THE MIGRATION OF ADULT FEMALE BLUE CRABS, *CALLINECTES SAPIDUS* Rathbun, IN CHINCOTEAGUE BAY AND ADJACENT WATERS[1]

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ABSTRACT

A total of 392 adult female blue crabs were tagged at four different points in the Chincoteague Bay area from 31 July to 7 September 1953. Over a period including June 1954, about 25% were recaptured, mostly to the south of the release points. Only three had moved northward, and only two were recaptured outside the area; one in Delaware Bay and one at Oyster, Virginia. Factors that may influence their movements and some ecological considerations are discussed.

INTRODUCTION

The Chincoteague Bay area, composed of Chincoteague, Sinepuxent, Isle of Wight, and Assawoman Bays, is an estuarine system separated from the Atlantic Ocean by a series of narrow barrier islands with major inlets at Ocean City, Maryland, and Chincoteague, Virginia. An ecological study of this area was initiated in August 1951, primarily to determine the cause or causes of the marked decline in oyster production. The biology of the blue crab, *Callinectes sapidus* Rathbun, in these waters was included in this study since the crab is closely associated with the oyster communities and is, in itself, a valuable marine resource. The present paper deals with its migratory activities in these waters. Knowledge of its movements is necessary to an understanding of its life history and might aid in providing an estimate of the amount of recruitment and/or loss from the resident population. Ultimately, these studies might form a basis for necessary management practices that would avoid erroneous procedures based solely on findings in other estuaries.

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The pattern of movement of the blue crab in Chesapeake and Delaware bays has been the subject of extensive studies. In 1925 Fiedler (1930) tagged almost 1800 crabs in the Chesapeake area and recaptured 10.8%. Later Truitt (1936, 1937) tagged more than 4600 crabs, by several methods, in the same body of water. Although two of his methods failed to provide a large number of returns, results from the entire series were adequate to outline some of the patterns being followed by the crabs. From 1943 to 1946, Cronin released over 1300 crabs in the Chesapeake area. The bright red external tags used in this experiment provided a high (22.6%) rate of return. Cronin's data substantiated and refined the findings of Fiedler and Truitt, and in 1949 he summarized the results of various tagging observations. These workers determined that female crabs, after reaching maturity, move toward the mouth of Chesapeake Bay, wintering near the spawning area and moving into it during the spring. The males showed a nondirectional and random migratory pattern.

In Delaware Bay, Cronin (1952, 1954) tagged over 1100 crabs from 1952 to 1954. Returns from these releases indicated that the crabs there move widely, with no simple pattern, and that adult females move both up and down the estuary. No specific movement toward the capes was observed but, as Cronin pointed out, there is little crabbing conducted at the capes so that returns from that area would be limited.

There is no published information available concerning the movements of blue crabs inhabiting Chincoteague Bay and its adjacent waters. The direction of movement, the effects exerted by inlets, and any tendency they may have toward congregating or schooling during the winter are points to be considered. The discussion in this paper is based almost entirely on the results of tagging. It is unfortunate that adequate supplementary information on the habits and life history of the crab in Chincoteague Bay is not available.

ACKNOWLEDGMENTS

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DESCRIPTION OF THE AREA

The Chincoteague Bay area covers about 120 square miles at mean low tide (Truitt, 1953). The shores of the embayments are characterized by low relief and support a typical saltmarsh succession consisting primarily of cordgrass, *Spartina alternifolia* Loisel. The bays, adequately described by Sieling and McGary (1952), are shallow, averaging about five feet in depth; and the bottom consists mostly of mud and sand. The watershed of the area amounts to only 205 square miles, thus providing little freshwater runoff. During certain periods of the summer, evaporation exceeds precipitation to such an extent that the central part of the bay may exhibit higher salinities (>35 ‰) than those found in the open ocean (McGary and Sieling, 1953). The effects of the two inlets are marked, causing a system of complex tides and currents which influence temperature and salinity distribution to some degree throughout the area. Tidal currents near the inlets provide an influx of ocean water accompanied by considerable flow while those portions of the bay remote from these inlets undergo little change from these tidal movements. The currents within most of Chincoteague Bay, primarily due to wind, are so slight (0.3 knots) that accurate measurements are difficult to obtain. Fig. 1 gives the surface salinity distribution from Ocean City to Chincoteague Inlet during the period of study.

