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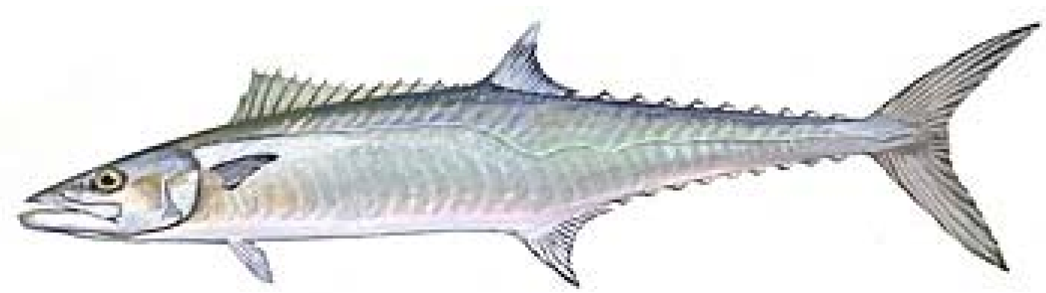
A VISION FOR THE KING MACKEREL FISHERY



FINAL REPORT OF THE
ATLANTIC KING MACKEREL FISHERY
STAKEHOLDER WORKGROUP

Submitted to the

South Atlantic Fishery Management Council

December 4, 2008

EXECUTIVE SUMMARY

A workgroup of stakeholders developed a common vision of what an ideal king mackerel fishery would look like, and then evaluated the efficacy of a series of options suggested by workgroup members to achieve their goals for the fishery. The efficacy of options was evaluated through a formal decision analysis in which expected outcomes from each option were estimated and compared to the stakeholders' goals for the fishery.

Based on this process, the workgroup developed 17 consensus recommendations that seek to improve the long term sustainability and quality of Atlantic king mackerel fisheries. **It should be emphasized that members of the workgroup voted as individuals: their votes should NOT be taken as construing endorsement by the agencies and organizations of which they are members.** The workgroup made three specific recommendations for the recreational fishery that seek to avoid the Atlantic king mackerel stock from becoming overfished or experiencing overfishing, while maintaining an year-round recreational fishery: These recommendations are:

- 8 million lb annual total allowable catch, and a 2 fish per angler daily bag limit for the recreational fishery in all states.
- 8 million lb annual total allowable catch, 2 fish per angler daily bag limit in all states, and a 28" minimum size limit for the recreational fishery.
- 8 million lb annual total allowable catch, status quo bag limits, but with a 32" minimum size limit for the recreational fishery.

To improve our ability to manage this species in the future, the workgroup also recommended four management principles be adopted:

- The Atlantic and Gulf Councils should consider the effects of fishing on the stock in Mexican waters in their future stock assessments.
- The Council should consider the Gulf of Mexico king mackerel stock as well as the Atlantic stock before any adjustments are made to the Atlantic king mackerel stock quota. Mixing zone allocation decisions should be informed by a stakeholder process and based on a comprehensive analysis of the underlying biology of the two fisheries.
- Decisions affecting the Atlantic king mackerel fishery should be considered in conjunction with the Gulf king mackerel fishery before changes in management are made.
- The Council's stakeholder process should be expanded to include a more direct and interactive stakeholder driven process that seeks to improve input in developing scientifically-based management advice and exploring potential consequences of alternative management actions, such as the FishSmart process, to guide the Council's management decisions.

INTRODUCTION

Federal and State legislation requires jurisdictions to ensure that populations of marine fish are exploited at sustainable levels. Several issues make ensuring that this mandate is achieved a challenge. These issues include:

- *We manage the fishermen and not the fish*. In the near-term, we cannot directly change the underlying productivity of the fish species we catch. Rather, we control the timing, location, number and characteristics of fish harvested. These controls can be effected either through influencing the behavior of fishermen or by regulation.
- *Abundances of marine fish are inherently variable*. Interannual differences in abundance of more several orders of magnitude are not uncommon in some species. This means that management regulations have to be reviewed frequently to reflect changing circumstances.
- *Each species is often targeted by multiple stakeholder groups that may have different visions for the characteristics of a well managed fishery.* This can lead to conflicts among stakeholder groups.
- *Harvest patterns in marine fisheries have changed.* Historically, the principal stakeholders in marine fisheries were commercial interests. However, marine recreational fishing has increased in importance over the last 50 yrs and in some fisheries recreational anglers are now the principal stakeholder group.
- *Society's interest in maintaining healthy marine ecosystems has increased.* This has lead to a recognition that we must also conserve the ecosystem services that exploited species might provide. Examples of such services might include maintaining biodiversity, filtering of primary production, transfer of energy between benthic and pelagic ecosystems.

Existing approaches to fisheries management are not always best suited to contend with these issues. In particular the fishery management process has yet to fully integrate the views of diverse stakeholder groups into management decisions. An often noted criticism is that input from stakeholders is sought only after management options have been formulated. This has led to the perception among some stakeholders that their views are not fully valued, and that managers are seeking only a rubber stamp of approval.

In 2007, The Gordon and Betty Moore Foundation funded a team of scientists and representatives from the American Sportfishing Association, a trade group representing fishing tackle and boat manufacturers, to assess the potential of a new approach that can incorporate multiple stakeholder viewpoints in the management process. The project, termed FishSmart, seeks to increase the quality of marine recreational fisheries by reducing the impact of marine recreational fishing while still maintaining a quality fishing experience through a combination of changes to regulations, angling practices, and through the development of new tackle. At the heart of this aim is the important goal that fisheries management will be more likely to achieve its goal of sustainable fisheries if all stakeholders contribute and are more fully engaged at multiple stages of the management process.

The FishSmart project is overseen by a national steering committee that includes representatives from State and Federal government, angling organizations, trade groups, environmental NGOs and academicians. The project funded by the Moore Foundation had two central objectives. First, we sought to document and analyze marine recreational fisheries around the nation to identify changes in harvest patterns and to identify characteristics of species that might make them particularly responsive to changes in recreational fishing activity. Second, we sought to identify a target species that could serve as a case study for the development and testing of a stakeholder driven process designed to explore and recommend options for improving the quality of marine recreational fisheries for the target species. Following extensive review of candidate fisheries, the steering committee endorsed the selection of the king mackerel fishery in the southeast Atlantic as the first system in which the FishSmart process would be implemented.

PROBLEM STATEMENT

The FishSmart process was implemented to solve two problems simultaneously.

Problem 1: *Involvement of stakeholders at critical decision-making stages of the management process is can be improved*. Marine fisheries management in the US is regulated through the council process. From its outset, the council process has made efforts to include a variety of stakeholders in evaluating management decisions. This is to be applauded. However, there remain important deficiencies with the level of involvement and the stage at which that involvement occurs. These deficiencies have led to a broad level of dissatisfaction among key stakeholder groups including marine recreational anglers and environmental non-governmental organizations.

Problem 2: *The recreational fisheries for the Atlantic migratory group of king mackerel are not currently structured to provide the highest quality angling experience*. The recreational fisheries for king mackerel in the Atlantic are diverse and include important charter and tournament elements in addition to participation by individual anglers. Stakeholders seek to understand and advise on alternative management options that could be implemented through regulation, or through voluntary efforts that would bring benefits to all stakeholder groups.

PROCESS

THE WORKGROUP

The core of the FishSmart process was the involvement of a workgroup of stakeholders in a facilitated process that sought to develop a common vision of what an ideal king mackerel fishery would look like, and then evaluate the efficacy of a series of options suggested by workgroup members to achieve their goals for the fishery. The efficacy of options was evaluated through a formal decision analysis in which expected outcomes from each option were estimated and compared to the stakeholders' goals for the fishery. The timeline for the process is given in Appendix I

Workgroup members were selected to represent key groups of stakeholders. Potential members were identified following extensive consultation with steering committee members, South Atlantic Fishery Management Council (SAFMC) staff, Gulf of Mexico Fishery Management Council (GMFMC) staff, recreational angling organizations, sports writers and editors of sport fishing magazines, and with individual anglers. Because the workgroup had to be limited in size to less than 25 to ensure its effectiveness, and because constituent groups of stakeholders had to be represented effectively, members chosen were recognized leaders among their constituents. To participate, members had to be willing to work constructively with stakeholders of different interest groups. An additional and important requirement for members was that they had to commit to attending all of the workshops. This was an important criterion for workgroup membership because the workshops built upon one another and educating new members partway through the process would have severely diminished the rate of progress. Further, continuity was viewed as important to maximize the development of positive working relationships among stakeholder groups. Participation of individuals in the process was voluntary, and some members forfeited income in order to attend workgroup meetings, so members had to be satisfied that the process would be a valuable use of their time.

The final workgroup was composed of 13 members. Stakeholder groups represented included: independent recreational anglers, angling organizations, charter captains, tournament organizers and participants, commercial fishers, tackle shop owners, environmental NGOs and state biologists and managers. Group members included the sitting Chair, the past Chair and two current members of the SAFMC king mackerel advisory panel, as well as the managing partner of the Southern Kingfish Association, the largest U.S. tournament circuit for the Atlantic migratory group of king mackerel. The workgroup members are identified in Appendix II.

Workgroup deliberations and recommendations depended upon consensus-building techniques using professional facilitators. Facilitators were from the Florida Conflict Resolution Consortium – a legislated division of Florida State University. The facilitators brought considerable experience in consensus development among stakeholders in a range of situations including other fisheries and natural resources in Florida and the Southeast. The facilitation team used a variety of techniques that included shared visioning, brainstorming, ranking and prioritizing approaches. General consensus is a participatory process whereby, on matters of substance, the members strive for agreements which all of the members can accept, support, live with or agree not to oppose. In instances where the workgroup found that 100% acceptance or support was not achievable after vigorously exploring possible ways to enhance the members' support for the final package of recommendations, final consensus recommendations required at least 75% favorable vote of all members present and voting. This super majority decision rule underscored the importance of actively developing consensus throughout the process on substantive issues with the participation of all members. While workgroup members, staff, and facilitators were present at discussions, only workgroup members voted on proposals and recommendations.

It should be emphasized that members of the workgroup voted as individuals: their votes should NOT be taken as construing endorsement by the agencies and organizations of which they are members. Indeed, reflective of the organizational structure of the Coastal Conservation Association, workgroup members from that organization did not vote on any recommendations that involved specific regulatory changes

The workgroup met on four occasions between April - November 2008. There were four general stages to the workgroups deliberation:

- Establishment of a goal that expressed the workgroup's vision for an ideal king mackerel fishery. (Meeting 1)
- Development by the workgroup of a range of fishery options for either voluntary action or regulation that could be implemented to achieve the goal. (Meetings 1-3)
- Development of a series of quantifiable performance measures that express the extent to which the options help meet the fishery goal (Meeting 1-3)
- Based on evaluation of the performance of the options relative to the selected performance measures, the workgroup developed a suite of recommendations to be communicated to the SAFMC. (Meeting 4)

Executive summaries for meetings 1-3 are provided in Appendices III-V.

THE MODEL AND ITS ROLE

The evaluation of the options suggested by the workgroup centered on the development of a decision analysis model that estimated the ability of options to meet stakeholder objectives. Accordingly, in conjunction with stakeholders, a computer simulation program was developed as the primary tool to evaluate alternative management strategies for the fishery. Other options for the fishery were identified and recommended by the workgroup, but could not be evaluated by the model. The use of a simulation model to quantify the performance of alternative management options was recommended by the external peer review team that reviewed the most recent stock assessment for king mackerel.

Full details of the model are provided in Appendix VI and are only summarized here. An age-, size-, and sex-structured stochastic simulation model with four intra-annual periods and two areas was developed. The model contained three fishery sectors: recreational, tournament, and commercial. Parameter values and their uncertainty were largely taken from the SEDAR 16 stock assessment model. One notable exception to this was the stock recruitment parameters. The steepness of the stock-recruitment relationship was not well defined because of a lack of contrast in the estimates of stock size. Therefore, we used a meta-analysis of other mackerel stocks to estimate the steepness of the stock-recruitment relationship.

Uncertainty was included in the model through parameter uncertainty, inter-annual variation, and uncertainty in how the fishery will respond to changes in the population and regulations. Inclusion of uncertainty is a critical part of the modeling process, but explicit inclusion of some factors was very difficult. For example, workgroup members had long discussions about future trends in recreational fishing effort and effects of increasing fuel prices, changes in management of other fisheries, and overall declining participation rates in U.S. recreational fisheries. We were unable to include these considerations in the model explicitly. However, we conducted sensitivity analyses to evaluate how future effort patters could affect the efficacy of different options. Other major uncertainties included effects of global warming, economic impacts of changes in the fishery, and uncertainty about migration patterns and timing of migration.

Based on workgroup discussions regarding features desirable in the ideal king mackerel fishery, the model was used to assess the utility of management and voluntary changes in angling practice with respect to the following performance measures:

- Spawning Population in Weight relative to SSB at $F_{30\%}$
- Instantaneous fishing mortality rate relative to $F_{30\%}$
- Proportion of the year open to recreational fishing
- Commercial Harvest in Weight, Numbers
- Recreational Harvest in Numbers
- Tournament Harvest in Numbers
- Harvest of Fish between 10 and 12 pounds (Commercial Target)
- Harvest of Fish > 20 pounds (Recreational Target)
- Harvest of Fish > 50 pounds (Tournament Target)
- Average Fish Weights in each Sector
- Proportion of Population ≥ 15 years old
- Number of Deaths due to Release Mortality
- Average Weight of Spawners

GUIDING PRINCIPLES

The workgroup unanimously adopted the following guidelines to govern its discussions.

