The islands of Nusa Lembongan, Nusa Ceningan and Nusa Penida are situated a few kilometres south-east of Bali, Indonesia. The Nature Conservancy and Conservation International have been working over the past few years to propose the Penida Marine Protected Area that encompasses all three islands.

The region has exceptional marine biodiversity with 247 species of corals and 562 species of fish recorded by surveys in 2008. With a population of 45,000 residents, growing tourism, fisheries and seaweed culture industries there is need to zone the area for a range of uses by communities, tourists and for the protection of important marine habitats. In addition to coral reefs the islands of Lembongan and Ceningan also have extensive mangrove and seagrass habitat.

Seaweed farms cover 308 ha, mangroves 231 ha and seagrass meadows 108 ha. But little is known of the types of seagrass meadows that occur, their functional relationship with other habitats and if they are being impacted by the expansion of seaweed farms.

Many of the seaweed farms are placed directly above seagrass and this can lead to seagrass die off in these areas. Surprisingly though, during our preliminary investigation, intertidal seagrass was surviving below seaweed cultured on ropes placed about 5cm from the sediment surface, despite the obvious shading. At other farms though there was no seagrass present underneath the seaweed cultures.
A clear management imperative is to identify existing important seagrass habitats for fisheries and resident turtle and dugong and protect these from future encroachment of seaweed farms. The proposed zoning plan for the Penida Marine Protected Area is a first step to ensuring sensitive marine habitats are protected from such impacts. Falls in market demand and an oversupply of seaweed has led to a 70% reduction in the price for seaweed over the past 5 or so years, and this may inadvertently help to protect those remaining seagrass meadows. From 2nd-5th November 2009, Wildlife Conservation Society staff from the Indonesian Marine Program travelled to Lembongan and Ceningan Islands with the purpose of identifying what type of seagrass meadows exist and if meadows are suitable for monitoring by local schools and NGOs using Seagrass-Watch methods. Such a program would raise awareness of the importance of seagrass and also help understand if existing meadows remain healthy. Eight species of seagrass were found during the visit and number of different meadow types were identified including those dominated by *Ecklonia* and *Thalassia* and those comprised predominantly of *Cymodocea*, *Halodule* and *Thalassia*. Sites considered representative of the wider area and in proximity to schools were considered suitable for monitoring. Further discussions with NGO’s working on the island and local schools will aim to establish a Seagrass-Watch program as part of a wider program for the Bali Lombok region.
September saw members of the Seagrass-Watch HQ join with the Mapoon rangers to undertake their quarterly Seagrass-Watch sampling and set up an additional site at Cullen Point. The rangers completed Seagrass-Watch Level 1 training in Cairns earlier in 2009.

As a community very much linked to the sea through fishing, seagrass meadows are an important habitat of great value. So developing capacity within the community to monitor and understand this significant resource is of great importance, especially in an era of climate change and increased industrial development.

Seagrass meadows at Cullen Point near Mapoon were found by the rangers to be dominated by *Halodule uninervis* and *Halophila ovalis*. Comparison of these assemblages with monitoring of seagrass in other areas of the Cape by Seagrass-Watch and Fisheries Queensland indicates that these meadows are in a reasonably healthy state. This is especially the case given the high rainfalls and flooding of early 2009. Seagrass at Cullen Point had a reasonable seed-bank present within the sediment indicating the meadow would have good resilience to periods of stress.

The species of seagrass at Cullen Point are of the type commonly use by dugong and turtle as a food source. Although the rangers didn’t observe any dugong during the recent monitoring, their feeding trails were observed across the sites. This indicates the area is likely to be important for these globally endangered species.

It is also the value of seagrass as a fish nursery and fish feeding area that is particularly important to the Mapoon community. Continued monitoring and assessment of the seagrasses of Cullen Point can only help to conserve these important habitats.

