Movement Patterns and Stock Affinities of King Mackerel in the Southeastern United States

Frederick C. Sutter III
Florida Marine Research Institute, Department of Natural Resources
100 Eighth Avenue SE, St. Petersburg, Florida 33701-5095

Roy O. Williams
Florida Marine Fisheries Commission, 2540 Executive Circle West
Suite 106, Tallahassee, Florida 32301

Mark F. Godcharles
National Marine Fisheries Service, NOAA
9450 Koger Boulevard, St. Petersburg, Florida 33702

Abstract.–King mackerel *Scomberomorus cavalla* were tagged and released from southeastern Florida, the Florida Keys, and South Carolina from 1975 through 1979 to document spatial and temporal movement patterns. Distance traveled by tagged king mackerel was not significantly related to size (fork length), but was correlated with number of days-at-large. King mackerel show a cyclical pattern of movement along the Atlantic seaboard of the southeastern United States and coastal waters of the Gulf of Mexico. A migratory behavior may exist in which fish return to the area of release over a period of up to 5 years. The number of fish moving away from the area of release and their direction of movement depend on whether the fish are associated with Atlantic or Gulf waters. Some king mackerel may be residents in southeastern Florida waters. The seasonal overlap between the two recognized stocks of king mackerel in southeastern Florida is estimated to be as high as 29.4–41.8%.

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Historically, the king mackerel *Scomberomorus cavalla* has supported important recreational and commercial fisheries in the southeastern United States (Finucane et al. 1986, Brusher and Palko 1987). Concern over declining king mackerel abundance has resulted in state and federal regulation of recreational and commercial king mackerel fisheries. As part of the management strategy of this resource, two migratory groups ('stocks') of king mackerel have been established for the southeastern United States (SE U.S.): an Atlantic stock and a Gulf of Mexico stock (Williams and Godcharles 1984). From 1 November through 31 March, the range for the Gulf stock includes the entire Gulf of Mexico, extending up the Florida east coast to the Volusia/Flagler county line (Fig. 1, line A). Fish found north of this line are considered to be Atlantic stock. From 1 April through 31 October, the boundary for the Gulf/Atlantic stocks is the Collier/Monroe county line on Florida's west coast (Fig. 1, line B). A 'transition' zone, therefore, is created along the southern Florida coast (Fig. 1, shaded area).

Stock definitions were largely generated from a cooperative tagging program by the Florida Department of Natural Resources (FDNR) and National Marine Fisheries Service (NMFS) to study king mackerel resources in the SE U.S. Although these data have been utilized in various resource assessments by state and federal agencies, little of this information has been formally published. In this paper, we describe the tag returns with respect to temporal and spatial movement patterns and stock affinities of *S. cavalla*.

Materials and methods

A total of 12,493 fish were tagged in four spatial/temporal regions along the SE U.S. from 1975 through 1979 (Table 1, Fig. 1). King mackerel were captured by fishermen, under contract to FDNR, using hook-and-line. Biologists from FDNR measured fork length (FL) of the fish and examined them for any debilitating injuries. Fish in good condition were placed ventral-side-up in a wet tagging cradle covered with plastic and foam rubber. A 7- to 10-mm longitudinal incision was made along the anterior portion of the abdomen permitting the insertion of an internal anchor tag with an external plastic streamer. Tagged fish were returned to the water, usually within 25–35 seconds after dehooking. Latitude, longitude, and condition of each release were recorded.

The tagging program was publicized through posters, newspaper and magazine coverage, and contacts with fishermen and fish dealers. To enhance returns, tag numbers were randomly selected for rewards of \$5, \$10, or \$25. Recreational anglers and commercial fishermen were encouraged to provide the following information with each return: date, latitude and longitude, fork length, weight, sex, and type of recapture gear.

An accurate description of the length of each tagged and recaptured fish was needed to examine the relationship between size and movement. To determine whether particular length categories were disproportionally reported, we used chi-square tests to compare the length distributions (50 mm FL intervals) of all released fish with the length-at-tagging of recaptured fish for each of the four tagging regions. Length-at-tagging for recaptured fish was used because accuracy of recaptured-fish length measurements could not be determined and because the effects of growth prior to recapture were unknown and could bias the comparisons.

