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Toxifying and detoxifying shellfish

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TOXIFYING AND DETOXIFYING SHELLFISH

The rates at which shellfish accumulate and eliminate toxins are species-specific. Low water temperature seems to retard toxin loss but the precise relationship between temperature and the uptake and release of toxins is not fully understood. Further, the rate of detoxification is highly dependent on the site of toxin storage within the animal. Toxins in the gastrointestinal tract (e.g., the blue mussel) are eliminated more quickly than toxins bound in tissues (scallops; the clams *Spisula*, and *Saxidimus*).

The existing data on toxin retention for a number of bivalve species are summarized in the accompanying table. Mussel (*Mytilus* and *Modiolus*) accumulate paralytic shellfish poisoning (PSP) toxins faster than most other species of shellfish and also eliminate them more quickly. Oysters, on the other hand, accumulate the toxins more slowly than mussels, but they take considerably longer to detoxify. In contrast, species such as *Saxidimus giganteus* and *Spisula solidissima* may remain toxic for extended periods (in the case of *Saxidimus*, for more than 2 years). Differences among species regarding toxin accumulation and retention time should be given serious consideration when species are evaluated for culture in areas prone to toxic algal blooms.

Detoxifying shellfish contaminated with paralytic shellfish toxins has been attempted in an effort to reduce the "off market" period. The most obvious method is to transplant shellfish to waters free of the toxic organisms and allow them to self-depurate. While this is satisfactory for many species of shellfish, detoxification rates vary considerably between species and some remain toxic for extended periods of time. Detoxification using temperature or salinity stress has been tried with marginal success. Chlorination has also been used in France but this alters the flavor of the shellfish and decreases marketability.

Ozonation is a promising method although its capabilities are limited. Several investigations have used ozone to inactivate PSP toxins in shellfish exposed to blooms of *Protogonyaulax tamarensis, catenella* and *breve*, although others have obtained conflicting results.

Conventional wisdom now holds that ozonized seawater can be used to detoxify shellfish recently contaminated by the vegetative cell phase of toxic dinoflagellates, but not if they were intoxicated by cysts. In a study during a red-tide outbreak, ozone treatment of seawater prevented shellfish from accumulating paralytic shellfish poison. From these various results, it has been concluded that inactivation can be achieved in bivalves without measurably altering their physical state, and that it can be done rapidly enough to be economically feasible. Ozone is useless in detoxifying bivalves that have ingested cysts or have had the toxins bound in their tissue over long periods of time.

At present the economic feasibility of detoxifying shellfish on a large scale in artificial systems is questionable. In areas prone to regular outbreaks of toxic algal species, culturists and commercial fishermen alike must still depend on reliable monitoring systems to warn of toxic shellfish.

Monitoring

The advantages of being able to predict the occurrence of potentially detrimental algal blooms are obvious. Early detection would allow officials to warn people, and a forewarning to culturist could save them from economic disaster. Unfortunately, what is lacking is an effective way of predicting the onset of algal blooms.

There is increasing evidence that most blooms originate in the ocean rather than in bays, and it is possible that key meteorological and oceanographic parameters could be used to evaluate the probability of a bloom. Oceanographers are already capable of identifying areas where there is a high probability that a bloom will occur, but accurate prediction is still not possible. Undoubtedly, as more studies explore the correlations between bloom events and environmental parameters, predictive capability will improve.

Approximate toxin retention time for various species of bivalve molluscs

Species	Toxin Source	Retention Time
Anadara maculosa	*Pyrodinium bahamense*	6 weeks
Arctica islandica	*Protogonyaulax tamarensis*	2 months *in vivo*
Choromytilus meridionalis	*Gonyaulax catenella*	3 months
Clinocardium nuttali	*Gonyaulax acatenella*	9 weeks
Crassostrea cuculatta	not specified; probably *Pyrodinium bahamense*	2 months
Crassostrea echinata	*Pyrodinium bahamense*	3 weeks in closed system; longer *in vivo*
Crassostrea gigas	*Gonyaulax acantenella*	1-9 weeks
Crassostrea virginica	*Gymnodinium breve*	2-6 weeks
Meretrix casta	not specified; probably *Pyrodinium bahamense*	1 month
Modiolus auriculatus	*Pyrodinium bahamense*	6 weeks
Modiolus modiolus	*Gonyaulax tamarensis*	up to 60 days
Mya arenaria	*Gonyaulax acatenella*	5 weeks
	Gonyaulax temarensis	4-6 weeks
Mytilus californianus	*Gonyaulax catenella*	< one month
Mytilus edulis	*Protogonyaulax tamarensis*	10-50 days
	Gonyaulax acatenella	4-11 weeks
Patinopecten yessoensis	*Protogonyaulax tamarensis*	6 weeks to 5 months
Placopecten magellanicus	*Protogonyaulax tamarensis*	6 months in closed system; can be year-round *in vivo*
Protothaca staminea	*Protogonyaulax acatenella*	5 weeks
Saxidomus giganteus	*Protogonyaulax acatenella*	>2 years
Saxidimus solidissima	*Gonyaulax catenella*	<one month
Spondylus sp	*Pyrodinium bahamense*	highly toxic after months
Tresus capax	*Gonyaulax acatenella*	11 weeks
Venerupis japonica	*Gonyaulax acatenella*	5 weeks

Since most blooms originate offshore, satellite imagery, satellite-tracked monitoring buoys, aircraft and balloons could be part of an early warning system for detecting blooms. These vehicles would be equipped with sensors to monitor specific environmental parameters known to be asssociated with algal blooms. Instrumentation for satellites and aircraft has been developed which utilizes the light absorbed or emitted as fluorescence from algae. Unfortunately, there is no definitive way to distinguish between toxic and nontoxic blooms.

In the absence of predictive capabilities, monitoring remains the most powerful tool available to management. Monitoring of phytoplankton is simple and relatively inexpensive, and it can forewarn of potentially harmful conditions and detect new species that may pose a hazard. This type of monitoring is an integral part of mariculture in Japan.

Many countries have established comprehensive monitoring programs, but these are usually in response to a massive outbreak of toxic algae. It is an unfortunate human tendency to lavish the most attention on blooms that result in fatalities.

While regular water sampling and satellite monitoring will help locate toxic blooms in their early stages of development, the methods are by no means failsafe, making it difficult for farms and aquaculture facilities to plan their harvests. Even in the event of an early warning, it is impossible to prevent most species of bivalves from becoming toxic. An early warning can, however, prevent the sale and consumption of toxic shellfish and allow growers to harvest early or plan their harvests to minimize economic damage.

Source: Sandra E. Shumway, "Toxic Algae - a serious threat to shellfish aquaculture," **World Aquaculture,** Vol. 20(4), December 1989.