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SHORT COMMUNICATION

Integrating pelagic and coastal MPAs into large-scale ecosystem-wide management

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ABSTRACT

1. Marine Protected Areas (MPAs) have gained increasing popularity worldwide as tools for biodiversity conservation and management of human uses. This rise in popularity has been accompanied by an increasing body of scientific papers and books on MPA design and management, the vast majority of which are almost completely focused on coastal or insular MPAs.

2. A small number of MPAs have also been established in the pelagic domain, however, these pelagic sites have been considered in isolation from coastal/insular MPAs, even when the sites are adjacent or nearby. Pelagic and coastal ecosystems are not at all isolated from each other, but interconnected both physically via the flow of water, and biologically, via the movement of organisms.

3. In order to maximize the effectiveness of MPAs, it is suggested that spatial management planning encompass large areas that span both coastal and pelagic domains. This requires integrated, large-scale spatial management, which may extend across borders and thus require international cooperation.

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Q1 Marine Protected Areas (MPAs) are increasingly popular tools for biodiversity conservation (from species to ecosystems) and management of human uses (e.g. tourism, fisheries) (Jackson *et al.*, 2001; Worm *et al.*, 2006). The proliferation of MPAs has been accompanied by an increasing number of papers and books published on the subject (Claudet, 2011 and references therein). This significant body of scientific literature focused almost completely on MPAs located in coastal or insular areas. Recently a number of MPAs have been established in the pelagic domain, but these MPAs are relatively rare. Pelagic MPAs, in fact, account for approximately 2% of the 4435 MPAs established worldwide (i.e. less than 100) (Wood *et al.*, 2008). A significant proportion of biodiversity and ecological processes in the oceans and seas thus remain underrepresented. This remains the case even though the need to establish pelagic MPAs has been debated extensively (Game *et al.*, 2009, 2010; Kaplan *et al.*, 2010). In this note we go further from simply stating that more pelagic MPAs need to be established to improve the representativity of the oceans' ecosystems by MPAs. Indeed, based on the new insights provided by recent research outcomes, the point is stressed that pelagic and coastal MPAs are more intermingled than previously thought and that, therefore, they should be planned in unison,

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and management of existing MPAs adapted to recognize the important linkages between coastal and pelagic domains.

In order to maximize the potential to achieve conservation and help steer use towards sustainability in the marine environment, two conditions must be met: (1) achieve greater integration between pelagic and coastal domains (using MPAs as complementary tools for large-scale marine spatial planning); and (2) ensure that pelagic MPAs contribute to large-scale ecosystem-wide management.

An example is provided from the NW Mediterranean Sea region which hosts a high
F1 concentration of MPAs (Figure 1(A)). These include the Pelagos Sanctuary, a largely pelagic, 87 000 km^2 MPA, and 11 coastal/insular MPAs (established at the national level) falling within the borders of the Pelagos Sanctuary (Figure 1(A)). The Pelagos Sanctuary was established in 1999 by treaty between France, Italy and Monaco, in order to protect cetaceans and their feeding grounds in the Ligurian Sea (Notarbartolo-di-Sciara *et al.*, 2008). It should be noted that neither the location, size, nor the management regime of the coastal MPAs within the bounds of the Sanctuary were planned with the greater context in mind – the Pelagos Sanctuary in essence 'inherited' these protected areas as part of its expansive domain. Yet to date the links between successful conservation and management within the coastal MPAs and the health and welfare of Pelagos have not been closely examined. These connections are both biological and use- or management-related.

