REPORT TO CONGRESS

Shortage in the Number of Individuals with Post-Baccalaureate Degrees in Subjects Related to Fishery Science

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

U.S. Department of Education
November 2007

EXECUTIVE SUMMARY

In the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006, the United States Congress directed a study be conducted on the shortage in the number of individuals with post-baccalaureate degrees who have the ability to conduct high-quality scientific research in fisheries stock assessment and related fields (P.L. 109-479, sec. 217). To accomplish this, two independent studies were conducted—one to estimate the demand for stock assessment scientists and one to estimate the supply. This report presents the results of both studies.

Results from the demand study indicate that the market for stock assessment scientists is increasing. This is primarily due to the increased mandates requiring the skills of stock assessment scientists established under the reauthorized Magnuson-Stevens Fishery Conservation and Management Act. The minimum number of new stock assessment scientists (individuals who have the ability to conduct high-quality scientific research in stock assessment, fishery population dynamics, and related fields) needed is estimated to be a minimum of 18–34 per year, over the next 10 years or 180 – 340 nationwide, cumulative. The actual number is likely to be higher for a number of reasons discussed in the report.

Results from the supply study indicate that the supply of stock assessment scientists currently being produced by all quantitative fishery service programs nationally is severely limited due to insufficient numbers of faculty and graduate students in the discipline, among other reasons. Insufficient and inconsistent funding for academic scientists and dissertation research is the proximal cause of the shortage. It is estimated that approximately 16 new qualified stock assessment scientists are being produced, on average, in the entire nation each year by all U.S. institutions of higher education.

Comparing results of the two studies indicates an overall shortage of at least 2–18 qualified stock assessment scientists per year or 20 – 180 cumulative, over the next decade, with the requirement tending toward the higher number. Potential retirements of highly experienced current staff will be substantial in the upcoming decade, which will result in declining expertise even if individuals are replaced. Thus there is an urgent need to hire new stock assessment scientists as soon as possible.

NOAA's National Marine Fisheries Service (NMFS), aware of the shortage of stock assessment scientists, has established a number of programs aimed at increasing the supply of individuals entering careers in the discipline. These programs are designed to address many of the causes of the shortage identified in the supply study and these programs are training individuals that are successfully transitive into NMFS positions. At the scale currently implemented, however, the programs in place are insufficient to mitigate the looming shortage. Without these programs, the shortage would be even greater.

Increasing the number of graduate students studying stock assessment must be a major component of any strategy to increase the supply of stock assessment scientists. To accomplish this, funding must be increased. The President's 2009 budget includes an additional $1 million to accomplish this.

As the leading employer of stock assessment scientists, the burden of reducing the shortage of stock assessment scientists largely lies with NMFS. The agency is now experiencing a "perfect storm" involving a large number of stock assessment scientist retirements, an increasing workload mandated by the reauthorized Magnuson-Stevens Act, and a decreasing supply of incoming stock assessment scientists. Producing additional stock assessment scientists requires time, time to find promising students and time to train them adequately. The new mandates under the reauthorized Magnuson-Stevens Act do not allow for delays, which means that efforts to increase the supply must begin immediately.

Institutions of higher education and the private sector can take a number of actions to share the responsibilities required to eliminate the shortage.

TABLE OF CONTENTS

EXECUTIVE SUMMARY ii
TABLE OF CONTENTS iv
1 INTRODUCTION 1-1
1.1 Organization of Report 1-3
1.2 Literature Cited 1-4
2 DEMAND REPORT 2-1
2.1 Introduction 2-2
2.2 Methods 2-2
2.3 Results 2-3
2.3.1 National Marine Fisheries Service Science Centers 2-3
2.3.2 Fisheries Management Councils 2-3
2.3.3 Interstate Marine Fisheries Commissions 2-4
2.3.4 State Marine Fisheries Management Agencies 2-4
2.3.5 Total Demand 2-5
2.3.6 Personnel Moves 2-5
2.4 Discussion 2-6
2.5 Tables 2-8
2.5.1 Demand at National Marine Fisheries Service Science Centers 2-8
2.5.2 Demand at Regional Fishery Management Councils 2-9
2.5.3 Demand at Interstate Marine Fisheries Commissions 2-10
2.5.4 Demand at State Marine Fisheries Management Agencies 2-11
2.5.5 Total Reported and Extrapolated Demand Over the Next 10 Years 2-12
3 SUPPLY REPORT 3-1
3.1 Introduction 3-2
3.2 Methodology 3-2
3.2.1 Identifying Programs at U.S. Institutions of Higher Learning 3-2
3.2.2 Survey Instrument Development 3-3
3.2.3 Survey Implementation 3-4
3.3 Results 3-5
3.3.1 General Fisheries Program Information 3-5
3.3.2 Priority for Education in Population Dynamics/Stock Assessment 3-6
3.3.3 Current Fisheries Student Enrollment and Graduation Numbers 3-6
3.3.4 Quality of First-Semester Master of Science Students 3-7
3.3.5 Courses and “Essential Courses” Taken by Graduate Students 3-8
3.4 Discussion 3-8
3.5 Literature Cited 3-12
3.6 Figures 3-13
3.6.1 Figure 1. Post-baccalaureate degrees conferred 3-13
3.7 Tables 3-14
3.7.1 Table 1 3-15
3.7.2 Table 2 3-16
3.7.3 Table 3 3-17
3.7.4 Table 4 3-18

3.7.5 Table 5 3-19
3.7.6 Table 6 3-21
4 COMPARISON OF DEMAND TO SUPPLY 4-1
5 CURRENT NMFS PROGRAMS TO INCREASE SUPPLY 5-1
5.1 Increasing Faculty Numbers 5-1
5.1.1 Providing Support to University Faculty 5-1
5.1.2 Interacting with Neighboring Universities 5-1
5.1.3 Stationing NMFS Stock assessment scientists on University Campuses 5-2
5.2 Increasing Graduate Student and Postdoctoral Associate Numbers 5-3
5.2.1 Supporting University Research 5-4
5.2.2 Providing Doctoral Fellowships 5-4
5.2.3 Awarding Postdoctoral Fellowships 5-5
5.3 Improving the Quality of Incoming Graduate Students 5-5
5.3.1 Providing Undergraduate Scholarships and Internships 5-6
5.3.2 Strengthening Quantitative Programs at Individual Universities 5-6
5.3.3 Identifying and Mentoring Top Undergraduates Nationally 5-7
5.4 Discussion 5-8
6 RECOMMENDATIONS TO INCREASE THE SUPPLY 6-1
6.1 NMFS 6-1
6.2 Institutions of Higher Education 6-1
6.3 The Private Sector 6-2
6.4 Literature Cited 6-3
7 Executive Summary: NRC 2000 Report 7-1
8 Supply Report Appendices 8-1
8.1 Appendix A 8-1
8.2 Appendix B 8-5
8.3 Appendix C 8-11
8.4 Appendix D 8-12
8.5 Appendix E 8-13
8.6 Appendix F 8-15
8.7 Appendix G 8-18

1 INTRODUCTION

In the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006, the United States Congress directed a study be conducted on the "Shortage in the Number of Individuals with Post-Baccalaureate Degrees in Subjects Related to Fishery Science" (P.L. 109-479, sec. 217). Specifically, section 217 of the Act stated:

> "(a) IN GENERAL.—The Secretary of Commerce and the Secretary of Education shall collaborate to conduct a study of—
>
> (1) whether there is a shortage in the number of individuals with post-baccalaureate degrees in subjects related to fishery science, including fishery oceanography, fishery ecology, and fishery anthropology, who have the ability to conduct high quality scientific research in fishery stock assessment, fishery population dynamics, and related fields, for government, nonprofit, and private sector entities;
>
> (2) what Federal programs are available to help facilitate the education of students hoping to pursue these degrees; and
>
> (3) what institutions of higher education, the private sector, and the Congress could do to try to increase the number of individuals with such post-baccalaureate degrees.
>
> (b) REPORT.—Not later than 8 months after the date of enactment of this Act, the Secretaries of Commerce and Education shall transmit a report to each committee of Congress with jurisdiction over the programs referred to in subsection (a), detailing the findings and recommendations of the study under this section."

The discipline of stock assessment[1] is critical to the management of fish stocks and fisheries. Stock assessment scientists[1] develop the tools used to evaluate the status of fish stocks and fisheries and advise managers on the likely effects of alternative management policies (e.g., quotas, closed areas, fishing gear changes). They are critical advisors in the design of monitoring and research programs, which provide the input necessary for science-based management. The work of stock assessment scientists is essential to avoid overfishing of fisheries and fish stocks and to help develop rebuilding strategies. Neither

[1] For the purposes of this report, with the exception of Chapter 3, the term "stock assessment" will be used to represent "stock assessment, fishery population dynamics, and related fields." The term "stock assessment scientist" will be used to represent "individuals who have the ability to conduct high quality scientific research in stock assessment, fishery population dynamics, and related fields."

adaptive management nor ecosystem-based management would be possible without the critical involvement of fishery stock assessment scientists.

Individuals who have the quantitative skills required to conduct high-quality scientific research in stock assessment work on more than just fish and fisheries. Stock assessment skills are essential for the management of both marine and terrestrial species. Implementation of legislation such as the Marine Mammal Protection Act and the Endangered Species Act requires the continual involvement of individuals with such skills. Stock assessment is a critical component of estimating population viability, and population dynamics models are often used to assess recovery strategies.

Stock assessment scientists are employed by many organizations. International, federal, state, and tribal fisheries management agencies require their services. The largest U.S. and international employer of stock assessment scientists is NOAA's National Marine Fisheries Service (NMFS). Other agencies, including the U.S. Fish and Wildlife Service and the U.S. Geological Survey, hire individuals with these skills as well. Resource stakeholders, such as commercial and recreational fishing groups, and non-governmental organizations (NGOs) also employ stock assessment scientists to represent and counsel them. Finally, environmental consulting firms may also hire stock assessment scientists to play a critical part in the development of many environmental impact statements.

Over time, the management of fisheries has required the increased involvement of stock assessment scientists for science-based advisory services. Legislation has given scientists, and stock assessment scientists in particular, a larger role in the management process. Increased data availability and computing power have allowed more complex questions to be answered such as the ecosystem-wide impacts of fishing regulations. Over time, additional fish stocks have become the subject of management, increasing the workload of stock assessment scientists. Currently the U.S. manages 530 fish stocks nation-wide, as well as 155 marine mammals and 11 sea turtle stocks. All require specific analysis to track populations in response to management. The increasing need for the application of stock assessment is not unique to fish stocks or marine resources; this need is increasing throughout natural resource management as a whole.

The demand for many professions increases over time, and this is of no concern when the supply equilibrates with the demand. In the case of stock assessment, this may not be the case. For years there have been anecdotes of organizations, including NMFS, having difficulty finding a sufficient quantity and quality of stock assessment scientists to hire. University professors have complained of having difficulty finding incoming graduate students to work on stock assessment research projects.

As a result of these concerns, NMFS created a strategy to help meet its anticipated staff needs in the area of stock assessment starting in the year 2000. In that year, NMFS asked the National Research Council (NRC) of the National Academy of Sciences to convene a workshop to review NMFS' plans for meeting its anticipated staff needs in stock assessment and social sciences. The report from the workshop is attached in Section 7 of this report. The NRC panel concluded, "For stock assessment scientists, NMFS is the

primary employer and demand is already large relative to the total supply. NMFS' anticipated expansion in this area exceeds the present capacity of university programs" (NRC 2000).

Seven years have passed since the NRC panel's workshop, and the demand for stock assessment scientists continues to increase because of changing federal legislation. With the reauthorization of the Magnuson-Stevens Act, Congress increased the responsibilities of science in the fishery management process and the importance and role of stock assessment scientists. Section 104(a)(15) of the reauthorized Act requires federal fishery management plans to establish:

> "a mechanism for specifying annual catch limits in the plan (including a multiyear plan), implementing regulations, or annual specifications, at a level such that overfishing does not occur in the fishery, including measures to ensure accountability."

Addressing this critical new requirement, along with new requirements in other parts of the Act, creates substantial new responsibilities for stock assessment scientists.

The purpose of this report is to determine whether the anticipated supply of stock assessment scientists is sufficient to meet the anticipated demand.

1.1 Organization of Report

The Congressional requirement seeks the following information:

(1) Whether there is a shortage in the number of individuals with post-baccalaureate degrees in subjects related to fishery science, including fishery oceanography, fishery ecology, and fishery anthropology, who have the ability to conduct high quality scientific research in fishery stock assessment, fishery population dynamics, and related fields, for government, nonprofit, and private sector entities.

> Chapter 2 of this report presents a study conducted by NMFS on the demand for stock assessment scientists. Chapter 3 presents a study conducted by the American Fisheries Society on the supply of stock assessment scientists. Chapter 4 identifies the potential gaps between supply and demand.

(2) What Federal programs are available to help facilitate the education of students hoping to pursue these degrees.

> Chapter 5 of this report presents a detailed list of the programs NMFS and NOAA currently have in place to augment the supply of stock assessment scientists.

(3) What institutions of higher education, the private sector, and the Congress could do to try to increase the number of individuals with such post-baccalaureate degrees.

Chapter 6 of this report presents recommendations regarding what more can be done to meet critical demand for these occupations.

1.2 Literature Cited

National Research Council (NRC) 2000. Recruiting fishery scientists: Workshop on stock assessment and social science careers. Commission on Geosciences, Environment, and Resources. Ocean Studies Board. The National Academies Press. 26 pages (Executive Summary attached as Chapter 7).

2 DEMAND REPORT

ESTIMATING THE ANTICIPATED DEMAND FOR INDIVIDUALS WITH POST-BACCALAUREATE DEGREES IN SUBJECTS RELATED TO FISHERY SCIENCE WHO HAVE THE ABILITY TO CONDUCT HIGH QUALITY SCIENTIFIC RESEARCH IN FISHERY STOCK ASSESSMENT, FISHERY POPULATION DYNAMICS, AND RELATED FIELDS

Jim Berkson, Ph.D.
Unit Leader and Associate Professor
National Marine Fisheries Service Recruiting Training Research (RTR) Unit at Virginia Tech
Blacksburg, Virginia 24060

November 2007

2.1 Introduction

In the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006, the U.S. Congress directed a study be conducted on the "Shortage in the Number of Individuals with Post-Baccalaureate Degrees in Subjects Related to Fishery Science" (P.L. 109-479, sec. 217). This section of the report looks at one component of the issue—the demand.

2.2 Methods

Biologists with expertise in fishery stock assessment are employed by management agencies (international, federal, state, interstate, and tribal), universities, environmental consulting firms, and non-governmental organizations. Given the limited timeframe and resources available, this study was restricted to a subset of the organizations that hire biologists with this background.

A questionnaire was sent out to the following:

a) The six NMFS Science Centers
b) The eight Regional Fishery Management Councils
c) The three Interstate Marine Fisheries Commissions
d) The 22 state natural resource agencies with marine fisheries responsibilities

The questionnaire asked the following five questions:

1. To what degree is the need for stock assessment personnel increasing, staying the same, or decreasing at your Center?

2. How many new stock assessment full-time equivalent (FTE) positions would you create if resources were available to support them in the next 3–5 years? 5–10 years?

3. How many stock assessment personnel are likely to retire at your Center in the next 3–5 years? 5–10 years?

4. How many of your stock assessment personnel are likely to move to other positions, thus requiring replacements to complete their stock assessment duties in the next 3–5 years? 5–10 years?

5. To what extent do stock assessment personnel at your Center leave to accept positions at other agencies or outside of government?

When ranges were given, they were entered as a minimum and a maximum value. When no answer was provided, a value of zero was entered by default.

To estimate the number of full-time positions (FTEs) required, results from Question 2 (new hires to fill newly created positions) were added to results from Question 3 (new hires to replace retirees). Not all of the organizations who were sent questionnaires responded. To account for this, two estimates were calculated—one involving just the organizations responding and one extrapolated to account for all of the organizations sent questionnaires, including those that did not respond.

