Changes of bottom ichthyocenosis structure on the shelf of West Kamchatka under changing environments in the last two decades

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Summary

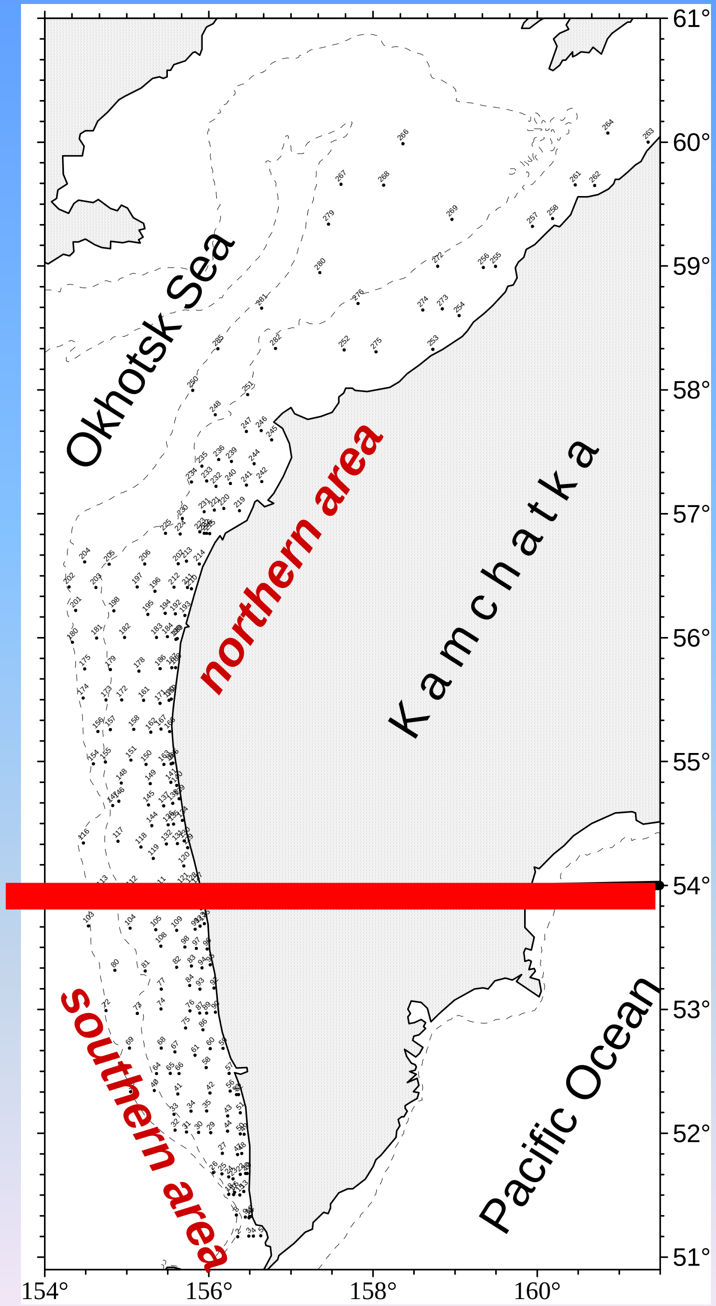
1. Changes and shifts of species composition and distribution of mass fish species in the last 2 decades

2. Water temperature changes and their possible influence on the bottom communities

Goal:

- To reveal principal reconstructions in the bottom fish community on the shelf of western Kamchatka

- To understand their reasons and possible mechanisms that should be taken into account for forecasting and rational exploitation of the stocks



Areas of the study and typical grid of trawlings

Data

Trawl surveys of the whole shelf of West Kamchatka were conducted in summer seasons of 1989, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2005, 2007, 2008, and 2009.

Bottom temperature were measured over the whole shelf annually since 1986, in April

Both trawl and temperature data are integrated in the two areas divided by 54ºN

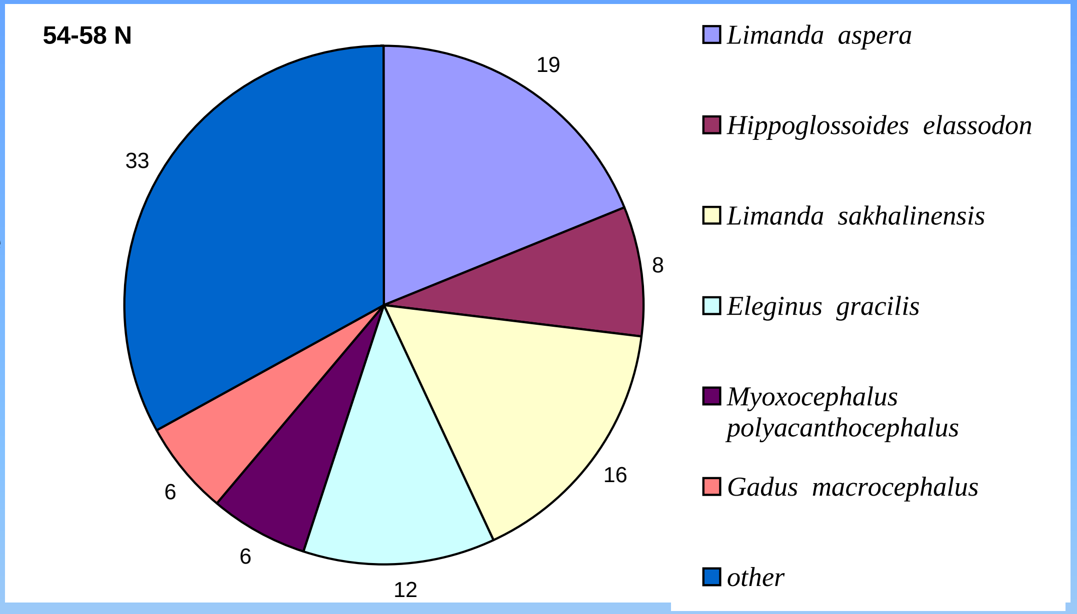
Species composition of bottom ichthyocenoses

Six species make on average 67 % of the bottom fish biomass in the northern area and 55 % of their biomass in the southern area. These species are:

