Northwestern Pacific subarctic marine ecosystems structure and possible trends of changing in nearest future

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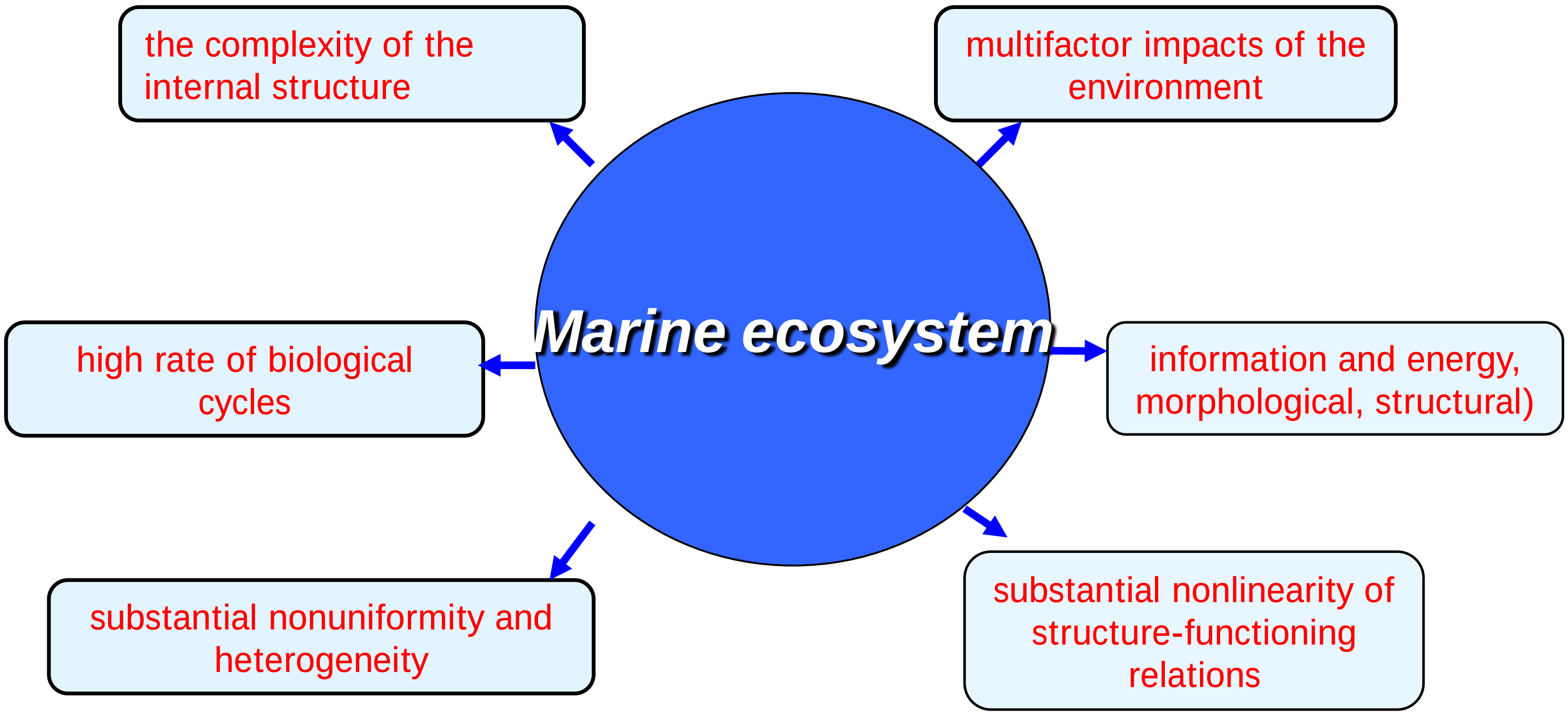
North Pacific Marine Science Organization

The difficulty of ecosystems studies connected with following parameters are inherent in any marine ecosystem



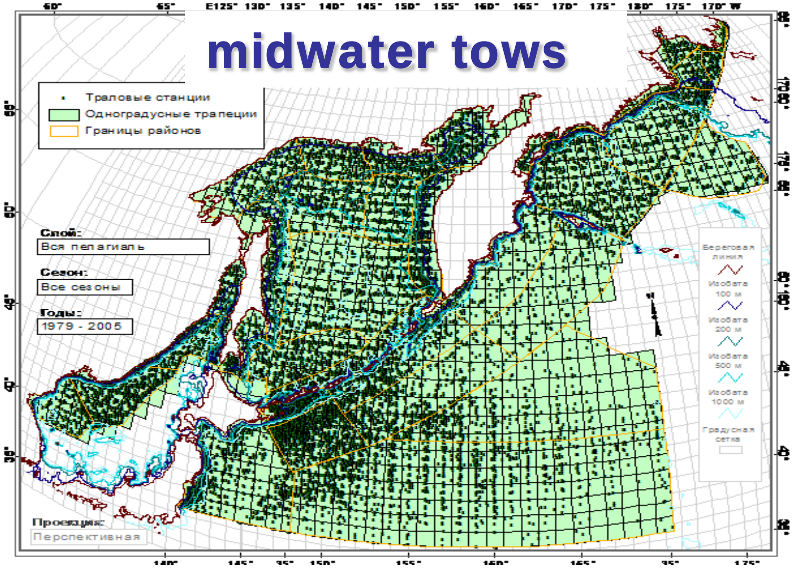
The main directions of my report

1. What we know about the ecosystems of Okhotsk Sea and the western Bering Sea? (Structure, dynamics and functioning)

2. Where are we going right now? (Look into the future)

3. What is the basis of our research

What is the basis of our research?

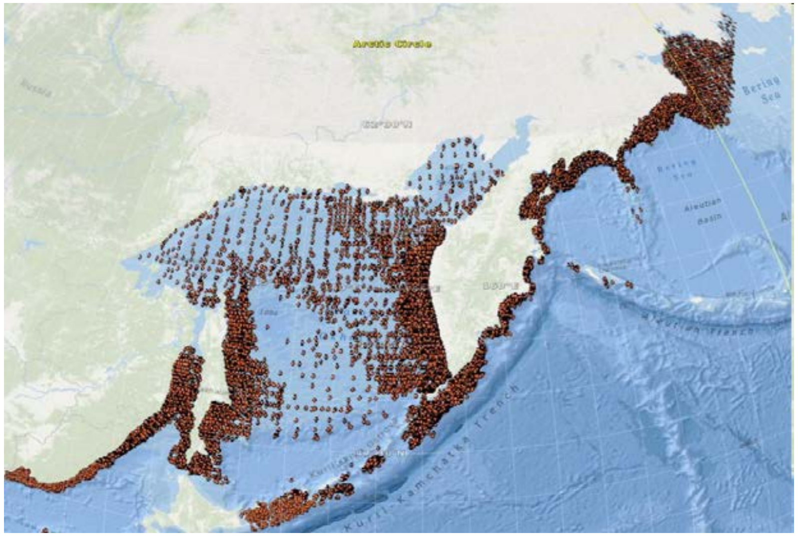


midwater tows

Our researches are based on really big volume data because ecosystem survey in the Sea of Okhotsk and the Bering Sea conducted almost every year:

About 500 research cruises, 22 000 plankton stations, 30 000 midwater tows, 35000 bottom tows and processed more 700 000 fish stomach

bottom tows



more then 2000 publications

What we know ?