First, there is the issue of dispersal of marine species within and between MPAs, which inexorably links different areas (even coastal and pelagic domains) inspace. Many benthic invertebrates (sessile and mobile) and fishes produce free swimming or planktonic propagules (e.g. eggs, larvae). Propagules are retained and/or exported large distances by currents or other mesoscale oceanographic structures (see Figure 1(B) as an example in the Ligurian Sea, NW Mediterranean) (Bakun, 2006). Dispersal patterns underpin the spatial scales of connectivity among populations and should therefore be considered when planning effective networks of MPAs (i.e. multiple MPAs properly spaced from each other to ensure

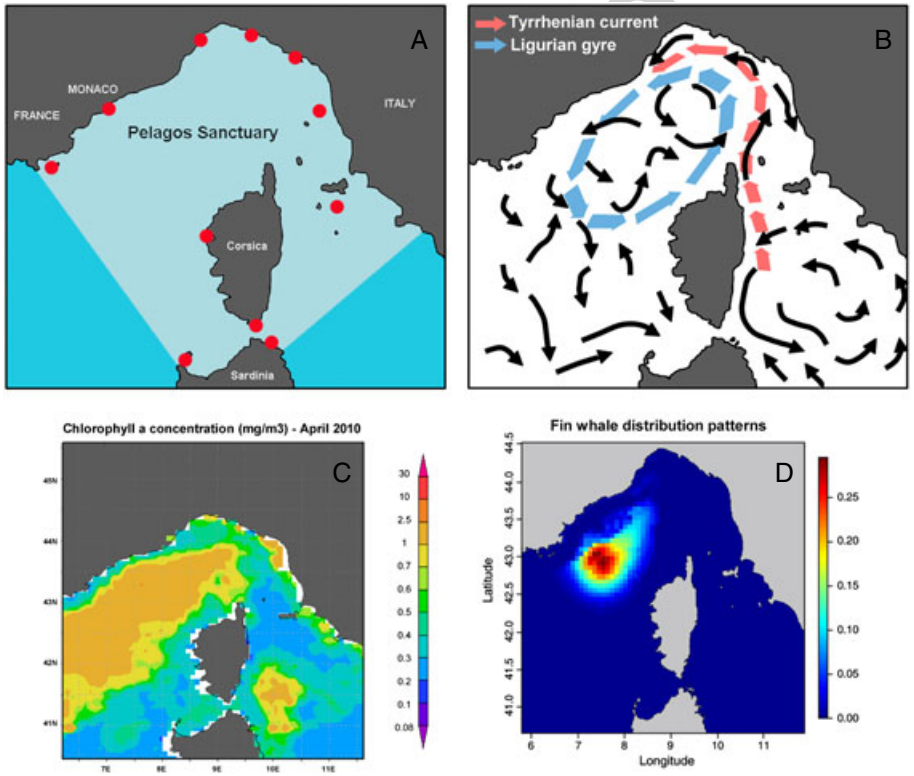

Figure 1. (A) Map delinating the Pelagos Santuary in the NW Mediterranean and the location of coastal/insular MPAs (red dots) embedded within its borders. (B) Basic scheme of the current circulation in the Ligurian Sea (modified from Bianchi and Morri, 2003) and, superimposed, an example of average monthly currents in June 2008 taken from: http://gnoo.bo.ingv.it/mfs/web_ita/analysis_archive.htm. (C) Surface chlorophyll a concentration in the Pelagos Sanctuary in April 2010, detected by remote sensing. Analyses and visualizations in this figure were produced with the Giovanni online data system, developed and maintained by the NASA GES DISC taken from: http://disc.sci.gsfc.nasa.gov/. (D) Predicted probabilities of occurrence of fin whales (*Balaenoptera physalus*) in the Ligurian Sea in June 1998 based on interpolation and extrapolation from Generalised Additive Models (GAM) (modified from Panigada *et al.*, 2008).

ecological effective exchanges of individuals at whatever life stage) (Gaines *et al*., 2010).

Propagules of marine species (including coastal species) also support the pelagic food web. Many of these propagules spend part of their life in the open sea as meroplankton, during a phase that may be short compared with the lifespan of the species, but which is crucial for life histories, population dynamics (in terms of spreading, population replenishment, and persistence), genetic variability, and biodiversity maintenance (Gaines *et al*., 2007). Pelagic systems in turn, from primary producers up to apex predators (Figure 1(C)), sustain unique assemblages having at their top species with great conservation value, such as large predatory fishes, birds, and cetaceans (Figure 1 (D)) (Croll *et al*., 2005; Hyrenbach *et al*., 2006). Thus the supporting processes – including the links to coastal species – must be considered in designing effective protection for them.

