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Review

Challenges for coastal zoning and sustainable development in the northern Patagonian fjords (Aysén, Chile)

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ABSTRACT. The Chilean government in 1994 enacted its National Policy for the Use of the Coastal Fringe (NPUCF) to promote sustainable development within the context of international requirements. One of the main NPUCF goals was to promote the harmonious coastal development by zoning of these coastal areas for defined uses. In this study, the first zoning process in Chile is discussed, which took place in the fjords and channels of Patagonia Aysén region. Its potential contribution to sustainable development is discussed using an integrated management that includes the physical, biological and social dimensions. The potential contribution of the zoning process to achieve sustainable development is threatened by significant gaps in areas of fairness, competitiveness and governance, which have to be diminished. The natural wealth of this region, abundant in resources for economic growth and human development, strongly contrast with one of the lowest rates of national competitiveness for local development.

Keywords: zoning, sustainable development, integrated coastal zone management, fjords, channels, southern Chile.

Desafíos para la zonificación del borde costero y desarrollo sostenible en los fiordos norpatagónicos (Aysén, Chile)

RESUMEN. El Gobierno de Chile promulgó en 1994 su Política Nacional de Uso del Borde Costero (PNUBC) para impulsar el desarrollo sostenible dentro del contexto de las prescripciones internacionales. Una de las principales metas del PNUBC fue promover un desarrollo costero armónico mediante la zonificación de estos espacios costeros para usos definidos. En este estudio se analiza el primer proceso de zonificación en Chile, que tuvo lugar en los fiordos y canales patagónicos de la región de Aysén. Se discute su potencial contribución al desarrollo sostenible aplicando un manejo integrado que incluye las dimensiones físicas, biológicas y sociales. La potencial contribución del proceso de zonificación para alcanzar el desarrollo sostenible está amenazada por brechas importantes en aspectos de equidad, competitividad y gobernabilidad, que han de disminuirse. La riqueza natural de esta región, abundante en recursos para su crecimiento económico, y su desarrollo humano, contrasta fuertemente con uno de los índices más bajos de competitividad nacional para el desarrollo local.

Palabras clave: zonificación, desarrollo sostenible, manejo costero integrado, fiordos, canales, sur de Chile.

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INTRODUCTION

From an initial focus on environmental protection, the international community has gradually adopted a more holistic view, today defined by the concept of sustainable development (Vallega, 1993), and illustrated by the twelve principles of the ecosystem approach (Secretaría del Convenio Sobre la Biodiversidad Biológica, 2004).

Within the framework of the international provisions, the Chilean Government announced its National Policy for the Use of the Coastal Fringe (NPUCF) in 1994. At the same time, it created the National Commission for

the Use of the Coastal Fringe (hereafter the Commission), to implement such policy by coordinating the several ministries and governmental agencies with competence in this territory. A key responsibility assigned to the Commission was to conduct a territorial planning process to define a coastal zoning (CZ) for each administrative region (*i.e.*, at a scale of several thousand square km). In these zonings, preferential uses have been defined for specific zones along the coast, which do not directly exclude other uses that may be allowed in a zone as long as they fulfill compatibility criteria defined for each preferential use (SERPLAC Región de Aysén, 2004). Previously established activities have also been permitted to remain in a zone, regardless of the preferential use allocated by the CZ.

The need to change from sectorial coastal zone management, within a multiple use framework, to an integrated approach, was discussed initially at the United Nations Convention on the Law of the Sea (UNCLOS) and became explicit in the Action Plan for Sustainable Development (Agenda 21) issued at the United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit. This occurred in a context of increased pressure on coastal ecosystems (Donnan, 2001) due to expanding coastal urbanization, increasing fisheries, aquaculture, mineral and fuel resources exploitation, and the growth of tourism.

Here, we present a case study corresponding to the first regional CZ process conducted in Chile, and discuss its potential contribution to achieving a truly integrated management that considers the physical, biological and social dimensions of the northern Patagonian Fjords, a particularly pristine and underdeveloped area of southern Chile. We reviewed some environmental, equity, competitiveness and governance issues that condition the contribution of this particular CZ to local sustainable development, and formulate recommendations for its improvement and future applications in other coastal areas.

Coastal zoning in Chile in the framework of international sustainable development

Chilean (NPUCF) policy involves all state agencies and applies to the entire country. Its explicit goal is the harmonization of multiple uses for coastal resources by a range of compatible productive and recreational activities, within a context where further economic development is desired for the country and its coastal areas. Broadly, the underlying principles of the NPUCF are aligned with the sustainable development aim inspiring most major international frameworks (Table 1). However, it's clear focus on harmonization leads to a rather weak emphasis on social, ecological and governance principles, such as those proposed by the ecosystem approach (Table 1). As an example, the NPUCF does not contain any specific mention of sensitive or essential habitats, such as those that serve as refuge, spawning or nursery areas for threatened or exploited species (Rosenberg *et al.*, 2000). These can play a fundamental role in protecting biodiversity, or to sustain pelagic and demersal fisheries (*e.g.*, Andrew *et al.*, 2002; Mora *et al.*, 2009; Leal *et al.*, 2010; Moreno *et al.*, 2011).

