Northeast Gulf Science

Volume 11
Number 1 *Number 1*

Article 7

7-1990

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Carol L. Roden
National Marine Fisheries Service

Ren R. Lohoefener
National Marine Fisheries Service

Carolyn M. Rogers
National Marine Fisheries Service

Keith D. Mullin
National Marine Fisheries Service

B. Wayne Hoggard
National Marine Fisheries Service

DOI: 10.18785/negs.1101.07

ASPECTS OF THE ECOLOGY OF THE MOON JELLYFISH, *Aurelia aurita*, IN THE NORTHERN GULF OF MEXICO

In the spring and fall of 1987, aerial surveys were used to study the distribution and abundance of surfaced and near-surface schools of red drum (*Sciaenops ocellatus*) and other marine animals. One species commonly observed in large aggregations was the moon jellyfish, *Aurelia aurita*. When near the surface and aggregated, the cream to pink globular animals were obvious.

Little is known about the abundance and distribution of *Aurelia* in the Gulf of Mexico. Various trawl studies have reported sporadic moon jellyfish captures (National Marine Fisheries Service Resource Surveys cruises, *pers. obs.*). The short lifespan of the adult medusae (Loosanoff 1962) makes abundance and distribution studies difficult. Our aerial surveys provided a unique opportunity to study the abundance and distribution of near-surface aggregations of moon jellyfish.

STUDY METHODS

The coastal Gulf of Mexico, from the Rio Grande River, Tex. to Key West, Fla., was divided into 7 study areas. Military airspace restrictions precluded surveys between Perdido Bay, Ala. and Cape San Blas, Fla. Logistics precluded study of the area between Lake Calcasieu and White Lake, La.

Spring surveys (April through July) and fall surveys (September through December) were conducted in each of the 7 study areas with 2 exceptions. The Central Florida study area was studied only in the fall and the Louisiana study area was surveyed twice in the spring. A 21 day period per study area was allotted to each spring and fall survey. Weather was the major limiting factor and 6 to 11 survey days were accomplished in each area per season.

Transect directions were either north-south or east-west, generally perpendicular to the mainland. Offshore transects extended from the mainland or barrier islands 15 to 20 minutes of latitude or longitude seaward (28 to 37 km). Inshore transects were flown over the waters of bays and sounds up to 10 NM (19 km) inland. Each study day, a random starting point and random direction of work were chosen. Approximately 10 to 12 transects, 4 minutes of latitude or longitude apart, were flown per day. We used a single-engine, overhead wing aircraft with retractable landing gear (Cessna 172-RG type) as a study platform. Two trained and experienced observers, one on each side of the aircraft, surveyed through open windows. Surveys were conducted only when seas were no greater than 3 feet and whitecaps covered less than 50% of the sea surface (Beaufort scale 3). The aircraft's airspeed was approximately 167 km/h. Daily survey duration was usually 4 to 4.5 hours, and usually flown between 1000 and 1500 h. A 55 degree angle of observation was defined by placing tape reference marks on window frames and wing struts. Because of the fuselage, the angle between 0 and 21 degrees could not be observed. Thus, sightings were made in a 34 degree effective strip (between 21 degrees and 55 degrees) on both sides of the airplane. Survey altitude alternated between 305 m (1000 ft), with a survey strip width of 637 m, and 475 m (1500 ft), with a survey strip width of 954 m.

DATA ACQUISITION AND ANALYSIS

Data were recorded using a portable computer interfaced with a Loran-C navigation device. The aircraft's position (latitude and longitude) was automatically recorded every 30 seconds, along with time, heading, and ground speed. Observers recorded, and updated as necessary, altitude and environmental conditions including weather, sea state, water turbidity, sunlight penetration, glare, and water color.

A ratio estimator was used to estimate the density of moon jellyfish aggregations 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 moon jellyfish aggregations observed per day, and $\bar{a}$ is the mean area sampled per day. The standard error of $\hat{R}$ (Cochran 1977) was estimated by:

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

where n is the number of survey days (i) per study area. Approximate 95% confidence intervals were estimated as $\hat{R}$ plus or minus twice the standard error of $\hat{R}$.

RESULTS

Estimated *Aurelia* aggregation densities varied greatly between spring and fall (Table 1). In the spring, moon jellyfish were observed offshore only in the south Texas study area (0.27 aggregations/100 NM^2), and inshore only in the North-Central Gulf area (0.11 aggregations/100 NM^2).

