Fluctuations of pelagic fish populations and climate shifts in the Far-East regions

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Study Objective

To investigate the alternation of dominant species and the regional synchrony in long-term catch trend for seven pelagic fish populations in the Tsushima Warm Current(TWC) and Kuroshio-Oyashio Current(KOC) regions.

Data and Methods

Dominant pattern exhibiting a peak of abundance and regional synchronies in the fluctuation patterns for seven fish populations are examined in relation to the climate shifts on the basis of historical catch records from the Annual Fisheries Statistical Reports for the FAO area 61 and on the climate indices (e.g. NPI) and upper layer thermal anomalies in the two regions (Minobe, 1997, Minami et al., 1999; NFRDI, 1957-2005).

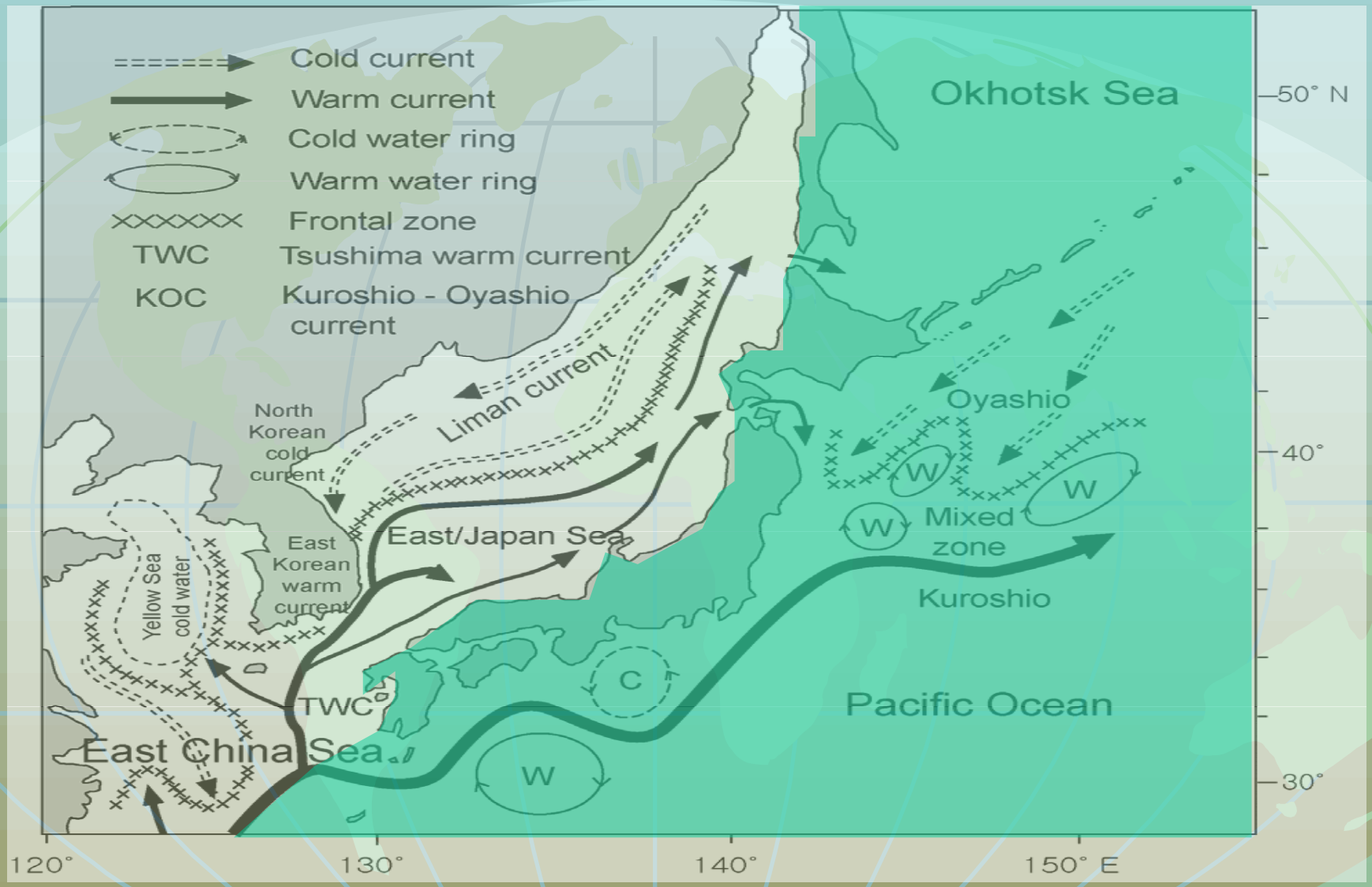

Fig. 1-a. Schematic current systems in the East/Japan Sea and its adjacent waters. TWC indicates the East/Japan Sea, East China Sea and Yellow Sea, and KOC indicates the Kuroshio-Oyashio Current regions and the Okhotsk Sea.

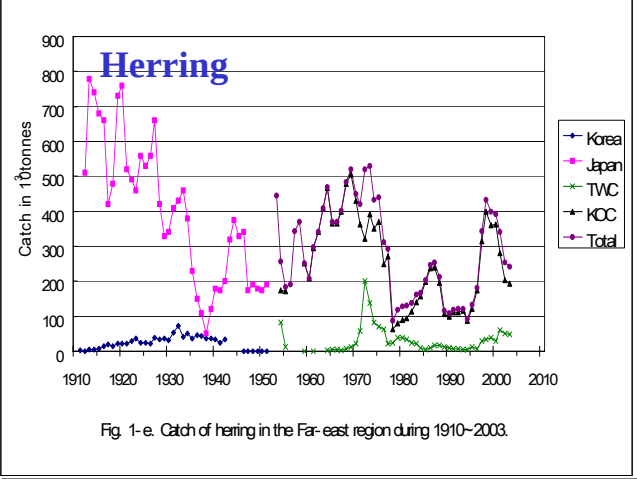

Fig. 1-e. Catch of herring in the Far-east region during 1910~2003.

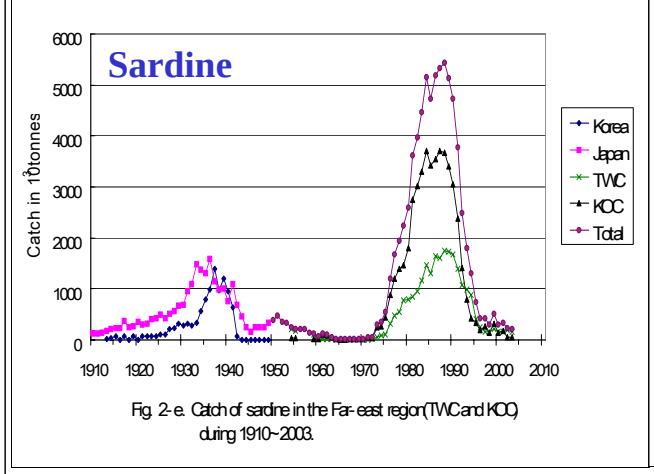

Fig. 2-e. Catch of sardine in the Far-east region(TWC and KOC) during 1910~2003.

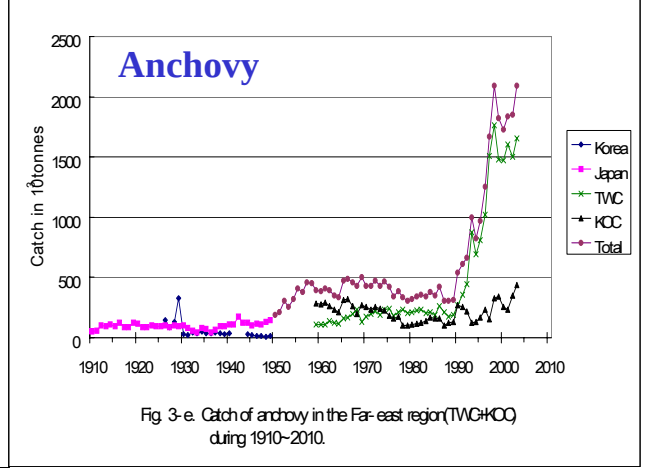

Fig. 3-e. Catch of anchovy in the Far-east region(TWC+KOC) during 1910~2010.

