A2: 17:45-18:00 Apr.26

Symposium on "Climate Change Effects on Fish and Fisheries: Forecasting Impacts, Assessing Ecosystem Responses, and Evaluating Management Strategies", Sendai, Japan, 26-29 April 2010.

Response of yellowtail, *Seriola quinqueradiata,* in the Japan Sea to sea water temperature over the last century and potential effect of global warming

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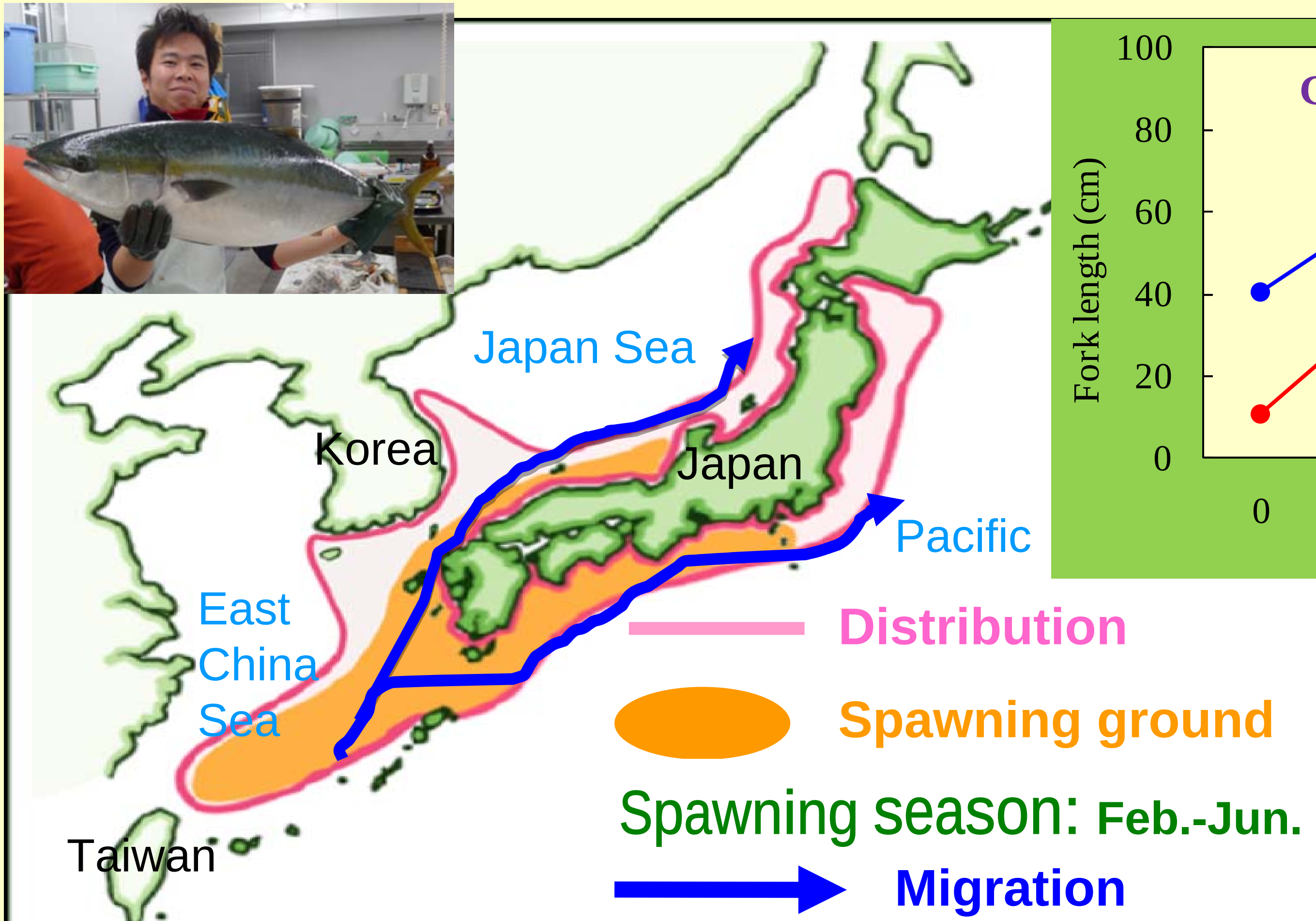
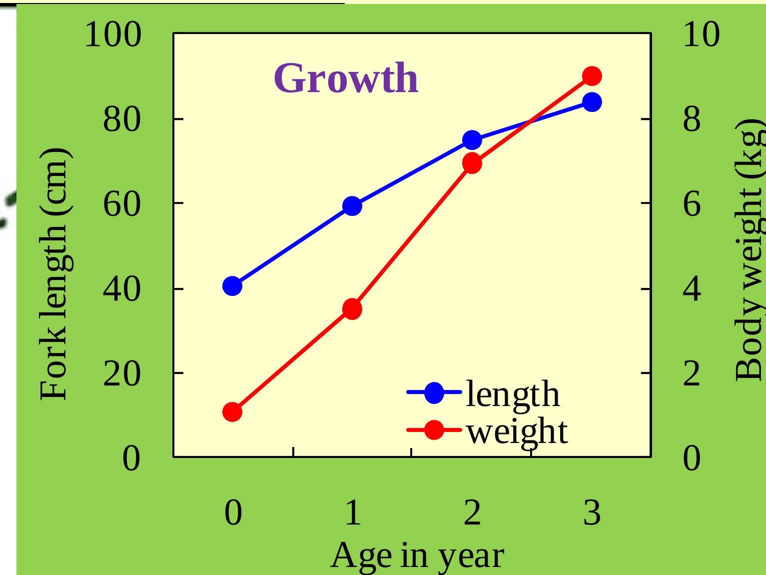
Outline

- Background：yellowtail
- Long-term variation in catch and size composition of yellowtail and its response to SST
- Impact of future global warming
- Conclusions

