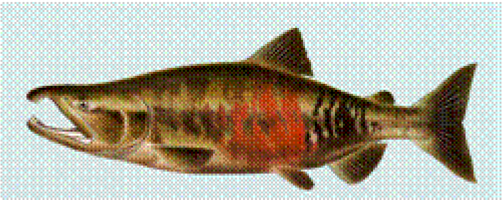
Linkages between coastal and open ocean habitats of Pacific salmon and small pelagics in the Northwestern and central Pacific



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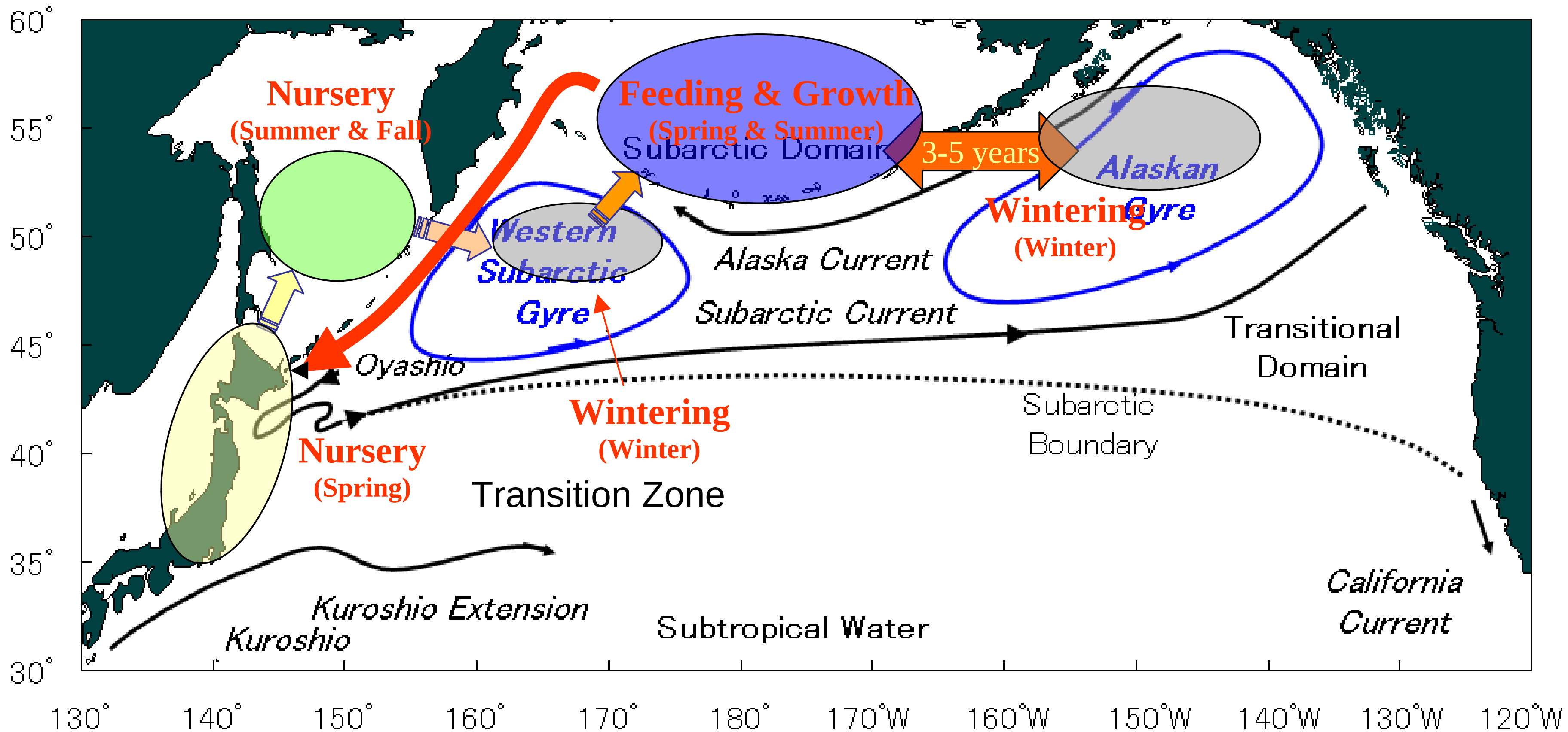
* National Research Institute of Fisheries Science
** Hokkaido Tokai University

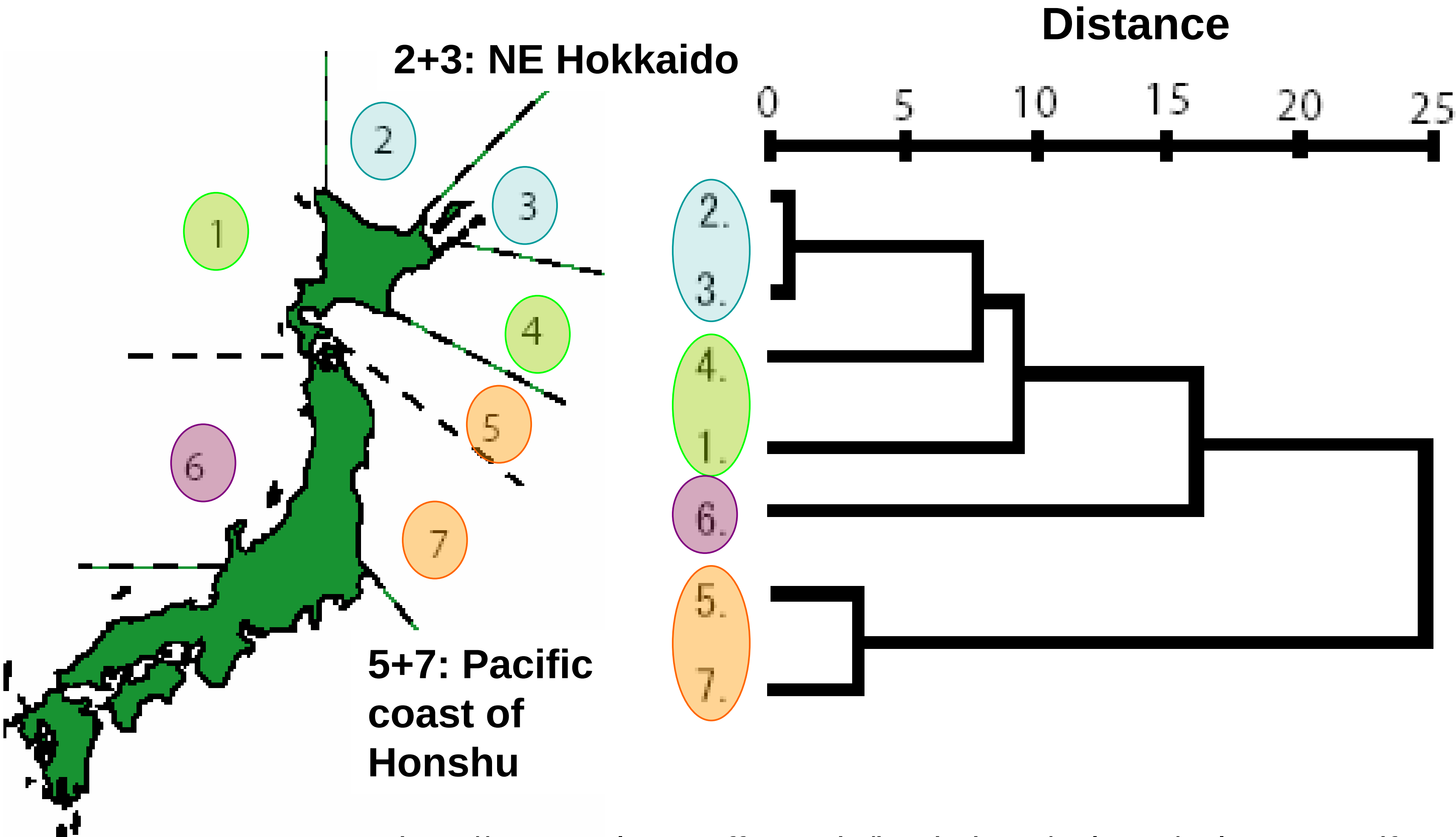
- Distribution, migration and population dynamics
- Their inter-annual and inter-decadal variations
- Possible factors causing these variations

