Chapter 12

Giant clams: jewels of New Caledonian reefs

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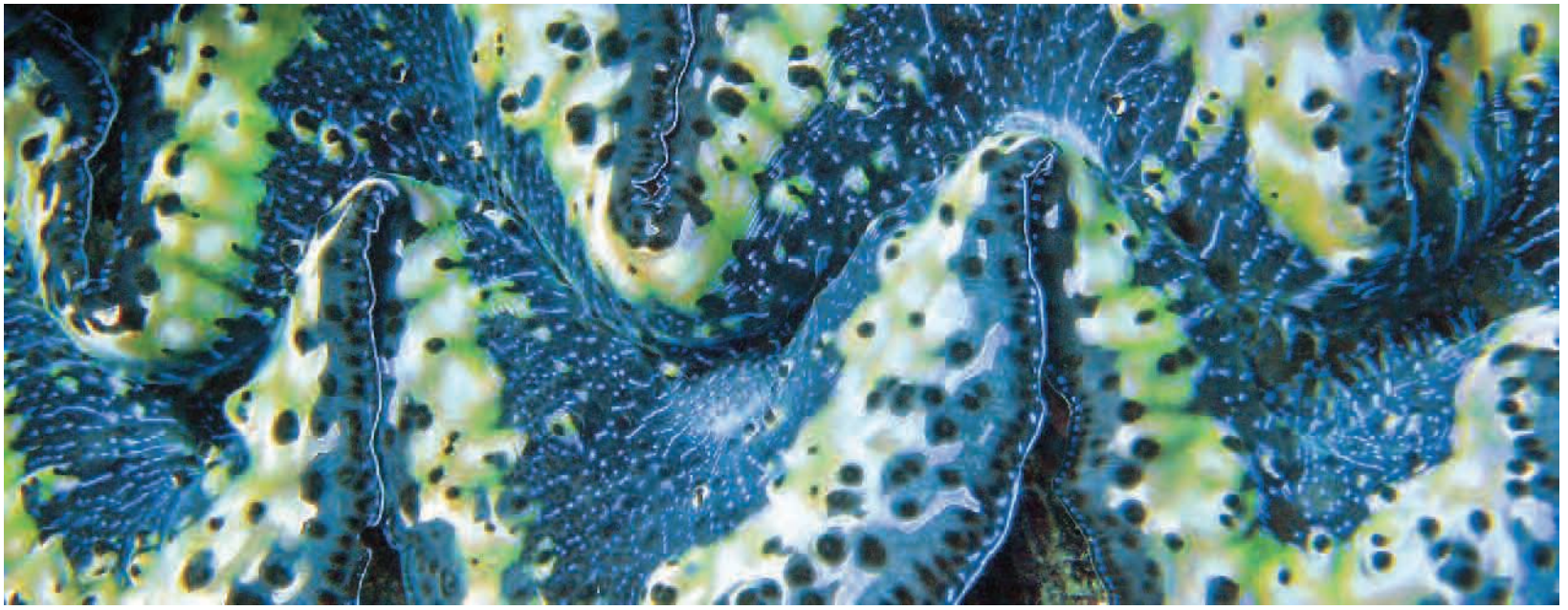


The shimmering colors of giant clams are due to microalgae that live their mantle. *Tridacna maxima*. © IRD/S. Andréfouët

Massive but relatively little-known seashells

Giant clams are marine bivalve mollusks (class Bivalvia[2] like oysters, mussels, clams, etc.), which live in the warm coastal waters of the Indo-Pacific region. They are mainly found in shallow lagoons and on the outer slopes of reefs down to 30 m deep, depending on the species. They contribute to the construction of coral reefs and act as a physical substratum for many reef organisms. Giant clams have long been exploited for their flesh and shells, and they have important economic, food and heritage significance for many communities in the Indo-Pacific region.

Out of the dozen species currently known, seven that belong to two distinct genera are present in New Caledonia: *Tridacna maxima, T. crocea, T. squamosa, T. derasa, T. mbalavuana, T. noae* and *Hippopus hippopus*. Their density and distribution vary widely from one species to another, due to different ecological requirements, but also because they undergo different fishing pressures, as fishermen tend to target particular species and reefs.