Modern understanding of the structure and dynamics of the main components of the Okhotsk Sea and the western Bering Sea ecosystems

- Quantative assessments of the main components of the middle and upper trophic levels
- Species composition and quantitative data of plankton, nekton, nektobenhtos and benthos
- Long-term dynamics of these components and main species
- Information about some aspects of the ecosystem functioning (bioproductivity, trophic relations, energy flows

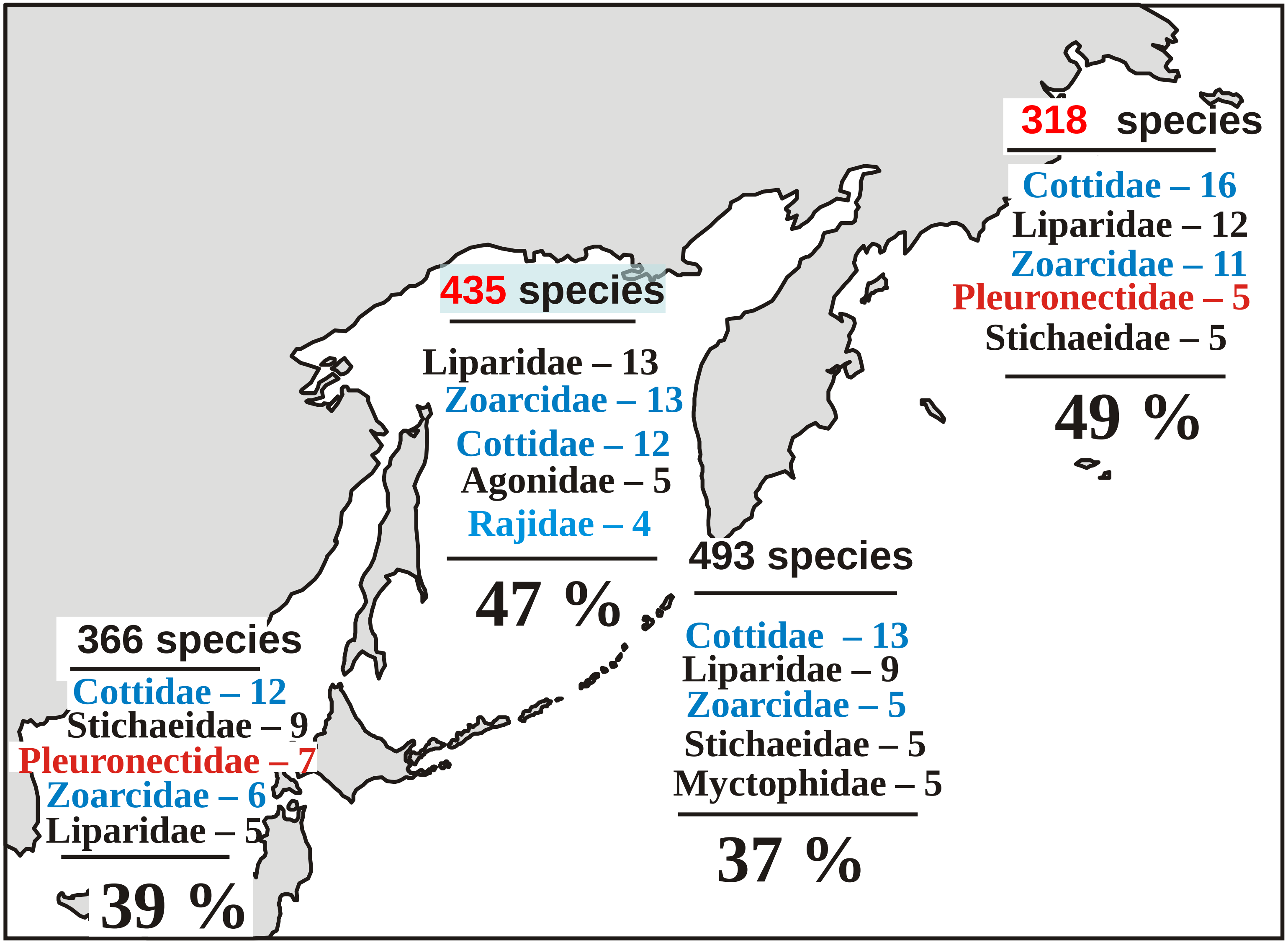
Quantitative estimates of the components of the secondary and higher trophic levels in the Far Eastern Russian economic zone (Shuntov, 2010)

Groups	Quantitative estimates
Zooplankton	1000 mln tons
Zoobenthos	500 mln tons
Phytobenthos	25 mln tons
Nekton (pelagic fishes and squids)	80 mln tons
Demersal fish	5 mln tons
Sea birds	50 mln sp.
Seal	3-5 mln sp.
Dolphin	300-500 ths. sp.
Whales	50-100 ths. sp.

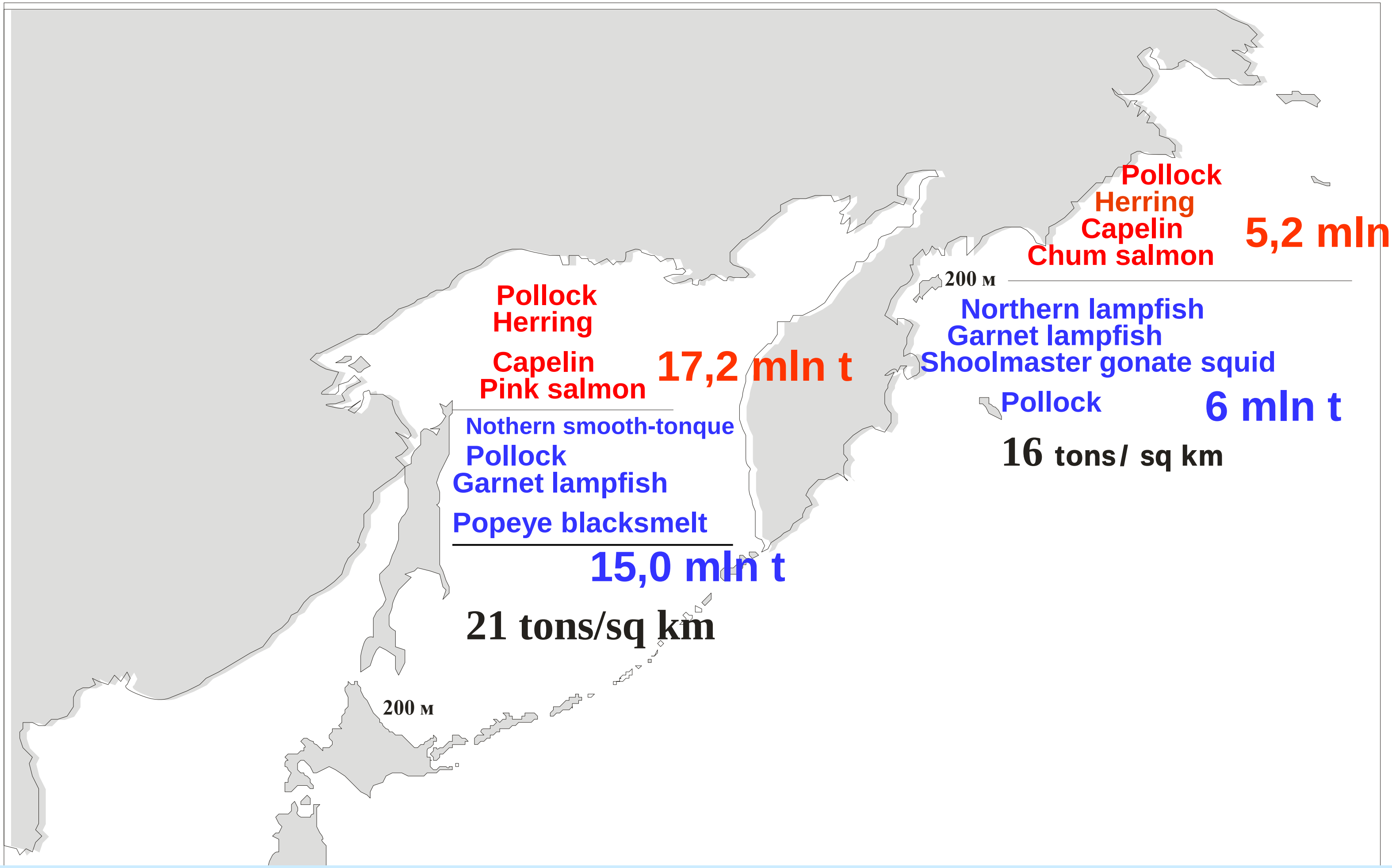
The main result of our researchs are estimate of components of trophic levels, which radically changed the idea of the fish productivity of the Far Eastern seas

The total number of fish species in different regions of the Russian marginal seas and the proportion of species from it total number (%) in staff of first five families

The 435 species in the Sea of Okhotsk - and 318 species in the Bering Sea



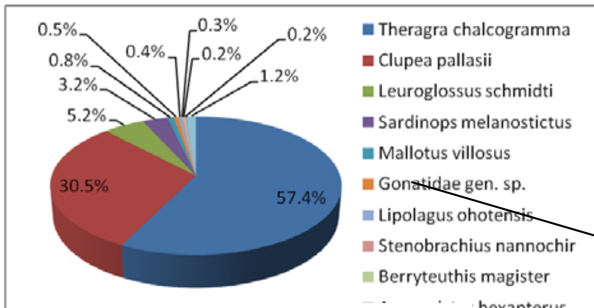
Annual average of the species composition of nekton in epipelagic and mezopelagic layers (mln t)



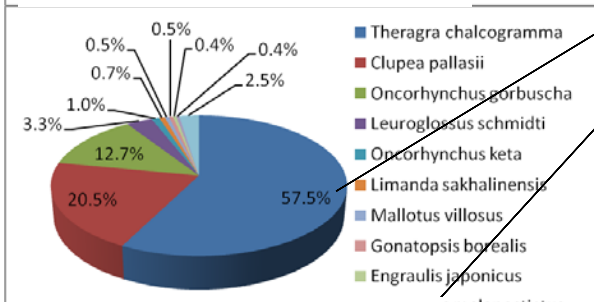
Dominant and subdominant species plays main role in the functioning of biocenosis in the Okhotsk Sea, western Bering Sea and adjacent Pacific ocean. The contribution of other species in the matter and energy flows are very limited.

