Research Needs For Sustainable Blue Crab Production in Maryland

A Workshop Report

Sea Grant
Maryland Sea Grant College
College Park, Maryland

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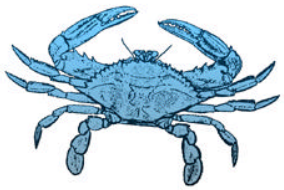

Reed Education Center
Smithsonian Environmental Research Center
Edgewater, Maryland
June 14, 2000

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Preface

For more than a century, research by numerous scientists on the complex life history and biology of *Callinectes sapidus* has contributed significantly to our understanding of the organism throughout its range on the Atlantic seaboard. While the earliest account of blue crab life history dates back to John Hopkins scientist William K. Brooks (Brooks 1882), other Maryland researchers such as R.V. Truitt (1939) and Eugene Cronin (1947; Pyle and Cronin 1950) at the Chesapeake Biological Laboratory began making seminal contributions to our understanding early on.

Over the last 25 years, research has intensified on many aspects of blue crab life history, physiology, ecology and recruitment. Olmi and Orth (1995), for example, provide a valuable historical context that highlights the long-term commitment of the research community to furthering our knowledge about blue crab recruitment throughout its range on the Atlantic seaboard. Most recently, in March 2000, a Blue Crab Symposium held at the Benthic Ecology Meeting in Wilmington, North Carolina, brought together researchers on a broad spectrum of blue crab issues, among them, reproduction and embryonic development, diseases and defense responses, planktonic, juvenile and adult ecology, and population dynamics.

In these last several years, research findings and monitoring indicators, both of which have contributed to blue crab management strategies in Chesapeake Bay, have been signaling that blue crabs are near the lowest point measured since fisheries-independent surveys began. This led the states of Maryland and Virginia to allocate $300,000 for a comprehensive analysis of the blue crab and its management in the Bay. Undertaken by the Chesapeake Bay Commission's Bi-State Blue Crab Advisory Committee. This investigation included researchers, resource managers, legislators, seafood processors and watermen. After an intensive two years of research, analysis and public hearings, the Bi-state Committee reached a consensus that blue crab stocks in the Bay were well below the long-term average and recommended an action agenda for modifying the management of the blue crab resource. In its conclusions, the Committee noted that management is not fixed, that it is "a work in progress" and that there are numerous areas where information and scientific knowledge "remain incomplete at best."

It is for this reason that Maryland Sea Grant convened a meeting of scientists in the state to help provide input on priority areas of research that could better contribute to more effective management of the blue crab resource in Chesapeake Bay. The participants were asked to draw on current scientific knowledge about the blue crab (for example, from the Blue Crab Symposium) to address specific issues of blue crab ecology, reproductive biology, population dynamics, habitat, and stock enhancement as a management tool. The scientists identified important short and long-term research priorities that could better inform sustainable management of the Bay blue crab; these priority needs cover (1) reproductive biology, (2) physiology, molecular biology and behavior, (3) habitat and (4) anthropogenic influences. This brief report summarizes their recommendations, which should be of aid in determining statewide goals for research over the coming years.

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Background

The blue crab is by far the dominant contributor to Maryland's seafood harvesting and processing activities. In 1999, blue crab harvest accounted for over 60% of Maryland watermen's commercial fishing income, $38.9 million of a total ex-vessel value of $63.3 million. Additionally, crabmeat production occurs in approximately 44 Bay area processing plants. These processing plants employ over 1,200 workers, and in 1999 had a sales volume estimated at $30.3 million.

Both the harvesting and processing sectors have been under stress in the Chesapeake Bay for some years now, with increasing commercial and recreational fishing effort yielding fewer numbers of crabs per unit of effort and smaller average sizes. In order to increase from current levels and sustain the blue crab resource, it is necessary to understand its population dynamics and the concurrent linkages to the harvesting and processing industries. Currently, the Bi-State Blue Crab Advisory Committee (BBCAC) of the Chesapeake Bay Commission is examining the status and health of the blue crab resource with the aim of determining how to improve management of the fishery. The ultimate goal is to ensure a healthy crab population and an economically viable industry. While the BBCAC effort is focusing some attention on blue crab biology and ecology — specifically the role of seagrass habitat and predation in effecting population abundance— less attention is being paid to the changing dynamics of the blue crab processing industry. Over the last two years this market has had to compete with a large increase in imports of crabmeat. Prior to that the expansion of the market for softshell crab was emphasized with a concurrent increase in crab shedding systems used to take advantage of the softshell market.