[2] Mollusks whose body is protected by a calcareous shell in two more or less symmetrical parts

Tridacna maxima, with a maximum length of 35 cm, is the most common species. It lives in densities of, on average, about a hundred individuals per hectare of reef but because of its relatively small size and because it generally lives embedded in hard substratum, it is fished very little or not at all.

Tridacna crocea (maximum length: 15 cm) has an average density similar to *T. maxima*, but its spatial distribution is highly heterogeneous, as individuals often tend to cluster in particular areas of the reef. This species is small and deeply embedded in corals, which make them difficult to extract; it is not collected in New Caledonia but is harvested elsewhere, such as in Vanuatu.

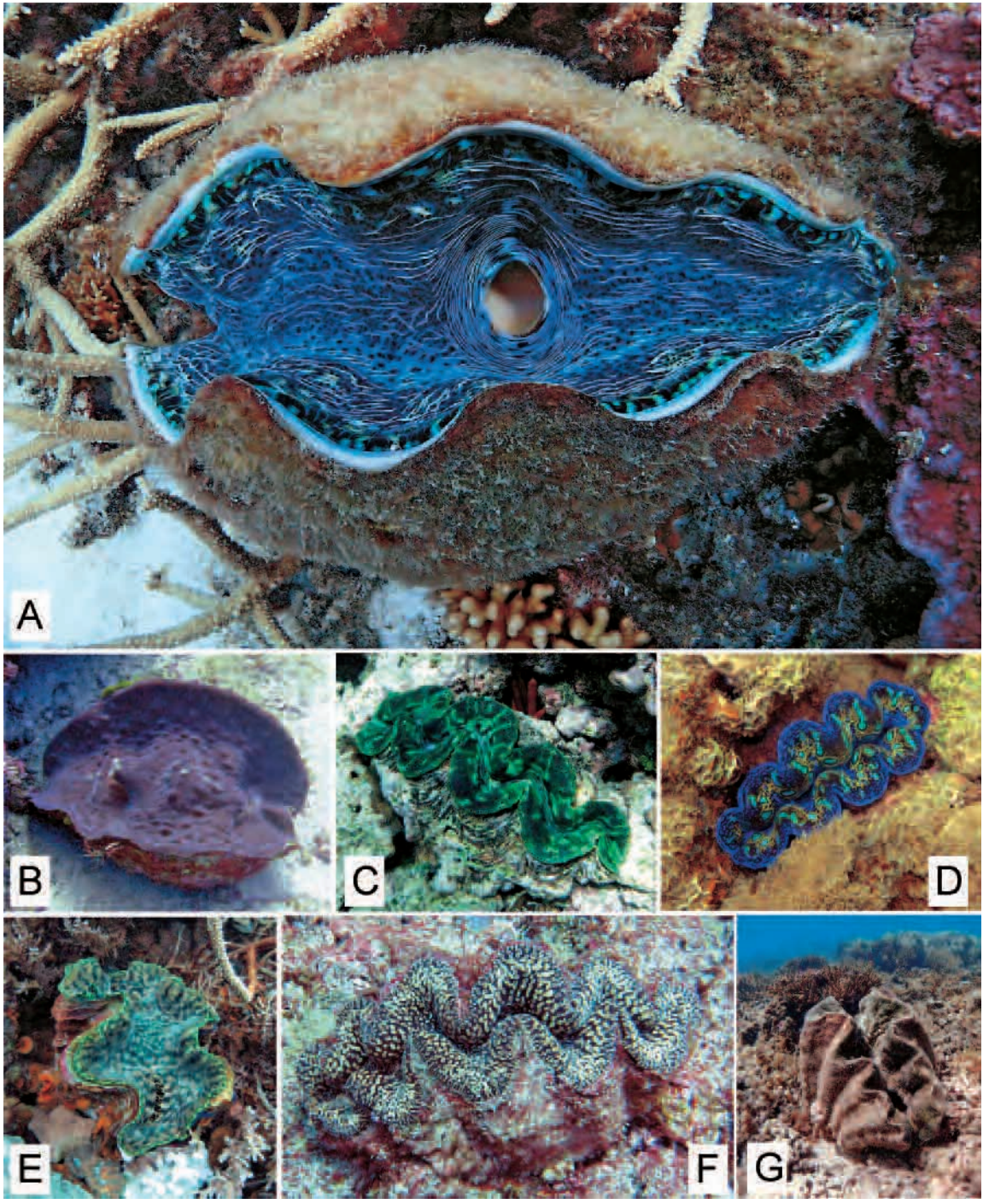
Larger in size (maximum length: 42 cm) and easier to take than the previous two, *Tridacna squamosa* is sought-after by fishermen. Their density is relatively low with only a few individuals per hectare of reef. Even larger and not attached to the substratum, *Tridacna derasa* (maximum length: 60 cm) is highly sought-after by fishermen. As a consequence, it is now rare in New Caledonia (approximately two individuals per hectare). The situation is similar for the "rolling" giant clam (bear paw clam) *Hippopus hippopus* (maximum length: 50 cm), which is also particularly easy to collect because individuals are not fixed to the substratum and they mainly live on shallow and sandy-detritic bottoms. The very low densities that have been observed (less than one individual per hectare) are likely to be the result of overfishing throughout the territory.

