Biología Pesquera 16: 79-97, 1987 ISSN N° 0067 - 8767

THE SHELLFISHERY IN CHILE: AN ANALYSIS OF 26 YEARS OF LANDINGS (1960-1985)

LA PESQUERIA DE MARISCOS EN CHILE: UN ANALISIS DE 26 AÑOS DE DESEMBARQUES (1960-1985)

Rodrigo H. Bustamante[1] *and Juan C. Castilla*

ABSTRACT

This work compiles information on the development of the Chilean shellfish fishery. The landings and exportations values are analysed between 1960 and 1985. Correlations between work-force (number of artisanal shellfishermen), landing and economical values of shellfish exportation are presented. A panoramic view of landings and their exportation for the main shellfish species is given. Moreover, an analysis of the present shellfish legal regulation in the country is compiled. Finally, we discuss the present state of the art regarding the basic knowledge on these resources accumulated in the country and identify gaps and the future lines of research that should be developed.

Key words: shellfish-artisanal-work force-exportation-regulations-management.

RESUMEN

Este trabajo recopila información acerca del desarrollo histórico del desembarque de mariscos chilenos y el valor de sus exportaciones en los últimos 26 años (1960-1985). Se correlacionan la fuerza de trabajo (número de pescadores artesanales), volumen de desembarque y valorización de sus exportaciones. Además, se entrega una visión panorámica de las tendencias de los desembarques para las principales especies de mariscos y se analizan las actuales medidas de regulación pesquera. Finalmente, se discuten algunos de los avances en la investigación de los mariscos en Chile, los principales vacíos de conocimiento y las necesidades de desarrollar líneas de investigación futuras en el país.

Palabras claves: mariscos-pesquería artesanal-fuerza de trabajo-exportación-regulación-manejo.

INTRODUCTION

The Chilean littoral extends over about 4,600 km and the country has been divided from North to South into 12 regions and a Metropolitan area (Figure 1). Its three main types of shores are: 1) exposed rocky compact shore, (18°20′ S-33°00′ S); 2) exposed sandy shores (33°00′ S-43°00′ S); and 3) insular littoral, mostly near the southern islands, fiords and channels (43°00′ S-60°00′ S). Chile is a maritime nation with old and rich traditions. Upwelling along most of its coast makes this one of the most productive marine regions of the world. Chile is particularly well known by the diversity and quality of its shellfish and algae resources. Mainly exploited by artisanal fishermen, these resources are extremely important in the economy of the country and they have played key roles as local protein sources in the last decade. They also have made important contributions to world shellfish and algae landings and are marketed worldwide.

Chilean shellfish landings consisting mostly in mollusks have averaged from 1978 to 1984 about 1.5% of the world production, the most important species being *Concholepas concholepas* (Bruguière) know in Chile as "loco". This species accounted for the largest

Estación Costera de Investigaciones Marinas (ECIM) Las Cruces, Chile. Facultad de Ciencias Biológicas. Pontificia Universidad Católica de Chile, Casilla 114-D, Santiago, Chile.
[1]Present Address: Department of Zoology, University of Cape Town, Rondebosch 7700, Cape Town, South Africa.

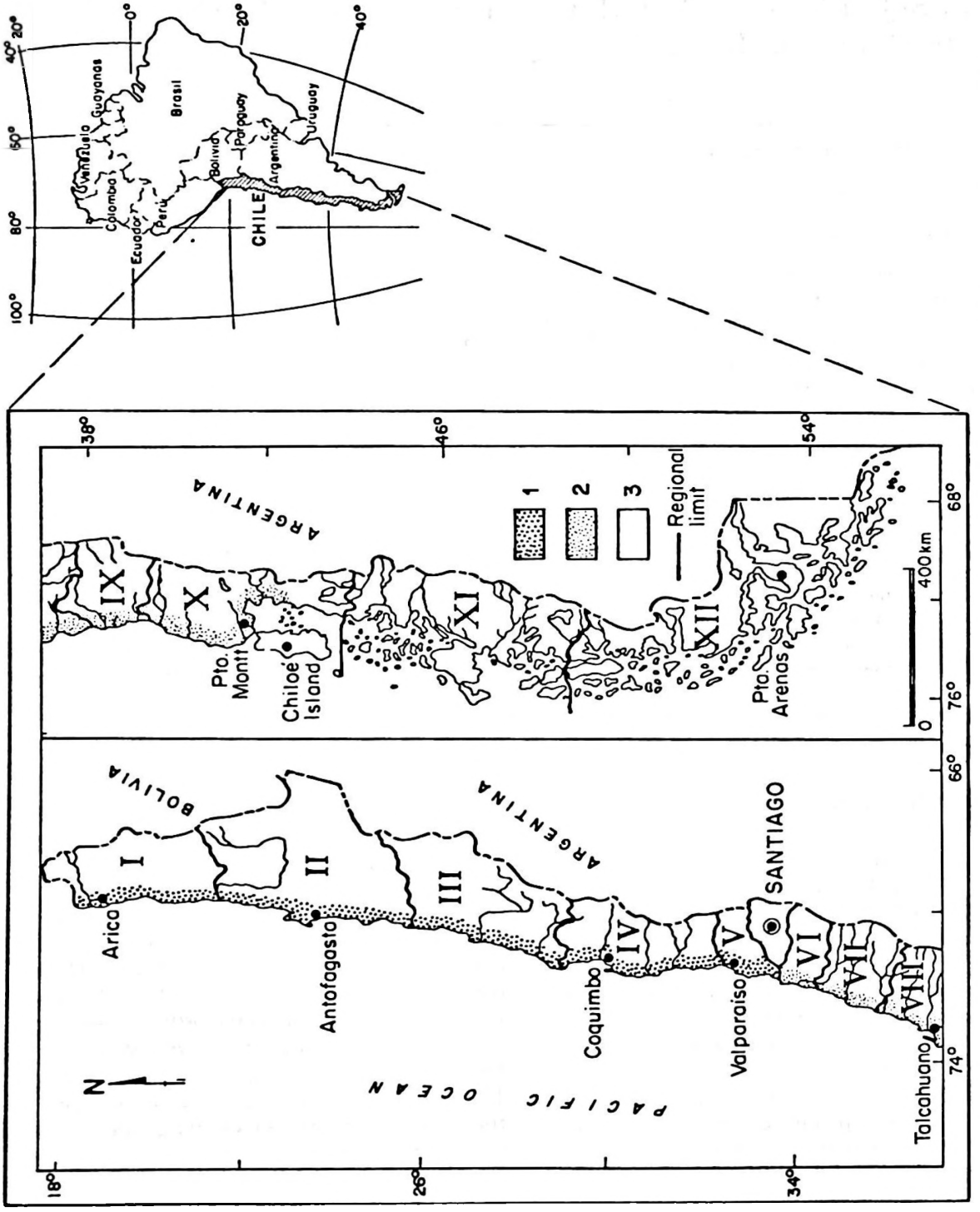

Figure 1. Geographical and regional division of Chile, and the main types of littoral coastline: 1. = Dominated by exposed compact rocky shore; 2. = Dominated by exposed sandy shore; 3. = Mostly insular littoral.

world commercial gastropod fishery in 1984. On that year, Chilean landings of "locos" reached 18,359 t, but the maximum catch was near 25,000 t in 1979 (F.A.O., 1986).

During the last decade there is a strong trend toward diversification in the exportation of many shellfish resources. Loco, the red sea urchin, clams and king crab are exported to Asian, Northamerican and European markets. In 1985, exports to Japan amounted to 46,425 t, to U.S.A. 35,553 t, and to Spain 24,884 t (CONAPACH, 1986). On the other hand, consumption of shellfish products has always been important in the country. Both factors have encouraged the increase in shellfish catches.

This work presents data on the development of shellfish landings, and its exportations in Chile. Artisanal work force and fishing arts are described and quantified. A panoramic overview is given on the trends of landings and on the present regulations. Suggestions for the development of future research lines are also given.

MAIN SHELLFISH SPECIES

Chilean marine invertebrate fisheries include a great number of species commonly designated as "mariscos" (shellfish). This group comprises about 60 species (Castilla and Becerra, 1975). Of these, only 36 are registered in fishery statistics (SERNAP, National Fisheries Service). Table 1 lists the main species included in the classes Mollusca, Crustacea, Echinodermata, and Urochordata. The remaining species, not included in this analysis, are fished sporadically and in a volume under one t per year (SERNAP, 1985); their demand corresponding mostly to local markets (i.e. crabs, *Taliepus* spp, or clams, *Mulinia* spp). The geographical distribution of most of the species is restricted to the Southern cone of South America [i.e. loco snail, *Concholepas concholepas;* prawn, *Heterocarpus reedi*) (Bahamonde); red sea urchin, *Loxechinus albus* (Molina); clam, *Venus antiqua* (King and Broderip); and the giant barnacle, *Austromegabalanus psittacus* (Molina)].

