Coastal submesoscale circulation and thermal limits determine home migration of chum salmon

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Effects of Sea Temperature

- Offshore sea is most productive environment
- Primary control on salmon distribution is temperature
- Salmon show sharp thermal limits *(which appear to be the result of reducing their metabolic rates in time of low food abundance)*
- All salmon show extremely sharp declines in abundance with temperature
- *(Welch, Ishida, Chigirinsky, 1995, 1997)*

outline

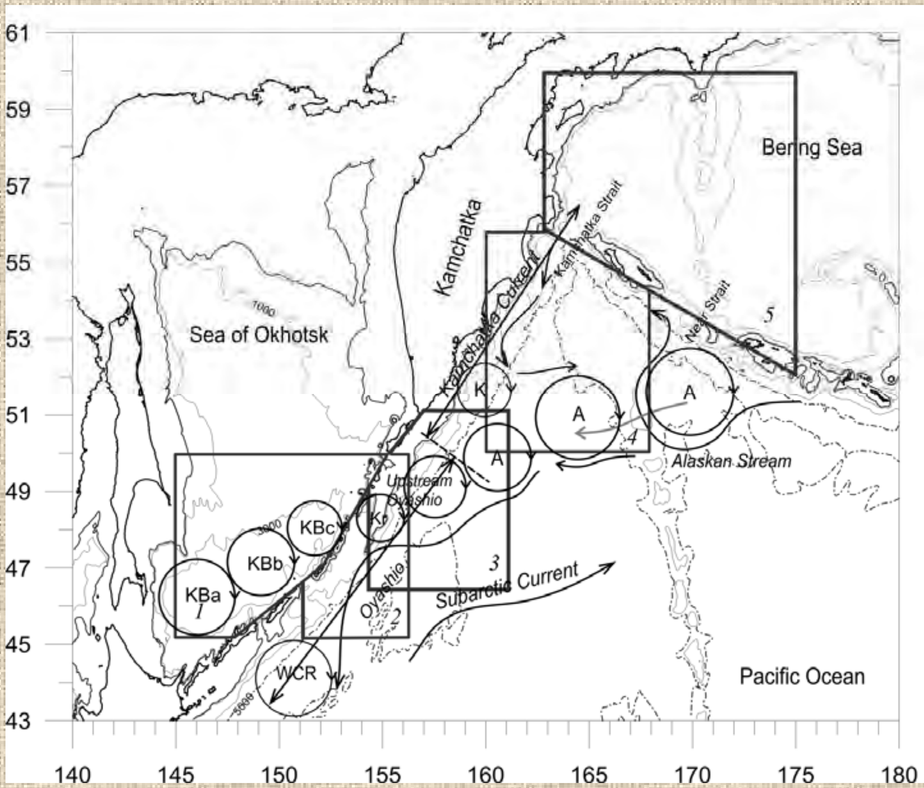
- Sharp thermal boundaries limit the distribution of salmon species in the Pacific Ocean and adjacent seas
- Warming can shift the position of the thermal limits

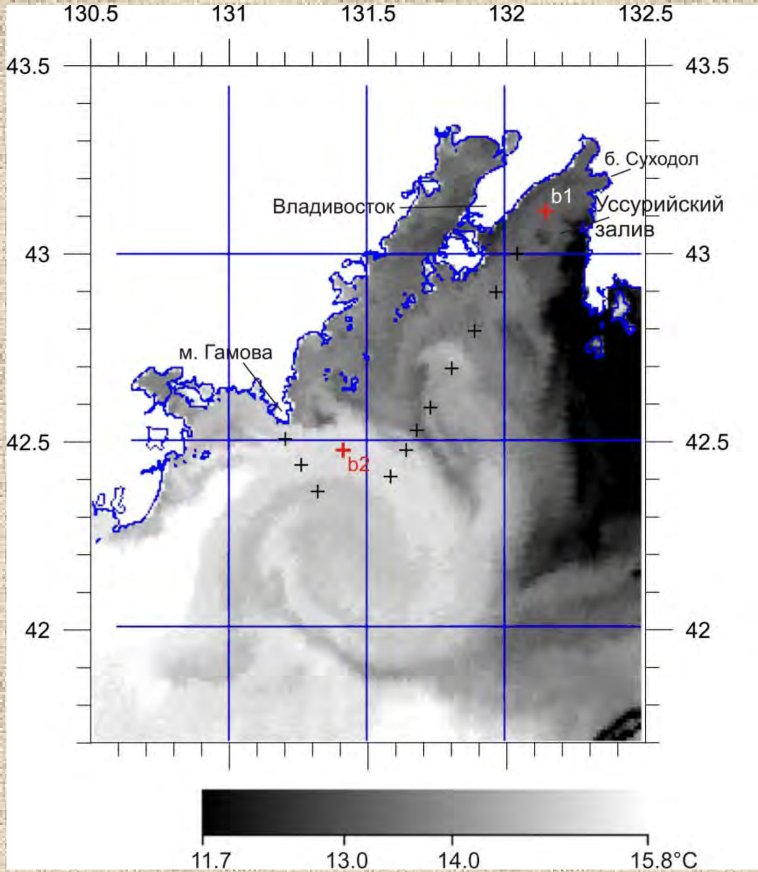
- vast regions of the Oyashio and Bering Seas exhibit a warming trend. This rate of warming is much faster than that of the Global Ocean and the Okhotsk Sea.

