2nd Climate Change Effects Symposium (Yeosu, 2012)

Jellyfish blooms as consequences of human perturbed environmental and ecosystems

Shin-ichi Uye (Hiroshima University, Japan)

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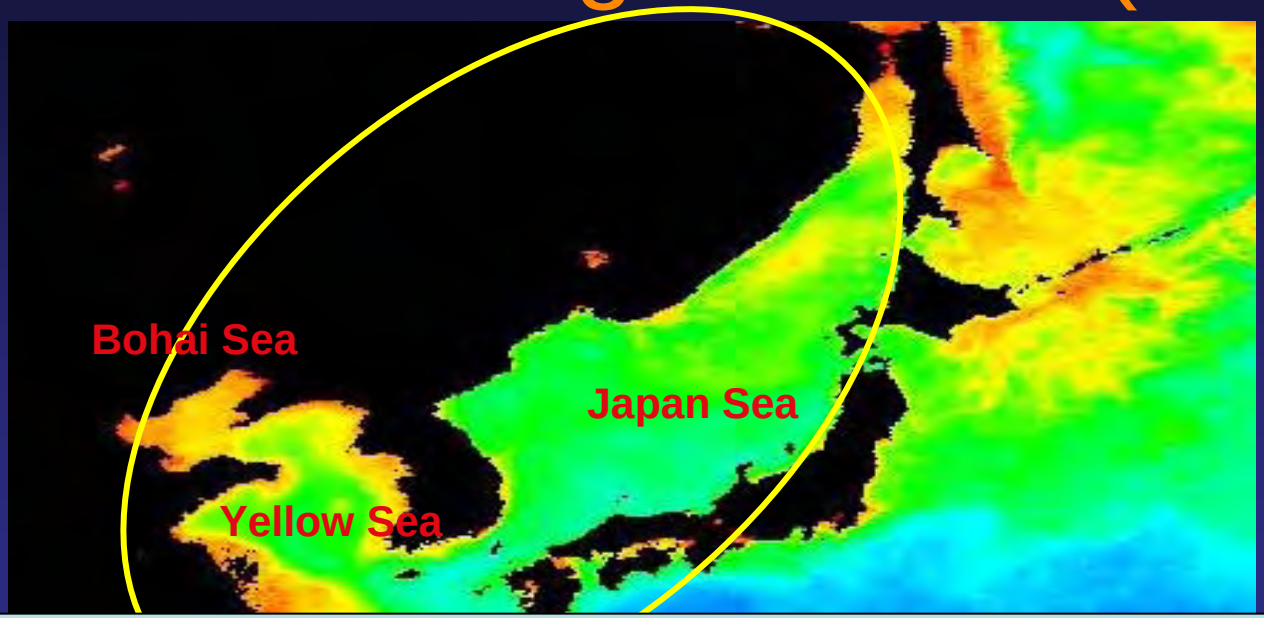
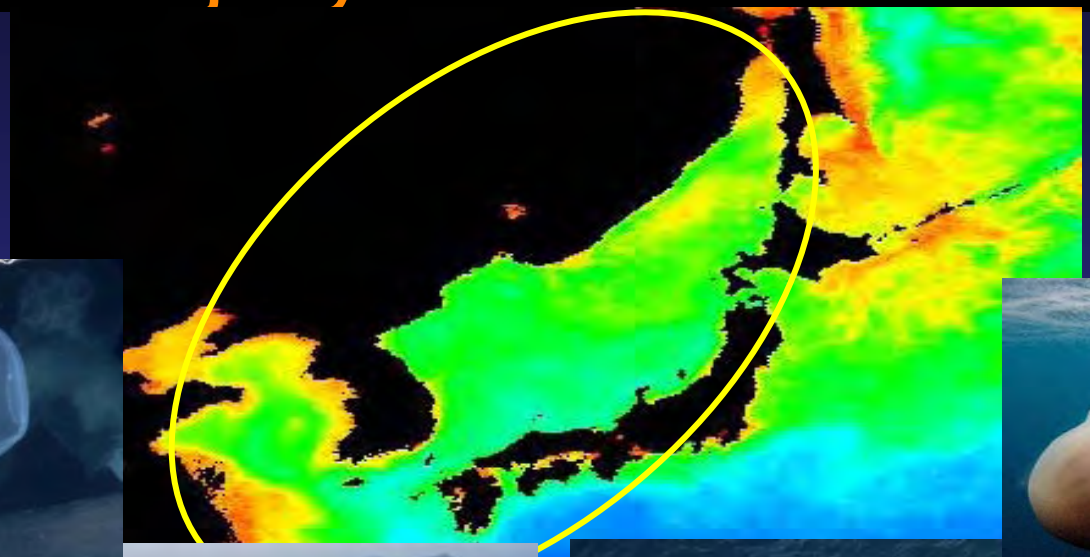
East Asian Marginal Seas (EAMS)

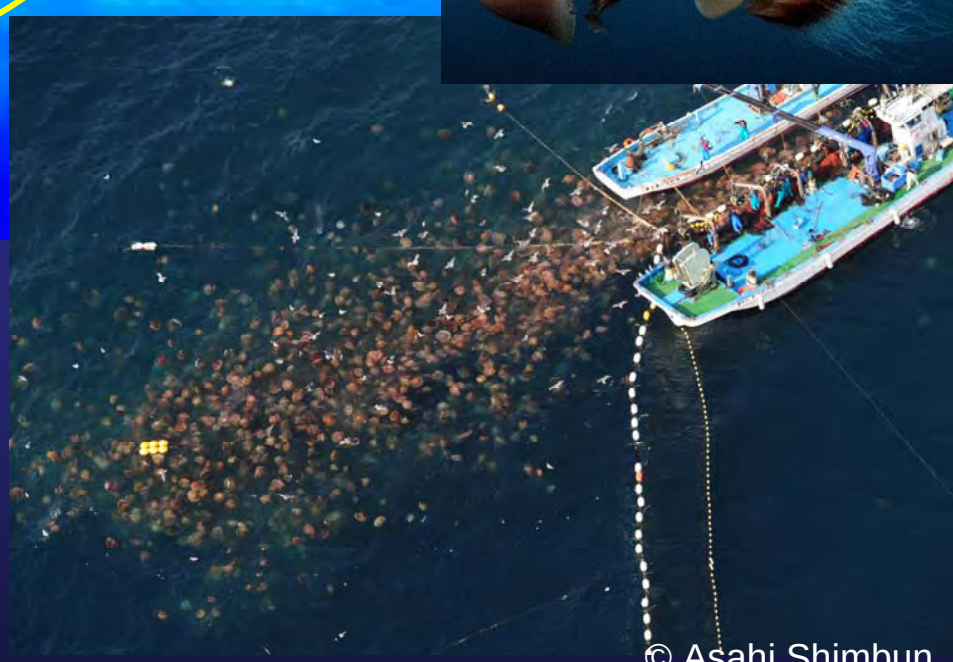


Area: 0.8 % of the total marine area
Fish catch:11% of the world marine fish catch
Human population: ca. 800 million
Environmental hot spot: global warming, eutrophication, harmful algal bloom, photochemical smog, yellow dust, **jellyfish bloom**

Recent jellyfish blooms in EAMS



Bloom of *Aurelia aurita* in coastal waters around EAMS



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Bloom of *Nemopilema nomurai* over entire EAMS

Increase in *Aurelia aurita* medusae in the Inland Sea of Japan (Seto Inland Sea)

No data
No scientific proof

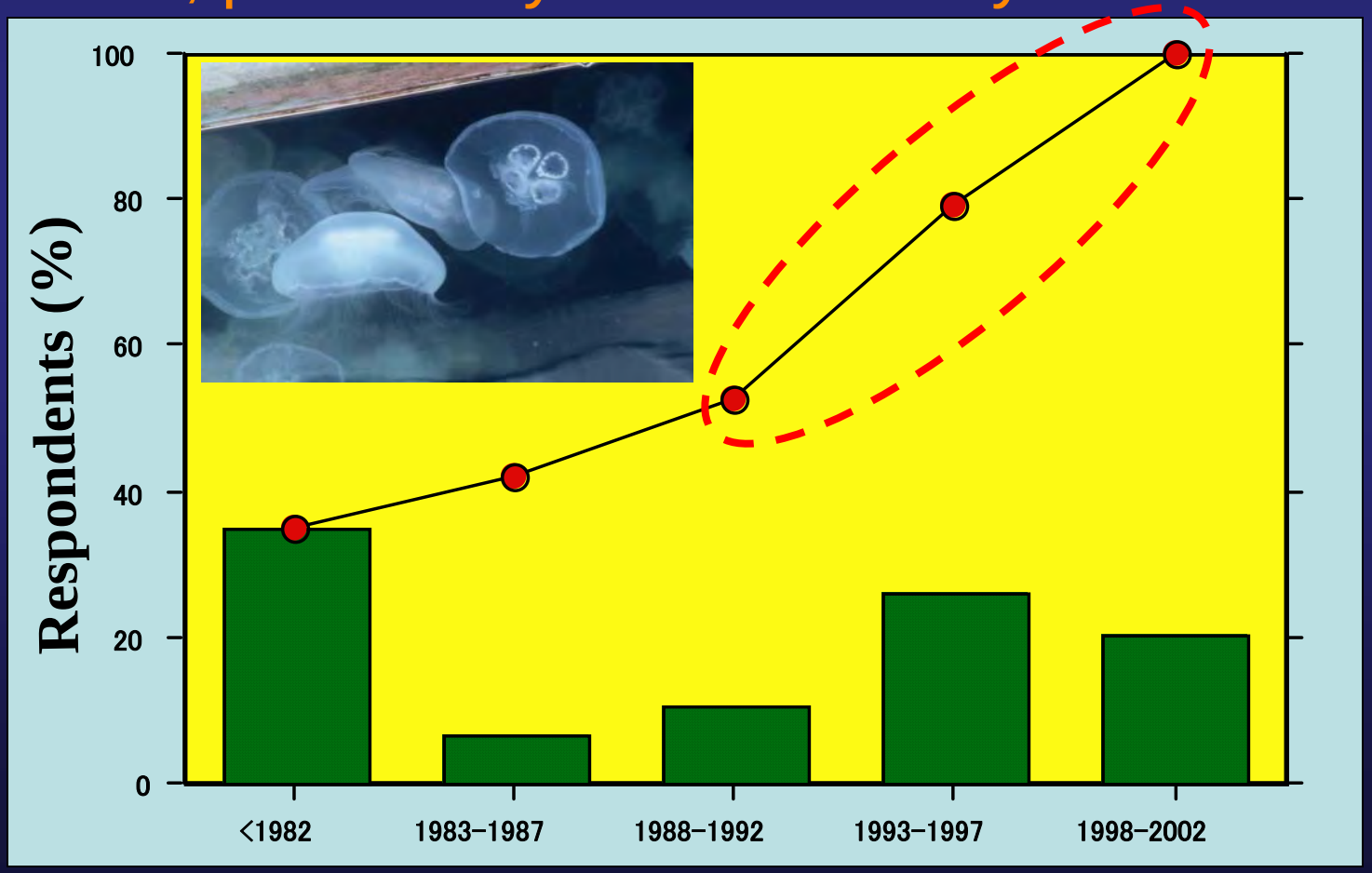
Pool of fishermen in 2002
Total respondents: 1,152
Experience: >20 years

Question: “Did *Aurelia aurita* medusae increase in the last 20 years?”

