



**Joint SAFMC and GMFMC Scientific and Statistical  
Committee (SSC) *ad hoc* Sub-Committee Meeting:  
King Mackerel Stock Identification**

**April 13, 2006**

**Double Tree Club Hotel Atlanta Airport  
3400 Norman Berry Drive  
Atlanta, GA 30344**



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## Executive Summary

A joint *ad hoc* sub-committee comprised of Scientific and Statistical Committee members (Appendix 1) from the South Atlantic and Gulf of Mexico Fishery Management Councils (hereafter referred to as the SSC Panel) was convened in Atlanta, GA, on April 13, 2006, to address king mackerel stock identification and mixing rate issues raised in reviews of the recent stock assessment conducted under the auspices of the Southeast Data, Assessment and Review (SEDAR) process. (SEDAR 5, the Southeast Data Assessment and Review process for Atlantic and Gulf king Mackerel reviewed mixing rates between the two migratory units. The process included three workshops, a Data Workshop, an Assessment Workshop, and a Review Workshop.) A Terms of Reference and list of documents for the SSC Panel were provided by both Councils (Appendix 2).

The SSC Panel addressed each of the Terms of Reference, and a detailed description of the discussion and conclusions of the panel are presented below. A summary of the conclusions of the panel are as follows:

1. The SSC Panel concurred with conclusions of the SEDAR Data Workshop, Assessment Workshop and Review Workshop that tagging data were not conducive to estimating annual mixing rates between migratory groups, as the tagging studies were not designed to specifically address the mixing issue, but clearly showed significant winter mixing between groups. The SSC Panel concluded the genetic evidence confirmed distinct Gulf and Atlantic genetic signatures exist. The SSC Panel concurs with Gold et al. (2002) that genetic tags based on reported nuclear DNA microsatellite libraries are not robust enough for effective migratory group discrimination. Overall, the SSC Panel concluded otolith shape and chemistry analyses effectively distinguished king mackerel migratory groups, and can be used to provide a range of mixing rate estimates.

2. The SEDAR Review Workshop, except two members, agreed that the base model should provide the principal criteria for management advice. It has been the model used in the past (historical consistency). The SEDAR Review Workshop, except two members, decided there was only weak scientific justification to change the model or its input parameters. A majority of SEDAR Review Workshop participants agreed that to change the model at this point would not add any certainty to the management advice, given the sensitivity of the model to other poorly estimated biological parameters such as growth and fecundity estimates. The SSC Panel considered it important to note that historical consistency is not a criterion to be considered when making key decisions regarding a benchmark assessment and pointed out that there was no scientific data to justify the continued acceptance of the status quo (100% Gulf migratory group in the mixing zone). However, a member of both the SEDAR Review Workshop and the current SSC Panel reported that mixing was only one of the many assessment issues that required major review for a benchmark assessment, and that this last point was the most critical point to understand concerning the decisions of the SEDAR Review Workshop. Changing mixing rate estimates without making changes to other assessment components seemed inappropriate to a majority of the members of the SEDAR Review Workshop.

3. The SSC Panel was not made aware of, and did not have any personal knowledge of any additional research addressing Terms of Reference (TOR) article 3, however the SSC Panel did discuss research ideas/recommendations that might assist in elucidating the mixing rate issue temporally and spatially.

4. The SSC Panel recommends maintaining the current stock definition of a single stock with separate Gulf and Atlantic migratory groups as genetic differences are sufficiently weak (region explained only 0.19% of the total genetic variance (Gold et al. 2002) that the current paradigm of one stock (i.e. management unit) with different migratory units need not be changed. The SSC Panel agreed by consensus that otolith shape and otolith chemistry data suggest somewhere between 20% and 80% of the winter mixing zone landings likely are contributed by the Atlantic migratory group. Given the interannual and spatial variability in mixing rate estimates, the SSC Panel hypothesized the actual contribution of the Atlantic migratory group to winter mixing zone landings in any given year would lie somewhere in the range of 20%-80%.

