The
Marine Sciences Research Center
State University of New York
Stony Brook, NY

Documentation
prepared
for
review by the
Provost's Council on Institutes and Centers
and Council on Academic Standards

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List of Acronyms

MSRC	Marine Sciences Research Center
LIMRI	Living Marine Resources Institute
WRMI	Waste Reduction and Management Institute
ITPA	Institute for Terrestrial and Planetary Atmospheres
LIGRI	Long Island Groundwater Research Institute
SBCF	Stony Brook Community Fund
CEIE	Center for Excellence and Innovation in Education
WISE	Women in Science and Engineering
NOAA	National Oceanic and Atmospheric Administration
NASA	National Aeronautics and Space Administration
DOE	Department of Energy
ONR	Office of Naval Research
EPA	Environmental Protection Agency
JGOFS	Joint Global Ocean Flux Study
STEP	Science and Technology Entry Program
CISK	Convective Instability of the Second Kind

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A. BACKGROUND INFORMATION

1. Overview

The Marine Sciences Research Center (MSRC) is the sole unit of the State University of New York system charged with research education and public service in the marine sciences. Impetus for creation of the MSRC at Stony Brook came from a 1965 study of Long Island's critical needs done by the Long Island Regional Planning Board. The Planning Board's report "Status and Potential of the Marine Environment" argued that the importance of the marine environment to Long Island's economy demanded an organized research unit dedicated to understanding that environment and capable of providing input to policy decisions related to the coastal ocean. Authorization to establish the Marine Sciences Research Center subsequently came through a resolution by the State University of New York Board of Trustees, and SUNY-Stony Brook was designated as the SUNY campus to host such a research center. The first faculty appointments were made in 1968.

The mission of the MSRC, as stated in our recently developed five year strategic plan (see appendices), is to increase fundamental understanding of the oceans and atmosphere and their interactions and to apply this understanding to the resolution of societal problems as they relate to the environment on local, regional, national, and international levels. Particular attention is focused on the coastal zone where interactions between the air, land, and sea are most intense and complex, the natural resources of the sea are most abundant, and the impacts of human activities are most prominent. Given the diversity of environmental issues facing the highly-populated coastal regions of New York State, there is no other location better suited than Stony Brook for this mission.

The mission is accomplished through:

- Interdisciplinary research on the processes that govern the oceans, atmosphere and their inhabitants.
- A multidisciplinary approach to undergraduate education and the training of new researchers and scholars through graduate education.
- Informing, educating, and making accessible to the public, the results of research in a manner that enhances the basis for management and public policy decisions.
- Acting as a catalyst for bringing together scholars from different disciplines throughout the Stony Brook campus, the University system, and the nation to stimulate and focus research on environmental issues.

Two aspects of MSRC's mission - a striving for excellence in coastal oceanography and a commitment to using research to solve societal problems - constitute a combination virtually unique among the nation's oceanographic institutions. Although increasing numbers of

oceanographic institutions have begun to focus on the coastal ocean, few are as active as MSRC in translating advances in research into solutions to environmental problems resulting from society's use of the coastal ocean. To facilitate this translation in key areas, two institutes were created - The Living Marine Resources Institute (1985) and the Waste Reduction and Management Institute (1985). Both institutes are active in critical areas involving living marine resources and marine and terrestrial waste management issues.

MSRC's ability to address environmental issues, particularly with respect to global change, was increased with the incorporation of the Institute for Terrestrial and Planetary Atmospheres in 1992. In 1994, the Center joined with the Departments of Applied Mathematics and Statistics and Earth and Space Sciences in creating the Long Island Groundwater Research Institute to study groundwater hydrology and chemistry and tackle problems of groundwater contamination.

As MSRC has grown, its ability to compete effectively for federal research dollars has grown as well. Research expenditures in 1996 were over $7M, up 26% from the previous year, despite decreases in University support for MSRC and the loss of several faculty. Indeed our level of research support represents a leveraging of state support by a factor of almost three to one.

MSRC was established without a formal educational program, but it quickly became apparent that achieving its goal of excellence in oceanography, as well as acceptance and support within an academic institution, required one. In 1970, a Master of Science program in Marine Environmental Studies was created to train environmental scientists for positions in environmental planning, protection and management in both the private and public sectors.

A 1975 review of MSRC raised the question of whether the Center could be expected to realize its full research potential and contributions to graduate education without a Ph.D. program. Acting on the Review Committee's report, MSRC created a Ph.D. program in Coastal Oceanography that received formal endorsement from the State Education Department in 1978. The quality of MSRC's doctoral program in oceanography was recognized in 1995 when the National Research Council ranked our Ph.D. program 8th in the nation. We are the smallest program in the top 10 and the only one to focus on coastal oceanography.

As MSRC has grown since the late 1970s, its educational mission has expanded as well. The creation of the Waste Management Institute (now Waste Reduction and Management Institute) in 1985 led to a Certificate Program in Waste Management, in collaboration with the School for Professional Development. At the undergraduate level, tracks have been created in geology, chemistry and engineering for

students who wish to study geological oceanography, oceanic chemistry and applied environmental science, respectively. Responsibility for the atmospheric sciences major was added to MSRC with the Institute for Terrestrial and Planetary Atmospheres in 1992, and the major has been revised to accommodate undergraduate tracks in meteorology and ocean physics.

The 1994 Middle States accreditation review of Stony Brook criticized the university for its lack of an organized focus on environmental programs. MSRC has most of the expertise in the environmental sciences on campus and we believe there are existing opportunities in this area at the graduate level. However, we perceived a need for a program at the undergraduate level designed to teach students about environmental issues and problems and the multidisciplinary approach necessary to approach them. *We have responded to the Middle States evaluation by developing a major in Environmental Studies, designed as a BA and incorporating input from the social sciences, policy and management, engineering and applied science, as well as the natural sciences.* The curriculum has been approved on campus and announced to the other SUNY campuses. Formal approval is likely by fall, 1998. MSRC is also preparing a field-oriented Marine Sciences Summer Semester to attract undergraduates from Stony Brook and elsewhere to the campus for the summer.

In its 29 years, MSRC has come a long way, yet we face formidable challenges to maintain our quality. Recent budget cuts have severely hampered our ability to accomplish our mission and to address issues such as faculty salary equity relative to other comparable units on campus. Such problems are occurring at a time when other institutions (including universities in New Jersey and Connecticut) are strengthening their marine science programs, and increasing numbers of them are focusing on the coastal ocean. Despite these uncertainties and pressures, the MSRC has taken on the task of looking to the future. We have completed a strategic five year plan that includes goals linked to the President's Five Year Plan and the Provost's Academic Plan. The remaining sections of this report summarize MSRC's accomplishments and directions for the future and highlight some of the problems that must be solved if MSRC is to retain its national ranking.

2. Comparison With Other Institutions

Given MSRC's ranking of eighth in the National Research Council evaluation of doctoral programs in oceanography, it is useful to compare our organization, size and resources with other institutions that were ranked. The most up-to-date and accurate compilation of data pertinent to US marine (and atmospheric) science programs is that prepared in fall, 1996, by the Consortium for Oceanographic Research and Education (CORE). Table 1 shows a listing of the programs ranked in the top 10 by the NRC as well as a few others with

Table 1: Comparison of MSRC with other marine and atmospheric science programs (data from CORE, 1996)

NRC Ranking*	Unit	Organization	Faculty (tenure track, research)	Employees (Post-docs, technicians, other staff)	Undergraduate Majors	Graduate Students
1	University of California Scripps Institution of Oceanography	Institution within state university	174	1142	36	189
2	MIT-Woods Hole Oceanographic Institution	Free standing research institution linked to private university	127	896	0	130
3	University of Washington	College	87	536	192	270
4	Columbia University (Lamont-Doherty Earth Observatory)	Research institution within university	84	295	0	79
5	Oregon State University	College (includes atmospheric sciences)	81	201	0	77
6	University of Rhode Island	School (Graduate School of Oceanography)	52	201	0	109
7	University of Hawaii	(School (including earth science and technology)	139	363	56	145
8	SUNY-Stony Brook	Research Center as academic division	45	77	30	124
10	University of Maryland	Center (incorporating several institutes and labs)	59	192	0	121
11	University of Miami	School (includes atmospheric sciences)	91	314	0	193
15	University of South Florida	Department	27	78	0	115
n.r.	Virginia Institute of Marine Science	School	70	288	0	78

* Ranking of doctoral program by National Research Council, 1995).

which MSRC might be compared. The table shows that the marine science programs are commonly organized like MSRC, as a free-standing college, school or institute within a university, rather than as a traditional academic department. For MSRC, this arrangement has permitted maximum flexibility in operating our research vessel and field station at Flax Pond, in conducting our outreach activities and in developing educational programs.

MSRC is the smallest unit among the top 10 in terms of faculty and staff and has the smallest ratio of staff to faculty (Fig. 1, Appendix D-4). Yet our graduate student enrollment is high, and the number of graduate students per faculty member (~3) is second only to the University of Washington (Fig. 2, Appendix D-4). *A very high proportion, about 85%, of the graduate students at MSRC are supported with federal research funds, as opposed to institutional funds such as TAs and fellowships (Fig. 3, Appendix D-4).* MSRC's ability to support students with federal research dollars is particularly impressive when we are compared with comparably sized marine sciences units in state universities (e.g. University of Maryland and University of South Florida). The picture of MSRC that emerges from these comparisons is that of a unit that maximally leverages its state resources in terms of seeking external funding for graduate students, yet is resource-poor in terms of staff support relative to faculty effort.

3. Research at MSRC

MSRC faculty and graduate students are engaged in research in all aspects of marine and atmospheric sciences. Each of the traditional disciplines that contribute to the study of the oceans and atmosphere are fully represented within MSRC. These include physical, geological, chemical, biological, and fisheries oceanography together with atmospheric sciences. However, we view our science as an inherently multidisciplinary enterprise that fosters collaboration across disciplinary boundaries. Hence, by design there are no formal academic departments within MSRC. The lack of organizational barriers encourages different subsets of the MSRC faculty to form, dissolve, and re-form as needed to tackle a vast array of oceanographic questions or environmental problems that confront our society. In some cases, permanent institutes have been formed to focus attention on special areas of major concern: these include Living Marine Resources, Terrestrial and Planetary Atmospheres, Waste Reduction and Management and the Long Island Groundwater Research Institute. The institutes draw upon faculty and graduate students from throughout MSRC, the University, and other institutions to solve critical research problems on local, regional, and global scales.

MSRC faculty and students have adopted the belief that advances in scientific research must ultimately be coupled with solutions to societal problems. Hence, both basic and applied research are emphasized and encouraged. We strive for excellence in research and

also are committed to the rapid utilization of research results for stewardship of the environment.

MSRC faculty also are active in helping develop research agendas and programs nationally and internationally. Faculty have served as members of steering committees for programs such as the Joint Global Ocean Flux Study (JGOFS) and as principal organizers of multi-institutional efforts.

The publication record of our faculty and students reflects our commitment to communicating results. Over the period 1992-96, MSRC faculty published 689 articles in peer reviewed journals, of which 277 included graduate students as authors. Another 117 papers were published with one or more graduate students as sole authors.

Graduate students are an integral part of our research activity. Over the past five years, *each MSRC faculty member has supported an average of three graduate students per year.* Many faculty members rely exclusively on graduate students, rather than technicians or post-doctoral fellows, to accomplish the objectives of their grants and contracts. This gives our graduate students an excellent opportunity to experience first-hand the excitement of undertaking research with some of the world's leading scientists while also receiving financial support.

MSRC faculty also involve Stony Brook undergraduates and high school students in research. *Over the past five years, 95 undergraduate students have conducted independent research with MSRC faculty. More than 61 Long Island high school students have worked with faculty on research projects,* primarily in association with the Westinghouse Science Competition. Several of these students have been Westinghouse national finalists and one was the national champion.

Our faculty have been extremely successful in attracting financial support for research. Expenditures on research projects have risen rapidly throughout the history of MSRC. In 1996, expenditures reached a record level of $7.0 million; about 2 times that of 1989 and about 3.5 times that of a decade ago (Fig. 4, Appendix D-15). The source of this support for MSRC research is broadly based (Fig. 5, Appendix D-15). *Over the period 1992-1996, the NSF was the largest source of support at about 28% of total expenditures, followed by NASA (15%), the U.S. Navy (12%), DOE (10%), NOAA (9%) and a wide variety of other agencies and private foundations.*

4. Educational and Teaching Missions of MSRC

The MSRC is the sole oceanographic unit within the State University of New York and consequently has the responsibility for educational programs in oceanography for the entire SUNY system. It has also

