#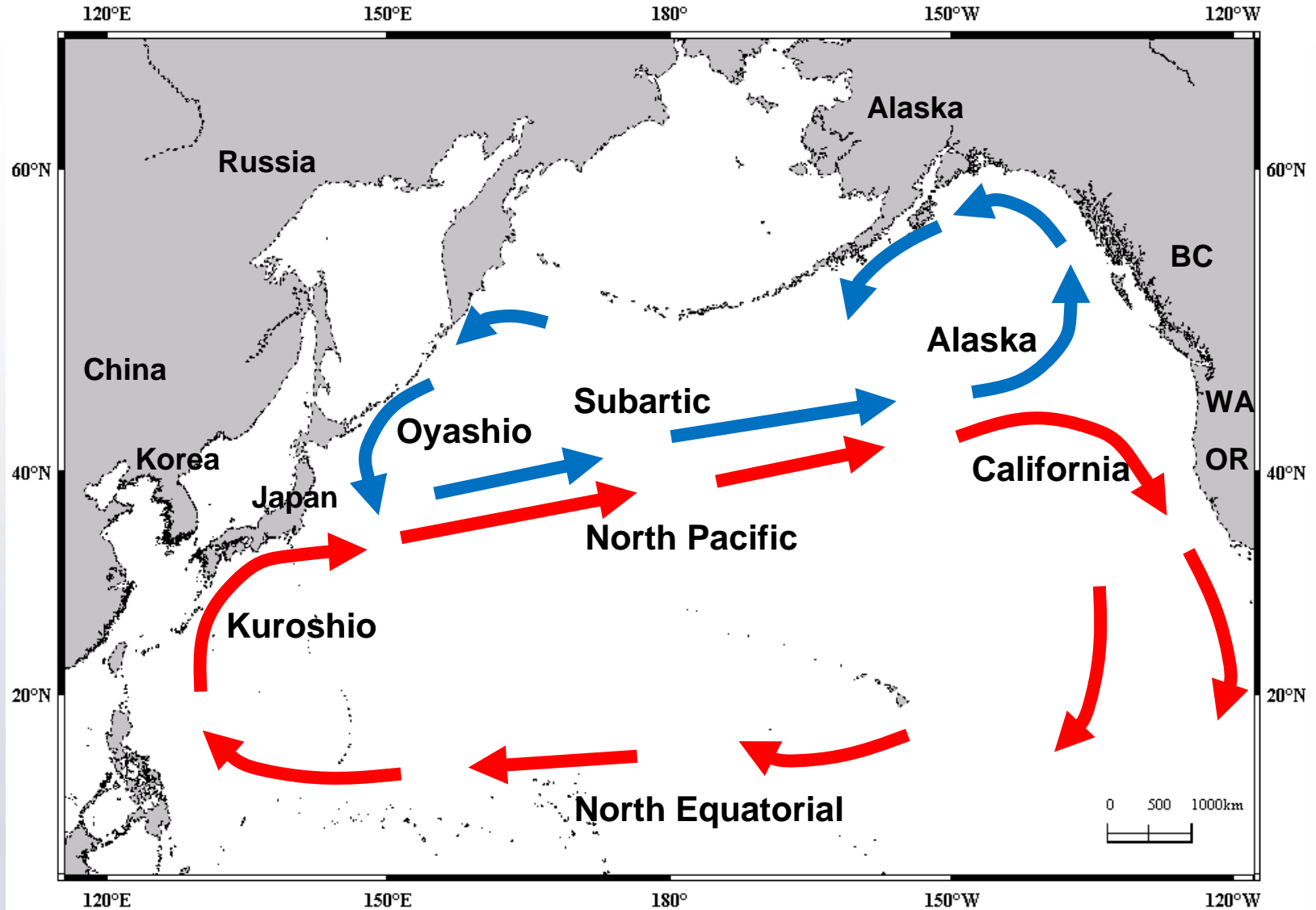 Comparison of ecological characteristics of fish communities and oceanographic features in the western and eastern North Pacific Ocean

Suam Kim[1], C.-I. Zhang[1], S. Kang[2], H. Seo[2], M. Kang[1], and J. Kim[1]
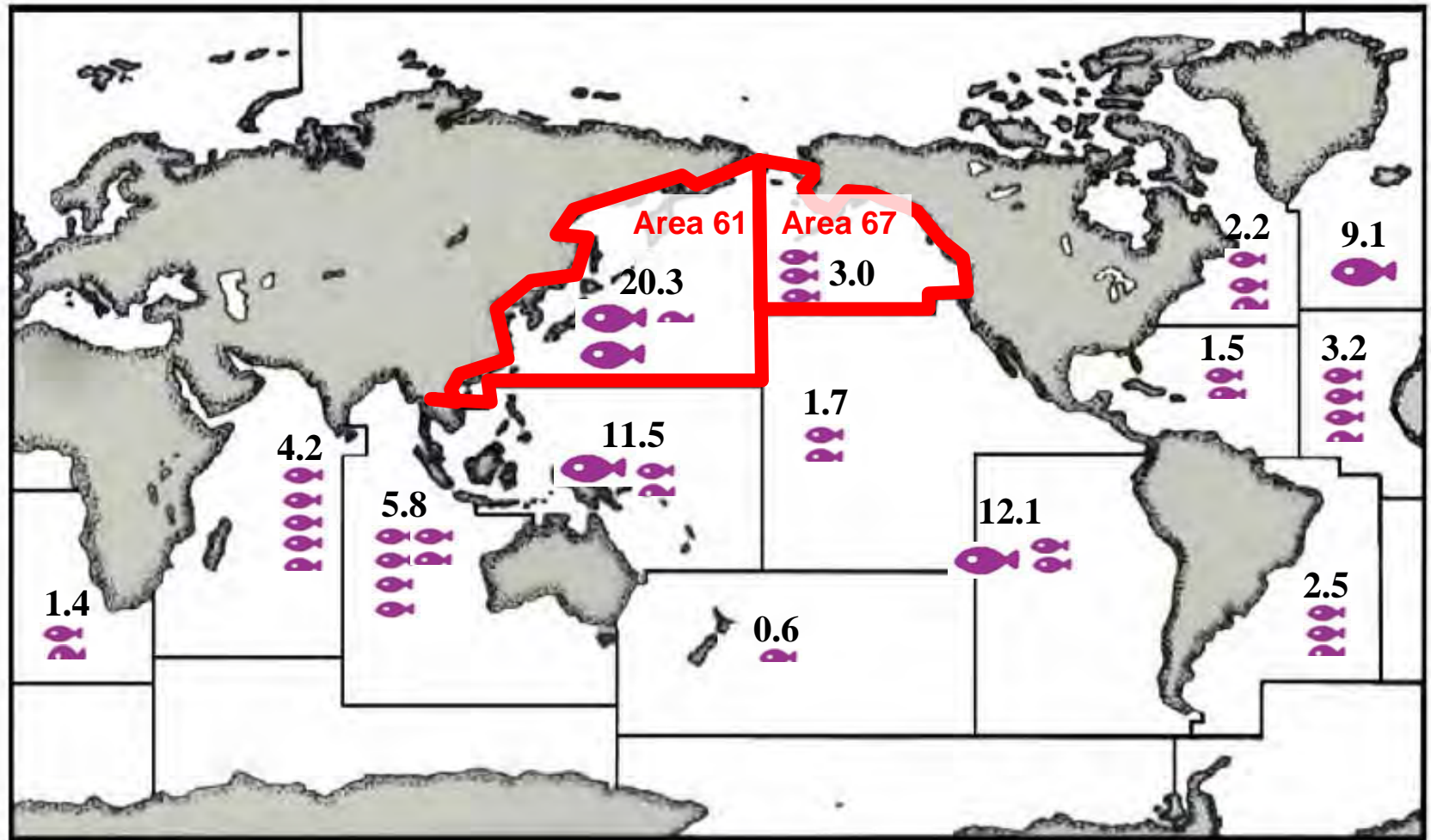
1: Pukyong National University
2: National Fisheries Research and Development Institute
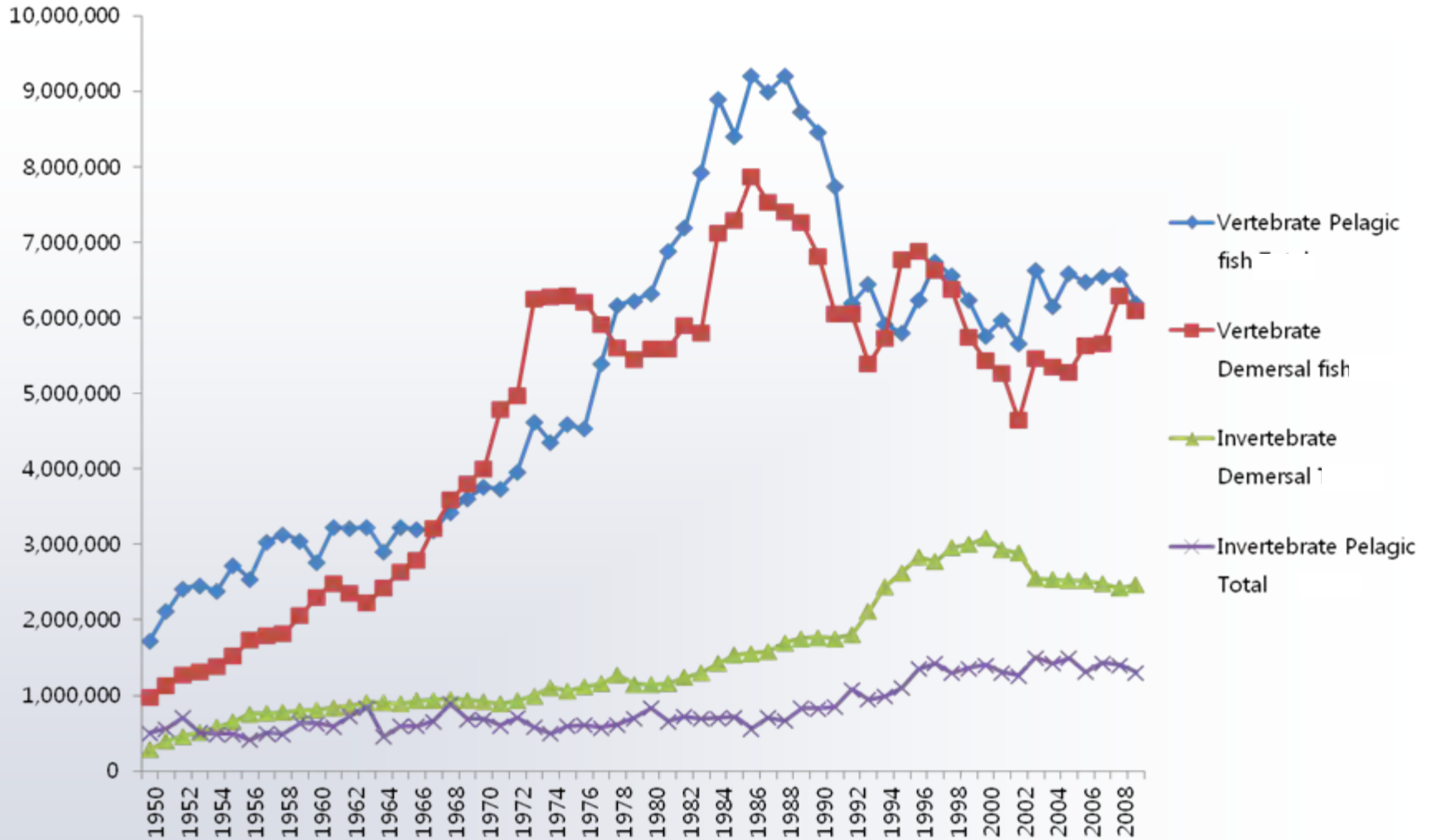
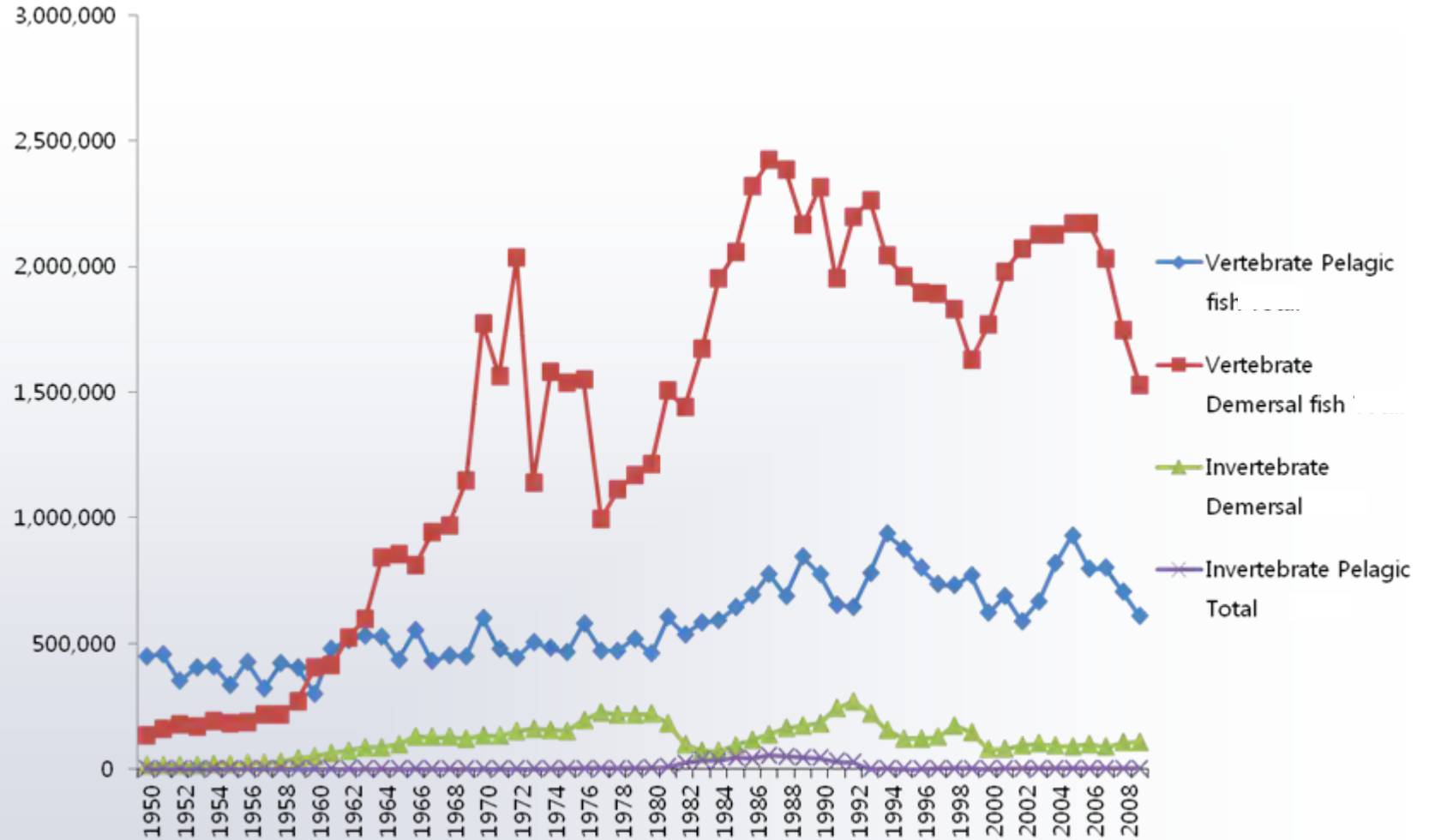# Current System in the North Pacific Ocean

