COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: Jeffrey Buckel

Technical monitor: Katy West

Grant Award #: NCSU Project ID# 553947 (NCDENR Task Order #4044)

Grant Title: Diet composition of predatory fishes captured in North Carolina: a cooperative program with North Carolina Division of Marine Fisheries

Grant Award Period: August 2011 – December 2017

Performance Reporting Period: 1/1/17 – 6/30/17 **(6 months)**

Project Costs:

Category	Expenditures
Personnel	$168,917
Fringe	$18,068
Travel	$8,335
Equipment	$0
Supplies	$7,744
Current services	$875
Contractual	$7,000
Other	$22,539 (tuition)
Total Direct	$233,666
Indirect	$35,200
TOTAL	$268,866

Total Cumulative Expenditures: $268,866
Total Remaining Balance: $909

Description of Work**:**
This project collects diet data by utilizing fishes collected in Programs 915 and 195 and is serving as the building block for a potential food habits program by NCDMF. The objectives for CRFL grant #4044 are:

1. To design and conduct a food habits collection program for the Pamlico Sound region.

2. To determine diet and prey selectivity of predatory fishes and incorporate diet information into the NCDMF database by linking individual predator records with their stomach contents.
3. To utilize food habits in models that estimate predation mortality for economically and ecologically important species.
4. To utilize food habits data to estimate trends in trophic indicators for the Pamlico Sound fishery.
5. To determine the potential for fish stomach contents to be informative about recruitment for fishes with cryptic early life history stages.

Project Status/Work Accomplished:

All predator stomachs have had their contents identified (n = 17,396). All data entry and data QA into the NC Division of Marine Fisheries database have been completed.

Samantha Binion-Rock is continuing to work on data analyses and writing. She developed a spatial kernel density approach to estimate the percent contribution each prey contributes to a predator's diet and the resulting manuscript is currently in review at *Canadian Journal of Fisheries and Aquatic Sciences*. She has completed analyses identifying important forage fish in Pamlico Sound using 3 different metrics: qualitative, Connectance, and SURF. She has also completed several multivariate analyses comparing predator diets across time and space. These analyses include ANOSIM, nMDS, SIMPER, agglomerative cluster analysis using average linkage, and SIMPROF. The multivariate analyses allowed for the identification of trophic guilds in Pamlico Sound. The gill net and trawl survey data were analyzed separately for the forage fish and trophic guild analyses. Samantha has begun developing an ecosystem model for Pamlico Sound using Ecopath with Ecosim and has identified which functional groups to include in the model.

Deviations:
The main deviation from the proposed work is the much larger sample size for most species compared to the sample size proposed and the inclusion of predators from Programs 365 and 462.

COASTAL RECREATIONAL FISHING LICENSE

ANNUAL PERFORMANCE REPORT

Recipient: Dr. Jeffrey A. Buckel, Dr. Joseph E. Hightower

DMF/CRFL Technical Monitor: Lee Paramore

Grant Award #: NCSU Project ID# 556497 (NCDENR Task Order #5110)

Grant Title: Sources of Mortality and Movements of Weakfish Tagged in North Carolina

Grant Award Period: 07/01/13 – 08/31/18

Performance Reporting Period: 1/1/17 – 6/30/17 **(6 months)**

Project Costs:

Category	**Expenditures**
Personnel	$107,595 ($35,962 encumbered)
Fringe	$10,588
Travel	$4,869
Supplies	$106,101
Current services	$7,786
Fixed charges	$884
Contractual	$26,634
Other	Tuition = $21,642
Total Direct	$286,098
Indirect	$42,265
TOTAL	$328,363

Total Cumulative Expenditures: $328,363
Total Remaining Balance: ($357,073–$328,363-35,962) = (-$7,251)

Description of Work**:**

List the project objectives or provide a brief description of the funded activity, giving enough detail to acquaint the reader with the project.

OBJECTIVES:

1) To estimate seasonal and annual rates of fishing and natural mortality for legal-size weakfish (>12" or 30.5cm TL).
2) To estimate seasonal and annual rates of natural mortality for weakfish in North Carolina tributaries.
3) To estimate movement and stock mixing of weakfish along the U.S. east coast.
4) To obtain and synthesize diet information for potential weakfish predators

Project Status/Work Accomplished:

For each objective, describe tasks scheduled for the reporting period and the activities undertaken to complete them. Describe the specific accomplishments, and list products (publications, web pages, data, technology, etc.) completed during the reporting period. Attach copies of the publications, as appropriate.

A total of 240 conventional-tagged fish were released from January to July 2017 by researchers. All of these tags were released between Cape Lookout and Swansboro. Commercial fisherman returned 3 tags and recreational fisherman returned 2 tags for a total of 5 tag returns in 2017. To date, a total of 3,821 fish have been released since 2013. We have had 140 tag returns with 26 being recaptured by researchers, 26 by commercial fisherman, and 88 by recreational fisherman.

For the predation of weakfish by dolphins objective, a NOAA technician has identified all the stomach contents from 165 stranded dolphin stomachs and measured otolith lengths to reconstruct prey length. Data is currently being entered into an Access database and going through QA/QC. A literature review on possible weakfish predators is currently ongoing. A meeting in May with NOAA collaborators reviewed the project's progress and outlined the final analysis and scientific paper objectives for the project.

An array of ~35 acoustic receivers are deployed in Bogue Sound from Emerald Isle to Barden's Inlet and were downloaded once in April. One receiver was lost during this time period. Since fall 2015, we have released 212 telemetry-tagged weakfish in Bogue Sound. A total of 117 transmitters have expired as of the end of August 2017. As of our latest download, it appears that 82 fish emigrated in an average of 41 days. Spring 2016 weakfish emigrated quicker on average as compared to the fall seasons (spring 2016 = 34.4 days; fall 2015 = 48.7 days; fall 2016 = 45.5 days). Three weakfish were returned after being caught by recreational fisherman. Five weakfish were recaught by researchers using hook and line and survived for at least 8 days post release. A single fall 2015 weakfish returned to Bogue Sound after emigrating out of Bogue Sound through Beaufort inlet in mid-January and then reentering the array in late March near Emerald Isle. No weakfish to date have been detected on receivers outside the bounds of our array from Emerald Isle to Cape Lookout. We will continue to maintain the array until all our weakfish tags have expired at the end of February 2018.

Deviations:

If there were changes to the goals/objectives during the reporting period, please detail the circumstance and nature of change. Explain any special problems or circumstances which prevented the accomplishment of scheduled tasks. Describe actions to resolve problems encountered and provide the details of any changes made to goals and objectives of the project.

There were no deviations from our goals/objectives over the last six months.

Additional Guidance:

If your scope of work is broken into discrete jobs/tasks, please use the Job/Task titles as subheading under which to report accomplishments.

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: Frederick S. Scharf, Jeffrey A. Buckel, Joseph E. Hightower, Tom Wadsworth, William E. Smith

Grant Award #: 2014-F-015, contract #5805

Grant Title: Estimating mortality for southern flounder using a combined telemetry and conventional tagging approach

Grant Award Period: July 1, 2014 – June 30, 2018

Performance Reporting Period: January 1, 2017 – June 30, 2017

Project Costs: $456,059 awarded for four-year project

Expenditures for the Period:

Category	Expenditures
Personnel	28,748
Fringe	2,866
Travel	7,840
Equipment	
Supplies	2,642
Construction	
Contractual	8,574
Other	3,600
Total Direct	54,270
Indirect	5,399
TOTAL	59,669

Total Cumulative Expenditures: $390,946
Total Remaining Balance: $33,583

Description of Work**:**

1) To estimate seasonal and annual rates of natural mortality for southern flounder in a NC estuary.

2) To provide updated estimates of fishing mortality that can be used to ground truth stock assessments.

3) To examine spatial variability in natural and fishing mortality for southern flounder within NC.

Project Status/Work Accomplished:

Tagging of the third annual cohort of southern flounder with acoustic transmitters concluded in September 2016 with 10 additional transmitters deployed since summer. In total, 81 transmitters were deployed in the New River estuary in 2016 between May and September. From August 24, 2016 to the close of the fishery on December 1, 2016 fishermen captured 17 fish from the 2016 cohort as well as 1 fish from the 2015 cohort that had overwintered in the estuary. In total, 31 fish were returned by fishermen in summer and fall of 2016. Of these, 16 were harvested by commercial gill net, 8 by commercial gig, 4 by recreational hook and line, and 3 by recreational gig. Time at large for harvested fish ranged between 4 and 458 days with an average ± SD of 77 ± 95 days.

Detection data was retrieved from all stationary receivers in October 2016. In addition, during December 2016, the subset of stationary receivers in the lower river and covering major migration corridors was downloaded to detect additional emigrants that had left the system after October. A total of 23 fish from the 2016 cohort emigrated from the system during the fall migratory period. The timing of emigration events ranged from September 1, 2016 to December 3, 2016 with ~65% of emigrants leaving the system during the month of October. Active tracking was conducted on a monthly basis from September 2016 through January 2017 in order to determine the fates of fish still in the system during the fall and winter. Active tracking near the initial release sites as well as within designated regions of the river yielded detections of 28 different individuals from the 2016 cohort. In addition to tracking fish that were still at large, 3 acoustic transmitters that had been previously returned by fishermen were re-deployed on the river bottom, each at a unique site. This was done to assess our ability to detect transmitters which were no longer contained within a fish (i.e., in order to simulate a natural mortality event and subsequent scavenging of the carcass). We wanted to determine if we could repeatedly return to locations of natural or surgery-related mortalities over monthly time scales and detect those transmitters.

Conventional tagging of southern flounder continued throughout the summer and fall with a total of 710 fish released as part of the joint tagging project during 2016. Fishermen reported 25 UNCW/NCSU high-reward tags from May 2016 through January 2017. Of these reported tags, 13 were harvested by recreational hook and line, 3 by recreational gig, 6 by commercial gillnet, 2 by commercial pound net, and 1 by commercial gig. Time at large ranged from 3 to 616 days with an average ± SD of 150 ± 165 days.

Tracking of the 2016 cohort of telemetered southern flounder continued during the winter and spring months and concluded in June 2017. Detection data was retrieved from all stationary receivers in April 2017 and again in June 2017, at which time all receivers were removed from the system. One additional fish emigrated from the system at the end of December 2016 increasing the total number of emigrants to 24 from the 2016 cohort. Active tracking continued on a monthly basis from January 2017 to June 2017 to determine the fates of fish overwintering in the estuary. Active tracking efforts yielded detections of 10 different individuals from the 2016 cohort. Five of the 10 individuals were relocated at their original release sites during multiple searches over the fall and winter months with no evidence of movement away from the original release location and were determined to be surgery-related mortalities. There were no reported captures of telemetered southern flounder from January 2017 to June 2017. However, 1 additional fish from the 2015 cohort that was determined to have overwintered in the estuary was captured in November of 2016 and 1 fish from the 2016 cohort that was detected emigrating from the New River in fall 2016 was captured outside the system in August 2017.

All 3 of the acoustic transmitters deposited on the river bottom during the fall of 2016 were continuously detected at their original deployment coordinates over a period of ~ 6 months with no apparent loss of signal strength. Relocations of the 3 “simulated” mortalities as well as 5 suspected surgery-related mortalities suggested that active tracking surveys covering full sections of the estuary would likely detect transmitters deposited on the river bottom after a natural mortality or surgery-related mortality and subsequent scavenging of a carcass over monthly time scales.

Conventional tagging of southern flounder resumed in February 2017 and continued through the spring months with a total of 202 fish released as part of the joint tagging project as of June 2017. Fishermen reported 4 UNCW/NCSU high-reward tags between March 2017 and June 2017 with 2 fish harvested by commercial gill net, 1 fish caught and released by commercial gill net, and 1 fish harvested by recreational hook and line. Time at large ranged from 96 to 322 days with an average ± SD of 193 ± 84 days.

Passive and active tracking data for telemetered southern flounder in the New River estuary were used to develop a capture history of observed fates for each individual fish. The capture history was incorporated into a multistate capture-recapture model to estimate instantaneous rates of fishing mortality (F), natural mortality (M), and emigration (E) at the estuary scale. Tag returns from the statewide tagging program were analyzed using a joint likelihood model to estimate mortality, reporting rate, and tag loss parameters. This method utilizes the instantaneous rates formulation of the Brownie tag return model to estimate F, M, and the low-reward tag reporting rate (λ) and an exponential decay model to estimate initial tag-retention and chronic tag loss parameters. After fitting the separate telemetry and tag-return models, a combined model was developed using both the telemetry and tag-return likelihood functions. In the combined model framework, F was estimated independently at the estuary (telemetry data) and state scale (tag returns) while M became a shared parameter across spatial scales. Estimates of emigration (E) from the telemetry data were used to inform the tag return likelihood by adjusting the number of conventionally tagged fish available for harvest. The best supported combined model estimated an average annual M of 0.84 and an average annual E of 1.26 with annual F values ranging from 0.49 – 1.61 at the estuary scale and 0.23 – 0.69 at the state scale from 2014 to 2016, respectively.

<u>Deviations</u>:

None

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: North Carolina Division of Marine Fisheries (Randy Gregory)

Grant Award #: 2F40 F016

Grant Title: NC DMF Carcass Collection Program

Grant Award Period: July 1, 2014 – June 30, 2017

Performance Reporting Period: January 1, 2017 – June 30, 2017

Project Costs: 32,800.00

Expenditures for the Period:

Category	**Expenditures**
Personnel	0.00 (n/a)
Fringe	0.00 (n/a)
Travel	0.00
Equipment	2,506.00
Supplies	3,081.00
Construction	0.00 (n/a)
Contractual	0.00 (n/a)
Other	913.00
Total Direct	10,323.00
Indirect	0.00
TOTAL	10,323.00

Total Cumulative Expenditures: $10,323
Total Remaining Balance: $ 6,882

Description of Work**:**

The objective of this project is to develop a three-year statewide freezer carcass collection program in order to obtain fishery-dependant length, sex, age, and age samples of recreationally important finfish.

Project Status/Work Accomplished:

There are 11 fully operational freezer sites accepting carcass donations (Table 1.). Staff from the Division has made scheduled checks to freezers to collect carcasses and resupply freezers with collection bags and information cards. Fish samples collected from the freezers (Table 2.) have been processed and entered

into the biological database under program 930. Rewards and letters thanking anglers for their participation are also being mailed monthly.

Deviations:

A no cost extension was requested for the remaining funds in this grant. Due to issues with the postage machine angler rewards could not be mailed as scheduled, and orders placed for angler rewards have not yet been received. The no cost extension was necessary to cover these expenses.

Additional Guidance: Nothing additional at this time.

Table 1. Freezer and participating tackle shop locations.

CCP Participating Locations		
Tackle Shop	Location	Phone
Jennettes Pier	Nags Head	252-255-1501
Fishing Unlimited	Nags Head	252-441-5028
Frank and Fran's	Avon	252-995-4171
East Side Bait and Tackle	Washington	252-946-2186
Cape Pointe Marina	Harkers Island	252-728-6181
Freeman's Bait and Tackle	Atlantic Beach	252-726-2607
Dudley's Marina	Cedar Point	252-393-2204
The Tackle Box	Southport	910-540-4938
Frisco Rod and Gun	Frisco	252-995-5366
Red Drum Tackle	Buxton	252-995-5414
East Coast Sports	Surf City	910-328-1887

Table 2. Number of Fish Collected by Species

Species	**No. Collected**
Black Drum	20
Bluefish	9
Cobia	6
Gulf Flounder	1
Red Drum	1
Sheepshead	11
Southern Kingfish	42
Spanish Mackerel	3
Speckled Trout	34
Summer Flounder	7
Weakfish	11
Total	**145**

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: Jeffrey A. Buckel, Timothy A. Ellis, Jan R. McDowell

Grant Award #: NCSU Project ID#558061 & 571502 (NCDENR Task Order #5807 & 7134)

Grant Title: Stock structure of spotted seatrout: assessing genetic connectivity at northern latitudinal limits

Grant Award Period: July 1, 2014 – December 31, 2016 (remaining funds January 1, 2017 to December 31, 2017)

Performance Reporting Period: January 1, 2017 – June 30, 2017

Project Costs:

Category	Expenditures (old account & new account)
Personnel	$93,132 & $1,680
Fringe	$16,533 & $261
Travel	$8,789 & $0
Supplies	$11,787 & $0
Current services	$2,715 & $0
Fixed charges	$0 & $0
Sub-Contractual	$45,017 & $0
Other	
Total Direct	$179,607 & & $1,941
Indirect	$26,941 & $110
TOTAL	$206,548 & $2,051

Total Cumulative Expenditures: $206,548 (old account) & & $2,051 (new account)
Total Remaining Balance: $0 in old account & $18,847 remaining in new account

Description of Work**:**

List the project objectives or provide a brief description of the funded activity, giving enough detail to acquaint the reader with the project.

1) Estimate the level of genetic separation among spotted seatrout sampled across multiple large, widely distributed estuaries in NC during the summer spawning season.
2) Determine if the summer spawning population(s) of spotted seatrout in NC are genetically distinct from those of VA and SC.

3) Assay the genetic variation of several known large winter population(s) of spotted seatrout in NC and compare these results to those of Objective 2 in order to examine seasonality in stock mixing and to characterize stocks in NC overwintering estuaries.
4) Integrate the results of proposed genetic analyses with those of prior tagging research from NC, VA, and SC, to determine stock mixing rates and to identify stock boundaries for management.

Project Status/Work Accomplished:

For each objective, describe tasks scheduled for the reporting period and the activities undertaken to complete them. Describe the specific accomplishments, and list products (publications, web pages, data, technology, etc.) completed during the reporting period. Attach copies of the publications, as appropriate.

Objectives 1-4: All field sampling was completed in 2016. Laboratory analyses were also completed in 2016, including proofreading of all genetic laboratory results. Proofreading and preliminary statistical analyses revealed inconsistencies in the allele scoring of some samples. Therefore, reanalysis of these tissue samples across the microsatellite loci in question was conducted in February and March 2017. Scoring errors were rectified and data were recompiled for further statistical analyses. Currently, final statistical analyses are underway, results are being summarized, and the final project report is being written.

Deviations:

If there were changes to the goals/objectives during the reporting period, please detail the circumstance and nature of change. Explain any special problems or circumstances which prevented the accomplishment of scheduled tasks. Describe actions to resolve problems encountered and provide the details of any changes made to goals and objectives of the project.

No changes were made to the goals/objectives during this reporting period.

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: DEQ/DMF Marine Patrol

Grant Award #: 2F40 F025

Grant Title: Full-Time Law Enforcement position to CRFL Grant

Grant Award Period: January 1, 2015 – June 30, 2017

Performance Reporting Period: January 2017 – June 2017

Project Costs:

Expenditures for the Period:

Category	**Expenditures**
Personnel	$ 29,350
Purchased Services	$ 8,424
Equipment	0
Supplies	$ 2,398
TOTAL	$ 40,172

Total Cumulative Expenditures: $ 40,172
Total Remaining Balance: $ 140,037

Description of Work**:**

Transfer funds for the 120-position located in Dare County from commercial license receipts revenue to CRFL grant funds. The 120 position is in District 1 where most the fishing activity has become recreational.

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Project Status/Work Accomplished:

During this reporting cycle the 120 position has been vacant for most of this reporting cycle. The officer that was in this position transferred to a new position in February and the 120 position is still currently vacant. Marine Patrol has interviewed for this position and hope to be able to fill this position soon. Once this position is filled the monies provided by this grant will ensure continuance patrol coverage necessary to ensure compliance of all fishermen, both commercial and recreational, by enforcing all general statutes and rules and regulations governing North

Carolina's fisheries. This position starting in July1, 2017 will continue to be funded by CRFL monies within the Division's 5-year CRFL grant.

Deviations:

None

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: DEQ/DMF Marine Patrol

Grant Award #: 2F40 F026

Grant Title: Temporary Tele-Communications position to CRFL Grant

Grant Award Period: June 1, 2015 – June 30, 2017

Performance Reporting Period: January 2017 – June 2017

Project Costs:

Expenditures for the Period:

Category	**Expenditures**
Personnel (Temp)	$ 8,401
Purchased Services	$ 360
Equipment	$ 353
Supplies	0
TOTAL	$ 9,115

Total Cumulative Expenditures: $ 9,115
Total Remaining Balance: $ 22,588

Description of Work**:**

Transfer salary funds for a temporary tele-communication position from commercial license receipts and state appropriations to a Coastal Recreational Fishing License (CRFL) grant. This CRFL grant will continue to allow our temporary tele-communicator to provide officers with the information necessary for proper enforcement and to provide the public with quality customer service.

Project Status/Work Accomplished:

During this reporting period our communication section was fully staffed and as a result of our communication section being fully staffed our temporary position was not needed to work as often. Our temporary communication position is mainly needed when our full-time dispatchers are on vacation or if one of the full-time positions becomes vacant.

This position starting in July1, 2017 will continue to be funded by CRFL monies within the Division's 5-year CRFL grant.

Deviations:

None

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: Roger A. Rulifson and R. Wilson Laney

Grant Award #: Contract 6982

Grant Title: Cooperative Winter Tagging Cruise, 2016, for Atlantic Striped Bass and Affiliated Species (Continuation)

Grant Award Period: 15 September 2016 – 30 June 2017, NCE to 31 December 2017

Performance Reporting Period: 1 January 2017 – 30 June 2017

Project Costs: $105,917

Expenditures for the Period: Start with $16,420 from last interim report.

Category	**Expenditures**
Personnel	
Fringe	
Travel	
Equipment	
Supplies	
Construction	
Contractual	
Other	
Total Direct	
Indirect	
TOTAL	$

Total Cumulative Expenditures: $104,961
Total Remaining Balance: $ 830.78

Background: Winter tagging of striped bass and Atlantic sturgeon off the coasts of NC and VA was initiated by the NCDMF in the late 1960s and early 1970s and was reinitiated in 1988 at the recommendation of ASMFC's Striped Bass Technical Committee by five principal partners. These partners along with others including multiple university partners conducted the Cooperative Winter Tagging Cruises (CWTCs) from 1988 through 2010. Cruise data are used in determining the fishing mortality on the coastal migratory stock of striped bass, including those from the Albemarle-Roanoke stock. The Cruise provides a fishery-independent examination of the striped bass, which constitute the NC winter ocean fishery, and is otherwise sampled only from fishery-dependent sources. NOAA historically provided funding for vessel operations;

however as of 2011, this source of funding was not forthcoming. Funding from the NC Marine Resources Fund (Coastal Recreational Fishing License, CRFL) was used to conduct the Cruise during 2013, 2014 and 2015. In addition, a second component – a charter boat cruise – was used to catch striped bass exclusively by hook and line for examination, tagging, and release. These two tagging efforts – one from capture by trawl, and the second by hook and line – will allow modelers to determine relative estimates of survival from the two methods, and provide a better estimate of population size of the offshore migratory stock

Revised Project Milestones

An activity schedule in table format for the duration of the project, starting with Month 1 and concluding at the end of the requested award period, including a maximum three-month report writing period is presented below. A combination of variables has slowed our ability to continue progress. In late July we received the striped bass ages. We continue to work on the Alosines; ageing from otoliths will be initiated at the end of August. Vacations of State and Federal personnel have slowed progress in GIS mapping, reporting of striped bass recaptures, and analysis of fish community data.

Milestones

Objective	***SEP***	***OCT***	***NOV***	***DEC***	***JAN***	***FEB***	***MAR***	***APR***	***MAY***	***Jun***	***Jul***	***Aug***	***Sep***	***Oct***	***Nov***	***Dec***
2. Ageing		***xxxxxxxxxxxxxxxxxxxxxxxxx***									***xxxxxxxxxxx***					
3. F calc.								***xxxxxxxx***					***xxxxxxxxx***			
4. Winter maps	***xxxxxxxxxxxxx***												***xxxxxxxxxx***			
5. Migration							***xxxxxxxxxxxxxxxxxx***						***xxxxxxxxxxx***			
6. Capture mortality								***xxxxxxxx***					***xxxxxxxxxx***			
7.Alosines	***xxxxxxxxxxxxxxxxxx***								***xxxxxxxxxxxxxxxxxxxxxxxx***							
9. Fish community		***xxxxxxxxxxxxx***										***xxxxxxxxxx***				
13. reports				***xxx***					***xxxxxx***						***xxxxxx***	

a. **Describe tasks scheduled for this period**:

Specific CWTC objectives were to (bold italics indicating work to be accomplished):

1. Capture, document, tag and release striped bass on the NC/VA wintering grounds.
2. Characterize the age structure of the stock on the winter grounds.
3. Estimate fishing mortality (F) of the coastal migratory stock.
4. Map the distribution of striped bass and associated species during the winter.
5. Map the movements and migration of striped bass using recapture data.
6. Assess catch/release mortality of trawl-caught versus hook-and-line caught fish.
7. Document all alosine species encountered (alewife, American shad, blueback herring and hickory shad).
8. Document and retain any species needed by NCDMF for aging to meet ASMFC and ACCSP targets.
9. Completely characterize each trawl catch to document all striped bass associates.
10. Capture, document, tag and release any Atlantic Sturgeon encountered during the Cruise.
11. Tag Atlantic Sturgeon over 800 mm TL with acoustic tags.
12. Capture and retain samples of adult Atlantic menhaden for aging and reproductive analysis

by NMFS and ASMFC.

13. Provide a final report of publishable quality for submission to fishery management agencies.

Objective 1: Capture, document, tag and release striped bass on the NC/VA wintering grounds.

The long running Cooperative Winter Tagging Cruise (CWTC) conducted both the trawl-based Cruise using the R/V Savannah based out of the Skidaway Institute of Oceanography, and the hook-and-line based striped bass tagging using the charter vessel F/V Midnight Sun out of Rudee Inlet, Virginia, during January and February 2016. A total of 1,240 (hook-and-line) + 110 (trawl) = 1,350 striped bass were captured, tagged and released for both vessels combined during the survey period.

<u>R/V Savannah - Trawl</u>

The R/V Savannah was delayed arriving from Skidaway, Georgia, due to poor weather along the coast. The ship arrived in Beaufort, NC, and berthed at the Duke University Marine Lab during early morning of Friday, January 8, 2016. Loading of supplies and equipment took place that day, and construction and fitting of the tagging table along with two seawater tanks and associated plumbing was completed by Friday as well. Departure was further delayed by inclement weather offshore for several days. Final departure of the R/V Savannah was at 0850 on Monday, January 11, to head northward around Capes Lookout and Hatteras. Vessel crew conducted safety training of the scientists. Once rounding Cape Hatteras, shake-down trawling was conducted beginning January 12 to determine gear stability and train the crew/scientists on deployment and retrieval. Subsequently, the ship traveled northward to continue sampling on January 13 at the Virginia state line. For each haul, all available bridge data were logged, and each species was identified and counted. Either the entire catch, or subsamples of each species were measured (mm TL).

The at-sea portion of the Cruise occurred from January 11 to January 19, 2016, a period less than the desired 10 days at sea caused by bad weather at the beginning and during the cruise period. At one point (January 17, at 2300 hr to January 18 at 0700 hr), the ship had to lay-to, and anchored off Chincoteague, VA, during the worst of the storm. From there, the ship continued to fish and head back to Beaufort arriving on January 19. There were a few gear issues. On tow # 88 on January 18, we encountered a structure charted but not avoided, which necessitated switching the net for one of the same design.

A total of 110 Striped Bass were captured and measured, and all were tagged and released during the Cruise. All Striped Bass captured by trawl in 2016 were in Maryland waters. Cruise personnel secured verbal and electronic authorization from Maryland DNR-Fisheries Service staff to conduct sampling in Maryland waters since no Striped Bass had been encountered in North Carolina or Virginia waters.

A list of species captured, as well as total counts will be provided in the final report but final numbers have not been confirmed for this Semi-Annual report (see Table 9 for preliminary list of

collected species, and total numbers by species). Preliminary bridge data for the cruise are summarized in Table 1.

Table 1. The ranges and means of tow speeds (knots), tow depths (ft), water temperatures (C), and salinities (ppt) for the 102 trawls conducted during the CWTC January 11-18, 2016 onboard the R/V Savannah (preliminary results).

Variable	Number of tows	Mean	Min	Max
Tow speed (min, kts)	102	3.1	2.8	3.5
Tow speed (max, kts)	102	3.1	2.8	3.5
Water temp (oC)	102	11.2	7.5	18.9
Air temp (oC)	102	6.4	-0.6	12.2
Salinity (ppt)	102	33.4	31.1	37.8
Depth (min, m)	102	17.8	7.4	31.8
Depth (max, m)	102	19.1	7.4	31.8

R/V Midnight Sun – Hook and Line

The hook-and-line component of the grant was fully coordinated and implemented by Charlton Godwin, North Carolina Division of Marine Fisheries. The fishing vessel used for the ten day-long trips conducted this year was the privately-owned FV Midnight Sun, which operated out of Rudee Inlet, VA (Table 2). Tagging operations in 2016 took place from January 26 through February 12 resulted in a total of 1,273 Striped Bass captured, and 1,239 tagged and released. A number of fish were injured during hook-and-line capture and were not tagged. Those fish were all released alive, without tags. All fish this year were located in the EEZ off Virginia; none were captured and tagged in waters off NC. This number was above last year's total and considerably above the two prior years. (see Table 3 courtesy of the Maryland Department of Natural Resources-Fisheries Service, NC Division of Marine Fisheries, and USFWS, unpublished data).

