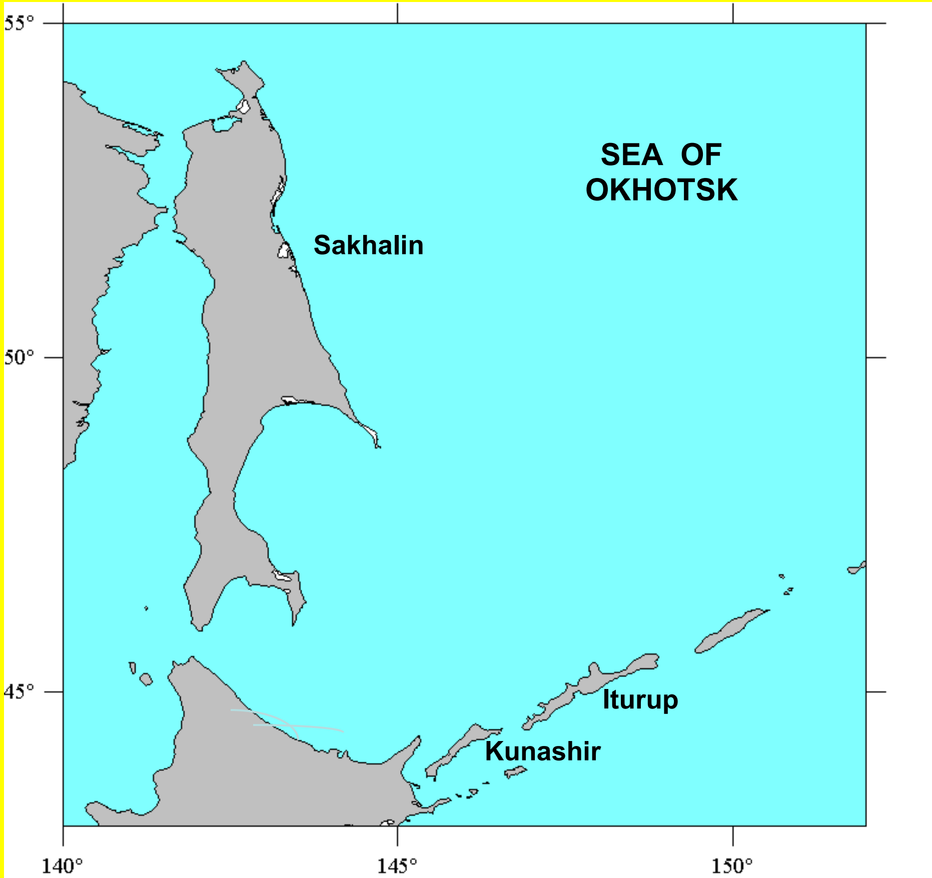
Alexander M. Kaev
(Research Institute of Advanced Development, Sakhalin State University)

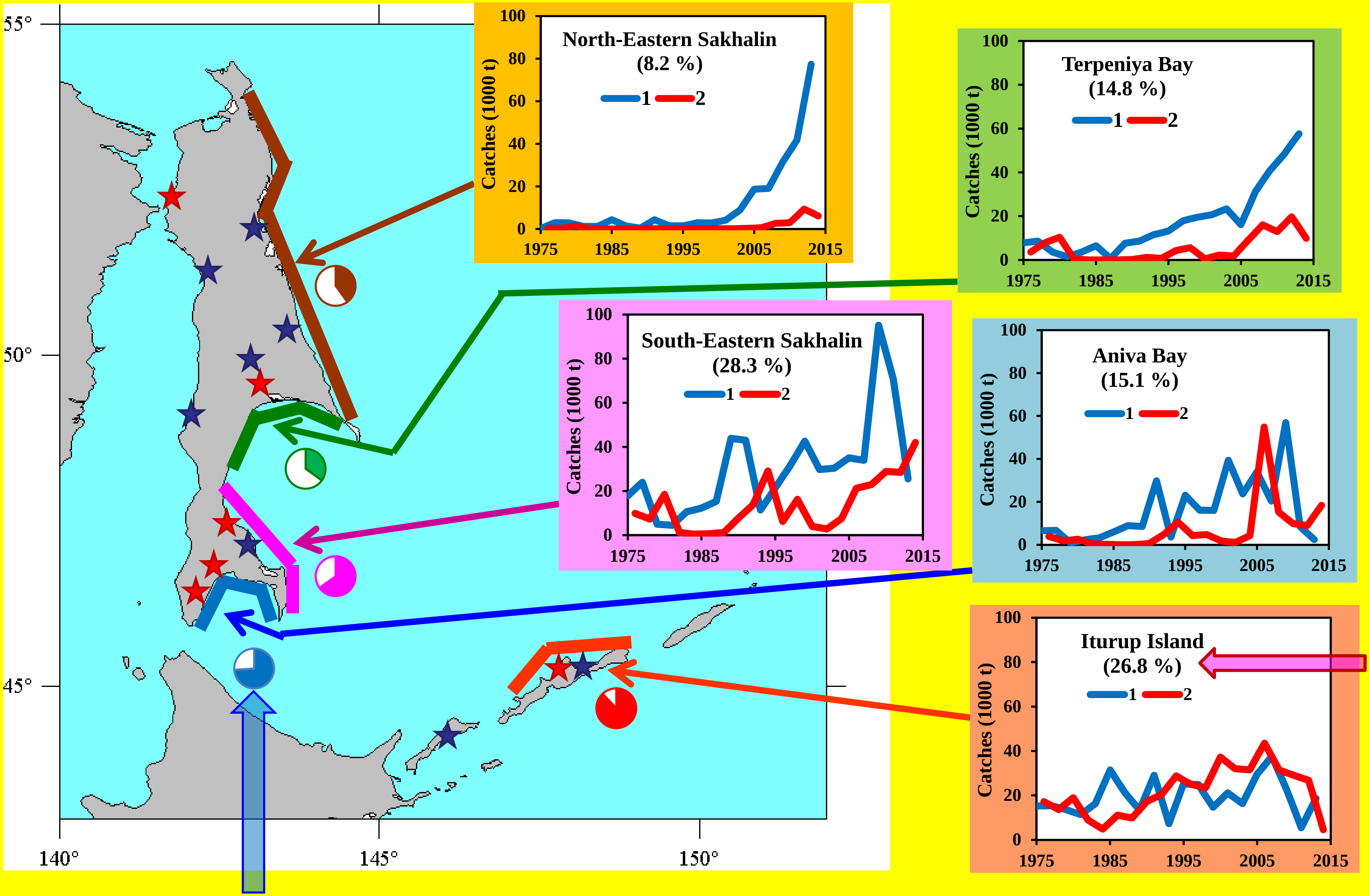
Status of pink salmon in the Sakhalin-Kuril region in a long-term aspect



Pink salmon catch in 2001–2014 46,242 to 255,644 t (averaged 123,261 t)

Sakhalin-Kuril region possesses a very large pink salmon stock on the Asian coast of North Pacific that is confirmed by their annual catches.

Pink salmon catch dynamics in the basic fishery regions:
1 – odd years, 2 – even years



[Explanation of the previous slide]

This slide shows dynamics of pink salmon catches in the main fishery regions.

On Iturup Island, we observed a change in dominant lines, and in the rest regions a generative line of the odd years dominates.

Percentage contributions of fishery regions by catches are given in brackets.

You can see that pink catches are greater in the southern areas where almost all hatcheries are concentrated.

However, in recent years the increase in pink catches was higher in the northern areas.

But we have no opportunity to compare characteristics of pink salmon reproduction all over these areas in more detail because of the lack of data.

Color segments on circles show proportions of spawning areas in the monitored rivers of the total number of pink salmon spawning areas in rivers for each region.

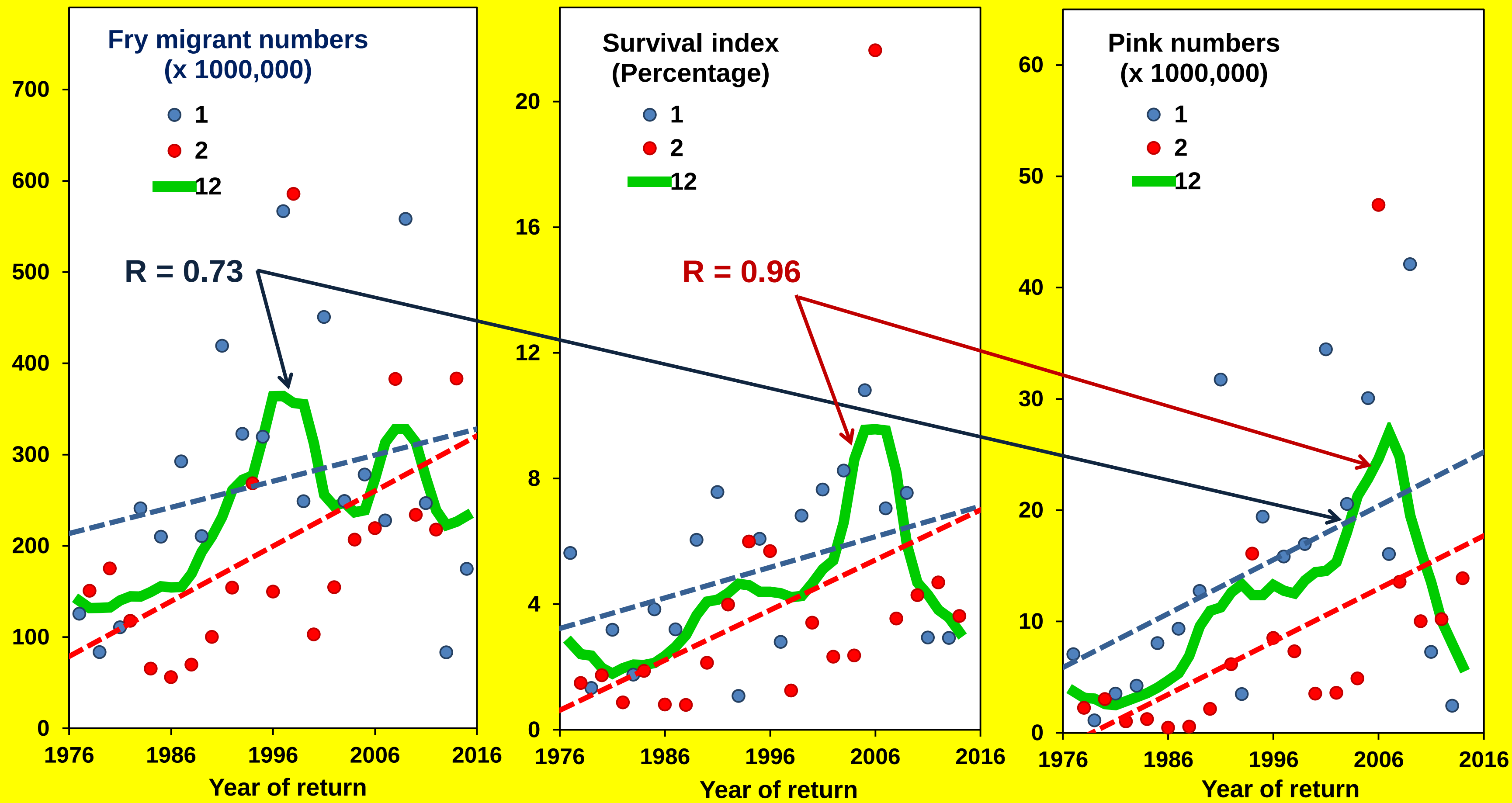
As we see, northern areas are poor for the lack of research stations as well.

