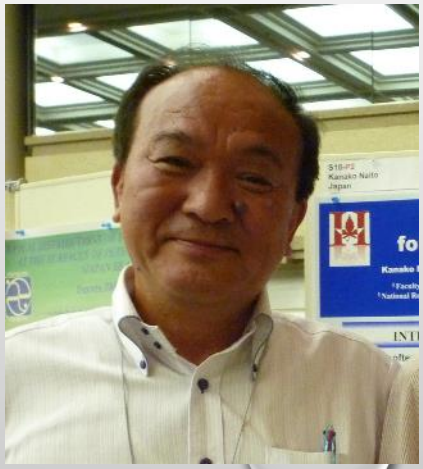
LONG-TERM TREND OF HARMFUL ALGAL BLOOMS AND ENVIRONMENTAL FACTORS IN THE SETO INLAND SEA OF JAPAN

TETSUYA NISHIKAWA, ICHIRO IMAI, SETSUKO SAKAMOTO

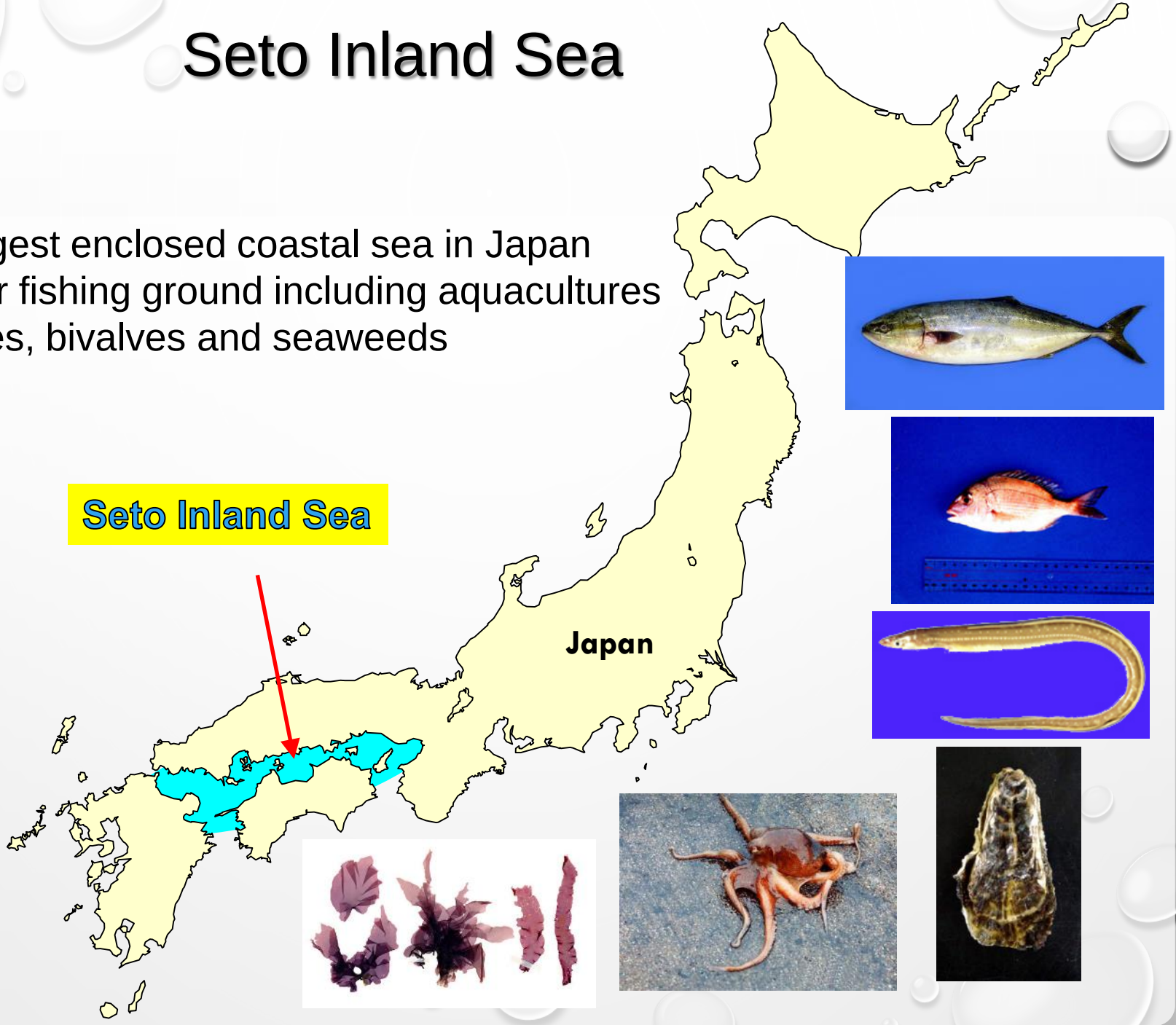
Fisheries Technology Institute, Hyogo Prefecture