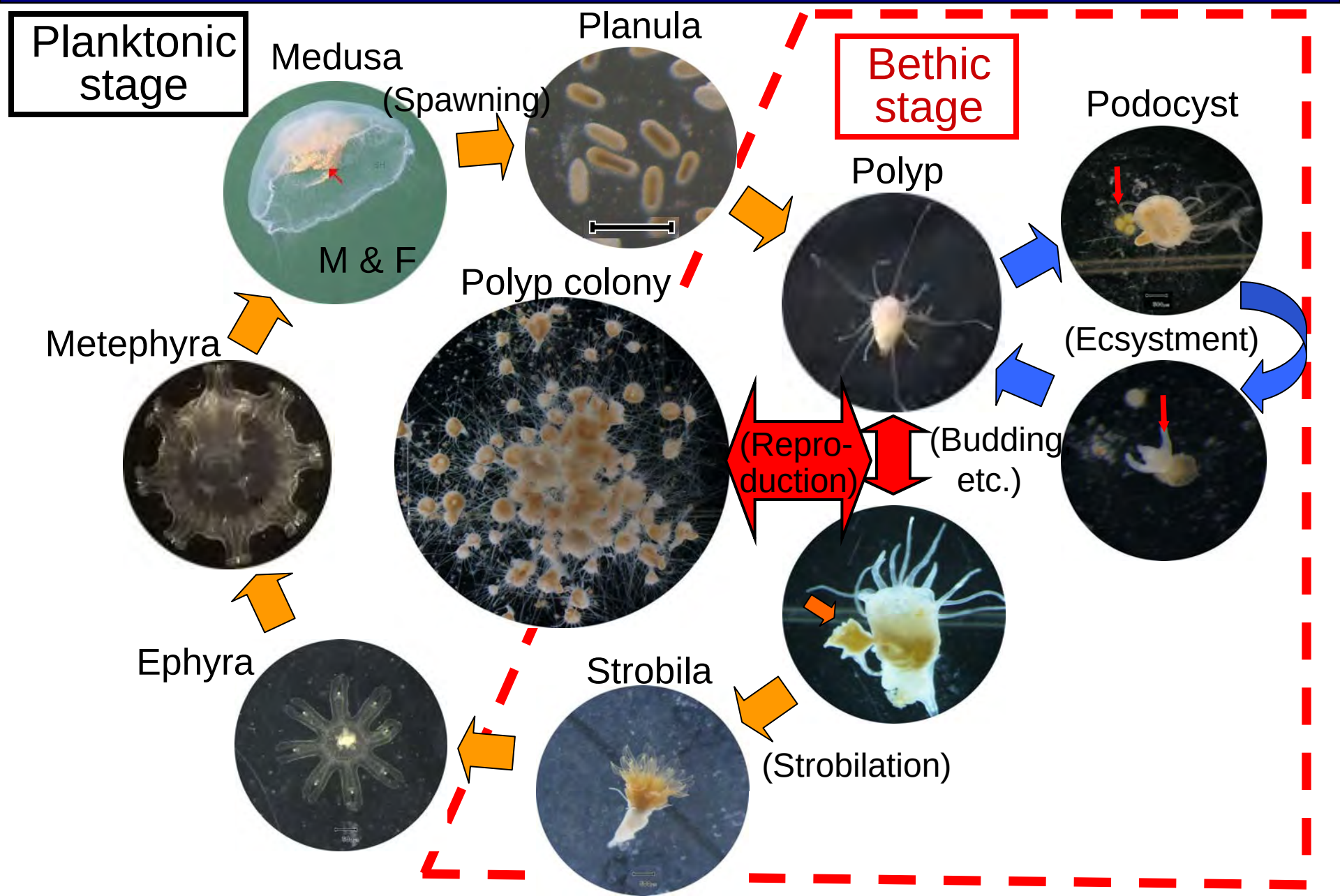
Respondents:

35%: “No, current medusa population level is the same as before 1982”

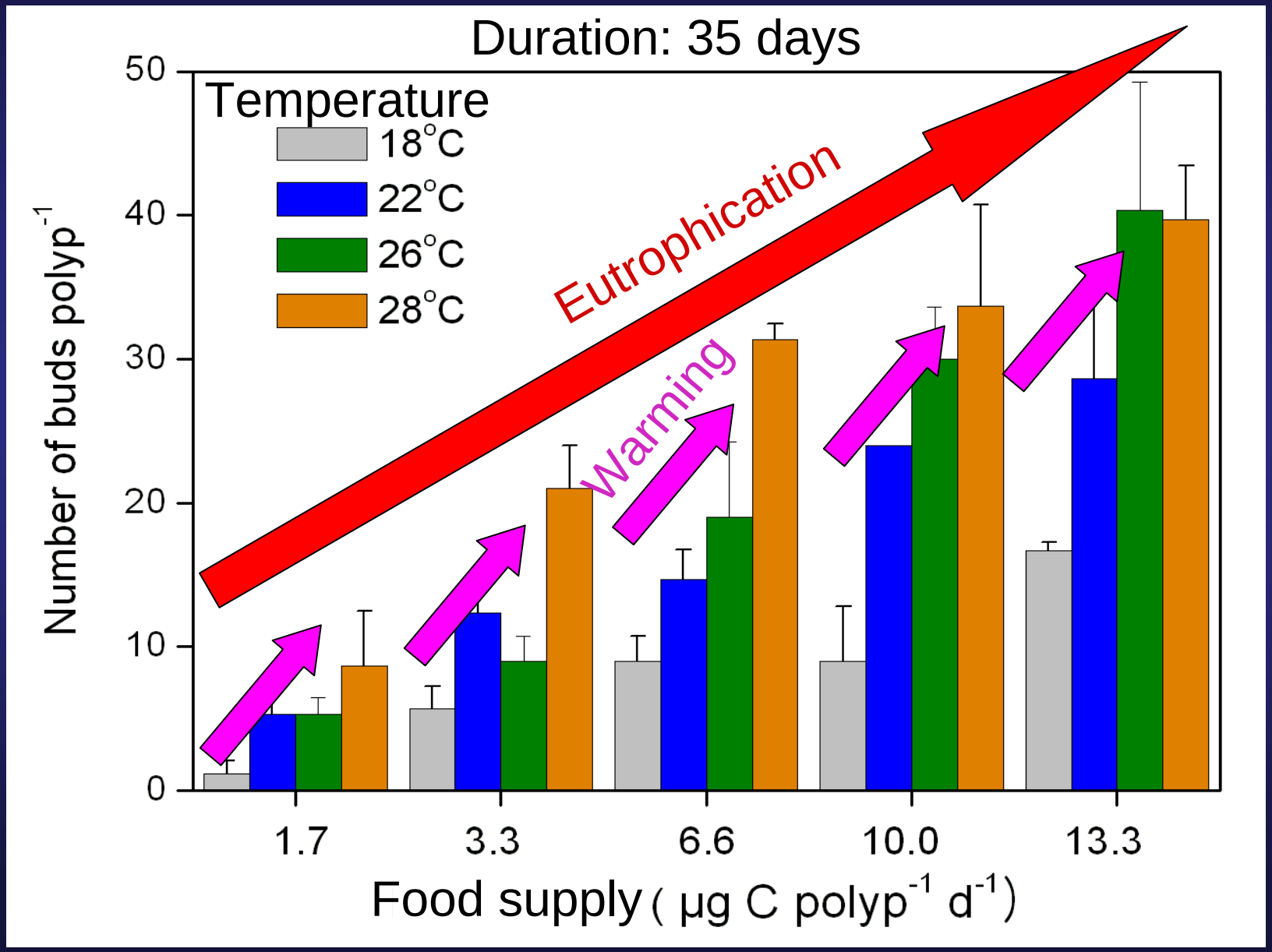
65%: “Yes, particularly in the last 10 years”



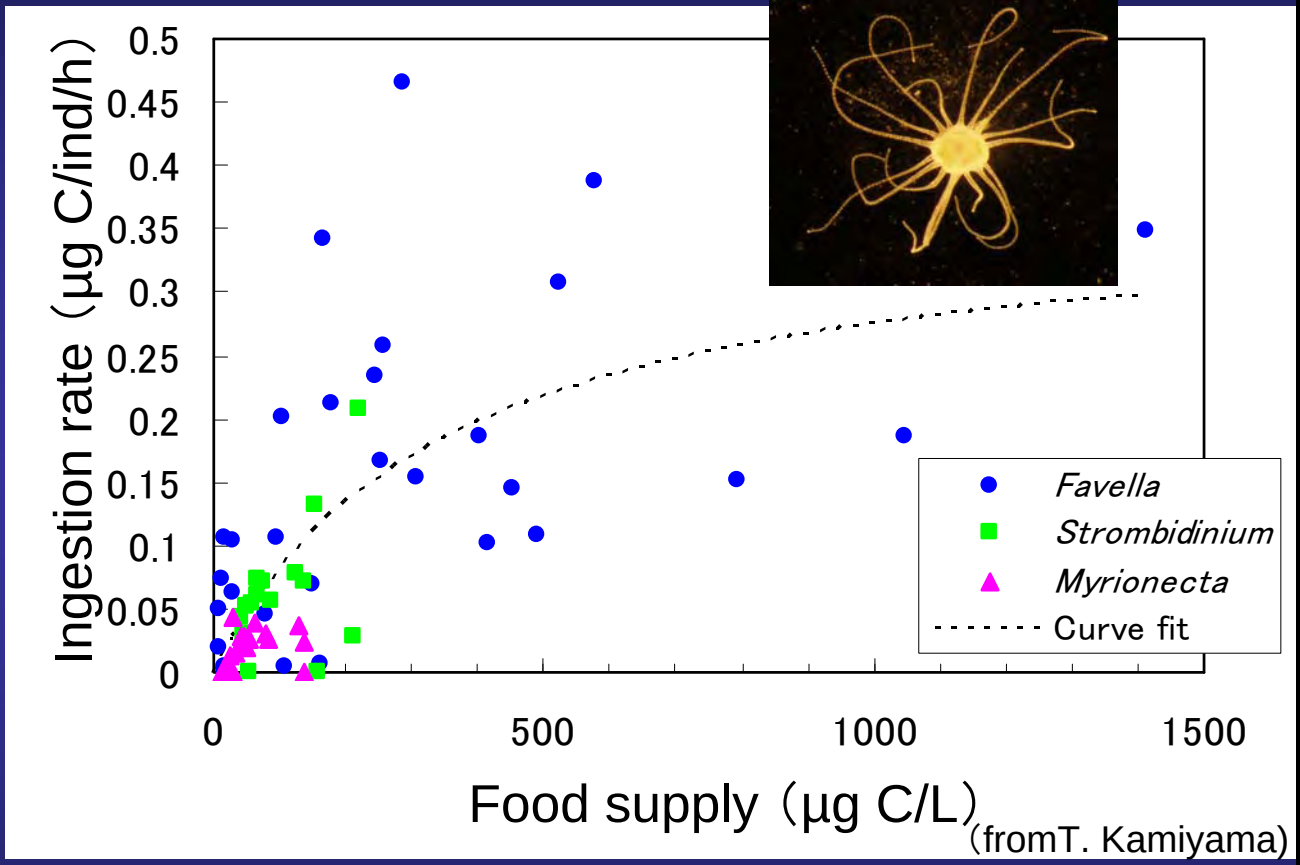
Life cycle of *Aurelia aurita*



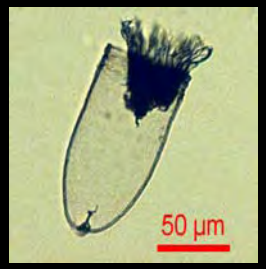
Effect of temperature and food supply on polyp reproduction rate