Principle 1: The overall purpose of the FishSmart workgroup is to build consensus on recommendations for the development and use of the FishSmart mModel, to sustain and enhance the king mackerel fishery along the Atlantic coast.

Principle 2: The FishSmart workgroup will operate under clear, concise, consistent, and fair procedural protocols.

Principle 3: The FishSmart workgroup will strive to achieve consensus on substantive recommendations made to FishSmart project staff.

Principle 4: FishSmart workgroup members will each serve as an accessible liaison betweenthe workgroup and their representative constituency stakeholder groups.

GOALS

The workgroup adopted the following goal statements that reflected both the process followed and the workgroup's goal for the fishery

GOAL FOR THE WORKGROUP PROCESS

The goal of the FishSmart workgroup is to develop a package of recommendations informed by a model collaboratively developed by the workgroup and the FishSmart project staff evaluating Atlantic king mackerel fishery practice and management options and alternatives. The workgroup recommendations will be directed to the FishSmart project staff and shared with fishery managers. The project's ultimate goal is to ensure that the regulation, management and angling practices of the fishery are informed by best available science and shared stakeholder stewardship values, resulting in an enhanced and sustainable Atlantic king mackerel fishery.

GOAL FOR THE ATLANTIC KING MACKEREL FISHERY

A sustainable Atlantic King Mackerel (AKM) fishery should be managed to prevent overfishing from occurring, prevent the species from being overfished, to ensure optimum yield is not exceeded, while maintaining the genetic diversity of fish and providing acceptable levels of access and allocation for all sectors while conserving biological and ecological functions.

OUTCOMES AND RECOMMENDATIONS

In their first meeting, the workgroup identified the following desirable characteristics for the fishery ten years hence in 2018:

- There is an abundant fishery.
- Angler recruitment increased
- A fishery configured much as it is today with the same success with sustainability of the fishery.
- Fishery open 365 days a year with limitations on the harvest so you can take something home to eat.
- A healthy, sustainable stock population that is meeting the needs of the public- be they commercial, conservation or recreation interests
- A sustainable fishery with educated input from all users of the fishery on how to "divide the pie"
- Adequate but enforceable rules
- Regulated in an environment where scientists, managers and users work closely together.
- Educated users actively participating in an updated and new management process.
- The necessary, right and accurate data will be collected regarding recreational angling- accurate and utilized in the management
- Recreational landings data will be accurately incorporated into the management.
- Fishery managers are working with Tournament organizers to collaboratively collect important data.
- Communication technology is used to facilitate the education process- e.g. recreational anglers input daily catch into a system to assist with management of the AKM fishery
- Global climate change has no significant impact on the sustainability of the fishery.
- Education is a key factor in sustaining the stock- educating the public, fishing public and managers and regulators.
- Better education of the why and how regarding regulations is the key through user groups such as fishing clubs, etc.
- Regulators and managers have an easy job because all sectors are well informed, organized and environmentally responsible.
- Regulators and managers would be looking for a job because the fishery would be self-regulated
- Management is not the "miserable science" it is today

Equally, the following outcomes were identified as highly undesirable outcomes for the fishery in ten years in 2018

- An unsustainable fishery
- Phenomenally regulated fishery- heavy hand of government on fishery
- More ecologically destructive than today.

- Decline of fishery has a undesirable impact on the economy
- Decline in stock happens so fast that it requires draconian regulatory framework.
- Impositions of seasons and more closed areas.
- No tournaments
- Decline in the stock brings on additional regulation, reduction of bag limits for commercial quota, increase size limits, slot size
- A stock assessment not reflecting the current realities of the Atlantic AKM fishery
- An enhanced and sustained fishery you can't eat because of mercury poisoning and other pollution.
- Some parts of the fishery proving to be ecologically unsustainable

In their efforts to achieve their shared vision and to avoid the undesirable outcomes identified above, in their fourth meeting, the workgroup developed 17 consensus recommendations for actions that the workgroup believes would improve the quality and sustainability of the king mackerel fisheries.

All of the FishSmart recommendations were developed through an interactive consensus process and reflect 75% or greater support by the workgroup members. These consensus recommendations reflect their individual expertise and collective judgment and not necessarily those of the organizations to which members belong.

The workgroup developed recommendations under four general areas:

- **Management regulations:** - recommendations in this area focus on specific changes to regulation that the workgroup recommend be implemented by management agencies. These recommendations were developed as a result of evaluation of the results of the modeling exercise to quantify the performance of a range of management alternatives suggested by the workgroup.
- **Voluntary actions or behaviors: -** recommendations in this area focus on how anglers can alter their behavior independent of regulation to improve the quality of the king mackerel fisheries.
- **Management Principles** – recommendations in this area focus on broad, over-arching principles that should characterize good management practice for the king mackerel fishery. These recommendations arose from discussions among the workgroup members, and were to an extent influenced by uncertainties recognized in the model, and to a lesser extent by output of the model.
- **Stakeholder education initiatives:** - recommendations in this area focus on communication and education initiatives that are recommended to be implemented by the workgroup. The majority of these initiatives focus on altering angler behavior and increasing compliance with management policies.

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Next we present the recommendations specific to the recreational fishery for each area.

A. MANAGEMENT AND REGULATION RECOMMENDATIONS

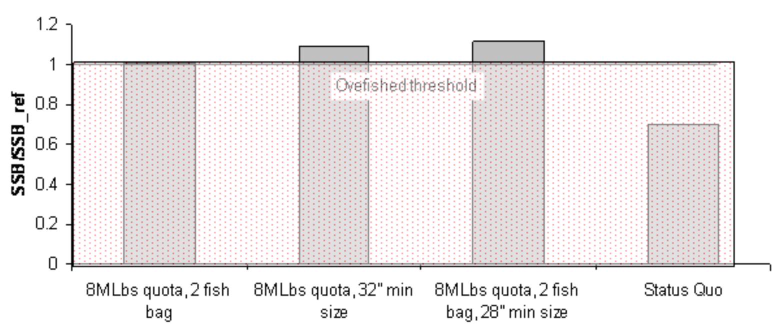
The workgroup considered a number of different and specific management actions and combination of actions. Each option was evaluated using the simulation model to weigh the relative performance of the different options considered. Based on the results of these simulations, the workgroup reached consensus on the following specific management recommendations.

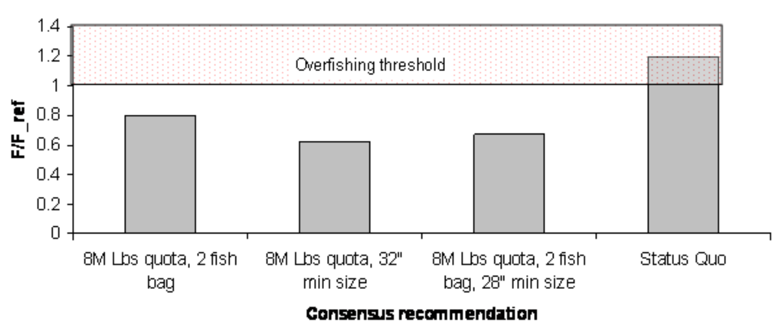
A.1. The workgroup recommends that the management options considered by the Council should be designed to meet the following three minimum criteria:

- The option should maintain the Atlantic king mackerel stock above the overfished and below overfishing thresholds over a period of at least 15 years.
- The option should result in the least impact to both recreational and commercial sectors.
- The option should avoid seasonal and area closures.

A.2. The FishSmart workgroup proposed three consensus Atlantic king mackerel management options that each met and exceeded the minimum criteria defined above. *(see A.1)* The modeling results and analysis suggest that each may perform differently relative to their overall effects: on the recreational and commercial fishery; on increasing spawning stock biomass; and on fish mortality. As a result, the FishSmart workgroup decided to recommend these management options be considered and evaluated by the Council. The workgroup did not establish a priority order for the following three combination options:

- 8 million lb annual total allowable catch, and a 2 fish per angler daily bag limit in all jurisdictions for the recreational fishery.
- 8 million lb annual total allowable catch, 2 fish per angler daily bag limit in all jurisdictions, and a 28" minimum size limit for the recreational fishery.
- 8 million lb annual total allowable catch, status quo bag limits, and a 32" minimum size limit for the recreational fishery.





B. STAKEHOLDER ACTIONS AND BEHAVIORS RECOMMENDATIONS

Recreational anglers have historically contributed to the sustainability and viability of the AKM fishery through their stewardship efforts. The workgroup recommends and supports the following additional actions be continued or undertaken by the recreational sector:

B.1. Mandatory web-based trip and catch reporting for head boats.

B.2. Mandatory web-based trip and catch reporting for charter boats.

B.3. Encourage voluntary reporting by recreational anglers of catch and effort on a web-based system.

B.4. Mandatory reporting of catch for all tournaments.

B.5. Fishing tournaments that include king mackerel should only allow the weigh-in of 1 fish per boat, with the exception of youth, seniors and ladies categories.

C. MANAGEMENT PRINCIPLES RECOMMENDATIONS

The FishSmart workgroup developed consensus recommendations on principles that should be incorporated in future management. The workgroup believed that adoption of these principles by the relevant management councils will lead to fishery policies that meet the minimum criteria for sustainable fisheries (see A1), and broad acceptance of these policies by an educated and informed stakeholder community.

GENERAL RECOMMENDATIONS

C.1. Increased and ongoing collaboration among all fishery stakeholders, managers, scientists and regulators will result in:

- Quality input that will be key to achieving a more sustainable fishery;
- A fair allocation among stakeholders;
- Maximum access to the Atlantic king mackerel fishery;
- An effective management process.

C.2. A commitment to the best available science conveyed to the stakeholders in a transparent, consistent and understandable format should lead to effective management of the Atlantic king mackerel fishery.

OTHER KING MACKEREL STOCK PRINCIPLES RECOMMENDATIONS

C.3. The Atlantic and Gulf Councils should consider the effects of fishing on the stock in Mexican waters in their future stock assessments.

C.4. The Council should consider the Gulf of Mexico king mackerel stock as well as the Atlantic stock before any adjustments are made to the Atlantic king mackerel stock quota. Mixing zone allocation decisions should be informed by a stakeholder process and based on a comprehensive analysis of the underlying biology of the two fisheries.

C.5. Decisions affecting the Atlantic king mackerel fishery should be considered in conjunction with the Gulf king mackerel fishery before changes in management are made.

OTHER MANAGEMENT PRINCIPLES RECOMMENDATIONS

C.6. The Council's stakeholder process should be expanded to include a more direct and interactive stakeholder driven process that seeks to improve input in developing scientifically-based management advice and exploring potential consequences of alternative management actions, such as the FishSmart process, to guide the Council's management decisions.

C.7. The Council should continue to focus on Atlantic king mackerel in the context of an ecosystem based management approach.

C.8. Artificial habitats and their effects on the king mackerel fishery population and migration patterns should be studied, and as appropriate, considered in management decisions.

D. EDUCATION INITIATIVES RECOMMENDATIONS

The FishSmart workgroup recognized the importance of educational and outreach activities for ensuring compliance with fishery management policies. An educated stakeholder will be the strongest proponent of sound and sustainable stewardship of the resource. Accordingly, the workgroup make the following recommendations:

D.1. Stakeholders and managers should support the development of a consistent message developed by stakeholder perspectives, which will result in increased angler recruitment and a broader understanding of both benefits and challenges for the fishery.

D.2. Simplifying, and unifying where possible, the enforceable regulatory structure designed with educated user input will result in greater compliance and lead to a more sustainable fishery.

CONCLUSIONS

The FishSmart workgroup developed 17 consensus recommendations that they believe would, if implemented, improve both the sustainability of the king mackerel stock in the Atlantic, and the quality of the fisheries that rely on the stock. These recommendations include both specific regulatory changes that would reduce the overall allowable quota to eight million pounds and simultaneously increase minimum size limits or restrict bag limits. Extensive simulation modeling suggests that these recommended options avoided exceeding the Atlantic king mackerel overfishing and overfished thresholds over the next 15 years with a greater than 50% probability.

The workgroup also recommended management principles that seek to recognize the impacts of stock structure and migratory behavior on management decisions. The workgroup recognizes that achieving some of these principles will take time and effort. However, the workgroup believes that we should begin down this path now so that improvements in our understanding of the species' biology and the spatial distribution of catch and effort can be incorporated into the next assessment.

The stakeholders who participated in the FishSmart process felt that it offered many benefits to the existing advisory panel process and should be considered as a model to encourage future stakeholder involvement. Chief among its advantages is that it includes stakeholders in developing, evaluating and recommending management options for the Council to consider. Evaluation of stakeholder views following the FishSmart process indicated that all were unanimously positive and supportive of the future adoption of a process like FishSmart in future efforts to seek stakeholder involvement.

