AIP 2025. Vol. 53:1-22
https://doi.org/10.22352/AIP202553009

ARTÍCULO CIENTÍFICO

Diet adjustment by *Lontra felina* (Molina, 1782) (Mustelidae, Carnivora) to El Niño /La Niña impact at Punta Patache (20° 48'S), Northern Chile

WALTER SIELFELD[1], MARCELA COLLAO-BARREDA & JORGE ACEVEDO[2]
[1] https://orcid.org/0000-0002-7055-5015
[2] https://orcid.org/0000-0002-6106-0838

OPEN ACCESS

Recibido:
24/09/2025
Revisado:
26/12/2025
Aceptado:
28/12/2025
Publicado en línea:
30/12/2025

Editor en Jefe:
Dr. Américo Montiel San Martín

ISSN 0718-686X

ABSTRACT

To study the effect of ENSO (El Niño Southern Oscillation) events on the diet of the chungungo [*Lontra felina* (Molina, 1782)] in northern Chile, fecal samples from Punta Patache (20°48'S, 70°11'50''W) were studied and analyzed. The samples were collected during three periods with different degrees of ENSO impact on the coastal macroalgal community. Feces from the following periods were studied and compared: Period 1 (1985/87): absence of kelp beds due to mortality generated by ENSO 1982/83, with extensive bleached bottoms with calcareous algae; Period 2 (1995): beginning of the cold ENSO phase with partial recovery of the intertidal belt of *Lessonia spicata*, the subtidal belt of *L. trabeculata* but absence of *Macrocystis integrifolia*; Period 3 (1999/2000): corresponds to the cold ENSO phase of 1998/2001 with reestablishment of the inter and subtidal kelp forests.

In the absence of kelp beds (period 1), the diet consisted primarily of fish (73.7% of prey), 18.4% crustaceans, and 7.9% mollusks. With the settlement of macroalgae (period 2), fish consumption decreased to 49.3% of prey and increased to 29.0% crustaceans and 13.0% mollusks. With the reestablishment of the kelp beds (period 3), fish consumption decreased to 22.6% of prey, while crustaceans accounted for 41.9% and mollusks 19.4%. Echinoderms were also consumed in 3.2%. Overall, the diversity (H') of fecal composition increases as kelp beds develop, from 2.15 (period 1) to 2.5 (period 2) and 2.8 (period 3) (statistically significantly different; $p < 0.06$).

The results show that the chungungo exhibits great adaptability to environmental changes, being able to survive in conditions of high impacts and low prey diversity

(period 1 of this study). However, it is unknown how these trophic restrictions can affect the nutritional and health status of the otters, their population density, reproductive rates, survival of offspring and adults, and other aspects important for species protection and conservation programs.

Key words: *Lontra felina*, northern Chile, diet adjustment, ENSO effects

Author contributions:
All authors greatly contributed to the manuscript. WS: coordination, sampling activity, data analysis, and manuscript writing. MC: sampling activity, data analysis, and manuscript reviewing. JA: sampling activity, conceptualization, and manuscript reviewing.

Competing interests
The authors declare that they have no competing interests.

Funding
This study was partially financed through the following projects:

Ajuste de dieta a cambios ambientales de tipo El Niño/La Niña en Lontra felina (Molina, 1782) (Mustelidae, Carnivora) de Punta Patache (20° 48'S), norte de Chile

RESUMEN

Con el fin de estudiar el efecto de los eventos ENSO (El Niño Southern Oscillation) sobre la dieta del chungungo [*Lontra felina* (Molina, 1782)] en el norte de Chile, se estudiaron y analizaron muestras fecales de Punta Patache (20°48'S, 70°11'50''W) colectadas en tres periodos con distinto grado de impacto de la comunidad litoral de macroalgas por eventos ENSO. Se estudiaron y compararon fecas de los siguientes periodos: Período 1 (1985/87): sin bosque de macroalgas pardas a causa de su mortalidad generada por ENSO 1982/83, con extensos fondos blanqueados con algas calcareas; Periodo 2 (1995): comienzo de fase fría ENSO con una recuperación parcial del cinturón intermareal de *Lessonia berteroana*, submareal de *L. trabeculata* y ausencia de *Macrocystis integrifolia*; Periodo 3 (1999/2000): corresponde a la fase fría ENSO 1998/2001 con reestablecimiento del bosque inter y submareal de macroalgas.

En ausencia de macroalgas (period 1) la dieta estuvo centrada principalmente en peces (73,7% de las presas) 18,4% de crustáceos y 7,9% moluscos. Con el repoblamiento de las macroalgas (periodo 2) los peces presentan una reducción a 49,3% de las presas y un aumento a 29,0% de crustáceos y 13,0% de moluscos. Con el reestablecimiento de los bosques de macroalgas (periodo 3) el consumo de peces baja a 22,6% de las presas y los crustaceos ascienden a 41,9% y moluscos 19,4%. Se agrega además un 3,2% de equinodermos. Conjuntamente la diversidad (H') de la composición fecal aumenta en la medida que se desarrollan los mantos de macroalgas desde 2,15 (periodo 1) a 2,5 (periodo 2) y 2,8 (periodo 3) (significativamente distintos estadisticamente; $p< 0,06$).

Los resultados indican que el chungungo presenta gran adaptabilidad a cambios ambientales, siendo capaz de sobrevivir en condiciones de alto impacto y baja diversidad de presas (periodo 1 de este estudio). Se desconoce sin embargo cómo estas restricciones de diversidad trófica afectan el estado nutricional y sanitario de los individuos, su densidad poblacional, las tasas de reproducción, la supervivencia de crías y adultos, y otros aspectos importantes para los programas de protección y conservación de la especie.

Palabras clave: *Lontra felina*, norte de Chile, ajuste dietario, efectos ENSO

INTRODUCTION

The chungungo, *Lontra felina* (Molina, 1782) (Carnivora: Mustelidae) inhabits the Pacific coast of South America, from northern Peru (9° S) to Cape Horn (55° S) in southern Chile and Strait of Lemaire (Pohle, 1919) and Los Estados Island in Argentina (Cassini, 2008; Alfaro-Shigueto *et al*., 2011; Valqui, 2012).

The habitat used by *L. felina* is the steep and exposed rocky Pacific coast, where its activity includes a home range of up to about 4 linear km of coast, 100 m offshore and up to 30 m inland from the continental coastal strip (Castilla & Bahamondes, 1979; Cabello, 1983; Sielfeld, 1990; Ebensperger & Castilla, 1991; Medina-Vogel *et al*., 2004, 2006; Villegas *et al*., 2006; Badilla & George-Nascimento, 2009).

In northern Chile these hard bottom habitats are dominated by vast kelp beds (Dayton, 1985; Steneck *et al*., 2002; Vásquez, 1992; Villegas *et al*., 2008) represented by *Lessonia spicata* in the intertidal (González *et al*., 2012) and *Lessonia trabeculata* and *Macrocystis integrifolia* (Bory) in the shallow subtidal (Villouta & Santelices, 1984; Hermosilla-Núñez *et al*., 2018).

These kelp beds provide a three-dimensional structured habitat for the settlement and development of a diverse invertebrates and fish fauna (Vásquez, 1992, Vásquez *et al*., 2001; Vega *et al*., 2005; Villegas *et al*., 2008).

As has been pointed out for *M. integrifolia* by Dayton (1972), the brown macroalgae represent structuring species that determine the diversity and trophic structure of the coastal ecosystems (Graham, 2004; Lilley & Schiel, 2006), offer protection and food supply (Vargas *et al*., 1999 a, b; Berrios & Vargas, 2004; Medina *et al*., 2004) for a varied fish fauna (Nuñez & Vásquez, 1987; Godoy, 2000; Angel & Ojeda, 2001; Pérez-Matus *et al*., 2007; Villegas *et al*., 2008) that includes different economically important resources (Graham *et al*., 2007) associated with the artisanal fishery, and supplement detrital channels and energy export to other systems (Harrold *et al*., 1998; Kaehler *et al*., 2000; Graham, 2004).

Several studies on the fauna associated with brown macroalgae forests (e.g. Ávila *et al*., 2005; Cancino & Santelices, 1984; Smith *et al*., 1996; Romo, 2004; Vásquez *et al*., 2001; Villegas *et al*., 2007) and details about the feeding of the chungungo (e.g. Ostfeld *et al*., 1989; Lariviére, 1998; Sielfeld, 1990; Medina-Vogel *et al*., 2004, 2008; Ruiz, 2009; Mangel *et al*., 2010) indicate its importance as top predator in the food web of these kelp structured systems.

Every diet analysis is embedded in time and space and is part of a dynamic process that results in temporal and spatial variation in dietary composition (Somers & Nel, 2003). Temporal variations are generally influenced by prey activity and abundance (Carss, 1995).

Along with this, the Southern Oscillation (ENSO) should be considered, causing climatic and oceanographic changes, more or less drastic and periodic (increased temperature, decrease in coastal upwelling, reduction in primary productivity) and generating mortality of communities, among them brown macroalgal forests (Martinez *et al*., 2003; Castilla & Camus, 1992; Tegner & Dayton, 1987), seabirds (Tovar & Cabrera, 1985) and sea mammals (Sielfeld & Guzmán, 2002). The recovery of these systems is variable in time and space (Foster & Van Blaricom, 2001) and very slow along the northern coast of Chile (Camus, 1994; Martinez *et al*., 2003).

Specifically, the strong 1982-1983 and 1997-1998 ENSO events produced the kelp extinction in Northern Chile (Soto, 1985; Tomicic, 1985; Vásquez *et al*., 2006) and California and Mexico (Ladah *et al*., 1999; Edwards, 2004). Regarding the structure of kelp-dominated subtidal rocky-shore communities in Antofagasta (23°26'S/70°36'W) during ENSO 1997/1998, Vásquez *et al*. (*op.cit*.) indicated a reduction of diversity (H') from around 1.5 to 0.5, a reduction in macroinvertebrate density of around 5 ind/m^2 to 1 ind/m^2, but no important variation in total species number.