Temporal recapture relationships were determined by grouping returns into seven subareas for each of the four tagging regions along the SE U.S. (Fig. 1): South Atlantic Bight (SAB = Georgia, South Carolina, and North Carolina); northeastern Florida (NEFL = Georgia/Florida line to north side of Cape Canaveral); southeastern Florida (SEFL = north side of Cape Canaveral to Monroe/Dade line); the Florida Keys (FK = Monroe/Dade to Monroe/Collier line); southwestern Florida (SWFL = Monroe/Collier line to Apalachee Bay); the northeastern Gulf (NEG = Apalachee Bay to Mississippi River); and the northwestern Gulf (NWG = Mississippi River to Texas/Mexico border). Subareas for this analysis were chosen to provide as much resolution as possible given the distribution of tags and recaptures. Current stock

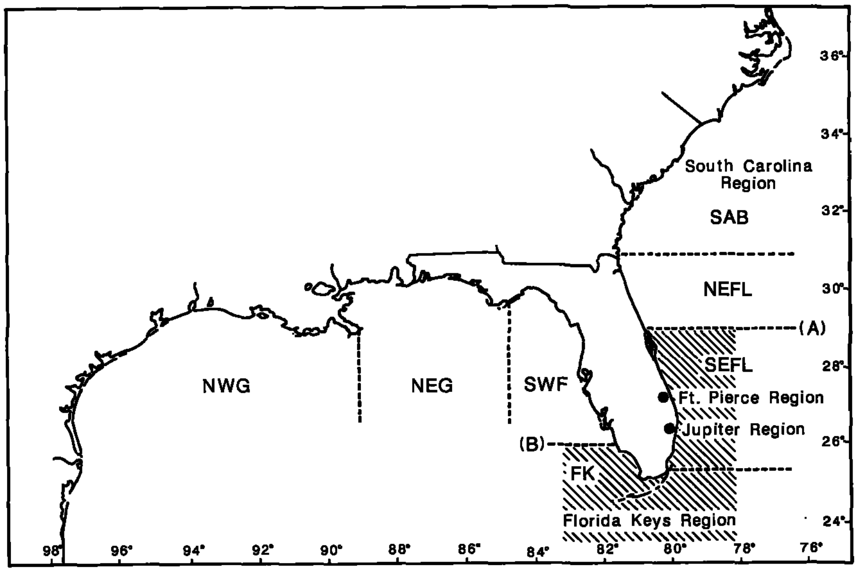

Figure 1
Location of seasonally shifting boundaries (labeled A and B) of the two stocks of king mackerel in the southeastern United States. The 'transition' zone formed by these two lines is outlined by the shaded area. Recapture subareas as defined in the text are also given (dashed lines).

Table 1
Number of king mackerel tag releases, by year.

	Location and month of release			
Year	South Carolina[1] May, June	Ft. Pierce[2] December–March	Jupiter[3] May, June	Florida Keys[4] February, March
1975	—	880	372	—
1976	—	1904	1318	974
1977	—	1666	588	844
1978	—	1966	396	776
1979	809	—	—	—
Total	809	6416	2674	2594

[1] Northern boundary of release area defined by 33°50.0′N latitude, and southern boundary by 32°03.0′N latitude.
[2] For all years, except 1975, annual totals for the Ft. Pierce area include December releases of the previous year. Northern boundary of release area defined by 28°45′N latitude and southern boundary by 27°07′N latitude.
[3] Northern boundary of release area defined by 27°07′N latitude and southern boundary by 26°19′N latitude.
[4] Eastern boundary of release area defined by 81°10′W longitude, southern boundary by 24°10′N latitude, western boundary by 83°30′W longitude, and northern boundary (Gulf of Mexico, only) by 27°00′N latitude.

definitions were considered in combination with other published king mackerel studies (e.g., Brusher and Palko 1987, Trent et al. 1987) to formulate possible subareas. The larger subareas (Fig. 1) reflect little or no tag releases and few returns, while the smaller subareas along south Florida were utilized for locations of directed tagging efforts. Returns in each subarea were sorted by year and month of recapture. A continuous time-scale, representative of the relative time of freedom and independent of actual year of release or return, was created for each subarea by designating the first 12 months after release as year 1, the second as year 2, and continuing for up to 3–5 years. Therefore, fish released in May of 1975, 1976, 1977, or 1978, for example, would be assigned a May, year-1 release date.

The spatial patterns of king mackerel returns were categorized according to the relative direction of movement through coastal SE U.S. waters rather than according to strict compass headings, because fish were released and recaptured on both the Atlantic and Gulf coasts. Fish were considered to be moving 'Atlantic-ward' if they were recaptured in Atlantic waters north of their release location or if they had moved toward the Atlantic from a release location in the Florida Keys region. Individuals were classified as moving 'Gulf-ward' if they were recaptured south of their release area or in the Gulf of Mexico. However, fish released from the Florida Keys region had to be recaptured north of the Monroe/Collier county line (B in Fig. 1) to be classified as moving Gulf-ward. Distance from tagging location was determined for each tag return. Returns were grouped into 50-km increments (i.e., 0–49 km, 50–99 km, etc.) when within 800 km of their release site and in 100-km blocks thereafter. This created a continual distance gradient for fish moving either Gulf-ward or Atlantic-ward from each of the four tagging regions. The 100-km increments were used since only 9.5% of the recaptures occurred more than 800 km from the release sites.

