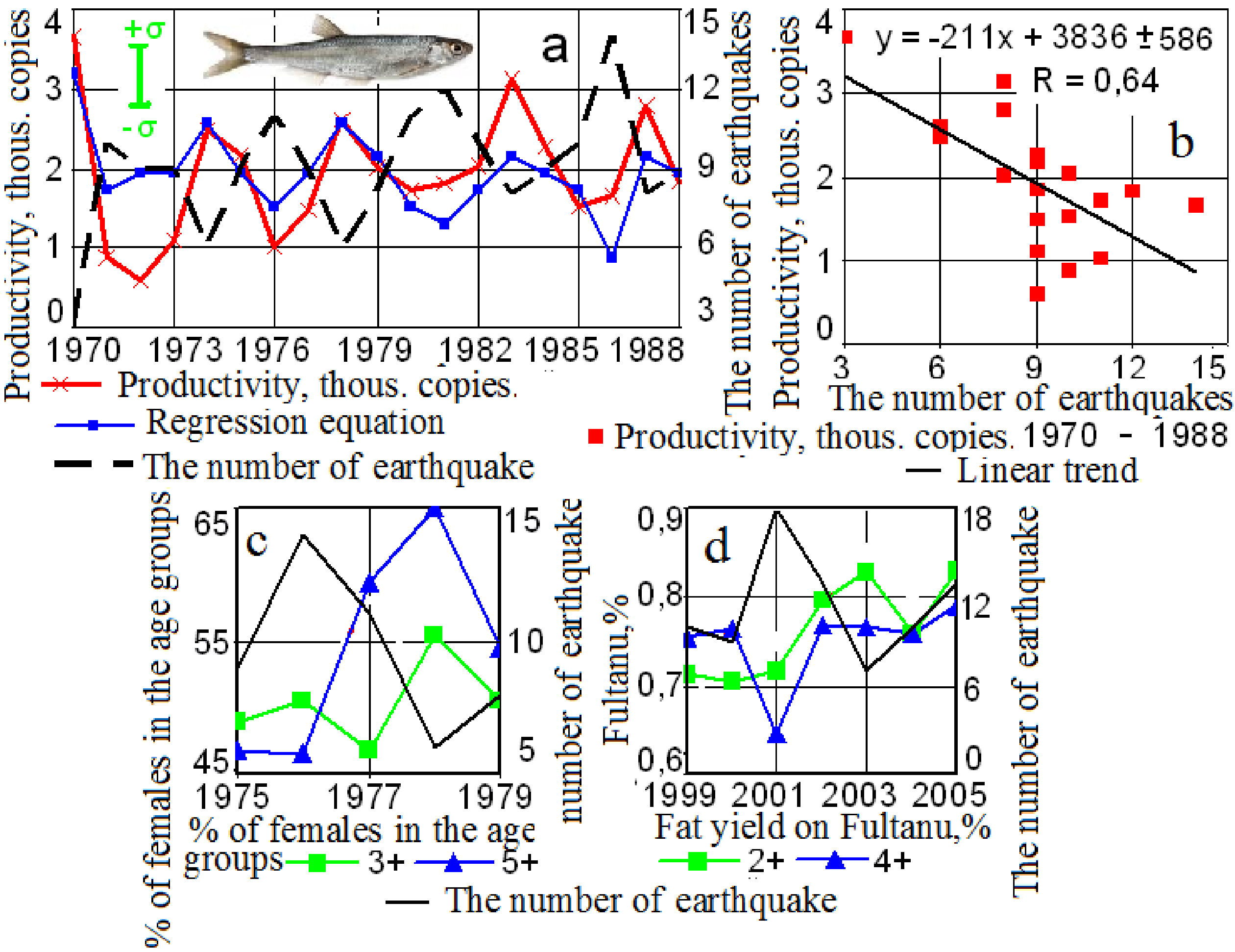

Fig. 6. *Ratio of the sprat productivity with the number of earthquakes (a, b), ratio of percent of females, fat fish and number of earthquakes (c, d).*

After capelin suffocation repeatedly observed in the *Barents Sea*, it was suggested that the capelins are characterized by genetically determined post-spawning death ("forgetting" about the mass presence of repeatedly spawning species). However, in the selected party there was no decrease in number during 90 days after the spawning [1]. Emergence of productive generations, vitality of north-east Arctic cod, herring and capelin near the Norwegian coast are not systematic. Conditionally, hydro biologists could explain by cooling decrease in catches in 1977-1978 maximum in half of 4÷5 sharp declines in capelin reproduction. It remains unclear why a similar sharp cold in 1979 and 1981 did not cause decreasing responses in the population dynamics (Fig. **7**). In warm years since the mid 80ies of XX century in the region, as a rule, there were favorable conditions for capelin reproduction – high biomass of plankton, crustacean concentrations exceeded the average annual by 2-3 times. Therefore, capelins had a high level of fat. But the young fish issue became significant -over 60-80% of the population of the capelin stock - only at the end of 80’s and 90’s. It was also not possible to attribute the lack of reproduction to the predator load, since the trophic effect of cod was significant only in the late 1990s. But if you look for reasons for the catches decline in seismic stresses, it can be found that reduced reproduction and catches were preceded by seismic stresses resulting in the deaths of fingerlings (there is no change in age 2+ after seismic stresses of 1983-1984 and 1992), violations of reproductive function in surviving fish. Earthquakes occurred eastward of 15ºE have an impact only on the part of spawning fish, which is manifested in the stagnation of reproduction and catches. Due to seismic stresses, there is no stable link between spawning stock and replenishment. Mass replenishment occurs only due to recruits, who was not affected by the seismic impact, i.e. in the second or third year after the earthquake. Presence of CH_4 back puffs on the Lofoten shelf - spawning and wintering place for capelin – is seen from increase in CH_4 concentration in the days of rare earthquakes in the lower troposphere over the region. This is due to biogas - CH_4 from a soft sedimentary cover with thickness of kilometers.

