MARINE FISHERIES INITIATIVE

MARFIN

17TH ANNUAL CONFERENCE
DECEMBER 11-12, 2007
ST PETERSBURG, FL

Marine Fisheries Initiative Program

(MARFIN)

Seventeenth Annual MARFIN Conference

December 11-12, 2007

National Marine Fisheries Service
State/Federal Liaison Branch
263 13th Avenue South
Southeast Regional Office
St. Petersburg, Florida 33701
(727) 824-5324

Cover Photo by Terri Almquist

HISTORY OF THE MARFIN PROGRAM

The Marine Fisheries Initiative (MARFIN) Program received its initial impetus from a 1983 discussion paper entitled: "Research Needs For Information Leading To Full and Wise Use of Fishery Resources In The Gulf of Mexico," by Dr. Thomas D. McIlwain of the Gulf Coast Research Laboratory while he was in the office of then Representative Trent Lott[1]. This paper, sometimes referred to as the Lott-McIlwain paper, proposed an additional investment in fisheries research and development in the Gulf of Mexico to increase the economic contribution of marine fisheries, develop more valuable products from existing fisheries, develop export markets, forecast variation in yields, and conserve and maintain presently exploited resources.

The next step in the evolution of MARFIN was the preparation and publication of the Marine Fisheries Initiative - Gulf of Mexico Phase[2]. This publication, developed by a joint industry, federal, state, and academic task force, detailed the research and development efforts necessary to enhance, restore, and maintain fisheries in the Gulf of Mexico. The program focused on funding projects that had the greatest probability of maintaining and improving existing fisheries, increasing revenues for the domestic industry, increasing yields from fisheries, and generating increased recreational opportunity and harvest potential. Projects were to be selected for funding on their likelihood of achieving these benefits through both short-term and long-term research with consideration of the magnitude of the eventual benefit that might be realized. Both short-term projects yielding immediate benefits and long-term projects were to receive high-priority emphasis. Planning emphasis was placed upon attaining priority goals either through a single project or a series of projects necessary to attain that goal.

In 1992, the MARFIN program was expanded to include a South Atlantic component (North Carolina, South Carolina, Georgia, and the Atlantic coast of Florida). The goals and objectives of the South Atlantic Phase of MARFIN are described in Special Report No. 13 of the Atlantic States Marine Fisheries Commission, Marine Fisheries Initiative (MARFIN) South Atlantic Phase[3].

The Lott-McIlwain paper and the Marine Fisheries Initiative publication were instrumental in gaining public support for the MARFIN program. On December 4, 1985, the conference report of the House and Senate that appropriated funds for the Departments of Commerce, Justice, State, the judiciary, and related agencies for the fiscal year (FY) ending September 30, 1986, allocated $2,850,000 for the MARFIN Program.

The following list represents funding for each year from the start of the MARFIN program until the current year:

* Fiscal Year 1986 - $2,850,000
* Fiscal Year 1987 - $3,500,000
* Fiscal Year 1988 - $3,500,000
* Fiscal Year 1989 - $3,000,000
* Fiscal Year 1990 - $3,000,000
* Fiscal Year 1991 - $2,986,000

* Fiscal Year 1992 - $4,000,000 (This includes $500,000 of the South Atlantic MARFIN and $1,300,000 for shrimp trawl bycatch studies.)

* Fiscal Year 1993 - $3,540,000

* Fiscal Year 1994 - $3,542,000

* Fiscal Year 1995 - $3,540,000

* Fiscal Year 1996 - $2,760,000 (No new projects were accepted during FY 1996 due to a reduction in congressional allocation, and because of the large number of active multi-year projects selected during previous funding cycles.)

* Fiscal Year 1997 - $3,000,000

* Fiscal Year 1998 - $3,000,000

* Fiscal Year 1999 - $3,000,000 (This includes $500,000 for the Northeast Region.)

* Fiscal Year 2000 - $2,750,000 (No new projects were accepted during FY 2000 due to a reduction in congressional allocation, and because of the large number of active multi-year projects selected during previous funding cycles.)

* Fiscal Year 2001 - $3,500,000 (This includes $250,000 for the Northeast Region and $750,000 for red snapper research.)

* Fiscal Year 2002 - $3,500,000 (This includes $250,000 for the Northeast Region and $750,000 for red snapper research.)

* Fiscal Year 2003 - $3,250,000 (This includes $250,000 for the Northeast Region and $500,000 for red snapper research.)

* Fiscal Year 2004 - $2,500,000

* Fiscal Year 2005 - $3,400,000

* Fiscal Year 2006 - $2,400,000

* Fiscal Year 2007 - $2,400,000

* Fiscal Year 2008 - Unknown at this time.

MARFIN promotes and endorses programs that seek to optimize economic and social benefits from marine fishery resources through cooperative efforts that evoke the best research and management talents of the Southeast Region. The intent of the MARFIN program is to focus projects on key fisheries issues in the southeast United States.

[1]Office of Representative Trent Lott, Washington, DC; Dr. Thomas D. McIlwain; May 1983

[2]Gulf States Marine Fisheries Commission, P.O. Box 426, Ocean Springs, MS 39564; J.Y. Christman, D.J. Etzold, T.D. McIlwain, L.B.Simpson, Eds. January 1985

[3]Special Report No, 13 of the Atlantic States Marine Fisheries Commission; E.J. Joseph, V.G. Burrell, D.M. Cupka, P.J. Eldridge, August 1988

SEVENTEENTH ANNUAL MARFIN CONFERENCE
December 11-12, 2007

Fish and Wildlife Research Institute (KAS Auditorium)
100 Eighth Avenue SE
St. Petersburg, FL 33701
(727) 896-8626

Tuesday, December 11, 2007

8:00am	Registration
8:30am	Welcome & Conference Objectives *Dr. Roy E. Crabtree* Regional Administrator NOAA Fisheries, Southeast Region *Ellie F. Roche* Chief, State/Federal Liaison Branch NOAA Fisheries, Southeast Region

SESSION I - Reef Fish: Session Chair – *Larry Simpson*

8:45-9:05am	Grant# NA04NMF4330072 *PI: Dr. Behzad Mahmoudi, Jr.* Recipient: Florida Fish and Wildlife Conservation Commission Title: Development of a Spatially-Explicit Age-Structured Model for Assessment and Management of Grouper Stocks in the U.S. Southeast Region
9:10-9:40am	Grant# 05MFIH07, 06MFIH06 & 07MFIH09 *PI: Jennifer Potts* Recipient: NMFS Beaufort Laboratory Title: Age and Growth of SEDAR Priority Species of the Snapper Grouper Complex of the U.S. South Atlantic
9:45-10:05am	Grant# 06MFIH03 *PI: Dr. Andrew David* Recipient: NMFS Panama City Laboratory Title: Further Studies on the Susceptibility of Reef Fish to Surface Trolling at the Madison-Swanson Marine Protected Area in the Northeastern Gulf of Mexico
10:05-10:25am	**Break**

10:30-11:05am	Grant# 07MFIH010 *PI: Dr. Doug DeVries* Recipient: NMFS Panama City Laboratory Title: A Comparison of Chevron Traps and Stationary Video Drop Camera Arrays for Assessing Abundance, Demographics, and Community Structure of Reef Fish on the Inner Shelf of the Northeastern Gulf of Mexico Grant# 05MFIH05 *PI: Dr. Doug DeVries* Recipient: NMFS Panama City Laboratory Title: Recruitment Indices for the Shallow-Water Grouper Complex
11:10-11:30am	Grant# 05MFIH03 *PI: Dr. Joseph Powers* Recipient: NMFS Southeast Fisheries Science Center Title: Development of Model-Based Ecosystem Management Criteria for Assessing Bycatch and Reef-Fish Assemblages
11:35-11:55am	Grant# NA17FF2010 *PI: Karen Burns* *Carolyn Weaver will present* Recipient: Mote Marine Laboratory Title: Evaluation of the Efficacy of Current Minimum Size Regulations for Selected Reef Fish Based on Release Mortality and Fish Physiology
11:55am-1:30pm	**Lunch Break**
1:30-1:50pm	Grant# 05MFIH04 & 06MFIH14 *PI: Robert Allman* Recipient: NMFS Panama City Laboratory Title: Spatial and Temporal Demographics of Gulf of Mexico Reef Fish and Mackerels
1:55-2:15pm	Grant# NA05NMF4331069 *PI: Bobby Spaeth* Recipient: Madeira Marine Services Title: Industry Based Observer Program in the Reef Fish Fishery-Gulf of Mexico

SESSION II - Essential Fish Habitat: Session Chair – *Dr. LaDon Swann*

2:20-2:40pm

Grant# NA04NMF4330077
PI: Dr. Joanne Halls
Andy Shepard will present
Recipient: University of North Carolina, Wilmington

Title: Fisheries and Habitat Assessment of the *Oculina* Banks Habitat Area of Particular Concern: A Multi-Media Approach Using GIS and the World Wide Web

2:40-2:55pm **Break**

2:55-3:15pm

Grant# NA17FF2876
PI: Dr. Felicia Coleman
Dr. Chris Koenig will present
Recipient: Florida State University

Title: Demographics, Density and Seasonal Movement Patterns of Reef Fish in the Northeastern Gulf of Mexico Associated with Marine Reserves

3:20-3:40pm

Grant# NA17FF2878
PI: Dr. Robert Chapman
Recipient: South Carolina Department of Natural Resources

Title: Can Marine Protected Areas Conserve Genetic Diversity in Tomtate (*Haemulon aurolineatum*) and French Grunt (*Haemulon flavolineatum)?*

3:45-4:05pm

Grant# NA05NMF4331077
PI: Tom Matthews
Recipient: Florida Fish and Wildlife Conservation Commission

Title: The Effects of Lobster Traps on Coral Communities in the Florida Keys

SESSION III - Red Snapper: Session Chair – *Dr. Robert Shipp*

4:10-4:30pm

Grant# NA17FF2012
PI: Dr. Sandra Diamond
Matthew Campbell will present
Recipient: Texas Tech University

Title: Estimating Discard Rate and Release Mortality of Red Snapper in Texas Fisheries

4:35-4:55pm	Grant# NA17FF2880 *PI: Dr. John Gold* Recipient: Texas Agricultural Experiment Station Title: Development of Assays for Major Histocompatibility Complex (MHC) Class I and Class II Loci in Gulf Red Snapper for Use in Stock Structure Analysis and Assessment of Genetic Health
4:55pm	**Wrap–up and End of Today's Presentations**

Wednesday, December 12, 2007 - Continuation of the Red Snapper Session

8:00am	Registration
8:30-8:50am	Grant# NA17FF2881 *PI: Karen Burns* *Carolyn Weaver will present* Recipient: Mote Marine Laboratory Title: Geographic Comparison of Age, Growth, Reproduction, Movement and Survival of Red Snapper off the State of Florida
8:55-9:15am	Grant# NA04NMF4330367 *PI: Dr. Will Patterson* Recipient: University of West Florida Title: Estimation of the Source of Red Snapper Recruits to the West Florida Shelf with Otolith Microchemistry
9:20-9:40am	Grant# NA17FF2865 *PI: Dr. Nelson Ehrhardt* Recipient: University of Miami Title: Linking Spatial-Temporal Population Size Structures and Fishing Effort Dynamics to Assess the Effectiveness of Minimum Size for Red Snapper Management

SESSION IV - Economic/Sociocultural: Session Chair – *Mark Robson*

9:45-10:05am	Grant# NA04NMF4330316 *PI: Dr. Benjamin Blount* Recipient: University of Texas at San Antonio Title: Factors Affecting Participation in Marine Fisheries: Case Studies in Georgia and North Carolina
10:05-10:20am	**Break**

10:20-10:40am Grant# 05MFIH02
PI: Dr. Brent Stoffle
Recipient: NMFS Southeast Fisheries Science Center

Title: Profiling the St. Croix Fisheries: An Examination of the Social, Cultural and Economic Importance of the St. Croix Fisheries and the Community Designation Process

10:45-11:05am Grant# NA04NMF4330079
PI: Thomas Murray
Dr. Manoj Shivlani will present
Recipient: Thomas J. Murray & Associates, Inc.

Title: Tortugas 2000- A Post Mortem: Evaluation of Actual Versus Projected Socioeconomic Impacts of the Dry Tortugas Ecological Reserve

11:10-11:30am Grant# NA04NMF4330080
PI: Dr. Richard Woodward
Aaron Mamula will present
Recipient: Texas Agricultural Experiment Station

Title: Cost and Effectiveness of Sequential License Buy-back Programs in the Gulf of Mexico

11:35-11:55am Grant# NA17FF2868
PI: Dr. Richard Kazmierczak, Jr.
Recipient: Louisiana State University

Title: An Intertemporal and Spatially-Dynamic Supply Model of the Gulf of Mexico Shrimp Fleet for Use in Management and Bycatch Reduction

11:55-1:30pm **Lunch Break**

1:30-1:50pm Grant# NA17FF2879
PI: Dr. Walter Keithly
Recipient: Louisiana State University

Title: An Economic Analysis of Fleet Dynamics in the Gulf of Mexico Grouper Fishery

SESSION V - Other Topics: Session Chair – *Dr. LaDon Swann*

1:55-2:15pm Grant# NA05NMF4331081
PI: Dr. Nelson Ehrhardt
Recipient: University of Miami

Title: Meta-Population Stock Assessment Methods Incorporating Climatic and Ecosystem Effects for the Florida Spiny Lobster Fishery

2:20-2:40pm	Grant# NA17FF2885 *PI: Dr. Charles Wenner* Recipient: South Carolina Department of Natural Resources Title: Atlantic Croaker (*Micropogonias undulatus*) along the Middle Atlantic Coast and Southeast Coast of the United States
2:45-3:05pm	Grant# NA17FF2882 *PI: Dr. Richard McBride* *Michael Murphy will present* Recipient: Florida Fish and Wildlife Conservation Commission Title: Fishery and Population Characteristics of Wahoo (*Acanthocybium solandri)* in Florida and Adjacent Waters of the Western North Atlantic Ocean
3:05-3:20pm	**Break**
3:20-3:40pm	Grant# NA04NMF4330293 *PI: Dr. Peter Rand* *Chris Taylor will present* Recipient: The Wild Salmon Center Title: Identifying Spawning Grounds and Classifying Habitat for Red Drum (*Sciaenops ocellatus)* in Pamlico Sound, NC
3:45-4:05pm	Grant# 05MFIH06 *PI: Dr. James Nance* Recipient: NMFS Galveston Laboratory Title: BRD Evaluation Observers
4:10-4:30pm	Grant# NA17FF2867 *PI: Judy Jamison* *Gary Graham will present* Recipient: Gulf and South Atlantic Fisheries Foundation Title: Technology Transfer of New Turtle Excluder Device Modifications and Updated Bycatch Reduction Device Information to the Southeastern Shrimp Industry
4:30-4:45pm	**Summary and Conclusions** – *Robert Mahood*
4:45pm	**Adjourn the Seventeenth Annual MARFIN Conference**

SESSION I - Reef Fish

Session Chair: Larry Simpson

Development of a spatially-explicit age-structured model for assessment and management of grouper stocks in the U.S. Southeast region

MARFIN Grant No. NA04NMF4330072

Funding Amount: $68,044 Federal ($14,018 non-Federal)

Drs. Behzad Mahmoudi, Carl Walters, and Steve Martell

Florida Fish and Wildlife Conservation Commission
Fish and Wildlife Research Institute
100 Eighth Ave SE
St. Petersburg, Florida 33701

Study Objective: To develop an age- and spatially-structured model for stock assessment and management of important grouper species (i.e., gag, red grouper, and scamp) in the southeast and the Gulf of Mexico. Analysis of historical stock assessment data and policy analysis for sustainable harvesting are greatly complicated by two aspects of the life histories of most grouper species: (1) protogyny (change in sex from female to male as fish grow), and (2) strong ontogenetic and seasonal migration patterns from onshore to offshore areas, with accompanying changes in exposure to fishing effort that is often concentrated in more accessible, inshore areas. Area closure (no-take marine reserves) is considered as one of the tools by management councils for reducing the risk of overfishing and for rebuilding stocks. However, evidence that such reserves actually enhance fishery yields is limited, primarily because of difficulties in quantifying the exchange of individuals between local populations within and outside the protected area. The design of marine reserves must incorporate understanding of how dispersal influences population dynamics in a given area, and thus a need for a spatially-structured population model.