Asterisks indicate research stations for annual studying pink fry migrants in the monitored rivers. Blue-colored stations have been closed in the recent years.

We can see that in northern areas these proportions compose less than a half.

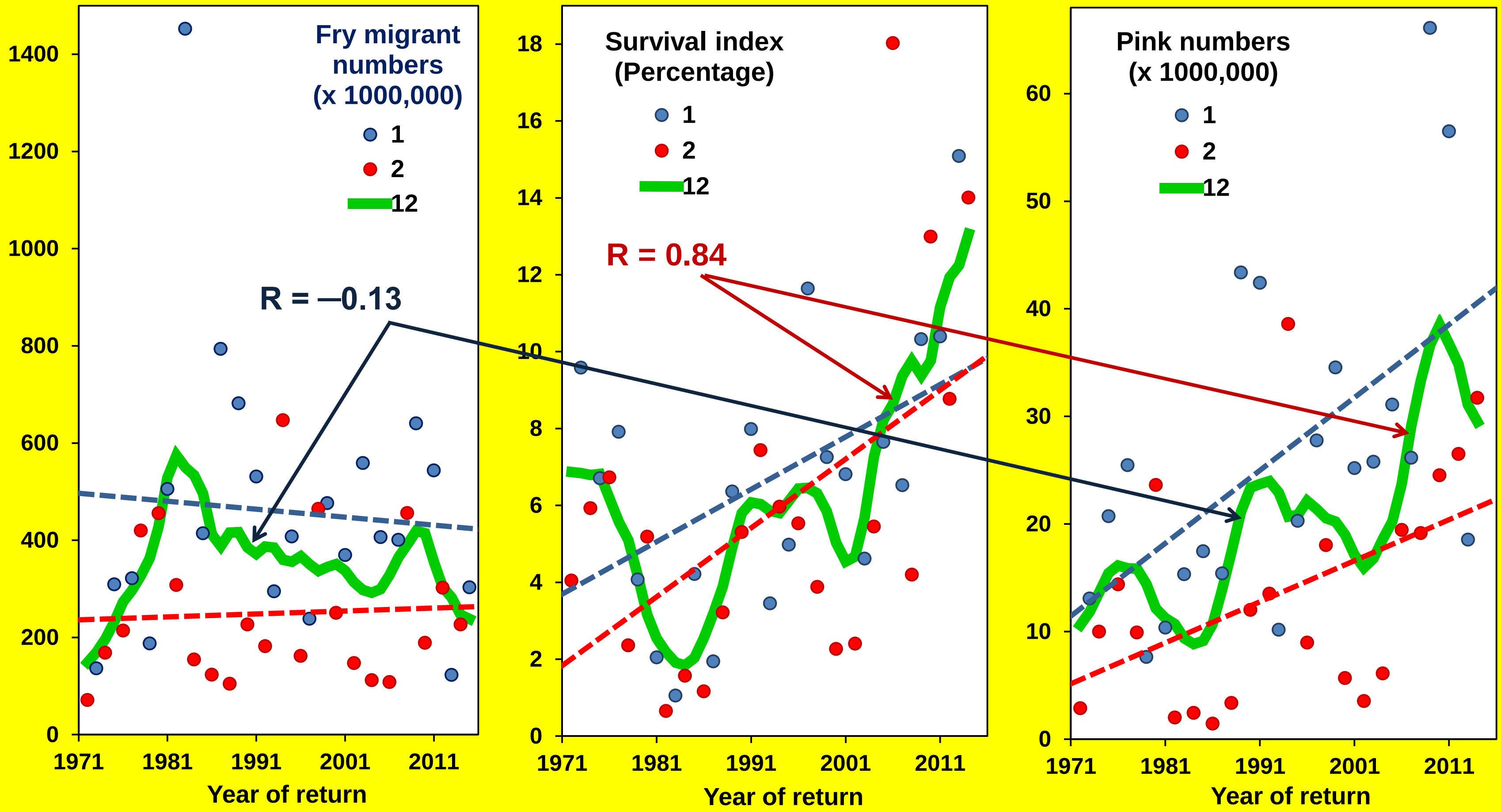
So, the monitoring data allow us to consider changes in pink salmon abundance in details only for the three regions: southeastern Sakhalin, Aniva Bay and Iturup Island.

Temporal changes in fry abundance, marine survival, and return of pink salmon (Aniva Bay): 1 – odd years, 2 – even years



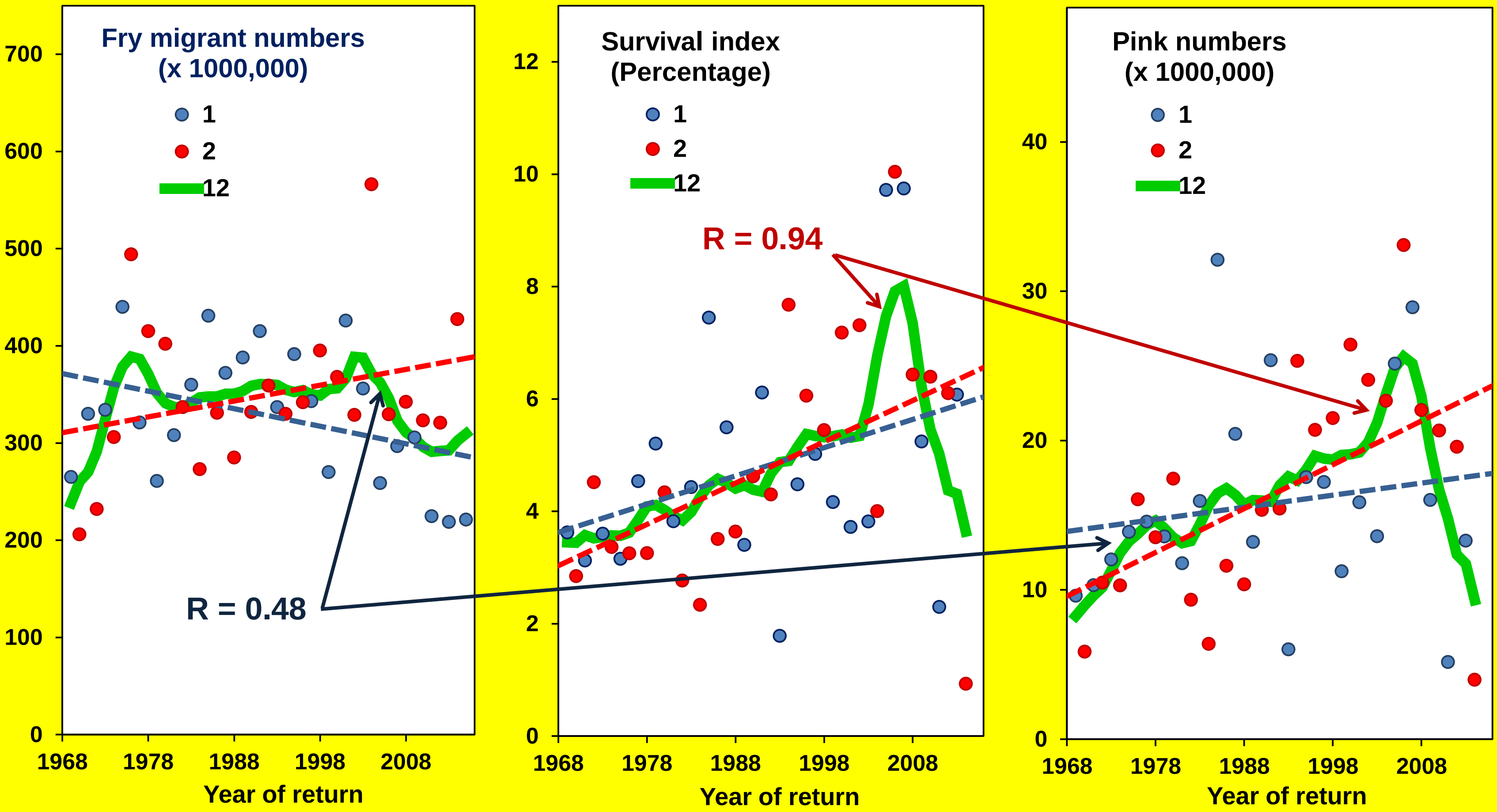
Only in Aniva Bay, fry abundance has positive trends for different broodlines. However, changes in marine survival and abundance of pink salmon agree better.

Temporal changes in fry abundance, marine survival, and return of pink salmon (southeastern Sakhalin): 1 – odd years, 2 – even years



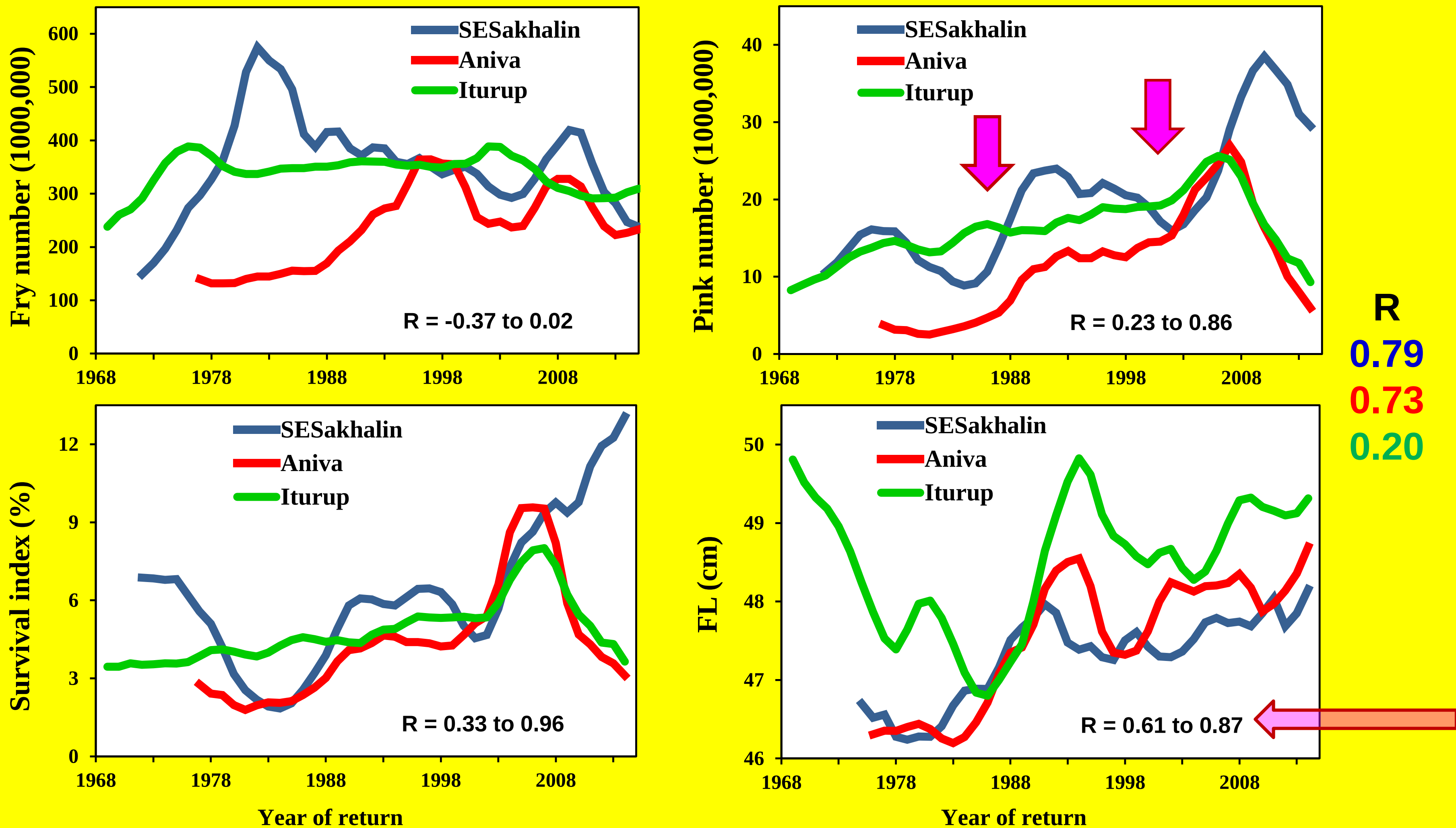
In southeastern Sakhalin, fry abundance has small and different-directed trends for odd- and even-year broodlines, but changes in marine survival and abundance of pink salmon have positive trends and agree well.

