Marine Conservation in Chile: Historical Perspective, Lessons, and Challenges

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Abstract: *Chile is one of the world's leading countries in landings (catch) of marine resources. The pioneer studies of human impacts on coastal marine communities provided the scientific basis on which to establish novel resource management strategies for exploited wild populations but were not used to develop a comprehensive marine conservation plan that would also include no-take areas. We reviewed the development of marine conservation actions since approximately 1970 to date, focusing on the (1) complex legal framework for establishment of marine protected areas, (2) scientific grounds that provided the impetus to establish areas where exploitation is regulated, (3) private efforts that were critical to creating the first marine protected areas, and (4) lessons and constraints derived from this process as well as the challenges ahead. The existing legal tools for the protection of the ocean include natural sanctuaries, marine reserves, marine parks, national monuments, and management and exploitation areas for benthic resources. These instruments may be applied in coastal marine protected areas. It is remarkable that most of the existing marine protected areas in Chile are sponsored and administered by private organizations. We think the sequence in which the development of the different conservation instruments occurred, with a high priority reserved for initiatives tending to promote exploitation of the ocean (aquaculture and fisheries), poses challenges and constraints for establishing a network of marine protected areas that combine such apparently diametrically opposing goals as exploitation and preservation of marine species. More recently, the value of preserving biodiversity became evident with the creation of the first marine parks. We encourage more scientific information on patterns of biodiversity, biological processes, and assessment of human impact to be incorporated in the process to reach the goal of preserving 10% of the representative marine habitats along Chile's coast.*

Key Words: management areas, marine parks, marine protected areas

Conservación Marina en Chile: Perspectiva Histórica, Lecciones y Desafíos

Resumen: *Chile es uno de los países líderes en la captura de recursos marinos. Los estudios pioneros de impactos humano sobre las comunidades marinas costeras proporcionaron la base científica para el establecimiento de estrategias novedosas de manejo de recursos para poblaciones silvestre explotadas pero no fueron utilizados para desarrollar un plan integral de conservación que también incluya a áreas de no captura. Revisamos el desarrollo de acciones de conservación marina desde 1970 aproximadamente hasta la fecha, concentrándonos en (1) el complejo marco legal para el establecimiento de áreas marinas protegidas; (2) bases científicas que proporcionaron los impulsos para el establecimiento de áreas donde la explotación es regulada; (3) esfuerzos privados que fueron críticos para la creación de las primeras áreas protegidas marinas; y (4) las lecciones y restricciones derivadas de este proceso, así como los desafíos a futuro. Las herramientas legales existentes para la protección del océano incluyen santuarios naturales, reservas marinas, parques marinos, monumentos nacionales y áreas de manejo y explotación de recursos bénticos. Estos instrumentos pueden ser aplicados en áreas protegidas marinas costeras. Es notable que la mayoría de las áreas protegidas marinas existentes en Chile estén financiadas y administradas por organizaciones privadas. Pensamos que la*

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secuencia en que ocurrió el desarrollo de los diferentes instrumentos de conservación, con una alta prioridad reservada para iniciativas tendientes a promover la explotación del océano (acuacultura y pesquerías), representa desafíos y restricciones para el establecimiento de una red de áreas marinas protegidas que combinen metas aparentemente diametralmente opuestas como la explotación y preservación de especies marinas. Más recientemente, el valor de la preservación de la biodiversidad se hizo evidente con la creación del primer parque marino. Hacemos un exhorto para que más información científica sobre patrones de biodiversidad, procesos biológicos y de evaluación del impacto humano sean incorporados al proceso para alcanzar la meta de preservar 10% de los hábitats marinos representativos a lo largo de la costa de Chile.

Palabras Clave: áreas de manejo, áreas marinas protegidas, parques marinos

Introduction

Chile is one of the world's leading countries in landings (catch) of marine resources (FAO 1998). The export of fish, fish products, invertebrates, and algae from both exploited wild populations and aquaculture is one of the nation's most important sources of income. The bulk of the landings consist of pelagic resources, although nearshore invertebrates and algae represent a large share and have disproportionately large economic and social impacts (e.g., Bustamante & Castilla 1987; Castilla 1997; Leiva & Castilla 2002). Currently, aquaculture of exotic salmon species represents a large fraction of the nation's export. Most industrial and small-scale fisheries are regulated by a series of management tools implemented in the last two decades, for example, Individual Transferable Quotas for industrial fisheries, Territorial Users Fishery Rights (TUFRs), and Community Fishery Quotas for the small-scale fisheries (Castilla & Defeo 2001; Castilla et al. 2005*a*). The principle behind the assignation of user's rights for the exploitation of benthic resources (TUFRs) or aquaculture is based on a plan that prioritizes these productive activities among the different regions of Chile.

