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Behavior, Distribution, and Relative Abundance of Cownose Ray Schools *Rhinoptera bonasus* in the Northern Gulf of Mexico

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BEHAVIOR, DISTRIBUTION, AND RELATIVE ABUNDANCE OF COWNOSE RAY SCHOOLS *Rhinoptera bonasus* IN THE NORTHERN GULF OF MEXICO

In spring and fall of 1987, aerial surveys were used to study the distribution and abundance of red drum (*Sciaenops ocellatus*) schools in the northern Gulf of Mexico. Data were also collected on other marine animals observed on or near the water's surface. One schooling species frequently observed was the cownose ray (*Rhinoptera bonasus*). Because of their distinctive color, blunt snout, and falcate pointed pectoral fins, cownose rays can be readily identified from aerial surveys.

Little is known about the abundance and distribution of cownose rays in the Gulf of Mexico; most accounts are largely anecdotal (Simmons 1957, Clark 1963, Parker and Bailey 1979, Hoese and Moore 1977). Most cownose ray research has been done in Chesapeake Bay and offshore of Virginia (Smith 1980, Smith and Merriner 1985, 1986, 1987). Our study presented the opportunity to study the abundance, distribution, and behavior of cownose rays in the Gulf of Mexico.

METHODS

Study Periods

We wanted to compare the spring and fall distributions of red drum schools so we defined two 1987 study periods: "spring" (April to early July) and "fall" (late August to early December). A study window of 21 days was allocated to each study area and, per season, the study month was randomly selected per study area. Poor weather conditions were a limiting factor and data were collected from 6 to 11 survey days per study area. In an attempt to standardize the environmental conditions, we generally only surveyed from about 1000 to 1500 h.

Study Areas

For logistical convenience, we divided the northern Gulf, from the Rio Grande River, Texas to the Florida Keys into 7 study areas (Figure 1). Because of military air space restrictions, the area from Perdido Bay, Alabama to Cape San Blas, Florida was not studied. The Louisiana area was surveyed twice in the spring (April and June). Because of logistical constraints, the Central Florida area was not studied during the spring surveys but was studied in November (Figure 1). The other study areas were surveyed once in both spring and fall. Each study area was divided into an "inshore" and a "Gulf" study area. Inshore areas were bays and sounds. Transects over inshore bodies of water generally traversed the bay or sound. Occasionally, time constraints and the large body of inshore water (*e.g.*, Chandeleur Sound) forced us to truncate inshore transects at about 10 NM. Gulf transects, over the Gulf of Mexico, extended from the mainland, or, if inshore waters were present, from the inshore to Gulf delineation, seaward 15 to 20 minutes latitude or longitude. This distance was chosen for logistical reasons.

Survey Methods

The study platform was a single-engine, overhead-wing aircraft, with retractable landing gear. Each survey day we flew systematic transects from a single randomly selected starting point. The transects were 4 minutes latitude or longitude apart and the direction of each survey day's study (along the mainland) was randomly selected. We averaged about 10 to 12 transects per survey day. We generally surveyed only when the sea height was less than 1 m, and less than 33% of the sea's surface had whitecaps.

