

Whale Sharks (*Rhincodon typus*) in the Northcentral Gulf of Mexico: A Rationale for Research

ERIC R. HOFFMAYER, JAMES S. FRANKS, and JOHN P. SHELLEY
Center for Fisheries Research and Development
Gulf Coast Research Laboratory
The University of Southern Mississippi
P.O. Box 7000
Ocean Springs, Mississippi 39566 USA

ABSTRACT

The whale shark, *Rhincodon typus*, has a circumtropical distribution, excluding the Mediterranean Sea. Internationally, the whale shark is listed as 'vulnerable', however, little is known about this species in the Gulf of Mexico (GOM), and information on whale sharks in the northcentral GOM is especially lacking in the scientific literature. Based on reported sightings and encounters, peak occurrence of whale sharks in the northcentral GOM is June–October, however, the nature of their seasonal occurrence, as well as life history aspects, movement patterns, habitat requirements, and population structure, are virtually unknown for the northcentral GOM. Research needs can be addressed regionally through collaborative research using a combination of questionnaires, aerial surveys, satellite imagery and telemetry, and at-sea research. As a 'first-step' response to the need for comprehensive information, the authors provide an outline of suggested research and describe a recently developed whale shark sightings questionnaire which is provided via the internet or hard copy. Future research will substantially advance understanding of the biology, ecology and behavior of whale sharks in the northcentral GOM.

KEY WORDS: Whale shark, *Rhincodon typus*, northcentral Gulf of Mexico

Tiburones Ballena (*Rhincodon typus*) en la Región Central Norte del Golfo de México: Un Razonamiento para su Investigación

El tiburón ballena, *Rhincodon typus*, presenta una distribución circumtropical, excluyendo el Mar Mediterráneo. Internacionalmente, el tiburón ballena es mencionado en "peligro", sin embargo, poco se sabe acerca de esta especie en el Golfo de México (GM). La información de esta especie en la región central del norte del GM es mínima especialmente en la literatura científica. Basados en reportes de avistamientos y capturas, la ocurrencia máxima del tiburón ballena en la región central del norte del GM es durante Junio - Octubre, sin embargo, la naturaleza de su presencia estacional, así como los aspectos de su historia de vida, patrones de movimiento, requerimientos del hábitat, y su estructura poblacional son virtualmente desconocidos en la región

central del norte del GM. La investigación necesaria puede ser desarrollada en colaboración a nivel regional usando una combinación de cuestionarios, observaciones aéreas, imágenes de satélite e telemetría, e investigación marina. Como un “primero-paso” en respuesta a la necesidad de recopilar información detallada, los autores sugieren un plan de investigación y describen el reciente desarrollo de un cuestionario de avistamientos del tiburón ballena. Este cuestionario fue divulgado por ellos en la forma de un documento o en formato digital via internet. La futura colaboración investigativa va a incrementar substancialmente nuestra comprensión de la biología, ecología y comportamiento de los tiburones ballena en la región central de norte del GM.

PALABRAS CLAVES: Tiburones ballena, *Rhincodon typus*, central norte del Golfo de México

INTRODUCTION

The whale shark, *Rhincodon typus*, is an epipelagic shark which has a circumtropical distribution, except for the Mediterranean Sea. It is the world's largest known fish, reaching up to 15 meters (m) and 18 metric tons (Colman 1997), and is generally encountered as single individuals but may form aggregations of up to hundreds of individuals (<http://www.fao.org>). Whale shark populations have decreased radically in some parts of the world, and the necessity of protecting this species on an international basis is emphasized by its listing as 'vulnerable' by the International Union for the Conservation of Nature and Natural Resources (IUCN, <http://www.redlist.org>) and its inclusion in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, <http://www.cites.org>). In the United States, whale sharks are protected from directed commercial fishing, landing or sale in waters of the Gulf of Mexico (GOM) and Atlantic Ocean (<http://www.fao.org>). Whale sharks are studied by various organizations around the world (e.g., The Marine Conservation Society Seychelles, The Shark Research Institute, The Nature Conservancy, University of York, University of Western Australia), however, little is actually known about the biology and life history of the species. Published scientific information on whale sharks in the GOM is scant, and studies directed at their biology, ecology and migratory behavior in the northcentral GOM are non-existent.

