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MARINE NOTES

SPOTLIGHT ON MANAGEMENT

The Bottomline on Blue Crabs

Setting Thresholds for the Last Great Fishery

BY JACK GREER

At the front of a small conference room overlooking the York River, Tom Miller is projecting chart after chart of blue crab research and monitoring data. The data come from countless trawls and dredges launched by researchers and resource management agencies in both Maryland and Virginia — independent sources that do not rely on records of commercial and recreational harvests in the Bay. For some time now, the numbers have pointed toward smaller crabs, fewer spawning females and a shrinking crab population. The technical experts gathered here are confronting a fundamental question: how many crabs can we take from the Chesapeake Bay before we risk crashing the stock?

The question is a straightforward one. The answer, it appears, is not.

According to Miller and other scientists in the Bay region, how one views this fishery depends on a number of factors, including assumptions about a crab's life cycle, and about how the fishery functions. To wrestle with these assumptions, Miller, a researcher at the University of Maryland Center for Environmental Science has joined his counterparts from the Virginia Institute of Marine Science (VIMS), the Old Dominion University, the Virginia Marine Resources Commission, the Maryland Department of Natural Resources and the National Marine Fisheries Service. All told, there are many decades of fisheries research and management experience in this one small meeting room, and statistical information reaching back to the 1950s and earlier.

Sandy Rodgers

With harvests down and scientific surveys showing stocks near historic lows, a bi-state committee recommends Baywide action.

A Baywide Approach

These technical experts have come together at the behest of the Chesapeake Bay Commission's Bi-State Blue Crab Advisory Committee (BBCAC) — an advisory group assembled in 1996 at the request of the governments of Maryland and Virginia — which is comprised not only of fisheries managers but also of commercial watermen, seafood processors, conservationists and legislators from Maryland and Virginia. This bi-state committee is attempting to determine whether or not the blue crab is in trouble, and if it is, what should be done about it. To help answer that question, a Technical Workgroup has also been formed to analyze all facets of the blue crab fishery, including the setting of a "threshold" — the point beyond which fishing pressure could threaten the health of the Bay's valuable blue crab stock.

For some years, scientific arguments have raged over whether and where such a threshold line should be drawn. Some experts point out that data on the blue crab are spotty. In fact, there is general consensus among the BBCAC group that given the value of the blue crab in the Chesapeake Bay — both commercially and recreationally — it is surprising how little we have invested in tracking and studying this regional resource.

"Given how important this fishery is to the region, I'm surprised at the level of support for data gathering," says Josef Idoine, an expert brought in from the Woods Hole Laboratory of the National Marine Fisheries Service to help with the analysis.

On the bright side, some very valuable data do exist, including commercial harvest data, a new economic survey of commercial crabbers, and four fisheries-independent surveys — monitoring that is independent of harvest figures. Those fishery-independent surveys are:

- VIMS Trawl Survey — Virginia portion of the Bay, since 1955
- Calvert Cliffs Survey — Calvert Cliffs area, since 1968
- Maryland Trawl Survey — Eastern shore and Patuxent River (limited), since 1978
- Winter Dredge Survey — sole Baywide survey, since 1990

Of these, only the winter dredge survey was designed to serve as a Baywide monitoring tool; for that reason, the research community has agreed that this assessment will drive decision making as we move into the future. To construct a Baywide picture of stock abundance based on available data from each state, fisheries experts decided to average the results of all the surveys, standardizing them to the past ten years — the decade of the 1990s — when all four surveys, including the winter dredge survey, were in effect.

The researchers found that an average constructed from all the surveys reveals the following picture:

- The lowest recorded level of the blue crab spawning stock occurred more than 30 years ago, in 1968.
- Stock measurements taken in 1999 and 2000 hover just above that historical low point.
- The highest rates of fishing mortality — when harvesting pressure on the crab stock became dangerously high — occurred in the 1970s and again in the 1990s.

Given the variable nature of this fishery (see sidebar on The Fluctuating Blue Crab Fishery) resource managers must determine when fishing pressure is too high and when the stock begins to face the threat of serious depletion or even collapse.

