Workshop Background Materials: Chesapeake Bay Information (w/ abstracts)

Cownose Rays in the Chesapeake Bay: What do we know?

Thursday, October 22nd, 2015
National Aquarium, Baltimore, MD

Age, Growth and Reproduction (pg. 1-3)
Diet Studies (pg. 3-5)
Population Dynamics (pg. 5-8)
Habitat Interactions (pg. 9)
Workshop and Marketing in Virginia (pg. 9)
Shellfish Predation Deterrents (pg. 10)

Age, Growth and Reproduction

Fisher, R.A. 2010. Revised 2012. Life history, trophic ecology, & prey handling by cownose ray, Rhinoptera bonasus, from Chesapeake Bay. Final Report to NOAA Chesapeake Bay Office for (NA07NMF4570324) Grant No. 713031. Link

Executive Summary
Concerns over predation on commercial bivalve resources have been raised by fishery and aquaculture operations for many years and in several regions of the world. However, little evidence of actual predation on these resources has been documented and little is known about cownose ray biology and population that could be used to manage a fishery. As a member of elasmobranchs fishes, cownose ray pose significant fishery management concerns: late age at sexual maturity, low fecundity, and long gestation. In addition to these biological constraints, demographic, social behavior, and trophic ecology characteristics of cownose ray subjected to a commercial fishery could impact management decisions. This study aimed to document the age and growth and predation for cownose ray (*Rhinoptera bonasus*), the western Atlantic species of ray, focusing on the population that utilizes the Chesapeake Bay for pupping and mating during summer months.

Fisher, R.A., G.C. Call and J.R. McDowell. 2014. Reproductive variations in cownose rays (*Rhinoptera bonasus*) from Chesapeake Bay. Environmental Biology of Fishes 97(9): 1031-1038. DOI: 10.1007/s10641-014-0297-9

Abstract: The cownose ray, Rhinoptera bonasus, a K-selected species in Chesapeake Bay is subject to an unregulated fishery with no management plan in place. Understanding the reproductive potential for cownose ray is important for successful conservation and management. This study marks the first observation of multiple embryos and right uterus functionality. Eight instances of multiple embryos in cownose rays are reported; two sets of twin live births from captive rays and six separate in utero multiple embryos discovered during necropsy of fishery-dependent and -independent samples. All multiple embryos were in the left uterus. Live births in captivity were confirmed as two sets of twins through direct sequencing of a portion of the mitochondrial DNA and analysis of nuclear microsatellite loci from the newborn pups and putative mothers. In addition, first- and third- quarter term embryos were removed from the right uterus of two female rays during necropsy, marking the first reports of gestation in the right oviduct of cownose rays. The recovery of a three-quarter term albinistic cownose ray embryo through necropsy is also reported.

Fisher, R.A., G.C. Call and R.D. Grubbs. 2013. Age, Growth, and Reproductive Biology of Cownose Rays in Chesapeake Bay. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 5: 224-235. DOI: 10.1080/19425120.2013.812587

Abstract: The Cownose Ray Rhinoptera bonasus is an opportunistic predator of benthic invertebrates and has had a long history of negative interactions with commercial shellfish industries. Most recently, Cownose Rays have been implicated in negatively affecting the recovery of bay scallop Argopecten irradians stocks in North Carolina and oyster restoration and commercial aquaculture efforts in Chesapeake Bay. A mitigation attempt to decrease predation on shellfish has resulted in an unregulated fishery for Cownose Rays. Cownose Ray life history suggests that they are highly susceptible to overexploitation. We determined age, growth, and size at maturity for Cownose Rays collected in Chesapeake Bay. In total, 694 rays were used for the study: 246 males ranging in size from 30.0 to 98.0 cm disc width (DW) and 448 females ranging from 30.0 to 110.5 cm DW. The oldest individual observed was a female (107 cm DW) estimated at age 21. Our data suggested that Cownose Rays grow considerably faster during the first few years than has been previously reported, thus producing higher estimates of the growth coefficient k. The best-fit growth models (three-parameter von Bertalanffy models) estimated k-values of 0.2741 for males and 0.1931 for females. The large sample size and inclusion of many older animals (n = 119 rays over age 10) resulted in theoretical maximum size estimates that matched the observed sizes well. The median size at 50% maturity was 85–86 cm DW for males and females (corresponding to ages of ~6–7 for males and ~7–8 for females). Fecundity in Cownose Rays was typically one embryo per mature female, with a gestation period of 11–12 months. Our study confirms that the Cownose Ray is a K-selected species with late maturity, long gestation, and low reproductive potential, indicating that it could be highly susceptible to overexploitation.

