NOTE

DISTRIBUTION AND ABUNDANCE OF *SICYONIA PENICILLATA* LOCKINGTON, 1879 IN THE GULF OF CALIFORNIA, WITH SOME NOTES ON ITS BIOLOGY[1]

Penaeid shrimp on the continental shelves of México are heavily exploited and represent one of the major sources of seafood. It is also an important source of revenue as most of the catch is exported. Of the different species which are commercially fished, the genus *Penaeus* constitutes practically the entire catch (Dilio-Fuentes et al. 1976; Klima 1981; Mathews 1981). In the Gulf of California, on the Pacific side of México, there is a very important trawl fishery for *Penaeus* (*Farfantepenaeus*) *californiensis* Holmes and, to a lesser extent, for *P.* (*Litopenaeus*) *vannamei* Boone and *P.* (*L.*) *stylirostris* Stimpson which are both predominantly caught in coastal lagoons. Small catches of *P.* (*F.*) *brevirostris* Kingsley are also taken in the southern Gulf of California (Edwards 1978; Mathews 1981). In the area, however, the fisheries for *Penaeus* shrimp have shown a steady fall in catch since 1962 (Lluch-Belda 1974; Rodríguez de la Cruz 1981a). One of the major consequences has been an increasing but still limited interest for the bycatch of *Penaeus* shrimp and more attention has recently been given to other species or genera that were previously considered too small or not abundant enough (Hernández-Carvallo 1976; Grande-Vidal and Díaz-López 1981; Paul 1981). Thus, other contributors to the total catch are *Xiphopenaeus riveti* Bouvier, which has been increasingly important in the Gulf of California fishery since 1972 (Hernández-Carvallo 1976), and *Trachypenaeus pacificus* Burkenroad, which occasionally appears in local markets, and has effectively occupied a secondary part in recent fisheries (Rodríguez de la Cruz 1981b; Mathews 1981).

Although there are 19 species of *Sicyonia* reported from American waters, little information has been published on the relative importance that the genus has or might have for fishery development. Commercial catches have been reported for *S. brevirostris* Stimpson along the coast of the southeastern United States (Pérez Farfante 1980) and in the Gulf of México (Arreguín-Sánchez 1981), and this species seems to be one of the most abundant decapod crustaceans in these areas (Kennedy et al. 1977; Huff and Cobb 1979; Soto 1980; Wenner and Read 1982). Comparatively, on the Pacific coast of America, two species have been occasionally caught in large quantities. *Sicyonia ingentis,* the only species of the genus found north of México, is actively fished off the coast of California (Frey 1971; Mearns and Greene 1974), while in the Southern Hemisphere, the importance of rock shrimp in fishery activities has recently increased and *S. disdorsalis,* one of the four species occurring in the area, represented about 5.8% of the total catch of penaeid shrimp in northern Perú in 1977 (Arana and Méndez 1978). *Sicyonia disdorsalis* is also the dominant species in the southeastern Gulf of California (Hendrickx et al. 1982) and is commonly found as a member of the *Penaeus* bycatch (Paul and Hendrickx 1980).

The information in this paper was obtained while processing the material collected during a 2-wk cruise in the Gulf of California, and it is presented as a contribution to the study of the biology and fishery of *S. penicillata* on the Pacific coast of México. Information related to the distribution, abundance, and habitat of the species in the Gulf of California, biometric data, and natural diet is also included.

