7. Marine, Earth, and Atmospheric Sciences Graduate Degree Programs
This section of the Self-Study and Comprehensive Review is presented according to the Revised Format for the Graduate Self-Study (The Graduate School)

1. Program Description

1.1 Exact Title of Program: Marine, Earth, and Atmospheric Sciences

1.2 Department or Interdisciplinary Group Authorized to Offer Degree Program(s):
Department of Marine, Earth, and Atmospheric Sciences

1.3 Exact Titles of Degrees Granted:
Doctor of Philosophy (PhD)
Master of Science (MS)

1.4 College or School: Physical and Mathematical Sciences

1.5 Brief History and Mission:

Provide a brief history of the development of the graduate program(s). Briefly describe the mission of the program: its general aims, goals, and objectives

The present department and graduate programs were formed by a merger of the Departments of Geosciences and the Department of Marine Science and Engineering in January 1981. At that time MS degrees in Geology and Meteorology were administered by the Department of Geosciences and MS and PhD degrees in Marine Science and Engineering were administered by the Department of Marine Science and Engineering. The MS degrees in Geology and Meteorology were phased out and the degrees in Marine Science and Engineering were broadened and renamed to their present title

Graduate enrollment in Fall 1990 graduate stood at 80 students. Approximately 60% were in the MS program and 40% in the PhD program and these percentages have remained more or less constant till the present. In the early and mid 1990's funded research and student support rose dramatically under a new department head and overhead funds returned to the department were utilized to support research assistantships, largely for international students. Enrollment rose to 130 in the Fall of 1997 with 29% international enrollment and a total of 91 FTEs. With the elimination of overhead funds enrollment dropped to a low of 100 in Fall 2001 with 76 FTEs. Since then enrollment has climbed steadily to a high of 122 students in Fall 2005 with 15% international enrollment and a total of 92 FTEs(an all time high). Most full time students were supported on TAs and grant supported RAs.

The primary mission of the graduate program is to educate our students to become effective researchers in their fields so that they may enjoy productive careers in industry, government, and academia. This closely interfaces with the mission of the university, namely "to serve its students and the people of North Carolina as a doctoral/research-extensive land -grant university."

With the increased awareness of our citizens of environmental problems and issues we foresee a continued important role of our programs in the future of the state and nation.

1.6 Degree Program Objectives:

For each degree program, indicate the specific objectives it is designed to achieve, particularly regarding student learning objectives. Note particularly any recent change in objectives or directions.

Doctor of Philosophy(PhD) Degree

- To prepare students for successful careers in academia, government, and industry.
- To prepare students to be effective researchers in marine, earth, or atmospheric science.
- To continue and improve a successful graduate program with national and international visibility that provides expertise to local, state, federal and international institutions.

Master of Science (MS) Degree

- To prepare students for successful careers in academia, government, and industry.
- To prepare students to be effective researchers in marine, earth, or atmospheric science.
- To continue and improve a successful graduate program with national and international visibility that provides expertise to local, state, federal and international institutions.

1.7 Degree Program Outcomes/Faculty Expectations:

For each degree program, indicate the degree program objectives/faculty outcomes.

Doctor of Philosophy (PhD) Degree

PhD Objective #1 To prepare students for successful careers in academia, government, and industry.

- Students should communicate research to local, regional, national and international audiences through presentations in venues ranging from graduate seminars through professional meetings and through publications in professional journals.
- Students should participate in professional organizations by becoming members and attending meetings.
- Students should broaden their professional background through activities such as teaching, and successful employment, grant, fellowship or internship applications.

PhD Objective #2 To prepare students to be effective researchers in marine, earth, or atmospheric science.

- Students should become independent researchers with the ability to recognize significant problem areas and formulate and test meaningful hypotheses.
- Students should develop a comprehensive knowledge of past and current publications in their field and demonstrate an ability to critique that literature.
- Students should communicate the solutions to research problems in a manner that demonstrates an understanding of the broader impacts of their research to their field.

PhD Objective # 3. To continue and improve a successful graduate program with national and international visibility that provides expertise to local, state, federal and international institutions.

- The program should influence policy through the participation of faculty on state and federal and international committees and entities.

- The program should attract, recruit, retain, and position high quality students for employment in academia, government, and industry.
- The program should graduate full time students in a timely manner

Master of Science (MS) Degree

MS objective #1 To prepare students for successful careers in academia, government, and industry.

- Students should communicate research to local, regional, national and international audiences through presentations in venues ranging from graduate seminars through professional meetings and through publications in professional journals.
- Students should participate in professional organizations by becoming members and attending meetings.
- Students should broaden their professional background through activities such as teaching, and successful employment, grant, fellowship or internship applications.

MS objective #2 To prepare students to be effective researchers in marine, earth, or atmospheric science.

- Students should become independent researchers with the ability to recognize significant problem areas and formulate and test meaningful hypotheses.
- Students should develop a comprehensive knowledge of past and current publications in their field and demonstrate an ability to critique that literature.
- Students should communicate the solutions to research problems in a manner that demonstrates
- An understanding of the broader impacts of their research to their field.

MS objective # 3. To continue and improve a successful graduate program with national and international visibility that provides expertise to local, state, federal and international institutions.

- The program should influence policy through the participation of faculty on state and federal and international committees and entities.
- The program should attract, recruit, retain, and position high quality students for employment in academia, government, and industry.
- The program should graduate full time students in a timely manner.

1.8 Responsiveness to Local and National Needs

The multi-disciplinary nature of the Department of Marine, Earth and Atmospheric Sciences (MEAS) at North Carolina State University lends itself to the study of such problems as prediction of severe weather (e.g. hurricanes), coastal erosion, pollution of surface and ground water, and climate change. While basic research is always important, many of our research projects also have direct application to current issues such as water quality/water supply, seafood harvests, climate change, weather prediction and land use. The research conducted in the department serves as a foundation to a very broad spectrum of environmental-related sciences and social-economic sectors. These research opportunities are documented in Chapter 8 of this report.

In North Carolina and the Nation at large, economic advancement is highly dependent upon science and technology. For most of the 20th Century, the economy of North Carolina was built largely upon agriculture, especially tobacco, and the manufacture of textiles and furniture. During the previous two decades the state's economy has been transforming rapidly with increasing emphasis on high technology industries. This has attracted a large influx of population to North Carolina from other states in the Nation and dramatically

enhanced the vulnerability of the environment due to increased population pressure (approx. 20% increase from the 90s to the 00s). The national and international high market competitiveness has also exponentially increased the demand on the department for its traditional leadership role in providing scientific solutions to existing and emerging environment problems, particularly in North Carolina. The research conducted in the department is playing a critical role in increasing the scientific knowledge base, and advising business, industry and governments on wise use of state's resources and potential impacts of human activities on the environment. The demand for MEAS science is rising as government agencies and businesses discover that the global environment, like the global economy, is truly interconnected.

Some of the key social-economic sectors at the State and National levels which are benefiting from the department's research activities in atmospheric science, geology, and marine science include, consulting firms; regulatory agencies; mass media; business/industry; federal, state and local governments; academic laboratories; research and educational organizations; non-profit environmental watchdog groups; ground water contamination; mitigation of natural disasters/hurricanes; management of coastal zones with dynamic geology; monitoring and predicting pollution; management of marine resources; researching sustainable fisheries; construction geology; geological surveying; mining industry; and volcanic/earthquake activity. Below is an abbreviated list of specific private and public clients who significantly utilize MEAS research in performing their operations and delivering their services.

1. NC Department of Air Quality (DAQ)
2. State Climate Office (SCO) on the NCSU campus
3. NWS forecast office on the NCSU campus
4. Student-led weather forecasting for WKNC radio
5. Local chapters of the American Meteorological Society
6. Center for Marine Science and Technology (CMAST)
7. Consortium for Oceanographic Research and Education (CORE)
8. North Carolina Department of Environment and Natural Resources (DENR)
9. City of Raleigh Municipal Utilities Division
10. U.S.Environmental Protection Agency (EPA) center in nearby Research Triangle Park
11. Wake County
12. The National Oceanic and Atmospheric Administration (NOAA)
    a. The National Weather Service (NWS) forecast offices in the Southeast United States
        1. RDU - Raleigh, NC
        2. MHX – Morehead City, NC
        3. ILM - Wilmington, NC
        4. AKQ - Wakefield, VA
        5. RNK – Blacksburg, VA
        6. CHS – Charleston, SC
        7. GSP – Greer, SC
        8. CAE – Columbia, SC
    b. The Coastal Services Center, Charleston, SC
13. NC Department of Water Resources
14. NC Department of Transportation
15. Duke Energy
16. NC Electric Cooperatives

17. Progress Energy

The NCSU MEAS department is one of the largest interdisciplinary environmental sciences departments in the nation's universities and its traditional leadership role in responding to these needs will continue to play a critical role in development of the State and the Nation in the years ahead.

1.9 Administration:

Briefly the programs administrative structure. List the major departmental committees that relate to graduate education and their structure and function. Describe any important formal and informal relationships the department has at the graduate level with other departments, institutes, centers, etc. at NC State and beyond.

The Director of Graduate Programs (DGP), who reports to the Department Head, oversees the graduate program. The DGP is aided in his tasks by the Student Services Assistant, who serves both undergraduate and graduate students, the Graduate Course Action Committee (GCAC), and ad-hoc committees set up from time to consider specific issues. The specific responsibilities of the DGP are as follows.

- Handles all correspondence between Graduate School and the graduate program;
- Initiates program-related proposals to the Administrative Board, either informally through contact with Graduate Deans or formally through written proposals to be considered at Administrative Board meetings;
- Seeks approval of College Graduate Studies Committee and College Associate Dean for Academic Affairs prior to submitting to ABGS.
- Oversees student recruitment;
- Conducts orientation of new graduate students;
- Advises students requesting admission to graduate program;
- Recommends admission or denial of graduate applicants;
- Conducts the daily administration of departmental graduate programs;
- Assigns initial advisors to new graduate students.
- Appoints graduate students to assistantships and fellowships;
- Approves students' plans of work after approval by Graduate Committee; submits plan to Graduate School;
- Submits requests for scheduling preliminary and final oral examinations and graduation checkouts;
- Transmits information from Graduate School to student
- Monitors graduate students' progress and graduation credits
- Advises students who encounter difficulties
- Assists new students in selecting major advisor;
- Nominates eligible students for individual fellowships and transmits their applications to Graduate School;
- Assists Graduate School in conducting the 10-year review of the graduate program, by initiating process of self-study upon notification by Graduate Dean;
- Assists Graduate School in developing fellowship proposals, including recruitment of Graduate Faculty to draft proposals and participate in proposed fellowship project;
- Assists Graduate School in managing fellowship awards to the program's graduate students.