FAO Capture Fisheries

Total catch (in 2007) = 81.2 million tons

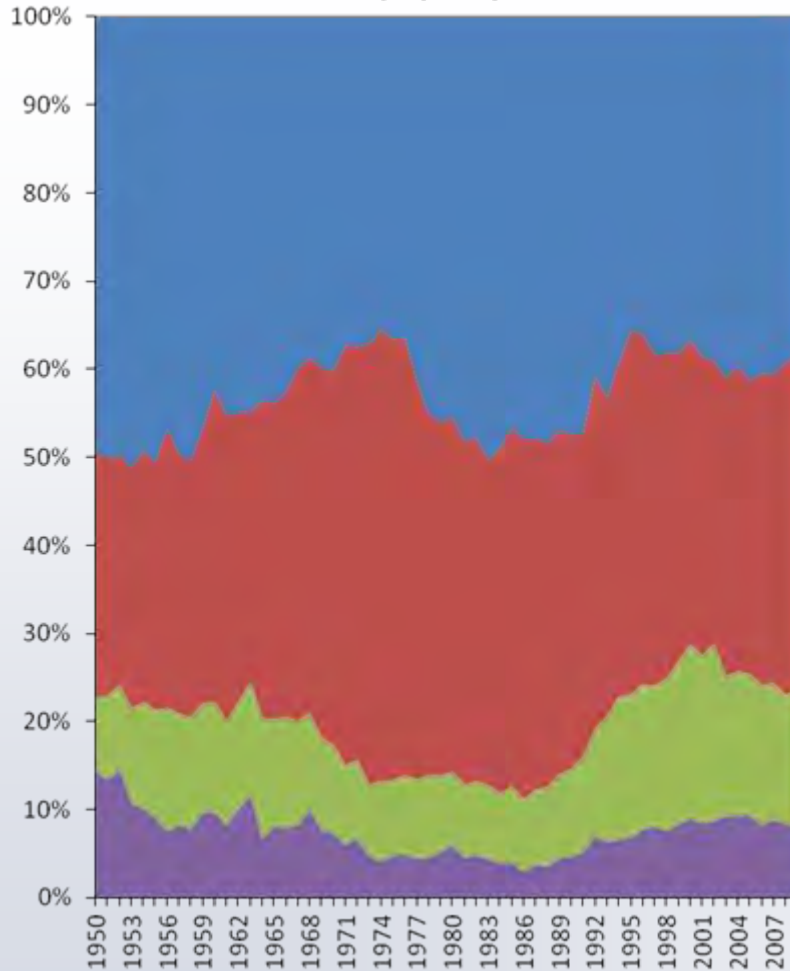# Catch composition of Area 61, 1950-2009

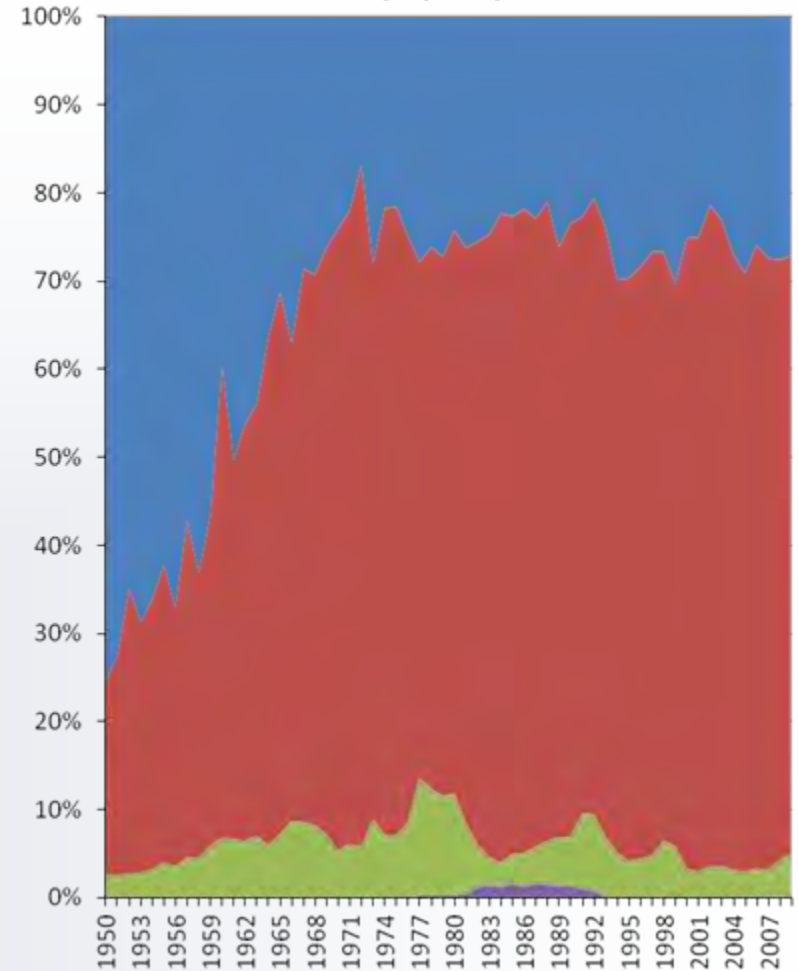# Catch composition of Area 67, 1950-2009

Catch composition in relative scale

Area 61 | **Area 67**

Legend:
- Vertebrate Pelagic Fish
- Vertebrate Demersal Fish
- Invertebrate Demersal
- Invertebrate Pelagic

The number of commercial species in Area 61 and 67, 1950-2009

Major groups	Groups	Area 61 (NW Pacific)	Area 67 (NE Pacific)
Vertebrates	demersal fish	97 (42.4%)	52 (42.6%)
	pelagic fish	66 (28.8%)	34 (27.9%)
	miscellaneous	4	4
Invertebrates	benthos	51 (22.3%)	26 (21.3%)
	squid	7	3
	miscellaneous	4	3
	sum	229	122

(data from FAO)

This study aims

- to compare the characteristics of fish community at the eastern and western boundary areas of Pacific subarctic,

- to identify the changes in species composition in two ecosystems during the last 2 decades, and

- to provide the basis in fishery management under changing environment.

Study Areas

Western Pacific
26-46°N, 118-155°E

Eastern Pacific
42-55°N, 125-157°W

Data and Methods (I)

- **Physical data**
  - **1. Sea surface temperature (SST)**
    - Dataset: SODA V2.2.4 monthly mean
    - Resolution: 0.5 ° x 0.5°
    - Subset: 74 x 40(PW), 64 x 26(PE) grid points
    - Depth: 5 m
    - Time period: 1970-2008
    - Season: Jan.- Mar. (Winter)

  - **2. Climate indices**
    - PDOI: http://jisao.washington.edu/pdo/PDO.latest
    - AOI: http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/ao.shtml
    - SOI: http://www.cru.uea.ac.uk/cru/data/soi.htm
    - ALPI: http://www.pac.dfo-mpo.gc.ca/sci/samfpd/climate/clm_indx_alpi.htm

Data and Methods (II)

- **Fisheries statistics**
  - **1. Sources for fisheries statistics**
    - Food and Agriculture Organization, FAO;
      - http://www.fao.org/fi/statist/FISOFT/FISHPLUS.asp#Dwonload
    - Canadian Fisheries Statistics;
      - http://www.dfo-mpo.gc.ca/stats/commercial/sea-maritimes-eng.htm
    - USA Commercial Landed Catch, Pacific Fisheries Information Network, PacFIN;
      - http://pacfin.psmfc.org/pacfin_pub/woc.php
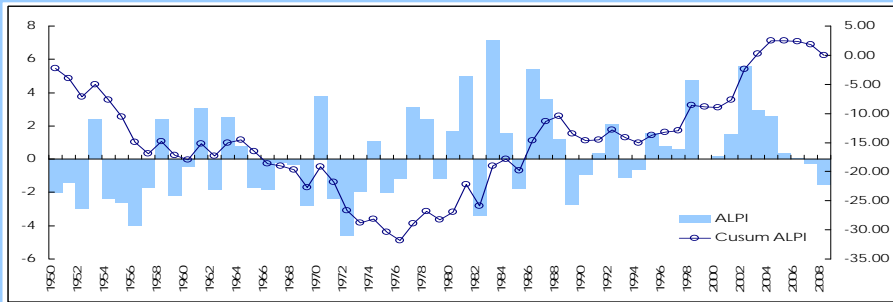
  - **2. Source for fish habitat**
    - FishBase; http://www.fishbase.org

