AN UNPRECEDENTED SCIENTIFIC COMMUNITY RESPONSE TO AN UNPRECEDENTED EVENT: TROPICAL STORM AGNES AND THE CHESAPEAKE BAY

M.P. Lynch

Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, VA 23062

ABSTRACT

In June 1972, the remnants of Hurricane Agnes brought destructive floods to the watershed of the Chesapeake Bay basin. Unlike Hurricane Isabel, Agnes did not strike Chesapeake Bay directly, but deposited a record amount of rainfall on the watershed. The evening that the Agnes rainfall began in earnest coincided with a meeting of the Citizens Program for the Chesapeake Bay. The directors of the three largest Chesapeake Bay research institutions, Drs. Donald W. Pritchard, L. Eugene Cronin, and William J. Hargis Jr., were in attendance at this meeting. The potential magnitude of the Agnes rainfall was readily apparent at the meeting as one of the planned evening events had to be moved due to a foot of water in the meeting room. The following morning at breakfast, the three directors committed their institutions to "Operation Agnes," extensive studies of the biological, chemical, and physical impacts of this event.

Hargis, Cronin, and Pritchard were good friends and strong competitors of long standing. Since 1949, Pritchard had been the first full-time director of the Chesapeake Bay Institute (CBI); Cronin had headed the Chesapeake Biological Laboratory (CBL) since 1951; and Hargis had been director of the Virginia Institute of Marine Science (VIMS) (and its predecessor the Virginia Fisheries Laboratory-VFL) since 1959. In 1964, the three directors had set up an informal Chesapeake Bay Research Council (CBRC) to coordinate some of their Chesapeake Bay research activities. They used the CBRC mechanism to coordinate "Operation Agnes," a commitment that was made without any assurance of financial support for these studies. The gamble taken by the three laboratory directors was successful, eventually resulting in a peer-reviewed book published by The Johns Hopkins University Press entitled *The Effects of Tropical Storm Agnes on the Chesapeake Bay Estuarine System*.

Operation Agnes was the last project undertaken by the CBRC. Reorganization by two of the parent institutions and incorporation of the Chesapeake Research Consortium (CRC) resulted in a realignment of Chesapeake Bay scientific leadership and the leadership of Operation Agnes moved from CBRC to CRC.

The scientific community's response to Tropical Storm Agnes—an unprecedented event—was in itself unprecedented. A number of coincidences came into play: recent (1969) experience with flooding from Hurricane Camille; fortuitous attendance of the leaders of the three largest Chesapeake Bay research institutions at a meeting directly affected by Agnes; and the prior mobilization of the three institutions to conduct extensive hydrographic studies throughout Chesapeake Bay. The most important factor, however, was the strong commitment of three laboratory directors to the understanding of the Chesapeake Bay system.

The Event[1]

In June 1972, the remnants of Hurricane Agnes reached the Chesapeake Bay region as a tropical depression with winds of less than 39 mph

[1] *Information in this section was primarily developed from the summaries of Agnes impacts produced by the Chesapeake Bay Research Council and the Chesapeake Research Consortium [1, 2].*

K.G. Sellner (ed.). 2005. Hurricane Isabel in Perspective. Chesapeake Research Consortium, CRC Publication 05-160, Edgewater, MD.

(63 km. As it passed through the Chesapeake region, it picked up strength from coastal waters and again became a tropical storm. From 21 through 23 June, rains directly attributed to Agnes reached the Chesapeake basin, falling on a watershed already saturated with precipitation dropped by a cold front that produced rainfall of 2.5–7.5 cm with isolated stations reporting up to 15 cm. Agnes produced measured rainfall over the entire watershed in excess of 13 cm with about a third of the area receiving more than 30 cm from June 21–23, 1972. Other storms, such as Hurricane Camille (August 1969), had produced greater rainfall at selected stations, but no recorded storms had produced the amount of rainfall that fell over such a large area as Agnes.

