HOOK SELECTIVITY IN THE LONGLINE FISHERY OF *DISSOSTICHUS ELEGINOIDES* (NOTOTHENIIDAE) OFF THE CHILEAN COAST

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Abstract

Existing information from technical publications on Chilean fisheries of the Patagonian toothfish, *Dissostichus eleginoides* is reviewed in order to study selectivity of different types and sizes of hooks used in longlines. Original data obtained during 1991 off the coast of Valdivia, South East Pacific, are also taken into consideration. The data show that circle hooks are far more efficient than straight hooks. The length frequency distributions of fish caught with straight hooks Nos 3 and 4 are not significantly different, but hooks No. 3 are nearly 31 % more efficient than hooks No. 4. Using different bait does not result in significant differences. It is worth noting that the ratio of females increases significantly in catches, when the size of straight hooks is increased (e.g., from 4 to 3) or when circle hooks are used instead of straight hooks.

Résumé

L'examen des informations contenues dans les publications techniques sur les pêcheries chiliennes de légine australe, *Dissostichus eleginoides*, a pour but d'étudier la sélectivité des différents types et tailles d'hameçons des palangres. Les données originales obtenues en 1991 au large de la côte de Valdivia, dans le secteur sud-est du Pacifique, sont également prises en considération. Ces données indiquent que l'efficacité des hameçons recourbés est nettement supérieure à celle des hameçons droits. Les distributions de fréquences de longueurs des poissons capturés avec des hameçons droits N^{os} 3 et 4 ne présentent pas de différence significative, mais les hameçons N^{o} 3 sont de près de 31% plus efficaces que les hameçons N^{o} 4. Le changement d'appâts ne crée pas de différences significatives. Il convient de noter que la proportion des femelles augmente notablement dans les captures lorsqu'on augmente la taille des hameçons droits (de 4 à 3, par ex.) ou lorsqu'on passe d'hameçons droits à des hameçons recourbés.

Резюме

В целях изучения селективности крючков различных типов и размеров, используемых при ярусном промысле, делается обзор существующей информации по промыслу Чили патагонского клыкача, *Dissostichus eleginoides*, взятой из технических публикаций. Также приняты во внимание первоначальные данные, полученные в течение 1991 г. у

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побережья Вальдива, юго-восточная часть Тихого океана. Данные показывают, что закругленные крючки гораздо эффективнее одногибых. Частотное распределение длины рыбы, выловленной одногибыми крючками №3 и №4 не отличается значительно, но крючки №3 почти на 31% эффективнее крючков №4. Использование разной наживки не приводит к большим различиям. Следует отметить, что соотношение самок значительно возрастает при увеличении размера одногибых крючков (например от №4 до №3) или когда вместо одногибых крючков используются закругленные крючки.

Resumen

Se examina nuevamente la información actual procedente de publicaciones técnicas, relacionada con la pesquería chilena de austromerluza negra, *Dissostichus eleginoides*, con el fin de estudiar la selectividad de diferentes tipos y tamaños de anzuelos empleados en la pesquería de palangre. Además se ha tomado en consideración la información original obtenida en 1991 a la altura de Valdivia, Pacífico sudoriental. Los datos muestran que los anzuelos curvos son mucho más efectivos que los anzuelos derechos. Las distribuciones de la frecuencia de tallas de peces capturados con anzuelos derechos No. 3 y 4, no difieren mayormente, pero los anzuelos No. 3 tienen una eficacia de alrededor de un 31% más que los anzuelos No. 4. Empleando diferentes tipos de cebos no causa una notable diferencia. Vale tomar en consideración que la proporción de las hembras aumenta considerablemente en las capturas cuando se aumenta el tamaño de los anzuelos derechos (es decir, de 4 a 3) o cuando se emplean los anzuelos curvos en lugar de los anzuelos derechos.

1. INTRODUCTION

Exploratory fishing for the Patagonian toothfish (*Dissostichus eleginoides*, Smith, 1898) in Chile started as early as 1955, the year in which the exploration of the continental slope began for fishery purposes, mainly searching for pink ling (*Genypterus blacodes*) as the target species (González, 1962). In the late sixties, Pavez *et al.* (1968) designed a special longline gear to be used at depths greater than 1 000 m, and obtained first catches of commercial interest for the fishery. After that, fish pots and gill nets were tested, proving that the longline method was far more efficient than others (Inostroza, 1975). During 1990, catches of *D. eleginoides* with longlines along the Chilean coast reached a record of 9.387 tonnes (SERNAP, 1991).