Methods and Materials: The spatially-explicit fish population dynamics model (Fishmod) developed by co-authors (Drs Carl Walters and Steve Martell) of this project was modified to include groupers life history parameters and fisheries characteristics. Fishmod is intended to provide a flexible framework for developing spatial (grid, raster cell) models of age-structured population dynamics responses by multiple fish stocks (and/or species) to multiple fishing gears. It combines spatial population dynamics simulation, including seasonal and ontogenetic (by age) movement among grid cells, with simulation of spatial allocation of fishing effort. Sub-routines developed for Fishmod have three main uses: (1) evaluation of population impacts of alternative harvest management policies involving spatial closures, size limits, and limits on fishing effort; (2) stock assessment (estimation of abundance and recruitment relationships) using spatial catch and size/age composition data, in a "stock synthesis" (forward simulation) approach where the model is fit to time series data by nonlinear search procedures applied to key parameters; and (3) trouble shooting for stock assessment methods that involve spatially aggregated data, where Fishmod is treated as a realistically complex reference model for generating fake data to challenge the estimation methods. The basic time unit or step in Fishmod is a month rather than a year as typically used in fish stock assessment models, allowing use of the model for short-lived species (e.g. prawns) along with evaluation of seasonal management policies and possible benefits of using seasonal harvest and relative abundance data in assessment (e.g., of seasonal depletion patterns).

Spatial maps with cells, as small as 2nm x 2nm, can be set up quickly using a Global bathymetry database provided by Reg Watson of the UBC Sea Around Us Project. Users can provide information about a variety of map attributes or layers for each grid cell, ranging from habitat quality to relative fishing cost. In Fishmod, stocks are created by seeding the nursery cells. Each stock is assigned a species code and distinctive growth, fecundity, vulnerability and movement schedules. The species code is used to summarize predicted changes (and outputs such as catch) at species as well as stock level. This convention allows flexibility in representing both stock and species structures of fisheries, one species may be represented by several spawning stocks while another might be treated as a single large stock. As each simulation proceeds, total biomass of fish (summed over stocks and ages) vulnerable to each gear type is calculated monthly for each map cell, and these biomass distributions along with map information on fishing costs/preferences are used to predict monthly spatial distributions of fishing effort. Effort can be smeared widely over the map by using a simple gravity model (effort on each cell proportional to total biomass) or a more complex Ideal Free Distribution model that attempts to predict the effort pattern that would maximize profitability of fishing given perfect information on the distribution of vulnerable biomass.

For modeling grouper populations, the standard age-structured model accounting of survival, growth, catch, maturity-egg production, and recruitment is complemented by (1) a spatial dispersal/migration submodel, (2) recognition of substock structure in the form of inshore (nursery) areas to which animals return for spawning (separate age structure accounting for substock from each nursery area), and (3) spatial fishing effort dynamics in which fishers are assumed to allocate effort in relation to local abundance and regulations such as marine protected areas. Parameters for each of the submodels were either taken from independent studies (e.g. growth and natural mortality rate parameters) or estimated by comparing model predictions to available data using statistical criterion (i.e., likelihood or least squares methods). Time forcing inputs consisted of historical removals or fishing effort data, and observation models were constructed to statistically compare model predictions to field observations from catch statistics and fishery-independent biomass estimates.

Catches generated from different sectors of the grouper fishery generally represent vulnerable biomass at given space and time, gear selectivity, and fishing effort. Each age of each of the stocks is assigned a distribution over the model spatial cells at each (monthly) simulation time step, and this distribution is updated over time using very flexible age-stock dependent migration rules along with population dynamics (growth/mortality/recruitment) bookkeeping. Fishing effort can be treated as either a driving (historical or policy) input or as a dynamic variable that responds to changes in the distribution and availability of fish; spatial effort dynamics can be simulated with several types of models (gravity, IFD profit maximizing). Assuming ideal free distribution for fishing effort reduces the need for a time series of spatially explicit fishing effort data. This convenience, however, comes at a cost of losing the ability to estimate model parameters that are important for determining dispersal and migration patterns. Therefore, wherever possible we used data that was informative about the distribution of fish and fisheries operations.

Stock assessment (fitting of the model to historical data) is done by maximizing a likelihood function for space-time catch and size composition data given model parameters. One model map layer is used to assign each model map cell to a statistical data unit (or larger spatial statistical cell),

and monthly catches by gear and species are predicted for each of these statistical units. This approach allows comparison and fitting of the model to either aggregate catch data (all model cells assigned to a single statistical unit) or to spatially disaggregated data that may not be of the same resolution as used for movement and spatial policy simulations (e.g. statistical data may be available at 1 degree resolution, while model cells may be 0.1 degree on a side).

Conclusion and Recommendation: Harvest policy evaluation interface in Fishmod provides many control options for limiting exploitation rates on fish populations. These options include adjusting size limits, seasonal closures by specific gear types, effort limitation and latent effort, limiting annual catch or (TAC's), and spatial policy options such as permanently closed areas or restricting fishing effort to certain regions (can also be gear or fishery specific). The Fishmod also includes a closed-loop simulation subroutine, where each model run simulates the process of collecting data from a spatially explicit population, and then estimate key population using a deterministic delay-difference model. The multi-attribute utility (MAU) subroutine in Fishmod is used to provide quantitative comparisons of policy options that involve multiple and possibly conflicting objectives and performance measures. The MAU subroutine simulates impact of each of the management scenarios on a range of management performance measures, ranging from biological output measures (catch), to economic support measures (fishing effort allowed), to biological sustainability measures (stock biomasses at end of the simulation scenario). The preliminary simulation runs and sensitivity analyses prove that Fishmod is an effective tool for incorporating spatially structured population dynamics into assessment. However, the appropriate future use of this model for management purposes requires high resolution spatial data for life history parameters, movement and migration rate, topography and habitat distribution, size/age composition from each fishing gear, and catch and effort distribution for each fishery. While Fishmod can sometimes provide detailed, quantitative predictions about the efficacy of various policy alternatives, its central value is likely to be as a strategic "policy screening" tool to help identify both policy opportunities and difficulties that arise from complex spatial dynamics.

Age and Growth of SEDAR Priority Species of the Snapper Grouper Complex of the U.S. South Atlantic

MARFIN Grant Nos. 05MFIH07, 06MFIH06 and 07MFIH09

Funding Amounts: 2005: $118,300; 2006: $109,449; 2007: $120,000

Jennifer C. Potts, Daniel R. Carr, and Stephanie A. McInerny

NOAA Fisheries Service
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Study Objectives: To age species managed by the South Atlantic Fishery Management Council's (SAFMC) Snapper Grouper Fishery Management Plan (FMP) in the order identified by the Southeast Data Assessment and Review (SEDAR) planning committee. A secondary objective was to create reference collections of processed aging structures for exchange with other agencies' laboratories to assess consistency of assigning ages for eventual merging of data sets for stock assessments.

Methods and Materials: Hardparts (e.g., otoliths, spines, etc.) from fish used for age and growth studies were collected from various fisheries operating along the southeastern United States from North Carolina through the Florida Keys. They were received and cataloged at the NMFS Beaufort laboratory, and the data were reviewed for use in aging studies. The otoliths of gag (*Mycteroperca microlepis*), red porgy (*Pagrus pagrus*), greater amberjack (*Seriola dumerili*) and red snapper (*Lutjanus campechanus*) were selected for processing based on the SEDAR schedule. Otoliths that could not be read whole were sectioned on a slow speed saw with a diamond wafering blade at a thickness of 0.3 – 0.5 mm. The sections were mounted on glass slides with thermoplastic and then covered with a liquid coverslip. The sections were viewed under a dissection microscope connected to an image analysis system, and opaque zones were enumerated.

Whole otoliths and sections were exchanged between our laboratory (NMFS-B) and other fish aging laboratories to determine consistency of age assignation. These exchanges have led to the maintenance of reference collections for quality assurance/quality control. Aging error matrices were constructed from new data and existing data. The age comparison data were used in subsequent population assessments.

Conclusions and Recommendations: Approximately 3,500 **gag** otolith samples collected from 1975 to 2005 from recreational and commercial fisheries were processed for aging. Of those, 97% were aged and ranged in age from 0 to 30. Otoliths of gag were relatively easy to read and age. The otoliths can be read whole up to age 8. Otoliths of larger, older gag need to be sectioned to enumerate the opaque zones (annuli). An aging workshop was held with participants from NMFS-B, South Carolina Department of Natural Resources (SCDNR), and National Marine Fisheries Service's Panama City Laboratory (NMFS-PC). All three labs used

the same otolith processing methodology. Only minor differences in the interpretation of the otolith structure existed between the labs. The differences were primarily with the older fish and assignment of the marginal edge type – translucent or opaque. All three groups identified the same structure as first increment and average percent error (APE) in each pairwise comparison was under 5%, suggesting no appreciable bias. The gag age data for the South Atlantic region generated by NMFS-B and SCDNR were combined for SEDAR10.

Approximately 1,500 **red porgy** otoliths were processed for aging and 85% of those were assigned ages ranging from 1 to 19 years. The otoliths were collected from 1979 to 2004 from the recreational and commercial fisheries. All of the otoliths were sectioned before reading them. Interpretation of the otolith structure was not as easy as gag. Interpretation of the first increment has been problematic and some fish appear to form check marks between the true annuli that may be misleading. Other laboratories aging this species tend to use whole otoliths, not sections. During the workshop on aging, differences in interpretation of the first annulus came to light. In an exchange of whole otoliths and then the same otoliths sectioned, analysis showed that all readers consistently aged the fish one year older when reading sections versus the whole otolith. This data set was used to create error matrices to correct for whole otolith ages or section otolith ages for the purpose of SEDAR. By using the error matrices more age data could be included in the stock assessment (SEDAR Update 2).

Between 1998 and 2006, 1,756 **greater amberjack** otoliths were collected from fisheries operating primarily along the east coast of Florida. The otoliths were thin sectioned and 90% (n = 1,576) were assigned ages. An aging workshop for greater amberjack was held with participants from NMFS-B, SCDNR and University of Florida, Gainesville. As a result, age data from NMFS-B and SCDNR were determined to be consistent with each other and were combined for the SEDAR-15 stock assessment. Max age was 13 years, though previous studies reported max age of 17. Female greater amberjack tended to be the largest fish and had a slightly higher modal length than males. Overall size-at-age was not significantly different for males and females. Because the samples for this study were all collected in years with minimum size regulations, determining theoretical growth for the youngest fish may not be accurate. We choose to use the Diaz et al. methodology for determining the von Bertalanffy growth parameters, which resulted in the following equation: $L_t=1153(1 - e^{-0.35(t + 0.50)})$, L is fork length in mm.

A total of 6,370 **red snapper** otoliths were collected from the US South Atlantic recreational and commercial fisheries from 1977 through 2006 for an age and growth study in support of SEDAR-15. A reference collection from the NMFS Panama City Lab was exchanged with NMFS-B to aid in initial aging of this fish. Further exchanges of otolith sections with personnel from SCDNR were carried out to determine consistency in age determination of red snapper so subsequent age data sets could be combined for SEDAR assessments. The maximum observed age in this study was 54 years. The collection spanned over years with changes in fishery management regulations: 1983 – 12 inch total length (TL) minimum size and 1992 – 20 inch TL minimum size. Data from this study supports the hypothesis that minimum size limits cause the fishery to selectively remove the fastest growers from the population. For fish of ages 2 to 5 years, those most affected by the size limit, there was a shift to fish being larger-at-age after 1992 compared to before that time. Growth for the red snapper overall is represented by the following von Bertalanffy equation: $L_t = 897 * (1 - e^{-0.234 (t + 0.41)})$.

Further Studies on the Susceptibility of Reef Fish to Surface Trolling at the Madison-Swanson Marine Protected Area in the Northeastern Gulf of Mexico

MARFIN Grant No. 06MFIH03

Funding Amount: $82,000

Dr. Andrew W. David

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Southeast Fisheries Science Center
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Study Objective: Determine susceptibility of reef fish to surface trolling commonly used to target coastal pelagic and highly migratory species in the Madison-Swanson MPA. This project was conducted as outlined in a settlement agreement of a lawsuit filed against the U.S. Department of Commerce by The Ocean Conservancy.

Methods and Materials: A local charter boat was hired to make twenty trips to the Madison-Swanson MPA and troll for four hours per trip using techniques commonly used to target coastal pelagic and highly migratory species. Three variables were examined: vessel speed, trolling weight, and lure type. Each variable had two levels, speed was either low (4.1 - 6.0 kt) or high (6.1 - 8.0 kt), weights were either low (12 oz) or high (24 oz) and lures were either natural (ballyhoo) or artificial (plug). Equal fishing time was allotted for each of the six combinations tested. Two of the eight possible combinations were not evaluated as high speed/high weight combinations were assumed to have high probabilities of breaking the lines. Additionally, the twenty trips were equally divided between the first and second halves of the six month open-to-fishing season. A total of eighty hours of trolling was stipulated in the settlement agreement. NOAA Fisheries biologists participated in each trip and recorded times and positions of every deployment and retrieval of gear as well as data on all fish caught. Data was analyzed for any statistically significant differences in catch rates related to the factors tested.

Conclusions and Recommendations: Thirty-one fish were caught during this study, thirty were coastal pelagic species and one was a large coastal shark. The species breakdown was eighteen wahoo, five barracuda, two king mackerel, two dolphin (mahi), two bonita, one blackfin tuna and one spinner shark. There were no statistical differences in catch rates attributable to the vessel speed, trolling weight or lure type factors. Additionally the season and time of day did not affect catch rates. The only factor which revealed any significance was the duration of the trolling trial in which the shortest durations trials (1 - 5 min) produced higher catch rates than any other duration interval ($p = 0.0002$ for all fish and $p = 0.0096$ for wahoo). The principal conclusion drawn from this study is reef fish are not susceptible to surface trolling operations specifically targeting coastal pelagic and highly migratory species.

A comparison of chevron traps and stationary video drop camera arrays for assessing abundance, demographics, and community structure of reef fish on the inner shelf of the northeastern Gulf of Mexico

MARFIN Grant No. 07MFIH10

Funding Amount: $42,000

Dr. Douglas A. DeVries, John H. Brusher, and Dr. Gary R. Fitzhugh

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Study Objectives: To compare the performance of chevron traps and digital video drop camera arrays in assessing the relative abundance and community structure of reef fish on the inner shelf of the northeastern Gulf of Mexico. Secondary objectives were to continue using chevron traps to examine annual regional catch, recruitment, and demographic patterns of several economically important reef fish species in the northeastern Gulf and continue surveying the area for new natural reef sites to expand the sampling universe.

Methods and Materials: A video drop camera array and chevron fish trap were used to survey 83 natural hard bottom sites between 86.2W off the Florida Panhandle and 28.3N off the northwestern Florida peninsula; 59 sites were east and 26 west of Cape San Blas (the Cape). Respective depth ranges in the two areas were 7.5-28.0 m (mean=16.0) and 18.4-32.0 m (mean=25.2). The survey sampling design was systematic (fixed sites – natural hard bottom only) because of a limited sample site universe and logistic constraints.

