Northeast Gulf Science

Volume 2
Number 1 *Number 1*

Article 1

6-1978

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DOI: 10.18785/negs.0201.01

Northeast Gulf Science Vol. 2, No. 1, p. 1-23 June 1978

BIOLOGY AND ECOLOGY OF THE ATLANTIC STINGRAY, *DASYATIS SABINA* (PISCES: DASYATIDAE), IN NORTH CAROLINA AND GEORGIA

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ABSTRACT: The seasonality, distribution, ecology, movements, catch per unit effort, breeding season, and length-weight relationships for the Atlantic stingray, *Dasyatis sabina,* trawled in North Carolina (1973 through 1976) and Georgia (1967 through 1969) are compared and discussed. Occurrences in relation to water temperature, salinity, and oxygen content are also reported and compared with previous literature. Dispelling popular belief, *D. sabina* throughout its range is a minor numerical component of the fish faunas studied.

Dasyatis sabina (Lesueur), the Atlantic stingray, ranges from Chesapeake Bay to Mexico (Bigelow and Schroeder, 1953; Parker, 1972; Sainz, 1976). Records of its possible range including Surinam and Brazil are undoubtedly based on *Dasyatis guttata* (Bloch and Schneider) (Boeseman, 1948). *D. sabina* is generally believed most plentiful in coastal waters of Florida and the northern Gulf of Mexico (Bigelow and Schroeder, 1953) and in the Atlantic is often encountered from North Carolina to Georgia (Anderson, 1968; Dahlberg, 1975). It is known to penetrate freshwater as far as 322 km up the Mississippi River (Gunter, 1938a) but usually occurs in brackish estuarine or oceanic shallows of less than 2 m (de Sylva, 1974). Sage *et al.* (1972) documented a growth and seasonal distribution study of some 300 specimens from Texas, while Funicelli (1975) reviewed the food, morphometrics, and distribution of *D. sabina* in Mississippi Sound and the offshore waters of the north central Gulf of Mexico. We have determined seasonality, distribution, ecology, movements, catch per unit effort, breeding season, and length-weight relationships for Atlantic stingrays trawled in North Carolina, 1973 through 1976, and Georgia, 1967 through 1969.

STUDY AREAS

North Carolina: *D. sabina* was trawled at 22 stations with 7.6 m (2035 tows) and 12.2 m (3089 tows) otter trawls in the lower 40.3 km of the Cape Fear River estuary, Masonboro Sound at Carolina Beach Inlet, and the adjacent Atlantic Ocean off the Cape Fear River from February 1973 through November 1976 (Fig. 1). Sampled habitats varied in depth from one to 12.2 m and were subject to wide daily tidal fluctuations of ±2m. Cape Fear River and adjacent inshore ocean waters were colored tea to coffee brown throughout most of the year. Occasionally highly saline "green" offshore waters were found at the oceanic stations and were common at Carolina

Beach Inlet (CBI) stations on flood tides. On ebb tides, Carolina Beach Inlet waters were brown from the nearby sounds or Cape Fear River water, the latter carried there via Snows Cut (Fig. 1). CBI station substrates were mostly sand with some oyster bars located peripherally to the 2.5 m deep Intracoastal Waterway. Cape Fear River deep channel station (10.5 - 12.5 m) substrates were of mud, clay, and were interspersed with large dead trees (often of 3 m diameter), and other types of debris. River shoal stations were muddier on the west side and sandier on the east side. Substrates at the Carolina Power and Light Company power plant intake canal (dug in 1972) stations were of silty-mud. Spoil bank islands dotted the length of both sides of the river channel. Sizeable stands of *Juncus* marsh occurred only on the west side of the river near the intake canal or near the mouth of the Cape Fear River (Fig. 1). River currents ranged seasonally between 0.51 - 3.09 m/sec. It is difficult to categorize the Cape Fear River in terms of reaches, as used by Dahlberg (1972) for Georgia habitats, as most river stations from Snows Cut south to the mouth (Fig. 1) varied seasonally from 0-28 ppt salinity. Salinities of 0-20 ppt were encountered, in 1976, for several weeks at the uppermost river stations at Buoy 42. These were the result of spring or sporadic summer heavy rain runoff or possibly the prolonged summer drought experienced throughout the eastern seaboard of the United States in 1976. Salinities at CBI usually varied between 15 and 34 ppt, although strong ebb tides from the Cape Fear would lower these to 6 ppt. River and nearby ocean water temperatures ranged seasonally 8-30°C.

Georgia: Atlantic stingrays were trawled at 14 stations with 6 m wide otter trawls in the middle and lower 19 km estuarine reaches of Sapelo and St. Catherines Sounds from January 1967 to December 1969 (Fig. 2), as described by Dahlberg (1972, 1975) and Sikora *et al.* (1972). Georgia habitats ranged in depth from 5.8-14.3 m and were subject to tidal fluctuations of 1.4-3.2 m (Ragotzkie and Bryson, 1955). Water color was tan to dark brown (Dahlberg, 1972). River currents varied, depending on season and tide, between 0.51-1.54 m/sec. Designation of upper, middle, and lower reaches within each sound was based on salinity ranges given by Carriker (1967) as middle 18-25 ppt and lower 25-30 ppt. Mean middle reach salinities ranged 19.2-22.5 ppt (station 10-13) while lower reach stations (1-9, 14) ranged 27.9-28.9 ppt. Following heavy rains, salinities at the uppermost station (11) dropped to 9.2 ppt in January 1970 and 4.8 ppt in April 1971. Water temperatures varied seasonally between 8-31°C (Dahlberg, 1972). *Spartina alterniflora* was the dominant salt marsh plant (Fig. 2) throughout the study area (Dahlberg, 1975).

METHODS

Trawl tows at each North Carolina river station were of 15 min duration; ocean station tows were of 30 min duration. All North Carolina live specimens were measured (pectoral fin width (mm)), weighed (g), sexed, checked for breeding state, and released after being tagged through the snout with 12mm Peterson disk tags to obtain seasonal and coastal migration data. The preserved Georgia specimens, captured during 15 min tows, were measured, weighed, sexed, breeding state noted, and examined for embryos. In North Carolina, water tem-

