MODELING THE BIOECONOMICS IMPACTS OF CO-MANAGEMENT IN CHILEAN ARTISANAL FISHERIES

MAURO ARIAS ROJAS
EVA IGLESIAS MARTINEZ

Department of Agricultural Economics and Social Sciences. Agricultural Engineer School of Tecnical University of Madrid
Tel: +34 913 363 270
Email: marovet@gmail.com
eva.iglesias@upm.es

Paper prepared for presentation at the 107th EAAE Seminar *"Modeling of Agricultural and Rural Development Policies"*. Sevilla, Spain, January 29th -February 1st, 2008

Abstract

The failure of the centralized management system and the intense over-exploitation of benthonic resources along the Chilean coast motivated the design and implementation of an innovative co-management policy in 1999. Although its positive effects have already been recognized at biological and organizational level, doubts have been posed with regards to its economic sustainability.

In this paper, we present a bio-economic evaluation at national level for one of the most important and valuable benthonic resources, the Loco ecosystem. A dynamic simulation model is developed in order to compare and evaluate the effectiveness of the traditional centralized management and the co-management system recently implemented in Chile.

The results show that the amount of captures and effort devoted during the centralized management period were significantly underestimated due to the existence of illegal captures. On the other side, the results reveal that, after a fearful beginning, the values for revenues, capture and stock were larger than those that would have been obtained in case the former centralized system had persisted.

Keywords: natural resource modeling; marine policy; co-management policy; artisanal fisheries management; Territorial Use Right Fisheries

1. Introduction

Ten million people in Latin America depend directly from fishing (Agüero, 1992), being 95% artisanal fisheries (FAO, 1993). Nevertheless, up to 75% of the marine resources with commercial value are exploited or over-exploited, leaving only 25% of the resources sub-exploited (FAO, 2004).

One of the main cornerstones in the current policy agenda is to avoid marine resources extinction and to guarantee the sustainability of artisanal fishery communities. In recent, decades, the old centralized management policies are giving way to new decentralized management policies, as is the case with the recent management benthonic resources policy in Chile.

The *Loco* (*Concholepas concholepas*) is the main benthonic resource exploited by the artisanal fishermen in Chile. Since it is a highly demanded product with high market prices, it has been subject to intense over-exploitation.

The loco regulation has been historically based on a centralized management system. This system turned out to be ineffective and constantly mocked by its users[1] (Stotz, 1997). Therefore, several years ago, the Administration adopted an innovative co-management system where small-scale fisheries and local authorities share responsibilities over management, assessment and enforcement of benthonic fishery policy.

Although, the evaluation of the new system appeared to have positive impacts in the management of artisanal fisheries, some doubts have been posed with regards to its economic sustainability (SUBPESCA, 2004 and Montoya, 2006)

In this paper, we present a bioeconomic evaluation at national level for one of the most important and valuable benthonic resources, the Loco ecosystem. A dynamic simulation model is developed in order to compare and evaluate the effectiveness of the traditional centralized management and the co-management system recently implemented in Chile.

2. Background

2.1. The evolution of fisheries policy

After the II World War, the sea was seen as a potential source of proteins that should be exploited (Sanchirico y Wilen, 2002). Nevertheless, it was soon realized that unlimited and uncontrolled access to marine resources was not efficient from a social point of view. As a consequence, the resource would be prone to exhaustion (Gordon, 1954; Schaefer 1954; Hardin, 1968; Ostrom, *et al,* 1994; Conrad, 1995).

The open access system together with increasing demand and technological progress resulted in inefficient fishing overcapacity and dramatic over-exploitation of marine resource. In this context, centralized management systems were adopted and evolved through different policy strategies. First steps worked towards the implementation of *open access regulated system*, where both resource extraction quantity and arts of fishing were regulated. This strategy gave way to *restricted access regulated system*, where the number of fishermen was also limited. Despite the positive evolution of centralized policy, low sustainability of these management systems was often reported (Sanchirico y Wilen, 2002).

---

[1] Be a system that does not permit the control of the access to the resource, management centralized system fisheries behavior is like than free access management systems fisheries bahavior (Conrad, 1995).

