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Species profile of round scad

Decapterus punctatus (Cuvier 1829)

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INTRODUCTION

Members of the genus Decapterus usually occur in schools and are distributed throughout the world in tropical and subtropical waters. Decapterus is found generally in inshore waters, although larvae and young may occur in oceanic waters (Berry 1968). Fishes of this genus are important both for human consumption and for bait. In the Philippines, the round scad (Decapterus spp.) is the largest commercial fishery, reaching over 100,000 tons per year (Ronquillo 1970).

The increasing demand for protein for humans has put additional pressure on fish species not formerly exploited to the fullest. This species profile will attempt to bring together information on aspects of Decapterus punctatus so future management and research plans can be developed. Emphasis will be centered on the species in the Gulf of Mexico.

TAXONOMY

Current scientific name:	Decapterus punctatus (Cuvier)
Previous scientific names:	Scomber hippos (non Linnaeus) Mitchell 1818
	Caranx punctatus Cuvier 1829
	Caranx punctatus Agassiz in Spix 1831
	Caranx punctatus Cuvier in Cuvier and Valenciennes 1833
Preferred common name:	Round scad

MORPHOLOGY

The round scad is a small carangid with a slender and rounded body with a slender caudal peduncle. The eye is moderate with a well-developed adipose eyelid. Gill rakers on upper gill arch range from 11-16, teeth are minute and are in a single row in both jaws. There are two well developed and separate dorsal fins including a finlet. The body is well covered with cycloid scales. Total scales and scutes in the lateral line number 77-98. The lateral line is curved and contains 12-14 black spots, usually formed when the fish reaches 10 cm fork length.

The color is greenish to greenish blue above, silvery on the sides and a narrow bronze stripe extends from the tip of the snout along the lateral line to the caudal peduncle. A small black spot is on the margin near the upper edge of the opercle.

IDENTIFYING CHARACTERISTICS

In the western Atlantic, three species of Decapterus occur: D. punctatus, D. macarellus, and D. tabl (Fig. 1). The following key to the three species is from Berry (1968).

KEY TO WESTERN ATLANTIC DECAPTERUS

1A. Dark spots (10-14) present along curved lateral line (at sizes larger than ca. 90 mm SL). Curved lateral line strongly arched. Curved lateral line with 37-56 scales and usually 1-5 scutes. Total lateral line scales and scutes (excluding peduncle scales) 72-98. Vertebrae 10 + 15.................Decapterus punctatus (Fig. 1A)

1B. No spots in curved lateral line. Curved lateral line moderately to weakly arched. Scales in curved lateral line 61 or more. No scutes in curved lateral line. Total lateral line scales and scutes 103 or greater. Vertebrae 10 + 14................................2

2A. Curved lateral line moderately arched. Anterior scales in straight lateral line 0-8. Scutes in straight lateral line 34-44.... ....Decapterus tabl (Fig. 1B)

2B. Curved lateral line weakly arched. Anterior scales in straight lateral line 19-33. Scutes in straight lateral line 23-32.......... ....Decapterus macarellus (Fig. 1C)

Larval identification is illustrated with morphological changes from 2.3 mm standard length to 23.0 mm standard length in Figure 2.

DISTRIBUTION AND RANGE

Adults

The round scad occurs in the western Atlantic from Massachusetts through Bermuda, southward through the Gulf of Mexico, the Caribbean and West Indies to Rio de Janeiro (Fig. 3). According to Berry (1968) this areal distribution is continuous. The species is probably most abundant in the eastern Gulf of Mexico (Aprieto 1974, Finucane et al. 1978, Leak 1977, and Montolio 1976). The occurrence of schooling adults and the largest commercial fishery of round scad are also from the eastern Gulf of Mexico (Juhl 1966, Klima 1971, Klima and Wickham 1971, Wickham and Russell 1974, and Hastings et al. 1976). Records of adults west of the Mississippi River are scarce (Roithmayr 1965, Chittenden and McEachran 1976).

Most of the fishing for adult round scad in the Gulf of Mexico occurs along the northwest Florida coast. The annual catch in pounds from Florida's west coast has gradually increased from 1952 to 1982. In 1982 the catch yielded 1,756,000 pounds (Fig. 4). Records of adult abundance from areas of the Gulf of Mexico are available from NMFS, Pascagoula Laboratory in Pascagoula, Mississippi. Data from their shrimp and fish trawls (40 ft head rope) from 1950 to 1985 reveal that adult round scad are abundantly concentrated off Florida's west coast in the winter. In the spring, abundance shifts northward with highest concentrations off Mississippi and Alabama. In the summer, abundance has shifted farther west to Louisiana and Texas. In the fall, the fish are still concentrated in the northern gulf (Figs. 5, 6, 7, and 8).

Larvae

Larvae of round scad have been found during all seasons. Larval abundance is probably highest in the eastern Gulf of Mexico, based on collections by Aprieto (1974), Montolio (1976), Leak (1977), and Finucane et al. (1978). Larval abundance changes with season, as Montolio (1976) found highest concentrations of larvae in the eastern Gulf of Mexico in the spring, lesser concentrations in the northern, eastern, and southern gulf in the summer, and high concentrations in the north central gulf and off Yucatan in the fall (Fig. 9). A larval survey in the western Gulf of Mexico by Finucane et al. (1978) noted *D. punctatus* larvae from April through September, with highest abundances in August 1977 (Fig. 10). Larval surveys in the Yucatan and Florida straits indicated round scad larvae to be numerous in October 1962, April 1963, May-June 1968, and May 1969. Larvae were collected at water temperatures between 21-31°C (Lyons 1978). Thus, recruitment from the Caribbean into the Gulf of Mexico also occurs.

Along the south Atlantic coast of the United States, larvae were collected from May through November with abundance high from July to September (Hildebrand and Cable 1930). In another survey (Fahay 1975) larval *D. punctatus* were collected during all seasons with peak abundance in the spring between New River, North Carolina, and Palm Beach, Florida. While sampling larval carangids along the Florida coast and northward to the Carolinas, Aprieto (1974) found larval and juvenile *D. punctatus* in all months with their greatest abundance in the eastern area of the Gulf of Mexico (Fig. 11). Dooley (1972) also found *D. punctatus* from November through May with a peak in March. These specimens were associated with sargassum. In a larval survey of the eastern Gulf of Mexico during 1971-74, Houde, et al. (1979) found that the abundance of *D. punctatus* larvae was highest in September 1972, with secondary peaks of abundance in May 1971, 1972, and 1973 (Fig. 12).

REPRODUCTION

The spawning areas of round scad include almost the entire continental shelf from approximately North Carolina southward throughout the Gulf of Mexico and Caribbean (Hildebrand and Cable 1930, Aprieto 1974, Montolio 1976, Johnson 1978, Finucane, et al. 1978, Reintjes 1979, Lyons 1978, Leak 1981, Houde, et al. 1979, and Herrema, et al. 1985). Larvae beyond the continental shelf are less abundant, except possibly in the Caribbean (Montolio 1976).

Information on reproductive biology is sparse. In a survey of the coastal waters of northwest Florida, round scad appeared to have a spawning season that extended throughout the year. Ripe males and females (Stage IV) were present from April through October. Peak spawning based on GSIs probably occurred in the spring and fall (J.H. Finucane, personal communication). Males matured at a smaller size than females with 50% of the males and females maturing at 125-129 mm fork length. All males were mature at 145-149 mm and all females at 130-134 mm. Estimates of batch fecundity of 20 fish ranged from 21,000 ova for a 146 mm female to 146,000 for a 188 mm female. D. punctatus are believed to be serial spawners. The size-at-maturity of round scad in the Gulf of Mexico was estimated to be 140 mm (J.H. Finucane, personal communications), while Leak (1981) reported mature females as small as 107 mm. Houde, et al. (1983) stated that fish 135 mm are less than one year of age and may contribute significantly to spawning in the eastern gulf.

AGE AND GROWTH

Age and growth information on D. punctatus is limited to the work of Houde and Berkeley (1981, 1982a, 1982b, 1982c), and Houde, et al. (1983). Specimens of D. punctatus for these reports were collected in the Gulf of Mexico from Port St. Joe to Destin, Florida.

To determine the age and growth of D. punctatus, the alternating hyaline and opaque zones on otoliths were judged to be annual marks. Fork length-otolith radius relationship was $FL = -1.08 + 75.75\,R$, where $n = 2019$, and $r^2 = 0.80$ (FL = fork length in mm, R = otolith radius in mm, n = sample size, and r^2 = coefficient of determination). The von Bertalanffy growth model was fitted using Beverton's method (Ricker 1975) to the mean back calculated lengths at age for combined 1981-82 data. The equation for round scad was $L_t = 221.78(1-e^{-0.32(t\ +\ 1.94)})$ where L_t = length (mm) at time; t = time in yrs. Estimated mean back calculated fork lengths at age were: Age I, 136.0 mm; Age II, 159.7 mm; and Age III, 176.9 mm (Fig. 13).

MORTALITY

The instantaneous rate of total mortality (Z = 0.92) is considered to approximate closely natural mortality. Annual mortality rate is estimated to be 60% and the annual survival rate is estimated to be 40% (Berkeley and Houde 1984). Based on spawning surveys of egg abundance of about 350 kilotons (Leak 1981, Houde and Berkeley 1982b), and present catches comprising about 1% of this total, Houde, et al. (1983) indicated that highest yields could be attained from these stocks under a high rate of exploitation, if recruitment could be sustained at the high F values that give maximum yield-per recruit. For round scad the theoretical maximum yield-per-recruit at recruitment length of 105 mm FL would be at high rates of exploitation (F = 0.85). At the respective F_{max} the yield-per-recruit for round scad was 19.5 g. The yield-per-recruit curves were flat topped, with little gain in yield expected beyond F levels of 1.5 (Fig. 14). Round scad grows fast, reaching 50-65% of their estimated asymptotic length at one year of age. This fast growth and high natural mortality (M = >0.82), indicates that optimum harvesting is best at a young age. As 0+ round scad contribute substantially to spawning in the eastern Gulf of Mexico, round scad may be less susceptible to recruitment overfishing. The percent of the population for 1981-82 in the following age groups were 0+, 75.1%; 1+, 19.0%; 2+ 5.8%; and 3+, 0.1%.

LENGTH-WEIGHT RELATIONSHIP

The length-weight relationships of round scad were determined by Houde and Berkeley (1982b) and later summarized by Berkeley and Houde (1984). Samples are from the eastern Gulf of Mexico collected during 1981-82. The estimated lengths and weights at age for round scad for males and females are presented in Table 1. The relationship of weight (g) to length (mm fork length) for 1981-82 and by sex for both years combined is presented in Table 2.

TEMPERATURE RELATIONSHIPS

Adult round scad have been caught in surface water temperatures of 12 to 30°C and in bottom water temperatures of 13 to 27°C. The percent frequency of occurrence and the average pounds of round scad in trawl catches varied considerably over the temperature ranges (Fig. 15 and 16). However, when considering the commercial catches of round scad from northwest Florida, production was the highest during the spring and summer months when water temperatures were the highest (Fig. 17). Catch rates during December, January, February, and March were the lowest and represent less than one percent of the total catch.

DEPTH RELATIONSHIPS

In experimental trawls by the NMFS, adult round scad were caught at depths ranging from 1 to 200 fathoms in the Gulf of Mexico. The frequency of occurrence of individuals appearing in the trawls increased as the depth increased to 65 fathoms and then decreased thereafter (Fig. 18). In the commercial fishery of round scad in northwest Florida, the principal gear used is the beach seine, and catches are made in depths of 1 to 2 fathoms. However, with the advent of the purse seine, commercial catches in deeper water may become more common.

FOOD HABITS

Information on food habits of D. punctatus in the Gulf of Mexico is restricted to preliminary work by the authors on specimens from northwest Florida. The diet consists mainly of planktonic forms, with various larval crustaceans (mainly crab larvae), copepods, ostracods, and mysids leading the list of frequency of occurrence. Other items frequently occurring were radiolarians, fish eggs, gastropods, pelecypods, amphipods, Amphioxus, scaphopods, and shrimp. In the Caribbean, Randall (1967) found the stomach contents of 10 round scad 131 to 171 mm to be 60% copepods, 18.5% gastropod larvae by volume with the remainder being ostracods, pteropods, shrimp larvae, and unidentified remains. Schekter (1972) examined the stomachs of 12 larval and juvenile round scad, 7.1 mm to 37.2 mm SL, from the Miami area of the Florida Current, and found 188 food organisms, all copepods.

PREDATORS

The consumption of D. punctatus by coastal pelagic predators is fairly common and in food studies, the round scad is often listed. The main predator in northwest Florida on Decapterus is the king mackerel. Examination of king mackerel stomachs revealed a frequency of occurrence of 25.6% and a percentage volume of total stomach contents of 29.9% for D. punctatus(Saloman and Naughton 1983a). The presence of round scad was also common in Spanish mackerel, bluefish, and crevalle jack collected in northwest Florida (Saloman and Naughton 1983b, 1984; Naughton and Saloman 1984).

SEX RATIO

The ratio of females to males varied between months, with females dominating in collections from northwest Florida. In 1980 females comprised more than 59% of the population in 6 of 7 months and in 1981 females comprised more than 64% in 6 of 8 months (Fig. 19). This information differs from the work of Berkeley and Houde (1984), as they found males were more abundant in 1981 and 1982 (Table 3). The difference could be attributed to sample size, as the number of specimens examined by Berkeley and Houde (1984) were approximately 1/3 the number we examined. Examination of sex in relation to size of D. punctatus reveals that the larger fish (>165 mm FL) had a higher proportion of males than females (Fig. 20).

AGE STRUCTURE

The age structure of the population of round scad in northwest Florida varied from year to year and also within months of each year. The mode of the length-frequency distribution of the population for the years 1980 to 1982 changed from 155 mm FL in 1980 to 165 mm FL in 1981 and to 145 mm FL in 1982 (Figs. 21, 22, and 23). In 1980 the size grouping at 155 mm FL was the highest in 5 of 6 months sampled. In the other two years (1981 and 82) the mode changed from month to month. Based on the length-frequency distribution of the population and age estimates by Berkeley and Houde (1984) where age I fish are 136.0 mm FL and age II, 159.7 mm FL, the modal frequency of the population was between ages I and II.

