Stone Crabbing in Belize: Profile of a Developing Fishery and Comparison With the Florida Stone Crab Fishery

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ABSTRACT

Belize fishermen have traditionally harvested stone crabs (*Menippe mercenaria)* for local consumption as a by-catch of the spiny lobster fishery. Although catch rates can be equivalent to those in some areas of Florida where stone crabbing is commercially profitable, stone crabs have not been targeted as a commercial species in Belize. Increases in dockside price, greater export potential resulting from better marketing connections, and a desire of some fishermen to harvest stone crabs during the closed lobster season have stimulated recent interest in the development of a Belize stone crab fishery.

In March, 1988, we surveyed the stone crab fishery in Belize. We documented the stone crab catch at two different sites (Hick's Cay; Stone Crab Point), experimented with bait treatments and types of traps, collected samples for genetic stock identification, surveyed the habitat in areas fished for stone crabs, and interviewed industry representatives. Catch per unit effort varied between sites and bait treatments, and among trap types. Highest catch per unit effort, obtained in baited Florida-style stone crab traps, was comparable to that of productive areas of Florida. Mean size of captured crabs was largest in Florida-style traps. Baited traps captured 2.5-5.5 times more stone crabs than did unbaited traps. Further, baiting traps significantly reduced the incidence of lobster by-catch. Ample habitat apparently suitable for stone crabs exists, but the habitat surveyed in the area with highest catch per unit effort (Hick's Cay) did not appear suitable for stone crabs. Apparent differences in electromorph frequencies and, possibly, habitat usage suggest that Belize stone crabs may be genetically distinct from Florida stone crabs.

INTRODUCTION

The Florida stone crab (*Menippe* spp.) fishery supplies an economically important and highly popular seafood product (stone crab claws) to Florida markets and speciality markets throughout the United States. The Florida stone crab fishery ranks eighth in the state in dockside value and, until recently, produced essentially the entire supply of commercially marketed stone crab claws (Adams and Prochaska, in press). Both annual landings and effort generally increased through the early history of the Florida stone crab fishery. However, with the exception of two years of unusually high production (1981, 1982), annual landings have fluctuated around two million pounds for the past 10 years, despite increases in effort. Annual catch per unit effort stabilized at about 6 pounds of claws per trap from 1974 through 1982, but declined to an average of approximately 5 pounds per trap from 1983 through 1987.

The continually escalating demand for stone crab claws and the well-developed Florida market have prompted industry producers, interested in augmenting their annual harvests, and wholesalers, attempting to fill market demands during the closed summer season, to seek stone crab claws from other regions in the United States and from other countries. Fishermen from the Florida Keys have traveled as far as the Bahamas to harvest stone crab claws (G. Graves, Keys Fisheries, Marathon FL, pers. comm.), and stone crab claws have been imported from both Texas (Adams and Prochaska, in press) and Belize (Bert and Hochberg, 1988).

In Belize, stone crabs have traditionally been a by-catch of the large and well-developed spiny lobster (*Panulirus argus*) fishery (Northern Fishermen Cooperative Society, Ltd. (NFCSL), 1986). Stone crabs have not been targeted for harvest because market value has been comparatively low (*e.g.*, dockside price, $3.75 U.S./lb for stone crab claws vs. $9.25 U.S./lb for spiny lobster in 1987; NFCSL, 1987). Fishermen who harvested stone crabs usually sold them directly to local markets or friends, or kept them for personal consumption. Interest in importing Belize stone crab claws to the United States has generated cooperative efforts between Belize industry representatives and south Florida wholesalers to develop a directed Belize stone crab fishery. One such effort involved a joint endeavor between a north central Belize fishing cooperative and a Florida corporation involved in marketing stone crab claws. The two businesses worked together to elevate fishing cooperative dockside prices for stone crab claws so that exporting claws through the cooperative would be more financially attractive to fishermen, and to implement good harvesting and processing techniques to assure a high quality product. Good preliminary progress was made in all aspects of developing the north central Belize stone crab fishery (Bert and Hochberg, 1988).

Appropriately, the two businesses then realized the need for assessing the potential of the fishery for further development. To this end, we were invited to Belize to survey the country's north central stone crab fishing grounds, obtain an understanding of Belize stone crab fishing practices and the fishing industry, and identify research necessary to determine the potential for continued development and expansion of the Belize stone crab fishery. We here define the catch during March in north central Belize, compare certain characteristics of the catch with those available for various Florida stone crab fisheries, describe practices of the Belize stone crab fishery and compare those with Florida practices, and outline management considerations for monitoring the growth of the Belize stone crab fishery.

METHODS

Our program included the following:

1. Field sampling of catch in traps
2. Electrophoretic analysis of crabs for comparison of allozyme frequencies in Belize to those of stone crabs in the continental USA and Bahamas
3. Habitat surveys in areas where trapping is conducted by local fishermen
4. Interviews with northern fishermen cooperative society members and tours of fishery operations

Our study was conducted during March, 1988.

