Effects of climate change on the World's Ocean ECCWO5 ID 16093

Long-term decline of fish weight in western North Pacific associated with climate change and intra- and inter-species competition

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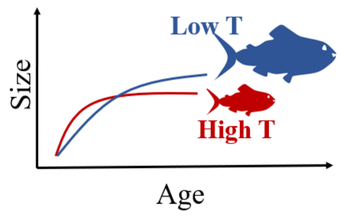
Introduction

The universal of TSR is under debated

Mostly observed in the lab | Observation in nature



Temperature-size rule (TSR)
(Atkinson et al., 1996)

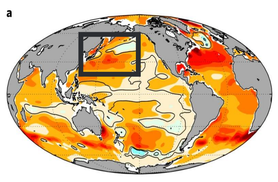
• North Sea • West of Scotland • Mediterranean Sea	Higher temperature, smaller adult size (Baudron et al., 2014; Ikpewe et al., 2021; van Rijn et al., 2017)
• Around Australian continent	Higher temperature, half increased half decreased (Audzijonyte et al., 2020)

Western North Pacific (WNP) remains unclear

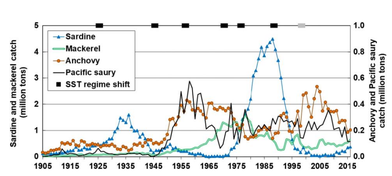
❖**Temperature-size rule**
Warming trends

❖ **Inter(intra) species competition**

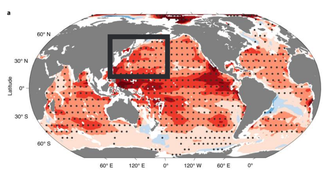
❖ **Bottom-up effects**
Stronger stratification



Upper OHCA linear trends 1968–2019
(Johnson & Lyman, 2020)



Prominent SPF species replacements since the 1900s
(Yatsu 2019)



0–2,000 m stratification trend 1960-2018
(Li et al., 2020).

In this study

Step 1: Collect size data of fish around Japan

Step 2: Extract common trends using dynamic factor analysis (DFA)

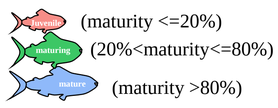
Step 3: Discuss the common trends and their possible drivers
- **Temperature-size rule**
- **Inter- and intra-species competition**
- **Bottom-up effect**

Data and Methods

➢ **Weight-at-age data**

Name	Region	Time series availability
Japanese sardine	P, T	1978–2018 (6 populations, 4 species)
Japanese jack mackerel	T	1995(1997)–2018 (17 populations, 13 species)
Chub mackerel	P, T	
Blue mackerel	P, ECS	
Alaska pollock	P	
Round herring	T	
Japanese anchovy	P, T	
Pacific cod	NP	
Japanese amberjack	J	
Pacific sand lance	ESE	
Japanese spanish mackerel	SE	
Pointhead flounder	JS	
Broadbanded thornyhead	NP	

P: Pacific
NP: North Pacific
ECS: East China Sea
T: Tsushima current
JS: Japan sea
SE: Seto land Sea
ESE: East of SE



(maturity <=20%)
(20%<maturity<=80%)
(maturity >80%)

[1] Fisheries Agency and Fisheries Research and Education Agency of Japan, 2019

➢ **Statistical analysis**

Dynamic Factor Analysis

$$W_i(t) = Z_{1,i}x_{1,t} + \cdots + Z_{n,i}x_{n,t} + a_i + \varepsilon_{i,t}, \qquad \varepsilon_t = MVN(0, R)$$

W	Standardized weight anomaly time	a	Offset
x	Common trend	ε	Errors with Multivariate normal distributions
Z	Factor loadings	R	Error covariance matrix