Thermal barriers

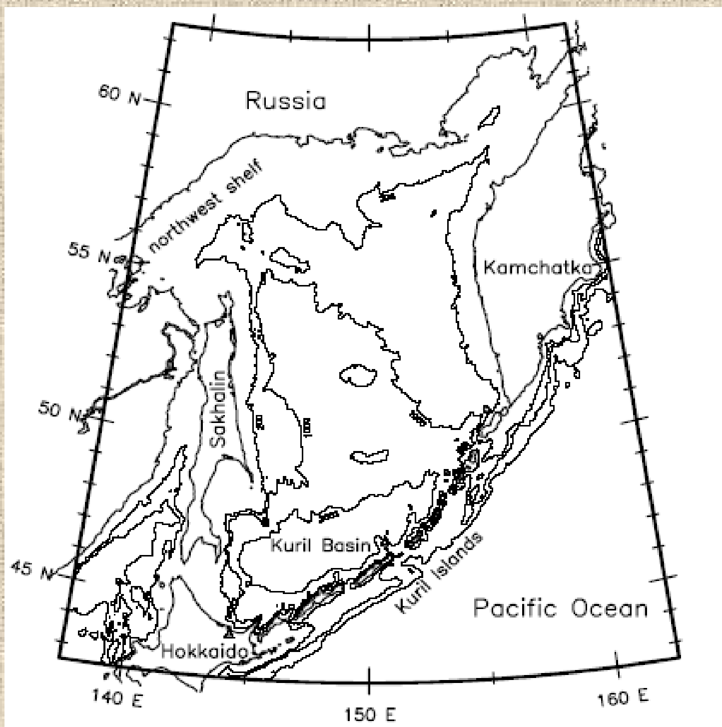
- Sharp step-function response to temperature in the ocean *(Welch, Chigirinsky, Ishida,1995)*
- The critical temperature defining the southern boundary for chum and pink salmon is 10.4°C
- Thermal barriers form an effective limit to the offshore distribution of salmon and can limit their distribution to a relatively small are of the Subarctic Pacific