In accordance with information by DeWitt *et al.* (1990) and data from the actual fishing of *D. eleginoides*, the distribution area of this species includes the South East Pacific Ocean, covers the continental slope of the Chilean-Peruvian trench and reaches the Arica coast in the north of Chile. Besides that, it has also been reported from the Argentinean-Patagonian zone and from the Antarctic (Figure 1). In front of the coast of Chile adult fish mainly inhabit waters between 500 and 2 500 m depth (Salas *et al.*, 1987), living near the bottom and migrating to the upper layers (Oyarzún *et al.*, 1988). Recent developments in this fishery in Chile shows a worrying tendency to deplete stocks and to expand the fishery further south (Lemaitre *et al.*, 1991). It indicates that the moment for establishing fishery regulations is not too distant.

Studies of hook selectivity could result in the development of a conservation measure analogous to the selection of distance between knots in gill nets, which might later be used as an ultimate management measure. Fishery of *D. eleginoides* has been recently introduced in some areas of the CCAMLR Convention Area. Information presented in this paper can, therefore, be used by the CCAMLR Working Group on Fish Stock Assessment for comparative analyses.

2. CHILEAN FISHERY LEGISLATION

The fishery of *D. eleginoides* is regulated in Chile by Decree No. 439 of the Economy Ministry of 1985, which establishes that only vessels of a maximum length of 15 m and operating up to 12 000 hooks each can be used. The length of Chilean vessels was increased to 18 m by Decree No. 43 of 1986 of the same Ministry. This amendment relates to vessels that operate further south of 32°45'40" (Point Liles), and maintains the restriction of hook number. The regulation does not consider types and sizes of hooks utilised.

3. FISHING WITH LONGLINES

The first selectivity study of hooks used in deep-water longlines was performed by Zapata (1976) with different sizes of Mustad Kirby hooks, model 2330. He recommended hooks Nos 4 and 5. He also suggested that a time between setting and hauling of a longline should be 14 to 16 hours.

However, the most complete study of the *D. eleginoides* fishery was carried out by Salas, Robotham and Lizama (1987) (from here on, SRL) in the VIII Region of Chilean waters. They used three horizontal longlines of 1 500 hooks each, with five sections with hooks No. 3 and five sections with hooks No. 4. The hooks used were also of Mustad Kirby, model 2330. The efficiency of the previously described straight hooks with long shank (model 2330) was compared with the efficiency of circle hooks (Mustad Tuna Circle, model 39965 ST, size 14/0) (Figure 2).

Sections of different types of hooks were arranged randomly along the longline according to methodology described by Pope *et al.*, (1983).

Each section comprised of 150 hooks placed 2 m apart on 60 cm branches made of 3 mm diameter polypropylene rope. The length of the longline was 3 080 m. Salted common sardines (*Clupea bentincki*) and mackerel (*Trachurus murphy*) were used as bait. Below we describe recent information obtained off the coast of Valdivia (X Region) on fishing with circle hooks and fresh mackerel bait.

For comparison all data were expressed in CPUE units defined as g/hook in each catch; indicating hook efficiency. Length composition of catches is illustrated in Figures 3 and 4 using the same method as SRL (1987).

4. CATCH EFFICIENCY OF STRAIGHT AND CIRCLE HOOKS

Catch efficiency of straight hooks (No. 4) and circle hooks was expressed in the same units of effort (g/hook) in order to obtain comparable results. Types of hooks used in 1987 in VIII Region do not differ significantly from hooks used in X Region (Valdivia zone). For this reason we consider it possible to pool data from these regions together for the analysis (Table 1, data from SRL, 1987 for VIII Region and original data for X Region combined). The comparison of all data showed that catch efficiency of circle hooks was significantly higher than

that of straight hooks. Circle hooks apparently have better retention rate of captured fish. This analysis agrees with the conclusion of SRL (1987) that circle hooks are significantly more efficient.

