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Article *in* Canadian Journal of Fisheries and Aquatic Sciences · January 1998

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Artisanal "Caletas" as units of production and co-managers of benthic invertebrates in Chile

Juan C. Castilla, P. Manríquez, J. Alvarado, A. Rosson, C. Pino, C. Espoz, R. Soto, D. Oliva, and O. Defeo

Abstract: In Chile, small-scale fisheries exist for about 60 benthic invertebrates, with about 15 000 t (US$166 million) landed per year. Mollusc dive fisheries, with more than 10 000 professional registered divers, represent about 70% of total invertebrate landings. The fishery for the gastropod *Concholepas concholepas*, the "loco," was closed between 1989 and 1992. The closure was lifted twice in 1993, for a total of 14 days, under new management regulations institutionalized in the 1991 Chilean Fishery and Aquaculture Law (No. 18,892). The loco fishery landed 8574 t in 1993, with an export value of US$64 million. Existing regulations to control both dive fishery effort and access to fishing grounds are described. Fishery monitoring was conducted during the 1993 loco fishing seasons in 4 Caletas (small-scale fisher associations, each centered around a cove) in central Chile. Annual closures of small coastal MEAs (management and exploitation areas) resulted in larger CPUE (catch per unit effort) and reduced travel time. Larger size loco receiving higher prices resulted. Future co-management options to better achieve sustainable exploitation of Chilean benthic invertebrates are discussed.

Résumé : Au Chili, il existe des pêcheries à petite échelle pour environ 60 invertébrés benthiques et les débarquements s'élèvent à environ 15 000 t (166 millions de dollars US) par année. Les pêcheries de mollusques exploitées par des plongeurs, on dénombre plus de 10 000 plongeurs professionnels enregistrés, comptent pour environ 70 % des débarquements totaux d'invertébrés. La pêcherie du gastropode *Conchelopas conchelopas,* ou « loco », a été fermée entre 1989 et 1992. La fermeture a été levée deux fois en 1993, pour un total de 14 jours, suite à l'adoption de nouveaux règlements de gestion édictés dans la Loi chilienne sur la pêche et l'aquaculture de 1991 (n° 18 892). La pêche au loco a produit des débarquements de 8 574 t en 1993, pour une valeur à l'exportation de 64 millions de dollars US. Le présent article décrit les règlements en vigueur pour contrôler à la fois l'effort de pêche des plongeurs et l'accès à la pêcherie. La surveillance de la pêcherie a été réalisée durant les saisons de pêche du loco de 1993 dans 4 Caletas (petites associations de pêcheurs centrées autour d'une anse) au centre du Chili. Les fermetures annuelles de petites « zones de gestion et d'exploitation » côtières ont entraîné des prises par unité d'effort (PUE) plus élevées et une réduction du temps de déplacement. Résultat : des prises de plus grande taille qui commandent un prix plus élevé. Des options de cogestion futures pour assurer une exploitation plus durable des invertébrés benthiques du Chili sont discutées. [Traduit par la Rédaction]

Introduction

Dive fisheries for benthic invertebrates in Chile are important both economically and socially. Over 60 invertebrates are harvested, current landings are about 150 000 $t \cdot yr^{-1}$, worth around US$166 million$\cdot yr^{-1}$, and about 70 000 small-scale (artisanal) fishers participate. Of these fishers, more than 10 000 are registered divers. Molluscs represent about 70% of total shellfish landings, and include the unique high-priced gastropod *Concholepas concholepas* (Bruguiere 1789), locally known as "loco" (Castilla 1982, 1988*a*; Castilla and Jeréz 1986; Geaghan and Castilla 1986, 1988; Castilla et al. 1994; Castilla 1995).

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Correct citation: Castilla, J.C., Manríquez, P., Alvarado, J., Rosson, A., Pino, C., Espoz, C., Soto, R., Oliva, D., and Defeo, O. 1998. Artisanal "Caletas"as units of production and co-managers of benthic invertebrates in Chile. *In* Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management. *Edited by* G.S. Jamieson and A. Campbell. Can. Spec. Publ. Fish. Aquat. Sci. 125 pp. 407–413.