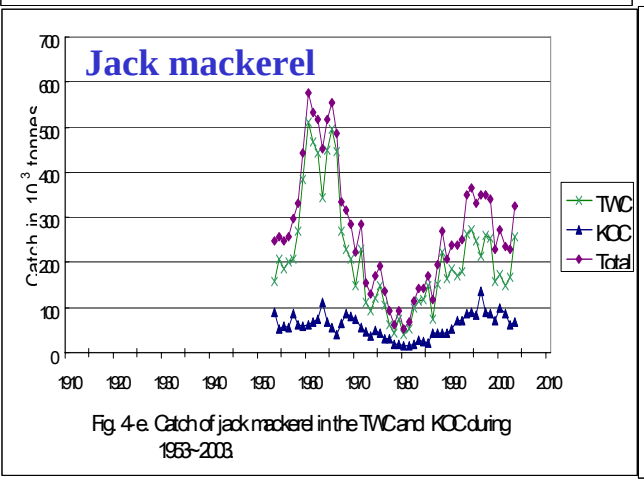

Fig. 4-e. Catch of jack mackerel in the TWC and KOC during 1953~2003.

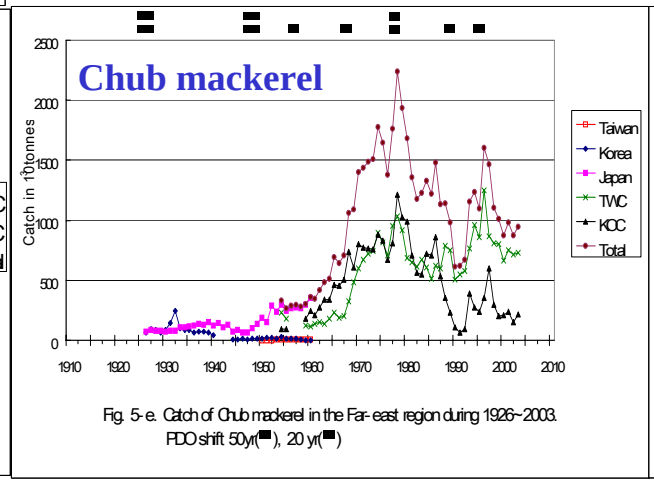

Fig. 5-e. Catch of Chub mackerel in the Far-east region during 1926~2003.
PDO shift 50yr(■), 20 yr(■)

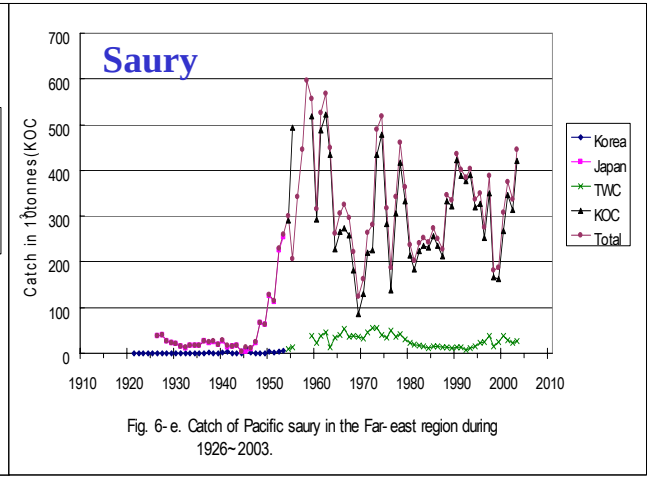

Fig. 6-e. Catch of Pacific saury in the Far-east region during 1926~2003.

