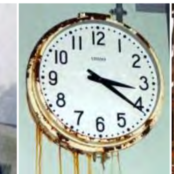
PICES 2013 Annual Meeting, S8: Ecosystem indicators to characterize ecosystem responses to multiple stressors in North Pacific marine ecosystems. 2013/10/17-18

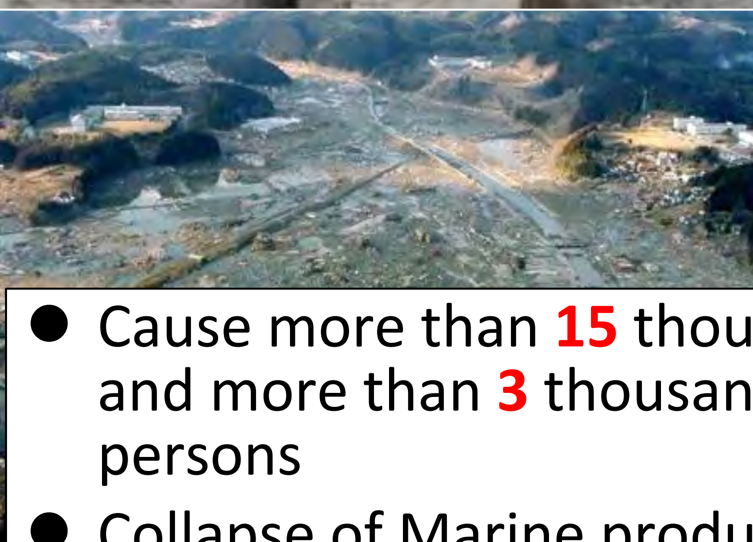
Risk management for recovering chum salmon populations in the Iwate coastal ecosystem after the Tohoku catastrophic earthquake and tsunami

Yuxue Qin[1], Yuichi Shimizu[2], and **Masahide Kaeriyama**[1]
[1]Hokkaido University, [2]Iwate Pref. Fish. Tech. Cen., Japan
salmon@oia.hokudai.ac.jp

Great Tohoku Earthquake & Tsunami

11 March 2011

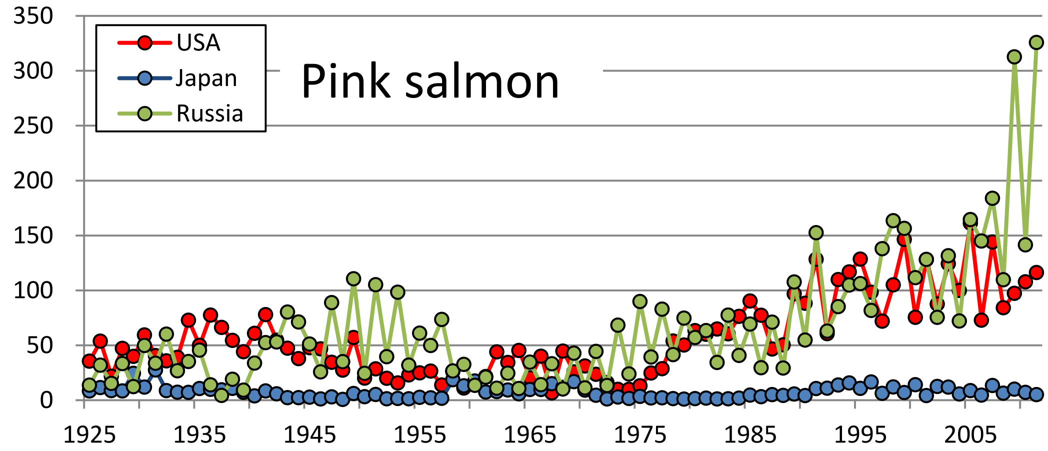


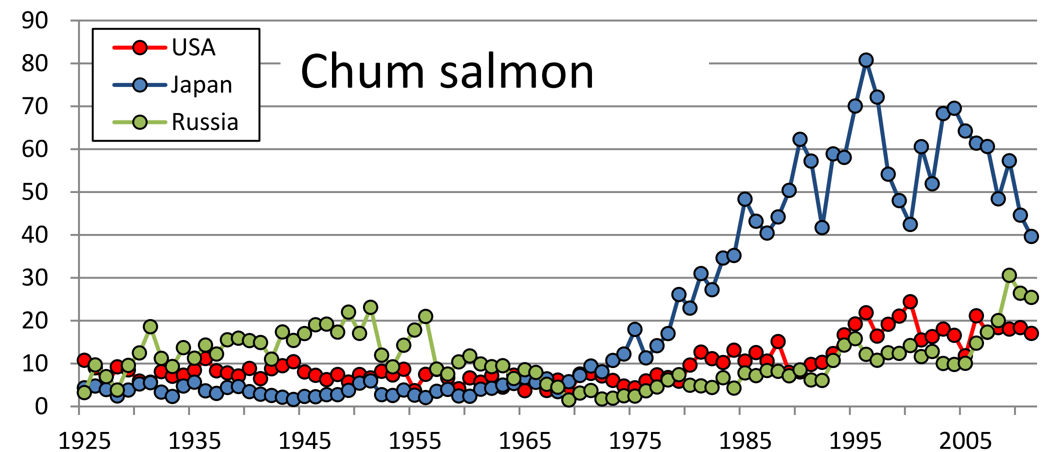


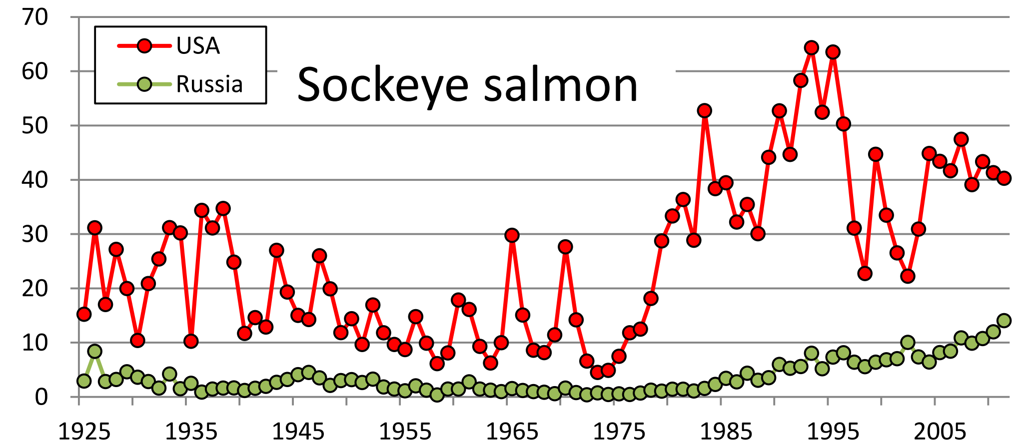
- Cause more than **15** thousand deaths, and more than **3** thousand missing-persons
- Collapse of Marine products industry including salmon hatchery programs
- Fukushima nuclear plant crisis showed a lack of risk management

