DRAFT – SUBJECT TO CHANGE

APPENDIX X.X. COLD STUN MANAGEMENT

ISSUE

Implement additional management measures to protect spotted seatrout spawning stock biomass after periodic cold stun events.

ORIGINATION

The North Carolina Division of Marine Fisheries (DMF).

BACKGROUND

Spotted seatrout (*Cynoscion nebulosus)* and other finfish that over-winter in estuarine environments in North Carolina are susceptible to periodic cold stun events. Cold stun events occur when water temperatures drop below a fish's metabolic minimum, impairing their physiological functions and rendering them lethargic or immobile. These events are associated with rapid weather changes that disrupt the thermal balance of coastal waters. In North Carolina, cold stuns can be triggered by snow and ice melt following a winter storm or by sudden and-or prolonged periods of cooler temperatures from cold fronts. Cold stun events can be localized to individual tributaries, or they can be widespread across multiple estuaries. Mass mortality events can occur in these periods of sub-optimal water temperatures because the impaired function of the fish makes them unable to move to warmer waters. Cold stuns are not always lethal, but if water temperatures drop too low or remain low for too long and fish are unable to move to find thermal refuge, they are unlikely to survive. Fish in a stunned state are also easy targets for scavengers, predators, and can be susceptible to harvest with methods like dip nets.

Cold Tolerance

To better understand environmental conditions that lead to spotted seatrout cold stuns, several studies have investigated the temperatures at which spotted seatrout become stunned and experience mortality. In North Carolina, laboratory experiments suggest the temperatures in which spotted seatrout become stunned, or experience a complete loss of equilibrium, range from 2 to 4°C (Ellis et al. 2017). However, spotted seatrout begin showing signs of stress at temperatures as high as 7°C. An adult spotted seatrout's critical thermal minimum, or the lowest temperature spotted seatrout can be exposed to for a short time and still survive, was found to be approximately between 2-3°C. When adult spotted seatrout were acclimated and exposed over time to low water temperatures, a water temperature of 3°C was found to be 100% lethal after less than 2 days (Ellis et al. 2017). At 5°C, 93% were still alive after 5 days, but only 15% survived after 10 days. There was high survival (83%) after 10 days at 7°C. Based on this research, we have learned that spotted

seatrout's survival of cold stun events is not only related to water temperature, but also the length of time they are exposed to these stressful conditions. Similar studies from South Carolina and Texas conducted on spotted seatrout saw comparable temperatures leading to spotted seatrout loss of equilibrium and mortality (Anweiler et al. 2014; McDonald et al. 2010), although lower temperatures were required to induce mortality in adults (~2°C) than juvenile (~3°C) spotted seatrout, indicating the possibility of size-dependent mortality (McDonald et al. 2010).

For spotted seatrout, cold water temperatures disrupt cellular processes, making it difficult to maintain osmotic balance of ion concentrations within their body (Hurst 2007). If temperatures drop below a threshold for long enough, and the fish is unable to leave the area, the imbalance will impact their central nervous system and result in loss of equilibrium, causing the "stunned" response where fish float on top of the water or lay along the bottom.

Population Impacts of Cold Stuns

Spotted seatrout mature quickly, with most able to reproduce by age one. Spotted seatrout are also highly fecund, meaning they can produce many offspring within a spawning season and over an individual's lifetime. Females spawn multiple times throughout a season and can produce 3-20 million eggs per year (Murphy et al., 2010; Nieland et al., 2002; Roumillat & Brouwer, 2004). Though spotted seatrout have a high capacity to replenish spawning stock biomass (SSB), they are also especially susceptible to cold stuns due to their limited tolerance for abrupt temperature shifts, particularly when these shifts occur outside of their preferred thermal range (Ellis, 2014). North Carolina spotted seatrout are more so susceptible to being impacted by cold stuns because they are near the northern extent of their geographical range.

Cold stun mortality has been shown to have population-level effects on spotted seatrout in North Carolina (NCDMF 2012; Ellis 2014; Ellis et al. 2018) by reducing stock size and annual cohort strength (Hurst 2007). Overall, the rate of mortality due to fishing activity or natural causes like cold stuns vary seasonally and annually. Using tag return data, spotted seatrout natural mortality has been estimated to be higher than fishing mortality during winters in which cold stuns occurred (Ellis et al. 2018; Loeffler et al. 2018; Bauer and Flowers 2019). The division does not have a method to quantify the severity of a cold stun on spotted seatrout SSB in real-time, or as the cold temperatures are occurring. However, eliminating or reducing harvest after a cold stun event protects the remaining SSB by ensuring surviving adults have a chance to spawn.

