No. 142, Original

In The
Supreme Court of the United States

STATE OF FLORIDA,

Plaintiff,

v.

STATE OF GEORGIA,

Defendant.

DIRECT TESTIMONY OF ROMUALD N. LIPCIUS, Ph.D.

October 26, 2016

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INTRODUCTION AND OVERVIEW

1. I, Romuald N. Lipcius, Ph.D., offer the following as my Direct Testimony.

2. I am a fisheries management and marine ecology professor at the Virginia Institute of Marine Science, College of William & Mary, Department of Fisheries Science. I have over 35 years of experience in studying the biology of the eastern oyster and other marine species and in researching and advising marine fisheries and their management.

3. I was asked by the State of Georgia to analyze the claims made by the State of Florida that Georgia's water consumption caused the collapse of the Apalachicola Bay oyster fishery in 2012. I also was asked to assess whether there was scientific evidence supporting Florida's assertion that low flows from the Apalachicola River otherwise reduced biological productivity in the Bay.

4. In addition, I evaluated analyses and conclusions that were conducted by the State of Florida's experts, Drs. J. Wilson White and David R. Kimbro, related to the above issues.[1]

5. To perform this research, I identified and analyzed official data and information collected by the State of Florida and federal agencies regarding the oyster and stone crab fisheries in Apalachicola Bay and Apalachee Bay from the last 3 decades, and in some cases longer, including information and data concerning:

(a) harvest practices and pressure on the oyster and stone crab resources;

(b) oyster habitat, river flow, and oyster bar conditions in Apalachicola Bay;

(c) fishery management actions taken by the State of Florida;

(d) oyster, stone crab, and rock snail biology and population dynamics; and,

(e) fishery production for species other than oysters.

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[1] Florida recently provided new analyses performed by Drs. Kimbro and White in their written directs on October 14, 2016, and additional materials that Drs. Kimbro and White relied on in support of such analyses on October 20, 2016. Given the limited time I have had to review this new material, I reserve my right to supplement or modify my testimony related to these additional analyses after I have had more time to review them.

6. I also reviewed the testimony of Florida state officials responsible for fishery management, the testimony of oyster experts from the University of Florida who researched the decline of the Apalachicola Bay oyster population, and other documents and exhibits that were produced as part of the trial discovery materials in this case.

7. My opinions and conclusions are based on: (1) the work I completed in the course of providing an expert report in this case; (2) my 35 years' experience studying the biology of the eastern oyster and other marine species and the marine fisheries that manage the harvest of such animals; and (3) my extensive experience conducting research and providing technical and restoration advice to fishery management regarding the eastern oyster and other invertebrate species.

SUMMARY OF OPINIONS AND CONCLUSIONS

8. I conclude to a high degree of scientific certainty that low river flow from the Apalachicola River did not cause the 2012-2013 Apalachicola Bay oyster fishery collapse. The scientific evidence does not support that conclusion. This evidence includes the following:

(a) Total oyster abundance did not decline throughout the entirety of Apalachicola Bay over the relevant time period. Instead, substantial declines occurred only at the most heavily harvested oyster bars, whereas other oyster bars that were not heavily harvested did not exhibit such reductions in oyster abundance; in fact, many remained healthy or even had higher oyster abundance during and after the collapse;

(b) There was no positive statistical correlation between river flow and oyster landings, whether analyzed in the same year or using different time lags to account for oyster biology and growth rates;

(c) There is no scientific evidence that oyster mortality in Apalachicola Bay was abnormally high prior to or during the oyster collapse, as would be expected if low river flow caused the collapse;

(d) Contrary to Florida's experts' assertions, there is no evidence that an abnormal increase in the level of predation of oysters by rock snails – an oyster predator that prefers conditions of extended high salinities – that could have caused the collapse.

(e) A nearby oyster fishery that receives water from a watershed that does not depend on Apalachicola River flow (and thus have flows that could not be related to Georgia's water use) also experienced a simultaneous, significant oyster population decline due to over-harvesting.

9. Accordingly, the hypothesis that low Apalachicola River flow was the cause of the Apalachicola Bay oyster fishery collapse in 2012-2013 is contrary to all available scientific evidence and must be rejected.

10. Given that low river flows did not cause the collapse, I evaluated alternative hypotheses. Because there was no sudden natural meteorological event during the relevant period, such as a hurricane or extreme freshwater influx that could have caused the collapse, I analyzed all data and information available regarding: Florida's management of the oyster fishery; harvesting pressure and rates; and oyster bar restoration efforts.

11. Based on my analysis, I conclude to a high degree of scientific certainty that the collapse of the Apalachicola Bay oyster fishery was caused by unsustainable harvesting practices that were permitted by the Florida state agencies responsible for management of the Apalachicola Bay oyster fishery. The voluminous scientific evidence supporting this conclusion includes the following:

(a) There were simultaneous and substantial declines in both legal-size and sublegal-size oysters on all major fished bars in the Bay.[2] If low river flows had caused the collapse, declines in sublegal-size oysters should have been observed prior to the declines of legal-size oysters, because

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2 Whether an oyster is "legal" is defined by Florida statute. Specifically, a legal oyster - one that may be harvested - must be three inches in length or greater. *See* Fl. Admin. Code 68B-27.015(1). However, because of the nature of oyster harvesting, Florida permits possession by oystermen of certain "tolerance" levels of oysters that are less than three inches in length. Fl. Admin. Code 68B-27.015(3)(a)-(b). These are commonly referred to as "sublegal" oysters.

lower river flows would have decreased survival rates of sublegal-size oysters;

(b) Apalachicola Bay oyster harvesting pressure – as measured by landings, catch-per-unit-effort, fishing trips, and fishing exploitation rates – increased dramatically in the years immediately preceding and during the fishery collapse;

(c) There was a substantial degradation in the oyster shell habitat necessary for the oyster population to recover on the heavily fished oyster bars, and this degradation coincided with the spike in harvesting pressure; but the State of Florida engaged in minimal re-shelling (habitat restoration) immediately before and at the time of the collapse;

(d) There is significant anecdotal evidence that illegal and sub-legal oyster harvesting was taking place and was not policed by Florida oyster fishery managers in the years prior to and during the collapse.

12. Separately, there also is no evidence to support a claim that overall ecosystem productivity of Apalachicola Bay was impaired due to low water flows. Fishery landings of other harvested marine species – including blue crab, pink shrimp and white shrimp – did not decline during the 2012-2014 period.

13. Finally, recovery of the Apalachicola Bay oyster fishery is feasible. This, however, can only take place if Florida fishery managers: (1) significantly enhance their re-shelling program to restore oyster habitat that has been degraded from harvesting; and (2) manage the fishery in a responsible manner that prevents unsustainable levels of harvest.

14. I elaborate on each of these analyses and conclusions in the sections that follow.

PROFESSIONAL BACKGROUND

15. I am a fisheries management and marine ecology professor at the Virginia Institute of Marine Science, College of William & Mary, Department of Fisheries Science. I have a Ph.D. (1984) in Biological Science with an emphasis in Zoology and a minor in Statistics

from Florida State University, and a B.S. (1976) in Zoology from the University of Rhode Island.

16. My scientific expertise and research specialties include marine conservation ecology, fisheries management, mathematical biology, ecological statistics, and ecology and management of the eastern oyster, blue crab, spiny lobster, queen conch, and various other marine crustaceans and molluscs.

17. For the last 30 years, I have been the Commonwealth of Virginia's expert on fishery management and ecology of the blue crab. In the past 25 years, I have also been the Co-Principal Investigator of the Blue Crab Stock Assessment in Chesapeake Bay, and a member of technical teams for the Gulf of Mexico and Chesapeake Bay oyster and blue crab stock assessments, as well as oyster and blue crab conservation and restoration analyses, reports, and projects. In addition, for 12 years I have been engaged as a scientific advisor on oyster ecology and restoration to the U.S. Army Corps of Engineers, NOAA Chesapeake Bay Office, and Chesapeake Bay Program Fisheries Goal Implementation Team.