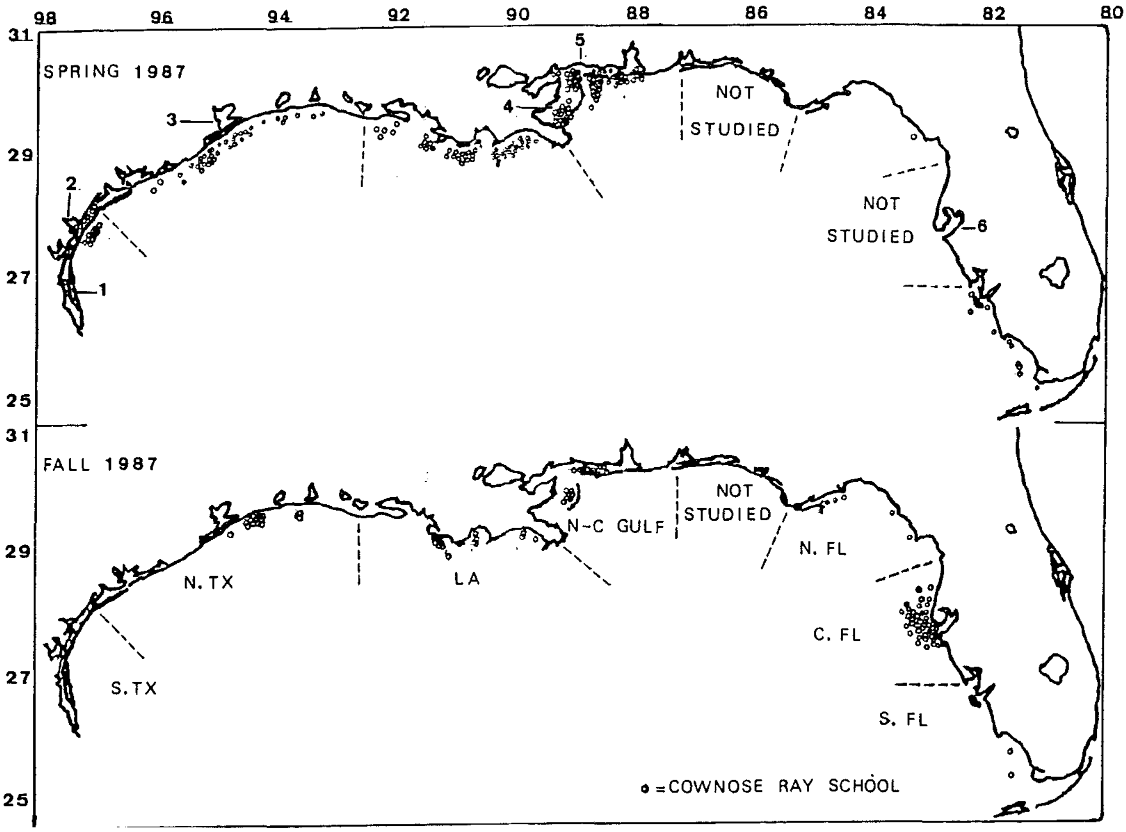

Figure 1. Approximate locations (open circles) of spring (top figure) and fall (bottom figure) cownose ray schools observed in the Gulf of Mexico during 1987 aerial surveys. Spring locations of schools in the Louisiana study area are from the June study. Study areas are delineated by dashed lines and named in the fall figure. Numerals in the spring figure refer to localities mentioned in the text: (1) Laguna Madre, (2) Corpus Christi Bay, (3) Galveston Bay, (4) Chandeleur Sound, (5) Mississippi Sound, and (6) Sarasota and Tampa Bay.

Only data collected under these conditions were used in analyses.

While surveying, the aircraft's airspeed was about 160 kmh. The observation strip was defined by a 55° angle from each side of the aircraft and was delineated by placing reference marks on the window frames and wing struts. However, the angle from the trackline (vertical) to 21 degrees on each side of the trackline could not be observed. Therefore, the actual observation angle included 34 degrees on each side of the aircraft. The survey altitude, either 305 m (1000 ft) or 475 m (1500 ft), was alternated among survey days. The 34° angle of observation and altitude defined the width (either 638 or 954 m) of each strip transect.

Data Acquisition and Analysis

Five experienced observers conducted the surveys. Usually two surveys in different study areas were conducted during the same time period. Observers trained by flying with professional fish (generally red drum) spotter pilots during the spring and summer of 1986. The observers acquired more experience during a fall 1986 pilot study that used basically the same methods and study areas. During each survey, two observers, one on each side of the aircraft, observed through open windows. To communicate, the observers and pilot used an intercom system.

A LORAN-C navigation device was interfaced with a small portable computer. The aircraft's position (latitude and longitude) was automatically recorded every 30 seconds. The observers subjectively rated and recorded weather conditions, water color and turbidity, sea state, glare, and sunlight penetration of the water. Turbidity and glare affected our ability to see into the water column. Usually, we could only record marine animals sighted on or near the water's surface. We recorded data for 44 species or types of marine animals.

