

FINAL REPORT

**MARYLAND BLUE CRAB STOCK ENHANCEMENT
REVIEW**

Review Committee

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ACKNOWLEDGEMENTS

The members of the Maryland Blue crab Stock Enhancement Review Committee would like to express our appreciation to all who worked to make this a successful process. The staff of the Maryland Department of Natural Resources including Lynn Fegley and Glenn Davis, and many of the BCARC partners led by Yoni Zohar pulled together much of the information for the briefing book in a very short time frame. Doug Lipton of the University of Maryland Sea Grant Program lent his time and expertise to brief the committee on the economics of the Maryland blue crab fishery and many of the BCARC partners provided in-depth presentations of various aspects of their research. Derek Orner of the NOAA Chesapeake Bay Program Office provided scientific guidance to the Review Committee as an ex-officio member. Andrew Loftus coordinated the review process and edited the report.

EXECUTIVE SUMMARY

MARYLAND BLUE CRAB STOCK ENHANCEMENT REVIEW

At the request of the Maryland Secretary of Natural Resources, a review was conducted to evaluate the efficacy, both from a biological and economic viewpoint, of stocking juvenile blue crabs to enhance the adult stock of blue crabs in the Chesapeake Bay. The focus of this review was on the Blue Crab Advanced Research Consortium (BCARC). BCARC is an integrated program to raise juvenile crabs in hatchery facilities (under the auspices of the University of Maryland Biotechnology Institute's Center of Marine Biotechnology) and develop a responsible approach to stock enhancement in the Chesapeake Bay.

The accomplishments and procedures followed, by BCARC in the past eight years have, without doubt, been excellent and provide a strong basis for evaluating a fully developed stock enhancement project. However, the available information is not sufficient to definitively evaluate the probable success of stocking efforts for significantly enhancing the spawning population. The BCARC effort would not be an enhancement project during the next several years but would still be in a "proof-of-concept" phase. During this phase, BCARC would need to demonstrate that they could develop the capacity for full production (10 million juvenile crabs per year), provide solid research results enumerating the actual contribution of released crabs to the spawning stock, provide some evidence that the offspring of these hatchery crabs return back to the Chesapeake Bay blue crab stock, and demonstrate its economic viability. As a proof-of-concept effort, the panel finds merit in funding for four years; three years to ramp up juvenile production and continue research and a fourth to enable a full evaluation of the effect of stocking as well as to evaluate the effectiveness of management measures.

Even in full production mode (2012 and beyond), the stock enhancement effort should only be viewed as a potential supplement to sustainable rational management. The 2008-2009 regulatory actions taken by the Chesapeake Bay jurisdictions to restrict harvest of mature females are predicted to result in 20-25 million additional mature females on the spawning grounds at the mouth of the Bay annually. At the full production mode (sometime beyond 2012), the BCARC efforts will result in an estimated additional 1 million mature females on the spawning ground. Considerable uncertainty exists about the success of either of these approaches. Continuing to fund the stock enhancement program would allow the established research to continue and provide an "insurance policy" while the actual effects of both the recent management efforts and the potential effect of stocking efforts are evaluated. If the BCARC effort were allowed to end completely, re-starting or reconstituting the enhancement effort (facilities and expertise) would be very difficult and expensive. However, the Review Committee also recognizes that it would be relatively expensive to continue as well.

Field trials conducted by BCARC demonstrate that hatchery-produced crabs stocked as juveniles can survive, grow to adults, and that the females migrate to the spawning grounds. Although the likely quantitative effect of stock enhancement is difficult to ascertain, any increase in females will have a positive influence on the condition of blue crab stocks not only in the Chesapeake Bay but on the Atlantic seaboard.

It is imperative that decision makers realize the importance of proper stock management with or without stock enhancement. The BCARC stock enhancement program (and the proof-of-concept phase) is predicated on substantial changes in the management structure for blue crabs. This includes establishing migration corridors (complete closure of all crabbing, not just harvest) to allow females to reach the spawning grounds at the mouth of the Bay and/or selection of stocking sites in close proximity to the existing Virginia refuge zone. Without associated management regulations, the effect of stocking would be muted. With strong management measures, applied consistently over time, there may be no need for enhancement. This also may be a point for consideration in the funding decision process.

Based on experience, the Review Committee has reservations about the ability of the state agencies to maintain the management restrictions recently put in place to protect mature females. These restrictions will only reach their full potential if policymakers continue to support them, as constituent pressure to relax restrictions likely will grow in the face of anticipated increases in stock size and as a generally declining economy drives more people to consider commercial fishing as a way to augment personal income. The Review Committee expresses substantial concerns about the potential impact of the “latent fishing effort” (represented in the thousands of crabbing licenses that exist but are not currently used) on wild and stocked crabs. If a large influx of crabbers materializes to take advantage of increasing stock sizes or in response to the difficult economy, improvements in stock condition can quickly be overwhelmed by increasing effort. Both Maryland and Virginia have taken measures to begin to control this latent effort and these efforts should be expanded and continued.

The economic efficacy of the blue crab stock enhancement program could not accurately be determined, although we believe that data does exist to conduct a more thorough economic analysis. The success of either stock enhancement or management regulations will depend on whether increases in stock abundance will increase yields. The change in yield could increase or reduce economic impacts (jobs, income, and sales) depending on how prices are affected; that is whether they remain the same or decline. If prices remain the same, revenues will increase and economic impacts will increase. If prices decline as supplies increase, then revenues will increase by lesser amounts or decline. A decline in revenues if prices fall sufficiently would cause economic impacts to decline even as benefits to blue crab consumers increase.

In terms of budgetary implications, a 3-year budget totaling \$8.1 million was presented to the Review Committee. BCARC estimates that production costs alone (cost/juvenile crab produced) would be \$0.25 during the proof-of-concept phase. However, this considers only production costs, not research and evaluation costs. Factoring in all costs, the cost/juvenile produced would range from \$1.96 - \$4.87 (or \$20-\$49 per mature female resulting) based on the budget and other factors presented by BCARC. In the context of the focus on stock enhancement, some proposed program items could be removed that, although worthy, do not contribute directly to the enhancement goal. However, the Review Committee strongly suggests that the genetic analysis component be reviewed to ensure that it is adequate. With proper direction, the genetic analysis component could be used to evaluate the success of management measures to protect mature females, and especially their contribution to future year classes of recruits, as well as any contribution of stocking to the population.

Additionally, the economic analysis component should be increased and be made an explicit part of the on-going research program and a professional communications position should be added to the program.