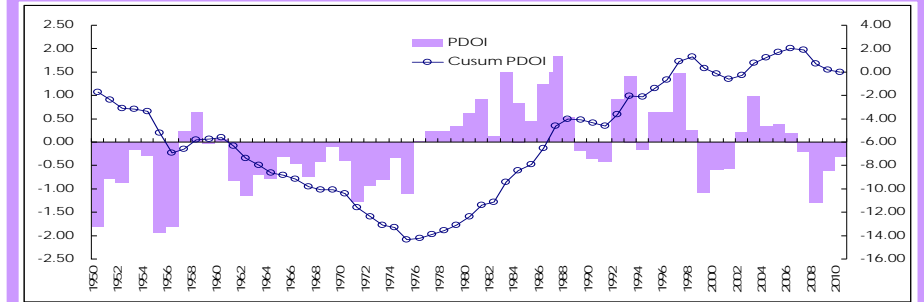- **Statistical methods**
  - **1. Cumulative Sum (CuSum)**
  - **2. Cross-Correlation Function (CCF) Analysis**

Climate Indices, 1950-2008
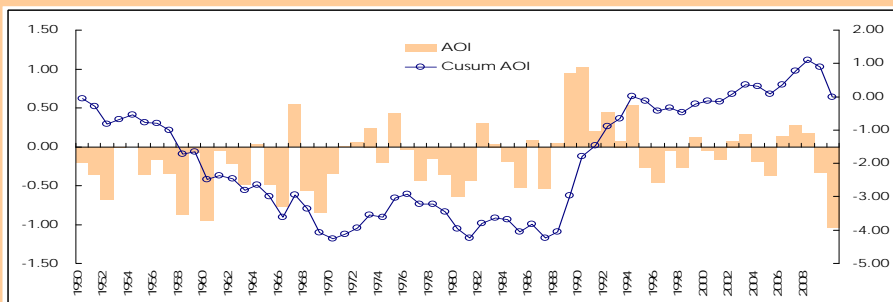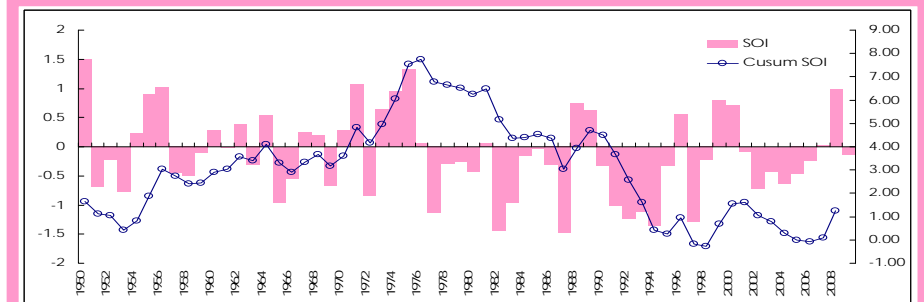
Interannual changes in winter SST
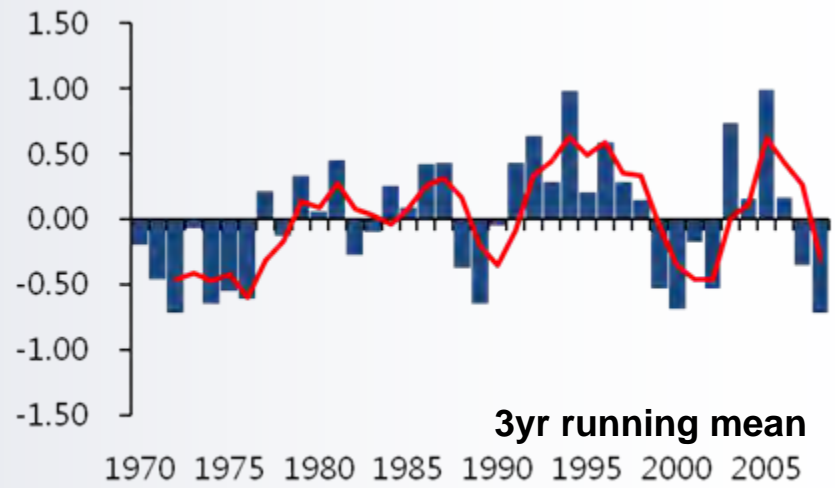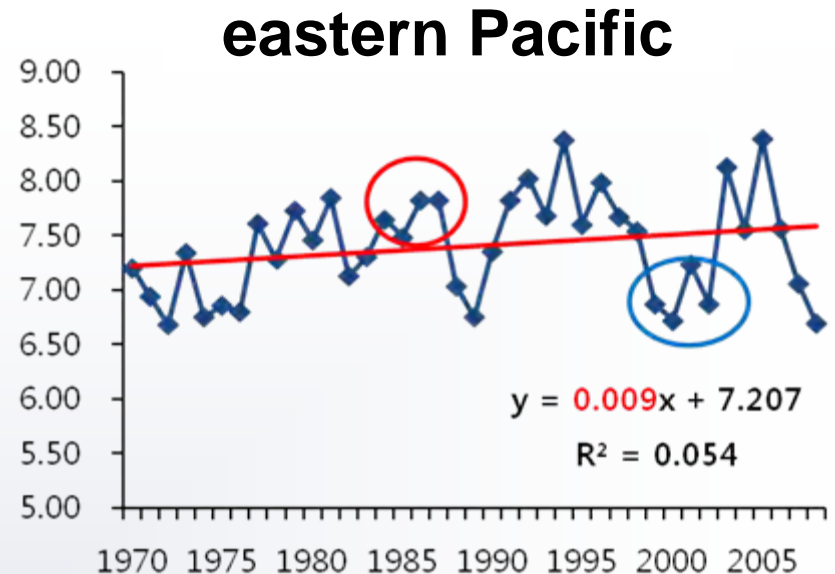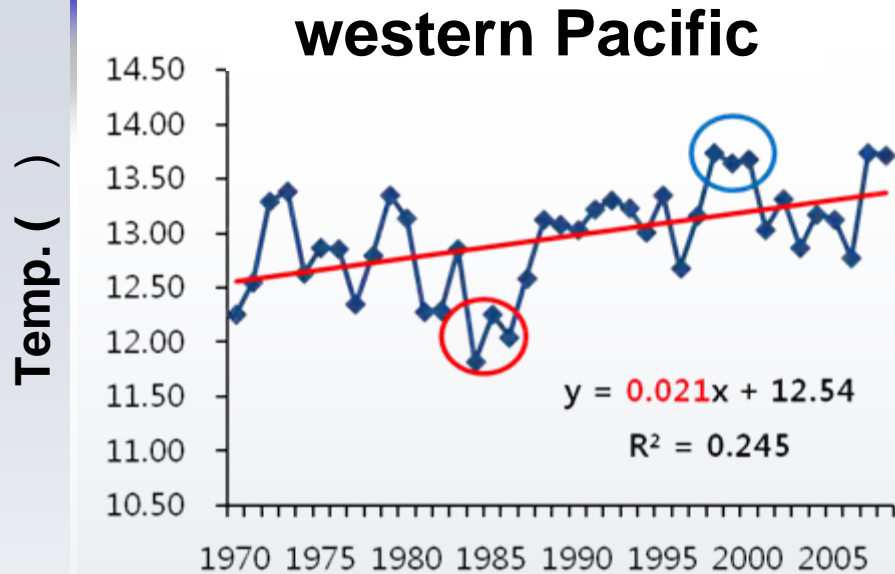
Spatial distribution of winter SST

LAS 7.+/Ferret 6.2
SODA V2.2.4 monthly means
Temperature [deg°C, 5 m]
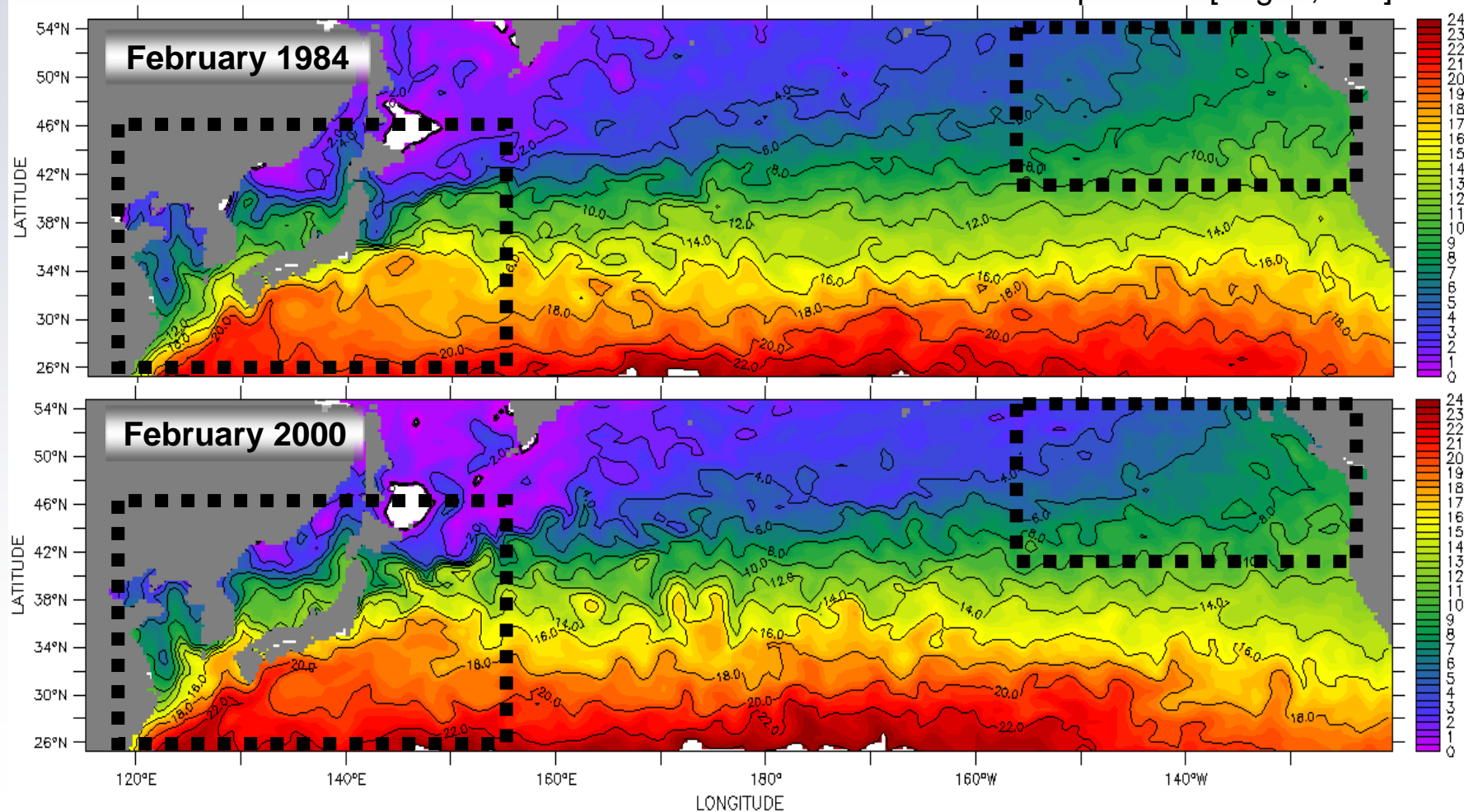
Contrasting pattern in spatial SST

