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A comparison of fish community and trophic structure from three marine ecosystems around Japan: Synchronies, differences and environmental forcing

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Outline

- **Background and Objectives:**

  Features of the three marine ecosystems

- **Variability in the fish community structure**

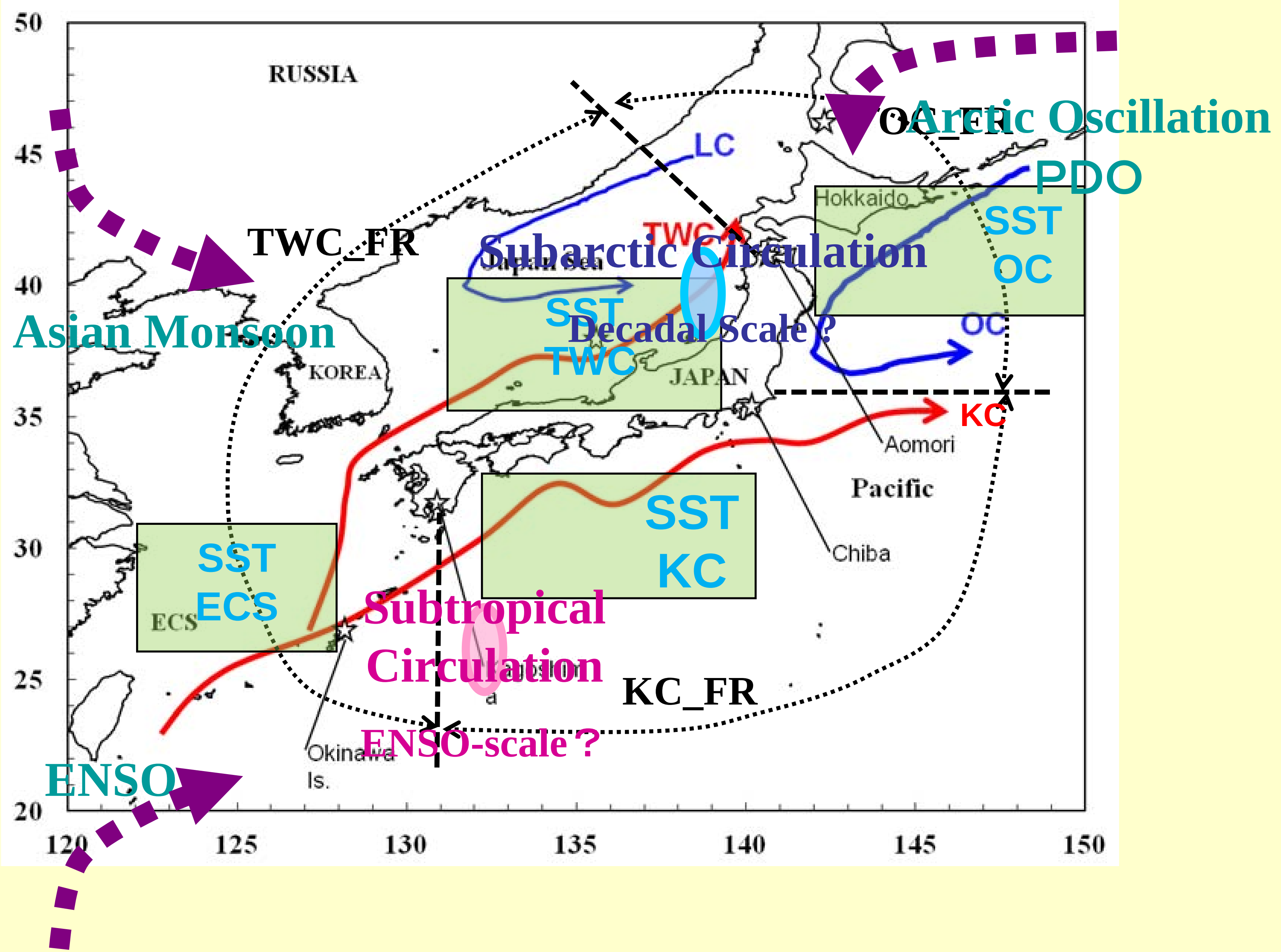
  A comparison between the three ecosystems from PCA result and community index

- **Impacts of climate variability**

  GAM (Generalized Additive Model) determined environmental forcing

- **Summary**

Oceanographic structure and fisheries region



Re… …WC

The late 1980s regime shift was the most evident change in TWC, seemed different with the mid-1970s regime shift in the North Pacific. Even within an ecosystem such as TWC, response to climate regime shift is species-specific, and the forcing is different.

Our question:

What is the difference and the similarity between ecosystems?

cold 1980s ← regime shift → warm 1990s

Tian et al. (2008)

Objective

- **To identify the variability in the three marine ecosystems (TWC, KC and OC) around Japan using common approach.**

To make a comparison between the three ecosystems to determine the synchronies, differences and environmental forcing.