Temporal changes in fry abundance, marine survival, and return of pink salmon (Iturup Island): 1 – odd years, 2 – even years



We observe the same situation on Iturup Island.
In other words, pink salmon abundance is determined, to a greater extent, by fish survival in the sea waters.

Temporal changes in fry abundance, marine survival, adult return, and length of pink salmon in different regions



[Explanation of the previous slide]

Changes in pink salmon body length are similar in different regions, but as for changes in fry abundance, marine survival, and adult returns, there are essential differences.

This can be proved not only by the curves configuration, but also by the range of changes in correlation.

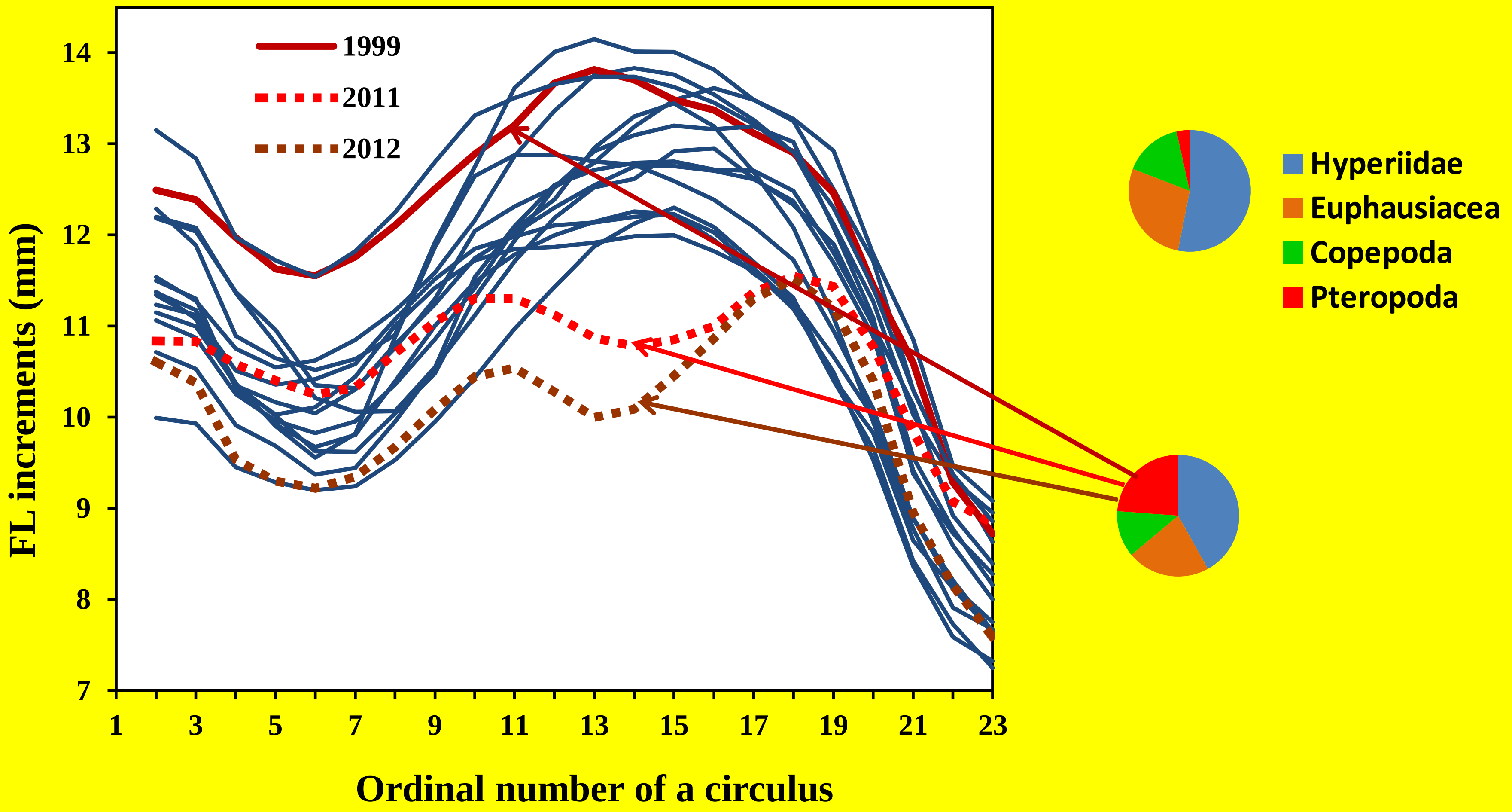
That is, length changes are a result of growth in similar conditions, and the abundance formation is under a strong influence of the local conditions.

During a study time period we have observed the increase in pink salmon abundance.

It being known that in the late 1980s and the beginning of the current century there was an intensive increase in abundance, as if fixing the periods with its different levels.

Increase in pink salmon abundance was accompanied by the increase in body size.

Increments of pink salmon body length during formation of one scale circulus at the first year of life (generations of 1994–2001 and 2005–2013)



[Explanation of the previous slide]

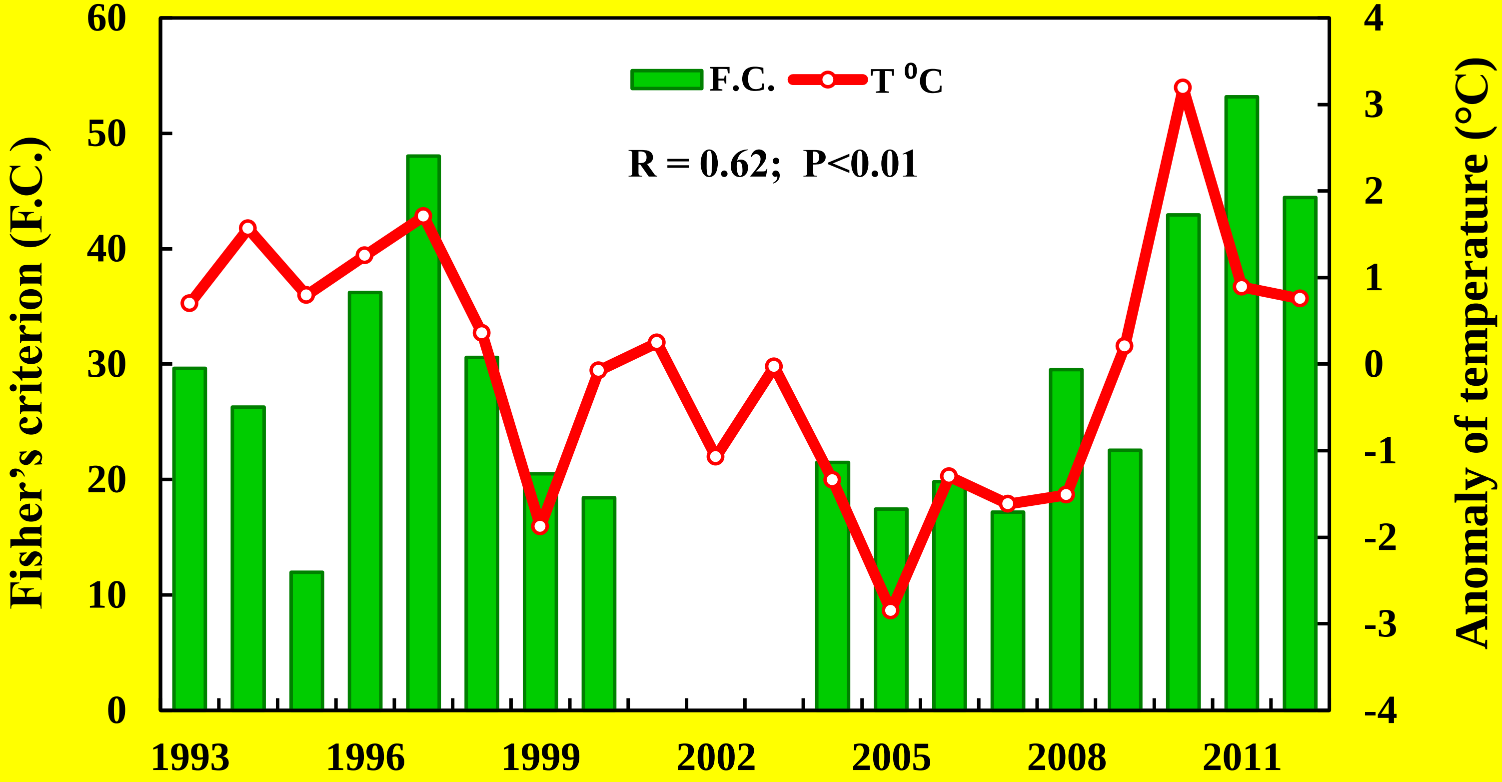
When studying pink salmon growth, we have found two generations with a clear anomaly of increments for a period of their inhabiting a central part of the Okhotsk Sea.

From the data of TINRO, a diet of pink salmon in this period consists, mainly, of *Hyperiidae*, *Euphausiacea*, and *Copepoda*.

At first, I suggested that the main cause of decrease in growth for these two generations appeared to be the changes in food composition, because a great number of the lower-calorie *Pteropoda* have been found in their food.