Growth, migration, distribution and spawning ground of yellowtail



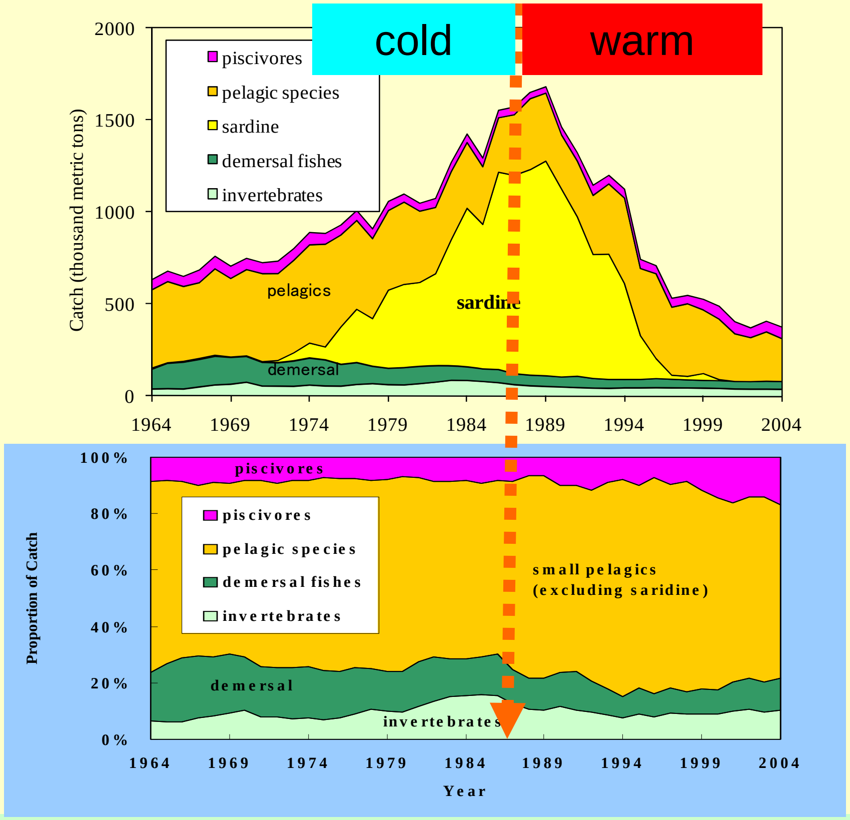


Growth is fast; two years old fish is over 6 kg in body weight.

Summer: young fishes make northward migration to recruitment

Winter: large (2+) fishes make southward migration to spawning

Catch trend in the Japan Sea: what is about the high trophic level fishes (piscivores) or yellowtail ?



The proportion of large-predatory fishes increased with decline in the demersal fishes as a consequence of the late 1980s regime shift (Tian et al., 2008).

- Yellowtail is the most important, large predatory fish in Japan Sea, accounted for about 50 % of total piscivores catch in recent years.
- Migration and distribution are different between thermal regimes: over-wintering area extended to north of Noto Is. during warm 1990s, and caused changes in migration and fishery. (Tian et al., 2010)
- The Japan Sea is one of the most rapid warming LMEs (Belkin, 2009); the mean SST increased 1.6°C over the last 100 years (JMA).

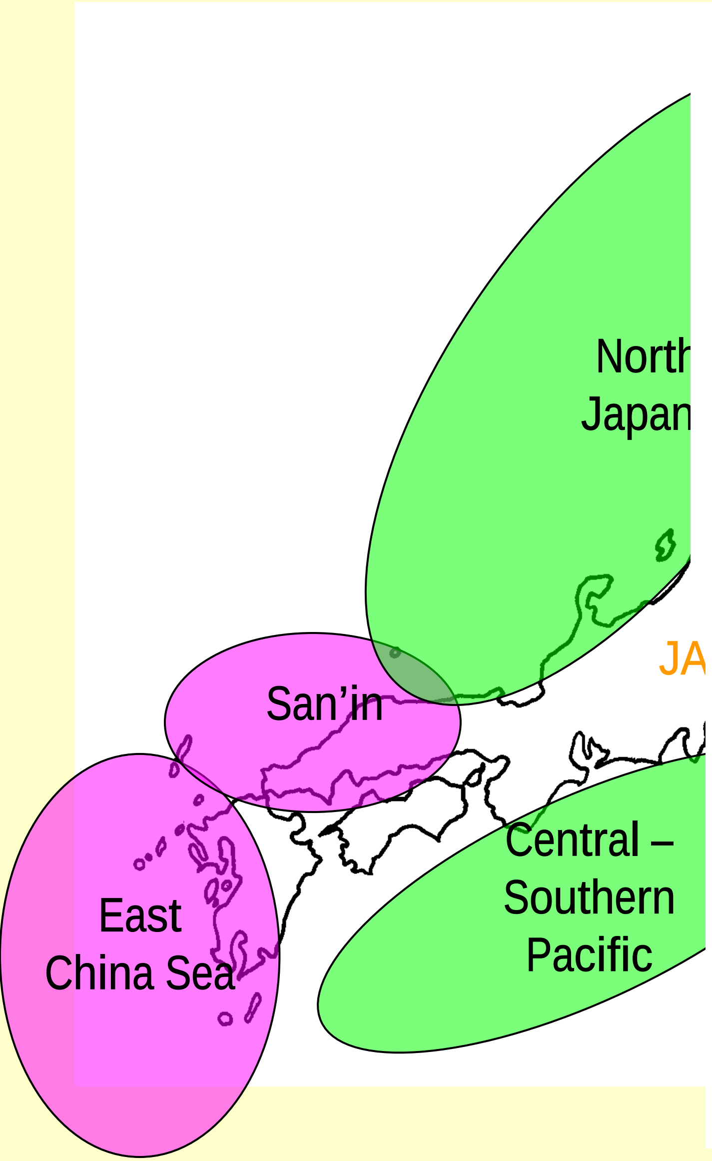
Objectives

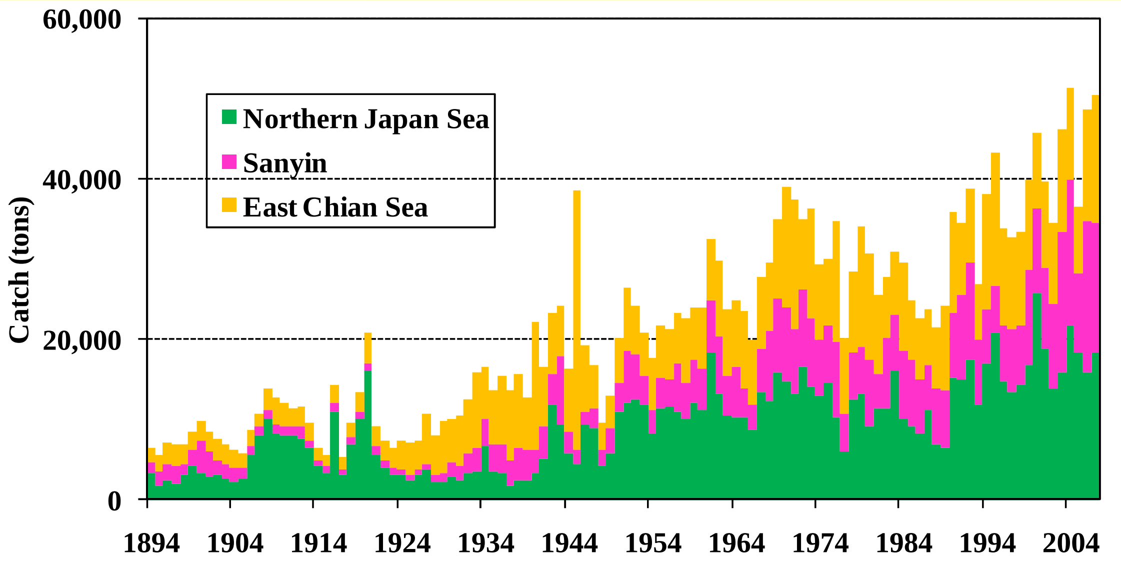
- To identify the long-term variability of yellowtail and its response to water temperature.
- To forecast the potential effect of global warming on yellowtail based on the prediction of IPCC scenario for future water temperature.