Species composition and density of nekton

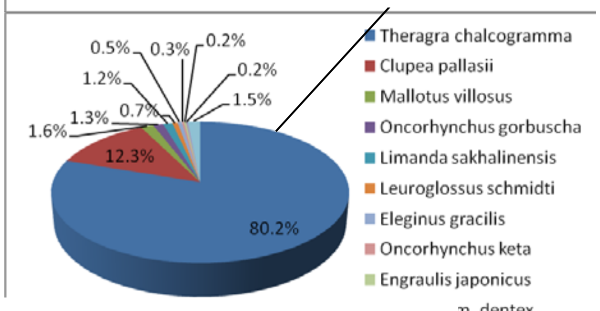
Okhotsk Sea



1980-1990 (21.5 t/sq. km)



1991-95 (7.5 t/sq. km)

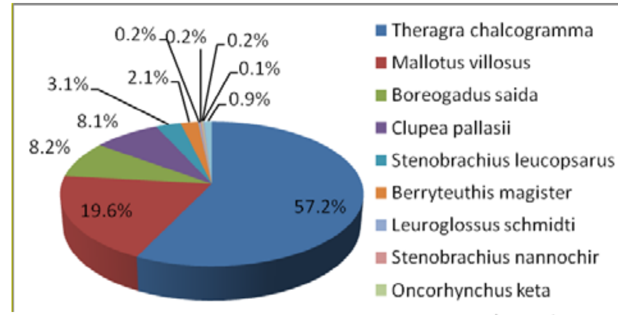


1996-2005 (18.5 t/sq. km)

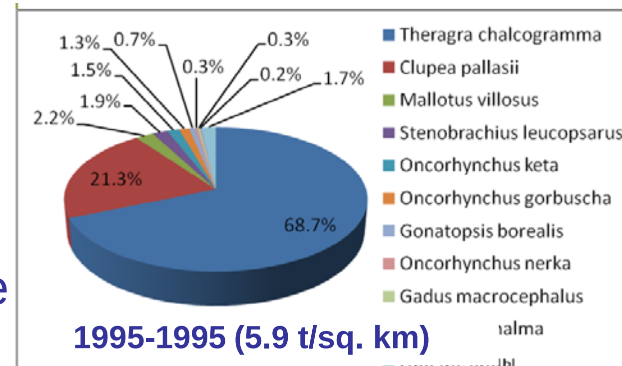
Theragra chalcogramma

Interannual dynamics of nekton determined by relatively limited number of most common species of fish and squid. As a rule, the interannual variation of abundance such species determines significant increasing and decreasing the catch of commercial fish.

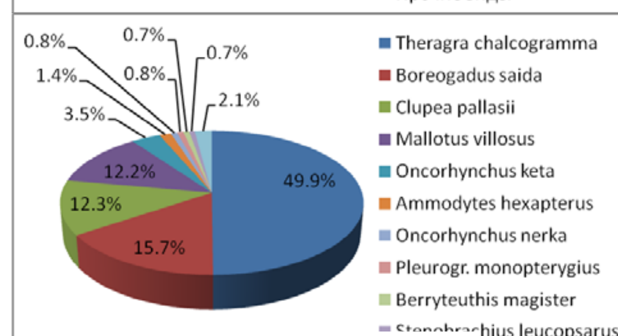
Western Bering Sea



1980-1990 (21.9 t/sq. km)



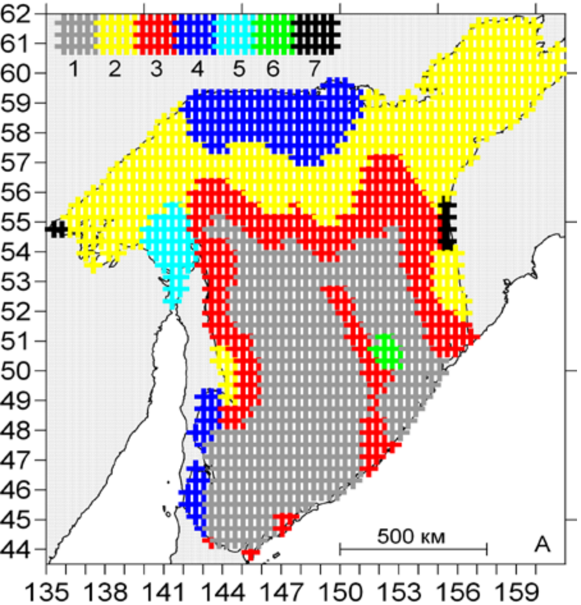
1995-1995 (5.9 t/sq. km)



1996-2005 (12.5 t/sq. km)

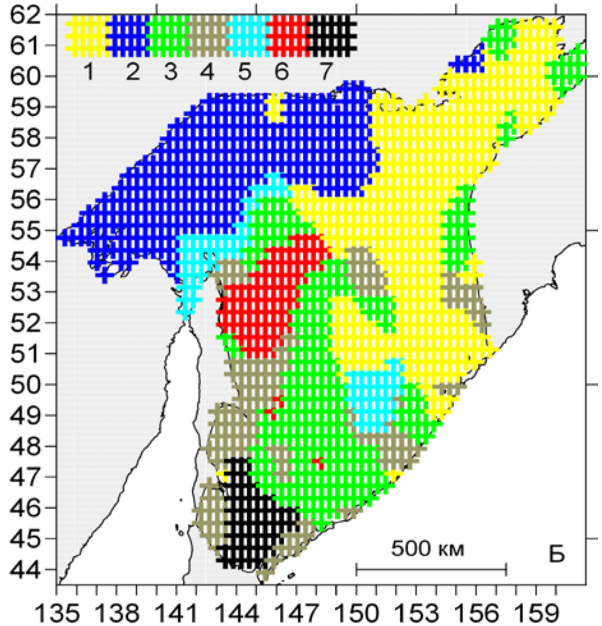
Biocenosis zoning

1982–1990



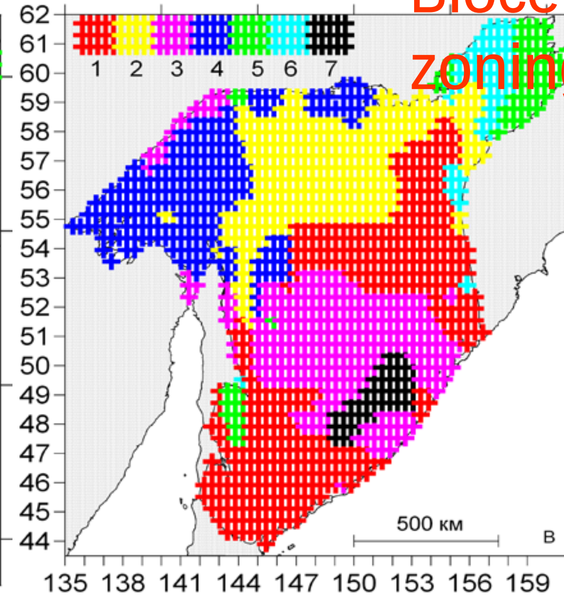
1 (35.3 %) Leuroglossus schmidti + Theragra chalcogramma
2 (31.3 %) Theragra chalcogramma + Clupea pallasii
3 (20.0 %) Theragra chalcogramma + Leuroglossus schmidti
4 (9.7 %) Clupea pallasii + Theragra chalcogramma
5 (2.6 %) Clupea pallasii + Oncorhynchus keta
6 (0.7 %) Theragra chalcogramma + Myctophidae gen. sp.
7 (0.4 %) Theragra chalcogramma + Osmerus mordax dentex