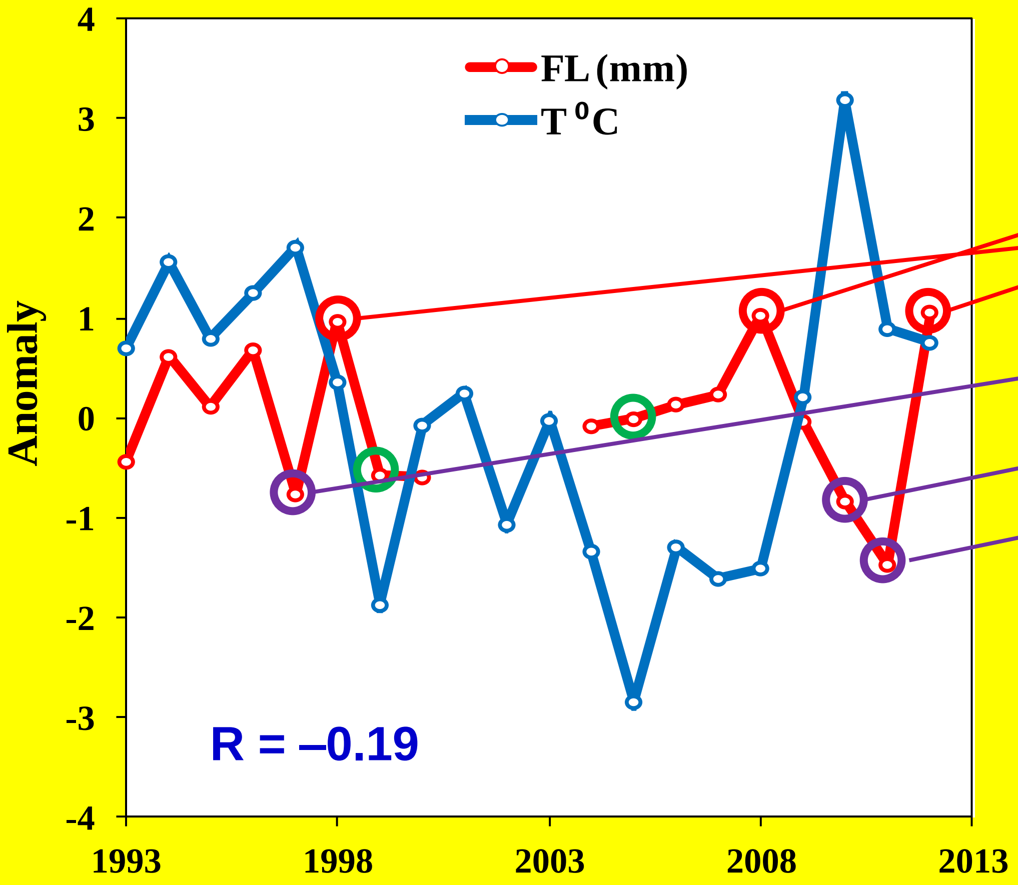
However, many *Pteropoda* in food was also found in one of the generations with the most rapid growth.

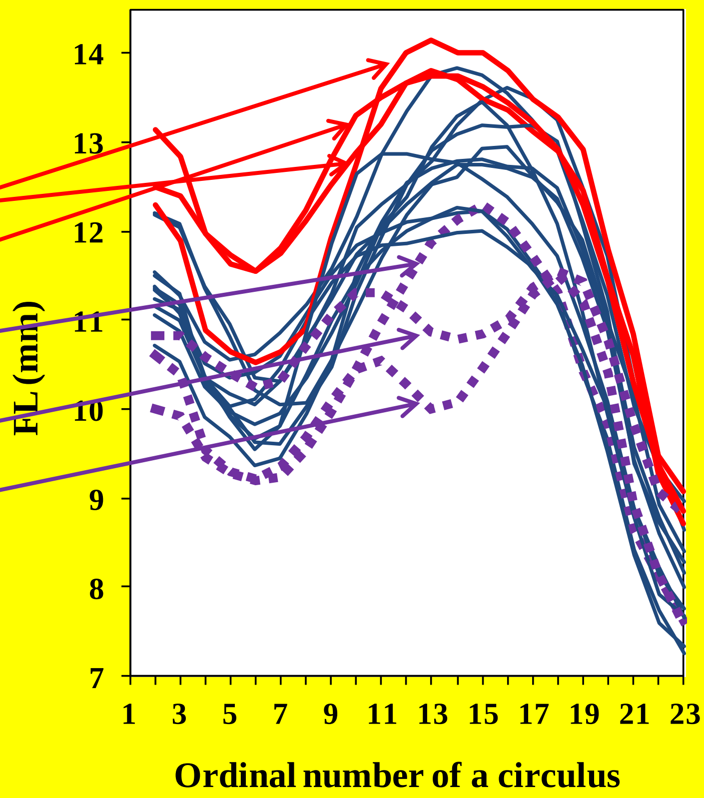
A summarized level of differences (by Fisher's criterion) of the intercirculi spacing increments in pink salmon of each generation from the rest generations and changes in sea surface temperature in the southern part of the Sea of Okhotsk (data of TINRO ship observations)



Then I focused my attention on the water temperature, as it is well correlated with the total value of the differences between the growth curves.

Increments of the body length (average per 1 circulus) during feeding of juvenile pink salmon in the central-southern part of the Sea of Okhotsk and changes in sea surface temperature





[Explanation of the previous slide]

At the first sight a water temperature could not be the cause of such changes in growth as well, because a relationship between the calculated lengths of juvenile pink and water temperature appeared to be weak.
But I was interested in this negative correlation.

It appeared that the largest growth of pink was observed at the average temperature or at the negative anomaly.

At the same time, the largest negative anomalies have not resulted in essential deterioration of growth.

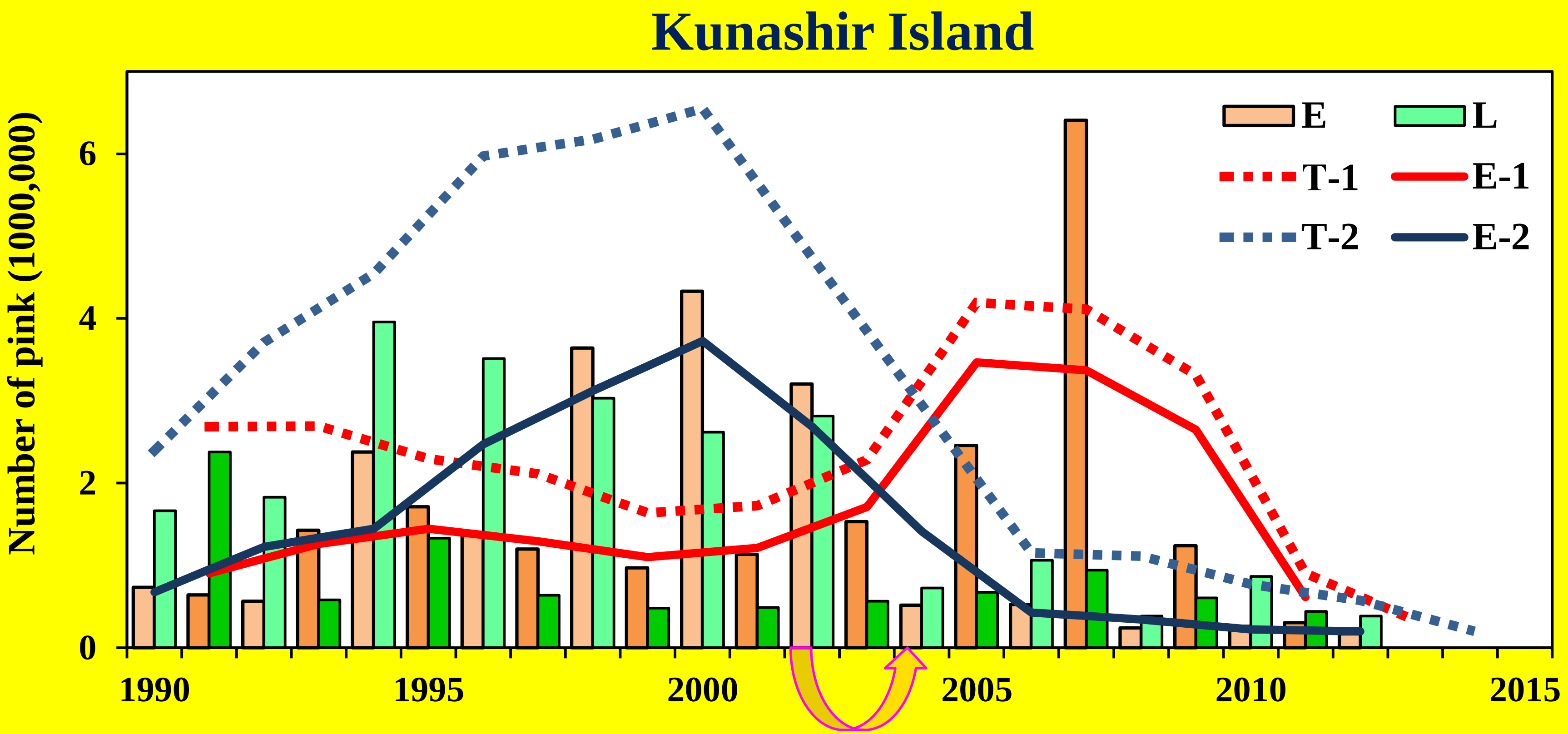
On the contrary, the greatest deceleration in growth occurred when the temperature was somewhat higher than the average level or it had a significant positive anomaly.

These data allow us to suggest that pink salmon deceleration in growth was mainly determined by the temperature water regime, that is “overheating”, and appearance of a low-calorie food in fish diet just promoted this deceleration.

Undoubtedly, habitat conditions, especially, for young fish, are of great importance for further formation of Pacific salmon abundance.

Abundance of early and late temporal forms of pink salmon in 1990–2012:

E – Early, L – Late, T = E+L, 1 – odd years, 2 – even years



[Explanation of the previous slide]

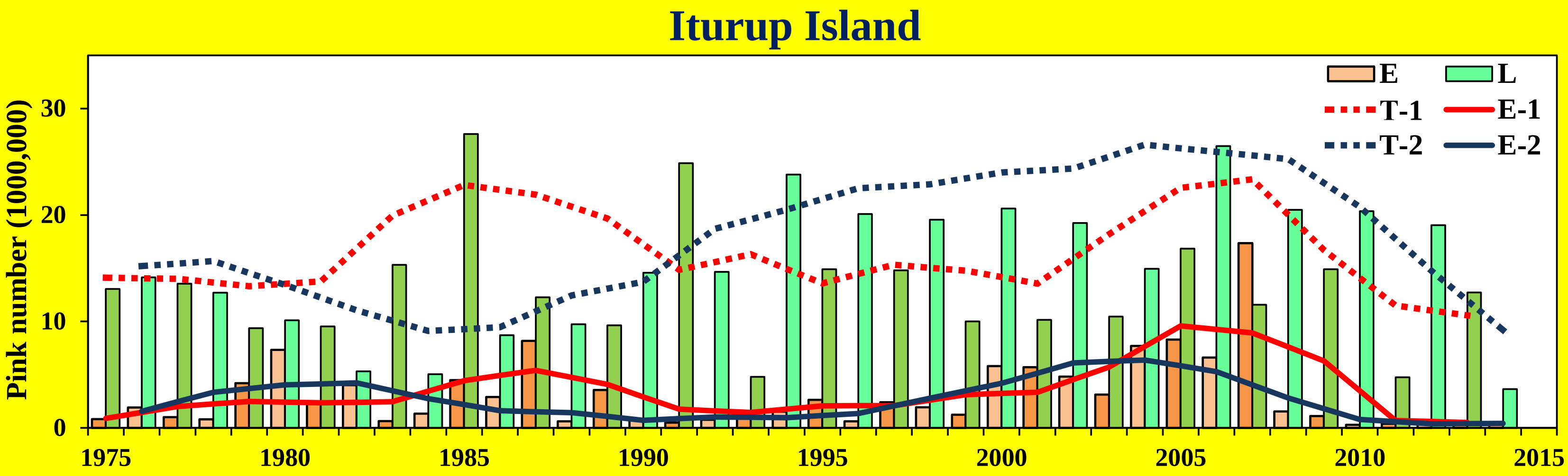
At the same time, the abundance of pink salmon, their biological indices, and run timing are determined not only by the environmental conditions but also by the ratio of early and late temporal forms (*Kaev A.M. Production trends of pink salmon in the Sakhalin-Kuril Region from the viewpoint of run timing // NPAFC Technical Report. 2012. № 8. P. 21–25*).