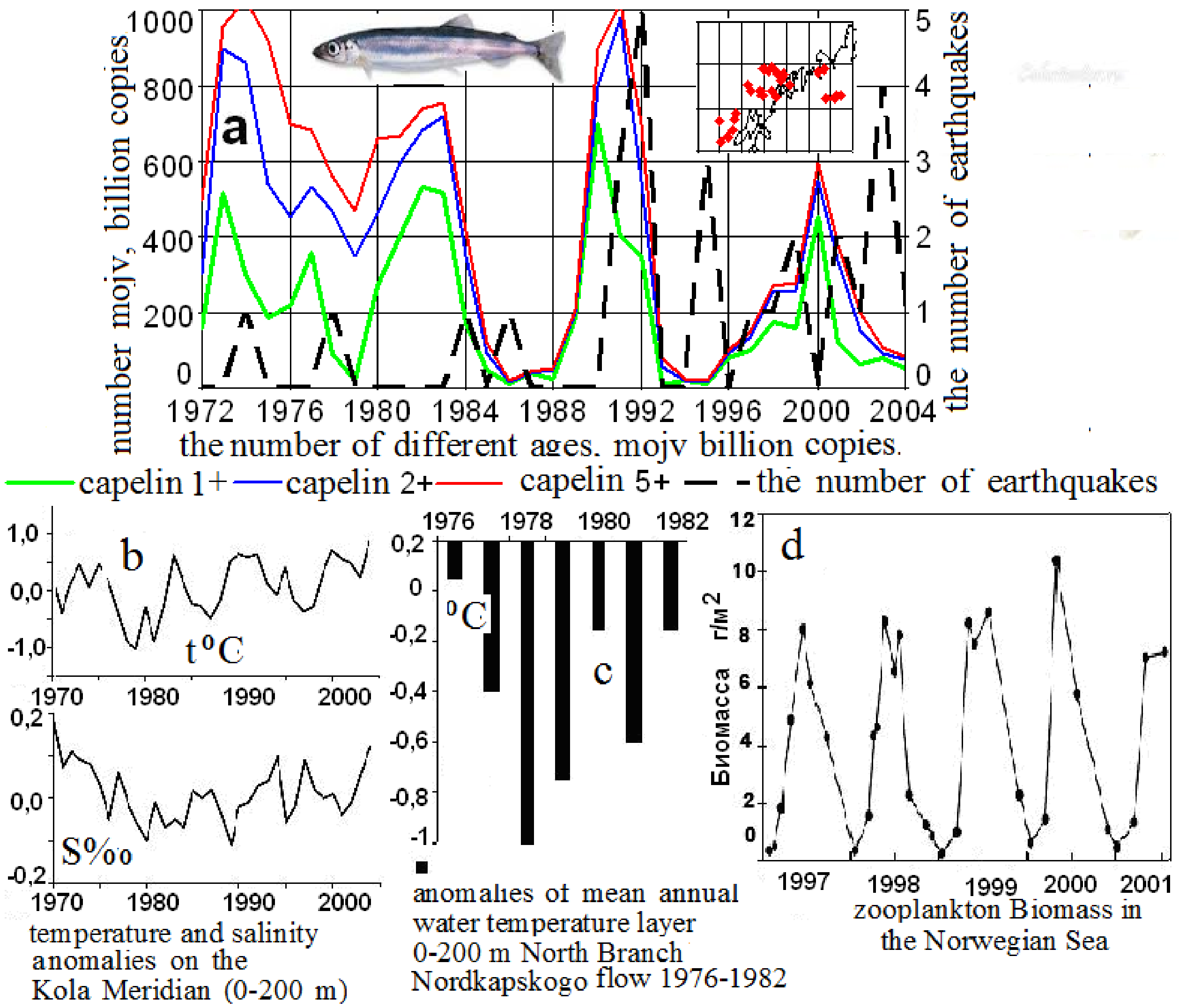

Fig. 7. *Number of capelins of different ages and number of earthquakes (a). Changes in temperature and salinity of water on the Kola meridian (b), anomalies in the average annual water temperature of 0-200 m layer in the northern branch of the Nordcape current (c), zooplankton biomass in the Norwegian Sea (d).*

The temperature and biomass of zooplankton do not influence the relationship between the number of pelagic larvae of Atlantic cod and rate of its replenishment, as well as the number of haddock, sea baste, capelin and herring larvae. For cod, negative problems are due to the accumulations of hydrocarbons at the point of spawning and migration (Fig. 8,9) [5]. From 20 to 100% re-spawning cod do not spawn [4]!

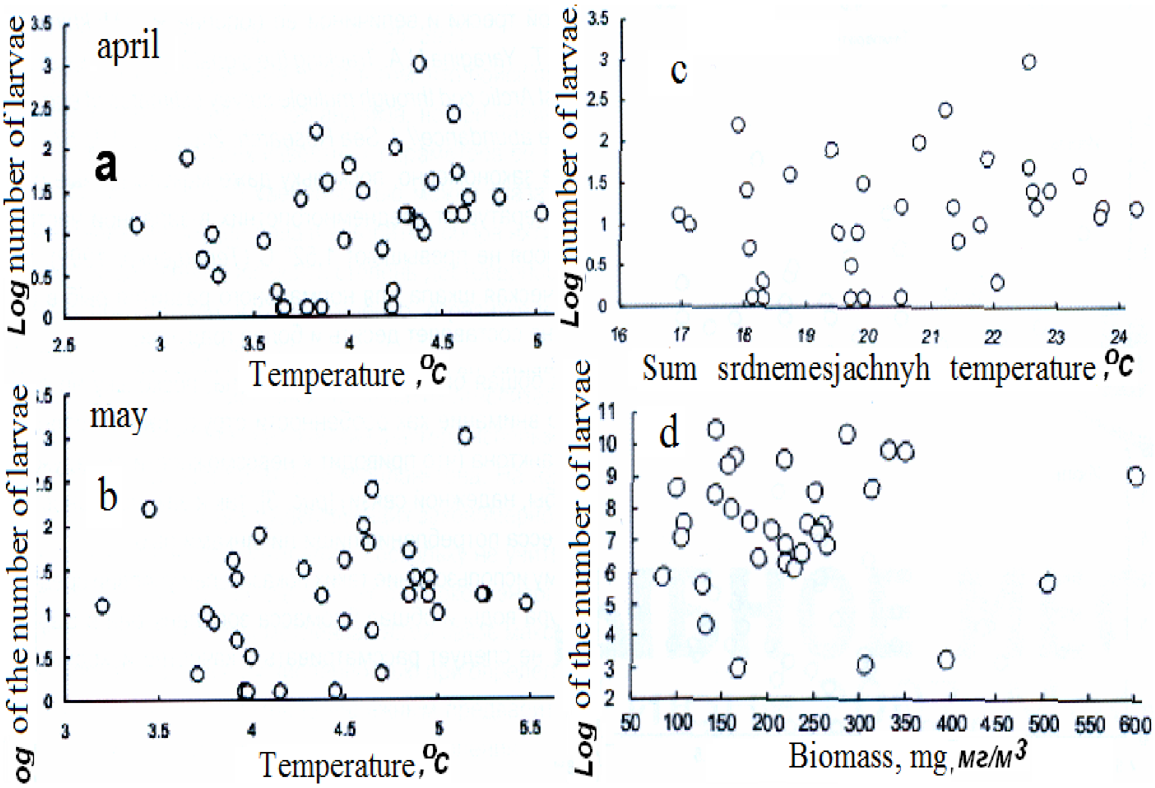

Fig. 8. Number of cod larvae and water temperature in April, may and sum of average monthly water temperatures in 1959-1993 (a-c). Number of larvae of cod, haddock, sea baste, capelin, herring, flounder and zooplankton biomass (d).

