Atlantic States Marine Fisheries Commission

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MEMORANDUM

January 20, 2016

To: **American Eel Management Board**

From: **American Eel Technical Committee**

RE: **TC Review of North Carolina's American Eel Aquaculture Plan**

Addendum IV allows States/Jurisdictions to submit Aquaculture Plans that if approved would allow a State to harvest a maximum of 200 pounds of glass eels from within its waters for use in domestic aquaculture facilities. However, the State must objectively show that the harvest will occur from a watershed that minimally contributes to the spawning stock of American eel.

In December 2015, North Carolina submitted an Aquaculture Plan for 2016 which was reviewed by the Technical Committee (TC). The TC provided comments to the State of NC at that time. A revision to NC's Plan was submitted to, and discussed by, the TC in January 2016. While many of the concerns were addressed in the revision, including a reduction in the number of sites being considered, a more detailed description of the proposed sites, requirements for tracking mortality, and gear specifications, the TC recommended the following changes be made in NC's plan:

1) NC should follow the 25 pigmented eel tolerance per pound of glass eels as stated in Addendum III. However, the States of South Carolina and Maine seem to be enforcing this tolerance in different manners. South Carolina requires fishermen to pick out pigmented eels from their catch, whereas Maine defines a pigmented eel as an eel that will not pass through a 1/8 inch non-stretchable mesh (anything that passes through the 1/8 inch mesh is considered a non-pigmented eel).
   - North Carolina is requiring the use of a 1/8-inch non-stretchable mesh to remove pigmented eels from harvest.
2) Eels weighed at the facility should be reported to the nearest 0.10 lbs. instead of 0.25 lbs.;
   - North Carolina has changed its measurement requirement to nearest 0.10 lbs. in its final version of its Aquaculture Plan included in Supplemental Materials.
3) NC should be required to report back to the TC at the end of the first year with harvest data, including date, location, number of glass eels harvested, effort, and water temperature.
4) The language regarding harvest of adult female eels from the Chesapeake Bay should be removed in the section regarding the justification of minimal contribution.
   - North Carolina has removed this language in its final version of its Aquaculture Plan included in Supplemental Materials.

TC Recommendation

Ultimately, the TC concluded that NC has no data with respect to survival or reproductive success of eels for any waters within its state. Therefore, the TC cannot determine if the proposed harvest is coming from a watershed that "minimally contributes" to the spawning stock, which is a requirement for approval of the plan.

If the Board approves NC's plan, the TC recommends that more biological data be collected including young-of-year abundance surveys and water quality data for the waterbodies where harvest is proposed to occur. Although the TC recognizes that these data sets will not determine whether the harvest contributes minimally to the spawning stock (that would require parts of a life cycle survey), it will provide some information for the TC to evaluate the relative abundance of glass eels within the watershed.

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MEMORANDUM

January 27, 2016

TO: American Eel Management Board

FROM: Michael Waine, Senior Fishery Management Plan Coordinator

SUBJECT: Final Version of North Carolina's Aquaculture Plan

Enclosed is the final version of North Carolina's Aquaculture Plan with the recommended changes suggested by the American Eel Technical Committee. Specifically, the language concerning harvest in the Chesapeake Bay was removed and the reporting requirement for the weight of harvested eels was changed from the nearest 0.25 lb. to 0.1 lb.

North Carolina Aquaculture Plan for American Eel Pursuant to Addendum IV to the ASMFC Interstate Fishery Management Plan for American Eel

North Carolina Department of Environmental Quality
Division of Marine Fisheries
PO Box 769
Morehead City, NC 28557

January 2016

BACKGROUND

Globally, the U.S. is a minor producer of aquaculture products, ranking 15th in a United Nations Food and Agriculture Organization report (FAO 2014). It would be beneficial to expand aquaculture in the U.S. as approximately 91% of seafood (by value) consumed in the U.S. originates overseas. Roughly half of this comes from aquaculture and has driven the U.S. seafood trade deficit to over $11.2 billion annually (NOAA 2016). By passing the National Aquaculture Act of 1980 (and subsequent amendments), Congress put forth that it was in the national interest and the national policy to encourage the development of aquaculture in the U.S.

In the early 1990s North Carolina was one of several states to impose a 6-inch minimum size limit in part to protect elvers/glass eels for local aquaculture while awaiting recommendations on glass eel/elver fishery development that was expected in the Atlantic States Marine Fisheries Commission fishery management plan for American eel (ASMFC 2000). In October 2014 the ASMFC adopted Addendum IV to the Interstate Fishery Management Plan for American Eel (ASMFC 2014; http://www.asmfc.org/uploads/file//55318062Addendum_IV_American_Eel_oct2014.pdf). Addendum IV implemented a provision allowing states and jurisdictions to submit an Aquaculture Plan to allow for the limited harvest of American eel glass eels (hereinafter "glass eels") for use in domestic aquaculture facilities. Specifically Addendum IV states:

> *"Under an approved Aquaculture Plan, states and jurisdictions may harvest a maximum of 200 pounds of glass eel annually from within their waters for use in domestic aquaculture facilities provided the state can objectively show the harvest will occur from a watershed that minimally contributes to the spawning stock of American eel. The request shall include: pounds requested; location, method, and dates of harvest; duration of requested harvest; prior approval of any applicable permits; description of the facility, including the capacity of the facility the glass eels will be held, and husbandry methods; description of the markets the eels will be distributed to; monitoring program to ensure harvest is not exceeded; and adequate enforcement capabilities and penalties for violations."*

Pursuant to Addendum IV to the Interstate Fishery Management Plan for American Eel, the North Carolina Division of Marine Fisheries (NCDMF) is submitting the following Aquaculture Plan for approval. The NCDMF has selected tributaries in watersheds where the state can objectively show American eels in these areas minimally contribute to the spawning stock of American eel. Only one aquaculture operation, the American Eel Farm (AEF), has requested to be included in the Aquaculture Plan for consideration.

POUNDS REQUESTED

North Carolina requests to harvest 200 lb. of glass eels, the maximum amount allowed under the Aquaculture Plan provision of Addendum IV to the Interstate Fishery Management Plan for American Eel.

DATES OF HARVEST

Glass eels shall be harvested from February 22, 2016 through May 31, 2016 or until 200 lb. of glass eels are harvested, whichever occurs first.

DURATION OF HARVEST

Since the initial Aquaculture Plan is only valid for one year the duration of harvest requested is limited to the 2016 glass eel harvest season. A renewal plan will be submitted by June 1, 2016 and at that time additional harvest years will be requested along with any modifications deemed necessary to ensure the success and continued approval of the plan.

METHOD OF HARVEST

NCDMF will limit the number of individuals authorized to harvest under this plan (3 individuals including the permittee). Glass eels shall be harvested using either fyke nets or dip nets. Fyke nets shall be constructed as follows:

- Shall be thirty (30) feet or less in length from cod end to either wing tip
- Shall be fitted with netting that measures 1/8-inch bar mesh or less
- Shall contain a ½-inch or less bar mesh excluder panel that covers the entrance of the net
- Shall have no more than two funnels, one cod end, and two wings

Dip nets shall be constructed as follows:

- Shall be no more than 30 inches wide at the widest point of the net mouth
- Shall be fitted with netting that measures 1/8-inch bar mesh or less

To mitigate the harvest of elvers (fully pigmented eels), all captured eels shall be graded upon capture on the water using a 1/8-inch bar mesh non-stretchable grading screen and any eels that fail to pass through the screen will be immediately returned to the water where captured. Any eels that pass through the screen will be harvested and count toward the 200 lb. annual glass eel harvest limit.

MINIMAL CONTRIBUTION JUSTIFICATION

While we have no quantitative data on the abundance of glass eels, it could be argued the harvest of 200 lb. of glass eels in itself is small enough to have a minimal impact on the spawning stock of American eel (see Appendix 1). Natural mortality is thought to be very high for during the early life stages (leptocephalus, glass eel, and elver) due to the high fecundity of American eel (ASMFC 2000, 2012). Assuming a mortality rate of ~97-98%, of the 200 lb. of glass eels proposed to be harvested approximately 195 lb. would otherwise perish naturally in the wild.

To mitigate the impact to the spawning stock, proposed harvest sites will be located in areas that have been impacted by human activity. Development in and along estuaries, rivers, and streams may have a negative impact on eel health, growth, and survival. Machut et al. (2007) found the condition (weight) of American eels in six tributaries of the Hudson River in New York

was significantly lowered with increasing riparian urbanization. Intense urbanization in the watersheds of these creeks and rivers has hardened the natural landscape, limiting their capacity to infiltrate and store rainfall as they did prior to development. Mallin et al. (1998) conducted a four year review of the tidal creeks of New Hanover County, NC where the authors demonstrated a very close parallel between water quality in the creeks and the amount of impervious surfaces in the watershed. Water quality in coastal waters is negatively impacted when the natural landscape is changed by drainage, hardened surfaces, and vegetation removal. Altering the land cover in an area by adding roofs, driveways, parking lots, yards, ditching, cutting down trees and underbrush all drastically change the hydrology of a watershed. Contaminations of heavy metals, dioxins, chlordane, and polychlorinated biphenyls as well as pollutants from nonpoint source can bioaccumulate within the fat tissues of the eels, causing dangerous toxicity and reduced productivity (Hodson et al. 1994). Unlike discharge from "point sources," such as water treatment plants, nonpoint source pollution is becoming increasingly difficult to control and regulate as populations in coastal North Carolina continue to increase.

The Shellfish Sanitation and Recreational Water Quality Section of the Division of Marine Fisheries is responsible for monitoring coastal waters as to their suitability for shellfish harvest and monitoring and issuing advisories for coastal recreational swimming areas. All of the proposed sites occur in creeks or rivers that are fully or partially closed to shellfish harvest due to unacceptably high levels of fecal bacteria (http://portal.ncdenr.org/web/mf/shellfish-closure-maps) and often suffer from chronic, stream-wide oxygen problems. Despite being able to live in a wide range of temperatures and different levels of salinity, American eel are very sensitive to low dissolved oxygen levels (Hill 1969, Sheldon 1974). Shellfish closures and swimming advisories are indicators of poor water quality and some of these waters are classified as "impaired" (Category 4 or 5) under Section 303(d) of the Clean Water Act by the North Carolina Division of Water Resources (NCDWR; http://portal.ncdenr.org/web/wq/ps/bpu/watershed-plan-map). These designations were considered when choosing primary and alternate harvest sites as eels in these waters are likely to experience greater physiological stress and potentially higher mortality compared to eels in other areas.

No harvest sites are located within the Albemarle Sound estuary system. The region's watershed contains the Chowan, Roanoke, and Pasquotank river basins and is approximately 8,000 square miles, encompasses over 5,000 miles of freshwater rivers and streams and over 930,000 acres of brackish, estuarine waters. The Chowan, Roanoke, and Pasquotank are three major rivers that flow into the Albemarle Sound estuary (APNEP 2016). On average, the Albemarle Sound area has accounted for approximately 96% of yellow eel landings from 2010 – 2014. By directing glass eel harvest away from this area there should be little impact to the existing yellow eel fishery (which presumably occurs in areas of higher yellow eel abundance). In addition, no sites are located within the Tar-Pamlico River Basin. This basin is approximately 6,000 square miles and encompasses over 2,500 miles of freshwater rivers and streams and over 660,000 acres of brackish, estuarine waters.

Glass eels actively migrate toward land and freshwater and ascend rivers during the winter and spring. It has been demonstrated, in European glass eel, that this change in behavior was caused by the detection of the odor of freshwater, as well as temperature gradients (Facey and Van Den Avyle 1987). By limiting the proposed harvest sites to small coastal systems, large areas of freshwater habitat were removed from consideration, thus reducing the potential impact to the overall spawning stock of American eel.

In addition, North Carolina will direct harvest away from protected areas such as National Wildlife Refuges, National Estuarine Reserves, National Forests, National Seashores, North

Carolina Coastal Reserves, North Carolina State Parks, North Carolina Preserves, North Carolina Strategic Habitat Areas, and Natural Heritage Natural Areas.

LOCATION OF HARVEST

North Carolina's internal waters are classified as either inland, joint or coastal fishing waters. The North Carolina Marine Fisheries Commission (NCMFC) and NCDMF have jurisdiction of coastal waters while the North Carolina Wildlife Resources Commission (NCWRC) has jurisdiction of inland waters and both agencies (NCWRC and NCMFC/NCDMF) have authority within joint waters. Other than a few specific regulations, none of which pertain to American eel, commercial activities and recreational activities using commercial gear (devices) occurring in joint waters is under the jurisdiction of the NCMFC/NCDMF.

North Carolina will approve ten (10) primary sites and three (3) alternate sites should there be little or no success harvesting glass eels at the primary sites. Alternate sites will only be used if attempts have been made to harvest from all primary sites and they are found to be unproductive. This will be determined at the discretion of the NCDMF and will take into account the amount of effort put forth at the primary sites, the number of pounds of glass eels harvested, and the timing within the recruitment season.

Primary Sites

North Carolina proposes to direct glass eel harvest to areas likely to minimally contribute to the spawning stock based on criteria such as basin size, waterbody length, habitat condition, and proximity to the Atlantic Ocean (distance from an inlet). Specifically, primary harvest sites will be located in two small coastal river basins, the Lumber and White Oak (Figure 1). These river basins contain smaller watersheds which include; creeks, streams, lakes, reservoirs, and sections of rivers. Proposed primary harvest sites meet one or more of the following conditions: 1) drainage basin includes residential areas, 2) drainage basin includes industrial areas, 3) drainage basin includes agricultural areas 4) small waterbody less than 7 miles in length, 5) proximity to the Atlantic Ocean, or 6) classified as "impaired" by the NCDWR (Table 1).

Directing glass eel harvest to waterbodies in close proximity to the Atlantic Ocean (via inlets) increases the likelihood of harvesting newly recruited glass eels versus elvers compared to more inland areas. In addition, the number of glass eels per pound is higher compared to the number of elvers in a pound. Therefore, if only glass eels are harvested, the aquaculture facility would have a higher yield (in number of eels) available for grow out. Other benefits from directing glass eel harvest to smaller coastal systems include:

1) Decrease potential interaction with parasitic swim bladder nematode (Hein et.al., 2015)
2) Increased survival in the aquaculture facility if harvested before first feeding event
3) Harvested eels coming from impaired areas have not started to feed and bioaccumulate contaminants

Primary Glass Eel Harvest Sites (~ 2.9 miles average length):

1.) Bradley Creek, New Hanover County (~2.5 miles; Figure 2, Figure 13)
2.) Futch Creek, New Hanover and Pender counties (~2.1 miles; Figure 3, Figure 13)
3.) Goose Creek, Carteret County (~1.2 miles; Figure 4, Figure 14)
4.) Howe Creek, New Hanover County (~2.8 miles; Figure 5, Figure 13)
5.) Mill Creek, Pender County (~0.9 miles; Figure 6, Figure 15)

6.) Queen Creek, Onslow County (~6.8 miles; Figure 7, Figure 16)
7.) Sanders Creek, Carteret County (~0.9 miles; Figure 8, Figure 14)
8.) Saucepan Creek, Brunswick County (~3.2 miles; Figure 9, Figure 17)
9.) Shallotte River, Brunswick County (~6.9 miles; Figure 9, Figure 18)
10.) Whiskey Creek, New Hanover County (~1.3 miles; Figure 10, Figure 13)

Alternate Sites

Proposed alternate harvest sites are small creek systems located near the mouth of the Neuse River (Figure 1) and meet one or more of the following conditions: 1) drainage basin includes residential areas, 2) drainage basin includes industrial areas, 3) drainage basin includes agricultural areas, 4) small waterbody less than 7 miles in length or 5) classified as "impaired" by the NCDWR (Table 1).