The relative magnitude of movement for tagged fish moving at least 100 km away from each release location, either Gulf-ward or Atlantic-ward, was determined by plotting the cumulative percentage of fish moving through, or recaptured in, each respective distance block. A 100% value was given to the block nearest the tagging area (either Atlantic- or Gulf-ward) because all fish had to move at least 100 km to be included in the analysis. The 100-km limit was used to prevent including in the analysis fish that were exhibiting random movement patterns associated with the release locations. Since measurements of fishing effort (commercial and recreational) and catchability were not available for the time-frame of our study, we had to assume that the number of returns was a reflection of relative effort. We based this assumption on the migratory nature of this species (Beaumariage 1973, Collette and Russo 1984), knowing that fishermen target king mackerel as they become available along various coastal waters.

Stock definitions for king mackerel in the southern Atlantic and Gulf of Mexico management zones were evaluated using a discriminant function technique based on a measure of generalized squared distance (SAS 1985). The classification variable used in the analysis was membership, based on when and where a specific fish was released, of the fish in either the Atlantic or Gulf stock. Number of days at large, distance from release to recapture locations, and month and location of recapture were used as quantitative variables. A test of the homogeneity of within-covariance matrices was made to determine whether the within- or pooled-covariance matrix would be used in the discriminant function. The percentage of posterior probability of classification of each return for its original stock (i.e., Atlantic or Gulf), calculated as part of this discriminant function test, was used as an indicator of the affinity of a king mackerel for its nominal stock group. The two king mackerel stocks were then divided into five substocks to refine the indices of stock affinities. The Atlantic stock was separated into two substocks: a combination of the SAB and NEFL subareas that form the SE U.S. Atlantic coast substock; and the southern Florida summer substock, which is a conglomerate of the SEFL and FK subareas from April through October. The Gulf stock was divided into three substocks: the southeastern Florida winter substock that consists of the SEFL subarea from November through March; the Florida Keys winter substock, which corresponds to the FK subarea from November through March; and a combination of all Gulf of Mexico subareas (NEG and NWG subareas) that form the combined Gulf substock. King mackerel from a one-time tagging effort off the Texas coast during 1977 (*N* 319) by FDNR were included in the stock affinity analysis as part of those fish released as combined Gulf substock. These Texas fish were not included in any of the other analyses of the 12,493 tagged fish.

Results

Fish length did not influence movement and was not a factor in the probability of recapture. Neither length-at-tagging (r 0.08; df 1,147; F 0.722) nor length-at-return (r 0.075; df 1,654; F 3.688) was significantly correlated with the distance that a fish traveled from its release area. Bias associated with tag return relative to length was examined by comparing length of re-

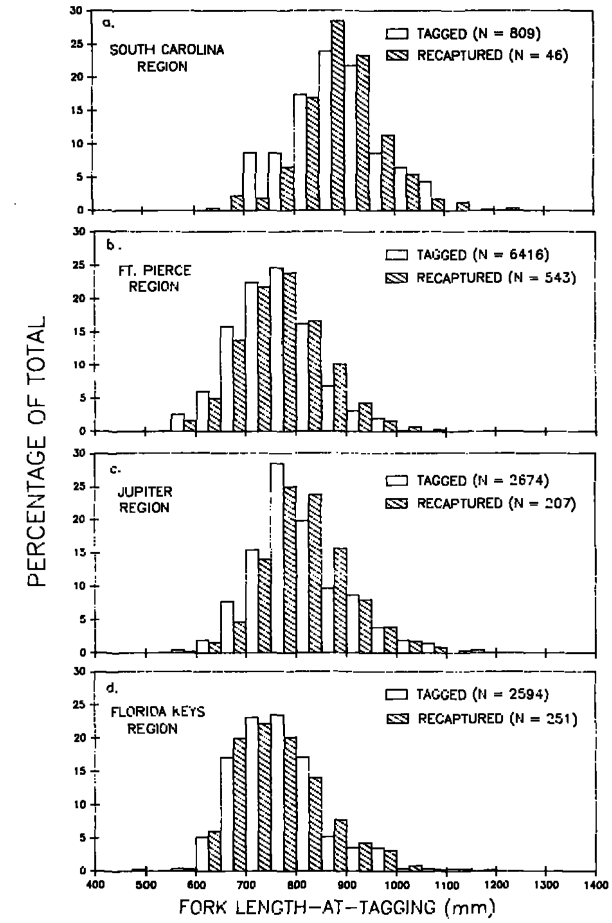

Figure 2
Length-frequencies at release and subsequent length-at-tagging of recaptured king mackerel from the four tagging regions. Fish were grouped by 50-mm FL interval; mid-range values are used for each plot.

