A Summary of Paralytic Shellfish Poisoning in Canada

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History

Paralytic shellfish poisoning (PSP) occurs along both the east and west coasts of Canada. The first published report occurred in 1793 in British Columbia when some of the crew members of Captain George Vancouver's expedition suffered from PSP after eating contaminated mussels. Because of taboos against eating shellfish among certain coastal tribes of North American Indians, it is likely that cases of PSP extend back even earlier than this, however. In total, there have been more than 300 documented cases of PSP in Canada since 1793, resulting in about 35 deaths. Many instances of PSP have probably gone unreported, especially among native peoples in remote areas.

Geographical Distribution

Toxic dinoflagellate blooms and contaminated shellfish are distributed as shown in Fig. 1. It is considered that shellfish can become contaminated along the entire coastline of British Columbia (west coast), although certain areas are inaccessible for sampling. On the east coast, toxic dinoflagellate blooms contaminate shellfish along the St. Lawrence River Estuary and throughout the central and southern Bay of Fundy. In 1982, the first occurrence of PSP (from mussels pickled in vinegar) was reported in Newfoundland, Canada's easternmost province. Because shellfish were found to be toxic in several separate locations in Newfoundland, it may be that the toxic dinoflagellate is endemic to the region, but only occasionally experiences conditions conducive to bloom formation.

Causative Dinoflagellates

The dinoflagellates responsible for PSP in British Columbia are *Gonyaulax (= Protogonyaulax) catenella* and *G. acatenella.* In eastern Canada, the culprit is *G. excavata* (= *G. tamarensis* var. *excavata*). Several of the toxins from the west and east coast dinoflagellates are identifical to those found in *Pyrodinium bahamese* var. *compressa* in Palau. Thus, the PSP situation in Canada and the results of investigations on the dinoflagellates, shellfish, and finfish involved has applicability to the emergent PSP problem in Southeast Asia.

Shellfish Contamination

A number of Canadian species of filter-feeding shellfish accumulate paralytic shellfish toxins and pose the risk of PSP to vertebrate consumers. Carnivorous shellfish also become toxic, acquiring the toxins secondarily from their filter-feeding prey. Along the west coast PSP is often associated with the consumption of butter clams (*Saxidomus giganteus*) and blue mussels (*Mytilus edulis*). In eastern Canada, PSP is most often associated with consumption of soft-shell clams (*Mya arenaria*), blue mussels, and rough whelks (*Buccinum undatum*), the latter of which is a popular food item in the Province of Quebec.

It should be noted that sea scallops (*Placopecten magellanicus*) in the Bay of Fundy accumulate extremely high amounts of toxins. Fortunately, the part of the organism that is eaten in this area, i.e., the adductor muscle, remains poison-free. Sometimes, scallop viscera become most toxic during the winter, when *Gonyaulax* blooms do not occur, pointing to the probable acquisition of toxins