Although conceived as a major tool to implement the NPUCF, the CZ did not initially have a regulatory role. This was partially corrected with the inclusion of zoning in the Fishery Law (Law 18892) and the definition of a Strategic Environmental Assessment (SEA) for national policies in Law 19300. Law 18892 ruled that no new aquaculture permits should be granted in areas whose defined preferent use was considered incompatible with aquaculture activities, although the former should interact with the compatibility criteria defined by preferential uses in CZ.

Either as an indicative planning tool or as a regulatory factor, the CZ is expected to help reduce social conflicts and undesired environmental impacts that threaten the sustainability of fast growing developments exhibited by coastal activities in Chile (*e.g.*, Buschmann *et al.*, 2009; Molinet *et al.*, 2011).

During its first 15 years, the Commission produced CZ for 3 of the 14 administrative regions with coasts in the country. But the Commission is still far from becoming a mature management organization able to conduct the decision-making, coordination, monitoring and assessment tasks required, assuring sustainability along the extensive Chilean coast. Moreover, a formal assessment and feedback procedure suitable for updating and improving the three CZ already approved in the country has not been implemented.

Coastal zoning in the Aysén Region

The Aysén Region, in the northern Patagonian Fjords, Chile, is one of the three Chilean administrative regions surrounding the Patagonian Fjords and Channels System (Fig. 1). This is an extensive network of islands, channels and fjords of glacial origin (Pickard, 1971; Viviani, 1979), considered one of the largest, most complex and least studied estuarine systems in the world (*e.g.*, Silva *et al.*, 1995; Strub *et al.*, 1998; Acha *et al.*, 2004). The Patagonian Fjords host a large species diversity, communities and ecosystems (CONAMA, 2003; Lysenko & Philip, 2003; Osorio *et al.*, 2003; Pequeño & Riedeman, 2006), and possess three World Biosphere Reserves.

Table 1. Comparative table of four approaches to reach a sustainable development in aquatic systems *versus* the National Policy for the Use of the Coastal Fringe (NPUCF) in Chile. ICZM: Integrated Coastal Zone Management, EA: Ecosystem Approach, E-B MSP: Ecosystem-Based Marine Spatial Plan.

Strategies	NPUCF Chile	ICZM	EA for Aquaculture?	EA for Fisheries	E-B MSP
Goals	Sustainable use of coastal areas as a finite resource Economic development Conservation of coastal environments Compatibility of uses	Controlling development and other human activities affecting the condition of economic resources and environmental quality in coastal zones	Human well-being Ecological well-being Governance	Sustainable use of the whole system Optimum sustained yield.	Healthy ecosystems Delivery of ecosystem services Sustainable uses
Principles	State policy, National policy, applied throughout the country Coordinated inter-institutional system Multidisciplinary, in order to include the different uses	Special management and planning approaches Land and sea uses must be planned and managed in combination Coastal management boundaries should be issue-based and adaptive	Ecosystem-based aquaculture Human well -being and equality Complementary uses (in the context of other sectors)	Ecological Management Precautionary approach Governance	Ecological Economic Governance Social
Functioning	A National Commission of Coastal Zone Use and Regional Commissions. A zoning has been proposed in the public sector. This is being discussed by stakeholders.	According to the country, based upon at least three essential criteria (Karim & Hoque 2009): An enabling legal framework An enabling institutional framework. Stakeholders and their participation.	Not implemented yet	According to the country	Non-applicable
Management	Not defined	Defined by countries (e.g. Korea, Karim & Hoque 2009)	Not defined yet	Management plans	Adaptive management proposed

