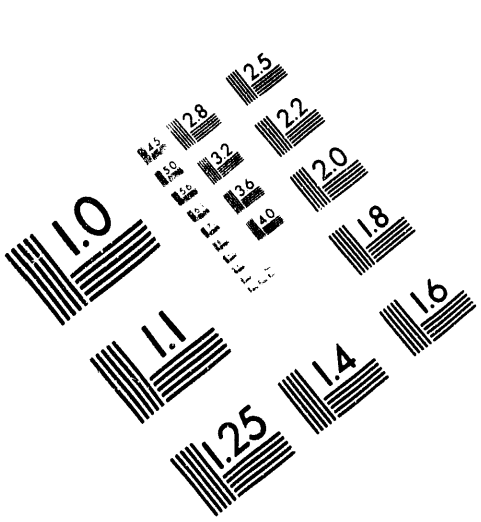

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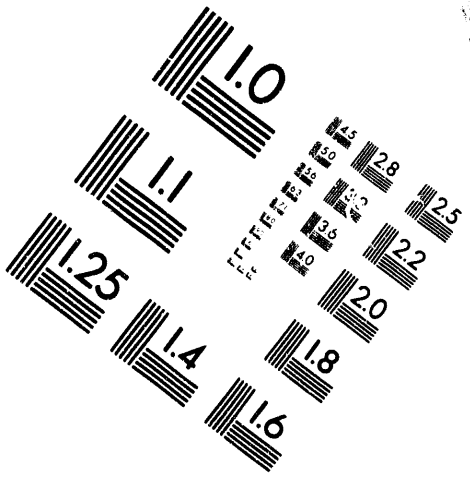

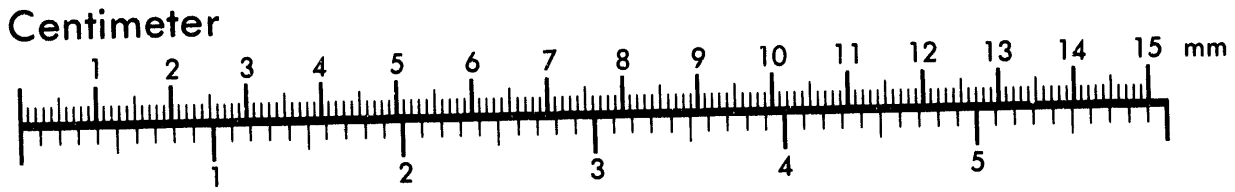

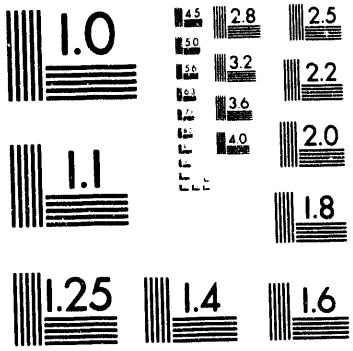

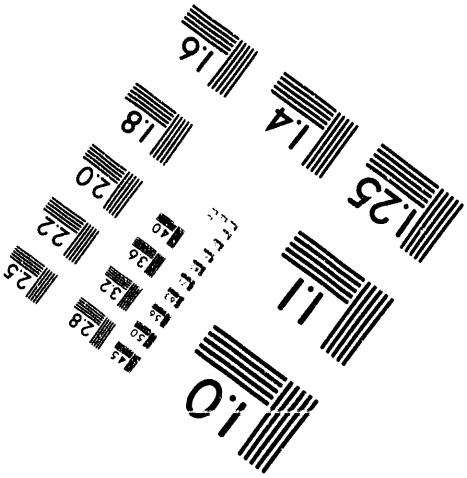

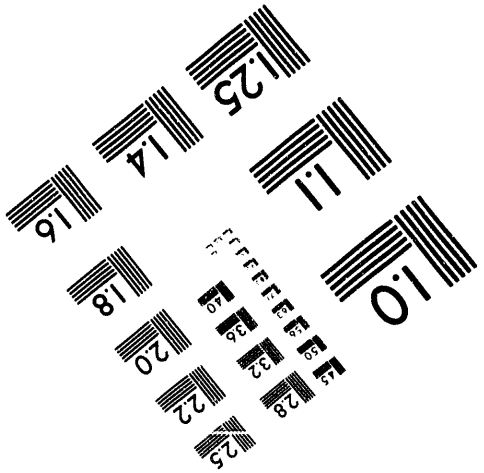

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BIOLOGICAL PROCESSES IN THE WATER COLUMN OF THE SOUTH ATLANTIC BIGHT: ZOO PLANKTON RESPONSES

Final Report

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September 25, 1992

PREPARED FOR THE
U.S. DEPARTMENT OF ENERGY
UNDER CONTRACT DE-FG09-85-ER60354

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9. Patent Clearance ("x" one)
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   - [ ] b. Report has been sent to responsible DOE patent group for clearance.