Annual change in catch of pink, chum, and sockeye salmon in the North Pacific Ocean, 1925-2011

(NPAFC Doc. 1422)



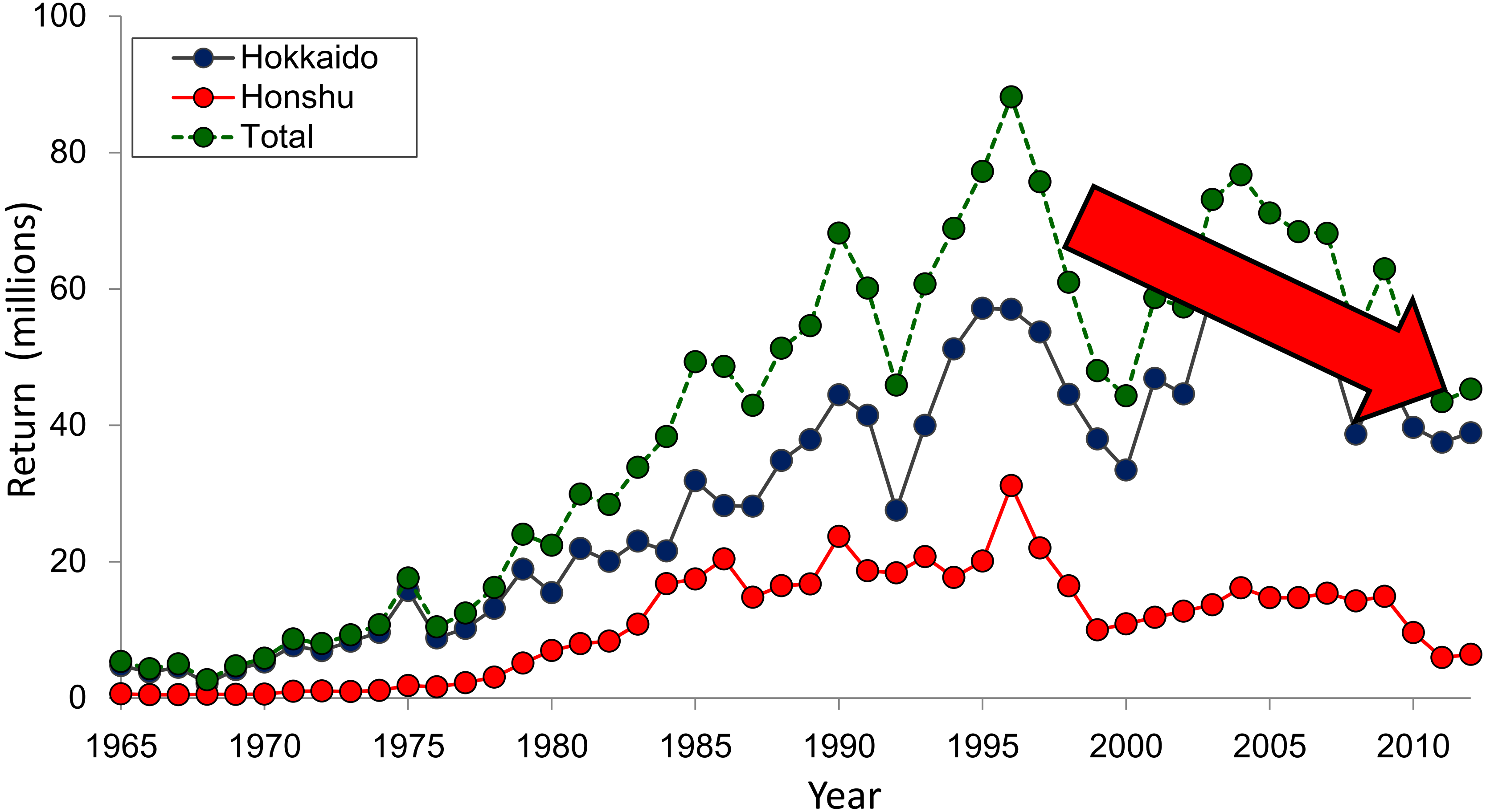




Recent trend of salmon biomass

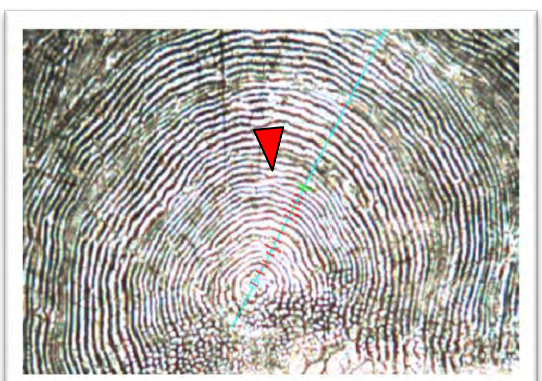
	Japan	USA	Russia
Pink salmon	↓	↓	↑
Chum salmon	↓	↓	↑
Sockeye salmon		↓	↑

Annual change in return of chum salmon in Japan during 1965-2012



Recent Return → **Decrease trend in Iwate since the late 1990s, and in Hokkaido since the early 2000s**

Survey on growth and trophic condition of juvenile chum salmon in the Tohoku Neritic Region