Hokkaido University

Seto Inland Sea

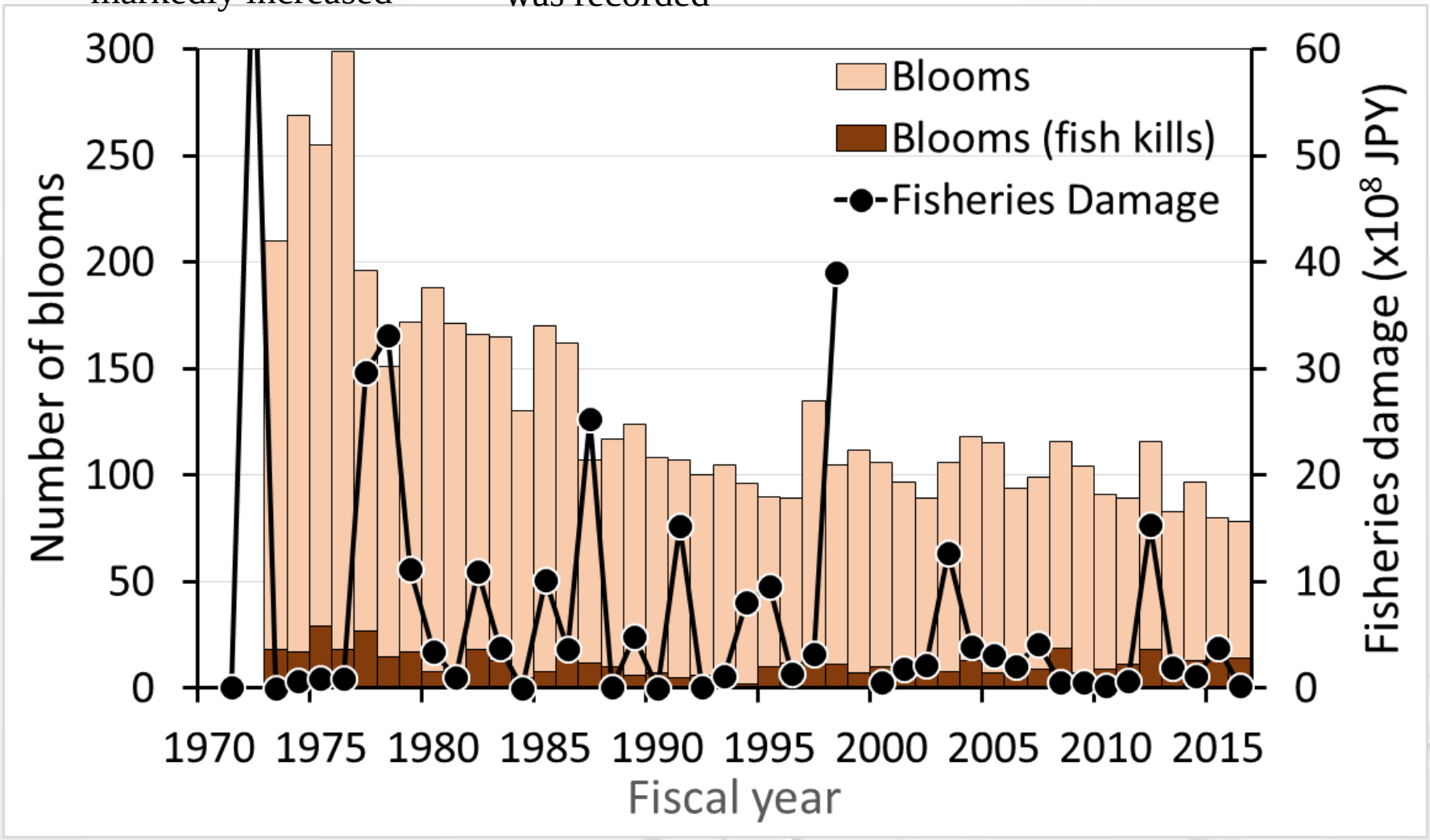
- the largest enclosed coastal sea in Japan
- a major fishing ground including aquacultures of fishes, bivalves and seaweeds



Occurrences of red tides in the Seto Inland Sea

- In 1960s and 1970s, red tide incident had markedly increased

- In 1976, the maximum 299 incidents per year was recorded



Countermeasure for eutrophication

- Special law (<u>enacted in **1973**</u>)

  "Law Concerning Special Measures for Conservation of the Environment of the Seto Inland Sea"

  → Total Pollutant Load Control
  Reduce the total quantity of organic pollutants in term of COD

- Controls of total P input (from **1979**)
- Controls of total N input (from **1996**)

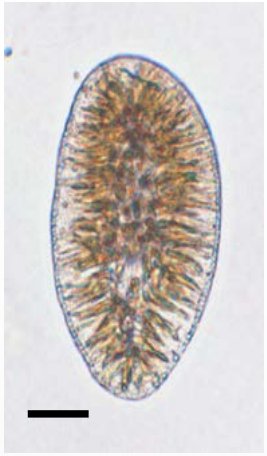
Representative organisms of noxious red tide in the Seto Inland Sea