As a result of rapid development of Asian markets for Chilean shellfish, following aggressive overseas marketing between 1976 and 1982, shellfish export surpassed domestic consumption and some shellfish resources began to show signs of overexploitation. Bustamante and Castilla (1987) recommended immediate conservative management actions to achieve more rational management of these resources.

The Chilean Fishery and Aquaculture Law, Ley de Pesca y Acuicultura, No. 18,892, passed on September 28, 1991, contains several innovative management tools. Aims of management are to rehabilitate shellfish stocks damaged during the export boom, and to ensure rational and sustainable exploitation of small-scale fishery resources (Castilla 1994; Payne and Castilla 1994). With respect to small-scale fishery activity, this law contains two sets of regulations. The first resolves past conflict over access to fishing grounds by both the artisanal and industrial (company-owned) fleets by assigning an exclusive fishing area within 8 km (5 miles) from shore to the artisanal fleet. This fleet comprises about 11 000 vessels of <50 t gross registered weight (Aranda et al. 1989). Approximately 85% of this fleet is composed of small, 7–8 m wooden boats (sail, oar, or outboard powered) with a crew of 2–4 fishers.

The second regulation relates specifically to the management of benthic resources by allowing exclusive fishing rights on defined management and exploitation areas (MEAs) of

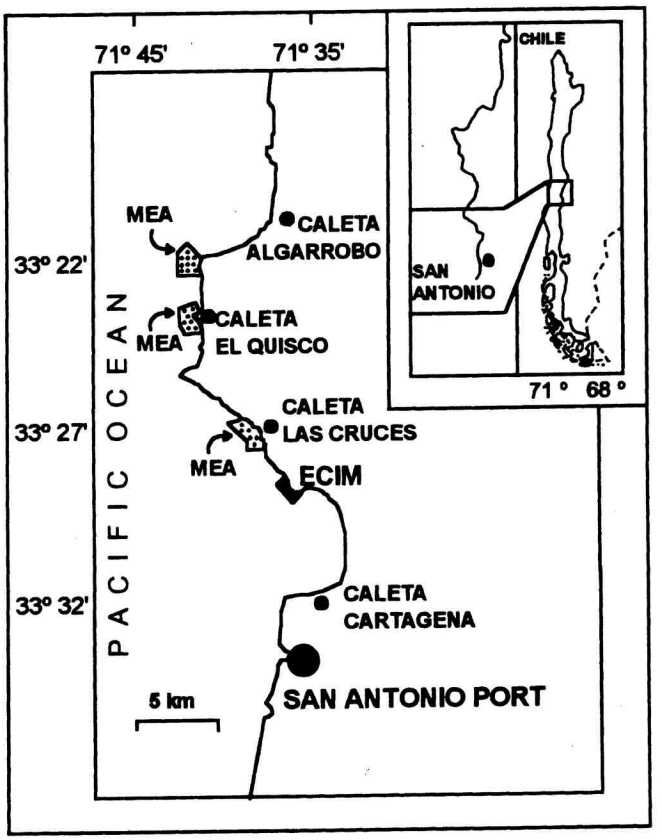

Fig. 1. Locations of the 4 Caletas monitored during the 1993 loco fishing seasons. Management and Exploitation Areas are shown in front of their coves. The Las Cruces Marine Coastal Station (ECIM) and its Marine Preserve location (black) is also shown.

inshore sea bottom to registered organizations or communities of artisanal fishers. In addition, there is a special clause whereby a benthic resource can be declared "fully exploited." In such cases managers can set both fishery and fisher harvest quotas.

This law has been in operation for just over five years, and fishers are still adjusting to changes, particularly regarding establishment of MEAs (Castilla 1994).

Traditional small-scale fishermen's unions, "Sindicatos," are playing a key role in the implementation of MEAs. Sindicatos (Morales 1993; Payne and Castilla 1994; Minn and Castilla 1995) have operated for decades and may be formed by a minimum of 25 members dedicated to artisanal, technical, or professional activities. In the artisanal fishery, Sindicatos operate in small coastal villages known as "Caletas," usually located around coastal coves. In Chile there are about 190 active, recognized Caletas, most of them organized in Sindicatos. According to the Fishery and Aquaculture Law, exclusive fishing rights for benthic resources in an MEA can only be granted to organized groups of small-scale fishers. The system of Sindicatos allowed rapid adoption of MEAs and allows the possibility of co-management of local resources.