5. The SSC Panel interpreted TOR 5 as directing the SSC Panel to recommend a method to allocate past winter mixing zone landings to either migratory group for the purpose of stock assessment and not as making a recommendation as to the allocation of future landings in a management context. To avoid confusion, the SSC Panel adopts the term “partition” rather than allocate. The SSC Panel did not have the time to discuss TOR 5 in sufficient detail, but concurred that no single value within the range of 20-80% was more defensible than another to partition past winter landings. As such, to partition past landings into the Gulf and South Atlantic migratory groups for the purpose of stock assessment, the SSC Panel suggested that imprecision in mixing zone estimates be incorporated in assessment models by randomly selecting a mixing rate between 20-80% for each year, as opposed to a randomly drawn mixing rate that is held constant across years. The sensitivity of the stock assessment output to the uncertainty in the mixing percentages should be tested by comparing model output of multiple runs where the mixing rate is randomly selected each year. The uncertainty in the mixing rate can, and should, be incorporated directly into the uncertainty in the stock assessment output by including the randomly drawn mixing rates into the bootstrap routine currently employed. A similar approach could be taken if the new benchmark assessment were to use a Bayesian framework.

## **Background**

The king mackerel fishery in the Southeast US was managed as a single stock under the original Coastal Pelagics Fishery Management Plan (CPFMP). Early tagging work indicated that some fish from the Gulf group migrate to a winter mixing zone in the Florida Keys and Southeast Florida. Although genetic studies using electrophoresis were unable distinguish more than one diverse stock, the Gulf of Mexico and South Atlantic Fishery Management Councils established two migratory groups: one in the Atlantic and the other in the Gulf (Amendment One to the CPFMP in 1985). A mixing zone was established from the Monroe/Collier County to the Flagler/Volusia County lines in Florida to attempt to

partition landings to either migratory group depending on time of year. Since the mid 1980s, all fish caught in the mixing zone from November through March have been attributed to the Gulf migratory group. The original purpose of that management decision was to set conservative winter regulations to protect the overfished Gulf migratory group, although it was recognized that some of the fish in the mixing area came from the Atlantic migratory group.

Attributing all winter landings to the Gulf migratory group has been controversial since the creation of the winter mixing zone. Fishermen have presented consistent anecdotal information that management of the mixing zone does not reflect real conditions. Tagging data also demonstrate that a significant percentage of winter mixing zone landings were contributed by the Atlantic migratory group. However, early attempts to establish a more accurate winter mixing rate were not successful because tagging data were judged to be insufficient to establish a mixing rate. Several attempts to examine genetic population structure and mixing between the two king mackerel migratory groups have been conducted since the 1980s in attempts to estimate population connectivity more accurately. Beyond regulatory considerations, the need to estimate winter mixing accurately was emphasized by Legault's (1998) estimate that attributing all winter mixing zone landings to the Gulf actually overestimated that group's productivity and health.

Several of the documents pertaining to king mackerel migratory pathways, population structure, or stock identity documents considered during the SEDAR 5 process were presented to the SSC Panel. Discussion was therefore restricted to those documents provided to the SSC Panel and the SSC Panel's evaluation of those documents

**TOR 1. Review documents pertaining to king mackerel stock identification and migratory unit discrimination presented to or cited by SEDAR 5 workshops.**

Studies conducted to estimate king mackerel population connectivity and structure fall into three categories: tagging, population genetics, and using otoliths as natural tags. The earliest attempts to examine mixing between Atlantic and Gulf migratory groups were based on tagging data that date to the 1960s. Three significant tagging studies conducted since the 1970s were reviewed by DeVries (2003; SEDAR5-DW-5) and Diaz (2003; SEDAR5-DW-9): Florida Department of Environmental Protection (FDEP) and National Marine Fisheries Service (NMFS) from 1975-1979 in US southeast, Texas, and Mexico; NMFS from 1983-1986 in northern Gulf and Mexico; and, NMFS from 1985-1993 in winter mixing zone. Nearly 25,000 fish were tagged and over 1,200 individuals were recaptured among these studies. Data from these studies suggest separate migration pathways exist for eastern Gulf and Atlantic fish and that mixing between the two groups is significant in winter off south Florida. However, attempts to estimate a mixing rate between the two groups based on tagging data have not been successful. **The SSC Panel concurred with conclusions of the three SEDAR 5 workshops that tagging data are not appropriate for estimating annual mixing rates between migratory groups, as the tagging studies**