Smith, J.W. and J.V. Merriner. 1986. Observations on the Reproductive Biology of the

Cownose Ray, *Rhinoptera bonasus*, in Chesapeake Bay. Fishery Bulletin 84(4). Link

Abstract: Cownose rays, *Rhinoptera bonasus* , are abundant in Chesapeake Bay during summer. We made observations on the reproductive biology of specimens collected primarily from commercial pound nets and haul seines from May through October 1976-78. Clasper development suggested that males began to mature at disc widths (DW) of 75-85 cm. Males judged as mature averaged about 90 cm DW. Macroscopic inspection of the oviducts suggested that females began to mature at 85-92 cm DW. Females judged as mature averaged 96 cm DW. Only the left reproductive tract in female cownose rays appeared functional and only one embryo per gravid female was observed. A total of 67 embryos ranging 18-440 mm DW were collected and the sex ratio of the embryos was 1:1. Gravid females carried three-quarter term embryos in May and parturition occurred in late June and July. Full-term embryos averaged about 40 cm DW. Gestation of another group of embryos began by August. Growth of these embryos was rapid and they were relatively large when cownose rays left the Chesapeake Bay in October. Cownose rays exhibited aplacental viviparity. Yolk reserves supplied the initial energy demands of the embryos (up to about 20 cm DW), but histotrophic secretions of uterine villi provided nutrition for the young through the remainder of gestation.

Diet Studies

Bade, L.M., C.N. Balakrishnan, E.M. Pilgrim, S.B. McRae and J.L. Luczkovich. 2014. A genetic technique to identify the diet of cownose rays, *Rhinoptera bonasus*: analysis of shellfish prey items from North Carolina and Virginia. Environmental Biology of Fishes 97(9): 999-1012. DOI: 10.1007/s10641-014-0290-3

Abstract: Cownose rays are implicated in the consumption of commercially important shellfish on the U.S. East Coast. We tested this assumption by developing a molecular technique for species identification from cownose ray gut contents. Digestive tracts sampled from 33 rays in Pamlico Sound, NC and Chesapeake Bay, VA contained pieces of partially-digested tissue, well-digested tissue, fluid, and minute shell fragments which made visual identification to the species level nearly impossible. We sequenced the cytochrome oxidase subunit I (COI) for seven locally acquired bivalve species, chosen for their commercial and ecological importance in NC and VA. Sequences were used to design species-specific primers for each bivalve species to amplify polymerase chain reaction (PCR) products. We designed primers such that PCR products were sufficiently different in size to be distinguishable from one another when resolved on an agarose gel, and multiplexing of several species in one reaction was possible. Digestive tract sample testing revealed that cownose rays in Chesapeake Bay ate stout tagelus and soft shell clams. There was no evidence of the rays in the study consuming commercially important oysters, hard clams, and bay scallops. Further sampling over an extended period of time and additional locations is required to confirm these results. Our diagnostic tests could easily be expanded to elucidate the impact of cownose ray predation on prey populations.

Fisher, R.A. 2010. Revised 2012. Life history, trophic ecology, & prey handling by cownose ray, Rhinoptera bonasus, from Chesapeake Bay. Final Report to NOAA Chesapeake Bay Office for (NA07NMF4570324) Grant No. 713031. Link

Executive Summary
Concerns over predation on commercial bivalve resources have been raised by fishery and aquaculture operations for many years and in several regions of the world. However, little evidence of actual predation on these resources has been documented and little is known about cownose ray biology and population that could be used to manage a fishery. As a member of elasmobranchs fishes, cownose ray pose significant fishery management concerns: late age at sexual maturity, low fecundity, and long gestation. In addition to these biological constraints, demographic, social behavior, and trophic ecology characteristics of cownose ray subjected to a commercial fishery could impact management decisions. This study aimed to document the age and growth and predation for cownose ray (*Rhinoptera bonasus*), the western Atlantic species of ray, focusing on the population that utilizes the Chesapeake Bay for pupping and mating during summer months.