***Chattonella* spp.**

C. marina

C. antiqua

C. ovata

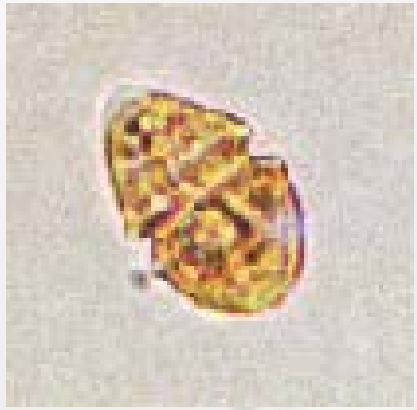


Heterosigma akashiwo

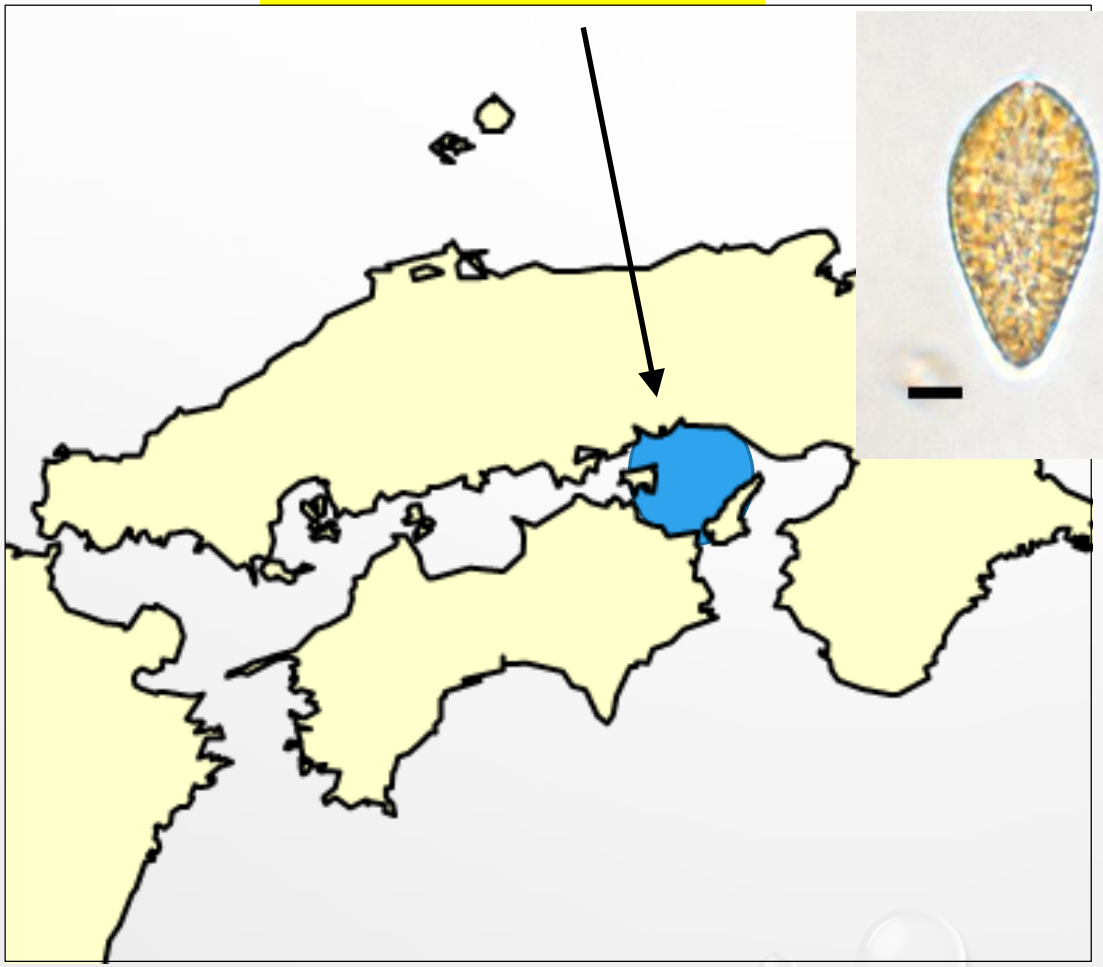
Cochlodinium polykrikoides

Karenia mikimotoi

Heterocapsa circularisquama



Harima-Nada,
Eastern part of Seto Inland Sea



***Chattonella* spp.**

C. marina

C. antiqua

C. ovata

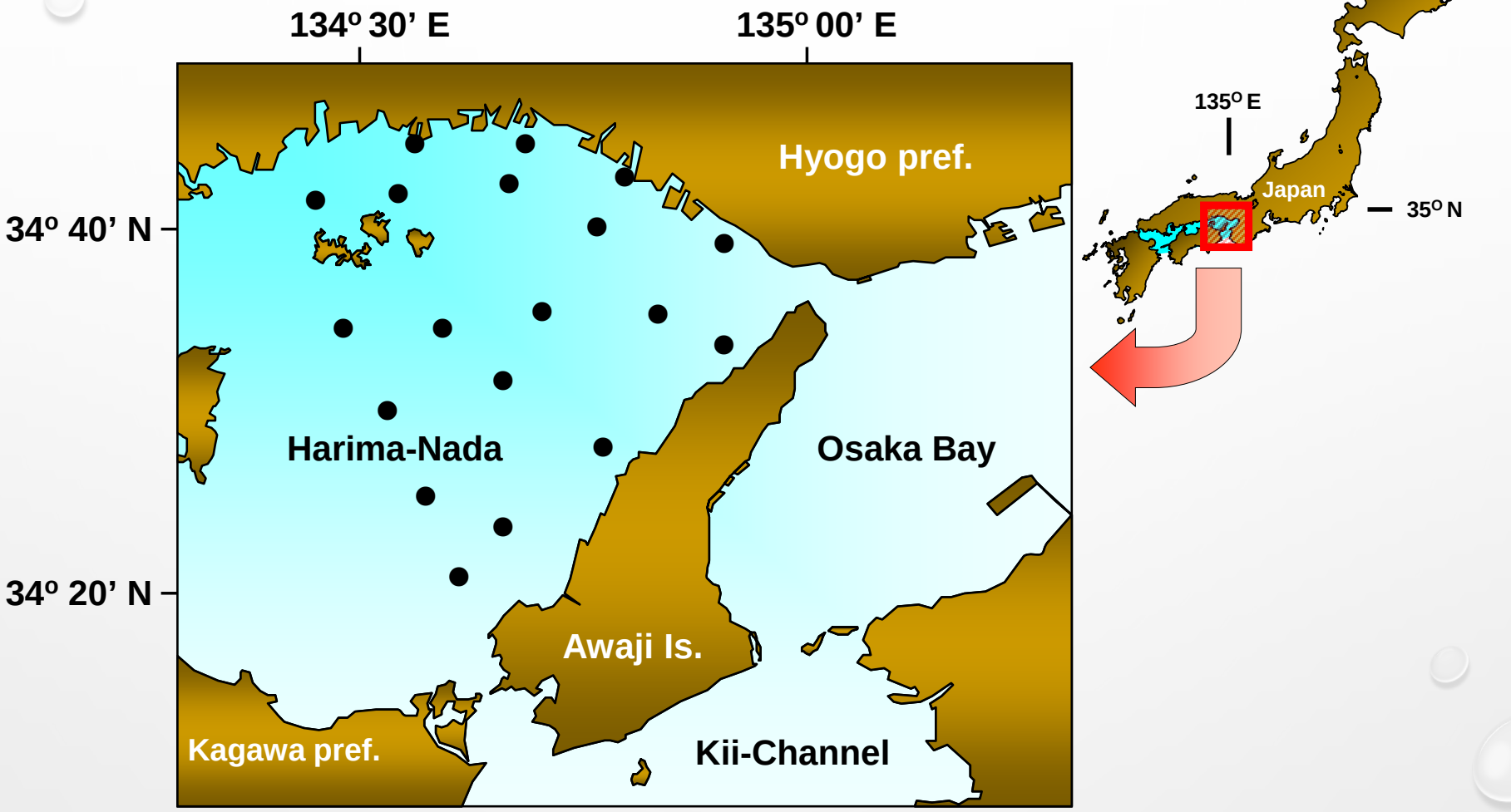
Incidence of red tide outbreaks of *Chattonella* spp. and fisheries damaged from 1972 to 2016 in Harima-Nada

Year	Maximum cell density (cells ml^{-1})	Fish damaged	Amount of loss (1,000 yen)
1972	1,500	Yellowtail	7,137,564
1977	3,160	Yellowtail	2,970,000
1978	8,655	Yellowtail	3,277,269
1979	14,500	Yellowtail, Red sea bream	340,508
1982	7,517	Yellowtail	768,288
1983	13,550	Yellowtail, Conger eel, Darkbanded rockfish, etc	54,032
1986	385	Yellowtail	101,600
1987	1,030	Yellowtail, Black porgy, Gizzard shad, Flatfish, Darkbanded rockfish, Striped mullet	1,628,450
1999	5,500	-	-
2000	95	-	-
2002	14,200	-	-
2003	5,200	Yellowtail, Greater amberjack	1,155,177
2008	317	-	-
2011	180	-	-

- : Data unknown

Sampling stations for long-term monitoring in Harima-Nada

(by Fisheries Technology Institute, Hyogo Pref.)



Analysis of the dynamics on *Chattonella* spp.