Alternate Glass Eel Harvest Sites (~3.0 miles average length):

1.) Dawson Creek, Pamlico County (~5.4 miles; Figure 11, Figure 19)
2.) Orchard Creek, Pamlico County (~1.9 miles; Figure 12, Figure 20)
3.) Pierce Creek, Pamlico County (~1.7 miles; Figure 12, Figure 21)

MONITORING PROGRAM

To monitor and regulate the harvest of glass eels the NCDMF will issue an Aquaculture Collection Permit (ACP) to the AEF. To aid in monitoring and enforcement the NCDMF will limit the number of individuals authorized to harvest under the ACP (3 individuals including the permittee). All individuals listed on the ACP must possess a valid North Carolina Standard Commercial Fishing License (SCFL) or Retired Standard Commercial Fishing License (RSCFL) issued by the NCDMF. Only individuals listed on the ACP shall participate in the harvest of glass eels. Any vessels used for glass eel harvest under the ACP shall have a valid North Carolina Commercial Fishing Vessel Registration (CFVR) issued by the NCDMF. Restrictions will be placed on the ACP requiring certain conditions and procedures to be followed, such as:

General Conditions

- No more than three (3) individuals (including the permittee) shall be authorized to harvest under the ACP
- Individuals must agree to warrantless inspections and searches of any gear, vessels, equipment, vehicles, and their person
- Individuals and vessels participating in the glass eel harvest must be properly licensed by the NCDMF and abide by all fisheries rules and permit conditions
- Fyke nets and dip nets are the only gear authorized to use for glass eel harvest under the ACP
- No more than five (5) fyke nets and/or dip nets (five pieces of gear total) may be fished by an individual designee under the ACP
- A fyke net may not be placed within fifty (50) feet of any part of another fyke net
- Fyke nets and dip nets for glass eel harvest may only be fished and the cod ends closed from two hours before sunset to two hours after sunrise
- From two hours after sunrise through two hours before sunset the gear may remain in the water and the terminal portion of a fyke net cod end contain a rigid device with an

opening not less than three (3) inches in diameter and not exceeding six (6) inches in length that is not obstructed by any other portion of the net
- Tamper evident tags shall be used to secure the cod ends of the net closed while the gear is fishing
- Tamper evident tags shall be used to secure the cod ends open when the gear is not fishing
- Immediately report to NCDMF if a net is tampered with including the location of the net and the date and time it was noticed
- All gear shall be removed from the water from 11:59 pm on Friday through 12:01 am on Monday (similar to South Carolina regulation). This creates a 48-hour rest period to allow glass eels to migrate up these smaller systems to help minimize the impact to the spawning stock.
- All gear and harvest restrictions detailed in the Method of Harvest section will be listed as conditions under the ACP

Before Harvest

- Fishermen harvesting glass eels under the ACP shall call-in to NCDMF the following information:
    - Weekly: GPS coordinates of each net once they are set, if nets are moved during the week the new coordinates must be immediately reported once the nets are reset
    - Daily:
        - Landing site they will be leaving from and returning to once fishing activity is complete
        - Names of individual(s) involved
        - Number of fyke nets and dip nets that will be used
        - Description and registration number of the boat(s) to be used for harvest
        - Description and license plate number of the vehicle(s) to be used for transport

During Harvest

- Require the use of a 1/8-inch bar mesh non-stretchable mesh grading screen to cull the glass eels at the harvest site to limit the harvest of elvers
- Record the time the gear began and ended fishing and the estimated number of pounds of glass eels harvested from each piece of gear (individual fyke or dip net)

After Harvest

- Require each fisherman harvesting glass eels under the ACP to call-in to NCDMF the estimated harvest in pounds to the nearest 0.25 lb. prior to leaving the harvest site and report an estimated time of arrival at the landing site. Zero pounds shall only be reported if no glass eels are harvested.
- Once all gear is fished, the fisherman must travel directly to the designated landing site
- Once at the designated landing site all eels must be offloaded and transported directly to the AEF facility
- Require AEF to hold all glass eels that perish during transport to the facility and all eels that perish in the facility for inspection
- All glass eels that perish during transport will count against the 200 lb. harvest limit

- Require AEF to call-in to NCDMF by noon each day the total harvest in pounds to the nearest 0.1 lb. of glass eels received (including those days when no glass eel harvest occurred). Zero pounds shall only be reported if no glass eels are harvested and received.

The above conditions and procedures will allow the NCDMF to limit the effort (amount of gear and number of individuals) involved in glass eel harvest under the Aquaculture Plan. Dual reporting by the fishermen on the water and by the AEF will allow the NCDMF to monitor the 200 lb. glass eel harvest limit. These controls will allow the NCDMF to ensure the glass eel harvest does not exceed what is authorized in the Aquaculture Plan. Any harvest that exceeds the 200 lb. harvest limit shall be immediately returned to the water where captured.

ENFORCEMENT CAPABILITIES AND PENALTIES FOR VIOLATIONS

The North Carolina Marine Patrol has four officers stationed in Brunswick County, three officers in New Hanover County, two officers in Pender County, three officers in Onslow County, six officers in Carteret County, two officers in Craven County, and two officers in Pamlico County.

Violations of the ACP permit conditions will be addressed according to the NCDMF SOP for Permit Violations and suspensions will be carried out in accordance with NCMFC Rule 15A NCAC 03O .0504 (see Appendix II).

All charges for violations will be charged under N.C. General Statute § 113-187 (d) (4): Violating the provisions of a special permit or gear license issued by the Department. All fines will be at the discretion of the court, however fines may not always be levied for the first offense.

The call-in requirements under the Monitoring Program section will allow enforcement officers to know when and where lawful harvest is occurring. It will also allow for random inspections to take place at the harvest and landing sites to ensure the conditions of the permit and all applicable NCMFC rules and regulations are being followed. Random inspections will also be performed at the aquaculture facility to ensure the proper records are being kept to account for all eels in the facility as required under N.C. General Statute § 113-170.3 and NCMFC Rule 15A NCAC 03O .0502 (8) (see Appendix III).

SIZE LIMIT EXEMPTION

The intent is to raise the eels as close as possible to the legal minimum size of 9 inches total length prior to sale. Given the difficulty in measuring live eels, prior to sale, all eels shall be graded using a ½-inch by ½-inch non-stretchable mesh grading screen. Any eels that do not pass through the grading screen may be sold and any that pass through the grading screen shall remain in the possession of the AEF until such time as the eels are large enough to not pass through the grading screen. On inspection, a 10% tolerance by number will be allowed for eels that pass through the grading screen.

PRIOR APPROVAL OF PERMITS

The AEF has all necessary permit approvals in place with the exception of an Aquaculture Collection Permit from the NCDMF. This permit will be issued upon approval of the Aquaculture

Plan by the ASMFC American Eel Management Board. The permits currently held by the AEF are:

- North Carolina Department of Agriculture Aquaculture Operation Permit valid until 2017
- North Carolina Division of Marine Fisheries Aquaculture Operation Permit renewed annually. To be eligible for an ACP, an Aquaculture Operation Permit is required (see Appendix IV: NC Marine Fisheries Commission (NCMFC) Rule 15A NCAC 03O .0501 (e))
- US Fish & Wildlife Import / Export permit renewed annually
- North Carolina Division of Marine Fisheries Standard Commercial Fishing License
- North Carolina Division of Marine Fisheries Dealer License
- North Carolina Farmer Tax Exempt Permit

As noted in NCMFC Rule 15A NCAC 03O .0501 the appropriate licenses from the Division of Marine Fisheries must be held by the permittee or designees. A North Carolina Standard Commercial Fishing license is required to fish commercial gear such as fyke nets, a Commercial Fishing Vessel Registration (CFVR) is required for vessels used to harvest seafood and a Dealer License is required to sell fish taken from the coastal fishing waters. The AEF will need to secure these licenses before the ACP is granted.

DESCRIPTION OF THE MARKET

The AEF indicated they have identified clients for food and bait markets domestically as well as overseas. The long-term intent is to develop and expand the US domestic market as much as possible. For proprietary business reasons specific details were not provided.

DESCRIPTION OF THE FACILITY

American Eel Farm

Design, Capacities and Technical Facts

The AEF, located in Trenton, North Carolina, is a state-of-the-art Recirculated Aquaculture System (RAS) which has been operating since 2003 (https://www.youtube.com/watch?v=4YnQn7aivw4). It is a proven Danish system designed overseas for eel grow-out and imported to the US. The AEF was initially operated in North Carolina as the North Carolina Eel Farm (corporate filing date May 21, 2002). The facility has a 13-year operation history. There is no other facility specifically designed to grow out glass eels to yellow eels at a commercial level in the US. The facility has the capacity to grow out in excess of 900 pounds of glass eels. There is historical proprietary data on a large scale commercial level that no current fish farm, University, or government agency in the US can match.

The facility has three separate closed recirculating systems. The two main systems are identical RAS units each containing twelve (12) 1,000 gallon tanks and independent water treatment systems for both RAS units. Each RAS contains twelve (12) raceway tanks with 900 US usable gallons. The tanks are not operated at full capacity since eels are capable of escaping the tanks. Each raceway tank is equipped with a fine mesh screen outlet cover with a

motorized brush system, to keep the mesh clean. In each tank there are also water level switches that activate an alarm if the water level gets too high. Each tank is outfitted with aeration and back-up emergency oxygen lines which automatically activate in case of a power outage. Each tank also has the ability to be isolated from the system and individually cleaned if necessary without draining entire system.

There are three automatic feeders for the first three tanks that are ideal for the small eels. As they are graded the larger eels can be fed by hand or additional automatic feeders can be installed.

There is a new (1 year old) Pacific Oxyguard water quality monitoring system that monitors pH and oxygen saturation levels. The system has the ability to send alarms remotely and is programmed to call to a farm manager's cell phone if oxygen levels drop or the pH levels fluctuate. The system can be expanded by adding more test probes and programming if desired.

This system design is based on proven *Anguilla anguilla*, *A. mossambica*, *A. bicolor* and *A. marmorata* aquaculture techniques. The systems are technically sound, energy efficient, and easy to operate. The system has been successful with American eels as proven by recorded growth rates, low food conversions and low incidence of disease and mortality.

Attached to those 24 tanks is a complete water treatment unit equipped with a HydroTech drum filter type 803 / 40 micron mechanical filtration unit. This unit has a max flow of 31,500 gal/hour or 63,000 gal/hour if both sections are in operation. The two drum filters sieve feces and other large particles out of the water. The filters are continuously sprayed (adjustable timing possible) with water to self-clean. The waste water runoff from this event drains into a small channel within the drum filter and then drains into a system pipe which gravity feeds into the main channel in the tank room that runs the full distance from tank #1 to tank #24 where the waste water is then pumped into a small pond on the property by a sump pump through a 12" PVC drain pipe.

After mechanical filtration, water is gravity fed into 2 parallel 18 foot tall silos (four total for both sections) with patented Inter Aqua Advance (IAA) A/S Moving Bed Bio Reactor (MBBR) technology for biological treatment of the water (removal of ammonia and dissolved organic matter). Each silo has a volume of 1,300 gallons and is 55 % filled with IAA bio-curler bio media. This technology is superior to simple trickling filter bioreactors in that the attached blower motors run constantly to keep the media moving. This also acts as a self-cleaning process within the silos and contributes to the CO_2 stripping process.

With an optimum temperature for the growth of the eel at 24 degree C. or 74 degree F. The water treatment unit will be able to handle up to 250 lb. dry feed per day per section (500 lb. per day total). After the MBBR water flows by gravity into a common pump sump.

The water can be circulated with 3 separate pumps (per section, 6 pumps total), one 3 HP Low Head main pump and two 3 HP medium pressure pumps with 20 psi into two oxygen-cones (per section 4 total) for supersaturating of liquid oxygen into the water. In total the 3 pumps give a minimum flow capacity of 31,500 gal/hour (63,000 gal/hour total).

There is a carbon dioxide stripper for tanks #1 - #24 which has counter flow packed tower technology and utilizes structured packing of vacuum formed sheets of PVC. These packing's will provide maximum wettability, thereby maximizing the stripping effort.

The UV system has recently had the bulbs updated. The water passes through the device and the UV lighting assists in disinfecting the water by destabilizing the DNA of germicidal bacteria. However there have been reports that a UV disinfection system is not needed with eels so this system may be reconsidered.

There is a back-up liquid oxygen system tied into the main oxygen source with two air stones per raceway as a safety net. It is serviced simply by attaching the flow meter to a large liquid oxygen tanks. Should there be the need, the main liquid oxygen source would back feed the tanks with 150 PSI automatically.

The system is supported by three deep water wells all of which are operable and are wired with three phase wiring for better conservation as well as on independent breakers so as to always allow for a water source to be actively supplying water. One is about 300' deep and the other two about 200'. Additionally, there is public water tied into the facility. There is a heating system that can heat the water entering from the wells prior to entering the main water source if needed by passing heated water through several tubes mounted in the well reserve tanks for both sections. These well reserve tanks are equipped with automated on/off valves allowing water to be called automatically from the well when the water level reaches a preset level.

The water is distributed back to the raceway tanks via a common pipe manifold situated on the wall at the end of the tanks, with a separate valve to each tank for maintenance. A flow rate of 31,500 gal/hour (per system or 63,000 gal/hour total) will give an exchange rate of 3 to 5 times/hour to maintain self-cleaning and an adequate oxygen level in the raceway.

There is a third system which has two large 9,000 gallon tanks supported by similar filtration, aeration and small bio-reactors. This system is separate from the other two. Total capacity for AEF is about 50,000 gallons with about 40,000 being usable. Additionally, there is plenty of room to expand on the flat 2 acre site on which the facility is located. With 226 days a year of sun and a mean annual temperature of 70 degrees there is also a great opportunity to develop a medium to large scale aquaponics system on site.

In addition to the main tank room and the state-of-the-art water treatment room there is a main office area, sales office area, a furnished residential area, a full bathroom with laundry, a feed room, packaging room, a mechanical room, an electrical room, storage rooms and two large covered exterior areas one @ 15' X 85' and the other @ 15' X 50'. The grounds are gated and there is a security system with 16 infrared cameras capable of being viewed remotely. The facility has cable connections for internet and TV as well as two satellites for backup. The steel building construction is insulated with pressed foam to help minimize temperature fluctuations on hot or cool days. There is a heating system but it is not necessary to use when system is running due to local climate and the ground water temp of 68 degrees.

With the general geographic location being the Southeast USA along with the well-insulated building the water temperature for maximum growth rate could be efficiently maintained. Trenton, NC has a climate that is very suitable to aquaculture/agriculture in general. The annual average mean temperature is 70 degrees where the ideal temp for grow-out of eels is 74 degrees. There is no snow fall (very rare) and few days below freezing (very rare).

Eel Grow Out

Eels can be stocked in high densities in the raceway tanks. Stocking densities of 300 kg/m^3 or 2(+) lb./gal are often seen in eel farms. It is estimated that juvenile eels have an oxygen demand of 300 mg/kg/hour. The liquid oxygen system at the AEF is sufficient to reduce mortality and sustain eels in high densities. Estimated grow out time from the glass eel phase to 9 inches averages around 210 days. Individual eels grow at different rates so total grow out time will be longer. Due to the varying growth rates it is estimated that one-third of the eels will be harvested in 5 - 7 months, another group will be harvested at 8 - 10 months, and the rest will be harvested at 11 - 12 months after harvest.

A large mobile stainless steel grading machine in the main tank room will be used to grade the eels every four to six weeks. A well-managed RAS eel farm can expect a weaning rate of 80 - 90%. Eels feed ratio is greater than 1:1 in most studies depending on the amount of protein in the feed. There are studies in Japan and China that show a faster grow out however this outline is one the AEF is comfortable with.

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TABLES

Table 1. Sub Basin and stream characteristics for proposed primary and alternate harvest sites.

			Sub Basin					Stream						
Sub Basin Unit 14-Digit HUC*	Site Name	Site Type	Acres	Square Miles	Percent Urban	Percent Agricultural	Percent Developed	Stream Length (approx. miles)	Surface Water Acres	Shellfish Harvest Prohibited - Prohibited Territory Map	Distance to Atlantic Ocean (miles)	Overall Category	Reason Impaired	Coastal/Joint/Inland Waters
03020106020060	Queen Creek (entrence)	Primary	22,549	35.3	18	13	31	6.8	915	small area not prohibited (entrance)	2.9	Impaired (Cat 5)	Shellfish, Fish Tissue (Hg)	coastal (main stem)
	Queen Creek (lower)							6.8		small area not prohibited (entrance)		Impaired (Cat 4)	Shellfish, Fish Tissue (Hg)	
	Queen Creek (mid)									prohibited		Impaired (Cat 4)	Shellfish, Fish Tissue (Hg)	
	Queen Creek (upper)									prohibited		Impaired (Cat 4)	Shellfish, Fish Tissue (Hg)	
03020106020040	Sanders Creek (lower)	Primary	8,146	12.8	31	8	39	0.9	73	lower section not prohibited	9.3	Impaired (Cat 5)	Shellfish, Fish Tissue (Hg)	coastal (main stem)
	Sanders Creek (mid)									prohibited		Impaired (Cat 5)	Shellfish, Fish Tissue (Hg)	
	Sanders Creek (upper)									prohibited		Impaired (Cat 5)	Shellfish, Fish Tissue (Hg)	
	Goose Creek (lower)	Primary						1.2	233	lower section not prohibited	6.9	Impaired (Cat 5)	Shellfish, Fish Tissue (Hg)	coastal (main stem)
	Goose Creek (upper)									prohibited		Impaired (Cat 5)	Shellfish, Fish Tissue (Hg), Enterrococcus	
03030001040010*	Mill Creek (lower)	Primary	51,667	80.8	18	6	24	0.9	112	prohibited	3.2	Impaired (Cat 5)	Shellfish, Fish Tissue (Hg)	coastal (main stem)
	Mill Creek (upper)									prohibited		Impaired (Cat 5)	Shellfish, Fish Tissue (Hg)	
03030001040020*	Futch Creek (lower)	Primary	44,860	70.2	43	1	44	2.1	155	prohibited	2.6	Impaired (Cat 5)	Shellfish, Fish Tissue (Hg)	
	Futch Creek (upper)									prohibited		Impaired (Cat 5)	Shellfish, Fish Tissue (Hg)	
	Howe Creek (Moore Creek)	Primary						2.8	305	prohibited	1.3	Impaired (Cat 5)	Shellfish, Fish Tissue (Hg), Enterrococcus, Dissolved Oxygen, pH, Turbidity, Chlorophyll a	coastal (main stem)
	Bradley Creek (lower)	Primary						2.5	275	prohibited	2.2	no data, Category 4 Hg Only	Fish Tissue (Hg)	coastal (main stem)
	Bradley Creek (upper)									prohibited		Inconclusive Data (Cat 3)	Fish Tissue (Hg)	
	Whiskey Creek	Primary						1.3	72	prohibited	3.5	Impaired (Cat 5)	Shellfish, Fish Tissue (Hg), Enterrococcus	coastal (main stem)
03040207020060	Shallotte River (lower)	Primary	41,271	64.6	17	10	27	6.9	795	lower section not prohibited	1.3	Impaired (Cat 4)	Shellfish, Fecal Coliform, Fish Tissue (Hg), Mercury, Lead, Nickel, Copper, Zinc, Chromium, Cadmium, Arsenic, Dissolved Oxygen, Water Temperature, pH, Turbidity	coastal (main stem)
	Shallotte River (mid)									prohibited		Impaired (Cat 4)	Shellfish, Fecal Coliform, Fish Tissue (Hg)	
	Shallotte River (upper)									prohibited		Impaired (Cat 4)	Shellfish, Fecal Coliform, Fish Tissue (Hg)	
03040207020090	Saucepan Creek	Primary	6,488	10.2	17	3	20	3.2	86	prohibited	0.7	Impaired (Cat 4)	Shellfish, Fecal Coliform, Fish Tissue (Hg)	coastal (main stem)
03020204060020*	Orchard Creek	Alternate	30,685	48.0	1	4	5	1.9	123	prohibited	35.3	Impaired (Cat 5)	Shellfish, Fish Tissue (Hg)	coastal
03020204060010*	Pierce Creek	Alternate	20,349	31.8	4	12	16	1.7	59	prohibited	36.8	Impaired (Cat 5)	Shellfish, Fish Tissue (Hg)	coastal
03020204040010	Dawson Creek (lower)	Alternate	21,288	33.3	5	25	30	5.4	355	prohibited	42.6	Impaired (Cat 5)	Shellfish, Fish Tissue (Hg), Enterococcus, Recreation Advisory	coastal (lower)
	Dawson Creek (mid)									prohibited		Supporting (Cat 2)		inland (upper)
	Dawson Creek (upper)									prohibited		Impaired (Cat 5)	Fish Tissue (Hg), Benthos Severe	inland (upper)

*Indicates the sub-basin contains multiple waterbodies (streams) and the numbers presented are for the sub-basin as whole and not the individual harvest site.