Besides these five species, two others have only recently been recorded in New Caledonia. Their distributions are limited to the northeast of Grande Terre and to the Loyalty Islands. *Tridacna noae* (maximum length: 30 cm), is relatively rare and was recently distinguished from *T. maxima* by genetics. *Tridacna mbalavuana* (maximum length: 56 cm) is the rarest species in New Caledonia, with only a few isolated individuals identified to date. Lastly, *T. gigas*, a species formerly present in New Caledonia, is now considered to be extinct and observed only in the form of fossils or sub-fossils.

The ecological importance of giant clams

Like corals, giant clams host photosynthetic unicellular algae called zooxanthellae. Zooxanthellae provide their host with part of the energy necessary for their growth, reproduction and survival. These symbiotic microalgae are also responsible for the shimmering colors of the giant clams' mantle. As with corals, environmental stress can disrupt the symbiotic relationship and lead to bleaching followed by the death of the animal. During their adult stage, giant clams also filter seawater to feed on particles and micro-organisms. The symbiosis with zooxanthellae provides them with the products of photosynthesis (glucose, oligosaccharides, and amino acids) and supplements the nutrient intakes resulting from seawater filtration. Through this process, giant clams filter seawater by absorbing plankton, sediment particles and pollutants and as such, are often seen as good indicators of water quality and of the health of the coral reef ecosystem. In addition, giant clams contribute to the carbon cycle through the absorption of dissolved inorganic carbon and respiration, and through the photosynthesis of their symbiotic zooxanthellae.

Giant clams have a two-phase life cycle, with a pelagic larval phase and an adult benthic phase. Adults are usually attached to the substratum with their byssus or simply rest on the bottom. Giant clams have a hermaphrodite mode of reproduction, where each adult individual has both male and female gonads. Male gametes are released first, followed about 30 minutes later by female gametes, which limits the possibility of self-fertilization. Fertilization takes place in open water within a few hours of gamete release, and embryos turn into larvae after 24 hours, which are called trochophores and then veligers depending on their stage of development. When they start developing a "foot", they become pediveligers and attach to the substratum (about 15 days after fertilization) to metamorphose into juveniles. This larval phase ensures population connectivity (box. 16) and some giant clams can live for several decades.