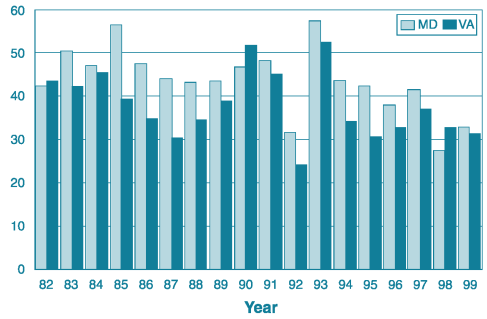
Drawing the Line

After two days of heated debate, the researchers gathered at VIMS came to a consensus. They agreed to set the threshold for fishing pressure at a point that represents preserving ten percent of the blue crab's spawning potential — what they call F10%. They concluded that if the commercial and recreational harvest of crabs goes beyond that point — with fishing pressure removing more than 90% of the blue crab's spawning potential — then the crab stock faces a risk of collapse.

This fishing threshold, according

The Fluctuating Blue Crab Fishery

Commercial Blue Crab Harvest in Maryland and Virginia from 1982 to 1999



The summer of 2000 looks to be one of the worst on record for the Maryland blue crab fishery. According to Harley Spier of the Maryland Department of Natural Resources, Maryland crabbers hauled in only about 3.5 million pounds in July, and 2.9 million in August. This falls far below the five-year average for July and August, which is about 7.2 million pounds for each month. So far, according to Spier, Maryland crabbers have harvested a total of 15.3 million pounds for the year, and even with a good October and November it is not likely that they will come anywhere near the 38 million pound five-year average.

Following — much less predicting — the blue crab fishery is extremely difficult. Not only do stocks rise and fall depending on a range of factors, including climatic changes and shifts in the food web, but the fishery itself fluctuates, depending on economic and social factors, as well as crab stocks.

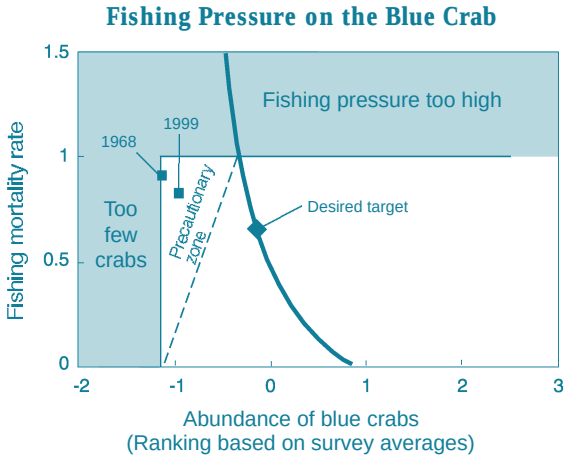
In order to gain as clear a picture as possible, resource managers and researchers rely on carefully controlled monitoring efforts, where they examine the same areas in the same ways year after year, or employ specially designed random sampling surveys. The newest and increasingly the most important of these monitoring efforts is the winter dredge survey, until recently funded by the Federal government (through the National Oceanic and Atmospheric Administration) but now supported by the states of Maryland and Virginia. The survey shows that Bay crab stocks at the end of the 1990s have declined, hovering just above the historical low-point of 1968.

Now it appears that the commercial harvest may be tracking with the fisheries-independent surveys. Although dismal news, it should perhaps not come as too much of a surprise, since the harvest has tracked fairly well with the monitoring surveys for the last several decades.

In decades past, the crab has always rebounded, often quite quickly. Watermen and researchers alike are hoping that this will happen again — and current recommendations for a fishing threshold are meant to ensure that stocks do not drop so low that they can't bounce back.