1991–1995

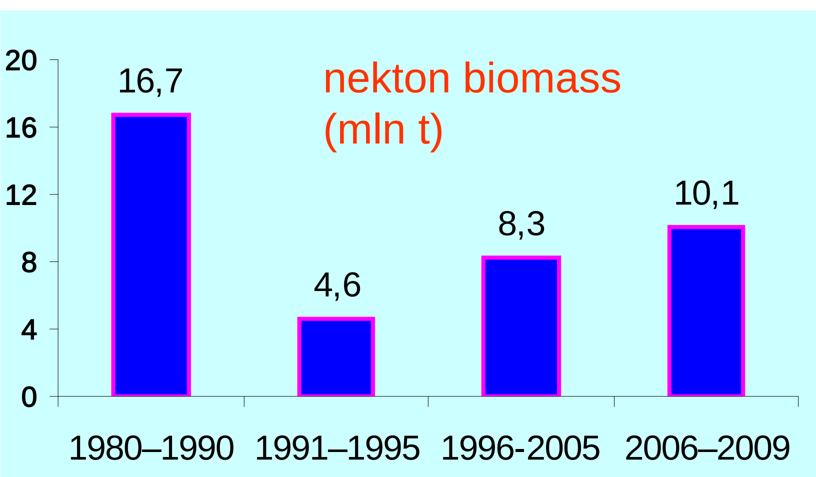


1 (30.1 %) Theragra chalcogramma + Clupea pallasii
2 (21.7 %) Clupea pallasii + Theragra chalcogramma
3 (20.7 %) Leuroglossus schmidti + Oncorhynchus gorbuscha
4 (11.4 %) Lamna ditropis + Oncorhynchus gorbuscha
5 (6.3 %) Clupea pallasii + Leuroglossus schmidti
6 (5.8 %) Leuroglossus schmidti + Theragra chalcogramma
7 (4.1 %) Sardinops melanostictus + Oncorhynchus gorbuscha

1996–2005



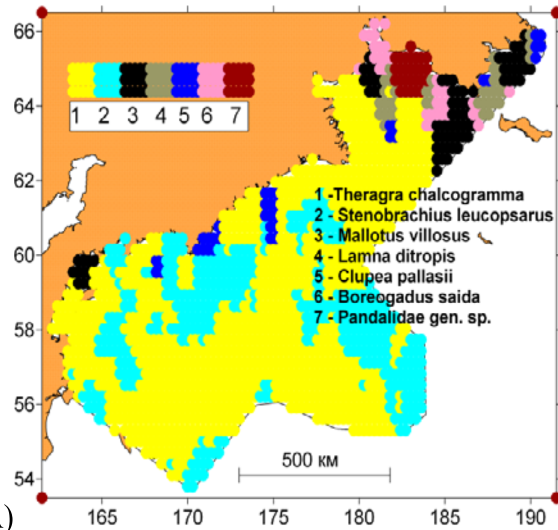
1 (31.0 %) Theragra chalcogramma + Leuroglossus schmidti
2 (20.3 %) Theragra chalcogramma + Clupea pallasii
3 (20.2 %) Oncorhynchus gorbuscha + Oncorhynchus keta
4 (16.0 %) Clupea pallasii + Theragra chalcogramma
5 (5.0 %) Mallotus villosus + Theragra chalcogramma
6 (4.3 %) Theragra chalcogramma + Mallotus villosus
7 (3.2 %) Oncorhynchus keta + Oncorhynchus gorbuscha



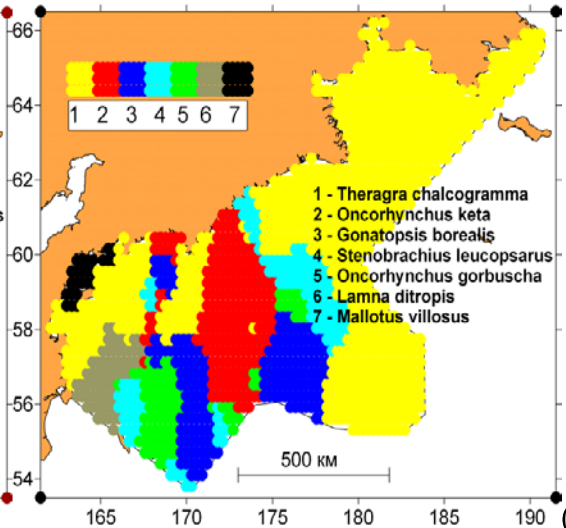
The one of the options biocenotic zoning of epipelagic was developed on base of information on the species structure of nekton and it presented on the slide. During the some time biocenosis with a predominance of some species are replaced by others. This process was accompanied by a decreasing of nekton biomass in the epipelagic

The same biocenotic zoning has been done for the western Bering Sea

1982-1990



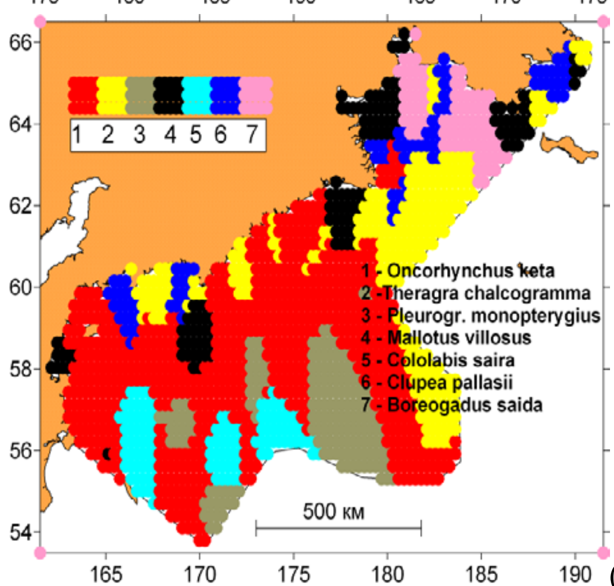
(A)



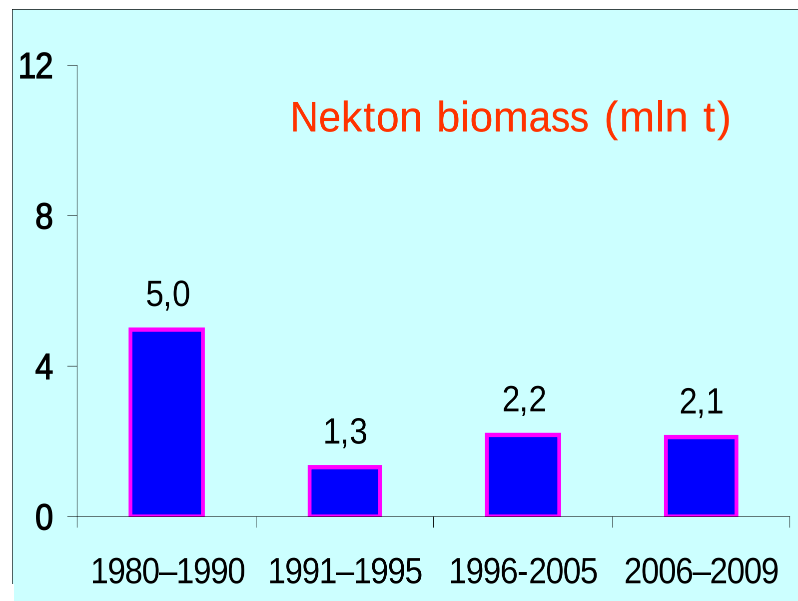
(Б)

1991-1995

1997-2005



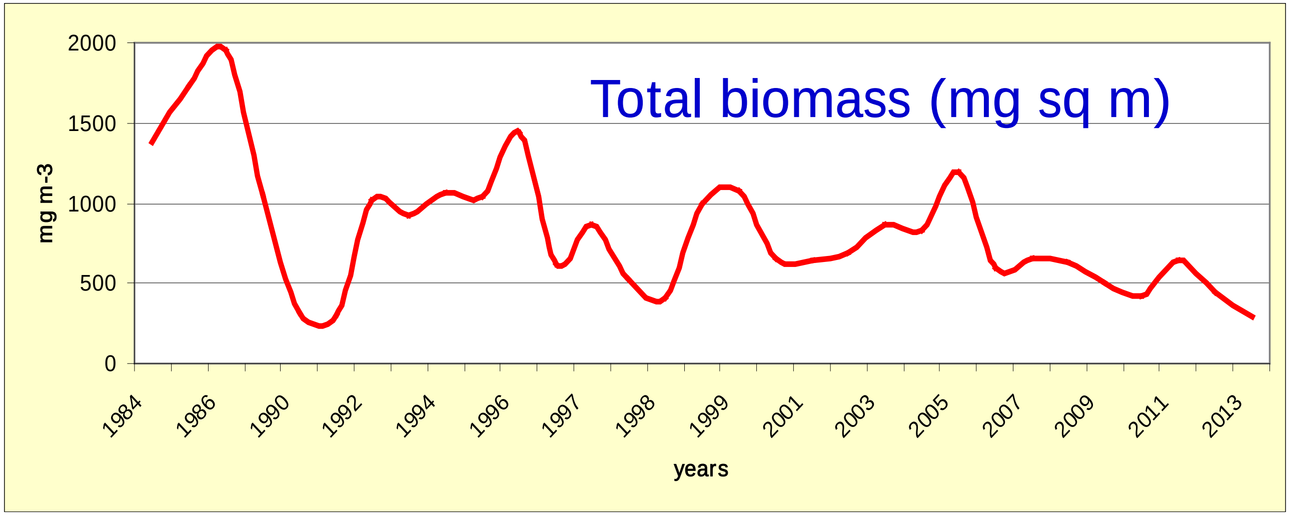
(B)