The aim of Seagrass-Watch in Mapoon is to undertake quarterly monitoring. Unfortunately the lack of daytime tides early in 2010 mean that sampling won’t be possible until the end of the Wet season in April. Fisheries Queensland, supported by Cape Alumina Ltd, will continue to assist with monitoring when it resumes.
In recent years, dugong numbers have rapidly declined throughout the Western Indian Ocean region as a result of hunting, accidental capture in nets and habitat destruction. To address these issues, Community Centred Conservation (C3) and local partners initiated the project ‘Dugongs without Borders’ in Northern Madagascar in May 2009. The project aims to build national and regional capacity in Comoros and Madagascar for collaborative dugong research and conservation initiatives. One component of this project is the collation of information on seagrass habitat in the region, including baseline surveys and mapping, using the Seagrass-Watch protocol.

According to interview surveys that we conducted in July and August 2009 among fishers and retired dugong hunters in Northern Madagascar, it would appear that the region may still host a significant dugong population and interviewees were even able to identify past and present dugong feeding sites. We are now concentrating our seagrass mapping work at these sites in order to assess dugong habitat and consider options for its protection.

Following a training session in Seagrass-Watch methods with our partner organisations, we conducted preliminary seagrass mapping at Ramena, Antaravy, and Nosy Hara Marine Park (Ampasindava and Vohilava) from September to November 2009. Our work has revealed the presence of 8 species including: *Thalassia hemprichii*, *Cymodocea rotundata*, *C. serrulata*, *Halodule uninervis*, *Halodule wrightii*, *Syringodium isoetifolium*, *Halophila ovalis* and *Zostera capensis*. There was good news for dugongs because seagrass meadows generally appeared healthy and extensive.

Working in this remote region has proven to be quite a challenge with many sites only accessible by boat and located in remote areas where freshwater is scarce; fortunately the incredible hospitality of local communities has greatly aided our work. This is the first phase of a series of seagrass mapping work planned for the upcoming months. The information gathered on seagrass habitats in Northern Madagascar will provide us with a better idea of the importance of particular sites for dugongs and priorities for conservation with the help of local stakeholders.

For further information, please visit our website at www.c-3.org.uk

C3-Madagascar is an official partnership between C3 and the University of Antsiranana and we are grateful to our other local collaborators: Madagascar National Parks and Centre National de Recherches Océanographiques. This work has been generously funded by the BP Conservation Leadership Programme and Convention on Migratory Species of Wild Animals (CMS).
Portugal, is a country in the southwest of Europe. It has an area of 92.4 km² and is the most western nation of the European continent. The southern and western boundaries of the main Portuguese territory is the Atlantic ocean; it has also two autonomous regions, the Azores and Madeira archipelagos. Only 3 species of seagrass occur in Portugal, *Zostera marina*, *Zostera noltii* and *Cymodocea nodosa* in areas easy to observe. The Luiz Saldanha Marine Park created in 1998 with 52 km² is part of Arrábida Natural Park, managed by Nature Conservation & Biodiversity Institute.

It is a remarkable area in what concerns the biodiversity not only at national but also at European level, indeed more than 1000 species of floral (e.g. anemones, starfishes, sea urchins, crustaceans, seahorses) and fauna (e.g. seagrass meadows) has been identified. It should be emphasized that the preservation of these seagrass meadows is crucial.

This park is included in the national list of sites of the UE Natura 2000 Network Arrábida-Espichel. The LIFE Biomares project (LIFE is the EU’s financial instrument supporting environmental and nature conservation projects throughout the EU), was developed because of the willingness to help preserve and restore the biodiversity of the Professor Luiz Saldanha Marine Park for the conservation of other species, as for instance the seahorses. The Life Biomares project includes several actions such as: restoring the seagrass meadows found in Portinho da Arrábida in order to restore the previously associated biodiversity.