FIGURES

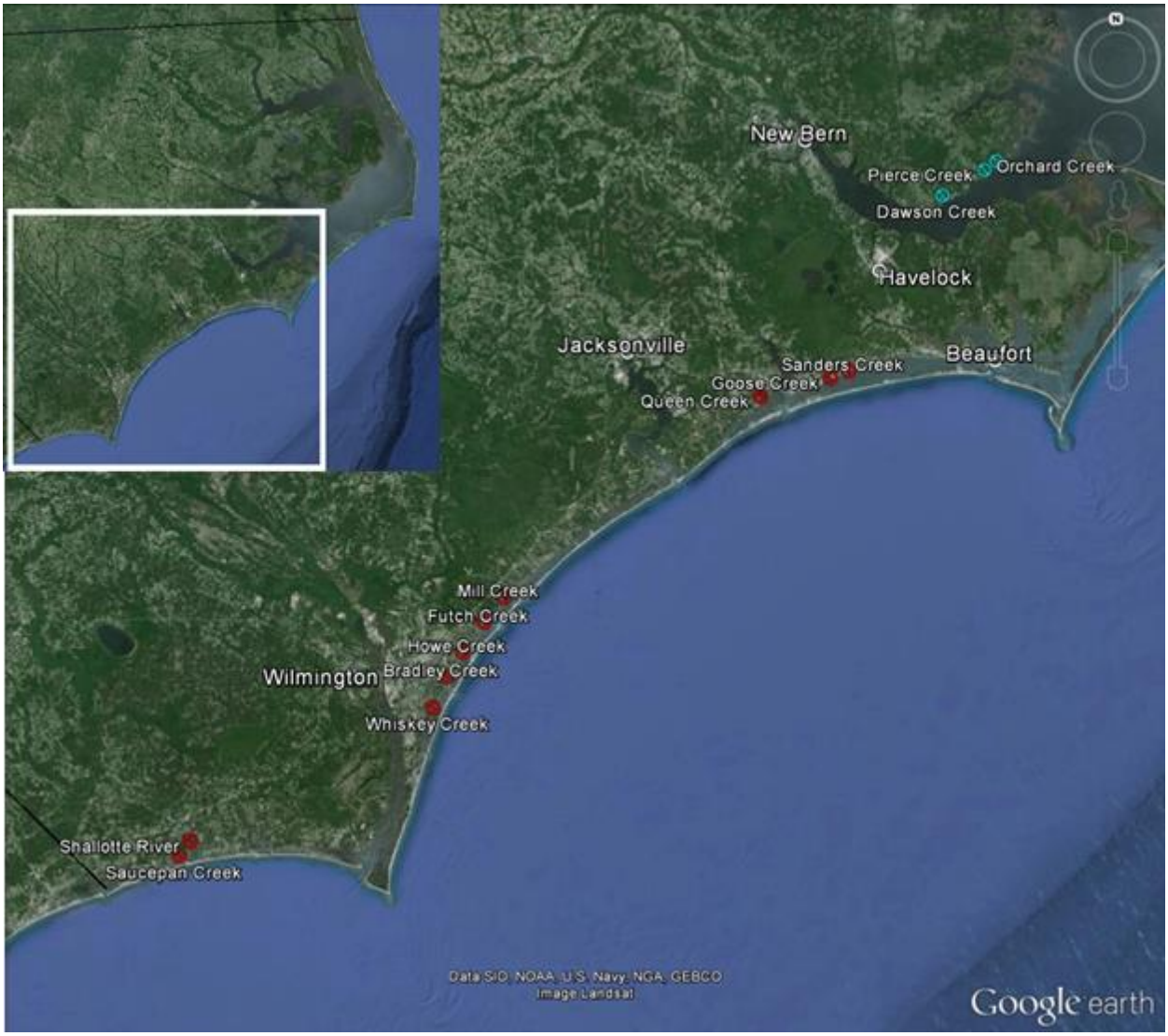

Figure 1. General location of proposed primary (red circles) and alternate (blue circles) harvest sites along the North Carolina coast.

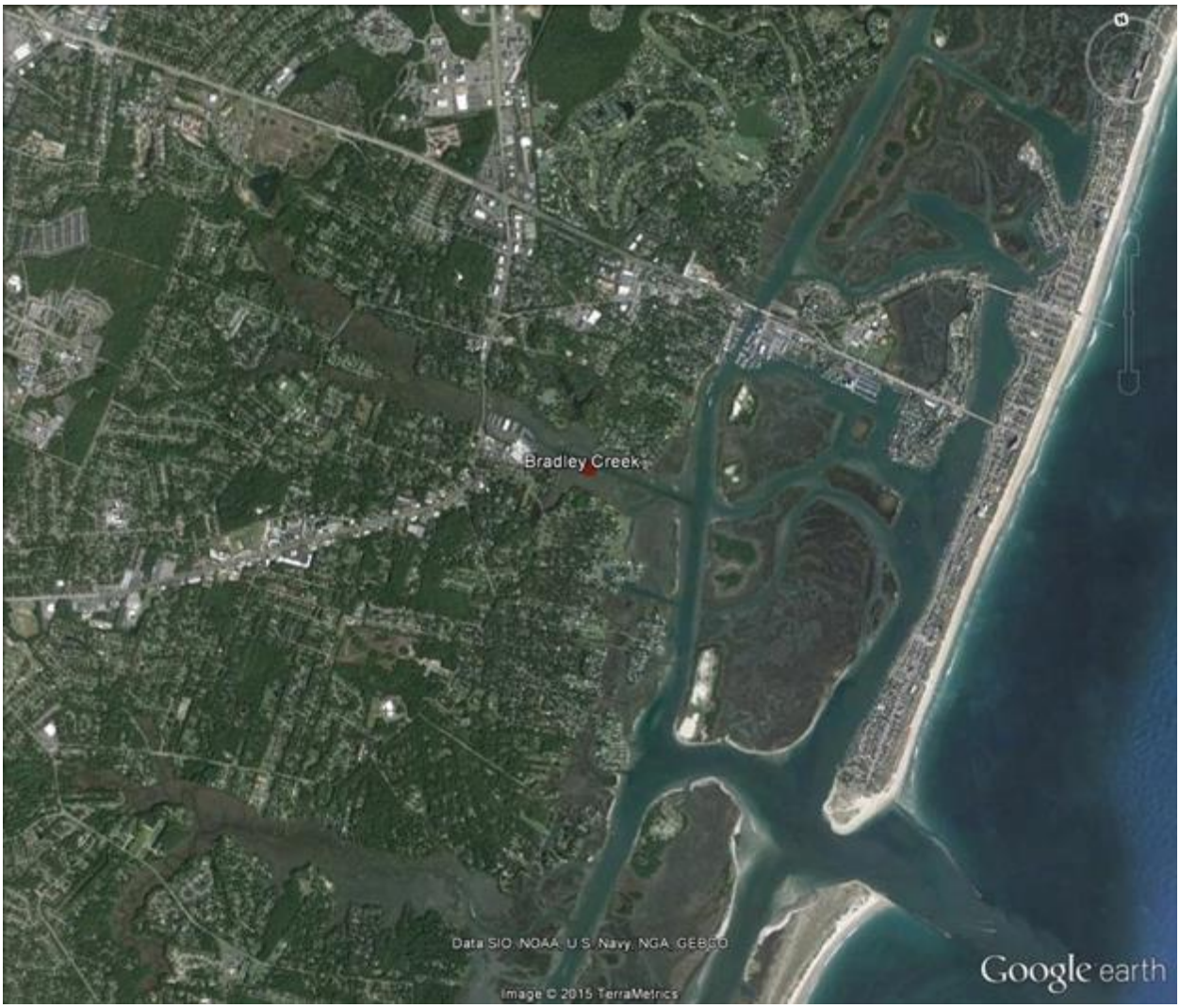

Figure 2. Bradley Creek harvest site.

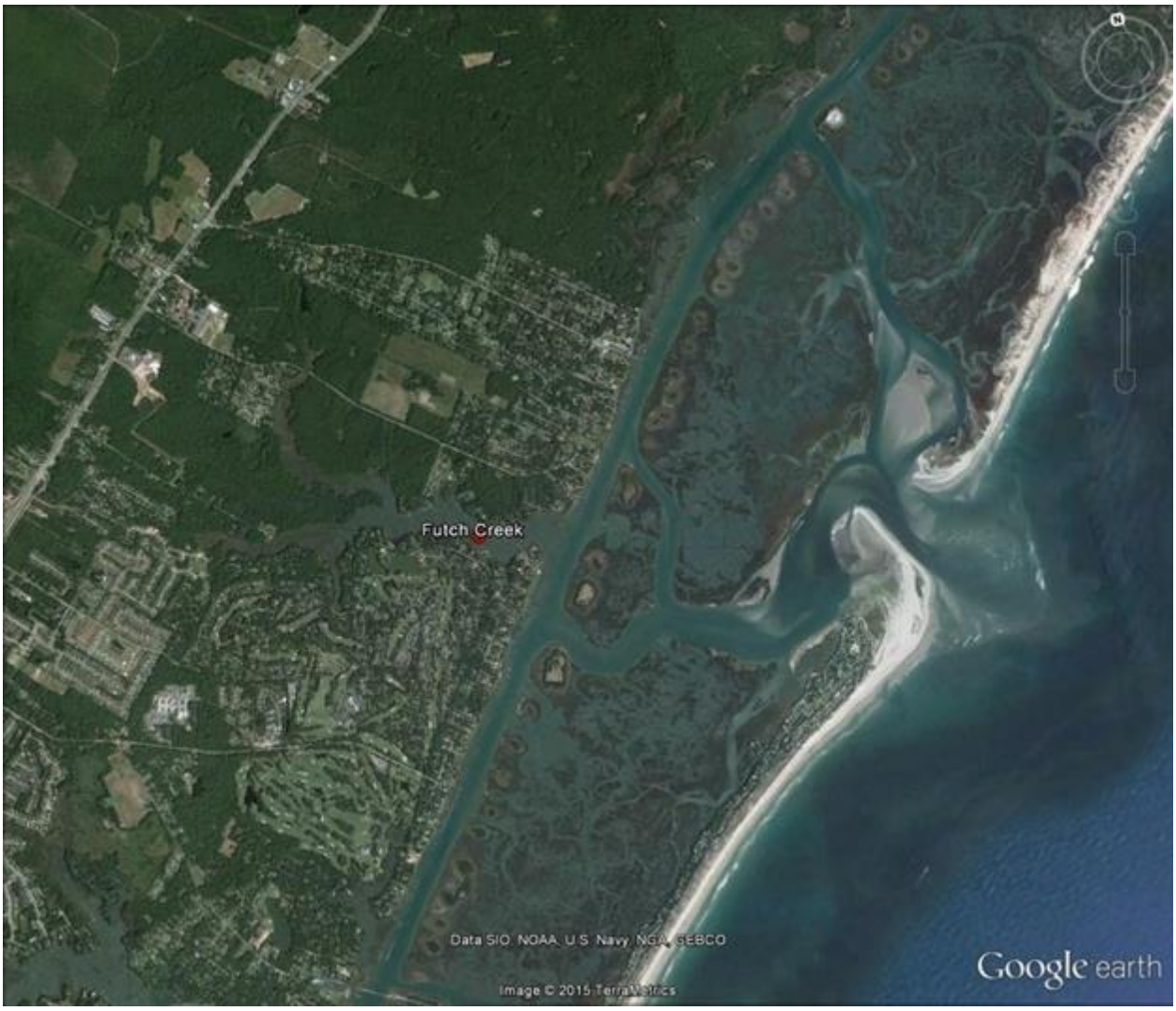

Figure 3. Futch Creek harvest site.

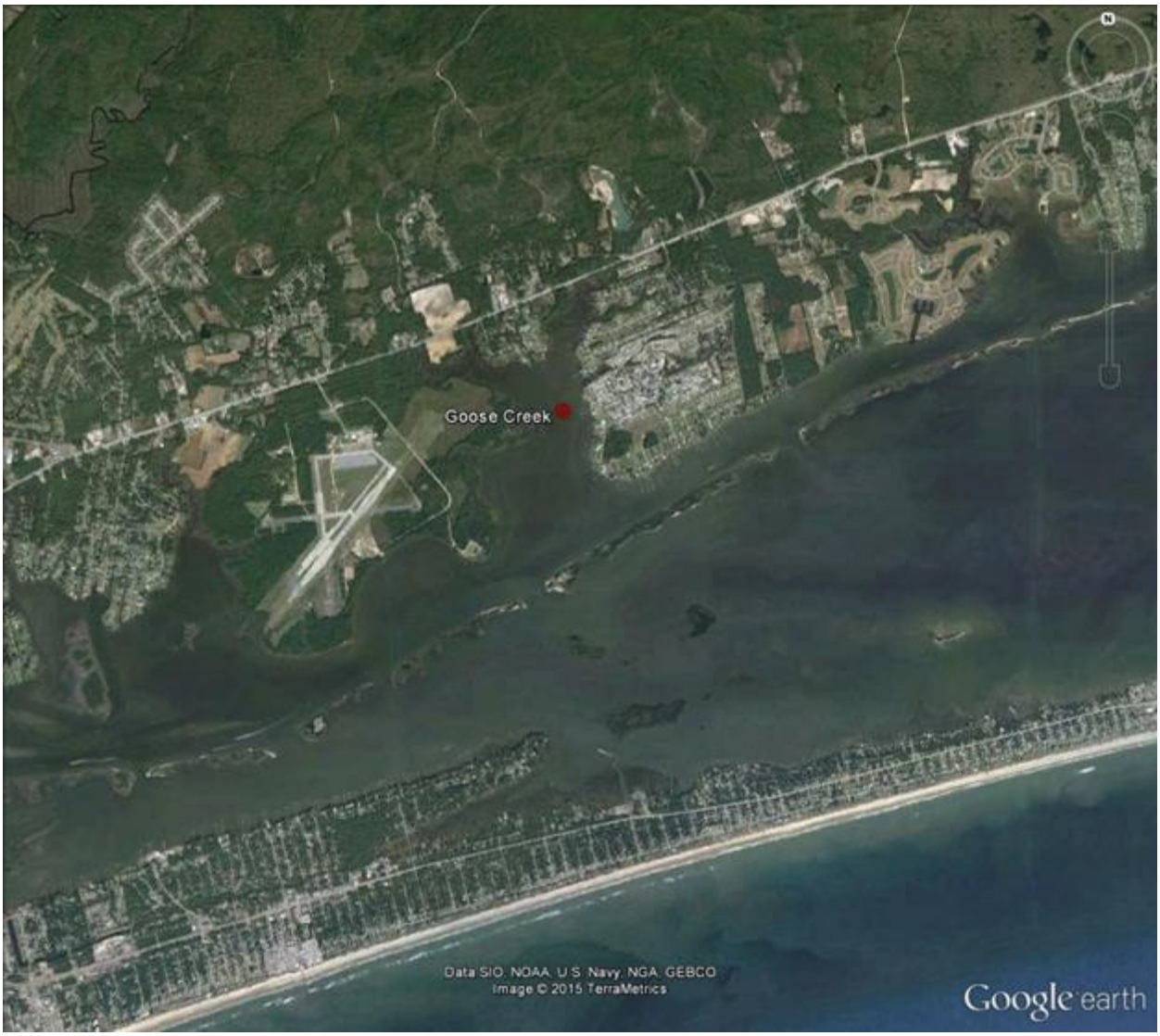

Figure 4. Goose Creek harvest site.