5. SELECTION OF BAIT

The question if the type of bait affects fishing efficiency has also been approached in several studies. Table 2 presents the available data on three types of baits used in *D. eleginoides* fishery: salted sardine, salted and fresh mackerel. The first two types of bait are commonly used in longline fishery along the Chilean coast.

The first two sets of data came from the study of SRL (1987). Data of sets 3 to 7 were collected from the X Region during 1991. In July 1991 we also obtained data from fishing operation of a longline vessel which used fresh mackerel bait during five fishing trips. A comparison of CPUEs obtained with different type of bait do not reveal statistically significant differences, although fresh bait data have larger variance (Table 2). The belief that fresh bait is more efficient is therefore based on fishermen tending to recall cases of larger catches than on results of statistical analyses.

6. SIZE SELECTIVITY

In general, catches consisted of fish larger that 50 cm length (total length, TL), both males and females. In my observations the smallest fish caught in 1991 off the coast of Valdivia was a male of 47 cm TL and 800 g weight (gutted). The largest specimen caught during research surveys in Chilean waters was a female of 174 cm TL and 51.4 kg weight (gutted).

Length range of fish caught by different size of straight hooks in the VIII Region is presented in Table 3 together with mean length. Length frequency distribution of catches is shown in Figure 3. The differences observed in length composition of fish caught by straight hooks Nos. 3 and 4 do not seem significant when length distributions are compared for different depth ranges. In accordance with SRL (1987) efficiency of hooks No. 4 was approximately 31% higher than that of hook No. 4. This conclusion is in agreement with Zapata (1976). Figure 3 demonstrates that bigger fish are caught at greater depth and females are, in general, more abundant in catches than males. In studies of SRL (1987), the highest proportion of females was 1:2.4 when using straight hook No.3 and 1:1.56 when using smaller size straight hook No.4. In case of circle hooks the highest proportion of females was 1:3.6.

Figure 4 presents data collected in August 1991 off the coast of Valdivia from longline catches at depth from 500 to 2000 m using circle hooks and similar data for straight hooks from SLR (1987). Statistical comparison of these data by Kolmogorov-Smirnov test (Rohlf, Sokal, 1989) gives D_{max} values for males and females greater than corresponding critical values of D taken from Table 31 of Sokal and Rohlf (1989). Therefore, in both cases there is evidence these length samples are significantly different in their distribution. We observe that circle hooks catch bigger fish than straight hooks. Unfortunately, both data sets are not collected simultaneously and we can not be absolutely sure about the selection effect of hooks of bigger sizes.

7. CONCLUSION

Two types of hooks have been used in deep-water longline fishery for *D. eleginoides*, straight and circle hooks. Circle hooks were found to be significantly more effective than straight hooks, when corresponding values of CPUE (g/hook) are compared. Length distributions of fish caught by straight hooks Nos. 3 and 4 do not differ significantly, although

hooks No. 3 were about 31% more efficient than hooks No. 4. No significant differences are found in the fishing efficiency when different types of bait have been used. We believe that higher efficiency of circle hooks relates to a higher rate of fish retention by this type of hooks.

In spite of the finding that differences in length composition of fish caught at the same depth by straight hooks of different sizes are not significant (when Kolmogorov-Smirnov test is used), it is of interest that a proportion of female is larger when bigger straight hooks or circle hooks are used. Higher fishing mortality of females could endanger the population of *D. eleginoides* because the population recovery rate would be lower than in case when 1:1 sex ratio is maintained.

However, a proportion of females and their length is also increased in catches taken at greater depth. Due to operational constraints vessels smaller than 18 m length rarely fish deeper than 2 000 m thus establishing a sort of a refuge zone for *D. eleginoides* in deeper waters. Therefore, if a decrease in catchability of longlines is required, prohibiting the use of circle hooks could be imposed as a future management measure.

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Table 1: Catch by units of effort (g/hook) for straight and circle hooks in *D. eleginoides* fishing in the VIII Region (data from SRL, 1987) and in the X Region (original data).