This action will be implemented by transplanting plants (*Zostera marina*, *Zostera noltii* and *Cymodocea nodosa*) collected from donor meadows (such as the Sado estuary and Ria Formosa). The donor populations will be subject to mapping and special monitoring to evaluate the impact of removal of plants. Experiments involving germination of seeds and plant growth from seeds to increase the genetic diversity of the transplanted population, will also be conducted in laboratory, under controlled environment; the installation of “eco-friendly” moorings that consists of fixed anchors with turnbuckle and swivel systems, with a surface buoy, so that mooring cables do not drag over the sea floor. Informing and raising awareness of the general public and more direct users about the marine biodiversity of the
marine park with an itinerant exhibition at the Oceanographic Museum.

The project has several partners, including: Nature Conservation & Biodiversity Institute, ICNB, Algarve Sea Sciences Centre (CCMAR), Biological Resources National Institute, I.P. (IRNB / L-IPIMAR), Psychology Superior Institute (ISPA). Consejo Superior of Investigaciones Científicas (CSIC) IMDEA (investigation laboratory) and Spain Superior Council of Scientific Investigation (CSIC), Cement General Company, S.A. (SECIL) and National Oceanic and Atmospheric Administration (NOAA).

Due to the importance of seagrass ecosystems it is crucial to conduct systematic monitoring of biotic (e.g. fauna, flora) and abiotic factors (e.g. substrate, temperature). Estremoz Science Center in collaboration with Evoras’ Science and Technology University intends to implement monitoring activities in coastal areas with school communities and others. We also intend to inform and raise awareness for this ecosystem and write guides and activity books to be available on our website or in Estremoz Science Center. This monitoring activity is part of the Seagrass-Watch global monitoring program. The project will be conducted in coastal areas with environmental groups, educational institutes and local participants.

References:

Collecting flowers for germination.

Experiments involving germination of seeds and plant growth from seeds to increase the genetic diversity of the transplanted population.

Left: Seed bags in place over a transplanted area of seagrass.
Below: Outreach and education, on the importance of seagrass ecosystems and how fragile they are.

Left: Diver collecting flowers for germination.
Below: Seed bag ready to be deployed.
On the 29th September 2009 at 6:48am Samoa time, an 8.3 magnitude quake struck approximately 195 km south of the Samoan archipelago. The ensuing tsunami killed over 150 people in American Samoa, Samoa and Tonga. Two-weeks after the tsunami a team of scientists assembled in Samoa to undertake impact assessments and provide recommendations to prevent future loss of life and infrastructure.

The marine assessment team (including Seagrass-Watch participants) undertook surveys from 14th-17th September. The surveys focused on assessing the extent of damage to the marine environment, identifying the main causes of the damage and assessing the state of marine resources in the affected areas. Sites were chosen because of their close proximity to the worst impacted villages, being part of community conservation areas, important nurseries, foraging and nesting sites for turtles and important tourism areas. A range of methods were used (manta-tow, transects, photo-quadrats, sonar, timed-swim, underwater visual census and rapid-assessment) to provide the widest geographic coverage as well as site-specific assessment.

The impact to reef habitats was found to be highly variable. This was attributed to many factors, such as the presence of offshore islands, the depths between the islands and the mainland fringing reefs, the width of the reefs, land topography and the presence of rubble and other loose debris in the water at the time of impact. Rubble on the reef-crest and back-reef became missiles and severed tips of many branch corals. Large boulders (2-4m wide) were toppled, or shifted a fair distance towards the shore, damaging corals on the way. Steep slopes close to the high water mark facilitated the mixing and swirling of the waves resulting in the severest impacts on coral communities. Debris from land also accentuated the damage. Only a few sites showed evidence of backwash. At deeper waters (30m), the reef was intact and minimal impact was noted. Evidence of seagrass meadows being impacted included the presence of clumps of Halophila ovalis ssp. bullosa found 100m inland. No Syringodium isoetifolium (the only other seagrass species in Samoa) was observed during the surveys. This species generally disintegrates faster than Halophila.