Material and Methods

Samples of benthic fauna were collected in May 1982 at 32 different sampling stations on the continental shelf of the Gulf of California, México (Fig. 1). Of these 32 collections, 28 were made with an 11 m headrope commercial otter trawl, with a stretched mesh of 6.5 cm, equipped with a 2.5 cm bar mesh inner cod end bag. Four samples were made with a 3 m wide rectangular oyster dredge equipped with 2.5 cm bar mesh collection bags. Tows were made from the 50 m RV *El Puma,* of the Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, at speeds of between 2 and 4 km/h and were about 30 min in duration. At the end of each tow, samples were first sorted into major groups (mollusks, crabs, shrimp, echinoderms, and fish) and fresh weights for each group were obtained to the nearest 100 g with

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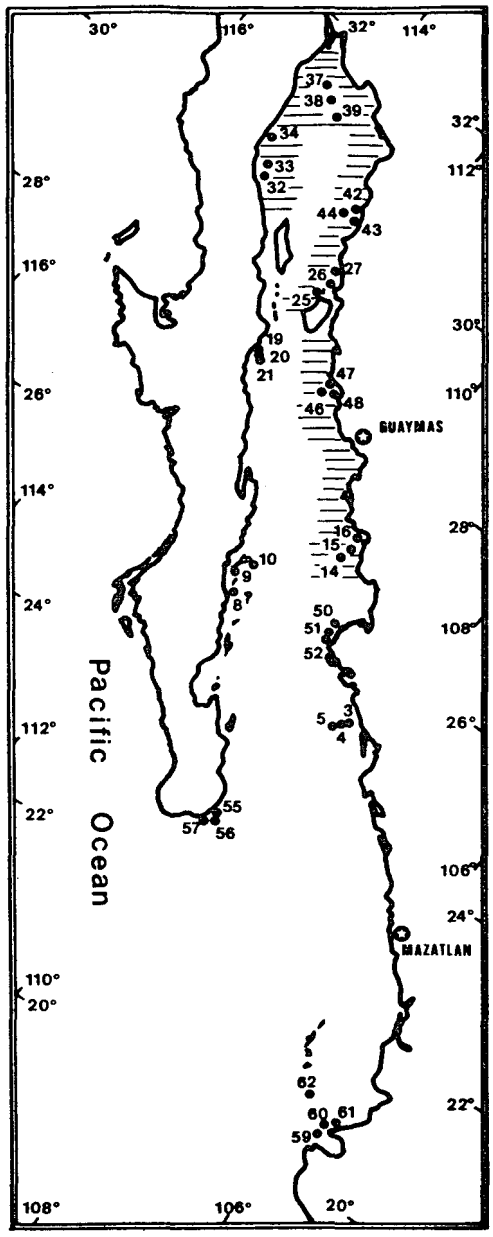

FIGURE 1.—Location of the sampling stations (solid circles) and distribution of *Sicyonia penicillata* (striped area) according to the occurrence of this species in the samples.

spring balances. Whenever members of one species or genus accounted for a large part of the total catch, they were weighed apart from the rest of the catch.

Samples were immediately fixed with a 8% seawater solution of Formalin[2], except for the *Sicyonia* samples that were stored in the deep freezer of the vessel at a temperature of −25°C. Frozen samples of *S. penicillata* were later used in the laboratory to determine individual weights (W) with a top pan electric balance (± 0.05 g precision). Total length (TL: rostrum tip to telson tip) and carapace length (CL: orbital margin to mid-posterodorsal margin of carapace) of the shrimps were obtained with a dial caliper to the nearest 0.1 mm. Determination of linear and exponential relationships, TL-CL and W-CL, followed the method of Sokal and Rohlf (1969).

The analysis of the foregut contents was done with a series of 20 specimens that were selected at random from among the material obtained during trawling activities. The foreguts were removed by dissection, their contents analyzed under magnification, and the frequency of occurrence of each food item was calculated and expressed as a percentage of the total number of foreguts examined.

Results and Discussion

Geographic Distribution

Sicyonia penicillata was first described by Lockington (1879) from Bahía Bolinas (sic), Baja California (?Bahía Ballenas) and Bahía de Los Angeles in the Gulf of California. Brusca (1980) reported the species as the most common rock shrimp from the Gulf of California (Gulf) and from the west coast of Baja California where it was found as far north as the Laguna Ojo de Liebre (lat. 27°45′N). It also occurs in bays of the western side of the Gulf (Burkenroad 1934, 1938).