The Student Services Assistant particularly helps the DGP in items 1., 4., 7. and 11.

The Graduate Course Action Committee (GCAC) is composed of the DGP and one faculty member from each of our disciplines. GCAC considers proposals of faculty to establish new graduate level courses. It reviews the course proposal, recommends changes, and approves or rejects the proposal. If approved at the departmental level the DGP then brings the proposal to a college level committee for its consideration. If the course action is approved at the college level it goes to a university level committee.

1.10 Graduate-level relationships with other departments, institutions, etc

Faculty in Marine, Earth, and Atmospheric Sciences are involved in many research collaborations with colleagues in other NCSU departments, including Agriculture and Resource Economics, Biological and Agricultural Engineering, Civil Engineering, Mathematics, Physics, Plant Pathology, Soil Science; The Science House, and the NCSU/CALS Turf Center.

Formal collaborations also exist with research programs at other USA universities, including Auburn University, California Institute of Technology, Columbia University, Duke University, East Carolina University, Elizabeth Rogers College of Charleston, Florida International University, Humboldt State University, Montana State University, North Carolina A&T State University, Purdue University, Robeson Community College, Stanford University, SUNY Stony Brook, Texas A&M University, University of Colorado, University of Georgia Marine Education Center and Aquarium, University of North Carolina at Chapel Hill, University of North Carolina at Wilmington, University of Maryland, University of Minnesota, University of South Carolina, University of Utah, University of Washington, Virginia Institute of Marine Sciences, Virginia Polytechnic Institute and State University, and Woods Hole Institute of Oceanography. International collaborations exist with colleagues at Chinese Academy of Meteorological Sciences, Memorial University of Newfoundland, University of East Anglia, Ocean University of China; Chinese Academy of Meteorological Sciences, Institute of Oceanography at the National Taiwan University, National Taiwan Normal University, Shanghai Typhoon Institute, the University of Tokyo, and Victoria University (New Zealand).

In addition, there are formal relationships in place with BAMS, Inc , California Air Resources Board, Charles Darwin Research Station (Galapagos, Ecuador), Geological Survey of Canada, NASA Goddard Space Flight Center, North Carolina State Climate Office, North Carolina Department of Environment and Natural Resources (NCDENR), North Carolina Water Resources Research Institute ,NOAA, The National Weather Service, Pacific Northwest National Lab, the U.S. Environmental Protection Agency, r, the U.S. Geological Survey, Mote Marine Laboratory, Research Triangle Institute, Smithsonian Institution, South Carolina SeaGrant, and the Virginia Department of Environmental Quality. A more detailed account of these collaborative arrangements is given in Section 8.

II . FACULTY

2.1 Faculty list (Tenure track only)

List of tenure track faculty hired prior to Fall 2006 and numbers of completed committees chaired for the period May 1996- December 2005.

PROFESSOR	RANK	*1 # MS (co)chaired	*2 # PhD (co)chaired
Aneja, Viney	Full	20	7
Arya, Pal	Full	7	5
Blair, Neal	Full	2	2
Clarke, Julia **	Assistant	0	0
Cudaback, Cynthia **	Assistant	0	0
DeMaster, Dave	Full	4	2
Eggleston, Dave	Full	8	8
Fodor, Ron	Full	4	0
Fountain, John **	Full	0	0
Genereux, David	Associate	3	1
Hibbard, Jim	Full	7	0
Janowitz, Jerry	Full	1	2
Kamykowski, Dan	Full	3	3
Kimberley, Mike	Associate	1	0
Lackmann, Gary	Associate	8	2
Leithold, Lonnie	Associate	6	1
Lin, Yuh-Lang	Full	17	12
Liu, Paul **	Assistant	1	0
Parker, Matthew **	Assistant	0	0
Raman, Sethu	Full	18	10
Schweitzer, Mary **	Assistant	0	0
Semazzi, Fred	Full	3	6
Shaw, Ping-Tung	Associate	0	1
Showers, Bill	Associate	1	2
Wolcott, Tom	Full	4	2
Xie, Lian	Full	6	5
Yuter, Sandra **	Assistant	0	0

Zhang, Yang **	Associate	0	0

** indicates here less than 5 years
*1 # of MS students who completed degree 1996-2005
*2 # of PhD students who completed degree 1996-2005

This semester, Fall 2006, we have hired three new faculty at the assistant professor level: Annantha Aiyyer, Delwayne Bohnensteihl, and Nicholas Meskhidze and one at the associate professor level: Ruoying He.

During the ten year period, calendar years 1996-2005, 178 students received MS degrees. Of these 110 committees were chaired or co-chaired by the above named faculty with 14 of these committees co-chaired. Another 68 committees, about 40% of the total, were chaired by 19 faculty members (15 tenure track) who are no longer with the department; 6 retired and 13 have taken employment elsewhere. During this period 78 students received PhD degrees. Of these 61 were chaired or co-chaired (8) by the above faculty and 12 by faculty who are no longer with us.

2.2 Visiting, Part-Time, and other Faculty

Many other MEAS Graduate Faculty members who were in residence in the period 1996-2005 contributed to our program but are not on the above list due to retirement (most)or taking positions elsewhere or out of the department (* below). Their names and titles are below.

Tenure track faculty

D. Evans	Assistant Professor*
L. Carey	Assistant Professor*
S. Snyder	Assistant Professor*
M. Bevis	Associate Professor*
S. Businger	Associate Professor*
T. Drake	Associate Professor*
C. Knowles	Associate Professor
S. Koch	Associate Professor*
A. Riordan	Associate Professor
E. Stoddard	Associate Professor
G. Watson	Associate Professor
D. Wolcott	Associate Professor
V. Cavaroc	Professor

T. Clark Research Professor
J. Davis Professor
T. Hopkins Research Professor
J. Morrison Professor*
L. Pietrafesa Professor*
D. Russell Research Professor
C. Welby Professor
V. Saxena Professor*

Visiting and other non-tenure track faculty

A number of other Graduate Faculty in non-tenure track positions were in residence in this period and contributed to our program:

R. Barrick Visiting Assistant Professor
J. Charney Visiting Assistant Professor
H. Mitasova Research Assistant Professor*
D. Schowalter Visiting Assistant Professor
C. Thomas Visiting Assistant Professor *
M. Kaplan Visiting Associate Professor
H. Reichle Jr. Visiting Professor

* In residence currently

In addition to the above faculty a large number of adjunct faculty who were not in residence also contributed by serving as members of students' advisory committees. Due to their large number and relatively small impact on our program these will not be listed.

2.3 Advising of Graduate Students

A. Initial Advising.

An initial advisor is assigned to each incoming student. Students supported in whole or in part as a Research Assistant (RA) are assigned as the initial advisor the faculty member providing the support. No RAs are supported by departmental funds. Students on Teaching Assistantships (TAs), or the few unsupported students who enroll, are assigned by the DGP to faculty members whose research interests most closely match their own as expressed by the students in their applications. During their first year, students are strongly encouraged to find a faculty member willing to serve as their permanent (major) advisor and chair of their advisory committee. For most students, especially those on RAs, the initial advisor becomes the permanent advisor. Perhaps 30% of students do switch to a new permanent advisor.

By the end of the first year students have obtained a permanent advisor who will serve as chair or co-chair of their advisory committee and have selected a research topic. Based on their research topics and in consultation with their advisor the students will ask additional faculty to serve on their

advisory committees. The students then fill out a Plan of Work (POW) which includes the names of their chair and other members of their advisory committee, a tentative thesis (MS) or dissertation (PhD) title, and a list of courses they have taken and plan to take to fulfill the minimal degree credit hour requirements. The names of the advisory committee and the POW, signed off by the committee and the DGP are then submitted to the Graduate School for its approval.

B. The Advisory Committee

The role of the advisory committee is to provide advice to the student, approve the research proposal, and evaluate performance on Preliminary Written and Oral (PhD) and Final Oral examinations (MS and PhD) and approve the thesis or dissertation. Our goal is to have the committee and POW submitted and approved within 12 months of entry of the student into the program. Masters' committees are composed of a minimum of three members including the chair, and PhD committees have a minimum of four members including the chair. The department requires that at least two members be tenure track faculty in the department and the Graduate School requires that the minimum number of members also be members of the Graduate Faculty. Many committees have more than the minimum number of members. If no member of a PhD committee is from outside the department, the Graduate School will assign a Graduate School Representative to the committee at the time of the Preliminary Oral Examination..

C. New Faculty

Each new faculty member is assigned a mentor who is a tenured faculty member. These mentors advise new faculty with regard to building and managing a research group, publishing, securing funding, teaching and service. New faculty also attend orientations offered by the College and Provost's office, In addition, the Faculty Center for Teaching and Learning at NCSU offers a semester long orientation program that meets on a weekly basis.

2.4 Faculty Quality

Faculty quality in MEAS is assessed by three methods. Teaching evaluations (both student evaluations and peer reviews) provide the primary mechanism to ensure quality classroom instruction by faculty. The process of nominating faculty for outstanding teacher awards is another mechanism. Overall quality and quantity of contributions in all aspects of faculty responsibility including teaching, advising, research, and service are assessed on an annual basis using Faculty Activity Reports (FARs). The FARs provide an annual summary of faculty members' achievements in research (awards and honors, research grants and contracts, invited lectures and conference presentations, publications, and supervision of research personnel), classroom instruction and student advising (courses taught, undergraduate and graduate advisees, and supervision of teaching laboratories), and service (graduate committee memberships, departmental, college and university activities, professional organization activities, interdisciplinary and collaborative activities, and community and public service). The Department Head reviews the FARs and generates a written evaluation. In addition to written evaluations, the Head also has annual review meetings with each faculty member to discuss their performance and plans for the future. The senior faculty reviews all Assistant Professors and non-tenured Associate Professors to evaluate their progress toward tenure and promotion. In addition, post-tenure reviews are conducted for tenured Associate Professors every three years and for Professors every five years by a committee appointed by the Department Head.

2.5 Faculty Distribution

Distribution of research expertise in various areas of marine, earth and atmospheric sciences is vital to providing graduate students with a diversity of graduate courses as well as choices of thesis/dissertation research. It is one of the primary goals of the Department to provide a comprehensive graduate education including broad choice of graduate courses and research topics. To be recognized as a top quality graduate program, it is necessary to establish and maintain excellence in research in a variety of areas and also to establish strengths in certain core areas. To accomplish these goals, the strategy for new faculty hiring should focus on maintaining our core strengths in each of the disciplines of marine, earth and atmospheric sciences, while continuing to build strengths in interdisciplinary areas.