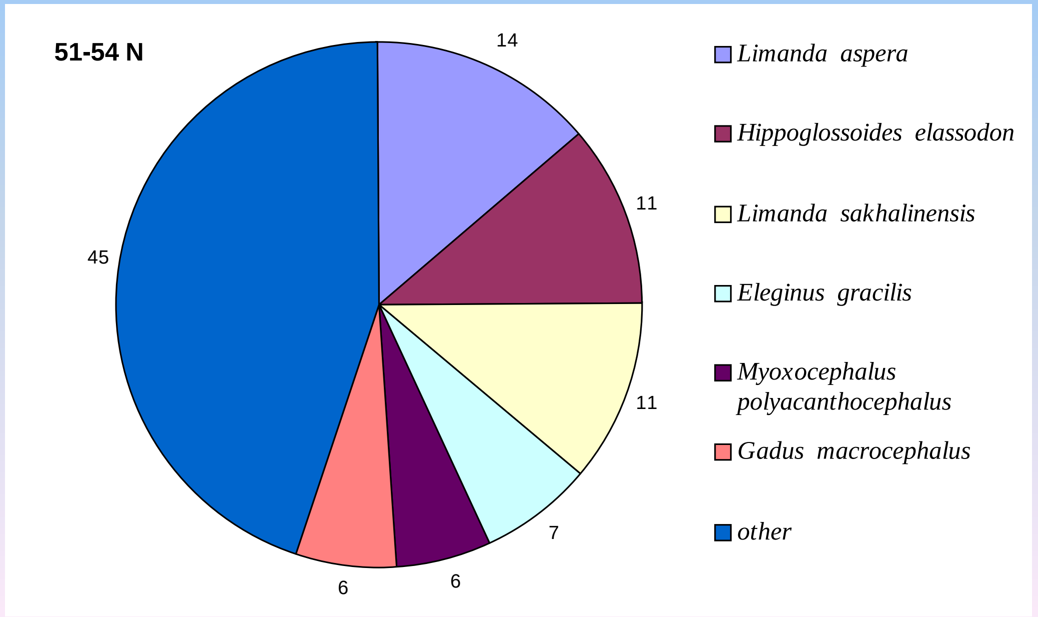
1. **Yellowfin sole *Limanda aspera***
2. **Brown sole *Limanda sakhalinensis***
3. **Flathead sole *Hyppoglossoides elassodon***
4. **Saffron cod *Eleginus gracilis***
5. **Pacific cod *Gadus macrocephalus***
6. **Great sculpin *Myoxocephalus polyacanthocephalus***

The first 4 species (3 sole species and saffron cod) make about a half of the biomass. Their stock and distribution are analyzed

northern area



southern area

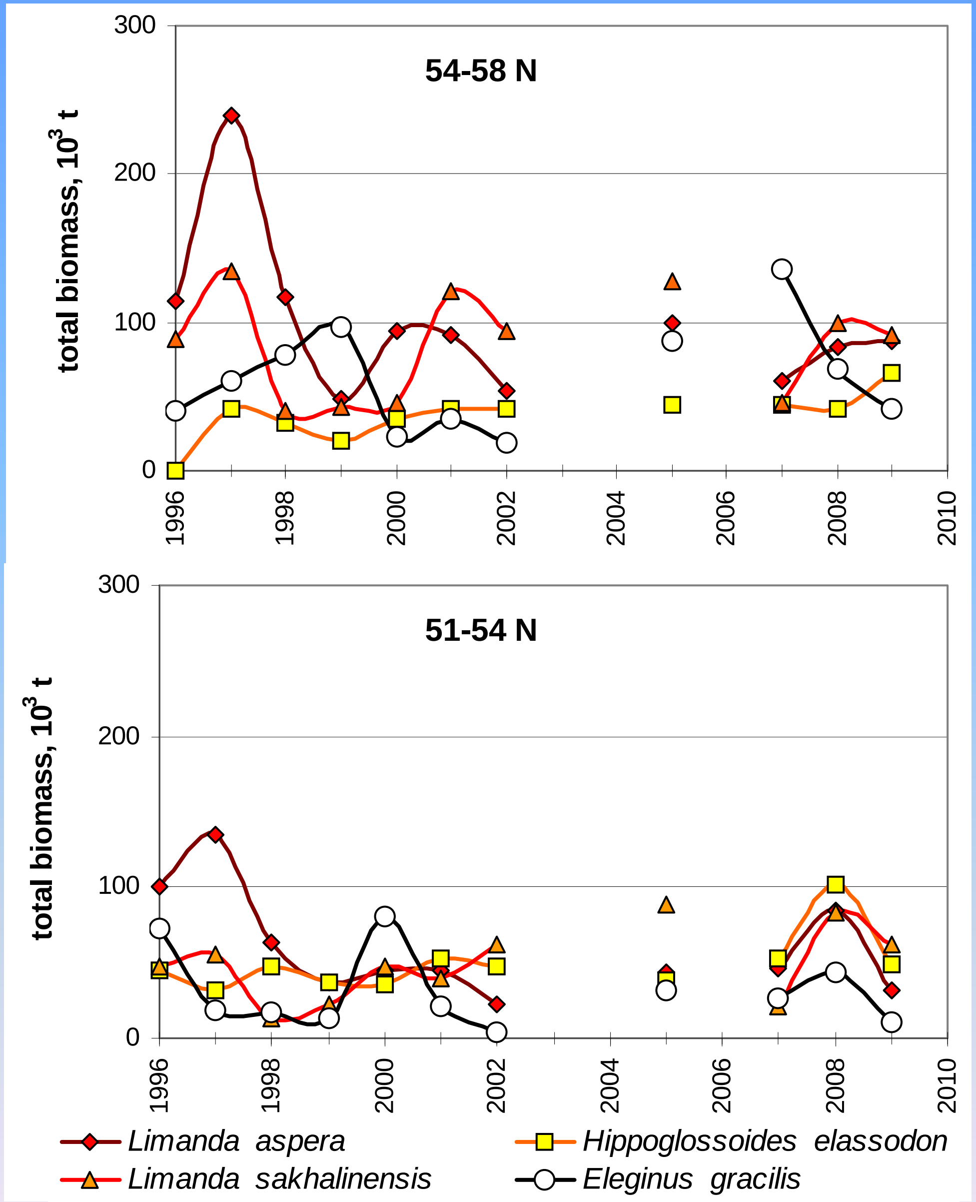


Stock dynamics

All main species had prominent and incoherent year-to-year fluctuations, so their ratio was changed.

