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A FLORIDA SEA GRANT PUBLICATION June 1976 SUSF-SG-76-003

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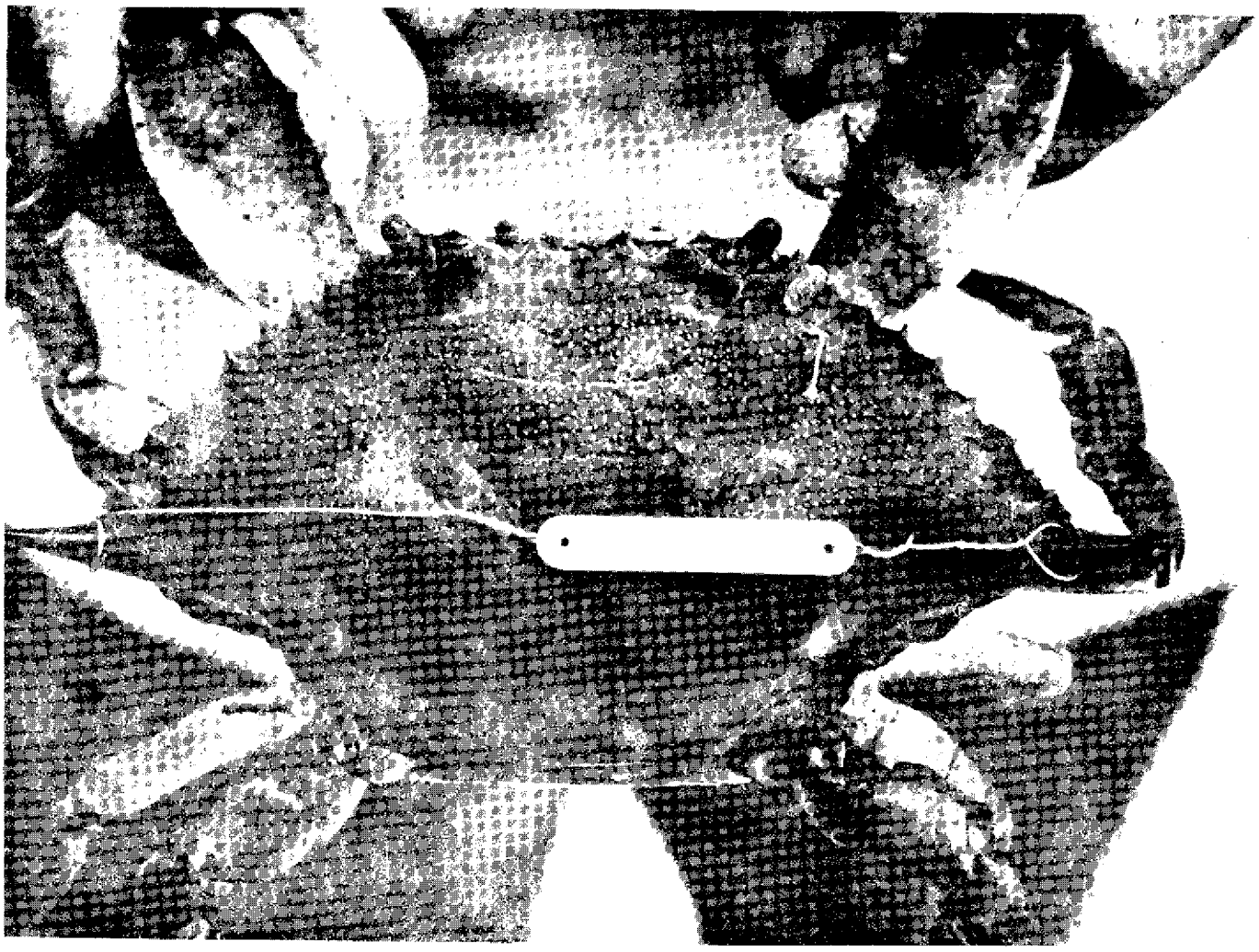
by Michael J. Oesterling



REPRODUCTION, GROWTH, AND MIGRATION OF BLUE CRABS ALONG FLORIDA'S GULF COAST

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A MARINE ADVISORY BULLETIN
IN COOPERATION WITH THE
SCHOOL OF FOREST RESOURCES AND CONSERVATION
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The blue crab, Callinectes sapidus Rathbun, is a common coastal inhabitant of Florida. The relative ease in which it may be captured and delicacy of the meat (Callinectes-beautiful swimmer; sapidus-savory) makes it a highly prized sport and commercial fisheries species. Dock-side values for crabs landed in Florida during 1973 and 1974 were $1.7 million and $2.2 million respectively (Fla. Dept. Nat. Res., 1974, 1975). Preliminary values for 1975 indicate a value of approximately $2.5 million (personal communication with Don Aska, Florida Marine Advisory Program).

Although the Florida blue crab industry is a multi-million dollar industry, relatively few studies have been conducted on the blue crab's life history in Florida waters (Futch, 1965; Tagatz, 1965, 1968a, 1968b). With the present concern over declining yields (Mahood et al., 1970; Tagatz, 1965), the need for studies dealing with the biology of the blue crab is evident.

A member of the family Portunidae, or swimming crabs, the blue crab ranges from Nova Scotia to northern Argentina, with introduced individuals reported from Europe and the Mediterranean Sea. Typically it is characterized as a coastal inhabitant ranging from the shoreline to approximately 90 meters of depth, but primarily found from shallow water to 35 meters of water. It can be found in fresh water, such as Florida's Salt Springs, to hypersaline lagoons, such as Laguna Madre de Tamaulipas, Mexico. Although considered a scavenger, its normal diet consists of a variety of materials, including fishes, bottom invertebrates, and plant matter. But, it is more characteristically an omnivore that prefers fresh to putrid flesh.

REPRODUCTION

The sex of a blue crab is easily recognized by the shape of the abdomen on the underside of the body. In the male, the abdomen is long and narrow, resembling an inverted T (Figure 1A). This shape persists throughout the male's life, from first crab stage until death. In the female, however, there are two different abdomen shapes, depending upon maturity. A juvenile female has a grayish-white triangular abdomen (Figure 1B). Adult females have a broadly rounded, or semi-circular, blue-green abdomen (Figure 1C).

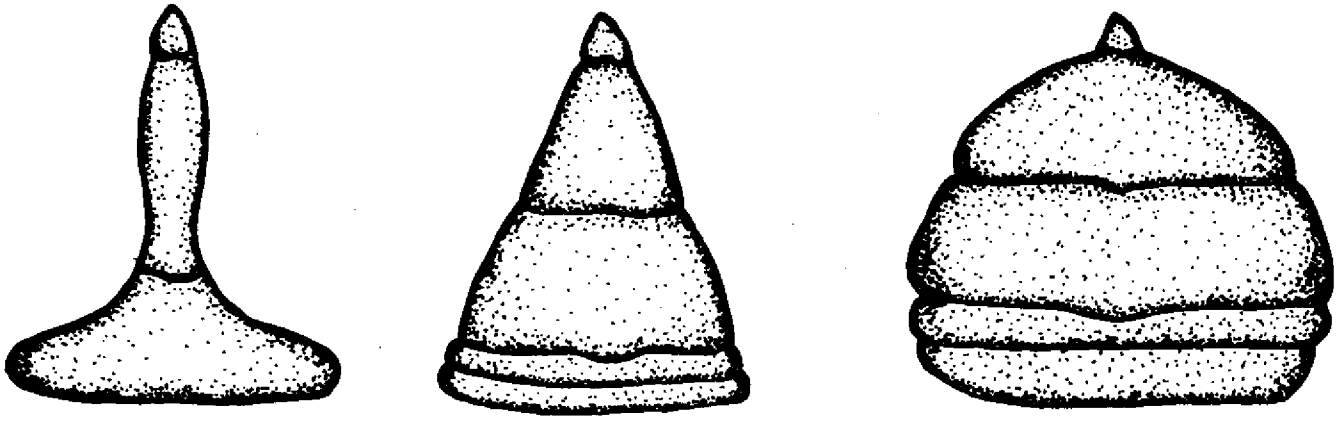


Figure 1. Abdomen shapes of blue crabs can be used to identify the sex of the crab. Figure 1A. is a male crab; this shape does not vary throughout life. Figures 1B. and 1C. are female crabs. Juvenile females (B.) have a triangular abdomen, while adult females (C.) have broadly rounded abdomens.

