

ADD-ON CONSERVATION BENEFITS OF MARINE TERRITORIAL USER RIGHTS FISHERY POLICIES IN CENTRAL CHILE

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Abstract. To combine the rational use of marine benthic resources and economic development of small-scale fishers, Chile passed legislation in 1991 establishing a comanagement policy that grants exclusive territorial user rights for fisheries (TURFs) to artisanal fisher organizations in well-defined inshore coastal areas, known as Management and Exploitation Areas for Benthic Resources (MEABRs). In general the policy has been proclaimed a management and economic success because benthic resource abundances have increased inside MEABRs in comparison with open-access areas. However, there is a lack of studies assessing the impact of this management policy on nontargeted subtidal species and community assemblages and the policy's implications for biodiversity and conservation. This study starts to fill this gap and links the allocation of TURFs for benthic resources with add-on conservation benefits for species that are not directly linked with the fishery policy.

Comparative subtidal surveys inside vs. outside MEABRs were used to assess the effects of three MEABRs on managed targeted benthic species, biodiversity (species richness), and community assemblages in central Chile. Surveys focused exclusively on subtidal kelp forest habitats dominated by *Lessonia trabeculata*, spanning 4–12 m in depth and with similar levels of habitat complexity. The study comprised: (1) quantification of kelp forest complexity, (2) understory survey of sessile species, (3) quantification of conspicuous benthic macro-invertebrates, including those under management, and (4) quantification of reef-fish species inside the kelp habitat. Results showed population enhancement of target-managed invertebrates inside MEABRs. Moreover, reef-fish species were significantly more diverse and abundant inside MEABRs, and community assemblages of nontarget benthic invertebrates and reef fish were significantly different inside vs. outside MEABRs. The comanagement of inshore benthic resources in Chile, through MEABRs aims for the sustainability of invertebrate and algae stocks. However, our study shows that this management tool, which in practice restricts access to the entire management area, provides important conservation add-on effects for species that are not the focus of the management policies. Therefore, in Chile, the hundreds of already established MEABRs could represent an important ancillary network, which complements the biodiversity objectives of fully protected areas such as no-take marine protected areas or others.

Key words: *benthic resources; biodiversity; Chile; comanagement; conservation; nearshore; reef fishes; sustainability.*

INTRODUCTION

Fisheries management approaches based on top-down and centralized government interventions have proven to be inadequate (Myers and Worm 2003, Pauly et al. 2003, Defeo et al. 2007). As a consequence, in recent years researchers have promoted the implementation of comanagement and bottom-up marine management policies (Sandersen and Koester 2000, Castilla and Defeo 2005, Gelcich et al. 2007). One approach has been to grant exclusive territorial user rights to small-scale fishers (TURFs), particularly for the management of inshore benthic resources. The rationale behind

TURFs is based on a common property approach, which assumes that user rights will create institutional incentives among fishers for sustainable resource use (Ostrom 1990). However, knowledge about the wider ecological effects of these new marine governance and management tools on marine biodiversity, community assemblages, and conservation is still in its infancy, even though this understanding is crucial for joint approaches to achieve management and conservation outcomes (Castilla 2000, Folke et al. 2005, Huitric 2005).

In Chile, TURFs take the form of Management and Exploitation Areas for Benthic Resources (MEABRs; see Castilla 1994, Castilla et al. 1998, Gelcich et al. 2005, 2006). Through the MEABRs comanagement policy, the Chilean Undersecretary of Fisheries assigns temporary TURFs to artisanal fisher organizations (unions, associations) in defined geographical coastal areas, ranging

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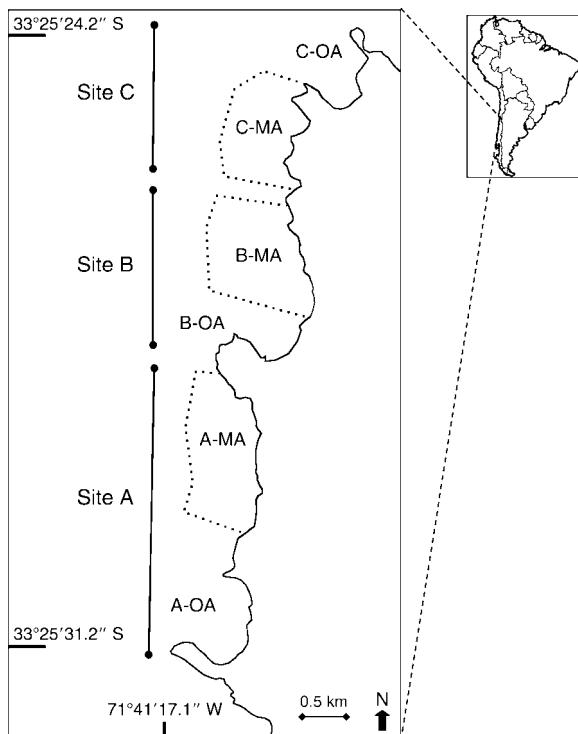