Research Fields
The distribution of research active faculty is categorized below according to three broad disciplines and their sub- fields, as well as some of the interdisciplinary areas of research (note that some faculty are involved in research in multiple areas):

Marine Science
Biological Oceanography: Eggleston, Kamykowski, Wolcott
Chemical Oceanography: Blair, DeMaster
Physical Oceanography: Cudaback, He, Janowitz, Shaw, Xie
Estuarine and Coastal Processes: He, Janowitz, Liu,Shaw, Xie
Marine Physiological Ecology: Eggleston, Kamykowski, Wolcott

Earth Science
Geochemistry: Kimberley, Showers
Geophysics: Bohnenstiehl
Hydrogeology: Fountain, Genereux
Igneous Petrology: Fodor
Paleontology: Clarke, Schweitzer
Sedimentation and Stratigraphy: Leithold
Structural Geology: Hibbard

Atmospheric Sciences
Air Quality and Air Pollution Meteorology: Aneja, Arya, Meskhidze, Raman, Zhang
Atmospheric Boundary Layer and Turbulence: Arya, Lin, Raman
Atmospheric Chemistry: Aneja, Meskhidze, Zhang
Climate Dynamics and Modeling: Meskhidze, Semazzi
Convective Systems/Storms: Lin, Parker, Yuter
Mesoscale Meteorology: Lackmann, Lin, Raman
Physical Meteorology: Meskhidze, Yuter
Radar Meteorology: Yuter
Tropical Meteorology and Climatology: Aiyyer, Raman, Xie
Weather Analysis and Forecasting: Lackmann, Lin, Parker

Interdisciplinary
Air-Sea Interaction: Raman, Xie
Environmental Fluid Mechanics: Arya, Cudabach, Janowitz, Raman
Geophysical Fluid Dynamics: Janowitz, Lin, Shaw
Marine Biogeochemistry: Blair, DeMaster, Meskhidze, Showers
Marine and Coastal Meteorology: Raman, Xie
Marine Geology/Geophysics: Bohnenstiehl, Leithold, Liu
Ocean-Atmosphere Coupled Modeling: Xie

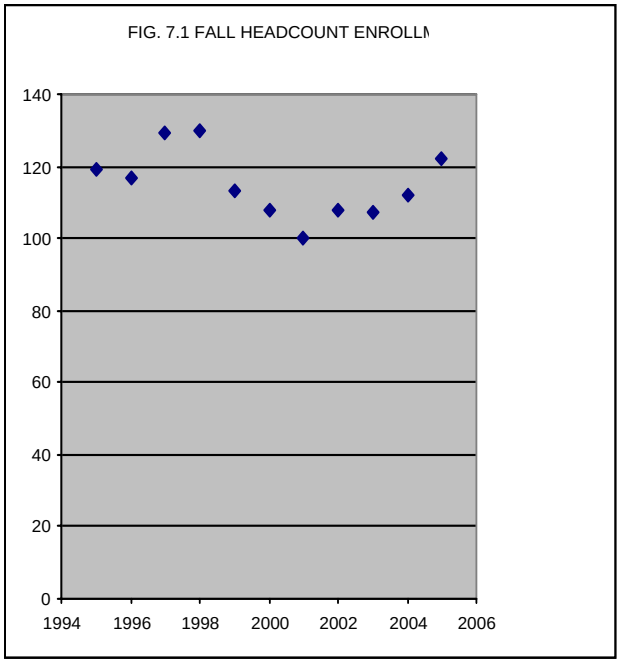
Graduate Courses
Although some of our graduate courses have significant interdisciplinary content, they are generally categorized in terms of their closest association to the three broad disciplines of marine, earth, and atmospheric sciences. These are listed in Appendix II.

III STUDENTS

A sense of the development of the graduate program can be gained by examining Figure 7.1 and 7.2 which show the total Fall enrolment and incoming class, the sum of MS and PhD students, over the period Fall 1995 through the present. Between fifty and sixty percent of the students major in Atmospheric Science and between twenty and twenty five percent major in Marine Science and in Earth Science. About 40 percent of the total count of students is PhD over this period though it varies somewhat from year to year

3.1 Enrollment:

Fall enrollment for the period 1995/96 through 2004/05 is shown in Figure 7.1. Enrollment for Fall 2005 was a total of 122 graduate students with 92 FTE students, 34 women and 18 international students. Enrollment in Fall 1990 (not shown) was 80 students and rose to a high in the mid to late 1990's as did the fraction of international students (~ 30 %). Research overhead funds returned to the department were used in that period by the department to pay for RAs for international students in an effort to increase enrollment with the vain hope that additional resources would then flow from the college to the department. With a change in department head and a loss in overhead funds this policy was dropped and enrollment dropped to a minimum in Fall 2001. Since then enrollment has been rising and the number of FTEs is now at an all time high with the largest number of US students (104) and the lowest percentage of international students (<15%) in recent history. Fifty to sixty percent of our students major in Atmospheric Science with twenty to twenty five percent each in Marine Science and Earth Science. These percentages have remained relatively constant with time. Space issues play a strong role near term in future growth. We have now run out of desk space for additional students. In the past each graduate student was provided with a desk outside of the area where he or she worked. With the recent increase in faculty there is no space left for additional student desks. With the completion of Jordan Hall II expected in 2007, labs may be shifted from Jordan Hall to the new building creating additional space for graduate students in Jordan Hall.



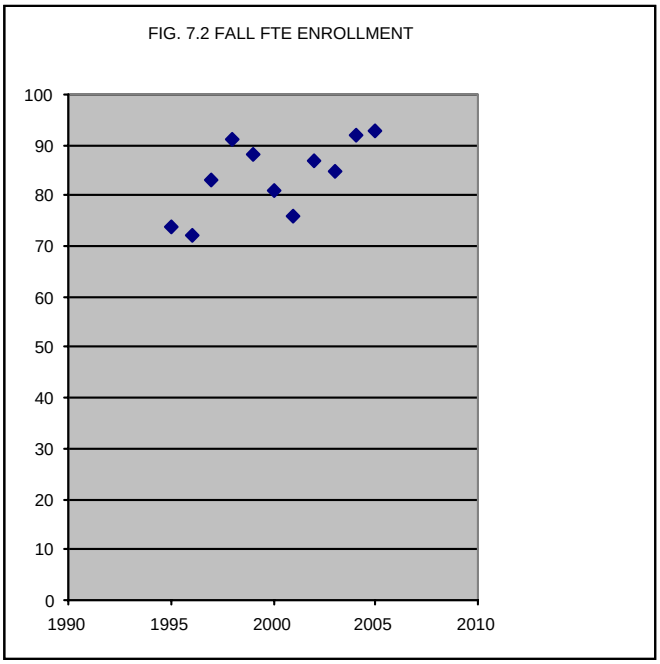
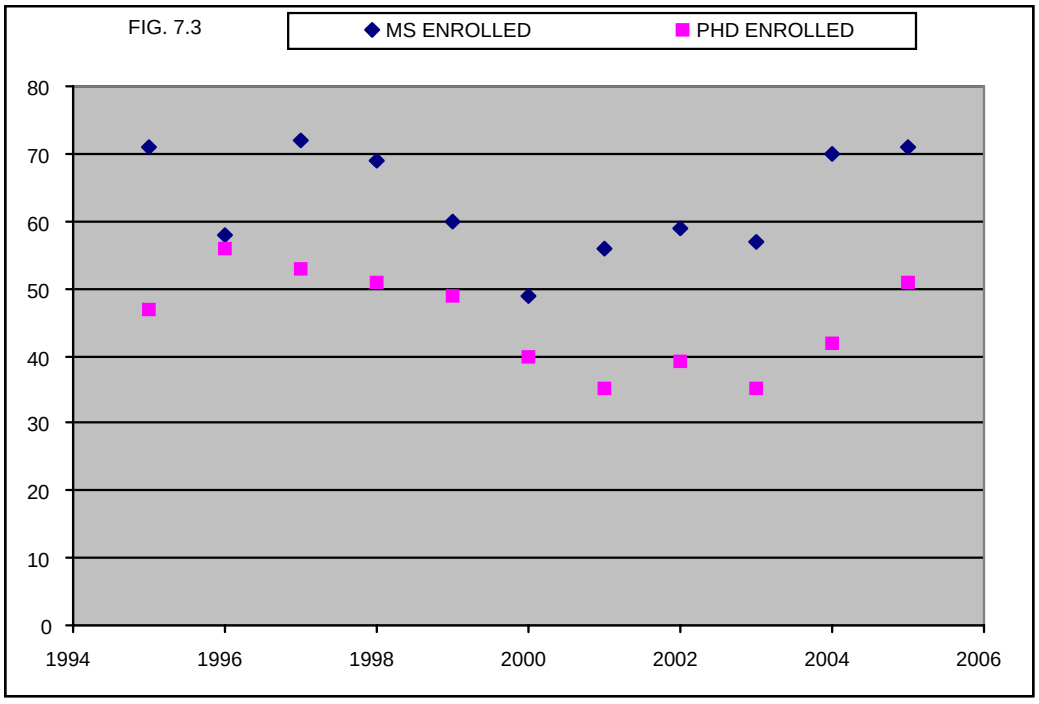
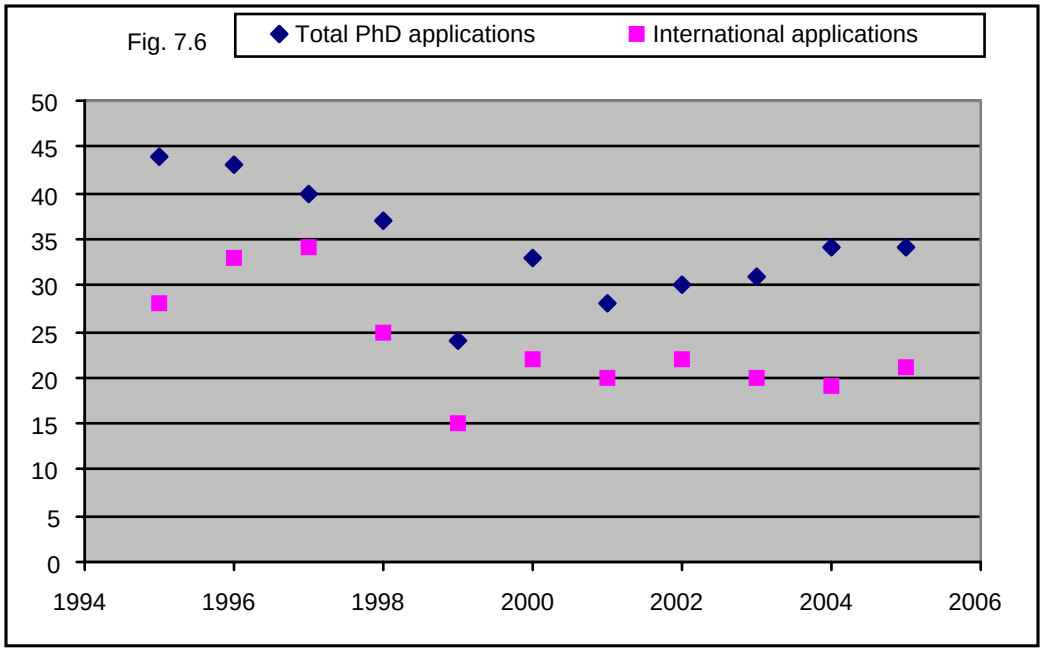
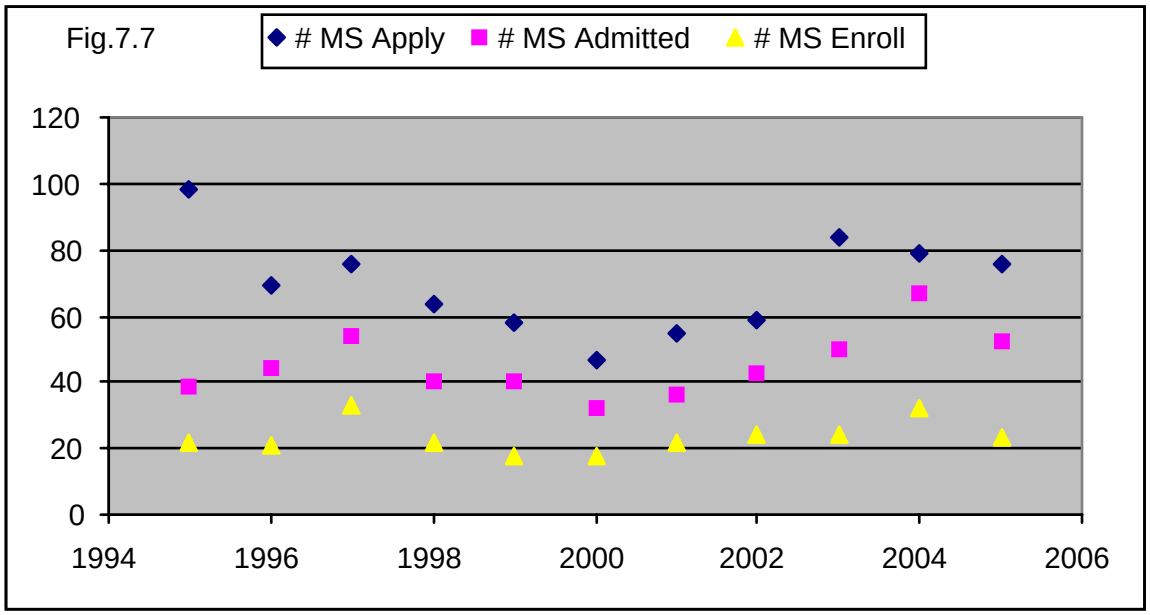