Female blue crabs obtain adult status at the same time they reach sexual maturity. At this transition time, the molt from juvenile to adult, mating must take place. Female blue crabs will mate only once in their lifetimes. Unlike the female, the male reaches sexual maturity before it is fully grown. A male may mate with more than on female and at any time during its last 3 growth stages.

Prior to the female's molt from juvenile to the adult, she will move to lower salinity waters, mir with a male and will be carried, or cradled, underneath the male. While in this cradling position, the female completes her final molt into the adult. At this time, while in the soft inter-molt stage, copulation (lasting several hours) takes place. The male transfers his sperm to the female, which she stores in seminal receptacles within her body. The sperm are able to live in this condition for about one year. Following copulation, the male will again cradle the female beneath him until her new shell hardens. Cradling of the female serves a two-fold purpose. Since the female mates but once in her life, cradling of the female assures that there will be a male present when she is able to copulate. When in the soft stage, the crab is extremely vulnerable to predators. Cradling thus also serves to shield the female until she once again has her hard protective shell. Once the female's new shell has hardened, the male will release her.

Spawning (laying of eggs) usually takes place one to nine months after mating; most spawning occurring in the spring and summer months. It is generally considered to occur in higher salinity waters at the mouths of estuaries and offshore areas. Egg laying itself is quite rapid and may be completed within two hours. Eggs are passed through the seminal receptacles to be fertilized on their way to the outside of the female. As the eggs pass out of the body, they are attached to the small appendages (swimmerets) of the female's abdomen. When first laid, the eggs are orange, but as they mature, they pass through a progression of color changes to yellow, brown, and finally dark brown.

At the time of spawning, the female blue crab puts out 700,000 to 2 million eggs. A very small number of these will live to become adults. Only about one ten-thousandth of one percent (0.000001) of the eggs will survive to become mature crabs (Van Engel, 1958). The eggs are carried 7 to 14 days, at which time they hatch into a planktonic zoea larval stage (Figure 2). The zoea are only about 1/25 of an inch long and, contrary to some folk-lore, do not devour their mother. Zoea stages (7 stages) persist for 31 to 49 days, depending upon the temperature and salinity. The zoea then metamorphose into a single megalops stage which has both planktonic and benthic (bottom) features (Figure 3). For 6 to 20 days the megalops stage persists, at which time it changes into the first crab stage; the point when the crab-form is first seen.

Larval (zoea) development takes place "offshore" in more saline waters than the confines of the estuary (Figure 4). The young crabs, however, spend the majority of their growing life within the nursery grounds of estuaries. During the megalops and first few crab stages, there is a movement shoreward toward the nursery grounds. It has been suggested that the megalops takes advantage of incoming tidal currents by rising into the water column during flood tide, settling and holding to the bottom during ebb tide, and thus eventually reaching the estuary.

GROWTH

Following the first crab stage, growth is rapid. The adult crab stage can be reached 12 to 18 months after egg hatching. After reaching the adult, blue crabs live about one year longer.

Due to the hard outer shell, size increases occur only when the crab molts. This process takes place much more frequently while the crab is small and periods between molts increase as the crab grows. Small crabs only 1/5 inch wide may molt every 3 to 5 days, crabs 1/2 to 1 inch every 10 to 15 days, and crabs greater than 4 inches wide may molt every 20 to 50 days (Van Engel, 1958). An interesting facet of blue crab growth is presented by the female blue crabs which complete their growth in size at the same time they become sexually mature and adults.

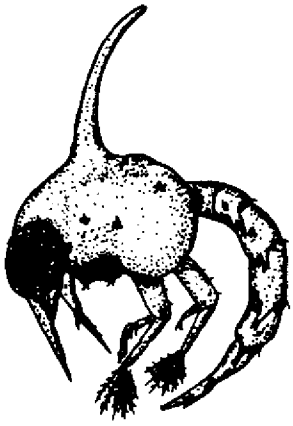


Figure 2. Zoea larval stage of the blue crab. There are 7 zoea stages persisting 31 to 49 days. (drawing after Costlow and Bookhout, 1959)

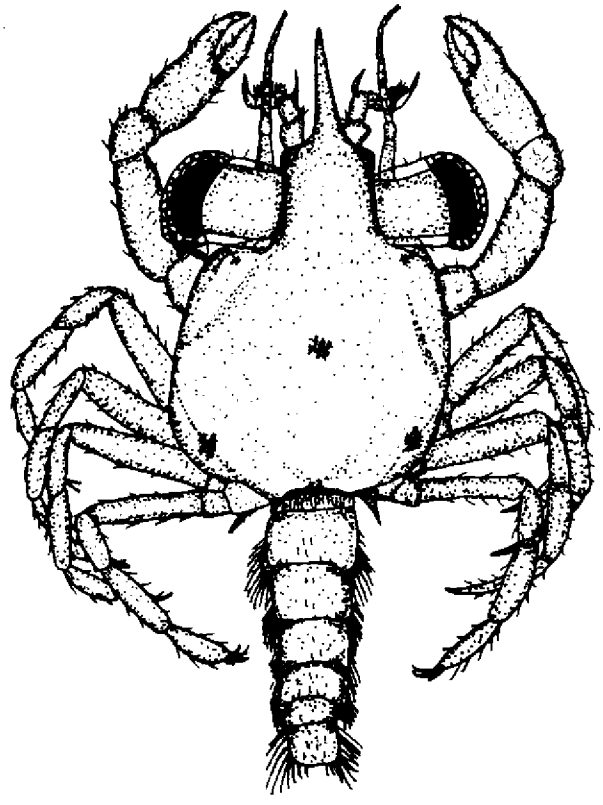


Figure 3. Megalops larval stage of the blue crab. There is a single megalops stage that lasts 6 to 20 days. (drawing after Costlow and Bookhout, 1959)

The actual process of molting and growth is fairly complex. Prior to shedding of the old shell, a new shell begins forming underneath the old. As the new shell develops, there are visual indications that can be used to predict when a crab will shed. Along the outside edges of the broadened swimming legs, fine lines can be seen beneath the old shell. There are successive color changes in this line as the time for molting approaches. A white line indicates molting will occur in one or two weeks; a pink line means that molting will take place in 3 to 6 days; and a red line crab (a peeler) will molt in 1 to 3 days.

With the time of molting approaching, the crab resorbs some carbohydrates, proteins, and calcium from the old shell. These are stored within the body for reuse and to help form the new shell. Muscle attachments to the old shell are loosened and re-attached to the forming shell. Since even the old stomach lining will be lost, all feeding ceases. Finally the old shell will split open along pre-determined fracture lines and the crab will simply back out of the old shell. At this time the crab

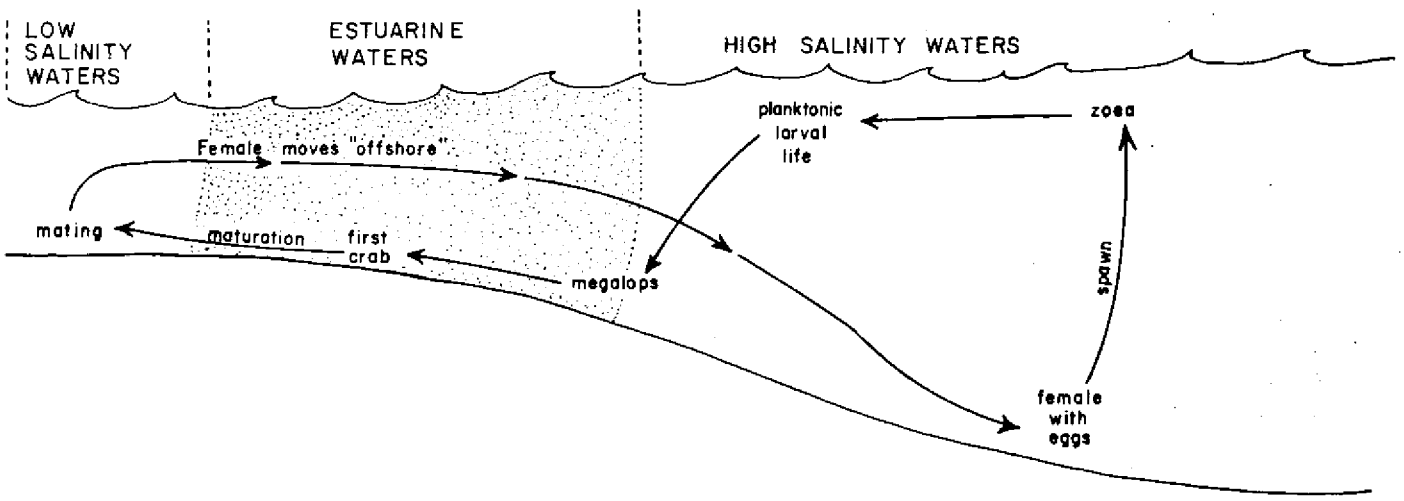


Figure 4. Stylized life cycle of a blue crab.

is very soft and defenseless. For this reason molting takes place in hiding. Just before and immediately after molting, large quantities of water are absorbed by the crab. This aids in the expansion of the new shell to a larger size than the old shell. The amount of size increase is probably controlled both genetically and by the environmental conditions. Greater size increases are usually associated with lower salinity waters. Finally, after about 3 days, the new shell is completely hardened. Since there are varying intervals between molts, depending on the size of the crab, the times presented above would, of course, also vary with size, smaller crabs taking less and larger crabs longer times.