The decision for the state of Maryland is whether to support four years of funding (or develop alternative funding via partnerships with the Commonwealth of Virginia or other options) to: 1) determine if stock enhancement will be effective (e.g., research and evaluation, not enhancement) and cost effective; 2) continue well established research; and 3) continue the availability of blue crab juveniles for stock enhancement in the case of stock failure. Integral to this decision is a commitment to substantially modify management regulations to maintain a focus on bolstering the spawning population, not on simply enhancing the fishery.

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MARYLAND BLUE CRAB STOCK ENHANCEMENT REVIEW

Background

The Blue Crab Advanced Research Consortium (BCARC) is a coalition of university, state, federal, and private-sector partners dedicated to developing tools and techniques for effectively enhancing blue crab populations through the use of hatchery-reared juvenile animals. The centerpiece of the BCARC Program is the blue crab hatchery and grow-out facilities operated under the auspices of the Center of Marine Biotechnology (COMB) under the University of Maryland Biotechnology Institute. The objective for the stock enhancement component of the BCARC program is “augmenting the spawning stock in the spawning grounds” which is at the mouth of the Chesapeake Bay.

Since 2001, BCARC has received \$16.06 million in federal funding (\$11.16 of which funded Maryland efforts) and \$800,000 in private and state funding. During that time, they have built a physical infrastructure (located primarily in Baltimore with a grow-out facility at Piney Point) and established a diverse team of professionals specializing in endocrinology, genetics, hatchery production, disease, and other specialties required for such an initiative. Other state, federal, and private BCARC partners in Maryland, Virginia, Mississippi, and North Carolina focus on stock enhancement, pond aquaculture, and other aspects related to the mission of the partnership.

In 2008, the federal funding that provided the core support for this program was discontinued. Through a no-cost extension, the BCARC partnership will be able to continue in operation until June of 2009. Without replacement of this funding, the BCARC program, including the core hatchery component, will discontinue.

Review History and Process

In mid 2008, University of Maryland Chancellor William Kirwan and Maryland Secretary of Natural Resources John Griffin agreed to move forward with an independent review of the impact and efficacy of using stock enhancement as a component of efforts to increase the spawning stock of blue crabs in the Chesapeake Bay. Using a list of potential independent experts to serve on this Review Committee as a basis, four experts in their respective fields were selected:

Mr. Lee Blankenship, Director of Biological Services, Northwest Marine Technologies
Dr. Richard Forward, Professor of Zoology, Duke University
Dr. Paul Sandifer, Senior Scientist for Coastal Ecology, NOAA National Ocean Service
Dr. John Ward, Senior Economist, Office of Sustainable Fisheries, NOAA National Marine Fisheries Service.

In late November-early December, a briefing book was prepared with materials provided by the Maryland Department of Natural Resources and the BCARC partners containing key information

needed for this review. On January 8-9, 2009, the Review Committee met in Annapolis to hear presentations from BCARC partners and the Maryland DNR and to query them on specific aspects of the program. The findings contained within this report are derived from this process.

Review Charge

The objective of the review as provided by Secretary Griffin was to “evaluate the efficacy, both from a biological and economic viewpoint, of stocking juvenile blue crabs to enhance the adult stock of blue crabs in the Chesapeake Bay.” To assist in accomplishing this, the Review Committee was provided with a series of guidance questions to help focus the review. While the Review Committee has made every attempt to address these guidance questions, we did not feel restricted simply to these questions if a topic was uncovered that directly applied to the review objective. Nevertheless, the structure of this report is centered on those guidance questions.

Review Findings

General Summary

Status of Chesapeake Blue Crab - The Review Committee has little doubt that the blue crab population in the Chesapeake Bay is currently near a historical low based on the time series of data available. Information provided by the Maryland Department of Natural Resources (MDDNR) staff, the Chesapeake Bay Stock Assessment Committee (CBSAC), and BCARC partners, indicate that the limited recruitment of juvenile crabs into the population is likely a major contributing factor to these low numbers. Note that the Review Committee is not making any judgments as to the causative factors for this limited recruitment, but simply that evidence indicates that low recruitment in general is occurring. Since a population limited by juvenile recruitment is a potential candidate for stock enhancement, the blue crab population in the Chesapeake Bay qualifies as a candidate species. It should be noted that both BCARC and CBSAC agree that survival rates of mature females are low and may be preventing recovery, which has led to the Bay jurisdictions’ recent management actions to reduce harvest of mature female crabs by 34%.

General Impressions of BCARC Efforts to Date - Since the BCARC effort began to explore the use of hatchery-reared blue crabs for research and management in 2001, the partners have established an impressive track record of aquacultural and scientific achievement. Following the established standards for responsible stock enhancement¹, the effort has developed an infrastructure and procedures that are necessary precursors to any sound stock enhancement or research program. In addition to researching the stock enhancement objective, BCARC partners have conducted limited aquaculture assessments (e.g., for pond culture and soft shell crab markets) that appear to have substantial promise but do not have direct implications for the stock enhancement purposes that are the focus of this review.

¹ Blankenship, H. L. and K. M. Leber. 1995. A responsible approach to marine stock enhancement. In: Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society Symposium 15:165-175.

Finding 1. The work conducted by BCARC to date has followed established scientific principles and standards. This provides a knowledge base that is necessary for any stock enhancement initiative.

Proof of Concept, Not Enhancement - Notwithstanding a substantial record of accomplishment, the BCARC effort is not yet developed to the point that it could be a fully functional stock enhancement program nor even to the state that its potential for effective contribution can be fully evaluated. This is not a criticism of the program. BCARC should be applauded for investing the time needed to establish the foundation on which a more fully developed program potentially could be developed. This includes: 1) developing the techniques for successful mass rearing of blue crabs to early juvenile stages; 2) conducting basic genetics work to allow the identification of different stocks of crabs and to delineate between stocked and naturally produced crabs; 3) exploring potential diseases that could affect reared and wild crabs prior to stocking crabs into open waters; 4) investigating possible morphological and behavioral differences between stocked and wild crabs, and; 5) conducting limited, controlled stocking events to test various hypotheses before more extensive (and expensive) stocking for potential enhancement purposes is conducted. Due to this measured and deliberative approach, the effort has not yet demonstrated the efficacy of stock enhancement to increase the spawning population of blue crabs and, in fact, is only now on the cusp of being able to launch a pilot, or proof-of-concept project that may enable them to produce and stock crabs in sufficient quantities to allow for more substantive analysis of the possible contribution of stock enhancement to the overall blue crab population. According to the information provided to the Review Committee, BCARC would require three full years to develop the production capacity for an adequate “proof-of-concept” program. For purposes of this report, “proof-of concept” entails three critical elements: 1) demonstrating the ability to actually raise 1.5 million juvenile crabs in year 3 within the footprint of available facilities as an indicator of capacity to produce the ultimate desired number of crabs for stocking (10 million) in expanded facilities in follow-on work after the proof-of-concept stage; 2) providing solid research indicating reared juveniles actually grow and contribute to the spawning stock at the mouth of the Bay, and; 3) providing some evidence that the offspring of these hatchery crabs return back to the Chesapeake Bay blue crab stock.