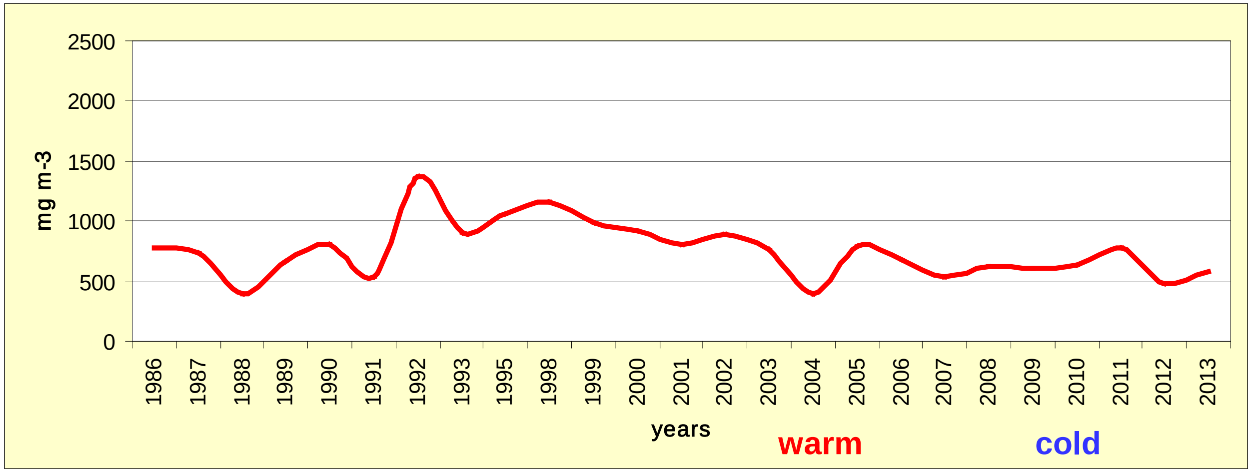


The limited number of species and groups also plays main role in staff of zooplankton Bioproductivity, turnover biomass rate and, accordingly quantity of food resources of nekton depends from abundance these species

Okhotsk Sea

Thysanoessa rashii
Metridia okhotensis
Sagitta elegans
Pseudocalanus minutus
Calanus glacialis
Neocalanus plumchrus
Thysanoessa longipes



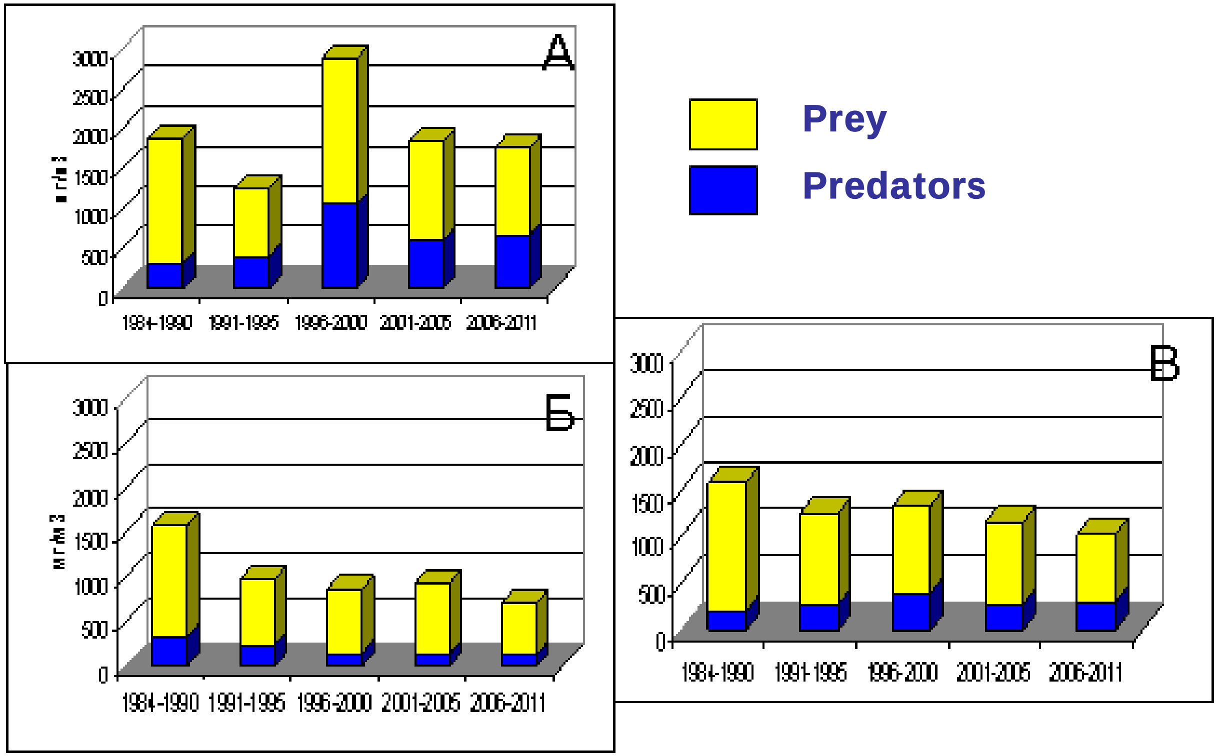


Western Bering Sea

Calanus glacialis, Eucalanus bungi, Neocalanus plumchrus, Pseudocalanus minutus, Metridia pacifica, Oithona similis, Neocalanus cristatus Thysanoessa inermis, Th. raschii, Th. longipes, Sagitta elegans *Themisto pacifica.*

Interannually, the average total biomass of zooplankton normally varies not more than by 1.5-2 times .
There was no evident relation between plankton abundance and type of year (warm or cold type).

The trophic structure of zooplankton undergone significant changes in 1984-2011.

