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TITLE: Characterizing driver?response relationships in marine pelagic ecosystems for improved ocean management

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ABSTRACT:

Scientists and resource managers often use methods and tools that assume ecosystem components respond linearly to environmental drivers and human stressors. However, a growing body of literature demonstrates that many relationships are-non-linear, where small changes in a driver prompt a disproportionately large ecological response. We aim to provide a comprehensive assessment of the relationships between drivers and ecosystem components to identify where and when non-linearities are likely to occur. We focused our analyses on one of the best-studied marine systems, pelagic ecosystems, which allowed us to apply robust statistical techniques on a large pool of previously published studies. In this synthesis, we (1) conduct a wide literature review on single driver-response relationships in pelagic systems, (2) use statistical models to identify the degree of non-linearity in these relationships, and (3) assess whether general patterns exist in the strengths and shapes of non-linear relationships across drivers. Overall we found that non-linearities are common in pelagic ecosystems, comprising at least 52% of all driver-response relation- ships. This is likely an underestimate, as papers with higher quality data and analytical approaches reported non-linear relationships at a higher frequency (on average 11% more). Consequently, in the absence of evidence for a linear relationship, it is safer to assume a relationship is non-linear. Strong non-linearities can lead to greater ecological and socioeconomic consequences if they are unknown (and/or unanticipated), but if known they may provide clear thresholds to inform management targets. In pelagic systems, strongly non-linear relationships are often driven by climate and trophodynamic variables but are also associated with local stressors, such as overfishing and pollution, that can be more easily controlled by managers. Even when marine resource managers cannot influence ecosystem change, they can use information about threshold responses to guide how other stressors are managed and to adapt to new ocean conditions. As methods to detect and reduce uncertainty around threshold values improve, managers will be able to better understand and account for ubiquitous non-linear relationships.

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