Natural history data for most species in Table 1 is scant. For some species [i.e. scallops, *Chlamys sp*; black mussel, *Mytilus edulis chilensis* (Hupe); oyster, *Tiostrea chilensis* (Phillipi)] data on reproduction and growth are known (Becerra *et al.*, 1986). The natural history is practically unknown for species like the snails, *Thais chocolata* (Duclos) and *Rapana (Chorus) giganteus*; the razor clam, *Tagelus dombeii* (Lamarck); or the purple crab, *Homalaspis plana* (Milne Edward). In contrast, there has been a great number of studies for the basic biology and fishery of a few species like *C. concholepas* due to their economic importance. In particular *C. concholepas* is widely documented as to fishery aspects, growth rates, rates of natural and fishing mortality, determination of fishing stock, estimates and assessment of the fishery effort and a further knowledge on population parameters (Castilla, 1982; IFOP, 1985b; Castilla and Jerez, 1986; Geaghan and Castilla, 1986; Ortiz *et al.*, 1986; Rivas and Castilla, 1986; Bustos *et al.*, 1986).

FISHING ACTIVITIES AND WORK-FORCE

Chilean shellfisheries are both artisanal (boats $\leq$ 15 t) and industrial (trawled boats $\geq$ 15-280 t or more). In the last case the fleet is devoted to the extraction of the prawn, *H. reedi*; the red and yellow squat-lobsters, *Pleuroncodes monodon* (Milne Edwards) and *Cervimunida johni* (Porter) Hancock (1969). About 150,000 t of shellfishes were landed in 1985, 92% by the artisanal sector and 8% industrial. Artisanal fisheries take almost all the species in Table 1, using manual collection during low tides, drags, traps or bag nets, free diving or apnea and semi-autonomous or hooka diving (Duran *et al.*, 1987). Diving is widely used, particularly hooka diving. For example 77% of landings of species such as loco, clams, crabs, red sea urchin and sea squirt, are fished with hooka diving (SERNAP, 1983). Hooka gear or "material", as it is known in Chile, includes: a wooden boat or "chalana" (6-9 m long), outboard motor (10-45 hp), air compressor (hooka), and a crew of 3-4 (boatman, an assistant, and one or two divers). Such artisanal fishing is the most popular in I to IX regions. In the southernmost zone (X to XII regions), larger boats (10-20 m) are used, preferably with inboard motor, due to harsher climatic conditions.

Figure 2 shows the increase of the workforce in artisanal fishery over the different regions of the country, according to estimates from censuses performed from 1961 to 1983. In 1961 there were only 4,564 artisanal fishermen in the country, whereas the 1983 census indicated 43,631 people directly involved in artisanal fishery. Historically, the

Table 1
Scientific name, common name and geographical range of the 27 principal Chilean shellfish species

Scientific name		Common name Chilean (English)	Geographical distribution
A) Mollusks			
Gastropods:			
1. *Concholepas concholepas*		Loco (Loco)	Mollendo (Perú)-Magallanes (Chile)
2. *Fissurella* spp. (5)	*1.*	Lapas (Key-hole limpet)	Ecuador-Perú-Chile
3. *Thais chocolata*		Caracol locate (Snail)	Ecuador-Valparaíso (Chile)
4. *Rapana (Chorus) giganteus*	*2.*	Caracol Trumulco (Snail)	Pascamayo (Perú)-Magallanes (Chile)
5. *Tegula atra*		Caracol negro (Black snail)	Pascamayo (Perú)-Magallanes (Chile)
Bivalves:			
6. *Venus antiqua antiqua*		Almeja (Clam)	Callao (Perú)-Chile-Argentina-Uruguay
7. *Protothaca thaca*	*3.*	Almeja (Clam)	Ancón (Perú)- Arch. Chonos (Chile)
8. *Mesodesma donacium*		Macha (Surf clam)	Ba. Sechura (Perú)-Chiloé (Chile)
9. *Tagelus dombeii*		Berberecho (Razor clam)	Tumbes (Perú)-Gfo. Corcovado (Chile)
10. *Aulacomya ater*		Cholgua (Giant mussel)	Callao (Perú)-Chile-Southern Brazil
11. *Mytilus edulis chilensis*		Chorito (Black mussel)	Iquique (Chile)-Northern Brazil
12. *Chlamys purpurata*		Ostión (Scallop)	Paita (Perú)-Coquimbo (Chile)
13. *Tiostrea (Ostrea) chilensis*		Ostra (Oyster)	Ecuador-Chiloé (Chile)
Cephalopods:			
14. *Octopus vulgaris*		Pulpo (Octopus)	Cosmopolitan
B) Crustacean:			
15. *Heterocarpus reedi*		Camarón nailón (Prawn)	Taltal (Chile)-Puerto Saavedra (Chile)
16. *Rhycocinetes typus*	*4.*	Camarón de roca (Prawn)	Isl. Lobos Afuera (Perú)-San Antonio (Chile)
17. *Pleuroncodes monodon*		Langostino colorado (Red squat lobster)	Isl. Lobos Afuera (Perú)-Ancud (Chile)
18. *Cervimunida johni*	*5.*	Langostino amarillo (Yellow squat lobster)	Taltal (Chile)-Isla Mocha (Chile)
19. *Jasus frontalis*		Langosta (Crayfish)	Isl. J. Fernández (Chile)-Isl. Desventuradas (Chile)
20. *Lithodes antarcticus*		Centolla (King crab)	Pto. Montt (Chile)-Ba. Camarones (Argentina)
21. *Homalaspis plana*		Jaiba mora (Purple crab)	Guayaquil (Ecuador)-Magallanes (Chile)
22. *Cancer edwardsi*	*6.*	Jaiba mola (Crab)	Guayaquil (Ecuador)-Magallanes (Chile)
23. *Cancer plebejus*		Jaiba reina (Crab)	Pascamayo (Perú)-Magallanes (Chile)
24. *Austromegabalanus psittacus*		Picoroco (Giant barnacle)	Pascamayo (Perú)-Magallanes (Chile)
C) Echinoderm:			
25. *Loxechinus albus*			
D) Urochordates:			
26. *Pyura chilensis*		Piure (Sea squirt)	Mollendo (Perú)-Chiloé (Chile)
27. *Pyura preaputialis*	*7.*	Piure (Sea squirt)	Antofagasta (Chile)

1. In landings statistics, shown as "Lapas" (at least 5 species).
2. In landings statistics, shown as "Caracoles".
3. In landings statistics, shown as "Almejas" (at least 5 genera).
4. In landings statistics, shown as "Camarones".
5. In landings statistics, shown as "Langostinos".
6. In landings statistics, shown as "Jaibas" (at least 5 species).
7. In landings statistics, shown as "Piures". *P. preaputialis* is fished only in Antofagasta.