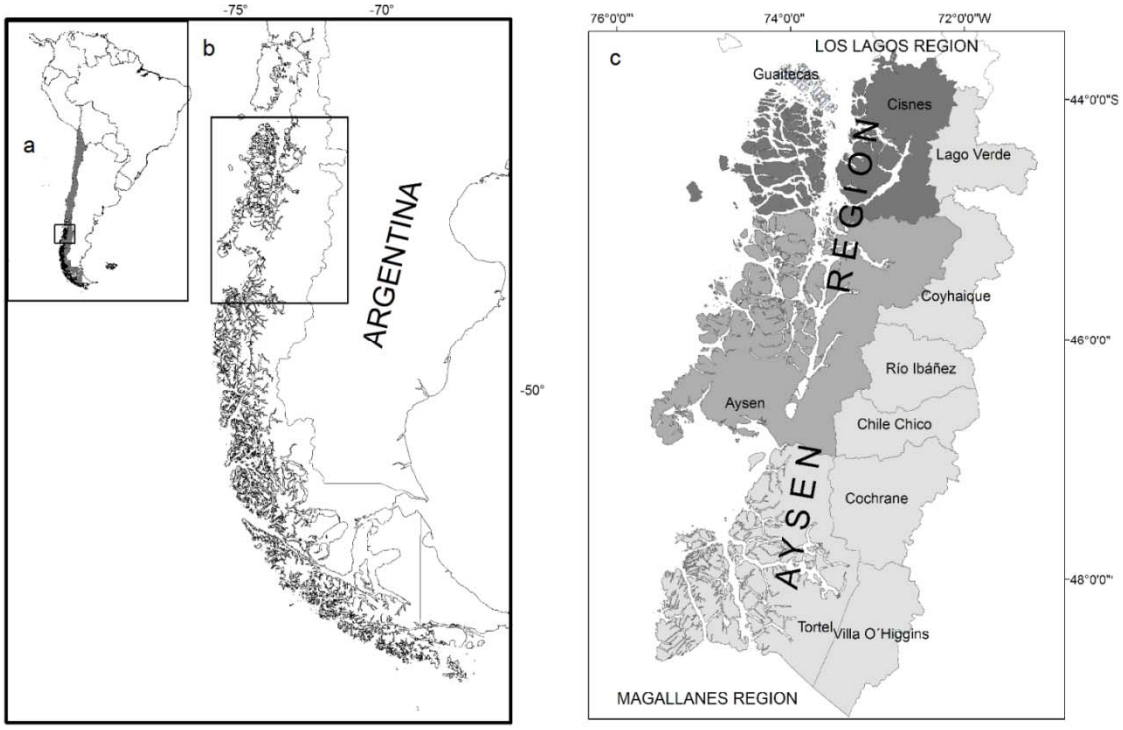

Figure 1. a) The study area on the northern seaboard of the Aysén Region, southern Chile, b) Aysén region (framed) and the southern Chile Inland Sea, c) the administrative division of the Aysén Region, highlighting the study area, i.e. the municipalities located along the northern seaboard (Guaitecas, Cisnes and Aysén).

Biogeography (Viviani, 1979; Lancelloti & Vázquez, 2000; Häussermann, 2006) and oceanographic criteria (Silva *et al.*, 1995) divide the Patagonian Fjords System into three main sections: the Northern (Corcovado Gulf-Taitao Penin-sula), Central (Taitao Peninsula-Magellan Strait) and Southern (Magellan Strait-Cape Horn) regions. Here, we focus on the Patagonian Fjords of the Aysén region, where, despite its low human population density (0.8 inhabitants' km^{-2}) there is high demand for the use of coastal areas, mainly for fishing, aquaculture and tourism. This area includes three municipalities: Aysén, Guaitecas and Cisnes, which comprise the Province of Aysén, one of the four provinces that belong to the administrative Aysén Region in the northern Patagonian section (Fig. 1).

These Patagonian Fjords were colonized during the second half of the 19th century to exploit natural resources, such as cypress wood (*Pilgirodendrum oviferus*) and marine mammals (sea otters and sea lions) for pelts (Martinic, 2005). In subsequent decades, most of the coastal villages experienced a very slow population and economic growth, conditioned by limited public and private investment and local subsistence economies, heavily based on small-scale fisheries. As a result, urban centers in the Aysén Patagonian fjords and channels basin are scarce and small, with a total population below 28,000 inhabitants distributed among nine towns and villages (Fig. 2).

Traditional small-scale fisheries are still the main economic activity for most villages in the area, with 2,993 artisanal fishermen registered in 2011 who operate 943 small wooden and fiberglass boats (<18 m). Nonetheless, the relative importance of this sector has decreased since the early 1980s when salmon aquaculture started initiating an uninterrupted growth period that lasted for *ca*. 22 years. In recent years, the fisheries and aquaculture sectors have generated a gross annual income around US$ 206.000.000, equivalent to 24% of the regional gross product (Molinet *et al.*, 2007).