Along the coast of Chile, particularly in the south, a large number of areas are assigned to the aquaculture industry, which focuses heavily on exotic species (e.g., *Onchorhynchus* spp., *Salmo salar*, *Crassostrea gigas*, *Haliotis rufencens*). Besides the increasing fishing pressure and the outburst of aquaculture activities, other human activities occurring far inland and on the coast, such as habitat alteration, mining, pollution (Castilla 1996*a*; Correa et al. 1996; Castilla & Correa 1997), and invasion of exotic species (Castilla et al. 2005*b*) have only recently received attention. It is also significant that the majority of the population of Chile lives in coastal zones, with major cities located on the coast. Seaport activities, formerly concentrated in only a few harbors, are now widespread among several major ports. These varied activities can have large, diverse, and yet unquantified effects on marine ecosystems, affecting regulation of marine communities and altering natural habitats.

Chile has been a pioneer in studies of human impacts on coastal marine communities (e.g., Moreno et al. 1984; Castilla & Durán 1985; Castilla & Bustamante 1989). The advances made are based on experimental ecological studies, which reveal the tremendous impact of humans on inshore coastal ecosystems (Castilla 2000). Two small marine reserves in central and southern Chile were key in demonstrating and quantifying the nature and intensity of the effects of fishing on nearshore communities (e.g., Moreno et al. 1984; Castilla & Durán 1985; Castilla 1999). This promising scientific start in the early 1980s was an impetus to implementation of novel resource management strategies for exploited wild populations. Although this represents an important step toward the conservation of the ocean, these strategies should have been accompanied by the development of a comprehensive marine conservation plan that also included no-take areas. The intricate administrative system, with several overlapping governmental agencies sharing responsibility, may have delayed the development of such a plan.

Achieving multiple marine conservation goals in developing countries might depart from strategies used in the developed world and may require (1) a different sequence of events, (2) the establishment of different time frames, and (3) the use of a different set of solutions than in developed countries. We think, however, that the development of marine conservation plans and the scientific basis for sustainability have not kept pace with the rates at which the ocean is being affected by exploitation. Nevertheless, in the past three decades some progress has been made, among which we highlight several private and independent efforts, perhaps not well harmonized, to preserve coastal zones where flagship marine species such as penguins (*Spheniscus humboldti* and *S. magellanicus*), sea otters (*Lontra felina*), sea lions (*Otaria bryona*), and whales (*Megaptera novaeangliae*) occur. The newly created coastal marine protected areas in southern (2003) and northern Chile (2004) open a promising new chapter.

We reviewed the development of marine conservation actions since approximately 1970 to date, focusing on the (1) legal framework for the establishment of marine

protected areas, (2) scientific grounds that provided the impetus to establish areas where exploitation is regulated, (3) private efforts that were critical to creating the first marine protected areas, and (4) lessons and constraints derived from this process and the challenges ahead. Here we consider conservation an applied discipline that integrates principles of natural and social sciences with the objective of achieving long-term persistence and sustainable use of ecosystems. Furthermore, we recognize that humans influence the success of conservation projects and need to be factored into the "conservation formula" (Vogt et al. 2001).

Marine Conservation Problems and Instruments

Several types of human impacts clearly affecting nearshore ecosystems can be identified along the coast of Chile, although the intensity, extent, and persistence of each source vary geographically. The predominance of specific activities in different regions is clear. Mining occurs mostly in northern Chile; industry, forestry, and agriculture are the main productive activities in central and southern Chile, and aquaculture (mainly salmon) peaks in the south. The most important human impacts along the Chilean coast, in terms of geographical extent and persistence, are sewage discharges and the exploitation of invertebrates and algae in rocky shores (Fernández et al. 2000). Central Chile has the largest human population and consequently the largest impact (Fig. 1a). Areas with smaller human population sizes on the coast tend to have fewer landings of both benthic invertebrates and fish, although there is not a direct relationship between coastal human population size and landings. Although the effect of sewage discharges on the structure and functioning of coastal communities is not well known, it is clear that fishing has a strong effect on coastal ecosystems (Moreno et al. 1984; Castilla 2000). On intertidal and shallow subtidal rocky bottoms, the most important human impact is the collection of invertebrates and macroalgae by small-scale fishers and subsistence fishers. Collection of invertebrates and macroalgae for human consumption can be traced back to hunter-gatherers (9000 years ago) in northern and central Chile (Jerardino et al. 1992). The introduction of diving technology and access to new foreign markets over the past few decades, however, have produced an exponential increase in exploitation rates that has led to symptoms of overexploitation of the main target species. The same trend is observed in pelagic fisheries. A chronic problem in the regulation of invertebrate fisheries in Chile is the lack of adequate enforcement of fisheries legislation, partly because of the very long coastline and sparseness of landing sites but also because of the lack of efficient control of the small-scale fisheries.