Fisher, R.A., G.C. Call and R.D. Grubbs. 2011. Cownose Ray (*Rhinoptera bonasus*) Predation Relative to Bivalve Ontogeny. Journal of Shellfish Research 30(1): 187-196. DOI: http://dx.DOI.org/10.2983/035.030.0126

Abstract: The purpose of this study was to determine the ability of the cownose ray, Rhinoptera bonasus (Mitchill, 1815), to manipulate oysters and clams, to test for relative prey preference, and to investigate whether susceptibility to cownose ray predation changes with bivalve ontogeny. We investigated patterns of predation for captive adult and young-of-year cownose rays on 4 species of bivalves, including Crassostrea virginica (Gmelin, 1791), Crassostrea ariakensis (Fujita, 1913), Mercenaria mercenaria (Linnaeus, 1758), and Mya arenaria Linnaeus, 1758. In oyster (C. virginica) trials, predation probabilities by adult rays were highest at shell heights of 30–70 mm and shell depths of 8–22 mm. The rates of predation by adult rays in trials in which samesize oysters were used were higher than rates in most comingled trials. Adult rays showed no differences in predation between native oysters (C. virginica) and nonnative oysters (C. ariakensis; $P > 0.05$). Adult rays selected hard- and soft-shell clams (Manly-Chesson index M. mercenaria, $\alpha = 0.736 \pm 0.002$, electivity $= 0.473 \pm 0.007$; M. arenaria, $\alpha = 0.742 \pm 0.003$, electivity $= 0.485 \pm 0.013$) over oysters (C. virginica, $\alpha = 0.263 \pm 0.002$, electivity $= -0.473 \pm 0.007$; $\alpha = 0.257 \pm 0.003$, electivity $= -0.485 \pm 0.003$). In young-of-year feeding trials, oysters with a shell height of 10–35 mm and a shell depth of 3–12 mm had the highest probability of predation. Native oyster and hard clam peak force or load crush tests resulted in forces of 200–1,500 N and 400–1,400 N across shell depths of 10–35 mm and 21–34 mm, respectively, before valve failure. The results of this study indicate that cownose ray predation on shellfish is limited by shell size and is likely related to ray jaw gape and bite force.

Kolmann, M.A., D.R. Huber, P.J. Motta and R.D. Grubbs. 2015. Feeding biomechanics of the cownose ray, Rhinoptera bonasus, over ontogeny. Journal of Anatomy 227(3): 341-351. DOI: 10.1111/joa.12342

Abstract: Growth affects the performance of structure, so the pattern of growth must influence the role of a structure and an organism. Because animal performance is linked to morphological specialization, ontogenetic change in size may influence an organism's biological role. High bite force generation is presumably selected for in durophagous taxa. Therefore, these animals provide an excellent study system for investigating biomechanical consequences of growth on performance. An ontogenetic series of 27 cownose rays (Rhinoptera bonasus) were dissected in order to develop a biomechanical model of the feeding mechanism, which was then compared with bite forces measured from live rays. Mechanical advantage of the feeding apparatus was generally conserved throughout ontogeny, while an increase in the mass and cross-sectional area of the jaw adductors resulted in allometric gains in bite force generation. Of primary importance to forceful biting in this taxon is the use of a fibrocartilaginous tendon associated with the insertion of the primary jaw adductor division. This tendon may serve to redirect muscle forces anteriorly, transmitting them within the plane of biting. Measured bite forces obtained through electrostimulation of the jaw adductors in live rays were higher than predicted, possibly due to differences in specific tension of actual batoid muscle and that used in the model. Mass-specific bite forces in these rays are the highest recorded for elasmobranchs. Cownose rays exemplify a species that, through allometric growth of bite performance and morphological novelties, have expanded their ecological performance over ontogeny.