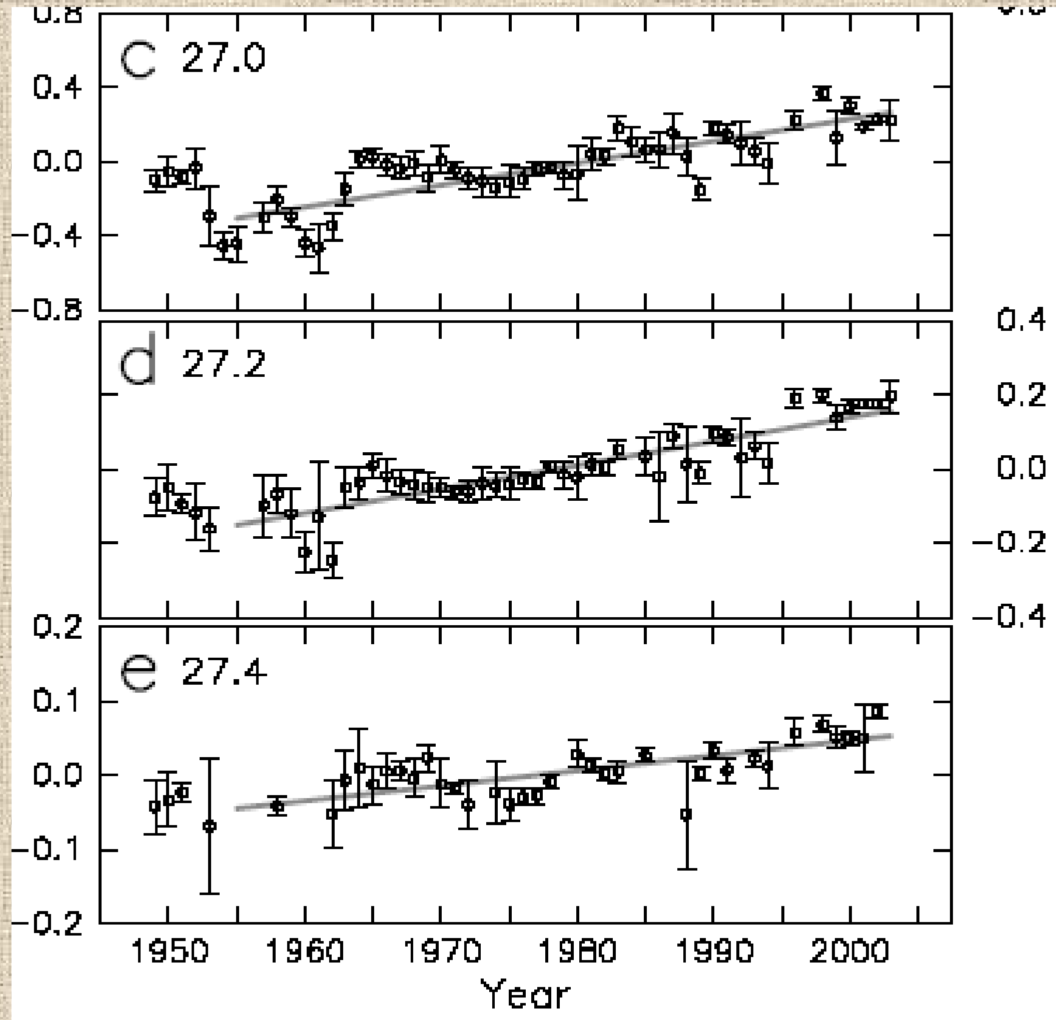
Region of study



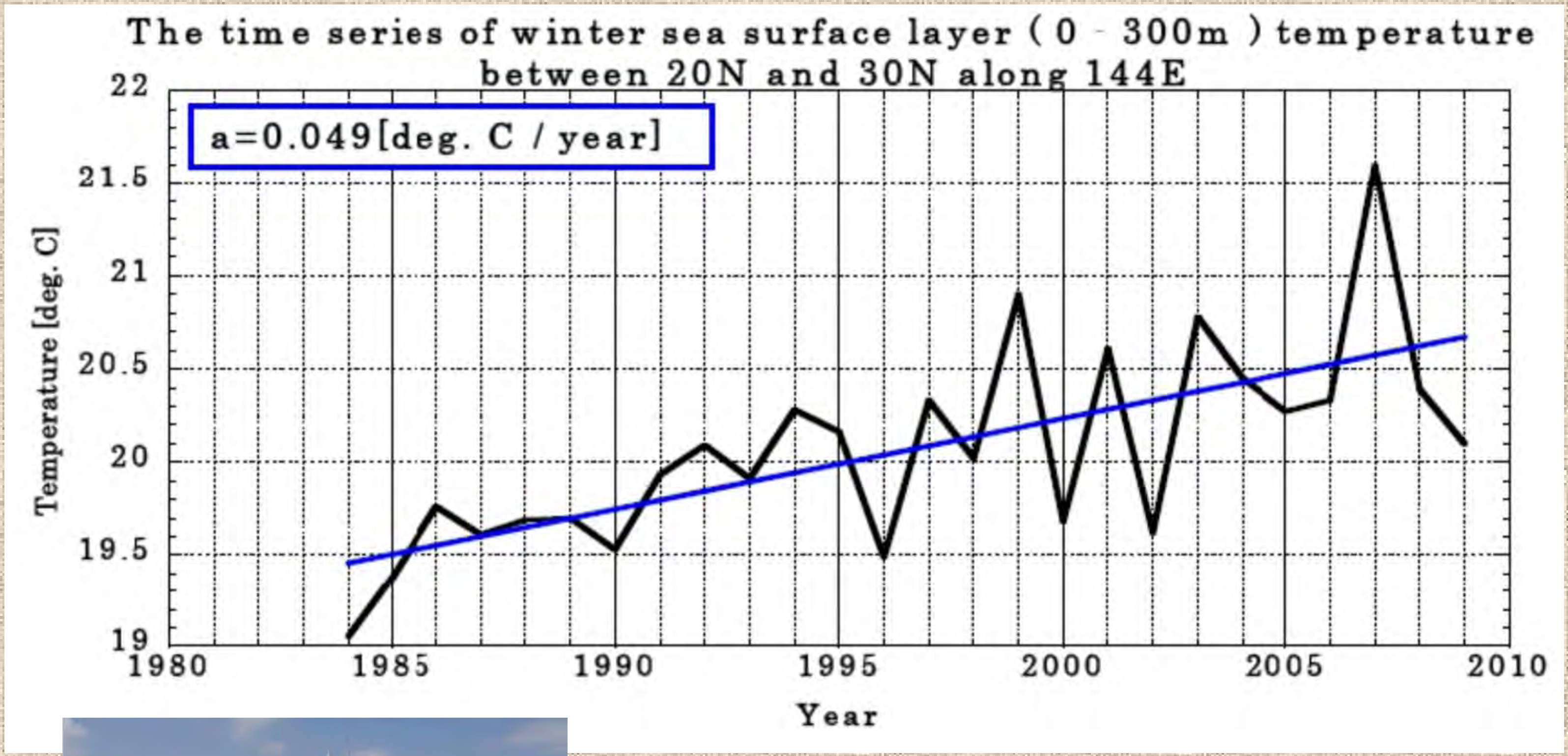


OSIW exhibits a warming trend Warming of Intermediate Water in the