As projected by BCARC, continued funding at the levels requested would allow them to produce and stock 500,000 juvenile crabs in 2009, 1 million juvenile crabs in 2010, and 1.5 million juvenile blue crabs in 2011. Since juvenile crabs require 1-2 years to grow to a mature crab, the Review Committee believes that at least one more year would be required to evaluate the success (number of stocked female crabs reaching the mouth of the Bay) of the prior years’ stocking, meaning that the proof-of-concept phase is, at a minimum, a four year effort.

Finding 2. The BCARC effort in its current phase (2009-2011) cannot be considered a stock enhancement project but rather is a proof-of-concept phase preceding a full fledged enhancement program. This should be considered as a 4 year endeavor, at a minimum, to fully evaluate the *possible* effect of stocking on blue crab populations.

Economic Efficacy - The Review Committee was asked to assess various aspects of the economic efficacy of stock enhancement efforts and compare those with the cost/benefit of traditional blue

crab management options. A comprehensive cost-benefit analysis was not provided to the Review Committee; minimal and disparate information was provided to determine the change in economic value for the stock enhancement project. A second necessary component of this assessment is the economic impact of both the proposed and traditional management options. However, an accurate measure of economic impacts (jobs, income, and sales) depends on the accurate estimation of changes in costs and benefits due to the enhancement projects. Given the information that the Review Committee was either provided or has as prior knowledge, we believe that the basic data for such calculations may exist. However, this is not something that could be completed in a brief review process. Instead, a concerted effort by a professional with experience in the field of resource economics is needed to collect and analyze the information, including the ongoing value of contributions from BCARC research, in order to provide a solid basis for making these assessments. As an example, the proof-of-concept phase of the project may provide more favorable culture cost estimates due to economy of scale.

A second consideration for the economic efficacy of this project is the concern with the uncertainty associated with present management strategies. The large number of inactive permits (discussed later), and the inability to constrain behavior of existing watermen creates uncertainty about the probability of success of the existing management programs. Economic value based on cost-benefit analysis and economic impacts based on input-output models and their multipliers depend upon human activities. If those activities result from open access management, then economic values are depressed while if they result from rational or rights-based management then economic values can be substantial. The uncertainty of the outcomes of management strategies affect the degree of change in economic values and the resulting economic impacts on jobs, income, and sales. Given this degree of uncertainty, the cost of maintaining the option to adopt a stock enhancement program over the next four years is represented by the budget of this proposed project. That is, if present management measures fail to increase stock abundance as a result of open access fishery behavior by watermen with latent permits, the loss in net benefits that may result could be possibly offset to some, as yet unknown, degree by the adoption of stock enhancement techniques to prevent a failure of the fishery.

Finding 3. Determining the economic efficacy of stock enhancement is difficult, but the information likely exists and could be analyzed with additional resources.

Finding 4. The cost of more fully evaluating a stock enhancement option via the proposed proof-of-concept phase is likely less than the costs of a fishery collapse if existing management measures are not successful.

Need for Improved Communication – Often, because of the structure of research institutions and state government, communication and information exchange are not optimal. The BCARC partnership is composed of diverse entities from state, federal, university, and private sectors. The BCARC grow-out facility at Piney Point is a MDDNR-owned facility operated through a Memorandum of Understanding between the two entities. Despite these partnerships, the Review Committee is concerned about the perceived lack of integration of the BCARC efforts into the overall bay-wide blue crab management planning process. The day-to-day working partnerships of BCARC appear oriented toward other research entities (e.g., VIMS, North Carolina State University, Smithsonian Environmental Research Center, etc.), not directly with

the MDDNR, Potomac River Fisheries Commission, and Virginia Marine Resources Commission who ultimately manage this public resource and without whose active participation no operational enhancement effort could be successful. We are not discounting the individual interactions between specific BCARC partners and these agencies, but as an entity with the ultimate goal of enhancement of a public resource, the partnerships with management agencies likely can be improved. This will become particularly important if BCARC moves into a more substantial enhancement phase and if substantial funding is received from the MDDNR or other agencies. It is somewhat perplexing that after eight years of what should have been considered “temporary” funding (Congressional appropriations) BCARC has not developed a long range funding plan with the state agencies responsible for the management of this resource and is now in a position to scramble to find such funding in a period of a few months. If MDDNR decides to fund some or all of the BCARC work, it may be advantageous for the agency to assign one of their biologists as a co-investigator with the BCARC team.

Finding 5. The Review Committee feels that increased interaction between management agencies and BCARC is imperative, particularly if the effort moves forward into the proposed proof-of-concept phase and possibly beyond and receives core funding from these agencies.

Potential for Increasing Blue Crab Numbers

Question #1: *Is there promise for substantially increasing the number of blue crabs in the Bay based on the research done to date by BCARC scientists?*

As stated in the “General Summary” above, the BCARC effort, if continued, would be only in a “proof-of-concept” phase through at least 2012. BCARC field trials have indicated that “localized enhancement of blue crab populations is successful at small spatial scales”² and under certain conditions. Stocking in these field trials was conducted in areas with low blue crab juvenile density and suitable habitat conditions. Although survival rates at individual sites and at different times of the year vary, survivorship to maturity averaged 12%³. At a very minimum, stocking is likely to result in some additional female blue crabs entering the spawning population, assuming some effective level of protection from fishing mortality as they move from the stocking sites to the spawning grounds at the mouth of the Bay. Whether this potential addition of a small number of adult females would effect the future blue crab population remains an open question. At low stock abundance levels, every additional female could be considered an asset. However, whether these levels would be “substantial” depends entirely on the number of crabs that are stocked, the relative size of the spawning stock in any given year, the actual survival of females that reach the mouth of the Bay and *spawn* and the eventual recruitment of juveniles from such spawns.

Finding 6. Although preliminary trials indicate that hatchery-reared juvenile blue crabs can survive and migrate to the spawning areas at the mouth of the Bay, the Review Committee cannot conclude that there is “promise for substantially increasing the number

² “Executive Summary for External Review” – Blue Crab Advanced Research Consortium, December 2008.