Selection of Indicator Species

25 commercially important species from small pelagic to large predatory fishes with different trophic level and habitat are selected to representing the ecosystem

Groups	Tsushima	Kuroshio	Oyashio
Large Predatory Species (8 taxa)	Swordfishes and billfishes	*Same*	Same
	Bluefin tuna	*Same*	*Same*
	Albacore	*Same*	*Same*
	Yellowfin tuna	*Same*	*Same*
	Frigate mackerel	*Same*	*Same*
	Sharks	*Same*	*Same*
	Yellowtail	*Same*	*Same*
	Japanese-Spanish mackerel	*Same*	Salmons & trouts
Small Pelagic Species (6 taxa)	Japanese sardine	*Same*	*Same*
	Japanese anchovy	*Same*	*Same*
	Round herring	*Same*	Pacific saury
	Horse mackerel	*Same*	Pacific herring
	Chub mackerel	*Same*	*Same*
	Common squid	*Same*	*Same*
Demersal Species (8 taxa)	Walleye pollock	Deepsea smelt	*Same*
	Pacific cod	Flathead mullet	*Same*
	Arabesque greenling	Lizardfish	*Same*
	Largehead hairtail	*Same*	Skates
	Croake	Sand lance	Sand lance
	Bastard halibut	*Same*	*Same*
	Flatfishes	*Same*	*Same*
	Tanner crab	Silver seabream	*Same*
Invertebrates (2 taxa)	Shellfishes	*Same*	*Same*
	Sea urchin	*Same*	*Same*
Seaweeds	Seaweeds	*Same*	*Same*

Total 25 species taxa

Data and Analysis

1. Data sets: 1955-2010

    1)Japanese catch statistics: 25 taxa by fisheries region

    2) SST: JMA data set → area-averaged time series as index of the ecosystem

    3) Four climate indices: AOI, PDO, SOI, and MOI

2. Same analysis done for the three ecosystems

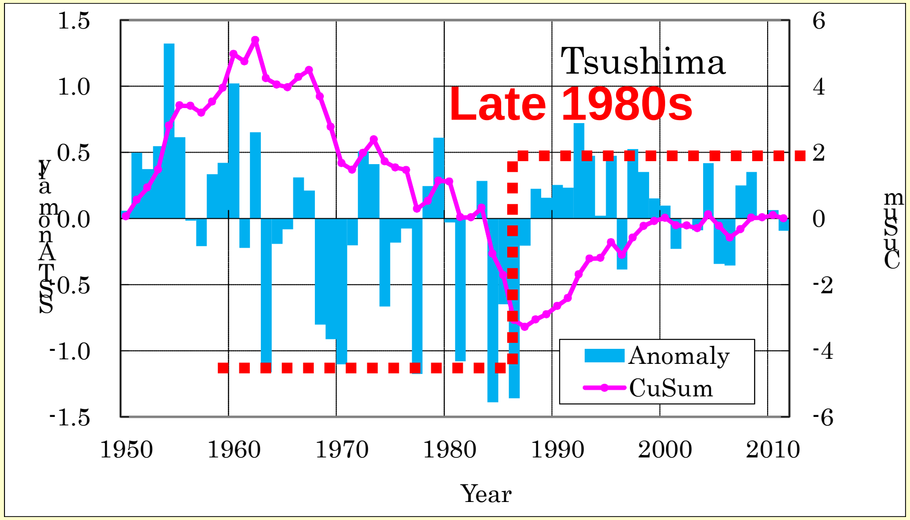
    1)Data transfer: log (catch +1)

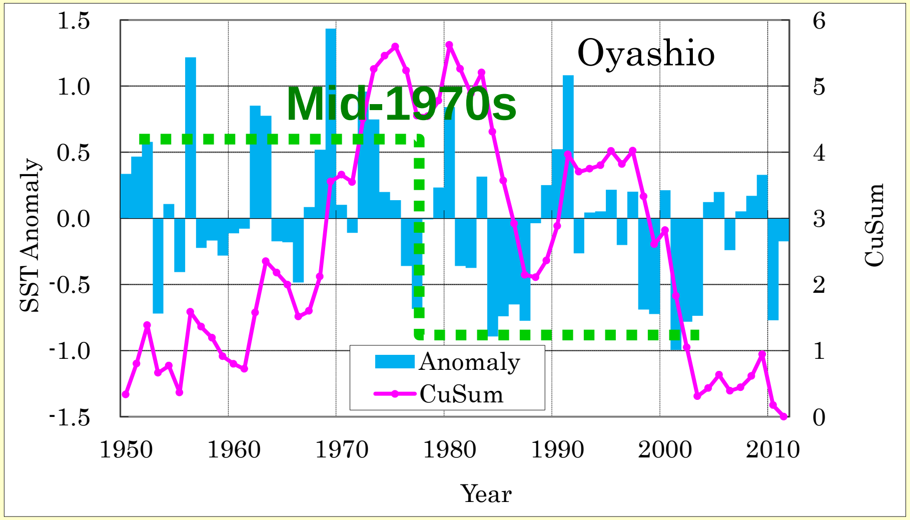
    2)PCA: applied fisheries data to determine the PCs