Polyp's main food: Microzooplankton



(fromT. Kamiyama)



Favella spp.
ESD=55 µm, 46 µm

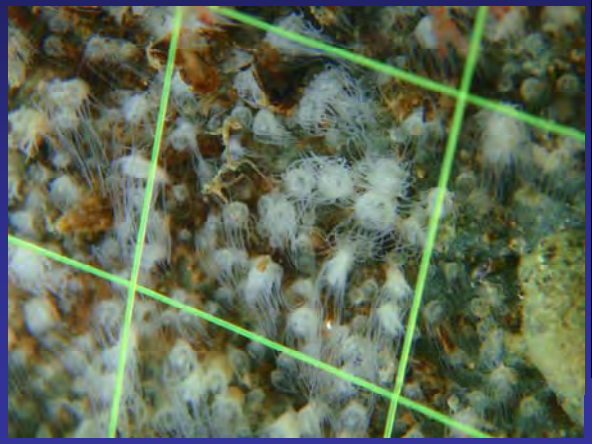
Strombidium sp.
ESD=38 µm

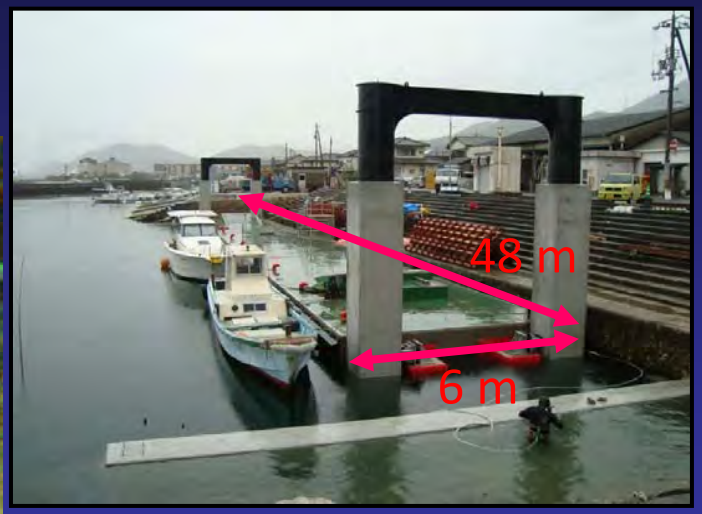
Myrionecta rubra
ESD=21 µm

Microzooplankton increase:
- Eutrophication
- Change in nutrient (N, P, Si) composition
- Dominance of microbial food chain

Polyp's habitat: Artificial structures

Polyps





Ephyrae

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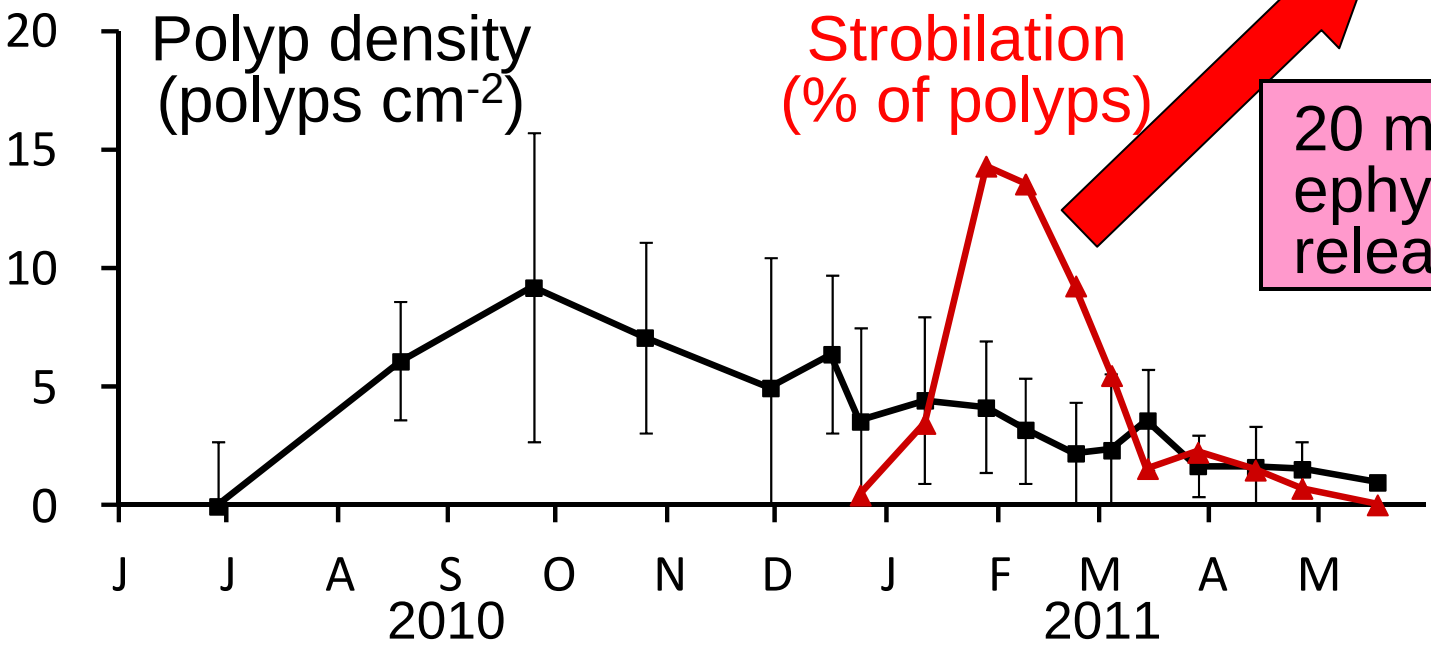
Installed on 9 April, 2010



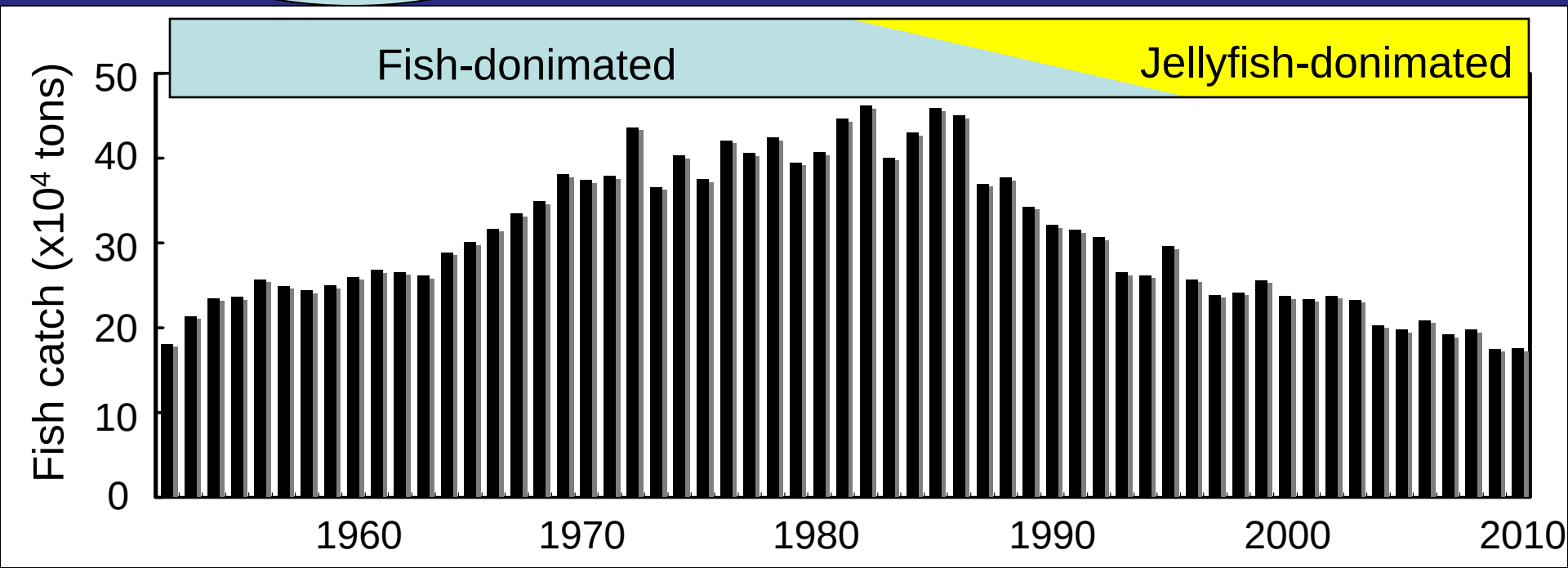
Ecosystem change in the Inland Sea of Japan