Estimates were extrapolated within each organizational grouping individually (Councils, Commissions, and states). Non-respondents were assumed to require the average response within their group. For instance, if two of the three Interstate Commissions responded, the extrapolated results were calculated by assuming the third Commission required the average of the two responding Commissions. This is equivalent to multiplying the sum of the two Commissions who responded by 3/2 (1.5) to account for the one Interstate Commission that did not reply. No extrapolations were needed for the NMFS Science Centers, as all six responded to the questionnaire.

2.3 Results

2.3.1 National Marine Fisheries Service Science Centers

All six Science Centers responded to the questionnaire and all indicated that their need for stock assessment personnel was increasing. Most indicated the increased need was due to the added requirements of the reauthorized Magnuson-Stevens Act. The Pacific Island Fisheries Science Center also reported that, as the newest Center, they needed additional positions to fully establish a stock assessment program.

Under adequate budget scenarios, the Centers would create 52–54 new positions in the next 3–5 years and 43–48 additional new positions over the following 5–10 years for a total of 95 – 102 positions over the next decade(Section 2.5.1). The Centers expect 15–17 stock assessment scientists to retire in the next 3–5 years and 25–27 to retire in the next 5–10 years (Section 2.5.1). Together this calls for an additional 67–71 new stock assessment scientists in the next 3–5 years and 68–75 in the next 5–10 years (Section 2.5.1). For the Science Centers alone, the demand is expected be between 135 and 146 new stock assessment scientists over the next 10 years. Because all six Centers responded, no extrapolations were required.

2.3.2 Fisheries Management Councils

Five of the eight Fishery Management Councils (Mid-Atlantic, Caribbean, Pacific, North Pacific, and Western Pacific) responded to the questionnaire. With the exception of the North Pacific, the remaining four responded that their need for stock assessment scientists was increasing. They pointed out that the need for highly trained individuals to conduct stock assessments was increasing, but the majority of their stock assessment

work is conducted by stock assessment scientists employed by the NMFS Science Centers. Therefore, the majority of their demand is already covered in section 2.3.1 of this report.

Regarding their own hires, the responding Councils expect to hire a limited number of stock assessment scientists (2–4) to fill new positions and to replace retiring personnel (Section 2.5.2). Extrapolating for the three Councils that did not respond (New England, South Atlantic, and Gulf of Mexico) brings the expected hires over the next 10 years to between 4 and 7 (Section 2.5.2).

2.3.3 Interstate Marine Fisheries Commissions

Two of the three Interstate Marine Fisheries Commissions (Atlantic States and Gulf States) responded to the questionnaire. Both responded that they had an increasing need for stock assessment scientists. The Atlantic States Marine Fisheries Commission specifically noted having insufficient personnel to conduct the work required. The Interstate Commissions rely on the state marine fishery management agencies (Section 2.3.4) and the NMFS Science Centers (Section 2.3.1) to conduct the vast majority of stock assessments involving species in their jurisdiction.

Because they do limited stock assessment work using their own employees, the two Commissions expect to hire 1–3 stock assessment scientists to fill new positions over the next 10 years (Section 2.5.3). No retirements are expected during the next 10 years (Section 2.5.3).

Extrapolating to include the Pacific States Marine Fisheries Commission, which did not respond to the questionnaire, the total number of new stock assessment scientists needed is estimated to be between 2 and 5 over the next 10 years (Section 2.5.3).

2.3.4 State Marine Fisheries Management Agencies

Responses were received from eight of the 22 state marine fisheries management agencies (Connecticut, Delaware, Virginia, North Carolina, Louisiana, Texas, California, and Washington). Seven of the eight responding states (all except for Texas) responded that their need for stock assessment scientists was increasing. The reasons varied and included the need for new and updated assessments (Connecticut and California), the need for both interstate and within-state assessments (Virginia), losing staff to NMFS due to lack of competitive salaries (North Carolina), and the need for assessments relating to Endangered Species Act–listed species, assessments involved in litigation, and new Magnuson-Stevens Act requirements (Washington).

The eight responding states replied that under optimistic budget scenarios they would hire 18–22 new full-time stock assessment scientists over the next 3–5 years and 8–16 over the next 5–10 years (Section 2.5.4). Retirements would require the hiring of 7–10 new

stock assessment scientists over the next 3–5 years and 7–14 over the next 5–10 years (Section 2.5.4). This brings the total hires over the next 10 years to between 40 and 62 (Section 2.5.4).

Extrapolating for the 14 states that did not respond (see the list in Section 2.5.4) creates an estimate of between 120 and 186 new stock assessment scientists needed by state agencies within the next 10 years (Section 2.5.4).

2.3.5 Total Demand

Of the 21 responding organizations, 19 (90.1 percent) replied that their need for stock assessment personnel was increasing. None of the 21 answered that their need was decreasing.

Combining the results from the Science Centers, Councils, Commissions, and states who responded to the questionnaire provides an estimate of between 178 and 215 new stock assessment scientists anticipated to be hired over the next 10 years to (Section 2.5.5). Extrapolating to account for the organizations not responding to the questionnaire brings this estimate to between 261 and 344 (Section 2.5.5)

2.3.6 Personnel Moves

Questions 4 and 5 inquired about stock assessment scientists moving to other positions within and outside of their current agency.

Question 4 asked about the number of stock assessment scientists who are likely to move to other positions, requiring replacements to complete their stock assessment. This was interpreted by respondents to mean two kinds of moves:

> 1) individuals who left stock assessment positions to accept other positions within the organization, such as management positions, requiring the hiring of new individuals to fill the vacated stock assessment positions, and
>
> 2) those who left a stock assessment position at one agency location to move to a stock assessment position at another agency location. For example, if an individual left a stock assessment position at the NMFS Southeast Fisheries Science Center to take a position as a stock assessment scientist at the NMFS Northeast Fisheries Science Center.

The first case creates demand, generating the need to hire a new stock assessment scientist. In the second case, the individual fills one position within the agency while vacating another, amounting to no change in demand, except if they fill positions not engaged in fishery assessment output.

Responses to Question 4 indicated that stock assessment scientists who work for the Science Centers and states move to other positions frequently. Respondents indicated a range of 20–36 stock assessment scientists moving over the next 3–5 years and 27–36 over the next 5–10 years. Extrapolated values range from 30–63 over the next 3–5 years and 35–52 over the next 5–10 years. It is important to note that recycling internal candidates for personal growth opportunities does not help in meeting the overall shortage.

Question 5 sought a descriptive response as to whether stock assessment scientists leave to accept positions at other agencies or outside of government. The responses received were highly dependent on the individual organization responding. Some organizations reported this rarely happens, whereas others said it was a common occurrence. Several of the states (Delaware, North Carolina, and California) reported high turnover, with employees often moving to NMFS because of the higher salaries paid.

2.4 Discussion

Nineteen of 21 responding organizations (90.1 percent) identified that their need for stock assessment scientists was increasing, largely due to the increased mandates associated with the reauthorized Magnuson-Stevens Act. The need for additional assessments on previously non-assessed fish species, more frequent updates of assessed stocks, and assessment-related work on threatened and endangered species all are increasing the demand.

Collectively, respondents will require between 178 and 215 new stock assessment scientists to be hired over the next 10 years, which averages 18–22 per year. The total need, as indicated by the extrapolated value, is estimated to be between 261 and 344 over the next 10 years (averaging to 26–34 per year).

This is a substantial increase over the number that is currently employed. The NMFS Science Centers currently employ 90 stock assessment scientists. The minimum estimate of new hires needed by the Science Centers over the next ten years is 135, which is 150% of the current number employed.

Estimates calculated are undoubtedly low for the following reasons:

1. To focus this study, we chose to target marine fisheries management agencies. Many types of organizations employing stock assessment scientists were not included in the study. These included both state and federal agencies that work on inland fisheries (rivers, lakes, reservoirs, etc.) that may involve marine fish that swim there; federal agencies such as the U.S. Fish and Wildlife Service and the U.S. Geological Survey; tribal fisheries management agencies; non-governmental organizations; environmental consulting firms; and academic institutions.

2. Employers also hire individuals with these unique skills to work on non-fisheries issues and non-fish species. For example, individuals trained to conduct stock assessments work with marine mammal and sea turtle populations.

3. A number of stock assessment scientists eventually will leave their current jobs to accept non-stock-assessment positions, such as supervisory or management positions, requiring their replacement with new hires. Although this was incorporated into Question 4, due to the phrasing of the question it is not possible to separate out those who move to non-stock-assessment position from those who move to stock assessment positions in other parts of their current agency. Therefore, we know that some portion of the 47–72 (reported) and 65–115 (extrapolated) stock assessment scientists likely to move to other positions over the next 10 years will need to be replaced and are not included in the estimates calculated by summing the results of Questions 2 and 3.

4. As in any job sector, employers want the supply of potential employees to exceed the demand to allow for competition for the available jobs. The goal is not to hire the only qualified individual, but rather to hire the most qualified individual from a pool of qualified candidates.

There are many possible ways to calculate extrapolated values. We chose to use a simple ratio of the total organizations sent questionnaires to those that responded, by organization category. Other ways to calculate this could involve weighting the organizations by their overall budgets, the number of species they assess, or the current number of stock assessment scientists hired. As there was no one best way to do this, we chose the most straightforward way. Some of the non-responding organizations may not have responded because they did not anticipate needing additional stock assessment scientists in the future. If that is the case, the resulting extrapolations would be high.

Given the uncertainty associated with these extrapolated estimates, we have greater confidence in the number calculated by only summing those organizations that did respond. However, it should be considered a minimum estimate.

2.5 Tables

2.5.1 Demand at National Marine Fisheries Service Science Centers

	New FTE positions				**Retirements**				**Subtotals**				**Totals**	
	3-5 Years		5-10 Years		3-5 Years		5-10 Years		3-5 Years		5-10 Years		**Over 10 Year Period**	
Science Center	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	**Min**	**Max**
Northeast	5	5	10	10	2	3	6	6	7	8	16	16	23	24
Southeast	12	12	4	4	3	2	3	3	15	15	7	7	22	22
Southwest	10	11	12	17	4	5	8	9	14	16	20	26	34	42
Northwest	3	4	2	2	0	0	1	2	3	4	3	4	6	8
Alaska	11	11	12	12	4	4	5	5	15	15	17	17	32	32
Pacific Islands	11	11	3	3	2	2	2	2	13	13	5	5	18	18
Total	52	54	43	48	15	17	25	27	67	71	68	75	**135**	**146**

2.5.2 Demand at Regional Fishery Management Councils

	New FTE positions				Retirements				Subtotals				Totals	
	3-5 Years		5-10 Years		3-5 Years		5-10 Years		3-5 Years		5-10 Years		Over 10 Year Period	
Council	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Mid-Atlantic	0	0	1	1	0	0	0	0	0	0	1	1	1	1
Caribbean	0	1	0	1	0	0	0	0	0	1	0	1	0	2
Pacific	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Pacific	0	0	0	0	0	0	1	1	0	0	1	1	1	1
Western Pacific	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	1	1	2	0	0	1	1	0	1	2	3	**2**	**4**
Extrapolating for Missing Responses	0	2	2	3	0	0	2	2	0	2	4	5	**4**	**7**

* Extrapolating for Northeast, Gulf of Mexico, and South Atlantic

2.5.3 Demand at Interstate Marine Fisheries Commissions

	New FTE positions				Retirements				Subtotals				Totals	
	3-5 Years		5-10 Years		3-5 Years		5-10 Years		3-5 Years		5-10 Years		Over 10 Year Period	
Commission	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Atlantic States	0	1	0	1	0	0	0	0	0	1	0	1	0	2
Gulf States	1	1	0	0	0	0	0	0	1	1	0	0	1	1
Total	1	2	0	1	0	0	0	0	1	2	0	1	**1**	**3**
Extrapolating for Missing Responses	2	3	0	2	0	0	0	0	2	3	0	2	**2**	**5**

* Extrapolating for Pacific States

2.5.4 Demand at State Marine Fisheries Management Agencies

	New FTE positions				Retirements				Subtotals				Totals	
	3-5 Years		5-10 Years		3-5 Years		5-10 Years		3-5 Years		5-10 Years		Over 10 Year Period	
State	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Connecticut	0	1	0	1	1	1	1	6	1	2	1	7	2	9
Delaware	0	1	0	1	0	0	1	1	0	1	1	2	1	3
Virginia	1	2	3	3	0	0	0	1	2	2	3	4	5	6
North Carolina	0	1	0	1	0	0	0	0	0	1	0	1	0	2
Louisiana	5	5	2	3	1	2	2	3	6	7	4	6	10	13
Texas	0	1	0	1	0	0	0	0	0	1	0	1	0	2
California	6	6	3	6	2	4	0	0	8	10	3	6	11	16
Washington	5	5	0	0	3	3	3	3	8	8	3	3	11	11
Total	18	22	8	16	7	10	7	14	25	32	15	30	**40**	**62**
Extrapolating for Missing Responses	54	66	24	48	21	30	21	42	75	96	45	90	**120**	**186**

* Extrapolating for Maine, New Hampshire, Rhode Island, New York, New Jersey, Maryland, South Carolina, Georgia, Florida, Alabama, Mississippi, Oregon, Alaska, and Hawaii

2.5.5 Total Reported and Extrapolated Demand Over the Next 10 Years

	Reported		Extrapolated	
Organization	Min	Max	Min	Max
Science Centers	135	146	135	146
Councils	2	4	4	7
Commissions	1	3	2	5
States	40	62	120	186
Total	**178**	**215**	**261**	**344**

3 SUPPLY REPORT

SURVEY OF INSTITUTIONS OF HIGHER LEARNING TO INVESTIGATE POSSIBLE SHORTAGES IN THE NUMBER OF INDIVIDUALS WITH POST-BACCALAUREATE DEGREES IN SUBJECTS RELATED TO FISHERY SCIENCE

Kevin M. Hunt
Department of Wildlife & Fisheries
Mississippi State University
Mississippi State, Mississippi 39762

John C. Whitehead
Department of Economics
Appalachian State University
Boone, North Carolina 28608

Debra J. Murie
Department of Fisheries and Aquatic Sciences
University of Florida
Gainesville, Florida 32653

Thomas J. Kwak
U.S. Geological Survey
North Carolina Cooperative Fish and Wildlife Research Unit
North Carolina State University
Raleigh, North Carolina 27695

Submitted exclusively to the Executive Director of the American Fisheries Society, U.S. Secretary of Commerce and the U.S. Secretary of Education

October 2007

Note that this is an independent study. The content of the study has not been altered. The formatting has been changed to fit that of the overall report.

3.1 Introduction

The National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), requested the Executive Director of the American Fisheries Society (AFS) for assistance in providing an objective review of graduate-level fisheries programs at U.S. Institutions of Higher Learning to address, in part, Sections (a)1 and (a)3 of the Public Law. The AFS Executive Director requested that we, as representatives of the AFS Marine Fisheries, Socioeconomics, and Education sections, design and implement a survey that would seek to answer questions raised in the reauthorized Magnuson-Stevens Act.

3.2 Methodology

3.2.1 Identifying Programs at U.S. Institutions of Higher Learning

To identify institutions that would be contacted for information on their graduate programs, and to identify the number of Master of Science and Doctor of Philosophy students conferred degrees each year in fisheries science, we requested the U.S. Department of Education's National Center for Education Statistics (NCES) to provide us with the list of all universities who reported any post-baccalaureate fisheries science graduates since the 1986-87 academic year. From the NCES Classification of Instructional Programs (CIP) codes (which is the federal taxonomic scheme designed to support accurate tracking, assessment, and reporting of fields of study and program completions), the NCES promptly provided the graduate statistics of 11 institutions reporting post-baccalaureate degrees under the current "03.0301 Fishing and Fisheries Science and Management" CIP code and its predecessor codes used in the 1980s and 1990s. Unfortunately, many universities with well-known fisheries science programs were not included in the list because they chose to report their fisheries science graduates under a separate CIP code. Therefore, to obtain an exhaustive list of universities with programs, we obtained the contact information for member universities of the National Association of University Fisheries and Wildlife Programs (NAUFWP) that were listed as having graduate programs in fisheries science. Additionally, because many of the universities in NAUFWP were Land Grant institutions in interior states, we believed we were likely missing some marine fisheries programs located at Sea Grant institutions and elsewhere in coastal states. We then searched the worldwide web pages of all public institutions in each coastal state for marine fisheries or fisheries-related programs. In the search, we sought evidence of a fisheries science department, or related departments not including "fisheries" in the name, such as biology or marine sciences, but that offered fisheries-related courses. The results of these latter efforts yielded a database that contained an additional 80 universities for a total of 91 public universities with known or possible graduate-level fisheries science programs. We then sent a letter (Appendix A) via e-mail to the head of each of those departments informing them of the pending study. Additionally, we advised department heads, if we incorrectly listed them as having a graduate-level fisheries science program, to respond accordingly and we would remove them from the list. Sixteen department heads responded that they did not have a graduate

program in fisheries science. We assumed the remaining 75 institutions had a graduate-level fisheries science program, and they were targeted for this study.