SODA v2.2.4 monthly means
Temperature [deg$^\circ$C, 5 m] anomaly
(Feb. 2000 – Feb. 1984)
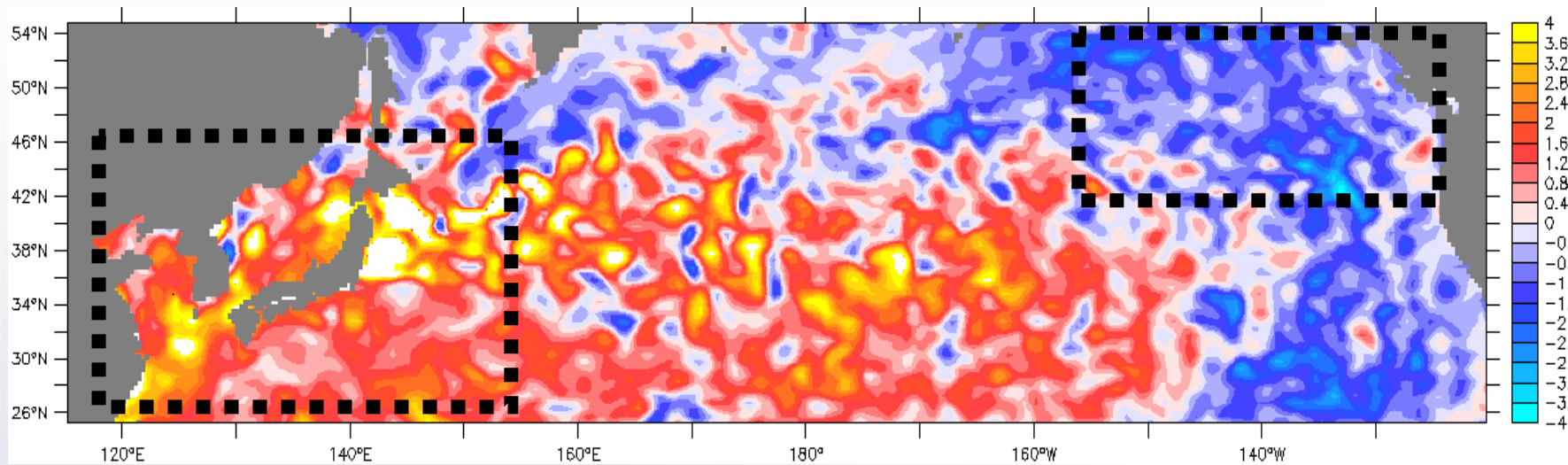
Difference in winter SST between 1984 and 2000

-> changes in SST is not the same in whole Pacific

Warming trend in 21st century

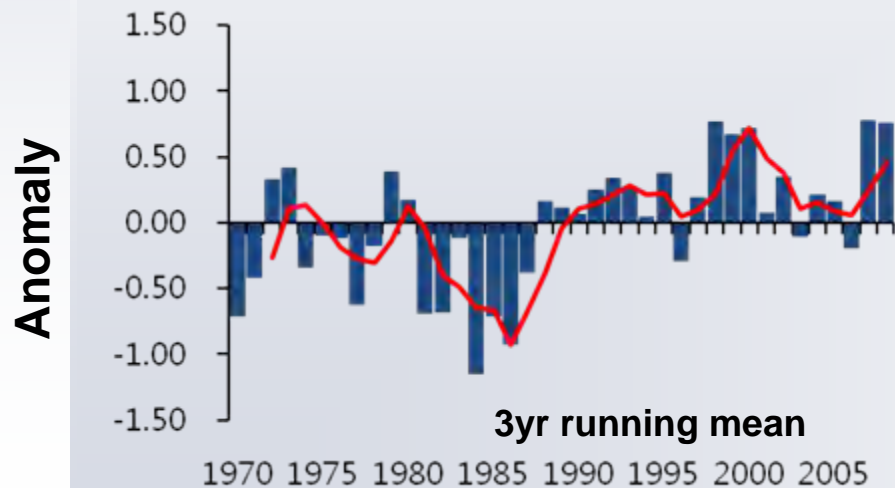**Annual mean temperature**

y = 0.0417x + 15.626
(World average)

y = 0.0618x + 11.156
(western Pacific)

y = 0.0426x + 5.7471
(eastern Pacific)
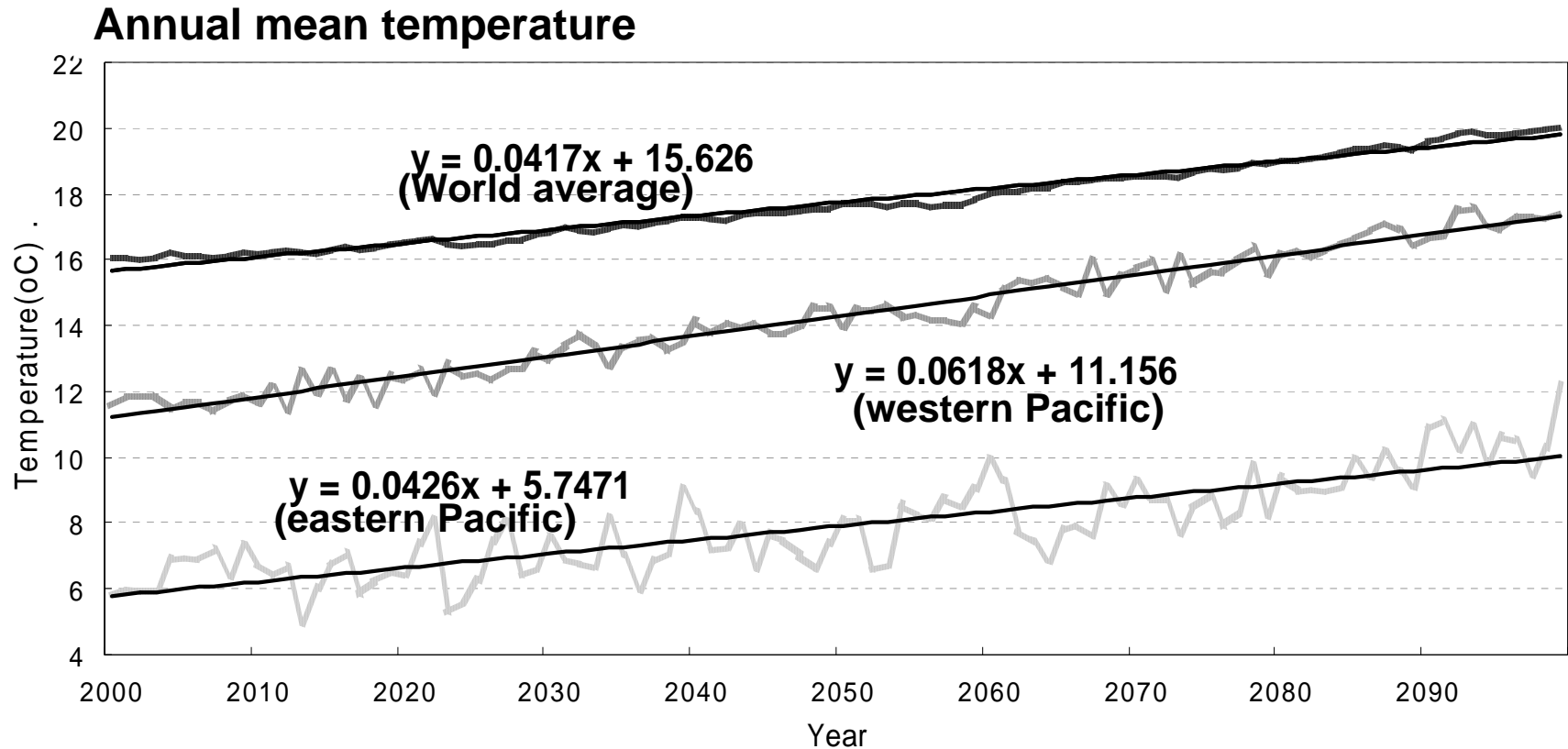
(McFarlane et al., 2009)

Catch from the western Pacific (Korea+Japan)
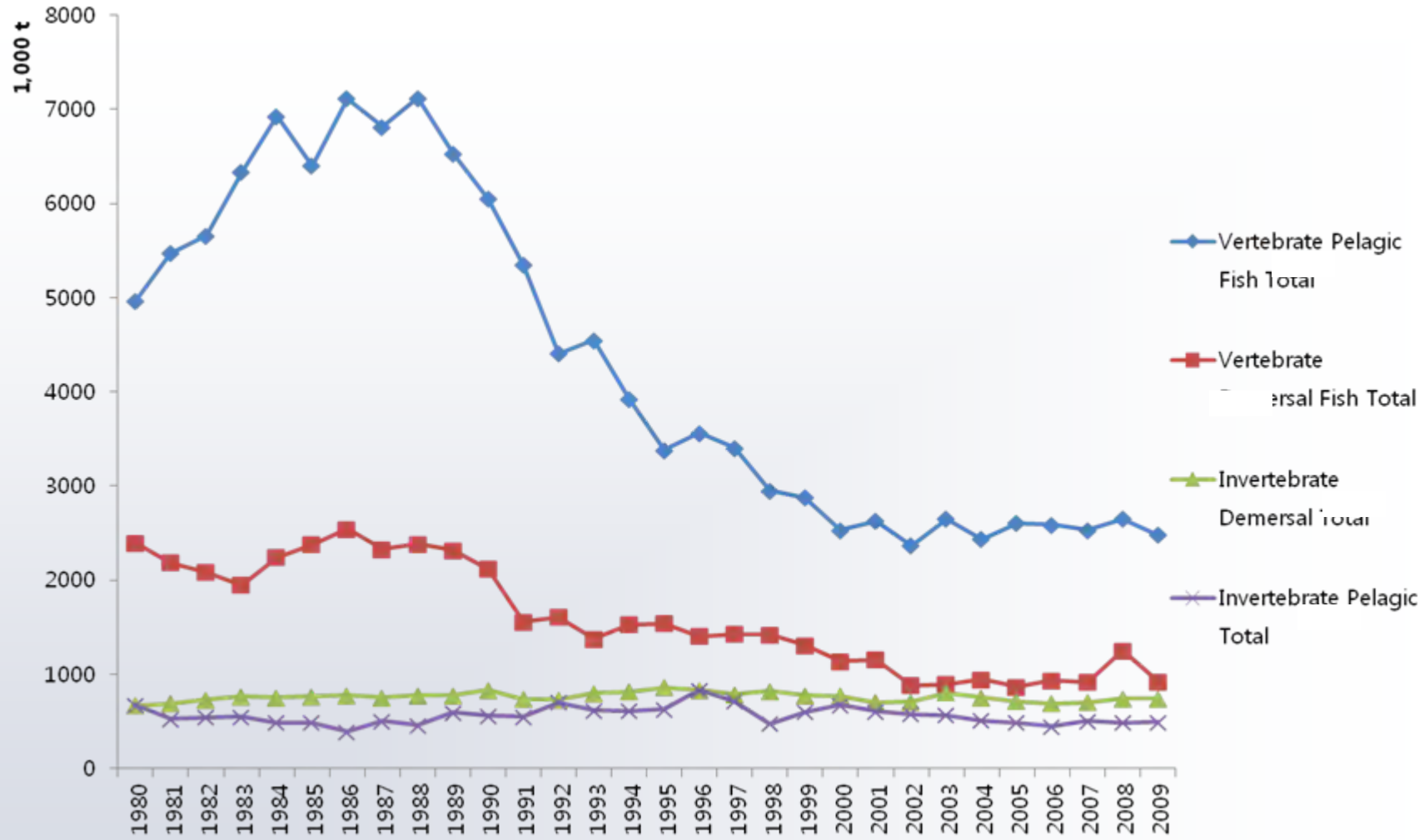
Catch from the eastern Pacific
(BC+WA+OR)