FISHERIES

The commercial fishery for round scad is primarily located in northwest Florida. The product is used almost exclusively for bait. The annual catch of round scad from northwest Florida has shown an increasing trend since the 1950s. Production reached its peak in 1982 with over 1,700,000 pounds (Fig. 4).

Methods of capture are primarily the beach seine and the purse seine. With more boats equipped with a purse seine, the production should increase as schools in deeper water can be harvested.

Handling of the catch for the bait market includes the following steps. The fish are iced upon capture; on arrival at the fish house, they are boxed in five pound boxes and frozen. The next day the boxes are opened and water is sprayed on the fish and then are immediately refrozen. This process creates a glaze of ice on the fish which results in a higher quality product.

COMPOSITION

Hale (1984) gave the proximate composition of round scad from gulf waters as: protein - 22.6%; fat - 2.6%; moisture - 73.95%; ash - 2.60%. Sidwell (1981) listed the following microelements from raw muscle (in ppm): zinc - 4.61; arsenic - 0.46; cadmium - 0.03; copper - 0.51; and mercury - 0.10. Additional information regarding the proximate composition of round scad is given in Tables 4 and 5.

MARKETING

The following information was obtained from M.E. Smith (NMFS, Pascagoula, MS, personal communication).

Domestic Market - The only known market at this time for these fish is as bait by sportsmen. The value of the fish at the wholesale level, packed in five pound cartons is about $.35 per pound.

Export Market - The relatively small size of the gulf round scad limits the use of the fish as an export item. The same genus of fish has been seen in the Orient and are marketed heads-on, split, salted, and dried. In Hong Kong the dried form, depending on the degree of quality of the product, is valued at about $.82 per pound at the wholesale level. The product is imported from countries having very low wage scales; therefore, it is doubtful U.S. producers could be competitive.

The larger red tail scad (*D. tabl*) is also available from the gulf and ranges in size from 10" to 14". This species closely resembles red finned scad which is sold fresh in Japan. It is possible that this species would be equally acceptable by Japanese markets. A value cannot be placed on the red tail scad at this time.

INFORMATION NEEDS

More information is needed on the distribution and abundance of the adults. The fishery in northwest Florida occurs during the warm months. During the winter, round scad migrate to unknown areas, most probably to offshore waters. Mark and recapture studies would be futile, since no fishery exists in other areas for recaptures to be made. Needed biological information includes reproductive biology (especially fecundity), effort data from the commercial fishery, recruitment and mortality estimates (McIlwain 1983). Economic and marketing information on this fishery is also desired.

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Table 1. Estimated lengths and weights at age for *D. punctatus* based on 1981 and 1982 samples. Lengths were back-calculated from fork length-otolith relationships and weights were then determined from length-weight relationships (Berkeley and Houde 1984).

A. Fork lengths (mm)

Year	Age 1 Males	Age 1 Females	Age 2 Males	Age 2 Females	Age 3 Males	Age 3 Females
1981	135.5	136.7	160.4	159.3	169.4	-
1982	155.5	150.9	176.6	159.4	-	171.7
Means	145.5	143.8	168.5	159.4	169.4	171.7
Combined male and female means	144.7		164.0		170.6	

B. Weights (g)

Year	Age 1 Males	Age 1 Females	Age 2 Males	Age 2 Females	Age 3 Males	Age 3 Females
1981	30.5	31.3	52.0	50.9	61.8	-
1982	47.9	43.4	73.4	52.1	-	66.8
Means	39.2	37.4	62.7	51.5	61.8	66.8
Combined male and female means	38.3		57.1		64.3	

Table 2. Length-weight relationship for *D. punctatus* in the eastern Gulf of Mexico (W = weight in g; L = fork length in mm) (Berkeley and Houde 1984).

Year	Relationship	n	r^2
1981	$W = 5.00 \times 10^{-6} L^{3.18}$	3,683	0.92
1982	$W = 2.93 \times 10^{-6} L^{3.29}$	3,624	0.95
Sex			
Female	$W - 2.25 \times 10^{-6} FL^{3.34}$	935	0.92
Male	$W = 2.96 \times 10^{-6} FL^{3.28}$	1,041	0.95

Table 3. Sex ratio of *D. punctatus* collected off northwest Florida (Berkeley and Houde 1984).

Month	Male		Female		Male:Female
	No.	%	No.	%	
1981					
Apr	77	49.7	78	50.3	0.99:1
May	82	49.7	38	50.3	9.99:1
Jun	193	54.5	161	45.5	1.20:1
Jul	71	46.7	81	53.3	0.88:1
Aug	21	65.6	11	34.4	1.91:1
Sep	43	43.0	57	57.0	0.75:1
Oct	51	57.3	38	42.7	1.34:1
Nov	37	92.5	3	7.4	12.3:1*
Total	575	52.9	512	47.1	1.12:1
1982					
Mar	34	54.8	28	45.2	1.21:1
Apr	-	-	-	-	-
May	92	52.8	83	47.2	1.12:1
Jun	165	52.6	149	47.4	1.11:1
Jul	44	40.4	65	49.6	0.68:1
Aug	55	55.6	44	44.4	1.25:1
Sep	35	72.9	13	27.1	2.69:1
Oct	54	45.0	66	55.0	9.82:1
Nov	-	-	-	-	-
Total	480	100.0	448	100.0	1.07:1

*Many specimens were too young to be sexed.

Table 4. Seasonal proximate chemical composition of three product forms of _D. punctatus_. (Data from M. Hale, NMFS, Charleston Laboratory.)

Product form	Month of harvest	Number of		Average weight, g	Moisture %	Protein %	Ash %	Fat, %	
		Samples	Individuals					Ether	SAK
Whole	Sep 1978	4	20	38.3	75.44	19.95	2.98	2.05	2.72
Whole	Apr 1979	1	7	27.5	72.90	19.58	4.30	3.56	4.08
Whole	Aug 1979	3	12	37.0	73.32	20.46	4.82	1.56	2.13
Whole	Jan 1980	1	4	48.7	71.05	19.99	3.97	5.79	6.31
Whole	Jul 1980	2	16	27.6	74.27	20.39	4.06	2.15	3.19
Range:				14.2-48.7	71.1-76.8	19.6-20.8	3.0-5.1	0.9-5.8	1.7-6.3
Overall average:				35.95	74.18	20.03	3.89	2.25	2.96
Headed & Gutted	Sep 1978	3	30	29.9	75.48	22.01	2.52	0.89	1.64
Headed & Gutted	Apr 1979	1	9	34.9	72.10	21.28	3.26	3.30	4.03
Headed & Gutted	Aug 1979	3	13	39.6	73.38	22.05	3.61	1.22	1.85
Headed & Gutted	Jan 1980	1	2	55.0	71.45	22.27	3.24	3.21	4.07
Headed & Gutted	Mar 1980	1	-	-	73.72	20.10	2.58	3.50	5.46
Headed & Gutted	Jul 1980	2	27	23.9	75.44	21.13	3.41	1.35	2.34
Range:				13.0-55.0	71.2-76.3	20.1-22.6	2.1-3.8	0.6-3.5	1.4-5.5
Overall average:				35.13	74.06	21.64	3.12	1.73	2.52
Fillets	Sep 1978	3	26	29.9	76.09	22.12	1.41	.87	1.34
Fillets	Apr 1979	1	15	27.5	74.49	21.87	1.38	2.31	3.25
Fillets	Aug 1979	1	13	33.6	75.64	22.35	1.56	.51	1.29
Fillets	Jan 1980	1	9	55.8	74.72	23.07	1.37	1.53	2.78
Fillets	Mar 1980	1	-	-	75.39	21.50	1.17	1.87	2.94
Fillets	Jul 1980	2	44	25.4	76.45	22.41	1.54	.21	1.53
Range:				12.7-55.8	74.5-77.2	21.5-23.0	1.2-1.6	0.2-2.3	0.9-3.3
Overall average:				31.93	75.71	22.22	1.42	1.03	1.90

*Ether fat = triglycerides; SAK = total lipids by chloroform/methanol.

Table 5. Seasonal fatty acid composition of *D. punctatus* flesh. (Data from M. Hale, NMFS, Charleston Laboratory.)

Fatty acid	Season and number of composite samples Spring (1)	Summer (3)	Fall (3)
14:0	2.15	2.74	3.20
16:0	20.13	19.60	18.12
18:0	8.77	11.49	9.94
16:1	6.63	4.90	4.22
18:1	15.78	10.49	7.69
20:1	0.93	0.54	1.51
22:1	0.19	0.15	-
18:2W6	1.82	1.59	2.00
18:3W3	1.09	0.72	0.96
18:4W3	1.22	1.27	0.79
20:4W6	2.38	3.22	3.99
20:5W3	6.72	6.14	7.59
22:5W6	1.59	1.93	2.21
22:5W3	2.05	2.15	2.04
22:6W3	20.63	23.74	26.26
Total Saturated	34.52	37.18	33.32
Total Monoenes	25.64	17.76	15.03
Total PUFA (Polyunsaturated fatty acids)	39.84	45.06	51.65

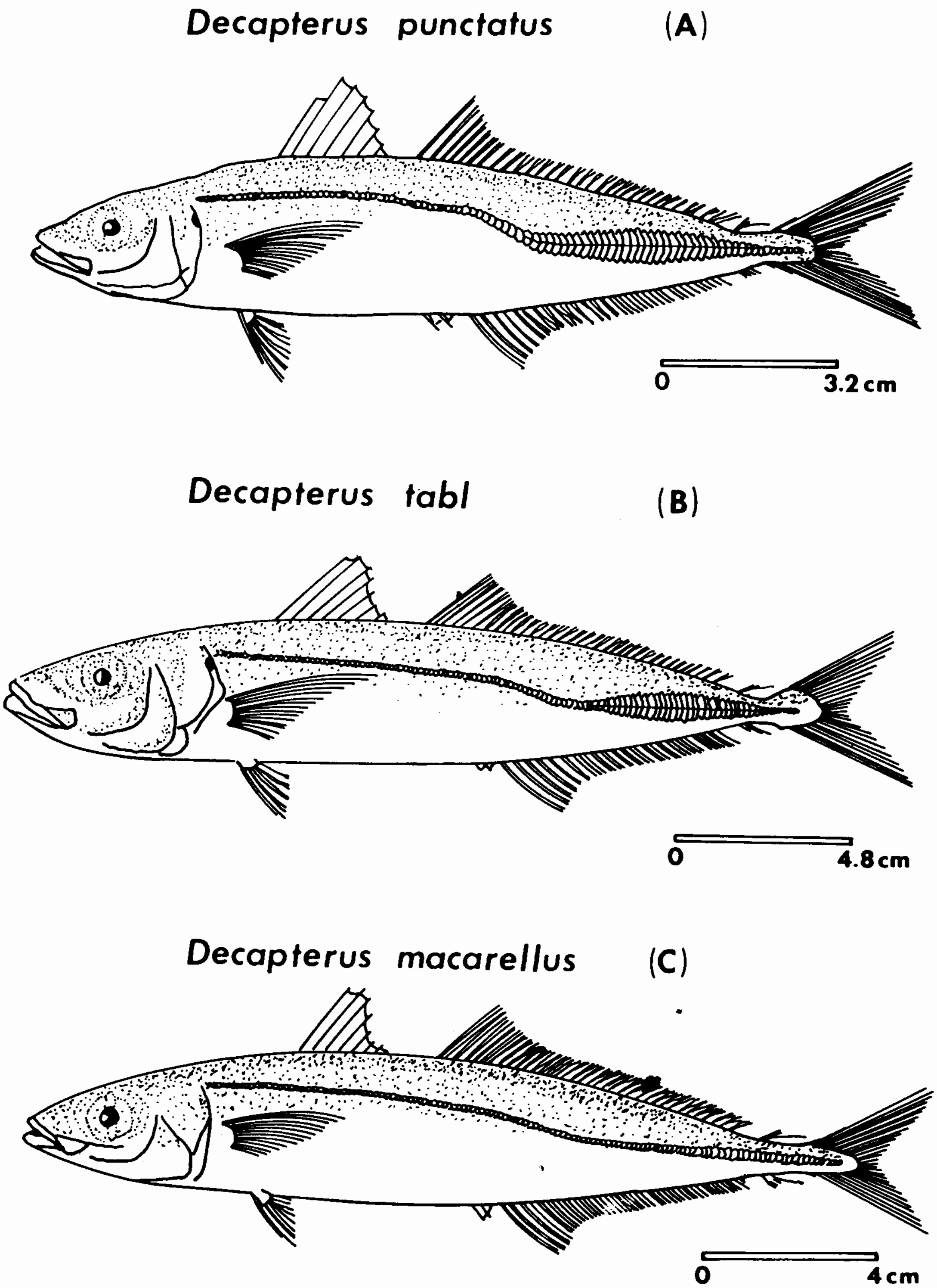

Figure 1. Three species of Decapterus in the western Atlantic.