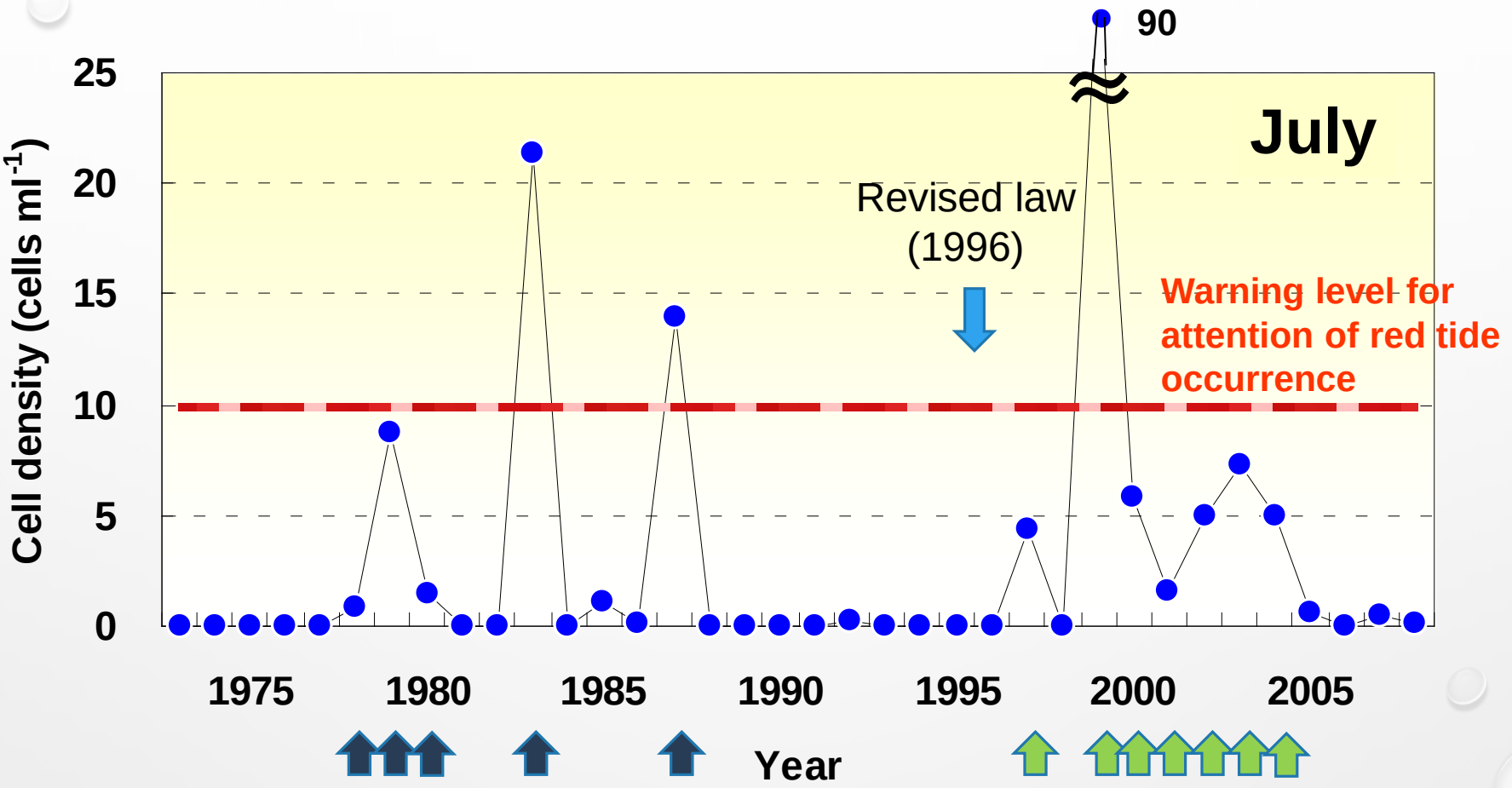
(by Fisheries Technology Institute, Hyogo Pref.)

- Location: 19 sampling stations in Harima-Nada
- Period: 1973-2008 (36-years)
- Month : July-August
- Items :
  1) Water temperature, nutrients concentration
     (3 layers : 0, 5 or 10 m, B-1 m)
  2) Cell density of *Chattonella* spp.* (surface)

*: *Chattonella antiqua*, *Chattonella marina* and *Chattonella ovata*

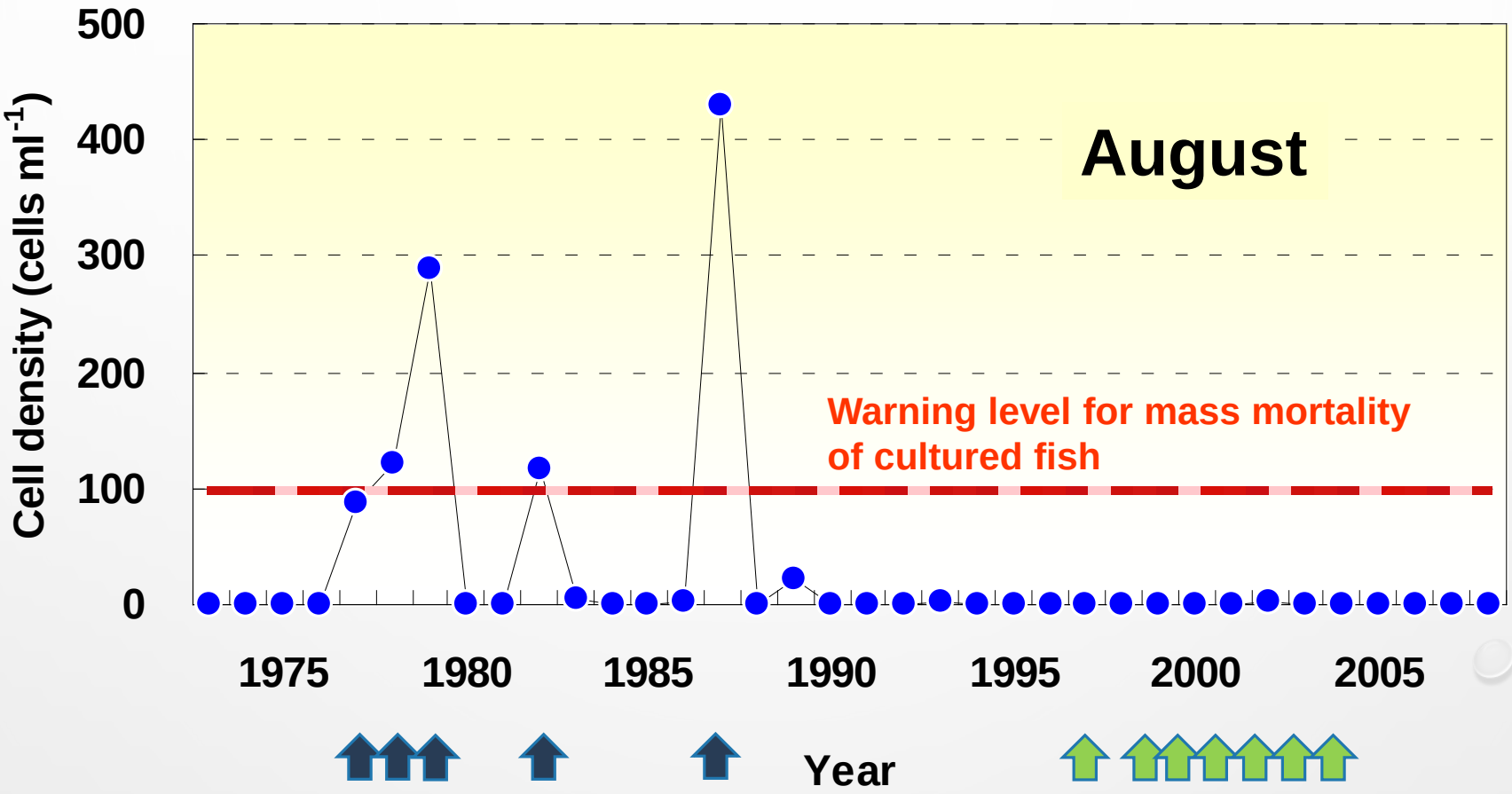
Long-term changes in the **cell densities** of *Chattonella* spp. in **July** from 1973 to 2008