Yellowfin sole dominated in the bottom communities in 1990s, but brown and flathead soles became dominant in recent decade.

Saffron cod was abundant in certain years.



Year-to-year dynamics of the species biomass

northern area

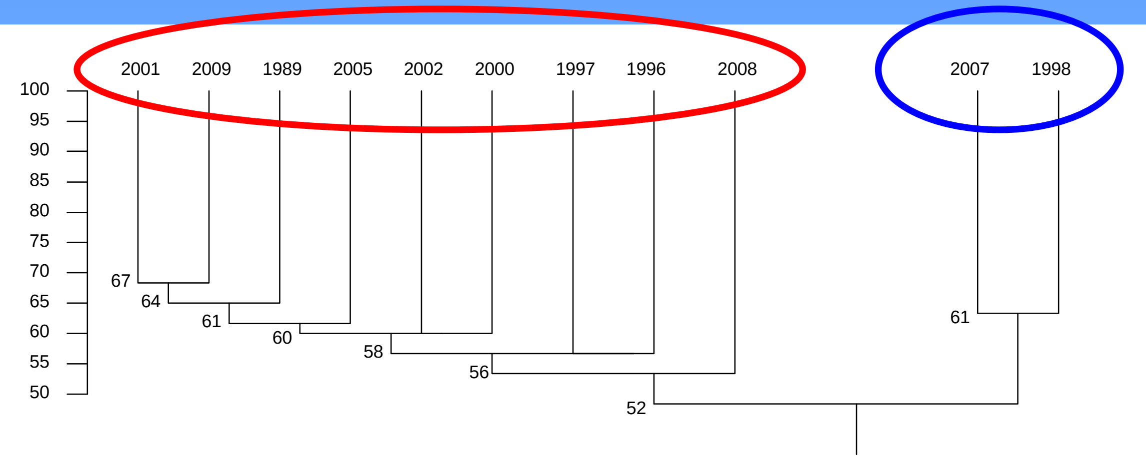
Similarity

Similarity of the bottom communities in different years is estimated using Bray-Curtis measure:

$$S_{jk} = 100 \frac{\sum_{i=1}^{N} 2 \cdot \min\left(y_{ij}, y_{ik}\right)}{\sum_{i=1}^{N} \left(y_{ij} + y_{ik}\right)} \%$$

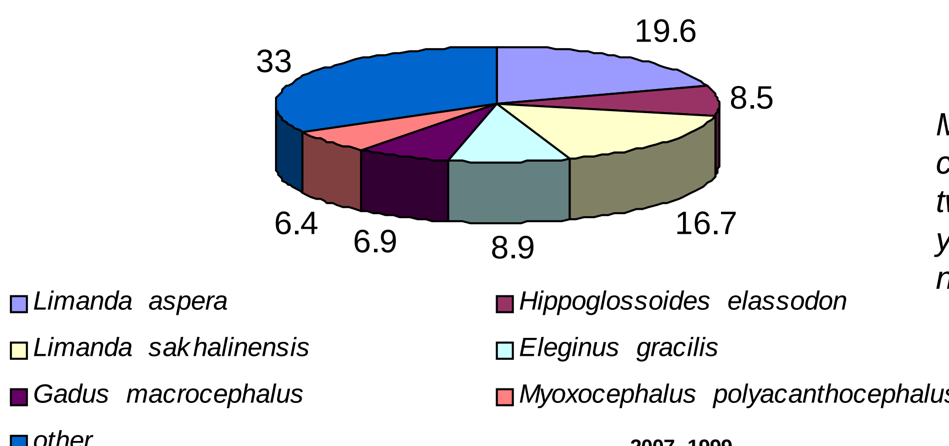
In the northern area, the species composition was rather stable, with a predominance of yellowfin sole.

However, saffron cod became abundant in some years, as 1998 and 2007



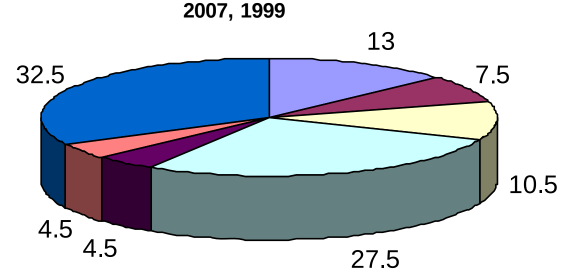
Dendrogram of the mass species composition similarity between different years