MIGRATION

Movements in blue crab populations have been well documented by previous studies (Cargo, 1958; Darnell, 1959; Fischler and Walburg, 1962; Judy and Dudley, 1970; Tagatz, 1968a; Van Engel, 1958). These are not full population migrations, but are made up of the female component of the population only. Female blue crabs have been found to have a definite migrational pattern related to their life cycle stage. Just before their last juvenile molt into the adult, female blue crabs move into the lower salinity waters (shoreward and into creeks and marshes). At this time they pair with a male for mating. While the female is in the soft stage, just after the final molt, copulation takes place. The male then releases the female following the hardening of the female's new shell. When released, the females begin to move to higher salinity waters "offshore" for spawning (Figure 4). The net result is a latitudinal movement onshore/offshore. This would tend to keep crabs from one estuarine system from mixing with those of adjacent systems.

Although this pattern may hold true for the regions in which it was described, this appears not to be the case for populations of blue crabs along Florida's Gulf coast. The basic pattern of mating in lower salinities and spawning in higher salinities still applies, but the classic onshore/offshore latitudinal movement does not. Instead, there is an onshore/along-shore type movement, where, following mating, females move along-shore to specific spawning areas.

RESEARCH

A study to determine the Gulf coast migrational patterns of marketable-sized Florida blue crabs, to determine the source areas for the Gulf fisheries, and to provide basic population data for future management programs was conducted using a tag-recapture program.

Basically, the tag-recapture program entailed tagging a crab and releasing it in the hopes that it would be recaptured at some future date. Sites chosen along the Gulf coast as release points corresponded to major blue crab fisheries. These sites were, from south to north along the coast: Chokoloskee Bay; Fort Myers; Punta Gorda; New Port Richey; Crystal River; Horseshoe Beach; Steinhatchee; Keaton Beach; Panacea; and Apalachicola (Figure 5). Arrangements were made at each site to purchase 500-600 live blue crabs from either a local processing house or individual crabber with the stipulations that the crabs were caught in the immediate vicinity and immediately preceeding the scheduled tagging. On the day of the tagging, crabs were obtained as soon after their initial capture as possible, thus assuring healthy, lively crabs. Crabs were then tagged with a dorsal carapace tag (Figure 6). Each tag included a sequence number, the address and telephone number to contact upon recapture, and what data were requested concerning the recapture (date, site, etc.). Data recorded for each crab included the tag number, sex, carapace width (mm) measured dorsally from lateral spine to lateral spine, and general condition (missing limbs, etc.). Crabs were then released in the same general area

of capture, but at a distance from existing traplines to assure adequate mixing with the untagged population and to avoid excessive immediate recaptures.

All taggings were conducted in the months from September through March. It appears that the greatest portion of the female migration takes place during this time. In a preliminary study (Oesterling, unpublished data), taggings were conducted throughout all 12 months of the year. During the warmest months (May through August) there were no long distance movements observed. Therefore, to focus our efforts on the most productive periods, taggings were only conducted in the fall/winter/early spring period.

Besides the actual field work, an extensive public notification program was conducted. Notices of the project, its purpose, and what to do with a tagged crab, were sent to licensed commercial crabbers, processing houses, Marine Patrol agents, local newspapers, and the scientific community along the Gulf coast. Although there was no reward offered for the return of a tagged crab, there was excellent cooperation from the commercial interests along the Gulf coast, with 87% of all returns coming from the commercial community. Persons or agencies submitting return data were individually acknowledged with a letter describing the program and the tagging history of the captured crab.

RESULTS

During the period of time from November, 1974, through December, 1975, 16 blue crab taggings were conducted at 10 different sites along Florida's Gulf coast. There was a total of 6287 crabs tagged and released, 3231 (51.4%)males and 3056 (48.6%) females (Table 1). Recaptured crabs numbered 675, all but 6 of which had complete, usable data. Of the returns, 349 (51%) were females, and 326 (48.3%) were males. This was for a return rate of 10.7%. These numbers of themselves do not convey any idea as to the migrational patterns that may have been observed. However, there were several notable returns and, more importantly, trends. By and large, females traveled the greatest distance. This is consistent with previous studies. Females ranged as far as 297 miles from the release point (Table 2). In fact, 9 females moved over 200 miles or more. In contrast, 95% (308) of the males recaptured were returned from within 11 miles of the release site (Table 2). Although one male crab did travel 132 miles, this was an exception rather than the rule. The greatest time periods that crabs have spent from tagging until recapture were 205 and 245 days, both were male crabs. In the case of the crab that was captured 245 days after tagging, it was recaptured within 1 mile of the release site (Apalachicola). Once again this conforms to previous studies stating that males do not migrate significantly. The most notable trend was the direction of the females' movement. All non-local movement was in a northerly direction along the peninsular portion of the State and westerly along the panhandle. This trend is represented graphically in Figures 7 through 15. These maps depict the release sites and capture sites for tag returns.