The chungungo demonstrate great sinantropic capacity to adapt to human-modified environments (fishing, urban, ports, industrial, etc.) and to coexist with them (fishing coves, port sectors, management areas, etc.) (Cursach *et al*., 2012) under a series of threats arise in these conditions in relation to mortality and/or health, incidental capture in fishing gear, pumping and filtering systems of water for industrial purposes in mining ports, physiological stress, zoonotic diseases, ingestion of toxic substances and contact with harmful compounds (Cursach *et al*., 2012).

However, in conditions not affected by humans no attention has been paid to the dependence of the food web on the temporal variability of the macroalgae, a key issue in ecology (Bustamante & Branch, 1996; Graham, 2004; Graham *et al*., 2007).

In this study, the trophic behaviour of the chungungo at Punta Panache: Northern Chile was analyzed in kelp absence after 1982/83 strong ENSO, the partial recovery of the kelp beds at the final phase of the weak 1994/95 ENSO event and the restoration of the kelp beds in 1998/2001 La Niña cold phase after strong 1997/98 ENSO. In this sense, the study attempts to explain how the otters diet changes with the different prey availability resulting from the ENSO effects on the intertidal/shallow subtidal community structure described by Soto (1997), Martinez *et al*. (2003), Castilla & Camus (1992), Tegner & Dayton (1987) and fish (Sielfeld *et al*., 2010).

MATERIAL AND METHODS

The study was based on fecal analysis, a frequently used method in feeding studies of otters (Melquist & Hornocker, 1983; Reid *et al*., 1994; Spinola & Vaughan, 1995; Quadros & Monteiro-Filho, 2001; Copp & Roche, 2003; Somers & Nel, 2003; Watson & Lang, 2003; Medina-Vogel *et al*., 2004; Parker *et al*., 2005, Chehebar, 1985; Chehebar *et al*., 1986; Medina, 1995, 1997, 1998; Choupay, 2003) because visual monitoring of feeding behavior is difficult, especially in solitary and low-density species such as the chungungo (Valqui, 2004).

However the fecal analysis underestimates larger prey an overestimates smaller ones (Carss & Parkinson, 1996; Jacobsen & Hansen, 1996), a specially important aspect when assessing the presence of fish in the feces. When consuming fish, only part of the epaxial and hypaxial muscles of the trunk and tail are consumed, without ingestion of cephalic structures that facilitate identification, as was observed during visual observations of the capture and consumption of *Paralabrax humeralis*, *Scartichthys viridis/gigas*, *Genypterus blacodes* and *Scysiases sanguineus*, which were detected in the fecal analysis (pers. obs.). Also soft-bodied prey may be underrepresented and those with shells and hard structures are overrepresented (Larivière, 1998).

Punta Patache (20°48'S, 70°11'50''W), 66 Km south of Iquique: Northern Chile (Fig. 1) supports a small, most probably open group of around 5-6 individuals (Table 1) that interacts

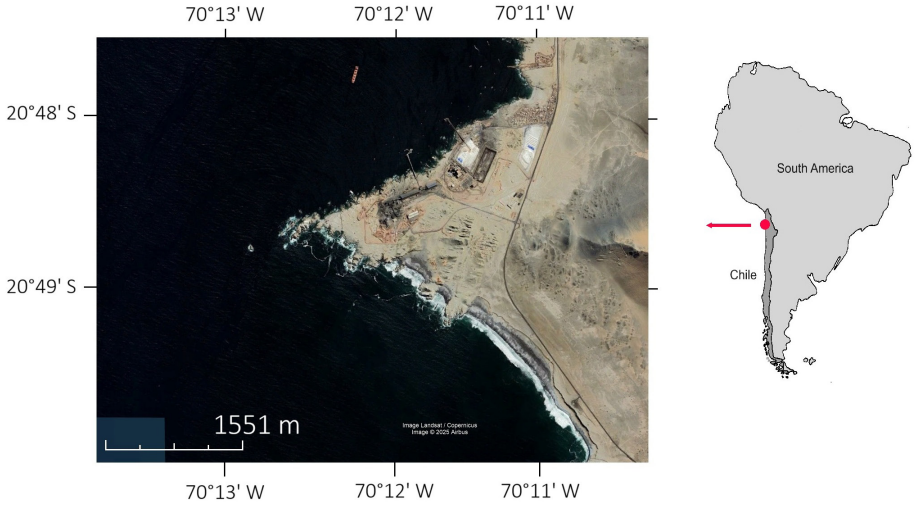


Figure 1:
The study area at Punta Patache, northern Chile.

with similar groups of Punta Patillos (20°43'S, 70°11'W) to the north and Chanavaya and Pabellón de Pica (20°54'S, 70°08') to the south. Otters were most frecuently observed swimming or interacting in tide pools (Fig. 2).

For the study 95 otter scats were collected between 1985 and 2000. According to a sighting programm (Table 1) the site was permanently inhabited by 3 - 4 individuals, reflecting its endangered status according to the International Union for Conservation of Natural Resources (IUCN, 2004; Alvarez & Medina, 2018; Valqui, 2012) due to hunting (Iriarte & Jaksic 1986) and habitat destruction by the growing port facilities, and explaining the relatively small scat sample size.

The shoreline is characterized by a rocky substratum, associated during the cold oceanic phase with an intertidal *Lessonia berteroana* belt and subtidal *L. trabeculata* forests and patches (Fig. 3). *Macrocystis pyrifera* desappeared from the area during El Niño 1082/83 and did not recover during the study period.

The samples were taken and placed individually in labeled paper bags and kept dry until cleaning and analyses. Hard part remains were separated from the moistened scats (otoliths, scales, spines, dentaries, chelae, shells, skeletons, etc.), by use of sieves (mesh size 1-10 mm) and washed with flush water. All the recovered parts were sorted under an Olympus SZ 30 stereomicroscope and Identification was conducted by use of reference specimens and support of the following literature: Chirichigno (1970), Retamal (1981), Zuñiga (2002): Decapoda, Viviani (1969): Anomura Porcellanidae; Marincovich (1976), Guzmán *et al.* (1998): Mollusca: Gastropoda & Pelecypoda; Tommasi (1968): Echinodermata.

Remains and/or structures impossible to identify to specific level, were grouped as "indeterminate" category and excluded from statistical analyses.

The minimum number of individuals was estimated from the greatest number of unique or paired structures. Presence of non-unique structures (teeth, vertebrae, legs) constituted a single individual.

Figure 2: Chungungos at Punta Patache: a: juveniles playing in a tide pool (1/08/2000); b: female teaching its cubs to dive in calm water (11/01/2001); c: general aspect of feces with scales and fish bones (5/10/1995).

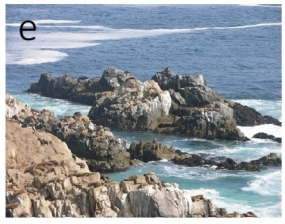


Figure 3: Habitat of chungungo at Punta Patache: a: general aspect of the study area (21/01/2010); b: channels (20/03/2008); c: caves (19/03/2008); d: islets (19/03/2008); e: roqueries (09/05/2010).

Small size species (<10 mm) and small specimens (<20 mm) of other species, are indicated with asterix (*) in table 1 and were excluded fron subsequent statistical analyses. They are part of the normal trophic spectrum of various rockfish species in the region (Berrios & Vargas, 2004; Fuentes, 1981, 1982; Medina *et al.*, 2004; Núñez & Vásquez, 1987; Vargas *et al.*, 1999 a,b,c; Pérez-Mattus *et al.*, 2012) and here considered as part of the stomach content of rockfish preyed upon by the chungungos.

For the statistical analysis the following methods applied to pinnipeds were used (see: Majluf, 1985; Bustos *et al.*, 2014):

Numerical method (%N): the percentage representation of a prey (species) within the total prey (all species), expressed as: $\boldsymbol{N = (ni / Nt) \times 100}$, where ***ni*** = number of individuals of the ith taxon, and ***Nt*** = total number of individuals of all the taxa in the analyzed feces.

Frequency of occurrence method (%F): the percentage representation of the occasions of appearance of a given prey within the total number of samples analyzed, expressed as: $\boldsymbol{F = (n/Nf) \times 100}$, where ***n*** = number of feces where the ith taxon is present, ***Nf*** = total number of analyzed feces.

Relative Importance Index (RI): expresses the importance of each prey item, expressed as: $\boldsymbol{RI = \%N \times \%F}$, which allows to estimate the preferred food (Holden & Raitt, 1974; Balbontin *et al.*, 1997; Vargas *et al.*, 1999 b), where: ***% N*** is the numerical abundance and ***% F*** the occurrence frequency.

