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Conservation of aquatic resources through the use of freshwater protected areas: opportunities and challenges

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Abstract Freshwater environments are currently experiencing an alarming decline in biodiversity. As a result, scientists and managers must look for alternative management techniques to protect these aquatic systems. One such option that has potential to protect freshwater environments from numerous threats is the use of freshwater protected areas (FPAs). FPAs are portions of the freshwater environment partitioned to minimize disturbances and allow natural processes to govern populations and ecosystems. While similar conservation practices are well established in the terrestrial and marine environments, the use of FPAs for conservation of freshwater environments has been relatively slow. Despite this, numerous examples exist in which FPAs have been incorporated into successful management approaches for freshwater environments. In this paper, we outline some of the past success stories where FPAs have been used to protect freshwater environments, discuss some of the reasons that this technique has not proliferated to the same degree as marine protected areas, and present some of the challenges that managers and scientists must overcome if they wish to implement FPAs. We recommend that the term Freshwater Protected Area be adopted to such conservation efforts, thereby standardizing terminology and facilitating literature searches and dissemination of research findings. Furthermore, we encourage freshwater scientists, conservationists and managers to develop and implement FPAs in innovative and creative situations thereby permitting the growth of the research base for this valuable conservation technique.

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Abbreviations
FPA Freshwater Protected Areas
MPA Marine Protected Areas

Introduction

Throughout the world, freshwater ecosystems are experiencing serious threats to both biodiversity and ecosystem stability. This situation has been recognized by numerous authors for quite some time (Williams et al. 1989; Warren and Burr 1994; Cowx 2002), and many strategies have been proposed to solve this crisis (see examples in Moyle and Yoshiyama 1994; Sedell et al. 1994; Li et al. 1995; Cowx 2002; Crivelli 2002; Filipe et al. 2004). One conservation option that has the potential to provide protection to imperilled freshwater habitats concerns the use of freshwater protected areas (FPAs). FPAs are analogous to marine protected areas (MPAs; aside from the obvious difference in system focus and scale) and are regions of the environment set aside from human disturbance thereby theoretically enabling populations and ecosystems to return to original, undisturbed states (Crivelli 2002). While this approach to freshwater, conservation is by no means novel, we propose that it is an underused and often overlooked option for freshwater conservationists that deserves wider consideration, application, and research. Building on this brief background, there are three main goals for this paper. First, we hope to highlight the need for additional conservation measures in freshwater environments. Second, we wish to show that FPAs have been part of successful management and conservation programs designed to protect freshwater environments in the past, and that there is ample biological evidence to suggest they can and should be applied to conservation issues in the future. Finally, we wish to identify current challenges to use of FPAs with hopes of advancing the science and application of this conservation strategy.

Background

The threats currently challenging the integrity and stability of freshwater ecosystems have been the subject of numerous reviews and books in the recent past (Williams et al. 1989; Warren and Burr 1994; Bruton 1995; Brönmark and Hansson 2002; Cowx 2002; Saunders et al. 2002). While our goal is not to review this extensive body of literature, we feel that a brief synopsis highlighting the breadth of the challenges facing freshwater environments is warranted. Threats to freshwater ecosystems include (but are not limited to) habitat alteration and degradation (eutrophication, acidification, sedimentation, increased turbidity, removal of riparian vegetation, channelization), contamination by toxic substances such heavy metals, introduction of non-native species, hydrological manipulations (dams, groundwater removal, water removal for irrigation), overharvest of commercially/recreationally valuable species and global pressures (increased ultra-violet light, global warming etc.) (e.g., Bruton 1995; Richter et al. 1997; Ricciardi and Rasmussen 1999; Baras and Lucas 2001; Brönmark and Hansson 2002; Collares-Pereira et al. 2002; Cowx 2002; Collares-Pereira. and Cowx 2004) and have been listed in Table 1. These threats are further compounded due to the relatively small size of some freshwater environments, the fact that many organisms may be restricted in distribution (i.e., the presence of a dam, surrounding ecosystems may extend beyond the tolerance limits of that species, etc.) and some freshwater organisms may be subjected to point-source disturbances but unable to escape the changes that are occurring–essentially acting as island populations.

