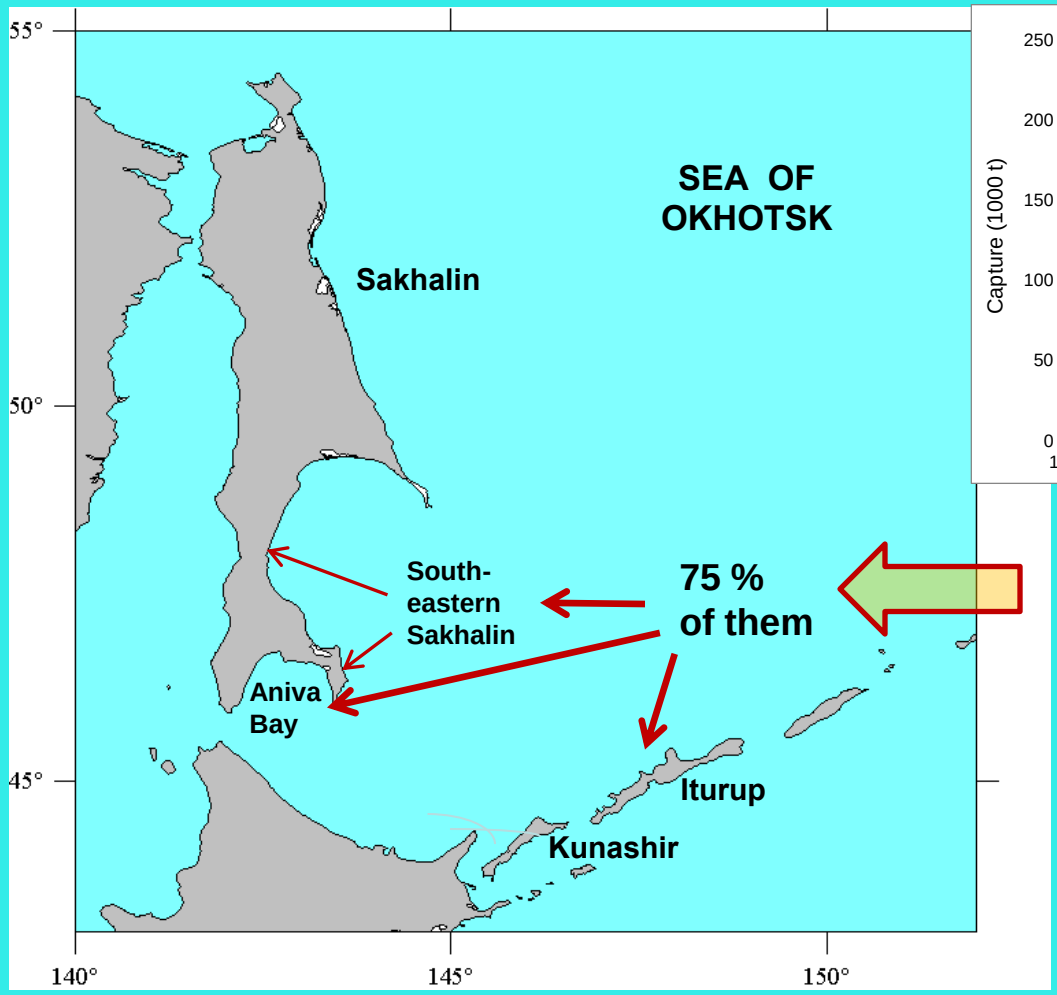
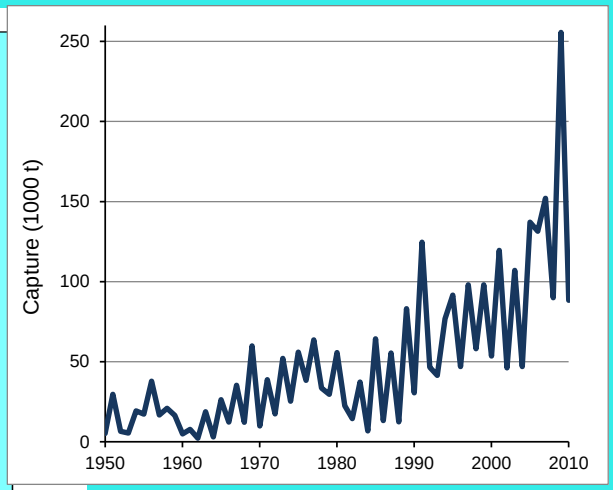
Alexander M. Kaev

Production trends of pink salmon in the Sakhalin-Kuril region from the viewpoint of run timing



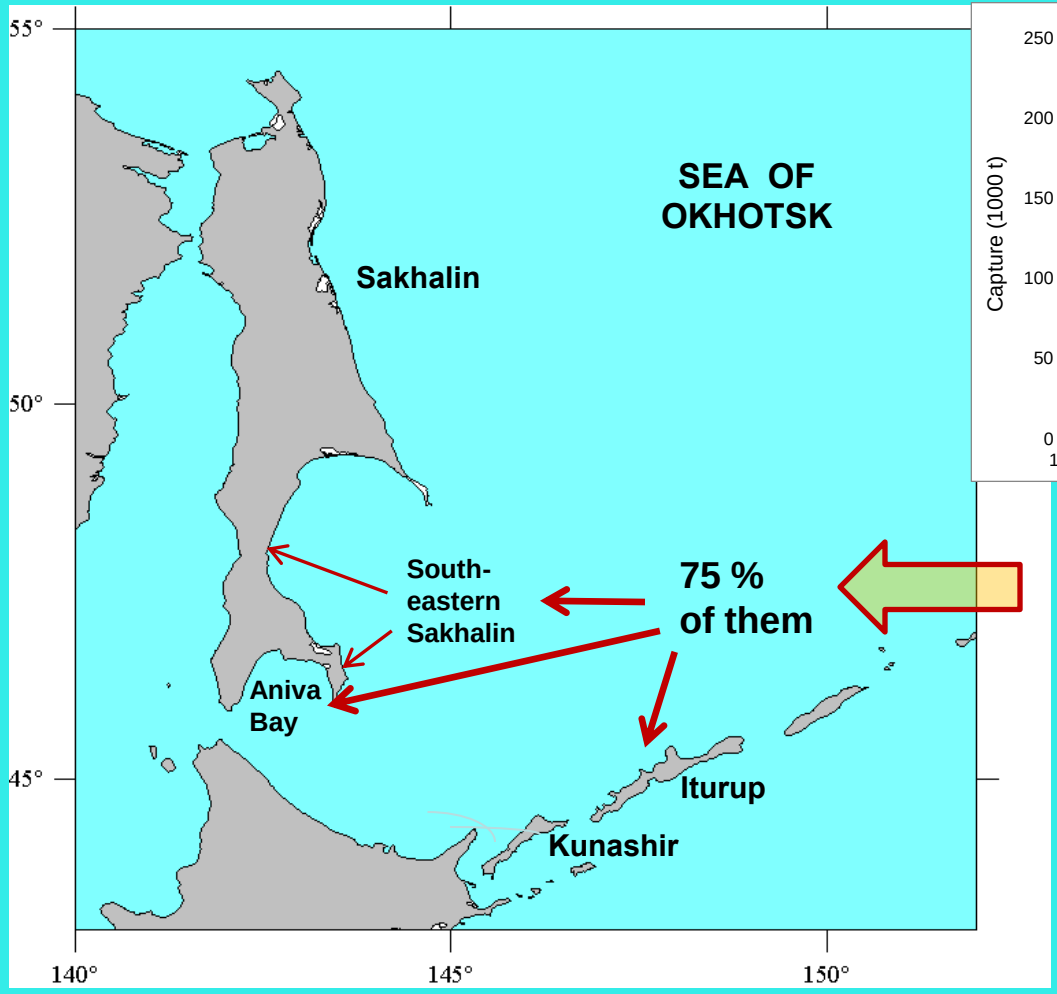


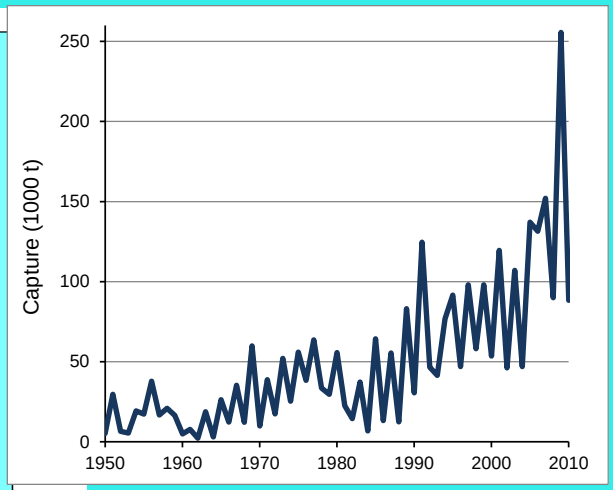
Pink salmon catch dynamics in Sakhalin region

There are two mass species of Pacific salmon in Sakhalin-Kuril region: pink and chum. I'll speak only about pink salmon because changes in chum salmon abundance are determined mainly by the activity of hatcheries. Pink salmon has a rapid growth, short life and the great variability in abundance, so it attracts attention as a possible indicator of environmental processes.

Alexander M. Kaev

Production trends of pink salmon in the Sakhalin-Kuril region from the viewpoint of run timing





Pink salmon catch dynamics in Sakhalin region

We offer you the results of analysis of pink salmon stock status in the three southern areas of the region. These areas are prominent not only for high abundance of pink salmon, but also for the most continuous periods of its study.

Indices and their abbreviations:

RI – Reproduction Index : Ratio between the number of downstream fry migrants and number of pink salmon escaped for spawning (SakhNIRO data).

SI – Survival Index : Percentage of pink salmon returns to the total number of wild and hatchery fry migrants (SakhNIRO data).

CT – Cold Type : Number of "cold" decades in atmospheric processes over the Okhotsk and Japan Seas in October-March (TINRO-Center).