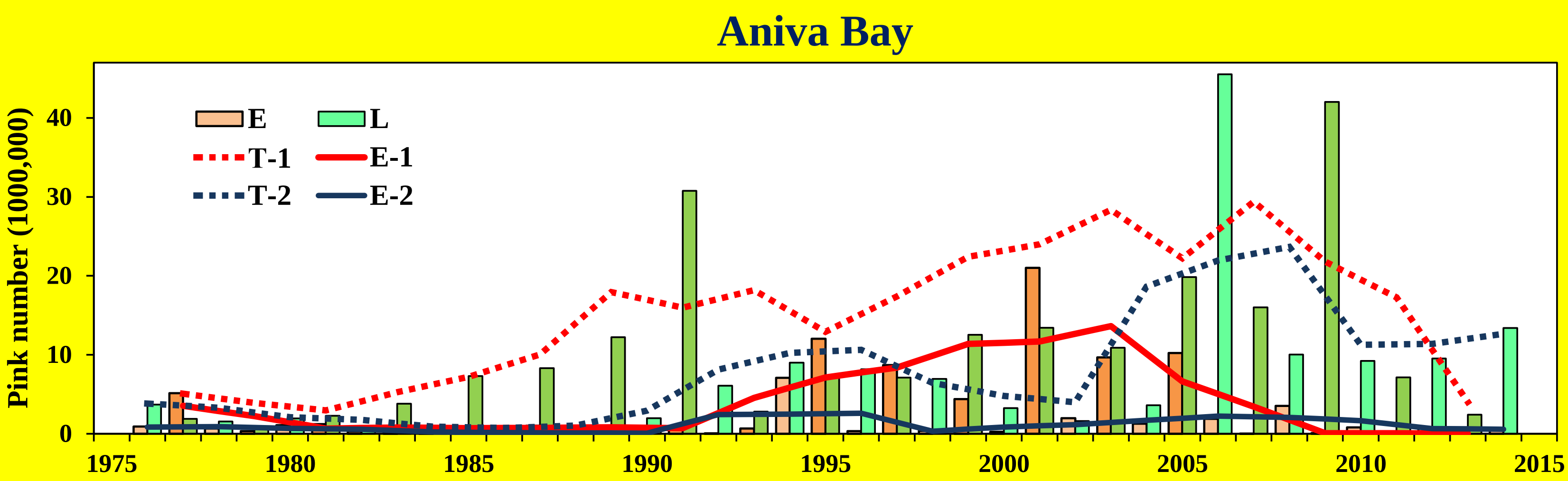
Abundance of the early temporal form is more changeable. When environmental conditions become poorer, an early form declines in number first and then the late one.

First I paid attention to this phenomenon in 2004, when the early temporal form experienced a more drastic decline in abundance that subsequently resulted in a factual cessation of pink salmon fishery on Kunashir Island in the even years. Later the like situation had repeated for the odd years.

Abundance of early and late temporal forms of pink salmon in 1975–2014:

E – Early, L – Late, T = E+L, 1 – odd years, 2 – even years





[Explanation of the previous slide]

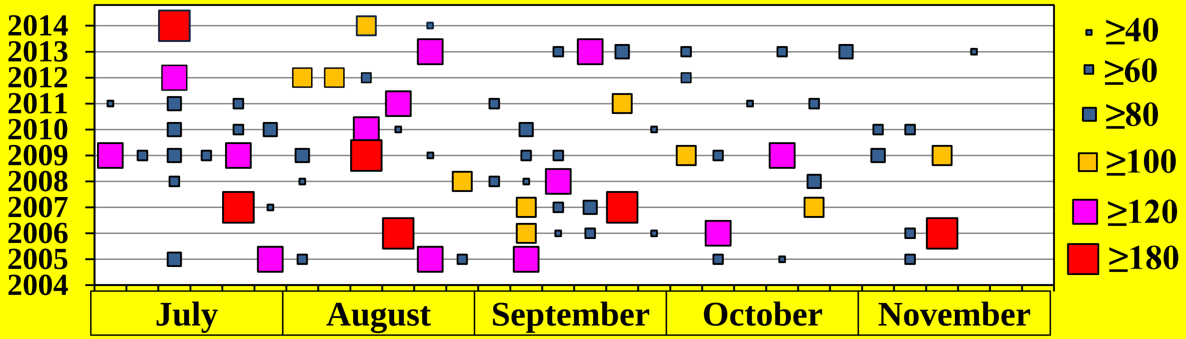
Taking into account that the early temporal form declined in abundance in pink runs to Iturup Island and Aniva Bay, I suggested that soon in these regions the catches should go down significantly, and this event had happened.

Now I will try to show some “local” causes of pink salmon decline in abundance.
During the freshwater period, evidently, precipitations number is one of the important factors.

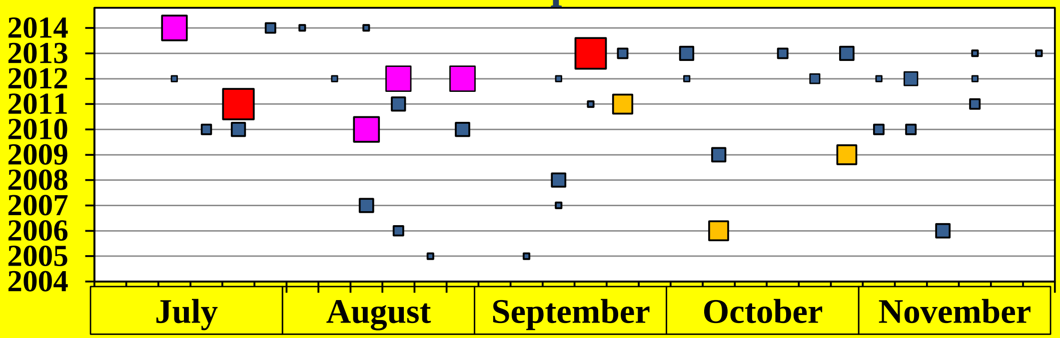
Moisture accumulation in soil both provides for water flowage on spawning areas in the winter period, and reduces frost penetration.
However, strong floods destroy spawning ground.

Heavy shower rains (mm) in July to November 2005 – 2014

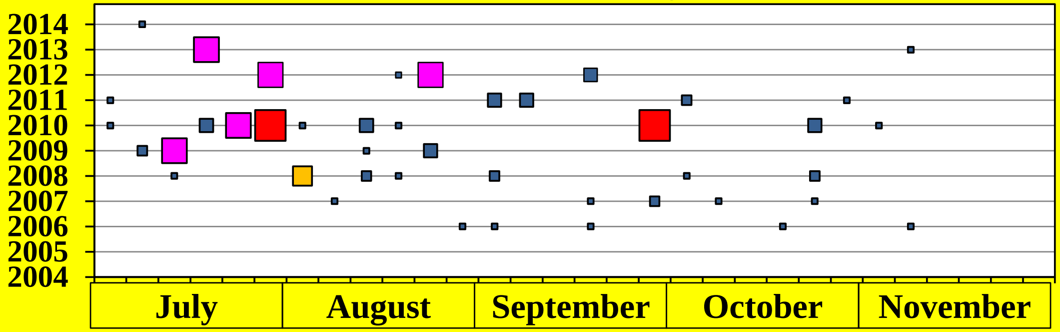
Kunashir Island



Iturup Island



Aniva Bay



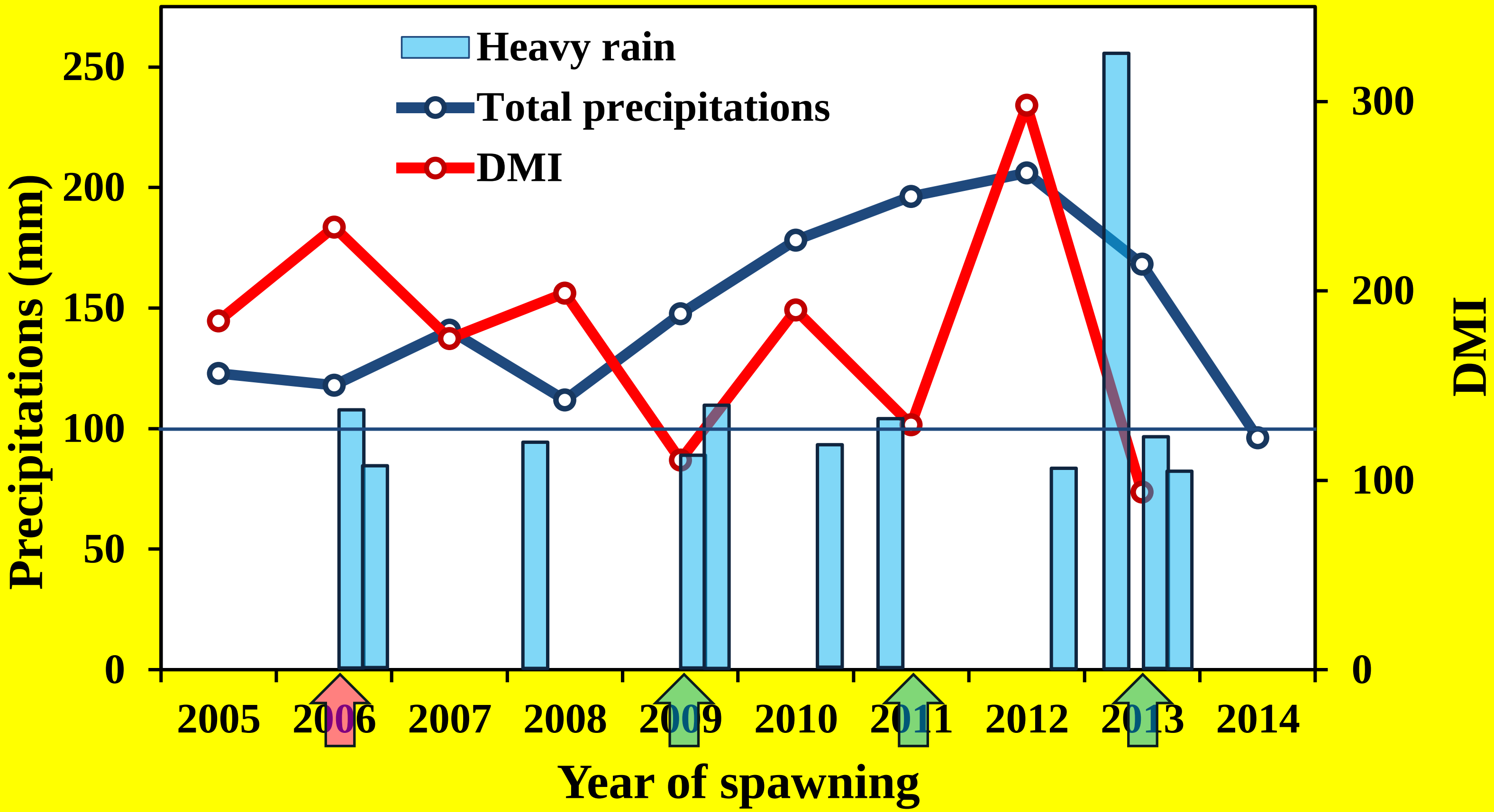
[Explanation of the previous slide]

This slide shows precipitations which could cause floods. Unfortunately, the data available are only since 2005.