Sea of Okhotsk since the 1950s *(M. Itoh)*





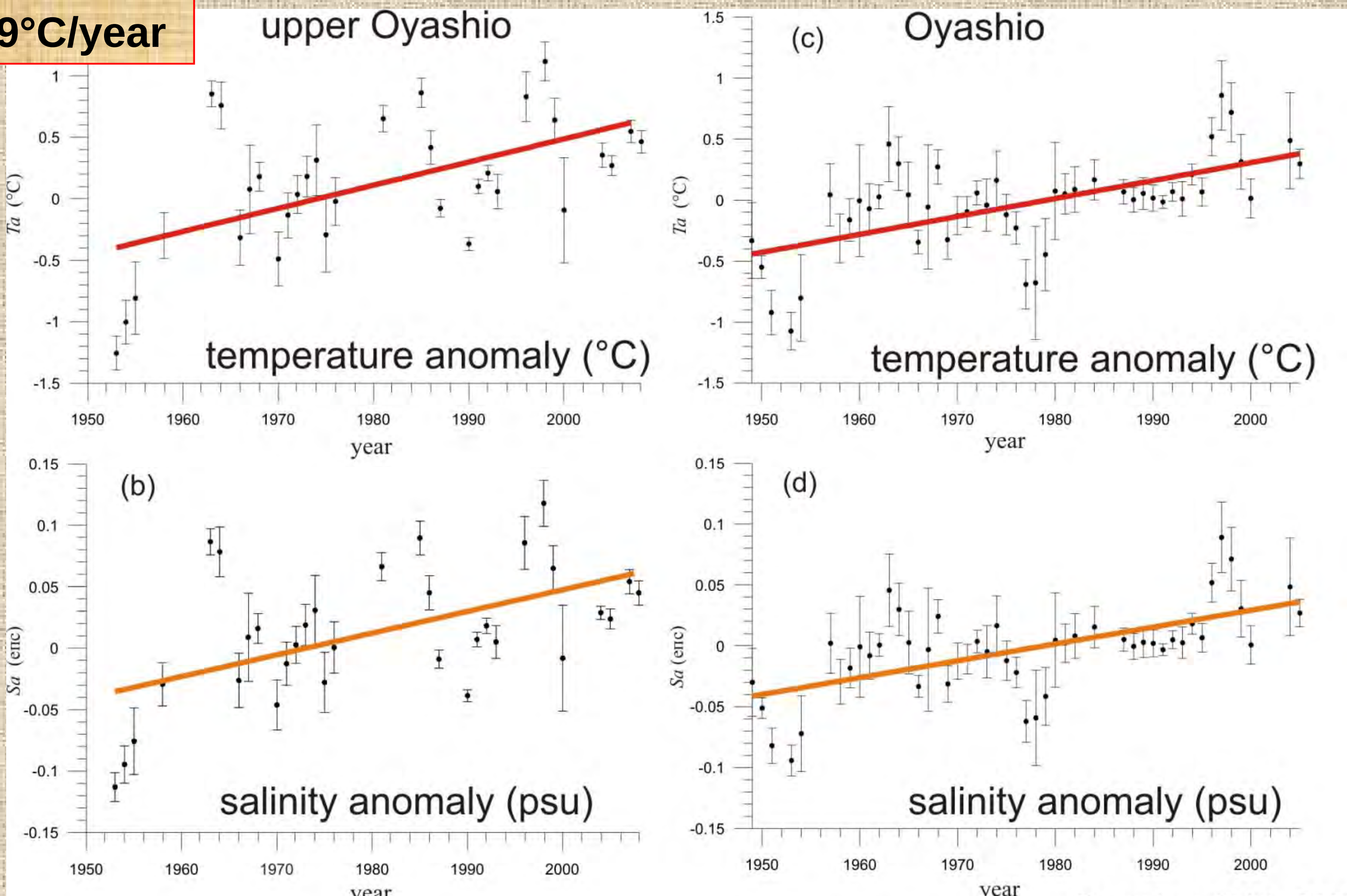
Subtropical Pacific upper layer temperature ascends at a rate 0.049°C per year