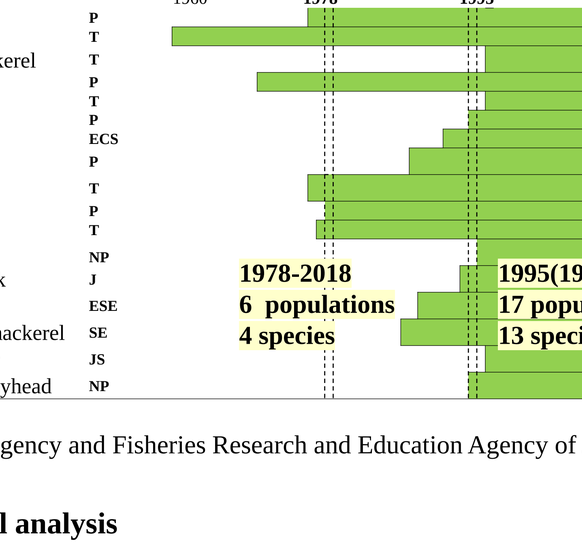
Results and Discussion

Common trends 1978 – 2018

6 juvenile time series ➔ 2 common trend

3 maturing time series ➔ 1 common trend

6 mature time series ➔ 2 common trend



Low values in the 1980s
Decreasing in the 2010s

Sardine_P/T: Pacific/Tsushima current stock of the Japanese sardine

ChubM_P: Pacific stock of the chub mackerel

RoundH_T: Tsushima current stock of the round herring

Anchovy_P/T: Pacific/Tsushima current stock of the Japanese anchovy

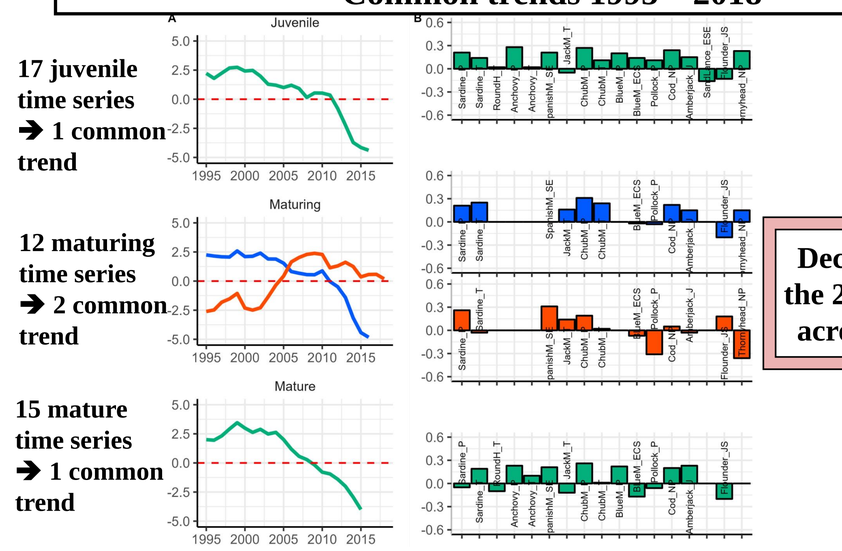
Results and Discussion

Common trends 1995 – 2018

17 juvenile time series ➔ 1 common trend

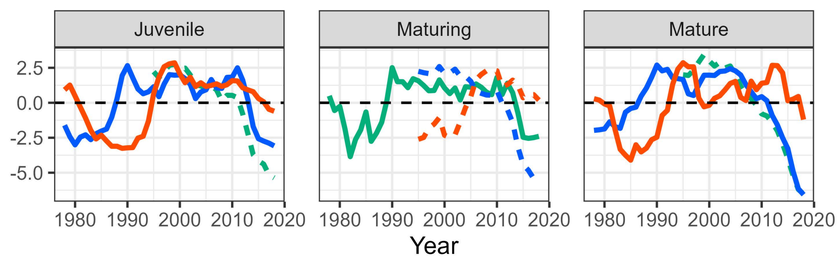
12 maturing time series ➔ 2 common trend

15 mature time series ➔ 1 common trend



Decreasing trends in the 2010s was detected across a wider range

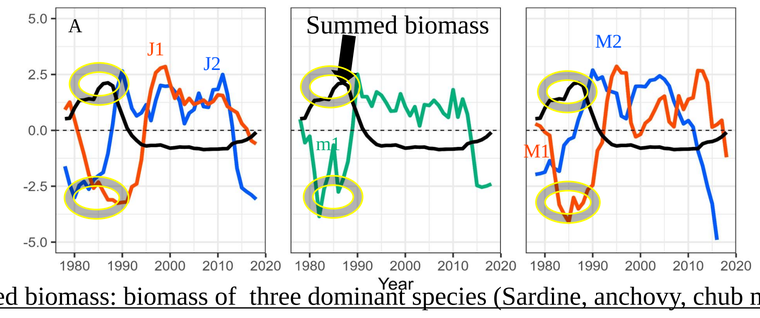
The trend in the 2010s decreased to a low level similar with 1980s