(mean at 19 sampling stations in the surface layer of Harima-Nada)



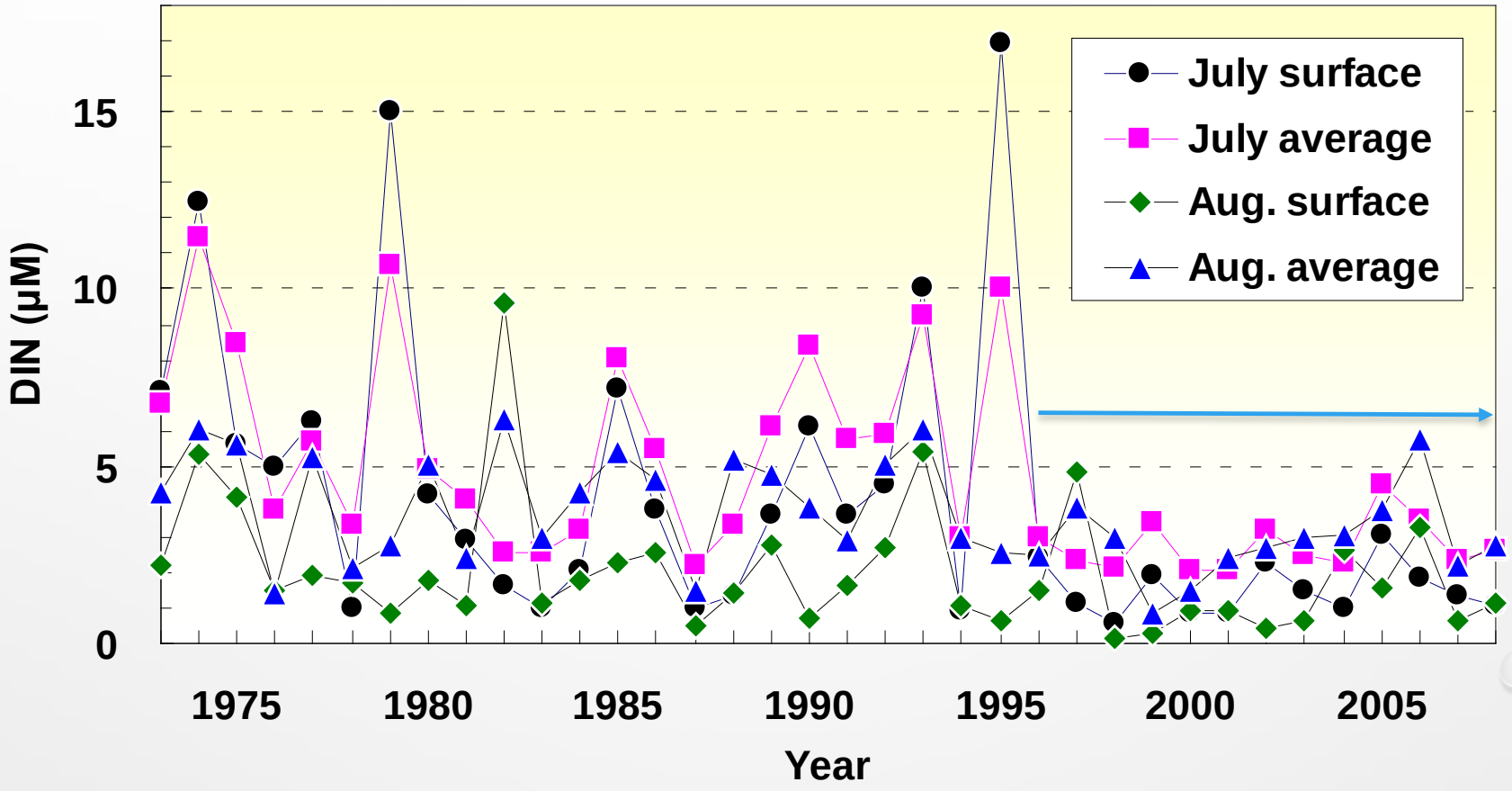
Long-term changes in the **cell densities** of *Chattonella* spp. in **August** from 1973 to 2008

(mean at 19 sampling stations in the surface layer of Harima-Nada)