**were not designed to specifically address the mixing issue. However, tagging data clearly demonstrate significant winter mixing between eastern Gulf and Atlantic migratory groups.**

Genetics studies examining king mackerel population structure among Atlantic and Gulf regions date to the early 1980s. Techniques applied reflected the state-of-the-art when studies were conducted. For example, early studies of May (1983) and Johnson et al. (1994) employed protein electrophoresis. Gold et al. (1997) examined variation in mitochondrial (mt) DNA, and Gold et al. (2002; publication from MARFIN NA57-FF-0295 S5RD04) examined variation in nuclear DNA microsatellites. Johnson et al. (1994) concluded there were significant genetic differences between eastern Gulf and western fish but no difference between Gulf and Atlantic fish based on polymorphism of only one (PEPA-2) of 48 enzymes they analyzed. Gold et al. (1997) reexamined polymorphism of PEPA-2 and concluded no difference existed among regions and differences reported by Johnson et al. (1994) likely suffered from not controlling for age or sex. Gold et al. (1997) did report that mtDNA data were consistent with separate (but weakly so) Gulf and Atlantic genetic stocks, but no difference existed between eastern and western Gulf fish. Gold et al. (2002) reported significant differences also existed in variation among nuclear DNA microsatellites between Atlantic and Gulf fish, thus providing the most compelling evidence to date that Gulf and Atlantic migratory groups constitute unique genetic stocks. While Gold et al. (1997) and Gold et al. (2002) indicated that genetic differences between Gulf and Atlantic fish are *very* [the author's emphasis] weak (less than 0.2% of the variation was explained by migratory group), the SSC Panel agreed that any genetic differences are noteworthy given the extensive mixing between Gulf and Atlantic migratory groups. Furthermore, the SSC Panel cautions that the fact no genetic differences have been substantiated between fish from the eastern versus western Gulf does not indicate necessarily that population structure does not exist, only that genetic exchange between the eastern and western Gulf is greater than between the Gulf and the Atlantic.

Gold et al. (2002) attempted to estimate migratory group composition of winter landings from several areas around the tip of the Florida peninsula based on their library of seven nuclear DNA microsatellites. Their estimates of the ratio of Atlantic to Gulf fish in their samples were basically 50:50 regardless of geographic position within the mixing zone or month of sample collection. One interpretation of those results might be that Atlantic and Gulf fish mix perfectly in the winter mixing zone. **However, the SSC Panel concurs with the authors of the study that genetic tags may have been too weak to apply as effective tags to distinguish migratory groups, thus producing results consistent with a random draw.**

Most recently, DeVries et al. (2002; S5RD05) distinguished eastern Gulf from Atlantic fish using otolith shape analysis, while Patterson et al. (2004; publication from SEDAR5-DW-11 and SEDAR4-AW-7) employed otolith shape analysis along with analysis of otolith chemistry to distinguish fish from the two migratory groups. DeVries et al. (2002) were able to distinguish Gulf from Atlantic females based on otolith shape characteristics with an overall accuracy of 74.3%. They applied this natural tag to winter mixed-stock landings caught in 1996-97 off southeast Florida and estimated 99.8% of landed females were

contributed by the Atlantic stock. Estimates of winter mixing derived from otolith shape analysis in two subsequent fishing years (1999/00 and 2000/01) ranged from 59 to 64% Atlantic fish (DeVries 2003). Further analysis also revealed natural tags derived from otolith shape data applied to subsequent years' winter landings gave different results than tags derived from fish sampled in the immediately proceeding summer, thus suggesting otolith shape characteristics show interannual variation despite consistent differences in group-specific growth rates.

Patterson et al. (2004) tested for differences in otolith shape characteristics between migratory groups, sexes, and years (2001 and 2002). They reported significant differences existed between groups and sexes but not years, yet classification accuracies were greater when years were modeled separately. Overall, classification success (65.8 – 76.4) was similar to that reported by DeVries et al. (2002), although it was generally higher for females than males. Year-specific natural tags based on otolith shape were applied to winter landings from three zones around the tip of south Florida for the 2001/02 and 2002/03 fishing years. Estimates from maximum likelihood stock composition models indicated a trend in percent Atlantic group contribution that was lowest in the western zone (basically the Tortugas gillnet fishery) and highest in the eastern zone (see Patterson et al. 2004 Table 2). Estimates of Atlantic group contributions were lower for all zones in 2002/03, but in both years the 95% confidence intervals were broad.