At each site, during daylight hours, the camera array was deployed first for 30 minutes, followed by the trap for 1.5 hours. The array consisted of 4 high definition, digital video cameras mounted horizontally at 90° angles to each other in, and 30 cm above the bottom of, an aluminum frame. Parallel lasers mounted above and below each camera were used to estimate the sizes of fish which crossed the field of view perpendicular to the camera. The chevron traps were identical to those used in the South Atlantic MARMAP survey except throat size (area) was 50% smaller. Traps were baited with 3 previously frozen Atlantic mackerel *Scomber scombrus*. All fish were identified, counted, and measured (TL and FL). Otoliths were removed from all groupers and from a maximum of 5 individuals/species/site from red, vermilion, and lane snappers, black seabass, red porgy, white grunt, and gray triggerfish (dorsal spine). In catches with >5 of any of these species, a random subsample of 5 was processed. Fish sampled for otoliths were sexed macroscopically; all others were released alive.

With the video data, tapes of all four cameras were scanned, then 20 minutes of the one with the best view of the habitat (if there was a difference) was analyzed in detail. If none was obviously better, one tape was randomly chosen. All fish were identified to the lowest discernable taxon. The estimator of abundance was the maximum number of a given species in the field of view at any time during the first unoccluded 20 minutes of the 30-minute videotape.

Conclusions and Recommendations: Video data from the drop camera array revealed, not surprisingly, considerable selectivity in the chevron fish trap catches. Although processing of the 2007 video data has not been completed, data from the 2006 survey (89 sites E and 25 W of Cape San Blas) showed that the traps tended to select against gag and excluded most scamp and hogfish, and all gray snapper. In 2006, gag were observed with the video gear at 33% of sites east and at 40% west of the Cape, but were caught in the trap at only 10% and none of the sites in those respective areas. Scamp were present in video data from 11 and 72% of sites east and west of San Blas, but were captured in the trap at only 1% and none of those sites. Hogfish, rare west of the Cape, were observed visually at 23% of the eastern sites but caught at none. Gray snapper were observed at 20 and 60% of sites east and west, but none were captured in either area. Red grouper, red snapper, gray triggerfish, white grunt, and red porgy appear not to be selected against by the chevron trap, or only slightly. Red grouper were present in 27 and 10% of video and trap samples at eastern sites, and in 28% of both gears at western sites. Red snapper were observed at 92 and 14% of sites east and west, and were present in 88% (E) and 8% (W) of trap catches. Gray triggerfish occurred in 39 (E) and 92% (W) of video samples vs. 25 (E) and 64% (W) of trap samples. White grunt were observed at 42 (E) and 40% (W) and caught in the trap at 47 (E) and 8% (W) of the sites. Red porgy were present at 12% of western sites in both gears. Lasers were not installed on the camera array until 2007, so sizes from 2006 collections could not be compared between the video and trap data.

Overall species composition data from 2006 also demonstrated how selective the chevron trap was compared to the camera array. East of Cape San Blas at least 80 species were observed in the video data, but only 21 were captured in the trap. In the west, 54 species were observed with the camera array compared to 11 captured in the trap.

The mean catch rate of red grouper east of the Cape in 2007, as in 2006, continued to be about 25% of the rate seen in 2005–about 0.1 vs. 0.4. As in 2005 and 2006, the 2002 year class (5 year olds) dominated the catch, although sample size was small. All but one of the gags caught east of the Cape were either age one or three. In 2005 and 2006, two and three year olds dominated the catch. The complete absence of two year olds in 2007 may reflect the loss of most of that cohort during the severe red tide in the northeast Gulf in summer of 2005. Trends in annual CPUE for white grunt and black seabass east of the Cape were also consistent with the hypothesis that the 2005 red tide significantly impacted reef fishes in the region. Mean CPUE for white grunt dropped 71% from 2005 to 2006 (5.5 to 1.6), then rebounded 200% to 4.8 in 2007. The pattern for black seabass was similar but not as dramatic, falling from a mean of 0.8 fish/trap hour in 2005 to 0.3 in 2006 (58%), then increasing 54% in 2007 to 0.5.

This study further demonstrates the value a regional fishery-independent survey of hard bottom habitats using chevron traps and stationary video arrays. The two gears complement each other. The former provides invaluable age and reproductive data and CPUE data. The latter, because it is much less selective, yields more unbiased abundance estimates on many more species and provides considerable data on reef fish ecology, distribution, and community structure. Such site-specific, long-term data on exploited and unexploited reef fishes will be invaluable for ecosystem-based fisheries management and documenting potential climate change effects.

Recruitment Indices for the Shallow-Water Grouper Complex

MARFIN Grant No. 05MFIH05

Funding Amount: $55,900

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Study Objectives: To develop age-based annual recruitment indices of shallow water groupers (gag *Mycteroperca microlepis*, scamp *M. phenax*, and red grouper *Epinephelus morio*) in the northeastern Gulf of Mexico using a fishery-independent trap survey targeting young (approximate age 0-3) individuals. Secondary objectives were 1) examine catch composition and demographics of the trap catches and regional patterns, 2) continue surveying for new natural reef sites to expand the limited universe of sampling sites, and 3) begin working with the Florida Fish and Wildlife Research Institute to evaluate the effectiveness of other gear types for surveying reef fish and expand the areal coverage to the entire West Florida inner continental shelf.

Methods and Materials: The survey sampling design was systematic (fixed sites – natural hard bottom only) because of a limited sample site universe and logistic constraints. We used chevron fish traps identical to those used in the South Atlantic MARMAP survey except that throat size (area) was 50% smaller. Traps were baited with 3 previously frozen Atlantic mackerel *Scomber scombrus* and soaked ~1.5 hours during daylight hours. All fish were identified, counted and measured (TL and FL). Otoliths were removed from all groupers and from a maximum of 5 individuals/species/site from all snappers (lane, red, vermilion), gray triggerfish, black seabass, red porgy, and white grunt. In catches with >5 of any of these species, a random subsample of 5 was processed. Fish sampled for otoliths were sexed macroscopically; all others were released alive. A total of 101 trap sets were made Jun 9 – Oct 15, 2005, at 75 unique sites – 24 west and 51 east of Cape San Blas. Of the latter, 24 sites were sampled twice (different dates) and one three times. Site depths were 6.4 - 24.3m (mean= 12.8m) east, and 20.0 – 31.4m (mean =25.0m) west, of Cape San Blas. Sampling ranged as far west as 86.2° W and as far south as 29.1° N, and was focused off Panama City, Carrabelle, and Steinhatchee, FL.

Conclusions and Recommendations: Chevron fish traps were fairly effective at capturing young gag and red grouper, but caught no scamp in 2005. Gag were caught in 20.8 and 37.5% of sets east and west of Cape San Blas, respectively, and ranged from ages 1 to 5 years (mode=3) and 305 to 647 mm TL (mean=436). Red grouper were caught in 29.9 and 41.7% of sets east and west of Cape San Blas, respectively, and ranged from ages 3 to 7 years and 333 to 630 mm TL (mean=432). The age structure of red grouper differed greatly east and west of Cape San Blas -- three year olds (2002 year class) dominated in the east and six year olds in the west.

This finding suggests the Big Bend region may be the recruitment source of red grouper exploited west of Cape San Blas. About 96% of the gag and 77% of the red grouper caught were below the recreational (and commercial for the latter) size limit, so the survey should provide fishery managers with valuable information on population trends before these species recruit to the fisheries.

Other exploited reef fishes caught in the survey included red, lane, and vermilion snappers (*Lutjanus campechanus, L. synagris, Rhomboplites aurorubens*); gray triggerfish *Balistes capriscus*; red porgy *Pagrus pagrus*; white grunt *Haemulon plumieri*; black seabass *Centopristis striata*; and hogfish *Lachnolaimus maximus*. As with the groupers, there were large regional differences in catch rates. Red snapper were by far the most common reef fish taken west of the Cape, occurring in 87.5% of sets with a mean catch/trap hour of 6.9, compared to 6.5% in the east with an average catch/trap hour of 0.3. Gray triggerfish were also much more common west of San Blas (58.3% of sets vs. 14.3%), and red porgy and vermilion snapper occurred exclusively there (41.7 and 33.3% vs. 0% for both). For these three species, much of these differences are likely due to the difference in depths sampled in the two areas (deeper in the west). In contrast, white grunt and black seabass occurred exclusively east of the Cape, with the former present in 75.3% of the sets with a mean catch/trap hour of 5.5. Black seabass occurred in 35.1% of eastern sets and catch/trap hour averaged 0.8. Hogfish were caught at only two sites (one fish at each), and both sites were east of the Cape. Based on considerable video and diver observation data, the regional differences seen in these latter three species appear to be real differences in their zoogeography and not just the effects of sampling depth differences.

Given that red and vermilion snappers, gray triggerfish, red porgy, white grunt, and black seabass occurred in 33-88% of trap sets, at least within areas (east and west of Cape San Blas), it is likely that for these species, as well as gag and red grouper, a regional-scale fishery-independent survey utilizing chevron traps would be an effective way to monitor population and recruitment trends. An additional 16 unexploited species were caught during the survey, and such spatially-explicit information could provide insight into community structure and demographics on these very important hard bottom habitats. Such information will become increasingly valuable as management agencies move towards ecosystem-based fisheries management.

Surveying for new hard bottom sites to add to the sampling universe was quite productive in 2005. Twenty-seven new sites were found and sampled in the region east of Cape San Blas.

Development of Model-Based Ecosystem Management Criteria for Assessing Bycatch and Reef-Fish Assemblages

MARFIN Grant No. 05MFIH03

Funding Amount: $100,000

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Study Objective: The goal of the proposed research is to develop Ecosystem Management Criteria for use in managing assemblages of marine fish communities. This was done by the development of relevant models of species interaction and probability distributions of important factors such as relative species abundance frequencies; and by exploring the impact of fishing on the models and determine important model factors that contribute to community structure.

Methods and Materials: The modeling approach used was the implementation of generalized Lotka-Volterra (L-V) equations extended to N species. The L-V approach is mathematically tractable; however, this approach does not consider non-linear interactions. Therefore, the analyses must be considered a first-order approximation. These models are NOT methods to predict particular species dynamics in response to ecosystem perturbations. Rather it is a method to examine general ecosystem structure and the changes to that structure resulting from perturbations.

A fully documented modeling package, LV Sims, was created which generates model ecosystems with a specified structure (or inputs data from real ecosystems), creates exploitation patterns, runs the L-V simulations and analyzes and plots results.

Conclusions and Recommendations: Using LV Sims examples of ecosystems and simulations were run subject to various levels of exploitation (F). Approximation formulae for the species abundance distributions (SADs) were developed which are a function of the species specific-productivity and migration parameters of the L-V system which ignore 3^{rd} and 4^{th} order derivatives. Approximations are useful in many cases. However, better estimates will probably require numerical solutions including the higher order terms. Future work will investigate maximum likelihood estimates of SAD parameters from real relative abundance data (e.g. trawl data) and relate results to underlying L-V parameters. Also, we need examine how F affects the SAD and under what conditions system "falls apart" and explore their use as management benchmarks.

Evaluation of the Efficacy of Current Minimum Size Regulations for Selected Reef Fish Based on Release Mortality and Fish Physiology

MARFIN Grant No. NA17FF2010

Funding Amount: $359,804 Federal ($133,852 non-Federal)

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Study Objectives: **1)** Test the hypothesis that red grouper are more susceptible to depth-induced mortality than red snapper, based on swim bladder size, thickness, and the number of rete mirabile and gas gland cells in the swim bladder. **2)** Test the hypothesis that smaller red grouper (< 30.5 cm) survive rapid decompression better than larger (> 38 cm) fish based on changes in swim bladder structure with size between 30.5 – 38 cm. **3)** Test the hypothesis that circle hooks greatly reduce release mortality in red snapper. **4)** Quantify undersize and legal catch for red grouper, *Epinephelus morio,* gag, *Mycteroperca microlepis*, red snapper, *Lutjanus campechanus*, vermilion snapper, *Rhomboplites aurorubens*, and mangrove snapper, *Lutjanus synagris*. **5)** Obtain catch and release mortality rates relative to depth and gear for target species. **6)** Obtain movement patterns for target species in the Gulf of Mexico and South Atlantic off Florida. **7)** Determine tag shedding rates for red grouper, gag, and red snapper tagged with passive integrated transponder (PIT) tags and single-barbed dart tags.

Methods and Materials: **1)** Histological examinations were conducted to assess general appearance of swim bladders, gas glands, rete mirable, and hemorrhages. Representative samples embedded in paraffin were sectioned at 4 μm and stained in hematoxylin and eosin to compare and photograph secretory and resorption structures. **2)** Necropsies were performed on acute mortalities to determine cause of death and to examine swim bladder condition. **3)** Red snapper and red grouper were caught on circle and J hooks, tagged, and released. Recaptures were compared for difference in release mortality relative to hook type. **4)** Red grouper, gag, red snapper, vermilion snapper, and mangrove snapper caught off Florida were quantified and measured aboard headboats, charter, and recreational vessels by Mote Marine Laboratory (MML) staff, student interns, and volunteer taggers. **5)** Target species were tagged with Hallprint® single-barbed plastic dart tags and released off recreational-for-hire and recreational vessels by MML staff, interns, and volunteer taggers. Tag number, species, size, date, depth (ft), gear type, and fish condition were recorded for each tagging event. Recaptures were reported via a dedicated hotline. Data included tag number, date, depth (ft), gear type, condition of fish, and whether fish was re-released. A quarterly top tagger prize ($50), an annual tag lottery ($100; both tagger and fisher reporting recapture), and a quarterly newsletter were employed to keep anglers informed and provide incentive for tagging and reporting target species. **6)** Original tagging and recapture locations were recorded to the nearest 1' of latitude and longitude. Distance for each recaptured fish was calculated. **7)** Some target species were tagged with both

Hallprint® single-barbed plastic dart and PIT tags. MML staff and interns used PIT readers to check all target species caught aboard headboats.

