30 October 2008

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Final Report

Award Number:	RF 07-16
Project Title:	Abundance, Distribution and Biology of Sharks and Rays in Chesapeake Bay and Virginia's Coastal Lagoons: Continuation of a Long-term Monitoring and Research Program
Recipient:	Virginia Institute of Marine Science
Principal Investigators:	R. Dean Grubbs, Ph.D. John A. Musick, Ph.D.
Award Period:	1 June 2007 to 31 May 2008
Period Covered by this Report:	1 June 2007 to 30 September 2008

This report summarizes the progress for project RF 07-16: Abundance, Distribution and Biology of Sharks and Rays in Chesapeake Bay and Virginia's Coastal Lagoons: Continuation of a Long-term Monitoring and Research Program. The stated objectives of the study were to:

1. continue the VIMS fishery-independent longline survey to monitor abundance of sharks using Chesapeake Bay and lagoons along Virginia's Eastern Shore and to provide vital biological data needed for continued management of dominant species,

2. continue juvenile sandbar shark tagging program to examine long-term movements, degree of site fidelity, and occurrence of philopatry while in the Chesapeake Bay nursery and during migrations to and from wintering areas,

3. continue to monitor trends in age, size, and sex composition of juvenile sandbar sharks in the nursery areas and examine the effects of recent management efforts on existing juvenescence trends in Chesapeake Bay and in Virginia coastal waters,

4. continue tracking studies to determine the distribution and habitat use of sharks and rays in coastal lagoons along Virginia's Eastern Shore,

5. complete the aging study comparing life history parameters of sandbar sharks before and after overexploitation to determine the biological potential for sustainability, and

6. complete genetics projects including investigations of philopatry and effective population size of adult female and juvenile sandbar sharks using Chesapeake Bay and Eastern Shore lagoons.

Objectives 1-2 : During the contract period, four standard research cruises were conducted aboard the Research Vessel Bay Eagle (18-21 June, 18-20 July, 6-8 and 15-16 August, 12-13 and 24-25 September). A total of 42 longline sets in Virginia estuarine and coastal waters fished a total of 3,840 standard 9/0 J-hooks and 1,190 smaller circle hooks. The smaller circle hooks have higher catchability and lower mortality for juvenile sharks. In addition, a total of 107 ancillary longline sets were made in coastal waters, lagoons, flats, and tidal creeks along the Eastern Shore of Virginia (primarily in the Hog Island Bay system). These sets fished 7,867 circle hooks. The catch from all sampling included more than 1,094 sharks from 16 species and 286 batoids (skates and rays) from seven species. Of these, approximately 800 sharks and 80 rays were tagged. Nearly one-half of the sharks caught (N=528) were sandbar sharks. Nearly 6,000 sandbar sharks have now been tagged by VIMS since 1995 and about 120 of these have been reported as recaptured. Tagged sandbar sharks have been recaptured up to ten years after tagging and as far away as Port Aransas, Texas in the Gulf of Mexico. Sandbar sharks have been recaptured in Virginia waters as much as six years after tagging. During the contract period two publications based on our long term-monitoring and tagging programs were published by the American Fisheries Society, one on spatial delineation of summer nurseries for sandbar sharks in Chesapeake Bay (Grubbs and Musick,2007), and the other on long-term movements,migration,and habitat definition for juvenile sandbar sharks in Chesapeake Bay (Grubbs et.al. 2007) (See Appendix 1.).

Objective 3: Current catch data were examined and compared with historical data to examine trends in age, size, and sex composition of juvenile sandbar sharks in the Virginia nursery areas. These trends were similar to those observed over the past decade with sharks 70 cm pre caudal length (PCL)or less dominating catches, and only the first three year-classes represented. Historical catches in the nurseries included up to five or six year-classes .Sex composition in these younger year classes also remained close to 50/50. Our research has not shown signs that the sandbar shark population is recovering from overfishing even after 15 years of management by the National Marine Fisheries Service (NMFS). Indeed in August 2008 NMFS declared the sandbar shark a protected species, and restricted the bottom longline fishery for sharks to a small number of "research" vessels. Also the Atlantic States Marine Fisheries Commission (ASMFC) adopted an Interstate Coastal Shark Management Plan which closed state waters from Virginia to New Jersey from May15-July15 to protect pregnant and pupping sandbar sharks. The P.I.(Musick) chaired the ASMFC Technical Committee that developed the FMP.

Objective 4: The coastal lagoons of Virginia provide a source of protection and food for many migratory elasmobranchs. Previous studies have examined the importance of these lagoons for sandbar sharks as a nursery. Little research has been conducted on the batoids and other sharks that inhabit the region. These lagoons have distinct environmental gradients with regards to sediment types and concurrent fauna, temperature regimes and tidal influences. Habitat use and movements of elasmobranches may vary according to these variables. VIMS scientists are currently studying the abundance and distribution of the rays and sharks that inhabit the region. Vemco VR2 receivers were deployed in early June throughout the lagoon system and inlets along Virginia's Eastern Shore in order to assess habitat use by the bluntnose stingray, the southern stingray, and the spiny butterfly ray. A total of 42 Vemco VR2 acoustic receivers were deployed throughout the Wachapreague lagoon systems. This array monitored the movement of 12 spiny butterfly rays, one smooth butterfly ray, and seven southern stingrays implanted with Vemco acoustic transmitters. Vemco receivers were also deployed at Quinby and Machipongo Inlets to determine if previously implanted southern and bluntnose stingrays exhibit philopatry within the lagoons. In addition, multi-year transmitters were implanted into six adult female sandbar sharks to examine philopatry of the adult females. Among the most significant results, three of five bluntnose stingrays implanted with transmitters in 2006 returned to Hog Island Bay in 2007, but none of the five southern stingrays tagged in 2006 have been detected in the receiver array in 2007..Also an adult female sandbar shark captured on the barrier island pupping grounds and tagged with a sonic transmitter in 2006 returned in 2008, presumably to pup again . This is the first time that direct evidence of a two year reproductive pattern has been shown for this species and the first time that female philopatry to a pupping area has been confirmed. Results of the batoid study are in preparation and will be completed as an MS thesis by Joshua Smith in December 2008. In addition during the contract period two peer-reviewed papers were published on habitat utilization and movements of juvenile sandbar sharks from the Eastern Shore nursery, one on a delineation of the nursery based on longline suveys, and sonic tracking (Conrath and Musick,2007a), and the other on over-wintering grounds ,based on satellite tracking (Conrath and Musick,2007b). (See Appendix 2)

