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A regional assessment of cumulative impact mapping on Mediterranean coralligenous outcrops

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In the last decade, the 'Cumulative Pressure and Impact Assessment' (CPIA) approach emerged as a tool to map expected impacts on marine ecosystems. However, CPIA assumes a linear response of ecosystems to increasing level of cumulative pressure weighting sensitivity to different anthropogenic pressures through expert judgement. We applied CPIA to Mediterranean coralligenous outcrops over 1000 km of the Italian coastline. Extensive field surveys were conducted to assess the actual condition of coralligenous assemblages at varying levels of human pressure. As pressure increased, a clear shift from bioconstructors to turf-dominated assemblages was found. The linear model originally assumed for CPIA did not fit the actual relationship between expected cumulative impact versus assemblage degradation. A log-log model, instead, best fitted the data and predicted a different map of cumulative impact in the study area able to appreciate the whole range of impact scenarios. Hence, the relative importance of different drivers in explaining the observed pattern of degradation was not aligned with weights from the expert opinion. Such findings stress the need for more incisive efforts to collect empirical evidence on ecosystem-specific responses to human pressure in order to refine CPIA predictions.

Worldwide, marine coastal systems are threatened by increasing human pressures often acting simultaneously¹. Ecological research has documented the impact of individual stressors on species, habitats and ecosystems. Studies have shown that sedimentation, nutrient enrichment, pollution, resource exploitation, presence of non-indigenous species, habitat destruction and fragmentation can alter ecosystem functioning at varying scales in time and space, changing the number and composition of species and their relative abundances through direct and indirect effects^{2,3}.

The need for a deeper understanding of the effects of multiple stressors on ecosystems was highlighted about twenty years ago⁴ and is still considered one of the most challenging questions for ecosystem-based management⁵. In this framework, environmental impact assessments have attempted to move from considering single-source of impact towards more comprehensive approaches investigating ecological responses to multiple interacting human disturbances⁶. Mesocosms⁷, manipulative⁸ or correlative field experiments⁹, and modelling¹⁰ have been used to quantify the effects of multiple stressors on marine biodiversity. More recently, the recognition that human activities and their potential impacts are spatially explicit has led to the development of the cumulative pressure and impact assessment (CPIA) approach⁶, which focuses on mapping the distribution of human pressures and expected impact on marine ecosystem. However, despite its application to different environmental contexts worldwide (e.g. ^{1,11,12}), the CPIA approach still relies on the assumptions that the effects of pressures are fully additive and that cumulative impacts increase linearly at increasing pressures¹³. This could be not retained to changing environmental settings, strongly affecting the reliability of the ensuing impact estimates¹⁴. A further issue in CPIA concerns the use of scores based on expert judgement to weight the potential effects of anthropogenic pressures

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