A.		Hook	
Data set	Region	Straight	Circle
1	VIII	80	231
2		83	142
3		28	99
4	X	44	99.5
5		45.1	90.4
6		60.8	75.1

B.					
Source	Sum-of-Squares	df	Mean-Square	F-Ratio	P
Region	5129.46	1	5129.46	3.581	0.095
Hook type within region	10374.60	1	13074.6	9.129	0.017
Hook type	2293.56	1	2293.56	1.601	0.241
Error	11458.06	8	1432.25		

Table 2: Catch by units of effort for circle hooks 14/0 with three types of bait in experimental fishing of *D. eleginoides* in the VIII Region (SRL, 1987) and in the X Region (Sardine = *Clupea bentincki*; Mackerel = *Trachurus murphy*).

Data Set	Region	Type of Bait		
		Salted Sardine	Salted Mackerel	Fresh Mackerel
1	VIII	147 (g/hook)	61 (g/hook)	--
2		48	56	--
3	X	68.4	76.1	110.0
4		87.1	101.4	80.3
5		44.7	65.0	40.0
6		--	--	65.1
7		--	--	57.4
Mean:		70.74	71.9	79.04
SD:		26.14	18.1	41.6

(One way ANOVA, F = 0.113; df = 2; P = 0.894)

Table 3: Length range and mean length of *D. eleginoides* by hook sizes and fishing depth.

Fishing Depth (m)	Hook Size (No.)	Fish Length Range (cm)	Fish Mean Length (cm)
500 to 1 000	3	51 - 110	77.1
	4	54 - 95	73.4
1 001 to 2 000	3	53 - 146	82.4
	4	53 - 110	75.9
2 001 to 3 000	3	72 - 131	97.0
	4	75 - 133	95.4

