Workshop Background Materials: Atlantic/Gulf Coast Studies (w/ abstracts)

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

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

Age, Growth and Reproduction

Neer, J. A. and B. A. Thompson. 2005. Life history of the Cownose Ray, Rhinoptera bonasus, in the northern Gulf of Mexico, with comments on geographic variability in life history traits. Environmental Biology of Fishes 73:321–331. Doi: 10.1007/s10641-005-2136-5

Synopsis: We determined age and growth, size at maturity, and fecundity for cownose rays, Rhinoptera bonasus, collected from the northern Gulf of Mexico. Vertebral age estimates ranged from 0+ to 18+ years for females and 0+ to 16+ years for males. Annual deposition of growth increments was verified with marginal increment analysis. Likelihood ratio tests indicated that the growth of the cownose ray was best described by a combined sexes Gompertz model. Median size at 50% maturity was determined to be 642 mm DW for males and 653 mm DW for females, or 4–5 years of age. Median pup size-at-birth was estimated to be 350 mm DW, with a gestation period of 11–12 months. In all cases, gravid females contained only one pup. Statistically significant differences were detected between growth curves for the Gulf of Mexico and the western Atlantic Ocean. Cownose rays in the Gulf of Mexico had lower estimates of DW_∞ and K, and a higher theoretical longevity than their conspecifics in the western Atlantic Ocean. Cownose rays in the Gulf of Mexico also attain maturity at a smaller size and earlier age than their counterparts in the western Atlantic Ocean.

Diet Studies

Ajemian, M.J. and S.P. Powers. 2012. Habitat-specific feeding by cownose rays (*Rhinoptera bonasus*) of the northern Gulf of Mexico. Environmental Biology of Fishes 95(1): 79-97. Doi: 10.1007/s10641-011-9858-3

Abstract: Past studies have suggested that increases in cownose ray (Rhinoptera bonasus) abundance may pose problems for fisheries management due to their specialized diet of exploitable mollusks.

However, more recent work has identified cownose rays as opportunistic generalists, consuming mainly non-commercial prey (e.g. soft-bodied invertebrates) most abundant in their locale. To better assess the generalist vs. specialist foraging behaviors of cownose rays, including their impact to commercial shellfish of the north-central Gulf of Mexico, we conducted gut content analysis on 201 individuals from coastal Alabama. Prey items were analyzed for frequency of occurrence and percent composition by weight, which were used to develop an index of importance. Our diet analysis indicated a minimal impact of cownose rays to exploitable shellfish species of coastal Alabama. Further, we observed important spatial and ontogenetic diet variability: adult diets were dominated by crustaceans along barrier islands and open waters of the Gulf of Mexico, whereas juvenile and young-of-the-year individuals almost exclusively consumed bivalves in riverine and estuarine areas. Individual cownose ray diets were primarily monotypic (54.3%) and appeared selective for amphipods (i.e. Haustorius sp.) when hyperabundant along gulf barrier islands and bivalves at estuarine sites regardless of ambient densities. While this study highlights the importance of locality in determining dietary composition of cownose rays, we do not suggest this species is opportunistic or completely mollusk-specialized. Alternatively, we propose cownose rays exhibit a continuum of foraging behaviors between specialization and generalization, depending on locale and prey availability.

Ajemian, M.J. and S.P. Powers. 2013. Foraging effects of cownose rays (*Rhinoptera bonasus*) along barrier islands of the northern Gulf of Mexico. Journal of Experimental Marine Biology and Ecology 439: 119-128. Doi: 10.1016/j.jembe.2012.10.021

