在攝影鏡頭24小時的監測下，海底生物百態無所遁形。/ 林芳邦提供
Thanks to underwater monitoring system, every image of marine creatures in the proximity can be captured. / Photo provided by Dr. Fang-pang Lin

大海監測 不再視茫茫

A Clearer View of the Ocean

海底影像監測的秘密

The Secret Behind the Underwater Monitoring System

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有過潛水經驗的人應該知道，想要觀賞水底下的景致並非容易的事。即使再清澈的海水湖面，皆會因天氣或氣流等不同的因素，影響水下觀測的作業。風浪大時，前進方向不易且有安全顧慮；平靜無波時則因無洋流擾動，水中懸浮粒子停滯，影像觀測亦難以進行。

Divers know how difficult it is to observe the scenery under the water, as different weather conditions or ocean currents may disturb underwater observations. Stormy waves are dangerous while calm ones contain more suspended particles (because without the disturbance of ocean currents) that will hinder image monitoring.

無論波浪動或靜皆有不同的執行難度，加上浮力、呼吸與體力的考量，海底觀測的挑戰比想像中更大。

大海監測絕非易事，但國家公園區域範圍涵蓋海域的墾丁國家公園，仍持續進行著，希望在高科技的協助下，更能落實海洋保育。像是1998年聖嬰現象海水暖化所造成的珊瑚礁白化，令全球措手不及，加上過度捕撈、工業污染、水質優養化等人為破壞，海底生態搶救如隔山救火，海底影像監測的建立，的確刻不容緩。

污染浩劫　監測啓動

「2001年，希臘貨輪阿瑪斯號在鵝鑾鼻龍坑外海擱淺，導致1,100公噸的燃料油污染了整個龍坑海域，也為珊瑚礁帶來嚴重浩劫。」國立海洋生物博物館生物馴養組研究員的樊同雲博士回想這起因原油污染對海域生態構成的長期影響，仍心有餘悸。當1980年的暖化效應發燒，全球如火如荼地投入珊瑚礁生態監測，這起油污事件更顯示了海底監測須實行的重要性。

要在茫茫大海中規劃監測系統、還必須懂得分析得來的數字背後所代表的意義，絕非易事。和樊同雲一樣投身該領域的，還有在英國威爾斯接受數值模擬教育、牛津從事飛機設計的林芳邦博士。

「為何在英國學尖端電腦運算的科技人，會一頭栽入生態保育？」林博士笑著說，他認為身為台灣人，就該為這塊土地盡份責任，能藉由影像傳達更能使大眾瞭解海底世界的奇妙，才能激發珍惜的心。

海底監測系統及其周邊儀器除了廣泛應用在珊瑚礁生態以外，還能監測海水的溫度、深度、濁度以及潮位，有的儀器甚至可精算出硬珊瑚、軟珊瑚、柳珊瑚、海葵、海綿、大型藻等生物在海底的覆蓋率。

林博士表示，透過監測所了解的海底世界，往往更加迷人。「海底生物和人類一樣具有好奇心，有些還會對鏡頭探頭探腦，就連已瀕臨滅絕的大海龜和具毒性的海蛇，都曾在監視器前留下蹤影呢！」

The task of underwater monitoring is much tougher than one can ever imagine, as factors such as waves, buoyancy, the observer's breathing and vigor all come into play.

However, in Kenting National Park, where water areas are included, underwater monitoring is still ongoing as of today. It is hoped that marine conservation can be enhanced with the help of new technology of underwater image monitoring system, so that problems such as the coral bleaching caused by the El Niño effect in 1998, over-fishing, industrial pollution and eutrophication can be tackled in a timely manner.

Eco-monitoring Prompted by Pollution

"In 2001, a Greek cargo ship stranded in the coast off the South Cape of Kenting, leading to a spill of 1,100 tons of fuel oil and devastating the corals in the area," recalled Dr. Tung-yung Fan, a research fellow at the National Museum of Marine Biology and Aquarium. The world first took notice of the effect of global warming around 1980 and started to carry out the eco-monitoring of corals, and the oil spill highlighted the importance of such practice.

To conduct eco-monitoring under the vast ocean, data analysis is crucial but difficult. Besides Fan, Dr. Fang-pang Lin, who studied numerical simulation in Wales and designed airplanes in London, also still took on the challenge.

When asked why a computing expert like him would ever want to devote himself to eco-conservation, Lin said he felt obliged to do something for his land and he hopes to unveil the beauty of the underwater world through images to promote the protection of the marine ecosystem.