Compared to other commercially and recreationally important fish species in North Carolina, spotted seatrout are more likely to experience population-level impacts from cold stun events. Spotted seatrout are a subtropical fish species, with North Carolina being one of the northernmost points of their range. Consequently, spotted seatrout are not as well adapted as other species to withstand winters with below average temperatures and winter

storms that occur every few years. In addition, spotted seatrout in North Carolina overwinter in shallow estuarine creeks and bays which makes them more susceptible to being stunned or dying compared to other species that overwinter offshore, like weakfish, adult red drum, and mature southern flounder (Ellis 2014; Ellis et al. 2017b; McGrath and Hilton 2017; Bacheler et al. 2009; Krause et al. 2020). By overwintering in shallow creeks and bays, spotted seatrout have an increased risk of exposure to rapid declines in water temperature, usually due to runoff following snow or ice melt from a winter storm. Spotted seatrout can also become trapped in estuarine creeks due to rapid water temperature drops making escape difficult and mortality likely.

North Carolina Cold Stun Response

In 2015, the NCDMF started a comprehensive, statewide water quality monitoring program (Program 909) and deployed an array of continuous water temperature loggers. A total of 80 loggers at 55 stations measure the water temperature every 15 minutes. Station locations are distributed throughout coastal North Carolina with specific locations that staff determined were either representative of the riverine and estuarine systems they were in and-or locations of historic cold stuns (Figure X). At depths greater than 2 meters, two loggers were placed to monitor temperatures at the surface and bottom to help managers identify water column stratification and turnover events.

Combining known spotted seatrout temperature tolerances and available water temperature data allows for more quantitative information that can be used in determining the necessity of a potential fishery closure. Quantitative temperature triggers that incorporate estimated probabilities of mortality could inform spotted seatrout fishery closure decisions.

