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Direct and Indirect Effects of the High Seas Fisheries on the Marine Mammal Populations in the Northern and Central Patagonian Coast

by

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ABSTRACT

Interactions between marine mammals and fisheries were monitored in the Atlantic Patagonian coast since 1989. The national fleet in the area is composed of approximately 194 vessels (80% trawlers; 15% jiggins; 5% longliners). The fleet operates the whole year from 7 harbours between Escondida Is. and San Jorge Gulf (80,000nm^2). The important target species are: hake (*M. hubbsi*), squid (*I. argentinus*) and shrimp (*P. muelleri*), while several tons of fish are discarded. The dusky dolphin (*L. obscurus*), the Commerson´s dolphin (*C. commersonii*) and the southern sea lion (*O. flavescens*) are incidentally caught. The dolphins get entangled mostly in mid-water trawls at night, while the sea lions do it in any kind of trawl. Mortality rates obtained are 70-200 dusky dolphins (70% females) and 170-480 sea lions per year (mostly males; figure estimated to be 1-2% of the population size in the area). Feeding habits of top predators and fish catch and bycatch of the fishery was also studied. Dusky dolphins in the area prey mostly on anchovies (10-20cm) and squid (3-18cm), while hake was the most important for Commerson´s dolphins (5-13cm) and male southern sea lions (10-50cm). Squid is also important for sea lions (15-33cm) overlaping in size with the commercial sizes of the fishery. Fishing areas for squid taken by jigging vessels overlap in part with those of foraging sea lions. Even that the commercial size for hake is 30cm or larger, smaller hakes are discarded largely by the fishery. A combination of operational and specific effects were detected on the

populations. While at present times, mortality rates seem to be low and that there is no enough evidence of competition for prey species, a concern exists about the large amounts of fish (particularly hake) discarded by the fishery.

INTRODUCTION

The study of interactions between marine mammals and fisheries along the Southwestern Atlantic Ocean began in 1974 in the coast of Uruguay (Brownell and Praderi, 1974; Kasuya and Brownell, 1979; Praderi, 1976, 1979, 1982, 1983 and Crespo et al., 1986; Praderi et al., 1989). The franciscana dolphin, *Pontoporia blainvillei* was the species most often affected by incidental mortality in these small-scale fisheries. The same situation was observed involving the franciscana along the southern coast of Brazil by Pinedo (1985, 1986) and Praderi et al. (1989).

The coast of Argentina was preliminary surveyed between 1984 and 1986 by Pérez Macri and Crespo (1989) and by Crespo and Corcuera in 1990 (Crespo et al., 1994a,b,c), with the aim to study the interactions between fisheries and franciscana dolphins and other cetacean species (*Tursiops truncatus* and *Lagenorhynchus obscurus*). Fishery mortality of pilot whales *Globicephala melas* was also found by Bastida and Lichtschein (1986). Mortality rates were only roughly estimated for *P. blainvillei* (Pérez Macri and Crespo, 1989). Southern Santa Cruz Province and Tierra del Fuego Island were surveyed by Goodall et al. (1994).

Preliminary estimations of Argentina's marine mammal mortality were not very accurate or complete, although the record of information was initiated with intensity in several areas like Necochea-Claromecó since 1988 and the coasts of Patagonia since 1989 (Monzón and Corcuera, 1990; Corcuera et al. 1994; Crespo et al. 1994a, b, c).

The biology of several marine mammal species was developed mainly on the base of specimens recovered from fisheries, which were the base for studies regarding the specific interactions (those concerning predator-prey relationships, competition for common resources and transmition of parasites).

Those studies were developed after the study of operational interactions and they include: age and reproduction of franciscana, dusky dolphin, southern sea lion, Burmeister's porpoise and Commerson's dolphin (Corcuera and Monzón, 1990; Monzón and Corcuera, 1990; Dans et al., 1993a,b; Crespo et al., 1994d), physical maturity (Corcuera et al., 1994), feeding habits (Pinedo 1982; Pérez Macri, 1986; Crespo et al., 1994c; Koen Alonso et al., 1993 a,b), parasites (Raga et al., 1990; Reyes et al., 1992, 1993), chlorinated hydrocarbons (Borrel et al., 1990).

MATERIALS AND METHODS

Interviews to government officers and fishermen

The information was recorded interviewing fishermen from 88 vessels mainly from the industrial fishery operating at Puerto Madryn, Comodoro Rivadavia, Puerto Deseado and Ushuaia. With less effort, information was gathered from the smaller harbours at Rawson, Camarones, Caleta Córdoba and southern coast of Santa Cruz Province. Aditional information was recorded reviewing files and interviewing officers from Fisheries Agencies at Chubut and Santa Cruz Provinces and the National Coast Guard.

Monitoring of fishing vessels

The main characteristics of the fishing operations were recorded in the harbours between the fishing trips by means of monitoring a total of 20 vessels since 1992 to 1994. The duration of the fishing trips, the fishing area, type of gear, target species, fishing operations and marine mammals catches were recorded.

Research trips and sampling on fishing vessels

A total of 150 days were expended on board of fishing vessels by members of the research team in order to evaluate by themselves cetacean sightings, incidental mortality and other by-catch information.

By-catch material of the shrimp and the hake fisheries were also collected on board with the objective of evaluating the species discarded and its relative abundance. For that purpose, 90-100kg of fish and other species caught were sampled of each tow. Tows were sampled during morning, afternoon and evening operations. Each tow was sampled at the beggining, in the middle and at the end of fish processing in order to avoid differences in buoyancy of fish composition.

Classification of the fishing types of the trawling fishery

In order to assess correctly the impact of the fishery on the marine mammal populations, the fishing fleet was classified in homogeneous components. Those fishing types were defined according to gear (mesh size, size of the mouth of net), gear type (bottom or mid-water trawling), target species (hake and shrimp) and time of operation (diurnal or nocturnal activity).

Nominal fishing effort was preliminarly estimated for each fishing type. It was considered the total number of fishing days per year as a summation of the individual days per vessel.

Calculation of marine mammal by catch

The catch rates were calculated in three different ways:

1) Total catch rate

$$TCR = \Sigma(m_i) / \Sigma(t_i)$$

where m_i is the number of animals caught by the vessel i during the survey, and t_i is fishing days of the vessel i during the survey

2) Average catch rate: is the mean value of individual vessels catch rate.

$$ACR = \Sigma(m_i/t_i) /n$$

3) Maximum catch rate MCR: it considers a uniform catch rate and equal to the maximum individual vessel rate within a fishing type. It is calculated for a fishing type on the base of the vessel with the highest catch rate, and applied to the remaining vessels of that type.

The number of animals annualy caught was estimated multiplying the catch rate by the nominal fishing effort for each type.

Age and reproductive condition of the animals caught by the fishery

In order to know age and sex composition of the catches, age and reproductive status were determined for 25 dusky dolphins (*L. obscurus*), 9 Commerson's dolphins (*C. commersonii*) and 7 southern sea lions (*O. flavescens*) incidentally caught in trawling nets in northern Patagonia. The specimens collected were mainly frozen on board at -20°C.

Standard length was measured following Norris (1961). Several teeth were collected from each individual. After decalcifying them in 5% formic or nitric acid, haematoxylin-stained sections 16 to 18µm thick were obtained (Hohn, 1980; Perrin and Myrick, 1980; Crespo et al., 1994d). Growth layers groups in dentine and cementum were counted assuming annual deposition.

During dissection, mammary glands were examined for presence of milk production and uterine horns were examined in order to search for foetuses. Ovaries were fixed in 10 % formalin solution or Bouin liquid. The number of corpora lutea and corpora albicantia were counted by slicing the cortex at 2 to 3 mm intervals.

Each female was classified into the following status (Perrin and Donovan, 1984): *Immature*: the female did not present corpora lutea or corpora albicantia; *Mature*: at least one corpus luteum or one corpus albicans was present; within this cathegory, they were classified resting, lactating, pregnant or pregnant and lactating.

Testes were fixed in 10 % formalin or Bouin´s solution. After removal of the epididymides, each testis was weighed and measured by means of a caliper. An epididymal smear was taken in order to determine the presence of spermatozoa. By means of histological analysis and the prescence of sperm production, each male was classified into the the following categories (Hohn et al., 1985): *Immature*: narrow seminiferous tubules without lumen; only spermatogonia can be observed; interstitial tissue may be abundant. *Pubescent*: elongated seminiferous tubules with small and empty lumen; spermatogonia, spermatocytes and some spermatids but no spermatozoa can be observed; scarce interstitial tissue, and *Mature*: greater seminiferous tubules with spermatozoa in the larger lumina; all stages of maturation of germinal cells can be observed; scarce interstitial tissue.

Stomach contents and relative importance of prey analysis

The study of feeding habits was performed by means of the food remains found in the stomachs of dusky and Commerson´s dolphins and southern sea lions. A total of 20 dusky dolphins and 9 Commerson´s dolphins was analyzed. Dolphins were all caught by fishing vessels at San Jorge Gulf between 1989 and 1994, while most of them were caught between 1992-1994 (73%). The sample of sea lions (11 males and 13 females) comes both from fishing vessels and dead individuals collected in beaches and rookeries between 41°S and 47°S. More than 70% was collected between 1991-1995.

Prey species were identified by means of otholits and bones in the case of fish, lower beaks for squid and exoskeletons for crustaceans. The importance of preys was studied by means of the Index of Relative Importance IRI (Pinkas *et al.*, 1971), replacing the volume term by the percentage of the estimated weight (Castley *et al.*, 1991).