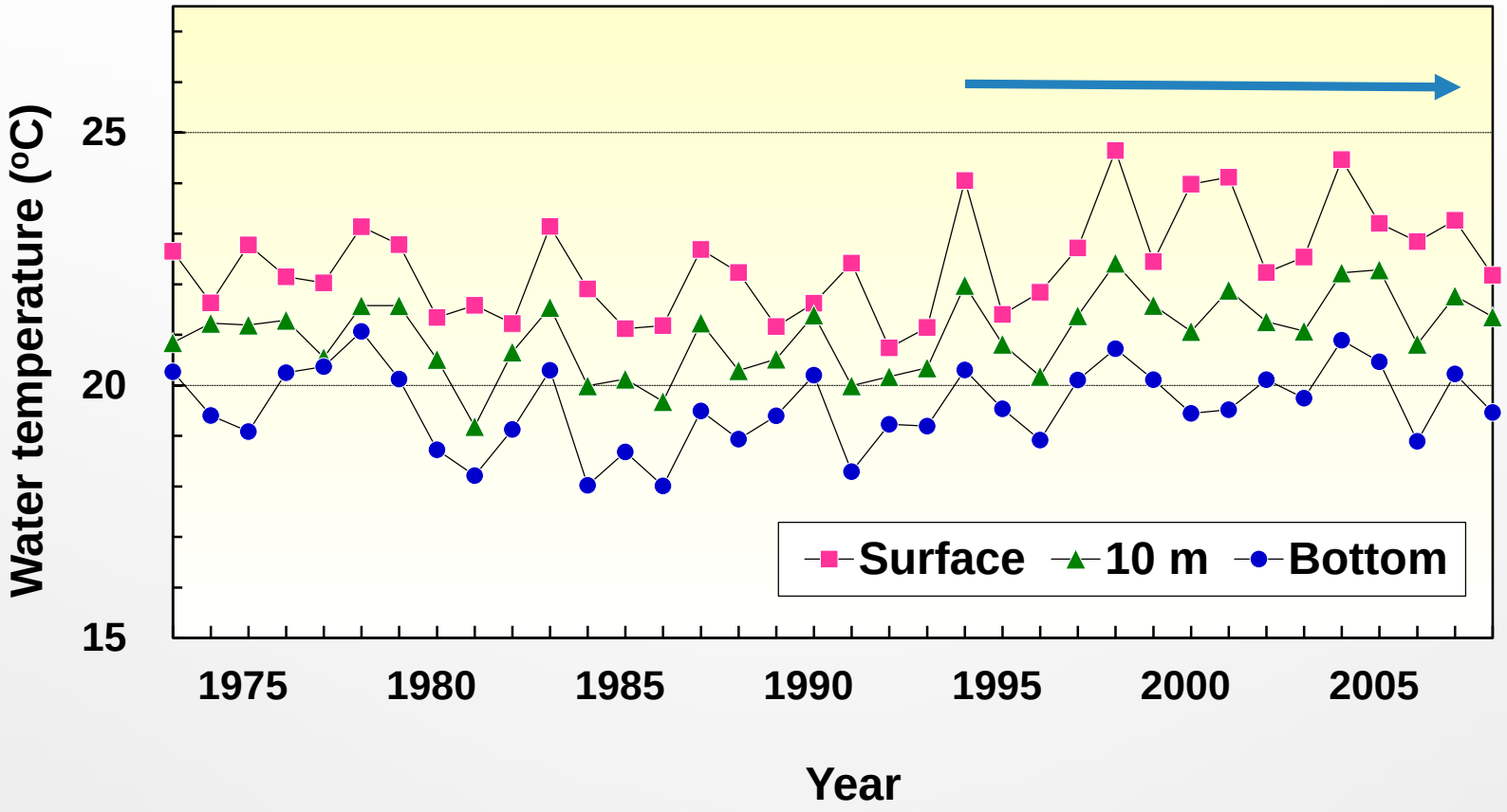
Long-term changes in **DIN concentrations** in **July and August** from 1973 to 2008

(mean at 19 sampling stations in Harima-Nada)



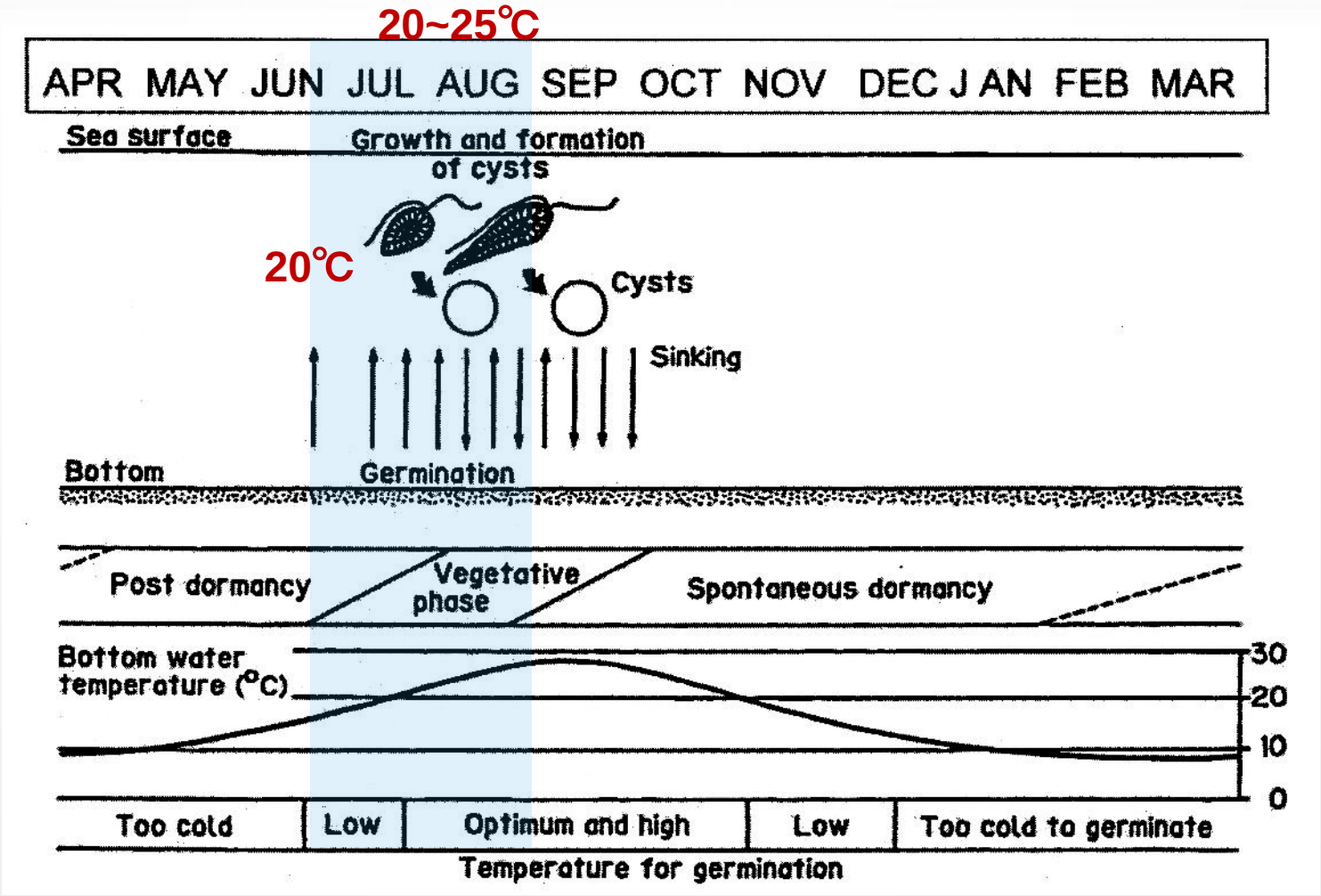
Long-term changes in **water temperature** in **July** from 1973 to 2008

(mean at 19 sampling stations in Harima-Nada)



Schematic representation of the annual life cycle of *Chattonella* in the Seto Inland Sea

