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# Regime shifts in the fish assemblages around Japan over the last century and their early warning signals

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# Outline

- **What we had known**

  **Features of the late 1980s regime shift around Japan from our previous studies**

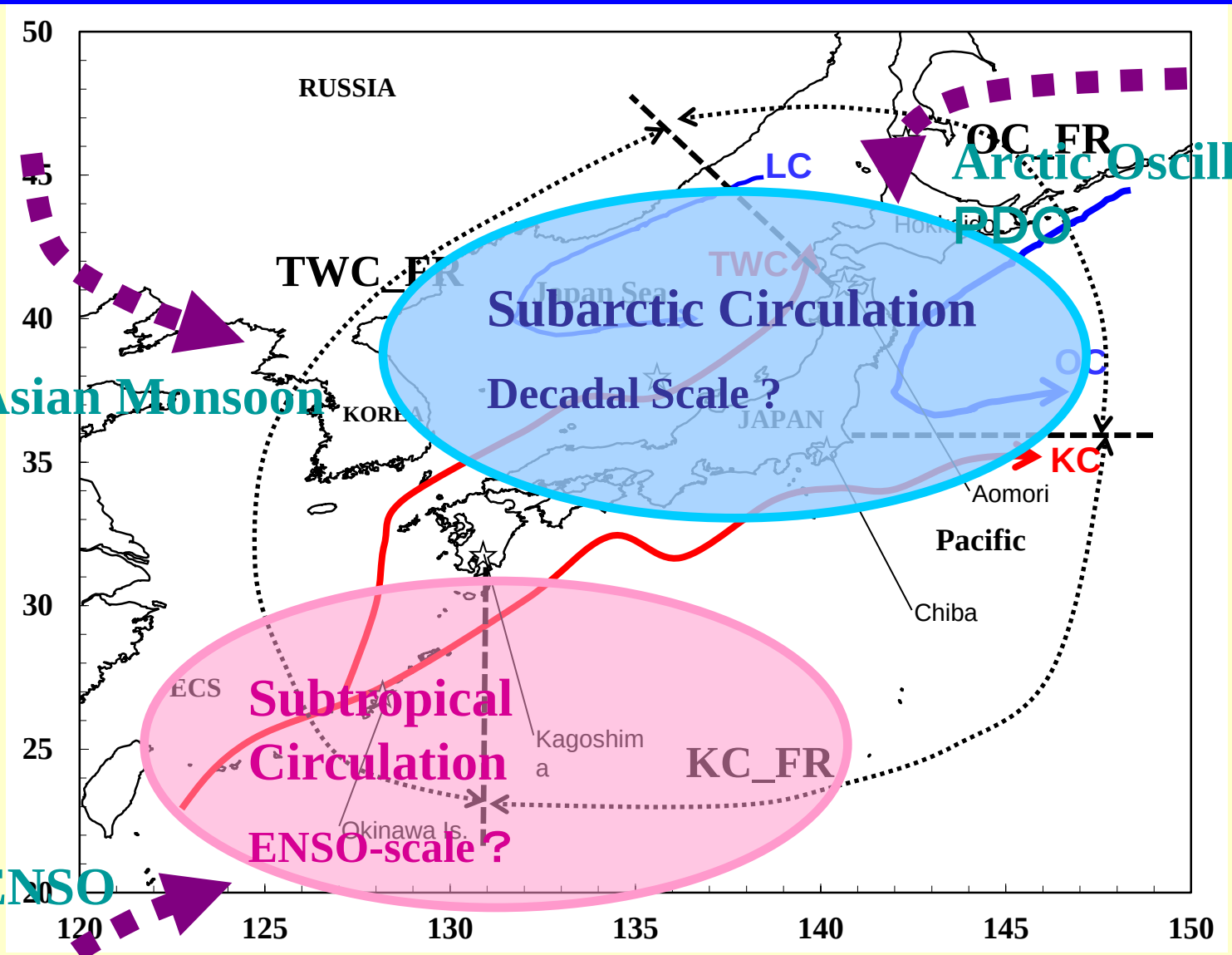
- **Regime shifts occurred before 1950**

  **PCA results for 1900-2010, particularly focused on the regime shifts before 1950s.**

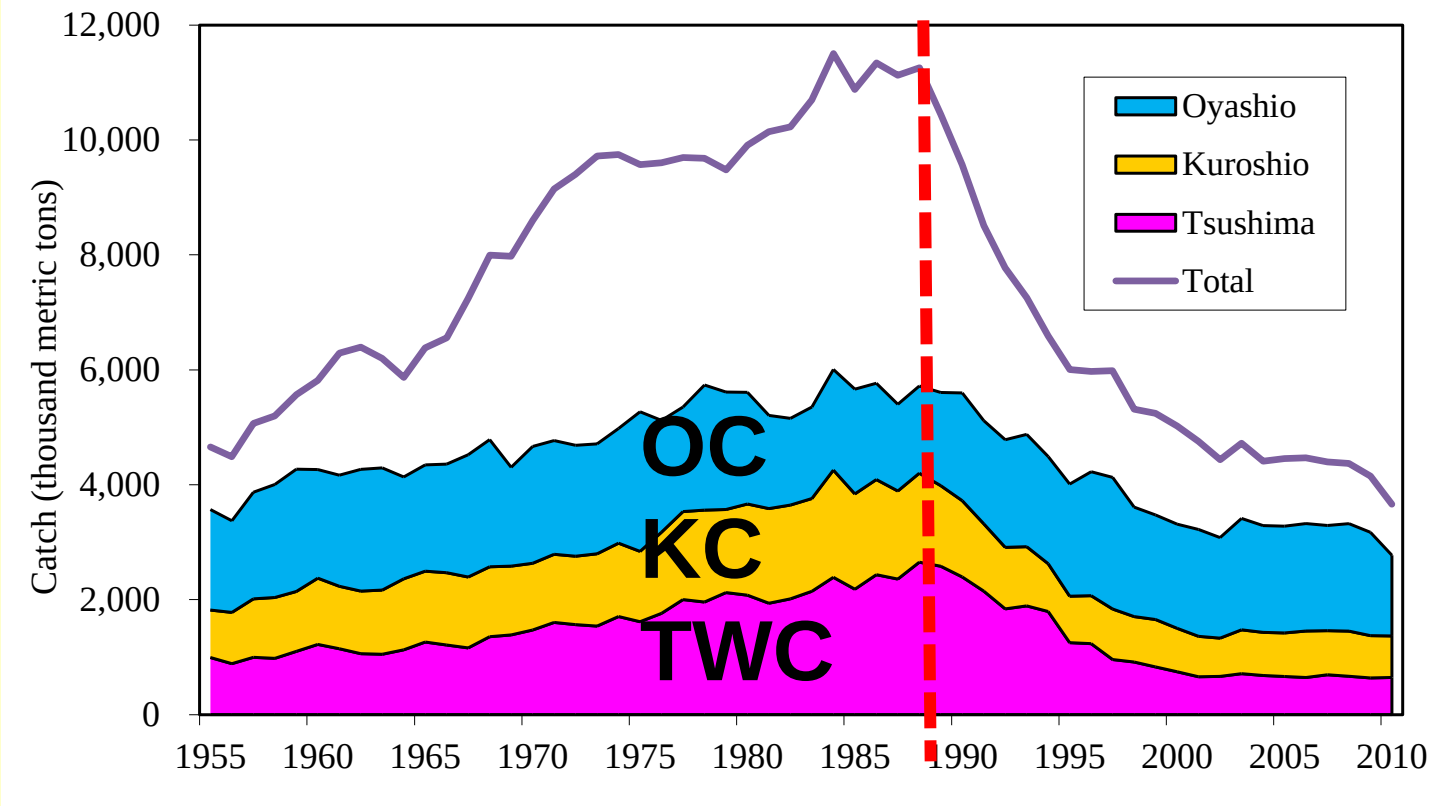
  **Outlooks on early warning signals for future regime shift.**