PROJECT SUMMARY

The main goal of our research was to determine and understand the major processes governing the abundance, distribution, composition and eventual fate of zooplankton on the southeastern shelf of the U.S. in relation to water circulation. Over much of the shelf circulation is dominated by the Gulf Stream and/or atmospheric forcing. Most of our studies concentrated on processes on the middle and outer shelf. On the latter, pronounced biological production occurs year-round at frequent intervals and is due to Gulf Stream eddies which move by at an average frequency of one every week. These eddies are rich in nutrients which, when upwelled into the euphotic zone, lead to pronounced primary production which then triggers zooplankton production.

During summer when shelf waters become less dense upwelled Gulf Stream water can intrude onto the continental shelf if the following conditions occur simultaneously: a frontal eddy passing at the shelf break, the Gulf Stream being close to the shelf break, and wind stress being north-to-eastward. If these conditions prevail for more than one week most of the continental shelf can be flooded by upwelled water, sometimes covering in excess of 10,000 km^2, on occasion reaching the shore. Depending on the species, concentration and spatial extent of seed populations of phyto- and zooplankton, these can develop into blooms usually resulting in exhaustion of nutrients by phytoplankton within 2 weeks, much of the phytoplankton being consumed by developing zooplankton populations which are either smaller copepods or rapidly growing tunicates. Copepod populations can increase as rapidly as 9% per day, and tunicates (salps) as fast as 50% per day, the latter being able to outgrow and contain developing phytoplankton populations. Only large phytoplankton cells remain

ungrazed and can continue to exist in dense patches. The longer intruded Gulf Stream water remains on the middle to inner shelf the higher the probability of the phytoplankton being consumed by zooplankton. Longer residence times of mid shelf water are observed during summer because of weak winds and only intermittent effects of the Gulf Stream. Therefore, the probability is high that most of the primary production is consumed or decomposed, and part of the herbivorous-omnivorous zooplankton is consumed by carnivores including vertebrates before this water leaves the inner and middle part of the continental shelf.

During winter, the water on the continental shelf is of higher density (cooler), not permitting nutrient-rich, upwelled water to advance far shoreward, usually not advancing farther shoreward than the 30 m isobath. On- or offshore displacement of water is mainly due to intermittently occurring atmospheric forcing supported by Gulf Stream forcing at the shelf break. Gulf Stream eddies, or part of them, are repeatedly displaced onto the outer, and occasionally middle shelf; they are characterized by developing or advanced phytoplankton blooms, and quite often by tunicates which, like in summer, have the potential to consume much, if not most of that primary production. This implies, that even during winter, not only considerably high primary but also secondary (zooplankton) production is observed on the middle and outer shelf. Temperatures in these productive waters usually exceed 16°C. Residence times of water on the shelf are shorter than in summer which implies that, unless tunicates prevail much of the primary production leaves the shelf without being consumed. Thus, export of organic matter from the shelf can be pronounced.

During spring, meteorological conditions strongly affect processes of the middle

and inner shelf waters. Direction and strength of wind stress as well as periods of unidirectional forcing largely determine the extent of water displacement. Strong forcing and extended periods of wind stress towards offshore, in conjunction with pronounced runoff, can result in displacement of inshore water to the outer shelf, displacing at the same time offshore water of higher density towards shore. Weaker forcing with short periods of wind forcing in one direction increases the residence time of water in each respective shelf region and does not allow for much cross-shelf exchange. Secondary production under the first regime appears to be much more pronounced than under the second one.

These observations were only possible because of the interdisciplinary nature of DOE's Southeastern Continental Shelf Program, and the fact that virtually all participants shared shiptime and data and contributed to manuscripts in a truly cooperative manner.

