GLASS SPONGES AND SPONGE REEFS IN BRITISH COLUMBIA WATERS

**By Dr. Sally Leys, Department of Biological Sciences,
University of Alberta**

What are glass sponges?

Sponges are normally thought of as soft and porous, hence absorbent. But most sponges have both a spongy, organic skeleton, and a hard mineral skeleton, and are not very soft at all. In one group, the glass sponges, the mineral skeleton is made of nearly pure glass (silica dioxide). These animals harness silica from the ocean and secrete it into long sharp shards, called spicules, which they mount together like a set of tent poles.

There are two main types of glass sponges: those whose spicules are loosely held together by the soft tissue **– non-reef forming species**; and those that form the silica into a rigid, 3-dimensional scaffolding that can be over a meter in height and width, and resembles a delicate, porous glass palace – the **reef forming variety**. The animal's soft tissue wraps around this scaffolding giving the whole structure a creamy-white appearance.

The cloud sponge (*Aphrocallistes vastus*)

Glass sponges are found throughout the world in deep oceans (500-3000 m); for example, they are known from the Caribbean, the IndoPacific, the north and south Atlantic. However, there are only four places in the world that glass sponges can be found in waters shallower than 500 m: Antarctica, fjords of New Zealand, some caves in the Mediterranean, and the coastal waters of western Canada.

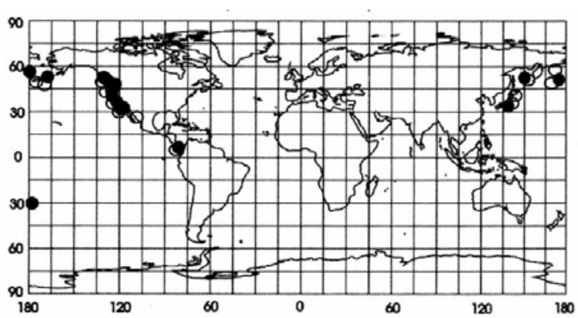
Glass sponges are particularly unusual animals because the majority of their soft tissue is made of a giant multinucleated cell, not individual cells like other animals. Because of this, at least one species can send electrical signals through the whole animal, in the same way that signals travel through nerves. These signals are typically in response to touch or to sediment in the water. The signal reaches all parts of the sponge and causes the sponge to stop filtering water. After a few minutes, the sponge will start its filtering again, but if the irritation is still there it will stop again, and it will keep testing the water in this way until the water is clear of sediment or the disturbance has gone.

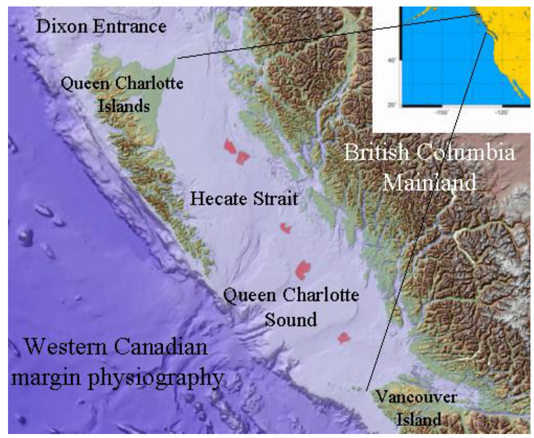
What are sponge reefs?

Sponge reefs are made by the type of glass sponge that has a rigid 3-D skeleton. The reefs form just like coral reefs, by new generations growing on previous generations. The offspring of glass sponges are free-swimming larvae about a tenth of a millimeter in length, and although scientists don't yet know when larvae are released by reef forming glass sponges, they have found juvenile sponges attached to the skeleton of dead sponges in summer months.

Though glass sponges are found in coastal waters in other parts of the world, the distribution of the main reef forming species is heavily biased to cold northern Pacific waters (see figure below). Glass sponge reefs have only been found on the continental shelf of western Canada. Four reefs in Hecate Strait and Queen Charlotte Sound cover over 425 km^2 (see figure below). Two smaller reefs have been found in Georgia Strait. It is conceivable that more reefs could exist where there are favourable conditions for reef growth, northwards along the Alaskan continental shelf and around the Bering Strait toward Japan.

Figure: (Left) the present day distribution of the two primary reef forming species, *Aphrocallistes vastus*, the cloud sponge (closed circles), and *Heterochone calyx* (open circles). Distribution represents documented collections of individuals, not reefs. [Adapted from Leys & Reiswig 2004, Grzimek's Animal Life Encyclopedia, and Reiswig, 2002, Systema Porifera pp1281-1360]
(Right) Locations of known sponge reefs in Hecate Strait, Queen Charlotte Sound. [From Conway et al., 2001. Geoscience Canada 28:71-78.]





What are the conditions sponge reefs need for growth?
Because glass sponges are only found in very select locations, presumably they have very particular requirements for growth; the reefs even more so. Scientists believe there are four main requirements for the growth of glass sponges: cold water, low light, high dissolved silica concentrations and low sedimentation rates.

The first three requirements are found throughout coastal waters of the Pacific Northwest. In many of the fjords of western Canada individual sponges can be found as shallow as 18 m, but they are more common deeper than 30 m, and large numbers live between 40 and 260 m. The water temperature at these depths is between 6 and 12°C. Very little light penetrates deeper than 15 m in most coastal waters, and light is all but absent deeper than 100 m. High silica concentrations seem to be critical for the growth of reef sponges, presumably because vast amounts of silica are needed for constructing the glass sponge skeleton. Whereas levels of dissolved silica are low in both the Atlantic and in tropical Pacific waters, silica concentrations are high in coastal waters of the Pacific Northwest and also in Arctic and Antarctic oceans.

