Shellfish Poisoning in Japanese Waters

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Historical and Present Status of Shellfish Poisoning

Paralytic shellfish poisoning (PSP) was first confirmed in Japan in 1948. Since then, 90 people have been affected and 3 deaths have been reported.

The causative species have been identified as *Protogonyaulax tamarensis* and *P. catenella.* In 1977-1978, shellfish poisonings became a problem in northern Japan. Initially, the problem involved scallops, but the areas of poisoning are continuing to expand from northern to southern waters and the number of affected species is also increasing.

Along with a rapid increase of the culture of shellfish, administrative measures had to be set up by prefectural governments to regulate the harvest and shipping of shellfish.

In 1978, the Fisheries Agency, Ministry of Agriculture, Forestry and Fisheries, started monitoring the culture of shellfish and regulating shipping and set up values of toxification. In 1980, the Ministry of Welfare established laws to control shellfish poisoning following the measures used by the Fisheries Agency. Although the regional monitoring network has been functioning since 1981 in Northern waters and is administered by the Fisheries Agency, it was expended in 1984 to cover the whole of Japan.

With respect to diarrhetic shellfish poisoning (DSP), the first confirmed case was reported in 1977 in northern Japan. The causative species were identified as *Dinophysis fortii* and *D. acuminata.* Toxicological analyses were carried out and the nature of the toxins was identified. The areas of DSP poisoning and the number of species affected have been expanding ever since.

Figure 1 shows the expansion of areas of shellfish poisoning in recent years. Between 1978 and 1982, the number of areas affected by PSP increased from 2 to 10 and the number of shellfish species affected increased from 3 to 8. For DSP, the number of areas affected increased from 3 to 20 and the number of species affected increased from 3 to 10.

Shellfish production has continued to expand over the years. In the coastal waters of Japan, total production reached 680,000 tons in 1982, which amounts to 21% of coastal fisheries production. The increase in production is especially noticeable with respect to scallops and oysters.

Monitoring System for Shellfish Poisoning

Figure 2 is an example of the shellfish monitoring and investigation systems in Seto Inland Sea, western Japan. The systems are being conducted in five different regions around Japan. About 150 scientists, plus 200 administrative staff, are engaged at present. The budget of the Fisheries Agency reached ¥0.5 billion, which was also used for information exchange and investigation of red tides involving several noxious species without toxins (Fig. 23).

Present Guidelines for Monitoring Shellfish Poisoning

The amount of toxins in shellfish, occurrence of causative plankton species, and environmental factors concerned should be measured at an appropriate interval. Through these operations, the distribution of affected shellfish and degree of toxification will be clarified. An effective monitoring system could thus be established to prevent damage to human health and fisheries activities in inshore waters.

(1) The sampling station should be established to take into account the area of shellfish production