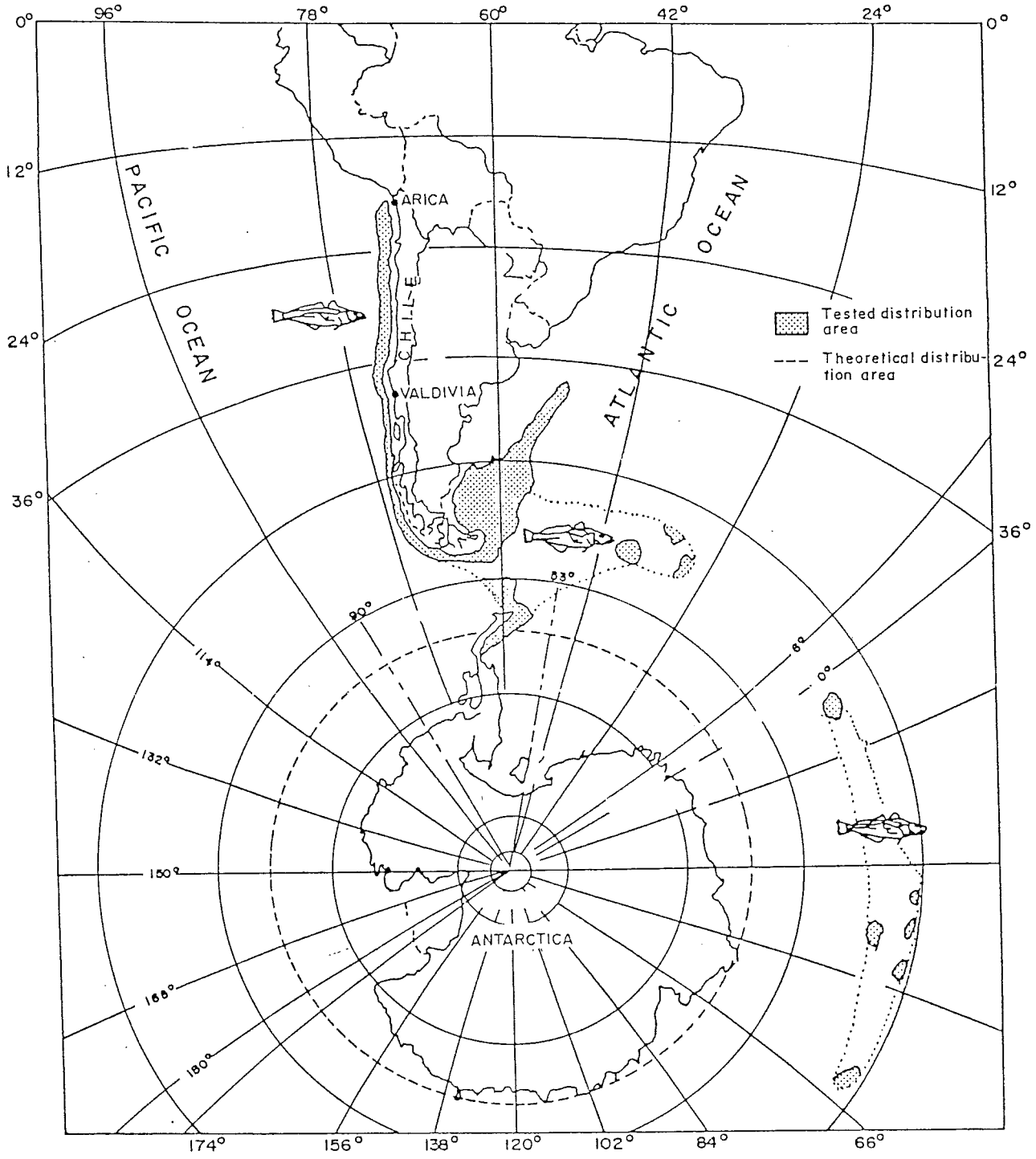

Figure 1: Geographical distribution of *D. eleginoides*.

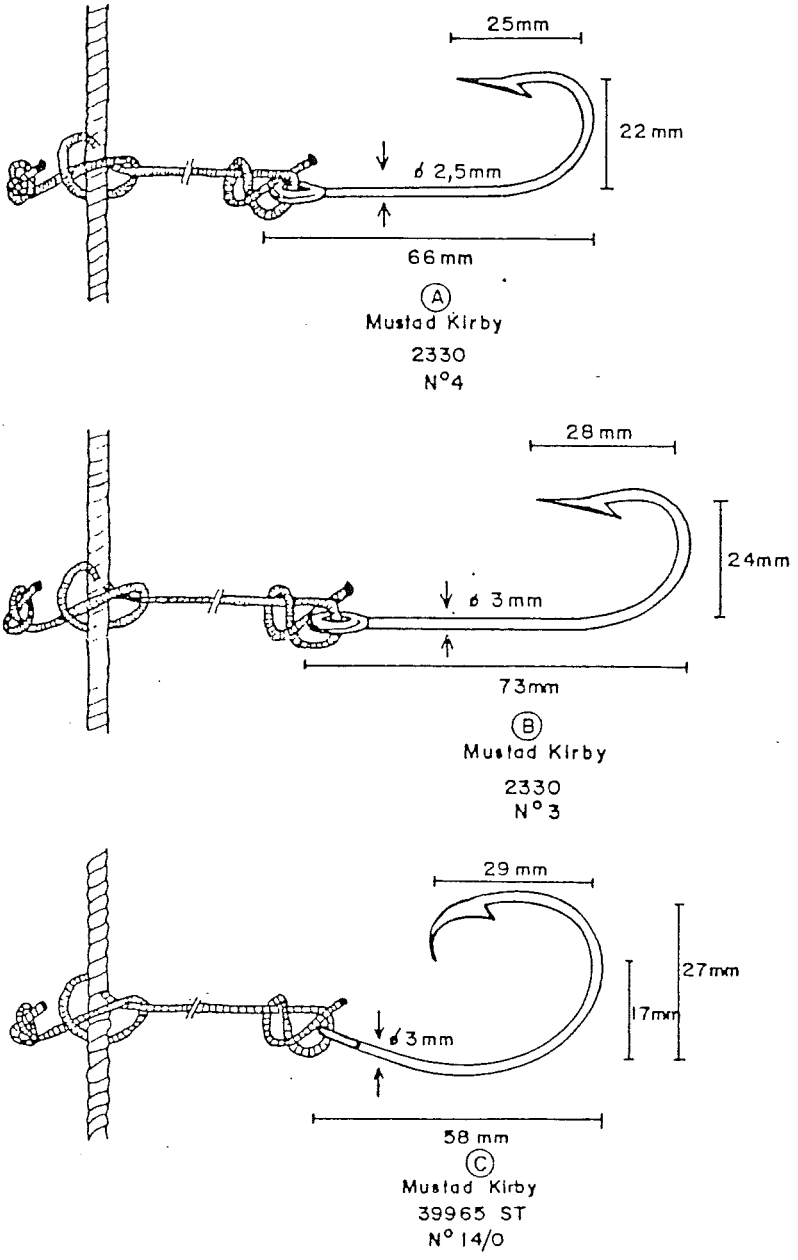

Figure 2: The type of hooks used in the longline fishery of *D. eleginoides* in Chile.