Hattori, 2009

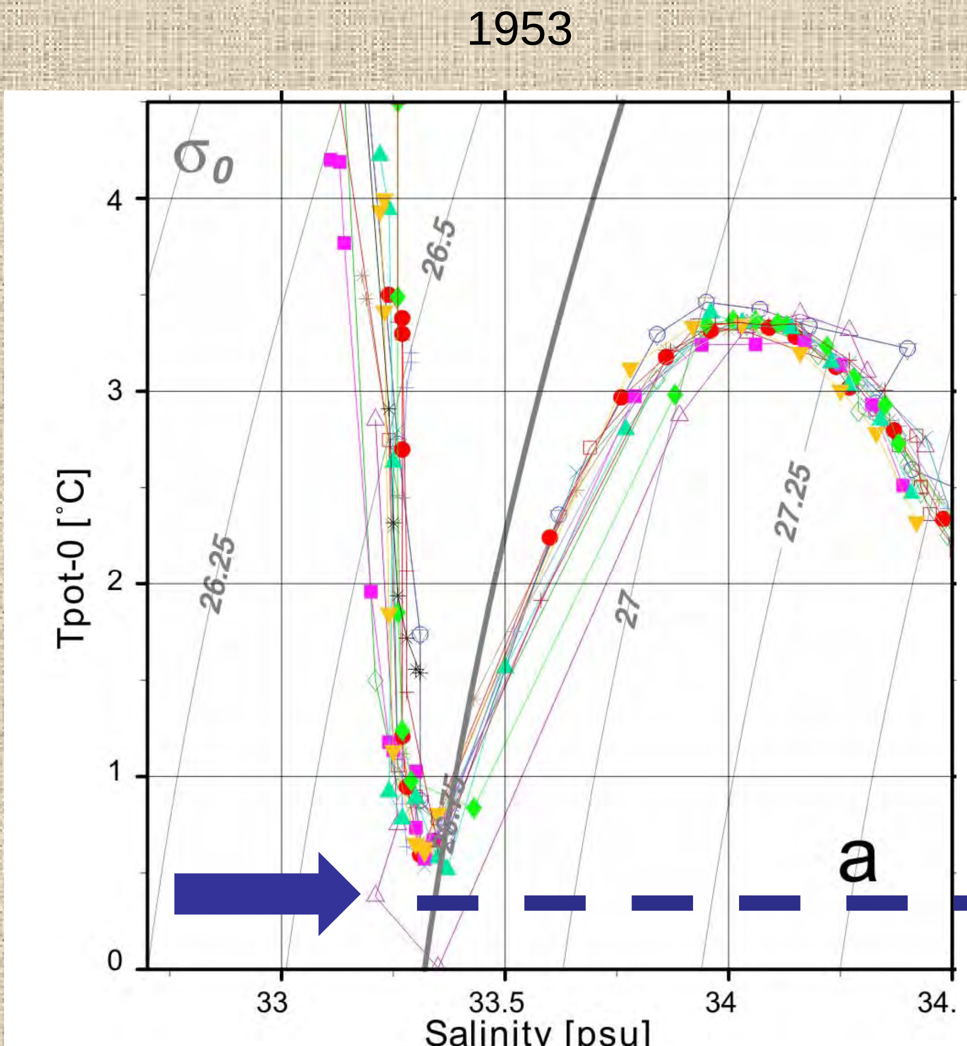
Mid-depth warming and increase of salinity in the Kamchatka Current and Upstream Oyashio