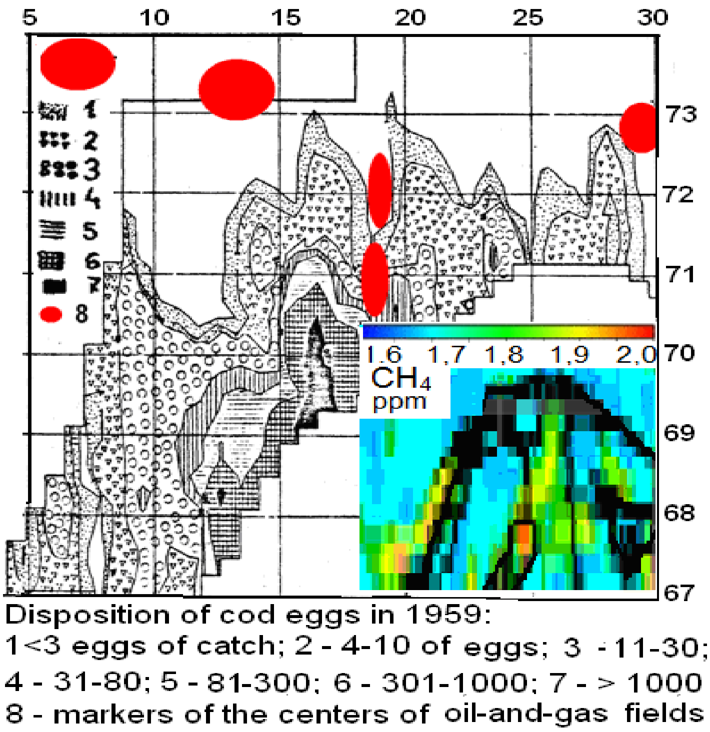

Fig. 9. *Markers of the centers of oil and gas accumulations on the background of cod larvae distribution [9]; on the insert - CH_4 content of in the atmosphere [10].*

PINRO staff [3] believes that, at present, "importance of biotic and abiotic factors in formation of the yield of the *Barents Sea* flounder generations, including such as value of population fertility and number of brood stock" (Fig. 10**)** is not clear. Although [25] the paper notes vulnerability of flounder to lithospheric toxicants. Its survival in the *Barents Sea* is minimal if increased seismic activity occurred in its years of birth (1972, 1976, 1978, 1980, 1983 1985), and, contrary, all the bursts of survival were in the years when the born flounder was almost not affected by seismic stresses

(1974, 1979, 1984 and 1986). Catches of pilchard and capelin in the *Norwegian Sea* are also limited by seismic stresses (Fig. 11).

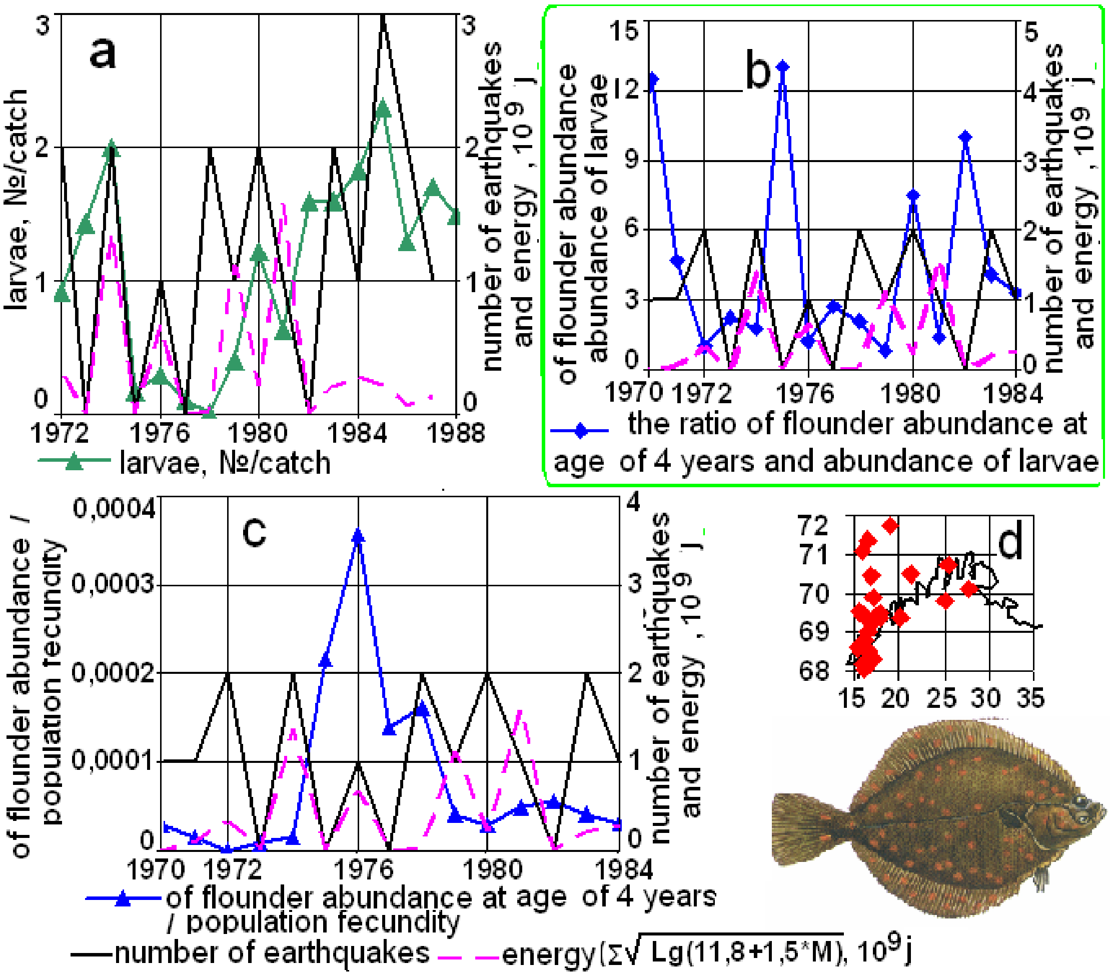

Fig. 10. *Comparison of seismic activity shifted by 4 years back with the ratio of number of sea flounder at the age of 4 years to the number of larvae (a-c). Earthquake epicenters (d).*