Appendix I

DATES	***ACTIVITIES***
December 2006	Funding granted by the Moore Foundation
January – July, 2007	Project FishSmart Research Team formed and initial research conducted.
August 2007	National FishSmart Steering Committee meets to advise FishSmart Research Team on selection of a fishery case study.
October 2007	The Atlantic population of king mackerel is selected as the first fishery case study for Project FishSmart with endorsement of national FishSmart Steering Committee.
February 11 – 15, 2008	Southeast Data Assessment and Review (SEDAR) Data Workshop, Charleston, SC
February 2008	Workgroup member selection
April 10 – 11, 2008	**Workgroup Meeting I**
May 5 – 9	SEDAR Assessment Workshop, Miami, FL
June 8 – 10	Scientific and Statistical Committee (SSC) of the South Atlantic Fishery Management Council (SAFMC) meeting; distributed overview of FishSmart process to the SSC for their review.
June 18 – 19, 2008	**Workgroup Meeting II**
June 25 – 26, 2008	Project FishSmart Steering Committee receives progress report and discusses potential application to other fisheries following the conclusion of the Atlantic king mackerel stakeholder Workgroup.
August 4 – 8, 2008	SEDAR Assessment Review Workshop
September 15 – 19, 2008	SAFMC Meeting
October 16 - 17, 2008	**Workgroup Meeting III**
November 6 - 7, 2008	**Final Workgroup Meeting IV**
Nov. 30 – 5, 2008	SAFMC Meeting, Wilmington, NC.; FishSmart Workgroup results presented to the Scientific and Statistical Committee of the SAFMC.
December 2008	Delivery of FishSmart Workgroup Results and Research to Moore Foundation.

Appendix II Workgroup members and representation

Independent Anglers

- *Bob Dunagan: Georgia*
- Bob Pelosi: SAFMC Mackerel Advisory Panel member, Florida

Angler Organization Representatives

- Scott Whitaker: Executive Director, CCA-SC, South Carolina
- Jim Duggan: CCA-FL, Florida

Charter/Party Captains

- John Adair: Cocoa Beach/Cape Canaveral, Florida

Tournament Representation

- Eddie Cameron: Large Tournament Fisherman & Organizer, North Carolina
- Jack Holmes: Managing Partner, Southern Kingfish Association, Atlantic & Gulf Coasts

Commercial Fishermen

- Ben Hartig: Chair of Mackerel Advisory Panel for SAFMC, Florida

Biologists/ Management

- Randy Gregory: State, North Carolina
- Bill Sharp: Division of Marine Fisheries Management, FWC, Florida

Environmental Organizations

- Michelle Owens: Environmental Defense, North Carolina
- Laura Geselbracht: The Nature Conservancy, Marine Conservation Planner, Florida

Tackle/Bait Shop Owners

- Mike Able: South Carolina

Appendix III

PROJECT FISHSMART WORKGROUP—MEETING II

June18-19, 2008

EXECUTIVE SUMMARY

The second meeting of the Fish Smart Stakeholder Workgroup was held June 18-19, 2008 in Jacksonville, FL. Attendees included representatives of a broad range of stakeholder groups including charter, private, and tournament recreational anglers, angler organizations, the commercial hook and line fishery, non-governmental conservation organizations, state management agencies, and tackle shop owners. Representatives were present from North Carolina to South Florida. Several Workgroup members also serve as members of the King and Spanish Mackerel Advisory Panel that advises the South Atlantic Fishery Management Council.

Tom Miller welcomed the Workgroup, introduced Russ Nelson a member of the Fish Smart national Steering Committee and set forth the objectives for the session. Tom Ihde presented an overview of the project timelines and the related SEDAR process of the South Atlantic Fishery Management Council, which the Research Team has been participating in. The Workgroup reviewed and unanimously adopted its goal and guiding principles, which had been developed at the first session.

Mike Wilberg presented the group with an overview and description of the preliminary model inviting comments and suggestions on issues such as starting abundance, growth and maturity, migration, reproduction, natural mortality, fishing mortality, selectivity and retention probabilities. He then provided an overview of the preliminary model results. He presented the performance measures including:

- Spawning population in weight, numbers;
- Commercial catch in weight, numbers;
- Recreational catch in numbers; tournament catch in numbers;
- Number of fish between 10-12 pounds (commercial target);
- Number of fish greater than 20 pounds (recreational target);
- Number of fish greater than 50 pounds (tournament target);
- Average fish weights in commercial, recreational and tournament sectors;
- Number of spawners greater than 15 years old; and
- Number of deaths due to release mortality.

He presented and the Workgroup discussed the model options including:

- Status quo in recreational effort;
- Increase in recreational effort- 2% per year;
- No catch and release fishery;
- 30% of recreational fishery is catch and release;

- 25% release mortality; and
- 12.5% release mortality.

The Workgroup then discussed reactions to the performance measures at the end of day one.

On day two the Workgroup reviewed, ranked and discussed a series of key modeling issues and related assumptions. These included: abundance, growth, migration, reproduction and natural mortality. The Workgroup then engaged in a discussion and ranking of the performance measures in the preliminary model and new performance measures identified on day one. It then identified and discussed uncertainties such as: fish health/condition; level of prey (Multi-species interactions); natural mortality (health of population, availability of prey, predation); spatial distribution; change of migration/spawning; timing (Climate); fishing effort and catch & release.

The Workgroup then discussed the following options:

- Bag Limits to Avoid Closures; Managing with a Quota
- Larger Size Limits (16-19) e.g. 15 Pound Limit for Tournaments;
- Closed Seasons
- Closed areas;
- Federal Managed (EEZ) vs. State Waters;
- If Charter Boards and Fishing Clubs Adopted Voluntary Catch/Release for AKM over 15 pounds;
- Slot Limits; and
- Best Practices-Handling Fish at Boat to Lower Mortality.

The Research Team presented their plan for developing options for the Workgroup to review at the 3rd meeting. The Workgroup discussed the possibility of a 4th meeting and agreed to decide at the conclusion of the 3rd meeting. The meeting adjourned at 2:30 p.m.

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The second meeting of the Fish Smart Stakeholder Workgroup was held June 18-19, 2008 in Jacksonville, FL. Attendees included representatives of a broad range of stakeholder groups including charter, private, and tournament recreational anglers, angler organizations, the commercial hook and line fishery, non-governmental conservation organizations, state management agencies, and tackle shop owners. Representatives were present from North Carolina to South Florida. Several Workgroup members also serve as members of the King and Spanish Mackerel Advisory Panel that advises the South Atlantic Fishery Management Council.

Tom Miller welcomed the Workgroup, introduced Russ Nelson a member of the Fish Smart national Steering Committee and set forth the objectives for the session. Tom Ihde presented an overview of the project timelines and the related SEDAR process of the South Atlantic Fishery Management Council, which the Research Team has been participating in. The Workgroup reviewed and unanimously adopted its goal and guiding principles, which had been developed at the first session.

Mike Wilberg presented the group with an overview and description of the preliminary model inviting comments and suggestions on issues such as starting abundance, growth and maturity, migration, reproduction, natural mortality, fishing mortality, selectivity and retention probabilities. He then provided an overview of the preliminary model results. He presented the performance measures including:

- Spawning population in weight, numbers;
- Commercial catch in weight, numbers;
- Recreational catch in numbers; tournament catch in numbers;
- Number of fish between 10-12 pounds (commercial target);
- Number of fish greater than 20 pounds (recreational target);
- Number of fish greater than 50 pounds (tournament target);
- Average fish weights in commercial, recreational and tournament sectors;
- Number of spawners greater than 15 years old; and
- Number of deaths due to release mortality.

He presented and the Workgroup discussed the model options including:

- Status quo in recreational effort;
- Increase in recreational effort- 2% per year;
- No catch and release fishery;
- 30% of recreational fishery is catch and release;

- 25% release mortality; and
- 12.5% release mortality.

The Workgroup then discussed reactions to the performance measures at the end of day one.

On day two the Workgroup reviewed, ranked and discussed a series of key modeling issues and related assumptions. These included: abundance, growth, migration, reproduction and natural mortality. The Workgroup then engaged in a discussion and ranking of the performance measures in the preliminary model and new performance measures identified on day one. It then identified and discussed uncertainties such as: fish health/condition; level of prey (Multi-species interactions); natural mortality (health of population, availability of prey, predation); spatial distribution; change of migration/spawning; timing (Climate); fishing effort and catch & release.

The Workgroup then discussed the following options:

- Bag Limits to Avoid Closures; Managing with a Quota
- Larger Size Limits (16-19) e.g. 15 Pound Limit for Tournaments;
- Closed Seasons
- Closed areas;
- Federal Managed (EEZ) vs. State Waters;
- If Charter Boards and Fishing Clubs Adopted Voluntary Catch/Release for AKM over 15 pounds;
- Slot Limits; and
- Best Practices-Handling Fish at Boat to Lower Mortality.

The Research Team presented their plan for developing options for the Workgroup to review at the 3rd meeting. The Workgroup discussed the possibility of a 4th meeting and agreed to decide at the conclusion of the 3rd meeting. The meeting adjourned at 2:30 p.m.

Appendix V

PROJECT FISHSMART WORKGROUP—MEETING III

October 16-17, 2008

EXECUTIVE SUMMARY

The third meeting of the Fish Smart Stakeholder Workgroup was held October 16-17, 2008 in Jacksonville, FL. Attendees included representatives of a broad range of stakeholder groups including charter, private, and tournament recreational anglers, angler organizations, the commercial hook and line fishery, non-governmental conservation organizations, state management agencies, and tackle shop owners. Representatives were present from North Carolina to South Florida. Several Workgroup members also serve as members of the King and Spanish Mackerel Advisory Panel that advises the South Atlantic Fishery Management Council.

Tom Idhe welcomed the Workgroup, introduced Patricia Dooer a member of the Fish Smart national Steering Committee and set forth the objectives for the session. Tom Ihde presented an overview of the project timelines and the related SEDAR process of the South Atlantic Fishery Management Council, which the Research Team has been participating in. The Workgroup reviewed and unanimously adopted its goal and guiding principles, which had been developed at the first session.

Tom Ihde welcomed the members to the third meeting of the Fish Smart Stakeholder Workgroup. He noted that health problems had prevented Tom Miller from making the trip. The objectives for the meeting were to work with fishery stakeholders to determine:

- ✓ To Review Regular Procedural Topics (Agenda and Meeting Report)
- ✓ To Review FishSmart Project Timelines and Receive an Update on SEDAR Timelines
- ✓ To Review Project FishSmart Revised Model Design
- ✓ To Review Revised Performance Measures Employed in the Model
- ✓ To Review Results of Options Evaluated by Project FishSmart Model
- ✓ To Evaluate Level of Acceptability of Performance Measures and Results of Options Modeled
- ✓ To Evaluate Whether Workgroup's Options Achieved Fishery Goals
- ✓ To Determine Whether Additional Options are Needed
- ✓ To Adopt Revised Performance Measures and Options for Evaluation at October Meeting
- ✓ To Identify Needed Next Steps and Information, and Agenda Items for Next Meeting

Workgroup members include representatives from North Carolina to South Florida of a broad range of stakeholder groups including charter, private, and tournament recreational anglers, angler organizations, the commercial hook and line fishery, non-governmental conservation organizations, state management agencies, and tackle shop owners. Workgroup members Scott Whitaker, Bob Dunagan were unable to participate in the 3rd meeting. Tom Ihde introduced Patricia Doerr, a consulting scientist with the American Sport Fishing Association and member of the Fishsmart national Steering Committee providing the project with guidance. The group unanimously adopted the facilitator's 2nd meeting June summary that had been circulated to members in advance.

Tom Idhe noted that the Fishsmart National Steering Committee met in Anapolis in June a week after the last Workgroup meeting in Jacksonville. The Steering Committee was pleased to hear of the progress Workgroup making and discussed ways to help get the word out. He noted that the Workgroup has a morning timeslot on the December 1, Wilmington, North Carolina meeting of the Scientific and Statistical Committee's of the South Atlantic Fishery Council. He invited workgroup members to participate. He then introduced Patricia Doerr, director of Ocean Policy with the American Sport Fishing Association and member of the Fishsmart National Steering Committee. She noted that she was looking forward to the discussion and that the steering committee had talked about spreading the word and indicated they were ready to do that when the time comes. Mr. Idhe reminded members to keep in mind as they were digesting the new modeling information, the overall workgroup goal is to develop recommendations to share not only with Council but with stakeholders themselves. Facilitator Jeff Blair took the roll call noting that both Bill Sharpe and Jim Duggan were on their way to the meeting.

Appendix VI

FishSmart: Decision Analysis for the Recreational Fishery for the South Atlantic Migratory Group of King Mackerel

South Atlantic Fishery Management Council Scientific and Statistical Committee Meeting, 12/1/2008

By

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Introduction

Federal and State legislation requires jurisdictions to ensure that populations of marine fish are exploited at sustainable levels. Several factors make ensuring that this mandate is achieved a challenge. These factors include:

- *We manage the fishermen and not the fish*. We cannot directly change the underlying productivity of the fish species we catch. All we can control is the timing, location, number, and characteristics of fish harvested either through influencing the behavior of fishermen or by regulation.
- *Abundances of marine fish are inherently variable*. Interannual differences in abundance of several orders of magnitude are not uncommon in some species. This means that management regulations have to be reviewed frequently to reflect changing circumstances
- *Each species is often targeted by multiple stakeholder groups that may have different visions for the characteristics of a well-managed fishery.* This can lead to conflicts among stakeholder groups.
- *Harvest patterns in marine fisheries have changed.* Historically, the principal stakeholders in marine fisheries were commercial interests. However, marine recreational fishing has increased in importance over the last 50 yrs and in some fisheries recreational anglers are now the principal stakeholder group.
- *Society's interest in maintaining healthy marine ecosystems has increased.* This has lead to the recognition that we must also conserve the ecosystem services that exploited species might provide. Examples of such services might include maintaining biodiversity, filtering of primary production, transfer of energy between benthic and pelagic ecosystems.

Existing approaches to fisheries management are not well suited to deal with these multiple factors. In particular the fishery management process has yet to fully integrate the views of diverse stakeholder groups into management decisions. In particular, input from stakeholders is often sought only once management options have been formulated. This has led to the perception among some stakeholders that their interests are not fully valued, and that managers are seeking only a rubber stamp of approval.

