Preliminary Analysis of Tag and Recapture Data of the Greater Amberjack, *Seriola dumerili,* in the Southeastern United States

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ABSTRACT

Greater amberjack, *Seriola dumerili,* tag and recapture data are summarized for 1959-1995 from five historic marine tagging programs. 13,856 fish have been tagged during this period and 10.3% (1,456) were recaptured. Recapture averages are 1.9 years at liberty (84% of returns), with a high of 14 years occurring. 48% of all fish showed no net movement. Results indicate that a spring movement of Atlantic Ocean stock occurs from the Carolinas to southeast Florida. There is a 1.3% exchange between Atlantic and Gulf of Mexico fish (1.6% exchange between the Gulf of Mexico to the Atlantic). These movements may be spawning related.

KEY WORDS: Greater amberjack, movement, migration, *Seriola dumerili,* tag and release, stock

INTRODUCTION

Greater amberjack, *Seriola dumerili*, have always been an important by-catch in reef fish fisheries and are now frequently the primary species targeted by recreational and commercial fishermen along the southeast coasts of the United States. They are widely distributed from Virginia to Florida on the U.S. Atlantic coast, from Florida through Texas in the Gulf of Mexico, into the Caribbean, and into waters off Central and South America to Brazil. However, definitive information on the stock structure is not available in the literature. Anecdotal references to the occasional occurrence in a particular region or fishery during certain seasons are available, although accounts of movement patterns have been limited to only a few scientific studies.

As more desirable species became unavailable, commercial landings of this species rose explosively during the 1980s. Landings in the Gulf of Mexico rose from 10,000 pounds in 1962 to a high of 2,858,000 pounds in 1988 and since then have dropped dramatically (McClellan and Cummings, 1996). In the Atlantic Ocean, landings rose from about 6,000 pounds in 1962 to 2,300,000

pounds in 1991 and have since leveled at 1,900,000 pounds per year (Cummings and McClellan, 1996). Prior to this period in the early 1980's, they were considered less desirable because of parasite infestations commonly found in many parts of the flesh (Berry and Burch, 1979). With the Gulf red snapper (*Lutjanus campechanus*) and king mackerel (*Scomberomorus cavalla*) stock crashes in the late 1980s and the "blackened fish" rage and ensuing crash of the red drum (*Sciaenops ocellatus*), greater amberjack became a targeted commercial species. Concern by recreational fishermen in the early 1990s about the notion that the sizes of fish taken commercially had significantly reduced strengthen the need for information about the status of the stocks.

Separate greater amberjack management units, corresponding to the Atlantic Ocean and Gulf of Mexico groups, are now assumed under current management regimes by the South Atlantic Fishery Management Council and Gulf of Mexico Fishery Management Council. The geographic boundary of these management units is defined as the intersection of the outer boundary of the U.S. EEZ and 83 00'W longitude, proceeds north to 24 35° N latitude (Dry Tortugas), east to Marquesas Key, then through the Florida Keys to the mainland. Migration patterns must be evaluated before assumptions regarding stock boundaries are made so that exploitation rates and stock size levels can be accurately determined.

To further the knowledge on movements of greater amberjack along the southeastern U.S., tag and recapture data from historical projects conducted over a 36 year period, 1959 - 1995, were reviewed and analyzed. The major objectives of this study were to:

i) Evaluate movements with respect to temporal patterns in recapture.
ii) Describe patterns in movement with regard to direction.
iii) Quantify the magnitude of interchange between the Gulf of Mexico and Atlantic Ocean, and vice versa.
iv) Hypothesize probable mechanisms affecting movements.

MATERIALS AND METHODS

Tag and recapture data were obtained for greater amberjack from both historic and currently active marine tagging programs. The basic mechanisms and methology for tagging greater amberjack is described by Scott *et al.* (1990). The National Marine Fisheries Service (NMFS), Woods Hole Oceanic Institute (from 1959) and NMFS, Cooperative Gamefish Tagging Program (from 1977) have provided tagging equipment to recreational and commercial fishermen all along the southeast U.S. coasts. The Mote Marine Laboratory Cobia, Amberjack, and Dolphin program (MML CAD) included the greater amberjack in its migration studies, with fish primarily tagged along the southwest Florida

Amberjack, and Dolphin program (MML CAD) included the greater amberjack in its migration studies, with fish primarily tagged along the southwest Florida coast. Greater amberjack have also been tagged extensively along the South Carolina coast by the Marine Gamefish Tagging Program of the South Carolina Department of Natural Resources (SCDNR) since 1991. Returns from the American Littoral Society and the Gulf Coast Conservation Association of Louisiana (LAGCCA) programs were also used in this study.

Data from these programs were grouped into eight subareas to determine patterns in temporal and spatial movements (Figure 1). Subareas were selected for maximum spatial resolution to account for general knowledge of greater amberjack migrations. Several data sets represented specific geographical regions, relative to a tagging site or fishing area, that suggested maintaining these areas separate in the study.

Four subareas were defined for the Atlantic Ocean region. The spawning activity and fishing activity known to occur south of Cape Canaveral, Florida through the Florida Keys suggested the SEFL subarea. NEFL is the area between the Georgia state line and Cape Canaveral, Florida. The waters off Georgia and the Carolinas extending to Cape Hatteras, NC was defined as the SAB area since this was an area of tagging activity by the SCDNR. Known concentrations off Virginia suggested the NCH area.

In the Gulf of Mexico, four subareas were also defined based on the above criteria. Louisiana and Texas became the WG for the area west of the Mississippi River. Directed tagging by fishermen east of the Mississippi to the Florida State line suggested the NEG subarea, and intense fishing off the Panhandle of Florida and the Middle Grounds off Tampa, Florida suggested the NWFL subarea. Tampa to the Dry Tortugas became the SWFL subarea.

Temporal movement was obtained by grouping returns into 12 month year classes, where 0 – 365 days equal year 1 class , 366 – 730 days equal year 2 , etc.. The distribution of recaptures by month and year was computed for each release subarea to evaluate the timing of amberjack returning to a specific subarea.

Spatial movements were evaluated by partitioning the recapture observations by release subarea to allow for long distance movements. Minimum distance traveled was computed for each recapture and all movements were considered to be net movement in a straight line and could not take into account any circular or random movements. Fish were considered to have moved if the distance between release and recapture was greater than one degree or 60 nautical miles.