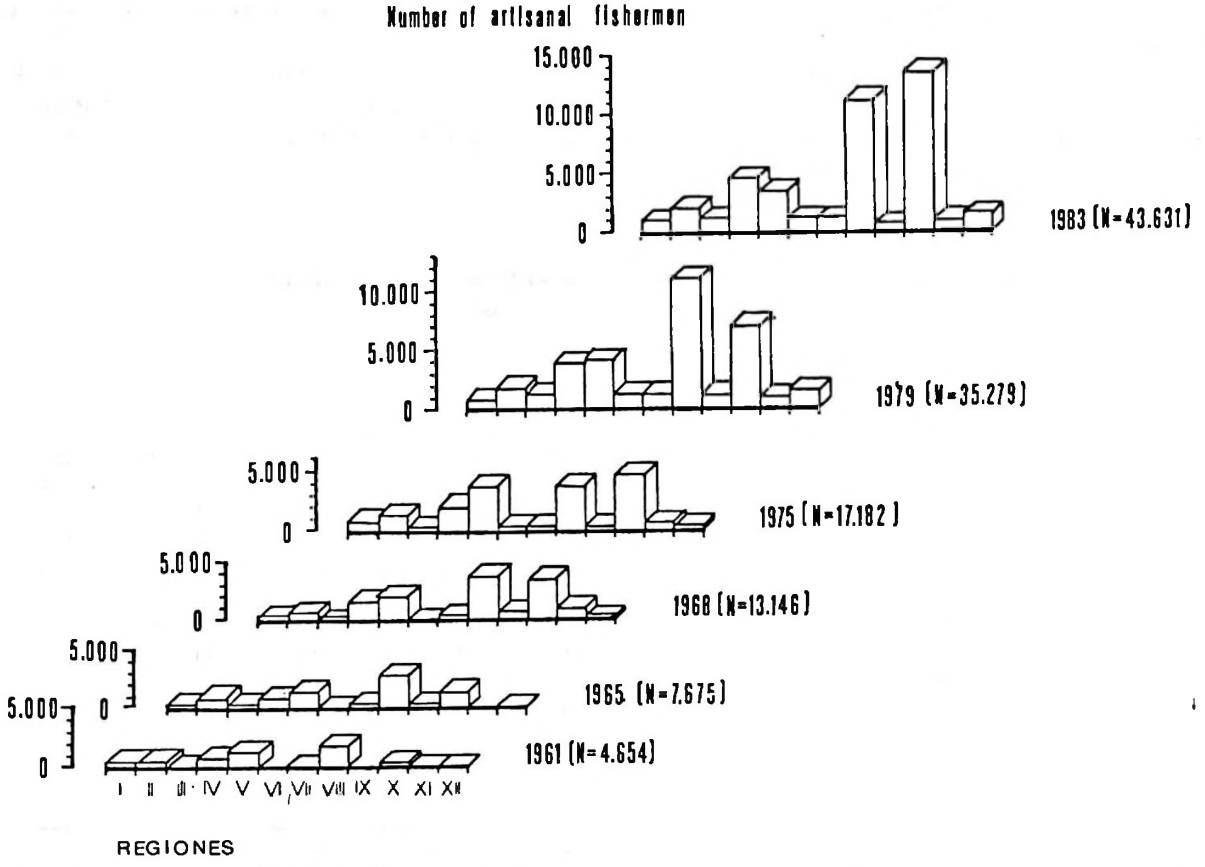

Figure 2. Regional distribution of the artisanal fishery work-force in the country between 1961-83.

regions IV, V, VIII, and X have shown the greater concentration of artisanal fishermen. These regions are located around the ports of Coquimbo, Valparaíso, Talcahuano and Puerto Montt respectively, and these areas are well known upwelling zones. In the 1983 census those 4 regions had 33,564 artisanal fishermen, accounting for 76% of the total artisanal work-force in the country. Only 26.7% of the artisanal fishermen harvested shellfish exclusively. Activities of artisanal fishermen are not always the same: the crew and "material", in one boat are often employed in fish and/or shellfish extraction. Figure 2 shows a gradual increase in the number of artisanal fishermen as well as the appearance of new important fishing areas since 1965 (regions VI, IX, and XII). Table 2a summarizes the distribution of the artisanal work-force by regions and type of activities in 1983 (SERNAP, 1983). Tables 3a and 3b show fleet composition in artisanal fishery by region and propulsion method (SERNAP, 1982). An increase of 282% in the number of boats can be observed. Region X has shown the larger increase in its fleet, while region VIII has a somewhat constant fleet. The use of motors is the propulsion form showing a larger increment.

LANDINGS AND EXPORTATIONS

Exports statistics of Chilean shellfish register the volumes and values (U.S. dollars) of the exported products. In this case volumes refer only to flesh (dry, curated and/or frozen). On the other hand, landings statistics register the "live" weight of shellfish. Therefore we cannot directly compare such volumes, and in this analysis only landed volumes are related with their export values and work-force. Figure 3 shows the historical series of shellfish landings in the country, their exportation value and the work-force registered from 1961 to 1983. In 1985, the volume of shellfish landings represented 3.2% of the total Chilean fisheries landings (fishes and shellfish). Between 1960 and

1985, artisanal landings increased 440%, from 30,000 t to 150,000 t. The mean annual growth rate in landings between 1960 and 1973 was of 7,300 t, while between 1974 and 1985 it was 18,300 t. At the same time the values of shellfish exports increased from US$ 1.2 millons in 1960 to US$ 14.8 millons in 1975. Since 1976, the values of shellfish exports increased, reaching approximately US$ 100 millons in 1983. In 1985, ex-

Table 2
Distribution of work-force in the artisanal fishery by region and tipe of activity (1983 census)

Region	Fishermen	Shell Fishermen	Algae Gatherers	Beach Helpers	Boat Builders	Mechanics	Total Region	Incidence %
I	679	335	35	68	9	5	1,131	2.6
II	926	531	367	75	20	4	1,923	4.4
III	379	655	152	65	23	18	1,292	3.0
IV	1,410	2,158	566	345	35	5	4,519	10.4
V	2,706	493	—	645	34	8	3,886	8.9
VI	179	337	757	24	17	—	1,314	3.0
VII	415	513	293	6	22	—	1,249	2.9
VIII	5,012	2,159	3,600	285	112	26	11,194	25.7
IX	709	72	77	12	19	1	890	2.0
X	4,209	4,040	5,432	215	52	17	13,965	32.0
XI	778	211	20	—	21	2	1,032	2.4
XII	1,053	151	—	5	20	7	1,236	2.8
Total	18,455	11,655	11,299	1,745	384	93	43,631	100
Percentage	42.3	26.7	25.9	4.0	0.9	0.2		

Source: Servicio Nacional de Pesca (SERNAP, 1983).

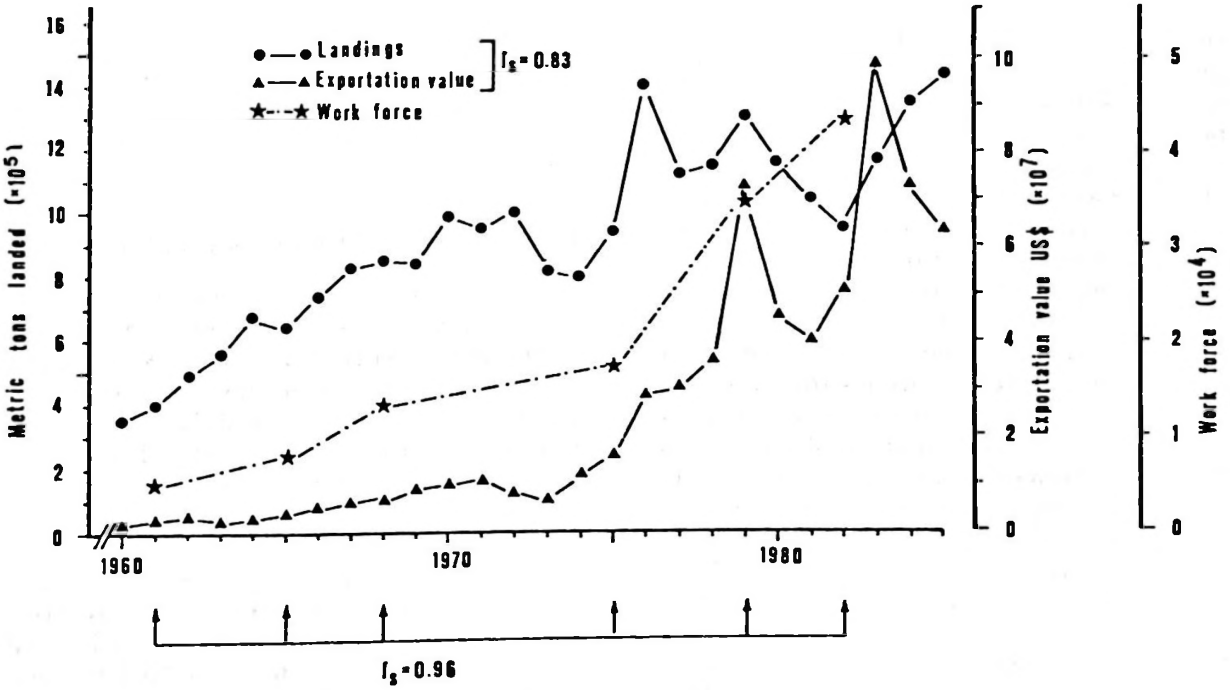

Figure 3. Chilean shellfish landings in metric tons; total value of shellfish exportations in U.S. dollars; and work-force in number of fishermen, between 1960-85.

ports declined to only US$ 62.5 millons (Depto. de Pesca y Caza, 1960-66, SAG, 1967-77; SERNAP, 1978-85; ODEPA, 1976-85). Shellfish landings and export values are closely related between 1960 and 1985 (Spearman Rank correlation, rs = 0.83, $P < 0.001$). A significant correlation was found between landing, export values and workforce (rs = 0.96, $P < 0.001$).

LANDINGS BY GROUPS OF SPECIES

Figure 4 shows the total landings of mollusks, crustacean, and other shellfish species for 1960-85 (Depto. de Pesca y Caza, 1960-66; SAG, 1967-77; SERNAP, 1978-85).

MOLLUSKS

Landings increased steadily from 15,834 t in 1960 to 78,299 t in 1985. This group includes gastropods like *Concholepas concholepas* (loco), *Fissurella spp.* (key-hole limpets including at least 5 species), *Rapana (Chorus) giganteus*, *Tegula atra* (Lesson), *Thais chocolata* (snails); bivalves like *Venus antiqua*, *Protothaca thaca* (clams), *Tiostrea chilensis* (oyster), *Mytilus edulis chilensis* (black mussel), *Aulacomya ater* (Molina) (giant mussel); and the cephalopod *Octopus vulgaris* (Linné) (octopus). During 1960-74, the black and giant mussels accounted for up to 60% of the shellfish landings. However, from 1975 to 1985, the most valuable mollusks were loco and clams, representing over 50% of the mollusk landings. Between 1976 and 1978 new species were added to shellfishery, like the key-hole limpets (*Fissurella* spp), the razor clam (*T. dombeii*) and surf clam [*Mesodesma donacium* (Lamarck)] wich represented 17% of total mollusks landings in 1985.