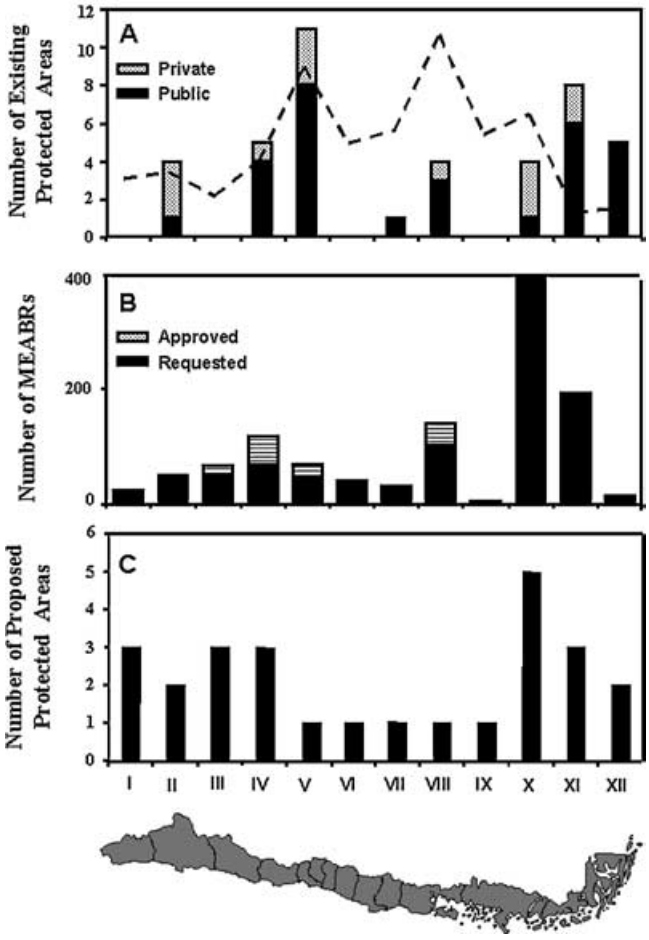

Figure 1. Number of (a) public and private marine protected areas in Chile per administrative region (12 regions with coastal access) from north (I) to south (XII), including natural sanctuaries and national parks with coastal areas and private marine concessions (broken line is distribution of human population); (b) management and exploitation areas for benthic resources (MEABRs) requested (n = *1031) and in operation for at least 1 year* (n = *185); and (c) proposed coastal marine protected areas, according to the new plan of priority areas for marine conservation.*

Another problem is that, despite new fisheries legislation (Ley de Pesca y Acuicultura 1989), there has not been a concomitant development in the national system of marine protected areas that could serve as a buffer for exploited zones (Botsford et al. 1997; Castilla 2000).

The Chilean administration counts on a series of legal instruments that can be used to develop a network of marine protected areas comprising from fully protected zones to management areas (Table 1), offering interesting challenges in structuring a marine conservation network. The existing legal tools include natural sanctuaries,

Table 1. Existing instruments for the protection of coastal areas and the ocean in Chile and the governmental agencies involved.

Protection instrument[a]	*Administrative office*	*Conservation goal*	*Number of areas (% representation)*[b]	*Advances in marine conservation issues*	*Observations*
Natural sanctuary[c] (1970)	Ministry of Education (Board of National Monuments)	preserve historical, archeological, paleontological, or natural sites, allowing educational and research activities	11 (5.2) 11 (1.04)	public awareness; potential for extending the protection to the ocean	current sanctuaries do not always have approval of Ministry of Defense and Fisheries Administration
National reserve[c] (1984)	Ministry of Agriculture	preserve natural ecosystems, allowing educational and research activities	0 (0)		some national reserves include shore but only up to 80 m of the high tide level
National park[c] (1984)	Ministry of Agriculture	preserve natural ecosystems, allowing educational and research activities	0 (0)		some national parks include shore but only up to 80 m of the high tide level
Natural monuments[c] (1984)	Ministry of Agriculture	preserve natural ecosystems (marine and terrestrial), allowing educational and research activities	0 (0)		
Marine reserve (1989)	Ministry of Economy (Fisheries Administration)	restrict fishing reaching a sustainable exploitation of resources, preserve reproductive or genetic stocks	3 (1.41) 3 (0.28)	protection of reproductive stock of exploited and valuable species	restricted to coastal areas
Marine park (1989)	Ministry of Economy (Fisheries Administration)	preserve marine biodiversity, allowing research	0 (0)	protection of biodiversity; education	coastal waters and open ocean; requires approval of Ministry of Defense and National Committee for the Use of Coastal Areas
Coastal marine protected areas (1995)	Ministry of Defense (Subsecretary of the Navy)	potentially preserve biodiversity, regulate fishing, and promote education	7 (2.40) 8 (0.75)	potential for protection; public awareness; education	coastal waters and open ocean; requires approval of Fisheries Administration and National Committee for the Use of Coastal Areas
Management and exploitation areas for benthic resources (1989)	Ministry of Economy (Fisheries Administration)	manage fishing of benthic resources	185 (87.3) 1031 (97.2)	control and comanagement of benthic resources	restricted to coastal areas; requires approval of Ministry of Defense and National Committee for the Use of Coastal Areas
Marine concessions (1989)	Ministry of Defense (Subsecretary of the Navy)	different purposes, including conservation	8 (3.3) 8 (0.75)	potential for conservation, research, and education; public awareness; education	restricted to coastal areas; requires approval of Fisheries Administration and National Committee for the Use of Coastal Areas