FIG. 1. Map of the study area in central Chile showing the location of the three sites A, B, and C. Management and exploitation areas for benthic resources (MEABRs), delimited by dotted lines, are A-MA, B-MA, and C-MA; open-access areas are A-OA, B-OA, and C-OA.

from ~50 to 300 ha of seabed. This includes the right to exclude organization nonmembers from the assigned seabed. MEABRs are created and assessed considering economically important benthic species such as the carnivorous muricid gastropod *Concholepas concholepas* (considered in ~80% of MEABRs), key-hole limpets, *Fissurella* spp. (~70%), and the red sea urchin *Loxechinus albus* (~30%) (Castilla et al. 2007b). Biological and economic success of MEABRs policy has been proclaimed based on the substantial increases of abundances and sizes of managed species within MEABRs in comparison with open-access areas (Castilla et al. 1998, Subpesca 2002). According to the Chilean National Fisheries Service (SERNAPESCA 2005) in Chile there is a total of 547 decreed MEABRs, which cover ~1023 km², and of these 301 are in full operation. MEABRs spread across the ~4000 km of coast of Chile and thus have the potential to scale-up the sustainable use of benthic resources and also enhance marine conservation initiatives (Castilla 2000, Castilla et al. 2007b). This may provide one of the fundamental building blocks to construct in Chile an interconnected network of nearshore areas linking those established for the sustainable use of benthic resources with those aimed specifically for conservation and maintenance of biodiversity.

In this study we tested the hypothesis that MEABRs in central Chile, provided they have been properly managed (i.e., adequately surveyed, correct application of the MEABRs total allowable catch policy) for several years, not only sustain targeted benthic resources, but additionally provide add-on conservation benefits for species that are not directly connected to the policy. If the hypothesis is proved correct, then MEABRs could complement networks of no-take Marine Protected Areas (MPAs), to create an integrated management–conservation scenario.

METHODS

Study sites

In central Chile (~32°6' S–33°50' S) there are currently 32 MEABRs (SERNAPESCA 2005). Here we used the three oldest MEABRs established in this zone: El Quisco Sur (A-MA, ~160 ha); El Quisco Norte (B-MA, ~60 ha), and Algarrobo Sur (C-MA, ~80 ha). We chose them as they have been in place for 7–12 years and have been harvested as MEABRs for 6–11 years. We also considered that surveillance by artisanal fishers of these MEABRs has been effective and in place for 6–12 years. These MEABRs have a 24 hour/day self-guarding system to counter illegal poaching. The MEABRs are situated along 13 km of linear coast and are spatially separated by open-access diving areas, which are free to be exploited. All these areas have similar subtidal habitat characteristics with regard to seabed, depth ranges, and existence of extensive *Lessonia trabeculata* kelp forests.

Sampling methods

Comparisons between open-access areas and MEABR areas were used to assess the effects of commercial species management on subtidal biodiversity and community assemblages at three different sites, between December 2005 and January 2006 (Fig. 1). Within each site, an MEABR area and an open-access area were surveyed, by diving, using three subtidal band transects per area. Transects were placed in forests of *L. trabeculata*, ranging from 4 to 12 m in depth. Diving activities were done from a boat. The position of transects was randomly selected within MEABRs and in open-access areas. To avoid spatial dependence, replicate transects were placed at a minimum distance of 200 m from each other. Transects were 100 m long × 2 m wide and were divided into 11 stations at 10-m intervals. They were set perpendicular to the coast and were surveyed by semiautonomous “hooka” divers. The study quantified four variables: (1) habitat complexity, (2) *L. trabeculata* understory species, (3) macro-invertebrates (>3 cm maximum length), and (4) reef-fish species. In surveys we used nondestructive visual sampling methods.

Habitat complexity.—Physical variables, such as depth and substrate type (sand, bedrock, rock cobble), were measured at each station. The presence or absence

TABLE 1. Summary of ANOVA results for *Lessonia trabeculata* complexity measures, substrate type, and transect depth.

Habitat complexity	Inside/outside, df = 1		Site, df = 2		Inside/outside × site, df = 2		Residual, df = 12
	MS	F	MS	F	MS	F	MS
<i>L. trabeculata</i>							
Density	1.014	3.16	6.61	20.59***	0.321	0.20	1.57
Holdfast diameter	42.91	2.08	712.9	34.54***	20.64	0.43	47.54
Kelp type (% short)	0.02	12	0.02	13	0.001	0.05	0.036
Substrate							
Rocky substrate (%)	<0.01	<0.01	0.08	12	0.006	0.48	0.014
Transect depth							
Depth (m)	0.006	<0.01	17.82	7.61***	8.96	3.83	2.34

*** $P < 0.001$.

of major benthic topographic features (ledges, crevices, overhangs) were measured along 10-m intervals. *L. trabeculata* forest complexity included: (1) *L. trabeculata* density in one 1-m² quadrat at each of the 11 stations of the transects, (2) diameter of 22 kelp holdfasts per transect (two plants chosen randomly at each station), and (3) a qualitative determination of kelp types (short stem, <20 cm; long stem, >20 cm), at 10-m intervals.