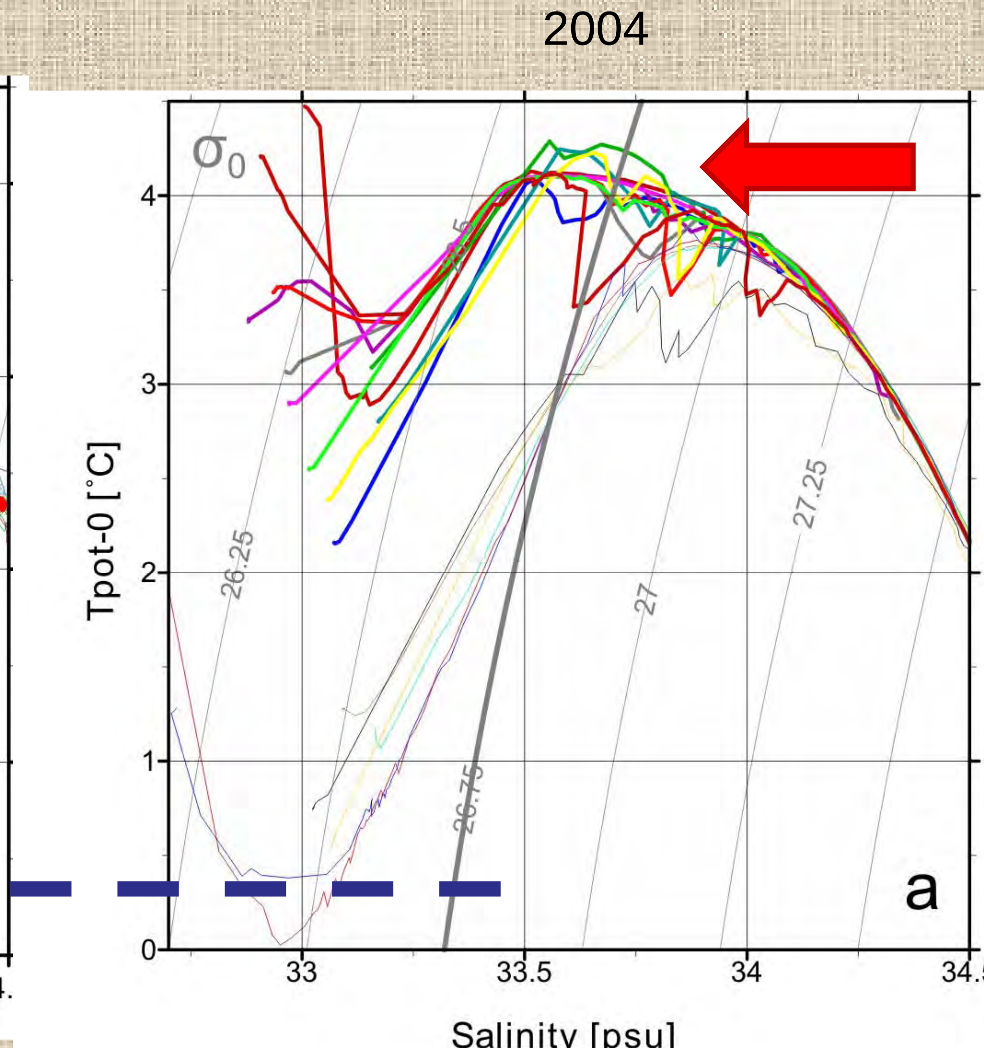
ΔT=0.019°C/year



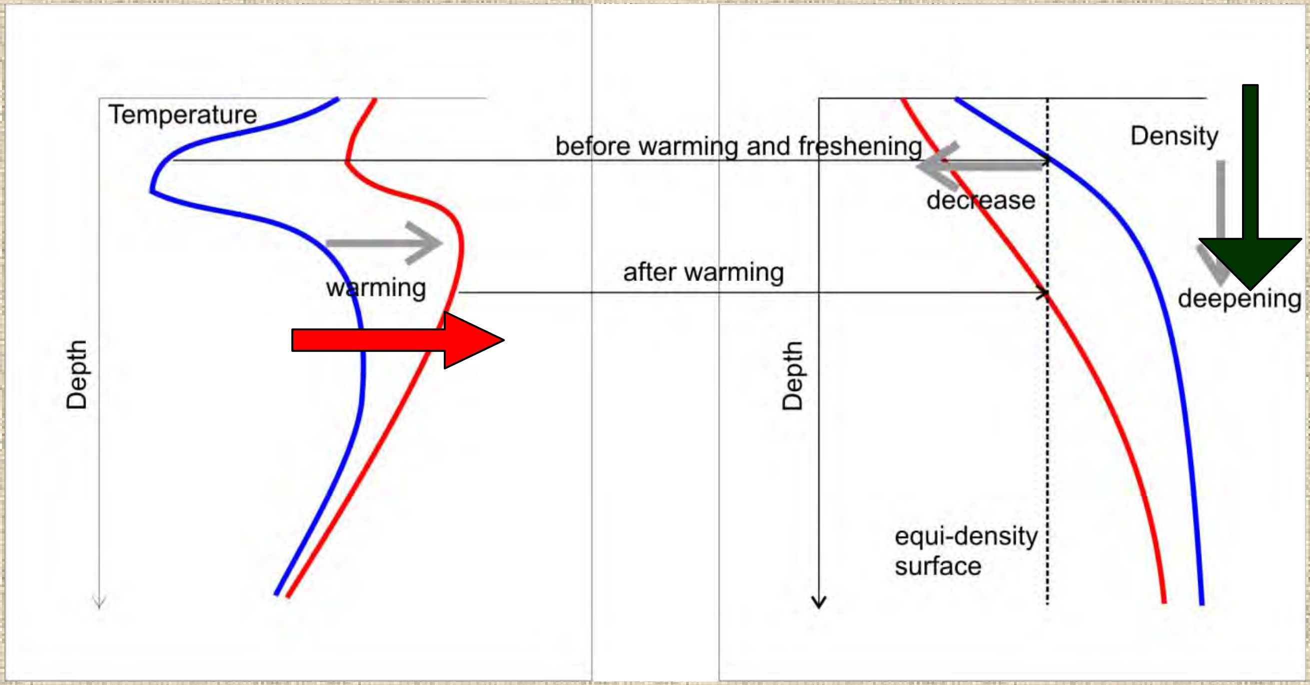
Rogachev, Shlyk, 2009

Warming in the Kamchatka Current since 1950s

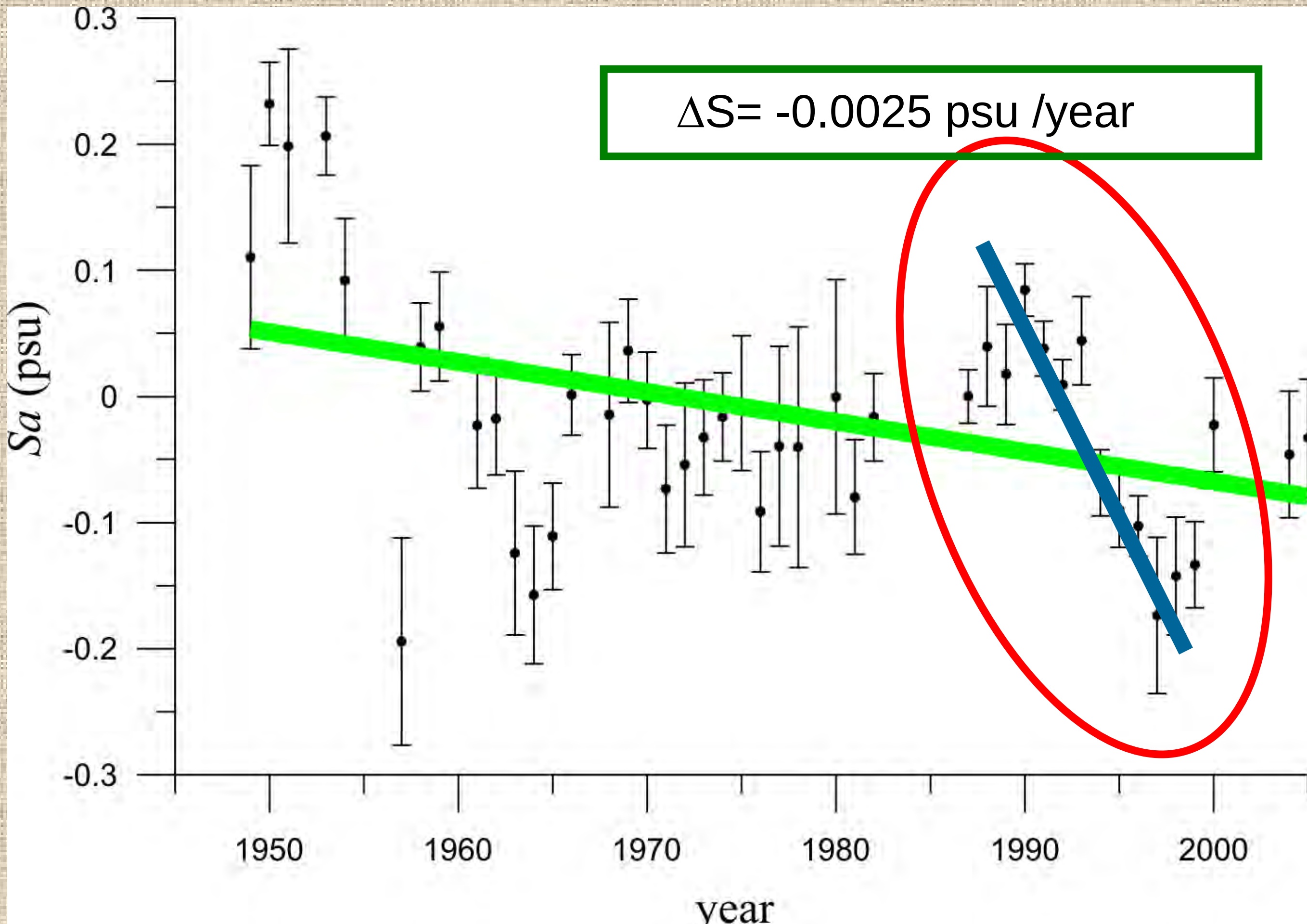




The cause of intermediate layer warming is deepening of isopycnals



Surface freshening in the Kamchatka Current and Upstream Oyashio was much faster during thermohaline transition (1989-1997)



Warming in the Pacific subarctic

- Kamchatka Current and Oyashio intermediate water exhibits a warming trend since 1950s.

- Kamchatka Current and Oyashio warming is likely linked to the penetration of warm water westward by the Alaskan Stream and its Aleutian eddies.