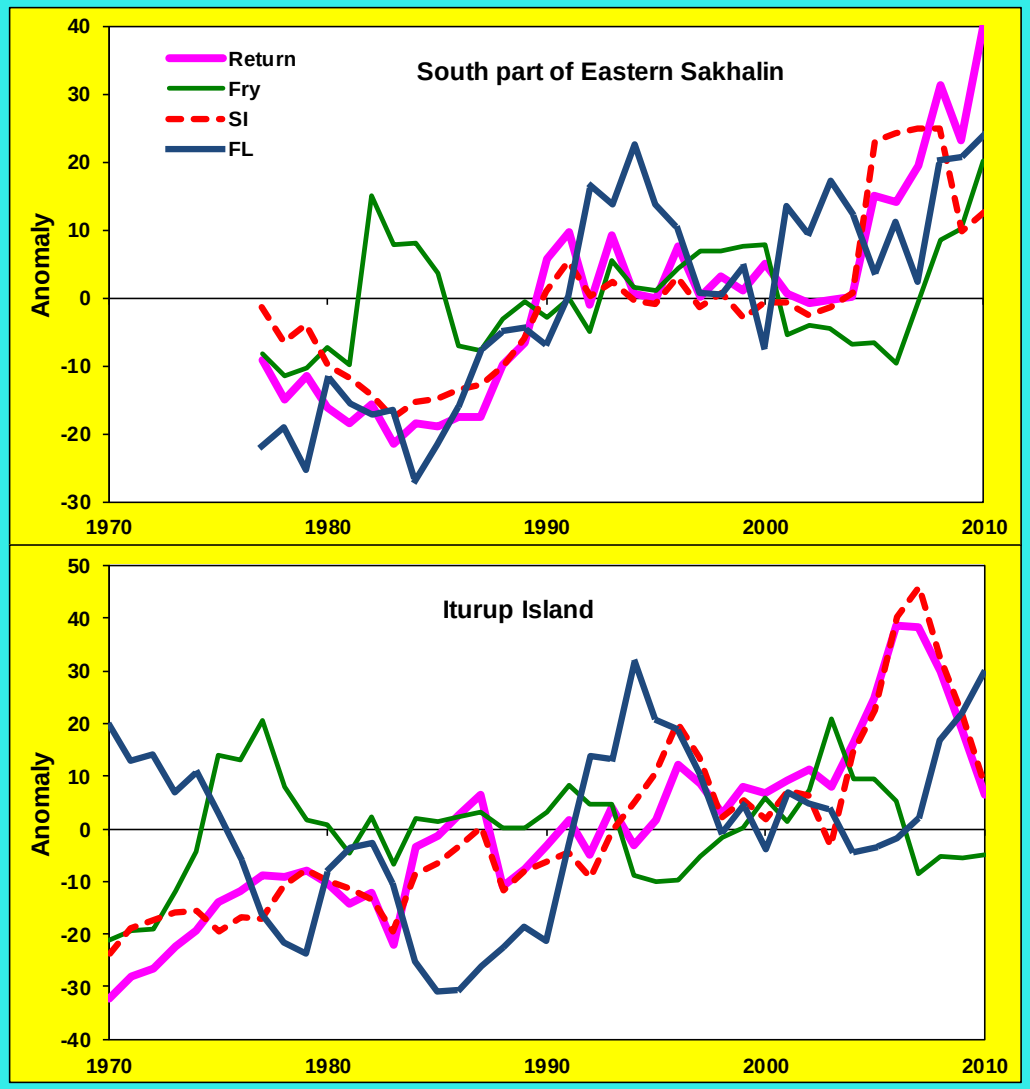
PDO – Pacific Decadal Oscillation (University of Washington, PDO). **PDO** – Pacific Decadal Oscillation (University of Washington, PDO).

SST – Sea Surface Temperature in summer and autumn in the Okhotsk Sea (NOAA Earth System Research Laboratory: NCEP/NCAR Reanalysis Project).

W – Wolf number : Numerical index of the sunspots number (The Solar Influences Data Analysis Center, SIDC).

First of all I'll indicate the meaning of some terms and their abbreviations. PDO, SST, and W are generally accepted, but others are not so acceptable. They are Reproduction Index, Survival Index and Cold Type.

Temporal changes in fry abundance, return, marine survival (SI), and length (FL) for South Sakhalin and Iturup pink salmon



Correlation

Return with:

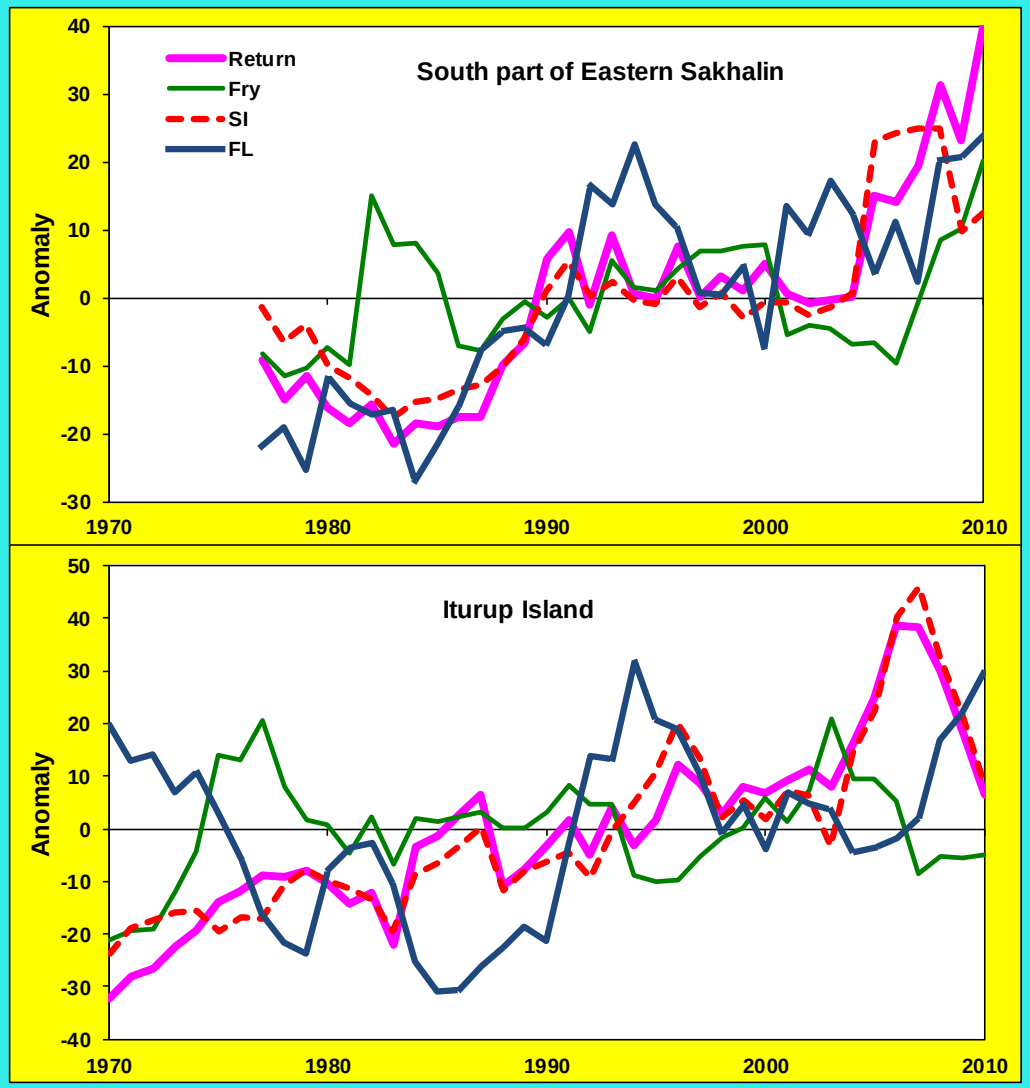
- **Fry 0.37**
- **SI 0.76**
- **FL 0.06**

Return with:

- **Fry 0.31**
- **SI 0.88**
- **FL -0.15**

This slide shows that high abundance and large sizes were characteristic for pink salmon in the past 20 years. For better view of the long-term changes, the data are presented as a 4 year running average, because pink has the odd and even-year generations. Will you pay attention to a high correlation between returns and marine survival index, and low between returns and fish length.

Temporal changes in fry abundance, return, marine survival (SI), and length (FL) for South Sakhalin and Iturup pink salmon



Correlation

Return with:

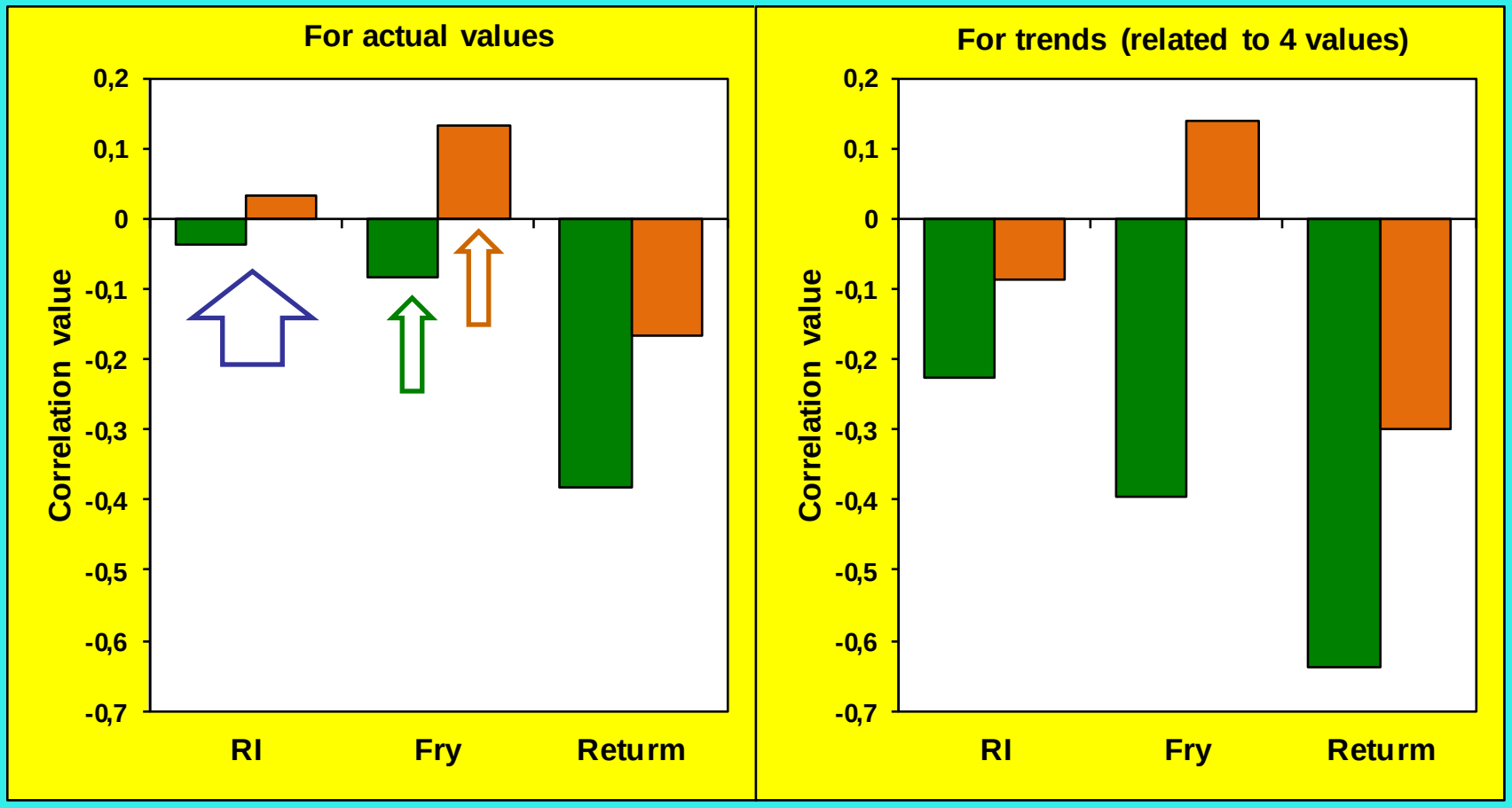
- **Fry 0.37**
- **SI 0.76**
- **FL 0.06**

Return with:

- **Fry 0.31**
- **SI 0.88**
- **FL -0.15**

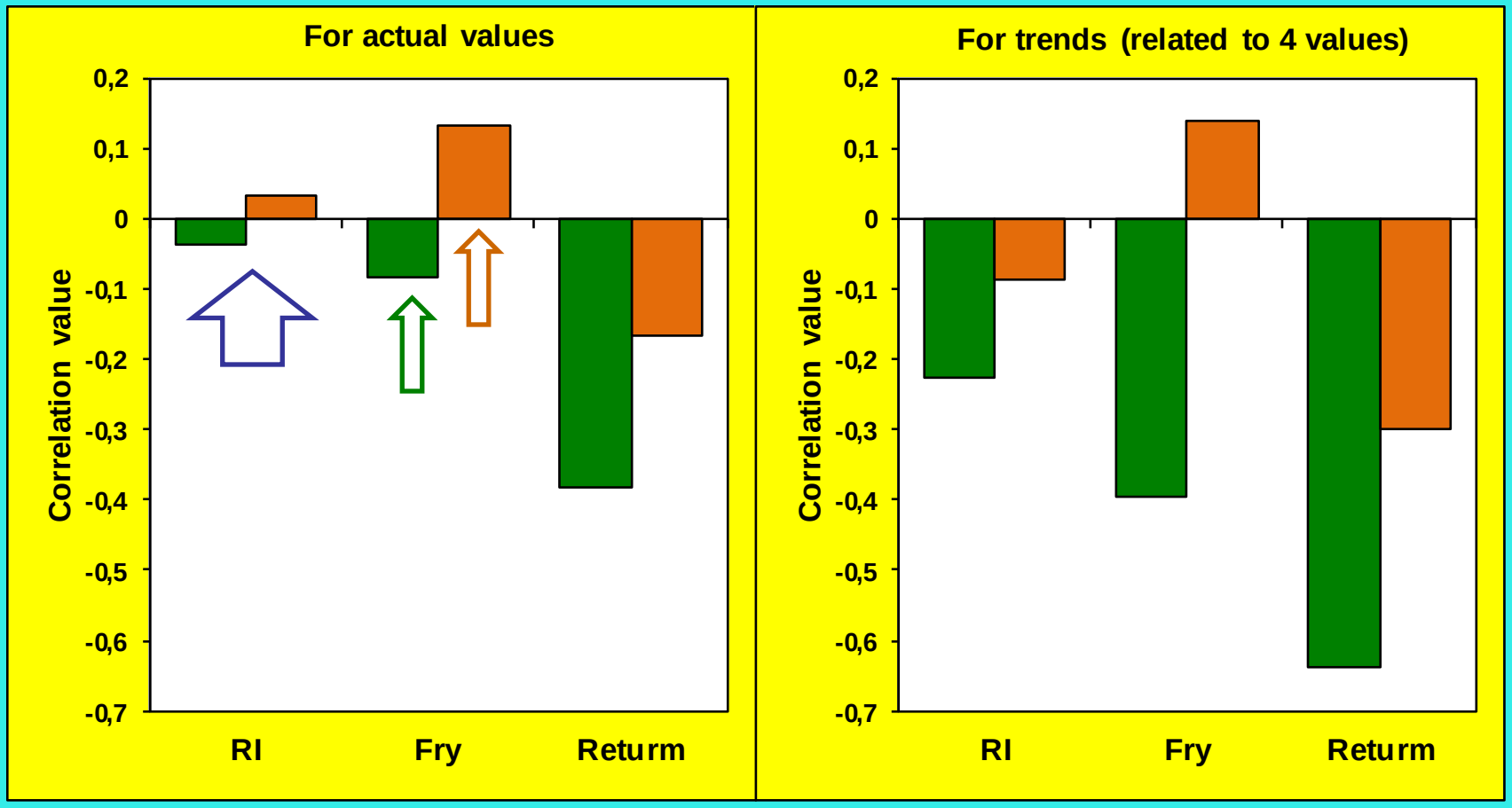
Many researchers have compared changes in Pacific salmon abundance with the global climatic indices. For example, a detailed report on chum salmon study was presented by Dr. Kaeriyama in 2009 at the PICES. I can hardly add to it something more.

The correlation between the number of "cold" decades in winter and: reproduction efficiency in rivers (RI), abundance of fry migrants, and return of pink salmon for South Sakhalin [green] and Iturup Island [orange]



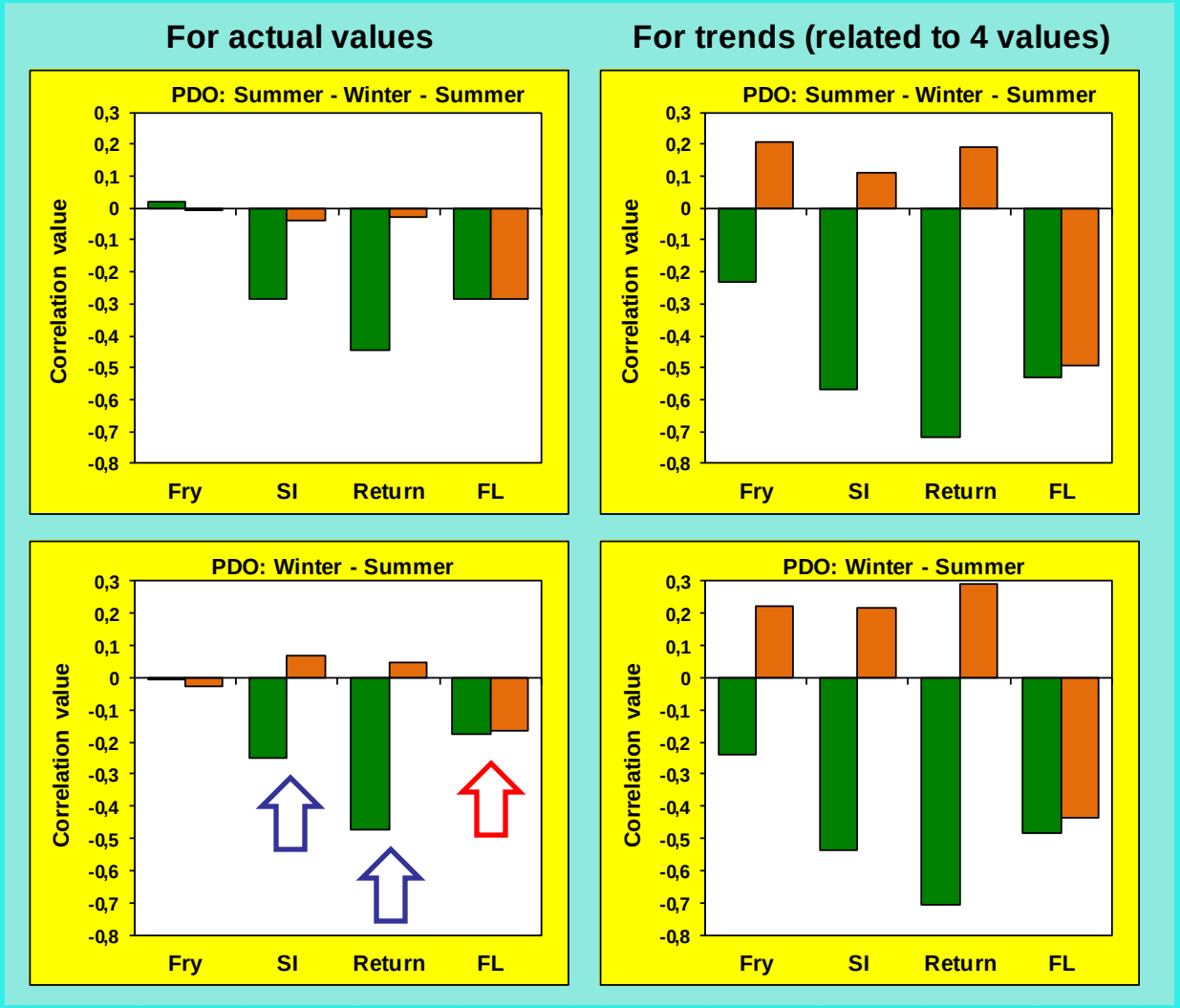
I just want to draw your attention to some details in respect of pink salmon. This slide shows the values of correlation between changes in pink salmon state and winter index "Cold Type". Reducing return of generations that survived in the cold winters can be regarded as a casual coincidence with the general process of forming the abundance of pink salmon.

The correlation between the number of "cold" decades in winter and: reproduction efficiency in rivers (RI), abundance of fry migrants, and return of pink salmon for South Sakhalin [green] and Iturup Island [orange]



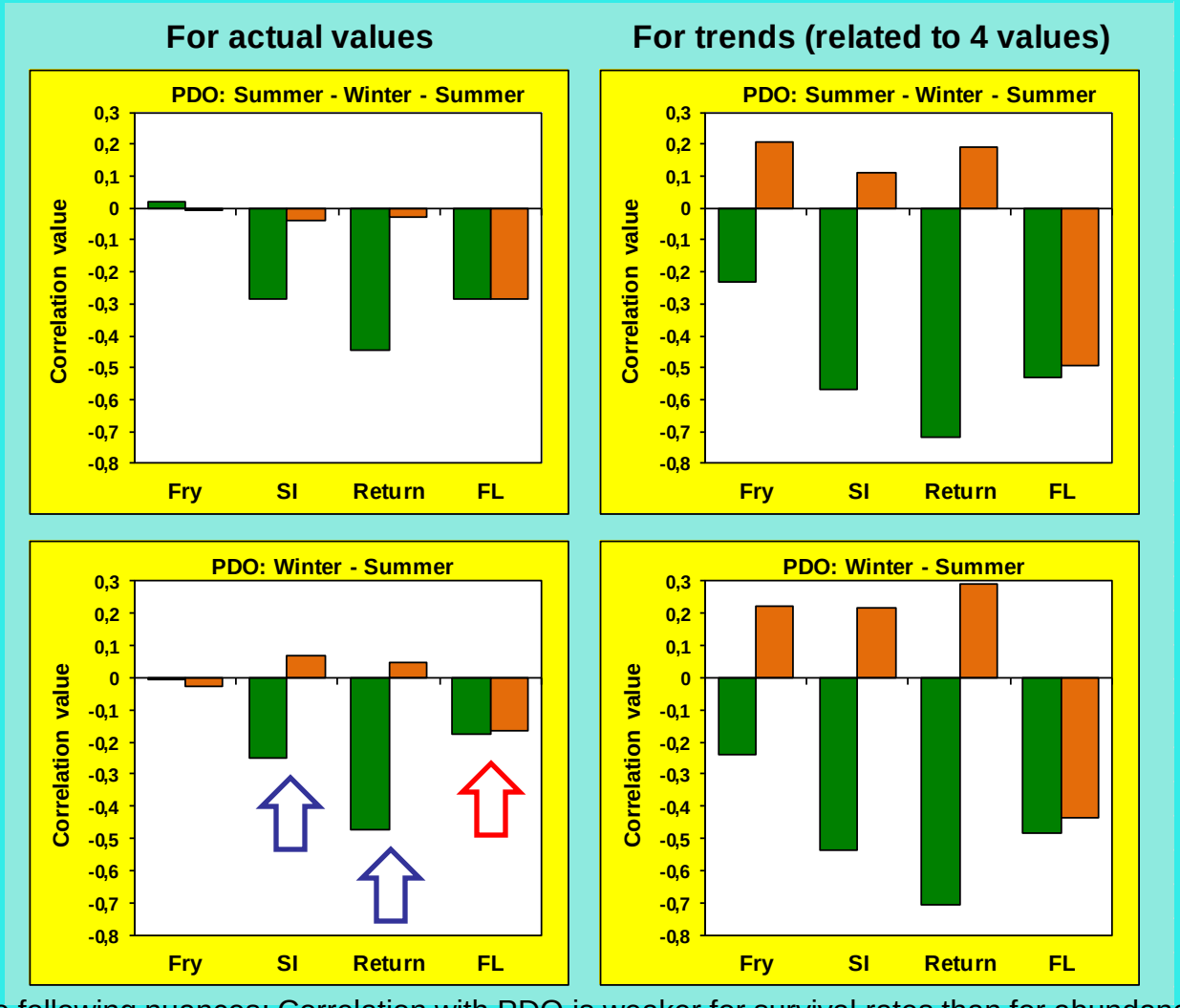
Since the correlation with juveniles abundance is much weaker and has different signs for Iturup and Sakhalin. Moreover, cold or warm winters have no significant effect on survival from spawning to downstream migration.