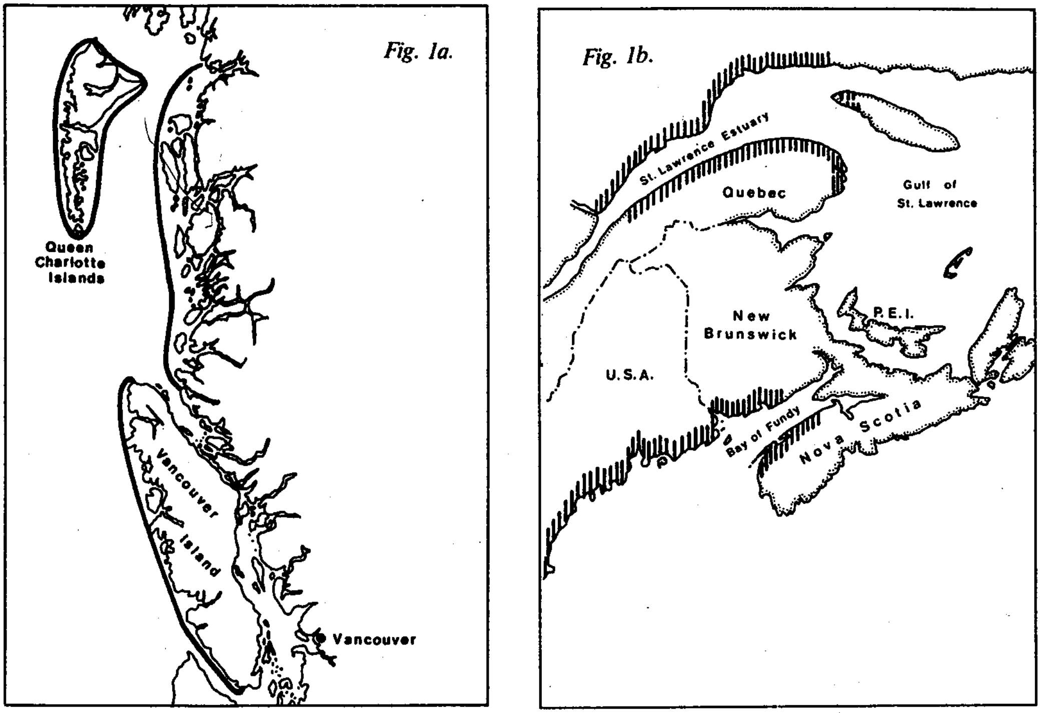

Fig. 1. The locations along the Canadian coasts of blooms of toxic dinoflagellates and of shellfish which accumulate the paralytic toxins. In British Columbia (Fig. 1a), the areas closed permanently to harvesting of certain shellfish are indicated. On the east coast (Fig. 1b), toxic shellfish occur in the southern Bay of Fundy and St. Lawrence River estuary (hatched areas). The first case of PSP in Newfoundland (off the map to the east) was reported in 1982.

through ingestion of overwintering *Gonyaulax* cysts.

Toxic Bloom Patterns

On the west coast of Canada, toxic *Gonyaulax* blooms may occur at any time between April and November. Most filter-feeding shellfish that become toxic during the blooms lose the toxins within several weeks to a few months. The butter clam, however, stores the toxins (in its siphon) for long periods and commonly remains toxic during the winter.

Gonyaulax blooms occur annually on the east coast of Canada some time between June and September. Blooms generally last for 3 or 4 weeks, during which time shellfish become toxic. Until recently, shellfish usually cleansed themselves of toxins by September or October and were then safe for harvesting. Over the past 5 years or so, however, shellfish in many prime digging areas in the Bay of Fundy have remained toxic year round, consistent with a trend of intensification of *Gonyaulax* blooms in the Bay of Fundy since about the mid-1970s. The reason for the intensification is unknown, but it is unlikely that pollution is involved because of the small amount of industrial and municipal input into the bay and the tremendous tidal mixing action in the area.

It should be stressed that the occurrence of a visible red tide is not necessary for the contamination of shellfish with dangerous levels of dinoflagellate toxins. In fact, red tides caused by *Gonyaulax* species are unusual in Canadian waters, yet recurring *Gonyaulax* blooms contaminate shellfish annually.

Toxicity Monitoring

The monitoring system for paralytic shellfish toxins in Canada is quite simple and effective. It was developed by Canadian scientists in the mid-1940s and has been employed, with little change, to the present. The safety threshold was chosen to be 80 μg of toxins/100 g meat. This figure has, over the years, become the international standard.

In brief, shellfish samples are collected by fisheries officers at least weekly during the potential danger period, paying special attention to key stations that are recognized through experience to precede adjacent areas in terms of the timing of the annual rise in toxicity. Samples are taken to the regional fisheries inspection laboratory (Department of Fisheries and Oceans) for extraction according to the AOAC method (Appendix 4). Extracts prepared by regional laboratories on both coasts are sent by air express to a central mouse-bioassay facility in Ottawa, which is part of the Department of Health and Welfare. Toxicity results are telephoned to the regional laboratories where the decision is made to close or open areas to shellfish harvesting. The process requires 1.5-2 days from the time of sampling. If the toxicity score exceeds 80 μg/100 g meat, the entire shellfish area is posted with warning signs (Fig. 2) and the area becomes officially closed to harvesting. Regional laboratories also have the capability to conduct mouse bioassays, but do so only for checking commercial shipments, distributors, restaurants, etc., and for research purposes.