As a result of these factors, the loss of biodiversity in freshwater is believed to exceed that observed in both terrestrial and marine environments (Ricciardi and Rasmussen 1999). Freshwater fishes, for example, may be the most threatened group of vertebrates on Earth after amphibians (Bruton 1995), and the global extinction rate of fishes is believed to be in excess of higher vertebrates (Bruton 1995; Sisk et al. 1994). This decline in freshwater fisheries may now be visible in some recreational fisheries in Canada (Post et al. 2002). In addition, with the growth of the world's population expected to continue, both the global consumption of freshwater and the human impacts on freshwater aquatic ecosystems will undoubtedly exceed current levels (Gleik 1998; Malmqvist and Rundle 2002). Studies have shown that small changes to species compositions in aquatic communities can result in changes to primary productivity (Carpenter et al. 1985), macrophyte communities (Power 1990) and species diversity (Paine 1966). Furthermore, changes to the relative abundance of individuals or species within an aquatic community can negatively impact species richness, ecosystem biomass, the age of first maturity for fishes, or food web dynamics (Shuter and Koonce 1977; Micheli et al. 1999; Rochet and Trenkel 2003) underscoring the need to maintain the structure of aquatic communities. Clearly, current approaches to conservation and the protection of biodiversty in the freshwater environment are substantially lacking in effectiveness, and additional, innovative approaches to management techniques may be required. Establishing protected areas with a reduced level of human intervention may be one such approach.

Protected areas

Conservation of large tracts of land has long been the cornerstone of terrestrial conservation efforts (Soulé and Terborgh 1999). For decades, scientists, managers and policy makers have utilized size, diversity and connectivity in the design of reserves to guard against a loss of biodiversity in terrestrial ecosystems. Recently, the use of large, undisturbed portions of habitat for conservation has become prominent in the marine environment (Kelleher and Kenchington 1992; Polunin 2001). Marine ecosystems are currently degrading due to a number of problems including habitat destruction, over-harvest of resources, pollution, introduction of non-native species and climate change (Carr et al. 2003; Hixon et al. 2001; Jameson et al. 2002), and scientists are increasingly utilizing marine protected areas (MPAs) to prevent further decline. Marine protected areas can be defined as ''Any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other

Table 1 Anthropogenic and environmental threats currently facing marine and freshwater environments that can act to reduce biodiversity and reduce ecosystem integrity

Threat	Freshwater environment			Marine environment		
	Severity of threat	Protection from FPA	Comments	Severity of threat	Protection from MPA	Comments
Species introductions	H	L	Introduced species may outcompete endemics	H	L	Intoduced species can outcompete endemics
Dams/weirs/barriers	H	M	Prevents movements and isolate populations	N/A	N/A	N/A
Global warming	H	L	Can change water temperatures to exceed thermal maximum of species	H	L	Can change water temperatures to exceed thermal maximum of species
Shoreline development	H	H	Can modify spawning/rearing areas and change water temperatures	L	H	Can modify spawning/rearing areas and change water temperatures
Commercial harvest	H	H	Excessive harvest can negatively influence populations	H	M	Excessive harvest can negatively influence populations
Recreational fishing	M	H	See Post et al. (2002) for evidence of population declines due to recreational angling	L	M	Some evidence of negative influences on marine populations
Artisanal fishing	M	H	Excessive harvest can negatively influence populations	L	M	Consequences likely localized in marine environments
Flow regulation	H	L	Differences in water levels can negatively influence spawing/rearing areas, altered behaviour and energetic costs	N/A	N/A	N/A
Tourism	L	H	May help promote the popularity of closed areas	L	H	May help promote the popularity of closed areas
Eutrophication	H	L	Changing nutrient levels can disrupt food webs	L	L	May be a problem in near-shore areas
Acidification	H	L	Acid rain has damaged many freshwater ecosystems	L	L	Not a problem for many marine envi ronments
Ultraviolet (UV) radiation	M	L	Increased UV radiation can negatively influence many littoral processes/organisms	M	L	Increased UV radiation can negatively influence many littoral processes/organisms

Table 1 continued

Threat	Freshwater environment			Marine environment		
	Severity of threat	Protection from FPA	Comments	Severity of threat	Protection from MPA	Comments
Boating sedimentation	L	H	Can be a problem in shallow environments	L	H	Not likely a problem for many offshore marine environments but may be problematic in shallow zones
Atmospheric pollutant deposition	M	L	Many potential pollutants can enter freshwater environment through atmosphere	M	L	Many potential pollutants can enter marine environment through atmosphere
Mineral abstraction	M	L	Runoff and tailings can negatively influence freshwater environments	L	L	Not likely a problem for many marine environments