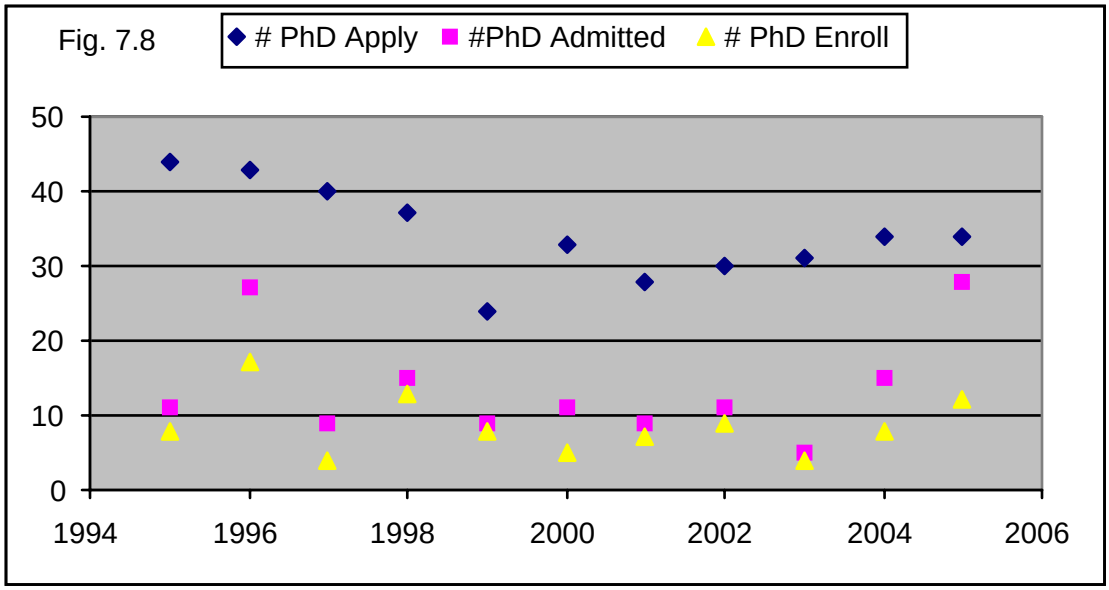
Figure 7.3 shows the numbers of enrolled MS and PhD students over the ten year time period. The fluctuations in enrollments is due to the year to year variation in the number of degrees awarded which decreases the class size in the subsequent year as well as the variation in the number of assistantship offers available for applicants. This will be discussed in detail later. The diversity of the department is shown in Figure 7.4 which shows the number of enrolled students that are international and the number of enrolled students that are women. As indicated earlier the percentage of international students has dropped over the period. The percentage of international students stood at 14.8% in Fall 2005, half of its value a decade earlier. There is no long term trend in the percentage of women which stood at 29% in Fall 2005. The department generally has between zero and four Afro-Americans enrolled with no trend. These small numbers were not plotted.



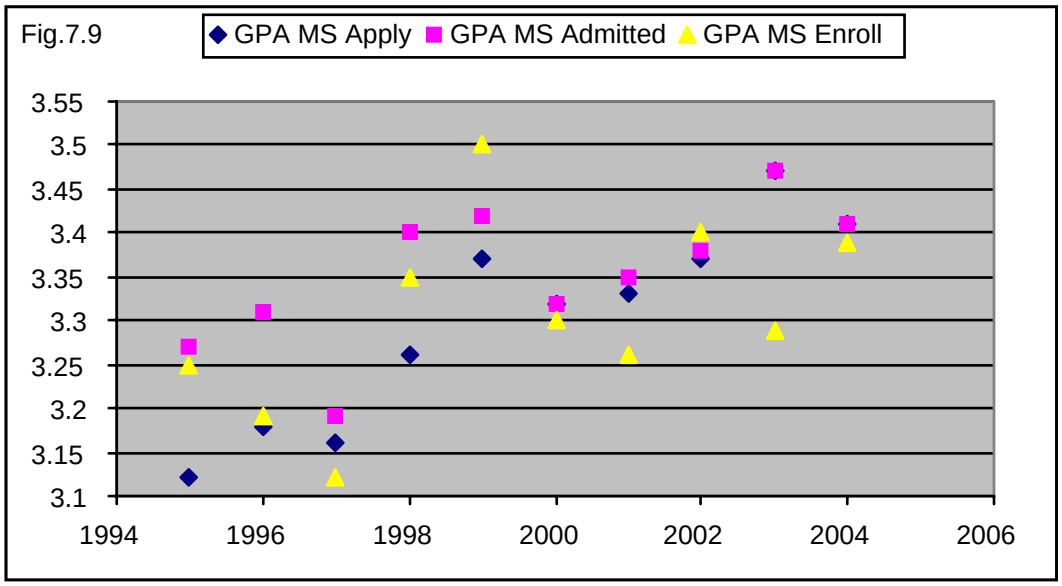


Figures 7.7 and 7.8 show the total number of students applying, admitted, and enrolling in our MS and PhD programs respectively. For MS applicants, averaged over the decade, about 2/3 of those who apply are admitted, and about 1/2 of those admitted do enroll. For PhD applicants, averaged over the decade, about 1/3 of those who apply are admitted and about 2/3 of those admitted enroll. Those who enroll are generally those who have received assistantship offers.