Marine animals were also affected. Turtles, sharks, holothurians and dolphins were stranded inland, resulting in some deaths. Some were successfully released back into the sea by Government, SPREP and the community. The recovery of the reefs is already occurring with the high abundance of turf algae (cyanophytes, chlorophytes and rhodophytes). The good flushing of the inshore reefs by the swells and fine conditions should ensure things will be back to normal in a relatively short period of time. Some factors may conspire to slow the recovery process including Crown-Of-Thorns outbreak (20 counted in 100m transect), cyclones with associated heavy rain resulting in land run-off, damage caused by debris already in the water, and elevated sea surface temperatures. An immediate recommended action was to remove and dispose debris found in the water, as well as COTS. This should help coral fragments to stabilise and re-establish. Continuous monitoring as well as establishing long-term monitoring sites was also recommended.
A recent report about the benefits of seagrass ecosystems to climate health has greatly excited one of the resource’s fastest growing fan bases the dedicated participants of the Broome Community Seagrass Monitoring Project. We already knew the value of seagrass as a marine nursery, habitat, food, water purifier, fisheries sustainer, coastal stabilizer and marine indicator. Now we have learned from the report entitled “Blue Carbon: the Role of Healthy Oceans in Binding Carbon”, launched by international organizations including the United Nations Environment Programme and the Intergovernmental Oceanographic Commission of UNESCO, that seagrass is one of the most cost effective carbon capture and storage systems on the planet, Carbon (see Seagrass-Watch Issue 36). With other healthy marine ecosystems, it could help deliver up to 25% of the emissions reductions needed to avoid ‘dangerous’ climate change.

This finding was of particular interest to Broome residents, who have also recently learned that sea levels in Western Australia are rising at a rate double that of the world average with our Kimberley region experiencing even higher level rises than the WA average. Statistics from Australia’s National Tidal Centre have shown that globally, sea levels have increased by just over 3mm, while in the Kimberley, levels rose by more than 8mm.

The knowledge that monitoring seagrass meadows through our community project may not only protect marine health, but help to reduce the impacts of climate change, such as these sea level rises, was very inspiring for our participants.

These participants came out in force for our October monitoring session in Roebuck Bay. The monitoring was characterised by unusual visual conditions, with a sublime sunset caused by smoke-filled skies casting eerie hues onto glistening meadows at the Demco site. Then, at the Town Beach site, a thick blanket of heavy mist rolled over the bay from Roebuck Plains, engulfing our site in a ghostly fog.

A special highlight of this season’s monitoring was the number of newly trained participants attending each session. These participants recently completed a Seagrass-Watch Level 1 workshop, so were able to contribute a higher level of skill and knowledge to the monitoring process. During the October monitoring we found that most areas of seagrass had flourished, with thick green meadows of *Halophila ovalis* and *Halodule unineuris* containing all sorts of macrofauna. We also recommenced seed monitoring, which aids seagrass resilience calculations.

This season we launched into the new Coastwest funding period, which has been supplemented by a second grant from the Port of Broome. We have also seen the start of intertidal mapping and a new phase of community education, with presentations delivered to students from Broome primary schools and Notre Dame University.

The Environs Kimberley Seagrass Monitoring Project is co-managed by EK and DEC and supported by Coastwest, the Port of Broome and Seagrass-Watch HQ.

References:
http://news.bbc.co.uk/2/hi/asia-pacific/3449760.stm
In India, seagrasses are spread along the east and west mainland coasts and also in the shallow lagoons of Lakshadweep and sheltered coasts of Andaman and Nicobar islands. Of the 14 seagrass species reported from India, Gulf of Mannar ranks highest with 13 species, followed by Palk Bay (11 species), Andaman and Nicobar islands (9 species) and the Lakshadweep islands (8 species). However, seagrasses in different parts of India are facing varied threats from human disturbances and natural phenomenon.