DOI: 10.18785/negs.0201.01

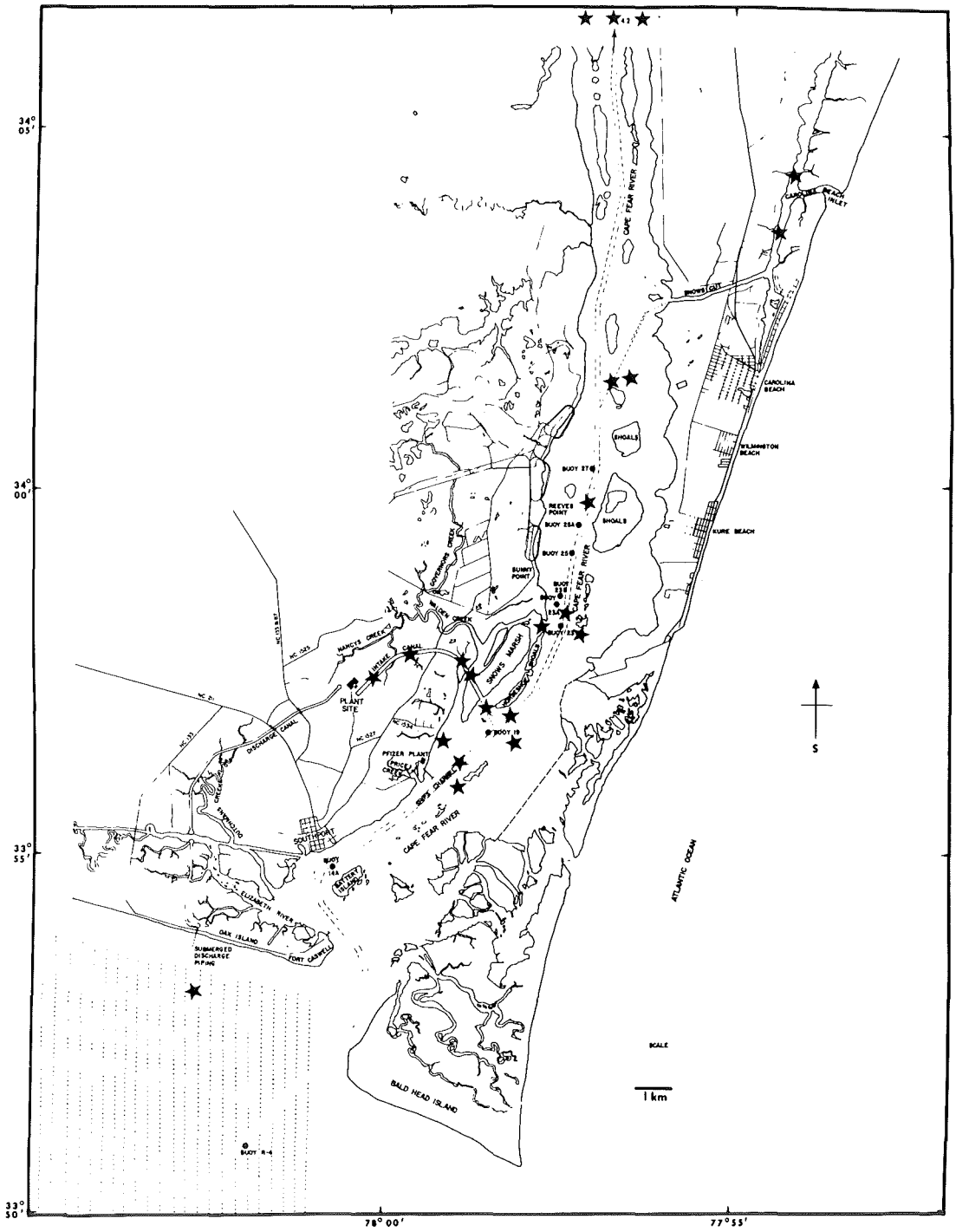

Figure 1. Sample sites in the lower Cape Fear River, Carolina Beach Inlet, and adjacent Atlantic Ocean areas, North Carolina.

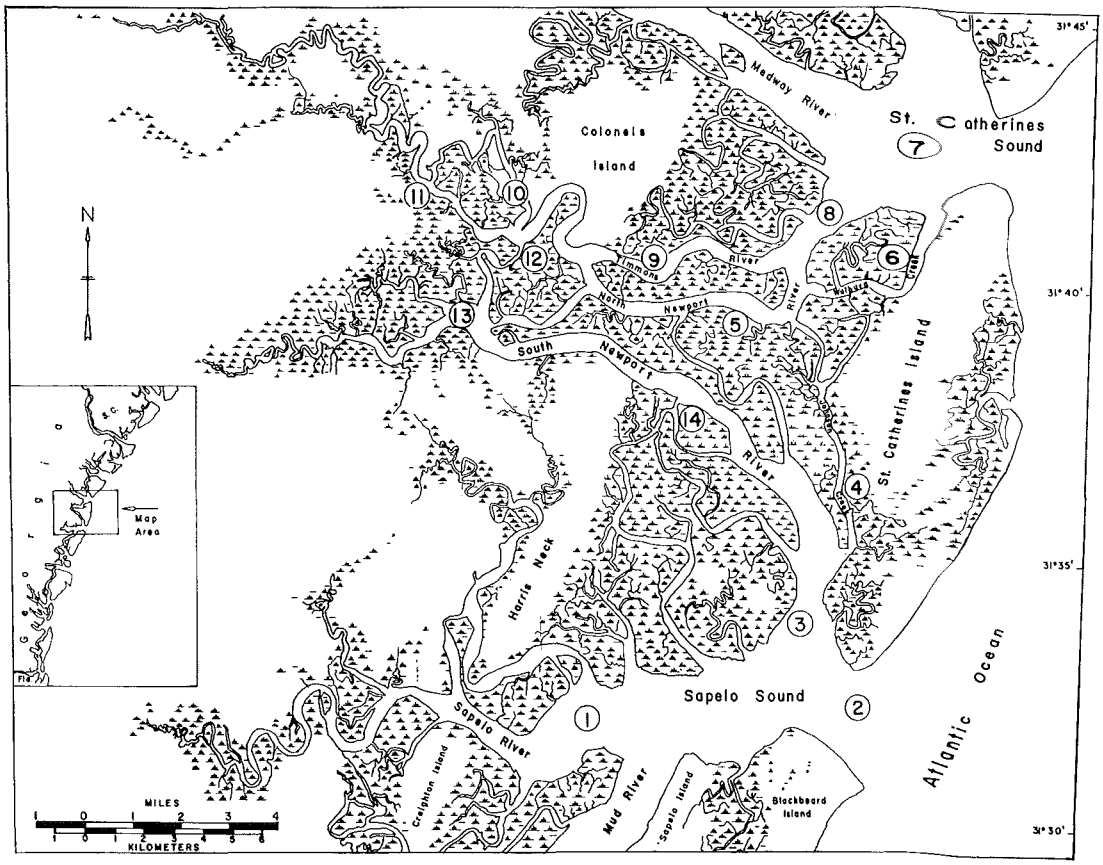

Figure 2. Georgia study area illustrating sampling stations and extent of salt marsh.

peratures and dissolved oxygen values were obtained with Taylor mercury field thermometers and a portable Yellow Springs Instrument Model 57 temperature-oxygen unit. Salinities were recorded with an American/Optical refractometer. Georgia water temperatures and salinities were recorded with a portable Beckman RS5-3 Induction Salinometer. Dissolved oxygen was determined with a YSI Model 41. Length-weight curves for male and female *D. sabina,* from each area, were generated using the formulae $\log w = a + b \log L$ and $w = cL^n$. Catch per unit effort (CPUE) was defined as the catch of *D. sabina* per 15 min tow. We realize and caution interpretations made comparing catches obtained during 15 and 30 min trawl tows until gear efficiences have been resolved (Schwartz and Howland, 1978).

SEASONAL DISTRIBUTION

The movement of Atlantic stingrays into bays or estuaries during warmer months has been described by Bigelow and Schroeder (1953), Gunter (1945), and Sage *et al.* (1972). While sizeable numbers of stingrays seem, at times, to move into Gulf or Texas waters (Sage *et al.*, 1972; Gunter, 1938b, 1945), monthly catch data for the southern Atlantic of the United States and an estuary near Brunswick, Georgia during 1931-35 by Anderson (1968) surprisingly failed to show occurrence variation which could be attributed to seasonal move-

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ments. Bigelow and Schroeder (1953) noted that nearly year round residence of *D. sabina* occurred in inshore waters of the southern Atlantic states. They likewise suggested that movement offshore or southward from North or South Carolinian waters occurred when water temperatures chilled below 16°C in November and inshore movement prevailed when temperatures rose above 16°C in April. Movement north to off Chesapeake Bay was apparently limited by water temperatures, which did not warm until July or August (Bigelow and Schroeder, 1953). DeSylva (1974) believed that movement into deeper waters occurred during the late fall. Funicelli (1975) simply stated movement south and offshore of Mississippi Sound occurred during winter months. Sage *et al.* (1972) noted fall movements offshore into the Gulf of Mexico was water temperatures cooled following cold northerly winds. Gunter (1945) noted a similar exodus to Gulf waters off Texas during early fall and winter when November to February water temperatures were 10.6-14.9°C. In his study, no *D. sabina* were caught in waters cooler than 13.7°C or above 30.5°C.