1996/12/05 ♀: 64 cm-FL, 633 µm-SL

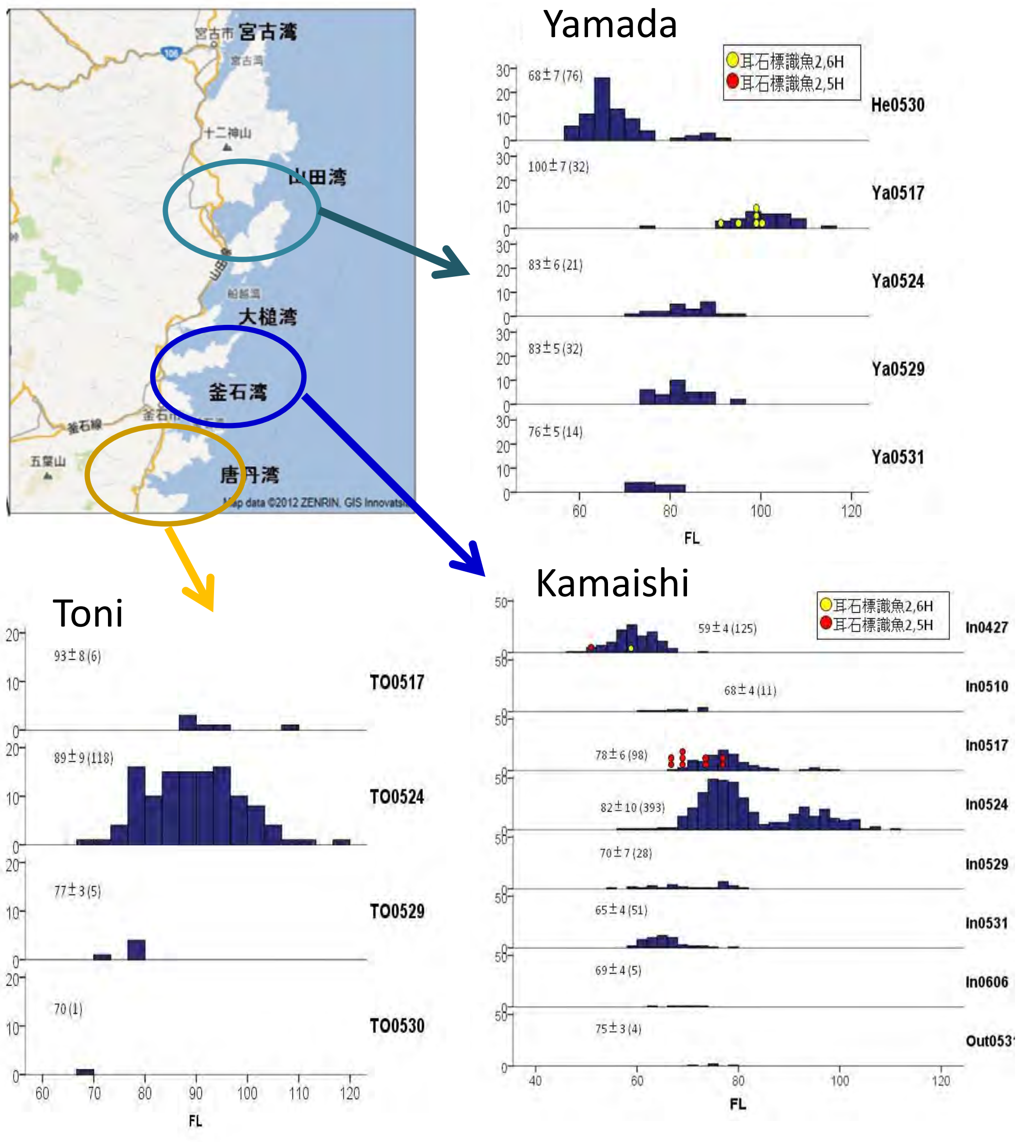
Objectives

- To recover the salmon industry for cheering on peoples in the Tohoku Region.
- To clarify the recovery process of coastal ecosystems and the life history of juvenile chum salmon in this area after the earthquake and tsunami.

Material & Method

- We surveyed growth and trophic condition of juvenile chum salmon collected by a lamp-balanket net using analyses of scales and carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope during springs in 2012 & 2013.
- We evaluated change in body size of juvenile at an offshore migration using scale analysis of adult returning to the Tsugaruishi River and a back calculation method.

Body size of juvenile chum salmon at the offshore migration during spring in 2012



2012 Spring

Period: April - May

Body size: Bimodal distribution

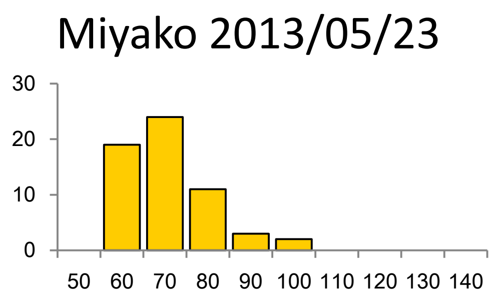
Large: 100 mm-FL

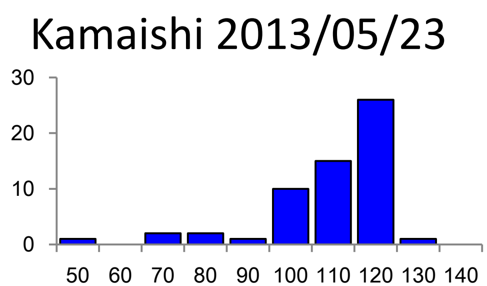
Small: 80 mm-FL

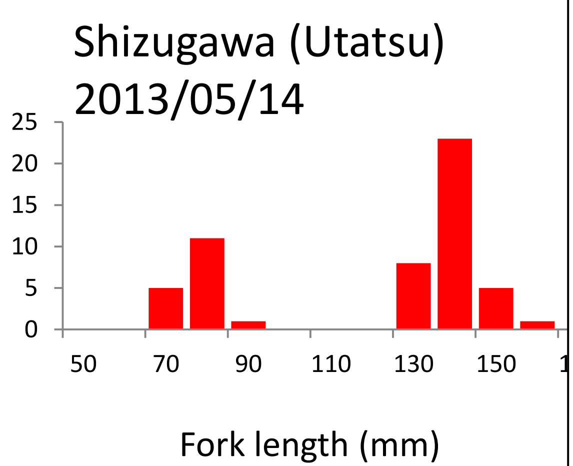
Small size, Short stay

- Body size and period of juvenile at the offshore migration in 2012 were smaller and earlier than those before the earthquake and tsunami.

Body size of juvenile chum salmon at the offshore migration during spring in 2013