Traps were deployed at two locations in north central Belize (Figure 1). Eleven traps formed a single line at the Stone Crab Point site and 81 traps were arrayed in 4 lines of 28-21 traps each at the Hick's Cay sites. Traps in both areas were placed at approximately 75 m intervals. Sampling intervals varied, as did types of bait and types of traps used. Belize-style stone crab traps, constructed similarly to Florida-style stone crab traps (Figure 2) except for details (discussed later), were used exclusively at Stone Crab Point. Belize-style stone crab traps, Florida-style stone crab traps, and Red Lobster lobster traps, which were larger than the stone crab traps, cylindrical, and constructed of plastic, were used at Hick's Cay. Traps at Stone Crab Point were baited with mullet and shad; some traps at Hick's Cay were baited with shark and some were not baited. We collected an array of biological and morphological information from each crab captured (Table 1) and noted by-catch (organisms other than stone crabs) in traps.

Stone crabs to be used for electrophoretic analysis were collected from traps at the Hick's Cay sites (Figure 1) and transported alive to the Florida Marine Research Institute for dissection and analysis of tissues. Electrophoretic procedures followed Bert (1986). Twenty stone crabs from Belize, 5 *M. mercenaria* from the Florida Keys, and 5 *M. adina* from Texas were analyzed for variation in 23 proteins used by Bert (1986). The Texas and Florida Keys samples served as standards for comparison of Belize stone crab allozyme banding patterns with the two species found in the Gulf of Mexico. Belize stone crabs phenotypically resembled *M. mercenaria* and were presumed to be that species. Allele frequencies at polymorphic loci were tested for significant differences between the Belize sample and continental USA *M. mercenaria*, and between the Belize sample and a *M. mercenaria* sample from the Bahamas (Chi-square or G test). Genetic distances were calculated among continental USA *M. mercenaris*, continental USA *M. adina*, Bahamas *M. mercenaria*, and the Belize sample using the method of Nei (1972). Allele frequency values for

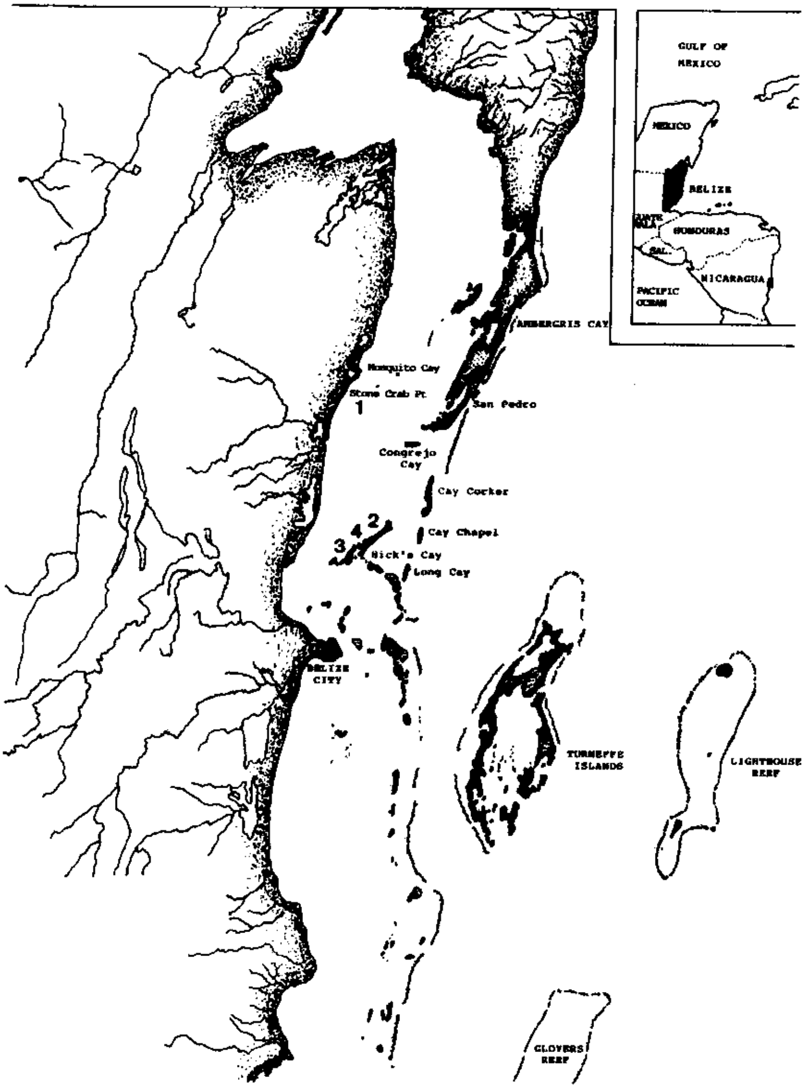

Figure 1. Location of sampling sites for stone crabs in Belize, C.A. Traps were sampled east of Stone Crab Point (1) and west of Hick's Cay (2-4) during March, 1988. Semi-quantitative, *in situ* (snorkeling) habitat surveys were made at all Hick's Cay sites. Stone crabs for electrophoresis were collected from all Hick's Cay sites.