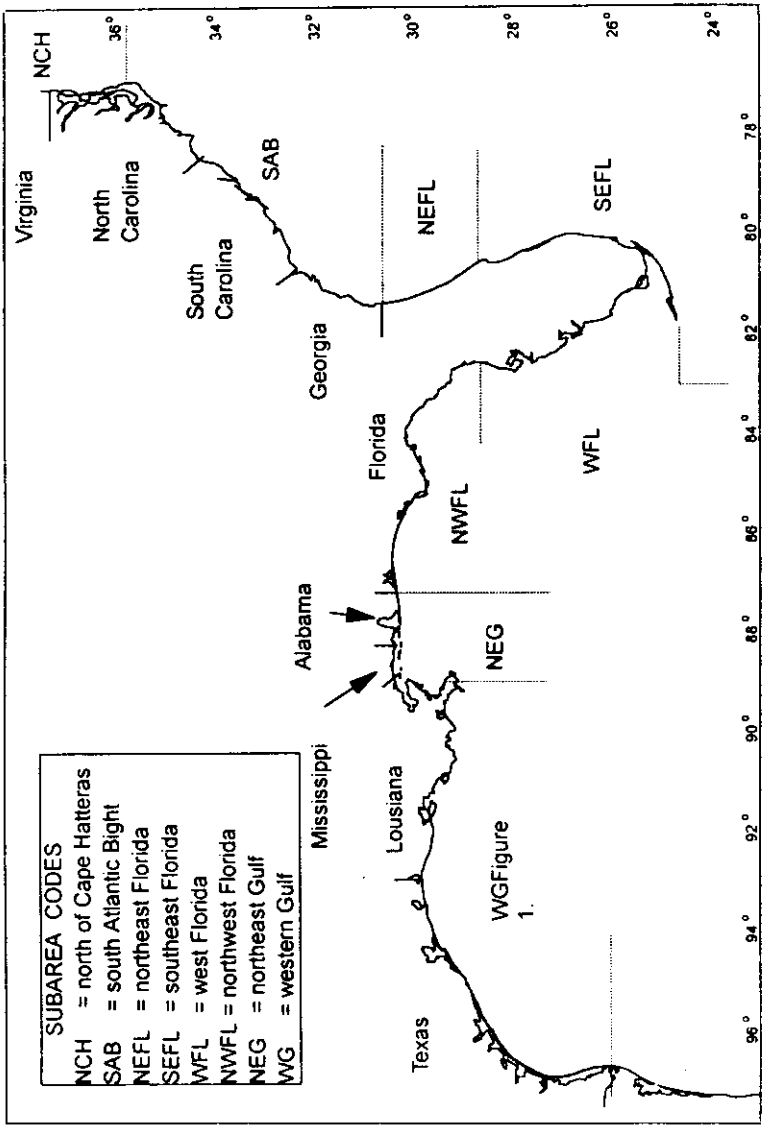

Figure 1. Locations of the subarea boundaries for greater amberjack releases and recaptures in the southeastern United States.

Relative direction of greater amberjack movement was calculated to address movement between subareas by grouping the observations into 90 degree spatial unit blocks according to release and recapture information.

RESULTS

Complete data on the date and location of tagged greater amberjack were reported for 13,792 of 13,856 fish tagged and 1,423 of 1,456 fish recaptured between 1959 and 1995 (Table 1) from the five programs combined. Burch (1979) estimated 82% of the species composition was greater amberjack in the recreational fishery off southeast Florida. Two/thirds of all releases were made in the Atlantic with SEFL contributing 43% of these (Table 2). Spring-summer releases were made in (SAB, NCH, NEFL) the northern subareas of the Atlantic while releases in SEFL were made in Winter-spring. Gulf of Mexico releases were primarily in the summer months. Release times are a function of the fishing pressure at these times (Figure 2).

Tag recapture rates varied by tagging program, release year and area, and were not adjusted for possible biases due to mortality, tag shedding, non-reporting, or fishing effort. The average annual rate of amberjack recaptures ranged from 1% to 29%, return rates by program varied from 1 to 11%, and averaged 10.3% overall (Table 2).

Atlantic Ocean recaptures time at large ranged from 0 to 14 years and were at average 1.9 years. 41% of recaptures were made within 90 days, 69% within one year and 85% within 2 years (Figure 3a). Relative to direction, 48% of the fish recaptured showed zero net movement, 33% within 25 nm (Figure 3b). Low positive correlation existed between distance moved and time at large with mean migration distance increasing during the first 120 days (Figure 4a). Displacement rate averaged 1.25 nm/day for the 462 recaptures showing movement and a negative relationship occurred with the highest with fish at large for a short period of time (Figure 4b). Returns to the different subareas occurred at varying rates, most within three years (Figure 5).

Gulf of Mexico recapture rates averaged 13% annually with a range from 0.6% to 66.7%, and recaptures time at large ranged from 1 to 6 years , 1.2 years on average (Figure 6a). 37% of recaptures were made within 90 days, 84% within one year and 98% within 2 years. Relative to direction, 30% of the fish recaptured showed zero net movement, 58% within 25 nm (Figure 6b)and the maximum movement was 3600 nm. Low positive correlation existed between distance moved and time at large with mean migration distance increasing during the first 120 days (Figure 7a). Displacement rate averaged 3.7 nm/day for the 376 recaptures showing movement and a negative relationship occurred with the highest with fish at large for a short period of time (Figure 7b). As with the Atlantic region, greater amberjack were at large in the different subareas at

varying rates, most within two years (Figure 8).

The magnitude of movement between the two regions, the Atlantic and Gulf of Mexico, was evaluated from the observations of fish released in one region and later recovered outside the original release region (Table 3a,b). Fish released in the Atlantic Ocean generally were recaptured in that region, with about 43.4% of the fish making no net movement, and of those making movement 37.1% were recaptured within 25 nm of the release site. Of the fish making movements, 60.5% of NEFL and 61.3% of SAB fish moved between 100-500 miles. NCH fish traveled more than 500 miles 48.6% of the time implying a movement out of the area. SEFL fish moved between 1 – 25 miles 51% of the time, suggesting a resident population.

Directional movement of greater amberjack released in the Atlantic were analysed (Figure 9a). Those released in NCH and SAB showed a more south to westerly movement component. Since fish released from the NCH subarea made more extensive movements than the other Atlantic subareas and most of the returns were from south of the NCH, they possibly were making southerly migrations. Movement was predominantly to the south and east for fish released in the NEFL and east for those from SEFL.

Greater amberjack released in the Gulf of Mexico had less variable movements than those from the Atlantic. Of those showing movement, 90.6% were recaptured between 1 – 100 miles from the release point (Table 3b). Of the fish showing movement from all areas, the majority moved less than 100 miles. Most WFL subarea fishes showed an east to north component while those from the other areas showed random movement (Figure 9b).