Second, the strong link between pelagic and coastal areas (MPAs included), especially when taking into account species throughout their entire life cycles and the functional links within inter- (pelagic and coastal) and intra-ecosystem food webs, has important implications for management. When such linkages are not considered, MPAs are less effective in meeting their conservation objectives and providing benefits to society (Agardy *et al*., 2011). Moreover, the creation of effective networks of MPAs (and not just 'paper parks', Guidetti *et al*., 2008) is a commitment of countries that are signatory to international agreements to protect marine biodiversity. In the Mediterranean Pelagos Sanctuary example, France and Italy, for instance, are bound by the Marine Strategy Framework Directive (ec.europa.eu/environment/water/marine.htm) and by the Habitats Directive (http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm) as EU Member States (Fenberg *et al*., 2012). In addition, France, Italy and Monaco are parties to the Convention of Biological Diversity (www.cbd.int), committed, by virtue of being in the NW Mediterranean, to the designation of MPA networks by the regional convention ACCOBAMS (www.accobams.org), and as signatories of the treaty establishing the Pelagos Sanctuary, have committed to giving particular attention to this portion of the Mediterranean marine environment, although implementation of such commitment has fallen short of expectations so far (Notarbartolo di Sciara, 2011).

All the above issues and the situation in the NW Mediterranean offer a unique opportunity for improving management, by integrating pelagic and coastal ecosystems into a single big picture. The true challenge is the vision that, based on the accepted tenet that there are no borders at sea, MPA management within a geographically defined area like the NW Mediterranean would take place by envisaging it as a unique 'ecological and management' unit. To reach wide conservation objectives, an ecosystem-based transnational management scheme where pelagic and coastal systems are seen as functionally connected is required. As a consequence, the Pelagos Sanctuary would accrue its value from being simply an important area for the conservation of marine mammals and pelagic communities, to being an important protected environmental matrix hosting also propagules of coastal species and thus providing large-scale support to both coastal and pelagic populations, communities, and biodiversity.

The above issues stress the prominent role that life histories and oceanographic patterns may represent within the wide frame of conservation issues. Crippling information gaps in this field emphasize the urgent need to invest future research effort to make progress in the novel field of 'conservation oceanography' (compared with 'fishery oceanography' proposed by Cury *et al*., 2008), i.e. a discipline that relates marine living populations of species and their interactions to environmental conditions and human impacts, to better understand the species' ecosystem-wide responses to multiple stressors (from localized human impact to global change), and predict failure or success of MPA networks or other conservation/management measures.

From an ecological and management perspective, therefore, pelagic and coastal ecosystems are not isolated but interconnected and, at least in the geographical contexts where coastal and insular MPAs are nested within a greater pelagic MPA, all ecological elements should be subjected to an integrated management regime to enable networks of MPAs to reach the highest conservation targets and best outcomes possible.

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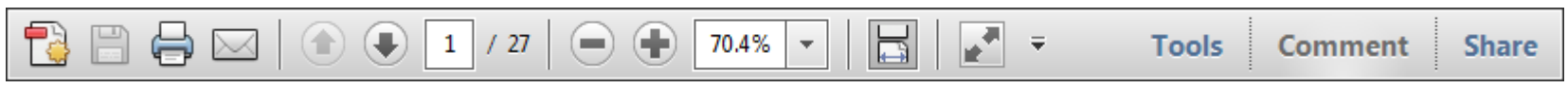

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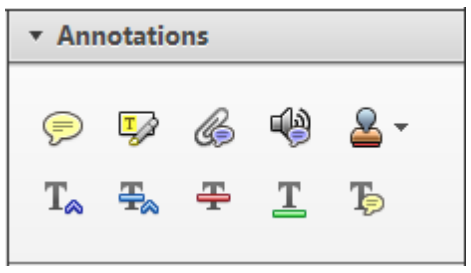