- **Summary (and discussion)**

# Oceanographic structure and fisheries region



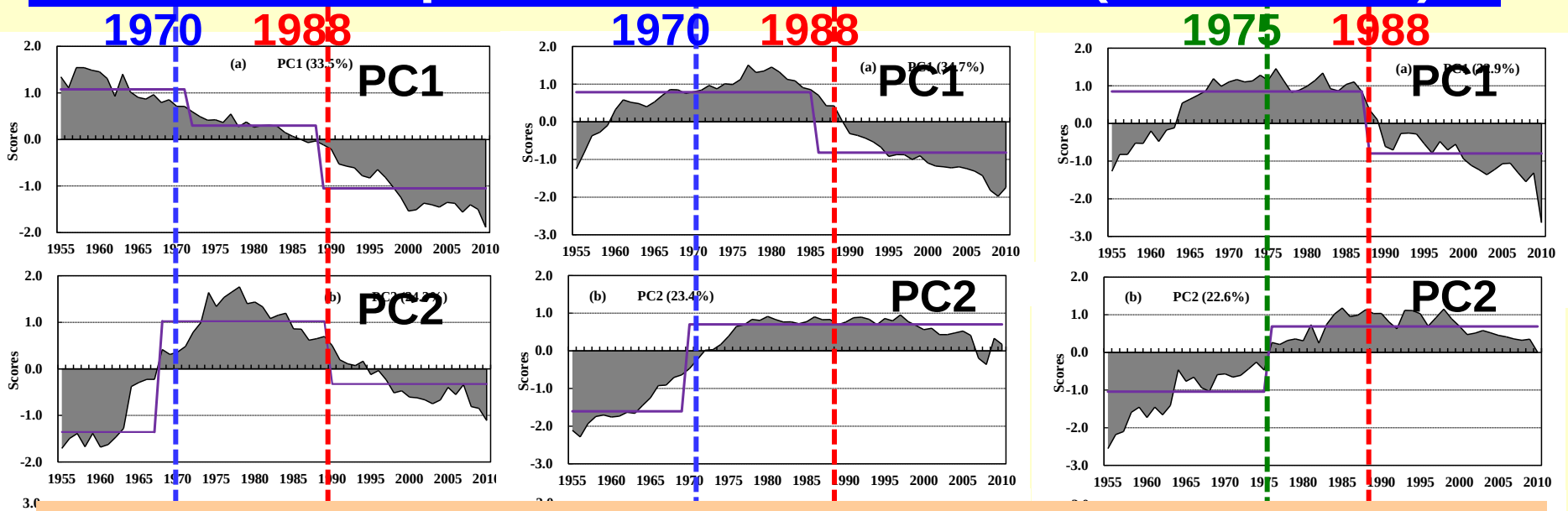
# Catch trend by fisheries region: 1955-2010




These 25 indicator species from the three regions accounted for about 75%(56-93%) of total Japanese catch, and the trends are generally same to total.

**Tian et al. (2014) ICES JMS**

# Variation patterns from PCA (PC1-PC4)




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

**The late 1980s regime shift was the most evident change in Japanese water, seemed different with the mid-1970s regime shift in the NE North Pacific. The late 1980 regime shift was also identified in the East China Sea, and in North Atlantic.**