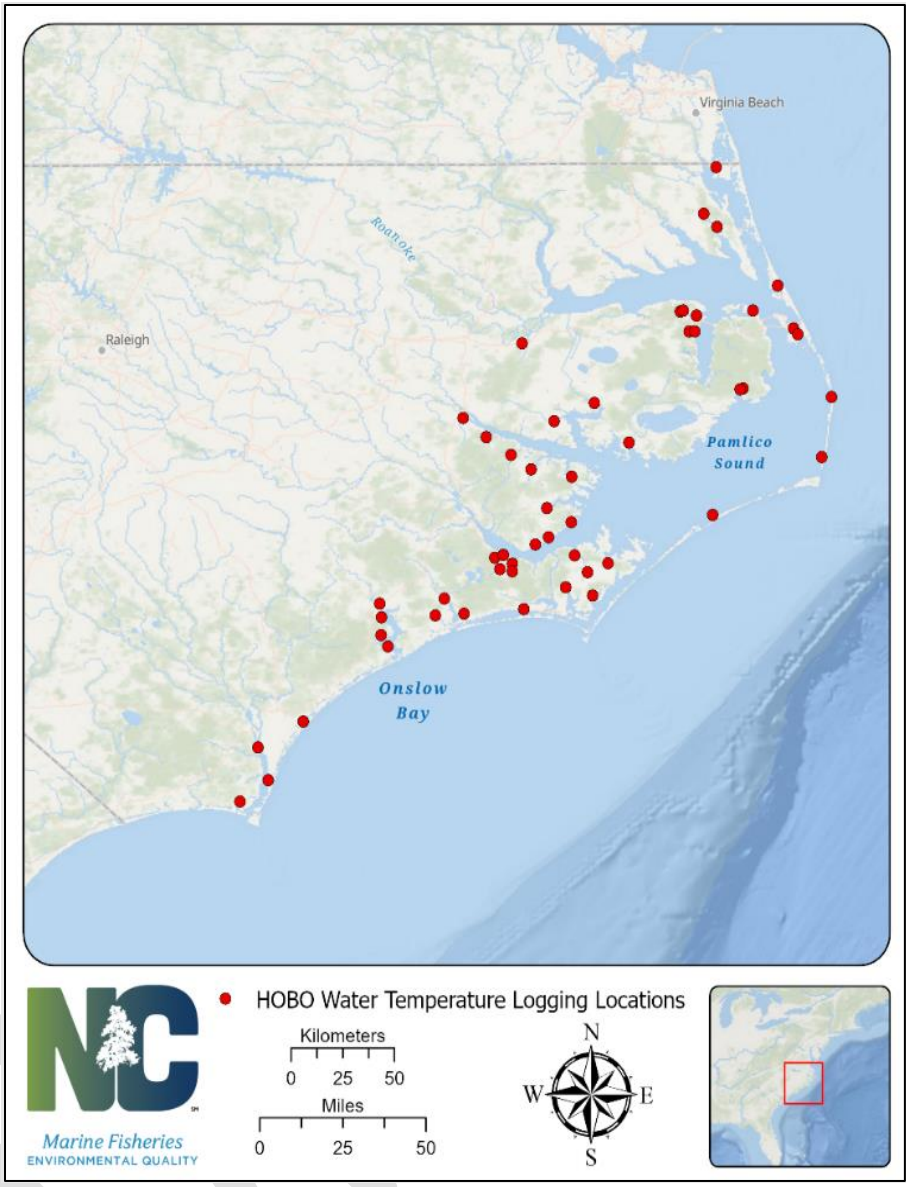

Figure X. Locations of NCDMF water temperature loggers in coastal North Carolina.

Mortality due to cold stuns is recognized in the 2012 Spotted Seatrout Fishery Management Plan (FMP) as a factor impacting the abundance of spotted seatrout in North Carolina (NCDMF 2012). At their February 2012 business meeting, the Marine Fisheries Commission (MFC) directed the division to remain status quo regarding spotted seatrout management, with the assumption that in the event of a "catastrophic" cold stun the director would use proclamation authority to enact a temporary closure (NCDMF 2012). The objective of a spotted seatrout fishery closure after a cold stun event is to allow surviving fish an opportunity to spawn during their spring spawning season, potentially increasing recruitment the following year.

Spotted seatrout have a long history of cold stuns and winter mortality in North Carolina. Spotted seatrout cold stuns have been recorded in North Carolina as far back as over 300

years, and have occurred as recently as the winters of 2000, 2002, 2004, 2009, 2010, 2013, 2014, 2017, and 2022.

AUTHORITY

G.S. 113-134 RULES
G.S. 113-182 REGULATION OF FISHING AND FISHERIES
G.S. 113-182.1 FISHERY MANAGEMENT PLANS
G.S. 113-221.1. PROCLAMATIONS; EMERGENCY REVIEW
G.S. 143B-289.52 MARINE FISHERIES COMMISSION-POWERS AND DUTIES
15A NCAC 03H .0103 PROCLAMATIONS, GENERAL
15A NCAC 03M .0512 COMPLIANCE WITH FISHERY MANAGEMENT PLANS
15A NCAC 03M .0522 SPOTTED SEATROUT

DISCUSSION

Several management strategies can be used to further protect spotted seatrout SSB after periodic cold stun events. These strategies may include temporary slot limits, fishery closures, spatial (area) closures, or some combination of these options. Management strategies also include the need for the use of adaptive management. Given the inherent difficulty in quantifying the severity of cold stun events as they occur, subsequent management strategies also lack precise quantification methods to determine effectiveness. The proposed management strategies are therefore grounded in a pragmatic, common-sense approach to protect SSB.

Slot Limits

Size and slot limits are a common management strategy to limit harvest of specific size and-or age classes of fish in a stock. By setting a minimum size limit based on length at maturity, management can ensure a portion of the females in the stock have a chance to spawn at least once before harvest. The upper bound of a slot limit likewise helps protect larger females which have a greater reproductive capacity, meaning they can produce more eggs. Theoretically, the ability of the spotted seatrout stock to recover faster after significant cold stun event, would be enhanced if larger females are protected. Estimates of spotted seatrout fecundity range from 3 to 20 million eggs per year depending on age, length, and water temperature (Lowerre-Barbieri et al., 2009; Nieland et al., 2002; Roumillat & Brouwer, 2004). Spotted seatrout are batch spawners, meaning they can spawn multiple times in one season. The number of eggs produced within each batch also depends on age and length (Figure X). Spotted seatrout fecundity estimates specific to North Carolina and Virginia are not available at this time.

For example, if a slot limit with a trophy fish allowance is adopted for sustainable harvest (Appendix X.XX, this amendment), the slot limit could be temporarily narrowed and-or the trophy fish allowance could be temporarily removed. Reducing or narrowing the slot limit following a closure, whether by increasing the lower bound or decreasing the upper bound, would ensure more mature fish are available to spawn. Because larger females are more fecund, it may be more important to focus on their protection after a cold stun event. This could be achieved by removing any prospective trophy fish allowance and-or by decreasing the upper bound of the slot limit in response to a severe cold stun event. This temporary slot limit could be put into place until after the peak spawning season (July) or until after most of the spawning season (October).