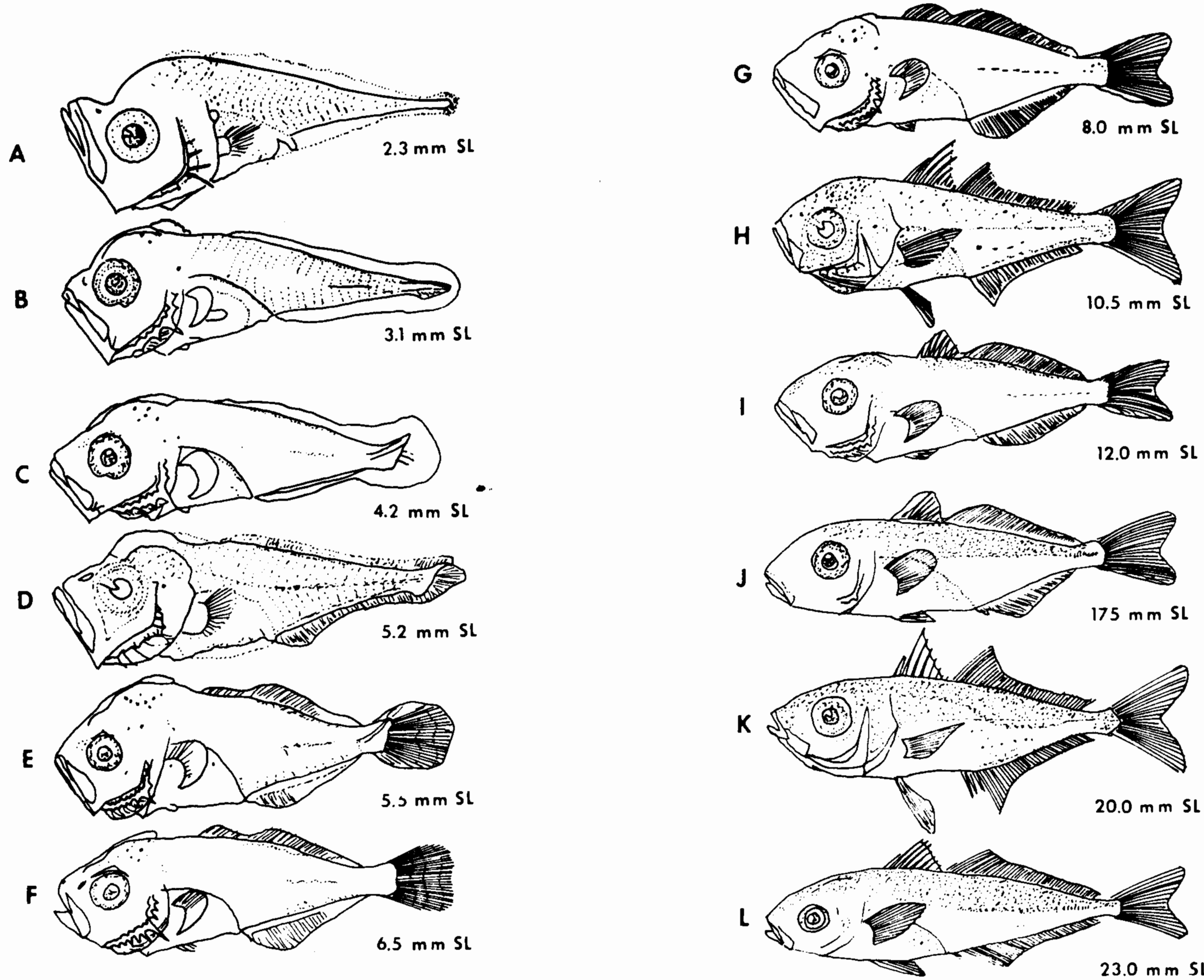

Figure 2. Larvae of D. punctatus. (A, D, H, and K taken from Hildebrand and Cable 1930; B, C, E, F, G, I, J, and L taken from Aprieto 1974.)

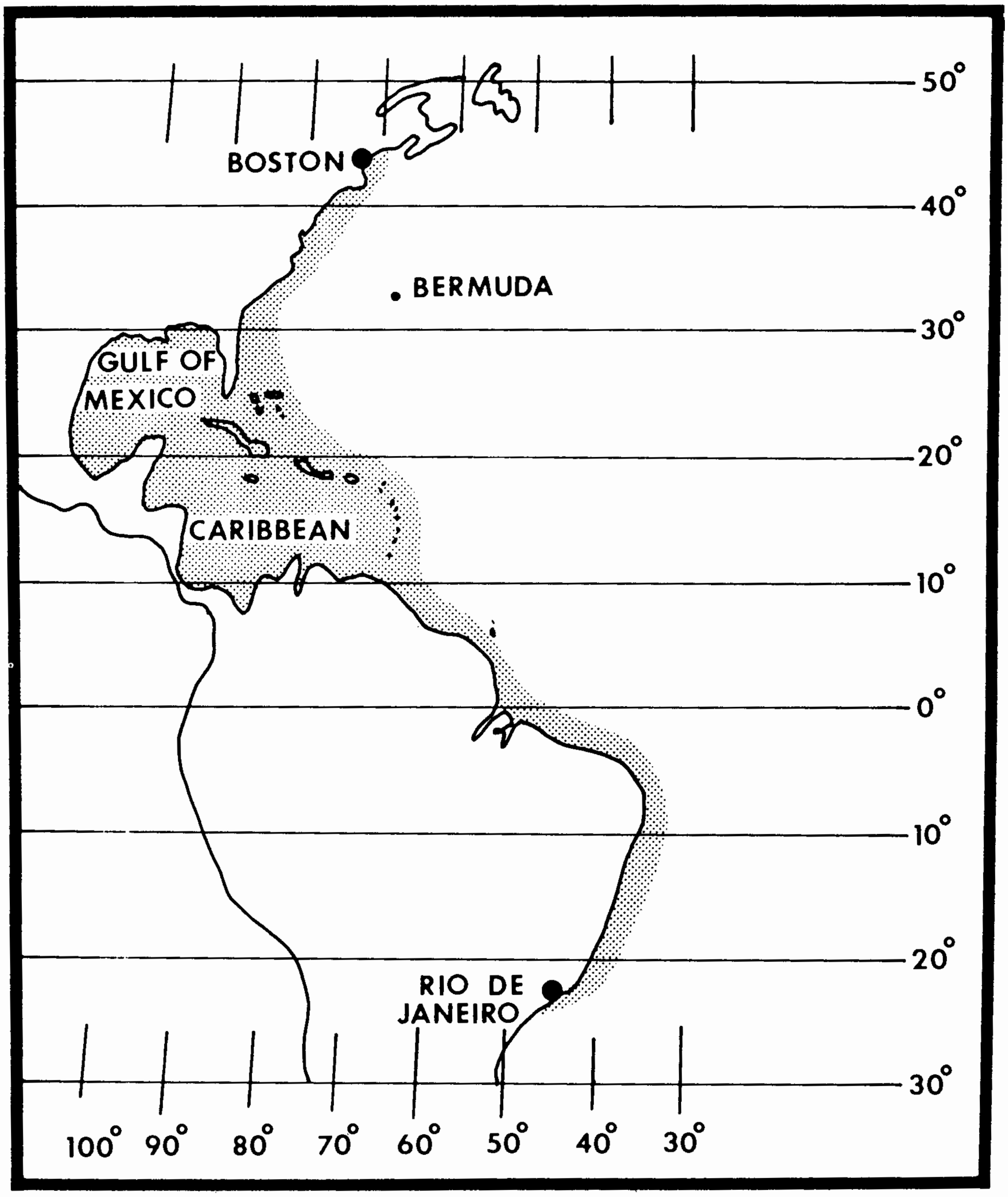

Figure 3. Distribution and range of round scad (D. punctatus) in the western Atlantic.

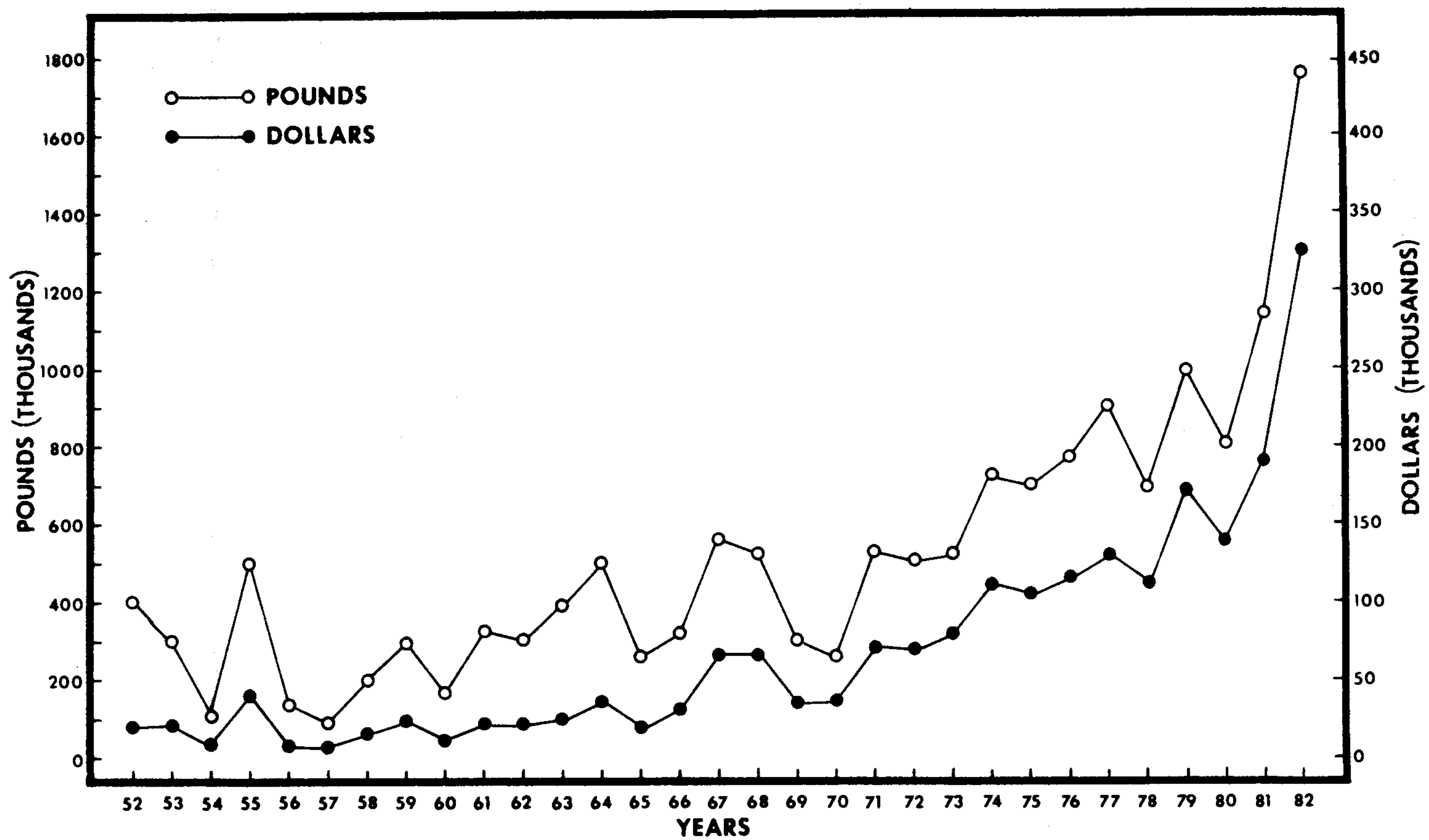

Figure 4. Annual catches and values of D. punctatus in pounds and dollars from the west coast of Florida, 1952-1982.

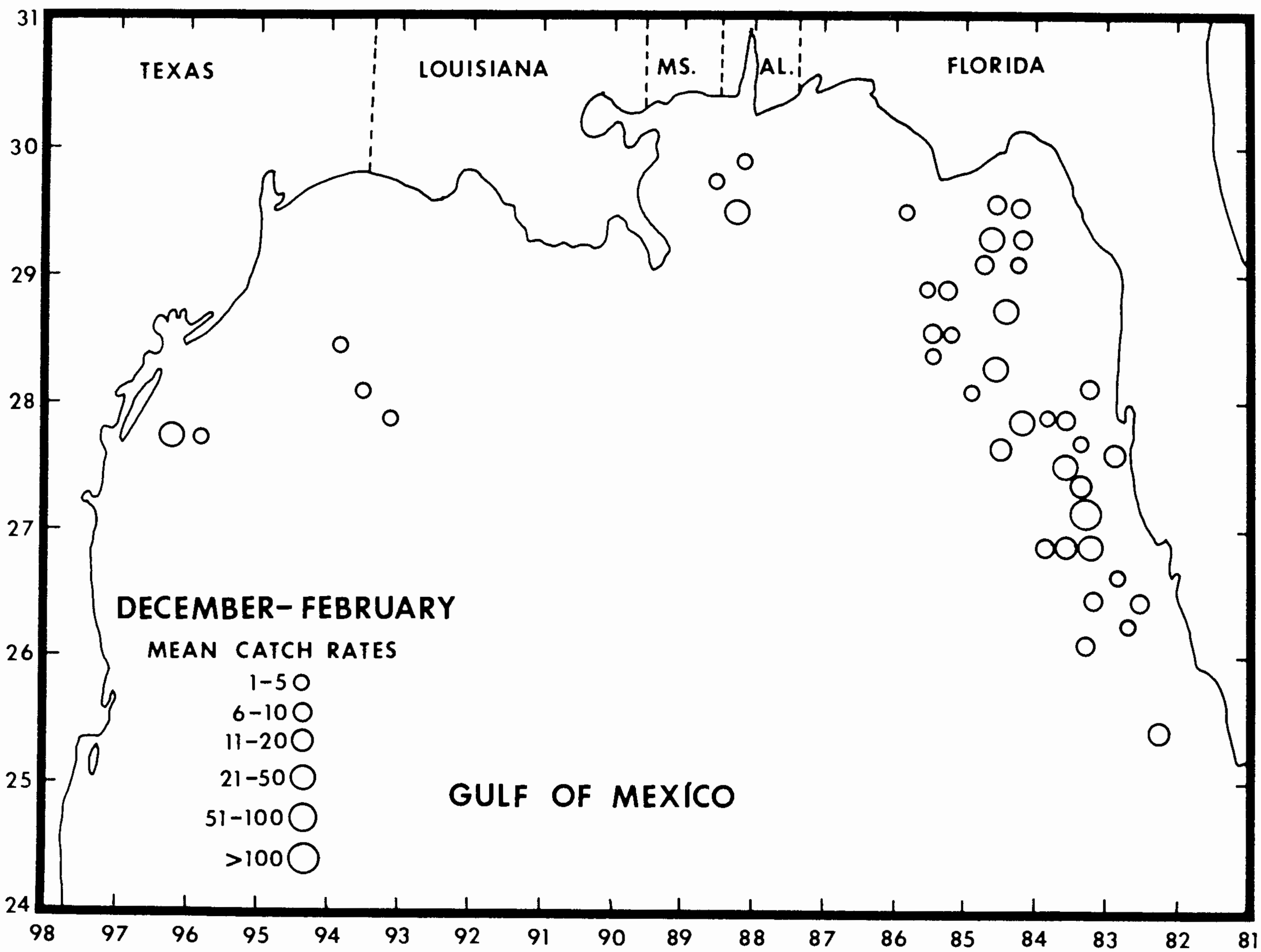

Figure 5. Abundance and distribution of adult _D. punctatus_ collected by trawl in the winter.