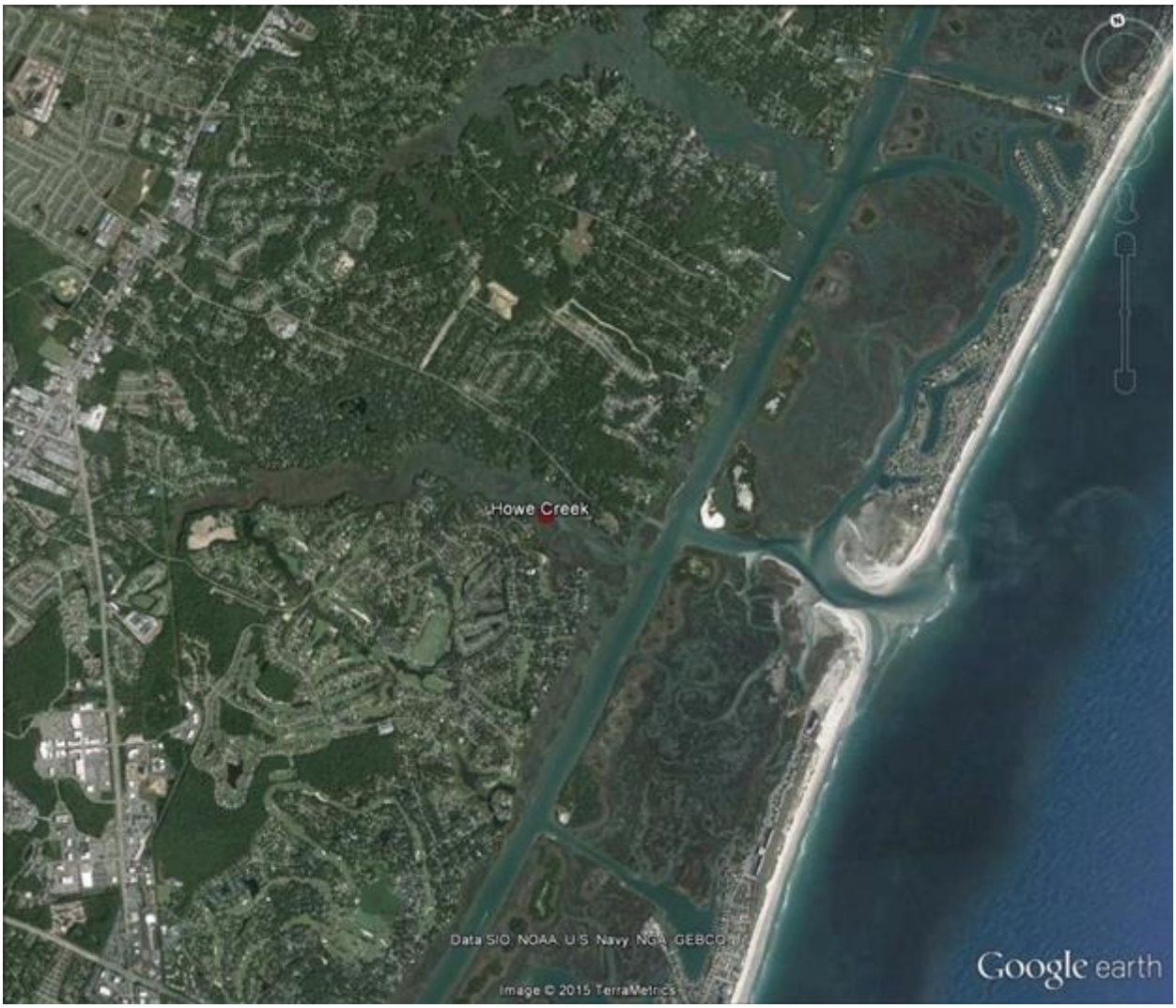

Figure 5. Howe Creek harvest site.

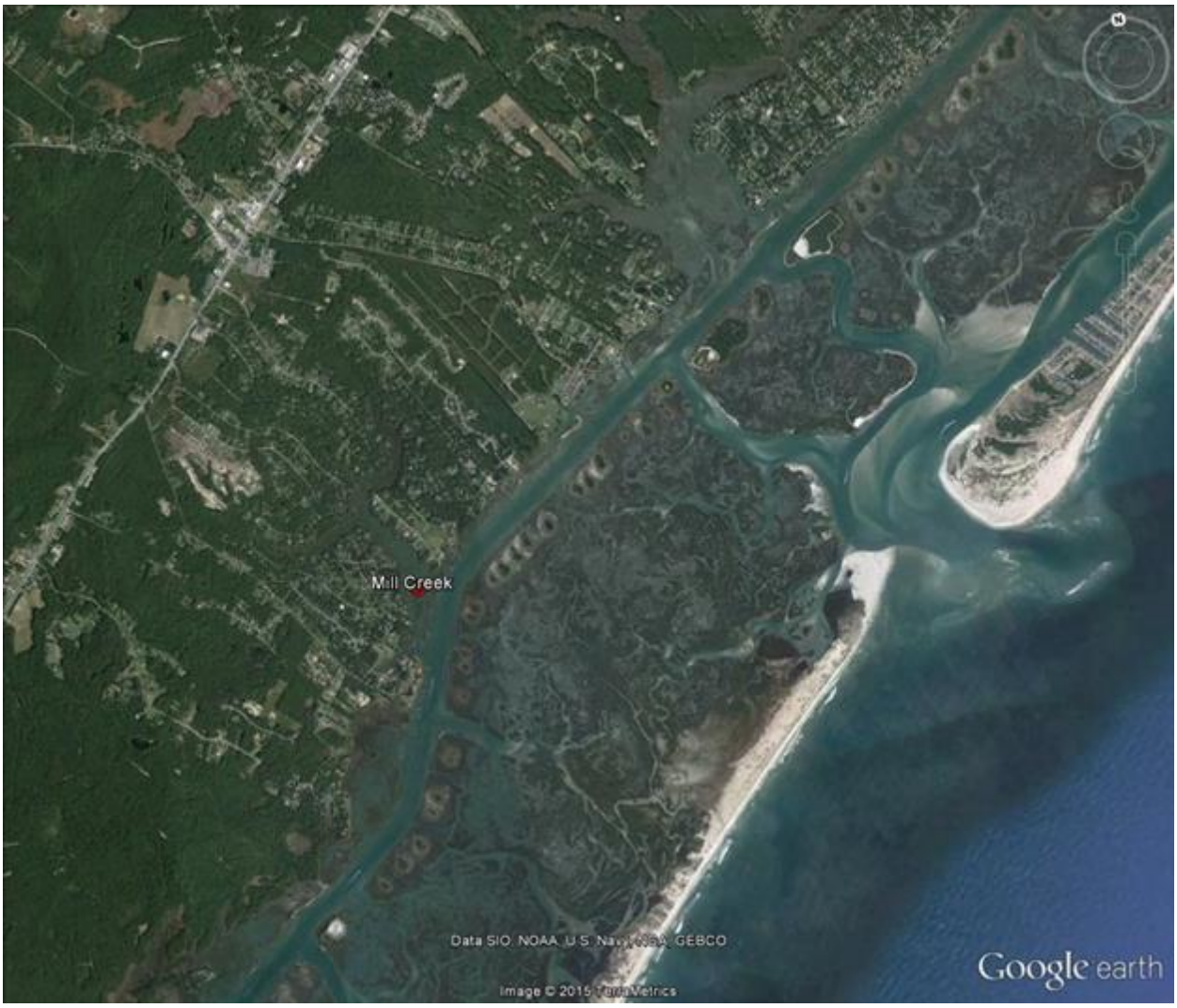

Figure 6. Mill Creek harvest site.

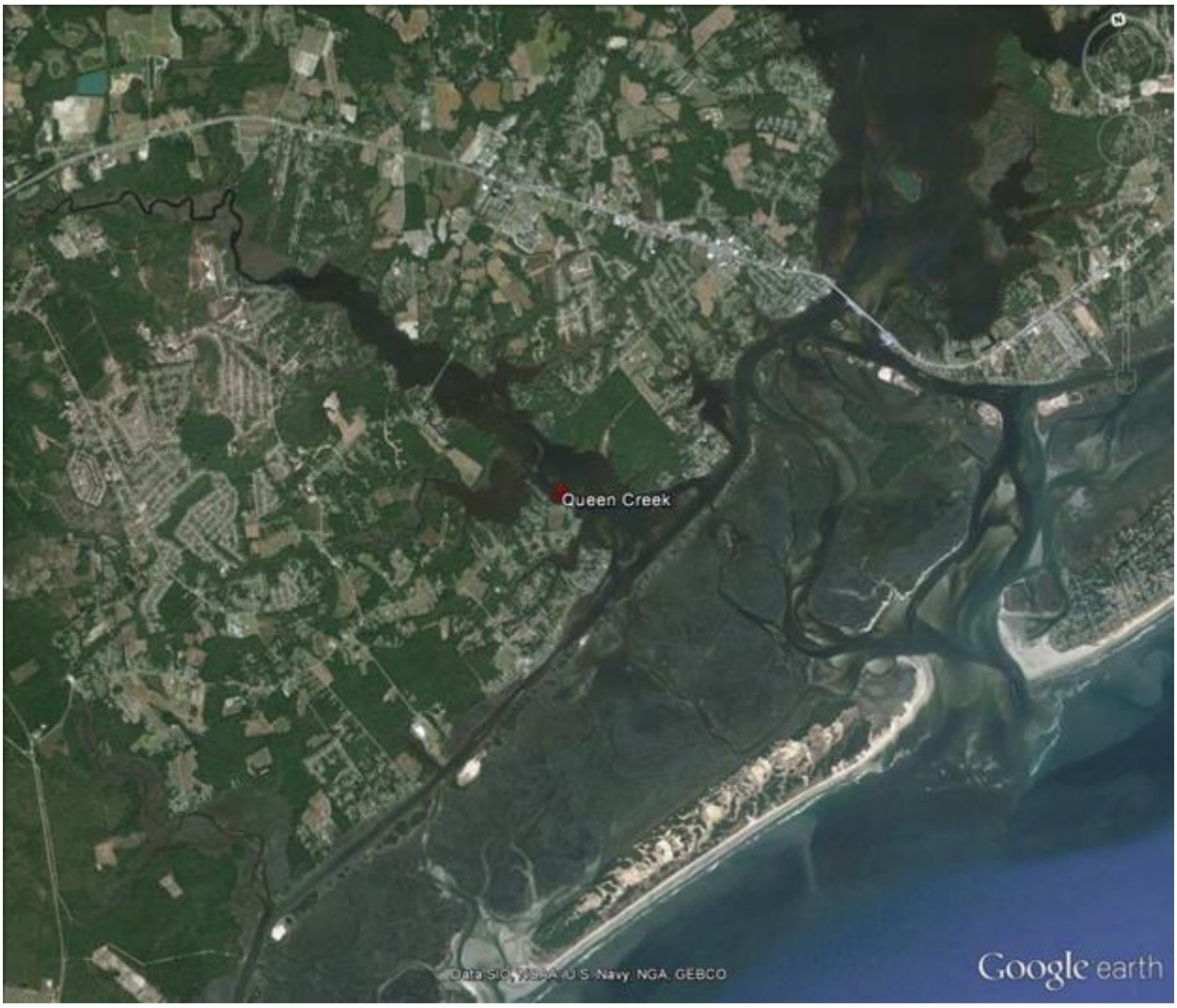

Figure 7. Queen Creek harvest site.

Figure 8. Sanders Creek harvest site.

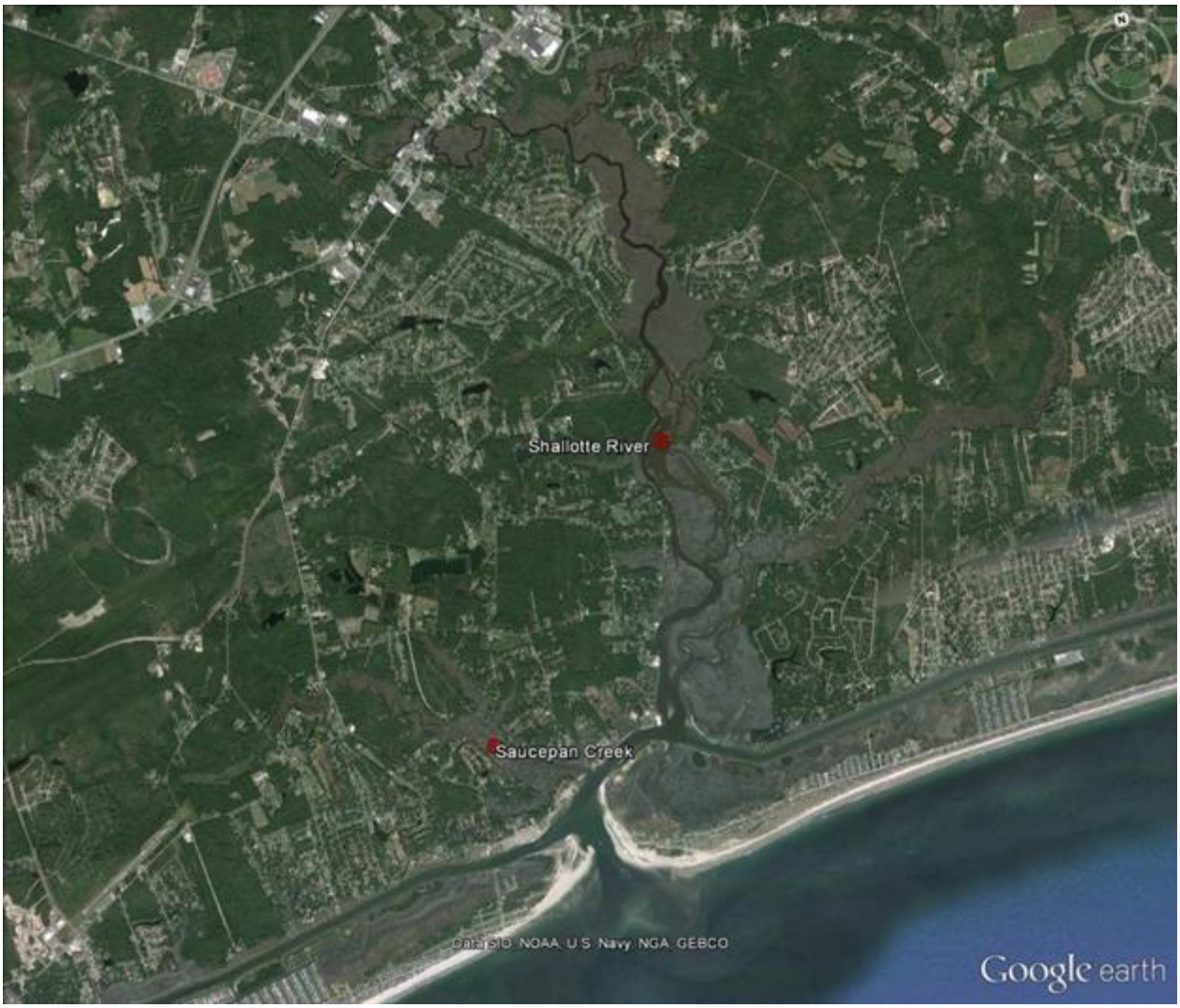

Figure 9. Saucepan Creek and Shallotte River harvest sites.