Wet weight (W) and size of the preys were estimated from regressions between W and size (total length TL for fish or dorsal mantle length DML for squid) and between size and measures of otholits or beaks (otholit length OL, lower rostral length LRL or lower hood length LHL) (Pinedo, 1982; George-Nascimento *et al.*, 1985; Clarke, 1986 and unpublished data).

The study of overlap in the use of resources was carried out by means of the Adjusted General Overlap Index (GOa) (Petraitis, 1979; Ludwig and Reynolds, 1988). The null hypothesis of the complete overlap was tested by means of the V statistic (Ludwig and Reynolds, 1988). The overlap analysis between marine mammals and fisheries was restricted to the important preys in the diet of the marine mammals studied. In order to analyze the use of common resources, prey species were categorized in size classes as follows:

1) The hake *Merluccius hubbsi* was divided in 3 categories: a) primary juveniles less than 12cm TL; b) secondary juveniles between 12 and 30cm; c) preadults and adults more than 30cm (Angelescu and Prenski, 1987).

2) The shortfin squid *Illex argentinus* was divided in 2 categories: a) less than 20cm DML; b) more than 20cm DML (commercial size is 20cm).

3) The patagonian squid *Loligo gahi* was included in only one

category because almost all sizes could be marketable and even small individuals are being caught by the trawling fishery (personal observations).

4) The southern anchovy *Engraulis anchovy* was divided in 2 categories: a) juveniles less than 10cm TL; and b) preadults and adults more than 10cm TL (Angelescu, 1982) (commercial size is 10cm or larger).

RESULTS

Description of the highseas fisheries

Fisheries along the coast of Patagonia involve five fishing ports at Chubut Province (Puerto Madryn, Puerto Rawson, Camarones, Caleta Córdoba and Comodoro Rivadavia), two at Santa Cruz Province (Puerto Deseado and Punta Quilla) and one at Tierra del Fuego Province (Ushuaia). Most of the larger vessels operate from Puerto Madryn and Puerto Deseado (Table 1). It should be mentioned that an unknown number of fishing vessels operate from northern harbours (e.g. Mar del Plata in Buenos Aires Province) and foreign vessels that fish on the border of EEZ (Exclusive Economic Zone).

Government agencies classify fishing vessels into 4 categories, which are: Close Coastal, Distant Coastal, Freezing and Factory vessels, which differ one of each other depending on vessel length, power of the main engine, fish processing and freezing hold capacity.

The most common fishing gear in the north and central Patagonia is trawling, which is used by 80% of the total of fishing vessels (including all types of vessels: CC, DC, FZ and F). Two other fishing gear, jigging and longlining, are used by a low number of freezing vessels (11 and 34 from a total of 194 respectively) (Table 1).

The trawling fishery

The trawling fleet uses two different types of net: a) one conventional net operated from the stern (66% of the trawlers); b) two smaller nets operated from the sides of the vessel by means of two rig system (34% of the trawlers), used exclusively for shrimp.

The mesh sizes in the bag (streched) are 12cm and 6cm for hake and shrimp trawl nets respectively. The nets are made of nylon multifilament. Small vessels carry on board only one net. Vessels over 30m length carry more than one net which are ready to be changed when sailing. The larger vessels (FZ and F) carry net echosounder and all, except of NC, have detection equipment.

The main characteristics of each type of trawling vessels are detailed in Table 2.

The most important target species for trawling fleet include: shrimp *Pleoticus muelleri*, and hake *M. hubbsi*. Also, other commercial associated species are shortfin squid (calamar común) *I. argentinus*, patagonian squid *L. gahi*, southern salmo *Pinguipes* sp., pink cusk-eel *Genypterus blacodes*, grouper *Acanthistius brasilianus*, sole *Paralichthys* sp., southern anchovy *Engraulis anchoita*, "palometa" *Parona signata* and "rubio" *Helicolenus lahillei*.

The most important fishing grounds for the trawling fleet are located in the following areas:

Escondida Island (43°30´-44°S;64°-65°18´W)
Bajo de los Huesos (43°-43°30´S;64°-65°W)
North of San Jorge Gulf and Camarones Bay (44°-46°S;65°-67°W)
South of San Jorge Gulf (46°-47°S;65°-66°W)
Puerto Deseado (46°-48°S;62°-65°W)

The vessels showed a different spatial and temporal distribution depending on the target species; those fishing for hake operate farther from the coast and move northward during summer (Fig. 1 and 2), while those fishing for shrimp use to fish closer to the coast remaining in the same area the whole year (Fig. 3).

The national and foreign fleet for squid

The national fleet for squid jigging is around 60 vessels, from wich 34 operate from Patagonian harbours (Table 1). At least 50 more foreign vessels (joint venture business) operate from regional harbours (Puerto Madryn, Puerto Deseado and Punta Quilla). All these vessels fish inside the EEZ of Argentina.

Outside of the 200nm EEZ border of Argentina, an international fleet operates in the continental shelf, mainly composed by jigging vessels. An estimated number of vessels operating in this area is no less than 150 (Anonymous, 1994).

The target species are shortfin squid *I. argentinus* and black squid *Martialia hyadesi*, which are found alone or in mixed groups. The Patagonian squid *Loligo gahi* is also caugth.

Areas for squid jigging range from Mar del Plata (38° S) to San Sebastián Bay (53° S), from the 100m isobath in the continental shelf to the continental slope. The fishing area can be divided in three subareas for different seasons in the year. In the southern area between 48° and 53°S (100-200m) the vessels fish from February to early April. Between 43° and 48°S (100-200m) vessels operate from mid-April to early July. In the north (38° to 43°S; 70m to the continental slope) the vessels operate from mid-July to September (Fig. 4).

Recent records of interactions between the jigging fishery were detected even that they are not quantified. Sea lions and Commerson´s dolphins seem to entangle lines of jigging machines, take squid and scatter the school.

The longline fishery

The longline fleet is composed at least of 19 vessels operating from Puerto Madryn, Puerto Deseado and Ushuaia in two separate fishing areas (Fig. 5).

The target species include Patagonian tootfish *Dissostichus eleginoides*, pink cusk-eel *Genypterus blacodes* and hake *M. hubbsi*. The bait used for longlines is mainly squid.

Fishing areas for Patagonian tootfish are mainly at Burwood Bank, neighbouring areas off Tierra del Fuego, Staten Island and South Georgias Islands, and the continental slope up to 47°S. Fishing area for pink cusk-eel and the hake is from Rawson (43°S) to Puerto Deseado (47°S) and from 64°W to the continental slope.

Fishing vessels for Patagonian tootfish *Dissostichus eleginoides* increased as a consequence of high commercial values. Associated species include Patagonian hake *Merluccius australis*, Spiny dogfish *Squalus sp.*, Dogfish *Mustelus schmitti* and rays (rayas), southern salmo, grouper, "brótola austral" and "rubio".

Close to Tierra del Fuego, killer whales (*Orcinus orca*) and sperm whales (*Physeter macrocephalus*) have been recorded to still bait and catch from longlines. These operational interactions have not been quantified yet.

Fishing types and nominal fishing effort for the trawling fishery

A total of 9 types were defined for the trawling fleet studied. The types were defined as follows:

Type 1: It is used by close coastal vessels, fishing in diurnal bottom trawling. The mouth of the net is 1.5m height and 8m width, and the target species are hake and shrimp.

Type 2: It is used by distant coastal vessels, fishing in diurnal bottom trawling. The mouth of the net is 3m height and 25m width, and the target species is hake.

Type 3: It is used by freezing and factory vessels, fishing in diurnal bottom trawling. The mouth of the net is 3m height and 42m width, and the target species is shrimp.

Type 4: It is used by factory vessels, fishing in diurnal bottom trawling. The mouth of the net is 3.5m height and 49m width, and the target species are hake, grouper, southern salmo, pink cusk-eel and squid.

Type 5: It is used by two rig vessels, fishing in diurnal bottom trawling. Each net has a mouth 0.8 to 1.5m height and 28m width, and the target species is shrimp.

Type 6: It is used by factory vessels, fishing in diurnal bottom trawling. The mouth of the net is 5m height and 42m width, and the target species are hake, grouper, southern salmo, pink cusk-eel and squid.

Type 7: It is used by factory vessels, fishing in diurnal bottom trawling. The mouth of the net is 7m height and 52m width, and the target species is shrimp.

Type 8: It is used by factory vessels, fishing in nocturnal mid-water trawling. The mouth of the net is 20m height and 40m width, and the target species is shrimp.

Type 9: It is used by factory vessels, fishing in nocturnal mid-water trawling. The mouth of the net is 42m height and 42m width, and the target species is shrimp.

The total number of effective fishing days per year of the patagonian trawling fishery is 33,103.1 days/year for a total of 149 fishing vessels. The fishing type 5 fish for almost half of the total fishing effort (46.37%), while it is followed in importance by type 2 (30.11%), type 4 (11.49 %) and type 1 (3.27%) (Fig. 6).

Estimation of marine mammals caught

From March 1992 to June 1994, an estimated total of 97 marine mammals were incidentally caught, for a total of 5,761 fishing days for the monitored fishing vessels. Out of the 88 fishing vessels, 20 of them belonging to seven trawling types were monitored continuously. Those vessels were selected on the base of the credibility of fishing officers.

Southern sea lions catches were recorded in 7 fishing types. Dusky dolphins were caught by 3 different fishing types while Commerson's dolphins were caught only by one fishing type (Tables 3 and 4). The estimated number of specimens caught by the fishery varies depending on the different calculations carried out. The specimes caught ranged between 168 and 487 southern sea lions, 53 and 197 dusky dolphins. Commerson's dolphins incidentally caught per year have no reliable figures.