[a] *Year each instrument was established is in parentheses.*
[b] *The first line indicates the existing areas, and the second adds the existing and planned areas.*
[c] *Sea or coastal area is included.*

marine reserves, marine parks, national monuments, and management and exploitation areas for benthic resources (Table 1). From those, marine parks, marine reserves, and management and exploitation areas are established exclusively for the protection of the ocean (Morales & Ponce 1997). Some existing instruments such as national parks, national reserves, natural monuments, and natural sanctuaries are for land protection but have the potential to be expanded to marine ecosystems if other agencies become involved (Table 1). Finally, marine concessions (Table 1) open opportunities for conservation plans sponsored by private organizations or public agencies (Table 1). Some of these legal tools have already been used in an uncoordinated way (see below) and could be inserted in a future network of marine protected areas. More recently, coastal marine protected areas have been introduced (Table 1) and can be created for multiple uses that may include activities such as fishing, ecotourism, and preservation of marine ecosystems.

The administrative system behind the establishment of marine protected areas in Chile is complex, involving agencies that have the power to establish a given instrument and to administer the use of the ocean and coast. Formally, the Ministry of Defense (Subsecretary of the Navy), the Ministry of Economy (Fisheries Administration), the Ministry of Agriculture, and the Ministry of Education (Board of National Monuments) are the primary agencies that use legal instruments to protect the marine environment directly or indirectly (Table 1). Some of these agencies play a critical role, such as the Subsecretary of the Navy, because the sea and the seafloor administratively fall under the Navy's jurisdiction. When a person, organization, or institution, private or public, wishes to occupy a portion of the ocean for any purpose (private pier, aquaculture, no-take area), prior approval of the Subsecretary of the Navy is needed. Nevertheless, other agencies that regulate the use of the ocean and its exploitation become involved in the process because consultation among agencies is required (e.g., Fisheries Administration, National Committee for the Use of Coastal Areas). For this reason several administrative offices need to approve the establishment of a given instrument, and in some cases two of these instruments have to be approved in order to establish a marine protected area. The National Environmental Agency (Comisión Nacional de Medio Ambiente [CONAMA]) has recently been involved in the establishment of coastal marine protected areas, mostly through catalyzing conservation projects. The implementation and enforcement of marine protected areas are equally complex because they can be carried out by private organizations or public agencies. The lack of funding for public agencies responsible for the control of marine protected areas has been a major point of discussion lately and needs to be resolved before major steps to establish fully protected marine areas are taken.

Existing and Potential Marine Protected Areas

Established Natural Sanctuaries

Eleven natural sanctuaries of the 27 existing in Chile were created to protect marine species or coastal habitats (Table 2; Fig. 1a). Most of these sanctuaries are located in the most populated regions of Chile (central Chile) and are sponsored and administered by private organizations (Table 2). This instrument is among the oldest in Chile for the protection of marine species or ecosystems (Table 2). Existing sanctuaries are an important legacy because they promoted early protection of marine areas and generated public awareness regarding the urgent need to protect marine ecosystems. Two aspects, however, need to be considered. First, these areas were established for particular purposes (i.e., presence of flagship species) without consideration of the overall goal of conservation of the marine biodiversity of Chile. Second, actual protection is uncertain because the sanctuaries are not associated with an instrument to protect the ocean (e.g., marine concession) and because enforcement is carried out by different authorities, which may not always have the expertise and persistence to implement or control protected areas.

Marine Concessions and Consolidation of University Sites

Marine concessions can be assigned to private institutions (i.e., universities, industrial companies, fishery associations), usually for renewable periods of 5 years, for uses such as research, conservation, and protection of marine resources and coastal systems; exclusive use for coastal and underwater installations; genetic reserves of exploited species; and management and exploitation areas (see below; Table 1). The different classes of marine concessions are administered through a set of conditions and technical requisites.