Castilla (1994) presented arguments for incorporation of exclusive fishing rights for benthic resources and the MEA concept in the new fishery law. In both cases, the main element catalyzing inclusion was scientific data, mostly from the central coast of Chile, on natural enhancement and recruitment of benthic invertebrates (Castilla 1988*b*) in coastal preserves without human intervention (Castilla and Durán 1985; Durán and Castilla 1989; Durán et al. 1987; Castilla 1990*a*). The precedent-setting, pilot, loco restocking experiment conducted between 1987 and 1990 with the Sindicato of Caleta Quintay in central Chile (Castilla and Jeréz 1986; Geaghan and Castilla 1986), which resulted in Chile's first MEA of 57 ha, was also important. This Sindicato was given exclusive fishing rights for harvest of *C. concholepas* in their MEA in April 1991, prior to the current fishing law being gazetted.

Between 1991 and 1993, several Caletas obtained provisional control over small areas, usually <100 ha of sea bottom, called "Destinacions Marinas" (Payne and Castilla 1994; Minn and Castilla 1995; Pino and Castilla 1995). Before MEAs are formally established, these Destinacions, which require a benthic resource management plan, permit similar benthic resource management.

Social and economic problems inherent in the early loco fishery (Castilla and Jeréz 1986; Geaghan and Castilla 1986, 1987, 1988) also played a key role in rationalizing the benthic resource management tools implemented in the Chilean Fishery Law. Prior to 1991, management options failed to halt declining catches and resulted in unemployment in Caletas. Loss of revenue in turn created problems, including illegal resource harvesting and tax evasion.

Under regulations stated in the 1991 Fishery Law, loco fishing, closed in 1989, was legally reopened twice in 1993, for a total of 14 days. In 1993 the species was declared "fully exploited" to permit experimentation with adaptive fishing options.

Artisanal *C. concholepas* fishery landings are updated and summarized and results from the 14-day, 1993 fishing season are documented and discussed. The effects of the 1991 Chilean Fishery Law on loco harvesting by both MEA-registered and nonMEA-registered Caletas on the central coast of Chile are reviewed and co-management of this resource is evaluated.

Material and methods

Landings and export values (1960–1993) of locos reported in this paper are based on both Annual National Fishery Service Statistics (Anuarios Estadísticos del Servicio Nacional de Pesca, SERNAP) and data from the Custom Bulletin of the Central Bank of Chile (Boletín Aduanero, Banco Central de Chile).

In 1993, the loco fishery was opened twice: 18–22 January (summer) and 26 July – 3 August (winter). A quota of 1500 locos per registered diver per fishing season was permitted. This applied to most Caletas, although in selected ones, the fisher quota was increased to 4000 per season. In the summer fishery, there were about 7000 enrolled divers in the National Small-Scale Fishery Register (Registro Nacional de Pescadores Artesanales de Chile), while in the winter fishery, there were about 10 000 divers. Locos could only be sold in batches of 150, and batch-coupons allowed sales to be tracked both to diver and wholesaler.

Landing points at selected Caletas (Fig. 1) were specified to facilitate fishery monitoring. Field samplers recorded relevant characteristics of the artisanal fleet and fishery at each landing point. As has been the case for the past 30 years,

minimum legal size of harvestable loco was 10 cm (maximum diameter of the peristome). The 1993 loco harvesting monitoring program described in this paper was conducted independently by our research team, based at the Estación Costera de Investigaciones Marinas (ECIM), Las Cruces, in four Caletas of central Chile (Fig. 1).

The Caletas

Caleta El Quisco (33°23' S, 71°42' W)
Caleta El Quisco is a well-organized Sindicato (Payne and Castilla 1994) having 139 members in 1993, with 24 summer and 42 winter registered divers. The artisanal fleet was composed of 31, 7–8 m wooden boats, each equipped with 25–40 Hp outboard engines and surface hooka air compressors with one or two hose outlets for divers (Castilla and Jeréz 1986). Unilaterally, this Sindicato in 1990 totally banned diving on 57 ha of sea bottom (Fig. 1) next to their cove. The Sindicato took legal possession of this Destinación area on July 9, 1993. Since 1991, our research team has worked jointly with this Sindicato to implement fishery monitoring and assess invertebrate stocks. During the 1993 fishing seasons, El Quisco divers extracted their quotas exclusively from their Destinación.