18. I have more than 100 publications in peer-reviewed scientific journals and conference proceedings, and have received nearly 70 research grants totaling over $10 million from agencies including the National Science Foundation, National Oceanic and Atmospheric Administration, U.S. Army Corps of Engineers, National Undersea Research Program, and others. In the course of my career, I have peer-reviewed well over 1,000 scientific journal articles, and I have reviewed dozens of professors' applications for tenure at universities and colleges across the country (including applications for tenured positions at my own institution).

19. A complete copy of my *curriculum vitae* can be found in GX-1025.

I. PRIMER ON OYSTER BIOLOGY

20. There are a number of pertinent biological and ecological characteristics of the eastern oyster that are important to understanding the fishery collapse in Apalachicola Bay. Accordingly, I briefly discuss here the critical portions of oyster life cycle and ecology that are relevant to the analysis of an eastern oyster population decline, such as occurred in 2012-2013 in the Bay.

21. The eastern oyster's life cycle has two major phases: one in the water column, and another on the sea bottom. Mature oysters (those on the sea bottom) release their unfertilized eggs and sperm into the water column, where fertilization occurs. For fertilization to be successful, there must be a sufficiently high density of adult oysters on the sea bottom. Once fertilized, oysters become "larvae" that swim in the water column for about two weeks; the larvae then have only about one week to search for and find "substrate" on which to settle.

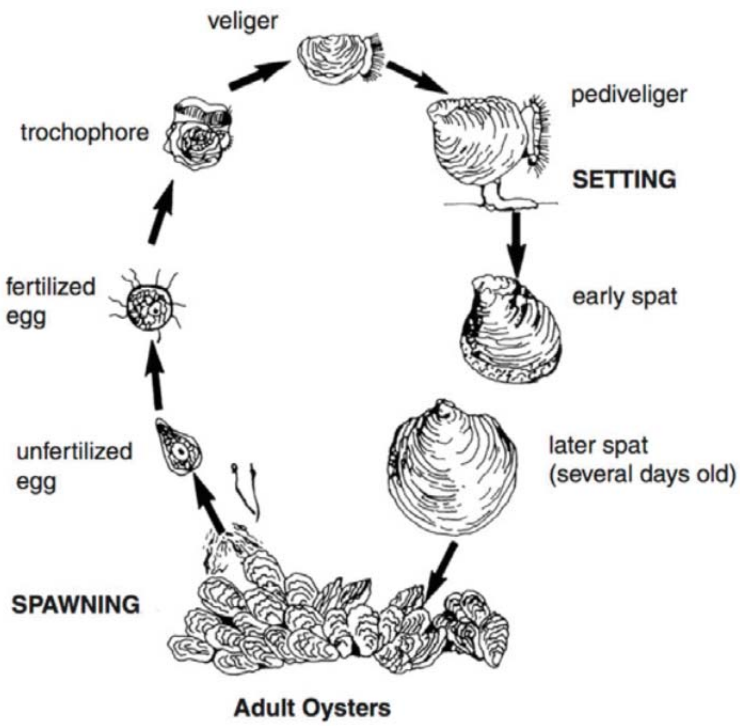
22. Larvae must attach to "substrate" on the sea bottom. Substrate includes oyster shell, the preferred substrate, or other hard structures on the sea bottom, which oysters use to maximize growth, reproduction, and survival. When oyster larvae successfully attach to substrate, they become "spat."

23. Critically, if adequate substrate is unavailable, the larvae will die, either by being carried by currents out of the Bay, by settling on suboptimal substrate (for example, "shell hash"), or by remaining in the water column and perishing.

24. After settlement, the young oyster will grow, mature, and reach legal size after approximately 15 months, depending mostly on water temperature. Biological and physical stressors, such as predation, disease, fishing, and storms, may reduce survival. Significantly, healthy oyster bars (reefs), characterized by more shell substrate, reduce oyster mortality by providing refuge from predation, by reducing physical stress, by enhancing growth and reproduction, and by decreasing the impact of disease.

25. Lipcius Demo. 1, below, displays the different stages of the life cycle of the eastern oyster. The figure is excerpted from JX-62, S.J. VanderKooy, *The Oyster Fishery of the Gulf of Mexico, United States: A Regional Management Plan*, Oyster Tech. Task Force, Gulf States Marine Fisheries Comm'n at 3-11 (2012). JX-62 is a type of publication that marine scientists routinely rely upon when conducting analyses of marine populations, and I did so in this case.

Lipcius, Demo. 1: Life Cycle of the Eastern Oyster.



26. A sustainable oyster fishery management strategy therefore must account for the amount of substrate removed from the oyster bars during the fishing season (that is, oyster shells from both live and dead oysters that are tonged up in the harvesting process), and replace as much of that shell as possible in order to sustain the total amount of oyster habitat, as well as to rejuvenate the oyster population and decrease oyster mortality. If oyster bars are not re-shelled after harvesting, eventually the amount of suitable substrate available for larval settlement and juvenile growth will be eliminated, along with the number of harvestable oysters that would otherwise grow on the oyster reef.

II. ALL SCIENTIFIC EVIDENCE PROVES THAT LOW RIVER FLOW FROM THE APALACHICOLA RIVER DID NOT CAUSE THE OYSTER COLLAPSE IN APALACHICOLA BAY.

27. To analyze Florida's assertion that low river flow caused the collapse of the Apalachicola oyster fishery, I employed a very basic scientific research methodology used by all scientists seeking to investigate a particular hypothesis. Specifically, for a given hypothesis, I identified the type of evidence that should exist if the hypothesis were correct. Once the types of

evidence were identified, I analyzed and evaluated whether such evidence exists or could be inferred indirectly from other available evidence.

28. Florida's hypothesis – that low river flows caused the collapse of the oyster fishery – is easily testable using contemporaneous, official data collected by relevant Florida state agencies with responsibility for monitoring and managing the fishery. Florida's data, however, does not support Florida's hypothesis and in fact disproves it. In short, the scientific evidence shows that low river flow did not cause the Apalachicola Bay oyster fishery collapse.

29. The basic claim Florida asserts is that low river flows caused by Georgia's consumption caused the collapse of the Apalachicola oyster fishery. It is important to understand, however, that there are two intermediate steps underlying Florida's theory. Florida's position is that, first, low river flows resulted in higher salinity, and second, this higher salinity caused high oyster morality due to physiological stress, predation or disease.

30. As a threshold matter, there is no instance in the scientific literature of drought-induced high salinity in an estuary having caused a population-wide collapse of an entire eastern oyster fishery. I analyzed all the relevant, published and peer-reviewed studies and articles on this subject, and it has never been documented.[3]

31. There are, however, historical instances of oyster fishery collapses due to environmental stresses other than drought. Such environmental events involve hurricanes, or "freshets" – extreme inflows of freshwater that *lower* salinity to levels that are beyond the tolerance of oysters and have the capacity to decimate a population. In fact, an excellent example is the oyster fishery collapse in Apalachicola Bay in 1985 due to Hurricanes Elena and Kate, which devastated the Bay's oyster beds and left the local economy in shambles. *See* JX--2, Mark Berrigan, *Management of Oyster Resources in Apalachicola Bay following Hurricane Elena*, J. of Shellfish Res. (1988).

[3] This is consistent with my investigations of similar ecosystems in the Gulf of Mexico that experience salinity fluctuations, such as the coasts of Louisiana and Texas. Analyses of these systems indicate that oyster populations do not collapse bay-wide due to disease and predation during high-salinity periods accompanying droughts. *See* Powell, et. al, *The Status and Long-Term Trends of Oyster Reefs in Galveston Bay, Texas*, J. of Shellfish Res. (1995).