At the time the Aysén CZ was defined, this region was ranked below the national competitiveness mean, meaning public infrastructure, mean scholarship, connectivity, and access to service indices well below the rest of the country (Molinet *et al.*, 2007). The particular situation of the three coastal municipalities was no better, with only one of them (Aysén) with indices above the regional mean. Nevertheless, a growing demand for coastal land and waters of the region from the tourist and aquaculture industries has

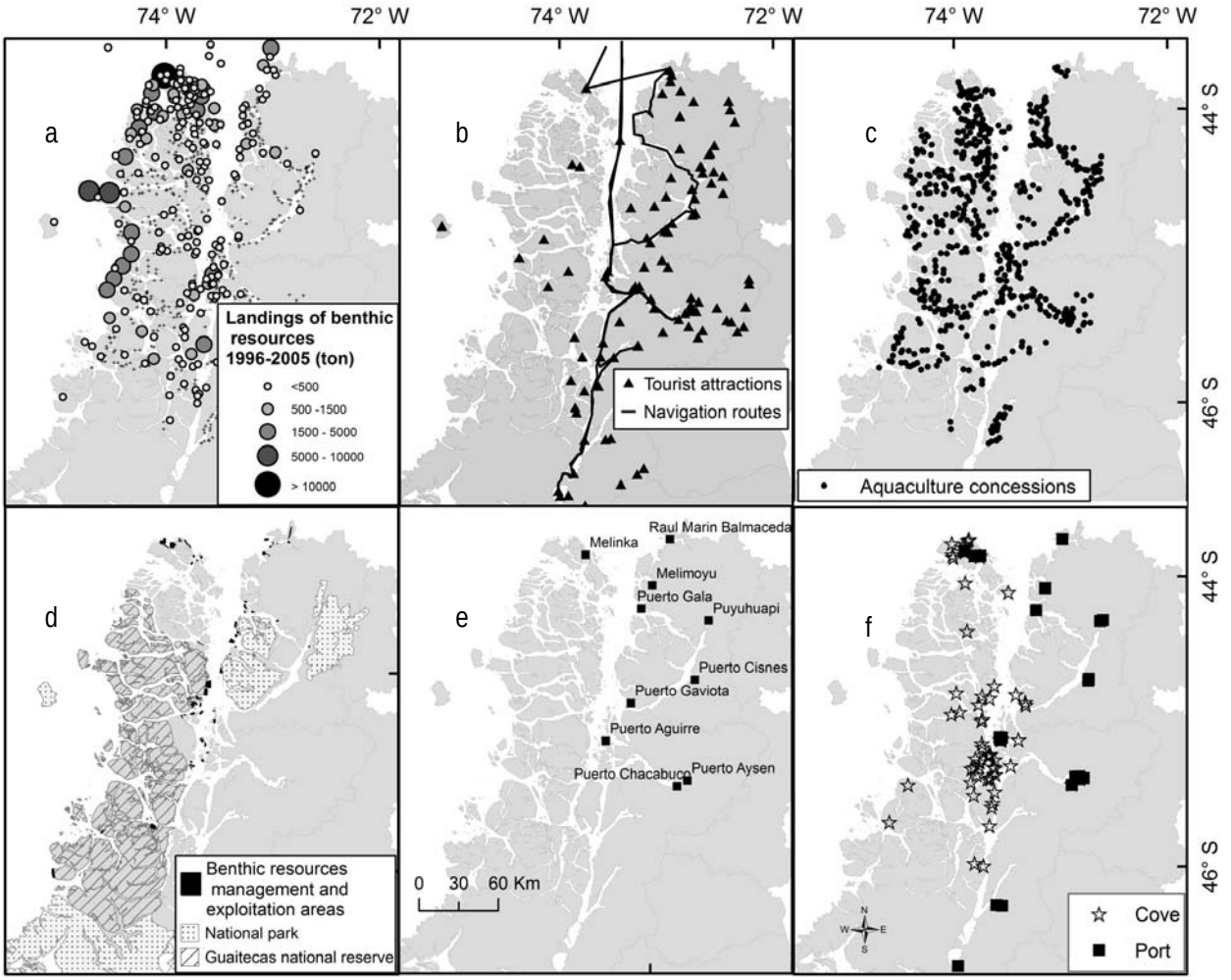

Figure 2. Economic activities in the Aysén Region inland sea. a) Benthic fisheries, such as urchins, clams and algae, b) tourist activities, such as boat trips, visiting tourist attractions (triangles), c) aquaculture concessions awarded, d) areas of Management and Exploitation of Benthic Resources and Protected Terrestrial Areas, e) towns and villages along, f) fishing docks for artisanal fisheries and ports.

become evident since the 80' (Fig. 2), offering new opportunities to the local economy. Thus, the Aysén Regional Commission faced a complex coastal zoning process, challenged to improve the quality of life in coastal communities by balancing the needs of new private investments, local cultural and traditional activities, and to protect the marine ecosystem, keys to further developments in the area.

Despite some difficulties, the Aysén Region CZ was the first regional plan to be approved in Chile. It assigned to each section of the coastal zone one out of six preferential use categories (Fig. 3): 1) tourism, 2) benthic fisheries, 3) aquaculture, 4) conservation, 5) preservation, and 6) interim preservation zones.

Larger areas of the coastal zone were intended for preservation (701,815 ha), followed by aquaculture (525,150 ha), and benthic fisheries, whereas a smaller area was intended for preferential use by tourism (192,806 ha) (Fig. 4).