Migration of Japanese stocks of chum salmon

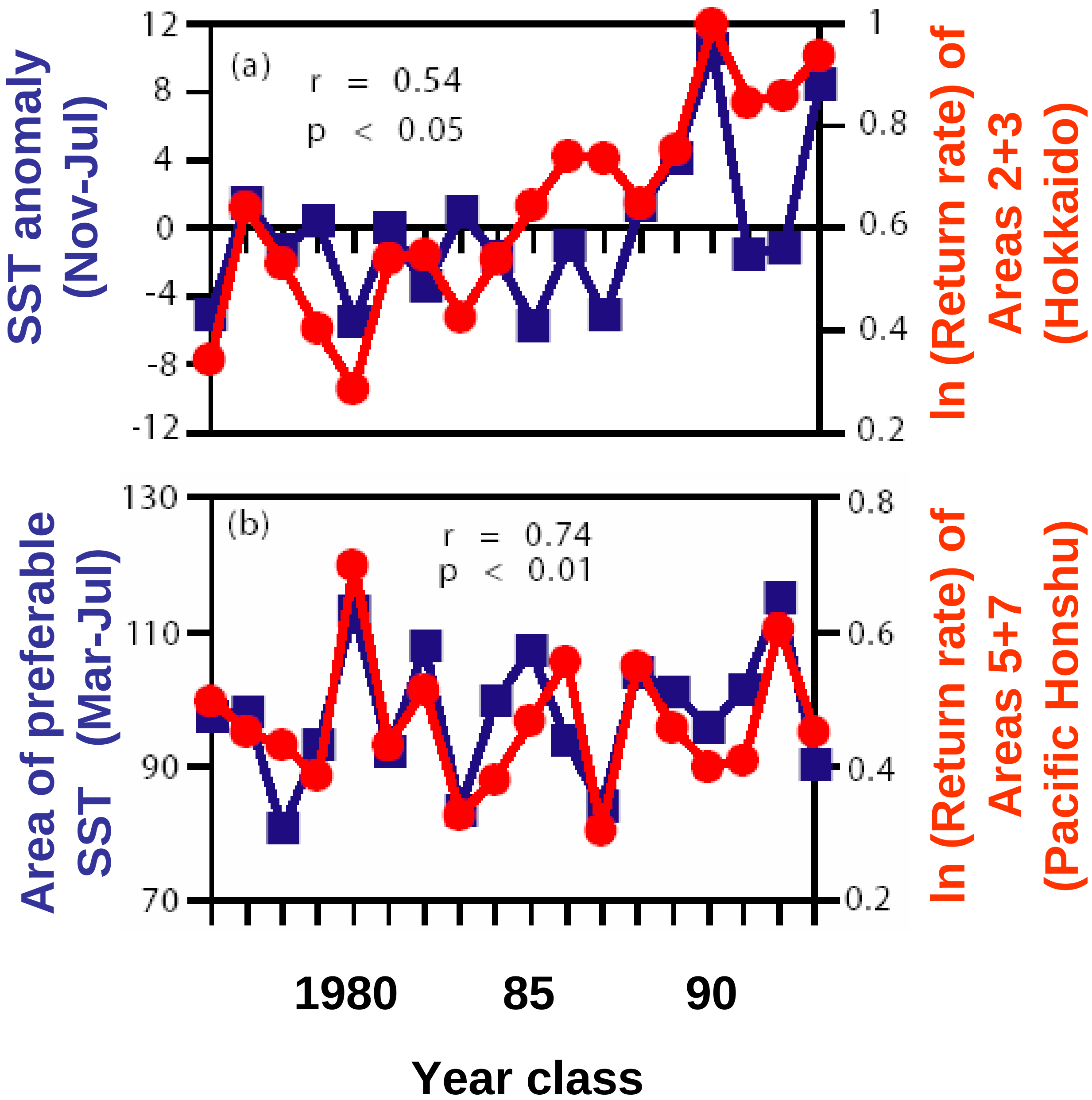


Cluster analysis of return rates during 1976-93 of Japanese stocks of chum salmon by hatching area

(Saito, 2000)



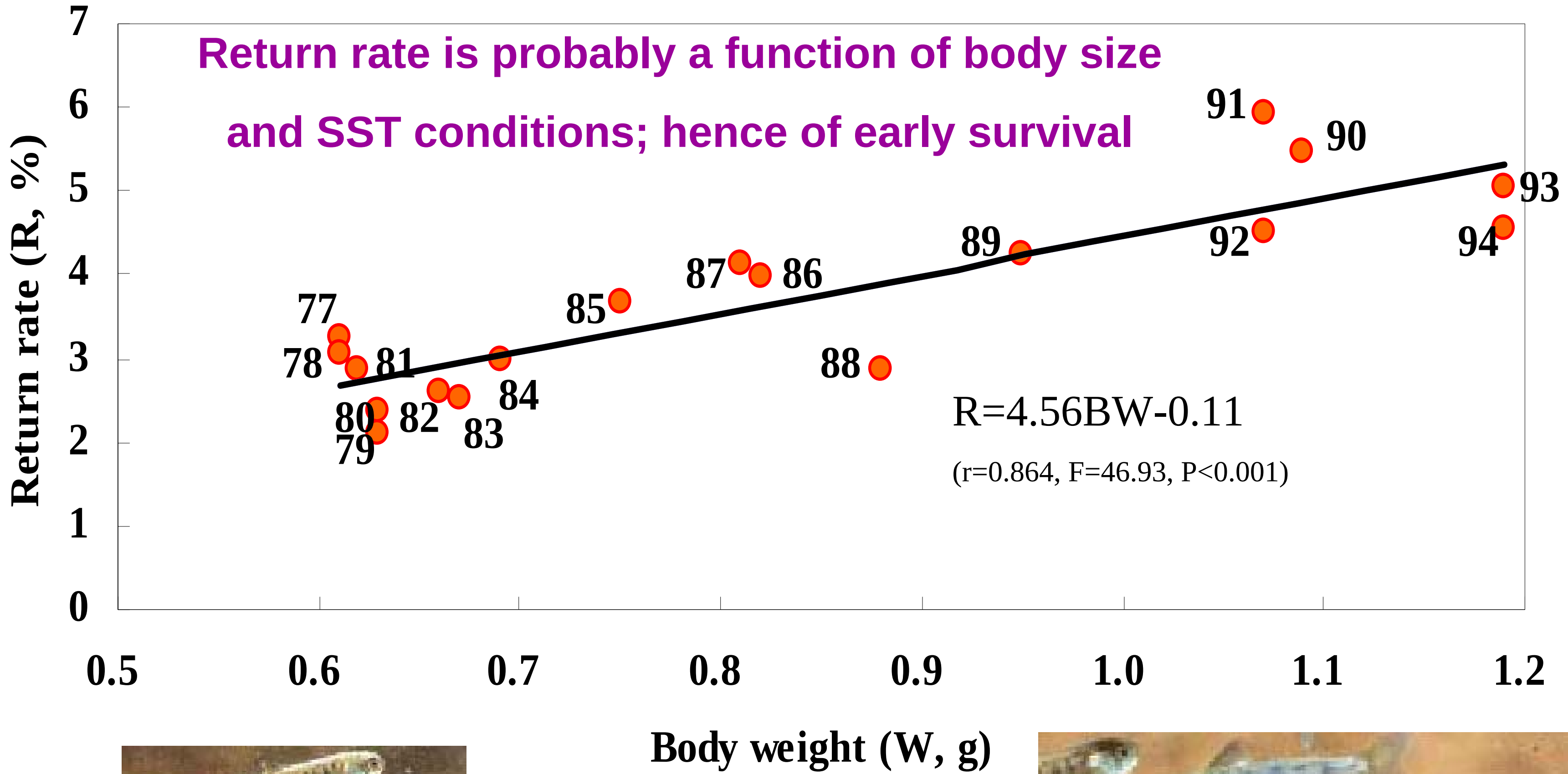
http://www.salmon.affrc.go.jp/kankobutu/salmon/salmon09.pdf



SST of coastal area and return rates of Japanese stocks of chum salmon by hatching area during 1976-93

(Saito, 2000)

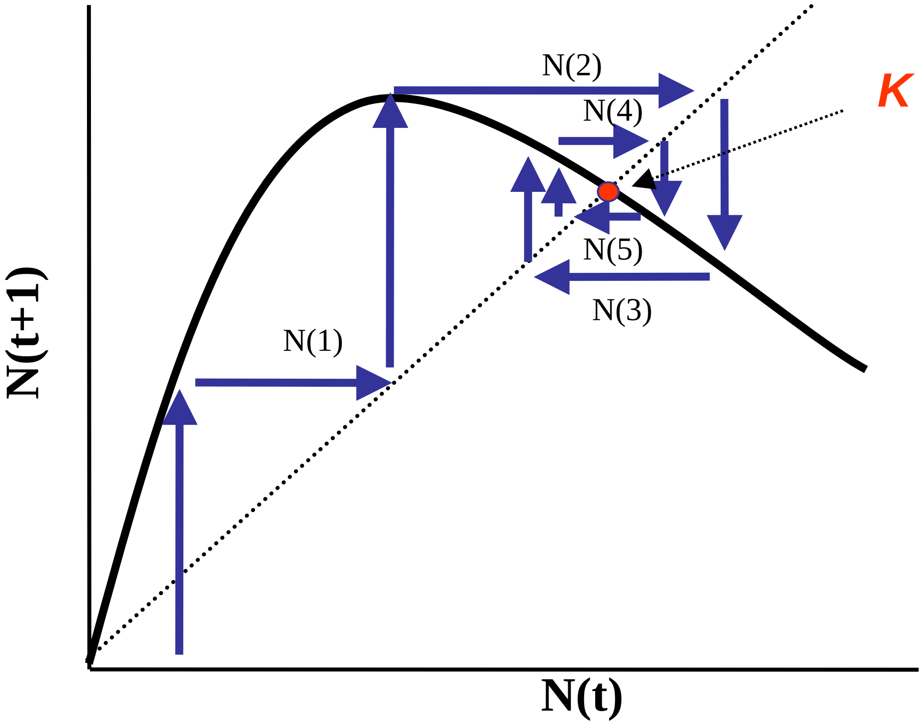
Body size of juvenile chum salmon released and return rate in the Hokkaido stocks