Perhaps the most powerful natural tag of king mackerel migratory groups yet analyzed is based on otolith chemistry differences between groups. Patterson et al. (2004) reported there were significant differences in otolith elemental signatures between groups but not years nor sexes. However, classification success was higher when individual fishing years and separate sexes were modeled. Classification accuracies ranged from 67.8 to 90.9%, thus indicating otolith elemental signatures provided a more robust natural tag than did otolith shape. Trends in percent Atlantic group contribution estimates were similar to otolith shape results among the winter regions, but one major difference was confidence intervals were not as broad with the otolith chemistry approach (see Patterson et al. 2004 Table 6). **Overall, the SSC Panel concluded using otolith chemistry appears to be a useful technique to distinguish king mackerel migratory groups, yet currently there are too few data to make definitive statements about average mixing conditions in south Florida in wintertime.**

In summary, the SSC Panel reviewed tagging, population genetics, and otolith-based studies of king mackerel migratory group mixing. While all studies provided insight into mixing between groups, the information available differed among approaches. Tagging data generally demonstrated different migratory pathways exist between Atlantic and Gulf king mackerel, but mixing does occur between groups, mostly in winter. The SSC Panel concurred with results from the SEDAR process that tagging studies were not designed to estimate mixing rates and applying their results for that purpose was not appropriate. Results from the most recent genetics studies indicated there were weak but significant differences in both mtDNA and nuclear DNA microsatellites between Gulf and Atlantic fish. The SSC Panel commented that any significant differences were remarkable given inter-group mixing, but estimating stock mixing with genetics data seems precarious and ill advised. Perhaps the most powerful techniques reviewed by the SSC

Panel for distinguishing Gulf and Atlantic fish was analysis of otolith shape and otolith chemistry. Otolith chemistry provided the most robust migratory group-specific natural tags. Otolith chemistry-based estimates of migratory group contribution to landings in three zones around south Florida in winter 2001/02 and 2002/03 indicated a significant contribution by the Atlantic stock. However, the broad range in the SSC Panel's mixing estimate presented below reflects 1) the temporal variability in mixing estimates, 2) the spatial variability in mixing estimates, and 3) the lack of precision of zone-specific estimates in both years of the Patterson et al. (2004) study.

**TOR 2. Review recommendations of the SEDAR 5 Workshops pertaining to king mackerel stock id and allocation of landings into migratory units.**

SEDAR 5, the Southeast Data Assessment and Review process for Atlantic and Gulf king Mackerel reviewed mixing rates between the two migratory units. Results were presented in several documents.

**Assessment Workshop Document**

The Assessment Workshop concurred with the Data Workshop that no consistent stock allocation was evident from the various studies. The Assessment Workshop also concurred with the Data Workshop that studies should be continued to provide additional information on stock mixing rates, and to evaluate consistency in results between years. The Assessment Workshop did conclude that some mixing occurs, particularly during the November-March period when landings from the mixing area (Collier/Monroe County to Volusia County) have historically all been assigned to the Gulf stock. The assessment working group therefore decided it was likely that (1) less than 100% of the mixing area fish in November-March were from the Gulf stock and (2) less than 100% (and less than 98%) of those fish were Atlantic stock.

The Review Workshop reported that estimates of overlap from their analyses were not consistent with the hypothesis that 100% of the fish in the mixing area belong to the Gulf migratory group. Given the similar estimates of abundance for the two migratory groups, results of the Assessment Workshop's analyses were more consistent with the hypothesis that the Gulf group fraction in the mixing area is between 25% and 75%.

The Assessment Workshop considered assessments assuming different catch levels of Gulf migratory group fish from the mixing zone ranging from 100% (status quo) to 2% for the purpose of advising the Councils on possible mixing scenario impacts on perceived stock productivity, status, and ABC calculations. However, attention was focused on scenarios for which 25% to 75% of landings within the mixing area during November-March was assumed to be from the Gulf Migratory Group.