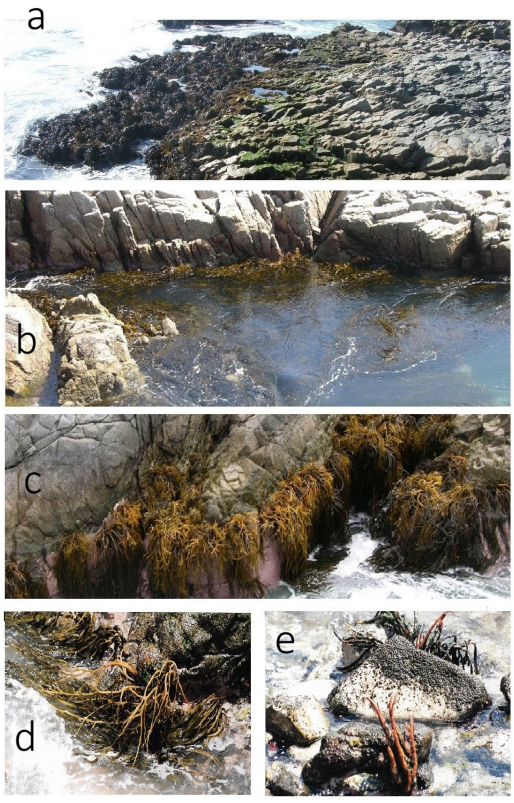


Figure 4:
The kelp bed and ENSO effect: a: extense *Lessonia spicata* belt during La Niña conditions (19/03/2008); b: wave protected rocky cove with intertidal *Lessonia spicata* belt and subtidal *Macrocystis integrifolia* during La Niña conditions (19/03/2008; c: *Lessonia spicata* belt affected by El Niño 1997/98 warming (03/08/1997); d: *Lessonia spicata* with dead phylloids during El Niño 1997/98 (10/01/98); e: dead *Lessonia spicata* during El Niño 1997/98 (05/03/98)

The SIMPROF function for significance level of sample statistics was performed as part of CLUSTER analyses generated by PRIMER-6 package (Clarke & Gorley, 2006). To examine differences between groups, ANOSIM was used to test the Bray-Curtis similarity for significance levels (p) and strength of factors (R) on the samples.

The analyses of diversity were conducted with untransformed abundance data in PAST 4 (Hammer 1999-2012) by Shannon diversity index (H') where differences between periods was tested with diversity t-test. (Bootstrap 999; p = 0.005)

The samples (see: table 2) were collected during the following periods:

Period 1 (1985/87): with cold/neutral conditions during 1985/86 and weak ENSO conditions during 1986/87 (thermal anomaly 2.2°C) (Fuenzalida, 1992), but in the study sector of Punta Patache still showing the devastating effects of ENSO 1982/83 (thermal anomaly 4.4°C) with the disappearance of the macroalgal belts and extensive areas covered by calcareous algae (bleached bottoms). During this period Martinez *et al.* (2003) analyzed the lack of colonization of *M. pyrifera* and Soto (1997) the incipient development of the intertidal belt of *L. spicata*. Fig. 4 ilustrates ENSO effects on kelp beds of Punta Patache.

Period 2 (1995): It extends from the final phase of the weak warm event in 1994/95 (thermal anomaly 1-1.2°C) that followed a moderate event in 1991/1992 (anomaly 2.4°C) (Fuenzalida, 1992), until the beginning of the cold phase in 1995/97 (NOAA, 2017). In the study area persisted the absence of *M. pyrifera*, a partial development of *L. spicata* belts and isolated individuals of *L. trabeculata*.

Period 3 (1999/2000): corresponds to the cold phase La Niña 1998/2001 (Schwing *et al*., 2002) with reestablished subtidal forests of *M. pyrifera* and *L. trabeculata* and the intertidal belt of *L. spicata*. Details in this regard for the northern zone and especially on invertebrates associated with the holdfasts were given by Godoy (2000), invertebrates between holdfasts by Villegas *et al*. (2007) and fish associated with the macroalgae by Pérez-Mattus *et al*. (2007).

Date	Solitary	2 individuals	3 individuals	Totals
30/11/1997			1h + 2 j	3
31/01/1998		2 i		2
01/05/1998			1 h +2 c	3
08/07/1999	1 m		1 h +2 j	4
01/09/1999	1 i ; 1 i	2 i		4
29/10/1999		2 i		2
11/11/1999	1 h			1
16/11/1999	1 i; 1 i			2
19/01/2000		1 h + 1 c		2
04/02/2000	1 i			1
07/03/2000	1 i			1
27/04/2000	1 i	1 h + 1 c		3
18/06/2000	1 i			1
08/07/2000	1 i			1
11/08/2000		2 j		2
10/09/2000	1 i			1
05/11/2000		1 h + 1 j		2
11/01/2001			1 h +2 c	3
13/01/2001	1 i			1
01/01/2002	+-	1 h + 1 c		2
Totals	**11**	**18**	**12**	41

Table 1: Sighting of *Lontra felina* at Punta Patache during November 1997 to January 2002 (m= males; h = females; c= cubs; j= juveniles; i = indeterminate) (Source: Sielfeld, 2003).

PERIOD	DATE	FECES (*n*)
Period 1: 1985 – 1987	17 May 1985	6
	13 November 1985	7
	13 April 1986	2
	07 July 1986	7
	06 October 1986	3
	21 January 1987	1
	Total feces period 1	26

Table 2. Number and collecting date of the analyzed feces samples

Period 2: 1995	23 September 1995	10
	30 September 1995	4
	08 October 1995	9
	Total feces period 2	23
Period 3: 1999 – 2000	08 July 1999	4
	01 September 1999	6
	29 September 1999	8
	13 December 1999	6
	19 January 2000	4
	04 February 2000	5
	12 August 2000	5
	10 September 2000	1
	03 November 2000	5
	30 December 2000	2
	Total feces period 3	46
Periods 1985 – 2000	Total feces all periods	95

RESULTS

70 species were identified in the scat samples along the complete sampling period. The most represented groups were gastropods (23 sp.), crustaceans (23 sp.), fishes (10 sp.) and bivalves (7 sp.), less represented were polyplacophorans, cirripeds, brachiopods, birds, bryozoans, algae and echinoderms (Table 3).

Considering the trophic level of the species (Table 3) 27.7% are filters (18 species), 27.7% herbivores (18 species), 21.5% carnivores (14 species), 10.8% omnivores (7 species) and 6.1% suspensivores (4 species). Algae (2 species), planctivores (1 species), scavengers (1 species) represent ≤ 3.0% of species.

If considering total prey specimens by trophic level (Table 4) 46.0% are carnivores (63 specimens), 27.7% filters (38 specimens), 16.1% herbivores (22 specimens) and 8.0% omnivores (11 specimens).

By period (Fig. 5), in absence of kelp (period 1 an 2) feeding concentrates on carnivores (45.5% and 53.6%), corresponding principally on fish and including in period 1 13.6% planctivores (anchovy). With restablished kelp beds (period 3) the trophic niche expands to filters (porcellanids, bivalves), omnivores (grapsids, xanthids) and herbivores (fisurellids).

Because of small size 35 species (see table 3; with (*)) were excluded from posterior analyses, being most likely part of the gut contents of fish depredated by the otters.

The remaining true prey species (Table 3) were represented by 9 rock fishes and the epipelagic *E. ringens,* only detected during period 1. Of the rockfishes *Ch. variegatus* and *Ch. crusma* were present during the three periods, *A. pictus* only during period 1, *S. maculatus* and *N. latifrons* periods 1 and 2, and *G. nigra*, *P. chilensis*, *A. microcirrhis* and *A. porosus* period 3. Al carnivorous species.

Crustacean included 10 anomuran filtering species, mainly 9 porcelanids (*Petrolisthes, Liopetrolisthes, Allopetrolisthes, Pachycheles*) and the pelagic/benthic *P. monodon*. Porcelanids were most abundant during period 2 (8 species, 69. 57% of total specimens).

The most frequent items for the complete period (1985-2000) (table 3) were Osteichthyes (68.42%), Crustacea (56.84%) and Mollusca (25.26%). The best represented items in terms of prey numbers were Osteichthyes (46.34%), Crustacea (32.32%) and Mollusca (14.63%) (table 3). Osteichthyes Relative Importance Index (IR) is most important over Crustacea (table 4) and at specific level the most important are *Ch. crusma* (IR =64.23), *Ch. variegatus* and *S. darwini* (IR=51.66), *N. latifrons*, *A. angulosus* and *A. punctatus* (IR=31.47) and *A. spinifrons*, *P. tuberculatus* and *L. mitra* (IR=16.04).

Feces samples of the three periods are well separated groups (Significance level of sample statistics = 55.8%; SIMPROF Pi= 0.65, p= 0.001; Fig. 6). Period 1 represents food items during an ENSO impacted period with missing kelp beds, Period 2 during a partially reestablished kelp bed and Period 3 with completely reestablished kelp conditions. Periods 2 and 3 are most similar (32.1) but significantly separated (Pi=3.69, p=0.001).

SIMPER (Similarity percentage) analysis shows that 3 periods have different prey compositions.

Periods 1 and 2 have a mean dissimilarity of 0.612. The species that mostly contribute to dissimilarity are *Semicossyphus* (7.1%), *Acanthistius* (5.1%), *Fisurella peruviana* (5.1%) and *Allopetrolisthes spinifrons* (4.1%). Periods 1 and 3 have a mean dissimilarity of 0.806. The species that mostly contribute to dissimilarity are *Fisurella peruviana* (8.3%), *Birds* (8.3%), *Acanthistius* (6.9%) and *Petrolisthes tuberculatus* (5.6%). Periods 2 and 3 show a mean dissimilarity of 0.714. The species that mostly contribute to dissimilarity are *Semicossiphus* (8.2%), Birds (6.1%) and *Chromis*, *Nexilosus*, *Chiton cummingsi* (5.1%).

The diversity (Shannon Index) showed an increasing value (period 1: H'= 2.15; var= 0.023; period 2: H'= 2.50; var= 0.0010; period 3: H'= 2.83; var=0.011), statistically different (p<0.06).