The correlation between PDO and: abundance of fry migrants, marine survival (SI), return, and length (FL) of pink salmon for South Sakhalin [green] and Iturup Island [orange]



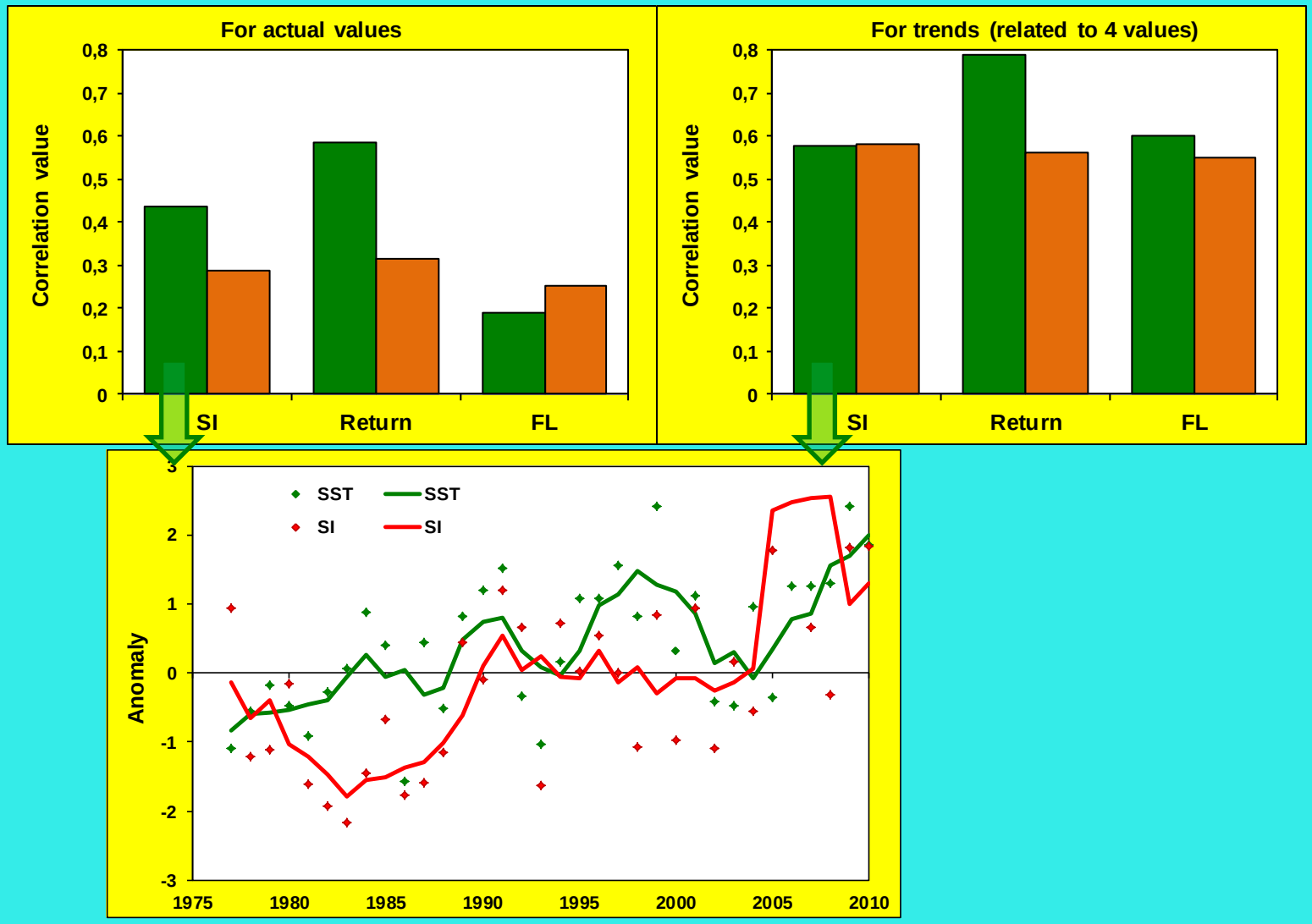
This slide shows the correlation with PDO. There is not much difference whether we use PDO values for the entire marine period of pink salmon, i.e., in the Sea of Okhotsk and the Pacific, or only in the Pacific.

The correlation between PDO and: abundance of fry migrants, marine survival (SI), return, and length (FL) of pink salmon for South Sakhalin [green] and Iturup Island [orange]



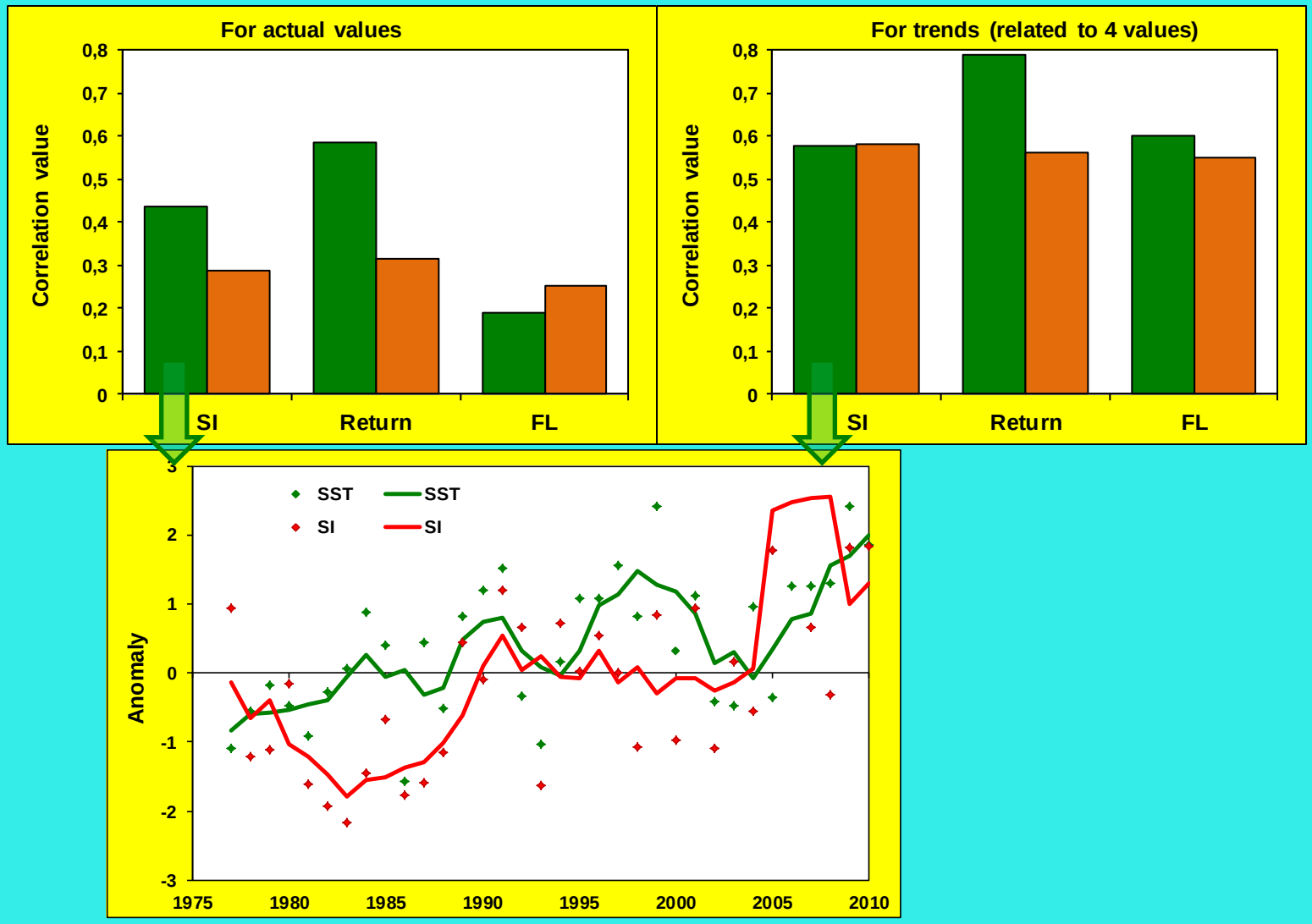
Will you pay attention to the following nuances: Correlation with PDO is weaker for survival rates than for abundance of pink salmon. It is clear that pink salmon returns first depend on fry abundance, and then on their marine survival. Relationship of abundance and survival of pink salmon from different regions with PDO varies significantly, while for fish length it is almost equal. It is clear that similar changes in fish length reflect similar habitat conditions in the open sea waters. But the index of survival seems to be more associated with the coastal lifespan, where local, provincial factors are of the great importance.

Correlation between SST and: marine survival (SI), return, and length (FL) of pink salmon for South Sakhalin [green] and Iturup Island [orange]



This slide shows the correlation with SST. Here the relationship with return is also higher than with survival. However, the relationship with survival index is the strongest compared to other options.

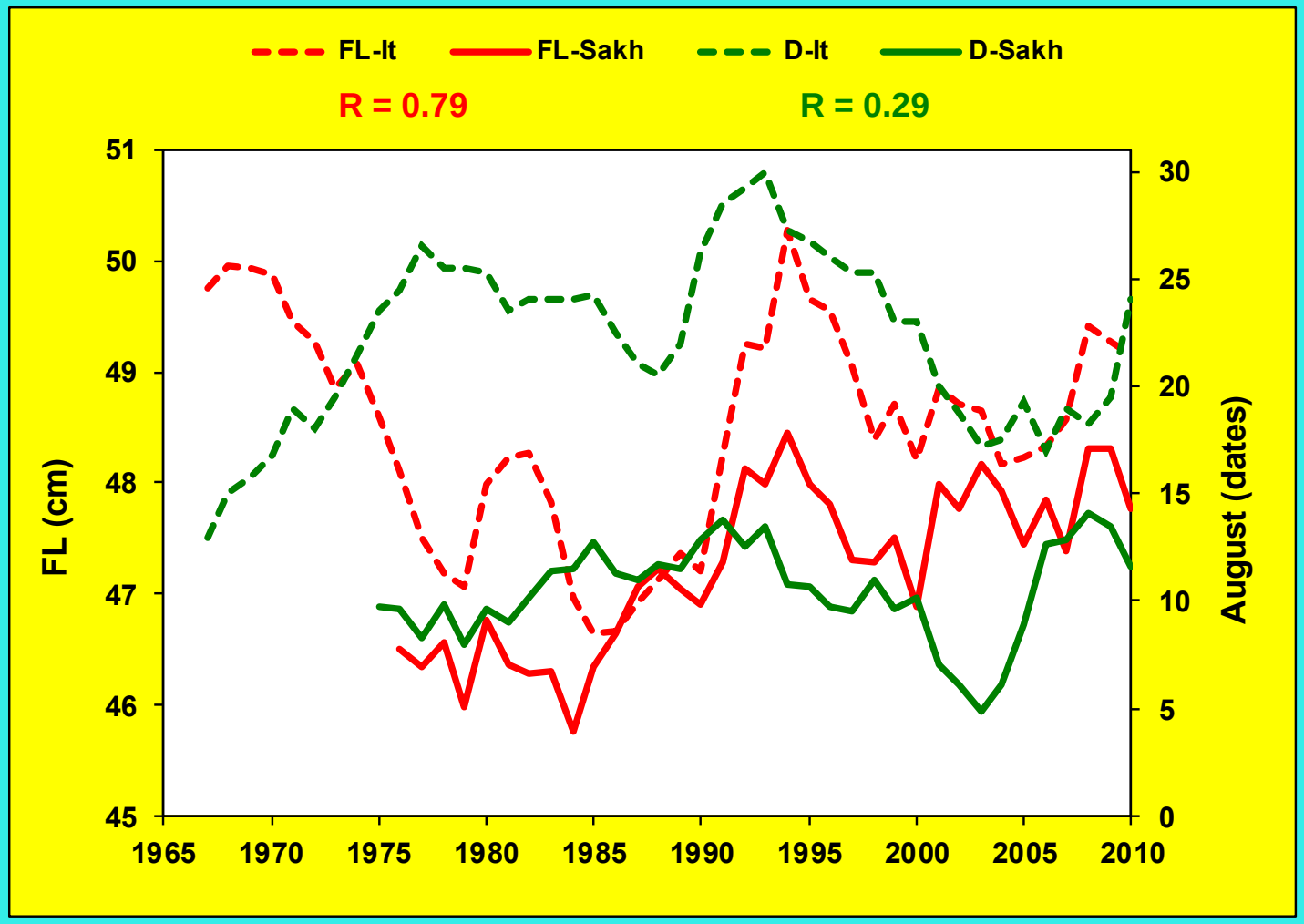
Correlation between SST and: marine survival (SI), return, and length (FL) of pink salmon for South Sakhalin [green] and Iturup Island [orange]



But in this case as well, it is insufficient for a reliable forecast, because in some periods there are very large differences. When compared with the global climatic indices, the same directed changes in pink salmon from different areas are marked only for fish length that is explicable in terms of their living in similar conditions in the ocean. In this view, we can consider changes in the timing of pink salmon approaches to the coast.