RATIO OF STAFF / FACULTY

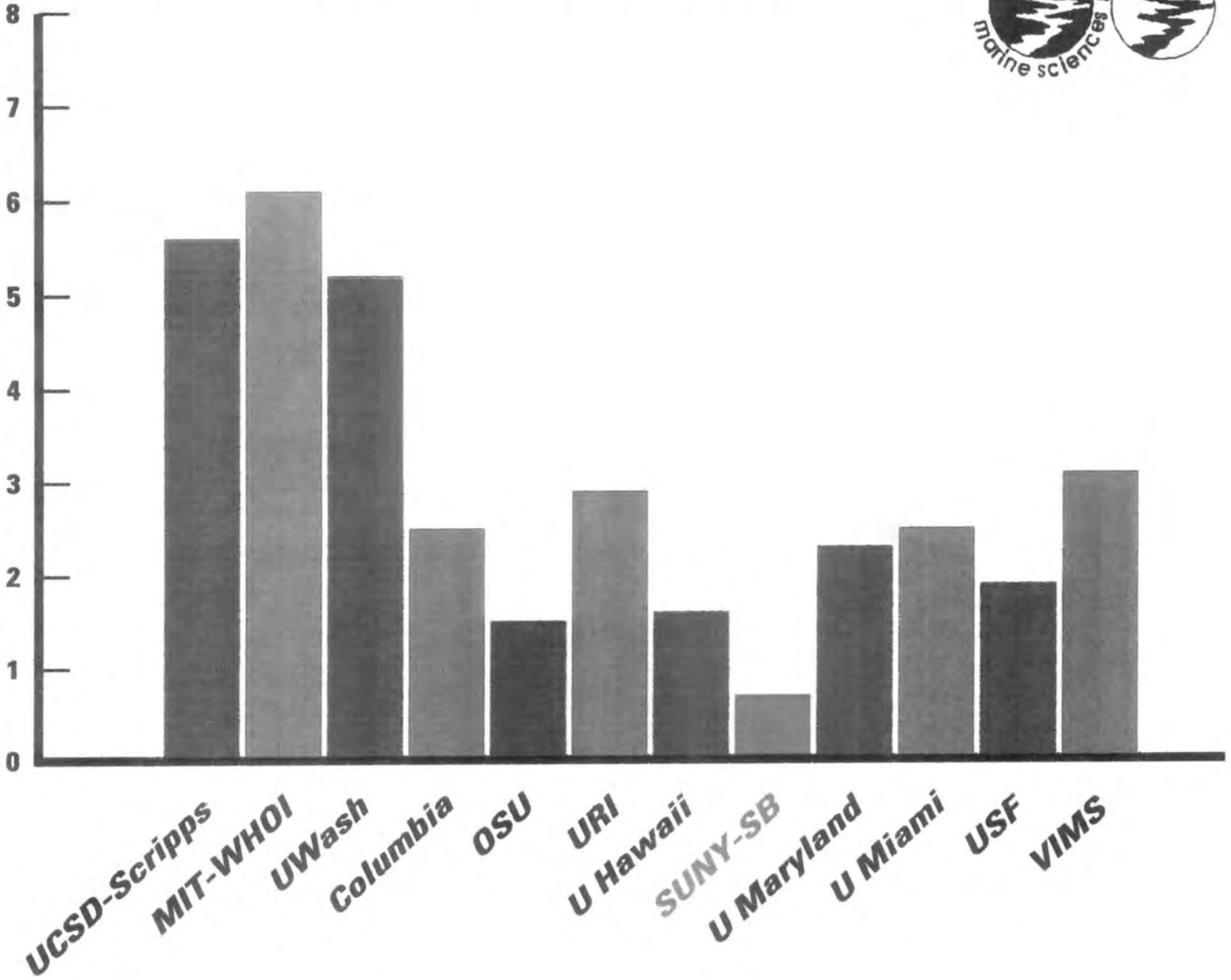


Figure 1

RATIO OF GRAD STUDENTS / FACULTY

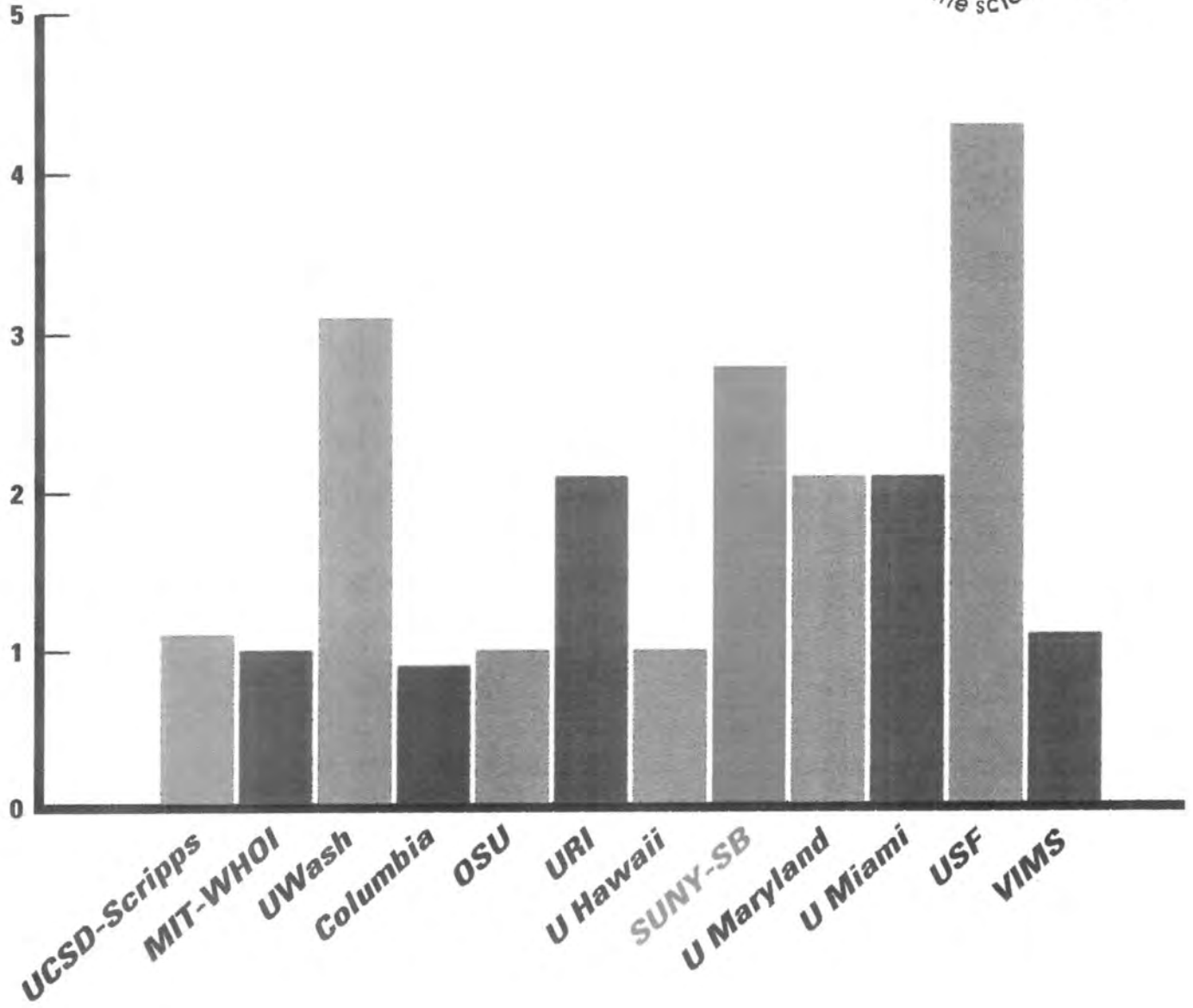


Figure 2

% GRAD STUDENTS ON FEDERAL SUPPORT

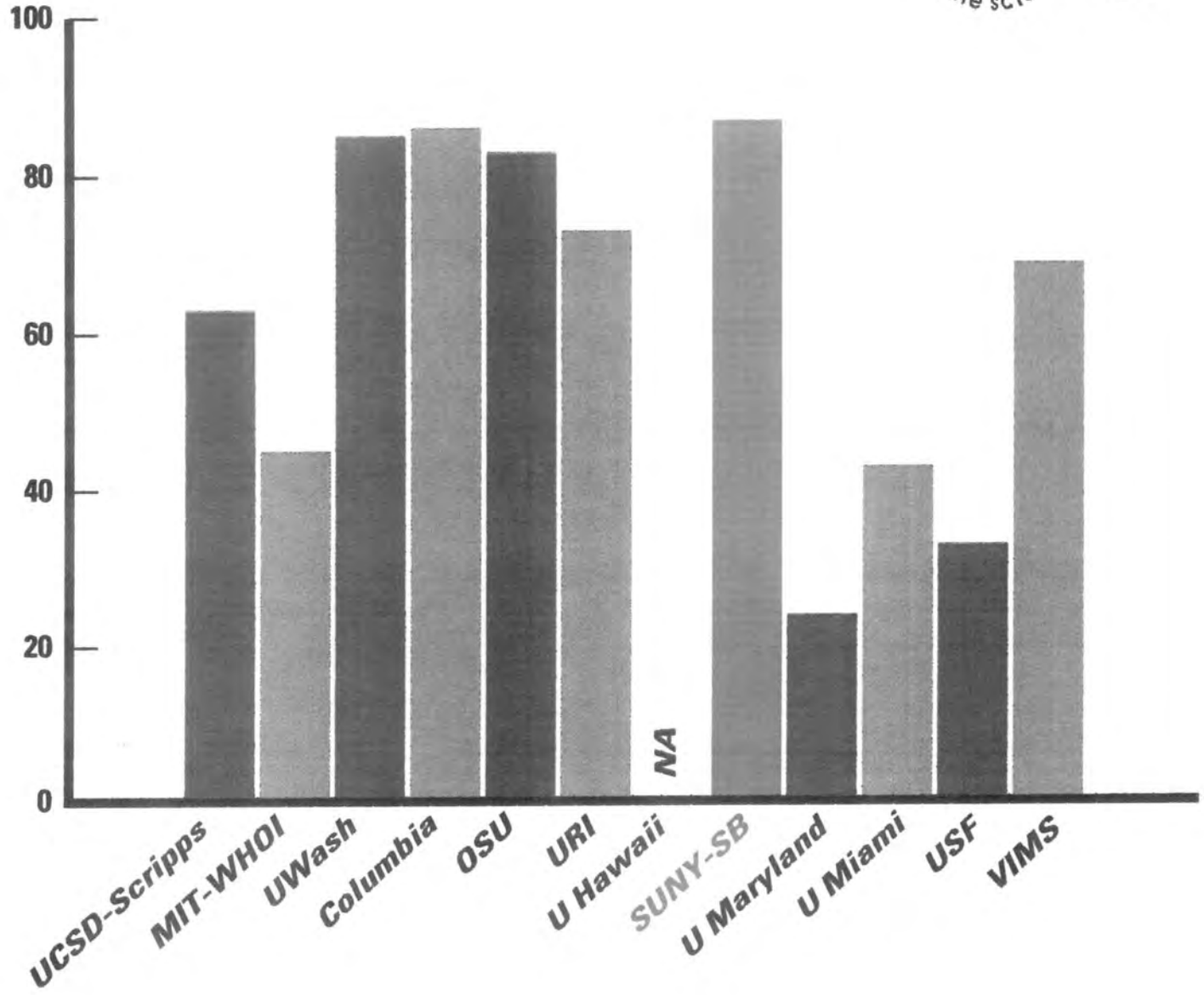
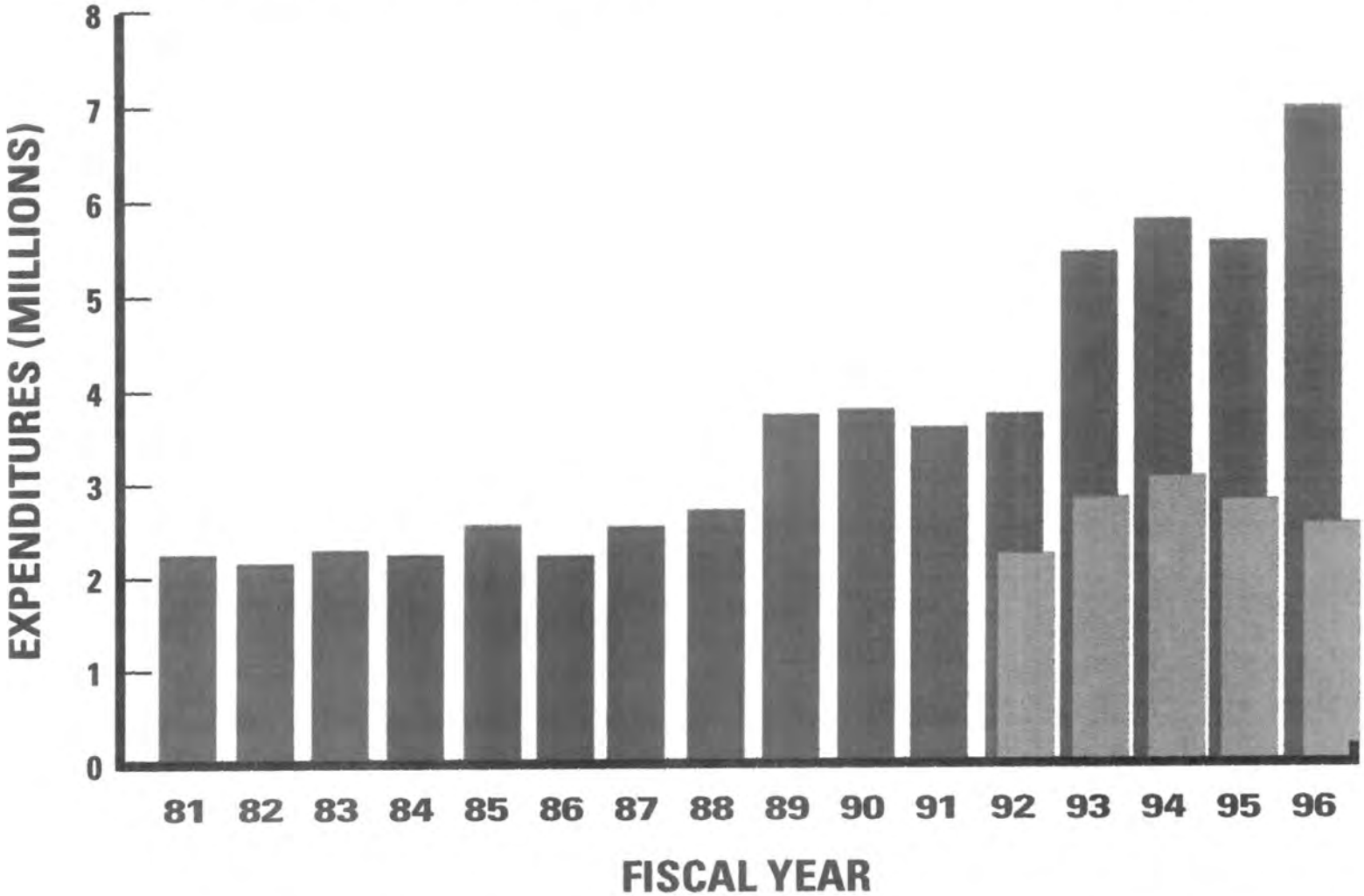


Figure 3

RESEARCH FOUNDATION EXPENDITURES FOR MSRC VS. STATE BASE ALLOCATIONS*



*STATE ALLOCATIONS CITED FOR FISCAL YEARS 92/93 THROUGH 96/97

Figure 4

SOURCES OF RESEARCH FUNDING

FIVE YEAR SUMMARY
1992-1996

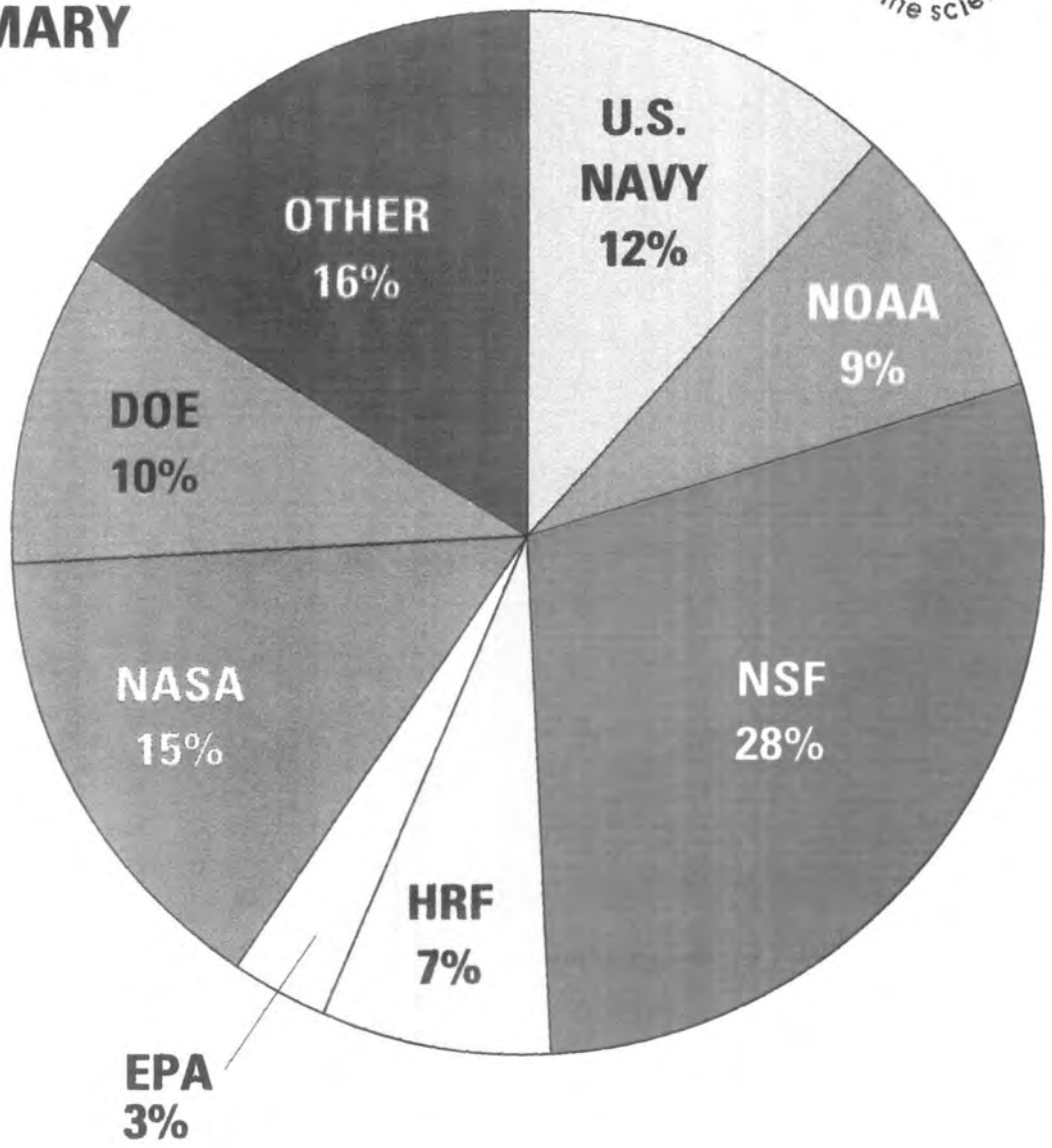


Figure 5

been preeminent over the years in offering educational programs in atmospheric sciences and applied environmental sciences at Stony Brook. We offer a Master's degree in Marine Environmental Studies and a PhD degree in Coastal Oceanography with two tracks - one in oceanography and one in atmospheric sciences. Graduate offerings also include a certificate program in Waste Management as well as contributions through the Long Island Groundwater Research Institute to the hydrology program leading to a Master's degree in Earth and Space Science.