Carrying capacity *K*:
Replacement level in the Ricker curve without fishing

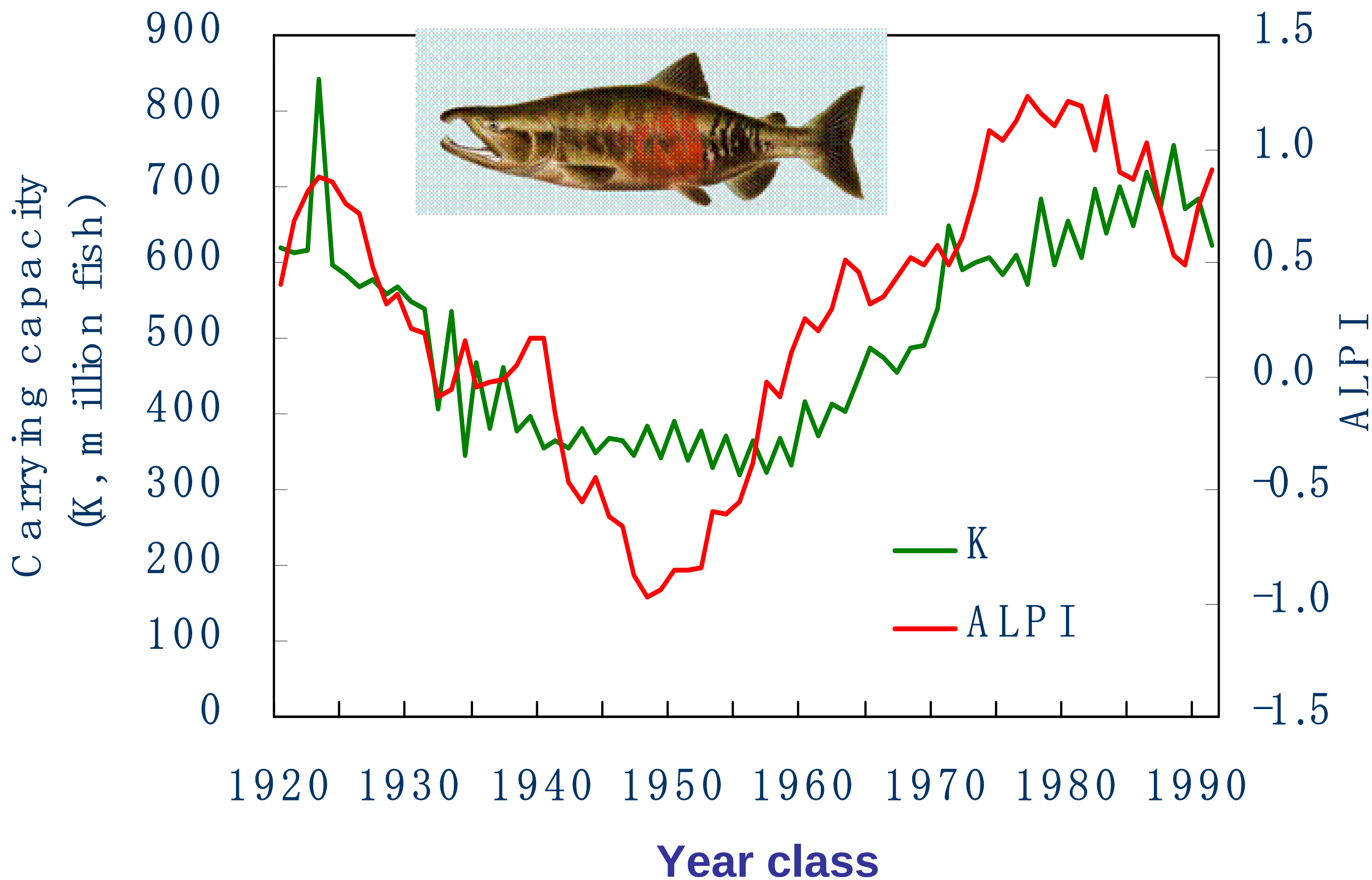
$$N_{(t+1)} = aN_{(t)} \exp(-bN_{(t)})$$

$$K = \ln(a) / b$$

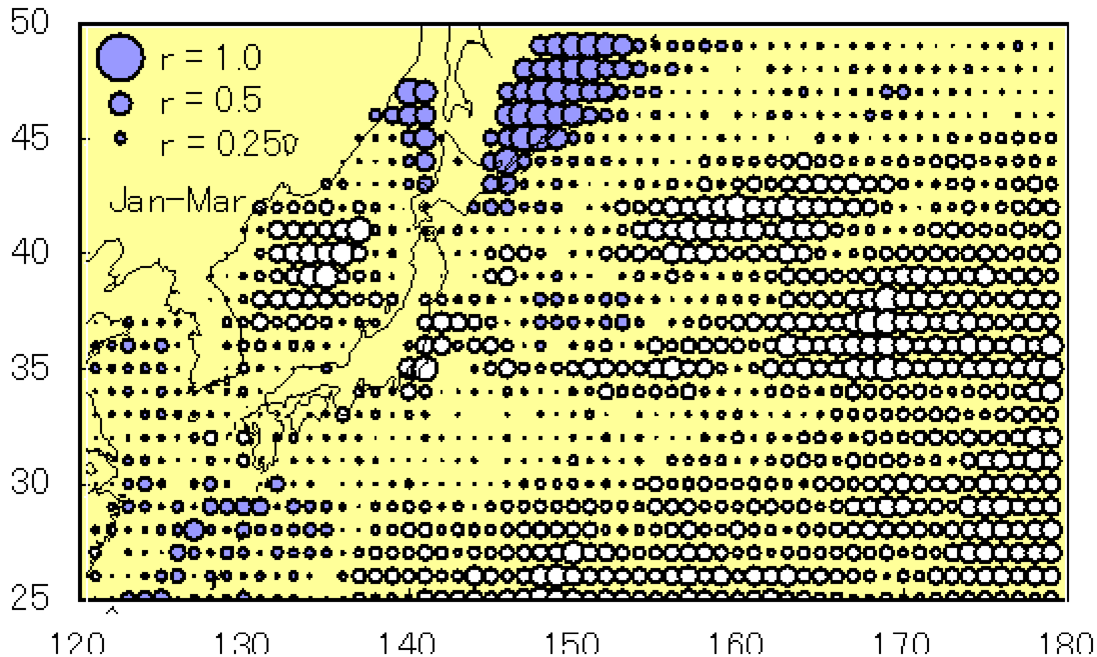


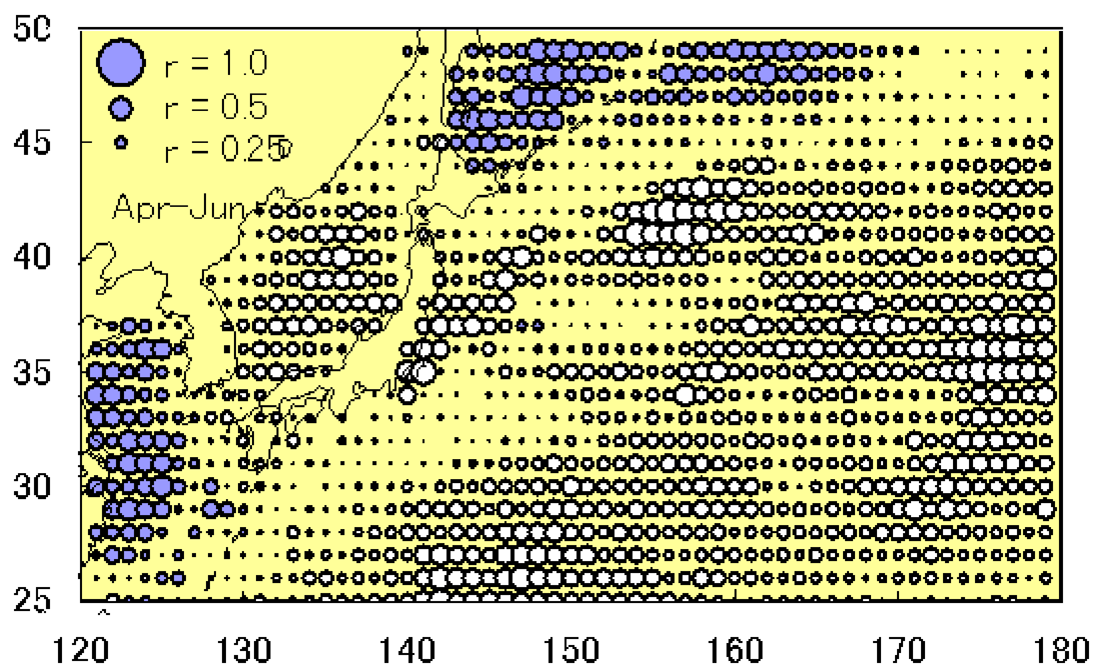
K in year *y* : determined by two parameters, *a* & *b* ,as estimated from the past 20years data from year *y*

Changes in total carrying capacity (*K*) of sockeye, chum, and pink salmon in the North Pacific Ocean and the Aleutian Low Pressure Index (ALPI)



ALPI: Beamish et al. (1997) http://www.pac.dfo.gc.ca/sci/samfpd/downloads/alpi.txt





Correlation coefficient (*r*) between ALPI and SST (1-degree block)