2013 Spring

Period: March – May

Body size: Bimodal distribution

Large: FL>120 mm

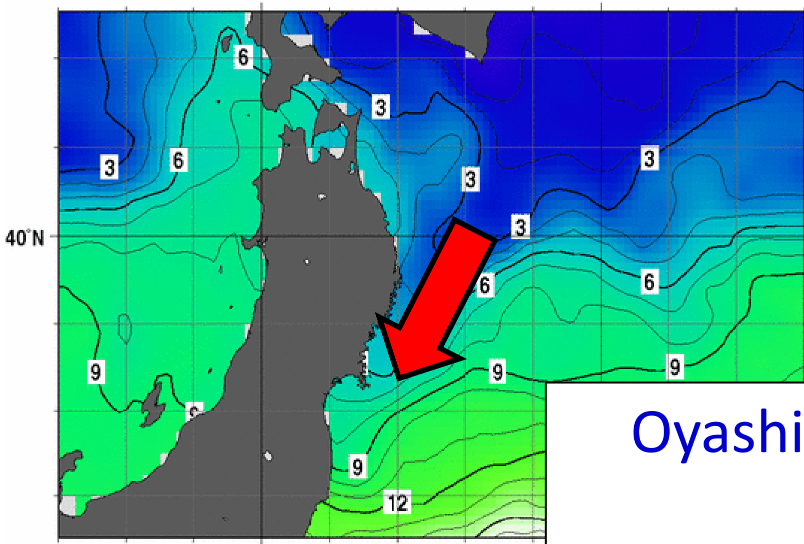
Small: 80 mm-FL

Large size, Long stay

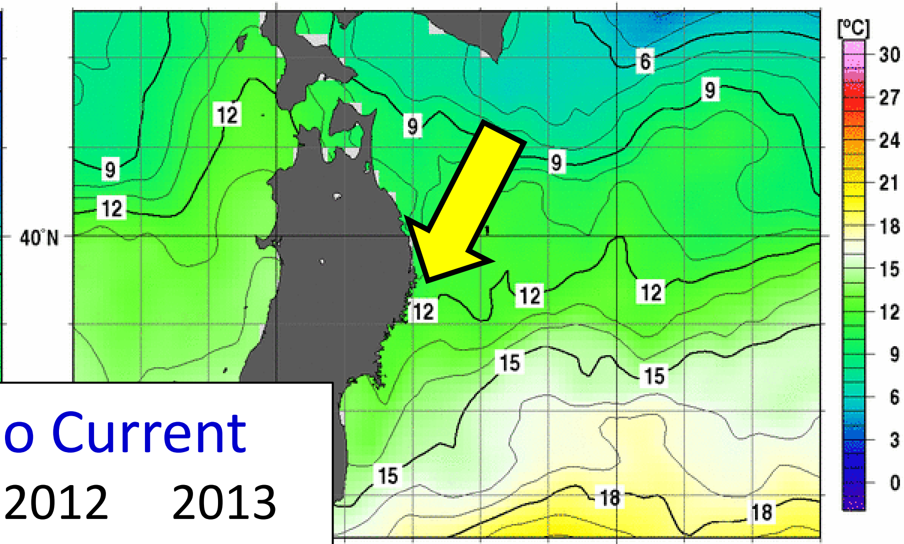
- Juvenile migrated to the offshore at more than 120 mm in FL in the middle and late May, and 70-80 mm in FL in late May of 2013.
- In Utatsu of the Shizugawa Bay, especially, they migrated to the offshore at large (140 mm in FL) with the juvenile of small size (80 mm in FL).