Since aquaculture is the fastest growing economic activity in the area, most environmental concerns within the different CZP working groups focused on it. Thus, compatibility criteria were heavily focused on aquaculture, trying to ensure that other uses would be protected from direct or indirect negative effects attributed to it. Some key compatibility criteria issued to address such concerns were the following (Fuentes *et al.*, 2004; SERPLAC Región de Aysén, 2004):

i) No aquaculture leases should be granted within a radius of 3 km from existing or projected tourist facilities;

ii) No aquaculture leases should be granted within a radius of 3 km from resources classified as "of

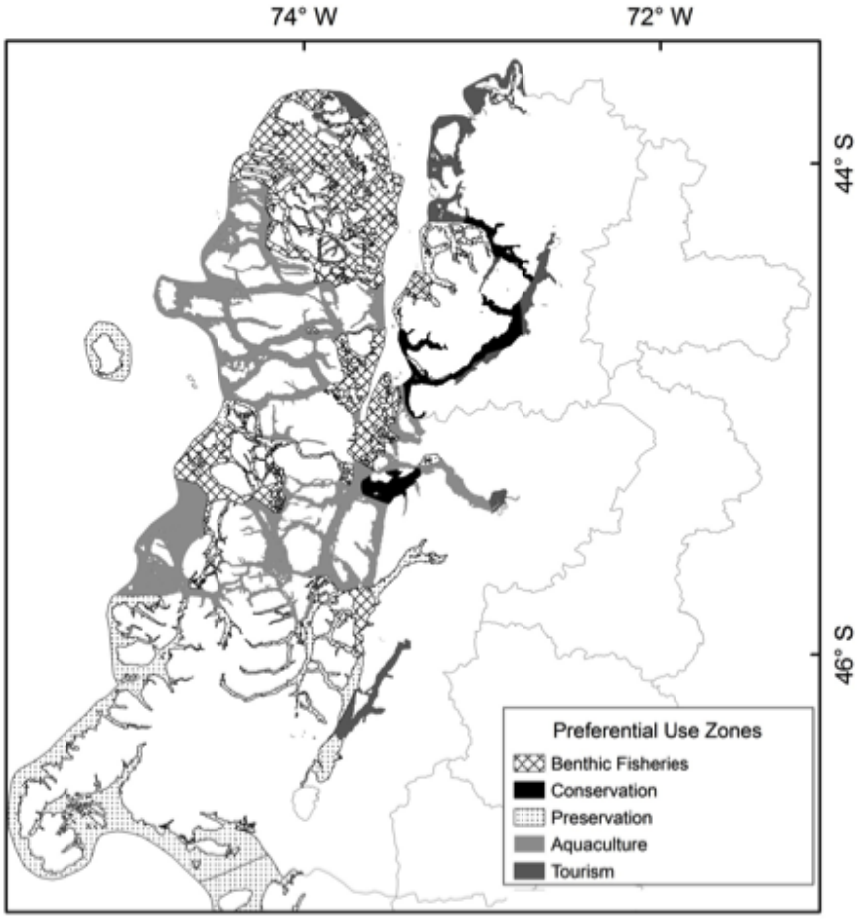

Figure 3. Aysén Region macrozoning. Five preferential uses defined.

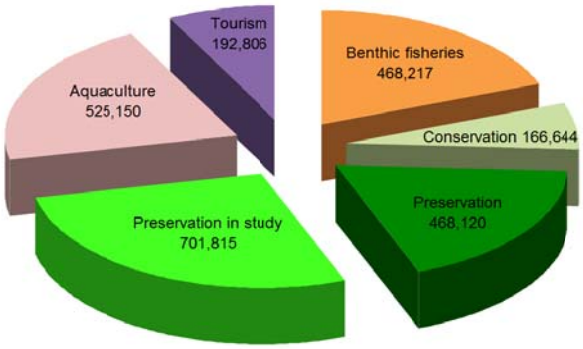

Figure 4. Coastal zone Area (in hectares) intended for different preferential uses, as defined in the zoning process of the Aysén Region.

tourist or scenic interest" by the Environmental Evaluation Service;

iii) No industries, mines or ports that may impact the water column should be installed within a radius of 3 km from granted aquaculture leases.

Besides the legal links established between new aquaculture permits and CZ by the last General Fisheries and Aquaculture amendment, the Aysén CZ has had practical implications for the spatial distribution of aquaculture leases, the allocation of territorial fishing rights (benthic resource management and exploitation areas) and the approval of environmental permits at a regional scale. For instance, the supreme decree that established suitable areas for aquaculture in Aysén, in 1994, was modified in 2009 to reduce the extension of these areas in close agreement to those defined as preferential for aquaculture use by the Aysén CZ.