Giant clam species known from New Caledonia.
A: *Tridacna derasa*, Aboré Reef Reserve.
B: *T. mbalavuana*, Touho Reef.
C: *T. maxima*, Merlet Reserve.
D: T. crocea, Port-Bouquet Reef
E: *T. squamosa*, Prony Bay.
F: *T. noae*, Tiga Island.
G: *Hippopus hippopus*, reserve of Larégnère Islet.
B: © IRD/C. Fauvelot; F: © IRD/D. Grulois;
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Emblematic species threatened by overfishing

In the Pacific, the use and consumption of giant clams began shortly after the arrival of the first human populations. This is evidenced by the numerous human artifacts found throughout their distribution range. Prestigious objects and more durable than wood, giant clams have been a popular currency and continue to play an important role in the cultural practices of most Pacific islands. Their flesh, including the adductor muscle, gonads and mantle, is also an important source of protein. Traditionally a subsistence resource, this fishery has gradually evolved towards commercial exploitations, leading to the local extinction of large giant clams in the most populated areas of the Southwest Pacific. The vulnerability of giant clams to overfishing, coupled with uncertain population dynamics (slow growth and erratic recruitment), has led to the decline of most species.

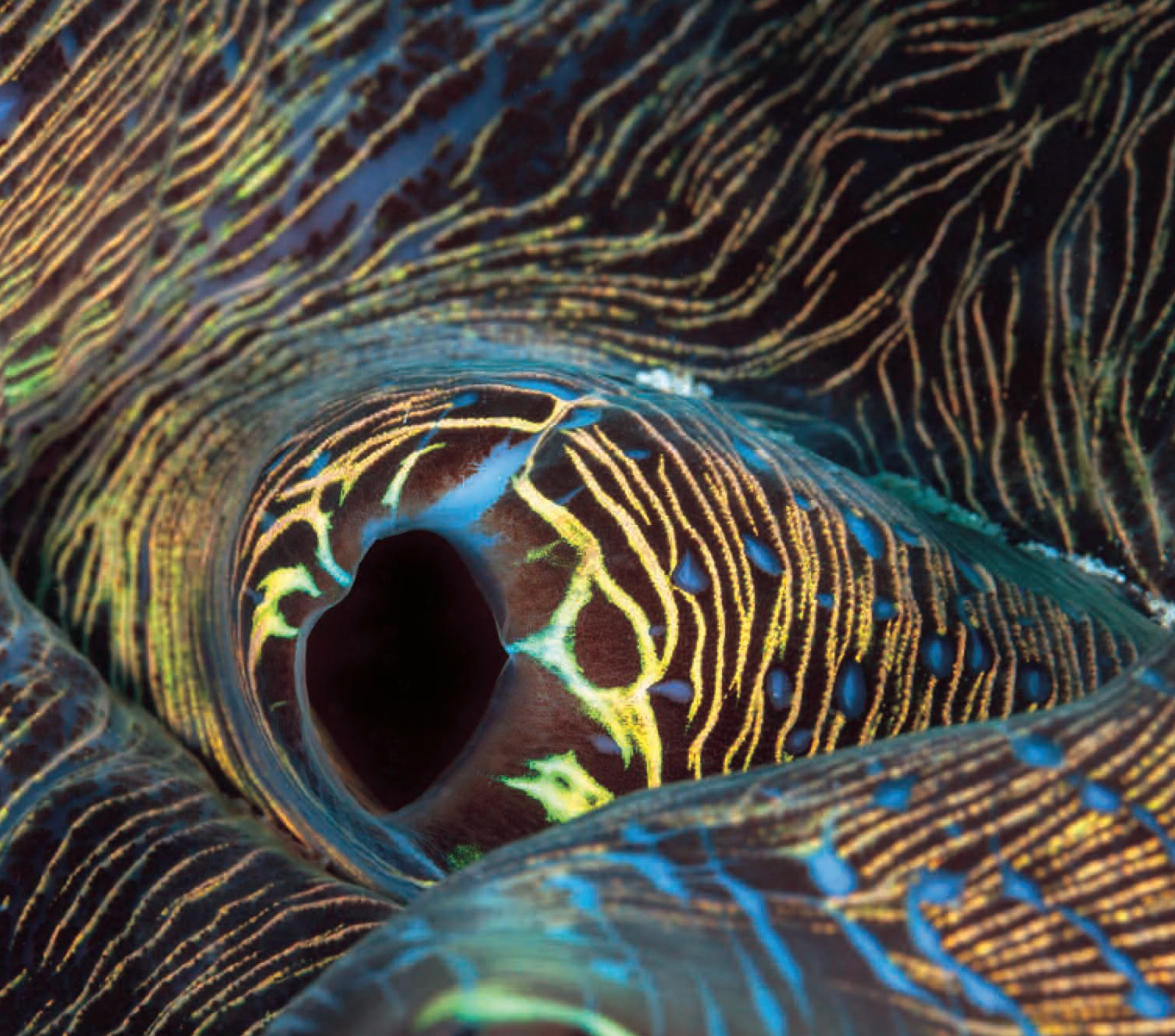
Four of the 12 known species are listed as "vulnerable" in the Red List of Threatened Species established by the International Union for Conservation of Nature (IUCN). Three species are estimated to be "low risk and dependent on conservation" and only one species, T. crocea, is still in the "low risk/least affected" category. Although the remaining four species have not yet been assessed by the IUCN, all giant clams are listed in Appendix II of a convention regulating the international trade in endangered wildlife (CITES, Convention on International Trade in Endangered Species of Wild Fauna and Flora). This indicates that (i) they are not necessarily threatened with extinction, but their international trade must be controlled to avoid certain types of exploitation that would be incompatible with the species' survival and (ii) their international trade cannot take place without a permit.