1989,1996,1997,1998, 2000, 2001, 2002, 2005, 2008, 2009



Mean species composition in two groups of years in the northern area

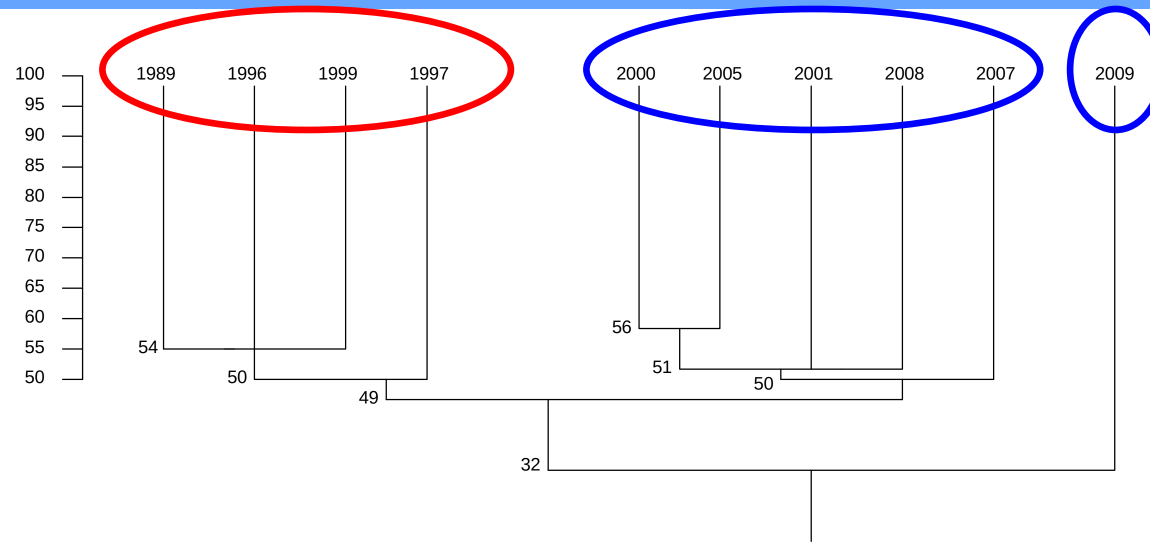
2007, 1999



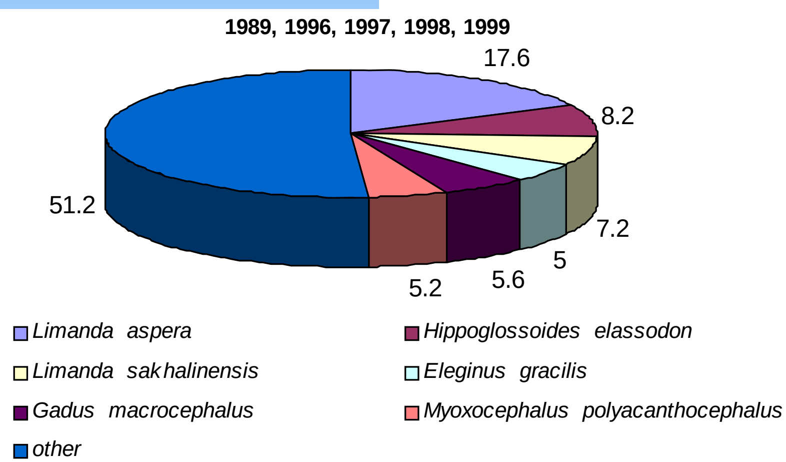
southern area

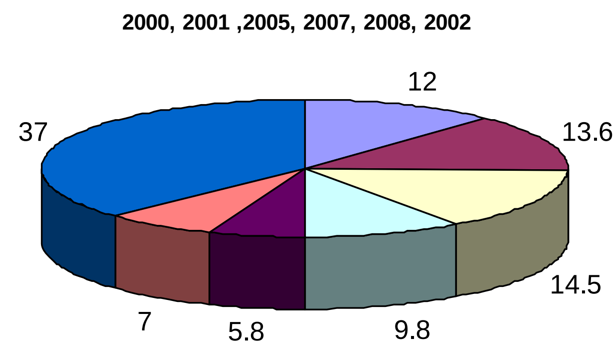
Similarity

In the southern area, the species composition changed significantly in the year 2000: yellowfin sole dominated in 1990s, but brown sole or flathead sole became dominant in 2000s. The year 2009 had unusual composition with minor species abundance, as poachers and sculpins



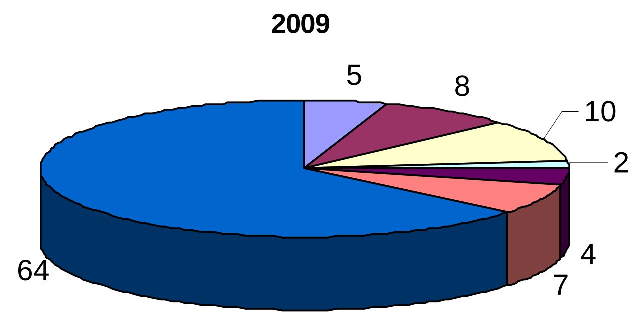
Dendrogram of the mass species composition similarity between different years





So, the bottom fish community in this area changes from the monodominant to polydominant one

Mean species composition in two groups of years in the northern area

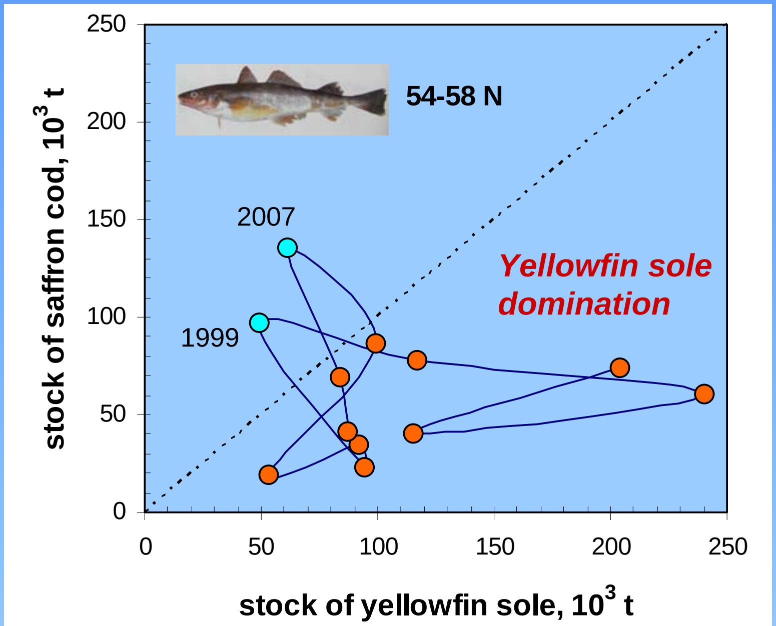


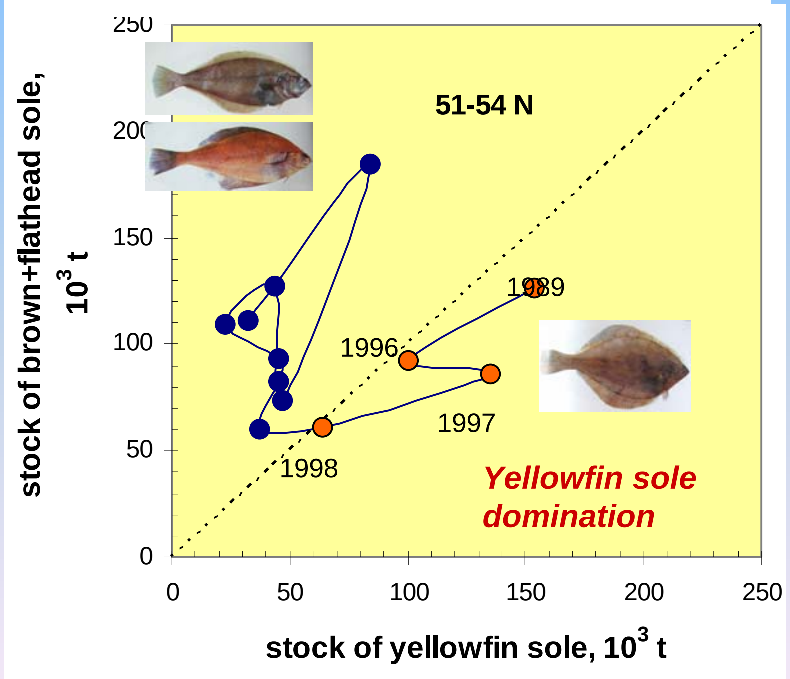
Species composition dynamics

The structure changes were caused mostly by the change of the ratio between the main species: yellowfin sole and saffron cod in the northern area and yellowfin sole and two other sole species in the northern area.