**Question: What happened in the fish assemblages around Japan particularly before 1950?**

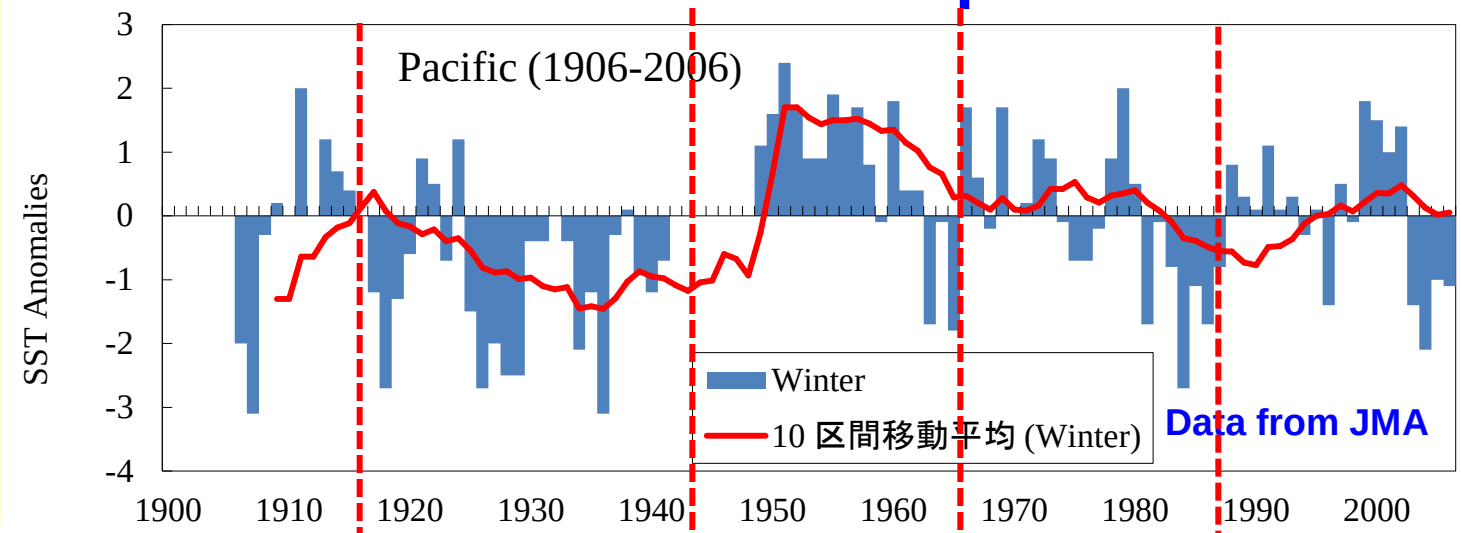
cold 1980s regime shift warm 1990s

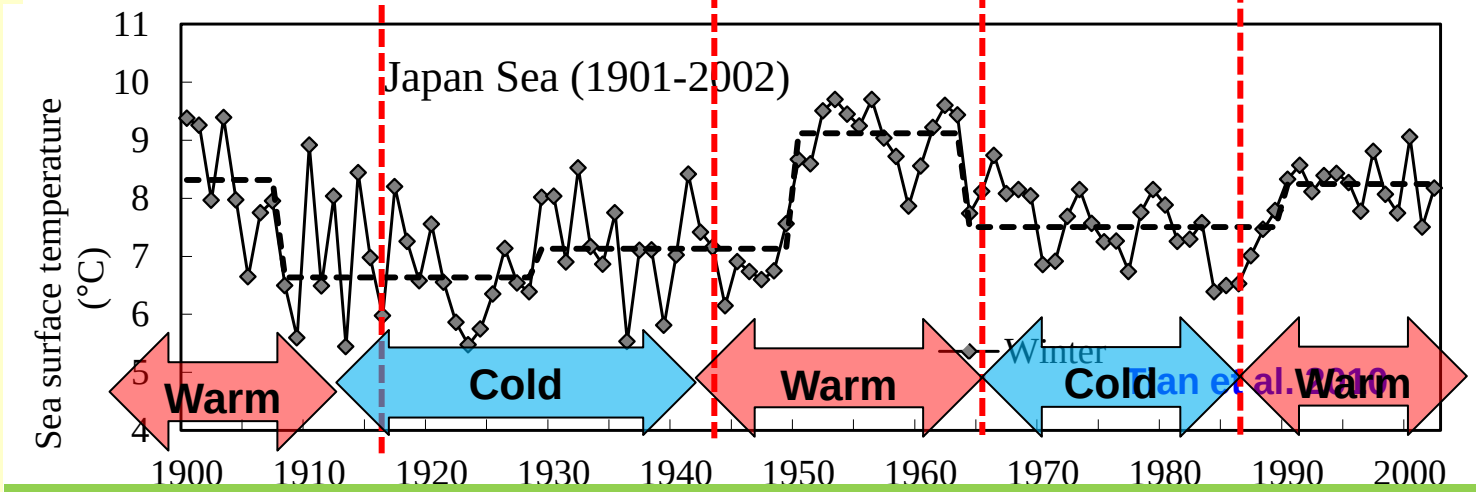
Tian et al. (2008)

# Objective

- **To identify the long-term variability in the fish assemblages around Japan over last century, particularly focused on regime shifts occurred before 1950s.**
- **To discuss the possibility in using ecological indicators to detect the early warning signal of regime shift.**