Sessile species in the L. trabeculata understory.—Macro-invertebrate and macroalgal coverage were recorded at every station along the transects. In each station one 0.5 × 0.5 m 100-point quadrat was surveyed. Species that could not be identified in situ were collected and identified in the laboratory. Species richness was measured as total number of species per transect.

Macro-invertebrates.—Density and richness of benthic macro-invertebrates (>3 cm) were sampled by two divers along the 100 × 2 m transect, covering a total area of 200 m² per transect. Macro-invertebrate density was registered at every 10-m interval mark as this was logistically easier for divers. However, data are presented as number of individuals in 200 m². Species richness was measured as total number of species per transect.

Reef fish.—Densities of reef fish were sampled along one side of the 100-m transect (band transects; Bortone et al. 1989) accounting for a total area covered of 100 m². Quantification of reef fish was done by diver visual searching along the transects (Godoy 2007). One diver (N. Godoy) conducted all fish surveys. Reef-fish richness was measured as total number of species per transect.

Statistical analysis

The statistical software package PRIMER (Plymouth Routines in Multivariate Environmental Research; Clarke 1993, Clarke and Warwick 2001) was used to undertake multivariate analysis of: (1) the sessile species found in the *L. trabeculata* understory, (2) the benthic macro-invertebrate community, and (3) the reef-fish community. Abundance data were fourth-root-transformed and standardized (between 0 and 1) for invertebrate and reef fish to ensure that all species, abundant or rare, contributed to the analysis. Additionally, multivariate analysis using species presence-ab-

sence data was undertaken. We used the Bray-Curtis index of similarity. Nonmetric multidimensional scaling (MDS) was used to display similarities between inside vs. outside MEABRs for invertebrates and reef-fish communities. Differences in community assemblages were tested a priori for significance with the ANOSIM procedure (randomized permutation test, Clarke and Warwick 2001). Similarity percentages analysis (SIMPER) identified those species that accounted for the largest differences between MEABRs vs. open-access areas (Clarke and Warwick 2001).

For univariate analysis differences between MEABRs vs. open-access areas were analyzed as treatment (hereafter inside vs. outside MEABRs for simplicity), crossed with sites and transects nested within the interaction of treatment and sites. When an interaction was significant, the means were compared using the SLICE procedure in PROC GLM (SAS Institute 1996). All effects except treatment were considered random. For all ANOVAs, data were tested for homoscedasticity, and transformed with $\log(x + 1)$ when necessary. Transect averages were used in ANOVAs for holdfast density and size. Percentage cover per transect of the “small bushy *L. trabeculata* type” and the percentage of rock as a substrate type were used in ANOVAs examining *L. trabeculata* type and substrate, respectively.

RESULTS

Habitat complexity.—*L. trabeculata* forest densities inside vs. outside MEABRs showed no significant differences (Table 1). However, density values were significantly different among sites (Table 1). Sites A and B had densities of 2–3 plants/m², while site C had ~1 plant/m². *L. trabeculata* holdfast diameter showed no differences between inside vs. outside MEABRs, but did differ significantly among sites (Table 1). Average holdfast sizes for sites A and B ranged between 21 and 23 cm, and ~18 cm for site C. Overall, ~60% of *L. trabeculata* forest was composed of short-stemmed bushy plants. The proportion of this type of *L. trabeculata* plants and substrate (mainly rock, ~90%) within transects did not show significant differences

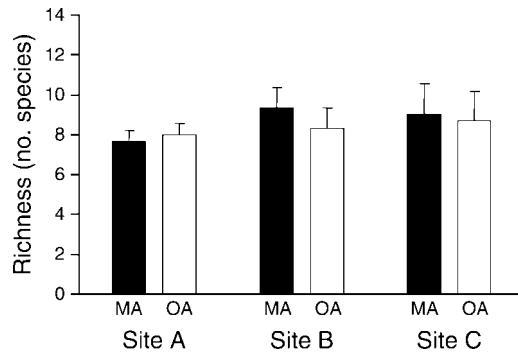


FIG. 2. Kelp understory species richness (mean number of species present + SE) at the three sites in Chile. Solid columns represent MEABRs (MA, management areas), and open columns represent areas outside MEABRs (OA, open access). Overall richness includes: Lithothamnioides, *Hildenbrandia lecanellieri*, *Bossiella chiloensis*, *Corallina officinalis*, *Gelidium* spp., *Plocamium cartilagineum*, *Chondrus canaliculatus*, *Hymenena durvillaei*, *Schottera nicaensis*, *Pterosiphonia dendroidea*, *Ceramium* spp., *Dendrymenia skottsbergii*, *Ralfsia confusa*, *Glossophora kunthii*, *Halopteris hordacea*, *Colpomenia sinuosa*, *Lessonia trabeculata*, *Codium dimorphum*, *Ulva* spp., *Austromagalanus psittacus*, *Balanus laevis*, *Balanus flosculus*, *Phragmatopoma moerchii*, polychaetes of the family Terebellidae, *Pyura chilensis*, and unidentified Porifera.

when comparing inside vs. outside MEABRs (Table 1). All of the surveyed transects had large rocks (~8 m) but lacked major topographic features such as large crevices or overhangs.