Table 2. Results of the 2016 Cooperative Winter Tagging Cruise Hook and Line tagging effort for striped bass, January 26-February 12, 2016.

2016	Trip#	Date	#Tagged	#Caught
	1	1/26	201	209
	2	1/27	10	10
	3	1/28	8	8
	4	1/30	221	225
	5	1/31	9	9
	6	2/1	157	163
	7	2/2	61	64
	8	2/6	305	312
	9	2/9	99	101
	10	1/12	168	172
	Totals		1,239	1,273

Objective 1 has been completed.

Table 3. Total Atlantic Sturgeon and Striped Bass captured, by year and gear type and total tagged/released, during Cooperative Winter Tagging Cruises off the coasts of North Carolina, Virginia and Maryland, 1988-2016 (data compiled by Maryland Department of Natural Resources, Fisheries Service, Annapolis; North Carolina Division of Marine Fisheries, Elizabeth City; and U.S. Fish and Wildlife Service, Annapolis, MD and Raleigh, NC; NA=not applicable, since sturgeon were not captured by hook-and-line gear). All numbers are subject to further revision.*

YEAR	GEAR TYPE	TOTAL STRIPED BASS CAPTURED	STRIPED BASS TAGGED AND RELEASED	TOTAL ATLANTIC STURGEON CAPTURED	ATLANTIC STURGEON TAGGED AND RELEASED
1988	trawl	1,619	1,338	20	20
1989	trawl	1,168	1,156	2	2
1990	trawl	3,008	2,010	11	11
1991	trawl	1,810	1,780	3	3
1992	trawl	1,062	1,017	7	7
1993	trawl	577	530	0	0
1994	trawl	5,311	4,631	7	7
1995	trawl	911	644	0	0
1996	trawl	781	698	15	15
1997	trawl	1,391	1,356	5	5
1998	trawl	468	463	1	1
1999	trawl	282	277	2	2
2000	trawl	6,493	6,237	8	8
2001	trawl	2,476	2,447	4	4
2002	trawl	4,183	4,087	23	22
2003	trawl	1,929*	1,908	8	8
2004	trawl	2,738	2,708	1	1
2005	trawl	4,297	4,263	1	0
2006	trawl	4,574	4,462	29	24
2007	trawl	370	370	13	13
2008	trawl	1,040	1,033	73	69
2009	trawl	147	146	31	29
2010	trawl	572	567	1	1
2011	hook & line	108	108	NA	NA
2012	hook & line	6	6	NA	NA
2013	hook & line	1,130	1,114	NA	NA
2013	trawl	895	893	4	0

YEAR	GEAR TYPE	TOTAL STRIPED BASS CAPTURED	STRIPED BASS TAGGED AND RELEASED	TOTAL ATLANTIC STURGEON CAPTURED	ATLANTIC STURGEON TAGGED AND RELEASED
2014	hook & line	925	921	NA	NA
2015	hook & line	1,058	1,042	NA	NA
2015	trawl	454	333	6	6
2016	hook & line	1,273	1,240	NA	NA
2016	trawl	110	110	2	0
TOTALS	ALL GEARS	53,166	49,895	277	258

***Subject to revision, July 29, 2016.** [Numbers in this table will be revised based on Beth, Josh and Wilson's final resolution of the numbers.]

Objective 2: Characterize the age structure of the stock on the winter grounds.

The age structure of the stock will be characterized using scales retained from a subsample of the fish tagged and released, as well as from any mortalities. There were no mortalities this year during either trawling, or hook-and-line sampling, so no otoliths were extracted and no subsample is available of otolith-scale sets for comparison of aging techniques. All scale samples have been provided to the North Carolina Division of Marine Fisheries for aging. The length frequency structure of both years for the trawling and the charter boat capture are depicted in Figure 1.

[We will insert the 2013, 2014, 2015, and 2016 age composition figures when data are finalized.]

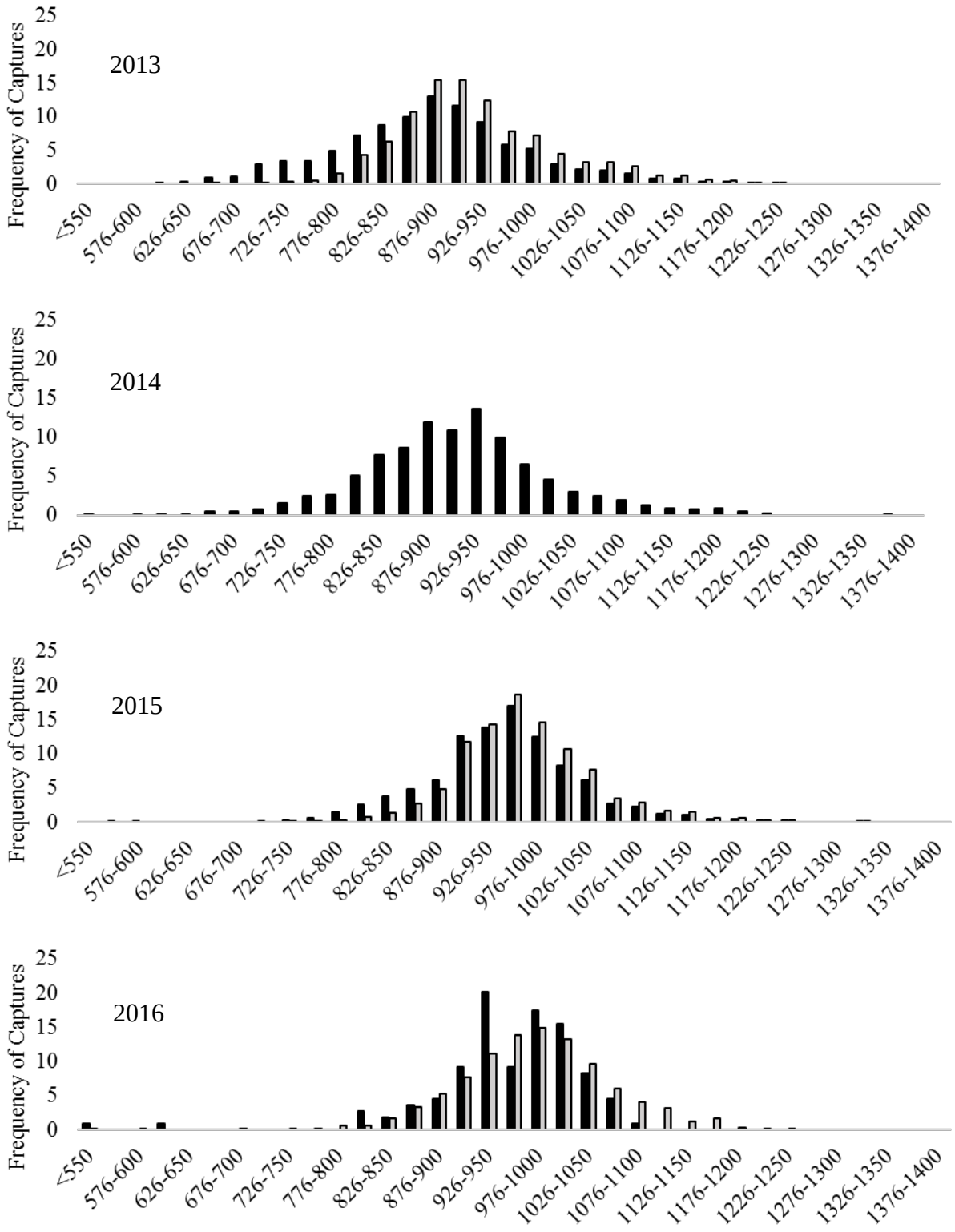


Figure 1. Length frequencies of Striped Bass by size class (mm) captured by hook and line (black) sampling and for the trawling (grey) portion of the study (preliminary data subject to change).

Objective 2 is ongoing by NCDMF employees.

[Secure all additional data from NCDMF and insert, as noted above, and then discuss whether there is any significant difference between the length/age compositions of trawl-caught, versus hook-and-line-caught, tagged/released individuals.]

Objective 3: Estimate fishing mortality (F) of the coastal migratory stock.

The fishing mortality of the stock is being estimated by Dr. Stuart Welsh, Assist Leader-Fisheries, West Virginia University and U.S. Geological Survey, West Virginia Cooperative Fish and Wildlife Research Unit, once a year has passed, based on reports of tag returns received (Table 4; Figure 2). Dr. Welsh is a member of the Atlantic States Marine Fisheries Commission (ASMFC) Striped Bass Tagging Subcommittee. All tag recaptures are being reported to the U.S. Fish and Wildlife Service (USFWS), Maryland Fish and Wildlife Conservation Office, located in Annapolis, Maryland, and incorporated into the databases for the ASMFC/USFWS coastwide striped bass tagging program. Two databases are maintained. The primary database is maintained by the Maryland Department of Natural Resources-Fisheries Service, at their Annapolis, Maryland offices. That database contains the data for all Atlantic Sturgeon and Striped Bass captured during all Cruises, both trawling, and hook-and-line. A second database is maintained by the USFWS at the Maryland Fish and Wildlife Conservation Office, also located in Annapolis, MD. That database contains only the data for tagged Striped Bass, both releases and recaptures. A separate database maintained by the USFWS at the same office, houses all Atlantic Sturgeon capture, tag, and recapture data.

Table 4. A comparison of the estimated mortality rates of Striped Bass >= 711 mm TL captured by hook-and-line (Hookline) during the charter boat sampling, and by trawl during the CWTC trawl survey, and released near the point of capture for 2013, 2014, and 2015. Estimates subject to revision.

Capture method and est. 9% mortality for hook&release	year	Number released	recaps killed	recaps Released alive	catch rate
Hookline	2013	1112	52	19	0.14848586
Hookline 9% mort	2013	1012	52	19	0.16317128
Trawl	2013	817	51	22	0.20779369
Hookline	2014	918	48	16	0.16213204
Hookline 9% mort	2014	835	48	16	0.17816707
Trawl	2014	0	0	0	#DIV/0!
Hookline	2015	1042	49	25	0.16515645
Hookline 9% mort	2015	948	49	25	0.18149061
Trawl	2015	330	16	9	0.17618041

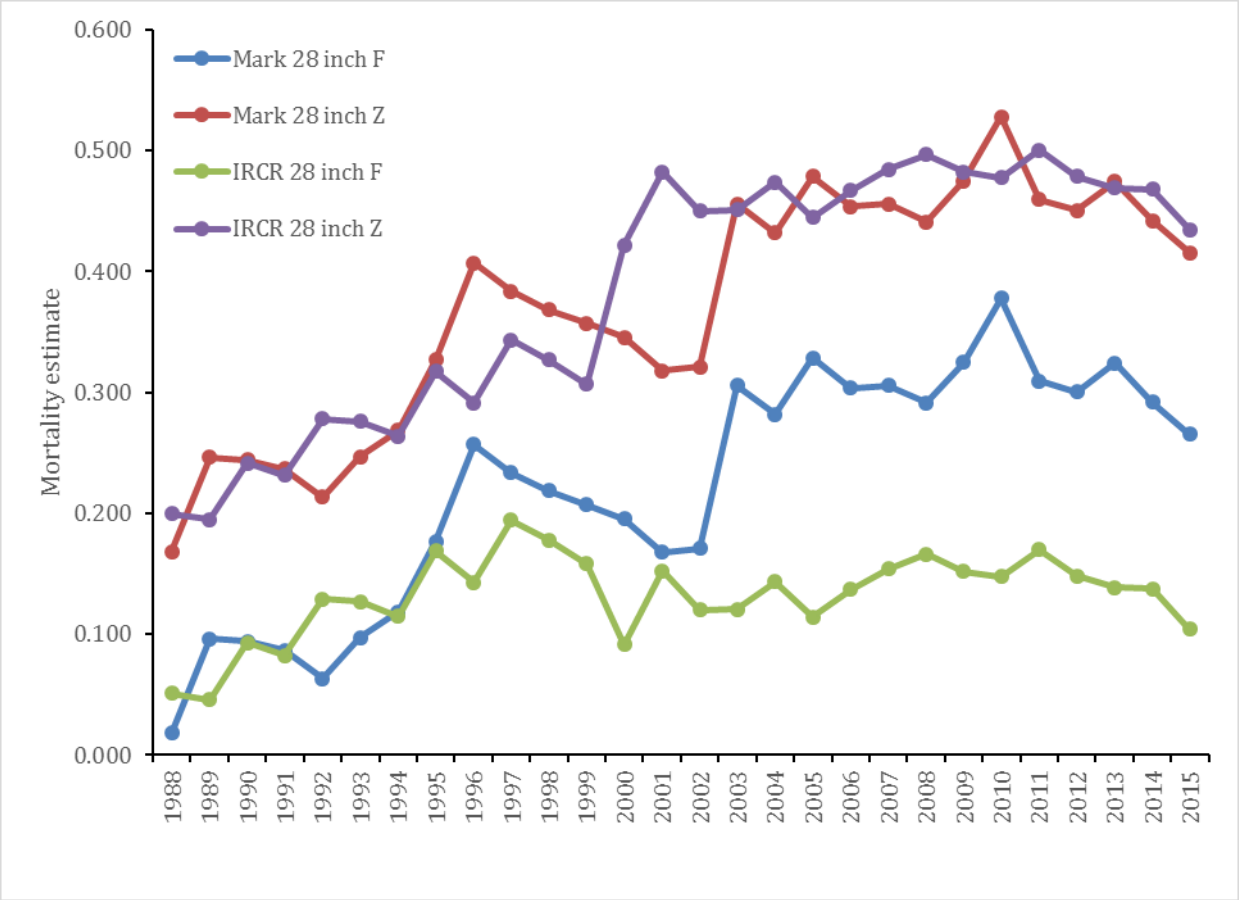


Figure 2. Mortality estimates (F and Z) for the offshore migratory stock of striped bass >= 28 inches tagged and released from the Cooperative Winter Tagging Cruises, 1988 to 2015 (data subject to revision). Mark = Seber; IRCR = instantaneous rate.

[In the final report we will include discussion indicating whether there is any significant difference between the observed mortality of trawl-caught, versus hook-caught, Striped Bass within and among years.]

Objective 3 is ongoing by Dr. Welsh at USGS.

Objective 4: Map the distribution of striped bass and associated species during the winter. Figure 3 shows the locations of sampling, and the resultant Striped Bass and Atlantic Sturgeon captures.

Objective 4 is ongoing.

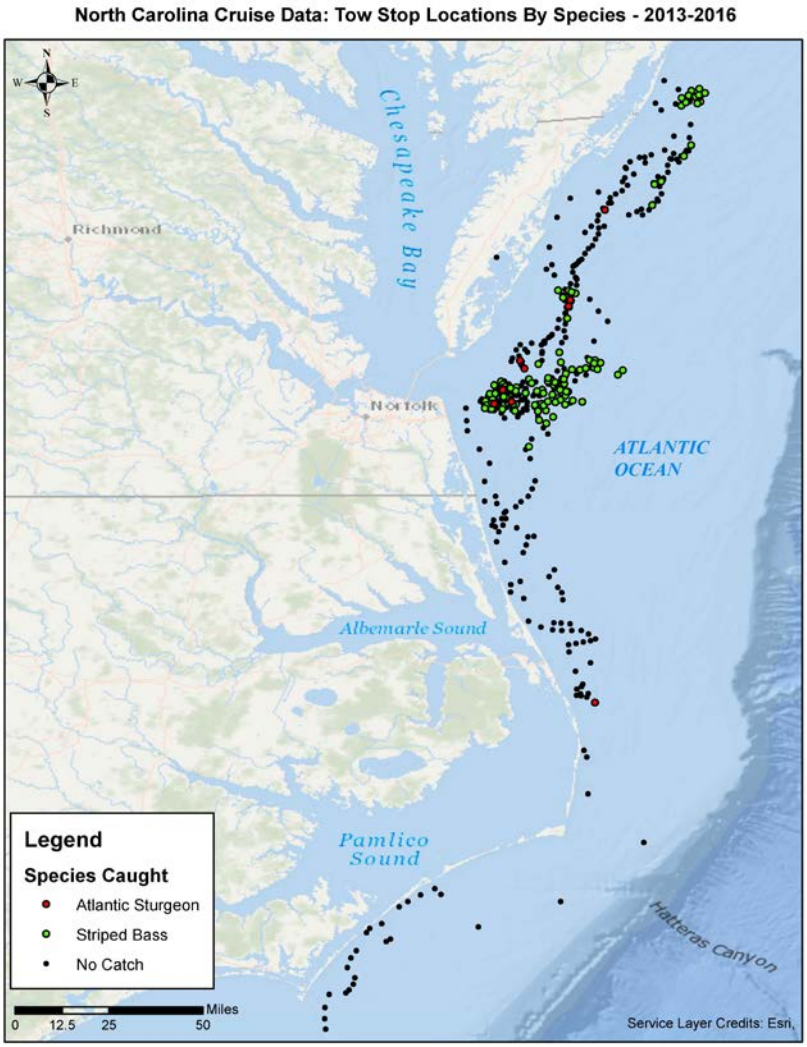


Figure 3. GIS plot show where Striped Bass and Atlantic Sturgeon were collected during the annual Cooperative Winter Tagging Cruises, 2013-2016.

Objective 5: Map the movements and migration of striped bass using recapture data.

[GIS plots go here]

Objective 5 has not been initiated.

[Brian Van Druten, USFWS, has done some mapping and we will insert what he has provided; ultimately need to have maps of returns for each year, 2013-2016, for both the CRFL and SK final reports. We now have the data and are working on these figures].

Objective 6: If possible employ acoustic tags in a subset of tagged striped bass to assess catch/release mortality of trawl-caught versus hook-and-line caught fish.

The only Striped Bass collected during 2016 were in Maryland and Virginia, and we were not able to surgically implant any VEMCO V-16 transmitters into any Striped Bass. No surgically certified staff were available for the Charter vessel; we did have surgical staff onboard the R/V Savannah but no fish were acoustically tagged.

Objective 6 was unsuccessful and could not be completed.

Objective 7: Document all alosine species encountered (Alewife, American Shad, Blueback Herring and Hickory Shad).

All alosines in trawl samples were identified (Table 5), and samples were retained for transport back to East Carolina University for additional study (Table 6). In most cases all fish from a given tow were retained. Associated data are being compiled.

Table 5. Alosine species captured during the annual Cooperative Winter Tagging Cruises, 2013-2016.

Species	2013	2015	2016
American Shad	0	0	0
Alewife	156	78	28
Blueback Herring	0	0	9
Hickory Shad	6	3	0

Table 6. The number of Alewife and Blueback Herring retained for laboratory examination during the Cooperative Winter Tagging Cruises in years identified below. Hickory Shad were collected only in 2003 (7) and 2005 (%), and American Shad were caught in 2009 (1).

Species	2005	2008	2009	2010	2013	2015	2016
Alewife							
N	15	26	50	70	79	7	26
Mean FL	132.1	227.7	233	217	237.4	246.1	231.3
STD FL	48.8	24.3	29.7	45.2	19.1	11.1	24.4
Min FL	81	159	110	114	203	230	139
Max FL	225	276	335	266	278	263	261
Blueback Herring							
N	21	97	159	390	0	72	9
Mean FL	113.9	197.6	187.8	198.5		217.7	175.1
STD FL	35.7	23	29.8	24.2		29.1	6.9
Min FL	77	75	103	34		90	165
Max FL	177	250	266	247		255	188

Otoliths are currently being photographed for ageing. The relationship between fish length (FL, mm) and gonad size (weight, g) was different each year and by sex; the time of year that the CWTC occurred may also have influenced the results (Figures 4-9). We continue to analyze data, and with securing the ages of the individuals we will be able to expand the analyses for the final report.

Objective 9 is ongoing.

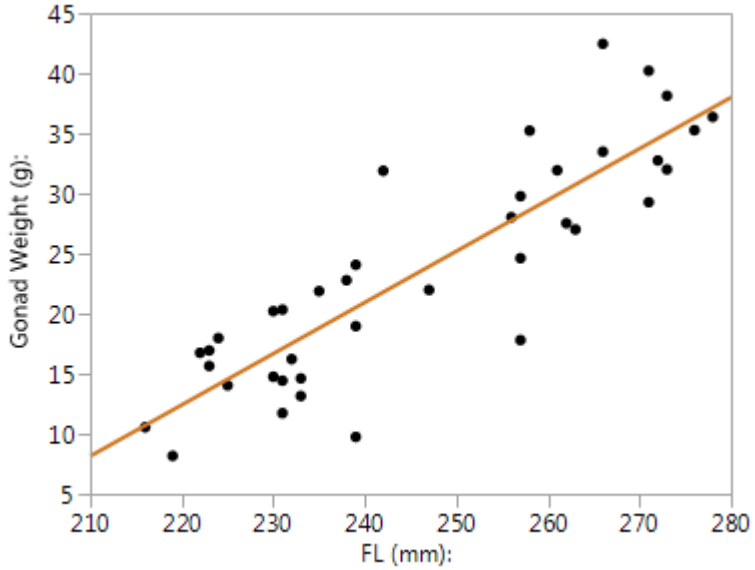


Figure 4. Female Alewife caught by the 2013 CWTC, January 8-16, 2013. GWT = -81.363 + 0.426FL; r2 = 0.76, n = 39, F=116.12; P<0.001.

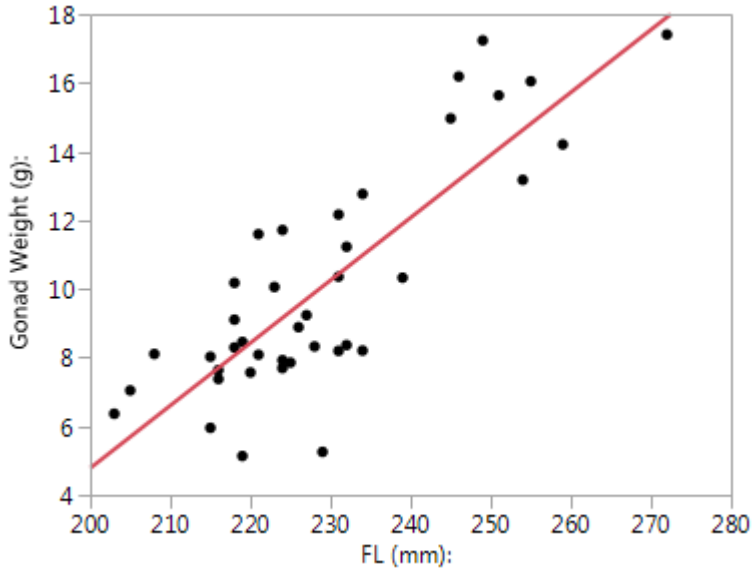


Figure 5. Male Alewife caught by the 2013 CWTC, January 8-16, 2013. GWT = -31.692 + 0.182FL; r2=0.69; n=40; F=84.53; P<0.001.

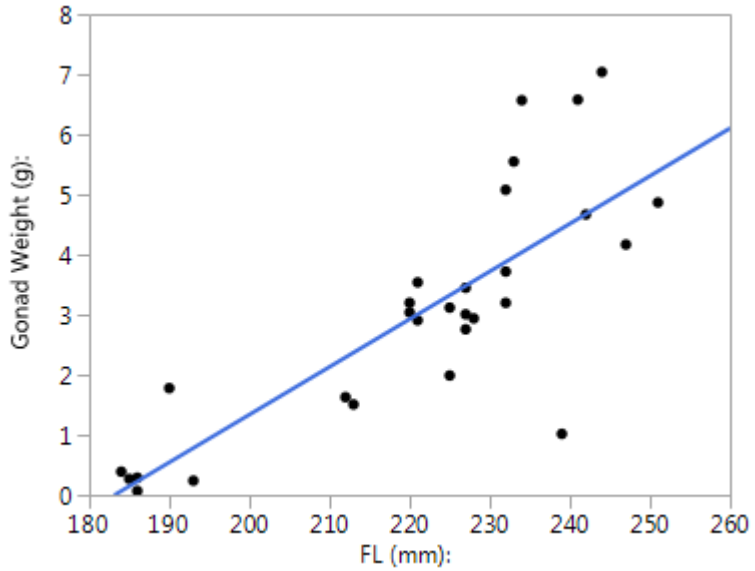


Figure 6. Female Blueback Herring caught by the 2015 CWTC, January 10-18, 2015. GWT=-14.540+0.079FL; r2=0.64; n=30; F=49.99; P=<0.001.

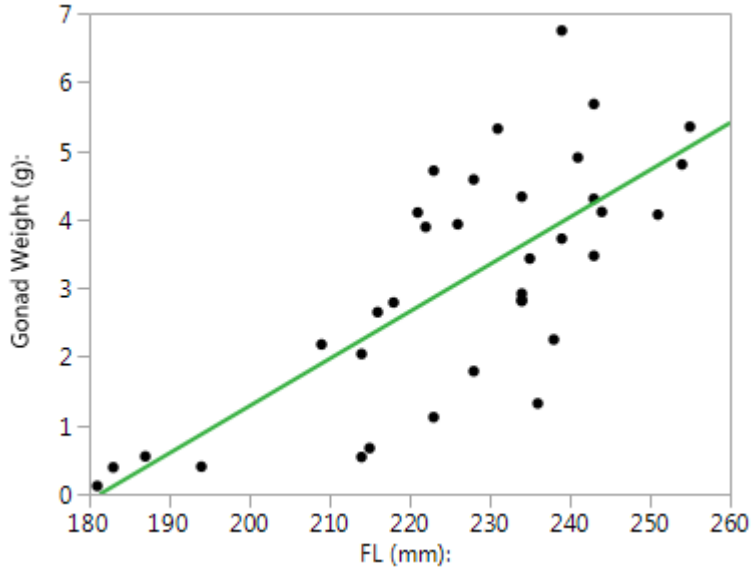


Figure 7. Male Blueback Herring caught by the 2015 CWTC, January 10-18, 2015. GWT=-12.456+0.069FL; r2=0.55; n=35; F=39.743; P<0.001

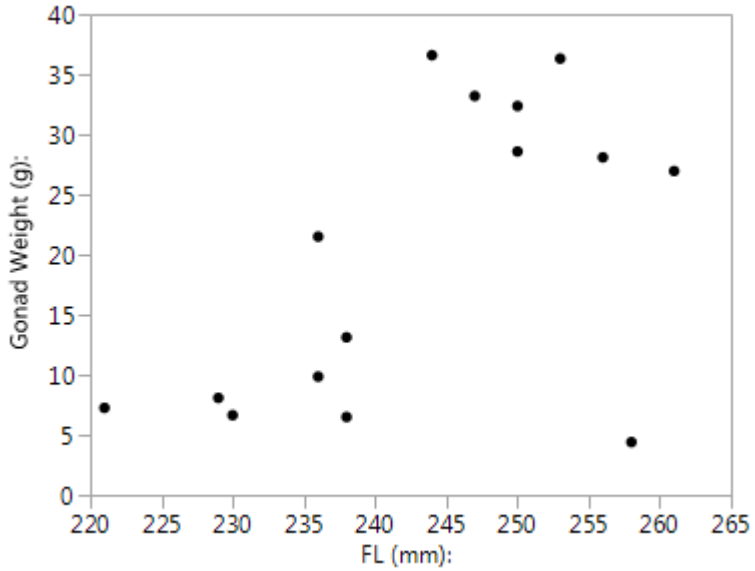


Figure 8. Female Alewife caught by the 2016 CWTC, January 12-18, 2016.

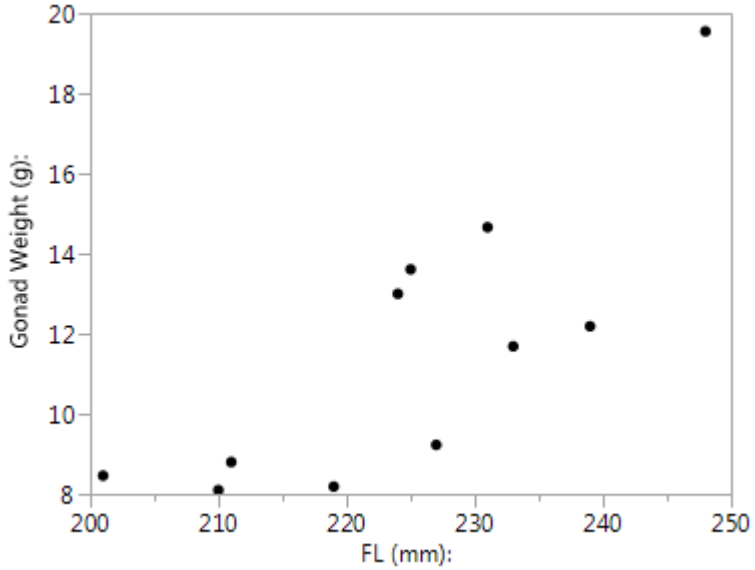


Figure 9. Male Alewife caught by the 2016 CWTC, January 12-18, 2016.