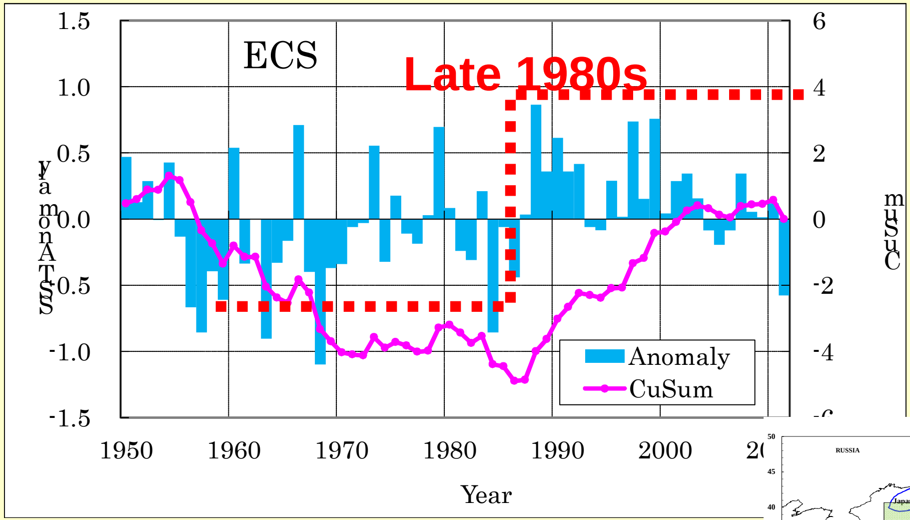
    3)GAM: applied to PCs ~ environmental variables. (AIC was used as model selection.)

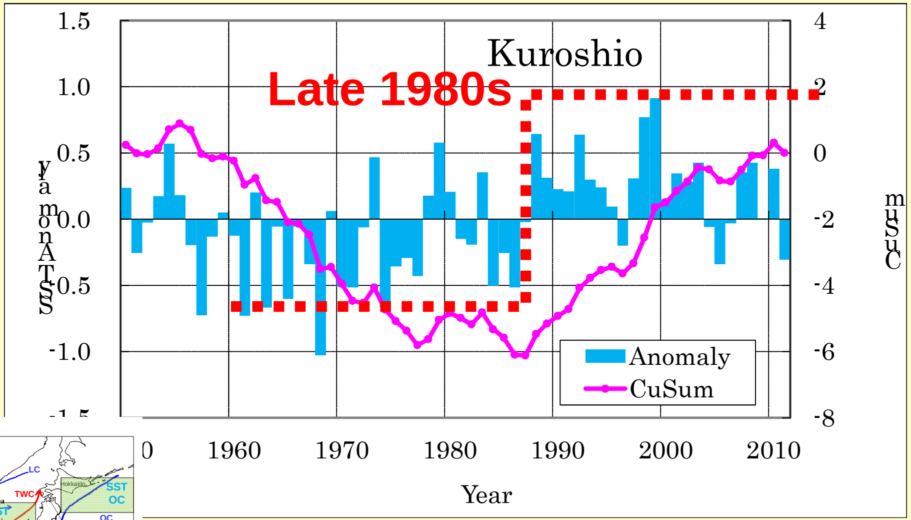
    3)Community index: MTL, DI, FiB and PS/ZS ratio (Tian et al., 2006, 2008)