Sessile species in the L. trabeculata understory.—In total, with the methods used, we identified 26 taxa of sessile understory species. *L. trabeculata* understory species richness varied between 6 and 13 species per transect and did not show significant differences between inside vs. outside MEABRs ($F_{1,12} = 0.57$, $P = 0.46$; Fig. 2) or among sites ($F_{2,12} = 0.55$, $P > 0.4$).

Percentage cover was mainly distributed among encrusting lithothamnioid algae (~40–60%), *Gelidium* spp. (~10%), barnacles (~5–10%), and bare rock substrate (~5–15%). Community assemblages showed no significant differences between MEABR and open-access areas (ANOSIM, $R = 0.03$, $P > 0.47$).

Macro-invertebrates.—Macro-invertebrate species richness did not differ significantly inside vs. outside MEABRs (Table 2). However, invertebrate species community assemblages showed significant differences when comparing inside vs. outside areas using presence-absence data (ANOSIM, $R = 0.51$, $P < 0.01$) and standardized abundances data (ANOSIM, $R = 0.88$, $P < 0.01$; Fig. 3). SIMPER analysis revealed that four species accounted for ~50% of the differences: *Concholepas concholepas*, *Fissurella* spp., *Heliaster helianthus*, and *Stichaster striatus*. Densities of *C. concholepas* and *Fissurella* spp., the two species targeted to be managed inside the MEABRs, were up to 15 times more abundant inside than outside MEABRs areas (Fig. 4). Multivariate analysis performed excluding *C. concholepas* and *Fissurella* spp., still showed significant differences in community assemblages inside vs. outside MEABRs (ANOSIM, $R = 0.721$, $P < 0.001$). Results of the SIMPER analysis reveal that the species accounting for the major dissimilarity in this case were the starfishes *H. helianthus*, *Odontaster penicillatus*, and the crabs *Cancer setosus* and *Homalaspis plana*. Univariate analysis showed that *C. concholepas*, *Fissurella* spp., and *Heliaster helianthus* had significantly greater densities inside MEABRs. *Cancer setosus*, *O. penicillatus*, and *S. striatus* had greater abundances in open-access areas (Table 2, Fig. 4). *C. concholepas* and *S. striatus* showed significant interaction between treatment (MEABR or open-access area) and sites; however the SLICE procedure indicated that differences in density were

TABLE 2. Summary of ANOVA results for macro-invertebrate species abundances and richness.

Species and richness	Inside/outside, df = 1		Site, df = 2		Inside/outside × site, df = 2		Residual, df = 12
	MS	F	MS	F	MS	F	
Mollusca							
<i>Concholepas concholepas</i>	9.153	22.65*	0.178	0.44	0.404	13.27***	0.030
<i>Fissurella</i> spp.	7.04	196.5***	0.27	7.5	0.035	0.73	0.05
<i>Acanthopleura echinata</i>	1.144	3.78	0.303	1	0.303	2.86	0.106
Echinodermata							
<i>Meyenaster gelatinosus</i>	0.261	1.05	0.024	0.09	0.249	1.55	0.16
<i>Stichaster striatus</i>	7.224	7.01	1.36	1.32	1.031	10.36*	0.099
<i>Heliaster helianthus</i>	7.498	68.72*	0.139	1.27	0.109	1.05	0.103
<i>Odontaster penicillatus</i>	2.26	80.05*	0.165	5.83	0.028	0.19	0.15
<i>Athyonidium chilensis</i>	0.06	1	0.06	1	0.06	2.71	0.02
<i>Tetrapyrgus niger</i>	0.049	1.91	0.923	36.23*	0.025	0.06	0.419
<i>Loxechinus albus</i>	0.028	8.51	0.117	1.6	0.074	0.77	0.095
Crustacea							
<i>Cancer setosus</i>	0.298	43.64*	0.267	39.06*	0.006	0.09	0.078
<i>Homalaspis plana</i>	0.206	25.81*	0.193	24.18*	0.008	0.04	0.18
<i>Gaudichaudia gaudichaudi</i>	1.94	6.71	0.077	0.27	0.289	1.35	0.21
Invertebrate richness	0.50	0.75	2.00	3.00	0.66	0.55	1.22

* $P < 0.05$; *** $P < 0.001$.