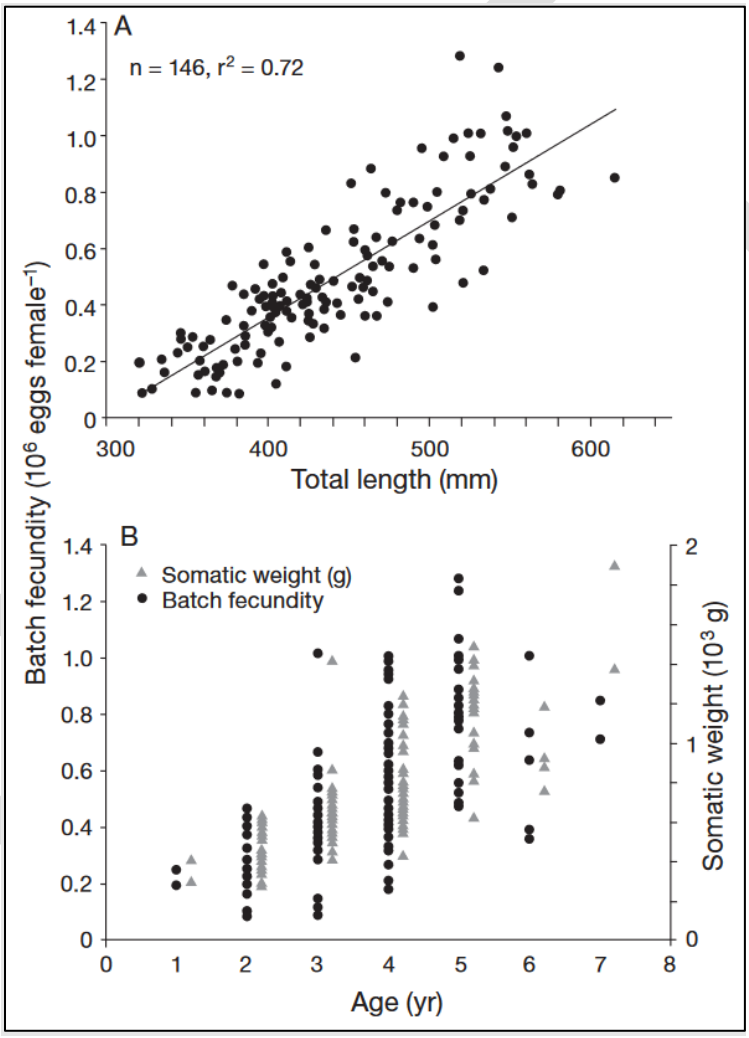

Figure X. Taken from Lowerre-Barbieri et al. (Lowerre-Barbieri et al., 2009). Batch fecundity as it relates to size at age or spotted seatrout. (A) Batch fecundity to total length, with the predicted linear relationship, and (B) individual batch fecundities and somatic weights plotted by age.

Seasonal Closures

The spawning season for spotted seatrout varies by location (Brown-Peterson et al., 2002; Nieland et al., 2002; Roumillat & Brouwer, 2004) and can occur with one or two peaks in spawning activity. In North Carolina, spotted seatrout have a protracted spawning season, usually lasting from April to October (Burns, 1996). Larger and older females are more developed at the beginning of the spawning season and will spawn sooner than smaller fish and also will spawn for a more protracted season. Smaller fish, that are virgin spawners at the beginning of the season, might enter the spawning stock and spawn later in the year through October.

Following a significant cold stun event, the spotted seatrout fishery has historically been closed until June 15th. North Carolina spotted seatrout have been observed to have a peak in spawning activity in May and June (Burns, 1996), with some individuals spawning later into the fall months. The option to maintain the status quo would continue to close the fishery until June 15th after a significant cold stun event. However, extending the standard closure to June 30th may ensure that more of the spawning peak is protected and would likely allow most of the larger, older fish to spawn at least once before the chance of significant harvest. Another option would be to extend the standard closure until October 15th, ensuring most surviving fish have the opportunity to spawn during the entire spawning season, but this would result in less fishing opportunities for anglers and likely have a diminishing return for the stock over protection during the peak spawn.