We see that even on the neighbor islands Iturup and Kunashir the meteorological conditions differed significantly.

The extremely large precipitations on Iturup Island and in Aniva Bay appeared later that quite agrees with the later timing of pink salmon decline in abundance in these regions compared to Kunashir Island.

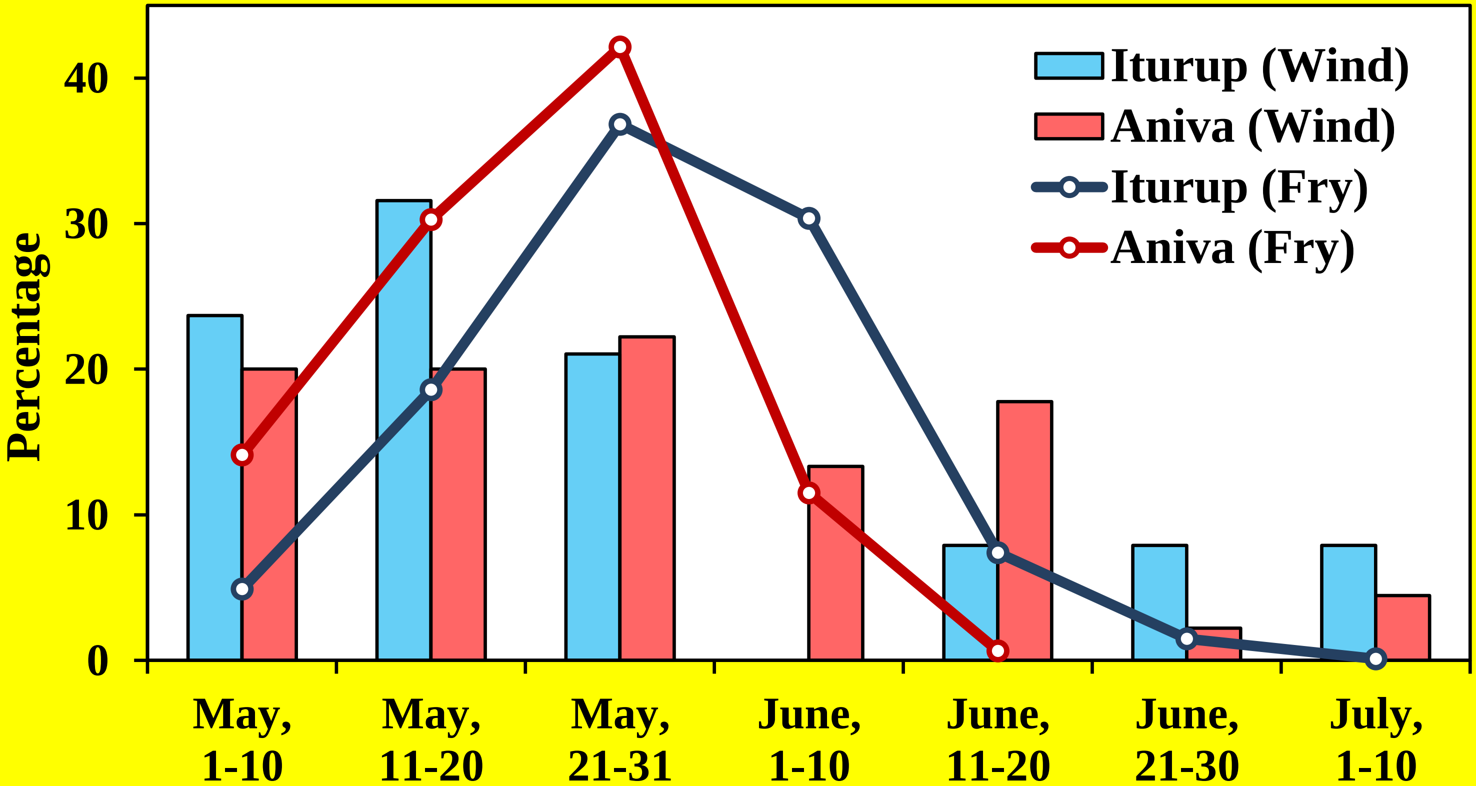
Changes in downstream migration index (DMI), number of precipitations in August-October (monthly average), and number of heavy shower rains in the autumn season on Iturup Island in 2005–2014: DMI = Fry migrants number / 0.5 of total spawners in the river



This slide on the example of Iturup Island demonstrates a decline in abundance for fry migrants, when heavy shower rains happened during a spawning or after it.

Apparently, precipitations with one hundred millimeters and more in volume are the most critical for a spawning process. In three of the four cases, such rains resulted in decrease of the downstream migration index.

The ratio of days with strong winds in May – early July on Iturup Island and in Aniva Bay, and dynamics of downstream migration of fry pink salmon in these areas (on average over the long-term period)



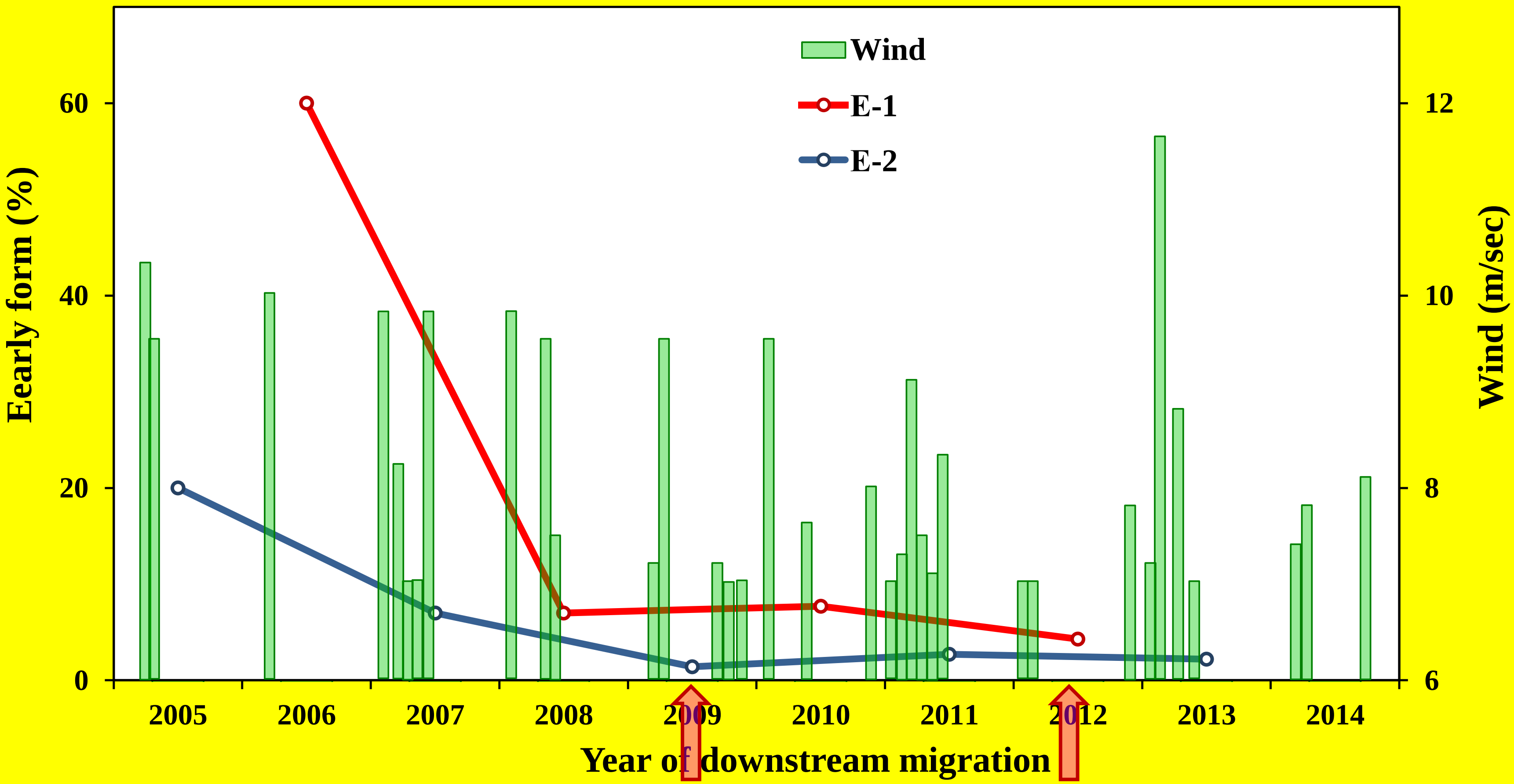
[Explanation of the previous slide]

Now about early marine period of life of pink salmon. Earlier I noticed that storms negatively influenced on fry, especially on those which recently migrated from rivers. (*Kaev A.M. 1992. On the presence of the risk-group among the chum salmon, Oncorhynchus keta, juveniles when fattening in estuarine zone // Journal of Ichthyology. V. 32. № 2. P. 53–60*)

When comparing Iturup and Aniva areas we see that on Iturup a downstream migration occurs later, and the days with strong winds, by contrast, are often observed earlier.

That is, on Iturup these winds influence stronger on fry which enter the sea earlier. Perhaps, this is one of the reasons that the proportion of the early temporal form of pink salmon on Iturup is lower, on average, than in Aniva Bay.