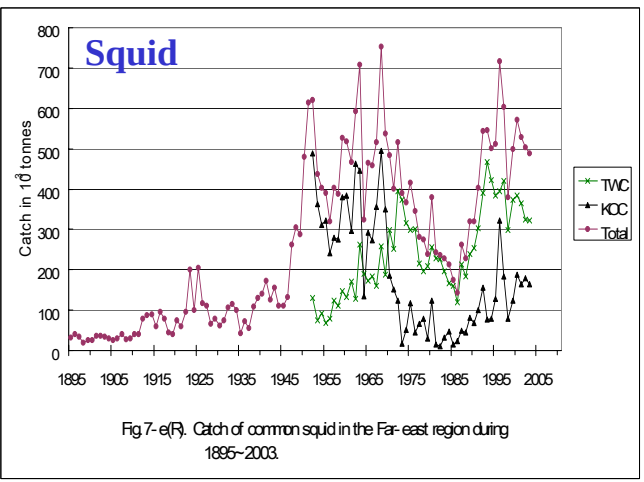

Fig.7-e(R). Catch of common squid in the Far-east region during 1895~2003.

Fig. 1. Time series of catches for small pelagic fish populations from the TWC (Yellow Sea-East china sea-East/Japan Sea) and KOC (NWPacific-Okhotsk Sea) regions. Environmental index (PDO) is included.

Basin scale synchrony

Abundance of herring, sardine, jack mackerel, chub mackerel, saury and common squid of the TWC region have been varying substantially in phase with those of the KOC region.

Fig. 2. Abundant periods and fishing nature for pelagic fishes in the KOC (Northwest Pacific and Okhotsk Sea) and TWC (Yellow Sea, E. China Sea and East/Japan Sea), 1870-2003.

Common name	Time	Abundant period, (peak year), Regional difference in catch			Main fishing gear	Factors leading to different amplitude
Pacific herring	1870-2003	1880-1910 (1897) KOC>TWC	1964-1975 (1973) KOC>TWC	1997-2000 (1998) KOC>TWC	Gill-net, Purse seine	KOC>TWC (Cont.) Inhabit subarctic coastal waters and Yellow Sea
Pacific sardine	1910-2003	1930-1941 (1937) KOC=TWC		1980-1992 (1988) KOC>TWC	Purse seine Setnet	KOC>TWC (Cont.) Incidental fishing in limited area of TWC
Japanese anchovy	1910-2003	1955-1975 (1969) KOC=TWC		1990-2003 (1998) KOC<<TWC	Purse seine Boat seine (KOC) Drag net, Gill-net Setnet (TWC)	KOC<<TWC(1990's) Changes in community structure in YS, ECS
Jack mackerel	1952-2003	1959-1966 (1960) KOC<<TWC		1989-1998 (1994) KOC<<TWC	Purse seine	KOC<<TWC (Cont.) Inhabit southern warm waters
Chub mackerel	1926-2003	Possible (1920's)	1970-1980 (1978) KOC=TWC	1993-2003 (1996) KOC<TWC	Purse seine	KOC<TWC(1990's) Heavy fishing in KOC
Pacific saury	1921-2003	1955-1963 (1958) KOC>>TWC	1973-1979 (1974) KOC>>TWC	1988-2003 (1990) KOC>>TWC	Stick held-dipnet (KOC) Gill-net (TWC)	KOC>>TWC (Cont.) Inhabit haline waters, abundant in KOC
Common squid	1895-2003	1950-1972 (1968) KOC>TWC		1990-2003 (1996) KOC<TWC	Jigging and Trawl (from 1990's)	KOC<TWC(1990's) Availability, shifted fishing to TWC