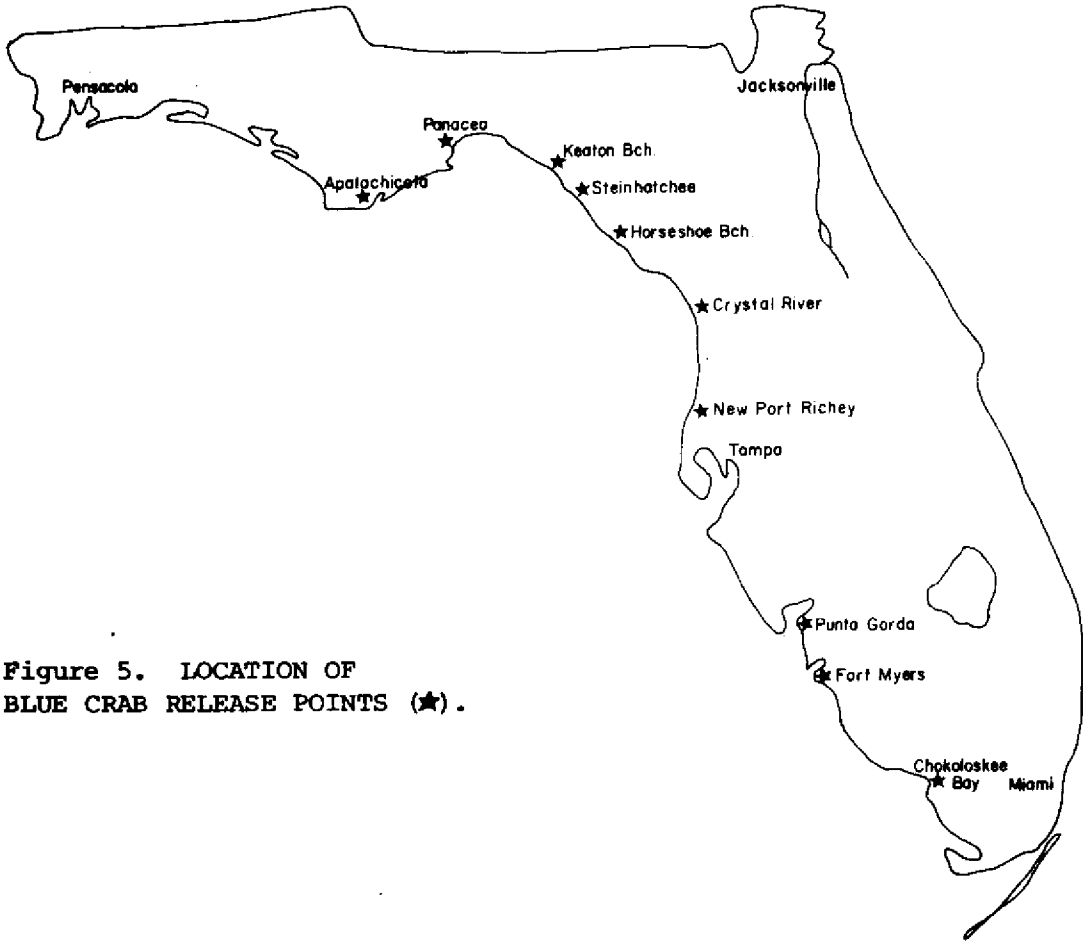
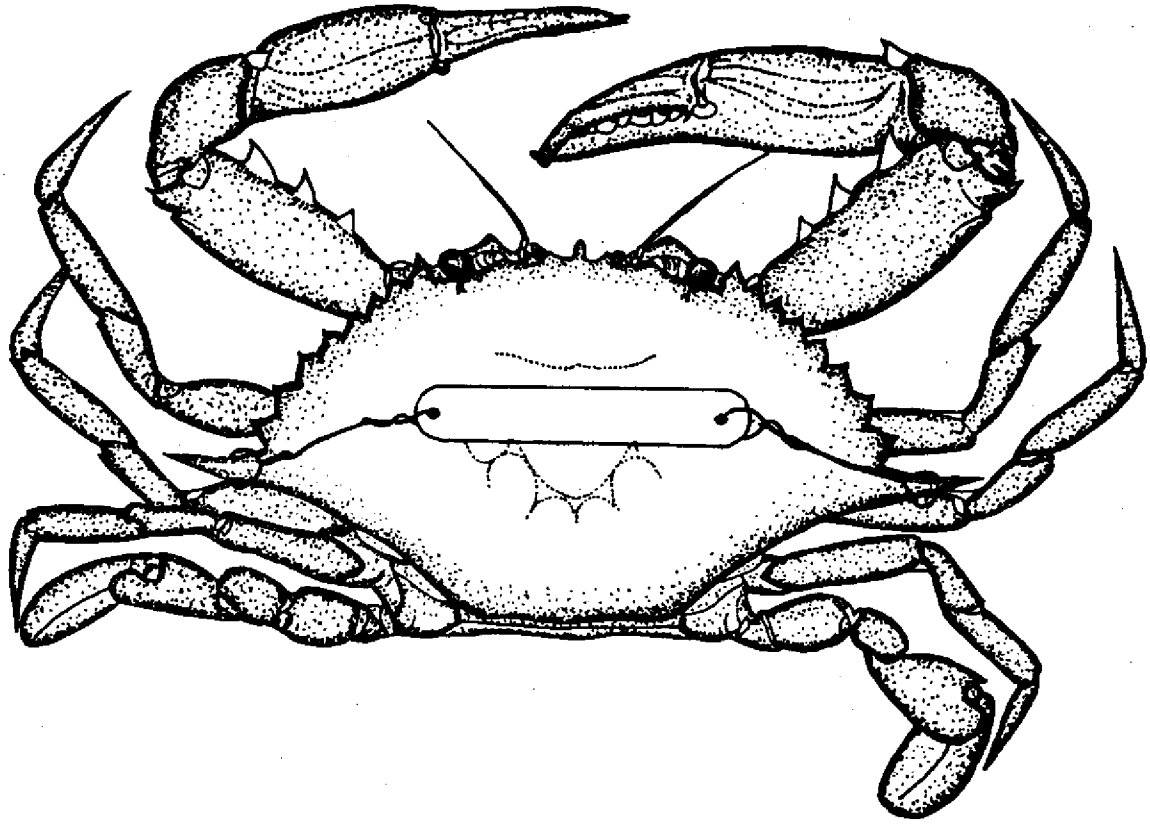


Figure 5. LOCATION OF BLUE CRAB RELEASE POINTS (★).

DISCUSSION

In this study, male crabs exhibited no real trend in their movements, other than remaining in their "home estuary." When they did travel, it was not as dramatic as the females. Although one male did travel 132 miles, generally there was a tendency to disperse back into the surrounding creeks and marshes. This is in keeping with Cargo's (1958) Virginia findings that males exhibit a nondirectional and random movement within their home estuary. Further substantiation of this were the 2 male crabs caught 205 and 245 days after tagging, but only a short distance from the initial release point.

Data obtained from this study correspond to the general movement patterns of previous studies, insofar as mating occurs in lower salinity waters and spawning occurs in higher salinity waters. Concerning the actual pathways in which the movement from lower to higher salinity is accomplished, however, present results for the Gulf coast of Florida are contradictory to previous observations from the eastern seaboard. According to Judy and Dudley (1970) working in North Carolina waters, "crabs scatter widely within their respective habitats but show only limited movements to other inland and coastal waters." It's obvious from the distances traveled (Table 2) and Figures 7 through 15, that the crabs along the Gulf coast have more than "scattered widely." We must assume that these crabs have indeed



(Figure 6. Tag placement on a blue crab and the information included on both sides of a tag. The tag attached to the crab is the actual tag size. Tag color was orange with black lettering.)

moved along shore to a neighboring coastal area. In the case of the crab that moved 297 miles from Punta Gorda to the Pancea area (Figure 8), the crab had to pass through at least 7 estuarine areas along the coast.

Already pointed out has been the fact that migrations of females are directly linked to reproduction. The migration that we observed would correspond to the movement after mating, towards the spawning area. In the classic description, this would be the "offshore," higher salinity waters. For the Gulf coast this would be a site, or sites, to the north of the mating estuary. There appears to be one primary source area (spawning ground) for the blue crab fisheries along the Florida Gulf coast; this being located in the Apalachicola Bay region. In all tagging returns

TABLE 1. Tagging sites, dates of taggings, and number of crabs tagged at each tagging (by sex and total). There were 16 taggings conducted at 10 different sites along the Gulf coast.

TAG SITE	TAGGING DATE	MALES TAGGED	FEMALES TAGGED	TOTAL TAGGED
Chokoloskee Bay	6 December 1974	124	115	239
Fort Myers	14 October 1975	472	85	557
Punta Gorda	7 February 1975	435	105	540
	13 October 1975	416	97	513
New Port Richey	6 November 1974	230	90	320
	28 January 1975	155	15	170
	23 September 1975	248	19	267
Crystal River	21 January 1975	126	358	484
Horseshoe Beach	30 January 1975	4	303	307
Steinhatchee	25 November 1974	231	291	522
	3 October 1975	135	63	198
	29 October 1975	251	74	325
Keaton Beach	29 January 1975	10	336	346
Panacea	16 January 1975	33	669	702
Apalachicola	11 March 1975	114	224	338
	28 October 1975	247	212	459
	TOTALS	3231	3056	6287

Table 2. Miles travelled by recaptured crabs. The columns labelled MALES and FEMALES are the number captured of that sex at some miles from the release site. Note the concentration of males recaptured under ten miles distance from the release site and the spread of females up to almost 300 miles.

MILES TRAVELLED	MALES	CUMULATIVE % MALE RETURNS	FEMALES	CUMULATIVE % FEMALE RETURNS
0	32	9.9	32	9.3
1	66	30.3	23	15.9
2	87	57.1	16	20.6
3	52	73.2	35	30.7
4	42	86.1	40	42.3
5	9	88.9	14	46.4
6	2	89.5	10	49.3
7	6	91.4	-	
8	3	92.3	13	53.0
9	7	94.4	1	53.3
10	-		6	55.1
11	2	95.1	6	56.8
13	-		1	57.1
14	-		1	57.4
15	1	95.4	3	58.3
16	4	96.6	14	62.3
17	-		1	62.2
18	1	96.9	-	
20	-		15	67.0
23	1	97.2	1	67.3
24	2	97.8	21	73.3
25	1	98.2	1	73.6
26	-		2	74.2
29	-		3	75.1
30	-		5	76.5
31	1	98.5	-	
32	-		3	77.4
33	-		3	78.3
34	-		3	79.1
35	1	98.8	7	81.2
37	-		2	81.7
38	-		8	84.1
40	-		2	84.6
43	-		1	84.9
45	-		2	85.5
47	-		4	86.7
48	-		1	87.0
50	1	99.1	5	88.4
53	-		1	88.7
55	-		1	89.0
60	-		7	91.0
61	1	99.4	-	
63	1	99.7	4	92.2
64	-		2	92.8
65	-		3	93.6
66	-		1	93.9
67	-		1	94.2
68	-		1	94.5
72	-		1	94.8
80	-		2	95.4
94	-		1	95.7
112	-		1	95.9
115	-		1	96.2
120	-		1	96.5
126	-		1	96.8
132	1	100.0	-	
134	-		1	97.1
157	-		1	97.4
200	-		3	98.3
208	-		1	98.6
225	-		1	98.8
243	-		1	99.1
264	-		1	99.4
276	-		1	99.7
297	-		1	100.00