Along with each threat is a relative ranking of the severity of each threat (L = low threat, M = moderate threat, H = high threat, N/A = not applicable) and the amount of protection offered by either Freshwater Protected Areas (FPAs) or Marine Protected Areas (MPAs) to the threat (L = Low level of protection, M = Moderate level of protection, H = High level of protection, N/A = not applicable). Threats were compiled from Bruton (1995); Brönark and Hansson (2002); Cowx (2002); Jameson et al. (2002) and Saunders et al. (2002)

effective means to protect part or all of the enclosed environment'' (Kelleher and Kenchington 1992), and likely originated in the 1950's as a result of increased fishing effort and technology, and greater numbers of human forays into the marine environment because of a rise in the popularity of SCUBA diving (Ray 1999).

While the objectives of MPAs are often diverse and may include a number of different goals including the conservation of biodiversity and habitat, protection of rare and/or endangered species, or the control of exploitation rates and maintaining-traditional values (National Research Council 2001; Jones 2002), their efficacy in many aspects of marine conservation has been well documented. In a recent synthesis of over 100 MPAs ranging in size from 0.002—846 km^2, Halpern (2003) concluded that MPAs were associated with increases in species diversity, biomass, organism size and organism density relative to unprotected areas. These benefits spanned several trophic states from invertebrates to top carnivores, and occurred regardless of reserve size. Also, MPAs can increase the opportunities for non-consumptive use of marine resources such as ecotourism and aesthetic uses (Murray et al. 1999), protect vulnerable species or habitats (Murray et al. 1999; Shipp 2003), export biomass to surrounding waters (Carr and Reed 1992; Murray et al. 1999), and have been shown to increase scientific understanding by providing unexploited areas against which change can be measured (Murray et al. 1999). Based on these benefits, it is not surprising that Hixon et al. (2001) cited marine protected areas as ''the most immediate and effective conservation action'' concerning the protection of marine ecosystems, and strongly advocated continued use and examination of MPAs.

Several authors have suggested, however, that MPAs are not the answer to all of the challenges facing the marine environment. For example, MPAs often fail to protect highly migratory fishes that may travel beyond their borders (Shipp 2003) and do little to deal with nonpoint source pollution or larger scale environmental degradation such as coral bleaching. Furthermore, increases in population size resulting from reserve protection may not translate into increases in recruitment (Shepherd and Pope 2002) and the socio-political issues concerned with site selection and role of MPAs often makes their implementation problematic and complicated (Jones 2002). Jones (2002) reported that over one-quarter of global MPAs are failing to meet their management objectives, and MPAs cannot defend marine environments from all external sources of ecosystem disturbances (Jameson et al. 2002). Despite these (and other) shortcomings, however, properly managed MPAs can and do play a role in the protection of marine environments (McClanahan 1999; Halpern 2003).

Freshwater protected areas

To date, the use of closed areas designed to shield freshwater biota from natural and anthropogenic disturbances has been quite slow relative to the marine environment (Crivelli 2002; See summary of FPA reviews in Table 2). Cowx (2002), for example, reported that the use of protected areas was the third most popular action used to protect freshwater fish populations after rehabilitation and stock enhancement. Interestingly, many of these closed areas were not originally designed with the intention to specifically protect fish (Crivelli 2002). With the strong emphasis on the use of protected areas in marine environments (i.e. MPAs), it is surprising that a greater number of managers and freshwater scientists have not tried to apply the

Table 2 Recent syntheses that have discussed the use of Freshwater Protected Areas (FPAs) in freshwater conservation. Also listed are the major recommendations and conclusions concerning FPAs for the papers. Chosen citations focus on more holistic examples although some are more site-specific when they also include more general recommendations