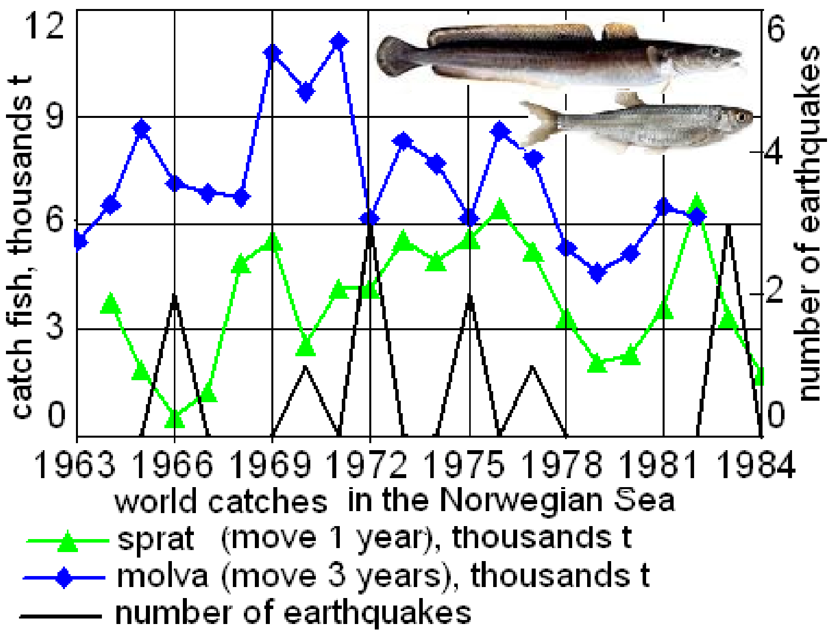

Fig. 11. *Comparison of the world catches of capelin and sprat in the Norwegian Sea with seismic activity.*

After the increase of earthquake frequency, local minima of catches of fish in lakes *Baikal, Sevan* and *Issyk-Kul* occur with interval of 2÷5 years (depending on the age of recruits) (Fig. 12) [18]. Mass life-sustaining offspring can only be received from species who avoided seismic stress.

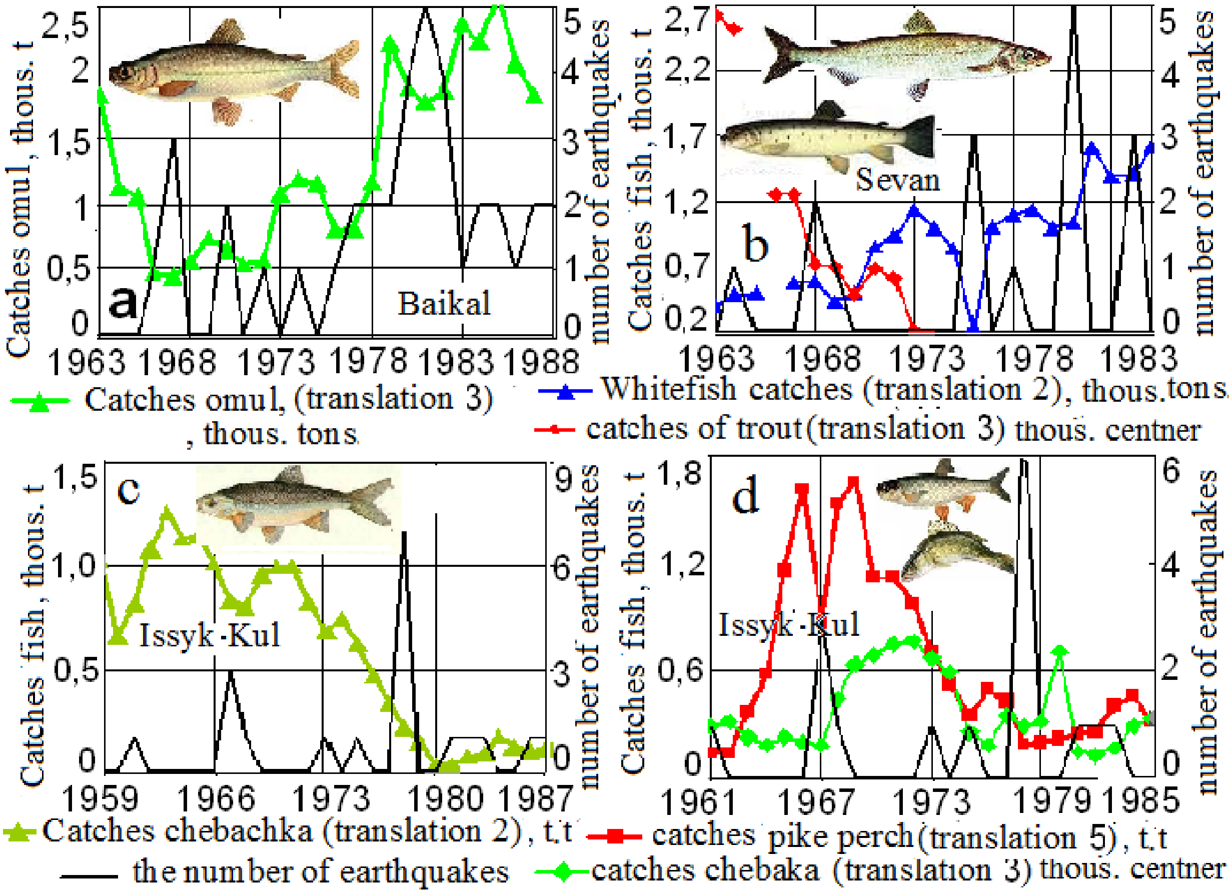

Fig. 12. *Comparison of fish catches in lakes Baikal, Sevan and Issyk-Kul with seismic activity.*

Seismic stress for above carp gudgeon and roach is accompanied by increased production of scavengers - crawfish's (Fig. 13) [14]. Coefficients of correlation between prey of fish and crayfish is ≈ -0,8.