This record rainfall resulted in immediate flooding of the major Bay tributaries; most rivers crested at record levels. Peak normalized flow [Normalized flow = (average flow for a period)/(normal average for the same period)] was rapid and exceeded 60 in the James and Rappahannock rivers, slowed to 30–40 in the Susquehanna and York rivers, with the Potomac falling between the two. Flow rates also decreased faster in the James and Rappahannock rivers compared to the York and Susquehanna rivers. Salinities were depressed throughout the system for extensive periods of time. The floods of Agnes were estimated to be a 1-in-200 year event.

Unlike Isabel, winds were relatively low during Agnes, seas were not unusually high, and shore erosion in the tidal Chesapeake remained relatively low. Large quantities of sediment, however, were stripped from the watershed and transported to the tidal Chesapeake. In ten days, an estimated 31 million metric tons, compared to an average annual discharge of .5–1 million metric tons, flowed down the Susquehanna River over the Conowingo Dam at the head of the Bay. Deposition over some areas of the upper Bay was 15–25 cm, with up to 1 meter in channels. Rappahannock River sedimentation from Agnes amounted to between 2 and 7.5 mm, equivalent to about one-third of annual deposition. The extensive runoff also resulted in unseasonably large increases in nutrients, particularly nitrogen. This nitrogen was rapidly tied up in the sediments, with the majority of nitrogen remaining in the estuary and not transported to the Atlantic. Release of nutrients from the sediments in the following year resulted in extensive blooms. Dissolved oxygen concentrations were depressed both in the Bay and its tributaries, with the extent of depressed-oxygen waters much greater than normally found in summer months.

The entire biological community was disrupted to some extent. Soft-shell clams and oysters were the hardest hit shellfish. Blue crabs were initially thought to be displaced like finfish populations, but subsequent analyses of blue crab reproductive patterns indicated a major shift in 1972. Oyster drills, molluscan predators of oysters and other shellfish, were essentially eradicated in the Rappahannock and Piankatank rivers and severely depleted in the James and York rivers.

Aquatic vegetation was severely impacted. Hardest hit was eelgrass, which was reduced by about 89%. For all species combined, reduction was about 67%. In the tributaries to the lower Bay, eelgrass has not recovered to pre-Agnes levels through 2004.

Impacts to benthos and phytoplankton were most severe in the polyhaline zones. Many of these species were eliminated from their normal range. Fewer organisms from the mesohaline and oligohaline zones were as severely impacted and many actually extended their normal ranges downstream.

Economic losses in the tidal Chesapeake and its tributaries related to Agnes were estimated at $42.7 million in 1972 dollars (about $185.4 million in 2003 dollars.)

THE SCIENTIFIC COMMUNITY RESPONSE

In 1972, research in the Chesapeake Bay was dominated by three institutions: the Chesapeake Biological Laboratory (CBL) founded in 1925, the oldest of the three and the largest unit of the University of Maryland's Natural Resource

Institute; the Virginia Institute of Marine Science (VIMS), which had been founded in 1940 as the Virginia Fisheries Laboratory; and the Chesapeake Bay Institute (CBI), a unit of The Johns Hopkins Institute which had been formed in 1948 with equal funding from Maryland, Virginia, and the Office of Naval Research.

In 1964, the long-time heads of these three institutions—Dr. Donald W. Pritchard, the first permanent director of CBI (appointed 1949); Dr. L. Eugene Cronin, second permanent director of CBL (appointed 1951); and Dr. William J. Hargis, Jr., the fourth permanent director of VIMS (appointed 1959)—executed a memorandum of agreement which established a Chesapeake Bay Research Council (CBRC). This agreement replaced the compact that governed the funding and operations of CBI, which had by then fallen into disuse.