Discriminant analysis based on time at liberty and location and month of recapture shows the percentage of amberjack released as either Atlantic Ocean or Gulf of Mexico fish and classified into the same management unit using time at liberty and location and month of recapture. 99% of Atlantic fish were therefore classified as Atlantic at recapture and 96.8% of Gulf of Mexico released fish were classified as Gulf of Mexico at recapture (Table 4a). The analyses were further extended to separate subareas (Table 4b). These show that NCH fish were classified as Atlantic management unit 100% of the time, with SAB 98%, NEFL 98% and SEFL 99%. In the Gulf of Mexico, the WG subarea was classified at 100%, with WFL 82.7%, NWFL 97.2%, and NEFL 92.8% as part of the Gulf of Mexico management unit.

Spatial patterns in greater amberjack movements that could be considered to have major impact (Table 5a-c) included:

i) 11 recaptures from the Atlantic to Gulf of Mexico movement (1.3%).
ii) 8 recaptures from Atlantic to Caribbean (1%).
iii) 2 recaptures from Atlantic to Bahamas (1%).

iv) 9 recaptures from Gulf of Mexico to Atlantic (1.6%).

DISCUSSION

The ability to successfully tag greater amberjack was demonstrated by reasonably high recapture rates, 10.3%, over the 36 year period. This study corrobated temporal and spatial patterns of movement reported previously (Burch, 1979; Sutherland and Scott, 1989; Burns and Neidig, 1992; Davy, 1994). Greater amberjack are recaptured within a relatively short period of 90 days, 41 and 31 percent of recaptures, for Atlantic Ocean and Gulf of Mexico, respectively. The time period is more variable for the Atlantic (1 – 4 years) than the Gulf of Mexico (1 – 6 years). Whether the differences in recapture rates is because of fishing pressure, tagging effort, reporting rates, tag loss, natural mortality, or other factors, is unknown.

This study showed the variability in temporal movement is in part related to the area of release. Greater amberjack released in the NCH subarea were reported recaptured during the fall there but also in the spring in the SEFL. Releases in the SAB also showed up in the spring in the SEFL. These support the hypothesis of a southerly migration down the Atlantic east coast and a subsequent northerly migration. Because of large concentrations spawning annually off SEFL in the spring, this migration may be spawning related. A resident stock of amberjack off the east coast of Florida is suggested because of the lack of movement of fish tagged in SEFL and NEFL, and has also been suggested by previous investigators.

Most greater amberjack made limited movements, with about 64.4% for the Atlantic Ocean and 54.0% for the Gulf of Mexico of all recaptures made within 25 nm of the release site. Distance moved and time at large had low positive correlation. Fish from the Gulf of Mexico were at liberty for shorter time periods, and recaptures were closer to tagging sites than the Atlantic Ocean, which suggests Atlantic fish participate in longer migrations. In the Atlantic, 72.9% of all fish were recaptured within 100 miles, while 92.7% of GOM fish traveled less than 100 miles.

Directionally, Atlantic Ocean fish moved predominantly in a south/southwest direction and Gulf of Mexico fish showed no trend. Some fish in the WFL subarea showed a tendency to migrate into the SEFL. The two recaptures from NEFL to the Bahamas suggest movement across the Gulf Stream. Movement between the two regions is rare, but does occur 1.3% of the time from Atlantic to Gulf of Mexico and 1.6% vice versa. Movement of fish from the Atlantic to the Caribbean was reported seven times over the 36 years.

Table 1. Summary of greater amberjack releases, recaptures, and percentage recapture for individua tagging programs used in this study, 1959 - 1995. Programs are coded as follows: ALS = American Littoral Society; LAGCCA = Gulf Coast Conservation Society Lousiana; MML (CAD) = Mote Marine Laboratory (Cobia, Amberjack, and Dolphin Program); NMFS (CGFTP) = National Marine Fisherie Service (Cooperative Game Fish Tagging Program); SCDNR (MGFTP) = South Carolina Department of Natural Resources (Marine Gamefish Tagging Program).

PROGRAM (# YEARS)	*RELEASES*	*RECAPTS.*	*%*
ALS (9)	390	4	1.0
LAGCCA (6)	37	2	5.4
MML (5)	1033	112	10.8
NMFS (36)	11698	1270	10.9
SCDNR (19)	634	35	5.5
COMBINED (36)	13792	1423	10.3

Table 2. Summary of greater amberjack releases, recaptures, and percentage recapture by subarea of release between 1959 and 1995 for the Atlantic Ocean region, Gulf of Mexico region, and Other regions. Codes for subareas are as follows: NCH = north of Cape Hatteras; SAB = south Atlantic Bight; NEFL = northeast Florida; SEFL = southeast Florida; WFL = west Florida; NWFL = northwest Florida; NEG = northeast Gulf; and WG = western Gulf.

	Released	Recaptured	Percent
Atlantic Ocean			
NCH	1767	87	4.9%
SAB	1599	50	3.1%
NEFL	1914	123	6.4%
SEFL	3908	568	14.5%
TOTAL	9188	828	9.0%
Gulf of Mexico			
WFL	770	66	8.6%
NWFL	2913	422	14.5%
NEG	468	56	12.0%
WG	194	25	12.9%
TOTAL	4345	569	13.1%
Other Regions			
Bahamas	174	13	7.5%
Other	56	3	5.4%
Unknown	29	10	34.5%
Total	259	26	10.0%
All Combined			
Total	13792	1423	10.3%

Table 3. Magnitude of transfer between subareas for greater amberjack as a percentage of the recapture subarea total. Values are the number of returns for fish at large for five years or less.

a.

RECAPTURE SUBAREA: ATLANTIC OCEAN REGION										
RELEASE SUBAREA	NCH		SAB		NEFL		SEFL		TOTAL	
	N	Percent	N	Percent	N	Percent	N	Percent	N	Percent
NCH	46	55.4%	1	1.2%	2	2.4%	31	37.3%	80	96.4%
SAB			21	37.5%	6	10.7%	21	37.5%	48	85.7%
NEFL	1	0.9%	2	1.8%	62	54.4%	39	34.2%	104	91.2%
SEFL			6	1.1%	24	4.2%	525	92.9%	555	98.2%
WFL							5	7.7%	5	7.7%
NWFL	1	0.2%			1	0.2%	1	0.2%	3	0.7%
NEG							1	1.9%	1	1.9%
WG										
BAHAMAS										
CARIBBEAN					1	33.3%			1	33.3%
UNKNOWN										
TOTAL	48	3.4%	30	2.1%	96	6.8%	623	44.2%	797	56.5%

b.