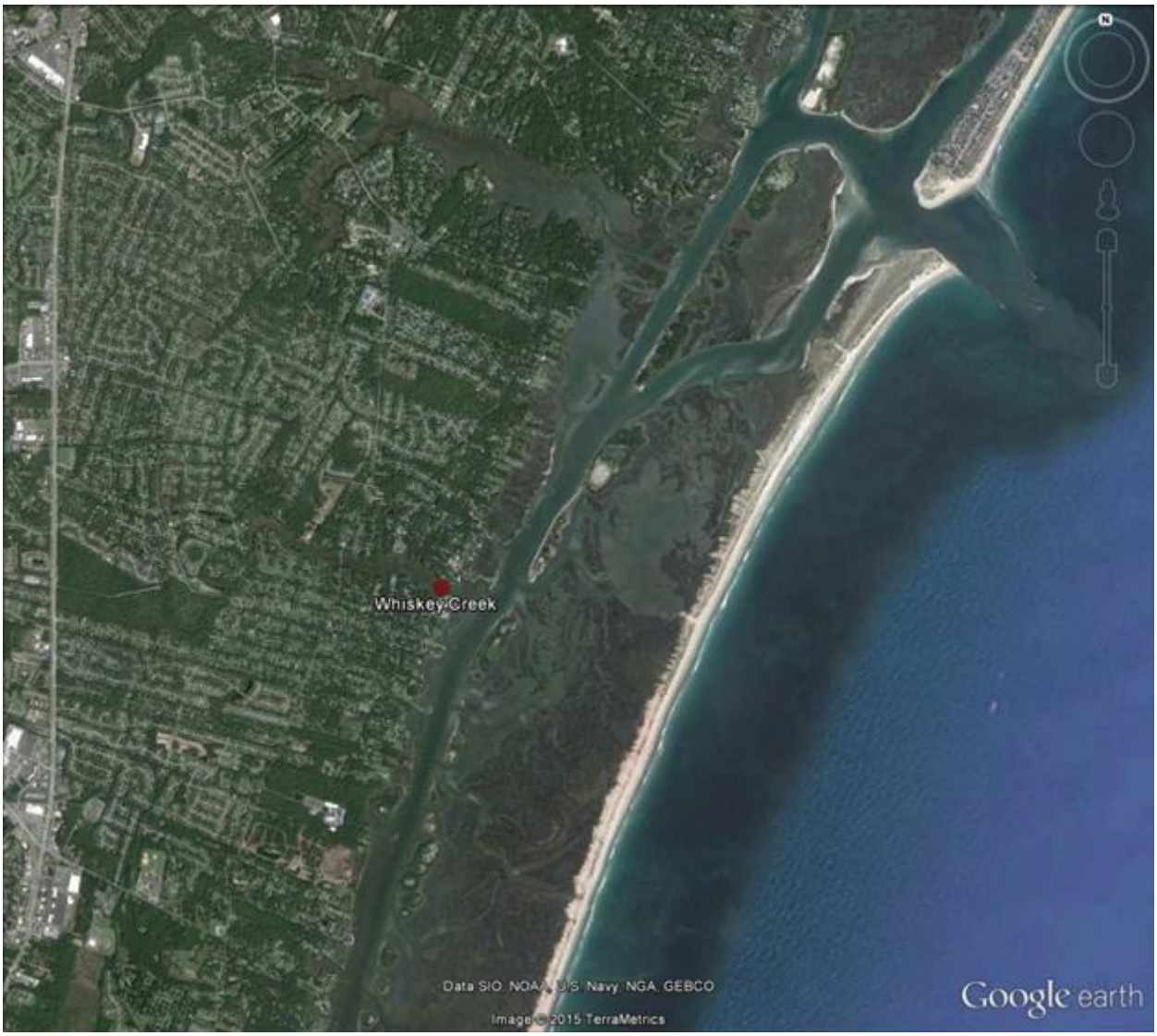

Figure 10. Whiskey Creek harvest site.

Figure 11. Dawson Creek harvest site.

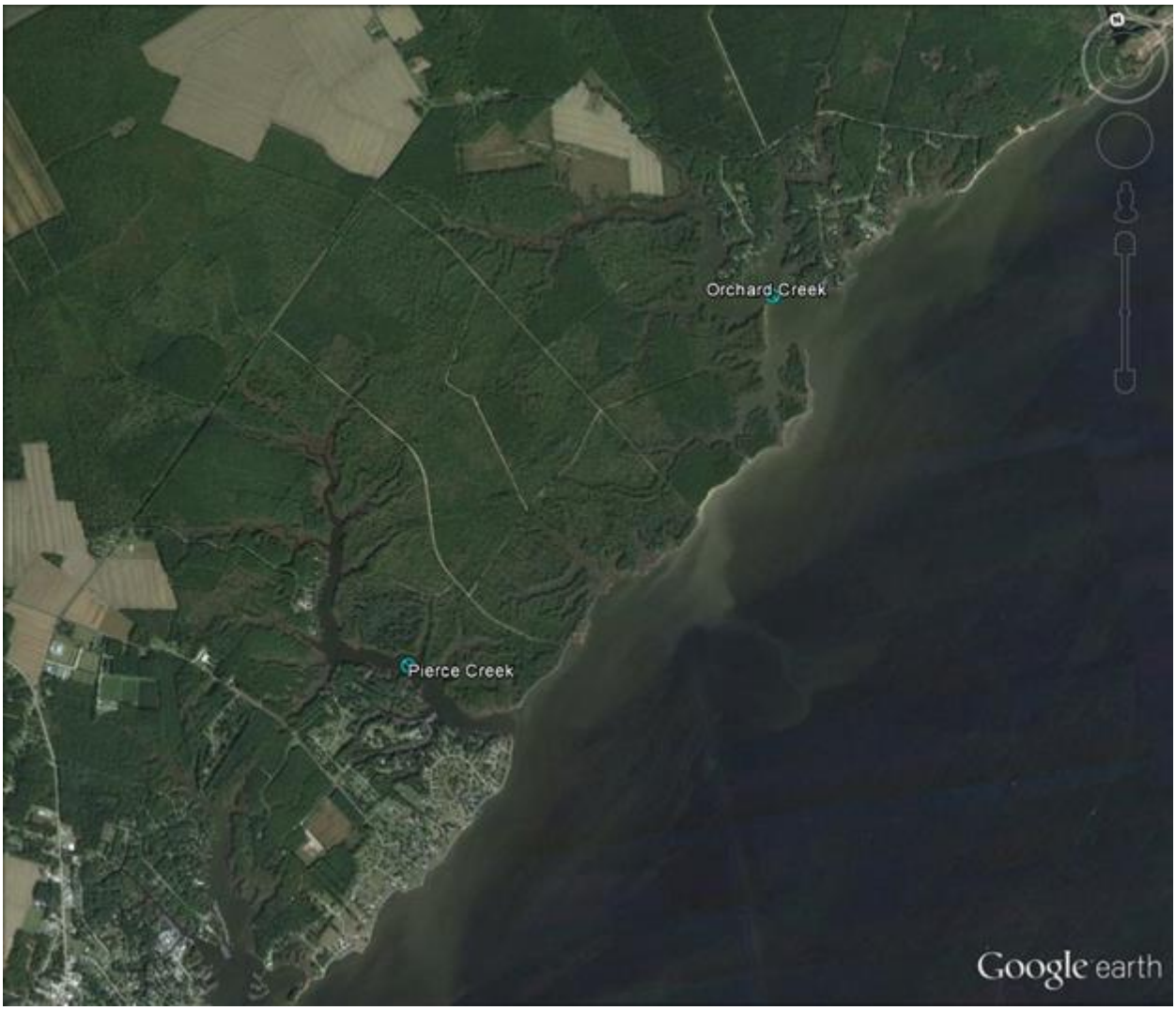

Figure 12. Orchard Creek and Pierce Creek harvest sites.

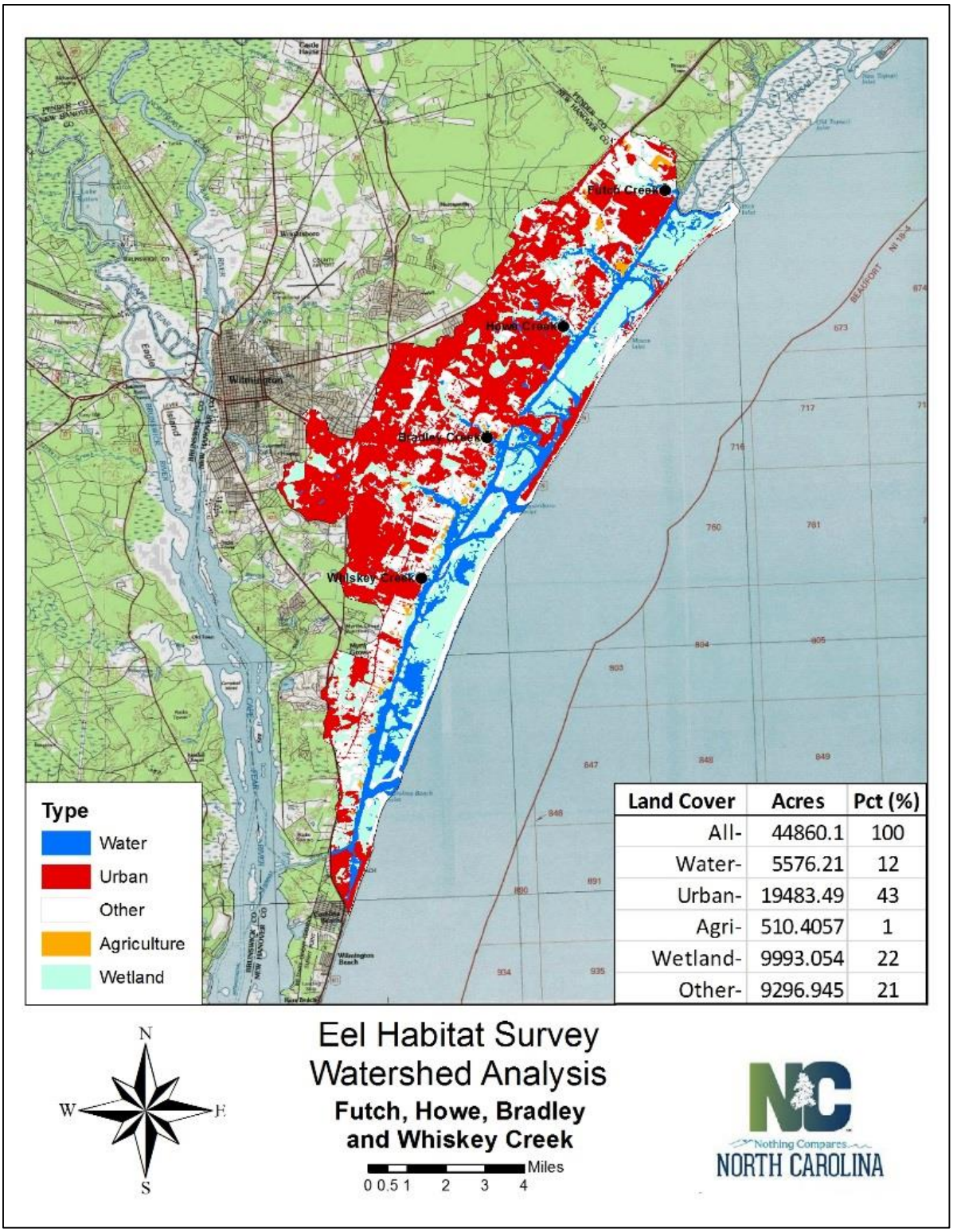

Figure 13. Land use characteristics for the sub-basin containing Bradley, Futch, Howe, and Whiskey creeks.

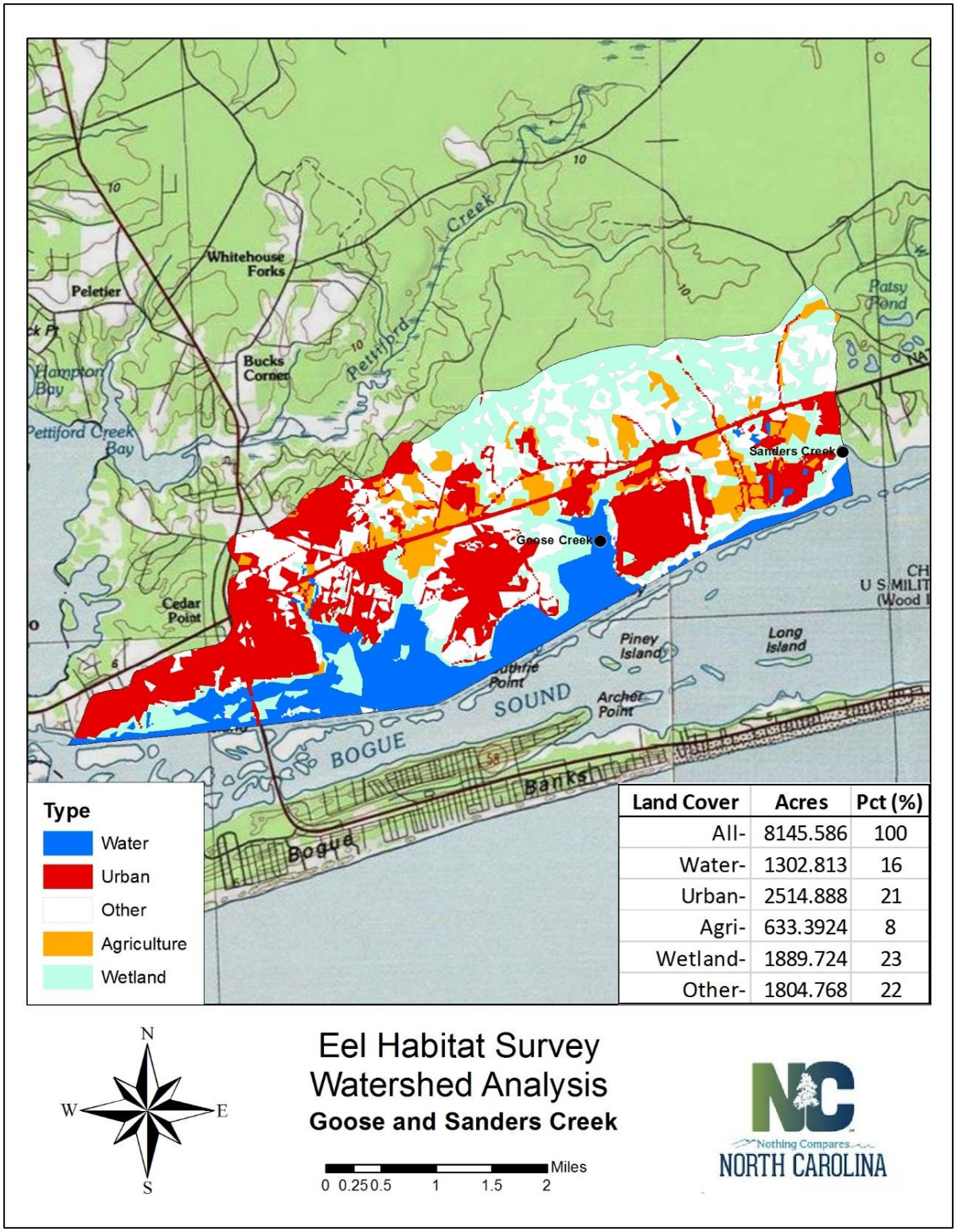

Figure 14. Land use characteristics for the sub-basin containing Goose and Sanders creeks.

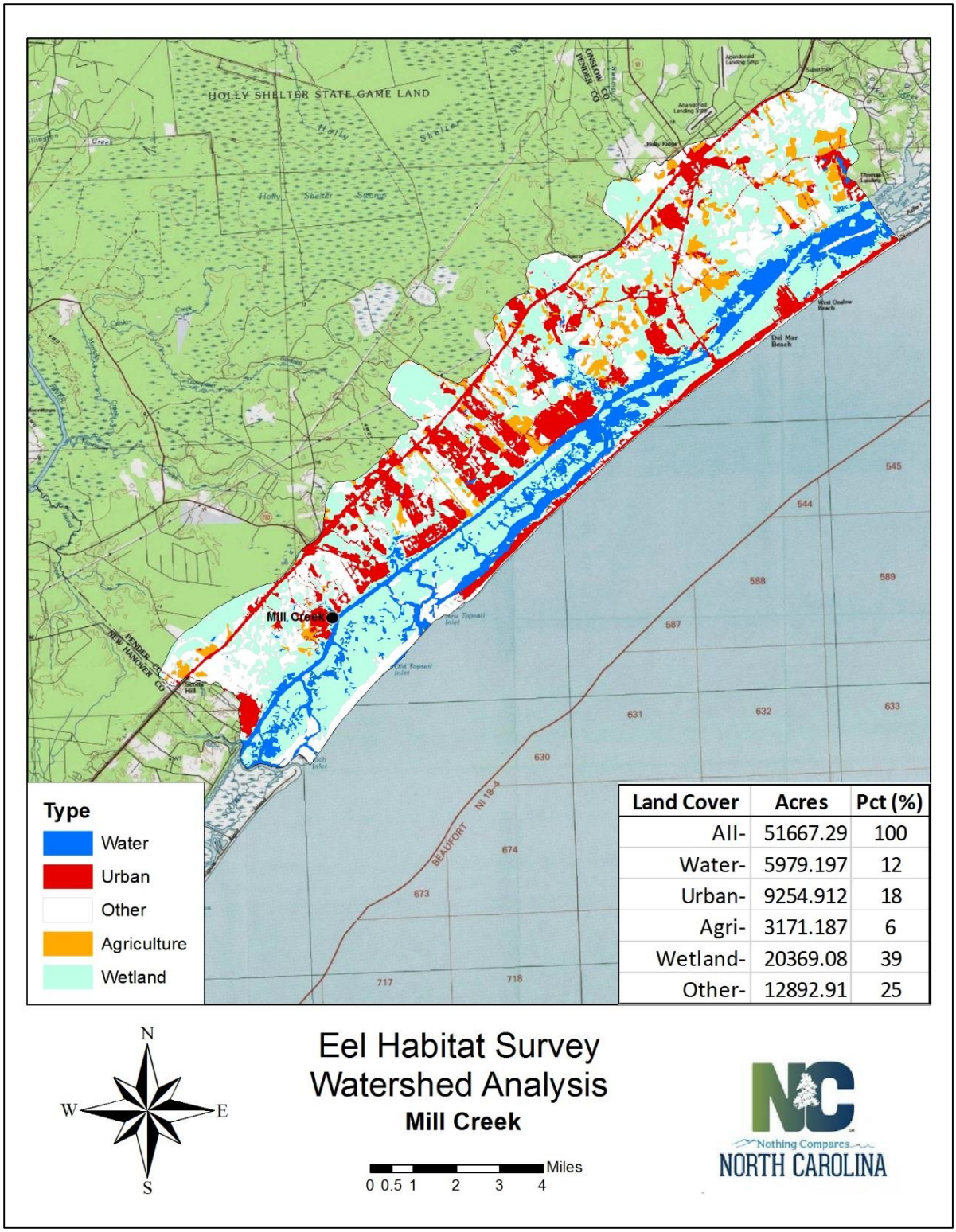

Figure 15. Land use characteristics for the sub-basin containing Mill Creek.

