Relationship between Pacific cod (*Gadus macrocephalus*) catch and environmental factors in the East/Japan Sea

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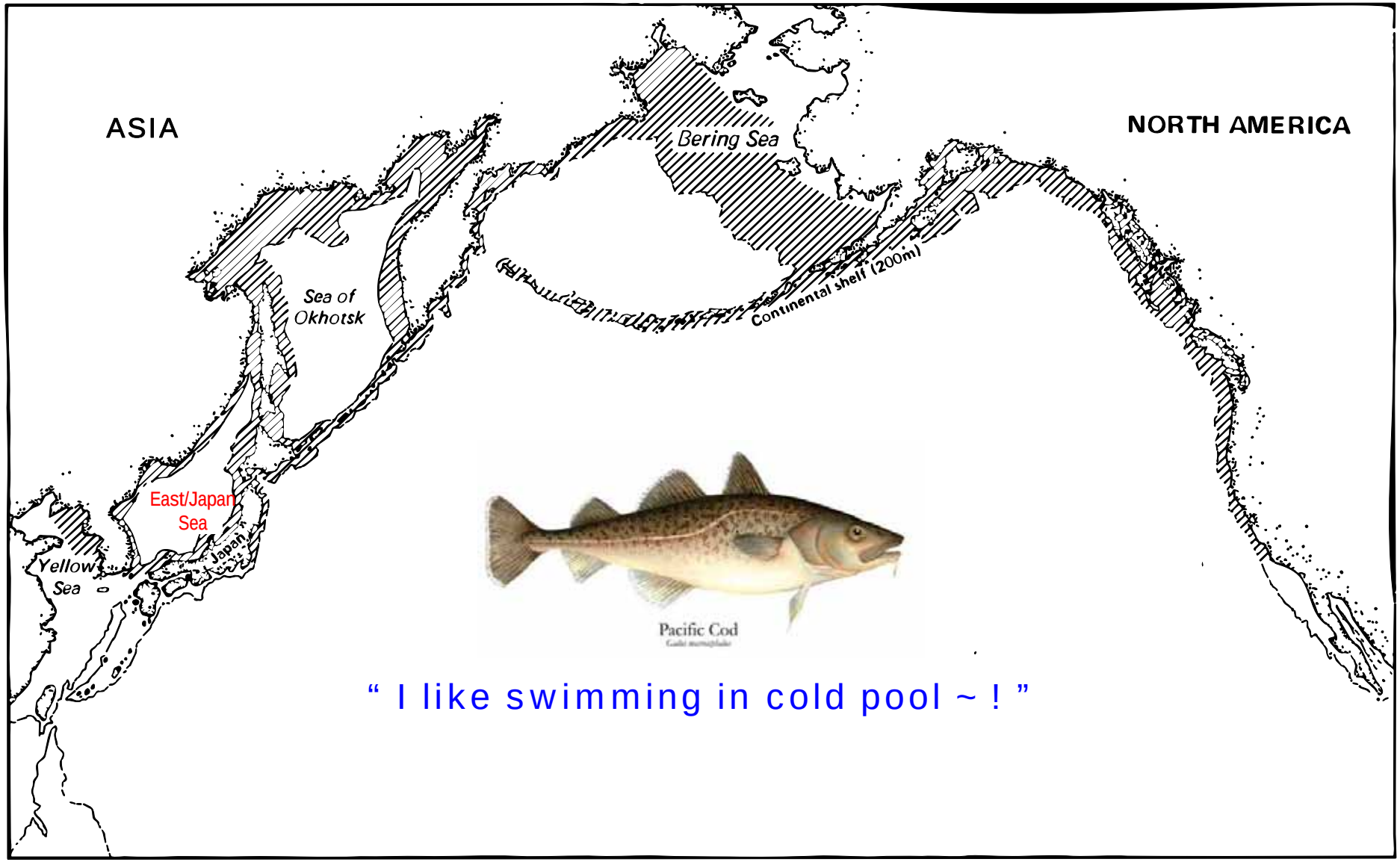
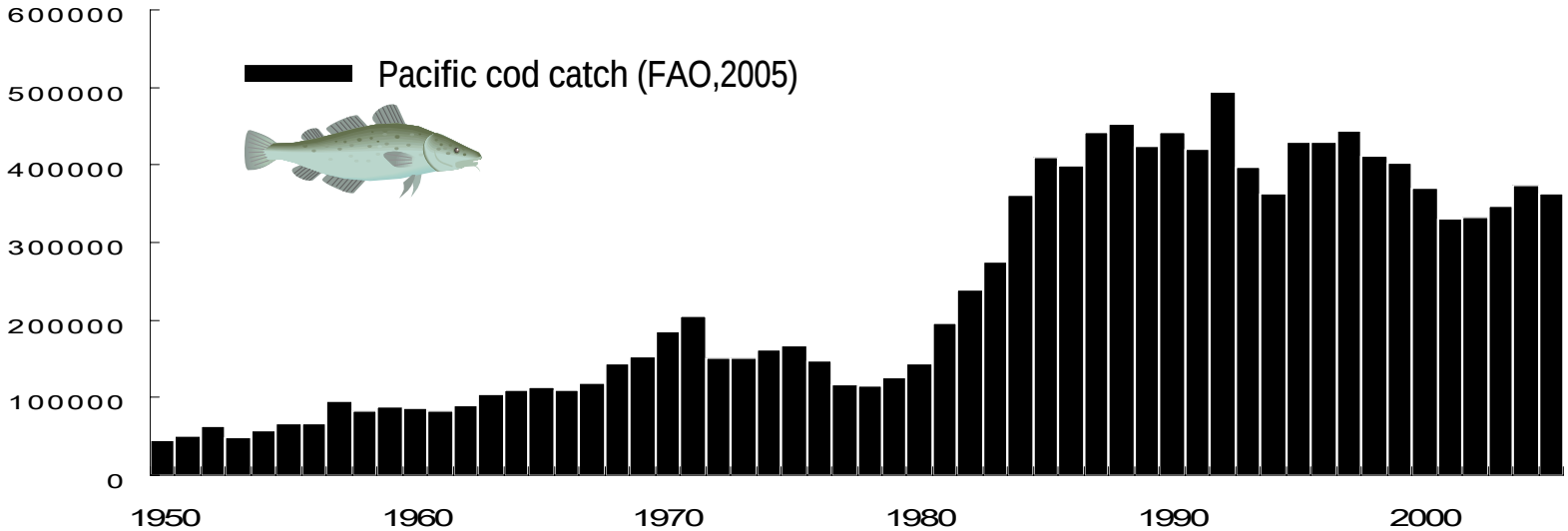
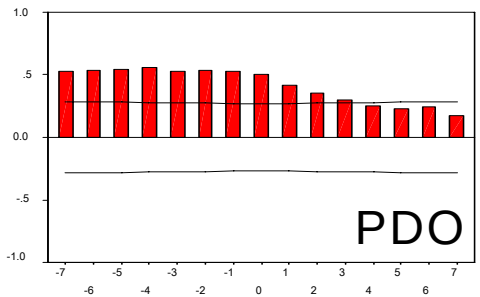


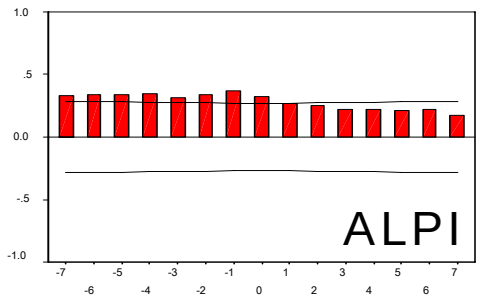
" I like swimming in cold pool ~ ! "