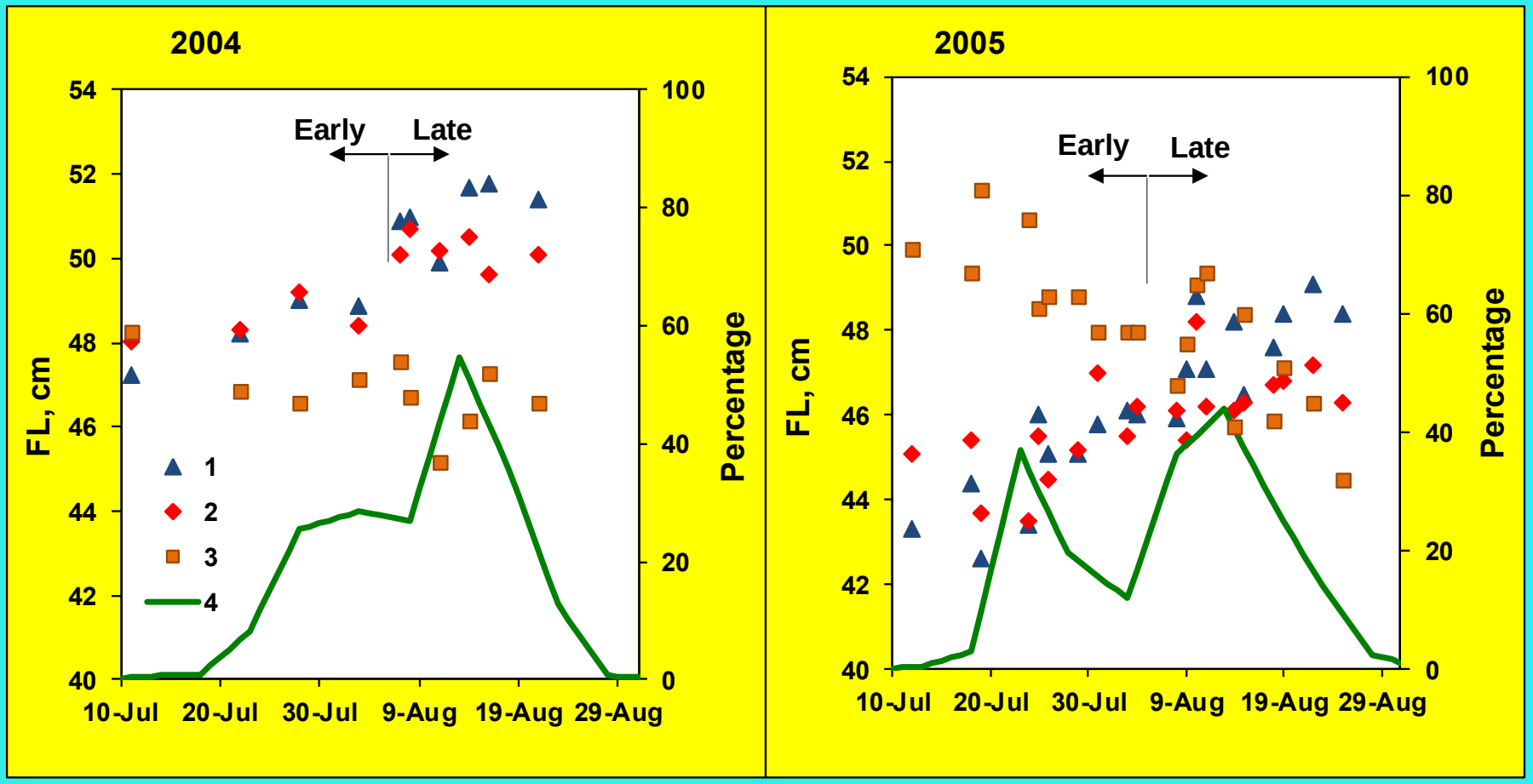
Changes in fork length (FL) and migration timing (D: date of the 50% capture) for Iturup (It) and South Sakhalin (Sakh) pink salmon in 1967-2010

(Data are presented as a 4-year running average)



This slide shows that changes in directions in the long-term trends of fish length and migration timing happened more or less simultaneously for pink salmon in different areas. However, the coherence of changes for pink salmon migration timing in different areas is easy to be criticized, because the correlation is much weaker than that between the changes in fish length. And there are the reasons. When studying the trends, we usually use indices that characterize the studied stock of pink salmon as a whole.

Changes in catch, length and sex composition of pink salmon in Aniva Bay in 2004-2005 : 1 – FL males, 2 – FL females, 3 – percentage of males (%), 4 – capture (‰)



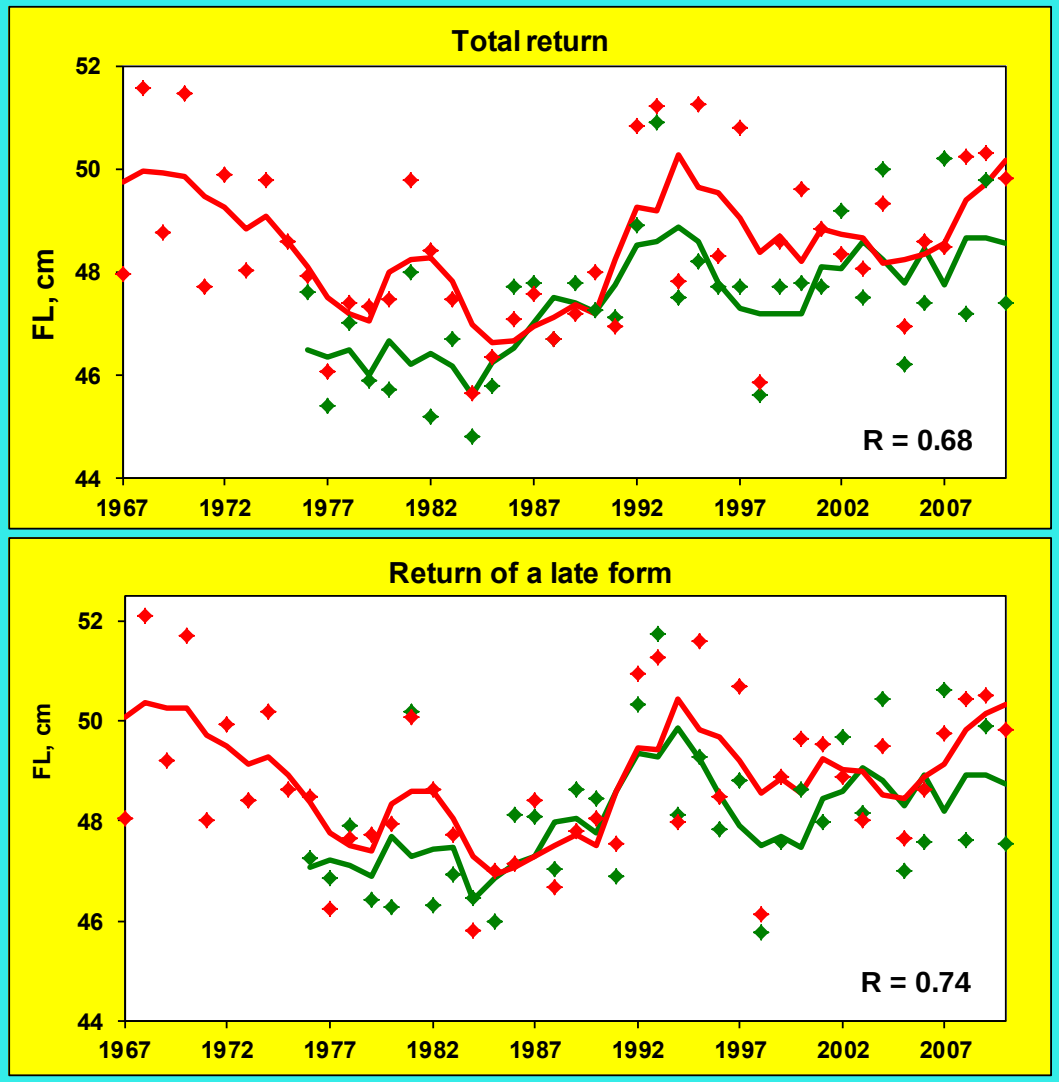
However, a stock of pink salmon is not uniform. In the Sakhalin-Kuril region, two forms of pink salmon, early and late, follow each other. To date, these forms are most studied in two areas - Aniva Bay and Iturup Island. This slide shows the dynamics of pink salmon run to Aniva Bay for two years. To identify the changing forms, we use catch dynamics, proportion of males and fish length.

Mean length of fish, absolute and relative fecundity of females for early and late forms of pink salmon over the observation period in Aniva Bay and on Iturup Island

Indices		Early form		Late form		*F*
		M	*SD*	*M*	*SD*	
Aniva Bay, *N*=20 (4.1 - 7.3 - 12.9)*						
Males:	FL, cm	45.0	1.71	48.9	1.84	47.9
Females:	FL, cm	46.4	1.34	48.1	1.23	16.9
	Fecundity	1453	133	1379	89	4.3
	Fecundity/FL	31.3	2.31	28.6	1.42	19.3
Iturup Island, *N*=32 (4.0 - 7.1 - 12.0)*						
Самцы:	FL, cm	46.7	1.66	48.6	1.84	17.6
Самки:	FL, cm	48.9	1.07	48.8	1.37	0.0
	Fecundity	1550	102	1417	133	20.4
	Fecundity/FL	31.7	1.79	29.0	2.28	28.3

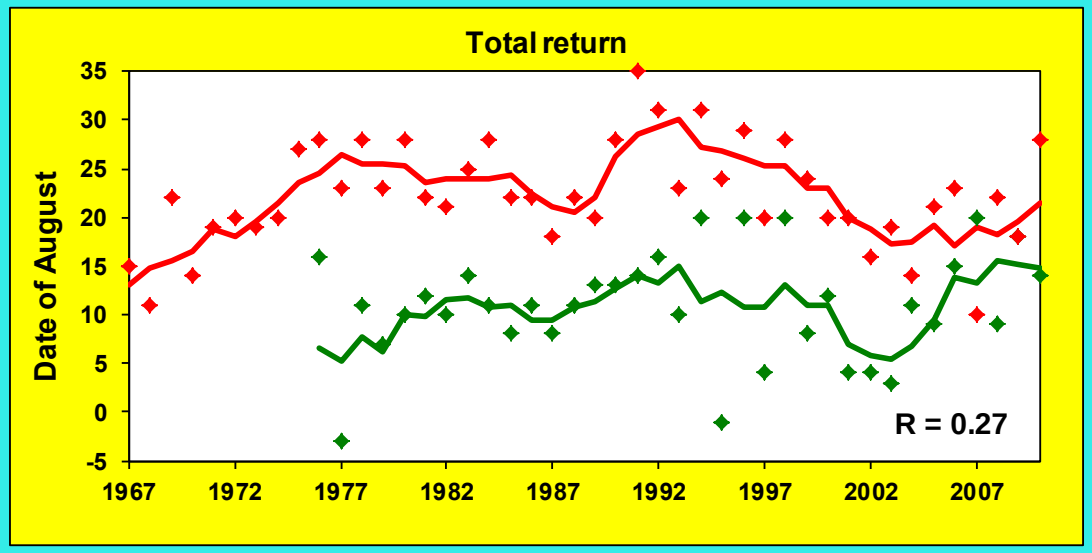
The appearance of the late form is usually accompanied by significant increase in male sizes, while the length of females may remain unchangeable. Pink females of the late form have a lower fecundity per unit body length, while their absolute fecundity may change not very much. Ratio of early and late forms may vary greatly by years in the migratory flow of pink salmon. How does this affect indices of pink?