Abstract: Large mobile predators are hypothesized to fulfill integral roles in structuring marine foodwebs via predation, yet few investigations have actually examined the foraging behavior and impact of these species on benthic prey. Limited studies from the Cape Lookout system implicate large schooling cownose rays (Rhinoptera bonasus) in the devastation of patches of commercially harvested bay scallop via strong density-dependent foraging behavior during migrations through this estuary. However, despite the extensive Atlantic range of R. bonasus, the pervasiveness of their patch-depleting foraging behavior and thus impact on shellfisheries remains unknown outside of North Carolina waters. To further understand the potential impacts of cownose rays on benthic prey and the role of bivalve density in eliciting these impacts, we conducted exclusion and manipulation experiments at two sites in the northern Gulf of Mexico frequented by rays during spring migrations. Despite a correlation in ray abundance with haustorid amphipod (primary natural prey) density at our study sites, we were unable to detect any effect of rays on amphipod densities. In addition, through manipulation of predator access, we determined the main cause of mortality to manipulated patches of hard clams was predation by smaller predators such as Callinectes sapidus and not cownose rays. While cownose rays consume hard clam in other parts of their range, we suggest rays along northern Gulf of Mexico barrier islands may prefer foraging on smaller and thinner-shelled bivalves (e.g., Donax sp.), as well as more abundant amphipod crustaceans. We caution that these preferences may have reduced our ability to detect effects of rays on manipulated prey, and thus future impact experiments should strongly consider the local diet of these predators and explore novel techniques to estimate effects on small crustaceans. Further synchronized experimentation along basin-wide scales may elucidate the environmental factors that determine the severity of cownose ray foraging impacts across their range.

Collins, A., M.R. Heupel, R.E. Hueter and P.J. Motta. 2007. Hard prey specialists or opportunistic generalists? An examination of the diet of the Atlantic cownose ray *Rhinoptera bonasus*. Marine and Freshwater Research 58(1): 135-144. Doi: 10.1071/MF05227

Abstract: Atlantic cownose rays (Rhinoptera bonasus) are benthic, suction feeders whose foraging activities have been implicated in severe damage to commercial shellfish industries. With jaws highly modified for durophagy, it has been assumed that R. bonasus are crushing specialists that feed primarily upon hard molluscan prey. Stomach contents from R. bonasus caught within Florida's Charlotte Harbor estuary between July 2003 and July 2004 were analysed using the index of relative importance (IRI) to determine most important prey types. Prey items were identified from 38 families and fell into nine distinctive groups. The three most dominant prey groups were crustaceans (%IRI = 55.31), polychaetes (%IRI = 25.20) and bivalves (%IRI = 12.58). Shoalmates had more similar diets than non-shoalmates, suggesting group feeding. Most small or softer-bodied prey consumed were relatively intact, indicating lack of prey processing and capture through suction feeding.All larger, harder-bodied prey showed evidence of crushing (fractured and broken shells).Although R. bonasus has been characterised as a hard prey specialist, these results suggest it may behave as an opportunistic generalist, modifying feeding behaviour to consume readily available prey.

Population Dynamics and Spatial Distribution

Craig, J.K., P.C. Gillikin, M.A. Magelnicki and L.N. May. 2010. Habitat use of cownose rays (*Rhinoptera bonasus*) in a highly productive, hypoxic continental shelf ecosystem. Fisheries Oceanography 19(4): 301-317. Doi: 10.1111/j.1365-2419.2010.00545.x

Abstract: Highly productive surface waters and hypoxic (dissolved oxygen, DO ≤ 2.0 mg L−1) bottom waters develop seasonally on the northwestern Gulf of Mexico continental shelf due to nutrient and freshwater inputs from the Mississippi-Atchafalaya River system. We investigated the spatial distribution of the cownose ray (Rhinoptera bonasus), a highly mobile, bentho-pelagic species that is a seasonal resident of the shelf, in relation to surface chlorophyll, bottom-water hypoxia, and other environmental variables (salinity, temperature, depth). We used synoptic trawl and aerial surveys to investigate ray distributions at both shelfwide (100–1000s km) and local (5–50 km) spatial scales. Shelfwide sampling indicated that rays were associated with regions of high surface chlorophyll and low bottom salinity and DO, conditions characterizing the Mississippi-Atchafalaya plume region. Local sampling in and around the hypoxic zone indicated that rays preferred habitats where bottom waters were hypoxic but they primarily occupied normoxic (DO > 2.0 mg L−1) waters above the bottom hypoxic layer. Stomach fullness and diet composition were similar between rays sampled in habitats with hypoxic versus normoxic bottom waters. These results indicate that cownose rays are strongly associated with riverine-influenced regions of the shelf and preferentially use habitats with hypoxic bottom waters, perhaps for benthic foraging. Collectively, our results highlight the importance of considering the responses of mobile species to enhanced productivity and to hypoxia-induced habitat degradation, which are both the products of coastal eutrophication.