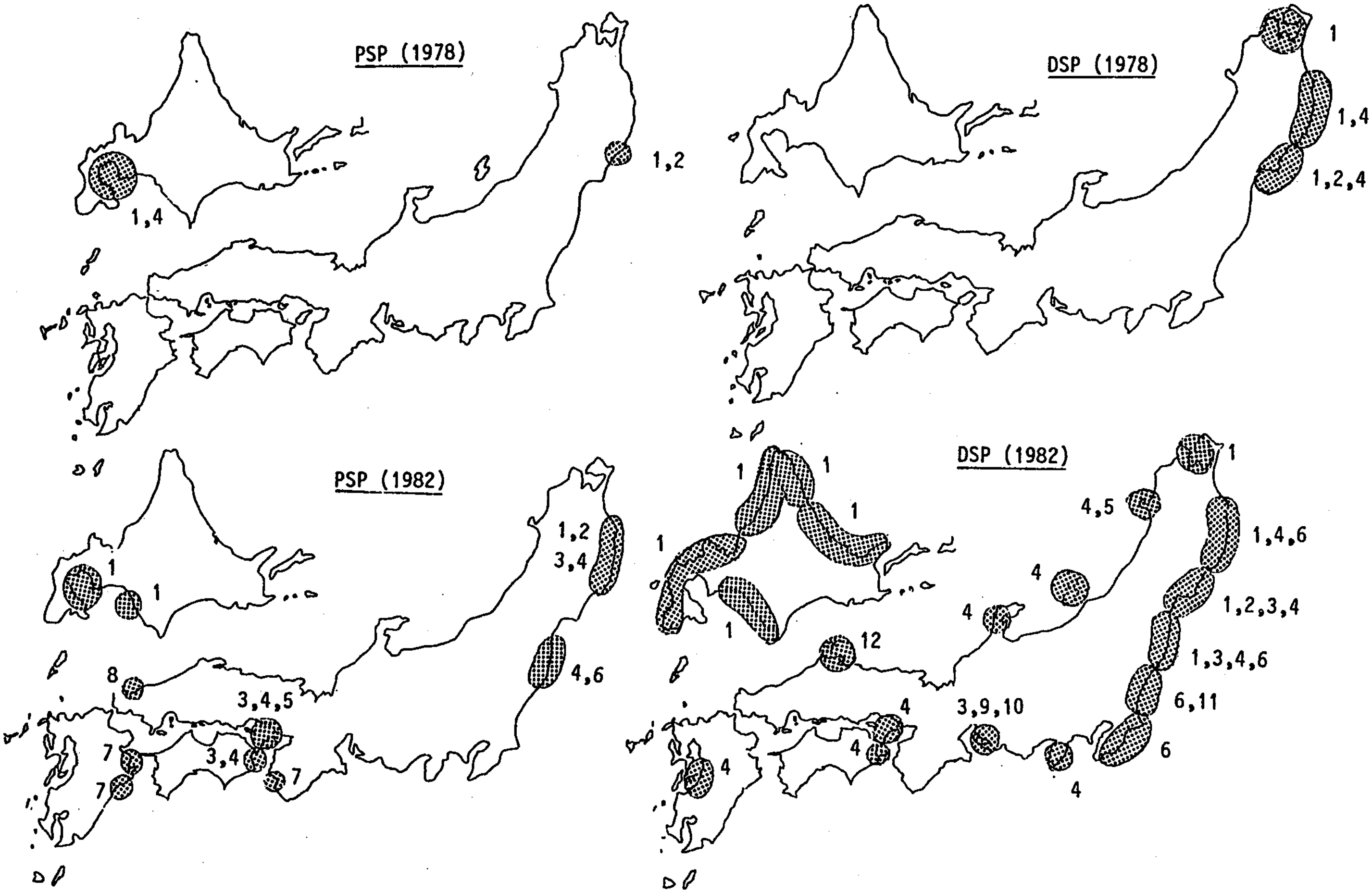

Fig. 1. Expansion of areas affected by shellfish poisoning.

1. *Patinopecten* (M.) *yessoensis*
2. *Chlamys* (A.) *f. nipponensis*
3. *Ruditapes philippinarum*
4. *Mytilus edulis*
5. *Mytilus coruscus*
6. *Gomphina* (M.) *melanaegis*
7. *Chlamys* (M.) *nobilis*
8. *Crasostrea gigas*
9. *Fulvia mutica*
10. *Mactra* (M.) *chinensis*
11. *Meretrix lamarchii*
12. *Pecten* (N.) *albicans*