Three stock assessments in the El Quisco Destinación have been conducted. The first, from February to March 1992, was near the beginning of the annual aggregation of loco for spawning and prior to the January 1993 (summer) fishery. Spawning aggregations, characteristic of muricid snails, occur mainly between March and June (Castilla 1979, 1982). The second survey was from March to May 1993, in the middle of the species spawning aggregation, after the first fishery opening but before the July (winter) fishery. The third survey was during March–May 1994, also at the peak of spawning.

The Destinación was subdivided into 5 areas, each of approximately 10 ha. Number of locos was recorded along 100-m random subtidal transect lines, either perpendicular or horizontal to the coast. Locos 1 m on either side of the line in 1992 (10 transects) and 1.7 m on either side of the line in both 1993 (29 transects) and 1994 (42 transects) were counted. Mean density of locos per transect was estimated using the geometric mean to correct for normality. Confidence intervals were calculated as described by Sokal and Rohlf (1981). Total MEA population was extrapolated for 35 ha of suitable habitat. Population size structure based on randomly collected samples of over 500 individuals per assessment was used to estimate harvestable stock.

Caleta Algarrobo (33°22'S, 71°40'W)
Caleta Algarrobo is a well-organized Sindicato (Payne and Castilla 1994) having 90 members in 1993, with 25 summer and 36 winter registered divers and an artisanal fleet of 28 wooden boats. The Sindicato has forbidden diving in a coastal area of approximately 56 ha since 1991 (Fig. 1), although this has been only partially enforced. In January 1993, they obtained legal possession of this area as a Destinación. In 1993, Algarrobo divers harvested around 90% of locos landed from common diving grounds 32–40 km away from their cove. On the last fishing day of the winter season (August 3), 8300 locos (9.7% of their quota) were harvested from their Destinación.

Caleta Las Cruces (33°33'S, 71°37'W)
Caleta Las Cruces is a poorly organized Sindicato (Payne and Castilla 1994; Minn and Castilla 1995) having 33 members in 1993, with 15 summer and 11 winter registered divers and an artisanal fleet of 8 wooden boats. Sindicato members could not agree to conserve a local coastal area, but they nevertheless obtained, with support from our research group, a Destinación of 84 ha in February 1993 (Fig. 1). In 1993, Caleta Las Cruces divers harvested all their locos from common access diving grounds 8–11 km from their cove.

Caleta Cartagena (33°33'S, 71°36'W)
Caleta Cartagena, also a poorly organized Sindicato (Payne and Castilla 1994), had 27 members with 15 summer and 26 winter divers in 1993 and an artisanal fleet of 25 wooden boats. The Sindicato has taken no steps to conserve a coastal area and has not been granted a Destinación. Cartagena's divers harvested locos in 1993 from common access diving grounds, both relatively close and distant from their cove. They also illegally harvested locos by poaching at night from Destinacións granted to other Caletas.

The 1993 loco fishery

Catches at El Quisco were recorded during both the summer (5 days) and winter (9 days) fishing seasons. Algarrobo and Las Cruces catches were only monitored during the winter. The following data were recorded on a boat-by-day basis: number of divers, travel time (including travel time to diving grounds and underwater searching time), dive time per diver, fishing location, and catch of locos. This permitted calculation of both travel time and CPUE. Individual CPUE was pooled per Caleta. CPUE and travel time were compared using Tukey's multiple comparison procedure.

Maximum diameter of the peristome and weight (including shells) were recorded from 50 randomly selected locos per boat landing. Harvested loco size frequencies by different Caletas were based on daily measurements of 100 (minimum of 2 trips per day) to 1150 locos (23 trips per day). At Caleta Cartagena, only price and catch data were available.