Arriving at a Threshold

To help resource managers better protect Chesapeake blue crab stocks from overharvesting, researchers have calculated a two-part threshold regime, based on fisheries-independent monitoring (particularly the winter dredge survey) and levels of fishing effort. As this graph indicates, there would be a desired target to aim for each year — which would likely fall along the curved line that shows where researchers expect to find the equilibrium between fishing pressure and the stock size needed to sustain the population. Depending on the results of monitoring data, managers could adjust levels of fishing effort (e.g., numbers of pots) to approach that target. If the data indicates low stocks, fishing effort would be reduced to stay out of the "precautionary zone," an area that signals that the fishery could be in trouble. The low-stock threshold is marked by the 1968 level, the lowest observed by independent surveys. The 1999 level lies very close to that line.



to Miller and other scientists, represents a "control rule," and they agreed that if the fishing mortality rate — the measure used to gauge fishing pressure — crosses that ten percent line, resource managers should take "immediate and substantive" action.

Furthermore, regardless of the fishing mortality rate, if the size of the spawning stock — as measured in the winter dredge survey — should fall below a certain level, that should signal another warning. Since there is no way to know exactly how far crab stocks can fall and still recover in a reasonable time, the scientists agreed to use the lowest level on record in 1968 as a benchmark.

"We need to base these thresholds on experience as well as data," said John Hoenig of VIMS, adding that 1968 provides us a concrete low point from which we know the stock can recover.

In other words, based on experience we know that the Bay's crab stock can go as low as it did in 1968 and still recover reasonably quickly. Beyond that level no one can be certain how well or how fast the stock might bounce back. According to Miller, the space to the left of that line represents "unknown territory."

Researchers agreed to set the threshold for fishing pressure at a point that represents preserving ten percent of the blue crab's spawning potential

"It's all about levels of risk," says Ann Swanson, Executive Director of the Chesapeake Bay Commission and chair of the Technical Workgroup. "We will never know the exact point at which the crab stock will falter unless we allow the fishery to collapse. But the cost of doing that is simply too high."

Researchers and resource managers in the Chesapeake region have the benefit of seeing how other fisheries have collapsed — the New England cod fishery, for example. In that case, attempts at maintaining a "maximum sustainable yield" ultimately led to overfishing and a collapse of the stocks.

Devon Rothschild

Researcher Tom Miller was among the scientists who met at VIMS to consider setting a threshold for the blue crab fishery.

On the other hand, says Miller, the American lobster fishery has adopted a fishing threshold of 10 percent, the same level recommended by the Technical Workgroup for blue crabs in the Chesapeake. Some have suggested that the lobster fishery could possibly serve as a helpful model for managing the blue crab.

Predators and a Shifting Environment

"It's predation. Why can't anyone see that?" said a waterman at a recent [September 2000] meeting of the Bi-State Blue Crab Advisory Committee, where Miller and others presented the findings of the Technical Workgroup. At least 100 watermen had journeyed to Annapolis to observe the meeting — even though the Bi-State Committee's function is purely advisory, and public hearings were not to be held for another month. Their concern was that regulations would go into effect to revive a fishery that had declined through no fault of their own, largely because of natural cycles that bring more crabs into the Bay one year and more fish in another.

"Everybody knows that when you have a big year for rockfish [striped bass] you have a bad year for crabs," said Larry Simns, president of the Maryland Watermen's Association; his view seemed to reflect the consensus of the watermen in the room.

Others, though, like former state senator Bernie Fowler, recall times when rockfish were plentiful and crabs were too. "We used to be able to catch plenty crabs and plenty

hardhead, spot and rockfish," said Fowler at a recent meeting of the Chesapeake Bay Commission, the group that established the Bi-State Blue Crab Advisory Committee.

What do the scientists say about predation?

Jacques van Montfrans and his colleagues at VIMS, with support from the states of Maryland and Virginia through the Chesapeake Bay Commission, have been studying this issue. To determine what fish have been eating, they captured fish in Virginia grass beds in the lower Bay and examined food found in their guts. Van Montfrans and his fellow researchers have concluded that rockfish do indeed feed on blue crabs, as do red drum and croaker.

Of these three species, rockfish seemed to feed most heavily on small blue crabs, followed by red drum and then by croaker. Since red drum are far less numerous than rockfish, they are less likely to have a large impact, says von Montfrans. And while croaker have abounded this past year, they appear less likely to feed as heavily on blue crabs. According to van Montfrans, who is continuing to analyze gut contents of fish, the overall impact on juvenile crabs caused by striped bass and croaker feeding in seagrass beds requires further evaluation based on data gathered in the fall of 2000.