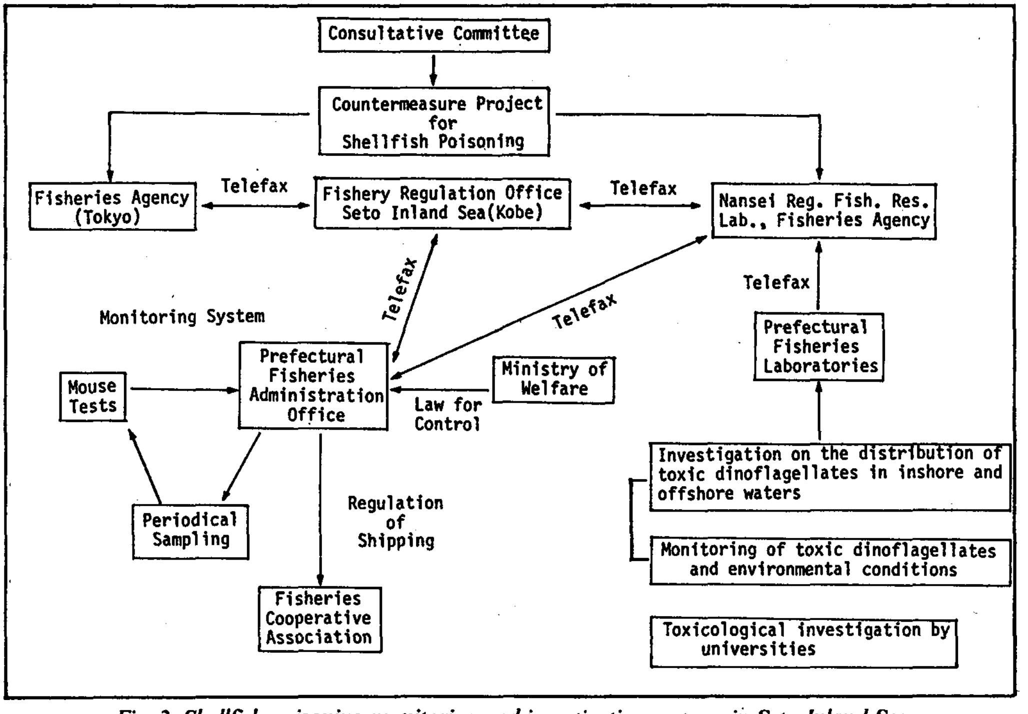

Fig. 2. Shellfish poisoning monitoring and investigation systems in Seto Inland Sea.

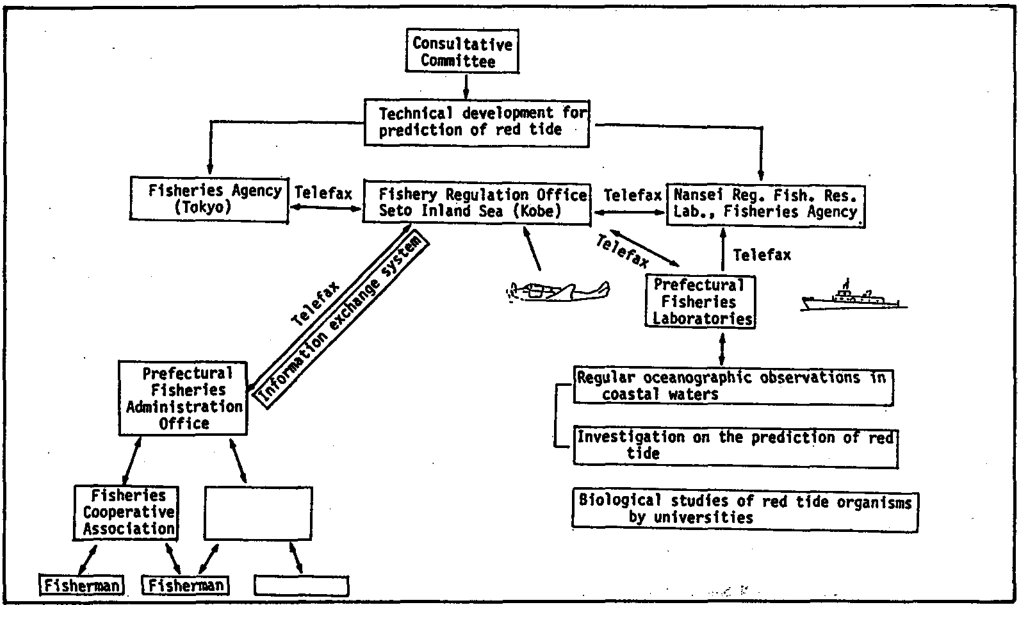

Fig. 3. Information exchange and red-tide investigation systems in Seto Inland Sea.

and distribution of toxic organisms. The period of sampling has to be selected depending on the characteristics of poisoning.

(2) Items of investigation and method of analysis:

(a) *Examination of shellfish toxicity:* Toxicity tests for PSP and DSP are necessary for each species of shellfish.

(i) Care should be taken to ensure that representative specimens are collected to reflect the areal distribution of the particular shellfish population.

