Marine Protected Areas and Fisheries

Marine Protected Areas (MPA), is an umbrella term which covers a wide variety of management strategies for specific coastal or marine areas. Under the IUCN definition, MPAs can be implemented with a wide range of goals and varying levels of protection. Within an MPA's boundaries, seasonal or permanent bans may be placed on single or multiple activities. As a result, temporary fishing closures and Marine reserves, where all extractive activities are banned within its boundary, both qualify as MPAs. The variation in management measures has led to a large number of terms, over 50, being used for MPAs (MPA News Editorial Staff, 2008).

A marine protected area is:

"any area of intertidal or sub-tidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or the entire enclosed environment".

–International Union for the Conservation of Nature (IUCN)

MPAs are a promising and increasingly popular management tool which could balance conservation with sustainable use of marine biological resources (Agardy *et al*., 2003). Despite an initial lag, there is a growing body of evidence for the biological effects of MPAs (Harmelin-Vivien *et al.,* 2008; Lester *et al.,* 2009). Techniques, including mathematical models, genetic analysis, measurements of abundance, biomass and/or mobility, tag-and-recapture and acoustic tracking; have all been used to record biological effects of MPAs (Fenberg *et al.,* 2012).

Generally, MPAs or reserves have a positive effect on biomass, abundance and richness of animals relative to unprotected areas. A recent analysis of global data indicates that the positive effects of MPAs are not due to displacement fishing or better locations of MPAs

(Lester *et al*., 2009). Furthermore, these effects have been found to be long lasting and can manifest within short time spans of 1-5 years (Halpern & Warner 2002; Pérez-Ruzafa *et al.,* 2008). In Europe, studies on MPAs have concentrated on the southern region and have been found to mirror global patterns (Fenberg *et al*., 2012).

MPAs effects can benefit fisheries by increasing both the recruitment of commercially important species in open areas and the abundance of harvestable animals. MPAs are thought to achieve this by two mechanisms. MPAs provide a **refuge** for exploited species such as cod, whiting (*Merlangus merlangus*), scallops (*Pecten maxiumus*), hake or skate (*Dipturus spp*). Thus MPAs can allow for natural growth of older populations of fish. Additionally, adult individuals can emigrate or **"spill-over"** the boundaries of the protected site into the surrounding area. The export or spill-over of individuals can come as result of increased competition or density-independent processes such as migrations (Abesamis *et al.,* 2005).

Impacts of Fishing MPAs can mitigate.

→Fishing changes not only the size and age structure of exploited species, it also affects the biomass of individuals; predatory fish biomass is now only 10% of its pre-industrial levels of exploitation (Worm & Myers 2003).

→Fishing can induce evolutionary changes in the life-history of the species. By targeting large individuals, fishing has selected for earlier sexual maturation at smaller sizes. This has negative consequences for yield and for the fecundity of a species, which further increases the probability of its collapse (Kuparinen & Merilä, 2007).

→Additionally, there has been a decline in mean trophic level of marine food webs, resulting in the phenomenon of "fishing down the food web" (Essington *et al.,* 2006).

The most recent evidence of MPA effects was in the UK. It was found that even small, newly established MPAs can produce significant results. Lundy Island (off southwest England) designated an area of 3.3km^2 as a reserve in 2003. By 2007, legal-sized and commercially-important European lobsters (*Homarus gammarus*) were found to be 9% larger and 5 times more abundant within the area's boundaries (Hoskin *et al.,* 2011). Additionally, Lamlash bay (off the west coast Scotland) established a 2.67km^2 reserve in 2008. By 2010, SCUBA dive surveys discovered that juvenile scallops were of a significantly greater age, size and biomass within the MPA's boundaries (Howart *et al.,* 2011).

It should be noted that there is great variation in the magnitude MPA effects. The variation is likely due to a number of ecological and socio-economic factors (Lester & Halpern 2009). Social factors of MPAs include: management, enforcement, compliance and governance structure (Charles & Wilson, 2009; Jennings, 2009). Other influential factors include: design of the site, years since establishment and life history of protected species (Fenberg *et al.,* 2012). The size of an MPA is thought to influence the magnitude of the effect. Diffusion models found that MPAs with radii smaller than 2,000m had significantly lower abundances within their boundaries relative to larger areas (Pérez-Ruzafa *et al*., 2008).

Important factors for an MPA's performance

→The level of protection within the MPA's boundary. If there is only seasonal restriction on one fishing gear or a permanent ban on all extractive activities.

→The life history of a species includes its life-span, growth, mobility, natural mortality and reproductive patterns. An animal will only benefit from protection if it spends time within a MPAs' boundary. So less mobile animals whose home range is compassed by the MPA will gain greater protection.

→Design and spacing of the protected areas has implications for their success. For an MPA to be viable in the long run sufficient movement of animals within and between sites must occur. The recommended size and spacing for this occur in UK waters is 10-20km^2 and 40-80km^2 respectively (Roberts *et al.,* 2005).

→Compliance with and enforcement of protective measures of the site.

Large, long-lived predatory animals such as Serranidae (bass and groupers), Lutjanidae (snappers), Balistidae (triggerfish), Scaridae (mostly tropical parrot-fish), Acanthuridae (surgeonfishes) and Haemulidae (grunts) are vulnerable to overfishing and so are more likely to benefit from protection (PDT 1990; Roberts & Polunin 1993; Bohnsack 1996). Highly protected or more restrictive sites have been found to yield greater benefits (Lester & Halpern, 2008).

To what extent the surrounding area and subsequent fishery actually benefits from an MPA can also vary. Estimates based on Mediterranean MPAs predict that the spill-over phenomenon occurs on a scale of just hundreds of metres (Harmelin-Vivien *et al*., 2008). Empirical evidence suggests that spill-over occurs on a larger spatial scale. Capture-recapture methods have shown that the export of European spiny lobster, *Palinurus elephas*, from a Mediterranean reserve is able to support catch rates up to 1,500m away (Goñi *et al.,* 2011). Additionally DNA profiling has revealed that approximately half of all juvenile fish from a reserve and from fished reefs up to 30km away had originated in protected areas covering less than a third of an Australian reef (Harrison *et al.*, 2012). There is need of further research to support the use of MPAs as fishery management tools. Restrictions on activities must ultimately be compensated by harvestable animals over time.

That said, MPAs have economic benefits beyond the replenishment of fish stocks. Protected areas can contribute to local economies via creation of jobs, increased recreational and tourist opportunities. SCUBA divers and dive operators in Southern Europe were surveyed and it was found that reserves were an important addition to the attractiveness of the area. Encouragingly, the benefits generated by these activities were significantly greater than the management costs of the marine reserves (Roncin *et al.*, 2008).

MPAs should be included in modern fisheries management. They can achieve things which many conventional tools cannot. MPAs allow the development of natural older populations of fish, maintenance of genetic variability and prevention of fishery-induced evolution. At present, the majority of the commercial fish stocks of the Northeast Atlantic are either fully exploited, over exploited or depleted. This is despite their management strategies being arguably amongst the most elaborate of the world (Pullin *et al.,* 2009). By protecting the habitat of overexploited species is the only definite way to ensure its recovery and future sustainable use (Roberts *et al.,* 2005).

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