The mainland

Seagrasses on the east coast of India, especially in Palk Bay and Gulf of Mannar, suffer large scale losses due to southwest monsoonal winds and northeast monsoon cyclones which are prevalent in this part of the sea. Further, most of the key fish landing centres of this region are endowed with extensive seagrass meadows which face destruction due to fishing related activities, especially anchoring of boats. Every time one anchor is lifted, at least 1kg of seagrasses is uprooted. The quantity may look small, but when such destruction is caused by 100s of boats every day then the damage is severe and needs immediate attention. Seagrasses growing in the tidal pools and partially exposed during low tides are showing heat stroke like symptoms due to elevated surface water temperature. Increases in surface water temperature over 38°C for 5-6 days wilts the seagrass leaves by denaturing the chlorophylls and results in leaf death.

A striking feature leading to the denudation of seagrass meadows, noticed in the Pamban area of Gulf of Mannar, is the harvesting of milky white paper shells (*Tellina angulata*) having good market value in the ornamental shell industry. This has induced the local fisherwomen to dig out the seagrass meadows of this region (which are the habitats of this bivalve) on a large scale to collect shells. Harvesting the shells physically destroys the underground rhizomes and roots of the plants, affecting seagrass growth. It has been found that over 153 ha of dense of sparse seagrass meadows have been lost during 2002-2004 in this region. 80% of this loss was caused by shell harvesting.

Trawling and bottom set gill net operations are largely causing physical damage to the seagrasses by uprooting the plants and removing the healthy leaves. It
is estimated that approximately 20-25 kg of seagrasses is removed by a trawler and about 30-40 kg of seagrasses is being removed by the shore seine operations (the quantity varies depending on the seagrass density) on a single day in the Palk Bay and Gulf of Mannar region.

Nutrient enrichment due to varied factors is promoting the growth of seaweeds. The seaweeds are capable of growing rapidly and can smother entire seagrass meadows and reduce light availability. Also, when seaweeds decay, they release humic substances which cause deleterious effects to seagrasses.

The islands
Lakshadweep

Water quality is one of the important parameters that determines the health of the seagrass ecosystem. In Lakshadweep islands, though the water quality remains largely pristine, disposal of tuna and other fish wastes and untreated solid waste disposal have caused localised eutrophication. The enhanced nutrients have resulted in the proliferation of seaweeds and reduction of light availability, thus suppressing the seagrass growth. Tourism developments, mostly along the coastal areas, has also lead to the destruction of seagrasses.

Most interesting feature found in this part of the Arabian Sea is the increased number of green turtles (Chelonia mydas) which graze intensively on the seagrass meadows. Interaction with the local people of these islands has clearly indicated that there is a gradual increase in the turtle population over the last five years in many islands especially Agathi, Kavarath etc.

Though some of the local fisherfolk insist on the seasonal hunting of green turtles, those in opposition have suggested translocating some of the turtle population to the other islands having good seagrass meadows.

Andaman and Nicobar

Dugongs (Dugong dugon) and green turtles have been regularly reported from Andaman and Nicobar islands (D'souza and Patankar, 2009). Seagrasses of these islands are also facing serious threats from intensive shipping, boating and tourism activities.

The Boxing Day tsunami of 2004 severely altered the coastal geomorphology of the Andaman and Nicobar islands and also devastated the seagrasses by uprooting the plants, lifting the land and dumping sediment on seagrass meadows. Our recent studies on the distribution of seagrasses of the Andaman and Nicobar islands have revealed the disappearance of seagrasses from the North Reef and Interview islands of North Andaman, where extensive seagrass meadows were reported earlier.

Similarly, remote sensing studies have confirmed the disappearance of seagrasses from many locations (Lakshman beach, Inhengloi) of the Great Nicobar island, from where dense seagrass meadows were previously reported. Seagrasses of the northern part of the Andaman islands have been largely destroyed because of low tide exposure due to lifting of land while the southern part of the Andaman islands and Nicobar group of islands have been deposited with huge amounts of sediments and coral debris. However, these seagrasses are now showing little recovery from the physical damages caused by the sheer power of tsunami waves. Adequate and immediate attention should be paid to the conservation of seagrass resources because losses reported from several parts of the country may also lead to the loss of associated biodiversity, fishery and other ecological functions and services in the coastal zone.