GULF OF MEXICO REGION										
RELEASE SUBAREA	WFL		NWFL		NEG		WG		TOTAL	
	N	Percent	N	Percent	N	Percent	N	Percent	N	Percent
NCH	1	1.2%	1	1.2%					2	2.4%
SAB							1	1.8%	1	1.8%
NEFL			2	1.8%					2	1.8%
SEFL	3	0.5%	2	0.4%			1	0.2%	6	1.1%
WFL	53	81.5%	3	4.6%	1	1.5%	1	1.5%	58	89.2%
NWFL	1	0.2%	398	94.8%	14	3.3%	2	0.5%	415	98.8%
NEG			12	22.2%	41	75.9%			53	98.1%
WG			1	4.0%			24	96.0%	25	100.0%
BAHAMAS										
CARIBBEAN					1	33.3%			1	33.3%
UNKNOWN			6	50.0%					6	50.0%
TOTAL	58	4.1%	425	30.1%	57	4.0%	29	2.1%	569	40.4%

c.

OTHER REGIONS								
RELEASE SUBAREA	BAHAMAS		CARIBBEAN		UNKNOWN		TOTAL		TOTAL
	N	Percent	N	Percent	N	Percent	N	Percent	N
NCH					1	1.2%	1	1.2%	83
SAB			1	1.8%	6	10.7%	7	12.5%	56
NEFL	2	1.8%	5	4.4%	1	0.9%	8	7.0%	114
SEFL			2	0.4%	2	0.4%	4	0.7%	565
WFL					2	3.1%	2	3.1%	65
NWFL					2	0.5%	2	0.5%	420
NEG									54
WG									25
BAHAMAS	13	100.0%					13	100.0%	13
CARIBBEAN			1	33.3%			1	33.3%	3
UNKNOWN					6	50.0%	6	50.0%	12
TOTAL	15	1.1%	9	0.6%	20	1.4%	44	3.1%	1410

Table 4. Posterior probability values for membership in the a.) Atlantic Ocean or Gulf of Mexico region or b.) subarea management units of greater amberjack based on a measure of generalized square distance. Number of recaptures are in parenthesis.

a.

RELEASE REGION	RELEASE REGION: Atlantic Ocean	RELEASE REGION: Gulf of Mexico	Affinity Value
Atlantic Ocean	99.1 (816)	0.9 (7)	99.1
Gulf of Mexico	3.2 (16)	96.8 (482)	96.8
Total	832	489	1321

b.

RELEASE SUBAREA	Atlantic Ocean Region: NCH	SAB	NEFL	SEFL	Gulf of Mexico Region: WFL	NWFL	NEG	WG	Affinity Value
Atlantic Ocean									
NCH	90.7 (78)	5.8 (5)	3.5 (3)						100.0
SAB	10.0 (5)	38.0 (19)	48.0 (24)	2.0 (1)			2.0 (1)		98.0
NEFL	2.5 (3)	12.3 (15)	54.9 (67)	28.7 (35)		1.6 (2)			98.4
SEFL	0.4 (2)	3.2 (18)	5.0 (28)	90.8 (513)	0.5 (3)	0.2 (1)			99.3
Gulf of Mexico									
WFL		3.4 (1)		13.8 (4)	79.3 (23)	3.4 (1)			82.7
NWFL		1.8 (7)	1.0 (4)			69.7 (271)	27.5 (107)		97.2
NEG		5.4 (30	1.8 (1)			10.7 (6)	82.1 (46)		92.8
WG						4.2 (1)	12.5 (3)	83.3 (20)	100.0
Total	88	68	127	553	26	282	157	20	1321

Table 5. Greater amberjack tag returns indicating movement between the Atlantic Ocean and Gulf of Mexico regions and movement between the U.S. And other countries are included. Codes for subareas are as follows: NCH = north of Cape Hatteras; SAB = south Atlantic Bight; NEFL = northeast Florida; SEFL = southeast Florida; WFL = west Florida; NWFL -= northwest Florida; NEG = northeast Gulf and WG = western Gulf.

a.

RELEASE SUBAREA	ATLANTIC OCEAN REGION									
	NCH		SAB		NEFL		SEFL		TOTAL	
NCH	46	58.4%	1	1.2%	2	2.4%	31	37.5%	80	96.4%
SAB			21	37.5%	6	10.7%	21	37.5%	48	85.7%
NEFL	1	0.9%	2	1.8%	62	54.4%	39	34.2%	104	91.2%
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b.

RELEASE SUBAREA	GULF OF MEXICO REGION									
	WFL		NWFL		NEG		WG		TOTAL	
NCH	1	1.2%	1	1.2%					2	2.4%
SAB							1	1.8%	1	1.8%
NEFL			2	1.8%					2	1.8%
SEFL	3	0.5%	2	0.4%			1	0.2%	6	1.1%
WFL	53	81.5%	3	4.6%	1	1.5%	1	1.5%	58	89.2%
NWFL	1	0.2%	398	94.6%	14	3.3%	2	0.5%	415	98.8%
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RELEASE SUBAREA	OTHER REGIONS								TOTAL
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NCH					1	1.2%	1	1.2%	83
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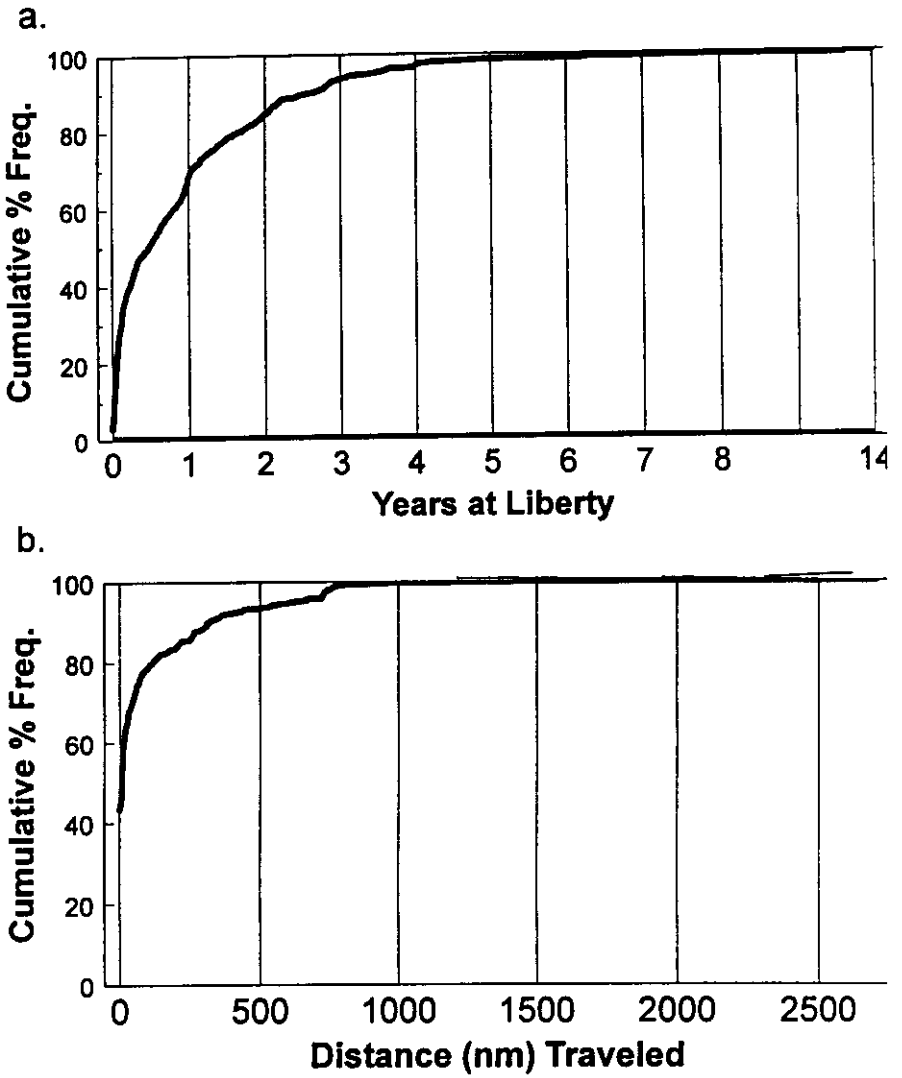