Fall aggregations of near-surface moon jellyfish were much more abundant. Except in south Texas, *Aurelia* were observed in all offshore study areas. The only inshore sightings were in the North-Central Gulf study area. Fall offshore densities ranged from 0.06 aggregations/100 NM^2 (Louisiana study area) to 5.57 aggregations/100 NM^2 (North-Central Gulf study area). The North-Central Gulf density estimate was several times greater than that of any other study area.

We flew several transects, especially in the North-Central Gulf study area, where moon jellyfish aggregations in the strip were so numerous that counting them was difficult. Aggregations ranged in size from scattered small "spots" to areas where the observer's entire field of view was surfaced moon jellyfish. Aggregations were generally tightly packed and shape varied from circular to an elongated oval.

DISCUSSION AND CONCLUSIONS

Aurelia aurita has a worldwide distribution. The occurrence of swarms of adult medusae varies seasonally among geographical locations (Gunter 1950, Loosanoff 1962, Franks *et al.* 1972, Burke 1975, 1976, Fotheringham 1980, Moller 1984, Veer 1985). In our survey, moon jellyfish aggregations were observed in each study area and were most abundant during the fall. Moon jellyfish aggregations in the three study areas west of the Mississippi River were not common in either spring or fall, but abundance greatly increased east of the Mississippi River in the fall (Fig.1) and the greatest density was found in the North-Central Gulf study area.

Fall sightings in the North-Central Gulf inshore waters, where temperatures and salinities vary greatly among seasons, were common. Franks *et al.* (1972) believed moon jellyfish were limited to high salinity waters. However, Gunter (1950) found the jellyfish in waters with salinities as low as 16.0 ppt. We observed them both offshore, in oceanic salinities, as well as inshore, in areas where salinities were greatly influenced by fresh water runoff. In the winters of 1969-70 and 1970-71, moon jellyfish were taken in the inshore waters of the Mississippi Sound where salinities ranged from 29.2 to 31.6 ppt (Burke 1975). Burke (1976) again found moon jellyfish in the winters of 1971-72 and 1972-73 at stations on both the north and south sides of the Mississippi barrier islands. He noted that

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Table 1. Areas studied in 1987 and seasonal densities of offshore moon jellyfish aggregations. Density estimates ($\hat{R}$) are aggregations per 100 square nautical miles and ($\hat{se}_{\hat{R}}$) are the standard errors of the density estimates.

	Spring			Fall		
Study Area	Month	$\hat{R}$	($\hat{se}_{\hat{R}}$)	Month	$\hat{R}$	($\hat{se}_{\hat{R}}$)
South Texas	April	0.27	(0.15)	September	0	
North Texas	May	0		September	0.13	(0.08)
Louisiana	April	0		October	0.06	(0.07)
North-Central Gulf	May	0		September	5.57	(1.29)
North Florida	June	0		November	1.14	(0.36)
Central Florida		not studied		November	1.42	(0.40)
South Florida	July	0		December	0.27	(0.16)

thousands of *Aurelia* were present in the Mississippi Sound in December 1966, but were "peculiarly absent from Mississippi waters until the winter of 1969" (Burke 1975).

Shepherd (1969) believed moon jellyfish medusae were passively aggregated by wind and waves and spawning occurred at that time. Brewer (1978) suggested that sessile stages of marine invertebrate larvae do not randomly settle but rather they select suitable substrates for attachment. However, the soft mud to sandy-mud substrates and the rarity of solid substrata, especially inshore, in the North-Central Gulf study area have been considered unsuitable for moon jellyfish larval development (Burke 1976). Examination of dredge samples, oyster reefs, emplaced artificial reefs and fouling plates failed to produce sessile *Aurelia* larvae (Burke 1975, 1976).

During our aerial surveys, if other marine animal species were observed within a moon jellyfish aggregation, or on the periphery of an aggregation, it

