

Mission Report

Emergency Tsunami Coral Reef Clean-Up Operations

Project Monitoring and Media Trip Similan Islands 21 – 23 April, 2005



Project Coordinator Aie on her way to the project site



One of the two diving boats that UNDP are funding to support reef clean-up and rehabilitation.



Hakan Bjorkman speaking with Permanent Secretary Petipong Pungboon Na Ayudhaya on Similan Island.



Khun Nangnoi Yotsoonthorn of For Sea Foundation



Reef Rehabilitation of Fan coral 100 meters off-shore of Similan Island #4. Fan coral is taken from the dive site to the boat and affixed with concrete to rocks before being re-submerged.

Objectives	<ul style="list-style-type: none"> • To monitor the UNDP/UNOPS project “Emergency Post-Tsunami Coral Reef Clean-Up Operation” • To invite journalists to inform public of project achievements
Team	<p><u>UNDP</u> Hakan Bjorkman, DRR Thailand Phansiri Winichagoon, Programme Manager Amanda Pitt, UNRC, Public Information Officer Punnipa Ruangtorsak, Communications Associate Dennis Duncan, Communications Consultant</p> <p><u>UNOPS</u> Siamak Moghaddam, Portfolio Manager</p> <p><u>MEDIA</u></p> <p>1. Mr. Kamol Sukin Senior reporter The Nation</p> <p>2. Ms. Krittiya Wongtavavimarn Reporter (Feature) Bangkok Post</p> <p>3. Ms. Nipaporn Tadhun Reporter (Jud Pra Kai) Krung Thep Thurakij</p> <p>4. Ms. Ratchaneekorn Sangsai Writer Kinnaree In-Flight Magazine</p> <p>5. Ms. Chintana Kuanoon and Mr. Pakpoom Pumipas Reporter + cameraman TV 9</p> <p>6. Mr. Simon Hand Associate Editor Art ASIA Press (Phuket magazine, Bangkok Airways in-flight magazine)</p> <p>7. Mr. Paul R. Foley P.R. Ecological Writer</p>

Mission in Brief

The team flies to Phuket and after a briefing by project manager on progress of project, goes to actual dive site in Similan Islands where coral is being repaired and monitors situation. Journalists are free to ask questions and move about at their leisure. Team returns to mainland and does inspection of tsunami damage in Kao Lak, Phang Nga province. Team returns to Bangkok.

Thursday 21 April

Arrived Phuket 7pm. Gathered for Briefing 8pm.

Briefing by the Department of Marine and Coastal Resources

Briefing provided by:

Dr. Niphon Phongsuwan, Chief Marine Biologist, Phuket Marine Biological Centre, as Project Manager;

Lyndsey Elizabeth Hill, Technical Coordinator for the Reef Clean up, Rehabilitation and Protection Project.

Clean-up issues:

Participants were informed that the initial phases of the clean-up operation have been successful with 95 percent of priority designated areas cleared of land washed debris. By far, the greatest amount of debris was found in and around the area of Ton Sai Bay, Phi Phi Islands .

It was noted the most difficult portions to clean-up were those entangled in fishing nets, known as “net balls”. Each could weigh anywhere from one to four tons. It was explained that they were dangerous to cut through and could take a considerable amount of time to bring to surface. One four-ton net ball took 20 divers four days to bring to the surface with the help of a hydraulic crane.

Rehabilitation issues:

Participants were informed that rehabilitation portion of the project was on schedule. Conversation centered on the current exercise in Similan Islands where around 200 fan corals knocked down by the tsunami had been up-righted. It was noted that this type of rehabilitation had never been embarked on in the past and that it was considered “uncharted territory”. As transplanting to new habitats was impossible due to the environmental sensitivity of the species, fan coral has to be put back exactly in the area it had been found. The first method included spiking the coral bottoms with steel nails in directly into the bedrock. This was found to have its limitations as natural ocean currents could loosen them. It was also feared that fan coral “roots” would not have grown substantially enough to stabilize them through the monsoon season. It was pointed out that the average time for coral to reattach naturally to the sea floor was one month.