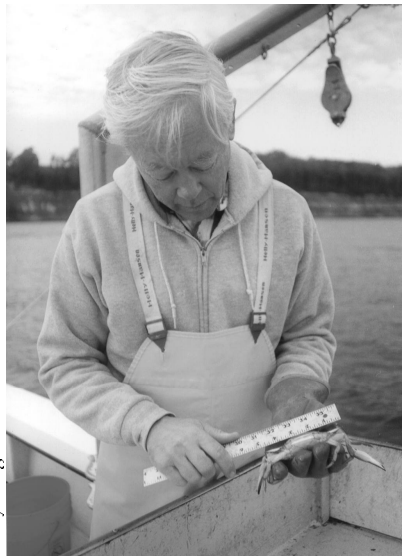
VIMS scientists also point to other factors that can affect crab populations — for example, when confined to small refuges, such as the Bay's devastated grass beds, cannibalism can increase significantly.

What role does predation play in the current crab decline?

According to van Montfrans and other scientists on the Technical Workgroup, the decline in crab stocks probably results from a number of factors, including predation, fishing, habitat and environmental factors, such as climatic cycles. Van Montfrans adds that current populations of striped bass are probably not higher than historical levels — before heavy fishing pressure reduced their numbers. Also, von Montfrans notes, his results probably overstate the situation in the entire Bay, since his study area focuses only on underwater grass beds in the lower Bay — a well-known nursery ground for juvenile crabs. The smaller the crab, the more likely it will become fish food.

With catastrophic declines in Bay grasses since the 1970s, juvenile crabs are caught between shrinking grass beds and hard bottom. That is, they either take their chances in the open on barren bottom, or they crowd together in the remaining grass beds. Either way they are more vulnerable to predators like striped bass.

Tracking the Blue Crab Baywide



Sandy Rodgers

George Abbey, a researcher at the Academy of Natural Sciences, has been tracking fluctuating crab stocks in Maryland, for 32 years.

Tracking and monitoring the Chesapeake Bay blue crab presents no small challenge. It takes the wisdom of watermen, the experience of seafood processors, the painstaking work of scientists, and the practical knowledge of resource managers. The late Gene Cronin, a well known and long-time crab biologist, often emphasized how important it was to treat the crab as a Baywide resource.

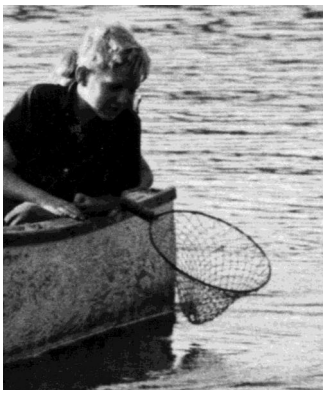
In particular, two efforts have helped provide the knowledge we need and the synthesis required to make difficult decisions on a Baywide basis.

The Chesapeake Bay Stock Assessment Committee (CBSAC). Established in 1985, CBSAC brings together fishery researchers and natural resource managers to collect and analyze data needed for stock assessment. After the 1987 Chesapeake Bay Agreement called for the development of a Baywide stock assessment program, CBSAC took the lead in developing such an effort. CBSAC represents one of the primary funders of stock assessment research and analysis in the Chesapeake Bay, and works closely with technical experts from the Maryland Department of Natural Resources and the Virginia Marine Resources Commission, who serve on the committee alongside fisheries scientists. CBSAC focus not only on crabs, but on selected species important to the Bay's commercial and recreational fisheries.

The Bi-State Blue Crab Advisory Committee (BBCAC). Established in 1996 by the Chesapeake Bay Commission, BBCAC was created to help pull together the expertise provided by CBSAC and others, and to combine it with the input of important stakeholders, including elected officials, seafood processors, watermen and conservationists. To guide this effort, BBCAC in turn established a Technical Workgroup, comprised of leading fisheries scientists, resource managers, marine resource economists and policy experts. Unlike CBSAC, this bi-state committee and its workgroup focus exclusively on the blue crab. Also unlike CBSAC, the bi-state crab committee has served essentially as a blue ribbon panel, and will likely cease to exist once it has made and measured the impact of its recommendations.