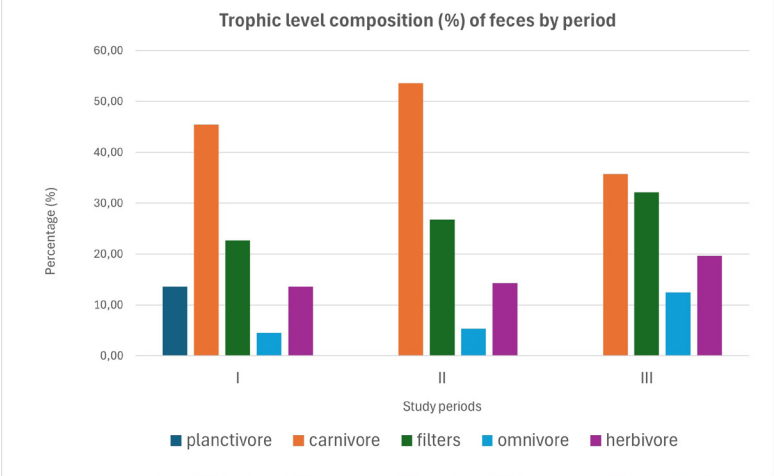
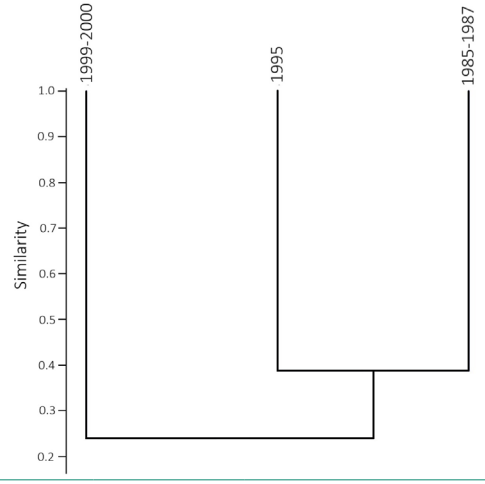


Figure 5: Trophic level composition (%) of feces by period.



.Figure 6: Dendrogramm

Class	Order	Families	*Species*	1	2	3	TI
Osteichthyes	Clupeiformes	Engraulidae	*Engraulis ringens Jenyns, 1842*	+			P
	Perciformes	Serranidae	*Acanthistius pictus (Tschudi, 1845)*	+			C
		Cheilodactylidae	*Cheilodactylus variegatus Valenciennes, 1833*	+	+	+	*C*
		Pomacentridae	*Chromis crusma (Valenciennes, 1833)*	+	+	+	*O*
			Nexilosus latifrons (Tschudi, 1844)	+	+		O
		Labridae	*Semicossyphus darwini (Jenyns, 1842)*	+	+		C
		Phocidae	*Graus nigra Philippi, 1887*			+	*C*
		Pinguipedidae	*Pinguipes chilensis (Molina, 1782)*			+	*C*
		Cliniidae	*Auchenionchus microcirrhis (Valenciennes, 1836)*			+	*C*
	Batrachoidiformes	Batrachoididae	*Aphos porosus (Valenciennes, 1837)*			+	*C*
Aves	Order indet.	Fam. *indet.*	*sp indet.*		+	+	*C*
Crustacea	Caridea	Rhynchocinetidae	*Rhynchocinetes typus H. Milne Edwards, 1837*	+			C
	Anomura	Porcellanidae	*Allopetrolisthes angulosus (Guérin, 1835)*	+	+	+	*F*
			Allopetrolisthes punctatus (Guérin, 1835)	+	+	+	*F*
			Allopetrolisthes spinifrons (H. Milne-Edwards,1837)		+	+	*F*
			Petrolisthes desmarestii (Guérin, 1835)	+			F
			Petrolisthes granulosus (Guérin, 1835)		+		F
			Petrolisthes tuberculatus (Guérin, 1835)		+	+	*F*
			Petrolisthes violaceus (Guérin, 1835)		+		F
			Liopetrolisthes mitra (Dana, 1852)	+		+	*F*
			Pachycheles grossimanus (Guérin, 1835)		+	+	*F*
		Paguridae	*Pagurus perlatus H. Milne Edwards, 1848(*)*			+	*O*
			Pagurus edwardsi (Dana, 1852) (*)			+	*O*
		Galatheidae	*Pleuroncodes monodon (H. Milne-Edwards, 1837)*			+	*F*
	Brachyura	Grapsidae	*Grapsus grapsus (Linnaeus, 1758)*		+	+	*O*
			Leptograpsus variegatus (Fabricius, 1793)			+	*O*
		Xanthidae	*Pilumnoides perlatus (Poepping, 1836)*	+	+	+	*O*
		Majidae	*Pisoides edwardsi (Bell, 1835)*			+	*C*

Tabla 3: Systematic list of prey species found in the otter scats during 1985 –2000 in Punta Patache, Northern Chile. 1: period 1985/87; 2: period 1995; 3: period 1999/2000; TI: trophic level (C=carnivore; O=omnivore; D=detritivore; H=herbivore; P=planctivore; S=suspensivore; F=filters; Sc=scavengers; Pp= primary producers)(for data see: Sielfeld 2025, in press).

		Atelecyclidae	*Acanthocyclus gayi/hassleri.*			+	*C*
	Cirripedia	Cthamalidae	*Notochtamalus scabrosus (Darwin, 1854)*			+	*S*
		Balanidae	*Balanus laevis Bruguière, 1789 (*)*			+	*S*
	Amphipoda	Ampeliscidae	*Ampelisca gibba Sars, 1882 (*)*			+	*D*
	Isopoda	Sphaeromatidae	*Sphaeromatidae sp. (*)*	+	+	+	*D*
Mollusca	Gastropoda	Littorinidae	*Nodilittorina peruviana (Lamarck, 1822) (*)*	+			H
		Fisurellidae	*Fissurella crassa Lamarck, 1822*		+		H
			Fissurella peruviana Lamarck, 1822	+	+	+	*H*
			Fissurella maxima Sowerby, 1835			+	*H*
			Fissurella latimarginata Sowerby, 1835			+	*H*
		Calyptraeidae	*Crepidula dilatata (Lamarck, 1822) (*)*			+	*S*
		Turbinidae	*Prisogaster niger (Wood, 1828) (*)*			+	*H*
		Trochidae	*Tegula atra (Lesson, 1830) (*)*		+		H
			Tegula luctuosa (Orbigny, 1840) (*)		+		H
			Tegula tridentata (Potiez & Michaud,1838) (*)		+		H
		Phasaniellidae	*Tricolia umbilicata (Orbigny, 1840) (*)*		+		H
			Tricolia macleani Marincovich,1973 (*)		+	+	*H*
		Columbellidae	*Mitrella caletae (Preston, 1915) (*)*			+	*C*
			Mitrella unifasciata (Sowerby, 1832) (*)		+	+	*C*
		Thaididae	*Concholepas concholepas (Bruguière, 1789)*		+	+	*C*
			Crassilabrum crassilabrum (Sowerby,1834) (*)			+	*C*
		Siphonariidae	*Siphonaria lessoni Blainville, 1824 (*)*	+	+	+	*H*
		Acmaeidae	*Collisella orbigny (Dall, 1909) (*)*	+	+	+	*H*
			Scurria bohmita (Ramirez, 1974) (*)			+	*H*
			Scurria plana (Philippi, 1846) (*)			+	*H*
			Scurria parasitica (Orbigny, 1841) (*)		+		H
		Nassariidae	*Nassarius gayi (Kiener, 1835) (*)*	+		+	*Sc*
	Polyplacophora	Chitonidae	*Chiton cumingsii Frembly, 1827*		+	+	*H*
			Chiton granosus Frembly, 1827			+	*H*
	Bivalvia	Mytilidae	*Aulacomya ater (Molina, 1782) (*)*	+			F
			Semimytilus algosus (Gould, 1850) (*)	+	+	+	*F*
		Petricolidae	*Petricolaria rugosa (Sowerby, 1834) (*)*			+	*F*
		Leptonidae	*Kellia tumbesiana Stempell, 1899 (*)*			+	*F*
		Chamidae	*Chama pellucida Broderip, 1835 (*)*			+	*F*
		Erycinidae	*Lasaea petitiana (Récluz, 1843) (*)*	+		+	*F*
		Hiatellidae	*Hiatella solida (Sowerby, 1834) (*)*		+		F
Brachiopoda	Lingulida	Discinidae	*Discinisca lamellosa (Broderip, 1833) (*)*	+			F
Echinodermata	Echinoidea	Arbaciidae	*Tetrapygus niger (Molina, 1782)*			+	*O*
Bryozoa	Cheilostomata	Fam. indet.	*Bryozoa indet. (*)*			+	*S*
Algae	Rhodophyta	Corallinaceae	*Corallina chilensis Decaisne, in: Harvey, 1849 (*)*		+	+	*Pp*
	Phaeophyta	Laminariaceae	*Lessonia nigrescens Bory, 1826 (*)*			+	*Pp*