³ “Executive Summary for External Review” – Blue Crab Advanced Research Consortium, December 2008

of blue crabs in the Bay.” In fact, it is clear that the greatest potential for an increase in the spawning population through stocking would be when that population was reduced to very low levels and when strong protection was given to migration corridors for stocked crabs.

Finding 7. Adding any additional females to the spawning stock, regardless of the stock size, could be beneficial, with the greatest benefit occurring when the spawning stock is very low.

A crucial aspect of the ability to detect the contribution of hatchery reared crabs to the spawning population will be maintaining a strong genetic identification component. By identifying unique genetic markers in hatchery reared blue crabs, BCARC researchers have been able to track the movement of these crabs as they are harvested or collected by scientists. This or similar efforts could also provide crucial information for detection of recruits from wild spawners, thereby providing some measure of the ultimate success of management measures. The Review Committee considers this component of the program to be crucial to future efforts to assess the success of the stocking efforts and strongly encourages that due consideration be given in the budget and the program development to maintaining this technical capability.

Finding 8. The ability to detect hatchery blue crabs through unique genetic markers has been a strong component of the BCARC effort to date. Future efforts should improve upon the markers (as needed) and reduce the cost/crab in order to evaluate stocked crab contributions. This is a crucial component and must be maintained.

Quantitative Effect on Spawning Stock

Question #2: *What would be the likely quantitative effect of the BCARC program on the Chesapeake Bay spawning stock?*

BCARC partners have estimated that the number of adult female crabs that reach the spawning grounds at the mouth of the Bay would be approximately 10% of any given stocking *in the absence of any fishing mortality*.^{4,5} For example, a stocking of 1 million juveniles (50% males; 50% females), as is the goal in the second year of the proof-of-concept phase, would yield 100,000 adult female crabs reaching the spawning grounds if they were allowed to traverse the corridors to this area without being harvested. There is no empirical evidence to support this survival rate for hatchery reared crabs; it was derived simply by applying the natural mortality of juvenile crabs over a two-year time period (time to reach maturity and migrate to the mouth of the Bay).

Finding 9. The estimate that 10% of the total number of blue crabs stocked will result in spawning females at the mouth of the Bay is not supported by empirical data. A sensitivity

⁴ Lipcius, Rom. Personal communication, Blue Crab Stock Enhancement Review, January 9, 2009.

⁵ Zohar, Yonathan, Hines, Anson H., Zmora, Oded, Johnson, Eric G., Lipcius, Romuald N., Seitz, Rochelle D., Eggleston, David B., Place, Allen R., Schott, Eric J., Stubblefield, John D. and Chung, J. Sook. 2008. The Chesapeake Bay Blue Crab (*Callinectes sapidus*): A Multidisciplinary Approach to Responsible Stock Replenishment. *Reviews in Fisheries Science*, 16:1, 24 - 34

analysis of this estimate should be conducted to provide a potential range of the impact of stocking on the spawning population.

Finding 10. The objective for both enhancement and management is to increase the spawning stock. It is not clear what the impact on recruitment would be from a given increase in the spawning stock, regardless of how achieved (i.e., by harvest management, stocking, or combination of the two).

Benefits and Detriments of stock Enhancement

Question #3: *What are the benefits and detriments of enhancement for the replenishment of the blue crab in the Chesapeake Bay?*

From 2001-2008, the BCARC partners have generally followed the principles outlined for a responsible approach to stock enhancement. Broadly, these principles require consideration of all potentially beneficial and detrimental aspects of stock enhancement, including disease consideration in the hatchery and the wild, impact of stocking on wild populations, genetic considerations, interaction with other components of the ecosystem, and various rearing practices. No concerns have been identified regarding disease issues or substantial differences in morphology between hatchery and wild crabs. Limited field trials have indicated no ecosystem impacts when hatchery crabs are stocked in open waters.

Finding 11. There appears to be little risk or potential detriment from going forward into the proof-of-concept phase of this program, assuming the responsible approach to stock enhancement continues to be followed.

Given the advances made by BCARC in the last eight years in research and development of hatchery production, and the fact that the Review Committee has not seen any evidence of biological risk of stock enhancement, policy makers should give prudent consideration to maintaining components of this program as an “insurance policy” against stock collapse or lack of desired effect from increased harvest management regulations. As stated previously, the greatest benefits of a stock enhancement program of this type would come at times of very low levels of the spawning stock. Developing and maintaining production capability for the event of further stock collapse will not prevent the collapse but it would be ready in the event that stock supplementation was desperately needed. It should also be noted that the potential benefits of stock enhancement are not limited to the state of Maryland. Due to open ocean currents and vagaries of weather that influence the dispersal of larval blue crabs, the Chesapeake Bay blue crab stock impacts, and is impacted by, other stocks of blue crab along the East coast. Maryland enhancement projects, if successful, will undoubtedly benefit Virginia and likely North Carolina, and Delaware as well.

Finding 12. Any potential increase in the contribution of larvae resulting from the spawn of hatchery produced crabs at the mouth of the Bay would likely be advantageous to the mid Atlantic population of blue crab.

A drawback from any stock enhancement project is the potential to divert the public's (and policy maker's) attention from the root cause of the problems of low stock abundance. Unless a decision is made to use stocking for the purposes of "put-and-take" or simply research (e.g., life history etc.), the focus should be on restoring the wild population to levels that do not require stock enhancement. However, some view stocking as a curative for deeper ills restricting the productivity of the system. Simply putting "more crabs in the water" may divert attention from tackling tough (and often expensive) root causes, such as habitat degradation, over harvesting, and lack of sufficiently strong protection for wild spawners. Additionally, under political pressure, hatchery production could easily be diverted to the potentially more lucrative blue crab aquaculture industry and thereby dilute resources being applied to management activities. Although no evidence was presented that would cause the Review Committee to believe that the Chesapeake Bay blue crab stock enhancement program is viewed as the ultimate cure, it is a caution that should be raised about any stocking project.

