Paralytic Shellfish Poisoning
Safe Shellfish

by

D. B. Quayle

Fisheries Research Board of Canada
Biological Station, Nanaimo, B.C.

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The two main problems connected with the safe use of molluscan shellfish are those of sewage pollution and paralytic shellfish poisoning.

The solution to the problem of sewage pollution is relatively simple. Pollution is directly related to the bacterial content of the waters in which the shellfish are grown, and there is constant surveillance both of these waters and of the shellfish themselves by public health authorities. Consequently, any shellfish entering the market are perfectly safe. When oysters or clams are gathered for personal use, care should be taken to see that the area from which they are collected is well removed from any source of pollution such as a sewer or septic tank outfall. In addition, stored shellfish should be adequately refrigerated.

The problem of paralytic shellfish poisoning is a much more difficult one and it is the purpose of this account to indicate why this is so and to show how personal use of shellfish may be made as safe as possible.

History of shellfish poisoning in British Columbia

The history of shellfish poisoning in British Columbia began in June, 1793, when one of Captain George Vancouver's sailors died and four others became quite ill after eating mussels at Poison Cove, in Matheson Channel not far from Ocean Falls.

The next known occurrence happened in Barkley Sound in May, 1942, when three persons died and eight others became ill from eating clams or mussels. Also during the same week three others died from eating clams near Port Angeles, Washington. As a consequence of this outbreak, a testing program was instituted and the first results, in 1942 and 1943, caused the whole west coast of Vancouver Island and the Gordon Group of islands in Queen Charlotte Strait to be closed to the taking of butter clams and mussels. This closure continued until 1953.

Widespread sampling during this time showed the poisonous shellfish to occur mainly along the shores of the outer coast, for no significant toxicity was found in Georgia Strait or in the mainland inlets.

However, this supposition proved unfounded when, in late October 1957, 60 certain and 50 probable cases of illness occurred from eating various species of shellfish, including oysters, in the Comox area. This was the first time oysters had been definitely implicated in poisoning on the Pacific coast. At this time, toxicity was recorded along the east coast of Vancouver Island, between Campbell River and Ladysmith.

The next known outbreak occurred in mid-June of 1963, when high toxicity in butter clams was found near Namu, on the central British Columbia coast. Subsequent testing showed toxic clams to occur along the whole coast between Cape Caution and the Alaskan border, including the Queen Charlotte Islands. The closure applied at that time is still in effect, for there is still a moderate amount of toxin present in these areas and, as a result, commercial production of butter clams has been seriously curtailed. In August of 1964, several cases of illness, apparently due to eating butter clams, were reported in the Prince Rupert area. After a considerable amount of detective work by the Department of Fisheries, the source of the clams was found to be in the Cosine Island area, about 50 miles south of Prince Rupert. The toxicities were at an extremely high level. This was a case where the individuals concerned either did not know of the closure or failed to heed it.

On June 1, 1965, one death occurred and four people became ill from eating cockles taken from a small bay in Malaspina Inlet which lies in the northeast corner of Georgia Strait. Several other species of shellfish including clams, mussels and oysters were found to be quite toxic. Subsequent testing showed that all species save butter clams had lost most of the poison within six weeks of the peak toxicity, and as of November 1, 1965, only butter clams were kept under a ban in this area, which takes in Fishery District 15.

The location of all of these outbreaks is shown in Fig. 1.

It may be concluded from this historical summary that outbreaks of shellfish toxicity may occur almost anywhere along the British Columbia coast, at any time between May and October, inclusive. However, the danger of toxicity may exist throughout the year owing to the ability of certain species to retain some poison for a considerable time. For this reason, it has not been possible to harvest butter clams in southeastern Alaska for many years.

Source of the toxin

Extensive studies over the past thirty years have shown that the source of the poison is a microscopic, one-celled organism, about 1/1000 of an inch in diameter, which occurs in sea water in varying abundance in various parts of North America. This organism is enclosed in armour made up of intricately shaped plates. The species involved on the Pacific coast are *Gonyaulax catenella* and *Gonyaulax acatenella* (Fig. 2). On the Atlantic coast of North America, where shellfish toxicity occurs mainly in the Gulf of St. Lawrence and the Bay of Fundy, the causative organism is *Gonyaulax tamarensis*.