Marine concessions for research and conservation purposes have existed in Chile since 1941 (Table 3), and most of them were requested and administered by Chilean universities. Two of them were critical for the understanding of human impact on coastal communities in Chile: Mehuín (1978, approximately 40°S) and Las Cruces (1982, approximately 33°S; Table 3). In both cases the specific scientific goals guiding their establishment were assessments of human impact (rocky intertidal food gathers, skin divers, and small-scale professional divers) on intertidal and nearshore benthic populations and communities. Both areas clearly showed dramatic effects of humans on marine communities and the speed at which local, previously exploited populations can recover after the exclusion of humans (e.g., Moreno et al. 1984; Castilla & Durán 1985). These two concessions are remarkable because they were among the first to be established in

Table 2. Natural sanctuaries in Chile that include coastal areas (intertidal, subtidal, or both).

Name	*Location*	*Year established*	*Area (km^2)*	*Conservation goals*	*Administrative office*
Laguna Conchali	IV Región (Los Vilos)	2000	0.509	saltmarsh and dunes; high diversity of migratory birds	Sociedad Minera Los Pelambres
Isla de Salas y Gómez	V Región	1976	2.5	high diversity of subtropical, oceanic species of the Southeastern Pacific, especially fish (tuna, sword fish, sharks); high diversity of marine birds; no permanent human settlement	
Rapa Nui	V Región (several small islands around Easter Island, inca: Motu Nui, Motu Iti, Motu Kao Kao, Motu Tautara y Motu Marotiri)	1976	0.056	high diversity of benthic algae (144 species; 14 of them endemic); high diversity of subtropical fish species (tuna, sword fish, sharks); islands used by several species of marine birds	CONAF,* through the Parque Nacional Rapa Nui
Islote Pajaro Niños	V Región (Algarrobo)	1978	~0.035	20 bird species (including migratory birds), two penguin species (*Spheniscus humboldti* and *S. magellanicus*)	Cofradía del Mar (marina) through a marine concession and CONAF* for the terrestrial sector
Isla de Cachagua	V Región (Zapallar)	1979	NA	high diversity of macroalgae and marine invertebrates; several bird species, including migratory birds on island; some species very abundant (e.g., *Calidris alba*, *Pelecanus thagus*); two vulnerable species (marine mammal *Lontra felina* and the penguin *S. humboldti*) highly abundant on island (10% of the worldwide population in this protected area)	CONAF*
Islote Peña Blanca	V Región (Algarrobo)	1982	NA	marine macroalgae, invertebrates, birds	Algarrobo City Hall
Oceanic Rocks	V Región (Viña del Mar)	1990	0.008	high abundance of marine birds	Concón City Hall
Campo Dunar de la Punta de Concón	V Región (Concón)	1993	NA	marine birds (including the Humboldt Penguin and migratory birds) and mammals	
Península de Hualpén	VIII Región (Lenga River, Laguna Verde, Caleta Lenga, and San Vicente Bay)	1976	12.9	macroalgae, birds (terrestrial and aquatic)	
Islote y Lobería Iglesia de Piedra	VIII Región (Cobquecura)	1992	2.5 including the marine corridor used by *Otaria byronia*	large colony of *Otaria byronia* (1800 individuals); high abundance of fish and invertebrates (including, octopus, an important prey item of *O. byronia*)	Cobquecura City Hall
Estero de Quitralco	XI Region (Aisén)	1996	176	diversity of marine species characteristic of fiords of southern Chile (marine invertebrates, birds, mammals); several threatened bird species	

*Corporación Nacional Forestal (National Forest Service).

Table 3. Marine concessions assigned to Chilean universities or private companies.

Marine concession	*Organization*	*Year*	*Area (km^2)*	*Purpose*
Montemar	University of Valparaíso	1941	0.013	research
Mehuín*	Universidad Austral	1978	—	research
Las Cruces	Pontificia Universidad Católica de Chile	1982	0.048	research and preservation of marine biodiversity
Punta Coloso	Minera Escondida Limitada	1990	0.918	research
Lenga	Universidad Católica de la Santisima Concepción	1993	0.08	research
Antofagasta	Universidad de Antofagasta	1993	0.17	research
Herradura	Universidad Católica del Norte	1997	0.43	research
Quintay	Universidad Andrés Bello	1997	0.002	research

**No longer a marine concession.*

the country, they persisted for several years without human impact, and regular monitoring programs were carried out before and immediately after closure. The marine concession of Mehuín lasted for approximately 21 years, ending in 1999 after incursions of local fishers, who depleted the protected resources. The concession of Las Cruces still exists and was recently declared a coastal marine protected area of Chile. Since 1990 other Chilean universities have established marine concessions for research purposes, although in most cases actual protection and scientific monitoring schemes have not been implemented (Table 3). We think marine concessions in Chile are interesting tools because of their contribution to marine conservation and their enormous potential for education. Currently marine concessions account for an important fraction of the existing fully or partially protected marine areas in Chile (Fig. 1a).