Coastal zoning and sustainable development in Aysén: the day after

As described above, the Aysén CZ allocated most of its territory to conservation, aquaculture and artisanal fisheries uses. It is not possible to quantify the actual degree of influence of the CZ upon the subsequent growth and distribution of economic activities. Nevertheless, it is clear that these followed the general

trajectories expected by the Commission and the goals reflected in the allocated territory by them to each preferential use. Thus, while a vast proportion of the coastal zone remains practically unused in the south, artisanal fisheries and aquaculture remain the dominant uses of the Aysén coastal zone and the key players in local economies, mainly in the central and northern part of the region. Also, as expected, artisanal fisheries have been rather stationary, while salmon aquaculture has grown very rapidly. The stagnation of the fisheries sector has resulted mostly from limited stock availability, unfavorable market prices, and red tides. The renewed territorial expansion of the aquaculture sector in Aysén has been triggered by new regulations passed after the major sanitary crisis experienced by this industry between 2007 and 2010, which have led to more extensive production systems.

Equity and competitiveness

There is an increasing awareness of the need to base development processes on adequate knowledge and sustainable use of endogenous resources (Méndez, 2002). The characterization of a territory requires a holistic geographic perspective, where development must be evaluated not only by economic-business changes, but also by social and entrepreneurial innovations. Such innovations can be reflected in different tangible effects, such as economic and human population growth, increased territorial competitiveness or enhanced physical capital (Mecha, 2001; Méndez, 2002).

The Aysén Region is seventh in the national competitiveness ranking (Gobierno de Chile, 2009). Two of its main weaknesses are the limited public infrastructure and the low level of business activity, which showed no changes between 2003 and 2008 (Fig. 5). Molinet *et al.* (2007) built a similar competitiveness index suitable to be applied at the municipal level (MCI). This index considered five groups of variables: business, personal services, infrastructure, connectivity and municipal resources (Table 2), and was applied to the 10 municipalities of the region. This analysis showed large differences among the three municipalities that surround the northern Patagonian Fjords System in the Aysén Region: Aysén, Cisnes and Guaitecas, and between these and the rest of the region.

As an example, competitiveness was particularly low for Guaitecas, which was a main center for salmon farming and artisanal fishing long before the CZ was approved. In Guaitecas, less than 50% of the population had completed their primary education and was classified as a semi-qualified work force (Table 3). This low educational level has limited their access to further technical training and better job opportunities and salaries. In contrast, the municipality of Aysén ranks first in the region, a difference that results from historically higher levels of public and private investments related to its previous condition as main port and capital city of the region.

The contrast between low competitiveness of local communities and abundance of valuable natural resources in a given territory seems to explain why most of the wealth generated by these resources is finally captured by people and companies from elsewhere. These include qualified workers, professionnals and investors linked to aquaculture and tourist companies and their providers. A very illustrative and common picture in Guaitecas corresponds to salmon farms operated from self-sufficient pontoons, supplied from ports located in the neighboring of Los Lagos Region and operated by workers from distant cities.

Neither the CZ nor other territorial planning tools would be sufficient to assure that local inhabitants receive a fair share of the wealth obtained from natural resources of their territory. Thus, if equity, social justice and sustainability principles are to be followed, design and implementation of specific actions aimed to increase local competitiveness become urgent.

The salmon industry is projected to grow in this area at annual rates greater than 10% and is portrayed as the main private activity generating jobs in the region. Nonetheless, the recent sanitary crisis of this industry revealed the weaknesses of mono-production schemes to sustain local economies, and repositioned the artisanal fisheries as a relevant activity, which helped to mitigate the impacts of the crisis. Considering this experience and the fully exploited status of most local fisheries, there is a clear need to increase development sustainability, *sensu* Mayer *et al.* (2004) in this coastal area. Hence, we propose the following goals: i) improve fisheries management to avoid further over-exploitation and/or to rebuild local stocks, ii) increase the added value of fishing products, which are mainly exported as raw material for processing elsewhere, and iii) diversify local economies, incorporating other sectors and products, for example tourist activities of special interest.

Coastal zoning and governance in Aysén

Governance is considered today a key factor to achieve sustainable development. Social conflicts among current or potential users tend to increase the exploitation pressure on coastal resources, to reduce actual enforcing of regulations and to impose a heavy burden on biodiversity (Rakotoson & Tanner, 2006; Heylings & Bravo, 2007; Bloye, 2009).