Mean SST isothermal diagrams around Japan

2012 March



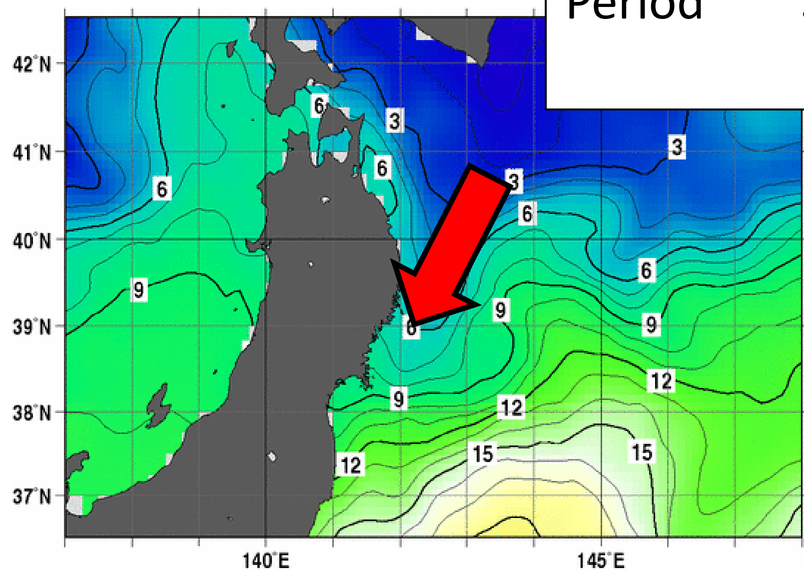
May



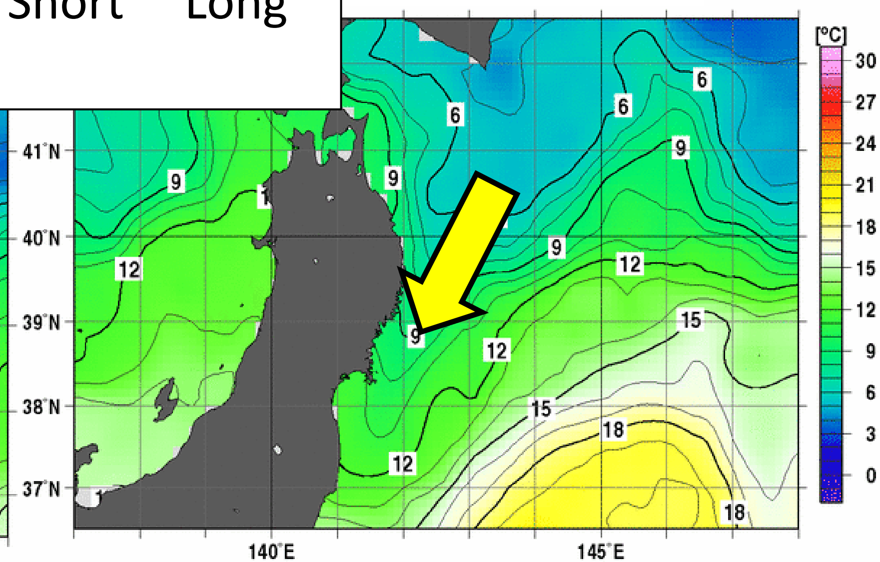
Oyashio Current

	2012	2013
Intensity	Strong	Weak
Period	Short	Long

2013 March

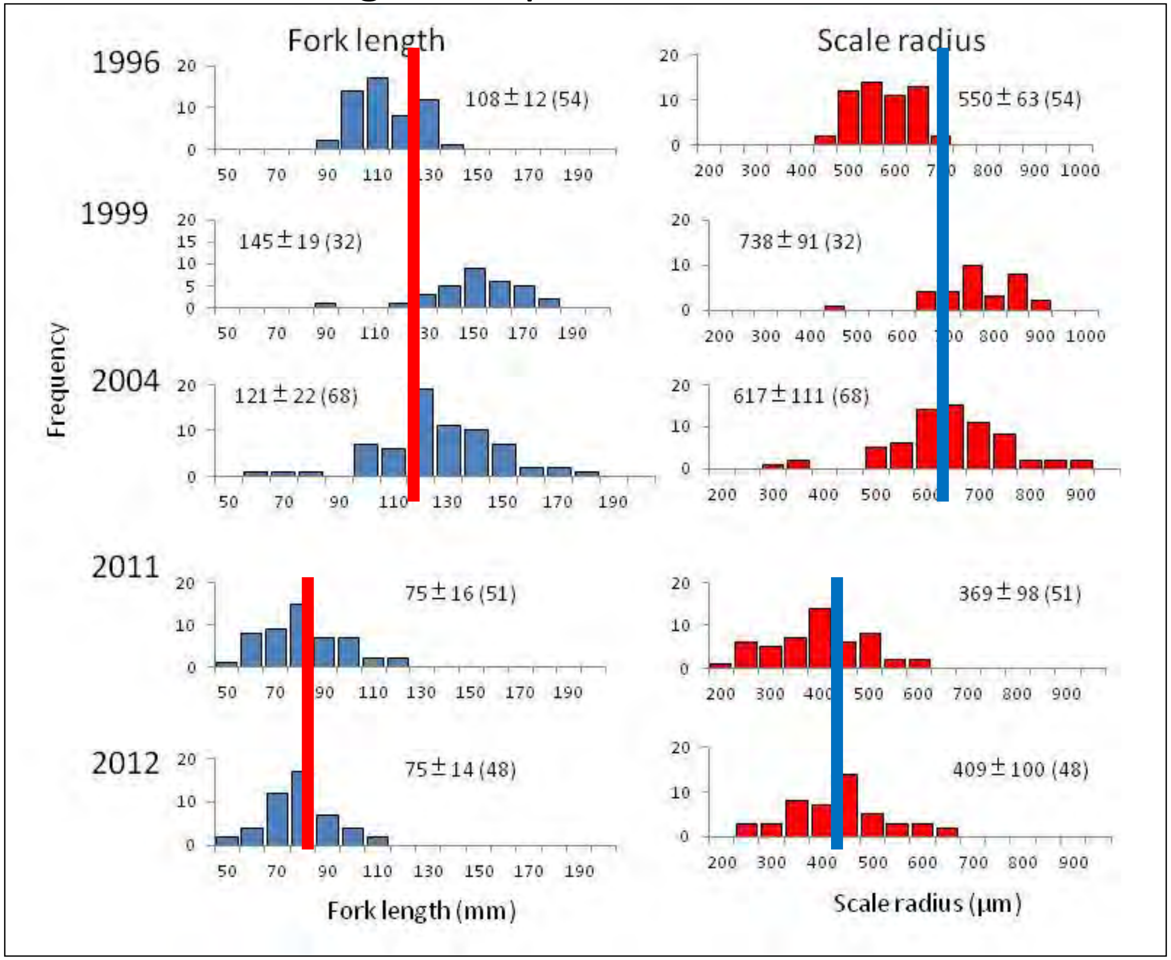


May

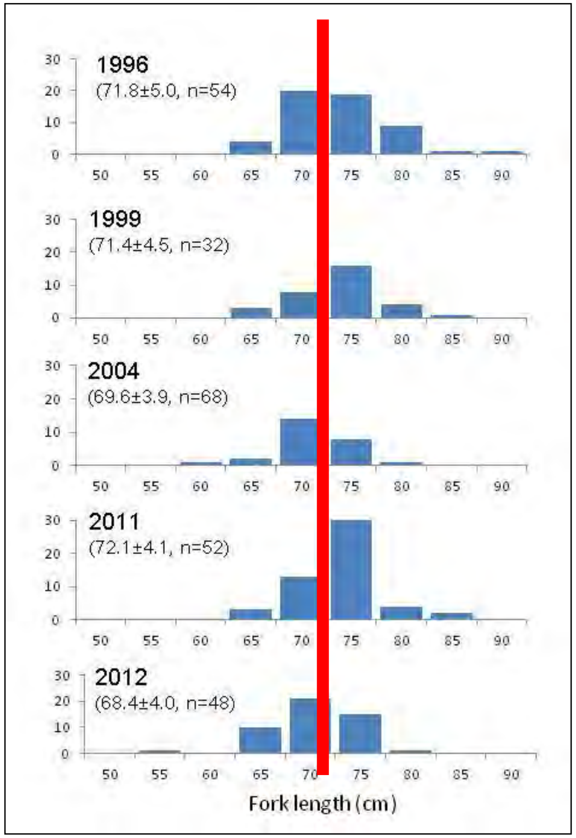


Scale analysis of adult chum salmon returning to the Tsugaruishi River in 1996-2012