PACIFIC COD DISTRIBUTION

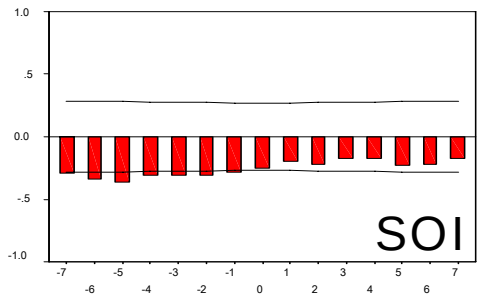
Pacific cod catch (1950-2005)



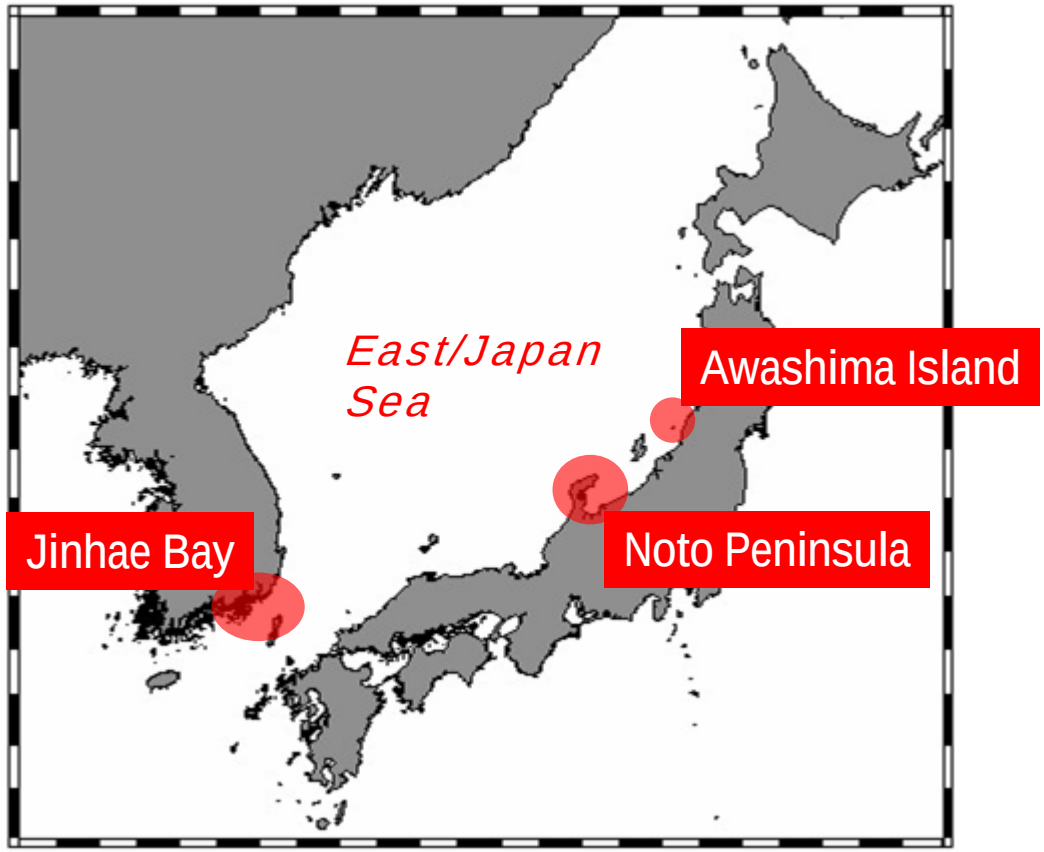




Positive correlations between cod catch and PDO and ALPI

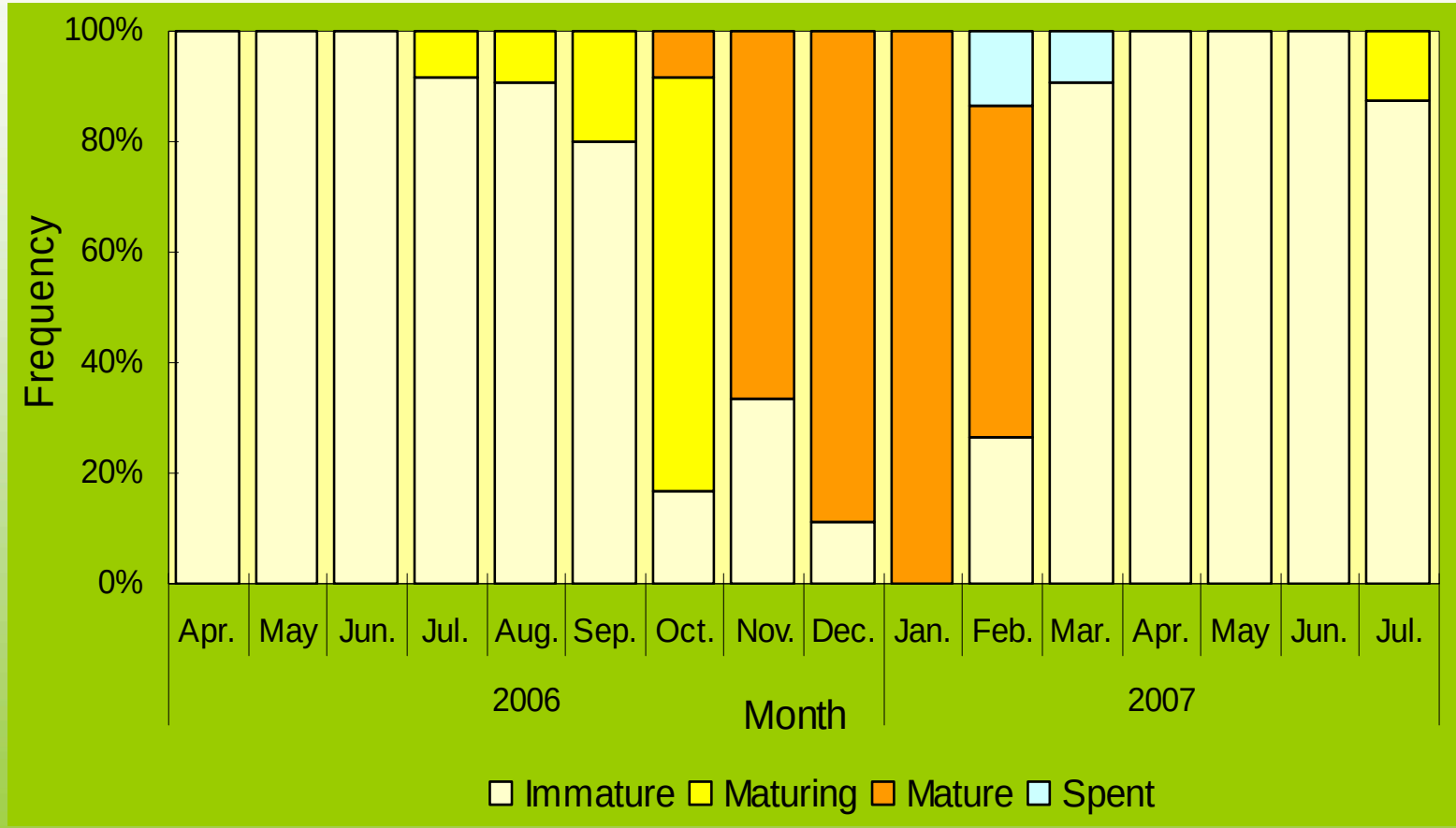


Negative correlation between cod catch and Southern Oscillation Index

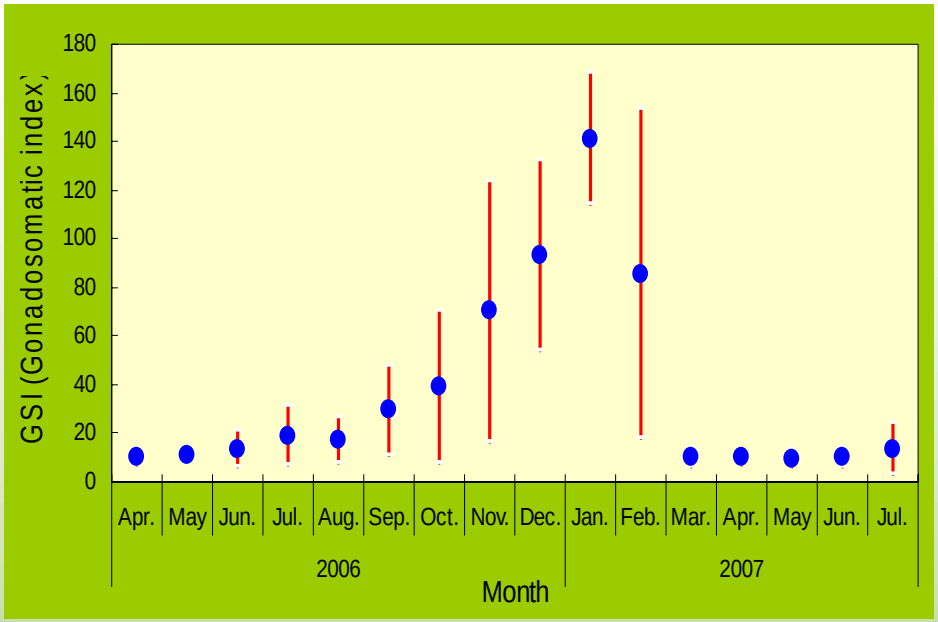


- Pacific cod migrate from nursery ground to winter spawning area every year. In the southern East/Japan Sea, three spawning areas are identified.
- Peak spawning period → January

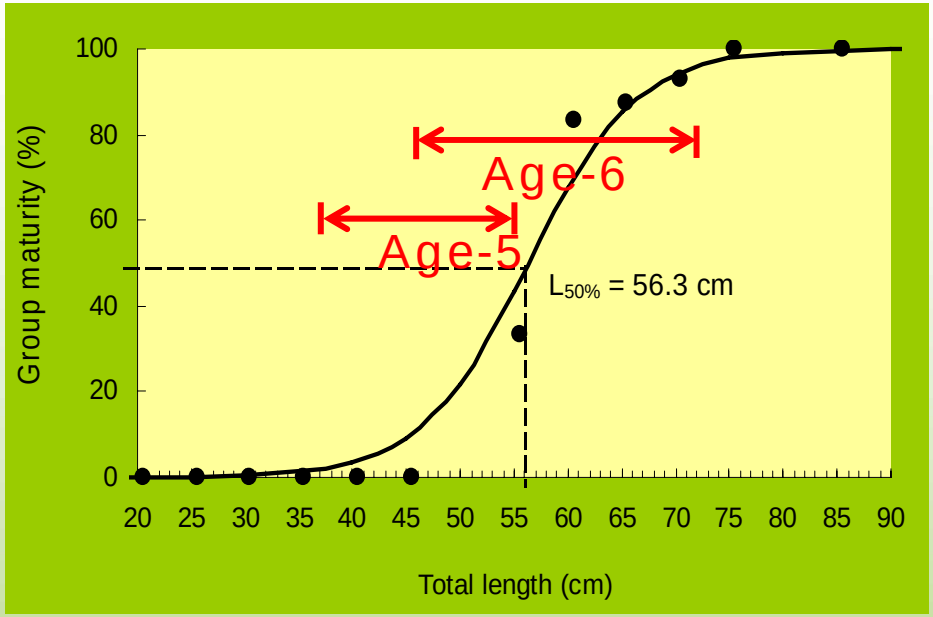
Proportion of maturation status for female *G. macrocephalus*



(Cha, 2007, pers. comm.)



Monthly gonadosomatic indices (GSI) of female *G. macrocephalus*