In 2007, The Gordon and Betty Moore Foundation funded a team of scientists and representatives from the American Sportfishing Association, a trade group representing fishing tackle and boat manufacturers, to assess the potential of a new approach to incorporating the multiple stakeholder viewpoints in the management process. The project, termed FishSmart, seeks to increase the quality of marine recreational fisheries by encouraging changes to regulations, to angling practice and behavior, and the development of new tackle that in combination result in a smaller effect of marine recreational fishing on the resource while still maintaining a quality recreational experience. At the heart of the process are the central assumptions that fisheries management will more likely achieve its goal of sustainable fisheries if all stakeholders contribute and are fully empowered at all stages of the management process.

The project had two central objectives. First we sought to analyze data from marine recreational fisheries around the U.S. to identify changes in harvest pattern and to identify characteristics species that might make them particularly responsive to changes in recreational fishing activity. Second, we sought to identify a target species that could serve as a case study for the development and testing of a stakeholder driven process designed to explore and recommend options for improving the quality of marine recreational fisheries for the target species. Following extensive review of candidate fisheries, the steering committee endorsed the selection of the king mackerel fishery in the southeast Atlantic as the first system in which the FishSmart process would be implemented.

The most important features of candidate fisheries were that: 1) the recreational fishery comprises the largest portion of the landings, 2) there was some conservation concern for this fishery, but not so much so that stakeholder views had become entrenched, 3) the stock had sufficient data available such that an assessment was possible, 4) management action was likely in the near future, and 5) management and stakeholders were welcoming of our involvement. Following this review, the steering committee endorsed the selection of the fishery for the Atlantic migratory group of king mackerel (*Scomberomorus cavalla*). This stock was primarily chosen as the first case study for FishSmart both because it is an important marine recreational fishery and because it was believed that stakeholder recommendations could be made to managers before management recommendations were formally adopted.

The application of the FishSmart process to king mackerel involved establishing a workgroup of representatives of the principal stakeholders in the king mackerel fisheries. The workgroup worked closely over a period of eight months to develop a suite of recommendations for management approaches that they believed would lead to an improved king mackerel fishery and would also satisfy requirements under federal law. Here we briefly describe the selection of the workgroup, how it functioned, provide a full description of the decision analysis model that was developed to evaluate options, and the recommendations developed by the workgroup that were based on the decision analysis.

Methods

Workgroup

The core of the FishSmart process was the involvement of a workgroup of stakeholders, in a facilitated process, that sought to develop a common vision of what an ideal king mackerel fishery would look like, and then evaluate the efficacy of a series of options suggested by workgroup members to achieve their goals for the fishery. Workgroup members were selected to represent classes of stakeholders. Potential members were identified following extensive consultation with steering committee members, South Atlantic Fishery Management Council (SAFMC) staff, Gulf of Mexico Fishery Management Council (GMFMC) staff, recreational angling organizations and with individual anglers. Because the workgroup had to be limited in size to less than 25 to ensure its effectiveness, and because constituent groups of stakeholders had to be represented effectively, members were chosen from recognized leaders among their constituents. Members also had to be willing to work constructively with stakeholders of different interest groups. An additional and important requirement for members was that they had to commit to attending all of the workshops. This was an important criterion for workgroup membership because the workshops build upon one another and educating new members partway through the process would have severely diminished the rate of progress we could expect to achieve. Further, continuity was viewed as important to maximize the development of positive working relationships between stakeholder groups. Participation of individuals in the process was voluntary, so members had to be satisfied that the process would be a valuable use of their time.

The final workgroup was composed of 13 members. Stakeholder groups represented included: independent recreational anglers, angling organizations, charter captains, the tournament sector, commercial fishers, tackle shop owners, environmental NGOs and state biologists and managers. Group members included the sitting Chair, the past Chair and two members of the SAFMC king mackerel Advisory Panel and the managing partner of the Southern Kingfish Association, the largest U.S. tournament circuit for the Atlantic migratory group of king mackerel.

The Workgroup conducted its work using consensus-building techniques with the assistance of professional facilitators. Facilitators were from the Florida Conflict Resolution Consortium – a division of Florida State University. The facilitators brought considerable experience in consensus development among stakeholders in a range of situations including other fisheries and natural resources in Florida. The facilitation team used techniques such as brainstorming, ranking, and prioritizing approaches. General consensus is a participatory process whereby, on matters of substance, the members strive for agreements in which all of the members can accept, support, live with or agree not to oppose. In instances where, after vigorously exploring possible ways to enhance the members' support for the final package of recommendations, and the Workgroup found that 100% acceptance or support was not achievable, final consensus recommendations required at least 75% favorable vote of all members present and voting. This super majority decision rule underscored the importance of actively developing consensus throughout the process on substantive issues with the participation of all members. While all workgroup members, staff, and facilitators were present at discussions, only workgroup members voted on proposals and recommendations.

Workshops

The workshop process enabled stakeholders to evaluate the effectiveness of different management and voluntary options for achieving their objectives for the king mackerel fishery (Table 1). Stakeholders developed a stochastic simulation model with us over the course of a series of four workshops. An experienced, professional facilitation team ensured that each workshop was a smooth and efficient process, that the goals of each of the workshops were met, and that all stakeholders in the workgroup were able to express their views and fully contribute to the process. The workshops sought to first develop a vision for the future fishery that is shared among all stakeholders by defining objectives as a group. Subsequent workshops then focused on identifying options and performance measures that stakeholders believed to be important (Table 2). Within the process, we defined options as voluntary behaviors or management actions that could be used to achieve the objectives of the group, while performance measures were defined as metrics that could be used to gauge whether options achieved the shared objectives. The simulation model described the dynamics of the fishery over a 50-year period for each of the chosen options that the stakeholders wanted to evaluate, and summaries were based on 5-, 15-, and 50-year summaries. The performance measures also provided a basis for ranking the outcome of different options. Upon completion of the option evaluation process, the workgroup recommended a package of preferred options to the SAFMC.

Model Description

We developed a stochastic simulation model that was age-, size-, sex-, and spatially-structured. The model included ages 1 through 19+, where 19+ was an aggregate age class of all fish age 19 and older, and 131 length bins from 30 cm to 160 cm, which includes most of the range of potential king mackerel sizes. All metrics of length and weight are presented in English units to conform with common measures used in the fishery and for regulations although the model used metric units internally. Two areas (northern, NC-GA, and southern FL) and a 3-month time step were included to allow for seasonal north-south migration of king mackerel along the Atlantic coast.

Recruitment (number of age 1 individuals) followed a Beverton-Holt stock recruitment function (Eq. 4.1; Fig. 1; Mace and Doonan 1988), where recruitment was a function of spawning stock biomass, the biomass of mature females (SSB; Eq. 4.2), and a lognormal error (Eq. 5.1). The parameters of the stock recruitment function were h, SSB_0, and R_0. The steepness parameter, h, of the Beverton-Holt model and its coefficient of variation were estimated using a meta-analysis (Myers 1996) of seven other mackerel stocks and was drawn from a lognormal distribution for each simulation (Eq. 5.2). SSB_0 was determined by diving mean SSB from the stock assessment (Eq. 4.3; SEDAR 16 review workshop report) by a uniformly distributed random number that assumed the current status of the stock was between 0.3 and 0.7 of virgin SSB (Eq. 5.3). After h and SSB_0 were determined for a simulation, R_0 was calculated by solving Eq. 4.1 for R_0 given the other parameters and median recruitment and mean SSB from the stock assessment (Eq. 4.4). This procedure forces the stock-recruitment curve through the median recruitment and mean SSB. The sex ratio at recruitment was 1:1. The CV of interannual recruitment variation was estimated from the variability of the assessment model estimates of recruitment and was random among simulations (Eq. 5.4).

Abundance in the first year of the model began at the estimated abundance at age in 2007 from the assessment modified with a lognormal error (Eq. 5.5). After the first year and first age, abundance of a cohort in an area changed because of mortality migration (Eq. 4.5). Fish migrated from north to south in the fall and from south to north in the spring (Fig. 2). The fall migration was assumed to occur instantaneously on October 1 and the spring migration on April 1. Mortality was a function of natural mortality, mortality from harvest, and mortality of releases (Eq. 4.6). Age-specific migration rates were multiplied by a lognormally distributed scalar with a coefficient of variation of 20% (Eq. 5.6).

Natural mortality was a decreasing function of size (Lorenzen 1996), and the same pattern of natural mortality was used in the model as in the stock assessment (Fig. 3; Anonymous 2008). This was converted to age-based mortality by taking the weighted average of the length-specific mortality rates weighted by abundance. The natural mortality curve was scaled so that the average was the same as the value calculated using Hoenig's (1983) method and a maximum observed age of 26 for king mackerel (Anonymous 2008). These functions were sex-specific because females and males have different growth patterns and the Lorenzen (1996) method models natural mortality as a function of mass (Anonymous 2008). Median natural mortality-at-age and length was multiplied by a lognormal random scalar with a CV of 20% for each simulation to include uncertainty about the natural mortality rate (Eq. 5.7).

The fishery included three sectors – recreational (private, charter, and headboats), commercial, and tournament. For the recreational sector, median fishing mortality followed three general patterns with annual lognormal errors: constant over time, increasing at 0.5% per year for the first 25 years, then constant for the remaining 25 years, and decreasing at 0.5% per year for the first 25 years, then constant for the remaining 25 years. For the commercial and tournament sectors, fishing mortality varied about a constant median (Eq. 5.8). We also conducted sensitivity analyses where the recreational fishing mortality was reduced by 50%, but the results of these simulations are not shown. The patterns of seasonal and spatial fishing mortality for each sector were based on the seasonal pattern of landings in the fishery during different months for the recreational and commercial fisheries. Age-based fishing mortality rates from harvest and releases were calculated from the overall fishing mortality, the selectivity and retention functions, the proportion of dead discards, and released fish mortality rates (Eqs. 4.7 and 4.8). Age-based selectivity and retention were the weighted average of length-based selectivity and retention (Figs. 4 and 5) weighted by the proportion at age of a given length (Eqs. 4.9 and 4.10). The proportion of catch released dead and the release mortality were both randomly drawn for each simulation (Eqs. 5.9 and 5.10). Values for selectivity at length were taken from a previous version of the stock assessment model (Ortiz et al. 2008) that estimated the length-based selectivity (Fig. 4). Retention in the commercial and recreational sectors was based on past practices and regulations, and selectivity and retention of the tournament sector were based on expert judgment of the workgroup panel members (Fig. 5). Because most king mackerel tournaments do not allow fish less than 10 lbs to be entered, the retention function was zero for sizes where the average weight was less than 10 lbs and increased such that a 25 lb fish was always retained. Size limits were implemented by modifying the retention functions so that only legal sized fish were retained. The proportion of dead discards used in most of the model runs was 0% for the commercial fishery and 15.5% for recreational and tournament fisheries (see Table 1) because this was the average proportion of dead releases during the most recent five years (B1 classification in MRFFS). We used an expert judgment poll to estimate the mortality rate of fish released alive, and the average estimate from the workgroup was 12.5%. This value is somewhat less than estimates from a telemetry study that estimated release mortality of 20%. The proportion of dead discards and the release mortality rate were randomly drawn for each simulation from a lognormal distribution with CVs of 10% and 20% respectively to represent uncertainty in these quantities.

Bag limits and quotas required a different approach than size limits. Overall fishing mortality in an area, season and fishery were modified to simulate the effects of these regulations (Eq. 4.11). Bag limits were implemented by decreasing F by the proportional decrease in catch caused by the bag limit (Eq. 4.12; Porch and Fox 1991). A truncated negative binomial distribution was used to model the distribution of catch-per-trip under a bag limit (Eq. 4.13), and a negative binomial distribution was used in the absence of a bag limit (Eq. 4.14). The distribution of catch-per-trip was similar among trips of different sizes and therefore, only a party size of two was used in the model (NOAA MRFFS, unpublished data). The parameters of the distribution of catch-per-trip were randomly chosen for each simulation (Eq. 5.11) and were independent of population size because an analysis of the MRFFS catch-per trip data showed no relationship with estimated population size from the stock assessment (NOAA MRFFS, unpublished data). Combinations of size and bag limits were implemented by first determining proportionally how much catch should be reduced by the bag limit. The mean parameter of the catch per angler distribution was decreased by this proportion, thus causing catch per angler decrease. Additionally, the median release mortality of fish released because of higher size limits was increased to 20% to simulate the effects of potentially increased handling caused by effects of more fish being measured.

Quotas were implemented to constrain the catch so it could not be more than the quota. The overall quota was constant throughout a simulation. The quota was divided between commercial (37.1%) and recreational and tournament sectors (62.9%). The approximate day the quota was reached was estimated by calculating the fraction of the catch in the season that was necessary to achieve the quota and multiplying the number of days in the season by this fraction.

Catch, harvest (retained catch in numbers), and deaths due to catch and release were calculated with the Baranov catch equation (Eqs. 4.15, 4.16, 4.17). Alternative catch and release practices were simulated by adjusting median of the proportion of fish that are released dead, the median mortality rate of fish that are released alive, and by changing the proportion of fish that are released alive (sometimes by size class).

Mean length at age was constant over time and followed a von Bertalanffy growth model (Eq. 4.18; Fig. 6). Parameters of the model were separate for males and females because females grow faster and to larger size than males and were randomly drawn for each simulation (Eq. 5.12 and 5.13). Parameters of the growth model were taken from the stock assessment (Ortiz and Palmer, 2008). Length-at-age was normally distributed about the mean and had a constant sex specific coefficient of variation (CV; Eq. 4.19). The coefficient of variation for the first age was reduced to 5% because fish were predicted to be too large with higher levels of CV. Numbers-at-length were calculated by summing the product of numbers-at-age and sex and the proportion for each age of a given length (Eq. 4.20).