Results

Loco fishery development

Loco catches landed between 1960 and 1993 illustrate the three major phases through which many Chilean invertebrates evolved (Fig. 2A). The first phase (1960–1974) was for domestic consumption only, and landings ranged from 3000 to 6000 t. The second phase (1975–1981) included both export and domestic consumption and was characterized by a lack of fishery management. Landings peaked in 1980 at 24 856 t. Thereafter, landings decreased, in spite of strong Asian market demand, as initial fishery regulations proved ineffective (Fig. 2B). The fishery was then closed for three months per year from 1982 to 1985 to protect reproductive aggregations, and was completely closed between 1989 and 1992. In 1993, the fishery was reopened for a total of 14 days with a landing of 8574 t whole weight (specimens with shell). Exported meat (the foot: frozen, canned, or dried) weight reached 2392 t. Export value increased between 1978 and 1993 from approximately US$5 million to 64 million (Fig. 2A).

Fig. 2. (A) Landings and export value of the fishery for *Concholepas concholepas* between 1960 and 1993. (B) Fishing effort regulatory measures: white bars indicate no regulation; black bars indicate fishing bans.

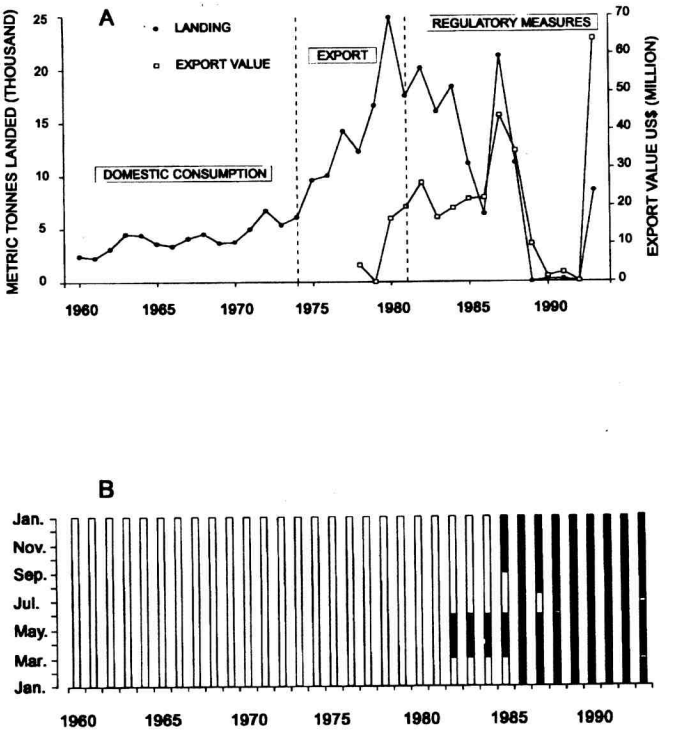

Fig. 3. (A) Locos landed at the 4 monitored Caletas during the 1993 summer and winter fishing seasons. Numbers on top of the bars indicate registered divers. Black bars indicate the number of locos harvested relative to assigned quotas; white bars indicate the quota portion not landed. (B) Landing value of locos. Numbers on top of the bars indicate the mean selling price (US$) per loco. Black bars indicate the total income received by the fishers, and white bars indicate income lost because the quota was not reached.

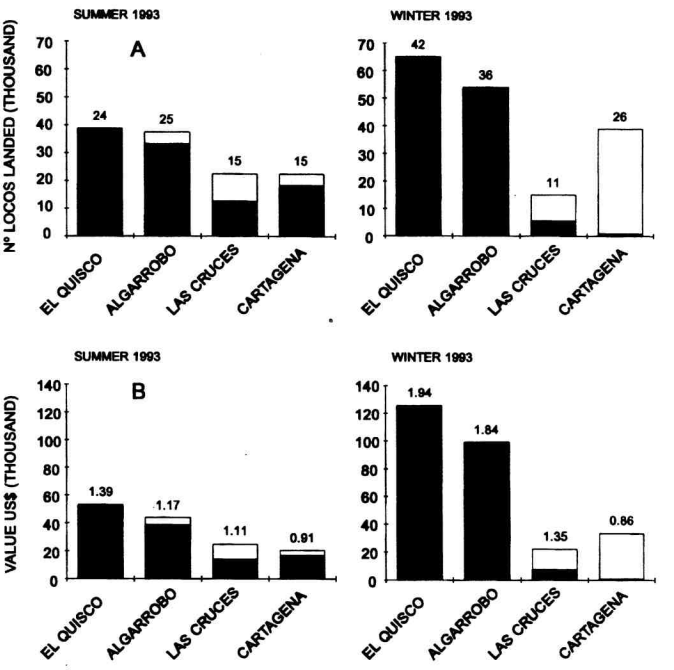

Table 1. Number of loco, *Concholepas concholepas*, in the 35 ha of suitable habitat at El Quisco Destinación.