Conclusions and Recommendations: **1)** Red grouper have larger (in relation to body size), thinner swim bladders than red snapper. Red snapper swim bladder ruptures are smaller than those of red grouper. Red grouper > 380 mm FL have an area on the posterior swim bladder ventral wall, absent in red snapper that contains some rete and convoluted tissue that may aid in gas absorption and secreation. Rete area increased significantly with body size (FL) for both species, although the relationship between rete area and body size was weak, particularly for red snapper. Red snapper had a significantly higher percentage of rete area than red grouper when adjusted for size (ANCOVA, $F_{3,196} = 41.042$, $p < 0.001$ overall, $p = 0.022$ by species). Gas gland area was not related to FL for red snapper. The relationship was significant, but weak for red grouper. Red grouper had a significantly higher percentage of rete area occupied by gas gland than did red snapper when adjusted for fish size (ANCOVA, $F_{3,200} = 13.258$, $p < 0.001$ overall, $p = 0.007$ by species) and a closer association and more connections between gas gland cells and rete. Both species had increased rete and swim bladder hemorrhaging with increasing 50 mm increments of length (ANOVA, red snapper rete, $F_{1,8} = 20.41$, $p = 0.003$, $r^2 = 0.708$, red snapper gas gland, $F_{1,8} = 17.38$, $p = 0.004$, $r^2 = 0.672$, red grouper rete, $F_{1,11} = 16.21$, $p = 0.002$, $r^2 = 0.580$, red grouper gas gland, $F_{1,11} = 19.77$, $p = 0.001$, $r^2 = 0.631$). Retal hemorrhaging was significantly higher in red grouper than red snapper, when adjusted for length (ANCOVA, $F_{3,21} = 5.96$, $p = 0.026$), but no significant difference occurred between species in gas gland hemorrhaging ($p = 0.786$). Overall, red snapper survive rapid decompression better than red grouper because of smaller tears in the swim bladder, a smaller swim bladder that holds less gas producing less hemorrhaging, especially in smaller fish. **2)** Necropsies (4 red grouper, 107 red snapper, and 4 vermilion snapper) were conducted. Most red snapper died from hook mortality. **3)** Circle hooks did not increase survival of red snapper but were effective for red grouper. Of 3,203 red snapper caught on circle hooks, 8.1% were recaptured, whereas 2,259 red snapper were caught on J hooks and 11.9% were recaptured. Of 762 red grouper tagged with circle hooks15.9% were recaptured whereas 3922 were captured on J hooks and 7.3% were recaptured. **4)** Red grouper (473 legal and 5,318 undersized), gag (442 legal and 2,855 undersized), red snapper, (1,154 legal and 5,737 undersized), vermilion snapper (563 legal and 564 undersized), and mangrove snapper (904 legal and 3,138 undersized) were measured during 467 headboat, 90 charter, and 427 recreational fishing trips. **5)** Red grouper (n = 4,997), gag (n = 2,704), red snapper (n = 5,481), vermilion snapper (n = 465), and mangrove snapper (n = 3,180) were tagged. Recapture rates were 8.7% for red grouper, 11.9% for gag, 9.7% for red snapper, 0.2% for vermilion snapper, and 8.7% for mangrove snapper. **6)** Most fish showed limited movement, but some were recaptured up to 360.3 km (red grouper) and 583.2 km (red snapper) from the original tagging location. **7)** Six hundred six fish were double tagged (474 red grouper, 3 gag, and 129 red snapper). Most fish were recaptured with both tags present. Tag shedding rates were calculated as 0.2% for red grouper, 0% gag, and 0% for red snapper.

Circle hooks should be used when fishers target red groupers. Circle hooks do not enhance red snapper survival. Although the effects of barotraumas affect both red grouper and red snapper, some red grouper begin to experience difficulties at 27.4 m (90 ft) whereas red snapper trauma occurs closer to 42m (140 ft). Both species benefit from venting at the appropriate depth.

Spatial and Temporal Demographics of Gulf of Mexico Reef Fish and Mackerels

MARFIN Grant Nos. 05MFIH04 & 06MFIH14

Funding Amounts: 2005: $168,000; 2006: $109,449

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Study Objectives:

Our overall objectives were to determine basic life history parameters for Gulf of Mexico reef fish and mackerels for the purpose of improving stock assessments. Species selected for study were based on recent stock assessment schedules and included: vermilion snapper, gag, red grouper, and king mackerel.

For this presentation we are highlighting three research areas. A main objective was to examine small scale spatial variation in the population structure of vermilion snappers using fishery-independent sampling. A second objective was to examine the criteria used to assign sexual maturity in order to investigate evidence of reproductive asynchrony in gag and red grouper. We also report on efforts to update king mackerel reproductive parameters including fecundity.

While life history and demographic information are critical to age-structured assessments (and our MARFIN supported work was instrumental in recent Gulf vermilion snapper, red grouper and gag assessments), our desire is to move towards ecosystem-based fishery management by linking demographic and spatial information. By example, we briefly report on our collaboration with the FISHMOD project (Behzad Mamoudi, PI); a spatially explicit modeling approach for assessment and policy formulation.

Methods and Materials:

Vermilion snapper were collected from seven reef sites in the northeastern Gulf of Mexico 30 to 75 kilometers (km) off Panama City, Florida, during monthly sampling trips over a two-year period. All sites were within 10 to 50 km of one another and consisted of low profile (vertical profile $\leq$ 1 m) natural hard bottom at depths from 30 to 68 m. Sampling was by hook and line. Fish were aged using sagittal otoliths.

Reef fish and mackerel otoliths and gonads were collected through fishery-dependent sampling and processed in the laboratory. Hydrated ovaries from king mackerel were used to generate fecundity estimates. A gonadosomatic index (GSI) was used to discern distinct spawning patterns in shallow water groupers, lutjanids and mackerels. We compiled annual estimates of

proportions of vitellogenic female groupers by size and age and reviewed the histological criteria used to discriminate immature females from those exhibiting evidence of having spawned in the past.

Conclusions and Recommendations:

Vermilion snapper ranged in age from 1 to 14 years and were fully recruited to the sampling gear by age 4 or 5 at most reef sites. Significant differences were noted in length and age by reef sites, depth zones, and distance from shore. Differences were noted in growth by depth zone, distance from shore, and reef site using size at age and otolith weight at age. Growth of vermilion snapper was consistently faster at one mid-depth site than at all other sites. Growth as described by the von Bertalanffy growth equation differed significantly between sexes, however, the growth coefficient (k) did not differ. Total mortality (Z) did not differ among sites, depths, or distance from shore. These results underscore the importance of spatial scale for understanding the dynamics of reef fish populations.

Based on GSI values, gonad development was much less synchronous in the groupers than lutjanids. There were many gag and red grouper collected during the peak spawning months which were well above the size at 50% maturity but had very small ovaries, suggesting they were remaining in a resting stage. Histological results clarified this supposition. We estimated that up to 30% of mature gag and red grouper may fail to spawn in a given year, and that this is more likely to occur among young mature adults than older females supporting the prediction of an energetic model. From this and a growing number of other investigations, skipped annual reproduction may be more common than realized and result in shifting "effective" maturity (and estimates of reproductive potential) to older ages. Work is currently being completed regarding review and update of reproductive parameters for king mackerel for SEDAR 16 scheduled for 2008. Hydrated gonads were collected from 160 king mackerel 165-1254 mm fork length with the majority collected off southeast Florida (82%). Hydrated gonads were also collected off northwest Florida; this is the first known instance of significant numbers of spawning fish being caught in the northeastern Gulf of Mexico.

Spatially-explicit fisheries' modeling (FISHMOD) has been initiated for the shallow-water grouper complex in the eastern Gulf of Mexico (MARFIN #04MF008 to Mahmoudi et al.) and our MARFIN supported work has been a major contributor to this effort. FISHMOD uses global bathymetry spatial maps to design a variety of map layers (water depth, habitat suitability, etc.) and biological information such as growth, fecundity, vulnerability, and age-specific movement schedules. Simulations examine a variety of policy options including the trade-offs among closed areas, seasons, and gear restrictions. The habitat-fisheries linkage is essential to this modeling process but as yet is data poor, limiting broader applications. The need for improved geo-spatial information will continue to be a major requirement for this and next generation models that will be the primary tools for ecosystem-based fisheries management.

Industry Based Observer Program in the Reef Fish Fishery – Gulf of Mexico

MARFIN Grant No. NA05NMF4331069

Funding Amount: $317,625

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Study Objective: The project objective was to establish a one year, industry based, observer program for the reef fish fishery in the Gulf of Mexico. Observers would collect fishery dependent information on by-catch, catch composition, and discard mortality.

Methods and Materials: Observers were carried on a voluntary basis. The vessels to be randomly selected to carry observers were derived from a list of permitted reef fish vessels provided by the National Marine Fisheries Service Southeast Fisheries Science Center. Six independent observers were hired and placed on vessels participating in the reef fish fishery. The original design of the project was to have 12 observers working on the reef fish boats. However, the relatively small size of many of the vessels, which limited berthing space to crew only, and the lack of participation in the voluntary program reduced the need to hire more than six observers.

Observers were instructed to alternate sampling procedures between sets on longline vessels. On the first set the observer would identify and measure every 10^{th} fish for species composition and length. On the alternative set observers would identify and observe the condition of groupers upon release. A set of forms, based on NMFS sampling protocol, was provided to each observer and a grading system was created to code each fish's condition upon release. Observers were directed to identify hook size and gear specifics such as length of longline cable. Additionally, any sea turtle interactions were to be recorded by the observer.

Conclusions and Recommendations: A total of 13 longline trips and one vertical line trip were observed, representing 111 days at sea. From these trips a total of 156 sets were sampled. The average vessel size was 45 feet. Gear used was consistently 13/0 circle hooks fished on monofilament leaders. Main line averaged 9 miles of galvanized cable fished with 200 hooks per mile. Leaders measured an average of 8 feet. Vessels averaged 2.3 sets per day.

There were 2,544 fish caught and a total of 1,987 were released. Of the 1,987 released, 1,308 were released alive which represents a total fishing mortality of 34.2%. Fishing mortality increased with depth caught. In the 20-29 fathom depth, of the 1,664 fish released 1,147 fish were released alive for a 31.1% mortality. In the 30-39 fathom range, 85 of the 143 released were released alive for a 40.6% mortality. In the 40 fathom and greater depth range only 76 of 180 fish were released alive for a 57.7% mortality.

Three loggerhead turtles were captured. Two had 3 foot carapace length and the third had a 4 foot carapace length. Two were hooked in the mouth and the other was hooked in the flipper.

The results of this observer project illustrate the need for a continued observer presence in the reef fish fishery. The only way to obtain information, which is vital to fishery management, is through observer projects such as this.

SESSION II – Essential Fish Habitat

Session Chair: Dr. LaDon Swann

Fisheries and Habitat Assessment of the *Oculina* Banks Habitat Area of Particular Concern: A Multi-Media Approach Using GIS and the World Wide Web

MARFIN Grant No. NA04NMF4330077

Funding Amount: $84,771 Federal ($5,210 non-Federal)

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Study Objectives:
The Oculina Banks Habitat Area of Particular Concern (OHAPC) is a marine protected area off the east coast of Florida in 70-110 meters depth and is constructed by the ivory tree coral, *Oculina varicosa*. In a project concluded in 2003, a decision-support system was developed for data visualization and dissemination to regional stakeholders. In 2004, the MARFIN program supported further development of the Oculina DSS to incorporate historical (analog) data, further analyze these data, and identify changes that have taken place in fisheries and habitat resources.

Methods and Materials:
To meet the project goals, several tasks were accomplished, including:

1. Rescued and analyzed submersible video imagery collected between 1977 and 1982.
2. Analyzed dive data from video imagery collected in 1995.
3. Converted GIS decision support system from Arcview version 3.2 to ArcGIS 9.1.
4. Created new GIS data layers from rescued and analyzed imagery.
5. Collected and georeferenced fish catch data.
6. Quantified topographic change in the OHAPC.
7. Updated the UNCW Oculina website.

Conclusions and Recommendations:
All the proposed tasks have been accomplished. Work continues to refine and improve the Oculina Decision Support System (GIS and Web site). The Oculina GIS has been upgraded from ESRI's Arcview 3.2 to ArcGIS 9.1; the web-based DSS has been upgraded from ESRI's ArcIMS 4.0 to ArcIMS 9.1. Multibeam bathymetric data from 2002 and 2005 surveys were compared to NOS fathometer surveys from the 1960s. MARFIN support was used to partner with other NOAA programs (NURP and Ocean Exploration) to create a new multimedia dive information system called the Southeast Atlantic Deep Sea Coral (SEADESC) database; historic and recent

Oculina ROV and submersible dives were entered into the system. A resulting multi-media report is available from NOAA's Ocean Exploration program.

MARFIN sponsored products from this project contributed to several Web sites, including:

- UNCW's Oculina website with GIS enabled data visualization: www.uncw.edu/oculina
- South Atlantic Fisheries Management Council's archive of research and mapping of Oculina Banks: http://www.safmc.net/HabitatManagement/DeepwaterCorals/OculinaBank/tabid/246/Default.aspx
- 2006 AUV mapping mission co-sponsored by NOAA's National Undersea Research Center (NURC) and NOAA's Coral Reef Conservation Program (CRCP): http://www.uncw.edu/nurc/auv/oculina2006/
- 2005 ROV survey co-sponsored by NURC and CRCP, hosted by Harbor Branch Oceanographic Institute's (HBOI) At-Sea archive: http://www.at-sea.org/missions/oculinabanks/preview.html

The project helped support several presentations and publications including:

Maness, A., N. Grindlay, and A. Shepard. 2005. Investigating the use of acoustic seabed classification as a tool for benthic habitat characterization of the Oculina Habitat Area of Particular Concern, southeast Florida Shelf. Poster # OS15F-09, Amer. Geophys. Union, 2005 Annual Meeting. San Francisco, CA.

Reed, J.K., **A.N. Shepard**, C. Koenig, K. Scanlon, and G. Gilmore. 2005. Mapping, habitat characterization, and fish surveys of the deep-water Oculina coral reef Marine Protected Area: a review of historical and current research. Proceedings of Second International Symposium on Deep Sea Corals, Sept. 9-12, 2003, Erlangen, Germany. Springer-Verlag.

Maness, A. In prep. Habitat mapping in the Oculina Bank Habitat Area of Particular Concern. Master's Thesis, University of North Carolina- Wilmington. [Final due December 2007].

Most important, project results have added new information to help the SAFMC and NOAA make decisions about the continuation of the Oculina Habitat Area of Particular Concern. The Council subsequently developed an Oculina Experimental Closed Area Evaluation Plan that built on project results and mandates continuation and expansion of the Oculina DSS approach as long as the MPA exists.

Demographics, Density and Seasonal Movement Patterns of Reef Fish in the Northeastern Gulf of Mexico Associated with Marine Reserves

MARFIN Grant No. NA17FF2876

Funding Amount: $373,531

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Study Objective: Shelf-edge marine reserves Madison Swanson and Steamboat Lumps were established in 2000 by the Gulf of Mexico Fishery Management Council and the National Marine Fisheries Service to, among other things, allow the study of causes of apparent fishing-induced sex-ratio alterations in gag. Males historically comprising 15 to 25% of the gag population now only comprise 2 to 5%. The objectives of this study were (1) to evaluate the gag sex-ratio problem and (2) to evaluate reserve function by non-destructively determining demographic patterns (size, age, sex ratio, movement, and density) for economically important reef fish (gag, scamp, red grouper, and red snapper) within and outside the reserves.

Methods and Materials: In this study we developed methods to non-lethally sample gag and other reef fish at shelf-edge depths (50-120 m) to quantify demographics (size, age, sex ratio, movement, and density) both inside and outside of the reserves. Fish were captured on gag spawning aggregation sites with chevron traps or by hook and line, then brought to a depth that was 35 - 40% of the depth of capture. While at that depth divers vented the fish with modified pole spears, then the fish were brought to the surface. (This method circumvented lethal embolism.) Once on board, the fish were held in tanks with flowing seawater, then sampled for size, age (dorsal spines and rays), sex and reproductive condition (gonad biopsy), population density (ROV video), and genetics (fin clip).

Conclusions and Recommendations: Results indicate that male gag remain on spawning sites year round; this has important implications for the mechanism of gag sex-ratio alteration. Large red snapper males and females and scamp males also remain close to spawning sites year round. Home ranges of all reef fish were small relative to the size of the reserves, and size and age of red grouper, red snapper, and scamp were significantly greater inside the reserves than outside. There was no significant difference in age and size of gag inside relative to outside the reserves. The density of gag and red snapper on gag spawning sites was significantly greater inside the reserve than outside. The percentage of male gag (8%) was significantly greater inside the reserve than outside for 2003 only, then declined rapidly as poaching increased. Poaching, primarily on gag, was intense in 2004 and 2005 and likely distorted the sex ratio, size and age structure results.

We demonstrate that red grouper are habitat engineers and may create important nursery habitat for juveniles of other reef fish such as vermilion snapper. Red grouper exhibit lek-like pair mating and males produce a stereotypic sound just prior to spawning.

Can Marine Protected Areas Conserve Genetic Diversity in Tomtate (*Haemulon aurolineatum*) and French Grunt (*Haemulon flavolineatum*)?