Analysis of the age and reproductive condition of the animals caught by the fishery

Dusky dolphin

The ages in the sample incidentally caught ranged between 0 and 11 years old. The sample is biased toward females (70% of the catch). Among them (n=18), 44% were mature and 50% of them were pregnant. The average age of the females was 5,88 ± 2,09 years old. There were 7 males in the sample, 2 of them were determined as immature males including one suckling calf (possibly newborn). Among the other 5 males in the sample, 4 were determined as mature, as observed from the great testicular weights and sperm production. All these males were 8 years old or more. The average age of the males was 7,21 ± 3,21 years old.

Commerson's dolphin

Even that the sample is small (n = 9), a high percentage of the individuals were females (n = 7), showing a bias in the catch as it was observed for the dusky dolphin. Among the females 57% were mature (3 resting and 1 lactating). There were no pregnant females in the sample. The average age was 8,68 ± 4,09 years, with a range between 3 and 14 years old, wider than the range ages of the female dusky dolphins. Only two males were found in the sample (n=2), which ages were 7,5 and 10 years old.

Southern sea lions

In the case of southern sea lions, a bias exists toward young males in the catch. The age classes in the sample ranged from young males 1 year old to adult males 8 or more years old, with an average age of 3.1 ± 2.9 years. Two adult females were recovered. One of them was 14 years old, probably pregnant due to the presence of a corpus luteum. The other female recovered was 18 years old and it was in a lactating condition.

Analysis of marine mammals feeding habits

Twenty seven prey species were found for the three marine mammal species studied. Fish accounted for seventeen species, but in general terms, the most important preys included the hake, the shortfin squid, southern anchovy and patagonian squid (Fig. 7).

In the case of sea lions, the analysis was performed separately by sex. Twenty one prey species were found in males and eighteen were found in females. Nevertheless, the spectrum of important preys is more restricted for males than for females. The most important preys for males include hake and shortfin and patagonian squids. Females include four important prey species: shortfin squid, hake, raneya *Raneya flumnensis* and red octopuss *Enteroctopus megalocyathus* (Fig. 7).

With respect to the dolphin species, the prey collection is more restricted than that of the southern sea lion (8 species for the dusky dolphin and 9 for commerson's dolphin). Most important prey species for dusky dolphins include anchovy, shortfin and patagonian squid and hake in decreasing order. In the Commerson's dolphins, the hake seem to be an exclusive species followed by the shortfin squid. Dusky dolphins have a wider spectrum when compared to the Commerson's dolphin.

Regarding the use of hake and shortfin squid by the top predators, the Commerson's dolphin use the smaller sizes on both prey species (Fig. 8 and 9). Dusky dolphin consume hakes of similar and larger sizes overlaping in part with both male and female sea lions. Most of the hakes consumed by the sea lions belong to sizes caught by the fishery even that only a part of them include commercial sizes (Fig. 8). With respect to the shortfin squid, both dolphin species feed on non commercial sizes, while the sea lions feed on larger sizes (commercial and non commercial) (Fig. 9).

The results obtained lead to conclude that the hake is the most important prey for the marine mammals studied followed by the shortfin squid, the patagonian squid and the southern anchovy.

The preliminar information gathered on hake sizes caught by the hake fishery (one shipment carried out in winter; intermediate continental shelf; mesh 12cm) suggest that the fishery caugth sizes above 20cm of TL with a mode in 30cm TL, range 20-50cm (Fig. 10). Hake is also caught as by catch in the shrimp fishery (mesh 6cm). In this case the sizes ranged from 10 to 50cm of TL. The analysis of hake size caught in two shipments showed that in coastal areas (northern San Jorge Gulf in winter) smaller hakes are caught when compared to the intermediate continental shelf (eastern Mazarredo in winter). In the former case a mode was found in 20cm, while a bimodal distribution was found in the latter (modes in 20 and 35cm) (Fig. 10).

Other important preys for marine mammals caught as by catch in the shrimp fishery in the northern San Jorge Gulf were the Patagonian squid with size range from 4 to 20cm of DML (Fig. 11) and southern anchovies above 10cm of TL.

Analysis of the use of common resources

Considering both sexes of the sea lion, dusky dolphin, Commerson's dolphin and coastal and offshore samples from the shrimp fishery like diferent predators, was constructed a preliminary common resources utilization curve with the most important preys for marine mammals (Fig. 12). The GOa was calulated using these data.

The general overlap between all predators together was low (GOa=0.221) and significantly different of the complete overlap (V=13848.1 df=30 $p<0.05$). The overlaps between marine mammals and samples from the shrimp fishery taken by pairs, was different of the complete overlap (Table 5). The extreme points were the high overlap between sea lion males and coastal samples (GOa=0.913) and the low overlap between Commerson's dolphin and the offshore sample (GOa=0.042) (Table 5).

DISCUSSION

The historical evidence about the development of fisheries in the patagonian shelf, and the effects on marine mammal populations and the environment in general, would have began in the early 70's. Fishing for hake and shrimp by means of trawling leaded to introduce larger freezing vessels and factory ships expanding continuously the fishing areas. Changes operated in the fleet during the last 25 years, increased the probability of entanglement of marine mammals. The fishing effort continued to increase at the begining of the 90's with the incorporation of jigging and longline vessels including fishing areas not previously exploited (Crespo et al., 1994a, b).

The hake fishery (conventional trawlers) fish between Península Valdés and Puerto Deseado, between 15 and 120mn of the coast (Fig. 1 and 2). The shrimp fishery (rig system trawlers) is more coastal (within 80nm) fishing between Escondida Island and San Jorge Gulf (Fig. 3). Fishing for patagonian grenadier *Macruronus magellanicus* and southern blue whiting *Micromesistius australis* for surimi (mid-water and bottom trawlers) takes place between Burwood Bank and the shelf between Malvinas island and Tierra del Fuego. Squid fishery is carried out in the shelf mainly between 100m and 200m isobaths (Fig. 4). The longline fishery, which target species include the Patagonian tootfish and the pink cusk-eel, expanded to new areas close to the slope (surroundings of Tierra del Fuego) and shelf in front of Santa Cruz Province in sea bottoms avoided by trawlers (Fig. 5).

Incidental mortality in present times affect at least to the southern sea lions and the dusky and Commerson's dolphins. Sea lions are caught in all fishing types while the fishing type affecting mostly to dolphin species is the mid-water trawling for shrimp, which was widely used during the 80's and seems to be declining in use by the national fleet in EEZ's waters. Nevertheless, mid-water trawling is still being used with unknown effects in the patagonian grenadier and southern blue whiting fishery. Other operational interactions like damage to the catch or gear do not seem to be important in those fisheries.

With respect to trawling vessels, incidental mortality affects in a different way to sea lions and dolphins, when the type of fishing vessels, catch rates and sex and age classes caught are analyzed.

The figures of sea lions annualy caught seem to be the higher among the marine mammals studied (Table 3 and 4). The number of animals caught range between 1-2% of the population size estimated for the area in 30,000 individuals (Szapkievich and Crespo, 1992). Both species of dolphins seem to have lower In the case of dolphins we ignore the population size even that pilot surveys leaded to think that there are low density areas for

these species (unpublished data).

Another fact to be considered is that the effects on the sea lion population would not be the same to those operating on dolphins. The age structure of the sea lion catch is biased toward subadult and probably adult males (which are thrown back to sea). In the case of dusky dolphins, the age structure of the catch is biased toward females of high reproductive value (Dans et al., 1993a,b; unpublished data). Half of the female sample are mature females and half of them are pregnant. In the Commerson's dolphin, the age range is wider even that there were not found pregnant females. The effects of the incidental mortality on these populations are clearly different without considering the absolute figures and its implications on population size. In addition, mortality of sea lions would be older than that of dolphin species.

Regarding ecological interactions, particularly the use of common resources, even that exists an overlap between the marine mammals analyzed and fisheries, it is not consider to exist high competitive effects between them. A retrospective analysis of those kind of interactions is impracticable today as a matter of lack of previous information.

The hake is the most important prey for the Commerson's dolphin eating small sizes neither captured not discarded by the fishery (Fig. 7, 8, 10 and 12). The same situation is observed in dusky dolphins which feed mainly on anchovies (Fig. 7 and 12). The following prey for both species of dolphins is the shortfin squid, smaller than those sizes of commercial value (Fig. 7, 9 and 12).

Therefore, dolphins seem to be less affected than sea lions in the use of food resources, while they seem to be more susceptible to competitive effects. Dolphins have more restricted food preferences which suggest prey selection. It must be considered that most of dolphins were collected during shrimp fishing operations and it was never found a shrimp in stomach contents and that anchovy is a shrimp-associated species. Anchovy is usualy not collected in the shrimp nets, leading to conclude that the fishing for shrimp has beneficial effects on the anchovy and indirectly on the dolphins and other species which feed on them.

It must be mentioned that other feeding studies carried out in commerson's dolphins at the extreme south of South America were completely different, in which crustaceans, sardines and silversides were the most important feeding items (Bastida et al., 1988).