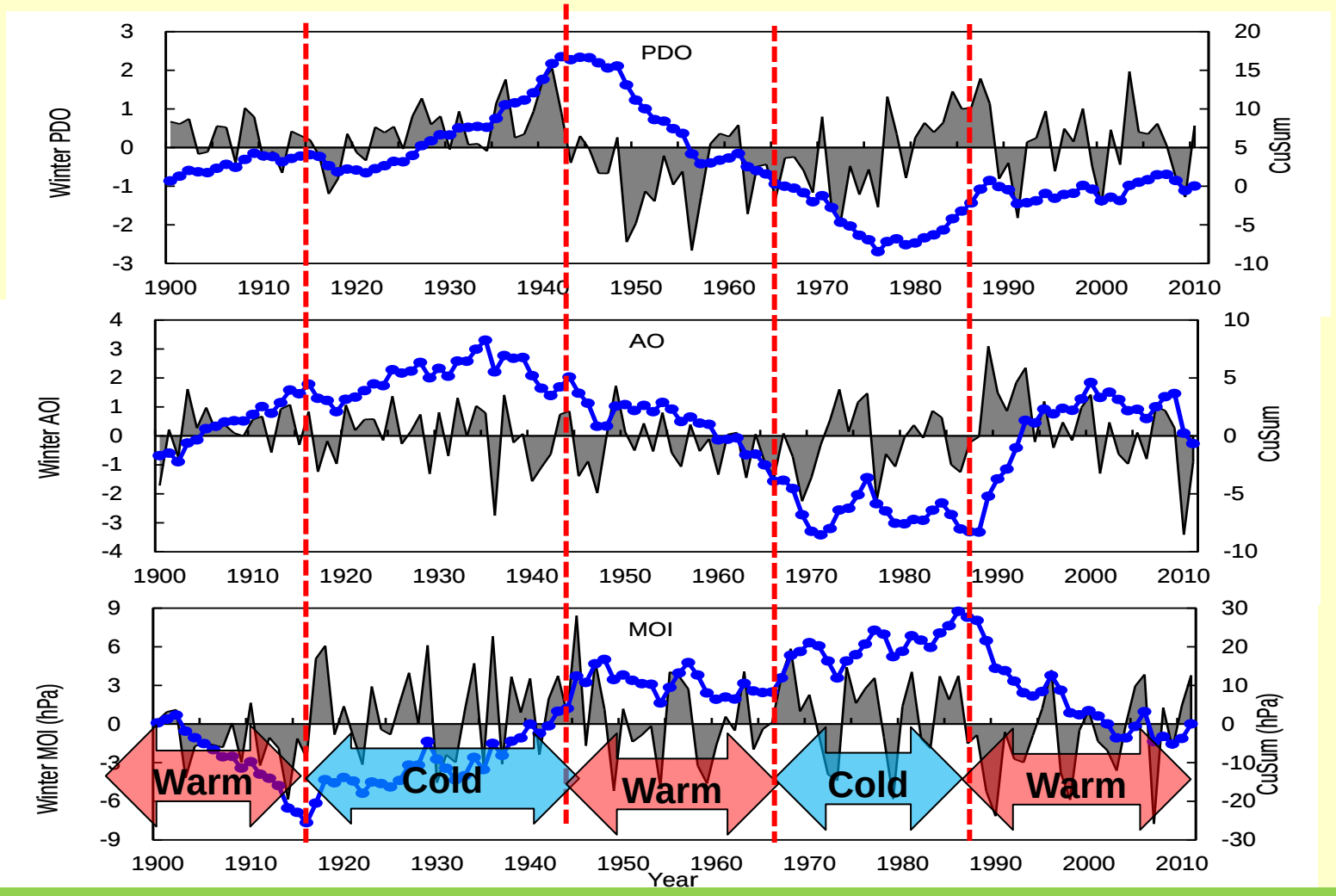
# Trend in SST around Japan since 1900




**SSTs showed cold period during 1920s to 1930s and warm period during 1950s to early-1960s.**

# Trend in Climate Index: 1900-2010



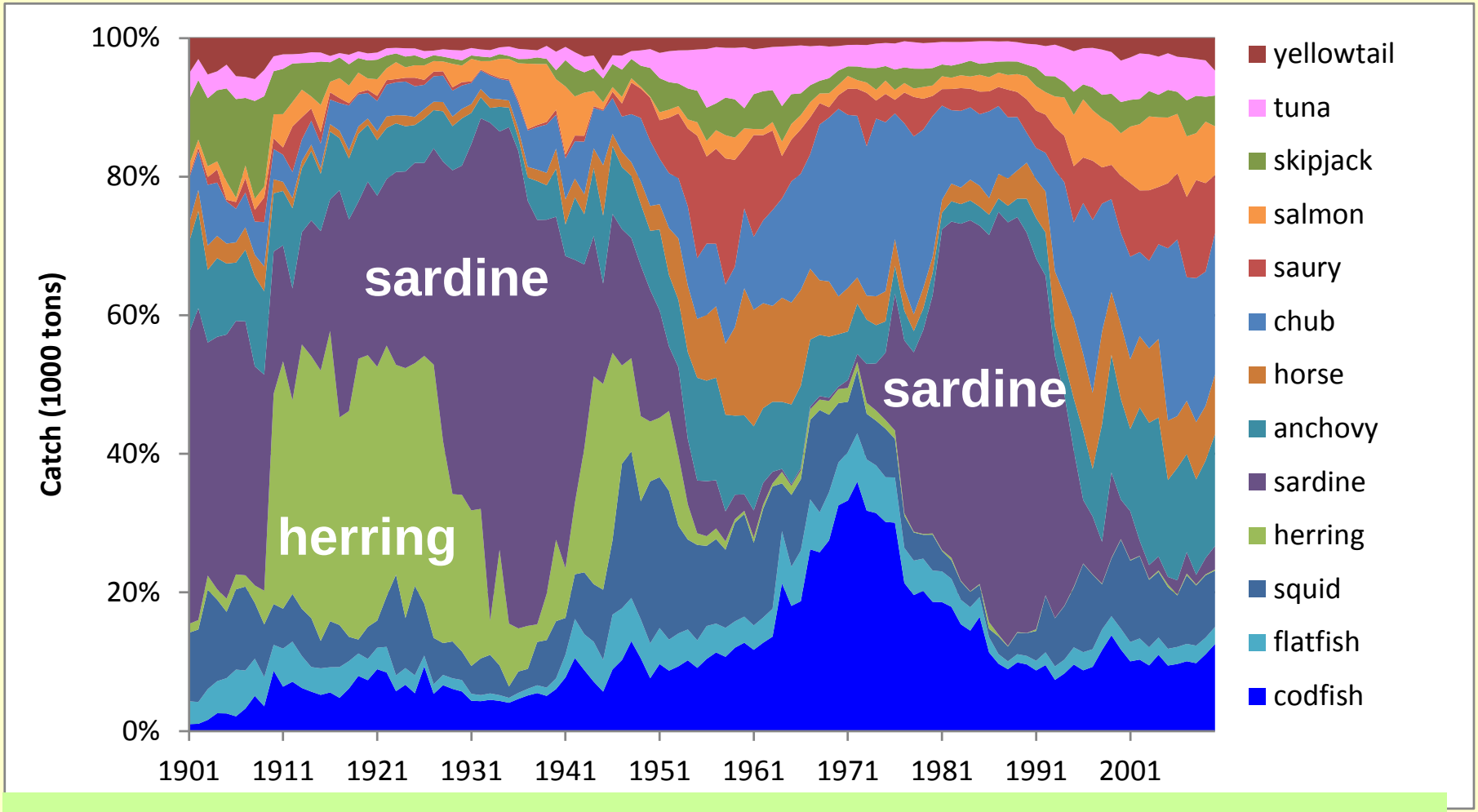

**Cold (warm) periods corresponded well to the intensify (weakening ) in AO and MOI.**

# Selection of Indicator Species

**13 (not 25) commercially important specie from small pelagic to large predatory fishes with different trophic level and habitat are selected to representing the structure of fish assemblage.**