Information on the age, growth and reproduction of whale sharks, worldwide, is scant at best. Size and age at sexual maturity, as well as maximum age, are speculative, but whale sharks may not reach maturity until 30 years of age and longevity could be up to 100 years (Taylor 1994). Interestingly, there are no records of whale sharks between one and four m in length, which could indicate rapid growth at an early age. Pai et al. (1983) reported a mature male which was 8 m in length and three immature females between 8 - 9 m. Wintner (2000) reported three mature males estimated to be between 20 - 27 years of age and an immature female estimated to be 22 years old. It appears that males mature at a smaller size and earlier age than females. Until recent time there was much debate over the reproductive strategy of whale sharks. In 1955 a large egg case containing a whale shark

embryo was collected in a shrimp trawl off the Texas coast (Baughman 1955), suggesting oviparity as the mode of development. However, a pregnant female (10.6 m) which was harpooned near Taiwan in 1995 and contained 300 embryos at various stages of development (i.e. egg case, yolk sac, free living) revealed that whale sharks utilize yolk-dependent viviparity (Joung et al. 1996). Nothing is known about whale shark age, growth and reproduction in the northcentral GOM.

Whale sharks are considered to be highly migratory (Eckert and Stewart 2001) with movements that appear to be timed to coincide with blooms of planktonic organisms and changes in temperatures of water masses (<http://www.fao.org>). In the Western Central Atlantic, specimens tagged off Belize demonstrated movement to Honduras and further northward toward the Yucatan peninsula (Whale Shark News 2001), and one specimen moved from Honduras into the GOM (Alex Antoniou Per. comm.), however, to our knowledge, documentation indicating that whale sharks are a shared, migratory stock between the GOM and Caribbean regions is non-existent. The migratory behavior of whale sharks in the GOM is unknown, and information on its occurrence in the northern GOM is sparse. The northern GOM is considered to be one of twelve regions in the world where whale sharks predictably occur (Whale Shark News 2001), however, with the exception of sightings/encounters recorded during offshore fisheries research activities (the authors) and marine mammal aerial surveys (Childs et al. 2000, K. Mullins, NOAA Fisheries, USA Pers. comm), available information on whale shark occurrence in the northcentral GOM is largely anecdotal and based on sightings reported by offshore recreational anglers, divers, and the offshore petroleum industry (vessels, aircraft, and platforms). The limited available information suggests that whale sharks occur most frequently in the northern GOM during warmer months of the year (May – November), but they have been observed yearound.

Movements and distribution of whale sharks in the GOM may be related to specific biological events and oceanic conditions, such as the Loop Current and northern GOM oceanic frontal features (e.g., convergent zones, upwellings, temperature discontinuities, etc) which represent major pelagic ecosystems and tend to provide optimal conditions for plankton production (Don Johnson, GCRL Per. comm.), a primary food of whale sharks (Colman 1997). Whale sharks also feed on small crustaceans, small fishes, squid and jellyfish (Colman 1997, Heyman et al. 2001), and as reported for other oceans of the world (e.g., Heyman et al. 2001, Graham and Roberts 2003) seasonal aggregations of whale sharks have been associated with mass spawning of corals in the GOM at the Flower Garden Banks National Marine Sanctuary off Texas, USA (Clarke and Nelson 1997). Whale sharks associate with, or attract, other pelagic fishes, including remoras, cobia, jacks, and tunas (Gaertner and Medina-Gaertner 1999), which appear to be feeding on the same resource as the whale shark (Clark and Nelson 1997, Colman 1997, Heyman et al. 2001). Tunas, in particular, are reported to associate with whale sharks (Cropp 1978 - Australia, Iwasaki 1970 - Japan, Baughman 1955 - Honduras, Gudger 1941 and Springer 1957 - U.S. and Mexico, Gulf of Mexico). On September 18, 2002 during a *Sargassum* habitat research cruise in the northcentral GOM, we

encountered two whale sharks (~10 m in length) accompanied by large schools of yellowfin, blackfin and skipjack tuna (*Thunnus albacares*, *T. atlanticus*, and *Katsuwonus pelamis*, respectively) which were feeding on small fishes believed to be clupeids that may have been food for the whale sharks as well.