Smith, J.W. and J.V. Merriner. 1985. Food habits and feeding behavior of the cownose ray, *Rhinoptera bonasus*, in lower Chesapeake Bay. Estuaries 8(3): 305-310. DOI: 10.2307/1351491

Abstract: The most important food item of the cownose ray,Rhinoptera bonasus, in the Virginian tributaries of lower Chesapeake Bay is the soft shell clam,Mya arenaria. The Baltic macoma,Macoma balthica, ranks a distant second. Adult rays feed on deep burrowing mollusks, juveniles on shallow- or non-burrowing bivalves. Foraging schools of rays invade tidal flats during the flood tide. Stirring motions of the pectoral fins combined with suction from the expansive orobranchial chamber are probably used to excavate deep burrowing bivalves.

Population Dynamics

Blaylock, R.A. 1993. Distribution and abundance of the cownose ray, Rhinoptera bonasus, in lower Chesapeake Bay. Estuaries 16(2): 255-263. DOI: 10.2307/2F1352498

Abstract: Aerial surveys were conducted in the lower Chesapeake Bay during 1986–1989 to

estimate abundance and examine the distribution of the cownose ray,Rhinoptera bonasus, during its seasonal residence, May–October. Most of the survey effort was concentrated in the lower and mid-bay regions. Cownose rays appeared uniformly distributed across the bay during mid-summer, but were more abundant in the eastern portion of the bay during migration. North-south distribution varied and reflected the general seasonal migration pattern. Mean abundance increased stepwise monthly from June through September and declined dramatically in October with their emigration from the bay. Abundance estimates from individual surveys varied. The greatest range of individual survey abundance estimates occurred in September (0–3.7×10^7 cownose rays) due to high variation in school size and abundance between surveys. Monthly mean cownose ray abundance ranged from 0 in May and November to an estimated maximum of 9.3×10^6 individuals in September. The magnitude of the population suggests that the cownose ray plays an important role in the trophic dynamics of the Chesapeake Bay ecosystem. The historical data were insufficient to determine whether the population has increased, but these surveys provided the baseline data which would allow future investigation of cownose ray population dynamics in lower Chesapeake Bay.

Carney, S.I., D.M. McVeigh, J.B. Moss, M.D. Ferrier, and J.F. Morrissey. In review. Preliminary investigation of mitochondrial genetic variation in the cownose ray Rhinoptera bonasus from the Chesapeake Bay and Gulf of Mexico. Submitted to the Journal of Fish Biology.

Abstract: The aim of this study was to preliminarily assess levels of genetic variation of *R. bonasus* in the Chesapeake Bay and one region of the Gulf of Mexico. Mitochondrial haplotypes of rays collected from four locations (three in the Chesapeake Bay and one from the Gulf of Mexico) were identified and their frequencies compared between sites to begin to gain insight into this species' patterns of movement and potential population structure. By examining genetic variation in mitochondrial cytochrome oxidase I and cytochrome b, we identified a total of 6 polymorphic nucleotides and 14 haplotypes. The haplotype frequencies from the three sites in the Chesapeake Bay show that genetic variation is not uniformly distributed. Haplotype frequencies between relatively close Chesapeake sites (Mechanicsville and St. George) were more distinct than between those that are farthest apart (Mechanicsville and Reedville), suggesting that, upon their annual migratory return, individuals may use different areas of the Bay to forage, pup, and mate. However, further genetic and tagging studies are needed to conclusively determine the degree of philopatry exhibited by this species.