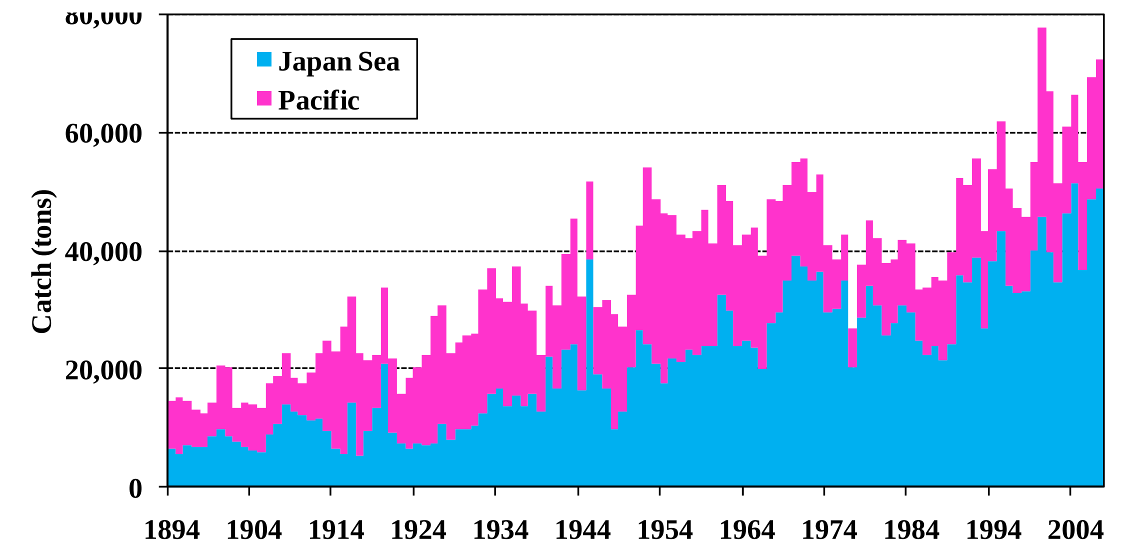
Data sets

- **Catch data:** Japanese catch data by fisheries region (1894-2005) and by fisheries method (1952-2005)
- **Size composition data:** Long-term time series of 2^+ fishes (Buri) from set net fisheries (1900-2005) for Japan Sea; Age composition data for stock assessment (1994-2008) from Tian and Sakaji (2010)
- **50m depth WT:** 1964-2004: good indicator of TWC
- **SST data:** 1900-2002 from Tomosada (2006) for the Northwestern Pacific (around Japanese waters)
- **Future water temperature prediction:** for 2025, 2050, 2100 from JADE (Japan Sea Assimilation Experiment) model (http://jade.dc.affrc.go.jp/jade/) based on the IPCC A1B Scenario

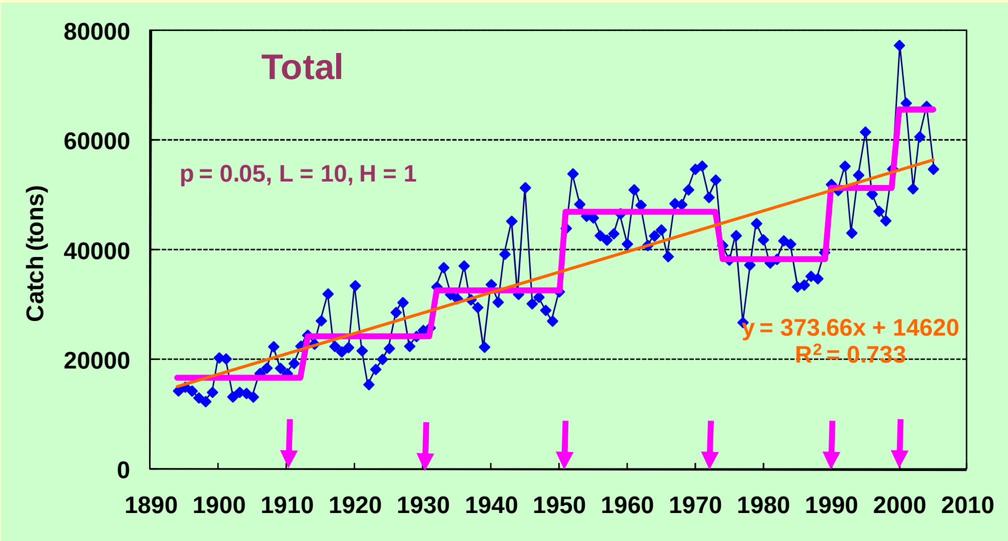
Catch trend of yellowtail by fisheries regions

