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BLUE CRAB MORTALITIES ASSOCIATED WITH PESTICIDES, HERBICIDES, TEMPERATURE, SALINITY, AND DISSOLVED OXYGEN*

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Commercial fisheries landings of the blue crab in the Chesapeake Bay have fluctuated widely since the late 1920s (Figure 1). Records of annual landings prior to 1929 are sparse and permit little more than a guess of trends, although a discontinuous series of catch records from 1907 to 1926 from individual watermen, on file at the Virginia Institute of Marine Science (VIMS), may provide sufficient baseline data for interpretations or estimates of trends in the early period.

Fluctuations in landings result primarily from variations in crab year-class strength and the distribution of the stock, both of which are largely determined by density-independent factors of the environment. Spawning stocks are believed to produce numbers of larvae in excess of what is needed to maintain the adult population at a high level. The effect of environmental variables on year-class strength cannot clearly be determined when annual landings are used as the measure of fishing success. Annual landings in the Chesapeake are derived predominantly from two separate year classes of crabs, while a third year class may contribute about 5% of the catch. Retabulation of the data into 12-month biological-year landings from September of one year through the following August, feasible only since 1960 when monthly landings data were first published by the National Marine Fisheries Service (NMFS), permits the identification of single year classes, with an approximate 2-month overlap of adjacent year classes in mid-summer.

Although the exact mechanisms through which environmental variables affect year-class strength are unknown, it is expected that they occur at critical times in the life cycle of the blue crab. We have identified four major stages in the life cycle: (1) egg extrusion (spawning), hatching, and growth of larvae, (2) larval and early post-larval (megalopal) distribution, (3) the juvenile stage distribution, and (4) adult

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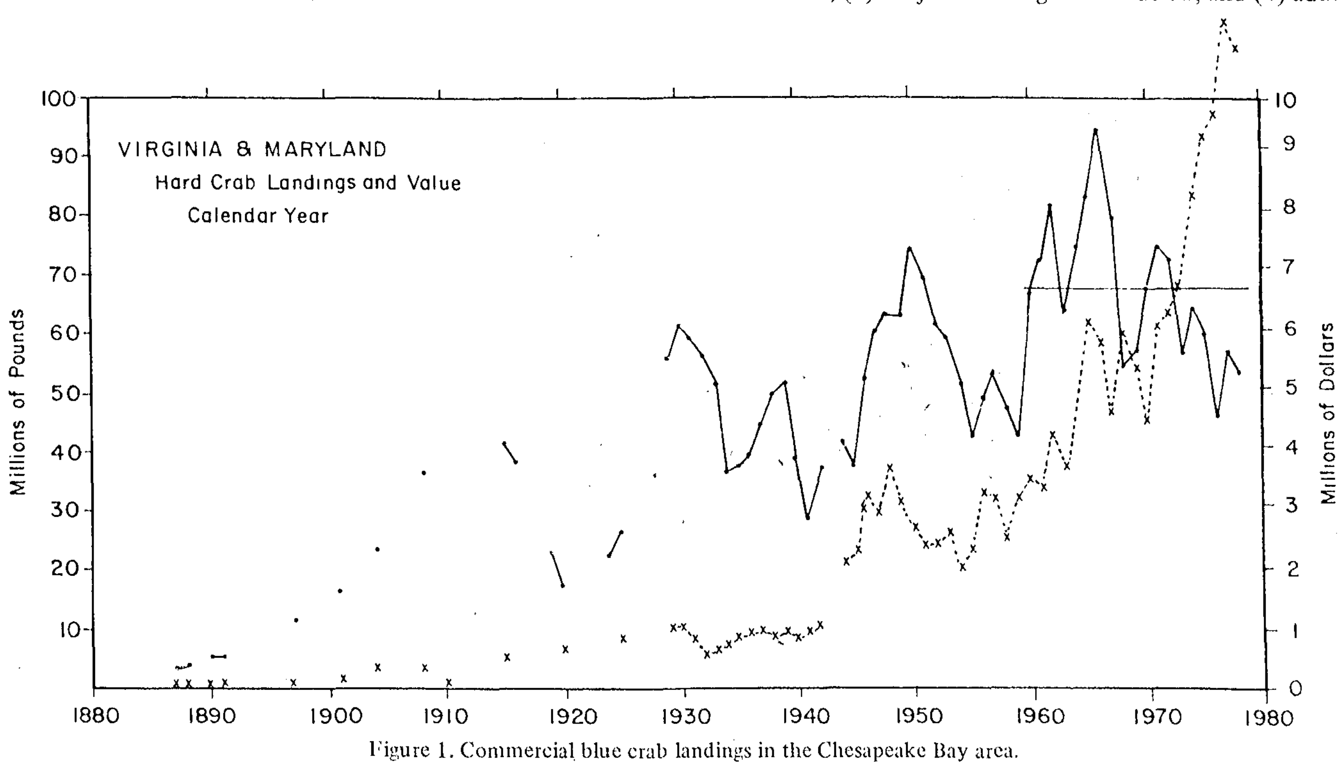