Under this collaboration, the three institutions developed several agreements related to data collection, data storage, and data sharing. With the advent of the US Army Corps of Engineer's (CoE) Chesapeake Bay Study in 1965, the council developed a major cooperative program to collect prototype data for the hydraulic model of the Chesapeake Bay that was eventually built at Matapeake, Maryland.

The three laboratory directors, although strong competitors, were very good friends and shared a common goal of doing the best science possible in the Chesapeake Bay. Each recognized that good science required good funding and that good funding came as a result of strong public and political support. All three directors maintained close ties with organized citizens groups. They were all on the Board of Directors of the Chesapeake Bay Foundation and had formed an *ad-hoc* Science

Figure 1. The Chesapeake Bay's "Big Three." From left to right: Bill Hargis, Don Pritchard, and Gene Cronin. Photo taken at the Bi-State Conference on Chesapeake Bay 1977, Patuxent Naval Air Station, Maryland.

Advisory Committee for the Citizen's Program for Chesapeake Bay (now known as the Alliance for Chesapeake Bay), an umbrella organization of Chesapeake Bay organizations started in 1971.

The Citizens' Program was holding its 1972 meeting in Fredericksburg, Virginia when the rains from Agnes began falling on the watershed. By the evening of the first day of the meeting, it became apparent that a flood event was underway as the rooms scheduled for the evening's event flooded. The following morning at breakfast the "Big Three," (Pritchard, Cronin, and Hargis, Figure 1) realized the storm presented them with a unique opportunity to study a major flood event. They agreed to put their institutions' resources out in the Bay and tributaries as soon as possible to capture the hydrographic results of the expected floods. By that afternoon and the following day, all three institutions had personnel on the water.

This commitment was made without any identified funding. The institutions had the personnel, supplies, and equipment available because they were prepared to do extensive hydrographic data collection for the CoE's model during the summer of 1972. The CoE, however, had directed this effort be postponed until later in the summer when low salinities from the wet winter would return to more normal conditions. Dr. W. Jackson Davis, VIMS Assistant Director for Fisheries Science, who along with the writer of this paper had accompanied Hargis to the Fredericksburg meeting, was assigned the task of overall Operation Agnes coordination. The author was assigned the task of trying to beg, borrow, or otherwise cajole logistic and financial support for the operation.

The words "unprecedented scientific community response" are used in the title. In 1972, there were essentially no regular surveys conducted within the Bay region except for fish and shellfish monitoring. No continuous data monitoring stations existed except for NOAA tide gauges, National Weather Service weather stations, and U.S. Geological Survey stream gauges. The only significant quantities of instrumentation to collect quality hydrographic data were the instruments purchased for CoE model data collection. Yet despite this lack of equipment and resources, the most extensive study of the impact of a major storm event was successfully mounted based on the determination of three scientists that such an endeavor was an opportunity not to be missed.

The response to the CBRC initiative was extremely gratifying. Several federal agencies committed funding within a few days of the event, bypassing normal lengthy reviews. The CoE, Philadelphia District was the first agency to provide new funding. The CoE, Norfolk District also contributed new money. Eventually the CoE, Baltimore District was persuaded that the Agnes expenditures were appropriate for this CoE study and fully funded the CBRC hydrographic studies. The fact that Drs. Pritchard, Cronin, and Hargis were on the Scientific and Technical Advisory Committee for this CoE study and Bill Hargis represented the Commonwealth of Virginia on the CoE Study Steering Committee may have helped persuade the Baltimore District.

New or reprogrammed funds were made available by the National Science Foundation's (NSF) Research Applied to National Needs (RANN) program and Oceanographic section. NOAA's Sea Grant Program and National Marine Fisheries Service's (NMFS) Anadromous Fish (PL 88-903) and Jellyfish (PL 89-720) programs provided some new funds and allowed substantial reprogramming of committed funds. In Maryland, the state's Department of Natural Resources and the U.S. Fish and Wildlife Service allowed reprogramming of the Bureau of Sport Fisheries Dingle Johnson funds. Financial support was also provided by the U.S. and Virginia offices of Emergency Preparedness, the Environmental Protection Agency, the Food and Drug Administration, and Columbia Natural Gas Corporation.