Area Closures

Historically, cold stun events have varied in their spatial impacts and have ranged from a few isolated creeks in one river system to multiple riverine and estuarine systems. Cold stun events can also occur over large areas of the state, causing more significant losses in all major systems.

Previous cold stun closures have closed the spotted seatrout fishery statewide. Tagging and genetics data suggest that spotted seatrout exhibit high site fidelity to their natal estuary with periods of greater movement during the spawning season (Ellis, 2014; O'Donnell et al., 2014; Ward et al., 2007). This, coupled with limited movement in the winter months, supports the idea that effects of a cold stun may vary regionally. Using available information about spotted seatrout temperature tolerances, mortality probabilities to sub-optimal temperature exposure, and available continuous water temperature monitoring, the division could potentially identify areas of concern when freezing temperatures are predicted to occur. However, the division does not have the ability to quantify or predict the severity of a cold stun event so selecting specific areas for closures would be difficult and may minimize the overall desired impact of maximizing spawning potential following a significant cold stun event.

A statewide closure encompasses all estuarine and riverine systems where spotted seatrout overwinter, protecting all spotted seatrout in North Carolina from fishing pressure. This ensures areas without documented kills or continuous water temperature monitoring are still protected and that remaining spotted seatrout will have the opportunity to spawn before being subject to harvest. However, this strategy will cause fishing opportunities to be lost in areas that may not be affected by cold stun conditions. However, a tradeoff would be that a statewide closure protects fish that may migrate into open areas during more active movement periods during the onset of the spawning period. A statewide closure will also aide Marine Patrol in enforcement of the closure and not burden fisherman with changing boundaries. Further, spotted seatrout are assessed and managed as a single stock in North Carolina. Simply closing a small area or region where a cold stun is observed will shift effort to surviving portions of the stock and potentially amplify the negative effects of a cold stun event.

Adaptive Management

The current adaptive management framework for cold stun events allows the Director to close the spotted seatrout fishery through June 15th following a significant cold stun event. Since the adoption of the original FMP in 2012 the spotted seatrout fishery has been closed twice due to cold stun events (2014 and 2018). The adaptive management framework for cold stun event closures can be refined to further aid in stock recovery following a cold stun event. Adaptive management may be used to temporarily adjust management measures such as size or slot limits, season closures, trip limits, bag limits, and gear requirements if it is determined that additional protections for the stock are needed after a significant cold stun event. Management needed will take into consideration factors such as the size and scope of the cold stun event, the rate of air and water temperature change, and the length of exposure to extreme temperatures. Below is an example of a revised adaptive management framework for cold stun events for consideration.

1) If a significant cold stun event occurs the Director will close the spotted seatrout fishery statewide through June 15th.
2) Temporary measures that may be implemented through adaptive management to aid in stock recovery after the standard closure period following a cold stun event include:
    a. recreational bag limit
    b. commercial trip limit
    c. size limit changes
    d. seasonal closure
    e. gill net yardage restrictions
    f. Use of adaptive management to further aid in stock recovery once the fishery reopens following a cold stun event is contingent on approval by the Marine Fisheries Commission

PROPOSED MANAGEMENT OPTIONS

(+ potential positive impact of action)
(- potential negative impact of action)

1. **Status quo; do not implement additional post-cold stun management measures. The spotted seatrout fishery will close, state-wide, until June 15th following a documented significant cold stun event.**
   + Stakeholder satisfaction in maintaining consistency with previous closures
   - Current reopening date of June 15th may not last past the peak in spawning activity

2. **Close the spotted seatrout fishery, state-wide, until June 30th following a significant cold stun event.**
   + Protects adult fish past the peak in spawning activity
   + Allows more fish to spawn at least once
   + Maximizes spawning potential of larger fish
   - Lost fishing opportunity

3. **Implement or amend a state-wide, temporary, narrow slot limit through October 15th as part of the standard response following a cold stun event.**
   + Prioritizes the protection of larger females with a greater reproductive capacity
   + Will allow more larger, more fecund fish to spawn
   - Lost resource access
   - Additional regulatory complexity

4. **Close the spotted seatrout fishery, state-wide, until October 15th following a significant cold stun event.**
   + Protects adults throughout most of the spawning season
   + Allows more fish to spawn at least once
   - Lost fishing opportunity

5. **Implement adaptive management framework.**
   + Greater flexibility without the requirement to amend or supplement the FMP
   + Improved decision making with more real time monitoring and evaluation
   - Increased potential for management changes for public

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