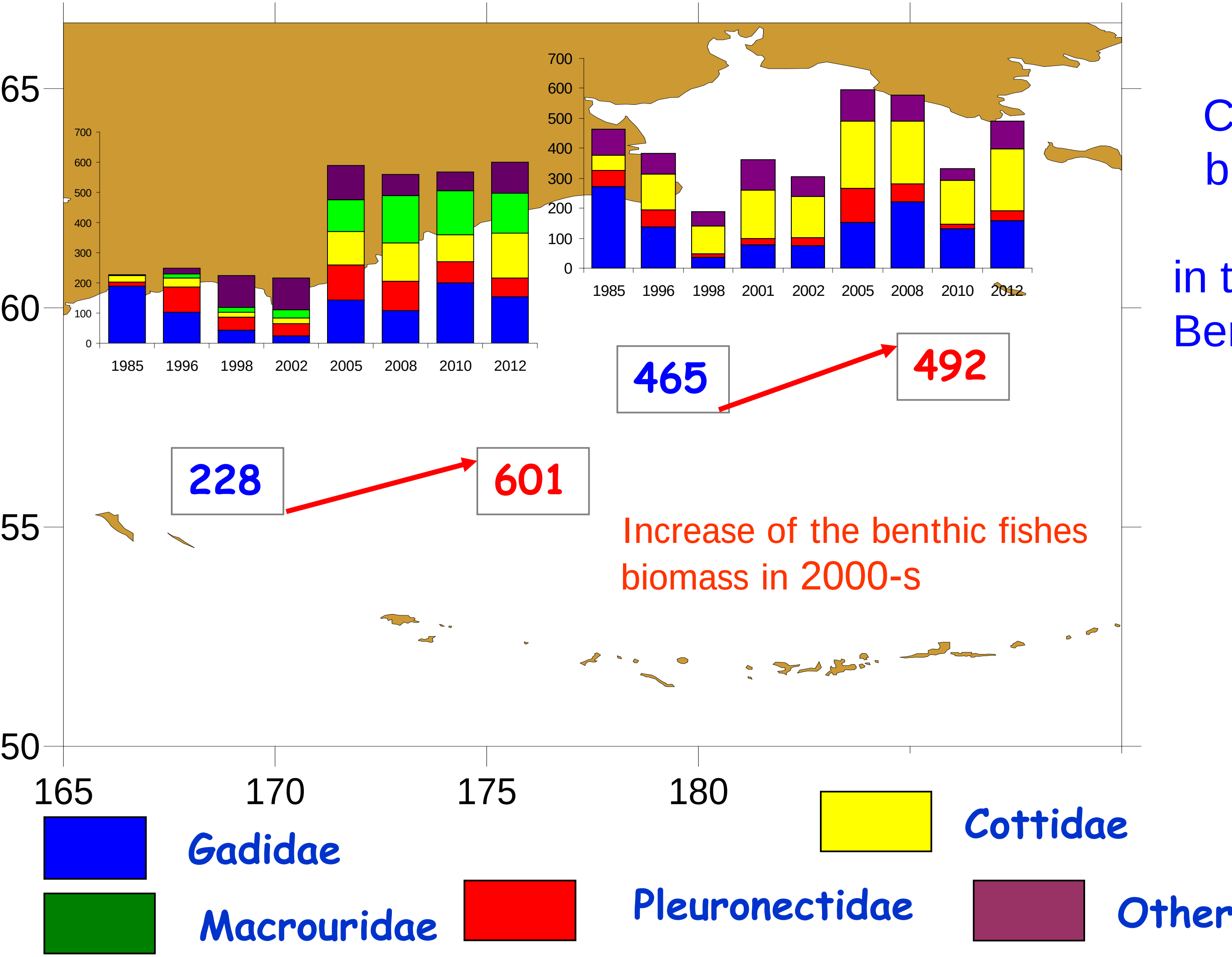


Dynamics of trophic structure (mg cub.m) in the Okhotsk Sea: A – an internal shelf, B - an external shelf; B - deep-water areas

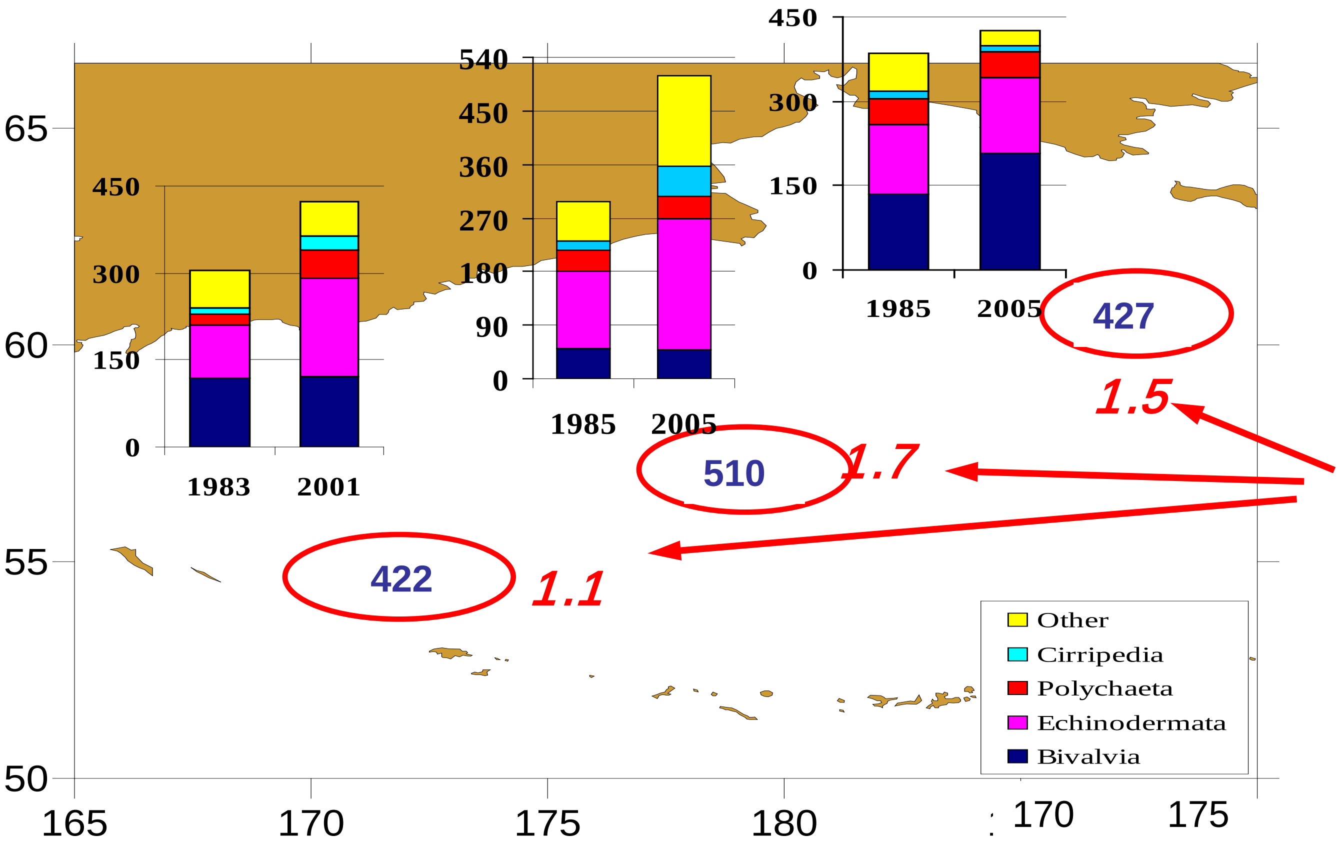
The proportion of predators increased in staff of zooplankton

The increasing number of planktonic predators (basically chaetognaths) as result had decreased the amount of nekton forage. I'll say about it later.

As for the benthic communities, they are more stable compared to pelagic communities



Composition and biomass (th. t) of benthic fishes in the north-western Bering Sea in 1985-2012



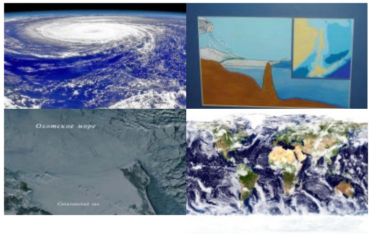
Increase of the benthic species relative biomass in 2000-ies in the western Bering Sea

The benthos biomass increased in period from the 1980-s to the 2000-s but did not found any relations with variability of the consumers abundance, for example Pacific cod and other species on bottom.

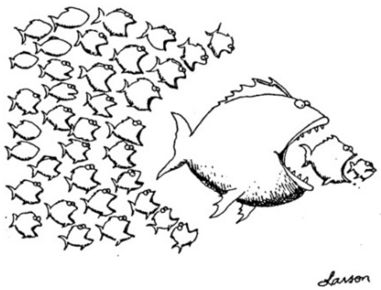
What determines the current dynamics of the biota??

Our research support idea that the natural factors are main reason of dynamics.

Climate-oceanologic factors
(global and regional)



Ecosystem interactions
(bottom-up and top-down control)



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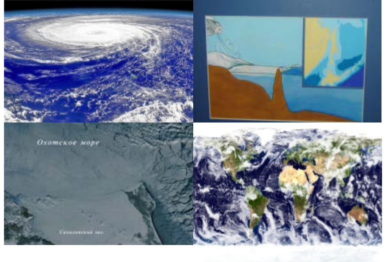
Population factors



Effect of climate-oceanologic factors's dynamics on biota ?