Objective 7 is ongoing. [Rulifson to insert appropriate data here for all the alosine work.]

Objective 8: Document and retain any species needed by NCDMF for aging to meet ASMFC and ACCSP targets. Multiple individuals of target ASMFC and NCDMF interest were retained, and otoliths and/or scales retained for aging.

Objective 8 is completed. [We just need to create and insert a table here which documents all of the species that we/NCDMF retained for aging. I know that included Atlantic Croaker, Kingfishes, Spot, Weakfish, Summer Flounder, Southern Flounder?, and Sheepshead at a minimum. Wilson will coordinate with NCDMF].

Objective 9: Completely characterize each trawl catch to document all Striped Bass associates.

Data are being compiled from the 2016 trawl survey. Table 7 compares the species composition among the three years, and looks at the top ten species in terms of abundance.

Table 7. Most abundant species co-occurring with Striped Bass in tows from the 2013, 2015, and 2016 Cruises.

Year	Number of Tows Containing Striped Bass	Number of Striped Bass Captured	Associate Species (number of co-occurring tows)	Abundance of Associate Species in Tows Containing Striped Bass
2013	78	1196	Spiny Dogfish (78)	3209
			Atlantic Herring (19)	109
			Clearnose, Winter, Little Skates (60)	146
			Summer and Windowpane Flounders (51)	363
			Butterfish (10)	58
			Hakes (11)	43
			Weakfish (13)	28
			Squid (40)	390
			Bay Anchovy (48)	--
			Horseshoe Crab, Starfish, Other Non-finfish Species (48)	--
2015	31	335	Spiny Dogfish (30)	364
			Atlantic Herring (8)	74
			Clearnose, Winter, Little Skates (28)	135
			Butterfish (9)	81
			Hakes(12)	66
			Squid (27)	292
			Horseshoe Crab, Lobster, Other Crab Species (9)	16
			Blueback Herring (8)	24
			Summer, Windowpane, and Smallmouth Flounder (10)	22
			Menhaden (4)	11
2016	13	110	Spiny Dogfish (13)	166
			Atlantic Cutlassfish (6)	21
			Atlantic Herring (4)	73
			Alewife (8)	25
			Horseshoe Crab (8)	16
			Little and Winter Skates (10)	29
			Hakes (7)	58
			Summer and Windowpane Flounders (13)	41
			Squid (13)	329
			American Lobster and Various Crab Species (7)	13

Objective 9 is ongoing.

Objective 10: Capture, document, tag and release any Atlantic sturgeon encountered during the Cruise.

A total of four Atlantic Sturgeon were captured during trawl sampling in 2013 (Table 8). Each was measured, scanned for PIT tags and released. All fish were negative for PIT tags. No finclips were taken for genetic analysis, nor were any tags emplaced in the fish, due to the lack of NMFS authorization to tag or take tissue. No Atlantic Sturgeon were captured during 2014, since no trawling was conducted and Atlantic Sturgeon were not encountered with hook-and-line gear. In 2015, six Atlantic Sturgeon were captured, tagged, sampled for tissue and released, since we had authorization from the NMFS SE Region to conduct tagging and sampling in that year. For 2016, we were again not authorized to process Atlantic Sturgeon. Two individuals were captured, scanned for PIT tags, measured and released (both were negative for PIT tags). A summary of Atlantic Sturgeon captured during the 2013, 2015 and 2016 Cruises is provided in Table 8.

Table 8. Summary of Atlantic Sturgeon captured during the 2013, 2015, and 2016 Cruises; n=12.

Date	Haul #	Start Time	Stop Time	Start Latitude	Start Longitude	Stop Latitude	Stop Longitude	Min. Tow Speed	Max. Tow Speed	Water Temp. °C	Air Temp. °C	Salinity (ppm)	Min. Depth (m)	Max. Depth (m)	Total Length (mm)	Fork Length (mm)	Girth (mm)	Tagged Y/N	Genetics Y/N
1/9/2013	45	19:46	20:07	3657.01	7544.31	3657.32	7545.60	3.0	3.2	8.9	13.0	29.6	16.6	16.9	1944	1770	870	N	N
1/12/2013	121	4:19	4:39	3653.11	7547.40	3654.12	7547.55	3.0	3.1	8.8	12.0	27.9	17.1	17.2	1178	1030	465	N	N
1/12/2013	145	23:07	--	3703.50	7541.23	3702.28	7540.60	2.9	3.3	9.0	7.0	30.3	17.9	18.6	1265	1130	--	N	N
1/13/2013	199	16:25	16:50	3655.68	7544.62	3654.57	7543.61	3.2	3.3	9.7	11.0	29.4	16.0	19.6	1551	1350	630	N	N
1/11/2015	9	11:05	11:20	35.7333	-75.4080	35.7459	-75.4052	3.0	3.0	13.7	10.7	34.2	20.0	61.7	1310	1170	--	Y	Y
1/16/2015	103	16:37	16:57	37.2942	-75.5037	37.2758	-75.5052	3.4	3.5	7.3	6.8	33.4	60.4	63.1	1522	1330	660	Y	Y
1/16/2015	103	16:37	16:57	37.2942	-75.5037	37.2758	-75.5052	3.4	3.5	7.3	6.8	33.4	60.4	63.1	1841	1598	780	Y	Y
1/16/2015	103	16:37	16:57	37.2942	-75.5037	37.2758	-75.5052	3.4	3.5	7.3	6.8	33.4	60.4	63.1	1858	1630	781	Y	Y
1/16/2015	105	18:08	18:29	37.2980	-75.4996	37.2792	-75.5068	3.3	3.3	7.3	6.8	33.4	55.3	63.4	1560	1350	--	Y	Y
1/16/2015	106	18:54	19:16	37.2830	-75.5009	37.3029	-75.5004	3.3	3.3	7.2	6.8	33.4	60.0	63.8	1520	1290	--	Y	Y
1/13/16	21	13:24	13:39	37.0571	-75.6872	37.0686	-75.6935	3.0	3.0	10.5	-0.3	32.5	15.5	17.9	1760	1550	--	--	--
1/13/16	27	22:15	22:30	37.6385	-75.3769	37.6515	-75.3662	3.1	3.1	9.6	2.3	33.0	17.6	14.5	1670	1380	--	--	--

Objective 10 has been completed.

Objective 11: Tag all Atlantic sturgeon over 800 mm TL with acoustic tags.

Objective 11 was not conducted because we had no one aboard with appropriate authorization to conduct this task.

Objective 12. Capture and retain samples of adult Atlantic menhaden for aging and reproductive analysis by NMFS and ASMFC.

Menhaden were captured and retained for aging and reproductive analysis.

Objective 12 has been completed.

Objective 13: A final report will be prepared upon completion of the grant period.

Deviations:

If there were changes to the goals/objectives during the reporting period, please detail the circumstance and nature of change. Explain any special problems or circumstances that prevented the accomplishment of scheduled tasks. Describe actions to resolve problems encountered and provide the details of any changes made to goals and objectives of the project.

There were no deviations during the reporting period for this interim report.

Table 9. Cooperative Winter Tagging Cruise 26: R/V Savannah Cruise SAV-16-01: January 11-18, 2016. List of common names of species captured during the 2016 annual CWTC, and the number captured, tagged or retained (data preliminary, subject to change; invertebrate names are preliminary and subject to further revision).

Species	Total
Atlantic Angel Shark	1
Atlantic Croaker	260
Atlantic Cutlassfish	73
Atlantic Herring	274
Atlantic Mackerel	5
Atlantic Menhaden	280
Atlantic Midshipman	1
Atlantic Sharpnose Shark - F	6
Atlantic Spadefish	3
Atlantic Stingray	3
Atlantic Sturgeon	2
Alewife	28
Bay Anchovy	709
Bay Whiff	1
Bighead Searobin	29
Black Drum	2
Black Sea Bass	2
Bluefish	40
Blueback Herring	9
Blue Runner	9
Bullnose Ray - F	16
Bullnose Ray - M	10
Butterfish	61
Clearnose Skate-F	19
Clearnose Skate-M	20
Cubbyu	1
Cusk Eel	2
Dusky Flounder	1
Fourspot Flounder	3
Flounder sp	38
fringe flounder	1
Gadidae Sp	2
Greater Amberjack	1
Grey Triggerfish	4
Hake Sp	18
Horseshoe Crab	204
Inshore Lizardfish	33
Leopard Searobin	41
Little Skate-F	59
Little Skate-M	56
Longspine Porgy	896
Northern Kingfish	69
Northern Puffer	50
Northern Sea Robin	122
Pigfish	331
Pinfish	140
Plainhead Filefish	5
Red Hake	38
Rock Sea Bass	1
Round Herring	2
Sea Robin Sp	1
Sheepshead	17
Skate spp	1
Silver Hake	222
Silver Porgy	5
Snakefish	3
Southern Hake	110
Southern Stingray	1
Spotted Eagle Ray	2
Silver Perch	105
Smallmouth Flounder	103
Smooth Butterfly Ray -F	1
Smooth Butterfly Ray -M	3
Southern Kingfish	489
Spiny Butterfly Ray -F	10
Spiny Butterfly Ray - M	3
Spiny Dogfish	1233
Spot	37
Spotted Hake	643
Star Drum	4
Striped Anchovy	18
Striped Bass	110
Striped Burrfish	5
Striped Sea Robin	11
Summer Flounder	54
Weakfish	778
Windowpane	124

Winter Skate-F	101
Winter Skate-M	61
Winter Skate-unknown gender	1

INVERTEBRATES (preliminary)

Longfin Squid	1068
Shortfin Squid	24
Brief Squid	14
Bob tail Squid	22
Brown Shrimp	1
Flathead Shrimp	7
Roughhead Shrimp	14
Roughneck Shrimp	2
Penaeid Shrimp	6
Trachypenaeid Shrimp Sp	1
White Shrimp	12
Mantis Shrimp	5
Pink Shrimp	15
Pink Speckled Shrimp	7
Sand Shrimp	2
Shrimp Sp	1
Crab sp	17
Blue Crab	2
Jonah Crab	35
Lady Crab	126
Mud Crab	3
Portunid Crab spp	13
Rock Crab	30
Sand Crab	106
Spider Crab	29
Sand Dollar	12
Surf Clam	1
Whelk	2
American Lobster	2
Box Jelly	2
Jellyfish	1
Northern Moon Snail	3
Moon Jelly	2
Channeled Whelk	1
Starfish	25
Urchin Sp	104
White Urchin	1
Hermit Crab	3
Babys Ear	3

[NOTES: Common and scientific names for fishes follow Page, L.M., H. Espinosa-Pérez, L.T. Findley, C.R. Gilbert, R.N. Lea, N.E. Mandrak, R.L. Mayden and J.S. Nelson. 2013. Common and scientific names of fishes from the United States, Canada, and Mexico, 7th Edition. American Fisheries Society, Special Publication 34, Bethesda, Maryland. 384 pp.; common and scientific names for decapod crustaceans follow Williams, A.B., L.G. Abele, D.L. Felder, H.H. Hobbs, Jr., R.B. Manning, P.A. McLaughlin, and I. Pérez Farfante. 1988. Common and scientific names of aquatic invertebrates from the United States and Canada: decapod crustaceans. American Fisheries Society, Special Publication 17, Bethesda, Maryland. 77 pp; common and scientific names for mollusks follow Turgeon, D.D., J.F. Quinn, Jr., A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P.M. Mikkelsen, R.J. Neves, C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltema, F.G. Thompson, M. Vecchione and J.D. Williams. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks, 2nd edition. American Fisheries Society, Special Publication 26, Bethesda, Maryland. 526 pp.;

Some fish and one invertebrate specimens were retained and transferred to the North Carolina State Museum of Natural Sciences (NCSM) as voucher specimens, for collection of tissue for genetic analysis, and/or to confirm identifications; most alosines were retained and transferred to East Carolina University (ECU) for further analysis; some fish specimens were retained for aging by the NC Division of Marine Fisheries (NCDMF).]

Table10. Definition of the metadata from the CWTC and the Charter boat tag and release program.

Tagged Fish Released from All	
Relbat Batch Num	
Rel Agency	Organization or project responsible for tagging and release of the fish: NCCOOP = Cooperative Winter Tagging Cruise
Rel State	State associated with waters where fish were released after tagging
Rel Date	Date fish was released with tag (month/day/year)
Deploy Start	Start time of capture effort. For trawls, beginning of trawl deployment; for hook and line, time of lines set in the water.
Deploy End	End time of capture effort. For trawls, end of trawl deployment; for hook and line, time of lines retrieved (based on full set) from the water.
Set Soak Time	Total time of capture effort for that set.
Start Time	
End Time	
Fish Caught	Number of fish caught during capture effort: trawl = number of fish in tow; hook and line = number of fish in set.
Fish Tagged	Number of fish tagged during capture effort: trawl = number of fish in tow; hook and line = number of fish in set.
Min Tag No	First tag number for fish tagged in set.
Max Tag No	Last tag number for fish tagged in set.
Comment	
Site	Location of capture effort - generalized by area.
Latitude	Latitudinal coordinate of capture location
Longitude	Longitudinal coordinate of capture location
NOAA Code	
Surf Salin	Salinity of surface water (<10m) at time and location of capture
Water Temp	Water temperature of surface water (<10m) at time and location of capture
Air Temp	Air temperature at time and location of capture
Gear Type	H=hook and line; T=trawling
Mesh Size	N/A for hook and line; T = (codend)
Gear Depth	Depth in meters that gear was deployed at for capture effort
Gear Length	
Thread Type	
Type Fish	
Hatchery	
Relind_Batch Num	
Tag Num	Number designated on tag inserted into fish.
Tag Type	

Total Length	Total length in millimeters of tagged fish
Fork Length	Fork length in millimeters of tagged fish
Weight	Weight in kilograms of tagged fish
Sex	Gender of tagged fish: M=male; F=female; U=unidentified
Scale	Y=scales were removed and saved for aging; N = scales were not removed
Year Class	Year class of the tagged fish, determined by scale age
Other Tag	FALSE = additional tag was not place on/in fish; TRUE = additional tag was place on/in fish
Fish Examined	
Comments	
UpDate	
Recapture Data	
TagNum	Number designated on tag inserted into fish.
Event	
RepDate	Date that recapture of tagged fish was reported (day-month-year)
CapDate	Date that recapture of tagged fish occurred (day-month-year)
CapWeek	Consecutive week of the year in which fish was recaptured.
CapMonth	Consecutive month of the year in which fish was recaptured.
CapDay	Consecutive day of the month in which fish was recaptured.
CapYear	Year in which fish was recaptured.
State	State where fish was recaptured
recap.Site	Generalize description of area of fish's recapture
Region	Region where fish was recaptured
Code	
Recapturer	
recap. GearType	Gear type used by recapturer (H = hook and line; O = ; A = ; D= ; P = ; S =)
Disposition	Disposition of recaptured fish: K=killed; R=re-released; D= ; S= ; T=
Tag Removed	Y=tag was removed; N= tag was left in/on fish
Portion Removed	Both = both dart and streamer portion; Streamer = streamer only. Portion of tagged removed if 'Tag Removed' field = Y
Other Tags	Additional tags reported on fish
Length	Length in millimeters of fish when recaptured
recap. ForkLength	Fork length in millimeters of fish when recaptured
recap. Weight	Weight in kilograms of fish when recaptured
recap. Sex	Gender of fish at recapture: M=male; F=female; U=unidentified
recap. YearClass	
recap. Scale	
Tag Sent	Y= tag was returned to agency; N=tag was not returned to agency
Reporter Type	R= ; F= ; S =
Recapturer type	

BatchNum	
RelAgency	Organization or project responsible for tagging and release of the fish: NCCOOP = Cooperative Winter Tagging Cruise
RelState	State associated with waters where fish were released after tagging
RelDate	Date fish was released with tag (month/day/year)
Deploy Start	Start time of capture effort. For trawls, beginning of trawl deployment; for hook and line, time of lines set in the water.
Deploy End	End time of capture effort. For trawls, end of trawl deployment; for hook and line, time of lines retrieved (based on full set) from the water.
Set SoakTime	Total time of capture effort for that set.
Start Time	
End Time	
Fish Caught	Number of fish caught during capture effort: trawl = number of fish in tow; hook and line = number of fish in set.
Fish Tagged	Number of fish tagged during capture effort: trawl = number of fish in tow; hook and line = number of fish in set.
MinTagNo	First tag number for fish tagged in set.
MaxTagNo	Last tag number for fish tagged in set.
Relbat.Site	Location of capture effort - generalized by area.
Latitude	Latitudinal coordinate of capture location
Longitude	Longitudinal coordinate of capture location
NOAACode	
SurfSalin	Salinity of surface water (<10m) at time and location of capture
WaterTemp	Water temperature of surface water (<10m) at time and location of capture
AirTemp	Air temperature at time and location of capture
Relbat. GearType	H=hook and line; T=trawling. Gear type used to initially capture fish for tagging.
Mesh Size	N/A for hook and line; T = (codend)
Total Length	Total length in millimeters of tagged fish
Relind. ForkLength	Fork length in millimeters of tagged fish
Relind. Weight	Weight in kilograms of tagged fish
Relind. Sex	Gender of tagged fish: M=male; F=female; U=unidentified
Relind. Scale	Y=scales were removed and saved for aging; N = scales were not removed
Relind. YearClass	Year class of the tagged fish, determined by scale age
Comments	
Tag Type	
Value	
End Date	
Advertised	

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: Dr. Jeffrey A. Buckel

Grant Award #: NCSU Project ID# 570300 (NCDENR Task Order #6426)

Grant Title: Evaluation of changes in available spawning and nursery habitats for river herring in North Carolina

Grant Award Period: 7/1/2015-6/30/2018

Performance Reporting Period: 1/1/17 – 6/30/17 **(6 months)**

Project Costs:

Category	**Expenditures**
Personnel	$34,811 ($7,269 encumbered)
Fringe	$4,185
Travel	$3,425
Equipment	0
Supplies	$500
Fixed	$1,637
Contractual	0
Other(tuition)	$16,704
Total Direct	$61,261
Indirect	$6,563
TOTAL	$67,824

Total Cumulative Expenditures: $67,824 (-$7,269 encumbered)
Total Remaining Balance: $91,246 - $67,824 - $7,269 = $16,152

Description of Work**:**

1) To identify historic spawning and nursery river herring habitat.
2) To evaluate the impact of culverts on river herring spawning migration from historic NCDOT data.
3) To identify any habitat areas where spawning or juvenile river herring were once absent, but are now beginning to reappear or were once present, but are now absent.
4) To recommend areas of the state to prioritize for future sampling efforts.

Project Status/Work Accomplished:

The accomplishments over the last six months that addressed each objective are detailed below:

Steven Lombardo (graduate student) resided in Elizabeth City from February 2017 to May 2017, conducting Program 150 sampling, analyzing program 150 data for spawning phenology and land cover/habitat use associations, assessing data quality for the culvert study, and taking courses. A presentation on river herring spawning run phenology that shows a reduction in time on spawning grounds was prepared and given at the 2017 meetings of the North Carolina Chapter and Tidewater Chapter of the American Fisheries Society. Findings show temporal shifts have occurred in both species runs, from the implementation of Program 150 to the present. All 2016 data have been incorporated into the analyses and represent the final form of the dataset, as the 2017 data will not be through the verification process in time. There is currently insufficient data to perform the culvert passage analysis, even when including 2017 data. An insufficient amount of sampling replicates and a scarcity of river herring reaching these locations prevented any analysis from being conducted. A recommendation to conduct sampling specifically at culverts will be made if questions regarding fish passage are still pertinent. The study on land cover effects was recently presented at the national AFS meeting in Tampa. While attending the meeting, Steven was invited to present his research to the Albemarle-Pamlico National Estuary Partnership in November.

Steven Lombardo is currently residing in Morehead City and is taking his final course and writing two thesis chapters, one on river herring spawning phenology and the other on the effects of land cover on habitat use.

Deviations:

There were no deviations from our proposed objectives.

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: Dr. Jeffrey A. Buckel

Grant Award #: NCSU Project ID# 570221 (NCDENR Task Order #6431)

Grant Title: Marine Fisheries Fellowship Program

Grant Award Period: 7/1/2015-6/30/2020

Performance Reporting Period: 1/1/17 – 6/30/17 **(6 months)**

Project Costs:

Category	**Expenditures**
Personnel	$74,341
Fringe	$7,746
Travel	$1,627
Equipment	0
Supplies	$1,355
Construction	0
Contractual	0
Other	0
Total Direct	$85,068
Indirect	$12,760
TOTAL	$97,829

Total Cumulative Expenditures: $97,829
Total Remaining Balance: ($102,107 - $97,829 = $4,278)

Description of Work**:**

1) To provide an educational opportunity for a graduate student to spend one year working for the NCDMF.

2) To provide support for management priorities of the NCDMF on a substantive issue related to fisheries biology, management, stock assessment or coastal habitat identification and protection.

3) To enhance technology transfer from NCDMF and NCSG research to the user community in the most effective and efficient manners.

Project Status/Work Accomplished:

The accomplishments over the last six months that addressed each objective are detailed below:

Marine Fisheries Fellow (2017-2018) – Thom Teears

Jeff Buckel worked with DMF staff to identify a topic for the 2017 Marine Fisheries Management Fellow. The topic was approved by the CRFL subcommittee in June 2016. Michelle Duval, NC Sea Grant director Susan White, and Jeff Buckel interviewed several outstanding candidates and chose Thom Teears for the 2017 fellow. Thom Teears is currently applying data poor stock assessment approaches to sheepshead data from North Carolina.

Thom Teears has familiarized himself with data-limited approaches to stock assessment by studying and applying various methods including catch-based (median catch & ORCS), depletion-based (DCAC & DB-SRA) and abundance-based (Simple, life-history analysis & F_{msy}/M) methods to the sheepshead catch time series. Tagging data of sheepshead indicated that sheepshead will migrate from one state to another therefore, the stock assessment was expanded to a coast-wide assessment to include sheepshead from Virginia to the Atlantic coast of Florida to ensure the fish stock was accurately assessed. Thom also developed estimates of input parameters based on the literature, management history and life-history of sheepshead. The results of this work were presented in a power point on July 11th to Jeff Buckel and personnel from NC DMF to include Laura Lee and Anne Markwith for the purpose of informing DMF staff on stock status and for improved stock management.

Thom has been collaborating with fisheries scientists from VA, NC, SC, GA and FL in order to collect data from fisheries independent and dependent sources from surveys, commercial fishing databases, recreational fishing databases, age data, and tagging data in order to develop a data-moderate assessment using Stock Synthesis software. Thom has been graphing and preparing data using R software for input into Stock Synthesis and for creating abundance indices. Thom met with Jeff Buckel and Jim Morley on August 11th to discuss alternative data sources to further inform the stock assessment and to explore methods for standardizing abundance indices, estimating fecundity and characterizing juvenile habitat.

Deviations:

There were no deviations from our proposed objectives.

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: North Carolina Division of Marine Fisheries (Randy Gregory)

Grant Award #: 2F40 F035

Grant Title: Validating and updating maturation schedules for better management of North Carolina fisheries

Grant Award Period: July 1, 2016 – June 30, 2019

Performance Reporting Period: January 1, 2017 – June 30, 2017

Project Costs:

Expenditures for the Period:

Category	**Expenditures**
Personnel (Temp)	12,598
Travel	198
Equipment	6,160
Supplies	6,777
Other	11
TOTAL	25,744

Total Cumulative Expenditures: 25,744
Total Remaining Balance: 32,768

Description of Work**:**

The objective of this project is to collect and analyze maturity data from two target species; striped mullet and spotted seatrout. As well as 7 ancillary species; Atlantic croaker, black drum, kingfish species, red drum, river herring, sheepshead and southern flounder. These data will be used to improve the accuracy of NCDMF management targets and assessments of fishery stock viability for these species. To estimate current length – and age-at-maturity data for the target species and to generally assess the accuracy and quality of maturity data currently being collected by NCDMF.

Project Status/Work Accomplished:

Sample Collection:

- The first year of sampling was successfully completed as of June 30th, 2017. Samples were collected for the two target species, striped mullet and

spotted seatrout, as well as from four of the ancillary species; sheepshead, river herring, kingfish and black drum, for a total of 438 samples. Data for each species are broken down by field office and month of collection in Tables 1 through 6. The majority of the samples were collected by existing Division programs, but some directed trips were taken to acquire fish in size categories not typically encountered. It is likely that directed trips will be required to adequately sample some of the species size categories since their capture through existing programs is unlikely.

Histology:
All year one stiped mullet and spotted seatrout gonad samples have either been prepared for histology sampling or have already been sent to NCSU for processing. All are expected to be completed by the end of August. The ancillary species samples are currently being processed and should be ready for histology processing by the next shipment date in August. A histological guide is being created to aid in the training of biologists for reading their respective species histology slides. Training of the striped mullet and spotted seatrout biologists will begin soon. In addition, all target species samples have also been prepared for whole mount analysis which will be conducted concurrently with the histology analysis.

Deviations:
At the discretion of the project biologist the sampling schedule was adjusted to prioritize striped mullet collection during the first sampling season. Ancillary species sampling was postponed to work out logistical concerns and to ensure that target species sampling was accomplished successfully without distractions that can occur when beginning a new project with multiple species. Ancillary species collection began in February with river herring and no further changes to the sampling schedule were made. Similarly, the first set of samples sent to the NCSU Histology Lab were not sent until December, however, no further postponement has been experienced.

Additional Guidance: Nothing additional at this time.

Table 1. Number of striped mullet gonad samples collected by each field office during the first year of sampling.

	Month			
Field Office	September	October	November	December

Elizabeth City	0	0	0	0
Manteo	7	17	10	0
Morehead City	20	11	19	12
Washington	8	19	23	12
Wilmington	18	17	0	10
Total	53	64	52	34

Table 2. Number of spotted seatrout gonad samples collected by each field office during the first year of sampling.

	Month				
Field Office	March	April	May	June	July
Elizabeth City	0	0	0	0	0
Manteo	2	4	7	31	27
Morehead City	18	23	5	13	0
Washington	2	8	1	3	0
Wilmington	1	2	1	6	0
Total	23	37	14	53	27

Table 3. Number of river herring gonad samples collected by each field office during the first year of sampling.

	Month		
Field Office	February	March	April
Elizabeth City	1	0	0
Manteo	0	0	0
Morehead City	0	0	0
Washington	0	0	0
Wilmington	0	0	0
Total	1	0	0

Table 4. Number of sheepshead gonad samples collected by each field office during the first year of sampling.

	Month			
Field Office	February	March	April	May

Elizabeth City	0	0	0	0
Manteo	0	0	1	2
Morehead City	0	0	3	14
Washington	0	0	0	1
Wilmington	0	0	5	2
Total	0	0	9	19

Table 5. Number of black drum gonad samples collected by each field office during the first year of sampling.

	Month		
Field Office	April	May	June
Elizabeth City	0	0	0
Manteo	0	1	0
Morehead City	3	5	0
Washington	0	5	0
Wilmington	1	0	0
Total	4	11	0

Table 6. Number of kingfish gonad samples collected by each field office during the first year of sampling.

	Month		
Field Office	April	May	June
Elizabeth City	0	0	0
Manteo	0	1	1
Morehead City	0	0	12
Washington	0	0	4
Wilmington	19	0	0
Total	19	1	17

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: Frederick Scharf, Lee Paramore, Laura Lee

Grant Award #: 2016-F-038

Grant Title: A comprehensive evaluation of the North Carolina red drum juvenile abundance index: assessment of spatial and temporal persistence and the potential for a partial replacement design

Grant Award Period: July 1, 2016 – June 30, 2019

Performance Reporting Period: January 1, 2017 – June 30, 2017

Project Costs: $195,331 for 3 years

Expenditures for the Period:

Category	**Expenditures**
Personnel	$20,010
Fringe	$ 2,543
Travel	
Equipment	
Supplies	
Construction	
Contractual	
Other	
Total Direct	$22,553
Indirect	
TOTAL	$22,553

Total Cumulative Expenditures: $33,130
Total Remaining Balance: $27,152

Description of Work**:**

Objectives:

1. Analyze the North Carolina red drum juvenile abundance index (JAI) historical data to evaluate persistence (or lack thereof), both spatially and temporally.

2. Assess variability in the year class strength signal across fixed sampling stations to determine the relative contribution of individual sampling stations and their impact on

the year class signal.

3. Supplement the current fixed station survey with sampling at random stations in each of the main survey regions (NOBX, OBX, Pamlico River, Neuse River, New and White Oak Rivers) to evaluate the potential for a partial replacement survey design to reduce bias.