Maturation curve for female *G. macrocephalus*, and size at age from Choi (2007).

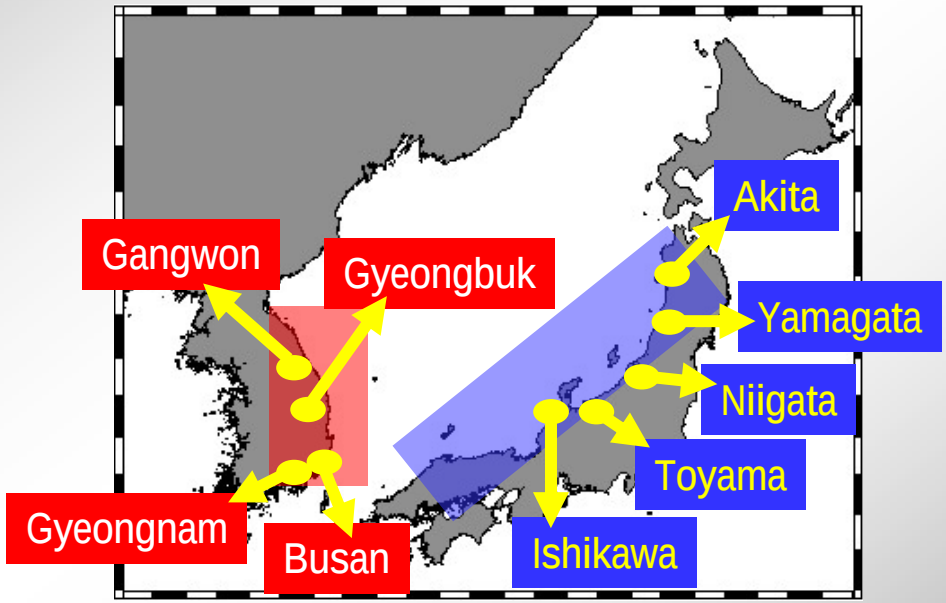
(Cha, 2007, pers. comm.)

Objective

- To compare the relationship between cod populations and environmental (climate/oceanographic) conditions in the Southern East/Japan Sea

Materials & Methods

Cod catch data



- Eastern Korea (EKOcod) - Gangwon, Gyeongbuk, Gyeongnam and Busan (1970-2006) → from Korean fisheries yearbook
- Daily radio report on fishing location and catch from fishing vessels to Fisheries Cooperative during from 2001 to 2006

- Western Honshu (WHScod) - Aomori, Akita, Yamagata, Niigata, Toyama, Ishikawa and southern area (1964 – 2005) → from Annual Report of Catch Statistics on Fishery and Aquaculture in Japan