32. It is possible that oyster predators can overrun a particular reef or portion of a reef and impact the oyster population in a localized area. But such an event has never been documented for a fishery on a population-wide basis.

33. Notwithstanding these facts, I comprehensively and scientifically tested the assumptions underlying Florida's theory of a salinity-driven fishery collapse with the available data. My analysis shows that Florida's theory is unsupportable.

A. <u>No Bay-Wide Decline In Oyster Abundance</u>.

34. First, if low river flow were the cause of the fishery collapse in Apalachicola Bay, as Florida asserts, then total oyster abundance should have dropped sharply throughout Apalachicola Bay. In other words, there should be no difference in the relative number of oysters on oyster bars that were the major fished bars versus those that were not. This is because if increased salinity from low river flow caused a Bay-wide oyster population collapse, the number of oysters on all bars, whether harvested or not, should have declined in a similar fashion.

35. But the official data on oyster abundance in Apalachicola Bay collected by the Florida Department of Agriculture and Consumer Services ("FDACS") does not support Florida's assumption. FDACS routinely collected data concerning oyster abundance on the Bay's major fished oyster bars and other oyster bars from 1982 through the time of the 2012-2013 collapse. GX-1031 is a true and accurate copy of the FDACS survey data collected from 1990 through 2014. As discussed more fully below, this FDACS survey data is the same data used by Dr. White and Dr. Kimbro in their direct testimony in this case. *See, e.g.*, White Direct Testimony, ¶ 30; Kimbro Direct Testimony, ¶¶ 3, 55, 98. Experts in my field routinely study and rely on "fishery-independent" data such as these to evaluate how environmental and anthropogenic factors affect underlying populations of marine species, including oysters. "Fishery-independent" data means it has been collected by scientists, rather than by participants in the fishery.

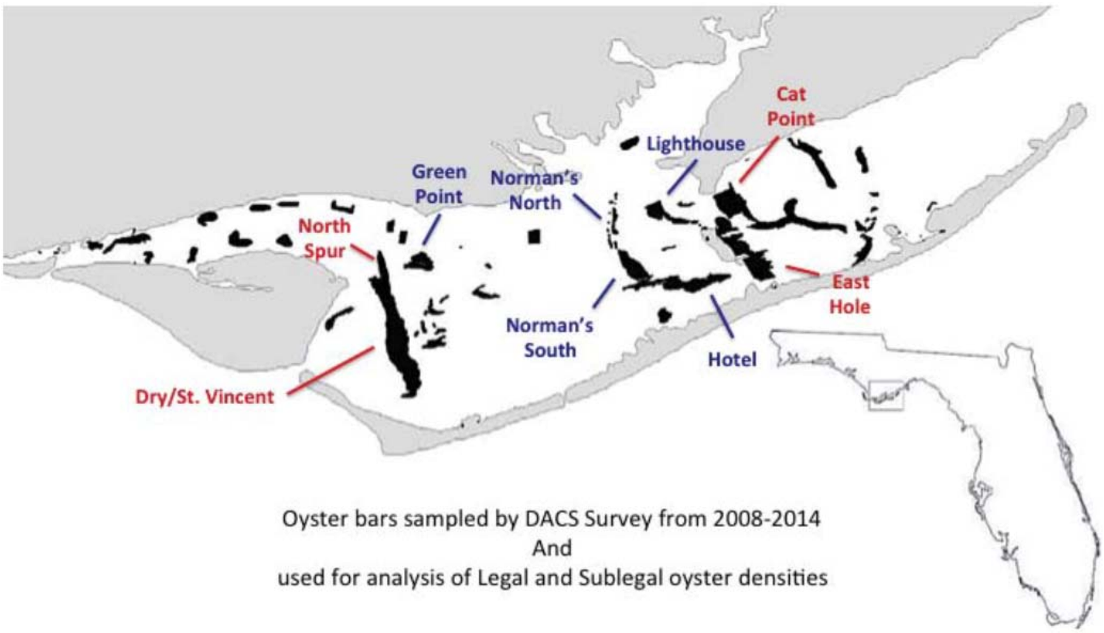
36. Specifically, fishery-independent data are collected by scientists using resource surveys, such as trawl, quadrat, or seine surveys. The FDACS survey process involves using divers to collect oyster substrate and attached oysters using 0.25 m^2 "quadrats" (created with

PVC pipes), from individual oyster bars throughout the Bay. The FDACS survey results that are generated from these surveys are split into those of "legal oysters," which are oysters > 75 mm in shell length, and those of "sublegal oysters," which are oysters < 75 mm in shell length. I have personally surveyed numerous oyster populations in intertidal and subtidal oyster habitats of Chesapeake Bay using the quadrat method, and experts in my field routinely rely on surveys generated using the quadrat method to study oyster populations.

37. Lipcius Demo. 2, below, is a map showing oyster bars in the Bay that were sampled by FDACS from 2008-2014, and that I used in my spatial analysis to assess whether low river flows caused the collapse of the Apalachicola Bay fishery in 2012-2013. Lipcius Demo. 2 was adapted from JX-62, VanderKooy, *The Oyster Fishery of the Gulf of Mexico, United States: A Regional Management Plan* at 17-5. Experts in my field regularly consider these types of publications, and I did so in my work preparing my expert opinions for this case. I have adapted the image to highlight in red reefs that are considered by Apalachicola Bay oystermen to be the major-fished oyster bars. The non-major fished oyster bars are highlighted in blue.

38. As you can see in Lipcius Demo. 2, the oyster bars contained in my analysis are spread throughout the Bay – some closer to the river mouth, and others farther away. This spatial dispersal helps ensure that my abundance analysis is not skewed by localized salinity conditions.

Lipcius, Demo. 2: Oyster bars in Apalachicola Bay sampled by FDACS pre- and post-oyster collapse.



39. To standardize the spatial analysis of oyster abundance at specific oyster bars, I used the FDACS survey data to compare densities of legal and sublegal oysters pre-collapse (May 2008-July 2012) with those during and after the collapse (October 2012-August 2014). I selected only oyster bars in the FDACS survey data that were sampled both before and after the collapse, and which therefore allow an objective comparison of the condition of heavily fished oyster bars with those that are not heavily fished. This standardization is done to ensure the accuracy of subsequent population analyses of specific species.

40. Using the standardized indices, I derived mean densities of legal and sublegal oysters located on oyster reefs in Apalachicola Bay over the relevant time frame (2008-2014). I then compared the mean densities of both legal and sublegal oysters found on major fished oyster bars (Cat Point, Dry/St. Vincent, North Spur, East Hole), with the other bars that were not heavily fished (Green Point, Norman's North, Norman's South, Lighthouse, and Hotel) during the years 2008-2014.