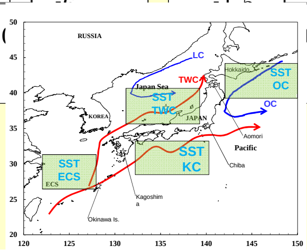
SST trends


Tsushima
Late 1980s
SST Anomaly
CuSum
Year
Anomaly
CuSum

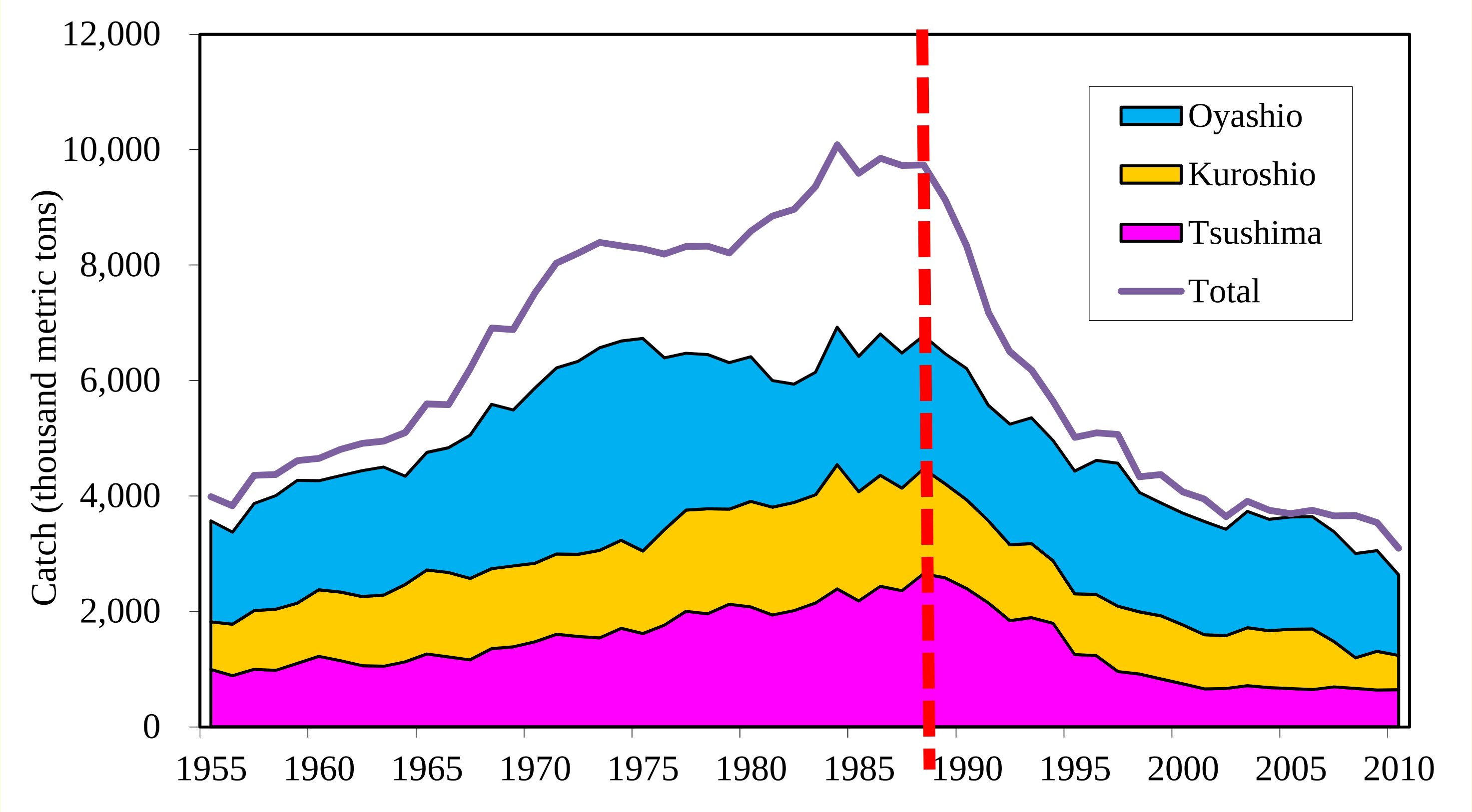

Oyashio
Mid-1970s
SST Anomaly
CuSum
Year
Anomaly
CuSum


ECS