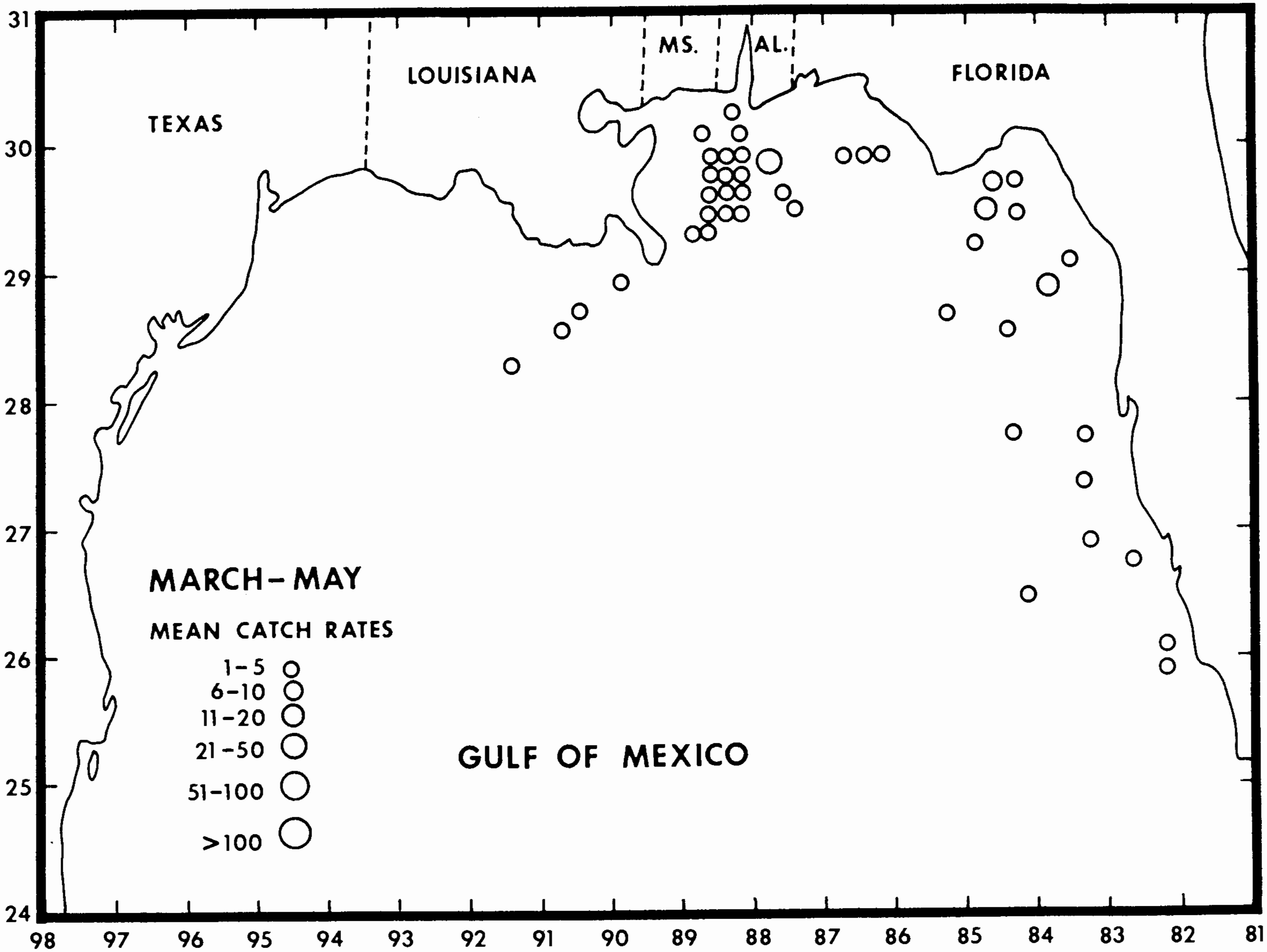

Figure 6. Abundance and distribution of adult D. punctatus collected by trawl in the spring.

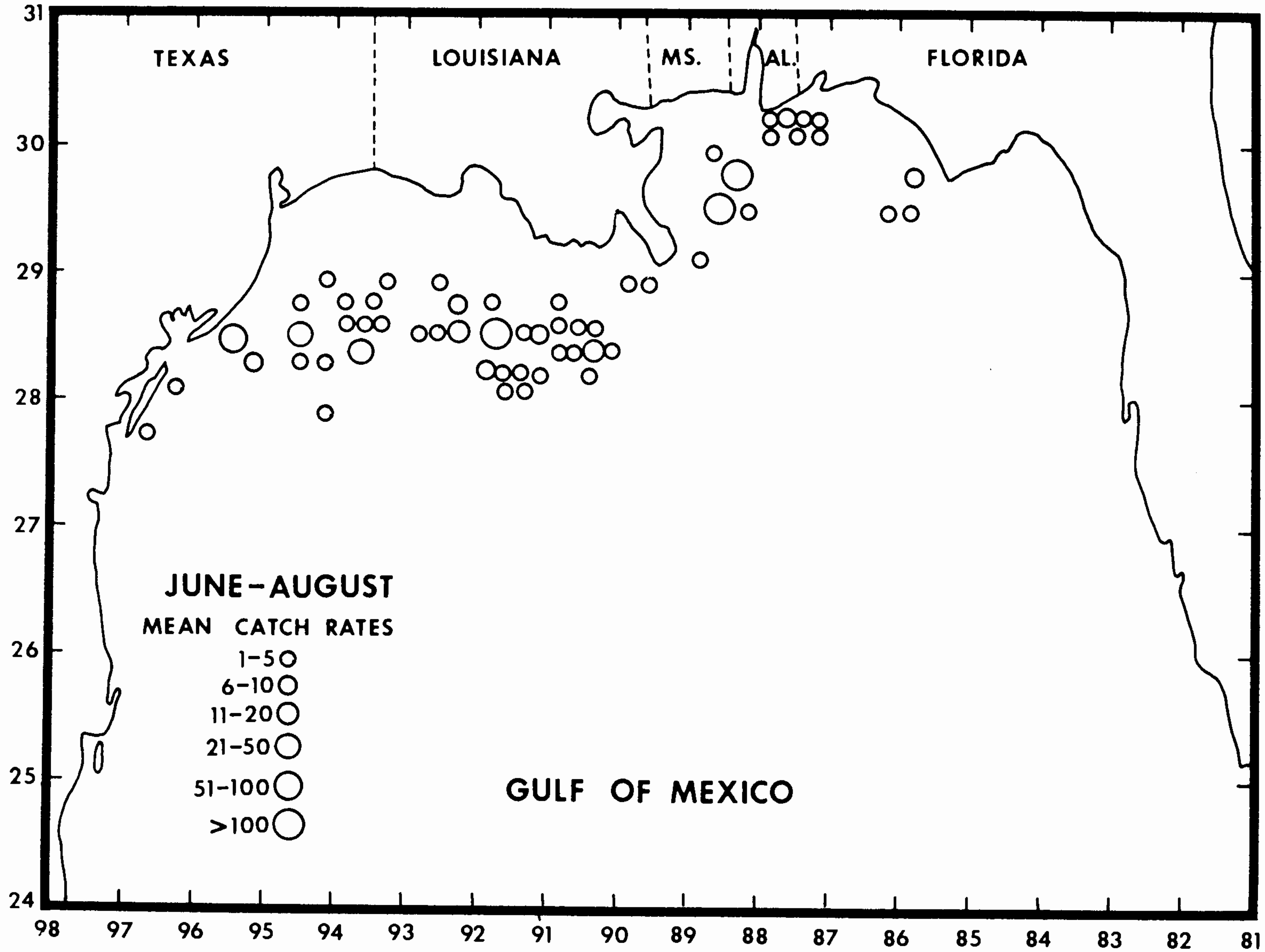

Figure 7. Abundance and distribution of adult D. punctatus collected by trawl in the summer.

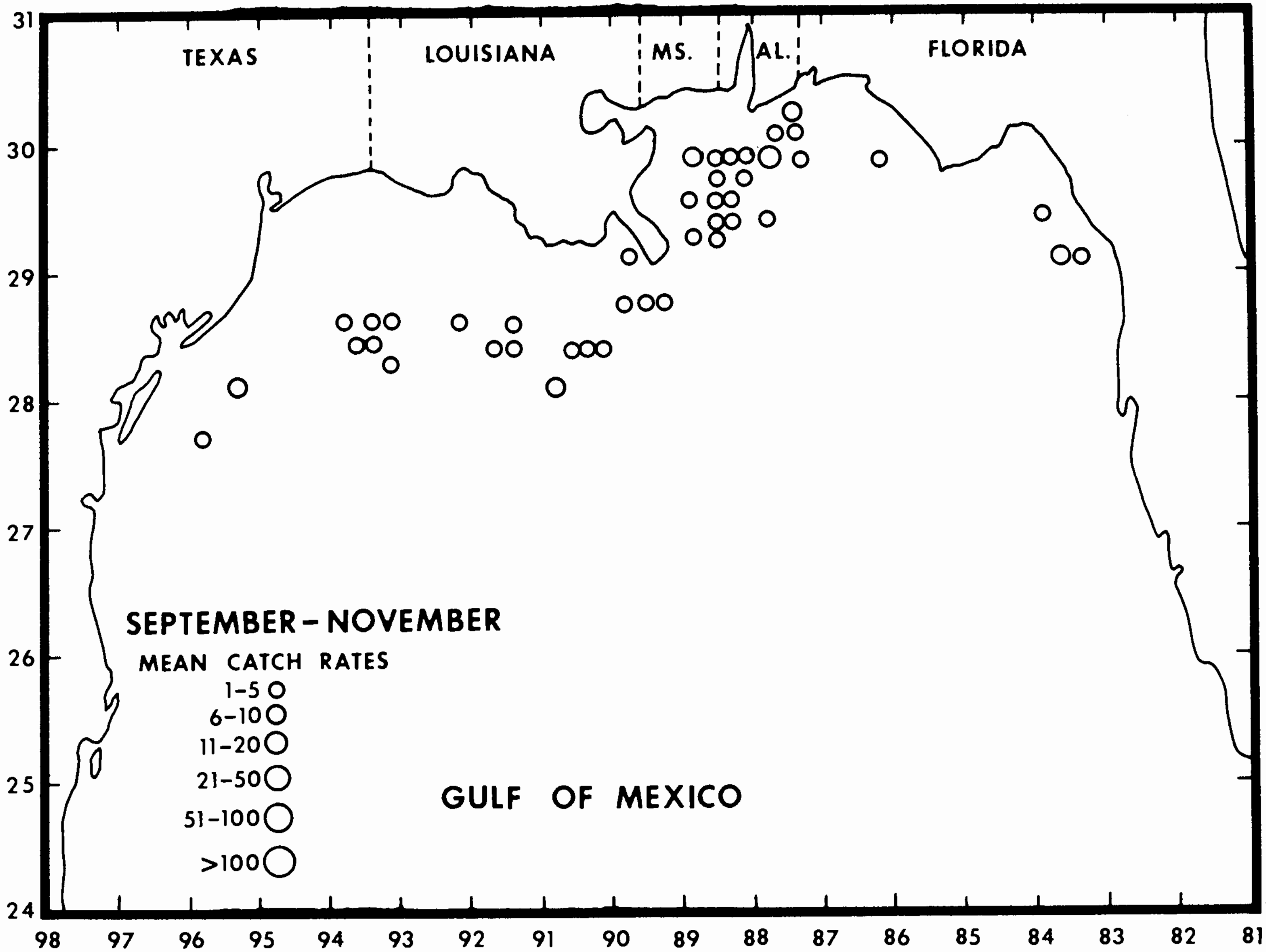

Figure 8. Abundance and distribution of adult *D. punctatus* collected by trawl in the fall.

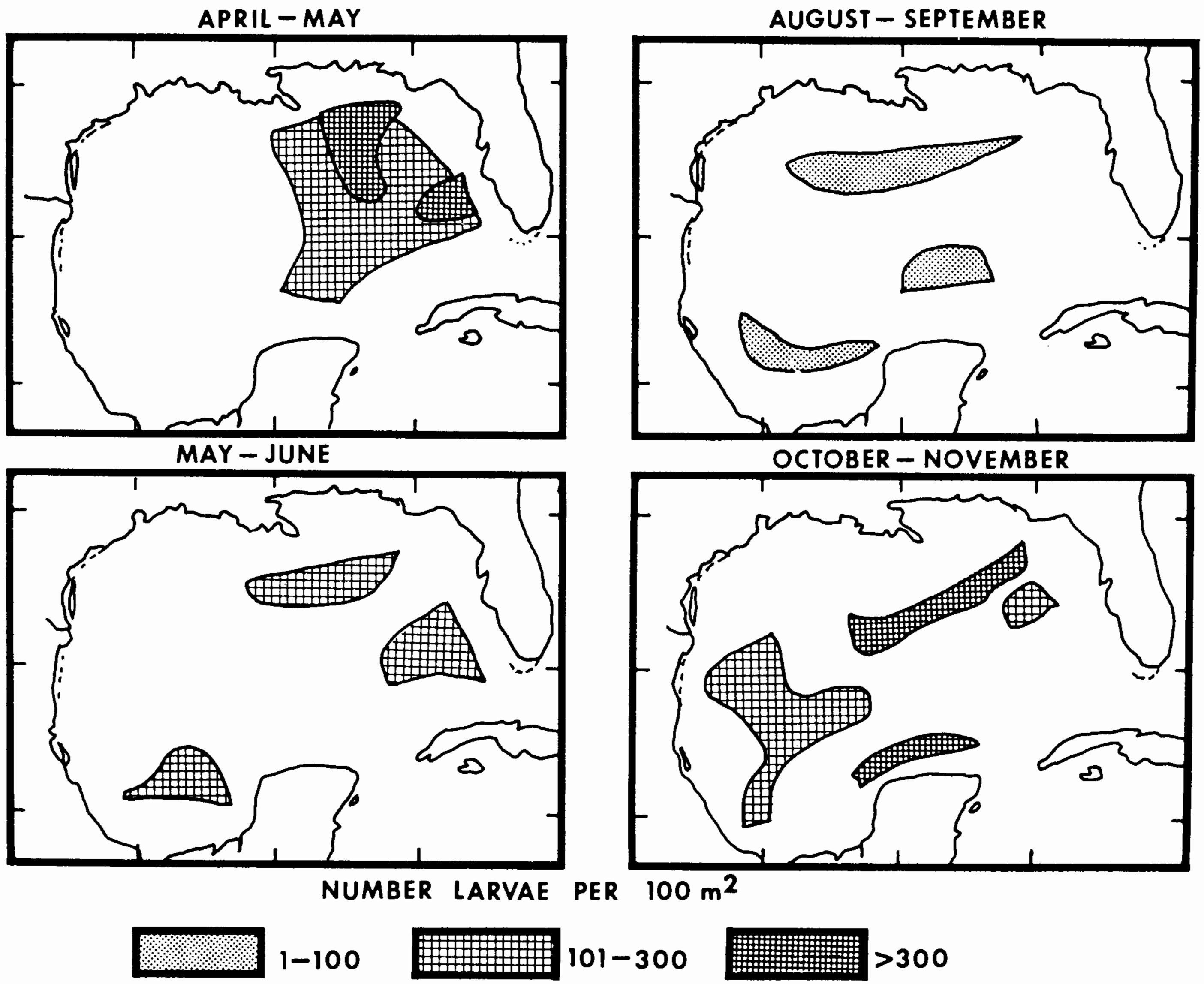

Figure 9. Abundance of larval D. punctatus in the Gulf of Mexico. Data taken from Montolio (1976).