Paper	Year	Focus	Conclusion/Recommendations
Williams	1991	Historical perspective of protected areas for freshwater fishes in western United States	Set species-specific goals for recovery plans, protect areas of high diversity with refuges
Lyle and Maitland	1992	Overview of the use of the nation nature reserve system for fish in the United Kingdom	Nature reserve can improve fish conservation; Focus on acquisition of new reserves for threatened species
Keith	2000	Overview of the use of freshwater protected areas in France	Must inventory species, develop site-specific management plans for each threatened fish species
Crivelli	2002	Causes of fish decline; Effects of reserves; Challenges and prospects	Must compliment reserve creation with catchment-scale management programs for optimum benefits
Cowx	2002	Threats to freshwater fishes; Problem with current conservation practices; Options for future conservation	Conservation efforts should integrate research to identify problem areas; Utilize protected areas to promote stability; Consider multiple-user framework
Saunters et al.	2002	Catchment-scale management; Flow regimes; Non-native species	FPAs should be located in intact catchments with natural flow regimes and without introduced species; Conservation ef forts should be focused on headwaters and riparian zones

same general principles and techniques to freshwater environments, especially when the numerous success stories involving FPAs are also highlighted.

From a direct standpoint, FPAs have played an important role in the rehabilitation and conservation of a number of freshwater species. Freshwater preserves have been used in the conservation of several rare fish species in the western United States beginning primarily in the 1960's (Miller and Pister 1971; Williams 1991; Means and Johnson 1995), but some no-fishing reserves were put in place beginning in the 1940s (Miller 1972). Elson (1940) reported benefits to culturing muskie (*Esox m. masquinongy*) in outdoor, natural sanctuaries free from human disturbances, and FPAs designed to protect nesting black bass (*(Micropterus spp*.) from angling during the brood guarding stage have proven to both increase angler catch-per-unit effort (Sztramko 1985) and increase population-level reproductive success (Suski et al. 2002). A no-fishing reserve in a Zimbabwe lake proved successful at increasing both the number and size distribution of several freshwater fish families (Sanyanga et al. 1995), and the establishment of no-fishing refuges has played a large part in the rehabilitation of exploited lake trout (*Salvelinus namaycush*) populations in both Lake Huron (Reid et al. 2001) and Lake Superior (Schram et al. 1995). Kocovsky and Carline (2001) documented that an unexploited walleye (*Sander vitreus*) population in Pennsylvania exhibited greater population density and greater adult size relative to other exploited populations, while Champeau and Denson (1987) reported that, after opening a Florida lake to public fishing, both the biomass of largemouth bass and angler catch-per-unit effort fell considerably due to angling-induced mortality of fish.

From an indirect standpoint, the presence of an FPA on a waterbody will function to minimize human disturbance in an area, which may benefit freshwater environments at multiple levels. Boat traffic on a lake, for example, has been shown to increase the addition of gasoline-derived chemicals in water (An et al. 2002). In addition, boat traffic can also increase the resuspension of benthic sediments into the water column, which may adversely affect both fish and macrophyte communities in a lake (Anthony and Downing 2003). Furthermore, boat traffic can impact the hearing capability of fish [(i.e., fathead minnow (*Pimphales promelas*, Scholik and Yan 2002)], and numerous studies have documented the negative impact of boat traffic on the reproductive success aquatic birds (Burger 1998, 2003). Finally, conflict between the users of freshwater resources has been documented (Jones 2003), and will likely continue to escalate as human demands on freshwater resources continues to grow. The presence of FPAs on a waterbody may help ameliorate some of these conflicts by segregating user groups into defined areas. It is important, therefore, that scientists, managers and conservationists continue to design and implement FPAs, and explore their usefulness at protecting freshwater environments at a number of different trophic levels and in innovative and creative situations.

In addition to these documented FPA studies, a number of researchers have strongly suggested developing freshwater refugia to aid in the conservation and protection several different aquatic species. Wei et al. (1997), for example, claimed that the establishment of FPAs may be the only way to protect two species of Acipenseriforms in China. Cambray (2002) provided an overview of the conservation needs of an endangered African anabantid that was focused on the use of freshwater protected areas to protect fish from harvest during the reproductive period. Rahr et al. (1998) and Lichatowich et al. (1999) called for a refuge system to protect dwindling native Pacific Salmon (*Oncorhynchus spp*.), and Williams and