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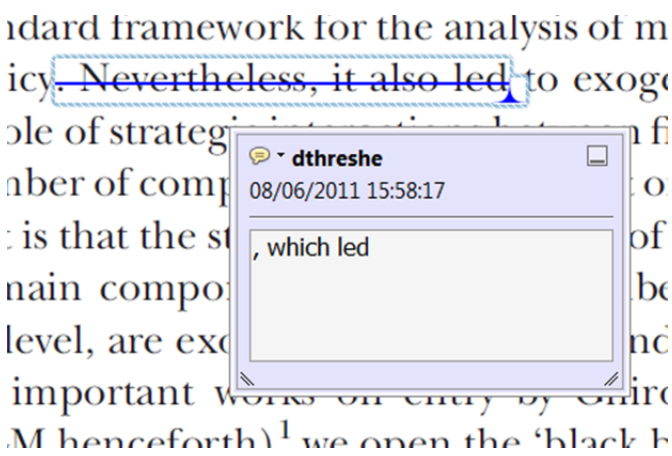

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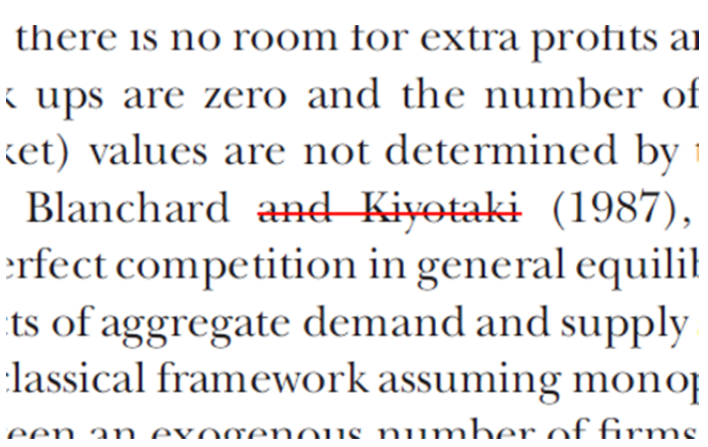

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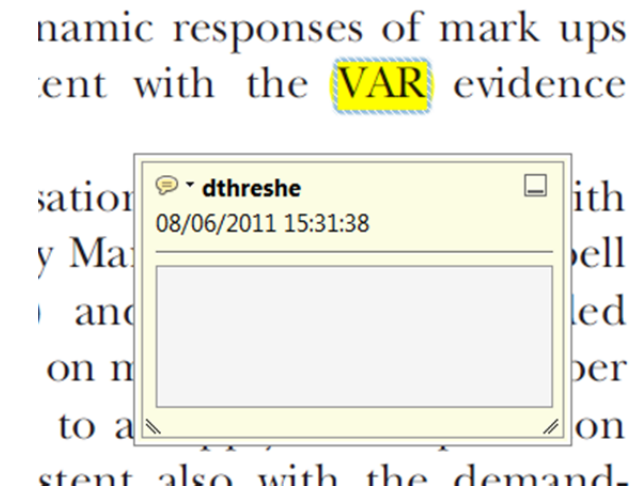

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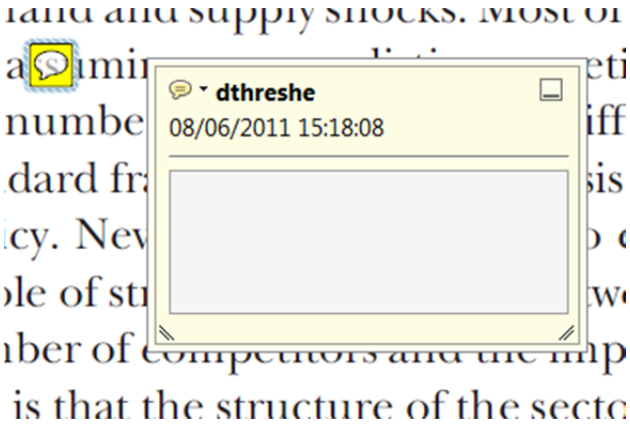