The MS Program was designed to train professionals in the field of applied marine environmental science and management. Established in 1970, the program provides a highly valued and functional professional training. Recognizing the interdisciplinary nature of this field, all students are required to achieve a broad background in oceanography by taking four core courses in biological, geological, chemical and physical oceanography. They must also demonstrate the ability to synthesize and integrate the disciplines in a course in oceanographic problem solving. All students are required to prepare a thesis under the guidance of an advisor and two readers. These are most often field and laboratory studies of a technical nature, although many have direct application to management problems in the marine environment.

Our MS graduates have careers as environmental managers at the federal, state and local levels of government and they are laboratory scientists in other research facilities and environmental consulting firms. Some have gone on to careers in education, both within the formal school system and in special programs in aquaria or environmental centers. The success of our alumni attests to the strength of this program (see section B).

Our PhD program was established in 1978. The degree was designated to reflect our concentration on the coastal ocean, but two tracks in atmospheres and oceans were developed when ITPA joined the Center. All students are required to demonstrate a broad foundation in either oceanography or atmospheric sciences by successfully completing a departmental examination. They then go on to prepare and defend their proposed research and to complete and defend their thesis. *The PhD degree is designed to train world-class oceanographers and atmospheric scientists who can compete with the best research scientists and faculty in the world.* Our success in this program is evidenced by its recent high ranking by the National Research Council and the placement of our graduates. After a period of steady growth (Fig. 6, Appendix D-10), the size of our graduate population has tended to remain constant with between 120 and 130 full time students. About half are in the master's program. Our part-time student population is very small, as discussed in a later section.

Virtually all our students are supported during their studies, many initially with teaching assistantships and later as research assistants.

MSRC's commitment to undergraduate education has expanded dramatically in the past five years. Our undergraduate involvement began modestly in 1980 when we assumed responsibility for the introductory oceanography course from the Department of Earth and Space Sciences. A few introductory courses and some advanced speciality courses were created and offered as a service to undergraduate education. Since that time our undergraduate offerings have grown steadily (Fig. 7, Appendix D-8). Existing undergraduate opportunities include an undergraduate major in Atmospheric and Oceanic Sciences, minors in marine science and environmental science and undergraduate tracks in Geological Oceanography within the Department of Earth and Space Sciences, Oceanic and Atmospheric Chemistry within the Department of Chemistry and Applied Environmental Science within the Department of Applied Mathematics and Statistics. Introducing undergraduates to laboratory research has also been an important aspect of MSRC's involvement with undergraduates. *Currently, about 25 undergraduates per year are involved in research with MSRC faculty (Fig. 8, Appendix D-12).*

As mentioned above, we are applying our capability to create new courses to develop an undergraduate program in environmental studies, taking advantage of our strengths in marine and atmospheric science, policy and management. Our undergraduate programs are relatively new and growing. A major effort will be required to nurture those programs and to establish an effective and comprehensive system for student advising.

Faculty in the MSRC are expected to teach one course per semester. This teaching load is partly due to the Center's origin as an organized research unit to which educational programs were added later. Currently, about 40% of the Center's faculty are on organized research lines and about 60% hold instructional lines. The former carry no formal teaching obligation. However, as educational programs were developed and instructional faculty were hired, the MSRC policy has been to require the same obligations with respect to teaching and research from all faculty, without regard to formal line designation. This has resulted in teaching loads that are lower than the University's stated requirement of two courses per semester for faculty in units with a Ph.D. program. *Development of the Environmental Studies major will add about thirteen new undergraduate courses to MSRC's portfolio. Teaching loads for the Center's faculty are expected to increase as a result.*

5. MSRC's Involvement in Outreach

MSRC has strived from its inception to develop and implement effective outreach programs. Indeed, one of the hallmarks of the

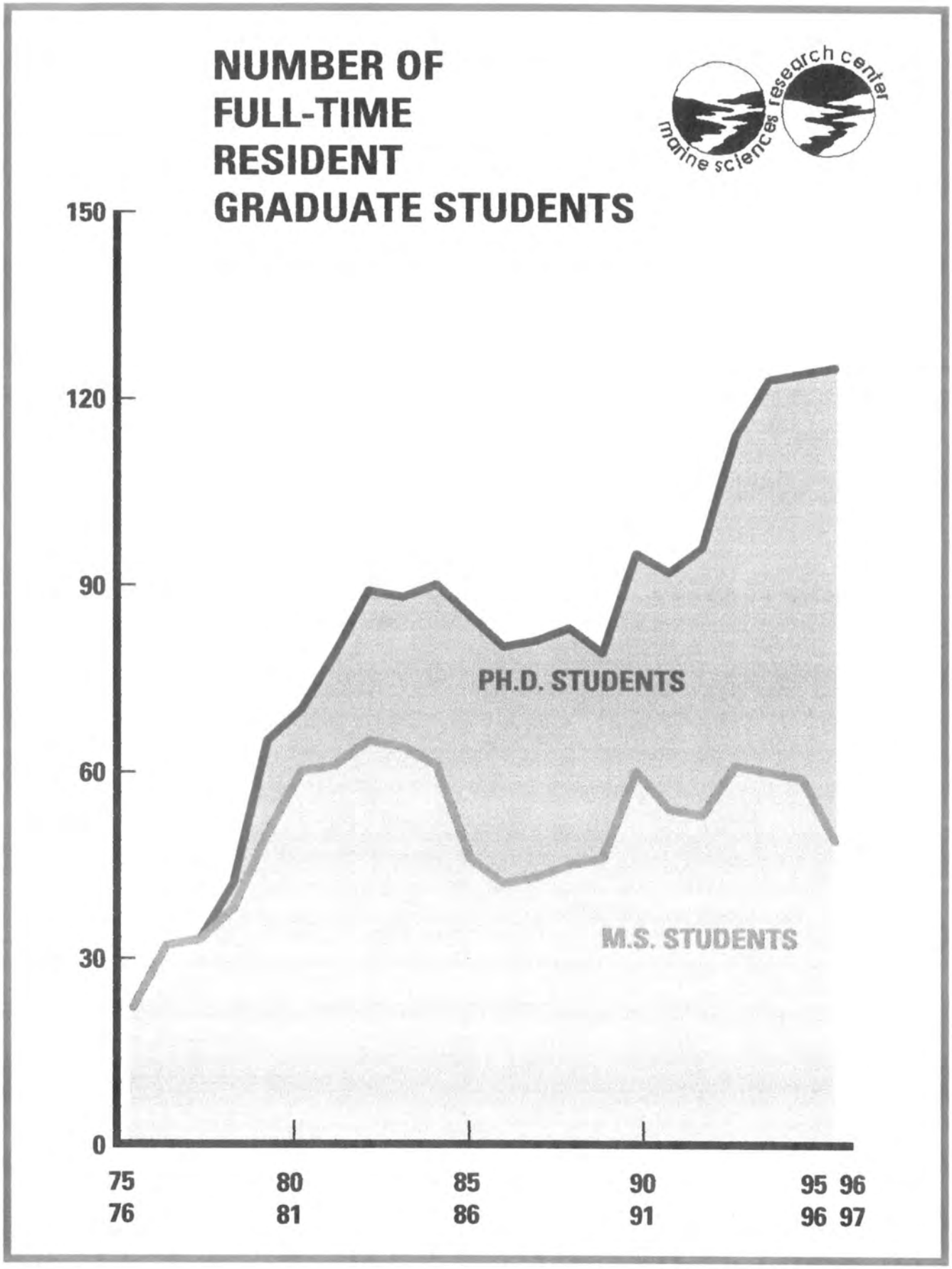

NUMBER OF
FULL-TIME
RESIDENT
GRADUATE STUDENTS
marine sciences research center
150
120
90
60
30
0
PH.D. STUDENTS
M.S. STUDENTS
75
76
80
81
85
86
90
91
95 96
96 97

Figure 6

ANNUAL NUMBER OF COURSES GIVEN*

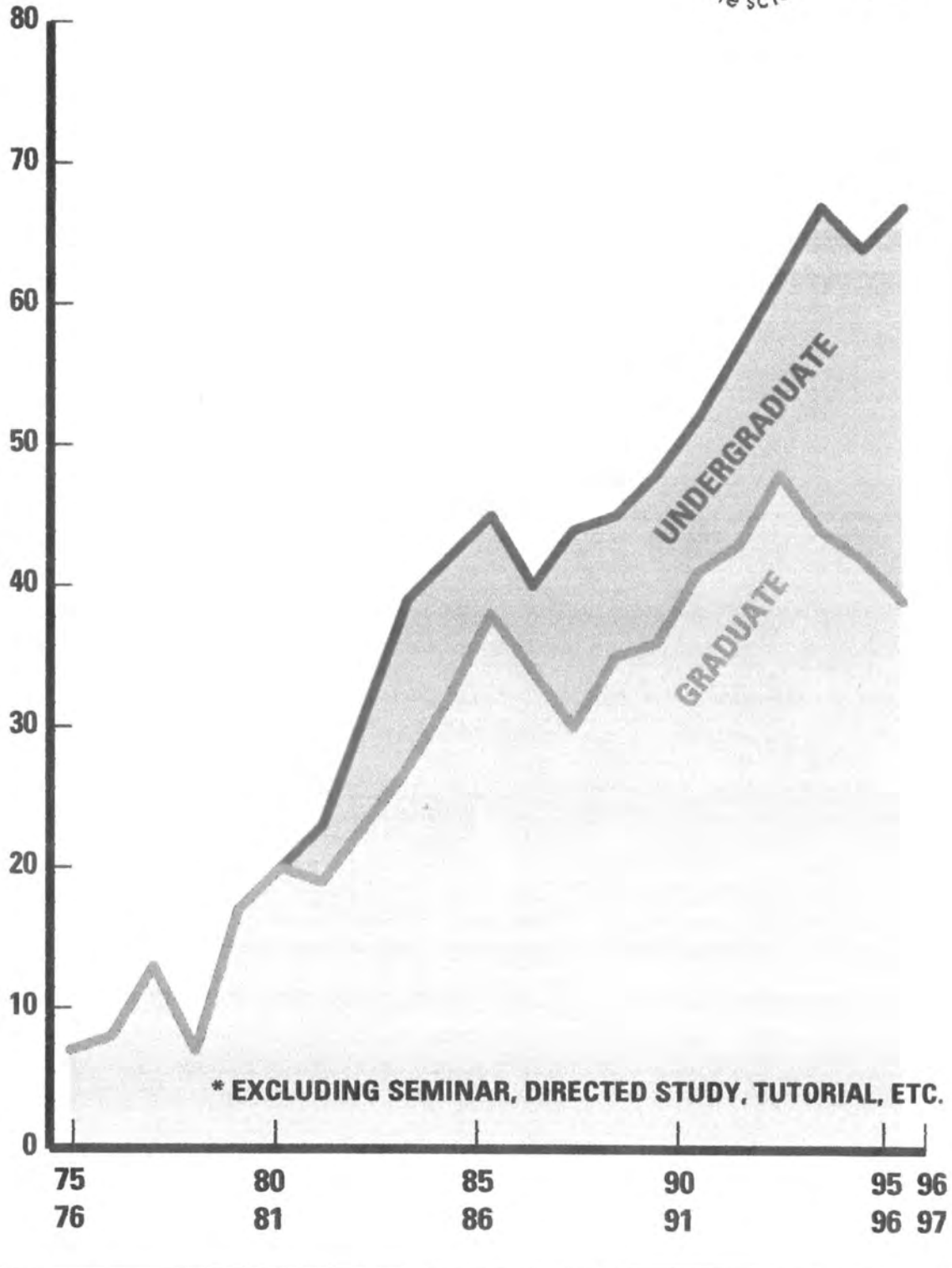


Figure 7

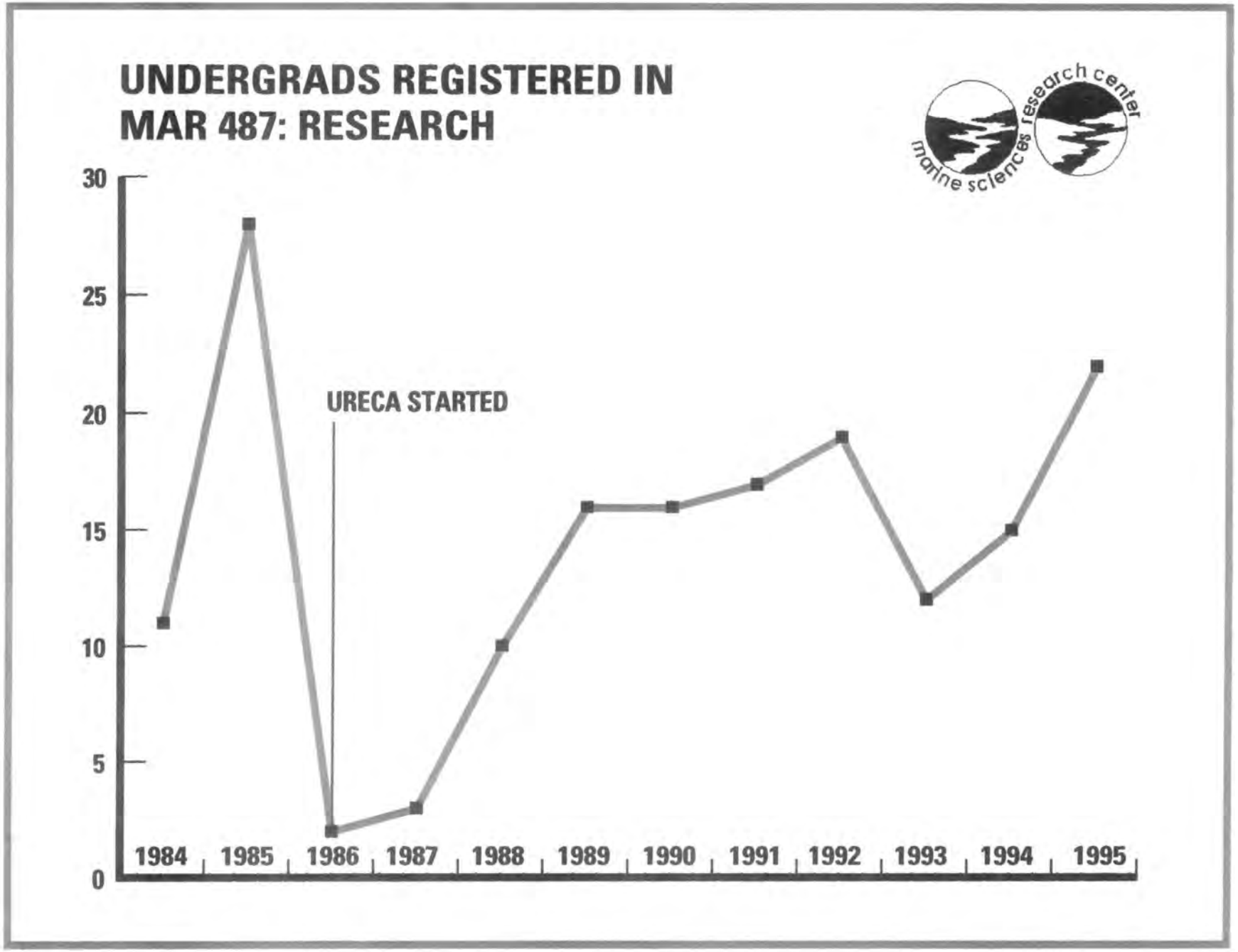

UNDERGRADS REGISTERED IN
MAR 487: RESEARCH
marine sciences research center
30
25
20
15
10
5
0
URECA STARTED
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995

Figure 8

Center has been a commitment to putting information about marine and atmospheric environments in the hands of people who need this information.

"Outreach" describes a wide assortment of activities that are not appropriately classified as research or formal (undergraduate/graduate) education. Some outreach activities involve solely the transfer of information; e.g. a briefing before the Suffolk County Commissioner of Health about the presence in Long Island waters of toxic dinoflagellates or a field trip aboard the Center's research vessel for a high school class. Many of MSRC's outreach activities are more action-oriented, involving the presentation and discussion of information about a marine or atmospheric issue or problem, an analysis of the merits of different ways of dealing with the problem, and an attempt to arrive at a consensus of what step(s) should be taken.