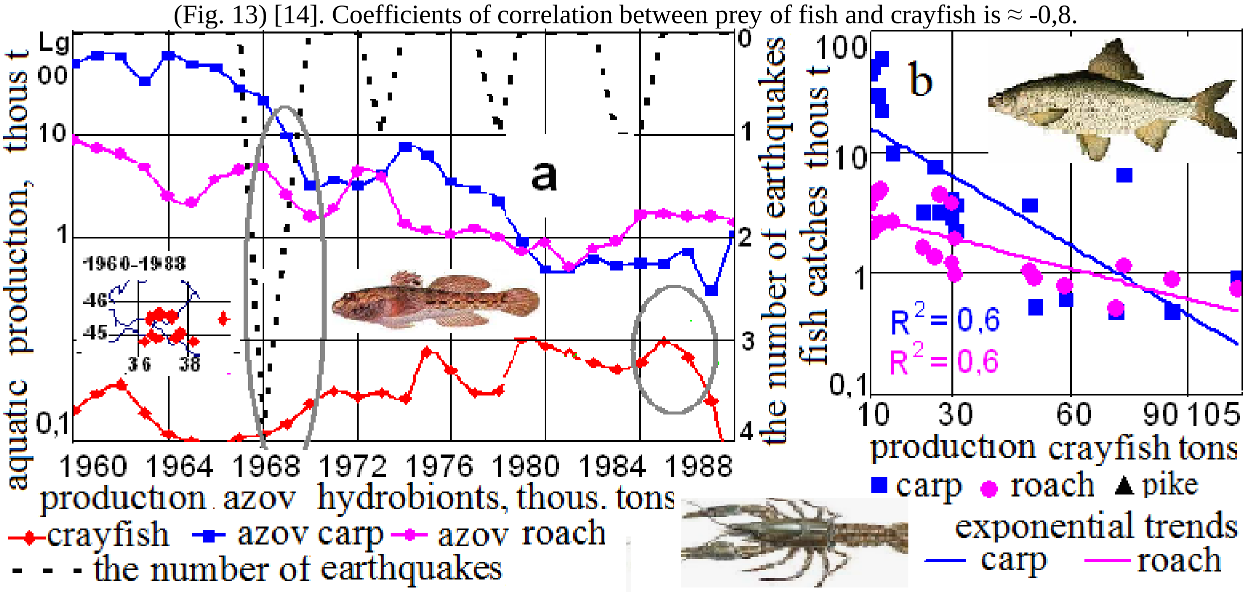

Fig. 13. *Comparison of the number of earthquakes and catches of crayfish, azov carp gudgeon and roach.*

Seismogenic CH_4 degassing is everywhere negative for commercial aggregations of aerobic hydrobionts. The earthquakes activation is accompanied by a fall by several times of aerobic fish and shellfish production in the *North Sea, Iceland, Taiwan, Peru, Chile* and *Argentina*, and, on the contrary, antiphase production of crustaceans sharply increases (Fig. 14,15) [17].

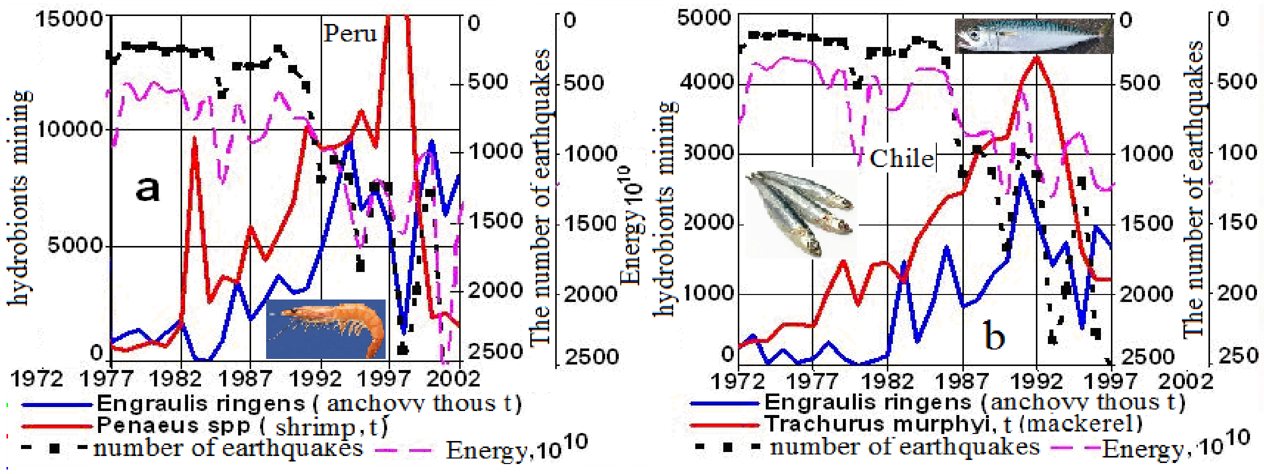

Fig. 14. *Catches in Peru (a) and Chile (b) and seismic activity in the regions.*

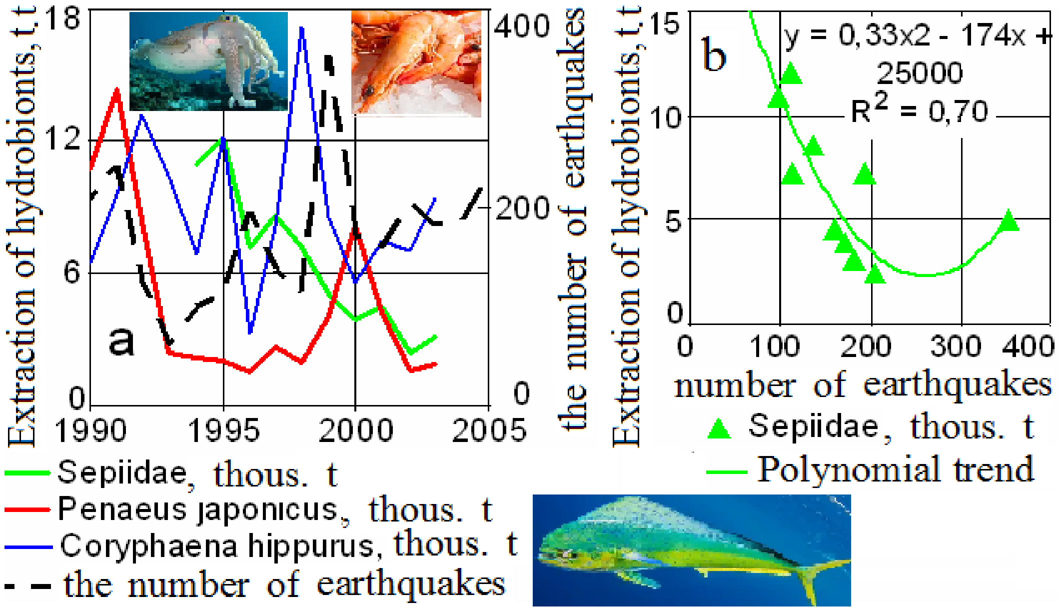

Fig. 15. *Comparison of seismic activity with the production of dolphinfish, cuttlefish, shrimps by Taiwan (a); trends in seismic activity and shrimp's production (b).*

In the absence of massive degassing, for example, in the *Balkhash* lake (it is impossible to produce CH_4 from sedimentary basalt cover, nor by heating, or by compression, in contrast to limestone's and shales of the *Novaya Zemlya*), simultaneous decline of catches of different aerobic fish should not follow even after earthquakes with M≥6 (Fig. 16) [14].