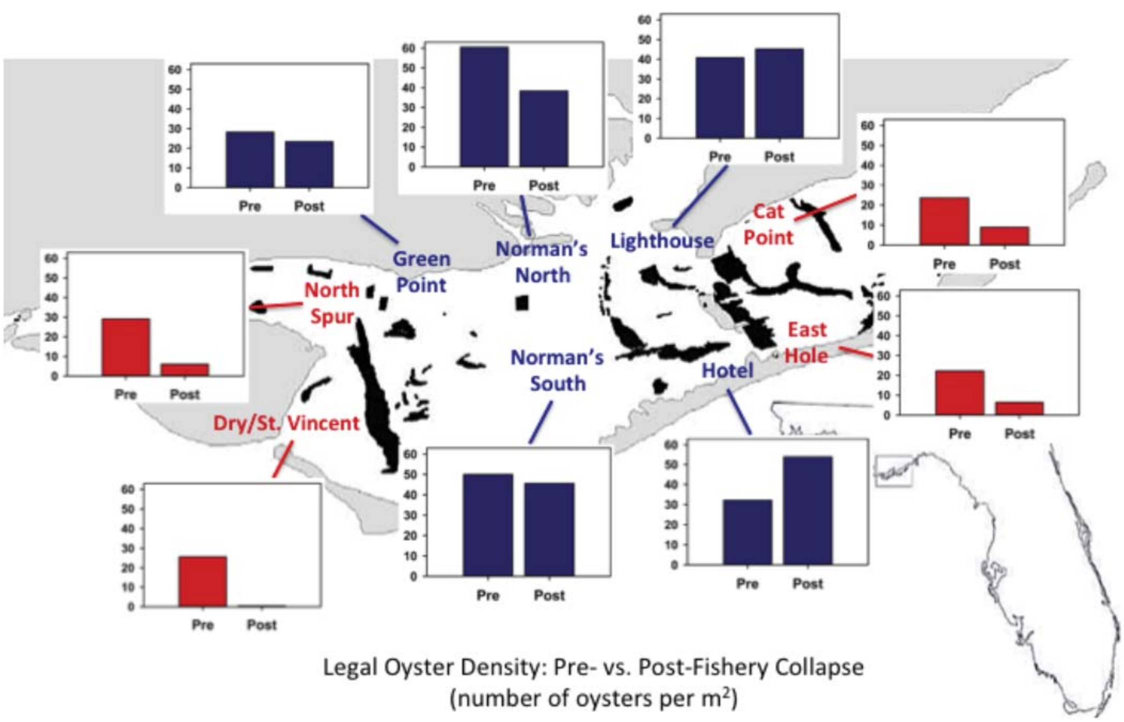
41. Analysis of these fishery-independent data from before and after the collapse results in several important findings:

(a) Legal oyster density dropped conspicuously and dramatically during and immediately after the collapse (October 2012 through August 2014) at all of the major fished oyster bars. On average, legal density dropped by 78 percent on these bars.

(b) However, legal density *rose* by an average of 3 percent at the five oyster bars that were not heavily fished. In fact, even *after* the fishery collapse, the legal densities at the five oyster bars that were not heavily fished and/or that had been re-shelled, as reflected in the FDACS data, were in the range of densities at *healthy* oyster bars before the fishery collapse (about 25-60 oysters per m^2).

42. The results of this analysis are shown in Lipcius Demo. 3 below, which was also adapted from JX-62 to show the bars used in the analysis.

Lipcius, Demo. 3: Indices of abundance for legal oysters on the four major fished oyster bars (red) compared to five non-major fished bars (blue) in Apalachicola Bay from before (May 2008-July 2012) and after the fishery collapse (October 2012-August 2014).



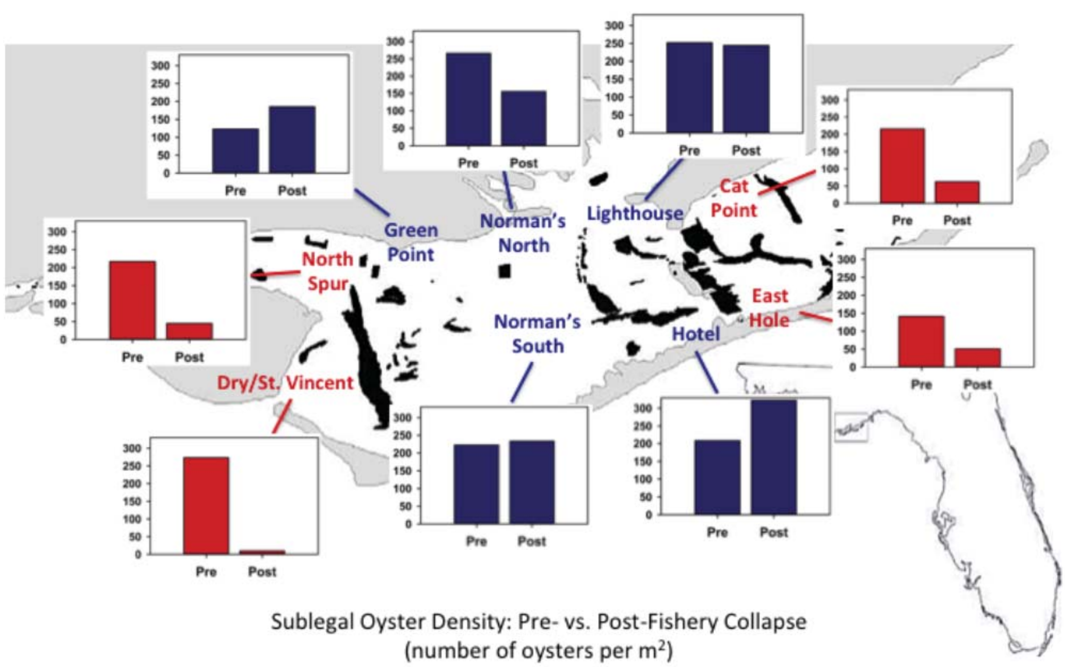
43. I next performed the same analysis with respect to sublegal oysters – those that are less than 75 mm in size. Similar to the legal oyster density analysis above, the findings revealed that:

(a) Sublegal oyster density dropped conspicuously and dramatically during the collapse (October 2012 through August 2014) at all of the major fished oyster bars, an average 78 percent overall.

(b) But the situation was just the opposite for the bars that were not heavily fished or that had been re-shelled. For those bars, sublegal density *increased* by 13 percent, and the densities at those remained within the range of healthy oyster bars (about 125-300 oysters per m^2) even after the collapse.

44. These results are shown in Lipcius Demo. 4 below, which was also adapted from JX-62. The four major fished oyster bars are reflected in red, while the five other bars are in blue. Indices of abundance for sublegal oysters on all bars has been compared from before the collapse (May 2008-July 2012) and after the fishery collapse (October 2012-August 2014).

Lipcius, Demo. 4: Indices of abundance for sublegal oysters on the four major fished oyster bars compared to five other bars in Apalachicola Bay.



45. These findings, standing alone, contradict Florida's hypothesis that low river flow and resulting high salinities caused a Bay-wide collapse in legal and sublegal oyster abundance. Oyster bars that were not heavily fished generally did the same, or even better, post-collapse than pre-collapse, which would not be reflected in the data set if high salinities had collapsed the Bay's oyster population. The findings are, however, consistent with the possibility that overharvesting or unsustainable harvesting was taking place prior to and during the collapse. I discuss this further below, in Section III.

46. As I discuss further here and in the following sections, I have reviewed the direct testimony submitted by Drs. White and Kimbro and the underlying data they rely upon for their conclusions. Given that this data was provided to me by Florida only very recently, I have not yet been able to conduct a comprehensive review of the new analyses and experiments Drs. White and Kimbro conducted. I have, however, already identified numerous, significant errors and mischaracterizations in their testimony concerning these new analyses.

47. As a threshold matter, Dr. Kimbro's testimony (i) reflects a lack of knowledge about fisheries management and eastern oyster biology; (ii) presents results that are not scientifically credible; (ii) directly contradicts statements made in his expert report; (iii) misinterprets analyses in my expert report; and in at least one instance, (iv) omits statistical results and experimental data. Consequently, I find Dr. Kimbro's conclusions regarding the cause of the oyster fishery collapse in Apalachicola Bay to be unreliable.