3.2.2 Survey Instrument Development

To develop the survey instrument, we sought input from the AFS parent society, section members, university administrators, and state and federal agency administrators. The survey (Appendix B) asked heads to provide information on their graduate program in six areas: (1) general fisheries program information with an emphasis on population dynamics faculty; (2) level of priority of population dynamics/stock assessment in their program, and their ability to train students in same; (3) current fisheries science graduate student enrollment with an emphasis on population dynamics; (4) quality of incoming Master of Science students; (5) graduate course offerings and percentage of students taking those courses, including an "essential curriculum" required for stock assessment positions ; and (6) their suggestions for correcting any perceived shortfalls in the number of fisheries graduates with adequate training in population dynamics/stock assessment from an academic and congressional perspective.

We initially sought information on general fisheries program activities at institutions. First, we asked department heads to characterize whether their program was "comprehensive with both inland and marine components," "strictly inland fisheries," "strictly marine fisheries," "primarily inland with some marine fisheries," or "primarily marine with some inland fisheries." Second, we asked department heads to indicate the number of full-time equivalent (FTE) faculty, postdoctoral researchers, and research associates housed in their academic department, how many of the FTE faculty would be retiring in the next 5 years, and the number of those retirees that would be replaced. Similarly, we asked how many of the FTE faculty conducted population dynamics research, how many of them would retire in the next 5 years, and the number of retiring population dynamics faculty that would be replaced. Third, to determine whether there was an immediate need for population dynamics faculty, we asked department heads "If you could hire two additional fisheries-related faculty members today, what areas of expertise would you most likely seek?" Fourth, we asked department heads if they had tried to hire any population dynamics faculty within the past 5 years and whether they were able to fill the position. Finally, we asked department heads whether they believed their programs would grow in terms of faculty in the next 5 years.

Second, we asked department heads what level of priority (not a priority, low, medium, or high) graduate education in fisheries population dynamics/stock assessment was to them, and whether they believed they had all the resources necessary to train students in conducting population dynamics/stock assessment-related work.

Third, we sought information on current fisheries enrollment by asking department heads to indicate their current number of Master of Science and Doctor of Philosophy students, the percent of those that conduct population dynamics research for their theses/dissertations, and whether that percentage had "decreased," "stayed the same," or

"increased" over the past decade. Next, we asked department heads whether they believed enrollment would "decrease," "stay the same," or "increase" in the next 5 years. In an open-ended question, we asked those who indicated "increase" to tell us why they perceived growth. Next, we asked department heads to indicate how successful they were at recruiting graduate students (a) to their overall program, and (b) capable of conducting population dynamics research using a 5-point scale with response format 1 = "not at all successful," 2 = "slightly successful," 3 = "moderately successful," 4 = "very successful," and 5 = "extremely successful."

Fourth, we sought information on the quality of students entering post-baccalaureate studies. We asked department heads to rate the aptitude and ability of their recent first-semester fisheries graduate students in 12 skill areas related to graduate student success using a 5-point scale with response format 1 = "very weak," 2 = "weak," 3 = "adequate," 4 = "strong," and 5 = "very strong." The 12 skill areas included aptitude in statistics, mathematics, modeling, fishery biology, fishery ecology, fishery management, fishery science, and population dynamics, and the ability to think critically, synthesize information, and effectively communicate verbally and in writing. Next, to assess whether there had been any major shifts in aptitude and abilities, we asked department heads how recent first semester graduate students compared to entering students in the past decade in each of the 12 areas using a 3-point scale where 1 = "decreased," 2 = "stayed the same," and 3 = "increased."

Fifth, we wanted to investigate the types of coursework recent fisheries-related graduate students completed. To do this, we initially developed a list of 32 graduate-level courses potentially available to fisheries students at most institutions. From that list, we requested the Director of the NMFS Office of Science and Technology to poll the NMFS Science Centers to devise an "essential curriculum" that would prepare graduates for employment as stock assessment scientists for the Federal Government. The "essential curriculum" included nine courses: Population Dynamics, Fish Ecology, Multivariate Statistics, Sampling Theory, Fisheries or Natural Resources Modeling, Bayesian Statistics, Stock Assessment, Risk and Decision Analysis, and Fisheries or Natural Resources Computer Programming. We then asked department heads to indicate whether each of the 32 courses was available at their institution, and if so, the percentage of their graduate students that typically take each course as part of their program of study. If a course was offered but department heads did not report the percentage of students taking the respective course, missing values were replaced with the average percentage from respondents to calculate a nationwide enrollment estimate per course. Next, we determined how many institutions offered all or part of the "essential curriculum."

Finally, we requested department head suggestions for correcting any perceived shortfalls in the number of fisheries graduates with adequate training in population dynamics/stock assessments from an academic and congressional perspective.

3.2.3 Survey Implementation

Following procedures developed by Dillman (2000) for internet surveys, we sent department heads with fisheries-related programs (n = 75) a second letter via e-mail in July 2007 (Appendix A), that again included a statement on the purpose of the study and provided a link to the website containing the web-based form of the survey instrument. Two additional follow-up e-mails were sent 10 and 25 days after the first request to nonrespondents. Because we encouraged department heads to be candid and asked information about the quality of students and their programs that could create negative consequences from existing students, or affect graduate student recruitment, we informed them that their answers would remain confidential and their institution would not be identified. All correspondence, survey instruments, and procedures were approved by the Mississippi State University Institutional Review Board for the Protection of Human Subjects (Docket #07-085).

3.3 Results

3.3.1 General Fisheries Program Information

Slightly over 57 percent (n = 43; number of respondents) of the 75 department heads at selected U.S. Institutions of Higher Learning completed the on-line survey. A majority (55.8 percent) of those responding characterized their programs as "strictly inland fisheries" or "primarily inland with some marine fisheries." Only 23.2 percent indicated they were "strictly marine" or "primarily marine with some inland components," and 20.9 percent indicated they were "comprehensive with both inland and marine components." Department heads indicated that their programs had an average of 6.48 full-time equivalent (FTE) faculty positions, 1.5 FTE postdoctoral researchers, and 3.0 FTE research associates (not students). Combined, institutions with graduate-level fisheries science programs housed an average of slightly over 11 FTE fisheries positions in their department. Department heads indicated that an average of 2.6 FTE faculty, slightly over 40 percent of the FTE faculty, conducted population dynamics research.

When we asked department heads how many of their FTE faculty would be retiring in the next 5 years, they indicated that an average of 1.42 FTE faculty, or about 22 percent of their entire departmental fisheries faculty, would be retiring. Department heads expected that 91 percent of retirees would be replaced. Similarly, department heads indicated that they would lose an average of 0.6 FTE, or about 21 percent, of their population dynamics faculty. However, they expected only 77 percent of these positions would be replaced. Nevertheless, when we asked department heads whether they saw their fisheries program growing in terms of faculty in the next 5 years, 50 percent (n = 21) indicated their department would grow.

To determine immediate needs for faculty positions, we asked department heads to indicate the areas of expertise they would seek if they could hire two additional faculty members today. Department heads indicated that they would most likely seek faculty with expertise in fish ecology (n = 11), population dynamics (n = 10), human dimensions

of fisheries (n = 9), aquaculture (n = 9), fishery statistics (n = 6), and fish physiology (n = 6) (Table 1). Thirty-one percent (n = 13) of department heads indicated that they have tried to hire a population dynamics/stock assessment FTE faculty member during the past 5 years, and 84.6 percent (n = 11) of those indicated they were able to hire someone fitting the job advertisement. Of the remaining two universities, one dropped their search, and the position at the other remained vacant until filled 5 years later.

3.3.2 Priority for Education in Population Dynamics/Stock Assessment

When we asked department heads the level of priority for graduate education in fisheries population dynamics/stock assessment in their programs, 7.3 percent (n = 3) indicated it was "not a priority," 19.5 percent (n = 8) believed it was a "low priority," 41.5 percent (n = 17) indicated it was a "medium priority," and 31.7 percent (n = 13) believed it was a "high priority" in their programs. Additionally, 69 percent (n = 29) of department heads believed their program has the necessary resources to train students to conduct population dynamics/stock assessment-related work. Of the 30.9 percent (n = 13) department heads who felt their program did not have the necessary resources, most indicated through their open-ended comments (Appendix C) that this was a result of a lack of faculty in population dynamics or stock assessment.

3.3.3 Current Fisheries Student Enrollment and Graduation Numbers

Department heads from fisheries science programs (n = 42) reported they housed an average of 22.4 graduate students (13.9 Master of Science and 8.5 Doctor of Philosophy students) in 2006-07. A plurality (47.7 percent; n = 20) of department heads felt that enrollment would "stay the same" in the next 5 years, while 45.2 percent (n = 19) felt enrollment would increase, and only 7.1 percent (n = 3) believed enrollment would decrease. In open-ended comments, many of the department heads expressed that the anticipated growth in their faculty would create increases in the number of graduate students, although not necessarily in the area of fisheries population dynamics (Appendix D). Responding institutions (n = 7) using the 03.0301 "Fishing and Fisheries Science and Management" CIP code reported a current average of 36.4 graduate students in their programs. Extrapolating to all 11 institutions using that CIP code, we estimated that these institutions currently house about 400 graduate students. Responding institutions (n = 36) who use other CIP codes indicated they currently had an average of 19.4 graduate students, or 53.3 percent of those reporting in the 03.0301 CIP code. Extrapolating to the 64 institutions not using the 03.0301 CIP code, we estimated that these programs currently house about 1,242 graduate students. Collectively, we estimate that there are currently about 1,642 graduate students attending U.S. Institutions of Higher Learning as part of a fisheries science program. Overall, department heads indicated that 33.2 percent of their graduate students conducted population dynamics research as part of their program of study. Thus, we estimate that about 545 graduate students in the United States are currently emphasizing population dynamics, as defined by individual

department heads, as part of their thesis or dissertation research. Most (73.8 percent; n = 31) department heads felt that the percentage of graduate students conducting population dynamics research had "stayed the same" over recent years, while 9.5 percent (n = 4) felt it had "decreased" and 16.7 percent (n = 7) felt it had "increased" over recent years.

Since 1986, the 11 institutions using the 03.0301 CIP code awarded an annual average of 111.5 (range = 86 to 160) post-baccalaureate degrees in "Fishing or Fisheries Science and Management," or about 10.1 per institution annually (Figure 1). With institutions that do not use the 03.0301 CIP code only averaging 53.3 percent the number of graduate students as those reporting in the 03.0301 CIP code, we assumed they would produce only 53.3 percent of the graduates as well. Thus, we estimate that about 5.4 graduate students on average are awarded post-baccalaureate degrees annually at institutions using another CIP code. Extrapolating to the 64 institutions not using the 03.0301 CIP code, we estimated they annually produce a total of 346 graduates. Collectively, we estimated that about 458 post-baccalaureate degrees in fisheries science are awarded to individuals annually in the United States by institutions with fisheries science programs.

When we asked department heads their success in recruiting Master of Science and Doctor of Philosophy students into their programs, 66.7 percent felt they were "very" or "extremely successful" in recruiting Master of Science students, and 50.0 percent felt the same for Doctor of Philosophy students (Table 2). However, only 45 percent and 38.4 percent of department heads indicated that they were successful in recruiting Master of Science and Doctor of Philosophy students, respectively, who were capable of conducting population dynamics research.

3.3.4 Quality of First-Semester Master of Science Students

When we asked department heads to rate the aptitude and ability of their recent first-semester fisheries graduate students in 12 skill areas related to graduate student success, incoming students were rated strongest in their ability in verbal communication skills, aptitude in fish biology and ecology, and their ability to think critically (Table 3). Most (> 50 percent) felt students were "adequate," "strong," or "very strong" in all areas except "aptitude in modeling" (Table 3); 61 percent of department heads felt their students were "weak" or "very weak" in modeling. Additionally, 41.5 percent of department heads felt their incoming Master of Science students were "weak" or "very weak" in terms of "aptitude in population dynamics," and 28.8 percent felt the same for entering students' "aptitude in statistics." Department heads felt that less than 20 percent of incoming graduate students were "weak" or "very weak" in all other aptitudes and abilities. Nevertheless, despite indicating some weaknesses of incoming graduate students, most department heads (> 85 percent) felt the quality of incoming students had "stayed the same" or "increased" compared to incoming students in the past decade (Table 4). "Aptitude in population dynamics" was the only skill area that exhibited a larger percentage decrease than increase over the past decade.

3.3.5 Courses and "Essential Courses" Taken by Graduate Students

When we asked department heads to indicate courses offered at their institution and the percentage of graduate students taking those courses, results indicated that current students are taking a myriad of courses as part of their program of study (Table 5). Introduction to Statistics, Fisheries Management, Regression, Ichthyology, Population Dynamics, Limnology, Fish Ecology, Multivariate Statistics, Non-parametric Statistics, Fish Biology, and GIS and/or Remote Sensing were the top 11 courses, taken by 30 percent or more of all current fisheries graduate students at U.S. Institutions of Higher Learning. Nevertheless, only three of these courses—Population Dynamics, Fish Ecology, and Multivariate Statistics—were part of the "essential curriculum" identified by the NMFS Science Centers.

Of the nine graduate courses in the "essential curriculum", Fisheries or Natural Resources Computer Programming had the lowest enrollment, with only 3.5 percent of the fisheries graduate students taking the course. In order to take all nine of the essential courses, students would have to be enrolled in computer programming. Therefore, a maximum of 3.5 percent of the fisheries graduate students could be taking all nine of the courses. Assuming that there are about 458 students graduating with post-baccalaureate degrees, and estimating that 3.5 percent of the students take all nine courses, we estimate that 16 graduate students per year are currently being produced nationally who have taken the nine courses deemed essential by the NMFS Science Centers for a newly hired stock assessment scientist to be effective in his/her position. The small number of current graduate students taking courses in the "essential curriculum" is likely, in part, a result of many institutions not offering the courses (Table 6). Only three of the responding department heads indicated all nine courses were offered at their university, and 51 percent (n = 22) indicated they only offered between one and four of the courses at their institution.

3.4 Discussion

Based on the small percentage of fisheries programs at U.S. Institutions of Higher Learning offering all nine courses in the "essential curriculum," and the corresponding low number (estimated to be 16) of post-baccalaureate students with the potential to be graduating each year with the necessary coursework to conduct stock assessment work, it appears there is a shortage of fisheries students with the ideal training for federal fisheries agencies. Further, not all graduate students enrolled at an institution offering all nine courses will take them. For example, each student taking computer programming can take any combination of the 32 courses presented among others. Additionally, not all programs require their students to take that many courses, preferring instead that they focus more on their research. Because of these factors it is likely that the number of graduates who have taken the "essential curriculum" is well below what is needed by the federal government and other employers.

Whereas the number of current graduate students currently focusing on population dynamics as part of their thesis or dissertation research (estimated to be 545) makes the estimated number of students qualified to conduct stock assessments appear low, it is important to distinguish between population dynamics research (e.g. tagging studies, mark-recapture work, electro-shocking/pound-netting, estimating mortality, age and growth) and the rigorous mathematical modeling associated with stock assessments. Specifically, not all students studying population dynamics go beyond the biological requisites of their respective study and incorporate their findings into stock assessment models. Confounding this, even if the number of qualified graduates was greater than estimated, many of those who are qualified to conduct stock assessments will enter the academic profession as faculty, postdoctoral researchers, and research associates; begin work for a state fisheries agency or in the private sector; or are international students who will take their skills back to their home country (non-U.S. citizens cannot be employed by the Federal Government, except through contract).