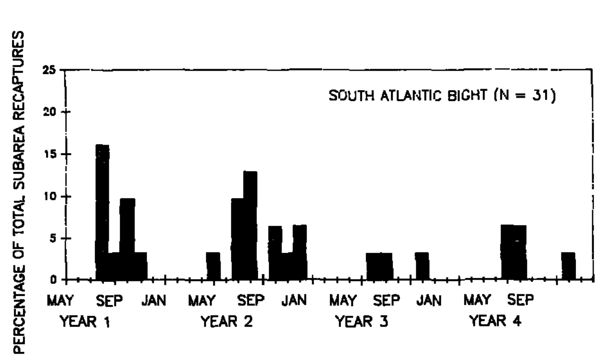

Figure 3
Monthly return percentage of king mackerel released from South Carolina region and recaptured in the South Atlantic Bight (SAB) subarea, using a continuous time-scale representative of relative time of freedom. Returns begin with May of year 1.

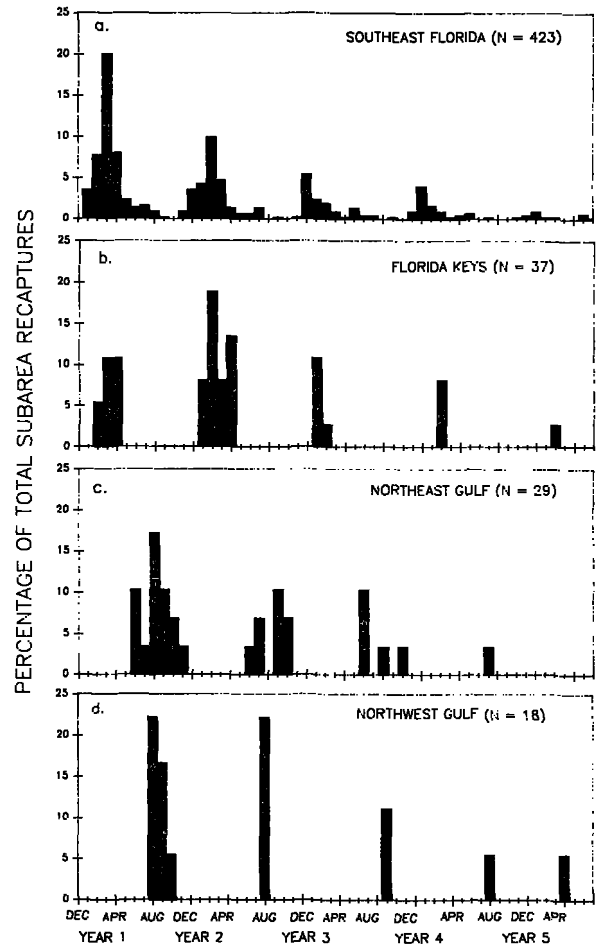

Figure 4
Monthly return percentage of king mackerel released from Ft. Pierce region and recaptured in the (a) southeastern Florida (SEFL), (b) Florida Keys (FK), (c) northeastern Gulf (NEG), and (d) northwestern Gulf (NWG) subareas, using a continuous time-scale representative of relative time of freedom. Returns begin with December of year 1.

leased fish and length-at-tagging of recaptured fish (Fig. 2a–d). No significant differences in lengths were noted for fish from any of the four tagging regions (South Carolina, χ^2 13.05, $0.25<P<0.50$, df 13; Ft. Pierce, χ^2 19.14, $0.25<P<0.50$, df 16; Jupiter, χ^2 18.76; $0.25<P<0.50$, df 16; and Florida Keys, χ^2 8.83, $0.90<P<0.95$, df 17).

Temporal recapture patterns

King mackerel released from the South Carolina region (809 tagged; 46 returned) generally returned to the SAB subarea (N 31) from June through August and from October through November of each recapture year (Fig. 3). Insufficient returns in the other SE U.S. subareas precluded further analysis of the fish released from the South Carolina region.

King mackerel released from the Ft. Pierce region (6416 tagged; 543 returned) were recaptured in all seven subareas; numbers in four subareas were adequate to describe temporal trends (Fig. 4a–d). Peak periods of recapture in the SEFL subarea (*N* 423) occurred from December through March, with a smaller peak from May through July (Fig. 4a). The number of recaptures was highest during the first recapture year, progressively decreasing from year 2 through year 5. Fish recaptured in the FK subarea (*N* 37) from the Ft. Pierce tagging region (Fig. 4b) also showed a strong annual cycle of recapture from winter through early spring, generally following the peak recaptures from SEFL by 1–3 months. A bimodal annual cycle was noted for fish recaptured in the NEG subarea (*N* 29; Fig. 4c); the first cycle occurred during June and July, and another occurred from August through October. In NWG waters (*N* 18), returns of fish tagged in the Ft. Pierce region occurred most frequently from July through August (Fig. 4d).