METHODS AND MATERIALS

Tagging was limited to adult female crabs for two reasons: 1) Male crabs exhibit no recognizable indication of the attainment of maximum size whereas females do in that the triangular abdomen becomes broad and semicircular. By tagging such specimens, there was assurance that the tag would not be lost through molting. 2) There might be some indication of movement toward the spawning areas. The experimental animals were obtained through the co-operation of commercial crabbers who permitted the investigators to accompany them when fishing their gear. The crabs were tagged and released in the area where they were captured; this avoided displacement of tagged animals to another area and prevented the uncertain effects of holding them out of water for extended periods.

The red plastic strip tags used have been described by Cronin (1949). Each tag, prior to use, was provided with a two inch loop of soft stainless steel wire (.022 in.) at the left end and a straight length (about 5 in.) of the same wire at the other end. The tags were then arranged in numerical order on strips of masking tape in groups of 25 to facilitate recording at the time of tagging. The tag was applied

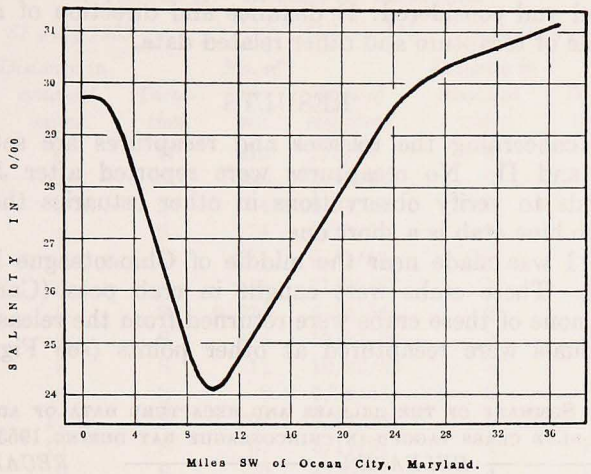

Figure 1. Graph of average salinity gradient from July 1953 through June 1954 in Chincoteague Bay.

simply by slipping the wire loop over the left lateral spine of the crab's carapace, stretching the tag snugly in a saddle fashion across the back and twisting the other length of wire around the right spine. This routine permits rapid tagging with a minimum of handling.

By releasing the tagged crabs at four well separated locations (noted below), variation was achieved with respect to the physical boundaries and to local hydrographic characteristics of the area. In addition, this practice served to subject tagged individuals to various levels of fishing pressure within the area. Several fishing methods were employed by crabbers during the period following the release of the crabs.

The returns were received in two ways. Fishermen who knew of the study often contacted an investigator in the field who obtained the necessary data and paid the reward of $1.00 per tag. Most crabbers, however, sent the tag to the U. S. Fish and Wildlife Service which then forwarded it and accompanying data to the Chesapeake Biological Laboratory at Solomons. A letter, enclosed with the reward, thanked the person for his co-operation, explained briefly the purpose of the study, and outlined when and where the crab had been tagged. This latter method of handling the returns is believed to be effective in avoiding a noncooperative attitude toward a laboratory in another state.

The release and recapture data were plotted on rough charts to facilitate analysis and interpretation. The following developments

were noted and considered: 1) distance and direction of movement, and 2) time of recapture and other related data.

RESULTS

Details concerning the releases and recaptures are set down in Tables I and II. No recaptures were reported after June 1954, which tends to verify observations in other estuaries that the life span of the blue crab is a short one.

Release I was made near the middle of Chincoteague Bay on 31 July 1953. These crabs were caught in crab pots (Cargo, 1954). Although none of these crabs were returned from the release location, 17 individuals were recaptured at other points (see Fig. 2a). Of

TABLE I. SUMMARY OF THE RELEASE AND RECAPTURE DATA OF ADULT FEMALE BLUE CRABS TAGGED IN CHINCOTEAGUE BAY DURING 1953

RELEASES				*RECAPTURES*	
Release	*Location*	*Date*	*Number tagged*	*Total number*	*Number with usable data**
I	Off Public Landing, Md.	31 July	98	23	19
II	Off Sandy Point, Md.	10 Aug.	102	24	24
III	Off White Rock, Md.	11 Sept.	97	27	22
IV	At Fenwick Island Light, Del.	17 Sept.	95	43	40
	TOTALS		392	117 or 29.8%	105 or 26.7%

* These returns provided adequate information on the location and date of recapture.

these, one had moved six nautical miles northward and was recaptured 10 months after release. The other 16 recaptured animals apparently moved in a southerly direction for distances ranging from two to ten nautical miles, and one individual presumably went out of the bay at Chincoteague, Virginia, since it was recaptured 3½ months later at Oyster, Virginia, 60 nautical miles from the point of release. These distances are given as direct routes since they obviously cannot represent the actual paths taken by the animals.