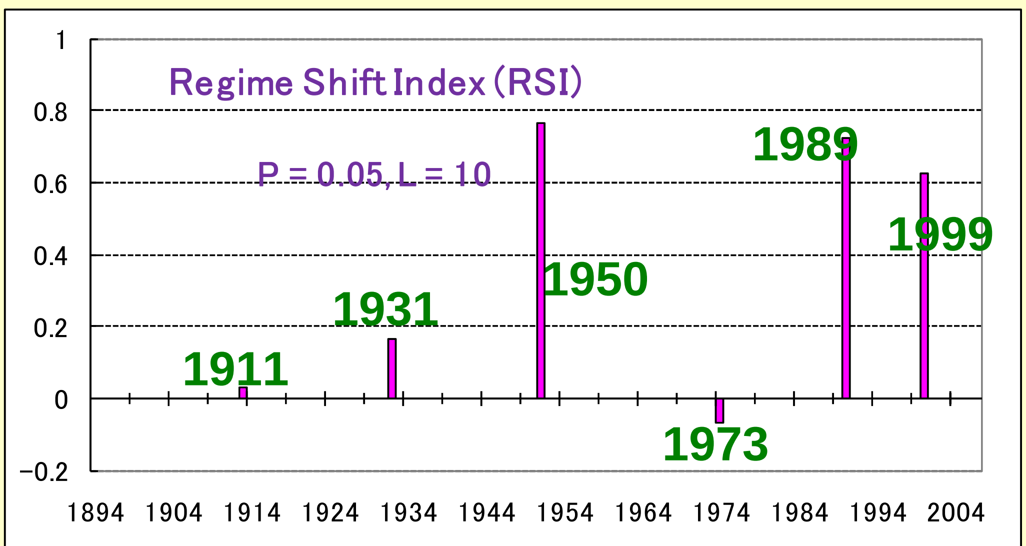






Long-term trend in the catch over the last 100 years



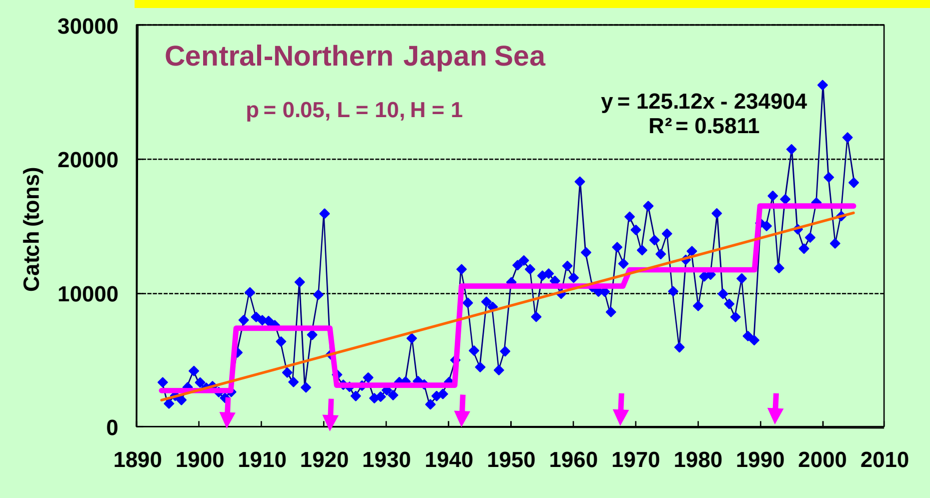


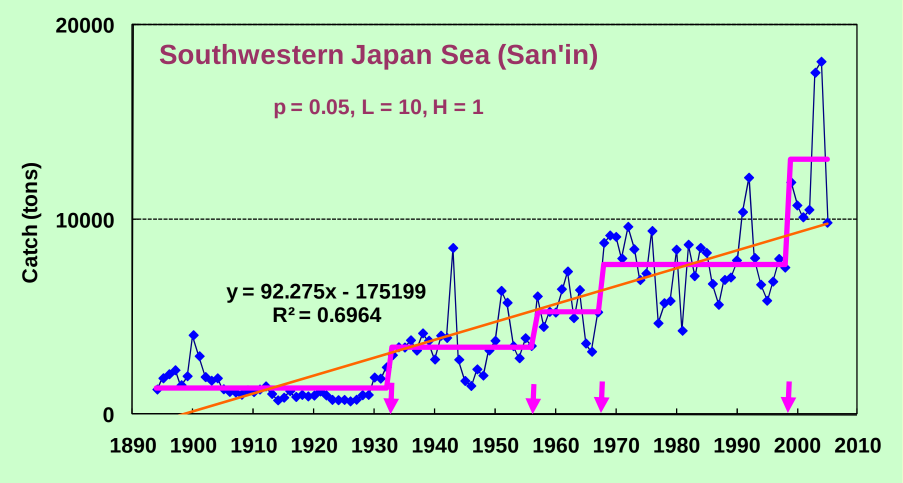
"Apparently" ,an increasing trend with evident decadal variation pattern

Six regime shifts occurred during the last century with about 20 years period by the STAR method of Rodionov (2004) after removed auto-correlation

Variation in the Japan Sea by fisheries region

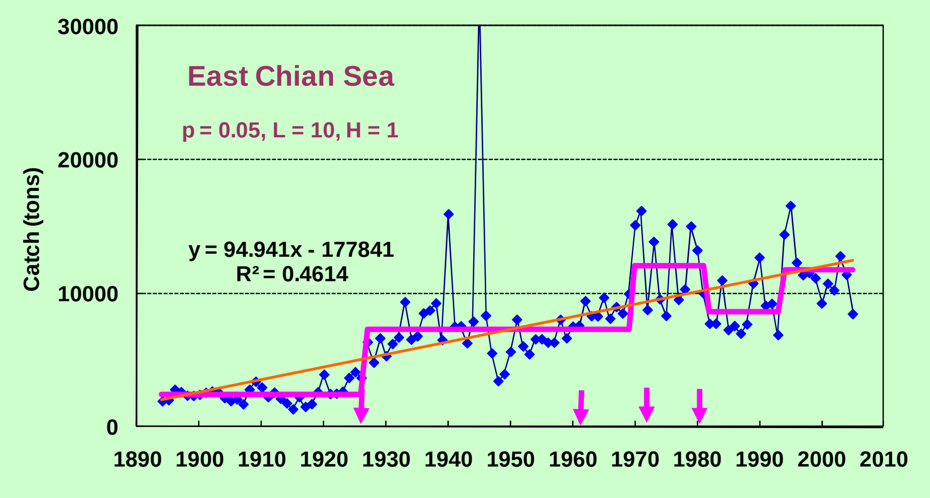
Set net dominant fishery | Purse seine dominant fishery