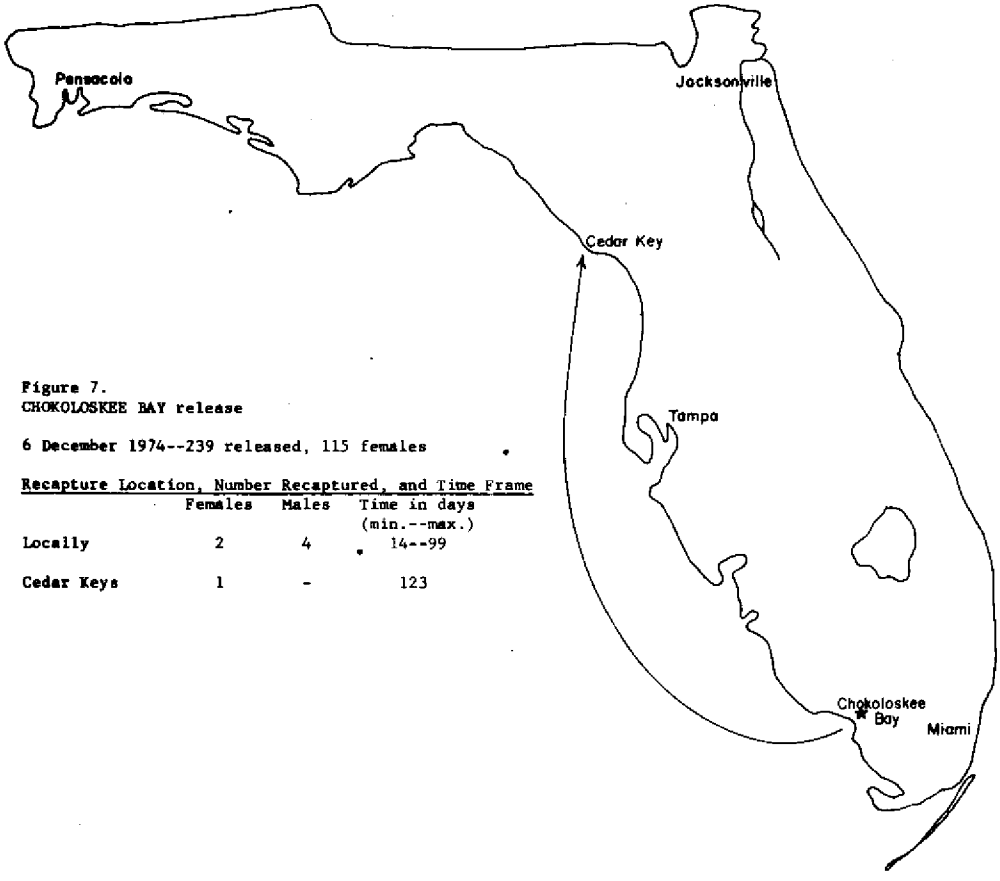


Figure 7.
CHOKOLOSKEE BAY release

6 December 1974--239 released, 115 females

Recapture Location, Number Recaptured, and Time Frame

	Females	Males	Time in days (min.--max.)
Locally	2	4	14--99
Cedar Keys	1	-	123

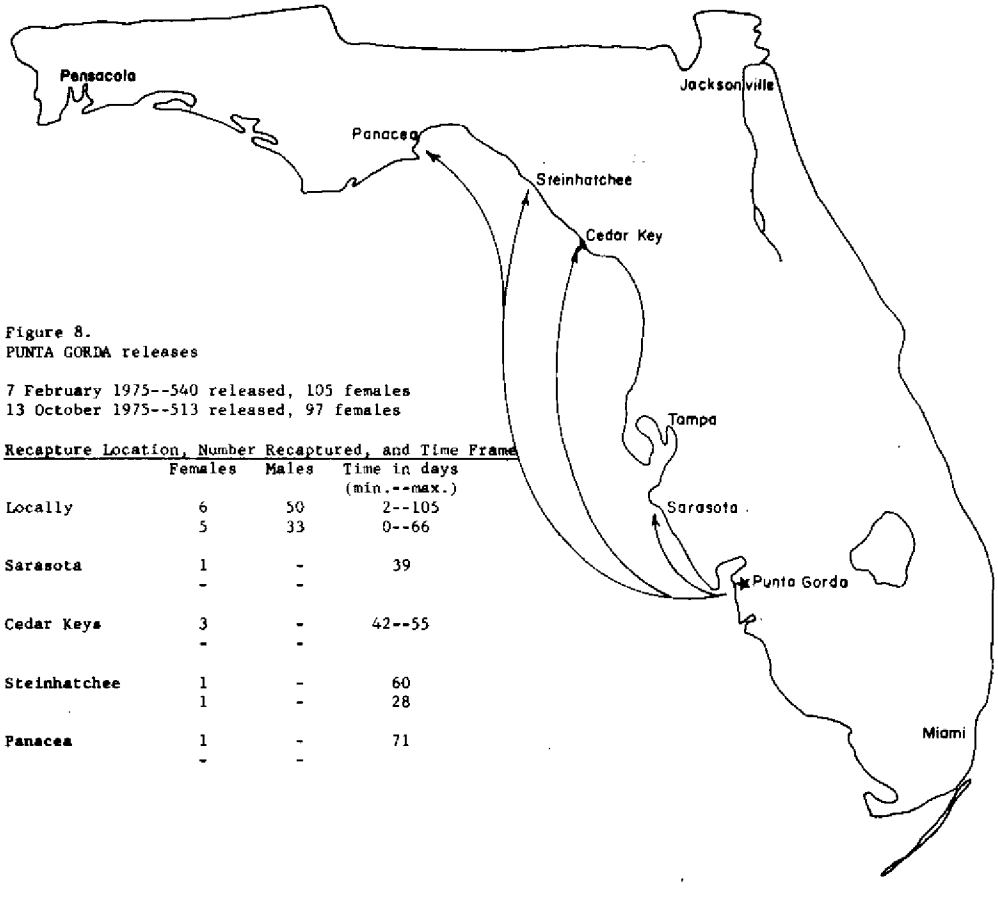


Figure 8.
PUNTA GORDA releases

7 February 1975--540 released, 105 females
13 October 1975--513 released, 97 females

Recapture Location, Number Recaptured, and Time Frame

	Females	Males	Time in days (min.--max.)
Locally	6	50	2--105
	5	33	0--66
Sarasota	1	-	39
	-	-	
Cedar Keys	3	-	42--55
	-	-	
Steinhatchee	1	-	60
	1	-	28
Panacea	1	-	71
	-	-	