Figure 2. Atlantic Ocean recaptures as a cumulative percentage of total number of recaptures for greater amberjack released from the Atlantic Ocean for a). the time at large from the day of release and b.) the straight- line distance traveled from the point of release. Not all recaptures were used in the analyses because of incomplete data.

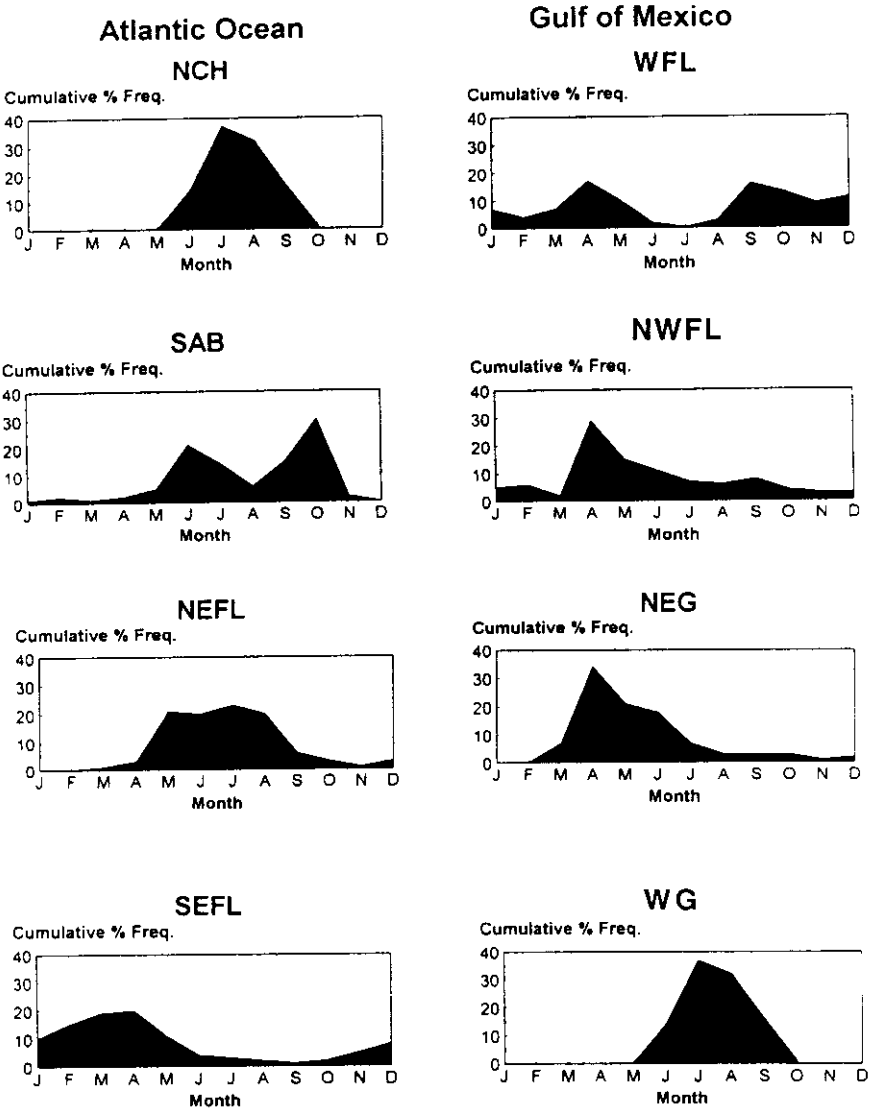

Figure 3. Patterns of fishing effort reflected by release percentages by subareas in Atlantic Ocean and Gulf of Mexico regions. All releases are combined by month for all years by release subareas.