In last decades, a market approach has been promoted in fisheries policy and management.. Legal frameworks based on marketable fisheries property rights have reached a notable development in some countries (Ahmed *et al,* 1992; Dubbink y Vilet, 1995). Nevertheless, the implementation of this approach is limited in developing countries where artisanal fisheries account for a large share of total harvest. Fears that market could displace artisanal fisheries and trigger the survival of local communities has been often reported (FAO, 1996; Castilla, 1996; Parma, *et al.,* 2001 y McGoodwin, 2002).

Opposite to traditional centralized policy or more recent market approaches, an alternative solution has been proposed based on self-organized resource governance systems also known as *co-management system* (Schlager y Ostrom, 1992). Under this approach, stakeholders share responsibilities in resource management and community participation is considered essential to achieve the success of the measure, (Ostrom, 1990; Bromley, 1992; Pomeroy y Berkes, 1997; Sick, 2002). User participation encourages sustainability and helps to reconcile both the private economics benefits and the resource conservation for its children and community (Sick, 2002 y FAO, 1996).

2.2. Co-Management in Chile

In order to avoid both resource exhaustion and illegal extraction, the Chilean government tried to implement different management strategies such as *partial and total closures*, total allowed catch (TAC) and individual quotas (IQs) (Keene, *et al.,* 2002). However, little success and lack of enforcement has been reported (Stotz, 1997).

The implementation territorial use right fisheries system (TURF) in Chile constitutes a completely novel resource allocation model in a country with no prior experiences in co-management systems. Therefore, the Chilean experience has been presented as one of the most important and ambitious initiatives in artisanal fisheries (Villena and Chavez, 2004).

The TURF system has delimited coastal areas where fishery communities participate and take responsibilities in the management of benthonic resources (SUBPESCA, 2000). The only way for one community to become part of the TURF is to develop a benthonic resource assessment in the requested area. Once a sustainable exploitation plan is presented, the community can request the administration an exclusive exploitation permit on the fishing area.

Several studies have already reported a positive evaluation of this system, mainly in what concerns biological aspects. Important improvements, both in size and biomass of the resource, have been appreciated in TURF areas (Castilla and Fernández, 1998; Pizarro *et al.* 2001, 2002 y 2004;

Universidad Católica del Norte, $2005_{1;}$ and Montoya, 2006). However, others studies have posed substantial doubts and even indicate negative results in the economic aspect (Soto, 2002; SUBPESCA, 2004; Universidad Católica del Norte, 2005_2; and Chavéz and Zúñiga *et al.* 2005).

3. Methodology

3.1. Model selection

Although the positive effects of the AMERB system have been recognized and confirmed at biological and organizational level, hardly one has managed to quantify its benefits from an economic point of view (SUBPESCA, 2004_1).

In the present study, a bioeconomic evaluation of this recent co-management fishery system is developed at national level. Information has been gathered in the twelve Chilean regions that represent more than four thousand kilometers of coast along which 400 thousand persons depend upon artisanal fisheries to live (FUNASUPO, 1997). At present, more than 500 handling areas are actually operating and the same number is already in the way to be approved.

A bioeconomic model is developed in order to simulate the evolution of the ecosystem should the traditional centralized policy still be in place. It is assumed that the traditional centralized management system based on closures and quotas exerted an inoperative monitoring and enforcement, actually operating as a *de facto* free access system. The results of the model allow us to evaluate and compare the effectiveness of the traditional centralized management systems and the co-management system recently implemented in Chile.

This system may be simulated by a dynamic model in discrete time given by equations (1)-(3) where X_t is the state variable that represents the biomass or existing tons of loco in period t, and E_t is the control variable that represents the effort or diving hours devoted to catch the resource during the same period.

$$(1) \quad X_{t+1} = X_t + f(X_t) - h(X_t, E_t)$$

$$(2) \quad E_{t+1} = E_t \; g(X_t, E_t)$$

$$(3) \quad X_t = X_{0;} E_t = E_0 \quad \text{for } t = 0$$

$$(4) \quad X_t \geq 0 \quad \text{and} \quad E_t \geq 0$$

Where:

X_t : loco biomass in period *t*, measured in tones.