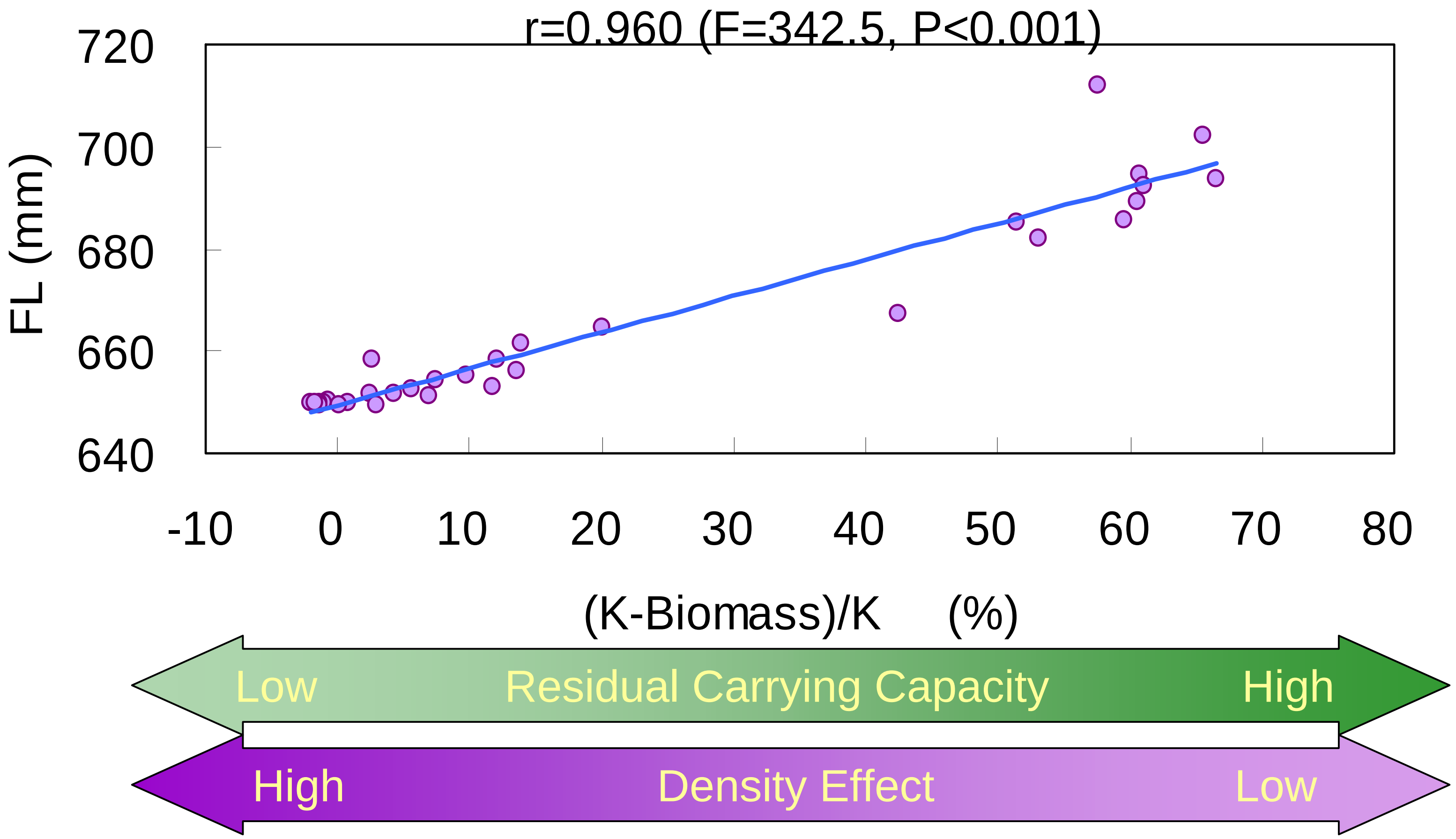
Jan-Mar

○ : **Positive *r***

● : **Negative *r***

Apr-Jun

Chum salmon growth and residual of *K*



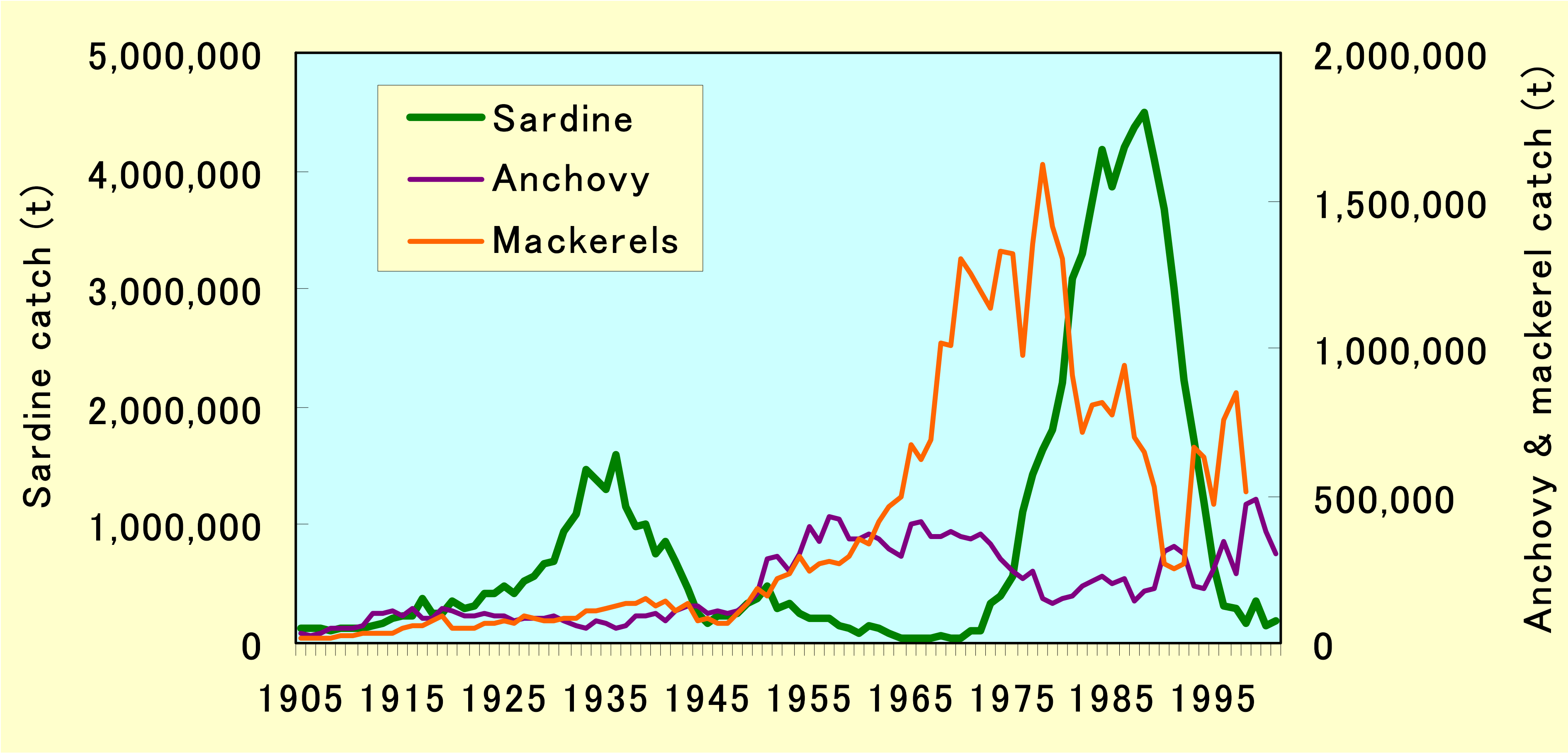
FL: mean fork length of age-4 adult returning to 11 rivers in Hokkaido

Biomass: average of past 20 years from year of K calculation

Salmon dynamics

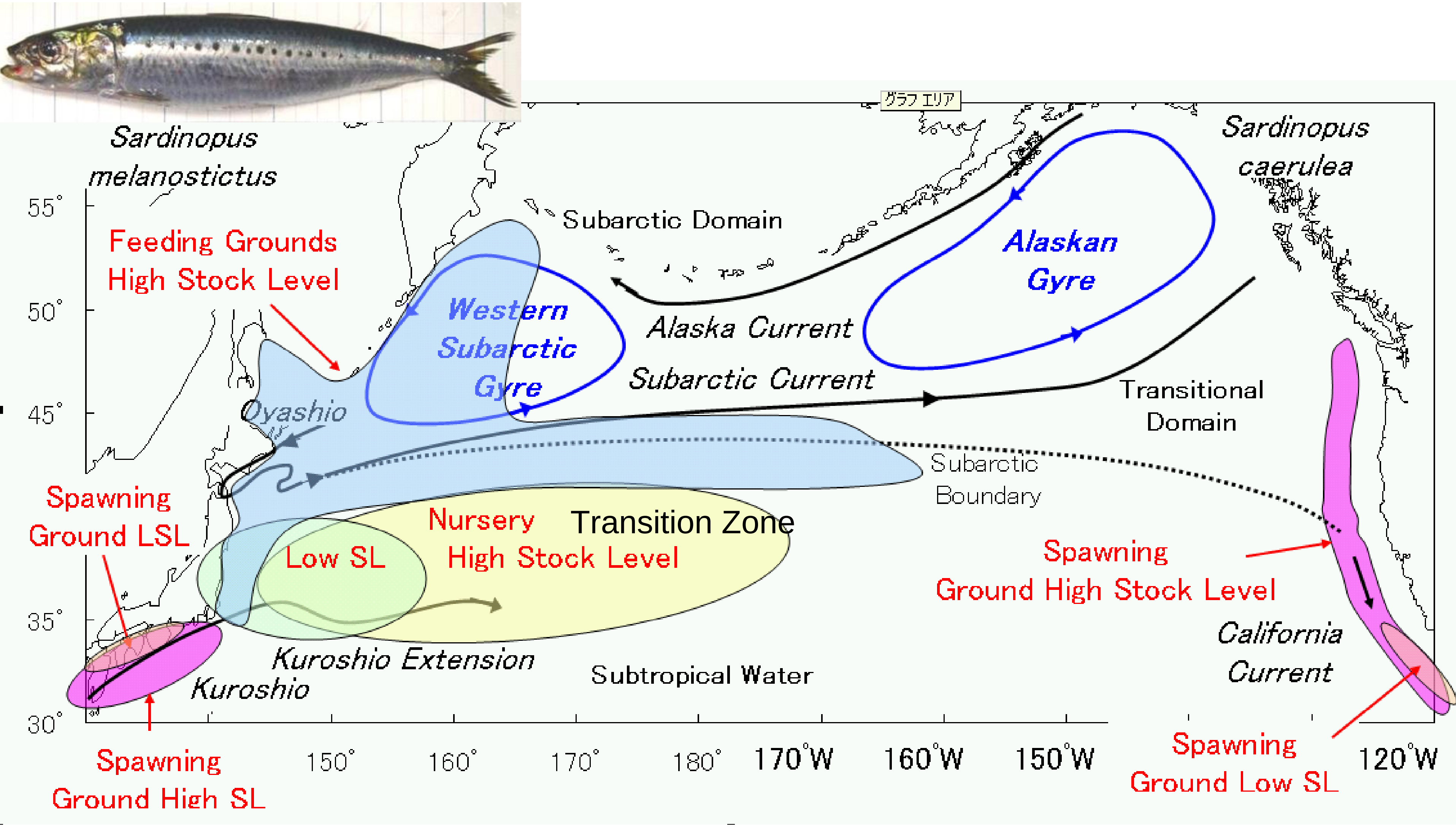
- Return rate < coastal environment (SST and presumably, zooplankton and predators) < ALPI
- Return rate < juvenile body size at release from hatcheries
- Growth < Density-dependent < Residuals of *K*
- *K* < Subarctic ecosystems <ALPI
- Biomass < Early survival, *K* and human impacts (hatchery, fishing)
- WSA Gyre is a passage for Japanese chum salmon, but its importance relative to other areas remains unresolved