Fish-donimated ecosystem

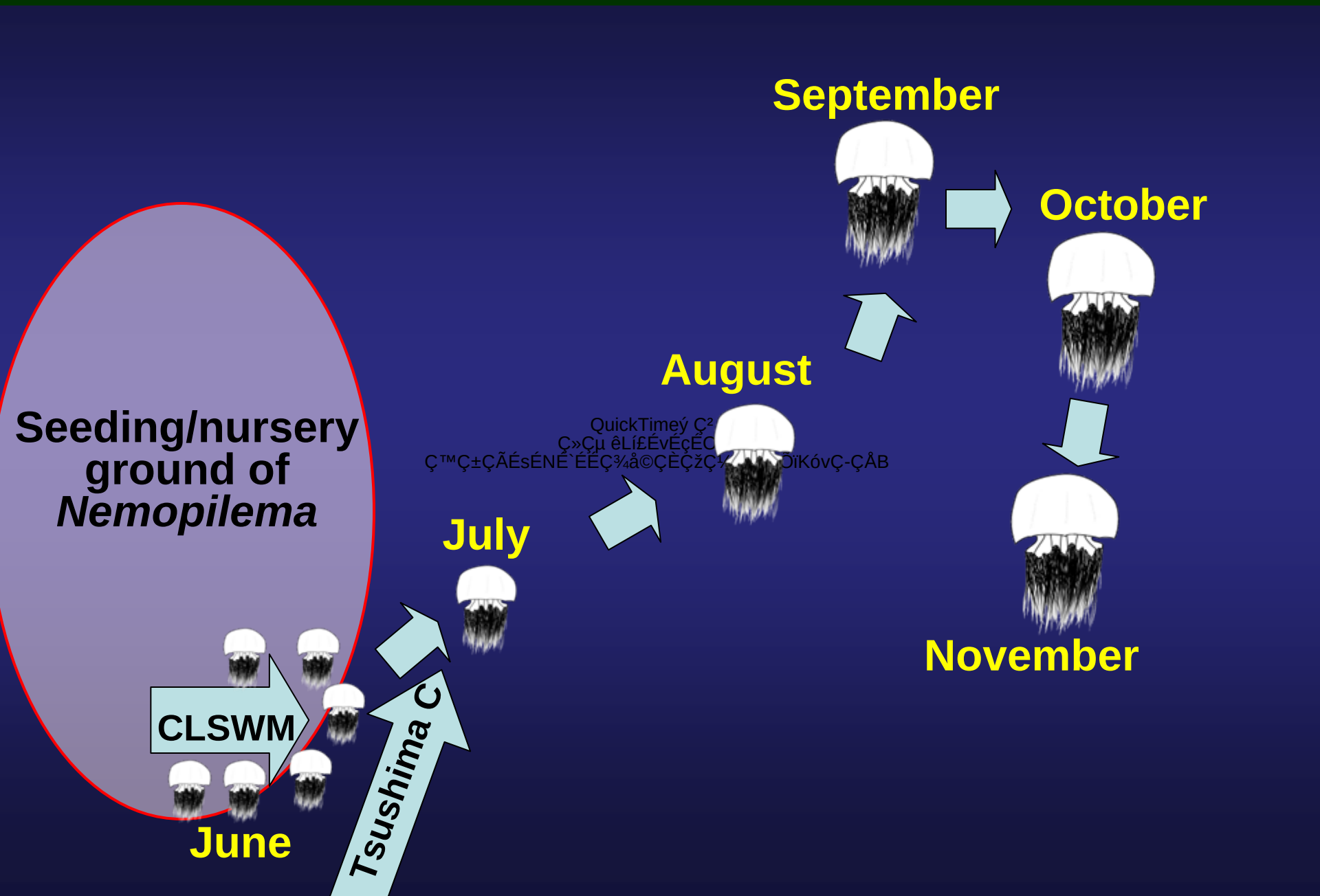
Warming
N/P ratio

Marine construction
Overfishing

Jellyfish-donimated ecosystem



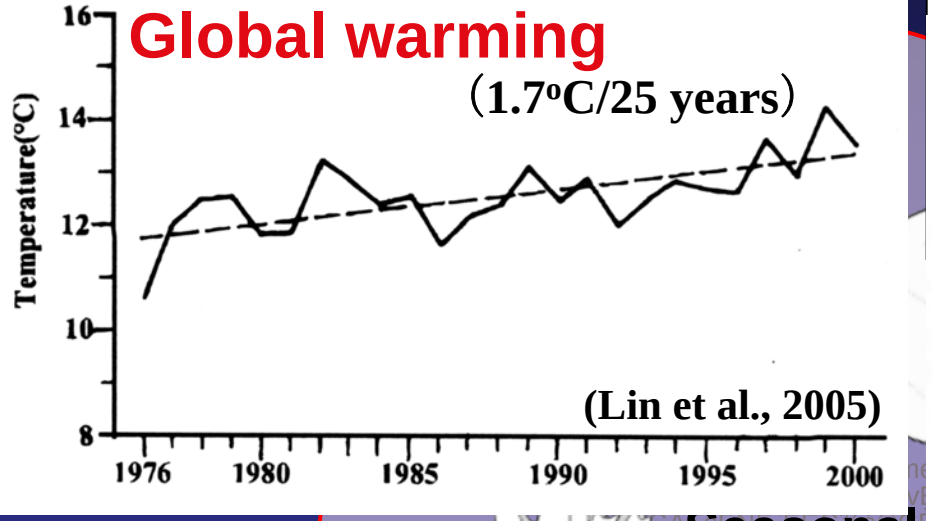
Transport of *Nemopilema* to Japanese waters



Bloom of *Nemopilema* in the Japan Sea

Causes: Environmental and ecosystem changes in Chinese coastal waters

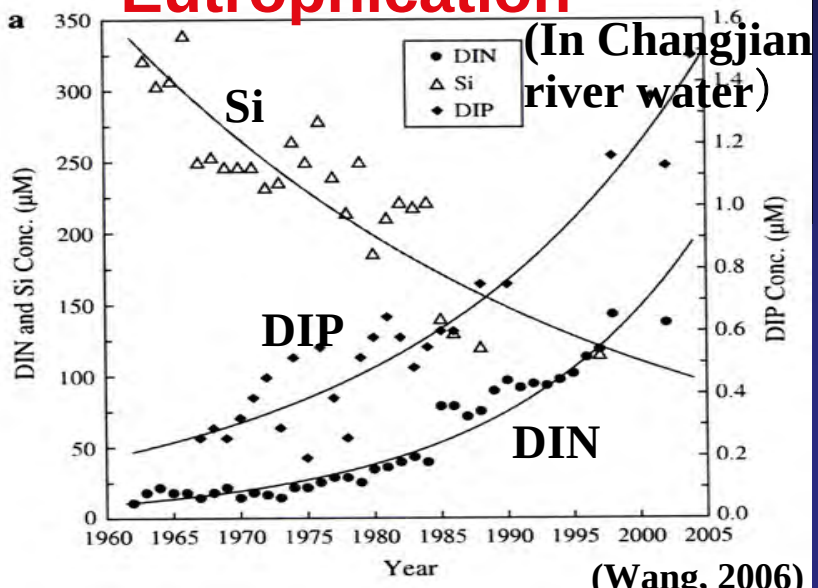
Global warming



(1.7°C/25 years)

(Lin et al., 2005)

Eutrophication

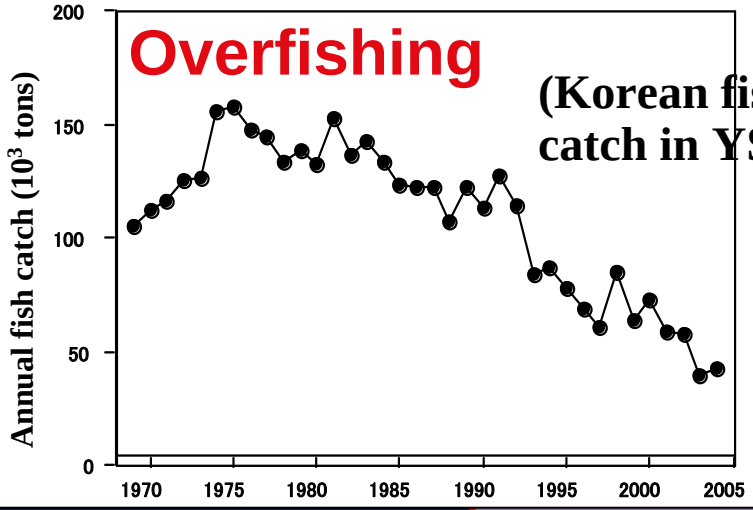


(In Changjian river water)

(Wang, 2006)

Seasonal

Overfishing



(Korean fish catch in YS)

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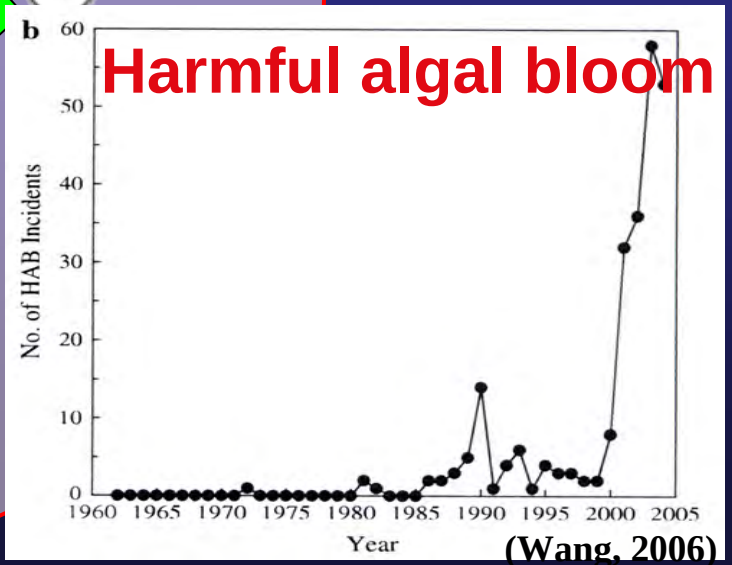
Harmful algal bloom



(Wang, 2006)

Marine construction

Ecosystem shift in Chinese costal waters

Human forcing

1) global warming
2) eutrophication
3) overfishing
4) marine construction
5) others