During the present study, *S. penicillata* was found in the northern part and along the east coast of the Gulf, south to Punta Arboleda (lat. 26°45′N), and was captured at 13 of the 32 sampling stations (Fig. 1). Although a wide continental shelf runs uninterruptedly from this latter locality south to Bahía Banderas, at the southern tip of the Gulf, the species seems to be absent from the southeastern part of the Gulf. Indeed, monthly sampling made in Bahía de Mazatlán over a 2-yr period and intensive trawling operations made on the continental shelf of southern Sinaloa (lat. 22°14′ to 23°37′N) on three occasions during a period of 1 yr did not bring up a single specimen of *S. penicillata,* and the dominant species for this

[2]Reference to trade names does not imply endorsement by the National Marine Fisheries, Service, NOAA.

area appears to be *S. disdorsalis* (Hendrickx 1984). Although several species of *Sicyonia* from the Pacific coast of America have a wide distribution range, *S. penicillata* seems to be restricted to the southern half of Baja California and the central and northern Gulf of California (Hendrickx 1984).

Abundance

A total of 3,502 specimens were collected during the sampling operations, including 1,919 females (55%) and 1,583 males (45%). Generally *S. penicillata* was rare or uncommon at most of the trawl stations. Most of the catches were <1 kg/h and commercial-size catches were obtained only twice during the survey (33 and 66 kg/h). The largest catches of all were from the northernmost part of the Gulf at stations 38 and 39 (Table 1) and represented 97 and 88% of the crustacean catch and 6 and 69% of the total catch, respectively. All of the sampling was done during daytime or at dusk. Nighttime captures might prove to be much higher as has been the case with *S. brevirostris* on the Florida's West Central Shelf (Huff and Cobb 1979).

TABLE 1.—Sampling conditions and abundance (kg/h of trawling) of *Sicyonia penicillata* in the Gulf of California during the survey (catch = 0 for the rest of the stations).

Sampling station	Depth (m)	Abundance (kg/h)	Substrate	Sand (% by weight)	Silt	Clay
15	53	1	Fine sand with shell fragments	69	23	8
25	75	1	Very coarse sand with shell fragments	100	—	—
27	30	1	Sand	100	—	—
32	39	1	Green mud	24	43	34
33	80	1	Compact green mud	2	46	52
34	26	2.2	Green mud	8	42	50
37	35	1	Fine sand; silty (brown to grey mud)	79	12	9
38	60	66.4	Fine sand; silty (brown to grey mud)	75	18	7
39	100	33	Very fine sand	72	17	10
43	73	1	Silty sand	—	—	—
44	100	1	Silty sand	54	29	17
47	49	1	Fine sand	83	10	7
48	54	1	Fine sand	78	14	8

Bathymetric Range and Substrate

The species seems to occupy a wide bathymetric range. It has been reported by Burkenroad (1938) from the beach level (under stone) down to a depth of 72 m. In the present study, the shrimp were collected at depths between 26 and 100 m (Table 1). Information on bottom substrates was obtained from samples collected during the same cruise and processed by the Laboratorio de Geología Marina of the Marine Station of Mazatlán and have been summarized in Table 1. Maximum abundance was found at stations with smooth bottom made of compact mud and of very fine sand, although specimens were also collected in small numbers on bottoms made of coarse sand and of crushed shell-sand.

The distribution pattern of the species in the Gulf indicates a preference for the shelf of the northern Gulf and the eastern central Gulf. No specimens were found at station 19 and southward, along the Baja California coast, where sand and gravel were observed. The absence of *S. penicillata* from the southeastern Gulf platform, where substrate varies with depth from fine sand to mud (mostly silty mud mixed with clay), is probably due to other factors such as water temperature or dissolved oxygen level which can be lower than 1 ml/l at bottom level in this area (January and April data) (Hendrickx et al. 1984), or to competition with *S. disdorsalis*.