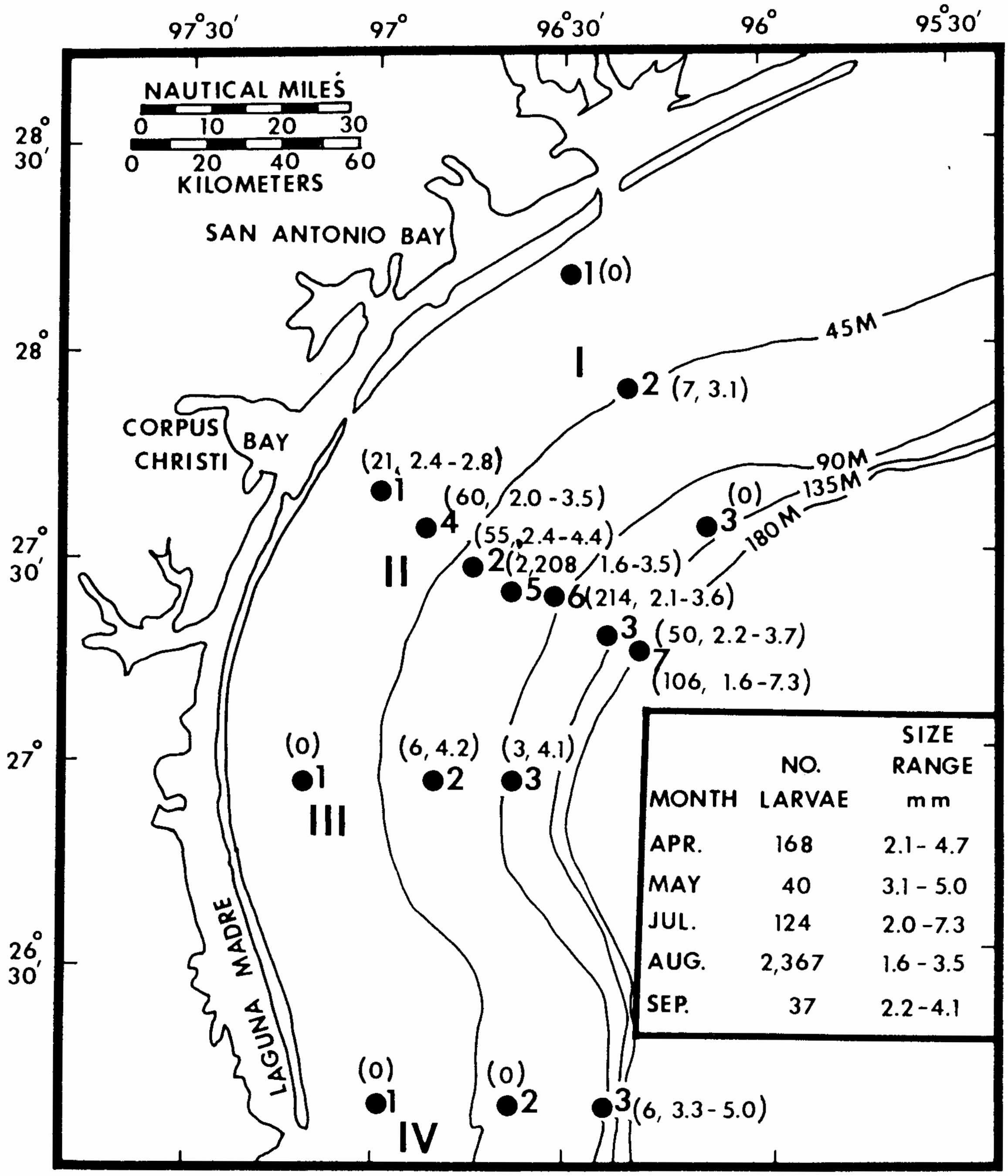

Figure 10. Abundance and size of larval D. punctatus collected in the Gulf of Mexico off the Texas coast in 1977. Data taken from Finucane et al. (1978).

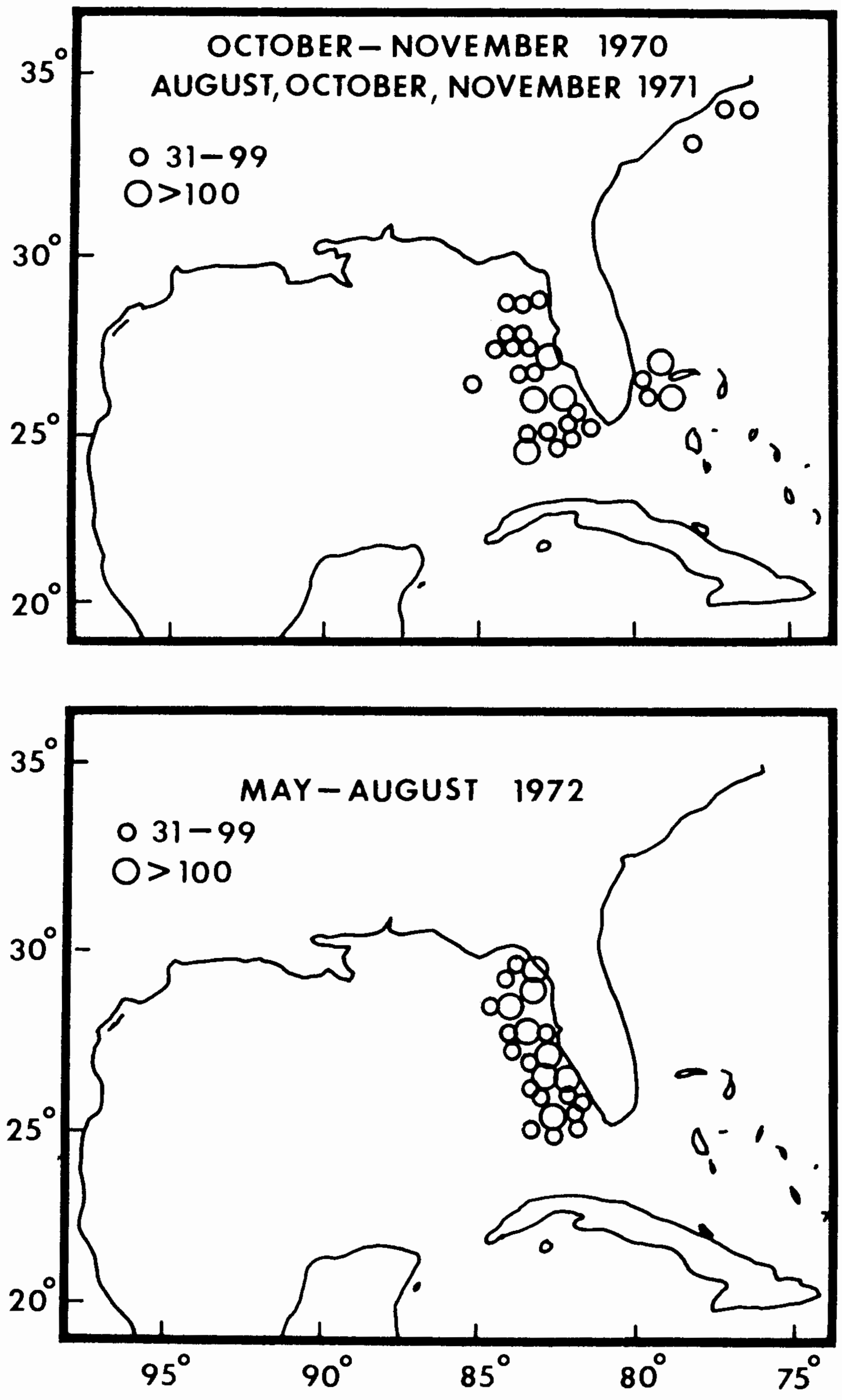

Figure 11. Abundance of larval D. punctatus in the south Atlantic and Gulf of Mexico. Data taken from Aprieto (1974).

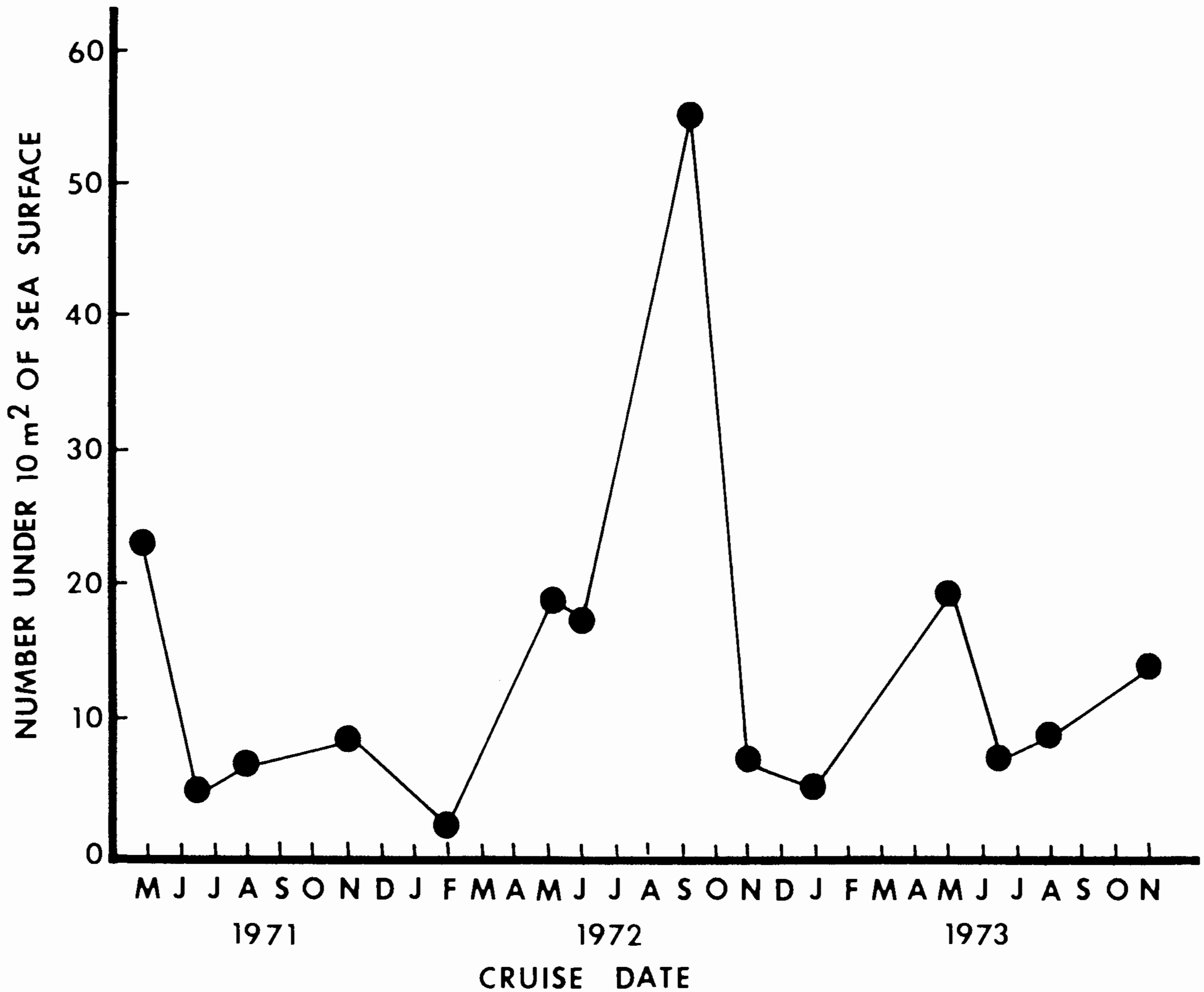

Figure 12. Abundance of larval *D. punctatus* in the eastern Gulf of Mexico, September 1972 - November 1973 (Houde *et al.* 1979).