Goodman, M.A., P.B. Conn and E. Fitzpatrick. 2011. Seasonal Occurrence of Cownose Rays (*Rhinoptera bonasus*) in North Carolina's Estuarine and Coastal Waters. Estuaries and Coasts 34(3): 640-651. Doi: 10.1007/s12237-010-9355-5

Abstract: The seasonal occurrence of cownose rays (Rhinoptera bonasus) within North Carolina's estuarine and coastal waters was examined from aerial surveys conducted during 2004–2006. Generalized linear models were used to assess the influence of several variables (month, year, habitat type, sea surface temperature, and turbidity) on predicted counts of cownose rays. The spatial distributions of rays were compared by season, and differences in group size were tested as a function of season and habitat. Cownose ray data associated with the North Carolina Division of Marine Fisheries (NCDMF) fishery independent gill net sampling program in Pamlico Sound was also examined as a function of season and year, and compared with aerial observations. Rays immigrated into the region in mid-spring (April), dispersed throughout the estuary in the summer (June–August), and emigrated by late autumn (November). Predicted counts were highest in the spring (April, May) and autumn (September–November) for coastal habitats and highest in the summer for estuarine habitats. Predicted counts were also higher in the coastal region than estuarine and higher when sea surface temperatures were above average. Comparison of group size by habitat type revealed substantially larger group sizes in the coastal habitat than the estuarine. In addition, for the estuary, spring surveys had larger group sizes than summer surveys; for the coastal habitat, autumn group sizes were significantly larger than spring or summer group sizes. The NCDMF gill net sampling surveys indicated similar trends in monthly migration patterns as well as increased ray abundance in 2008 and 2009 compared with 2003–2007. These results suggest that North Carolina's waters serve as important habitat during the seasonal migration of cownose rays, as well as during the summer when the species may utilize the estuarine region as a nursery and/or for foraging.

Grubbs, R.D., J.K. Carlson, J. Romine, T.H. Curtis, and D. McElroy. 2011. Save the Bay, Eat a Ray: A Purported Trophic Cascade Mediated by Declines in Large Shark Populations and the Consequences of Applying Simplistic Models to Complex Ecosystems. Conference Paper for American Fisheries Society 140th Annual Meeting. Link

Abstract: Top-down versus bottom-up control of marine ecosystems has been debated for decades. Mechanisms driving mortality and energy flow are often system dependent and difficult to distinguish, especially in large systems with complex trophic webs. Large sharks have long been described as "apex predators" that assert top-down influences on ecosystems, though little empirical evidence for this existed. As populations of large sharks declined in recent decades, numerous researchers have sought "evidence" for cascading effects of these predator reductions on lower trophic levels. For example, it was reported that predation release due to declines in large coastal sharks in the northwest Atlantic Ocean led to dramatic increases in populations of smaller elasmobranchs, including cownose rays (Rhinoptera bonasus). Increased predation by cownose rays was in turn reported to have caused declines in populations of commercially important bivalve mollusks, even causing fishery collapses for some taxa. This purported trophic cascade has been cited frequently in the scientific literature, in the media, and has been used successfully to justify market development and harvesting of cownose rays in spite of the facts that cownose rays have among the lowest lifetime fecundity of any marine vertebrate and congeners have been driven to endangered status by relatively small fisheries. Recently, the harvest and consumption of cownose rays has been touted as environmentally-friendly. For example, the "Save the Bay, Eat a Ray" media campaign suggests that by consuming cownose rays, citizens will be aiding recovery of the degraded Chesapeake Bay. We will challenge the validity of this trophic cascade by presenting alternate hypotheses for the observed changes in relative abundances of large sharks and meso-predators and challenge the magnitudes of these population changes. For example, abundance