Late 1980s
SST Anomaly
CuSum
Year
Anomaly
CuSum


Kuroshio
Late 1980s
SST Anomaly
CuSum
Year
Anomaly
CuSum


RUSSIA
LC
Japan Sea
TWC
SST TWC
SST OC
OC
KOREA
JAPAN
SST ECS
SST KC
Pacific

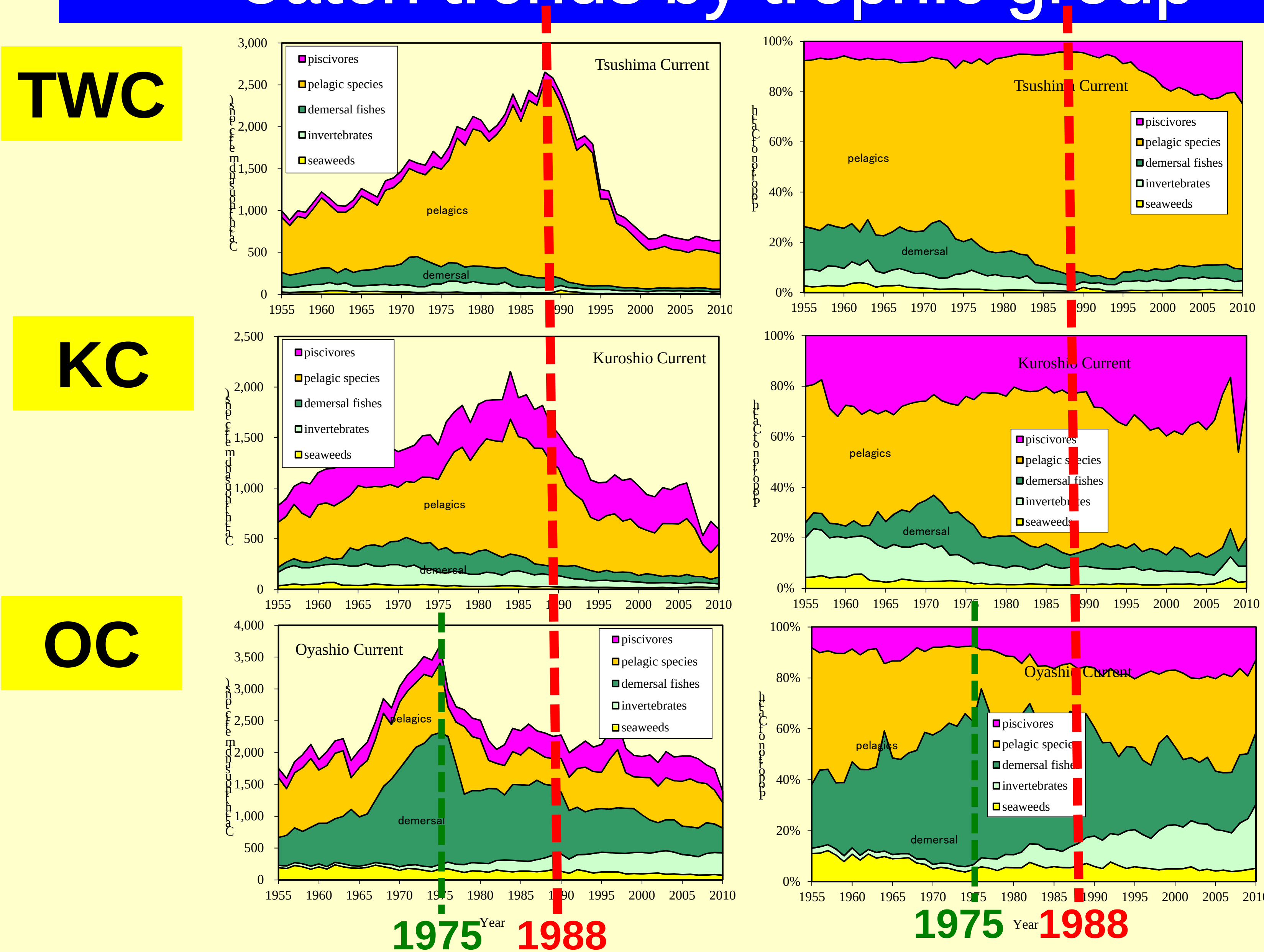