Environmental data

※Climate index

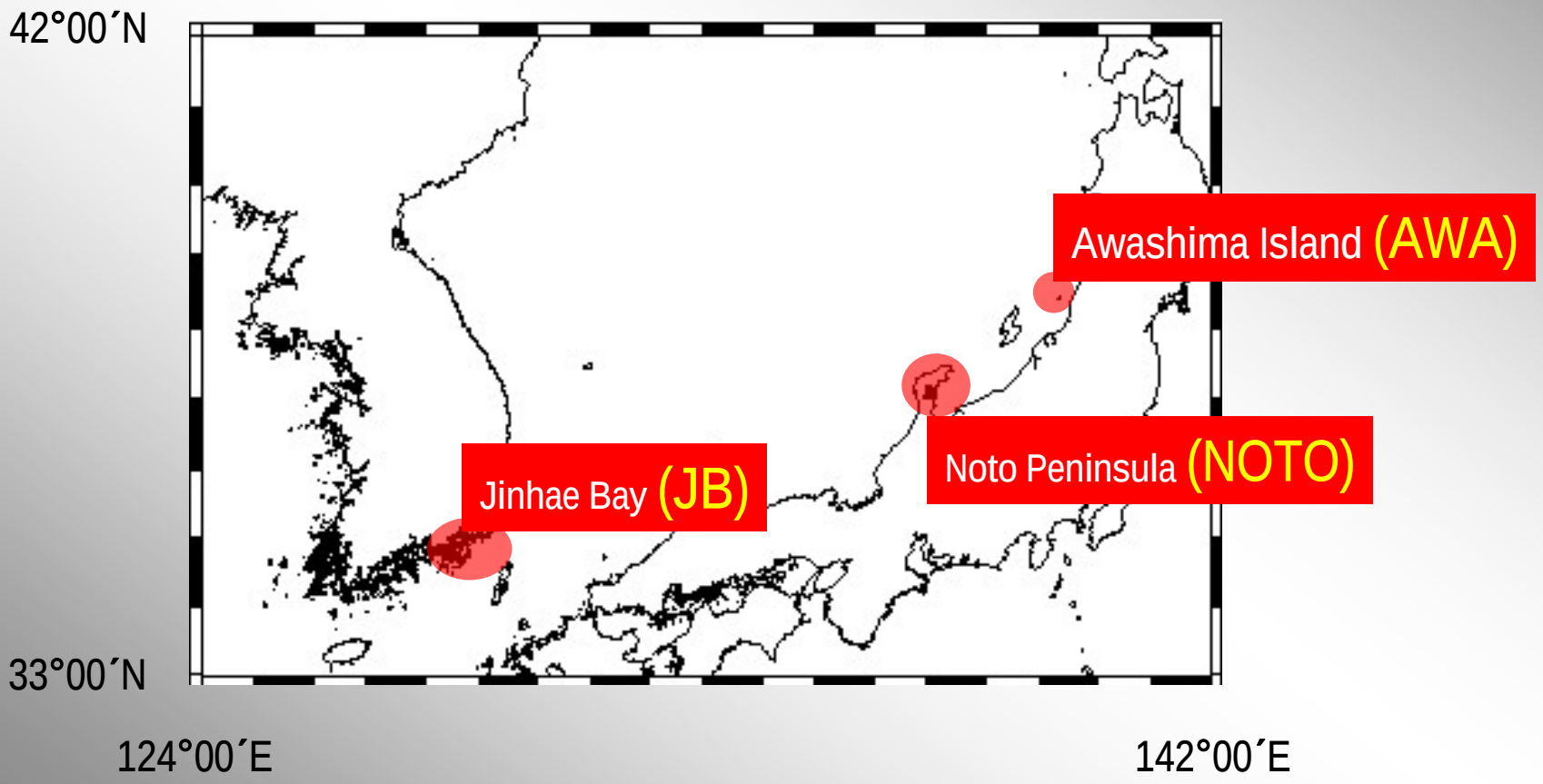
- Arctic Oscillation Index (1950-2006)

※Oceanographic data

- Seawater temperature at spawning area (1968-2005)
- Zooplankton in nursery/feeding area (1967-2002)