When different estimates of mixing rates were incorporated into actual assessments, the uncertainty in the estimates meant fishing mortality rate benchmarks were insensitive to mixing proportion assumptions. However, estimates of long-term productivity (proxies for MSY, OY) and estimates of

spawning abundance which could support these yield levels (proxies for  $B_{MSY}$ ,  $B_{OY}$ ) did change with reduction in assumed proportion of Gulf group fish catch from the mixing zone. Considering the uncertainty in the estimates, the sensitivity of these benchmarks for the Gulf group was more apparent than for the Atlantic group. When all other variables were held constant, reduced levels of historical catch for the Gulf group result in lower estimates of MSY, OY, and the associated equilibrium biomasses.

Ultimately, while the Assessment Workshop was unable to select the most appropriate form of mixing analysis based on available data, the information available to the group indicated that mixing scenarios within the range of 25% to 75% Gulf group catch from the mixing zone appeared more consistent with the tagging data interpretation than either the status quo assumption or the assumption of only 2% of the catch from the Gulf group during the entire assessment time period. The Assessment Workshop recommended that research and evaluation of tag data, ongoing otolith chemistry and shape analysis studies, and microsatellite genetic marker data be continued to improve estimation of stock structure and mixing proportions.

#### Review Workshop Consensus Summary Document

The Review Workshop concurred with the opinion of the Assessment Workshop Panel that both migratory groups contribute to winter landings in the mixing zone. Mixing scenarios within the range of 25 to 75% Gulf group catch from the mixing zone appeared consistent with tagging data and preliminary results from otolith shape and chemistry studies, and were perceived to be more likely than the 100% used in the base line assessments. However, a majority of the Review Workshop felt the alternate mixing scenarios suggested were based on imprecise mixing rate estimates. Furthermore, the assessment model was sensitive to other biological parameters thought to be poorly estimated. Therefore, the Review Workshop concluded it was premature to implement a change in the winter mixing estimate in the base model, preferring instead to consider the effects of alternate mixing scenarios by means of sensitivity analysis.

Ultimately, the Review Workshop, except two members, agreed that the base model should provide the principal criteria for management advice. It has been the model used in the past (historical consistency). The Review Workshop, except two members, decided there was only weak scientific justification to change the model or its input parameters. Will Patterson, a member of both the SEDAR Review Workshop and the current SSC Panel reported that a majority of Review Workshop members agreed that to change the model at this point would not add any certainty to management advice given the uncertainty in other biological parameters to which the base assessment model was similarly sensitive but which were not addressed completely in the previous workshops. It is important to note that this statement and its justification does not appear in the report. The SSC Panel believes it is important to note that historical consistency is not a criterion to be considered when making key decisions regarding a benchmark assessment. This seriously calls into question whether this assessment was, in fact, a benchmark assessment.



#### Minority Opinion by Joe Grist and Ben Hartig

Two members of the Review Workshop wrote a minority opinion concerning mixing rates, stating that given the best scientific data available and taking the conservative approach, a more appropriate mixing distribution to base the best management recommendations on would be 50/50 Atlantic/Gulf, providing analysis with a sensitivity range of 25-75%. Grist and Hartig stated this takes into account that the mixing zone is not likely comprised of 100% Atlantic or Gulf group fish, as demonstrated by previous scientific studies and the SEDAR5 Review Workshop.

#### Atlantic King Mackerel Advisory Report

The special comments section reports sensitivity runs that considered alternative stock compositions in the mixing zone showed the status of the Atlantic stock was rather insensitive to the assumed mixing rates, both in terms of associated stock biomass and F values and in terms of status of the stock and the fishery in relation to overfishing.

#### Gulf King Mackerel Advisory Report

The special comments section reports sensitivity runs that considered alternative stock compositions in the mixing zone showed the status of the Gulf stock was sensitive to the assumed mixing rates, both in terms of associated stock biomass and F values, and in terms of status of the stock and of the fishery in relation to overfishing.