Table 3a:
Distribution of the number of boats in the Chilean artisanal fishery by region between 1965 and 1983

Number of Boats

Regions	1965	1968	1979	1983
I	115	135	278	273
II	134	184	584	625
III	57	176	409	420
IV	193	305	589	867
V	473	807	842	928
VI	25	1	53	82
VII	163	135	109	146
VIII	1,866	1,999	1,837	2,228
IX	77	258	136	275
X	636	752	1,474	3,743
XI	13	443	162	508
XII	40	107	376	611
Total	3,792	5,311	6,849	10,706

CRUSTACEAN

This group includes the decapods *Homalaspis plana* and *Cancer spp.* (crabs, at least 5 species), *Lithodes antarcticus* (Jacquinot) and *Paralomis granulosa* (Jacquinot) (king crabs); galateids *Pleuroncodes monodon* and *Cervimunida johni* (red and yellow squat lobsters); the pandalid *Heterocarpus reedi* (prawn); and *Austromegabalanus psittacus* (giant barnacle). Landings for the most important species grew steadily from 11,850 t in 1960 to 72,194 t in 1976, resulting from greater industrial catch of squat lobsters and prawns wich accounted for 96% of the crustacean landing in 1976. After 1976 crustacean landings steadily declined (Fig. 4), and recovered slightly during 1981-85. In1985, crabs and king crabs accounted for 33% of the crustacean caught in the country. An important fishery exist on the giant barnacle, *Austromegabalanus psittacus*, known in Chile as "picoroco", but this crustacean is mainly consumed locally. Small

Table 3b:
Distribution of number (and percent) of Chilean artisanal fleet by propulsion method between 1965-1983

Number of Boats (Percent)

Propulsion Method	1965	1968	1979	1983
Motor	1,327 (35)	2,124 (40)	3,014 (44)	5,353 (50)
Sail	417 (11)	531 (10)	685 (10)	
Oars	2,048 (54)	2,656 (50)	3,150 (46)	5,353 (50)
Total	3,792 (100)	5,311 (100)	6,849 (100)	10,706 (100)

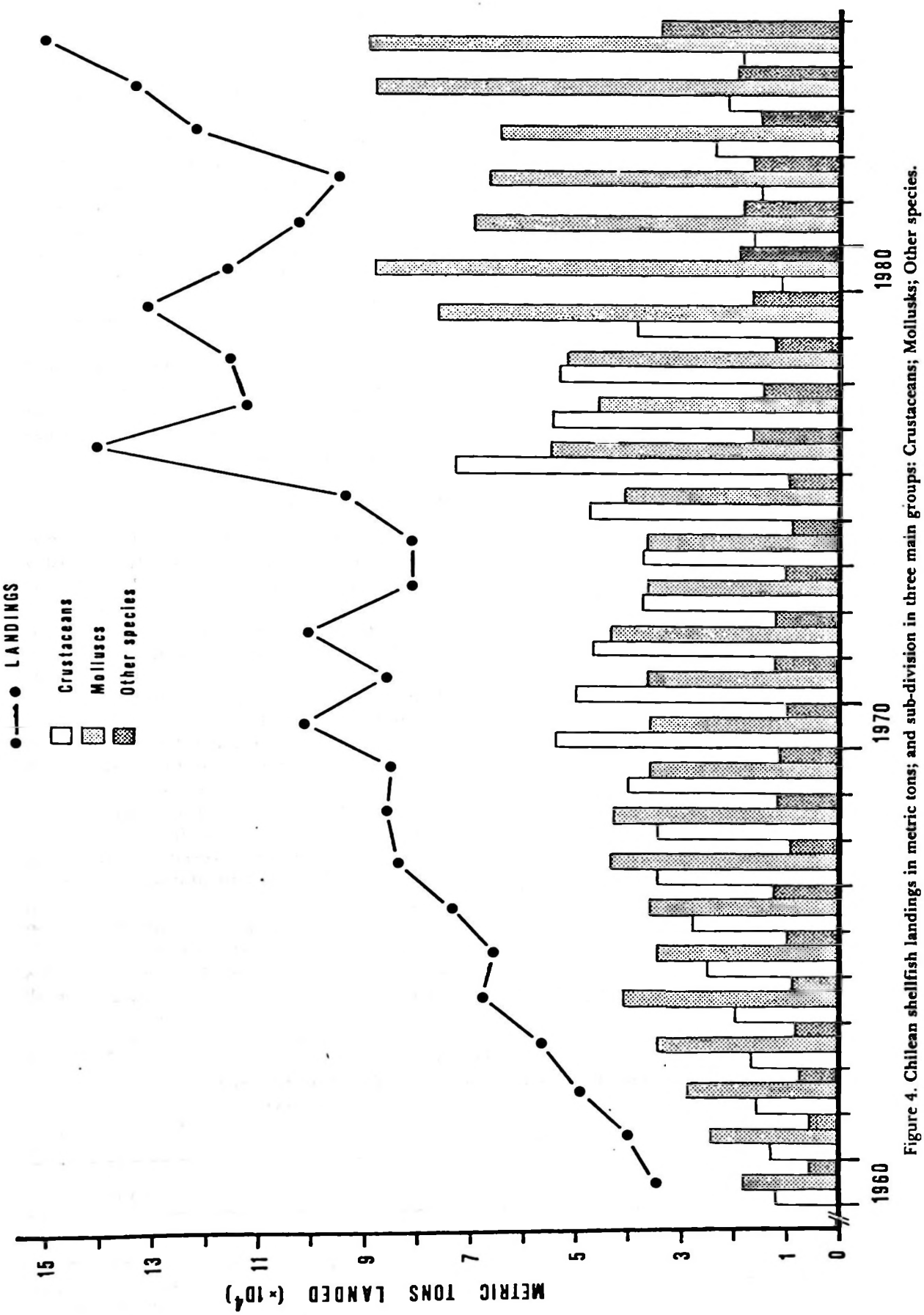

Figure 4. Chilean shellfish landings in metric tons; and sub-division in three main groups: Crustaceans; Mollusks; Other species.

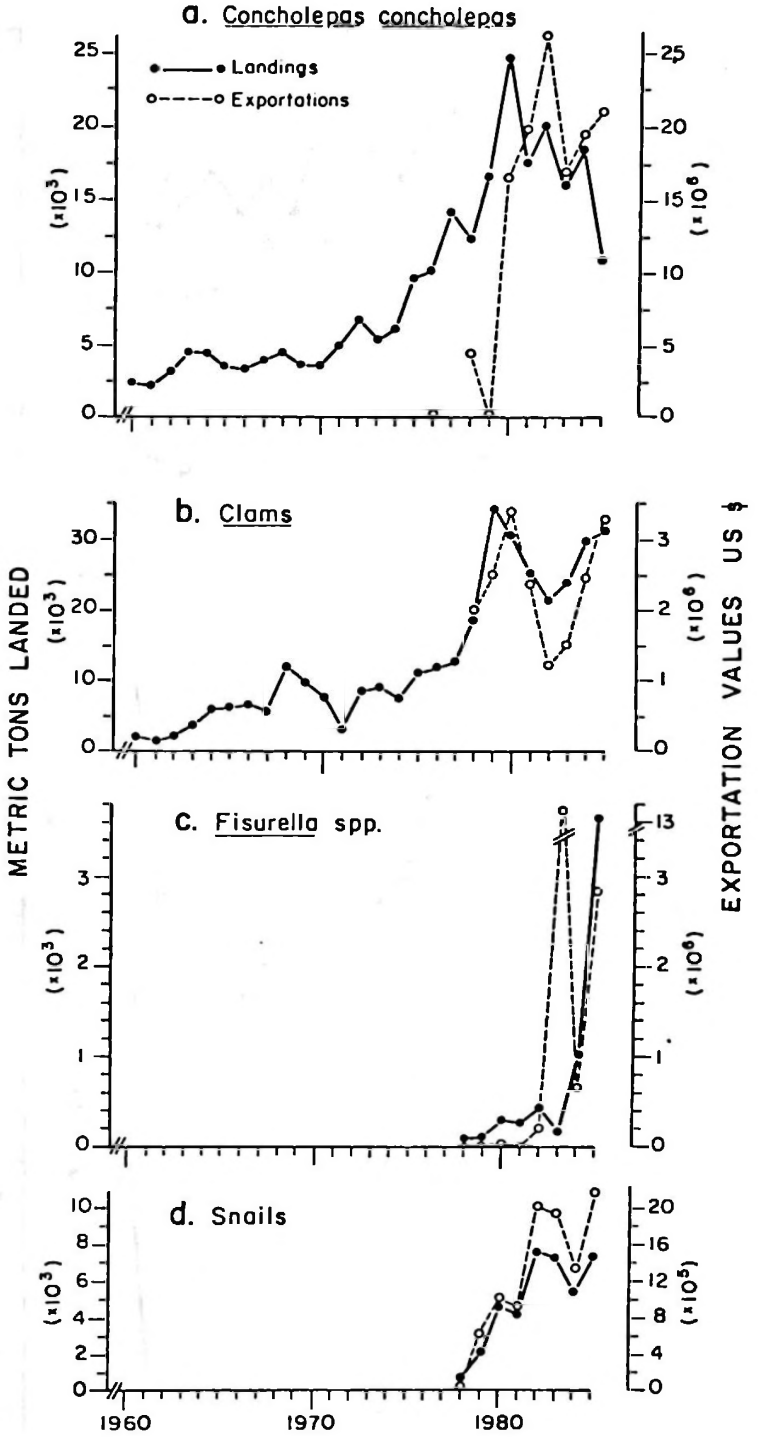

Figure 5. **Chilean mollusk landings in metric tons (• —— •); and their exportation values in US$ (O---O), between 1960-85.**