No published data were found which recorded the oxygen content of the waters frequented by *D. sabina.* Few researchers have captured *D. sabina* during the extremes of winter. Funicelli (1975) recorded *D. sabina* in Mississippi Sound and offshore northern Gulf of Mexico waters of 10.5-22.1 and 16.7-23.9°C respectively. Hoese (1973) captured only four *D. sabina*, all during winter sampling in ocean stations off Georgia. Gunter (1938b) noted several stingrays captured in Louisiana during the winter months of 1933. He (1945), likewise, noted concentrations of 13-46 cm (disk length) specimens at Aransas Bay in November to February 1941-42. Reid (1954) found a 35 cm (total length) specimen in Florida (December) in waters of 10°C and 24.8 ppt salinity, while capture of a 45 cm TL specimen occurred in water of 16.5°C and 26.8 ppt in January. Reid also noted *D. sabina* frequenting the "flats" in Florida in February. Anderson (1968) reported monthly winter catches in Georgia estuaries and offshore waters.

In relation to water temperatures, Shealy *et al.* (1974), in South Carolina, found *D. sabina* in waters of 17.1-27.5°C. Tagatz (1967) noted *D. sabina* in the St. John's River, Florida in water 8.8-32.8°C. Reid (1954) recorded a range for Florida waters inhabited by *D. sabina* of 7.2 - 32.3°C. Gunter and Hall (1965) found *D. sabina* in 14-29°C waters of Charlotte Harbor, Florida. Burger (1972) noted specimens from Charlotte Harbor, in the laboratory, tolerated 12°C, but failed to state for what period of time. Dunham (1972) and Juneau (1975) noted *D. sabina* in Louisiana waters of 9.8-28 °C and 29.4-29.9 °C, rarely below 10°C, while Miller (1965) found them in 12.8-14.7°C waters.

Gunter (1938a, 1956) reported the euryhaline *D. sabina* far up river in the freshwaters of the Mississippi River in Louisiana. Shealy *et al.* (1974) and Bearden (1965) found *D. sabina* in South Carolina waters where salinities ranged 0.2-28.9 and 1.2-33 ppt respectively. Dahlberg (1972) mentioned Georgia captures at 25-31.3 ppt salinities. Tagatz (1967) found *D. sabina* in the St. John's River, Florida waters of 0-25.8 ppt. Gunter and Hall (1963) call attention to several Atlantic stingrays being captured in 0.2-0.3 ppt waters of the St. Lucie Canal, Florida. Funicelli (1975) recorded specimens in Mississippi Sound waters where bottom salinities ranged

0.6-31.6 ppt. Dunham (1972) noted Louisiana *D. sabina* frequenting waters of 7.1-29.8 ppt while Juneau (1975) found them in 0.3-2.0 ppt. Gunter (1945) found *D. sabina* in other Texas waters of 2.2-36.7 ppt, but they were rare in waters above 30 ppt salinity. Simmons (1957) noted their occurrence in Laguna Madre waters of up to 45 ppt, but that they generally preferred waters of less than 30 ppt salinity.

North Carolina: Of 419 *D. sabina* captured during 1973-1976 most occurred at ocean and lower Cape Fear River stations of 18E and 19 (Table 1). Station 18E was a 0.5-3.7 m deep, gradually shoaling sandy-silt slough on the lower east side of the river and possessed a porous Castle Hayne rock formation substrate near its junction with the main river. Buoy 19 channel station had a mud-clay substrate.

The number of *D. sabina* captured increased during the 1973-1976 study period (Table 1). This stemmed, in part, from the slow adjustment of the river to the generally lower salinities of 1973 caused as an aftermath of Hurricane Agnes in 1972 and the drought conditions which culminated in 1976. The latter decreased river runoff such that higher salinities were recorded further up river than usual, i.e. stations at Buoy 42 possessed salinities of 7-20 ppt for several weeks in the fall of 1976.

Seasonally *D. sabina* were most common during the warm months of May to September (Table 2). Note that water temperatures as low as 11.0°C were frequented during early winter and spring samples (Table 3), conditions lower than that noted by Burger (1972) or Bigelow and Schroeder (1953). Likewise, only one *D. sabina* was captured when water temperatures exceeded 29°C (Table 3). The smallest male *D. sabina* (115 mm DW) (disk width) occurred in waters of 21°C while the largest male, 460 mm DW, was trawled from water only 13°C; other intermediate sizes were found in waters as warm as 29°C (Table 3). In general small Cape Fear *D. sabina* frequented warm waters while larger specimens were caught in much colder waters (Table 3).

North Carolina *D. sabina* were usually captured in waters of high salinity (Table 4); large adults occurred in waters of a much wider and lower range of salinities than did young *D. sabina* (Table 4). *D. sabina* were captured in waters with 2.6 to 13.0 mg/1 oxygen (Table 5); however, most males and females were captured in waters of 4-9.9 mg/1 oxygen.

Georgia: Two hundred *D. sabina* were collected in the waters of Sapelo and St. Catherines Sounds (Table 6) by trawl (166), angling (22), and as 12 aborted young. Most captures occurred during spring and summer months (Table 7). The relatively high catches in the lower reach stations during October and November of 1967 and 1969 appeared to represent fall seaward movements (Table 14). Since *D. sabina* feed primarily on invertebrates and some fishes (de Sylva, 1974; Funicelli, 1975; Gunter, 1945), this food preference could explain its summer occurrence over the soft substrates of the middle reach habitats as lower reach habitats possessed substrates where sand and shell predominated, with soft substrates occurring primarily in intertidal "mud flats".

Movement into the sounds was apparent during the spring (March-May) of the three consecutive sample years (Tables 7 and 14). *D. sabina* apparently left the area during the late fall of each year, as only four, all males, were captured during December and

DOI: 10.18785/negs.0201.01

TABLE 1. Effort (by type trawl)* and numbers of 412 male and female *D. sabina* captured, by station, during 1973-1976 in North Carolina Cape Fear River and adjacent study areas.