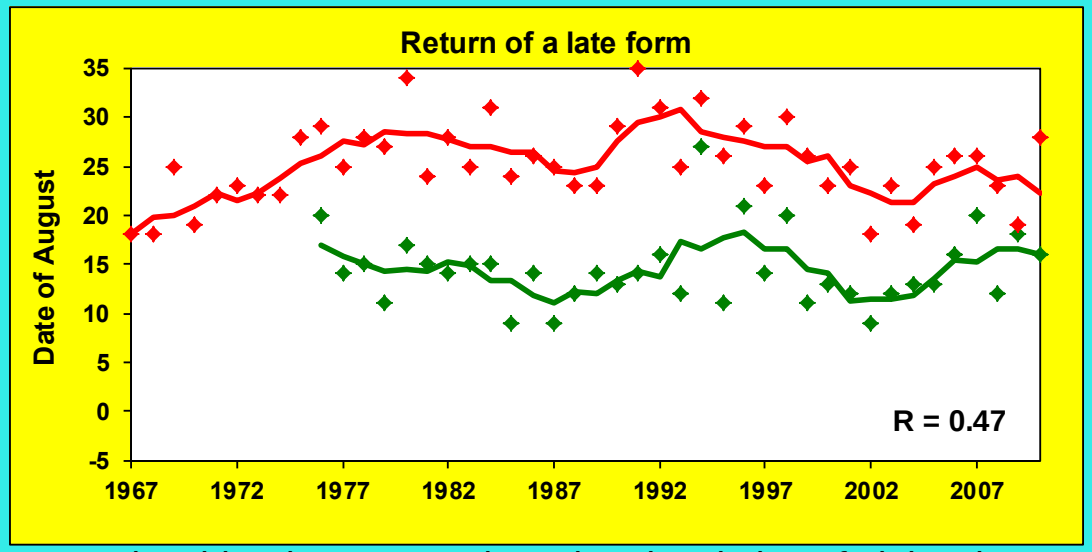
Annual changes in pink salmon length in Aniva Bay (green) and on Iturup Island (red) in 1967-2010



This slide compares annual changes in pink length from different areas, calculated for the totality of fish. And this is only for the late form. As you can see, changes in fish length in different areas have become more coherent.

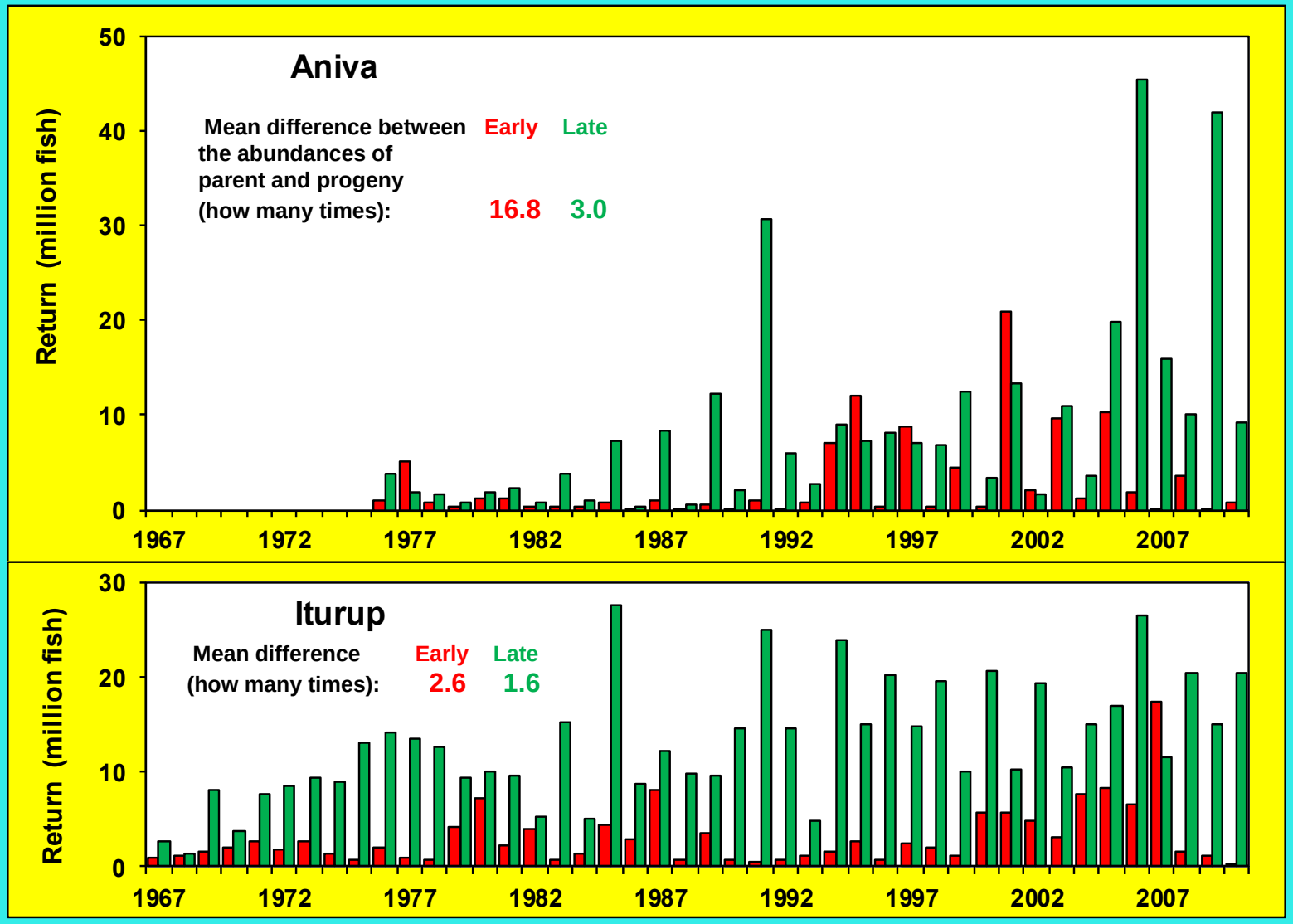
Annual changes in pink salmon migration timing (D: date of the 50% capture) in Aniva Bay (green) and on Iturup Island (red) in 1967-2010





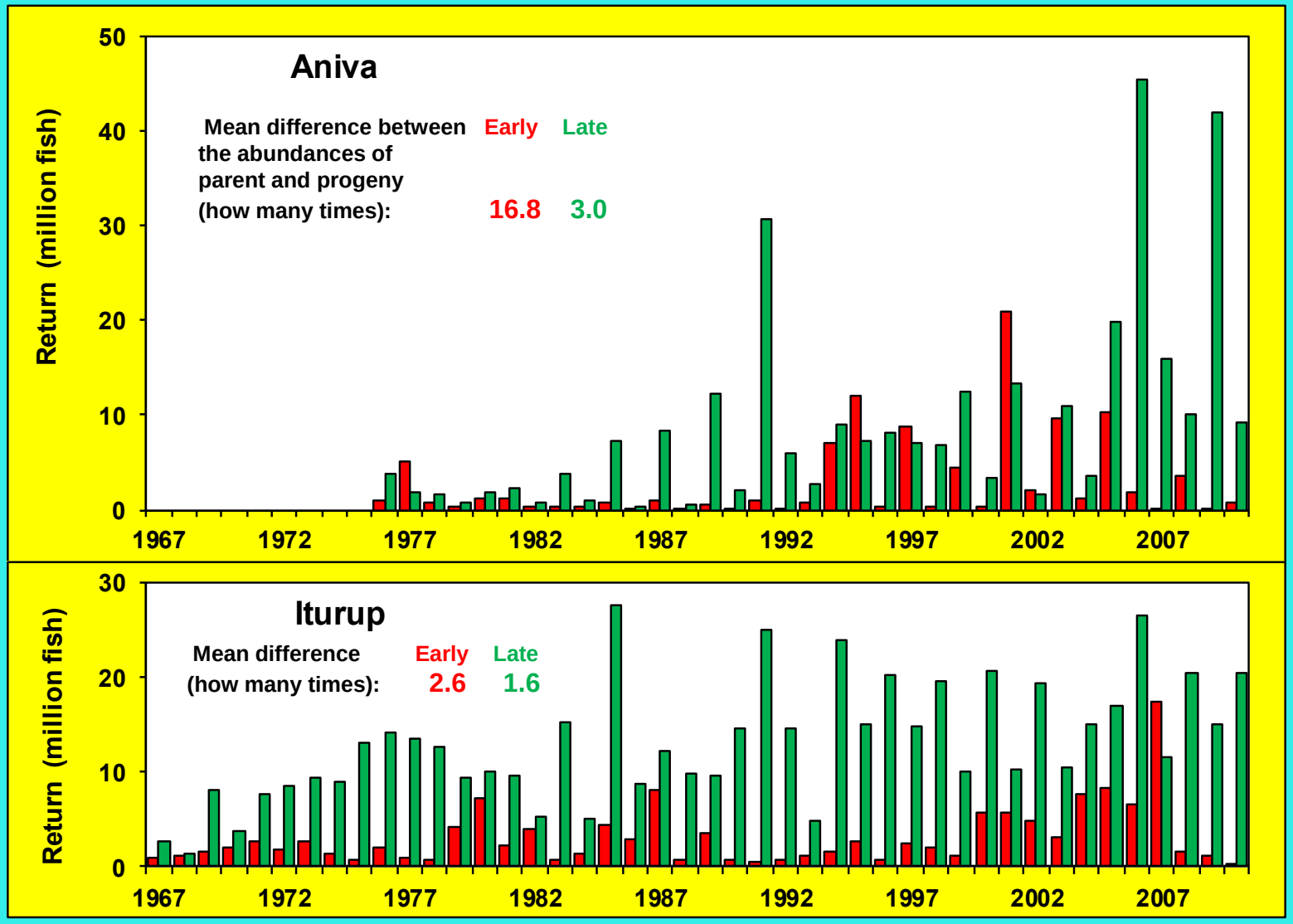
The changes are even more noticeable when comparing migration timing of pink salmon. This is for the totality of fish. And this is only for the late form. That is, the changes in migration timing in different regions have appeared to be more similar as well.