E_t : effort units during period t, measured in diving hours.

$f(X_t)$: Loco growth function

$h(X_t,E_t)$: Catch function. Representa la mortalidad causada por la actividad pesquera.

$g(X_t,E_t)$: Normalized benefits in fisheries activities.

The state equation in (1) represents the dynamic behavior of the resource and predicts the evolution of the stock through time. Thus, the quantity of resource in the following period are determined taking into account the resource stock available in the previous period plus the stock growth function. Since the resource is exposed to the fishing activity, the individuals captured by the fishermen, given by $h(X_t,E_t)$, are then deducted.

It is assumed that biological population growth follows a logistic functional form as illustrated in equation (5), where r > 0 refers to the intrinsic rate of population growth and k > 0 is kown as the carrying capacity of the system. The logistic growth function has been widely used in fisheries evaluation studies (Seijo et al., 1997)

$$(5) \quad f(X_t) = rX_t\left(1 - \frac{X_t}{k}\right)$$

Loco resource capture within a given period is assumed to depend on available stock and effort according to a Cobb Douglas function as in (6) which enables to test decreasing, constant or increasing returns to scale.

$$(6) \quad h(X_t) = \alpha X_t^{\beta} E_t^{\gamma}$$

Equation (2) represents fisherman behavior in a free access situation, assuming inoperative monitoring and enforcement of centralized regulation. Following a similar approach to Smith (1969) and Bjørndal and Conrad (1987), this equation states that changes in effort devoted to the loco capture depend on the benefit obtained in the previous period, $g(X_t,E_t)$. This is, an increase in net benefits will translate in greater effort devoted to capture within the next period.

Normalized benefit $g(X_t,E_t)$ is defined in (7) as the ratio between net income and the effort cost, where p is the market price of the resource and c is the opportunity cost of effort:

$$(7) \quad g(X_t, E_t) = \frac{p\alpha X_t^{\beta} E_t^{\gamma} - cE_t}{cE_t}$$

In general, it is assumed that the extra effort is produced by the entry of new agents, rather than by changes in effort of existing agents (Anderson, 1986). In the same way, it is assumed that changes in effort take place as an immediate response to changes in the benefits (Gordon, 1954).

3.2. Estimation of model parameters and coefficients

Few works have attempted to characterize the biological parameters of the loco population. One of these is González et al. (2005), who determined the value of the intrinsic rate of growth, r. On the other hand and taking into account estimations carried out by Stotz and Pérez (1992) and González et al. (2005), the carrying capacity was calculated at national level.

A multiple linearized regression analyses on cross-section data was carried out in order to estimate the unknown parameters in equation (6). Since there were no time series available, information was gathered at national and regional level on loco captures, stock and effort for the 1996 period (Ecofish, 1998; IFOP, 1994, 1996, 1999 y 2003). The regression results are reported below:

$$(8) \quad \ln Y_t = \ln 0{,}0057 + 0{,}492 \ln X_t + 0{,}718 \ln E_t \qquad R^2 = 0{,}942 \text{ and } n=12$$

$$(-5{,}927) \qquad (3{,}996) \qquad (2{,}257)$$

The model was fitted by the usual least squares procedure. Numbers in parentheses denote t-statistics and show that each regression coefficient is statistically significant. The coefficients show the correct sign and reveal increasing return to scale. The model R^2 of 0,942 is relatively high and there was no evidence of auto-correlation.

Finally, personal interviews were carried out to characterize artisanal fisheries and gather information on extraction and effort costs. Data on resource price was obtained through official fiseheries statistics (IFOP).