Japanese catch of Japanese sardine, anchovy and mackerels during 1905-2001

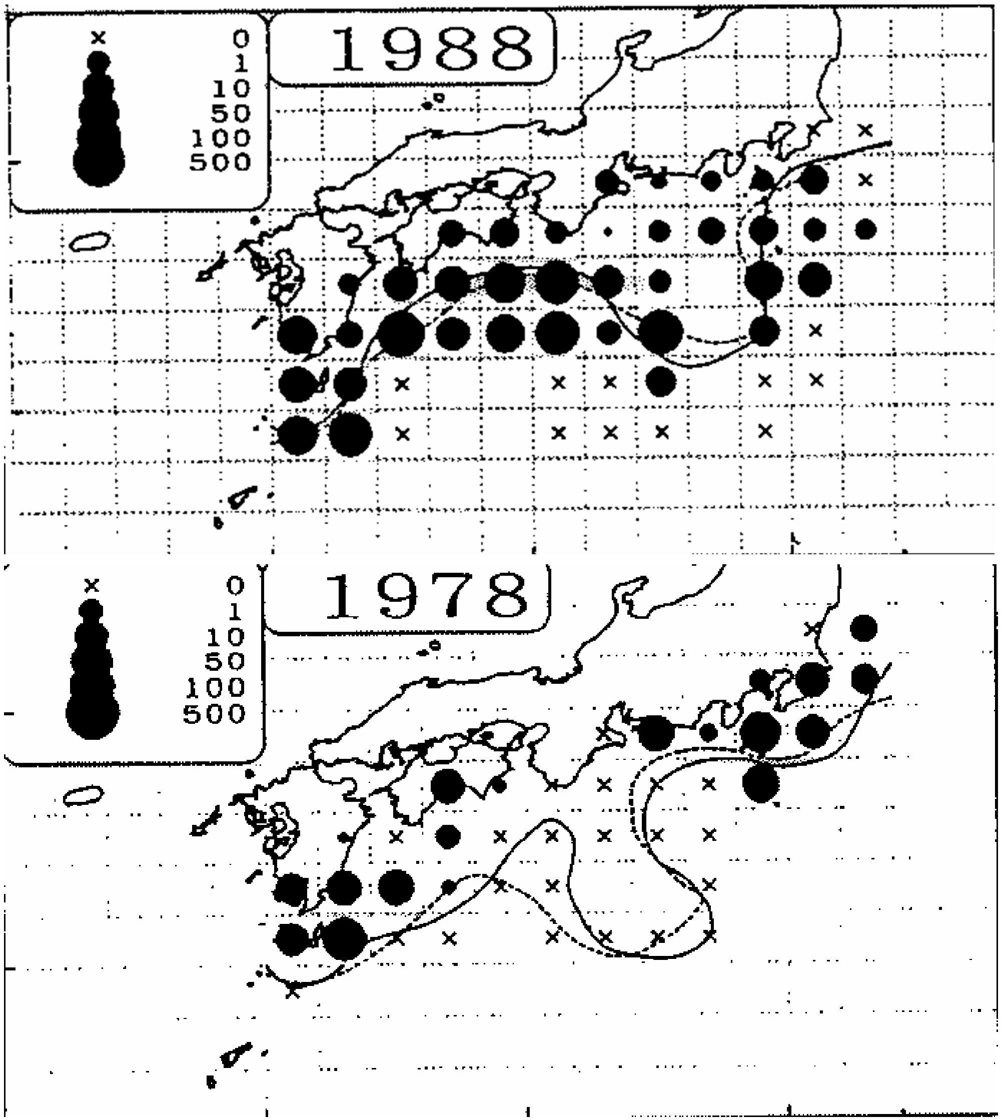


Mackerels: chub mackerel + spotted mackerel

Distribution and migration of Japanese sardine and California sardine



Egg distribution of Japanese sardine



High stock periods:

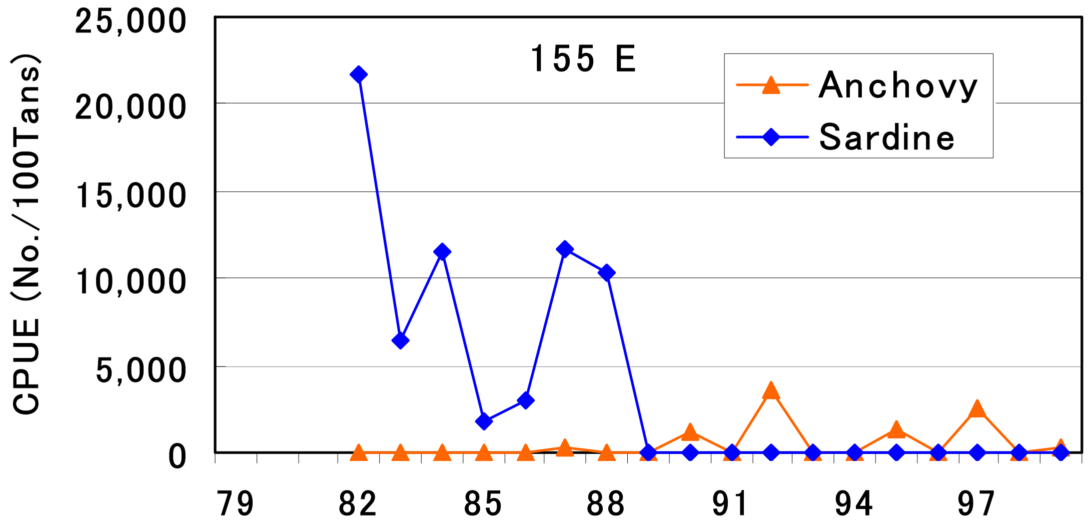
Spawning grounds extend across Kuroshio current

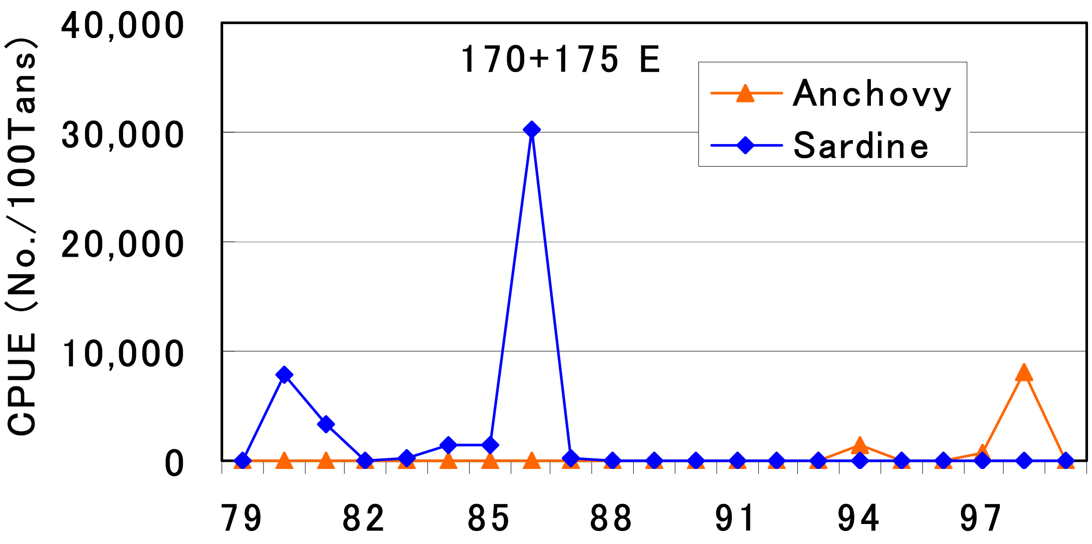
Line: Kuroshio axis

Low stock periods:

Spawning grounds confined within inshore areas

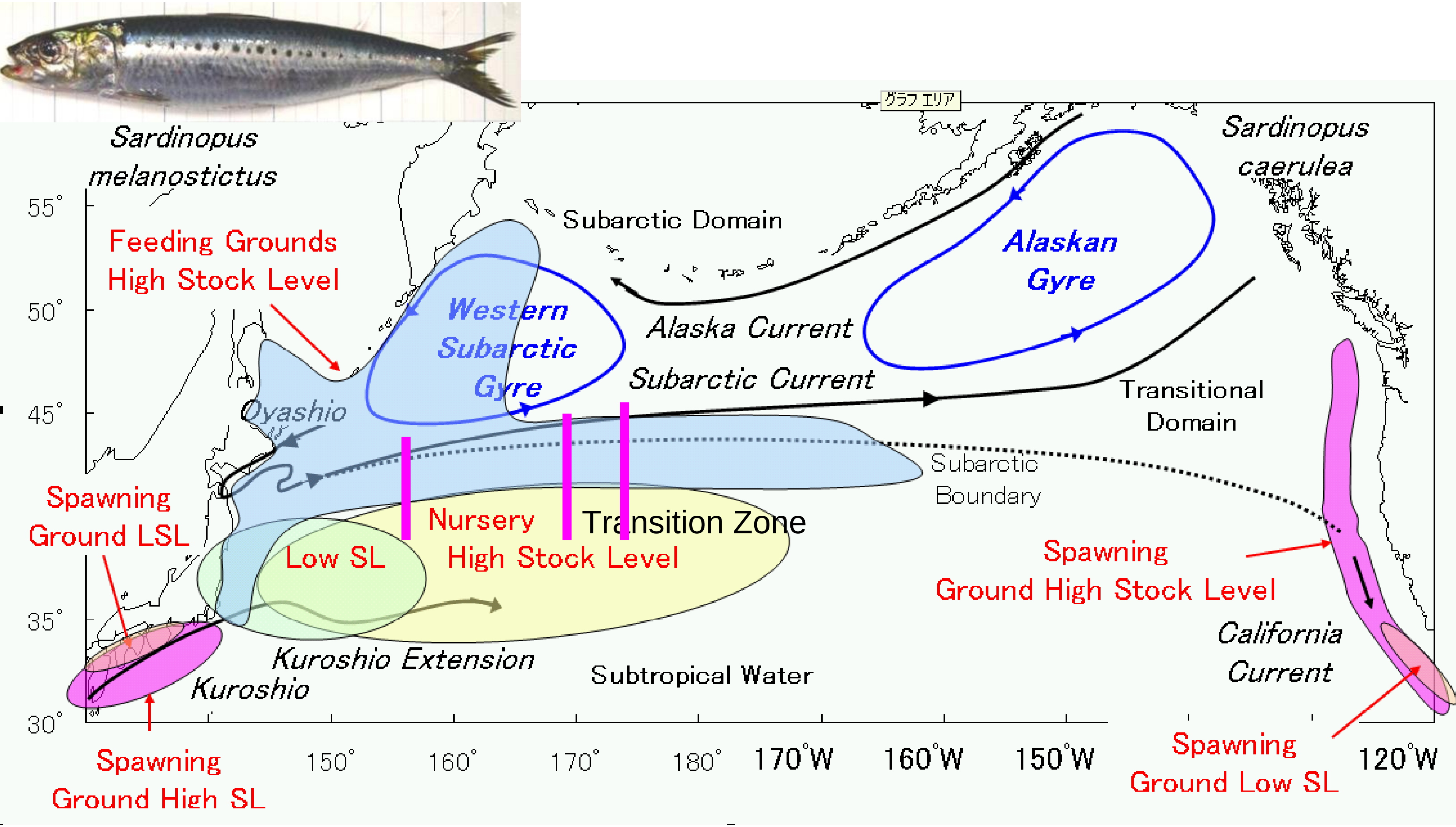
CPUE of Japanese sardine and anchovy by research gillnet surveys along 155º E, 170º E and 175º E in June-July during 1979-1999



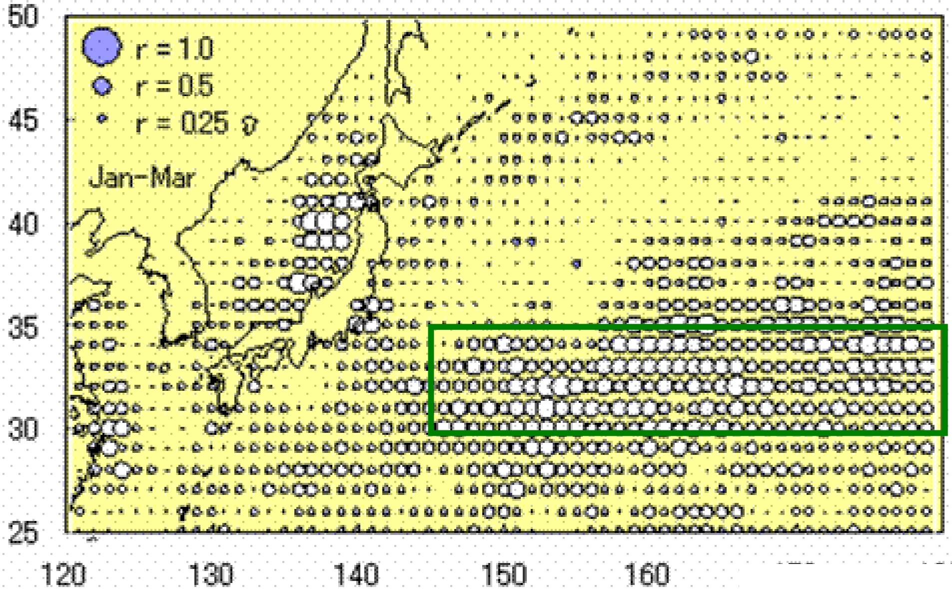


Data from Hokkaido University gillnet monitoring surveys

Distribution and migration of Japanese sardine and California sardine



Correlation coefficient (*r*) map between winter SST and LNRR of Japanese sardine



●: positive *r*

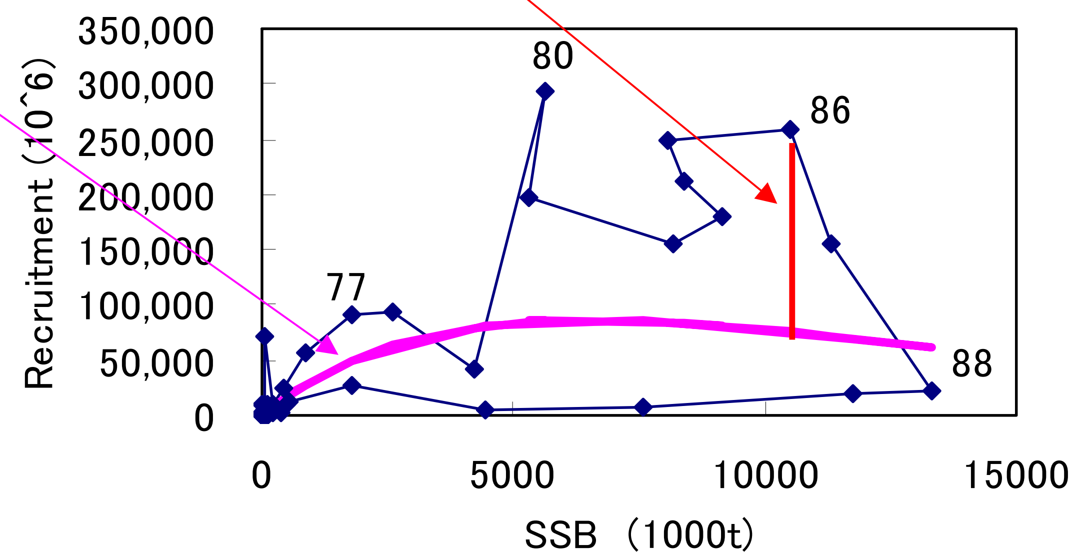
○: negative *r*

Kuroshio Extension (KE)

LNRR=

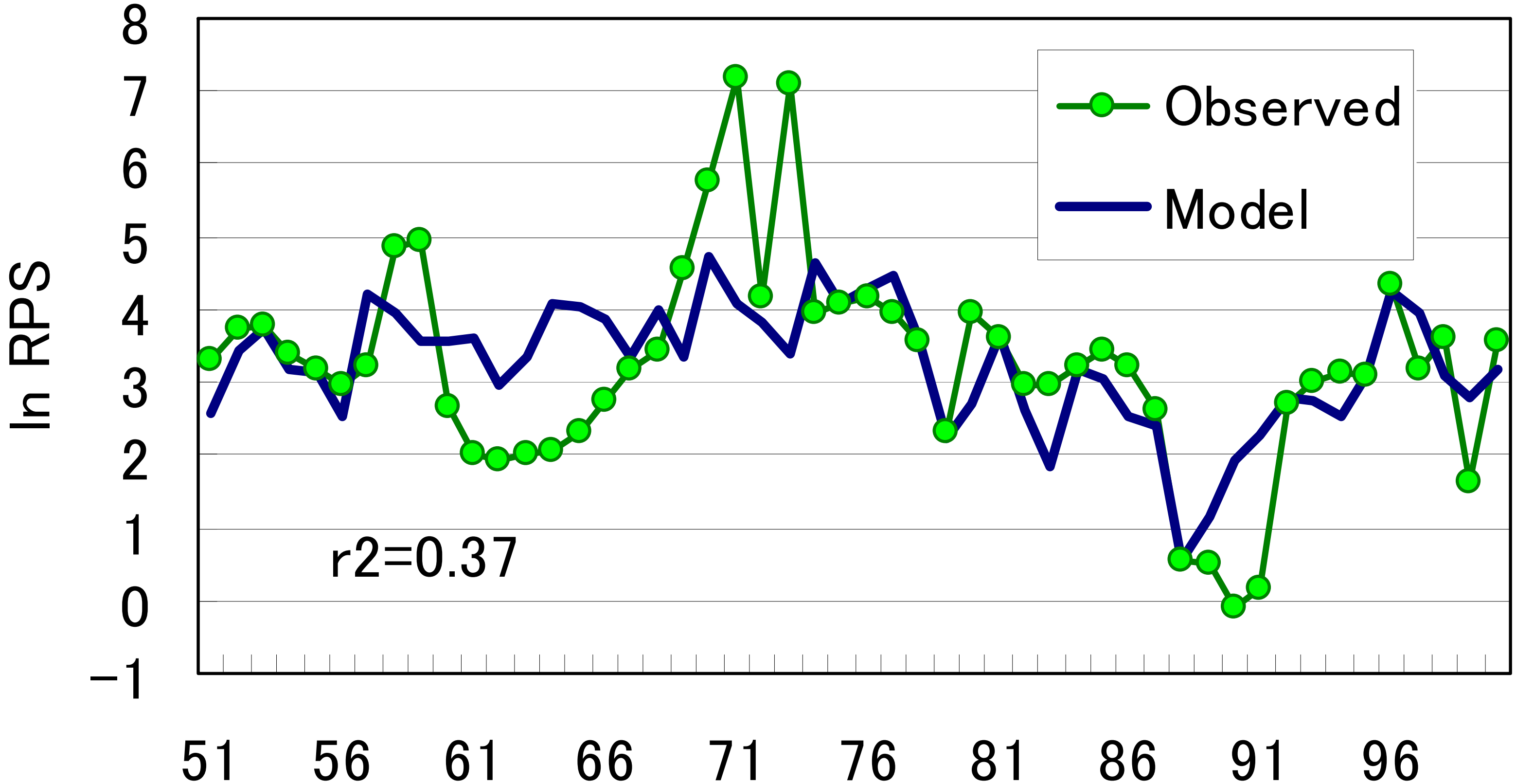
ln (Recruitment Residuals)