The following section briefly describes the principal audiences served by the Center and the type of activities and programs often used to deal with each. Table 2 presents a list of some of these efforts. Section B of this report presents an evaluation of the effectiveness of the Center's outreach programs.

a. Governmental Agencies and Other Organizations

MSRC maintains strong and effective ties to federal, state, and municipal agencies with environmental resource management responsibilities. Over the years, MSRC has organized or hosted many meetings, conferences, and symposia, on issues and problems faced by these agencies. Such meetings range from the large, scheduled, and fully orchestrated to the small, impromptu, and very informal. Examples of large meetings from the past five years at MSRC include: several meetings on the brown tide microalgae bloom; a major Coastal Summit to examine future directions in coastal resource issues; new directions in environmental technologies; integrated water, wastewater management, and integrated solid waste management; and developing management/research strategies for the Hudson River Estuary.

MSRC also has strong ties to the New York Sea Grant program. The main office of the program is based at Stony Brook and now has office space within MSRC. Many MSRC faculty have been funded by New York Sea Grant and, over the past two years, Sea Grant and MSRC have collaborated on several outreach projects, including a Brown Tide Summit and the Long Island Sound Research Conference. As a new Sea Grant director (Dr. Jack Mattice) begins his appointment, we look forward to continuing strong ties and collaboration with the program.

TABLE 2

PAST AND PRESENT MSRC PUBLIC OUTREACH EFFORTS

General Public

- MSRC Open House
- Environmental Art Exhibition
- Environmental Writers Forum and Exhibition
- Sunday Brunch Series
- Adult Education Lecture Series (w/Stony Brook Community Fund)
- "How Sound is Long Island Sound?" Educational Movie
- "Alive in an Urban Habor" Educational Movie
- "The Missions of MSRC" Film Clip
- Maritime/Environmental Affairs
- School of Professional Development (CED) Courses
- Mass Media Coverage (Articles, Interviews, etc.)
- MSRC Speakers Bureau
- Celebrate the Hudson River Estuary (in New York City)

Pre-College Students

- USB Open House
- Science and Technology Entry Program
- Flax Pond Tours
- ONRUST Tours
- Westinghouse Competition Involvement
- Peconic Dunes Environmental Camp (Camp Seawolf w/CEIE)
- New York Academy of Sciences Involvement
- Project WISE Involvement
- West Meadow Creek "4th Grade" Field Trips (w/SBCF)
- "Discovery" Tours (w/SBCF)

School Teachers

- School University Partnership for Environmental Education and Research
- LILCO/MSRC Teacher Workshop Series
- Smithtown Middle School Workshop
- The Science Museum of Long Island Sound Film Series
- MSRC Newsletter

MSRC is frequently asked to provide representatives, and often to chair, local, regional, and national advisory bodies dealing with environmental management needs. Center faculty and administrators are involved in this service. For example, there are three EPA National Estuary Management Conferences in New York's marine waters (Long Island Sound Study, NY-NJ Harbor Estuary Program, Peconic Estuary Program) and a fourth, state-level program whose management focus is akin to that of the National Estuary Program (South Shore Estuary Reserve). MSRC is represented on the technical committees of all these programs and, in the case of the South Shore Estuary Reserve and Long Island Sound programs, on the management committees. Other examples of MSRC service on advisory committees can be found in the self-study documents of the Waste Reduction and Management Institute, the Institute for Terrestrial and Planetary Atmospheres, and the Living Marine Resources Institute, as well as in the profiles of individual Center faculty in the Appendix.

b. Organized School Groups

Environmental issues have become a more important part of the K-12 curriculum in the Long Island-New York metropolitan region, and MSRC is increasingly called on to contribute its knowledge and information about the environment to support this movement. Our response takes several forms. *We have offered tours of the Center and the Flax Pond Marine Laboratory to school groups.* These visits typically incorporate an initial overview presentation of the Center and its overall mission & programs, followed by a more in-depth introduction to one or two on-going research or management-related activities. *Several years ago, the Center began a collaboration with the Stony Brook Community Fund to develop and conduct environmental education programs for organized groups at the Fund's Marine Conservation Center,* located on a local salt marsh preserve. In this collaboration, MSRC graduate students develop and teach educational programs to school groups about the local marine environment, its post-glacial geological history, and the history of its human habitation.

Teacher workshops, both for training and curriculum development purposes, is another vehicle MSRC has used to meet the needs of the organized education system for environmental information. *Teacher training and curriculum development workshops assist local schools with their need for accurate and up-to-date environmental information.* An example of this type of activity is the 1993 SUPEER (School-University Partnership for Environmental Education and Research) program, described in detail in Section B of this report.

c. General Public

MSRC has traditionally attached great importance to its responsibility to provide the general public with information about marine, atmospheric, and other environmental resources, and the issues involved in conserving and managing these resources. To address this largest and most diverse of possible audiences, we have instituted over time a wide assortment of activities. *Every spring, we co-host a public lecture series at the Stony Brook Community Fund's Marine Conservation Center. Periodically, the Center holds an Open House at which we invite the public to see a variety of displays, exhibits, demonstrations, etc. about the research being done at MSRC.* In the past, we have been active in generating informational articles about the Center generally or specific research activities and placing these in local newspapers and regional magazines. These pieces are usually tied in to an environmental issue that is generating public interest and discussion. In addition to proactive use of the printed media, MSRC faculty and administrators have made themselves accessible to the campus-wide news organization for the purpose of responding to requests for interviews and comments from the print and electronic media. We have used video media as well as the public print media in highlighting the Center's research and how it contributes to regional environmental problems. Examples include educational videos on environmental management problems of Long Island Sound ("How Sound is the Sound"), and restoring water quality in New York Harbor ("Alive in an Urban Harbor"). In conjunction with the New York State Department of Environmental Conservation and the University's Center for Excellence and Innovation in Education, *MSRC has developed an environmental summer camp on the east end of Long Island.* The camp's curriculum introduces children to the coastal marine environment through a series of exercises and activities. Now in it's third year, the camp has funding for four additional years.

6. MSRC Organization and Governance

The MSRC is a separate academic division within the State University of New York at Stony Brook. It was created with a director who reports to the Provost of the University. *In 1983, the title of Dean was added by Provost Homer Neal in recognition of the growth of educational programs within MSRC. The Center's administration (Fig. 9) consists of an Associate Director whose responsibilities include staff supervision, facilities oversight and outreach, and two associate deans in the areas of research and education.* The Associate Dean for Education oversees the graduate program (as Graduate Programs Director) and is assisted by a Director of Undergraduate Studies. The Center's administration team is complemented by the Executive Assistant to the Dean and the Directors of the Living Marine Resources Institute, Waste Reduction and Management Institute and Institute for Terrestrial and Planetary Atmospheres.

ORGANIZATIONAL CHART OF THE MARINE SCIENCES RESEARCH CENTER

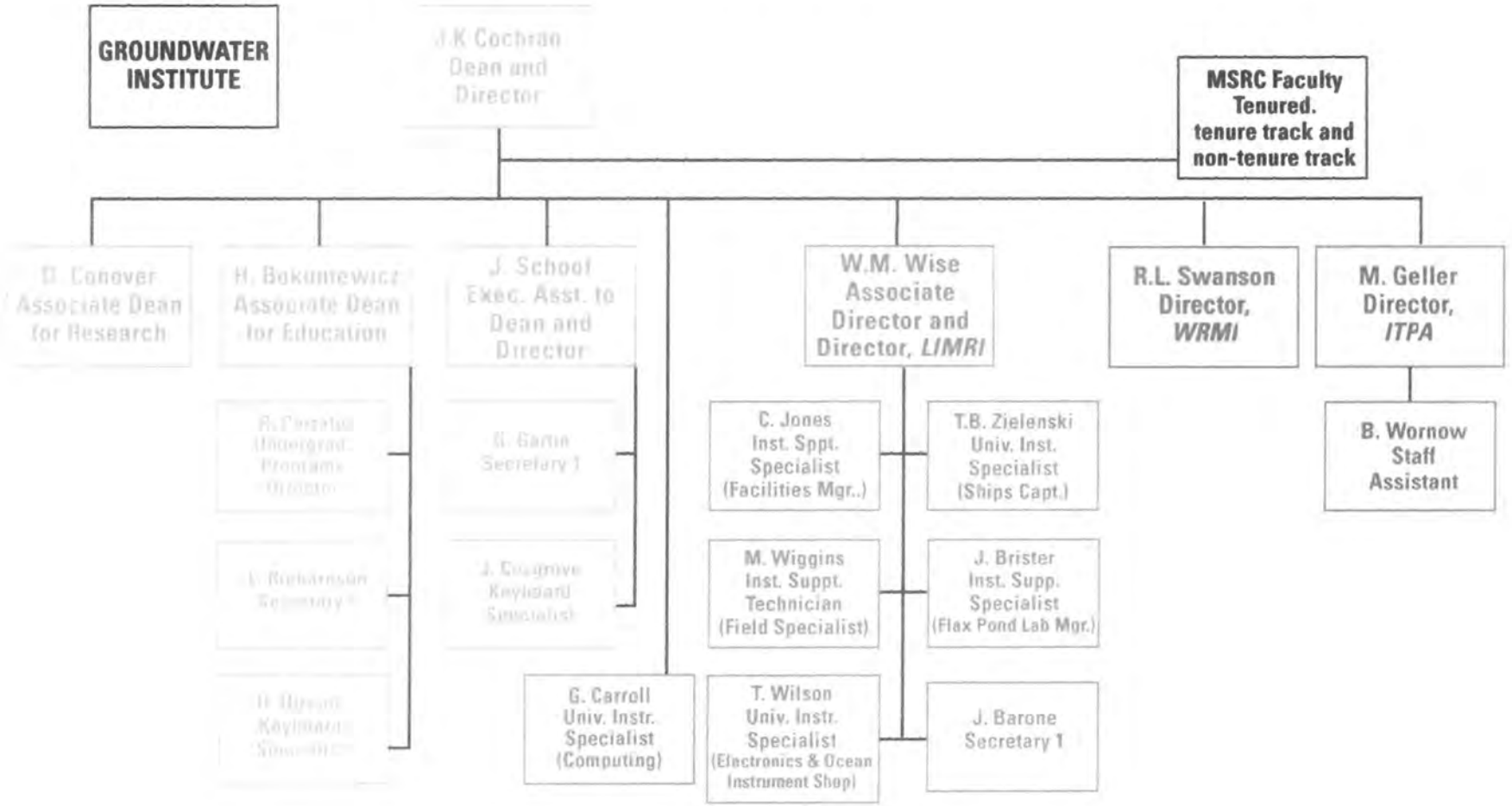


Figure 9

As described in more detail in the institute self study portions of this report, some MSRC faculty lines are explicitly associated with the institutes, others have disciplinary association with the institutes and some have no direct connection to any of the institutes. However, *all faculty, whatever their institute connection, are required to participate fully in the educational programs of MSRC, to pursue scholarly research and to support and advise graduate students.*

The Dean of the MSRC is advised by an elected faculty committee (the Executive Committee) including faculty of different academic rank and length of service to the Center. MSRC administrative staff have ex-officio positions on the Executive Committee. *The Executive Committee meets monthly through the academic year to consider issues of importance to the Center and to advise the Dean on courses of action.* The Executive Committee also serves as a screening committee for adjunct appointments and its tenured members provide advice to the Dean on reappointments of junior faculty (tenure-track assistant professors).

The faculty of the MSRC meet regularly (approximately monthly) through the academic year to discuss matters of interest. Specific topics for which more extended discussion is needed become the subjects of "faculty forums" dedicated solely to the topic of interest.

The Dean is advised on matters of faculty merit salary increases by a five member committee consisting of the associate deans and three senior faculty elected by all faculty. The basis for merit reviews are written statements of progress submitted by faculty (usually the Annual Addenda to Faculty Personnel File required by the Provost's Office).

The Dean of MSRC sits on the Provost's Council and Executive Council and is one of three academic deans in the University. For purposes of promotion and tenure and most undergraduate curriculum issues, the MSRC uses the relevant committees of the College of Arts and Sciences senate. Equal employment issues are handled by the MSRC EEO committee.

B. ASSESSMENT OF PROGRESS AND ACCOMPLISHMENTS

1. Research Activity

In this section, we describe the major research accomplishments of our faculty and students over the past five years. For sake of clarity, these accomplishments are organized by the subdisciplinary distinctions traditionally recognized within the fields of oceanography and atmospheric science. Each faculty member is listed within the group that represents his or her primary research area. However, it is important to remember that, in practice, these disciplinary areas purposefully lack formal definition or functional significance. The

faculty interact and collaborate extensively across these boundaries. For example, this is especially true with respect to the interaction between physical oceanographers and atmospheric scientists (e.g., oceanic/atmospheric coupling); geochemists, geologists, and biologists (e.g., benthic ecology); and physical, biological, and fishery oceanographers (e.g., larval transport). Numerous coalitions of faculty exist in other areas as well.

a. Biological Oceanography

Josephine Aller, Associate Research Professor - *benthic ecology, microbiology, biogeochemistry*
Edward Carpenter, Professor - *phytoplankton ecology, nitrogen cycling, toxic effects*
Andre Chistoserdov, Assistant Professor - *microbiology, molecular genetics, biotechnology*
Alessandra Conversi*, Assistant Professor - *zooplankton/climate interactions, water quality monitoring*
Elizabeth Cosper, Associate Research Professor - *phytoplankton physiology and ecology*
Adria Elskus, Assistant Research Professor - *environmental toxicology, pollutant metabolism, reproductive endocrinology*
Nicholas Fisher, Professor - *phytoplankton physiology and ecology, metal biochemistry*
Valrie Gerard, Associate Professor - *seaweed ecology and physiology*
Darcy Lonsdale, Associate Professor - *zooplankton physiology, ecology, and life history*
Glenn Lopez, Professor - *benthic ecology, animal-sediment interactions*
Anne McElroy, Associate Professor - *aquatic toxicology fate/effects of organic contaminants*
Gordon Taylor, Assistant Professor - *microbial ecology, biogeochemistry, biofouling*
Jeannette Yen, Associate Professor - *zooplankton ecology, predator/ prey behavior,, ipid metabolism*
*affiliated with WRMI

The past five years have been productive ones for biological research at MSRC. The biological faculty work at many different levels, from molecules to ecosystems, and on a wide variety of different organisms. Research on finfishes and shellfishes are reported under fishery oceanography.

i. *Planktonic processes*

The MSRC continues to provide major discoveries on marine pelagic ecosystems, in particular the algae, bacteria and zooplankton living in the water column. A particular strength is the study of nitrogen fixation by planktonic marine cyanobacteria (*Trichodesmium, Richelia*). MSRC scientists have determined that these microorganisms provide a major input of nitrogen to the euphotic zone in tropical and subtropical seas that equals or exceeds that of nitrate flux from deep water. MSRC researchers encountered a *Trichodesmium* bloom in the Arabian Sea which covered 2 million km^2, the largest phytoplankton bloom ever recorded.

Approximately 20% of the nitrogen fixed by Trichodesmium intakes, a substantial fraction, is released into the sea as glutamate, which in turn can fuel heterotrophic bacterial growth.

Bacterioplankton are responsible for most heterotrophic activity in the water column. A field study focusing on hypoxia in the western Long Island Sound determined that most of the summer oxygen depletion was due to bacteria below the mixed layer. The researchers found that hypoxia correlated with enhanced nutrient loading, which in turn correlated with rainfall. Molecular biology also provides powerful tools to study marine bacteria. MSRC research has focused on methylated amine metabolism by bacteria. Methylamine dehydrogenase genes have been cloned and sequenced, and a small plasmid that can serve as a potential cloning tool was discovered in one species.

Phytoplankton research has continued at a rapid pace at MSRC. Research has focused on novel and nuisance phytoplankton blooms, exemplified by the repeated brown tides that have been damaging to L.I. waters. An important discovery was the establishment of the role of viruses in controlling brown tide.