These factors have prompted Maryland Sea Grant to sponsor two meetings to complement the on-going efforts of the BBCAC. The first, held June 14, 2000, at the Smithsonian Environmental Research Center in Edgewater, Maryland, brought scientists together to discuss how we can best apply our current knowledge of blue crab biology, ecology and population dynamics to more effectively inform management efforts, and to identify key gaps requiring further research. A second meeting held in early autumn examined how we can more effectively apply our knowledge about seafood processing, product development and marketing in order to increase benefits from the blue crab resource.

This report summarizes key elements of the first meeting and identifies research needs that the participating scientists agreed would, if satisfied, provide important information relevant to the long-term health of this resource in Chesapeake Bay. It was clear that viewpoints differed as to the priority of these areas and which would have the greatest impact in the development of management strategies. As facilitators, we believe the summaries that follow provide a context for further discussions and general guidelines for the development of new funding initiatives that should incorporate input developed from other venues as well. Ultimately, these efforts also provide a context for discussion at many levels and the development of programs with appropriate scientific underpinnings.

Summaries of Presentations and Discussions

Concern over Blue Crab Declines in 2000

Douglas Lipton, Maryland Sea Grant Marine Economic Specialist, provided a chronology of the recent political and industry actions that have focused attention on the blue crab industry. In particular, he discussed the petition filed by domestic crabmeat producers to place a quota or tariff on imported crabmeat from Asia. This petition led to discussions among stakeholder groups to improve the situation regarding crab and crabmeat production in Maryland. On July 11, the International Trade Commission voted against the domestic industry by a 4-2 vote, thus, denying them federal assistance to compete with imported products. Meanwhile, the General Assembly appropriated $100,000 for crab research at the University of Maryland Center of Marine Biotechnology in 2000.

Research Issues

Blue Crab Ecology in the Chesapeake Bay

Victor Kennedy, Horn Point Laboratory, University of Maryland Center for Environmental Science (UMCES), presented an overview of the research that has led to the current understanding of the basic biology of *Callinectes sapidus* in Chesapeake Bay. Kennedy detailed the ecology and life history as well as the role of blue crab as both predator and prey. He emphasized the complex interaction between the highly motile blue crab and the physical as well as chemical dynamics of the estuarine system. Both estuarine circulation and signals from key habitats (e.g., seagrasses) are central elements in the blue crab's life history. The regulation of these interactions is largely unknown and constitute an important area of study that would almost certainly benefit long-term management efforts. Migration, spawning and molting are all thought to be tied to specific environmental cues that, to date, are not well understood. Similarly, it is known that a variety of small-scale interactions among populations within a given locality relate to food availability, habitat diversity and population level. Kennedy noted that the effect of predation on the crab population is a complex process and that cannibalism is important throughout the organism's life-history. In particular, our understanding of predation on crab larvae, post-larval stages and juveniles is poorly known. Crabs are thought to possess very keen olfactory senses that could be critical in the turbid, low light environments they occupy. The link to specific habitat types at different stages of the life-cycle is thought to be very important, as is the concept of physical refuges — particularly for soft shelled, post-molt individuals. Crabs are also susceptible to diseases of various types, both in natural populations as well as more intensive crab shedding operations and may be impacted by anthropogenic influences as well.

Reproductive Biology

Anson (Tuck) Hines, Smithsonian Estuarine Research Center (SERC), discussed various aspects of the reproductive biology of blue crab and its implications for resource management strategies.

Females mate once during their terminal molt while males mate multiple times. The quantity of sperm delivered by males per mating is dependent upon the interaction of several factors, including the size of the individual and the interval between mating. Hines noted that complete recharge of seminal fluid requires about 10 days and hence repeated matings during that interval yield less sperm per event. Data from the Rhode River suggests that about 50% of males are sperm-depleted at any given time. Pressure from the fishery also interacts with the organism's reproductive biology. Harvests are weighted preferentially towards large males and therefore lead to the development of a population dominated by small individuals. Thirty years of monitoring data by George Abbe, (Academy of Natural Sciences Estuarine Research Center, personal communication) on the Patuxent River has revealed that although the size of females has remained steady, there has been a distinct decrease in the size (carapace width) of males in his samples.