Ricker curve



Extended Ricker model of Japanese sardine

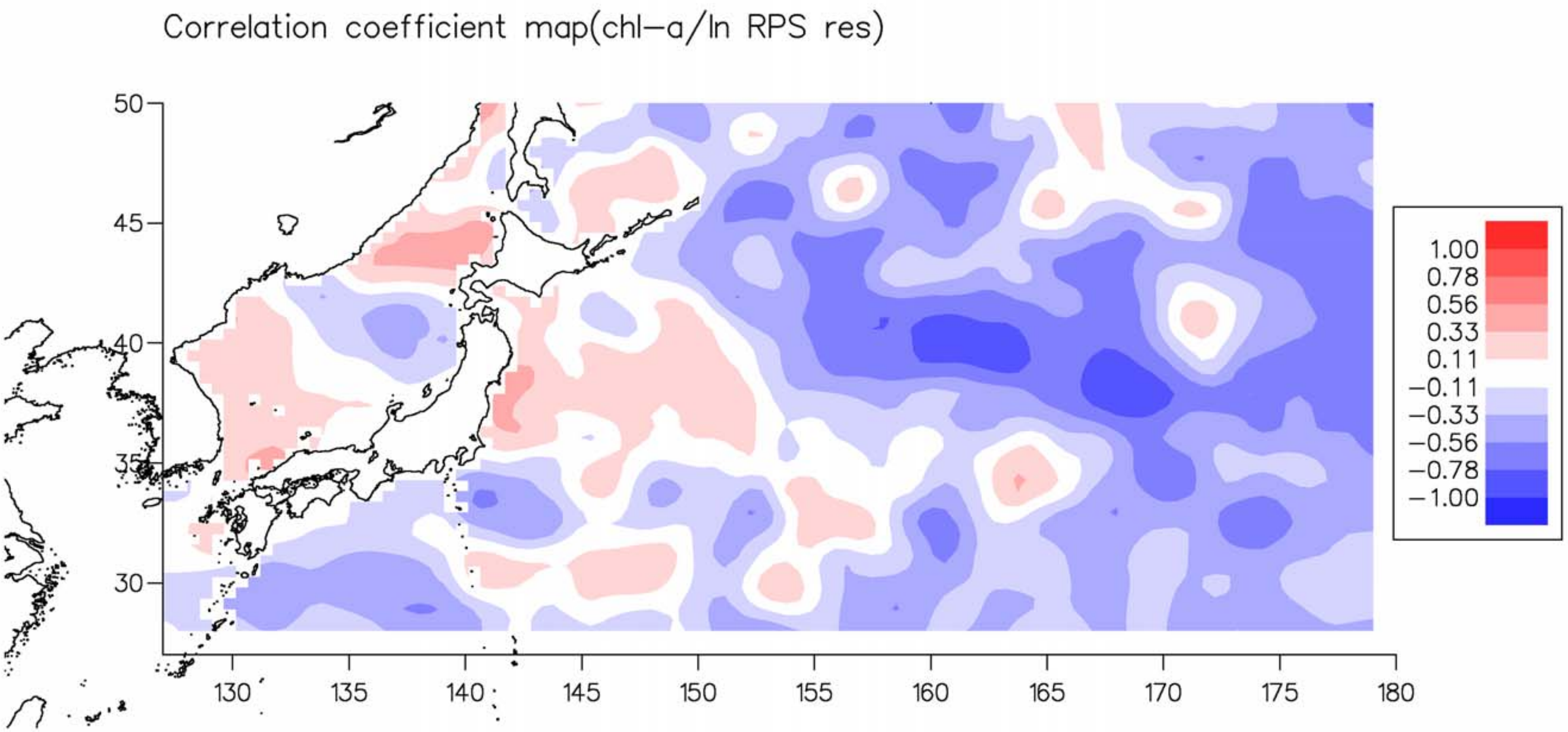
ln (RPS) = ln (Recruitment/SSB) = *a* -*b*SSB + *c*KEST + *d*



SSB: spawning stock biomass

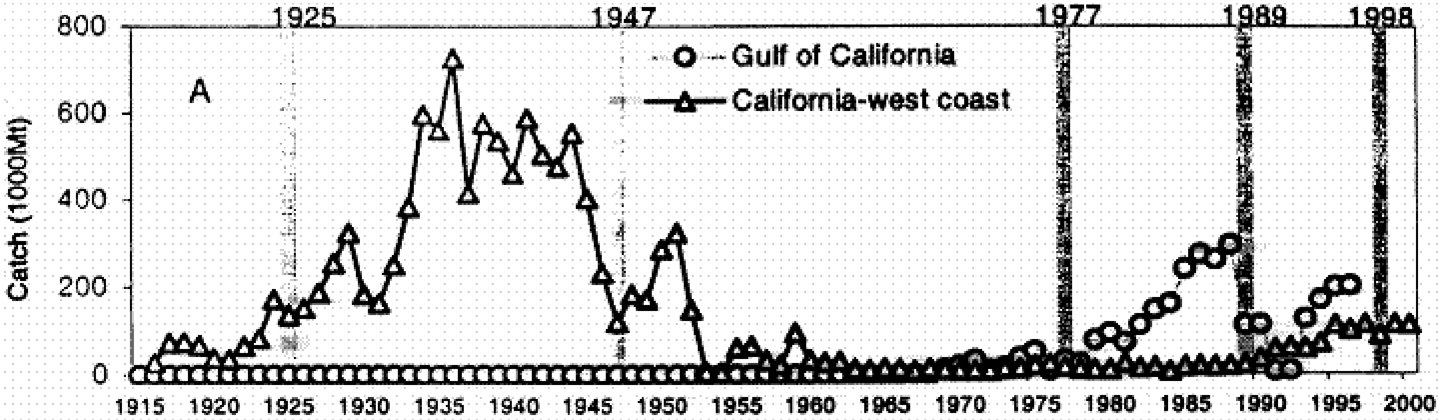
KEST: winter SST of Kuroshio Extension

Correlation map between spring SeaWiFS Chl-a and Japanese sardine LNRR Saito (unpublished)

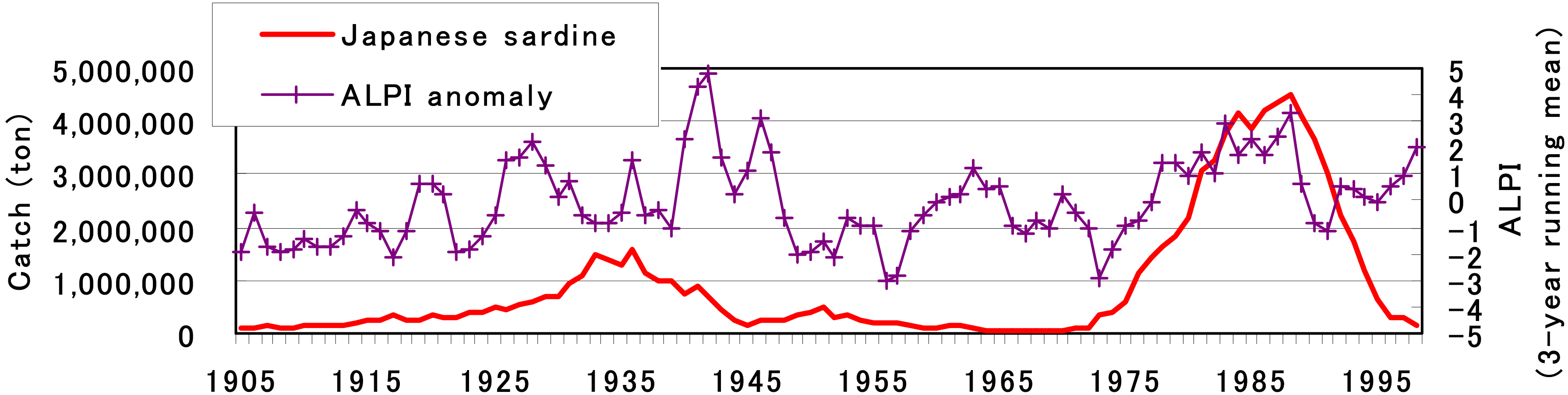


Japanese sardine catch: APLI or overfishing?