As seagrasses are widely recognized as key ecosystems in the coastal zone, they must be given due consideration for research, monitoring and conservation as compared to coral reefs and mangroves, by the resource managers and policy makers. Though several state and central government organisations have now started to pay good attention on seagrass research, it is time to develop a macro level plan on seagrass conservation for sustainability, future prosperity and posterity.

2009 saw the number of sites being monitored in the Torres Strait increase from the already established sites at Thursday Island, Horn Island and Hammond Island. The addition of new sites was due to the Torres Strait Regional Authority’s Land and Sea Management Unit’s focus on Torres Strait Island communities addressing key environmental priorities through the establishment of the Indigenous Land and Sea Ranger Program. One of the priorities of the Ranger Program is to implement the recommendations of the community formulated Dugong and Turtle Management Plans. In most plans better knowledge and skills for monitoring seagrass habitat are highlighted. Due to the staged rolling out of the Ranger Programs two new communities, Mabuyag and Mer started Seagrass-Watch. In September, a training workshop on Mer attracted an enthusiastic group. Two rangers (James and Frank) from Badu attended the workshop so that they could report back to their island community and gauge whether there was sufficient interest to initiate seagrass monitoring on Badu.

The established sites around the central island continued to be monitored by Tagai College students under the guidance of teachers Ann More and Andrew Denzin. This year however the Tagai College program stepped up a notch by being recognized by Queensland Studies Authority (a statutory body of the Queensland Government) as an enrichment course community based learning program. Students enrolled in 60 hours of extra curricula activities with milestones that were recorded in a log book before they were awarded their Certificate of Achievement Level 1. In addition to their certificate the students also gain a point towards their Queensland Certificate of Education (QCE) - Queensland’s senior school qualification. The QCE is awarded to eligible students usually at the end of Year 12, but is still valid for a person to claim up to the age of 25. Congratulations to the six students (50% of the enrolment) who gained credit in this inaugural year.
Seagrass-Watchers from the University of the South Pacific, International School Suva and several additional participants gathered to monitor the two sites on the mudflats adjacent to Corpus Christi on the 14th November 2009.

This monitoring event was relatively new to some participants and as such was a great way of diversifying their field experience. A minor hiccup was encountered by the University student group with regards to a lack of steel quadrats. However, under the guidance of group leader Dr Gilianne Brodie, the resourceful USP students were able to construct their own quadrats using nylon rope and driftwood found lying along the Nasese shore line.

A short briefing by Seagrass-Watch Fiji Local coordinator, Dr Posa Skelton, on the identification of seagrass, and with the aid of identification keys and self explanatory datasheets, the survey was made much easier for participants.

During the monitoring event, participants identified and learnt about the three species of seagrass (Halodule uninervis, Halophila ovalis and Halodule pinifolia) that we can find on the Nasese foreshore. Besides recording seagrass plant parameters, sediment samples were also sieved to look for the Halodule uninervis seeds.

International School students stated that there was a need to create awareness around Fiji on the importance of seagrass.

One unexpected find on the day was hundreds of small living bubble shells from the opisthobranch mollusc family Bullidae genus Haminoea. Dr Brodie commented that she thought their presence was probably reproduction related and that she remembered recording a mass occurrence of these animals just like this at the same location in March 1985.

**Giant clams**...continued from page 24...

Indo-Pacific is the Horse's Hoof or Bear Paw clam Hippopus hippocus.