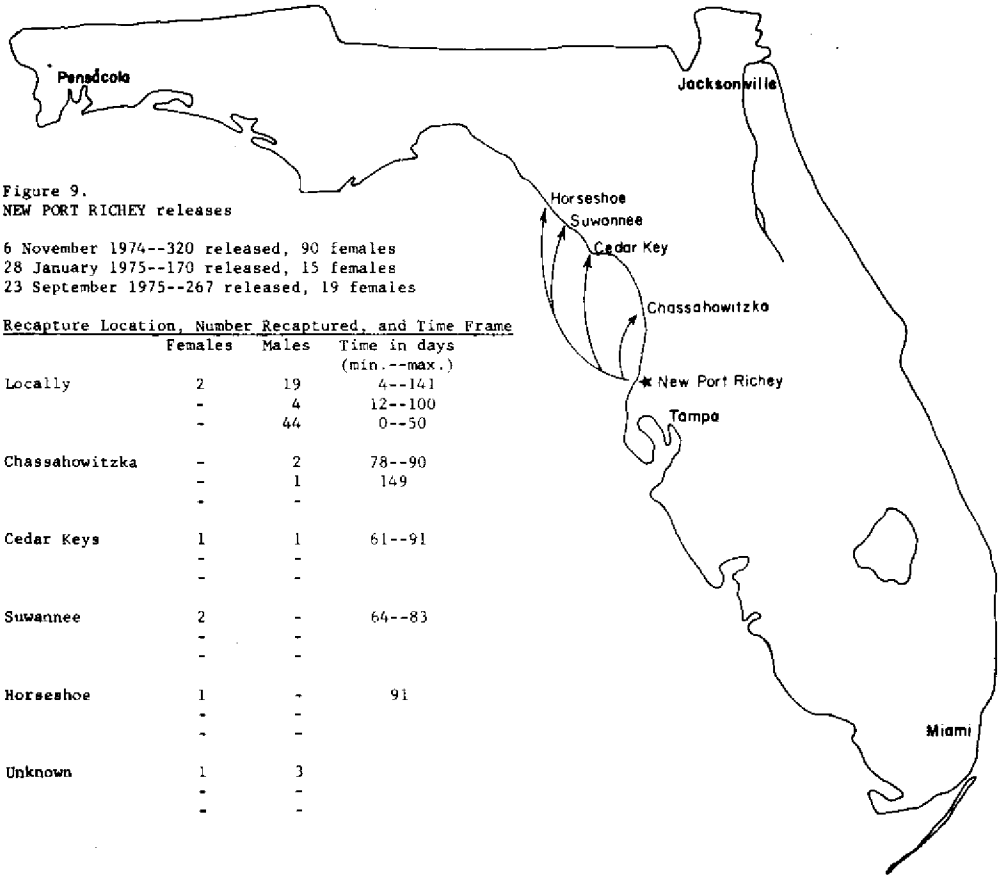


Figure 9.
NEW PORT RICHEY releases

6 November 1974--320 released, 90 females
28 January 1975--170 released, 15 females
23 September 1975--267 released, 19 females

Recapture Location, Number Recaptured, and Time Frame

	Females	Males	Time in days (min.--max.)
Locally	2	19	4--141
	-	4	12--100
	-	44	0--50
Chassahowitzka	-	2	78--90
	-	1	149
	-	-	
Cedar Keys	1	1	61--91
	-	-	
	-	-	
Suwannee	2	-	64--83
	-	-	
	-	-	
Horseshoe	1	-	91
	-	-	
	-	-	
Unknown	1	3	
	-	-	
	-	-	

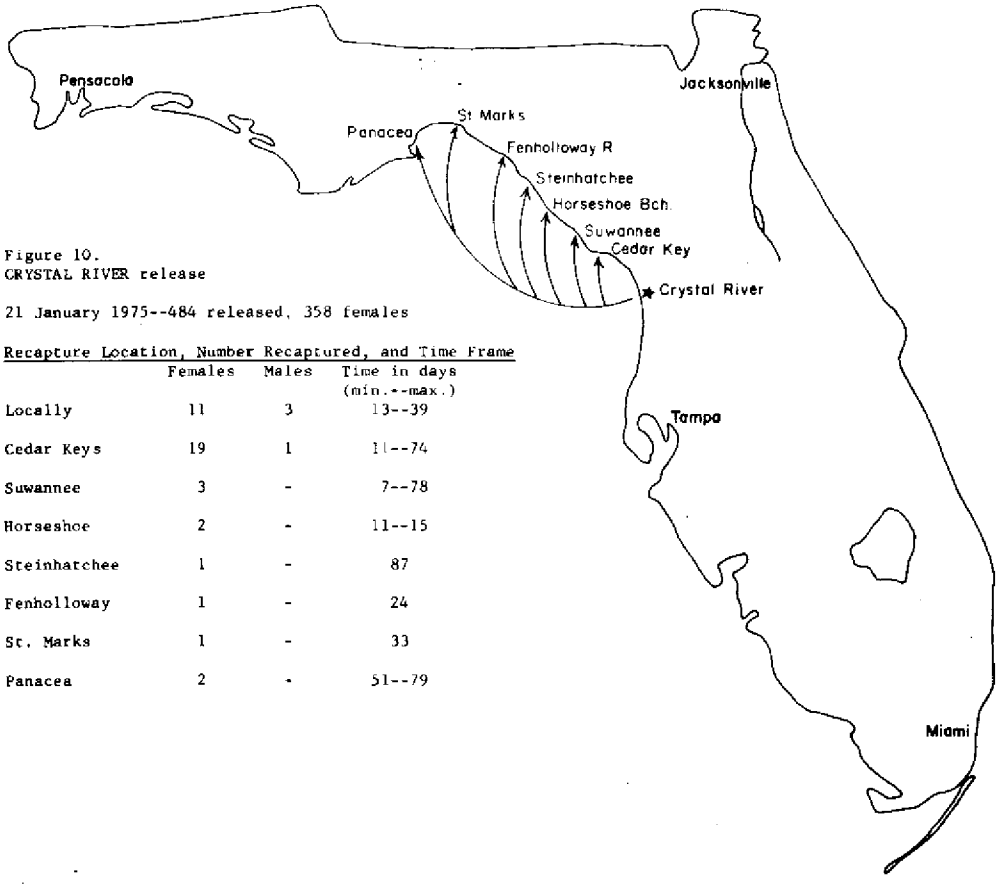


Figure 10.
CRYSTAL RIVER release

21 January 1975--484 released, 358 females

Recapture Location, Number Recaptured, and Time Frame

	Females	Males	Time in days (min.--max.)
Locally	11	3	13--39
Cedar Keys	19	1	11--74
Suwannee	3	-	7--78
Horseshoe	2	-	11--15
Steinhatchee	1	-	87
Fenholloway	1	-	24
St. Marks	1	-	33
Panacea	2	-	51--79

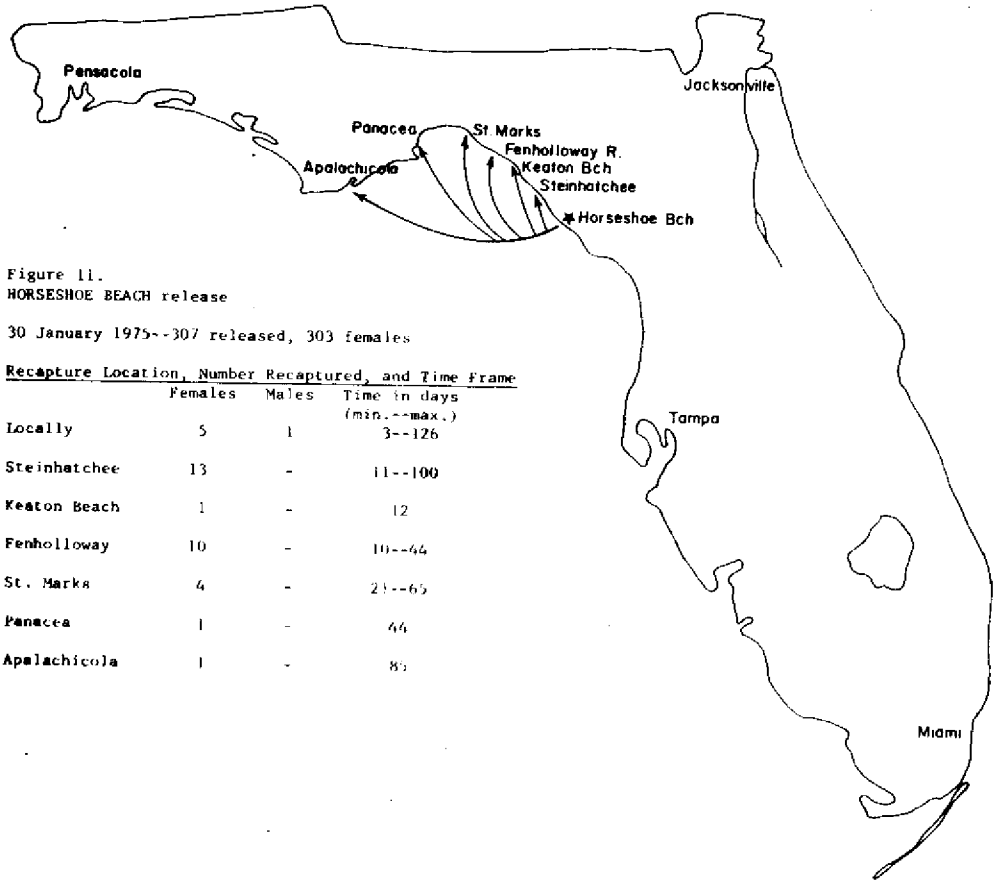


Figure 11.
HORSESHOE BEACH release

30 January 1975--307 released, 303 females

Recapture Location, Number Recaptured, and Time Frame

	Females	Males	Time in days (min.--max.)
Locally	5	1	3--126
Steinhatchee	13	-	11--100
Keaton Beach	1	-	12
Fenholloway	10	-	10--44
St. Marks	4	-	21--65
Panacea	1	-	44
Apalachicola	1	-	85