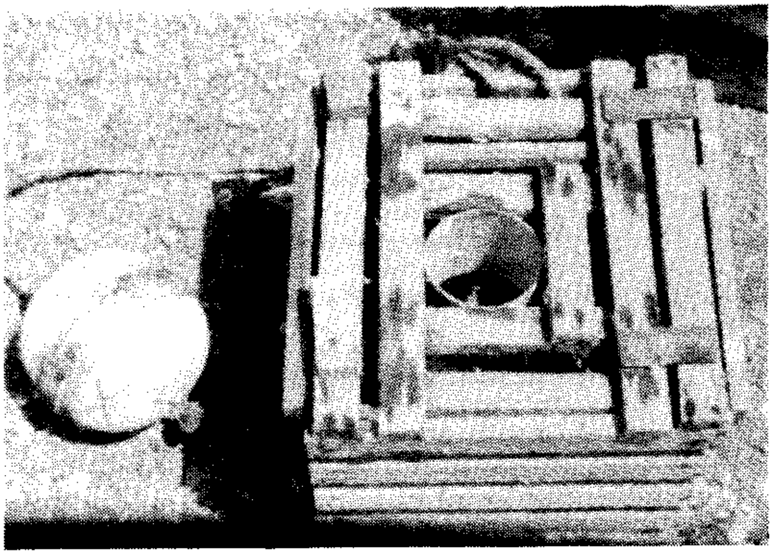

Figure 2a. Florida-style wooden stone crab trap.

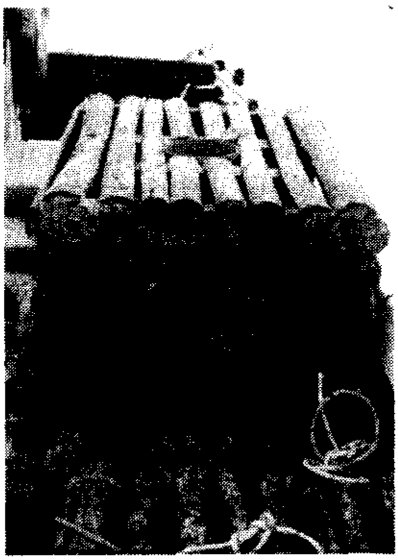

Figure 2b. Belize-style wooden stone crab trap.

Table 1. Outline of biological and morphological variables recorded on stone crabs captured in this study.

- I. Biological Data
  - A. Sex
  - B. Reproductive state
  - C. Exoskeleton condition
  - D. Degree of fouling
  - E. Principal fouling organism
  - F. Injuries
  - G. Claw type (each claw)
- II. Morphometric Data
  - A. Propodus (claw) length
  - B. Carapace width
  - C. Carapace length

continental USA *M. mercenaria* and *M. adina*, and Bahamas *M. mercenaria*, were drawn from Bert (1986). Values for continental USA *M. mercenaria* were obtained by averaging values from Bert's four south Florida sites (TAM, BAY, KEY, BIS); values for *M. adina* were averaged from her northern and western Gulf of Mexico sites (FUL, GRI, OCS).

We performed both aerial and *in situ* habitat surveys. The objective of the aerial surveys was to obtain an overview of the regional ecosystem and identify areas that might serve as stone crab nursery grounds or areas of high densities of adults. We logged approximately 60 min of aerial survey time from altitudes ranging between approximately 200 and 1000 m. Generally north-south transects extending from the latitude of Belize City to the latitude of Mosquito Cay, and ranging from the mainland shore to the barrier reef (Figure 1) were inspected for water clarity, topography, and bottom type. *In situ* (snorkeling) surveys were conducted at the Hick's Cay sites, the region of most local stone crab commercial fishing activity, and observations from the boat were made at Stone Crab Point. We logged 60 min of *in situ* survey time and observed approximately 6500 m^2 of benthic habitat.

To understand the mode of operations of the local fishing industry, we toured two processing houses, one in Belize City and one on Cay Corker, and interviewed 20 fishermen, processors, and wholesalers. We discussed a broad array of topics related to the Belize and Florida stohe crab fisheries, including: fishing practices, fisheries management regulations, organization of fishery operations, and stone crab biology and ecology. We spent approximately 16 hours in discussions with local and regional industry representatives.

