self-limited; most patients recover in 3 or 4 days, and only a few require hospitalization. Treatment is supportive and focused on hydration. Toxins can be detected in food samples by a mouse bioassay, an immunoassay, and high-performance liquid chromatography with fluorometric detection (HPLC-FLD).

PARALYTIC SHELLFISH POISONING

Paralytic shellfish poisoning is induced by ingestion of any of a variety of feral or aquacultured filter-feeding organisms, including clams, oysters, scallops, mussels, chitons, limpets, starfish, and sand crabs. The origin of their toxicity is the chemical toxin they accumulate and concentrate by feeding on various planktonic dinoflagellates (e.g., *Protogonyaulax, Ptychodiscus*, and *Gymnodinium*) and protozoan organisms. The unicellular phytoplanktonic organisms form the foundation of the food chain, and in warm summer months these organisms "bloom" in nutrient-rich coastal temperate and semitropical waters. In the United States, paralytic shellfish poisoning is acquired primarily from seafood harvested in the Northeast, the Pacific Northwest, and Alaska. These planktonic species can release massive amounts of toxic metabolites into the water and cause mortality in bird and marine populations. The paralytic shellfish toxins are water soluble as well as heat and acid stable; they cannot be destroyed by ordinary cooking or freezing. Contaminated seafood looks, smells, and tastes normal. The best-characterized, most potent, and most frequently identified paralytic shellfish toxin is saxitoxin, which takes its name from the Alaska butter clam *Saxidomus giganteus.* Saxitoxin appears to block sodium conductance, inhibiting neuromuscular transmission at the axonal and muscle membrane levels. A toxin concentration of >75 μg/100 g of foodstuff is considered hazardous to humans. In the 1972 New England "red tide," the concentration of saxitoxin in blue mussels exceeded 9000 μg/100 g of foodstuff.

The onset of intraoral and perioral paresthesias (notably of the lips, tongue, and gums) comes within minutes to a few hours after ingestion of contaminated shellfish, and these paresthesias progress rapidly to involve the neck and distal extremities. The tingling or burning sensation later changes to numbness. Other symptoms rapidly develop and include light-headedness, disequilibrium, incoordination, weakness, hyperreflexia, incoherence, dysarthria, sialorrhea, dysphagia, thirst, diarrhea, abdominal pain, nausea, vomiting, nystagmus, dysmetria, headache, diaphoresis, loss of vision, chest pain, and tachycardia. Flaccid paralysis and respiratory insufficiency may follow 2–12 h after ingestion. In the absence of hypoxia, the victim often remains alert but paralyzed. Up to 12% of patients die.

TREATMENT PARALYTIC SHELLFISH POISONING

Treatment is supportive and based on symptoms. If the victim comes to medical attention within the first few hours after poison ingestion, the stomach should be emptied by gastric lavage and then irrigated with 2 L (in 200-mL aliquots) of a solution of 2% sodium bicarbonate; this intervention has not been proved to be of benefit but is based on the notion that gastric acidity may enhance the potency of saxitoxin. Because breathing difficulty can be rapid in onset, induction of emesis is not advised. The administration of activated charcoal (50–100 g) and a cathartic (sorbitol, 20–50 g) makes empirical sense because these shellfish toxins are believed to bind well to charcoal. Some authors advise against administration of magnesium-based solutions (e.g., certain cathartics), cautioning that hypermagnesemia may contribute to suppression of nerve conduction.

The most serious problem is respiratory paralysis. The victim should be closely observed for respiratory distress for at least 24 h in a hospital. With prompt recognition of ventilatory failure, endotracheal intubation, and assisted ventilation, anoxic myocardial and brain injury may be prevented. If the patient survives for 18 h, the prognosis is good for a complete recovery.