The underlying causes for this indicated shortage are varied and involve various components of the academic process and federal funding agencies. In open-ended comments provided by administrators on what institutions and the U.S. Congress could do to correct a perceived shortfall (Appendices E and F), many pointed to the lack of faculty and lack of funding in this area from the Federal Government. This shortage can lead to numerous secondary problems including non-quantitative programs of study, and the perception among students that research in this area is unimportant. Department heads also indicated the de-emphasis of quantitative courses at the undergraduate level as a hindrance to producing future stock assessment scientists. From an economic perspective, a shortage in a labor market exists when there is excess demand for labor. Over time, a shortage will be bid away as compensation rises. Employers who wish to hire workers will offer higher compensation. With the higher compensation, additional employees will offer their services. With increasing employees and fewer employers seeking employees at the higher compensation, the shortage will be bid away. The only way a persistent shortage will exist is if compensation is not flexible upwards or if there are other labor market rigidities (Mankiw 2007).

The results of this survey provide some clues about these additional labor market rigidities. First, there are likely some barriers on the supply side of the market. Graduate programs are increasingly recruiting from a pool of students who are underprepared for graduate school and the statistical and modeling rigor of population dynamics and stock assessment. Students with a lack of mathematical training will be discouraged when faced with the daunting challenge of the quantitative courses necessary for stock assessment training. This is a limitation to the supply side of the market. It is unclear from the results of this survey whether additional incentives provided to graduate students, such as research support, would increase the number of population dynamics researchers trained in graduate programs. On the demand side of the market, there may be institutional rigidities that limit employers' ability to increase compensation offers when faced with a shortage. Much of the demand for fisheries scientists is in the public sector where the federal and state governments have pay scales and other employment

restrictions. Relaxation of these restrictions might lead to higher salaries and incentive for graduate students to pursue training in population dynamics and stock assessment.

Despite the bleak prognosis alluded to above, qualified students likely exist or are trainable to work in this area. Many fisheries science graduate students probably have some of the courses desired by the Federal Government, as well as other related courses. Further, it is important to understand that there are alternate mechanisms available for students to learn the material contained within the "essential curriculum" outside of a classroom. Many students learn through hands-on graduate research assistantships, and undergraduate students can gain knowledge through internship opportunities with professionals who know the material and how it is applied. We also know that graduate students must be capable of learning material independently and spend much of their time doing so. At this point in their careers, they cannot expect to learn everything needed in the classroom. For this reason, we would expect the number of students who know the material contained in the essential curriculum to be higher than purely the number who have taken formal essential courses. Further, some recent Ph.D. recipients may have taken some of the "essential curriculum" elsewhere as part of their Master of Science program. However, quantifying that information would have required having a record of graduate courses completed by each recent Ph.D. recipient in the United States, which was well beyond the scope of this study.

In an international workshop convened in 2001, leaders in government, industry, academia, and NGOs developed eight consensus strategies and recommendations significant to development of training capacity for future fisheries professionals at international, national, and regional scales (Jodice et al. 2002). Those strategies included identifying the gaps between those supplying and demanding management training. Our survey and report constitute an important contribution toward that goal for meeting the demand for quantitative fisheries scientists by Institutions of Higher Learning in the United States. Now that some of the gaps have been identified, future challenges will involve elucidating a more in-depth understanding of the reasons and mechanisms for the imbalance and developing strategies to mitigate that condition.

In addition to graduate students being informed by administrators upon enrollment as to the career potential as a stock assessment scientist if they were to take a quantitatively oriented program, open-ended comments provided by department heads (Appendices E and F) indicated numerous suggestions for increasing graduates in this area. Along with increased funding to support faculty, research, and students, other suggestions included bolstering math and statistics courses in undergraduate curricula, recruiting students from mathematics or statistics programs who may have a career interest in fisheries or natural resources or developing joint degree programs, and doing a better job at identifying qualified students as early as possible (especially in undergraduate programs) and getting them into quantitatively oriented degree programs. Also, more undergraduate and graduate internships with federal stock assessment scientists were suggested by department heads. This, along with possible increases in funding and curriculum changes, may help to increase the number of institutions where population dynamics and stock assessment education is viewed as a high priority. A 1991 survey of state fish and wildlife agency employees revealed a strong correlation between education and the

perception of a subject's importance, suggesting that universities are able to influence the direction of the fisheries profession considerably (Adelman et al. 1994).

Creative partnerships should be developed that capitalize on the close ties between universities and federal fisheries management agencies, including NOAA and the U.S. Geological Survey. Additionally, as customers of Institutions of Higher Learning, NOAA and other federal fisheries agencies need to make their academic needs known and work with the institutions to make sure essential courses are offered at each institution with a fisheries program—marine or inland. Nevertheless, whereas population dynamics in inland and marine fisheries may share some common characteristics (e.g., estimating mortality, age and growth, age at maturity), stock assessments may not. Inland fisheries scientists often estimate abundance in specific lakes using either CPUE (block netting or creel surveys) or tagging studies (invariably closed assumption versus the open assumption used in most marine fisheries). This may be to regulate the fisheries via length limits and bag limits, or to estimate stocking densities. However, other than large lake and river systems (i.e., the Great Lakes), these scientists typically do not use stock assessment methods common to marine fisheries. As suggested by one department head, institutions need to work creatively to "engage NOAA/NMFS and other agency scientists as courtesy faculty and graduate committee members," and/or offer marine fisheries stock assessment workshops for faculty at primarily inland fisheries programs.

Whereas the U.S. Department of Education has devised a comprehensive taxonomic scheme (CIP codes) for institutions to report graduates in as fine a detail as possible, many institutions with fisheries science programs report their graduating fisheries students in a non-fisheries CIP code. Based on conversations with department heads, it appears each institution has its own reason for reporting fisheries graduates where they do. For example, some fisheries programs developed within an existing forestry, wildlife, or marine sciences program, and those CIP codes are used based on precedent. Others report their fisheries students under a "natural resources" CIP code that allows the university to promote their broader strengths. Regardless, the ability of institutions to decide what CIP codes they report for their graduates defeats the intent of the Department of Education's taxonomic scheme to accurately track fields of study, at least in this case. What at first appeared to be a simple request from the U.S. Congress—to document the number of fisheries science graduates produced annually—turned into a month-long "fishing expedition" just to identify probable institutions with fisheries science programs, let alone answer the questions posed by Congress.

Institutions that do not report fisheries students using the CIP code for fisheries may unknowingly be putting themselves at a competitive disadvantage in student recruitment efforts, and possibly are affecting nationwide fisheries student recruitment. Through the course of our internet searches for fisheries programs, it became apparent that the 11 institutions using the fisheries CIP code were consistently identified more than others on various commercial and federal career and degree-related websites. It appears that many of these services use the CIP codes to direct students with interests in fisheries to appropriate institutions. Also, having only 11 institutions nationwide being identified as

having fisheries programs in many searches, some college-bound students may get the impression the field is smaller or more specialized than it is, is not available in their state, and is either very competitive or, worse, not important. Institutions of Higher Learning and the Federal Government must work cooperatively to further the fisheries science profession as a viable career option if they expect programs to prosper and vacancies to be filled in the future.

We assert that the results of this survey are as accurate as possible given the limitations and challenges described above. The results presented herein, quantitative and otherwise, depended upon the diligence of respective department heads to compile the best data available and to report their perceptions related to subjective questions to most accurately represent the condition at their institution. Further complicating the survey environment is that, in some universities, the fisheries program and its faculty and students may be located among multiple departments or other administrative units. However, while complications in obtaining results and minor inconsistencies in them may exist, the overall trends revealed are consistent and suggest that there are low numbers of quantitatively educated fisheries graduates with sufficient training to fill employment needs in stock assessment positions.

3.5 Literature Cited

Adelman, I. R., D. J. Schmidly, and Y. Cohen. 1994. Educational needs of fisheries and wildlife professionals: results of a survey. Fisheries 19(11): 17–25.

Dillman, D. A. 2000. Mail and internet surveys: the tailored design method. John Wiley and Sons, Inc., New York.

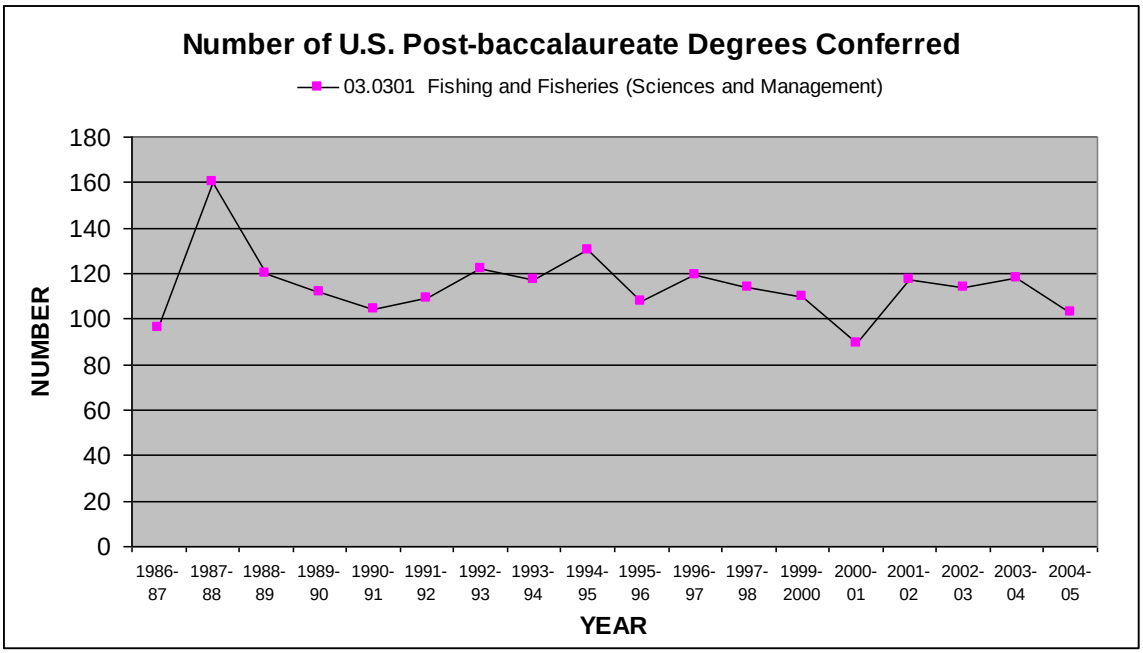
Jodice, L. W., G. Sylvia, M. Harte, S. Hanna, and K. Stokes. 2002. The Training Managers for 21st Century Fisheries Initiative: summary and recommendations from the inaugural international workshop. Proceedings of the IIFET 2002 Conference, Wellington, New Zealand. Oregon State University, Newport, Oregon.

Mankiw, N. G. 2007. Principles of economics, 4th edition. Thomson Southwestern, Florence, Kentucky.

3.6 Figures

3.6.1 Figure 1. Post-baccalaureate degrees conferred

Post-baccalaureate degrees conferred in "Fishing and Fisheries Science & Management" (CIP code 03.0301) by degree-granting institutions: United States, academic years 1986-87 through 2004-05 (n = 11). Data come from the U.S. Department of Education, Institute of Educational Sciences, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), 1986-87 through 2004-05, "Completions Survey" (IPEDS-C:87:99), and Fall 2000 through Fall 2005 (Completions component).



3.7 Tables

3.7.1 Table 1

Fisheries department heads (n=43) responses to "If your department could hire two additional fisheries-related faculty members today, what areas of expertise would you most likely seek?" Ranked by the number of times mentioned.

Category	Sub-category	Number of times mentioned
Fish ecology		**11**
	General fish ecology	*6*
	Lower trophic levels	*2*
	Freshwater fish ecology	*2*
	Marine fish ecology	*1*
Population dynamics		**10**
	General	*9*
	Marine fisheries	*1*
Human dimensions		**9**
	General human dimensions	*8*
	Policy	*1*
Aquaculture		**9**
	General aquaculture	*5*
	Fish health/disease	*3*
	Non-game aquaculture	*1*
Fisheries statistics		**6**
Fish physiology		**6**
Toxicology		**5**
Fisheries management		**4**
	General fish management	*3*
	Marine fish management	*1*
Modeling		**3**
Population genetics		**3**
Ichthyology		**3**
Economics		**3**
Marine conservation		**2**
Limnology		**2**
Fisheries extension		**2**
Water quality		**2**
Marine fisheries		**2**
Aquatic entomology		**1**
Invasive species		**1**
Acoustics		**1**
Fisheries oceanography		**1**

n missing=2

3.7.2 Table 2

Fisheries department heads (n=43) responses to "How successful are you at recruiting students into your Master of Science and Ph.D. program in general, and recruiting students capable of conducting population dynamics research?"

Item by Degree	Not at all	Slightly	Moderately	Very	Extremely	Mean[b]
Master of Science						
Successful in recruiting M.S. students in general (n=42) [a]	0.0	7.1	26.2	50.0	16.7	3.76
Successful in recruiting M.S. students capable of conducting population dynamics research (n=40)	0.0	20.0	35.0	40.0	5.0	3.30
Ph.D. Level						
Successful in recruiting Ph.D. students in general (n=40)	2.5	10.0	37.5	40.0	10.0	3.45
Successful in recruiting Ph.D. students capable of conducting population dynamics research (n=39)	2.6	20.5	38.5	33.3	5.1	3.18

[a] number missing for each item = 43 – sample size.

[b] mean based on response format where 1="not at all successful"; 2="slightly successful"; 3="moderately successful"; 4="very successful"; 5="extremely successful".

3.7.3 Table 3

Fisheries department heads (n=43) responses to "Please indicate the degree of weakness/strength of your recent first semester Master of Science students in each of the following areas." Ranked by mean score.

APTITUDE	Sample Size[a]	Very Weak	Weak	Adequate	Strong	Very Strong	Mean[b]
Ability in verbal communication	41	0.0	0.0	51.2	43.9	4.9	3.54
Aptitude in fishery biology	41	0.0	9.8	36.6	46.3	7.3	3.51
Aptitude in fishery ecology	40	0.0	5.0	50.0	40.0	5.0	3.45
Ability to think critically	41	0.0	7.3	46.3	43.9	2.5	3.41
Ability in synthesizing information	41	0.0	9.8	53.7	31.7	4.8	3.32
Aptitude in fishery management	41	2.4	9.8	51.2	31.2	2.4	3.24
Aptitude in fishery science	41	2.4	14.6	43.9	36.6	2.5	3.22
Ability in written communication	41	0.0	17.1	61.0	21.9	0.0	3.05
Aptitude in mathematics	41	0.0	19.5	70.7	7.3	2.5	2.93
Aptitude in statistics	41	2.4	24.4	58.6	12.2	2.4	2.88
Aptitude in population dynamics	41	4.9	36.6	46.3	9.8	2.4	2.68
Aptitude in modeling	41	7.3	53.7	29.3	7.3	2.4	2.44

[a] number missing for each item = 43 – sample size.

[b] mean based on response format where 1="very weak"; 2="weak"; 3="adequate"; 4="strong"; 5="very strong".

3.7.4 Table 4

Fisheries department heads (n=43) responses to "Please indicate the degree of weakness/strength of your recent first semester Master of Science students in each of the following areas compared to students in the past decade" Ranked by mean score.

APTITUDE	Sample Size [a]	Decreased	Stayed the Same	Increased	Mean[b]
Aptitude in fishery ecology	40	2.5	72.5	25.0	2.23
Aptitude in statistics	41	2.4	75.6	22.0	2.20
Aptitude in modeling	41	2.4	75.6	22.0	2.20
Ability in verbal communication	41	4.9	70.7	24.4	2.20
Aptitude in fishery biology	41	2.4	80.5	17.1	2.15
Ability in synthesizing information	41	9.8	68.3	21.9	2.12
Aptitude in fishery science	41	2.4	85.4	12.2	2.10
Aptitude in fishery management	39	5.1	82.1	12.8	2.08
Ability in written communication	40	12.5	70.0	17.5	2.05
Ability to think critically	41	12.2	70.7	17.1	2.05
Aptitude in mathematics	41	9.8	80.4	9.8	2.00
Aptitude in population dynamics	41	14.6	78.1	7.3	1.93

[a] number missing for each item = 43 – sample size.
[b] mean based on response format where 1="decreased"; 2="stayed the same"; 3="increased".