In addition to state resource agencies and conservation groups, other important partners include the Potomac River Fisheries Commission, the U.S. Environmental Protection Agency and its Chesapeake Bay Program, and the National Oceanic and Atmospheric Administration, including the NOAA Chesapeake Bay Office in Annapolis, which sponsors CBSAC, and the Sea Grant programs of Maryland and Virginia. All of these partners have supported and funded Bay stock assessment work for many years.

The Role of the Recreational Crabber


M.E. Warren

How many of us have scooped up crabs with a dip net or even set a pot or two to catch enough for a mid-summer backyard crab feast? Whether we run trotlines, pull pots or dangle chicken necks, all of us who take crabs from the Chesapeake are harvesters in our own right.

The effects of these often small and casual harvests remain largely unknown. Neither Maryland nor Virginia nor the Potomac River Fisheries Commission has a very good handle on just how many crabs recreational crabbers take from the Bay, or whether their impact is significant when it comes to protecting the health of the crab stock.

According to the Maryland Department of Natural Resources, we do know that in 1999 some 29,000 Marylanders purchased a recreational crab license. This allows recreational crabbers to use 1,200 feet of trotline, or to set 30 pots to catch crabs for their own consumption. Some watermen have expressed concern over whether or not particularly active recreational crabbers may be taking more than they can eat — perhaps even selling some of their catch.

According to resource economist Doug Lipton, "Being able to catch crabs at the end of your dock or down at a community beach has been a traditional birthright for people living in Bay country. And there really has been no way to record or capture this part of the fishery."

Many watermen and others have pointed out that if the commercial fishery faces tighter restrictions, then recreational crabbers will need to "share the pain" as well. Terry Conway, representing Handy's Seafood, but also speaking for a growing consortium of crab processors, has called for a recreational crabbing license, and better tracking of the recreational catch.

Fisheries scientist Tom Miller and several colleagues now have a grant from the Maryland Department of Natural Resources to conduct a preliminary study on the potential effect of recreational crabbing. To track the project's progress, go to his web site at: www.cbl.umces.edu/~miller/recreati.htm.

"We really can't be sure of how our current samples would relate to the rest of the Bay without carrying out similar studies in those areas," says van Montfrans. Feeding studies recently conducted at the University of Maryland, Eastern Shore found that blue crabs made up approximately five percent of a rockfish's diet, with sand shrimp and other prey occurring in larger numbers in sampled gut contents.

Josef Idoine, who has watched other fisheries decline from his vantage point at the NMFS Woods Hole laboratory, argues that whether environmental factors — such as predation by striped bass, or, for that matter, periods of heavy rainfall — have caused a decline in crab stocks or not belies the real issue.

"What we have to guard against," says Idoine, "is a stock perched on the edge of disaster." For example, he says, imagine that a stock has been driven down to its lowest levels by a combination of environmental factors and fishing pressure. At this point the stock would be at risk of collapse, if pressures on the stock remained high, or if some unforeseen disaster struck, such as disease or an exotic parasite. Such was the case, one could argue, with the once famed Chesapeake Bay oyster, which was heavily overfished and then devastated by parasites most likely introduced from foreign waters.

In other words, even if the low crab stock can be explained by environmental factors such as predation by striped bass, Idoine argues, fishing pressure should be reduced to avoid shrinking the stock even further.

This is especially true, says Miller, when fisheries-independent surveys suggest that the fishing mortality rate has exceeded a point that would leave ten percent of stock's spawning potential. According to Miller, the fishing mortality rate is always calculated in relation to the estimated natural mortality rate, which accounts for death by natural causes, including predation. When natural mortality rates are high, the effect of fishing pressure is greater, since the stock is smaller and less able to sustain heavy fishing.