Station	YEAR															
	1973				1974**				1975**				1976			
	M	F	E		M	F	E		M	F	E		M	F	E	
			ST	LT			ST	LT			ST	LT			ST	LT
Ocean	2		2	249	14	7	9	231	9	12		332	11	12		269
18E	3		30	33	6	5	15	54	6	18	9	73	19	11	5	74
18	1		4	69	2	2	3	48	7	4		74	8	6		82
18W	1	1	52		1	1	58	1	1	3	74			2	70	
Canal Screens							2	1		1	40	1	1	1	67	
Canal 1st Bend							7	4	3	2	20	58		5	6	69
Canal 2nd Bend											5	8	5	5	19	22
Canal Mouth							2	1			9	42	4	2	31	53
19E			52	9	3		62	2	3	5	76	1	36	15	70	
19		1	2	65	1	3	4	51	9	3	1	78	3	4		82
19W		2	54		1	2	57	20	1	3	73	11	2	4	70	3
23E	1	2	55	2		4	64	1	1	2	76		6	8	75	
23		1	2	66	2	2	3	49		5	1	66	3			75
23W		1	50		2	1	63		1	1	74		10	3	73	
27			1	25			1	49	3	2	1	64	3	2		65
174			1	25			3	49	2	3	1	68	2		2	63
Snows Cut		1	30			5	69		1	2	78				77	
42E	NS	NS			NS	NS			NS	NS					33	
42	NS	NS			NS	NS			NS	NS			5	3		24
42W	NS	NS			NS	NS			NS	NS					34	
CBI			9	27			15	36			2					
CBI North							1	6		3	14	55	1	1	23	62
CBI South							2	7	2	1	16	61	7	2	24	62
TOTAL	8	9	344	570	32	32	440	610	49	70	570	992	126	86	679	1005

NS = No Samples

*ST = Small 7.6 m semiballoon otter trawl; LT = Large 12.2 m semiballoon otter trawl.

**Seven damaged (5, 1974; 2, 1975) specimens not included.

January. Water temperatures, which were seasonally well above those noted by Bigelow and Schroeder (1953), could have influenced any inshore-offshore movements. Likewise, temperature, salinity, and oxygen data, while not recorded for all specimens, provided useful ecological information to help explain the seasonal occurrences of *D. sabina* in Georgia waters.

Most *D. sabina* were caught in Georgia waters where temperatures ranged from 10.8-31.7°C. Young (106-139 mm DW) usually frequented waters warmer than 25°C (Table 8). *D. sabina* greater than 140 mm DW were found in waters of 25-35°C (Table 8).

Waters of 9.9-33.1 ppt salinity were inhabited by *D. sabina,* with young specimens occurring more often in higher salinity waters, even though the occurrence of all sizes was similar for males and females (Table 9). Note that newborn *D. sabina* were found mostly in the lower reaches in high salinity waters (Table 9) in July-August (Table 7).

Dissolved oxygen values ranged 3.2

TABLE 2. Disk width size (mm) frequencies of 412* male and female *Dasyatis sabina* trawled, regardless of trawl size, in the Cape Fear River, Carolina Beach Inlet, and adjacent ocean areas of North Carolina 1973-1976.

Disc Width (mm)	Month																			
	F		M		A		M		J		J		A		S		O		N	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
100-119									1	1				1						
120-139															3	2			1	
140-159			2		3					1					15	13	5	2		
160-179	2		1	1	8	5	4	6				2		1	12	14	5	7	3	
180-199	1	2	3	2			6	9		3		2	1		4	7	1	2	1	
200-219	2		3	2	3	2	5	5	2			2	1		1	4	8	3	1	1
220-239		1		1	1	5	5	6		1	5	3		3	4	2	4	2	1	2
240-259			1	1	3	3	5	3		1	3				3	1	11	2	1	1
260-279			1	1	4	2	2	1	1		1				1	2	6	3	1	
280-299			1	1		1	2				2		1		2			1		2
300-319				1	4	2	1	1			4	1			1	1	4	1	4	1
320-339					3						2				1		2		2	1
340-359			1	2		1	1	3	1						1	2				
360-379						1		2			1					1				
380-399				2		3		1			2									
400-419				4		3														
420-439								1								3		1		
440-459				1				1												
460-479																			1	
480-499				2																
TOTAL	5	3	13	21	29	28	31	39	4	7	20	10	3	5	48	52	46	24	16	8

*Seven damaged specimens not included.

to 9 mg/1 and most males and females were captured in waters of 5-7 mg/1 oxygen (Table . 10). Young Georgia *D. sabina* unlike North Carolina specimens, were encountered more often in slightly lower oxygen waters (4-6 mg/1), while adults occurred in a wider range of conditions.

MOVEMENTS

North Carolina: Tag returns for 23 of the 419 *D. sabina* tagged during the four-year study (5.5% recapture rate) indicated a southerly movement along the coast to at least Myrtle Beach, South Carolina between October and December, with definite inter-river movement during other months (Table 11). More males than females occurred in the returns (Table 11) even though nearly equal numbers of each sex were tagged (see totals for each sex, Table 2). Note that one recapture was at nearby Myrtle Beach, South Carolina, 5 December, 1973, indicating that perhaps all do not move appreciable distances to the south during the winter. Longest at liberty before recapture was about 8.5 months. Several were recaptured at or near their original tag site after a winter in the ocean (Table 11).

CATCH PER UNIT EFFORT

While the literature was replete with statements that *D. sabina* was common, abundant, or the most common stingray in an area (Dahlberg, 1975; Bearden, 1965; Jordan and Gilbert, 1883a, 1883b;

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TABLE 3. Water temperatures when 412 male and female *D. sabina* were captured 1973-1976 in Cape Fear River and adjacent area of North Carolina.*

Disc Width (mm)		Temperature (°C)																			
		10-14				15-19				20-24				25-29				30-35			
		73	74	75	76	73	74	75	76	73	74	75	76	73	74	75	76	73	74	75	76
100-119	M												1								
	F																2				
120-139	M										2						2				
	F																2				
140-159	M							1	1	1	3	3	3	3	2	4	4				
	F											2	3	1	1	4	4				1
160-179	M			3		1	1		5		3	6	6		2	5	3				
	F			1	1	2	1	1	3	2	2	4	4	1		9	7				
180-199	M				2				1			3	7				4				
	F			1	2		1		1		3	2	3			7	6				
200-219	M		3		1				6	1	1	2	7		1	3	2				
	F			1			2		4		2	2	2	1		2	3				
220-239	M						1		2	1	1		5		2	2	6				
	F			1				3	3		2	2	7		3	2	3				
240-259	M						1		8		3	4	3	1	1	2	4				
	F						2				3	1	1	1	2		2				
260-279	M			2	1			1	7				2		1	1	2				
	F			1					2			3	1		1		1				
280-299	M			1			1						2		1	1	2				
	F								3				2								
300-319	M				1			1	3			2	6				5				
	F			1				1	1		1		3				1				
320-339	M				1		2	1	1		1	1					2				
	F															1					
340-359	M											1	1				2				
	F			1			1		1			1	2	1		1	1				
360-379	M																				
	F			1								2			1		1				
380-399	M																2				
	F			1			1	2	2												
400-419	M																				
	F			3			1	2								1					
420-439	M																				
	F						1	2					1		1						
440-459	M																				
	F			1									1		1						
460-479	M				1																
	F																				
480-490	M																				
	F			2																	

		1973		1974		1975		1976	
		DW	°C	DW	°C	DW	°C	DW	°C
MALE	A Smallest at temperature	150	21	130	23	142	28	115	21
	B Lowest temperature and size	170	18	200	14	167	12	335	11
	C Largest at temperature	245	27	338	17	340	23	460	13
	D Highest temperature and size	152	28	229	28	288	29	186	29
FEMALE	A Smallest at temperature	120	28	150	28	150	26	102	29
	B Lowest temperature and size	161	18	178	16	300	11	195	12
	C Largest at temperature	350	26	450	26	490	12	446	24
	D Highest temperature and size	150	29	250	28	150	30	102	29

DW = Disk Width
*7 damaged not included.