Table1: Biological parameter value

Parameter	Description	Value	Source
p	Price per resource unit (U$ per ton)	3.358,08	Ecofish, 1998; IFOP, 1994, 1996, 1999 y 2003
c	Cost per diving effort unit (U$ per diving hours)	50,24	Personal interviews
r	Rate of Population Growth	0,0068	González et al. (2005)
k	Carrying Capacity (resource ton)	8.531.738	Stotz and Pérez (1992) and González et al. (2005),

Table 2: Coefficient Value

Coefficient	Description	Value	Source
α	Independent Coefficient	0,0057	Own elaboration
β	Dependent Coefficient of X	0,492	Own elaboration
γ	Dependent Coefficient of E	0,718	Own elaboration

4. Discussion of results

The dynamic model simulates fishermen behaviour and the evolution of the loco ecosystem under the traditional centralized management policy. As explained before, it is assumed that policy enforcement is ineffective and, thus, fishermen operate under a *de facto* free access situation. Model results are analyzed and compared with reported official data for two different periods: the first period between 1996 and 1997 corresponds to closure and quota systems under the *traditional centralized approach*, while in the second period from year 2000 on, a TURF or *co-management approach* progressively replaced the old policy.

Model results obtained for the first period 1996-1999 are illustrated in table 1 and a comparison of official and model catch values is plotted in figure 2. The white area in figure 2 shows that according to official data annual catches amount to around 2000 tons per year. However, catch levels obtained through the simulation model, depicted in the grey area, were significantly larger than the official catch data through the whole period 1996-1999.

This significant difference may confirm that total fishing catch is underestimated and gives a picture of the potential importance of illegal fishing activities, as has been reported by several authors (Keene, *et al.*, 2002 ; Stotz, 1997). The IFOP (1999) recognizes that actual catches and effort could be higher than reported *official* values, due to illegal fishing activities. Montoya (2006) estimates that illegal fishing may represent more than 50% of allowed catches in 1996.

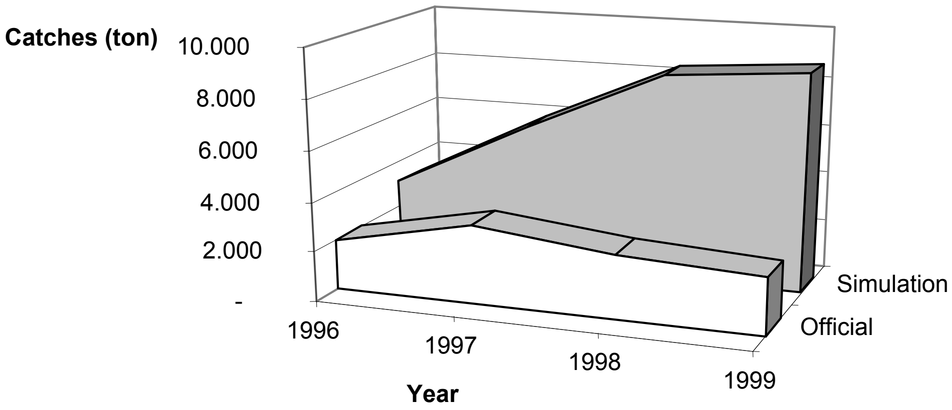

Figure 2: Comparison between the official catches values and free access simulation catches values obtained during centralized management period.

However and according to simulation values, it has to be noted that catch rates decelerates from 1998 on. Simulation results in Table 1 show that in the beginning of the period, artisanal fisheries profit rises as catch level increases. However, as fishermen increase their catch over the natural population growth level, a lower resource biomass can be expected. Smaller resource biomass forces them to increase the effort and time devoted to *loco* search and catch. As a consequence increasing cost, diminishing net income and lower incentives for illegal fishing may explain the deceleration of the catch rate.

Table 3: Stock, effort and profit under open access simulation values between 1996 and 1999.

Variable	**Year**			
	1996	**1997**	**1998**	**1999**
Catches (ton)	3.090_2	5.884	8.402	8.785
Stock (ton)	32.163_1	29.291	23.606	15.364
Effort (hrs)	130.571	206.522	393.273	561.605
Profit (US$)	$3.815.792_2$	9.382.396	8.456.996	1.284.310

Source: Own elaboration

1. Corresponds to official values ($X_{0,}$). Values determined through field work by Ecofish (1998) and IFOP (1999).
2. Corresponds to 150% of official values ($Y_{0,}$ y E_0). Values determined through field work by Ecofish (1998) e IFOP (1999).

