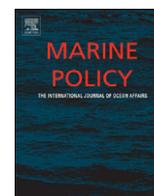




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## Are marine reserves and non-consumptive activities compatible? A global analysis of marine reserve regulations

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### ABSTRACT

Marine reserves are places where wildlife and habitats are protected from extractive and depositional uses of the sea. Although considered to be the pinnacle in marine conservation, many permit non-consumptive activities with little or no regulation. This paper examines the potential impacts of 16 non-consumptive activities including scuba diving, sailing, scientific research and motor boating, and how they might compromise the conservation objectives of marine reserves. Examination of 91 marine reserves from 36 countries found little agreement or consistency in what non-consumptive activities are permitted in marine reserves and how they are regulated. The two most common activities allowed without regulation were swimming (mentioned in 80% of marine reserves and allowed in 63% of these) and kayaking (mentioned in 85%, allowed in 53%). Scuba diving was mentioned in 91% and allowed without regulation in 41%. A risk score for the likely level of threat to wildlife and/or habitats that each activity could produce was then assigned based on effects reported in the literature. The risk analysis suggests that motor boating and activities which include or require it have a high potential to negatively impact wildlife and habitats if inadequately managed. Hence protection against extractive or depositional activities alone is insufficient to secure the high standard of protection usually assumed in marine reserves. For this to be achieved activities typically considered as benign must receive appropriate management, especially with increasing recreational use.

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### 1. Introduction

Marine habitats and species are affected by a multitude of human impacts including fishing, pollution, habitat destruction and introduced species, among others [1]. As a result, in many places species have declined in abundance, diversity has decreased and habitat complexity has been reduced [2]. Marine reserves, sites that are protected from extractive and depositional activities, are increasingly seen as a way to help address many of these impacts [3,4] and have been shown to effectively protect biodiversity and enable ecosystem recovery [5–7]. Currently, marine reserves protect just a fraction of the world's oceans, calculated at 0.1% in 2007 [8], whilst wider, multiple-use marine protected areas cover 1.6% of the global ocean surface [9]. Yet despite their limited extent, marine reserves are widely seen as the 'pinnacle of protection' for marine life and as a way to provide resilience against future stressors such as climate change [10].

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Marine reserves have been variously defined [11,12], but their usual aim is to prohibit extractive or depositional activities and to maintain or recover the ecosystem(s) to a natural state in which marine life can thrive and natural processes dominate ecosystem dynamics [13–15]. Ballantine [11] states that the aim of marine reserves is to “maintain (or restore) the intrinsic biodiversity and natural processes [within the marine environment]. No fishing is permitted or any removal of material. No dredging, dumping, construction or any other direct disturbance is allowed”. Lubchenco et al. [16] defined fully protected marine reserves as “areas of the ocean completely protected from all extractive and destructive activities”. In New Zealand marine reserves are “specified areas of the sea and foreshore that are managed to preserve them in their natural state as the habitat of marine life for scientific study [...]. Within a marine reserve, all marine life is protected and fishing and the removal or disturbance of any living or non-living marine resource is prohibited, except as necessary for permitted monitoring or research. This includes dredging, dumping or discharging any matter or building structures” [13]. In Australia the term ‘marine reserve’ is used to define “an area of sea especially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources, and managed through legal or other effective means” [14]. In Wales in the United Kingdom, the establishment of

marine reserves which will be known as ‘highly protected marine conservation zones’ is currently underway. These are defined as “sites that are protected from extraction and deposition of living and non-living resources, and all other damaging or disturbing activities” [17]. Damaging activities are defined as “acts that potentially result in permanent or temporary physical harm or injury to species, or cause permanent or temporary alteration to natural features within the marine environment”. Disturbing activities are defined as “acts that interfere with the normal functioning of populations beyond the natural variability of the ecosystem” [17].

Some marine reserve equivalents, such as IUCN Strict Nature Reserves and Wilderness Areas, and the Australian Great Barrier Reef Marine Park Preservation Zones restrict public access. However, the scope for creating such ‘no use’ zones is extremely limited, so it has generally been taken for granted that non-consumptive activities be allowed (i.e. activities which do not result in extraction of a resource or deposition of materials). Many marine reserves positively encourage such uses, which are often recreational or educational, and so many marine reserves play an important economic and social role. However, this creates a potential problem in that, unless suitably managed, some non-consumptive activities have the potential to cause significant environmental damage, especially in marine reserves with high visitation and/or highly sensitive features [18]. To determine which non-consumptive activities are compatible with the goal of complete ecosystem protection a better understanding of the potential impacts of non-consumptive activities is required. This would allow marine managers to make decisions as to whether marine reserves that allow certain non-consumptive uses are protected enough to deliver demanding conservation objectives.