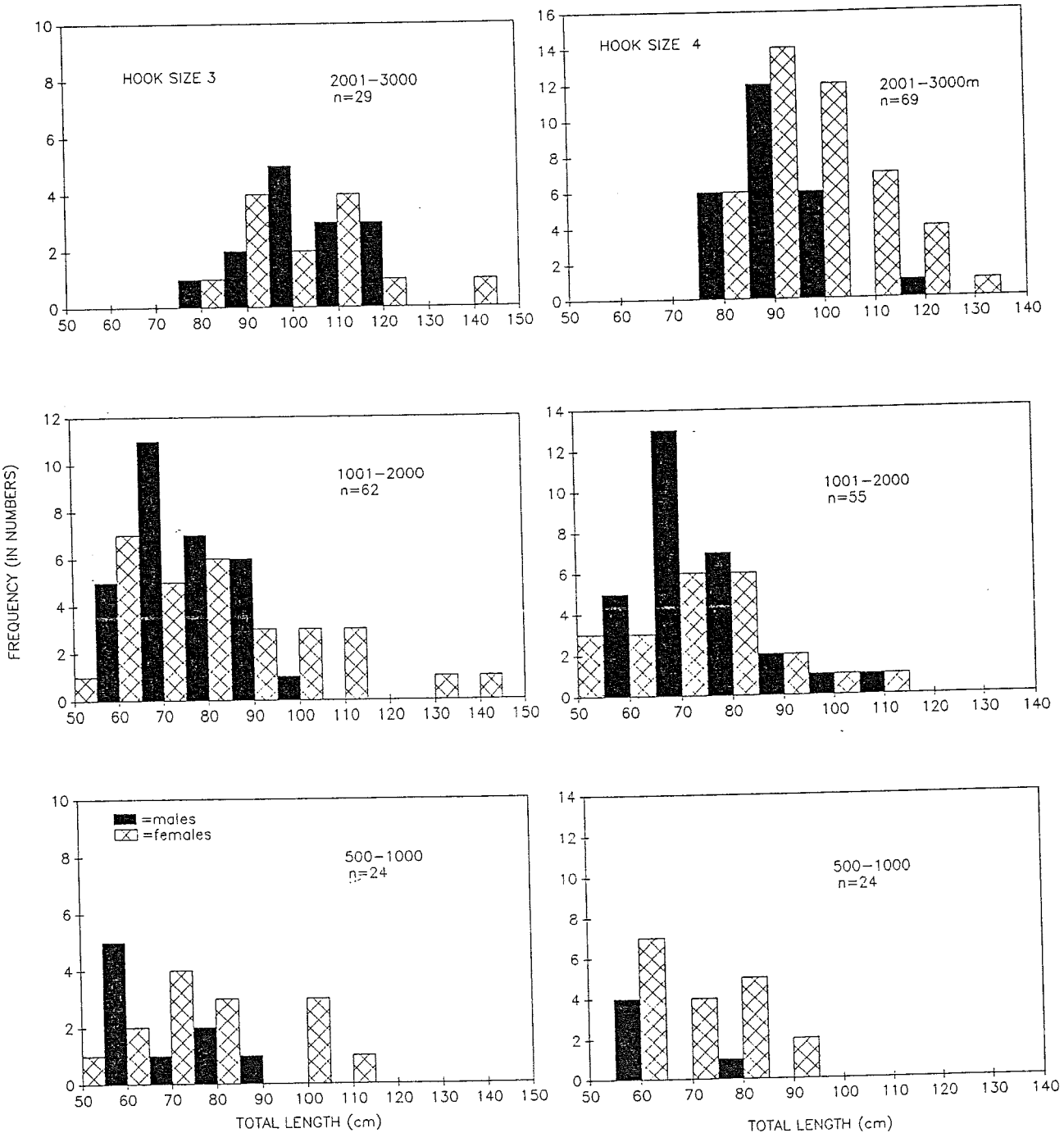

Figure 3: Length composition of *D. eleginoides* fished with straight hooks (Nos. 3 and 4) off the coast of VIII Region of Chile (from SRL 1987).