RESULTS

Composition of Catch in Traps

Because sampling was confined to a single month, it is possible that our data may not be wholly representative of catch rates or catch composition. However, long-term trapping studies conducted in Florida (Bender, 1971; Sullivan, 1979; Bert *et al.*, 1986; T.M. Bert and R.J. Hochberg, Florida Marine Research Institute, St. Petersburg, FL, unpubl. data) have shown that large samples, such as that collected in this study, accurately represent the characteristics of the catch for that month (or season).

Population Structure of Trapped Crabs

Catch per unit effort (CPUE) ranged from less than 0.1 to nearly 2 stone crabs per trap per day. Baited traps captured 2.5-5.5 times more stone crabs than did unbaited traps, regardless of the type of trap used (although sample sizes were small for Red Lobster ® and Florida-style traps; Table 2). Although traps at Stone Crab Point were baited, CPUE was very low compared there, compared to that at Hick's Cay.

Average size (carapace width, CW) of stone crabs captured varied between areas and among trap types (Figure 3). Mean size of males captured in each type of trap at Hick's Cay was larger than mean size of males captured at Stone Crab Point. Mean size of females captured in Florida-style traps was larger than mean size of females captured in Belize-style and Red Lobster® traps (t test, $p = .057$). In general, large males and small females were captured in Belize-style and Red Lobster® traps and large crabs of both sexes were captured in Florida-style traps. Baiting traps had no notable effects on size of crabs captured.

Nearly 70% of the stone crabs captured had at least one claw that met Florida minimum legal size requirements (70 mm propodus length), and more than half of the crabs bearing legal-sized claws had two legal-sized claws (Table 3). Approximately 45% of the crabs trapped ($N = 127$) were females. Thirty-five percent of the females captured were ovigerous. Average size of ovigerous females (85.5 mm CW; s.d., 8.9 mm CW) did not differ from that of non-ovigerous females (88.3 mm CW; s.d., 19.7 mm CW), but the size range of ovigerous females (73.1-101.4 mm CW) was more restricted than that of non-ovigerous females (31.8-123.5 mm CW). No females greater than 101 mm CW ($N = 6$) were carrying eggs; in contrast, 40% of females 101 mm CW or less ($N = 51$) were ovigerous. These size-specific differences in egg bearing were highly significant (t test, $p < 0.01$).

Effects of Trap Baiting on Lobster By-Catch

Baiting the traps significantly reduced lobster by-catch (Table 4); the proportion of unbaited traps that contained spiny lobsters was significantly

Table 2. Catch of stone crabs per trap per day (CPUE) in two areas of Belize (SCP: Stone Crab Point; HKC: Hick's Cay; see Figure I for locations). Belize-style stone crab traps were used at the Stone Crab Point site, and three types of traps were used at the Hick's Cay sites (Bel: wooden Belize-style stone crab traps; RLob: plastic Red Lobster® lobster traps; Fla: wooden Florida-style stone crab traps). Traps at the Stone Crab Point site were baited with mullet heads and shad (Y). At the Hick's Cay sites, some traps were baited with shark (Y), and some were not baited (N).

Area	Trap Type	Bait Treatment	Number of Traps	CPUE
SCP	Bel	Y	11	0.08
HKC	Bel	N	91	0.20
	Bel	Y	15	0.49
	RLob	N	3	0.67
	RLob	Y	1	I.67
	Fla	N	2	0.33
	Fla	Y	2	I.83

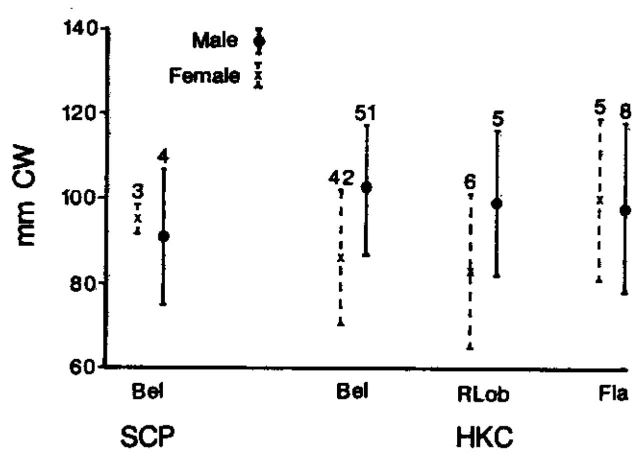

Figure 3. Mean size of stone crabs captured at two sites in Belize. SCP = Stone Crab Point; HKC = Hick's Cay. Three types of traps were deployed at Hick's Cay. Bel = Belize-style stone crab traps; RLob = Red Lobster® lobster traps; Fla = Florida-style stone crab traps. CW = carapace width. Numbers above bars show sample sizes.