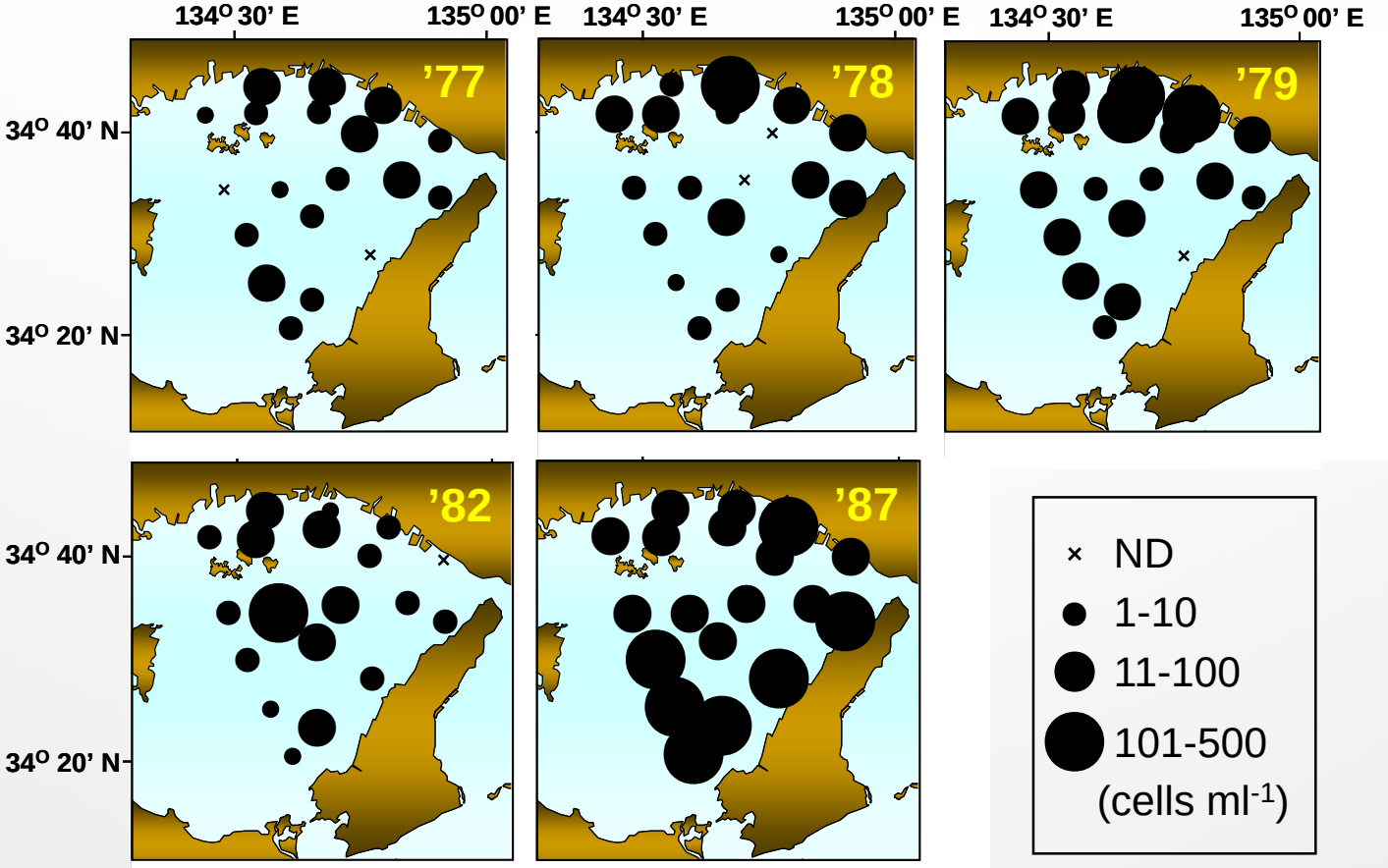
(including vegetative and cyst phases, with bottom water temperature)



Imai and Itoh (1987)

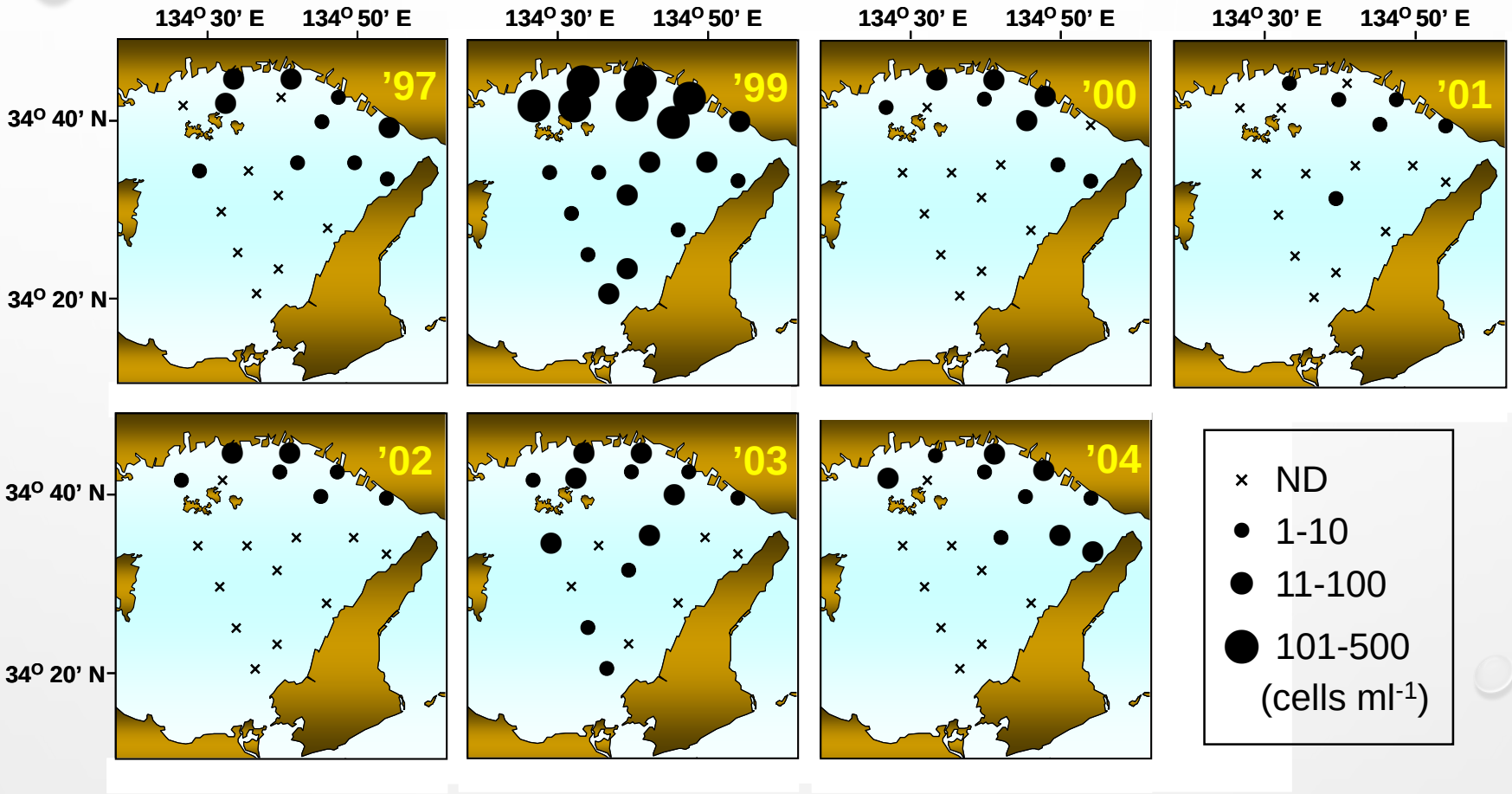
Horizontal distributions of **cell density** of *Chattonella* spp. in August (before 1996)