TABLE 4. Salinities (ppt) when 412 male and female *D. sabina* were captured 1973-1976 in Cape Fear River and adjacent areas of North Carolina*.

Disc Width (mm)		Salinity (ppt) 5-9				10-14				15-19				20-24				25-29				30-35			
		73	74	75	76	73	74	75	76	73	74	75	76	73	74	75	76	73	74	75	76	73	74	75	76
100-119	M												1												
	F																				2				
120-129	M																		1		2		1		
	F																	1			1				
140-159	M										1	1	1	1	3	4		1	1	4	4	2	2		
	F										1			1	4	1				4	4			1	
160-179	M				1		1	3			2		5			6	6			5	3	1	3		
	F		1					1	1			1	3		1	4	4	3		10	7	1	2		1
180-199	M			1					2				1			2	7				3				1
	F							1	2				1		2	2	3		1	3	9				
200-219	M								1				6		2	2	7		2	1	2	1	2		
	F		1					1			1		4			2	2	1		3	3				
220-239	M					2				1			2			1	5	1	1		4		2	1	
	F							1				3	3		2	1	7			2	4		2		
240-259	M												8		1	4	3	1		2	5		3		
	F					1							2		1	1	1	1			2		2		
260-279	M						2		1			1	6				2			1	3		1		
	F					1	1						4			3	1								
280-299	M						1				1				1		2				2				
	F												2				2								
300-319	M								1			1	2			2	6				6				
	F						1					1	1				3		1		1				
320-339	M								1			1	5			1					1		1		
	F																		1						
340-359	M								1								1				2				
	F						1			1	1		2			1	2			1					
360-379	M																				1				
	F		1				1									2									
380-399	M																				2				
	F					1	1					2	2												
400-419	M																								
	F				1			3				2								1					
420-439	M																								
	F		1				1					3													
440-459	M																								
	F										1														1
460-479	M																				1				
	F																								
480-499	M																								
	F							1																1	

			1973		1974		1975		1976	
			DW	ppt	DW	ppt	DW	ppt	DW	ppt
MALE	A	Smallest at salinity	150	32	130	33	142	25	115	18
	B	Lowest salinity & size	152	21	220	10	183	9	165	7
	C	Largest at salinity	245	25	338	32	340	22	460	14
	D	Highest salinity & size	150	32	170	34	222	34	180	33
FEMALE	A	Smallest at salinity	120	26	150	19	150	22	102	28
	B	Lowest salinity & size	150	20	420	5	390	0	409	5
	C	Largest at salinity	350	17	450	10	490	31	446	18
	D	Highest salinity & size	161	31	250	34	440	35	175	35

DW = Disk Width

*7 damaged specimens not included.

McFarland, 1963; Reid, 1954), catch per unit effort trawl data seemed to contradict these generalizations. We realize that avoidance of various sampling gear may influence the observations and conclusions reached by others. Note that throughout its range the CPUE's summarized in Table 12 were low, even in the light of some sizable trawl efforts by Wang and Raney (1971) and Livingston (pers. comm.) in Florida and Perret *et al.* (1971) in Louisiana. The relatively high CPUE of Anderson (1968) resulted from one-hour tows with 22.9 m wide trawls.

North Carolina: The overall CPUE,

DOI: 10.18785/negs.0201.01

TABLE 5. Oxygen values (mg/1) for waters in which 412 male and female *D. sabina* were trawled in Cape Fear River and adjacent areas, North Carolina, 1973-1976 combined.*

Disc Width (mm)	Oxygen (mg/1)											
	2-3.9		4-5.9		6-7.9		8-9.9		10-11.9		12-13.5	
	M	F	M	F	M	F	M	F	M	F	M	F
100-119					1	2						
120-139			1		2	2	1					
140-159	2		7	2	11	14	3	2	2	1		
160-179		1	7	10	15	16	7	7	4	2	1	
180-199			2	7	9	14	5	3	1	1		1
200-219			2	3	15	22	7	4	1	1	1	
220-239	1		3	3	12	12	3	9	1	1		1
240-259	1		6	2	14	4	4	3	1	1		1
260-279			1	4	11	4	6					1
280-299			1		4	2	1	1	2			1
300-319			5	2	7	5	6	1				1
320-339			4		3	1	2		1			
340-359			2		1	6	1	2				
360-379			1			2		1		1		
380-399			2			3		1				2
400-419				1		1		3		1		1
420-439				1		3						1
440-459				1								1
460-479					1							
480-499				2								

		mg/1	DW	
MALE	Lowest O_2	2.6	225	16 Oct 73
	Largest	8.2	460	10 Nov 76
	Smallest	7.0	115	21 Jun 76
FEMALE	Highest O_2	13.0	318	12 Nov 74
	Largest	5.2	490	18 Mar 75
	Smallest	6.2	102	16 Aug 76

DW = Disk Width

*7 damaged specimens not included.

after 5210 tows between 1973 and 1976, yielding only 419 *D. sabina,* was 0.080 (Table 13). In terms of CPUE/sample year, increasing the sampling effort increased the numbers captured as the CPUE increased from 0.019 in 1973 to 0.126 in 1976. This increase was more likely a reflection of either more *D. sabina* in northern waters or the Cape Fear area recovery, following the hurricane of 1972, to levels more suitable for their existence. Adjusting the CPUE to make a rough comparison of this study's findings to those elsewhere (Table 12), the CPUE with the small trawl was 0.047 and for

TABLE 6. Distribution, by station, of 166 male, female and other* *D. sabina* trawled during 1967-1969 in Georgia estuaries. Lower reaches are stations 1-9 and 14 and middle reaches are stations 10-13.

Station	1967			1968			1969		
	M	O	F	M	O	F	M	O	F
1				1					
2	1	1		2		4	1	2	
3									
4		2	3	2		6	1		2
5	4		3	1		3	3		5
6	2	3	3	2		2			
7	2		1	2		1	5		4
8	1		1			2			
9	1	1		3	1	2	2		
10	1	2		2		1			3
11	9	1	13	5		3			3
12	1			3		5			
13	4	1	1	2		5			
14	2	1		3	1		3		3
TOTAL	28	12	25	28	2	34	15	2	20

* Sex was not recorded.

the larger trawl 0.034.

Georgia: Of the 200 *D. sabina* captured, 166 were taken in 485 trawls, CPUE = 0.342. In terms of middle and lower reach captures, more Atlantic stingrays were captured in the middle reach area than the higher saline and more exposed lower reach habitats (Table 14). Comparatively (Table 12), the adjusted Georgia CPUE of 0.246 was one of the highest recorded.

BREEDING SEASON

A spring to fall breeding season was suggested for *D. sabina* off Texas by Gunter (1945), although he (1938b) collected adults with milt in Barataria Bay, Louisiana on 4 and 16 February 1933. Dense aggregations in Texas inshore waters and of the Gulf of Mexico during February and March were thought to be breeding populations by Sage *et al.* (1972). Bigelow and Schroeder (1953) thought that young were born at "all times of the year except winter". Murray and Christmas (1968) noted gravid females dropping their young in Mississippi Sound during the summer. Funicelli (1975) found the smallest gravid female in Mississippi Sound was 218 mm while offshore specimens with well developed gonads measured 206 mm DW. Males were mature at 190 mm DW. In Charlotte Harbor, Florida, embryos appeared to increase in wing width from 35 mm on 19 June to 100 mm on 11 July 1940. Body widths of gravid females were 235-286 mm, and smallest disk length of a gravid female was 222 mm (Breder and Krumholz, 1941). Mature embryos were observed in June and July by Sage *et al.* (1972) and Joseph and Yerger (1956). One Louisiana specimen gave birth to three young on 5 June 1932 (Gunter, 1938b). Breder and

DOI: 10.18785/negs.0201.01

TABLE 7. Disk width size (mm) frequencies of 200 male, female, other*, and aborted *Dasyatis sabina* in a Georgia estuary, 1967-1969. Young aborted on deck in brackets and angled specimens in parentheses.