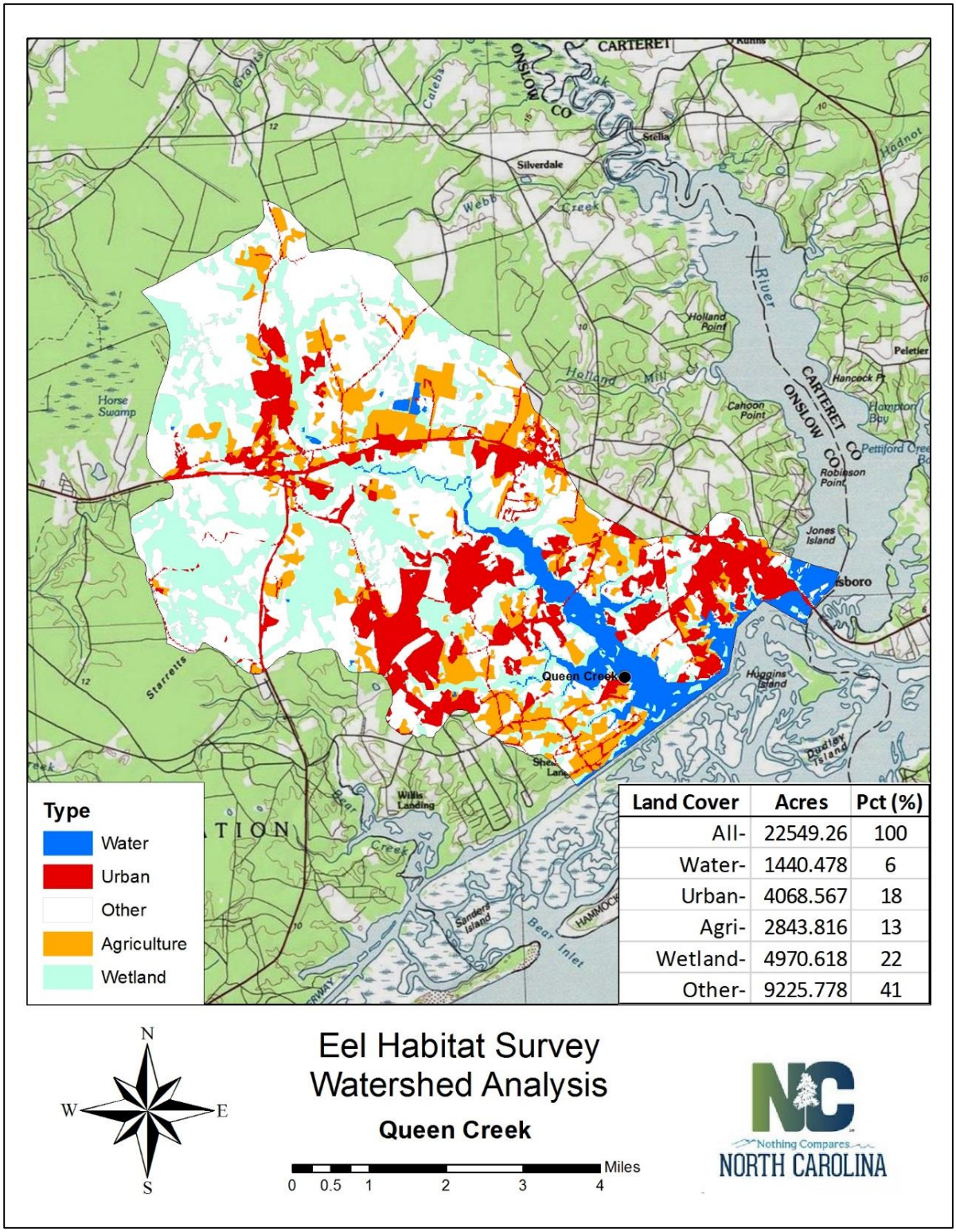

Figure 16. Land use characteristics for the sub-basin containing Queen Creek.

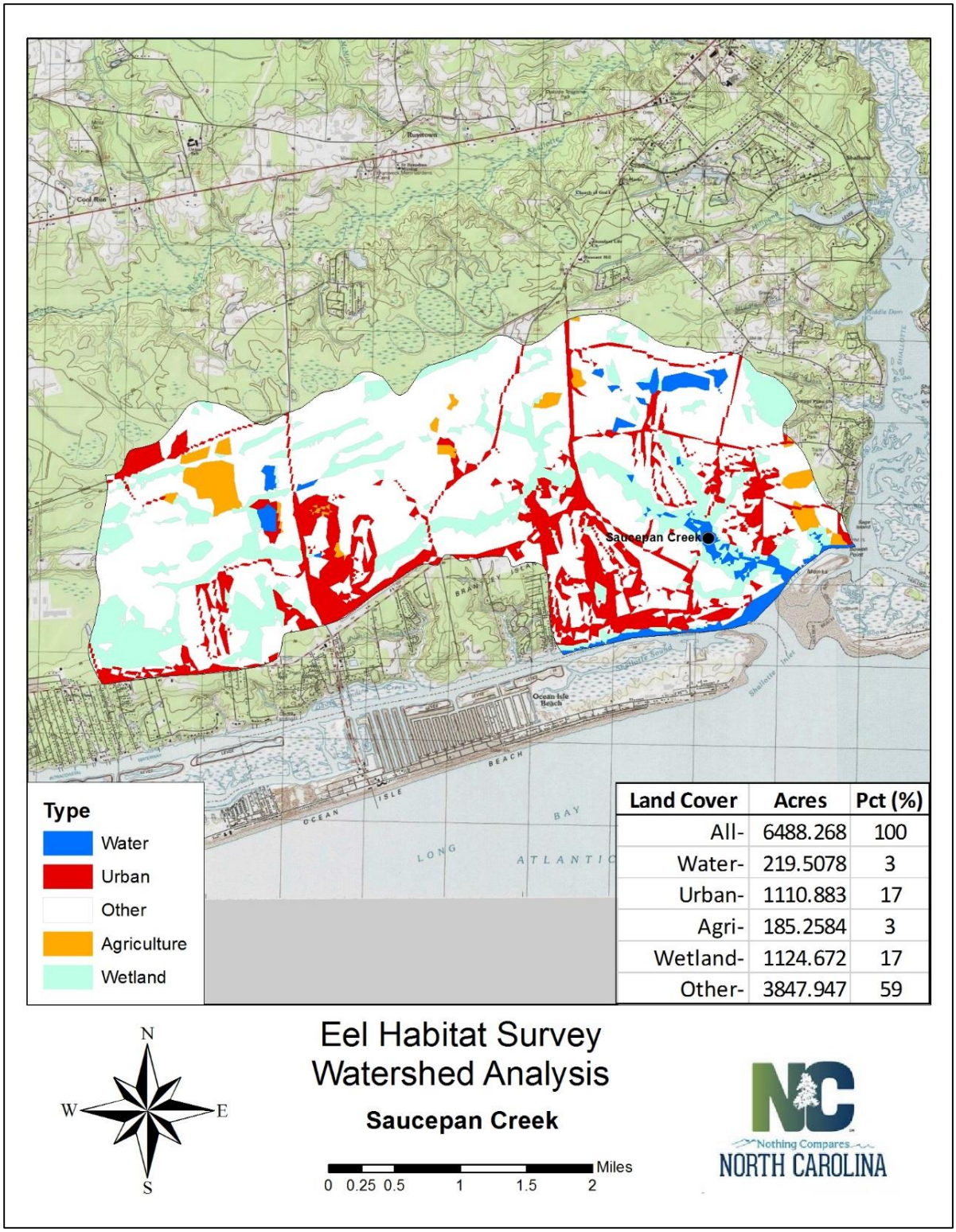

Figure 17. Land use characteristics for the sub-basin containing Saucepan Creek.

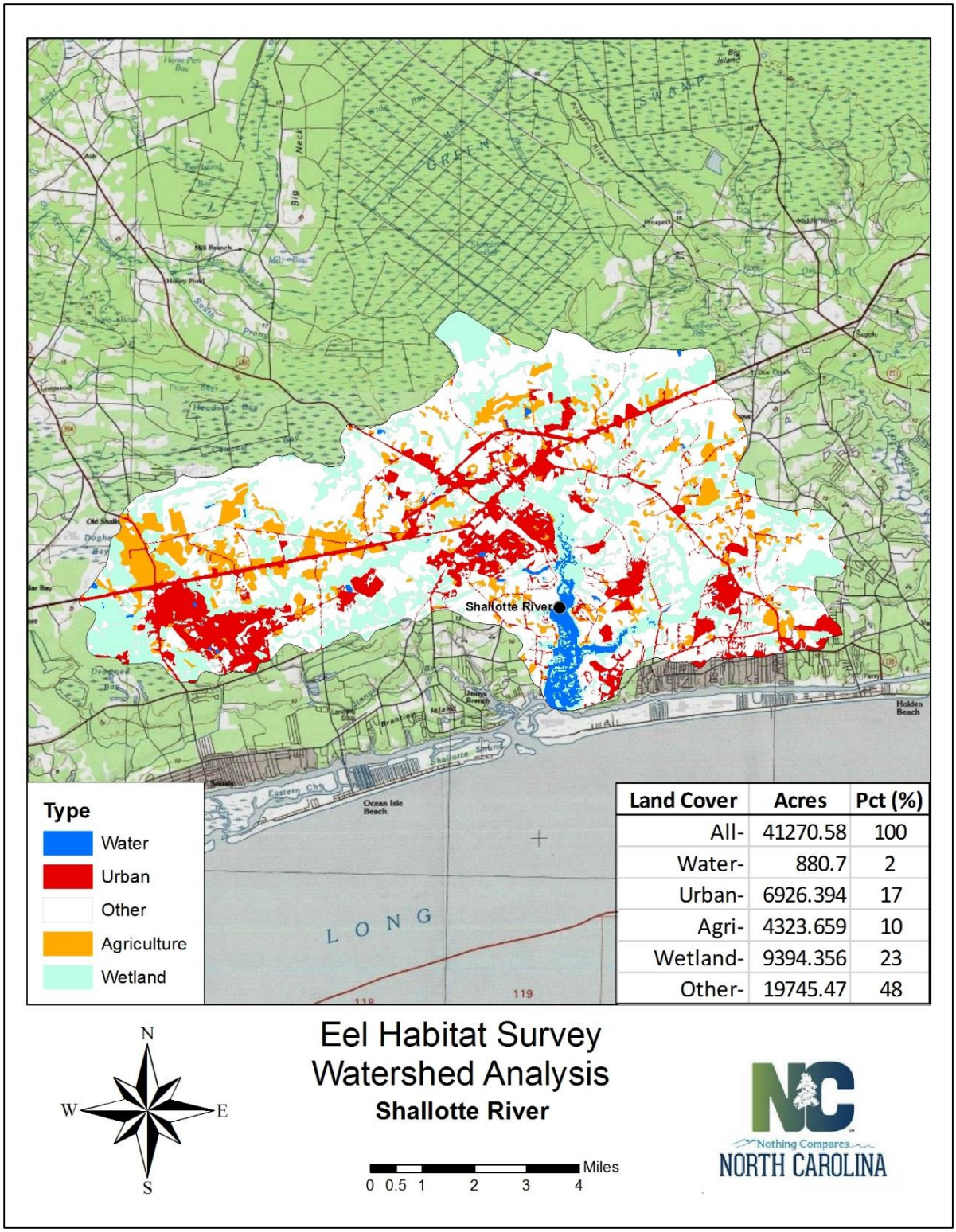

Figure 18. Land use characteristics for the sub-basin containing the Shallotte River.

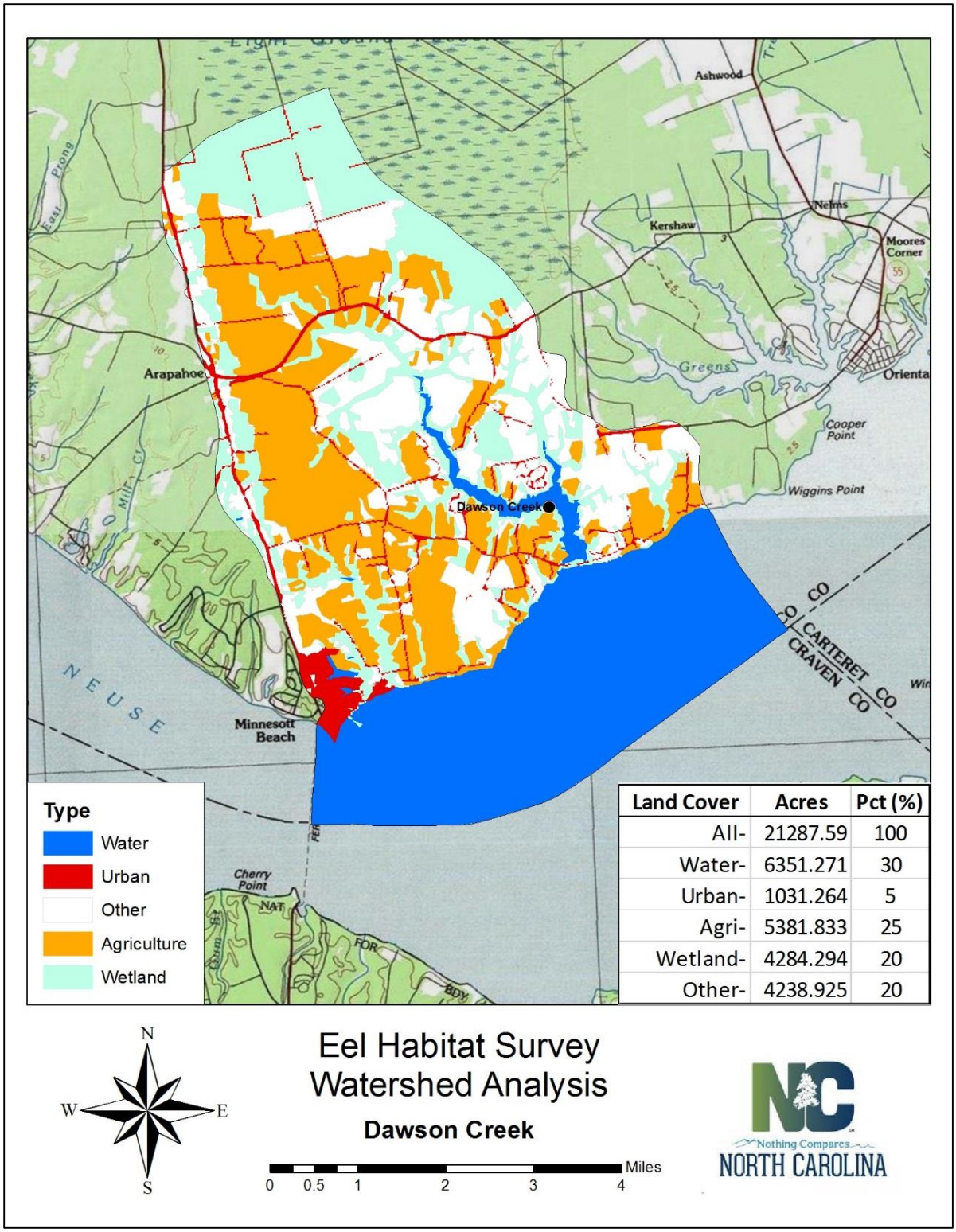

Figure 19. Land use characteristics for the sub-basin containing Dawson Creek.