In the north, the yellowfin sole domination was broken in some years only and returned again.

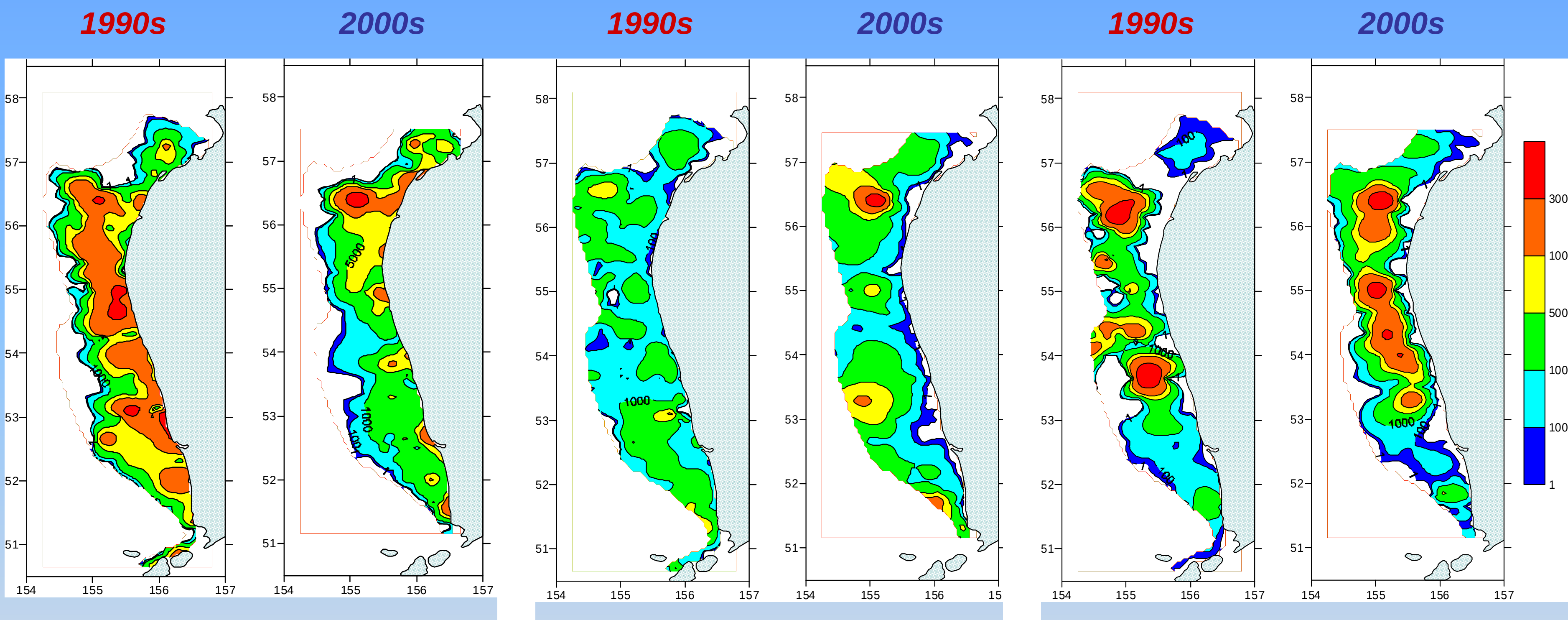
In the south, the yellowfin sole domination had stopped in the year 2000.





Year-to-year dynamics of the main species ratio

Distribution



Yellowfin sole *L. aspera*   Flathead sole *H. elassodon*   Brown sole *L. sakhalinensis*

Typical distribution density (kg/km^2) of mass bottom species in 1990s (1997) and 2000s (2007)

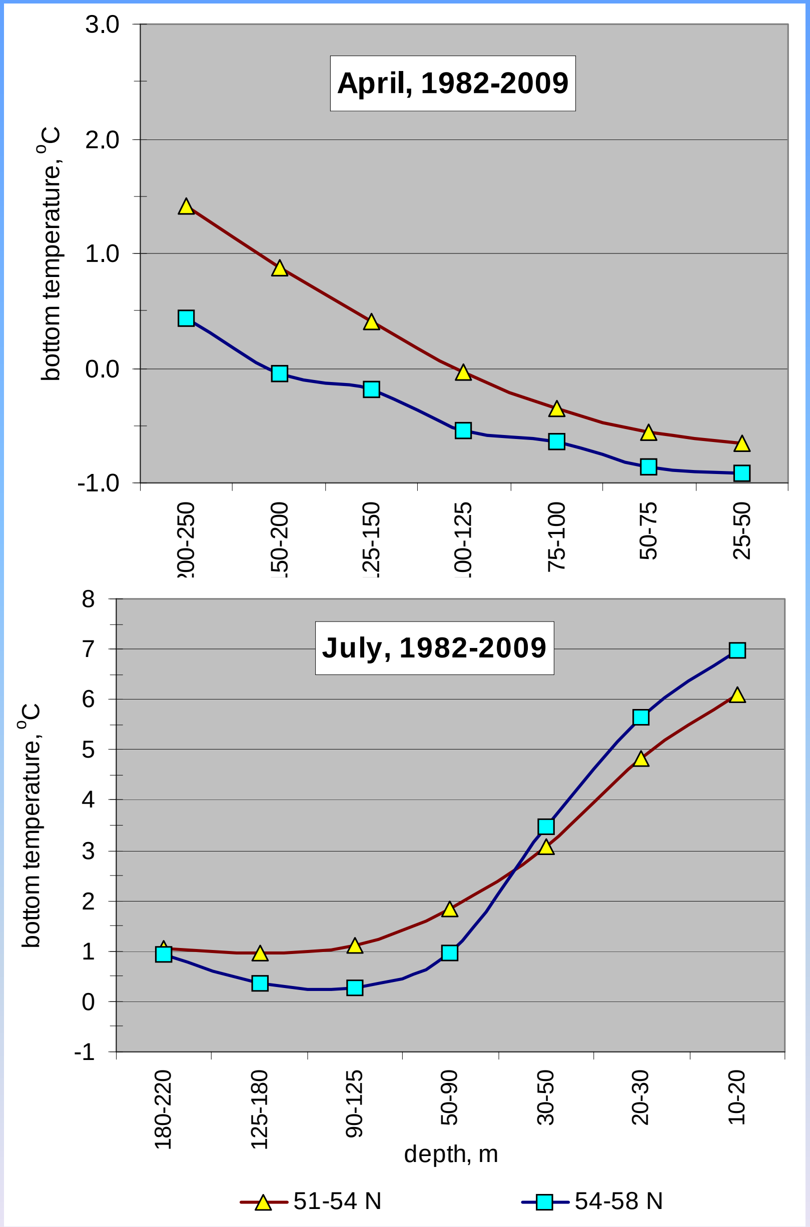
Correspondingly, distribution of the mass species was rather stable in the northern area but changed drastically in the southern area where abundance of the yellowfin sole decreased in 2000s.