PERIODS	1 (1985/87)				2 (1995)				3 (1999/2000)				TOTAL (1985/2000)			
Species	N	%	F	%	N	%	f	%	n	%	F	%	n	%	f	%
Fishes	28	73.68	26	100.00	34	49.28	23	100.0	14	23.33	14	34.78	76	45.51	65	68.42
E. ringens	3	7.89	3	11.54									3	1.80	3	3.16
A. pictus	5	13.16	5	19.23									5	2.99	5	5.26
Ch. Variegatus	1	2.63	1	3.85	4	5.80	4	17.39	4	6.67	4	8.70	9	5.39	9	9.47
Ch. Crusma	3	7.89	3	11.54	6	8.70	6	26.09	1	1.67	1	2.17	10	5.99	10	10.53
N. latifrons	2	5.26	2	7.69	5	7.25	5	21.74					7	4.19	7	7.37
S. darwini	1	2.63	1	3.85	8	11.60	8	34.78					9	5.39	9	9.47
G. nigra									2	3.33	2	4.35	2	1.20	2	2.11
P. chilensis									2	3.33	2	4.35	2	1.20	2	2.11
A. microcirrhis									1	1.67	1	2.17	1	0.60	1	1.05
A. porosus									2	3.33	2	4.35	2	1.20	2	2.11
Pisces indet.	13	34.2	13	50.00	11	15.94	11	47.83	2	3.23	2	4.35	26	15.57	26	27.37
Crustaceans	**7**	**18.42**	5	19.23	20	28.99	20	86.96	26	43.33	26	56.52	53	31.74	54	56.84
R. typus	1	2.63	1	3.85									1	0.60	1	1.05
A. angulosus	1	2.63	1	3.85	2	2.90	2	8.70	4	6.67	4	8.70	7	4.19	7	7.37
A. punctatus	1	2.63	1	3.85	2	2.90	2	8.70	4	6.67	4	8.70	7	4.19	7	7.37
A. spinifrons					4	5.80	4	17.39	1	1.67	1	2.17	5	2.99	5	5.26
A.. sp.					1	1.45	1	4.35					1	0.60	1	1.05
P. desmarestii	1	2.63	1	3.85									1	0.60	1	1.05
P. granulosus					1	1.45	1	4.35					1	0.60	1	1.05
P. tuberculatus					1	1.45	1	4.35	4	6.67	4	8.70	5	2.99	5	5.26
P. violaceus					3	4.35	3	13.04					3	1.80	3	3.16
L. mitra	2	5.26	2	7.69					3	5.00	3	6.52	5	2.99	5	5.26
P. grossimanus					2	2.90	2	8.0	1	1.67	1	2.17	3	1.80	3	3.16
P. monodon									1	1.67	1	2.17	1	0.60	1	1.05
G. grapsus					1	1.45	1	4.35	2	3.33	2	4.35	3	1.80	3	3.16
L. variegatus									1	1.67	1	2.17	1	0.60	1	1.05
Grapsidae indet.									1	1.67	1	2.17	1	0.60	1	1.05
P. perlatus	1	2.63	1	3.85	2	2.90	2	8.70	1	1.67	1	2.17	4	2.40	4	4.21
P. edwardsi									1	1.67	1	2.17	1	0.60	1	1.05
Acanthocyclus sp.									1	1.67	1	2.17	1	0.60	1	1.05
Porcellanidae sp.					1	1.45	1	4.35	1	1.67	1	2.17	2	1.20	2	2.11
Molluscs	**3**	**7.89**	**3**	**11.54**	**9**	**13.04**	**8**	34.78	12	20.00	12	26.09	24	14.37	24	25.26
F. crassa					1	1.45	1	4.35					1	0.60	1	1.05
F. peruviana	3	7.89	3	11.54	6	8.70	6	26.09	1	1.67	1	2.17	10	5.99	10	10.53
F. maxima									3	5.00	3	6.52	3	1.80	3	3.16
F. latimarginata									1	1.67	1	2.17	1	0.60	1	1.05
C. concholepas					1	1.45	1	4.35	1	1.67	1	2.17	2	1.20	2	2.11
Ch. Cumingsii					1	1.45	1	4.35	5	8.33	5	10.9	6	3.59	6	6.32
Ch. Granosus									1	1.67	1	2.17	1	0.60	1	1.05
Echinoderms									2	3.33	2	4.35	2	1.20	2	2.11
T. niger									2	3.33	2	4.35	2	1.20	2	2.11

Table 4: Occurrence of prey by sampling period: s = samples; n = individuals ; % = percentage of total individuals.

Birds					6	8.70	6	26.09	6	10.00	6	13.04	12	7.19	12	12.63				
Birds indet.					6	8.70	6	26.09	6	10.00	6	13.04	12	7.19	12	12.63				
TOTALES	38	100.0	26	100.0	69	100.0	23	100.0	60	100.0	46	100.0	167	100.0	95	100.0				

PERIODS	1	2	3	TOTAL
Species	IR	IR	IR	IR
Fishes	7368.0	4928.0	785.33	3170.58
E. ringens	91.05			5.78
A. pictus	253.07			16.04
Ch. Variegatus	10.13	100.86	56.12	51.99
Ch. Crusma	91.05	226.98	3.49	64.23
N. latifrons	40.45	157.62		31.47
S. darwini	10.13	403.45		51.99
G. nigra			14.05	2.57
P. chilensis			14.05	2.57
A. microcirrhis			3.49	0.64
A. porosus			14.05	2.57
Crustaceans	354.22	2520.97	2370.45	1837.07
R. typus	10.13			0.64
A. angulosus	10.13	25.23	56.12	31.47
A. punctatus	10.13	25.23	56.12	31.47
A. spinifrons		100.86	3.49	16.04
P. desmarestii	10.13			0.64
P. granulosus		6.31		0.64
P. tuberculatus		6.31	56.12	16.04
P. violaceus		56.72		5.78
L. mitra	40.45		30.25	16.04
P. grossimanus		25.23	3.49	5.78
P. monodon			3.49	0.64
G. grapsus		6.31	14.05	5.78
L. variegatus			3.49	0.64
P. perlatus	10.13	25.23	3.49	10.27
P. edwardsi			3.49	0.64
Acanthocyclus sp.			3.49	0.64
Molluscs	91.05	453.53	504.84	369.55
F. crassa		6.31		0.64
F. peruviana	91.05		3.49	64.23
F. maxima			31.56	5.78
F. latimarginata			3.49	0.64
C. concholepas		6.31	3.49	2.57
Ch. Cumingsii		6.31	87.85	23.13
Ch. Granosus			3.49	0.64

Table 4: Relative Importance Index (IR) of major groups and prey species found in feces of the three sampling periods

Echinoderms		14.05	2.57
T. niger		14.05	2.57
Birds	226.98	126.23	92.45
Birds indet.	226.98	126.23	92.45

DISCUSSION

35 species (6 crustaceans, 25 mollusks, 1 brachiopod,1 bryozoan and 2 algae) found in the scats were considered as part of the normal trophic spectrum of various rockfish species in the region (Berrios & Vargas, 2004; Fuentes, 1981, 1982; Medina *et al*., 2004; Núñez & Vásquez, 1987; Vargas *et al*., 1999 a,b,c; Pérez-Mattus *et al*., 2012), and are part of the invertebrate community that live associated with the kelp forests (Cancino & Santelices, 1981, 1984; Vásquez & Santelices, 1984; Soto, 1997; Villegas *et al*., 2009; Godoy, 2000).

The items Crustacea and Mollusca are probably overestimated, since some of the species found in the feces may also have been part of the gut contents of fishes. For example *Petrolisthes*, *Liopetrolisthes*, *Allopetrolisthes* and *Pachycheles* (crustaceans), *Fisurella* and *Chiton* (mollusks), also constitute part of the diet of the fishes *Acanthisthius pictus*, *Pinguipes chilensis*, *Paralabrax humeralis* and *Semicossyphus darwini* (Vásquez, 1993; Vargas *et al*., 1999 a, b; Berrios & Vargas, 2004; Medina *et al*., 2004) also found in the present samples.

The results show a chungungo perfectly integrated into the rocky coastal ecosystem, primarily into the brown macroalgal forest communities on which it depends trophically, playing a role of

"top predator" or "keystone species" as coined by Paine (1969), extended by Power *et al*. (1996), and widely used for different species (e.g., Delibes-Mateos *et al*., 2007; Estes *et al*., 1998; Gaymer & Himmelman, 2008; Menge *et al*., 1994; Münzbergová & Ward, 2002).

The species involved in the chungungo diet (Tables 3 and 4) are part of the kelp community and the difference in trophic diversity between period 1 (absence of kelp; H' = 2.15) and period 3 (with kelp beds; H' = 2.83) show the importance of this relationship.

In conditions of high environmental impact such as period 1 of this study, the chungungo apparently shows a remarkable adaptability to environmental changes and low prey diversity. In this case, in abcense of kelp, the diet focused principally on rockfishes, and with the gradual development of the kelp beds and settlement of invertebrates the diet expands to herbivores (mollusks), filters and scavengers (crustaceans) (Fig. 5).

A similar situation has already been demonstrated by Cursach *et al*. (2012) and described as "synanthropic behavior", reflected in the adjustment of its trophic behavior to changes in food supply derived from anthropic effects of coastal intervention.

However, it is unknown how these restrictions on trophic diversity affect the nutritional and health status of individuals, its population density, reproduction rates, survival of pups and adults, and other aspects of importance to species protection and conservation programs.

Actually in Chile, the growing extraction pressure of rock fishes, seafood and kelp and

allocation of benthic resource management areas to coastal fishermen communities generate situations of kelp bed destruction and harvest comparable to the changes attributed to ENSO anomalies (Fig. 7).

