1976

The displacement and loss of larval fishes from the Rappahannock and James rivers, Virginia, following a major tropical storm

Walter J. Hoagman

John V. Merriner

The Effects of Tropical Storm Agnes on the Chesapeake Bay Estuarine System

The Chesapeake Research Consortium, Inc.

THE EFFECTS OF TROPICAL STORM AGNES ON THE CHESAPEAKE BAY ESTUARINE SYSTEM

THE EFFECTS OF TROPICAL STORM AGNES ON THE CHESAPEAKE BAY ESTUARINE SYSTEM

THE CHESAPEAKE RESEARCH CONSORTIUM, INC.

The Johns Hopkins University
Smithsonian Institution
University of Maryland
Virginia Institute of Marine Science

Project Coordinator, Jackson Davis (VIMS)
Volume Coordinator, Beverly Laird (VIMS)

Section Editors

Evon P. Ruzecki, Hydrological Effects (VIMS)
J. R. Schubel, Geological Effects (JHU)
Robert J. Huggett, Water Quality Effects (VIMS)
Aven M. Anderson, Biological Effects, Commercial (U.Md.)
Marvin L. Wass, Biological Effects, Non-Commercial (VIMS)
Richard J. Marasco, Economic Impacts (U.Md.)
M. P. Lynch, Public Health Impacts (VIMS)

November 1976

CRC Publication No. 54

Published for The Chesapeake Research Consortium, Inc.,
by The Johns Hopkins University Press, Baltimore and London

Manufactured in the United States of America

The Johns Hopkins University Press, Baltimore, Maryland 21218
The Johns Hopkins Press Ltd., London

Library of Congress Catalog Card Number 76-47392
ISBN 0-8018-1945-8

Library of Congress Cataloging in Publication data will be found on the last printed page of this book.

Preface

During June 1972 Tropical Storm Agnes released record amounts of rainfall on the watersheds of most of the major tributaries of Chesapeake Bay. The resulting floods, categorized as a once-in-100-to-200-year occurrence, caused perturbations of the environment in Chesapeake Bay, the nation's greatest estuary.

This volume is an attempt to bring together analyses of the effects of this exceptional natural event on the hydrology, geology, water quality, and biology of Chesapeake Bay and to consider the impact of these effects on the economy of the Tidewater Region and on public health.

It is to be hoped that these analyses of the event will usefully serve government agencies and private sectors of society in their planning and evaluation of measures to cope with and ameliorate damage from estuarine flooding. It is also to be hoped that the scientific and technical sectors of society will gain a better understanding of the fundamental nature of the myriad and interrelated phenomena that is the Chesapeake Bay ecosystem. Presumably much of what was learned about Chesapeake Bay will be applicable to estuarine systems elsewhere in the world. Most of the papers comprising this volume were presented at a symposium held May 6–7, 1974, at College Park, Maryland, under the sponsorship of the Chesapeake Research Consortium,Inc., with support from the Baltimore District, U.S. Army Corps of Engineers (Contract No. DACW 31-73-C-0189). An early and necessarily incomplete assessment, *The Effects of Hurricane Agnes on the Environment and Organisms of Chesapeake Bay* was prepared by personnel from the Chesapeake Bay Institute (CBI), the Chesapeake Biological Laboratory (CBL), and the Virginia Institute of Marine Science (VIMS) for the Philadelphia District, U.S. Army Corps of Engineers. Most of the scientists who contributed to the early report conducted further analyses and wrote papers forming a part of this report on the effects of Agnes. Additional contributions have been prepared by other scientists, most notably in the fields of biological effects and economics.

The report represents an attempt to bring together all data, no matter how fragmentary, relating to the topic. The authors are to be congratulated for the generally high quality of their work. Those who might question, in parts of the purse, the fineness of the silk must keep in mind the nature of the sow's ears from which it was spun. This is not to disparage the effort, but only to recognize that the data were collected under circumstances which at best were less than ideal. When the flood waters surged into the Bay there was no time for painstaking experimental design. There were not enough instruments to take as many measurements as the investigators would have desired. There were not enough containers to obtain the needed samples or enough reagents to analyze them. There were not enough technicians and clerks to collect and tabulate the data. While the days seemed far too short to accomplish the job at hand, they undoubtedly seemed far too long to the beleaguered field parties, vessel crews, laboratory technicians, and scientists who worked double shifts regularly and around the clock on many occasions. To these dedicated men and women, whose quality of performance and perseverance under trying circumstances were outstanding, society owes an especial debt of gratitude.