Other mass species stocks were relatively stable but their relative abundance became higher because of the yellowfin sole decreasing

Water temperature

Water structure is similar in both areas of the shelf. The upper layer, about 50 m, is extremely cold in winter and spring and rather warm in summer. The deeper layer has approximately stable temperature about +1ºC all the year round.

Yellowfin sole and saffron cod dwell mainly in the upper layer, but brown and flathead soles – in the deeper layer.

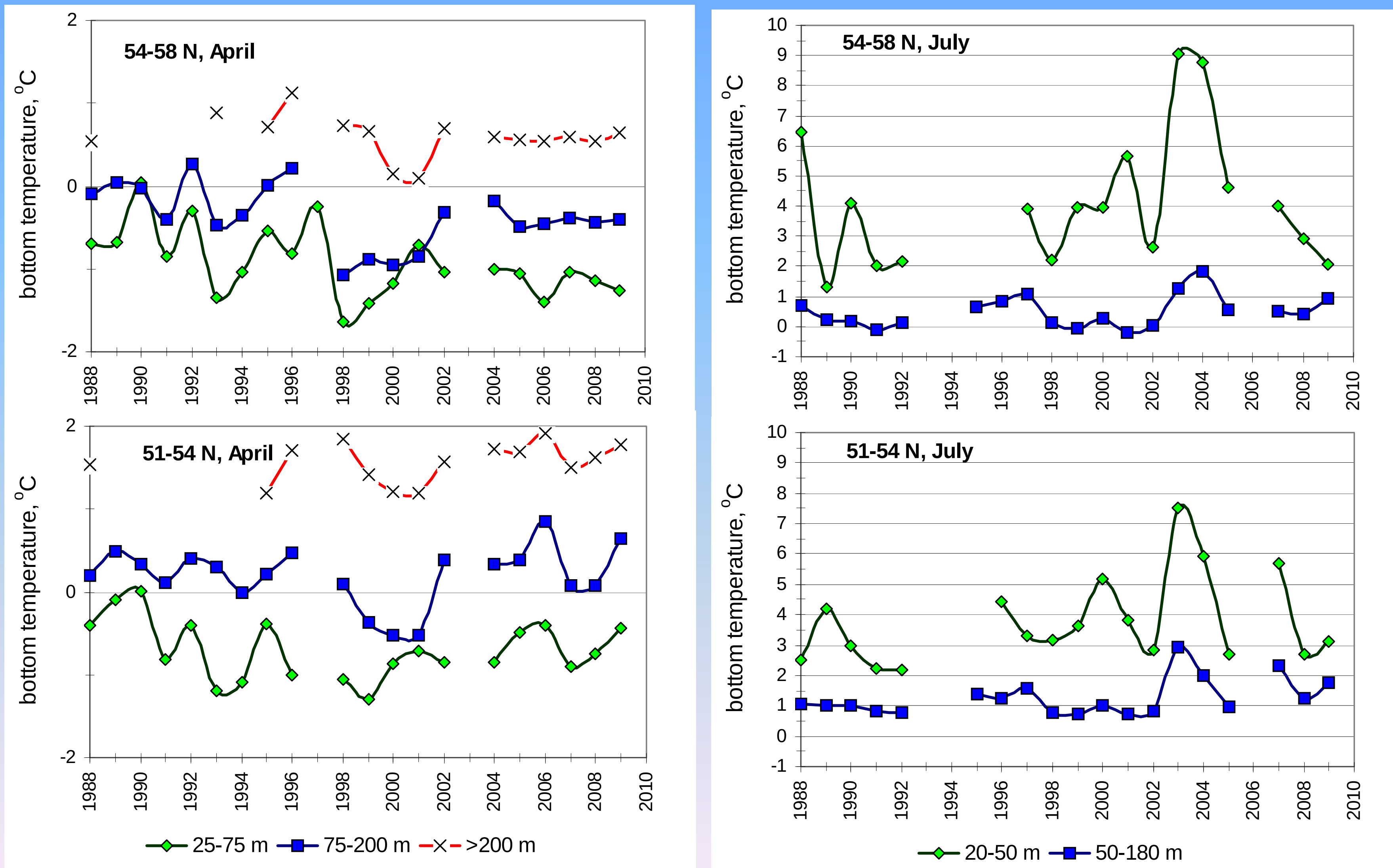


Mean profiles of water temperature at the sea bottom in the northern and southern areas of West Kamchatka shelf

Water temperature

Temperature in the deep layer has no prominent year-to-year changes.

On the contrary, the bottom temperature in the upper layer is very variable, both in spring and summer, with a prominent lowering in the early 1990s.