MARFIN Grant No. NA17FF2878

Funding Amount: $281,889 Federal ($48,360 non-Federal)

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Study Objectives: To determine the level of exchange among tomtate and French grunt populations and the impact of marine protected areas as a means of conserving genetic diversity.

Methods and Materials: The genetic variation within and among tomtate (*Haemulon aurolineatum*) and French Grunt (*Haemulon flavolineatum*),populations in the southeastern United States, the Gulf of Mexico, Bermuda, and the Caribbean were examined using nuclear genes and mtDNA. Nine novel dinucleotide microsatellites were developed for this study.

Conclusions and Recommendations: Tests for population differentiation indicated significant population structure in tomtate among nine locations and represented three distinct populations– continental U.S., Caribbean, and Bermuda. The observed patterns of genetic differentiation were consistent with both the current oceanographic regime, and the geologic history of the region.

The structure of French Grunt population was demonstrably different from tomtate, with low (non-significant) levels of genetic differentiation among populations in Florida, Belize, Puerto Rico, and the Virgin Islands. Significant differences were found between Bermuda and all other sampled locations.

Three main conclusions can be derived from these data for the implementation of marine protected areas. First, the data support establishment of MPAs in Bermuda and careful monitoring of reef fish populations. The levels of genetic differentiation in both species suggest that the Bermuda populations are largely self-recruiting and cannot be rapidly rebuilt by dispersal from distant populations. Second, MPAs have the potential to produce large local impacts in tomtate, but little impact at more regional scales. In French Grunt, the impact of MPAs is likely to have more regional scale consequences. Lastly, the data support the notion that ecosystem-based management of these and other reef fish species would be most effective using a series of marine protected areas along the continental margin and most (if not all islands) of the Caribbean.

The effects of lobster traps on coral communities in the Florida Keys

MARFIN Grant No. NA05NMF4331077

Funding Amount: $57,935

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Study Objective: The goal of this project is to address the ecological sustainability of coral communities with current trap fishing practices in the spiny lobster fishery. Specifically the distribution of traps and the habitats they affect were identified, when and how traps affect corals was established, and the recovery of injured scleractinian corals, gorgonians, and sponges was observed.

Methods and Materials: Trap distribution was established using a mail survey to all fishermen and the trap distribution was verified using belt transects that also identified the habitat where each trap was placed. The effect of traps on coral was measured by examining the percent cover under traps after they were placed and subsequently pulled compared to adjacent control areas that were unaffected by the traps. The effect of traps on coral was also measured in specific cases where traps moved as a result of high winds. The observations of buoyed and unbuoyed trap movement were in typical areas and depths (4, 8 and 12 meters) where traps were fished. The effect of trap impacts on individual species was assessed by observing specific injured organisms for recovery or decline for up to 6 months.

Conclusions and Recommendations: The Caribbean spiny lobster (*Panulirus argus*) is the target of a valuable recreational and commercial fishery. The commercial fishery currently uses approximately 480,000 traps that are divided between the waters of the Atlantic Ocean and the Gulf of Mexico including Florida Bay. Our surveys indicated that traps were widely distributed throughout all of the marine habitats around the Florida Keys and approximately 16% of the traps in the Atlantic were placed in coral or other hardbottom habitats. Generally, traps placed on reefs belonged to only a few fishermen. Proportionately fewer traps were on coral reefs in the Upper Keys, likely because the increased water clarity in this area allowed more careful trap placement in sand areas adjacent to reef habitat..

The current cause of damage to reefs from traps appears to be from trap movement during high winds. Routine fishing of a single trap appeared to do little damage to coral and reduced benthic cover by less than 1%. However, traps in coral and hardbottom habitats often moved several meters if high winds persisted for several days as commonly occurred during winter cold fronts. There was a significant loss of benthic cover when traps moved, primarily as a result of the detachment of organisms. Lost gear (unbuoyed traps) move considerably less than buoyed gear

but persists in the marine environment for years. Recovery from scrape or impact injuries was species specific and most species observed were fairly resilient to these injuries. However few branching or plate corals, that would likely be more susceptible to impact injuries, were present in the study area. We were unable to assess if branching and plate forming corals may have been excluded from the study areas because of historic trap use as our study area has been actively fished for decades.

There is a broad range of educational and regulatory options available to potentially reduce the effect of traps on coral. The limited number of fishermen placing traps on reefs may allow any trap-impact-reduction effort to utilize targeted educational programs directed toward specific fishermen. Reducing access to reefs during times or seasons with high winds would also likely reduce the damage associated with more typical trap movement from winter cold fronts. Current Sanctuary Protection Areas within the Florida Keys National Marine Sanctuary encompass most major reefs and afford adequate protection from the effects of routine trap movement but they are too small to prevent trap impacts resulting from trap movement during tropical storms and hurricanes. A general reduction in the number of traps available to the fishery would more broadly address all sources of trap impact including the increasingly frequent catastrophic impacts associated with hurricanes. The increased frequency and intensity of tropical storms and hurricanes in recent years has likely contributed to the recent declines in coral cover. These storms have caused the movement of many traps into protected areas and jeopardized the coral preservation efforts in these areas.

SESSION III – Red Snapper

Session Chair: Dr. Robert Shipp

Estimating Discard Rate and Release Mortality of Red Snapper in Texas Fisheries

MARFIN Grant No. NA17FF2012

Funding Amount $345,244

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Study Objective: To estimate discard and release mortality rate for the Texas headboat fleet.

Methods: Discard observations and fish tagging took place aboard participating head boats at four ports on the Texas coast from 1 October 2002 to 31 August 2005. A portion of the boat deck was randomly selected and angler catch was observed over the period of time spent at a fishing site. All red snapper captured were measured (tl, cm), and checked for external signs of barotraumas (protruding stomach, protruding anus, exophthalmia, and activity). Undersized red snapper were tagged with individually marked Floy tags and released. Fish activity on the surface was observed for 1 minute following release and noted as dead on deck, floating on surface, erratic surface swimming, or swam down.

Conclusions and Recommendations: During the sampling period 4,261 red snapper were observed. High discard rates observed in this study were similar to other discard observation studies from this region (74.3% overall). Discard rate was lowest from Galveston (69.7%) and highest from Port Aransas (76.5%). Discard rate was lowest in 2004 (71.6%) and highest in 2005 (77.8%). Artificial sites show a discard rate of 83.7% while natural sites were 74.3%. Surface observations of released fish showed that 0.7 % died, 8.6% floated on the surface, 3.6% swam erratically at the surface, and 87% swam immediately down. The incidences of death, floating on the surface and erratic swimming all increased as depth of fishing increased, while the rate of fish swimming down decreased. Of the total number observed, 50.7% of the subjects showed no external signs of barotrauma. This information does not include observations of inflated gas bladders, which in other studies is nearly 100%. Common barotraumas observed included stomach protrusion out of the mouth (24.7 %), intestines distended from anus (19%), and exophthalmia (3%). The rate of occurrence of exophthalmia and stomach protrusion increases as depth increases while the rate of anus distention lowered. Release behavior at the surface shows a high number of subjects are able to swim down (87%), indicating that immediate survival is high, but failing to address short term (hours) and long term (days) survival. Tag returns on the project were very low (~2%) which made analysis of the data in terms of short and long term survival problematic. Observation of predators such as Atlantic bottlenose dolphin and barracuda were frequent but were not consistently recorded as a piece of data (crew differences). Further studies involving release mortality, especially those addressing predation and delayed mortality following release are recommended. Monitoring discard rate for this fleet is also recommended given recent changes in TAC and size limits for various portions of the fishery.

Development of Assays for Major Histocompatibility Complex (MHC) Class I and Class II Loci in Gulf Red Snapper for Use in Stock Structure Analysis and Assessment of Genetic Health

MARFIN Grant No. NA17FF2880

Funding Amount: $34,350 Federal ($7,690 non-Federal)

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Study Objective: Experimental objectives of the one-year project were to develop polymerase chain reaction (PCR) primers for future study of allelic variation at orthologous and paralogous duplicates of major histocompatibility complex (MHC) genes (loci) of Gulf red snapper (*Lutjanus campechanus*).

Methods and Materials: Polymerase-chain-reaction (PCR) primers were designed, developed, and tested for amplification of alleles at MHC Class I, MHC Class IIα, and MHC Class IIβ loci in Gulf red snapper (*Lutjanus campechanus*). Two primer pairs were used to study allelic variation at MHC Class I loci: one primer pair allowed detection of 18 different alleles among 21 cloned fragments, while the second pair allowed detection of 36 different alleles among 41 cloned fragments. The number of alleles detected per individual ranged from four to 14 (first primer pair) and from nine to 14 (second primer pair), indicating a *minimum* of seven (7) MHC Class I loci in red snapper. One PCR primer pair for MHC Class IIα loci was used to amplify a single sequence, which was verified to be an allele of an MHC Class IIα locus. One primer pair for MHC Class IIβ loci was used to generate a series of MHC Class IIβ fragments; a total of 63 fragments were cloned and sequenced. A total of 54 different alleles were detected. The number of alleles detected per individual ranged from four to 17, indicating a *minimum* of nine (9) MHC Class IIβ loci in red snapper. Additional PCR primers for MHC Class IIβ loci were designed in order to determine if families of related fragments, generated from the same primer-pair combination but separated by size, could be used to distinguish red snapper from different geographic areas in the northern Gulf of Mexico. Amplifications with these primers indicated first, that there are at least eleven (11) MHC Class IIβ loci in red snapper, and second, that there were a number of undetected (null) alleles among the red snapper assayed. Homogeneity tests of allele (fragment) distributions did not reveal geographic differences among red snapper sampled from three localities in the northern Gulf. The tests were compromised by the absence of knowledge as to which alleles were allelic (at homologous loci) and which were not (paralogous loci). Initial plans were to carry out parent-offspring comparisons to discriminate orthologous from paralogous MHC loci. Crosses were to be undertaken at the Gulf Coast Research Laboratory (GCRL) in Ocean Springs, Mississippi. No successful crosses at GCRL occurred over the two-year period of this project (this initial year requested plus a one-year extension).

Conclusions and Recommendations: A number of PCR primers were developed for MHC Class I, MHC Class IIα, and MHC Class IIβ loci in Gulf red snapper. All will be useful in studies of stock structure and assessment of genetic health. The number of MHC loci inferred

(minimum of seven MHC Class I loci and a minimum of eleven MHC Class IIβ loci) mandate that future studies will need carryout parentage analysis in order to discriminate orthologous from paralogous loci. There also appears to be a number of 'null' MHC alleles, none of which can be verified without parentage analysis. The necessary genetic tools for these future studies of allelism at MHC loci are provided by this project.

Geographic Comparison of Age, Growth, Reproduction, Movement and Survival of Red Snapper off the State of Florida

MARFIN Grant No. NA17FF2881

Funding Amount: $623,161 Federal ($134,416 non-Federal)

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Study Objectives: **1)** To obtain red snapper life history information including age and growth and reproduction data off the southwest and northeast coast of Florida and compare these data with those from the northern Gulf of Mexico (GOM). **2)** To test the hypothesis that red snapper survive depth-induced trauma. **3)** To test the hypothesis that circle hooks greatly reduce release mortality in red snapper. **4)** To obtain catch and release mortality rates relative to depth and gear. **5)** To determine tag shedding rates for red snapper tagged with single-barbed dart tags and PIT tags. **6)** To obtain movement and migration patterns in the GOM and South Atlantic (SA).

Methods and Materials: **1)** *Age and Growth:* Mote Marine Laboratory (MML) personnel aboard recreational-for-hire and commercial vessels collected otoliths from red snapper in the GOM and SA. Fish total length (TL mm), fork length (FL mm), and sex were recorded for each sample. Otoliths were cut, read, and age determined by MML staff. *Reproduction:* Fish gonads were collected in the GOM and SA concurrently with otolith sampling. Collected gonads were immediately fixed in 10% neutral buffered formalin in the field. Total gonadal weight (g), TL mm, and FL mm, were recorded for each sample. Gonads were examined histologically to determine maturity classification. Batch fecundity and spawning frequency were determined for fish throughout the geographical areas sampled by University of Mississippi-Gulf Coast Research Laboratory (USM-GCRL) personnel. **2)** Necropsies were performed on 215 undersized red snapper caught aboard headboats, to determine cause of death. **3 & 4)** Red snapper were caught, tagged, and released by MML staff, student interns, and volunteers aboard recreational-for-hire, recreational, and commercial boats. Data recorded included: capture location coordinates (nearest 1°), water depth (ft), gear and hook type, FL (in), date of capture, and condition of fish. Recaptures were monitored via the Fish Tagging Hotline. **5)** MML staff and student interns caught undersized red snapper off headboats and double tagged fish with Hallprint® plastic dart tags and passive integrated transponder (PIT) tags. MML staff scanned all fish caught during headboat fishing trips on both coasts for PIT tag presence. **6)** MML staff used red snapper tagging and recapture data to analyze general distributional trends. Directional movement trends were analyzed using polar plots and Rayleigh tests. Spatial analyses were conducted using ArcInfo 9.0 (ESRI, 2004). Movements were projected in local UTM NAD 83 coordinate systems (16 N and 17 N in the GOM and 18 N in the SA). Sigmaplot, Oriana, and GEODISTN (Syrjala, 1966) were used to perform statistical analyses.

Conclusions and Recommendations: **1)** Due to multiple hurricanes during the study and closed seasons, a limited number of samples were collected in the Dry Tortugas and Florida Panhandle. Few samples were available from the southwestern central Florida Gulf as red snapper were just beginning to recruit into the fishery in this area during sample collection of this project. *Age and Growth*: A total of 228 otoliths were collected from red snapper in the GOM (Florida Panhandle, n = 68; south Florida Gulf, n = 67; Dry Tortugas n = 90, and the SA n = 62). Collected red snapper from the Florida Panhandle ranged from 261-470 TL mm and 1-3 years. Fish from the southwestern Florida Gulf (including Dry Tortugas) ranged in size (343-800 TL mm) and age (1-7 years). The broadest age range was collected from the SA; sampled fish ranged 1-17 years (129-937 TL mm). *Reproduction*: A total of 199 (Florida Panhandle, n = 37; southwestern Florida Gulf, n = 15; Dry Tortugas n = 81; SA, n = 66) red snapper gonads were sampled during the course of this project. SA fish female red snapper were reproductively capable and actively spawning from June-October, with peaks in GSI values in July and September for both males and females. No published fecundity estimate exists for the Florida east coast; however, estimates from this study show a relative fecundity of 235 ± 56 eggs/g. **2)** Necropsies were performed on 171 undersized red snapper obtained from headboats. Cause of death was determined. Results showed 23 died from depth-related causes, 64 from stress and other causes, and 84 from hook-induced trauma. **3)** MML staff, student interns, and volunteers tagged 2,336 red snapper on circle hooks, of these 173 were recaptured (7.4%). The 1,959 tagged fish on J hooks, had a 10.5% (205 fish) recapture rate. Similar recapture rates showed circle hooks did not enhance red snapper survival. **4)** Of the 378 red snapper recaptures, 342 (circle, n = 165; J, n = 177) were fish originally tagged at depths ranging 20-40 m. Red snapper survival at depths greater than 29.9 m varied by treatment (vented or not vented). Higher recapture rates were recorded for red snapper tagged at depths greater than 29.9m and vented at time of tag and release. **5)** MML staff tagged 57 red snapper with both dart and PIT tags, four (4) were recaptured, all with both tags. Double tagging was concurrent with another project, where 547 red snapper were double tagged, of these 36 recaptured; 34 (94%) of recaptured fish retained both tag types. **6)** Red snapper were at liberty from 2-819 days. Of the recapture reports that included coordinate data, 47 fish exhibited site fidelity; others (n = 118) showed movements of < 10 km, and 47 exhibited movements of ≥10 km. One fish traveled from the northern Gulf to the Atlantic. This study documented the beginning of the re-recruitment of red snapper off the southwest coast of Florida. As fish numbers increase and directed fisheries develop, additional research is necessary to determine the contribution of southwest Florida fish to the overall population of GOM red snapper and any differences in southwest Florida red snapper relative to other regions in Florida.