In 1999, the resource stock reaches an historical minimum and the administration decided to implement a total closure at national level. After that, the Administration decides a drastic change in the policy model due to the ineffectiveness of centralized system and starts the implementation of the co-management system.

Model results obtained for the second period 2000-2006 are illustrated in table 2 and a comparison of official and model catch values is plotted in figure 3. Official data in this period correspond to the implementation of the co-management system. During this time a biological recovery of the resource has been observed (Pizarro, *et al.,* 2002 y 2004; Chávez y Soto, 2002). Thus, it is assumed quotas have been respected and that illegal fishing does not occur so often.

At present, the resource can only be extracted in those areas explicitly requested by the fishermen. During the first years of operation the TURF areas did not surpass the hundred but soon reached almost 400. That explains the increasing trend in official catch values for this period, as it may be appreciated in the figure 3.

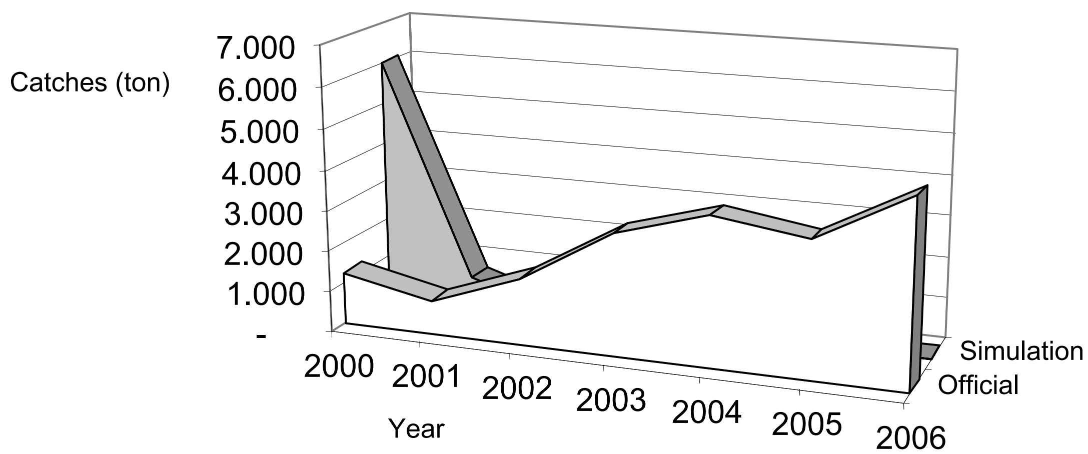

Figure 2: Comparison between the official catches values and free access simulation catches values obtained during co-management period.

Model results in table 2 illustrate what would have occurred if the traditional system would have not been replaced and allow to evaluate the potential gains of the co-management approach. Under this hypothetical scenario, profit turns negative due to severe resource depletion . Finally, the results forecast the resource extinction if the open access system had persisted. Decreasing profits would cause progressive exit and abandonment of fishery activity and the collapse of the system.

Table 4: Stock, effort and profit open access simulation values between 2000 and 2004.

Variable	Year				
	2000	2001	2002	2003	2004
Catches (ton)	6.022	706	5	0.03	**
Stock (ton)	6.683	707	5	0.03	**
Effort (hrs)	587.169	402.518	47.238	321	2
Profit (US$)	-9.276.872	-17.849.264	-2.357.083	-16.027	-109

Source: Own elaboration

** : Resource extinction.

Nevertheless, it has to be noted from figure 3 that the initial implementation of the co-management approach translated into lower catches, and lower profits, than those attained under the hypothetical persistence of the ineffective centralized policy. This initial cost may justify the substantial doubts that have been posed on the economic gains of the new approach. However, our results also reveal that this initial cost is largely compensated through a longer term economic sustainability.

5. Conclusions

The replacement of the closure and quota system under a traditional centralized policy and the implementation of a co-management approach is regarded as one of the most important and ambitious initiatives in artisanal fisheries.

A key element in this recent policy approach is that small-scale fisheries and local authorities share responsibilities over management, assessment and enforcement of benthonic fishery policy. Although the positive effects of this system have already been recognized and confirmed at biological and organizational level, substantial doubts have been risen with regard to its economic sustainability.