Financial Costs of Stock Enhancement

Focus Question #4: *What would be the cost of such an effort both in terms of capital investments and ongoing operational expenditures?*

The following 3-year budget has been provided by the BCARC partners for 2009-2011:

BUDGET REQUEST SUMMARY

Center of Marine Biotechnology, UMBI				Crab Project			Total
				Year 1	Year 2	Year 3	Years 1-3
Crab Project							
A. SALARIES AND WAGES							
MAN-MONTHS							
1. SENIOR PERSONNEL	No. of People	Amt. Of Effort					
a. (Co) Principal Investigator	0	-					
b. Associates (Faculty or staff)	6	varies	\$125,057	\$128,808	\$132,673	\$386,538	
Sub Total							
2. OTHER PERSONNEL							
a. Professionals	0	-					
b. Research associates	0	-					
c. Intern	3	100%	\$13,500	\$13,905	\$14,322	\$41,727	
d. Prof. School Students		-					
e. Pre-Bac. Students	0	-					
f. Secretarial-clerical		-					
g. Technical-shop	13	varies	\$226,634	\$325,233	\$396,790	\$948,657	
h. Other		-			\$0		
Total Salaries and Wages			\$365,191	\$467,946	\$543,785	\$1,376,922	
B. FRINGE BENEFITS 40% (when charged as a direct cost)				\$146,076	\$187,179	\$217,514	\$550,769
Total Personnel (A and B)				\$511,267	\$655,125	\$761,299	\$1,927,691
C. EQUIPMENT				\$300,000	\$300,000	\$300,000	\$900,000
D. EXPENDABLE SUPPLIES				\$175,000	\$179,650	\$184,440	\$539,090
E. TRAVEL							
1. Domestic - U.S. and its Possessions (Inc. Puerto Rico)				\$2,600	\$2,678	\$2,758	\$8,036
2. International				\$1,200	\$1,236	\$1,273	\$3,709
Total Travel				\$3,800	\$3,914	\$4,031	\$11,745
F. PUBLICATIONS AND DOCUMENTATION COSTS				\$1,000	\$1,030	\$1,061	\$3,091
G. OTHER COSTS							
1. Information Technology Costs				\$10,956	\$14,038	\$16,314	\$41,308
2. Analytical Services				\$10,956	\$14,038	\$16,314	\$41,308
3. Genetic Analysis				\$80,000	\$88,000	\$96,800	\$264,800
4. Consultant				\$5,000	\$5,000	\$5,000	\$15,000
5. Subcontract (SERC)				\$600,238	\$618,245	\$636,792	\$1,855,276
6. Subcontract (VIMS)				\$300,027	\$309,028	\$318,299	\$927,353
7. Subcontract (NCSU)				\$100,000	\$103,000	\$106,090	\$309,090
8. Subcontract (MWA)				\$37,184	\$74,368	\$76,599	\$188,151
9. Subcontract (Fishery Economist)				\$30,000	\$30,000	\$30,000	\$90,000
10. Maintenance Agreement for Equip Repair				\$10,000	\$10,000	\$10,000	\$30,000
11. Tuition							
12. ARC Charges				\$25,900	\$38,850	\$51,800	\$116,550
13. Vehicle lease				\$7,200	\$7,416	\$7,638	\$22,254
Total Other Costs				\$1,217,460	\$1,311,984	\$1,371,645	\$3,901,089
TOTAL DIRECT COSTS (A through G)				\$2,208,527	\$2,451,703	\$2,622,477	\$7,282,707
MODIFIED TOTAL DIRECT COSTS				\$908,262	\$1,121,430	\$1,261,295	\$3,290,988
INDIRECT COSTS							
	%	AMT					
On Campus	25.0%						
Off Campus							
Total Indirect Cost			\$227,066	\$280,357	\$315,324	\$822,747	
TOTAL COSTS				\$2,435,593	\$2,732,060	\$2,937,800	\$8,105,454

As can be seen, BCARC is projecting a need for \$8.1 million for a 3-year proof-of-concept phase. It is important to reiterate that this budget represents a “scale-up test phase,” not a full stock enhancement phase that would presumably occur in 2012 and beyond. As such, it does not include the capital and operating costs for the full-scale hatchery and nursery facilities necessary to produce the target of 10 million juvenile crabs per year beginning in 2012 and ongoing⁶.

Upon examination of this budget, it is clear that not all components are vital for the narrowly focused stock enhancement purposes that are the subject of this review. Although these components have merit in their own right and no negative judgment is being made by the Review Committee, they may be eliminated from a request for stock enhancement. For example, the “subcontract to NCSU” line item (\$309,090 over three years) is to support ongoing work in their pond aquaculture and soft shell crab production development. While this effort has shown tremendous promise in the initial funding period of BCARC, it is not vital to furthering the stock enhancement efforts in the Chesapeake Bay. Likewise, although the endocrinology work conducted at the Center of Marine Biotechnology lab has resulted in some very important and far reaching research results that may have practical application in future blue crab aquaculture, it would not be vital in a “bare bones” stock enhancement development phase (this function is not listed as a separate line item). If this effort is to proceed under a limited budget, the Review Committee would support the continuation of these functions but suggests separating the funding from the “stock enhancement” request that is being made. Although the Review Committee was not charged specifically with addressing these components, we would suggest that utilizing funding from alternative sources (e.g., aquaculture development, Department of Agriculture, Sea Grant, other competitive grant programs, etc.) may be one avenue through which to continue these components.

Conversely, the Review Committee identified three very important functions that may be under-funded or under-represented in the budget as presented. The current budget allocates \$90,000 for a fishery economist over three years. Adequate cost/benefit information and analyses will be vital to allow decision makers to determine the economic efficacy of the program at the end of the proof-of-concept phase. The necessary information and analyses must be gathered and conducted throughout the duration of this phase. We are concerned that this function may be under-funded to allow a strong cost/benefit analysis. In the private sector economics realm, an in-depth cost analysis of production processes coupled with natural resources impacts could cost \$240,000 for a 6 month initial effort in the first year and an additional \$120,000 in each succeeding year for 3 months of work. However, BCARC partners could likely leverage their partnerships with colleagues in associated university positions or Sea Grant to obtain a high quality analysis at substantially lower costs than these rates.

The “Genetics Analysis” line item (\$264,800) also appears to be the minimum amount that the Review Committee feels is necessary for this component. As stated previously, genetic analysis is the lynchpin for evaluating the contribution of hatchery-reared crabs to the spawning population (and subsequent larval recruitment) and could also be used to evaluate effect of management measures. This funding is only for sampling and analysis, with no funding for development of new genetic markers. Upon questioning, BCARC partners stated that they did not feel that they need additional markers at this time. If this is indeed the case, the Review

⁶ “Executive Summary for External Review” – Blue Crab Advanced Research Consortium, December 2008

Committee accepts this as the minimum budget needed but cautions against cutting corners in this line item.

The budget is completely lacking funding for a public information//interagency/policy communications position. The Review Committee strongly feels that the BCARC effort is suffering from the lack of such professional expertise. It important to present the contributions of this program to the public, management agencies, and policy makers in appropriate terms and we advise that any continued efforts by this consortium include a full time communications position for these purposes.

Finally, as mentioned previously, a three-year budget as presented for ramping up the production of juveniles would need to include a minimum, fourth year of funding for analysis of the final year of stocking to provide a reliable proof-of-concept demonstration. The Review Committee recommends that if this program is to continue, a fourth year of funding be added to the budget to focus on evaluation and analysis.