Ratio of early [red] and late [green] forms of pink salmon in Aniva Bay and on Iturup Island in 1967-2010



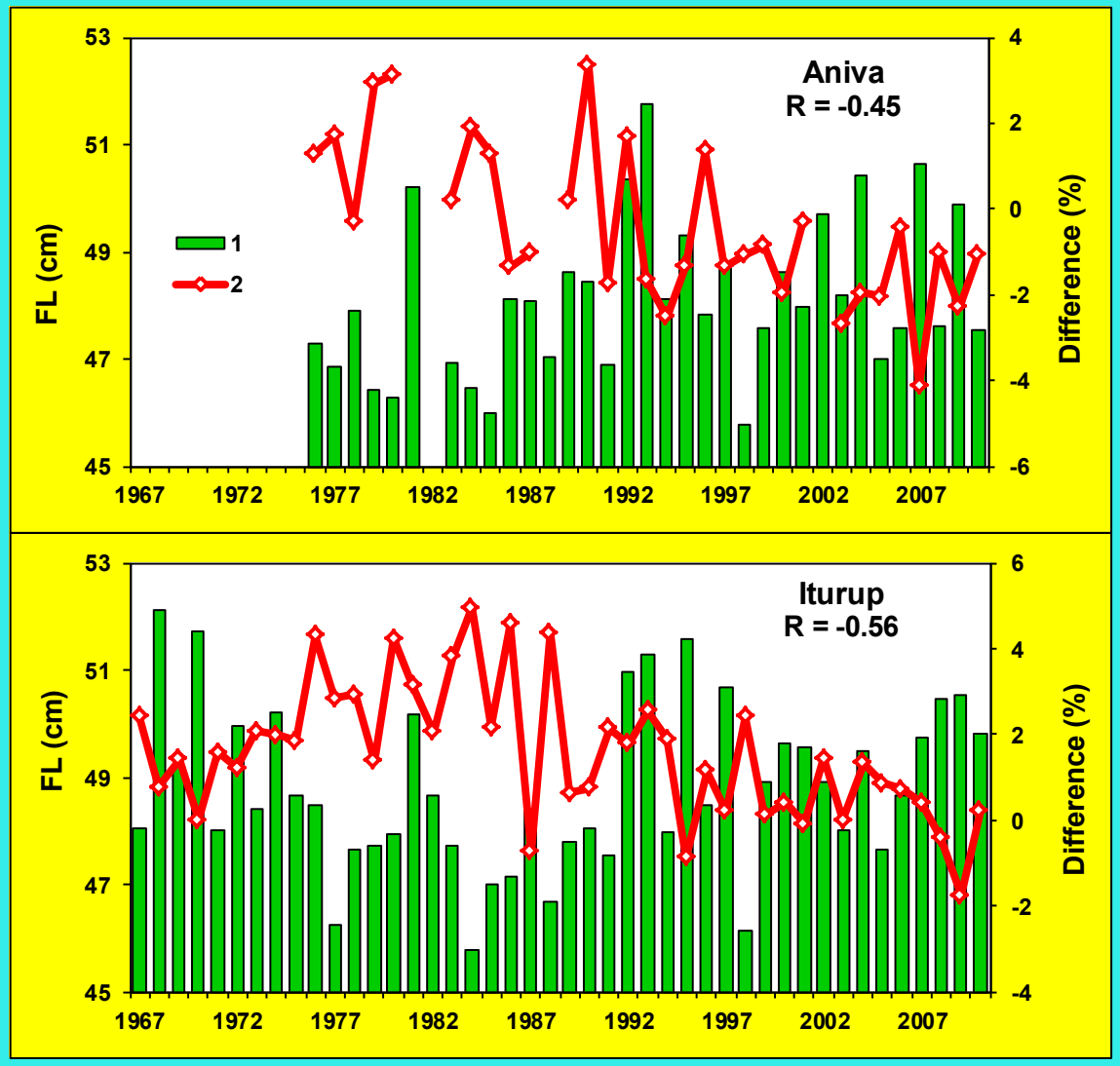
Judging from the fact that the mean abundance of the early form is lower and changes greater by years, the larger number of eggs produced by the early-form females reflects the higher mortality. The long-term trends of abundance of both forms in Aniva Bay and on Iturup Island are weakly agreed not only with changes in climatic indices, but also among themselves. I will not bore you with a demonstration of these weak dependencies.

Ratio of early [red] and late [green] forms of pink salmon in Aniva Bay and on Iturup Island in 1967-2010



However, studying the pink in the light of its different seasonal forms allowed us to reveal some interesting nuances. For a long time I could not understand why in contrast to chum salmon we fail to find pink response which counteracts the worsening conditions of feeding.

Annual changes in fish length (1) and ratio of male and female length (2) for pink salmon in Aniva Bay and on Iturup Island in 1967-2010

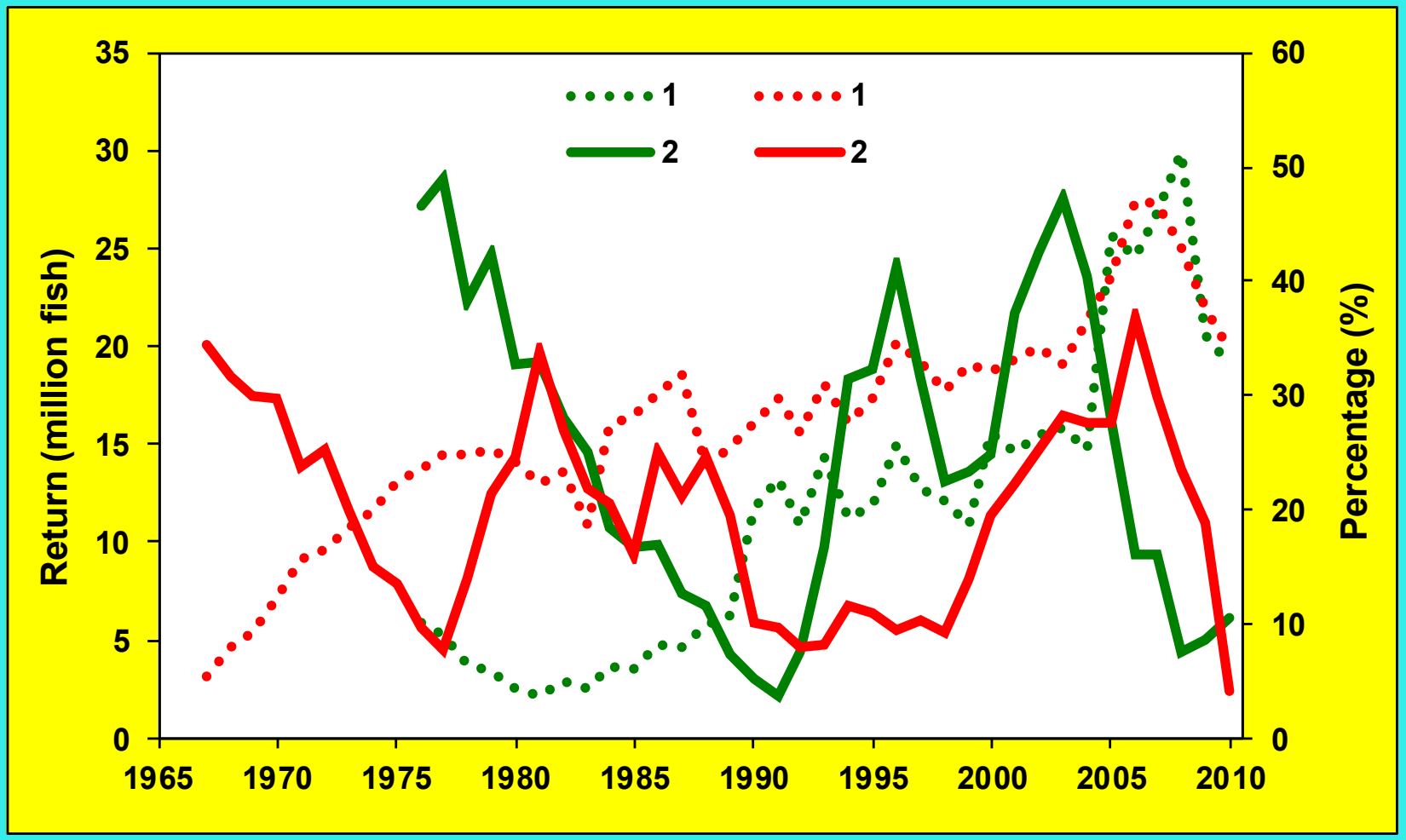


$$\text{Difference (\%)} = 100\,\frac{(FL_{female} - FL_{male})}{(Fl_{total})}$$

Only after examining the data appropriate to different pink forms I have obtained such a result. Females became relatively larger than males when growth was slowed. Taking into account a positive relation between female length and fecundity, this feature may be considered as a population response, which allows supporting reproduction when feeding conditions change for the worse.

Annual changes in returns (1) and proportion of the early pink salmon form (2) in Aniva Bay (green) and on Iturup Island (red) in 1967-2010

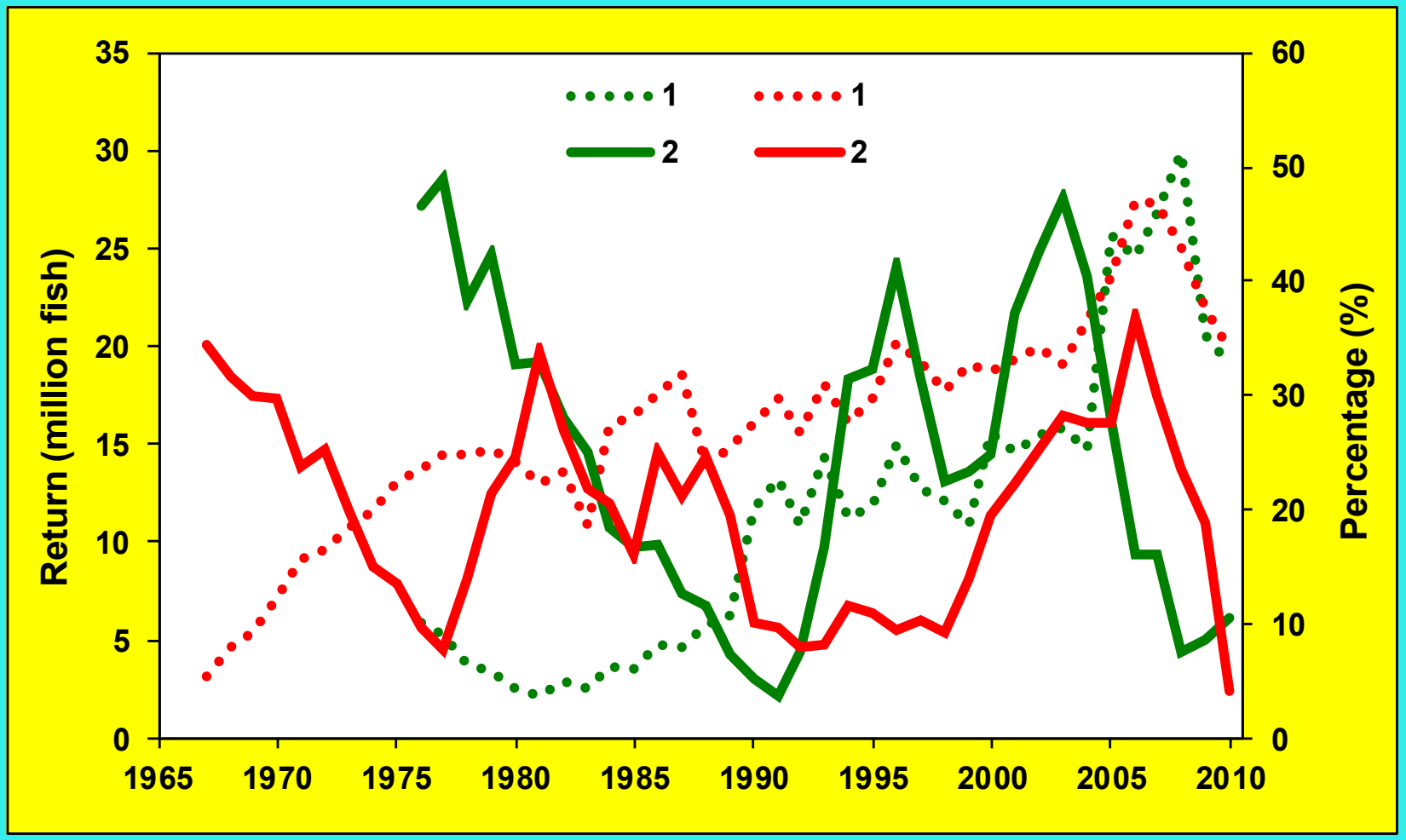
(Data are presented as a 4-year running average)



This slide shows one more result of studying the different forms of pink. Changes in the ratio of different forms of pink have the long-term trends and their directions in different areas coincide only for individual periods. Judging from the changes in abundance, the early form of pink is less resistant to environmental changes. Therefore, a synchronous decline in proportion of this form in different areas can be viewed as a warning of reducing the total abundance of pink salmon.