Frequency of days with strong winds during the downstream fry migration (May–June) in 2005–2014, and proportion of the early form (E) in the posterior pink salmon returns on Iturup Island in odd (1) and even (2) years



[Explanation of the previous slide]

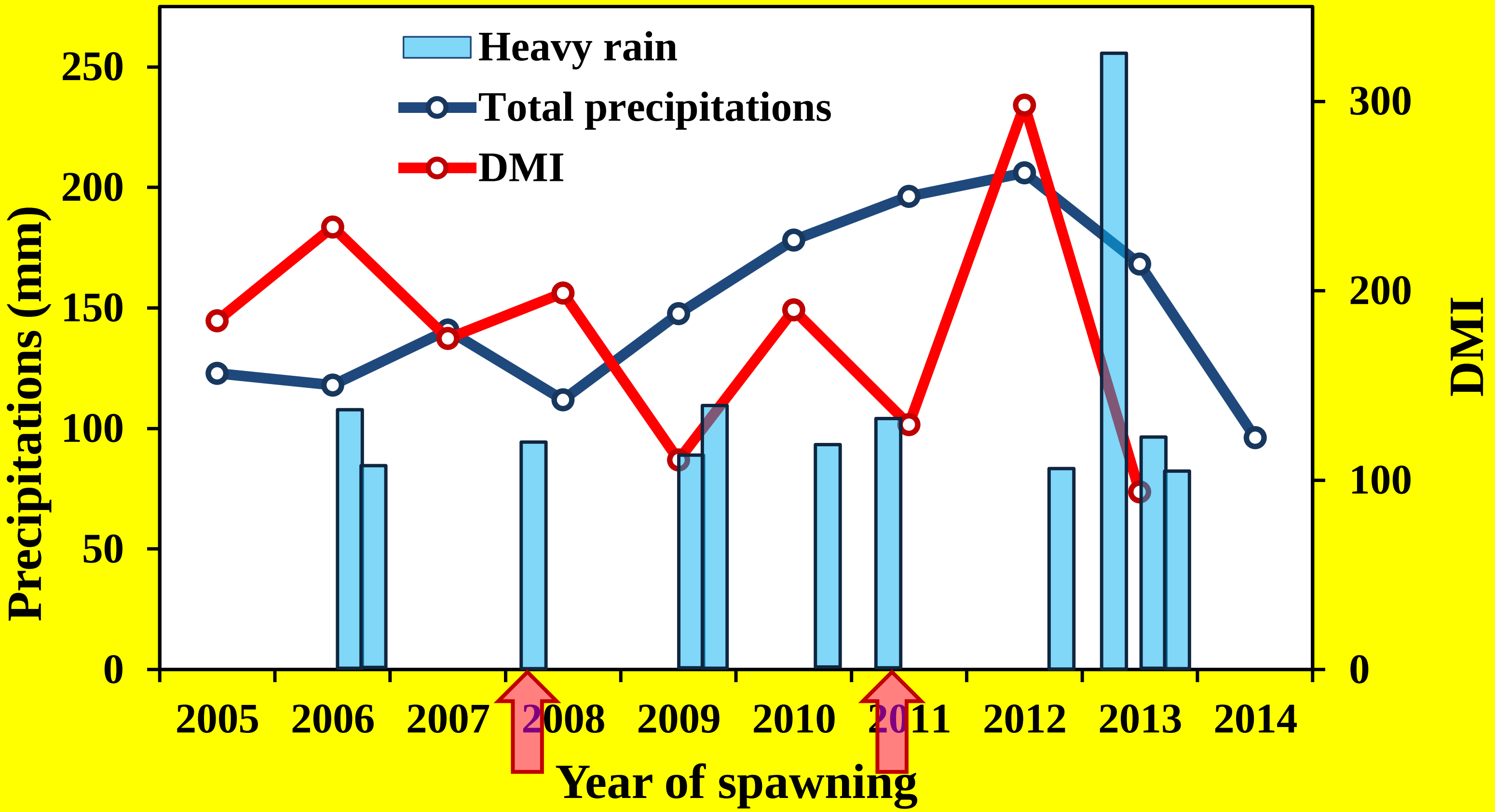
This slide shows a number of days with strong winds in May and June and a proportion of early pink salmon in the posterior returns.

It is difficult to analyze these indices for southern Sakhalin because in the beginning of this century many early pink salmon were captured in estuaries that lowered their proportion on the spawning areas.

As for Iturup Island, where the like captures were absent, it is clearly seen that the proportion of early pink salmon declined with the increase in storm numbers in May.

This conclusion is not true only for the two generations where a small proportion of the early pink salmon in adult returns was caused by other reasons.

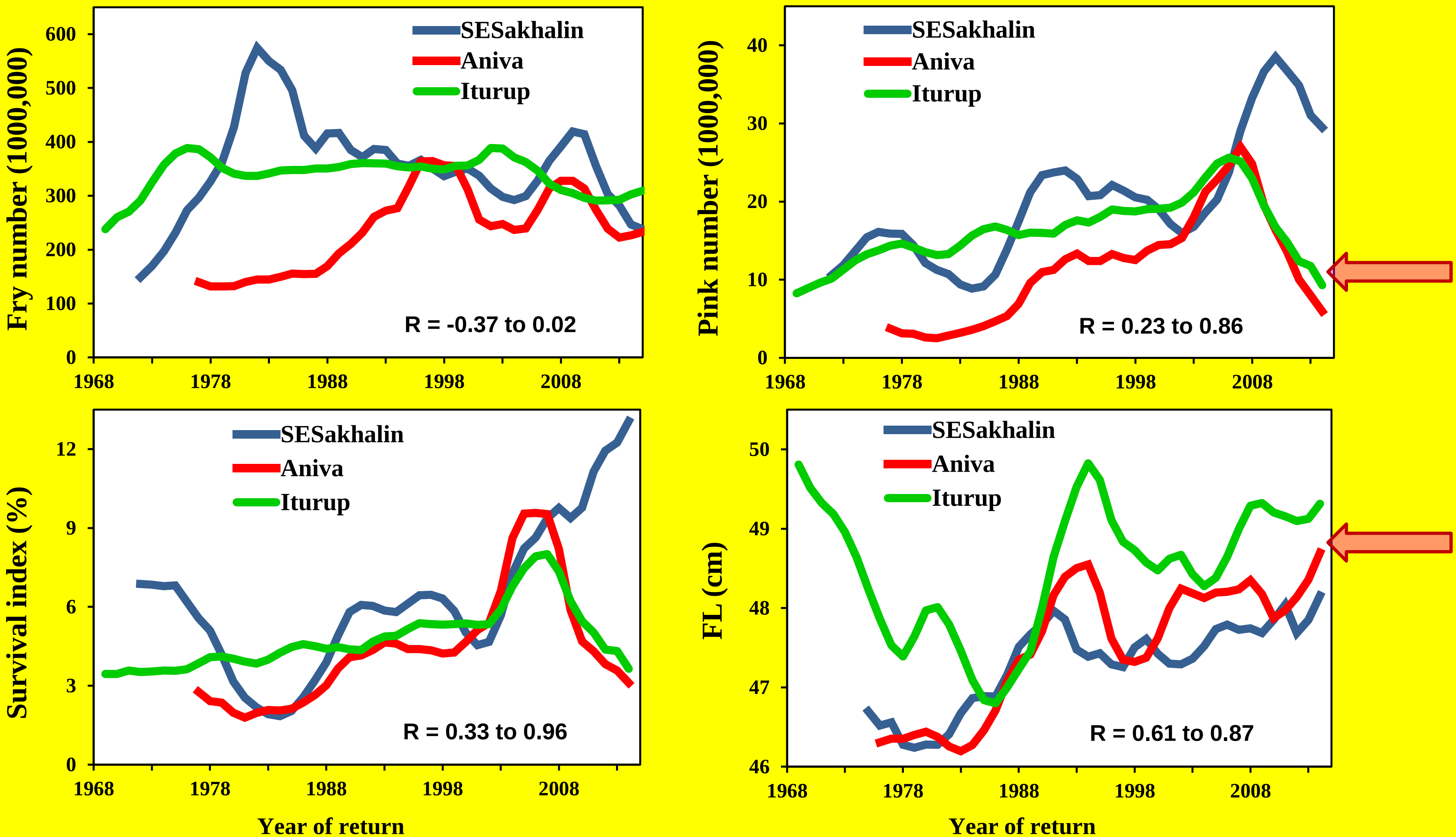
Changes in downstream migration index (DMI), number of precipitations in August-October (monthly average), and number of heavy shower rains in the autumn season on Iturup Island in 2005–2014: DMI = Fry migrants number / 0.5 of total spawners in the river



Here are the two generations in which the heavy rains affected mainly the early pink salmon spawning. That is, the action of negative factors strengthens in the rivers and coastal sea at the same time.

The decline in abundance for early pink salmon appeared to be in the northerly areas of eastern Sakhalin as well. That is, this process extends over other regions. And what will further develop this process?

Temporal changes in fry abundance, marine survival, adult return, and length of pink salmon in different regions



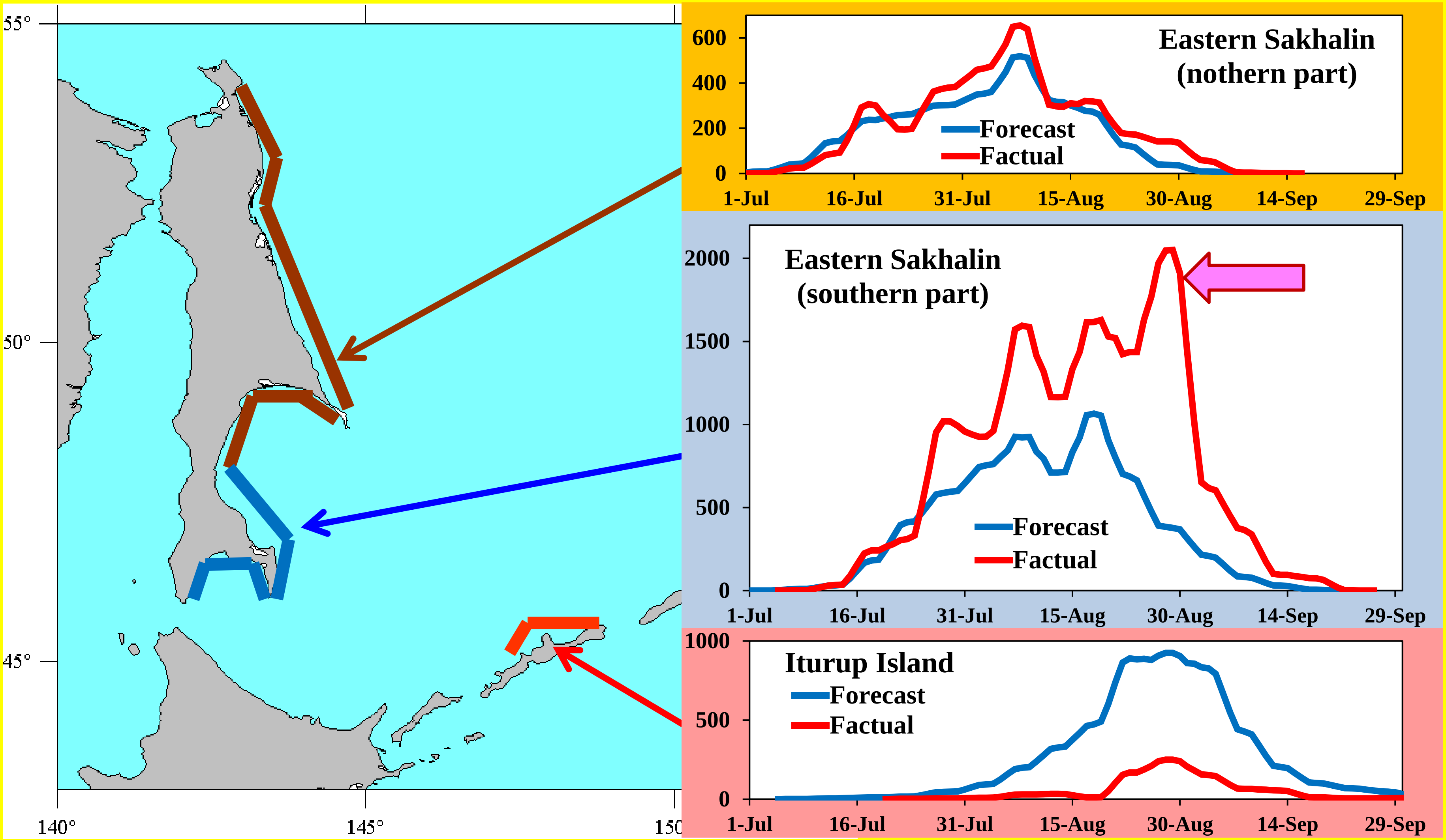
[Explanation of the previous slide]

The observed decline in pink salmon abundance under their remaining large sizes is a result of strengthening of the negative local factors, whereas the environmental conditions in the open sea waters keep favorable.