Maturity of females was described by a logistic function of length (Eq. 4.21; Fig. 9), which was estimated from data in Finucane et al. (1986). Using this relationship, female king mackerel reach 50% maturity at about 1.5 years of age. Mean mass-at-length followed a power function of length that was constant over time (Eq. 4.22; Fig. 7). For a given length bin, mass was normally distributed (4.23). The CV of this distribution (Fig. 8) changed with length (D. DeVries, unpublished data). Numbers-at-weight were calculated by summing the product of numbers-at-length and the proportion for each length of a given weight (Eq. 4.24).

Performance measures

Options were compared by evaluating how well they achieved the objectives. Three hundred 50-year simulations were run for each option (100 for each trend of recreational fishing mortality). This number allowed reasonably precise estimates of the median, mean, and interquartile range of performance measures. Performance measures were summarized as the average over 5, 15, or 50 years or as the proportion of years over 5, 15, or 50 years that an event occurred (e.g., proportion of years recreational quota was reached).

Although the workgroup originally suggested 22 performance measures (Table 2), three were primarily used to craft recommendations: proportion of years SSB was less than $SSB_{F30\%}$, proportion of years F was greater than $F_{30\%}$, and the proportion of the year closed to recreational fishing. The values for $SSB_{F30\%}$ and $F_{30\%}$ were taken from the base model for the south Atlantic migratory group stock assessment (Anonymous 2008).

Results

The status quo management and fishing practices predicted a long-term decrease in abundance of king mackerel (Fig. 10). This decline in abundance had a negative effect on most of the performance measures, although the mean size in the catch was relatively unaffected by changes in population size. All of the options remained above the SSB threshold (not overfished) and below the F threshold (not overfishing) during the first five years on average in at least 50% of the simulations (Figs. 10 and 11). However, most of the options were below the SSB threshold and above the F threshold in more than 50% of the simulations over 50 years. All of the options tested had a low proportion of years the recreational fishery was closed early because the quota was reached, except for the 5 million and 6 million lb quota options (Fig. 12).

The workgroup decided to base their recommendations on the performance of options over 15 years, with the goal of having greater than 50% of the simulations remain above the SSB threshold, below the F threshold, and have a low probability of recreational closures because the quota was reached. The workgroup chose three options that met their criteria for management recommendations: a 2 fish per angler bag limit, a 32 in minimum size limit, and a combination of a 2 fish per angler bag limit with a 28 in minimum size limit (Fig. 13). Of the recommended options, the 32 in minimum size limit was farthest from the overfishing threshold and the combination of a 2 fish per angler bag limit and a 28 in minimum size limit was most protective of SSB.

Recommendations

All of the FishSmart recommendations were developed through an interactive consensus process and reflect 75% or greater support by the workgroup members. **These consensus recommendations reflect their individual expertise and collective judgment and NOT necessarily those of the organizations whose members participated in the workgroup.**

The workgroup considered a number of different and specific management actions and combination of actions. Each option was evaluated using the simulation model to weigh the relative performance of the different options considered. Based on the results of these simulations, the workgroup reached consensus on the following specific management recommendations based on the decision analysis model. The other options of the workgroup are fully described in the companion paper in the SAFMC briefing document "A vision for the recreational fisheries for Atlantic king mackerel."

The Workgroup recommends that the management options considered by the Council should be designed to meet the following three minimum criteria:

- The option should maintain the Atlantic king mackerel stock above the overfished and below overfishing thresholds over a period of 15 years or more.
- The option should result in the least impact to both recreational and commercial.
- The option should prevent seasonal closures and avoid area closures.

The FishSmart Workgroup proposed three consensus Atlantic king mackerel management options that each meet and exceed the minimum criteria defined above. The modeling results and analysis suggest that each may perform differently relative to their overall effects on the recreational and commercial fishery, on increasing spawning stock biomass, and on fishing mortality. As a result, the FishSmart Workgroup decided to recommend these management combination options be considered and evaluated by the Council. The workgroup did not establish a priority order for the following three options:

- 8 million annual total allowable catch, and a 2 fish per angler daily bag limit for the recreational fishery.
- 8 million annual total allowable catch, 2 fish per angler daily bag limit, and a 28" minimum size limit for the recreational fishery.
- 8 million annual total allowable catch, and a 32" minimum size limit for the recreational fishery.

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Table 1. Stakeholder-identified options for the south Atlantic king mackerel fishery.

Options	Status quo (2007 SAFMC)	Values Compared to status quo
Management		
Size limits	24”	28”, 32”
Bag/creel limits	2 fish (FL), 3 fish (NC-GA)	2 fish, 1 fish (all areas)
Season limits	Closed when quota reached	Closed when quota reached
Constant quota control rule	10 M (million pounds)	4M, 6M, 7.1M, 7.5M, 8M
Voluntary		
Increased minimum size for tournaments	10 lbs. (~34 in)	15 lbs. (~38 in)
Increased catch and release fishing (CR)	26%	30%, 50%, 80% (over all sizes) release all fish > 20lbs.
Reduction of catch and release mortality (RM) (by half)	12.5%	6.25%,
Combinations		
Increase CR + reduce RM + increase min. size	As above for status quo	50% CR, 6.25% RM, 28” min. size

Table 2. Stakeholder-identified performance measures for the south Atlantic king mackerel fishery.

Performance measures
Population
Abundance (numbers)
Spawning stock biomass relative to $SSB_{F30\%}$ (SSB; biomass of mature females)
Average weight of spawners
Proportion of the population ≥ than 15 years old
Fishing mortality and SSB relative to threshold reference points
Fishery
Fishing mortality relative to $F_{30\%}$
Recreational harvest (numbers)
Recreational catch – all fish caught (numbers)
Tournament harvest (numbers)
Commercial harvest (weight, numbers)
Recreational harvest of fish larger than 20 lbs (recreational target)
Tournament harvest of fish larger than 50 lbs (tournament target)
Commercial harvest of fish between 10 and 12 lbs (commercial target)
Average weight in recreational harvest
Average weight in tournament harvest
Average weight in commercial harvest
Number of days in the recreational fishing season (before quota is reached)
Number of days in the commercial fishing season (before quota is reached)
Proportion of years that recreational quota is reached or exceeded
Proportion of years that commercial quota is reached or exceeded
Number of dead fish due to release mortality

Table 3. Symbols and descriptions of variables used in description of stochastic forecasting model. Indicators are used to denote structural parameters and error terms that were constant over simulations and time ("constant"), or were randomly drawn for a given simulation ("sim") or for each year ("year"). See text for additional details on distributions.

Symbol	Description
	Index variables
t	Time in seasons (1/4 of a year)
o	Area (NC-GA, FL)
x	Sex (male = 1, female = 2)
a	Age in years (1-19+)
l	Length bin (≤30, 30-31, …,159-160, ≥160 cm)
n	Season
f	Fishery
	Constants, state variables, and control variables
N	Actual abundance
R	Recruitment (age-1 abundance)
SSB	Spawning stock biomass (lbs, females)
L	Mean length (in)
CVL_a	Coefficient of variation of length-at-age
W	Mass-at-length (lbs)
CVW_l	Coefficient of variation in length-at-age
Ω	Maturity-at-length
F	Instantaneous fishing mortality rate from retained catch
E	Instantaneous fishing mortality rate from released catch
Z	Instantaneous total mortality rate
C	Catch in numbers (harvest)
$\dot{p}$	Proportions at length for each age
$\ddot{p}$	Proportions at weight for each length
s	Fishery selectivity (constant)
r	Fishery retention (constant)
v	Proportion released alive (constant)
p_q	Proportion of fishing mortality necessary to achieve quota
p_b	Proportion of fishing mortality achieved due to bag limit
$\widetilde{C}$	Catch achieved under bag limit
$\hat{C}$	Catch achieved with status quo bag limit
b,k	Parameters describing negative binomial distribution of catch per trip (sim)
g	Bag limit
$\overline{\lambda}$	Mean fishing mortality
	Structural parameters
h	Beverton-Holt stock-recruitment steepness parameter (sim)

SSB_0 Virgin SSB (sim)
R_0 Virgin average recruitment (sim)
λ Mean fishing mortality (for fully selected individuals) (year)
P Proportion of recruits allocated to an area (sim)
$\dot{a}$ Mass-at-length parameter (constant)
B Mass-at-length parameter (constant)
m_1 Maturity-at-length parameter, slope (constant)
m_2 Maturity-at-length parameter, half-saturation (constant)
L_∞ Asymptotic mean length (sim)
K Growth coefficient (sim)
t_0 Age at length zero (sim)
M Instantaneous natural mortality rate at age or length (sim)
d Proportion released dead (sim)
ω Proportion released alive that die (sim)
η Depletion from SSB_0 (sim)

Error terms

ε Recruitment error (year)
δ Error for δ fishing mortality (year)

Functions

Φ Normal cumulative distribution function
Γ Gamma function

Mean parameters

$\overline{\sigma}_R$ Median log-scale recruitment standard deviation (constant)
μ_{VB} Vector of mean L_∞ and K (constant)
$\bar{t}_0$ Median t_0 parameter (constant)
$\overline{P}$ Median migration rate vectors (constant)
μ_h Median steepness of the stock-recruitment function (constant)
$\overline{M}$ Median natural mortality vectors (constant)
$\overline{N}$ Median initial population size vectors (constant)
$\bar{d}$ Median proportion of dead discards (constant)
$\overline{\omega}$ Median release mortality (constant)
$\bar{b}$ Median b parameter for distribution of catch per trip (constant)
$\bar{k}$ Median k parameter for distribution of catch per trip (constant)

Standard deviation parameters

σ_R^2 Standard deviation for ε (sim)
σ_h^2 Log-scale variance for steepness (constant)
$\sigma_{\sigma_R}^2$ Log-scale variance for log-scale recruitment errors (constant)
σ_N^2 Log-scale variance for initial abundance (constant)

σ_P^2	Log-scale variance for migration rates (constant)
σ_M^2	Log-scale variance for natural mortality (constant)
σ_δ^2	Log-scale variance for annual error in fishing mortality (constant)
σ_d^2	Log-scale variance for the proportion of fish released dead (constant)
σ_ω^2	Log-scale variance for release mortality (constant)
σ_b^2	Log-scale variance for bag limit *b* parameter (constant)
σ_k^2	Log-scale variance for bag limit *k* parameter (constant)
Σ_{VB}	Variance-covariance matrix for L_∞ and K (constant)
$\sigma_{t_0}^2$	Log-scale variance for t_0 (constant)

Table 4. Description of equations used in the model.

Equation Number	Equation	Description
4.1	$R_{y,x,o} = 0.5P_o \dfrac{4hR_0SSB}{(SSB_0(1-h)+SSB(5(h-1))}e^{\varepsilon_y}$	Beverton-Holt stock recruitment
4.2	$SSB_t = \sum_o \sum_l N_{t,x=2,l,o} W_l \Omega_l$	Spawning stock biomass
4.3	$SSB_0 = \dfrac{\mu_{SSB}}{\eta}$	Virgin SSB
4.4	$R_0 = \dfrac{\mu_R\left(SSB_0(1-h)+\mu_{SSB}(5h-1)\right)}{4hSSB_0\eta}$	Virgin recruitment
4.5	$N_{t+1,a+\frac{1}{4},x,o} = \sum_o p_{a,n} N_{t,a,x,o} e^{-Z_{t,a,x,o}}$	Abundance
4.6	$Z_{t,a,x,o} = M_{a,x} + \sum_f F_{t,a,x,o,f} + \sum_f E_{t,a,x,o,f}$	Total mortality
4.7	$F_{t,a,x,o,f} = (1-d)\lambda_{t,f,o} s_{a,x,f} r_{a,x,f}(1-v)$	Fishing mortality of retained fish
4.8	$E_{t,a,x,o,f} = d\lambda_{t,f,o} s_{a,x,f} + (1-d)\lambda_{t,f,o} s_{a,x,f}\left(1-r_{a,x,f}(1-v)\right)\omega$	Fishing mortality of released fish
4.9	$s_{t,a,x,f} = \sum_l s_{l,f} \dot{p}_{a,x,l}$	Age-based selectivity
4.10	$r_{t,a,x,f} = \sum_l r_{l,f} \dot{p}_{a,x,l}$	Age-based retention
4.11	$\lambda_{t,f} = \begin{cases} \bar{\lambda}_{t,f,o} e^{\delta_t} & \text{No bag limit or quota effects} \\ p_q p_b \bar{\lambda}_{t,f,o} e^{\delta_t} & \text{Recreational fishery} \\ p_q \bar{\lambda}_{t,f,o} e^{\delta_t} & \text{Commercial and tournament} \end{cases}$	Effects of bag limits and quota on fishing mortality (recreational only)
4.12	$p_b = \dfrac{\tilde{C}_{t,f,o}}{\hat{C}_{t,f,o}}$	Effects of quota on fishing mortality
4.13	$\tilde{C}_{t,f,o} = \sum_{i=0}^{g} i \dfrac{\Gamma(i+k)}{\Gamma(k)i!}\left(\dfrac{b}{b+k}\right)^i \left(1+\dfrac{b}{k}\right)^{-k} + \sum_{i=g+1}^{\infty} g \dfrac{\Gamma(i+k)}{\Gamma(k)i!}\left(\dfrac{b}{b+k}\right)^i \left(1+\dfrac{b}{k}\right)^{-k}$	Relative catch under the bag limit
4.14	$\tilde{C}_{t,f,o} = \sum_{i=0}^{\infty} i \dfrac{\Gamma(i+k)}{\Gamma(k)i!}\left(\dfrac{b}{b+k}\right)^i \left(1+\dfrac{b}{k}\right)^{-k}$	Relative catch in absence of the bag limit
4.15	$C_{t,a,x,o,f} = \dfrac{f_{t,x,o} s_{a,x,f}}{Z_{t,a,x,o}}\left(1-e^{-Z_{t,a,x,o}}\right) N_{t,a,x,o}$	Catch