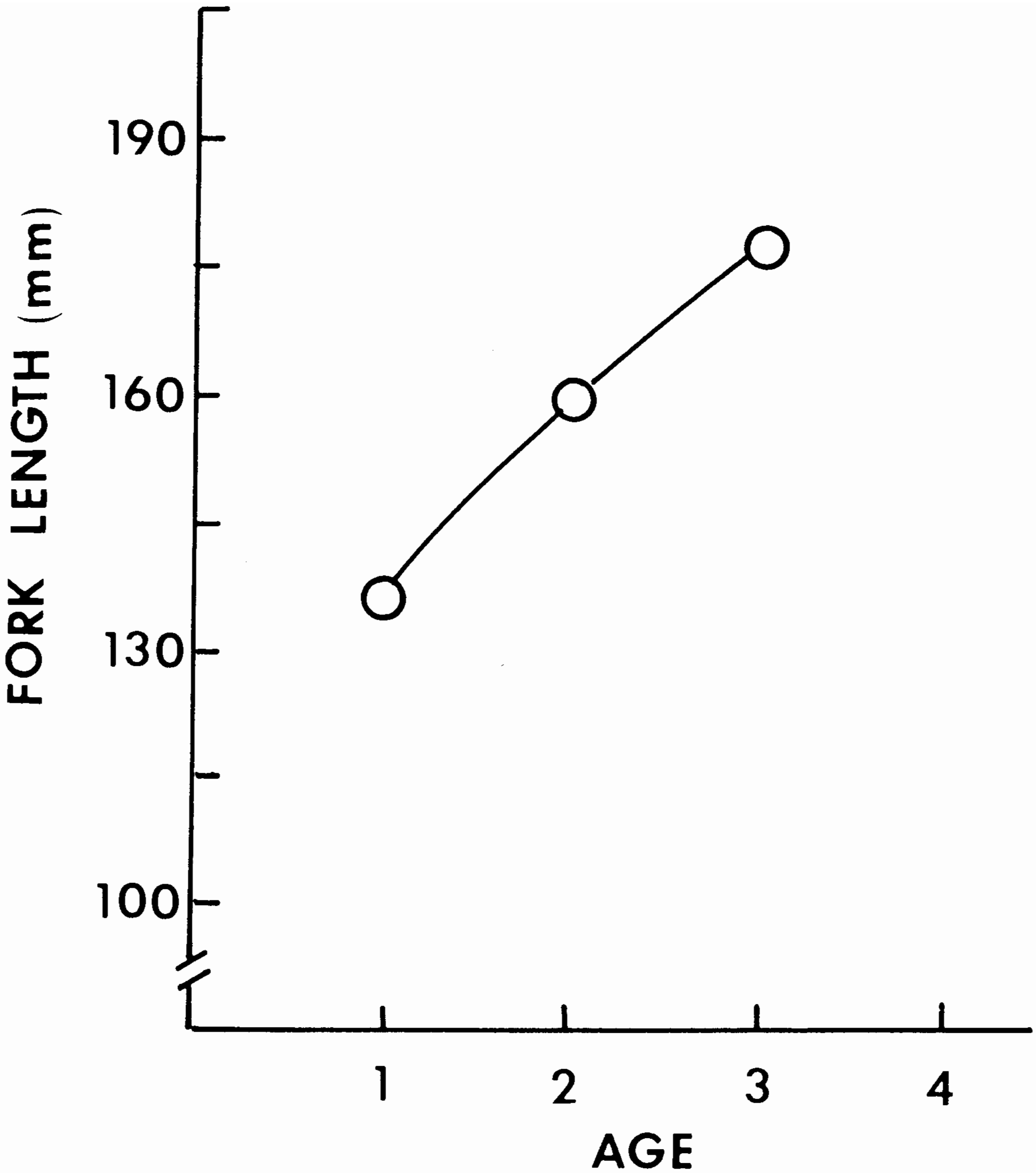

Figure 13. Back calculated lengths at age and fitted von Bertalanffy growth model line for D. punctatus from the eastern Gulf of Mexico (Houde et al. 1983).

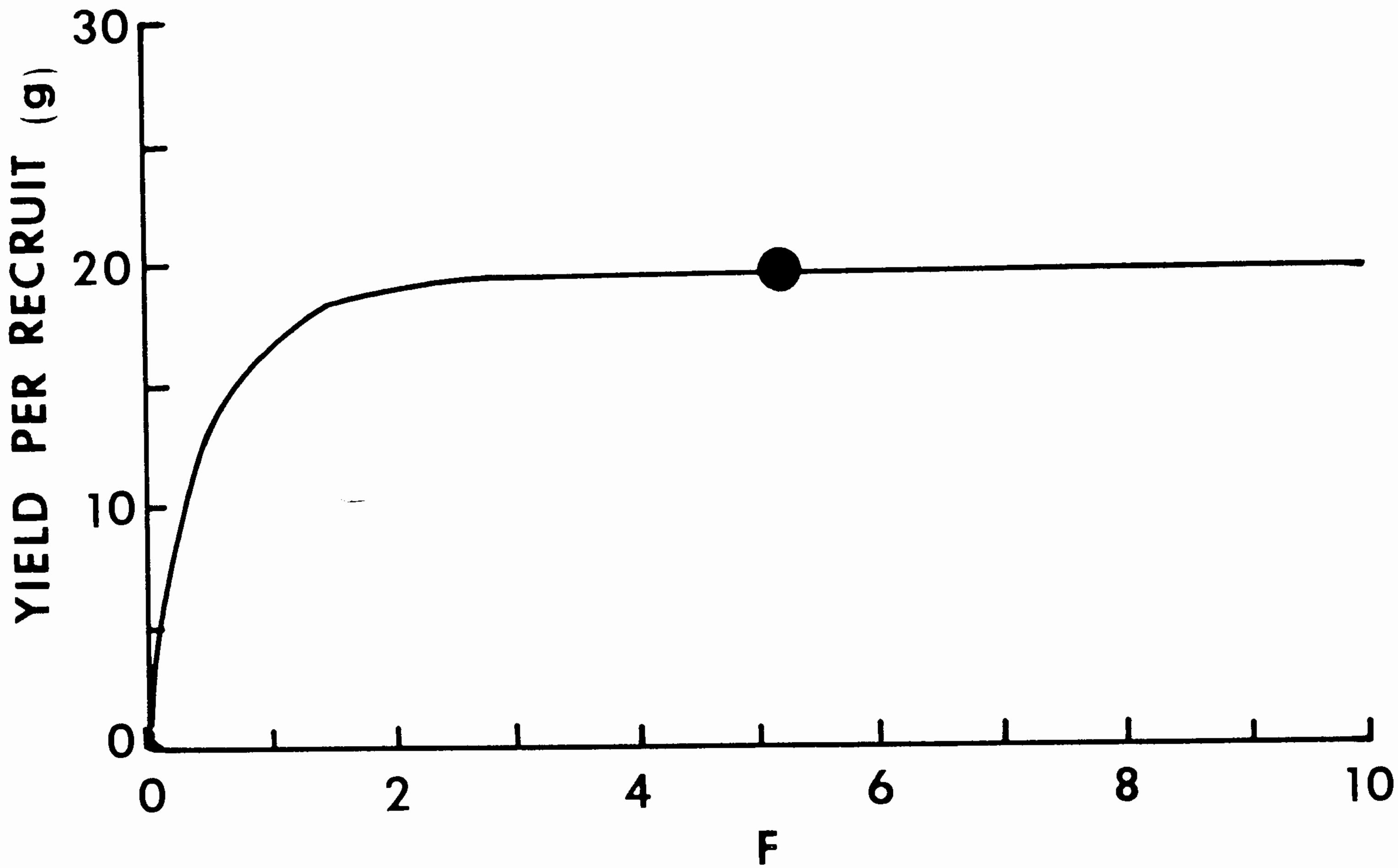

Figure 14. Predicted yield-per-recruit as a function of fishing mortality for D. punctatus from the eastern Gulf of Mexico (Houde et al. 1983).

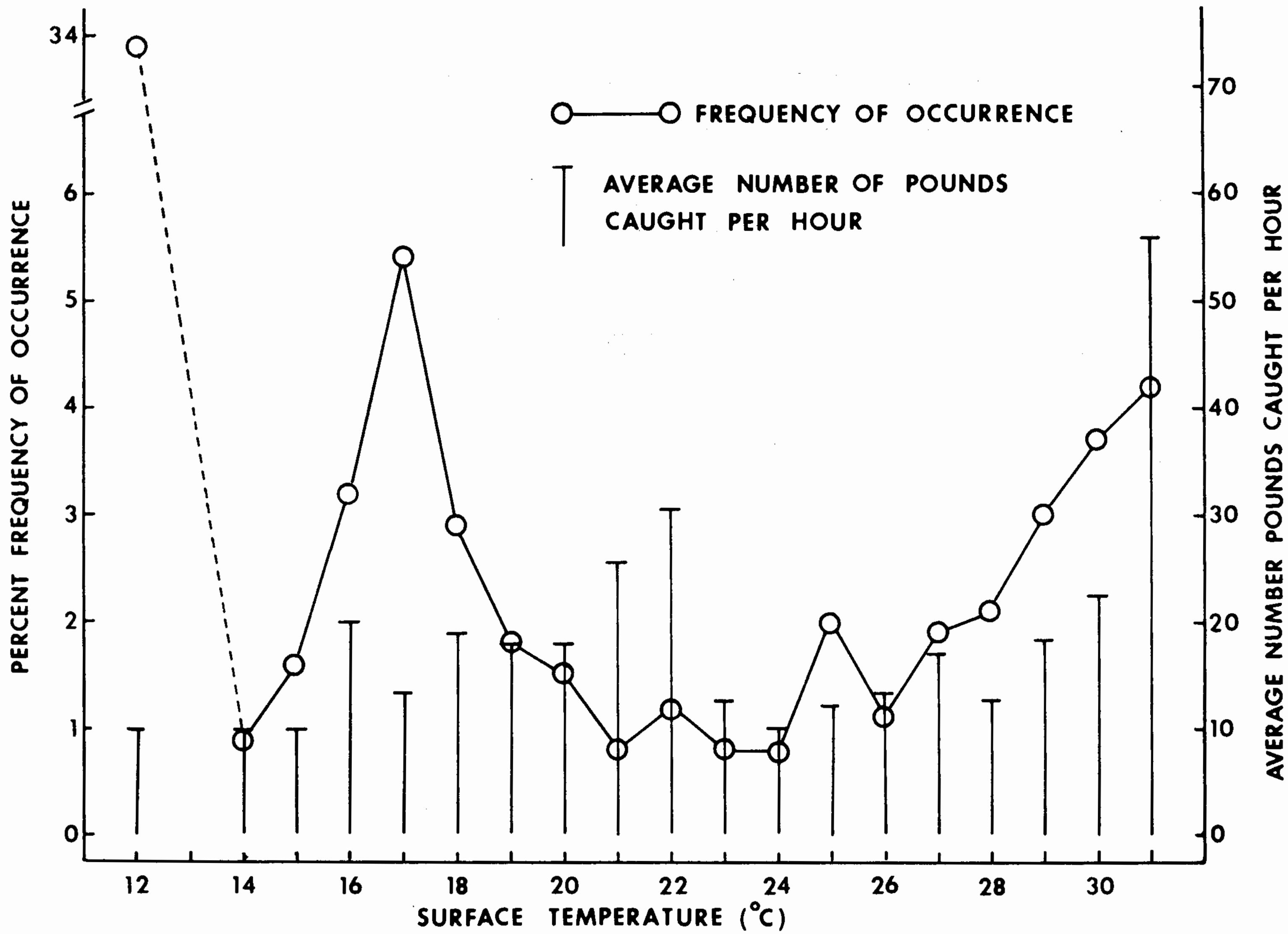

Figure 15. Percent frequency of occurrence of D. punctatus and the average number of pounds caught per hour of trawling in relation to surface water temperature when D. punctatus were present in shrimp or fish trawls in the Gulf of Mexico from 1950-1985. Data provided by NMFS, Mississippi Laboratory, Pascagoula, MS.

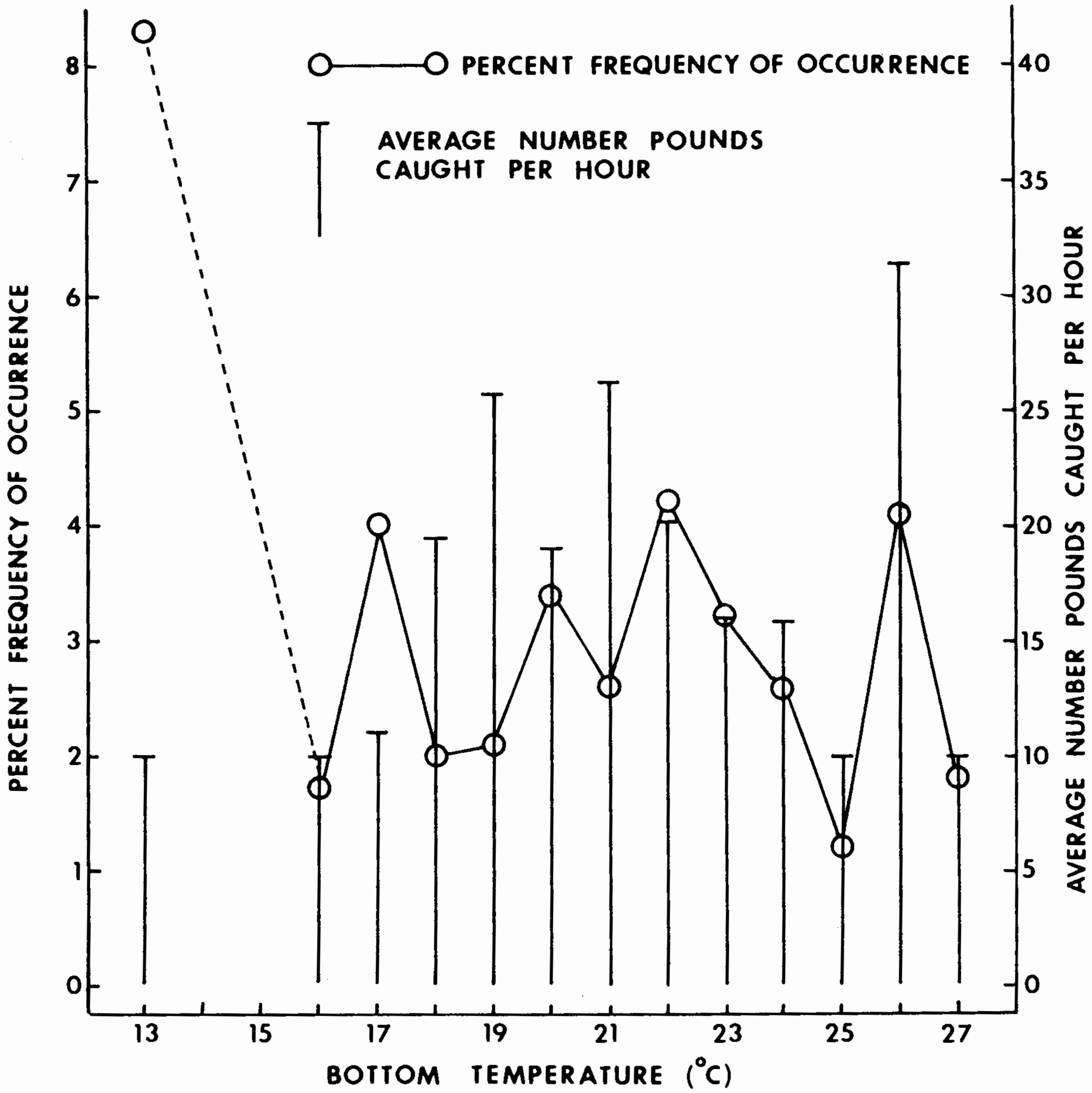

Figure 16. Percent frequency of occurrence of D. punctatus and the average number of pounds caught per hour of trawling in relation to bottom water temperatures when D. punctatus were present in shrimp or fish trawls in the Gulf of Mexico, 1950-1985. Data provided by NMFS, Mississippi Laboratory, Pascagoula, MS.