The sea lions overlap in a higher degree with the fishery when compared with the dolphins (Table 5). Even that, it must be considered that the species has a wider spectrum of food preferences. The hake, the most important target of the fishery, with higher levels of discard in the shrimp fishery, is largely preferred by sea lion males (Fig. 7, 8 and 12). Therefore, the hake and the shrimp fishery would be affecting more to sea lion males than to females. Females feed on a wider spectrum of preys than males do, some of them (like *raneya*) are not commercial and are not discarded by the fishery. In addition, *raneya* seems to be the way in which the acantocephalan *Corynosoma sp.*, parasites the sea lion as a final host. The sea lion is the only marine mammal of Patagonia in which this parasite was found (Reyes et al., 1992, 1993).

Regarding the interaction between the squid fishery and sea lion females, it must be considered that females use to be more coastal than males (Crespo, 1988) and that the fishing area of the jigging vessels is between 100 and 200m isobaths (Fig. 4). Therefore, competitive effects would only be tested under overfishing conditions of squid populations. It must be considered that new regulations were established since 1994.

If there exists any competitive effect of the fishery it is difficult to sustain at the light of the information recorded up to date. The opportunistic feeding pattern of the species and particularly of the female section of the population leads to

protect the sea lion of overfishing effects. Nevertheless, incidental mortality and competitive effects together, would have limited the recovery of the sea lion population after the depletion of the stock carried out between the 30´s and the 50´s (Crespo and Pedraza, 1991) since the development of the fisheries in the early 70´s.

Such situations of fast development of fisheries have been recorded previously in other parts of the world like the north Pacific after the second world war. The intensive fishing in the area is considered to be a cause of decrease in population levels of Steller sea lions (*Eumetopias jubatus*) and northern fur seal (*Callorhynus ursinus*), both due to incidental mortality and reduction of stocks of preys (Fowler, 1982; Loughlin and Nelson, 1986; Alverson, 1992).

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Table 1

Composition of the fishing fleet of the Patagonian coast, considering harbour, type of vessel and fishing gear. TRW: trawling, LL: longlining, JG: jigging, CC: close coastal, DC: distant coastal, FZ: freezing, F: factory

TYPE OF VESSEL	CC	DC	FZ			F	TOTAL
FISHING GEAR	TRW	TRW	TRW	LL	JG	TRW	
HARBOUR							
Puerto Madryn	-	5	25	4	14	13	61
Comodoro Rivadavia	2	15	3	-	-	-	20
Rawson	21	13	-	-	-	-	34
Caleta Córdova	6	-	-	-	-	-	6
Puerto Deseado	-	-	39	7	20	7	73
TOTAL	29	33	67	11	34	20	194

Table 2

Characteristics of the trawling fleet of the Patagonian coast. Standard deviations are expreesd as ± below the value.

TYPE OF VESSEL	LENGTH (m)	DSP (ton)	MAIN ENGINE (HP)	HOLD (m^3)	YEAR OF CONSTRUCTION	TRIP (days)
Factories	73.77	1592.08	2917.54	1663.13	1971	48.1
n = 20	±10.36	± 828.21	±1061.18	±1004.43	± 5	±11.3
Freezing	36.16	310.42	1041.37	292.90	1979	33.9
n = 67	± 7.75	± 180.03	± 426.64	± 177.58	± 9	± 5.5
Distant coastal	26.82	158.33	532.24	153.62	1977	4.5
n = 33	± 7.02	± 142.60	± 276.68	± 103.02	± 12	± 1.7
Close coastal	15.91	27.54	185.89	27.90	1955	0.5
n = 29	± 2.41	± 14.23	± 88.53	± 15.9	± 21	

Table 3

Estimated catch rates and total number of southern sea lions annualy caught related to fishing effort.

Type	Annual Effort	TCR	Nºind per year	ACR	Nºind per year	MCR	Nºind per year
2(FC)	8,197.2	0.01630	133.650	0.01300 (0.01700)	106.560	0.03800	311.490
2(FZ)	1,771.3	0.00650	11.510	0.00715 (0.00540)	12.660	0.01500	26.570
3	146.0	0.00775	1.132	0.00775	1.132	0.00775	1.132
4	3,806.6	0.00250	9.520	0.00360 (0.00630)	13.700	0.01100	41.870
5	15,351.0	0.00196	30.090	0.00188 (0.00250)	28.860	0.00625	95.940
6	460.0	0.00490	2.264	0.00630 (0.00880)	2.900	0.01660	7.636
7	160.0	0.00550	0.877	0.00550	0.877	0.00550	0.877
8	96.0	0.01800	1.740	0.01800	1.740	0.01800	1.740
Total			190.780		168.430		487.250

Table 4

Estimated catch rates and total number of dusky dolphins annualy caught related to fishing effort.

Type	Annual Effort	TCR	Nºind per year	ACR	Nºind per year	MCR	Nºind per year
2(FC)	8,197.2	0.00543	44.550	0.00400 (0.00650)	32.780	0.01500	122.960
5	15,351.0	0.00049	7.520	0.00039 (0.00120)	5.990	0.00390	59.900
8	96.0	0.14800	14.210	0.14800	14.210	0.14800	14.210
Total			66.280		52.980		197.070

Table 5

Adjusted general overlaps (GOa) between marine mammals and the samples from the shrimp fishery, V statistics and their statistical significations.

	Sea lion Male	Sea lion Female	Dusky dolphin	Commerson's dolphin
Coastal Sample				
GOa	0.913	0.504	0.614	0.151
V	40.63	254.23	603.66	1470.58
df	6	6	6	6
p	<0.05	<0.05	<0.05	<0.05
Offshore Sample				
GOa	0.480	0.389	0.126	0.042
V	559.87	648.31	4060.94	4850.64
df	6	6	6	6
p	<0.05	<0.05	<0.05	<0.05

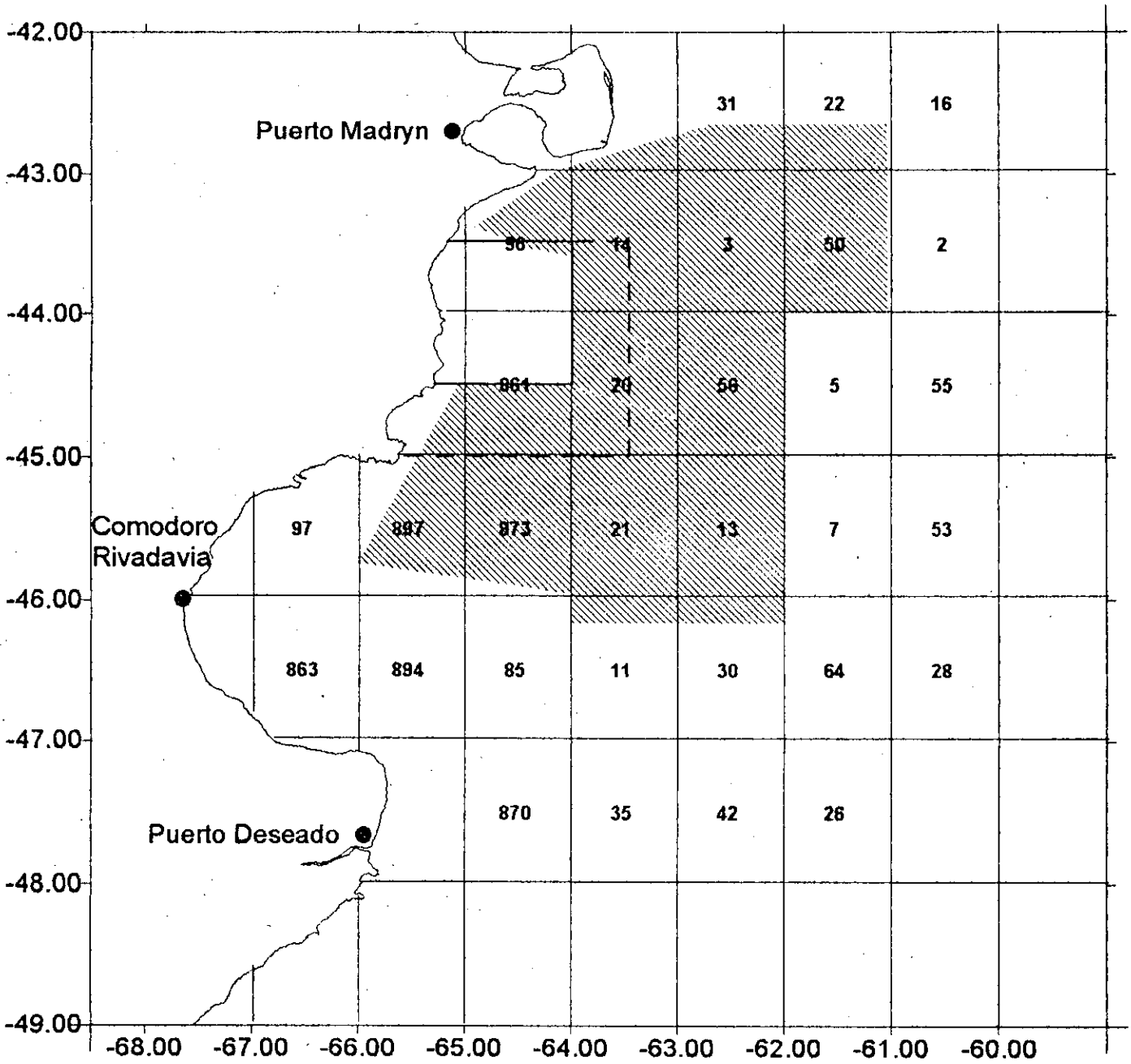

Figure 1. Fishing areas for hake in summer (September-February).

