Changes in occurrence of paralytic shellfish poisoning and the effects on bivalve aquaculture in Tohoku region of Japan after the Great East Japan Earthquake

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PSP: Paralytic Shellfish Poisoning
Bivalve aquacultures in the Pacific coast of Tohoku region, Japan

Scallop aquaculture  Oyster aquaculture
Percentage in total production in Japan

Scallop
- Aomori: 41%
- Miyagi: 6%
- Others: 50%
- Total: 219,649 ton

Oyster
- Iwate: 5%
- Miyagi: 21%
- Others: 74%
- Total: 200,298 ton

Source: Annual Statistics of Fishery and Fish Culture 2010 by Statistics Department of Ministry of Agriculture, Forestry and Fisheries, Japan
Tsunami by the Great East Japan Earthquake on 3.11 in 2011

Source: Miyako city (Iwate Prefecture, Japan) HP

from Tohoku Gakuin Univ HP
Bivalve aquacultures: destruction and reconstruction

Destruction of almost all facilities

Recovering

A example in South Iwate

March 14, 2011

June 1, 2015
Shellfish poisoning

- Indicate poisoning that occurs when shellfish are eaten by humans (in a narrow sense)
- Indicate situation when shellfish have biotoxins exceeding the quarantine levels of toxicity (in a broad sense)

E.g. Paralytic shellfish poisoning 4 MU/g
The number of PSP occurrence in Japan and the causative plankton

Source: Report of Research Meeting on Shellfish Poisoning in Tohoku Region, Japan
Life cycle of *Alexandrium tamarense*

- Occurrence of the vegetative cells is germination of the cysts
- The blooms mostly occur in cold water season (in spring)
- At the end of the blooms, the cyst was produced after sexual conjugation of vegetative cells

Distribution and abundance of *Alexandrium* cysts are important information to evaluate the risk of PSP occurrence

Source: MicrobeWiki (By Jack Cook, Woods Hole Oceanographic Institution)

Source: MicrobeWiki (Photo By D. Wall)
Distribution of mud contents (% of <63μm particles) and *Alexandrium* cyst density

Before the Earthquake

After the Earthquake

Max. 950 cysts cm⁻³

Max. 8,200 cysts cm⁻³

Kamiyama et al. (2014) J. Oceanogr. 70:185-
Changes in the maximum abundances of *Alexandrium* cysts in 3 bays

- **Sendai Bay (A)**: 2005 - 29 points, 2011 - 44 points
- **Kesennuma Bay (B)**: (11 points)
- **Ofunato Bay (C)**: 1988 - 25 points, 2012 - 100000 points

Kamiyama et al. (2014) J. Oceanogr. 70: 185-

Ogata et al. (2014)

Ishikawa et al. (2014) Nippon Suisan Gakkaishi 81 (2): 256-
Why did abundance of cysts increased in surface sediments after the tsunami?

Huge tsunami

- Re-suspended diverse sediment particles into seawater
- High specific gravity particles (minerals) were firstly settled
- Biogenic particles (cysts) with low specific gravity were settled at the end

The cysts buried in sediments were accumulated in surface sediment by the tsunami.
2. Changes in PSP occurrence after the tsunami

Increased cysts

PSP occurrence
Annual changes in maximum PSP toxicity of mussel and maximum *Alexandrium* density in Sendai Bay

![Graph showing annual changes in maximum PSP toxicity of mussel and maximum *Alexandrium* density.](http://www.pref.miyagi.jp/uploaded/attachment/272350.pdf)

Source: Miyagi Prefecture, HP
http://www.pref.miyagi.jp/soshiki/mtsc/kaidoku.html

**Drastic change after the tsunami**
Annual changes in the number of PSP occurrence in Kesennuma Bay

No occurrence for 24 years

Tsunami

The number of PSP occurrence

Source: Miyagi Prefecture, HP

Drastic change after the tsunami
Scenario for increasing PSP occurrence after the tsunami

In the areas where PSP had occurred in the past

- Mixing the bottom sediments
- Accumulation of cysts near the surface layer

Huge tsunami

High density of planktonic cells in seawater

Enlarge initial population

Supply the cyst on the sediments

Produce new cysts

Dense bloom
High PSP toxins in bivalves

Cycle of development of *Alexandrium* bloom and PSP
3. Effects of PSP occurrence on bivalve aquaculture after the tsunami
“Ofunato Bay“, Iwate prefecture

Backgrounds

- Main production area in Iwate Prefecture
  Scallop: 41%, Oyster: 31% in all area of Iwate Pref. (2010)
- Almost all aquaculture is family-run
  2 to 3 persons per a organization
- Almost all farmers simultaneously operate aquacultures for several target species in their culture area (scallop, oyster, sea squirt, seaweeds)
- PSP has often occurred
Harvest closure period for scallop and oyster by PSP in the southern part of Ofunato Bay

- The mean period after the tsunami become longer for both bivalves.
- The period for oysters is generally shorter than that for scallop.
- In particular, average 8 month period for scallop seriously influence the aquaculture management.

Data in southern part of Ofunato Bay

Source: Report of Research Meeting on Shellfish Poisoning in Tohoku Region, Japan
Main harvest period for scallop and oyster and abundance peak of *A. tamarense* in Ofunato Bay

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Main harvest period for oyster ≠ abundance peak period of *A. tamarense*
for scallop ⊃ abundance peak period of *A. tamarense*

Economical damages due to toxification are fewer for oyster than the scallop
Number of farmer in Ofunato Bay after the tsunami

- Decreased after the tsunami
- For oyster, generally changed similar to the number in all Iwate
- For scallop, decreased clearly, although all Iwate number increased

Decay of scallop aquaculture is specific in Ofunato Bay, caused by long harvest closure period for scallop
Number of facilities in Ofunato Bay after the tsunami

- Number of facilities
  - Oyster: recovered
  - Scallop: not recovered
- Number of facilities per a farmer
  - Oyster: increased
  - Scallop: still low level or decreased

The farmers are expanding each culture area, increasing the effort for oyster, decreasing the effort for scallop.
Effects of increasing PSP occurrence after the tsunami on bivalve aquaculture (An example in Ofunato Bay)

Occurrence of PSP

- Long period of harvest closure for scallop
- Farmers are shifting target species from scallop to oyster

What should I do?

- Decrease farmer’s income for scallop.
- The harvest closure period for oyster can be shorter
- Main harvest period is different from the occurrence period of the PSP causative plankton

Farmers are shifting target species from scallop to oyster