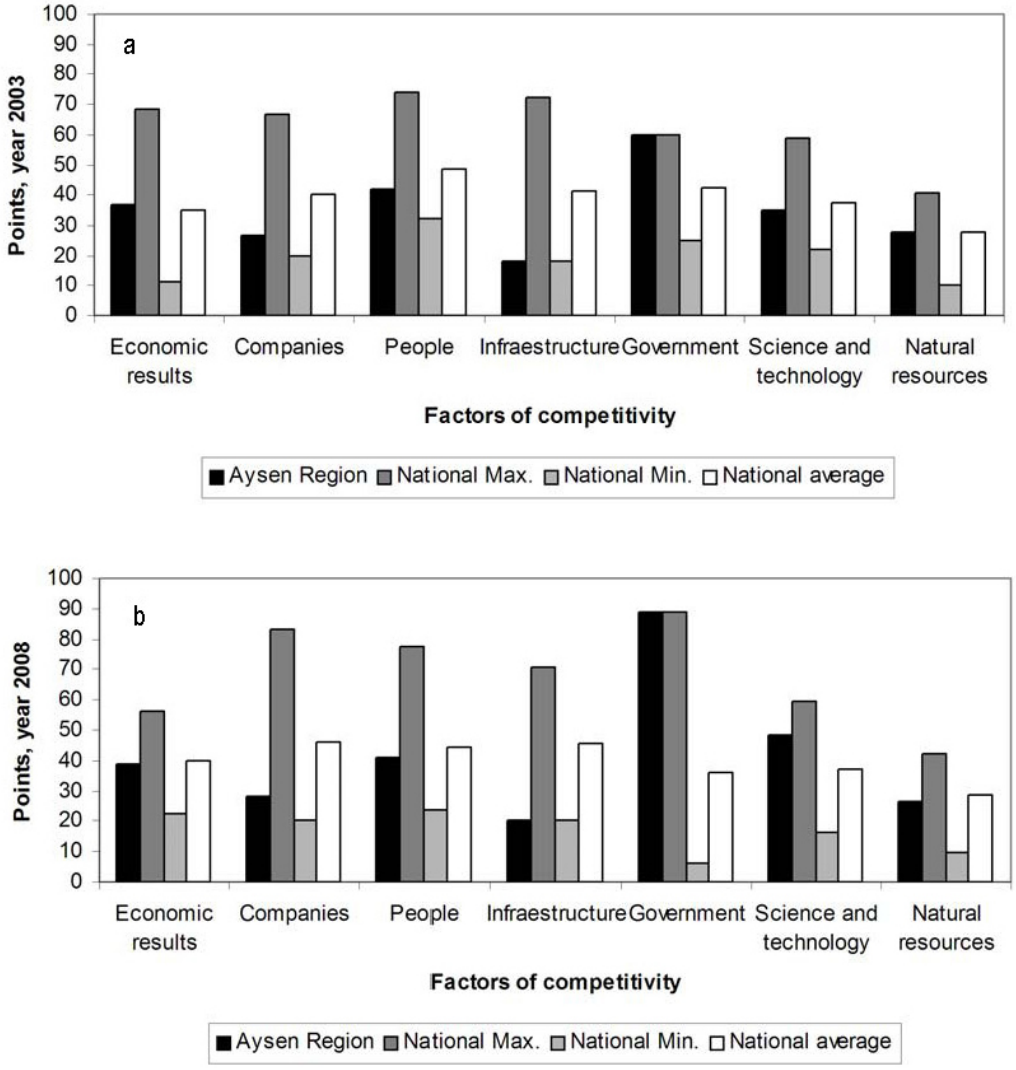

Figure 5. Competitiveness indices in the Aysén Region (*sensu* Pelluffo & Catalán, 2002) in a) 2003 and b) 2008.

Table 2. Variables used to calculate municipal competitiveness indices for the Aysén Region (Molinet *et al.*, 2007).

Index	Variable
Business Factor	Number of businesses and banks
People Factor	Student/Teacher Index; Simce Language competence score; Simce mathematics score; Simce science score; average PSU (university selection test) language score; average PSU. mathematics score; total population of the commune
Infrastructure Factor	Number of educational establishments; number of hospitals; number of nursing centers; number of medical consultancies; number of health centers; drinking water coverage; sewage network coverage; electric network coverage and number of fishing docks.
Connectivity Factor	km of road; density of roads (km km^{-2}); homes with a phone line; number of airfields.
Municipal Resources Factor	Income per capita; dependency on municipal funds.

Table 3. Competitiveness indices for the Aysén Region municipalities. Highlighted values correspond to the municipalities of Aysén, Cisnes and Guaitecas, located on the NW coast of the Aysén Region (Molinet *et al.*, 2007).