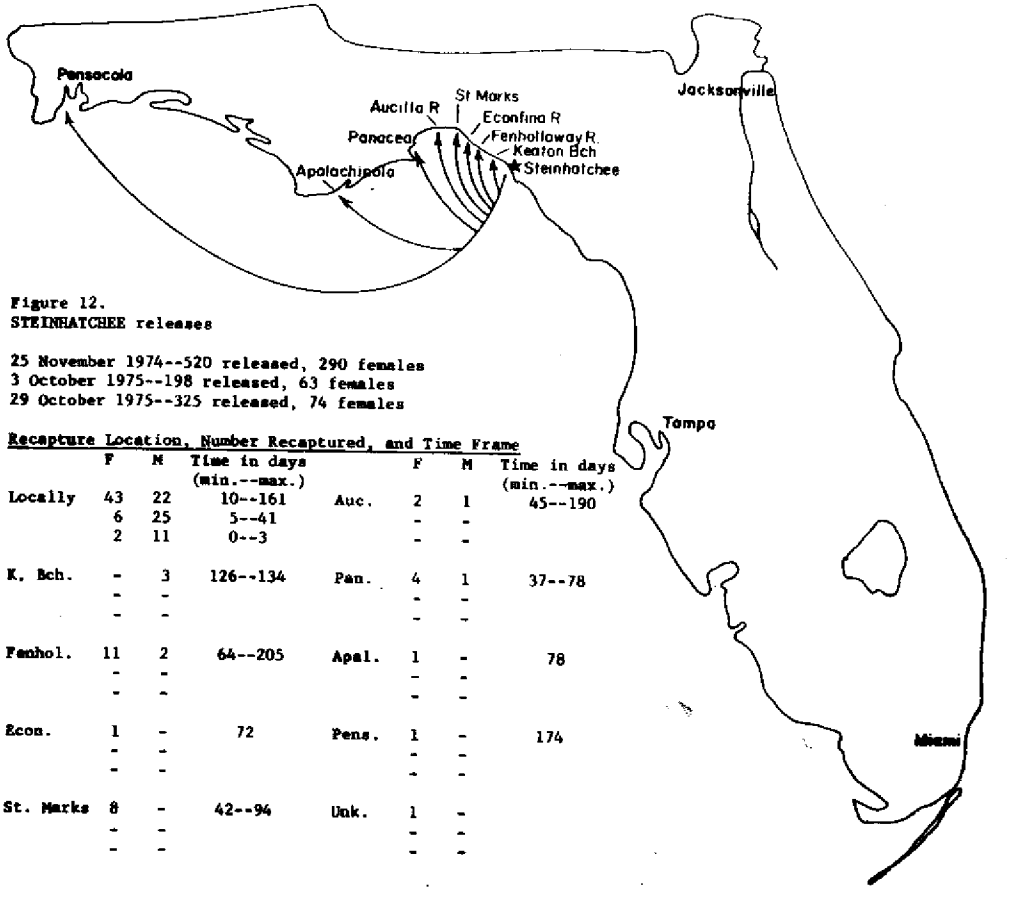


Figure 12.
STEINHATCHEE releases

25 November 1974--520 released, 290 females
3 October 1975--198 released, 63 females
29 October 1975--325 released, 74 females

Recapture Location, Number Recaptured, and Time Frame

	F	M	Time in days (min.--max.)		F	M	Time in days (min.--max.)
Locally	43	22	10--161	Auc.	2	1	45--190
	6	25	5--41		-	-	
	2	11	0--3		-	-	
K. Bch.	-	3	126--134	Pan.	4	1	37--78
	-	-			-	-	
	-	-			-	-	
Fenhol.	11	2	64--205	Apal.	1	-	78
	-	-			-	-	
	-	-			-	-	
Econ.	1	-	72	Pens.	1	-	174
	-	-			-	-	
	-	-			-	-	
St. Marks	8	-	42--94	Unk.	1	-	
	-	-			-	-	
	-	-			-	-	

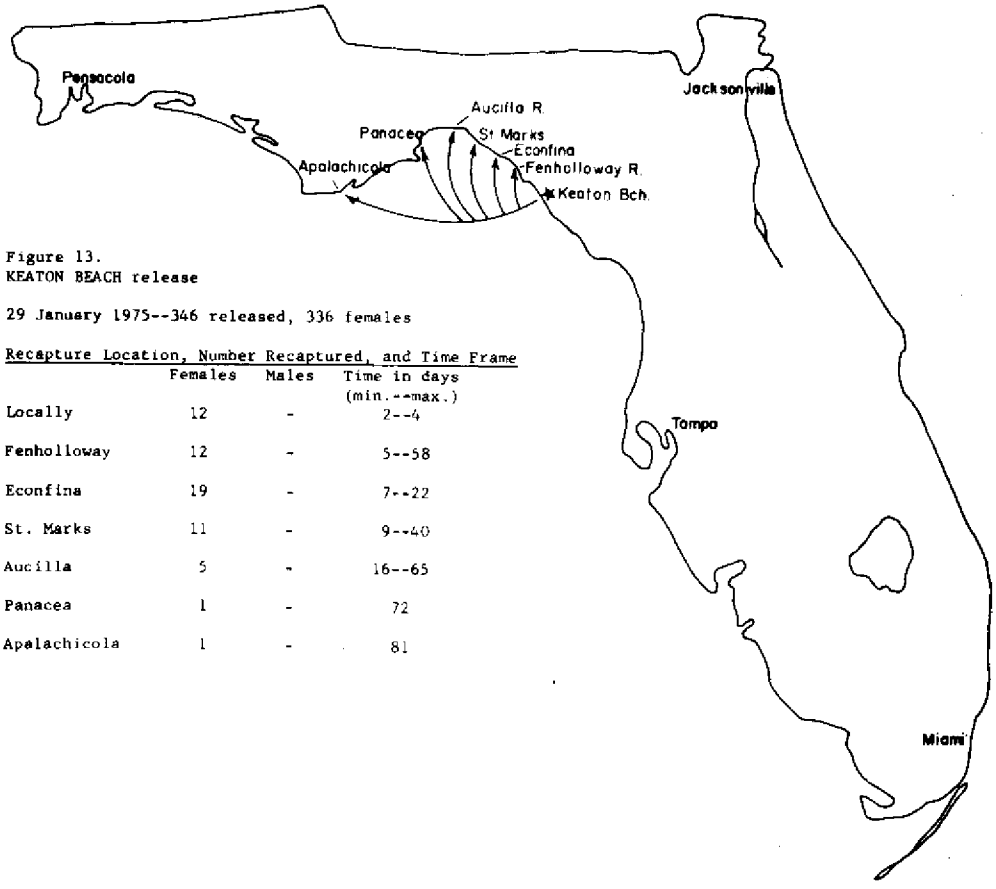


Figure 13.
KEATON BEACH release

29 January 1975--346 released, 336 females

Recapture Location, Number Recaptured, and Time Frame

	Females	Males	Time in days (min.--max.)
Locally	12	-	2--4
Fenholloway	12	-	5--58
Econfina	19	-	7--22
St. Marks	11	-	9--40
Aucilla	5	-	16--65
Panacea	1	-	72
Apalachicola	1	-	81