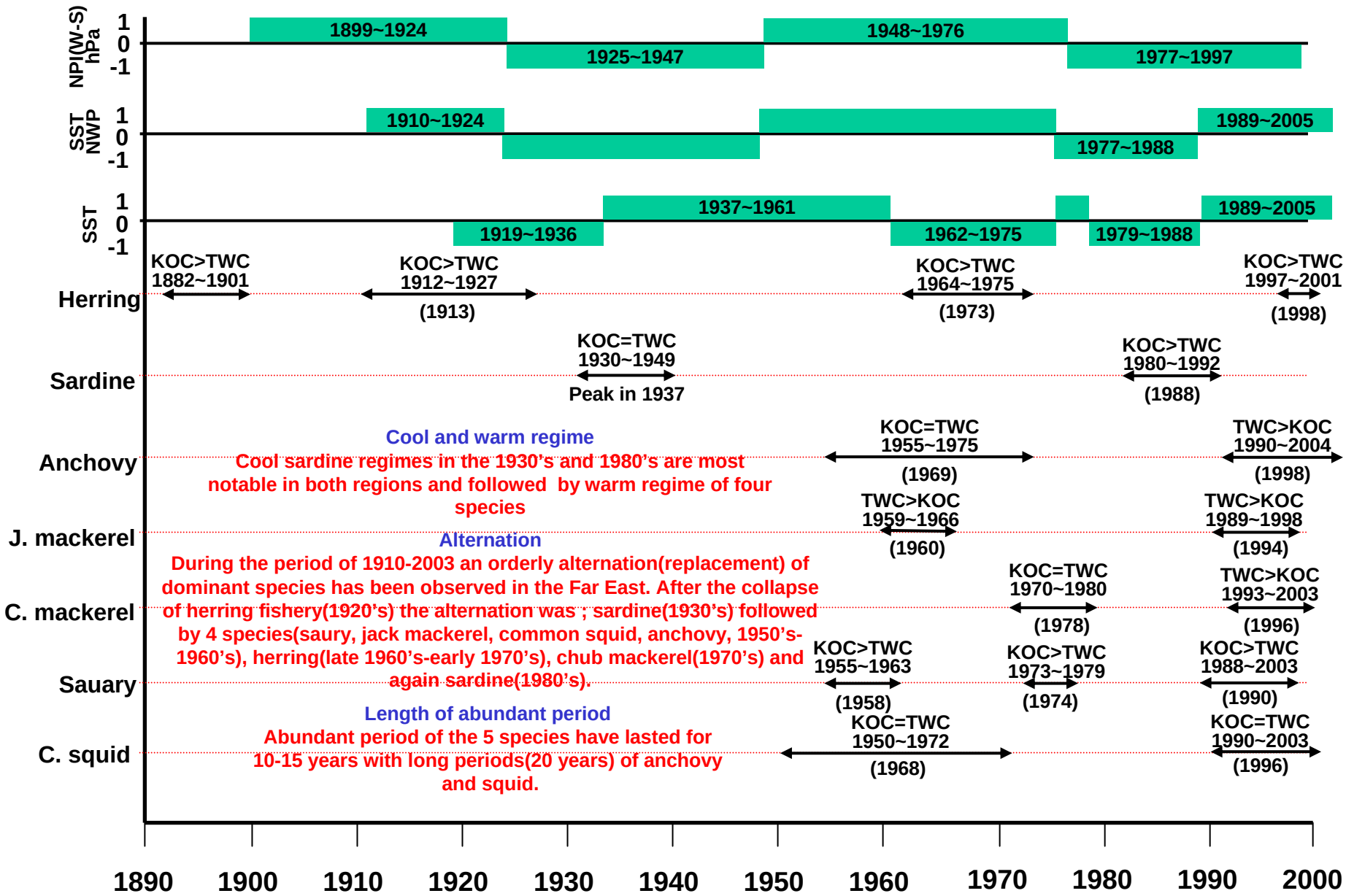

Fig. 3 . Changes in climate(NPI) and ocean(SST), and abuntant periods of pelagic fish in the northwest Pacific and its adjacent regions during 1890~2005.

Basin scale synchrony

Abundance of herring, sardine, jack mackerel, chub mackerel, saury and common squid of the TWC region have been varying substantially in phase with those of the KOC region.

Factors leading regional difference in amplitude of sardine catch

Regional difference in sardine catch (KOC>TWC) in the 1980's is due to the limited fishing(south of 38° 30´ N) and incidental catch by Korean fishing (purse seine targeting mackerel and file fish) in the TWC.

Synchrony under same climate forcing-single population

It is postulated that pacific sardine in two regions fluctuate with synchronous pattern under the same climate forcing and reveal different amplitude due to the different nature of fishing and availability, and hence same large single population to conserve.