Even though phytoplankton are the base of the ocean food web, many phytoplankton species have the additional capability of capturing particles. MSRC researchers showed that the dinoflagellate *Dinophysis norvegica* in the Baltic Sea displayed no net photosynthesis even though it had the capacity to photosynthesize. Instead, this alga was getting its primary nutrition via particle feeding, phagotrophy. In addition, researchers determined that phytoplankton possess several cell cycle proteins such as PCNA (proliferating cell nuclear antigen); antibodies to these proteins are used to measure species specific growth rates of phytoplankton *in situ*.

Grazing on phytoplankton by herbivorous zooplankton can control the distribution of elements in the ocean. An important discovery by MSRC scientists was that element assimilation by zooplankton is controlled by its distribution in the cytoplasm of ingested algae. In addition to element cycling, these results have lead to deep insight into the mechanism of digestion by the most important herbivore groups in the sea.

Research in Peconic Bay determined that most phytoplankton are too small to be eaten by copepods. Ciliates eat the small

algae, and are in turn eaten by copepods, demonstrating the importance of the microbial loop in coastal waters.

Innovative research, using videographic and optical high technology to study aquatic animal behavior and fluid physics, has revealed that zooplankton respond to small-scale signals embedded in the microscale structure of the ocean. The first electroantennagrams from copepods documents an acute sensitivity to fluid mechanical motion and to water-borne odors. This sensitivity is used by copepods to avoid lunging predators, to capture escaping prey, and to find attractive mates in the vastness of the ocean.

In studies of an Antarctic copepod, findings indicate that the extreme seasonality of food availabilty experienced by polar copepods enforces the temporal separation of these processes: size-selective feeding in summer vs. lipid-dominated metabolism and reproduction in winter.

Other research on estuarine copepods has determined that interpopulations differences in life history and physiological characteristics is the result of adaptation to local environmental conditions.

A major question is whether zooplankton populations will be effected by global warming. MSRC researchers, investigating zooplankton interannual variability, have discovered periodicities in the zooplankton variations similar to those found in well known atmospheric phenomena (such as the Quasi Biennial Oscillation), thus indicating the possibility of a connection between atmospheric oscillations and zooplankton variations from year to year. The underlying mechanisms for such a connection will be the subject of future studies.

ii. *Benthic processes*

One of the most enigmatic group of organisms in sediment are the deep deposit feeders. Recent work conducted at MSRC suggests that one such polychaete worm requires hydrogen sulfide, a toxic compound produced in high concentrations by bacteria in marine muds. This requirement is not due to the presence of symbionts. This is the first evidence that sulfide is required by animals.

Studies of the benthos are being used to interpret processes on the Amazon continental shelf. Benthic community and death assemblage analyses helped to interpret seabed diagenetic patterns, and were used as indicators of physical processes, including erosional/depositional cycles, current

and tidal regimes in the region, and the occurrence and fate of mobile mud belts on the shelf. In the Baltic Sea, MSRC researchers used the fecal pellets of benthic deposit feeders as tracers of storm driven sediment transport.

Seaweeds are not only a source of primary production, substratum and shelter in coastal, benthic communities, but as macroscopic plants with easily definable individuals, populations, and environments, also provide a powerful tool for bridging research on microalgae and higher plants. Recent seaweed research at MSRC showed that nitrogen nutrition is important to high-temperature tolerance of temperate algae, so that largescale declines in productivity during summer or during El Nino events are due to the interactive effects of N-limitation and heat stress on carbon metabolism. In contrast, heat sensitivity in cold-adapted arctic and antarctic seaweeds was not attributable to effects on carbon assimilation and may be due to temperature effects on nitrogen metabolism.

Biofilms, adsorbed organic molecules and bacteria on submerged surfaces, are important for many processes, including biofouling. MSRC researchers demonstrated for the first time that sorbed organic films respond to surfaces in the same way as bacteria and form new interfaces whose physical-chemical attributes are determined by the underlying substratum. Extracts from local algae and invertebrates display strong antibacterial and antifouling activity against blue and zebra mussels. A patent application was approved for this potentially economically important discovery.

iii. *Contaminant cycling, effects and resistance*
Contamination of coastal water leads to elevated levels of contaminants in benthic organisms and fishes, including species eaten by humans. Experimental data and models developed and modified at MSRC led to the accurate prediction of metal concentrations in marine bivalves such as the blue mussel, *Mytilus edulis*. Related work demonstrated that evolved resistance to Cd by an estuarine oligochaete controls the trophic transfer to predators; the cellular distribution of Cd in adapted vs. naïve worms was the controlling factor.

Research on uptake and metabolism of dietary carcinogens by fish indicates that the intestine plays an important role in limiting the exposure of target organs such as the liver. It was also shown that metabolites of polycyclic aromatic hydrocarbons are available for trophic transfer to predators via benthic prey organisms. Local populations of fish, such as

the common mummichog living in areas highly contaminated with such compounds, are capable of adapting biochemically to chronic exposure.

b. Marine and Atmospheric Geochemistry

Robert C. Aller, Professor - *diagenetic processes, animal-sediment interactions*
Vincent Breslin, Assistant Professor* - contaminant geochemistry
Bruce Brownawell, Associate Professor* - *organic contaminant geochemistry*
J. Kirk Cochran, Professor, Dean and Director - *natural and anthropogenic radionuclide geochemistry*
Cindy Lee, Professor - *organic geochemistry, organic C, N cycling*
James E. Mackin, Associate Professor - *geochemical modeling*
John Mak, Assistant Professor** - *atmospheric gases, light stable isotopes*
Frank Roethel, Lecturer* - *waste ash chemistry*
Sergio Sanudo-Wilhelmy, Assistant Professor* - *trace metal geochemistry*
Mary Scranton, Professor - *marine geochemistry of biogenic gases*
* affiliated with WRMI, ** affiliated with ITPA

Marine and atmospheric geochemical research and education at MSRC emphasizes process-oriented, interdisciplinary approaches to the study of Earth surface chemistry. Because surficial geochemical processes are often strongly dominated by biological activity, much of the research efforts center around what is termed biogeochemistry. The topics of research range from determining long-term, global-scale patterns and processes controlling elemental fluxes, to more specific, immediate regional concerns of chemical contaminant behavior in both sedimentary deposits, surface waters, and coastal zone groundwater. Remineralization of natural and anthropogenic organic compounds, nutrient cycling, trace metal behavior, radiochemical tracers of transport and reaction rates, diagenetic processes, dissolved and atmospheric biogenic gases, and chemical aspects of waste disposal are major areas of emphasis. Research involves sea-going field programs, field and laboratory-based experimental work, analytical methods development, and mathematical modeling.

i. *Geochemical Oceanographic Processes: Global Scale*

Study of the fundamental processes controlling elemental behavior and the need to quantify the global role of particular classes of environments, has lead MSRC researchers to organize, plan, or participate in a range of large international or national geochemically-oriented research programs. These have included participation in the Joint Global Ocean Flux Study (JGOFS - NSF) to examine organic compound and radionuclide cycling in the water column of the central equatorial Pacific, southern ocean, north Atlantic and Arabian Sea, the Arctic System Science (ARCSS-NSF) initiative to quantify chemical fluxes in arctic continental shelf regions, the AMASSEDS (NSF) and follow-up projects to study biogeochemical cycling on the tropical Amazon shelf and

delta, the CARIACO program to study remineralization of organic matter in the anoxic waters of the Cariaco, and the Ocean Margins Program (DOE) to quantify and model cycling of carbon along eastern N. America, particularly in the Cape Hatteras region. These programs, (or in the case of AMASSEDS , a follow-up) are continuing. A new major program, TROPICS, designed to study geochemical cycles in tropical shelf/margin environments of Oceania (the major region of river inputs to the ocean), is being planned and organized in conjunction with Australian scientists.

ii. *Geochemical Oceanographic Processes: Local Scale*
Although all biogeochemical studies emphasized at MSRC are process- or mechanistically - oriented, a significant proportion of research efforts are focused on near-term environmental pollution or waste disposal problems. These studies include participation in NY Sea Grant, NURP-UCAP funded Great Lakes research to examine the distribution and effects of ship-derived wastes such as coal and ash, trace metal contamination patterns in the Hudson and Peconic River estuaries, metal-brown tide relations in the Peconic estuary, and radiochemical contamination in the Ob River.

In addition to participation in relatively large multi-investigator programs, the MSRC faculty maintain a very broad variety of basic and applied research projects focusing on both remote and local environments. These include processes controlling decomposition of natural organic materials and nutrient cycling in oxic and anoxic environments, the effect of benthic fauna on transport and reactions of natural and anthropogenic sedimentary compounds, elemental cycling, reverse weathering and authigenic mineral formation in tropical deltaic sediments, metal speciation and factors controlling speciation of trace metals in estuaries, seasonal variations in carbon remineralization and oxygen uptake in the Hudson River, development of fluorescent probe analogue tracers of natural compounds for study of remineralization, exchange of particle reactive organic and inorganic contaminants between sediment and overlying waters, bioaccumulation of metal and organic contaminants, atmospheric deposition of metals and organic contaminants, factors controlling hydrocarbon degradation in soils and sediments, CCA-treated lumber as a source of metals in nearshore waters, contaminants in compost, and re-use of waste plastic and tire materials. The basis for funding these programs includes NSF, ONR, EPA, NOAA, DOE, Hudson River Foundation, local government agencies, and industry.

iii. *Instrumentation and Infrastructure*
MSRC has recently refurbished laboratory areas to achieve a class 100 facility for trace metal sample handling and analysis. Funding for a light stable isotope ratio mass spectrometer has been secured from NSF and the instrument will be acquired in spring, 1997, for use in atmospheric, natural water, sediment, and general geological research.

iv. *Future Development*
The general research areas and types of programs involving MSRC faculty are expected to remain similar to those of the recent past, as outlined previously. That is, a broad spectrum of basic and applied research efforts addressing both long term Earth surface processes and immediate societal issues. MSRC will attempt to acquire support for an ICP-MS facility to enhance analytical capability for metals and isotopic compositions of both water and solid samples. MSRC faculty are also involved in instrumentation acquisition in other units of the university, in particular, creation of a CCD single crystal diffraction facility (in Earth and Space Sciences) for study of mineralogical characteristics of authigenic precipitates in sediments, and acquisition of an environmental SEM / EDS facility for analysis of hydrated natural samples (in Material Sciences).

c. Geological Oceanography

Henry Bokuniewicz, Professor – *nearshore transport processes, coastal sedimentation, marine geophysics*
Daniel Conley, Assistant Professor – *sediment transport, wave boundary layers, nearshore processes*
Roger Flood, Associate Professor – *marine geology, sediment dynamics, continental margin sedimentation*
Chuck Nittrouer, Professor - *geological oceanography, continental shelf sedimentation*

Over the last five years, faculty and students in Geological Oceanography have undertaken investigations of fundamental research in sedimentation processes, sedimentary environments and the development of strata as well as applications of geological understanding to environmental problems in a number of areas both locally and worldwide.

i. *Estuarine processes*
The morphological control of physical processes in bar-built estuaries has been a major area of study. This research has involved measuring changes in the circulation in Moriches Bay caused by the 1992 Pikes Inlet breach on Westhampton Beach Island and predicting through numerical modeling of the effects of such a breach in other locations of the south shore. The observed changes in Moriches Bay, which included a 30% increase in tidal range and a 1.5 ppt change

in salinity, can have significant impacts on the surrounding communities as well as the local environment. The results of these studies were used by the State of New York in its breach management planning, and by the National Park Service in developing their policies regarding coastal erosion on Fire Island.

Estuaries of importance to the local shell fishing industry (Great South Bay and Port Jefferson Harbor) have been studied utilizing high-resolution digital side-scan sonar mapping techniques to show the variability of sediment type and bottom morphology. In Great South Bay, regions of high shellfish abundances are clearly resolved by this approach. In Port Jefferson the bottom still shows signs of extensive sand mining from a half-century ago that affects the distribution of both shellfish and fine-grained sedimentation. Our studies of Port Jefferson also include new techniques utilizing static and dynamic penetrometers to coastal sedimentation problems.

The turbidity structure of the Hudson River estuary has been a major focus of research. In general, high turbidity in estuaries is a manifestation of the processes that make estuaries traps for fine-grained sediment (and associated contaminants). In the Hudson, in particular, the processes of suspended sediment transport have implications for the management of sediment contamination in the estuary as well as for biological production (i.e., transport of larvae). Using the latest acoustic technology, a new mechanism for the maintenance of strong turbidity maxima has been described - that of tidally modulated and bathymetrically controlled salinity intrusions.

In addition, a wide variety of applied research has been undertaken in the Hudson River for public authorities. Habitat description investigations were done for the U.S. Army Corps of Engineers as well as studies of sedimentation, dredging and disposal problems for the Corps and the Port Authority of New York and New Jersey. Side-scan sonar, bathymetric, and sedimentological studies were also undertaken in the upper Hudson River (north of Albany) in support of a re-evaluation of the Hudson River Superfund Site.

ii. *Beach and sediment transport processes*

Beach dynamics, sediment transport, processes at inlets, and offshore sand deposits are closely linked. The last five years have seen the continuation of an 18 year program of monthly beach surveys at East Hampton to monitor beach dynamics on Long Island's south shore, making this the longest continuously active beach monitoring program in the nation.

Multiyear variations are associated with statistical variations in longshore transport, and the long-term impact of erosion-protection structures has been documented. Numerical modeling, including both wave and current driven sediment transport, is being used to understand how sediment bypasses inlets and to determine how changes in the system affect the bypassing. These activities are important to understanding the ramifications of natural events such as barrier island breaching as well of anthropogenic events such as dredging and construction of jetties and sea walls. Modeling of regional sand transport systems has also been undertaken in the Black Sea where study of littoral processes show the Danube-dominated shoreline to be one of the most active in the world. Studies of offshore sand reserves were also undertaken for the NY State Geological Survey, and we provided the U.S. contribution to a cooperative research report on marine mining for the International Council for the Exploration of the Seas.

Models of sediment transport on a large scale are only as good as the parameterization of small scale sediment mobilization and transport. These small scale processes are the focus of other studies in the nearshore processes laboratory. One such project is focused on understanding the various roles of turbulence in sediment mobilization and suspension. Observations are being carried out in an instrumented sediment-turbulence tank, as well as in the field where in situ measurements of sediment response to turbulence are being investigated. These latter observations will include direct measurements of the "skin friction" by a bed stress sensor which is being developed in a parallel study.

iii. *Continental Margins*

Continental margins (continental shelves, slopes and rises) contain most of the sediments deposited in the oceans, and an understanding of the processes that have built them provide the basis for interpreting their geological records. One large research effort, the NSF AmasSeds project (A Multidisciplinary Shelf SEDiment Study), which involved two dozen US principal investigators, was based at MSRC, and studied the fate of water, solute and particulate fluxes from the Amazon River during the present-day interval of high sea level. Studies of strata formation are also underway on the south coast of Alaska (glacial-marine sedimentation in a mountainous coastal environment), in a Baltic fjord and in the Florida Keys (to contrast the development of sedimentary fabric in siliciclastic and carbonate settings), and over a decade of NSF Antarctic research ended with a study of biogeochemical fluxes in the Ross Sea. A major new initiative

is the ONR-supported STRATAFORM program. This project, also based at MSRC, involves over 30 PIs across the US. SUNY fieldwork is undertaken along the coast of northern California, where the impact of event stratification (storms, floods, earthquakes) is studied to understand how the longer stratigraphic record is formed in continental margin environments. Project TROPICS (Tropical River/Ocean Processes In a Coastal Setting) has recently been planned with NSF support, and will investigate material flux around the island of New Guinea in conjunction with Australian scientists.