Fisher, R.A and J.R. McDowell. 2014. Discrimination of Cownose Ray, Rhinoptera bonasus, Stocks Based on Microsatellite DNA Markers. Final Report to NOAA Chesapeake Bay Office for (NA11NMF4570215) Link

Overview: The objective of the project was to develop and use microsatellite DNA markers to discriminate stocks of the cownose ray, Rhinoptera bonasus. The specific pbjectives that were approved were to collect neonate and/or pregnant female cownose rays from the Chesapeake Bay and the Gulf of Mexico; create a suite of molecular markers specific to cownose rays;

screen these new markers for reliability and variability in the cownose ray; and analyze cownose ray samples collected from the nursery groups in the Chesapeake bay and Gulf of Mexico to look for evidence of stock structure and to get baseline estimates of genetic diversity.

Grusha, D. S. 2005. Investigation into the life history of the Cownose Ray, *Rhinoptera bonasus*, (Mitchill 1815). Master's thesis. Virginia Institute of Marine Science, College of William and Mary, Gloucester Point. Link

Abstract: The primary goal of this research project was to further the understanding of the population biology of the cownose ray, Rhinoptera bonasus. The life history of the cownose ray has been well studied in the Chesapeake Bay, which serves as a primary nursery for young-of-year pups during the summer months. Studying the fall migration and identifying the wintering grounds of adult female rays were the focus of this study. Cownose rays were tracked with Pop-up Satellite Archival Tags (PSATs). PSATs were designed for tracking large pelagic fish in open ocean environments. To optimize the chances of success using this technology, several preliminary studies were undertaken prior to tag deployment. The forces of drag and lift exerted by a PSAT on a study animal were quantified. Published metabolic rates for related species were then used to estimate the energy cost of carrying a PSAT to a cownose ray. For a given velocity, the power required to carry a PSAT was compared to the swimming power expressed as a percentage, Tag Altered eXertion (%TAX). Based on a %TAX of less than 5%, the minimum size cownose ray suitable for tagging with a PSAT was determined to be 14.8 kg. Fish anesthetics were also studied to sedate the rays for optimal tag attachment and for examination to determine tolerance of various attachment devices. Eugenol was compared to tricaine methanesulfonate (MS-222) in a study conducted at the National Aquarium in Baltimore. Eugenol at 50 mg/l was found to be the dosage most comparable to MS-222 at 100 mg/l, but eugenol at 25 mg/l was also useful for lighter sedation and recovery times were shorter with the lower dose. Eugenol at 25 mg/l was used to sedate rays for tag deployment in the field. Several tag attachment techniques were evaluated on live cownose rays in a holding tank. A metal dart tag applied to the posterior medial pectoral fin and secured beneath the radial cartilages supporting the fin was the most satisfactory method. Seven adult female cownose rays were tagged with PSATs in the lower Chesapeake Bay in early September 2003. The tags were programmed to release and begin data transmission after six months. Data collection by the tags was excellent; however, data transmission was very poor. Three tags were found on Florida beaches and returned for download of archival data. Comparison of tag data to oceanographic sea surface temperature (SST) data and coastal bathymetry contours showed that the rays had very similar migratory behavior in terms of temperature and depth preferences. They moved from Chesapeake Bay down the South Atlantic Bight at a migration rate of approximately 6.7 NM/d arriving in southern Florida around late December. Based on SST comparisons, none of these rays migrated south of 27 °N. In contrast to the estuary based summer grounds, cownose rays remain off-shore during the winter months near the continental shelf break where it approaches the Florida coastline. The energy required for long-distance migration plus the stark contrast of the wintering grounds to the rays' summer

residence make a winter nursery unlikely.

Omori, K.L. 2015. Developing Methodologies for Studying Elasmobranchs and Other Data-Poor Species. Master's thesis. Virginia Institute of Marine Science, College of William and Mary, Gloucester Point. Link

Abstract: Fisheries have become increasingly important to manage and conserve, and this is particularly challenging for data-poor species. Elasmobranchs are commonly considered data-poor or data-limited species. Their life history characteristics make their populations susceptible to depletion from fishing pressures and habitat degradation. Thus, it is important to understand the movement patterns and habitat use of the targeted species as well as the models used in the stock assessment for the species. This thesis involves developing techniques and information for data-poor species, such as elasmobranchs. The objectives of this research were to 1) identify the wintering grounds for the cownose rays (*Rhinoptera bonasus*) from Chesapeake Bay, 2) determine summer and fall movement patterns for this species, and 3) understand how changes in the data input (i.e., catch and effort) affect the parameter estimates from a simple surplus production model.