Scale length and fork length backcalculated at the offshore migration period

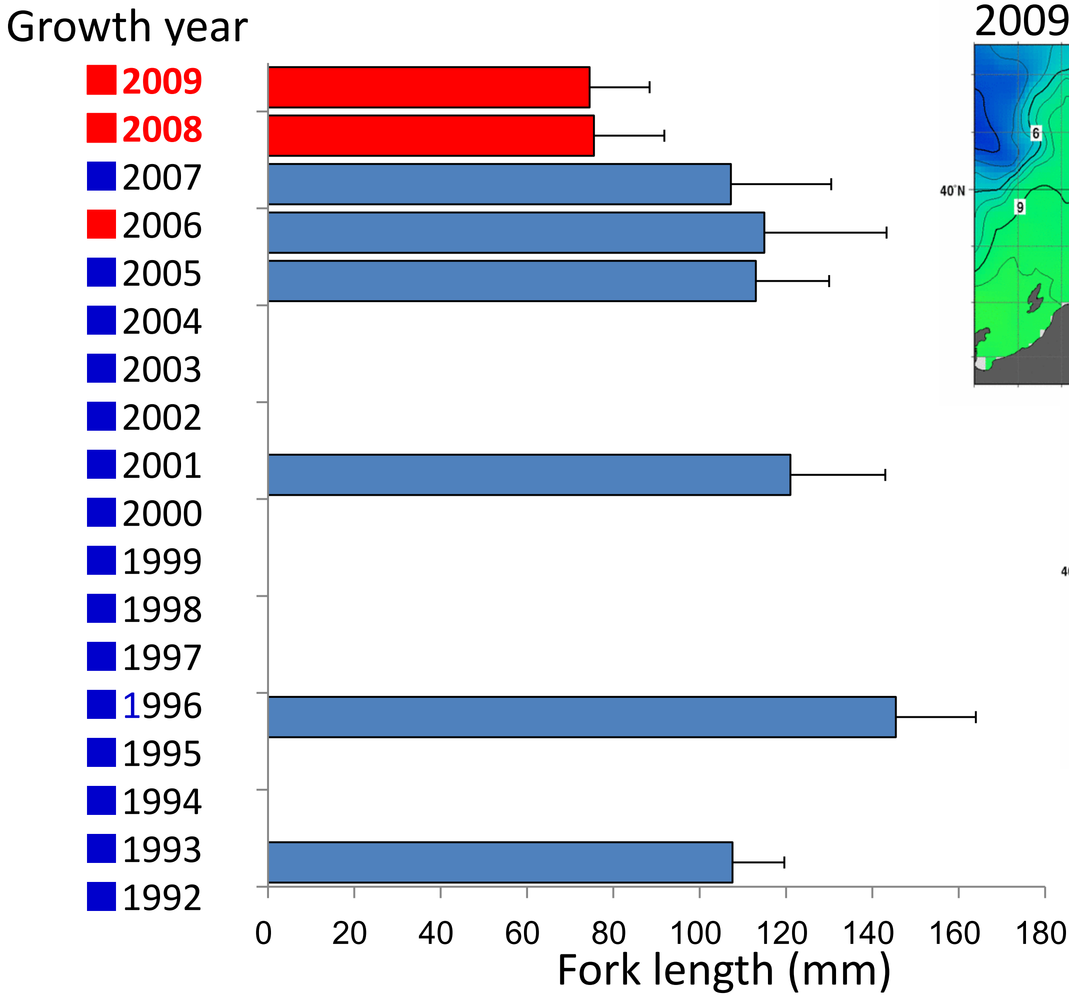


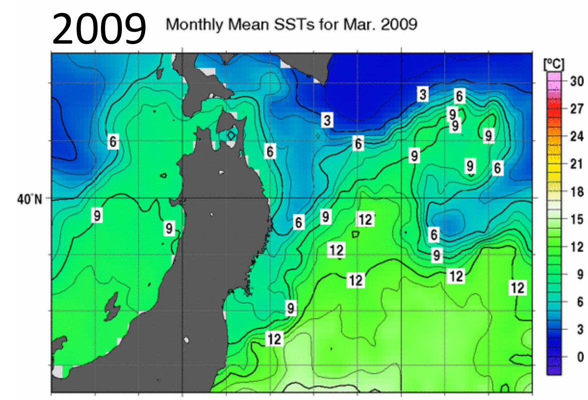
Fork length of adult

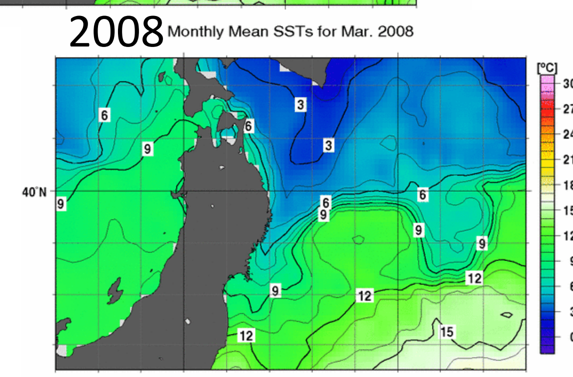


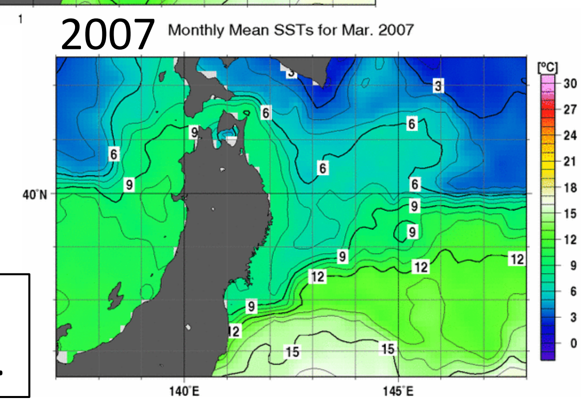
Estimated fork length of juvenile at the offshore migration in 1992-2009 in the Iwate Coastal Sea

using scale analysis of adult returning to the Tsugaruishi River and a back calculation method