A dynamic simulation model is developed in order to compare and evaluate the effectiveness of the traditional centralized management and the co-management system recently implemented in Chile.

The results show that the amount of captures and effort devoted during the centralized management period were significantly underestimated due to the existence of illegal captures.

This same behaviour would probably have continued if the ineffective traditional policy had persisted and illegal fisheries would have leaded the resource to extinction.

On the other side, the results reveal that, after a fearful beginning, the values for revenues, capture and stock were larger than those that would have been obtained in case the former centralized system had persisted.

In summary, even if the new co-management system has implied a cost in its initial phase, it has avoided the resource collapse in the short term, and guarantees larger biological and economic gains in the long term.

Reference

1. Agnello, R.J. and Anderson, L.G. (1983). *Production Responses for Multi-Species Fisheries*. *Can. Fish. Aquat. Sci.* 38: 1393–1404.
2. Agüero, M. (1992). *Contribuciones para el Estudio de la Pesca Artesanal en América Latina*. Editor ICLARM Conf. Proce. 35. Pp113. Amsterdan, Holanda.
3. Ahmed, M; Capistrano, A.D. and Hossain, M. (1992). *Redirecting Benefits to Genuine Fishers: Bangladesh`s New Fisheries Management Policy*. Naga, the ICLARM Quaterly. 15(4). Pp 31-34.
4. Anderson, L.G. (1986). *The Economics of Fisheries Management.* Revised and enlarged edition. The John Hopkins University Press, Baltimore.
5. Bjørndal, T., and Conrad J.M. (1987). *Capital dynamics in the North Sea herring Fishery.* Marine Research Economics. 4: 63-74.
6. Bromley, D.W. (1992). *The Commons Property, and Common-property Regimes. In Making the Commons Work: Theory, Practice, and Policy*. Ed. D.W. Bromley. Institute for Contemporary Studies, San Francisco.
7. Castilla, J.C. (1996). *La Futura Red Chilena de Parques y Reservas Marinas y los Conceptos de Conservación, Preservación y Manejo en la Legislación Nacional.* Revista Chilena de Historia Natural 69: 253-270.
8. Castilla, J.C. and Fernández, M. (1998). *Small-Scale Benthic Fisheries in Chile: on Comanagement and Sustainable Use of Benthic Invertebrates.* Ecological Applications 8 (Supplement): S124-S132.
9. Clark, Colin W. (1990). *Mathematical bioeconomics. The optimal management of renewable resources* (2^{nd} ed). John Wiley and Sons, New York, 386 pp.
10. Conrad, J.M. (1995). *Bioeconomic Models of the Fishery. The Handbook of Enviromental Economics.* Chap. 18. Editado por Daniel Bromley, Blackwell Publishers.

11. Chávez, M. and Soto, J. (2002). *Rentabilidad de las Áreas de Manejo y Explotación de Recursos Bentónicos de la IV Región.* Informe elaborado para SERNAPESCA, IV Región. Doc. no publicado.

12. Ecofish Consultores S.A. (1998). *Evaluación Indirecta del Stock del Recurso Loco (Concholepas concholepas) a Nivel Nacional.* Fondo de Investigación Pesquera: Informes Técnicos FIP. Subsecretaria de Pesca. FIP-IT/95-22B.

13. Food and Agriculture Organization. FAO. (1993). *Fisheries Statistics Series. Fisheries Series No. 40.* No. 111 (1993), p. 72. Rome, Italy.

14. Food and Agriculture Organization. FAO. (1996). *Precautionary Approach to Capture Fisheries and Species Introductions.* Technical Guidelines for Responsible Fisheries 2. Roma, Italy.

15. Food and Agriculture Organization. FAO. (2004). *The State of the World Fisheries and Aquaculture.* FAO Fisheries Department. Rome, Italy.