It should be noted that the Chesapeake Bay Institute, the Chesapeake Biological Laboratory, and the Virginia Institute of Marine Science, the three major laboratories doing research on Chesapeake Bay, undertook extensive data-gathering programs, requiring sizable commitments of personnel and equipment, without assurance that financial support would be provided. The emergency existed, and the scientists recognized both an obligation to assist in ameliorating its destructive effects and a rare scientific opportunity to better understand the ecosystem. They proceeded to organize a coordinated program in the hope that financial arrangements could be worked out later. Fortunately, their hopes proved well founded. Financial and logistic assistance was provided by a large number of agencies

that recognized the seriousness and uniqueness of the Agnes phenomenon. A list of those who aided is appended. Their support is gratefully acknowledged.

This document consists of a series of detailed technical reports preceded by a summary. The summary emphasizes effects having social or economic impact. The authors of each of the technical reports are indicated. To these scientists, the editors extend thanks and commendations for their painstaking work.

Several members of the staff of the Baltimore District, U.S. Army Corps of Engineers, worked with the editors on this contract. We gratefully acknowledge the helpful assistance of Mr. Noel E. Beegle, Chief, Study Coordination and Evaluation Section, who served as Study Manager; Dr. James H. McKay, Chief, Technical Studies and Data Development Section; and Mr. Alfred E. Robinson, Jr., Chief of the Chesapeake Bay Study Group.

The editors are also grateful to Vickie Krahn for typing the Technical Reports and to Alice Lee Tillage and Barbara Crewe for typing the Summary.

The Summary was compiled from summaries of each section prepared by the section editors. I fear that it is too much to hope that, in my attempts to distill the voluminous, detailed, and well-prepared papers and section summaries, I have not distorted meanings, excluded useful information or overextended conclusions. For whatever shortcomings and inaccuracies that exist in the Summary, I offer my apologies.

Jackson Davis
Project Coordinator

Acknowledgements

The Chesapeake Research Consortium, Inc. is indebted to the following groups for their logistic and/or financial aid to one or more of the consortium institutions in support of investigations into the effects of Tropical Storm Agnes.

U. S. Army
- Corps of Engineers, Baltimore District
- Corps of Engineers, Norfolk District
- Corps of Engineers, Philadelphia District
- Transportation Corps, Fort Eustis, Virginia

U. S. Navy
- Naval Ordnance Laboratory
- Coastal River Squadron Two, Little Creek, Virginia
- Assault Creek Unit Two, Little Creek, Virginia
- Explosive Ordnance Disposal Unit Two, Fort Story, Virginia
- Naval Ordnance Laboratory, White Oak, Maryland

U. S. Coast Guard
- Reserve Training Center
- Coast Guard Station, Little Creek, Virginia
- Portsmouth Supply Depot
- Light Towers (Diamond Shoal, Five Fathom Bank, and Chesapeake)

National Oceanic and Atmospheric Administration
- National Marine Fisheries Service (Woods Hole, Massachusetts and Sandy Hook, New Jersey)

The National Science Foundation

Food and Drug Administration

Environmental Protection Agency

U. S. Office of Emergency Preparedness

State of Maryland, Department of Natural Resources

Commonwealth of Virginia, Office of Emergency Preparedness

TABLE OF CONTENTS

C. Water Quality Effects

D. Biological Effects

THE DISPLACEMENT AND LOSS OF LARVAL FISHES FROM THE RAPPAHANNOCK AND JAMES RIVERS, VIRGINIA, FOLLOWING A MAJOR TROPICAL STORM[1]

Walter J. Hoagman[2]
John V. Merriner[2]

EXPANDED ABSTRACT

Methods

Two days after Tropical Storm Agnes, the Virginia Institute of Marine Science (VIMS) established an anchor station at Mile 15 in the Rappahannock and Mile 10 in the James River. Both stations were in mainstream, manned constantly for 10 days, and took continuous current data from meters placed at 0, 6, 8, and 15 m in the Rappahannock and 0, 4, 5, 8, and 14 m in the James. Concurrently, 0.85 m diameter plankton nets of No. 1 nylon mesh were hung in the flowing surface water for 10 minutes hourly. A small collection of midwater (4 m) plankton samples was obtained from the James station. The shoal areas were not sampled for larval fish. The ichthyoplankton and zooplankton captured were preserved and later identified to species. Both rivers experienced constant ebb tide for several days because of the freshwater layer sweeping to Chesapeake Bay. Below 4 m, the currents were often strongly opposed to the surface currents.

The number of larvae swept to Chesapeake Bay was computed by using a moving average of three of the 10 minute counts and the current measurements; then expanding to hourly estimates, with the flood tide periods subtracted from the loss on ebb tide to obtain daily totals. Outflow was nearly constant from 0-4 m over the first 6 days of sampling, but to allow for shoal areas where currents may have been slower and larvae less affected, only the upper meter in each river was used to calculate total volume containing fish larvae passing the river mile. The program began June 24, 1972 on each river and was discontinued on July 7, 1972, providing 184 surface samples from the Rappahannock, and 61 surface samples and 23 midwater samples from the James.