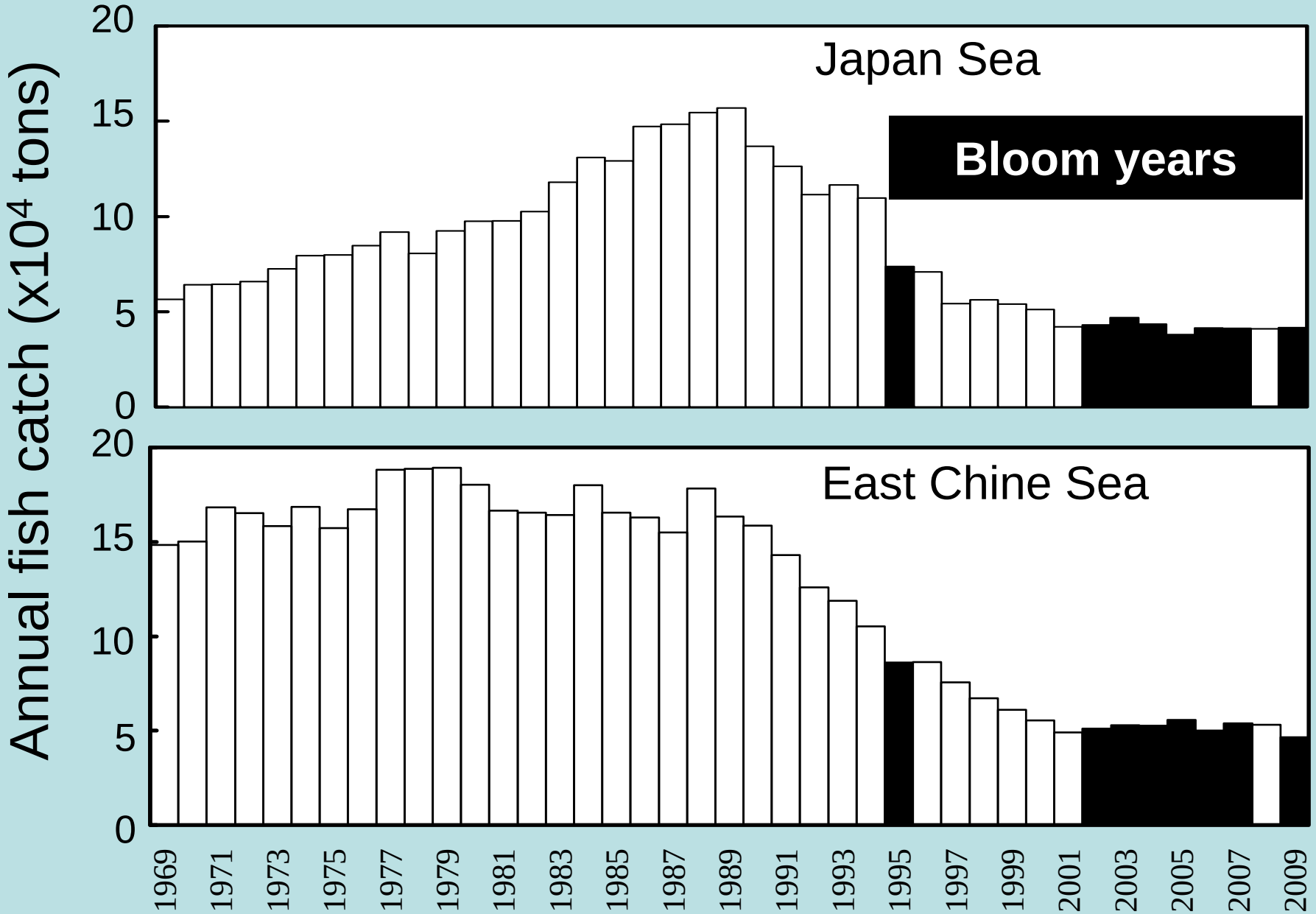
Jellyfish spiral

Jellyfish dominated ecosystem

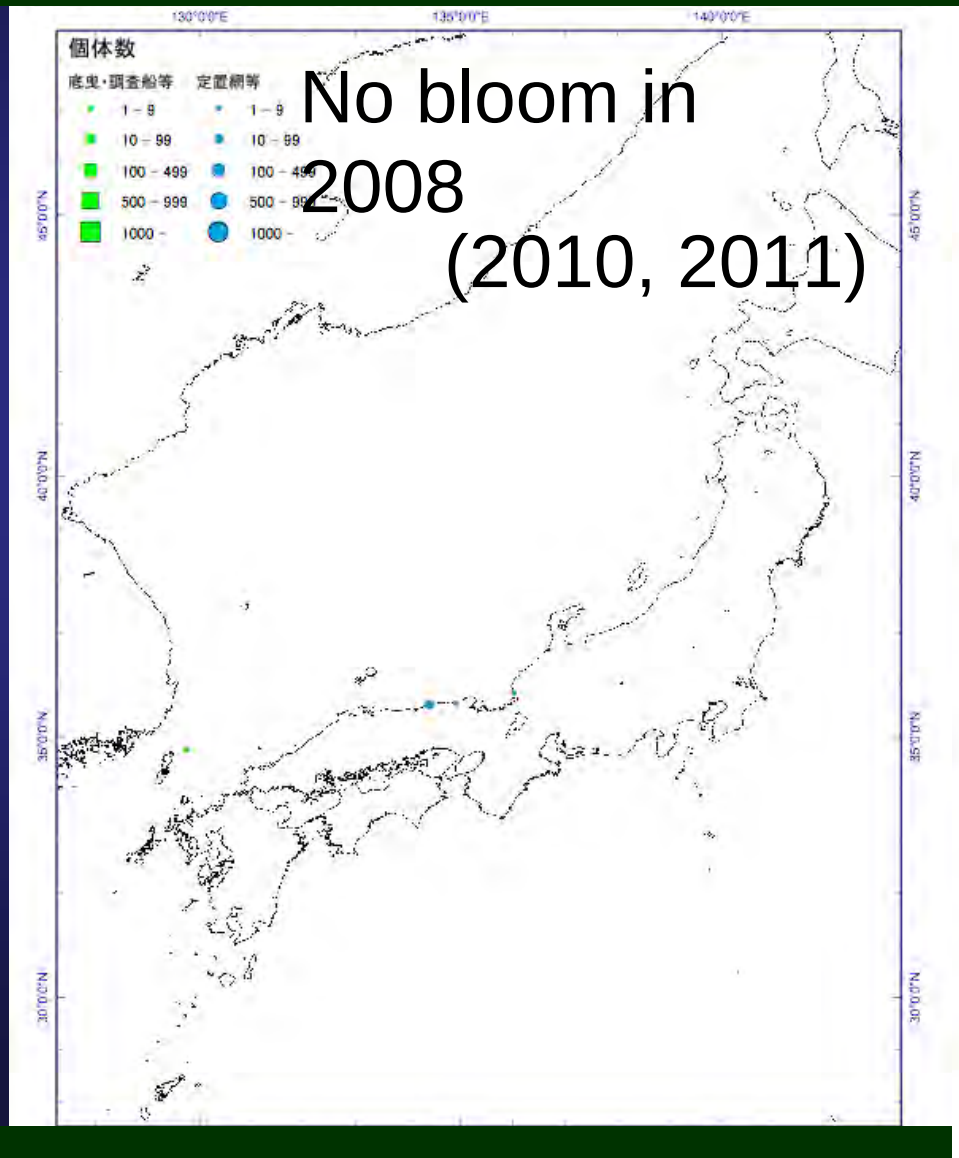
Fish dominated ecosystem

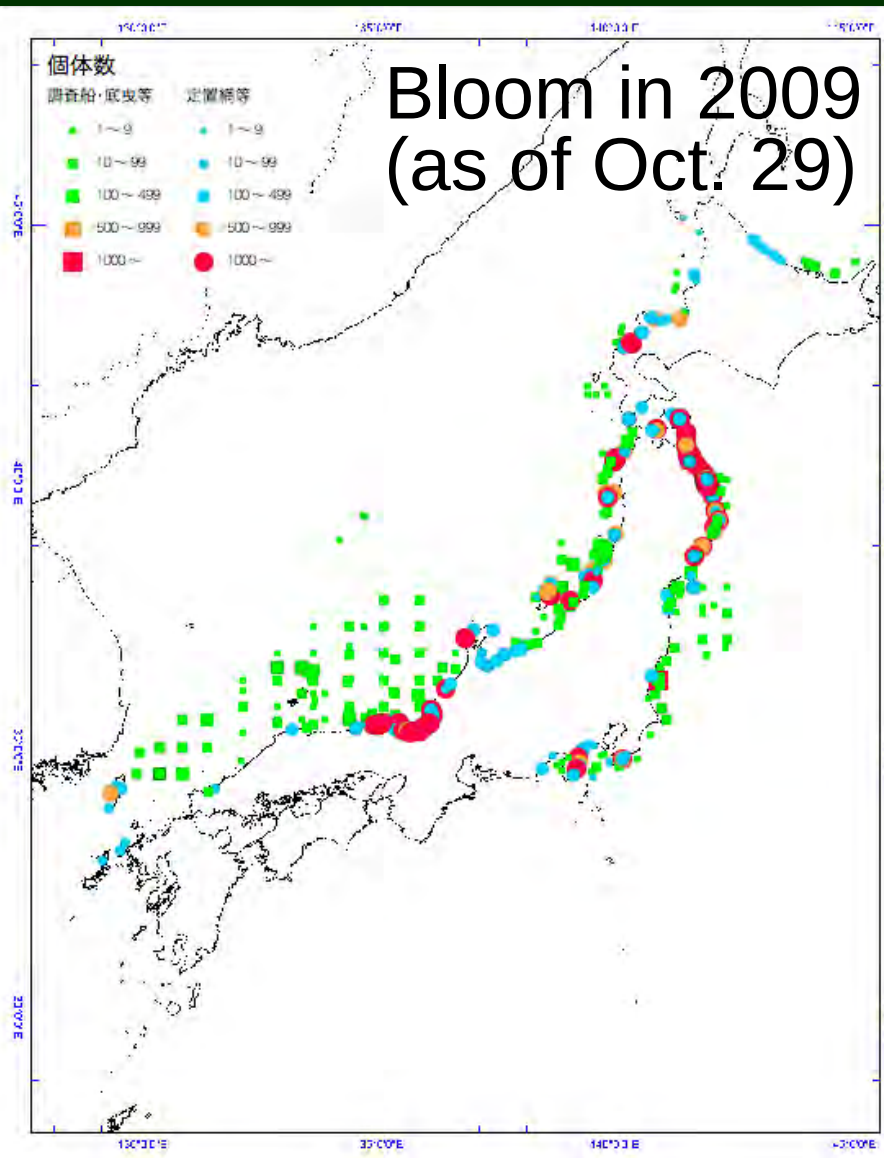
Favorable conditions conducive to recurrent jellyfish blooms have already prevailed in Chinese coastal waters

Recurrent *Nemopilama* blooms vs fish stocks



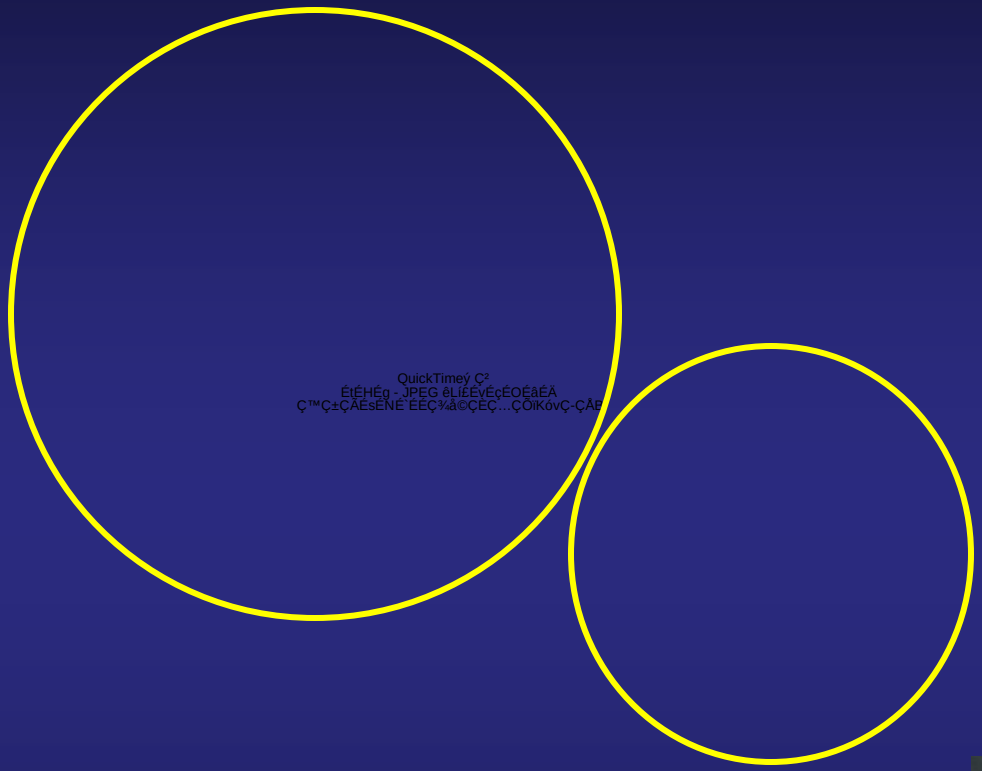
Environmental factors cannot explain year-to-year difference in the occurrence of *Nemopilema*



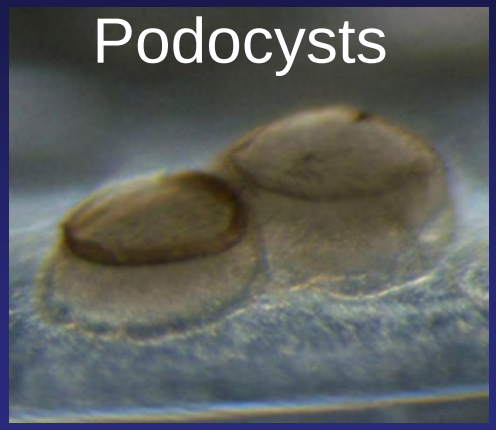


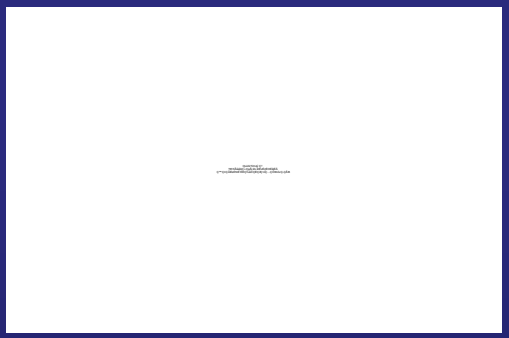
Podocyst production and excystment

Colonized polyps and podocysts



Polyp walks!