| | Groups | Common Name | Scientific name | Age (age comp.) Spawning Season | Habitat (Current) | TL |
|---|---|---|---|---|---|---|
| 4 | **Large predatory Species (4 taxa)** | Yellowtail | *Seriola* spp. | *7 (0-3)*<br>*L∞ (cm): 98*<br>*Feb.-June* | *Pelagic*<br>*Migratory*<br>*(Warm-water)* | 4.1 |
| | | Skipjack tuna<br>And Frigate mackerel | *Katsuwonus pelamis*<br>*Auxis* spp. | *8(1-4?)*<br>*L∞ (cm): 140*<br>*Nov-May* | *Pelagic*<br>*Migratory*<br>*(Warm-water)* | 3.8 |
| | | Tunas (Bluefin tuna) | *Thunnus* spp. | *10(0-3?)*<br>*300cm?*<br>*June July* | *Pelagic*<br>*Migratory*<br>*(Warm-water)* | 3.9 |
| | | Salmonidae<br>(chum salmon) | | *7(3-5)*<br>*100cm?*<br>*Dec-Mar* | *Pelagic*<br>*(Cold-water)* | 3.5 |
| 7 | **Small Pelagic Species (7 taxa)** | Japanese sardine | *Sardinops melanostictus* | *7(0-3)*<br>*25*<br>*Dec-May?* | *Pelagic*<br>*Migratory* | 3.0 |
| | | Japanese anchovy | *Engraulis japonicus* | *2(0-1)*<br>*15cm*<br>*All seasons* | *Pelagic*<br>*Costal*<br>*(Warm-Water)* | 2.8 |
| | | Pacific herring | *Clupea pallasii* | *18 (0-6)*<br>*40cm*<br>*Mar-May* | Pelagic<br>*(Cold-water)* | 3.6 |
| | | Horse mackerel | Carangidae<br>(*Trachurus japonicus*) | *3(0-2)*<br>*35cm*<br>*Feb-May* | *Pelagic*<br>*Migratory*<br>*(Warm-water)* | 3.2 |
| | | Chub mackerel | Scombrini<br>(*Scomber japonicus*) | *4(0-3)*<br>*43cm*<br>*Apr-June* | *Pelagic*<br>*Migratory*<br>*(Warm-water)* | 3.4 |
| | | Pacific saury | *Cololabis saira* | *2(0-1)*<br>*30cm*<br>*Nov.-June* | *Pelagic*<br>*Migratory*<br>*(Warm-water)* | 3.3 |
| | | Flying squid | *Todarodes pacifcus* | *1(0-1)*<br>*25cm(mantle len.)*<br>*Oct.-Mar* | *Pelagic*<br>*Migratory*<br>*(Warm-water)* | 3.0 |
| 2 | **Demersal Species (2 taxa)** | Codfishes (<br>Walleye Pollock abd<br>Pacific cod) | *Theragra chalcogramma*<br>*Gadus macrocephalus* | *12(3-5?)*<br>*120cm*<br>*Dec-Mar.* | *Demersal*<br>*(Cold-water)* | 3.5 |
| | | Flatfishes<br>(Bastard halibut) | Pleuronectidae<br>*(Paralichthys olivaceus)* | | *Demersal and Costal*<br>*(Warm-water)* | 3.6 |

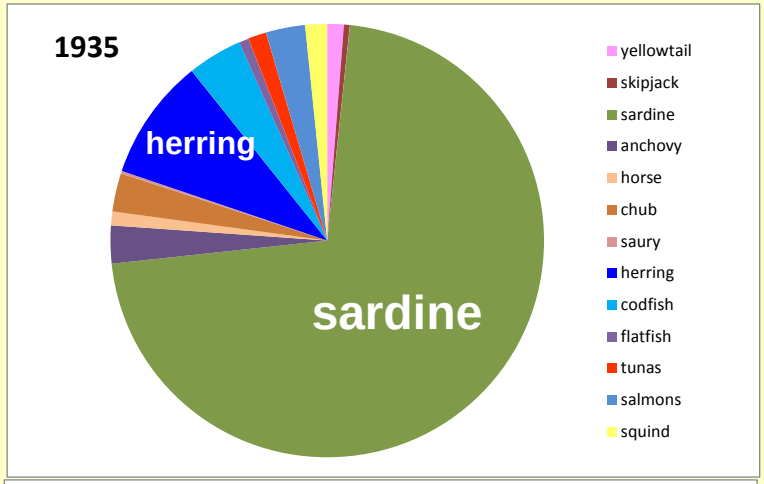
# Catch Trend from Japanese Water: 1901-2010

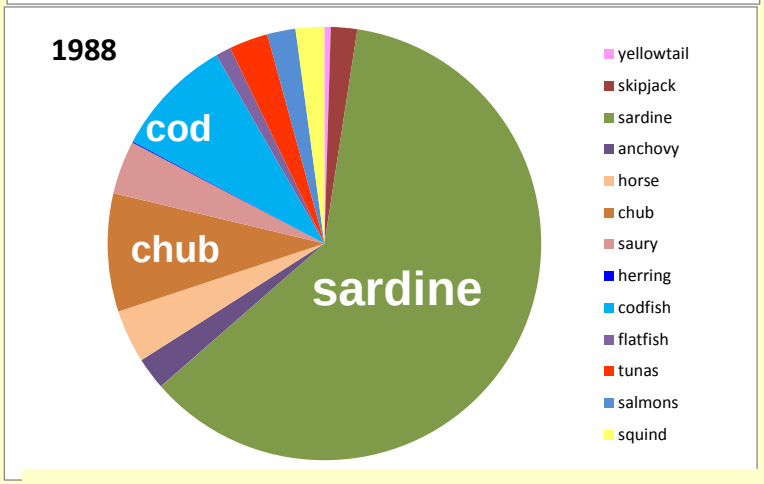



**The small pelagic group (zooplanktivores) is dominant (wasp-waist) with large inter-annual variations.**

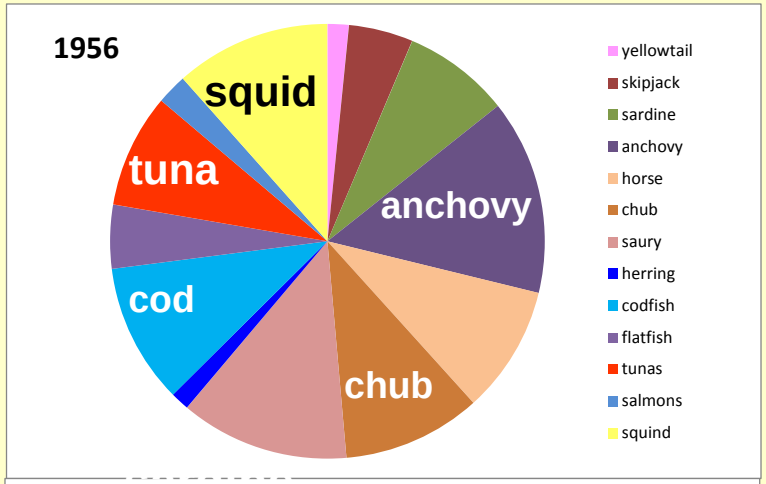
# Catch compositions in different regimes