Table 3. Proportion of crabs with claws meeting minimum legal size requirement of Florida (70 mm propodus length). Legal: crabs large enough to bear legal-sized claws (males, ≥78 mm CW; females, ≥87 mm CW; Bert *et al.*, 1986); sublegal: males <78 mm CW; females <87 mm CW.

Legal-Sized Claws/Crab	% Total Crabs (N=127)
0	31%
1	31%
2	38

Table 4. Effects of baited traps on lobster by-catch in stone crab traps in Belize. N: no bait; Y: baited.

Treatment	Number Traps	%Traps w/Lobsters	Average # Lobsters/Trap [1]
N	103	16	3.24
Y	18	6	1.00

[1] Calculated using only traps tht contained lobsters.

higher than that of baited traps (t test, $p < 0.05$). Fifty-four spiny lobsters were captured in traps that were unbaited; in contrast, only one spiny lobster was captured in a baited trap (Belize-style trap). Belize-style traps containing spiny lobsters (N = 14) averaged 3.2 lobsters per trap; Red Lobster® traps containing spiny lobsters (N = 2) averaged 4.5 lobsters per trap. No Florida-style traps (N = 4) captured spiny lobsters. Average size of trapped spiny lobsters was 64.5 mm carapace length (CL) and did not vary among trap types; only three lobsters captured met Florida minimum legal-size requirements (76 mm CL).

Genetic Characterization

All polymorphic loci in the Belize sample were in Hardy-Weinberg equilibrium. Allele frequencies (Table 5) and genetic distance values (Table 6) confirmed that the north-central Belize population was of the species *M. mercenaria*. Significant differences in allele frequencies were seen between the Belize sample and other *M. mercenaria* populations at the Ao-3 and Xdh loci (G test for independence, $p < 0.05$). The Bahamas sample differed significantly from other *M. mercenaria* populations at the Acp-3 and Pgm loci (G test for independence, $p < 0.05$).

Table 5. Allele frequencies for polymorphic and diagnostic loci for Belize (BZE), continental U.S.A. *(M. mer.)*, and Bahamas (BMS) *Menippe mercenaria*, and for *M. adina* (M.ad.). Continental U.S.A. *M. mercenaria* and *M. adina* values were obtained from Bert (1986). See text for further explanation. n = number of alleles (2 x number of individuals).

Locus	Alleles/ SampleSize	Population			
		BZE	M.mer.	BMS	M.ad.
Acp-2	100	0.917	0.979	0.854	0.958
	97	--	--	0.042	--
	102	0.083	0.021	0.104	0.042
	n	36	108	48	162
Acp-3	100	0.975	0.957	0.764	0.042
	102	--	0.005	0.008	--
	97	0.025	0.002	0.025	0.003
	98	--	--	--	0.023
	101	--	0.036	0.203	0.932
	n	40	390	118	374
Ald	100	1.000	1.000	1.000	1.000
	99	--	--	--	--
	n	40	134	98	138
Alp-1	100	1.000	0.991	0.904	0.835
	103	--	--	0.096	0.165
	95	--	0.003	--	--
	n	24	166	104	224
Alp-2	100	0.917	0.992	1.000	0.031
	110	0.085	0.005	--	0.969
	95	--	0.003	--	--
	n	12	268	108	332
Alp-3	100	0.572	0.548	0.360	0.587
	103	0.214	0.344	0.340	0.227
	106	0.214	0.108	0.260	0.186
	109	--	--	0.040	--
	n	14	196	50	192
Ao-3	100	0.225	0.957	0.911	0.923
	102	0.275	0.043	0.089	0.044
	98	0.450	--	--	0.033
	106	0.050	--	--	--
	n	40	352	56	294

Table 5 (continued).

Locus	Alleles/ SampleSize	BZE	Population M.mer.	BMS	M.ad.
Est-6	100	1.000	1.000	1.000	0.979
	98	--	--	--	0.021
	n	40	228	112	144
Got -1	100	1.000	0.997	1.000	0.994
	105	--	0.003	--	0.004
	95	--	--	--	0.002
	n	40	474	118	372
Got-2	100	1.000	0.998	1.000	0.996
	95	--	0.002	--	--
	105	--	--	--	0.004
	n	40	394	114	370
Hk	100	1.000	1.000	1.000	1.000
	96	--	--	--	--
	n	40	212	100	138
Idh-1	100	1.000	1.000	1.000	1.000
	95	--	0.006	--	0.012
	105	--	0.004	--	0.002
	n	36	182	56	362
Idh-2	100	0.605	0.572	0.564	0.970
	102	0.395	0.428	0.436	0.030
	n	38	388	110	362
Lap-1	100	1.000	0.980	0.991	0.986
	98	--	0.020	--	0.014
	102	--	--	0.009	--
	n	14	244	110	354
Lap-3	100	1.000	0.982	0.857	0.956
	102	--	--	0.009	--
	n	20	196	56	210
Ldh	100	1.000	1.000	1.000	1.000
	n	32	236	92	132
Mdh-1	100	1.000	1.000	1.000	1.000
	n	40	236	118	377

Table 5 (continued).