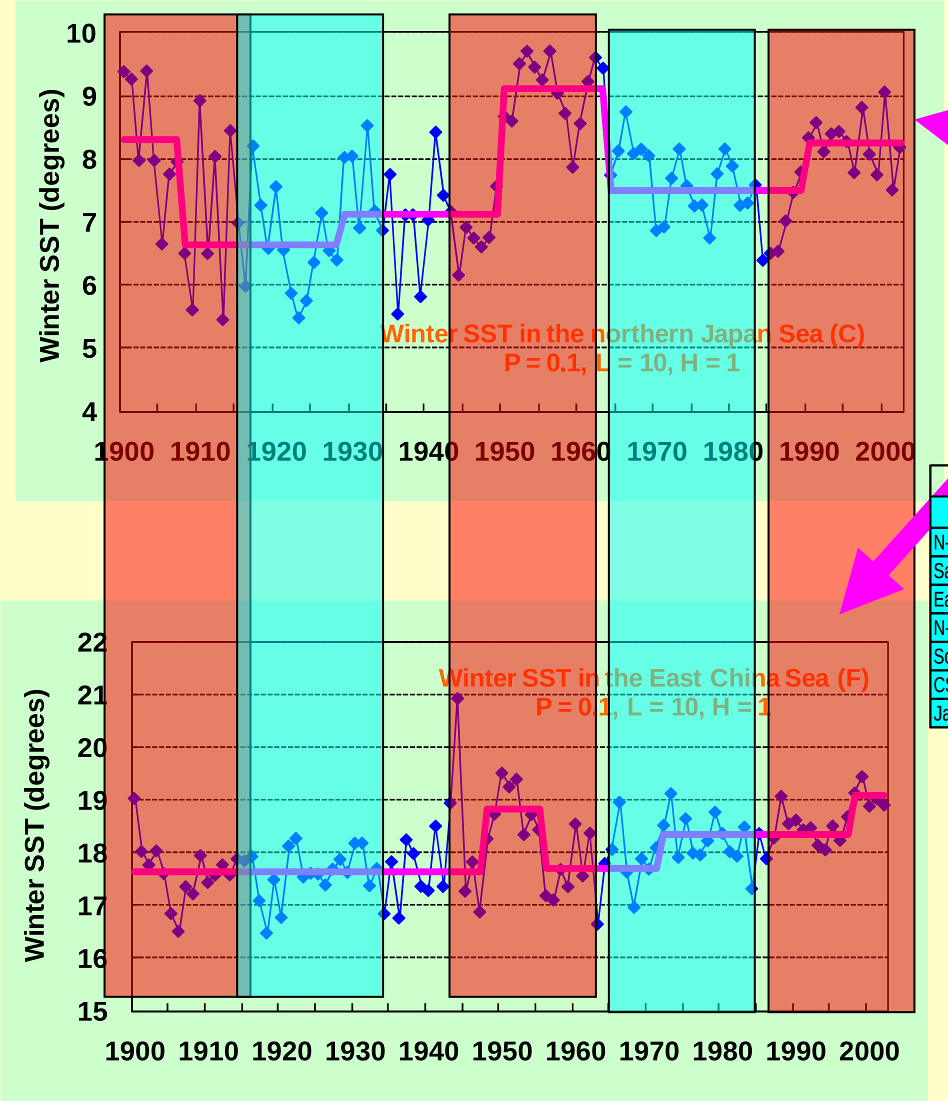


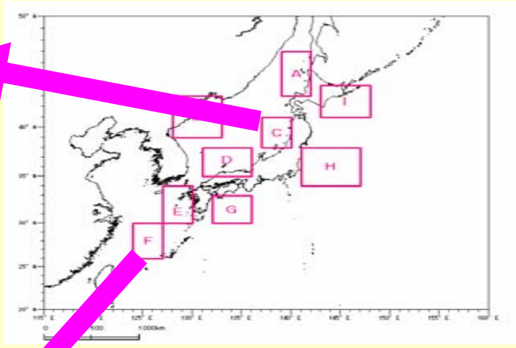
All showed an increasing trend with evident decadal variation pattern: high(low) catch in 1990s (1970-80s).

Trend from Set net indicated increasing abundance.



Winter SST trend by region：1900-2002



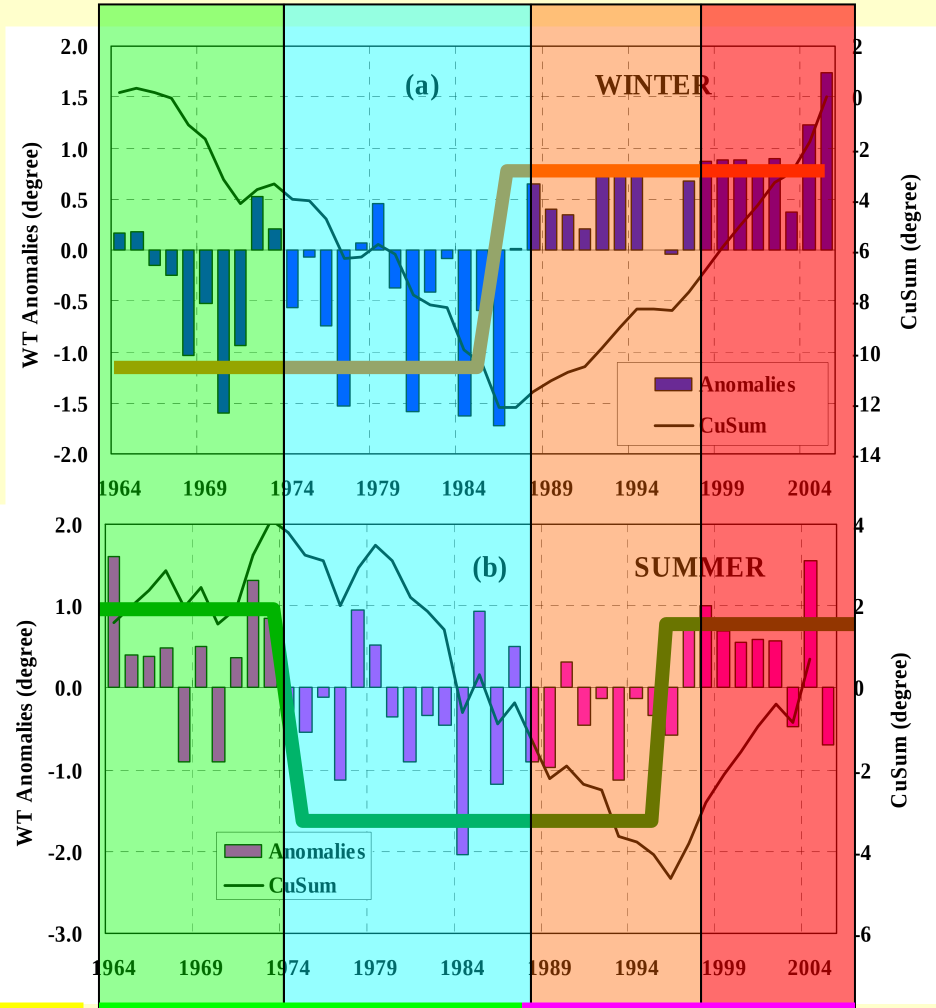


	Tsushima current water (Japan Sea)					ECS	Pacific waters		
Catch	A	A1	C	D	E	F	G	H	I
N-Japan Sea	-0.42	0.06	0.45	0.21	0.57	0.59	0.60	0.51	0.32
San'in	-0.43	-0.09	0.44	0.12	0.51	0.67	0.67	0.38	0.29
East China Sea	-0.36	-0.18	0.28	0.01	0.40	0.56	0.54	0.30	0.16
N-Pacific	-0.35	0.37	0.48	0.29	0.52	0.40	0.49	0.47	0.38
Sodo-bou	-0.44	0.10	0.47	0.21	0.58	0.58	0.68	0.35	0.18
CS-Pacific	-0.02	0.34	-0.02	-0.03	-0.02	-0.10	-0.04	0.06	-0.08
Japan Total	-0.50	0.13	0.51	0.19	0.63	0.68	0.73	0.53	0.32