Affixing corals to rebar rods which allowed greater anchoring worked, as did propping up with rocks found on the sea floor. Wedging live coral into fissures also worked. It was noted that corals thus affixed would be monitored in terms of future growth, health and rate of recovery. It was noted that a Coral Reef Specialist from Japan was testing with various epoxy resins to find solutions for “gluing” coral back to the sea floor. A report on this method would follow.

It was noted that currently in the Similan Islands the project was bringing complete fan corals – some 3-4 feet in diameter – out of the water and affixing them to dry rocks sourced from the island rocks with a cement compound, allowing them to dry before reinserting the structures back into their original underwater habitat. Before being submerged the coral would be measured and tagged for future monitoring.

In other areas, broken pieces of living stag horn coral was being affixed to the holes in concrete cinder blocks with cement. The cinder blocks were then placed in “colonies” on the seabed.

Protection

Although the project had not progressed toward the final protection stages, it was noted that the Department of Marine and Coastal Resources, the Phuket Marine Biological Centre and the Program operators were in discussion over which areas in the program zone would be eligible for:

- Mooring buoys to demarcate the zoning of snorkelling and diving areas
- Off-limits areas will be designed via the use of floating fences
- A diving / snorkelling trail will be created and monitored by a strong network of diving operators aimed at conserving certain reef areas
- A marine life underwater guide will be created in connection with the trail establishment to emphasize coral reef conservation
- Visibility materials such as signs and posters / brochures will be created to instill greater awareness of coral reef conservation.

Overall Synopsis:

- There was a general feeling among participants that the project was going well.
- It was noted that reporting could be better managed as situation on the ground was different to what information UNDP had. Project manager said would compile regular reports and send to Khun Phansiri.
- Was mentioned by one journalist that it seemed irregular that UNDP was undertaking a program that lacked adherence to the UNDP's mandate. Response was that healthy/unhealthy coral reef ecosystems have a direct affect on livelihoods related to tourism and fisheries thus it fell within UNDP's operating mandate.
- Was noted that coral reefs being rehabilitated would naturally regenerate to pre-tsunami conditions within five years and that UNDP program might be counterproductive when placed next to natural regeneration. Dr. Nippon assured that methods being used by the project would in no way inhibit the natural resiliency of reef zones but would in fact speed up reef growth to pre-tsunami conditions within three years.
- Dr. Nippon noted that one of the main focuses of this project was to study the methods being employed to revive coral colonies. He noted that because damage had been done in localized areas that were easily accessible to support networks (ie divers, boats, marine specialists), that there was an excellent opportunity to experiment with new methods of coral repair and rehabilitation. While he conceded that the “rehabilitation” portion of the program was not critical to the reef's regeneration, the scientific findings would be invaluable for rebuilding other reef ecosystems in the event of future calamities where reef systems had sustained such damage that there would be no chance for natural revival.

Friday 22 April

Took speedboat from Tab Lamu, Phang Nga province to Similan Island #4. Departed 10:30am arrived 12 noon. Registered with Department of National Parks, Wildlife and Plants guesthouse.

Meeting with Khun Pitong Pungbun Na Ayudhaya, Permanent Secretary, Ministry of Natural Resources and Environment

Hakan Bjorkman meets with the Permanent Secretary and his entourage who was visiting the island at the same time. Hakan briefs the PS about the scope and status of the UNDP-supported activities and discuss the need for longer-term rehabilitation and conservation effort beyond the initial clean up phase.

The discussion also focuses on the overall government strategic direction for integrated coastal resource management for the Andaman Coast. The Permanent Secretary welcomed UNDP's support in formulating a strategic plan, suggesting that at least some of the funding should be used for pilot testing of key priorities/activities of the strategic plan. It was agreed that this discussion be continued at a meeting scheduled for that next week between UNDP and MONRE.

Visit to two dive boats

Rendezvoused with two project dive boats to monitor ongoing rehabilitation operations. Meet up with Ms. Petchrung Sukpong, Project Coordinator, who welcomes team to the project boat and gives brief explanation of operations.

Khun Petchrung Sukpong, the Project Coordinator under Khun Niphon, introduces her team and along with Team Leader Charles Benties of Songkla University gives a brief synopsis of the situation.

Situation:

Boats are well organized and safe. Volunteers involved are young divers from all over the globe, but mainly Europe and North America. There is excellent morale onboard and an eagerness to be a part of the project.