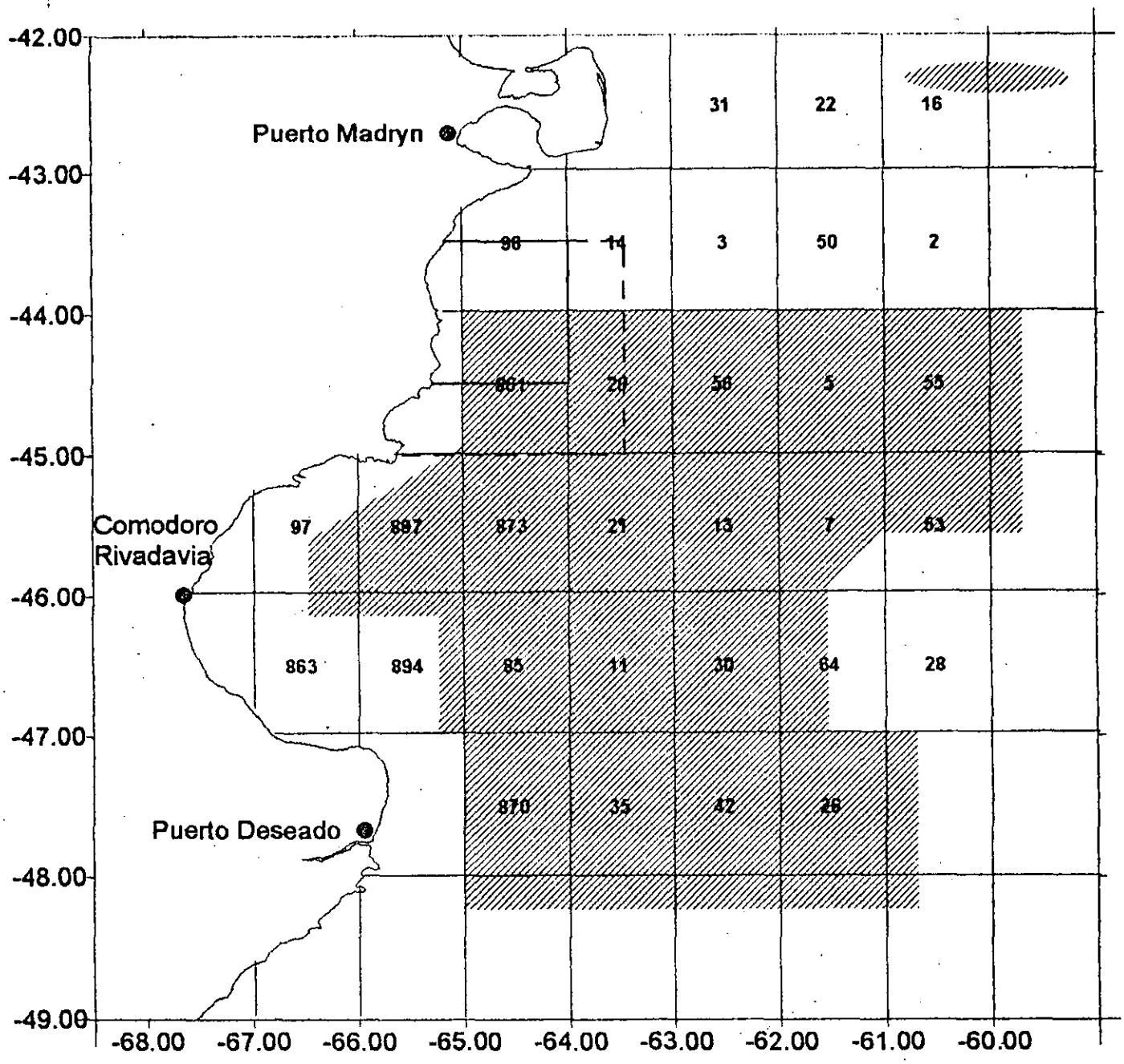

Figure 2. Fishing areas for hake in winter (March-August).

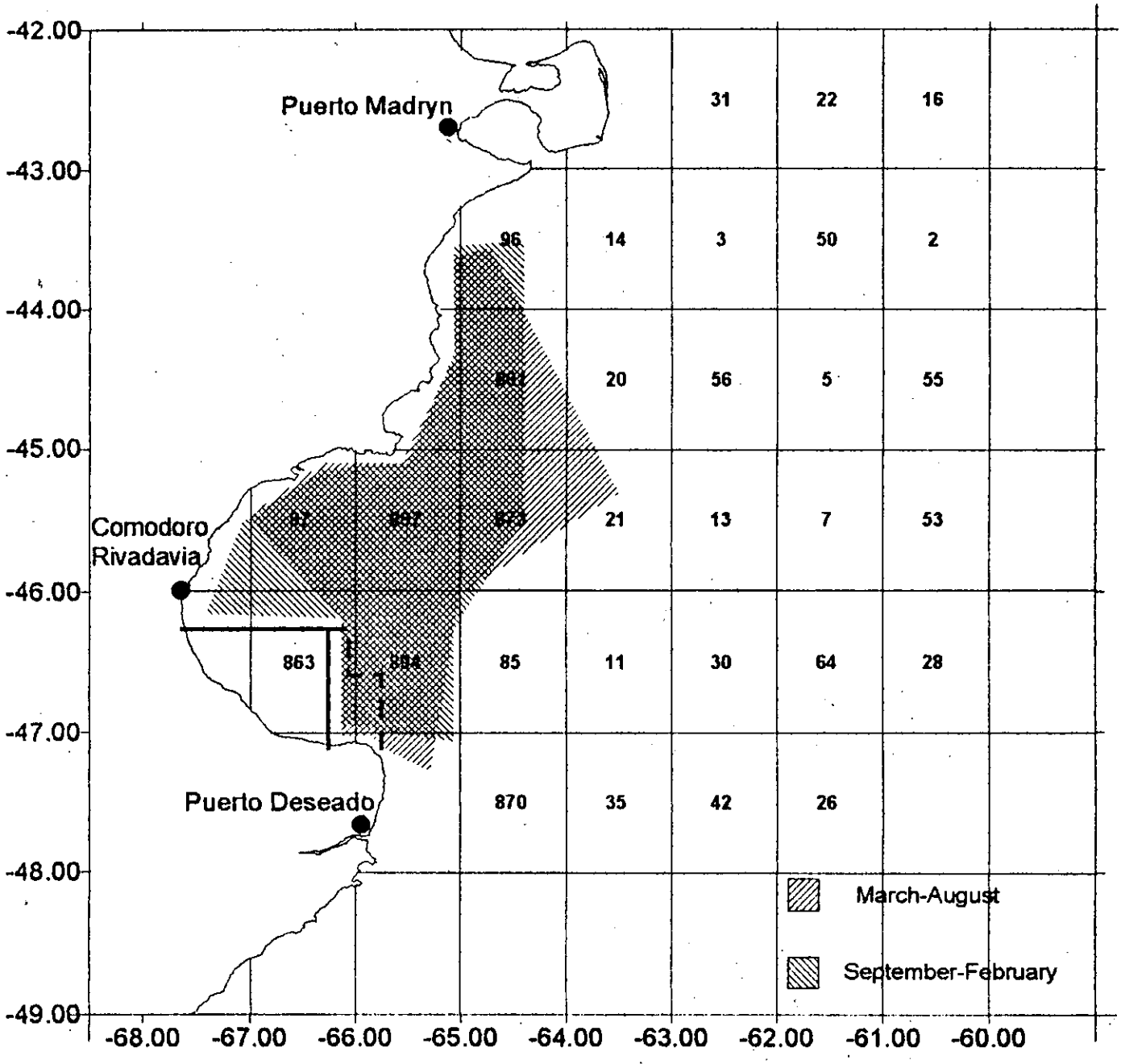

Figure 3. Fishing areas for shrimp (summer and winter).