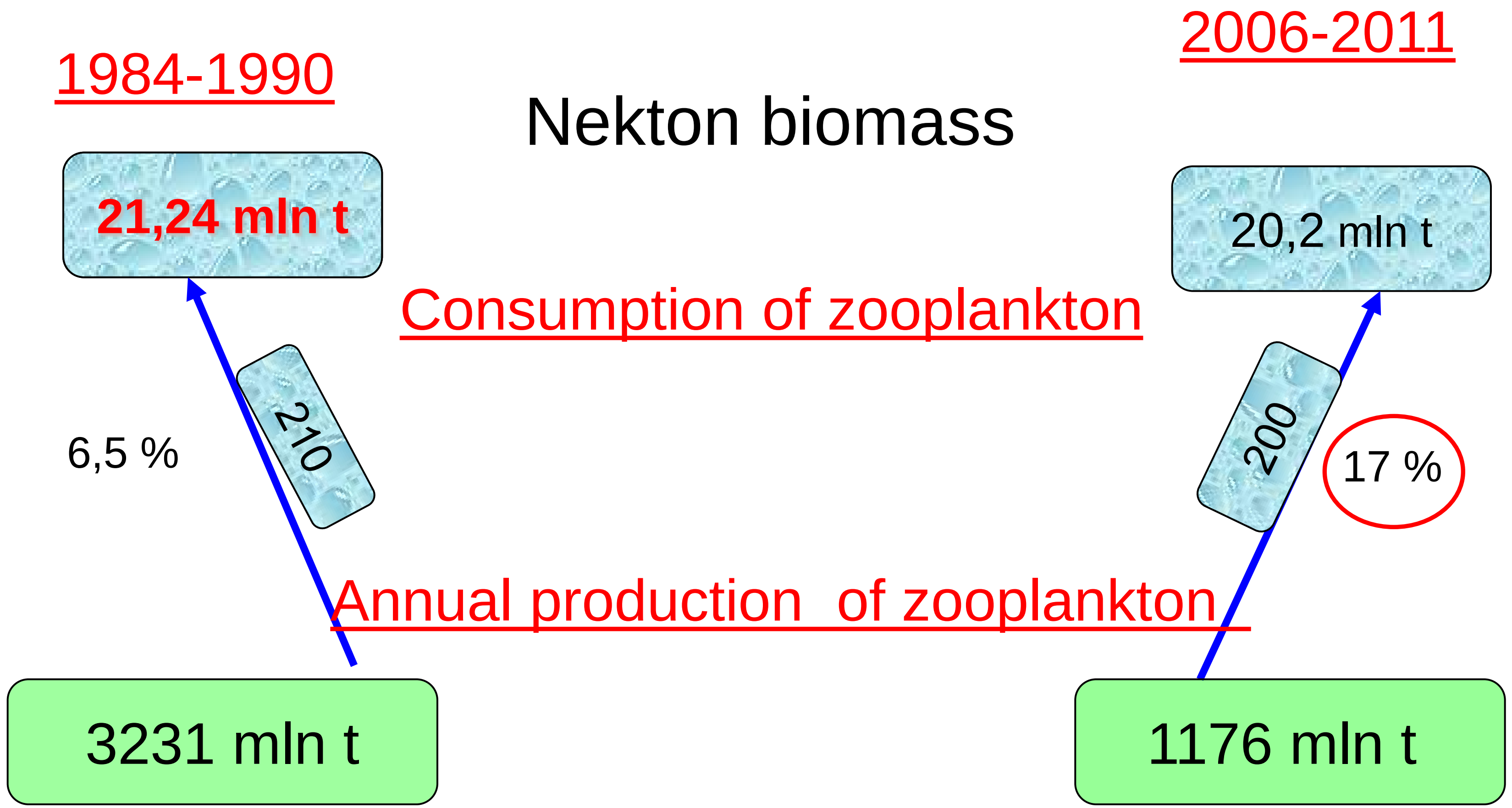
- The abundance dynamics and the state of the population of each species in the ecosystem is a result of the complex activities of various factors, including the cosmophysical, climate-oceanological, biocenotical and population ones
- Climate changes have a natural cyclic pattern. The modern climate state is a “common link” in the chain of the cycle of the planetary events, in which the nature epochs come to replace each other with a different periodicity in a wave-like manner.
- The reaction of the biota to the same climate influence can be different for different regional systems – the “provinciality” principle

For example the lowered walleye pollock production may be a result of 40-60 years cyclicity.

Ecosystem interactions (bottom-up control)

- Big volume of information for trophic characteristics nekton and nektobentos allows made important conclusion that the food competition in the pelagic and benthic communities does not reach the level at which could starts hard limiting species abundance. This is due to the partial dispersion of food ratio in ecologically similar species, but basically by very high biomass and production of zooplankton and benthos

Annual consumption of zooplankton (mln. t) by nekton in the Okhotsk



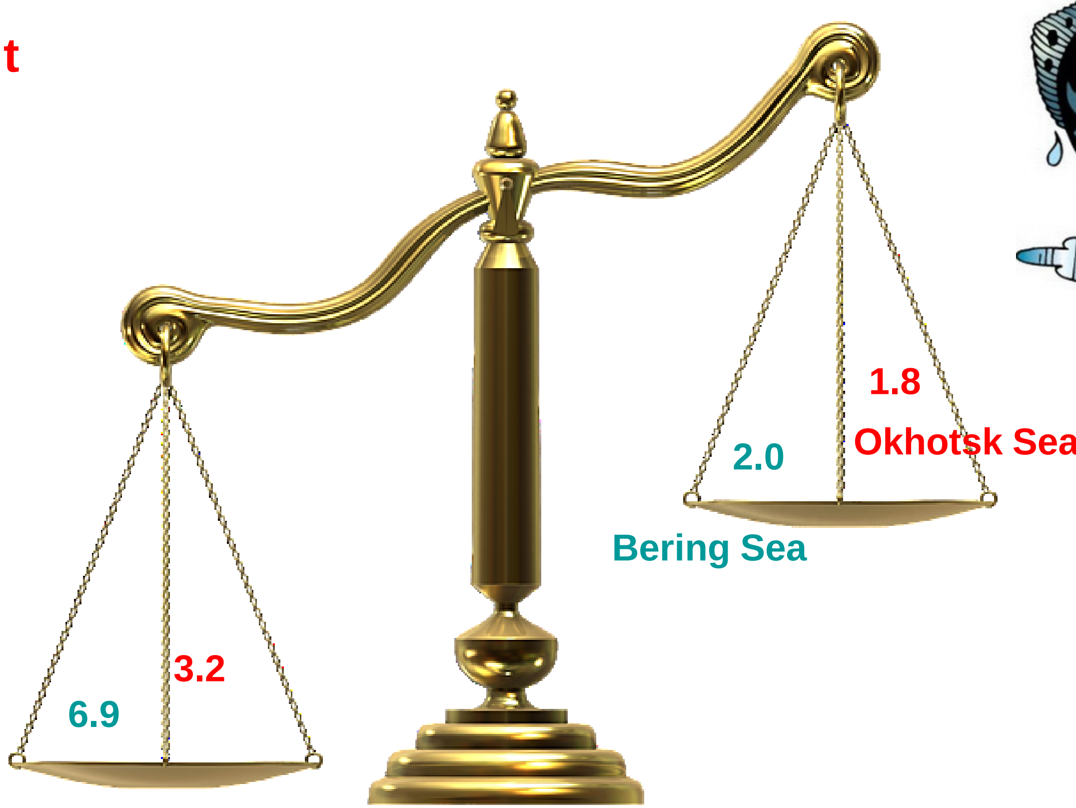
- For example, even in the periods of high biomass nekton and low biomass of zooplankton consumption does not exceed 17% of the total zooplankton production.
- **Forage resources of nekton and nektobenthic fishes are at a rather high level and do not limit species abundance**

•What can we say about the top-down effect and anthropogenic influence (commercial catches)?

Annual consumption of walleye pollock (mln. t) within Okhotsk and Bering Seas during 1980-s (Shuntov, Dulepova 1993)

All predators mln t

(cannibalism, other predatory fish species, marine mammals and birds)



Commercial catches of walleye pollock by large-scale fisheries much lower compared to natural mortality (cannibalism and predators consumption)

- Thus, our studies confirm idea about significant influence of predation (top-down control) in limitation of pollock abundance.
- In recent years, a lot number of new data demonstrates top-down control) for some other species (salmon, crab and shrimp).).