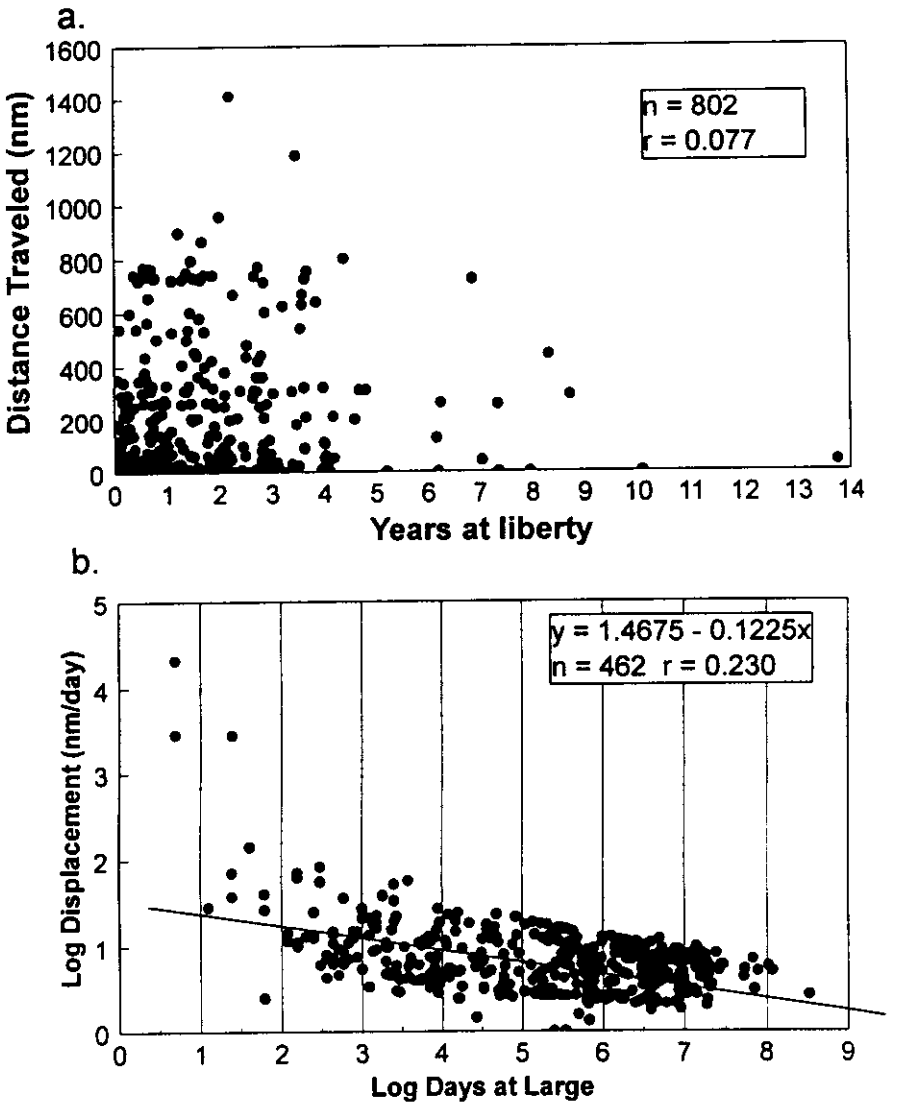

Figure 4. Greater amberjack relationships in the Atlantic Ocean region showing (a) the correlation between distance moved and years at liberty, and (b) the relationship between the log displacement rate (nautical miles per day) and log days at liberty. Not all recaptures were used in the analyses because of incomplete data.

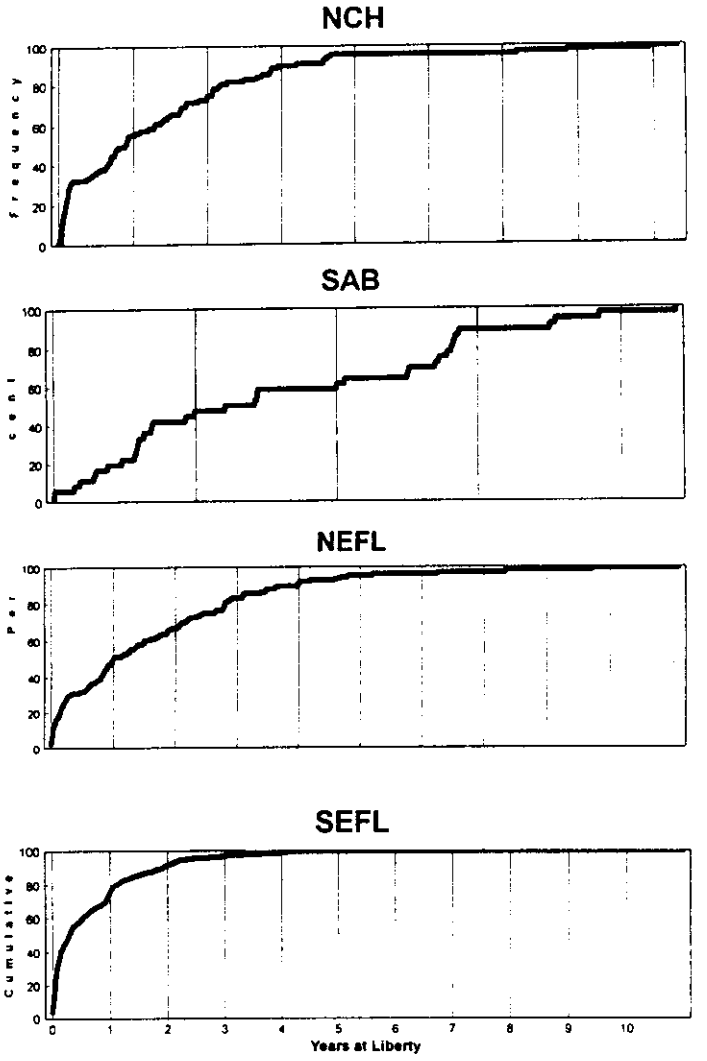

Figure 5. Time at liberty for greater amberjack released in the Atlantic Ocean region for each release subarea of (a) north of Cape Hatteras (NCH), (b) south Atlantic Bight (SAB), (c) northeast Florida (NEFL), and (d) southeast Florida (SEFL), as cumulative percentage of total number of recaptures.

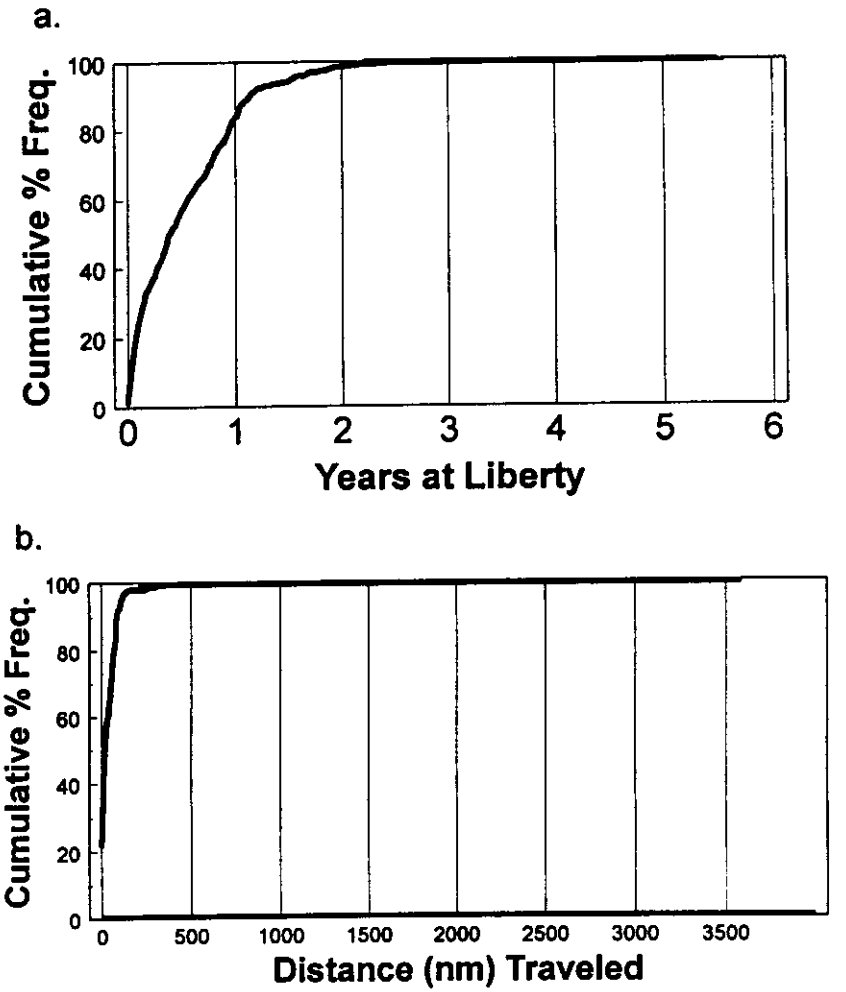

Figure 6. Gulf of Mexico recaptures as a cumulative percentage of total number of recaptures for greater amberjack released from the Gulf of Mexico for a.) the time at large from the day of release and b). the straight- line distance traveled from the point of release. Not all recaptures were used in the analyses because of incomplete data.