16. Fundación para la Superación de la Pobreza. FUNASUPO. (1997*). Visión del sector Pesquero Artesanal, Bases de una Propuesta para su Desarrollo: Diagnósticos y Propuestas.* http://www.fundacionpobreza.cl/fnp_secciones_detalle.asp?Id_Seccion=2&Id_Texto=79 [Consultado: 27 Junio del 2005]

17. González, J. *et al.* (2005). *Bases Biológicas para la Evaluación y Manejo de Metapoblaciones de Loco en la III y IV Regiones.* Informe Final Corregido. FIP Nº 2002-16.

18. Gordon, H. Scott. (1954). *Economic Theory of a Common-Property Resource: the Fishery.* The Journal of Political Economy, Abril 1954, 62, 124-42. Sección I, II, III.

19. Hardin, G. (1968). *The Tragedy of the Commons.* Science, v. 162 (1968), Pp 1243-48. AAAS.

20. Instituto de Fomento Pesquero. IFOP. (1994). *Monitoreo y Evaluación Indirecta del Stock del Loco (I-XII Región).* Fondo de Investigación Pesquera: Informes Técnicos FIP. FIP-IT/93-07. 225Pp.

21. Instituto de Fomento Pesquero. IFOP. (1996). *Monitoreo y Análisis de la Pesquería del Recurso Loco a Nivel Nacional.* Fondo de Investigación Pesquera: Informes Técnicos FIP. FIP 95-22. http://www.ifop.cl/fip_1995.html [Consulta: 13 enero del 2005].

22. Instituto de Fomento Pesquero. IFOP. (1999). *Monitoreo de la Pesquería del Recurso Loco, 1998.* Fondo de Investigación Pesquera: Informes Técnicos FIP. Subsecretaria de Pesca. FIP-IT/98-04. http://www.ifop.cl/fip_1998.html [Consulta: 13 enero del 2005].

23. Instituto de Fomento Pesquero. IFOP. (2003). *Ordenación Espacio Temporal de la Actividad Extractiva Artesanal entre la I y IV Regiones. Informe Final.* Fondo de Investigación Pesquera FIP Nº 2001-25. http://www.ifop.cl/fip_2001.html [Consulta: 13 enero del 2005].

24. Keene, S.; Gibrán, Y. and Stotz, W. (2002). *Competing Visions for Marine Tenure and Co-Management: Genesis of a Marine Management Area System in Chile.* Coastal Management, 30:85-99.

25. Mcgoodwin, J.R. (2002). *Comprender las Culturas de las Comunidades Pesqueras: Clave para la Ordenación Pesquera y la Seguridad Alimentaria.* FAO Documento técnico de Pesca Nº 401. Roma, FAO. 301p.
26. Montoya, M. (2006). *Diagnóstico Económico de la Pesquería del Recurso Loco (Áreas de Manejo).* Departamento de Estudios. Subsecretaria de Pesca. http://www.subpesca.cl [Consulta: 20 de diciembre del 2006].
27. Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge University Press. Cambridge.
28. Ostrom, E.; Gardner, R. and Walker, J.M. (1994). *Rules, Games, and Common-Pool Resources.* Ann Arbor. MI: University of Michigan Press.
29. Parma, A.M.; Orensanz, J.M.; Elias, I. and Jerez, G. (2001). *Diving for Shellfish and Data: Incentives for the Participation of Fishers in the Monitoring and Management of Artisanal Fisheries Around Southern South America.* Towards Sustainability of Data-Limited Multi-Sector Fisheries. Eds: Newman, S.; Gaughan, J.; Jackson, G.; Mackie, M.; Molony, B.; St John, J. y Kailola, P. Australian Society for Fish Biology Workshop Proceedings. Bunbury, Australia.
30. Pizarro, P.; Guzman, G.; Baeza, O.; Quesille, J. and Vega, C. (2001). *Estudio de Situación Base para el Área de Manejo y Plan de Manejo y Explotación del Área de Caleta Piragua-Iquique.* Universidad Arturo Prat, Departamento de Ciencias del Mar. Iquique, Chile. Doc. no publicado.
31. Pizarro, P.; Guzman, G.; Baeza, O.; Quesille, J. and Vega, C. (2002). *Primer Informe de Seguimiento del Área de Manejo de Caleta Pisagua-Iquique.* Universidad Arturo Prat, Departamento de Ciencias del Mar. Iquique, Chile. Doc. no publicado.
32. Pizarro, P.; Guzman, G.; Baeza, O.; Quesille, J. and Vega, C. (2004). *Segundo Informe de Seguimiento del Área de Manejo de Caleta Piragua-Iquique.* Universidad Arturo Prat, Departamento de Ciencias del Mar. Iquique, Chile. Doc. no publicado.
33. Pomeroy, R. and Berkes, F. (1997). *Two to Tango: The Role of Government in Fisheries Co-management.* Marine policy, Vol. 21, Nº5. Pp 465-480. United Kingdom.
34. Sanchirico, J.N. and Wilen, J.E. (2002). *Global Marine Fisheries Resources: Status and Prospects.* Resources for the Future. Sustainable Development. August 2002 - Issue Brief 02-17. http://www.rff.org/Documents/RFF-IB-02-17.pdf [Consulta: 15 mayo del 2005].
35. Schaefer, M. (1954). *Some Aspects of the Dynamics of Populations Important to the Management of the Comercial Marine Fisheries.* Bull.I-ATTC, 1(12):27-55.
36. Seijo, J.C.; Defeo, O. and Salas, S. (1997). *Bioeconomía Pesquera: Teoría, Modelización y Manejo.* FAO Documentos técnicos de pesca. T368. Rome, Italy.