Catch trend by fisheries region



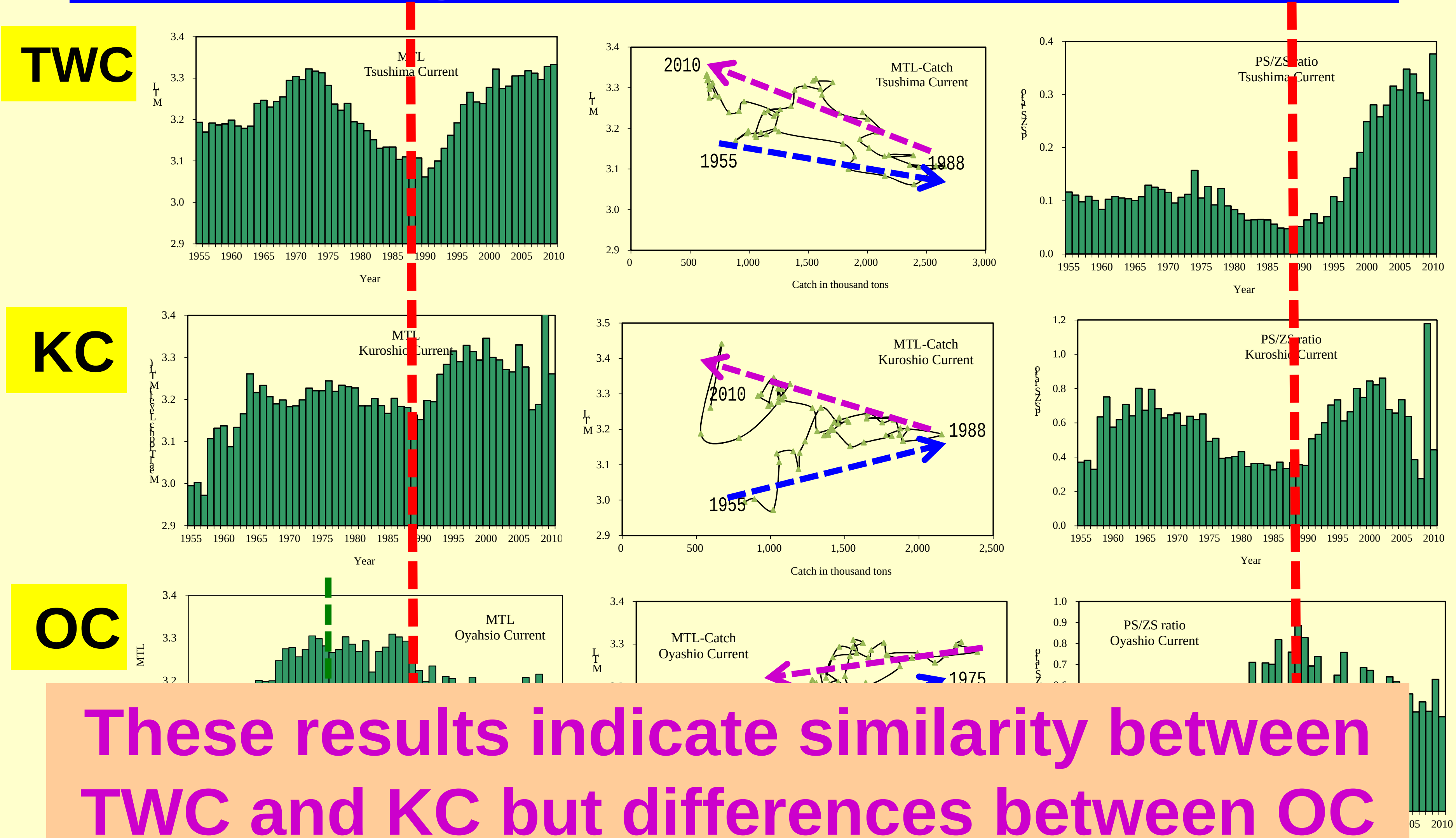
These 25 species from the three regions accounted for about 83% of total Japanese catch, and the trends are generally same to total.