This study examines what non-consumptive activities or uses are prohibited or allowed within marine reserves or their equivalents from across the world, and how permitted activities are regulated. Risks to wildlife associated with the various managed or unmanaged activities are assessed across a spectrum of intensity of use, and management options to improve compatibility with full ecosystem protection are discussed.

## 2. Methods

### 2.1. Non-consumptive activities in marine reserves

Ninety-one marine reserves or their equivalent (i.e. protected areas offering a high degree of protection from exploitation) from thirty-six countries were examined to investigate management approaches in use. Sixteen activities were identified as commonly receiving or being in need of management: catch and release angling, diving, snorkelling, swimming, boat mooring, anchoring, scientific research, jet skiing, kayaking, wildlife observation, motorised boating, water skiing, surfing, wind surfing, sailing and kite surfing. For all marine reserves examined each activity was then categorised as being either prohibited, allowed or regulated. If a marine reserve did not mention an activity, it was not included in the analysis for that activity. Doing this required the following assumptions: catch and release fishing was assumed to be prohibited alongside other forms of fishing unless it was explicitly stated as allowed, while boating was assumed to be allowed in cases where it was not specifically mentioned, but where anchoring and mooring were listed as permitted or regulated activities. Where boating or watercraft activities were mentioned but specific activities were not detailed, it was assumed that this included sailing, motor boating and kayaking. If regulations included a category termed ‘motorised watersports’ then jet skiing and water skiing were assumed to be covered by that unless

stated otherwise. The assumption that the non-mention of an activity in a marine reserve management plan means that the activity does not occur is a critical one. However, we attempted to address this problem by using the best available information from the Internet and available literature, in addition to making the assumptions detailed above for each of the marine reserves analysed.

For the sixteen activities, ‘high’ and ‘low’ impact versions of each were then assessed to consider their potential to negatively impact upon species or habitats within the marine reserve and to provide a range of intensity of impact for each activity (see Table 1). In classifying an activity as high impact it was assumed that no-take regulations would be adhered to but that otherwise it was unregulated. Classification of high and low impact versions of activities were based on effects reported in the scientific literature (see Supplementary Materials A for literature reviewed) and personal knowledge.

### 2.2. Risk analysis

A risk analysis was performed to identify the level of threat for high and low impact versions of each activity. This was done by assessing each activity against the six criteria listed in Table 2. The criteria were established by review of the scientific literature to determine the range of potential impacts likely to occur as a result of recreational activities [18,19], [Supplementary Materials A]. A risk score for each activity was attributed under each criterion and an overall risk score calculated by averaging across the six criteria. Averaging was performed so that impacts of different activities could be compared and ranked.

To evaluate whether the riskier activities identified were typically excluded from marine reserves, the average level of risk for each activity was plotted against the percentage of marine reserves sampled that either allowed or regulated that activity.

## 3. Results

### 3.1. Activities in marine reserves

A summary of the 91 marine reserves reviewed and which of the 16 non-consumptive activities they prohibit, regulate or allow is provided in Appendix A and summarised in Fig. 1. The most commonly prohibited activity (in addition to those extractive or depositional activities mentioned earlier as being fundamental to marine reserve status, such as fishing or dumping, and excluding reserves where the activity was not mentioned) was catch and release angling which was prohibited in 98% of marine reserves and permitted with regulation in 2%. Kite surfing and jet skiing were also commonly prohibited in marine reserves where these activities were mentioned, the figures being 63% and 61% respectively. However, kite surfing was only mentioned in 18% of marine reserves and jet skiing in 34%.

Activities most commonly permitted with regulation were scientific research (68%), mooring (62%), wildlife observation (52%) and motorised boating (51%). Mention of management for these was made in 82%, 49%, 32% and 92% of marine reserves sampled. Activities most commonly permitted without apparent regulation were swimming (63%), snorkelling (58%), kayaking (53%) and surfing (52%). These activities were mentioned in 80%, 81%, 85% and 27% of marine reserves sampled.

### 3.2. Risk assessment of non-consumptive uses

Table 3 shows results of the risk analysis. By considering each activity as either high or low impact the risk scores presented

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