Giant clams are popular aquarium animals for their colors (the most colorful being *T. maxima, T. noae, T. crocea and T. derasa*) and their role in the filtering of aquarium water and are listed among the 10 marine invertebrates most sought-after by aquarists.

Giant clam fishing is a traditional and widespread activity in New Caledonia. At least two species (*Hippopus hippopus* and *Tridacna derasa*) are commonly used for food and commercial purposes, either consumed directly or sold on markets, or sometimes exchanged through customary practices. Around the year 2000, an average of 4 tons of flesh was fished annually by professional fishermen. This number highlights the significance of giant clam exploitation to supply the local market, but is likely to have been underestimated given the lack of quantitative data on subsistence and recreational fishing. In addition, according to declarations by CITES, the export of giant clam shells remains significant (with over 19,000 shells between 1994 and 2003, mostly *H. hippopus and T. maxima*), although exports have been declining recently. The increase in fishing pressure due to the demographic development of New Caledonia raises serious concerns about the current and future state of the resource. Giant clam populations are showing signs of local overfishing (reduced densities, smaller sizes) in the most visited sections of the lagoon. Several conservation measures have been implemented in New Caledonia to try to manage the activity and stop overfishing (chap. 35).

Pollution and urbanization of the coastline can also affect giant clam populations, as do predation, diseases (viruses) and global warming. Impacts can include the loss of zooxanthellae (bleaching) due to increased water temperature, changes in growth associated with ocean acidification, and increased mortality of juveniles due to the combined effects of ocean warming and acidification. Adults and juveniles are consumed by many predators: the mantle, gametes, eggs are eaten by turtles, octopuses, some fish (triggerfish and wrasses) and some gastropods (families Pyramidellidae and Ranellidae). Boring sponges can weaken the animal by digging small holes in the valves. Lastly, flatworms of the genus *Stylochus* can slip in between the valves, and eat the tissues.

Giant clam's exhalant siphon (cylindrical opening) through which filtered water is expelled. © G. Boussarie



Box 16

Giant clam population connectivity

Population connectivity refers to the flow of individuals of the same species between sites. For fixed marine species such as giant clams, it refers to the flow of larvae that are exchanged between reefs. In New Caledonia, our studies have shown that the populations of giant clams *Tridacna maxima* and *Hippopus hippopus* were genetically heterogeneous, indicating limited connectivity. For *H. hippopus*, the exchange of larvae was limited between d'Entrecasteaux Reefs and the rest of New Caledonia (for sites that have been sampled), as well as between the Loyalty Islands and Grande Terre, albeit to a lesser extent. A higher connectivity was measured for *Tridacna maxima*; this connectivity seems to mainly depend on the geographical distance between reefs. For all species, results indicated that very few larvae originate from reefs outside of New Caledonia, meaning that giant clam populations cannot rely on an allochthonous supply of larvae to repopulate New Caledonian reefs.

Hand-picking of giant clams. © M. Juncker

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