Project Status/Work Accomplished:

During the winter/spring of 2017, we accomplished several tasks. First, all random stations that were visited during the 2016 sampling season were evaluated for inclusion in future sampling. This was accomplished through the assessment of field notes taken by each sampling crew during 2016 sampling. If sites did not contain appropriate red drum habitat (shallow, soft sediment, protected from high energy disturbances) and/or could not be sampled efficiently with the beach seine (i.e., maintenance of equal catchability across stations), then they were deemed inappropriate for inclusion in the survey. All sites that had received this designation were omitted from the randomization algorithm for 2017 and new maps were constructed to reflect these changes. The removal of sites that did not contain seinable, red drum habitat should permit for more efficient completion of random sampling in 2017. Random sampling maps will be adjusted continually each year until all sites have been visited at least once. Sample station numbers from 2016 were maintained for 2017 to ensure consistent station identification across years. 2017 sampling will begin in September 2017.

The catch per unit of effort (CPUE) patterns were compared between fixed and random stations during 2016. Statewide, mean CPUE at the random stations was slightly lower, but not significantly different, than the mean CPUE at the fixed stations. This was in contrast to observations in both 2014 and 2015, when the mean CPUE at random stations sampled in two regions (New River, and the Northern Outer Banks) exceeded the mean CPUE observed statewide at the fixed stations. When combined with the 2014-2015 data, the inclusion of random sites in 2016 would have altered the trajectory of the survey, with 2015 yielding the highest CPUE of the three years. If only fixed station data are viewed, the index shows an increasing trend beginning in 2014, with 2016 yielding the highest CPUE. During 2016, red drum were captured at random stations in all sampling regions, and the spatial patterns were closely aligned with those observed at the fixed sites (e.g., relative rank of CPUE among regions).

Lastly, we completed additional analyses of the historical index, which revealed several patterns of note. The use of median CPUE or the geometric mean CPUE yielded patterns that differed from the arithmetic mean CPUE during several years since 1991. For instance, the strong year class of 1997 revealed by the mean CPUE was not as strong as the 1998 year class when either the median or geometric mean CPUE was used. Further, the 2004 and 2005 year classes were both relatively stronger when the median or geometric mean CPUE was used compared to the arithmetic mean. Also, the 2011 year class strength was

dampened sharply when using the median CPUE, and each of the alternative indices predicted that 2016 was a better year class than predicted by the arithmetic mean. In addition, the percent of seines with a positive occurrence of red drum (i.e., non-zero catches) was more closely correlated with the median CPUE than with the arithmetic mean CPUE. Lastly, the variance to mean ratio (the amount of overinflation in the distribution) demonstrated steep peaks during two supposed strong year classes (1997 and 2011) that each were influenced largely by catches at a single station. A manuscript that details these analyses is currently in preparation.

Deviations:

None

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: Ariane Peralta

Grant Award #: 6436

Grant Title: Linking water quality, food quality, and larval fish condition to determine strategic habitat area quality

Grant Award Period: 07/01/2016-06/30/2017

Performance Reporting Period: 02/01/2017-06/30/2017

Project Costs:

Category	07/01/2016-01/31/2017	02/01/2017-06/302017	Total Expenditures
Personnel (includes educational)	$16,072.00	$14,020.07	$30,092.07
Fringe	$24.62	$197.17	$221.79
Travel	$-	$-	$-
Equipment	$-	$-	$-
Supplies	$-	$395.53	$395.53
Construction	$-	$-	$-
Contractual	$-	$4,645.42	$4,645.42
Other (boat)	$-	$2,932.23	$2,932.23
Total Direct	$16,096.62	$22,190.42	$38,287.04
Indirect	$2,414.50	$2,341.98	$4,756.48
TOTAL	$18,511.12	$24,532.40	$43,043.52

Total FY 16-17 budget: $80,506
Total Cumulative Expenditures: $43,043.52
Total Remaining Balance as of 30 June 2017: $37,462.48 (NCE requested)

Description of Work

We proposed to sample two potential strategic habitat areas in the Chowan and Tar-Pamlico Rivers at ten sampling sites in order to assess the linkages between water quality, food quality, and larval fish condition. We sampled 10 locations in two river systems throughout the spring period of larval river herring residency (Table 1). We added four locations Lower Chowan, Holiday Island, Lower Tar and Blounts Bay to give us full coverage of the systems, and we will process all samples.

Table 1. Sampling locations in 2017.

River	Location	Dates sampled 2017
Chowan	Rockyhock Creek, Lower Chowan, Holiday Island, Catherine's Creek, Wiccacon River	7, 17, 30 – March 13, 21, 27 – April 10, 16, 24 – May
Tar	Tranters Creek, Lower	9, 21 – March 11, 20, 28 – April 12, 17 – May
Pamlico	Blounts Bay, Blounts Creek, Pantego Creek/Pungo River	9, 21 – March 11, 20, 28 – April 12, 17 – May

Project Status/Work Accomplished

Activities 2017

At each location, we took a measurement of abiotic conditions using a YSI castaway hand-held CTD. We collected bottle samples for determination of: nutrient concentrations, chlorophyll *a* concentration, and phytoplankton pigment concentration. We conducted zooplankton tows for two mesh sizes (60 µm and 200 µm) (Figure 1), a push net and tow net (500 µm mesh) for larval fish abundance, and collected seston,

Figure 1. Zooplankton sampling in the Pamlico River

zooplankton, and larval fish for fatty acid analysis (Table 2). Samples are in various stages of processing, and we will dedicate the rest of the time (Table 2).

Table 2. Research activities conducted in 2017.

Activity	Number of samples	Status
CTD measurements	78	Processed (see below)
Nutrients	78	Processed
Phytoplankton chlorophll *a* (frozen)	78	Processed
Phytoplankton pigment (frozen)	78	Processed
Seston fatty acid (frozen)	78	Processed
Zooplankton (in formalin)	78 (60 µm mesh)	Process in 2017
	78 (200 µm mesh)	Processed
Zooplankton Fatty Acid (frozen)	100	Processed
Larval fish (ethanol)	156	Process 2017/2018
Larval fish fatty acid (frozen)	10	Processed

Preliminary data

There was one major weather event consisting of rainfall in the 3 to 5 inches on April 23 during the field season. The high rain event led to major flood conditions on the Tar/Pamlico River during the sampling on April 28.

We have processed a portion of the data collected during the spring of 2017 (Table 2). Abiotic conditions across the locations were similar. By design, the majority of sites had low salinities with the exception of three sites in the Pamlico River (Table 3). Salinity dropped at the three sites after the flooding occurred, and returned to increased salinity in May 2017 except for Blounts Creek. Temperatures increased throughout the sampling period, and temperature fluctuated during March 2017 after a cold front dropped air temperatures for a week (Table 3). Dissolved oxygen saturation and concentrations were variable and indicative of upper estuarine conditions, oscillating between low and high saturations and concentrations (Table 3).

Table 3. Ranges for selected variables at all sampling locations in 2017.

River	Location	Salinity	Temp (°C)	DO (% saturation)	DO (mg L^{-3})
Chowan	Wiccacon	0.03-0.05	10.6-22.4	22.6-80.5	2.05-8.51
Chowan	Catherine	0.05-0.10	7.1-22.4	18.3-73.2	1.66-8.15
Chowan	Holiday Island	0.04-0.10	8.0-23.2	74.5-98.6	6.41-11.13
Chowan	Lower	0.04-0.08	8.5-22.8	89.5-100.5	7.86-11.17
Chowan	Rockyhock	0.05-0.10	8.3-22.6	29.3-99.2	2.65-10.39
Tar	Tranter	0.03-0.06	9.2-22.3	49.0-88.0	4.45-9.89
Tar	Lower	0.03-0.06	10.3-22.5	52.1-92.1	4.68-10.08
Pamlico	Blounts Bay	0.12-8.10	9.6-23.4	15.6-101.3	1.32-10.97
Pamlico	Blounts Creek	0.03-2.30	11.2-22.8	5.1-85.0	0.47-9.32
Pamlico	Pantego/Pungo	0.92-9.08	9.3-23.9	46.6-99.0	3.94-10.04

A snapshot of a few selected nutrients (ammonium (NH_4^+), nitrate (NO_3^-) + nitrite (NO_2^-) and phosphate (PO_4^{3-})) is presented. Ammonium concentrations were similar throughout both rivers with Rockyhock Creek, Wiccacon River and Pantego Creek

having higher values (Figure 2). Nitrate + nitrate concentrations were similar throughout the both rivers, with Pantego Creek having higher nitrate + nitrite values (Figure 2). Phosphate concentrations showed similar values across all locations as well as some variation at individual stations (Figure 2). Phosphate levels were higher at less saline locations, and following the flood event in late April at areas that were higher salinity before the flood (Figure 2).

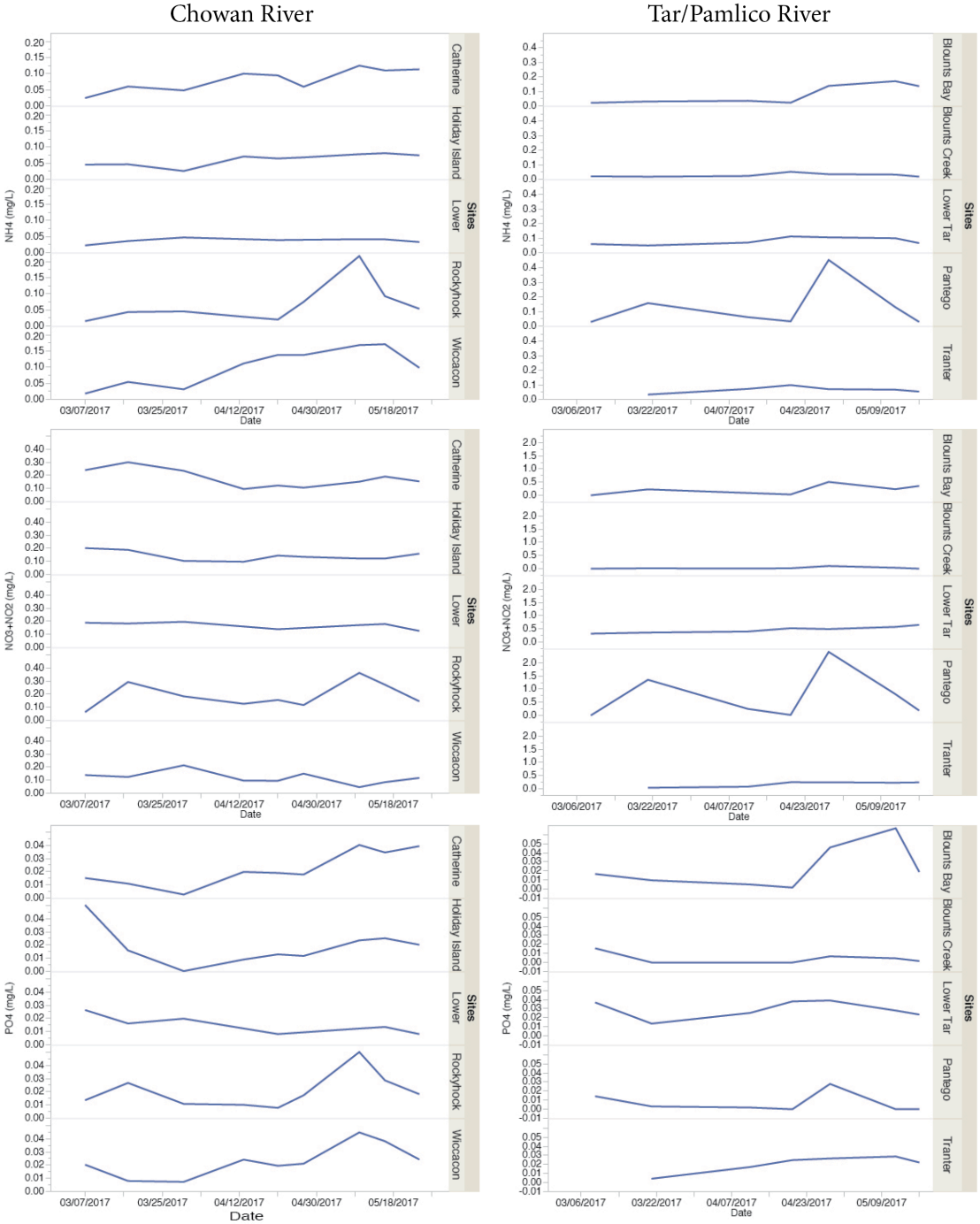


Figure 2. Nutrient data over time for the Chowan River and Tar/Pamlico River sampling sites.

We have counted 78 zooplankton samples at present and are able to present a preliminary view of the zooplankton community at all sites on the Chowan River. The zooplankton abundance increased in the middle of March for Lower Chowan River and Holiday Island, and in at the end of March for Wiccacon River and Catherine Creeks (Figure 3). The only decrease of zooplankton abundance in March occurred in Rockyhock Creek (Figure 3). *Bosmina* spp., *Daphnia* spp., Chydoridae and Cyclopoida represented the community in Wiccacon Creek, and had a peak of *Daphnia* spp. at the end of April, and a peak of *Bosmina* spp. mid-May (Figure 3). There was a peak of *Bosmina* spp. in mid-April for Catherine Creek with Chydoridae peaking in early March and May (Figure 3). *Bosmina* spp., *Daphnia* spp., Calanoida, and Cycopoida represented the zooplankton community at Holiday Island from March until end of April (Figure 3). *Leptodora* spp. became the dominant species at Holiday Island in May (Figure 3). The zooplankton communities in Rockyhock Creek were dominated by *Bosmina* spp., *Daphnia* spp., and rotifers throughout the sampling period (Figure 3). *Daphnia* spp. dominated the zooplankton community at the Lower Chowan River site from March to end of April, and then *Leptodora* replaced *Daphnia* spp. (Figure 3). There where similar or increased abundance of zooplankton in the Chowan River sites compared to 2016. The lower Chowan River site was dominated by *Daphnia* spp. this year, and *Bosmina* spp. last year.

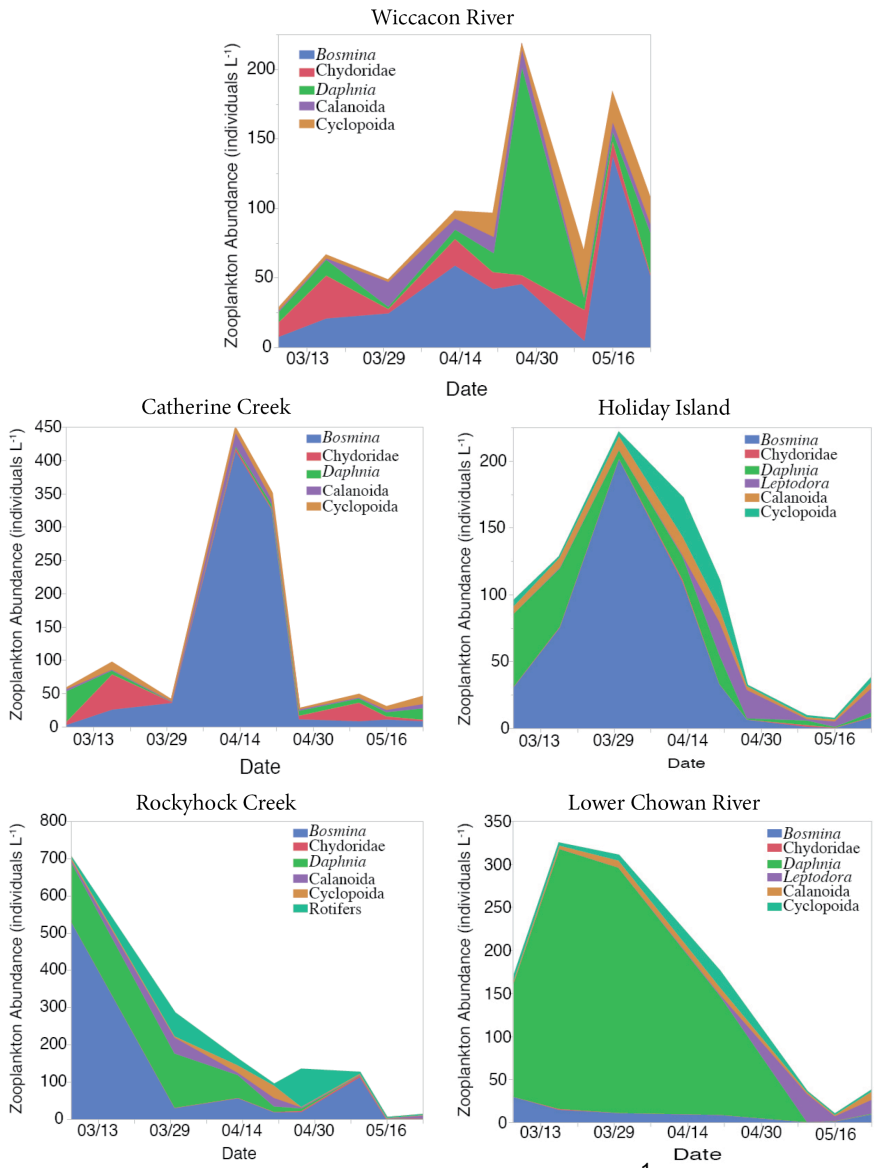


Figure 3. Zooplankton abundances (individuals L^{-1}) for the Chowan River sites.

The zooplankton fatty acid composition consisted of 24 separate fatty acids. Seven fatty acids were dominant among the monounsaturated and polyunsaturated fatty acids found in the 200µm mesh zooplankton in the Chowan River (Figure 4). The monounsaturated fatty acids (16:1n-7 and 18:1n-9) fluctuated through the system over the three months (Figure 4). EPA (20:5n-3) was the dominant fatty acid throughout the sites except for Holiday Island in May, Rockyhock Creek in April, Catherine Creek in May, and Wiccacon in May (Figure 4). High EPA percent composition was associated with cladoceran zooplankton (*Bosmina* spp., *Daphnia* spp., *Leptodora* spp. and Chydoridae), particularly in freshwater conditions. There was an increase in the mean percent of DHA (22:6n-3) found in zooplankton from March to May in all sites (Figure 4), reflecting the relative increase in copepods among the zooplankton (Figure 2).

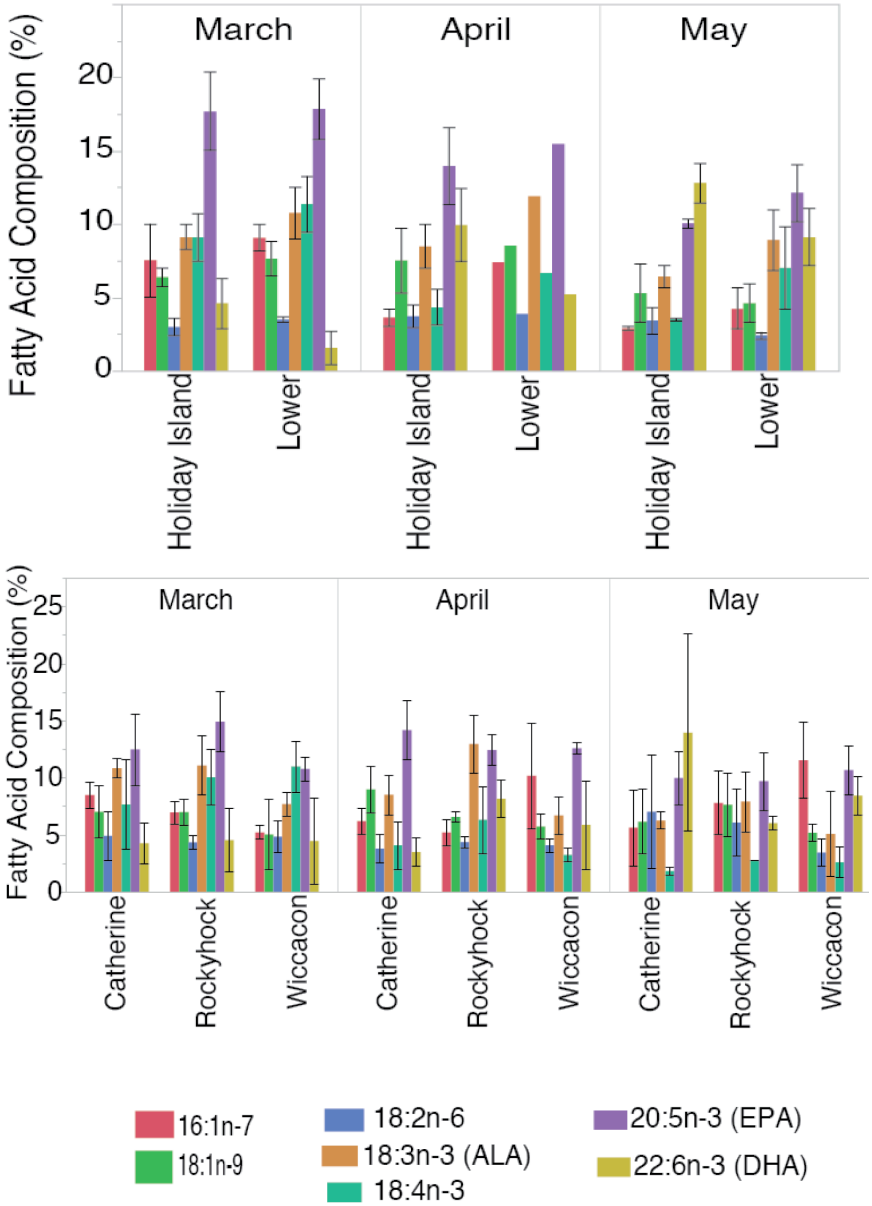
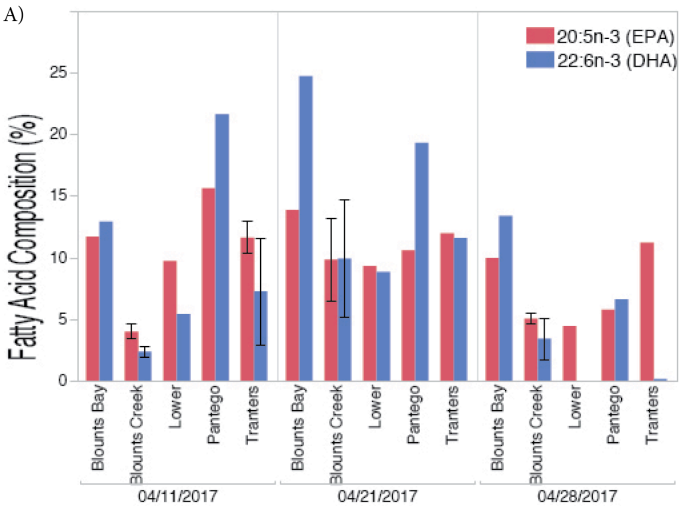


Figure 4. Zooplankton fatty acid composition (%, ± S.D.) for 200µm mesh size from all sites in the Chowan River.

We were able to observe fish larvae in the Chowan River beginning on 11 April 2017 at all sites. The earliest date fish larvae were observed was 17 March 2017 in the Wiccacon River. Fish were present at most sites in the Chowan until 16 May 2017. In the Tar/Pamlico River sites, fish first appeared on 13 April 2017, but only persisted until 21 April 2017 at Tranters Creek sites. Fish were likely flushed from the system when a flooding event occurred at this time.

The Tar/Pamlico River experienced the 6th highest freshwater input on record during spring 2017. One of the potential indicators for fish habitat quality is the presence and ratio of DHA and EPA, which are two important omega-3 fatty acids. The

zooplankton fatty acid at Blounts Bay and Pantego had increased levels of DHA compared to the rest of the sites (Figure 5A). Blounts Creek had similar ratios of DHA and EPA throughout the sampling period but had an increase of DHA and EPA before the flood and a decrease during the flood (Figure 5A). The zooplankton fatty acid composition had a high percentage of DHA before the flood, but DHA was absent during the flood for the lower Tar and Tranter Creek (Figure 5A). Saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA) were variable throughout the sampling period in April for all sites (Figure 5B). Omega-3 fatty acids were a higher fraction of the total fatty acids prior to the flood, but declined in proportion to omega-6 fatty acids during the flood (Figure 5). Omega-3 fatty acids are considered more aquatic based, and omega-6s are considered more terrestrial derived. Thus, the flooding may have reduced the general habitat quality of the nursery areas by reducing overall omega-3 fatty acid levels in general, and the ratio of omega-3 to omega-6 fatty acids specifically.



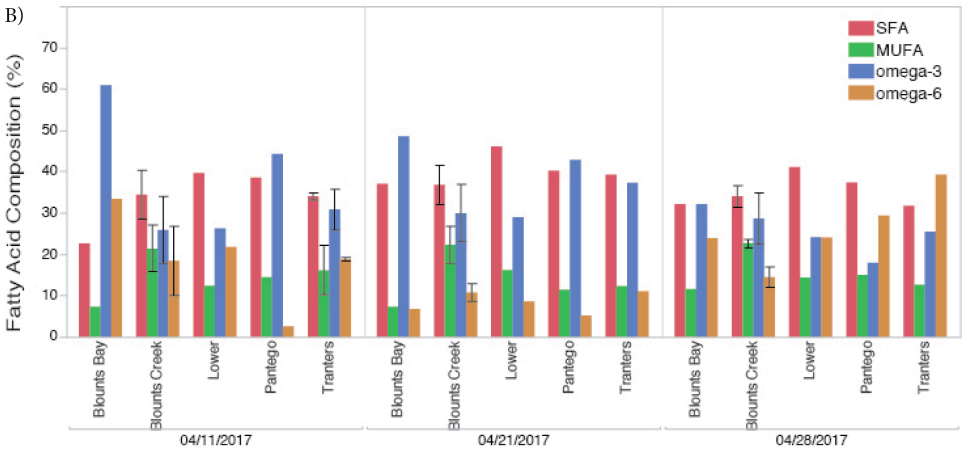


Figure 5. A) EPA and DHA (%) for zooplankton before (April 11 and April 21) the 6th worst flood for Tar/Pamlico River, and week of the flood (April 28). B) The zooplankton fatty acid composition for SFA, MUFA and PUFA split between omega-3 and omega-6.

We also collected ctenophores (comb jellies) at the Pantego River site throughout the sampling period except for the week during the flood event. In contrast, we observed small numbers at the one site during May 2016. The increase in ctenophore numbers reduced the zooplankton population compared to 2016 in the Pantego River. This could result in competition for food resources in an area that juvenile river herring were found in 2016, and other larval fish found in 2017.

Overall, the systems had differences between the two sampling years. There was increased salinity at Pantego River and Blounts Bay throughout the sampling period. We had increased water temperatures from last year because of the warmer winter. This resulted in larval river herring appearing earlier (March 17) compared to (April 6) in the Chowan River. The zooplankton had increased abundances in the Chowan River throughout the sampling period, and the peak of zooplankton abundance came earlier this year. This should allow for the larval fish to still be connected with their food source. We also observed a decrease of copepods in the Chowan River this year. This could lead to less nutritious food since cladoceran were the main food source. The nutrients (nitrogen and phosphorus) peaked mainly after the larger rain events throughout the two systems, but had similar concentrations throughout the systems. Integrating the biological components provides the opportunity to determine how differences in the food sources and phytoplankton can affect the larval river population. Results from our study will provide a better understanding of how changes in zooplankton and fatty acid composition could either increase or decrease the recruitment of river herring to the population.

Deviations

We have experienced no deviations at this time.

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: Charles H. Peterson, University of North Carolina at Chapel Hill, Institute of Marine Sciences; 3431 Arendell Street, Morehead City, NC 28557

Project Investigators: Charles H. Peterson & Carter S. Smith

Grant Award #: 6437

Grant Title: Quantifying fish enhancement and erosion protection provided by marsh sills: a "living shoreline" alternative to bulkheads and revetments

Grant Award Period: July 1, 2015 – June 30, 2018

Performance Reporting Period: December 31, 2016 – June 30, 2017

Project Costs:

Expenditures for the Period: 12/31/16 – 6/30/17

Category	Expenditures
Personnel	$16,128.36
Fringe	$(108.15)
Travel	$913.38
Equipment	-
Supplies	$425.08
Miscellaneous Services	$300.00
Total Direct	$17,658.67
Indirect	$2,648.84
Total Cumulative Expenditures:	$20,307.51
Total Remaining Balance:	$18,163.51

Description of Work:

The overall goal for this project is to collect data on the fisheries support services and erosion protection provided by marsh sills as compared to bulkheads, revetments and natural marsh shorelines, in order to most effectively guide homeowners' choices and to inform regulatory agencies. This goal will be accomplished through the following interconnected objectives: to **(1)** compile the first multi-storm performance assessment of different shoreline stabilization techniques, by assessing shoreline damage along North Carolina estuarine shores before and after Hurricane Matthew; **(2)** provide the

first quantitative data on the habitat value of different introduced hard substrates and acquire the basis for inferences on the most advantageous material (oyster shell vs. marl vs. granite) for marsh sills to maximize use by recreational fishes and their prey; **(3)** collect data on recreationally important fishes (red drum, speckled trout, 2 species of flounder, sheepshead, spot, and croaker) and their crustacean prey (blue crab, stone crab, penaeid shrimps) using modified and natural shorelines; **(4)** conduct mesocosm experiments to experimentally test fish preferences among estuarine shorelines stabilized through different means versus natural marsh shorelines; and **(5)** produce an engaging and informative short film, which will be used as part of a larger public outreach campaign to inform owners of estuarine shoreline property in North Carolina and NC residents more broadly about how to make the best shoreline stabilization choices.