Those molluscan shellfish that become toxic are all filter feeders. This means that they obtain nourishment by filtering out food particles contained in the water which is pumped in considerable quantities through a collecting system associated with the gills. Such filter feeders include most clams, and all oysters, mussels and scallops. Some of the edible molluscs of British Columbia that may become poisonous are shown in Fig. 3.

In one form or another Gonyaulax is probably present in small numbers everywhere along the coast throughout the year. But it is only in the summer when conditions of light, temperature, salinity, nutrients, minerals and vitamins are present in the right combinations that rapid multiplication occurs. Then they may become so numerous the water becomes coloured, hence the name "red tide" which has become associated with paralytic shellfish poisoning. However, in British Columbia, there are a dozen or so species of one-celled organisms that may cause coloured water; yet of all these, only the two species of Gonyaulax mentioned above are known to cause shellfish to become poisonous. Red tides in other parts of the world are known to cause mortality in fish or in molluscs, but such occurrences are not known here.

Thus, when filter feeding shellfish feed on such high concentrations of organisms (such increases are called "blooms"), they become toxic by extracting and storing the minute quantity of poison held in each Gonyaulax cell. Millions of cells may be ingested by a single shellfish which itself is not harmed by the toxin it stores. Indeed, the poison is particularly dangerous only to warm blooded animals.

The poison itself, one of the most potent known, is a complex chemical which affects the transmission of nerve impulses. The symptoms of paralytic shellfish poisoning in humans usually takes the form of initial tingling and numbness in the lips and tongue, followed by similar sensations in the finger tips and toes and a final loss of control of voluntary movements. Also there may be difficulty in breathing. The effect of the toxin seems to be greatest when the stomach is empty. So far there is no known antidote and treatment consists of emptying the stomach with an emetic, and the use of a rapid laxative. Artificial respiration should be applied if breathing becomes difficult.

Testing for the poison

Unfortunately there is still no rapid way of determining whether or not shellfish are toxic. A chemical test has been developed but it is a complex procedure unsuitable for general use.

The standard procedure for testing is to mince the meats of a dozen or so shellfish and to extract the toxin from a known quantity of this meat by boiling it in weak hydrochloric acid. The volume and the acidity are adjusted and the liquid is clarified, after which a small quantity is injected into the body cavity of test mice. From the death times of several mice, the poison content of the shellfish meat may be calculated in terms of what are called mouse units of toxin.

The amount of poison that will cause death cannot be stated with certainty, for it seems there are individual differences in susceptibility. However, mild symptoms of poisoning are known to occur at values up to 5000 mouse units per 100 grams of meat (3.5 ounces), and beyond that point the symptoms become more and more severe.

Testing is a cooperative venture between the Federal Department of Fisheries, the Federal Department of Health and Welfare, and the Provincial Department of Health.

Control measures

Since the mouse test is the only way to determine the toxicity of shellfish, control in British Columbia at the present time requires a continuous sampling program. To this end, samples of butter clams and oysters are taken at specific locations along the whole coast twice monthly, throughout the year. It is obvious this is not a perfect system since there is always a period of time between samples during which shellfish may become toxic. Further, it is impossible to adequately sample 10,000 miles of coastline. Nevertheless, the system has worked moderately well for the last twenty years.

In addition, in the Georgia Strait area, Provincial Public Health units and Department of Fisheries patrol vessels collect samples of coloured water whenever they are observed. These are sent as quickly as possible to the Biological Station at Nanaimo, where microscopic examination can rapidly determine whether or not the species causing the colouration is one of the toxic ones.

Whenever toxicity values of shellfish exceed 500 mouse units per 100 grams of meat, the area or areas involved are closed to the taking of shellfish and warnings are posted at wharves, marinas and post offices.

It should be remembered that no one in British Columbia has suffered poisoning from shellfish that have gone through commercial channels and the few poisonings that have occurred have resulted from personal use of shellfish.

Species of shellfish involved

As indicated previously all filter feeding molluscs may become toxic. This excludes, of course, crustaceans such as crabs and shrimps. However, not all filter feeders become toxic to the same extent, and the rate at which the toxin is lost varies from species to species.

