**NC Sea Grant 2023 Final Report:**

# Investigating the Impacts of Dredging on Coastal Inlet Habitat Function Using Acoustic Imaging

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**Project Narrative:**

*Abstract*

Despite the accepted importance of coastal inlets as foraging habitat and as critical movement corridors between estuaries and the littoral ocean, these areas remain understudied. Along with their ecological function, inlets play an important role in coastal economies. For instance, commercial shipping requires deep draft channels to be maintained through inlets to allow access to ports, requiring consistent dredging. Historically, inlet dredging has been restricted to winter months to mitigate the impacts on fish larvae and nekton. While it would be desirable to allow the dredging of port serving inlets year-round, the ecological tradeoffs of that strategy are unknown. We utilized a Before After Control Impact experimental design to investigate the impacts of inlet dredging on fish abundance and habitat utilization in Beaufort Inlet, NC in the summer and fall of 2022. Random stratified sampling was conducted using acoustic imaging sonar to determine the relative abundances and trophic guilds of fish in the inlet area. Overall, we saw low fish densities in the inlet and large temporal variations in abundances; peak abundances in Beaufort Inlet occurred in late August. Our data will provide important information to managers regarding the impacts of dredging on inlet use by fish as well as the duration of the disturbance. Additionally, this work will provide a baseline understanding of the seasonal trends in inlet utilization and will support future work identifying the drivers of large-scale inlet ingress and egress events.

*Introduction*

Coastal inlets, as well as the complex of minor channels leading into them, are known to be essential movement corridors for marine organisms at multiple life stages. Fish use these areas for foraging, staging, and migration between estuarine habitats and marine waters. In addition to their biological importance, inlet areas play a significant role in coastal economies. In North Carolina (NC), there are two deep-draft (depth > 40 ft) inlets; Beaufort Inlet leading to the Port of Morehead City and Cape Fear River Inlet leading to the Port of Wilmington. These ports contribute a combined $15.4 billion annually to the economy of NC and directly support 44,600 jobs (Head et al. 2018). These inlets need to be maintained by dredging to a depth that allows ship passage. Unfortunately, there are numerous biological concerns related to dredging including hydraulic entrainment, dispersal of high suspended sediment loads, decreased dissolved oxygen, underwater noise, and benthic habitat alteration (Reine et al. 2001, Tubman & Corson 2001, Nightingale & Simenstad 2001, Todd et al. 2015).

In recent years, federal funding to maintain deep-draft channels has slowed, resulting in challenges to maintenance dredging efforts (NC BIMP). A recent environmental assessment by the U.S. Army Corps of Engineers (USACE) concluded that there is no significant impact to dredging outside of the historically allowed dredging window of December 1 to April 15. (USACE 2021). This is surprising, as the historically allowed window was originally constructed to avoid conflicts with important biological events (e.g., fish migration and spawning, presence of sea turtles) and the impacts of dredging outside of that window in NC is unknown (NOAA Office for Coastal Management 2021). An examination of dredge impacts on inlet complex utilization by fish is needed, specifically during the previously closed dredging window, as well as a fine-scale inquiry into the response of fish to the dredge plume.

*Methods*

I deployed an Adaptive Resolution Imaging Sonar (ARIS), which is a high-resolution acoustic imaging device, from a research vessel (24' skiff) to record samples of fish in the water column and benthic habitats in Beaufort Inlet and the adjacent estuary (Hayes et al. 2015, Plumlee et al. 2020). The ARIS uses an array of 96 high-frequency acoustic beams to produce high-resolution images of fish and habitat features up to a depth of 35 meters at 7 to 15 frames per second. For example, at a depth of 15 meters (representative of much of Beaufort Inlet), the ARIS samples an area of 36 $m^2$ of seafloor, along with the overlying water column in a narrowing field approaching the water surface. I designated seven sampling strata, each roughly 0.20 $km^2$ in area; sized and positioned based on channel morphology. Four strata were designated as control sites, where dredging was not scheduled to occur during 2022, and three strata as impact sites over areas in which dredging occurred. Each strata was be gridded to allow for a random selection of sampling points. Sampling occurred on the incoming and outgoing tide when allowed by daylight hours. On each sampling day, five grid cells were sampled within each strata for a total of 70 sampling points (7 strata * 5 grid cells * 2 tides). One-minute duration, stationary samples were taken of the entire water column and benthos using the ARIS during daylight hours. Additional samples were taken using the ARIS in a horizontal configuration immediately following the vertical down samples to account for smaller fish moving along the surface. I also sampled with a SIMRAD split beam sonar, these samples were taken in tandem with the vertical down ARIS samples in order to allow a comparison of methods and target corroboration between the two techniques. Maintaining a stationary position was done using a trolling motor with a GPS anchor. Sampling trips were conducted on four dates before dredging commenced, ranging from 5/24/22 to 7/01/22. During dredging activity, we were able to sample our strata once on 7/17/22. Sampling during active dredging was limited due to poor weather conditions and repeated rescheduling of Great Lakes Dredge & Dock Corperation operations. After dredging operations ceased, we sampled six additional times (8/29, 9/21, 10/05, 10/26, 11/14, 12/2) the last of these concluding our sampling effort. To ensure that my standard daytime-falling tide sampling is representative, we conducted a diurnal/tidal pattern experiment, sampling on each combination of tide/daylight across a 48-hour period. These samples will be conducted in the same manner as described above. In situ environmental data was recorded at the surface and at depth for each sample position, including current velocity and direction, turbidity, temperature, dissolved oxygen, and salinity.