Miller (1990) recommended that conservation strategies be adopted "to protect remaining natural communities that support a relatively intact native fish fauna." Li et al. (1995) called for the identification of areas of high species diversity that can be protected by refuges to lower extinction risks for aquatic fauna in Oregon, while Moyle and Yoshiyama (1994) called for the creation of Aquatic Diversity Management Areas (ADMAs) to protect endangered and threatened aquatic species in California. For non-game fish such as catostomids (suckers), Cooke et al. (2005) recommended the use of FPAs not to reduce harvest, but instead to protect habitats and processes such as natural flow regimes and groundwater inputs (e.g., Power et al. 1999). Indeed, although freshwater protected areas are generally focused on fishes, they can target all forms of aquatic life, and even terrestrial life forms that depend upon aquatic ecosystem services. For example, a freshwater species that is not a fish that would benefit from freshwater protected areas is the giant freshwater lobster, *Astacopsis gouldi* of northern Tasmania. Based on their life-history characteristics (slow-growing, low reproductive rates) and numerous threats (clearance of riparian vegetation, channelisation, exploitation), the increased use of freshwater protected areas has been suggested as a tool for conserving these animals (Horwitz 1994). A study by Ricciardi et al. (1998) concluded that a "mass extinction of freshwater mussels in the Mississippi River basin" may result from invasions by the zebra mussel (*Dreissena polymotpha*), and recommended that refuges where *D. polymorpha* populations are low be utilized as sanctuaries to facilitate mussel management. Clearly, the benefits of FPAs have been both documented and acknowledged in multiple scientific studies on different taxa ranging from fish to invertebrates, but, for many different reasons, they have not been utilized to the same degree as MPAs.

Scarcity of FPAs

Research and previous studies have shown that, from a biological perspective, FPAs can and have been a successful management option for imperilled freshwater ecosystems, and can help protect freshwater environments from many of the threats they currently face (eg. Miller and Pister 1971; Cowx 2002). To date, however, the use of FPAs in aquatic conservation strategies has not proliferated to the same degree as MPAs. The reason for the lack of FPA proliferation likely can be attributed to three main issues. First, there are differences in the threats facing freshwater and marine environments, and the effectiveness of protected areas at ameliorating these threats varies greatly; a protected area is not the ideal solution to all of the challenges facing freshwater environments, and other conservation options may need to be employed rather than an FPA. As an example, if a protected area is implemented downstream from a point source of pollution, an FPA will do little to remedy the problem as pollutants will be carried downstream into the protected area. For this reason, several authors have emphasized the importance of a catchment focus in dealing with protection of freshwater environments (including riparian zones) (Sedell et al. 1994; Collares-Pereira and Cowx 2002; Crivelli 2002; Saunders et al. 2002).

A second reason that may explain a lack of FPA proliferation concerns the use of terminology. Currently, terms concerning the use of protected areas have not been standardized across studies potentially resulting in successful examples of protected areas in freshwater remaining undiscovered by other researchers. As discussed above, there are numerous examples showing how FPAs have been successful at protecting aquatic environments. Many of these studies, however, used different terminologies to name their protected areas (Table 3). In some cases, the same term defining a protected area has been used in disparate ways by different researchers, and some studies do not define the terms that they use to describe protected areas. For these reasons, we advocate the use of Freshwater Protected Areas (or the more general Aquatic Protected Areas) to standardize terms and facilitate the use of electronic searches. The term FPA is similar to the accepted and ubiquitous MPA, and also encompasses many of the general uses of protected areas that are outlined in Table 3.

The final probable explanation for a lack of FPA proliferation concerns the level of complexity in dealing with conservation strategies in freshwater environments. In general, biology is only one component of any successful conservation program; economics, sociocultural issues, political considerations and enforcement components must all be considered and coordinated prior to having a successful management strategy implemented and maintained (Krueger and Decker 1999; Meffe 2002). We believe that a lack of FPAs in freshwater conservation efforts is due in part to the complex and difficult task of assembling all of these components when considering management options for freshwater environments. For example, implementing a conservation program for freshwater environments requires the cooperation of multiple stakeholder groups, often spanning several ecosystems, and potentially involving multiple jurisdictions or countries, and these stakeholder groups must also decide on upkeep, enforcement and assessment programs (Collares-Pereira and Cowx 2004; Filipe et al. 2004). As well, many freshwater environments and their associated catchments are privately owned making it difficult to impose management plans that may not represent the wants/needs of the landowner. This contrasts with the marine environment where much of the area is public thereby removing a conservation impediment allowing MPAs to grow. The lack of FPA proliferation relative to MPAs, therefore, can likely be attributed to several points, all of which all of which should be addressed in future studies and applications.