Catch composition in relative scale

Korea + Japan

BC + WA + OR

- ■ Vertebrate Pelagic Fish
- ■ Vertebrate Demersal Fish
- ■ Invertebrate Demersal
- ■ Invertebrate Pelagic

Changes in catch ratio from the western Pacific (Korea+Japan)

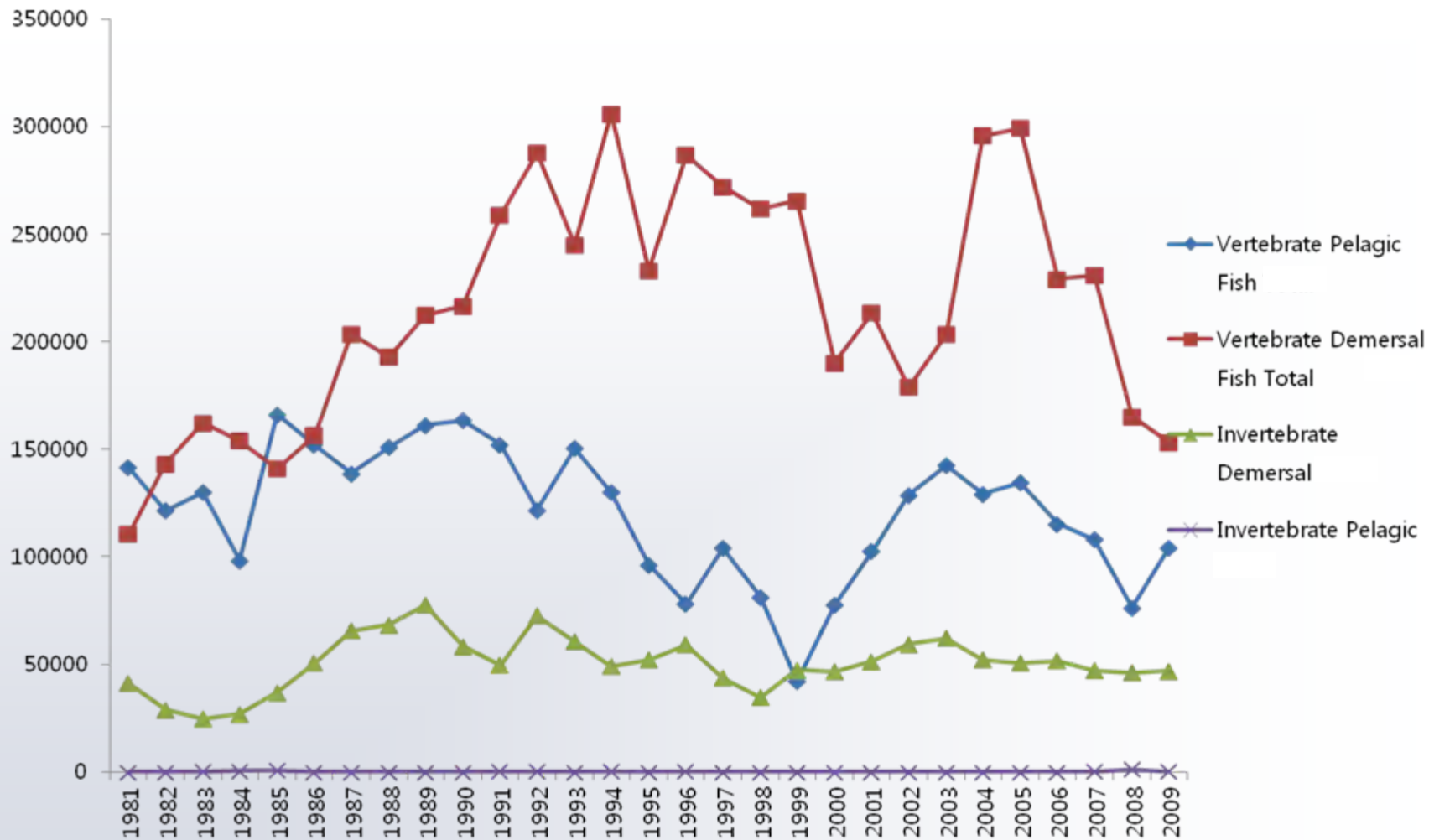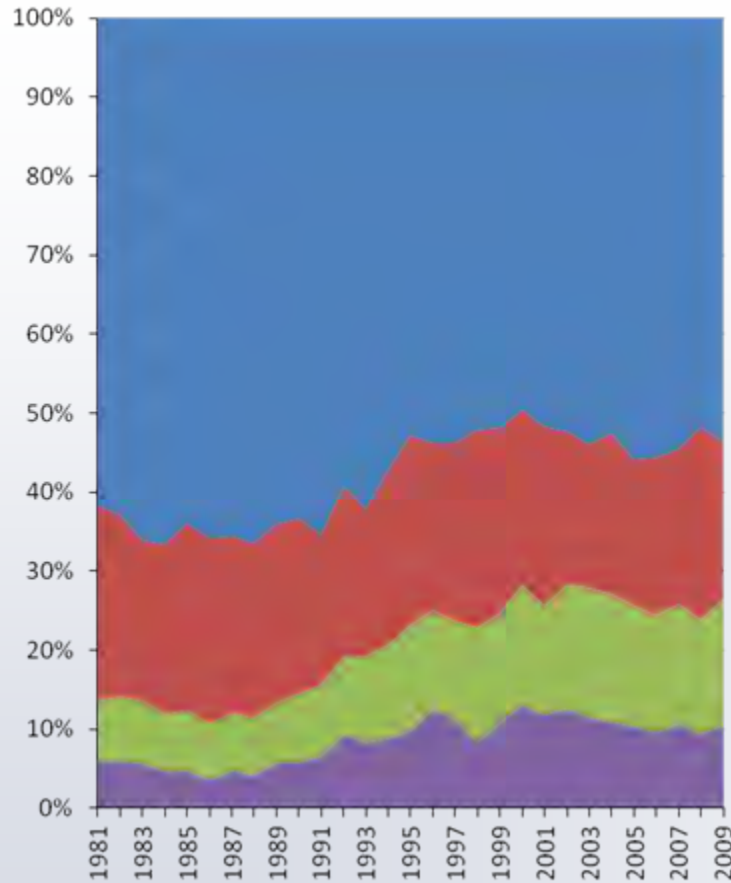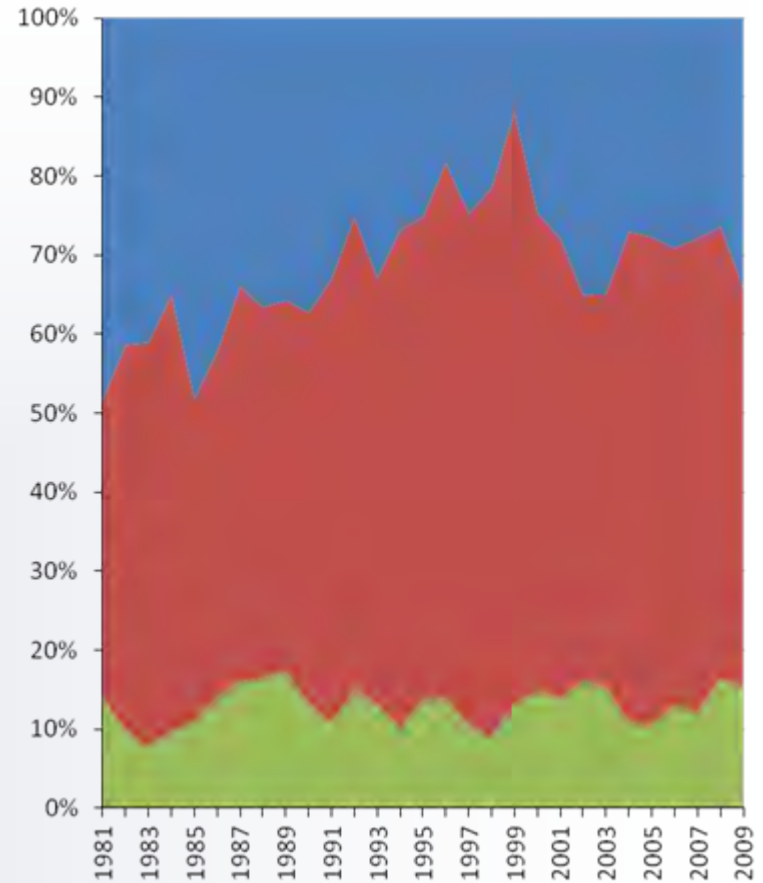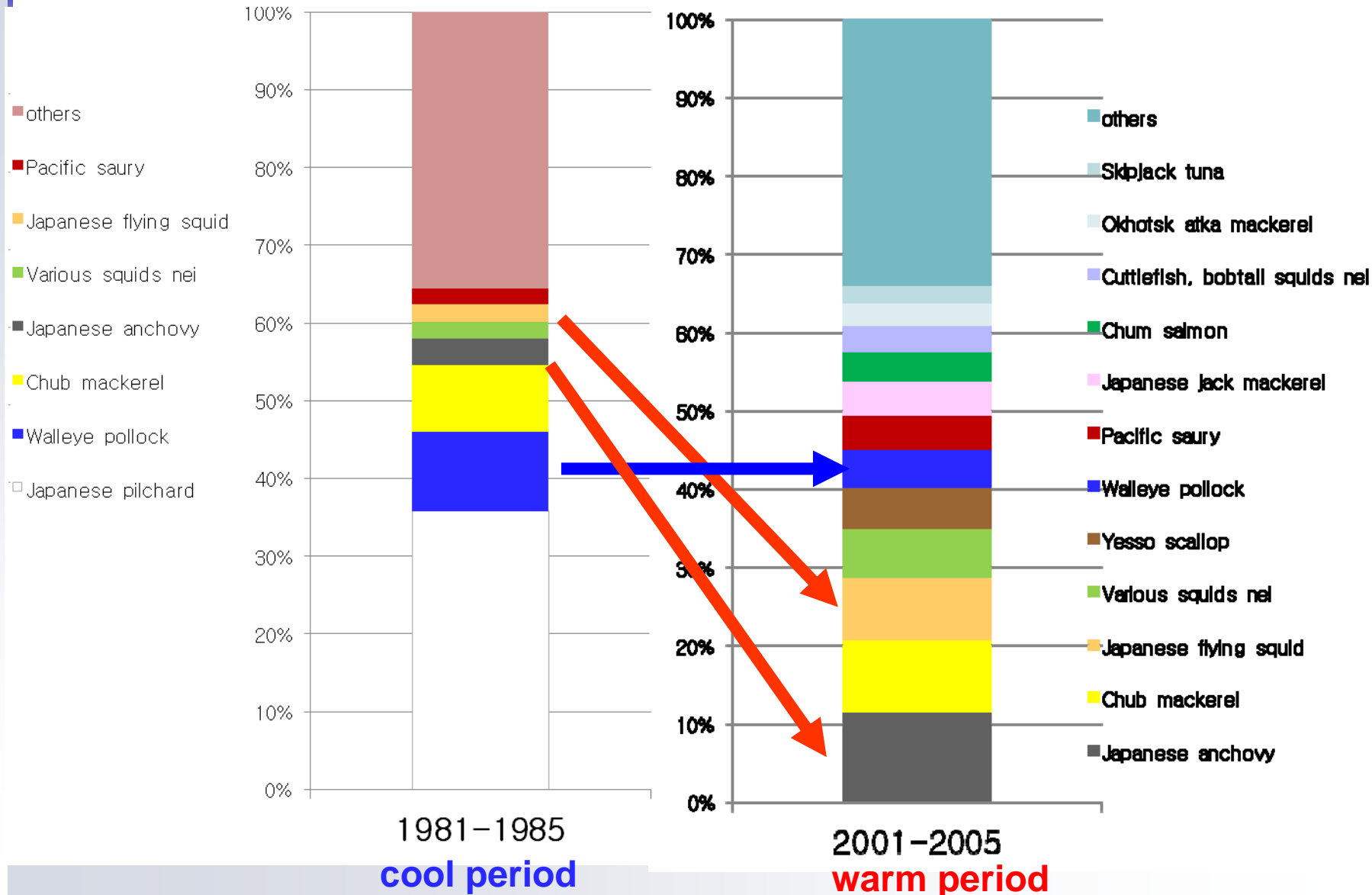|	1981-1985			2001-2005		
	Habitat depth	Species	ratios	Habitat depth	Species	ratios
1	P	Japanese pilchard	35.86	P	Japanese anchovy	11.79
2	D	Walleye pollock	10.25	P	Chub mackerel	9.66
3	P	Chub mackerel	8.64	P	Japanese flying squid	8.39
4	P	Japanese anchovy	3.39	P	Various squids nei	6.45
5	P	Various squids nei	2.21	D	Yesso scallop	5.46
6	P	Japanese flying squid	2.20	D	Walleye pollock	4.95
7	P	Pacific saury	2.09	P	Pacific saury	4.72
8	D	Threadsail filefish	1.88	P	Japanese jack mackerel	4.35
9	D	Largehead hairtail	1.66	P	Chum salmon	4.04
10	D	Japanese carpet shell	1.49	P	Cuttlefish, bobtail squids nei	3.51
11	P	Skipjack tuna	1.37	D	Okhotsk atka mackerel	2.86
12	D	Pacific sandlance	1.33	P	Skipjack tuna	2.40
13	D	Flatfishes nei	1.31	D	Largehead hairtail	1.44
14	P	Japanese jack mackerel	1.22	D	Pacific sandlance	1.29
15	P	Chum salmon	1.22	P	Japanese pilchard	1.27
16	D	Yesso scallop	1.10	D	Amberjacks nei	1.15
17	D	Clams, etc. nei	1.04	P	Clupeoids nei	1.06
18	P	Cuttlefish, bobtail squids nei	1.04	D	Flatfishes nei	1.02
19	D	Marine crabs nei	0.85	D	Clams, etc. nei	1.01
20	D	Okhotsk atka mackerel	0.82	D	Japanese carpet shell	0.88
	total number of species caught		**112**	total number of species caught		**114**