Whatever the reason for the decline in crabs, say scientists, fishing pressure should be reduced to avoid shrinking the stock even further

"Because we calculate fishing pressure as a rate instead of an absolute number," Miller adds, "harvests can be higher when there are more crabs in the Bay, but lower when stocks are down." Like an interest rate, he explains, the return on fishing effort depends on how much principal — in this case how many crabs — are in the bank. Miller and others hasten to explain that this is not a quota, which describes a certain fixed number. Harvests can go up and down, depending on the fluctuations of the stock, and still not cross the danger line.

In Search of Baywide Consensus

While setting a threshold will help guide efforts to manage the Chesapeake Bay blue crab, the future of the crab fishery will also largely depend on economic factors. To help document economic trends that drive the blue crab fishery, Anne Rhodes, a resource economist at the Virginia Commonwealth University, surveyed some 1,400 commercial crabbers in both Maryland and Virginia. Her work, supported by the Bi-State Blue Crab Advisory Committee, is helping to characterize the nature of the Bay's crab fishery.

Rhodes found, for example, that most respondents averaged about 50 years old and had been working the

water for some 25 years. She also found distinct differences among varying types of crabbing — potting, dredging and trotlining for hard crabs; and potting and scraping for peelers and soft crabs.

Looking for trends, Rhodes has compared her findings to an earlier survey she and her colleagues completed in 1992. "We have seen some shifts," she says. "For example, in 1992 hard crab potters in the medium range — that is, not the largest potting operations, but not the smallest either — got an average of about 60% of their income from crabs. By 1999, that average had dropped to 42%." On the other hand, she observes, "in 1992 those catching peelers averaged 42% of their income from crabs, but by 1999 average income from peelers rose to 53%."

This information tracks with the fact that the peeler fishery doubled in Virginia from 1995-1999.

According to Rhodes, the survey documents a number of areas where watermen in both states agree. Significantly, most commercial crabbers (77%) agreed with the statement that they were "worried about the future of the Bay's blue crab resource." An even greater percentage (83%) agreed that they had "little or no influence" on setting policy for blue crab management.

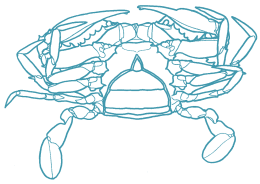
At public meetings conducted by the bi-state committee during the fall of 2000, many watermen expressed distrust of the process and often attacked the science that lies behind it.

Many of the problems facing crabbers, Rhodes feels, involve the current structure of the industry. "We have noted, she says, "shifts away from traditional marketing channels, such as picking houses and processors, to the basket trade and direct sales to the public." Many picking houses have gone out of business in recent years, she says, and it remains to be seen what shape the industry will take in the future. "I have heard of some crabbers creating cooperatives," she says, "especially in the peeler fishery, to sell their product. One group had their own plane, and they would fly product to Baltimore, New York and other places." Rhodes says that she also has heard of crabbers selling their catch over the internet.

"If it weren't for increases in prices, we wouldn't have been able to keep up," said long-time Virginia crab processor Weston Conley at a recent public meeting in Gloucester, Virginia. "Now," says Conley, who also serves as member of the Bi-State Blue Crab Advisory Committee, "prices have hit a wall." Like many other processors in the Bay region, he is very concerned about the future of the industry, especially the processing sector.

Rhodes has also heard concern ex-

Sanctuary in the Lower Bay



In June 2000 the Virginia Marine Resources Commission established a 660-square-mile sanctuary that reaches from the Maryland-Virginia line down to an area already protected by previously established sanctuaries. All waters in this area deeper than 35 feet will be off limits to crabbers during the summer, from June 1 to September 15.

These summer months are key for crabs. As the weather warms, female crabs emerge from their winter's rest in the mud and begin to move down the Bay to spawn.

According to Rom Lipcius of the Virginia Institute of Marine Science (VIMS), the females "dribble down" during much of the period from June to September, but twice a year a veritable migration occurs — once in spring, known as the spring peeler run, and again in the fall.

The spring run occurs in May or early June, Lipcius says, when females molt and mate and move down toward the Bay mouth. The fall run occurs largely in September. Females that do not spawn by mid-December will hold eggs and sperm and spawn the next spring, around May, says Lipcius.