Natural Diet

As in other penaeid shrimp, food in the stomach of *Sicyonia* is usually finely triturated, making difficult identification of the components of the diet (Cobb et al. 1973). Relative importance of various food items in the diet is listed in Table 2 (20 stomachs).

All stomachs examined were at least 30% full and 12 of them were at least 50% full. Sampling was done in late afternoon, and the degree of stomach fullness indicates that the species feeds during daytime. Crustaceans were the most frequent item in the diet, followed by small mollusks and polychaetes. Unidentifiable organic matter was present in almost every stomach (80%) and, in

TABLE 2.—Food items in the diet of *Sicyonia penicillata* (20 stomachs).

Food items		% Frequency of occurrence
Algae		15
Foraminifera		15
Nematoda		10
Polychaete fragments		40
Mollusca:	Gastropoda	20
	Fragments	40
Crustacea:	Copepoda	5
	Isopoda	10
	Amphipoda	35
	Fragments	70
Fish scales		30
Pellets		45
Unidentifiable organic matter		80
Sand, silt, etc.		20

many cases, it accounted for a large fraction of the content. *Sicyonia penicillata* seems to be a generalized carnivore, feeding on small benthic crustaceans, mollusks, and polychaetes.

Biometric Relationships

Biometric relationships were obtained from a series of 82 specimens selected from the total catch at station 38. Carapace length/total length relationships were assessed for 24 males (TL: 85-49 mm) and 58 females (TL: 97-43 mm). The male relationship was TL = 4.73 + 3.74 CL (r = 0.992) and the female relationship was TL = 4.51 + 3.63 CL (r = 0.991). Relationships assessed for each sex were significantly different from one another (t-test on slope; $P < 0.001$). Carapace length/weight relationships were also assessed for each sex and the following equations were obtained: male $W = 1.1 \times 10^{-3}\ CL^{2.9775}$ (r = 0.978) and female $W = 1.7807 \times 10^{-3}\ CL^{2.7733}$ (r = 0.985) (Fig. 2).

Fishing Potential

Commercial concentration of *Sicyonia penicillata* were found at two localities only (33 and 66.4 kg/h). These values are comparable with the catch reported for *Sicyonia* spp. by Cobb et al. (1973) off the northeast coast of Florida (up to 46 kg/h). There is little information available on commercial catch in the Gulf of California. Unpublished data obtained from the Mexican Fishery Institute (Instituto de Pesca) indicate total catch between 40 and 1,572.5 t/yr for the period of 1977-82 in the northern and central Gulf (data are for the fishing harbor of Guaymas, Sonora, for five consecutive fishing seasons: 1977-78, 40 t; 1978-79, 610.3 t; 1979-80, 1,572.5 t; 1980-81, 167.5 t; 1981-82, 207.0 t). These catches corresponded to mixed captures of rock shrimp where *S. penicillata and S. aliaffinis* seemed to predominate. In 1979-80, when the peak catch was obtained, large quantities of *Sicyonia* were brought by truck to Es- were dried in huge chile-ovens, peeled, and sold as appetizer or seasoning (D. Castro[3]).

Prior to this report, information related to fishery grounds, catches, and fishery potential were only available for two American species of *Sicyonia: S. ingentis,* along the coast of southern California, and *S. brevirostris,* in the South Atlantic Bight and in the Gulf of México. Data obtained on *Sicyonia penicillata* indicate that it is the most abundant rock shrimp for the entire Gulf of California. Although the annual rock shrimp catch in the area varied considerably over the past 6 yr (1977-82), it averaged over 500 t/yr. Comparative values for the three species may be found in Table 3. Although these data are not comparable with one another for each year, they clearly demonstrate the relative abundance of *S. penicillata* in the northern Gulf of California.

Sicyonia penicillata is a medium-sized species which average about 90 per kilogram in the northern Gulf of California, compared with *S. ingentis* which averages about 45 per kilogram in the Santa Barbara-Ventura area (Frey 1971). This small size, added to the processing difficulties for hard-shell shrimps, still represents a serious impediment for the development of a fishery.