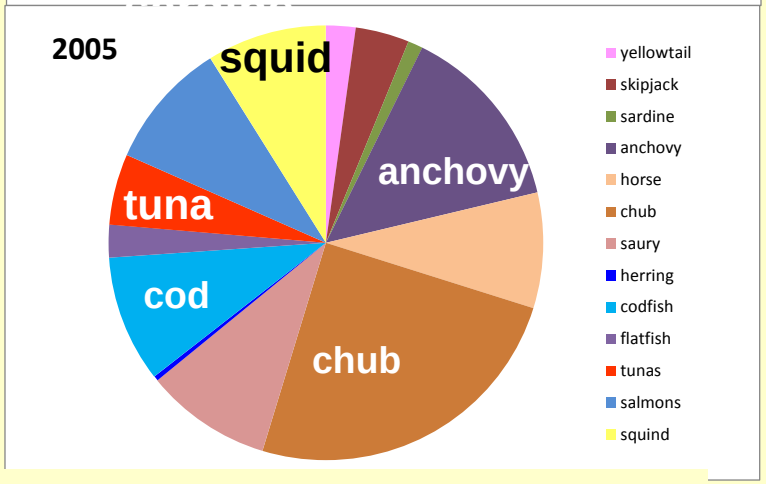
## Cold regime (1930s and 1980s)