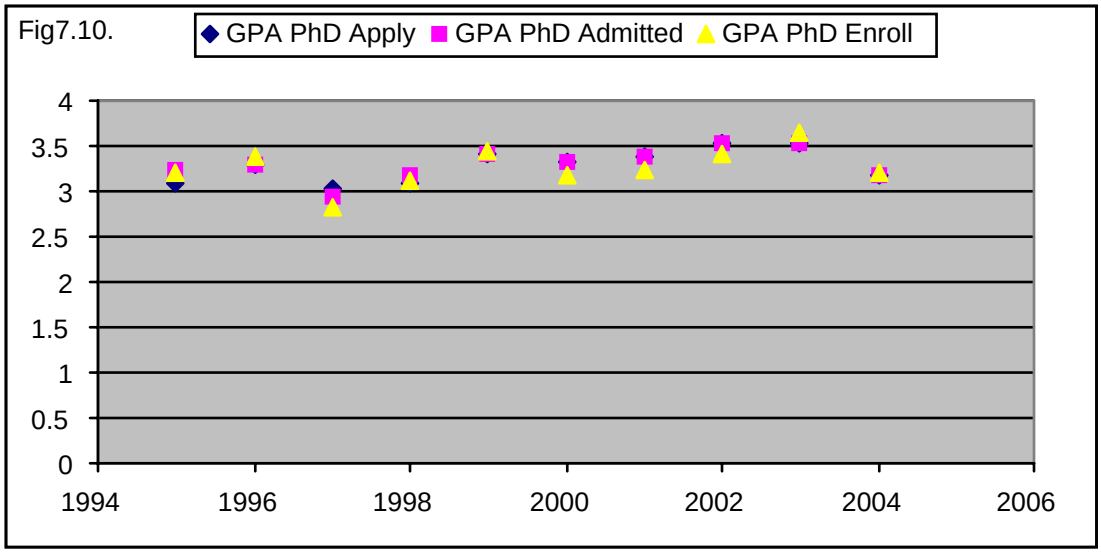




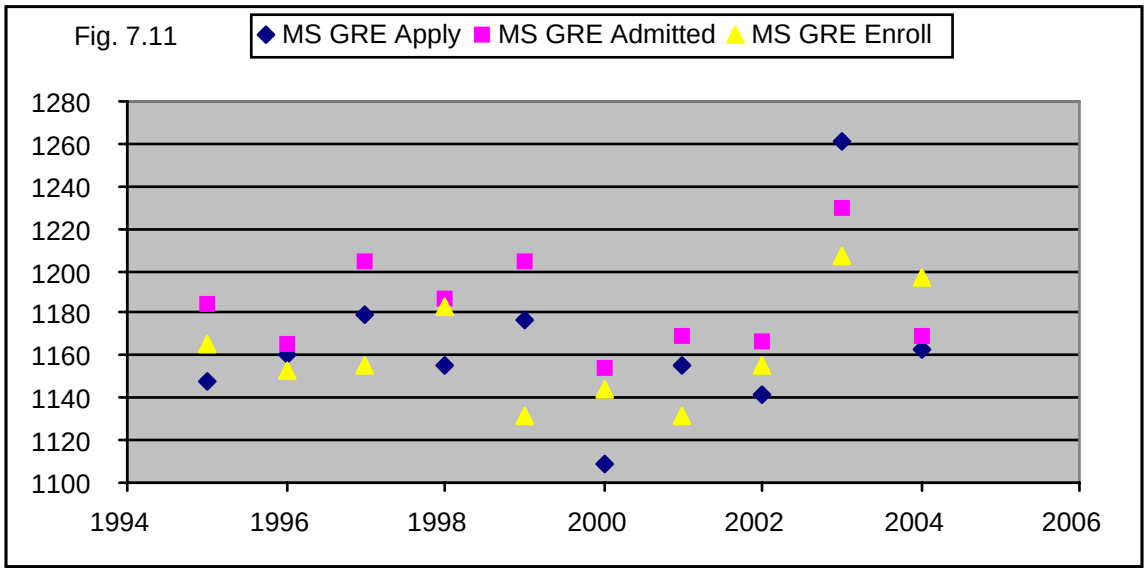
The next sets of figures reflect on the quality of our applicants. Figures 7.9 and 7.10 show the average undergraduate GPA of domestic applicants, admitted students, and enrolling students for each year in our MS and PhD programs respectively. For PhD applicants the undergraduate GPA is of less significance in the admission decision than MS level experiences. There has been some upward trend in undergraduate GPA over

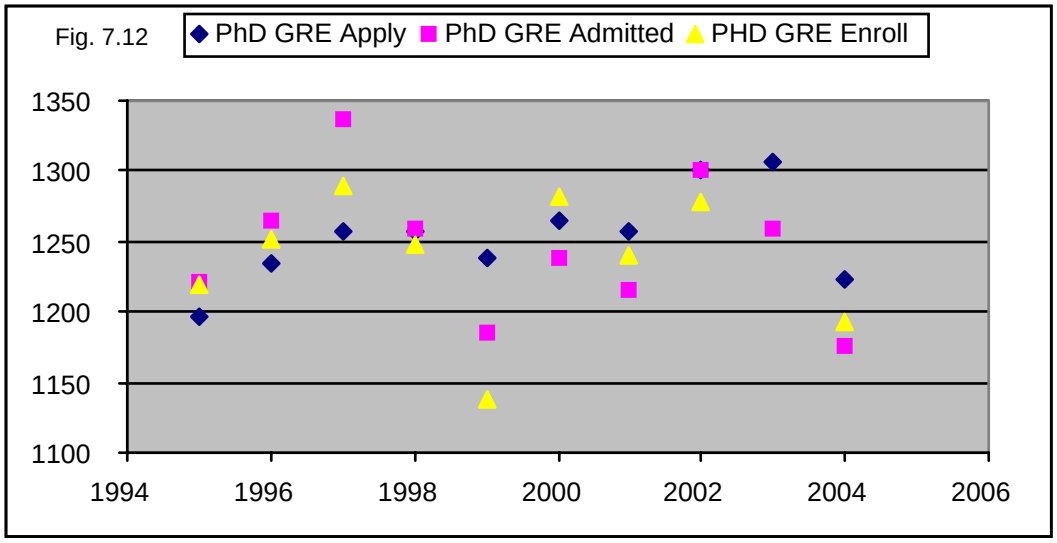


the decade though this may simply reflect grade inflation.



The final set of figures dealing with student quality, Figures 7.11 and 7.12 give GRE scores of applicants, admitted students, and enrolling students in our MS and PhD programs respectively. The numbers shown are the sum of the Verbal and Quantitative section scores on these exams. There appear to be no obvious trends.





3.3 Degrees Awarded

To some extent the success of our graduate programs is revealed in the success of our graduate students in obtaining their degrees and on the length of time required to do so. Figure 7.13 shows the numbers of MS and PhD degrees awarded over the ten year period, Appendix Ia and Ib lists our MS graduates and PhD graduates respectively for this period along with their thesis/dissertation titles and committee chairs. The fall off to the end of the period is ascribed to relatively weak recruiting a few years earlier at the start of the decade. Figures 7.14 and 7.15 shows the time for the graduates in each year to obtain their degrees, both the average time and the range. The longest times reflect those students who have left NCSU for full time employment before completing their theses or dissertations. Generally speaking it takes about three years for MS and five years for PhD students to obtain their degrees. Given the field related nature of many student projects these times are not inappropriate.

Fig. 7.13

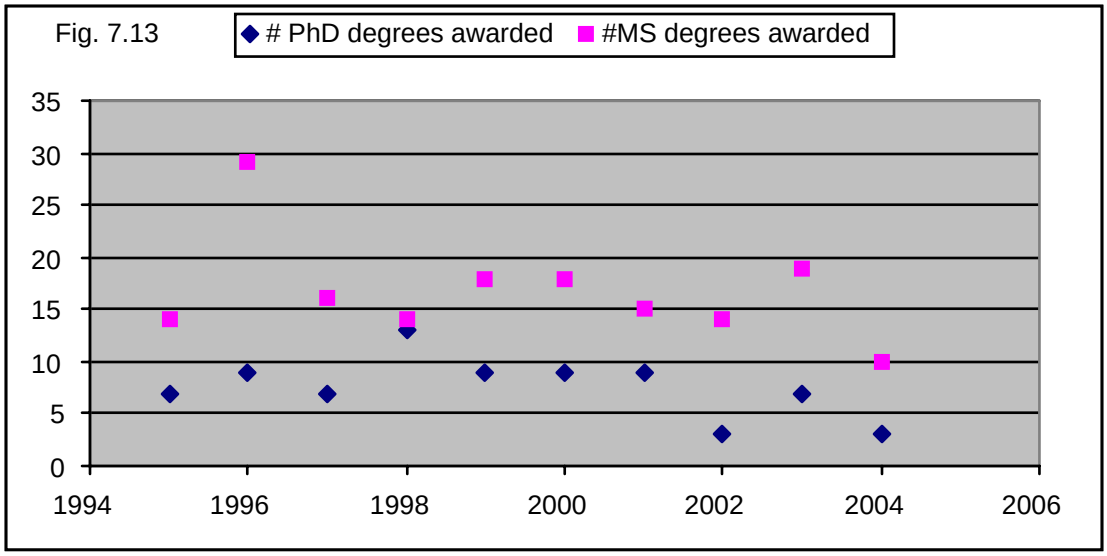
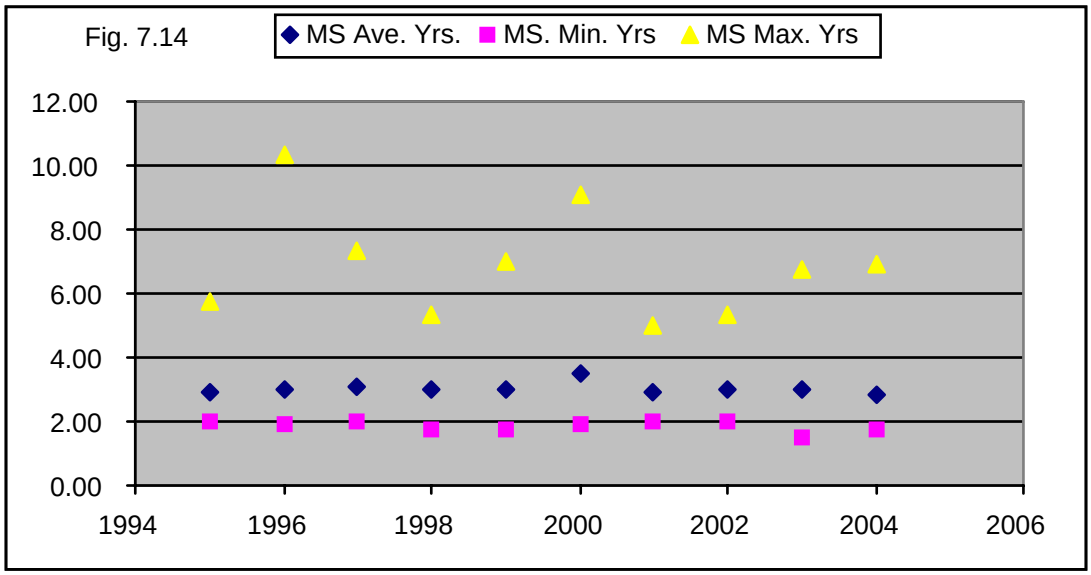
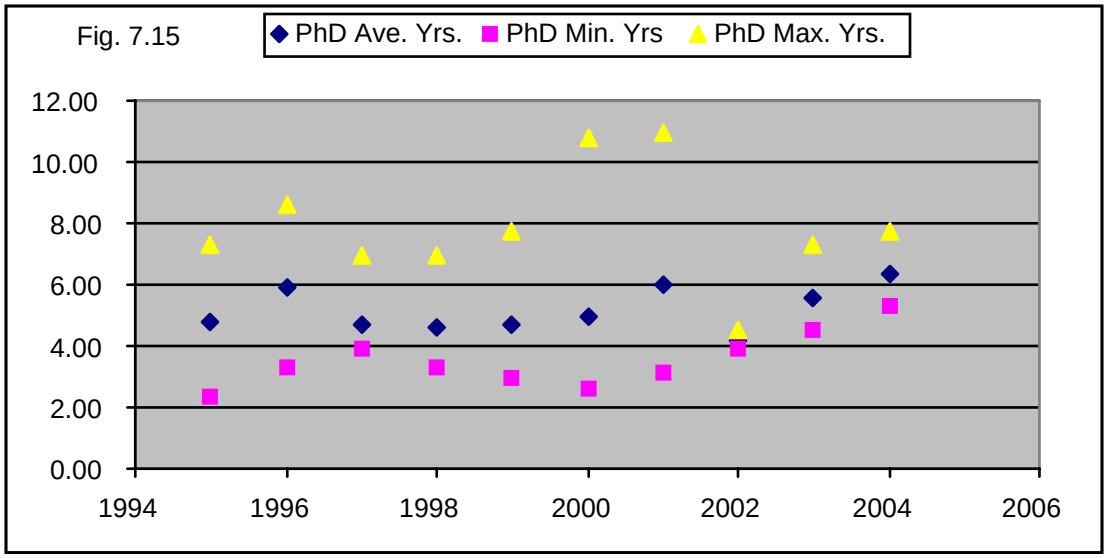
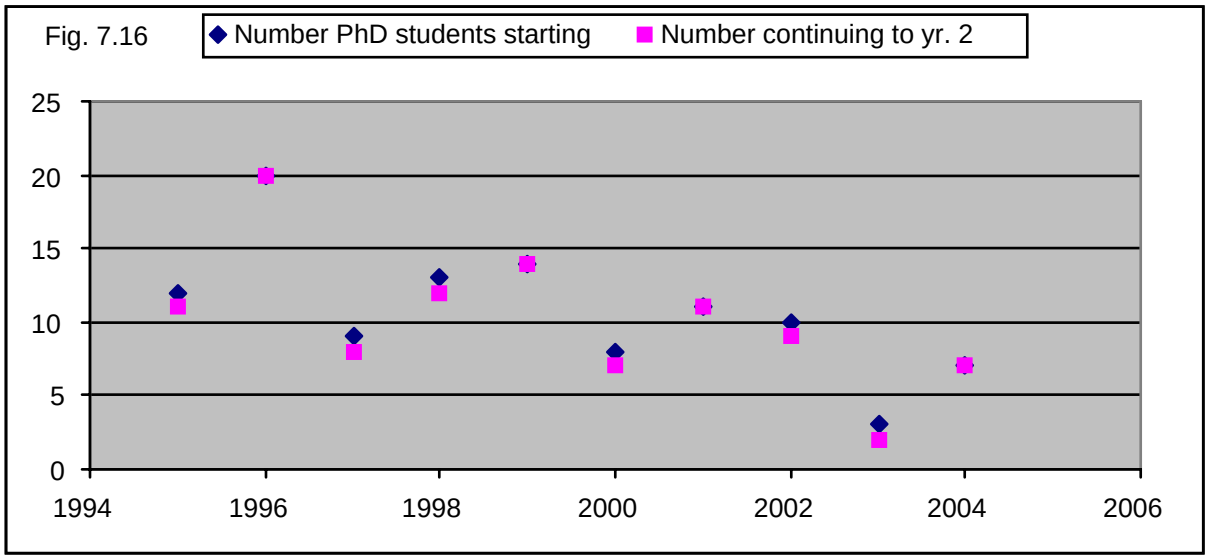