Management and Exploitation Areas for Benthic Resources

The goal of management and exploitation areas is the small-scale, rational exploitation of benthic resources. The management and exploitation areas are perhaps the most innovative fishery management and conservation tool implemented in Chile. The basic concept was inspired by the ideas of co-management and TUFRs (Castilla & Schmiede 1979; Castilla 1994; Bernal et al. 1999) and has been applied to the management of small-scale benthic resources (Castilla & Fernández 1998; Castilla et al. 1998; Castilla & Defeo 2001). The institutionalization of this tool is mainly based on the development of the pioneer experimental work at the university marine concessions of Las Cruces (Castilla 1994) and Mehuín (Moreno et al. 1984). In those experiments, significant increases in the abundance of several species of shellfish and macroalgae (i.e., loco [*Concholepas concholepas*], key-hole limpets [*Fissurella* spp.], sea urchin [*Loxechinus albus*], kelp [*Durvillaea antarctica*]) occurred after only 2–4 years of banning extractive activities. The application of this knowledge to fisheries gave rise to the technique that was baptized in Chile as "natural benthic resource re-stocking via rotational exploited areas" and applied in fisheries for the first time in central Chile.

Several similar initiatives carried out in the middle of a national loco overexploitation crisis, by far the most valuable benthic resource for small-scale fisheries in Chile, helped convince the Fisheries Administration to incorporate the management and exploitation areas in the Fishery and Aquaculture Law. The management and exploitation areas started to be implemented fully in Chile around 1995–1997 and are being used for more than 20 different benthic species (Castilla et al. 1998). This policy has gained support from the fisheries organizations and the Fisheries Administration and is now well established. In 2004 there were 185 management and exploitation areas in full operation along the Chilean coast and more than 1000 applications for new management and exploitation areas have been presented to the Fisheries Administration (Table 1, Fig. 1b). Hence, formalization of nearshore property rights or territorial user rights for fisheries (benthic resources), self-organized fisher communities, partnerships with the government, and co-management have greatly furthered progress in Chile. In addition, the empowerment of fisher communities represents a change in the attitudes of fishers not only with respect to fishing but more important with regard to the conservation and future sustainability of resources. Fishers show an understanding of their role in and the consequences of marine conservation, which has been generated through co-management experiences.

Marine Reserves, Marine Coastal Protected Areas, and Marine Parks

Three marine reserves have been established as genetic reserves of exploited species. In northern Chile a genetic reserve was established with the main goal of protecting the last wild population of the overexploited scallop *Argopecten purpuratus*, which is now cultured in that region (La Rinconada, Bay of Antofagasta). The other two marine reserves are located in southern Chile (Chiloé Island) and were created to protect the genetic structure

of wild populations of the mussels *Choromytilus chorus* and *Mytilus edulis* and the oyster *Ostrea chilensis*. These reserves are administered by the National Fishery Service (enforcement department of the Fisheries Administration). The effectiveness of these genetic reserves is still unclear.

The three existing protected areas in Easter Island were established as coastal marine protected areas, sponsored by the Subsecretary of the Navy. The goals of these areas are to protect the biodiversity associated with coral reefs and to help in the recovery of exploited populations (Table 4). These marine protected areas are small but are located in an area of high diversity of coral reef species. During 2001 another marine protected area was established in the Cumao Fjord, southern Chile, on the request of a private organization (Fundación Huinay) that is in charge of the administration of the area. The main goal is the protection of the fragile fjord ecosystems in southern Chile. In 2003 a coastal marine protected areas was created through the cooperation of CONAMA, the Fisheries Administration, and the Subsecretary of the Navy in a remote island in southern Chile, Isla Carlos III (Table 4). The main reason for establishing this marine protected area was the high abundance of marine birds (e.g., *Spheniscus magellanicus*, *Phalacrocorax* spp.) and mammals (e.g., whales, sea lions). In 2004 the coastal marine protected area of Caldera was established with the goal of protecting marine birds and mammals (Table 4). Two more marine protected areas were scheduled for implementation in 2005, one in central Chile (Las Cruces, already established although it maintains the status of marine concession) and one in central-southern Chile (Bahía Mansa; Table 4). In Las Cruces, the conservation goal is the protection of marine biodiversity characteristic of central Chile, whereas the motivation to establish a marine protected area in Bahía Mansa is the high abundance of marine birds and mammals and presence of abundant populations of loco, mussels, and macroalgae. No control or enforcement is yet operating in any of the coastal marine protected areas administered by public agencies.