Two reduction periods and different mechanisms

Temperature-size rule	Inter- and intra-species competition	Bottom-up effect
⊘		

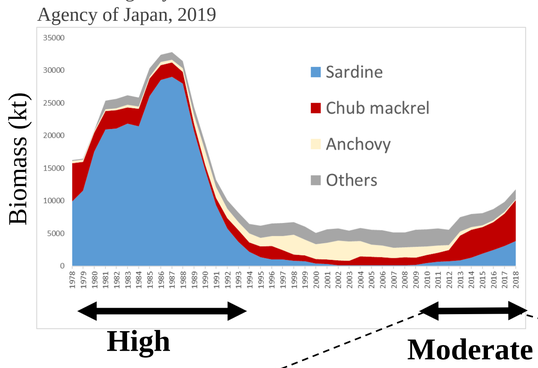
➢ **Reduction in the 1980s : competition from sardine**
➢ **Reductions in the 2010s: competition from sardine and chub mackerel + reduced carrying capacity**



Summed biomass: biomass of three dominant species (Sardine, anchovy, chub mackerel)

Inter- and intra-species competition from dominant species

*Others: Other 11 populations with available data length
Fisheries Agency and Fisheries Research and Education Agency of Japan, 2019



High sardine stock in the 1980s, Abundance increased and habitat expanded
Reduce the biomass of *Neocalanus* copepods (Tadokoro et al., 2005)

Intra-species competition (Kawabata et al., 2011)
Inter-species competition:
Overlaps in the food and habitat with species such as anchovy, chub mackerel, saury (Yatsu et al., 2019) and Japanese round herring (Hirai et al., 2017).

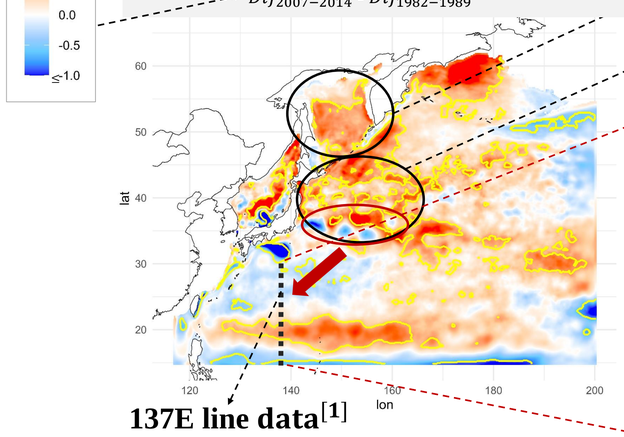
Biomass recover of sardine and chub mackerel in the 2010s

Stronger stratification and reduced carrying capacity

2007--2014 has stronger stratification

Stratification strength: temperature difference between the sublayer 0.5m and 200m $Dif: T_{-0.5m} - T_{-200m}$

$\overline{Dif_{2007-2014}} - \overline{Dif_{1982-1989}}$



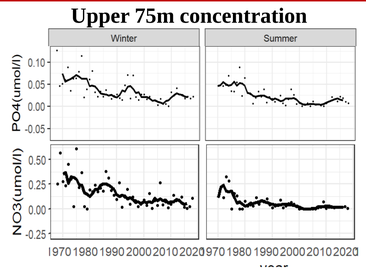
137E line data[1]

[1] Japan meteorological agency

Okhotsk Sea
Iron transportation (Nishioka et al., 2021).

Oyashio and Kuroshio Oyashio Transition Zone
Important feeding grounds (Yatsu, 2019)

Upper 75m concentration



Decrease around 20N: Stronger stratification;
Decrease around 25N: Subtropical mode water

Conclusions

- The common trends of weight of fish community in the WNP
- The weight decline in the 1980s was probably driven by the competition from high sardine biomass
- The weight decline in the 2010s was driven by both species competition and declined carrying capacity