P: pelagic fish and pelagic invertebrate

D: demersal fish and demersal invertebrate (crab and clam)

Proportion of major species in the western Pacific (Korea+Japan)

Left chart legend (cool period):
- others
- Pacific saury
- Japanese flying squid
- Various squids nei
- Japanese anchovy
- Chub mackerel
- Walleye pollock
- Japanese pilchard

Right chart legend (warm period):
- others
- Skipjack tuna
- Okhotsk atka mackerel
- Cuttlefish, bobtail squids nei
- Chum salmon
- Japanese jack mackerel
- Pacific saury
- Walleye pollock
- Yesso scallop
- Various squids nei
- Japanese flying squid
- Chub mackerel
- Japanese anchovy

1981-1985
cool period

2001-2005
warm period

Changes in catch ratio from the eastern Pacific (BC+WA+OR)

	1981-1985			2001-2005		
	Habitat depth	Species	ratios	Habitat depth	Species	ratios
1	D	Rockfishes	13.73	D	Hake	36.29
2	P	Pacific herring	10.73	P	Pacific sardine	9.11
3	D	Hake	10.18	P	Pacific herring	6.25
4	P	Pink salmon	9.99	D	Rockfishes	5.43
5	P	Sockeye salmon	8.70	D	Dungeness crab	4.47
6	P	Chum salmon	5.08	P	Chum salmon	4.28
7	D	Pacific cod	4.91	D	Pink shrimp	3.32
8	P	Coho salmon	4.55	P	Albacore	3.09
9	P	Chinook salmon	3.14	D	Unspecified flatfish	2.87
10	D	Dover sole	3.11	P	Pink salmon	2.58
11	D	Pink shrimp	3.05	D	Pacific halibut	1.87
12	D	Sablefish	2.65	P	Sockeye salmon	1.54
13	D	Geoduck	2.38	D	Other crab	1.48
14	D	Pacific halibut	1.81	P	Chinook salmon	1.41
15	D	Dungeness crab	1.64	D	Dogfish	1.19
16	D	Unspecified flatfish	1.08	D	Geoduck	1.07
17	D	Lingcod	0.95	D	Other sea urchin	1.03
18	D	Walleye pollock	0.92	D	Dover sole	0.98
19	D	Pacific oyster	0.91	D	Walleye pollock	0.93
20	D	Spiny dogfish	0.82	D	Sablefish	0.91
	total number of species caught		79	total number of species caught		71

P: pelagic fish and pelagic invertebrate
D: demersal fish and demersal invertebrate (crab, shrimp and clam)