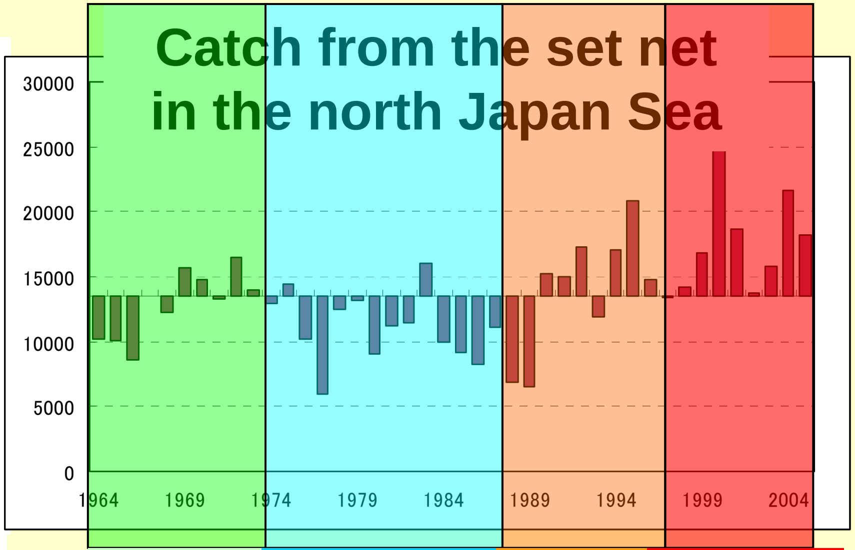
P<0.05
P<0.01

Positive correlations between catch and the SST, particularly in the spawning grounds (E,F) and northern Japan Sea（C）.

Response to Tsushima indicator: 50m depth WT



Win	cold		warm
Sum	warm	cold	warm



normal | bad | good | excellent

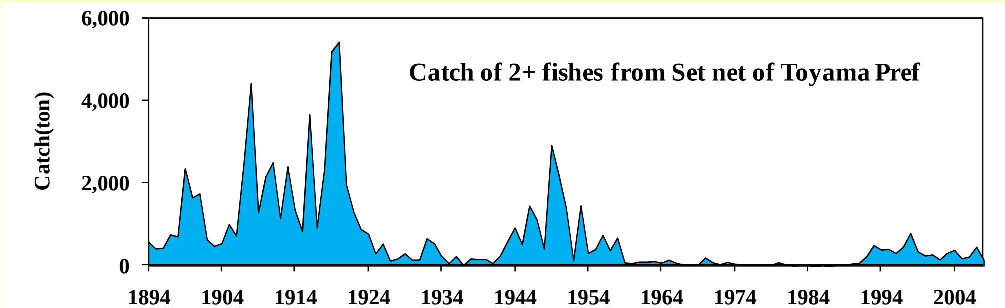
The catch was particularly good (bad) when the WT was higher (lower) both in the winter and summer.

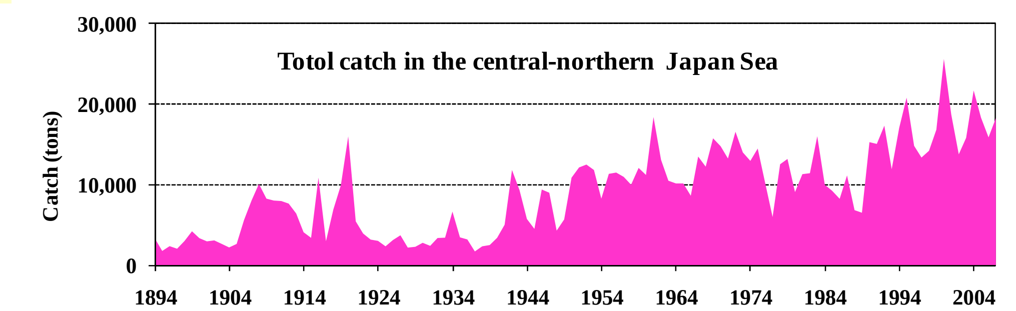
Good correspondence between WT and yellowtail

Positive effect of WT on yellowtail

Changes in size composition

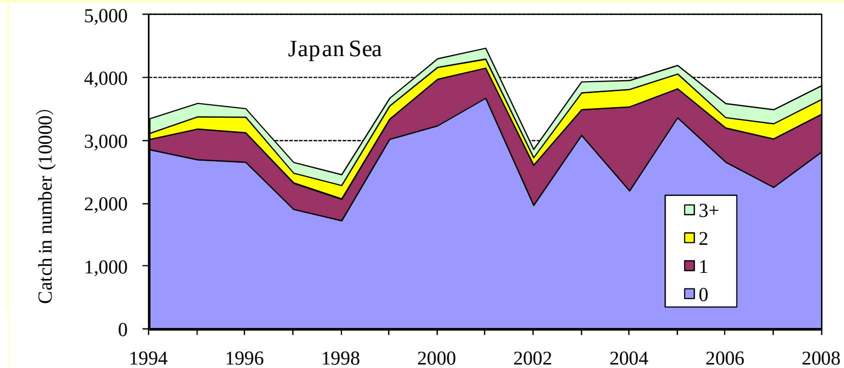
Long records for large fishes (2+)

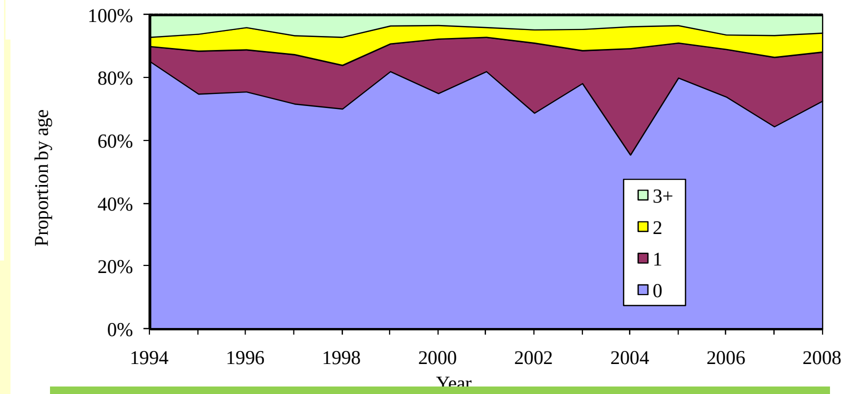




The 2+ fishes were high before 1950s with decadal variability; but decreased in spite of large increase in the total catch since 1960s.