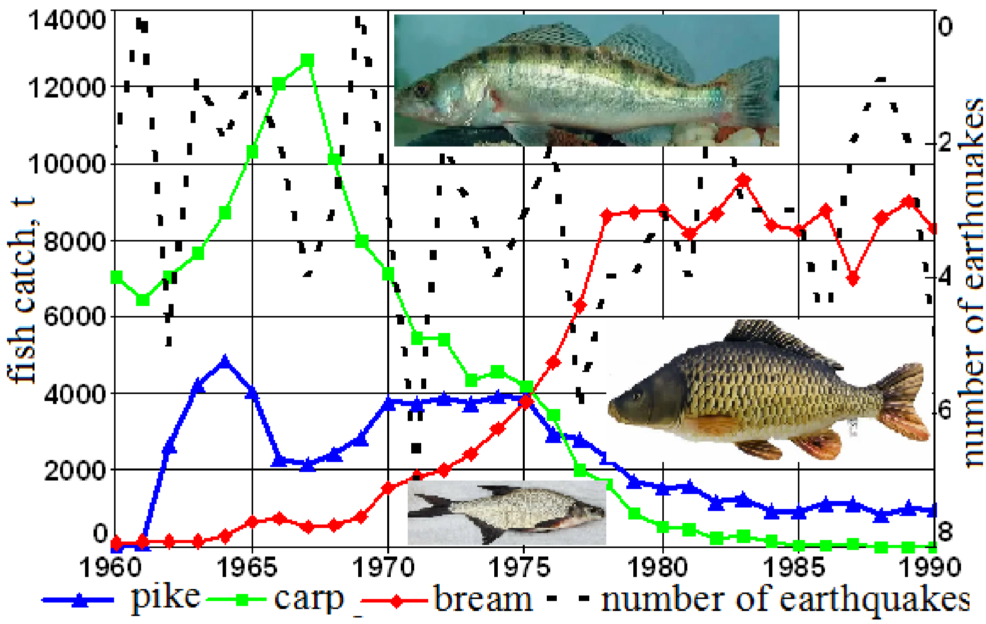

Fig. 16. Annual fish catches in the Balkhash Lake and number of earthquakes.

There are NO seismic factors in the standard list of analyzed factors affecting the state of fish accumulations [32]! In a more detailed analysis of the fish population development, it is necessary to take into account their migration.

4. The current fishery.

Seismic stresses cause reduction of shoal size and unusual fish behavior. For example, after the nuclear explosions in the *Novaya Zemlya*, according to the report at a conference of fishery employer *G. Matishov*, the whole polar cod tends to fresh waters near the Pechora coast [17], "jumping" into the nets. After a year or two, unpredictable declining catches occurred, up to collapse, and a ban on fishing.

Efficiency of the current winter azov anchovy fishing in the south-east part of the *Black Sea* is lower during earthquakes than average monthly, sometimes by 20-80% (Fig. 17). Catches fall in the time of earthquake. Catches of seabaste in the Barents and *Norwegian Seas* fall in seismic conditions relative to the average monthly by 20÷60%; as a result, to exhaust quotas, fishing season lengthens for a month and a half (Fig. 18).

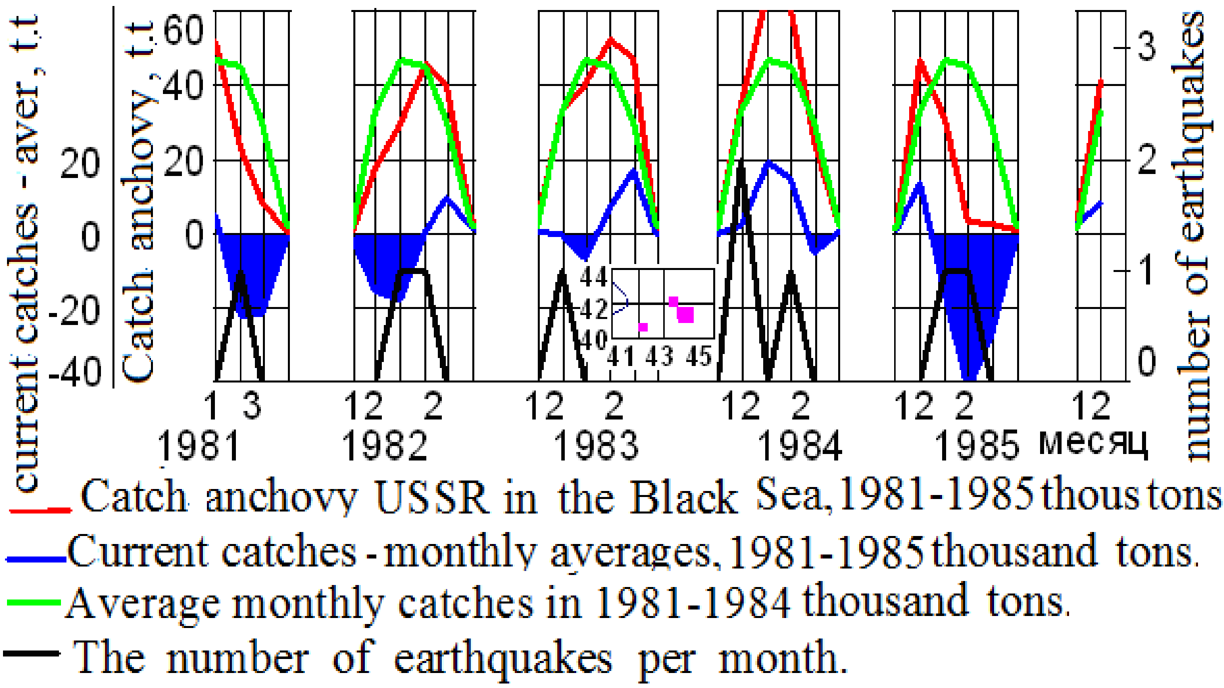

***Fig. 17.** Number of earthquakes, monthly catches of azov anchovy and their deviation from the average monthly in the south-east of the Black Sea. On the insert - earthquake epicenters.*