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Literature Cited

ARANA, P., AND M. MÉNDEZ.
1978. El género *Sicyonia* H. Milne Edwards, 1830 en el Pacífico Sur Oriental, con observaciones biológicas sobre *Sicyonia aliaffinis* Burkenroad, 1934 (Crustacea: Decapoda: Penaeidae). Rev. Com. Perm. Pac. Sur. 9:19-40.

ARREGUÍN-SANCHEZ, F.
1981. Diagnosis de la pesquería de camarón de roca (*Sicyonia brevirostris* Stimpson, 1871) de Contoy, Q. Roo, México. Cienc. Pesq. 1(2):21-41.

[3]D. Castro, Research Assistant, Centro de Investigaciones Pesqueras, I.N.P., Mazatlán, Sinaloa, pers. commun. July 1983.

TABLE 3.—Landings of *Sicyonia* in three North American fishing areas.

Species	Area	Year	Landings (t)	Author
S. ingentis	Southern California, USA	1961	13.7	Frey 1971
		1967-68	0.2	Frey 1971
S. brevirostris	Contoy, Quintana Roo, México	1971-78	15-300	Arreguín-Sánchez, 1981
(heads off)	South Atlantic and Florida, USA	1979	3,340.0	Pérez Farfante 1980
S. penicillata	Guaymas, Northern Gulf of California, México	1977-82	40-1,572.5	Unpubl. data

