Enhancing Biodiversity in the South China Sea through Restoration and Restocking

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EXTENDED ABSTRACT

While some parts of the South China Sea may be considered to still exhibit high levels of marine biodiversity, many of the areas that are either near population centers or which are relatively accessible to human exploitation have lost many populations of commercially important species, and possibly entire species. This, in part, is the reason for the interest of many groups to establish marine protected areas in various parts of the region, including possibly the greater part of the Spratly Islands archipelago. The underlying assumption is that a high biodiversity results in high productivity, probably also providing resilience in the face of climate change. It is common knowledge that many nations depend on the marine resources of the South China Sea. Hence, it is to the interest of all the riparian states to maintain and enhance this productivity, not only by reducing the stresses whether by overexploitation or by destructive or pollutive practices, but also by active restoration measures coupled with marine protected area development.

Since marine protected areas will be a major topic in this symposium, I will limit my treatment of the topic. If there is to be any enhancement of biodiversity in the South China Sea, some measure of protection or conservation of significant areas will be necessary. The conservation measures need not require strict reserves that are "no-take" zones, but any exploitation must be regulated so as not to destroy the support ecosystems, principally coral reefs, and no species must be depleted to the point of depensation or local extirpation. The sessions on mpa's and management may deal with the details of this need.

When people talk about preservation or conservation, the common thinking is simply to provide protection of an area, assuming that nature will then take care of the rest. In many situations, this is probably all that is necessary, plus the requisite amount of time, anywhere from years to decades, or possibly centuries. Depending on the management goals that are put in place, it may be necessary to consider active restoration of some form in. Restoration is to be considered if there is a desire to accelerate the recovery of ecosystems or of populations of certain species.

The science of restoration in the marine environment is perhaps most advanced with respect to mangroves, while that addressing coral reefs is still in its infancy, despite the claims of many commercial enterprises that promise to bring back reefs instantly. The focus of this presentation will be on coral reef restoration, to be followed by some proposals for restocking of some invertebrate species where the technology is available. I will not deal with the topic of artificial reefs because, with the extensive natural substrate that is available for transplantation or recruitment, the introduction of artificial substrates is considered a waste of resources.

Advances in recent years include the improvement of methods of attaching corals to natural substrates, the development of the nursery concept in coral restoration, and the continuing research on sexual methods of reproduction to produce genetically diverse juveniles in large numbers. The recent availability of epoxy clay and other adhesives for underwater use have made initial attachment of coral fragements practical. Initial nurseries were of the floating or

suspended types practical for deep water use, but more recent innovations adapting these to shallower sites and making them benthic structures make them less costly and just as efficient. Even more recently, the development of "rope nurseries" or "multiple clothes lines" for growing coral nubbins to the right size for transplantation has shown great promise. On the other hand, further research is needed on the use of inducers to attract larvae to settle on target substrates, as well as to enharnce the survival of settled larvae. This latter issue is generally side-stepped when one uses coral fragments or branches for transplantation, although the question of genetic diversity is sometimes brought up and the impact of coral predators needs to be reduced as well.

Questions about the appropriate species to use, the mix of species, the positioning of the transplants, all need to be further investigated. There has not been enough time to determine the proper positioning of source reefs and sink reefs, but this is obviously a need if there is to be large scale restoration. For this, the biologists will need the collaboration of the oceanographers.

Related to the above is the question of the restocking of invertebrates. The technology exists for the giant clams, the Tridacnidae, and recent efforts in the Philippines have given us an indication that the true giant clam, *Tridacna gigas*, has now begun to recruit locally from maricultured stock that was deployed in various localities. The restocking of echinoderms in some reefs has shown good results, specifically with the sea urchin *Tripneustes gratilla.* The sea cucumbers, particularly the sandfish, *Holothuria scabra*, are probably next in line. The restocking of fin fish is further down the road, but something that must be considered seriously, particularly for the highly desirable species like the Napoleon wrasse.

Ecological restoration has been defined as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (Society for Ecological Restoration International, www.ser.org). By judiciously undertaking some of the activities mentioned above in various areas of the South China Sea, we would be contributing to its ecological restoration. The question is whether this can be done in a coordinated fashion and in a large enough scale to make a difference. Scientist, managers, and politicians must join hands if we are to enhance the biodiversity of the South China Sea significantly and ensure its continued productivity.