The study of continental rise deposits has also utilized the resources of the international Ocean Drilling Program (ODP) to collect long sediment cores (up to about 500 m long) from continental margin environments that have been sites of rapid sediment accumulation during glacial intervals. One program, undertaken in 1994, focused on the Amazon Fan where sediments from the Amazon River were deposited when sea level was low. Deep-sea fans can contain significant hydrocarbon reserves, and our studies of the Amazon Fan provide some new insights into the development and structure of fans off muddy rivers. A new drilling program will occur in early 1997 focusing on the sedimentary and climatic record preserved in sediment drifts in the western North Atlantic, sites of rapid sediment deposition and thus high-resolution climatic records. Both of these efforts have been built on prior interpretations of high-resolution seismic data and improved regional understandings of sedimentary processes and have provided or promise to provide new insights into the development of continental margins.

iv. *Great Lakes*

In addition to its important marine environments in the south, New York State also has important and large fresh-water bodies to its north, including Lake Ontario, that provide opportunities for studies that complement marine studies as well as provide new insights into management problems. An integrated sediment trap/current meter study (in conjunction with the Great Lakes Environmental Research Laboratory, Ann Arbor) demonstrated that strong currents (up to about one knot) develop deep in Lake Ontario in response to fall and winter storms. These strong flows appear sufficient to resuspend bottom sediments and to reintroduce contaminants contained in those sediments (e.g., PCB, Mirex) to the lake and to created large-scale sedimentary features in the region. The activity of these currents may be part of the reason why contaminant levels have not dropped as rapidly as predicted in Lake Ontario. A second study in Lake Ontario

has focused on materials derived from cargo ships related to normal activities such as cleaning holds and washing decks. The study is trying to determine if these deposits, which have been identified on side-scan sonar records, have an impact on benthic communities. Our studies will help the U.S. Coast Guard develop realistic regulations governing this practice.

d. Physical Oceanography

Malcolm Bowman, Professor – *coastal dynamics, oceanic fronts, productivity and physical processes*
Kamazima Lwiza, Assistant Professor – *structure and dynamics of shelf seas, remote sensing oceanography, larval transport processes*
Harmut Peters, Adjunct Assistant Professor – *small scale processes, turbulent mixing, interaction and small and large-scale mixing (left MSRC in 1996)*
L. Swanson*, Adjunct Professor - *near-shore circulation, water quality monitoring*
Dong-Ping Wang, Professor – *coastal ocean dynamics*
Robert Wilson, Associate Professor – *estuarine and coastal ocean dynamics*
* affiliated with WRMI

Physical oceanographic research at MSRC concentrates on the coastal ocean, particularly the inner shelf and estuaries. While vigorously pursuing fundamental research of coastal processes, the faculty have also been effectively applying research results to the solution of problems that arise from society's uses and misuses of the coastal ocean. Both observational and modeling approaches are used extensively in a complementary fashion.

i. *Estuarine dynamics*

MSRC scientists have successfully developed a revolutionary, shallow-water microstructure profiler and used it to obtain detailed direct measurements of vertical mixing in the lower Hudson River. These data revealed striking temporal variations of turbulence within tidal cycles and between spring and neap. Intense vertical salt flux occurred on the ebb phase during spring tides.

Mapping of spatial structures of the estuarine outflow in the lower Hudson River using ship-board ADCP revealed a complex three-dimensional flow pattern which appeared to be controlled by bathymetry and stratification. This pioneering work is now being extended to other major estuaries, including the lower Delaware Bay and the lower Chesapeake Bay. In another study, MSRC physical oceanographers also found pronounced spring-neap modulations of circulation and stratification in the Hudson River. Furthermore, this work revealed a dramatic hydraulic control of estuarine flows near coastal promontories. The inertial accelerations have a significant influence on the tidal period internal motion, and are responsible for the lateral secondary circulation.

Together with physical oceanographers from the University of Otago, New Zealand, a sophisticated model is being used to simulate buoyancy driven circulation, and to assess the environmental impacts due to the outflow of a major hydroelectric powerstation in a branched fjord. In collaboration with Dutch investigators, MSRC scientists have studied the effects of interannual variations in Rhine River discharge on water column properties at selected North Sea sites. In another study, MSRC faculty and students successfully applied data assimilation method to a high-resolution estuarine tidal model.

ii. *Coastal processes*
MSRC physical oceanographers showed that the oceanic frontogenesis and the associated vertical circulation are consistent with the omega equation dynamics. A major European Union (EU) project, OMEGA, is planned in the western Mediterranean Sea, to verify the model prediction. Their study demonstrated the utility of data-adaptive modeling in environmental studies. With Taiwan University, MSRC faculty have implemented a coastal ocean model to predict upper-ocean temperature structures around Taiwan.

iii. *Larval transport processes*
MSRC physical oceanographers are working together with our fisheries faculty in two major field programs. One focuses on the recruitment of fish larvae to coral reefs near tropical islands. They have discovered surprisingly energetic mesoscale motions near Barbados, West Indies. Some of these motions, with time scales of a week, may be locally generated in the Tobago Basin. Others, with longer time scales, may originate from the low-salinity Amazon outflow. How recruitment success occurs despite the unsteady physical environment remains to be resolved. A second major study examines the interaction between physical parameters and vertical larval migration in the Hudson River. This project found that the net horizontal transport of larvae depends on the phase relationship between tidal flow and larvae vertical movement. So, larvae can be retained or transported upstream even when the tidal residual is seaward throughout the water column.

e. Fishery Biology/Oceanography

Monica Bricelj, Adjunct Associate Professor - *shellfish biology, effect of algal blooms, effects of predation on juveniles; bivalve physiological ecology (left MSRC in 1996)*

Robert Cerrato, Associate Professor* - *shellfish ecology, benthic ecology, population dynamics, age and growth of bivavlves*

David O. Conover, Professor - *fish ecology , life history strategies, physiological adaptation, dynamics of winter mortality, evolution of growth rate, ecology of bluefish*

Robert K. Cowen, Professor*- *fish ecology, larval ecology, larval transport processes, coral reef fishes, mechanisms of recruitment*

Steven Morgan, Associate Professor* - *larval ecology of marine invertebrates and vertebrates, larval transport, influence of physical regimes on reproductive timing, life history evolution*

Eric Schultz, Adjunct Assistant Professor - *fish ecology, life history evolution, mechanisms of winter survival, coral reef fishes, larval ecology (left MSRC in 1995)*

Su Sponaugle, Lecturer - *coral reef fishes, fecruitment, processes reef ecology, biodiversity conservation biology*

Peter Woodhead, Research Professor – *fish behavior and physiology, reef ecology*

*LIMRI faculty

The common thread running throughout MSRC's approach to fisheries science has been to understand the factors that limit recruitment of young into adult stocks. Over a decade ago, MSRC scientists recognized that one of the keys to understanding the dynamics of adult stocks was in determining the factors controlling the growth and survival of the early life stages--eggs, larvae and juveniles. These are the life history stages that are most susceptible to declining habitat quality and quantity.

Within the past five years, MSRC has solidified its position as one of the primary centers of knowledge on the early life history of a variety of finfish and shellfish species. Research topics of the fisheries faculty span a wide range of important problems including: physical mechanisms by which larvae are transported from spawning sites to juvenile nursery habitat; juvenile habitat requirements; mechanisms and rates of winter mortality among juvenile fishes, predator-prey interactions, mechanisms of genetic adaptation to environmental change, causes and effects of harmful algal blooms on resource species, and improved techniques of selecting native strains for aquaculture. Highlights are described below.

i. *Larval Transport Processes*

An important problem in marine ecology is the extent to which the dynamics of coastal fish populations are dependent on pre-settlement (i.e. pelagic larval) versus post-settlement (benthic juvenile) processes. MSRC fishery and physical oceanographers have combined forces to address this question by studying how the larvae of coral reef fishes are retained and eventually returned to the isolated, oceanic island of Barbados. Their emphasis has been on examining the extent to which offshore supply of larvae, coupled with the physical processes responsible for their concentration, contributes to successful settlement and recruitment to reefs.

Their findings thus far demonstrate how larval behaviors influence transport in a particular direction and how local and mesoscale perturbations to local flow conditions affect recruitment.

Larval transport processes are also being studied on the continental shelf of the Middle Atlantic Bight. Again, MSRC physicists and fishery biologists have teamed up to examine how changes in the physical environment (i.e., currents) affect major transport routes and ultimately recruitment success of a variety of commercially and recreationally important fish species. MSRC scientists have also examined the role of tidal flows, coupled with tidally-mediated vertical movements of larvae, in the ingress and/or estuarine retention of the larval stages of several crab species and the bay anchovy. These different studies have lead to a much stronger understanding of the causes of variable recruitment in marine populations.

ii. *Recruitment Dynamics of Bluefish*
MSRC is the only marine institute in the world with research focused on the recruitment dynamics of bluefish. For MSRC, this is a natural consequence of the fact that the bluefish is generally the dominant species (by weight landed) in the marine recreational fishery of the U.S. east coast, and also in many other portions of the world. MSRC scientists have demonstrated that recruitment tactics of bluefish involve an ontogenetic sequence of habitat shifts that are influenced by physical transport processes, migratory behavior, and the availability of suitable prey. Moreover, because of their exceedingly high predation rates, the abundance of bluefish may influence the dynamics of several other species.

iii. *Genetic Adaptation to the Environment*
MSRC researchers have been the leaders in demonstrating how marine fishes along the east coast of North America become genetically adapted to local climate conditions experienced by different populations. The primary traits being examined are growth rate and susceptibility to various sources of winter mortality. The most striking result has been the discovery that, in a variety of species, genetic capacity for growth varies inversely with length of the growing season across latitudinal gradients (i.e. countergradient variation). Hence, to maximize growth rate aquaculturists should choose broodstock from high latitude populations. Their results also suggest that coastal fish populations are more than capable of adapting to climate change.

Planktivorous fishes are important predators of zooplankton, including planktonic larvae of crabs. Research at MSRC indicated that life histories of crabs have evolved in response to temporal and spatial patterns in planktivory. Synchronous release of larvae is timed to avoid important predators. Species that did not share this hatching pattern were less vulnerable to predation because they were well defended morphologically or were less conspicuous; these traits have also evolved primarily in response to predatory fishes. Selection appears to be strong for suites of adult and larval traits that favor the successful return of offspring to adult habitats.

iv. *Shellfish Biology*

Long Island's most commercially valuable marine resource is its shellfisheries. In the last five years, MSRC researchers have made significant advances in our understanding of the physiology and population dynamics of major bivalve species including: the oyster *Crassostrea virginica*, soft shell clam *Mya arenaria*, blue mussel *Mytilus edulis*, hard clam *Mercenaria mercenaria*, bay scallop *Argopecten irradians*, and surf clam *Spisula solidissima*. Physiological studies have focused on the transfer of algal toxins through the food chain and have shown that suspension feeding bivalves can alter the potency of assimilated toxins. The ability of various bivalve species to ingest and utilize the brown tide organism *Aureococcus anophagefferens* has been quantified. Studies of the relationship between shell microgrowth patterns and physiological rate processes in the soft shell clam have improved our understanding of the connection between shell and tissue growth.

With regard to population dynamics, MSRC investigators have found that the northern puffer (*Sphoeroides maculatus)* and mud crab (*Dyspanopeus sayi*) are predators of juvenile bay scallops. This discovery is critical to the success of reseeding programs that seek to restore bay scallop populations eliminated by recent brown tide blooms. Other population studies have focused on the relationship between benthic habitat characteristics and the survival and recruitment of juvenile hard clams in Great South Bay; strategic planning for habitat restoration is the ultimate goal of this project. MSRC researchers also have provided fundamental information on the population dynamics and habitat requirements of surf clams in order to develop an appropriate management plan for the inshore component of this rapidly expanding NY fishery.

v. *Future Directions*

As the future unfolds, we predict that the path MSRC fishery scientists have taken will pay rich dividends. As pressures to further develop the coastal zone increase, the importance of understanding habitat requirements of resource species, particularly the larval and juvenile stages, will increase. The continued occurrence of brown tide blooms is a vivid reminder that fishery management is as much about maintaining habitat quality as it is about restricting the level of fishing effort. Unfortunately, faculty attrition has recently left some very significant gaps. We have lost expertise in aquaculture, even as that industry begins to grow and replace the lost harvesting potential of wild stocks. We have also lost expertise in shellfish biology, ecology and physiology. These areas need careful consideration for replacement as new faculty lines become available in the near future.

f. Atmospheric Sciences

Robert Cess, Distinguished Professor – *atmospheric sciences and climate*
Jane Fox, Professor - *planetary aeronomy*
Marvin Geller, Professor and Director, ITPA* - *atmospheric dynamics, climate and the upper atmosphere*
Sultan Hameed, Professor – *climate change: analysis, impact, predictability*
John Mak, Assistant Professor - *atmospheric gases, light stable isotopes*
Prasad Varanasi, Professor – *planetary spectroscopy, molecular physics*
Duane Waliser, Assistant Professor* – *ocean-atmosphere coupling in the tropics*
Minghua Zhang, Assistant Professor *– *climate modeling, atmospheric dynamics*
*ITPA faculty

MSRC atmospheric scientists have made significant research advances over the past five years in a wide variety of areas encompassing atmospheric dynamics and climate, atmospheric chemistry, remote sensing, and planetary atmospheres. A complete report is provided separately in the ITPA report. Highlights are outlined briefly below:

i. *Atmospheric dynamics and climate*

MSRC faculty have shown the effects of vertical shear on wave-CISK. This was done first using a simple idealized model. Later, this work was generalized to less simplified and more realistic situations. MSRC faculty also derived the first global climatology of the atmospheric tides in the mesosphere-lower thermosphere. A by-product of this latter investigation was to derive the atmospheric dissipation necessary to explain the measured tides.

Methods were developed to study climate feedbacks using atmospheric general circulation models. These methods were applied to water vapor feedbacks, which are the most important of the atmospheric feedbacks in determining the

surface temperature response to CO_2 induced greenhouse warming. These methods are currently being used by several research groups.

Atmospheric field programs use a variety of measurement techniques. The diversity of techniques, together with measurement errors, often result in data sets that are of insufficient data quality to do the budget studies for which these programs were developed. MSRC atmospheric scientists have developed variational methods to synthesize a variety of data that allow such budget studies to be carried out and to force off-line models. Our adjusted data sets are being used by many investigators around the world.

MSRC scientists have developed an empirical model for predicting California precipitation. They are now extending this work to develop schemes for the prediction of the intensities and locations of the Centers of Action in the North Atlantic and North Pacific.

MSRC faculty have also analyzed Chinese historical documents to produce histories of precipitation and temperature in Eastern China for the past two thousand years. These data are now being analyzed to determine the impact of climate changes on the historical development of China.

Evidence has been found for greater absorption of solar radiation by clouds than had been previously believed. This became a very big scientific controversy since it affected all climate models which did not take this into account. The Department of Energy set up a dedicated aircraft measurement program to investigate this "anomalous absorption." These measurements confirmed the "anomalous absorption. New experiments are being planned to find the spectral distribution of the enhanced absorption and its mechanism.

iii. *Atmospheric chemistry*
The stable isotopes ^{13}C and ^{18}O in carbon monoxide (CO) are very useful for constraining the relative source strengths from specific sources such as methane oxidation, combustion of fossil fuels, non-methane hydrocarbon oxidation, and biomass burning. Our faculty have established a laboratory, that will shortly include an isotope ratio mass spectrometer, for analyses of these isotopes from atmospheric gas samples. They are collecting these air samples from Barbados and from Montauk Point at the eastern tip of Long Island for analysis.

For several years, the paradigm for the Antarctic Ozone Hole that has existed was that cold temperatures in the polar vortex led to the formation of polar stratospheric clouds (PSCs) upon which heterogeneous reactions took place that transformed inactive chorine species, $ClONO_2$ and HCl, into active chlorine (e. g., ClO). MSRC faculty analyzed and presented the first direct measurements of the simultaneous formation of the PSCs, the depletion of $ClONO_2$ and HCl, and enhancements of ClO.

Measurements of the spectroscopic features (e. g., line shape and strength) of many important atmospheric species have been conducted. This includes the HCFCs, which are newly developed compounds that replace the CFCs that are known to lead to stratospheric ozone depletion. These results are being widely used by others in climate investigations.

iii. *Remote sensing*
Satellite data sets on outgoing longwave radiation (OLR) and tropical Highly Reflective Clouds (HRC) are widely used by climate researchers. MSRC faculty have found errors/biases in these data sets due to the changing equatorial crossing times of the polar orbiting satellite used to produce these data sets, and they have developed methods to correct them.