A direct human serum assay to identify the toxin responsible for paralytic shellfish poisoning is not yet clinically available; the mouse bioassay in widespread use may be replaced by an automated tissue-culture bioassay. A polyclonal enzyme-linked immunosorbent assay (ELISA) to measure specific toxins is under development, as is HPLC-FLD. In addition, an inhibition immunoassay that may be able to simultaneously detect paralytic shellfish, diarrhetic shellfish, and amnesic shellfish toxins is being investigated.

DOMOIC ACID INTOXICATION (AMNESTIC SHELLFISH POISONING)

In late 1987 in eastern Canada, an outbreak of gastrointestinal and neurologic symptoms (amnestic shellfish poisoning) was documented in persons who had consumed mussels found to be contaminated with domoic acid. In this outbreak, the source of the toxin was *Nitzschia pungens*, a diatom ingested by the mussels. Since the Canadian outbreak, the toxin has been found in shellfish from the United States, the United Kingdom, and Spain. In 1991, an epidemic of domoic acid poisoning in the state of Washington was attributed to the consumption of razor clams. A water-soluble, heat-stable neuroexcitatory amino acid with biochemical analogues of kainic acid and glutamic acid, domoic acid binds to the kainate type of glutamate receptor with three times the affinity of kainic acid and is 20 times as powerful a toxin. Shellfish can be tested for domoic acid by mouse bioassay and HPLC. The regulatory limit for domoic acid in shellfish is 20 parts per million.

The abnormalities noted within 24 h of ingesting contaminated mussels (*Mytilus edulis*) include arousal, confusion, disorientation, and memory loss. The median time of onset is 5.5 h. Other prominent signs and symptoms include severe headache, nausea, vomiting, diarrhea, abdominal cramps, hiccups, arrhythmias, hypotension, seizures, ophthalmoplegia, pupillary dilation, piloerection, hemiparesis, mutism, grimacing, agitation, emotional lability, coma, copious bronchial secretions, and pulmonary edema. Histologic study of brain tissue taken at autopsy has shown neuronal necrosis or cell loss and astrocytosis, most prominently in the hippocampus and the amygdaloid nucleus—findings similar to those in animals poisoned with kainic acid. Several months after the primary intoxication, victims still display chronic residual memory deficits and motor neuronopathy or axonopathy. Nonneurologic illness does not persist.

TREATMENT DOMOIC ACID INTOXICATION

Therapy is supportive and based on symptoms. Because kainic acid neuropathology seems to be nearly entirely seizure mediated, the emphasis should be on anticonvulsive therapy, for which diazepam appears to be as effective as any other drug.

SCOMBROID POISONING

Scombroid fish poisoning may be the most common type of seafood poisoning worldwide. It follows consumption of scombroid (mackerel-like) fish, which include albacore, bluefin, and yellowfin tuna; mackerel; saury; needlefish; wahoo; skipjack; and bonito, as well as nonscombroid fish, such as dolphinfish (Hawaiian mahimahi, *Coryphaena hippurus*), kahawai, sardine, black marlin, pilchard, anchovy, herring, amberjack, and Australian ocean salmon. In the northeastern and mid-Atlantic United States, bluefish (*Pomatomus saltatrix*) has been linked to scombroid poisoning. Because greater numbers of nonscombroid fish are being recognized as scombrotoxic, the syndrome may more appropriately be called *pseudoallergic fish poisoning.*

Under conditions of inadequate preservation or refrigeration, the musculature of these dark- or red-fleshed fish undergoes decomposition by *Proteus morganii* and *Klebsiella pneumoniae* bacteria, with consequent decarboxylation of the amino acid L-histidine to histamine, histamine phosphate, and histamine hydrochloride. Histamine levels of 20–50 mg/100 g are noted in toxic fish, with levels >400 mg/100 g on occasion. However, it is possible that some other compound may be responsible for this intoxication, because large doses of oral histamine do not reproduce the affliction. It is proposed that this unknown agent works by inhibiting the metabolism of histamine, promoting degranulation of mast cells to release endogenous histamine, or acting as a histamine receptor agonist. Whatever toxin or toxins are involved