In addition to monitoring the corals, the entire underwater monitoring system is also applicable to the monitoring of the water temperature, depth, turbidity and tide marks. In fact, some equipment could even calculate the cover rate of different corals and other immobile marine creatures.

Lin noted that, the world under the sea becomes more fascinating as more is revealed about it. "We have captured images of curious marine creatures, including the nearly extinct sea turtles and the venomous sea snakes."

1 2

1. 研究人員在大型水槽架設攝影機，模擬海底作業情形 / 林芳邦提供
The researcher is setting up the camera in the large sink to simulate the situations under the sea. / Photo provided by Dr. Fang-pang Lin
2. 海底攝影設備損壞率高，平均每4個月就要汰舊換新，一個小小的鏡頭就要價2萬元。/ 林芳邦提供
The lifespan of underwater photography equipment is short. On average, equipments have to be replaced every four months, and a small lens would cost $20,000 NT. / Photo provided by Dr. Fang-pang Lin

不過，也因為海底狀況瞬息萬變，在硬體設備的維護上是一種極大的壓力，「由於海底監測系統長期浸泡在海水中，承受著海流衝擊、水壓和水溫變動以及鹽度侵蝕等挑戰，因此硬體設備的穩定性就很重要。另外，每週須固定派潛水人員到海裡保養和清潔鏡頭，避免因生物如海藻快速附著生長在鏡頭上而影響影像品質。」樊博士說。

即使所費不貲，但為呈現海中影像，硬體設備還是不能馬虎。樊博士與林博士將於2010年8月一同進行墾丁國家公園後壁湖珊瑚礁生態監測計畫，此海底影像監測系統，將24小時全天候攝錄轉播珊瑚礁生態。先由樊博士所率領的研究團隊在後壁湖深約5米，具有豐富生態的珊瑚礁岩上架設3部攝影機，攝影機拍得的資料經由主機箱，將蒐集的監測資料傳送到國網中心的超級電腦，經過壓縮、轉換格式後，民眾便可在墾丁國家公園的網站上看見即時珊瑚礁生態影像，隨時能關心珊瑚一舉一動，像是美如海中雪的珊瑚產卵的實況，皆能及時呈現在你我眼前。

取得樊博士的分析資料後，林博士再利用影像串流原理，架構分散式系統，藉由本系統具有整合分散資源、分攤系統負載能力以及雙向交換等優勢，可根據使用者的需求，提供各種頻寬的影像，比如 MPEG、WMV、JPEG、FlashPix 等格式。

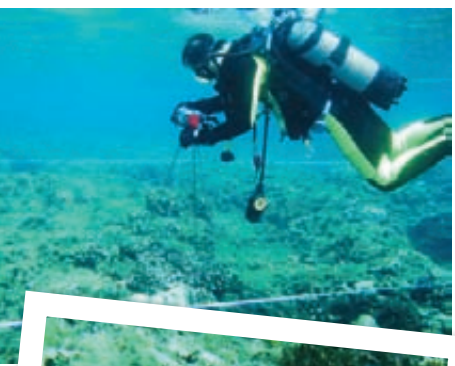
林博士表示，目前影像串流的技術，大多仍侷限在多媒體的應用。架設在後壁湖的監測系統，不但可完整

However, maintenance of the equipment can be a headache. “The cameras are long submerged in the seawater, impacted by the currents, water pressure, temperature fluctuation, and saline erosion, hence their maintenance is vital. The camera lenses have to be cleaned every week so they won't become home for creatures like seaweeds and affect the quality of the images captured.

Although maintenance is costly, it's crucial. Fan and Lin will be embarking on a coral monitoring project in August 2010, when the cameras will record and broadcast images of corals 24/7. Three cameras will be deployed on reefs 5 meters deep at waters where a variety of corals abound. The data collected by the cameras will be transmitted to receivers in a control room, through which it is then distributed to the National Center for High-Performance Computing. Following compression and format conversion of the images, people can enjoy live broadcast on the KTNP website of amazing phenomena such as the corals' mass spawning.

After the collected data is analyzed by Fan, then Lin would use streaming technique to install a multi-functional distributed system capable of providing images of different bandwidths such as MPEG, WMV, JPEG and FlashPix, based on the preference of the viewers.