Figure 1. Commercial blue crab landings in the Chesapeake Bay area.

distribution. If managerial decisions are to be made to protect the blue crab resource, then both qualitative and quantitative information regarding the resource must be better described, including its relationship to chemical, physical, and biological factors of the aquatic ecosystem, as well as its economic value. There is a growing awareness of the effects of specific factors on aquatic life. Temperature, salinity, and substrate are the primary factors affecting growth, survival, and distribution of the blue crab. That these factors are optimal in the Chesapeake Bay is suggested by the fact that hard-shell crab landings by Virginia and Maryland watermen account for 45% of the total of east and Gulf coast landings (of those that are reported).

Surface water temperature in the bay normally ranges from 30 to 80°F, with lower and higher values being recorded. Salinities where crabs have been found range from fresh water to 34 ppt. Male crabs and juveniles of both sexes adjust to low salinities at low temperatures during winter when crabs are in the tributaries of the bay. Adult female crabs cannot adjust to these conditions in winter. Their migration each fall to the deeper waters of the southern end of the Chesapeake Bay, where salinities are greater than 15 ppt and temperatures are greater than 38°F, removes them from the stress in most winters. Watermen relate extreme winter cold to large dredge catches of dead female crabs in winter and a subsequent scarcity of crabs in their catch the following spring. After the extreme cold spells in the Chesapeake region in January 1977 and in February 1978, dead crabs were found in the dredge catch through March, varying from 20% of the catch in the southern, more saline portion of the bay, to 100% at the Virginia-Maryland border, where the salinity averages 15 ppt. Landings of crabs from January through May 1977 were only 29% of the 5-month average catch for the prior 18 years, and landings from February through May 1978 were 50% of the 4-month average landings of the last 18 years.

Eelgrass (*Zostera*) beds and tidal marshes are nursery grounds for juvenile blue crabs. The decimation of eelgrass, beginning in 1973 in the Chesapeake Bay and continuing to the present, coincides with a gradual decline in blue crab landings. In 1972, the Chesapeake Bay blue crab catch was 72 million pounds. The catch declined to 45 million pounds in 1976, a decrease of 37%. A striking parallel exists between the recent decrease in landings and the reduction in landings between 1930 and 1934. The commercial catch of 60.5 million pounds in 1930 declined to 36 million pounds in 1934, a decrease of 40% over 5 years. Explanations are varied for the die-off of the eelgrass in these two periods, separated by over 40 years. Warmer than normal winter and summer water temperatures occurred in the bay since 1972; these variations would discourage regrowth in winter and encourage massive defoliation of eelgrass in summer. Cownose rays, which cause destruction of eelgrass beds by digging for bivalves for food, are not believed to have been numerous enough to cause more than isolated instances of the disappearance of eelgrass. Herbicides are a potential pollutant and would be delivered to the rivers and the bay along with other chemicals in agricultural runoff. Their affects on eelgrass are now being studied. The original demise of eelgrass in the early 1930s in the Chesapeake Bay has frequently been ascribed to a mycetozoan called *Labyrinthula.*

Alternative evidence has been given that *Labyrinthula* does not kill *Zostera* but invades already destroyed plants. Also, it has been suggested that the 1930 *Zostera* die-off could have been caused by abnormal winter temperatures.

That commercial crab landings did not disappear during these two episodes suggests that the eelgrass beds are not the sole nursery grounds for blue crabs in the Chesapeake Bay. The value of tidal marshland as a nursery ground should be investigated.

Low pressure centers accompanied by high winds over the southern end of Chesapeake Bay occur frequently in winter. Winds blowing onshore or offshore for long periods of time produce large magnitude water currents, called wind tides. When the wind is blowing onshore, there will be a strong onshore surface current and a strong offshore subsurface current. The strength of these currents will be enhanced in relatively shallow water, such as in the Chesapeake Bay and on the Virginia coast, and when there is a large atmospheric pressure difference occurring in the passage of a storm center.