ARIS samples will be processed by randomly selecting 10 image-frames from each 60-second recording and using SoundMetrics software (ARISFish) to record fish numbers, lengths, depth in the water column, directionality of movement, and behavioral traits that can assign each fish into a trophic guild (i.e., schooling forage fish, benthic oriented, transient predators) (Hughes & Hightower 2015, Becker et al. 2016, Boswell et al. 2019). Fish densities (standardized by sampling volume) will be averaged for each 60-second sample and then aggregated within strata to obtain means and estimates of uncertainty across dates. Fish densities, size structure and trophic composition will be measured throughout the season, allowing me to compare relative changes in impacted versus control strata. Size spectrum-based analysis of fish communities, such as what is described here, has become widespread and allows utilization of sonar technology to conduct research in previously inaccessible systems using non-lethal sampling (Andersen et al. 2016). A BACI experimental ANOVA design will be used to evaluate if dredged areas have an altered habitat function relative to control strata over the course of the impact and the period after. This design utilizes a repeated measures analysis where baseline (before) data and unimpacted controls allow the impact to be quantified. Finally, drivers of fish density (e.g., temperature, tidal cycle) will be investigated using generalized additive models.

*Results and Discussion*

Acoustic imaging sonar proved to be an effective sampling method in this environment. For instance, large schools of prey dispersed throughout the water column in multiple strata were observed as well as small to medium predators at both benthic and pelagic depths. Specific results of the BACI ANOVA relating to dredging impacts on abundance and dispersal are not yet known, as the analysis of the acoustics recordings (2,555 files and ~95 GB) is only 20% completed. Mean fish counts showed a strong seasonal pattern, but did not show a consistent difference between control and impacted strata, which preliminarily suggests that dredging did not impact fish use of this habitat (Figure 1). Across most sampling dates, fish abundance was low in the inlet, with the exception of our sampling in late August, 2022. Mean predatory fish count was frequently higher in dredged strata when compared to the control strata. Prey school size shows a similar

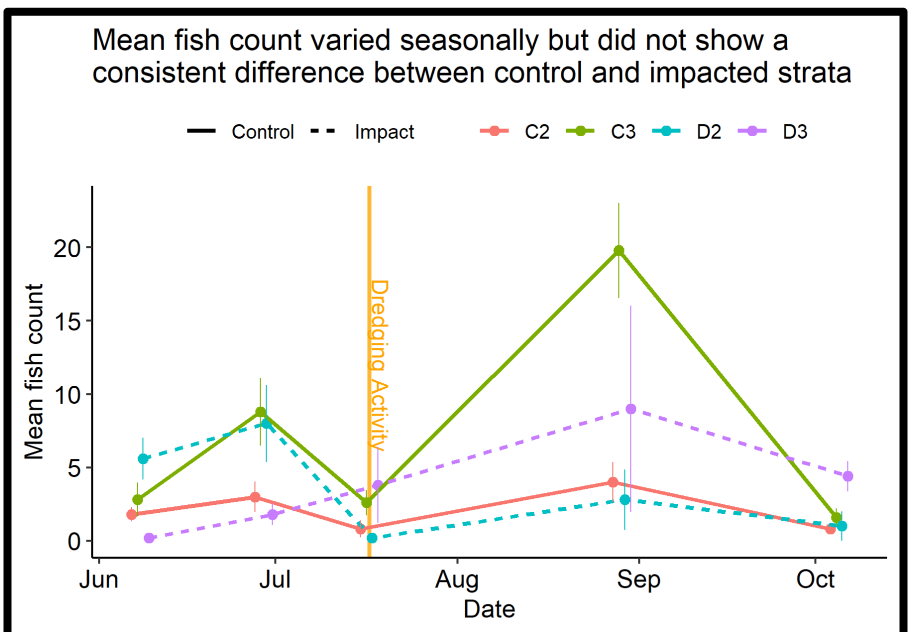


**Figure 1:** Mean fish counts across dates and strata for analyzed data.

relationship, peaking in late August and showing the largest sizes in the dredged strata (Figure 2).