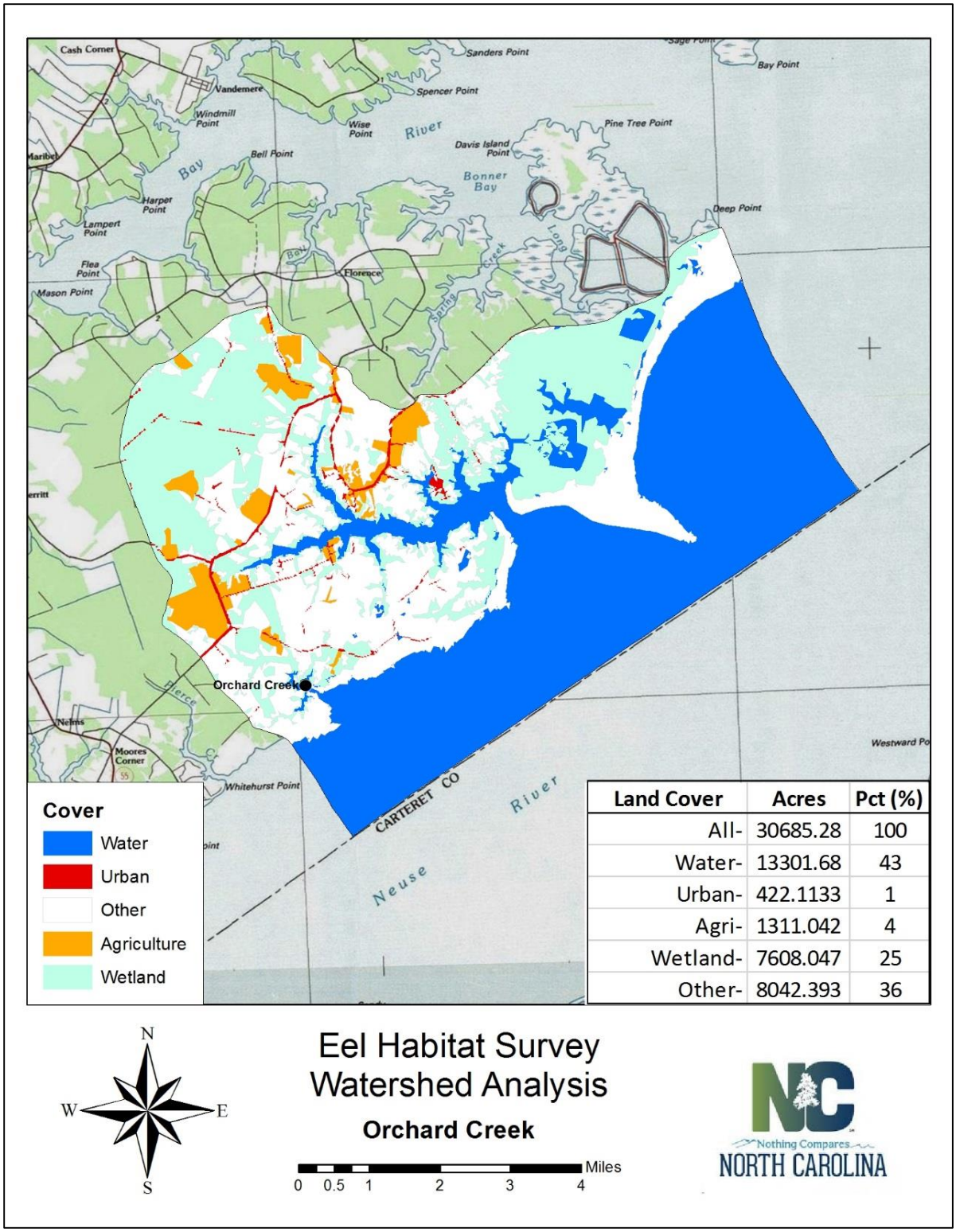

Figure 20. Land use characteristics for the sub-basin containing Orchard Creek

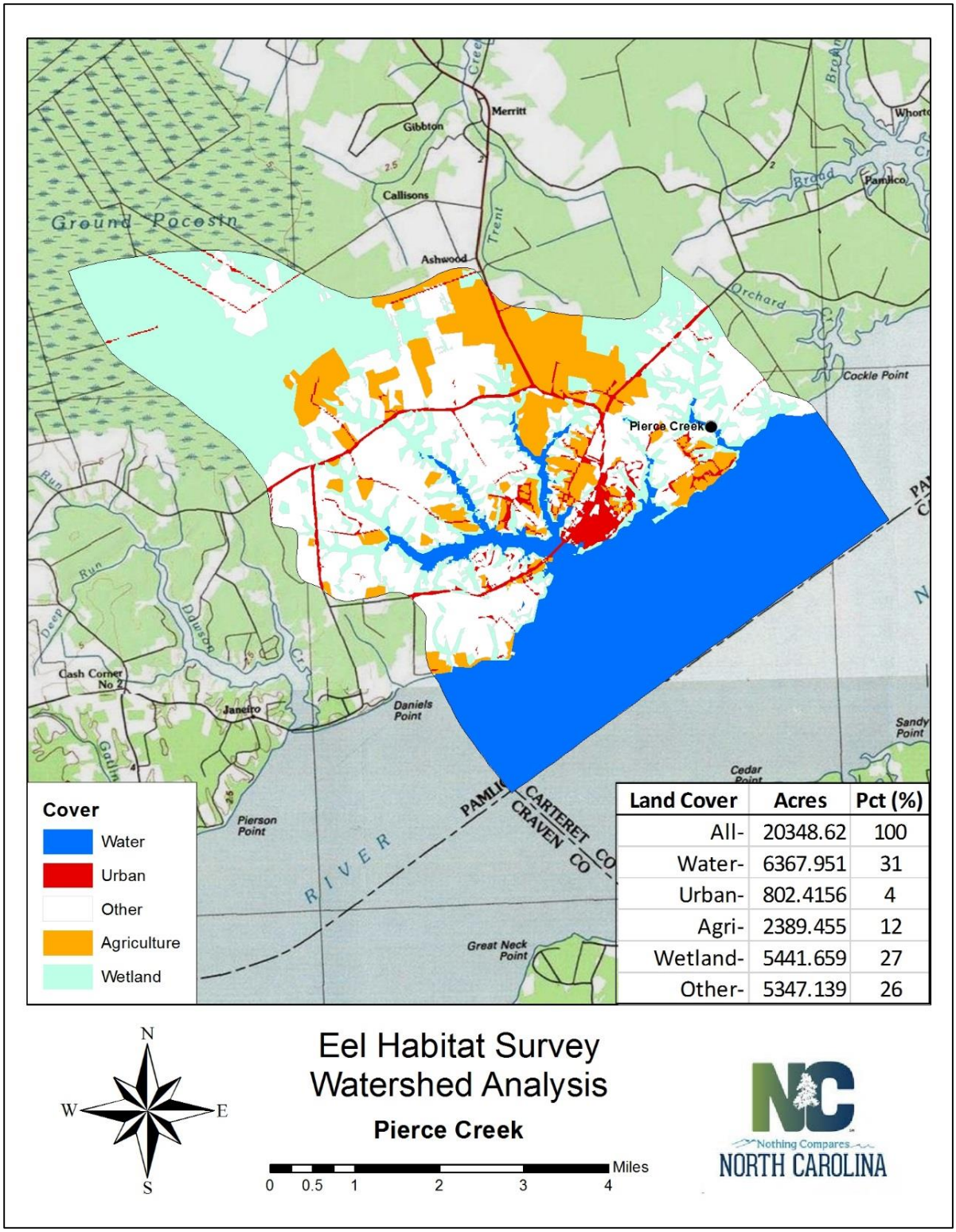

Figure 21. Land use characteristics for the sub-basin containing Pierce Creek.

APPENDIX I

TESTIMONY PRESENTED TO THE COMMITTEE ON MARINE RESOURCES
RE: H.P. 137, AN ACT TO RESTRICT THE TAKING OF EELS LESS THAN 6 INCHES IN LENGTH FROM MAINE COASTAL WATERS (EMERGENCY)

by
James D. McCleave
February 23, 1995

INTRODUCTION

The purpose of my testimony is primarily to educate the members of the committee, other legislators and interested persons about the unique life cycle of a truly fascinating and somewhat mysterious fish, the American eel. The unusual life cycle has some important implications for management and conservation of this species, which are different than for most species of fishes. I will present several of these implications. Finally, I do offer an opinion on the soundness of this particular bill.

I am a Professor of Oceanography and a Cooperating Professor of Zoology at the University of Maine, where I have been since 1968. I have conducted research on the biology of the American eel and the European eel since the early 1970s and have published more than 25 scientific papers on them. I also teach about eels in my classes at the University, and I occasionally have participated in workshops on eels with my European colleagues. A copy of my résumé is appended.

I offer this testimony as a friend of the eel, an awesome fish, and as a friend of eel fishers of all types. It is not my intention to support one group of harvesters over another. My conclusions and opinions are biologically based. The economics of the eel fishing and aquaculture industries and the economic consequences of management decisions are left to the realm of other experts.

LIFE CYCLE OF THE AMERICAN EEL

American eels are highly migratory, with spawning and larval development occurring in the ocean, and feeding and growth occurring in estuaries and fresh waters (rivers, streams, ponds, and lakes) [catadromous life cycle].[1] Spawning occurs near the surface over very deep water in a large area of the Sargasso Sea (Figure 1) and only there, meaning there is a single breeding population for the species. The Sargasso Sea is a large portion of the western North Atlantic Ocean east of the Bahamas and south of Bermuda. Spawning occurs in winter. Eggs hatch in a day or two in the warm water, releasing a long-lived larval stage [leptocephalus], which is flattened from side-to-side and shaped somewhat like a willow leaf. The leptocephali drift and swim in the upper few hundred feet of the

[1]My language is intended to be understood by the nonspecialist. However, the appropriate scientific terms are included in brackets for completeness and to allow direct reference later in the document.

ocean for several months, growing slowly to a length of 2-2.5 inches. The leptocephali dramatically alter their shape [metamorphose] to resemble a miniature, transparent eel, called a glass eel, during the subsequent autumn and winter. This metamorphosis occurs at sea, perhaps near the edge of the continental shelf. The glass eels enter estuaries and ascend rivers during winter and spring, earlier at the southern end of their range, later at the northern end. (My research group at the University of Maine has contributed substantially to this knowledge.) It is during the spring ascent that glass eels, sometimes termed elvers, are harvested commercially in Maine.

The glass eels in estuaries and fresh waters rapidly develop rather drab pigmentation in their skin, dark on the back and often yellowish on the belly, leading to the name yellow eel for this stage. Growth is generally slow, and yellow eels spend several years in estuaries and inland waters. Growth and age at maturity are not well known. Males probably remain as yellow eels for 4-6 years or more, and grow to about 12-18 inches or so. Females remain as yellow eels for many more years, probably 6-20 years in New England and the Maritime Provinces. During this growth period, yellow eels are fished commercially in estuarine and fresh waters, using baited traps or pots.

During late summer and early autumn, maturing yellow eels undergo a second metamorphosis in preparation for a migration to sea to spawn. The pigment on the belly frequently becomes an iridescent silvery, leading to the term silver eel. Silver eels migrate from fresh waters and estuaries to sea in late summer and autumn in the northern part of their range, including Maine, and later in the southern part of the range. During this migration in Maine, silver eels are fished commercially in fixed weirs or nets set across streams and rivers.

Silver eels migrate to the Sargasso Sea, *spawn once and die*. Little is known of this migration or actual spawning, but it seems likely that autumn migrants are the spawners of the subsequent winter. Evidence of the timing and location of spawning comes from the distribution in space and time of small leptocephali. (My research group at the University of Maine has contributed substantially to this knowledge.)

The yellow stage of the American eel ranges from the eastern Gulf of Mexico, all along the east coast of the US, through the states and provinces bordering the Gulf of Maine, to the states and provinces bordering the Gulf of St. Lawrence, to Newfoundland and Labrador. Yet all spawning of the resulting silver eels occurs in the Sargasso Sea.

POINTS OF EMPHASIS FROM THE LIFE CYCLE

- There is a single breeding population for the entire species regardless of where the yellow eels resided [panmixis]. All genetic evidence suggests that a female from Maine is as likely to spawn with a male from Georgia as with a male from Nova Scotia.
  - This means there is no 'homing' of offspring from eels of the Penobscot or Kennebec Rivers to those rivers.

- ◇ Glass eels entering the Maine rivers are just the same genetically as those entering elsewhere within the range.

- There is a single spawning by a female in her lifetime [semelparity]. An adult female may have to grow for 15 years before reaching maturity and spawning *once*.

- Females develop large numbers of eggs [high fecundity], probably 400,000-3,000,000 eggs per female increasing with female size.

- Nearly all the eggs produced by a female and fertilized by a male will die before reaching maturity [high mortality]. This is natural in fecund species; otherwise the earth would be covered with eels.

- Females are much larger at sexual maturity than males [sexual dimorphism].
  - ◇ Most females are larger than 20 inches (50 cm) at maturity.
  - ◇ Most males are less than 18 inches (45 cm) at maturity.

- Determination of whether an eel becomes a male or female is not completely under genetic (chromosomal) control, but the process of sexual determination is not fully understood.

HYPOTHESES RELEVANT TO CONSERVATION

There are two hypotheses, for which there is some scientific evidence, which are important to decisions on conservation of the species. Both hypotheses follow logically from an overriding hypothesis that eels encountering more productive waters have a greater tendency to become males, while those encountering less productive waters have a greater tendency to become females. (There is a body of life history theory that supports this different life history strategy for males and females.)

- There is a gradual increase in the proportion of eels that become females from the estuary toward the headwater streams, i.e. increasing up a given drainage. Within a river drainage, more productive waters are generally found in the lower reaches, especially the estuary.
  - ◇ If correct, this means that Merrymeeting Bay has a lower proportion of females than the higher waters of the Kennebec River.

- There is a gradual increase in the proportion of eels that become females from the southern part of the range to the northern part of the range [a cline]. Along the range of the eel, more productive waters are generally found to the south, less productive waters to the north, including Maine.

- If correct, this means that Maine is likely to have a greater proportion of female eels within its population than, say, Georgia.

MY OPINION ON EEL MANAGEMENT-CONSERVATION

Because of the wide range of the species, and because the species is a single breeding population, one political jurisdiction alone cannot conserve the species. However, Maine can act responsibly from an understanding of the eel's life history.

I will now argue against this bill. The first line of reasoning is on the basis of prudent interpretation of the implications of the life cycle. The second line of reasoning is on the basis of a scenario for interpretation of the high fecundity-high mortality consequences in this species.

From both lines of reasoning, I am led to the conclusion that *there is no biological basis underlying the restriction of harvest proposed by this legislation.* For certain, in my mind, there is *no emergency*. This is not to state that development of sound management and conservation practices are not needed.

IMPLICATIONS FROM THE LIFE CYCLE

In a one-time spawning [semelparous], fecund species with a long lifetime before that one reproduction, prudent conservation strategy would increasingly protect females the closer they get to reproduction. Mortality is high in a fecund species, but the rate of mortality declines exponentially with size. Mortality rate in leptocephali must be enormous; mortality rate in glass eels must be enormous as well. However, mortality rate in females larger than, say, 15 inches is probably very low. (Here I refer to natural mortality, not mortality from people's activities of fishing, damming, polluting, etc.)

Maine, acting in prudent fashion, might choose to protect preferentially maturing females. I stress females because only females produce young. One male may mate with many females, but only females bear eggs.

If the cline in increasing proportion of females from south to north is correct, Maine and the Maritime Provinces might give increased thought to protecting females. A greater proportion of the reproductive potential may be in the northern part of the species' range.

If there is an increasing proportion of females farther up a drainage, it may be prudent to harvest differentially fewer eels farther up drainages.

Weir fisheries, pot fisheries with mesh-size limits, and eel-size limits all shift the harvest toward a greater percentage of females. Because of the sexual dimorphism, the larger the mesh or the larger the size limit, the greater the pressure is transferred to prereproductive females. Further, because females are longer lived than males, greater fishing pressure is transferred to prereproductive females. This is exactly opposite from the desirable effect. It is more logical, if anything, to place a maximum size limit on the harvest of eels. Such a measure

is clearly against conventional wisdom for managing fishes, but this is an unconventional species.

States and provinces that do not allow weir fisheries prudently protect females, whether they know it or not. Only Maine and, to a very limited degree, New York allow weir fisheries for eels.

Likewise, states and provinces that restrict commercial fishing in fresh waters prudently protect females, whether they know it or not. Most states have a substantial or complete restriction on such fishing. Not Maine.

On the other hand, most states and provinces have minimum size limits on commercial eel harvest, generally 4 inches, 6 inches or 8 inches. I do not believe these jurisdictions made those regulations on any basis other than transfer of practices from management of other species, such as trout or bass. In the extreme, Prince Edward Island has a minimum size limit of 18 inches for eels. Other Maritime Provinces are considering similar regulations. This practice would ensure that nearly all harvested eels would be females, a completely counterproductive measure.

Just because other jurisdictions have similar regulation, we should not make the assumption that the regulations have biological basis. Maine should strive gain the information necessary to base regulations in accord with the life cycle of the eel.

IMPLICATIONS FROM MORTALITY RATES

Management of commercial and recreational harvest of fishes (or tolerance of dams and pollution) has always been based on the assumption that there are compensatory mechanisms within the biology of the species, i.e. mechanisms that allow increased survival or increased reproduction of the nonharvested individuals, so the population does not decline. This is the concept of sustainable yield. The key to success of this approach is to understand what the compensatory mechanisms are and when they occur in the life cycle with respect to when harvest occurs.