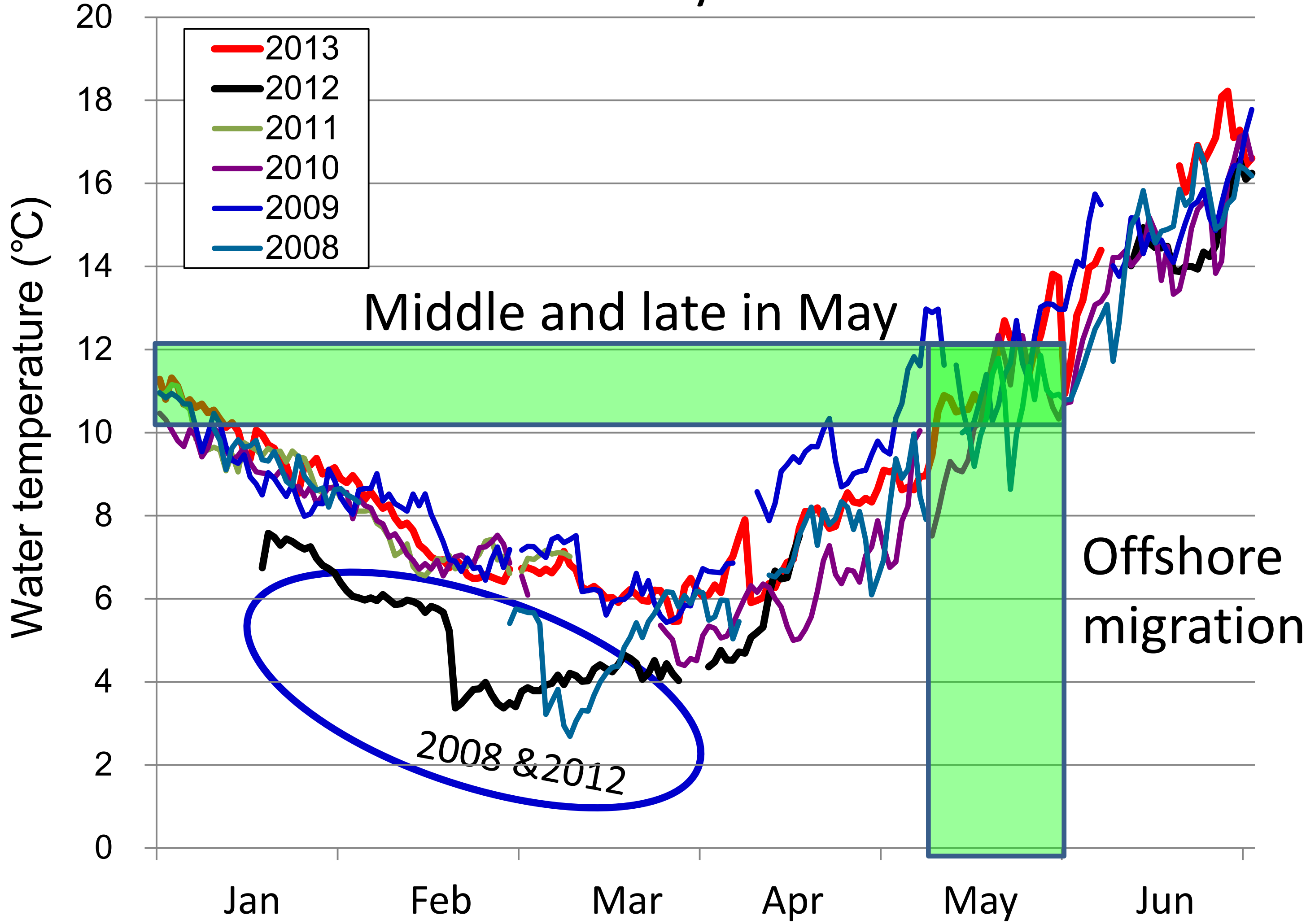






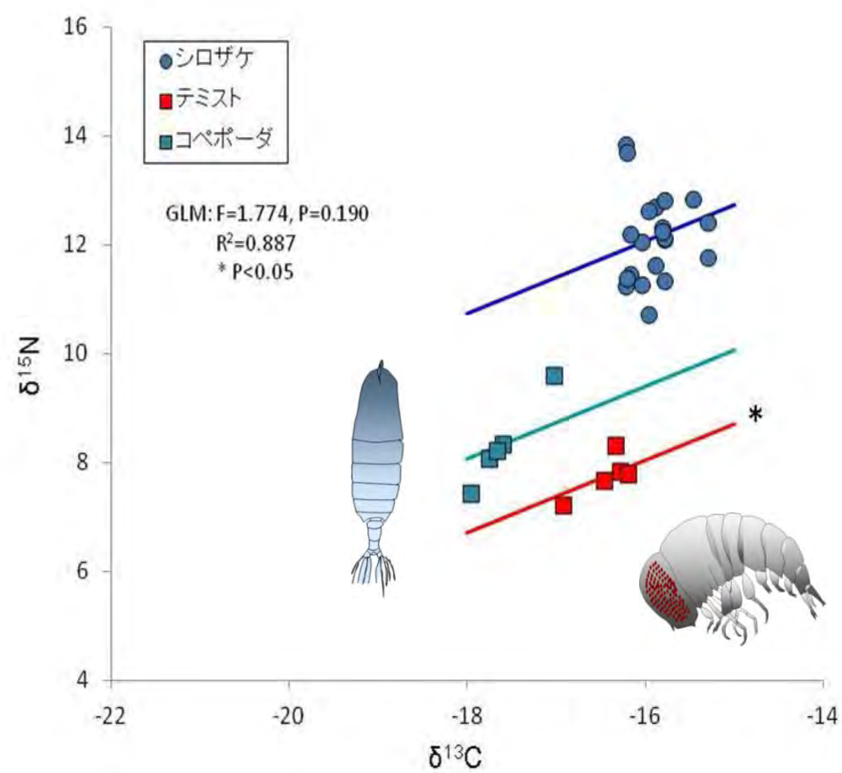
- In years when the Oyashio Current is strong in spring, the juvenile at the offshore shows a tendency to reduce a growth, except for in 2006.

Seasonal change in sea temperature（Depth of 1m) of the Otsuchi Bay in 2008-2013



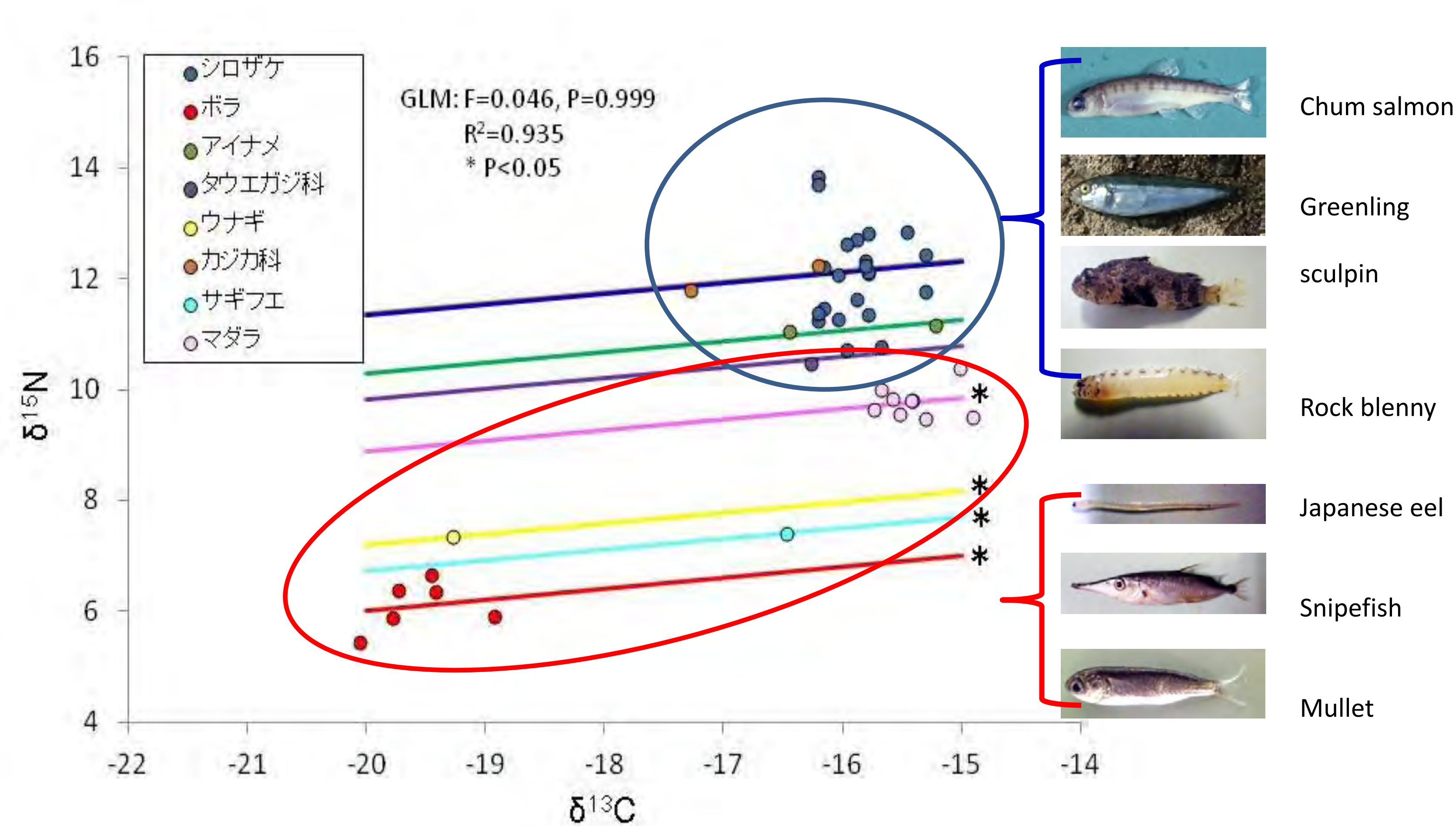
- In years when the Oyashio Current was strong, and the sea temperature was low in winter and early spring such as 2008 and 2012 years, juvenile reduced a growth, and had to migrate to the offshore at small body size.