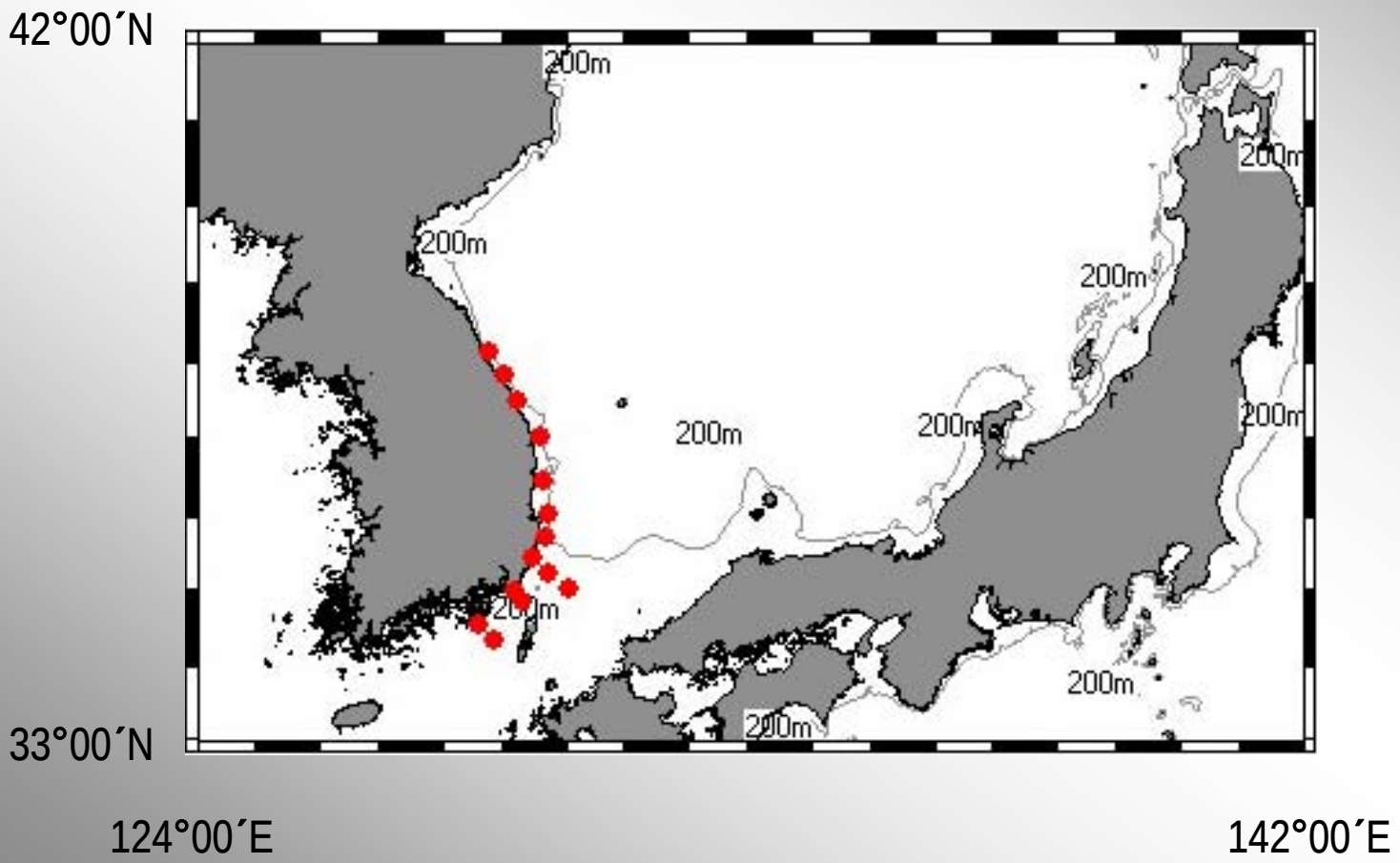
Seawater temperature data

→ **Spawning ground of Pacific cod** in the Southern East/Japan Sea



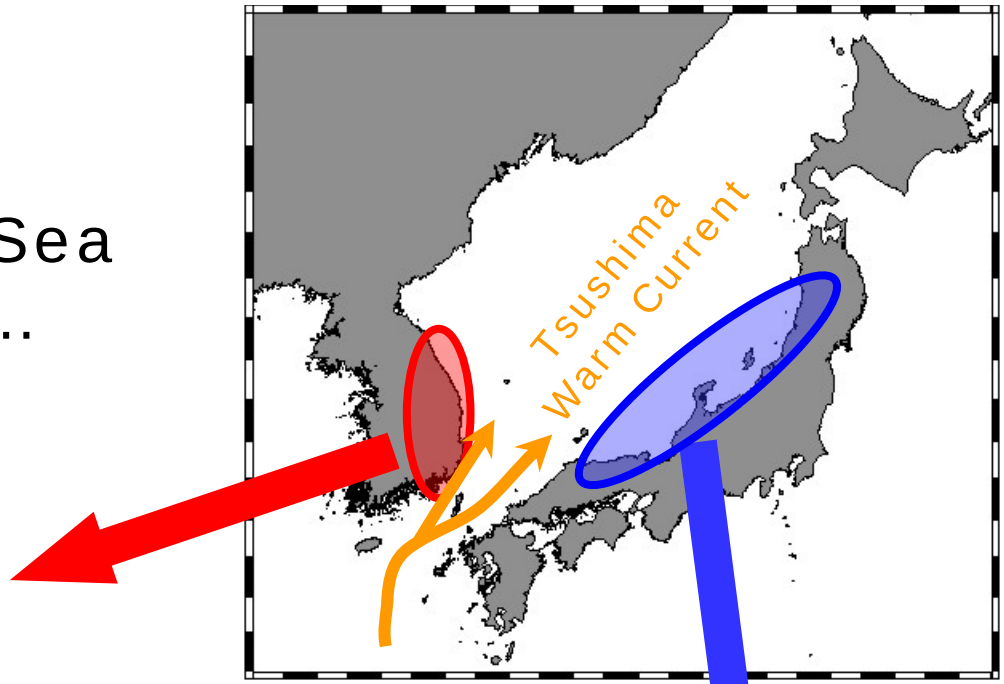
Zooplankton data

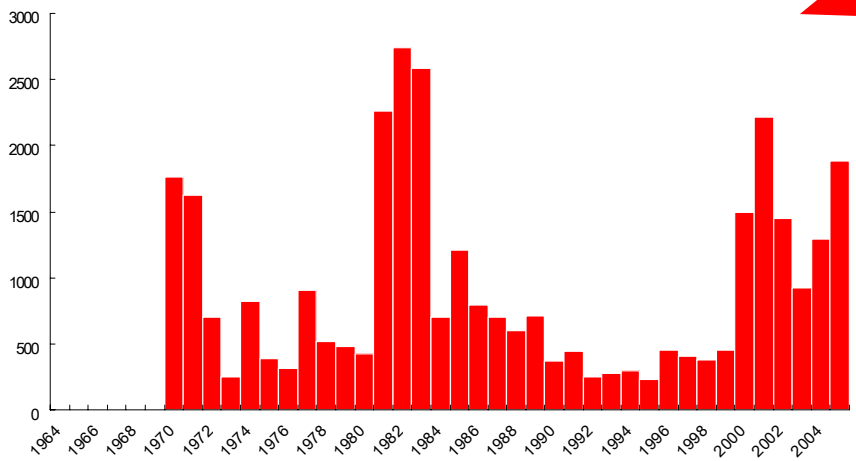
→ **Nursery/feeding grounds of Pacific cod** in Korea



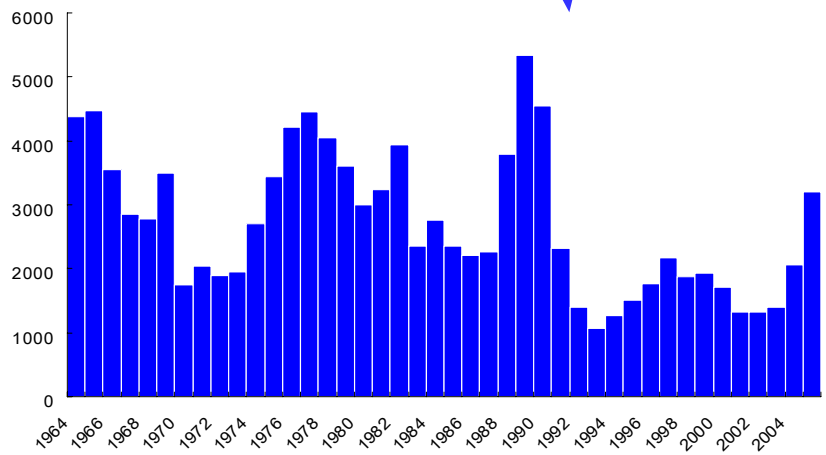
Results

Southern East/Japan Sea Cod (SEJScod) catch...



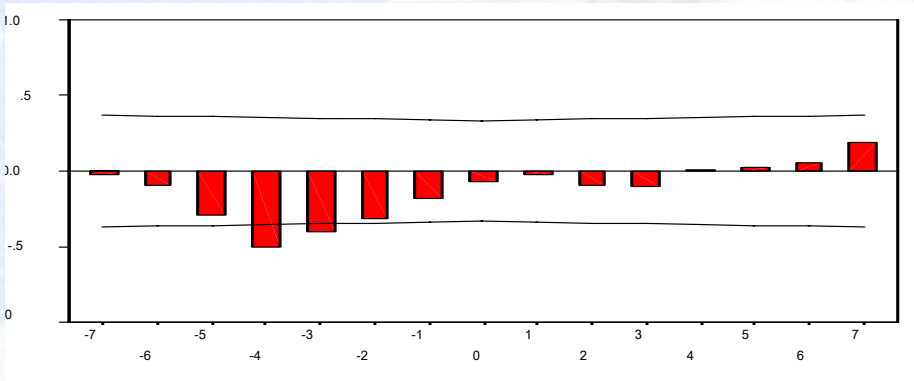


Eastern Korea cod catch (EKOcod)

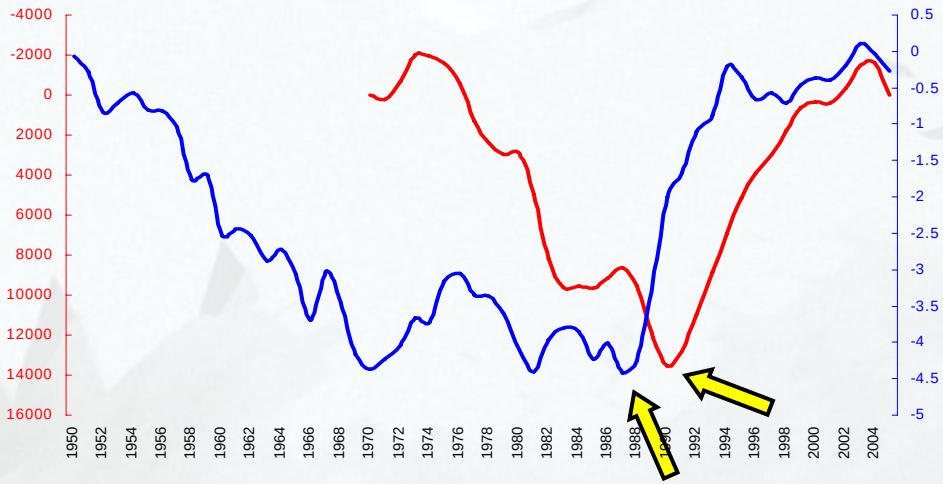


Western Honshu cod catch (WHScod)