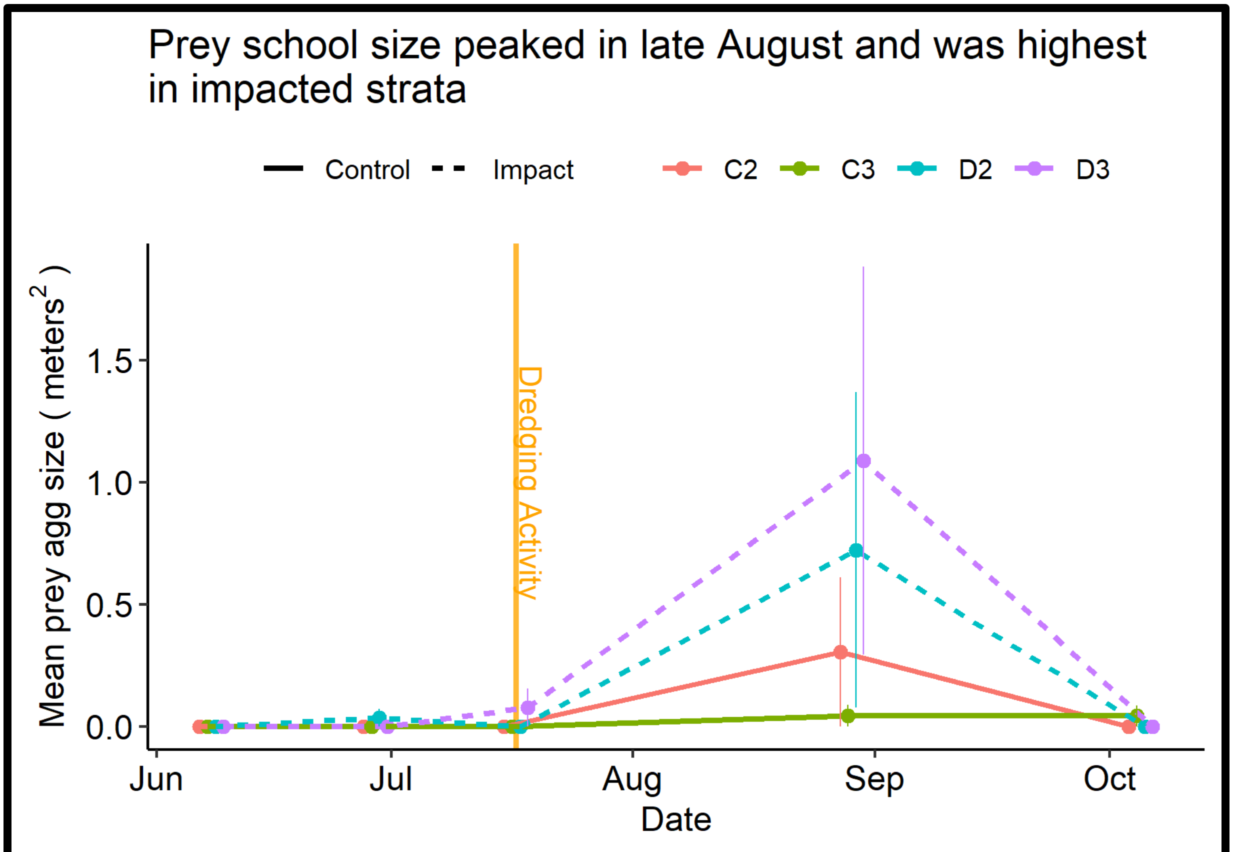


**Figure 2:** Mean prey aggregation area across dates and strata for analyzed data.

These results suggest that the impact of dredging is taking place at short time scales (i.e., hours to days) and fades quickly when looking at a monthly timescale. The relationships between predator abundance and prey school size are likely unrelated to dredging activity and instead are related to the dredged strata proximity to the inlet mouth and their increased depth when compared to the control strata. These results may change with further analysis, the above plots show only the incoming tide and do not represent the full temporal scale of our sampling. Preliminary results indicate that split beam and multibeam data show similar fish signals, although at different levels of detail; these samples will be used to corroborate targets and assess the relative merits of each approach in this setting (i.e. acoustic imaging vs. split beam).

These results have already been shared at the Tidewater Chapter Conference of the American Fisheries Society, disseminating them to managers and academics across NC, VA, and MD. I also presented this research at an Interagency Commission on Dredging, hosted by NOAA in February, 2023. I plan to finalize the data processing by the winter of 2023 and then begin more involved data analysis and working on a manuscript for publication of these results.