Locus	Alleles/ Sample Size	BZE	M.mer.	Population BMS	M.ad.
Mdh-2	100	1.000	1.000	1.000	0.997
	105	--	--	--	0.003
	n	40	236	114	370
6-Pgd	100	1.000	1.000	0.987	0.995
	95	--	--	--	0.005
	105	--	--	0.013	--
	n	40	180	78	156
Pgi	100	1.000	0.988	1.000	0.995
	95	--	0.003	--	--
	105	--	0.009	--	0.005
	n	32	388	112	368
Pgn	100	1.000	0.962	0.807	0.887
	102	--	0.038	0.184	0.110
	98	--	--	0.009	0.003
	n	38	390	114	368
Sod[1]	100	0.975	0.962	--	0.021
	115	0.025	0.038	--	0.079
	n	40	390	--	348
Xdh	100	0.429	0.277	0.234	--
	103	0.250	0.453	0.208	--
	106	0.321	0.270	0.208	--
	98	--	--	--	0.300
	96	--	--	--	0.357
	94	--	--	--	0.343
	n	28	248	106	70

[1] BMS is a fixed heterozygote and deemed uninterpretable. This locus was omitted from genetic distance calculations.

Habitat Surveys

Although inhibited by inclement weather, we obtained, through aerial surveys, a general idea of the habitat between the mainland and barrier reef and some understanding of the habitat at the two sampling sites. The habitat near the Belize mainland superficially resembled certain areas of Florida Bay where high densities of *M. mercenaria* are found. During windy weather, nearshore waters

Table 6. Genetic distances (Nei, 1972) between pairwise combinations of populations of Belize (BZE), Bahamas (BMS), and south Florida (*M.mer.*) *Menippe mercenaria* and *M. adina* (*M. ad.*). Values were calculated using allele frequencies listed in Table 5.

	BZE	M. mer.	BMS	M. ad.
BZE	—	0.002	0.008	0.121
M. mer.		—	0.007	0.127
BMS			—	0.118

in the vicinity of the mainland were turbid and visibility was limited. Sediments in the vicinity of Stone Crab Point were unconsolidated, composed of a mixture of marine and terrigenous fine-grained sandy muds, and subject to wind-generated transport. Farther offshore, the water was turbid to clear, apparently depending on direction and velocity of sustained winds. West of Hick's Cay, the sediment was unconsolidated, fine-grained, calcareous mud. Seagrasses were sparsely distributed in this area, and there was evidence of a high density of burrowing organisms. No stone crabs were found during *in situ* surveys of Hick's Cay, nor was evidence found of local habitation by stone crabs. Indeed, the habitat in the crabbing grounds at Hick's Cay appeared quite unsuitable for occupancy by *M. mercenaria*, according to descriptions of preferred stone crab habitat known for Florida *M. mercenaria* (Bender, 1971; Bert, 1985 a, 1985 b).

Belize Stone Crab Fishery Practices

Because, historically, stone crabs have been an incidental by-catch of the Belize spiny lobster fishery, they have been captured in Belize-style, open-ended spiny lobster traps. Recently, some Belize fishermen, using the closed wooden Florida stone crab trap as a model, constructed stone crab traps from the types of wood used locally to build Belize-style spiny lobster traps. The Belize-style stone crab trap closely resembles the wooden Florida-style trap in size [16 in x 16 in x 14 in (41 cm x 41 cm x 36 cm)] and construction, except that the average width of the gaps between the wooden slats forming the walls and lid of the Belize trap (mean = 19.7 mm; range, 16-24 mm; N = 11 measurements) is approximately 50% larger than that of the Florida-style trap (mean = 13.0 mm; range, 7-19 mm; N = 11 measurements). Small buoys are attached individually to each trap, and buoy lines are adjusted so that the buoys float at, or slightly below, the water surface. Belize fishermen do not bait their stone crab traps, and all experience at least some spiny lobster by-catch. Belize fishermen who use traps usually deploy a few hundred traps in fishing territories delineated by stakes placed in the water. A fisherman may have several territories, closely aggregated or widely dispersed. Belize fishermen generally service about 80 traps per day. Traps are usually serviced at 7-10 day intervals.

The only legal regulation on the Belize stone crab fishery is related to the size of claw harvested. Minimum legal size of stone crab claws in Belize is determined by weight [3 oz (412 g) claw], rather than by length (70 mm propodus length [PL], as in the United States. From field measurements of crabs bearing claws that were very near the Belize minimum legal weight limit, we estimated that the Belize minimum legal weight requirement is equivalent to a PL that is 2-3 mm larger than the Florida minimum length requirement. Although Belize has no seasonal restrictions on its stone crab fishery, fishermen have traditionally stopped crabbing during the closed spiny lobster season (March 15-July 15). Some local fishermen expressed interest in stone crabbing during the closed spiny lobster season, and a few were regularly servicing their stone crab traps during this season.