#### CIE Chair Report by Henrik Sparholt

Dr. Sparholt reported that a main issue discussed was mixing and whether the Review Workshop agreed that the current assumption about mixing used in the assessment was the best possible. An alternative was suggested and Dr. Sparholt reported there was an extended discussion about using alternative mixing assumptions in the baseline assessment. The general opinion was it was premature given the short time series of data and because several other aspects of the assessment (growth, fecundity, FADAPT model vs. more statistically robust methods for stocks where F is not much larger than M as in this case, mixing outside the mixing time, and uncertainties about the actual mixing values), were also in need of revision.

Will Patterson, a member of both the SEDAR Review Workshop and the current SSC Panel reported this last point was the most critical point to understand concerning the decisions of the Review Workshop. Mixing is only one of the assessment issues that required major review for a benchmark assessment. Changing it without considering changes to other assessment components seemed inappropriate. Unfortunately, this important point was only stated explicitly in one sentence that appeared in the SEDAR CIE Chair Report.

Report by CIE Panel Member Jon Volstad

Dr. Volstad reported that the base model was chosen by the majority after rejecting the reliability of mixing rate estimates and the potential effect of using alternative estimates of mixing rates was appropriately evaluated through sensitivity analysis.

**TOR 3. Review any additional research regarding king mackerel stock ID and migratory unit allocations available since the SEDAR 5 workshops.**

The SSC Panel was not made aware of, and did not have any personal knowledge of any additional research addressing Terms of Reference 3. However, the SSC Panel did discuss some research ideas/recommendations which could greatly assist in quantifying the mixing rate, and the temporal and spatial variability in the rate.

The SSC Panel considered the research studies on the stock resolution of king mackerel. Historical tagging studies show mixing, and it is absolutely clear that both stocks contribute to the fishery in the mixing zone. However, because of the inherent difficulty in conventional tagging over the time scale of seasons and years, varying fishing mortality and tag recapture reporting rates, and acquiring sufficient numbers of recoveries, estimating migratory group mixing rates in the winter mixing zone from tag/return data may prove to be intractable. There was a discussion about utilizing pop-up tags, and although they provide interesting data, they are cost prohibitive to get the accuracy and precision necessary to resolve the question before us.

The SSC Panel found that otolith morphology and chemistry provide the best available science to address mixing rates, and appear to be the most suitable tools to further elucidate temporal and spatial variability in mixing between the two migratory groups. The advantage of using otolith based techniques is they are naturally tags and require no effort or expense in placing a tag. Otolith chemistry (specifically, elemental and stable isotope analyses) may provide even greater accuracy and precision to address the issue of stock origin, if sufficient sample sizes are collected. Therefore, the SSC Panel recommends that a research project be initiated to address the limitations that exist with the current otolith based research. The most obvious problem is the small sample numbers in the existing studies. That limitation can be overcome easily simply by increasing sample sizes, which will result in increased precision of mixing estimates. Funding such a project was discussed and the point was made that perhaps this could be a targeted MARFIN project, similar to what was done with red snapper several years ago. The issue of migratory group mixing is of such importance to recreational and commercial fishing interests in both regions, as well as the environmental and conservation community, that it is appropriate to commit the resources to addressing it comprehensively.

**TOR 4. Recommend a stock definition for Gulf and South Atlantic migratory units of king mackerel.**

The SSC Panel concluded that it would be premature to recommend proposing a two stock management paradigm based on existing population genetic data, but we encourage additional genetic

research with samples taken south of Cape Canaveral during the summer as well as winter samples from Florida's southwest coast. The SSC Panel also pointed out that there was another migratory group in the western Gulf that moved primarily between Texas and Mexico and very little is known about the connectivity between that group and the other two migratory groups. **Therefore, the SSC Panel recommends maintaining the current stock definition of a single stock with migratory groups as genetic differences are sufficiently weak that the current paradigm of one stock (i.e. management unit) with different migratory units need not be changed.**

As discussed above, none of the reviewed literature supports the assumption that 100% of the fish caught in the mixing zone during the November-March belong to the Gulf migratory group. However, only a few of these studies provided uncertain estimates of the mixing proportions. Otolith shape analysis and otolith chemistry appear to be the most robust approaches currently available to estimate mixing. Based on these methods, Patterson et al. (2004) concluded that, "...there is sufficient evidence to compute stock assessment models assuming at least half and perhaps more of the king mackerel caught in the winter mixing zone are contributed by the Atlantic migratory group." However, estimates of mixing proportions from these models vary from spatially from year to year and have wide confidence bounds.