As of yet, there is only one marine park (Table 1), the most powerful instrument available for the preservation of marine biodiversity. The marine park Francisco Coloane is located at the core of the marine protected area of Isla Carlos III. Multiple-use (fishing, tourism, preservation of biodiversity) zoning of the remaining existing and planned coastal marine protected area has not yet occurred. Las Cruces is a no-take zone.

Lessons, Constraints, and Challenges

Although the current arrangement of existing marine protected areas in Chile is promising, the system has serious weaknesses. We think that the current status of marine conservation in Chile is the result of a combination of (1) a low priority assigned by the government to marine preservation in the past 30 years; (2) a high priority reserved for initiatives tending to promote exploitation of the ocean (aquaculture and fisheries); (3) a complex administrative system that has hindered the execution of some of the existing instruments; (4) a lack of planning at the national level to ensure an adequate balance among fishing, aquaculture, other human activities, and preservation of marine ecosystems; and (5) private initiatives (universities, industry) taking advantage of the existing legal framework. Although we value the advances made in Chile, we think the sequence at which the development of the different instruments occurred and the explosive growth of aquaculture pose challenges and constraints for establishing a network of marine protected areas that combine such apparently diametrically opposing goals as the exploitation and preservation of marine species.

The primary constraint to establishing areas for preservation of marine biodiversity in central Chile is the growing use of coastal areas for different human activities. For instance, in some regions of central Chile, management and exploitation areas have virtually blocked conservation initiatives because of the strong competition

Table 4. Existing and planned coastal marine protected areas of Chile.

Area	*Location*	*Year established*	*Area (km^2) or length (km) of coastline*	*Conservation goals*
Eastern Island (Coral Nui Nui)	27°08′S–109°25′W	1999		biodiversity associated with coral reefs
Eastern Island (Motu Tautara)	27°06′S–109°25′W	1999		biodiversity associated with coral reefs
Eastern Island (Hanga Oteo)	27°04′S–109°19′W	1999	1–3 km	biodiversity associated with coral reefs
Fiordo Comau	42°17′S–72°27′W	2003	~20 km	biodiversity of the fjord area
Isla Carlos III	53°35′S–72°20′W	2003	70 km^2	marine birds and mammals (whale, penguins, cormorants, sea lions)
Caldera	27°06′S–70°52′W	2004	30 km	marine birds and mammals
Las Cruces	33°30′S–71°38′W	2005	0.15 km^2	biodiversity of the area
Bahia Mansa	40°40′S–73°35′W	2005 (expected)	32 km	loco, mussels, macroalgae, dolphins, and marine birds)

for space between management and preservation areas. Moreover, management and exploitation areas represent 97% of all the existing instruments described above (Table 1). If managed properly, however, this problem could become an interesting challenge in which conservation and management work hand in hand in the same system of protected areas through the moderated exploitation of benthic resources within the management and exploitation areas. Perhaps the most interesting outcome of this initial constraint, marked by the strong priority in developing the fishing industry, is the lesson assimilated by fishers. They now value the importance of maintaining closed areas, which could serve as "seeding grounds" or larval production sites (Manríquez & Castilla 2001; Gell & Roberts 2002). Some fisher associations see the establishment of marine protected areas near their management and exploitation areas as positive for them. Under this scenario, however, pelagic species are not as protected as benthic species because pelagic resources can be fished in management and exploitation areas. It should also be considered that not all fisher associations properly operate their management and exploitation areas.

Similar constraints are imposed by the hundreds of aquaculture centers concentrated in southern Chile (south of 40°S). Although we did not address the conflict between conservation plans and the development of aquaculture in southern Chile, we see a potential for competition for space between marine concessions for aquaculture and marine preserves. More important, there are other serious constraints for conservation plans associated with the aquaculture industry. In the fjords in the southern extreme of Chile, vast zones have been assigned to salmon aquaculture, an activity that is not compatible with conservation plans because (1) salmon is an exotic species and escapees from the pens are in rivers and coastal waters of southern Chile (Soto et al. 2001; Castilla et al. 2005*b*); (2) organic matter is accumulating in the fjords and its effect only recently has begun to be evaluated (Soto & Norambuena 2004); and (3) the chemical compounds used to prevent infections and parasites may affect the entire ecosystem. Other regions may also be affected in the near future by the growing aquaculture industry of exotic species (e.g., abalone, turbot, bivalves). The problem is particularly relevant because the fauna from southern Chile differs from that of central and northern Chile and because an important fraction of the southern species exhibit small distributional ranges, resulting in a greater threat for extinction (Fernández et al. 2000).