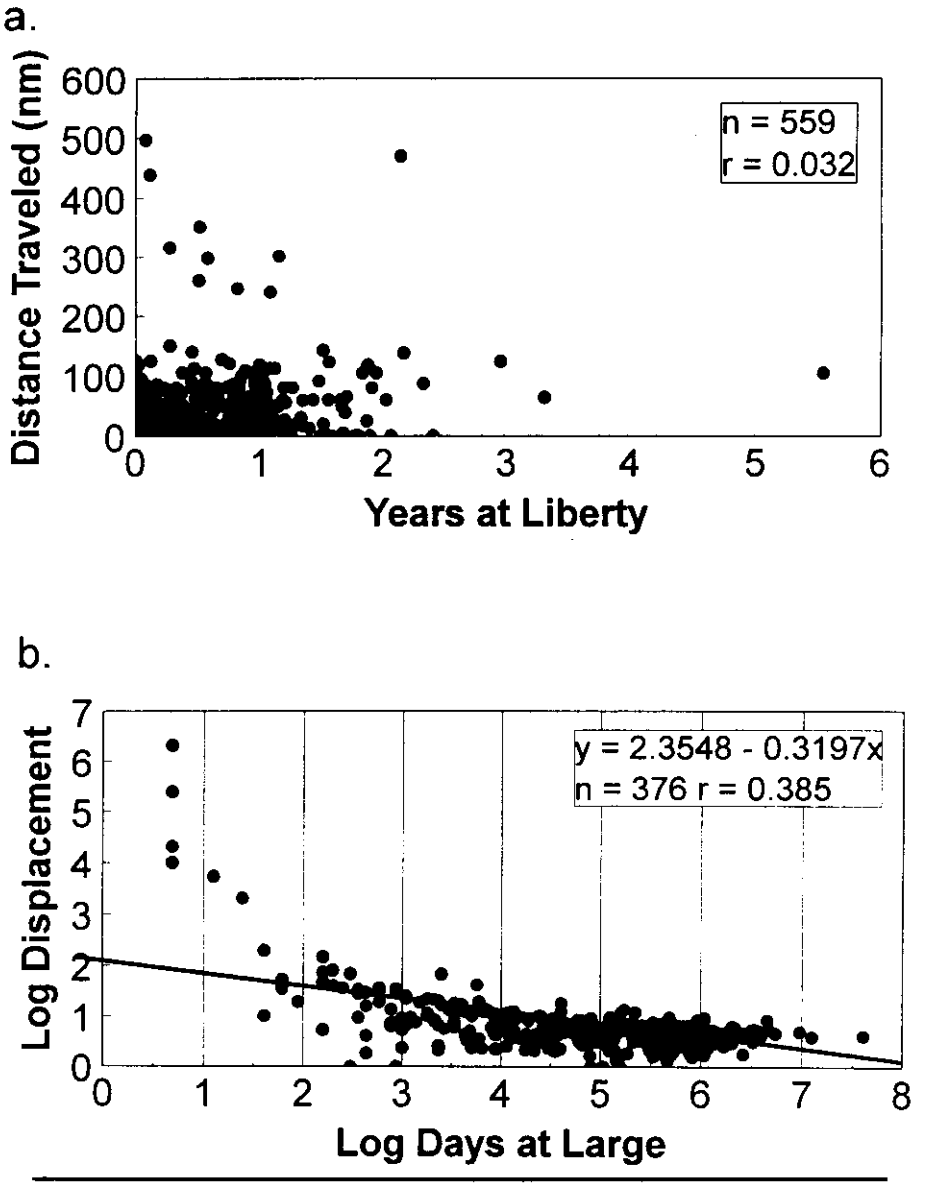

Figure 7. Greater amberjack relationships in the Gulf of Mexico region showing (a) the correlation between distance moved and years at liberty, and (b) the relationship between the log displacement rate (nautical miles per day) and log days at liberty. Not all recaptures were used in the analyses because of incomplete data.