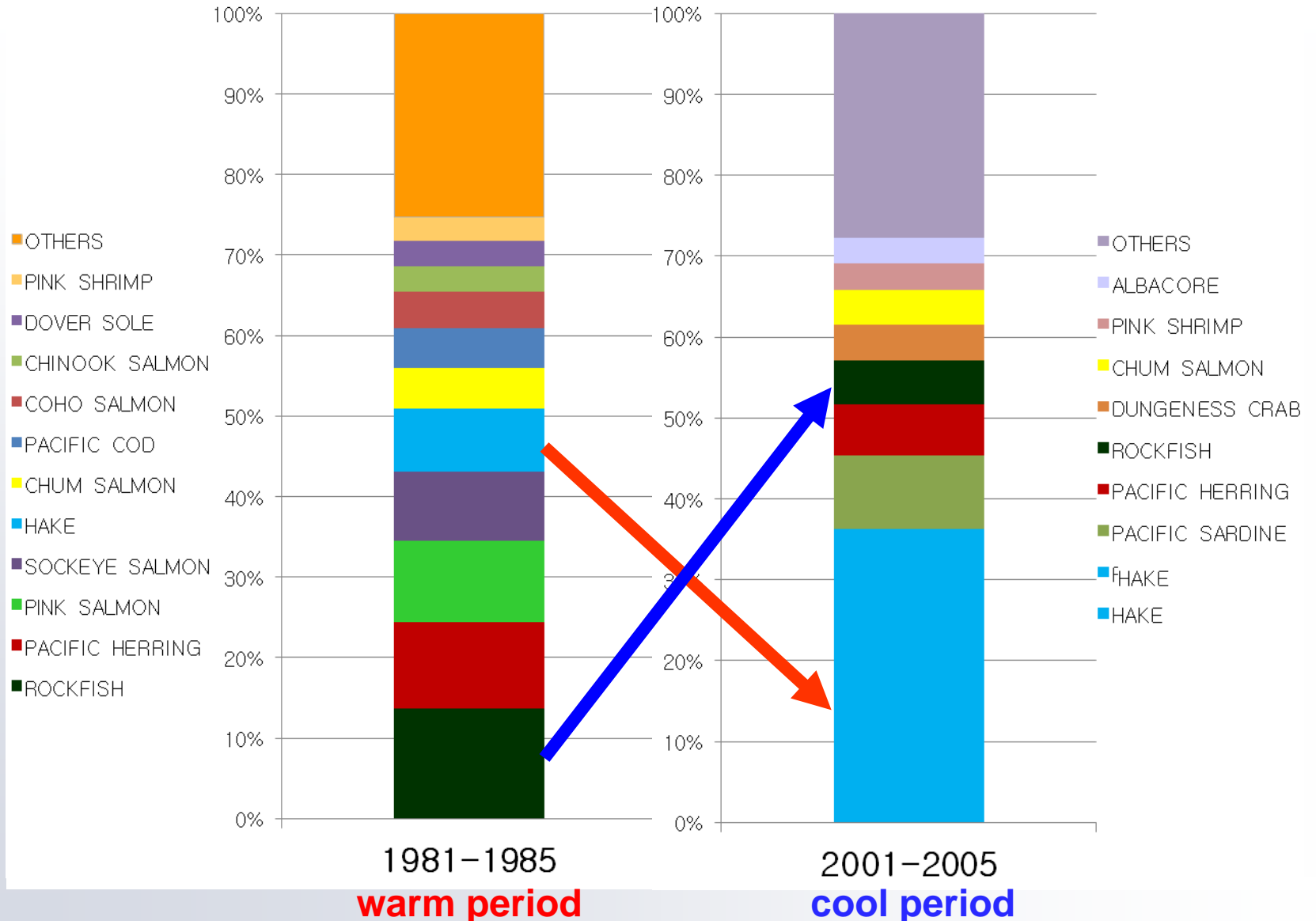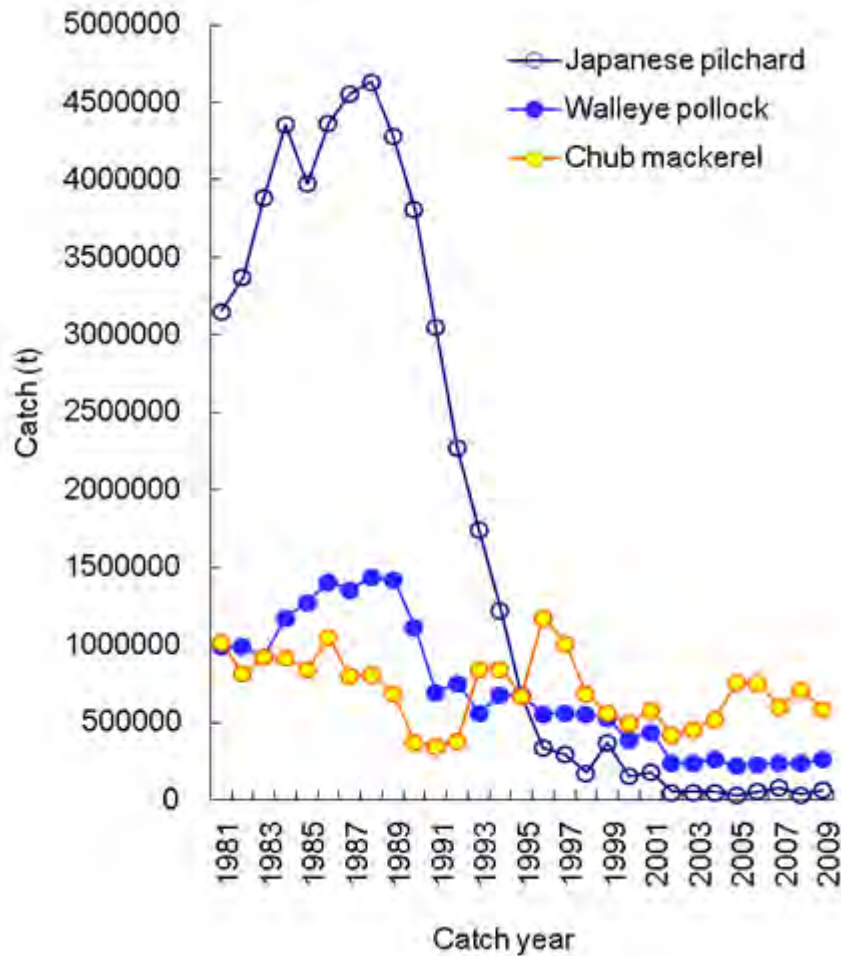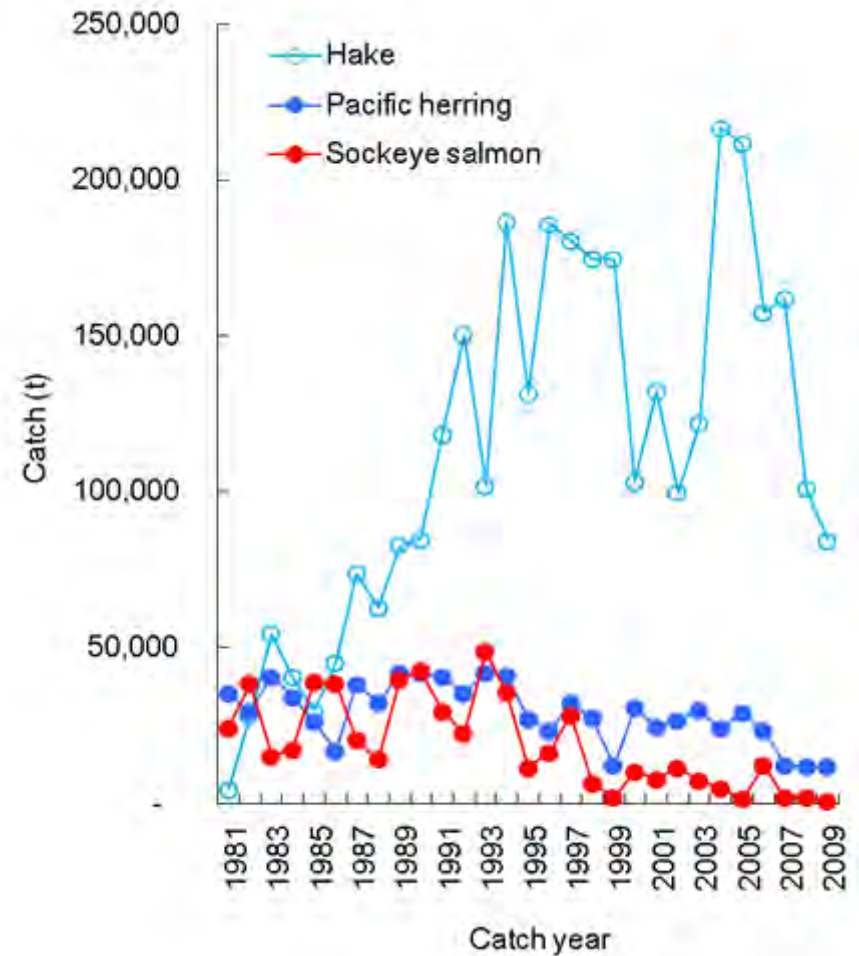# Proportion of major species in the eastern Pacific (BC+WA+OR)
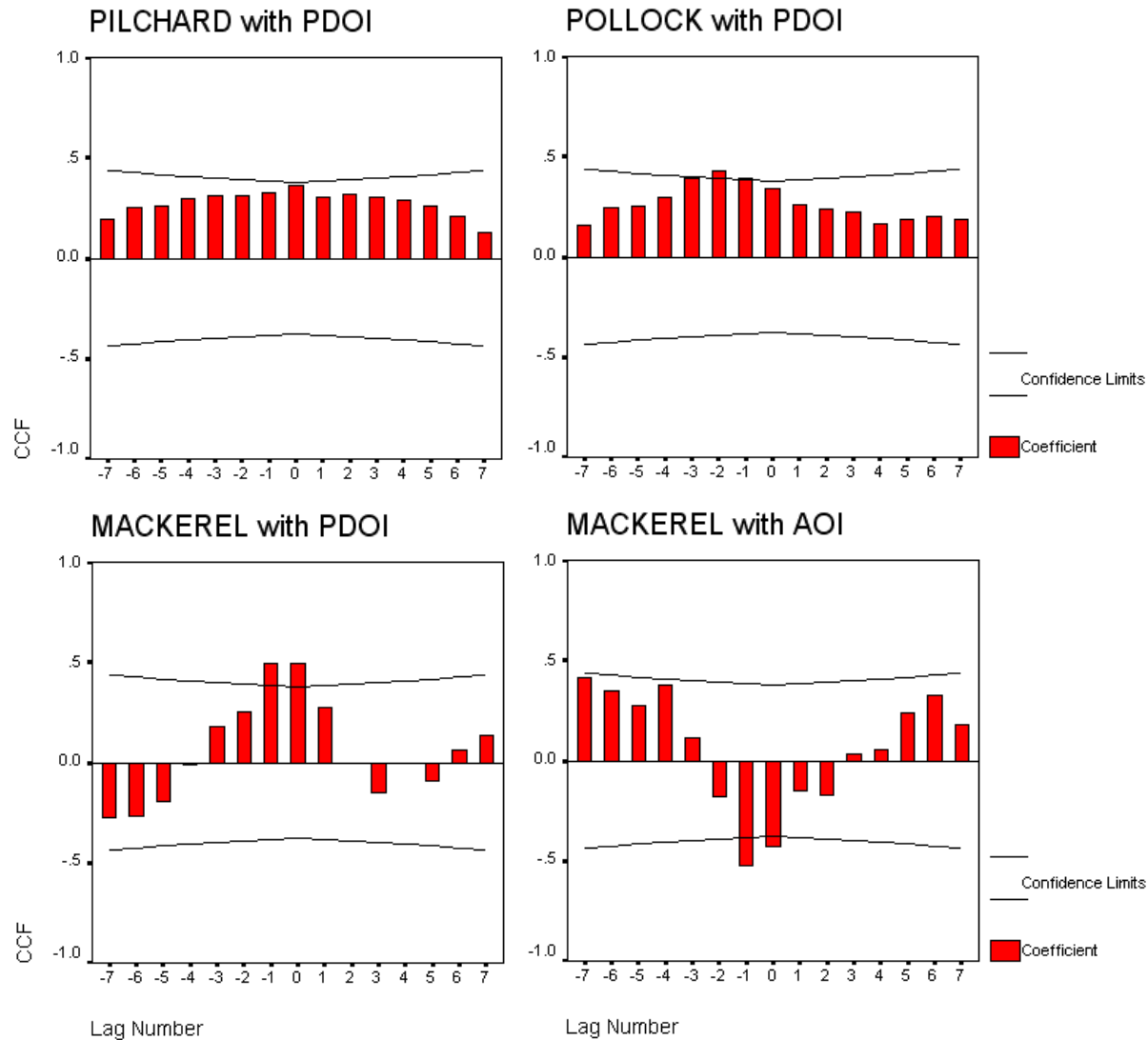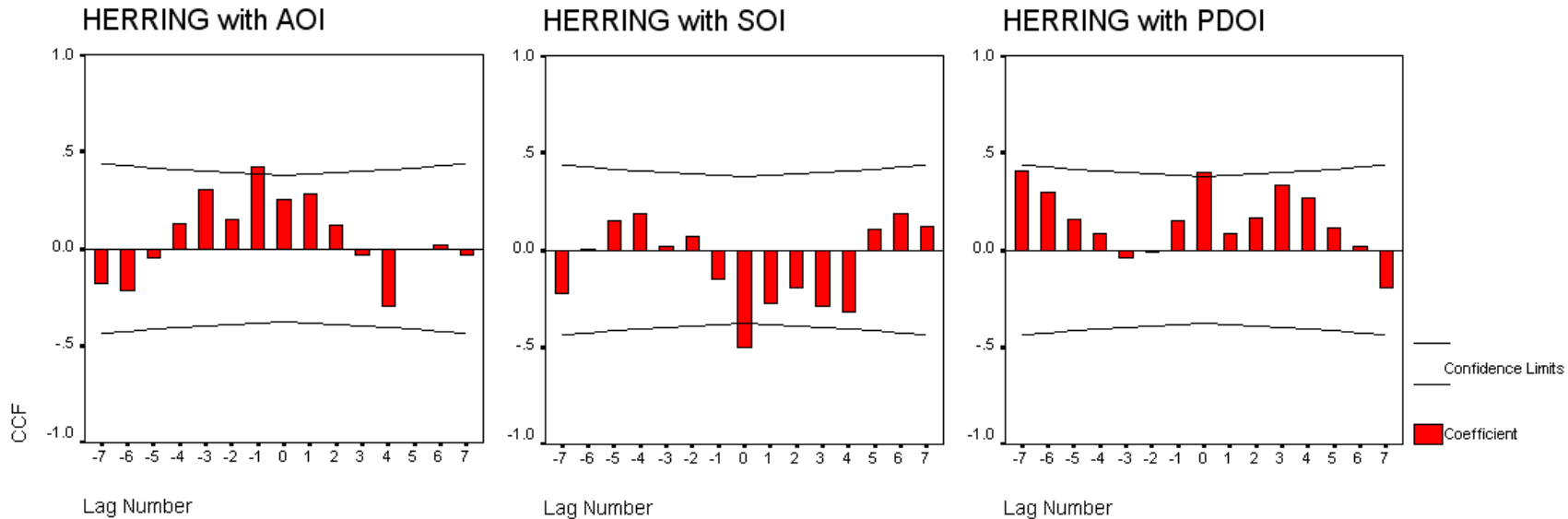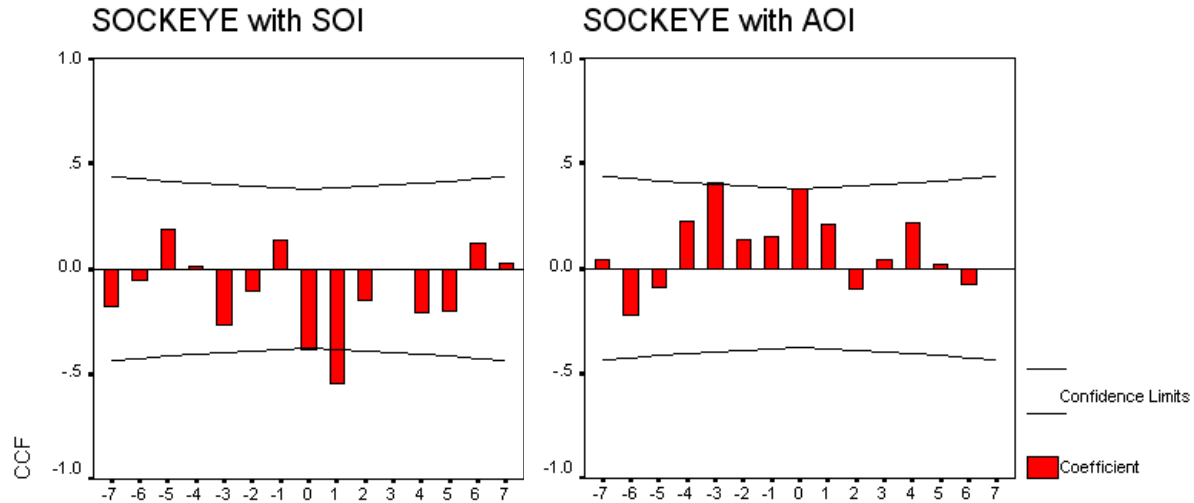
Catch of major species

Climate indices and fish catch in the western Pacific

Climate indices and fish catch in the eastern Pacific

Number of important species in the western and eastern Pacific, 1981-2009

Major groups	Groups	Western Pacific (Korea + Japan)	Eastern Pacific (BC + WA + OR)
Vertebrates	demersal fish	**45 (33.3%)**	**40 (39.6%)**
	pelagic fish	**53 (39.3%)**	**22 (21.8%)**
	miscellaneous	4	4
Invertebrates	benthos	**28 (20.7%)**	**32 (31.7%)**
	squid	2	1
	miscellaneous	3	3
	sum	135	101

Habitat depth and Maximum age for major species, 1981-2009

Western Pacific

Species	Habitat depth	Maximum age
Japanese pilchard	P	25
Walleye pollock	D	15
Chub mackerel	P	18
Japanese anchovy	P	4
Japanese flying squid	P	1
Pacific saury	P	4
Threadsail filefish	D	8
Largehead hairtail	D	15
Japanese jack mackerel	P	12
Chum salmon	P	4