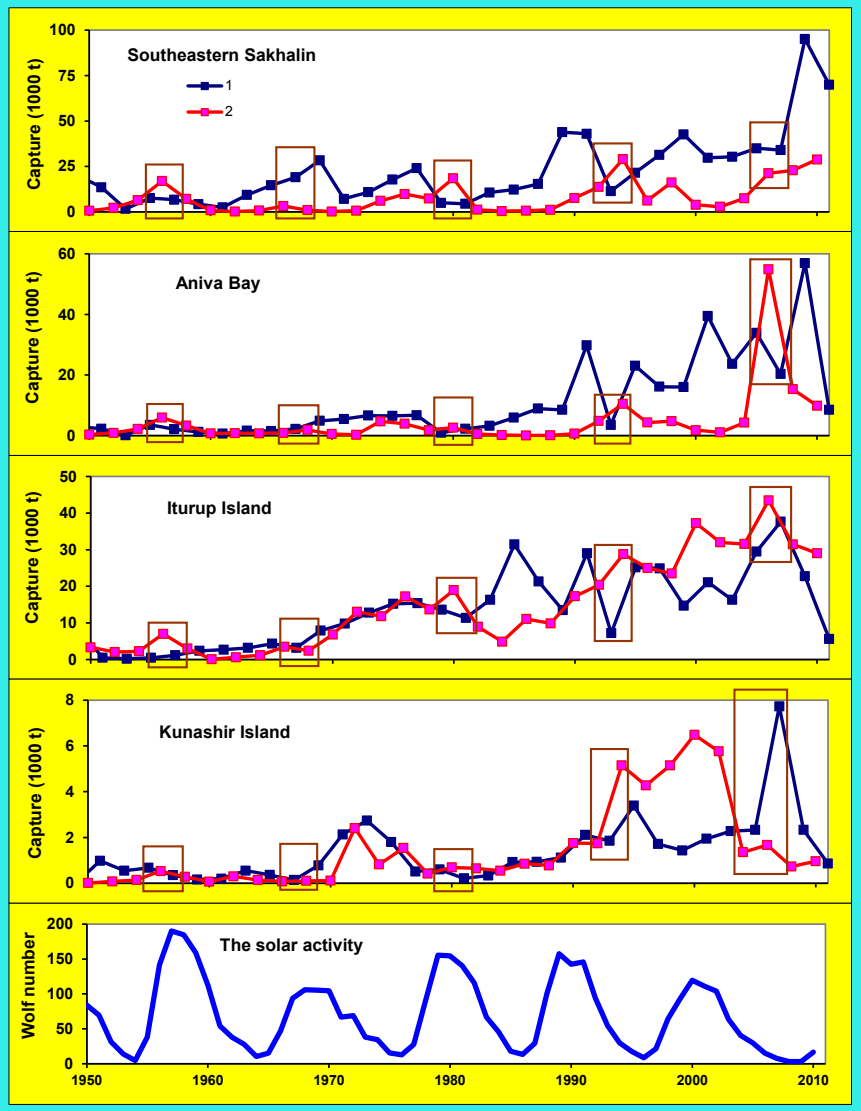
Annual changes in returns (1) and proportion of the early pink salmon form (2) in Aniva Bay (green) and on Iturup Island (red) in 1967-2010

(Data are presented as a 4-year running average)



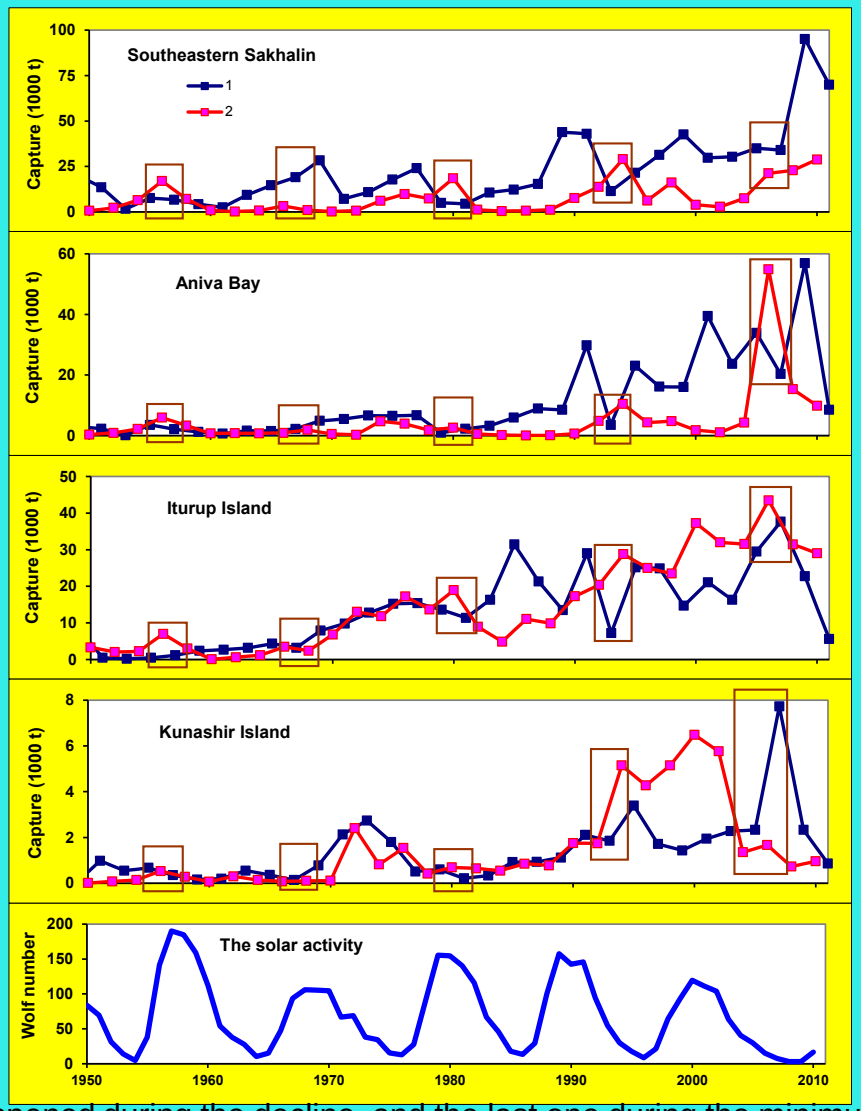
During the synchronous decrease in proportion of the early form, there was a decline in pink salmon abundance in the 1980s, especially noticeable on Sakhalin Island, and even a change of dominant lines on Iturup Island in 1993. Since 2005, again a synchronous decrease in proportion of the early form has been observed. Probably, this should be followed by the reduction in catches. And it seems that this process has already started.

Solar activity and dynamics of pink salmon catches in odd (1) and even (2) years in southern areas of Sakhalin Region in 1950-2011



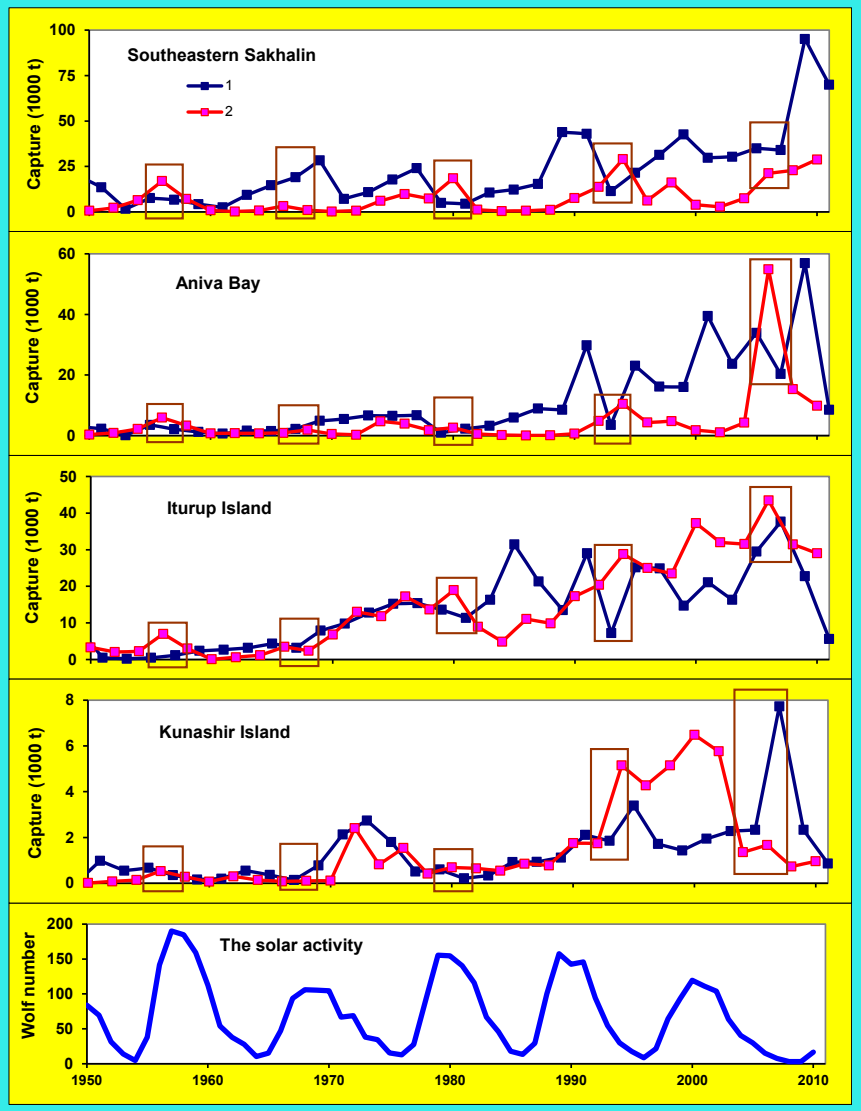
This slide shows an 11-year periodical solar cycle which, in the opinion of a lot of researchers, determines the wave long-term changes in salmon abundance. There are marked the simultaneously appeared failures in catch dynamics under which a short-term or periodic change in dominant lines was noted. First, they actually coincided with the maxima of solar activity.

Solar activity and dynamics of pink salmon catches in odd (1) and even (2) years in southern areas of Sakhalin Region in 1950-2011



However, next to the last failure happened during the decline, and the last one during the minimum of solar activity. That is, there is no explicit synchronization. Under the last failure, changes in abundance between parent and progeny generations, as well as between even and odd years, strike by their scale. These abrupt changes in catches as a sign of instability of the environment, as well as the subsequent decline have coincided with their synchronous decline in proportion of the early form of pink salmon in different areas.

Solar activity and dynamics of pink salmon catches in odd (1) and even (2) years in southern areas of Sakhalin Region in 1950-2011



If this hypothesis is true, its statistical evidence will not be soon. Now this is only an intuitive sense. I proceed from the assumption that pink salmon may respond to the environmental processes earlier than we begin to notice them. After all, pink feel the environment better than we with our standard research methods. ***Thank you for your patience!***