3.7.5 Table 5

Fisheries department heads (n=43) responses to "Please indicate which of the following graduate-level courses are offered by your university, and, if so, what is the percentage of your fisheries-related graduate students (M.S. and Ph.D.) that typically take each course?" Ranked by the percentage of U.S. fisheries students taking course (unweighted). Bolded courses are those indicated by NMFS Science Centers as essential courses in preparing students to conduct high-level quantitative population dynamics/stock assessments for the federal government and elsewhere.

Course	Percent of universities that offer course	Percent of fisheries graduate students who take course where offered	Percent of all U.S. fisheries graduate students who take course
Introduction to statistics	93.0	87.1	81.0
Fisheries management	86.1	59.7	51.4
Regression	83.7	55.3	46.3
Ichthyology	81.4	52.2	42.5
Population dynamics	***72.1***	***54.2***	***39.1***
Fish ecology	***60.5***	***57.0***	***34.5***
Multivariate statistics	***93.0***	***37.1***	***34.5***
Limnology	76.7	42.7	32.8
Fish biology	58.1	56.2	32.7
Nonparametric statistics	76.7	41.1	31.5
GIS and/or remote sensing	81.4	38.3	31.2
Fisheries science	48.8	56.3	27.5
Introduction to probability	63.4	42.0	26.6
Sampling theory	***60.5***	***34.8***	***21.1***
Fisheries or natural resources statistics	39.5	51.9	20.5
Technical writing	53.5	34.5	18.5
Fisheries or natural resource modeling	***53.5***	***34.2***	***18.3***
Fish physiology	46.5	32.2	15.0
Probability theory	55.8	25.8	14.4

Table 5. Continued

Course	Percent of universities that offer course	Percent of fisheries graduate students who take course where offered	Percent of all U.S. fisheries graduate students who take course
Population biology	33.3	40.0	13.2
Water quality	51.1	25.6	13.1
Bayesian statistics	***48.8***	***26.9***	***13.1***
Differential equations	79.1	15.8	12.5
Human dimensions of fisheries	48.8	25.3	12.3
Stock assessment	***30.2***	***37.5***	***11.3***
Economics	69.8	15.1	10.5
Fisheries or natural resources economics	37.2	22.8	8.5
Linear algebra	79.1	9.8	7.8
Numerical analysis	57.1	11.5	6.6
Risk and decision analysis	***44.2***	***14.1***	***6.2***
Fisheries or natural resources computer programming	***14.0***	***25.0***	***3.5***
Anthropology	46.5	7.2	3.4
Fisheries or natural resources anthropology	9.3	10.0	0.9

3.7.6 Table 6

Number of U.S. Institutions of Higher Learning that have curricula including the entire nine-course "essential curriculum" identified by NMFS Science Centers *(population biology, fish ecology, multivariate statistics, sampling theory, fisheries modeling, Bayesian statistics, stock assessment, risk and decision analysis, and fisheries computer programming)* or portions thereof (n=43).

Number of NMFS Science Center Curriculum Courses Offered by Institution	**Number**	**Percent**
Nine	3	7.0
Eight	4	9.3
Seven	3	7.0
Six	6	14.0
Five	5	11.7
Four	9	20.9
Three	3	6.9
Two	9	20.9
One	1	2.3
Total	43	100.0

4 COMPARISON OF DEMAND TO SUPPLY

Results from the Demand Report (Section 2.3) indicate the demand for stock assessment scientists is increasing. This is primarily due to the increased mandates requiring the skills of stock assessment scientists established under the reauthorized Magnuson-Stevens Act (Section 2.3). The minimum number of new stock assessment scientists needed (individuals who have the ability to conduct high-quality scientific research in stock assessment, fishery population dynamics, and related fields) is estimated to be approximately 180–340 over the next 10 years (Section 2.3.5). This number is likely a minimum, for a number of reasons (Section 2.4).

This is a substantial increase over the number that is currently employed. The NMFS Science Centers currently employ 90 stock assessment scientists. The minimum estimate of new hires needed by the Science Centers over the next ten years is 135, which is 150% of the current number employed.

Results from the Supply Report indicate that the supply of stock assessment scientists is limited due to a number of reasons involving faculty, graduate students, and undergraduate students.

The current proportion of faculty working on population dynamics in the departments surveyed is expected to decrease in the foreseeable future. Department Heads reported that the faculty being hired to replace retiring faculty, and those hired to fill new positions, will not be found in the field of population dynamics in the same proportion as currently found, in favor of other disciplines (Section 3.3.1). This is particularly disheartening because Department Heads mentioned in their comments that one of the greatest impediments to producing individuals capable of conducting stock assessment work was the lack of available faculty knowledgeable about the discipline (Section 7.3).

The lack of population dynamics faculty translates to a lack of graduate course offerings. Only 7 percent of the schools surveyed offered all nine courses deemed essential by the NMFS Science Centers. Only 27 percent offered seven or more of those courses (Section 3.7.6). Without the availability of most of the listed courses, students are receiving a subset of the tools they need to effectively enter careers in stock assessment which requires additional on the job training to meet the standards of the discipline.

The ability of undergraduate students entering the graduate programs is also a major concern. Department Heads reported that their incoming graduate students were weakest in the quantitative disciplines of math, statistics, population dynamics, and modeling, in that order (Section 3.7.3)—all essential building blocks to conduct stock assessments. In addition, the Department Heads reported that, compared to incoming students over the past decade, current incoming students were stronger in all disciplines listed, with the exception of math (as strong as in the past) and population dynamics (weaker than in the past) (Section 3.7.4). In addition, Departments are having a tougher time finding

graduate students capable of working on population dynamics than graduate students overall (Section 3.3.3).

The Supply Report estimated that approximately 160 new stock assessment scientists are expected to be produced over the next ten years by institutions of higher education (Section 3.3.5). Many assumptions were made in order to estimate this number and the true value could be higher or lower.

Comparing results of the two studies indicates that over the next ten years there will be a demand for approximately 180–340 new stock assessment scientists (which is likely low) and a supply of approximately 160 per year. This indicates an overall shortage of at least 20–180 over the next decade.

5 CURRENT NMFS PROGRAMS TO INCREASE SUPPLY

The NMFS, aware of the potential supply/demand problem, has already established a number of programs aimed at increasing the number of individuals with post-baccalaureate degrees who have the ability to conduct high-quality scientific research in fishery stock assessment, fishery population dynamics, and related fields, for government, nonprofit, and private sector entities.

5.1 Increasing Faculty Numbers

As part of the Supply Study, 31 percent of the Department Heads responded that they did not have the resources necessary to train students for population dynamics/stock assessment-related work (Section 3.2.2). These individuals were then asked, "What resources would be required to do so?" In response, 12 of 13 responded that they needed additional faculty with expertise in the discipline (Section 3.2.2, Section 7.3). Training the next generation of stock assessment scientists requires knowledgeable faculty. NMFS has implemented a number of programs to increase the number of faculty available to university students.

5.1.1 Providing Support to University Faculty

Adding new faculty, replacing retiring faculty, and/or keeping existing faculty requires funding. NMFS provides funding for university-employed faculty by supporting NMFS-related research. Through competitive research opportunities, NMFS provides grants and contracts to universities to receive specific research products. In many cases, the agency pays for the faculty time involved in the project. This serves the agency in two ways. First, the agency receives a needed research product. Second, by providing partial support for a faculty member, less support is required from the university, making it easier for the university to employ the faculty member. In this way, the agency provides the funding leverage needed for universities to add new, replace retiring, or keep existing stock assessment faculty. In the process, the agency increases not only the faculty available to conduct research, but the faculty available to teach, advise, and mentor as well. NMFS supports stock assessment faculty in this way at universities around the country.

5.1.2 Interacting with Neighboring Universities

The majority of NMFS Science Centers and Labs are located near universities with strong fisheries programs. In most cases strong relationships have developed between the

universities and the Centers and Labs, encouraging interaction between NMFS and university scientists.

Many agency stock assessment scientists have been appointed as courtesy or adjunct faculty at neighboring universities. These individuals may serve on graduate supervisory committees, supervise graduate students, and teach sections of courses or entire courses. This interaction serves to add faculty expertise to the university, without removing a stock assessment position away from its Science Center or Lab.

Examples include relationships between the Southeast Fisheries Science Center and the University of Miami, the Northwest Fisheries Science Center and the University of Washington, and the Northeast Fisheries Science Center and the University of Massachusetts. In each case, NMFS stock assessment scientists have courtesy or adjunct appointments at the universities, teaching and supervising graduate students and interacting with the university community.

Proximity makes this interaction extremely easy to initiate and maintain. Agency scientists can easily walk or drive to the university campuses regularly. Logistical issues are minimal as positions do not need to be relocated and universities do not need to provide office space.

It is important to note that a NMFS stock assessment scientist who spends time each week performing university duties cannot spend as much time performing standard agency stock assessment duties. For instance, if an individual is teaching and performing other university-related duties 15 hours a week, then only 25 hours a week are available for what would be considered normal work for a NMFS stock assessment scientist FTE stationed at a NMFS Science Center or Lab who is not working with a university. Thus, while benefiting the supply side by assisting in the training of new stock assessment scientists, this scenario also costs regarding demand, as the university duties takes time away from regular agency stock assessment duties.

5.1.3 Stationing NMFS Stock assessment scientists on University Campuses

NMFS is also stationing a number of stock assessment scientists on select college and university campuses with strong fisheries programs around the country. This serves two primary purposes. First, it allows NMFS to augment the number of university educators with stock assessment expertise and, second, it allows NMFS stock assessment scientists to interact more closely with university researchers, creating collaborations and sharing information.

The stock assessment scientists are normally given courtesy or adjunct faculty status at the universities and are able to perform many of the same duties as full time university-employed faculty, including teaching courses, supervising graduate students, leading seminars, etc. At the same time, these individuals can continue to perform many duties

for the agency such as working on stock assessments, conducting research, and serving on technical committees.

Examples include NMFS stock assessment scientists stationed at at Virginia Tech and at the University of Massachusetts–Dartmouth. The NMFS scientists teach stock assessment–related courses and supervise graduate students, while working on a number of ongoing projects for the agency. Just as importantly, the biologists interact regularly with the faculty and students of the universities, creating new research collaborations and participating in key information transfer between the agency and university on a scale not possible without being physically located on-site.

The process of stationing a NMFS employee on a university campus is much more complicated than the process of interacting with a neighboring university. The agency's personnel department must change the position description reflecting the position's location, and negotiations must take place with each university regarding logistics such as office space.

As with the case of interacting with a neighboring university, time spent by agency stock assessment scientist duties on university-related duties reduces the amount of time available to conduct agency-related stock assessment duties.

5.2 Increasing Graduate Student and Postdoctoral Associate Numbers

Increasing the supply of individuals with post-baccalaureate degrees capable of conducting stock assessments to the agency requires increasing the number of individuals receiving post-baccalaureate degrees in related fields. In the supply survey, a number of Department Heads reported that additional funding support is needed to admit more graduate students into their programs (Section 7.5, Section 7.6).

NMFS has a long history of supporting graduate students and postdoctoral associates, specifically those conducting research related to the needs of the agency. This benefits the agency in a number of ways including: (1) needed research is completed, often in a very cost-effective manner; (2) interactions with graduate students and postdoctoral associates bring new ideas, new collaborations, and new approaches to the agency's work; and (3) it plays a major role in training new stock assessment scientists by providing real-world problems to work on, the kind that the graduate students and postdoctoral associates will be working on when they begin their NMFS careers.

NMFS uses two general approaches to increase the number of graduate students and postdoctoral associates. In both cases, the agency issues grants and contracts to universities to conduct research. In the first approach a university and/or faculty member is the target of the funding, and graduate students and/or postdoctoral associates are hired by the university to become part or all of the mechanism by which the research is completed. In the second case, the agency seeks out top graduate students and

postdoctoral associates and their research ideas, and once identified, provides the funding needed to conduct the research.

Providing support for graduate students and postdoctoral associates not only provides the means for getting critical research completed, but also allows the individuals supported to complete coursework, including the essential courses identified in the Supply Report (Section 3.1.2).

5.2.1 Supporting University Research

As reported in Section 5.1.1, NMFS provides funding to universities to conduct agency-related research. The standard procedure is for universities to first compete to receive funding to conduct research critical to the agency's needs. In the majority of cases, proposals are submitted by faculty and proposals are evaluated based on quality of the ideas presented, the background of the faculty member, the reputation of the university, and other factors. Once a university and its faculty member are awarded research funding, often the next step is to hire one or more graduate students and postdoctoral associates to conduct all or part of the actual research. In many cases, the agency does not know the specific graduate students and/or postdoctoral associates who will be working on the research before the funding is awarded, usually because they are not hired until the funding is received, and the award is based on the ideas and reputation of the faculty member who submitted the proposal.

Over time the graduate students and/or postdoctoral associates conduct all or part of the research. Graduate students take courses, ideally including the essential courses available at the university. Learning takes place by conducting the research, and this experience also helps prepare these individuals for careers in the discipline.

NMFS supports graduate students and postdoctoral associates in this way at universities around the country, including those mentioned in Section 5.1.1.

5.2.2 Providing Doctoral Fellowships

In addition to NMFS' general approach of supporting graduate students by awarding research grants and contracts to universities, described in Section 5.2.1 above, NMFS also has a program that seeks out exceptional individuals to support through their doctoral studies. NMFS, working with the Sea Grant College Program, has established the NMFS–Sea Grant Joint Graduate Fellowship Program in Population Dynamics and Marine Resource Economics. Students apply for the program and applications are judged according to a number of factors, including: (1) the student's abilities and experience, (2) the student's doctoral research proposal, and (3) the university and agency scientists who have agreed to mentor the student. The Fellowship program is for doctoral students only, and provides full funding for 3 years of study.

This program allows the agency to identify and target top doctoral candidates, support the students' work on critically needed agency research, and give these top students the opportunity to take the essential coursework available. Ultimately, it is hoped that the individuals supported by the program will stay in the discipline. This program allows the agency to be very proactive regarding the supply/demand issue, by actively selecting and supporting students who show the greatest potential to succeed in the field. To date, 12 recipients of these Fellowships have completed their studies. Of those whose employment is known, approximately two-thirds now work for NMFS and one-third work in academia.

NOAA also has a Graduate Sciences Program (GSP), an effort under the NOAA Educational Partnership Program, that offers between two years (masters candidates) to four years (doctoral students) of NOAA-related research and training to college students pursuing graduate study at minority serving institutions in math, science, technical, or other NOAA-related fields. The program is designed to improve NOAA's outreach and recruitment efforts of under-represented individuals in NOAA's scientific mission-related occupational fields, such as fishery biology.

5.2.3 Awarding Postdoctoral Fellowships

Similar to the program described above for doctoral students, NMFS participates in a program that identifies and provides support for exceptional postdoctoral associates. The National Academy of Sciences/National Research Council Postdoctoral Fellowship Program provides advanced training for highly qualified postdoctoral associates and visiting scientists, while enhancing the research conducted in federal labs. This program provides research awards in the labs of over 30 federal sponsors. NOAA awards 80 of these Fellowships each year across all of its line offices, with only a fraction awarded to postdoctoral associates focusing on stock assessment. The Fellowships cost $68,000 to $85,000 per student per year, and are awarded for 1 year and renewable for up to 3 years. This is another program in which NMFS is able to select and support individuals who demonstrate the greatest potential to succeed in the field.

5.3 Improving the Quality of Incoming Graduate Students

The issues of concern raised in the Supply Report were not limited to faculty, graduate students, and postdoctoral associates. The issues begin at an earlier stage—the undergraduate level. Department Heads surveyed for the Supply Report indicated they were having a tougher time finding graduate students to work on population dynamics than graduate students overall (Section 3.3.3). They also reported their incoming graduate students were weakest in the quantitative disciplines of math, statistics, population dynamics, and modeling, in that order (Section 3.7.3)—all of which are essential building blocks required to conduct stock assessments. In addition, the Department Heads reported when comparing incoming students over the past decade, current incoming

students were stronger in all disciplines listed, with the exception of math (as strong as in the past) and population dynamics (weaker than in the past) (Section 3.7.4).