Eastern Pacific

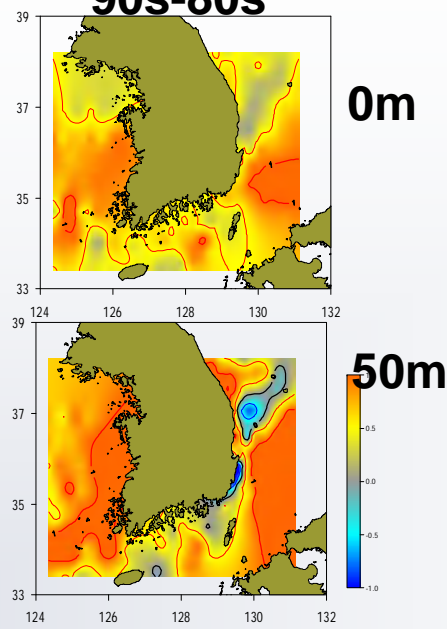| Species	Habitat depth	Maximum age
Rockfish	D	>>30
Pacific Herring	P	19
Pink salmon	P	3
Sockeye salmon	P	8
Hake	D	12
Chum salmon	P	7
Pacific cod	D	18
Dover sole	D	45
Sablefish	D	114
Pacific sardine	P	25

P: pelagic fish, D: demersal fish

Fish distribution and Seawater temperature
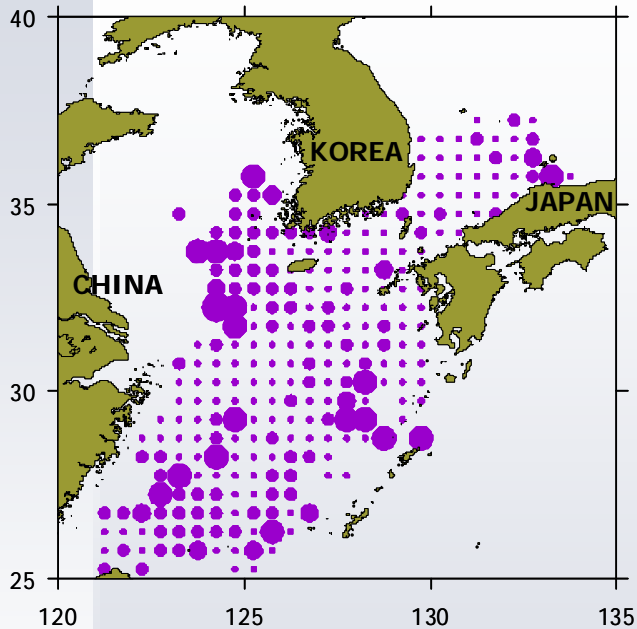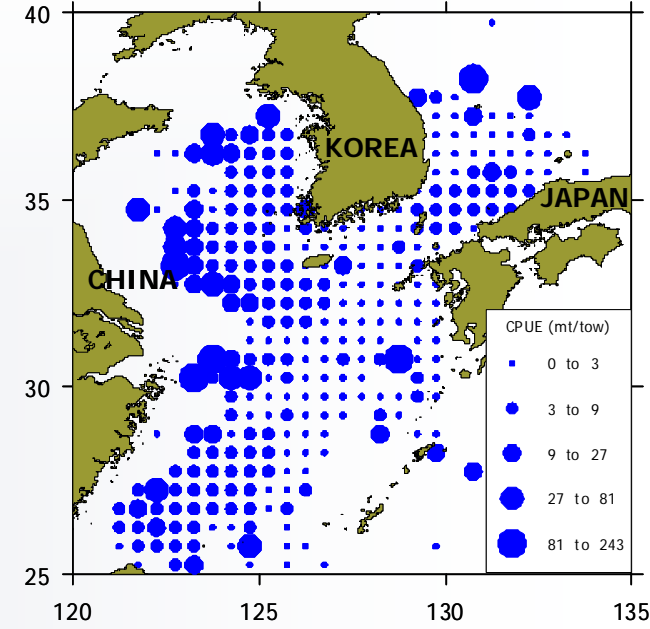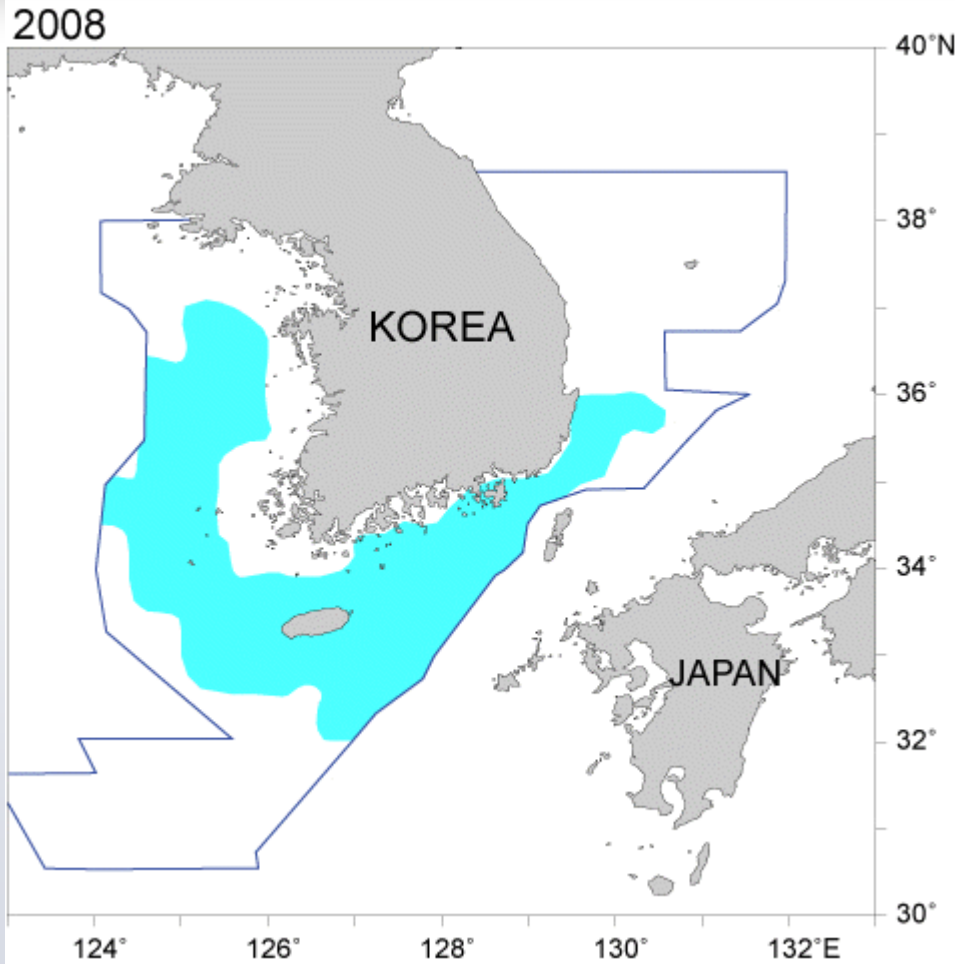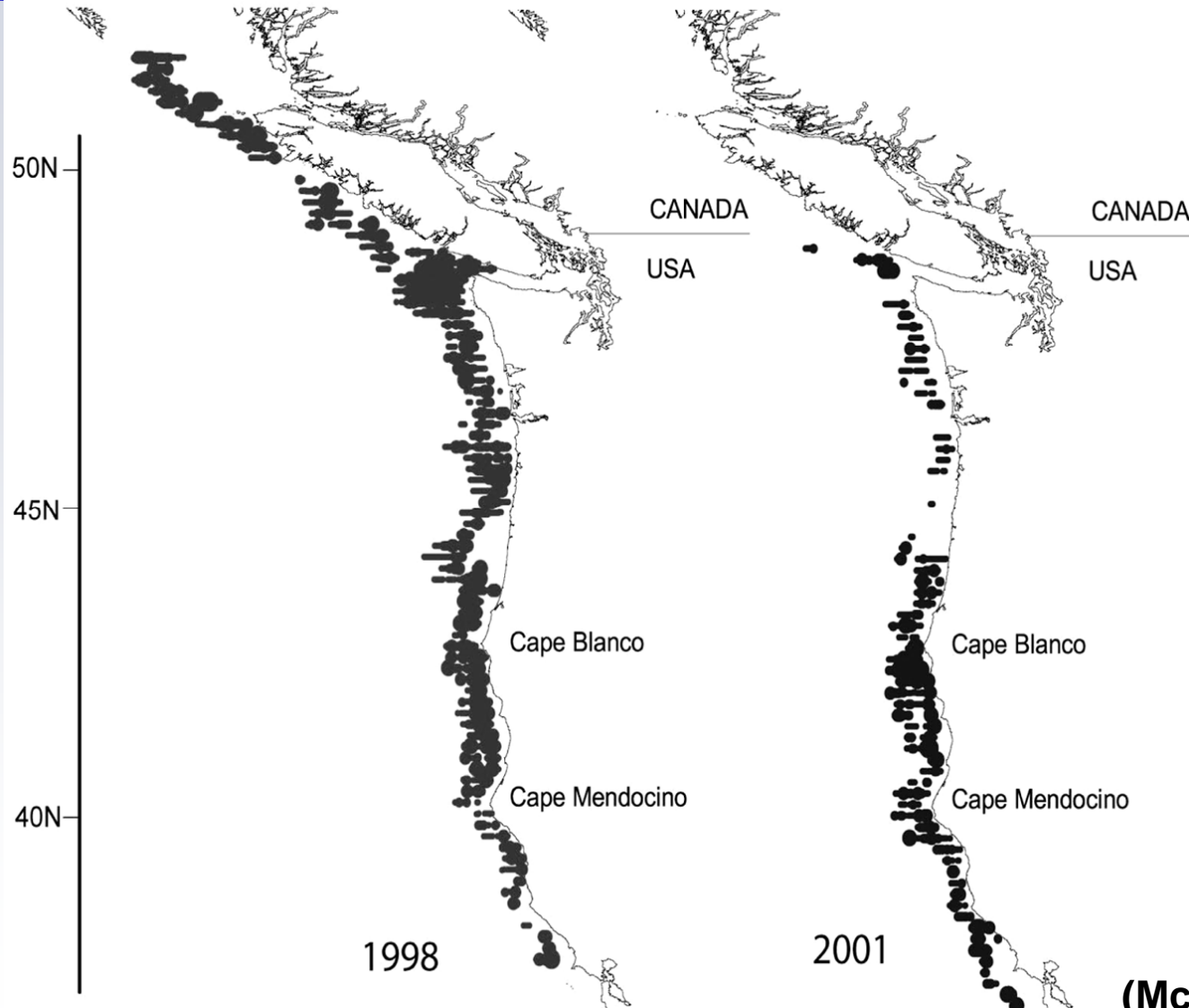

- **More fishing activities on chub mackerel were found in the southern area during the warm periods ('90s). Due to the SST increase in the 1990s, the habitat of chub mackerel seemed to expand to the north.**

Poleward movement of fish populations

Chub mackerel

Temporal comparison in spatial distribution of Pacific hake

(McFarlane *et al.*, 2009)

(El Niño year)   **(La Niña year)**

Summary (I)

- Warm and cool currents merge in the western Pacific, and flow eastward. The current diverges toward the pole and equator in the eastern Pacific.

- The SSTs of the eastern and western Pacific show an opposite pattern in the same period.

- Warming rate is higher in the western Pacific than the eastern Pacific, and enhanced SST could result in northward distribution of fish species in both ecosystems.

- Significant correlations were found between some climate indices and fish catches with or without time-lag.

- In cool period, yields seemed to be higher, and some dominant species occupy a large portion of catch, while more species evenly share catch proportion in warm years.

Summary (II)

- **The comparative analysis of fish catch between two ecosystems indicates that**
  - much **higher**/**lower** yields were shown in the **western**/**eastern** Pacific
  - Annual catch was much reduced in the western Pacific, while relatively stable in the east.
  - **pelagic**/**demersal** fish is more abundant in the **western**/**eastern** Pacific
  - the number of **pelagic**/**demersal** species is higher in the **western**/**eastern** Pacific
  - **short-lived**/**long-lived** fishes are dominant in the **western**/**eastern** Pacific
  - **higher**/**lower** proportion of invertebrate catches were reported in the **western**/**eastern** Pacific.