- SEJScod with Arctic oscillation index



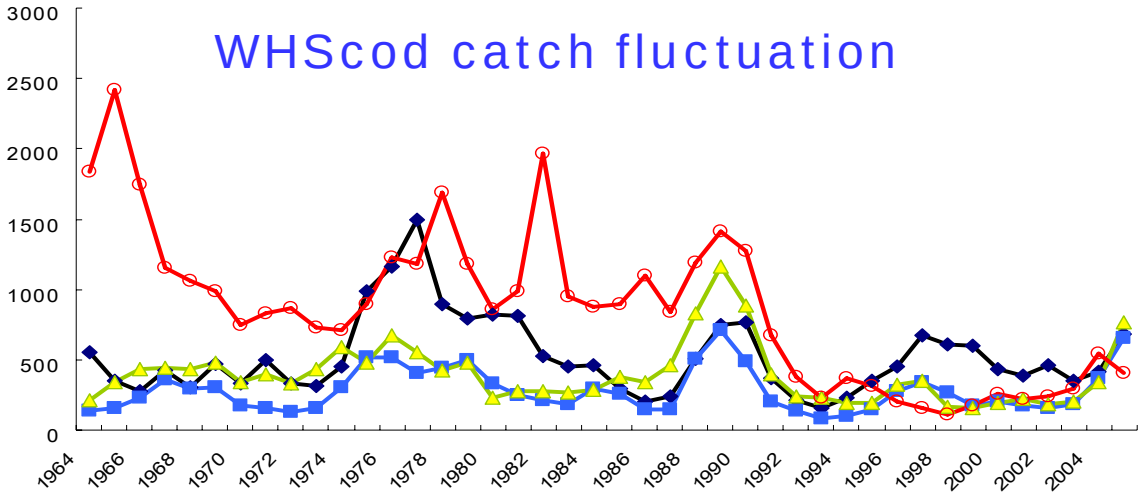
Negative correlation (r = -0.451) between SEJScod and Arctic Oscillation Index (winter) with a time-lag of 4 years

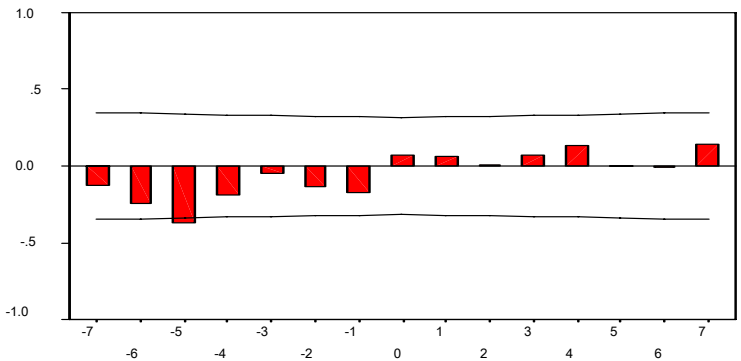


CuSum AOI

CuSum Cod

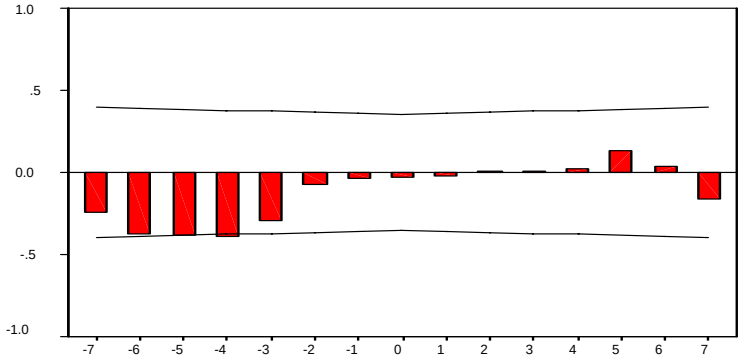
- WHScod with seawater temperature



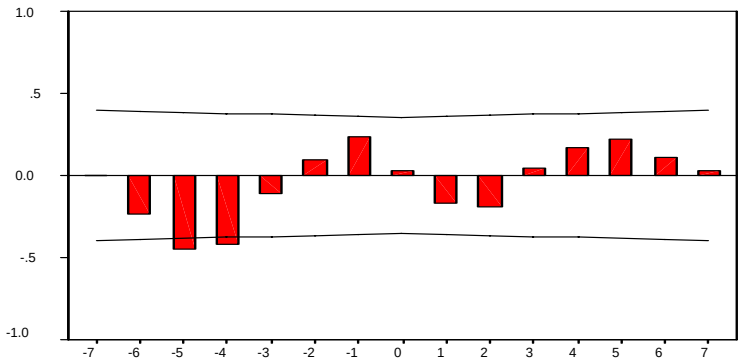


Negative correlation between Ishikawa cod catch and NOTO winter seawater temp. (75m) with a time-lag of 5 years

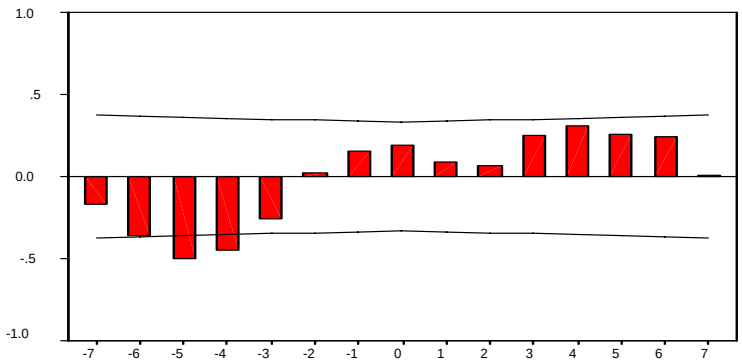
JAPAN



Negative correlation (r = -0.383)
between Akita catch and
AWA seawater temperature (75m, March)
with a time-lag of 5 years



Negative correlation (r = -0.449)
between Yamagata catch and
AWA. seawater temperature (75m, April)
with a time-lag of 5 years