4.16	$C_{t,a,x,o,f} = \frac{F_{t,a,x,o}}{Z_{t,a,x,o}}\left(1-e^{-Z_{t,a,x,o}}\right)N_{t,a,x,o}$	Retained catch
4.17	$C_{t,a,x,o,f} = \frac{E_{t,a,x,o}}{Z_{t,a,x,o}}\left(1-e^{-Z_{t,a,x,o}}\right)N_{t,a,x,o}$	Numbers of dead releases
4.18	$L_{x,a} = L_{\infty_x}\left(1-e^{-K_x(a-t_{0_x}}\right)$	Mean length at age
4.19	$\dot{p}_{a,x,l} = \Phi\left(\frac{l+1-L_{a,x}}{L_{a,x}CVL_{a,x}}\right) - \Phi\left(\frac{l-L_{a,x}}{L_{a,x}CVL_{a,x}}\right)$	Proportion at length
4.20	$N_{t,x,l,o} = \sum_a N_{t,a,x,o}\dot{p}_{a,x,l}$	Abundance at length
4.21	$\Omega_l = \frac{1}{1+e^{-m_1(l-m_2)}}$	Maturity
4.22	$W_{x,l} = \dot{a}l^B$	Weight at length
4.23	$\ddot{p}_{l,w} = \Phi\left(\frac{w+1-W_l}{W_l CVW_l}\right) - \Phi\left(\frac{w-W_l}{W_l CVW_l}\right)$	Proportion at weight
4.24	$N_{t,w,o} = \sum_l N_{t,l,o}\ddot{p}_{l,w}$	Abundance at weight

Table 5. Stochastic parameters and their distributions. LN indicates a lognormal distribution, N a normal distribution, and U a uniform distribution.

Equation number	**Distribution**	**Description**
5.1	$\varepsilon \sim N(0,\sigma_R^2)$	Stock recruitment deviations
5.2	$h \sim LN\left(\mu_h,\sigma_h^2\right)$	Steepness of the stock-recruitment relationship
5.3	$\eta \sim U(0.3,0.7)$	Mean depletion
5.4	$\sigma_R \sim LN(\overline{\sigma}_R,\sigma_{\sigma_R}^2)$	Interannaul recruitment variation standard deviation
5.5	$N \sim LN(\overline{N},\sigma_N^2)$	Initial abundance variation
5.6	$P_{a,n} \sim LN(\overline{P},\sigma_P^2)$	Migration rates
5.7	$M \sim LN(\overline{M},\sigma_M^2)$	Natural mortality variation
5.8	$\delta \sim N(0,\sigma_\delta^2)$	Fishing mortality deviations
5.9	$d \sim LN(\overline{d},\sigma_d^2)$	Proportion released dead
5.10	$\omega \sim LN(\overline{\omega},\sigma_\omega^2)$	Release mortality
5.11	$b \sim LN(\overline{b},\sigma_b^2)$	Bag limit parameters
	$k \sim LN(\overline{k},\sigma_k^2)$	
5.12	$L_{\infty_x},K_x \sim MVN(\mu_{VB},\Sigma_{VB})$	von Bertalnaffy parameters
5.13	$t_0 \sim LN(\bar{t}_0,\sigma_{t_0}^2)$	Age at length zero

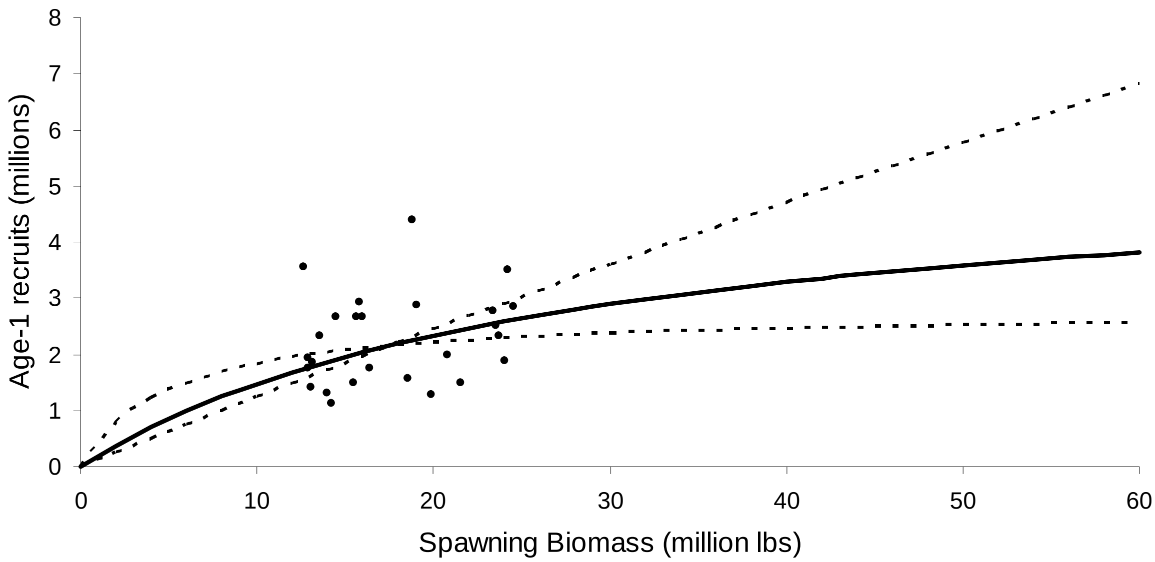

Fig. 1. Estimated stock and recruitment from the assessment model (filled circles), and the Beverton-Holt stock recruitment function used in the decision analysis model. The solid line is the median predicted relationship, and the dashed lines indicate curves generated using the upper and lower 95% confidence intervals of the parameters.

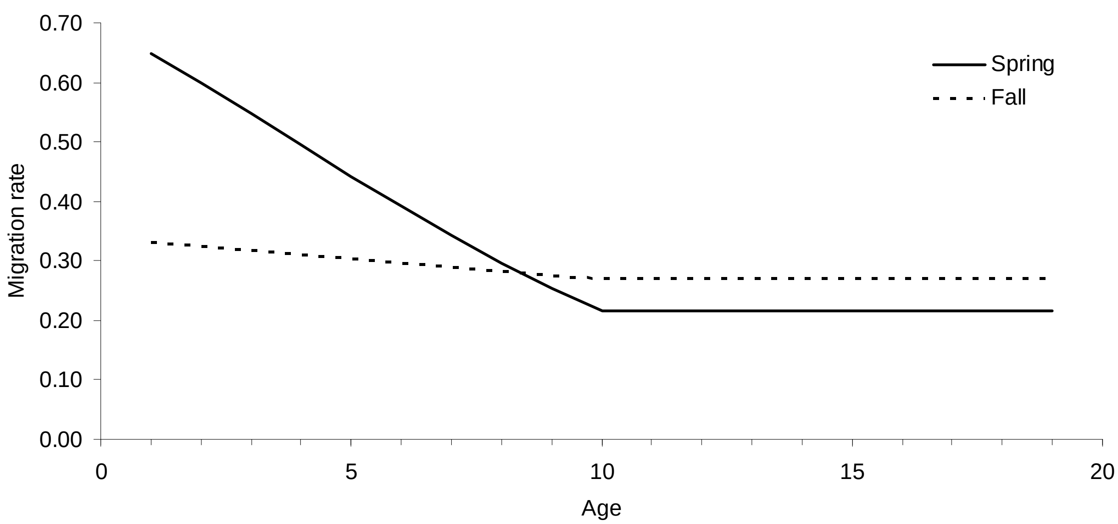

Fig. 2. Average migration rates by season and age. The dashed line indicates proportion of individuals that migrate south in winter, and the solid line indicates the proportion of individuals that migrates north in the spring as a function of age.

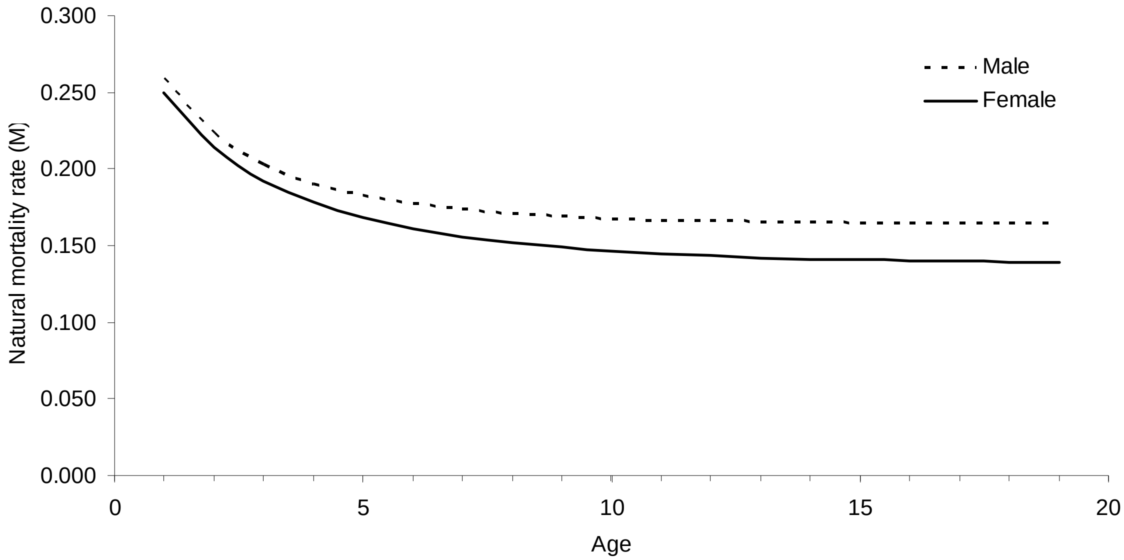

Fig. 3. Median instantaneous natural mortality as a function of age. The dashed line indicates natural mortality of males and the solid line indicates the natural mortality of females.

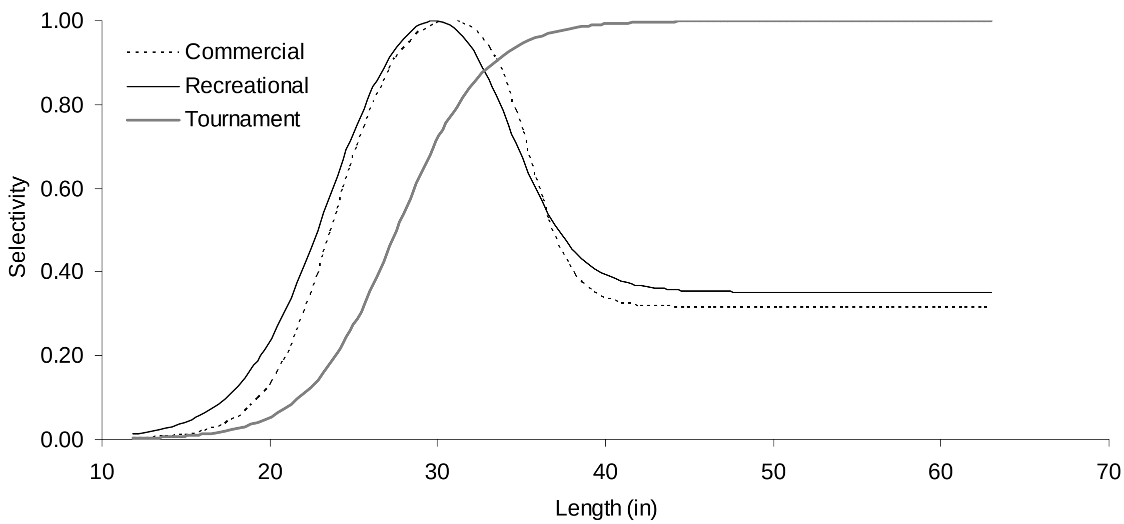

Fig. 4. Selectivity patterns as a function of length for commercial, recreational, and tournament fisheries.