The regularity of seasonal increases in tag returns from fish released in each of the Ft. Pierce region subareas indicates a predictable movement pattern. Fish move progressively through SEFL and FK waters in the late-winter and early-spring and travel to the northern Gulf of Mexico subareas during warmer spring and summer months. King mackerel then complete the cycle in late-summer and early-fall by returning to their release sites. This pattern of movement may occur over a period of 3–5 years. Whether all fish participate in this movement as part of an annual event is unknown.

Recaptures of fish released in the Jupiter region (2674 fish tagged; 207 returned) were concentrated in the SEFL and FK subareas (Fig. 5a–b). The temporal return pattern from SEFL (*N* 127; Fig. 5a) was not well defined; fish were returned in all months (most during May and June), although not in every year. The lack of a seasonal return pattern may be indicative of a year-round resident population of king mackerel in this subarea. An annual, cyclical trend for returns in the FK (*N* 25) was noted during winter months, with the magnitude of this trend decreasing over a 3-year recapture period (Fig. 5b).

King mackerel released from the Florida Keys region (2594 tagged; 251 returned) were recaptured often enough to allow a description of temporal return patterns in four subareas (Figs. 6a–d). Fish were recaptured in the SEFL subarea (*N* 34) from July through September, as well as from December through March (Fig. 6a). Recaptures in the Keys subarea (*N* 166) suggested an annual trend of returns during February and

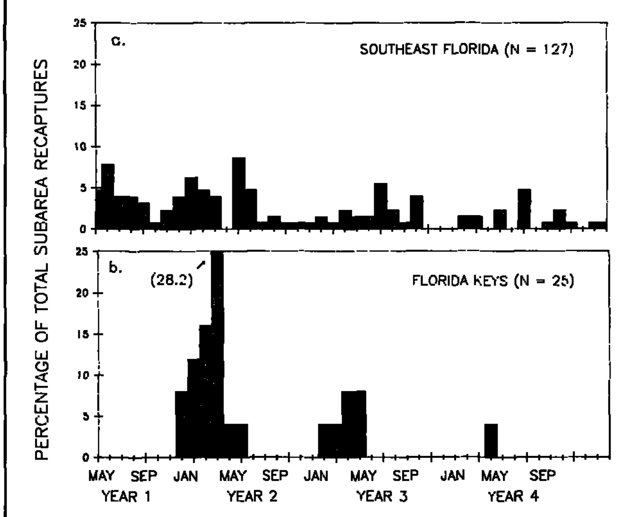

Figure 5

Monthly return percentage of king mackerel released from Jupiter region and recaptured in the (a) southeastern Florida (SEFL) and (b) Florida Keys (FK) subareas, using a continuous time-scale representative of relative time of freedom. Returns begin with May of year 1.

March, with numbers of recaptures steadily declining from Year 1 through Year 4 (Fig. 6b). A bimodal trend similar to that noted for fish released from the Ft. Pierce region (Fig. 4c) was also found for fish released from the Florida Keys region and recaptured in NEG waters (*N* 20; Fig. 6c). King mackerel returns were first reported during May and June from the NEG subarea. An increase in the frequency of tag returns from the NWG subarea (*N* 17) was then noted from June through August (Fig. 6d). King mackerel returned eastward to the NEG during August and September. These observations provide additional support for the possibility that king mackerel move annually through southeastern Florida and Gulf of Mexico waters.

Spatial patterns of movement

King mackerel exhibited different patterns in relative magnitude and directionality as they moved away from their release regions. Of fish recaptured from releases from the South Carolina region, 54.3% (*N* 25) moved more than 100 km. None of these fish were reported farther north (Atlantic-ward) than North Carolina (450 km), whereas 78.6% of those moving Gulf-ward moved at least 650 km to southeastern Florida waters (Fig. 7a). There was no significant difference (χ^2 0.36, $0.50<P<0.75$) in the king mackerels' direction of movement away from the South Carolina region: 44.0% (*N* 11) moved Atlantic-ward and 56.0% (*N* 14) moved Gulf-ward.