A ratio estimator was used to estimate the density of surfaced or near surfaced cownose ray schools per 100 square NM (Jolly 1969, Caughley 1977).

$$\hat{R} = \bar{y}/\bar{a},$$

where $\hat{R}$ is the estimated density, $\bar{y}$ is the mean number of cownose ray schools observed per survey day, and $\bar{a}$ is the mean area sampled per day. The standard error of R (Cochran 1977) was estimated by:

$$se_{(\hat{R})} = [1/(n)^{1/2}\bar{a}]\,[(\Sigma y_i^2 - 2\hat{R}\Sigma y_i a_i + \hat{R}^2\Sigma a_i^2)\,/\,(n-1)]^{1/2}$$

where n is the number of survey days (i) per study area.

RESULTS

Three types of ray [cownose ray, manta ray (*Manta birostris*), and unidentified rays] sightings were recorded. Occasionally, especially offshore of Florida, solitary spotted eagle rays (*Aetobatus narinari*) were sighted. A few white, presumably albino, cownose rays were observed.

In some areas cownose ray schools were so abundant it was difficult to count all schools in the strip. We estimated the school sizes ranged from only a few to thousands of rays per school; the larger schools were often arranged in multiple layers.

We noted three types of schooling behavior. Large schools of densely packed rays were often observed in shallow water raising clouds of disturbed silt. Generally, the visible rays were swimming in the same direction and the school's shape was not well defined. Another type of schooling behavior involved smaller schools, containing a few to perhaps a few hundred rays, almost motionless or swimming very slowly, usually in a well defined triangular or diamond shaped formation, with all rays in the school generally oriented in the same direction. These schools were usually not near other ray schools and were often observed in deeper waters. The third behavior was similar, except the schools were usually swimming fast and in the same direction, numerous schools were in the same general area, and the water was usually shallow. We did not note any seasonal difference in cownose ray schooling behavior.

Estimated densities of cownose ray schools in the inshore areas during the spring ranged from none in Northern Texas and Northern Florida to 8.38 schools/100 NM^2 in the North-Central Gulf. Gulf densities in the spring ranged from 0.02 schools/100 NM^2 in Northern Florida to 3.54 schools/100 NM^2 in the North-Central Gulf (Table 1).

Cownose ray schools were generally less abundant during the fall surveys. No inshore ray schools were observed in Southern Texas, Northern Texas, Northern Florida, and Southern Florida (Table 1). The greatest estimated inshore density was 1.3 schools/100 NM^2 observed in the North-Central Gulf. Gulf density estimates ranged from no schools observed in Southern Texas to 2.16 schools/100 NM^2 in Central Florida (Table 1).

In the spring, no schools were observed in the Gulf south of Corpus Christi Bay although inshore schools were sighted further south in Laguna Madre (Figure 1). In the fall, no inshore schools were sighted in Texas waters and no Gulf schools were sighted south of Galveston Bay. Cownose ray schools were very common in the shallow Louisiana Gulf

Table 1. Estimated density ($\hat{R}$, schools per 100 nm) and standard error (se) of cownose ray schools in the northern Gulf of Mexico study areas in 1987. N is the number of transects.

	SPRING				FALL			
Study Area	Month	N	$\hat{R}$	se	Month	N	$\hat{R}$	se
Southern Texas								
Inshore	May	77	2.17	0.69	Sept.	73	0	
Gulf		104	0.54	0.24		78	0	
Northern Texas								
Inshore	May	36	0		Oct.	57	0	
Gulf		94	1.60	0.26		97	0.65	0.26
Louisiana								
Inshore	April	55	0.16	0.16				
Gulf		98	1.31	0.37				
Inshore	June	43	0.77	0.57	Oct.	44	1.20	0.01
Gulf		100	2.37	0.72		72	0.64	0.32
North-Central Gulf								
Inshore	April	80	8.38	0.36	Sept.	84	1.27	0.45
Gulf		146	3.54	0.01		91	0.33	0.24
Northern Florida								
Inshore	June	57	0		Nov.	28	0	
Gulf		146	0.02	0.02		78	0.36	0.15
Central Florida								
Inshore					Nov.	35	1.20	0.94
Gulf						95	2.16	0.76
Southern Florida								
Inshore	July	21	1.86	1.24	Dec.	12	0	
Gulf		106	0.35	0.14		85	0.08	0.96

waters in both April and June but much less common in the fall. Numerous inshore ray schools were in the Chandeleur and Mississippi sounds in the North-Central Gulf study area in both spring and fall but schools in the Gulf were uncommon in the fall (Figure 1). Cownose ray schools were uncommon in North Florida in both spring and fall but were common in Central Florida in November. Gulf ray schools were uncommon in South Florida in both spring and fall and no schools were observed in the clear water near the Florida Keys (Figure 1).

