# Ancient art serving marine conservation

**Peer-reviewed letter**

Fishing dramatically affects species, habitats, and ecosystems worldwide (Worm *et al.* 2006). Assessing the extent of decline and degradation of populations and ecosystems subjected to fishing effort is crucial for understanding associated losses in productivity and resilience, and for establishing recovery targets. Determining meaningful conservation targets and designing effective conservation and restoration measures, however, are often impeded by a lack of proper baselines (Jackson *et al.* 2001; Lotze and Worm 2009). Protected, unfished sites (ie no-take marine reserves) can allow for an evaluation of the impacts of fishing through a comparison with unprotected sites. But most such marine protected areas are too small and "young" (established a few decades ago, at most) to provide information on "pristine" conditions (Erlandson and Rick 2010). Thus, reserves can reveal initial trajectories toward recovery, but not pre-exploitation conditions. We argue that to reconstruct historical baselines, non-traditional approaches – including the use of paleontological, archeological, and historical records, as well as anecdotal information and local traditional knowledge – can be paired with more conventional ecological approaches, such as field monitoring and molecular analyses (Desse and Desse-Berset 1999; Sáenz-Arroyo *et al.* 2005; McClenachan and Cooper 2008; Lotze and Worm 2009; Fortibuoni *et al.* 2010).

Fishing has occurred for millennia along the coasts of the Mediterranean Sea (Sala 2004). The dusky grouper (*Epinephelus marginatus*; Figure 1a) is a large, long-lived, slow-growing, protogynous (ie sex reversal from female to male) fish that has been decimated in recent decades by commercial and recreational fishing. Because of its low population resilience and important ecological role as an apex predator, the dusky grouper is categorized as Endangered on the IUCN Red List. Recent studies have shown greater abundance (by 5 to 10 times) and larger maximum sizes (~90–100 cm versus ~50–60 cm) of groupers within marine reserves as compared with groupers at fished sites (Di Franco *et al.* 2009), and that this species tends to occupy fairly deep reefs (below 10–15 m, with a reported depth range to 300 m; www.fishbase.org). Between 1998 and 2009, we surveyed 26 sites along the Italian coast (WebPanel 1) and found that dusky groupers were, on average, about six times as abundant in relatively deep (20–35 m) waters than in shallow (3–12 m) waters (*t* test: degrees of freedom = 34, $t = 5.6$; $P < 0.01$; Figure 1b). Moreover, individuals encountered at shallow depths were typically small-sized, and large adults were rarely observed at depths <5–10 m (Guidetti and Micheli unpublished data). However, archeozoological records show that large dusky groupers have been caught by humans since prehistory (more than 100 000 years ago), with their bones frequently found in ancient human settlements (Desse and Desse-Berset 1999). Mean body size estimated from bone remains was >70 cm, and many specimens were measured at ~90 cm. Population size structure is particularly important in this species, for which sexual maturity may be attained between 40 and 50 cm, and sex reversal from female to male between 80 and 90 cm (www.fishbase.org; Allsop and West 2003). Thus, the reproductive potential of the population, based on mean and maximum sizes currently observed in fished areas, is likely to have been negatively affected by fishing effort. It is difficult to reconcile, in any case, the present depth distribution and size of dusky groupers with the limited ability of prehistoric humans to fish at depth and to catch groupers of such size in large numbers (Desse and Desse-Berset 1999).

A survey of ancient works of art in the Mediterranean region revealed hundreds of Etruscan, Greek, and Roman paintings and mosaics representing fishing scenes and fish (WebPanel 1). We examined 73 Roman mosaics, 23 of which (dating from the 1st to 5th centuries CE) represented groupers. In 10 of the 23