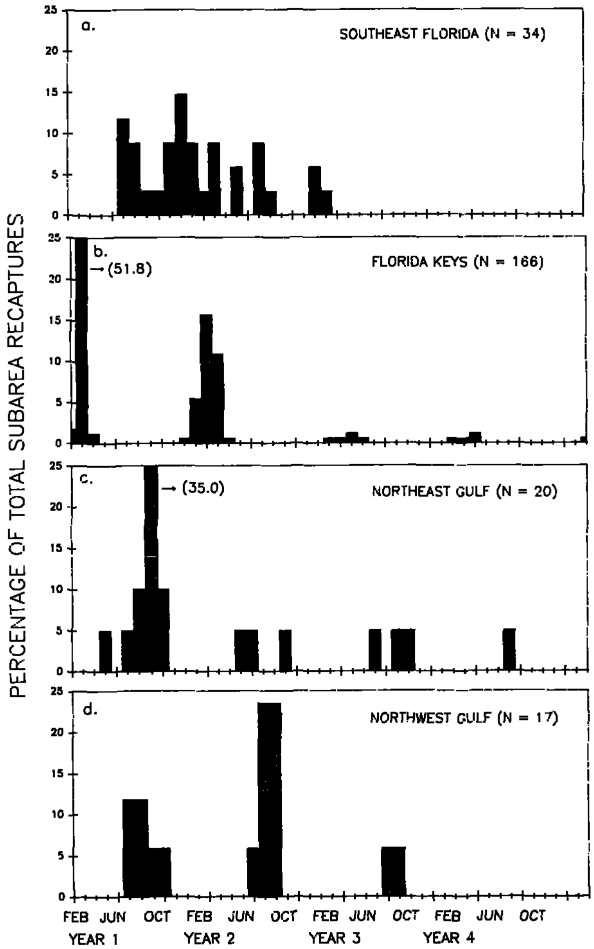

Figure 6

Monthly return percentage of king mackerel released from Florida Keys region and recaptured in the (a) southeastern Florida (SEFL), (b) Florida Keys (FK), (c) northeastern Gulf (NEG), and (d) northwestern Gulf (NWG) subareas, using a continuous time-scale representative of relative time of freedom. Returns begin with February of year 1.

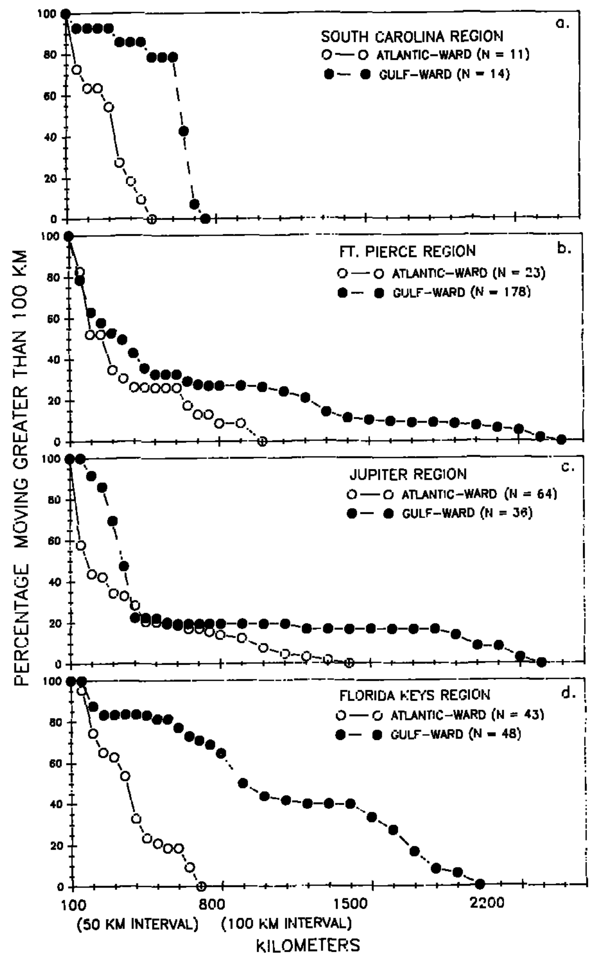

Figure 7

Relative movement of tagged king mackerel away from the four tagging regions of (a) South Carolina, (b) Ft. Pierce, (c) Jupiter, and (d) the Florida Keys, as a percentage of fish moving at least 100 km. The direction component is given by Atlantic-ward or Gulf-ward movement (see text for definitions).

A total of 37.0% (N 201) of the king mackerel recaptured from fish released from the Ft. Pierce region moved more than 100 km, with fish recaptured as far as 1000 km Atlantic-ward off North Carolina (Fig. 7b); fish moving Gulf-ward were recaptured as far away as Texas and Mexico (up to 2400 km). Within 800 km of the release site, the relative magnitude of movement away from the Ft. Pierce release region was similar for king mackerel with Gulf-ward affinity and those with Atlantic-ward affinity; however, a significantly greater number of fish (χ^2 119.53, $P<0.005$) moved Gulf-ward (88.6%; N 178). A similar trend in the relative magnitude of movement was noted for fish released from the Jupiter region; 48.3% (N 100) moved more than 100 km. A significantly higher percentage of these fish (χ^2 7.84, $P<0.01$) moved Atlantic-ward (64.0%; N 64; Fig. 7c). For fish moving more than 100 km (N 91), those tagged in the Florida Keys region moved farther from their release site into Gulf waters than did those fish moving Atlantic-ward (Fig. 7d). However, king mackerel released in the Florida Keys region did not show a significant difference in their relative direction of movement (χ^2 0.27, $0.50<P<0.75$): 47.3% (N 43) moved Atlantic-ward, 52.7% (N 48) moved Gulf-ward.