Project Status/Work Accomplished:

Hurricane damage assessments:

To evaluate the pre-storm condition of estuarine shorelines throughout NC, we have combined shoreline boat surveys with detailed site surveys across the coast of Eastern North Carolina.

Part I: For the boat surveys, three different estuarine shoreline stretches were evaluated in 2015 and 2016 for any existing storm damage (Figure 1), using a visual damage assessment protocol. These shoreline stretches were chosen because they represented a diversity of geographic and tidal regimes and because they each contained a bulkhead, natural marsh, and at least one marsh sill. These data were combined with data collected after Hurricanes Irene (2011) and Arthur (2014), which allowed for a multi-storm comparison of estuarine shoreline damage. The manuscript detailing these results was recently published in *Marine Policy* (see Publications below and the attached PDF of the manuscript). We have re-evaluated the boat survey paths after Hurricane Matthew in October 2016, to complete the Before/After comparisons of hurricane damage. The three survey areas differed greatly in the amount of observed damage that could be attributed to Hurricane Matthew. In PKS and Oak Island, less than 5% of the bulkhead shoreline was damaged, whereas nearly 30% of the shoreline was damaged in OBX (Figure 2).

Part II: For the more finely detailed site evaluations, we conducted surveys at 30 estuarine sites between Manteo in the North and Southport in the South. The sites were geographically grouped within regions, so that 1 bulkhead, 1 natural marsh, and 1 rock sill were paired (a total of 9 sets of structures throughout the state). Additionally, 3 of the sets of structures also contained an oyster bag sill (Figure 3). These site surveys represent a significant and valuable expansion of what was originally proposed. They will allow us to quantitatively evaluate how the elevation and vegetation profiles at sites are changing over time. All sites were sampled during May and June 2015, May and June 2016, and May and June 2017. Additionally, a subset of the sites were sampled in October 2016 right after Hurricane Matthew passed by the NC coast. The sampling was

conducted by Carter Smith, Isabelle Neylan and David Kochan (field technicians), six UNC undergraduates, and in collaboration with NERRS coordinator, Brandon Puckett.

DIDSON fish surveys:
After initial analysis of the GoPro footage from summer 2015, we determined that GoPros were ineffective at our sites because of unpredictable and high turbidity. We have chosen instead to use a Dual-frequency Identification Sonar (DIDSON) to observe fish abundance and biomass as well as behavior and habitat use along different estuarine shorelines. Using the accompanying DIDSON software we will get accurate abundance and biomass estimates for fish along different types of shorelines.

This summer, we are collecting DIDSON video footage every two weeks (May-July) by statically deploying the DIDSON in front of replicate natural marshes, marsh sills, and bulkheads in Pine Knoll Shores and Beaufort, NC (Figure 4). To avoid any issues associated with water depth (the DIDSON needs a minimum water depth of approximately 0.5 m in order to image), we have limited the sampling window to the two hours around high tide. We deploy the camera 5 meters from the structure or shoreline for 10 minutes (5 minutes of acclimation and 5 minutes of footage for analysis). Sites are sampled during the day, and all sites will additionally be sampled at night in late July. We are also setting 5 replicate minnow traps at each of the sites for a total 4-hour soak time. We are in the process of completing this fieldwork and analyzing the video footage.

Mesocosm experiments: To evaluate relative foraging efficiency along different types of shorelines, we constructed shoreline mesocosms (1.5 x 2 x 0.5 m^3) in experimental tanks behind the UNC Institute of Marine Sciences. We simulated five different shoreline treatments as follows: 1) natural marsh; 2) riprap revetment with no marsh; 3) bulkhead with no marsh; 4) oyster bag marsh sill; and, 5) rock marsh sill. We ran trials with Southern Flounder (predator) and pinfish (prey) to determine foraging efficiency and we used GoPros in the mesocosms to determine whether predator/prey fish behavior changed along different types of shorelines. We are in the process of analyzing these data.

Fyke net surveys: We collected fish abundance and biomass data as a function of shoreline type at four sites in North Carolina that were previously sampled by C.H. Peterson and R.K. Gittman and established as Before After Control Impact sites (Holly Ridge, Pine Knoll Shores, Hatteras, and Jones Island; Figure 3). At each site, two fyke nets were placed along a natural control marsh and two nets in the drop-downs or edges of an adjacent marsh sill (two oyster, two rock.) Nets were left to soak at night through one tidal cycle during spring tides for maximum tidal difference and all nekton caught were measured and weighed. Each site was sampled once per month from June through September. In addition, elevation and vegetation data along with rugosity measurements of the sills were taken from each site to account for physical differences that may be influencing fish use of the different shorelines. Preliminary results suggest that rock sills show significant enhancement of fish and crustacean use within 7 years of construction, but no significant enhancement was detected with the oyster bag sills.

Short documentary film: We have collected many hours of GoPro footage of fieldwork to include in the film. We are also in the process of putting together a stop motion animation to be included in the film that illustrates some of the underlying concepts of the research.

Modifications:

The major deviations from our proposed work are an expansion of the hurricane surveys with the inclusion of detailed elevation and vegetation site surveys at 30 locations throughout the state. This is a valuable expansion, because it has allowed us to quantitatively assess how the vegetation and elevation of sites stabilized through different means are changing over time and after Hurricane Matthew. The other major deviation is that the GoPro fish surveys will now be completed using a DIDSON (Dual frequency Identification Sonar) instead of GoPros. The DIDSON (approximate value of $200,000) is being loaned to us by Chris Taylor (NOAA's Beaufort Lab), and will significantly enhance our fish surveys by providing a much greater viewing depth and range, as well as highly accurate abundance and biomass data for all recorded fish.

Outreach and Results Dissemination:

Media Coverage:

- Coastal Daybreak Radio Interview, June 2017. https://youtu.be/TbpRG7YaPl8
- "Living shorelines more cost effective way to control coastal erosion" WNCT News by Pierce Legeion, May 2017. http://wnct.com/2017/05/29/new-research-living-shorelines-more-cost-effective-way-to-control-coastal-erosion/
- "Living shorelines withstand Matthew's force" Coastal Review Online, December 2016. http://www.coastalreview.org/2016/12/living-shorelines-withstand-matthews-force/
- "Living shorelines, a more natural approach to preventing coastal erosion" WNCT News by Pierce Legeion, May 2016. http://wnct.com/2016/05/17/living-shorelines-a-more-natural-approach-to-preventing-coastal-erosion/
- 'PKS Soundfront Environmental Study' *The Shoreline* by Barbara Milhaven, January 2016
- 'UNC doctoral students study living shorelines' *WCTI-12 News* by Chris Hoffman, July 2015 http://www.wcti12.com/news/unc-doctoral-students-studies-living-shorelines/34186894

Publications:

- Smith, C.S., R. K. Gittman, I. P. Neylan, S. B. Scyphers, J. Morton, F.J. Fodrie, J. H. Grabowski, C.H. Peterson. 2017. Hurricane damage along natural and hardened estuarine shorelines: using homeowner perspectives to promote nature based coastal protection. *Marine Policy* 81, 350-358.
- Smith, C.S., B. Puckett, R. K. Gittman, C.H. Peterson. Evaluating the performance of hardened versus natural shorelines during Hurricane Matthew (2016). In preparation for *Ecological Engineering.*

Presentations:

- Smith, C.S., B. Puckett, R.K. Gittman, C. H. Peterson. Evaluating the performance of hardened versus living shorelines during Hurricane Matthew (2016). Benthic Ecology Meeting, Myrtle Beach, SC, April 2017. *Oral presentation.*
- Smith, C.S., R. K. Gittman, I. P. Neylan, S. B. Scyphers, J. Morton, F.J. Fodrie, J. H. Grabowski, C.H. Peterson. Addressing homeowner misperceptions about the effectiveness, durability, and cost of hardened shorelines: An analysis of hurricane damage in North Carolina. MarCo Marine Consortium Graduate Student Symposium, Beaufort, NC, March 2017. *Poster presentation.*
- Smith, C.S. Addressing misperceptions about the effectiveness, durability, and cost of hardened versus living shorelines. Restore America's Estuaries Summit, Living Shorelines Workshop, New Orleans, December 2016. Invited speaker and panelist.
- Smith, C.S., R. K. Gittman, I. P. Neylan, S. B. Scyphers, J. Morton, F.J. Fodrie, J. H. Grabowski, C.H. Peterson. Addressing homeowner misperceptions about the effectiveness, durability, and cost of hardened shorelines: An analysis of hurricane damage in North Carolina. Restore America's Estuaries Summit, New Orleans, December 2016. Poster presentation.
- Smith, C.S. Shore protection structure performance over multiple storms: A socioeconomic analysis. NC Department of Coastal Management Staff Living Shorelines Training, Beaufort, NC, December 2016. Invited speaker.
- Neylan, I. Assessing the habitat use and optimal construction of marsh sills through benthic infaunal community composition. NC Sea Grant Graduate Training Symposium. New Bern, NC, April 2016. Poster presentation.
- Smith, C.S. Hurricane damage along natural and engineered shorelines: An economic and environmental evaluation. *Benthic Ecology Meeting.* Portland, Maine, March 2016. Oral presentation.
- Neylan, I. Assessing the habitat use and optimal construction of marsh sills through benthic infaunal community composition. *Atlantic Estuarine Research Society Meeting.* Virginia Beach, VA, March 2016**.** Poster Presentation.
- Smith, C.S. Hurricane damage along natural and engineered shorelines: An economic and environmental evaluation. *Atlantic Estuarine Research Society Meeting.* Virginia Beach, VA, March 2016. Oral presentation.

Outreach:

- C. Smith presented on preliminary results from this CRFL project at the North Carolina Department of Coastal Management Staff Living Shorelines Training
- Exploring Estuarine Shoreline Habitats Teacher's Workshop, July 2016
    - Isabelle Neylan and David Kochan (technicians) led a workshop on the methods and results of CRFL funded work for a group of ~30 NC science teachers.
- SciREN, February 2016.

- C. Smith wrote a lesson plan about the funded work that adhered to NC 4-6th science standards, and disseminated the lesson plan to NC science teachers at a networking event.

Appendix

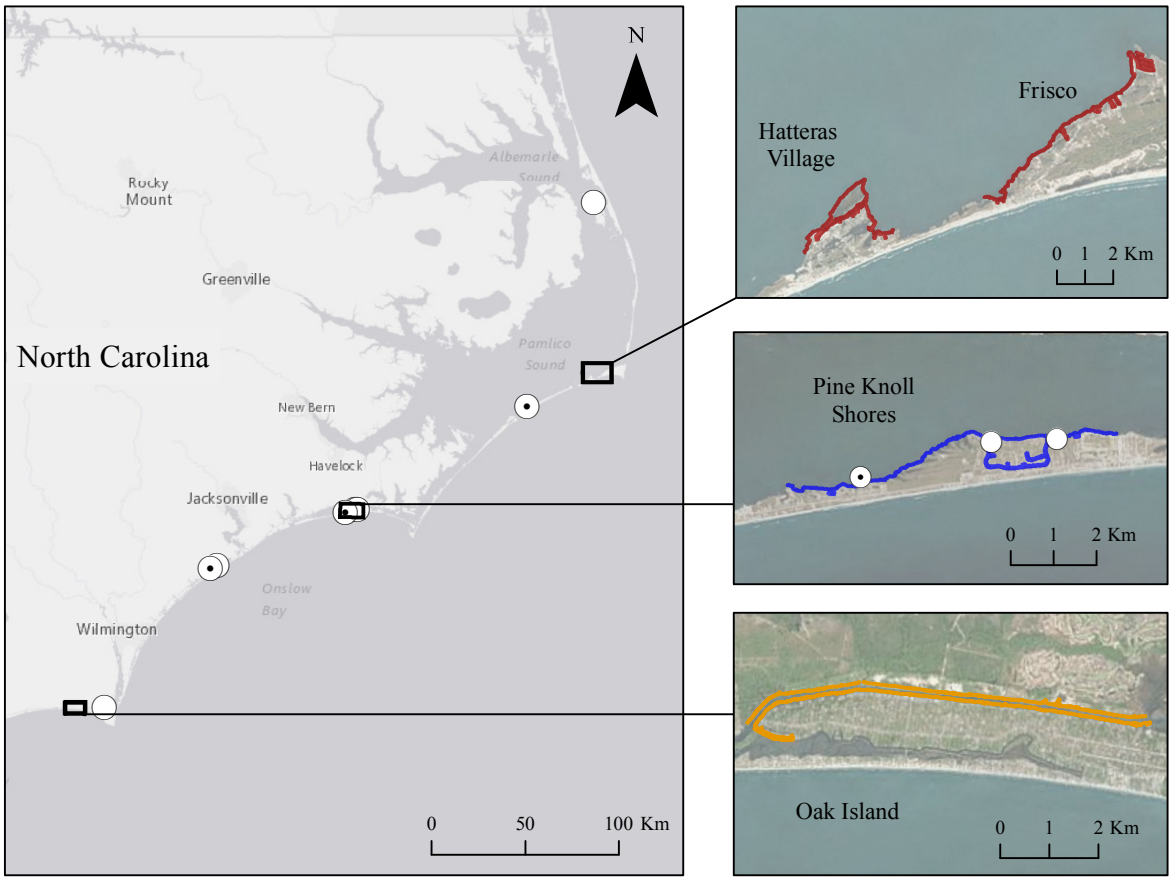


Figure 1. Shoreline boat survey tracks that were surveyed before and after Hurricane Matthew

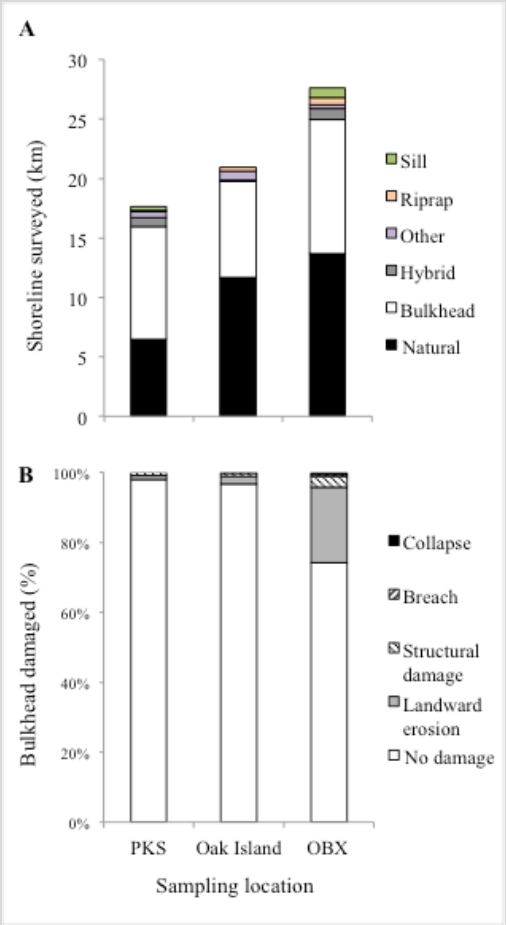


Figure 2. A) Total shoreline surveyed by region, and (B) percent of bulkheads damaged during Hurricane Matthew.

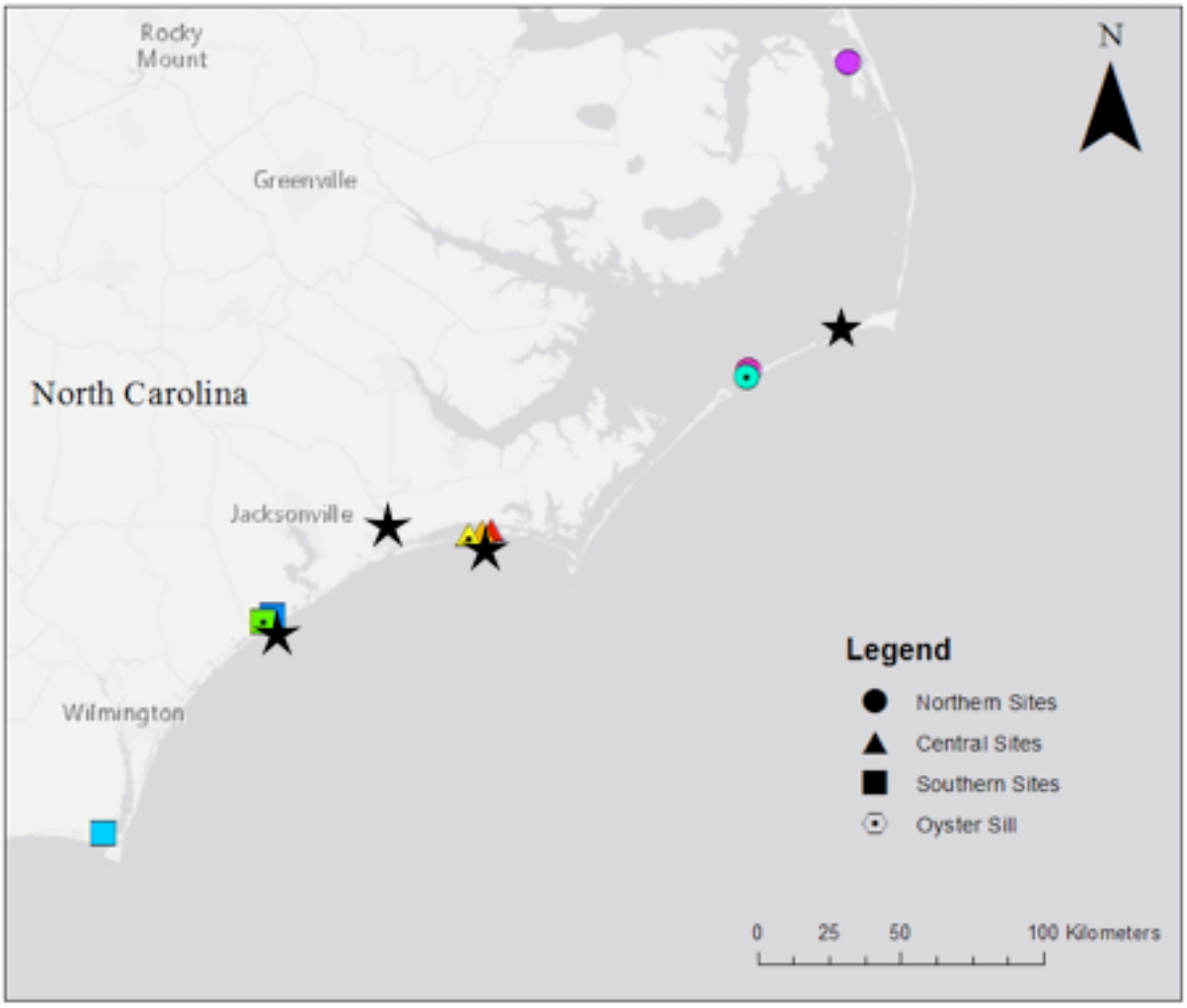


Figure 3. Locations of hurricane site surveys and fyke net sampling. Each solid colored shape represents 3 sites (1 bulkhead, 1 rock sill, and 1 natural marsh) and each dotted shape represents 4 sites (1 bulkhead, 1 rock sill, 1 oyster bag sill, and 1 natural marsh). Sites were surveyed in June 2015, May 2016 (before Hurricane Matthew), and October 2016 (after Hurricane Matthew). Black stars show the location of BACI fyke net sites, surveyed in summer 2016.

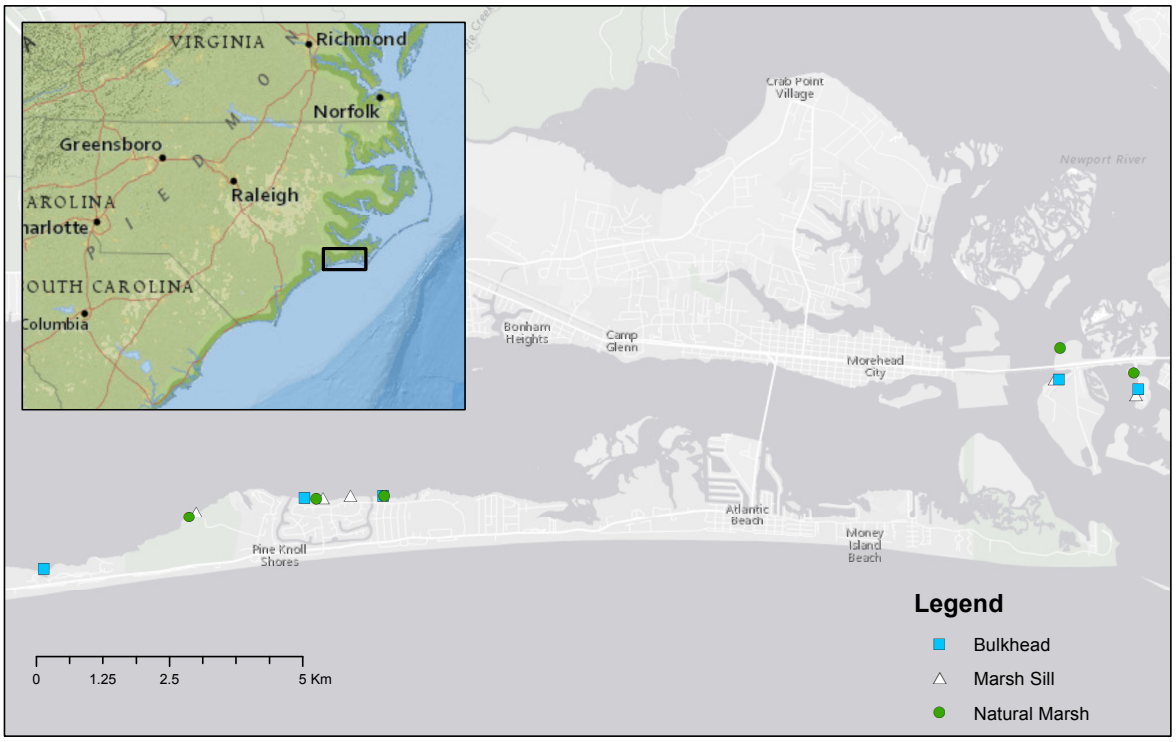


Figure 4. Map showing DIDSON sampling sites in Carteret county, NC.

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: University of North Carolina at Chapel Hill

Grant Award #: 5104916

Grant Title: Understanding and predicting the frequency and duration of hypoxic exposure in fish habitats in the lower Neuse River estuary

Grant Award Period: 1 July 2015 – 30 June 2018 (including 1 year no cost extension)

Performance Reporting Period: 1 Jan 2017 – 30 Jun 2017

Project Costs:

Expenditures for the Period:

Category	Expenditures Jan-Jun 2017
Personnel	17237
Fringe	3797
Travel	0
Equipment	0
Supplies	0
Construction	0
Contractual*	24434
Insurance	0
Tuition	2411
Total Direct	47878
Indirect	6820
TOTAL	54698

Total Remaining Balance: $16,348

*Duke University has completely expended the full amount ($24,464) in their subcontract with UNC; however, their last invoice has not yet reached UNC so that amount ($30) does not appear in this semi-annual report.

Description of Work:

The goal of this project is to quantify and develop predictive models for salinity variability and the frequency and duration of hypoxic conditions in fish habitats in the lower Neuse River estuary. The lower Neuse is a popular recreational red drum fishing site and its

wetlands and oyster reefs are utilized by juveniles of many recreationally-fished species. Hypoxia affects fisheries by reducing or degrading the habitat area available for fish utilization, increasing susceptibility to predation and disease, and causing fish kills. Dissolved oxygen (DO) and salinity are primary considerations when siting oyster sanctuaries. In this study we made continuous measurements of DO, salinity, temperature, and currents at multiple positions in the lower arm of the Neuse, including oyster sanctuaries and SHAs from June through October 2016. High resolution vertical profiles from an Autonomous Vertical Profiler (AVP) at a central site were available in real time (http://eddy.ims.unc.edu/garbacon.php) throughout this period. Intensive shipboard spatial surveys of these parameters were also conducted along three transects across the Neuse at biweekly intervals, on the same days as Modmod measurements. Our measurements are being used to develop and test a simple process-based model for salinity and DO variability. The model will be applied to long term data sets to statistically characterize salinity variability and quantify the duration and frequency of hypoxic exposure in fish habitats.

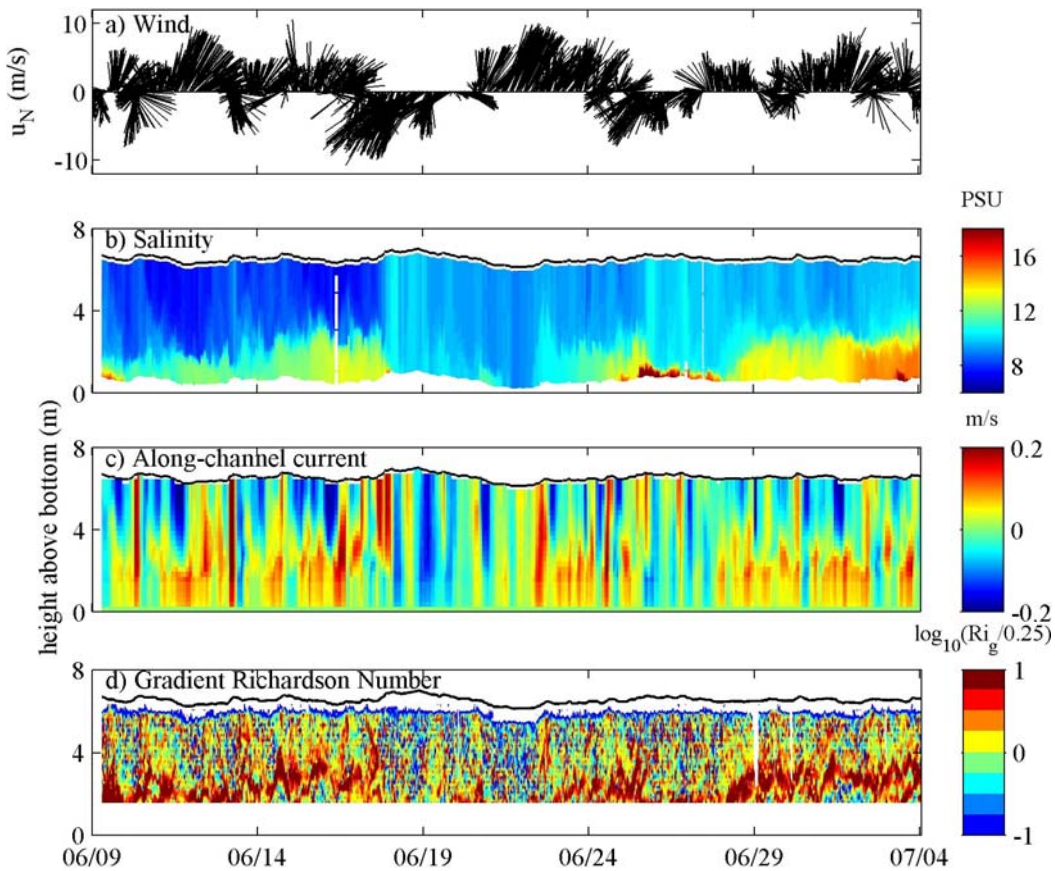


Figure 1. Conditions during the 1-month focus period in June and July 2016. Panels are time series of a) wind speed and direction measured by the anemometer on the AVP (lines indicate direction the wind is blowing to), b) salinity profiles measured by the AVP, c) along-estuary currents (positive up-estuary), and d) Richardson numbers indicating the stability of the water column and potential for mixing to occur. Ri>0.25 (warm colors) indicate that stratification is too strong for mixing to occur, and Ri<0.25 (cool colors) indicate that there is sufficient velocity shear to overcome the stratification and cause mixing.

Project Status/Work Accomplished:

Tasks conducted during this reporting period were:

(1) Process/analyze field measurements

(2) Development of model for salinity and dissolved oxygen variability

Other tasks scheduled for this reporting period will be conducting during the no-cost extension period.

(1) Process/Analyze field measurements and (2) Develop model for salinity variability

Our focus during this reporting period has been analyzing the field measurements from our 2016 deployment to elucidate and quantify the physical processes that drive water motion in the estuary. This is an important step in understanding and predicting how physical processes control salinity and dissolved oxygen distributions in the estuary. For this analysis, we have been focusing on a 1-month period in June-July 2016 when the water column varied between well mixed and strongly stratified, and several large up-estuary and down-estuary wind events occurred (Fig. 1).