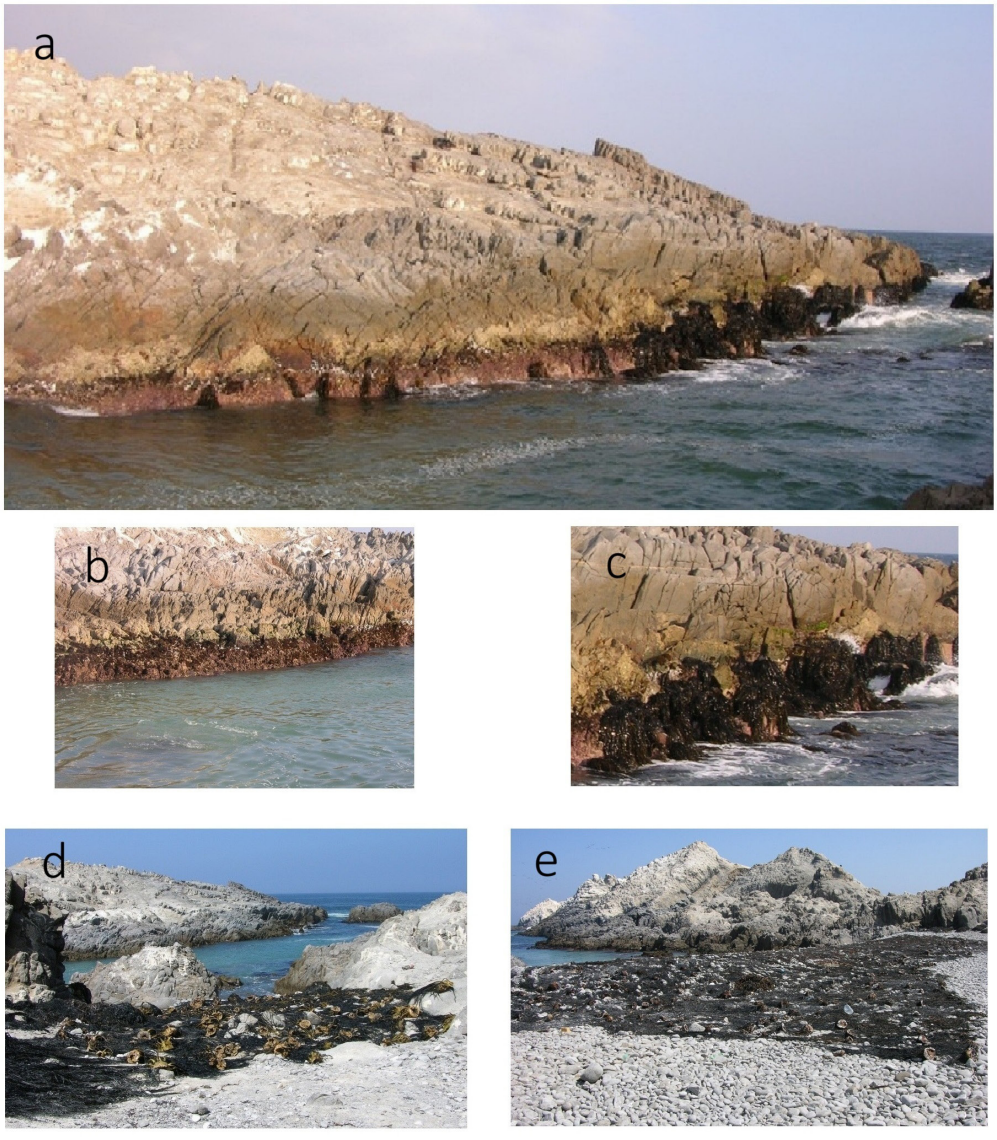


Figure 7: Kelp harvesting at Punta Patache: a: rocky shore affected by Lessonia spicata harvesting (26/07/2010); b: close up of harvested sector; c: detail of the unaffected sector; d: harvested Lessonia spicata and L. trabeculata in drying process on a boulder beach (20/03/2008); e: drying of kelp in another nearby area (19/03/2008).

The effects of the kelp harvest are not adequately addressed, principally for cases like the chungungo and several shorebirds (ej. Pato lile [*Phalacrocorax gaimardi* (Lesson & Garnot, 1828)], steamer duck (*Tachyeres pteneres* Forster, 1844), pilpilén (*Haematopus ater* Viellot & Oudart, 1825) and different plovers and sandpipers), but at least in case of the chungungo it is a fundamental aspect for the future conservation of otters.

The actual kelp harvest industry is extensive and along the coast from Arica to Chiloé (18°28′42″S - 18°28′- 43°34′S) and does not consider exclusion zones. According to the 2025 fishing yearbook (Desembarque total año 2024 por especie y región, SUBPESCA, 2025) the anual harvest reached 233.300 t of *Lessonia spicata/berteroana*, 52.517 t *Lessonia trabeculata*, 26.786 t *Macrocystis integrifolia* and 10.562 t *Durvillaea antartica* this last species harvested from Chañaral (26°S) to the south. In Northern Chile: Arica and Tarapacá Regions (18°28′S – 21°56′S) a harvest of 31.123 t of *L. spicata*, 2.585 t *L. trabeculata* and 65 t *M. integrifolia* were reported.

In terms of conservation and protection of the chungungo, the above data are of the utmost importance as they directly affect the habitat and alter the food chain of the system. Elements that further aggravate the situation are the lack of exclusion zones for kelp harvesting, as well as the fact that 75.5% of the harvest corresponds to intertidal species (*L. spicata, L. berteroana, D. antartica*) and are fundamental elements in the structuring of the chungungo's habitat (Villegas. *et al*., 2007).

ACKNOWLEDGEMENTS

The authors wish to thank to Compañía Minera Doña Inés de Collahusi SCM and Termoeléctrica CELTA S.A., both from Puerto Patache (Tarapacá Region), which made it possible to collect information on the chungungo diet in that area.

LITERATURE CITED

Alfaro-Shigueto, J., J. Valqui & J.C. Mangel. (2011). Nuevo registro de la nutria marina *Lontra felina* (Molina, 1782) al norte de su distribución actual. *Ecología Aplicada*, 10: 87-91.

Álvarez, R. & G. Medina-Vogel. (2008). *Lontra felina*. IUCN 2011: Red list of threatened species. International Union for Conservation of Nature and Natural Resources. [on line] <www.iucnredlist.org>

Ángel, A. & F.P. Ojeda. (2001). Structure and trophic organization of subtidal fish assemblages on the northern Chilean coast: the effect of the habitat complexity. *Marine Ecology Progress Series*, 217: 81-91.

Ávila, M., J. Cáceres, M. Núñez, P. Camus, H. Romo & R. Pérez. (2005). *Evaluación y manejo de praderas de feofitas en la provincia de Arauco*. Subsecretaría de Pesca, Chile. Informe Final Proyecto FIP 2003/19, 262 pp.

Badilla, M. & M. George-Nascimento. (2009). Conducta diurna del chungungo *Lontra felina* (Molina, 1782) en dos localidades de la costa de Talcahuano, Chile: ¿efectos de la exposición al oleaje y de las actividades humanas?. *Revista de Biología Marina y Oceanografía*, 44: 409-415.

Balbontín, F., A. Llanos & V. Valenzuela. (1997). Sobreposición trófica e incidencia alimentaria en larvas de peces de Chile central. *Revista Chilena de Historia Natural*, 70: 381-390.

Berrios, V. & M. Vargas. (2004). Estructura trófica de la asociación de peces intermareales de la costa norte de Chile. *Revista de Biología Tropical*, 52: 201-212.

Bray, J.R. & J.T. Curtis. (1957). An ordination of the upland forest communities of Southern Wisconsin. *Ecological Monographies*, 27:325-349.

Bustamante, R.H. & G.M. Branch. (1996). The dependence of intertidal consumers on kelp derived organic matter on the west coast of South Africa. *Journal of Experimental Marine Biology and Ecology*, 196 (1-2): 1-28.

Bustos, R.L., G.A. Daneri, A.V. Volpedo, A. Harrington & E.A. Varela. (2014). Diet of the South American sea lion *Otaria flavescens* during the summer season at Río Negro, Patagonia, Argentina. *Aquatic Biology*, 20: 235-243.

Cabello, C.C. (1983). La Nutria de Mar en la Isla de Chiloé. CONAF. Bol. Tec. 6: 1-37.

Cancino, J. & B. Santelices. (1981). The ecological importance of kelp-like holdfasts as habitat of invertebrates in Central Chile. II. In: Levring, T. (Ed.) *Factors affecting community organization.* Proceedings International Seaweed Symposium, 10: 241-246.

Cassini, M.H. (2008). Present status of *Lontra felina* in Argentina. *Endangered Species Update,* 25: 1-2.

Castilla, J.C. & I. Bahamondes. (1979). Observaciones conductuales y ecológicas sobre *Lutra felina* (Molina) 1782 (Carnivora: Mustelidae) en las zonas central y centronorte de Chile. *Archivos de Biología y Medicina Experimental*, 12: 119-132.

Castilla, J. C. & P.A. Camus. (1992). The Humboldt-El Niño scenario: Coastal benthic resources and anthropogenic influences, with particular reference to the 1982/83 ENSO. In: A.I.L. Payne, K.H. Brink, K.H. Mann & R. Hilborn (Eds.). Benguela trophic functioning, *South African Journal of Marine Science*,12:703-712.

Chehebar, C. (1985). A Survey of the Southern River Otter *Lutra provocax* Thomas in Nahuel Huapi National Park, Argentina. *Biological Conservation*, 32:299-307.

Chehebar, C., A. Gallur, G. Giannico, M.D. Gottelli & P. Yorio. (1986). A Survey of the Southern River Otter *Lutra provocax* in Lanin, Puelo and Los Alerces National Parks, Argentina, and Evaluation of its Conservation Status. *Biological Conservation*, 38: 293-304.

Chirichigno, N. (1970). *Lista de crustáceos del Perú (Decapoda y Stomatopoda) con datos de su distribución geográfica*. Instituto del Mar del Perú, 35:1-95.

Choupay, U. (2003). Dieta de la nutria de río Sudamericana, *Lontra provocax* Thomas 1908, (Mammalia, Carnivora, Mustelidae), en el Parque Nacional Laguna San Rafael. Tesis Biólogo Marino, Facultad de Ciencias del Mar, Universidad de Valparaíso, 60 pp.

Clarke, K.R. & R.N. Gorley. (2006). PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth Marine Laboratory, U.K., 190 pp.

Copp, G. H. & K. Roche. (2003). Range and diet of Eurasian otters *Lutra lutra* (L) in the catchment of the River Lee (south-east of England) since re-introduction. *Acuatic Conservation: Marine Freshwater Ecosystems*, 13: 65-76.

Cursach, J.A., J.R. Rau, F. Ther, J. Vilugrón & C.N. Tobar. (2012). Sinantropía y conservación marina: el caso del chungungo *Lontra felina* en el sur de Chile. *Revista de Biología Marina y Oceanografía*, 47(3): 593-597.