The period of time during which *Gonyaulax* occurs in sufficient numbers to cause toxicity is variable, but usually it does not last for

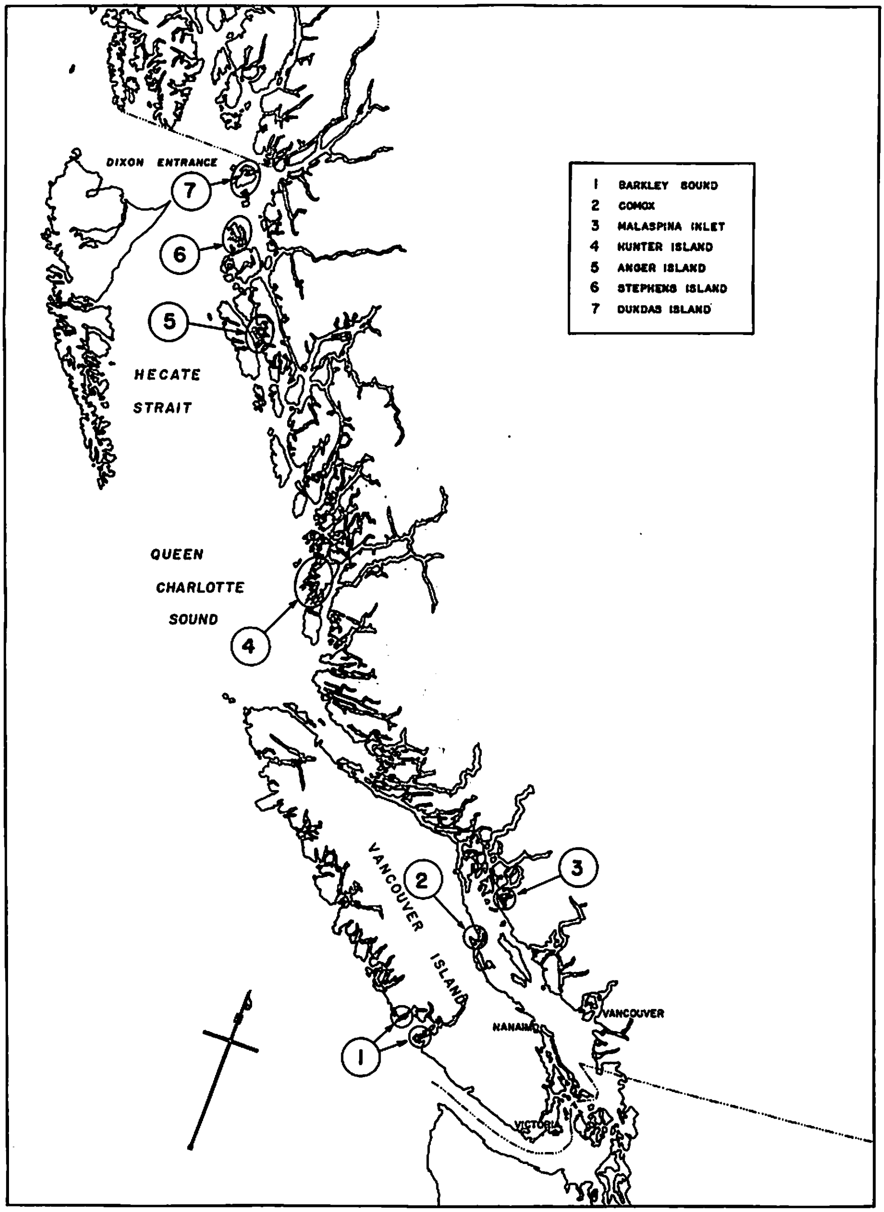

Fig. 1. Map of the British Columbia coast showing areas of outbreaks of paralytic shellfish poisoning.