The number of days-at-large was significantly related to the distance that a fish traveled after release (Y-intercept 130.609, slope 0.072, r 0.122, df 1, 1148, *F* 17.382). Several fish moved remarkable distances over short periods of time. For example, one fish released from Jupiter, Florida, traveled 2250 km in 77 days before being recaptured off the southern Texas coast.

King mackerel stocks in the southeastern United States

The percentages of king mackerel released as either Atlantic or Gulf stock and classified (using the posterior probability of the discriminant function analysis) into the same stock based on time and place of recapture are given in Table 2. The chi-square value for the test of homogeneity of the within-group covariance was significant (χ^2 41.89, df 6); therefore, the within-covariance matrices were used in this analysis. A total of 66.81% of king mackerel released as Atlantic stock was classified as the same stock upon recapture; therefore, this group was given a 66.81% affinity index value (Table 2). A 76.07% affinity index value was found for the Gulf of Mexico king mackerel stock. The percentage of classification for recaptured king mackerel in the five substocks is given in Table 3, again using the within-covariance matrices in the discriminant function (χ^2 245.87, df 24). All fish released in the SE U.S. Atlantic coast substock area were recaptured within the temporal and spatial definition of the Atlantic stock; i.e., they were all classified with either the SE U.S. Atlantic coast or southern Florida summer substocks (Table 3). Therefore, the SE U.S. Atlantic coast substock was given a 100% affinity value for the Atlantic stock. Southern Florida summer substock returns were similarly examined; 4.23% were classified with the SE U.S. Atlantic coast substock, and 53.97% were classified with the southern Florida summer substock, which yielded a 58.20% affinity index value. The combined Gulf substock had a 100% affinity-index value for the Gulf stock based on returns from the Florida Keys winter substock (9.09%) and from the Gulf waters (90.91%). The affinity-index value of the Florida Keys winter substock was 90.00% (Table 3), although some fish released in this area were classified in each of the five substock areas. King mackerel

Table 2
Posterior probability values for membership in either the Gulf or Atlantic stocks of king mackerel. Numbers of recaptured fish in parentheses.

	Percentage classified into stock		
Stock	Atlantic	Gulf	Affinity index
Atlantic	66.81 (151)	33.19 (75)	66.81
Gulf	23.93 (162)	76.07 (515)	76.07

Table 3
Posterior probability values for membership in the five substocks of king mackerel. Numbers of recaptured fish in parentheses.

	Percentage classified into stock					
	Atlantic		Gulf			
Substock	SE U.S. Atlantic coast	South Florida, summer	Southeast Florida, winter	Florida Keys, winter	Gulf combined	Affinity of index
Atlantic						
SE U.S. Atlantic coast	91.89 (34)	8.11 (3)	0.00 (0)	0.00 (0)	0.00 (0)	100.00
South Florida, summer	4.23 (8)	53.97 (102)	10.58 (20)	31.22 (59)	0.00 (0)	58.20
Gulf						
Southeast Florida, winter	5.58 (26)	23.82 (111)	14.81 (69)	55.36 (258)	0.43 (2)	70.60
Florida Keys, winter	2.00 (4)	8.00 (16)	5.50 (11)	80.50 (161)	4.00 (8)	90.00
Gulf combined	0.00 (0)	0.00 (0)	0.00 (0)	9.09 (1)	90.91 (10)	100.00

released as southeastern Florida winter substock were also classified into all substocks, yielding a 70.60% affinity-index value (combined Gulf, 0.43%; Florida Keys winter, 55.36%; and southeastern Florida winter, 14.81%).

Discussion

Two movement patterns were identified from our tagging study. King mackerel released in association with the Gulf of Mexico waters were found during winter months along the Florida Keys and along the southeastern Florida coast as far north as Cape Canaveral. By spring, these fish traveled along the western Florida coast toward northeastern Gulf waters, continuing westward during the summer. These king mackerel returned toward northwestern Florida in late-summer and early-fall, and then headed back to southern Florida waters by winter. Based on the recapture of fish from the same locations during roughly the same times of year over several consecutive years (e.g., Fig. 4a–d), we conclude that a periodic (annual) migratory behavior exists. The regularity of king mackerel movements through Gulf of Mexico waters was also noted during other tagging studies (Sutherland and Fable 1980, Fable 1988).