Once spawned, blue crab larvae drift like orphans toward the open sea. Fortunately for both watermen and Bay seafood lovers, they return, carried back into the Bay by low-lying high-salinity waters. Once in the Bay they will take their chances not only against an army of predators but also against commercial and recreational crabbers. Now, thanks to the new sanctuary, at least those spawning females that take to deeper waters will have nothing to fear from human predators from June through mid-September in the deeper waters of Virginia's portion of the Bay.

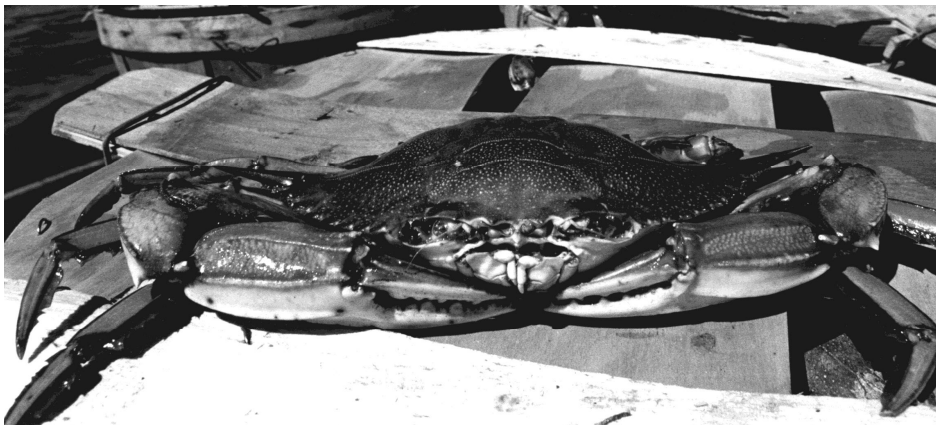
This approach toward conservation has appealed to both watermen and resource managers — to watermen because few pot for crabs in the deeper waters in warm weather, and managers because the sanctuary will prevent fishing pressure from moving into the middle of the Bay even when prices are high and crabs scarce.

"It is important to close off some areas before fishing pressure moves in," says Josef Idoine of the National Marine Fisheries Service, "instead of trying to close off an area already in heavy use."

According to Lipcius, who has closely monitored crab stocks in that region, the deep waters provide a significant site for spawning, and the added sanctuary should help protect some 40 percent of spawning females. "Our recent work has shown that spawning tends to reach from the Rappahannock River down to the mouth of the Bay," Lipcius says. "Spawning appears to move from the upper parts of this region [near the Rappahannock] early in the summer to near the Bay mouth by September." According to Lipcius, until the crab sanctuary was expanded, important parts of the spawning area were not protected, especially the upper part, near the Rappahannock River, during the critical June period.

Most researchers agree that a similar sanctuary would not make sense in Maryland, because of the Bay's bathymetry and a serious lack of oxygen in summer, as well as the general migratory patterns of crabs. Other adaptations of the sanctuary concept could make sense — for example, at other times of the year, perhaps at different depths. "We expect both Maryland and Virginia to take actions to conserve blue crab stocks," says Lipcius, "but we don't expect them to always take the same actions."

Even setting meaningful thresholds and targets will not secure the crab's future if we don't continue to improve water quality



Skip Brown

pressed by watermen. "We hear people say that you just can't make a living crabbing any more," she says, "unless you have a really big operation."

Other economists, such as Doug Lipton, have felt for some time that the Chesapeake crabbing industry is "overcapitalized." That is, there are too many pots, scrapes, traps and trotlines in the water relative to the number of crabs that can be caught. This heavy fishing pressure not only has the potential to deplete crab stocks, but it also means that the average commercial crabber is investing more in equipment and gear and getting less of a return for his investment.

"We have felt for some time," says Lipton, "that crabbers could significantly reduce the amount of gear they have in the water, and still catch the same number of crabs."

Lipton, a University of Maryland resource economist, is working with other economists, including VCU's Anne Rhodes and Leonard Shabman at Virginia Tech, to gauge the likely impact of reducing crab catches on the fishing industry.

"We have an idea of where the thresholds are," says Lipton, "so now we have to establish targets that will help point us toward where we need to go."