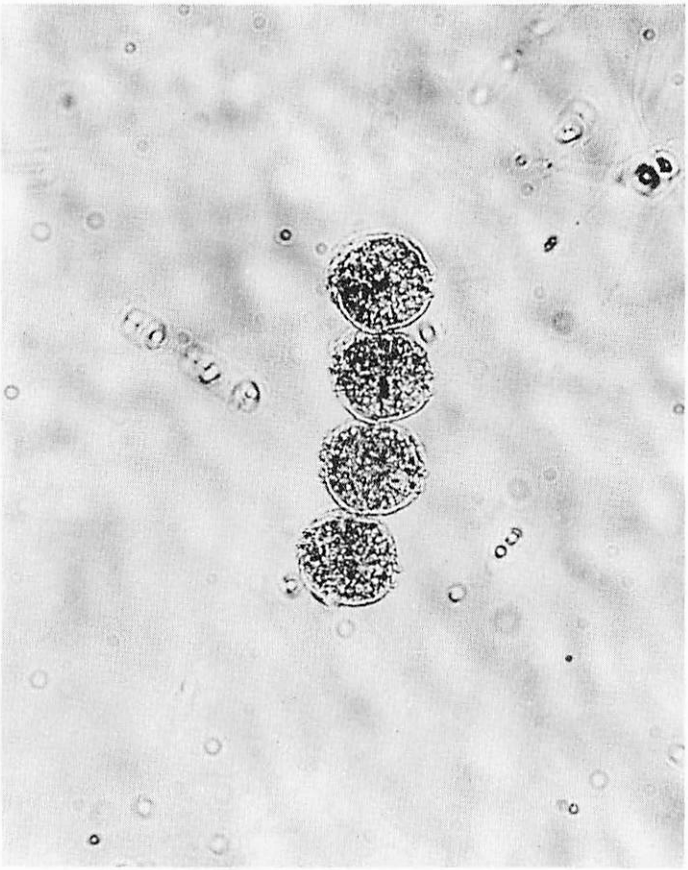

Fig. 2. Photomicrograph of a chain of four cells of _Gonyaulax acatenella_, one of the organisms causing paralytic shellfish poison. The lighter, smaller objects are mainly diatoms.

more than a week or so. Then when Gonyaulax disappears, the amount of toxin in the shellfish begins to decline and, with only one exception, all species of shellfish become virtually non-toxic in four to six weeks. The notable exception is the butter clam (Saxidomus giganteus), which may retain some toxicity for nearly two years after the initial toxification. The reason for this is that considerable proportion of the toxin becomes concentrated in the siphon (neck) and gills (Fig. 4). These organs lose their toxicity very slowly while the body of the clam does so relatively rapidly. At the time of peak toxicity, butter clams may concentrate up to 80% of the total toxin in the gills and siphons, which represent about 30% of the meat weight of a clam. The black tip of the siphon of a butter clam is its most poisonous part, and 112,000 mouse units per 100 grams of meat have been recorded for it.

Razor clams are seldom affected, and then only to a slight extent; and here the siphon tips, gills, stomach and digestive glands are normally removed both in the domestic and commercial preparation of this species.

Safe shellfish

Since there is the possibility of molluscan shellfish becoming toxic during the period from May to October, and of butter clams retaining toxicity during the whole year, the safe use of these species necessitates certain precautions.

First, it should be ascertained whether there is a ban in effect on the taking of shellfish in the particular area from which they are to be gathered. Local residents are usually aware of this owing to publicity and, in addition, there are the posted warning signs. If there is a ban in effect, the shellfish specified should not be used under any circumstances.

If there is no ban, additional protection may be obtained by proper preparation of the shellfish. Unless it is known that the shellfish to be used are entirely safe, they should be cooked fairly well for heat will destroy some of the poison content. The nectar or bouillon from the cooking process should not be used, for any poison in the clam meat, particularly if the siphons are present, will become concentrated in the cooking liquid.

The butter clam is the most abundant and widely used clam in British Columbia. Recalling the fact that most of the toxin in this species is contained in the siphon and gills, these should be removed before cooking. Thus the butter clam should be opened fresh like an oyster. This may be easily done by slipping a thin bladed knife into the open end, and severing first one and then the other of the two adductor muscles (Fig. 4) which hold the shells together. The body can then be removed from the shells. The mantle muscles are nipped off at each end near the adductor muscles, either with the fingers or with a knife. The two adductor muscles are also removed. Then the siphon and gills may be stripped off and discarded. As a final precaution, most of the dark (digestive) gland may also be removed from the top of the body. This then leaves five pieces of meat, the body, two adductor muscles and two mantle muscles (Fig. 5). These meats may then be cooked in the usual manner, although chowder preparation causes more reduction of toxicity in butter clams than does frying. Raw clam parts, obtained as described, when compared to similar parts from whole steamed clams are less toxic, so raw shucking of butter clams is recommended.