Trends of the catch-per-unit-effort (CPUE) for king mackerel from charterboat catches, reported by Trent et al. (1987), also support our conclusions. During 1983, 1984, and 1985, CPUE values of king mackerel generally increased along the northern Florida coast during late-May and June, followed by a peak in CPUE along the Alabama, Mississippi, and Texas coastlines. Another increase in CPUE was noted in Alabama during late-July and August, followed by a peak in northwestern Florida during late-August or early-September. Only winter peaks were noted in southern Florida, whereas no CPUE pattern was established for southeastern Florida. The lack of a consistent peak in this region as determined by tag returns from southeastern Florida may be evidence for a resident (i.e., non-migratory) population. Fable et al. (1987) noted winter resident population of large king mackerel (>800 mm FL) in the northwestern Gulf of Mexico. We found no size-component associated with tagged fish either staying or leaving southeastern Florida waters (χ^2 8.19, P>0.975, df 18), based on length-frequency distributions of recaptured fish (50-mm FL interval, 400–1300 mm).

Movement of king mackerel along the Atlantic coast was not as clearly defined. Fish traveled south from South Carolina waters during the spring and summer, distributing themselves along the south Atlantic coast as far as the eastern and southwestern coasts of southern Florida, and then returned northward in late-summer and early-fall. Trent et al. (1987) noted an increase in CPUE from charterboat catches from North Carolina during April and again during October and November. Progressive increases in CPUE were noted in South Carolina during May and later during August and September; peaks were noted in Georgia and northeastern Florida during late-May (after South Carolina peaks) and again during August (before South Carolina peaks).

Spring and summer movements of king mackerel may reflect migrations to their respective spawning areas. After spawning, they return to wintering areas in the fall. Ichthyoplankton collections indicate that king mackerel from the Atlantic coast spawn from April through October, with a peak during September (Collins and Stender 1987). Gulf of Mexico larvae collections and reproduction indices suggest a similar spawning season for the Gulf stock (Wollam 1970, Dwinell and Futch 1973, McEachran et al. 1980, Finucane et al. 1986).

King mackerel movement patterns, as determined from temporal and spatial variability in tag returns, must be viewed in relative and descriptive terms rather than in absolute rates of movement. The percentages of returns varied from 5.69% (South Carolina region) to 9.68% (Florida Keys region), but when numbers of recaptures were compartmentalized by subareas, these values were subsequently reduced. This reduction was magnified as distance from release site increased. Lower percentage of returns may be a function of actual proportion of fish moving away from location of release but may also reflect relative changes in effort and availability over time, or may be indicative of a "dilution" of tagged fish by king mackerel from other locations (e.g., with a resident population in the northwestern Gulf of Mexico). Combinations of these factors, as well as other environmental and biological parameters, are probably interacting, but are beyond the resolution ability of our database. However, we feel the observed trends, together with published information previously discussed, are strong enough to support our conclusions of king mackerel movement through SE U.S. waters.

Distance from the 'transition zone' along the southern Florida coast (Fig. 1, shaded area) was related to the affinity-index values calculated for each substock. Both the South Atlantic and combined Gulf substocks, located outside this transition area, had 100% classification (affinity) values with the appropriate Atlantic or Gulf stock. The Florida Keys winter substock, located in the southwest edge of this transition area, was closely tied to the Gulf stock (90.00% affinity). King mackerel released in southeastern Florida had the lowest affinity values (Table 3). Winter releases from the Ft. Pierce region (southeastern Florida winter substock), which would be included within the scope of the Gulf stock, were mistakenly classified 29.40% of the time with Atlantic stock waters. Most of these misclassifications were temporal in nature, the recaptures having been taken during summer months from southeastern Florida. The low affinity-index value for summer-month releases from Jupiter (southern Florida summer substock) is a result of fish being recaptured within either the Florida Keys winter substock (31.22%) or the southeastern Florida winter substock (10.58%) areas, yielding a total misclassification of 41.80% of Atlantic stock with Gulf stock waters.

Southeastern Florida waters are important to both Atlantic and Gulf stocks. Both stocks occupy this area during some part of the year; the observed seasonal overlap may range from 29.40% to 41.80% (Table 3) based on percent misclassification. The management problems of a mixed-stock fishery system are recognized (Hilborn 1985, Sinclair et al. 1985). For effective management an accurate distinction between stocks is vital (Misra 1985), yet genetic differentiation using electrophoretic variation has not yielded any differences between Gulf and Atlantic stocks of king mackerel (May 1983, Johnson 1988). An alternative management strategy, therefore, may be to designate the area between the Collier/Monroe line on the southwestern Florida coast and the Florida/Georgia line on the Atlantic coast as a mixing zone, to be managed with the most conservative measures available (i.e., Gulf or Atlantic stock) to ensure adequate stock protection.

Acknowledgments

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