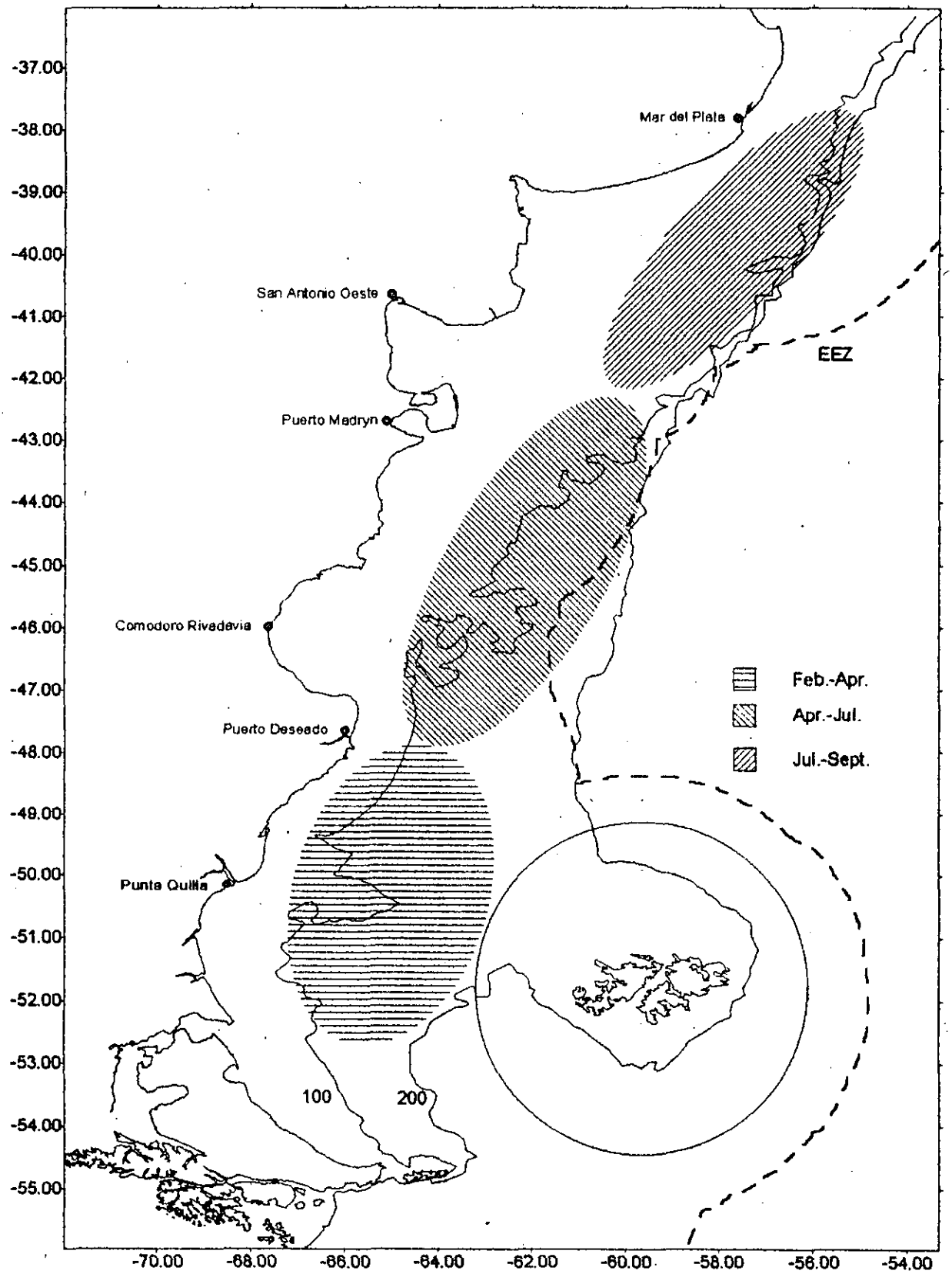

Figure 4. Fishing areas for jigging.

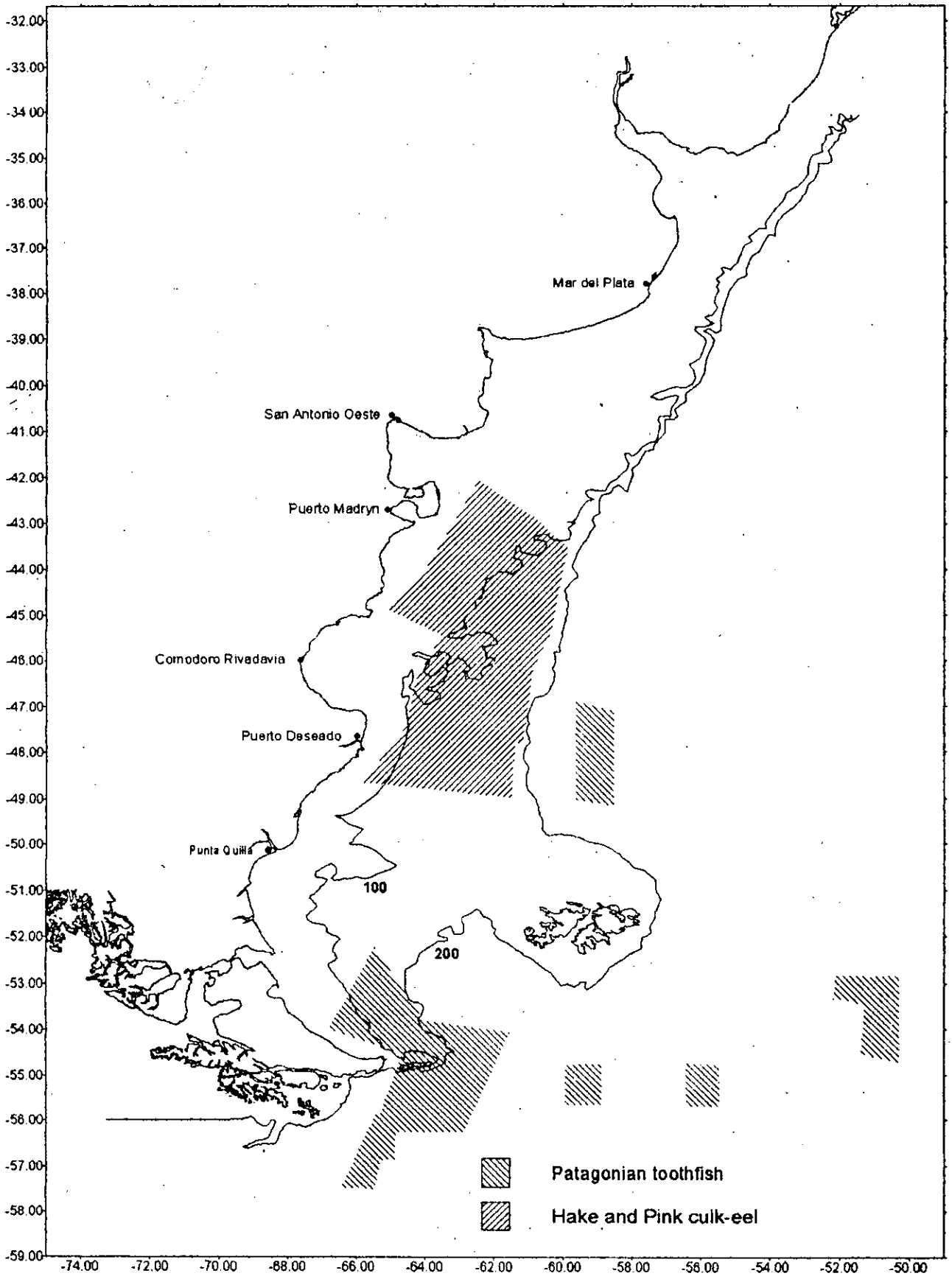

Figure 5. Fishing areas for longliners.

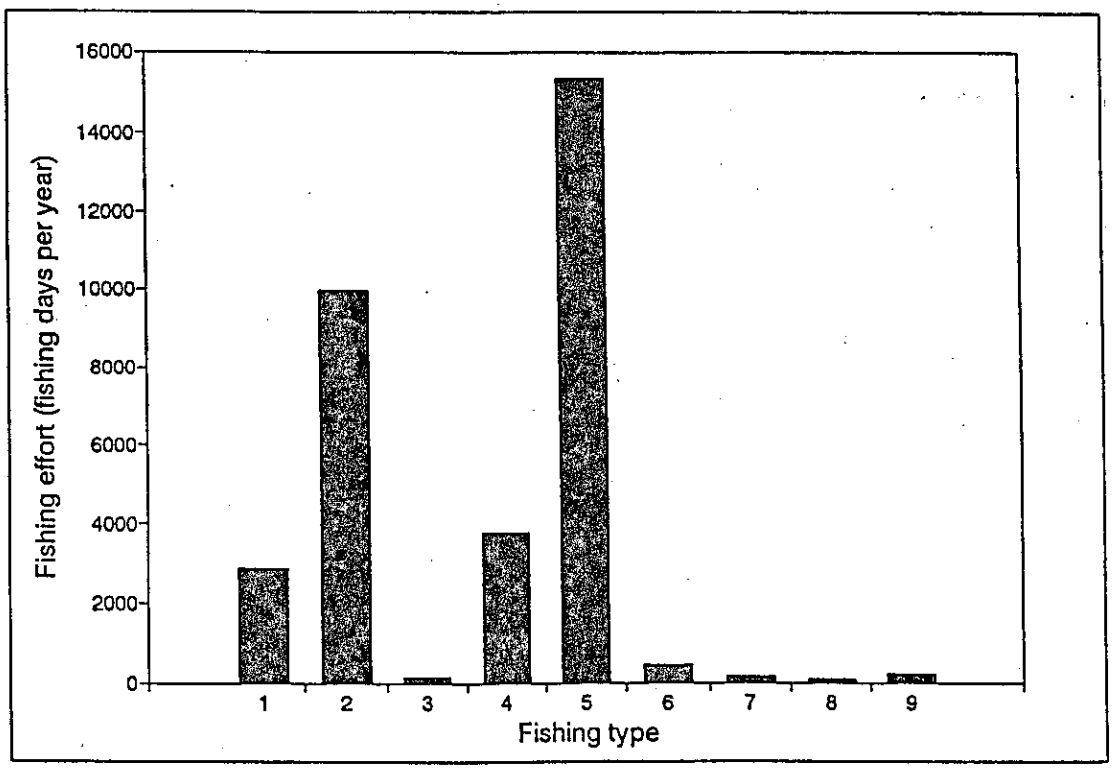

Figure 6. Distribution of the annual fishing effort of the fishing types 1 to 9 of the trawling fleet operating in northern and central Patagonia.