Taken together, natural mating strategies and selective harvest pressure yielding a preponderance of small males, suggest that over time a greater percentage of male crabs could be sperm-limited, therefore, delivering less sperm per mating. The implications of this depletion may be quite profound, but is, as of yet, unquantified. While Hines estimated that 95% of females in the Bay are mated, these matings may be based upon less than optimal sperm delivery and may yield insufficiently fertilized broods. Females mate only once, hence all fertilizations are tied to the quantity of sperm delivered during that event. They may contribute from 1-3 broods per season, each containing between 1-6 million eggs. On average, it is thought that females contribute 3-6 broods during their lifetime. The quality and fertility of eggs in a given brood is poorly understood, as is the age structure of the female population and its fecundity. In addition, it is also not known if sperm quality declines over time so that later broods have lower fertilization success.

Population Dynamics

Thomas Miller, Chesapeake Biological Laboratory, UMCES, posed fundamental questions about population dynamics that are critical for developing management strategies:

- What have been the patterns of abundance in the past and is there evidence for population regulation?
- What is the population structure and what are patterns of abundance likely to be in the future?
- Is the population sustainable and how can we ensure population sustainability?
- What patterns of exploitation are sustainable and what needs to be protected, e.g., life history stages, areas?

A major element in developing population models to answer these questions is a more accurate knowledge of blue crab growth in the field—in particular the rate of natural mortality. An integrated framework for management, Miller points out, must enable resource managers to identify (1) levels of crab abundance at which exploitation can occur, (2) combinations of crab abun-

dance and exploitation that are not acceptable for maintaining sustainable populations, and (3) combinations of crab abundance and exploitation that promote biologically optimal "use" of blue crabs. Miller argued that despite the lack of full knowledge about blue crab growth and ecology, population dynamics is sufficiently advanced to do the following:

- Project future population status over the short term
- Help guide resource management
- Quantify the impacts of alternative management actions
- Identify conservation measures compatible with sustainable exploitation

Miller's efforts are closely linked to the activities of BBCAC and aim at developing targets for blue crab fishing mortality and population abundance to support a sustainable fishery. The targets are based on models of the expected yield for every crab entering the population, but researchers acknowledge that there is an apparent uncoupling of spawning stock size and subsequent recruitment in this blue crab stock. BBCAC recommendations to fishery managers on harvest levels for ensuring sustainable populations are currently being discussed and managers will have to decide the mix of fishing activities (e.g., peeler and soft versus hard crabs) that they want to achieve.

Habitat

Court Stevenson, Horn Point Laboratory, UMCES, discussed the relationship between blue crab and Chesapeake Bay habitat. He noted that crabs are able to exploit a variety of habitats over the course of their life history, an observation supported by T. Hines who noted that crabs require an array or mosaic of habitat types to thrive. The actual make-up of these mosaics may vary and crabs appear to be adaptable to change. Stevenson suggested that research is needed to assess what types of alternate substrates can fill the role once provided by SAV and to what extent the decline of grasses impacts population levels. Marshes and small creek systems may play an important role for large adult crabs, while woody debris may be essential for juveniles. Anthropogenic influences have the potential to impact populations as well. New shoreline structures such as rip rap, jetties and piers may provide suitable physical substrate and cover while removal of woody debris for esthetic or navigational purposes has the potential to have a negative impact. Another important habitat issue is that of contaminants. Little is known regarding the impact that a variety of chemical contaminants present in the ecosystem have on the health of the blue crab population. Hence, anthropogenic alterations result in complex impacts that need to be assessed carefully within the context of crab biology and population dynamics.

Stevenson's presentation emphasized that habitat issues and responses in this area must consider multiple factors. He suggests that there is a net "habitat burden"to a population. If key habitats are lost, this burden may become sufficiently large to force declines or negatively

impact the recovery of the population. It is useful to think in terms of what habitat features are essential to crab stocks at given life cycle stages and where potential bottlenecks in population growth can occur if these areas are degraded or eliminated. The concept of refuges, therefore, needs to be very carefully considered within the context of the biology of the organism.

Stock Enhancement

Discussions during the workshop focused attention on the concept of blue crab stock enhancement—in particular the possibility of developing systems to efficiently produce mass quantities of larvae and/or juvenile crabs for release into Chesapeake Bay. Fisheries scientists and others voiced strong concerns that large scale stocking efforts would be ineffective as a means to enhance this fishery as it presently exists in a meaningful and economically viable way and noted that analogous efforts overseas had not fared well. While production of larvae and juveniles was viewed as potentially feasible, participants felt there were significant barriers to restocking. These included issues of predation, natural mortality and habitat, as well as the impact of natural variability in blue crab populations driven by multiple factors. In addition, the technology to assess whether or not stocking was having an impact on natural populations does not exist at present. Importantly, others felt that the issue of stock enhancement warranted further examination and should not be dismissed at this stage. Examples of success with non-crustacean species were noted, as were efforts to cultivate other crab species in the Pacific. There was little consensus among the groups on this point. We note, however, that there was interest within both groups for the development of intensive closed systems to produce and rear blue crabs under highly controlled conditions for research purposes. Given many of the research areas outlined previously, such systems were seen as an important tool for advances in many areas and indeed could be catalytic for the development of new collaborations within the Maryland scientific community.