This species reaches 50 cm shell length and can weigh up to 13 kg. The valves are an elongate triangular shape, thick, with 8-12 squarish extremities of the rib interstices. The byssal orifice is closed tightly in adults, and from the lower view the pattern of the rib interstices gives the species its common name. The mantle is yellow-brown with green or gray lines and does not extend over the valve margin. It is widespread in SE Asia, Australia to Vanuatu and parts of Micronesia.

Giant clams are harvested by Pacific Islanders for food. However giant clam shells are sold on the black market as decorative accoutrements, and the adductor muscle is prized as a delicacy (both in Japan and in France). There is concern among conservationists as the numbers in the wild have been greatly reduced by extensive overharvesting for food and the aquarium trade. The IUCN lists the giant clams as vulnerable.

**Attention! Clams are totally protected in Queensland, Australia**

Under Section 78 of the Fisheries Act, a person must not unlawfully take, possess or sell a regulated Fish - clams are a regulated fish (Regs, Schedule 4 Division 6).

**Max Penalty $75,000 (1000 penalty units)**

Clams must not be taken from the foreshores or any other place. Queensland Boating and Fisheries Patrol officers regularly patrol these areas. For more information on this or other fisheries issues visit FishWeb www.dpi.qld.gov.au/fishweb/ or contact your nearest Patrol Office.
When monitoring seagrass meadows on reef flats in the Indo-Pacific, it is not uncommon to come across one of the natural wonders of the marine realm; the giant clam.

As is often the case with large sea creatures, the giant clam has been historically misunderstood. They were once thought of as the “killer” or “man-eating” clam. Popular South Pacific legends described divers being drowned when the clam closed its shell on the diver’s arm or leg. However, no account of a human death by giant clam has ever been substantiated. While a clam is certainly capable of holding one fast in its grip, in reality the shell’s closing action is a defensive response, not an aggressive one, and the process of closing the shell valves is slow enough not to pose serious threat. Today the giant clam is considered neither aggressive nor particularly dangerous.

Giant clams are of the bivalve mollusc family Tridacnidae. They evolved over 65 million years ago in the Eocene, along with modern corals. Giant clams are the largest living bivalve molluscs. There are 7 species of giant clam, the largest is *Tridacna gigas*, which are native to the shallow (220 m) coral reefs of the South Pacific and Indian oceans. Individuals can weigh more than 250 kilograms, measure as much as 1.2 metres in length, and have an average lifespan of 100 years or more.

Being bivalves, giant clams have 2 shells (valves) which encase the animal. The valves are joined at the bottom, and the adductor muscles on each side hold the shell closed. If the adductor muscles are relaxed, the shell is pulled open by ligaments located on each side of the umbo.

Clams draw in and expel water for respiration and feeding through two siphons: the incumbent and excurrent. The water is moved by the beating of millions of cilia (hairlike structures) on the gills; other cilia strain food from the incumbent water and transport it, entangled in mucus, to the mouth.

The clams mantle tissues also act as a habitat for the symbiotic single-celled algae (zooxanthellae) from which it gets its nutrition. Adult clams can obtain over 90% of their food requirements from the photosynthetic products of the zooxanthellae. Giant clams differ from other molluscs in that by day, the clam opens its shell and extends its mantle tissue so that the algae receive the sunlight they need to photosynthesize. Clams also act as natural biofilters as they take up dissolved ammonia and nitrate from the surrounding seawater to supply their symbiotic zooxanthellae with nitrogen for growth.

Giant clams are hermaphrodites; each clam produces both sperm and eggs. They reach sexual maturity at 56 years, and are broadcast spawners, probably triggered by water temperature. The fertilized eggs develop through several larval stages that swim briefly before settling permanently on the bottom. Although larval clams are planktonic, they become sessile in adulthood. Juveniles settle and attached to rock or substrate using byssus (threads) present along with narrow byssal orifice.

Most clams are found on coral reefs, partly embedded in sand or rubble, although one species (*Tridacna crocea*, the Boring Clam) burrows into coral pockets. The most commonly encountered giant clam in seagrass meadows of the tropical continued page 23