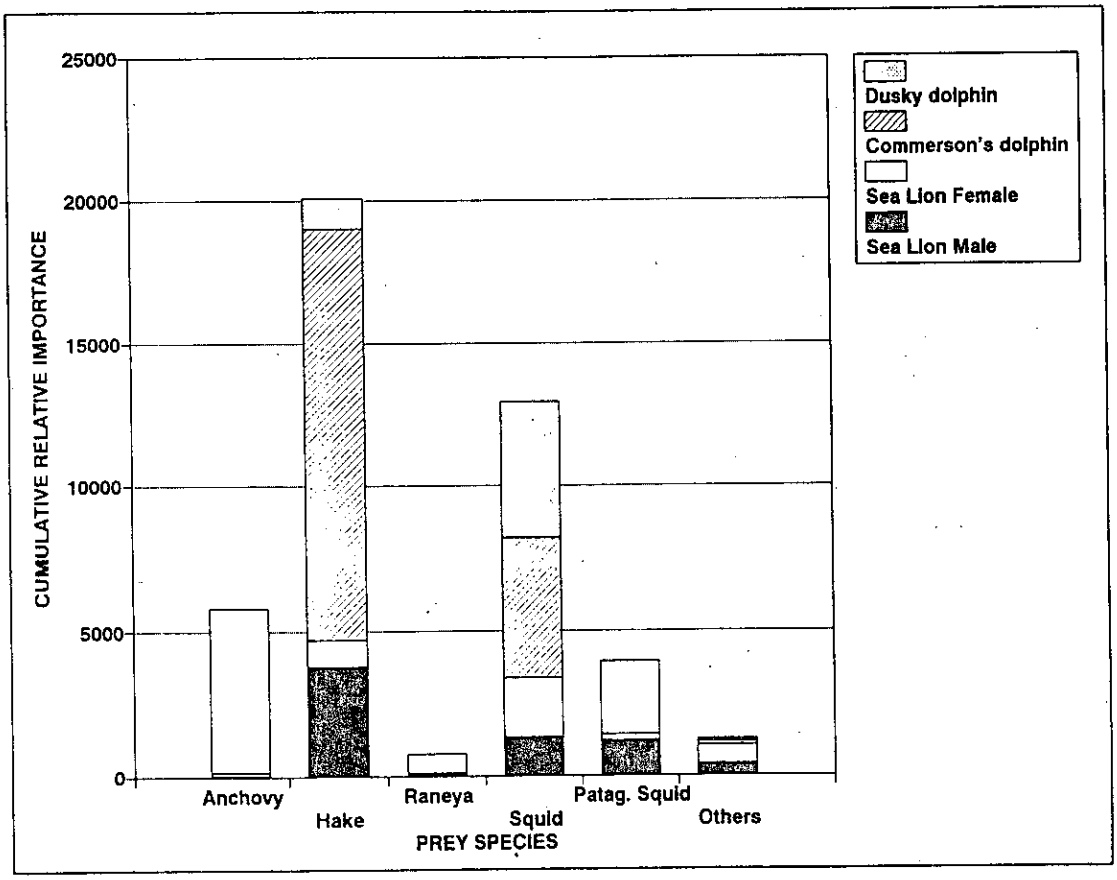

Figure 7. Cumulative relative importance (IRI) of preys of marine mammals studied.

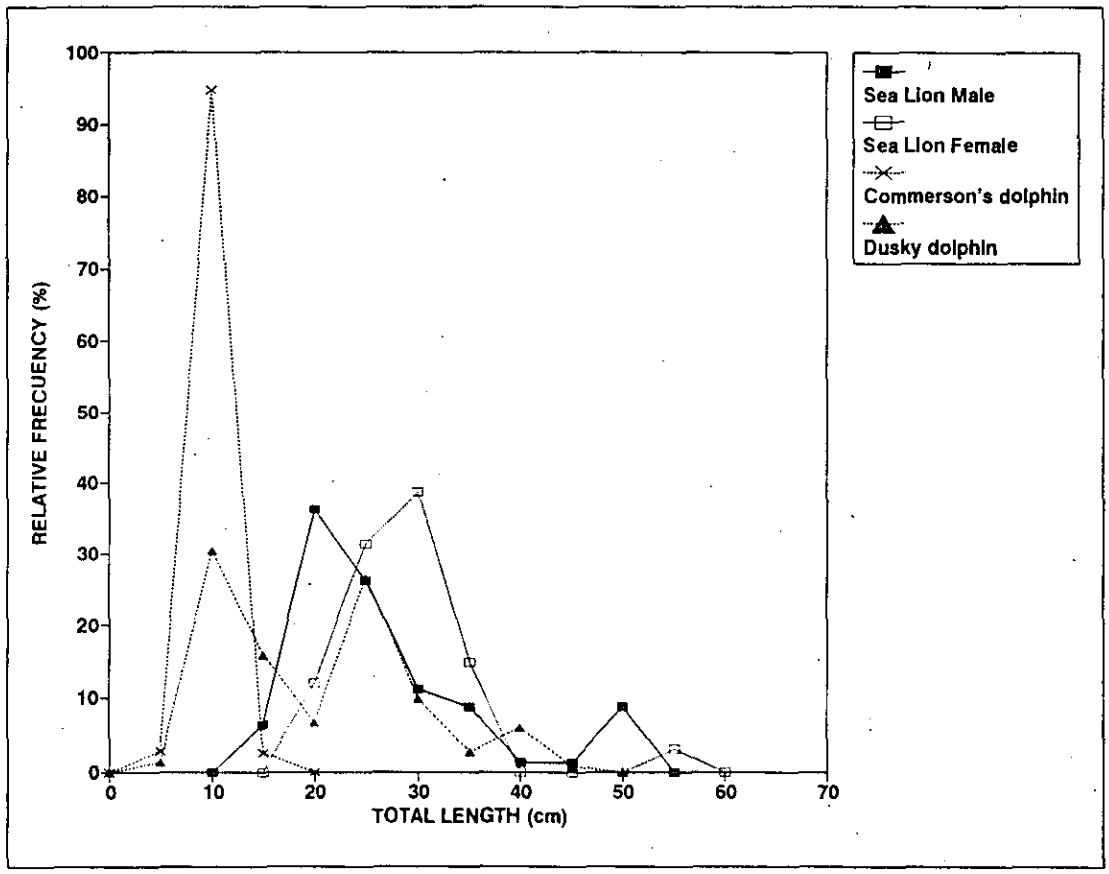

Figure 8. Size frecuency distribution of hake eaten by top predators.

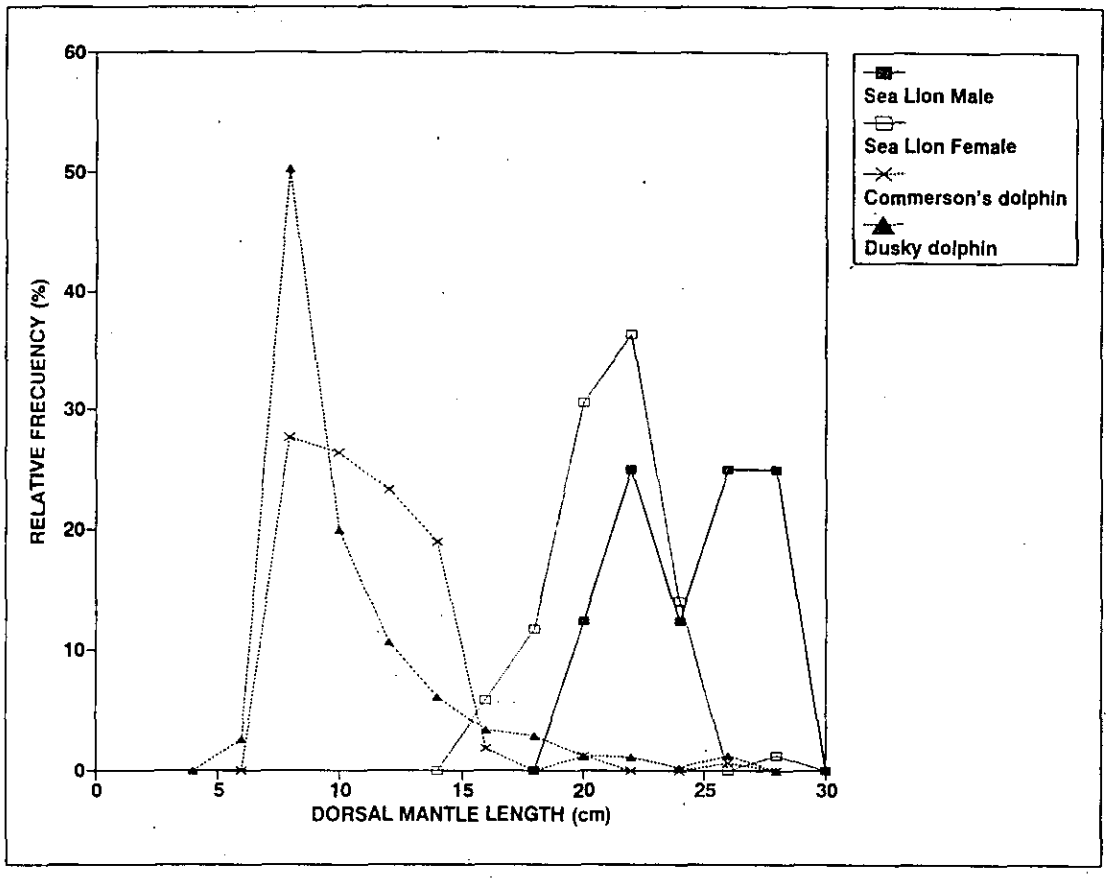

Figure 9. Size frecuency distribution of shortfin squid eaten by top predators.