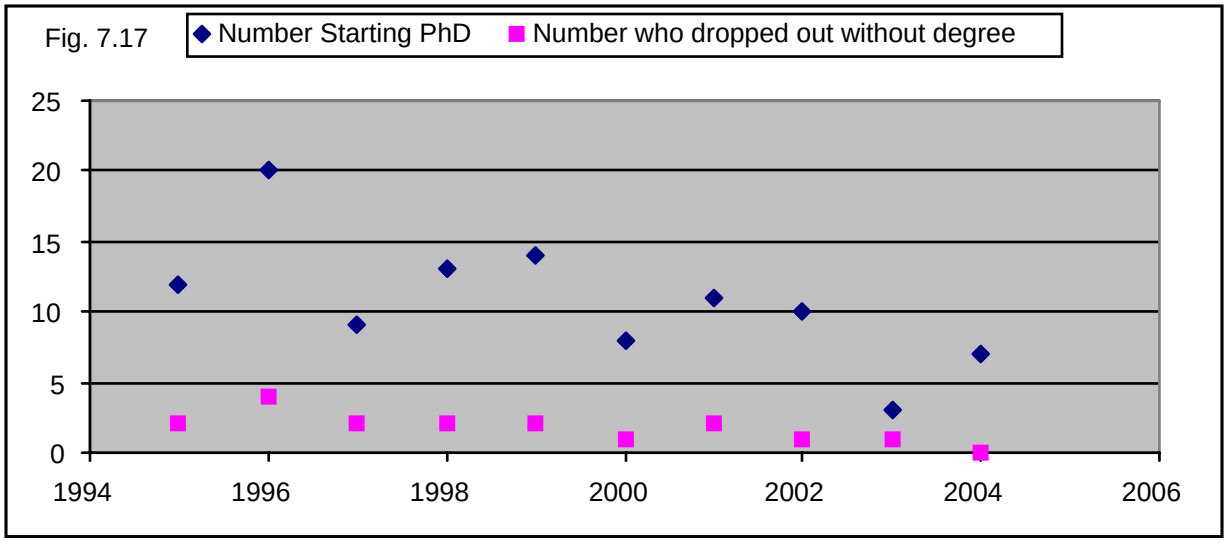
Fig. 7.14





Another measure of the success of the program, particularly the PhD program is the success or alternatively the attrition rate of students in the PhD program. Figure 7.16 shows the first year success rate of students entering each year, i.e., the number of PhD students starting their first year and the number of those PhD students that continue into year 2. In the four years where only one symbol is given, no students dropped out. Another measure is the overall attrition rate from the PhD program, Figure 7.17, i.e., the number of an entering cohort and the number of that cohort that dropped out of the program from the entrance year to the present without receiving an MS or PhD degree. The overall attrition rate is 15%. It should be pointed out that in the mid and late 1990's, a number of international students entered our PhD programs and after having taken a number of computer science classes switched to computer science and received MS degrees there. This negatively impacted our retention rate.





3.4 Need

The need for our graduates is best identified by the employment of recent graduates. Below is a listing of a of federal agencies, state agencies, universities, and private companies hiring about one quarter of our graduates in the last five years. Our faculty indicate that virtually all of our recent graduates had relevant gainful employment upon graduation

State agencies:

NC Aquarium, Manteo
GIS specialist, City of Covington, GA

Federal agencies:

NOAA Hydrometeorological Prediction Center (HPC) Washington, DC
UCAR Postdoc, Employer UCAR and Tropical Prediction Center
National Weather Service, Charleston, SC
NOAA Southern Mississippi River Forecast Center
U.S. Air Force, Chief Operational Climatology, Asheville, NC.
NOAA/US EPA, RTP, NC.
U.S. Environmental Protection Agency, Research Triangle Park, NC.
NOAA, Ashville, NC
NOAA/EPA, Research Triangle Park
Los Alamos National Laboratory, Los Alamos, NM
U.S.EPA, Research Triangle Park, NC
NOAA/National Climate Data Center, Asheville, NC
NWS/Charleston, SC
NWS, Hydrological Prediction Center

NWS/New Orleans
NOAA NESDIS

Universities:

Ph.D. Student at NCSU
Ph.D. Student at URI
Ph.D. Student at NCSU
Texas A & M University, Assistant Research Scientist
Research Scientist, Princeton University, NJ
Ph.D. Student at NCSU
Ph.D. Student at NCSU
Ph.D. Student at NCSU
Ph.D. Student at NCSU
Ph.D. Student at University of Kentucky
Post-Doctoral Fellow at NCSU
Post-Doctoral Fellow at NCSU

Private Companies:

Airdat, Inc. Raleigh
Sanoma Technologies, CA
Weston Solutions, Morrisville, NC
URS Corporation, Tampa, Florida
The Carolina Environmental Program, Chapel Hill, NC
Trigon Engineering Consultants Inc
ARCADIS G&M of North Carolina, Inc.
TV Meteorologist, Spokane, WA
CH2M Hill, Virginia Beach VA

3.5 Funding

Figure 7.18 shows the number of RAs, TAs, split TA-RA appointments and percentage of students supported for the period 1995/1996 through 2004-2005. The number of RAs has been rising consistently for the past five years especially when considering that half of the split appointments could be added to the RA number. Most of the unsupported students are either part time students working for state or locally located federal agencies or students who have other full time employment outside the local area and are completing writing their theses off-campus. In 2005-2006 only 5% of the students on campus were without support. Figure 7.19 shows the average annual stipend for this period for a calendar year though some students are paid only for 9 months. For the past several years, the standard stipend for the 9 month academic year has been $14,000. Most students are on RAs over the summer. Since Fall 1997 assistantship awards have carried tuition benefits, so students are only required to pay fees which are now about $600/semester. Awards also carry paid health insurance. We feel our current award package is reasonably competitive

Fig. 7.18

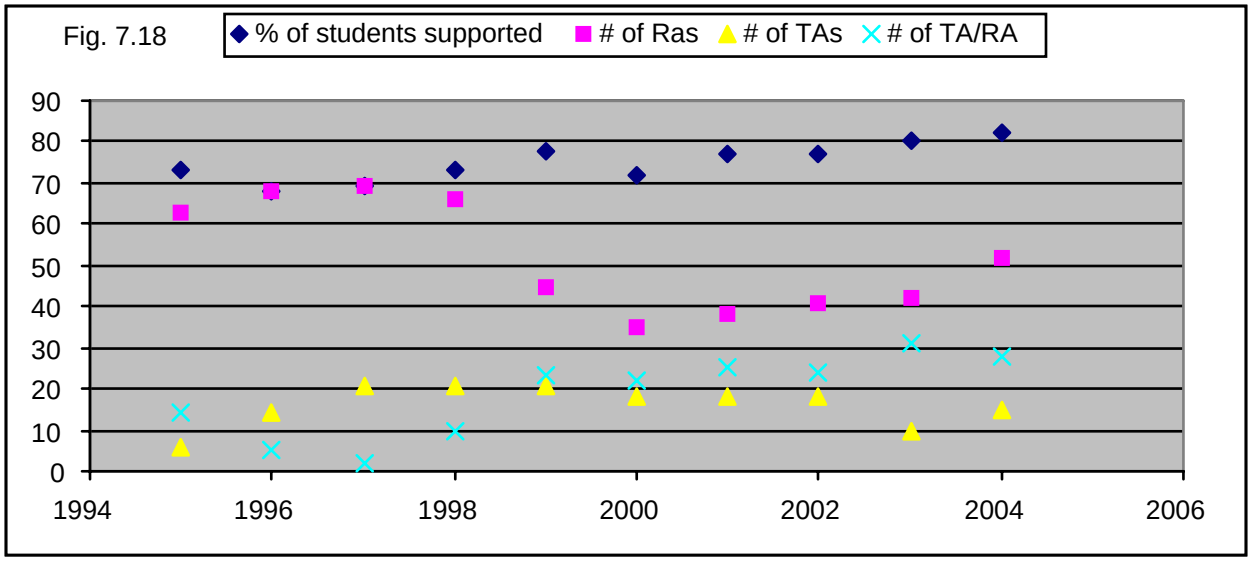


Fig.. 7.19

IV. CURRICULUM/ INSTRUCTION

Doctoral Degree

The doctoral degree is a research intensive educational experience. We generally require a research MS degree for admission to this program although exceptions are made for applicants with research experience comparable to that obtained at the MS level. Students are assigned an initial advisor upon entry and are expected to recruit faculty members to become their PhD Advisory Committee chairs by the end of their first year. The formal requirements and schedule of important events are as follows:

- Fifty four credit hours beyond the MS or seventy two beyond the BS are required.
- A doctoral dissertation is required.
- Students recruit a permanent advisor (committee chair), set up a PhD Advisory committee of at least four members, and submit a Plan of Work (course list, dissertation title, and committee names) by the end of the first year.
- Students complete most course work, and take a Preliminary Written Exam composed by their committee by the end of their fourth or fifth semester.
- Students prepare a written PhD research proposal and submit it to their committee by their fifth or sixth semester.
- Students take their Preliminary Oral Exam by the end of their fifth or sixth semester. They are examined on their proposal and on more general knowledge.
- Students complete their research, write up their dissertations, which may be collections of related published or submitted papers, and defend their dissertations at the PhD Final Oral Exam.

The only department requirement on course work is that students take PhD Graduate Seminar (MEA801) for one credit hour one time on their program; they present a seminar on their preliminary research in their third or fourth semester. The choice of other courses is left to the advisory committee though the quantity and level of course work should exceed that of MS degree holders. In Marine Science all students are required to complete the three graduate level core courses outside their own area (core courses are in Biological, Chemical, Geological, and Physical Oceanography). In Atmospheric Science all students are required to take or to have taken Environmental Fluid Dynamics and Dynamic Meteorology. All students are required to meet with their advisory committees at least once a year. Course numbers and titles are given in Appendix II.

4.2 Master's Degree

The department offers an MS degree that requires a thesis and a non-thesis MS degree. The latter is reserved for students on leave from state or federal agencies for a fixed period, has rarely been used and so our discussion will relate only to the thesis track degree. Students are assigned an initial advisor upon entry and are expected to recruit faculty members to become their MS Advisory Committee chairs by the end of their first year. The formal requirements and schedule of important events are as follows:

- Thirty credit hours beyond the BS are required. At least twenty hours must be at the graduate level and while credit hours from other departments at the senior (400) level do count, MEA courses at the 400 level do not.
- A master's thesis is required.
- Students recruit a permanent advisor (committee chair), set up a MS Advisory committee of at least three members, and submit a Plan of Work (course list, thesis title, and committee names) by the end of the first year.
- Students prepare a written MS research proposal and submit it to their committee by their third semester.
- Students complete their research, write up their theses, which may be collections of related published or submitted papers, and defend their theses at their MS Final Oral Exams.

The only department wide requirement on course work is that students take MS Graduate Seminar (MEA601) for one credit hour one time in their program; they present a seminar on their preliminary research in their third or fourth semester. Students are required to take a minimum of eighteen hours of lecture courses and six hours

of research (MEA 695). In Marine Science all students are required to complete two graduate level core courses outside their own area (core courses are in Biological, Chemical, Geological, and Physical Oceanography). In Atmospheric Science all students are required to take Environmental Fluid Dynamics (MEA 700) and Dynamic Meteorology (MEA 705). All students are required to meet with their advisory committees at least once a year.

4.3 Instructional Relationship to Other Programs

While the department has no formal teaching relationships with other departments at the graduate level, our students do take some course work, perhaps one quarter of formal course work, in other areas, principally Statistics, Computer Science, Soil Science, Zoology, Civil Engineering, Mathematics, and Geographic Information Systems. Also eight of our sixty graduate courses are cross-listed with other departments, viz., Civil Engineering, Mechanical and Aerospace Engineering, and Zoology.

4.4 Teaching and Research Participation

All our graduate students are involved in research. We have no formal training in research. The students work with their committee chairs and other committee members and, in essence, learn by doing.

Most of our domestic graduate students are involved in teaching sometime in the course of their stay here. Most of our first year students are brought in as TAs or with split TA-RA appointments the. The expectation, most realized in Atmospheric Science and Marine Science, is that they will switch to RAs in their second and subsequent years. We note that the Graduate School requires that international TAs from non-English speaking countries pass a test of spoken English before they are allowed to TA. Since our international students have not been able to pass this test with a sufficiently high score to TA independently, and we have no funding for graders, we do not offer TAs to international students. Our international students are brought in on RAs. Most TAs teach one section (TA-RA appointment) or 2 sections (TA appointment) of the labs associated with but independent of our Freshman-Sophomore survey classes.

There is some mentoring by the faculty who oversee the labs as well as an orientation to TAing workshop given by the Graduate School.

V. Assessment of outcomes/Faculty expectations

See Table 1 at the end of this chapter.

VI. Current research

Information on our research programs are presented as a separate chapter of this Self-Study and Comprehensive Review. See Chapter 8.

VII. Service/Outreach/Extension:

Professional expertise of our graduate program is made available to the local community, state, and nation through MEAS outreach programs and faculty services in scientific and professional organizations. Outreach is

a form of scholarship that is not the charge of any single program in MEAS, but involves the entire department; consequently, in this section we review all MEAS outreach efforts with the understanding that these efforts involve, but are not confined to, the graduate program.

Outreach goals for the Department of Marine, Earth and Atmospheric Sciences include the following:

- Increasing the enthusiasm of students to study science promoting Marine, Earth and Atmospheric Sciences programs to the public.
- Hosting visitors to the Jordan Hall and Research III facilities.
- Information and technology transfer to state, federal and other agencies.
- Promoting college and University Outreach initiatives.

Opportunities for Elementary, Middle and High School Students

School Visits:
MEAS faculty members and graduate students commonly make visits to elementary, middle and high schools. We actively promote NC State University and the department at high school career days, serve as judges during science fairs, host field trips for the N.C. Science Teachers Association and incorporate high school students in field and laboratory research activities.

Demonstration Tours:
During the university's fall and spring breaks, elementary through high school students visit the department. Students are assigned to groups of 20 to 30 members and are rotated through a series of hands-on activities and demonstrations presented by faculty members and graduate students. Topics include marine biology, geology, meteorology and remote sensing.

North Carolina Ocean Sciences Bowl:
The North Carolina Ocean Sciences Bowl is a quiz bowl open to NC high school students. Each year teams of five students coached by science teachers travel to NC State, UNC-Chapel Hill or UNC-Wilmington to answer questions about the oceans. The competition is a round-robin, double elimination event. Winning students receive scholarships to attend NC State if they enroll in a major within the College of Physical and Mathematical Sciences.

School Projects:
Schools are for Fish is for kindergarten through 5th-grade students. It is a series of fun activities that encourage children to mimic schooling fish, flocking birds, automobile traffic and other natural phenomena that are familiar but surprisingly full of good scientific questions. The activities can be used indoors or outdoors, can involve a lot of running and physical exercise, are well-suited to large groups and require a minimum of equipment.

Disseminating Expertise to the Public

Advising the Public:
MEAS personnel respond to telephone and in-person inquiries concerning issues limited only by the imagination. For example, by contacting MEAS Outreach personnel, the general public can ask about saltwater

aquarium set-up, the identity of marine organisms or minerals found during vacations, natural phenomena such as severe thunderstorms and tornados, and computing capabilities of the FOAMv facility.

Advising State of North Carolina Agencies:
Marine, Earth and Atmospheric Sciences has advised state agencies on many topics, including air quality in the southern Appalachian Mountains, evaluation of waste disposal sites, evaluation of groundwater contamination sites, management plans for fisheries species, sampling design and protocol for fishery-dependent and -independent surveys, and statistical data analysis and modeling. Faculty members have conducted training workshops for groundwater contamination regulators with the Department of Environmental Health & Natural Resources. MEAS faculty members or graduate students have given assistance to the N.C. Department of Environmental Health & Natural Resources, N.C. Department of Marine Fisheries, N.C. Fisheries Moratorium Steering Committee, N.C. Department of Agriculture, N.C. Geological Survey, N.C. Supercomputer Center, N.C. Ocean Task Force, N.C. Sand Resources Task Force, N.C. Division of Coastal Management, N.C. Division of Transportation and N.C. General Assembly.

Advising Federal Agencies:
MEAS has covered such issues as forecasts of flooding in coastal North Carolina, data collection and analysis of severe thunderstorms and tornados, weather prediction demonstrations, carbon-flux on the N.C. slope, carbon-cycling in coastal sediments, management plans for fisheries species in the South Atlantic Bight and Caribbean, and strategic long-term research initiatives for the National Undersea Research Program. Federal agencies given assistance include the National Science Foundation, Department of Energy, National Academy of Sciences, National Weather Service, National Marine Fisheries Service, National Park Service, South Atlantic Marine Fisheries Management Council, National Oceanic and Atmospheric Administration, U.S. Geological Survey and U.S. Army Corps of Engineers.

MEAS also provides advice to a wide range of agencies in other states and countries, as well as to various local and national environmental consulting firms. MEAS faculty members or graduate students have served as consultants to international agencies such as the Sian Ka'an Biosphere Reserve in Mexico, Ministry of Agriculture & Fisheries in the Sultanate of Oman, Fundacion LaSalle de Ciencias Naturales in Venezuela and Ocean Research Institute at the University of Tokyo, Japan. Advice offered covers issues such as fisheries, water, and land-use management plans.

In the Media:
Newspaper interviews with MEAS faculty members, offering expert opinions, have appeared in the Raleigh News & Observer, the Washington Post and the Baltimore Sun; and in such national science magazines as Discover. Faculty members also have given interviews and appeared as guests on local and national television programs, including the Weather Channel and Nova.

N.C. Museum of Natural Sciences:
Faculty members provide advice on setting up displays, assist in gathering specimens, field research, and conduct seminars geared to museum patrons.

VIII. Accreditation

There is no formal accreditation for our graduate program.

IX. Summary comments and vision for the future

To summarize this chapter and to give some indication of what we might expect in the future, we have to consider two factors mentioned earlier but not given much discussion.