The SSC Panel concluded that despite the interannual and spatial variability the best available science could provide a range within which the mixing proportion may lie, but could not be more precise than offering advice as to the range of possibilities. **The SSC Panel agreed by consensus that somewhere between 20% and 80% of the fish landed in the winter mixing zone belonged to the Atlantic stock.**

The rationale for this range is as follows. Patterson et al. (2004) sampled landings from three geographic regions around south Florida during the winter fishery in 2001-2002 and 2002-2003: the commercial gillnet fishery operating around and north of the Dry Tortugas (Zone I), the hook-and-line recreational fisheries centered in Islamorada (Zone II), and the troll commercial fisheries operating between West Palm Beach and Melbourne (Zone III). The sample size was skewed towards females, and a mixture of collection gear, so the SSC Panel based discussion on the female mixing percentages. Furthermore, otolith chemistry results provided higher stock discrimination accuracies, thus narrower confidence intervals for winter mixing estimates. Therefore, of the two techniques applied by Patterson et al. (2004), the SSC Panel only considered otolith chemistry results when estimating the range in migratory group winter mixing.

Zone I (farthest west) had the lowest percentage of landings from the Atlantic migratory group. Patterson et al. (2004) estimated that 21.1% (95% C.I. 7-35) and 21.3% (95% C.I. 9-37) of sampled females in Zone I for the 2001-02 and 2002-03 fishing seasons, respectively, were from the Atlantic migratory group. Thus, while a mixing percentage somewhere within the range of 7%-9% Atlantic fish (based on the lower confidence limits) may represent a minimum bound in Zone I, the SSC Panel did not feel that it would be appropriate to apply this minimum bound to the entire mixing zone. As such, the SSC Panel chose a minimum bound on the mixing level to be 20%.

Zone III (farthest east) had the highest percentage of landings from the Atlantic migratory group. Patterson (2004) estimated that 85.6% (95% C.I. 68-99) and 61.1% (95% C.I. 19-86) of sampled females in Zone I for the 2001-2 and 2002-3 fishing seasons, respectively, were from the Atlantic migratory group. Thus, while a mixing percentage somewhere within the range of 86-99% Atlantic fish (based on the upper confidence limits) may represent a maximum bound in Zone III, the SSC Panel did not feel that it would be appropriate to apply this maximum bound to the entire mixing zone. As such, the SSC Panel chose a maximum bound on the mixing level to be 80%.

**Given the interannual and spatial variability, the SSC Panel hypothesized the actual contribution of the Atlantic migratory group to winter mixing zone landings in a given year likely lies somewhere in the range of 20%-80%. However, the SSC panel attaches several caveats to this range in likely mixing between migratory groups.** The fact that this range is similar to the range described by the SEDAR5 Assessment Workshop is only coincidental.

Caveats related to selection of the 20-80 percent range of Atlantic/Gulf fish within the mixing zone

1. The current otolith chemistry analyses are limited to a two-year time series and are not representative of the entire mixing zone area.
2. With the current two-year time series of otolith chemistry data it is not possible to further refine the estimated range of mixing beyond the 20-80 percent range.
3. Estimates of the percentage of Atlantic contribution varies among regions within the mixing zone, with the lowest percentage of Atlantic fish in the more western Tortugas area in the Gulf of Mexico and the highest percentage of Atlantic fish in the more eastern Southeast Florida area in the South Atlantic. Therefore, a single mixing rate may be inappropriate.
4. Interannual variability in estimates of the percentage of winter mixing zone landings contributed by the Atlantic migratory group may reflect interannual differences in migratory pathways of the two migratory groups.
5. There is a combined temporal and spatial variation (interaction) in that the spatial variation in estimates also changes from year to year.
6. It will take considerable resources to increase the otolith chemistry samples or to conduct more precise analyses to improve precision of mixing estimates.