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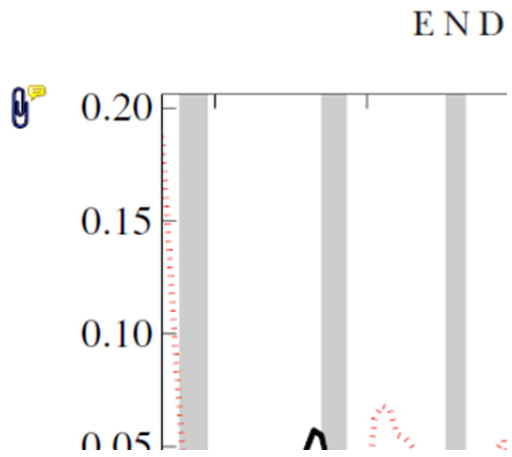

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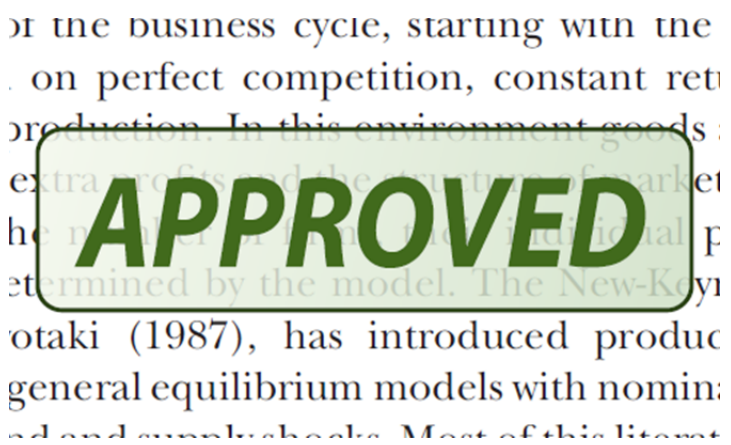

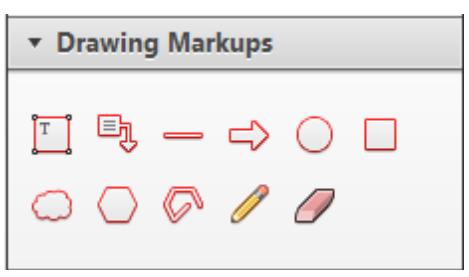

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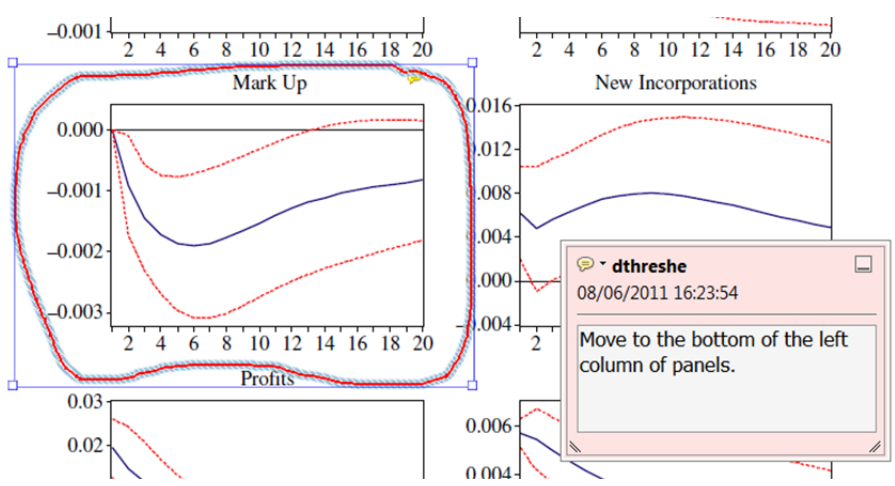

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