The 25 species are suitable as indicators of ecosystems.

Catch trends by trophic group

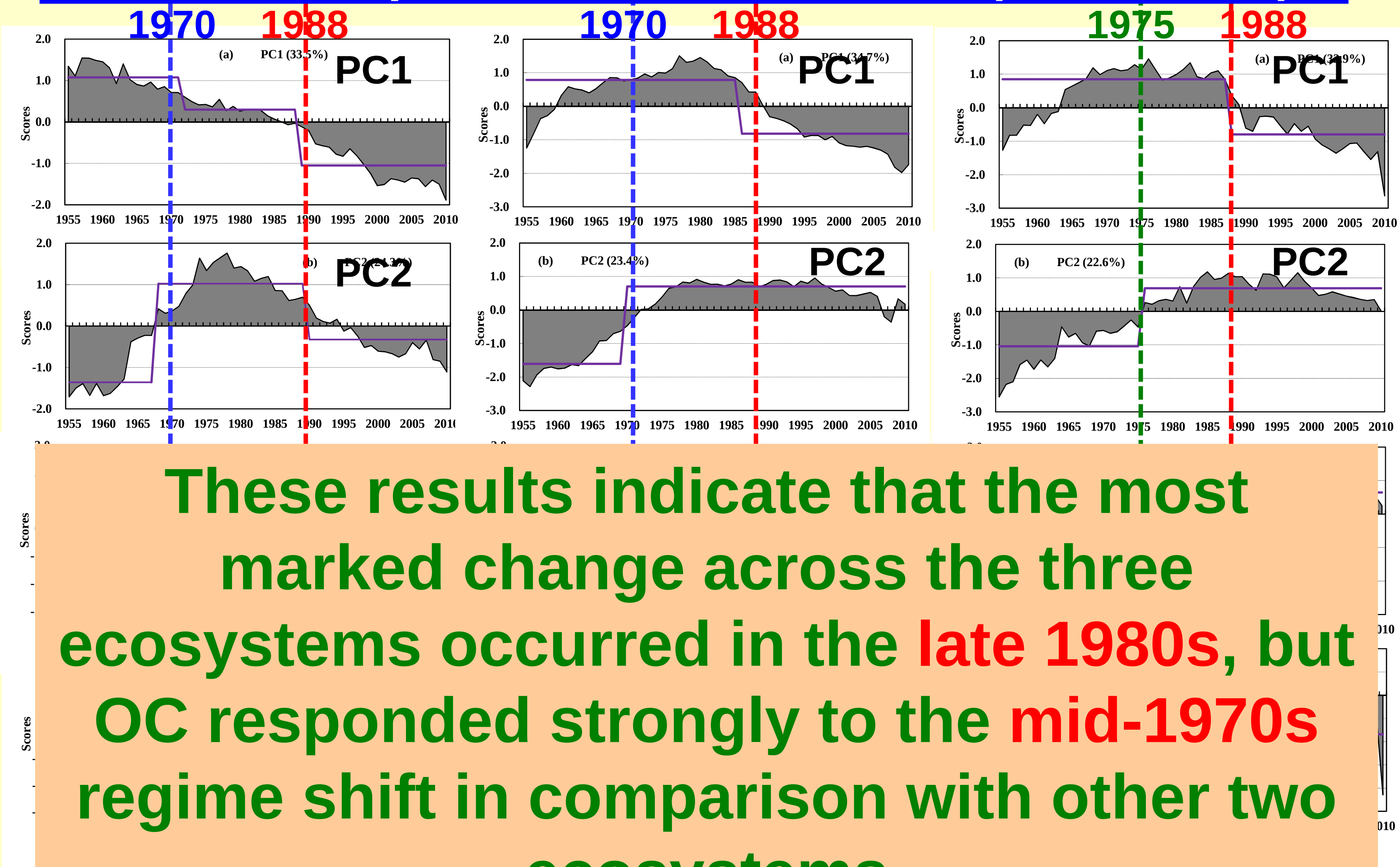


Community index: MTL and PS/ZS ratio



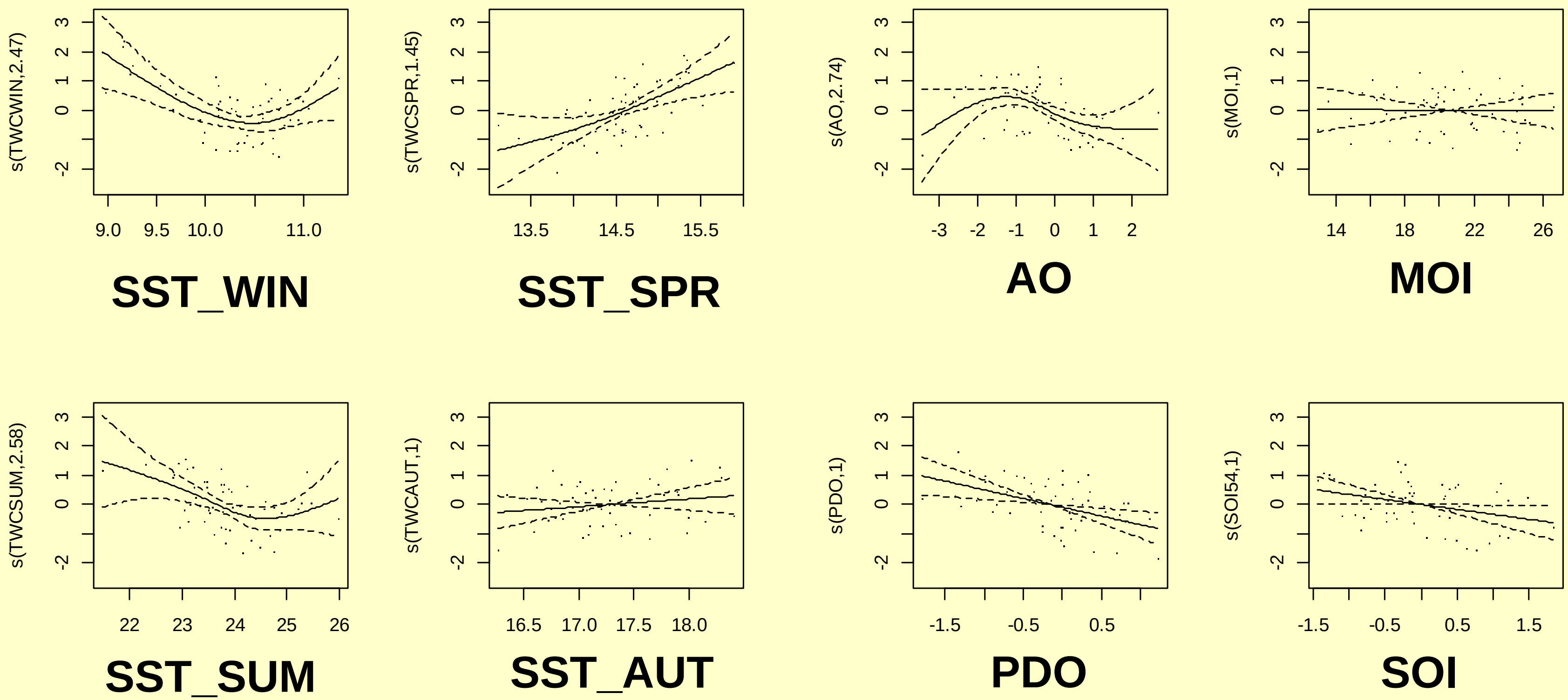
These results indicate similarity between TWC and KC but differences between OC and other two ecosystems.

Variation patterns from PCA (PC1-PC4)