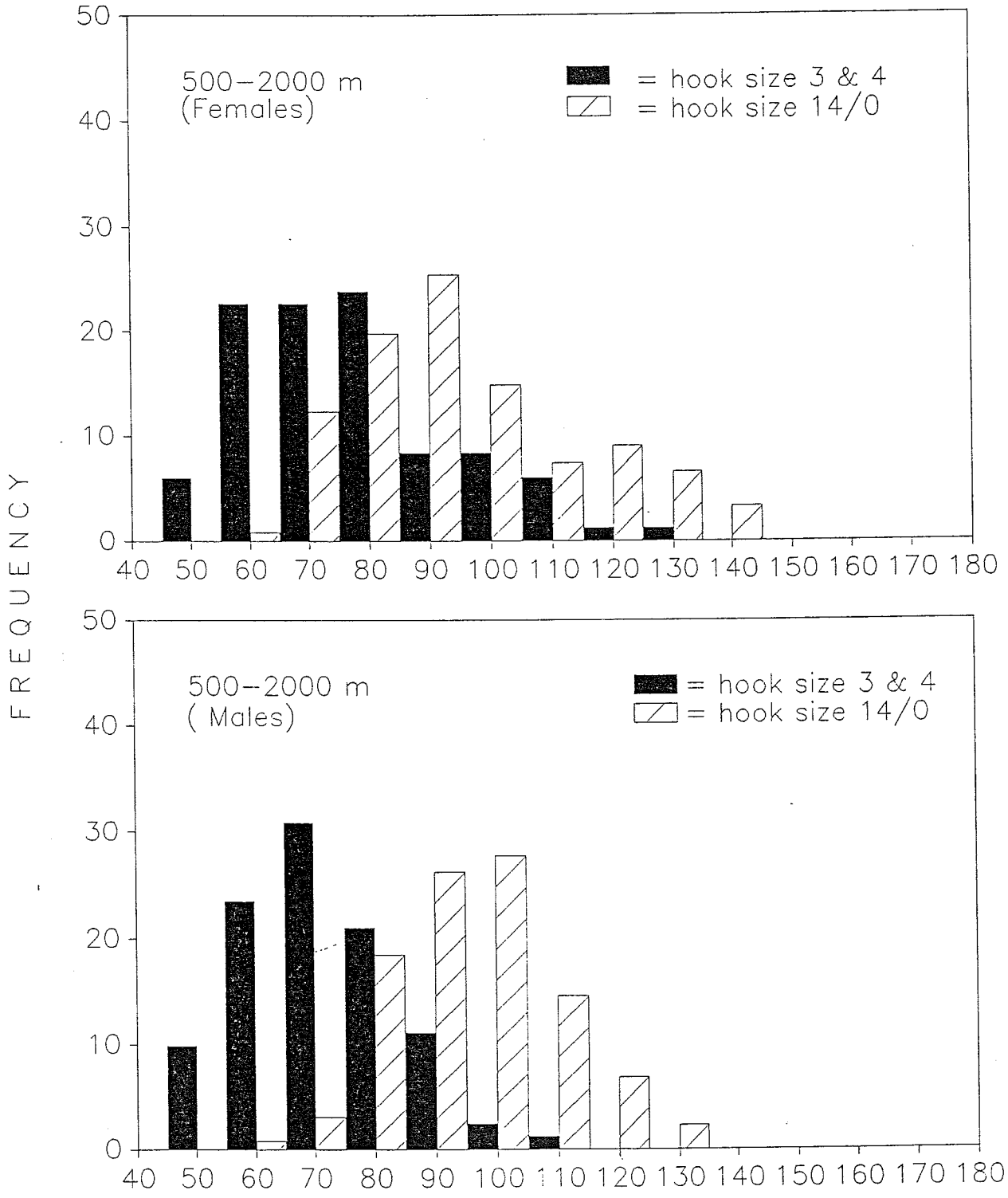

Figure 4: Length composition of *D. eleginoides* caught by straight (Nos 3 and 4) and circle (No. 14/0) hooks off the coast of the VIII and X Regions of Chile. Statistical analysis by using Kolmogorov-Smirnov test show significant differences in both cases (for males and females).

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