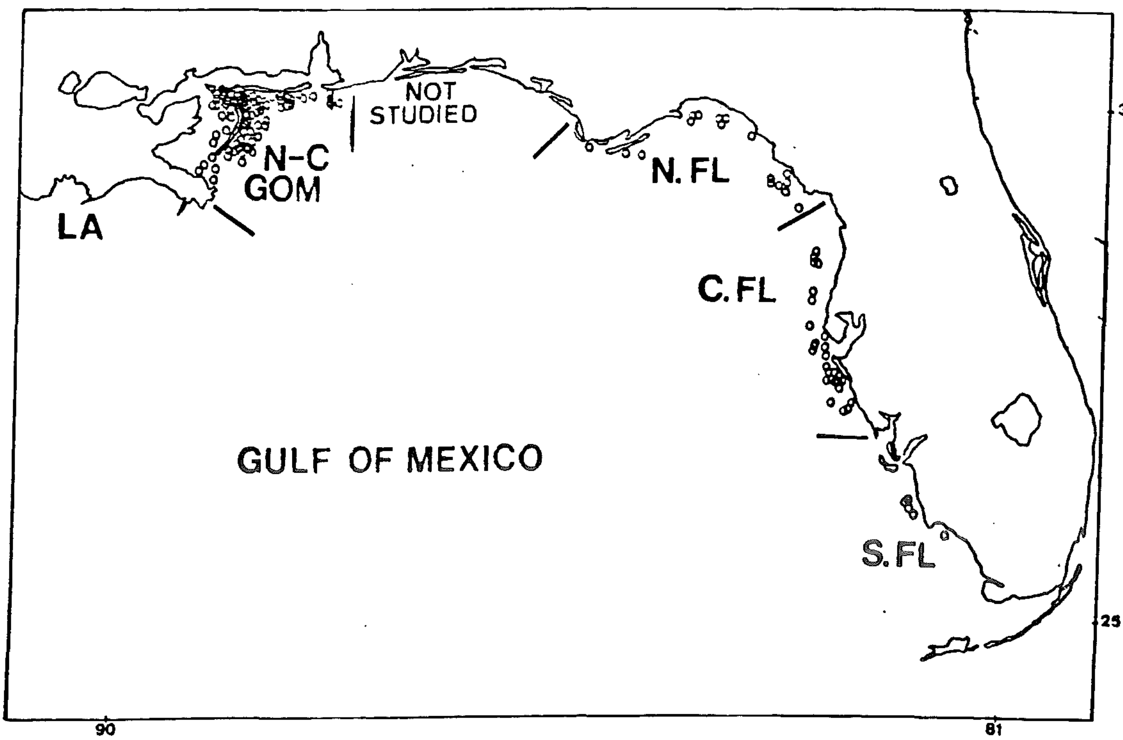

Figure 1. Aerial survey areas in the eastern Gulf of Mexico and locations of moon jellyfish aggregations (circles) sighted during the fall, 1987 surveys.

was considered as associated with the aggregation. Sharks were most commonly associated. Bottlenose dolphins were the second most common associate and sea turtles were the third most commonly associated animal.

Most of the associated sea turtles were identified as loggerhead sea turtles (*Caretta caretta*). However, during an earlier fall 1986 pilot study, several leatherback sea turtles (*Dermochelys coriacea*) were observed preying on moon jellyfish. All 5 species of sea turtles that are known to occur in the Gulf of Mexico have been reported to prey on jellyfish (Pritchard 1979, Hopkins 1984, Dodd 1988). The North-Central Gulf study area had one of the greatest densities of sea turtles during the 1987 aerial surveys. In the fall survey, sea turtles were relatively numerous around the Chandeleur Islands, and the moon jellyfish aggregation densitites in this study area were the greatest recorded during the surveys. Sea turtles may have been responding to an abundance of prey.

The factors that regulate the appearance, distribution, and densities of adult *Aurelia* aggregations are not well understood. Moon jellyfish are voracious feeders on zooplankton and larval fish (Arai and Hay 1982, Bailey and Batty 1983). Moller (1984) and Veer (1985) noted major declines in larval fish populations when an "outburst" of jellyfish occurred. The medusae are believed to provide protection, and, perhaps to a lesser extent, food for a variety of small and juvenile fish (Jachowski 1963, Mansueti 1963, Phillips *et al.* 1969). Adult moon jellyfish are sea turtle prey. All Gulf of Mexico sea turtles are currently classed as threatened or endangered species. *Aurelia* may be an important food source for these rare animals. The occurrence and density of moon jellyfish that we obseved, especially in the North-Central Gulf study area, indicate that this species is an important component of the ecosystem. Further research on these large aggregations, as well as the impact of *Aurelia* as predators, protectors, and/or prey, on juvenile fish and sea turtles, is needed.

ACKNOWLEDGMENTS

The authors thank Dr. Andrew Kemmerer, Mr. Joe Benigno, Dr. Bob Shipp and an anonymous reviewer for their valuable comments on this paper.

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Carol L. Roden, Ren R. Lohoefener, Carolyn M. Rogers, Keith D. Mullin, and B. Wayne Hoggard

National Marine Fisheries Service, Southeast Region, Mississippi Laboratories, Pascagoula Facility, Pascagoula, Miss. 39568-1207.