Municipality businesses	Factor index					
	People	Infrastructure	Connectivity	Municipality resources	Total	Ranking
Aysén	**0.50**	**0.93**	**0.96**	**0.67**	**0.63**	**3.676**
Chile Chico	0.25	0.778	0.583	0.667	0.25	2.528
Cisnes	**0.125**	**0.889**	**0.583**	**0.667**	**0.25**	**2.514**
Cochrane	0.25	0.889	0.375	0.333	0.25	2.097
Río Ibañez	0.125	0.481	0.333	1	0.125	2.064
Lago Verde	0.125	0.519	0.208	0.222	0.125	1.199
Guaitecas	**0**	**0.519**	**0.375**	**0.111**	**0.125**	**1.130**
Tortel	0.125	0.37	0.167	0	0.125	0.787

Hilborn *et al.* (2005) identified three main governance dimensions, linking the nature of the incentives for users to the failures and successes in, *e.g.*, fisheries management: i) the access structure to natural resources; ii) the decision making structure; and iii) the spatial scale of management. Firstly they argue that management failures tend to be less likely under restricted access regimes, where individuals perceive direct benefits from conservation. Secondly, that simpler and more transparent institutional arrangement facilitates participation and avoids responsibility from being diluted. Thirdly, that the scale at which regulations are set, data are collected and science is conducted should match the scale at which biological and social processes occur.

In the Chilean NPUCF, governance is not an explicitly stated principle. In the case of the Aysén coastal zoning process, the regional Commission created an *ad-hoc* consulting body, shaped as a working group, which incorporated and granted some participation to representatives from different activities and localities. The decision making structure was simple, with a single and clearly identified institution in charge of final decisions (the Commission), which is mainly formed by public employers. This structure did not avoid dilution of responsibilities because i) decision makers live far away from those who use the territory, and ii) the National Policy principle, which forces interests of economic development over local interests. In this way one of the three governance principles proposed by Hilborn *et al.* (2005) was not fulfilled in the Aysén zoning. The management scale was probably the smallest possible given the limited spatially-explicit information available at that time.

Participation of the coastal zone users remained active during the two years the process lasted. In our view, this participation was stimulated by some direct benefits they expected to obtain from the zoning process, mostly in terms of reducing or avoiding ongoing and potential conflicts, and/or obtaining privileged access to certain areas. The main conflicts identified by coastal zone users during the Aysén CZ process were:

a) Operational interference with the artisanal fleet by aquaculture farms that limit their access to fishing grounds and/or anchorage sites (Molinet *et al.*, 2002, 2007).

b) Exploitation of Aysén benthic resources by the larger artisanal fleet from the neighboring of Los Lagos Region (Moreno *et al.*, 2006).

c) Adverse effects of escaped salmon on native fishes due to predation and disease transmission (Soto *et al.*, 2001)

d) Lost of scenic value for tourism caused by aquaculture farms.

e) Potentially negative effects from planned mining activities on salmon farms.

Despite efforts made by the Commission to assure overall governance during the CZP process and implementation, there are several elements that threaten its social acceptance and may impose a need to review it in the near future. First, participation in final zoning decisions has been considered insufficient by some fishermen associations and community leaders. Second, there is a growing perception that limited benefit has been obtained by local inhabitants, local businesses and coastal villages by allowing the intensive use of natural resources in their territory by large companies from elsewhere. Third, a major geographic, socio-cultural and information gap existing between public decision makers in the regional capital and the inhabitants that face the effects from their decisions in coastal localities. Fourth, there is very limited scientific knowledge

about the structure and functioning of natural populations and ecosystems.

Conclusions and recommendations

Eight years after its promulgation, the Aysén CZ can be still considered a very immature process. We propose to review this tool, to consider the 12 principles of the ecosystem approach, and to focus on four main objectives: i) achieve an effective social participation from local communities; ii) promote a fair and equitable sharing of the benefits arising out of the use of local natural resources; iii) transform the CZ into a dynamic management tool; and iv) increase the knowledge basis available about marine ecosystems in the area.

In order to achieve an effective social participation from local communities, formal procedures for information, consultation, interaction and feedback between decision-makers and the communities must be established at the municipal level, including a formal, transparent and periodic process of review and update of the CZ. Participation procedures should consider an information transferring process to local inhabitants besides documentation and public access to all sessions conducted by the Commission and related working groups.

Achieving greater equity is maybe the largest challenge and most urgent task for Chile in the coming decades. Recent trends in social movements in Chile and elsewhere make it possible to anticipate increasing opposition to any zoning plan or management system unable to provide concrete and rather direct benefits to local communities from the wealth generated by their surrounding natural resources, i.e. income, infrastructure, access to education, health and other services, and overall quality of life.

Transforming CZ into more dynamic tools implies a semi-continuous cycle of research, planning, decision making, management and monitoring, as proposed in the Integrated Coastal Zone Management (ICZM) (Karim & Hoque, 2009) spatial marine management (Levin *et al.*, 2009; Foley *et al.*, 2010) and ecosystem approaches (FAO, 2003, 2010; Soto *et al.*, 2008).

The cornerstone for sustainable development of the Northern Patagonian Fjords is the generation of urgently needed knowledge about this complex mosaic of ecosystems, including the carrying capacity of its water bodies, the resilience of its exploited populations, and the sensitive habitats that must be protected to conserve biodiversity.

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