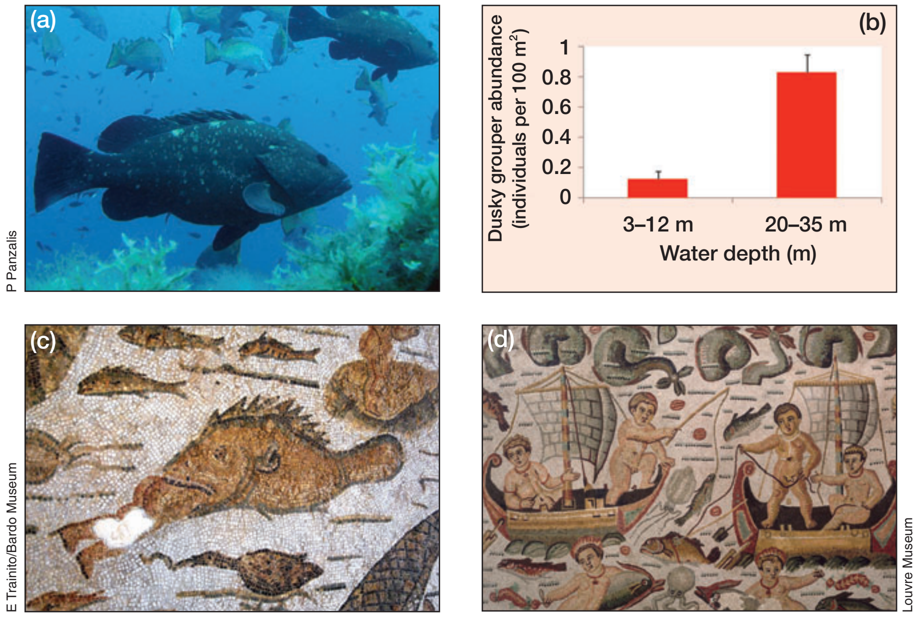


***Figure 1.*** *(a) The dusky grouper* Epinephelus marginatus*; (b) observed density (+1 standard error) of dusky grouper in shallow and deep reefs assessed by visual surveys at 26 sites in Italy; (c) fishing scene in a Roman mosaic from Bizerte, Tunisia, 5th century CE; Bardo Museum, Tunis, Tunisia; (d) "Triumph of Neptune and Amphitrite", Roman mosaic from Constantine, Algeria, 3rd century CE; Louvre Museum, Paris, France.*

cases, groupers are portrayed as being very large (approximately the maximum size reported from archeozoological data and from marine reserves established for several decades – in one case, so large as to be able to engulf a man; Figure 1c), and caught by fishermen using poles or harpoons from boats at the water's surface (Figure 1d), a technique that would surely yield no grouper catch today. These works of art and what they depict should be interpreted with caution (eg there are no known instances of dusky groupers attacking human swimmers), but nevertheless can be very informative. These representations suggest that groupers were, in ancient times, so large as to be portrayed as "sea monsters" and that their habitat use and depth distribution have shifted in historical times; apparently this species lived in shallow waters, where it is now rare if not completely absent. This notion is also supported by written evidence from ancient Roman sources: Ovid (see *Halieuticon Liber*) and Pliny the Elder (in *Historia Naturalis*) wrote that groupers were fished by anglers in shallow waters and that fish were so strong (ie big?) as to break fishing lines. Our evidence also agrees with anecdotal observations by contemporary scientists, who reported that groupers in long-standing no-take reserves seem to move from deep to shallow waters, whereas – in areas open to fishing, especially spearfishing – large groupers are extirpated from shallow reefs and are restricted to deep waters (La Mesa and Vacchi 1999).

Ancient art provides a link between prehistorical and modern evidence and suggests that shallow nearshore Mediterranean ecosystems have lost large, top predators (eg the dusky grouper and the nearly extinct Mediterranean monk seal [*Monachus monachus*]; Sala 2004) and their corresponding ecological roles. This loss is unaccounted for in current models of food-web dynamics and community responses to disturbance in rocky reefs. Reconstructing "pristine" patterns of habitat occupation of marine predators is crucial for understanding species' roles and food-web structure as they existed in the past (Sala 2004). Historical information and non-traditional datasets may help in setting appropriate conservation and fisheries management goals, including targets for assessing the recovery not only of endangered species (eg abundance, size structure, and spatial distribution) but also of food webs and whole ecosystems within marine reserves.

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## Confronting publication bias in marine reserve meta-analyses

Meta-analyses are increasingly used to synthesize the published literature on marine reserve performance. (Note that "marine reserves" and "marine protected areas" are terms synonymously used here to define an area of marine habitat established to meet conservation objectives by restricting recreational and/or commercial uses.) The advancement of reserve science relies on learning from reserve successes and failures alike. The clear advantage of a meta-analysis is that effect size of reserve performance can be calculated from multiple, disparate reserve studies. However, the prevalence of publication bias to depress the publication of neutral or insignificant reserve effects is rarely considered. Here, I question whether meta-analyses may be unintentionally perpetuating bias in the marine reserve literature and advocate for the use of statistical tools – at the meta-analysis author's disposal – to assess and correct for such bias. While I focus here on meta-analyses of marine reserves, the issues of publication bias discussed apply to meta-analyses in other ecological systems and even disciplines.

Although specific data on publication bias in ecology are rare (but see Jennions and Møller 2002), for marine reserves, bias is suspected to favor the submission, review, and acceptance of manuscripts reporting positive effects of reserve protection over negative or neutral effects (Halpern 2003). Hence, meta-analyses using only published studies may contain a disproportionate number of reserve "success stories". A literature review of marine reserve meta-analy-