Cownose rays have received negative attention in Chesapeake Bay for presumably heavy predation on commercial shellfish. Although the population size is unknown, there are concerns about the increase in abundance of this species, resulting in the need for management to control its population size. However, there are many questions regarding the movement patterns and habitat use for cownose rays, particularly for males. A total of 16 cownose rays in Chesapeake Bay were tagged with pop-up satellite archival tags (PSATs) to determine their wintering grounds and summer and fall movement patterns. Six tags (3 on females and 3 on males) were released on the programmed date and contained data on temperature, pressure (for depths) and light-level (for geolocations). The end locations from the satellite tags indicated that both sexes migrated to the coastal waters of central Florida for the winter. Females were exited Chesapeake Bay at the end of September and early October and migrated south to Florida. Males left the bay at the end of July and traveled northward to a second feeding ground in the coastal waters of southern New England. At the end of summer and early fall, the males made the southerly migration down the coast to Florida. There were no diel differences detected; however, male rays occupied a wider depth and temperature range compared to females.

Data-poor stocks are often regulated based on surplus production models when only catch and effort data are available. However, reported catch and effort rarely equal the true values. Reported data may not include bycatch, illegal fishing or local consumption, resulting in higher true catch and effort values than that reported. I used ASPIC (A Surplus Production Model Incorporating Covariates) software to examine the effects of underestimated catch and effort on parameter and ratio estimates (e.g., MSY, F/Fmsy and B/Bmsy) in a production model. Using three example fisheries, I determined that a fishery with constant underestimation of catch and effort over time can be managed based on the parameter estimates from the production model. The parameter estimates either yielded no errors or were underestimated by the same percentage as the underreported data; however, the ratios of parameter estimates were free of error due to cancellation of errors. Trends in underestimation of catch and effort

(e.g., improved reporting rates or increased illegal fishing) caused the errors in the estimates from the production model to be highly variable and scenario-dependent. Consequently, if underreporting of catch and effort is suspected, I would recommend conducting additional simulations specific to the fishery.

Patrick, Chris. 2015. "Tracking the Bay's cownose rays". Blog post. Smithsonian Environmental Research Center. Link

Researchers at the Smithsonian Environmental Research Center (SERC) are studying ray migration to determine if Chesapeake rays belong to a local, regional, or coast-wide population. Researchers from SERC's Fish and Invertebrate Ecology Lab and collaborators surgically implanted acoustic tags in 31 rays, mostly in Virginia, in summer 2014 to track their migration. They are tagging 20 to 25 more rays in summer 2015 from Maryland rivers. Four rays tagged and released from the VIMS pier in the York River last summer were recently heard back at the VIMS pier this summer, suggesting these rays returned to the same place they were the summer before. If this pattern continues, it may suggest the rays belong to regional or river-specific local populations, whose numbers could be more vulnerable.

Smith, J.W. and J.V. Merriner. 1987. Age and growth, movements and distribution of the cownose ray, *Rhinoptera bonasus*, in Chesapeake Bay. Estuaries 10(2): 153-164. DOI: 10.2307/1352180

Abstract: Ages were estimated for 115 of 899 cownose rays, Rhinoptera bonasus, collected primarily from commercial fishing gear, in lower Chesapeake Bay and vicinity from May through October, 1976-78. Age determinations were made using sectioned vertebral centra and estimates of von Bertalanffy parameters were for males DW = 119.2, K = 0.126, and to = -3.699, and for females DW, = 125.0, K = 0.119, and to = -3.764. Females attained a larger adult size and the oldest specimen aged was a female 13 years old and 107 cm disc width. Both sexes mature after reaching about 70% of their maximum size and ages at maturity were estimated at 5 to 6 years for males and 7 to 8 years for females. In spring migrating rays schooled by size; they arrived along the North Carolina coast by April and entered Chesapeake Bay by early May. Rays were abundant in the major Virginia tributaries of Chesapeake Bay throughout summer and occurred in salinities as low as 8% and at water temperatures between 15-29 °C. Size segregation continued during summer and adults schooled by sex. Most rays left Chesapeake Bay by early October.