a) Loco, *Concholepas concholepas.*

b) Almejas (Clams) *Venus antiqua, Protothaca thaca.*

c) Lapas (Key hole limpets) *Fissurella* spp.

d) Caracoles (Snails) *Rapana (Chorus) giganteus, Thais chocolata* and *Tegula atra.*

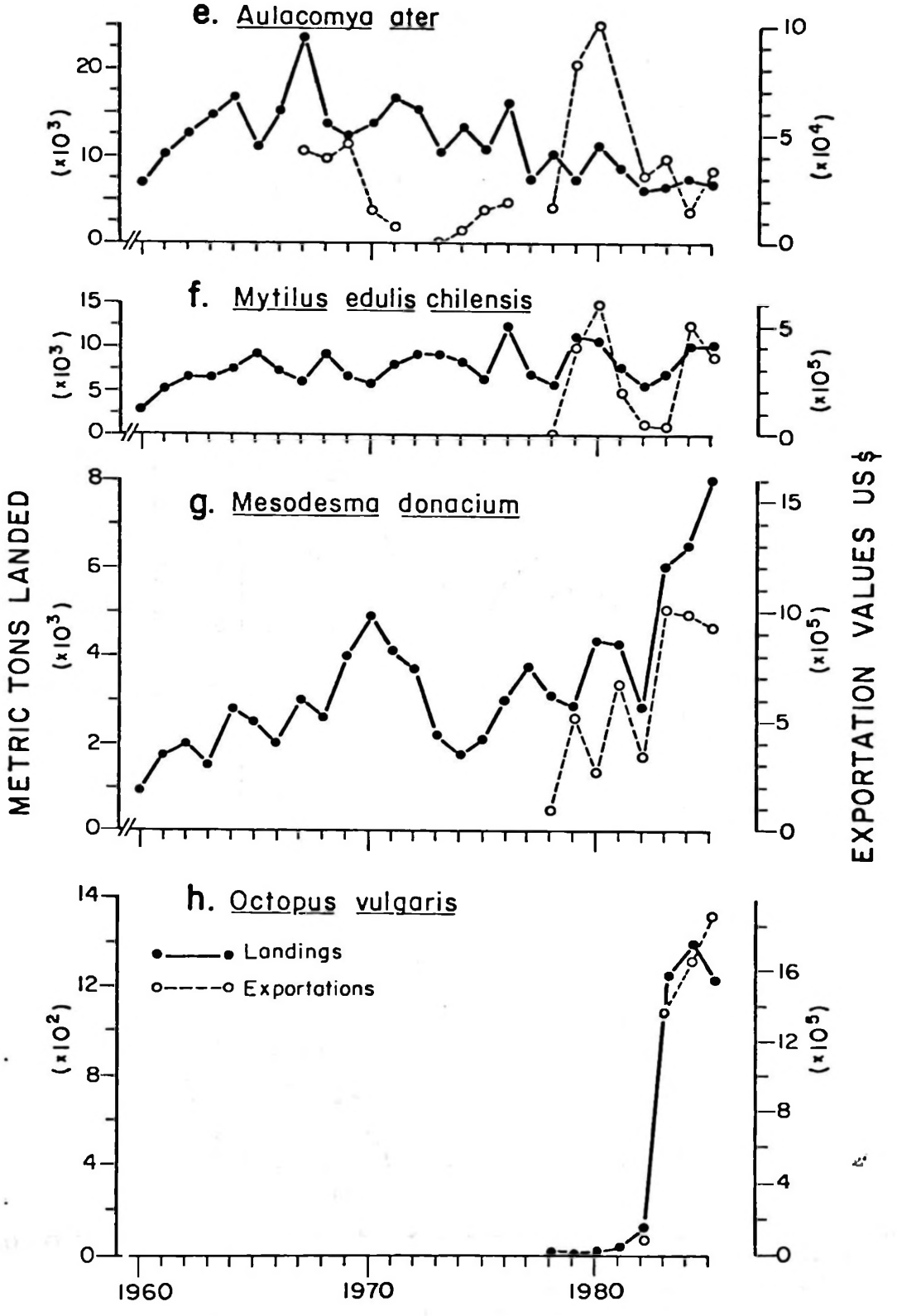

Figure 5. Chilean mollusk landings in metric tons (● —— ●); and their exportation values in US$ (O----O), between 1960-85.

e) Cholga (Giant mussel) *Aulacomya ater.*
f) Chorito (Black mussel) *Mytilus edulis chilensis.*
g) Macha (Surf clam) *Mesodesma donacium.*
h) Pulpo común (Octopus) *Octopus vulgaris.*

king crab or "centollón", *Paralomis granulosa*, the "gamba", *Hymenopenaeus diomedeae* (Faxon) and the spider crab, *Taliepus spp.*, representing 33% of the nation's crustacean landings in 1985, are relatively recent target-species.

OTHER SPECIES

This group includes sea squirts, *Pyura chilensis* (Molina) and *Pyura preaputialis* (Heller) locally known as "piures"; and an echinoderm, the red sea urchin or edible sea urchin, *Loxechinus albus*. These landings were relatively constant with a mean catch of about 10,000 t per year, from 1960 to 1975. The sea squirt (mainly *P. chilensis*) contribution ranged between 20% and 50% of the group landings. *P. preaputialis* is lightly exploited and only in the area close to the port of Antofagasta (II region). Landings after 1975 markedly increased, reaching 34,459 t in 1985. Between 1960 and 1975, the landings of piures and sea urchins were similar in volume (50% each). Notwithstanding, *L. albus* had a dramatic increase in its catch: from 9,809 t in 1976, to 30,575 t in 1985. Presently this target species contributes up to 95% in the landings of "other species".

MAIN TRENDS IN LANDINGS AND EXPORTATIONS

The development and increase of Chilean shellfish landing reflects both heavy exploitation of some target species (i.e., loco, sea urchins and clams) and the increased artisanal catch of new species. It also reflects the opening of international markets for Chilean shellfish that started in 1976-78. Figures 5, 6, and 7 show landings and export values of the most relevant shellfish species listed in Table 1 from 1960 to 1985.