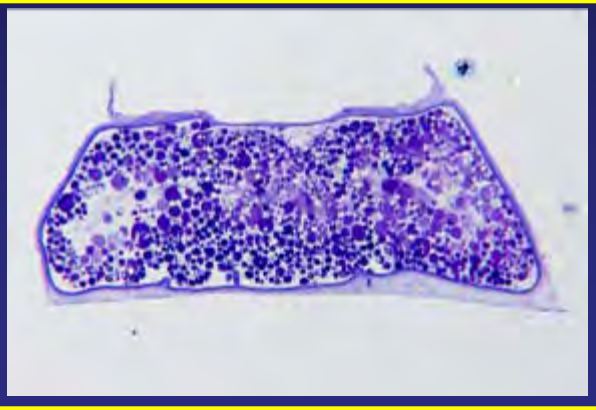
Dormant for at least 5.5 years

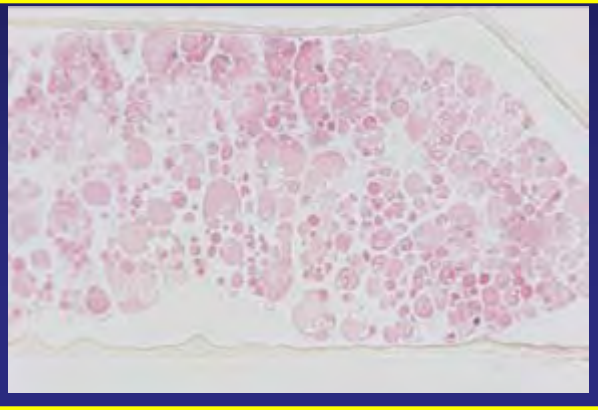
Histological change of podocyst with age

Internal structure

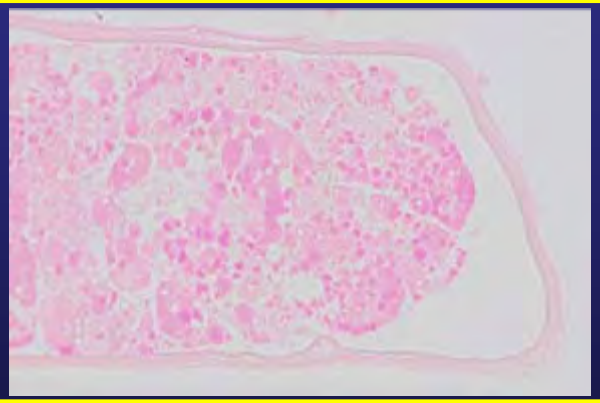
Nutrient reserves (Proteins)

4 months old





5 years old



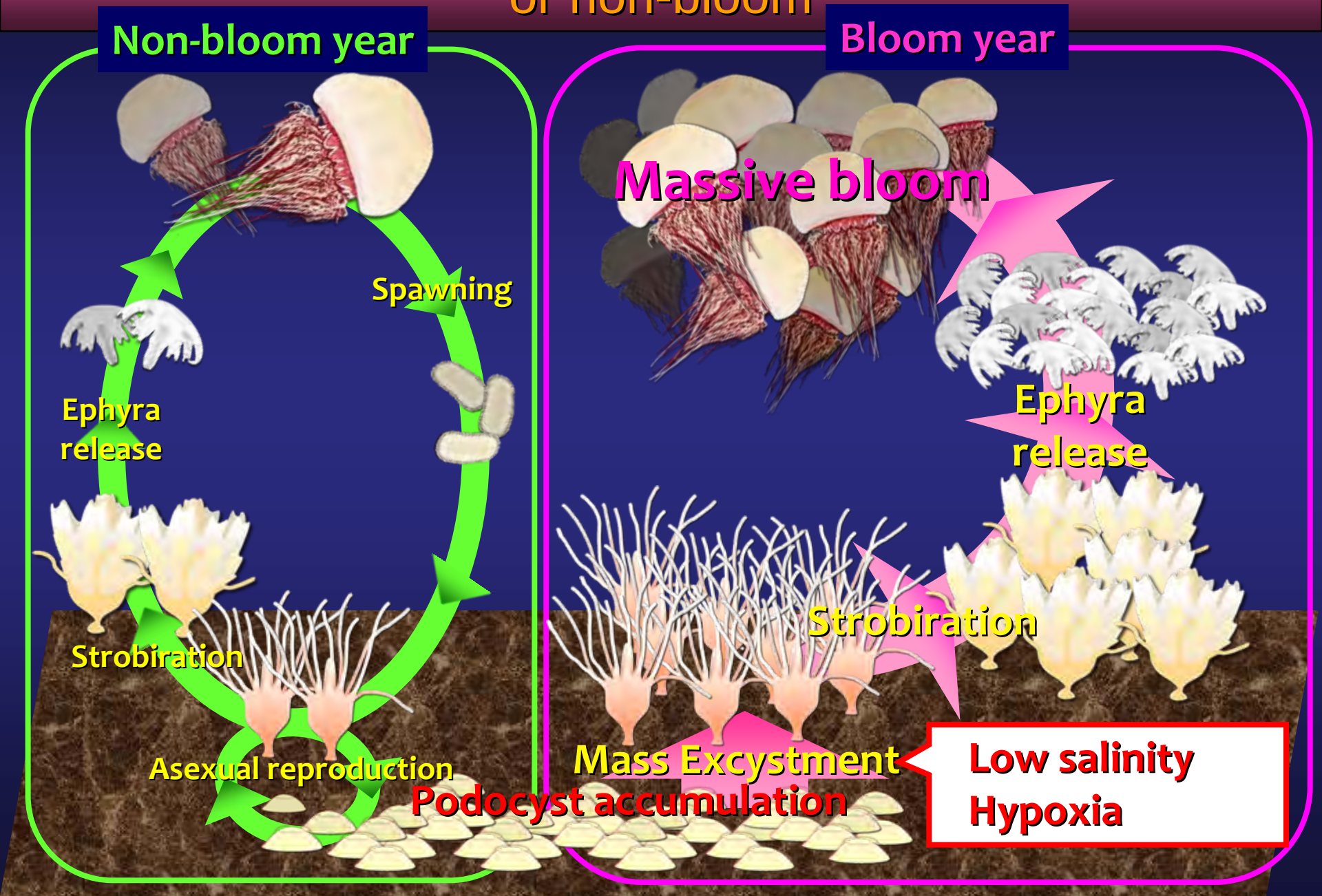
Even after dormancy of 5 years, no significant change occurred in the structure and nutrient reserves of podocysts

Induction of podocyst excystment

Temperature (°C)	Salinity	Excystment (%) for 80 days	
31	33	39	**High temp.**
27	33	55	
23	33	4	
19 (control)	33	1	
15-5	33	0	
19	24	7	**Low salinities**
19	16	20	
19	8	19	
19 (hypoxia)	33	13	**Deoxygenation**
19 (in mud)	33	25	

Excystment is induced when the podocysts are exposed to some extreme environmental conditions