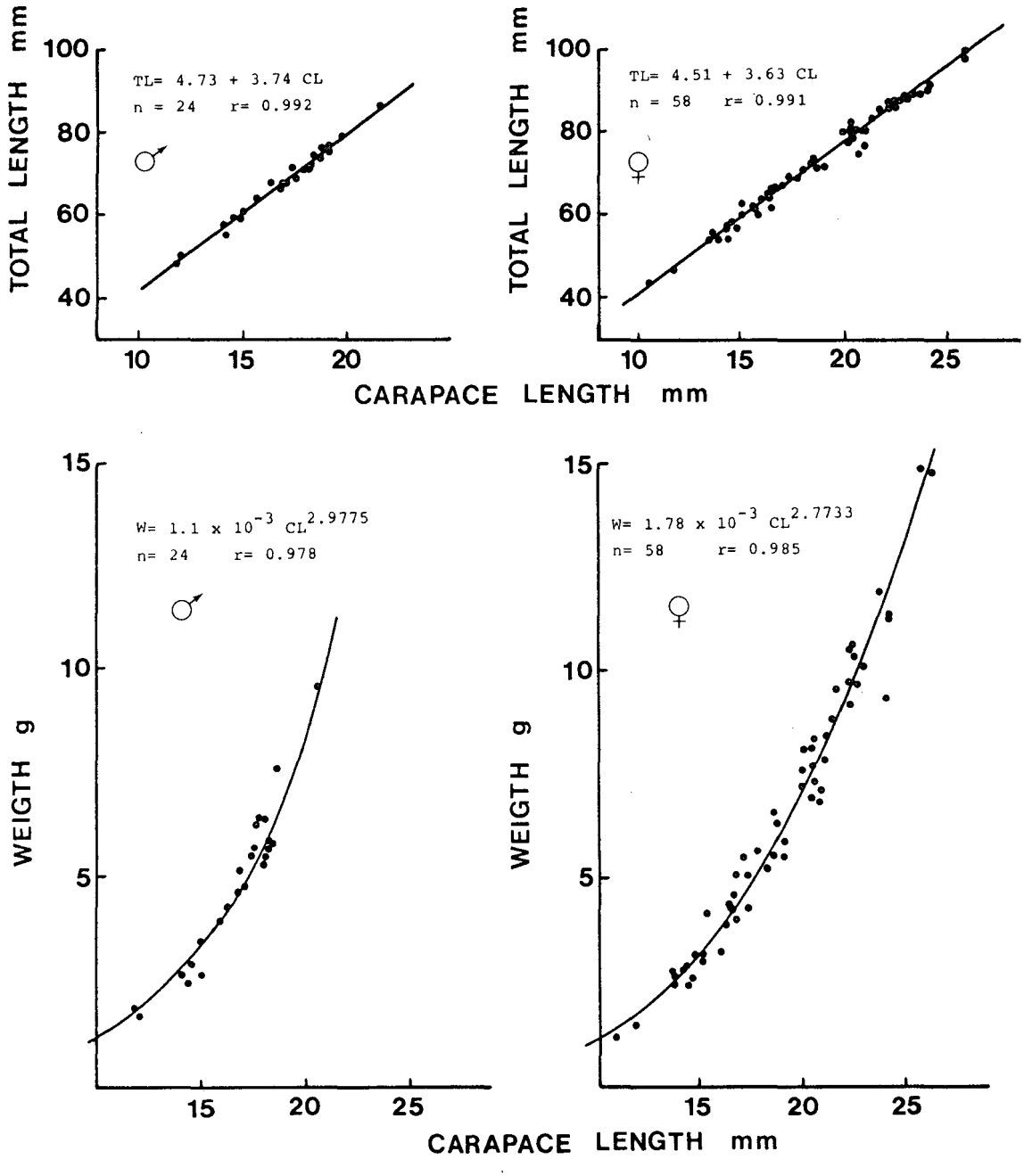

FIGURE 2.—Biometric relationships obtained for *Sicyonia penicillata*.

BRUSCA, R. C.
1980. Common intertidal invertebrates of the Gulf of California. 2d ed. Univ. Arizona Press, Tucson, 513 p.
BURKENROAD, M. D.
1934. Littoral Penaeidea chiefly from the Bingham Oceanographic Collection. Bull. Bingham Oceanogr. Collect. Yale Univ. 4(7):1-109.
1938. The Templeton Crocker Expedition. XIII. Penaeidae from the region of Lower California and Clarion Island, with description of four new species. Zoologica (N.Y.) 23:55-91.
COBB, S. P., C. R. FUTCH, AND D. K. CAMP.
1973. The rock shrimp, *Sicyonia brevirostris* Stimpson, 1871 (Decapoda, Peaneidae). Mem. Hourglass Cruise,

Fla. Dep. Nat. Resour., Mar. Res. Lab. 3(1):1-38.

DILIO-FUENTES, C., R. G. CASTRO, L. SCHULTZ, AND M. OROPEZA.
1976. Pesquería de camarón de altamar en el Golfo de México. *In* Instituto Nacional de Pesca (editor), Simposio sobre Biología y Dinámica Poblacional de Camarones, p. 188-194. Memorias, Guaymas, Sonora.

EDWARDS, R. R. C.
1978. The fishery and fishery biology of penaeid shrimp on the Pacific coast of México. Oceanogr. Mar. Biol. Annu. Rev. 16:145-180.

FREY, H. W. (editor)
1971. California's living marine resources and their utilization. Calif. Dep. Fish Game, Resour. Agency, 148 p.

GRANDE-VIDAL, J. M., AND M. L. DÍAZ-LÓPEZ.
1981. Situación actual y perspectivas de utilización de la fauna de acompañamiento del camarón en México. Cienc. Pesq. 1(2):43-55.

HENDRICKX, M. E.
1984. The species of *Sicyonia* H. Milne Edwards (Crustacea: Penaeidea) of the Gulf of California, Mexico, with a key for their identification and a note on their zoogeography. Rev. Biol. Trop. 32(2).

HENDRICKX, M. E., A. M. VAN DER HEIDEN, AND A. TOLEDANO-GRANADOS.
1984. Resultados de las Campañas SIPCO (Sur de Sinaloa, México) a bordo del B/O "El Puma". Hidrología y composición de las capturas efectuadas en los Arrastres. An. Inst. Cienc. Mar Limnol., Univ. Nac. Autón. Méx. 11(1):107-121.