Apparently, crabs on the bay bottom can be helplessly swept along by these currents, and their shells abraded by the rough, sandy bottom. On February 16, 1964, thousands of dead female blue crabs were washed ashore at Virginia Beach, on the ocean side of Virginia, south of the mouth of the bay. These females had matured and mated the previous fall and could have spawned in about 4 months. They were not old, not reproductively exhausted females such as are seen dead along the southern shore of the bay each fall. Their top shells were smoothly abraded, superficially exposing a chalky layer, but often the shell was worn through. On March 6, 1969, the day after a storm had moved through the southern end of the Chesapeake Bay, over 40% of the crabs caught by crab dredgers had abraded shells; one half of them were dead. The abrasions were distinctly different from the marks of dredges. About 14% of the crabs were crushed, or had dredge tooth marks through the carapace or were missing the carapace. Atmospheric pressure at the center of the low was 972 mb at its passage through the southern end of Chesapeake Bay on March 5. The position of the low at 0700 EST on March 7 is shown in Figure 2.

Variations in the chemical, physical, and biological factors may be man made. Some have been described as being stresses on water quality and act upon physiological processes or ecological relationships or both. Pollution crises have become more common in news headlines, not because more of them are occurring now than there were

FRIDAY, MARCH 7, 1969

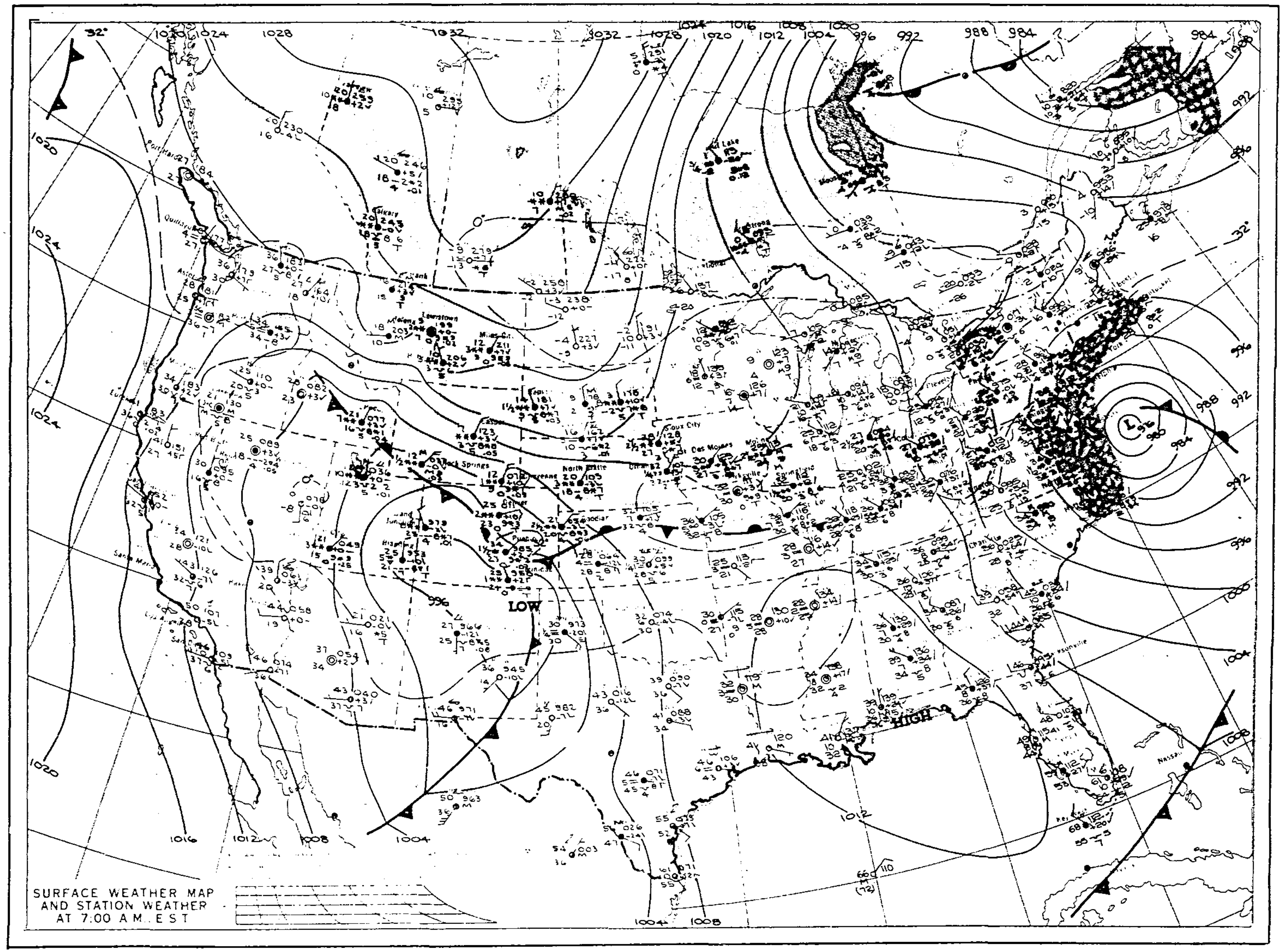

Figure 2. Weather map for Friday, March 7, 1969, showing position of low pressure at 0700 EST at the southern end of Chesapeake Bay.

25 or 50 years ago, but because we have developed more sensitive types of analytic instruments, devised better field sampling techniques and performed more numerous and more accurate, acute and chronic bioassays of potential pollutants on marine and estuarine organisms.

Awareness of chemical pollutants grows larger every year. Dichloro-diphenyl-trichloroethane (DDT), which had the most widespread use of all pesticides in the Chesapeake region from the end of World War II until the early 1970s, produced a characteristic paralysis and, ultimately, the death of blue crabs that were directly exposed or had consumed contaminated carcasses of other animals. The annual mortality from this pesticide remains unknown. The chlorinated hydrocarbon pesticide Kepone, released into the James River from the late 1950s to late 1975, was more restricted geographically in the Bay than was DDT. Mortality and lower rates of molting of crabs can be caused by the accumulation of the insecticide through consumption of contaminated live or dead animals which had accumulated Kepone. Commercial landings and juvenile crab abundance estimates have been lower in the James River than in the adjacent York and Rappahannock rivers for the past 15 years. However, the contribution of Kepone-related mortality to total deaths is unknown. There are numerous other potential sources of mortality in the James River. Between the James, York, and Rappahannock rivers, stresses on water quality are greatest in the James which has the heaviest industrial and municipal uses.