Year	Month	Reproductive stage[a]	Harvestable stock size[b]			Catches
			Mean	Lower limit	Upper limit	
1992	February–March	1	165438	33331	807174	39347[c]
1993	March–May	2	150660	53085	425017	65446[d]
1994	March–May	2	61965	41933	91424	No catches

Note: Limits represent 95% confidence limits around the mean.

[a]Stage 1 represents initial stage of aggregation and stage 2 represents peak stage of aggregation.

[b]Individuals equal or larger than 10 cm peristome diameter.

[c]Loco harvest during summer 1993.

[d]Loco harvest during winter 1993.

The 1993–1994 loco fishery in Caletas of central Chile

During the 5- and 9-day summer and winter 1993 fisheries, respectively, Caleta El Quisco quotas were 36 000 and 63 000 locos, respectively. Landings were 39 347 and 65 446 locos from their Destinación (Fig. 3A). In the summer fishery, divers harvested 95% of the quota in the first two days, with experienced divers filling their individual quota in 1–2 trips. Individual loco from the summer and winter fishery averaged US$1.39 and 1.94, respectively (Fig. 3B). Caletas fishing on common ground were unable to achieve their assigned quotas (Fig. 3A), and loco selling prices ranged from US$0.91–1.17 (summer) to 0.86–1.84 (winter) (Fig. 3B). El Quisco Destinación's locos commanded higher prices because they were larger than others harvested.

A 1992 stock assessment of the El Quisco Destinación, done one year before the fishery was opened, indicated that the harvestable number of locos (>10 cm) was 165 438 (large confidence limits due to limited surveying, Table 1). In summer 1993, El Quisco divers harvested their quota in 3 days, and also landed their quota during the 1993 winter fishery. CPUE declined during each 1993 fishing season (Fig. 4). El Quisco summer CPUE decreased from 500 to 300 locos·h^{-1}, and winter CPUE dropped from 186 to about 100 locos·h^{-1} (Fig. 4). In 1994, in spite of quota allocations, there were no catches inside

Fig. 4. Daily CPUE (locos/diving hour) at Caletas El Quisco, Algarrobo, and Las Cruces during 1993 fishing seasons. El Quisco MEA summer extraction was preceded by a 30-month closure period (September 1990 – January 1993), and the winter extraction by a 6-month closure (February – July 1993). Bars indicate standard errors.

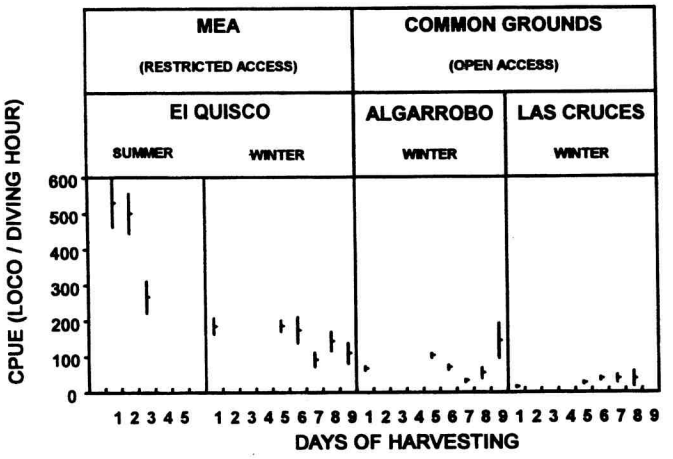

Table 2. Comparison of mean daily CPUE (loco per diving hour) from Caletas El Quisco, Algarrobo, and Las Cruces during 1993 fishing seasons, using Tukey's multiple comparison procedure.

Locality	*N*	Mean	SD	Tukey's multiple comparison grouping
El Quisco (summer)	3	433.02	143.50	a
El Quisco (winter)	6	148.30	40.70	b
Algarrobo (winter)	5	64.89	25.83	bc
Las Cruces (winter)	5	30.93	10.17	c

Note: Means with the same letter are not significantly different ($\alpha = 0.05$).