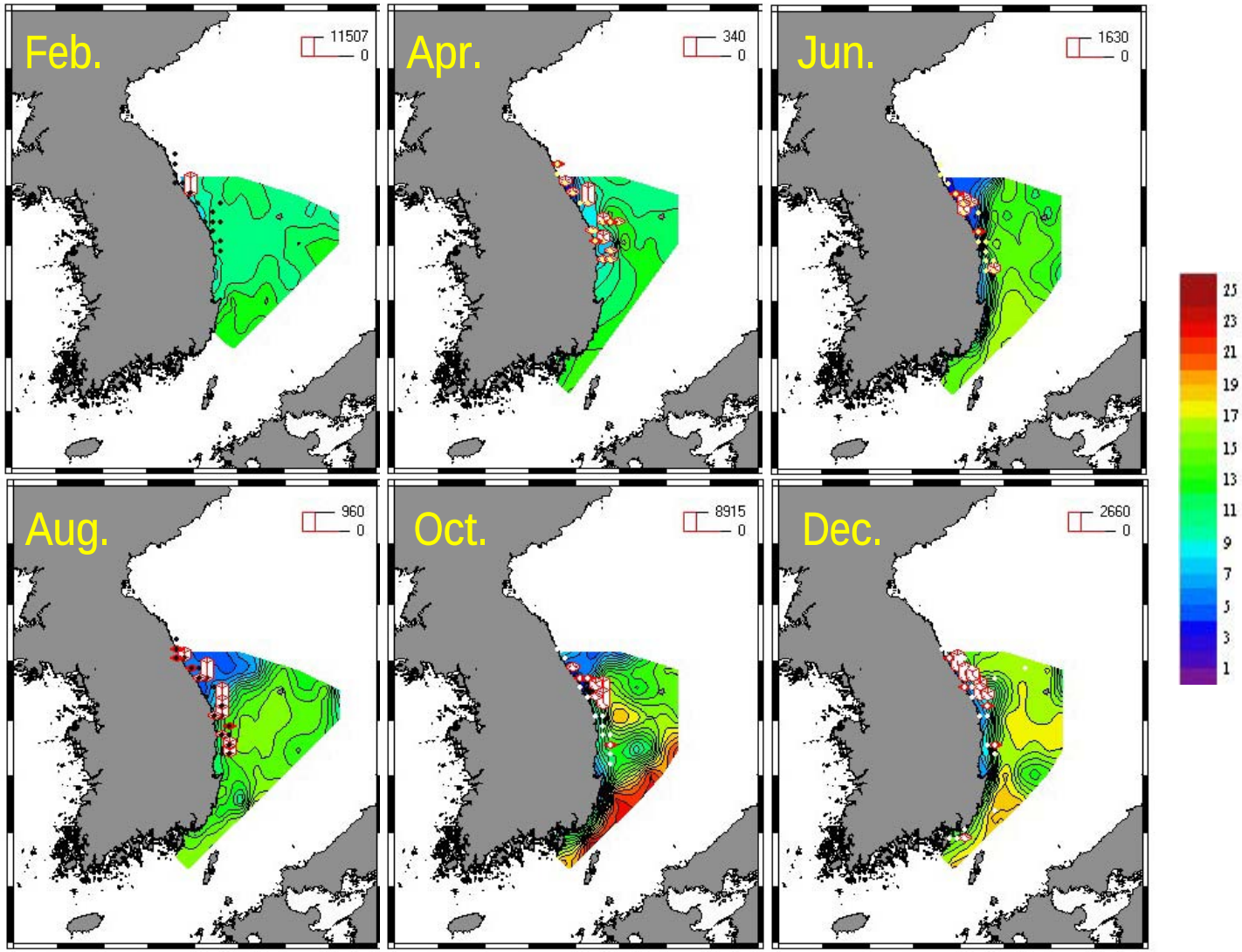
Negative correlation (r = -0.496)
between Niigata catch and
AWA seawater temperature (75m, April)
with a time-lag of 5 years

- What is an optimum environmental condition for Pacific cod in Korean waters?

Optimum range of cod habitat

KOREA

- Cod distribution in Korean waters (2004)

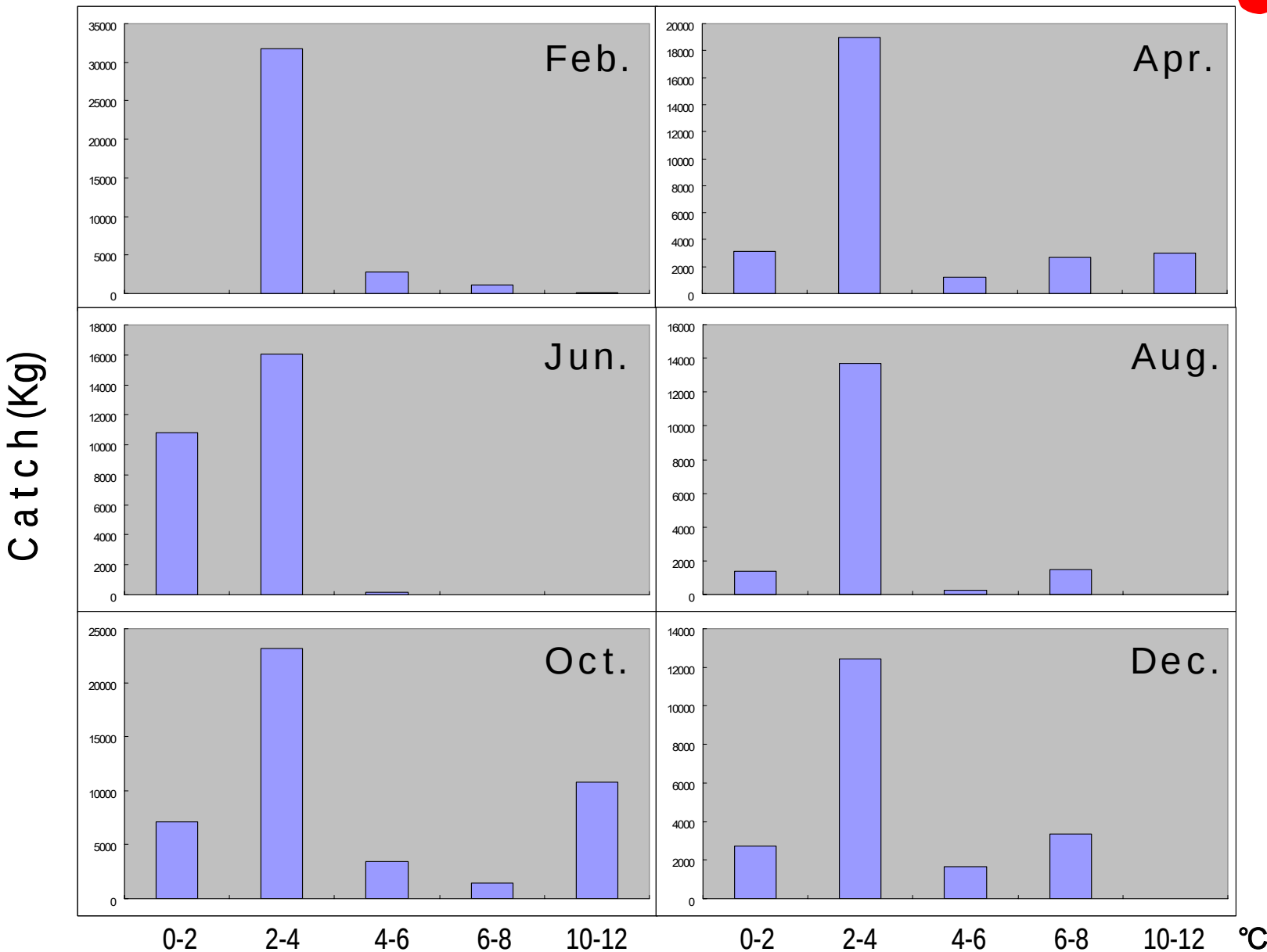


KOREA

PSU / ℃	0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12
34.4 - 34.6		193 ± 94 (n=2)				
34.2 - 34.4	73 (n=1)				500 (n=1)	2806 ± 332 (n=11)
34.0 - 34.2	17702 ± 466 (n=62)	65388 ± 1230 (n=106)	6119 ± 340 (n=19)	6754 ± 509 (n=19)	12305 ± 2740 (n=10)	770 ± 56 (n=10)
33.8 - 34.0	4448 ± 485 (n=18)	48594 ± 1607 (n=80)	3057 ± 541 (n=10)	1885 ± 109 (n=16)		
33.6 - 33.8		51 (n=1)	240 ± 87 (n=6)	1303 ± 277 (n=6)		