Release II took place on 10 August 1953 at Sandy Point in Sinepuxent Bay, a narrow extension of Chincoteague Bay to the north toward Ocean City. These crabs were caught by trotline (Cargo, 1954), and Fig. 2b shows the movement and location of recapture of 24 females. In this instance, most of the crabs were caught at or near the release point within 10 days. Nine migrated in a southerly direction and were not recaptured until April and May of 1954.

TABLE II. DETAILS OF RECAPTURE

Release I	*31 July 1953*			*Release III*	*11 September 1953*		
Date of recapture	*Distance in nautical miles*	*Direction*	*No. of days out*	*Date of recapture*	*Distance in nautical miles*	*Direction*	*No. of days out*
5/14/54	6	N	278	2/5/54	0	O	158
5/21/54	2	S	285	4/12/54	0	O	224
8/4/53	3	S	4	9/14/53	0	O	3
5/10/54	4	S	274	5/10/54	0	O	252
5/10/54	4	S	274	9/17/53	10	N	6
8/14/53	5	S	14	11/23/53	3	W	74
5/12/54	8	S	276	5/24/54	2	S	266
6/10/54	8	S	305	10/23/53	3	S	43
8/11/53	8	S	11	10/22/53	3	S	42
8/8/53	9	S	8	9/24/53	3	S	13
2/24/54	10	S	209	5/12/54	4	S	254
10/5/53	10	S	67	6/11/54	4	S	284
10/10/53	10	S	72	4/30/54	4	S	241
4/27/54	10	S	261	11/19/53	4	S	70
10/5/53	10	S	67	3/28/54	4	S	209
10/2/53	10	S	63	2/1/54	4	S	153
8/20/53	11	S	20	3/29/54	7	S	271
5/3/54	11	S	267	2/3/54	7	S	156
11/16/53	60	S	109	11/9/53	7	S	60
				3/23/54	7	S	204
				1/26/54	7	S	148
Release II	*10 August 1953*			*Release IV*	*17 September 1953*		
14 crabs	0	0	7 to 9	17 crabs	0	0	3 to 9
1/20/54	0	0	163	4/23/54	40	N	218
5/5/54	3	S	268	5/3/54	3	S	228
4/29/54	3	S	261	1/27/54	4	S	132
4/16/54	3	S	249	4/27/54	4	S	222
4/29/54	3	S	261	4/15/54	4	S	210
5/5/54	3	S	268	4/20/54	4	S	215
5/3/54	7	S	266	10/26/53	4	S	39
4/30/54	17	S	262	2/19/54	5	S	155
4/10/54	17	S	252	2/27/54	5	S	163
5/10/54	20	S	243	4/20/54	6	S	215
				2/18/54	6	S	154
				2/4/54	6	S	140
				1/28/54	6	S	133
				9/24/53	6	S	7
				2/1/54	6	S	138
				1/27/54	6	S	133
				2/11/54	15	S	147
				2/11/54	15	S	147
				5/23/54	20	S	248
				4/28/54	37	S	223
				*	6	S	*

* Date of recapture unreliable.

Release III was made at White Rock, a deep area (seven feet) in lower Chincoteague Bay. These crabs, secured by pots, were released on 11 September 1953. A few were caught shortly thereafter in the immediate area, and although one individual was recaptured about 10 nautical miles north of the release point, most recaptures were made to the south (see Fig. 2c).