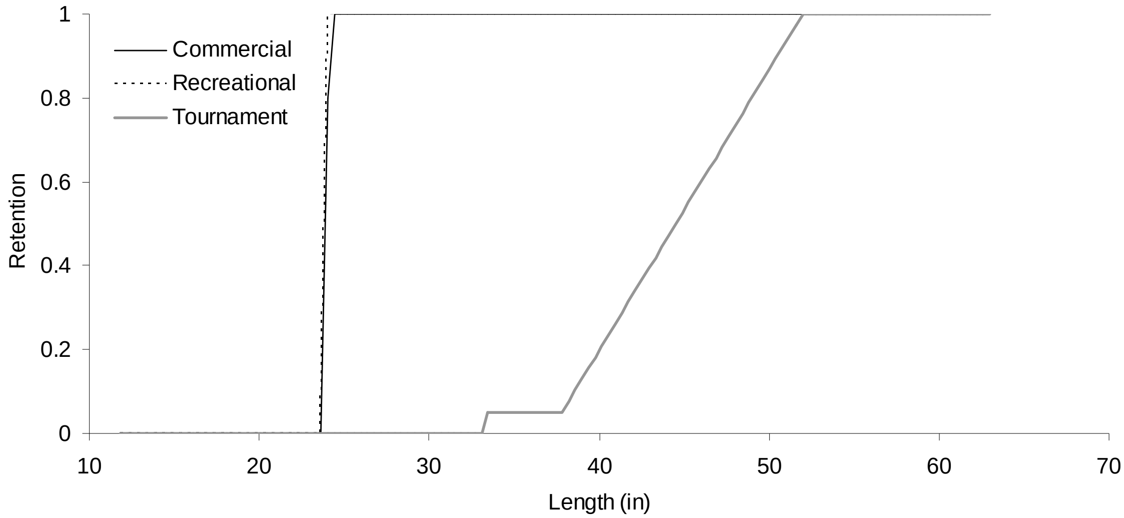

Fig. 5. Retention patterns as a function of length for commercial, recreational, and tournament fisheries.

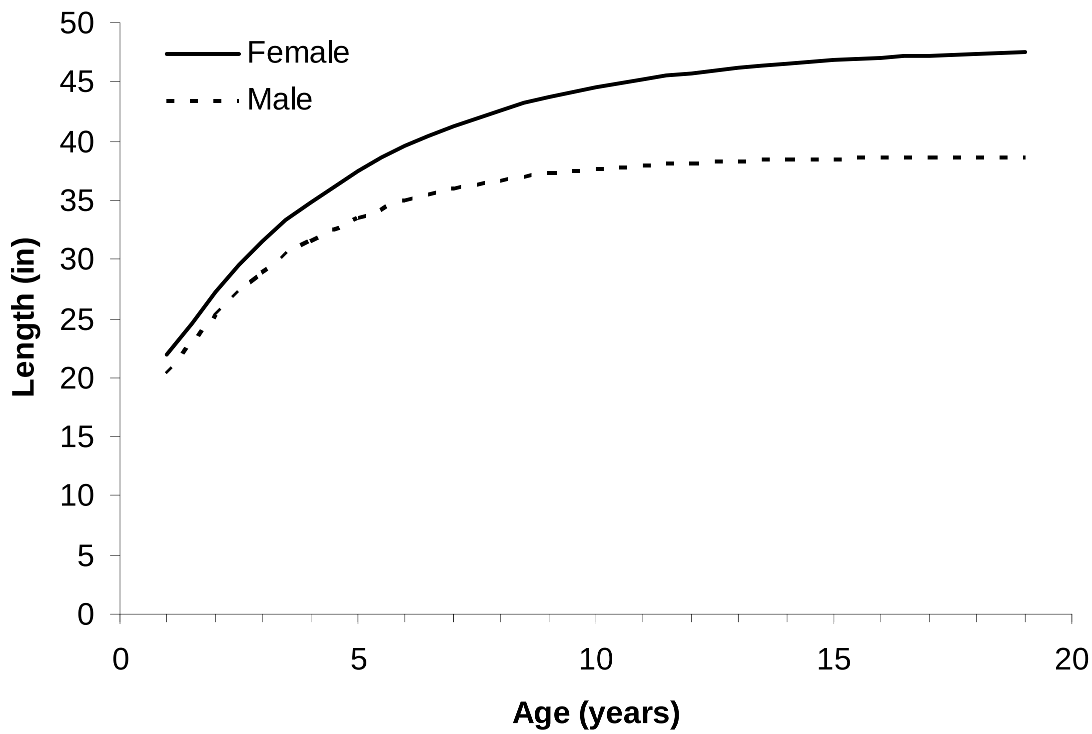

Fig. 6. Median pattern of mean length-at-age for male and female king mackerel.

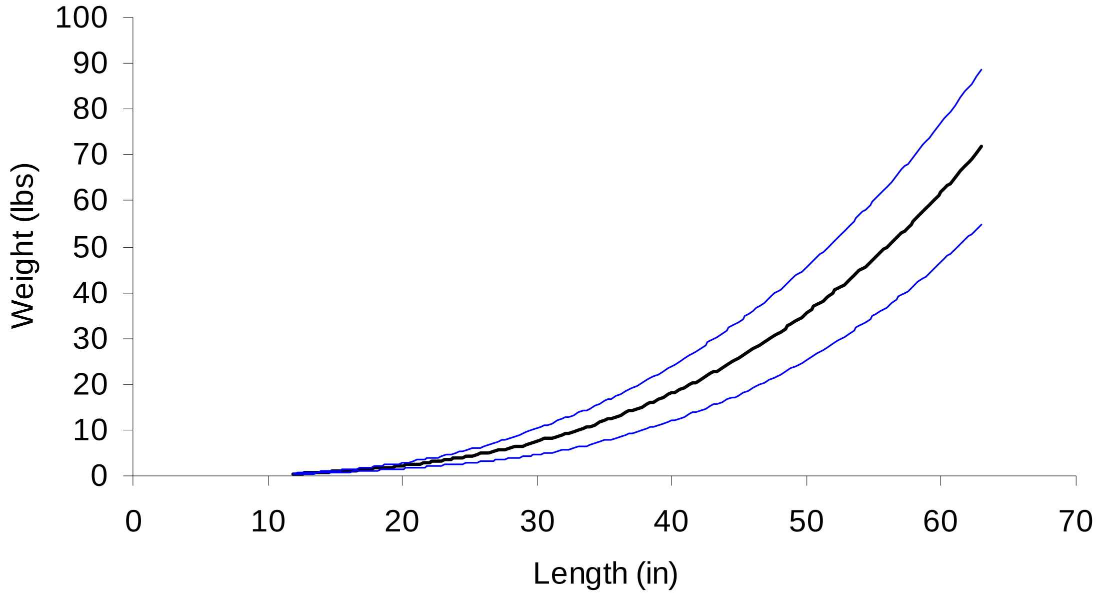

Fig. 7. Mean weight-at-length for king mackerel in the south Atlantic migratory group. The black line indicates the mean and the blue lines indicate the interval that includes 95% of the distribution of weight-at-length.

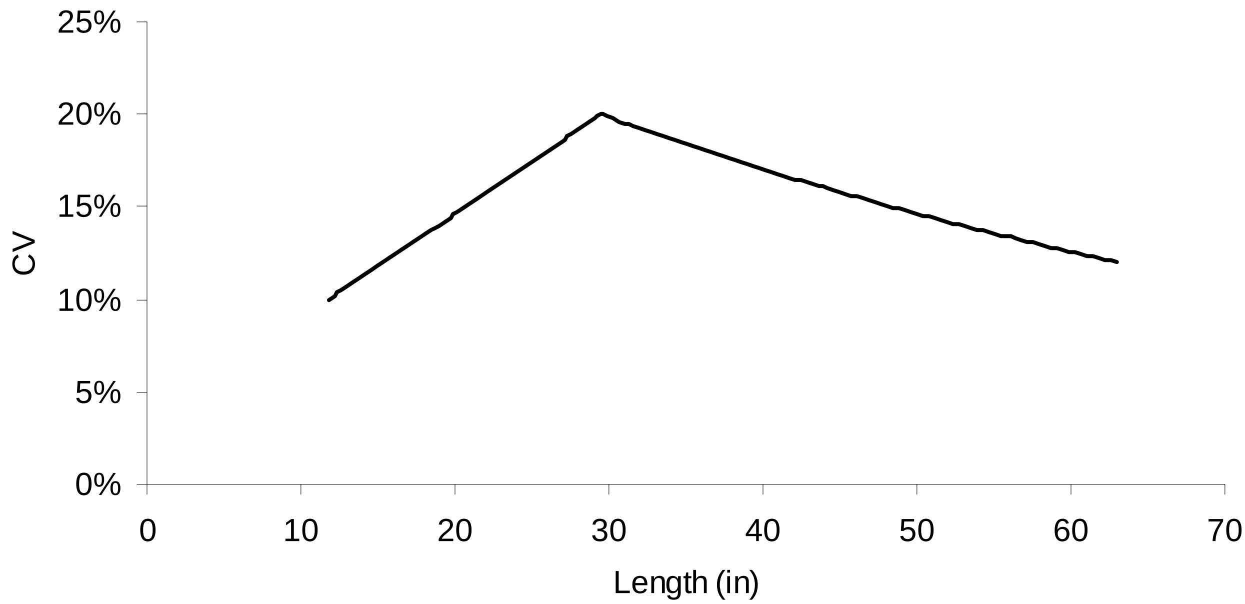

Fig. 8. Coefficient of variation (CV) in weight-at-length for south Atlantic migratory group king mackerel.

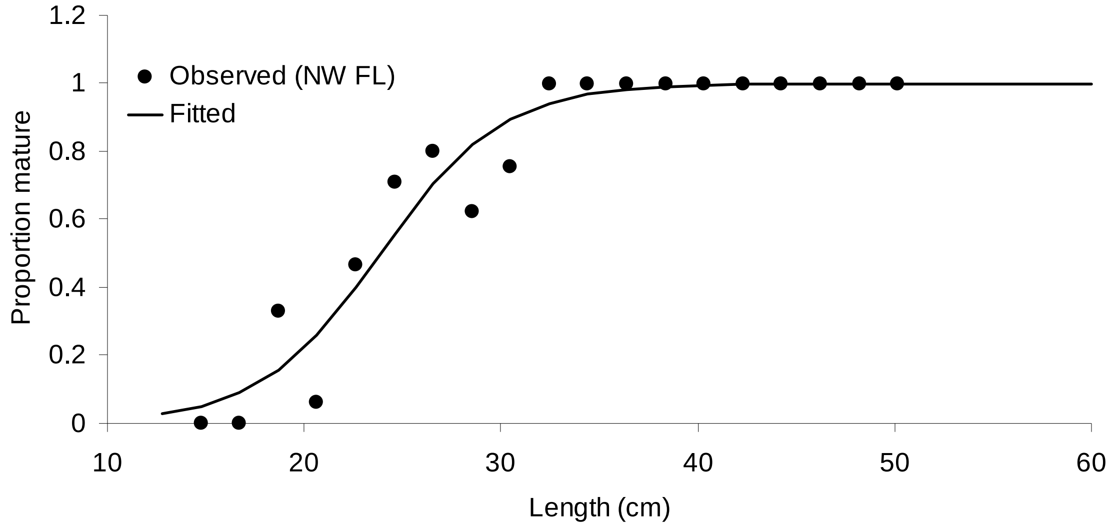

Fig. 9. Observed and estimated maturity as a function of length for female king mackerel.

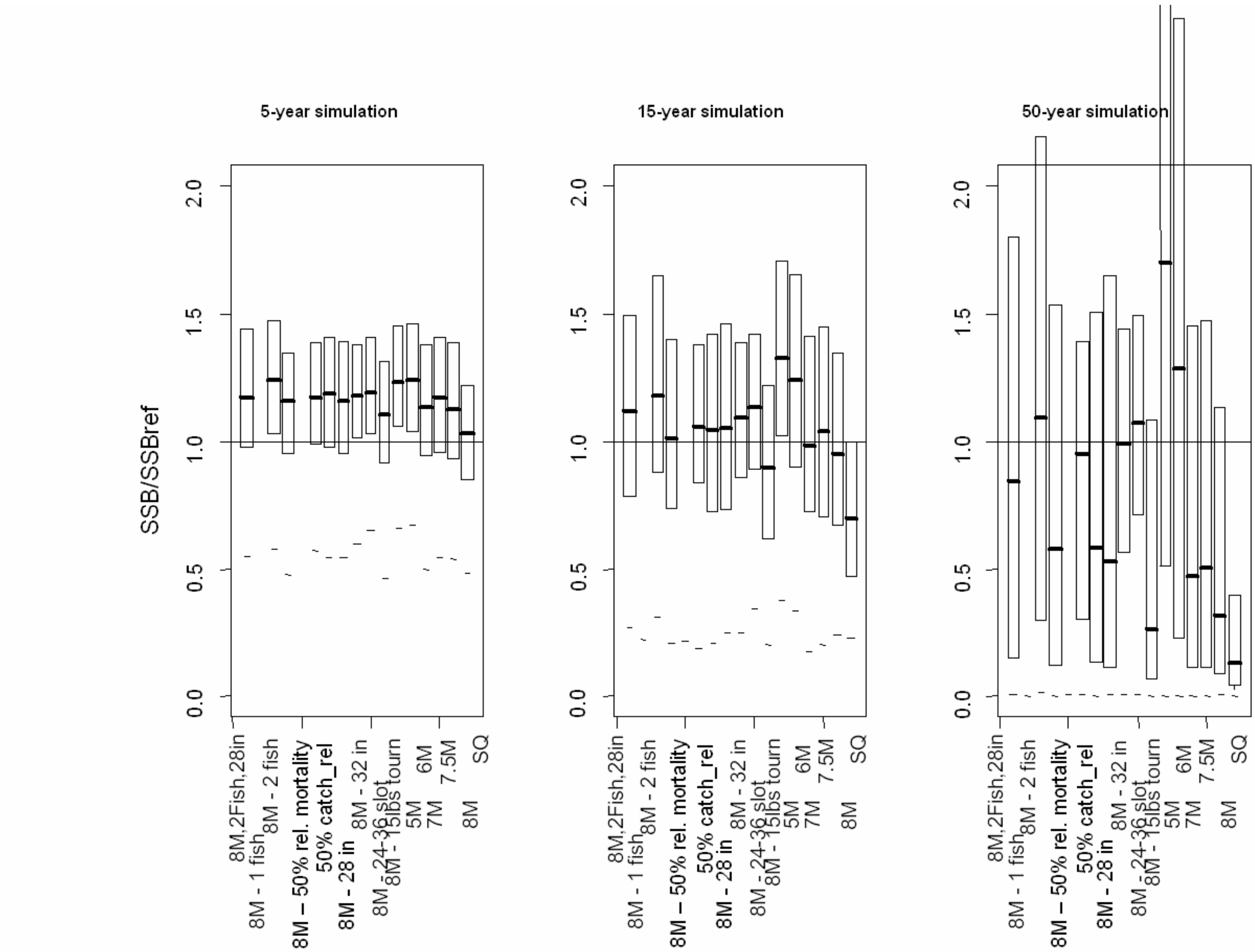

Fig. 10. Average spawning stock biomass (SSB) divided by SSB at $F_{30\%}$ for 5-, 15-, and 50-year summaries. Dark lines indicate the median, boxes indicate the interquartile range, and dashes beyond the boxes indicate the minimum and maximum. Options indicated by abbreviations: SQ indicates status quo of 10 million lb quota, 3 fish per angler bag limit in the north, 2 fish per angler bag limit in the south, 24 in minimum size limit for commercial and recreational, 34 in minimum size limit for tournaments, 15.5% of recreationally caught fish are released dead, 12.5% release mortality of fish released alive, and 26% catch and release fishing. Other options are the same except as described in the label: XM indicates the quota where X is millions of lbs, X fish indicates the bag limit in both areas, X in indicates the minimum size limit, 24-36 slot indicates 24-36 in slot limit, 50% rel. mortality indicates 50% percentage reduction in dead discards and release mortality, 50% catch_rel indicates 50% catch and release fishing, and 15lbs tourn indicates 15 lb minimum size for tournaments.