Regional different catch distribution-evolution

Significant differences in catch of anchovy, jack mackerel (KOC<TWC) and Pacific saury (KOC>TWC) between the two regions are attributed to the different distribution .

The jack mackerel and anchovy evolved in the southern waters and prevailed during the warm period (Ogawa and Nakahara, 1979). No adult Pacific saury are found in the western East China Sea and Yellow Sea since the fish inhabit high haline waters(Gong and Suh, 2004).

Squid phase in abundance fluctuation

The phase difference in the collapse of common squid between the TWC and KOC regions in the 1970's was attributed to the heavy fishing before the response of the squid to the climate shift in the mid 1970's.

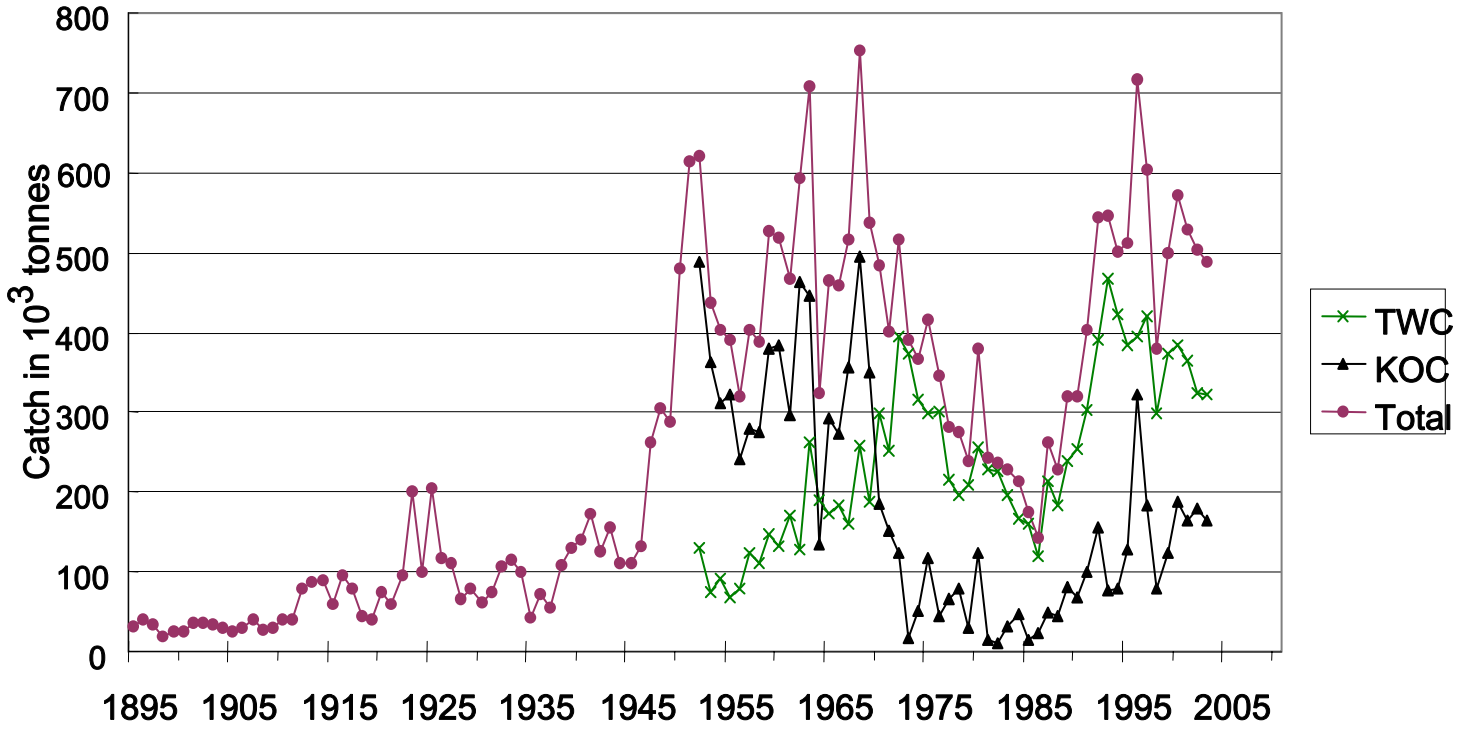

Fig.1-h. Catch of common squid in the Far-east region during 1895~2003.