Sediment is the most significant pollutant from agriculture affecting water quality, although little is known of the full nature of its effects except for physical alteration of the substrate and reduction of light penetration. Pesticides, herbicides, fertilizers, and animal wastes, which are carried off the land, are potential aquatic pollutants dissolved in the water or adsorbed on sediment particles. Soft-shell crab shedding losses dramatically increase following each heavy rainfall in summer in the Chesapeake region, especially when the water is colored with suspended sediments.

Isolated instances of crab and fish mortalities occur in small tributaries following excessive freshwater runoff. Rapid decomposition of organic matter washed from the land, and decomposition of animals and plants killed by fresh water deplete the oxygen from the upper reaches of the tributary. The oxygen-depleted water mass then moves downstream with an ebb tide and a wave of mortalities ensues. After heavy rains in Norfolk, Virginia, in August 1949, refuse from a city sewage outfall overflowed into the Lafayette River. Decomposition and the resulting depletion of oxygen killed thousands of fish and crabs. Dissolved oxygen ranged from 0.2 to 1.4 ppm.

Low levels of dissolved oxygen are barriers to the migration of juvenile crabs from high salinity waters at the southern end of the bay to the brackish waters of the tributaries, and barriers to foraging by all sizes of crabs in the deeper channels of the rivers. Oxygen depletion in the deeper waters of Chesapeake Bay and in the Rappahannock, York, and James rivers occurs frequently in middle and late summer. Over the past 30 years, commercial crab-pot fishermen have frequently reported dead blue crabs in pots set in summer in deep waters in the mouth of the Rappahannock River and along the western shore of the Bay from the Patuxent River, Maryland, to New Point Comfort, Virginia.

During juvenile blue crab abundance surveys in the Potomac River in 1979, the only year we have trawled in that river, we found dissolved oxygen levels in the deeper waters to be as low or lower than those in other rivers we surveyed.

In summary, I have described probable important causes of mortality among blue crabs in the Chesapeake Bay. Intuitively and through circumstantial and some direct evidence, I believe that 10 to 50% of the crab population may die at any one time from one or a combination of physical and chemical factors.