	MONTH																												
Disk Width	J	F			M			A			M			J		J			A			S		O		N			D
(mm)	M	M	O	F	M	O	F	M	O	F	M	O	F	M	F	M	O	F	M	O	F	M	F	M	F	M	O	F	M
88- 99																[4]		[1]											
100-119																		[2]	3[3]		3[2]								
120-139	1		2																1		3	1							
140-159		1	1		3		3					1	1																
160-179			1				1			1					1		1		3	1	1			1					
180-199					1			1			(1)			1					2		4			1	3				
200-219						1				2	2		2(1)	1		1	1		3			1		1	2			1	
220-239					2		2	2		2	4	1	6			4(1)	1		4	1	1			1	1	2			1
240-259							1	(2)			4(1)		1	1					5		3		1	4	3		1	2	1
260-279	1			1	1		1	(3)			1		1(1)					2(3)	1		4			3	2				
280-299							1								1	(1)		2			2				2	1			
300-319										(2)			1					(1)			3(1)								
320-339				1			1			(2)		1									1				1				
340-359																		(1)		(1)									
Adults Trawled	2	1	4	2	7	1	10	3	2**	5	11	3	12	3	2	5	3	4	22	2	25	2	1	11	14	2	1	4	2
Young Aborted																4		3	3		2								
Angling Catch								5		4	2					2		5		1	1								

Adults Trawled: 166 Young Aborted: 12 Angling Catch: 22 TOTAL: 200

* Sex not determined.

** Not Measured.

TABLE 8. Water temperatures (°C) when 103 male and female *D. sabina* were trawled in Georgia estuaries during March 1967-August 1969.

Disc Width (mm)	Temperature (°C)									
	10-14		15-19		20-24		25-29		30-35	
	M	F	M	F	M	F	M	F	M	F
100-119								2	2	
120-139							2	2		
140-159	1		2	3		1				
160-179	1			1		1	2	2	1	
180-199			1		1	1	2	2	2	
200-219					1	4	4		1	
220-239			2	2	4	5	6	1	3	
240-259				1	1		7	2		1
260-279		1	2	1		2	1	6	1	
280-299				1		1		4		
300-319								2		2
320-339				1						1
TOTAL	2	1	7	10	7	15	24	23	10	4

TABLE 9. Salinities (ppt) when 103 male and female *D. sabina* were trawled in Georgia estuaries during March 1967-August 1969.

Disc Width (mm)	Temperature (°C)									
	10-14		15-19		20-24		25-29		30-34	
	M	F	M	F	M	F	M	F	M	F
100-119								2	2	
120-139						1			2	1
140-159							2	3	1	1
160-179					1	1	2	2	1	1
180-199						1	3	2	1	2
200-219					2	2	3	2	1	
220-239	4		1	1	1	2	7	6		1
240-259		1		1	4	1	3	1	1	
260-279	1	2		1		2	2	4		2
280-299		1		1		3		1		
300-319				1		2		1		
320-339						1		1		
TOTAL	5	4	1	5	8	16	22	25	9	8

Krumholz (1941) noted delivery of young at about 100 mm DW while Funicelli (1975) considered *D. sabina* of 117-148 mm DW young of the year. The true breeding season has yet to be determined (although gonad material is presently being studied histologically by T. Lewis of Florida State University).

Viscous mucus in the cloacal grooves of elasmobranchs is considered a good

DOI: 10.18785/negs.0201.01

TABLE 10. Dissolved oxygen values (mg/1) when 67 male and female *D. sabina* were trawled in Georgia estuaries August 1967-August 1969.

Disc Width (mm)	Oxygen (mg/1)							
	2-3.9		4-5.9		6-7.9		8-9.9	
	M	F	M	F	M	F	M	F
100-119				2	1			
120-139			1	1				
140-159				1	3	3		
160-179			1	2	2	2		
180-199			2	1	1	1		
200-219			3	2	1	1		
220-239			6	4	2	1		1
240-259			3	2	2	1		
260-279		1	1	2	1	3		
280-299				1		1		1
300-319				2				
320-339						1		
TOTAL		1	17	20	13	14		2

MALE	Lowest O_2	4.1 mg/1	248 mm DW	30 May 1968
	Largest	5.7	268	16 Aug 1967
	Smallest	6.4	115	4 Aug 1969
FEMALE	Lowest O_2	3.7	260	7 Sep 1967
	Largest	6.8	335	25 Mar 1968
	Smallest	4.5	110	4 Aug 1969

DW = Disk Width

indicator of the mating season (Clark and von Schmidt, 1965). No one has determined histologically at what size *D. sabina* males are mature or ripe. Bearden (1965) noted 152-180 mm *D. sabina* were immature while Breder and Krumholz (1941) indicated a 220-230 mm disk width size for mature *D. sabina* females while giving no size for mature males. Burger (1972) studied rectal gland secretion but mentioned nothing about breeding state.

North Carolina: Since all North Carolina *D. sabina* were tagged for movement studies, no comments can be made regarding egg content of females or ripeness of males, even though no males were seen with mucus in their clasper grooves. No aborted young were obtained from any female captured in the Cape Fear and ajacent areas during the sample period 1973-76 (Table 3). However, the smallest individuals were taken in 1976 (Table 3). A male and female, both 115 mm DW (Station 19W), were captured 21 June 1976, while a 102 mm female was taken at 18E on 16 August 1976. All other specimens, in any one year, were larger than 120 mm DW. Apparently parturition occurs elsewhere or in the adjacent ocean as the younger sizes occurred during high water temperatures and at the lower stations when salinities were high (Tables 3, 4); capture upriver occurred from June to August when water temperatures ranged from 24-

TABLE 11. Size, sex, days at liberty, direction of movement data for 23 recaptured *D. sabina* originally tagged between 1973 and 1976 in the lower Cape Fear River and adjacent Atlantic Ocean.