It must also be remembered that the amount of toxin, when present, is proportional to the amount of shellfish meat, so the dose of poison is proportional to the amount of meat eaten.

If these precautions are carefully observed, the risk of being poisoned by clams is very much reduced.

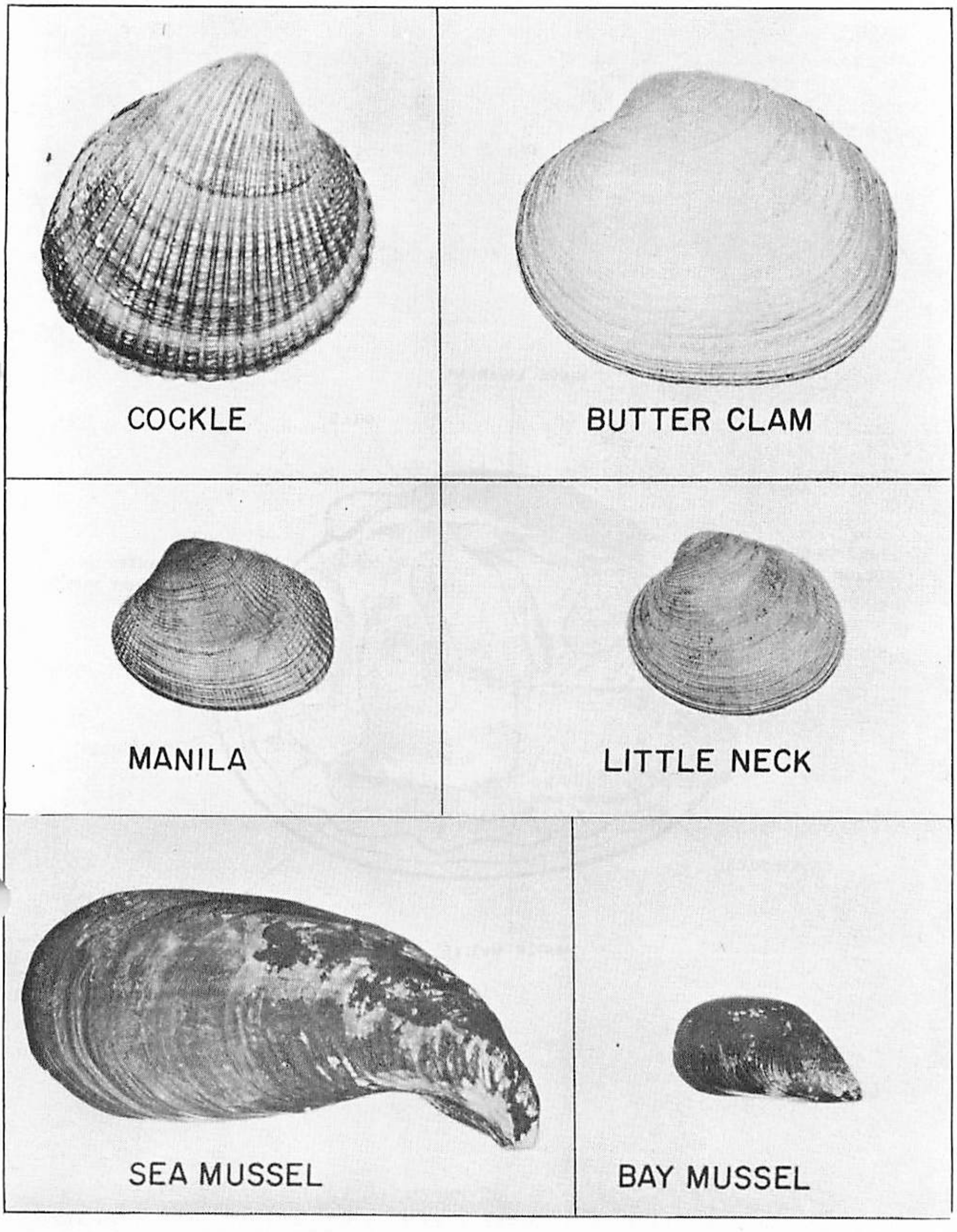

Fig. 3. The most frequently used species of edible molluscs that may become toxic.