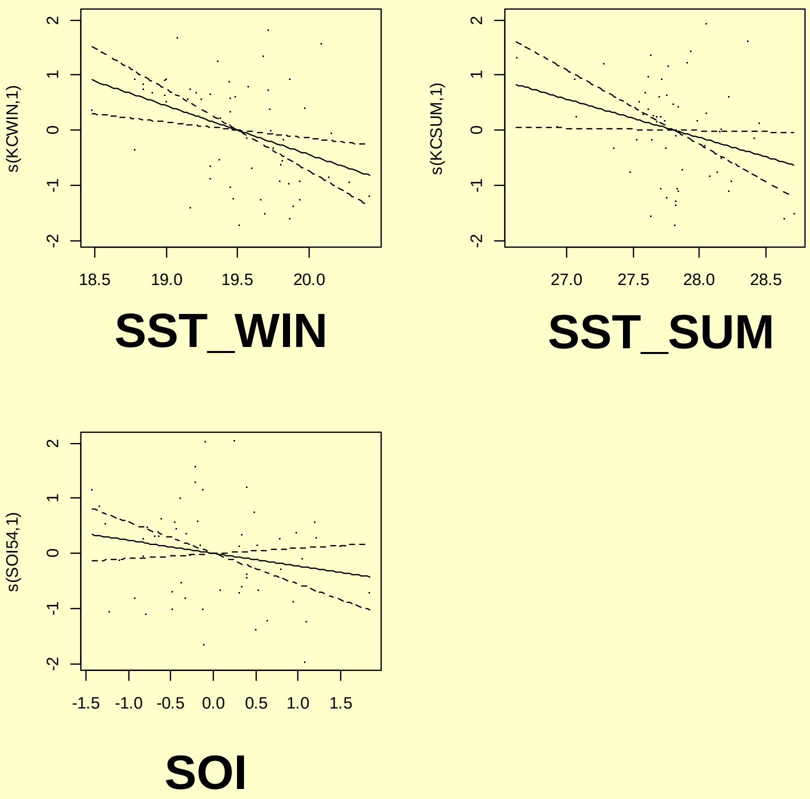
These results indicate that the most marked change across the three ecosystems occurred in the late 1980s, but OC responded strongly to the mid-1970s regime shift in comparison with other two ecosystems

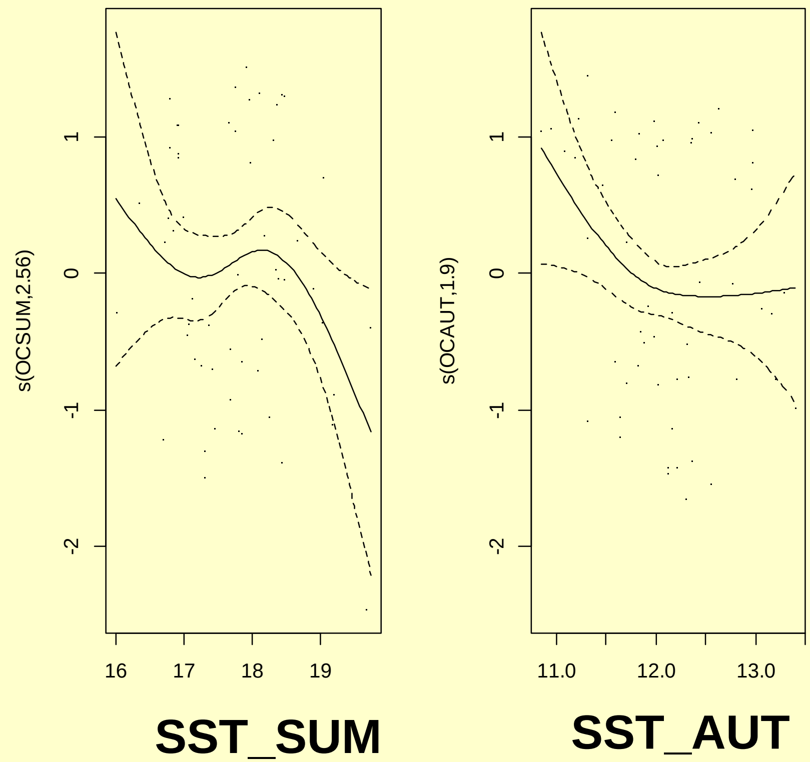
GAM: TWC PC1



Tsushima (model 3): D.E. (Deviance explained)=51.8%

GAM: KC & OC PC1





Kuroshio (Model 5)
D.E. = 24.4 %

Oyashio (Model 6)
D.E =21.6%

Summary of GAM for PC1-3

PCs	Tsushima	Kuroshio	Oyashio
PC1	SST_WIN, SST_SPR PDO, AO, SOI (D.E =51.8%)	SST_WIN, SST_SUM SOI (D.E =24.4.8%)	SST_AUT, SST_SUM (D.E =21.6%)
PC2	SST_WIN, AO (D.E =17.1%)	SST_WIN PDO, AO, SOI,MOI (D.E =44.6.8%)	SST_WIN, SST_SPR PDO, AO (D.E =57.2%)
PC3	SST_WIN, SST_AUT PDO, AO (D.E =37.8%)	SST_WIN, SST_AUT PDO (D.E =54.1%)	SST_AUT PDO (D.E =33.6%)

- SSTs, particularly winter SST have significant and strong effects on PCs across the three ecosystems.
- Climate effects are also significant for some regions

Summary

- A comparison study was done for three marine ecosystems around Japan.
- Community indices indicate similarity between TWC and KC, but difference with OC.
- Variation patterns from PCA indicate synchronies in the three ecosystems around the late 1980s, but OC also strongly respond to mid-1970s regime shift.
- GAMs indicate the importance of regional oceanographic conditions to the variability of fish communities.