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Estimation of the Source of Red Snapper Recruits to the West Florida Shelf with Otolith Microchemistry

MARFIN Grant No. NA04NMF4330367

Funding Amount: $71,931 Federal ($17,670 non-Federal)

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Study Objectives: This study was designed to estimate red snapper population connectivity among Gulf of Mexico (GOM) regions, including the west Florida continental shelf. The two primary objectives were to estimate the nursery source(s) of age-1 red snapper that recruited to the west Florida shelf with natural tags derived from otolith elemental and stable isotope (collectively, chemical) signatures, and to estimate post-settlement mixing, hence population connectivity, among several regions in the U.S. GOM. The assumption that the chemical signature at an otolith's core accurately reflects its nursery chemical signature was tested with a series of coring experiments. We also tested if hatchery-reared red snapper juveniles could be distinguished accurately from wild caught individuals with otolith chemistry.

Methods and Materials: Post-settlement movement and population connectivity in GOM red snapper were estimated for the 2004 cohort between 2004 and 2005. Age-0 red snapper (n = 175) were collected from four regions of the northern GOM [northeastern (NEG), north central (NCG), northwestern (NWG) and southwestern (SWG)] in fall 2004 to develop region-specific natural tags via analysis of otolith chemical signatures. Unfortunately, samples obtained from the NEG (n = 40) by shrimp trawl observers employed by the South Atlantic Fishery Development Foundation were discarded prior to shipment to the University of West Florida (UWF), thus were unavailable for analysis. A sample of hatchery-reared age-0 juveniles (n = 60) was obtained from an Auburn University experiment examining the potential for red snapper stock enhancement to test for differences in otolith chemistry between wild and hatchery-reared fish. Otoliths were extracted and analyzed with sector field-inductively coupled plasma-mass spectrometry (SF-ICP-MS) and isotope ratio-mass spectrometry (IR-MS) to estimate region-specific otolith chemical signatures. Differences among nursery regions in otolith elemental (Ba:Ca, Li:Ca, Mn:Ca, Mg:Ca, Pb:Ca, and Sr:Ca) and stable isotope ($\delta^{13}C$ and $\delta^{18}O$) signatures were tested with MANOVA. Stepwise linear discriminant function analysis then was performed to determine the accuracy of distinguishing regions with otolith chemical signatures.

A series of coring experiments was conducted to test whether there were significant differences in elemental and stable isotope signatures between the essentially two-dimensional structure of an otolith's extracted core versus the three-dimensional structure of a whole otolith. First, we tested for differences in elemental and stable isotope signatures between right and left otoliths of

age-0 fish (n = 10 for all experiments) with paired t-tests. We next tested whether coring otoliths with a Micromill precision coring drill or pulverizing otoliths with an acid-leached glass mortar and pestle caused any contamination of otolith samples. Lastly, we tested if two-dimensional right otolith cores had significantly different otolith and elemental signatures than matching left whole otoliths.

Sub-adult red snapper (n = 159) were collected among study regions in summer and fall 2005. Examination of whole otoliths revealed all samples from the NCG, NWG, and SWG were age-1 fish from the 2004 cohort. Fish (n = 21) collected by a National Marine Fisheries Service trap survey in the NEG proved to be at least 2 years old, thus no 2004 cohort fish were available from the NEG. Otoliths from the NCG (n = 57), NWG (n = 39), and SWG (n = 42) were sectioned and cored. Following a cleaning procedure, cores were analyzed with SF-ICP-MS and IR-MS. A maximum likelihood stock mixing model parameterized with residuals of age-0 otolith chemical signatures was computed to estimate the source of recruits to the NCG, NWG, and SWG, respectively, based on residuals of age-1 otolith chemical signatures from each region.

Conclusions and Recommendations: Age-0 red snapper sampled in fall 2004 had otolith chemical signatures (Ba:Ca, Li:Ca, Mn:Ca, Sr:Ca, $\delta^{13}C$, and $\delta^{18}O$) that were significantly different among GOM nursery regions (MANOVA, $p < 0.001$). Mean jackknifed classification accuracy from linear discriminant function analysis was 84.5% with hatchery fish in the model and 79.7% without hatchery fish, thus indicating otolith chemical signatures were robust region-specific natural tags. Results from coring experiments revealed that clean methods employed for coring and pulverizing otoliths did not lead to contamination of otolith chemical signatures, and chemical signatures of extracted cores of age-0 otoliths were demonstrated to correspond to signatures of whole otoliths. A maximum likelihood stock mixing model parameterized with residuals of otolith chemical signatures from fall 2004 age-0 samples was computed to estimate the source of recruits to each region based on residuals of otolith core chemical signatures of age-1 fish sampled in summer 2005. Results indicated little exchange occurred between the NCG and the two western regions, but 39% of the SWG sample was estimated to have been sourced from the NWG.

Results from this study confirm the utility of employing otolith chemical signatures to estimate red snapper population connectivity among regions as age-0 chemical signatures were estimated to distinguish nursery regions with high accuracy. Connectivity between the NWG and SWG was estimated to be high in the first year of life, which was different than previous results. That result also demonstrates the importance of examining interregional connectivity with cohort-specific as well as time-specific approaches. Ongoing research is concentrated on obtaining juvenile red snapper rarely encountered on the west Florida shelf, as well as examining connectivity between the SWG and Mexico.

Linking spatial-temporal population size structures and fishing effort dynamics to assess the effectiveness of minimum size for red snapper management

MARFIN Grant No. NA17FF2865

Funding Amount: $171,143 Federal ($17,354 non-Federal)

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Study Objectives: The goal of this project was to contribute to the recuperation of overexploited red snapper fisheries in the Gulf of Mexico. The contribution is by providing a better understanding of the effectiveness of minimum size regulations imposed on the fisheries as an instrument to control fishing mortality of the undersized, hence, immature fish.
To accomplish this goal the following objectives were proposed:

1. To develop a size-structured spatial yield-per-recruit model to assess minimum size options for red snapper.
2. To compile databases on the temporal-spatial nature of red snapper population size structures and of fishing effort practices in the Gulf of Mexico red snapper fishery.
3. To carry out risk assessment research on minimum size implementation as an effective management tool for recuperating the Gulf of Mexico red snapper fishery.

Methods and Materials: The Gulf of Mexico red snapper fishery is one of the most managed fisheries in the US. Management strategies were designed to recuperate the over exploited stock to at least 20% SPR by the year 2000; however, the milestone is now set at year 2032. This project analyzed the effect of stock recuperation under the various minimum sizes historically imposed on the directed fisheries (13" TL in 1984, 14" TL in 1994, 15" TL in 1995, 13" TL in 2007 in the commercial fisheries and 16" TL in the recreational fishery since 2000). An individual based length-age yield- and spawning-per-recruit model was developed using a computer intensive Monte Carlo procedure to create size-age transfer matrices. Seasonal fishing mortalities and exploitation patterns by gear type, natural mortality varying by age, fecundity and maturity by age and size as well as individual growth were obtained from the 2004 SEDAR process. This information was input to the -per-recruit model and in the resulting analyses.

Conclusions and Recommendations: Results show that the current SPR is about 2.8%. Minimum size regulations in the directed fisheries are of no significance to the SPR recovery plans due to high discard mortality below a minimum size (20 to 44%). At F=0.0 in the directed fisheries, the current shrimp bycatch mortality would generate at best a 15.29% SPR, which is indicative that any fishery management implemented in the directed fisheries will be futile unless the shrimp bycatch mortality is substantially reduced. If the shrimp bycatch is reduced by 50% when F=0.0 in the directed fishery, then SPR will be about 39.1%. Conversely, under the current

F in the directed fisheries and if shrimp bycatch is reduced by 50%, the SPR recuperates only to 7.23% and if shrimp bycatch is reduced zero, then SPR increases to about 18.5%. Consequently, any attempt to increase SPR above the 18.5% mark with no shrimp bycatch may be futile without a considerable reduction in F from the directed fisheries. It is concluded that minimum size regulations cannot contribute to the recuperation of the SPR to 20% while the shrimp bycatch mortality fully dominates the abundance of the mature cohorts, and when mortality of discards due to the minimum size or closed seasons in the directed fisheries are high.

Gains in YPR under zero shrimp bycatch are about 5.7 times larger than the YPR under the current exploitation conditions. The economic implications of such large yield waste have not been assessed. There are very limited gains in yield-per-recruit when minimum size is 13"TL at current F in the directed fisheries and for any level in shrimp bycatch mortality.

The SEDAR 2004 stock assessment results show that in spite of all management efforts, the red snapper spawning population abundance is at the lowest levels ever. This conclusion matched the findings in this project. Paradoxically, recruitment has increased substantially during the last 25 years. A significant effect of the North Atlantic Oscillation was observed regarding the recruitment of age 0, the shrimp bycatch index and CPUE in the recreational fisheries. Therefore, recruitment may not be density dependent within current parent stock abundance levels.

Further studies are needed regarding the nature of recruitment and environmental effects as well as an assessment of the value wasted by the shrimp bycatch relative to the value of the shrimp fisheries.

SESSION IV – Economic/Sociocultural

Session Chair: Mark Robson

Factors Affecting Participation in Marine Fisheries: Case Studies in Georgia and North Carolina

MARFIN Grant No. NA04NMF4330316

Funding Amount: $55,079 Federal ($26,468 non-Federal)

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Study Objective: To identify and describe the nature and extent of changes and related factors in commercial and recreational fishing in terms of numbers of fishers who have entered and left fisheries in McIntosh County, Georgia, and Brunswick County, North Carolina, during the decade 1994-2003.

Methods and Materials: Multiple methods were employed to obtain information from fishers, fish house owners and operators, the general public, and published documents. The same procedures were followed in each county. Those included informal and semi-structured interviews with commercial fishers and fish house owners, 15 in each state, both to sample perceptions and to inform construction of a survey questionnaire. The survey questionnaire contained questions about fishing experience and practices, including commercial fishing, opinions and attitudes about fishing, and socioeconomic status. Residents of McIntosh County completed 141 questionnaires; 1,000 were completed in Brunswick County. Dock intercept surveys of recreational fishers included 50 in McIntosh County and 100 in Brunswick County. License information and catch levels for each commercial fishery were obtained from the Georgia Department of Natural Resources and from the North Carolina Department of Environmental and Natural Resources. All front-page news accounts of fishing were photocopied from the newspapers, *The Darien News* (McIntosh) and *The State Port Pilot* (Brunswick).

Conclusions and Recommendations: The average age of commercial fishers was 49-50 years, and fewer than five percent of fishers were less than 40 years of age. Young people neither enter commercial fisheries, nor are they encouraged to become fishers. The major reason cited for not entering and also for leaving commercial fishers is the difficulty of making a living. Recreational fishing in McIntosh County was widespread among residents but mostly for individuals older than 25 years. The majority of recreational fishers in Brunswick County were recently arrived retirees and tourists. Tourism is more developed in Brunswick County, producing more recreational fishing, more head/party boats, and more waterfront alienation of fish houses and docks for commercial boats. As tourism and gentrification increase, commercial fishing decreases and recreational fishing increases. Commercial fishing in McIntosh County is likely to diminish in ways similar to earlier changes in Brunswick County toward more tourism and gentrification.

Profiling the St. Croix Fisheries: An Examination of the Social, Cultural and Economic Importance of the St. Croix Fisheries and the Community Designation Process

MARFIN Grant No. 05MFIH02

Funding Amount: $32,000

Dr. Brent W. Stoffle and Dr. Juan Agar

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Study Objective: The purpose of this research is twofold; 1) examine the relative social, cultural and economic importance of the St. Croix fisheries to local residents exploring whether St. Croix meets the Magnuson Stevens definition of a fishing community, and 2) examine local stakeholders' perceptions regarding the effectiveness and impact of Marine Protected Areas on the marine resources as well as user groups. This presentation focuses on the first research objective only–the assessment of the relative social, cultural, and economic importance of St. Croix fisheries to local residents. It appears that the findings support an Island-wide designation under Magnuson's definition of fishing community

Methods: The data collection portion of this research began in 2004 and culminated in 2006 upon the completion of the St. Croix Fisheries Workshop. During this timeframe more than 100 formal surveys and 100 interviews were conducted with local residents. Ethnographic methods were used to develop a holistic analysis and profile is in the final stages of creation. As well, an article regarding community designation has been completed and is in final stages of review. The MARFIN grant provided support for the 2005 portion of this iterative research process. Because of this support we were able to administer a formal survey with local stakeholders to be used in a comparative framework with the qualitative data collected in earlier research efforts.

Conclusions and Recommendations: Based on the research findings, an argument can be made for designating the island of St. Croix as a fishing community, as defined in National Standard 8, Magnuson Stevens Fishery Conservation and Management Act, should the Secretary and the Council so choose. This conclusion is based on two findings: 1) historic and contemporary use of and dependency on marine resources, and 2) social and economic networks that exist and are strengthened because of the local fishery. In order to assess dependency and fishing-related networks we had to explore such factors as island-wide settlement or patterns of residence of local fishermen, fishing grounds, landing sites, relative value of fish targeted (within the framework of the island's economy), catch distribution and use, household reliance, and social identity. Our findings suggest there is a historic and contemporary reliance on marine resources such that if removed from contemporary St. Croix society it would impact the sociocultural composition of that society and potentially weaken economic resilience.

Tortugas 2000–A Post Mortem: Evaluation of Actual Versus Projected Socioeconomic Impacts of the Dry Tortugas Ecological Reserve

MARFIN Grant No. NA04NMF4330079

Funding Amount: $61,628

Thomas J. Murray and Dr. Manoj Shivlani

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Study Objectives: The primary goal of this project was to estimate the actual socioeconomic impacts of the Dry Tortugas Ecological Reserve (TER), part of which was implemented in July 2001 in Gulf of Mexico Fishery Management Council waters, as measured by economic effects and user attitudes and perceptions. A secondary goal was to expand monitoring efforts to determine the regional impacts of marine reserves in the Florida Keys.

Methods and Materials: Focusing on the changes that are behaviorally influenced, re- surveys were completed for the fishing industry surveyed in 1997-1998 as part of the TER evaluations. This project compared the fishing activities spatially and updated the primary economic output and economic impacts for the region, and it described the social, cultural, and economic aspects associated with MPA regulations, both in the TER and in the Keys.

Conclusions and Recommendations: The area's fisheries experienced a consistent consolidation into fewer larger harvesters and fishing effort shifted away from the TER into waters closer to port. The investments on average in the 2004-05 samples increased for each investment type, as compared to the 1998-99 samples. Within the crustacean fisheries, average catch totals and fishing areas changed considerably. For example, within the stone crab fishery, effort expanded significantly, and the average catch among TER fishers almost doubled from 1998 to 2003 (but, it should be noted that catch per trip actually decreased, as average effort also increased considerably). Spiny lobster and shrimp landings within the TER samples decreased on average from 1998 to 2003. The average and total number of days fished in each major fishery reported by fishermen in the 1998-99 and 2004-05 samples increased following the TER closure, with the sole exception of the reef fish fishery.

Cost and Effectiveness of Sequential License Buy-back Programs in the Gulf of Mexico

MARFIN Grant No. NA04NMF4330080

Funding Amount: $182,348 Federal ($95,668 non-Federal)

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Study Objective: To evaluate the cost and effectiveness of sequential license buyback programs relative to one-shot buyback auctions.