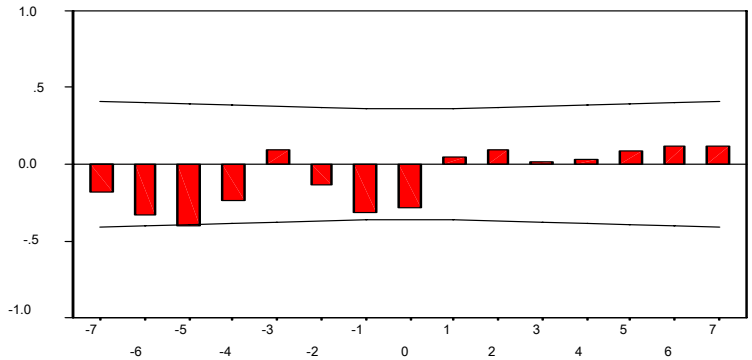
Seasonal distribution of cod catch in temperature range

KOREA

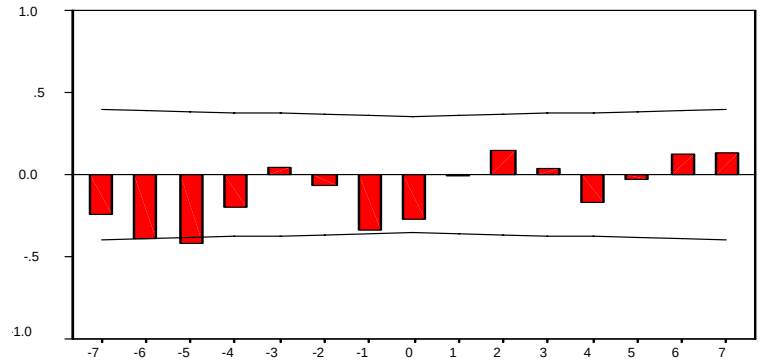


KOREA

- EKOcod with seawater temperature



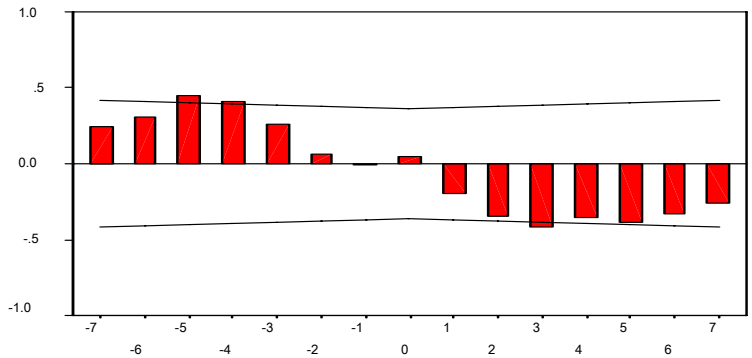
Negative correlation (r = -0.404) between EKOcod and JB seawater temperature (Feb. 75 m) with a time-lag of 5 years



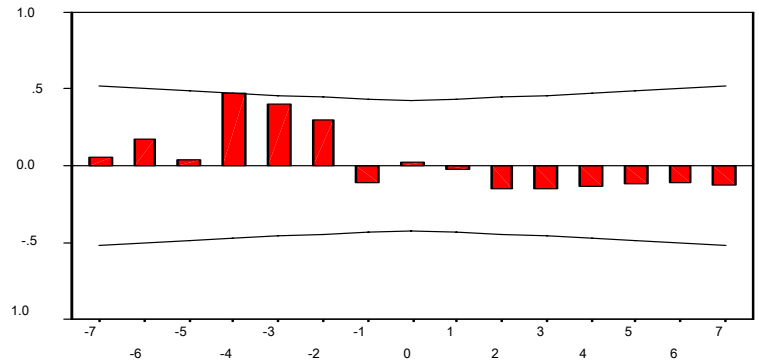
Negative correlation (r = -0.422) between (Busan + Gyeongnam cod) and JB seawater temperature (Feb. 75 m) with a time-lag of 5 years

KOREA

- EKOcod with zooplankton

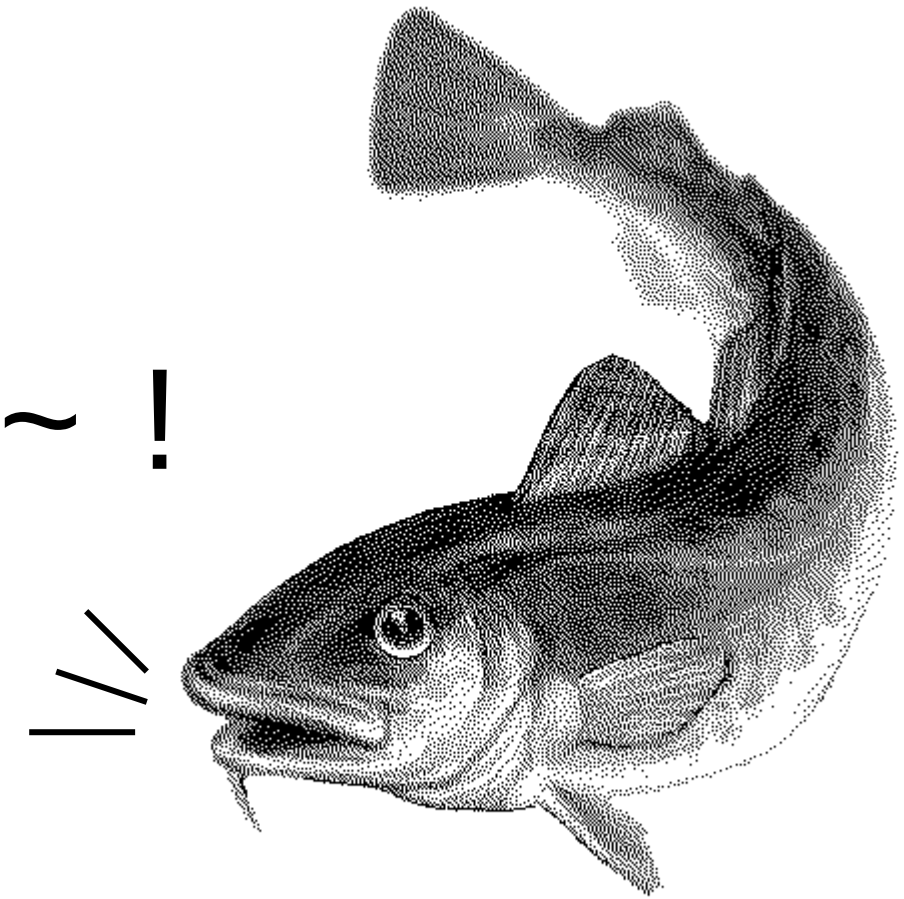


Positive correlation (r = 0.452) between EKOcod and zooplankton biomass (June) with a time-lag of 5 years



Positive correlation (r = 0.421) between EKOcod and Euphausiid (Feb.) with a time-lag of 4 years

Summary & Discussion

- Pacific cod appeared through a year along the eastern coast of the Korean Peninsula, and most P. cod were caught in seawater temperature range of 1-4℃ and salinity range of 33.8-34.2 psu.
- They mature sexually at age of 5, and peak spawning happened in January.
- The cross correlation function (CCF) analysis showed that both cod catches in Korea and Japan were also significant correlated with February temperature at 75m in the spawning ground with a time-lag of 5 years.
- Also, cod catch had a significant correlation with June zooplankton biomass with a time-lag of 5 years ($r = 0.452$) in the coastal area off the eastern Korea.
- The combined catch from southern East/Japan Sea indicated that there was a negative correlation between SEJScod catch and Arctic Oscillation index (AOI), and that the highest correlation ($r=-0.451$) was shown with a time-lag of 4years.

Thank You ~ !