The last requirement is that of low sedimentation rates. The exact role of sediment in promoting or harming sponge reefs is still unclear. While some sedimentation is presumably needed in order to help cement the skeletons into the reef matrix, reef forming glass sponges do not appear to thrive in regions where there is a lot of fine particulates both suspended in the water, and settling on the substrate. This is the evidence:

First, most animals that filter the water to feed have mechanisms to prevent clogging by sediment. The fact that one type of glass sponge that lives in B.C. fjords stops feeding when sediment is in the water suggests that this is also true of other glass sponges. Because the soft parts of all glass sponges are similar, it is presumed that all glass sponges are sensitive to sediment in the water.

Second, fewer glass sponges are found in areas of high sedimentation than in areas of low sedimentation. A survey of glass sponge distribution in four of British Columbia's fjords (Saanich Inlet, Howe Sound, Jervis Inlet, and Knight Inlet) shows that glass sponges are least abundant in Knight Inlet, which has the most sediment input due to runoff from the Klinaklini River. Fewest sponges were found near the head of Knight Inlet, and those that were seen were 'dripping in mud', according to observers in a submersible.

Finally, and most importantly, because the juveniles can only attach to hard surfaces, they are restricted to vertical surfaces that don't collect sediment (e.g. the walls of fjords), or to skeletons of dead sponges that are not yet covered in sediment, such as on the reefs. While the fjord walls have lots of glass sponges and young ones do attach to the skeletons of dead sponges, they can't form reef structures because eventually the skeletons fall off the walls.

The continental shelf is different. It is relatively flat, with a few 'valleys' that were scoured out by glaciers between 20,000 and 14,000 years ago. While much of the shelf is covered by sediment, a few areas have remained sediment-free. Today little new sediment is deposited on the shelf because it gets trapped in the deep fiords and channels at the edge of the Coast Mountains. Some of the sediment free areas are mounds of glacial boulders that were piled up as icebergs gouged out troughs in the seafloor. Currents moving over the shelf kept sediment off the boulders, allowing juvenile sponges to attach. When these first sponges died, young sponges grew on their skeletons, and the skeletons gradually filled in with accumulated sediment. After many years, only the surface of new live sponges is visible. Some of the ice scoured troughs are quite long, so one reef is 30 km long and 15 km wide and some are up to 21 m thick. At 150 to 240 m depths, they continue to be dark, cold, environments with locally high amounts of dissolved silica, the right conditions for growth of the reef forming sponges, and of sponge reefs.

Given the apparent sensitivity of glass sponges to high rates of sedimentation, the recent finding of a sponge reef on the Fraser Ridge at the mouth of the Fraser River – a highly turbid environment – might seem surprising. However, presumably the turbulence at the Fraser Ridge is sufficient to prevent sediment from staying, so that the juveniles could start the reef, and so that skeletons are not buried before new animals can attach. Whether the sponges don't feed during the entire period of spring runoff, is unknown. Tropical sponge populations have seasonal variations in feeding behaviour in response to turbulence caused by storms. It will be of great interest to discover whether the reef sponges on the Fraser Ridge are adapted to ride out the spring sediment loads from the Fraser River freshet, or whether the freshet actually carries more food than fine sediments for the sponges.

Where have sponge reefs been since the Jurassic?
Though the Canadian sponge reefs are certainly unusual in today's world, they were commonplace about 200 million years ago. At that time, a large shallow sea – the Tethys Sea – which occupied what is now most of Europe, must have had similar conditions to those in western Canadian waters today because vast reefs grew along its margins. During the Cretaceous (144 to 66 mya) these reefs diminished, and today the only sponge reefs known are those in Canadian waters. The change in reef abundance is probably due to loss of continental shelf habitats with the necessary conditions for growth of reef-forming sponges. Individual glass sponges, descendants of the species that form reefs, must have survived in coastal waters of the continents of the time, much as individual sponges do in Canada's Pacific coast fjords today.

How fast do the sponges grow and how old are the reefs?
Both types of glass sponge seem to grow at about the same rate at 2-7 cm/year, or 170 ml/yr. (Volume is the best measurement because they grow in 3 dimensions). Some animals grow much faster than others (perhaps because they're in better feeding grounds), and most grow quickly when they're small, and slow down as they get larger, so estimates of their ages vary considerably. The largest sponges (about 1-2 m in length and diameter) are estimated to be between 50 and 220 years old. One reef in Queen Charlotte Sound that is 5 meters thick is estimated to be nearly 6,000 years old.

What is the concern for the reefs?
Because the reefs form such large structures on the otherwise nearly flat, continental shelf, they trap nutrients and enrich the local environment. In a sense they act like an oasis, offering nutrients and shelter for other animals, thereby increasing the local biological diversity. We know that fish harvests are better near the reefs, as they are at the deepwater coral reefs near Scotland and Norway. However, trawl fisheries cause damage to both coral and sponge reefs. Sponges in one of the Hecate Strait reefs are almost all broken from the trawl doors that are towed along the bottom.

Norwegian fishermen were aware of the enhanced fish stocks generated by the deep water coral reefs and alerted their government of the damage they were inflicting. Fishery closure areas have since been designated to protect the reefs. In 2002 Canada's Department of Fisheries and Oceans designated the reefs in Hecate Strait and Queen Charlotte Sound as a 'sponge reef protected area' closed to groundfish trawling. Similar protection is proposed for the Darwin Mounds coral reefs near Scotland.

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