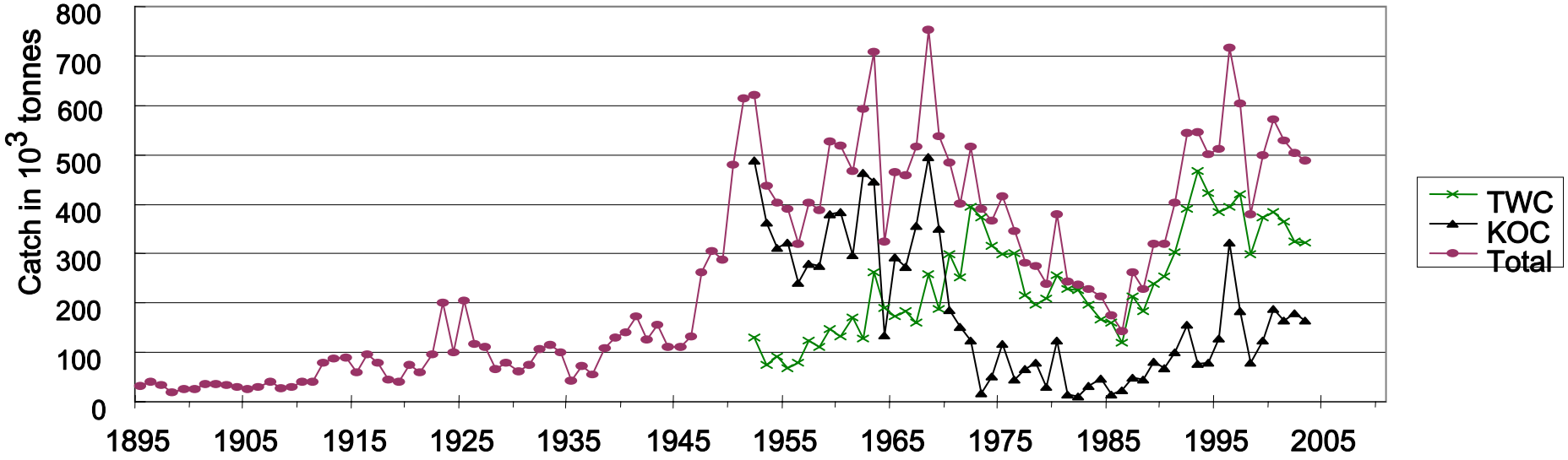

Fig.1-h. Catch of common squid in the Far-east region during 1895~2003.

Squid amplitude in abundance fluctuation

An amount of common squid taken in the TWC region were landed at the fishing ports along the Pacific coast (KOC region) which are included to the former region in the late 1960's.

Significant regional difference in the squid catch in the 1950's-1960's(KOC>TWC) is due to the shifts of fishing grounds depending on the changes in distribution in association with current-mediated migration circuits.

Conclusion

- An orderly alternation of dominant pelagic fish has been observed in the catch records from the Far Eastern regions (TWC + KOC) during the 20th century .

- The alternation was ; herring(1910’s – 1920’s), chub mackerel (possibly 1920’s), sardine(1930’s), four species(Pacific saury, jack mackerel, common squid and anchovy, 1950’s-1960’s), herring(late 1960’s-early 1970’s), chub mackerel(1970’s) and then sardine(1980’s). As sardine biomass decreased in association with the climate shifts(in the late 1980’s) catch of the four species increased in the warm regime in the 1990’s. The abundant period of each species has lasted for 10-20 years.

- The abundance of seven species has synchronous pattern of variability in the TWC and KOC regions, suggesting that they are controlled by the same climate forcing, and they reveal different amplitude(catch) due to the varying availability and fishing nature in each region, and hence single large population to conserve in spite of their widely distributed population area.