When the Department Heads were asked, "What, if anything, could Institutions of Higher Learning do to try to increase the number of students with adequate training in population dynamics/stock assessments?" several mentioned improving the quality of undergraduate education, specifically quantitative training (Section 3.7.5). Respondents also recommended the discipline be better promoted as being important and interesting (Section 3.7.5).

NMFS has implemented a number of programs specifically designed to improve the quality of incoming graduate students. The agency is applying existing scholarship and internship programs to identify and train top quantitative students. In another approach, NMFS stock assessment scientists are working with university undergraduate programs to assist in their quantitative training. A newly created program specifically identifies and works with strong quantitative students from around the country. All of these programs not only strengthen the skills of incoming graduate students, but also allow NMFS to identify undergraduate students who are most deserving of agency support as graduate students.

5.3.1 Providing Undergraduate Scholarships and Internships

NMFS, through its parent agency NOAA, offers a number of scholarship and internship programs aimed at identifying, supporting, and recruiting undergraduate students potentially interested in disciplines found within NMFS. While not specifically limited to students with interests related to stock assessment, these programs offer an excellent opportunity to provide support to students with the potential to excel in the discipline.

Scholarship programs offer tuition and stipends, allowing students to pursue their studies while reducing their concerns regarding the costs of higher education. Students can spend more of their time on their studies as a result. Internships provide students with opportunities to work with NMFS scientists at NMFS facilities, where they can learn first-hand about how the material taught in the classroom is applied in the real world.

The NOAA Undergraduate Scholarship program targets students attending Minority Serving Institutions and provides 2 years of funding for each student and a 10-week summer internship. The Ernest F. Hollings Undergraduate Scholarships Program is designed to increase undergraduate training in the disciplines applied by NOAA and to recruit and prepare students for public service careers with NOAA. It provides up to 2 years of funding for each student, along with a 10-week internship.

5.3.2 Strengthening Quantitative Programs at Individual Universities

NMFS is working with a number of universities around the country to improve the quantitative training in undergraduate fisheries-related programs. As presented in the Supply Report (Section 3.2.2, Section 7.3) and discussed earlier (Section 5.1), Department Heads suggested that increasing the number of faculty with quantitative/stock assessment training was needed to more effectively educate students.

One way to do this is to increase the number of faculty available through the use of NMFS stock assessment scientists on campus. As is the case with graduate training, NMFS is working with universities located close to Science Centers and Labs through regular interaction with agency stock assessment scientists (Section 5.1.2), and is stationing agency stock assessment scientists at universities with excellent fisheries-related undergraduate programs (Section 5.1.3).

The focus of the interaction with undergraduate students is usually much broader than that with graduate students. Agency scientists work to increase the quantitative content within the undergraduate curriculum. Efforts are made to increase students' interest in quantitative subjects. Increasing the number of quantitative courses offered, the rigor of quantitative courses offered, and/or creating internship and research opportunities for undergraduates may all be part of the program.

Programs have been set up at universities close to NMFS Science Centers and Labs, such as the University of California–Santa Cruz, and at universities where NMFS scientists have been stationed, such as at Humboldt State University. It is common for agency stock assessment scientists who are stationed at a university to work with both undergraduate and graduate students.

5.3.3 Identifying and Mentoring Top Undergraduates Nationally

Working with a number of specific universities (Section 5.3.2) is one way to reach undergraduate students, particularly if those universities produce a large number of strong, fisheries-related majors on a regular basis. However, undergraduate students with great potential to enter graduate school and careers in stock assessment do not only attend universities with ongoing relationships with NMFS. They may attend small liberal arts schools where there are few or no applied science courses. They may attend a university that only occasionally turns out a strong quantitative student. Undergraduates who have great potential may also be enrolled in majors other than fisheries, such as environmental science, conservation biology, marine science, or ecology.

NMFS has created the Population Dynamics Recruiting Program to work with students from across the country who have outstanding potential to succeed in the discipline of stock assessment. The program's goals are to (1) identify top students from around the country, (2) teach them about the role stock assessment biology and stock assessment scientists play in the world of marine resources management, and (3) mentor them into graduate school and beyond. Students apply to participate in the program's week-long workshops and extended summer programs.

Students gain quantitative skills while they participate in the program. While being mentored, they are also encouraged to take specific courses as undergraduates that will best prepare them to enter graduate school to conduct stock assessment research. The program focuses on a small number of outstanding students from across the country. As a result, the quantity and quality of students entering the stock assessment pipeline are increased.

5.4 Discussion

Recognizing the insufficient supply of individuals with post-baccalaureate degrees capable of doing stock assessment research, NMFS has been involved in a diverse set of activities designed to increase the supply with varying degrees of success.

At the scale currently implemented, the programs in place are not sufficient to eliminate the shortage. While the programs are positive contributions toward resolving the problem, the shortage of stock assessment scientists reported in this document include the current contributions of all of the NMFS programs presented in Sections 5.1, 5.2, and 5.3. Without these programs, the shortage would be even greater.

As shown in both the results of NRC Workshop in 2000 (Chapter 7) and the current Demand Report (Section 2.5.5), NMFS is the primary hiring source for stock assessment scientists. Because of this, NMFS has a special obligation to ensure that the supply of stock assessment scientists is sufficient to meet the expected demand. The current amount of funding allocated for these efforts will not meet the needs identified.

NMFS has established partially successful programs to increase the number of faculty (Section 5.1), increase the number of graduate students and postdoctoral associates (Section 5.2), and improve the quality of incoming graduate students (Section 5.3). The scope of many of these programs is limited at the present time. A few examples are provided below.

Stationing NMFS stock assessment scientists at universities increases the number of faculty with these abilities, but it also takes time away from the biologists' usual agency duties (Section 5.1.2). While this helps with the supply side of the problem, it adds to the demand side. Because of the agency's increasing workload for its stock assessment scientists, the agency is severely limited as to how many of its current stock assessment scientists can assist with faculty duties.

The NMFS–Sea Grant Joint Graduate Fellowship Program in Population Dynamics (Section 5.2.2) is a highly effective program, identifying and supporting top doctoral students focused on the discipline of stock assessment. Currently, two to three new fellowships are given out each year. Participants in this program have a very high likelihood of entering the profession. Increasing the number of students awarded

fellowships would increase the supply of stock assessment scientists being produced, and as a result, the current shortage would be reduced.

The Population Dynamics Recruiting Program identifies, trains, and mentors undergraduate students demonstrating potential to enter graduate school and careers in stock assessment (Section 5.3.3). As a result, it improves the quality of incoming graduate students bound for research in stock assessment. It currently works with a maximum of 15 top undergraduate students per year from around the country. The number of excellent students applying exceeds the number who can be admitted into the program. In addition, because the students are undergraduates and unsure of their futures, not all those admitted will enter graduate school to study stock assessment. Increasing the scale of the program to work with more students would increase the number and quality of incoming graduate students in this discipline.

With successful programs in place to increase the supply of stock assessment scientists, the primary issue becomes scale of the programs. Development of an overall strategy will require identifying the most effective combination of programs currently in place and the resources necessary to implement the strategy at a scale sufficient to eliminate the current and anticipated shortage of stock assessment scientists.

6 RECOMMENDATIONS TO INCREASE THE SUPPLY

This chapter will suggest recommendations that NMFS, institutions of higher education, and the private sector can do to increase the supply of stock assessment scientists.

6.1 NMFS

Increasing the number of graduate students studying stock assessment must be a major component of any strategy to increase the supply of stock assessment scientists. To accomplish this, funding must be increased. The President's 2009 budget includes an additional $1 million for graduate population dynamics fellowships, which have proven to be extremely successful (Section 5.2.2).

NMFS should also strengthen cooperative programs with colleges and universities with the capacity to train stock assessment scientists. NMFS can help increase the number of faculty teaching stock assessment by increasing funding to universities and by increasing the participation of NMFS stock assessment scientists on university campuses.

By improving partnerships with undergraduate institutions, NMFS can improve the quantitative background required of incoming stock assessment graduate students. This will also introduce the discipline and the agency to greater numbers of students.

As the leading employer of stock assessment scientists, the burden of reducing the shortage of stock assessment scientists largely lies with NMFS. The agency is now experiencing a "perfect storm" involving a large number of stock assessment scientist retirements, an increasing workload mandated by the reauthorized Magnuson-Stevens Act, and a decreasing supply of incoming stock assessment scientists. Producing additional stock assessment scientists requires time, time to find promising students and time to train them adequately. The new mandates under the reauthorized Magnuson-Stevens Act do not allow for delays, which means that efforts to increase the supply must begin immediately.

6.2 Institutions of Higher Education

Institutions of higher education can share the responsibilities of increasing faculty numbers, increasing graduate student and postdoctoral associate numbers, and improving the overall quality of incoming graduate students.

Department Heads may be misinterpreting the demand side of stock assessment as a growth industry. While most said it was a medium or high priority (Section 3.3.2), stock assessment faculty numbers are likely to decrease (Section 3.3.1). The results of this study indicate there is an increase in the workload for biologists

in this discipline and a clear need for new graduates in the discipline (Section 2.3.5). As a result, it is likely that funding for universities conducting research in this discipline will increase. Department Heads should reconsider their plans concerning replacing faculty and new hires, allowing more stock assessment scientists to be hired. Perhaps distribution of this report to the participating universities will encourage them to consider changing their plans.

Many universities have funding available for graduate and postdoctoral research assistantships and teaching assistantships to help support graduate students and postdoctoral associates, either partially or in full. Department Heads should consider allocating more of this funding to individuals within the discipline of stock assessment, leveraging additional federal funding to train new stock assessment scientists. Universities that can share the support of graduate students and postdoctoral associates with NMFS will allow NMFS' funding to go further.

Institutions of higher education must place a higher priority on their quantitative training at the undergraduate level. As reported in the Supply Report, incoming graduate students are weakest in the quantitative skills (Section 3.7.3), and their math and population dynamics skills are the only ones that have not improved over the past decade (Section 3.7.4). The discipline of stock assessment is neither the first nor only discipline to notice a decline in the quality of quantitative education in the U.S. system of higher education. There has been an ongoing multidisciplinary call to improve undergraduate Science, Technology, Engineering, and Mathematics (STEM) education nationally (NRC 1996; NSF 1996). Stock assessment is only one of many disciplines seeing the effects of decreased performance from incoming graduate students in quantitative fields.

6.3 The Private Sector

In the context of this report, the private sector is viewed as including the fishing industry, non-governmental organizations, and environmental consulting firms. Stock assessment scientists are employed by each of these, and therefore the private sector adds to the demand but not the supply. As reported earlier (Section 2.4), the demand for stock assessment scientists by the private sector was not included in the estimates provided by the Demand Report. The private sector can be thought of as competitors for the limited supply of stock assessment scientists available.

The private sector can help reduce the shortage of stock assessment scientists by doing many of the things NMFS is doing. Private sector stock assessment scientists can work with universities, helping teach courses and serving on graduates committees. The private sector can also provide funding for research, fellowships, and internship opportunities, even perhaps endowed faculty chairs. The costs for training do not have to be borne solely by the Federal Government.

The creativity of the private sector may lead to new programs to facilitate increasing the supply of and/or decreasing the demand for stock assessment scientists.

6.4 Literature Cited

National Research Council (NRC) 1996. *From Analysis to Action: Undergraduate Education in Science, Mathematics, Engineering, and Technology*. Washington, DC. National Academy Press.

National Science Foundation (NSF) 1996. *Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology*. Arlington, VA.

7 Executive Summary: NRC 2000 Report

Excerpted from the National Research Council (NRC) 2000 Report: Recruiting fishery scientists: Workshop on stock assessment and social science careers. Commission on Geosciences, Environment, and Resources. Ocean Studies Board. The National Academies Press. http://www.nap.edu/catalog.php?record_id=10000

"The National Marine Fisheries Service (NMFS) employs many fishery scientists with diverse skills. The agency finds that the supply of fishery biologists is adequate to meet most of its demand. However, increasing demands on the agency to understand fish populations and the social and economic conditions in fishing communities have created a need for additional experts in the fields of fisheries stock assessment and social sciences.

NMFS has developed plans for meeting its anticipated staff needs in stock assessment and social sciences and asked the National Research Council (NRC) to convene a workshop to discuss the plans and suggest other actions the agency might take to ensure an adequate supply of experts in these fields. Approximately 30 individuals gathered in Woods Hole, Massachusetts on July 17, 2000 under the auspices of the NRC's Ocean Studies Board to discuss NMFS' plans. This document summarizes the presentations and discussions at that one-day workshop. No attempt was made to reach consensus among the participants; thus, the suggestions recorded in this summary represent the personal views of workshop participants, as summarized by NRC staff.

Information was presented by NMFS at the workshop about their need to hire additional individuals in stock assessment and social sciences. NMFS proposed several actions to boost recruitment and retention of NMFS employees, including

- developing targeted recruitment programs and cooperative arrangements with universities,
- enhancing continuing education opportunities for NMFS employees,
- increasing recruitment of individuals from related fields,
- increasing diversity, and
- building capacity in minority-serving institutions.

A number of bottlenecks, differing by institution, constrain enrollment in graduate schools. At the most basic level, some universities do not receive enough applications from individuals with relevant skills who can meet their entry requirements. In some cases, universities cannot provide financial support at the beginning of a student's graduate education, even though such support could be forthcoming later when the student possesses greater skills that could be applied to his or her advisor's research projects. In other universities, both funding and qualified applicants are available, but either the number of faculty or the infrastructural support limit the expansion of fisheries education programs. Foreign students often bring financial support with them and can

surmount the other bottlenecks, but are ineligible for employment by NMFS and other federal agencies after graduation until they become permanent residents or U.S. citizens.

The supply and demand situation differs for stock assessment and social scientists. For stock assessment scientists, NMFS is the primary employer and demand is already large relative to the total supply. NMFS' anticipated expansion in this area exceeds the present capacity of university programs. On the other hand, NMFS is a minor employer of social scientists; thus, even relatively large changes in NMFS hiring decisions would add only a few slots and have a relatively small effect on the overall pool of social scientists available. NMFS' anticipated expansion in this area could probably be accommodated with little difficulty. A caveat, however, is that relatively few social scientists focus on fisheries and thus would require some persuasion to enter the field and time to learn the nuances of fishery issues.

Some suggestions for reducing the total demand for qualified scientists (including those at the Ph.D., Master's, and Bachelor's levels) may include (1) decreasing the regulatory requirements for fisheries, (2) managing more cautiously (e.g., setting lower total allowable catches) so that less information and analyses are needed, (3) developing and implementing management methods that require less stock assessment and social science advice, or (4) increasing technological capabilities for performing analyses without increasing staff levels. Another way to reduce the demand for stock assessment and social scientists within NMFS—and possibly total demand—would be to contract out a greater percentage of stock assessment and social science analyses to universities or private consultants.

However, most of the workshop discussions focused on ways to increase the supply of stock assessment and social scientists in the event that NMFS receives funding for its plans. Workshop participants considered both traditional and more innovative approaches. Traditional approaches included increasing the availability of graduate and post-doctoral fellowships, funding faculty positions in universities, sponsoring programs to reach undergraduates, placing NMFS employees in academic institutions, and disseminating information about career and employment opportunities more broadly. NMFS already is using many of these approaches and has made progress in targeted graduate fellowships for stock assessment science and fisheries economics, and in offering NRC and other post-doctoral fellowships to bring new individuals into NMFS laboratories. Many participants felt that NMFS could make additional progress using these traditional approaches.

As suggested by some participants, the most obvious approach to attract more stock assessment and social scientists to NMFS would be to offer higher salaries for individuals with these specialties. This is a particular need for stock assessment scientists because their quantitative skills enable them to find work in other, more lucrative, professions. If salaries cannot be increased to competitive levels, non-monetary incentives could be offered to make up for the salary differences. Examples include travel to professional meetings, support for individual career development, funding and release time to conduct research, and exposure to national-level policy and projects.

Some of the shortfall in qualified employees can be met by hiring individuals from related fields with similar skills, but these individuals often require additional training to acquaint them with problems specific to marine fisheries. As an alternative, intensive retraining of qualified staff might help reduce the current shortfall.