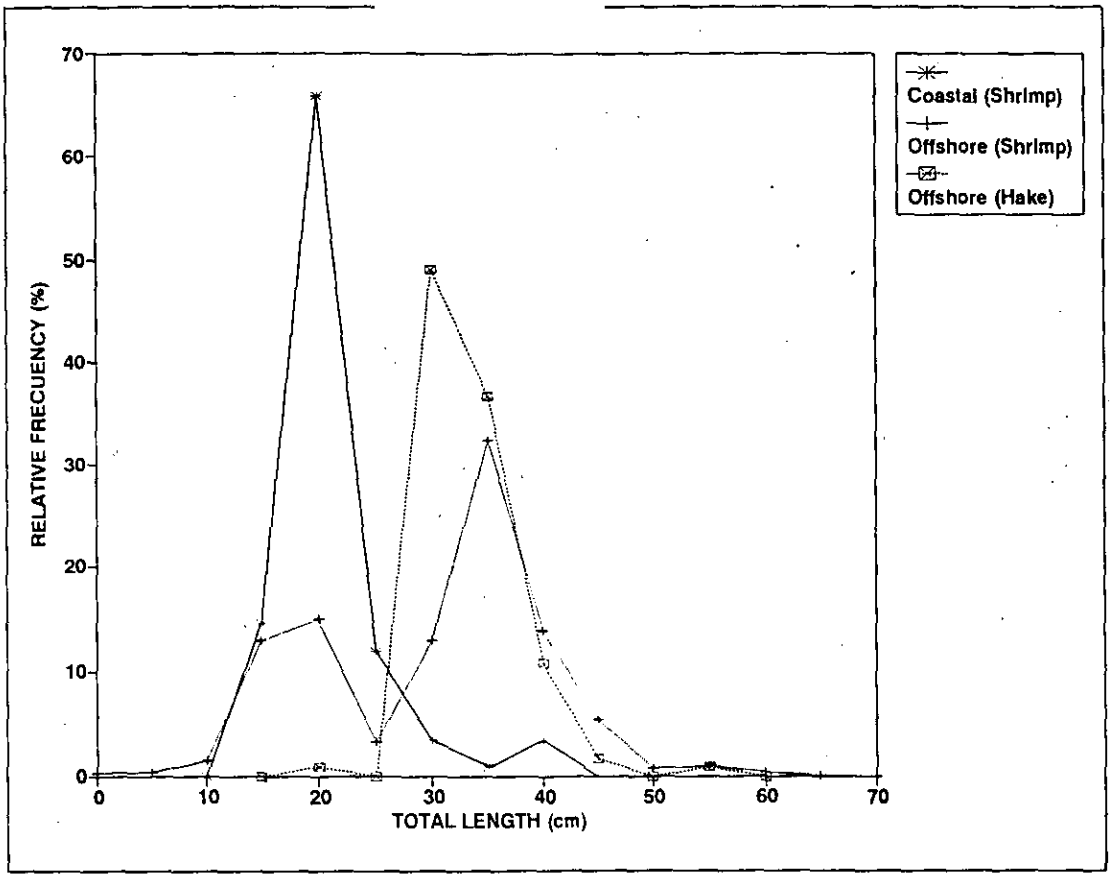

Figure 10. Size frecuency distribution of hake caught by the shrimp and hake fisheries in coastal and offshores areas surrounding San Jorge Gulf.

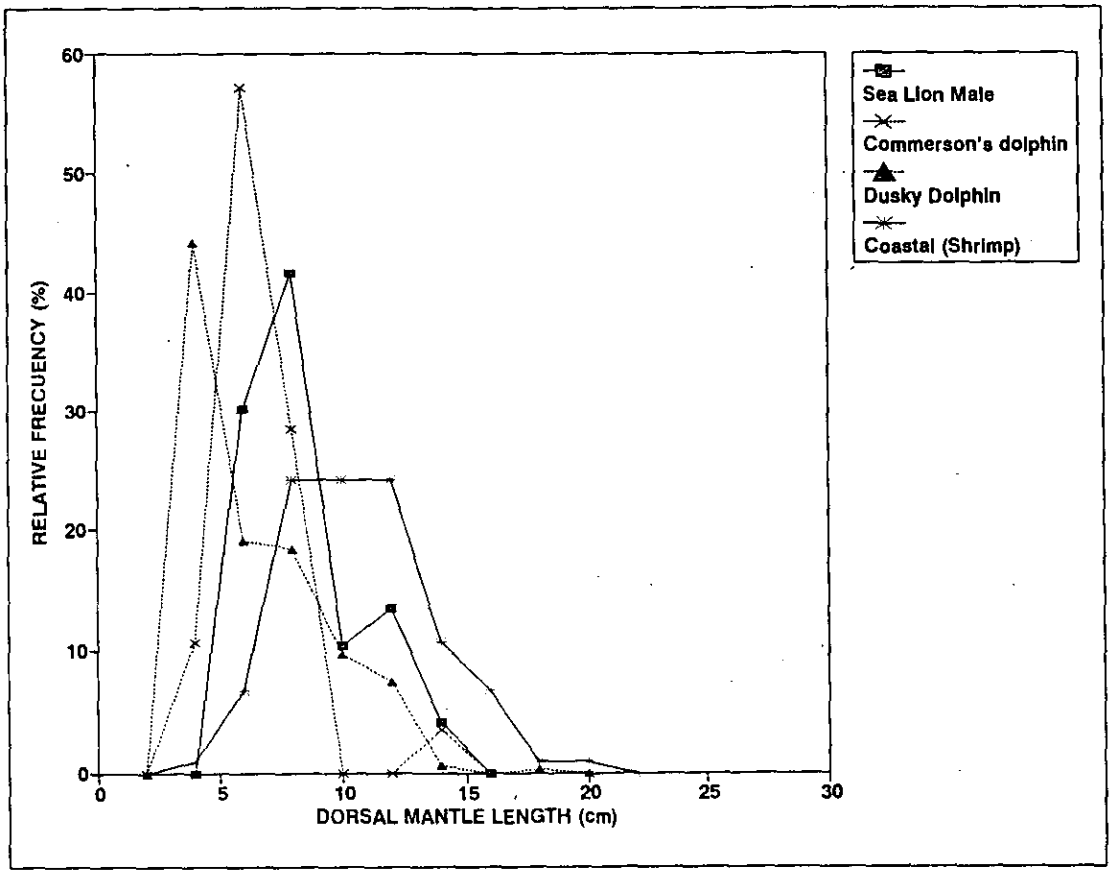

Figure 11. Size frecuency distribution of Patagonian squid eaten by sea lion male, Commerson's dolphin and dusky dolphin, and caught by the shrimp fishery in coastal areas.

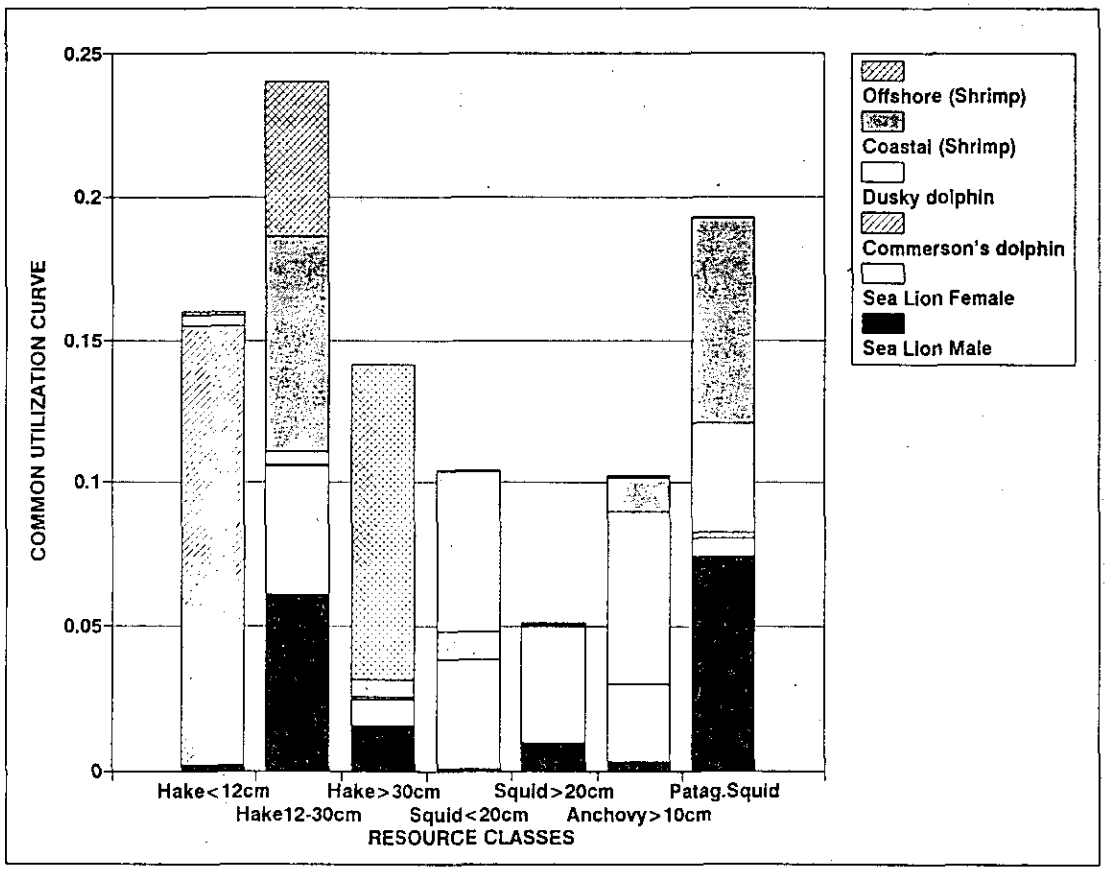

Figure 12. Common resources utilization curve constructed considering hake (3 categories), shortfin squid (2 categories), patagonian squid (1 category) and southern anchovy (1 category).