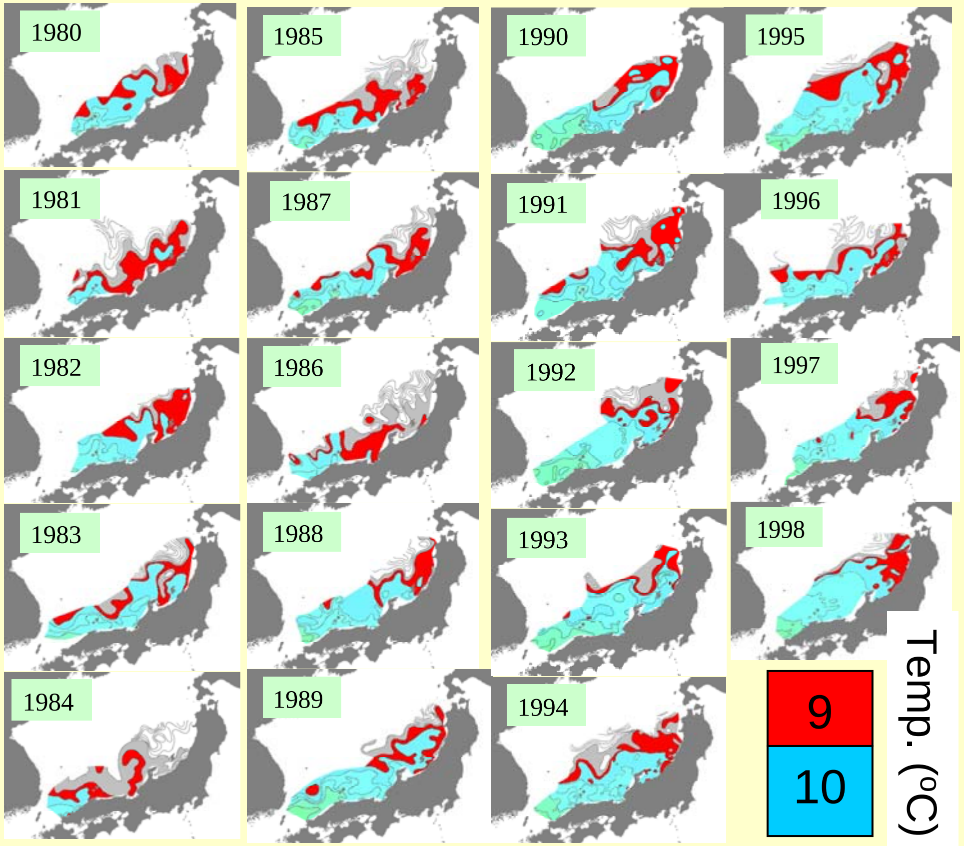
Age composition (1994-2008)



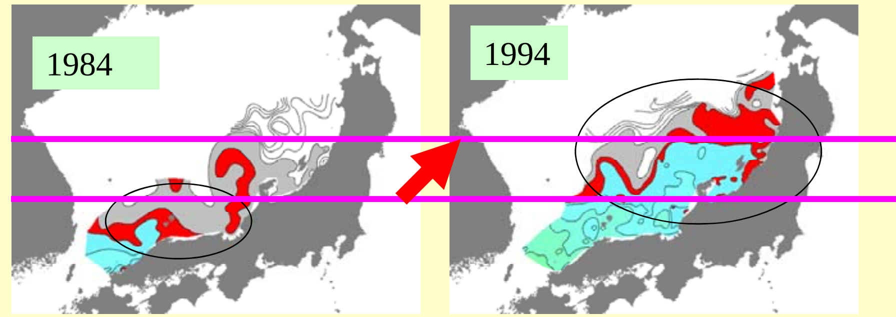


About 90 % of the catch was 0 and 1 year young fishes. The proportion of 2^{+} fishes was small.

Change in possible distribution from mapping of SST



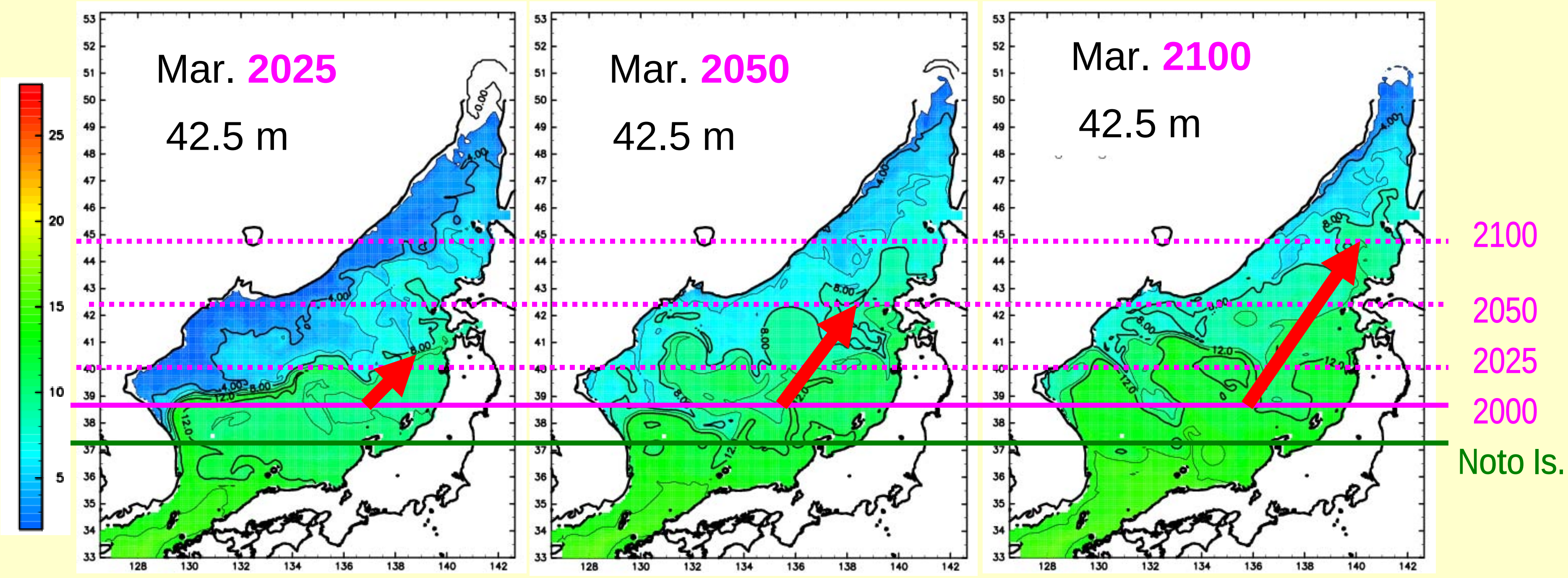
Cold 1980s **warm 1990s**



If we can forecast the water temperature, we can estimate the possible distribution of yellowtail.