48. With respect to my analysis of oyster abundance on major and minor fished bars, Dr. White, in his testimony, presents data for salinity in 2012 for the four major fished bars, and four of the five minor fished bars. White Direct. ¶¶ 114-17 and Figures 4, 5. Dr. White states that "overall, the harvested reefs had above-average salinities and the unharvested reefs had below-average salinities for this time period." This statement is incomplete and inaccurate for several reasons:

(a) First, I had considered whether or not salinity could be a confounding factor, and decided that it would be unlikely because the five minor bars span almost the full range of salinity encountered in the Bay from low to high. This decision is validated by my analysis of salinity at the major and minor bars showing that there is no statistically significant difference in salinity between the two groups of oyster bars.

(b) Second, the greatest salinity increase occurred at one of the minor fished bars ("Hotel" in Dr. White's Figure 4), and that bar had high oyster abundance prior to and after the collapse;

(c) Third, the salinity increase at another minor bar ("Green Point" in Dr. White's Figure 4) did not differ statistically from that at the major fished bars, and it also had high oyster abundance prior to and after the collapse.

(d) Fourth, the salinity values portrayed in Figures 4 and 5 are differences in salinity from the average salinity across all eight bars, not actual salinity values. Snail predation depends not on salinity differences, but on the actual salinity values.

49. Accordingly, I analyzed salinity at the four major fished bars and the five minor bars for the three years of the drought, 2010-2012, as presented in Lipcius, Demo. 5, below. I evaluated the salinity data using GX-1162 for the three major seasons in Apalachicola Bay for each of those years. Irrespective of year or season, there was no statistically significant difference in salinity between the major fished bars and the minor bars ($p \gg 0.05$). Lipcius, Demo. 5 below, reflects calculations of salinity data reflected in GX-1162, which contains outputs from Dr. McAnally's salinity models.

Lipcius, Demo. 5: Table of average salinity in 2010-2012 at the major and minor fished oyster bars.

	Mean Salinity for Major and Minor Bars					
	2010		2011		2012	
	Major	Minor	Major	Minor	Major	Minor
Winter/Spring	19.6	18.1	24.1	23.3	24.6	23.8
Summer	12.0	9.3	20.2	18.7	22.6	21.5
Fall	24.1	23.9	23.3	22.1	25.6	24.8

50. Moreover, I analyzed oyster abundance on all major and minor fished bars as a function of salinity. Using the abundance data from my expert report and the same salinity data, I analyzed whether salinity at a given oyster bar predicted oyster abundance at the bar either pre- or post-collapse. I found that in no case did the salinity level explain the patterns in abundance across the oyster bars in a statistically significant manner ($p \gg 0.05$).

51. Consequently, I conclude that salinity at the major and minor fished bars was not a confounding factor, and therefore that my conclusions remain valid.

B. <u>No Correlation Between Landings And River Flow</u>.

52. Another type of data that marine scientists regularly use to analyze marine fishery populations is called "fishery-dependent" data. This is data that reports the landings of a particular marine species being fished – that is, how much is being taken out of the water by fishermen and to the dock to be sold or eaten. Such data represent another critical category of information accepted worldwide by marine scientists as necessary to manage fished stocks effectively. The other data is the fishery-independent indices of abundance, discussed above.

53. One concern with fishery-dependent data, such as landings, is whether these data consistently reflect the magnitude of harvest from a fished population. Due to this concern, oyster fisheries throughout the Gulf of Mexico implemented mandatory reporting systems, which the State of Florida implemented beginning in 1986. Prior to 1986, the reporting system for landings was voluntary and not necessarily reliable. Consequently, I only used fishery-dependent landings data for Apalachicola Bay collected by the Florida Fish and Wildlife Commission (FWC) since 1986 to evaluate patterns in fishery harvest. Due to the nature of fishery-dependent data, these landings data provide a relative measure of harvest rather than an absolute measure; this type of data is used worldwide by marine scientists to evaluate the status of marine fisheries and is critical for stock assessments.

54. If low river flow caused the fishery collapse in Apalachicola Bay, as Florida suggests, then there should be some correlation between low river flows and lower oyster landings. These types of correlation analyses are commonly done by marine scientists, as they provide a direct way to assess whether a certain factor (here, river flow) correlates with another

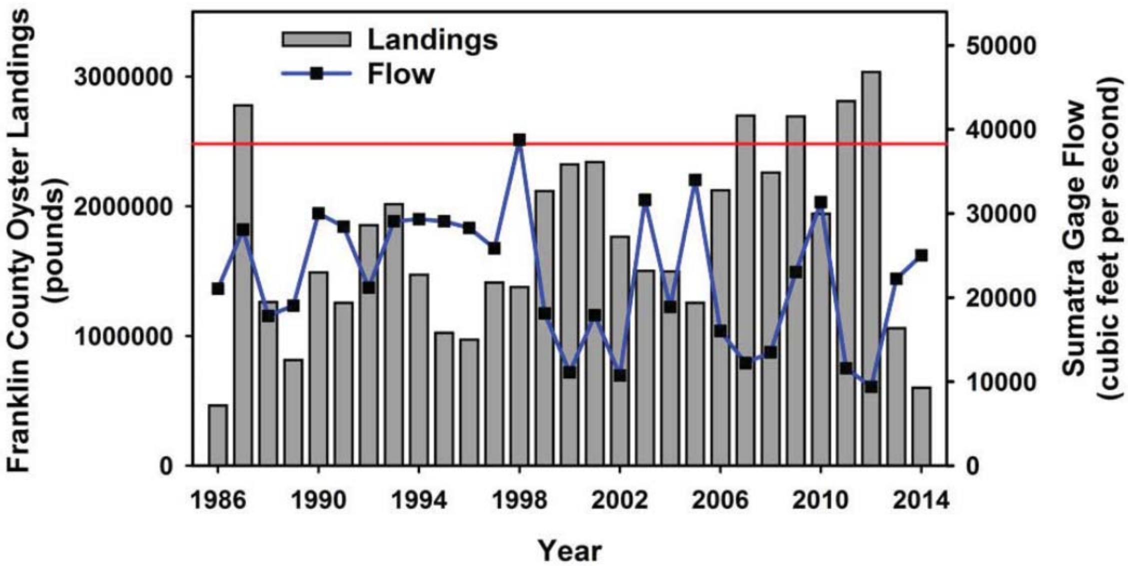
variable (oyster landings). Accordingly, there should be some correlation between low river flows and the fishermen (oystermen here) catching fewer fish if low river flows were responsible for collapsing the Apalachicola Bay oyster fishery.

55. To analyze this, I statistically correlated Franklin County (Apalachicola Bay) oyster landings with river flow (a) during the same year; (b) with a 1-year time lag (*i.e.*, river flow in one year and landings in the following year); and (c) with a two-year time lag (*i.e.*, river flow in one year and landings two years later).[4] I used all three of these time lags (0, 1 and 2) because they should encompass the potential relationships, if any, that exist between river flow and the range of biological responses of the oyster population as they grow from juvenile to adult.

56. The findings reveal that there was no statistical correlation between low river flows and low oyster landings. Correlations at time lags of zero, one, and two years were not statistically significant. In fact, the only statistically significant correlation was an inverse relationship between river flow and landings, meaning that highest landings occurred during years of low river flow – drought years – though with high variability (*i.e.*, $r^2 = 0.22$). The chart below (Lipcius, Demo. 6) demonstrates this conclusion. The redline is simply a reference point at 2,500,000 pounds.

[4] Lipcius, Demo. 6 is based on data contained in GX-1129 and GX-1195. GX-1129 contains annual landings data compiled by the State of Florida. GX-1195 contains Sumatra Flow gage data that was generated by the United States Geological Survey.

Lipcius, Demo. 6: Annual oyster landings and mean daily river flow in Apalachicola Bay.