Despite the nontraditional and uncoordinated approach that has been followed in Chile to establish marine protected areas, several protected areas exist in the most highly populated regions. Although in numbers they represent $< 4\%$ of the total existing instruments (Table 1), the marine concessions assigned to Chilean universities and natural sanctuaries can play a critical role. From this already small total number of protected areas, only a few are actually protected from exploitation (e.g., Las Cruces, Punta Coloso, Cumao). In some cases, the high cost of enforcement may have prevented the protection of marine concessions administered by Chilean universities. We highlight the tremendous relevance of these areas for future conservation, however, particularly in areas of increasing human activities. The educational asset, not yet explored, could be added to the goals of biodiversity preservation in private marine concessions. We think a system of incentives needs to be established to make private marine concessions more effective as protection tools and to promote education.

It is also important to consider the potential of combining conservation efforts of marine and terrestrial ecosystems. Besides recognizing the relevance of the connection between both ecosystems, extending the protection from land to the ocean is desirable because coastal areas surrounding terrestrial national parks and reserves have the advantage of already being partially protected for several years simply because the restrictions on land constrain access to the marine areas. Although we are convinced that the design of a network of marine protected areas cannot be accommodated in terrestrial conservation plans (Castilla 1996*b*; Fernández et al. 2000), existing protected areas on land that include coastal areas may represent an advantage in zones where conflicts of interest for establishing new marine protected areas may occur. We estimate that 26 protected areas on land (national parks, reserves, and monuments) include coastal areas. Several of these protected areas are located in southern Chile, a region that needs urgent attention.

In addition to the existing and planned protected areas, 26 more sites have been recently identified and proposed as priority areas for marine conservation (Fig. 1c). They were selected by two processes catalyzed by the National Environmental Agency. Both processes requested the opinions of Chilean scientists, which were used to establish a list of priority sites for marine conservation. The process also involved consultation with private and public organizations. Proposed marine protected areas are underrepresented in central Chile (V to IX administrative regions), where we have already identified several constraints for the development of conservation plans.

Although much of the original research was used by the public administration to establish alternative management schemes, the existing knowledge of patterns of diversity, primary oceanographic processes, and unique features of marine ecosystems was not incorporated in the list of priority sites. This contrasts with conservation programs carried out in other countries (i.e., New Zealand, South Africa). We hope more scientific information, using formal approaches, is incorporated in the future to reach the goal of preserving 10% of the representative habitats. Currently only the two main biogeographical regions identified along the coast of Chile (Fernández et

al. 2000; Camus 2001) seem to be represented by the 26 priority sites identified (Fig. 1c). Conventional biogeographical analyses have identified two major biogeographic regions for macroinvertebrates and fishes: (1) the Perú-Chile Province (from Paita in Perú to Chiloé in Chile, at 40–45°S) and (2) the Magellanic Province (40–45°S to 54–55°S; e.g., Viviani 1979; Brattström & Johanssen 1983; Lancellotti & Vásquez 1999). A major oceanographic feature (the West Wind Drift) coincides with the changes in the species composition and with changes in coastal physiography.

The main biogeographic regions identified for macroalgae differ from those determined for macroinvertebrates and fishes (break at approximately 54–55°S; Santelices 1980). Several studies identify a biogeographic break in central Chile, that consistently affects species from a diverse spectrum of taxa (macroinvertebrates, Lancellotti & Vásquez 1999; macroalgae, Santelices 1980; coastal reptiles, marine birds, M. Tognelli et al., unpublished data) and seems to be determined by coastal oceanographic processes (upwelling regimes) producing effects on larval recruitment, biological interactions, and community structure (e.g., Camus 1998; Brazeiro 1999; Navarrete et al. 2002). Relevant oceanographic processes such as upwelling centers with different regimes (persistence, intensity) need to be represented in the development of a network of marine protected areas. Unique ecosystems (fjords) and regions (areas limited by oxygen; Ulloa & De Pol 2004) also need to be considered.

To take advantage of the existing and planned, official and private, marine protected areas, some problems still need to be resolved to ensure that biodiversity is actually preserved. Most private protected areas, natural sanctuaries, and marine parks (existing and planned) were created in response to high abundance or diversity of marine birds and mammals, which represent < 5% of the total number of marine species reported for Chile (including macroalgae, fish, and macroinvertebrates). Thus it is unclear whether the marine biodiversity of Chile and critical processes can be preserved through the existing and planned marine protected areas. A large amount of information is readily available and should be integrated in an analysis to optimize the conservation plans for Chile. Effort also needs to be made to evaluate the risks of human impact in the existing areas (e.g., oil spills, ballast water in port areas) and to create a plan for alternative zones in areas of high risk. Finally, an evaluation of the multiple instruments and agencies involved in conservation planning and enforcement in Chile may be useful. It would be interesting to compare the advances made in establishing marine protected areas in countries with a single government agency responsible for conservation of natural ecosystems and control and enforcement of marine protected areas (e.g., New Zealand, South Africa) against Chile's system. Similar comparisons could be made regarding the diversity of legal instruments in Chile, with the three or four available in New Zealand and South Africa.

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