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RESERVES, RESILIENCE AND RECRUITMENT

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Background paper for Joint FFA/SPC Workshop on the Management of South Pacific Inshore Fisheries (Noumea, New Caledonia, 26 June - 7 July 1995)

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Marine reserves for the protection of fish stocks are an ancient idea but have recently become very fashionable. In this paper we argue that they are potentially a very useful management tool but they are not necessarily a panacea. A good deal of thought needs to be given as to what they can and cannot achieve and particularly to their location.

Much of the work determining the local effectiveness of reserves has compared fish populations and communities in reserve areas with those in non-reserve areas. This is not an ideal approach since there are many reasons, independent of their reserve status, as to why fish populations will differ in any two reef areas. The most effective means of examining the effectiveness of reserves are through long-term time series and large-scale controlled manipulations.

By far the most extensive long-term time series of the effects of fish reserves on coral reefs is the work of Russ and Alcala on Sumilon and Apo Islands in the Central Visayas region of the Philippines (Russ & Alcala 1994, in press). Their studies clearly demonstrate that fish populations *do* recover in reserves. They also clearly demonstrate, however, that closures need to be long term - decadal time scales - for recovery to occur after intensive fishing for two main reasons. First, recovery of biomass, which is closely related to spawning potential, recovers much more slowly than the numbers of fish. Secondly, *recovery of the numbers of any fish species are dependent on strong recruitment of juveniles which only occurs sporadically* (at annual time scales). The Sumilon studies also clearly demonstrate that even short term openings of reserves to intensive fishing can very rapidly undo the hard-won gains (Russ & Alcala in press)

Outbreaks of crown-of-thorns starfish (COTs) on the central Great Barrier Reef off NE Australia in the early 1980's had a dramatic effect on the amount of live coral on these reefs. Williams (1986, in prep.) studied the recovery of the fishes and corals on these reefs for thirteen years. Study sites which initially had around 70 percent live coral cover prior to the outbreaks had cover reduced to less than 5 percent by the COTS. The abundance and recruitment of a number of fish species closely associated with live coral also dropped dramatically (although many fish species were unaffected by the loss of live coral). Thirteen years after the outbreak, coral cover on these reefs has largely recovered to the original levels. The fish have also recovered, *provided recruitment of juvenile fishes has occurred.*

Both of the above studies suggest that coral reefs may be highly resilient to acute disturbances such as the effects of fishing or outbreaks of COTs, *provided that a there is a supply of fish recruits from outside the affected area.*

Positive effects of reserves on non-reserve areas are likely to be either:
(1) the movement of fish that have recruited to the reserve and grown there, to adjacent non-reserve areas, or
(2) providing sources of juvenile replenishment to non-reserve areas, via larval dispersal from the protected spawning stock.

A number of modelling studies, beginning with Beverton & Holt (1957), have modelled the impacts of fish reserves and all have concluded that the most likely value of reserves is in providing a source of larvae from a protected spawning stock, rather than the movement of older fish out of the reserves. Fish reserves thus offer the possibility of greatly increasing the resilience of reefs to fishing pressure by providing protected sources of larvae to non-reserve areas.

It is likely, however, that in many situations larvae spawned at a given site will be dispersed a large distance, perhaps hundreds of kilometres, from that site before they settle and recruit to a reef - generally a period of several weeks to several months (Doherty & Williams 1988). Reserves may thus be seeding reefs considerable distances downstream, perhaps even in a different, adjacent, country. Such a situation may occur between eastern Indonesia and the Philippines or northern Australia, for example. Conversely, the recruits arriving in a reserve may not have been bred there but come from some considerable distance upstream. All reefs will not be equally effective producers of recruits. Some reefs may supply larvae to a large number of downstream reefs. We refer to these as good *sources* (of replenishment). Other reefs may receive larvae from upstream reefs but their own progeny may reach few or no reefs. We refer to these reefs as *sinks*. The ways in which different reefs are linked by larval dispersal we refer to as *connectivity.*

Clearly, to be effective, the location of a reserve is critical. The ideal situation from both a fisheries and a conservation perspective would be to select a network of a minimum number of sites that are sources for a maximum number of other reefs. The worst scenario from a fisheries perspective would be to create reserves on reefs that are sinks. The production of these reefs would then be inaccessible to the fishery *and* they would be providing no replenishment to any other reefs.

The ability to identify the sources and fates of larvae from specific reefs is probably the greatest unanswered problem facing scientists working on reef fish and the primary focus of the Supporting Tropical Fisheries project at the Australian Institute of Marine Science.

Given the current critical levels of over-exploitation of many coral reefs and the general lack of effective fisheries management, networks of marine reserves may be the ONLY viable option available to maintain the levels of spawning biomass necessary to sustain reef fisheries in many areas - even in the absence of a good understanding of reef connectivity. A better understanding of connectivity will, however, permit much more effective decision-making on the number and location of reserves.

References:

Beverton, R.J.H. & S.J.Holt (1957). On the dynamics of exploited fish populations. *Fish. Invest Ser.* 2, 19. Min. Ag., Fish and Food, London, 533pp.

Doherty, P.J. & D.McB.Williams (1988). The replenishment of coral reef fish populations. *Oceanogr. Mar. Biol. Annu. Rev.* **26:** 487-551

Russ, G.R. & A.C.Alcala (1994). Sumilon Island Reserve: 20 years of hopes and frustrations. *Naga, The ICLARM Quarterly* **17**(3): 8-12

Russ, G.R. & A.C.Alcala (in press). Marine reserves: rates and patterns of recovery and decline in abundance of large predatory fish. *Ecological Applications*

Williams, D.McB. (1986). Temporal variation in the structure of reef slope fish communities (central Great Barrier Reef): short-term effects of *Acanthaster planci* infestation. *Mar. Ecol. Prog. Ser.* **28:** 157-164