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Review

Do drivers of biodiversity change differ in importance across marine and terrestrial systems — Or is it just different research communities' perspectives?

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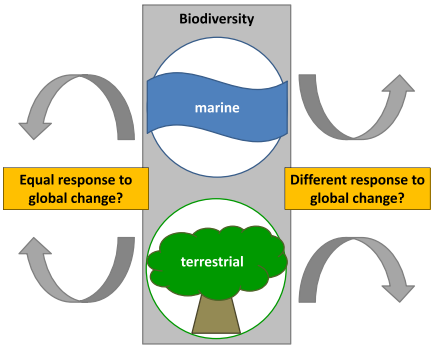
HIGHLIGHTS

- Global change affects biodiversity across the marine and terrestrial realm.
- We rate global change impacts by using expert questionnaires and literature review.
- Marine and terrestrial scientists largely differ in their judgement of impacts.
- Literature shows that terrestrial and marine ecosystems follow similar principles.
- Impacts on marine and terrestrial biodiversity will converge increasingly.

GRAPHICAL ABSTRACT



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ABSTRACT

Cross-system studies on the response of different ecosystems to global change will support our understanding of ecological changes. Synoptic views on the planet's two main realms, the marine and terrestrial, however, are rare, owing to the development of rather disparate research communities. We combined questionnaires and a literature review to investigate how the importance of anthropogenic drivers of biodiversity change differs among marine and terrestrial systems and whether differences perceived by marine vs. terrestrial researchers are reflected by the scientific literature. This included asking marine and terrestrial researchers to rate the relevance of

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different drivers of global change for either marine or terrestrial biodiversity. Land use and the associated loss of natural habitats were rated as most important in the terrestrial realm, while the exploitation of the sea by fishing was rated as most important in the marine realm. The relevance of chemicals, climate change and the increasing atmospheric concentration of CO_2 were rated differently for marine and terrestrial biodiversity respectively. Yet, our literature review provided less evidence for such differences leading to the conclusion that while the history of the use of land and sea differs, impacts of global change are likely to become increasingly similar.

Contents

1. Introduction

Global change affects ecosystems across the world from the deep seas (Hoegh-Guldberg and Bruno, 2010) to the high mountains (Pauli et al., 2012). Human existence crucially depends on the goods and services that both marine and terrestrial ecosystems provide (Millennium Ecosystem Assessment, 2005). However, for a sustainable provision of goods and services it is crucial to understand how global change affects different ecosystems, their biodiversity and associated ecosystem functions.

Webb (2012) stated that if ecosystems are defined in accordance with a specific research question, initially perceived differences between these systems can disappear. An example is the comparison of the community structure of coral reefs in the marine realm and tropical forests in the terrestrial realm. In contrast to Webb (2012), Sunday et al. (2012) suggested that even if ecological processes are similar in terrestrial and marine ecosystems, effects of global change can differ considerably between the two. Key questions are why such differences exist and how ecosystems respond to these differences.

The historic development and current state of biomass extraction – the oldest human impact on ecosystems (Table 1) – differs considerably between the terrestrial and marine realms and so might the response of biodiversity to biomass extraction. On land, a 12,000 year-old history of plant cultivation led to the dominance of artificial production systems at the level of primary producers. 34% of the earth's ice-free land surface has been converted to cropland (12%) and pastures (22%; Ramankutty et al., 2008). A considerable proportion of forests is not in a pristine state but heavily transformed by forestry (Food and Agriculture Organization of the United Nations, FAO, 2015). Fishing, collecting and cultivation of marine organisms started in an early stage of human existence as well, similar to hunting and gathering on land (Barrett et al., 2004). While the rate of increase in area used as cropland considerably decelerated within the last 50 years, the increase in the amount of marine aquaculture seems to stabilize (Fig. 1). According to FAO (2014), marine aquaculture had an average annual growth rate of 6.1% between 2002 and 2012. In contrast to terrestrial agricultural production, marine aquaculture is focussed on higher trophic levels such as finfish or crustaceans, albeit farmed marine plants account for approximately 18% of

Table 1
The history of the use of land and sea differs (numbers indicate the time period for which a certain practice has already been in use). Many kinds of use started later in the marine than in the terrestrial realm.

Land/sea use	Terrestrial biome	Marine biome	References
Hunting/fishing (referring to *Homo sapiens*)	200.000 years	200.000 years	Anton and Swisher (2004), Encyclopaedia Britannica (2016), Trinkaus (2005)
Food sampling (referring to *Homo sapiens*)	200.000 years	200.000 years	Anton and Swisher (2004), Encyclopaedia Britannica (2016), Trinkaus (2005)
Agriculture	11.000 to 12.000 years		Builth et al. (2008), Encyclopaedia Britannica (2016)
Aquaculture/mariculture (i.e. marine aquaculture)	Up to 10.000 years	ca. 500 years	Roberts (2007)
Share of total area agriculture/mariculture	38% of land cover	Marginal part of the marine biome	FAO; Statistics Division (2015)
Organisms used as human food resources	Primary producers (crop plants) and consumers (mainly herbivores)	Mainly consumers (fish, shellfish) and predators	FAO (2014), FAO; Statistics Division (2015)
Domestication of plants and animals	11.000 years	ca. 100 years	Duarte et al. (2007)