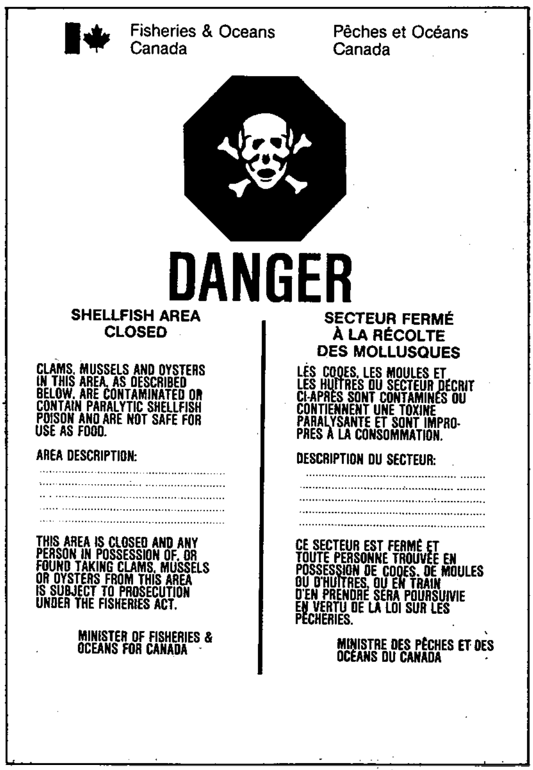

Fig. 2. A sign posted to notify the public of closure of shellfish area because the shellfish contain paralytic toxins from red-tide microorganisms.

In the Bay of Fundy, blue mussels become so highly toxic and are so rarely eaten by residents that a permanent ban on their harvesting has been enacted. In British Columbia, to cope with the problem of remote and inaccessible shellfish areas, permanent closures of vast stretches of coastline to the harvesting of shellfish are in effect.

Impact on Shellfish Industry

For many years, the shellfish industry in eastern Canada has operated with harvesting bans in effect during the summer months. Shellfish digging and distribution were geared to these summer closures. In recent years, however, continuous closure of many productive shellfish areas has been necessary and has resulted in considerable economic loss to the region through unemployment of shellfishermen and a shortage of shellfish supply.

The situation on the west coast is somewhat different. Permanent closures of vast shellfish areas have been in effect there for many years. The economic consequence is the loss of these potential resources.

Detoxification

Attempts at detoxifying shellfish contaminated with paralytic shellfish toxins have been made on several occasions over the years. Methods have included transplantation to waters free of the toxic dinoflagellates, and various temperature, salinity, and chemical treatments. So far, an economically feasible method has not yet been developed.

Several years ago, reports in the literature suggested that there may be some promise in using ozone to remove low to moderate amounts of toxins from shellfish. However, my laboratory has recently completed a rigorous series of studies on the effects of ozone on the detoxification of soft-shell clams and has not found any evidence of increased detoxification using ozone treatments.

Fish

Toxic *Gonyaulax* blooms can affect fish as well as shellfish resources. Herring kills in the Bay of Fundy in 1976 and 1979 were caused by *Gonyaulax* toxins, with toxin transfer through the food web. These events sparked a research program in my laboratory, the results of which may be summarized into the following general conclusions: (1) during toxic *Gonyaulax* blooms, marine zooplankton can accumulate the toxins, (2) the toxins can be transferred through the food web to fish, resulting in fish kills, (3) marine fish, in general, are sensitive to the toxins, in fact as sensitive as warm-blooded vertebrates, (4) since fish larvae are also sensitive to the toxins, recurrent *Gonyaulax* blooms may influence year-class strength of certain stocks, (5) fish, unlike shellfish, are not able to accumulate the toxins in their flesh, and (6) the toxins may be present in fish viscera and PSP may result if this material is eaten with little or no processing.

Current Research

Research in Canada on toxic dinoflagellates and shellfish toxicity is currently limited to two laboratories — Dr. F.J.R. Taylor's laboratory at the University of British Columbia (west coast) and my laboratory in St. Andrews, New Brunswick (east coast). The emphasis in Dr. Taylor's laboratory is on systematics and taxonomy, whereas the emphasis in my laboratory is on physiology and ecology. Current research focal points in Canada are the following: (1) taxonomy, systematics, and evolution, (2) physiology and ecology, using cultures in the laboratory, (3) investigations on bloom dynamics and controlling mechanisms, particularly long-term environmental cycles, (4) distribution of dinoflagellates relative to hydrographic conditions, (5) the role of overwintering cysts in bloom initiation, and (6) means of predicting dinoflagellate blooms, shellfish toxicity, and fish kills.