Source: *The Straits Times*, pA17
Date: 27 May 2024

Scientists in US, S'pore race to help endangered sea star, shellfish breed

The first is a victim of an underwater pandemic and the latter are overharvested for their shells

Ariel Yu

With its arms fanned wide open, the solitary creature sits regally on the Pacific Ocean floor, some 450m deep. One of the largest and fastest sea stars in the world, the sunflower sea star has up to 24 arms – the most of its kind – can reach a diameter of 1m and can move as quickly as 3m per minute across the seabed, thanks to more than 15,000 tube feet beneath its arms which draw in water and move it through internal canals of its body.

But it cannot outrun an underwater pandemic that has devastated sea star populations by the billions in the past decade. Scientists are racing to turn the tide on this decline through breeding programmes.

With colours ranging from orange to yellow to purple to brown, the majestic creatures have been turning into piles of white goo due to an unknown waterborne virus that has been attacking sea stars up and down the US West Coast, from Alaska to Mexico.

When the sea star wasting disease strikes, white lesions form on the creature's arms as connective tissue start to break down, causing the arms to fall off. While sunflower sea stars *(Pycnopodia helianthoides)* typically regenerate missing or damaged arms, the disease causes the body to dissolve into a jelly-like puddle and they die within days. Since the outbreak of the sea star wasting disease in 2013, an estimated 5.75 billion sunflower sea stars have died, decimating the global population by 94 per cent, the US-based global environmental organisation The Nature Conservancy says.

The sunflower sea star has suffered the most severe impact, and was listed as critically endangered in 2020 by the International Union for the Conservation of Nature.

While higher sea temperatures speed up the progression of the wasting disease, there is no clear link between climate change and the pandemic.

Efforts are taking off globally to help the sunflower sea star – as well as other marine species threatened by climate change and overharvesting – reproduce, to ensure the long-term survival of the species.

Sunflower sea stars are typically found in rocky reefs, kelp forests and sand flats in the eastern Pacific Ocean, from the Aleutian Islands in Alaska to Baja California in Mexico.

They feed on vegetation-eating sea urchins. When sea star numbers decline, the surging urchin populations devour kelp forests that are both habitats and food sources for all kinds of marine life, including fish, seals, sea lions, sea otters and whales.

In February, a research team at the Birch Aquarium at the Scripps Institution of Oceanography at the University of California in San Diego succeeded in breeding the sunflower sea star.

The team used a hormone mixture to induce male and female sunflower sea stars to release their sperm and eggs by the millions, which were collected for fertilisation in a controlled environment.

The team, made up of researchers from Birch Aquarium, Aquarium of the Pacific, California Academy of Sciences, San Diego Zoo Wildlife Alliance and Sunflower Star Laboratory, is part of a larger collaborative effort among researchers, marine conservation professionals and environmental educators to accelerate the recovery of the species along the US West Coast.

Another team in Washington, led by research scientist Jason Hodin, in 2023 reintroduced 48 juvenile sea stars aged between one and two years old into the ocean. They were released in cages to closely track their progress. One of the cages – containing 10 sea stars – was lost. Dr Hodin said the other 38, which have been brought back to the lab for further study, are "healthy and growing a lot", with other juveniles being reared.

Dr Hodin said a group of researchers led by marine ecologists Drew Harvell and Alyssa Gehman, including microbiologists from the University of British Columbia, could be close to finding the cause of the disease – which may be a bacterium.

A genomics team at the University of California, Merced, led by Professor Mike Dawson and research scientist Lauren Schiebelhut, is studying the genetic make-up of the sunflower sea stars that have survived the pandemic. It hopes to find the gene that helps the sea stars to fight the disease, so as to replicate it in a new generation.

Meanwhile, in Singapore, the National University of Singapore's Tropical Marine Science Institute has been assisting the boring giant clam *(Tridacna crocea)* and the tiger cowrie *(Cypraea tigris)* in boosting their numbers.

Overharvested for their attractive shells and popular with aquarium hobbyists, both shellfish are found in shallow reef waters and are deemed endangered here, although they have healthy populations elsewhere in the world.

The boring giant clam is an important food source for a wide array of predators and scavengers. Dense clusters of giant clams serve as shelters and nurseries for fishes.

Tiger cowries feed voraciously on invasive sponges that can overtake live corals, which allow other native creatures in reef habitats to have enough space and resources.

A three-year project led by principal investigator Neo Mei Lin was started in 2021 to study the breeding and culturing of boring giant clams and tiger cowries to develop the cultivation, management and harvesting of these shellfish.

Giant clams have both male and female reproductive organs.

Dr Neo's research team first injects the hormone serotonin into the clams' reproductive parts, which causes them to release sperm and eggs into the water. The sperm and eggs are collected separately before they are mixed in various tanks for fertilisation.

The researchers monitor the clam larvae and culture them for about a month as they develop into juvenile clams, and another two years before they reach adulthood.

Dr Neo's team reported in 2023 that they had succeeded in getting larvae of endangered tiger and Arabian cowries to develop and settle into juveniles by keeping them in optimal environmental conditions in the lab, where other previous reproduction studies had not succeeded.