The first step was to understand how the water in the estuary moves in response to the wind in a depth-averaged sense. For this analysis, we used a depth-averaged momentum balance:

$$\underbrace{\frac{\partial U}{\partial t}}_{\text{acceleration}} = \underbrace{-g\frac{\partial \eta}{\partial x}}_{\substack{\text{barotropic pressure gradient}\\ \text{due to along-estuary}\\ \text{water surface slope}}} \underbrace{-\frac{gH}{2\rho_0}\frac{\partial \rho}{\partial x}}_{\substack{\text{baroclinic pressure gradient}\\ \text{due to along-estuary}\\ \text{density gradient}}} + \underbrace{\frac{\tau_{w,x}}{\rho_0 H}}_{\text{wind stress}} - \underbrace{\frac{C_D U\left|\vec{U}\right|}{H}}_{\text{bottom stress}} - \underbrace{fV}_{\text{coriolis}}$$

Here U and V are depth-averaged along-estuary and across-estuary current respectively, η is water surface elevation, ρ is water density, ρ_0=1000 kg/m^3, H is water depth, g=9.8 m/s^2 is acceleration due to gravity, $\tau_{w,x}$ is along-estuary component of wind stress, C_D is bottom drag coefficient, f=8.3x10^{-5} is the Coriolis parameter, x is distance in the up-estuary direction and t is time. The right side of this equation contains the forces that control water motion, and the left side represents the response of the depth-averaged current to these forces. Each of the terms in this equation was computed from our measurements (Fig. 2).

The primary balance for low frequency (>18 hr) variations is between the surface wind stress and the barotropic pressure gradient (water surface slope, Fig. 2b,d). When wind stress is applied to the water surface, the water moves in the direction of the wind for a brief period, until a gradient in the water surface is established that balances the wind stress. At higher frequencies, in the 8-18hr band, the balance is mainly between the acceleration term and the barotropic pressure gradient term (Fig. 2c,e), and these terms vary at a period of around 12 hrs. This balance corresponds to a standing wave (seiche) that occurs along the length of the Neuse and Pamlico Sound with this period. The existence of this seiche was first documented by Luettich et al. (2002).

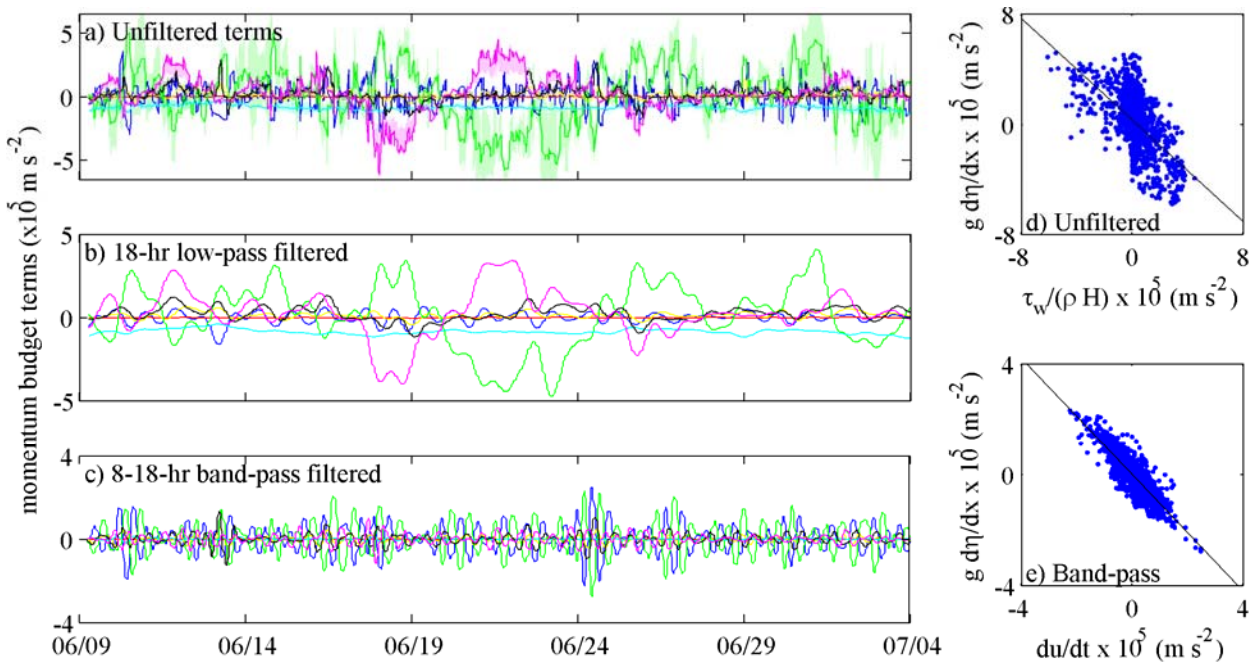


Figure 2. Terms of the depth-averaged momentum budget (Eq, 1), computed from the field measurements. Lines represent water acceleration (blue), barotropic pressure gradient force (green), baroclinic pressure gradient force (cyan), wind stress (pink), bottom stress (black), and Coriolis (red) terms. Positive force terms correspond to forces directed down-estuary; positive acceleration corresponds to up-estuary acceleration. Time series are a) unfiltered, b) 18 hr low-pass filtered, and c) 8-18 hr band-pass filtered momentum budget terms. Scatter plots are d) barotropic pressure gradient term against wind stress term showing the primary balance between these terms, and e) band-pass filtered barotropic pressure gradient against acceleration showing the balance between these terms due to the seiche in this frequency range.

After establishing the primary processes controlling water motion in a depth-averaged sense, we moved on to examine the differential motion between vertical layers with different densities. Most of the time, the water column was composed of two distinct layers with very different salinities, separated by an interface of varying thickness (Fig. 1b). We examined how the density and velocity difference between the two layers evolved over time during a typical up-estuary and down-estuary wind event (Fig. 3).

As up-estuary directed wind increased, the exchange flow became increasingly negative (Fig. 3c), meaning that the upper layer moved upstream relative to the lower layer. As a result, more saline water moved upstream in the upper layer, the density difference between the two layers decreased (Fig. 3b), and the two layers eventually mixed on 6/18. The result was a net upstream transport of salt during this period of increasing upstream wind. As the wind speed decreased from noon on 6/18, the exchange flow returned to its normal (positive) direction. There was downstream transport of fresher water in the upper layer and upstream transport of more saline water in the lower layer and the density difference between the two layers increased as a result. During this period of decreasing upstream wind stress, the salt was transported back downstream (negative salt flux, Fig. 3e).

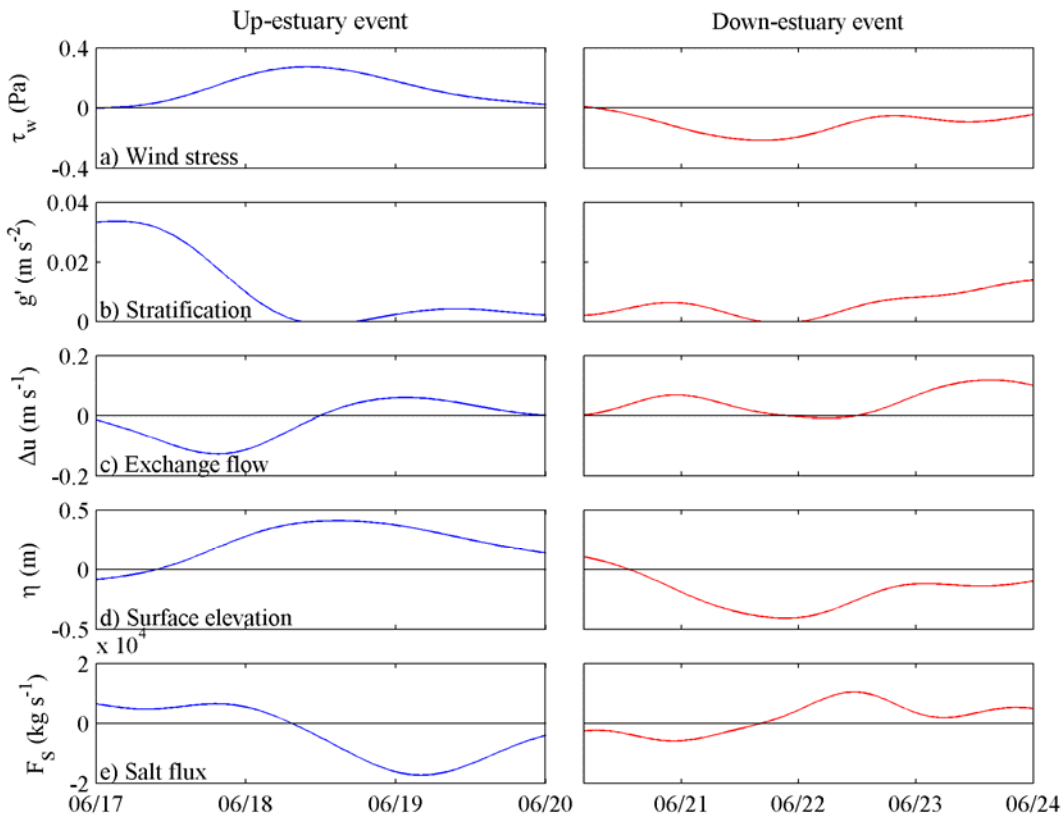


Figure 3. Response of the estuary to a typical up-estuary (left) and down-estuary (right) wind event. Rows are: a) wind stress (positive upstream), b) density difference between upper and lower layers, plotted as $g'=g\Delta\rho/\rho_0$, c) difference between the velocities in the upper and lower layers plotted as $\Delta u=u_{lower}-u_{upper}$ (positive upper layer moving downstream with respect to lower layer), d) surface elevation at the central site, and e) total salt transport with positive indicating upstream.

The situation was reversed for down-estuary directed wind. As down-estuary wind increased, the exchange flow became more positive, and stratification increased as a result. Net salt transport during increasing down-estuary wind was downstream. As the down-estuary wind decreased, the exchange flow remained in its positive (normal) direction and stratification continued to increase. Net salt transport during this period of decreasing down-estuary wind was upstream because the depth-averaged current was upstream.

We are currently computing terms of the two-layer momentum budget, in order to develop a quantitative understanding of the processes controlling the magnitude of the changes in stratification, exchange flow, and salt flux in response to wind. Once we have established the appropriate form of the two-layer momentum balance, we will have the ability to predict how salinity and stratification should be expected to vary in response to wind events with different magnitudes and directions.

Deviations:

No changes were made to the project goals or objectives during the reporting period. We plan to complete the proposed work during our one-year no-cost-extension period.

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: Antonio B. Rodriguez

Grant Award #: 6442

Grant Title: Enhancing the quality of fish habitat and quantity of oysters by refining reef-restoration techniques

Grant Award Period: 07/01/2015 to 06/30/2018

Performance Reporting Period: 01/01/2017 to 6/30/2017

Project Costs:
Year 1: $106,937; Year 2: $107,077; Year 3: $107,551; All Years: $321,565

Expenditures for the Period:

Category	**Expenditures**
Personnel	$38,071.66
Fringe	$6,557.10
Travel	$4,453.32
Equipment	$0
Supplies	$1,764.08
Construction	$0
Contractual	$0
Other	$7,232.25
Total Direct	$58,078.41
Indirect	$7,653.26
TOTAL	$65,731.67

Total Cumulative Expenditures: $65,731.67
Total Remaining Balance: $3,636.91

Description of Work:

The aim of this study is to increase the success of oyster-reef restoration efforts across the state by quantifying those intertidal reef-exposure boundaries and subtidal-reef areas that optimize productivity, defined by oyster density and reef growth rate, and fish-habitat quality, defined by rugosity. Despite the fundamental nature of these data, no direct measures of oyster-reef growth exist for natural intertidal or subtidal reefs, which are crucial for linking oyster-reef condition to community-level fishery production. Thus, our study will provide useful information about oyster-reef habitat that is necessary for predicting the sustainability of the fishery, as well as augmenting the

ecosystem services the reef structure provides, in particular fish habitat. Natural intertidal reefs located adjacent to saltmarshes (fringing reefs) and on sandy and muddy bars (patch reefs), subtidal reefs, and NC oyster sanctuary reefs are the focus of this study that addresses three main objectives:

Objective 1. Develop guidelines for choosing intertidal oyster-reef restoration sites that maximize the potential for reef growth and restoration success across the different tidal ranges and landscapes that exist in NC.

Objective 2. Improve restoration of subtidal oyster reefs by measuring spatial variations in natural and restored-sanctuary oyster-reef growth rates and use derived morphologic information (relief) of reef areas that grow the fastest to guide future restoration efforts.

Objective 3. Enhance fish utilization of restored oyster reefs by providing construction guidelines that maximize habitat complexity (rugosity).

Project Status/Work Accomplished:

Publications:

Ridge, J.T., Rodriguez, A.B., and Fodrie, F.J., in preparation, Changes in the composition of oyster reefs as they transition from catching up to keeping up with sea-level.

Ridge, J.T., Rodriguez, A.B., and Fodrie, F.J., (accepted), Evidence of exceptional oyster-reef resilience to fluctuations in sea level, Ecology and Evolution.

Ridge, J.T., Rodriguez, A.B. and Fodrie, F.J., 2016, Oyster-reef growth tracks annual fluctuations in water level, 18th International Conference on Shellfish Restoration. Graduate student, Justin Ridge, gave an oral presentation at the meeting about this work.

Jalowska, A.M., McKee, B.A., Rodriguez, A.B. and Ridge, J.T., 2016, Let the oyster reefs tell their story- A novel approach to reconstructing coastal environmental histories, AGU Ocean Sciences Meeting, Graduate student, Anna Jalowska gave an oral presentation at the meeting about an aspect of this work.

Objective 1:

Task A: Deploy/maintain loggers (67% complete)- The water-level and barometric-pressure loggers in Back Sound (behind Shackleford Banks) and in the Shallotte River Estuary were downloaded twice. The water level logger in Back Sound broke during the January to April 2017 deployment and those data were unrecoverable. We purchased a new logger and deployed it. Losing three months of data will likely not adversely impact the project because we will have almost 3 years of water-level data by the end of the project. We will investigate using the NOAA water level gauge on nearby Piver's Island to fill in those three months of lost data if other months are comparable. We have had no issues with the logger deployed in the

Shallotte River Estuary.

Task B: Intertidal reef scanning (60% complete)- Data from the first year of this project suggests that reef growth rates respond to short-term fluctuations in sea-level (interannual). To test that new hypotheses, we decided to increase the frequency of scanning intertidal reefs. We have scanned one patch reef and three fringing reefs in the Shallotte River Estuary and one fringing reef in Back Sound adjacent to Carrot Island. Those data were processed, maps were created and measurements of reef growth were derived. We continue to take advantage of spring tides with fair weather (no rain) for reef scanning.

Task C: Intertidal reef densities (50% complete)- No new progress with this task.

Objective 2:

Task A: Subtidal reef scanning (100% complete)- We processed data from year 1, which shows that the BlueView sonar cannot capture subtidal reef morphology or growth. The resolution is too low, and the targets are too difficult to position in exactly the same location each year underwater in zero visibility. This makes it impossible to measure reef growth and rugosity on subtidal reefs. We have increased the sampling frequency of the intertidal reefs to make up for this non-result and added a reef coring component to the project to compare reef composition across tidal ranges. Results from the intertidal reef sampling are exciting and warrants the additional emphasis.

Task B: Data processing; map generation (DEMs; 66% complete)- We have produced digital elevation models for all of the intertidal oyster reefs included in the study and one subtidal reef.

Task C: Generate rugosity maps (0% complete)- This task will begin later in Year 3.

Objective 3:

Task A. Fish surveying/collecting (60% complete)- In June and July, we deployed 7 cameras for 1.5 hours during the day and 1.5 hours at night on fringing and patch reefs and on a sand flat (control) in Core Sound. Minnow traps did not work well in this environment, but the cameras are capturing utilization of the reefs by fish. We have increased the frequency that the cameras are deployed. These data will be integrated with measures of rugosity in the fall of 2017.

Task B. Subtidal oyster densities (0% complete)- We will not be collecting subtidal oyster densities, because the sonar is not capable of measuring reef rugosity or growth.

Deviations:

The subtidal reef portion of the project has not returned quality results. The BlueView sonar had never before been used to image subtidal reef growth and rugosity and we have learned that a different method is needed to image subtidal

reefs. We have replaced this portion of the project with increased frequency of sampling intertidal reefs and the addition of some restored reefs into the data set. We also decided to sample the entire thickness of the reefs that we are working with in the Shallotte River estuary. This will allow us to compare the thickness and composition of reefs that formed in an area with a large tidal range to the reefs in Back Sound that grew in a setting with a low tidal range. We sampled the reefs by pounding an aluminum tube through the top of the reefs using a jack hammer. We already have those cores from reefs in Back Sound.

COASTAL RECREATIONAL FISHING LICENSE

ANNUAL PERFORMANCE REPORT

Recipient: Joseph Luczkovich, Hilde Speight[1], East Carolina University

Grant Award #: Task Order # 6795

Grant Title: Submerged Aquatic Vegetation (SAV) SONAR Mapping Surveys in low-salinity habitats: Neuse River

Grant Award Period: July 1 2016 – June 30 2017

Performance Reporting Period: Jan 1, 2016 – June 13, 2017

Project Costs:

Expenditures for the Period:

Category	Expenditures
Personnel	$ 14,873
Fringe	$ 1,026
Travel	$ 0.00
Equipment	$ 0.00
Supplies	$ 1,387
Construction	$
Contractual	$ 4,641
Other	$ 1,147
Total Direct	$ 23,074
Indirect	$ 10,057
TOTAL	$ 33,131

Total Cumulative Expenditures:
Total Remaining Balance: $43,972

Description of Work**:**

List the project objectives or provide a brief description of the funded activity, giving enough detail to acquaint the reader with the project.

To survey the low-salinity SAV resources in Neuse River using:

1) the Rapid Assessment Protocol described in Kenworthy et al (2012), surveying along the 1-m depth isobath along the entire shoreline of the Neuse River Estuary.

[1] formerly Zenil

2) the Sentinel Site Protocol with shore-normal transects at 20 sentinel sites at selected locations to be revised in a 5-year rotation. This will allow a statistical comparison of change in SAV habitats over time.

Project Status/Work Accomplished:

For each objective, describe tasks scheduled for the reporting period and the activities undertaken to complete them. Describe the specific accomplishments, and list products (publications, web pages, data, technology, etc.) completed during the reporting period. Attach copies of the publications, as appropriate.

Objective 1: The Rapid Assessment protocols were used to survey areas in the Neuse River and its tributaries in Aug-Sep 2016, May-June 2017 shown in Figures below:

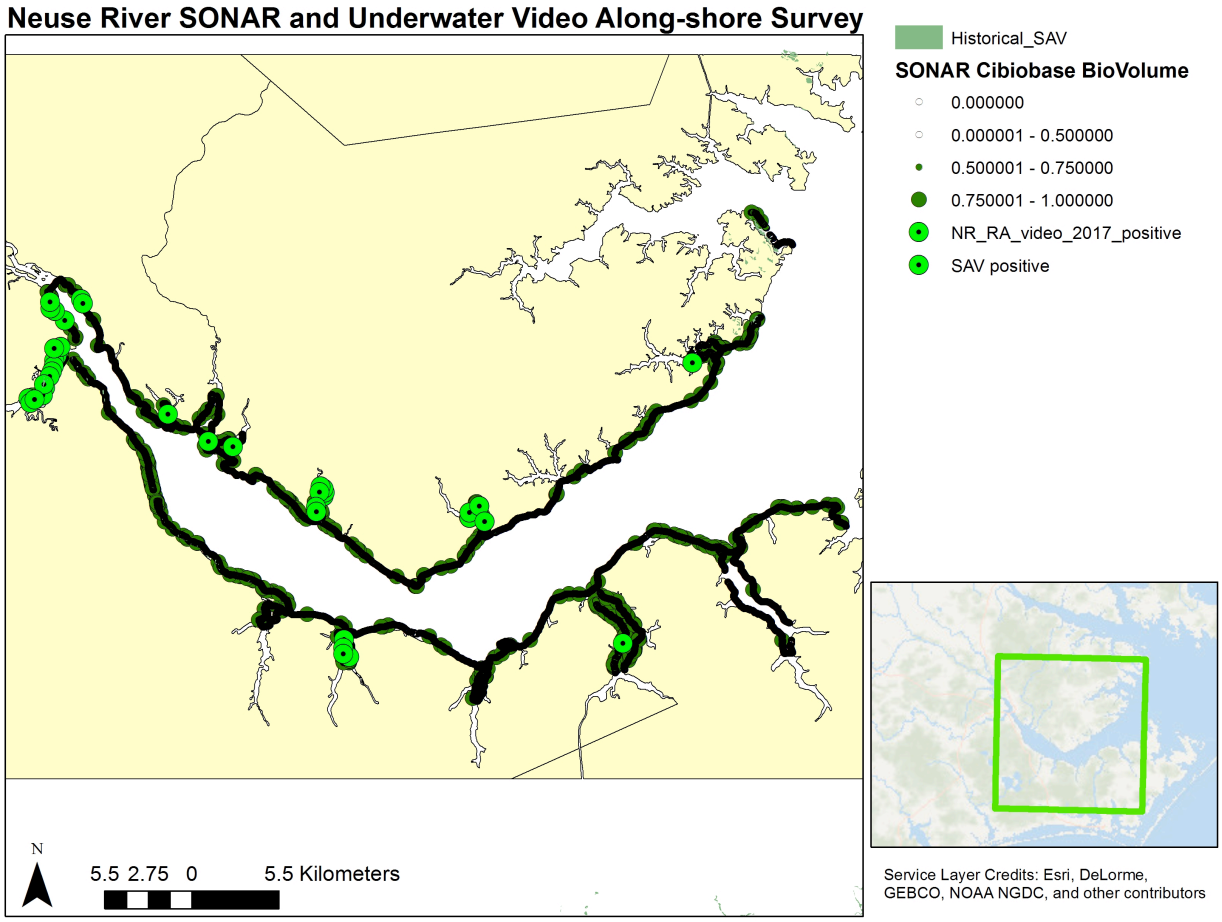


Figure 1 Biovolume of SAV surveyed and presence of SAV observed on underwater video at points surveyed @ 1m Rapid Assessment (RA) alongshore surveys in Fall 2016 and Spring 2017

Deviations:

If there were changes to the goals/objectives during the reporting period, please detail the circumstance and nature of change. Explain any special problems or circumstances which prevented the accomplishment of scheduled tasks. Describe actions to resolve problems encountered and provide the details of any changes made to goals and objectives of the project.

Objective 1 We completed the mainstem of the Neuse River in Fall 2016 and added the tributaries for the Spring 2017 survey.

In the original proposal, we had proposed to survey the main stem of the Neuse River in 2016, we accomplished this task; however, we only confirm SAV presence with video in one area (Trent River). We wanted to establish sentinel sites where we had visual confirmation of SAV, so we decided to sample the major tributaries to the Neuse. We expected to find more SAV based along the tributaries based on the historical SAV layer and anecdotal experience. Therefore, we sampled the Neuse's tributaries between May and June of 2017. We had multiple areas in the tributaries where we had visual confirmation of SAV, which allowed us to select sentinel sites.

Objective 2 could not be completed until Object 1 was done. We selected ten sentinel sites. In the original proposal, we wanted to establish sentinel sites using the following criteria:

Original criteria for establishing a Sentinel Site:

1) SAV was present during RA surveys (SONAR and underwater video) completed in Objective 1
2) SAV was present during historical surveys by NCDMF and other previous work.

However, we had little historical evidence of SAV in any of the tributaries, so few areas satisfied that criterion. Only two of the sentinel sites selected fulfilled all the original criteria, and these were selected. Two additional sites were selected in which there was evidence of SAV in the past but not in the present (presumed SAV loss). The rest of the sites were selected as being SAV areas discovered in 2016-17 near historical SAV areas, but not directly in a historical SAV area. From the possible sentinel sites meeting the above criteria, 10 were selected (Figure 8). We wanted to distribute the ten sites all around the Neuse with no focus in one area, except in the Trent River, where we found one of the largest beds, and we also had evidence of historical SAV presence. These 10 sentinel sites will be surveyed in June – Sep 2017. **We are requesting a no-cost extension to survey these 10 sites during the peak of the growing season.**

We chose 10 rather than 20 sentinel sites because the survey of the tributaries in Objective 1 took longer than anticipated. Furthermore, shoreline transect extensions are being done using quadrat and core methods on the essential sites to cover shallow water SAV (<0.7 m) and these take additional personnel. The shoreline transect extension were not part of the original proposal; however, a noticeable amount of the SAV observed is found in shallow areas of the Neuse River and its tributaries (<0.7 m) where SONAR use is not feasible.

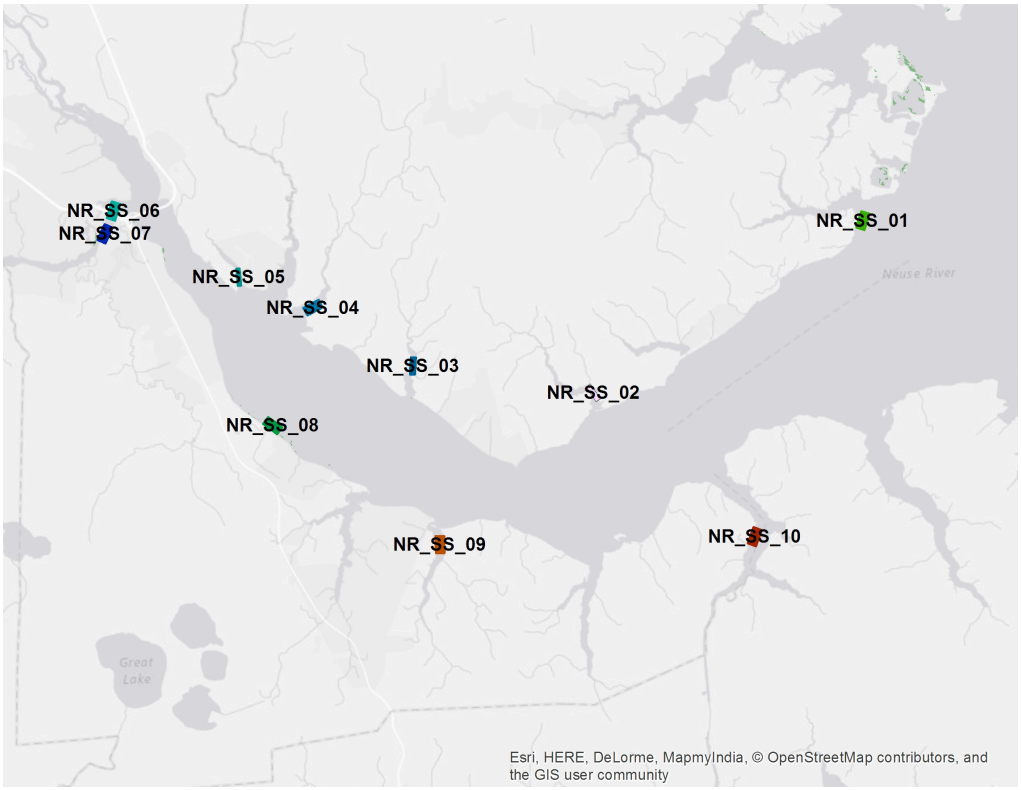


Figure 2 Proposed sentinel sites meeting selection criteria are shown as brown polygons.

Additional Guidance:
If your scope of work is broken into discrete jobs/tasks, please use the Job/Task titles as subheading under which to report accomplishments. Please report on the percent of completion of each separate job/task in your proposal.

Objective 1 – Along-shore survey @ 1 m (100 % completed)
Objective 2 - Sentinel site selection done (10% of objective) and survey of the ten sentinel sites is underway (90% of objective remains incomplete) – sites have been selected, but surveys are just now underway.

Task	**May 1 2017 – December 31, 2017**							
	May	June	July	Aug	Sep	Oct	Nov	Dec
Objective 1 Rapid Assessment surveys								
Objective 2 Sentinel Site surveys								
Data Analysis								
Performance Reports								
Final Report								

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: University of North Carolina at Chapel Hill (PIs: J. Fodrie, T. Rodriguez)

Grant Award #: 6796

Grant Title: Investigating rates of sedimentation in tidal creeks and resulting impacts on fishery production in primary and secondary nurseries

Grant Award Period: 7/1/16 – 6/30/19

Performance Reporting Period: 1/1/16 – 06/30/17

Project Costs:

Expenditures for the Period:

Category	**Expenditures**
Personnel	24,659.97
Fringe	3,139.05
Travel	457.31
Equipment	
Supplies	7,309.15
Construction	
Contractual	
Other	1,042.27
Total Direct	36,607.75
Indirect	5,491.24
TOTAL	42,098.99

Total Cumulative Expenditures: 81,363.09
Total Remaining Balance: 23,069.92

Description of Work**:**
Our research scheme has 3 main components: (1) determine the historic and present status and morphology of tidal creeks (vis-à-vis sedimentation rates), (2) assess the impacts of these changes on important benthic habitats, and (3) assess the impacts of these changes on fishery production of recreationally targeted species.

In year 1 of our study, we proposed to focus on Components 1 and 2.