A list of publications and manuscripts in press/accepted for publication, and of talks acknowledging DOE grants follows.

Publications and Talks which Acknowledge DOE Grant DE-FG09-85ER60354

Publications:

1978 Atkinson, L.P., G.-A. Paffenhöfer and W.M. Dunstan. The chemical and biological effect of a Gulf Stream intrusion off St. Augustine, Florida. Bull. Mar. Sci. 28(4):667-679.

1979 Paffenhöfer, G.-A. and S.C. Knowles. Ecological implications of fecal pellet size, production, and consumption by copepods. J. Mar. Res. 37:35-49.

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Pomeroy, L.R., J.O. Blanton, G.-A. Paffenhöfer, K.L. von Damm, P.G. Verity and H.L. Windom. Chapter 2: Inner Shelf Processes. In: Menzel, D.W., ed., "Ocean Processes: U.S. Southeast Continental Shelf,"f Washington, DC, U.S. Department of Energy.

Verity, P.G., T.N. Lee, J.A. Yoder, G.-A. Paffenhöfer, J.O. Blanton and C.R. Alexander. Chapter 3: Outer Shelf Processes. In: Menzel, D.W., ed., "Ocean Processes: U.S. Southeast Continental Shelf,"f Washington, DC, U.S. Department of Energy.

Talks:

G.-A. Paffenhöfer, B.K. Sherman and J.A. Odell. Biological developments in summer upwellings on the southern shelf. American Geophysical Union, Fall Meeting, San Francisco, CA, 7-15 December 1982.

G.-A. Paffenhöfer and K.B. Van Sant. Feeding of the marine plantonic copepod *Eucalanus pileatus* on living and non-living material. AGU Ocean Sciences Meeting, New Orleans, LA, 23-27 January 1984.

G.-A. Paffenhöfer, B.K. Sherman and J.A. Odell. Zooplankton developments in upwelled water masses on the U.S. southeastern shelf. AGU Fall Meeting, San Francisco, CA, 3-7 December 1984.

G.-A. Paffenhöfer, B.K. Sherman and T.N. Lee. Development and persistence of zooplankton patches during summer on the southeastern shelf of the U.S.A. AGU Ocean Sciences Meeting, New Orleans, LA, 13-17 January 1986.

G.-A. Paffenhöfer and T.N. Lee. Development and persistence of patches of thaliacea. International Symposium on Population and Community Ecology in the Benguela Upwelling Region and Comparable Frontal Systems, Cape Town, South Africa, 8 to 12 September 1986.

G.-A. Paffenhöfer, J.O. Blanton and L.-Y. Oey. Positive and negative effects of physical forcing on recruitment in the pelagic environment. AGU Fall Meeting, San Francisco, CA, 8 to 12 December 1986.

G.-A. Paffenhöfer. Characteristics of abundant subtropical copepods in estuarine, shelf and oceanic waters. AGU Fall Meeting, San Francisco, CA, 6 to 11 December 1988.

G.-A. Paffenhöfer. Marine cyclopoid copepods: Some considerations on their ubiquitous abundance. American Society of Limnology and Oceangoraphy, Annual Meeting, Williamsburg, VA, 10-15 June 1990.

G.-A. Paffenhöfer, L.P. Atkinson, L.R. Bulluck and P.G. Verity. Control of planktonic copepods by gelatinous zooplankton. ASLO Annual Meeting, Halifax, Nova Scotia, 10 to 14 June 1991.

G.-A. Paffenhöfer. Zooplankton processes in neritic regions. International Symposium - Benguela Trophic Functioning, Cape Town, South Africa, 8 to 13 September 1991.

GRADUATE STUDENTS SUPPORTED BY DOE

Don Deibel, graduated 1979, Ph.D. degree in Ecology, University of Georgia, thesis title: "Laboratory and field studies on the feeding, growth and swarm dynamics of neritic tunicates from the Georgia Bight."

Holly J. Price, graduated 1985, Ph.D. degree in Ecology, University of Georgia, thesis title: "Cinematographic analyses of the feeding behavior of marine calanoid copepods."

Marie H. Bundy, will graduate in 1993, Ph.D. degree in Ecology, thesis title: "Functional morphology, feeding and swimming behavior of the genus *Centropages* (Copepoda, Calanoida)"

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