57. My conclusion regarding the lack of connection between river flows and oyster harvest is consistent with the opinions expressed by University of Florida oyster experts who analyzed this same issue. Drs. Pine and Havens, who provided testimony in this case, both stated that they have seen no clear evidence that oyster harvest in Apalachicola Bay is tied to Apalachicola River flows (Pine Dep. Tr. pgs. 172, 291: "no obvious relationship between flows and reported oyster harvests; Havens Dep. Tr. pg. 175: "we never found any quantitative linkage between flow from the river and the crash with the oysters").

C. <u>No Increased Natural Mortality of Oysters in Apalachicola Bay</u>.

58. Another relevant data point I analyzed is a measure of natural mortality of oysters. Natural mortality is defined as oyster deaths that are not caused by human factors, such as fishing. If low river flow caused the fishery collapse in Apalachicola Bay, then natural mortality (due either to predation, disease or physiological stress) should have been abnormally higher immediately before and during the oyster fishery collapse.

59. To test this theory, I evaluated estimates of natural mortality for the Apalachicola Bay oyster population that were generated by oyster experts, including University of Florida scientists, who analyzed the relationship between river flow and natural mortality. One of the experts who jointly authored the report resulting from that analysis, Dr. Carl Walters,

is recognized as one of a handful of premier marine fisheries and stock assessment scientists in the world. They found no relationship between river flow and natural mortality from their analysis: As Dr. Pine reported in a peer-reviewed article: "We did not find correlations between Apalachicola River discharge measures (average monthly, total annual, total monthly, or coefficient of variation on annual discharge, mean seasonal, or total seasonal) and our estimated relative natural mortality rate (M) or oyster recruitment rates." GX-789, W. E. Pine III, et al, *The Curious Case of the Eastern Oyster Crassostrea Virginica Stock Status in Apalachicola Bay, Florida*, Ecology and Society 20(3):46 at 6 (2015). GX-789 is the type of peer-reviewed, scientific publication that experts in my field routinely generate, study, and rely upon when conducting analyses of marine populations.

60. I therefore analyzed the same data used by Dr. Pine. GX-1167 and GX-1168 are true and accurate copies of spreadsheets reflecting data sources produced by the University Florida in connection with this litigation. The data sources were used by Dr. Pine and his colleagues in the course of preparing GX-789 (the "*Curious Case*" paper). Such data is routinely used by marine scientists to assess factors that affect natural mortality of certain species. I conducted an independent evaluation of the data, and my results corroborated Pine's findings in the *Curious Case*.

61. My conclusion therefore is in agreement with that of Drs. Pine and Havens, members of the University of Florida research team. Dr. Havens testified in this case that he found that, while low river flow and drought may have "coincided in time" with "oyster mortality," no "cause-and-effect relationship between drought and low river flows on the one hand and oyster mortality on the other" could be established based on the contemporaneous data generated by the State of Florida and other sources of information. (Havens Dep. Tr. pgs. 225-226). Dr. Pine agrees with that conclusion, Pine Dep. Tr. pgs. 307-308, and it is consistent with my findings, as well.

D. <u>No Evidence of Increased Mortality Due to Predation.</u>

62. Florida's principal assertion for how low river flows caused the fishing collapse is that increased salinity stimulated the abundance and feeding rates of marine predators (primarily the rock snail and stone crab) in the Bay, and that these predators killed the oysters. Florida's

experts, Drs. David Kimbro and J. Wilson White, claim that experiments, analyses, and modeling they conducted support that premise. *See generally* White and Kimbro Directs.

63. It is recognized in marine ecology that predators such as the rock snail often become more prevalent and active when salinities increase, and this can elevate predation on oysters in localized areas (e.g., on a particular reef or portion of a reef) during the time that salinities remain high.

64. But there is no documented instance in the scientific literature of a population-wide collapse of oysters due to magnified predation resulting from high salinities during a drought, a phenomenon that Dr. Kimbro believes happened in this case. That is for good reason. The differences that exist in salinity throughout the Bay; the nature of predator feeding rates, which are lowered where sufficient shell habitat is available; the existence of refugia from predation by rock snails and stone crabs where salinities are low; and the fact that an estuary, even at elevated salinities, remains a suboptimal habitat for marine predators together indicate that a predator like the rock snail or stone crab will not be able to decimate a population as substantial as that of the oyster population in Apalachicola Bay throughout the whole of the Bay.

65. Not only is Florida's predation theory inconsistent with all the scientific literature, but it is refuted by the scientific evidence – including the official FDACS, Division of Aquaculture resource assessment data – and even the data collected by Dr. Kimbro himself.

66. To understand why Florida's hypothesis about the rock snail collapsing the entire oyster population of Apalachicola Bay is wrong, it is important to understand some basic facts about how rock snails feed on and kill oysters, and what evidence you would expect to find when that happens.

67. Rock snail feeding works as follows: when foraging for oysters, rock snails will mount the prey oyster and search for a suitable boring site, that is, a place to dig into the oyster shell and release chemicals to weaken the shell and allow the snail to eat the oyster. Much of the time you will find a dead oyster shell with an actual bore hole in it.

68. Sometimes a dead oyster shell will be found without an obvious bore hole. Irrespective of whether or not a bore hole is evident, after the snail finishes feeding, the oyster shell remains intact but with a gap between its two valves. Such an oyster is commonly referred to as a "box" by oyster biologists and fishery scientists throughout the Gulf of Mexico and Atlantic coast (or as a "gaper" by Dr. Kimbro in his expert report).

69. The presence of oyster boxes has long been used as a relative measure of natural mortality due to predation. Marine scientists routinely use oyster boxes as proxy because it represents the best available evidence that, in fact, an oyster was killed by a predator. The generally accepted definitions of boxes are (i) *new box*: oyster with articulated valves and a strong hinge ligament, and with inner surfaces clean or only lightly fouled; and (ii) *old box*: oyster with articulated valves and inner surfaces fouled (Ford, *et al.*, 2006). For oysters in environmental conditions like those in Apalachicola Bay, the dead oyster shells will remain for approximately 4 to 10 years.

1. **Low Box And Predator Density.**

70. To evaluate whether rock snails caused severe mortality prior to and during the oyster collapse, I analyzed two data sets to see whether boxes were widespread and abundant throughout the Bay, which could support a contention of Bay-wide predation. One data set was the official FDACS oyster resource data. The other was data from field surveys that Dr. Kimbro himself conducted.

71. Neither set of data supports the hypothesis that there was Bay-wide, abnormally high predation of oysters in Apalachicola Bay by rock snails (or by stone crabs). I explain my analysis below, but to put it in the simplest terms: If there had been a substantial increase and impact of marine predators in the Bay that crashed the entire oyster population within one to two years, as is Florida's hypothesis in this case, the data would have indicated a significant density of boxes, that is, dead oyster shells throughout the Bay's oyster bars.

72. Contrary to that expectation, the data reflects the existence of very few boxes - in fact, almost no dead oysters at all, which is consistent not with predation causing the collapse but with unsustainable harvesting practices, which involves the excessive removal of oysters and the dead oyster shells on which they settle, by oystermen.

73. Using the same FDACS data I described above, GX-1031, I looked at density data for the presence of old and new boxes in 2012 and 2013 for the major fished oyster bars (Cat Point, Dry/St. Vincent, North Spur, East Hole) and other oyster bars that were not heavily fished or which had been re-shelled recently (Green Point, Cabbage, Norman's South, Lighthouse, Hotel, East Plant).

74. If the rock snail caused the Bay's oyster collapse, the data should show that there were high numbers of boxes (that is, dead oysters) throughout the Bay. And, generally you would expect to find fewer boxes where there are a lot of live oysters, and more boxes where you do not have many live oysters.

75. But the official FDACS data do not show that. Regardless of whether one looks at the heavily-fished reefs (with fewer live oysters) or the lightly-fished reefs (more live oysters), there simply are few boxes, and that holds true whether you look for old boxes or new boxes.