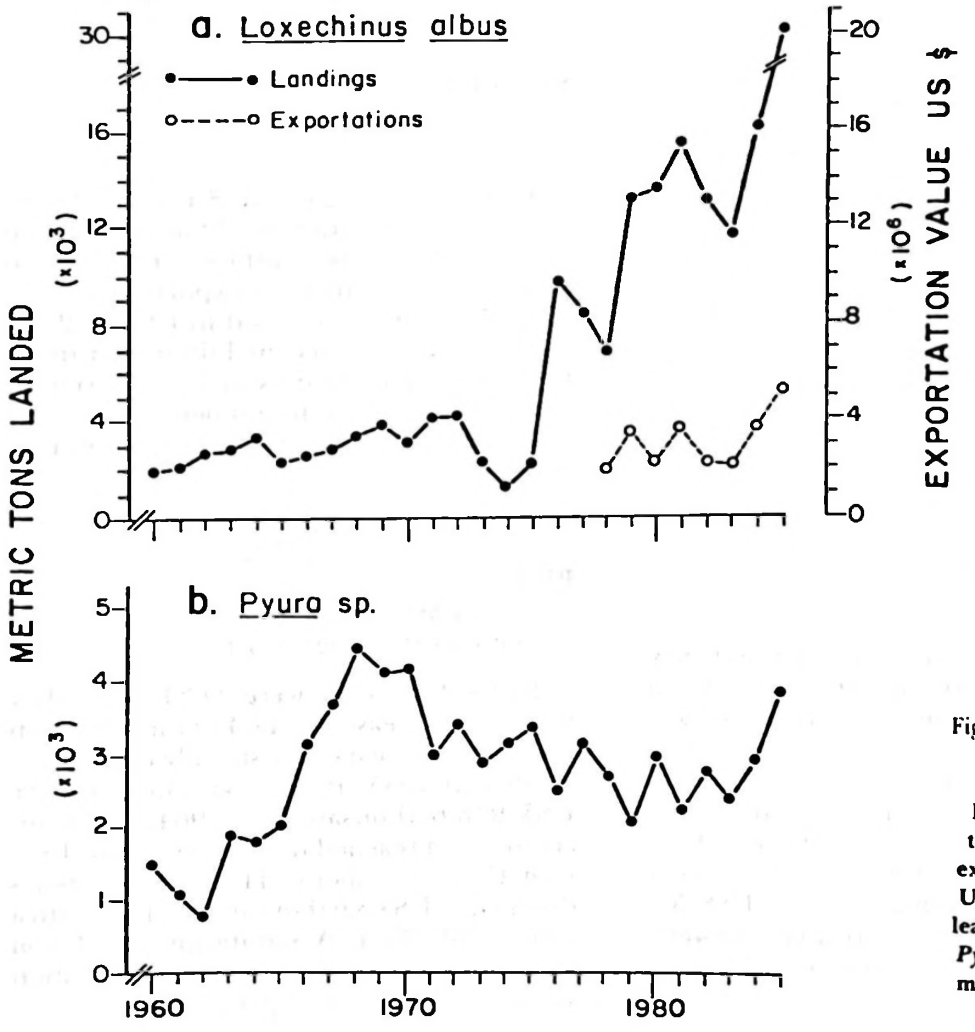

Figure 6a. Chilean red sea urchin *Loxechinus albus* landings in metric tons (● —— ●); and exportation values in US$ (O----O). b) Chilean piure (Sea squirt) *Pyura* sp. landings in metric tons (● —— ●) between 1960-85.

LOCO *(Concholepas concholepas)*
Figure 5a

This muricid gastropod is an important species in national shellfisheries. In 1960, landings were 2,455 t, thereafter they markedly increased up to 24,856 t in 1980. From then on, they have steadily decreased to 11,103 t in 1985. No regulatoring measures were enforced for the loco before 1982. On that year a three-month closed season was established as well as a new minimum size for its extraction: 10 cm in length of peristoma. The fall in loco catches became alarming and in 1985, a closed season was set for its fishing (March 1st 1985 to May 31 1987). A maximal annual capture of 4,000 t was established for the country. Only region XII (42°S) was excluded from all interdiction.

Export statistics for this species are available since 1976. Exports increased from US$ 158.1 thousands to US$ 21.8 millons in 1985. The relation between landed volume and export value is low but significant (Spearman Rank correlation, rs = 0.48; $P < 0.05$).

CLAMS [*Venus antiqua-Protothaca thaca* (Molina)] Figure 5b

Two clams species are registered in landing statistics, but the common name "almejas" for clams includes at least 3 genera and nearly 5 species more: *Mulinia* sp., *Semele* sp. and *Eurhomalea* spp. Clam landings increased from 2,131 t in 1960 to 34,241 t in 1979. In 1985, catches decreased to 32,329 t. Export values in 1969 were US$ 8.3 thousands, and they increased to US$ 3.3 millons in 1985. A close correlation was found between landing and exportation values (rs = 0.83; $P < 0.005$).

RED SEA URCHIN *(Loxechinus albus)*
Figure 6a

In 1960 landings were 2,067 t and they increased to 30,580 t in 1985. In 1981, a closed season of two months and a half was established for this species and in 1984, a total 2-year closed season was fixed for Regions I, II, and III. Exports of sea urchin roe are first registered in 1978, whit nearly 400 t and a value of US$ 2.1 millons. In 1985 exports were 607 t with a value of US$ 5.2 millons. A significant correlation between landings and export values was found (rs = 0.51; $P < 0.005$).

KING CRAB *(Lithodes antarcticus)*
Figure 7a

In 1960, a catch of 110 t was registered; in 1975 it increased to 609 t, and reached 2,616 t in 1985. From 1964 to 1973, exports fluctuated between US$ 48.8 thousands and US$ 55.3 thousands. Thereafter exports markedly increased to US$ 9.5 millons in 1985. Landings are closely related to the export values (rs = 0.92; $P < 0.001$).

CRAYFISH [*Jasus frontalis* (Milne Edwards)]-Figure 7b

In 1960, catches were 122 t and they decreased to 35 t in 1985, reflectings marked overfishing of this resource (Arana, 1985; IFOP, 1985a; Arana, 1987). Exports of crayfish where US$ 35.5 thousand in 1978 and US$ 11.9 thousands in 1985. Relation between landing and export value is low and non significant (rs = 0.40; $P > 0.05$).

SQUAT LOBSTERS
(P. monodon-Cervimunida johni)
Figure 7c

In 1960, landings were 8,122 t and they steadily increased to 62,662 t in 1976. From then on, landings drastically declined to 4,160 t in 1985. In 1964 exports were US$ 1.5 millons; they increased to US$ 16.2 millons in 1976, and declined thereafter down to US$ 906.1 thousands in 1985. A significant correlation was found between landing and exportation values (rs = 0.89; $P < 0.005$).

PRAWNS
[*H. reedi-Rhynchocinetes typus* (Milne Edward)]-Figure 7d

In 1960, landings were 2,634 t, and they markedly increased to 11,410 t in 1966. On the following years they steadily declined to 2,949 t in 1985. Prawn exportations were US$ 918.6 thousands in 1964. They increased and reached their maximun in 1983 with US$ 7.6 millons. Thereafter, exports declined to US$ 3.6 thousands in 1985 with a landing of 562 t. A significant correlation was found between landing and exportation values (rs = 0.68; $P < 0.01$).

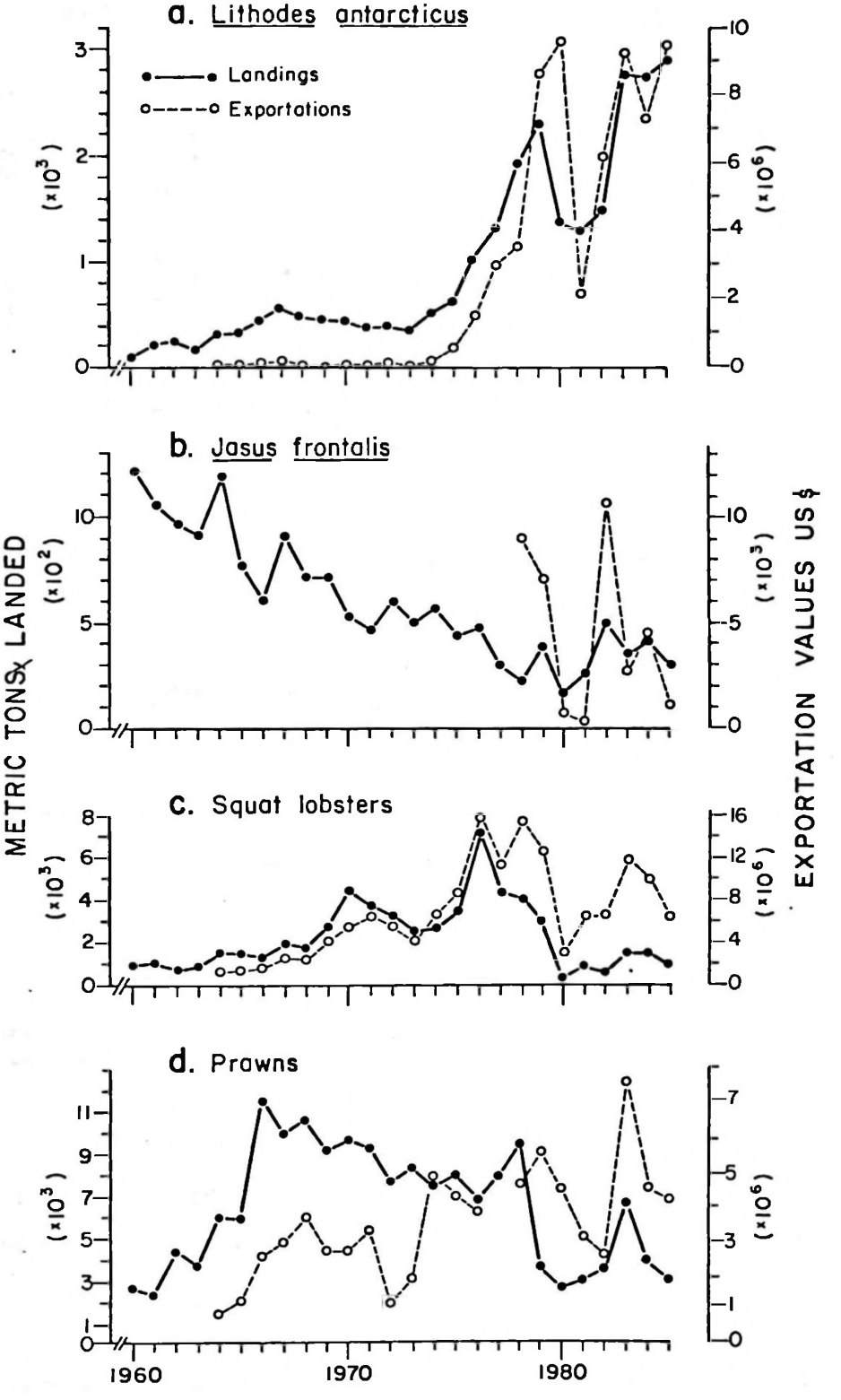

Figure 7. Chilean crustacean landings in metric tons (● —— ●); and their exportation values in US$ (O---O), between 1960-85.

