The late-1980s regime shift in the ecosystem of Tsushima Warm Current in the Japan/East Sea: evidence of historical data and possible mechanisms

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Outlines of This Study

1. Background and objectives
2. Data and methods
3. Late 1980s oceanic regime shift in TWC
4. Changes in plankton biomass
7. Summary and mechanisms of the late 1980s ecological regime shift in TWC
Cold Water Species
Atka mackerel, walleye pollock, Pacific cod, etc.

Warm Water Species
Tunas, yellow tail, Jack mackerel, common squid, etc.

Subarctic Circulation
Decadal Scale

Subtropical Circulation
ENSO-scale?

Asian Monsoon

JAPAN
RUSSIA
KOREA

130° 135° 140° 145°
TWO OBJECTIVES

1. To identify the regime shift in the ecosystem of TWC: from low trophic level plankton to fish community

2. To unravel the mechanisms whereby climatic and oceanic variability are linked to the ecosystem regime shift in TWC in late 1980s.
Data and Methods

1. Catch statistics: 1964-2004:
   54 species items, 90% of total catches

2. Japan Sea Offshore Trawl Data Set
   1974-2004: 27 demersal species, catches and CPUE with spatial resolution of 10 minutes


4. Oceanographic-climatic indices
   SST: $1^{\circ} \times 1^{\circ}$ grid data set from JMA, 1950-2004
   50 to 200 m depth WT: 1964-2004:
      an indicator of Tsushima Warm Current

5. PCA Analysis and GIS Approach
Indicator of Tsushima Warm Current

50 m depth water temperature (winter)

Late 1980s

Anomalies (winter)

regime mean

Anomalies (winter)

Spatial differences in winter SSTs

Regime difference:
mean of 1987-2004
- mean of 1976-86

Decadal mean - 30 years (1970-1999) mean
Spatial differences (1990s-1980s) in WT

Note
1990s: 1989-1995
Yearly changes in 200m depth water temperature by longitude and season

Mid-1970s global regime shift is not evident

Late-1980s oceanic regime shift is evident:
It occurred not only in the surface Tsushima warm water, but also in deep water.
Climate Indices

With late 1980s regime shift
AOI positive
Weakness of Asian monsoon
→
Increase of water temperature?
Phytoplankton (Diatom) : 1972-2004

**Diatom: spring**

![Graph showing anomalies (Log 10 (cell/l + 1)) for spring diatom from 1972 to 2004]

**Diatom: summer**

![Graph showing anomalies (Log 10 cell/l +1) for summer diatom from 1972 to 2004]

**Late 1980s**

Decadal variability and abrupt change around late 1980s

Different pattern in spring and summer reflecting different species composition?
Zooplankton (Wet weight): 1972-2004

Late 1980s

Zooplankton: winter

Late 1980s

Zooplankton: spring

Late 1980s

Zooplankton: summer

Late 1980s

Zooplankton: autumn

Large interannual and decadal variation: high (lower) during 1990s (1980s) except in winter
Catches Trend in the Japan Sea during 1964-2004

- Piscivores
- Pelagic species
- Demersal fishes
- Invertebrates
- Small pelagics (excluding sardine)
PCAs of 54 species items: 1964-2004

Late 1980s

Pelagic (26) species

Warm water  64%<----  PC1-3--→ 76%  Cold water

Demersal (28) species
Catch Trend of Indicator Species

(a) Tuna
(b) Yellowtail
(c) Horse mackerel
(d) Yellowtail pollock
(e) Japanese sardine
(f) Walleye pollock
(g) Crabs
(h) Scallop

Large fishes
- warm water migratory species
- Small pelagic species

Cold water or deep water demersal species
Community indices from 54 species
Mean Trophic Level and Simpson’s Diversity Index

Decadal scale changes
Decreased during Mid-1970s-1980s but increased during 1990s
### Offshore Bottom Trawl: Target species