California sardine

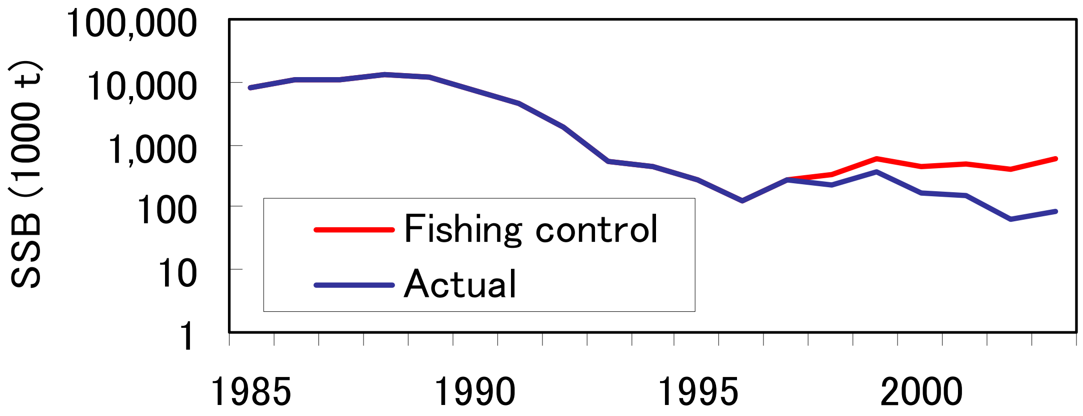


Japanese sardine

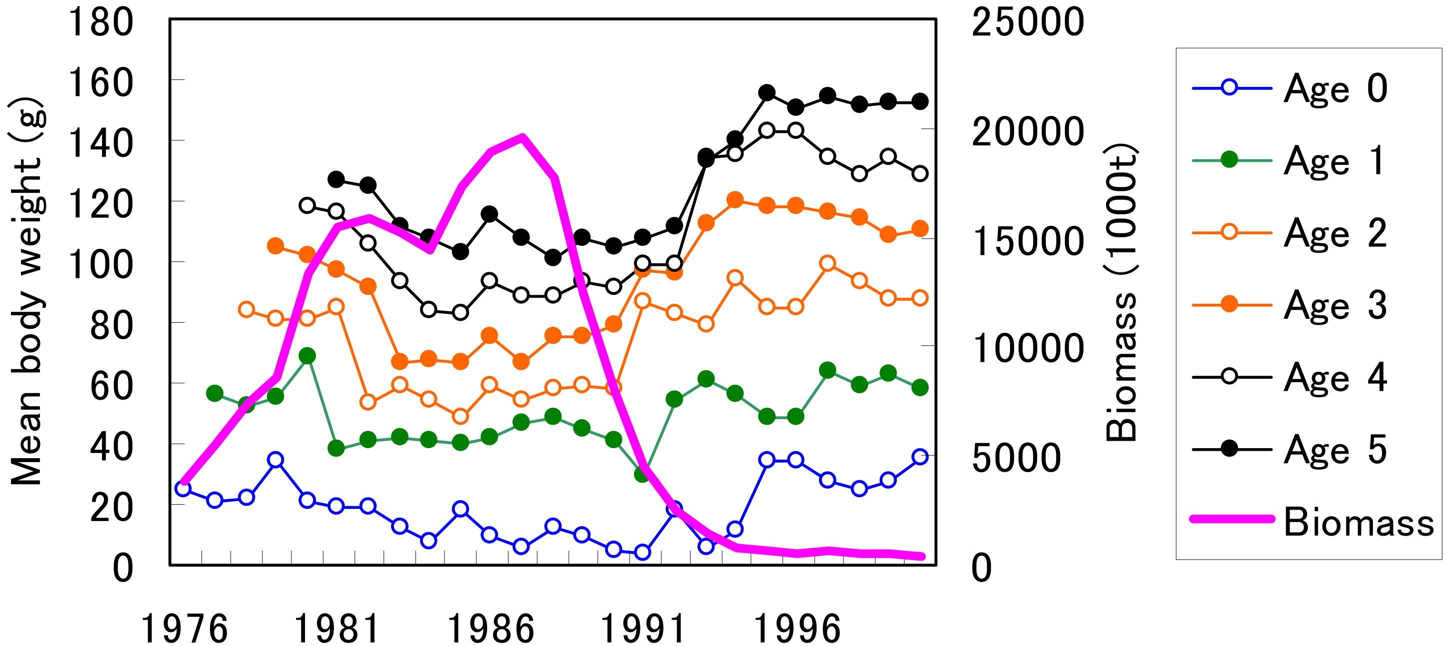


California sardine catch data: McFarlane et al. (2002)

Fishing effect and growth of Japanese sardine



F=0.5 actual F after 1997, using observed RPS values



Density-dependent growth

Japanese sardine dynamics

- Reproductive success (RPS) < SSB (density effects) + SST of Kuroshio Extension + unknown factors
- RPS < primary production of TZ and presumably by zooplankton spp composition, timing of blooming, etc.
- Biomass accumulation =

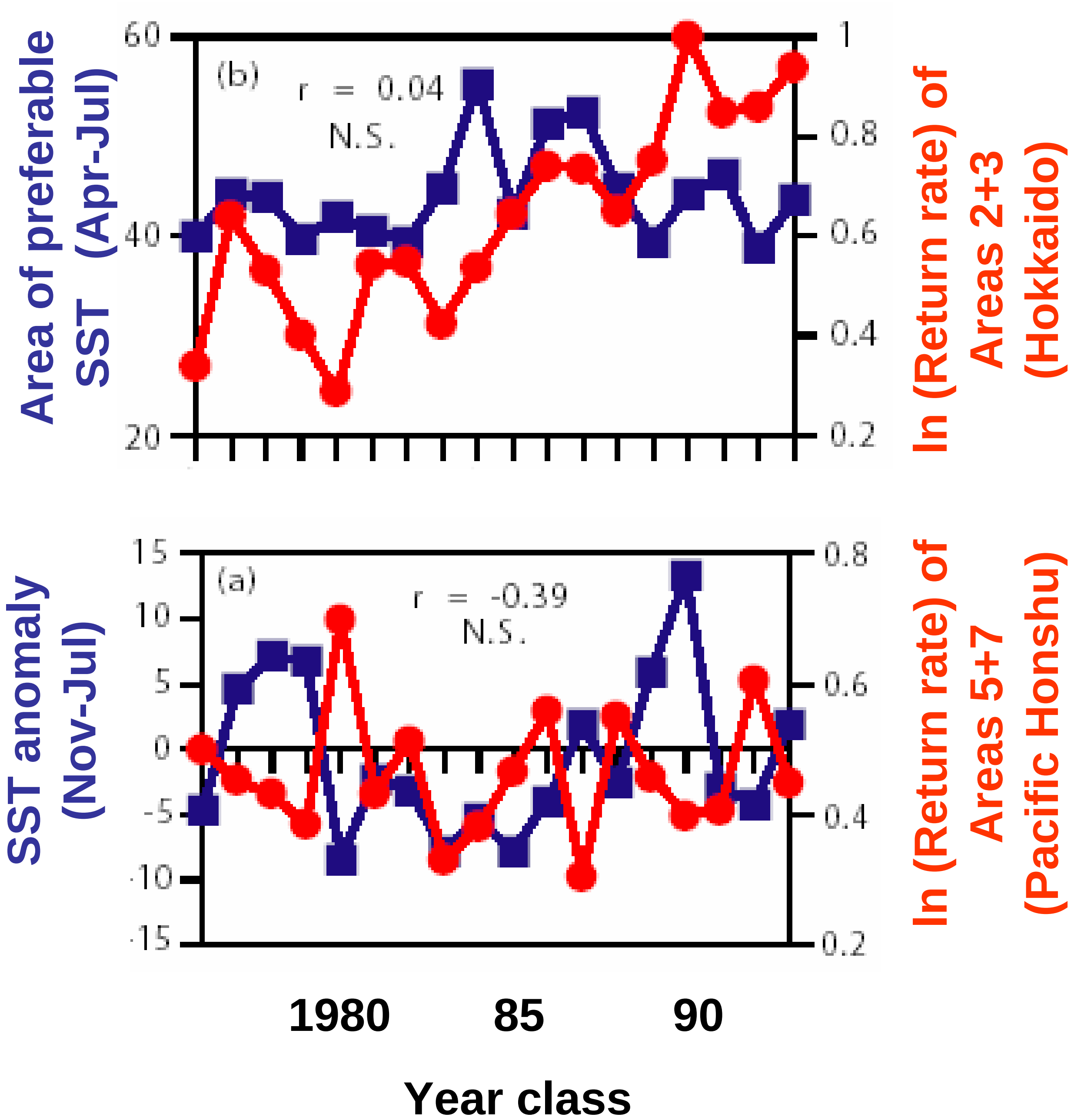
  SSB x RPS x Growth x Survival (after recruit)

  intensive fishing may prevent stock recovery
- Growth < density effect
- WSA Gyre is one of feeding grounds, but only when it is abundant
- Importance of WSAG relative to Transition Zone (TZ) remains unknown
- Kuroshio Extension and TZ are hot areas for RPS

Conclusions

- Japanese stocks of chum salmon and small pelagic fishes migrate between coastal water and open ocean, and between subarctic and transition zone.
- These stocks undergo decadal and annual variations in their abundance (and distribution of small pelagics).
- Population dynamics include both natural environment and human effects - e.g., fishing and stock enhancement.
- WSA Gyre is a passage for Japanese chum salmon, and feeding ground for Japanese sardine only when it is abundant; but effects of biological transport between WSA and ESA, and between WSA and TZ was unanswered.

- Ecosystems are OPEN; for modeling, these large-scale migrations and dynamics must be considered in order to obtain total picture for gyre-coastal systems.



SST of coastal area and return rates of Japanese stocks of chum salmon by hatching area during 1976-93

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