(at 19 sampling stations in the surface layer of Harima-Nada)



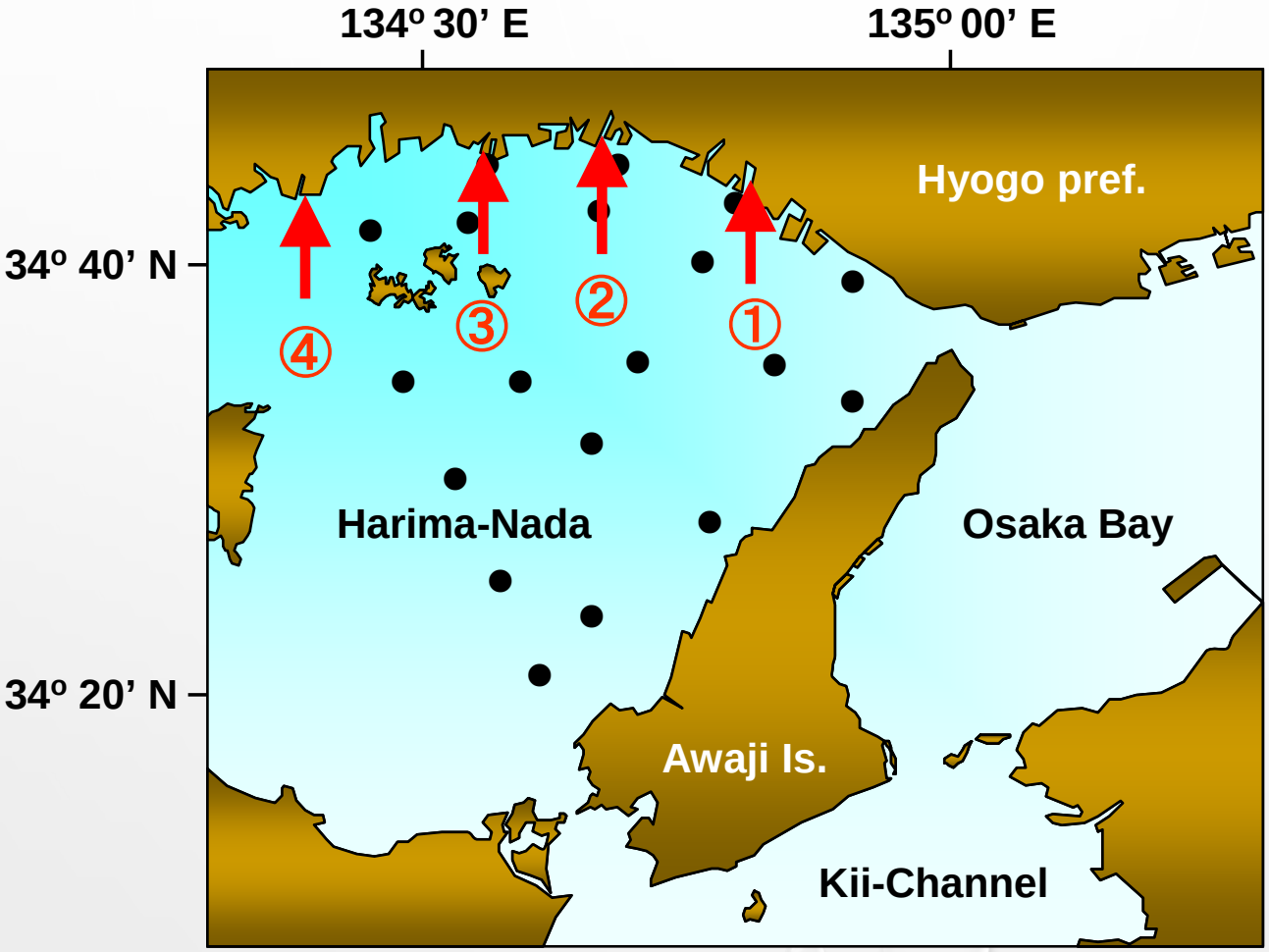
Horizontal distributions of cell density of *Chattonella* spp. in July (after 1996)

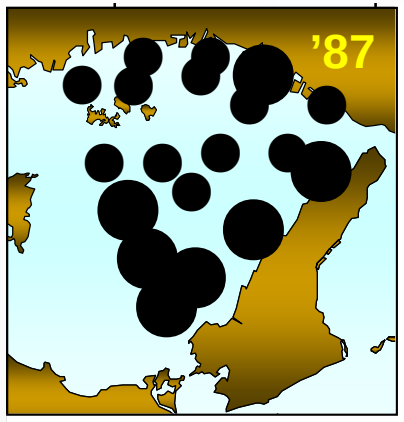
(at 19 sampling stations in the surface layer of Harima-Nada)

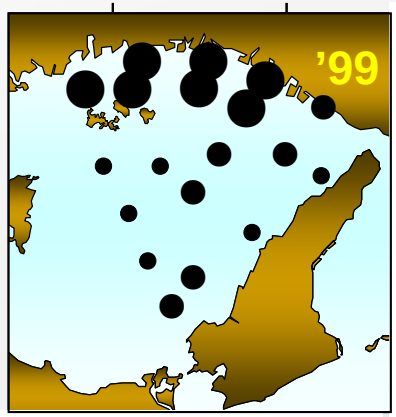


Large-rivers discharge into Harima-Nada

① Kakogawa ② Ichikawa ③ Ibogawa④ Chigusagawa







Summary

Long-term changes in *Chattonella* spp. in Harima-Nada

- From the1970s to 1980s (high nutrient levels)
  → High cell density, large-scale and prolonged red tide

Regulation by law and technical development contributed to decrease nutrients inputs

- After 1996
  - Low nutrient levels
    → Cell density and spatial scale of the distribution have become lower and smaller
  - Increase in water temperature
    → Earlier occurrence for several weeks
    → Frequency of small blooms increased in July

Thank you for your attention.