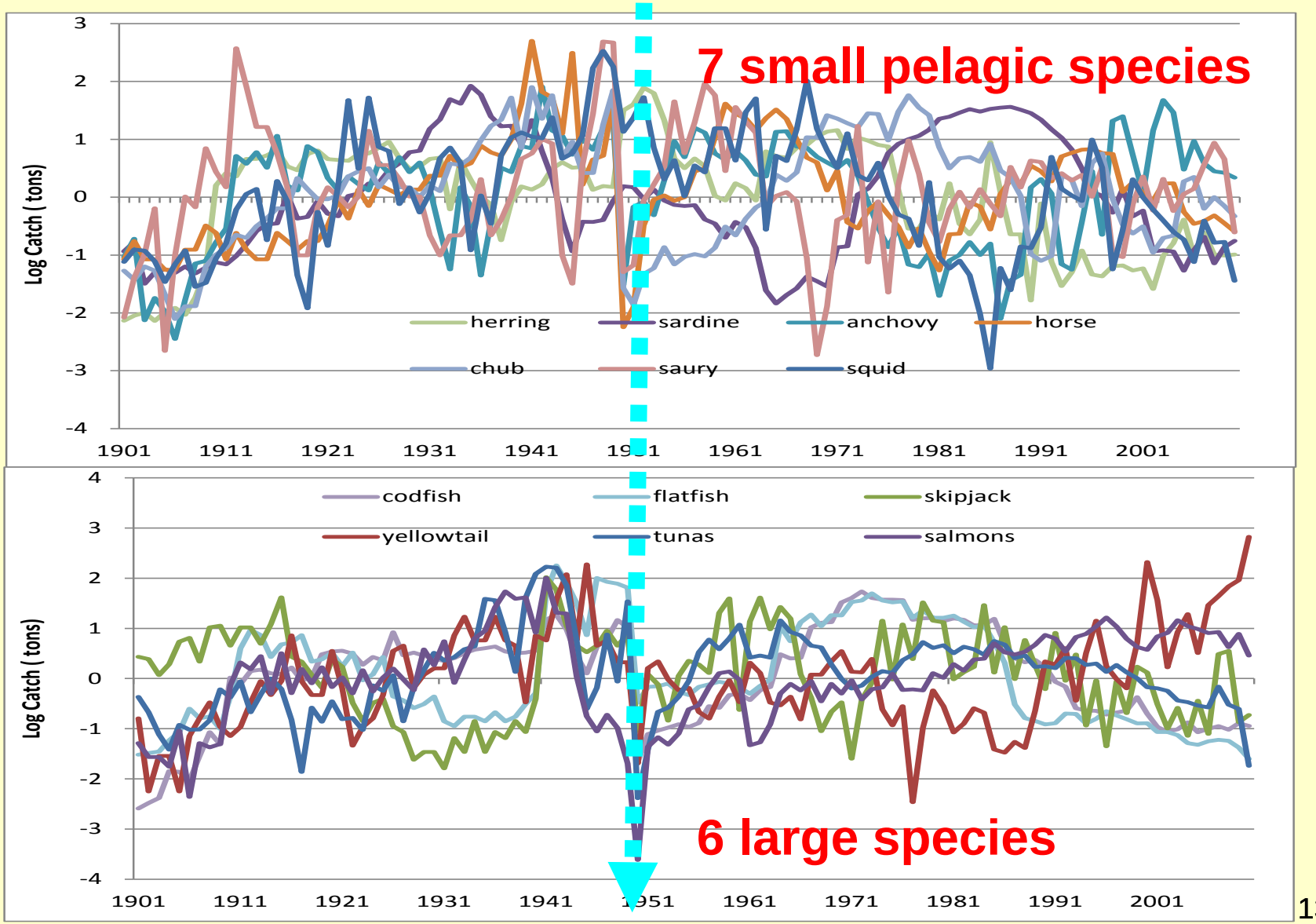

## Warm regime (1950s and 2000s)



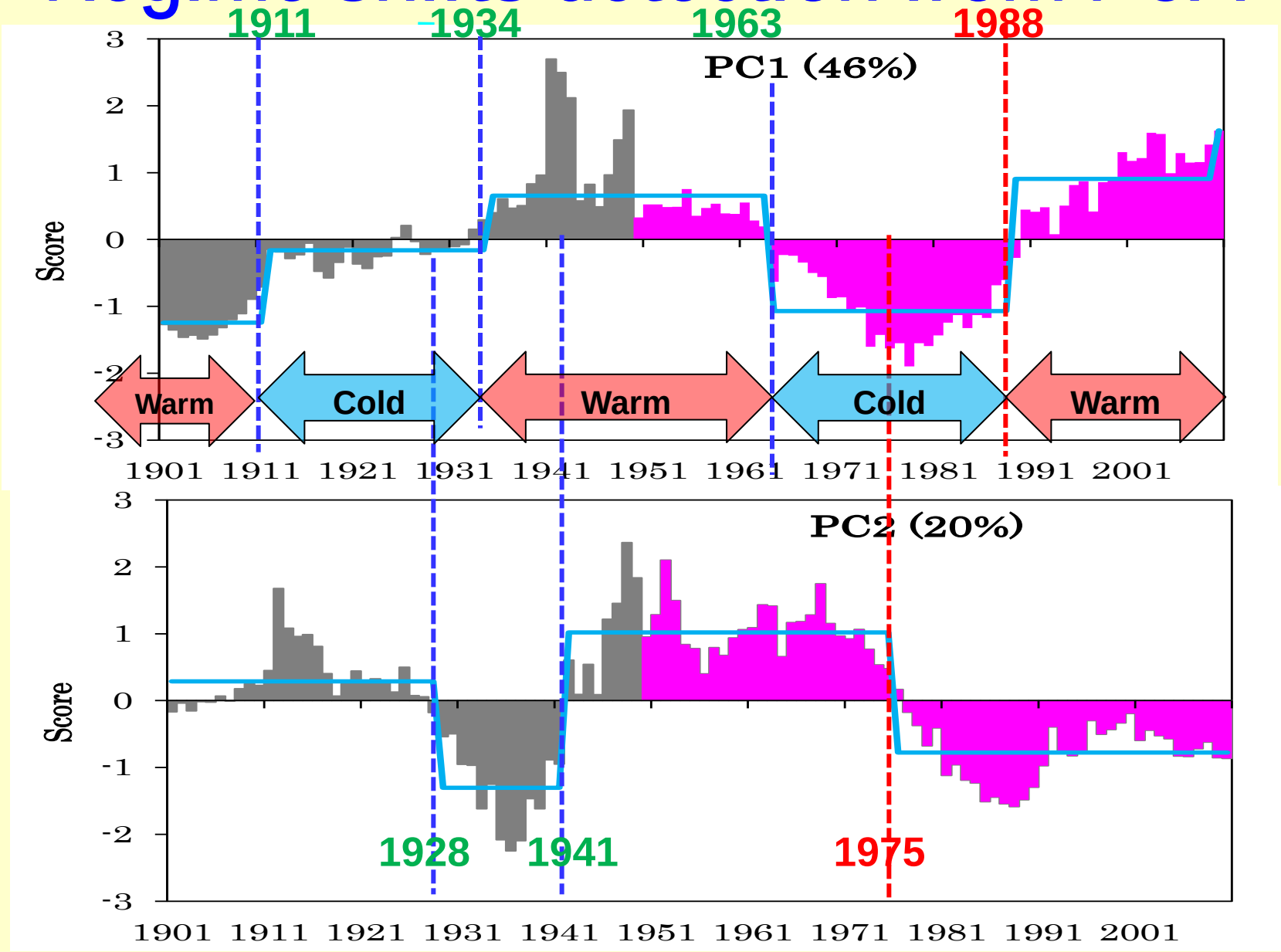




**1930s was characterized with extremely abundant sardine and herring.**

# Standardization of catch data for PCA

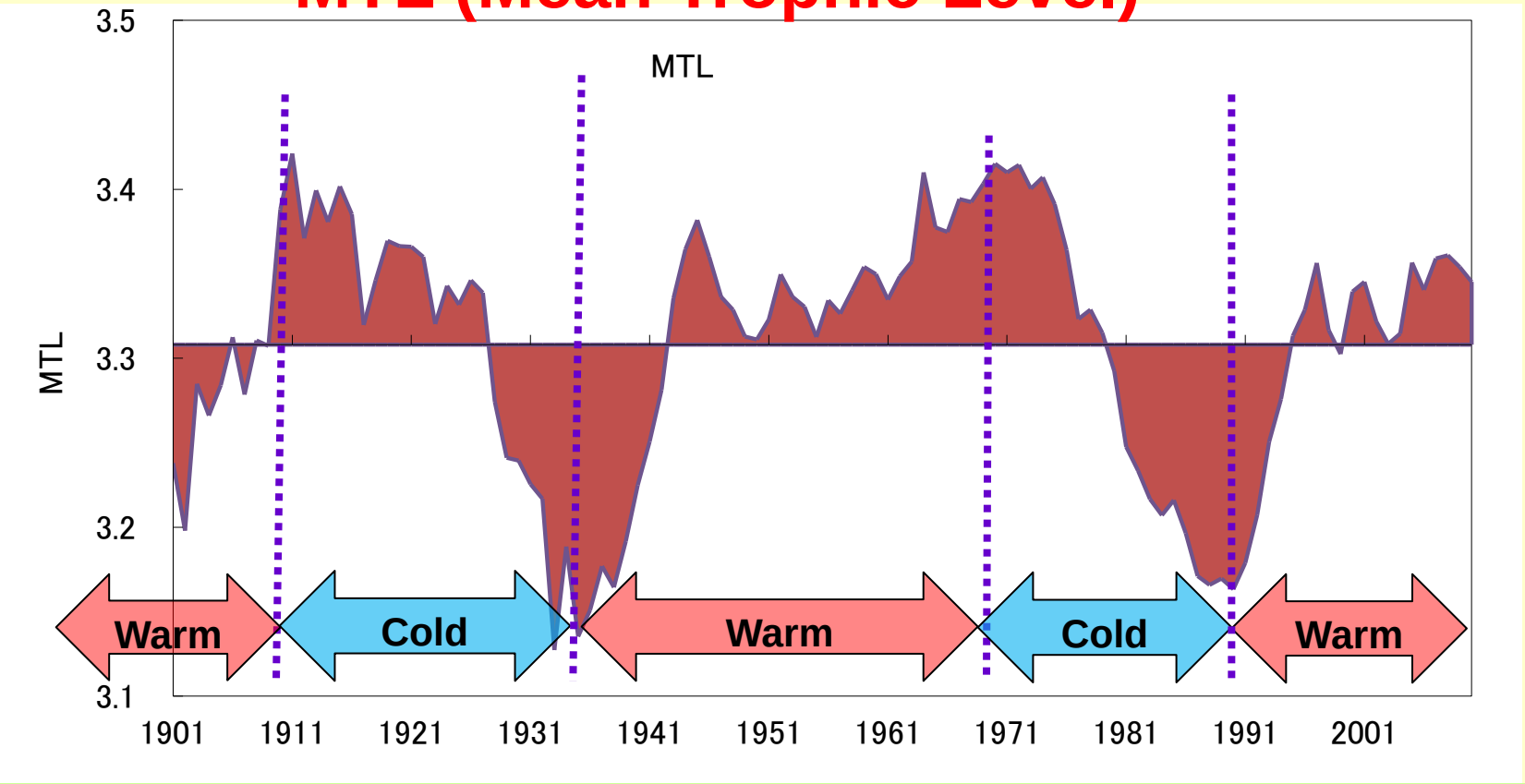


# Regime shifts detection from PCA



# Ecological Indicators

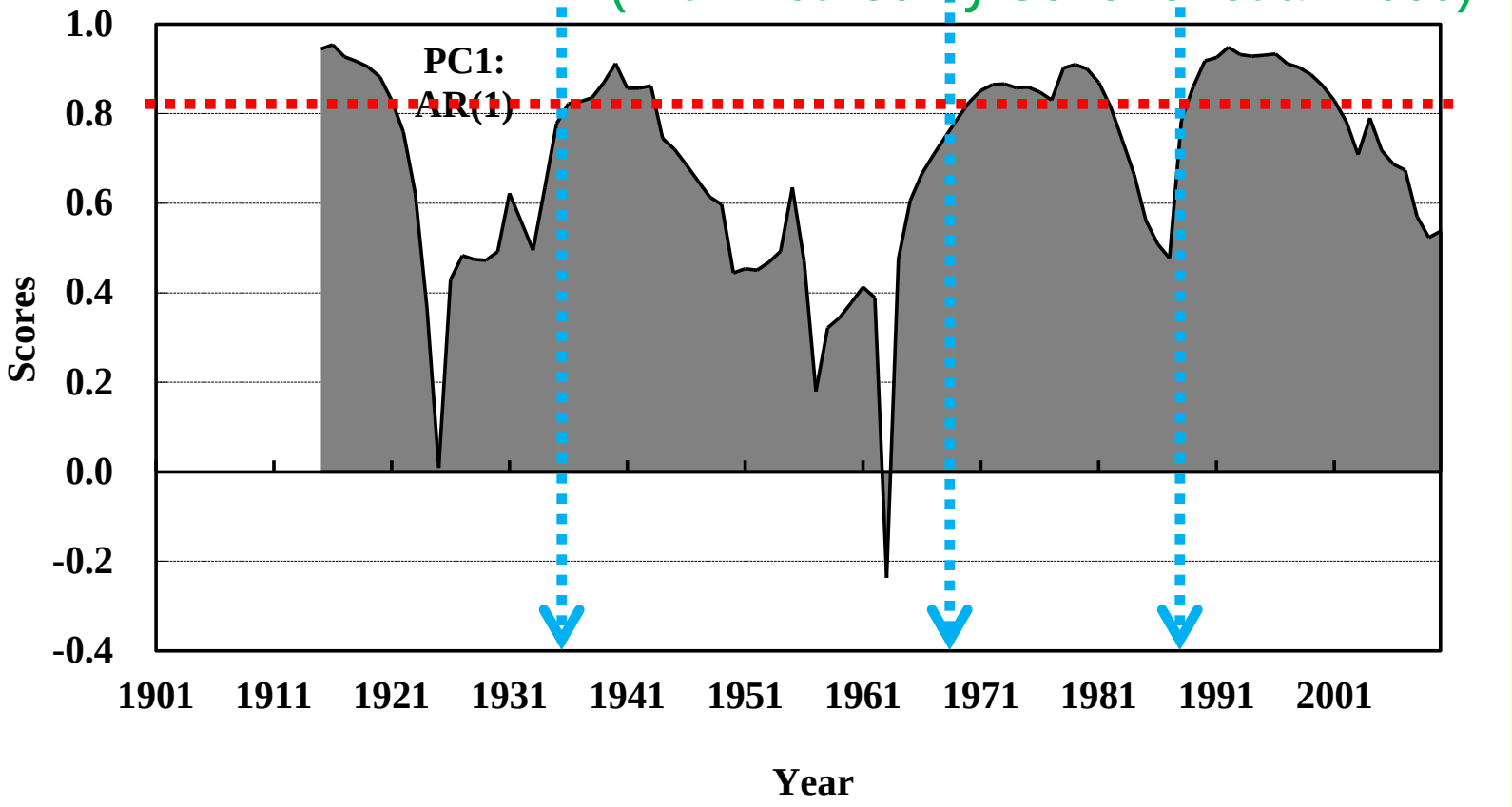
## MTL (Mean Trophic Level)




**The MTL decreased (increased) during cold- (warm-) regime, reflecting the changes in small pelagic species, indicating climate-forcing (regime shift) rather than fishing**

# Early Waning Signal from PCA (PC1)

(with method by Scheffer et al. 2009)




**Coefficient of AR(lag1) abruptly increased around early 1930s, early 1960s and late 1980s, demonstrating the usefulness as indicator of regime shift prediction.**

# Conclusions

- **Five regime shifts in the fish assemblage around Japan were detected over last century: 1911, 1934, 1963, 1975 and 1988.**
- **The regime shifts were well coincided with SST and climate index. Regime in 1920s-1930s was cold-period with abundant sardine.**
- **MTL decreased during cold regime reflecting the increase in small pelagic species, not from fishing down food web effect.**
- **Ecological indicators such as PC1 is useful as early warning signal for forecasting the future (current) regime shift.**