a) Centolla (King crab) *Lithodes antarcticus.*
b) Langosta (Crayfish) *Jasus frontalis.*
c) Langostinos (Squat lobsters) *Pleuroncodes monodon, Cervimunida johni.*
d) Camarones (Prawns) *Heterocarpus reedi, Rhynchocinetes typus.*

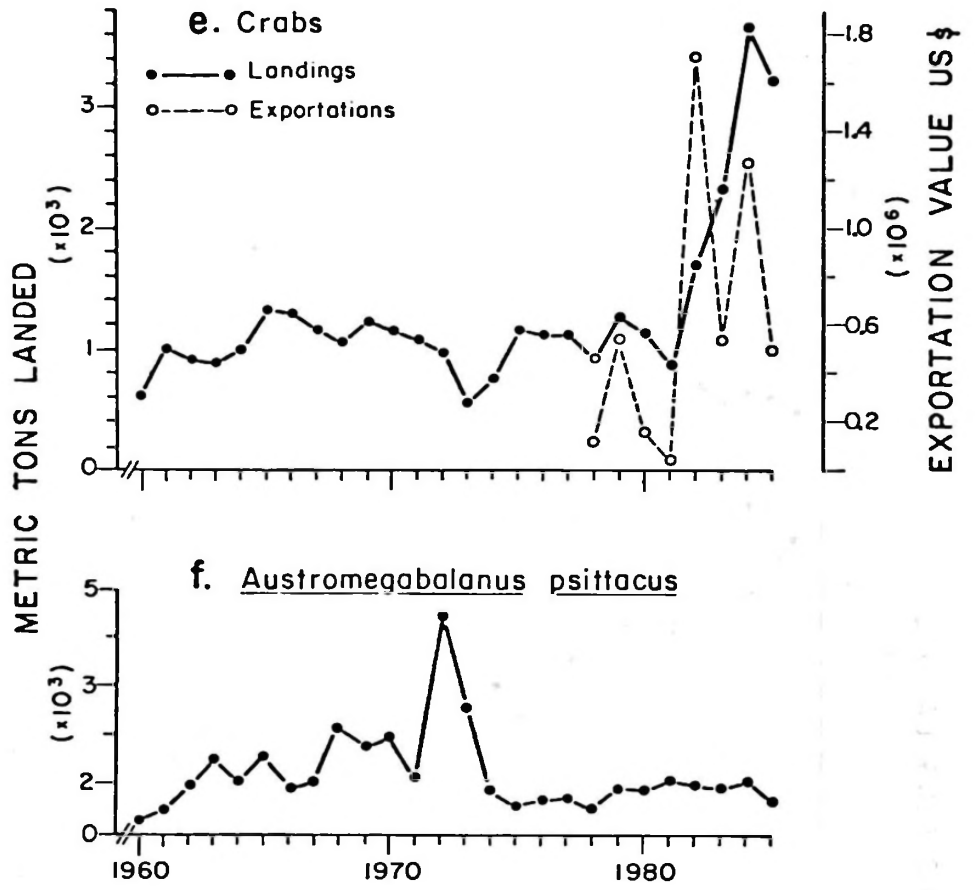

Figure 7. Chilean crustacean landings in metric tons (● —— ●); and their exportation values in US$ (O----O), between 1960-85.
e) Jaibas (Crabs) *Cancer spp., Homalaspis plana.*
f) Picoroco (Giant barnacle) *Austromegabalanus psittacus.*

RANKING OF SHELLFISH IMPORTANCE

The price of one kilogram (k) of shellfish exported has been defined in this paper as the *Unit Value* (UV). It is obtained dividing the total export value by the volume exported. Table 4 presents the mean value of one kilogram of shellfish resources exported in U.S. dollars over the last 6 years. At the same time, the quotient between the UV of the different shellfish species and the UV of one kilogram of fish meal was calculated (the fish product of greater national importance). According to these two criterias rankings of the main important species can be established. Table 4 shows that the first in importance are king crab and crayfish, followed by sea urchin and loco. The two latter species, although of relatively low UV are marketed in great volumes abroad. The species-resource of less commercial value is the black mussel. The mean value of fish meal in that period was US$ 0.5 per kilogram. When comparing the average UV of shellfish resources with average UV of fish meal, we observe that the price of king crab is 24.3-fold higher than that of fish meal, the loco 9.3-fold higher and black mussel 4.5-fold.

SHELLFISH REGULATIONS

Table 5 shows the main regulatory measures in force for commercial fishery; a) minimum size; b) closed seasons; c) regions exempted from closed seasons; d) fishing arts; and e) interdiction according to type of reproduction, catch quota, or genetic reserves. Chilean shellfishery comprises about 60 species of marine invertebrates (Castilla and Becerra, 1975). Out of 36 species registered in the statistics, 18 are subjected to some control (= 30% of commercial species). The milder regulatory measures correspond to

Table 4
Average unit value (UV) of 1 kg of shellfish product exported (U.S. dollars), for the 12 most important Chilean shellfish during the last 6 years

	1985	1984	1983	1982	1981	1980	Value $\bar{X}$	Ranking	Rel. with Fish Meal	Ranking
Langosta (Crayfish)	12.5	14.0	14.6	12.3	10.0	8.7	12.0	1	24.3	1
Centolla (King crab)	11.8	9.0	9.0	8.7	14.7	14.0	11.2	2	22.7	2
Erizo (Red sea urchin)	5.8	5.3	5.2	6.3	7.1	6.0	6.0	3	12.0	3
Loco (Loco)	9.8	4.1	3.6	4.4	3.4	2.3	4.6	4	9.3	4
Jaiba (Crabs)	2.7	4.4	3.6	8.3	2.2	4.4	4.3	5	8.6	5
Lapa (Key hole limpet)	3.5	2.5	3.2	2.9	3.0	3.2	3.0	6.5	6.2	6
Cholga (Giant mussel)	2.6	4.0	3.4	1.9	2.9	3.0	3.0	6.5	6.0	7
Macha (Surf clam)	2.7	2.9	3.1	2.8	2.9	3.2	2.9	8	5.7	8.5
Almeja (clams)	2.8	2.8	2.8	2.8	2.7	2.9	2.8	9.5	5.7	8.5
Caracol (Snails)	2.6	2.7	2.9	3.0	2.7	2.7	2.8	9.5	5.6	10
Chorito (Black mussel)	2.0	2.3	2.6	3.2	2.5	2.1	2.4	11	4.5	11
H. de Pescado (Fish meal)	0.9	0.4	0.4	0.3	0.4	0.5	0.5	12	1.0	12

fishing arts, restricted in some cases (i.e., scallops and snails) which may only be fished by diving; crayfish and king crabs, whose extraction is limited to the use of passive traps or "fykes" (Subsecretaria de Pesca, 1985).

Fishing quota are set in 1985. Maximum catch was fixed at 4,000 t for the loco in 1986, and fishery was restricted to particular geographical areas. Maximum catch permitted for squat lobster was 4,000 t in 1985 (between parallels 34° and 37°S). These quotas were established to counteract the high exploitation levels which showed clear signs of overexploitation (decreases in landings and increases in fishing efforts).

DISCUSSION

Castilla and Becerra (1975) reported that a substantial group of the Chilean commercial species were autochtonous or presented a geographical distribution restricted to the coasts of the South-East Pacific (i.e. loco, red sea urchin, sea squirt, giant barnacle, and squat-lobsters). On the other hand, some species risked overexploitation and their biology or fishery aspects were poorly known as to plan a rational management of these resources.

Ten years after, it is clear that these risks have become a reality. Furthermore, no capacity of regulatory response is observed, and extreme measures of closed seasons (years) have been adopted to protect these resources.