Unidentified sharks were often associated with the cownose ray schools. Commonly, the sharks were among the rays or swimming around the periphery of the ray schools. Black drum (*Pogonias cromis*), red drum, and Crevalle jacks (*Caranx hippos*) were observed to be associated with the cownose ray schools, especially in Louisiana Gulf waters. Occasionally, red drum schools were following the ray schools. Menhaden (*Brevoortia* spp.) schools were often mixed among cownose ray schools and also caused clouds of silt in the water. In the spring, we observed cobia (*Rachycentron canadum*) associated with ray schools.

DISCUSSION

Smith and Merriner (1987) noted cownose ray schools in the Chesapeake Bay often segregated by size. We did not note ray size differences among the schools we observed but our survey altitude may have been too high to observe such detail. Joseph (1961) reported an albino cownose ray and believed albinism in elasmobranchs was probably more common than records indicated.

We observed very few white, perhaps albino, rays among the great number of rays we observed.

Clark (1963) reported a cownose ray school off the coast of Sarasota, Florida that was estimated to contain about 6000 rays. Schwartz (1965) reported Gulf of Mexico schools "often containing 10,000 individuals" but he did not report how they were counted. We believe some schools we observed probably contained tens of thousands of rays. Smith and Merriner (1987) observed massive cownose ray schools formed off the North Carolina coast in April before entering Chesapeake Bay. Springer (1967) noted elasmobranchs in general often form large migrating schools. The large schools we observed were often in bays and sounds but also in shallow Gulf of Mexico waters. They occurred in both spring and fall surveys.

Clark (1963) noted that most of the rays in a large school offshore of Sarasota were oriented in the same direction. Smith and Merriner (1987) reported similar findings for rays in schools they observed. Most of the cownose ray schools we observed had all of the visible rays oriented similarly. This was not true of many shark schools we observed.

Smith and Merriner (1987) noted that most cownose ray schools they observed were "solid configurations" and a broad triangular formation was common. We noted three types of schooling behavior but we believe aerial observations specifically directed to studying cownose ray behavior would find much more detailed schooling behavior. We noted swimming formations, usually triangular diamond shaped, of cownose rays that differed mainly in swimming speed and abundance of schools.

We often observed ray schools causing silt clouds and assumed the rays were foraging. Similar behavior has been attributed to cownose ray schools in the Chesapeake Bay (Smith and Merriner 1985). Destruction of eelgrass beds in the Chesapeake Bay has been attributed to cownose ray digging activities (Orth 1975). Often the foraging schools we observed were extremely large and school's shape could be described as an oblong formation. Often we observed moving clouds of silt in deep water. These silt clouds may have been caused by foraging ray schools because, based on recovered prey items, cownose rays have been reported to forage in deep water (Smith 1980).

Bigelow and Schroeder (1953) reported the main prey items of cownose rays were oysters, clams, and other bivalve mollusks.Smith and Merriner (1985) reported soft shell clams (*Mya arenaria*) were the most important food item in the lower Chesapeake Bay. Oysters and mollusks are also a major prey of black drum and, to a lesser extent, red drum (Pearson 1929, Overstreet and Heard 1978). We often observed drum, sharks, and Crevalle jacks associated with foraging cownose ray schools. Professional fish spotter pilots use foraging ray schools as a cue to finding drum schools. During the spring surveys we infrequently observed cobia schools associated with cownose ray schools. Smith and Merriner (1982) reported cobia maintained a position over the rays and foraged on food rejected by the rays.

Cownose ray schools are probably an important component of the marine ecosystem. Karl and Obrebski (1976) found a similar species, the bat ray (*Myliobatis californica*), excavated deep depressions while foraging and attracted many species of fish that preyed on the exposed animals. Cownose ray digging behavior may provide mollusks for the drum and flush or expose prey for drum, sharks, and Crevalle jacks. Smith and Merriner (1982) thought foraging rays might provide cobia an otherwise unaccessible benthic prey. The associated sharks may also prey on cownose rays (Castro 1983).