Finding 13. The budget as presented only outlines three years of funding. The Review Committee feels that a fourth year of funding should be added as this is a proof-of-concept phase. In the context of this review (stock enhancement), several aspects of the budget can be scaled back, including endocrinology and aquaculture, while other aspects including genetics, economic analysis, and communications need to be increased or added to the budget. If the program is to continue for the purposes of stock enhancement, the BCARC partners should present a reconstituted budget focusing on this component.

Cost Effectiveness

Question #5: How does the cost effectiveness of a stock replenishment effort of this scale compare with harvest management plans recently implemented by Maryland and Virginia?

As stated throughout this review, the actual value and resulting effect of stock enhancement cannot be accurately predicted with the information available at this time. The Review Committee does not consider harvest management and stock enhancement to be an either/or situation; stock enhancement activities have merit but only if pursued in conjunction with complementary management practices. The stock enhancement program outlined by BCARC would require changes to the existing fishery management structure in order to stand a chance of meeting their expectations. In tagging experiments conducted in the Rhode River, 97% of mature females were captured before they could reach the lower Bay spawning grounds.⁷ If the juvenile blue crabs were stocked in Maryland waters, the success of the BCARC effort is predicated on the establishment of new “refuge corridors” that would not allow the harvest of female crabs migrating southward to the mouth of the Bay. Note that these could not simply be zones for no-take of females; they would need to prevent all chances of capture of females since some evidence has been presented by BCARC partners that indicates very low survival of females that are released from traditional crab pots. Alternatively, all hatchery crabs could be

⁷ Hines, et al. 2008. Release strategies for estuarine species with complex migratory life cycles: Stock enhancement of Chesapeake Bay blue crabs *Callinectes sapidus* . *Reviews in Fisheries Science* 16 (1) 175-185

released in Virginia waters, which are much nearer the spawning grounds. However, this would necessitate that Virginia keep the refuge zone as established and potentially expand the time period during which the crabs are protected.

As presented by BCARC, a three-year stocking effort during the proof-of-concept phase would result in the following juvenile crabs stocked:

- Year 1= 0.5 million
- Year 2= 1million
- Year 3 = 1.5 million.

The ultimate goal at full production levels would result in 10 million juvenile crabs stocked per year. Using the BCARC estimate that 10% of these would reach the spawning grounds as mature females in the absence of fishing pressure, the following contributions might be attained:

Year	# juveniles stocked	# mature females reaching the spawning ground (assuming no fishing mortality)	Targeted Production Cost/juvenile Crab ¹	Full Program Cost/Juvenile Crab ²	Full Program Cost/Mature Female Crab ³
2009	500,000	50,000	\$0.25	\$4.87	\$48.71
2010	1 million	100,000	\$0.25	\$2.73	\$27.32
2011	1.5 million	150,000	\$0.25	\$1.96	\$19.58
2012	10 million +	1,000,000	\$0.10 - \$0.25	?	?

¹ Target production cost/juvenile only from BCARC.
² Program cost/juvenile calculated by dividing the requested budget by the projected number of juveniles produced. This could change with additions or subtractions from specific budget categories, but is intended to provide an actual cost per juvenile considering all program needs, not simply production.
³ Program cost/mature female calculated by dividing the requested budget by the projected number of mature females reaching the spawning ground. This could change with additions or subtractions from specific budget categories, but is intended to reflect the cost for spawning stock enhancement.

It is important to reiterate that these numbers are rough approximations. The actual number of females reaching the spawning grounds would fluctuate with environmental variables including climate conditions, currents, the success of management measures, etc. The percent reaching the spawning grounds is expected to increase if management efforts establish effective migration corridors. Production costs are projected by BCARC and actual costs could be higher or lower. The “full program” cost per juvenile and cost per mature female could fluctuate depending on additions or subtractions from the budget as was presented to the Review Committee. While the goal of the BCARC program is to increase the number of mature females, it needs to be mentioned that an equal number of males will be available for harvest and will benefit Chesapeake Bay watermen.

Recent Management Actions – Management actions taken by Maryland, Virginia, and the Potomac River Fisheries Commission in 2008-2009 are intended to reduce the harvest of female crabs by 34%. The MDDNR estimates that approximately 100 million mature female crabs are harvested annually. A 34% reduction in this number would mean that 34 million mature females would survive annually that would have otherwise been harvested. Factoring in natural mortality, approximately 20 to 25 million mature female crabs would be expected to survive to reach the spawning grounds at the mouth of the Bay each year.⁸ If this reduced harvest has no impact on market prices and subsequent estimates of net benefits (economic value), the near term economic impact of the reduced harvest in Maryland is estimated to exceed \$3 million annually (\$403,578 to recreational crabbers, \$1,511,989 to commercial crab harvesters, and \$1,466,895 to processors).⁹ If, however, blue crab prices rise as a result of this reduced harvest, as is likely according to the blue crab disaster analysis conducted by the NMFS, net benefits to watermen would be higher while economic impacts would likely decline.

Finding 14. Information is not available at the present time to adequately assess and compare the true costs or benefits of either the stock enhancement approach or the management measures recently implemented for Chesapeake Bay blue crab stocks.

Finding 15. The budget of the stock enhancement proof-of-concept project represents the value of preventing the loss of net benefits resulting from a fishery collapse.

The Review Committee discussed at length the potential impact of the recent harvest management measures. The long history of management measures that have failed to succeed in stemming the decline of Chesapeake Bay blue crab stocks causes significant concern. However, most of the historical measures seem to have been directed at effort controls, whereas the recent actions are solidly focused on reductions in harvest and fishing mortality. Whether the expected reductions make a difference in the condition of blue crab stocks still remains to be seen but the Review Committee, like MDDNR, is hopeful. Nonetheless, the Committee expresses concern that the first signs of success (increased number of crabs) are likely to be met by calls for relaxing restrictions that will potentially negate the benefits of the restrictions at a time when they may be most valuable. Additionally, a great deal of latent effort exists in Maryland (and perhaps the other jurisdictions) that may surface as increased crab abundance (coupled with other factors such as a deteriorating job market) attracts people back to the fishery. In Maryland, approximately 6,000 licenses are issued that allow the commercial harvest of blue crabs, with only approximately 1,800 of those used in any given year.¹⁰ The MDDNR has indicated that the blue crab fishery is, in effect, now limited entry. A set number of licenses is currently allowed, and in their 2009 regulatory package, MDDNR is proposing to freeze all licenses that have not been used in 5 years (approximately 800-1,000 LCC licenses which are limited to 50 pots each). These licenses would be reissued under a controlled re-entry scheme depending on stock conditions. The more extensive harvesting licenses (Tidal Fish Licenses) may be subject to some type of buyback program in the future. In Virginia, the dredge fishery is being scaled back

⁸ Fegley, Lynn. "Review of Blue Crab Management in Chesapeake Bay." Power Point presentation given January 8, 2009 during the Blue Crab Stock Enhancement review.