At the time of Agnes, the only large, fast vessels dedicated to oceanography in the CBRC institutions were the R/V *Ridgely Warfield*, a catamaran operated by CBI specifically designed for coastal and estuarine oceanography along with two oil field crew boats operated by CBI. VIMS had several very large, slow boats (including a car/

passenger ferry and a converted Landing Craft Utility) and several smaller converted work boats and sport fishing boats. The existing combined fleet and assigned vessel operators were insufficient to handle the daily slackwater runs in the tributaries and mainstem Bay, as well as the continuous anchor stations desired and the desired sampling in the coastal Atlantic. There was also concern that the floodwaters would bring down large quantities of debris that could endanger small craft.

Fortunately several organizations in the region provided extensive vessel support. The Naval Ordnance Laboratory, Solomons, Maryland; Coastal River Squadron TWO, U.S. Naval Amphibious Base (USNAB), Little Creek, Virginia; Assault Craft Unit TWO, USNAB; U.S. Coast Guard Cutter, *Cuyahoga*, Yorktown, Virginia; and Fort Eustis, Virginia provided both fast and sturdy vessels to meet these needs. The U.S. Coast Guard also provided the Buoy Tender, *Red Cedar*, Portsmouth Virginia to set current meter arrays and the Cutter, *Point Martin*, Little Creek, Virginia to recover and re-establish stations run over by commercial shipping. Support for equipment recovery was also provided by the Navy's Explosive Ordnance Disposal Unit TWO, Fort Story, Virginia (diving) and the Naval Ordnance Laboratory, White Oak, Maryland (magnetometer). The National Aeronautic and Space Administration's Langley Research Center in Hampton, Virginia provided helicopters, remote sensing instrumentation, and personnel to measure Bay surface hydrographic conditions.

Shelf observation support was provided through NOAA by the NMFS's R/V *Albatross* from Woods Hole, Massachusetts and vessels and personnel from NMFS's Sandy Hook, New Jersey laboratory. The U.S. Coast Guard also supported shelf studies by providing personnel to make round-the-clock hydrographic observations at the Diamond Shoals, Five Fathom, and Chesapeake Light towers.

Operation Agnes caught the attention of others in the Bay scientific community and many scientists added an Agnes component to their studies. The first report detailing the effects of Agnes on the Chesapeake Bay was a report to the CoE, Philadelphia District prepared by the CBRC [1].

In addition to seeing Agnes visit the Chesapeake region, 1972 saw the formal start of a new organization that assumed the role of facilitation of inter- and multi-university projects that had been informally provided by the CBRC. This new organization, the Chesapeake Research Consortium, Inc. (CRC), grew out of a project funded by the NSF's RANN program. The original participants in the project were the University of Maryland, The Johns Hopkins University, and VIMS. These three institutions were joined soon after by the Smithsonian Institution (at the recommendation of NSF). The only principal in the CRC who was a member of the CBRC was Bill Hargis, director of VIMS. At both the University of Maryland and The Johns Hopkins University, the principals were drawn from the academic side of the organization as opposed to the Chesapeake Bay-oriented research institutions. The formal document establishing the CRC was signed in February 1972, but it had not yet become fully functional when Agnes struck.

After initiating Operation Agnes and coordinating the initial report [1], the CBRC essentially turned over completion of the project to the CRC. The CRC co-sponsored a conference on Agnes, *"A Symposium on the Effects of Tropical Storm Agnes on the Chesapeake Bay Estuarine System,"* with the CoE, Baltimore District. The results of this symposium were published as a two-volume CoE report containing about 47 technical papers. In 1976, The Johns Hopkins University Press published a 639-page report detailing the effects of Tropical Storm Agnes on the Chesapeake Estuarine System [2] for the CRC. This volume contained not only studies performed as part of Operation Agnes by CBI, CBL, and VIMS staff, but also studies by several other Chesapeake Bay scientists, notably those involved in coordinated studies at the Smithsonian Institution's Chesapeake Bay Center for Environmental Studies, now known as the Smithsonian Environmental Research Center.