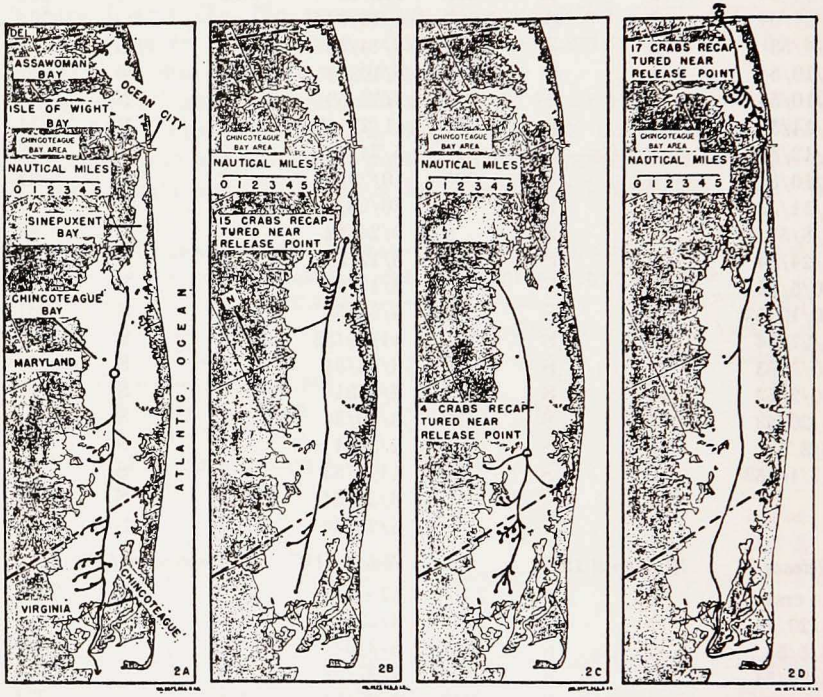

Figure 2. Charts showing locations of releases and recaptures. 2A. Release I. 2B. Release II 2C. Release III. 2D. Release IV. Releases indicated by open circles. Recaptures indicated by solid dots.

Release IV was made on 17 September 1953 at the extreme northern end of the area being studied. These crabs, caught on a trotline, were released in a narrow embayment just north of the Maryland-Delaware line. This release not only produced the largest number of returns but also provided some interesting data on crab movements. Except for the 17 that were returned from the immediate release area, most of the crabs moved southward, at least four bypassing the inlet at Ocean City. One of these was caught on 28 April 1954 at Assateague Cove at the extreme southern end of Chincoteague Bay, a distance of some 36 nautical miles. Another crab, which moved to

the north, was recaptured at Bower's Beach in Delaware Bay about seven months after release (Fig. 2d).

Twenty-eight tagged crabs were also released eight miles off Ocean City, Maryland, in a pilot experiment in which the crabs were obtained by hydraulic dredges fishing for surf clams. No returns were secured from this release.

Cronin (1949) pointed out the likelihood of a tag being overlooked if used internally, but it is apparent from this study that external tags may also be overlooked. If a tag is not observed at the time of recapture, then it is of little value in an experiment of this nature, since the data are frequently questionable. Several of these vividly colored tags were overlooked by crabbers and shippers and were subsequently returned from retail outlets in Chicago and New York. For purposes of this migratory study, recaptured animals that have escaped the notice of the crabber are lost and have not been included in the data presented.

DISCUSSION

Considerations of Techniques. This study has resulted in a return of about one third of the crabs tagged, which suggests that the watermen in the area are effectively fishing the available crop. The fact that the estuary is small and can be covered rather completely by the various gears probably contributes to this high percentage of returns. The returns of biological value amounted to 87% of the total returns. This is about average for external tags of this type (Cronin, 1949). Although it may be difficult, this percentage of usable tags might be increased somewhat by repeatedly publicizing the release date and by outlining briefly the purpose of the study and the necessity for returning all tags together with the information requested on the tag. Frequent personal contacts by field investigators during the course of a study may further increase the returns.

An interesting side light on tagging was observed during Release IV. While the first crabs taken were being tagged and returned to the water as quickly as possible, the crabber continued to fish his trotline in order to get an adequate number of additional specimens for a release. In the course of fishing, several of the newly tagged crabs were recaptured, and one individual was caught on three successive runs. This behavior suggests that the tagging experiment may have had little effect on a crab's subsequent reaction to a baited trotline or, perhaps, to his future well being.

It is evident that, since returns are dependent upon commercial fishing, the distribution of fishing pressure must have some effect upon the locale of these returns. This is important in analyses based

on clustered returns from one area. Crabbing in Chincoteague Bay is fairly homogeneously distributed because of its comparatively shallow depths. However, Figs. 2a, c and d show a clustering of returns just above Ocean City, Maryland, and in the southern part of Chincoteague Bay; both of these areas are close to centers of fishing activity. No specific evaluation of the influence of these factors was made during this study.

Considering the bias which can be exerted by such concentrations of fishing activity, it is possible that the clustering of returns might not have occurred if the fishing pressure had not been heavy in these areas. However, it is just as feasible to assume that the crabs would not have been recaptured there if they had not actually moved into the area, regardless of fishing pressure. Although the scattering of the released animals is probably somewhat more diffuse than the returns indicate, it is felt that the general picture of movement in a southward direction is valid. In this respect, crabs in the Chincoteague area appear to follow a pattern similar to that in Chesapeake Bay.