Aggregations of whale sharks have been reported from various locations around the world (e.g., Silas 1986 - Indian Ocean, Wolfson 1986 - Sea of Cortez, Colman 1997 and Taylor 1996 - Ningaloo Reef in Western Australia, Graham and Roberts 2003 - Belize), and offshore anglers periodically observe large aggregations in the northcentral GOM. The significance of the aggregations is unknown, except that Colman (1997) reported that whale sharks may aggregate in areas with dense accumulations of prey. Aggregations in the northcentral GOM typically occurred at or near petroleum platforms located at least 100 km offshore. Whale sharks may be attracted to platforms, which essentially function as fish attracting devices (FAD) (Franks 2000) and may provide foraging opportunities or serve as 'waypoints' or 'meeting points' along migratory routes.

NEEDS AND RATIONALE FOR RESEARCH

The conspicuous lack of scientific information on whale sharks in the northcentral GOM accentuates the need for answers to fundamental questions pertaining to numerous aspects of whale shark biology and ecology in the region. Additionally, research is needed to investigate the north-central GOM as possible whale shark spawning, nursery and juvenile habitat, and to study relationships between seasonal behavior (e.g., short-term and long-term movements) and oceanographic factors. A key factor in the sustainability of the whale shark population in the GOM is a clear understanding of the population dynamics of the animal. Understanding life history aspects of whale sharks and which biotic and abiotic factors affect the abundance, distribution, and seasonal movements of the species in the north-central GOM is important for the development of any future management and/or protection measures for the species and its habitat in the GOM.

A multi-disciplinary approach to research will be required to significantly improve our understanding of whale sharks in the northcentral GOM and will include at-sea studies, aerial surveys, laboratory assessments, questionnaires, oceanographic modeling, genetic analysis, and state-of-the-art technologies, including remote sensing, GIS, and satellite telemetry. Such an approach would necessitate the development of a comprehensive plan with a specific goal and well-defined objectives and would require collaborations among research and academic institutions, fisheries management agencies, fisheries councils and commissions, the offshore petroleum industry, NGOs, the recreational and commercial fishing industries, public education and outreach institutions and organizations, and other pertinent entities. Securing adequate funding will represent a major challenge to the implementation of this plan.

SUGGESTED PLAN OF RESEARCH

The goal is to understand the biology and ecology of the whale shark in the GOM and its role in the pelagic ecosystem of the GOM. Ideally, a regional plan of research to accomplish this goal would initially include input from experts and other informed sources to develop a consensus on needs and priorities for future investigations. In view of the current absence of such a plan and in an effort to initiate, and perhaps stimulate, the planning process, we offer the following brief outline for whale shark research in the northcentral GOM.

Additionally, we recommend that the research be conducted in two phases and suggest specific research topics for inclusion in each phase of the plan.

Outline of Research Plan

Phase I

A 'first-step' response involves the accumulation and review of available recent and historic (surveys, logbooks, etc.) sightings data and information and the development of a sightings database that will benefit future whale shark studies and serve to maximize the success of Phase II activities. The database will provide the following information for whale sharks:

- i) Inter-annual abundance and distribution,
- ii) Size range,
- iii) Behavior, and
- iv) Associated pelagic fishes