<table>
<thead>
<tr>
<th>No</th>
<th>Japanese Name</th>
<th>Scientific Name</th>
<th>English Name</th>
<th>Depth (m)</th>
<th>Life span (years)</th>
<th>Current</th>
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<tr>
<td>1</td>
<td>マダラ</td>
<td>Gadus macrocephalus</td>
<td>Pacific cod</td>
<td>200-300</td>
<td>&gt;12</td>
<td>CW</td>
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<td>2</td>
<td>スケトウダラ</td>
<td>Theragra chalcogramma</td>
<td>Walleye pollock</td>
<td>100-500</td>
<td>&gt;11</td>
<td>CW</td>
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<td>ホッケ</td>
<td>Pleurogrammus azonus</td>
<td>Arabesque greenling</td>
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<td>&gt;8</td>
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<td>Arctoscorpus japonicus</td>
<td>Japanese sandfish</td>
<td>300-500</td>
<td>5</td>
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<td>Squalus acanthias</td>
<td>Piked dogfish</td>
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<td>&gt;10</td>
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<td>Esbastes owstoni</td>
<td>Owenton's rockfish</td>
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<td>&gt;10</td>
<td>CW</td>
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<td>Hippoglossoides dubius</td>
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<td>8</td>
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<td>Pleuroneces herzensteini</td>
<td>brown sole</td>
<td>30-130</td>
<td>&gt;10</td>
<td>CW</td>
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<td>その他のカレイ</td>
<td>Pleuronectidae</td>
<td>other righteye flounder</td>
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<td>Pandalus borealis</td>
<td>Pink shrimp</td>
<td>200-600</td>
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<td>CW</td>
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<td>ズワイガニ</td>
<td>Chionoecetes opilio</td>
<td>Tanner crab</td>
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<td>&gt;10</td>
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<td>Hippoglossoides pinetorum</td>
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<td>Tanakius kitaharai</td>
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<td>Glossanodon semifasciatus</td>
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<td>ヒラメ</td>
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<td>チダイ</td>
<td>Eynnis japonica</td>
<td>crimson seabream</td>
<td>30-130</td>
<td>&gt;6</td>
<td>WW</td>
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<td>キダイ</td>
<td>Dentex tumifrons</td>
<td>deepsea snapper</td>
<td>&lt;200</td>
<td>&gt;8</td>
<td>WW</td>
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<td>Sciæniæ (Argyrosomus a)</td>
<td>Croaker</td>
<td>20-120</td>
<td>6?</td>
<td>WW</td>
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<td>Lepadotrigla micropetra</td>
<td>redwing searobin</td>
<td>70-140</td>
<td>6</td>
<td>WW</td>
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<td>タチウオ</td>
<td>Trichiurus japonicus</td>
<td>Largehead hairtail</td>
<td>20-140</td>
<td>8</td>
<td>WW</td>
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<td>アカムツ</td>
<td>Doederleina berycoides</td>
<td>blackthroat seaperch</td>
<td>80-150</td>
<td>10 (Female)</td>
<td>WW</td>
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<td>タコ類</td>
<td>Octopus</td>
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<td>&lt;200</td>
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</table>

**Total 27 speices items**

12 cold water species:
- Deep water
- Long-lived
- Northern distribution

15 warm water species:
- Coastal and continental shelf
- Short-lived
- Southern distribution

CW: Cold Water  WW: Warm Water  Nishimura (1969)
Changes in compositions
PCAs of demersal species from offshore trawl fisheries data during 1974-2004

PC1: changed around late 1980s

PC1-3: 65% of total variance
During warm regime, CPUE of the these cold water species in the southwestern region is decreased; while CPUE in the northern regions maintained in a relative high level: indicating a reduction of southwestern distribution.
CPUE for four **warm water** indicator species

During **warm regime**, CPUE of the these **warm water** species largely increased not only in the southwestern region but also in the northern regions: indicating northward expansion of distribution and increase in abundance level.
Walleye pollock

Cold regime
Increase in abundance
(Expansion of distribution)

Cold water species

Pacific cod

Cold regime
Decrease in abundance
(Reduction of distribution)

1980s
cold

1990s
warm

Cold water species

Walleye pollock

Increase in abundance
(Expansion of distribution)

Warm regime
Decrease in abundance
(Reduction of distribution)

Cold water species

Walleye pollock

Warm regime
Decrease in abundance
(Reduction of distribution)
Warm water species
Pointhead flounder

Cold water species
Witch flounder

1980s cold

1990s warm
Response process to late 1980s regime shift in TWC

- Warm water species: Pelagic, migratory (Summer-autumn)
  - Positive
- Cold water species: Demersal, habitat (Winter-spring)
  - Negative

Phytoplankton

- Cold water temperature
- Intensification of Aleutian Low and Asian monsoon
- Warm water temperature
- Weakness of Asian monsoon AOI positive

Zooplankton

- Cold 1980s
- Warm 1990s
Summary and Conclusions

1. An oceanic regime shift from cold to warm water is identified in TWC region in late-1980s and linked with global climatic changes.
2. Plankton biomass changed abruptly around late 1980s with decadal variability.
3. PCA and community indices suggested that the fish community in TWC changed around late 1980s.
4. Both the pelagic and demersal fish assemblages show decadal variation patterns and changed around late 1980s.
5. Response patterns are different between cold and warm water species: warm (cold) water species increased (decreased) their abundances and expanded (reduced) their distributions during the warm regime, and vice versa.
6. These suggested an ecosystem regime shift from low trophic plankton to high trophic fish communities, occurred in TWC in late 1980s, and is linked directly to the climatic-oceanic regime shift in the North Pacific.