Year/Season	Number Tagged	Location Capture	Date	Location Recapture	Date	Sex	DW	Days at Liberty	Direction Traveled	Distance (km)
1973 J-M*	0									
J-D**	17	18	4 Oct	Power Plant Screens	25 Apr 74	M	155	194	NW	4.8
		18E	24 Oct	Myrtle Beach, SC	5 Dec 73	M	206	42	SW	97.4
1974 J-M	36			0						
J-D	33	CF23	23 Oct	Off Ft. Fisher Air Base	30 Apr 75	M	320	189	E	1.0
1975 J-M	52	CF27	23 Apr	Off Ft. Fisher Air Base	30 Apr	M	277	7	SE	4.5
J-D	67	19	16 Jul	Caswell Beach	15 Sep	M	220	61	S	5.3
		19W	9 Sep	Power Plant Screens	14 Sep	F	180	5	W	3.0
		18	10 Sep	Long Beach	4 Oct	M	215	25	S	13.0
		18	10 Sep	19	15 Sep	F	350	5	N	1.6
		18W	11 Sep	Ocean	16 Nov	F	162	66	SW	12.8
		Ocean	15 Sep	E of 19-Rockwall	24 Sep	M	215	9	NE	15.0
		18E	16 Sep	E of 19-Rockwall	24 Sep	M	200	8	NE	2.0
		Power Plant Screens	18 Sep	Power Plant Screens	22 Sep	F	150	3	-	0.0
		18E	18 Sep	N Myrtle Beach, SC	7 Oct	M	200	20	SW	80.4
		Canal Bend	2 Oct	Power Plant Screens	2 Oct	M	167	0	W	1.2
		19	30 Oct	19	12 Jul 76	M	240	255	-	0.0
1976 J-M	81	Ocean	12 Apr	Hewletts Cr.	30 Apr	M	258	18	NE	15.0
		23E	5 Apr	Lower Cape Fear	31 Aug	F	280	148	S	5.2
		18W	17 May	Canal Mouth	23 Jun	F	172	37	NW	0.6
		Canal Mouth	25 May	Canal Mouth	13 Jul	F	190	49	-	0.0
		18E	26 May	19	12 Jul	M	267	47	W	2.0
J-D	131	19	12 Jul	23E	30 Sep	M	320	80	NE	2.8
		19	12 Jul	23W	21 Sep	M	300	71	NW	3.6
		Canal Bend	7 Sept	21	15 Sep	F	135	8	NE	4.4

DW = Disk Width

* J-M = January through May

** J-D = July through December

DOI: 10.18785/negs.0201.01

TABLE 12. A comparison of published and field observational data, throughout the range of *D. sabina*. CPUE has been adjusted to 4.9 m net and 15 min tow.

Literature Citation	State	Tow Time (min)	Size Trawl (m)	*D. sabina*/Tow	CPUE
Shealy, *et al.* 1974	S.C.	20	6.1 SB	3/268	.006
Dahlberg and Odum 1970	GA.	15	6.1	72/238	.243
Anderson 1968	GA.	–	22.9	3.4/hr. offshore	–
				4.4/hr. inshore	–
Tagatz 1967	NE FLA.	–	2.4	29/194	–
Wang and Raney 1971	SW FLA.	–	4.9	12/1169	–
Ogren and Brusher 1977	NW FLA.	10	3.7	56/312	.345
Livingston 1972-75*	NW FLA.	2	4.9	94/1258	.560
Livingston 1972-75*	NW FLA.	2	4.9	8/2910	.020
Livingston 1972-75*	NW FLA.	2	4.9	6/4002	.001
Perret, *et al.* 1971	LA.	10	4.9	32/1390	.035
Dunbar 1972	LA.	10/30	4.9	60/696	.013
Juneau 1975	LA.	10	4.9	5/562	.013
Dugas 1975	LA.	10	4.9	2/40	.075
Gunter 1945	TEX.	30	–	13/99	–
Sage, *et al.* 1972	TEX.	5	–	300/?**	–
McFarland 1968	TEX.	–	–	256/?***	–
Miller 1965	TEX.	15	5.8	8/?	–
Chittenden & McEachran 1976	TEX.	12	–	2/60	–

SB = Semiballon

* Data furnished by R. Livingston, Fla. St. Univ., for Apalachicola Bay, CPUE = .075 and two estuaries in Apalachee Bay, Fenholloway = .0027, Econfina = .0015.

** Collected during 6 months.

*** Total was 256 *D. sabina* of 56,398 specimens.

-29°C.

Georgia: Ripe males (here considered ripe if containing mucus in the clasper grooves) occurred in both reaches of the study estuaries, but were most abundant in the middle reaches. These were usually observed from April to August, while two were so noted as late as 16 November. Sizes of ripe males were 211-265 mm DW.

Yellowish eggs were found in three females (310-330 mm DW) caught by hook and line in the middle reaches (Halfmoon Landing) on 21 April 1967. The abortion of 88 - 118 mm DW embryos, upon capture of pregnant females (289-320 mm DW) was observed only at the middle reaches stations on 26 July 1967, 7 August 1968, and 4 August 1969 (Table 7). Several fetuses (111-120 mm DW) were also found in a 353 mm DW female collected by hook and line at Halfmoon Landing 16 August 1967.

Thus, newly born young 101-130 mm were trawled in August-September in the estuary, which serves as the nursery ground for Georgia *D. sabina*. Specimens 131-170 mm collected in the spring were considered age class 1 specimens.

LENGTH-WEIGHT RELATIONSHIPS

Gunter (1945) collected 130-460 mm disk length *D. sabina* in Texas, the smallest of which were taken in November and April in the Gulf of Mexico. We consider these sizes to be equivalent to wing widths as Breder and Krumholz (1941), Joseph and Yerger (1966), and Funicelli (1975) noted that the length-width shape of a *D. sabina* disk

TABLE 13. Catch per unit effort (CPUE), by trawl size, for 419 *D. sabina* caught in 5,210 trawl, 15-minute, tows in 1973-1976 from Cape Fear River and adjacent areas of North Carolina.

MONTH	NUMBER											
	1973			1974			1975			1976		
	N	tows		N	tows		N	tows		N	tows	
		ST*	LT**		ST	LT		ST	LT		ST	LT
J	-	-	-	0	5	0	0	0	24	0	0	26
F	0	44	30	2	19	36	3	34	61	3	44	65
M	0	41	42	1	35	37	13	54	109	20	121	148
A	0	40	80	8	47	66	23	97	136	27	89	125
M	0	57	116	22	69	85	13	83	135	31	96	106
J	-	-	-	2	9	21	1	0	28	8	0	31
J	0	0	23	3	18	23	3	0	31	26	0	31
A	1	0	35	4	5	17	0	0	33	3	0	39
S	3	67	110	17	84	98	42	122	179	47	126	159
O	13	70	80	5	105	156	14	113	193	37	92	169
N	0	25	54	7	44	71	7	67	63	10	111	106
D	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	17	344	570	71	440	610	119	570	992	212	679	1005
CPUE		0.019			0.068			0.076			0.126	

- = No Sampling.
ST = Small 7.6 m semiballon otter trawl.
LT = Large 12.2 m semiballon otter trawl.

is nearly equal. Sage *et al.* (1972), on the basis of weight histograms, concluded that females lived 6 years and attained a weight of just over 2000 g while males lived 3-4 years and attained weights of just under 1000 g. They also noted females grew 200 g in weight their first year followed by a marked increase in weight their second year, a condition they attributed to pregnancy. Subsequent yearly female growth rates were in 200 g increments.

North Carolina: North Carolina *D. sabina* fell within the size range noted by Gunter (1945), the largest males were 460 mm captured 28 May 1974 and 10 November 1976, while the largest females were 490 mm captured 18 March 1975. Weights far exceeded those reported by Sage *et al.* (1972) in that the heaviest females captured 18 March 1975 were 5216 g and 5433 g. Likewise, plotting the length frequencies of male and female *D. sabina* cited in Table 2, four age classes were suggested rather than the six, based on weight, proposed by Sage *et al.* (1972).

Males, by capture year, were generally smaller throughout a corresponding female size (width) range each year except for 1975 and 1976 (Fig. 3). Males smaller than 200 mm DW weighed about the same as did females. Females 200 to 350 mm DW were, except for 1976, usually heavier than corresponding sized males (Fig. 4). Females of all sizes were lighter than males throughout 1976 (Figs. 3, 4). No extraneous event seemed responsible for the 1976 female weight differences. Length-weight regression curves for each sex, by year, (Figs. 3 and 4) show good correlations except for the 1976 male length-width data where r = 0.8500.