I think if in the nearest future there is a trend change in pink salmon body size for lowering as an evidence of their life deterioration, then this process may become extensive and long.

Completing my report, I would like to draw your attention to another problem arisen in 2014.

Forecasted and factual Pink salmon catches in 2014 (metric tons)



[Explanation of the previous slide]

In the northern part of eastern Sakhalin the forecast appeared to be fully true both by the capture estimate and dynamics of catches.

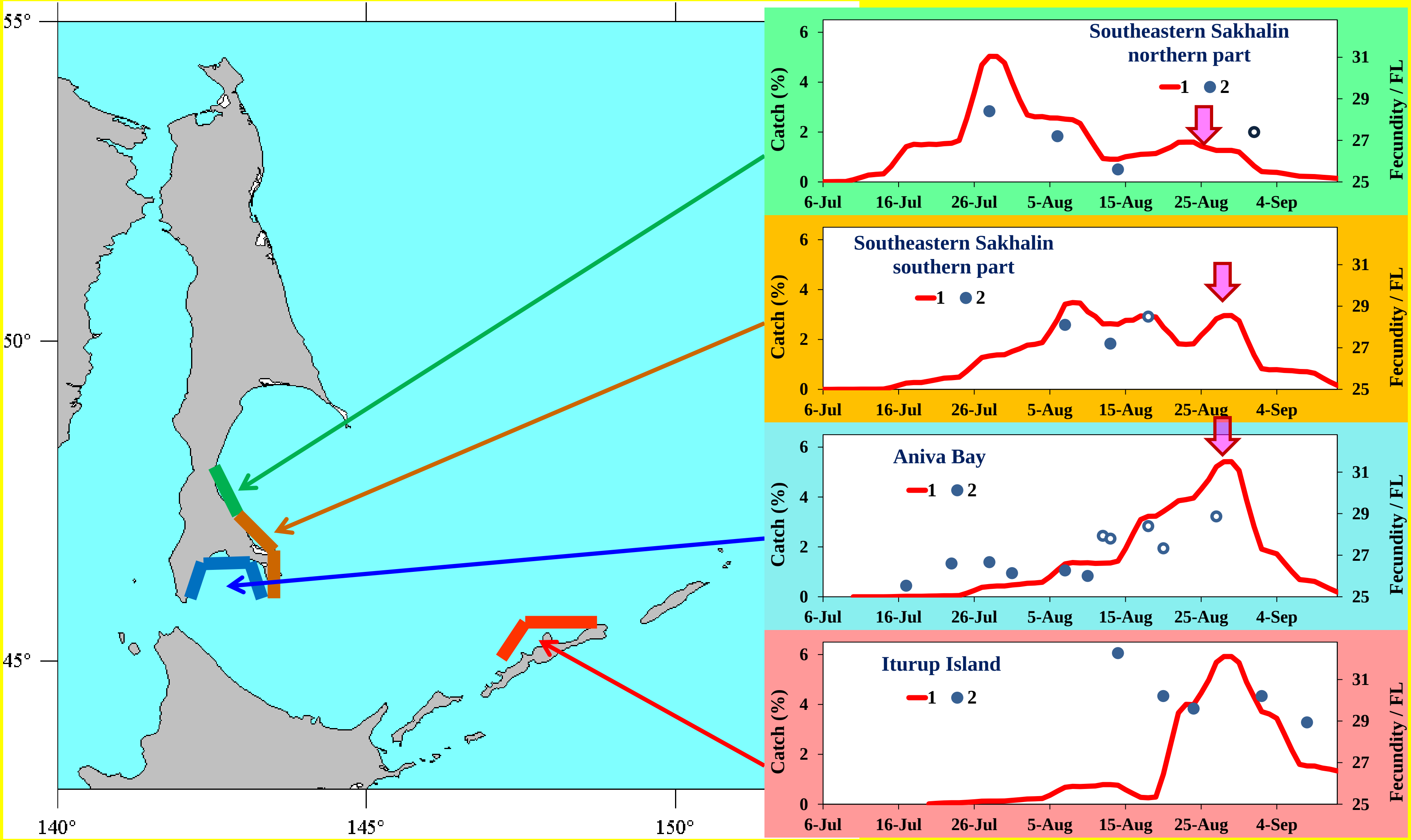
At the same time, in the southern part of eastern Sakhalin the catches appeared to be rather higher, and on Iturup Island rather lower than those forecasted.

Large errors of forecast occurred sometimes in the previous years.
One of the versions of these errors is the hypothesis of fluctuating stocks *(Glubokovsky M.K., Zhivotovsky L.A. Population structure in pink salmon: a system of fluctuating stocks // Marine biology. 1986. № 2. P. 39-44).*

When analyzing a catch dynamics, biological indices of fish and a structure of scales, I failed to find a confirmation for a mass re-distribution of pink salmon between areas. However, in 2014, I first recognized that such re-distribution had happened.

On Iturup Island a relative catch dynamics corresponded to the expected one, but in the southern part of eastern Sakhalin the dynamics of factual catches changed significantly: in late August there appeared one more peak of catches.

Dynamics of Pink salmon catches and relative female's fecundity in 2014: 1 – Catches, 2 – Fecundity (eggs) / FL (cm)



[Explanation of the previous slide]

This slide shows a detailed dynamics of catches. As you see, the proportion of catches coinciding by time with the largest catches on Iturup Island increases in the southern direction.

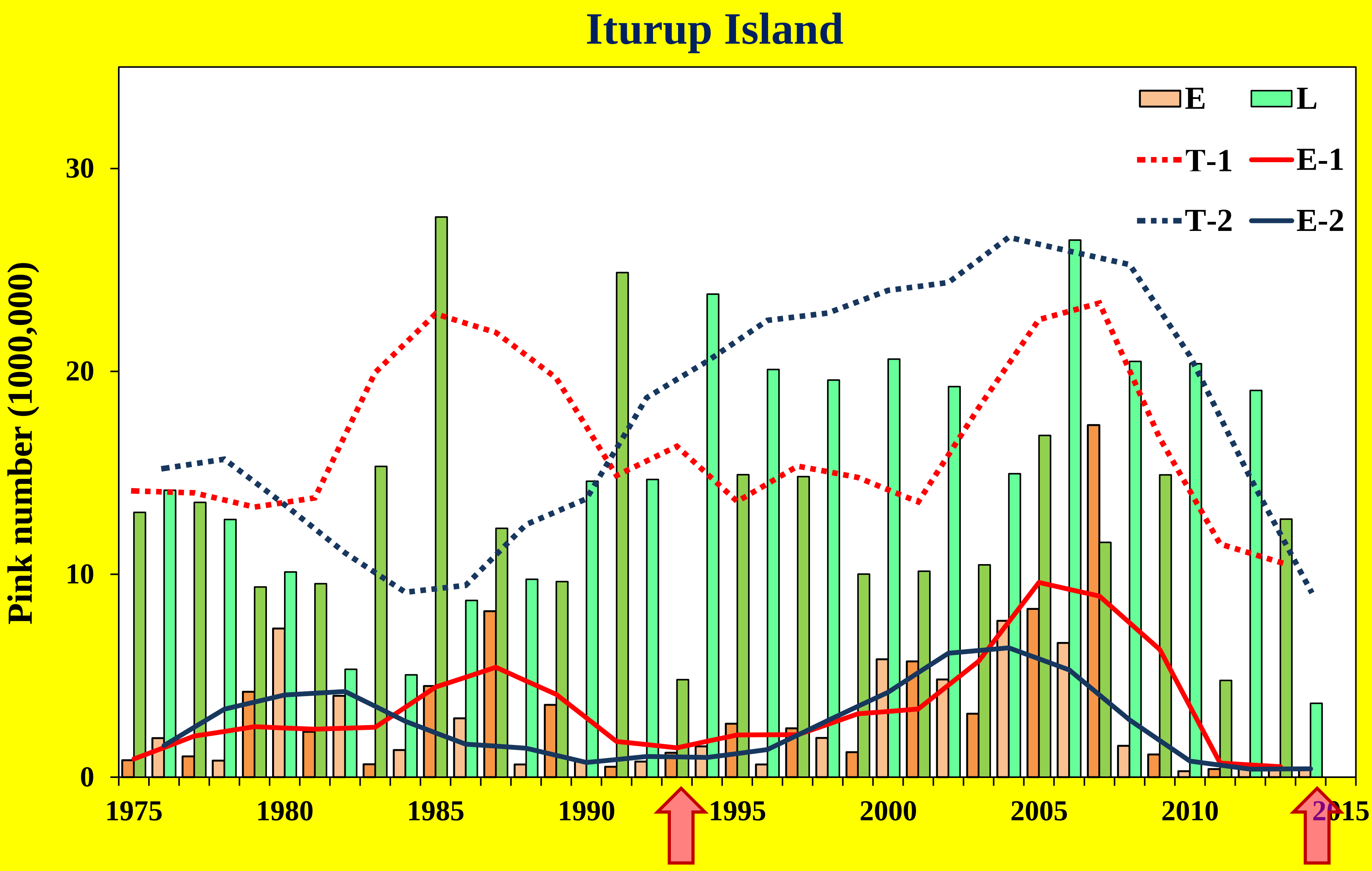
Of biological indices, here I give the relative fecundity of females. The values of this index were higher on Iturup than in Sakhalin.

This index on Sakhalin should have reduced in August, but its values in the second half of August increased unexpectedly (White symbols). This also indicates the possible appearance of the Kuril pink salmon on Sakhalin.

Iturup Island is one of the few areas in the North Pacific, where a change in dominant pink generations for long periods occurs.

Location of these areas is related with a system of sea currents (*Kaev, A.M. Development of some tendencies in pink salmon stock dynamics in the eastern Sakhalin and southern Kuril Islands // TINRO Bulletin «Studies of Pacific salmon in the Far East» 2012. № 7: P. 135–142*).

Abundance of early and late temporal forms of pink salmon in 1975–2014: E – Early, L – Late, T = E+L, 1 – odd years, 2 – even years



[Explanation of the previous slide]

By the way, the last change in dominant lines on Iturup Island in 1993 took place during the decline in early temporal form of both generative lines of pink salmon.

If now a recurrent change in dominant lines is traced out, then, perhaps, it is related with the massive straying of pink salmon. For the time being, this is only a hypothesis because to prove it we need the more reliable data.

So, my report is finished, and the end is not very optimistic because of the absence of these proofs. I hope to continue this research to increase our knowledge.

Thank you for your patience!