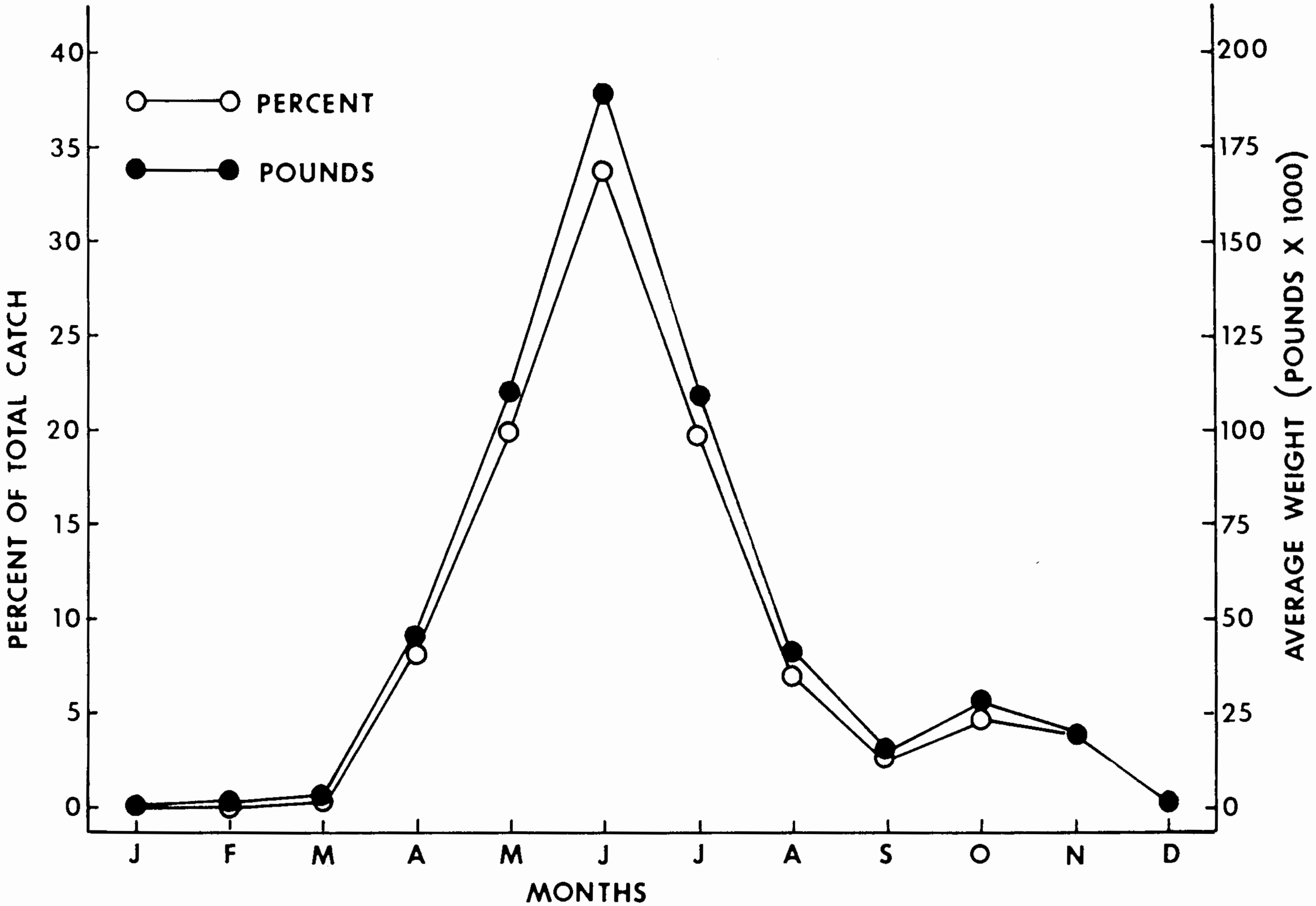

Figure 17. The percent and average weight of monthly catch of D. punctatus from the west coast of Florida, from 1952-1982.

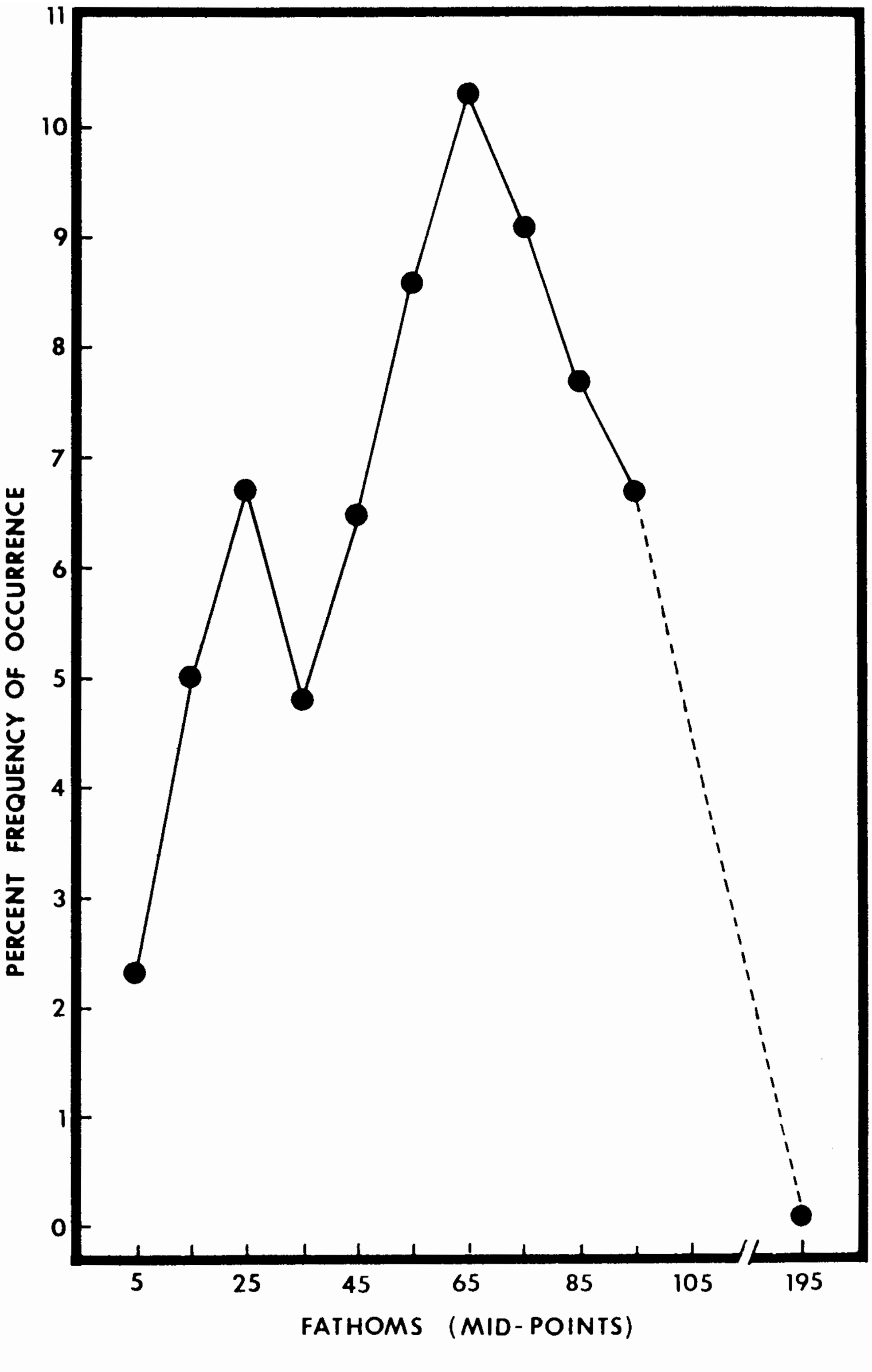

Figure 18. Percent occurrence of *D. punctatus* caught in shrimp and fish trawls at depths ranging from 1 to 200 fathoms in the Gulf of Mexico from 1950-1985. Data provided by NMFS, Pascagoula Laboratory, Pascagoula, MS.

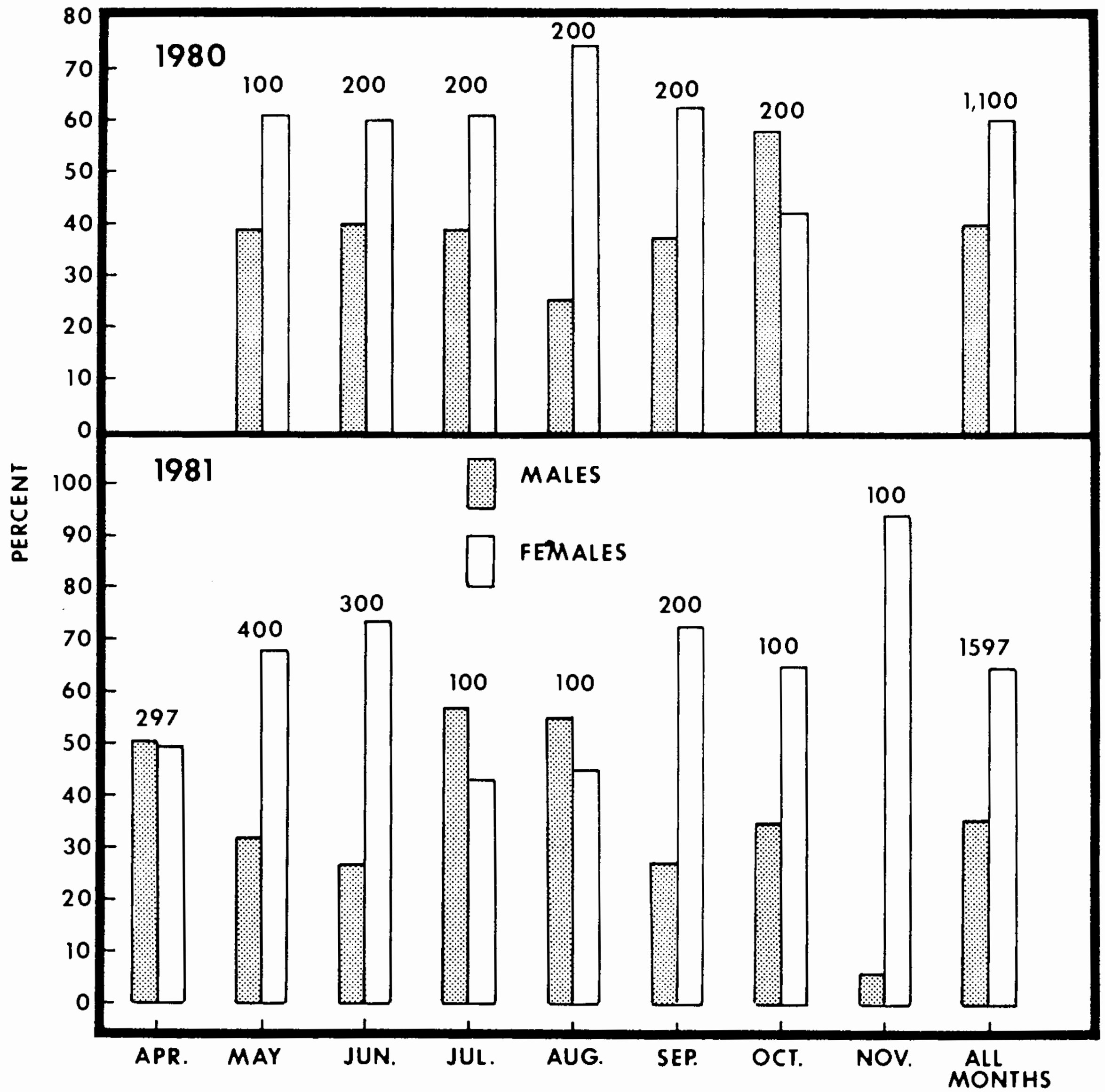

Figure 19. Monthly sex ratios of D. punctatus from northwest Florida during 1980 and 1981. Sample size is recorded above monthly columns.