76. Next, I looked at Dr. Kimbro's own field survey data, taken from GX-1188 and FX-843. Dr. Kimbro and colleagues conducted two field surveys on the Apalachicola Bay oyster bars in 2013, one in January and the other in June, in which they sampled densities of live oysters, "gapers," and predators, including stone crabs and rock snails. Since these surveys are from the time period during the collapse, obviously there should be many dead oysters if rock snails or other predators killed them. Lipcius, Demo. 7, below, shows the opposite.

Lipcius, Demo. 7: Kimbro Survey data for January and June, 2013

	January	June
Total Rock Snails	13	6
Total Stone Crabs	11	4
Total Live Oysters	9546	2311
Total Gapers	227	211
% Gapers	2.3%	8.4%
Rock Snail Density	0.1	0.1
Stone Crab Density	0.1	0.1
Oyster Density	187.2	56.4
Gaper Density	4.5	5.1

77. The density of gapers in both January and June 2013 was very low – less than a few snails per square meter in each survey. Significantly higher densities of predation are expected to be present in such surveys, especially to support a hypothesis that rock snail predation caused a significant oyster population decline.

78. In Dr. Kimbro's written direct, he explains that his survey data did not reflect an abundance of boxes because of turbid conditions. Kimbro Direct ¶ 90(g). As a researcher who has performed the exact same type of quadrat-diving method in Chesapeake Bay, I do not find Dr. Kimbro's explanation for why there is a paucity of predators reflected in his data set to be credible. It is common that quadrat surveys are conducted in turbid waters, and experienced divers are able to collect valid samples of oysters, boxes, and predators. Dr. Kimbro also asserts, incorrectly, that the reason few boxes were found was due to them becoming disarticulated within a few months, or otherwise separated due to harvesting via tongs. Kimbro Direct ¶ 90(c). But it is well-known among oyster biologists that boxes persist – first as new boxes, and then continuing as old boxes – for a year or more. And the fact that there were few boxes found on even the lightly-fished bars refutes his theory that tonging could be the cause for disarticulation of what should have been a substantial number of boxes if this were a large-scale, ongoing predator event, as Florida claims.

79. Another very important fact Dr. Kimbro's data reflects - is that the densities of both rock snails and stone crabs, the primary oyster predators - were extremely low, for both species on both surveys.

80. Such a low density is not characteristic of areas where rock snails are abundant. For example, Brown, et al., *Intraspecific Life History Variation in the Southern Oyster Drill, Stramonita Haemastoma: Patterns and Causes*, J. of Shellfish R. (2004) found an average of 11.4 rock snails per m^2 at Barataria Bay's Caminada Pass (Louisiana coast), a high salinity site. In other words, had Dr. Kimbro and colleagues observed such high densities in Apalachicola Bay, they should have collected approximately *100 times* as many rock snails as they did. Similarly, there were 11 stone crabs in January and 6 in June, which also equate to a low density of stone crabs, 0.1 stone crabs per m^2.

81. Such a low density of stone crabs is more representative of sand bottom, or shell hash than of oyster substrate. For example, Tolley and Volety, *The Role of Oysters in Habitat Use of Oyster Reefs by Resident Fishes and Decapod Crustaceans*, J. of Shellfish R. (2005), found about 2 stone crabs per m^2 on oyster reef, but only 0.2 per m^2 on sand bottom, a 10 fold difference.

82. If rock snails or stone crabs were killing oysters broadly across the Bay, Dr. Kimbro should have found exponentially higher numbers of these predators than he did. Other scientists have studied predator abundance of these species and have published papers on it. Based on this literature, Dr. Kimbro should have found 100 times as many rock snails as he did, and about 10 times as many stone crabs.

2. <u>Flawed Field Cage Experiments.</u>

83. Dr. Kimbro also performed certain field cage experiments that he says support the conclusion that increased predation caused the oyster collapse. But there are fundamental flaws with the methodology and interpretation of his field caging experiments.

84. The first and fatal flaw is that by the time of the first caging experiments (early 2013) the oyster fishery had already collapsed, and the experiments could no longer be relevant to assess the cause of the collapse. This is because the conditions in the Bay had already

changed – most prominently the fact that the oyster reefs were not in the same condition as they were preceding the collapse, which would be necessary to test Dr. Kimbro's hypothesis.

85. In a related manner, Dr. Kimbro's experimental design did not follow the established protocol for testing the impact of an environmental perturbation on a population in the field. The established protocol involves a BACI (Before-After-Control-Impact) experimental design with experimental and reference sites sampled prior to and after the impact. Dr. Kimbro has no substantive response to this criticism in his written testimony. In fact, he concedes that it "would be almost impossible" for him to have identified a bay that was identical to Apalachicola Bay to have served as a control for purposes of a BACI experiment. Kimbro Direct ¶ 106.

86. But in the experiments by Dr. Kimbro and colleagues, none of the sites was sampled prior to the impact (*i.e.*, rock snail predation), again obviating valid conclusions about the effect of rock snail predation on the oyster population. University of Florida scientists concluded, as do I, that no available trends on such predators "related to environmental conditions" existed at the time of the collapse. Without those, there were insufficient data to allow the scientists to draw conclusions about the impact. *See* GX-568, Havens, et al., *UF Sea Grant Apalachicola Bay Oyster Situation Report*, pg. 10. The upshot is that Kimbro's experiments, by commonly-accepted scientific principles and validation techniques employed for decades, explain nothing about the cause of the 2012 oyster collapse.

87. Contrary to Dr. Kimbro's suggestion, I take no issue with the value of a scientific approach that incorporates experiments, observations, and modeling. Experimental ecologists have known this for decades. I have been teaching this to graduate students since the 1980s. What Dr. Kimbro fails to note is that it is not just the approach that matters, but how the approach is carried out. If the experiments or models are faulty, then so is the approach, and this is the case with Dr. Kimbro's experiments.

88. Another flaw relates to the artificial nature of the field experiment. Specifically, the oyster bars where experiments were conducted were in a severely degraded state with little structure or oyster reef on the bottom, and were characterized by significantly different environmental conditions than those prior to the collapse. When you add experimental cages and rebar as Dr. Kimbro did here, it added significant structure that was otherwise absent from the

oyster bars. Rock snails are attracted to structure, not only to feed but also for egg laying. That's why Dr. Kimbro's photos show many rock snails and eggs on his cages. *See, e.g.*, Kimbro Direct ¶ 4, Figure 2. Dr. Kimbro's cages were the only structure available on the heavily fished oyster bars in the Bay. And this structure had live oysters attached to it, which also would attract predators. In short, Dr. Kimbro's cage experiments prove nothing about the cause of the oyster collapse in Apalachicola Bay.

3. <u>Erroneous Population Model.</u>

89. Dr. Kimbro also relies on analysis done by his colleague Dr. White, another of Florida's experts in this case. Dr. White used an integral projection model, which is an advanced type of population model used widely in studies of population dynamics and conservation. I am very familiar with this type of model. In fact, I have a scientific publication on the use of an integral projection model with the Pacific oyster.

90. As I explained in my deposition testimony in this case, the parameters and functions that Dr. Kimbro provided to Dr. White for running the integral projection model were so unrealistic that the model results cannot be relied upon to reach any conclusions about the cause of the oyster fishery collapse. Furthermore, the parameters and functions chosen for the model were biased toward showing an effect of high salinity on the oyster population. Even with these biases included in the model, however, the results still did not show a substantial effect of high salinity on the Bay's oyster population.

91. A few examples of the chosen parameters and functions will demonstrate the unrealistic nature of the modeling regarding the eastern oyster. For example, Dr. Kimbro had Dr. White parameterize his model for Dr. White's Expert Report by setting the average maximum size of an eastern oyster at 62 mm (about 2 ½ inches). But oysters in Apalachicola are not even legally harvestable until they reach 75 mm (3 inches), which they do in about 15 months, and estimates of average maximum size for the eastern oyster range to as much as 150-200 mm.