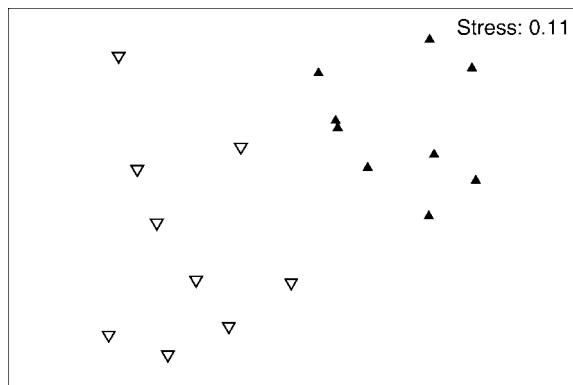


FIG. 3. A nonmetric multidimensional scaling (MDS) plot of relative similarities in macro-invertebrate community assemblages inside (solid triangles) and outside (open triangles) MEABRs.

significantly greater within MEABRs for *C. concholepas* at all three sites. *S. striatus* densities proved to be significantly lower for MEABRs in sites A and C than in B (Fig. 4).

Reef fish.—Reef-fish species richness differed inside vs. outside MEABRs, averaging nine species inside and six species outside (Fig. 5, Table 3). In addition, reef-fish community assemblages were also significantly different inside vs. outside MEABRs using presence-absence data (ANOSIM, $R = 0.39$, $P < 0.01$) as well as using

standardized abundance data (ANOSIM, $R = 0.452$, $P = 0.0001$; Fig. 6). SIMPER analysis revealed that four fish species accounted for ~48% of the differences: *Graus nigra*, *Pinguipes chilensis*, *Cheilodactylus variegatus*, and *Aplodactylus punctatus*. Univariate analysis showed densities of these species to be significantly greater inside vs. outside MEABRs (Table 3, Fig. 7). All other species showed no significant differences (Table 3). *G. nigra* was the only species that showed differences between sites. No reef-fish species showed significant (site \times treatment) interactions (Table 4).

DISCUSSION

A considerable amount of literature has assessed the contribution of no-take MPAs and marine parks for inshore marine conservation (i.e., Harmelin et al. 1995, Babcock et al. 1999, Halpern and Warner 2002, Branch and Odendaal 2003, Halpern 2003, Micheli et al. 2004, Russ and Alcala 2004, Parnell et al. 2005, Guidetti 2006). However, the study of add-on marine conservation effects associated with inshore areas not directly aimed for conservation (“ancillary areas,” see CBD 2004), such as MEABRs and TURFs has received little attention (McClanahan et al. 2006). Our study shows that MEABRs in central Chile subtidal *Lessonia trabeculata*, forest habitats, designed for the sustainable use of benthic invertebrates, not only have greater abundances of target comanaged invertebrates, but