MSRC scientists set up and ran a two-year trace gas measurement effort at the South Pole, which resulted in the first measurements of stratospheric ozone measurements above 30 km in the polar winter, the discovery of a distinctive and persistent double-peaked structure in polar ozone profiles, the best observations to date of nitric acid build-up and depletion in the polar summer-winter atmospheric cycle; the first ground-based measurements of NO_2 enhancement in the polar winter; and the first continuous, detailed measurements of subsidence rates in the middle and lower stratosphere over the winter polar region.

iv. *Planetary Upper Atmospheres*
Our faculty have modeled the ionosphere of Titan and showed that the major ions at the ion peak are not H_2CN^+, as several models had shown, but various hydrocarbon ions. This has revised completely our understanding of Titan's ionosphere.

2. Effectiveness of Educational Programs

The graduate program remains very competitive. We receive about 200 applications per year and typically admit a class of 20 to 30 students. The GRE scores for our entering classes have been regularly rising, with the Master's class performing as well (or better) than the PhD cohort (see appendices).

Our graduate student population has grown over the last five years to 120-130 students, about half of whom are in the PhD program (Fig. 10, Appendix D-13). Students are recruited into the program using teaching assistant (TA) lines supplied by the University and generally move to research assistantships (RAs) at the end of their first academic year. The ratio of TA lines to RA and other support has varied from 6 to 10:1 over the years. The allocation of TA lines to MSRC had been cut by 50% (from 24 to 12) in the last four years as a consequence of budget cuts and a re-evaluation of workload needs on campus. These cuts have affected our ability to recruit the highest quality students, but an increase in TA allocation to 20 for the 97-98 academic year will help with this situation. However, 10 of the 20 TAs must be assigned to assist in courses in other units, principally chemistry and biology. This is consistent with recent University policy of assigning TAs where needed to support the undergraduate educational mission of the University.

Our student population is diverse. About 50% are women and 14 countries are represented. Our undergraduate programs are very new and cannot be honestly assessed at this time. Our introductory undergraduate courses, however, have always had high enrollment and have been well received. Student reviews from MAR 101 (Long Island Sound: Science and Use) are appended as an example.

3. Effectiveness and Accomplishments of Public Outreach Efforts

As described in Section A, the Center has devoted considerable resources--personnel and financial--to public outreach activities. Taken by the broadest measure, and looking across our three main audiences (governmental environmental management agencies, the region's organized educational system and the general public), these efforts have been successful. The Center enjoys a high level of public visibility compared to most academic units of the University. The close interaction we have with the environmental management community has resulted in many instances wherein management decisions reflect the work and involvement of the Center. The impact of the Center on what environmental information is presented and how it is presented in the local organized school system is less clearly measured. The multiplicity of school districts in the Long Island-New York City metropolitanarea, the lack of a coordinative mechanism to share information between them, and the need to work closely with individual teachers to increase their comfort level with teaching what is often new and foreign information, make this audience a more difficult one to address.

a <u>Influencing Environmental Resource Management</u>

The efforts of the Center, and its several institutes, to inform and provide leadership in the development of scientifically sound environmental management decisions and strategies have paid off

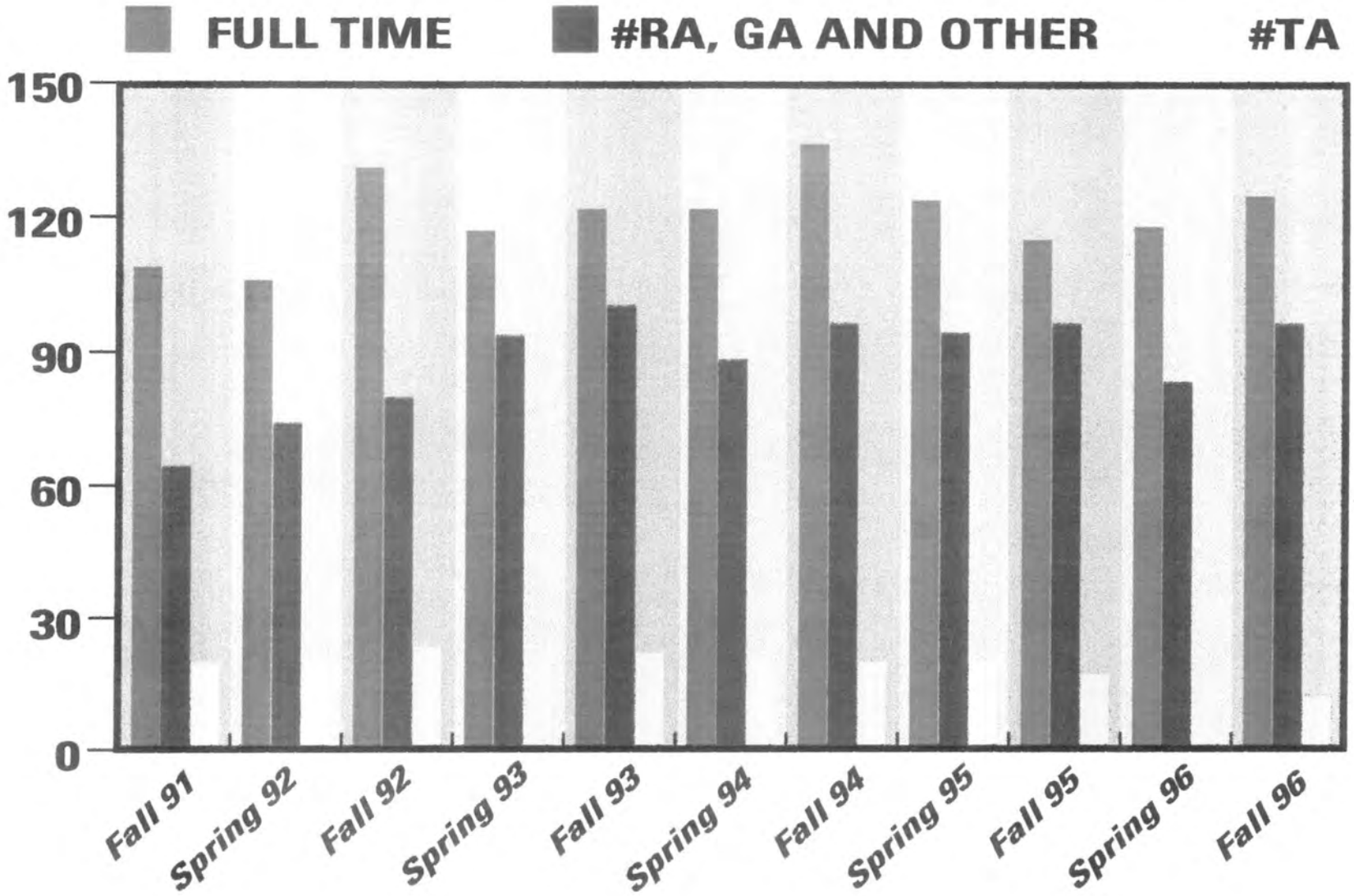


Figure 10

Note: These are estimates since some (2-5) students had support arranged off our books e.g. TA's in other units, BNL, NCAR, etc.

in several important areas. In the arena of living marine resource management, the shellfish management programs conducted by local towns and the State of New York depend very heavily on research conducted at MSRC. Management actions taken with respect to controlling or preventing the devastating brown tide algal bloom draw upon information produced by researchers at MSRC. MSRC faculty took the lead in developing a blueprint for a monitoring program in Long Island Sound. The research and outreach activities of the Waste Reduction and Management Institute have directly influenced the development of laws, regulations, and management practices of municipal, state, and regional governments in such issues as recycling activities, controlling Combined Sewer Overflow (CSO) inputs, the environmentally sound use or disposal of municipal solid waste incineration ash, and related waste management problems.

b. Organized Education System

As noted above, the success of the Center's recent outreach efforts to local school districts and related groups is more difficult to assess. The Coastal Ecology Program conducted jointly with the Stony Brook Community Fund has been highly successful in terms of the number of students served (about 1000 per year).

In 1993, MSRC developed the School-University Partnership for Environmental Education & Research (SUPEER) program, a teacher workshop series designed to identify environmental subjects of interest to high school teachers and to develop curricular materials on these subjects jointly with MSRC faculty. Over a series of weekend sessions, a module on shoreline erosion was produced and disseminated to participating teachers. Those participating in the program praised the product and we have now secured the resources to distribute it.

Indeed, future MSRC programs involving the development of curricular materials must take into account the obstacles to wide distribution of these materials, which involves not only getting the materials into the physical possession of a large number of teachers, but also the frequent need for supplemental training sessions with groups of teachers to get them to the point where they feel comfortable in teaching the material in their classroom.

c. General Public

The first several MSRC Open Houses were very successful in terms of attendance and the many positive comments received from our visitors about the exhibits and the insight into what we do that the event provided, but attendance lagged at later events. We probably have temporarily saturated the local demand for this type of activity and can only draw upon a geographically larger

pool of individuals through widespread advertisement throughout Long Island, which is quite expensive.

In an effort to reach out geographically, MSRC co-organized a one day event - "Celebrate the Hudson River Estuary" - in New York City in August, 1996. We conducted tours of our research vessel, demonstrated equipment used to sample the Hudson and discussed our research activities. Attendance was estimated at 1000, including many inner city children, and we plan to repeat it in summer, 1997.

Efforts to place articles about the Center, its research, and its role in solving regional environmental problems have enjoyed considerable success. Articles have appeared in Newsday, the New York Times, several local trade or industry newspapers on Long Island, and in other regional print media. However, continued success in this arena will depend on the availability of staff resources to organize and conduct this activity. In the past two years we have lost the MSRC editorial assistant and graphic artist. Both individuals were critical in maintaining an active public outreach program.

We have recently inaugurated a successful environmental summer camp on eastern Long Island (Camp Seawolf) in collaboration with the University's Center for Excellence and Innovation in Education and the New York State Department of Environmental Conservation. This week-long camp, given three times each summer, features a broad environmental curriculum with a strong marine element. The Center was directly involved in developing this element and MSRC graduate students teach it.

d. Limitations to Future Success

Planning, designing, conducting, and assessing successful public outreach activities require personnel and financial resources. These resource demands must be balanced against those presented by the Center's research and undergraduate/graduate education programs. In the past five years, financial and staff resources at the Center have shrunk. The state operating budget of the Center presently provides virtually no funding for outreach programs. We are committed to significantly expanding our efforts in undergraduate education at MSRC; this commitment will result in more resources being earmarked for undergraduate education. Only a few of the Center's public outreach activities have been financed with external funding. Those that did receive some external support almost always also received as much or more support from the Center, either in direct financial support or non-compensated staff time.

Given limited resources, the Center must do a better job of screening ideas for public outreach programs, only doing those that can either pay for themselves or that offer such compelling opportunities that they warrant the infusion of significant Center resources. This selectivity will result in fewer overall programs. In assessing possible programs, we need to look broadly to examine how a project or program fits into the overall suite of public outreach efforts at MSRC and make a realistic assessment of how long the project's needs can be sustained. We need to share in the development and conduct of these programs with other organizations, on- or off-campus, more so than we have in the past. We must explore and exploit opportunities for external funding to the fullest extent possible. A general description of future plans for public outreach at MSRC is contained in the MSRC Strategic Plan (see Appendix). As a result this planning exercise, a Public Outreach Programs Committee has been established. It will review these general plans and opportunities and, using the above-noted and other criteria, develop a more detailed plan for implementing specific new public outreach programs.

4. Quality and Placement of Graduate Students and Postdoctoral Fellows

The first students graduated from the Marine Environmental Studies (M.S.) Program at MSRC in 1971. The Center awarded its first Ph.D. degrees in coastal oceanography in 1981. Through 1996, 435 students completed graduate degree requirements at the Center. Of these, 57 individuals (13%) received the Ph.D. degree, 352 individuals (81%) received the masters degree, and 26 individuals (6%) received both degrees from the Center.

The overwhelming majority of the Center's graduates have gone on to careers in the fields in which they were trained--the marine and atmospheric sciences. Some have gone on to faculty positions at major universities throughout the world. Some have assumed research positions at governmental or private research laboratories. Many have entered environmental resource management positions and a few have become teachers. Some have gone on to additional training at the graduate or postdoctoral level. We have employment information (typically first employment) for 356 of the Center's 435 graduates. Figure 11 (Appendix D-13) shows employment of Masters and Doctoral students according to sector.

a Masters Students

The Center's Masters program was designed to provide individuals a broad background in the marine and atmospheric sciences from which to enter into a range of positions. It also prepares students for successful pursuit of more advanced degrees. Approximately one-third of our masters graduates move into positions with government environmental agencies at the

federal, state, or local levels (Figure 11). Over the years, these individuals have assumed positions of progressively greater responsibility in these agencies. MSRC alumni are employed by the US Environmental Protection Agency, the National Marine Fisheries Service, the New York State Department of Environmental Conservation, and the environmental agencies of various county and municipal governments in the region. Smaller but still substantial numbers of masters students find technician jobs at a university or K-12 teaching positions or join environmental consulting firms. For students finding technician positions in a university lab, this initial job is typically of relatively short duration, grant funded, and succeeded by a longer-term, more stable position with a governmental agency. Records indicate that less than 10% of our masters graduates find first (or subsequent) employment entirely outside the marine/environmental field.

b. Ph.D. Students

MSRC's doctoral program is designed to give students a consummate command of oceanography and atmospheric science at the highest level and to hone their abilities to design and conduct creative, insightful research. Approximately one-half of all Ph.D. graduates of the Center move directly into faculty positions at universities and colleges across the globe (Figure 11). An additional thirty percent of our doctoral degree recipients enter postdoctoral appointments of 1-2 years' duration at a major university or governmental research laboratory to allow them to further refine and development the research they initiated during graduate school.

Information on individual first employment of MSRC graduates over the past five years is presented in the Appendix, along with brief vignettes of MSRC graduates from throughout the Center's history who have made particularly important contributions in their chosen fields of endeavor.

c. Postdoctoral Fellows

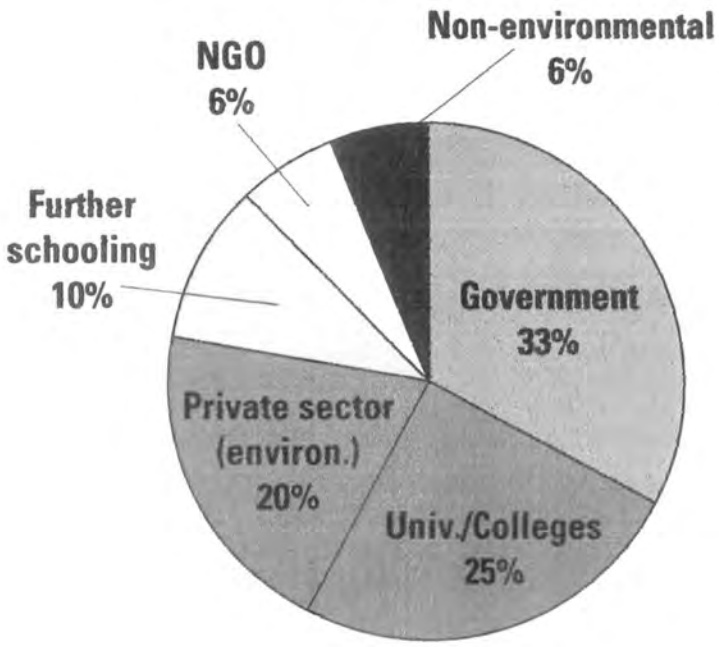
MSRC's postdoctoral fellows have gone on to careers in academia and research centers. A listing of current positions for postdoctoral fellows is in appendix D.6.

C. OUTLOOK AND PLANS FOR THE FUTURE

The Marine Sciences Research Center has reached the point at which key University decisions regarding the placement of MSRC within the academic framework of the University and the future allocation of resources to MSRC will affect our ability to maintain our national ranking. Our reputation for excellence was achieved during the twenty years of Jerry Schubel's tenure as Dean and Director, a period

FIRST EMPLOYMENT OF MSRC GRADUATES 1971-1996

a. MASTERS



b. PH.D.