Component 1: Evaluate sedimentation rates and characteristics of tidal creeks through ^{210}Pb analyses, porosity, and grain size measurements for lightly, moderately and heavily sediment-impacted creeks (collectively, representing a wide gradient of

“impact”). We will also measure metrics that correlate with sedimentation (temperature, salinity, dissolved oxygen).

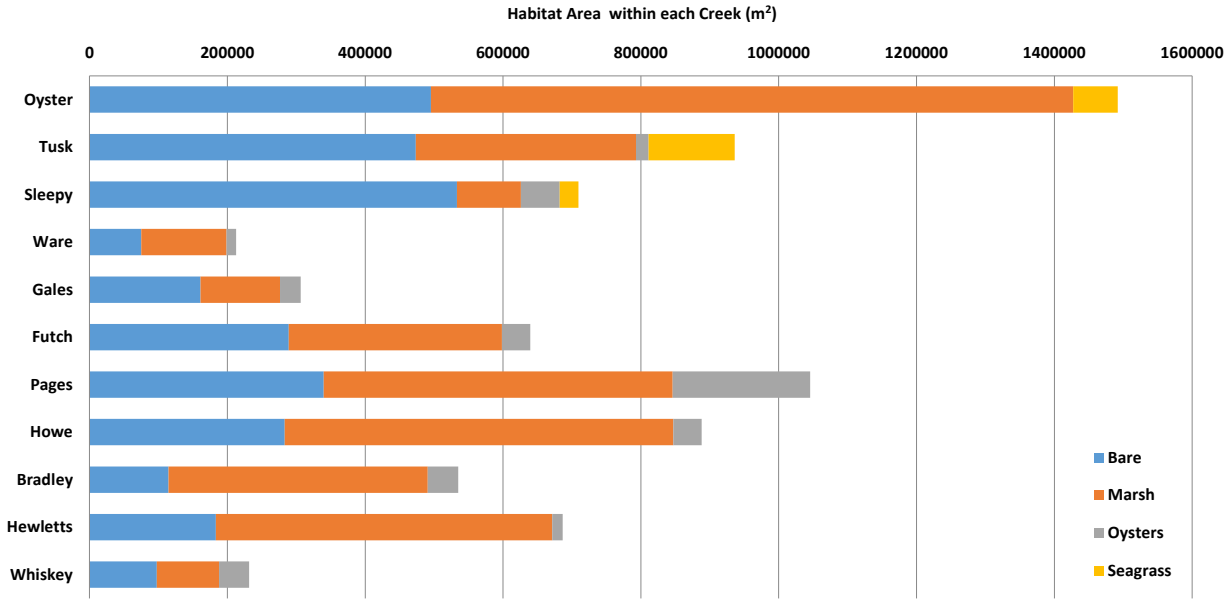
Component 2: Survey present and historic habitat structure (e.g. seagrass, oyster reefs, salt marsh) to determine if changes in sedimentation correspond to changes to benthic habitat and foraging grounds for juvenile fishes within tidal creek systems.

Project Status/Work Accomplished:
To date, we have made multiple visits to all 12 of our study sites distributed along the southern and central NC coast

During this 6-mo period, we have focused our work on:

1. Conducting vegetation surveys within each marsh (surveying within each creek = 12 total surveys).
2. Maintaining temperature/salinity loggers within all 12 tidal creek (1 at each site).
3. Conducting bathymetry mapping and ground truthing of side-scan-based habitat delineations (side-scanning conducted in fall 2016) in all 12 creeks (Figure 1).
4. Processing/preparation of all cores for ^{210}Pb, porosity, and grain-size measurements. All cores have ben sectioned, freeze dried, and transported to UNC-CH’s main campus where there are currently being analyzed to generate sedimentation profiles (1 creek finished before this reporting period, 11 more underway).
5. We have continued gathering publically-available data from USGS, NCDMF, etc., to generate a database of tidal-creek specific information regarding watershed size, land-use patterns and potential habitat change (over the last 25 years) within each watershed, and bottom type characteristics (i.e., marsh cover). Our own GIS-based mapping has contributed information on present-day and historical marsh platform coverage within each tidal creek system (Figure 1).

Figure 1. Cover of unstructured (bare sediment) and structured (biogenic) habitats within each study creek.



6. As of July 1, 2017, we have begun sampling tidal creeks (seasonally) to assess the abundance/distribution of nekton. Thus far, 5 creeks have been sampled (2.5 days of sampling per creek) using a combination of minnow traps, crab pots, gill nets, fyke nets, and trawls.

<u>Deviations</u>:
We have no major deviations to report. We did have 3 salinity loggers fail recently, and therefore we are in the process of determining how to collect salinity data from these creeks moving forward. Also, the analytical microwave on UNC-CH's main campus used to evaluate ^{210}Pb profiles failed this spring, and only recently became operational. Therefore, we are ~3 mo behind our idealized schedule to generate sedimentation profiles for all 12 creeks.

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: Take A Kid Fishing Foundation.Inc.

Grant Award #: 6444

Grant Title: North Carolina Marine Resources Fund (CRFL)

Grant Award Period: July 1, 2016 – June 30, 2017, with an extension granted till Sept 1, 2017

Performance Reporting Period: Jan 1, 2017 – Sept 1, 2017

Project Costs: $60,484.13

Expenditures for the Period: ***$60,484.13*** *(See attached excel spreadsheet)*

Total Cumulative Expenditures: **$60,484.13**
Total Remaining Balance: 0

Description of Work:
The Take A Kid Fishing Foundation, Inc. is a North Carolina based nonprofit organization whose mission is to enrich the lives of disabled and disadvantage youth through an opportunity to go saltwater fishing

The goal of the Foundation is to introduce fishing to children through their annual event. It provides "hands on" opportunities to children so they can learn about this healthy outdoor activity that can be enjoyed throughout life. This opportunity provides youth with real world experiences in the sciences while fostering a love for the outdoors. It is through this educational experience that they are able to develop skills and are encouraged to become conservationist and teachers in their own communities. The Foundation and its volunteers strive to develop an understanding within of how they can and should maintain our fishing resources. They provide instruction on the many ways they can minimize their impact on our coastal environment by utilizing ethical angling practices while enjoying the outdoors.

Each year the Foundation and its many contributors work throughout the year raising funds and awareness in preparation for the event. Donations are solicited for supplies, services and funds. Invitations are extended to children's homes, city and county youth organizations and orphanages. Supplies are prepped to ensure they are in proper

working condition and volunteers are organized to assist. Services are contracted for in anticipation of the needs of approximately 700 children and their chaperones.

Project Status/Work Accomplished:
In 2017 the Take A Kid Fishing Foundation hosted 688 children and their chaperons. Attendees were assigned to fish from seven locations across the county, aboard head boats and fishing piers. In addition, a half day tour was provided to all pier participants. Tours included the NC Aquarium, the Renegade Pirate Ship or the Morehead City Ferry Services' ECO Tour.

Volunteers from organizations like the Carteret County Board of Realtors, NC Marine Fisheries, Big Foot Cooking Team, Big Rock Sports, Big Rock Blue Marlin Tournament, Sound Bank, West Carteret High School, National Charity League, RSM, Swansboro Rotary, Onslow Bay Saltwater Fishing and Civitan Clubs spent the day preparing and serving meals, rigging rods, teaching skills and sharing information on the importance of ethical angling practices and conservation in our ocean environment. Eddie Cameron Construction, Big Rock Sports and Linda Rike Real Estate provided equipment, labor and trucks for the storage and distribution of all supplies. Pepsi, Harris Teeter, Walmart, Coke & Lowes Foods supplied bottled water & beverages. Area high school students volunteered their time to inspect, clean, repair and rig all 800 rods & reels prior to the event, in addition to assisting with supply distribution and providing hands on instruction during the event. These same students have pledged to provide additional support in 2018. The Swansboro Rotary Club hosted over 250+ participants & volunteers at their Swansboro Rotary Civic Center for an afternoon cookout. In addition they provided volunteers at the civic center and on the Emerald Isle boats and piers, financial support for bus and boat expenses in addition to providing all of their cookout supplies. At the same time the Big Foot Cooking Team hosted an additional 450+ participants & volunteers for a cookout in the Morehead City area at the Crystal Coast Civic Center.

The Foundation continued to work with NC Marine Fisheries & its many volunteers in educating participants on ethical angling practices through hands on instruction. Volunteers began each session with an introduction to fishing and water safety that continued throughout the day. They stressed the importance of using ethical angling practices while teaching skills. The kids were very excited to learn. Volunteers took time to talk with the children identifying species while providing information about their habitats, etc.

The Foundation shares its mission through the TAKF website. Encouraging others to create similar programs in their area while also providing information on fishing, ethical angling and conservation practices. Interested parties can find additional information on sponsorship and volunteer opportunities, make a donation, see photographs from events and contact us. The TAKF Website is currently undergoing a much needed update which should be completed by the end of this year.

The Carteret County News Times and area newspapers provided coverage of this

year's event spreading the word about the foundation's work and its need for continued support. Also featured was an article on TAKF being selected as RSM's 2017 charity recipient of the year. The RSM staff worked throughout the year to organize and hold events that raised over $3,457 for the TAKF event. New and renewed applications & requests were submitted to the Carteret Craven Electric Cooperative's & the Big Rock Blue Marlin Tournament's Foundation committees. Additional funds were raised through mailing lists updates and annual solicitation of our supporters. Articles were submitted for publication in tournament books and presentations made to spread the word about our mission, while soliciting financial support and the need for volunteers.

In order to meet the needs of the participants', the Foundation worked throughout the year to secure sponsorships that provide the needed services and in kind and cash donations that are utilized along with the CRFL grant funds to support the organization throughout the year. Organizations like the National Charity League, Swansboro Rotary, Onslow Bay Sports Fishing & Civitan Clubs, Walmart, Harris Teeter, Lowes Foods, Big Rock Blue Marlin Tournament, Big Foot Cooking Team, Carolina Ice, Boddie Noel Corporation (Hardee's), Biscuit Kitchen, Sanitary Restaurant, Glad Tidings Church, Carteret Craven Electric Corporation Foundation, Grady White, West Carteret Cheerleaders, NC Marine Fisheries, First Bank, Linda Rike Real Estate, Carteret County Board of Realtors, Big Rock Sports, Coke, Pepsi, Fish Bites, Coastal Builders, Calcutta Outdoors, RSM, Eddie Cameron Construction, Solskyn (Suntan) Skin Care Products, Bare Bottom Fishing, Southern Express & Diamond Limo, AARD T-shirts, Sysco Foods, ,Kona Ice, NC Aquarium, Morehead City Ferry Service, Crystal Coast Tours, NC Maritime Museum and area head boats & piers were just some of the many that joined with us in support of this year's event.

The TAKF event not only touches the lives of hundreds of disabled and disadvantaged youth, but it also benefits many of our youth. It is through volunteering that they see firsthand the importance of giving back to others. In addition it enables many of the homes & agencies to reward students for reaching academic and behavior goals. It also allows the Foundation to provide support to other well deserving organizations in their area like Hope Mission, who may receive a donation from that day's catch to feed the homeless. Any leftover suntan products are donated to groups like the junior life guard program in Atlantic Beach or the Boy's and Girl's Club's summer programs, while unused food supplies are given to local lunch box programs that feed under privilege children. Nothing goes to waste.

The Foundation is always looking for ways to share the joy of fishing with others. In 2017 the Foundation received a request to provide support to a group from "Little Houses of Hope". This Burlington, NC organization's mission is to promote breast cancer recovery by offering opportunities for survivors to reconnect and celebrate life. Survivors and their family members are treated to a fun filled week at the beach filled with activities that included a day of fishing sponsored by TAKF and the Bogue Inlet Pier.

Our goal is to continue providing children of NC with an opportunity to go saltwater fishing while also assisting others in the creation of similar programs throughout the US. The Foundation works to provide interested parties with information on how to find resources, organize, host and secure sponsorships for an event.

The following groups participated:
Wake Human Resources – Raleigh, NC
Peak Family (Autistic son) – Williamston, NC
Raleigh Police Dept Mentor Program – Raleigh, NC
Central Children's Home – Oxford, NC
NC Boy's & Girl's Home – Lake Waccamaw, NC
Falcon Children's Home – Falcon, NC
Grace Helping People Start Over – Fayetteville, NC
Sunshine Lady Boys & Girls Club – Morehead City, NC
Havelock Boys & Girls Club – Havelock, NC
*Beaufort Boys * Girl's Club – Beaufort, NC*
Boys & Girls Club of the Coastal Plains– Pitt County & surrounding areas
Craven County Dept of Social Services – New Bern, NC
Finn Foundation – Pink Hill, NC
Kennedy Children's Home – Kinston, NC
Nash County Dept of Social Service – Nashville, NC
Edgecombe County Dept of Social Services – Tarboro, NC
Sandridge Boys & Girls Club – Hubert, NC
Richlands Elementary Boys & Girls Club – Richlands, NC
Church of God Children's Home – Concord, NC

Fishing Locations:
Head boats
Carolina Princess – Morehead City
Capt Stacy – Atlantic Beach
Crystal Coast Lady – Beaufort
Nancy Lee – Swansboro

Piers
Bogue Inlet Pier – Emerald Isle Pier
Old Beaufort Seaport Pier – Beaufort

Half day tours combined with a half day of pier fishing
NC Aquarium – Pine Knoll Shores
Morehead City Ferry Service ECO Tours – Morehead City, NC
Renegade Pirate Ship – Beaufort

The 2018 event has been tentatively scheduled for Tuesday, July 24th. In January contracts will be sent out to all boats, piers, civic centers and tour locations to secure the necessary space for the coming year. Invitation to participants will follow in early

March of next year.

Deviations: None

Receipts are attached

Coastal Recreational Fishing License:
Semi-Annual Performance Report

Recipient: Charles H. Peterson, University of North Carolina at Chapel Hill, Institute of Marine Sciences; 3431 Arendell Street, Morehead City, NC 28557

Project Investigators: Charles H. Peterson & Avery B. Paxton

Grant Award #: 6446

Grant Title: Improving the fish production of artificial reefs by testing the most widely-recognized and pressing questions about reef design and function

Grant Award Period: July 1, 2015 – June 30, 2018. The project end date was extended from June 30, 2017 to June 30, 2018 under a no-cost extension for year 2 of this grant.

Performance Reporting Period: January 1, 2017 – June 30, 2017.

Project Costs:

Expenditures for the Period: *01/01/17 - 06/30/17*

Category	Expenditures
Personnel	$ 11,245.79
Fringe	$ 938.81
Travel (Domestic)	$ 26.23
Travel (Foreign)	$ 1,512.00
Supplies	$ 2,047.79
Misc. Services	$ 1,728.00
Total Direct	$ 17,498.62
Indirect	$ 2,624.82

*Total Cumulative Expenditures**	$ 20,123.44
Total Remaining Balance	$ 39,923.44

* For the period 01/01/17 – 06/30/17

<u>Description of Work</u>:

Objective: The overall objective of this study is to increase the fish production of artificial reefs by understanding consequences of siting location and buffer zones widths of varying distance between artificial reefs and existing natural reefs, the efficacy of Atlantic Pods, and the effect of artificial reefs on water column productivity and soundscape characteristics indicative of spawning. The project is broken into three components with respective objectives:

1. *Buffer zone between artificial and natural reefs:* To determine how placing artificial reefs in close horizontal and vertical proximity to natural hard-bottom influences the habitat utilization by recreationally and commercially important fish species and to specifically evaluate the proposed 200 ft buffer between artificial reefs and natural reefs. Fish utilization of artificial reefs will be determined as a function of proximity to natural reefs and substrate relief to address the hypotheses that:
    a. Artificial reefs located in close horizontal proximity to natural reefs have lower fish abundance than those located farther away because isolated artificial reefs form oases in otherwise habitat-limited surroundings.
    b. As horizontal distance from artificial reefs to natural reefs increases, the biomass of fish on artificial reefs also increases, such that buffer zones between artificial and natural reefs should be maximized.

2. *Effectiveness of Atlantic Pods:* To determine the efficacy of the novel artificial reef structures called "Atlantic Pods" by quantifying fish community development, as well as scouring, stability, and durability over time. Each of these attributes will be compared to other artificial reef structures of different shapes, sizes, and materials to determine which artificial structures perform the best as reef fish habitat. We hypothesize that Atlantic Pods will be effective artificial reef fish habitat but that the effectiveness of different types of reef structures will vary as a function of reef characteristics, such as shape, size, and material.

3. *Aggregation vs. production – water column and soundscape:* To test innovative mechanisms of enhancing production to help address the question of whether artificial reefs aggregate or produce biomass of fishes, including how artificial reefs form supplemental habitat throughout the water column above and how artificial reefs create novel soundscapes.

Expected Results: The results of this project will increase the performance of and range of materials used for artificial reefs to generate more fish for the public, including both recreational and commercial fishermen. We also test long-standing hypotheses on aggregation and production and are confident that our novel approaches will show increased production through documenting the water column 'footprints' and frequency of spawning on artificial reefs. More specifically, this study will provide a comprehensive assessment of how artificial reefs enhance fisheries, with a focus on establishing scientifically based buffer zones between artificial and natural reefs, documenting the effectiveness of new Atlantic Pod artificial reef modules, and determining how artificial reefs influence the water column directly above and behind them as

well as whether fish spawning sounds are present. We will achieve the following for each of the three project components:

1. *Buffer zone between artificial and natural reefs:*
    a. Determine how siting artificial reefs in close horizontal proximity to natural reefs impacts fish habitat utilization
    b. Scientifically evaluate the proposed buffer zone between artificial and natural hard-bottom reefs to be able to recommend a specific distance;

2. *Effectiveness of Atlantic Pods:* Determine the effectiveness of novel artificial reef modules called Atlantic Pods by monitoring the fish community development, the magnitude of induced scour and subsidence, and the durability and stability of the structures.

3. *Aggregation vs. production – water column and soundscape:*
    a. Address whether artificial reefs generate eddies and upwelling to impact water column productivity and increase the carrying capacity of artificial reefs as habitat for fishes
    b. Document whether species-specific spawning sounds occur as compared to ambient sound from to nearby soft-sediment areas.

These achievements will help fill knowledge gaps of how artificial reefs enhance fisheries and thereby improve the functionality of artificial reefs in the future.

<u>Project Status & Work Accomplished</u>:

1. *Buffer zone between artificial and natural reefs:* We have completed one full year (three seasons), of comprehensive sampling on artificial and natural reefs to determine an appropriate buffer zone, as well as a partial pilot season. Data processing and analysis is complete. We orally presented our findings at the Benthic Ecology Meeting in Myrtle Beach, SC during April 2017. In July 2017, we submitted a manuscript detailing our findings to the peer-reviewed journal *Marine Ecology Progress Series.* The manuscript information is as follows:

    R.C. Rosemond, A.B. Paxton, H.L. Lemoine, S.R. Fegley, and C.H. Peterson. *In review.* Fish use of reef structures and contiguous sand flats: implications for selecting minimum buffer zones between new artificial reefs and existing reefs. *Marine Ecology Progress Series.*

    We are on schedule for the buffer zone component. Our methods were as follows:

Site Selection: We surveyed six state-designated artificial reef sites in nearshore coastal waters of Onslow Bay, NC (Figure 1; Table 1). Each of the state-designated artificial reefs (e.g., AR-345) that we surveyed hosts several different types of submerged structures, ranging from concrete pipes to ships. These patches of different structures nested within each state-designated artificial reef site are called subsites. We sampled 4-5 subsites per artificial reef site. Some of the artificial reef sites also contain naturally occurring hardbottom of varying complexity, which we

also sampled as subsites. We sampled a total of 28 subsites, including both artificial and natural reefs, within nearshore waters at depths ranging from 11.6 m (38 ft) to 19.8 m (65 ft) (Table 1).

Each subsite reef was sampled seasonally to document temporal changes in environmental conditions, benthic communities, and fish communities during fall (August – October 2015), winter (December 2015 – January 2016), and spring (March 2016- May 2016). Several sites were sampled during summer 2016 (July) as a pilot study to test survey methodology. Our seasonal sampling corresponds to expected changes in the benthic community, where macroalgae reaches peak biomass during the fall, dies back during the winter, and begins to regrow during the spring.

At each subsite, divers established four transects, one along prominent reef and three radiating away from the reef (30 m on reef, and 0-30 m, 30-60 m, and 60-90 m away from reef). The reef survey transect was opportunistically directed towards any reef structure that was present. Using archived side-scan data, we selected headings for radiating surveys leading away from reef structure. Divers followed the heading from the reef in transect increments of 30 m, for 90 m total, unless environmental conditions were prohibitive. On both reef and radiating transects, divers surveyed fish community and habitat complexity.

Fish Community Assessments: To measure fish composition and abundance, divers sampled along a 30 m x 4 m belt transect while recording the species and abundance of all fish present throughout the water column, including both conspicuous and cryptic categories of reef fish. Fish length was estimated to the nearest cm. Position in the water column was estimated to be in the following categories: reef (0 to 1 m above the substrate), supra reef (1 to 2 m above substrate), and water column (>2 m above substrate).

For structural surveys, one 30 m x 4 m belt transect was conducted, whereas for radiating surveys, three back-to-back 30 m x 4 m belt transects were completed. Available diving time on the bottom determined the exact number of transects for radiating surveys. We avoided double counting of fish between transects by continuously looking forward and noting when a particular individual fish or school of fish crossed from one 30 m section to another.

Structural Complexity: To document how structural complexity affects fish community metrics, such as composition and diversity, we collected measurements of the contour of each reef using an Onset HOBO U20 Titanium Water Level Logger containing a pressure-transducer that records fine-scale variation in depth, from which bottom elevations are calculated. A diver swam over the reef with the logger suspended from a line and positioned as close to the substrate as possible. The logger was moved along the reef at a rate of 10 cm per second over the length of each 30 m transect. The logger was raised 1 m above and rapidly lowered back down to the substrate surface in a spike motion five times at the start and end of each transect and three times every 5 m between these endpoints. Because the logger records continuously during each dive, these spikes were used to identify each transect within the data stream and calibrate the distance surveyed. During post-dive processing, the distance calibration spikes were removed from each file using Microsoft Excel, and the raw pressure recorded by the pressure-transducer was converted from units of psi to m, assuming that atmospheric pressure was 1 atm, corresponding

to the water depth. If the sampling rate differed from the target rate of about 10 cm per second, then the transect length was scaled for comparison.

Results: At each site, we surveyed four transects: one 30-m transect across reef structure and three consecutive 30-m transects of increasing distance from the reef across sand bottom. Fish abundance, biomass, and species richness were highest on reefs and progressively decreased across contiguous sand flats. Environmental variables influenced these community metrics, but patterns of fish habitat use persisted. Fish community composition shifted gradually from reefs across contiguous sand flats, with fish communities on reefs most dissimilar to communities on sand bottom farthest from the reefs. A minimum buffer of 60 m (30 m around existing reefs plus 30 m around new reefs) or 120 m (60 m plus 60 m) between reefs would encompass 77% and 97%, respectively, of fishes utilizing sand-bottom habitat around each reef. Future artificial reef deployment should maintain these minimum buffer zones between reefs to more effectively enhance fisheries by minimizing attraction of fishes from existing reefs, while also maximizing food resource availability for reef fishes and area for routine reef fish behaviors.

2. *Effectiveness of Atlantic Pods:* We collected data on the effectiveness of Atlantic Pods as reef fish habitat seasonally during summer 2015, fall 2015, winter 2015-2016, and spring 2016, completing one year of sampling effort. Data processing is complete. Data analysis is complete. We presented preliminary results at the *Western Society of Naturalists* conference in CA during November 2016. We are currently preparing a manuscript on results from this component of the project. We are on schedule with the Atlantic Pod component. Our sampling methods are as follows:

Site Selection: To compare the effectiveness of artificial reef types of different sizes, shapes, and materials as reef fish habitat, we comprehensively surveyed 24 artificial reef structures off the coast of North Carolina in Onslow Bay (Table 1). We selected reefs to assess using side-scan sonar and GPS coordinates obtained from the Department of Marine Fisheries in North Carolina, as well as fishing charts, word of mouth, and roving diver surveys. Sites were selected based on occurrence in or near state waters and proximity to other artificial structures and natural reefs. Side-scan sonar imagery was also used in site selection because the imagery was spatially referenced with exact GPS coordinates. The NC DMF Artificial Reef Program provided us with side-scan sonar imagery for all reef materials except Atlantic Pods. We collected side-scan sonar of the Atlantic Pods using a Hummingbird side-scan unit with a hull mounted transducer to use for site selection. Sites were located either in nearshore, state waters (< 3 mi; 4.8km offshore) or offshore, federal waters (3-10 mi; 4.8-16 km offshore) and ranged from 11.6 m (38 ft) to 19.8 m (65 ft) in depth. Reef materials included concrete blocks, train cars, pipes, shipwrecks, tires, Reef Balls, and Atlantic Pods. Each site was visualized using side-scan sonar displayed in ArcGIS to determine an exact survey location and accompanying transect headings prior to *in situ* assessments.

Fish Community Assessments: To document which reef fish species occupy the Atlantic Pods and how the function of Atlantic Pods as fish habitat compares to other artificial reefs, we performed diver-conducted fish surveys. We counted fish along a 30 m x 4 m belt and roving-diver hybrid transect starting at the base of the artificial reef and continuing along the structure.

The survey path was directed towards structure as much as possible to ensure that we counted fish associated with the reef structure rather than expanses of sand between reef structures. We identified fish species to the finest taxonomic level possible, estimated fish size to nearest cm, recorded species abundance, and documented water column position of fish on waterproof paper mounted to a PVC slate. Water column position was recorded as one of three categories: 0-1 m above the reef surface, 1-2 m above the reef surface, >2 m above the reef surface.

Stability & Degradation: To analyze the stability of the Atlantic Pods relative to Reef Balls, we recorded observations and measurements of specific points on each structure. Divers recorded the position of pods along the seafloor and whether or not Pods were touching along 30-m x 4-m transects. Transects were combined back-to-back up to 90 m. Divers categorized the position of the Pod as "upright" if the Pod landed as originally intended with the square base of sitting flush against the bottom, "side" if the base of the Pod landed on the side, and "upside-down" if the top of the Pod was flush against the bottom. Divers also noted whether Pods touched. Degradation was measured at two randomly chosen Atlantic Pods or Reef Balls per site where these structures were present. At each structure, we chose a hole at the top of the Atlantic Pod or Reef Ball, and another hole at the bottom. We used a ruler with centimeters clearly marked to measure the width of the hole at the top, and the width of the hole at the bottom, including any growth since deployment. Then we used a knife to scrape away the growth from these same holes, over an area approximately a centimeter in length, until we had scratched off all growth. The width of the hole was re-measured without the growth. We repeated this process at another structure, for a total of two structures per site. These measurements will be compared to what the width of these sections had been prior to deployment to determine the rate of degradation.

Scour: To determine the impact that scouring has on the stability and biotic growth on the Atlantic Pods, and to compare them to these same measurements for Reef Balls, we measured sediment depth at two Atlantic Pods or two Reef Balls per site. We used a sediment T made of gray PVC pipe 40 cm in length with notched markings along the side indicating depth, we determined the four cardinal locations relative to the structure using a compass. At each of these locations, we took one measurement as close to the structure as possible, and one measurement 40 cm (one sediment T length) away from the structure, maintaining the same direction. To do this, we held firmly to the handholds at the top of the T and pressed into the sediment until the instrument would no longer penetrate deeper into the ground. At this point, the diver noted the depth of the sediment by looking at the markings on the side of the sediment T, and then repeated this for the remaining points. This process was repeated at a second structure, for a total of two structures per site.

Structural Complexity: To assess how the structural complexity of different artificial reefs types (e.g., Atlantic Pods, Reef Balls) influence reef fish community metrics, we collected measurements of the contour of each reef using an Onset HOBO U20 Titanium Water Level Logger containing a pressure-transducer that records fine-scale variation in depth, from which bottom elevations are calculated. See component 1 (Buffer Zone: Structural Complexity) above, for exact methods.

Preliminary Results: Analyses indicate that fish communities on Atlantic Pods, Reef Balls, and concrete pipes are similar, whereas the fish community on sunken ships is the most unique compared to all other structures.

3. *Aggregation vs. production – water column and soundscape:* We sampled the currents, zooplankton, fishes, and sharks in the water column beginning in May 2016 with improved technology (see Deviations below), and sampling concluded in September 2016. We have conducted five rounds of sampling for the soundscape. Data processing and analysis are ongoing for both components. In June 2017, we submitted a manuscript to the peer-reviewed journal *Ecological Engineering* on our findings from the video recordings obtained during the soundscape component of this project. The manuscript information is as follows:

   Paxton, A.B., L.W. Revels, R.C. Rosemond, R. Gaesser, H.R. Lemoine, J.C. Taylor, and C.H. Peterson. *In review*. Convergence of fish community structure between a newly deployed and an established artificial reef along a five-month trajectory. *Ecological Engineering.*

   We are on schedule for both the water column and soundscape components.