When interviewed, fishermen gave mixed opinions on the "best" fishing practices for the stone crab fishery, the amount and type of regulation needed for the fishery, and aspects of the biology and ecology of Belize stone crabs. Their general consensus concerning interest in developing the fishery was that a number of fishermen would enter the fishery if the price (dockside value) increased so that fishing for stone crabs was more financially competitive with fishing for spiny lobster. Fishing industry leaders were concerned principally with interactive effects of the developing stone crab fishery and well-established spiny lobster fishery (*e.g.*, poaching of the lobster by-catch in stone crab traps during the lobster closed season, and other potential problems associated with closing one trap fishery while leaving another open).

DISCUSSION

Characterization of the Belize Stone Crab Fishery

Characteristics of the Catch

Average number of stone crabs captured per trap per day at Hick's Cay in Belize compares favorably with numbers of crabs captured in Florida stone crab fisheries. Indeed, catch per unit effort in baited Florida traps at Hick's Cay was equal to, or better than, that of productive fishery areas in both southwest and northwest Florida (Bert *et al.*, 1986; Bert and Hochberg, unpubl. data). Average size of male stone crabs in Belize was significantly larger than those recorded for fished areas of southwest Florida (Sullivan, 1979; Bert *et al.*, 1986) and northwest Florida (Bert and Hochberg, unpubl. data) both during the month of March and throughout the year (t test, $p < 0.01$). Mean size of females in Belize was comparable to those obtained for Florida fisheries (Sullivan, 1979; Bert *et al.*, 1986; Bert and Hochberg, unpubl. data). Further, the proportion of stone crabs bearing two legal-sized claws at Hick's Cay was significantly higher than that of any area sampled by Bert and Hochberg (unpubl. data) in northwest

Florida (t test, $p = 0.05$), suggesting that commercial yield of claws per unit of effort is higher in Belize than in Florida. The comparatively large average sizes of stone crabs and high proportion of crabs with two harvestable claws in traps at Hick's Cay may be indicative of an area where the fishery is relatively new and undeveloped.

Sex ratio in Belize traps was very similar to that observed for the southwest Florida fishery in March (Bert *et al.*, 1986). Sex ratio of stone crabs in traps undergoes large seasonal shifts in Florida (Noe, 1967; Bender, 1971; Sullivan, 1979; Bert *et al.*, 1986; Bert and Hochberg, unpubl. data) associated with various reproductive activities, such as spawning, molting, and mating (Bert *et al.*, 1986). Similar seasonal shifts might be expected in Belize.

Spawning season for stone crabs begins progressively earlier as latitude decreases. Spawning season in Belize seems to fit that pattern. More than one-third of the captured females were carrying eggs. Approximately 5-11% of females in south Florida are ovigerous in March (Noe, 1967; Cheung, 1969; Sullivan, 1979; Bert *et al.*, 1986), and no ovigerous females were observed in northwest Florida during March (Bert and Hochberg, unpubl. data).

Stone crabs in north central Belize, and probably throughout the country, are genetically similar to south Florida stone crabs. Indeed, genetic distance values among *M. mercenaria* samples from Belize, Bahamas, and continental U.S.A. are no greater than those calculated among *M. mercenaria* populations from south Florida (Bert, 1985a). Either gene flow among Belize, Bahamas, and U.S.A. populations is sufficient to maintain genetic homogeneity or isolation among populations inhabiting these regions occurred too recently for a large number of genetic differences to accumulate.

Characteristics of the Industry

The current Belize stone crab fishery is small and localized; annual production levels are low (approximately 4000-5000 lb of claws in north central Belize in recent years; NFCSL, 1986, 1987) and could probably be increased. Adjusting local fishing practices could facilitate an increase in landings without the input of additional fishing effort. Stone crab fishing techniques and equipment used in Belize differ in several ways from those of Florida (*e.g.*, Belize: submerged buoys, no bait in traps, wide gaps between trap slats; Florida: surface buoys, baited traps, narrow gaps between trap slats). As with the emerging Belize stone crab fishery, the Florida stone crab fishery evolved from the spiny lobster fishery, and many lobster fishing practices were incorporated into the stone crab fishery. Eventually, Florida stone crabbing practices were modified to maximize the harvest/expense ratio. Harvest techniques still vary somewhat among fishermen and areas in Florida, but most fishermen have adopted the surface-buoyed, wooden slat trap, and virtually all fishermen bait their traps. Although limited, our data nevertheless suggest that the Florida-style trap captures more and larger crabs than either the Belize-style stone crab trap or the Red Lobster® spiny lobster trap, and that catch rates are highest when Florida-style traps are baited with a long-lasting bait (*e.g.*, shark). Belize stone crabbers could increase the yield from their traps if they baited the traps with a high-quality bait; greater increases in yield could result if the wooden slats used to construct the walls and lids of their traps were placed closer together.