Carbon and nitrogen stable isotope of juvenile chum salmon in the Kamaishi Bay in 2012



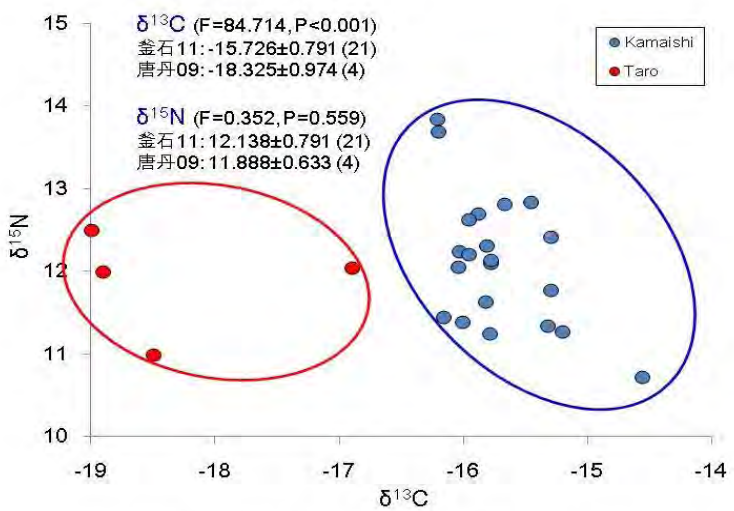
- Juvenile chum salmon
  δ^{13}C : -15.726±0.791‰
  δ^{15}N : 12.139±0.633‰
- δ^{15} N of juvenile chum salmon was 3.8-4.4‰ higher than their main preys (*Acartia clausi, Pseudocalanus minutus, Centropages abdominalis, Themisto japonica*)

Carbon and nitrogen stable isotope of juvenile chum salmon and other animals



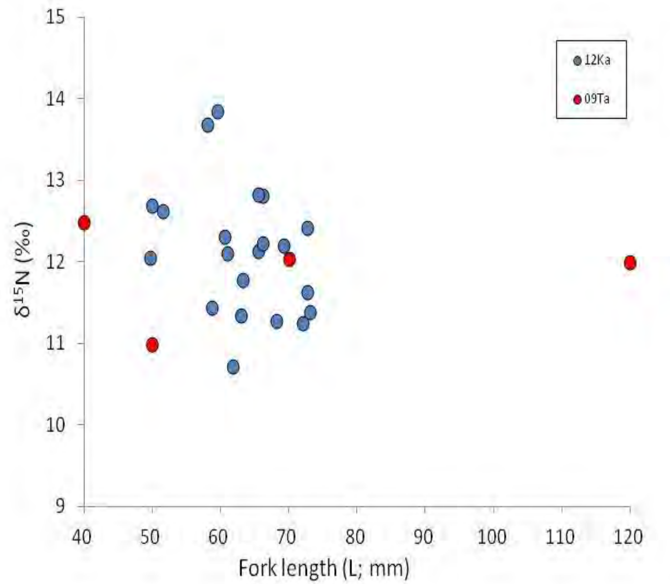
- Trophic position of juvenile chum salmon was as same as those of greenling, sculpin, and rock blenny, and was higher than juvenile Japanese eel, snipefish, juvenile Pacific cod, and mullet

Carbon and nitrogen stable isotope of juvenile chum salmon in the Iwate coastal water before or after the earthquake and tsunami



Relationship between carbon and nitrogen stable isotope of juvenile chum salmon collected at Toni Bay in 2009 and at Kamaishi Bay in 2012.

(Data source in Toni Bay: Ito 2010)



Relationship between fork length and nitrogen stable isotope of juvenile chum salmon collected at Toni Bay in 2009 and at Kamaishi Bay in 2012.

(Data source in Toni Bay: Ito 2010)

No difference

Conclusion from the survey of juvenile chum salmon in the Sanriku Coastal Waters

- It is very important to clarify how the survival of these juveniles is affected by the Oyashio Current, relating to difference in offshore migration pattern (smaller body size and earlier migration period), despite no change in their trophic level.
- Adopting a risk management approach for coastal ecosystems which include chum salmon populations will be necessary to ensure the sustainability of chum salmon in the Tohoku region after the Tohoku catastrophic earthquake and tsunami.

Index of health and benefits of Pacific salmon

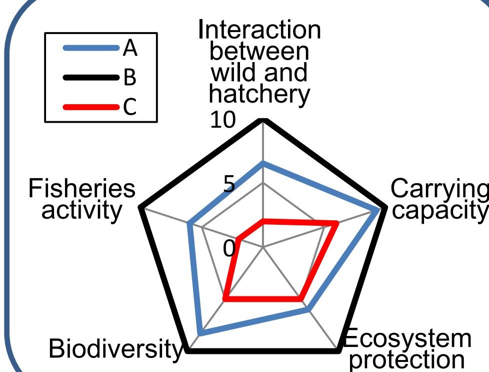
Interaction between wild and hatchery salmon	Freshwater	breeding competition, straying
	Ocean	density-dependent growth
Carrying capacity	Freshwater	spawning area
	Coastal Waters	productivity
	Ocean	climate change, productivity
Ecosystem protection	Freshwater	habitat loss, artificial river channelization, urbanization
	Coastal water	artificial coastline, overfishing
	Ocean	overfishing
Biodiversity	Habitats	habitat loss, artificial river channelization, urbanization
	Species	artificial coastline, overfishing
	Genetic	overfishing
Fisheries activity	Coastal fishery	overfishing
	Hatchery activity	replacement by hatchery juvenile

Index Score: $I = \sum \alpha_i I_i$

α_i: goal-specific weight

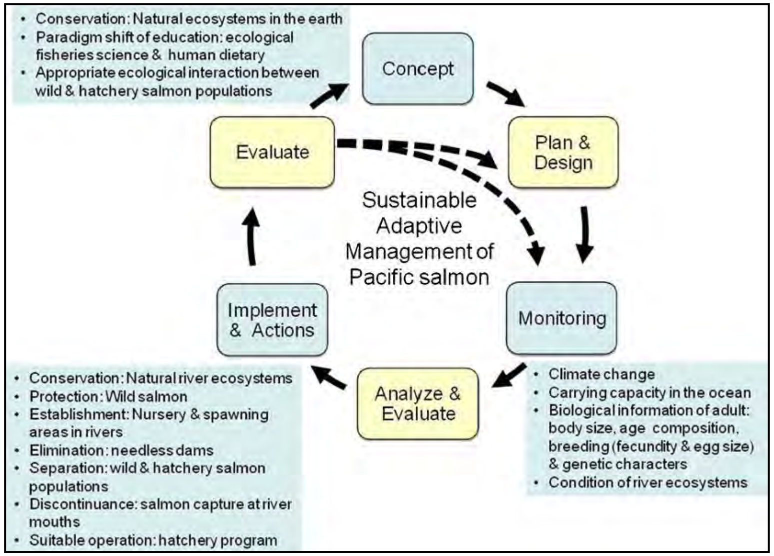
$\Sigma\alpha_i = 1$(default: $\alpha i = 1/N$)

I_i: average value of present and likely future status



Ecological Risk Assessment & Management

- An ecological risk assessment is the process for evaluating how the environment may be impacted as a result of exposure to one or more environmental stressors such as chemicals, land change, disease, invasive species and climate change (global warming).
- Object of ecological risk management is to protect the health of the natural environment, and to realize societies in harmony with nature for the benefit of biodiversity and human well-being.
- Ecological Risk Management → "Adaptive Management" & "Precautionary Principle"



Adaptive management for Pacific salmon

The Fukushima nuclear plant crisis is a lack of risk management