**TOR 5. Recommend the most appropriate method for allocating king mackerel landings into the Gulf and South Atlantic migratory units.**

The SSC Panel interpreted TOR 5 as directing the SSC Panel to recommend a method to allocate past winter mixing zone landings to either migratory group for the purpose of stock assessment and not as making a recommendation as to the allocation of future landings in a management context. To avoid confusion, the SSC Panel adopts the term “partition” rather than allocate. The SSC Panel did not have the

time to discuss TOR 5 in sufficient detail, but concurred that no one value within the range of 20-80% was more defensible than another to partition past winter landings. As such, to partition past landings into the Gulf and South Atlantic migratory groups for the purpose of stock assessment, the SSC Panel suggested that imprecision in mixing zone estimates be incorporated in assessment models by randomly selecting a mixing rate between 20-80% for each year, as opposed to a randomly drawn mixing rate that is held constant across years. The sensitivity of the stock assessment output to the uncertainty in the mixing percentages should be tested by comparing model output of multiple runs where the mixing rate is randomly selected each year. The uncertainty in the mixing rate can, and should, be incorporated directly into the uncertainty in the stock assessment output by including the randomly drawn mixing rates into the bootstrap routine currently employed. A similar approach could be taken if the new benchmark assessment were to use a Bayesian framework.

## **LIST OF ATTENDEES**

Joint SAFMC and GMFMC Scientific and Statistical Committee (SSC)

*ad hoc* Sub-Committee Meeting:  
King Mackerel Stock Identification  
Doubletree Club Hotel  
Atlanta, Georgia

April 13, 2006

### **SAFMC SSC:**

Jim Berkson, Co-Chair  
John Dean  
Pat Harris  
Andy Cooper

### **GMFMC SSC:**

Robert Muller, Co-Chair  
William Patterson  
Doug Gregory  
Jim Cowan (did not attend)

### **OBSERVERS:**

Myron Fishcher, GMFMC Council member  
Rick Leard, GMFMC Staff

### **SAFMC ADMINISTRATIVE STAFF:**

Cynthia Morant

# **SEDAR**

## **SouthEast Data, Assessment, and Review**

*South Atlantic Fishery Management Council  
Gulf of Mexico Fishery Management Council  
Caribbean Fishery Management Council  
NOAA Fisheries  
Atlantic States Marine Fisheries Commission  
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### Joint SAFMC – GMFMC SSC *ad hoc* Sub-Committee on King Mackerel Stock ID Workshop to address King Mackerel mixing rates Terms of Reference

1. Review documents pertaining to king mackerel stock identification and migratory unit discrimination presented to or cited by SEDAR 5 workshops.
2. Review recommendations of the SEDAR 5 Workshops pertaining to king mackerel stock id and allocation of landings into migratory units.
3. Review any additional research regarding king mackerel stock id and migratory unit allocations available since the SEDAR 5 workshops.
4. Recommend a stock definition for Gulf and South Atlantic migratory units of king mackerel.
5. Recommend the most appropriate method for allocating king mackerel landings into the Gulf and South Atlantic migratory units.
6. Prepare a consensus report documenting committee discussions and recommendations. The report should be finalized by the end of the workshop.

#### Suggested presentations:

Will Patterson: King mackerel stock discrimination using otoliths  
Doug DeVries: Review of stock structure of king mackerel  
Guillermo Diaz: King mackerel tagging overview and recapture locations  
J Gold: King mackerel genetic analyses

Reference documentation to be provided

SEDAR5-DW-5	A review of the stock structure of king mackerel off the southeastern US.	DeVries, D. and W. Patterson
SEDAR5-DW-9	Preliminary analysis of king mackerel tag data from the cooperative tagging center	Diaz, G. A.
SEDAR5-DW-11	Discrimination between Gulf of Mexico and Atlantic Ocean king mackerel with otolith shape analysis and otolith microchemistry: A progress report	Patterson, W. E., T.R. Clardy, D. A. DeVries, Z. Chen, and C. Palmer
SEDAR5-AW-6	Release locations of tagged king mackerel	Diaz, G.
SEDAR5-AW-7	Discrimination Among US South Atlantic and Gulf of Mexico King Mackerel with Otolith Analysis and Otolith Microchemistry. Summary of MARFIN Grant No. NA17FF2013	Shipp, R. L. and W. F. Patterson III.
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