Baiting traps has a highly desirable accessory benefit—significantly reducing the spiny lobster by-catch. In Belize, where the spiny lobster and stone crab fishing seasons are offset, baiting stone crab traps may be an effective way to reduce the potentially problematic lobster by-catch during the closed lobster season. Heatwole *et al.* (1988) demonstrated that baiting spiny lobster traps in south Florida significantly increased the catch of stone crabs and simultaneously decreased the lobster catch. Apparently, baiting any type of trap has this effect.

Development of the Belize Stone Crab Fishery

The potential for continued development and expansion of the Belize stone crab fishery seems to be good. The territory potentially available for stone crabbing in Belize is considerably greater than that presently fished. Whether a large-scale fishery can be developed in Belize depends on the productivity of unfished areas relative to the areas we sampled. If other areas in which catch rates approximate those of Hick's Cay can be located, the fishery could develop considerably beyond its present level. Whether the fishery could sustain itself depends upon certain biological and ecological characteristics of the local stone crab population.

At least two elements are required to sustain a vigorous stone crab fishery:

1. Good sources of juvenile recruitment with high rates of survivorship to adulthood, and;
2. Sufficient habitat to support large adult populations.

In Florida, productive stone crab fisheries are located in proximity to regions inhabited by a high proportion of females, and large numbers of small juveniles (Bert *et al.*, 1986; Bert and Hochberg, unpubl. data). The presence of these population constituents is apparently indicative of areas where females aggregate to spawn, relatively great numbers of larvae settle to metamorphose, and survival rates of juvenile crabs are high. Such areas can be geographically extensive, covering tens of square miles, and are clearly recognizable through trapping surveys. Stone crab catch rates are highest in, and surrounding, such areas. In Florida, these recruitment areas typically occur seaward of large, undisturbed estuarine drainage systems (*e.g.*, Wacasassa/Suwannee River, and Ten Thousand Islands regions). Certain areas of the nearshore Belize environment superficially appear to have the environmental characteristics associated with such stone crab recruitment grounds.

Adult stone crabs in southwest Florida are found in greatest densities in areas of seagrass (principally *Thalassia testudinum*) interspersed with rocky outcrop (Bert, 1985a). Our limited surveys were insufficient to determine whether suitable stone crab habitat is abundant in Belize, or whether their typical food, small and medium-sized mollusks (*e.g.*, conchs, scallops, clams), is common. Curiously, the habitat of the Hick's Cay fishing ground clearly would not be suitable Florida stone crab habitat, suggesting that Belize stone crabs occupy different habitat types than do Florida stone crabs. Areas of Florida Bay sampled by Bert *et al.* (1986: stations TKB, ASKI, BBK), where the habitat is similar to that of the Hick's Cay fishing ground, produced very low catch rates compared to those we recorded at Hick's Cay.

Further development of the Belize stone crab fishery also depends on economic incentive. Belize fishermen who use traps will need continued financial motivation to put forth the effort to fish for stone crabs. In the past, they have directed their efforts toward trap repair and replacement and boat maintenance during the closed spiny lobster season. During open spiny lobster season, the price differential between stone crab claws and lobster has continually relegated the stone crab fishery to its historic position as a spiny lobster by-catch fishery. Recent efforts to increase dockside price of stone crab claws have resulted in some fishing specifically for stone crabs. Continued effort directed toward harvesting stone crab claws at any time of year may increase only if dockside price for the product is more competitive with that of spiny lobster.

Monitoring Growth of the Belize Stone Crab Fishery

The growth and status of this fishery should be monitored to ensure that fisheries management agencies have appropriate information for regulating the fishery. The precision with which a fishery can be managed depends upon the detail of harvesting information available. Minimum information gathered should provide some value of catch per unit effort. To monitor the Belize stone crab fishery, at least the following information should be obtained:

1. Number of fishermen harvesting the resource
2. Number of traps in the fishery (or, preferably, number of trap-hauls)
3. Number of pounds landed
4. Areas fished

Preferably, numbers 1-3 would be collected by fishing area. If total number of traps used and total pounds landed are known, catch per unit effort can be calculated as pounds-per-trap for each season. Documenting the number of fishermen in the fishery gives an independent estimate of growth of the fishery.

More detailed information (*e.g.*, area-specific data) allows monitoring of the relative use and status of each fishing area.

Belize fisheries management groups are in a unique position regarding the Belize stone crab fishery. Rarely do management agencies have the opportunity to participate in the development and growth of a new fishery. With proper management, the Belize stone crab fishery could be developed to its fullest capacity and maintained as a viable and productive industry for many years.

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