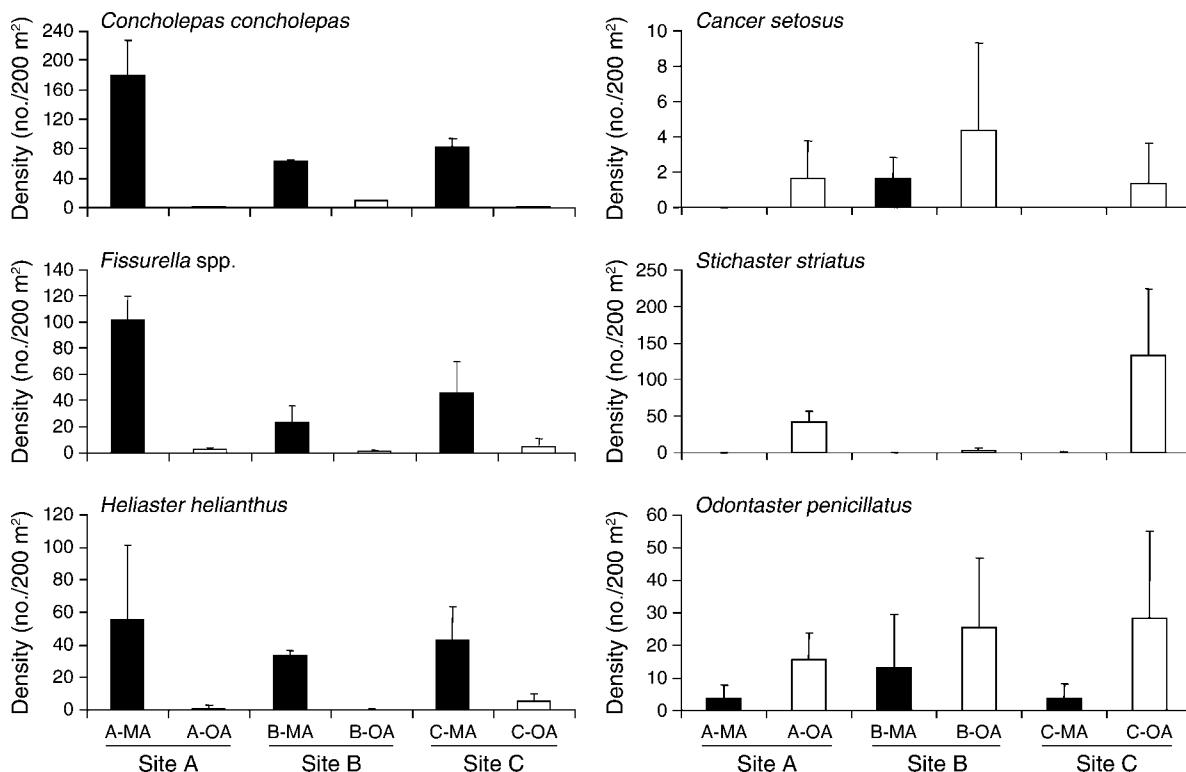


FIG. 4. Densities (mean + SD) of macro-invertebrates that contributed most to differences in biotic community composition inside vs. outside MEABRs. Solid columns represent MEABRs, and open columns represent areas outside MEABRs.

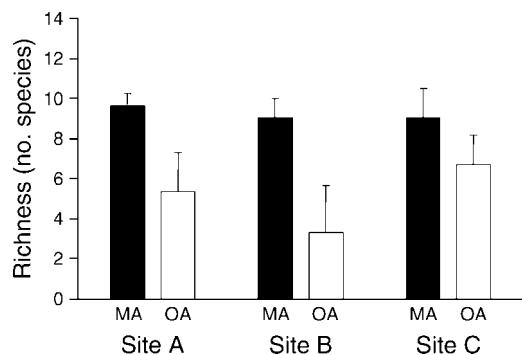


FIG. 5. Reef-fish species richness (mean number of species present + SD). Solid columns represent areas inside MEABRs, and open columns represent areas outside MEABRs. Richness includes: *Cheilodactylus variegatus*, *Graus nigra*, *Pingüipes chilensis*, *Aplodactylus punctatus*, *Scartichthys viridis*, *Girella laevisfrons*, *Chromis* spp., *Paralichthys adpersus*, *Labrisomus philippi*, *Sicyases sanguineus*, *Isacia conceptionis*, *Myliobatis chilensis*, *Schroederichthys chilensis*, *Bovichthys chilensis*, *Sebastes capensis*, *Eptaretus* sp., *Prolatilus jugularis*, *Raja* sp., and *Trachurus murphyi*.

additionally show greater richness of reef-fish species than open-access areas. However, the extent of MEABRs contribution to conservation in comparison with no-take MPAs remains uncertain. In spite of this, the existence of positive conservation effects of MEABRs on some components of the ecosystem is encouraging, especially for managers and policy makers facing joint societal and management dimensions of marine conservation, because it establishes the potential for MEABR to be considered a complement to no-take MPAs, providing an opportunity to scale-up marine conservation in Chile.

Benthic invertebrate community assemblages differ between MEABRs and open-access areas. As expected, the density of managed target invertebrate species is greater (up to 15 times) inside MEABRs, which is consistent with previous studies (Castilla et al. 1998, Subpesca 2002). Importantly, differences in community assemblages inside vs. outside MEABRs remained significant even when managed target species (*C. concholepas* and *Fissurella* spp.) were excluded from the multivariate analysis. This indicates that differences

are not exclusively a product of greater abundance of the comanaged resources. For example, the sea star *H. helianthus* was more abundant inside than outside MEABRs, whereas the sea stars *S. striatus* and *O. penicillatus* and the crab *C. setosus* appeared to be negatively affected, having lower densities inside MEABRs, suggesting that perhaps indirect effects of protection, through competitive or predatory interactions, may be taking place (Castilla 1999, Micheli et al. 2004).

Arguably the most important results of this study relate to the add-on conservation benefits of MEABR for species that are not directly connected to the comanagement policy. Specifically, reef-fish species, which are not part of any MEABR comanagement plan showed an increase in biodiversity (richness) and abundance inside vs. outside MEABRs. *G. nigra*, *P. chilensis*, and *C. variegatus* showed greater densities inside MEABRs and accounted for the largest differences in fish community assemblages. These species are top predators (Fuentes 1981, 1982, Vásquez et al. 1998, Angel and Ojeda 2001, Medina et al. 2004). For instance, *Pingüipes chilensis* feeds mainly on polychaetes, *Ophiactis kroyeri*, mollusks such as *Gari solida*, and *Cancer* spp. decapods (Medina et al. 2004). *Graus nigra* feeds mainly on echinoderms such as *Tetrapygyus niger* and *Stichaster striatus* (Fuentes 1981). Thus these reef-fish species may be playing important predatory roles inside MEABRs in the structure of benthic species assemblages.

Greater richness and abundance of reef-fish species inside MEABR would be related to the fact that in Chile they are constantly targeted by spear-gun fishing in open-access areas (SERNAPESCA 2005, Godoy 2007). This activity is not common inside MEABRs as fisher organizations restrict diving to stop illegal poaching of *Concholepas concholepas* and key-hole limpets. This restriction is due to the lack of trust between fishers, as spear-gun divers could poach on benthic resources. This establishes very strict de facto diver access regulations. Thus, protection associated with benthic species within MEABRs, under a TURFs regime appears to have add-on conservation effects over reef fish. The higher densities of top trophic level fish inside MEABRs are consistent with those reported by Micheli et al. (2004),

TABLE 3. Summary of ANOVA results for the most abundant reef-fish species abundances and overall richness.