In other words, while thresholds define a limit beyond which we should not pass, targets define goals toward which we should aim. (See sidebar, "Arriving at a Threshold.") According to Miller, targets may be based either on yield (what one expects to get out of the fishery) or on stock variables (how big one expects the stock to be). The yield targets, he says, are more grounded in concrete data, while the stock-based targets may be more subjective (since a certain stock size may be perceived as conservative by some but risky by others).

No matter where we set targets over the coming years, says Miller, they will have to be at levels lower than the recommended thresholds if we truly hope to sustain the blue crab fishery far into the future.

Of course even setting meaningful thresholds and targets will not secure the crab's future, notes waterman Larry Simns, if the Bay states do not also continue to significantly invest in improving water quality in the Chesapeake. We cannot forget that the Bay itself sustains the blue crab, says Simns, and that if water quality is not improved — to levels that will bring back underwater grasses for example — no amount of even the most prudent fisheries management will ensure the health of the crab fishery.

No doubt the crab's future will depend on a complex blend of factors — changes in climate and weather that can move crab larvae offshore and affect the stock from year to year, changes in fishing regulations that can reduce or expand effort, changes in social behaviors that can lead to more or less recreational crabbing, and more or less demand at restaurants and roadside stands, as well as changes in economic factors, such as the importing of crabmeat from other states and other countries, that can alter local markets and the character of local distributors and seafood processors.

Whatever the future holds for the blue crab, researchers and resource managers have now recommended a Baywide safe zone for the blue crab fishery. Any harvesting targets that fall within that zone, they say, will have the best chance of assuring a healthy crab population.

Fishing pressure — whether recreational, commercial or both — that steps outside that safe zone runs the risk of reducing crab stocks beyond the point of reasonable recovery. Whether in terms of fishing pressure or stock size, crossing that line, they say, will be courting disaster. "It's like walking out on thin ice," says Miller. "You can do it every now and then and be fine. But if you keep doing it, one day you're going to fall through."

Blue Crab Information on the Web

Blue Crab Advisory 2000, Chesapeake Bay Scientific Advisory Committee (CBSAC)
www.fisheries.vims.edu/cbsac/
Main CBSAC website
noaa.chesapeakebay.net/cbsac.htm
Maryland Sea Grant
www.mdsg.umd.edu/crabs/index.html
Chesapeake Bay Program
www.chesapeakebay.net/blue_crab.htm
Maryland Department of Natural Resources
www.dnr.state.md.us/bay/science/savecrab.html
Virginia Institute of Marine Science
www.vims.edu/adv/ed/crab/general.html
National Aquarium
www.vims.edu/adv/ed/crab/general.html
Blue Crab Archives
www.blue-crab.org/

End Notes

Web Sites of Note

■ **Marine Science Education:** www.mdsg.umd.edu/Extension/msgsnn/index.html. This website has current and archive copies of *Maryland Sea Grant School Network News*, a quarterly publication for Maryland educators focuses on local science education and information sharing. Print copies are available from Maryland Sea Grant.

■ **Classroom@Sea:** classroomatsea.noaa.gov. Classroom@Sea is a virtual learning community constructed by NOAA with the help of the University of Washington's College of Education. It connects NOAA's research vessels working in the world's oceans with classrooms around the globe to bring science to life.

■ **Oyster Reef Restoration:** www.vims.edu/fish/oyreef/rest.html. This site from the Virginia Institute of Marine Science covers issues of general oyster reef restoration methods, specific projects and educational programs

■ **Cooking Seafood:** www.vims.edu/adv/seafood/recipes.html. The Virginia Sea GrantSeafood Education Seminars bring together some of Virginia's best marine scientists, chefs and wine experts to create exciting educational programs. Visit their site to learn more about this interesting program and for links to a variety of delicious and nutritious seafood recipes.

■ **Whales:** hmsc.orst.edu/education/tailing/index.shtml. Learn about whales: where they live, their migration routes, their feeding grounds, where they give birth. This Oregon Sea Grant site includes links to other whale sites as well as e-mail forms to ask questions of marine mammal scientists.

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