Hypothetical scheme to cause *Nemopilema* to bloom or non-bloom



Forecast of *Nemopilema* bloom intensity by ferry-on-deck sighting survey

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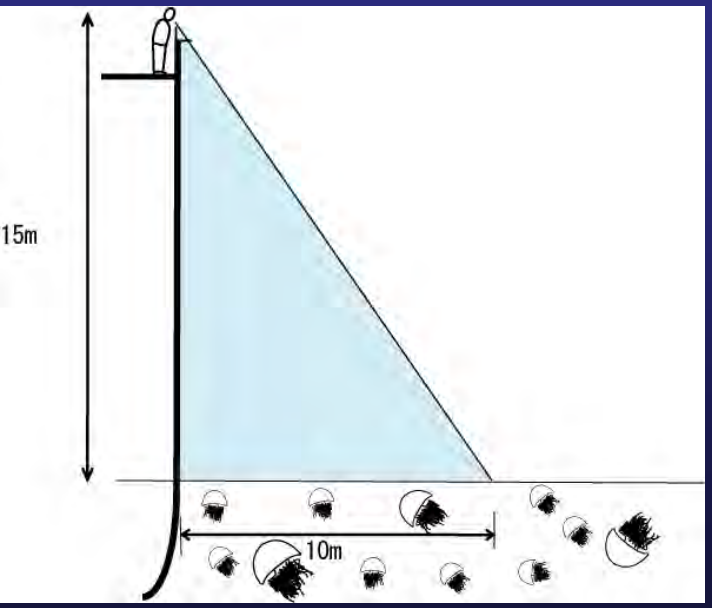
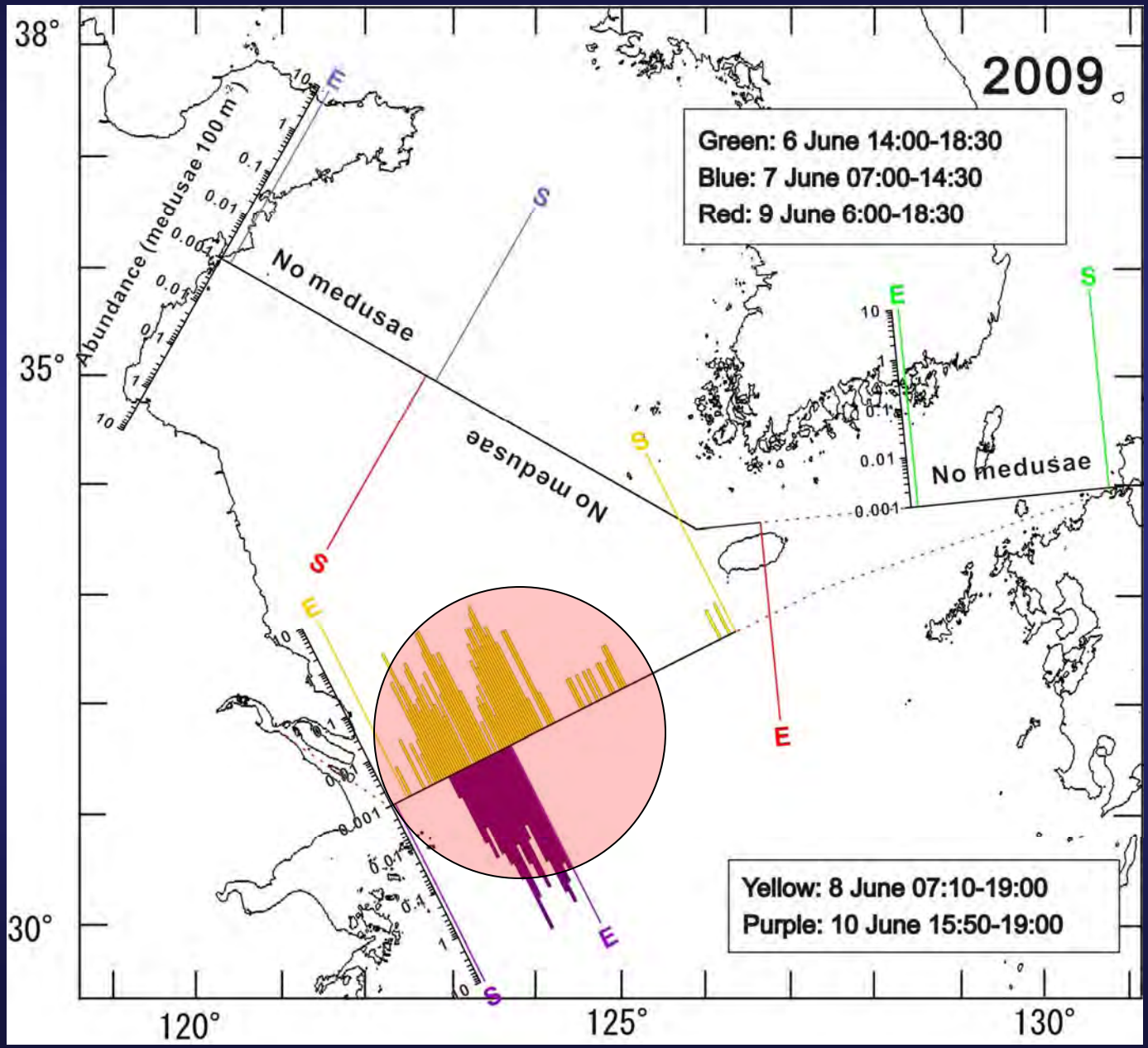
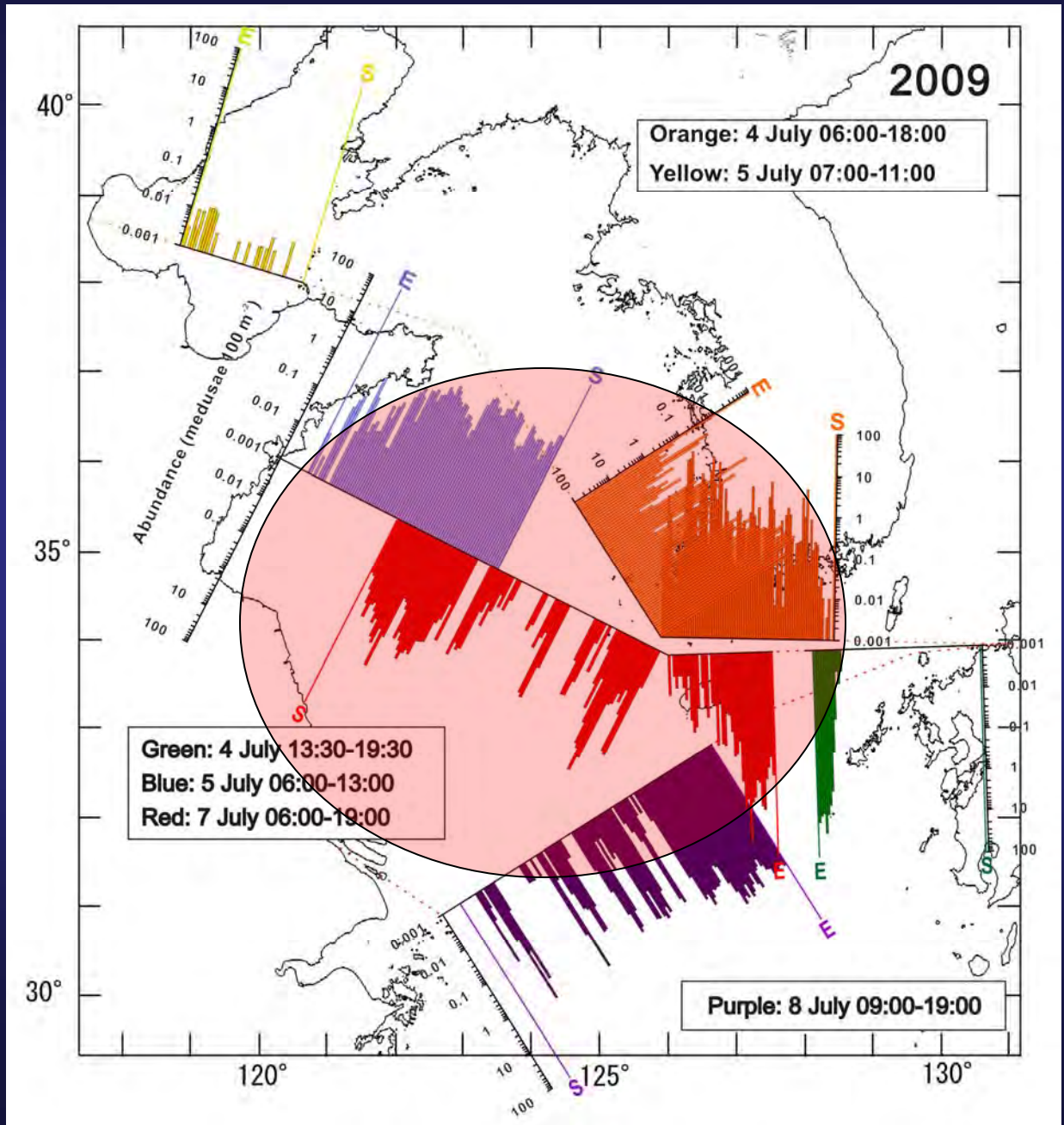