(ii) Sampling is preferably carried out directly by the staff on board research ships belonging to the fisheries laboratory. When collections are made using commercial boats, the position of the sampling station, depth, and water temperature should be measured and recorded by the official staff on board.

(iii) More than 300 g of meat is needed to make up one sample. Preparation of samples is again preferably carried out by the official staff. After measuring length, height, weight with shell, and weight without shell, the samples should be put into polyethylene bags, chilled with dry ice or ice as soon as possible, and sent to the designated laboratory. Detailed plans for shipping procedures should have been discussed earlier.

(iv) Toxicity measurements (mouse tests) are conducted, for the most part, using the mid-gut gland. The value is then converted into the amount per edible portion. When examination of the gut is not feasible because of the size of the species of shellfish, examination can be carried out using the edible portion or whole body.

(b) *Examination of plankton:*

(i) At the same time as the shellfish sampling is being carried out, an appropriate volume of water should be collected for plankton surveys.

(ii) Acetic acid with formaldehyde solution (glacial acetic acid: formaldehyde = 1: 1) is an effective fixative. Add the original solution to seawater samples to attain 5% of the total volume. For the concentrated sample stock, however, addition of 20% is required.

(iii) Seawater samples can be concentrated using the settling method. By several repetitions, the final amount could be reduced down to 10 mL; 1 mL for each microscopic counting is appropriate. The amount of seawater and volume of sample for final enumeration have to be determined based on the cell concentration in the field of survey.

(3) Reporting the results of the examination:

(a) Soon after the analyses have been carried out, data sheets should be prepared. These data sheets should be sent to the related organizations as quickly as possible, regardless of the positive or negative results. Because reports of the toxicity tests need to be prepared quickly, there is no need to wait until the completion of the plankton enumeration.

(b) Regulation of the management of these data is necessary, especially for public announcements.

Main Research Themes for Clarifying Shellfish Poisoning

To prevent or reduce the damage caused by shellfish poisoning, the following investigations are being carried out at the same time as monitoring operations.

(1) Analyses of the mechanisms of toxification:

(a) *Life history and ecology of toxic dinoflagellates:* The ecology of toxic dinoflagellates, e.g., distribution, seasonal fluctuation of vegetative cells, distribution and germination of cysts, transportation, and accumulation, is an important subject to investigate. The study of the life history of causative species is also useful.

(b) *Observation of the environmental conditions:* Measurements and analyses of related environmental conditions, e.g., weather, sea condition, transparency, water temperature, salinity, chlorophyll-*a*, and major nutrients, are useful tools to understanding the total scope of poisoning.

(c) *Feeding of shellfish and detoxification:* Rates of ingestion of toxic dinoflagellates by shellfish and the accumulation of toxins are measured through laboratory experiments together with observations in the natural environment. It is also important to develop techniques of detoxification.

(d) *Development of techniques to predict the occurrence of shellfish poisoning:* To prevent and reduce the damage caused by the poisoning of shellfish or fish, appropriate techniques to predict the appearance of toxic dinoflagellates, as well as the toxin accumulation in the shellfish, are being developed through the analysis of environmental and biological factors using computer systems. A biological or ecological model is also effective for short-period forecasting of the blooming of particular species. From an ecological point of view, research on zooplankton needs to be carried out as well because the grazing pressure of zooplankton has a close relationship with the production of phytoplankton.

(2) Toxicological studies: A biochemical approach is also effective in promoting measures to reduce damages from the poisoning of shellfish. It would be useful to develop a suitable technique of detoxification for humans as well as for shellfish.

Measurement of toxicity by chemical methods to replace the mouse tests will, hopefully, be developed in future studies.

Summary

Under the supervision of the Fisheries Agency, each prefectual government has the responsibility of carrying out monitoring programs. Although some problems exist, monitoring operations have been proceeding successfully. Investigations concerning various aspects of shellfish poisoning are being conducted by 6 national institutions, 15 universities, and about 30 fishereis laboratories. Because shellfish poisoning is a kind of natural phenomenon, the only defense is the establishment of precise monitoring techniques to reduce damages. Efforts to improve monitoring, however, need to be carried out through fundamental research.