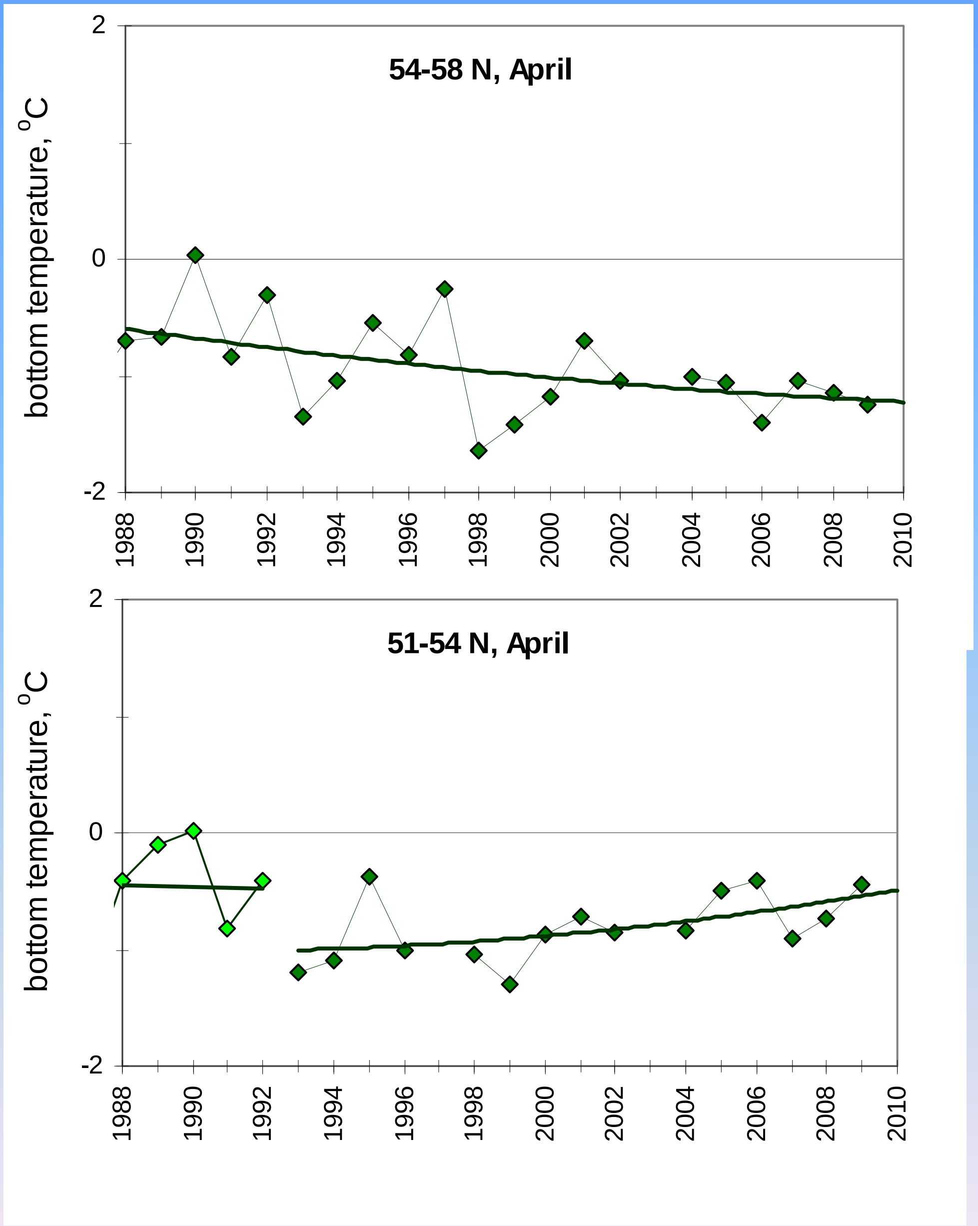


Year-to-year change of the bottom temperature averaged for certain depth intervals in the shelf of West Kamchatka

Water temperature

In the northern area, a permanent tendency to lowering is observed in the last 2 decades, with several extremely cold years.

In the southern area, the downward shift in 1992-1993 was replaced by slowly heightening of the bottom temperature.



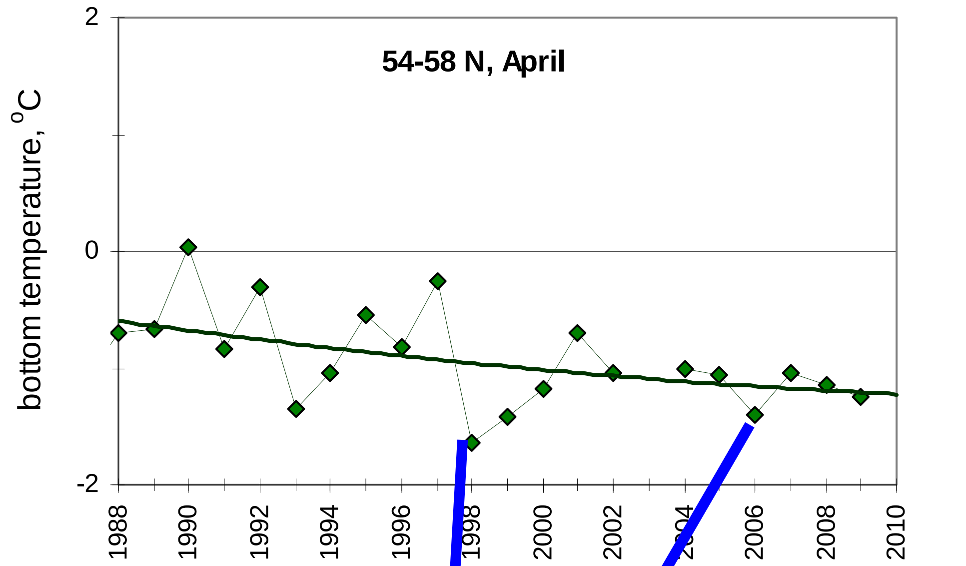
Year-to-year change of the bottom temperature at the depth 25-75 m on the shelf of West Kamchatka in April