Other less obvious, but potentially productive, approaches to meeting NMFS staffing needs could include working through scientific societies to find individuals in the academic or consulting communities who could fulfill NMFS' analysis needs, employing foreign scientists as guest researchers, nurturing applied mathematical ecology and population dynamics programs in universities, and sponsoring programs to reach high school students in an effort to influence their college careers."

8 Supply Report Appendices

8.1 Appendix A

Correspondence with University Department Heads Regarding the Survey

INTRODUCTORY EMAIL – LETTER #1

Dear [Department Head Name Inserted Here]:

I am writing to inform you of a congressionally-mandated survey of Fisheries Programs in U.S. Institutions of Higher Education that I am conducting for the U.S. Congress through the American Fisheries Society. This study was mandated in the recent re-authorization of the Magnuson-Stevens Fishery Conservation and Management Act (see attached). In general, the survey is designed to determine *"whether there is a shortage in the number of individuals with post-baccalaureate degrees in the subjects related to fishery science, including fishery oceanography, fishery ecology, and fishery anthropology, who have the ability to conduct high quality scientific research in fishery stock assessment, fishery population dynamics, and related fields, for government, non-profit, and private sector entities."* Specifically, the survey is designed to 1) characterize your program 2) assess the quality of recent incoming graduate students, 3) assess courses your graduate students take as part of their program, and 4) get your comments on what could be done by academic institutions and the U.S. Congress to increase the number of students capable of conducting population dynamics and stock assessment work for various entities.

The U.S. Congress has given a very short deadline for this study to be completed and I must have a preliminary report on survey results by the end of August, 2007. To facilitate timely completion of the survey, I will be sending you another email in about a week directing you to a web-based survey. Additionally, I am providing you now with a copy of the questionnaire (see attached) for a "heads-up" so that you may look up any needed information. With the exception of a few questions (Question #23 specifically), most of the information needed should be "top of mind" in your capacity as department head or chair. If needed information is not readily-available, your best estimate will suffice. The web-based survey will take about 20-30 minutes to complete. Although voluntary, I hope you will see the importance of this study for the future of fishery science programs in the United States. You may skip any items that you do not wish to answer.

If you do not have a graduate program, there is no need to complete the on-line survey. Please reply to this message and inform me you do not have a graduate program in fisheries science and I will remove you from the mailing list. For further questions about this project, feel free to contact me via email (kmhunt@cfr.msstate.edu) or by phone (662) 325-0989. For additional information regarding human participation in research, please feel free to contact the MSU Regulatory Compliance Office at (662) 325-5220.

Thank you in advance for your cooperation.

Kevin M. Hunt, Ph.D., Associate Professor & Director, Human Dimensions & Conservation Law Enforcement Laboratory, Forest & Wildlife Research Center, Mississippi State University, Mississippi State, MS 39762-9690.

SURVEY EMAIL – LETTER #2

Dear [Department Head Name Inserted Here]:

As per my email last week, I am seeking your assistance in completing a survey of Fisheries Programs in U.S. Institutions of Higher Education that I am conducting for the U.S. Congress through the American Fisheries Society. The survey is designed to 1) characterize your program 2) assess the quality of recent incoming graduate students, 3) assess courses your graduate students take as part of their program, and 4) get your comments on what could be done by academic institutions and the U.S. Congress to increase the number of students capable of conducting population dynamics and stock assessment work for various entities. All of your responses will be securely encrypted through the latest web technology, and results will be grouped together with other institutions in an unidentifiable manner. As such, please be as candid as possible in your responses to questions. If the U.S. Congress is to assist in any necessary improvements to fisheries programs, your honest assessment is essential in this regard.

The webpage link below will take you to the survey. Upon getting there, insert the following number into the password box:

[password number inserted here]

After doing so, you will be taken to the survey. Instructions for navigating through the survey are provided on the first page of the survey. Additionally, the confirmation/submittal page you are directed to after completing the survey is printable if you desire to keep your answers for your records. The survey should take about 20-30 minutes to complete and is completely voluntary, but I hope you will see the value of the survey for the future of fishery science education in the United States. You may skip any items that you do not wish to answer. I will be sending reminders every 10 days because of the short deadline imposed by the U.S. Congress. Please try to complete your survey by August 15th or sooner if at all possible.

I have I have tried to make the survey instrument as user friendly as possible, but if you run into any difficulties whatsoever, please contact me immediately by responding to this email or by calling me at (662) 325-0989. For additional information regarding human participation in research, please feel free to contact the MSU Regulatory Compliance Office at (662)325-5220.

Thank you in advance for your cooperation.

Website survey link: http://hdclel.cfr.msstate.edu/AFS/login.htm

REMINDER EMAILS – LETTER #3 & 4

Dear [Department Head Name Inserted Here]:

About 10 days ago, I sent you a request to complete a survey of Fisheries Programs in U.S. Institutions of Higher Education. As of today, I have not yet received a completed survey from you. I have currently heard from [x %] of institutions with fisheries programs, but I need to hear from the remainder for this study to be successful.

Conducted for the U.S. Congress through the American Fisheries Society, this survey is designed to 1) characterize your program 2) assess the quality of recent incoming graduate students, 3) assess courses your graduate students take as part of their program, and 4) get your comments on what could be done by academic institutions and the U.S. Congress to increase the number of students capable of conducting population dynamics and stock assessment work for various entities. All of your responses will be securely encrypted through the latest web technology, and results will be grouped together with other institutions in an unidentifiable manner.

The webpage link below will take you to the survey. Upon getting there, insert the following number into the password box:

[password number inserted here]

After doing so, you will be taken to the survey. Instructions for navigating through the survey are provided on the first page of the survey. The survey should take only about 20-30 minutes to complete and is completely voluntary, but I hope you will see the value of the survey for the future of fishery science education in the United States. You may skip any items that you do not wish to answer.

If you run into any difficulties with the survey whatsoever, please contact me immediately by responding to this email or by calling me at (662) 325-0989. For additional information regarding human participation in research, please feel free to contact the MSU Regulatory Compliance Office at (662)325-5220.

Thank you in advance for your cooperation.

Website survey link: http://hdclel.cfr.msstate.edu/AFS/login.htm

8.2 Appendix B

Survey Instrument Sent to Department Heads

SURVEY OF INSTITUTIONS OF HIGHER LEARNING TO INVESTIGATE POSSIBLE SHORTAGES IN THE NUMBER OF INDIVIDUALS WITH POST-BACCALAUREATE DEGREES IN SUBJECTS RELATED TO FISHERY SCIENCE

In the most recent re-authorization of the Magnuson-Stevens Fishery Conservation and Management Act, the United States Congress expressed concern about a potential decline in the number of fishery scientists graduating from U.S. academic institutions and commissioned this study to determine "*whether there is a shortage in the number of individuals with post-baccalaureate degrees in the subjects related to fishery science, including fishery oceanography, fishery ecology, and fishery anthropology, who have the ability to conduct high quality scientific research in fishery stock assessment, fishery population dynamics, and related fields, for government, non-profit, and private sector entities.*"

The below survey is designed to help answer the questions posed by the U.S. Congress. I have obtained information from National Center on Education Statistics which documents the number of degrees awarded in fisheries-related programs from 1985-2005, so I will only ask some brief questions on fisheries enrollment within your department and will follow-up with you personally as necessary. The remainder of the survey is designed to 1) characterize your program 2) assess the quality of recent incoming graduate students, 3) assess courses your graduate students take as part of their program, and 4) get your comments on what could be done by academic institutions and the U.S. Congress to increase the number of students capable of conducting population dynamics and stock assessment work for various entities.

Fisheries Program Information

1. Which of the following best characterizes your fisheries-related program?

   A. COMPREHENSIVE WITH BOTH INLAND AND MARINE COMPONENTS
   B. STRICTLY INLAND FISHERIES
   C. PRIMARILY INLAND WITH SOME MARINE FISHERIES
   D. PRIMARILY MARINE WITH SOME INLAND FISHERIES
   E. STRICTLY MARINE FISHERIES

2. How many fisheries-related full-time equivalent (FTE) positions are housed in your department?

   _____ FTE FACULTY (TEACHING, RESEARCH, and/or EXTENSION)

   _____ FTE POST-DOCS

   _____ FTE RESEARCH ASSOCIATES (NON-STUDENT)

3. Of the number of FTE FACULTY listed in Question #2, how many do you anticipate retiring in the next five years?

   _____ FTE FACULTY RETIRING IN NEXT 5 YEARS

4. Of the number of RETIRING FTE FACULTY listed in Question #3, how many of these retiring faculty do you anticipate replacing soon after their retirement?

_____ FTE FACULTY REPLACEMENTS

5. Of the number of FTE FACULTY listed in Question #2, how many conduct population dynamics-related research?

_____ NUMBER OF FACULTY WHO CONDUCT POPULATION DYNAMICS-RELATED RESEARCH

6. Of the number of POPULATIONS DYNAMICS FACULTY listed in Question #5, how many do you anticipate retiring in the next five years?

_____ FTE POPULATION DYNAMICS FACULTY RETIRING IN NEXT 5 YEARS

7. Of the number of RETIRING POPULATION DYNAMICS FACULTY listed in Question #6, how many of these retiring faculty do you anticipate replacing soon after their retirement?

_____ POPULATIONS DYNAMICS FACULTY REPLACEMENTS

8. Do you see your departmental fisheries program growing in terms of number of faculty in the next five years?

A. YES
B. NO

9. If your department could hire two additional fisheries-related faculty members today, what areas of expertise would you most likely seek?

_____ POSITION 1

_____ POSITION 2

10. Have you tried to hire a population dynamics FTE faculty member during the past five years?

A. YES – Please go to Question #11
B. NO – Please go to Question #14

11. If yes, were you able to hire someone who fit your job advertisement?

A. YES – Please go to Question #14
B. NO – Please go to Question #12

12. If no, did the population dynamics position go vacant?

A. YES – Please go to Question #13

B. NO – Please go to Question #14

13. If yes, how many years did this position remain vacant?

A. Less than one year
B. Between one and two years
C. Between two and three years
D. Between three and four years
E. Five years

Entering Student Quality

14. The following is a list of skill sets and abilities which are often instrumental in the success of fishery-related graduate students. In terms of aptitude, please indicate the degree of weakness/strength of your recent first semester Masters of Science fisheries students in each of the following:

A.	Aptitude in statistics	Very Weak	Weak	Adequate	Strong	Very Strong
B.	Aptitude in mathematics	Very Weak	Weak	Adequate	Strong`	Very Strong
C.	Aptitude in modeling	Very Weak	Weak	Adequate	Strong	Very Strong
D.	Aptitude in fishery biology	Very Weak	Weak	Adequate	Strong	Very Strong
E.	Aptitude in fishery ecology	Very Weak	Weak	Adequate	Strong`	Very Strong
F.	Aptitude in fishery management	Very Weak	Weak	Adequate	Strong	Very Strong
G.	Aptitude in fishery science	Very Weak	Weak	Adequate	Strong	Very Strong
H.	Aptitude in population dynamics	Very Weak	Weak	Adequate	Strong`	Very Strong
I.	Ability to think critically	Very Weak	Weak	Adequate	Strong	Very Strong
J.	Ability in synthesizing information	Very Weak	Weak	Adequate	Strong	Very Strong
K.	Ability in written communication	Very Weak	Weak	Adequate	Strong`	Very Strong
L.	Ability in verbal communication	Very Weak	Weak	Adequate	Strong	Very Strong

15. For these same skill sets and abilities, please indicate whether the skill level of your recent first semester Masters of Science fisheries students has decreased, stayed the same, or increased over the past decade.

A.	Aptitude in statistics	Decreased	Stayed the Same	Increased
B.	Aptitude in mathematics	Decreased	Stayed the Same	Increased
C.	Aptitude in modeling	Decreased	Stayed the Same	Increased
D.	Aptitude in fishery biology	Decreased	Stayed the Same	Increased
E.	Aptitude in fishery ecology	Decreased	Stayed the Same	Increased
F.	Aptitude in fishery management	Decreased	Stayed the Same	Increased
G.	Aptitude in fishery science	Decreased	Stayed the Same	Increased
H.	Aptitude in population dynamics	Decreased	Stayed the Same	Increased
I.	Ability to think critically	Decreased	Stayed the Same	Increased
J.	Ability in synthesizing information	Decreased	Stayed the Same	Increased
K.	Ability in written communication	Decreased	Stayed the Same	Increased
L.	Ability in verbal communication	Decreased	Stayed the Same	Increased

Fisheries Student Enrollment and Support

16. What is the current enrollment of M.S. and Ph.D. fisheries-related students in your program?

_____ M.S.

_____ Ph.D.

17. What percentage of your fisheries-related M.S. and Ph.D. students conduct population dynamics-related research for their theses/dissertations?

_____ PERCENT

Has that percentage decreased, stayed the same, or increased over recent years?

A. DECREASED
B. STAYED THE SAME
C. INCREASED

18. Do you believe the enrollment of M.S. and Ph.D. fisheries students in your program will decrease, stay the same, or increase in the next five years?

A. DECREASE
B. STAY THE SAME – ***Please go to Question #19***
C. INCREASE

If you perceive enrollment will decrease, what are your primary concerns that led to this assessment **OR** if you feel it will increase why, and what specific areas of fisheries do you see growing?

_____

_____

19. How successful are you at recruiting students in general into your Masters of Science fisheries program?

A. NOT AT ALL SUCCESSFUL
B. SLIGHTLY SUCCESSFUL
C. MODERATELY SUCCESSFUL
D. VERY SUCCESSFUL
E. EXTREMELY SUCCESSFUL

20. How successful are you at recruiting students capable of conductive population dynamics research into your Masters of Science fisheries program?

A. NOT AT ALL SUCCESSFUL
B. SLIGHTLY SUCCESSFUL
C. MODERATELY SUCCESSFUL
D. VERY SUCCESSFUL
E. EXTREMELY SUCCESSFUL

21. How successful are you at recruiting students in general into your Doctor of Philosophy fisheries program?

A. NOT AT ALL SUCCESSFUL
B. SLIGHTLY SUCCESSFUL
C. MODERATELY SUCCESSFUL
D. VERY SUCCESSFUL
E. EXTREMELY SUCCESSFUL

22. How successful are you at recruiting students capable of conductive population dynamics research into your Doctor of Philosophy fisheries program?

A. NOT AT ALL SUCCESSFUL
B. SLIGHTLY SUCCESSFUL
C. MODERATELY SUCCESSFUL
D. VERY SUCCESSFUL
E. EXTREMELY SUCCESSFUL

Fisheries Education

23. Please indicate which of the following graduate level courses are offered by your department or elsewhere on campus, and, if so, what is the percentage of your fisheries-related graduate students (M.S. and Ph.D.) that typically take each course. If a course is offered at the department level and elsewhere, please check departmental offering. If the course is not offered at your university, please leave blank.