Divers typically dive three to four times a day working in teams of four (there are 12 divers on board) and sleep onboard in cramped, albeit, not uncomfortable conditions. There is a resident cook and crew of three to maintain the boat.

Any diver is free to become involved with the rehabilitation project so long as they can rendezvous with the boat on their own accord, provide their own diving equipment and are able to live on board and abide by the boat's rules. She explains that the average stay for a diver is about two weeks, however there are divers who have been involved from the onset of the project.

The majority of new divers are local divers, or associates of local divers. In the first stages of the project a global appeal went out to volunteers that was met with much enthusiasm. It was explained that any further appeals are unnecessary as "word of mouth" recruitment brings in sufficient divers that are a) knowledgeable of the reef areas and b) are already acquainted with diving teams. It was made clear that bringing in divers that did not meet the above criteria could be detrimental to the ongoing project.

As it stands, foreign volunteers are key. However, the organizer is For Sea Foundation in coordination with Prince of Songkla University staff who work with Dr. Nippon,.

It seemed that all the needs of the project and divers were being sufficiently met.

Saturday 23 April

Team departs Similan #4 at 9:30am and arrives Tab Lamu, Phang Nga province at 12:00 noon. Team drives to Kao Lak to survey tsunami damages.

Returns to Phuket International Airport and departs at 2pm.

Conclusion

Summary analysis

- Effect of tsunami on reef and marine ecosystem generally positive. There have been many reports that water clarity has improved massively and that fish are in greater abundance than before the tsunami.
- Much of the damage done was from man-made land-based debris washed in to the reef areas. Most of this debris could be considered items in the non-sustainable tourism category such as machinery for water pumps, electrical generators, roofing tin, oil drums etc.
- Highly localised negative effects that make cleanup and rehabilitation easier, as well as provide microcosms for scientific study.
- Sedimentation issue will probably be resolved through water movement over monsoon season.
- Window of opportunity for righting overturned corals: six weeks from tsunami – long past.
- Some misguided voluntary work moving corals continued into April, damaging natural recovery. This points to an absence of co-ordination for such activities. It was stressed that coordination would be key to future events of this nature. There were also concerns over the general safety of the mission population where recreational divers are performing tasks usually done by qualified commercial divers. More concentration of safety needs to be adhered to.
- Natural organic debris may be positive input to ecosystem growth spurt.
- In addition, high nutrient loads from runoff from the tsunami and monsoon will likely lead to increased algal growth in many areas. In other places this has led to algae out-competing and killing hard corals. Thus a second round of monitoring of reefs should be planned for the middle or end of the next dry season when such effects will begin to become apparent.
- There is still extensive damage in Loh Dalam Bay, Phi Phi Island. Most of this damage is in 2 to 4 m of water depth and includes colonies up to 4 m in diameter. This Bay is the most extensive shallow water habitat in the area and thus is likely an important nursery ground for many local coral reef fishes that use deeper water areas later in their life. The death of these corals will likely cause harm down the line to obligate corralivores, like some butterfly fish. While the top of the colony of these corals is dead from the contact with the substrate, the sides are not. However, many of these sides are shaded and may die eventually and the colonies are now often unstable and will roll and cause further death in the monsoon. Righting these corals can be a

valuable restoration effort. Colonies larger than 0.75 to 1 m can probably be righted and left as is, while smaller colonies will need to be cemented in place to prevent them from rolling back over in the monsoon season or during heavy weather. In addition, the increase in dead coral substrates is likely to lead to an increase in herbivorous urchins and fishes that feed on the algae growing on the dead coral substrates. Some of these animals can cause further mortality of live coral in the future. So monitoring may be useful in this area.

- 95% of project sites visibly clear of debris. However, there are many sites within the 2-4 meter depth range in Koa Lak and Phi Phi Islands that have debris and overturned corals. Most of these areas are “non tourist” diving areas and are being overlooked even though they could be critical in the future for health of the entire eco-system.
- Significant work still necessary in Phi Phi and Khao Lak on visible debris, despite concerted clean-up actions.
- Some debris not from tsunami (15% of nets taken off reef are old ghost nets)
- Estimate of debris remaining impossible due to tsunami generated sedimentation cover.