⁹ Maryland Department of Natural Resources, proposed legislation for the 2009 crab fishery.

¹⁰ Lipton, Doug. "How Important Are Blue Crabs to Maryland?" Power Point presentation given January 8, 2009 during the Blue Crab Stock Enhancement review.

as well as additional measures to control latent effort.¹¹ While the Review Committee endorses these actions and proposals to control latent effort, it remains concerned about potential erosion of the political will to maintain restrictions based on some members' previous experiences with various fisheries.

Finding 16. Management actions need to be successfully maintained and their results carefully evaluated to see if the predicted reduction in harvest and increase in the spawning population are actually attained. It will take some time to determine if the new regulations will work, and it is essential that any pressures to relax these regulations be resisted to the fullest extent to allow continued population recovery and to allow adequate analysis of effects.

Finding 17. Additional controls on effort should be put in place to make sure that latent effort does not come back into the fishery when the stock size improves. A failure to do so will substantially undermine the potential success and evaluation of either a stock enhancement program or traditional management measures.

Finding 18. The focus of any blue crab stocking effort should be on increasing the actual spawning population, not on simply enhancing the fishery. This focus will necessitate prioritizing stocking areas to maximize access of females to the spawning area, including a regulatory framework to protect females as they move from the stocking sites to the spawning grounds in habitats in the lower bay.

Finding 19. A bioeconomic evaluation of this effort needs to be conducted to take into account different management strategies to determine if the potential net benefits derived from this program can be maintained or will be dissipated as effort levels increase for a variety of reasons.

Finding 20. If current stock enhancement efforts are abandoned, then the cost savings of \$8.1 million over three years should be compared with the potential loss in economic value if the stock collapses. The Review Committee concurs that losses from a complete collapse would be greater than the cost of maintaining the stock enhancement program as an "insurance" option. However, the Review Committee does not have the data necessary to determine if maintaining the stock enhancement project through the proposed proof-of-concept phase would actually result in an economically effective recovery.

Is Public Investment Justified at this Time?

Question #6: Is significant public investment in blue crab stock replenishment, including both capital and operating costs, justified at this time? If not, what conditions might change this?

The Review Committee feels that many factors not considered as part of this review must go into the decision of whether to fund this program. "Significant public investment" is a relative term

¹¹ Fegley, Lynn and Rom Lipcius. Personal Communication. Blue Crab Stock Enhancement Review, January 9, 2009.

and remains undefined. Indeed, the decision and relative cost of this effort in comparison to other opportunities may differ between tight economic or budgetary climates and times of relative prosperity.

However, it is worth repeating that, the Review Committee finds merit in funding the BCARC effort for a proof-of-concept phase but not replenishment per se at this point in time. BCARC has made significant progress in the past in eight years but is not yet ready to be fully implemented or evaluated as an expansive stock enhancement program. A major reason for this recommendation is that the infrastructure (including professional expertise and facilities) that has been established over the past eight years definitely has provided value in terms of increased useful knowledge about blue crab biology and development of mass culture techniques and has demonstrated some potential for being able to contribute to stock replenishment, particularly at very low levels of abundance of spawning stock. If the stock enhancement program were disbanded at this time but subsequently became needed in the relatively near future, it would be extremely difficult and costly to re-establish. However, the Review Committee also recognizes that it would be relatively expensive to continue as well, both for the proof-of-concept phase and for any subsequent operational phase.

Finding 21. It would be very difficult and expensive to re- start/reconstitute the enhancement effort once it is allowed to end.

Another asset of the BCARC program that has not yet been discussed is that of technology transfer. Partners in the BCARC program have produced more than 70 professional publications and numerous presentations on various phases of the work that they have conducted. At one level these are academic contributions that contribute to our understanding of the biology of blue crabs. However, at a more important level, the body of knowledge on rearing procedures, and when and where to release juvenile crabs for maximum survival, can be transferred to other similar operations worldwide. Since BCARC has done most of the research and development, it will be far easier to develop similar rearing and restocking efforts at other locations along the Atlantic and Gulf coasts. It should be emphasized that because blue crab larval development takes place in coastal/offshore areas, increasing the spawning stock in any estuary will benefit recruitment to other estuaries. It is unlikely at this time that the private sector could fully assume this level of investment, although certain components may be more attractive to it than others and perhaps conditions may change in the future.

Finding 22. Transfer of information and technology to management agencies and the scientific community is a very valuable asset of the BCARC program.

The decision to allocate public resources must also consider the alternative uses of funds that might be used to support the stock enhancement efforts. If stock enhancement efforts are funded, additional management restrictions (e.g., refuge corridors) will need to be implemented and funds will be needed to develop, manage, and enforce these zones. If the jurisdictions adhere to the most recent management actions and if those actions do result in a 34% reduction in the harvest of mature female crabs, then management actions alone will substantially overwhelm any potential contributions that the stock enhancement efforts could make at the

current stock levels or above. However, as noted previously, management efforts historically have been inefficient at restoring or stabilizing the blue crab populations.

Blue crab Economics – Decisions regarding the best use of public funds inevitably lead to a discussion of the economic importance of the activity that is affected. Blue crab harvest is economically important to the commercial and recreational crabbing sectors throughout the Chesapeake Bay. Gross income (ex vessel price) to commercial watermen from blue crab sales is nearly \$40 million/year in Maryland, accounting for 60%-70% of watermen's income. More than 300 U.S. citizens and additional migrant workers are employed in Maryland's 20+ crab processing plants. Additionally, an unknown number of recreational crabbers took 1 million trips in 2002, generating significant recreational opportunities and economic activity.¹² The Maryland economy and lifestyle are vitally dependent on a healthy and robust blue crab population. It is in this context that a decision regarding investment in stock enhancement as a potential "insurance policy" in case management efforts are unsuccessful should be evaluated.