Four semi-isolated western Atlantic populations of cownose rays have been suggested (Smith and Merriner 1987), with one population in the Gulf of Mexico. Cownose rays along the eastern United States coast are known to migrate north along the coast in the spring and south in the fall (Schwartz 1965, Smith and Merriner 1985). Smith and Merriner (1987) reported cownose rays reached North Carolina waters by April and had usually left the Chesapeake Bay by October. Based on tag returns, Schwartz (1965) suggested at least some eastern coast cownose rays migrated to northern South America during the winter months. Smith and Merriner (1987) thought it more likely that, during the winter, the rays migrated south to deeper water on the South Atlantic bight shelf.

In an abstract, Schwartz (1965) suggested that in the Gulf of Mexico, cownose ray schools migrated clockwise from the Yucatan Peninsula throughout the coastal bays and migrated from the west coast of Florida back to the Yucatan in the fall. He did not present data supporting this speculation. Hoese and Moore (1977), reviewed the fish of Texas, Louisiana, and adjacent Gulf of Mexico waters, and mentioned that "large schools of these rays are found in the saltier bays and on the inshore shelf in summer, with masses often seen leaving at the onset of cold weather." We did not observe any cownose ray schools south of Galveston Bay in the fall and more schools were offshore of North Florida in the fall, which might support Schwartz's hypothesis. However, our lack of spring data for the Central Florida study area, the decrease in South Florida cownose ray school abundance in December, and the apparent increase in abundance of Louisiana inshore schools during the fall survey confound our ability to speculate on migration routes. It seems equally possible that, as Smith and Merriner (1987) suggested, the cownose rays may migrate to deeper waters in the winter.

Parker and Bailey (1979) reported large numbers of sharks and rays, including cownose ray schools, in Gulf waters offshore of Corpus Christi in June, 1977. During the spring surveys, we did not observe cownose ray schools in the Gulf of Mexico south of Corpus Christi Bay. We did observe cownose rays much further south in the Laguna Madre. It may be that the steeper shelf and generally harder substrate offshore of southern Texas reduce cownose ray foraging habitat.

In North Carolina, cownose rays give birth in June and July and ovulate following parturition (Smith and Merriner 1986). Chesapeake Bay is thought to be an important estuary for cownose ray reproduction. Simmons (1957) reported cownose rays produced young in the upper Laguna Madre and Gulf of Mexico estuaries are probably habitat for reproducing cownose rays. We do not believe the aggregations of schools we observed in 1987 can be completely explained as aggregations of breeding or reproducing rays. The greatest density of schools we observed was in the Mississippi and Chandeleur sounds in April, but schools were fairly uncommon in Louisiana inshore waters during the same month. Schools were fairly abundant in the Laguna Madre in May but we could not find any schools in the Matagorda and Galveston bays during the same month.

Smith (1980) reported cownose rays were captured in Chesapeake Bay when water temperatures ranged from 15 to 29°C and salinity ranged from 8 to 30‰. Except for winter months, the monthly mean salinity and water temperature of Texas bays have been reported to be within these ranges (Benefield *et al.*

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1986). However, environmental factors may partly explain the absence of cownose rays in the Texas bays. Simmons (1957) reported very large cownose rays were abundant in the upper Laguna Madre during the spring when water temperature was below 25°C and salinity below 60‰. He reported combinations of high salinity and temperatures sharply reduced their numbers.

Usually, when we observed large aggregations of ray schools, either during the spring or fall surveys, we noted most schools caused silt clouds and we assumed they were foraging. If this is true, then perhaps prey abundance attracted the rays. However, Texas bays are known to support a diverse molluscan fauna (Ladd 1951, Pulley 1952, Hofstetter 1977), so the absence of ray schools in the Northern Texas inshore study area was probably not due to a lack of prey.

We found cownose rays in inshore and Gulf waters from southern Texas to southern Florida. Because it can readily be identified from aerial surveys, considerable information on the biology and distribution of cownose rays, along with information on interspecific associations, can be attained from aerial surveys. However, a tagging study would probably be required to answer questions about Gulf of Mexico cownose ray migrations.

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