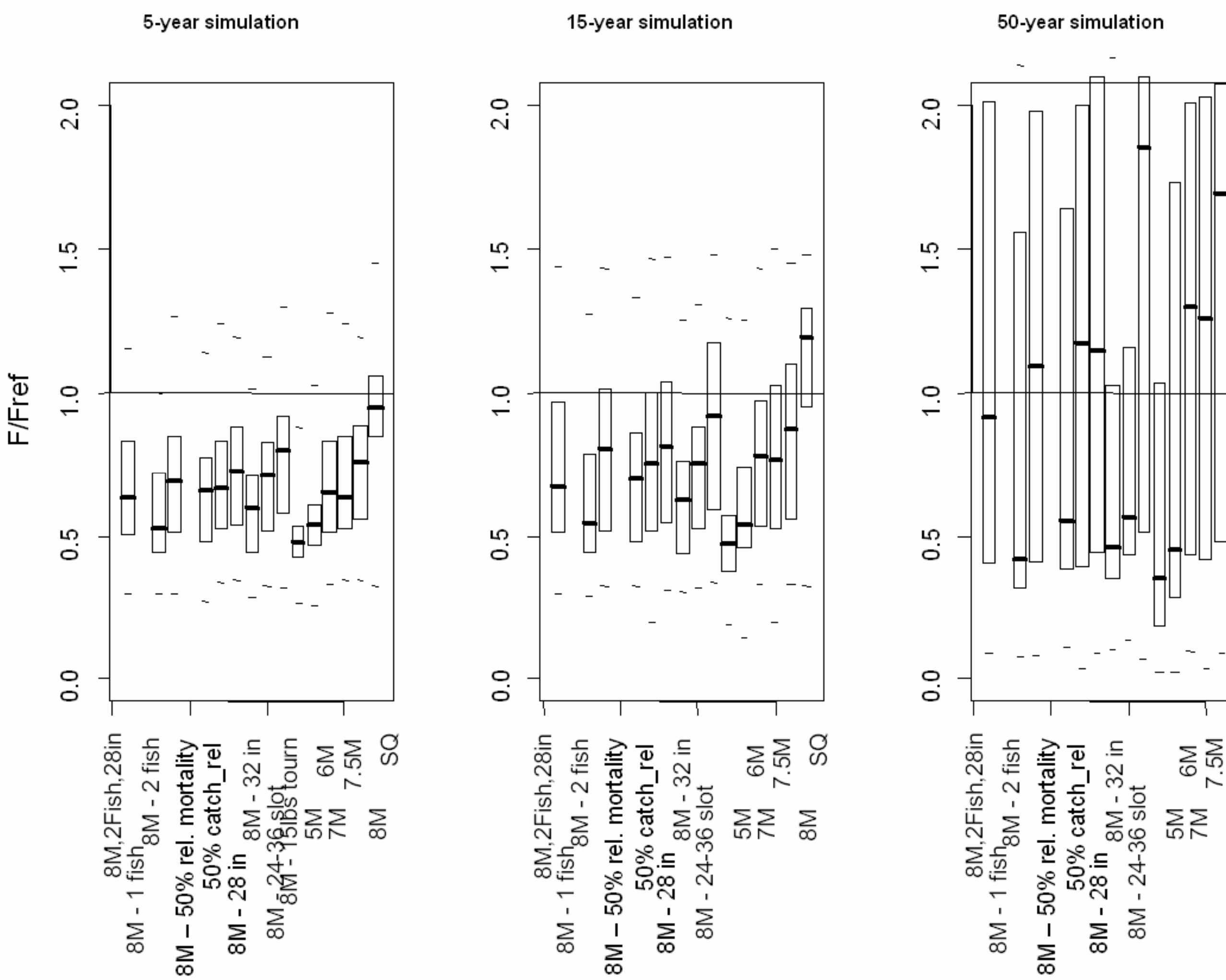

Fig. 11. Box plots of the proportion of years the recreational quota is reached for 5-, 15-, and 50-year summaries. Options and box plot definitions as in Fig. 10.

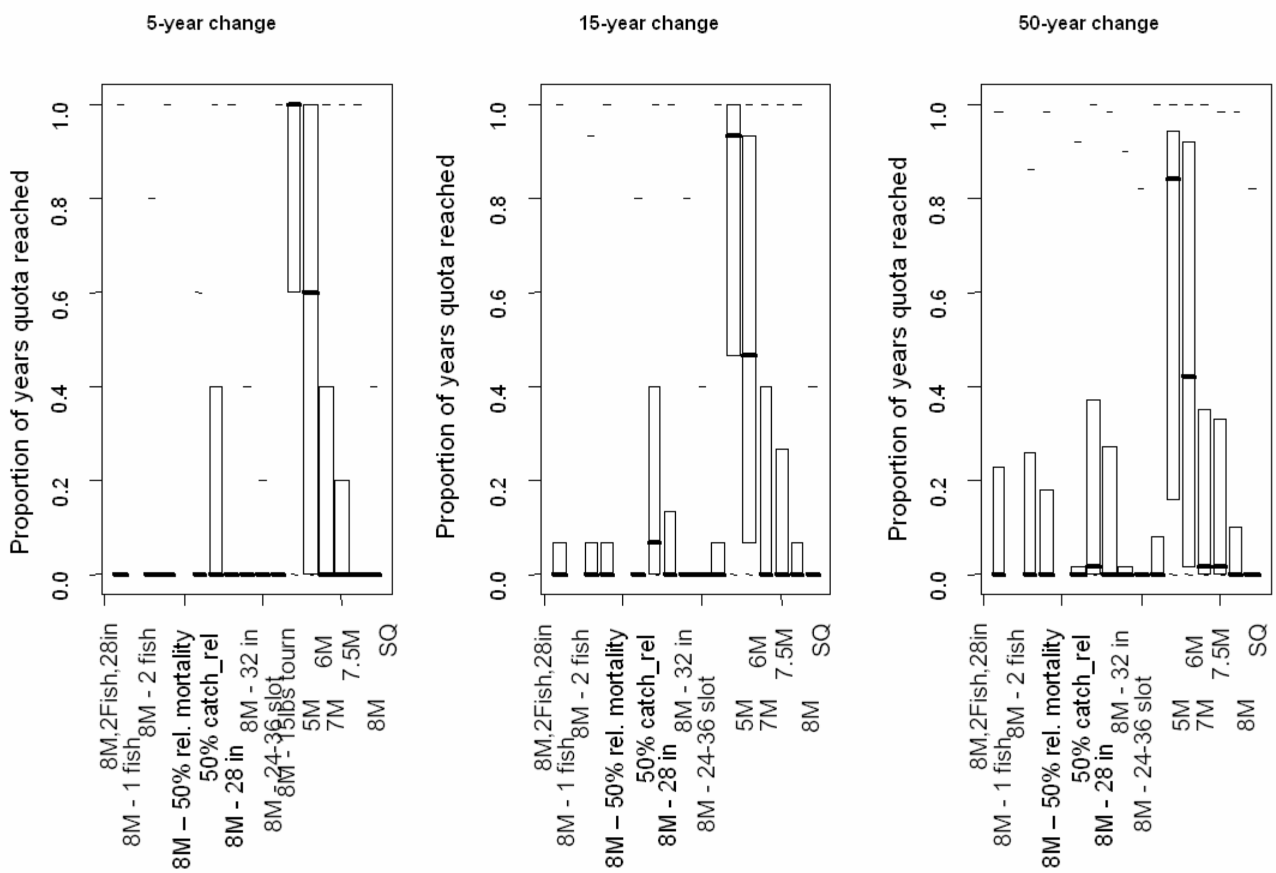

Fig. 12. Box plots of the average instantaneous fishing mortality rate (F) relative to $F_{30\%}$ for 5-, 15-, and 50-year summaries. Options and box plot definitions as in Fig. 10.

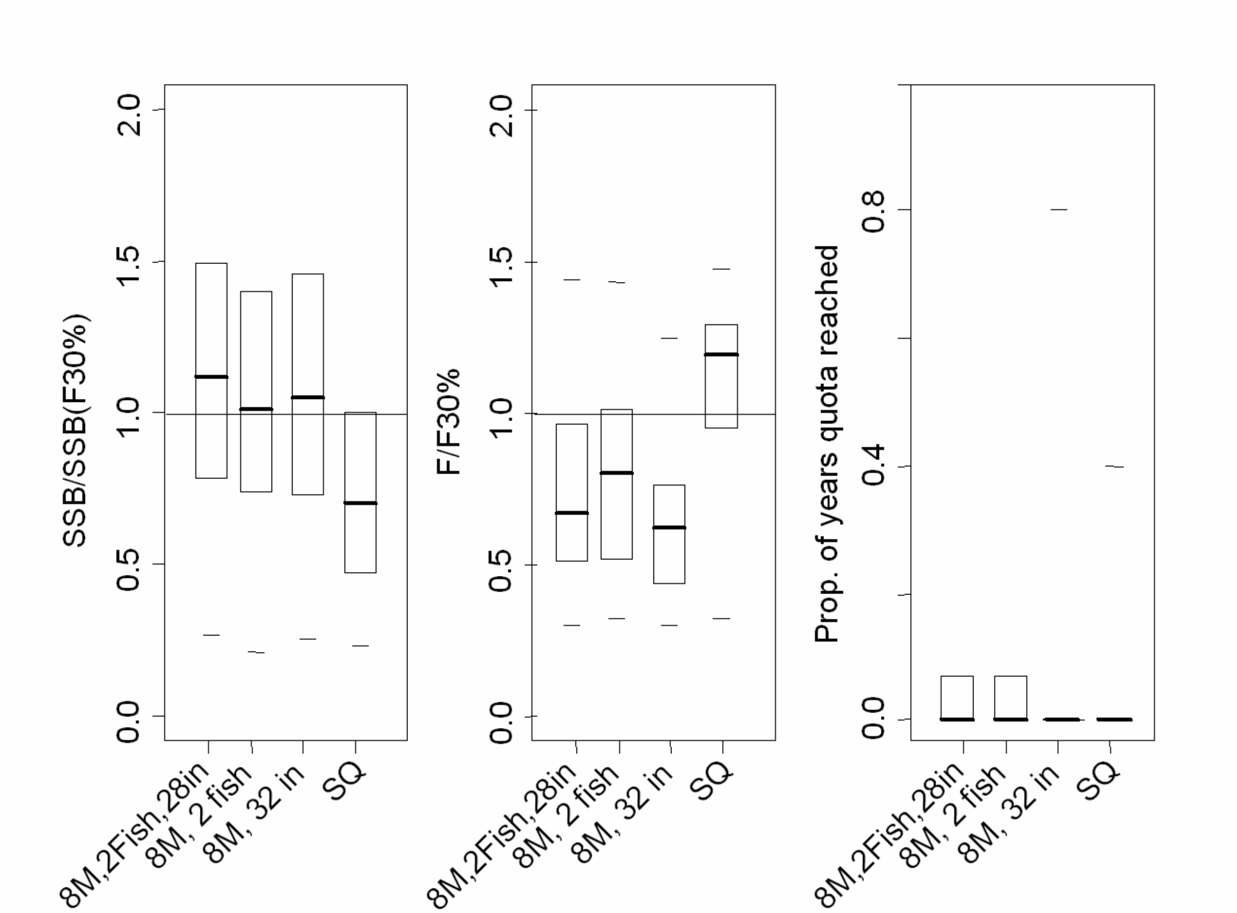

Fig. 13. Results for recommended management options averaged over the first 15 years if the simulation. Leftmost panes is for spawning stock biomass (SSB) divided by SSB at $F_{30\%}$, middle panel is for the instantaneous fishing mortality rate (F) relative to $F_{30\%}$, and the rightmost panel is for the proportion of years the recreational quota is reached. Box plot definitions as in Fig. 10.