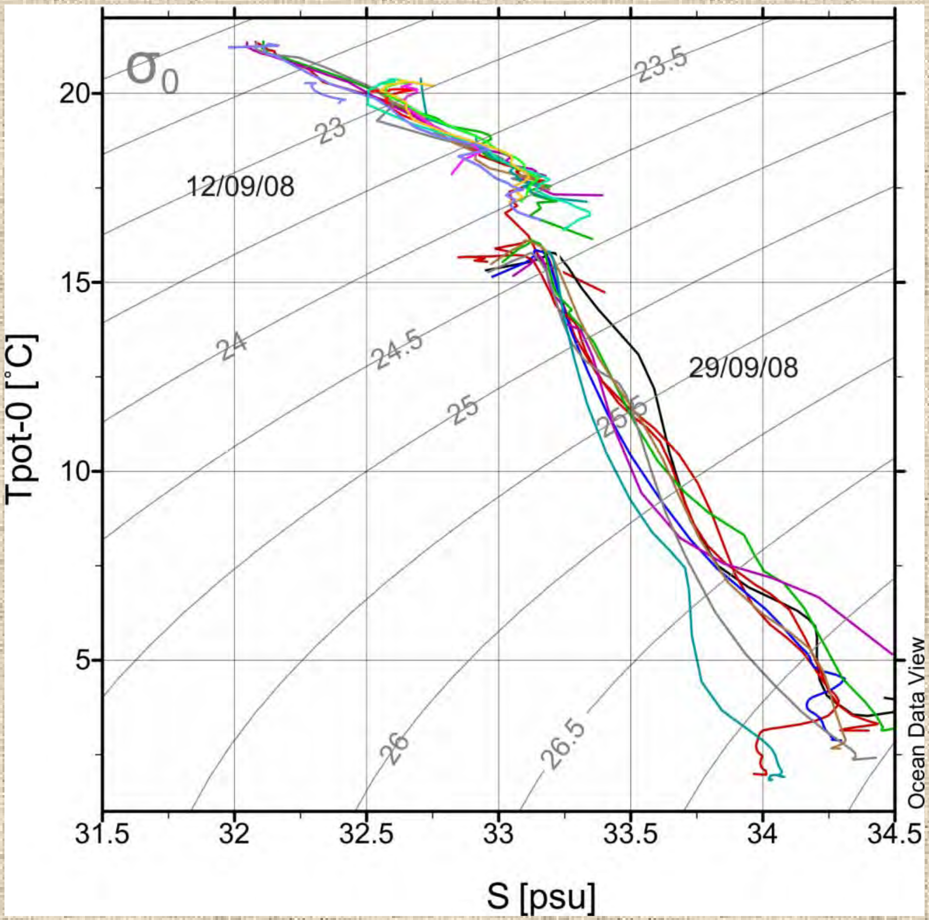
Significant salinity change

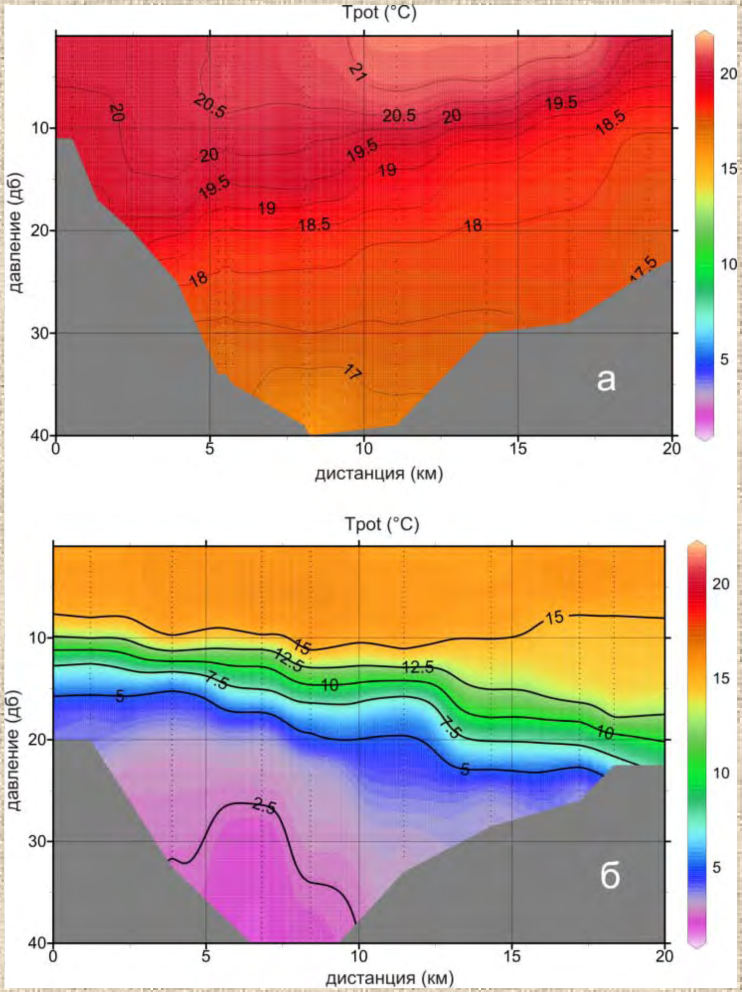
- Significant salinity changes are found in all ocean domains of the Pacific western subarctic

- Water mass formed in subtropics have become saltier and formed locally (of excess precipitation) have become fresher. This implies, that salinity changes are due to a strengthening of the hydrological cycle