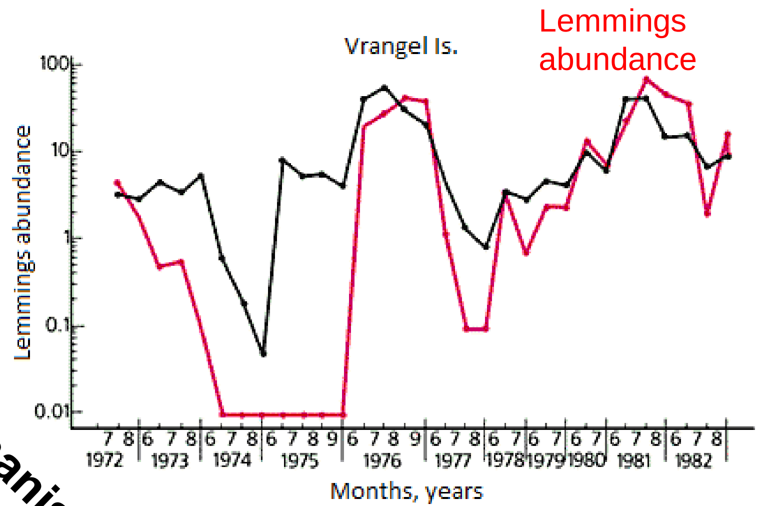
Population factors

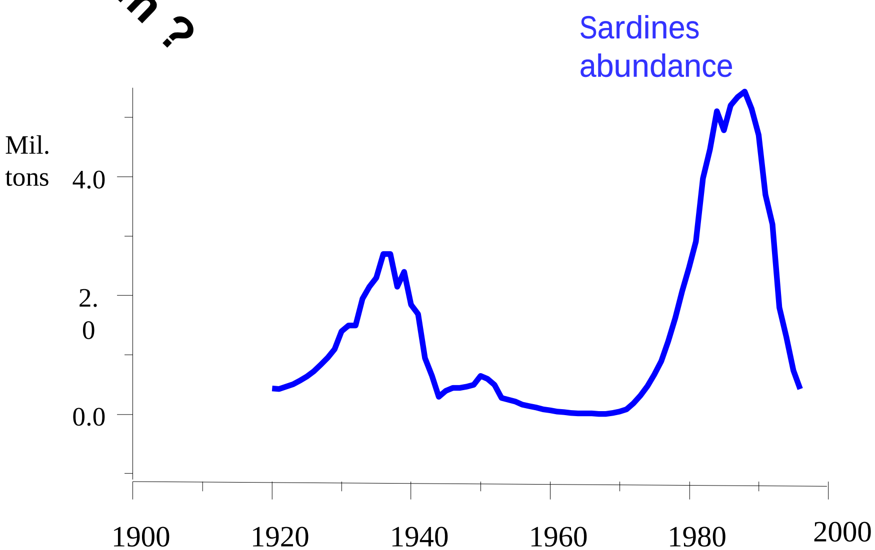
Mechanisms of auto-regulation:

high population density → stress → decline in population quality and viability → increasing mortality

Other factors could just increase or decrease population processes.

The same mechanism ?



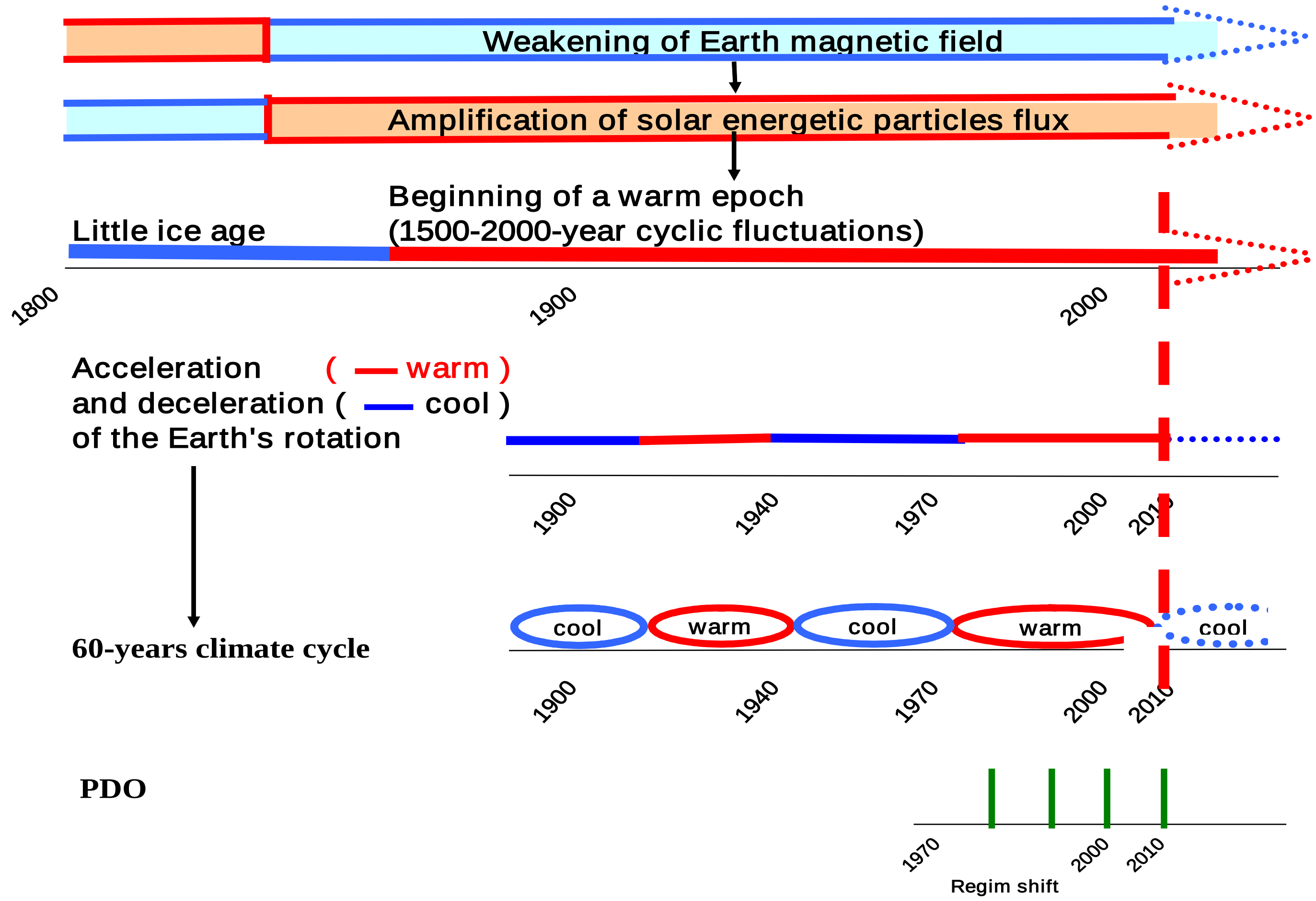


So phenomena are observed in the populations of fur seals, sardines, Pacific herring and pollock in the Far Eastern marginal seas.

Where are we going? (Look into the future)

For the forecast (most assumptions) on further trends in the composition and structure of populations, communities and ecosystems as a whole biota and climate trends, it is important to determine, within the limits of the natural cycle and how its phase we are now. Despite differences of opinion, some certainty in this matter is still available.

Long-term dynamics of some geophisical and climate factors in the last 1500-2000-years planetary cycle (Shuntov, Temnykh, 2012)



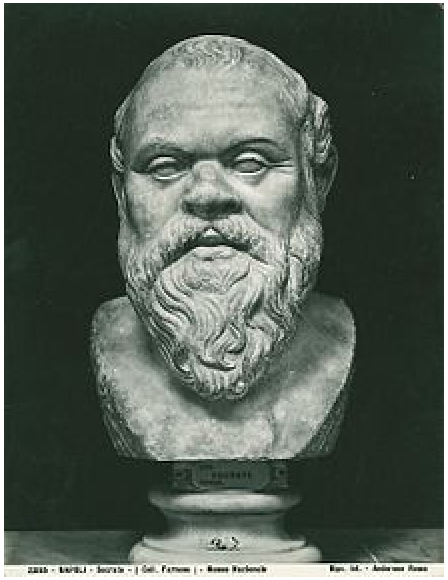
Next slide demonstrates long-term dynamics of some geophysical and climate factors in the last 1500-2000-years planetary cycle

- So, the period of end of the first and beginning of the second decade of the 21st century looks like are very specific and during this period has already began a large-scale changing of trends in the many of natural processes - internal and external geophysical and climatic and oceanological.
  Currently there is a transition period within 60 years cycle (half-cycle), similar to the period 1940-1970's. In addition, the last ten-years climate shift taken place in time between the first and second decades of the 21st century. . But it is doubtful whether this implies that the biota with a given sequence will be repeated events that observed after 1940, even if the next period will be much colder.

- We know and understand a lot about structure and dynamics of ecosystems , but clearly to predict direction of coming changes in ecosystems is not possible, in spite of the successes of modern simulation.
- The long-term and short-term predictions of abundance commercial species and it catch with faith in a clear rhythmic processes and complete repetition in environmental cycles, including communities structure, is not real.

  We can just suppose!!!

- Zooplankton - quantitative stock will stay on same level
- Benthic communities - will stable
- Bottom ichthyocenosis – will continue cyclical average periodicity, and flatfish, Pacific cod and gobies will predominant in bottom ichthyocenosis of the sub-Arctic waters
- Cetaceans and pinnipeds – will stay on stable level
- Pacific salmon - reduced abundance, but this reduction will not be a landslide as result of the artificial reproduction.



«As for me, all I know is that I know nothing….»

Socrates (469 - 399 bc)

«Fullness of knowledge always means some understanding of the depths of our ignorance…»

Robert Andrews Millikan

(Nobel Prize in Physics in 1923)

The metaphors Socrates and Millikan are quite useful for explaining process of understanding of ecosystem structure and functioning. In our case, meaning that the more and more we study the ecosystem, we have more questions in their structural organization and functioning