Georgia: The size range of trawled male *D. sabina* was 107-278 mm, whereas trawled females were 110-340 mm DW (Fig. 5). The largest male and female

DOI: 10.18785/negs.0201.01

TABLE 14. Catch per unit effort (CPUE) for 166 *D. sabina* caught in 485 six meter trawl, 15-minute, tows in Georgia estuaries 1967-1969.

	NUMBER											
	1967				1968				1969			
Month	Lower Reaches		Middle Reaches		Lower Reaches		Middle Reaches		Lower Reaches		Middle Reaches	
	N	tows	N	tows	N	tows	N	tows	N	tows	N	tows
J	1	9	0	4	0	10	1	4	0	10	0	4
F	4	20	1	8	2	20	0	8	0	10	0	4
M	1	10	2	4	9	10	6	4	0	8	0	4
A	0	8	0	4	2	10	6	4	2	10	0	4
M	3	20	15	8	2	20	6	8	0	9	0	4
J	–	–	–	–	1	10	0	4	3	8	1	2
J	0	19	9	8	2	9	2	3	–	–	–	–
A	8	10	3	4	18	18	8	6	7	8	5	2
S	2	10	1	4	–	–	–	–	–	–	–	–
O	5	20	1	8	0	10	0	2	19	8	0	2
N	5	10	1	4	0	10	0	2	–	–	–	–
D	2	10	0	4	–	–	–	–	0	8	0	2
TOTAL	31	146	33	60	36	127	29	45	31	79	6	28
CPUE	0.212		0.550		0.283		0.644		0.392		0.214	

– = No sampling.

captured by hook and line in the study area were 292 mm and 345 mm wide, respectively. One larger *D. sabina,* a 405 mm female, was captured by hook and line in Mud River (Fig. 2) on 10 August 1968.

Males were nearly identical to females in weight and size in specimens captured in 1969 until 240 mm DW were obtained, after which both approximated each others weight, even though females attained a larger overall size (Fig. 5). *D. sabina* 131-170 mm, collected during the spring, were considered age class 1. Note these specimens were larger than reported by Sage *et al.* (1972) for the same age class. While Sage *et al.* (1972) found that Texas females grew larger than males, Georgia females were heavier than corresponding sized males and exceeded the maximum size of males (Fig. 5).

Length-weight regressions were expressed as $\log y = -5.1460 + 3.3567 \log x$ ($r = 0.9899$) for males and $\log y = -4.5199 + 3.0914 \log x$ ($r = 0.9973$) for females. Power functions were generated by the expression $w = 0.000007 \times ^{3.3567}$ for males and $w = 0.000030 \times ^{3.0914}$ for females.

Thus, younger and heavier *D. sabina* frequented the estuaries of Georgia, while larger individuals occurred in the lower portions of the North Carolina Cape Fear River system study area. Young, in both areas, frequented habitats with higher water temperatures and salinities than did adults. Slightly lower oxygen conditions were inhabited by young Georgia individuals than those in North Carolina. Adults, in both study areas were found in a wider range of environmental conditions than were young throughout most years sampled. Definite southward movements from North Carolina were established by tagging studies. Some individuals apparently wintered in nearby ocean waters of both study areas. While popular belief assumed *D. sabina* were abundant, catch per unit effort data did not substantiate this belief nor did it reveal, throughout the range of *D. sabina,* centers of abundance.

ACKNOWLEDGMENTS

Many contributed directly or indirectly to the success of this study. In North Carolina, numerous graduate students, research assistants, and Institute of Marine Sciences personnel aided the field observations and documentation. Especial thanks are due Katy West who programmed the statistical analyses and generated figures

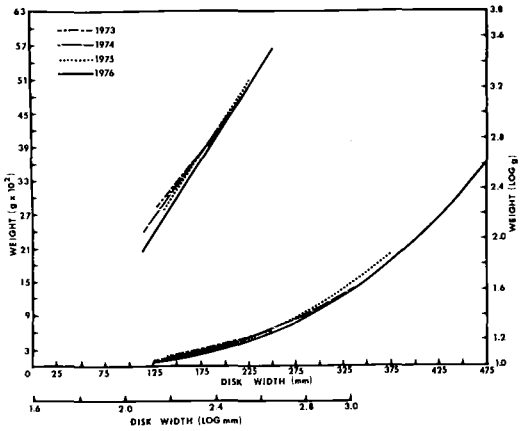

Figure 3. Length-weight regression and power curves, by year, for North Carolina male *Dasyatis sabina.*

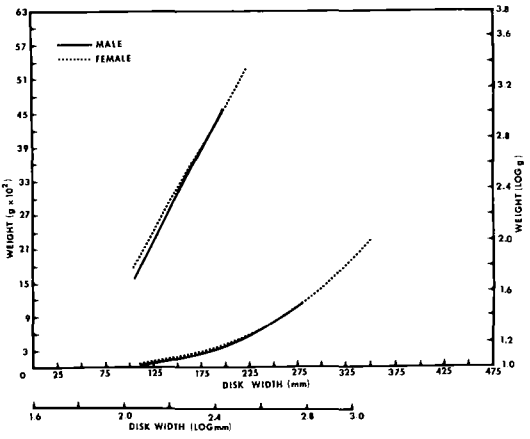

Figure 5. Length-weight regression and power curves for male and female Georgia *Dasyatis sabina.*

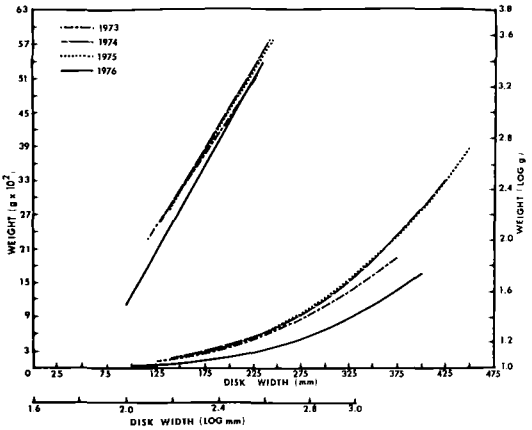

Figure 4. Length-weight regression and power curves, by year, for North Carolina female *Dasyatis sabina.*

3-5. Fred Rohde of the Institute reviewed the manuscript. Brenda Bright patiently typed various versions of the manuscript. Sport and commercial fishermen of the Cape Fear area were most helpful in supplying information regarding tagged fish recaptures. Various staff of the South Carolina Wildlife and Marine Resources Department, Charleston, alerted us to recaptures in that state. Carolina Power and Light Co., Raleigh, funded a study of the lower Cape Fear River fish fauna which included observations on *D. sabina.* Dr. W. Hogarth and K. MacPherson of CPL were most helpful in the field and supplied data from the Brunswick Steam Electric plant intake canal screens near Southport, NC.

Georgia observations were accomplished while that study was based at the University of Georgia, Institute of Marine Sciences at Sapelo Island, GA. Funding was provided by the Interstate Paper Company of Riceboro, GA, through the Georgia Water Quality Control Board. Ship support was NSF funded. Many Marine Institute staff likewise assisted in the collection and analysis of the field samples. Figure 2 was originally published in Sĭkora *et al.* (1972).

Dr. Robert Livingston, Florida State University, Tallahassee, FL, generously supplied catch per unit effort data from his vast west Florida bay studies.

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