Lin noted that the technique of streaming is predominantly confined to multimedia application. By contrast, the monitoring system deployed in Kenting not only displays precious images of corals in the area, but is developed in Taiwan, setting the precedent for



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1. 研究人員進行珊瑚礁穿越線的照相監測 / 樊同雲提供
The researcher was conducting the monitoring of the transect lines of coral reefs. /Photo provided by Dr. Tung-yung Fan
2. 水深、水溫的量測也是紀錄作業的重要流程之一 / 樊同雲提供
The measurement of water temperature and depth is also an important procedure of the recording task. /Photo provided by Dr. Tung-yung Fan
3. 研究人員施放浮標，並從海面標記監測地點位置 GPS/ 樊同雲提供
The researcher left the buoy under the sea and located the GPS position of the monitoring spot from above the sea. / Photo provided by Dr. Tung-yung Fan
4. 可長期監測溫度的記錄器 / 樊同雲提供
This is the recording machine for long-term monitoring of the water temperature. /Photo provided by Dr. Tung-yung Fan

呈現墾丁珊瑚礁的珍貴影像，在技術上也由國人自行開發，並為影像監測技術應用在海底生態首開先例。

環境變因及人才缺乏　都是挑戰

樊博士指出，在2007年夏季，整個西太平洋的溫度異常升高，依照常理來說，墾丁海域的珊瑚礁將因全球暖化而發生白化現象。

不過，經由監測發現，墾丁的珊瑚礁除了國家公園的保護得宜外，南灣海域還有世界少有、由內波引發的湧升流。湧升流水團的溫度和酸鹼度較低，營養鹽較高，使墾丁南灣的珊瑚礁長期承受環境的劇烈變動，因而發展出較高的抵抗力，暫時逃過白化、衰退或死亡的命運。

這麼說，墾丁珊瑚是得天獨厚、完全不受白化威脅囉？

「先別這麼樂觀。」樊博士無奈地表示。2009年莫拉克颱風將萬里桐的珊瑚礁及其他生物的覆蓋率，由原本的40%瞬間摧毀到10%，其他一些迎風面的珊瑚礁也受損嚴重，可見因氣候變遷而愈益增多的強烈颱風，將是珊瑚礁的最大殺手。

樊博士語重心長的說：「而一個影響海底監測成效的原因則是野外研究人才嚴重匱乏。大多數人寧可待在實驗室裡，對於須長期在海底從事生態調查研究，意願不高。」

其實，海底世界和陸地一樣，有著分明的四季生態，海洋生物也必須與惡劣的環境搏鬥才能獲得生存。國人應培養孩子多親近海洋的習慣，共同珍惜這一塊湛藍的海底寶藏。

the application of such technique in underwater eco-observation.

Challenged by Climate Change and Lack of Willing Researchers

The unusual rise of the temperature of the Western Pacific waters in the summer of 2007, as Fan pointed out, would have led to the bleaching of corals in Kenting area.

However, the observation showed the opposite. In addition to the protective measures taken by KTNP, in the waters of Nanwan are the rare upwelling currents with lower temperature, pH and higher nutrient. Because of these, the coral reefs in Nanwan are able to endure drastic changes in the environment and become more resilient to bleaching, decay or death.

However, this doesn't mean the corals in Kenting are well blessed and free from threats of any sort.

In 2009 the raging typhoon Morakot slashed the coverage of coral reefs and other creatures in Wan-li-ton from 40% to a meager 10%, while other corals situated on the windward side were also pounded. It is apparent that the growing number of super typhoons due to climate change will be the leading killer of coral reefs. "Another worry is the serious lack of field researchers who are willing to stay underwater for an extended period of time for research," noted Fan.

Just as the land animals, the underwater creatures also have to battle for their own survival under all kinds of harsh conditions. We humans, therefore, should learn to love the ocean, respect it and treasure it, as much as we do to the land.

簡介 *Profile*

林芳邦 Fang-Pang Lin

畢業於英國威爾斯大學史雲斯分校，目前任職於國家高速網路與計算中心應用組組長，主要研究領域為計算流體力學、網格產生、最佳化設計、格網運算、廣域觀測網等。

Graduated from University of Swansea Wales, U.K., Lin is currently a research scientist of Grid Computing Division of NCHC. His research specialties and interests include computational fluid dynamics, multigrid methods, optimization design, and grid computing, etc.

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Fan holds a Ph.D. in oceanography from National Taiwan University. He is currently a Research Fellow of Biology Department at National Museum of Marine Biology & Aquarium, and Associate Professor of Graduate Institute of Marine Biodiversity and Evolutionary Biology, National Dong Hwa University. He specializes in ecology, marine invertebrate zoology, evolutionary biology, and coral reef biology.