Methods and Materials: To determine the extent to which the repeated auction game induces speculation among bidders and to quantify the effects of independent variables such as vessel length and shrimp price we develop a dynamic econometric model of this auction. The model incorporates the learning that is made possible by the sequential nature of the auction through a Bayesian updating process carried out in the state equation of a dynamic optimization subroutine.

Using this model, we estimate the fisherman's intertemporal benefit function. This function characterizes the benefits of holding a license and by comparing its value for a particular fisherman with the value of a bid we can measure the speculative component at play in this auction.

The parameters of the econometric model then feed into a subroutine contained in the General Bioeconomic Fisheries Simulation Model (GBFSM). GBFSM simulates capacity reduction in the shrimp fleet for the Gulf of Mexico. Our prediction of the speculative premium induced by successive round bidding makes it possible to use GBFSM to evaluate the advantages and disadvantages of a sequential buyback program relative to using a one-time buyback program for capacity reduction.

Conclusions and Recommendations: We estimate a speculative premium in the bidding behavior of participants between $2,300 - $4,900. These figures suggest that the sequential auction format imposes an additional cost as bidders use the auction to engage in rent seeking. By removing the opportunity for learning and hence the speculative component a single shot auction may be capable of purchasing licenses at a lower cost to the agency.

An Intertemporal and Spatially-Dynamic Supply Model of the Gulf of Mexico Shrimp Fleet for Use in Management and Bycatch Reduction

MARFIN Grant No. NA17FF2868

Funding Amount: $287,233 Federal ($128,401 non-Federal)

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Study Objectives: To empirically analyze shrimp fleet and fisher behavior in U.S. economic exclusive zone territorial waters of the Northern Gulf of Mexico in terms of fishing effort, spatial and temporal allocation of effort, and economic reactions to market price distributions in order to help guide the decision-making process regarding management of the shrimp fleet.

Methods and Materials: Shrimp landings and vessel data covering the period 1965-2004 and maintained by the Southeast Fisheries Science Center (SEFSC) as part of the Gulf shrimp program were used in this study, with various shorter time periods examined depending on the purpose of each sub-analysis. These data, collected by port agents and through state trip ticket systems both from seafood dealers and through a sample of dockside interviews with fishers, include information on trip-level landings, value, and fishing location information. The interview data also contains more detailed information on fishing effort. Other data used including individual vessel characteristics from the SEFSC maintained Vessel Operating Units files or, where needed, U.S. Coast Guard registration records for merchant vessels and study-constructed GIS database files defining fishing locations in relation to vessel ports. Statistical regression and econometric estimations were used throughout to analyze the data, with the specification of model structure and variables guided by established economic theory and relevant past studies. Specifically, least squares regression was used in analyzing and developing a measure of standardized fishing effort, while iterative seemingly unrelated regression estimators were employed to analyze the effect of prices by size class on the harvesting of shrimp within the context of a Leontief revenue function. A mixed-logit approach was used to analyze location choice based on a number of market, spatial, temporal, and vessel characteristics.

Conclusions and Recommendations: Effort analysis affirms that data consolidation, non-random interview sampling, and the apparent substantial number of one-time or sporadic harvesters has the potential to bias fleet effort calculations. Problems related to data consolidation appear to have been particularly severe prior to the mid-1990s when many older vessels with significantly lower relative fishing power were not included as part of the detailed fleet data. The estimated net result of this consolidation was to significantly overestimate the fishing power of the fleet. In addition, on average from 1985-2004, 10 percent of the vessels

operating each year appeared to be either new to the fishery or newly recorded in the data, implying poor data collection procedures, high levels of fleet turnover, significant numbers of transient vessels in the fishery, or some combination of these explanations. Given that many current and future management problems will be focused on the spatial location of harvesting effort in offshore waters, better methods of monitoring and controlling vessel participation in the fishery need to be implemented to mischaracterizing the fleet and its potential fishing power in any given year.

Economic analysis of harvesting responsiveness to prices across shrimp size classes suggests that shrimp fishermen are primarily opportunistic harvesters that do not fully respond to market pricing signals. The exceptions to this included the largest shrimp (<15 count per pound), where own-price supply elasticities were estimated at 0.71, and the smaller size classed of shrimp, where own-price supply elasticities were estimated at 0.19, 0.32 and 0.47 for 40-50, 50-67, and >67 count per pound, respectively. Effort elasticities were highest for <15 count shrimp at 1.17 and declined monotonically to 0.16 for >67 count shrimp, suggesting that opportunities exist to target larger shrimp. Cross-price supply elasticities were generally small and displayed a non-systematic mixture of substitution and complementary relationships that is consistent with non-selective, opportunistic harvesting. The main exception to this finding was for the largest (<15 count) and smallest (>67 count) size classes. For the <15 count size class, significant and large (in absolute terms) negative cross-price elasticities indicated substitution with the next size class down, implying potential issues with grading given that targeting between such closely related size classes is not likely to be feasible. The smallest (>67 count) size class had significant and positive cross-price elasticities with the next larger size class (50-67 count), perhaps reflecting the temporal and spatial aggregation of these shrimp and the targeted effort that occurs in order to harvest them. Overall, these results indicate that shrimp fishermen may have a very limited ability or inclination to control their harvest structure once at a fishing location, and thus a limited ability to profit maximize. This can have important implications when developing management plans, as incorrect assumptions about decision making behavior are often at the root of unexpected outcomes from regulatory actions.

An Economic Analysis of Fleet Dynamics in the Gulf of Mexico Grouper Fishery

MARFIN GRANT No. NA17FF2879

Funding Amount: $208,980 Federal ($71,058 non-Federal)

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Study Objective: The grouper fishery is considered a multi-species fishery with fishermen targeting and harvesting numerous species within the grouper family and even species outside the family. The grouper fishery is, in general, managed without direct controls on effort and there is a paucity of information related to our economic understanding of the fishery. Without a more thorough understanding of the response of commercial grouper fishermen to changes in economic and regulatory measures, it is likely that implementation of these measures may, at a minimum, affect the harvesting (and stocks) of other species in the fishery that are not the subject of the regulation and may, in the extreme, not generate biological benefits for the species being targeted by the managers. Given this scenario, the overall objective of this project was to provide a more complete understanding of the behavior of fishermen in the Gulf of Mexico commercial fishing fleet.

Methods and Materials: To accomplish this objective, we first addressed the issue as to whether fishing behavior in the commercial grouper fishery is influenced by relative prices received for the harvested products. For example, if the price of one species increases relative to all other species in the multi-species grouper fishery, one might anticipate that a larger share of effort will be directed at that species. Furthermore, if two species are complements in the production process, an increase in the targeting of one species due to its relative price increasing translates into an increased harvest of the complementary species. In contrast, if two species are substitutes, the shifting of effort to one species in response to an increase in its relative price will result in a reduction in the harvest of the substitute species, *ceteris paribus*.

We considered four species (groups of species) for purposes of analysis; red grouper, gag/black grouper (essentially all shallow-water grouper species with the exception of red grouper), the deep-water grouper complex, and "all other" fish. Separate analyses were conducted for the vertical line fleet and the longline fleet, given the different technologies associated with the two gears. In general, results revealed a large amount of substitutability/complementary associated with the multi-product production functions.

Conclusions and Recommendations: Results suggest that any attempts to economically manage the grouper resource should be based on multiproduct production theory, not single species biological response functions. Unless explicit recognition of the economic interactions among species is incorporated into the regulatory process, management of the commercial grouper fishery may induce over- or under-exploitation of specific species resources.

The results further suggest that direct effort restrictions cannot be species-specific without leading to potential changes in the harvest of other species (groups) within the fishery. Given non-specific gear, indirect effort restrictions (such as changes in minimum sizes) may also affect the harvesting of other species in the fishery and may not achieve the biological benefits for the species being targeted by managers (due to release mortality associated with bycatch).

After examining the influence of relative price changes on the behavior of fishermen in the Gulf of Mexico commercial grouper fleet, we turned attention to examining the influence of risk on the behavioral pattern of fishermen. While we generally consider maximization of expected income as the objective of commercial fishermen, in reality, commercial fishermen are more likely to maximize expected utility from fishing activities. Expected utility can be expressed as a function of both expected income and risk. If fishermen, as a group, are risk averse, they would, as a group, be willing to forgo a portion of expected income if doing so maps into some reduction in risk.

Our analysis suggests that grouper fishermen (both the vertical line fleet and the longline fleet) exhibit risk averse behavior. As such they tend to employ more inputs than that needed to maximize expected income (the one exception appears to be with respect to crew size for the longline fleet). In doing so, there is an implicit tradeoff between expected income and risk. Specifically, the increased costs associated with the utilization of more inputs than that required to maximize expected income results in a loss in expected income but also a reduction in risk.

These findings would suggest that input restrictions imposed to protect/rebuild stocks would have less impact on the expected income of fishermen than if the fishermen had exhibited risk neutral or risk seeking behavior. In the extreme, one could even argue that if the risk averse behavior is very large, input restrictions could, conceivably, increase expected income. However, the analysis does not permit us to quantify the degree of risk aversion and, hence, it is impossible to quantify the change in expected income (or revenues) that might be forthcoming from additional regulation.

Current management practices do not consider risk behavior by the commercial fishing fleet and the Regulatory Impact Reviews, which analyze the benefits and costs associated with proposed management measures, tend to examine only changes in expected income associated with the different proposed management measures. Changes in expected utility associated with proposed management measures, however, are not synonymous with changes in expected income (except in the case of risk neutrality) and failure to adequately consider changes in expected utility (as opposed to changes in expected income) are likely to over-or underestimate the estimated welfare changes.

In the last section of the report, we examine the issue of technical efficiency in the Gulf of Mexico commercial grouper fishery. Technical efficiency, in general, refers to the ability of a firm (or industry) to produce maximum output for a given level of inputs. Such an analysis can provide guidance to fishery managers along several lines. For example, estimated changes in technical efficiency can be used to improve stock assessments since much of the data employed in these assessments are, in part, based on catch per unit effort estimates. As a second example, changes in efficiency need to be considered when developing appropriate management strategies for limiting effort in a fishery. Without considering changes in efficiency, the targeted level of

effort reduction in a limited entry program may fall short of that amount needed to achieve a given harvest goal.

Efficiency analysis suggests that technical inefficiency is a contributing factor in explaining differentials in harvests among vessels in both the vertical line segment and the longline segment of the commercial grouper fishery. For the vertical line sector, results suggest that as vessels become more specialized in the grouper fishery, crew is utilized more efficiently. Analysis of the vertical line fleet also indicated that overall industry technical efficiency was enhanced with increased specialization in the grouper fishery. For the longline fleet, results suggest that increasing crew size with an associated increase in effort (defined as number of number of hooks per gear multiplied by soak time) results in an improvement in average vessel efficiency.

Results suggest that efficiency of both the longline and vertical line components of the fishing fleet have been increasing over time. To the extent that this finding reflects technological improvements to vessels (as opposed to, say, increasing stock sizes or fewer vessels competing for a fixed stock on an annual basis[1]), the analysis would tend to indicate that estimated changes in catch per unit effort over time are likely to be biased. This would then call into question stock assessments which assume that an effective unit of effort has remained constant over time and would lend credence to periodically adjusting effective effort in these assessments.[2] The finding would also suggest that long-term management measures aimed at reducing fishing pressure would need to consider increasing effective effort when developing and implementing an appropriate management strategy.

[1] Given expansion in recreational activities, it would seem unlikely that fewer vessels (including recreational vessels) would be competing for a fixed stock.

[2] Indeed, there has been discussion at various SEDAR meetings to adjust effort based on the prevailing belief that effective effort has been increasing over time.

SESSION V – Other Topics

Session Chair: Dr. LaDon Swann

Meta-population stock assessment methods incorporating climatic and ecosystem effects for the Florida spiny lobster fishery

MARFIN Grant No. NA05NMF4331081

Funding Amount: $74,521 Federal ($5,421 non-Federal)

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Study Objectives: The goal of this project was to contribute new knowledge to avoid overexploitation and overcapitalization of the Florida spiny lobster fishery through a better understanding of the highly variable population dynamics of the species. The contribution to this MARFIN high priority species is by providing a better understanding of climate change and ecosystem dynamic effects on population abundance and exploitation rates. To accomplish this goal the following objectives were proposed:
1) To develop a stock assessment algorithm that includes environmental variables in stock recruitment prediction.
2) To apply the algorithm to assess the spiny lobster fishery in the Gulf of Mexico considering Meta population abundance estimated for lobster stocks in Brazil and Nicaragua-Honduras.
3) Develop a forecasting capability for the fishery.

Methods and Materials: Several large databases from the Florida Fish and Wildlife Conservation Commission (FFWCC) were available to the project. These consisted of a 1967-2003 tagging database (6811 useable tag-recapture observations); 1987-2006 monthly catch per trap, number of trips and soak-time by regions of the Florida Keys trap fishery; seasonal landings by size frequencies for all gears and bait; total seasonal landings by all gear. A 1987-2007 puerulus database (catch per day soaking of puerulus collectors set in two places in the Florida Keys). Food and Agriculture Organization of the United Nations (FAO) databases with biological parameters for *P. argus* compiled in the Caribbean region including growth, natural mortality and reproductive parameters. Oceanographic and meteorological databases from NOAA sources consisting in historic mean sea level for the Caribbean Sea and Gulf of Mexico, mean sea level data collected in the Florida Keys from 1988 to 2007 by the National Buoy Data Center (www.nbdc.noaa.gov), and sea surface temperature, oxygen, salinity, and conductivity from the Sombrero Key oceanographic station were available. Landings in weight, size and sex samples and CPUE by fleets for the fisheries in Nicaragua-Honduras shelf and Brazil were available to the project.

Segmented growth modeling by gender was carried out by fitting functional relationships for pre-molt and post-molt carapace sizes and molting frequencies estimated following an algorithm

adapted from Munro (1974) to estimate molt intervals. A segmented growth path was built starting with age at post larval settling.

The segmented growth paths were used to slice age frequencies from size frequencies found in the FFWCC size frequency database. Catch-at-age matrices were used in a gender specific tuned catch-at-age stock assessment algorithm. Tuning was accomplished by utilizing catch per unit of effort standardized to trap-trip corrected by soaking time. Three different procedures were used in the tuning: 1) q-constant estimated internally by groups of years that portrayed the trap reduction program implementation, 2) q-variable estimated internally for each fishing season, and 3) q externally estimated from a depletion model fitted to the monthly soak-time standardized catch per trap-trip. The adequacy of the tuning procedures was judged from the overall variance of the fitting of the objective functions and by an ad hoc analysis of the comparison of the recruitment at age 1 from the age-structured model and the recruitment index estimated from the seasonal depletion model. The resulting information consisted of recruitment abundance at age 1 for males and females, overall stock abundance (all ages), spawning stock according to maturity at age (age 3+), and stock fecundity according to fecundity at size translated to age by the segmented growth path. Fishing mortality rates at age by season and gender as well as an exploitation pattern were also obtained. Identical stock assessment procedures were used with the existing Nicaragua-Honduras and Brazil fisheries.

A puerulus abundance index was estimated from the nominal puerulus CPUE expressed as number of post larva per soak-time by means of a Generalized Linear Model (GLM) where years, seasons, and Florida Keys mean sea level corresponding to each soak-time were used as sources of variance. The annual puerulus estimate obtained by the GLM procedure was centered on the seasonal fishery (August to April), such that estimates could be used in further analyses relative to the recruitment and parent stock abundance previously estimated from the catch at age stock assessment algorithm.