Species and richness	Inside/outside, df = 1		Site, df = 2		Inside/outside × site, df = 2		Residual, df = 12
	MS	F	MS	F	MS	F	
<i>Cheilodactylus variegatus</i>	1.36	26.12*	0.148	2.84	0.052	1.75	0.029
<i>Graus nigra</i>	0.647	375.8***	0.034	19.53*	0.0017	0.18	0.009
<i>Pingüipes chilensis</i>	1.808	63.06***	0.039	1.38	0.028	0.43	0.067
<i>Aplodactylus punctatus</i>	0.955	36.63*	0.058	2.23	0.026	0.44	0.059
<i>Scartichthys viridis</i>	0.184	0.73	0.567	2.25	0.252	2.63	0.096
<i>Girella laevisfrons</i>	0.16	1.19	0.27	2.02	0.134	1.28	0.105
<i>Chromis</i> spp	0.516	1.06	0.15	0.31	0.488	2.71	0.179
Reef fish richness	76.1	18.01*	4.6	1.11	4.22	1.65	2.55

* $P < 0.05$; *** $P < 0.001$.

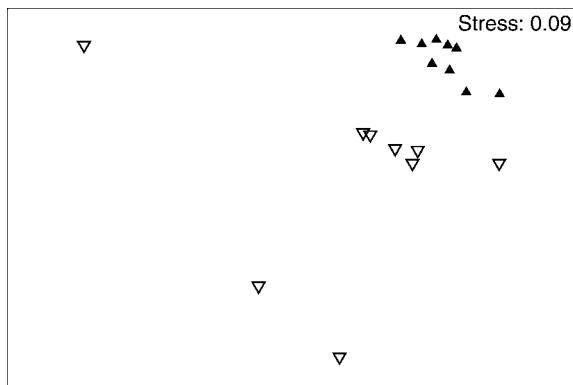


FIG. 6. MDS plot representing reef-fish community assemblages inside (solid triangles) and outside (open triangles) MEABRs.

who analyzed 20 different studies of fish assemblages from fished and reference conditions. The author indicates that reef-fish species responses to protection result in greater biomass/abundance of top trophic species in protected areas as compared to open-access ones. However, there is also the possibility that reef fishes, although known for a certain degree of “habitat fidelity” to subtidal kelp forests (Núñez and Vasquez 1987), could move actively inside MEABRs, as an active avoidance mechanism due to the less disturbed nature of MEABRs. This hypothesis needs to be tested.

Benthic invertebrate and reef-fish communities showed significant differences inside vs. outside MEABRs that are likely due to protection. However, sessile algae and macro-invertebrate understory coverage did not show differences inside and outside MEABRs. This might be related to the fact that trajectories of community-wide changes in marine reserves are not obvious (Sala et al. 1998, Micheli et al. 2004, Guidetti 2006). For instance, in Mediterranean

rocky reefs (Guidetti 2006) and coral reefs (Bellwood et al. 2004) and in Atlantic kelp forest ecosystems (Steneck et al. 2004) crossing thresholds in densities of consumers causes trophic cascades. In this study, the *L. trabeculata* forest ecosystem outside MEABRs and its understory might be still on an unrecognized trajectory to an alternate phase (i.e., barren ground, Bellwood et al. 2004), the ecological symptom being a reduced number of predatory invertebrate and fish species. MEABRs appear to be reducing fishing impact on populations of key predators and may therefore prevent related ecosystem-wide changes (Castilla 1999, Folke et al. 2005).

It is important to stress that this study did not undertake comparisons between MEABRs and no-take MPAs, thus the full extent of MEABR contribution to conservation cannot be assessed. For example Manriquez and Castilla (2001) evaluated the significance of no-take marine protected areas, MEABRs, and open-access areas as seeding grounds for *Concholepas concholepas* in the intertidal zone of central Chile between 1990 and 1993. They found that the open-access zone contribution, in terms of annual number of larvae within capsules measured in transects, was close to zero; MEABRs larvae contribution ranged between $\sim 4 \times 10^6$ and 9×10^6 and the no-take MPA contribution ranged from $\sim 11 \times 10^6$ to 290×10^6 larvae per band transect. Further, no-take MPAs are vital as a means of obtaining baseline data (Castilla 1999, Castilla et al. 2007a); thus MEABRs cannot replace the need for no-take MPAs, although they provide a good complement to achieve their objectives.

From a management perspective, MEABRs and TURFs in Chile have provided a way to engage small-scale fishers to participate in the surveillance and enforcement of limited access policies (Castilla and Defeo 2005, World Bank 2006, Castilla et al. 2007b).