HENDRICKX, M. E., A. M. VAN DER HEIDEN, A. TOLEDANO-GRANADOS, E. A. CUBERO-GOMEZ, AND J. L. ARREGUIN-ROMERO.
1982. Fauna bentónica de los sedimentos blandos de la Bahía de Mazatlán, Sinaloa. Inf. inédito, 28 p.

HERNÁNDEZ-CARVALLO, A.
1976. Sinaloa y algunos aspectos de su industria camaronera. *In* Instituto Nacional de Pesca (editor), Simposio sobre Biología y Dinámica Poblacional de Camarones, p. 447-450. Memorias, Guaymas, Sonora.

HUFF, J. A., AND S. P. COBB.
1979. Penaeoid and Sergestoid shrimps (Crustacea: Decapoda). Mem. Hourglass Cruise, Fla. Dep. Nat. Resour., Mar. Res. Lab. 5(4):1-102.

KENNEDY, F. S., J. J. CRANE, R. A. SCHLIEDER, AND D. G. BARBER.
1977. Studies of the rock shrimp, *Sicyonia brevirostris,* a new fishery resource on Florida's Atlantic shelf. Fla. Mar. Res. Publ. 27, 69 p.

KLIMA, E. F.
1981. The national marine fisheries research program in the Gulf of México. Kuwait Bull. Mar. Sci. 2:325-409.

LLUCH-BELDA, D.
1974. La pesquería de camarón de alta mar en el noroeste: un análisis biológico/pesquero. Secretaría de Industria y Comercio. Subsecretaría de Pesca. Inst. Nac. Pesca Ser. Inf. i 16, 76 p.

LOCKINGTON, W. N.
1879. Notes on Pacific coast Crustacea. Bull. Essex Inst. 10:159-165.

MATHEWS, C. P.
1981. A review of the North American penaeid fisheries with particular reference to México. Kuwait Bull. Mar. Sci. 2:325-409.

MEARNS, A. J., AND C. S. GREENE.
1974. A comparative trawl survey of three areas of heavy waste discharge. South. Calif. Coastal Water Res. Proj. Annu. Rep. TM 215, 76 p.

PAUL, R. K. G.
1981. The development of a fishery for Portunid crabs of the genus *Callinectes* (Decapoda, Brachyura) in Sinaloa, México. Tech. Rep. Overseas Dev. Admin., Lond., 78 p.

PAUL, R. K. G., AND M. E. HENDRICKX.
1980. Crustaceans in the shrimp by-catch off the coast of Sinaloa and Nayarit, México. Bull. South. Calif. Acad. Sci. 79:109-111.

PÉREZ FARFANTE, I.
1980. A new species of rock shrimp of the genus *Sicyonia* (Penaeoidea), with a key to the Western Atlantic species. Proc. Biol. Soc. Wash. 93:771-780.

RODRÍGUEZ DE LA CRUZ, M. C.
1981a. Estado actual de la pesquería de camarón en el Pacífico mexicano. Cienc. Pesq. 1(1):53-60.
1981b. Aspectos pesqueros del camarón de alta mar en el Pacífico mexicano. Cienc. Pesq. 1(2):1-19.

SOKAL, R. R., AND F. J. ROHLF.
1969. Biometry. W. H. Freeman, San Francisco, 776 p.

SOTO, L. A.
1980. Decapod crustacea shelf-fauna of the northeastern Gulf of Mexico. An. Cent. Cienc. Mar Limnol., Univ. Nac. Autón. Méx. 7(2):79-109.

WENNER, E. L., AND T. H. READ.
1982. Seasonal composition and abundance of decapod crustacean assemblages from the South Atlantic Bight, USA. Bull. Mar. Sci. 32:181-206.

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