The habitat temperature for yellowtail is higher than <u>10 ℃</u>. The estimated distribution by SST extended to the north of Noto Is. during the warmer 1990s compared with the cold 1980s, corresponded well with the result from <u>archival tagging experiment</u> (Tian et al., 2010).

Effect of future global warming

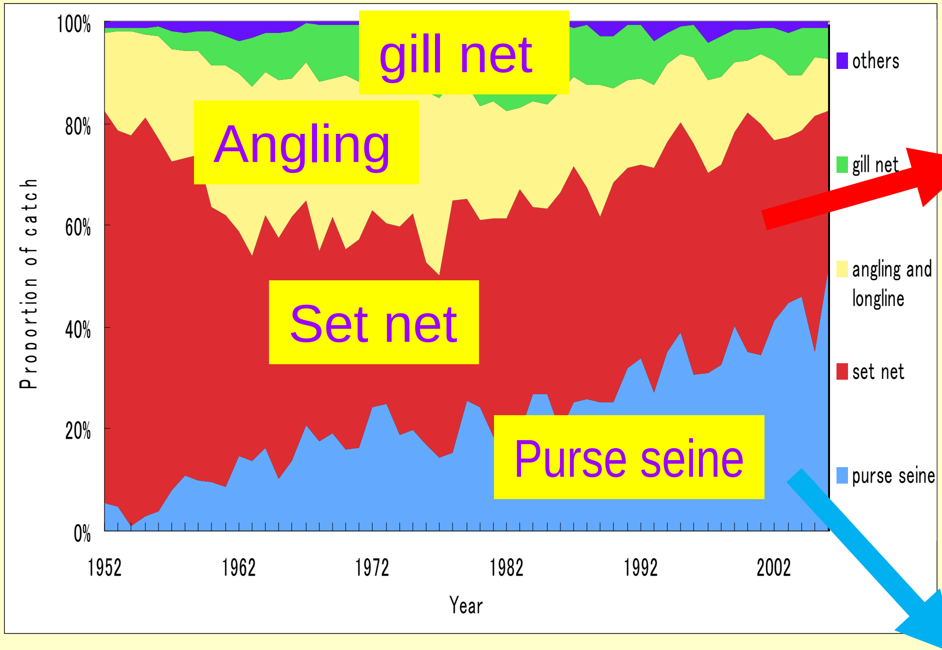


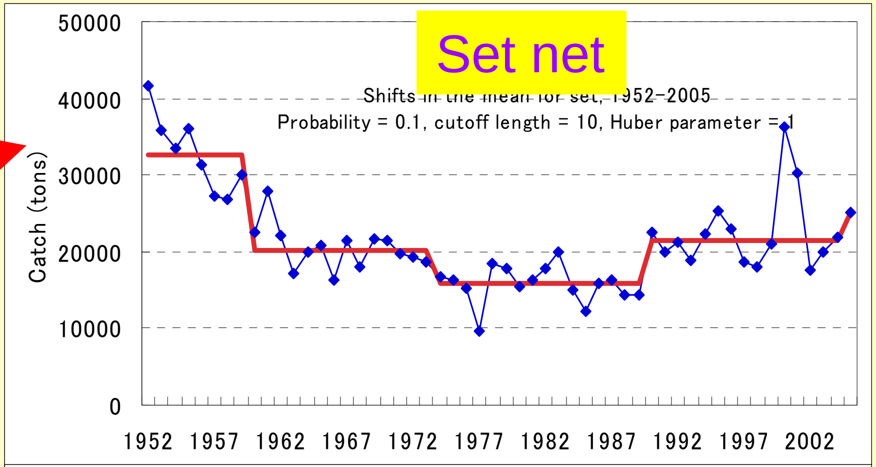
The future water temperature were estimated with JADE (Japan Sea Assimilation Experiment) model. It suggests the strength in the water of TWC. The possible distribution boundary in winter for yellowtail extended to the Hokkido in 2050, is assumed to affect the southward migration of adult fishes and the fishery, consequently.

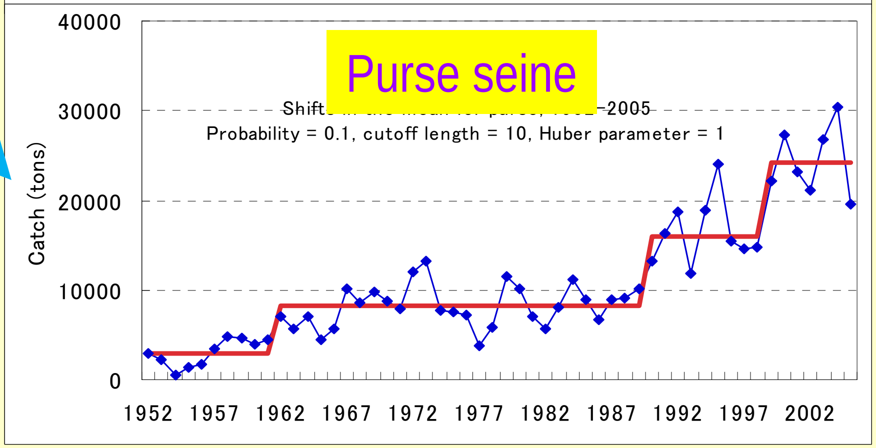
Conclusions

- Yellowtail catch showed decadal variation patterns with six regime shifts during the last century.
- There were good correspondence between SST and yellowtail; increase in SSTs has positive effect on yellowtail: particularly good (poor) catch occurred when both winter and summer WT were higher (lower).
- The catch from set net, particularly the 2+ adult fishes were lower compared with the level before 1950s, suggested the changes in the population structure and the impacts of fishing.
- Future global warming will extend the northward distribution in winter, and affect the southward migration pattern and fisheries structure, consequently.

Impact of fishing ?







Set net was the main fishery before 1950s, but the proportion of purse seine largely increased with marked decline in the set net, suggested impact of fishing.

The catch from set net during 1990s was same as 1960s, fairly lower than 1950s.