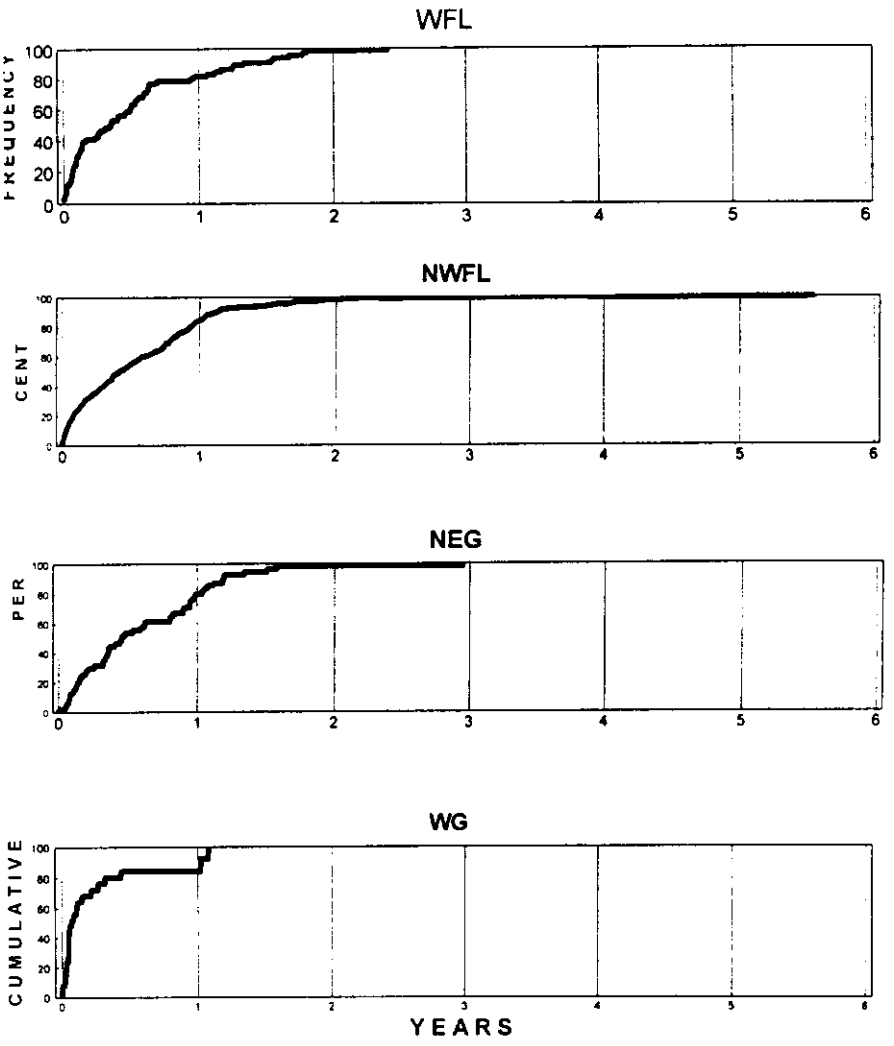

Figure 8. Time at liberty for greater amberjack released in the Gulf of Mexico region for each release subarea of (a) west Florida (WFL), (b) northwest Florida (NWFL), (c) northeast Gulf (NEG), and (d) western Gulf (WG), as cumulative percentage of total number of recaptures. Not all recaptures were used in the analyses because of incomplete data.

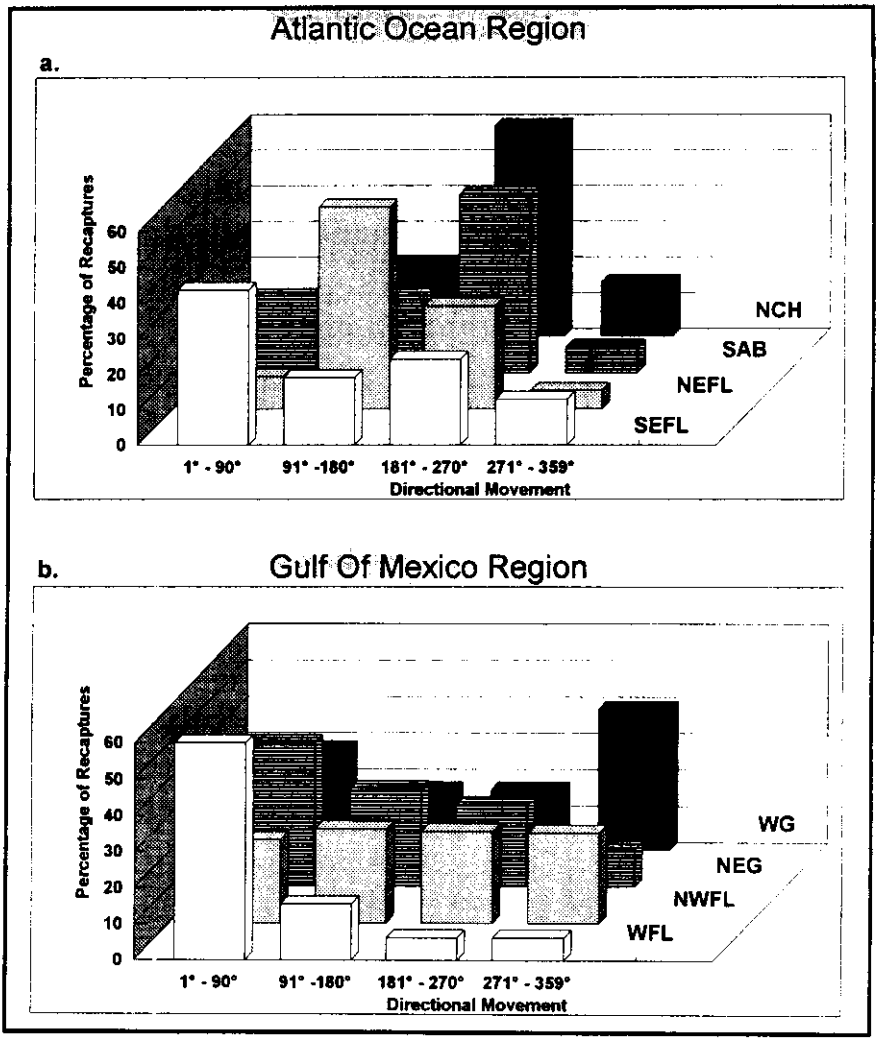

Figure 9. Relative directional movements of greater amberjack as: a.) Atlantic Ocean, and b.) Gulf of Mexico regions.

LITERATURE CITED

Berry, F. H. and R. K. Burch. 1979. Aspects of the amberjack fisheries. *Proc. Gulf Carib. Fish. Inst.* **31**:179-194.

Burch R. K. 1979. The greater Amberjack, *Seriola dumerili:* Its biology and fishery off southeastern Florida. M.S. Thesis. University of Miami, Coral Gables, Florida. 112 p.

Burns, K. and C. Neidig. 1992. Cobia, amberjack, and dolphin migration and life history study off the southwest coast of Florida. Final MARFIN Rept. to Contract No. NA90AA-H- MF747, Mote Marine Laboratory Tech. Rep. No. 267, 58 p., IV Appendices. Unpubl. Ms.

Cummings, N. J. and D. B. McClellan. 1996. Stock assessment of Gulf of Mexico greater amberjack through 1995. U.S. Dept. of Comm., NOAA, NMFS, SEFSC, Miami Lab. Contr. No. MIA-96/97-04. 60 p.

Davy, K.B. 1994. South Carolina marine game fish tagging program 1974 – 1992. Office of Fish. Manag., Marine Res. Div., South Carolina Dept. Nat. Resc., Charleston, S. C. 29422. 134 p. Unpubl. Ms.

McClellan, D.B. and N.J. Cummings. 1996. Stock assessment of Gulf of Mexico greater amberjack through 1995. U.S. Dept. of Comm., NOAA, NMFS, SEFSC, Miami Lab. Contr. No. MIA-96/97-03. 69 p.

Scott, E.L., E.D. Prince, and C.D. Goodyear. 1990. History of the cooperative gamefish tagging program in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea, 1954 – 1987. *Am. Fish. Soc. Symposium* **7**:841 - 853.

Sutherland, D. L. and E. L. Scott. 1989. Examination of amberjack tagging data for the southeastern United States. U.S. Dept. of Comm., NOAA, NMFS, SEFSC, Miami Laboratory, CRD-88/89-18. 34 p.