Results

Eighteen species of fish larvae were captured from the Rappahannock and 22 species from the James. *Gobiosoma bosci* typically made up 75-99% of the daily catches, followed by *Anchoa mitchilli* with 2-20%. The next most abundant were *Syngnathus fuscus* and *Menidia menidia*.

All of the *G. bosci* were young, ranging 4.2 to 10.1 mm total length with an average of 6.2 mm. *A. mitchilli* ranged 3.0 to 18 mm but the vast majority were near 10 mm. *S. fuscus* were below 50 mm average length and *M. menidia* were typically close to 20 mm. *Alosa sapidissima* and *Alosa* sp. (river herring) were few in numbers and very small (6.0-11 mm).

Catches of larval fish were highest at the beginning, then tapered off rapidly after six days. On June 24, 65 million *G. bosci* and 0.7 million *A. mitchilli* were swept past Mile 15 on the Rappahannock. Seven days later, strong flood tides began to reverse the flow and millions of fish larvae were carried

---

[1]Contribution No. 799 , Virginia Institute of Marine Science.
[2]Virginia Institute of Marine Science, Gloucester Point, Va. 23062.

back into the river. These estimates were subtracted from the estimated losses. In the Rappahannock, the grand total estimated loss from June 24 to July 7, 1972, using only the upper 1 m for calculation, was 93 million *G. bosci*, 3.6 million *A. mitchilli*, 1.8 million *S. fuscus*, and 2.2 million *M. menidia*. All other species had estimated losses of less than 0.5 million. The estimates are additionally conservative, because Agnes produced strong outflows on June 21, 22, and 23 and these days were not sampled or included in the total estimates.

The James River, using to 1 m only, lost 429 million *G. bosci*, 26 million *A. mitchilli*, 0.9 million *M. menidia*, 0.4 million *S. fuscus*, 13.1 million *Alosa aestivalis*, and 1.6 million *Dorosoma cepedianum*. June 25 and 28 were the days of greatest loss.

Midwater catches (4 m) of fish larvae from the strongly outflowing water demonstrate a high proportion of the total loss (unknown) was below 1 m. Between 0630 on June 25 and 1040 on June 28, 13 sets of surface and midwater samples were taken concurrently from the James station. The actual number of larvae captures was:

	G. bosci	*A. mitchilli*	*A. aestivalis*
Surface	627	62	56
Midwater	1,035	111	16
Midwater as % of Total Captured	62%	64%	22%

Based on these data, the 1 m estimate of total loss could be low by a factor of 5 to 10. The midwater data were not complete enough to allow volume estimates of flow or estimate total loss of fish larvae with catch data below 1 m.

Conclusions

The loss of fish larvae from both rivers was high for 4 species in the Rappahannock and 6 species in the James. The James lost 5 times the *G. bosci*, 7 times the *A. mitchilli*, and 30 times the *A. aestivalis* as the Rappahannock. The Rappahannock lost more *M. menidia* and *S. fuscus*, however.

In 1972, the juvenile *A. aestivalis* population in the James on September 1 was estimated to be 264 million (Hoagman & Kriete 1975). This was only 23% of the 1971 year class and 66% of the 1973 year class for the James.

Turner and Chadwich (1972) using 11 years of c/f sampling, gave a daily Z of 0.053 for *Morone saxatilis* over the sizes of 20 to 51 mm. Their Z may not apply to *A. aestivalis*, but without Z for these, an approximation of stock size on June 22 can be computed by substitution in the general population formula:

$$N_t = N_o e^{(Zt)}$$

$$264 = N_o e^{(-0.53 \times 71 \text{ days})}$$

$$N_o = 613 \text{ mill.}$$

An estimated loss of 13 million *A. aestivalis* because of Agnes, therefore, represents a 2% loss of the larvae. This would be the low estimate. More likely, the loss was above 5%, but probably less than 20%.

We do not know the actual impact on the stocks which had substantial larval losses. Agnes did not wipe out any river or stock it seems. The fish populations with high losses were abundant the year after Agnes, but quantitative measures of the relationship are not available.

LITERATURE CITED

Hoagman, W. J. and W. H. Kriete. 1975. Biology and management of river herring and shad in Virginia. VIMS Adadromous Fish Project, Annual Report, AFC-8-2, 105 p.

Turner, J. L. and H. K. Chadwick. 1972. Distribution and abundance of young-of-the-year striped bass, *Morone saxatilis*, in relation to river flow in the Sacramento-San Joaquin estuary. Trans. Am. Fish. Soc. 101(3):442-452.