Objective 5: VIMS scientists completed the sandbar shark aging study (based on vertebral analysis) to compare growth rates for sharks collected prior to population depletion (1980-1981) to those collected following depletion (2001-2005). Growth curves generated for samples from the two time periods were significantly different, suggesting that compensatory growth in response to depressed population levels was occurring. Few studies have reported such findings in long-lived elasmobranchs. More importantly, the faster growth rates observed resulted in sharks achieving size at maturity at an earlier age. This shift in a basic demographic parameter has a significant effect on the population models upon which management is based, and the new parameters will be used in the next NMFS stock assessment Also, VIMS tag returns have yielded sufficient data to estimate sandbar shark growth rates through length-based growth models. Growth estimates from tagging models yielded similar results to growth estimates produced via age-based models. This is the first time this has been accomplished for the sandbar shark within the Northwest Atlantic. . The findings of this research were presented in a PhD. dissertation completed in 2008 (Romine 2008) and are being prepared for submission for publication.. .(See Appendix 3)

Objective 6: VIMS sandbar shark genetics studies to determine effective population size and philopatry waere completed in a PhD. dissertation in 2008 (Portnoy 2008). A total of 902 sandbar sharks across five cohorts (2002-2006) were genotyped at eight polymorphic microsatellite loci. We calculated the effective number of breeders (N_b) and effective size $(N)_e$ for adults utilizing two of these nursery grounds, the lagoons of the Eastern Shore of Virginia and, Delaware Bay, by genotyping 902 animals across five cohorts (2002-2006) at eight polymorphic microsatellite loci. Effective size estimates were then compared to estimates of census size (N_c) of the 2004, 2005 and 2006 cohorts obtained from Delaware Bay. The N_e/N_c ratio was 0.45 or higher whether the Delaware Bay cohorts were considered as distinct year classes or combined. This finding is in sharp contrast to the N_e/N_c ratios found in other exploited marine species, which are usually several orders of magnitude smaller. Instead the N_e/N_c ratio of sandbar sharks is similar to that found in many marine and terrestrial mammals. The close coupling of census and effective size observed in the sandbar shark suggests that intense fishing may have a more direct detrimental impact on adaptive genetic variance in this and other shark species than it does in bony fishes.

Female sandbar sharks may be philopatric and have a two year reproductive cycle, but the level of fidelity to nursery grounds and the regularity of the reproductive cycle have not been verified. To this end, genetic data comprised of microsatellite genotypes and mitochondrial control region sequences were analyzed to look for patterns consistent with female philopatry to the), Eastern Shore Lagoons of Virginia (ES), Chesapeake Bay (CB), and Delaware Bay (DEL). A total of 676 juveniles from the three nurseries and 40 adults captured in and around the nurseries, were genotyped at the same eight microsatellite loci. In addition, the mitochondrial (mtDNA) control region was amplified and sequenced for a sub-sample of 154 juveniles. Pairwise F statistics were then calculated using the microsatellite and mtDNA data to look for patterns consistent with female philopatry. In addition, the microsatellite genotype arrays, from ES and CB, were screened for the presence of kin groups within nurseries across years. Periodicity was then assessed by looking for temporal patterns in the detection of these kin groups using the program Colony 1. Neither analysis detected evidence of strict female philopatry. The failure of the pairwise comparisons between nursery areas to detect significant mtDNA differentiation could be due to small levels of female straying or an insufficient amount of time for lineage sorting to occur in, factors that do not preclude female philopatry. It may also be that while most females exhibit strict philopatry, some change nursery grounds either during the while adults, juveniles or at first reproduction. There is reason to believe, however, that even if female philopatry was strict and there is no straying, that comparisons of mtDNA and nuclear data might still fail. When the number of generations since isolation is less than $N_{f(e)}$, daughter populations are likely to show extensive genealogical polyphyly. Since the nursery grounds in question are very geologically young (~ 10,000 years old), if sandbar sharks have a generation time of 20 years then the long term N_{ef} would have to be less than 500 for nursery grounds to appear monophyletic. (See Appendix 4).

The VIMS Shark Ecology Program represents one of the most productive elasmobranch research programs in the world and includes the primary long-term fishery-independent survey of shark abundance on the East Coast of the United States. Saltwater Recreational License funding by the Virginia Marine Resources Commission has allowed this critical program to continue. The data collected by this program monitoring coastal shark stocks have been

important in recent state and federal management decisions concerning over-exploited stocks of large coastal sharks. Information derived from the habitat, age and growth, and genetics studies will provide critical data for use in stock assessments and development of management plans.