Conclusions and Recommendations: The analyses in this project show a persistent and significant decreasing trend in the Florida spawning stock abundance. Such decline matches post larval abundance estimates also obtained by the project. This constitutes the first demonstration that larval recruitment to the Florida fishery is to a significant extent dependent on local spawning stock. It is concluded that lower landings observed since 2000 are due to low stock abundance, lower post larval abundance and subsequent lower recruitment. Fishing mortality rates follow an increasing trend reaching values that are twice as large as the natural mortality rate assumed for the species. Apical fishing mortality rate is more than 4 times the natural mortality rate. Regional ecosystem shifts are described as potential cause for the lower recruitment success estimated for the last seasons in the time series analyzed. The trend in the shifts of recruitment success is also observed in the analyses carried out for the Caribbean spiny lobster in the Honduras-Nicaragua fisheries. Furthermore, the importance of local spawning stock on puerulus recruitment abundance and their concomitant decreasing trends should prompt research pertaining regulations based biologically acceptable annual quotas.

Atlantic croaker (*Micropogonias undulatus)* along the middle Atlantic coast and southeast coast of the United States

MARFIN Grant No. NA17FF2885

Funding Amount: $223,732

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Study Objectives: The stock structure of the Atlantic croaker, *Micropogonias undulatus* L., along the Atlantic coast of the US was studied using parasites as biological tags.

Methods and Materials: This species' macroparasite community was determined from 487 specimens from the Mid-Atlantic and South Atlantic Bights. Parasites were identified, prevalences and intensities calculated, and the parasite community of Atlantic croaker was compared with respect to geography based on the various abiotic (temperature, salinity, depth, latitude) and biotic (host length, host sex, host age) variables associated with each site (host fish) by canonical correspondence analysis (CCA). Possible effects of host age and length, as well as season, on parasite prevalence and intensity were minimized by using only those fish of ages 0 and 1 collected in the fall.

Criteria established were used to select the most appropriate tags in the identification of croaker stocks including comparisons of prevalence and intensity between regions (0 = north of Cape Hatteras; 1 = between Cape Hatteras and Cape Fear, NC; 2 = south of Cape Fear, NC).

Conclusions and Recommendations: A total of 31 macroparasites from four phyla were found parasitizing the croaker, six of which represented new host records: one turbellarian, two monogeneans (*Encotyllabe* sp., *Diplectanotrema* sp.), one didymozoid, one philometrid nematode, and one acanthocephalan (*Pomphorhynchus rocci*). Ten species were appropriate tags for the identification of croaker stocks: one turbellarian; three monogeneans, *Diplectanotrema* sp., *Encotyllabe* sp., and *Macrovalvitrematoides micropogoni*; three digeneans, *Diplomonorchis leistomi*, *Opecoeloides fimbriatus*, and *Stephanostomum tenue*; one aspidogastrean, *Lobatostoma ringens*; two acanthocephalans, *Dollfusentis chandleri* and *Serrasentis sagittifer*.

The dominance of latitude in the CCA in determining the macroparasite community of croaker supported the use of parasites as tags to address stock structure, and the 10 tags supported the presence of two stocks of this fish roughly separated at Cape Hatteras, NC.

The abundance of Atlantic croaker in the NMFS fall groundfish survey along the Mid-Atlantic coast has shown a general increasing trend since the mid-1990's and presently is at near record levels. The SEAMAP South Atlantic survey does not show the same dramatic increasing trends

in abundance as seen in the Mid-Atlantic and has remained relatively stable over the time series. Spawning times, subsequent periods of estuarine recruitment, as well as the size and age composition of survey caught fishes are compared along the east coast of the US.

Fishery and population characteristics of wahoo (*Acanthocybium solandri*) in Florida and adjacent waters of the western north Atlantic Ocean

MARFIN Grant No. NA17FF2882

Funding Amount: $182,701 Federal ($49,697 non-Federal)

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Study Objective: To examine wahoo fishery data and collect wahoo from coastal and offshore waters of Florida to estimate life history parameters relevant for a stock assessment of this valuable marine species.

Methods and Materials: Wahoo fishery data were examined from three established databases (Florida and Federal databases): the Florida Marine Fisheries Information System (FMFIS), the Trip Interview Program (TIP), and the Marine Recreational Fisheries Statistics Survey (MRFSS). Suitable samples sizes of wahoo were obtained for all calendar months using a variety of fishery sources. Data collected were: length, weight, and sex. Various hard parts were taken during year 1 for aging purposes, and selected body parts were taken in years 2 and 3 for aging. Additional samples were taken for reproductive characterization. When ripe females are encountered, some of the gonad tissue was retained for fecundity analysis; otherwise all gonad material was histologically prepared and examined.

Conclusions and Recommendations: Wahoo achieve a very large size, are short lived, grow rapidly in their first year, and have high mortality rates. Wahoo ranged in size from 628 to 1956 mm fork length (FL; n = 575). The largest individuals were female and the sex ratio was significantly female biased (298 females: 223 males: 54 unknown sex). This study presents an edge analysis to support the use of sectioned otoliths for ageing wahoo. Annuli were formed primarily during winter-spring. Wahoo lived a median of 1.3 years, a mean of 1.8 years, and a maximum of 9.3 years (n = 469). They had a high instantaneous mortality rate (Z = 0.98), and they grew rapidly and to a large size; von Bertalanffy growth parameters were: L_∞ = 1701 mm fork length [FL], K = 0.381, t_0 = -1.63. Females had a very similar maximum age relative to males (maximum age 9.3 v. age 9.1 years), and they had a slightly, but not significantly, lower mortality (Z = 0.91 v. 1.1) than males. Females grew larger than males (L_∞ = 1797 v. 1555 mm FL, maximum observed = 1804 v. 1585 mm FL), but not significantly larger, creating only an appearance of sexual dimorphism.

Examination of gonad histology revealed that oocyte development was asynchronous and oocyte atresia was common during the spawning season; thus, fecundity was indeterminate. Wahoo were summer spawners: gonad-somatic indices of both sexes and the percent frequency of mature, active females were elevated from May to August. The smallest mature female was 880

mm FL, the largest immature female was 1150 mm FL. The size and age at 50% female maturity [1]occurred during the first winter of growth, at 925 mm FL and 0.64 years, respectivel[2]y. Thirteen percent of the mature females were inactive during the peak summer spawning season (June-August), which may be evidence for skip spawning or asynchronous spawning patterns among individuals. Wahoo are batch spawners, with a median spawning frequency of once every five days during May-August. Batch fecundity was positively correlated with fish size, varying between 0.44 and 1.67 million eggs. Although wahoo have been noted to have relatively small gonads, annual fecundity estimates are not small: on the order of 10-100 million eggs.

[1] Current Address: NOAA's National Marine Fisheries Service, Woods Hole, MA 02543-1026

Identifying spawning grounds and classifying habitat for red drum (*Sciaenops ocellatus*) in Pamlico Sound, NC

MARFIN Grant No. NA04NMF4330293

Funding Amount: $241,122 Federal ($22,686 non-Federal)

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Study Objectives: Our research is focused on identifying spawning grounds and classifying nursery habitat for red drum *Sciaenops ocellatus* in coastal North Carolina.

Methods and Materials: We addressed our research objectives using three primary methods: 1) passive acoustic sampling that was used to detect male courtship vocalizations, 2) neuston sampling to detect eggs and larvae of red drum, and 3) otolith microchemistry of settled young-of-the-year red drum to determine natal origin and determine if there are unique elemental signatures for different nursery habitats.

Conclusions and Recommendations: We found a significant relationship between the presence and frequency of courtship vocalizations and egg presence in the water column, helping to confirm that passive acoustic sampling is a reliable method to gauge spawning activity. In addition, we found courtship vocalizations to be more common in deeper water (> 4 m depth), and found a significant effect of year. We suggest this inter-annual pattern is driven by changes in the degree of saltwater intrusion into Pamlico Sound. We observed eggs and red drum pelagic larvae (2.6-8.6 mm TL) in the Neuse River estuary and Ocracoke Inlet. The concentration of eggs was observed to be significantly higher in Ocracoke Inlet. Comparison of elemental ratios at the core and edge of the otolith indicate that young-of-the-year red drum rearing in Neuse River tributaries during 2003 originated in higher salinity spawning environments. The year 2003 was marked by relatively high freshwater discharge, which resulted in unusually low salinity throughout the Neuse River estuary. We draw inferences on how the degree of saltwater intrusion may influence the use of estuarine habitat for spawning in this species. We observed significant differences in elemental composition at the edge of otoliths taken from YOY rearing in four different nursery grounds (upstream and downstream in the Neuse River estuary, and northern and southern Outer Banks), indicating that it may be possible to determine natal origin of adult red drum based on elemental composition of otoliths. Further research could lead to methods to determine the relative contribution of different nursery habitats to recruitment of red drum in coastal North Carolina.

BRD Evaluation Observers

MARFIN Grant No. 05MFIH06

Funding Amount: $207,848

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Study Objectives: The primary objective of this research is to provide and manage observer data on BRD effectiveness in finfish reduction and shrimp retention during commercial shrimping operations in the Gulf of Mexico and southeastern Atlantic. Observer data will be used to further refine catch rate estimates of selected finfish and shrimp by area and season. Specific objectives include: (1) provide data that can be used to estimate total bycatch of selected species in the U.S. South Atlantic and Gulf of Mexico for stock assessment analysis, (2) collect BRD evaluation data from commercial shrimp vessels operating in the U.S. Gulf of Mexico during periods of maximum shrimping activity, (3) manage and maintain a validated BRD data base for the use by all interested parties, and (4) statistically evaluate the data and create summary files for other user groups.

Methods and Materials: This research project represents the eleventh year of funding for bycatch characterization and BRD evaluation through MARFIN and it follows the guidelines found in the Research Plan Addressing Finfish Bycatch in the Gulf of Mexico and South Atlantic Shrimp Fisheries, prepared by the Gulf and South Atlantic Fisheries Foundation, Inc. under the direction of a Steering Committee composed of individuals representing industry, environmental, State, and Federal interests. The intent of the sampling design is to survey the commercial shrimp fishery in operation and not to simply establish a research survey study of the bycatch or the finfish populations. The sampling universe in this case consists of all tows from all vessels shrimping in the Gulf of Mexico and along the Atlantic coast of the southeastern United States. Parameters of interest are the catch totals and size distributions of species of finfish and invertebrates incidentally taken by the shrimp fleet.

The quantity and type of bycatch will change with fishing location, season, depth. Stratification by these variables minimized the variances of catch estimates. Thirty strata were identified using three seasons (season 1: January through April, season 2: May through August and season 3: September through December), five locations (Statistical zones 1-9, 10-12, 13-17, 18-21, and the U. S. Atlantic coast), and two depths (nearshore and offshore). The sample unit consists of a single subsample from a trawl haul.

NMFS trained observers collect the trawl haul subsamples and record the data following the established protocols published with the Bycatch Research Plan. In the characterization research phase, a 12-kilogram per tow hour subsample is obtained from one randomly selected net after each tow. In the BRD evaluation research phase, a subsample of one basket (i.e., about 32 kg) of the catch is obtained from the experimental net and the control net after each tow. In both research phases, the data collected consists of total tow weight, subsample weight, species composition, abundance, weight, and data for life history information. The allocation of samples is based only on intensity of shrimping effort and not on abundance levels of selected finfish species.

Project Findings: Over the past several years (February 1992 through August 2006) a total of 16,324 observer days has been secured by trained observers in the Gulf of Mexico and along the east coast of the United States. Most of these sea days were in waters off Louisiana (5,172 days) and Texas (4,843 days), followed by the west coast of Florida (2,382 days), Alabama-Mississippi area (2,194 days), and finally the east coast (1,733 days). These observer days were accomplished during 1,667 trips, varying in length from 1 to 62 days. From these observer days, trawl data have been collected from over 28,649 individual tows, with several hundred different species being documented from the trawls. As with sea days, most of the tows have been from the offshore waters (>10 fm) off Louisiana and Texas.

When all tows collected in the Gulf of Mexico were combined the statistics reveal that about 67% of the catch by weight is composed of finfish, while about 16% is composed of commercial shrimp species. Analysis of the catch by numbers of individuals showed the breakdown to be 50% finfish and 29% commercial shrimp. In the south Atlantic the statistics revealed that about 51% of the catch by weight is composed of finfish, while about 18% is composed of commercial shrimp species. Analysis of the catch by numbers of individuals showed the breakdown to be 54% finfish and 239% commercial shrimp.

The top 10 species in the Gulf of Mexico by weight were longspine porgy (15%), brown shrimp (9%), Atlantic croaker (9%), inshore lizardfish (6%), pink shrimp (3%), Gulf butterfish (3%), lesser blue crab (2%), white shrimp (2%), longspine swimming crab (2%), and brown rock shrimp (2%). The top 10 species in the Gulf of Mexico by number of individuals were longspine porgy (19%), brown shrimp (9%), Atlantic croaker (6%), longspine swimming crab (6%), Trachypenaeus shrimp (5%), pink shrimp (4%), mantis shrimp (3%), lesser blue crab (3%), brown rock shrimp (3%), and iridescent swimming crab (3%).

The top 10 species in the south Atlantic by weight were cannonball jellyfish (14%), white shrimp (9%), spot (9%), Atlantic menhaden (9%), jellyfish (8%), brown shrimp (8%), Atlantic croaker (6%), southern kingfish (4%), blue crab (4%), and star drum (3%). The top 10 species in the south Atlantic by number of individuals were brown shrimp (13%), spot (10%), white shrimp (10%), Atlantic menhaden (8%), cannonball jellyfish (6%), star drum (6%), pink shrimp (6%), Atlantic croaker (5%), jellyfish (4%), and blue crab (3%).

Technology Transfer of New Turtle Excluder Device Modifications and Updated Bycatch Reduction Device Information to the Southeastern Shrimp Industry

MARFIN Grant No. NA17FF2867

Funding Amount: $171,000

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Study Objectives:

Provide the shrimp industry with clear descriptions of new Turtle Excluder Device (TED) regulations.

Provide information and assistance with newly mandated TED modifications, i.e., demonstrate and teach construction changes needed in installing 71 inch escape hole; construction techniques for Double Cover TED.

Provide information of new BRD designs, exchange ideas regarding status of prototype gears being tested, and assist individuals with problems that they are encountering.

Share experiences of fishermen with BRDs and TEDs in one area (both positive and negative) with industry members in another so that heuristic experiences can be used as an asset.

Methods and Materials:

Formal and informal workshops and meetings were the methods most often used to engage industry members. Through close cooperation with National Marine Fisheries Service, an intensive outreach effort was performed throughout the Southeast Region. These efforts were augmented through the dissemination of handout materials, which included DVDs, multi-lingual publications, multi-lingual videos and a plethora of other materials, to net shops and TED/grid manufacturers, as well as shrimp fishermen. The purpose of formal workshops was to educate fishermen about new TED designs and related construction techniques. Although these workshops were an efficient method for contacting fishermen, it was not the most effective; individual problems were difficult to assess and rectify. It was found that informal dockside meetings were most effective, and allowed individual's problems to be resolved. Approximately 100 ports were visited during informal dockside visits. TED demonstrations were also conducted aboard several vessels and the results of these were extremely valuable to the shrimp community.

Conclusions and Recommendations:

Early TED demonstrations with the new gear yielded important information, which, through working with NOAA Fisheries, ameliorated a major problem in the Western Gulf Mexico. A very narrow window of time was provided to make changes to the TED designs. The success of industry meeting mandates for the new TED designs was apparent through compliance demonstrated by adaptation of the gear. Industry utilized the information provided by the Foundation and performed necessary steps to meet the newly established legal requirements. This was accomplished through personal contact of approximately 933 fishermen and the performance of formal workshops to approximately 405 individuals.

Although formal workshops are the most efficient method of information dissemination to the fishing industry, personal dockside contacts in fishing ports are the most effective. One-on-one assistance allows for individual problems to be addressed with gear. Greater understanding of gear modifications by fishermen can be achieved when working hands-on with their personal equipment.

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