With the tiger cowries, the researchers focused on providing the sea snails with optimal living conditions in the lab, but did not intervene directly to induce breeding.

"The bulk of work comes from upkeeping and feeding the broodstock, monitoring the status of the brooding females, collecting the larvae and keeping them in the lab for culturing, as well as growing out the larvae into juveniles," said Dr Neo.

Dr Neo's research team hopes to boost the production of both endangered marine species – for research and conservation. It has been able to produce juvenile boring giant clams about once every three months.

She said: "Assisted reproduction of marine species is akin to buying insurance, where we can withdraw this knowledge to help species recover their numbers in the event of challenges such as disease outbreaks and global warming."

arielyu@sph.com.sg

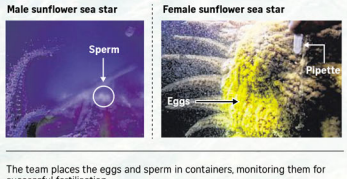
Breeding hope for ocean species

Researchers in California and Singapore are developing methods to boost the dwindling numbers of sunflower sea star, boring giant clam and tiger cowrie.

Sunflower sea star *(Pycnopodia helianthoides)*

Where it can be found	Alaska and the US West Coast.
Conservation status	Critically endangered globally.
Main threat faced	Sea star wasting disease caused by an unknown pathogen. Warmer waters due to climate change may exacerbate the spread of this disease.

Researchers at the Birch Aquarium at the Scripps Institution of Oceanography in San Diego carefully administer a hormone mixture to induce male sunflower sea stars to release sperm and the females, eggs. The animals are then placed in individual tubs.



The team places the eggs and sperm in containers, monitoring them for successful fertilisation.

- The fertilised sunflower sea star eggs take 47 days to develop into larvae, which then take about three years to reach adulthood.
- The fertilised eggs have been distributed among the researchers from various institutions and aquarium partners in California collaborating on this study, to care for the larvae until they reach adulthood.

Boring giant clam *(Tridacna crocea)*

Where it can be found	Indo-Pacific region, including south of Singapore, although rare.
Conservation status	Endangered in Singapore.
Main threat faced	Overfishing for food, their shells, and for the aquarium trade.
Other threats	• Coastal urbanisation and reclamation. • Global warming brings about higher sea temperatures that contribute to coral bleaching and possible death, putting the reef ecosystem where giant clams live at risk.

- Since October 2021, researchers from the Tropical Marine Science Institute at the National University of Singapore have studied assisted reproduction for boring giant clams. These clams are hermaphrodites and have both male and female reproductive parts simultaneously.
- Researchers inject clams with the hormone serotonin to trigger the release of sperm and eggs before placing them into individual tanks.

The clam first releases sperm, which the researchers collect with pipettes.

- The research team continues to monitor the clams for about 45 minutes, to see if the clams start producing eggs.
- If so, the clam is moved to a different tank, so that there is less chance of in-breeding.

- Researchers then set up various tanks with a mixture of sperm and eggs, and use a microscope to check for successful fertilisation every three hours.
- Sufficiently mature fertilised eggs are moved to another area of the research facility.

- It takes about one day for the fertilised eggs to develop into larvae, which take about a month to develop into juvenile clams that are at least 1mm in size.
- The team has been able to produce juvenile clams about once every three months.
- It takes two years for giant clams to reach adulthood and they can grow up to 15cm in size.

Tiger cowrie *(Cypraea tigris)*

Where it can be found	Indo-Pacific region, including the reefs north of Singapore, although rare.
Conservation status	Vulnerable species in Singapore, but not globally.
Main threat faced	Overfishing for their ornamental shells.
Other threats	• Rising sea temperatures contribute to coral bleaching, which may destroy coral reefs where tiger cowries live. • Fish bombing, a destructive form of fishing, kills animals and destroys corals in the blast area.

- At the St John's Island National Marine Laboratory, researchers from the NUS Tropical Marine Science Institute place both male and female tiger cowries in a seawater tank, which is kept in optimal condition.
- The tiger cowries are fed a variety of food, including prawns, cucumbers, cai xin and kai lan, which can enhance their growth and production of eggs and sperm.

- The mating process is difficult to observe and cowrie eggs are fertilised internally. An indication of success is when the female tiger cowrie lays an egg mass.
- Close to the date of spawning, the research team removes other cowries from the tank to make it easier to subsequently retrieve larvae.
- Larvae hatch from the egg mass after seven to 10 days, and can swim around to feed.

- Researchers collect these larvae and grow them in the laboratory under stable conditions, with regular seawater changes to prevent bacteria build-up that can impede larvae growth.
- It typically takes around 42 days from hatching for the tiger cowrie larvae to settle to the bottom of their tank that they are placed in and develop into young juveniles, which resemble the adult sea snails with a mottled shell.
- The research team continues to feed these young juveniles with vegetable leaves and prawns to boost their growth.
- The larvae take around 12 months to reach adulthood.

Sources: SAN DIEGO ZOO WILDLIFE ALLIANCE, NUS TROPICAL MARINE SCIENCE INSTITUTE, NATIONAL PARKS BOARD, IUCN RED LIST
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