Fig. 5. Mean size of the locos harvested at Caletas El Quisco, Algarrobo, and Las Cruces during 1993 fishing seasons. El Quisco MEA summer extraction was preceded by a 30-month closure period (September 1990 – January 1993), and the winter extraction by a 6-month closure (February – July 1993). Bars indicate standard errors.

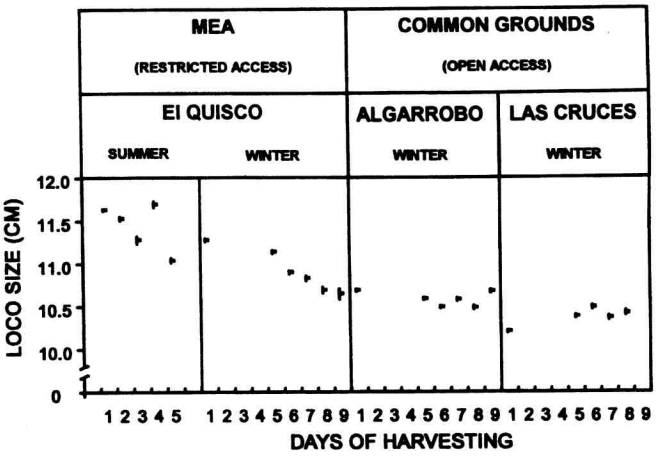

Table 3. Comparison of the mean daily travel time (h) from Caletas El Quisco, Algarrobo, and Las Cruces during 1993 fishing seasons, using Tukey's multiple comparison procedure.

Locality	*N*	Mean	SD	Tukey's multiple comparison grouping
El Quisco (summer)	3	1.69	0.31	ab
El Quisco (winter)	6	1.51	0.27	a
Algarrobo (winter)	5	2.68	1.06	b
Las Cruces (winter)	5	2.88	0.69	b

Note: Means with the same letter are not significantly different ($\alpha = 0.10$).

the Destinación due to lowering of loco market prices (Table 1).

At Algarrobo, CPUE ranged between 53 and 143 locos·h^{-1}, while at Las Cruces, CPUE ranged between 15 and 38 locos·h^{-1} (Fig. 4). Mean daily CPUE varied greatly both among fished locations and between summer and winter seasons (Table 2). Mean daily travel time in hours varied significantly by fishing locations, with El Quisco having the lowest values (Table 3).

In winter, Algarrobo divers selected diving grounds relatively far away, with a lower average CPUE (Fig. 4). On the last fishing day, Algarrobo divers dove at their Destinación, and achieved a CPUE similar to that obtained by El Quisco divers. Las Cruces divers had the lowest CPUE, and in contrast to Algarrobo divers, spent more time underwater searching for locos than travelling to fishing grounds.

During the summer fishery, El Quisco divers only harvested locos above 11 cm, larger than the minimum legal size (10 cm) and of higher value (Figs. 3 and 5). A declining trend in the size of harvested locos was observed over time (Fig. 5). Algarrobo and Las Cruces divers harvested locos no larger than 10.5–10.7 cm (Fig. 5), and obtained lower prices (Fig. 3B).

Discussion

Organized Caletas that were assigned Destinación (MEAs) and limited fishing on them prior to the 1993 loco fishing season (e.g., Caleta El Quisco) were rewarded with (*i*) an exclusive right to extract loco from their Destinación; (*ii*) highest CPUE during both fishing seasons (Fig. 4); (*iii*) harvest of the largest locos (Fig. 5), and (*iv*) highest market prices (Fig. 3B). Caletas that did not restrict diving activities before 1993 had to search distant common diving grounds, with greater travel time, to land assigned fishing quotas (Table 3) and consequently earned less profit (Fig. 3B). Cartagena could not even fulfill its assigned quotas. Furthermore, divers from these Caletas had CPUE 4–10 times lower than those observed at the El Quisco MEA.

Summer CPUE observed at Caleta El Quisco MEA (around 400 locos·h^{-1}) was comparable with CPUE in the early period of fishery development published by Castilla and Schmiede

(1979) for Caleta Horno in northern Chile (around 550 locos·h^{-1}). CPUE (30–60 locos·h^{-1}) observed on heavily exploited common fishing grounds in 1993 was comparable to that published by Geaghan and Castilla (1986, 1988) for Caleta Quintay in central Chile (80–160 locos·h^{-1}), when loco populations showed evidence of overexploitation.