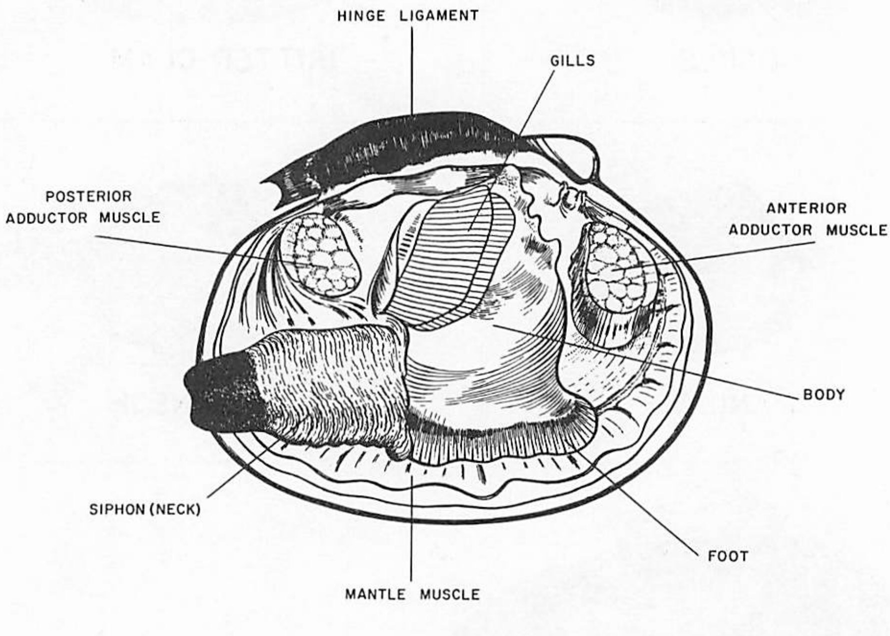

Fig. 4. The right side of a butter clam (Saxidomus giganteus) with the right shell and mantle removed to show the various parts of the body.

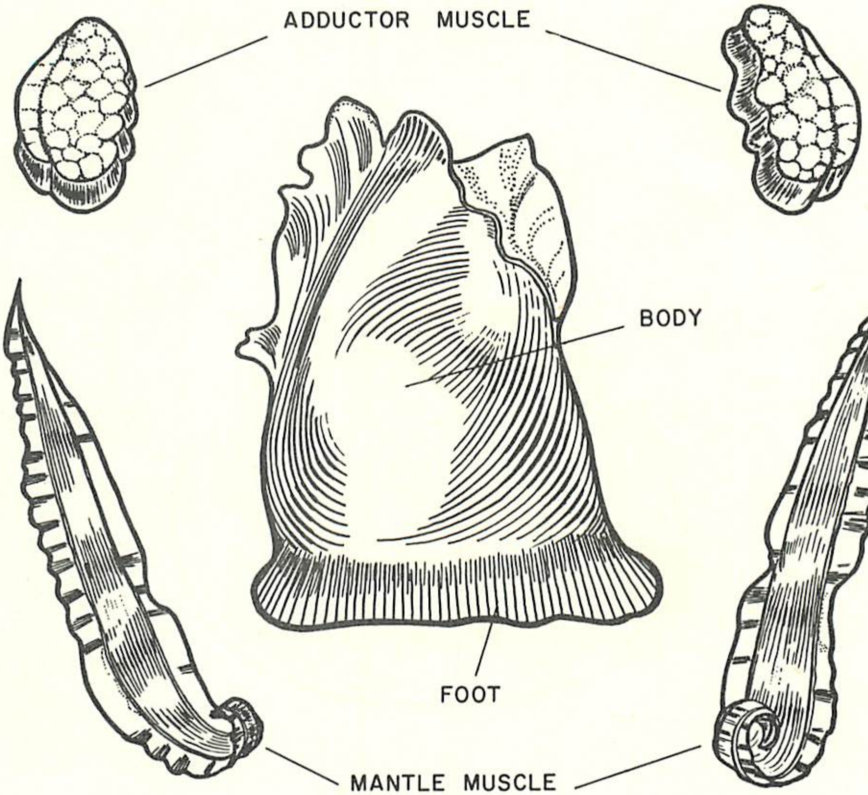

Fig. 5. The five edible parts of the butter clam remaining after the siphons and gills have been removed.