37. Sick, D. (2002). *Gestión de Procesos Ambientales a Través de Fronteras: una Revisión de la Literatura sobre Instituciones y Gestión de Recursos.* Iniciativa Programa MINGA. Centro Internacional de Investigaciones para el Desarrollo. Ottawa, Canada.
38. Smith, V.L.. (1969). *On Models of Commercial Fishing.* J. Polit. Econ. 77: 181-198.
39. Stotz, W. and Perez, E. (1992). *Crecimiento y Productividad del Loco Concholepas concholepas (Bruguière, 1789) como Estimador de la Capacidad de Carga en Áreas de Manejo.* Investigaciones Pesqueras (Chile) 37:, 13-22.
40. Stotz, W. (1997). *Las Áreas de Manejo en la Ley de Pesca y Acuicultura: Primeras Experiencias y Evaluación de la Utilidad de esta Herramienta para el Recurso Loco.* Estudios Oceanológicos 16:67-86.
41. Subsecretaria de Pesca. SUBPESCA. (2000). *Áreas de Manejo y Explotación de Recursos Bentónicos. Documento de Difusión nº1.* Junio 2000 (actualizado junio 2003). Departamento de Coordinación Pesquera. Departamento de Pesquerías. http://www.subpesca.cl/ [Consulta: 3 febrero del 2005]
42. Subsecretaria de Pesca. SUBPESCA. (2004). *Análisis del Desempeño Económico, de la Áreas de Manejo 2000-2002.* http://www.subpesca.cl/ [Consulta: 4 febrero del 2005]
43. Universidad Católica del Norte. (2005_1). *Formulación de Metodologías para Evaluar el Desempeño de Áreas de Manejo. Informe Final.* Grupo de Ecología y Manejo de Recursos, Universidad Católica del Norte. Coquimbo, Chile. Doc. no publicado.
44. Universidad Católica del Norte. (2005_2). *Diseño de Plan Piloto de Ordenamiento Espacial de Pesquerías Bentónicas en la IV Región.* Grupo de Ecología y Manejo de Recursos, Universidad Católica del Norte. Coquimbo, Chile. Doc. no publicado.
45. Villena, M. and Chávez, C. (2004). *Social Norm Compliance in Territorial Use Rights Regulations: A Game Theoretic Approach.* Econometric Society. Econometric Society 2004 Latin American Meetings, number 110. http://www.econometricsociety.org/ [Consulta: 18 mayo del 2005]
46. Zúñiga, S.; Bustos, E.; Morales, L. and Stotz, W. (2005). *Proyecto INVES Monitoreo Socioeconómico Áreas de Manejo, Primera Etapa.* Escuela de Ingeniería Comercial, Universidad Católica del Norte. Coquimbo, Chile. Doc. no publicado.