Best Approaches to Stock Enhancement

Question #7: *What, in the teams' view, are the best approaches to stock enhancement?*

The most ideal situation is for the blue crab management programs in the Chesapeake Bay to rebuild the spawning stock to a level that is sufficient to even preclude the discussion of any need for stock enhancement. If the continuing decline in the blue crab spawning stock is left unarrested, the Chesapeake stock may indeed drop to a level where stocking with hatchery-reared crabs could make a measurable and potentially meaningful contribution. The BCARC has rigorously followed best management practices for a "responsible approach" to stock enhancement, and those efforts have established a firm foundation for development of a stock enhancement program. However, their production capabilities are not yet to the point of being able to make significant contributions to the numbers of mature females on the spawning grounds

Concluding Remarks

The Review Committee compliments both the BCARC and the Maryland and Virginia blue crab management agencies for their significant accomplishments and major advances in efforts to restore an irreplaceable, formerly bountiful, natural resource. While this review focused on stock enhancement questions as requested, in attempting to answer those questions we also had to consider management actions. We have mentioned several times in this report that any chance for success of a stock enhancement program must be coupled with complementary strong fishery management regulations. If a decision is made to continue the BCARC effort, it cannot and will not succeed in either demonstrating the ability to enhance the Chesapeake Bay blue crab spawning stock, or in actually enhancing that stock, without significant changes to fishery

¹² Lipton, Doug. "How Important Are Blue Crabs to Maryland?" Power Point presentation given January 8, 2009 during the Blue Crab Stock Enhancement review.

harvest regulations that go above and beyond the actions implemented in 2008-2009 (e.g., stronger protection for migration corridors). Likewise, the significant management regulations implemented in 2008-2009 by the agencies (reduction in female harvest by 34%) will not reach their full potential for rebuilding the stock of blue crabs if they are not given sufficient time to work, if they are curtailed prematurely (i.e., at the first signs of rebuilding), or if the issue of latent fishing effort is not addressed very soon. The bottom line with regard to an investment decision is how high of a priority the State of Maryland (and Commonwealth of Virginia) place on the maintenance of an “insurance policy” against the potential failure of management efforts to restore the blue crab spawning population.

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APPENDIX I: AGENDA

MARYLAND BLUE CRAB STOCK ENHANCEMENT REVIEW

January 8-9 2009

Merrill Environmental Center, Chesapeake Bay Foundation
Annapolis, MD

Thursday, January 8

8:30 Opening Introductions and Remarks-Eric Schwaab, Deputy Secretary Maryland DNR

- a. Purpose of Review
- b. Review Guidelines and Scope
- c. Timeline for completion

Chesapeake Bay blue Crab Biology, Management, Fisheries, and Economics

- A. Basic blue crab life history-MDDNR staff
- B. Blue crab management – MDDNR staff
 1. CBSAC blue crab stock assessment-official estimates – Lynn Fegley, MDDNR
 2. Current blue crab management and projected effects
 3. Trends in recruitment, factors thought to be limiting stock growth.
- C. Economics of the blue crab fishery – Doug Lipton, Maryland Sea Grant
 1. What is the annual cost (economic impact) of the decline of the blue crab fishery?
 2. What's at stake?

10:00 Break

10:20 Review panel questions/discussion

11:00 History of the Blue Crab Advanced Research Consortium (BCARC) Program – BCARC Partners

- A. Initial rationale for establishing the effort
 1. Review status of the Chesapeake fishery and stock
 2. Asian stock enhancement programs for portunids
 - a. hatchery production
 - b. limited field tests
- B. Establishing the Chesapeake Bay blue crab as a candidate for stock enhancement
 1. Standards for responsible enhancement
 2. Evidence for recruitment limitation
 3. Spawning stock size
- C. BCARC's multi-disciplinary responsible approach to blue crab stock enhancement
 1. Team composition for responsible enhancement

2. Rigorous, experimental testing and incrementally progressive strategy

D. How is the BCARC approach intended to complement and enhance current management of the fishery?

12:00 Lunch – provided on site

1:00 BCARC research findings to date and evaluation of BCARC efforts

A. Advances in hatchery technology and basic biology

1. Development and optimization of blue crab hatchery technologies (larval, postlarval, juvenile production)
2. Endocrinology (basic biology, prospects for hormonal control of molting)
3. Blue crab genetics (basic biology, impacts on wild diversity, applied tagging technologies)
4. Disease (population impacts, disease management)

B. Evaluation of field efforts

1. Evidence for recruitment limitation in Chesapeake Bay
2. Comparison of hatchery-reared and wild crab juveniles
3. Field tests of enhancement (upper and lower Bay) (40 min)
4. Spatial & seasonal dynamics of mature female production, migration and exploitation
5. Advances toward integrated ecosystem assessment

C. Prospects for blue crab aquaculture

1. Blue crab pond culture
2. Blue crab soft-shell aquaculture

D. Budget (current and projected):

1. Budget and justification for funds requested from MDDNR/legislature
 - a. Facilities development
 - b. Operation and maintenance
 - c. Field stocking and monitoring
2. Vision and costs of full-scale production (10-20 million juveniles)

3:00 Break

3:20-3:45 BCARC Wrap Up

3:45 Review Panel Questions/Discussion

5:00 Adjourn

Friday, January 9

8:30 Convene -Wrap up any discussions not completed prior day.

9:00 Closing summaries

Address: "If enhancement were successful, what part of current programs could be eliminated and what would be gained (or saved)" and other issues.

a. MDDNR

b. BCARC

9:30 Review Panel Questions/Discussions to MDDNR and BCARC

10:00 Break

10:20 Review Panel convenes- closed door

(MDDNR staff and BCARC partners to be on hand nearby to answer any questions).

12:00 Lunch

1:00 Review Panel begins formulation of findings/recommendations

2:30 Review Panel to discuss questions/issues with BCARC/DNR

4:00 Next steps

4:30 Adjourn

APPENDIX II: PARTICIPANTS AND ATTENDEES

MARYLAND BLUE CRAB STOCK ENHANCEMENT REVIEW

January 8-9 2009

Merrill Environmental Center, Chesapeake Bay Foundation
Annapolis, MD

Mick Blackistone, MWA
Sook Chung, UMBI
Glenn Davis , MDDNR
Mike Deckert, UMBI
Dave Eggleston, NC State
Lynn Fegley, MDDNR
Tuck Hines, SERC
Eric Johnson , SERC
Ken Leber, Mote Marine Lab/UMBI
Rom Lipcius, VIMS
Doug Lipton, UMD Sea Grant
Al Place, UMBI
Ed Rhodes, Phillips Seafood
Eric Schott ,UMBI
John Stubblefield, UMBI
Alexi Sharov, MDDNR
Yoni Zohar, UMBI
Odi Zmora, UMBI

Review Committee

Lee Blankenship, Northwest Marine Technologies
Richard Forward, Duke University
Paul Sandifer, NOAA/NOS
John Ward, NOAA/NMFS

Derek Orner, NOAA/CBO (ex-officio)
Andrew Loftus, Review Coordinator