Next steps

- Monsoon due mid-May.
- Continual uncovering of hidden debris will take place throughout monsoon. There are still tremendous amounts of debris in the water in Phi Phi Island and Khao Lak, which as most of you know are the two worst hit areas of Thailand. The Thai government, the UNDP and UNEP, and even the large resort owners and other donors need to recognize that these areas need a HUGE amount of assistance in debris removal. Tonsai Bay, Phi Phi Islands could use the return of the pontoon that was removed by the government and the help of more divers and heavy lifting equipment to deal with much debris. Khao Lak needs many more teams of divers and heavy lifting equipment and regular lift bags if there is ever any hope of having beaches and shallow water environments that are clear enough of debris so that the environment is safe and tourists are comfortable using the ocean.
- It has been expressed that all efforts on land to restore tourism in Khao Lak will fail if the shallow water environment is so full of harmful or psychologically disturbing debris that tourists will not want to swim there. In this scenario, Khao Lak may become a bedroom community for Similan-bound SCUBA divers.
- Government and UNDP programs need to prioritize debris removal efforts. Recruitment of local fishers, dive operators, and other water users should be coordinated to provide lots of eyes to find toxics/ordnance from Thai Muang navy base, and other harmful debris that should be removed as soon as discovered. Regular observation of all ocean coastlines should occur to check for new leaks from rusting or punctured containers, especially near areas of water withdrawals or where groundwater wells occur near shore.
- Other priorities might include removing the likely high concentration of fishing nets from around Thap Lamu and Thai Muang which hosts turtle nesting, and any other areas where sea turtles or marine mammals are likely to spend lots of time.
- Debris uncovered by monsoon will include bodies.
- New debris, waste, and potentially damaging matter will arrive on Thailand's Andaman coast from monsoon currents from India, Sri Lanka, and Indonesia.

- Debris problem will cause secondary (possibly greater) negative impact when monsoon arrives, with persistent strong wave action crashing unsecured debris into otherwise intact reef.
- Debris can still be removed during this period, but on an opportunistic basis.
- Debris problem could be issue for a number of years.
- Education and public awareness with media should continue throughout monsoon season.

Suggestions For Training of Divers for Debris Removal

Dwayne Meadows, Ph.D.
 Aquatic Wildlife Conservation Planner
 Hawaii Division of Aquatic Resources and
 Pacific Cooperative Studies Unit
 2345 Ala Wai Blvd. #1107
 Honolulu, HI 96815
 cell: (808) 342-0380
 DwayneMeadows@msn.com

Dr. Meadows, who viewed the UNDP coral cleanup and rehabilitation project has extensive experience in reef clean-up techniques.

Divers involved in debris removal need better training. Debris removal is a dangerous activity that calls for methods used by commercial divers. Many practices common to recreational and scientific diving create additional safety hazards during debris removal. For example, divers should be instructed to minimize dangling equipment if there is any chance of working around entangling debris, including net material used for debris removal. For example, octopus regulators should NOT be exposed (whether attached to a lanyard or not). They should be put in a pocket or removed from regulator and not used (buddy breathing should be practiced). Other dangling objects like knives, slates, pressure gauges, and even BC inflator hoses should be removed or secured inside the BC, the cummerbund, or wetsuit. Full skin protection using a wetsuit or skins is best.

Lift bag operations. SOP for lift bags lifting anything more than nominal weight is for 2 divers to ascend or descend in a controlled manner with the object. Lift bag operator is responsible ONLY for vertical movement of the object. Second diver is responsible for horizontal movement and positioning. Lifting really heavy or dangerous objects from depth can be done more safely by staging the ascent so the object cannot rocket to the surface. This is done by attaching a long line from object to a lift bag. The lift bag is very near the surface so that when it is filled the object is only lifted slightly from the bottom. This is especially useful for objects buried in sand where extra lift is needed to free them from the sand, but as soon as that occurs, the object has excessive lift and can easily rocket, uncontrolled to the surface. Once the object is staged, additional lift bags or lifting lines can be used to safely get the object to the next stage or all the way to the surface. Lines can also be attached to objects being lifted and then to other structures to prevent excessive vertical movement.