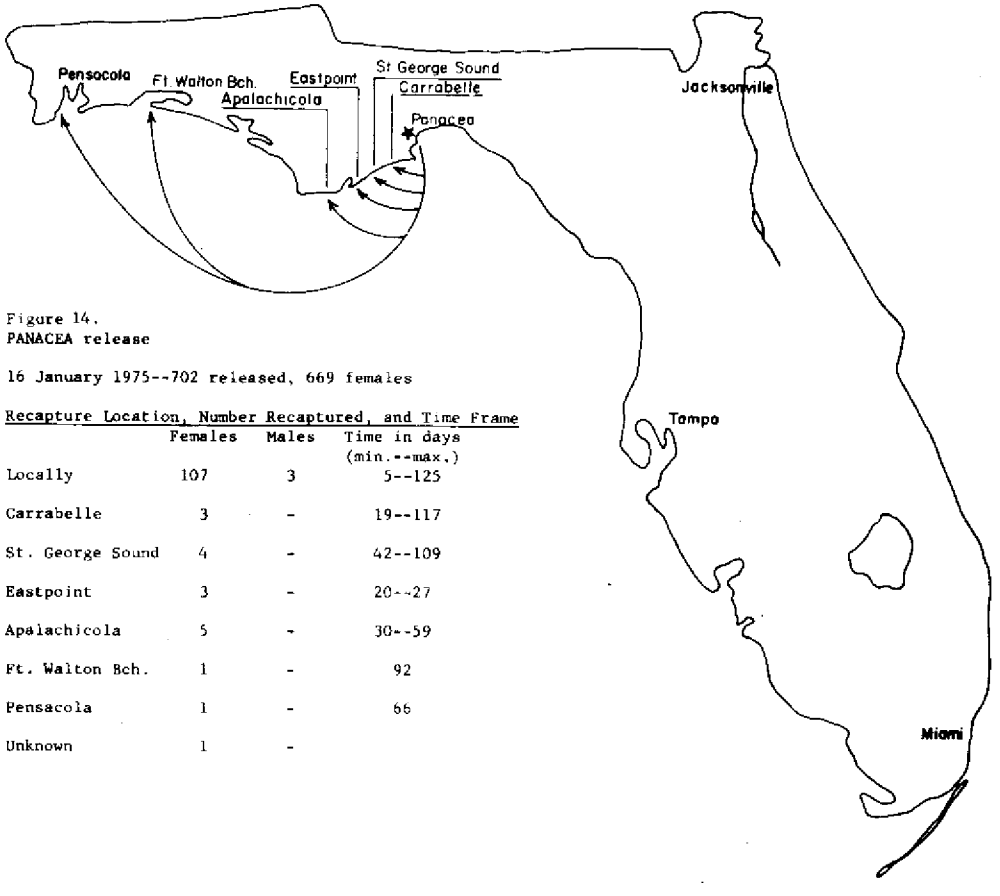


Figure 14.
PANACEA release

16 January 1975--702 released, 669 females

Recapture Location, Number Recaptured, and Time Frame

	Females	Males	Time in days (min.--max.)
Locally	107	3	5--125
Carrabelle	3	-	19--117
St. George Sound	4	-	42--109
Eastpoint	3	-	20--27
Apalachicola	5	-	30--59
Ft. Walton Bch.	1	-	92
Pensacola	1	-	66
Unknown	1	-	

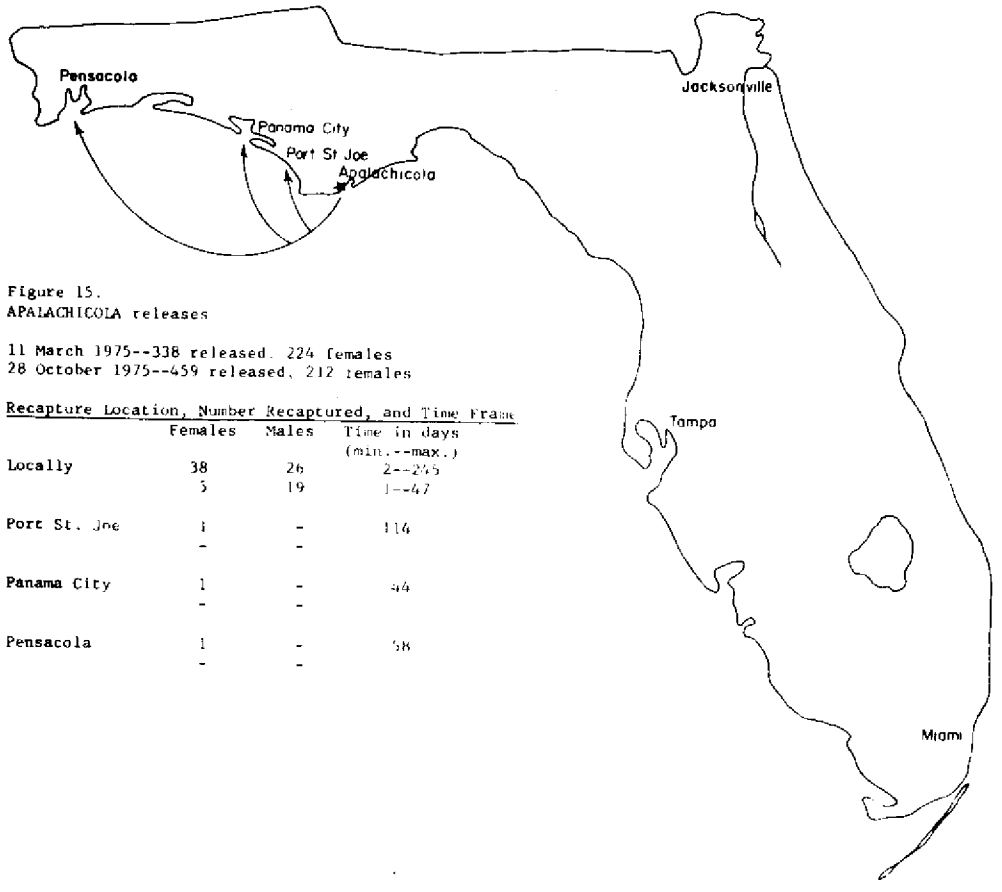


Figure 15.
APALACHICOLA releases

11 March 1975--338 released, 224 females
28 October 1975--459 released, 212 females

Recapture Location, Number Recaptured, and Time Frame

	Females	Males	Time in days (min.--max.)
Locally	38	26	2--245
	5	19	1--47
Port St. Joe	1	-	114
	-	-	
Panama City	1	-	44
	-	-	
Pensacola	1	-	58
	-	-	

from the Gulf coast, only 7 crabs have moved to the west of Apalachicola Bay (Figures 7-15). The majority of returns seem either to be heading towards or to terminate in Apalachicola Bay where great concentrations of egg-bearing female blue crabs are known to occur. This is not to say that blue crab spawning does not occur along the entire length of Florida's west coast; for indeed it does. However, the concentrations of spawning (egg-bearing) blue crabs along the Gulf coast do not approach the large number of ovigerous blue crabs found in the Apalachicola Bay area, which may be several orders of magnitude greater than any other Gulf coast area. Personal communications with local crabbers and shrimpers in the Apalachicola area and results from a questionnaire survey of commercial crabbers support the hypothesis of this area's importance as a source area for Gulf coast blue crabs. Further corroboration of this area's importance occurs in the return of tagged ovigerous crabs from the Apalachicola Bay region. Tagged crabs were caught bearing egg masses which were not present at the time of tagging. These egg masses were all orange in color, indicating that they had only recently been laid (Darnell, 1959; Van Engel, 1958). No other tagged ovigerous crabs were returned from any other location along the Gulf coast.

CONCLUSIONS

The blue crab population along Florida's Gulf coast appears to behave contrary to previous studies in regards to their migratory habits. Instead of the classic description of an onshore/offshore pattern, an onshore/along-shore type movement was described, where, following mating, female blue crabs leave the mating estuary and move towards specific spawning areas. For the Florida Gulf coast, there appears to be one primary spawning ground located in the Apalachicola Bay.

Presently the Army Corps of Engineers has plans for the construction of 4 additional dams along the Apalachicola River, together with the associated dredging, etc., that accompanies such activities. Perhaps the biggest question to be asked then is: "What impact will this have on the blue crab industry and Apalachicola Bay?". It has been presented in this study that female blue crabs move along-shore for great distances, and that these movements are directed towards the Apalachicola Bay region for spawning purposes. Therefore any damage to Apalachicola Bay (via reduced flow of waters and nutrients) or existing migrational pathways could injure the subsequent year's production of blue crabs. Any perturbations in the quality of life in Apalachicola Bay could adversely affect the hatching of eggs and greatly decrease the chance of larval survival, and ultimately the number of market-sized crabs available for the entire Gulf coast blue crab industry.

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The Florida Sea Grant Program is supported by award of the Office of Sea Grant, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, grant number 04-5-158-44, under provisions of the National Sea Grant College and Programs Act of 1966. The Florida Sea Grant Program was initiated in 1972 with three major components: applied marine research, education, and advisory services.

This public document was promulgated at a cost of $ 550.80 or 18.4 cents per copy, to provide current technical information to persons interested in the commercial fishing industry of Florida.

The Marine Advisory Program functions as a component of the Florida Cooperative Extension Service, Joe N. Busby, dean, in conducting Cooperative Extension work in Agriculture, Home Economics, and Marine Sciences, State of Florida, U.S. Department of Agriculture, U.S. Department of Commerce, and Boards of County Commissioners, cooperating. Printed and distributed in furtherance of the Acts of Congress of May 8 and June 14, 1914.

6/3M/76

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