Phase II

- i) Continuation of Phase I efforts,
- ii) Estimate relative abundance of individuals through robust, repeatable population surveys (aerial surveys),
- iii) Develop a photographic identification library (digital photography and video),
- iv) Examine population structure using genetic analysis,
- v) Determine critical habitat and environmental preferences using sighting information, at-sea research and satellite imagery,
- vi) Investigate movements at regional and oceanic scales using aerial surveys, electronic telemetry (sonic tags, satellite pop-off) and mapping to determine if individuals represent a resident or transient population, or both, and to examine potential threats to migratory behavior,
- vii) Determine relationships of abundance, distribution, and movement patterns with oceanic features and localized productivity events using at-sea research and satellite imagery,
- viii) Identify food sources and feeding grounds through zooplankton and nektonic sampling during observed feeding events, and
- ix) Investigate the association of pelagic fishes with whale sharks through the identification and examination of associated fishes (size range, reproductive condition and stomach contents) and an investigation of the ecological processes in areas where whale sharks and fishes form foraging assemblages.

Initiation of Phase I Activities

Access to information pertaining to future whale shark sightings and encounters is critical to the development of a sightings database and to future whale shark research. In response to this need and in an effort to initiate Phase I activities, we recently developed a succinct sightings questionnaire which is available at http://www.usm.edu/gcrl/whaleshark_survey and by hard copy distribution. We are in the process of notifying offshore fishers (recreational and commercial), oil and gas industry personnel, divers, dive boat operators, scientists, and others of its availability and the need for sightings information. Responders can provide information to us by completion of the electronic or paper version of the questionnaire. We will assess the relative value of submitted information as being from either log entry, other documentation or memory. Information greater than two years old will not be included in the database unless sufficient documentation of its validity is provided.

PRELIMINARY FINDINGS

A brief survey conducted by us generated several sightings for 2003 and 2004, the majority of which occurred in areas where whale sharks were historically observed by the U.S. NOAA Fisheries, Marine Mammals Aerial Surveys (W. Driggers, Per. comm.). Many sightings were in offshore waters in the vicinity of the Mississippi River Delta. The majority of sightings involved single whale sharks swimming at the surface, but aggregations were also observed. Whale sharks were observed within the northcentral GOM throughout the year, but most sightings occurred during summer. Because our preliminary data are based on a limited number of opportunistic sightings, we have no insight into whether whale sharks are transients in the northcentral GOM or comprise a resident population. Based on reported estimated sizes, both juvenile and adult sharks occur in the northcentral GOM, suggesting that the area may be an important nursery area. Our data show that pelagic fishes associate with whale sharks in the northcentral GOM, including several species of tuna. We will continue to collect baseline data using the sightings questionnaire and will report detailed findings in future publications.

ACKNOWLEDGMENTS

We thank offshore recreational anglers (J. Roberson, S. Schindler, N. Friedlander, M. Thomas, T. Lipps, B. Lewis, B. Lezina, S. Smith, D. Garstecki, R. Gremillion and R. Howland) and petroleum platform personnel (T. Flowers) for reports of recent whale shark sightings. We are grateful to W. Driggers and K. Mullin, NOAA Fisheries, Mississippi Laboratories, Pascagoula, USA, for data on whale shark sightings collected during marine mammal aerial surveys conducted in the GOM. Regan Hoffmayer provided immeasurable help and guidance during development of the sightings questionnaire. We thank T. Phan for website development and G. Sanchez for Spanish translation. We acknowledge G. Parsons, D. Stanley and S. Diamond who share with us an interest in initiating a whale shark research program for the

northern GOM. This paper was made possible, in part, by support from the GCRL Sargassum Research Project (funded by the Mississippi Department of Marine Resources and the U.S. Fish & Wildlife Service, Sport Fish Restoration Program) and the GCRL Pelagic Fisheries Research Program.