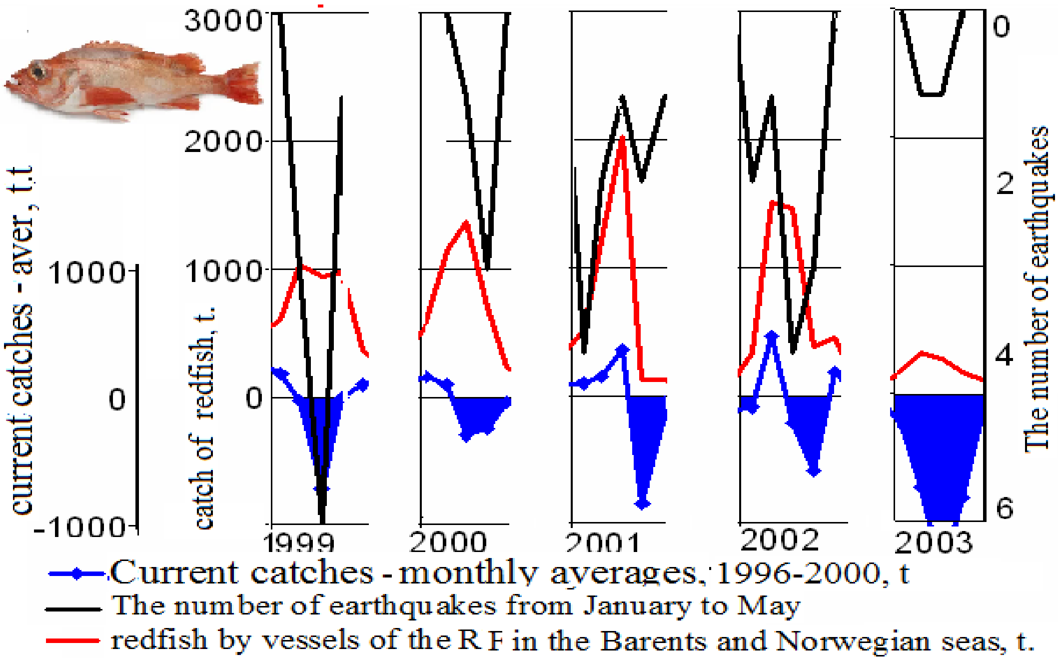

Fig. 18. *Comparison of monthly catches of seabaste in the Barents and Norwegian seas by Russian vessels with the number of earthquakes from February-March to May-July.*

In water areas exposed to a massive discharge of methane, juveniles of many commercial fish aerobic dies; reproductive functions are impaired in surviving fish - viability of juvenile, a sharp decline in the number of fingerlings, despite any biotic and abiotic conditions; after the mass CH_4 emission, commercial accumulations of fish disappear for a while, and therefore, it is not advisable to start fishing in the "infected" waters after receiving information that the emission occurred since the catches will be significantly lower than predicted and economically unprofitable, or to look for "the edges of infected" waters where the fish came to, even when the conditions in these areas are not uncharacteristic, for example, in terms of temperature, salinity, depth; after the abnormally seismic years, sharp falls of fish reproduction, shellfish biomass and growth of crustaceans number should be expected.

5. The seals

Catches (reproduction) of navaga in the *White Sea* are also limited by seismic activity (Fig. 19, a,b). A year or two after the increase of earthquake frequency, local minima are observed in navaga catches. In the seismically quiet years, from 70 to 100% of the fish are ready to spawn at the age of two years. In seismically active years, this number is reduced to 30%. Sharp falls of seals forage base (zoobenthos and fish) due to seismic stress in the period of birth and feeding of 6-8-year calves lead to collapses of seal production in the *White Sea*. A basic paradigm of the hydrobiology - food supply – works (Fig. 19, c) [16,30].

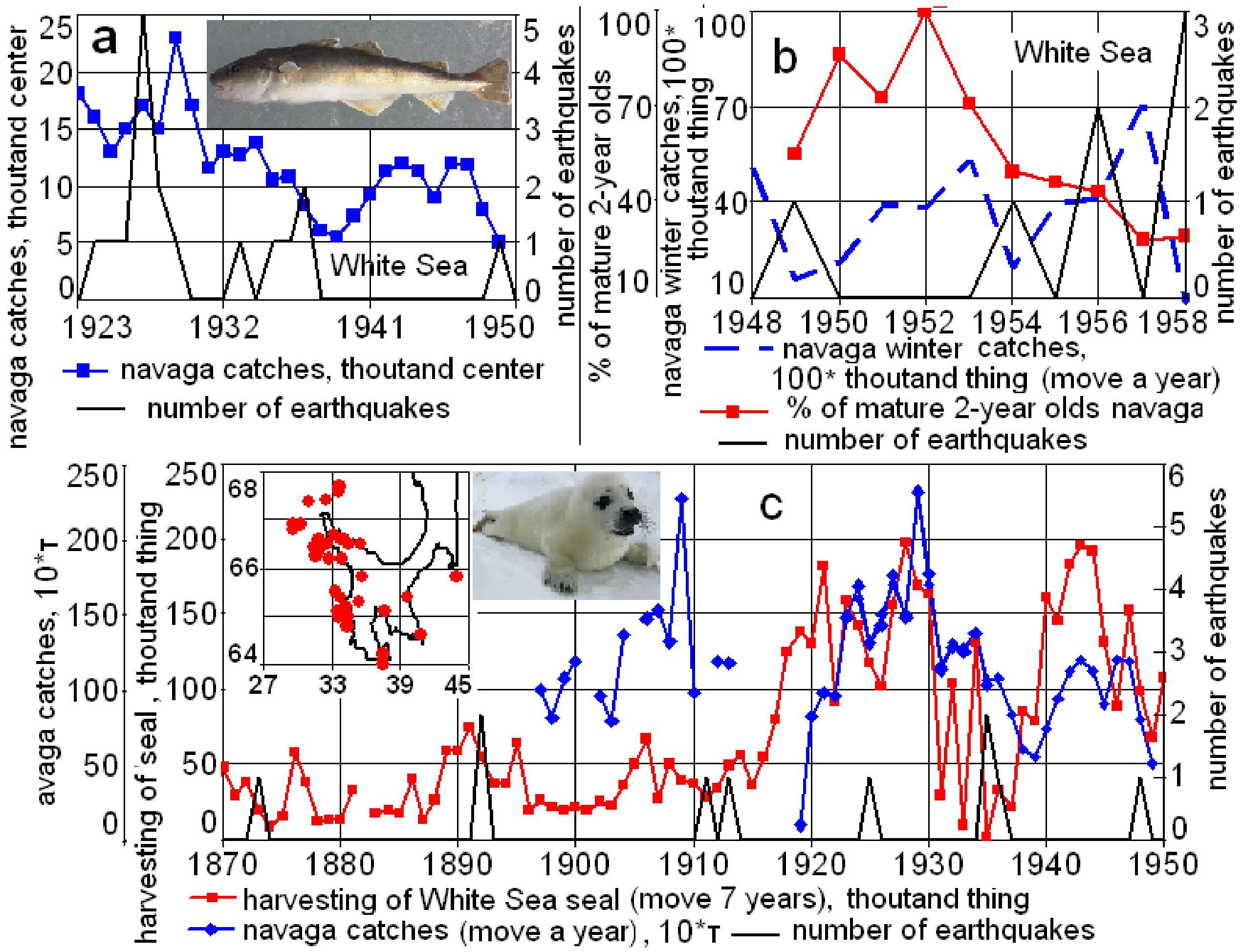

Fig. 19. Comparison of earthquake number with navaga catches, % of mature 2-year olds and harvesting of White Sea seal (insert shows epicenters of accounted earthquakes).