Appropriate safety and comprehensive first aid gear should be present including oxygen and adequate bandages for large bleeding wounds. Someone should be present or very nearby who has the training and can render assistance. All divers should have current tetanus vaccinations as cuts are common and bacteria are commonly stirred up with sediments that settle on the divers (many of us survivors had infected wounds that had to be surgically cleaned, sometimes multiple times with

additional tissue loss!!). Work around entangling objects like nets should involve only one member of buddy team exposed to entanglement at a time. Other should be safety diver. Snorkel groups should have SPARE-AIR or Pony bottles nearby in case of entanglement. One-up one-down buddy system should be employed for snorkelling ops.

Contacts and protocols for handling toxics, ordnance, entangled animals, recovered body parts, and identifiable personal belongings should be developed.

Systematic mapping of surveyed sites and large or dangerous debris locations need to be undertaken. GPS units and training should be provided to all debris removal teams. Manta-towboarding, where divers or snorkelers are towed behind boats, is an effective technique for surveying large areas more quickly than SCUBA or even snorkelling. SCUBA towboarding requires training and good communication devices between divers and boat operators.

Selected Media Responses to Date

April 27, 2005, Wednesday

LENGTH: 581 words

HEADLINE: Similan Coral Rescue Going Strong

BYLINE: The Nation Newspaper, Bangkok, Thailand

BODY:

Four months after the tsunami struck the Andaman coast, operations to survey and rescue underwater species at Similan Islands are continuing. Now that corals have been cleaned, teams hit the water over the weekend to revive the kalabangha, or sea fan.

Sea fans are not as prevalent as other types of coral, but they suffered more damage in some locations.

"Sea fans are large in shape and stand up in the current to trap plankton for food. So they can be damaged easier by tsunamis," said Nattaphol Pholbamrungwong, a marine biologist, last weekend.

The waters around Similan Islands are one most important habitats for sea fans in the Andaman Sea and a recent survey found five significant sites of critically damaged sea fans, he said.

"Without a rescue operation, broken sea fans would just die from a shortage of food. So we decided to launch this essential operation soon before the coming monsoon season," said Niphon Phongsuwan, a senior marine scientist at the Phuket Marine Biological Centre (PMBC).

"The key to the sea fan's survival is to make sure it can stand firmly at the right spot - in a current so it gets enough food," said Chaimongkhon Yaemngarmarun, another PMBC scientist.

Last week, the first crew of the sea fan rescue team was sent to Similan. It was led by the PMBC in cooperation with Prince of Songkhla University and under the sponsorship of the **United Nations Development Programme (UNDP)**. Foreign and local volunteers joined the crew of 40.

"The operation wasn't easy because we had no body of knowledge or experience to draw on to rescue the sea fans. So, everything was done on a trial-and-error basis. We cannot be certain of the efficiency of the operation until further monitoring," Chaimongkhon said.

First, the marine scientists tried to fix the sea fans to the seabed with stones and pieces of metal. That worked only at some sites. The second trial involved putting sea fans into a hole in the seabed and securing them with wooden wedges. The result was similar not much better.

Marine cement was used in the third attempt. Dive after dive the scientists tried to

glue the species onto the seabed, but the operation was unsuccessful.

"Marine cement needs some ten minutes to set, but the undersea currents were also strong," Natthaphol said.

The failure made the scientists decide to bring up the broken sea fans and repair them with stones piece by piece above water, waiting for the cement to harden before tagging them for observation and putting them back in their habitat.

"We found it was the best method, for a higher survival rate. We might consider applying this method to those we used the other method on before," Natthaphol said.

Team leader Charles Benzies said almost 200 sea fans had been revived by Friday at five dive sites around the Similan Islands - Stonehenge, Deep Six, Turtle Rock, Pusa Rock and North Point.

An evaluation would be conducted at least three times during the project, said Hakan Bjorkman, UNDP deputy resident representative. Nippon said the tsunami impact assessment on coral in the Andaman Sea had covered all 10 marine parks and one wildlife reserve.

Of all 174 sites checked in the six Andaman provinces, 13 per cent were impacted heavily and 9 per cent moderately. The impact was low in 17 per cent of the sites, very low in 21 per cent and 40 per cent were not affected at all, he said.