Water Column Productivity: To determine how artificial reefs support an overabundance of planktivorous fishes and whether this effect propagates through higher trophic levels, we remotely measured the concentration of zooplankton (prey), fish (target species), and sharks (predators), as well as water currents, surrounding artificial reefs. Sampling effort concentrated within the cylindrical volume of water extending from the center of artificial reefs outward 500 m in each direction in a star-shaped pattern. Instruments to measure current, zooplankton, fish, and sharks were mounted to a vessel via an overboard pole and collected data while the vessel moved 5 kts. Sites sampled include the *Indra* (AR-330), *James J. Francesconi* tug (AR-330), *Titan* (AR-345), *Spar* (AR-305), *Aeolus* (AR-305), and *Theodore Parker* (AR-315).

Currents: To determine if ambient currents are altered by the emergent structure of artificial reefs, the currents throughout the water column were measured with a hull-mounted current profiler, RDI Workhorse Sentinel 600 kHz Acoustic Doppler Current Profiler (ADCP). The vessel transited slowly over the survey area while the ADCP recorded. WinRiverII Software accounted for the vessel tilt, heading, and other parameters to accurately record water velocity throughout the water column.

Zooplankton, Fish, Sharks: To determine whether aggregations of zooplankton and fish, including planktivores and piscivores, and sharks occur surrounding artificial reefs, we acoustically sampled with splitbeam echosounder (SBES). SBES is a remote sensing technique used to measure fish acoustic density and biomass. It also detects zooplankton biomass and large fauna, such as sharks. SBES functions by emitting pulses of high-frequency sound from quadrants of a transducer. Sound waves reflect off of objects, such as swim bladders in fish, of different densities than the seawater they reside in. Return-signals from the reflections are used to determine the depth of the target based on the timing of the sonar ping return, the size of the target based on the strength of the target return signal, and the direction of the target based on angular positions. The return signal helps differentiate between zooplankton, fish, and sharks.

To acquire fisheries acoustics data, we used a Simrad EK60 SBES with two transducers and transceivers, one operating at a frequency of 38 kHz and the other at 120 kHz. These sensors have a narrow beam width that optimizes vertical resolution and detection of fish close to bottom structures. The transducers were mounted to an overboard pole, along with the ADCP, and collected data as we transited slowly over the designated survey area. Data collection parameters were managed within Simrad ER60 software. We are post-processing SBES data with Echoview software to interpret concentrations of zooplankton, fish, and sharks in the water column surrounding the artificial reefs. Data processing will remove vertical motion and delineate artificial reef structure. We will determine a threshold of target strength to differentiate among the different types of animals.

Soundscape: To determine characteristics of artificial reef soundscape, we deployed two high-frequency recording devices, a hydrophone and a video camera, on two artificial reefs. The hydrophone (SoundTrap 300, Ocean Instruments, New Zealand) records continuous acoustic signatures of biological and anthropogenic sounds (16-bit, 96 kHz) during day and night, while the video camera records time-lapse videography during the day and, with an LED light, the night. The hydrophone and video cameras were mounted on conical metal frames and deployed on two artificial reefs at AR-330, landing craft repair ship *Indra* and tug *James J. Francesconi* for two-week periods. The soundscape and associated fish community were sampled during May 2016, following the intentional sinking of the tug, as well as during July - August 2016, September 2016, November 2016, and April – May 2017.

Results from Video Recordings of Soundscape Component: We simultaneously collected time-lapse videos of fishes colonizing a new (2 wks old) artificial reef and those inhabiting a nearby (438 m away) established (> 20 yrs old) artificial reef. We found that fish community composition on the new artificial reef converged with the fish community composition on the established artificial reef over five months. Community development on the new reef followed a trajectory: schooling, planktivorous fishes initially colonized the reef in high numbers, whereas demersal fishes exhibited delayed colonization. These findings suggest that fishes may colonize human-made reefs along a specific trajectory of pelagic fishes followed by demersal fishes and that community convergence between reefs can occur over relatively short temporal scales given similar environmental conditions. When deploying additional structures, including human-engineered habitats, in the marine environment, our findings on fish colonization of artificial reefs are important to consider because they provide new insight into how artificial structures can be utilized to enhance particular fishes over different temporal scales.

Outreach and Dissemination of Results: We have engaged in the following outreach initiatives to highlight this CRFL – funded research on NC reefs:

Submitted Manuscript in July 2017: R.C. Rosemond, A.B. Paxton, H.L. Lemoine, S.R. Fegley, and C.H. Peterson. *In review.* Fish use of reef structures and contiguous sand flats: implications for selecting minimum buffer zones between new artificial reefs and existing reefs. *Marine Ecology Progress Series.*

Submitted Manuscript in June 2017: Paxton, A.B., L.W. Revels, R.C. Rosemond, R. Gaesser, H.R. Lemoine, J.C. Taylor, and C.H. Peterson. *In review*. Convergence of fish community structure between a newly deployed and an established artificial reef along a five-month trajectory. *Ecological Engineering.*

Invited Speaker, Brad Sneeden Marine Sciences Academy, 'What I love about being a marine scientist,' June 2017 (~40 students)

Oral Presentation, *Benthic Ecology Meeting*, 'Fish use of reef structures and surrounding sand habitat: implications for buffer zones between existing and new artificial reefs,' Myrtle Beach, SC, April 2017

Oral Presentation, *Coastal Carolina Scientific Diving Association – Scientific Diving Symposium*, 'Convergence of fish communities between a newly deployed and an established artificial reef occurred over five months and along a distinct trajectory,' Beaufort, NC, March 2017.

Oral Presentation, *Coastal Carolina Scientific Diving Association – Scientific Diving Symposium*, 'Inclusion of buffer zones between artificial reefs to more effectively enhance fisheries,' Beaufort, NC, March 2017

Oral Presentation, *NC Marine & Coastal Consortium Graduate Student Symposium*, 'Ecological effects of marine urbanization,' Beaufort, NC, March 2017

Invited Scientist, Scientist advisor for temperate reef ecosystem projects for Patrick Goff's middle school science students from Beaumont Middle School in Lexington, KY, March 2017 (~6 students)

Poster Presentation, *Western Society of Naturalists*, 'Metal ships, concrete modules, and rocky reefs: Quantifying how reef type influences fish communities,' Monterey, CA, November 2016.

'The science of North Carolina's artificial reefs,' Public Radio East, Down East Journal by Jared Brumbaugh, September 2016

Invited Scientists and Activity Coordinator, 'Offshore Reefs – "What? We have Reefs off NC?"' NC Seafood Festival, Morehead City, NC, 30 September 2016 (~150 students)

Invited Speaker, Duke Talent Identification Program, 'The Underwater World,' presentation on fish surveys and diving on reefs of NC, June 2016 (~20 students)

Invited Speaker, P.E.O. State Convention, 'Passport to the Graveyard of the Atlantic,' June 2016 (~400 people)

Oral Presentation, *International Temperate Reef Symposium*, **'**Existing natural and artificial temperate reefs provide valuable insights into future offshore renewable energy development,' Pisa, Italy, June 2016

Oral Presentation, *East Carolina University, Biology Department - Research in Progress Seminar Series,* **'**Offshore energy development and reef fish,' Greenville, NC, USA, April 2016

Oral Presentation, *Brown Bag Lunch Seminar*, 'Offshore energy development – what about our reef fish?' Morehead City, NC, USA, March 2016

'Shipwrecks off coast prove beneficial for marine life,' WCTI-12 News by Jonathan Weant, November 2015

Invited Speaker, Beaufort Ole Towne Rotary Club, 'Offshore Reefs: Secret Gardens of North Carolina,' 14 December 2015 (~50 people)

Speaker, Carteret Community College C-STEP 'Day at IMS,' 'A day in the life of a scientist studying offshore reefs of NC,' 30 October 2015 (~10 people)

Invited Scientists and Activity Coordinator, 'Offshore Reefs – "What? We have Reefs off NC?"' NC Seafood Festival, Morehead City, NC, 2 October 2015 (~150 students)

Lesson Plan, 'Ships, tires, and trains: What if we put them on the bottom of the ocean?' developed with educators and presented during SciREN Triangle, September 2016 (~150 NC educators)

Lesson Plan, 'SCUBA Dive into Sunken Treasure- Artificial Reefs!' developed with educators and presented during SciREN Triangle, September 2016 (~150 NC educators)

Paxton and her research team have also taught lectures for an Estuarine and Coastal Ecology course and Scientific Diving Course at UNC-IMS in fall 2015 and fall 2016 and used offshore reef research as case studies. They plan to teach similar lectures in fall 2017.

Deviations:

1. *Buffer zone between artificial and natural reefs:* We did not sample AR-350 because of limited underwater visibility. The visibility was too low to conduct fish surveys, likely because this site is located at the mouth of the New River. We conducted three back-to-back 30m transects radiating away from artificial reefs, which allows evaluation of the proposed 200ft buffer zone. For the second and third sampling seasons, we modified these radiating surveys to allow depiction of smaller scale variation (15 m) in the fish community over distance. The surveys are evaluated as six 15-m transects and three 30-m transects to learn how spatial scales influence fish use of reef structures. Last, we maintained three rounds of seasonal fish and relief surveys but no longer focused on sediment surveys. Scouring was measured only around Atlantic Pods and Reef Balls. We still measured structural relief along structural and radiating transects for each subsite.

2. *Effectiveness of Atlantic Pods:* We replaced roving diver surveys with a roving diver and belt transect hybrid survey. This was done by laying a transect tape for 30 m x 4 m along

the artificial reef structure, even if it didn't follow a straight heading. The belt transect provides easily replicable data while the roving diver survey is more random and not repeatable. By combining the two methods to form a meandering belt transect we could more adequately sample reef structures such as Atlantic Pods, Reef Balls, and Pipes that often occur with expanses of sand between individual structures. We also mapped the exact location of the Atlantic Pods by collecting new side-scan sonar data. The NC DMF Artificial Reef Program provided us with four points, one point for each corner of the rectangular area where Atlantic Pods were deployed. By collecting additional side-scan sonar, we pinpointed the exact location of each Atlantic Pod within each rectangle, allowing analyses of spatial distribution effects. We added a component of the project to compare Atlantic Pods to other artificial reef structures, such as Reef Balls, by also measuring their induced scour and stability. The buffer zone component of this project collected the remaining necessary data on fish and benthic community composition, as well as structural complexity. These comparisons will provide a better indication of how effective Atlantic Pods are as novel artificial reef structures.

3. *Aggregation vs. production – water column and soundscape:* We chose to delay our sampling effort of water column productivity until spring 2016 so we could have an extended, continuous sampling effort through early fall 2016. By waiting until spring 2016 to commence this sampling effort, we had the opportunity to improve upon the proposed research by using splitbeam fishery acoustics to more rigorously quantify the amount of zooplankton and planktivorous fishes in the water column above artificial reefs. We also used an ADCP to remotely sense the currents while surveying with the splitbeam system.

Appendix

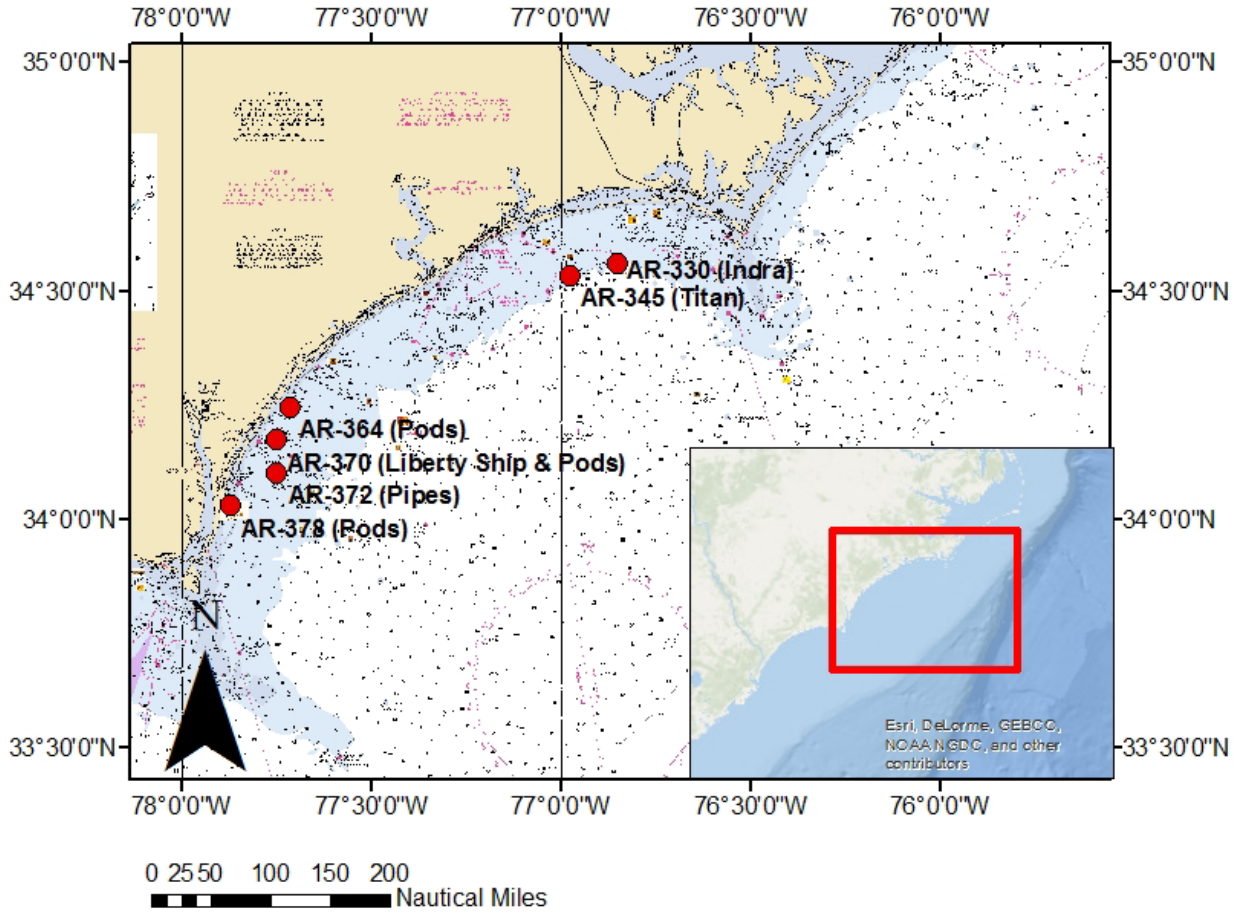


Figure 1: Location of artificial reef study sites in Onslow Bay, NC. Surveys for proximity and buffer zones of artificial reefs and natural reefs are conducted at all six reefs. Surveys on Atlantic Pod effectiveness are conducted on AR-364, AR-370, and AR-378.

Table 1: Twenty-eight study sites in Onslow Bay, NC used for buffer zone component. Site information and sampling dates.

Site	Subsite	Structure Type	Structure Material	Reef Type	Deploy-ment Year	Depth (ft)	Area (sqft)	Description	Longitude (DDM)	Latitude (DDM)	Distance to shore (miles)	Pilot Sampling Period (Summer 2016)	Sampling Period 1 (Fall)	Sampling Period 2 (Winter)	Sampling Period 3 (Spring)
330	BARGE	SHIP	METAL	Artificial	2009	64	3,800	200 FT Deck Barge TBM IX	76 51.080	34 33.796	8.65	N/A	9/8/15	12/11/15	4/26/16
330	H-UNITS	H-UNITS	CONCRETE	Artificial	2000	65	3,600	45 "H" Units	76 51.493	34 33.447	8.92	N/A	9/8/15	1/15/16	N/A
330	INDRA	SHIP	METAL	Artificial	1992	63	13,400	320 FT Landing Craft Repair Ship "INDRA"	76 51.115	34 33.706	8.75	7/27/15	9/8/15	12/11/15	4/26/16
330	PIPES	PIPES	CONCRETE	Artificial	1990	64	35,800	822 Tons Concrete Pipe	76 51.264	34 33.353	9.09	7/27/15	9/8/15	12/11/15	N/A
345	CONC	PIPES	CONCRETE	Artificial	1991	61	81,600	Consolidated Concrete: 750 Pieces Concrete Pipe, 1500 Tons Manhole Sections	76 58.417	34 32.292	8.95	N/A	10/15/15	N/A	4/21/16
345	RB1	REEF_ BALLS	CONCRETE	Artificial	2000	65	14,400	75 Reef Balls	76 58.348	34 32.337	8.93	N/A	10/15/15	1/27/16	4/21/16
345	RB2	REEF_ BALLS	CONCRETE	Artificial	2000	62	5,300	50 Ultra Reef Balls and 1 Reef Ball	76 58.605	34 32.397	8.77	N/A	10/15/15	N/A	4/21/16
345	TITAN	SHIP	METAL	Artificial	2004	64	2,600	116 FT Tug Boat "TITAN"	76 58.494	34 32.142	9.08	7/17/15	10/15/15	1/27/16	4/21/16
364	BARGE	SHIP	METAL	Artificial	1997	53	16,900	297 FT HT-290 Barge	77 42.888	34 14.794	2.25	N/A	9/21/15	12/10/15	3/9/16
364	DOMES	DOMES	FIBERGLASS	Artificial	1989	43	700	Fiberglass Domes and Cubes	77 42.822	34 14.966	2.17	N/A	9/21/15	12/10/15	3/10/16
364	PIPES	PIPES	CONCRETE	Artificial	1986	46	TBD	Concrete Pipes	77 42.998	34 14.662	2.25	N/A	N/A	12/10/15	N/A
364	PODS	ATLANTIC_ PODS	CONCRETE	Artificial	2015	46	TBD	200 Concrete Pods	77 43.008	34 14.634	2.26	N/A	9/21/15	12/10/15	3/15/16
364	TUGBOAT	SHIP	METAL	Artificial	1994	48	1,200	65 FT Tug "CAPTAIN JERRY"	77 42.828	34 14.853	2.25	N/A	9/21/15	12/10/15	3/9/16
370	BARGE	SHIP	METAL	Artificial	1973	49	3,700	90 FT Barge	77 45.530	34 10.502	2.60	N/A	9/9/15	N/A	N/A
370	LIBERTYS HIP	SHIP	METAL	Artificial	1974	51	28,600	440 FT Liberty Ship "ALEXANDER RAMSEY"	77 45.113	34 10.514	2.99	N/A	9/3/15	12/9/15	3/10/16
370	NR1	NATURAL_ REEF	ROCK	Natural	N/A	48	TBD	Natural Hardbottom	77 44.727	34 10.706	3.34	N/A	9/9/15	12/8/15	3/10/16
370	NR2	NATURAL_ REEF	ROCK	Natural	N/A	50	TBD	Natural Hardbottom	77 44.675	34 10.613	3.40	N/A	9/9/15	12/8/15	3/11/16
370	PIPES	PIPES	CONCRETE	Artificial	2008	50	TBD	155 Tons Concrete Pipes	77 45.397	34 10.562	2.71	N/A	9/3/15	12/8/15	3/11/16
370	PODS	ATLANTIC_ PODS	CONCRETE	Artificial	2015	51	TBD	200 Concrete Pods	77 45.373	34 10.537	2.74	N/A	9/15/15	12/8/15	3/15/16
372	NR1	NATURAL_ REEF	ROCK	Natural	N/A	60	TBD	Natural Hardbottom	77 45.120	34 06.418	5.62	N/A	9/2/15	12/3/15	3/17/16
372	NR2	NATURAL_ REEF	ROCK	Natural	N/A	54	TBD	Natural Hardbottom	77 45.067	34 06.158	5.78	N/A	9/2/15	12/9/15	3/15/16
372	PODS	ATLANTIC_ PODS	CONCRETE	Artificial	2015	56	TBD	200 Concrete Pods	77 44.882	34 06.490	5.80	N/A	9/2/15	12/9/15	3/16/16
372	RB1	REEF_ BALLS	CONCRETE	Artificial	2001	59	11,500	128 Reef Balls	77 44.897	34 06.300	5.87	N/A	9/2/15	12/9/15	3/16/16
372	TRAINCA RS	TRAIN_ CARS	METAL	Artificial	1986	57	6,100	Train Boxcars - in Multiple Pieces	77 44.819	34 06.115	6.02	N/A	9/3/15	N/A	3/11/16
378	NR1	NATURAL_ REEF	ROCK	Natural	N/A	40	TBD	Natural Hardbottom	77 51.580	34 02.069	1.70	N/A	9/14/15	1/20/16	5/10/16
378	PIPES	PIPES	CONCRETE	Artificial	2008	38	11,600	115 Tons Consolidated Concrete	77 52.260	34 01.905	1.13	N/A	9/14/15	1/21/16	N/A

378	PODS	ATLANTIC_ PODS	CONCRETE	Artificial	2015	45	TBD	200 Concrete Pods	77 51.990	34 01.892	1.39	N/A	9/14/15	1/20/16	3/17/16
378	RB1	REEF_ BALLS	CONCRETE	Artificial	2001	41	21,200	100 Reef Balls	77 52.255	34 01.782	1.14	N/A	9/14/15	1/20/16	5/10/16

Table 3: Milestone schedule. Legend: ✓ - Complete; □ - Planned; **Black –** General project; **Blue** – Summer sampling (period 1; pilot sampling); **Red** – Fall sampling (period 2); **Green** – Winter sampling (period 3); **Purple** – Spring sampling (period 4).

Year	**2015**						**2016**												**2017**											
Activity	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Buffer zone between artificial and natural reefs																														
Fish belt transects	✓		✓	✓		✓	✓		✓	✓	✓																			
Photoquadrat surveys	✓		✓	✓		✓	✓		✓	✓	✓																			
Structural relief surveys	✓		✓	✓		✓	✓		✓	✓	✓																			
Data processing & analysis		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓									
Prepare & disseminate reports							✓	✓					✓	✓				✓	✓	✓	✓	✓	✓	✓	✓					
Present results																						✓				□	□	□		
Effectiveness of Atlantic Pods on fisheries enhancement																														
Fish belt transects	✓		✓	✓		✓	✓		✓	✓	✓																			
Photoquadrat surveys	✓		✓	✓		✓	✓		✓	✓	✓																			
Scour & subsidence surveys	✓		✓	✓		✓	✓		✓	✓	✓																			
Durability & stability surveys	✓		✓	✓		✓	✓		✓	✓	✓																			
Data processing & analysis		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓											
Prepare & disseminate reports							✓	✓					✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Present results																	✓										□	□	□	
Aggregation vs. production - water column productivity and soundscape characteristics																														
Water column productivity																														
Splitbeam echosounder surveys											✓	✓	✓	✓	✓															
ADCP surveys											✓	✓	✓	✓	✓															
Data processing & analysis											✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	□	□	□		
Prepare & disseminate reports																			✓					✓				□	□	□
Present results																													□	□
Soundscape characteristics																														

Hydrophone active at *J.J. Tug* (AR-330)											✓		✓	✓	✓		✓					✓	✓								
Hydrophone active at *Indra* (AR-330)											✓		✓	✓	✓		✓					✓	✓								
Data processing & analysis												✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	□	□	□	□
Prepare & disseminate reports													✓	✓					✓					✓					□	□
Present results																													□	□

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: North Carolina Division of Marine Fisheries, Carole Willis

Grant Award #: 2P40 P035

Grant Title: Saltwater Fishing Tournament Efficiency Increase

Grant Award Period: July 1, 2015 through June 30, 2018

Performance Reporting Period: January 1, 2017 through June 30, 2017.

Expenditures for the Period:

Category	**Expenditures**
Personnel	n/a
Fringe	n/a
Travel	0.00
Equipment	0.00
Supplies	4,347.00
Construction	n/a
Contractual	n/a
Other	10,105.00
Total Direct	14,452.00
Indirect	0.00
TOTAL	14,452.00

Total Cumulative Expenditures: $14,452.00
Total Remaining Balance: $ 7,048.00

Description of Work**:**

The objective of this grant is to enhance the experience of recreational anglers as they visit the North Carolina coast, interact with weigh stations, and receive their citations by developing more efficient processes within the North Carolina Saltwater Fishing Tournament.

Project Status/Work Accomplished:

Citation applications were entered in to the access database then printed and mailed to anglers. The Sportfishing Specialist worked with recreational anglers and weigh stations (tackle shops, piers, and marinas) collecting information and awarded 9,541 (Table 1.) citations for 38 recreationally important species in North Carolina. Information collected included date, length (in), girth (in), weigh station and landings

frequency. Weigh stations (n=108) were also visited and given supplies for the season.

Table 1. Number of Citations Issued by Species.

Species	No.	Species	No.
Atlantic Bonito	4	Pompano	168
Amberjack	38	Porgy (Silver Snapper)	18
Barracuda	64	Red Drum	2672
Bigeye Tuna	187	Sailfish	1649
Black Drum	14	Sea Mullet	197
Blackfin Tuna	288	Shark	87
Black Sea Bass	36	Sheepshead	163
Blue Marlin	278	Spanish Mackerel	98
Bluefin Tuna	38	Spearfish	28
Bluefish	6	Speckled Trout	214
Cobia	487	Spot	0
Croaker	1	Striped Bass	1
Dolphin	124	Tarpon	35
False Albacore	18	Triggerfish	146
Flounder	292	Wahoo	694
Gray Tilefish	18	Weakfish	7
Grouper	119	White Marlin	987
Jack Crevalle	11	Yellowfin Tuna	39
King Mackerel	272		

Deviations:

Due to issues with the postage machine citation certificates could not be mailed as quickly as scheduled, a no cost extension was requested so that any mailing from the year could still be done.

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: Eastern Carolina Artificial Reef Association

Grant Award #: 6798

Grant Title: Multi-yea acquisition, establishment and monitoring of sunken vessel artificial reefs in Northern Onslow Bay, NC

Grant Award Period: July 1, 2016-June 30, 2017 extended

Performance Reporting Period: January 1, 2017-June 30, 2017
(2
Project Costs: $185,000.00

Expenditures for the Period:

Category	**Expenditures**
Personnel	10,000
Fringe	-0-
Travel	-0-
Equipment	-0-
Supplies	-0-
Construction	-0-
Contractual	59,131.72
Other	-0-
Total Direct	69,131.72
Indirect	-0-
TOTAL	$69,131.72

Total Cumulative Expenditures: $69,131.72
Total Remaining Balance: $115,868.28

Note: Personnel includes attorney fees, administration and outreach costs. Contractual includes cleaning and dockage fees.

Description of Work**:**

Identify two vessels about 100 feet in length that will be cleaned to EPA standards and placed in a permitted location within Northern Onslow Bay to create artificial substrate

Project Status/Work Accomplished:

1. *The Ft. Fisher was identified as the first almost 100 foot vessel for cleaning. The vessel was donated to ECARA.*

2. *We worked with Coleen Marine to clean the Ft. Fisher to EPA standards.*
3. *Submitted permit requests for the sinking of the vessel*
4. *Permits not received yet and therefore dockage fees accumulated for the vessel*
5. *Hosted informational gathering on the Ft. Fisher in June, 2017 to inform public about the benefits of artificial reefs.*

Deviations:

Delays in the permitting process have led to the Ft. Fisher remaining at the dock and awaiting sinking. The second vessel has not been identified as the permit is not in hand.

Additional Guidance:
If your scope of work is broken into discrete jobs/tasks, please use the Job/Task titles as subheading under which to report accomplishments. Please report on the percent of completion of each separate job/task in your proposal.

COASTAL RECREATIONAL FISHING LICENSE

SEMI-ANNUAL PERFORMANCE REPORT

Recipient: Long Bay Artificial Reef Association

Grant Award #: 6800

Grant Title: Enhancement of Inshore Artificial Reef (AR 430)

Grant Award Period: July 25, 2016 to September 30, 2017 (Extension Granted)

Performance Reporting Period: January 1, 2017 To June 30, 2017

Project Costs: $0.00

Expenditures for the Period:

Category	**Expenditures**
Personnel	0
Fringe	0
Travel	0
Equipment	0
Supplies	0
Construction	0
Contractual	0
Other	0
Total Direct	0
Indirect	0
TOTAL	0

Total Cumulative Expenditures: 0
Total Remaining Balance: $339,000.00

Description of Work**:**

The purpose of the project is to further develop artificial reef site AR 430 by deploying three thousand tons of concrete pipe in eight patch reefs in the permitted area of the reef site.

Project Status/Work Accomplished:

A contract has been executed with Coleen Marine, Inc. to acquire, transport, and deploy all the reef materials called for under Grant Contract No. 6800. Although the reef material is on hand at Coleen, scheduling conflicts and sea conditions have prevented any deployments for the reporting period. As a result, an

extension of the contract was requested, and subsequently granted, extending the contract period to September 30, 2017. The deployment plan remains the same with two roughly equal segments. NCDMF has been fully informed of the delays in completing the contract.

Deviations

No deviations, other than the expiration date, to Contract Grant No. 6800 have occurred and none are anticipated.

Additional Guidance:
If your scope of work is broken into discrete jobs/tasks, please use the Job/Task titles as subheading under which to report accomplishments. Please report on the percent of completion of each separate job/task in your proposal.