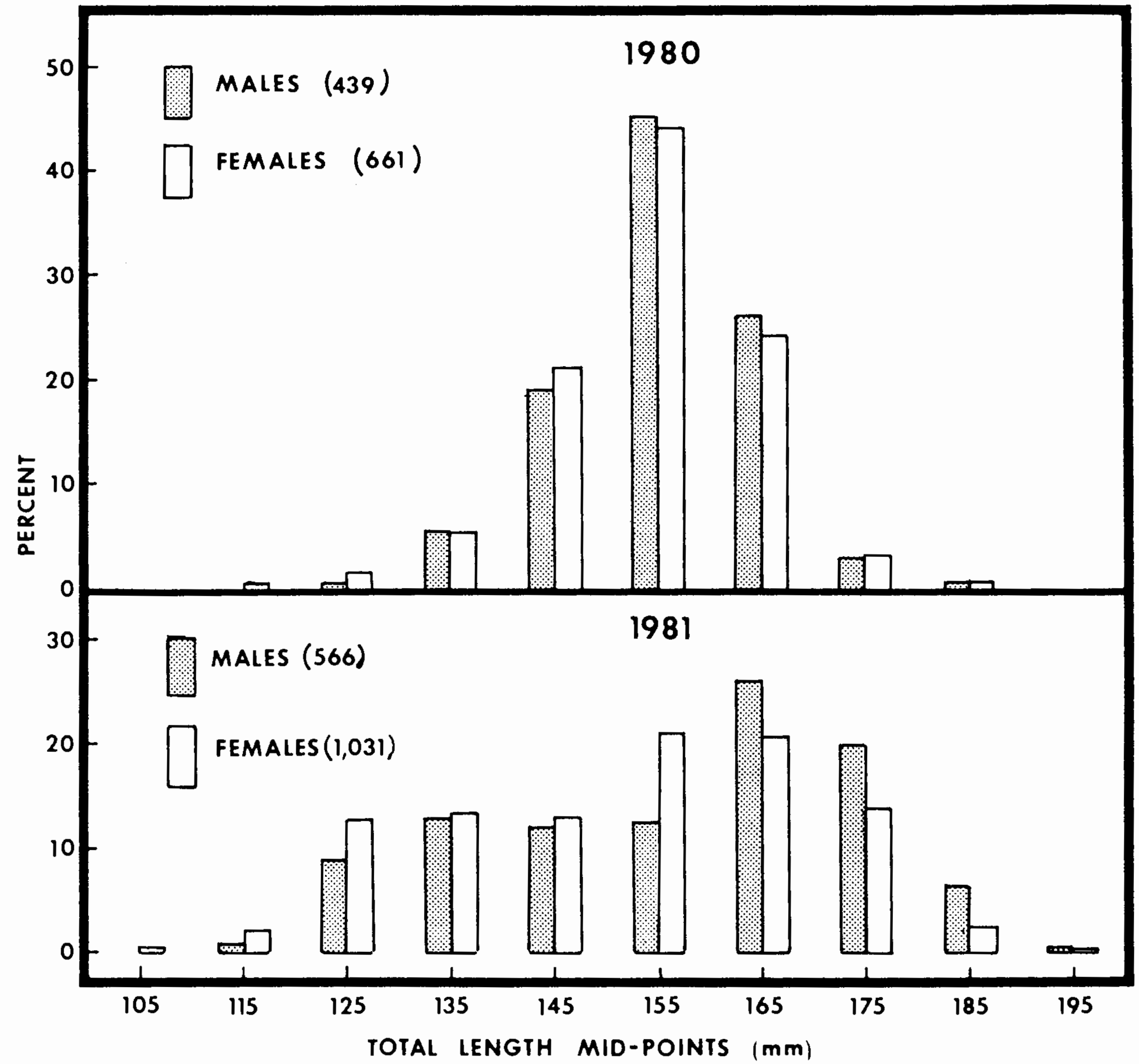

Figure 20. Sex ratio of _D. punctatus_ by size groups from northwest Florida (sample size in parentheses).

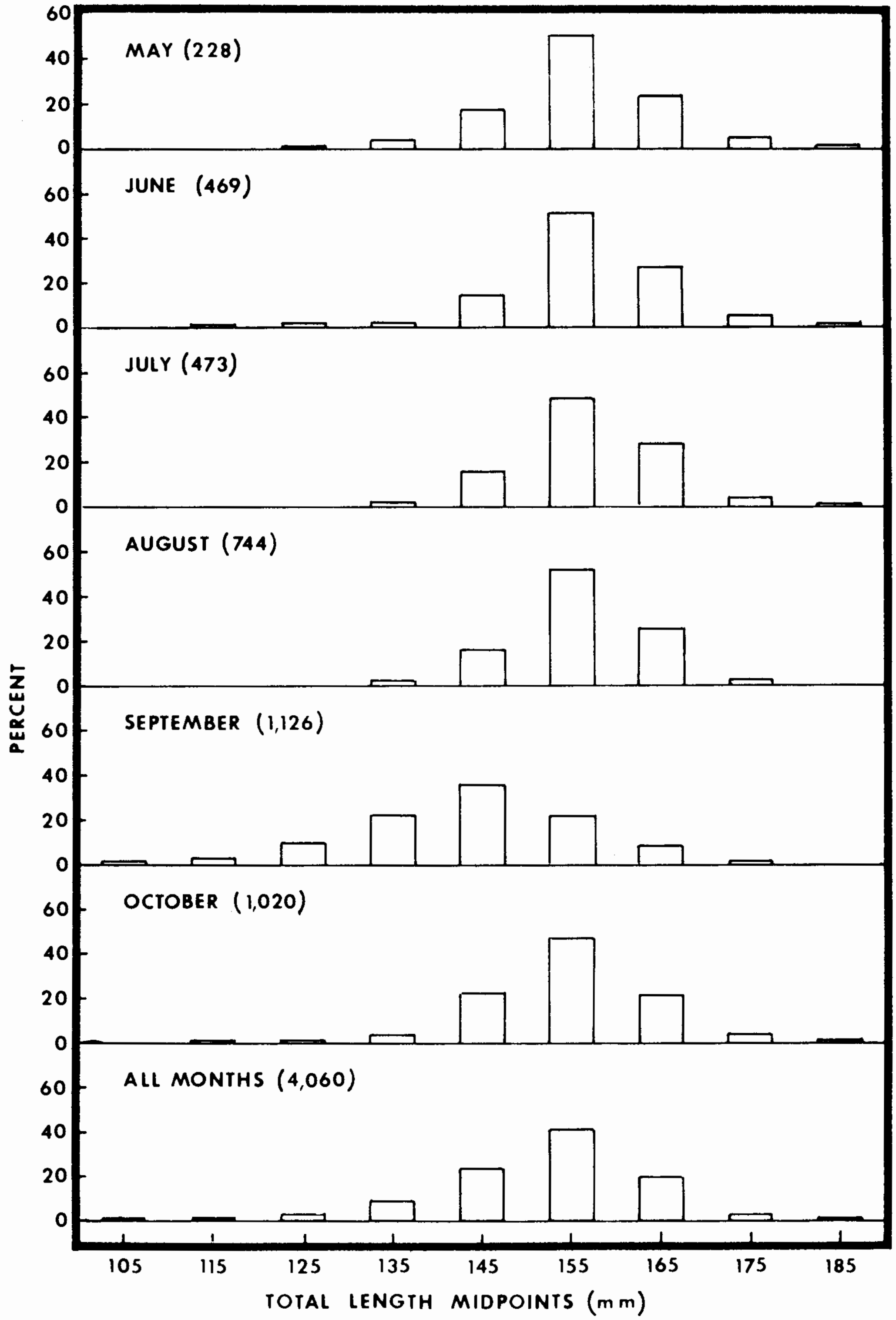

Figure 21. Length frequency distribution of D. punctatus from northwest Florida in 1980 (sample size in parentheses).

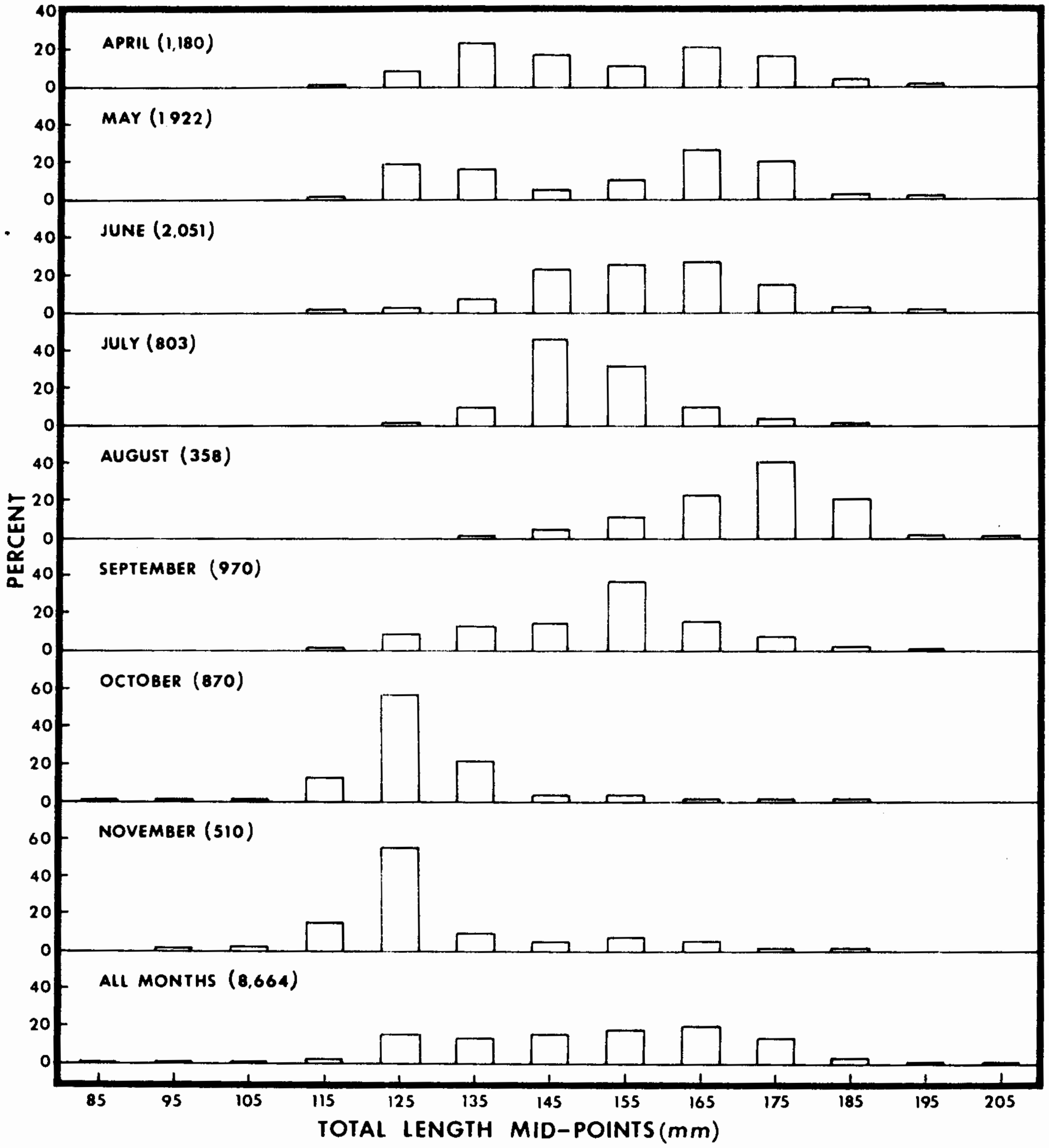

Figure 22. Length frequency distribution of *D. punctatus* from northwest Florida in 1981 (sample size in parentheses).

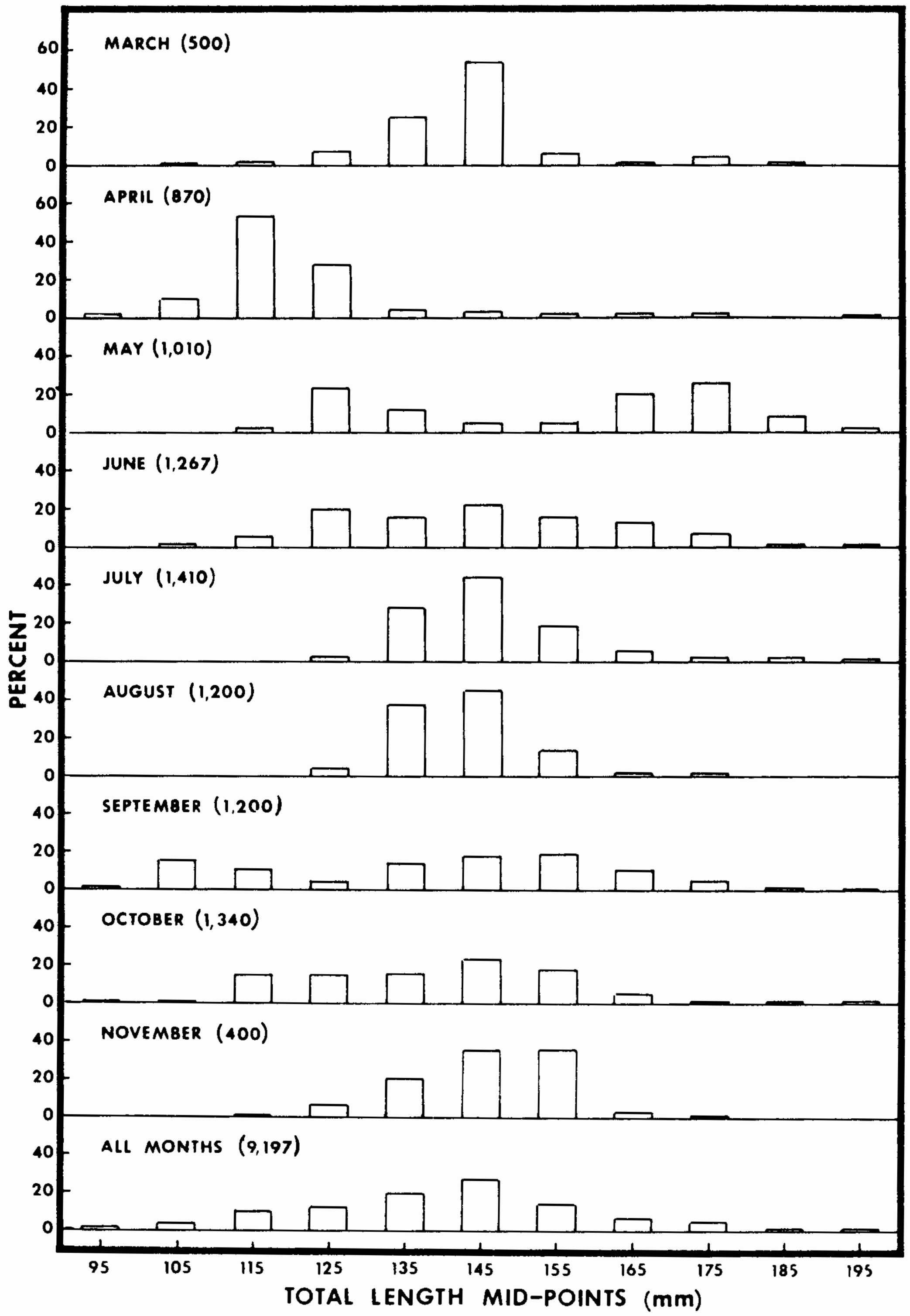

Figure 23. Length frequency distribution of D. punctatus from northwest Florida in 1982 (sample size in parentheses).