Water temperature

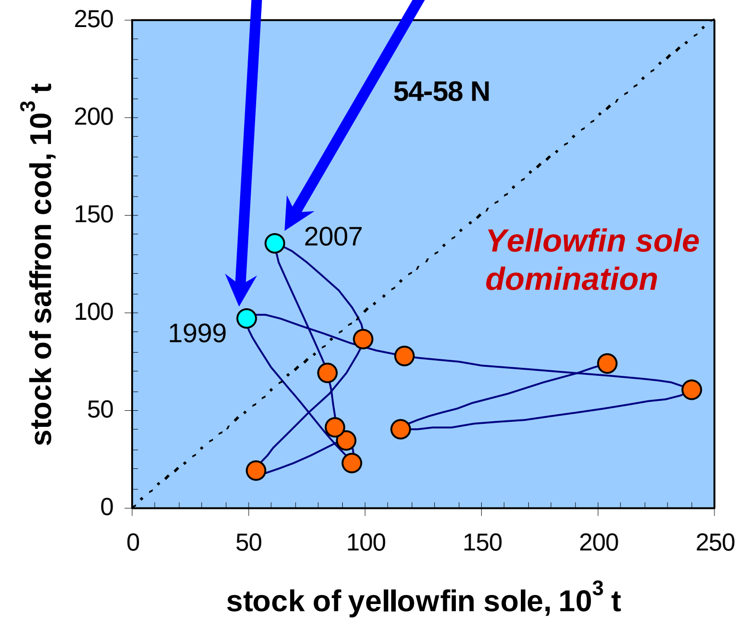
In the northern area, both cases of the high abundance of saffron cod happened in the next years after the temperature minimums.

Age of the saffron cod in trawl catches is predominantly 1+. So, its abundant generations were born in the coldest winters. This dependence is known for the Japan Sea, as well, where it is accounted for later spawning that provides the larvae hatchering in better feeding conditions during spring bloom of zooplankton. Possibly, this mechanism works here, too.

Obviously, gradual cooling was unfavorable for yellowfin sole but it didn’t cause the growth of other populations, except of some years, in the northern area.



Year-to-year change of the bottom temperature at the depth 25-75 m on the shelf of West Kamchatka in April



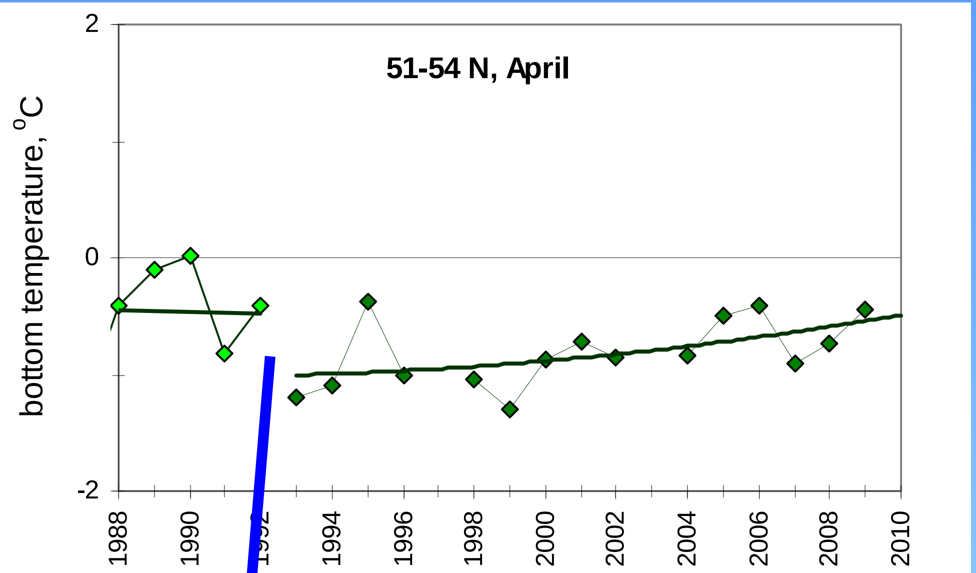
Year-to-year dynamics of the ratio between yellowfin sole and saffron cod in the northern shelf of West Kamchatka

Water temperature

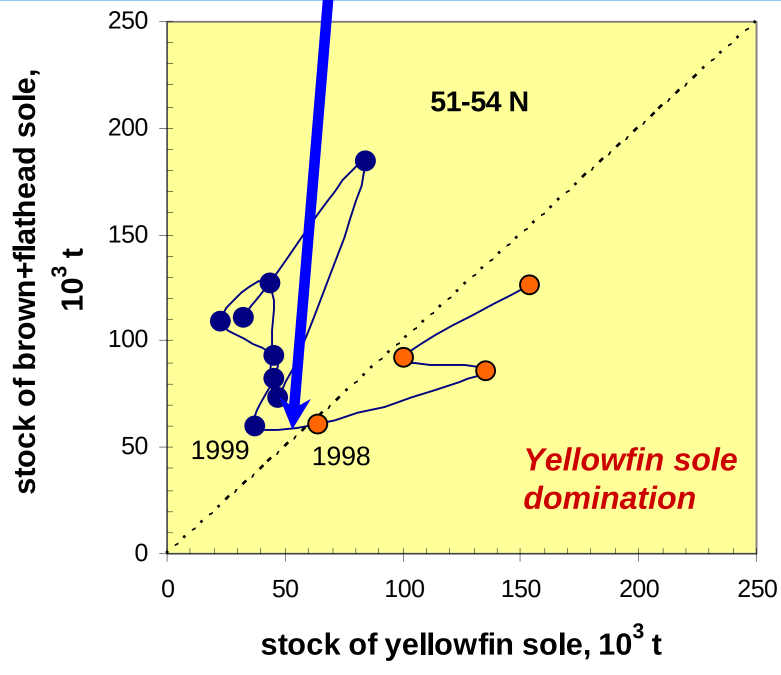
In the southern area, the temperature shift occurred in 6-7 years before the change of the bottom community structure. This time corresponds to the age of the highest biomass for flounders.

The decreasing of the yellowfin sole stock in the late 1990s was possibly caused by worsening the conditions for its reproduction in 1992-1993, because this species spawns in spring in the upper layer, so higher temperature is favorable for its larvae survival.

Other sole species had no any prominent changes of their stocks because of relatively stable conditions in the deeper layer.



Year-to-year change of the bottom temperature at the depth 25-75 m on the shelf of West Kamchatka in April



Conclusions

1. Bottom fish community on the shelf of south-west Kamchatka had a reconstruction in the late 1990s when the community with domination of yellowfin sole was replaced by polydominant community of flounders.

2. Bottom fish community on the shelf of north-west Kamchatka was rather stable in the last two decades, with domination of yellowfin sole, but abundance of saffron cod increased significantly after the coldest winters

3. The reconstruction of bottom community in the late 1990s was caused by shift to cooling of bottom water in the upper part of the shelf in 1993