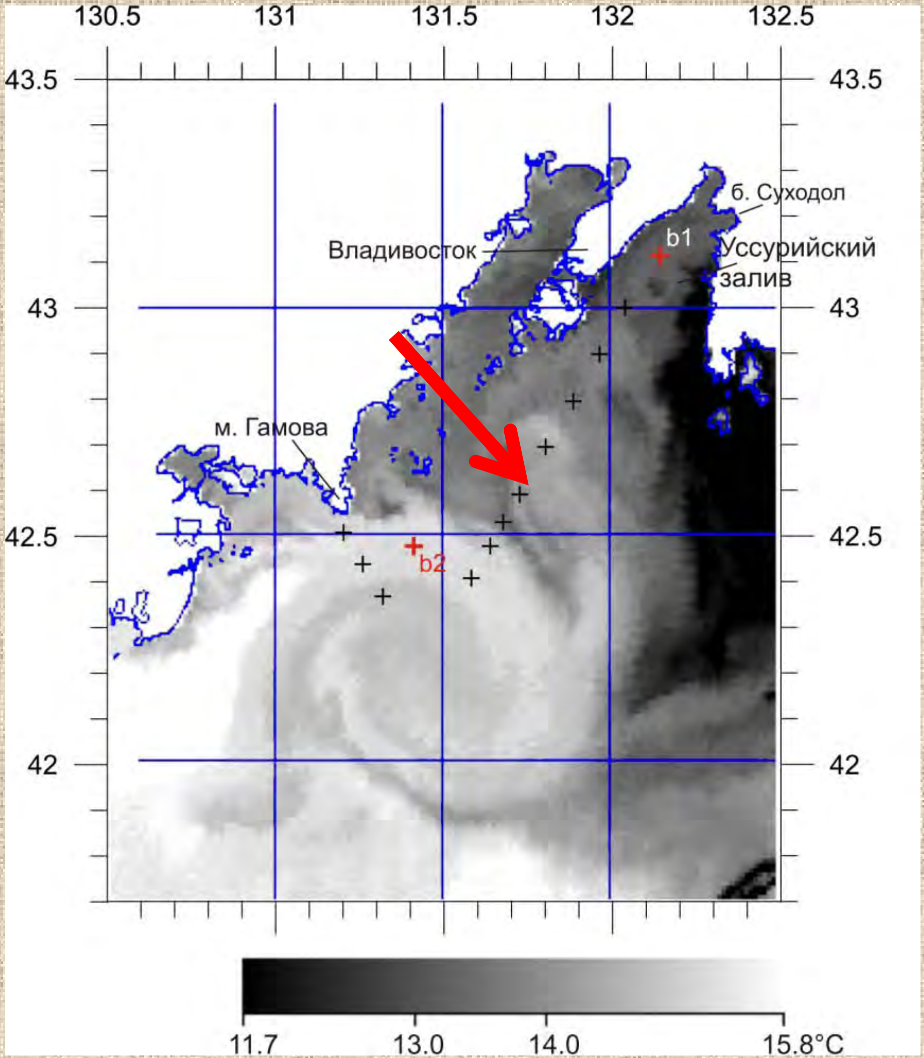
- The cause of intermediate layer warming and salinity changes are driven by isopycnal deepening

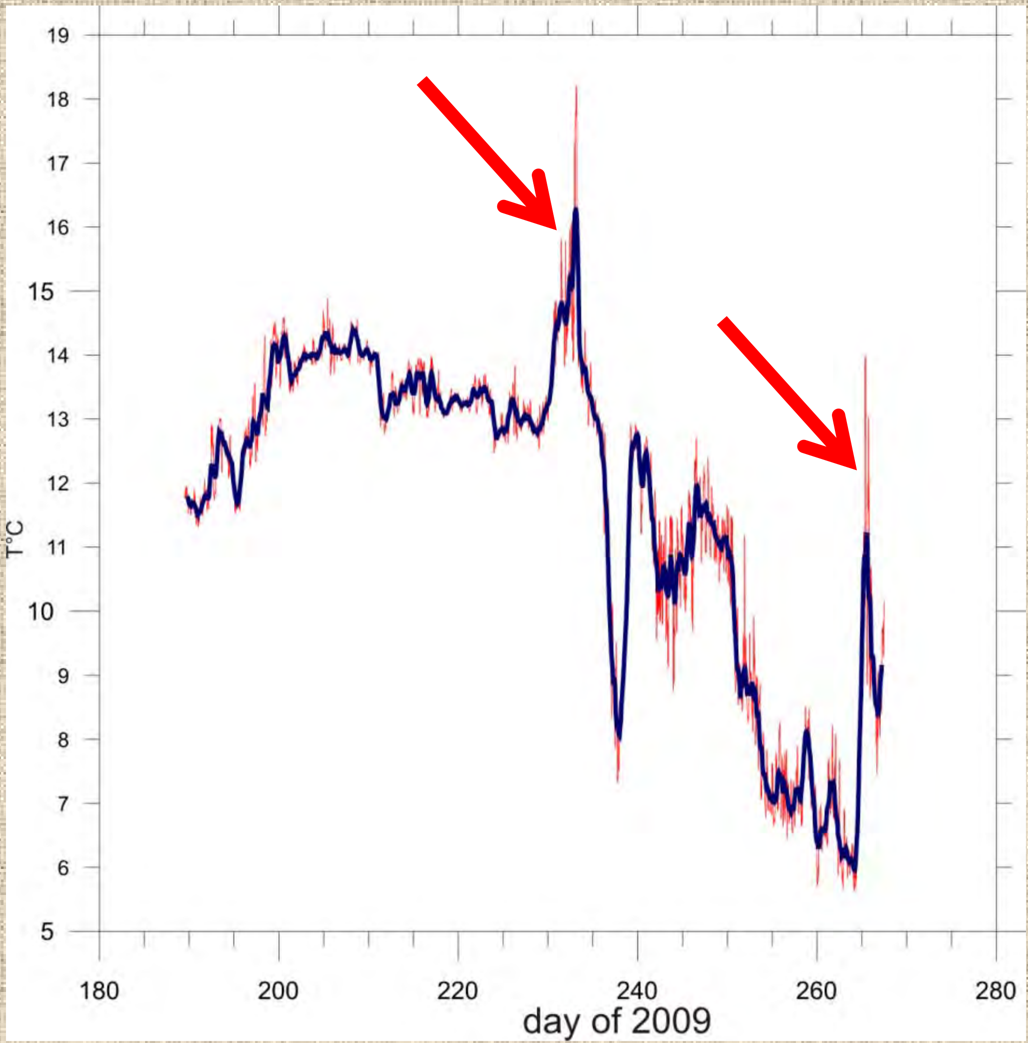
Properties of submesoscale streamer





Rapid water exchange with the slope water due to penetration of streamers





Submesoscale streamers determine high temperature during home mugration of chum salmon

- Mesoscale eddies and associated submesoscale streamers are important features of the region. We show that significant warming is established due to penetration of these warm submesoscale streamers. These events establish the advection of warm water from the deep sea and determine the thermal limits for species in shallow coastal area.
- Rapid water exchange with the slope region determines water properties and unfavorable regime for spawning migration of chum salmon to freshwater.

Acknowledgements

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