Kamol Sukin

The NationPhang Nga

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Financial Times Information

Global News Wire - Asia Africa Intelligence Wire

Thai Press Reports

May 3, 2005

LENGTH: 573 words

HEADLINE: THAILAND LAUNCHES OPERATION TO RESTORE CORAL REEFS IN SIMILAN ISLANDS FOLLOWING TSUNAMI

BODY:

Four months after the tsunami struck the Andaman coast, operations to survey and rescue underwater species at Similan Islands are continuing, The Nation reports.

Now that corals have been cleaned, teams hit the water over the weekend to revive the kalabangha, or sea fan.

Sea fans are not as prevalent as other types of coral, but they suffered more damage in some locations.

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Of all 174 sites checked in the six Andaman provinces, 13% were impacted heavily and 9% moderately. The impact was low in 17% of the sites, very low in 21% and 40% were not affected at all, he said.

LOAD-DATE: May 2, 2005

Xinhua General News Service

April 27, 2005

SECTION: WORLD NEWS; Political

LENGTH: 371 words

HEADLINE: Thailand continues saving coral reef after tsunami

DATELINE: BANGKOK

BODY:

Four months after last year's tsunami, Thailand still carried on diving missions to save coral reefs affected by the strong waves along its Andaman Sea coast.

Some 40 marine biologists and volunteer divers moved to **Similan Islands**, the country's top diving site, over the weekend to save the underwater creatures.

Sea fans, a kind of hard coral with its branches spreading in vertical direction as a fan, are the focus of the latest rescue mission.

"Sea fans are large in shape and stand up in the current to trap plankton for food. So they can be damaged easier by tsunamis," newspaper Nation on Wednesday quoted marine biologist Nattaphol Pholbamrungwong as saying.

He said the waters around **Similan Islands** are one most important habitats for sea fans in the Andaman Sea and a recent survey found five significant sites of critically damaged sea fans.

According to Nattaphol, divers had tried different ways to erect the broken sea fans and fasten them on to the underwater ground so as to enable them to take food again.

After several trials, the rescue team had to ring up the broken sea fans first and glue their roots to stones with marine cement above water, for the current was too strong for underwater operation to fasten the broken sea fans.

After the cement to harden, the rescue teams then tagged the corals for observation and put them back in their ocean habitat.

Among efforts to rebuild the tsunami-hit areas, Thailand tried hard to clean the underwater world and help coral reefs recover.

Since January, the authorities have organized volunteer divers for the rescue mission along the tsunami-affected areas, including resort islands famous for diving trips such as Phuket, Phi Phi and Raja.

An tsunami impact assessment was carried on coral in the Andaman Sea had

covered all 10 marine parks and one wildlife reserve, said Nippon Phongsuwan, a senior marine scientist at the Phuket Marine Biological Center.

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LOAD-DATE: April 27, 2005

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Bangkok Post Newspaper, Thailand

March 4, 2005

LENGTH: 1,148 words

HEADLINE: Fan Club to the Rescue

BYLINE: KRITTIYA WONGTAVAVIMARN

BODY:

Volunteer divers are racing against time to repair coral reefs damaged by the tsunami, paying particular attention to a tall, colourful creature called the sea fan

It's been a bit over four months since the tsunami left a swathe of devastation along our southwest coast but Jirapong Jeewarongkakul is still giving first aid to victims of that disaster, working tirelessly to prevent as many deaths as possible. He has no need of bandages, antiseptic or other medicine, though. And most of his work is carried out not in a hospital or makeshift clinic but at the bottom of the Andaman Sea.

For Jirapong is one of 30 volunteer scuba divers on a mission to save sea fans living in the waters around the Similan Islands.

Last week, officials from the Department of Marine and Coastal Resources again collaborated with the United Nations Development Programme on a reef-recovery project in the area, the last major rehabilitation effort scheduled before the monsoon starts in mid-May.

"Further operations will be difficult due to the strong currents whipped up by the southwest monsoon," explained Jirapong, a 35-year-old marine researcher at Prince of Songkla University.

"Many types of coral can naturally withstand the action of the waves but if rehabilitation is not completed before [the monsoon arrives], sea fans that are already in a fragile condition because of the tsunami may be uprooted, resulting in severe damage from which they may not recover."

The sea fan (kalabangha in Thai) is a marine animal that forms erect, flattened, branching colonies in tropical and subtropical waters. Colonies may grow to a metre or more in height and are often colourful, with purples, reds, and yellows

predominating. The individuals, or polyps, have eight feathery tentacles and feed on plankton organisms. Sea fans are classified in the phylum Cnidaria, class Anthozoa, order Gorgonacea.