LITERATURE CITED

- Baughman, J.L. 1955. The oviparity of the whale shark, *Rhincodon typus*, with records of this and other fishes in Texas waters. *Copeia* **1955**:54-55.
- Childs, J., C.M. Burks, K.D. Mullin, and J. Hewitt III. 2000 (Abst.). The occurrence and distribution of the whale shark (*Rhincodon typus*) in the northern Gulf of Mexico. Whale Shark Symposium, American Elasmobranch Society, Annual Meeting, La Paz, Mexico, June 2000.
- Clark, E. and D.R. Nelson. 1997. Young whale sharks, *Rhincodon typus*, feeding on a copepod bloom near La Paz, Mexico. *Environmental Biology of Fishes* **50**:63-73.
- Colman, J.G. 1997. A review of the biology and ecology of the whale shark. *Journal of Fish Biology* **51**:1219-1234.
- Cropp, B. 1978. *Shark Hunters*. Harrowood Books, New York, New York USA..
- Eckert, S.A. and B.S. Stewart. 2001. Telemetry and satellite tracking of a whale sharks, *Rhincodon typus*, in the Sea of Cortez, Mexico, and the north Pacific Ocean. *Environmental Biology of Fishes* **60**:299-308.
- Franks, J.S. 2000. Pelagic fishes at offshore petroleum platforms in the northern Gulf of Mexico: diversity, interrelationships, and perspective. *Colloque Caraïbe, Actes de Colloques Ifremer. Aquatic Living Resources* **13**(4):502-515.
- Gaertner, D. and M. Medina-Gaertner. 1999. An overview of the tuna fishery in the southern Caribbean Sea. Pages 66-86 in: M.D. Scott, W.H. Bayliff, C.E. Lennert-Cody, and K.M. Schaefer (eds.). *Proceedings of the International Workshop on the Ecology and Fisheries for Tunas Associated with Floating Objects*. February 1992. Inter-American Tropical Tuna Commission Special Report 11. La Jolla, California USA.
- Graham, R.T. and C.M. Roberts. 2003 (Abst.). Patterns of movement and site fidelity of whale sharks on the Mesoamerican barrier reef. 6th Congress on Marine Sciences, MarCuba 2003, Havana, Cuba.
- Gudger, E.W. 1941. The food and feeding habits of the whale shark (*Rhineodon typus*). *Journal of the Elisha Mitchell Science Society* **57** (1):57-72.
- Heyman, W., R. Graham, B. Kjerfve, and R.E. Johannes. 2001. Whale sharks *Rhincodon typus* aggregate to feed on fish spawn in Belize. *Marine Ecology Progress Series* **251**:275-282.
- Iwasaki, Y. 1970. On the distribution and environment of the whale shark, *Rhincodon typus*, in skipjack fishing grounds in the western Pacific Ocean. *Journal of the Collections Marine Science Technology, Tokai University* **4**:37-51.

-
-
- Pai, M.V., G. Nandakumar, and K.Y. Telang. 1983. On a whale shark, *Rhineodon typus* Smith, landed at Karkar, Karnataka. *Indian Journal of Fisheries* **30**:157-160.
- Springer, S. 1957. Some observations on the behavior of schools of fishes in the Gulf of Mexico and Adjacent waters. *Ecology* **38**:166-171.
- Silas, E.G. 1986. The whale shark (*Rhincodon typus* Smith) in Indian coastal waters: is the species endangered or vulnerable? Marine Fisheries Information Service, Technical and Extension Series 66, 1-19.
- Taylor, G. 1994. Whale sharks, the giants of Ningaloo Reef. Sydney: Angus and Robertson.
- Taylor, G. 1996. Seasonal occurrence, distribution and movements of the whale shark, *Rhincodon typus*, at Ningaloo Reef, western Australia. *Marine and Freshwater Research* **47**, 637-42.
- Whale Shark News. 2001. Newsletter of the UK Darwin Initiative, University of York, **1**(1):1-6.
- Wintner, S.P. 2000. Preliminary study of vertebral growth rings in the whale shark, *Rhincodon typus*, from the east coast of Africa. *Environmental Biology of Fishes* **59**:441-451.
- Wolfson, F.H. 1986. Occurrences of the whale shark, *Rhincodon typus*, Smith. Indo-Pacific Fish Biology: Pages 208-226 in: T. Uyeno, R. Arai, T. Taniuchi, and K. Matsuura (eds.). *Proceedings of the Second International Conference on Indo-Pacific Fishes*. Ichthyological Society of Japan, Tokyo, Japan.