A.	Fisheries Management	Dept. Offering	Elsewhere	____ % of students taking
B.	Fisheries Science	Dept. Offering	Elsewhere	____ % of students taking
C.	Fish Ecology	Dept. Offering	Elsewhere	____ % of students taking
D.	Fish Biology	Dept. Offering	Elsewhere	____ % of students taking
E.	Fish Physiology	Dept. Offering	Elsewhere	____ % of students taking
F.	Ichthyology	Dept. Offering	Elsewhere	____ % of students taking
G.	Limnology	Dept. Offering	Elsewhere	____ % of students taking
H.	Water Quality	Dept. Offering	Elsewhere	____ % of students taking
I.	Population Biology	Dept. Offering	Elsewhere	____ % of students taking
J.	Population Dynamics	Dept. Offering	Elsewhere	____ % of students taking
K.	Stock Assessment	Dept. Offering	Elsewhere	____ % of students taking
L.	Introduction to Statistics	Dept. Offering	Elsewhere	____ % of students taking
M.	Regression	Dept. Offering	Elsewhere	____ % of students taking
N.	Non-Parametric Statistics	Dept. Offering	Elsewhere	____ % of students taking
O.	Multivariate Statistics	Dept. Offering	Elsewhere	____ % of students taking
P.	Bayesian Statistics	Dept. Offering	Elsewhere	____ % of students taking
Q.	Introduction to Probability	Dept. Offering	Elsewhere	____ % of students taking
R.	Probability Theory	Dept. Offering	Elsewhere	____ % of students taking
S.	Sampling Theory	Dept. Offering	Elsewhere	____ % of students taking
T.	Fisheries or Natural Resource Specific Statistics	Dept. Offering	Elsewhere	____ % of students taking
U.	Economics	Dept. Offering	Elsewhere	____ % of students taking
V.	Fisheries or Natural Resource Specific Economics	Dept. Offering	Elsewhere	____ % of students taking
W.	Risk and Decision Analysis			
X.	Anthropology	Dept. Offering	Elsewhere	____ % of students taking
Y.	Fisheries or Natural Resource Specific Anthropology	Dept. Offering	Elsewhere	____ % of students taking
Z.	Human Dimensions of Fisheries or Natural Resources	Dept. Offering	Elsewhere	____ % of students taking
AA.	Differential Equations	Dept. Offering	Elsewhere	____ % of students taking
BB.	Linear Algebra	Dept. Offering	Elsewhere	____ % of students taking
CC.	Numerical Analysis	Dept. Offering	Elsewhere	____ % of students taking
DD.	GIS and/or Remote Sensing	Dept. Offering	Elsewhere	____ % of students taking
EE.	Fisheries or Natural Resource Specific Computer Programming	Dept. Offering	Elsewhere	____ % of students taking
FF.	Fisheries or Natural Resource Specific Modeling	Dept. Offering	Elsewhere	____ % of students taking
GG.	Technical Writing	Dept. Offering	Elsewhere	____ % of students taking

24. What level of priority is graduate education in fisheries population dynamics/stock assessment in your program?

A. NOT A PRIORITY
B. LOW PRIORITY
C. MEDIUM PRIORITY
D. HIGH PRIORITY

25. Do you believe your program has the resources necessary to train students to conduct population dynamics/stock assessment-related work?

A. YES – ***Please go to Question #26***
B. NO

If NO, what resources would be required to enable your program to train students to conduct population dynamics/stock assessment-related work?

_____

_____

Increasing Students with Adequate Training in Population Dynamics & Stock Assessments

26. What, if anything, could institutions of higher education do to try to increase the number of individuals with adequate training in population dynamics/stock assessments?

_____

_____

27. What, if anything, could the U.S. Congress do to try to increase the number of individuals with adequate training in population dynamics/stock assessments?

_____

_____

28. Is there anything else you would like to share with us about the status or future of fisheries education in the United States?

_____

_____

8.3 Appendix C

Open-ended Responses of Department Heads (n = 13) Who Felt They Didn't Have the Resources Necessary to Train Students for Population Dynamics/Stock Assessment-Related Work to, "What resources would be required to do so?"

- "A faculty member whose expertise is population dynamics"
- "Faculty expertise"
- "Additional faculty position."
- "More of a dept. emphasis on fisheries"
- "Additional faculty"
- "We're fine on individual species/local bio/eco/mgmt, but have less opportunity for genetics and broader areas of inquiry. Needed: more faculty."
- "Additional faculty position focuses primarily on pop. dynamics"
- "Need more specific courses on population dynamics and modeling. Of these, modeling is the greater need."
- "Additional faculty and additional graduate course offerings"
- "Affirmative answer is contingent on projected new faculty hires."
- "Faculty with skills and research interests in that area."
- "We need more faculty in the program to fully train our students due to recent faculty retirements."
- "Faculty members in this area"

8.4 Appendix D

Open-ended Responses of Department Heads (n = 9) to, "Why do you think graduate student enrollment will increase?"

- "New faculty member and change in another faculty member's responsibility from extension to research"

- "Two very new faculty members will add graduate students over the next few years."

- "We have a new program, only 5 years old. We work cooperatively with the fishing industries of New England and with state and Federal scientists. The mission of our department is to educate and conduct research in the interdisciplinary sciences related to the interactions between marine organisms and marine environments. This covers a wide range of categories including field exploration, laboratory experiments, theoretical research and modeling."

- "We have new programs in Great Lakes Ecology that should result in more enrollment"

- "Change in focus of at least one faculty member to fisheries. Aquatic/fish population restoration

  a) Expect new faculty hires in fisheries oceanography, population dynamics, and fisheries extension.

  b) A new fellowship available for the first time this year will help to attract students."

- "We will increase the number of faculty during the next five years, expecting more research in the whole aquatic ecosystem, including how it relates to fisheries. However if we are able to hire new faculty we would hope to increase our graduate enrollment, however research dollars to fund assistantships would be critical."

- "I believe numbers will increase because one of the retirees, who has not had students recently, will be replaced by a faculty member who will have students. In addition, our new fisheries faculty position (recently filled) will increase the numbers as his research program develops."

- "More faculty with expertise in this area and with increased funding"

- "Enrollment will increase as young faculty truly develop their research programs in fisheries population dynamics and landscape-scale fish ecology."

8.5 Appendix E

Open-ended Responses of Department Heads (n = 30) to "What, if anything, could Institutions of Higher Learning do to try to increase the number of students with adequate training in population dynamics/stock assessments?"

- "Better quantitative training"
- "Not viewed as a major focus or need at our university"
- "Provide competitive, well-funded graduate fellowships targeted on prospective students with strong backgrounds in quantitative biology/ecology. Increase rigor of math, modeling and statistics requirements for undergraduate majors in natural resources."
- "Continue to replace faculty as they retire."
- "Better promote this area and better educate students concerning the link between population dynamics/stock assessment and conservation/sustainability. Far more students would be interested if they appreciated this link instead of just thinking of this area as one for "math nerds"."
- "Increase the math curriculum in UG programs"
- "Highlight utility of population dynamics to current news-making topics such as MPAs, ecosystem management and endangered species"
- "Hire faculty with that expertise / work creatively to engage NOAA NMFS and other agency scientists as courtesy faculty and graduate committee members / provide students with internship opportunities with agencies"
- "Additional faculty, to pursue more diverse sources of research funding"
- "Devote more funds."
- "Add relevant faculty positions."
- "I don't know"
- "Focus on the basics in ecology, mathematics, and statistics during undergraduate (including natural resources programs). Make sure that students following a natural resources track embrace rather than avoid a watered down, non-scientific curriculum. Courses in policy and administration need to be offered and mandated at the graduate level. The students must understand the constraints under which population models and stock assessments will [be conducted]"
- "Increased support, funding for RA's and field programs. Increased involvement with NOAA (CMER program) and fishery councils."
- "Funding for graduate assistantships/fellowships"

- “Increase use of mathematics throughout undergraduate programs in fisheries and biology, increase awareness among advisors that fisheries is a field that emphasizes mathematical and statistical applications. This is both to direct appropriate students to the major at UG level and to direct quantitatively trained graduates toward fishery programs.”
- “Increased graduate funding, increased faculty funding”
- “It's not the institution but what employers want. Also, it is based on what funding is obtained and the objectives of that funding, if it has pop dynamics objectives, then it becomes a priority.”
- “Hire faculty with that expertise and bolster and support their fisheries departments and program.”
- “Build strong supporting infrastructure (faculty and curricula), recruit talented students, provide competitive student support”
- “Offer short-courses and/or workshops that focus specifically on fish population dynamics issues including examples from local, regional, national, and international fisheries.

  a) Provide additional resources for graduate student support.

  b) Increase faculty trained in those areas.”
- “Introductory courses that emphasize challenges and significance of fisheries resources”
- “Hire more faculty in this area”
- “Provide greater amounts of in-house graduate student support.”
- “Provide graduate stipends and research funding in this area”
- “Provide more faculty positions.”
- “Reallocate faculty FTE's to this area of research/teaching. Offer more assistantships in this area and greater undergraduate exposure. We have the ability to recruit students with the aptitude to take on projects in population dynamics, what we lack are the faculty and resources to conduct such research.”
- “Increased salaries for these state and federal positions”
- “Identifying promising candidates in fisheries, ecology, biology, math and statistics programs and interest them in the field, perhaps by means of targeted workshops or short courses”
- “Allocate more faculty positions to these areas (since faculty are the ones training graduate students)”

8.6 Appendix F

Open-ended Responses of Department Heads (n = 31) to "What, if anything, could the U.S. Congress do to try to increase the number of individuals with adequate training in population dynamics/stock assessments?"

- "Train more potential faculty and create more jobs. The perception is that most pop dynamics experts choose to work at NMFS rather than academia"
- "Fund USGS Units"
- "Provide special funding thru NSF to provide undergrad. & grad. fellowships for students with aptitude and attitude for this kind of work. If someone funds it, they will come."
- "Provide scholarships"
- "Fund graduate research in the area of population dynamics."
- "Support special undergraduate training programs, as at Virginia Tech this year. Allow affiliated NOAA employees, posted at academic institutions, to have a greater role in university teaching, specifically in this area, to enhance the faculty resources with this kind of expertise."
- "Increase funding in specific math tracks in UG"
- "Support funding for fisheries research, create an USDA NRI competition for stock-assessment. Repopulate the USGS Cooperative fish and wildlife research units with population dynamics people"
- "Recognize the seriousness of the problem and provide real funding commensurate with its importance to hire the necessary faculty and support students on national fellowships"
- "Fund research, graduate student fellowships"
- "Provide funds to partner university and federal and state fisheries agencies to fund both a faculty position and support Ph.D. level students"
- "Provide base funding and competitive funding to support research."
- "Provide funds to hire faculty within the Cooperative Fish and Wildlife Research Unit program within the USGS. Currently vacant positions are not being refilled due to lack of funds."
- "Specifically provide research opportunities, at the national level for non-sport fish related (i.e., commercial fisheries) issues...similar to the current level of DJ-WB funding. This is particularly germane to large rivers, the Great Lakes, and estuarine systems. State agencies typically do not support stock assessment research in these sorts of systems and the federal government provides limited opportunities."

- “Increased support for field based research and statistical analyses”
- “Increase fellowship programs for such undergraduate students, enhance funding for center's of excellence and require them to offer rigorous course work in math/stats, population dynamics and stock assessment.”
- “Develop specific scholarship and research fellowship programs for students in stock assessment”
- “Ensure that funding for research in fisheries goes to the land grants which would enable such graduate programs to flourish and train such individuals. Research funding stays with USFWS. Also, NSF and NRI programs are elitist and largely ignore applied programs such as fisheries”
- “FUND federal programs that facilitate fisheries education (e.g., USGS Cooperative Research Units, Agricultural Research Stations, federal research funding programs such as Federal Aid in Sport Fish Restoration and State [Wildlife Grants])”
- “Increase scholarship and internship programs, support workshop efforts”
- “Provide incentives (e.g., financial, future employment or internships, etc.) for students completing assessment programs.

  a) Provide additional resources for graduate student research. At present funding sources for population dynamics research is severely limited in the mid-Atlantic.

  b) Support federal jobs (e.g., USFWS, Co-op Units, NRL post-docs).”
- “Promote scholarships in support of students and programs”
- “Develop a program for funding for graduate fellows and postdoctoral fellows in population dynamics/stock assessment.”
- “Provide more funding for research that includes graduate assistantship stipends”
- “Develop a Graduate Training Grants program that would enable universities to increase the level of support to grad students working in this area.”
- “Funding for stipends and research. More support for the USGS fisheries and wildlife cooperative programs in this area which would help with graduate education.”
- “Increase the funding for the Cooperative Fish and Wildlife Research Units. Provide more research funding specifically targeted to fisheries and wildlife programs; when such funding is put in other places and is supposed to be directed at us it seldom gets to us.”
- “Provide funding for research in this area. Without funding new graduate students will move toward biology, management, ecology, etc. and later move on with these backgrounds and interests. Those who end up as faculty will do research/teach

courses in those same areas."

- "Provide graduate stipends and increased fishery-related grant funding"
- "At Virginia Tech (VT), we have a pilot program that we call the NMFS-VT Research, Training and Recruitment Unit hat identifies and trains students in the sorts of skills in which you express interest. NMFS has but limited funding. Congress might consider supporting creation of such units in other regions, perhaps the northeast, northwest, and perhaps elsewhere."
- "Increase research funding in this area (funding will attract research projects and thus graduate students)"

8.7 Appendix G

Open-ended Responses of Department Heads (n = 14) to, “Is there anything else you would like to share with us about the status or future of fisheries education in the United States?”

- “Yes. The status of fisheries science here in the U.S. has never been as high—and, thus the quality of our fisheries- education programs never as good—as in Canada. Maybe that is because fisheries have always been more important to Canadians than to U.S. citizens. Also, it may be because Canadian public schools still teach rigorous math and science courses. Fisheries education (even at top programs like Univ. British Columbia) must become more systemic, if the big problems like habitat degradation/loss and global climate change are going to be effectively addressed by future fisheries scientists. That means more emphasis on mechanism, quantification, and synthesis. It also means better skills in teamwork and communication. Finally, the survey exhibits strong bias toward population dynamics at the expense of mechanistic (physiology, toxicology) and genetic research. The word "genetics" does not appear in this document--not even in the extensive "relevant-coursework" area. Apparently fisheries genetics or training in the field seems to be of even minimal Re HSU - We offer MS degree only, hence few of our courses are formally taught at the graduate level (see earlier course listings) although they are typically taught to seniors and graduate students (e.g., our fishery management class). All of our MS students must take Ichthyology, Population Dynamics and Fishery Management.”
- “The trick for the future will be to re-cast stock assessment as useful for current and emerging paradigms, and to down play the association with the checkered past of marine fisheries management and commercial fishing.”
- “Vital area of education but it is generally ignored/relegated to the bottom of some funding agencies. Some departments/faculties have an inherent disdain for the applied science - I keep hearing it referred to in disparaging terms as simply "fish counting"”
- “Many of our fisheries-related Master's students come from the state Fish and Wildlife Research Institute (FL FWRI) and are paired with faculty who do basic research in specialized aspects of ichthyology (fish physiology, fish sensory biology, fish trophic ecology using stable isotopes). This pairing is often a mismatch between the needs of FWRI and the needs of the faculty for their research programs. There are more potential students from FWRI than can be handled by our current faculty. Also, as your line of questioning suggests, these students are often have fantastic knowledge bases from experience in the field, but are often weak or very weak in basic statistics and mathematical abilities. It seems to me that if the goal is to develop population modelers, then we are probably focusing on the wrong pool of people. We also need to attract students into the field from students with strong mathematical”
- “The focus of many programs has shifted to basic ecology, so fewer students have a

background in stock assessment and population dynamics necessary to be a successful fisheries manager. Increasing funding for management based and applied research is critical to accomplish the goal of preparing students for the profession"

- "Fisheries programs and students with an interest in fisheries in general seem to be declining nationwide, although this has not yet affected our program."
- "I believe field research is a critical component of graduate training and must be strengthened. This should be done in cooperation with the fishing industries and other interest groups."
- "There are too few incoming fishery graduate students with strong aptitude and high level of training in quantitative areas. Many of the strongest quantitative fishery graduate students migrate from other disciplines but do not have well rounded background in fisheries. Recruiting some of these students as undergraduates would be beneficial. Many graduate students avoid quantitative course work during their programs only to discover it is essential to their professional work and career. Ideally this awareness needs to be instilled during the UG years or early in graduate [school]"
- "It is becoming more holistic and environmental and less technical to stock assessment alone."
- "The field of Fisheries may be suffering from an image problem, where those not well acquainted with the field perceive it as less scientific than related fields, such as ecology or conservation biology. This may affect quality of recruited students. The field of fisheries has evolved and advanced steadily to be broad, relevant, rigorous, and highly scientific, but the general perception of the field has not evolved with the science and programs."
- "Lack of commitment by NOAA to academic research and graduate student training in fisheries is the principal impediment. Papers in Science and general coverage of fisheries is increasing; promoting ecosystem based fisheries assessment and management will stimulate educational opportunities"
- "The Cooperative Fish and Wildlife Research Unit program desperately needs to be expanded. Doubling that program would go a long way to solving many federal education and research problems in wildlife and fisheries."
- "Few go into this field because of the low starting salaries. Unless this changes fewer will enter the field."

- "The development and recruitment of individuals with expertise in the areas of fisheries that you identify with regard to the needs for support of the MSFCMA is a real need. If government invests now, we can meet the need for trained fisheries professionals. If not, we as a society will not be able to manage our fisheries effectively."