Dayton, P.K. (1972). Toward an understanding of community resilience and the potential effects of enrichments to the benthos at McMurdo Sound, Antarctica, in Parker, B.C. (Ed.): Proceedings of the Colloquium on Conservation Problems in Antarctica, pp.81-95, Virginia, USA.

Dayton, P.K. (1985). Ecology of Kelp Communities. Annual Review of Ecology and Systematics 16: 215-245.

Delibes-Mateos, M., S.M. Redpath, E. Angulo, P. Ferreras & R. Villafuerte. (2007). Rabbits as a keystone species in southern Europe. *Biological Conservation*, 137:149-156.

Ebensperger, L.A. & J.C. Castilla. (1991). Conducta y densidad poblacional de *Lutra felina* en Isla Pan de Azúcar (III Región), Chile. *Medio Ambiente*, 11:79-83.

Edwards, M.S. (2004). Estimating scale-dependency in disturbance impacts: El Ninos and giant kelp forests in the northeast Pacific. *Oecologia*, 138: 436-447.

Foster, M. S. & G.R. Van Blaricom. (2001). Spatial variation in kelp forest communities along the Big Sur Coast of central California, USA. *Cryptogamie, Algologie*, 22:173- 86.

Fuentes, H. (1981). Nicho alimentario de *Pimelometopon maculatus* (Perez, 1886) (Piscis; Labridae) en Playa Blanca, Iquique. *Boletín Sociedad de Biología de Concepción*, 51:109-117.

Fuentes, H. (1982). Feeding habits of *Graus nigra* (Labridae) in coastal waters of Iquique in northern Chile. *Japanese Journal of Ichthyology*, 29: 95-98.

Fuenzalida, R. (1992). Proceso de surgencia en la región norte de Chile, latitudes 20°30'S-21°45'S. *Investigaciones Científicas y Tecnológicas, Serie: Ciencias del Mar*, 2:79-104.

Fuenzalida, R., J. Blanco, R. Núñez & S. Hormazabal. (1999). Efectos oceanográficos y meteorológicos durante el evento El Niño 1997-98, en la zona de Iquique (20°S). *Revista de Investigaciones Científicas y Tecnológicas, Serie Ciencias del Mar*, 4(1-3): 56-59.

Gaymer, C. F. & J.H. Himmelman. (2008). A keystone predatory sea star in the intertidal zone is controlled by a higher-order predatory sea star in the subtidal zone. *Marine Ecology Progress Series*, 370: 143-153.

Godoy, N. (2000). *Macrocystis integrifolia* (Laminariales, Phaeophyta) en el norte de Chile: Distribución espacio-temporal y fauna asociada. Marine Biologist Thesis. Facultad de Ciencias del Mar, Universidad Católica del Norte, Coquimbo, Chile.

González, A., J. Beltrán, L. Hiriart-Bertrand, V. Flores, B. de Reviers, J.A. Correa & B. Santelices. (2012). Identification of cryptic species in the *Lessonia nigrescens* complex (Phaeophyceae, Laminariales). *Journal of Phycology*, 48(5): 1153-1165.

Graham, M.H. (2004). Effects of local deforestation on the diversity and structure of southern California giant kelp forest food webs. *Ecosystems*, 7(4): 341-357.

Graham, M.H., J. Vásquez & A.H. Buschmann. (2007). Global ecology of the giant kelp *Macrocystis*: from ecotypes to ecosystems, *Oceanography and Marine Biology Annual Review*, 45: 39-88.

Guzmán, N., S. Saa & L. Ortlieb. (1998). Catálogo descriptivo de los moluscos litorales (Gastropoda y Pelecypoda) de la zona de Antofagasta, 23°S (Chile). *Estudios Oceanológicos*, 17:17-86.

Hammer, Ø. (1999-2012). PAST, PAleontological Statistics, Version 2.17, Reference Manual, Natural History Museum, University of Oslo, ohammer@nhm.uio.no , 229 pp.

Harrold, C., K. Light & S. Lisin. (1998). Organic enrichment of submarine-canyon and continental-shelf benthic communities by macroalgal drift imported from nearshore kelp forests. *Limnology and Oceanography*, 43(4): 669-678.

Hermosilla-Núñez, B., M. Ortíz & F.A. Rodriguez-Zaragoza. (2018). Keystone species complexes in kelp forest ecosystems along the northern Chilean coast (SE Pacific): Improving multispecies management strategies. *Ecological Indicators*, 93:1101-1111.

Holden, M.J. & D.F.S. Raitt. (1974). *Manual of fisheries science. Part 2. Methods of resource investigation and their application*. FAO Fishery Technical Paper (115) Rev. l. 214 pp.

Iriarte, J. & F. Jaksic. (1986). The fur trade in Chile: an overview of seventy-five years of export data (1910-1984). *Biological Conservation*, 38: 243-253.

Kaehler, S.E., A. Pakhomov & C.D. McQuaid. (2000). Trophic structure of the marine food web at the Prince Edward Islands (Southern Ocean) determined by δ13C and δ15N analysis, *Marine Ecology Progress Series*, 208: 13-0.

Ladah, L.B., J.A. Zertuche-González & G. Hernández-Carmona. (1999). Giant kelp (*Macrocystis pyrifera*, Pheophyceae), recruitment nears its southern limit in Baja California after mass disappearance during ENSO 1997-1998. *Journal of Phycology*, 35: 1106-1112.

Larivière, S. (1998). *Lontra felina*. *Mammalian Species*, 575: 1-9.

Lilley, S.A. & D.R. Schiel. (2006). Community effects following the deletion of a habitat forming algae from rocky marine shores. *Oecologia*, 148(4): 672-681.

Majluf, P. (1984). *Ecology and breeding biology of the South American fur seal (Arctocephalus australis) at Punta San Juan, Perú*. Preliminary Report to the ARC-New York Zoological Society, December 1984, 10 pp.

Mangel, J, T. Whitty, G. Medina-Vogel, J. Alfaro-Shigueto, C. Cáceres & B. Godley. (2011). Latitudinal variation in diet and patterns of human interaction in the marine otter. *Marine Mammal Science*, 27: 14-25.

Marincovich, L. (1973). Intertidal mollusks of Iquique, Chile. *Natural History Museum, Los Angeles County Science Bulletin*, 16: 1-45.

Martínez, E.A., L. Cárdenas & R. Pinto. (2003). Recovery and genetic diversity of the intertidal kelp *Lessonia nigrescens* (Phaeophyceae) 20 years after El Niño 1982/83. *Journal of Phycology*, 39: 504-508.

Medina, G. (1995). *Feeding habits of marine otter (Lutra felina) in southern Chile*. Proceedings of the International Otter Colloquium 6: 65-68.

Medina, G. (1997). A comparison of diet and distribution of southern river otter (*Lutra provocax*) and mink (*Mustela vison*) in southern Chile. *Journal of Zoology (London)*, 242: 291-297.

Medina, G. (1998). Seasonal variation and changes in the diet of southern river otter in different freshwater habitats in Chile. *Acta Theriologica*, 43: 285-292. https://doi.org/10.4098/AT.arch.98-23

Medina M, C. Vega & M. Araya. (2004). Alimentación y relaciones tróficas de peces costeros de la zona norte de Chile. *Investigaciones Marinas*, 32: 33-47.

Medina-Vogel, G., C. Delgado & R.E. Álvarez. (2004). Feeding ecology of the marine otter (*Lutra felina*) in a rocky seashore of the south of Chile. Marine Mammal Science, 20 1): 134-144.

Medina-Vogel, G., J.L. Bartheld, R. Álvarez & C. Delgado. (2006). Population assessment and habitat use of marine otter (*Lontra felina*) in southern Chile. *Wildlife Biology*, 12(2):191-199.

Medina-Vogel, G., L.O. Merino, R. Monsalve Alarcón & J.A. Vianna. (2008). Coastal marine discontinuities, critical patch size and isolation: implications for marine otter conservation. *Animal Conservation*, 11: 57-64.

Melquist, W. E. & M.G. Hornocker. (1983). Ecology of river otters in west central Idaho. *Wildlife Monographs*, 83: 1-60.

Menge, B.A., E.L. Berlow, C.A. Balchette, S.A. Navarrete & S.B. Yamada. (1994). The keystone species concept: variation in interaction strength in a rocky intertidal habitat. *Ecological Monographs*, 64: 249-286.

Münzbergová, Z. & D. Ward. (2002). Acacia trees as keystone species in the Negev desert ecosystems. *Journal of Vegetation Science*, 13 (2):227-236.

NOAA. (2017). *Cold and Warm Episodes by Season 1950-2017.* National Weather Service. Climate Prediction Center (http://www.cpc.noaa.gov).

Núñez, L. & J.A. Vásquez. (1987). Observaciones tróficas y de distribución espacial de peces asociados a un bosque submareal de *Lessonia trabeculata*. *Estudios Oceanológicos*, 6: 79-85.

Ostfeld, R., L. Ebensperger, L. Klosterman & J.C. Castilla. (1989). Foraging, activity budget and social behavior of the South American marine otter *Lutra felina* (Molina, 1782). *National Geographic Research*, 5(4):422-438.

Paine, R. T. (1969). A Note on Trophic Complexity and Community Stability. *The American Naturalist*. 103(929): 91-93.

Parker, D. M., R.K. Burchell & R.T.F. Bernard. (2005). The diet of clawless otters at two sites along the Bloukvans river, Eastern Cape Province, South Africa. *African Zoology*, 40: 330-334.

Pérez-Matus, A., L.A. Ferry-Graham, AA. Cea & J.A. Vásquez. (2007). Community structure of temperate reef fishes in kelp-dominated subtidal habitats of northern Chile. *Marine and Freshwater Research*, 58: 1069-1085.