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透過復育與放流的方式提昇南海的生物多樣性

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摘 要

雖然南海的部分地區仍被視為具有高度的生物多樣性，但大部分地區已經成為人口中心或人類可以到達的地區，在人類開發程度高的區域裡具有經濟價值的動物數量已大幅減少或甚至完全消失。因此許多團體必須在南海的不同地點建立海洋保護區，包含大部分的南沙群島。建立保護區的基本假設是生物多樣性愈多、生產力就會愈高，因此可能提供了面對氣候變遷時的適應力與恢復力。大家都知道許多國家仰賴南海的海洋資源，所以沿海國家必須維持並提升南海的生產力，不只要減低過度開發、破壞、污染所造成的壓力，也要積極採取復育措施並規劃海洋保護區。

既然海洋保護區是本研討會的重要主題，我將以此為重點。若要提昇南海的生物多樣性，必須落實重點區域的保護與保育措施。不需要嚴格地規劃「禁補區」，但所有的漁撈活動都必須妥善規範，以免破壞生態系統，尤其是珊瑚礁，也絕對不可導致任何物種瀕臨絕種或區域性滅絕的情況。相信在海洋保護與管理的研討會中將會有更多細節的討論。

當大家提到保育時，通常都認為只要將一個區域劃定為保護區，接下來就交給大自然來處理就好了。在許多情況下，這個想法或許沒錯，假以時日，或許幾年、幾十年、幾百年後環境就會自然修復。但如果有不同的管理目標，或許就必須採取更積極的復育作為。若要加速恢復生態系統或特定物種數量的進度，就必須考慮復育措施。

海洋環境中關於復育的研究，最深入的應屬紅樹林，而珊瑚礁的相關研究還在嬰兒期，儘管許多商業機構宣稱他們將在短時間內讓珊瑚礁再現。本報告的重點是珊瑚礁復育，我會先介紹幾種無脊椎動物的放流（restocking）方式，因為我們已有現成的科技了。我今天不會提到人造珊瑚因為可移植或補充的自然資源很多，在這裡介紹人造物種顯得很多餘。

近年來的進展包括：改良珊瑚固定在天然基質上的方式、發展珊瑚復育中的養護觀念、持續發展養殖方式以大量培育富遺傳多樣性的新生珊瑚。目前可在水下使用環氧樹脂粘土（epoxy clay）與其他黏著劑修復珊瑚斷枝。早期深水養護採取漂浮或懸吊式，但近來的創新作法是讓珊瑚適應較淺的區域，我們可以把淺水區打造成海底結構，這樣花費較低、但效率不減。更近期的發展是「繩式養護（rope nurseries）」或「複布線（multiple clothes lines）」即栽培珊瑚小分枝到足以移植的尺寸，這種作法極可能成功。另一方面，我們也必須深入研究如何利用誘導劑吸引珊瑚蟲定居在目標基質上，並提升珊瑚蟲定居後的存活率。通常利用珊瑚斷枝或分枝移植時就不會採取誘引珊瑚蟲的方式，但移植法不會增加遺傳多樣性。此外，我們也必須降低珊瑚天敵的影響。

關於要用哪些物種才適合、何處適合放置移植物，這些問題都必須深入探討。我們沒有足夠的時間決定放置源礁（source reefs）與沉礁（sink reefs）的地點，但如果要大規模復育的話，顯然這是必須的。為此，生物學家必須要與海洋學家合作。

無脊椎動物的放流與上述各項議題相關。目前已有大蛤蚌、硨磲蛤的放流技術，菲律賓最近也開始將以海水養殖的大硨磲放流到不同地區。棘皮動物放流在珊瑚中的成果也很優秀，尤其是白棘三列海膽。而海參，尤其是糙參，可能是接下來要放流的項目。鰭魚放流排序雖然較晚，但也是我們必須慎重考慮的項目，尤其是像蘇眉魚等受到高度期待的魚種。

生態復育的定義是「協助已退化、遭破壞、或被摧毀的生態系統恢復痊癒的過程」（參見國際生態復育協會 Society for Ecological Restoration International）。在南海確實執行上述措施可有效促進生態復育。問題是我們能不能透過良好的協調進行大規模活動以真正發揮效果。科學家、管理單位、政治人物必須攜手合作才能大幅提昇南海的生物多樣性並確保南海的生產力得以永續。

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