The solid record of department accomplishment in the area of graduate education over the last ten years is a primarily the result of the efforts of the tenure track faculty listed in section II and the fifteen other tenure track faculty who are no longer with the department either through retirement or the voluntary choice of other employment; only one faculty member was denied tenure. A total of 47 tenure track faculty contributed to this record of which only 21 are currently with the department and have been with the department over five years; only one MS student has completed a degree under the faculty that have been here less than five years.. With the addition of four new faculty in Fall 1996, the number of tenure track faculty stands at 32, 11 of whom were not here five years ago. In 2001 we had 31 tenure track faculty. We have been told not to expect an increase in faculty but should be able to retain our slots which open due to retirement or other factors. We might expect that within five years perhaps five or more slots may open so that more than half of the faculty who will be here in five years were not here five years ago. Thus the record of accomplishment that will be compiled over the next ten years will be primarily in the hands of those who have not thus far contributed to our record.

Over the past five years, research funding, graduate enrollment and research related student support (number of RAs) have all increased. About two thirds of all student support is in the form of RAs. In the absence of RAs, only 29 students could be supported at the standard half-time rate of 20 hours service per week. Thus, since relatively few students in our areas enter or remain in graduate school without assistantship support, the number of RAs we will be able to provide is the prime determinant of future enrollment. Our faculty have been very successful in the past in securing research funding, and since the potential to secure funding plays a role in new faculty selection, we have every expectation that our newer faculty will be able to continue to compete successfully for external funding. However the availability of federal funding of scientific research in our areas over the next ten years remains hazy at best. If the federal government accepts global warming and other environmental issues as reality and if federal funds are switched from research in these questions to intervention and enforcement, federal support for research may drop.

We are considering extending our non-thesis MS to all applicants which may attract more part time students working in the local area, but the impact on FTEs should not be significant.

Given the issues of faculty turnover, fixed faculty size, and the uncertainty of federal funding, prognostication is difficult without some assumptions. We will assume that federal funding will remain at current levels, that it will take new faculty two or three years to spin up their research programs, and that over the next 10 years we will lose some faculty who have supported more than the average number of students in the past. With enrollment at 123 in Fall 2005, there may be some drop off from 123 initially but ultimately we can expect at most an increase a modest rise to 130 by Fall 2015.

Tables and appendices

TABLE 1 ASSESSMENT/FACULTY EXPECTATIONS

Objectives and Outcomes:

These are the program objectives:

- To prepare students for successful careers in academia, government, and industry.
- To prepare students to be effective researchers in marine, earth, or atmospheric science
- To continue and improve a successful graduate program with national and international visibility that provides expertise to local, state, federal and international institutions.

Objective 1: To prepare students for successful careers in academia, government, and industry.
1. a. Students should communicate research to local, regional, national and international audiences through presentations in venues ranging from graduate seminars through professional meetings and through publications in professional journals.
2. b. Students should participate in professional organizations by becoming members and attending meetings
3. c. Students should broaden their professional background through activities such as teaching, and successful employment, grant, fellowship or internship applications.

Objective: 2. To prepare students to be effective researchers in marine, earth, or atmospheric science
1. a. Students should become independent researchers with the ability to recognize significant problem areas and formulate and test meaningful hypotheses.
2. b. Students should develop a comprehensive knowledge of past and current publications in their field and demonstrate an ability to critique that literature.
3. c. Students should communicate the solutions to research problems in a manner that demonstrates an understanding of the broader impacts of their research to their field.

Objective: 3. To continue and improve a successful graduate program with national and international visibility that provides expertise to local, state, federal and international institutions.
1. a. The program should influence policy through the participation of faculty on state and federal and international committees and entities.
2. b. The program should attract, recruit, retain, and position high quality students for employment in academia, government, and industry.
3. c. The program should graduate full time students in a timely manner.

MEAS Data sources for assessment

Item A: Additional page in faculty annual activity report

(1) List the names of your graduate advisees who have:
Authored or co-authored at least one journal article, either submitted or published, in this reporting period.
Presented or co-authored at least one paper at regional, national, or international meetings in this reporting period.

TA'ed in this reporting period.
Been involved in grant applications in this reporting period.
Successfully applied for employment, fellowships, or internships in this reporting period.
Joined professional organizations (AMS, AGU, GSA, etc.) in this reporting period or earlier.
Refereed a publication for a national or international journal.
Communicated or assisted in communication of results to the broader community.
Passed Ph.D Preliminary Oral Exams; indicate semesters since start of Ph.D program till (including) the exam semester.
Participated in university sponsored activities to enhance teaching and/or research skills like Instructional Teaching Assistant Program or Preparing for Professoriate.

(2) List the number of (a) local-state and (b) national-international committees on which you served in this reporting period.

(3) List the number of invited talks given and workshops attended in this reporting period.

(4) List the number of recruiting activities for attracting high quality graduate applicants (including the number of e-mails sent to different potential applicants) in this reporting period.

Item B: Preliminary Ph.D Oral Exam Form

- Grade the examinee on a scale from F to A+ on the following questions.
- The student has shown an in depth knowledge of the literature in his/her research field and is able to place their research in the context of that literature.
- The student has formulated meaningful hypotheses or questions on her/his research topic.
- The student has shown the ability to clearly present the research questions orally.

Item C: Final MS or Ph.D. Oral Exam Form

- Grade the examinee on a scale from F to A+ on the following questions.
- The student has successfully tested the hypotheses of the research.
- The student has shown the ability to clearly present the results of her/his research orally.
- The student has shown the ability to present clearly the results of his/her research in writing.

Item D: Application Spreadsheet

Item E: Student files with Program Start and Graduation dates

APPENDIX Ia LIST OF MS RECIPIENTS 1996-2005

APPENDIX Ib LIST OF PHD RECIPIENTS 1996-2005

APPENDIX II MEAS GRADUATE COURSES

GRADUATE COURSES IN COMMON TO ALL MEA STUDENTS

MEA 601 Seminar. MEA 693 Master's Supervised Research. MEA 695 Master's Thesis Research. MEA 696 Summer Thesis Research. MEA 699 Master's Thesis Preparation. MEA 801 Seminar. 893 Doctoral Supervised Research.MEA 895 Doctoral Dissertation Research. MEA 896 Summer Dissertation Research. MEA 899 Doctoral Dissertation Preparation.

GRADUATE COURSES

Marine Science

MEA 540 Principles of Physical Oceanography. MEA(ZO) 549 Principles of Biological Oceanography. MEA 554 Marine Physical-Biological Interactions. MEA 562 Marine Sediment Transport. MEA 570 Geological Oceanography. MEA 573 Principles of Chemical Oceanography. MEA 591 Special Topics in Marine Science. MEA 611 Special Topics in Marine Science. MEA 615 Graduate At-Sea Laboratory. MEA 700 Environmental Fluid Mechanics. MEA 713 Mesoscale Wave Dynamics. MEA 721 Air-Sea Interaction. MEA(MAE) 725 Geophysical Fluid Mechanics. MEA(MAE) 726 Advanced Geophysical Fluid Mechanics. MEA 735 Fourier Analysis of Geophysical Data. MEA 741 Synoptic Physical Oceanography. MEA(CE) 742 Gravity Wave Theory I. MEA 743 Ocean Circulation. MEA 744 Dynamics of Shelf Circulation. MEA 745 the Physical Dynamics of Estuaries. MEA (ZO) 750 Marine Benthic Ecology. MEA 752 Marine Plankton Ecology. MEA(ZO) 754 Advances in Marine Community Ecology. MEA(ZO) 756 Ecology of Fishes .MEA 758 Laboratory and Field Methods for Investigation of the Seabed. MEA 759 Organic Geochemistry. MEA 760 Biogeochemistry. MEA 762 Marine Geochemistry. MEA 767 Continental Margin Sedimentation. MEA(MAE) 768, 769 Perturbation Method in Fluid Mechanics I, II. MEA 791 Advanced Special Topics in Marine Science. MEA 811 Special Topics in Marine Science.

Earth Science

MEA 570 Geological Oceanography. MEA 574 Advanced Igneous Petrology. MEA 575 Advanced Metamorphic Petrology. MEA 576 Applied Sedimentary Analysis. MEA 577 Electron Microprobe Analysis of Geologic Material. MEA 578 Depositional Environments and Lithostratigraphy. MEA 585 Physical Hydrogeology. MEA 592 Special Topics in Earth Science. MEA 599 Regional Geology of North America. MEA 612 Special Topics in Earth Science. MEA 758 Laboratory and Field Methods for Investigation of the Seabed. MEA 759 Organic Geochemistry. MEA 760 Biogeochemistry. MEA 763 Geochemistry. MEA 764 Sedimentary Geochemistry. MEA 785 Chemical Hydrogeology. MEA 788 Advanced Structural Geology. MEA 789 Topics in Appalachian Geology. MEA 790 Geotectonics. MEA 792 Advanced Special Topics in Earth Science. MEA 794 Regional Tectonics. MEA 795 Photogeology and Remote Sensing. MEA 796 Exploration and Engineering Geophysics. MEA 812 Special Topics in Earth Science.

Atmospheric Science

MEA 510 Air Pollution Meteorology. MEA 512 Satellite Meteorology. MEA 513 Radar Meteorology. MEA 514 Advanced Physical Meteorology. MEA(CE) 579 Principles of Air Quality Engineering. MEA 593 Special Topics in Atmospheric Science. MEA 613 Special Topics in Atmospheric Science. MEA 700 Environmental Fluid Mechanics. MEA 702 Advanced Cloud and Precipitation Physics. MEA 703 Atmospheric Aerosols.

MEA 705 Dynamic Meteorology. MEA 706 Meteorology of the Biosphere. MEA 707 Planetary Boundary Layer. MEA 708 Atmospheric Turbulence. MEA 710 Atmospheric Dispersion. MEA 712 Mesoscale Modeling. MEA 713 Mesoscale Dynamics. MEA 714 Atmospheric Convection.MEA 715 Dynamics of Mesoscale Precipitation System.MEA 716 Numerical Weather Prediction. MEA 717 Advanced Weather Analysis. MEA 719 Climate Modeling. MEA 720 Coastal Meteorology. MEA 721 Air-Sea Interaction. MEA(MAE) 725 Geophysical Fluid Mechanics. MEA(MAE) 726 Advanced Geophysical Fluid Mechanics. MEA(CE) 779 Advanced Air Quality. MEA 793 Advanced Special Topics in Atmospheric Science. MEA 813 Special Topics in Atmospheric Science.