Biological Considerations. It is apparent that the adult female crabs present in late summer move in a generally southward direction during the subsequent eight to ten months. The salinity gradients in Chesapeake and Delaware Bays gradually increase from the headwaters to the mouth. In Chesapeake Bay, adult females move toward the more saline waters and some do likewise in Delaware Bay, although their pattern is less consistent than that of the Chesapeake. The Chincoteague females, according to our observations, move in a southerly direction regardless of salinity gradients. Releases I and III (see Figs. 2a, c) were made far enough down in the main part of the bay to be influenced by the high salinity water that enters through Chincoteague Inlet to the south. Likewise, Release IV was made at a location where saltier water enters to the south of the release point. In the case of Release II, however (see Figs. 2b, d), the high salinity water is to the north. If adult females are attracted toward high salinities, then it might be expected that the crabs released south of Ocean City Inlet in Sinepuxent Bay would travel northward. Such was not the case. As did the crabs of Releases I, III, and IV, those from Release II also traveled in a southward direction.

Graham and Beaven (1942) showed that the zoeae of *Callinectes* are concentrated near the mouth of Chesapeake Bay. Subsequently, Sandoz and Rogers (1944) determined that salinities in excess of 20‰ resulted in the successful hatching of blue crab eggs into "normal" first stage zoeae and that, at salinities below this, many prezoeae were

produced and the percent of hatching was materially reduced. Salinity was therefore considered to be an important controlling factor that influences the survival of blue crab larvae. Although the spawning area in Chincoteague has not been investigated, it is probable that the relatively high salinity in the bay permits spawning to occur throughout most of the area during summer months. Inconclusive evidence from larvae collections suggests that spawning is concentrated in the lower parts of Chincoteague Bay. This is supported by reports from commercial watermen who have observed a large number of "sponge" or egg-bearing crabs in that area, and in the southerly portions of Isle of Wight Bay as well.

The Chincoteague area differs considerably from Delaware and Chesapeake Bays in ecological and physiographic conditions, and such differences must be weighed and considered. If the movement or migration of adult female blue crabs is influenced by a salinity factor, then one might expect different patterns of migration in the different bodies of water. The lack of a continuous salinity gradient is likely to exert considerable effect upon the forces which determine or influence the migratory patterns of these crustaceans. A gradual increase in salinity from the headwaters to the mouth, as is found in Chesapeake and Delaware Bays, may serve as an orienting factor in determining the migratory patterns of animals in such areas. Although the hydrography of Chincoteague Bay does not follow this regular pattern, the net movement was southerly in most cases. The reasons for this response have not been determined. The inlet at Ocean City was not opened until 1933. This event probably had a marked effect upon the hydrography of the region, but the effects upon the fauna of the area have not been investigated.

The recovery of one individual from Delaware Bay is highly unusual. Previous tagging experiments have shown that crabs rarely move from one estuarine system to another (Porter 1956). The routes open to the crab in this case are rather limited. One possibility is that the crab first moved south to Ocean City and then out into the ocean and northward into Delaware Bay. At least two northern routes were open to it: one utilizes an inlet from the ocean a few miles north of the release point; the other involves a passage through two narrow canals to Lewes, Delaware, and thence directly into Delaware Bay. Any of these routes would necessitate a journey of at least 40 miles.

From these results, then, it appears that these populations do practice some limited migration between estuaries and that mixing is possible. This may have an effect on the morphometric characteristics of a population if the degree of intermixture ever becomes

greater than is indicated at present. The Chincoteague crabs are significantly smaller than those of either the Delaware or Chesapeake populations (Porter 1955, 1956). If the size of crabs is genetically determined, intermixture might result in either an increase or decrease of size in the estuaries involved.

The use of the inlet at Chincoteague by migrating crabs is not unusual, fishermen having reported that crabs frequently pass through it. The coast line of the eastern shore of Virginia is broken and shallow and includes many islands so that this area does not differ greatly from Chincoteague Bay in topography.

The inlet at Ocean City may have less influence on the movement of crabs than Chincoteague Inlet. As shown in Fig. 2d, a few tagged crabs passed it and continued their migration down Sinepuxent Bay and even into Chincoteague Bay. This is probably part of a normal migration of adult females toward the assumed spawning area in lower Chincoteague Bay, but a considerable number of crabs from Release IV were recaptured in the Isle of Wight Bay, where spawning may also occur, since some were taken there late in the spring. The statements of local watermen, that sponge crabs do occur there in fair numbers, supports this theory. No data are available on the quantity or quality of the crabs outside the inlet. Crabs exist in shallow ocean waters along the coastal areas within their geographic range, but they have not been utilized in commercial numbers from such waters by Maryland crabbers. Recent hydrographic investigations (Sieling 1957) have shown that intrusion of saline ocean water through the inlet at Ocean City raises the salinity in the lower part of Isle of Wight Bay and in the upper part of Sinepuxent Bay, but the effect of this intrusion on the movements of crabs is not clear. Further study of the ecological relationships between the crabs and this exchange of water would be of interest and might prove of value as a basis for future investigations.

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