trends from stock wide surveys do not infer similar population declines for large sharks. Data on shark diets also suggest the potential for top-down regulation may have been exaggerated and in some cases the reported trophic linkages may not exist. The marine food web along the East Coast is extremely complex and we suggest the use of simplistic three-level trophic models may lead to inappropriate conclusions concerning the mechanisms behind observed changes in relative abundances. We will also demonstrate that harvesting cownose rays will not have the desired effect of limiting mortality on commercial bivalves and will propose alternatives. Finally, we will call for objective interpretation and the consideration of alternative explanations from future research analyzing relative abundance data for elasmobranch fishes.

Myers, R.A., J.K. Baum, T.D. Shepherd, S.P. Powers and C.H. Peterson. 2007. Cascading effects of the loss of apex predatory sharks from a coastal ocean. Science 315:1846–1850. Doi: 10.1126/science.1138657

Abstract: Impacts of chronic overfishing are evident in population depletions worldwide, yet indirect ecosystem effects induced by predator removal from oceanic food webs remain unpredictable. As abundances of all 11 great sharks that consume other elasmobranchs (rays, skates, and small sharks) fell over the past 35 years, 12 of 14 of these prey species increased in coastal northwest Atlantic ecosystems. Effects of this community restructuring have cascaded downward from the cownose ray, whose enhanced predation on its bay scallop prey was sufficient to terminate a century-long scallop fishery. Analogous top-down effects may be a predictable consequence of eliminating entire functional groups of predators.

Peterson, C.H., J.F. Fodrie, H.C. Summerson and S.P. Powers. 2001. Site-specific and density-dependent extinction of prey by schooling rays: generation of a population sink in top-quality habitat for bay scallops. 129(3): 349-356. Doi: 10.1007/s004420100742

Abstract: Bay scallops (Argopecten irradians concentricus) are patchily distributed on two dominant spatial scales: (1) geographically restricted to highly saline marine lagoons, and (2) locally abundant within such lagoons only in relatively discrete beds of seagrass habitat. In the Cape Lookout lagoonal system of North Carolina, adult bay scallop abundance in the most densely occupied seagrass bed (Oscar Shoal) exhibits repeatable declines from up to 70 m–2 to near zero in a 2- to 4-week period during late summer. This crash is completed before fall spawning can be initiated, thereby creating a population sink in what is the singly most productive patch of habitat. Field experiments conducted in the summers of 1996 and 1998 demonstrated that the seasonal extinction of bay scallops on Oscar Shoal can be prevented by the erection of 1-m2 stockades, made of 50-cm-high vertical poles, spaced every 25 cm, which inhibit access by cownose rays. Because these stockades were porous to emigration and physical transport, and open to access by all other predators of adult scallops, predation by migrating cownose rays is the only viable explanation for the crash. Consequently, the natural predation process in this system achieves the reproductive extinction of prey in the habitat patch of highest productivity. Over 7 years of observation, the mortality rate in this patch increased with summer density, reaching the asymptote of 100% at 10 m–2. The site-specific habitat selection by schools of rays may be based on prey density, which could render this example representative of a widespread generator of population sinks in habitat patches of high quality. The virtual extinction of scallops within Oscar Shoal despite nearby patches with relatively high density may be related to the highly efficient feeding behavior of schools and the high vulnerability of bay scallops in a context of multiple alternative prey types.