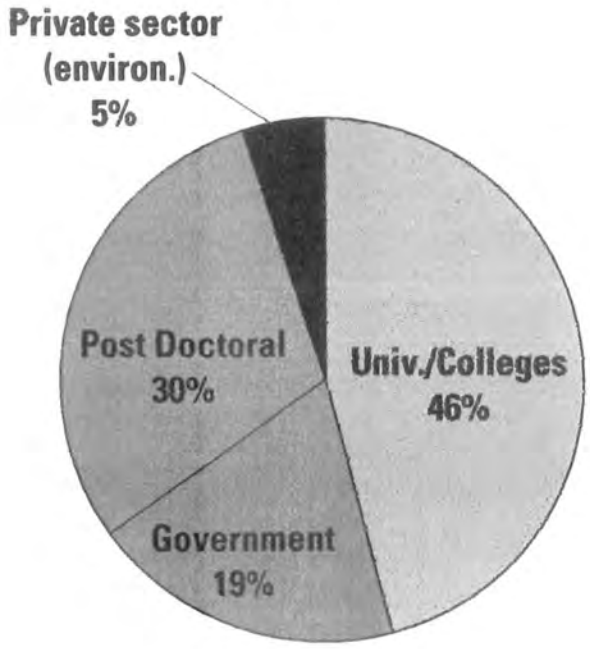


Figure 11

in which the Center enjoyed the growth, mainly in personnel resources, that enabled us to develop the research and educational programs described in this document. Dr. Schubel's departure coincided with a major political re-alignment at the state and federal levels and new leadership in the positions of President and Provost of Stony Brook.

Over the past two years, budget cuts have reduced MSRC's base budget allocation from the University by 14% and the special appropriation from the state legislature to the Waste Reduction and Management Institute by 75%. These cuts have required a significant fraction of the Waste Reduction and Management Institute's budget to be derived from the Center's base budget and have reduced substantially the funds available for non-personnel expenses (Fig. 12, Appendix D-15). They have also resulted in the loss of 40% of the state staff lines supplied to the Center and the losses have been in key areas such as public relations, graphic arts and support staff for our research vessel. Five faculty members have retired or left MSRC and the resources to selectively re-hire in key areas have been eliminated. We have eliminated our MSRC-wide post-doctoral program and Distinguished Visiting Scholars Program. The capability to effectively maintain and operate our research vessel has been reduced, even with increases in costs to faculty for the use of this facility. Budget cuts also have eroded our capability to offer a high quality graduate program; student travel funds and funds for outside examiners have been cut to minimal levels.

The impacts of budget cuts, particularly with respect to base salaries and operating costs, have been moderated by independent resources, largely those provided by faculty as part of their obligation to recharge one month of academic year salary to MSRC. This policy was established in ~1980 to provide the Center with flexible resources to undertake new initiatives. It recognizes the relatively greater proportion of time spent by MSRC faculty on research projects, including occasional extended absences on research cruises, relative to faculty in traditional academic departments. Budget cuts of the past two years have increasingly forced us to use these resources to cover basic operating expenses, and there is little additional flexibility left to use this strategy to deal with future decreases. During the 1995/96 academic year, the Center developed a five year strategic plan that identified existing strengths and problems and proposed courses of action to enable the MSRC to retain its reputation. The points summarized below are extracted from the plan, which is included in full as an appendix.

1. **Problems Requiring Immediate Attention**

The MSRC has several problems, some longstanding and some recent, that must be addressed. The list below is roughly in order of priority, but action must take place on all these items in the next 1-2 years.

a. Recruitment of MSRC Dean and Director

The continued strength of MSRC depends critically on leadership from the Dean and Director. Following Jerry Schubel's departure in 1994, the faculty made a strong recommendation to the Acting Provost for a broad (national and international) search that would recruit the best candidate. Initiation of the search was delayed by an internal review of MSRC, resolution of the ongoing search for a Provost and the outcome of the academic re-organization of the University. *A search for the MSRC Dean is now underway and it is imperative that a nationally and internationally recognized scholar with administrative experience be recruited to lead MSRC into the 21st century.*

b. Faculty retention

The reputation of any organization is built in large part on the quality of its personnel. Developing high quality teaching, research and outreach programs depends on the efforts of faculty, and retention of the most productive faculty in these areas is critical for the continued development of MSRC. An important consideration in this regard is the salary structure of MSRC faculty. *Over the years of the Center's growth, new resources were directed towards recruitment of additional personnel rather than recognition of existing high-performing faculty through salary increases.* This was apparently not the case in other academic units with which the expertise of our faculty is most comparable (the departments of Ecology and Evolution, Physics, Chemistry and Earth and Space Sciences). A detailed study of salary structure was made by a task force composed of MSRC faculty in 1994 and showed significant offsets at all academic ranks. A recent compilation by the University has shown the same offsets (Table 3). Coupled with the high cost of living in the Stony Brook area, these inequities have significantly affected faculty morale. The resources to address this issue are lacking, but as new resources become available, a portion of them must be directed to this problem.

c. Full Funding for the Waste Reduction and Management Institute

As described elsewhere in this report, the Waste Reduction and Management Institute (WRMI) was created in 1985 to help the MSRC deal with marine and terrestrial waste management issues. The institute is an important component of our outreach efforts and its faculty provide expertise enabling the Center to tackle issues ranging from the effects of marine and groundwater pollution to the disposal of municiplal solid waste. The Institute was funded for many years through special legislative initiative funds. *The University has committed $150,000 to MSRC's base budget for WRMI, leaving a shortfall of about $125,000 to support personnel commitments.* Legislative support in the past two years has barely made up the difference. There have been no

STATE ALLOCATION 92-96

*WRMI Salaries fully funded by Special Leg. Appro.

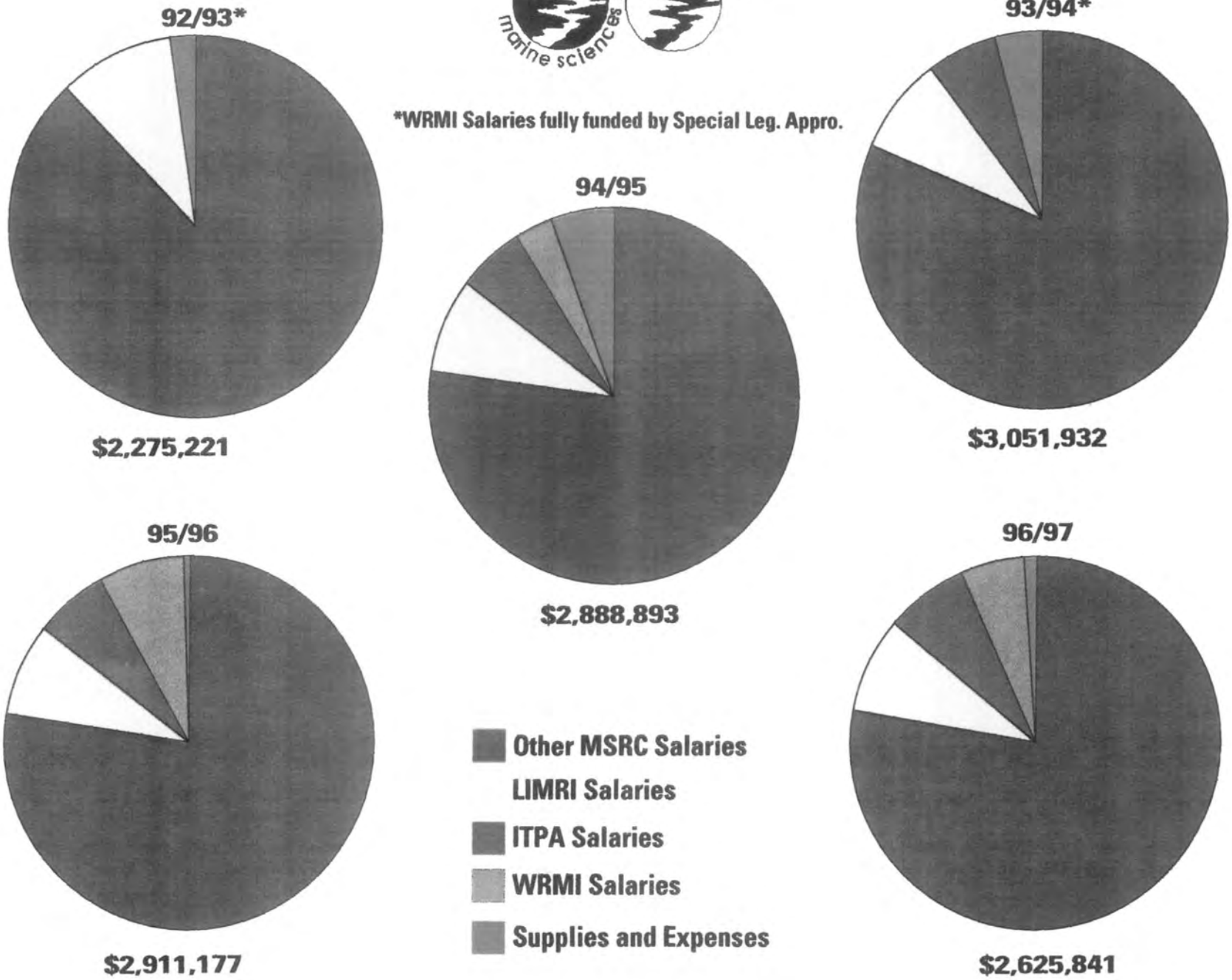


Figure 12

TABLE 3

SALARY COMPARISONS

Assistant Professor			
Department	**Low**	**Average**	**High**
MSRC	40,560	42,649	47,000
Chemistry	47,363	48,812	50,520
ESS(Geology) *	50,000	50,000	50,000
Physics	45,973	45,972	45,973
Ecology & Evolution	45,000	46,932	48,863

*only one position

Associate Professor			
Department	**Low**	**Average**	**High**
MSRC	44,944	49,103	57,263
Chemistry	52,739	62,443	70,593
ESS(Geology)	47,873	51,824	55,623
Physics	50,473	55,120	60,001
Ecology & Evolution	56,933	58,785	60,826

Full Professor			
Department	**Low**	**Average**	**High**
MSRC	57,623	69,210	91,854
Chemistry	61,094	77,408	96,768
ESS(Geology)	63,060	73,346	96,059
Physics	61,018	75,862	94,568
Ecology & Evolution	65,144	84,007	97,179

funds recently to support special initiatives or to cover basic operating expenses. The budget for the institute has been reduced to essential salary commitments. Recent efforts to ensure continued funding have centered on authorizing legislation passed in 1995 as a stepping stone to additional base support, but it has not yet been possible to get the Governor to authorize funding in the SUNY budget.

d. Selective Recruitment of Faculty and Staff

The MSRC has lost five state tenure-track faculty since the 1993/94 academic year. Attrition in state-funded staff has been greater--ten positions, a decrease of 40%. On the faculty side, many of the losses have been in physical oceanography. Our capabilities in aquaculture also have been compromised by reductions in faculty. Key staff positions in areas such as ship support, public relations and graphics arts have been lost. MSRC must be able to devote some resources to selective hiring in critical areas. Maintaining a strong capability in physical oceanography and adding a synoptic meteorologist to support further growth in the atmospheric sciences undergraduate major are important goals for faculty recruitment. In conjunction with other units, the Groundwater Institute has sought to recruit a hydrogeologist to the faculty. Securing proper support staff for the Center's research vessel is a priority in recruitment of staff.

e. Replacement of R/V Onrust

The Center's research vessel, R/V ONRUST is more than 25 years old. Breakdowns and repairs are increasingly frequent. The boat is relatively small and was designed before the extensive use of sophisticated electronic sampling devices and on-board computers. Her berthing arrangement is inadequate to take advantage of her cruising ability. *Coastal oceanography in the 21st century will involve extended cruises with large multidisciplinary teams of scientists using a wide variety of computer-linked electronic remote sensing and sample retrieval systems. The ONRUST cannot be modified to meet these needs.* Working with naval architects, MSRC has produced a general concept of the style, size, and layout of replacement vessel.

An appropriate vessel will cost $4 to 5 million. MSRC will pursue ways of supporting this construction cost. These range from inclusion of the project in the capital budget of the University and State to seeking additional support from federal funding and private sources. We will work closely with the University Development Office and the development officer assigned to MSRC to identify philanthropists with a keen interest in Long Island's marine environment.

2. New Initiatives

a. Development of an Undergraduate Major in Environmental Studies

MSRC's tradition of encouraging multidisciplinary research and using research results to help solve environmental management problems makes it the logical administrative home for an Environmental Studies major. This program will teach undergraduates that multiple, often conflicting, perspectives must be brought to bear to solve environmental problems and will give them the necessary background to analyze such problems. *The Environmental Studies major will involve faculty from many areas within the University, but administrative responsibility for it will rest with MSRC.* The major will be run in close association with the Environmental Studies Living/Learning Center in Gershwin College, especially for advising and career counseling. The program is being developed in cooperation with the Departments of Economics, Earth and Space Sciences, Ecology and Evolution, Physics, Philosophy, Political Science, Anthropology and the College of Engineering and Applied Sciences. The earliest date at which students are likely to be able to enroll in the major is fall, 1998. Resource needs for this program are mostly classroom space and administrative space in the academic core of the campus.

b. Development of a Summer Program for Undergraduates

MSRC is well poised to take advantage of expanded course offerings at the undergraduate level and our location on Long Island to offer a summer semester. A curriculum will be developed for initial offering in summer 1998. Our summer program will present a sequence of intensive laboratory and field-oriented coures where undergraduates experience hands-on involvement in the multidisciplinary approaches of marine and environmental sciences. A residential component also will be offered.

c. Construction of a Multi-Purpose Waterfront Marine Science Facility for Vessel Support, Research and Education

In order to expand the mission of MSRC in undergraduate education and public service and to upgrade our fleet of vessels, a need exists for a highly visible, shore-side marine science research and education facility that will become the symbol of the University at Stony Brook's commitment to education, research, and service in the public interest for the State of New York and the local community. *Unlike virtually all other oceanographic institutions of similar caliber, MSRC lacks a waterfront facility where vessels can be docked, where students learn from hands-on experiences, and where the public can learn about marine science.* The only such facility currently in place is the Flax Pond Marine Lab. Located at a secluded site on a salt marsh in the

village of Old Field, NY, the Flax Pond Lab has been a valuable resource for experimental and field studies involving marsh ecology and should be maintained. But its use for any other purpose is extremely limited: it lacks classrooms, it is inaccessible by vessel, it is barely accessible to the general public by any mode of transportation, and it lacks possibilities for expansion. In addition to space for deep water mooring, storage of field equipment, and staging of cruises, a shore-based facility should have classrooms, exhibit space, and hands-on seawater labs for education of undergraduates and other Long Islanders about the marine environment.

Options for acquiring a shoreside site or participating in the acquisition and development of such a site will be pursued. The Port Jefferson waterfront offers good possibilities for such a site.

d. Teaching Facilities

The Center complex was established with limited classroom facilities since, at the time we had only a graduate program and a small one at that. The graduate population has greatly increased and our undergraduate commitments are growing. While many of our new classes can be accommodated on main campus, others require some specialized facility. We need to establish an environmental teaching laboratory and to renovate and expand our recently established meteorology laboratory. The construction of a large lecture facility on South Campus is a priority as well.

3. Improvements in Existing Programs

a. Graduate Program

The MSRC MS and PhD programs, as described elsewhere in this document, are already recognized as being of high quality. We recognize both the importance of maintaining a strong professional Masters program and the need to consider carefully the rate of production of PhD's. Over the next five years, these programs will be strengthened through reinforced recruiting efforts to make potential students more aware of the possibilities at Stony Brook. We also plan to improve career counselling for our graduate students to familiarize them with the array of career possibilities open to them. We have already begun to organize and make better use of our own alumni in this effort. An important development goal will be to increase altenative sources of support for graduate students. This is particularly important as state funding of teaching assistants and federal research funds decline.

b. Outreach Activities

Outreach has always been an important mission at MSRC, but there are ways we can strengthen these efforts. We have established strong ties with local community organizations to develop environmental curricula. We will take advantage of

possibilities to extend these activities to magnet schools, for example, elsewhere on Long Island and in New York City. As the Long Island economy turns from a manufacturing base to a greater emphasis on high technology companies, we will identify arcas of collaboration and develop them. Opportunities for graduate student support are likely outcomes of such collaborations.