We present the consequences of alternative exploitation approaches. El Quisco fishers, the best organized, implemented a loco refuge area 2–3 years before the fishery season was opened. Compared with fishers from other Caletas, they did well financially during the 1993 fishing seasons. However, among El Quisco syndicated members this has created an expectation for future loco fisheries that may be unrealistic, as not all factors are under Caleta control (e.g., market and loco abundance). For instance, loco price dropped dramatically in 1994, and as a consequence fishers stopped fishing (Table 1).

Data show that natural restocking of locos can occur, as evidenced by a high CPUE at El Quisco MEA after a 2-year closing (see concept of natural restocking, Castilla 1990*b*). If recruitment is regular, periodic exploitation may be economically attractive (Figs. 3B, 4; Payne and Castilla 1994). Comparison of small-scale, restricted management to open access on "common grounds," i.e., the paradigm of the "tragedy of the commons," has been widely addressed in the literature (Hardin 1968; Berkes 1985, 1987; Ostrom 1990; Castilla 1990*b*; Waters 1991; Bromley 1991; Smith and Berkes 1991; Castilla 1994). Nevertheless, regulations institutionalized in fishery law to deal with this are rare, as many jurisdictions are apprehensive about assigning "ownership" of the sea bottom to interest groups. The Chilean Fishery and Aquaculture Law regarding the management of benthic invertebrates permits testing alternative management approaches which address this dilemma.

Chile is still at an early stage in dealing with "open versus restricted" access issues. Current Chilean experimental management policies for loco can be considered a form of adaptive management (Walters and Hilborn 1978; Walters 1986; Hilborn and Walters 1992). Research priorities are (*i*) to learn about the carrying capacity of coastal MEAs along different stretches of coastline; (*ii*) to understand temporal and spatial variation in recruitment under an open system scenario (Jamieson 1993); (*iii*) to determine genetic spatial variability (Guiñez et al. 1992); and (*iv*) to describe larval dispersal patterns.

It is hoped that "experimental-management" strategies will continue in Chile for benthic invertebrates. Guiding concepts should include (*i*) more effective limited access policies through the establishment of both new MEAs and community-based or co-management scenarios (Alcala and Russ 1990; Castilla 1994); (*ii*) increasing the number of species that can be harvested by Caletas; (*iii*) introduction of harvesting rotation techniques and/or marine protected areas; and (*iv*) creation of a process to establish a network of marine parks and reserves in Chile (Castilla 1996), as has been done in other countries (White 1986; Davis 1989; García-Rubies and Zabala 1990; Roberts and Polunin 1991, 1993; Polunin and Roberts 1993; Bohnsack 1993; De Martini 1993; Carr and Reed 1993).

Acknowledgments

We sincerely acknowledge the continuous help, support, and friendship provided by the fishers of Caleta El Quisco, particularly by the President Señor Francisco Ceballos and the Secretary Señor Miguel Ramírez. Similarly, the artisanal fishers of Caletas Las Cruces and Algarrobo helped with the locos fishery data gathering. Without their help the quality of the information recounted in this paper could not have been achieved, because in small-scale fishery activities much depends on the accurate report of sea-going events along hundreds of fishing trips. Additionally, we sincerely thank our friends Holly Payne, Isabelle Minn, Cristián Pacheco, Claudio Romero, and Sergio Silva for helping with diving and fishery data assembly at the Caletas. The Servicio Nacional de Pesca, SERNAP, provided us with vital information. Financial support was provided to the senior author by FONDECYT/Chile, Project No. 193/0684; The Costal Resource Research Network, Halifax, Canada; Cooperation Program between Italy and the Pontificia Universidad Católica de Chile and the European Community Research Program, Contract N.CI1* - CT93-0338. Our friends Miriam Fernández and Neil Andrew revised the manuscript and suggested important modifications. We also thank an anonymous referee for suggestions and particularly the editor of this volume, Dr. Glen Jamieson. The paper was completed in 1996 thanks to the support of a Pew Fellowship to the senior author. We thank the Pew Foundation and The Center for Marine Conservation, U.S.A.

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