Several reports on the effects of Agnes on the Chesapeake estuarine system were presented at

conferences and symposia and eventually in peer-reviewed journals as well as in the CRC book. The honor of producing the first peer-reviewed paper [3] went to Dr. J.D. Andrews[2] of VIMS who published his study of Agnes' impacts on epifauna in a 1973 issue of *Chesapeake Science*.

AFTER AGNES

In 1973, Dr. Pritchard resigned from the directorship of CBI for health reasons, but remained as a senior scientist. In 1974, he took a one-year sabbatical. After returning to The Johns Hopkins University, he became director of CRC in 1976. In 1977, he retired from The Johns Hopkins University and joined the staff of the State University of New York, Stony Brook. Dr. Pritchard died in 1999.

In 1975, the University of Maryland's Natural Resource Institute was merged into the newly formed Center for Estuarine and Environmental Studies. Dr. Cronin served as assistant director of CEES until becoming director of CRC, replacing Dr. Pritchard. He remained director from 1977 until his retirement in 1984. Dr. Cronin died in 1998.

Dr. Hargis remained as director of VIMS and a principal in CRC. He served part of the time as chairman of the CRC board until 1981 when he returned to full-time teaching and research. In 1991, he retired and remains active as an emeritus faculty member. VIMS was placed under the control of the Board of Visitors of the College of William & Mary in 1979.

WILL WE SEE ANOTHER OPERATION AGNES?

Will we see the equivalent scientific response to an "unexpected environmental event" in the future? I doubt it. The scientific infrastructure in the Chesapeake Bay has become more complex. There is no longer a "Big Three" that controls or oversees the major resources devoted to Bay research. Two of the institutions or successor institutions led by the "Big Three" are much larger now than in 1972. One has disappeared. Many other institutions have developed an interest and capability to study the Chesapeake Bay. The leadership of the Bay scientific community is not as centralized or as close (some might say "closed" instead of "close") as in 1972. The largest non-governmental organization, the Chesapeake Bay Foundation, has developed its own in-house scientific capability. The Bay is now being looked at with many more eyes.

In some ways, communication at the scientist level is better. The Scientific and Technical Advisory Committee (STAC) of the Chesapeake Bay Program and CRC have convened groups of scientists to address different problems over the years. The Chesapeake Bay Stock Assessment Committee, instituted by NOAA as part of its contribution to the Chesapeake Bay Program, has greatly improved communications between fisheries scientists working in the Bay. Communication among scientists at different institutions does not now flow through the institution's leadership.

In the 30-plus years since Agnes, however, it appears that the scientific leadership has been more and more constrained by non-scientific business managers in their own institutions and, more importantly, by business as opposed to scientific consideration in the funding agencies. In the early 1970's, a program officer in a federal agency such NSF, NOAA, or the CoE could make a commitment to a scientist that a study would be funded if the scientist began a project without a signed grant or contract and the money would materialize within a reasonable length of time. By the end of the 1970's, program officers would state up front they could not make any commitments until a grant or contract was signed by the contracts office.

A legitimate concern for "accountability" has led to a strong curtailment of the flexibility once possessed by laboratory directors and individual scientists. So many "sign-off" steps currently exist in the process to obtain reprogramming approval or to acquire funds on extremely short notice that

[2] *Dr. Andrews retired from VIMS in 1983. He died October 28, 2004.*

most "unexpected events" will have come and gone before approval is obtained

Fortunately, as was seen in Isabel's aftermath, advances in monitoring technology and practices allow us to track system responses to unusual events without the need to immediately launch major field efforts to capture the event.

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