Challenges & Future Studies

As with any management strategy, developing an FPA for a particular management problem will require scientists and managers to overcome a number of challenges, many of which may vary with geographical location and/or circumstances. The first obstacle is to identify areas or species that are in need of additional protection. Over time, a number of groups have encountered this problem and several papers have been written on this subject allowing researchers to share ideas and approaches (Sedell et al. 1994; Moyle and Yoshiyama 1994; Li et al. 1995; Filipe et al. 2004; Cooke et al. 2005; Higgins et al. 2005). Next, it is important to recognize that, while FPAs are effective at protecting freshwater ecosystems from many stressors, they cannot address all threats to freshwater environments. Similarly, there are lessons that can be learned from MPAs, but this must be done with caution as the system properties are indeed quite different. Once an FPA has been identified as the desired management tool in a particular situation, managers and scientists then need to consider issues such issues as FPA goals, monitoring regime, legislation used for enforcement, connectivity between FPAs and with the marine environment, and

Table 3 Terminology and confusion with FPAs. As evident from our synthesis, different types of FPAs have been used for some time but under different nomenclature. Below is a list of terminology commonly used to describe different protected areas along with their intended meanings

Terminology	Description	Examples/References
Refuge	Areas managed specifically for one or few species rather than general biota	Williams (1991); Moyle and Yoshiyama (1994)
Sanctuary	Typically focused on a species that is targeted for harvest such as gamefish or waterfowl. Implies no harvest or fishing activity rather than no use. Can be voluntary or mandatory	Suski et al. (2002)
Aquatic Diversity Management Area (ADMA)	Area designed to protect and maintain aquatic diversity. Uses compatible with the ADMA are permitted which may include some fishing activities and harvest	Moyle and Yoshiyama (1994)
Fishing reserve	Small areas designed to protect against habitat degredation and to limit exploitation	Crivelli (2002)
Preserve	Biological community is left to function in its natural state and managed to protect natural features	Williams (1991); Moyle and Yoshiyama (1994)
Closed area	Implies no use or passage-cultural or natural resource protection. Some locations are closed to the public but used by specialized groups such as the military.	No examples
Fresh water protected Area (FPA)	Any area of fresh water terrain, together with its overlying water and associated flora, fauna, historical and cultural features, including riparian regions and groundwater, which has been re served by law or other effective means to protect part or all of the enclosed environment	Kelleher and Kenchington (1992)

We advocate the use of freshwater protected areas (FPAs), or more generally aquatic protected areas (APAs), which would extend to marine systems as well. In general, the lack of consistent terminology makes it difficult to locate literature and is perhaps retarding the generation of broader interest of FPAs. Note that most of the historic terminology is based on traditional fisheries and wildlife management strategies focused on a single species or group of economically/recreationally valuable species other sociopolitical concerns that may develop from dealing with multiple stakeholders and usergroups. While many of these obstacles appear to be large and daunting, continued research, implementation, and publication of FPA examples will allow the development of a knowledge base of ideas and techniques used to overcome these challenges. Over time, as FPAs are applied to address additional conservation issues, this knowledge base will grow permitting the sharing of ideas and facilitating the implementation of FPAs to conservation programs.

Conclusions

Freshwater ecosystems are currently experiencing an alarming decrease in biodiversity and ecosystem integrity as a result of numerous different stressors. Existing management plans for aquatic ecosystems have largely been ineffective at preventing this decline, and changes to the manner in which freshwater habitats are protected must occur. At the 42nd meeting of the American Fisheries Society in 1912, Henry Ward proclaimed that ‘‘It is not so difficult to provide for the setting aside of short streams’’ to protect freshwater fishes (Ward 1913), and removing the threat of human disturbance through the use of protected areas has proven to be successful in many aspects of conservation in the marine environment. Research investigating the effects of similar protected areas in the freshwater environment are proportionally scarce, but biological evidence suggests that freshwater protected areas have the potential to protect freshwater environments from many deleterious stressors, and positively impact declines in biodiversity. We encourage the proliferation of studies examining the impacts of FPAs on the protection of biodiversity and ecosystem stability despite their inherent challenges, and feel that these areas may be effective at reversing an alarming trend in the destruction of freshwater habitat. The incorporation of FPAs in innovative ways to address conservation issues will increase our knowledge of the capabilities FPAs as a conservation tool, help develop techniques and models on which to deal with many sociopolitical and enforcement issues, and will aid in their implementation in future projects.

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