In Baikal, after earthquakes the number of puppies of the seal drops (Fig. 20) [15]/

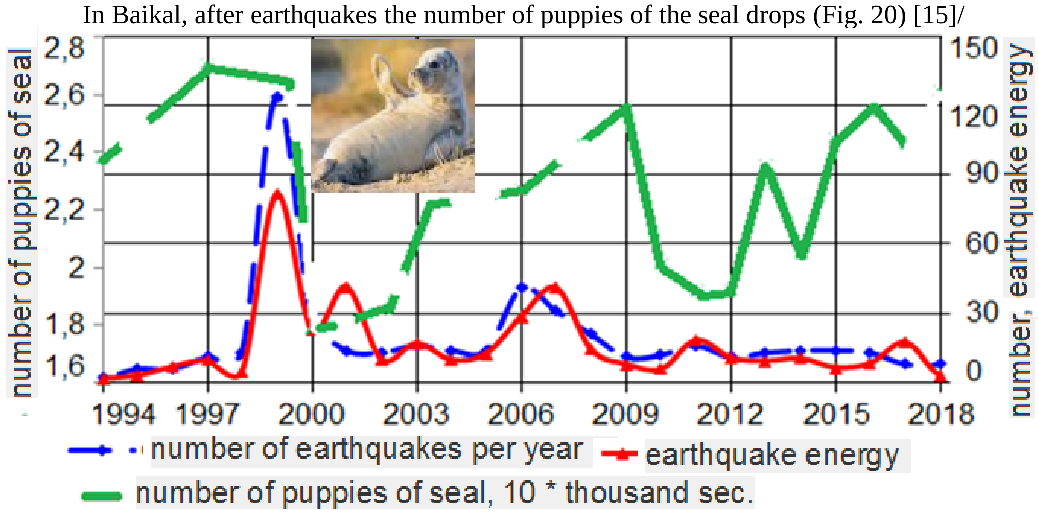

Fig. 20. Comparison of the number of earthquakes with t the number of puppies of the seal drops.

Life activity of Caspian seals (Phoca caspica), similarly to the *White Sea*, depends on the food base, which in turn is defined by the Terek seismic activity (Fig. 21). In 5-7 years after the increase in the earthquakes number, seal production falls. As a result, after 5-7 years, a small in numbers generation grows. This happened 5-6 years after the above-discussed seismic stress for benthos of 1988. In 1994, seal production fell more than twice compared to 1988-1993.

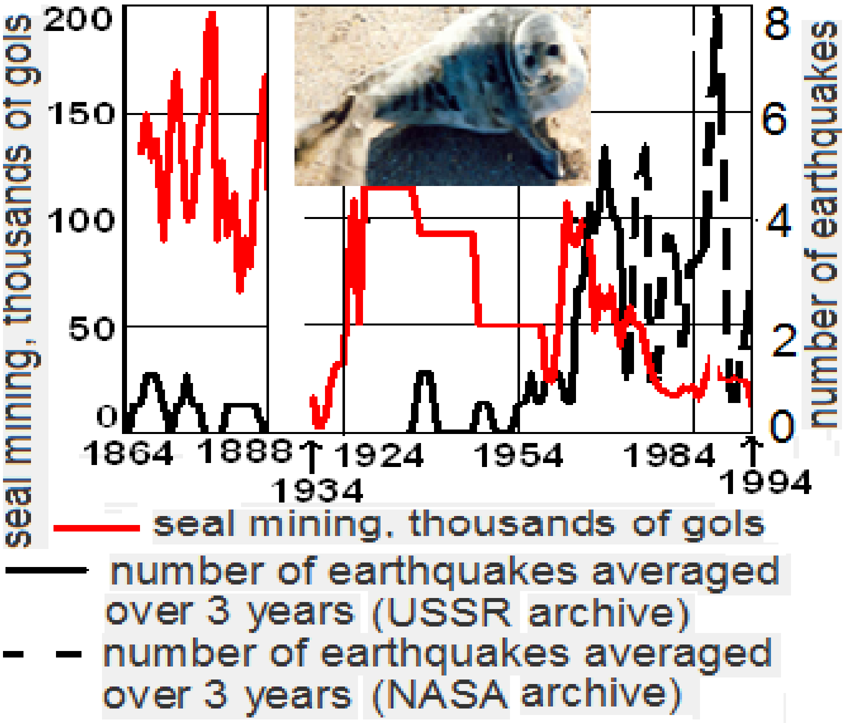

Fig. 21. *Comparison of seal production in the Caspian Sea and number of earthquakes averaged over three years in the region shifted by 5 years.*

6. Conclusion

Defluidization and sharp rises of radiation levels, electromagnetic and acoustic fields have a decisive influence on changes in the development of aerobic hydrobionts. Effect of the latter, as a rule, is local (previously, shortage of catches and fish suffocation in the *Caspian Sea* was explained by negative impact of seismic survey) and do not lead to large-scale violations of reproductive functions. Reproductive problems occur only at massive CH_4 degassing causing gas embolism and hypoxia.

At the seismic CH_4 degassing, pelagic fish throws out on the shore, bottom fish rises to the surface, crustaceans rise to the surface and come ashore, aerobic juveniles of commercial fish die, reproductive function of surviving fish is violated. After the massive CH_4 emission, commercial accumulations of fish disappear for a while - it is not advisable to start fishing in the "infected" waters after receiving information on the emission occurred since the catches will be significantly lower than predicted and economically unprofitable, or to look for "the edges of infected" waters where the fish came to, even when the conditions in this areas are not uncharacteristic, for example, in terms of temperature, salinity, depth, feed reserve. After the abnormally seismic years, sex ratio is sharply shifted towards unusually well-fed females with impaired reproductive functions, lack of juveniles or inviability, growth of crustaceans. So, it is possible to expect sharp fall of fish and mollusks reproduction and increase in the number of scavengers-crustaceans.

For administrators, recognition of seismotectonic anomalies indicates a problem of sales of regional quotas for aquatic organisms and getting funds for commercial exploration. Hidden information about the seismogenic infertility of the brood stock led to the ruining of fishery artels in the *Barents, White* and *Caspian Seas* who bought "blown" quotas.

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