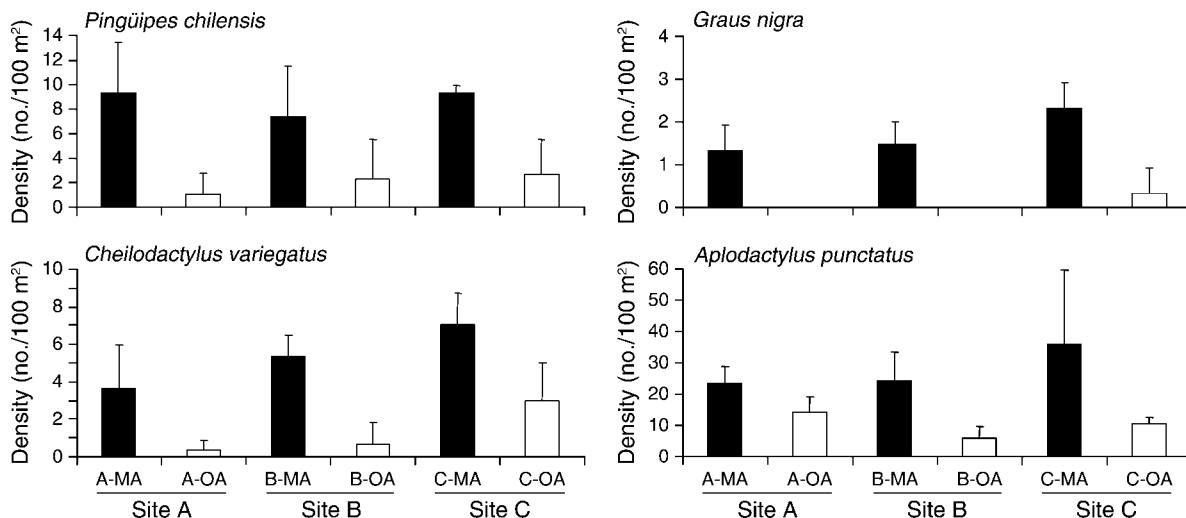


FIG. 7. Densities (mean + SD) of reef-fish species that contributed most to differences in community assemblages inside vs. outside MEABRs. Solid columns represent MEABR areas, and open columns represent open-access areas.

TABLE 4. Types of marine areas that have some level of protection within Chilean coastal waters and their relative contribution in number and area covered.

Protected area type	Area covered (km ²)	Percentage of area covered	No. areas decreed
Marine concessions with conservation purposes	~1.6	0.11	8
Terrestrial Natural Sanctuaries that include coastal areas	~194	14.18	11
No-take Marine Parks and Reserves†	~17	1.13	6
Multiple-use Marine Protected Area‡	~132	9.65	4
MEABRs	~1023	74.8	547

Note: A detailed description of the regulations governing each of these protection instruments can be found in Fernández and Castilla (2005). MEABRs, management and exploitation areas for benthic resources.

† The only Marine Park is within one of the multiple-use Marine Protected Areas.

‡ This number and area considers only areas that have been decreed in Chilean continental waters and therefore excludes areas in Easter Island.

This could become important in terms of generating positive environmental attitudes among fishers (Gelcich et al. 2005, World Bank 2006). Harvesting of benthic resources (mainly mollusks, crustaceans, and sea urchins) is done through diving with practically no collateral damage to other species or the habitat. This enables fishers to directly experience the wider conservation benefits of the MEABR policy on subtidal communities. In this way divers can appreciate the effects of protection while at the same time seeking to make a profit from production (Gelcich et al. 2007). This has an important educational potential, which could eventually be used to revert the existing trend in which small-scale and subsistence fishers perceive no-take marine MPAs as a threat (World Bank 2006).

Results from this study are encouraging; however some caution is necessary because our conclusions are narrowly based on *L. trabeculata* forests of central Chile. In this vein, it would be useful to study the effects of MEABRs on marine biodiversity and community assemblages in other types of subtidal environments along the country, such as those dominated by tunicates (*Pyura chilensis*, *P. preaputialis*), mussels (*Aulacomya atra*, *Mytilus chilensis*), and barnacles (*Austromegabalanus psittacus*). Additionally, the effect of TURFs on systems with different levels of grazing (e.g., by the sea urchin *Tetrapygus niger*) and in different seasons is an important issue to be addressed.

So far, the experience in Chile regarding the implementation of MEABRs provides hope that TURFs and bottom-up governance of marine resources can effectively complement no-take MPA networks. The presence of MEABRs, although probably providing fewer conservation outcomes, does allow marine conservation to scale up in size. Currently in the country there are only five no-take marine reserves, eight marine concessions with conservation purposes, four multiple use MPAs, and one marine park (Fernández and Castilla 2005; Table 4), covering a total area of ~150 km². In contrast there are 547 MEABRs, which cover an area of 1023 km² (SERNAPESCA 2005; Table 4). Thus, in the case of Chile, it becomes imperative to assess and recognize the value of these ancillary measures in terms of effective marine conservation.

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