Habitat Interactions

Orth, R. J. 1975. Destruction of eelgrass, *Zostera marina*, by the cownose ray, *Rhinoptera bonasus*, in the Chesapeake Bay. Chesapeake Science, 16(3), 205-208. DOI:

10.2307/1350896

Abstract: Destruction of Zostera beds in the York River, Virginia, is attributed to the digging activities of the cownose ray, Rhinoptera bonasus. The physically stable Zostera habitat with high faunal diversity and density was replaced by an unstable sand habitat with low faunal diversity and density.

Workshop and Marketing in Virginia

Fisher, R. (ed). 2009. Regional Workshop on Cownose Ray Issues Identifying Research and Extension Needs, Yorktown, VA, June 1-2, 2006. Virginia Sea Grant-09-06. VIMS Marine Resource Report 2009-06. Link

Introduction: The purpose of the Regional Workshop on Cownose Ray Issues was to provide research groups, regulatory agencies, and the fishing industry the opportunity to share information about the cownose ray issue in an attempt to consolidate future efforts. Historical and current information was presented about ray biology, predator control methods, ray impact on shellfish and SAV, ray harvesting and processing, and ray seafood product development. The potential to establish a responsible ray fishery was also addressed and research and extension needs for such a fishery were identified. Seafood marketing efforts for various ray products were highlighted with several ray products prepared by our collaborating culinary expert for sampling. The outcome of this regional workshop should be to provide a working reference for further research and extension efforts.

Fisher, R.A. 2012. Product Development for Cownose Ray. Final Report Submitted to the Virginia Marine Resources Commission. VIMS Marine Resource Report No. 2012-5. VSG-12-08. Link

Executive Summary: Various products from cownose ray were investigated within this project, from various human consumption products to bait for other fisheries. Collaborative efforts to demonstrate commodity use for the ray was performed between academia and various industries, including: fishing, seafood, pharmaceutical, pet food, and clothing. Products rendered for human consumption show tremendous potential, however, strong and effective consumer education together with dedicated commercial harvesting of ray is needed for products penetration into the various markets. Though cownose ray flesh maintains health-wise benefits of a low fat protein source, consumer acceptance of fish which deviates from the engrained idea that fish should be white and flaky, is paramount for ray market expansion. Likewise, without a sustainable supply of ray from a targeted or by-catch fishery, other viable ray product forms, as liver oil, cartilage, skin (leather), and bait markets will remain skeptical and hesitant to invest in products without consistent production. This project identified plausible markets for the cownose ray resource in the Chesapeake Bay, while also

complimenting other funded projects (Fishery Resource Grants and NOAA) researching ray utilization.

Shellfish Predation Deterrents

Fisher, R.A. and E.M. Stroud. 2006. An Evaluation of the Behavioral Responses of Rhinoptera bonasus to Permanent Magnets and Electropositive Alloys. VIMS Marine Resource Report No. 2006-12 VSG-06-14. Link

Introduction: The objective of this experiment was to determine if shark repellent technologies could be exploited to control cownose ray behavior. The potential use of these selective nonlethal repellent technologies involves the reduction of cownose Ray interactions with oyster beds in the Chesapeake Bay.

Mann, R, R.A. Fisher, M. Southworth, J. Wesson, A.J. Erskine and T. Leggett. 2014. Oyster planting protocols to deter losses to cownose ray predation. Final Report to NOAA Chesapeake Bay Office for (NA11NMF4570227). Link

Overview: The project focused on the value of shell overlays to oyster plantings as a ray predator deterrence mechanism. This was an academic/government/industry/non-profit collaboration wherein all parties began and ended the project with a singular commitment to stewardship of the Chesapeake Bay oyster resource for both ecological and economic purposes. The project addresses a critical issue, the potential loss of oysters to predation by cownose rays, in a controlled experimental design but at a scale commensurate with industry practices and large-scale restoration efforts.