Ferry survey during 6-10 June, 2009



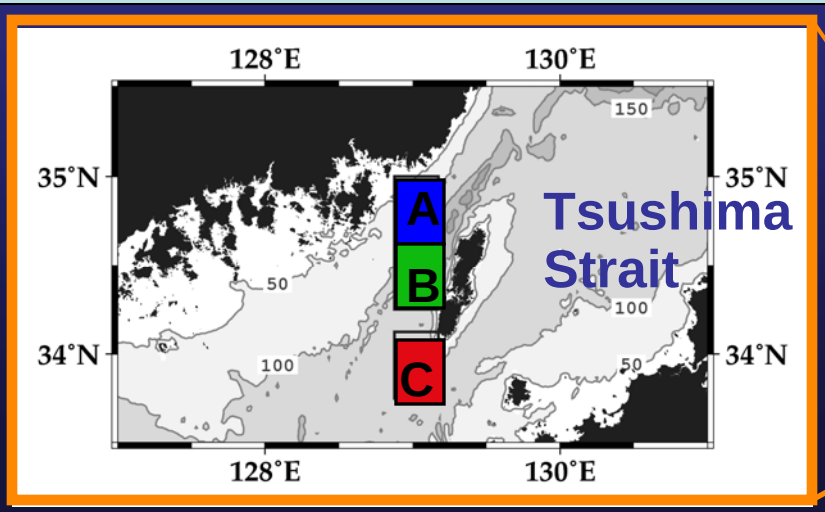
Ferry survey during 4-8 July, 2009

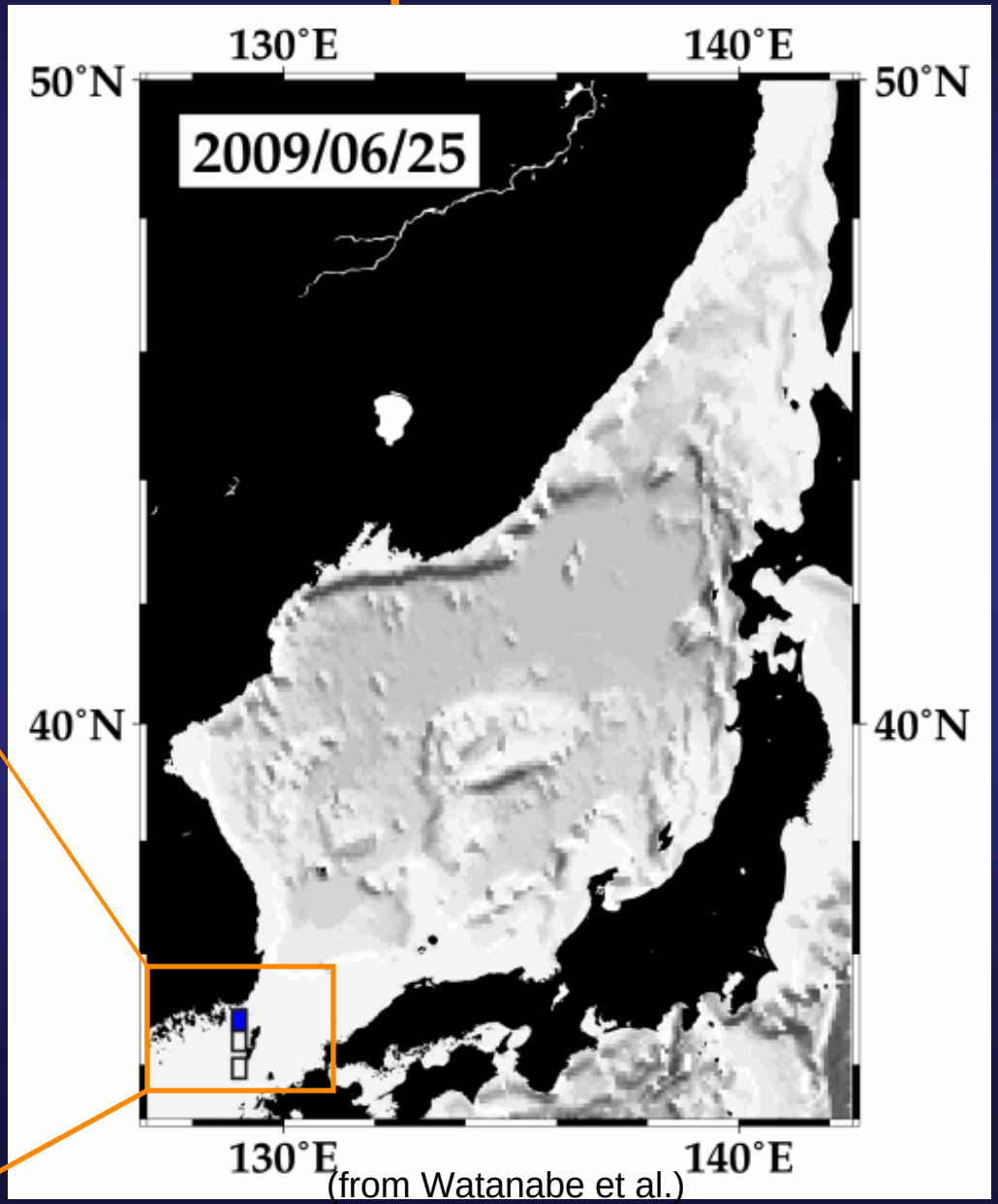


Simulated transport process of *Nemopilema* in the Japan Sea

Assumptions and conditions for the model

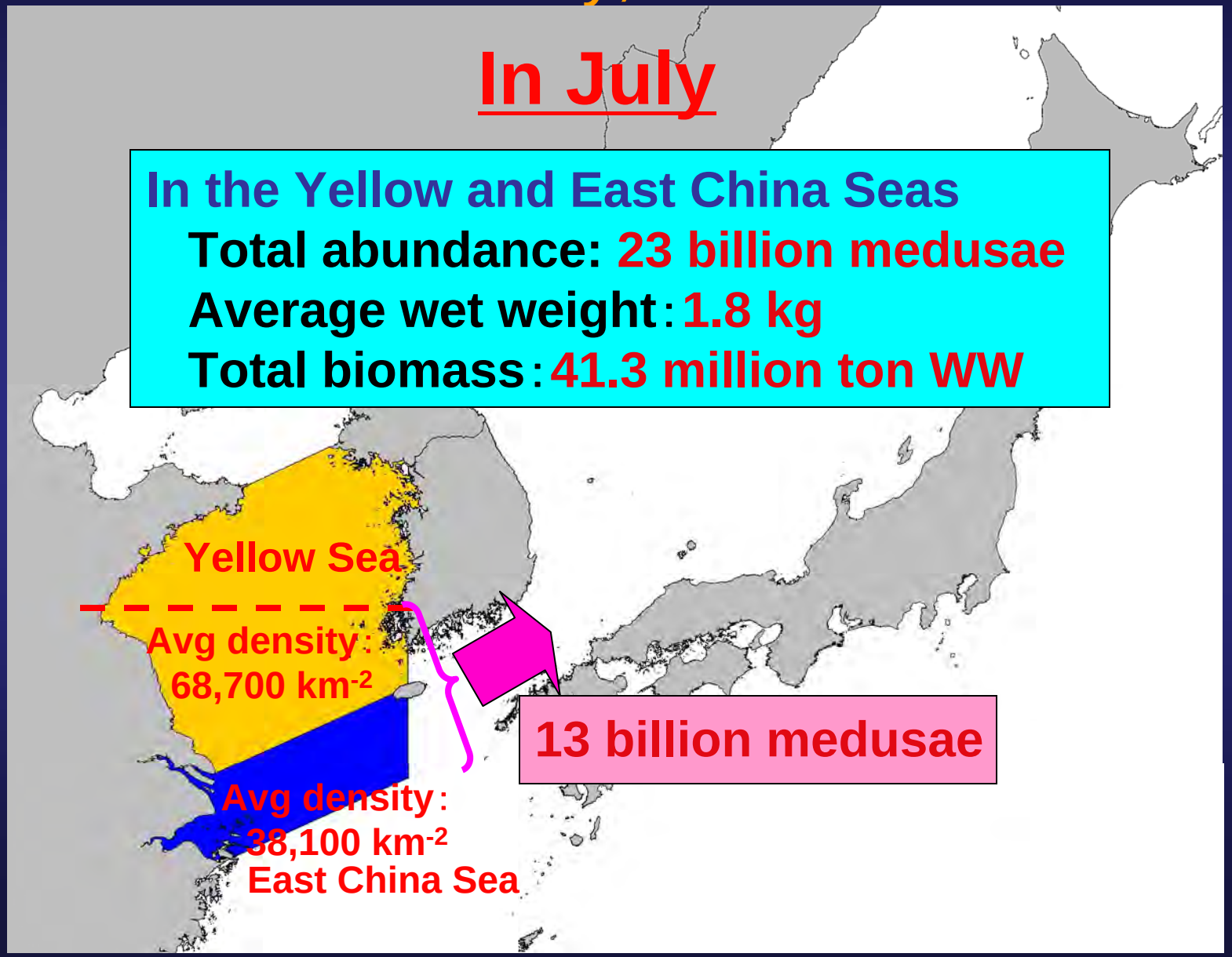
1) Initial position: Three (A, B and C) zones in the Tsushima Strait
2) Start of particle release: 25 June in A (blue), 30 June in B (green), 7 July in C (red)
3) Stop of particle release: 13 July
4) Calculation period: from 25 June to 15 September
5) Vertical movement: diel vertical migration



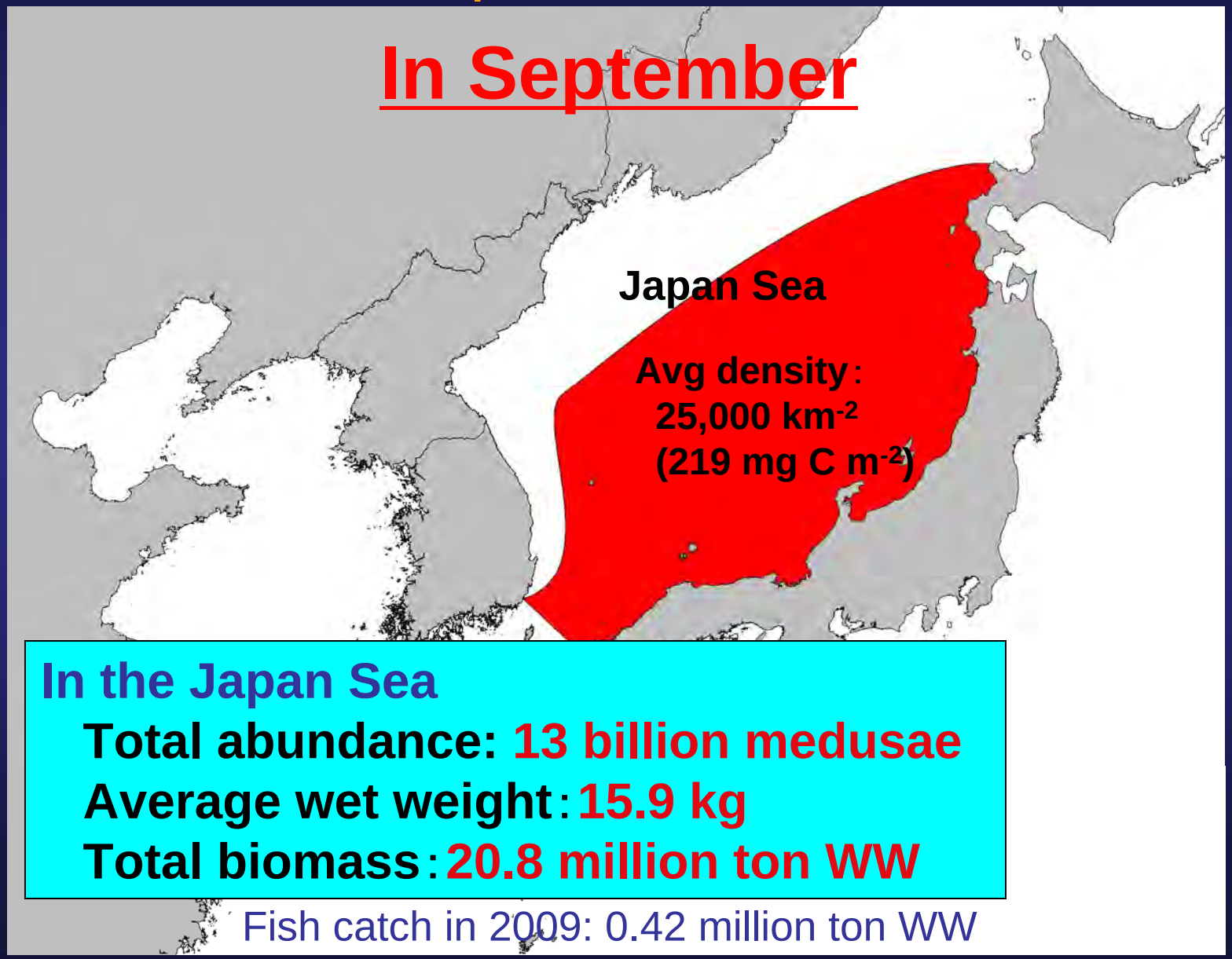


(from Watanabe et al.)

Abundance and biomass of *Nemopilema* in July, 2009



Abundance and biomass of *Nemopilema* in September, 2009



In the Japan Sea

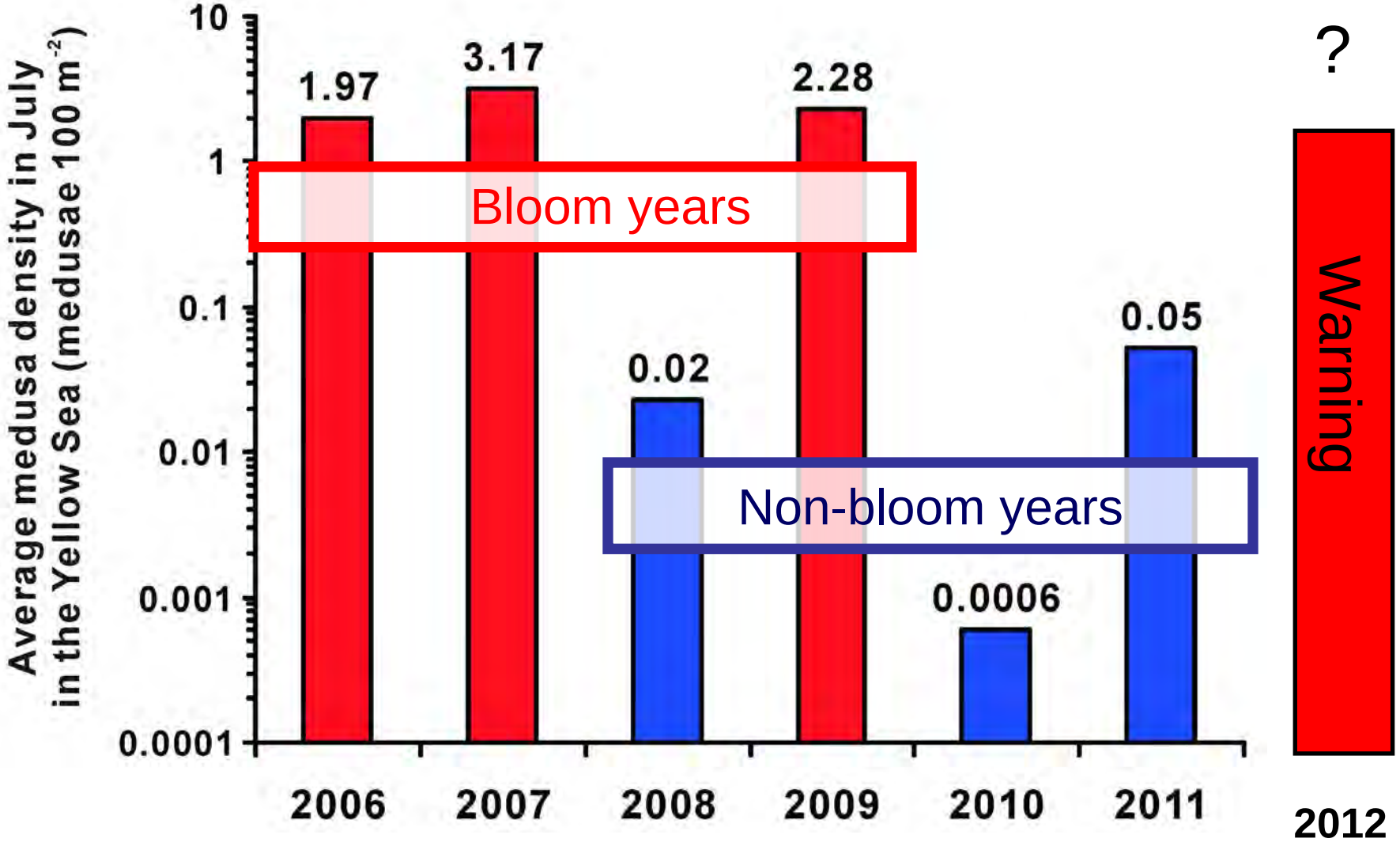
Total abundance: 13 billion medusae

Average wet weight: 15.9 kg

Total biomass: 20.8 million ton WW

Fish catch in 2009: 0.42 million ton WW

Annual change in average density of *Nemopilema* medusae in the Yellow Sea in July



Conclusion

1) Former productive and fish-dominated ecosystem in East Asian Marginal Seas may have sifted to jellyfish-dominated one, largely by human-induced perturbation in the region.
2) In the giant jellyfish blooms, which show a remarkable year-to-year difference in the intensity, some biological factors (e.g. podocyst dormancy and excystment) may also be important.
3) The year-to-year bloom intensity of the giant jellyfish can be forecasted by ferry sighting survey in early summer. These forecasts enable fishermen to prepare well in advance for possible jellyfish attacks.
4) Fishermen need modifications of fishing nets to cope with current jellyfish-dominated seas.