Pérez-Mattus, A., S. Pledger, F.J. Díaz, L.A. Ferry & J.A. Vásquez. (2012). Plasticity in feeding selectivity and trophic structure of kelp forest associated fishes from northern Chile. *Revista Chilena de Historia Natural*, 85:29-48.

Pohle, H. 1919. Die Unterfamilie del Lutrinae (Eine systematische tiergeographische Studie an dem Material der Berliner Museen). Archiv Naturg., Jahrgang 58, Abt.A. Heft 9: 1-247.

Power, M.E., D. Tilman, J.A. Estes, B.A. Menge, W.J. Bond, L.S. Mills, G. Daily, J.C. Castilla, J. Lubchenco & R.T. Paine. (1996). Challenges in the quest for keystones. *Bioscience*, 46(8): 609-620.

Quadros, J. & E.L.A. Monteiro-Filho. (2001). Diet of the Neotropical Otter, *Lontra longicaudis*, in Atlantic Forest Area, Santa Catarina State, Southern Brazil. *Studies on Neotropical Fauna and Environment*, 36: 15-21.

Reid, D.G., T.E. Code, A.C.H. Reid & S.M. Herrero. (1994). Food habits of the river otter in a boreal ecosystem. *Canadian Journal of Zoology*, 72:1314-1324.

Retamal, M.A. (1981). Catálogo ilustrado de los crustáceos decápodos de Chile. *Gayana (Zoología)*: 44:7-110.

Romo, H. (2004). *Las praderas de algas*. En: C, Werlinger (ed.) Biología Marina y Oceanografía: Conceptos y Procesos (Tomo II). Concepción, Chile. 696 pp.

Ruiz, E. (2009). *Estudio etológico de la nutria marina Lontra felina (Molina, 1782) en un ambiente antrópico, la bahía de Pucusana -Lima, Perú de junio a agosto del 2008.* Tesis para optar el título de Biólogo. Universidad Nacional Agraria La Molina (UNALM), Lima, 55 pp.

Schwing, F.B., T. Murphree, L. de Witt & P.M. Green. (2002). The evolution of oceanic and atmospheric anomalies in the northeast Pacific during the El Niño and La Niña events of 1995-2001. *Progress in Oceanography*, 53: 115-139.

Sielfeld, W. (1990). Dieta del Chungungo (*Lutra felina* (Molina, 1782)) Mustelidae, Carnivora) en Chile austral. *Investigaciones Cientificas y Tecnologicas, Serie: Ciencias del Mar*, 1: 23-29.

Sielfeld, W. (2003). *El chungungo [Lutra felina (Molina, 1782)] en Punta Patache, Iquique, I Región*. Universidad Arturo Prat, Centro de Investigación en Medio Ambient (CENIMA), Iquique. Informe técnico, 21 pp.

Sielfeld, W. & A. Guzmán. (2002). Effect of El Niño 1997/98 on the Population of the southern Sea Lion (*Otaria flavescens* Shaw) from Punta Patache/Punta Negra (Iquique, Chile). *Investigaciones Marinas Valparaiso,* 30(1): 159-160.

Sielfeld, W., J. Laudien, M. Vargas & M. Villegas. (2010). El Niño induced changes of the coastal fish fauna off northern Chile and implications for ichthyogeography. *Revista de Biología Marina, Montemar*, 45(Suppl. 1): 705-722.

Smith, S.D., R.D. Simpson & S.C. Cairns. (1996). The macrofaunal community of *Ecklonia radiata* holdfasts: Description of the faunal assemblage and variation associated with differences in holdfast volume. *Australian Journal of Ecology*, 21: 81-95.

Somers, M.J. & J.A.J. Nel. (2003). Diet in relation to prey of Cape clawless otters in two rivers in the Western Cape Province, South Africa. *African Zoology*, 38: 317-126.

Soto, R. (1985). Efectos del fenómeno El Niño 1982-83 en ecosistemas de la I Región. In: Taller Nacional Fenómeno El Niño 1982-83. Inst. Fomento Pesquero (Ed.), *Investigaciones Pesqueras (Chile)*, 32: 199-206.

Soto, R. (1997). *Estructura comunitaria de macroinvertebrados asociados al disco adhesivo de Lessonia nigrescens Bory, 1826 del intermareal rocoso en el extremo norte de Chile y su relación con el evento "El Niño" 1991/92*. Tesis Magister en Ciencias, Universidad de Concepción, 228 pp.

Spinola, R. M. & C. Vaughan. (1995). Dieta de la nutria neotropical (*Lutra longicaudis*) en la estación biológica La Selva, Costa Rica. *Vida Silvestre Neotropical*, 4: 125-132.

Steneck, R., M.H. Graham, B.J. Bourque, D. Corbett, J.L. Erlandson, J.A. Estes & M.J. Tegner. (2002). Kelp forest system: biodiversity, stability, resilience and future. *Environmental Conservation*, 29(4): 436-459.

Tegner, M. J. & P.K. Dayton. (1987). El Niño effects on southern California kelp forest communities. *Advances in Ecological Research*, 17:243-77.

Tomicic, J.J. (1985). Efectos del fenómeno El Niño 1982-83 en las comunidades litorales de la península de Mejillones. In: Taller Nacional Fenómeno El Niño 1982-83. Inst. Fomento Pesquero (Ed.), *Investigaciones Pesqueras (Chile)*, 32: 209-213.

Tommasi, L.R. (1968). Amphiuridae de la bahía de Valparaíso (Equinodermata, Ophiuroidea) Instituto Oceanográfico, Universidad de Sao Paulo. *Revista de Biología Marina*, 13(2): 71-84.

Tovar, H. & D. Cabrera. (1985). Las aves guaneras y el fenómeno "El Niño". Pp. 181-186. In: W. Arntz et al. (Eds.) *"El Niño" Su impacto en la Fauna Marina*. Instituto del Mar del Perú, Callao, Perú.

Valqui, J. (2012). The marine otter *Lontra felina* (Molina, 1782): A review of its present status and implications for future conservation. *Mammalian Biology*, 77: 75-83.

Vargas, M., P. Fuentes, P. Hernáez, A. Olivares & P. Rojas. (1999). Relaciones tróficas de cinco peces costeros comunes en el área submareal del norte de Chile. *Revista de Biología Tropical*, 47(3): 601- 604.

Vargas, M., S. Cifuentes & E. Emperanza. (1999). Espectro trófico de peces concurrentes al área de crianza Playa Chipana, del norte de Chile. *Revista de Biología Tropical*, 47(3): 597-600.

Vargas, M., R. Soto & G. Guzmán. (1999). Cambio interanuales en la alimentación de peces submareales del norte de Chile entre los 20o11'y 20o20'S. *Revista de Biología Marina y Oceanografía*, 34(2): 197-210.

Vásquez, J.A. (1992). *Lessonia trabeculata*, a subtidal bottom kelp in northern Chile: a case study for a structural and geographical comparison, pp. 77-89. In: U. Seelinger (Ed.) *Coastal plant communities of Latin America*. San Diego, California: Academic Press.

Vásquez, J.A., D.A. Véliz & L.M. Pardo. (2001). Biodiversidad de macroinvertebrados bajo las grandes algas. Pp. 293-308, in: K. Alveal & T. Antezana (Eds.). *Sustentabilidad de la Biodiversidad. Un problema actual, bases científico-técnicas, teorizaciones y perspectivas*. Ediciones Universidad de Concepción, Chile.

Vásquez, J.A., J.M. Alonso Vega & A.H. Buschmann. (2006). Long term variability in the structure of kelp communities in northern Chile and the 1997-98 ENSO. *Journal of Applied Phycology*, 18: 505-519.

Vega, J.M.A., J.A. Vásquez & A.H. Buschmann. (2005). Population biology of the subtidal kelps *Macrocystis integrifolia* and *Lessonia trabeculata* (Laminariales; Phaeophyceae) in an upwelling ecosystem of northern Chile: interannual variability and El Niño 1997-98. *Revista Chilena de Historia Natural*, 78: 33-50.

Villegas, M., A. Aron & L.A. Ebensperger. (2006). The influence of wave exposure on the foraging activity of marine otter, *Lontra felina* (Molina, 1782) (Carnivora: Mustelidae) in northern Chile. *Journal of Ethology*, 25(3): 281-286.

Villegas, M., J. Laudien, W. Sielfeld & W. Arntz. (2008). *Macrocystis integrifolia* and *Lessonia trabeculata* (Laminariales; Phaeophyta) kelp habitat structures and associated microbenthic comunity off northern Chile. *Helgoland Marine Research*, 62(Suppl. 1):33-44.

Villouta, E. & B. Santelices. (1984). Structure of subtidal kelp communities (*Lessonia*, Phaeophyta, Laminariales) in northern and central Chile. Revista Chilena de Historia Natural, 57:111-122.

Viviani, C. (1969). Los Porcellanidos (Crustacea Anomura) chilenos. *Beiträge zur Neotropischen Fauna*, 6(1): 1-14.

Watson, L.H. & A.J. Lang. (2003). Diet of Cape clawless otters in Groenvlei Lake, South Africa. *South African Journal of Wildlife Research*, 33: 135-137.

Zuñiga, O. (2002). *Guía de biodiversidad. Macrofauna y algas pardas. Crustáceos*. Centro Regional de Estudios y Educación Ambiental II Región de Antofagasta, Chile. 2(1):1-41.

Número afiliación	Nombre de la institución y/u organización
1	ProBiota EIRL, Iquique, Chile waltersielfeldkowald@gmail.com
2	Universidad Arturo Prat, Iquique, Chile
3	Centro de Estudios del Cuaternarios (CEQUA), Punta Arenas, Chile

Autor	Afiliación
Walter Sielfeld	1
Marcela Collao-Barreda	2
Jorge Acevedo	3