Sea fans and other gorgonians (corals having a horny or calcareous branching skeleton) are normally found in deep water. They hold themselves upright in the current to trap plankton but if they're struck down or flipped over into the sand, they'll slowly starve to death, explained team leader Charles Benzies.

"We have to make sure they can stand firmly in their normal position. The remaining debris [on the sea floor] might damage other coral formations, too, rendering the recovery process that much more difficult," he added.

The Similan Islands Marine National Park in Phangnga province is home to an extraordinary array of coral-reef ecosystems which provide habitats, breeding and feeding grounds for many rare and endangered marine species. The reefs are also the mainstay of dive tourism in the area.

The December 26 tsunami damaged the reefs in a variety of ways. According to Nippon Phongsuwan, a coral-reef biologist at Phuket Marine Biological Centre, many coral mounds were turned over and table corals were dislodged from their normal positions in Snapper Alley, around Pular Rock, Hanging Stone, Christmas Point, Deep Six and other dive sites off the Similan Islands. A number of sea fans were also damaged _ torn, broken or flipped over.

To save the lives of these creatures and speed up the revival of coastal tourism, teams of professional divers have been taking part in coral-reef clean-up operations since January. At this stage more than 95 percent of tsunami-affected sites have been rehabilitated.

"Fortunately, the Similans are now generally in a good condition," said Nippon. "Most of the area has been cleared up and a number of coral colonies have been repaired."

Divers gathered up coral fragments scattered on the sea floor and anchored them firmly in crevices between dead coral formations. Many of the corals that were flipped over were returned to their original positions in the first month following the tsunami. To increase their chances of survival, some coral fragments were also attached to hard, artificial substrates using fast-setting marine cement.

If the coral is still young, it can recover completely within two to five years, Nippon said.

"The work had to be done in the first month after the waves hit. If not, any coral surfaces buried in the ground will die from a lack of sunlight," he said. "Coral that was broken off we mended by sticking to the top of bigger formations with marine cement. Within one month the tissues will naturally bond together, ensuring that the coral survives and continues to grow and reproduce."

In the case of sea fans, however, rehabilitation is not such an easy task. Nippon conceded that insufficient research and a lack of sea fan specialists have proved major obstacles. Marine scientists have had to conduct the recovery operation by trial and error.

Since January, around 250 sea fans in this part of the Andaman have been temporary resettled _ either wedged into rock holes using pieces of wood or else

secured with wire tied to stakes driven into the sand. However, there are concerns that both methods will prove ineffective in the long run.

"The wedges and wire can tear the sea fans' delicate tissue and they might not survive," said Nattapon Ponbumrungwong, another volunteer diver who is studying for a PhD in biology at Japan's Waseda University. "So, we decided to attach them to stones with marine cement before putting them back into the sea."

The latter method has been in use in the Andaman since February. When a sea fan is stuck to a hard substrate with cement, it will gradually grow new holdfasts (root-like anchoring structures) which attach themselves firmly to the rock, allowing further growth and development, Nattapon explained. Parts broken off living sea fans can also be replanted as nursery stock to ensure a higher survival and reproduction rate, he added.

While these sea fan restoration efforts can be beneficial both in preserving biodiversity and protecting the local tourism industry, some people argue that the methods being used may damage delicate living creatures and have a negative impact on the marine ecosystem.

"We've found it [the cement technique] the most suitable way of sustaining sea fans until such time as they've regained enough strength to recover by themselves," said Nippon, adding that it is vital to ensure the continuity of the project.

"There's a need to continually monitor the situation, to follow up on any progress made, to compare results and decide what work needs to be undertaken in the future. Zoning should be initiated to distinguish sections that are ready for tourists from those that are not, especially in areas that were severely affected by the tsunami," he continued.

"Rehabilitating a few sites won't have a great impact on the dive-tourism industry as a whole. The operation may be time-consuming but it's the only solution if we want to maintain a balanced marine ecosystem and promote eco-tourism in the Andaman Sea. "For the reefs to fully recover, however, the most important thing is that all of us abstain from harming these marine creatures ever again."