The high increases in shellfish landing volumes in the last decade have mostly derived from heavy extraction of some target-species (loco, clams and sea urchins). This responds to the national policy of non traditional exports and the opening of new markets—specially Asian— for our shellfish products. From 1960 to 1985 twelve "nobel" Chilean shellfish species have been included into the international shellfish markets. It is worthnoting that from 1982 to 1985 the "nobel" species have been intensively fished due to the gradual diminution of the traditionally exploited stocks, or in response to closed seasons.

Castilla and Schmiede (1979) have postulated that the Chilean maintenance in time of great landing volumes for shellfish may be due to the existence of "buffer zones", along the Chilean littoral, wich would have been less exploited allowing repopulation of the fishing areas.

The case of the red sea urchin clearly illustrates the dramatic increase of shellfish landings in short periods. This species was first exported in 1978. Since 1976 substantial and sustained increases in landings are observed until reaching approximately 30,000 t in 1985. Exports on that year were over US$ 5,000,000; in fact, according to Sloan (1984) and F.A.O. (1986) Chile currently occupies the second place among the world exporters of this kind of resource. The risk of overexploitation has led to a total restriction of its fishery for several years in some regions of

Table 5
The 5 most important regulatory measures for the extraction of 17 species of shellfish along the Chilean coastline during 1985

Common Name in Chile (Scientific name)	Minimun legal size (cm)	Closed-season period Along the country	Region exempted from closed season	Fishing art	Others
Almejas *(Veneridae)*	5.5	—	—	—	—
Chorito *(M. edulis chilensis)*	5.0	Nov. 1st - Dec. 31 st	XII region	—	Genetic reserve at stuary of Queule river
Choro *(C. chorus)*	12.0	Sept. 18th - Dec. 31 st	—	—	—
Cholga *(A. ater)*	7.0	Oct. 1st - Jan. 31 st	I, II and III region	—	—
	5.5 (I and II Region)	Oct. 1st - Jan. 31 st			
Machas *(M. donacium)*	6.0	—	—	—	—
	5.0 (IX and X Region)	—	—	—	—
Ostra *(T. chilensis)*	5.0	Oct. 1st - Mar. 31 st	—	—	—
Ostión *(C. purpurata)*	9.0 (I to IX Region)	Sept. 1st - Jan. 31 st	—	Diving only	Closed-season for 3 years at Tongoy bay (30°18'2"S-30°17'33"S)
	8.0	Sept. 1st - Jan. 31 st	—	Diving only	
Caracol trumulco *(R. giganteus)*	9.0	Nov. 15 st - Jan. 15 st	—	—	Fishery of females with eggs forbidden throughout the year
Langostinos *(C. johnii* and *P. monodon)*	—	a) Total from May 1st to 31 st, 1985 between 34°00'00"S and 37°10'00"S b) From Aug. 16 th, 1985 to Jun. 1st 1986 between 34°00'00"S and 37°10'00"S	—	—	Fishery between 34°00'00"S and 37°10'00"S, from Jun 1st to Aug. 15th, 1985. Max. landing: 4,000 metric tons
Pulpo *(O. vulgaris)*	1.0 kg	From Nov. 15th-March 15th	—	—	—
Loco *(C. concholepas)*	10.0	a) Total from March 1st, 1985 to May 31 st, 1987 in I, II and III region	—	—	Fishery between 40°S to XI region included, between March 1st and Jul. 31 st, Max. landing of 4,000 metric tons
		b) Total from Sept. 25 th, 1985 May 31 st, 1987 between IV region and 40°S	XII region	—	
Langosta *(J. frontalis)*	11.0	May 15th - Sept. 30 th	A. Selkiri Isl.	Traps only	Fishery of females with eggs forbidden the year round
Jaibas and Cangrejos (Decapoda, Brachiura)	—	—	—	—	Fishery of females with eggs forbidden the year round
Centolla *(L. antarcticus)*	12.0	Total from Oct. 27 th, 1981 to Oct. 27 th, 1985 between 52°53'60"S and 53°28'00"S	—	Traps only	Fishery of females with eggs forbidden the year round
Centollón *(P. granulosa)*	8.0	—	—	Traps only	Fishery of females with eggs forbidden the year round
Erizo *(L. albus)*	7.0	Nov. 1st - Jan. 15th Total from Jan. 23 rd, 1985 to Jan. 18 th, 1987 in I, II and III region	XII region	—	

the country (Subsecretaria de Pesca, 1985). Similar situations have occurred with other shellfish like loco and squat-lobsters.

Regulatory measures adopted are mostly paliative and preventive: they are applied when there is evidence or suspicion of overexploitation. Unfortunately, in the country there are no solid historical data in terms of fishery stocks or variation in fishery efforts.

We conclude that artisanal shellfishery plays a crucial economic and social role in the country, with 11,655 shellfishermen directly devoted to this activity in 1983 (Table 2). Though it is not possible to calculate the number of workers laterally involved in shellfish extraction (helping hands in the coves, intermediaries, sellers, industrial workers or plant workers, carriers, etc.) they may be 10-15 fold this figure. Together with the increase in work-force (either direct or indirect) there has been a substantial development in governmental credits to the artisanal fishery subsector. In the period 1982-85, loans were granted for a total of US$ 15,300,000, particularly for purchasing motors, hulls and elements for fishing arts (CONAPACH, 1986).

On the other hand, the great contribution of the artisanal sector to the economy of the country is to be noted (about US$ 100,000,000 only in terms of exportation returns), as well as the added values of the resource shellfish, face to traditional products like fish meal. Chilean shellfish are recognized for their quality and diversity. Local comsumption is important both in urban centers and fishermen coves.

The challenges of research issues are varied and multiple, from basic knowledge, to technological and applied aspects, including shellfish aquaculture. At this respect Table 6 shows the species cultured in Chile, national landings, production and incidence on bivalve and mollusks landings. Aquaculture is less than 0.1% of the total mollusks landings, and in average near 5% of the total bivalves landings. It should be noted that only filter-feeder mollusks (bivalves) are currently cultured in Chile while herbivore and carnivore invertebrates (lapas, snails, locos, urchins) are still at a laboratory experimental stage. Thus, artisanal fishery is applying for assistance, financement and transference of technology for its development and the implementation of aquaculture (Morales y Gezan, 1986; Becerra *et al.*, 1986; CONAPACH, 1987).

The primary task to be undertaken is an accurate knowledge of the resource stocks and their variations in time, particularly in shellfish species threatened by overexploitation. Recently, Castilla and Jerez (1986), Geaghan and Castilla (1986) and Ortiz *et al.*, (1986) have assayed methodologies in coves in central Chile, in order to gather data base on artisanal fishery through time in order to develop a minimal predictive capacity. Also, it is necessary to implement statistical forms for catches and effort, that will allow to gather data base at least in a few groups of artisanal coves along the country. Also, studies of basic population parameters (like growth, recruitment and natural mortality) should be conducted. Without historical data base it will not be possible to rationalize shellfishery activities in the country.

ACKNOWLEDGEMENTS

We sincerely ackowledge financial support from following projects: IDRC/PUC 3-P-85-0069; Organization of American States (O.A.S.) 53C363; and FONDECYT N° 86/1100. Mrs. Ignacia Aguirre helped us to translate to English based on an Spanish draft.

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Table 6
The 6 species subjected to commercial farming in Chile, their production, national landings (t) of their fishery and their incidence (%) on bivalves and total mollusks landings between 1981 and 1985

Years

Species	1981			1982			1983			1984			1985		
	Landing	Farming	%	Landing	Farming	%	Landing	Farming	%	Landing	Farming	%	Landing	Farming	%
1. *Mytilus edulis chilensis* (Black mussel)	7,752	582	7.5	5,647	1,389	24.6	7,080	309	4.4	10,375	975	9.4	10,189	983	9.6
2. *Choromytilus chorus* (Shoe mussel)	129	31	24.0	152	240	157.9	279	63	22.6	490	136	27.8	1,136	133	11.7
3. *Chlamys purpurata* (Northern scallop)	—	—	—	441	1	0.2	429	—	—	4,990	57	1.1	1,410	39	2.8
4. *Tiostrea chilensis* (Chilean oyster)	506	119	23.5	586	185	31.6	582	12	2.1	978	120	12.3	892	274	27.3
5. *Aulacomya ater* (Giant mussel)	8,526	14	0.2	6,134	—	—	6,475	—	—	7,287	—	—	6,941	—	—
6. *Crassostrea gigas*[1] (Pacific oyster)	—	—	—	—	—	—	—	4	100	—	28	100	—	25	100
Total	16,913	746	4.4	12,960	1,815	14.0	14,845	388	2.6	24,120	1,316	5.5	20,568	1,454	7.1
Total landing of Mollusks	69,221	746	0.01	66,293	1,815	0.027	71,457	388	0.005	88,513	1,316	0.095	88,955	1,454	0.016
Total landing of Bivalves	47,206	746	1.58	37,825	1,815	4.8	52,913	388	0.73	62,151	1,316	2.07	65,166	1,848	2.33

[1]Exotic species (not included in the calculations).

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