Research Recommendations

Following overview presentations, participants identified important research areas that over the short-term and long-term could improve blue crab production in Chesapeake Bay and better inform sustainable management of a species that is of such economic and ecological importance. These research needs are presented in the following lists without priority. Further refinement of these research areas should be considered within the context of a formal program development and proposal review process.

Reproductive Biology

- Hormonal regulation of key aspects of crab reproduction, particularly basic aspects of endocrinology and the mechanisms regulating reproduction.
- Maturation processes (e.g., timing, cues) with an emphasis on improved understanding of the regulation of the terminal molt.
- Implications and impacts of smaller males and concurrent sperm limitation, and determine the biological consequences of increasing the minimum male harvest size.

Physiology, Molecular Biology and Behavior

- Cues, timing and regulation of molting, both in terms of natural populations as well as crab shedding applications.
- More refined condition indices for crabs at various life history stages to enable a more sophisticated understanding of environmental regulation of growth and development.
- Basis of aggression in crabs, which may provide important clues to the behavior of local populations.
- The molecular basis of molting to optimize production of soft shell and improve traditional crab shedding operations, including both flow-through and recirculating systems.

Habitat

- Minimum habitat needs and distributions for viable populations throughout the Bay. Assessing how alterations to habitat differentially impact crab life history stages.
- Importance of a mosaic of habitat types and new methodologies for accurately mapping and defining the relevant spatial and temporal scales that structure habitats that support viable populations. Linking these data to the development of spatially explicit models.

- Ecological implications of the loss of seagrass beds, in particular determining if small crabs are using alternate habitats (i.e., marshes and creeks) and their suitability with regard to issues such as size and predation pressure.

- If the decline in Bay grasses becomes a permanent element of the Bay ecosystem,will alternate natural habitats gain a greater role? What are the implications of sea level rise and the concurrent loss of marshes to crab populations?

Population Dynamics

- Estimates of natural mortality rate based upon marked recapture experiments or by catch curve analysis.

- Estimates of lifetime fecundity and recruitment.

- Quantify distributional patterns in Chesapeake Bay.

Anthropogenic Influences

- Given the importance of olfactory cues, assess potential impacts of anthropogenic influences (i.e., contaminants and toxic chemicals) on crab behavior.

- Impact of endocrine disruptors, as well as other toxic chemicals on reproduction, molting, and other physiological processes.

- Given the changing habitat of the Bay region, evaluate the role that alternate structures (rip rap, piers, debris) are playing for crabs at different life cycle stages.What are the impacts and potential benefits of ongoing habitat restoration efforts (particularly with regard to oyster reefs) to crab populations?

Summary

There is clearly strong support for significantly improving Baywide management of blue crabs as evidenced by widespread stakeholder concern. The BBCAC, along with its Technical Work Group, has issued a consensus statement that galvanized this point. Furthermore, Virginia has already taken regulatory action to ban summertime harvesting in a spawning sanctuary, and, reduce the number of peeler pots allowed to be fished. Further management changes are expected beginning in the 2001 crabbing season. There is strong agreement throughout the Bay watershed that developing a better understanding of issues related to reproductive biology, physiology, habitat requirements, anthropogenic factors and improved production of soft shell crabs are all major factors that, over the long term, will enhance the ability to sustainably manage this resource.

From this convening of Maryland researchers, it is clear that strong scientific expertise resides throughout the Bay region to begin making substantive progress on these issues. It was also clear that there are numbers of opportunities for constructive collaboration among scientists with very different backgrounds and approaches in addressing these issues. Because of concern over the blue crab resource expressed by federal and state agencies, legislators and important stakeholder interests, a receptive climate exists for the support of innovative research that can forge strong collaborations for addressing the complex issues detailed in this report. Solving these issues that will be essential for ensuring optimal production of the blue crab in Chesapeake Bay and for sustaining the communities that depend on this fishery for their livelihood.

Participants

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