Again, the eel is unique because of its high-fecundity, high-mortality characteristic. It seems unlikely to me that major compensatory mechanisms are to be found in the oceanic stages of the life cycle. The leptocephali probably have the highest mortality. Food limitation and inability to reach the continental shelf may be the critical factors, neither of which is under control of the leptocephali. Silver eels on migration to the Sargasso Sea to spawn probably have the lowest mortality, and they also have little opportunity for compensating mortality earlier in the life cycle.

In the elver-yellow eel stages, there is high mortality, but there is also the greatest likelihood of compensatory mechanisms for added mortality due to human activities. Because this is the growth phase, competition for food may occur among individual eels, causing starvation or at least slowing the growth. Reduced density of eels *may* result in higher survival, greater growth rate, and perhaps higher fecundity. On the other hand, not all outcomes of reduced density are

predictable. Because the mechanisms of gender determination are not known for eels, reduced density could increase the ratio of females to males (a positive compensatory mechanism) or decrease the ratio of females to males (a negative compensatory effect). However, most density-dependent effects are negative and have positive compensatory mechanisms.

I illustrate the subtle effects of compensatory mechanisms with a *hypothetical* numerical example. For the example, assume an average female has a fecundity of 1,000,000 eggs. Only one female and (less than) one male need to survive from those million eggs and reproduce to maintain a stable population. In the first scenario, I assume there is a compensatory mechanism for harvesting that can occur anytime after harvesting, regardless of when the harvesting occurs. In the second scenario, I assume there is a slightly greater compensatory mechanism in the yellow eel stage (likely, as described above).

- Scenario 1. Minor compensatory mechanism any time.
  - ◇ Fecundity 1,000,000 eggs produced by average female.
  - ◇ Assume 99.9% die at sea as leptocephali, leaving 1,000 glass eels.
  - ◇ Assume 99.2% of those die becoming silver eels, leaving 8 to migrate seaward.
  - ◇ Assume a harvest of half the migrating silver eels (4), leaving 4 migrants.
  - ◇ Assume 50% of those die, leaving 2 successful spawners.

  - ◇ Fecundity 1,000,000 eggs.
  - ◇ 99.9% die as leptocephali, leaving 1,000 glass eels.
  - ◇ Harvest half the migrating glass eels, leaving 500.
  - ◇ 99.2% die before becoming silver eels, leaving 4 to migrate.
  - ◇ 50% of those die leaving 2 successful spawners.

  - ◇ Conclusion: In this scenario, it does not matter when in the life cycle eels are harvested as long as the allowed harvest is set by actual mortality rates, rather than the hypothetical ones used in the examples here. Alternatively, harvest of a combination of life stages is possible, again as long as actual mortality rates are applied.

- Scenario 2. Greater compensatory mechanism in yellow eel stage.
  - ◇ Fecundity 1,000,000 eggs.
  - ◇ 99.9% die as leptocephali, leaving 1,000 glass eels.
  - ◇ Harvest half the migrating glass eels, leaving 500.
  - ◇ Now, if there is compensation such that mortality is reduced in the yellow eels stage by only 1%, 98.2% die before becoming silver eels, leaving 9 to migrate seaward.
  - ◇ Harvest half the migrating silver eels (4 or 5), leaving 4 to migrate.

- ◇ 50% of those die leaving 2 successful spawners.

- ◇ Conclusion: In this scenario, harvest of glass eels has no effect on the harvest of silver eels because of a compensatory mechanism in the yellow eel stage. Again harvest size needs to be determined with actual mortality rates.

CONCLUSIONS

I conclude from the two previous sections that there is no biological basis for assuming that harvest of glass eels *per se* is detrimental to the conservation of the American eel. Under certain conditions, the harvest of glass eels could have less detrimental effect on conservation than harvest of silver eels. Under certain conditions, the harvest of glass eels could occur while having little or no detrimental effect on harvest of silver eels.

I also conclude that the current regulatory structure for eels in the States and Provinces in the eel's range is not based upon sound biological principles. However, unregulated or unsoundly regulated commercial fishing in Maine and other jurisdictions is distinctly unwise. By testifying in opposition to this bill, I am not implying that there is not cause for concern and for possible regulations on commercial fishing for eels.

SCIENTIFIC RECOMMENDATIONS FOR CONSERVATION AND MANAGEMENT

In the short term for decision making in Maine, the following steps are important.

- Mortality rates and sources of mortality in the glass eel, yellow eel and early silver eels stages need to be determined to allow estimates of how much harvest could be allowed in what stages of life without deleterious effect on the stock.
  - ◇ Determine sources and rates of natural mortality, and determine whether there is density-dependent mortality, which involves determination of food-webs and predator-prey relations.
  - ◇ Determine sources and rates of anthropogenic mortality at different stages, which includes fishing mortality and nonfishing mortality (fish passage at dams, pollution, hydroelectric turbines, etc.).

- Fishing mortality needs to be determined from the activities of the fishing industry.
  - ◇ A licensing system for fresh waters and tidal waters specific to commercial fishing for eels should be instituted.
  - ◇ A reporting system for commercial catches by life-cycle stage or gear needs to be associated with the licensing system.

- Growth rates of males and females and fecundity of females of various sizes needs to be determined to allow assesment of harvest practices on the reproductive potential of the migrants that do migrate to sea to spawn.

- The distribution of sex ratio throughout selected drainages needs to be determined to allow assessment of harvest practices on abundance of females and males.

In the long term for decision making over the geographic range of the eel, the following steps are important.

- The mechanism of gender determination in eels needs to be understood, so effects of harvest practice on sex ratios can be determined.

- The distribution of sex ratio over the geographic range needs to be determined, so harvest practice could be adjusted over the range as appropriate to the life cycle.

APPENDIX II

NC Marine Fisheries Commission Rule 15A NCAC 03O .0504:

15A NCAC 03O .0504 SUSPENSION/REVOCATION OF PERMITS

(a) For violation of specific permit conditions (as specified on the permit), permits may be suspended or revoked according to the following schedule:

(1) violation of one specific condition in a three year period, permit shall be suspended for 10 days;
(2) violation of two specific conditions in a three year period, permits shall be suspended for 30 days;
(3) violation of three specific conditions in a three year period, permits shall be revoked for a period not less than six months.

If the permit condition violated is the refusal to provide information upon request by Division staff, either by telephone, in writing or in person, the Fisheries Director may suspend the permit. Such permit may be reinstated 10 days after the requested information is provided.

(b) All permits will be suspended or revoked when the permittee's license privilege has been suspended or revoked as set out in G.S. 113-171. The duration of the suspension or revocation shall be the same as the license suspension or revocation. In the event the person makes application for a new permit during any period of license suspension, no new permit will be issued during the suspension period. In case of revocation of license privileges, the minimum waiting period before application for a new permit to be considered will be six months.

(c) Permit designees shall not be permitted to participate in a permit operation during any period they are under license suspension or revocation.

(d) Upon service of a notice of suspension or revocation of a permit, it is unlawful to fail to surrender any permit so suspended or revoked.

Appendix III

NC General Statute 113-170.3:

G.S. 113-170.3. Record-keeping requirements.

(a) The Commission may require all licensees under this Article to keep and to exhibit upon the request of an authorized agent of the Department records and accounts as may be necessary to the equitable and efficient administration and enforcement of this Article. In addition, licensees may be required to keep additional information of a statistical nature or relating to location of catch as may be needed to determine conservation policy. Records and accounts required to be kept must be preserved for inspection for not less than three years.

(b) It is unlawful for any licensee to refuse or to neglect without justifiable excuse to keep records and accounts as may be reasonably required. The Department may distribute forms to licensees to aid in securing compliance with its requirements, or it may inform licensees of requirements in other effective ways such as distributing memoranda and sending agents of the Department to consult with licensees who have been remiss. Detailed forms or descriptions of records, accounts, collection and inspection procedures, and the like that reasonably implement the objectives of this Article need not be embodied in rules of the Commission in order to be validly required.

(c) The following records collected and compiled by the Department shall not be considered public records within the meaning of Chapter 132 of the General Statutes, but shall be confidential and shall be used only for the equitable and efficient administration and enforcement of this Article or for determining conservation policy, and shall not be disclosed except when required by the order of a court of competent jurisdiction: all records, accounts, and reports that licensees are required by the Commission to make, keep, and exhibit pursuant to the provisions of this section, and all records, accounts, and memoranda compiled by the Department from records, accounts, and reports of licensees and from investigations and inspections, containing data and information concerning the business and operations of licensees reflecting their assets, liabilities, inventories, revenues, and profits; the number, capacity, capability, and type of fishing vessels owned and operated; the type and quantity of fishing gear used; the catch of fish or other seafood by species in numbers, size, weight, quality, and value; the areas in which fishing was engaged in; the location of catch; the time of fishing, number of hauls, and the disposition of the fish and other seafood. The Department may compile statistical information in any aggregate or summary form that does not directly or indirectly disclose the identity of any licensee who is a source of the information, and any compilation of statistical information by the Department shall be a public record open to inspection and examination by any person, and may be disseminated to the public by the Department. (1997-400, s.5.1; 2001-213, s. 2.)

NC Marine Fisheries Commission Rule 15A NCAC 03O .0502:

15A NCAC 03O .0502 PERMIT CONDITIONS; GENERAL

The following conditions apply to all permits issued by the Fisheries Director:

(1) it is unlawful to operate under the permit except in areas, at times, and under conditions specified on the permit;

(2) it is unlawful to operate under a permit without having the permit or copy thereof in possession of the permittee or his or her designees at all times of operation and the permit or copy thereof shall be ready at hand for inspection, except for Pound Net Permits;

(3) it is unlawful to operate under a permit without having a current picture identification in possession and ready at hand for inspection;

(4) it is unlawful to refuse to allow inspection and sampling of a permitted activity by an agent of the Division;

(5) it is unlawful to fail to provide complete and accurate information requested by the Division in connection with the permitted activity;

(6) it is unlawful to hold a permit issued by the Fisheries Director when not eligible to hold any license required as a condition for that permit as stated in 15A NCAC 03O .0501;

(7) it is unlawful to fail to provide reports within the timeframe required by the specific permit conditions;

(8) it is unlawful to fail to keep such records and accounts as required by the rules in this Chapter for determination of conservation policy, equitable and efficient administration and enforcement, or promotion of commercial or recreational fisheries;

(9) it is unlawful to assign or transfer permits issued by the Fisheries Director, except for Pound Net Permits as authorized by 15A NCAC 03J .0504;

(10) the Fisheries Director, or his agent, may, by conditions of the permit, specify any or all of the following for the permitted purposes:

(a) species;
(b) quantity or size;
(c) time period;
(e) location;
(d) means and methods;
(f) disposition of resources;
(g) marking requirements; or
(h) harvest conditions.

(11) unless specifically stated as a condition on the permit, all statutes, rules and proclamations shall apply to the permittee and his or her designees; and

(12) as a condition of accepting the permit from the Fisheries Director, the permittee agrees to abide by all conditions of the permit and agrees that if specific conditions of the permit, as identified on the permit, are violated or if false information was provided in the application for initial issuance, renewal or transfer, the permit may be suspended or revoked by the Fisheries Director.

APPENDIX IV

NC Marine Fisheries Commission Rule 15A NCAC 03O .0501:

15A NCAC 03O .0501 PROCEDURES AND REQUIREMENTS TO OBTAIN PERMITS

(a) To obtain any Marine Fisheries permit, the following information is required for proper application from the applicant, a responsible party, or person holding a power of attorney:

(1) Full name, physical address, mailing address, date of birth, and signature of the applicant on the application. If the applicant is not appearing before a license agent or the designated Division contact, the applicant's signature on the application shall be notarized;

(2) Current picture identification of applicant, responsible party, or person holding a power of attorney. Acceptable forms of picture identification are driver's license, North Carolina Identification card issued by the North Carolina Division of Motor Vehicles, military identification card, resident alien card (green card), or passport; or if applying by mail, a copy thereof;

(3) Full names and dates of birth of designees of the applicant who will be acting under the requested permit where that type permit requires listing of designees;

(4) Certification that the applicant and his designees do not have four or more marine or estuarine resource convictions during the previous three years;

(5) For permit applications from business entities:

(A) Business Name;

(B) Type of Business Entity: Corporation, partnership, or sole proprietorship;

(C) Name, address, and phone number of responsible party and other identifying information required by this Subchapter or rules related to a specific permit;

(D) For a corporation, current articles of incorporation and a current list of corporate officers when applying for a permit in a corporate name;

(E) For a partnership, if the partnership is established by a written partnership agreement, a current copy of such agreement shall be provided when applying for a permit; and

(F) For business entities, other than corporations, copies of current assumed name statements if filed and copies of current business privilege tax certificates, if applicable; and

(6) Additional information as required for specific permits.

(b) A permittee shall hold a valid Standard or Retired Standard Commercial Fishing License in order to hold a:

(1) Pound Net Permit;

(2) Permit to Waive the Requirement to Use Turtle Excluder Devices in the Atlantic Ocean; or

(3) Atlantic Ocean Striped Bass Commercial Gear Permit.

(c) A permittee and his designees shall hold a valid Standard or Retired Standard Commercial Fishing License with a Shellfish Endorsement or a Shellfish License in order to hold a:

(1) Permit to Transplant Prohibited (Polluted) Shellfish;

(2) Permit to Transplant Oysters from Seed Oyster Management Areas;

(3) Permit to Use Mechanical Methods for Shellfish on Shellfish Leases or Franchises;

(4) Permit to Harvest Rangia Clams from Prohibited (Polluted) Areas; or

(5) Depuration Permit.

(d) A permittee shall hold a valid:

(1) Fish Dealer License in the proper category in order to hold Dealer Permits for Monitoring Fisheries Under a Quota/Allocation for that category; and

(2) Standard Commercial Fishing License with a Shellfish Endorsement, Retired Standard Commercial Fishing License with a Shellfish Endorsement or a Shellfish License in order to harvest clams or oysters for depuration.

(e) Aquaculture Operations/Collection Permits:

(1) A permittee shall hold a valid Aquaculture Operation Permit issued by the Fisheries Director to hold an Aquaculture Collection Permit.

(2) The permittee or designees shall hold appropriate licenses from the Division of Marine Fisheries for the species harvested and the gear used under the Aquaculture Collection Permit.

(f) Atlantic Ocean Striped Bass Commercial Gear Permit:

(1) Upon application for an Atlantic Ocean Striped Bass Commercial Gear Permit, a person shall declare one of the following gears for an initial permit and at intervals of three consecutive license years thereafter:
(A) gill net;
(B) trawl; or
(C) beach seine.
For the purpose of this Rule, a "beach seine" is defined as a swipe net constructed of multi-filament or multi-fiber webbing fished from the ocean beach that is deployed from a vessel launched from the ocean beach where the fishing operation takes place.
Gear declarations shall be binding on the permittee for three consecutive license years without regard to subsequent annual permit issuance.

(2) A person is not eligible for more than one Atlantic Ocean Striped Bass Commercial Gear Permit regardless of the number of Standard Commercial Fishing Licenses, Retired Standard Commercial Fishing Licenses or assignments held by the person.

(g) Applications submitted without complete and required information shall not be processed until all required information has been submitted. Incomplete applications shall be returned to the applicant with deficiency in the application so noted.

(h) A permit shall be issued only after the application has been deemed complete by the Division of Marine Fisheries and the applicant certifies to abide by the permit general and specific conditions established under 15A NCAC 03J .0501, .0505, 03K .0103, .0104, .0107, .0111, .0401, 03O .0502, and .0503 as applicable to the requested permit.

(i) The Fisheries Director, or his agent may evaluate the following in determining whether to issue, modify, or renew a permit:

(1) Potential threats to public health or marine and estuarine resources regulated by the Marine Fisheries Commission;

(2) Applicant's demonstration of a valid justification for the permit and a showing of responsibility as determined by the Fisheries Director; and

(3) Applicant's history of habitual fisheries violations evidenced by eight or more violations in 10 years.

(j) The Division of Marine Fisheries shall notify the applicant in writing of the denial or modification of any permit request and the reasons therefor. The applicant may submit further information, or reasons why the permit should not be denied or modified.

(k) Permits are valid from the date of issuance through the expiration date printed on the permit. Unless otherwise established by rule, the Fisheries Director may establish the issuance timeframe for specific types and categories of permits based on season, calendar year, or other period based upon the nature of the activity permitted, the duration of the activity, compliance with federal or state fishery management plans or implementing rules, conflicts with other fisheries or gear usage, or seasons for the species involved. The expiration date shall be specified on the permit.

(l) For permit renewals, the permittee's signature on the application shall certify all information as true and accurate. Notarization of signature on renewal applications shall not be required.

(m) For initial or renewal permits, processing time for permits may be up to 30 days unless otherwise specified in this Chapter.

(n) It is unlawful for a permit holder to fail to notify the Division of Marine Fisheries within 30 days of a change of name or address, in accordance with G.S. 113-169.2.

(o) It is unlawful for a permit holder to fail to notify the Division of Marine Fisheries of a change of designee prior to use of the permit by that designee.

(p) Permit applications are available at all Division Offices.