92. The new estimate used in Dr. White's revised model is 120 mm, which is nearly twice the previous estimate of 62 mm. As an analogy, this revision, for the purposes of Dr. White's model, is like first stating that the average maximum size of a human male is three feet

in height, then revising that statement to be almost six feet in height. Regardless of whether Dr. Kimbro claims the revised estimate simply reflects "updated" data, as Dr. Kimbro now states, Kimbro Direct ¶ 100, the failure to identify the unreality of this assumption in White's original model only further illustrates the unreliability of Dr. Kimbro's conclusions, and by extension, Dr. White's.

93. Similarly, Dr. White used an ideal salinity measure of 15 ppt for oyster survival and growth. But this is unsupportable in the scientific literature. Oyster scientists agree that optimum salinity for the eastern oyster is in the range of 18-22 ppt. In the revised model runs, Dr. White uses a salinity data point of 18 ppt for his model, but this parameter still does not accurately reflect reality: there should be a plateau of optimal salinities for the parameter in his model. Using a single point, in other words, creates a sharp "peak," such that deviating from that value either lower or higher dramatically affects oyster survival. This does not capture the realistic situation whereby optimal salinity is a range, not a single value.

94. By using these incorrect parameters Dr. White skewed his model to reflect a higher purported salinity impact on oyster abundance than really occurs, and which artificially depresses the oyster abundance output in his model.

95. Other aspects of the model render it further uninformative with respect to any issues relevant to the research question here:

(a) The model uses data only for a single, heavily-harvested oyster bar (Cat Point), and in his revised analysis a second heavily harvested oyster bar (Dry Bar), which are not reflective of the broad diversity of oyster bars in the Bay.

(b) White's original model only analyzed what impact on salinity there would be if Georgia consumed no water at all – an unrealistic scenario. Notably, Dr. White has now run Florida's "remedy" scenarios, *see* White Direct ¶¶ 153-154, and as I suspected, these remedy scenario model runs generate at most a 1 to 1.4 percent change in oyster biomass. Such a low value is fully inconsistent with a population collapse.

(c) The principal conclusion Dr. White offered in his Expert Report does not provide any specific calculation of the effect of lower water consumption. FX-798, Expert Report of Dr. White. And, although he now describes Georgia water consumption as "contribut[ing] materially to the 2012 oyster fishery collapse in Apalachicola Bay," White Direct ¶ 164, he provides no explanation as for how the 1 to 1.4 percent in biomass his model predicts under Florida's remedy scenario possibly could be understood to be "material."

96. Accordingly, Dr. White's analysis provides no valid scientific basis that could allow Dr. Kimbro to draw concrete conclusions about the relationship between Georgia water consumption, predation and the collapse of the oyster fishery in 2012.

E. Fisheries in Other Counties That Did Not Depend Upon Apalachicola River Flows Also Declined.

97. If low river flow in the Apalachicola caused by Georgia water use caused the oyster collapse, then counties in different watersheds of the Florida panhandle should not also have experienced a similar fishery decline.

98. If, on the other hand, there were simultaneous fishery declines in oyster fisheries that do not rely on Apalachicola River flow for freshwater, then that suggests that something other than water flow based on Georgia consumption – like fishing pressure and/or general drought conditions – caused the fishery declines.

99. To assess these alternative premises, I evaluated landings data for Wakulla County in the St. Marks River watershed of the Florida panhandle. Its coastal zone is in an entirely different watershed than Franklin County (*i.e.*, Apalachee Bay), and it has significant oyster fishery landings.

100. As with my analysis of Franklin County, I relied on Wakulla County landings and trip data from 1986-2014 because these were the longest harvest time series that could be standardized. These data are contained in GX-1248, and were obtained from the State of Florida's website that maintains the total landings data for all fished species throughout the state,

separated by county. Experts in my field routinely rely on this type of data from official state sources when conducting analyses of marine fisheries.

101. As reflected in Lipcius, Demo. 9, below,[5] similar to Franklin County, oyster landings from Wakulla County and Apalachee Bay declined significantly during 2013 and 2014, even though they have totally different watersheds.

102. In addition, there was a striking coherence of high landings and excessive fishing pressure in both counties, despite the different watersheds and hydrologic units. Oyster fisheries in both counties collapsed at the same time, which was preceded by high landings, high fishing effort, and declining CPUE.

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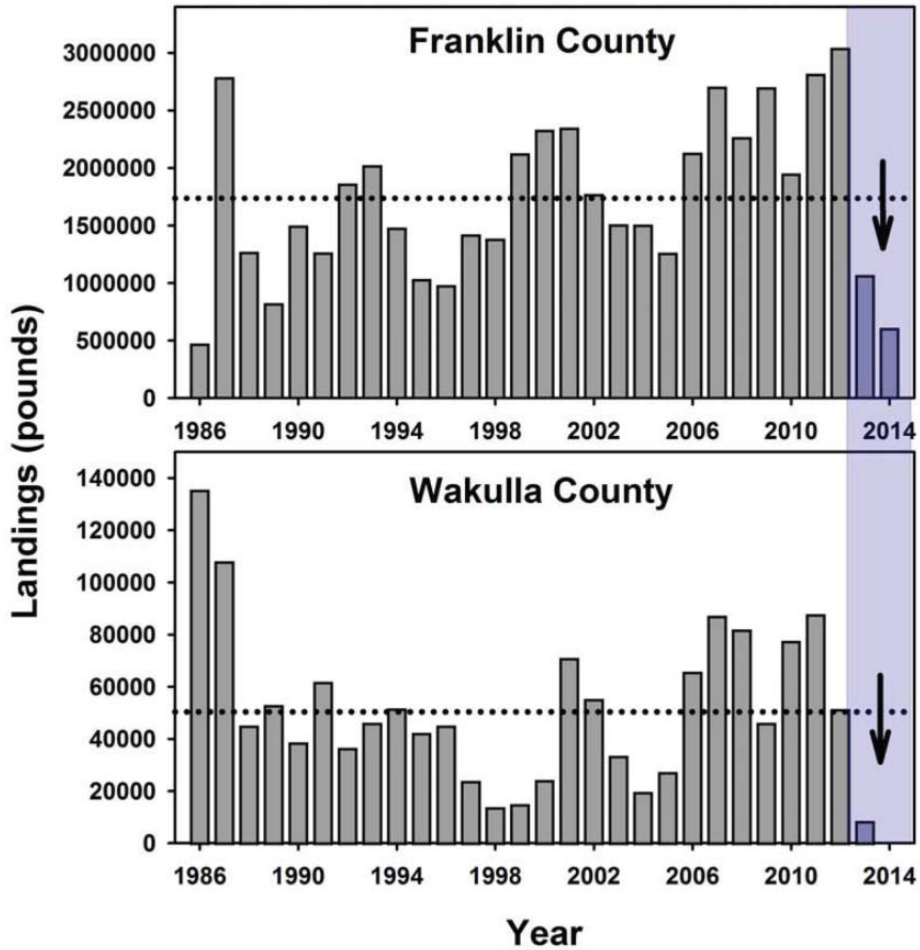
[5] Lipcius, Demo. 9 was generated using data from GX-1248. The blue shaded rectangle and downward facing arrows indicate the significant decline in oyster fishery landings during 2013 and 2014. The dotted lines reflect the declining CPUE of both counties. The horizontal line indicates the average of landings for each county over the time series.

Lipcius, Demo. 9: Fishery landings of the eastern oyster in Florida panhandle counties–Franklin County and Wakulla County.



103. This dual decline also was reflected in the Governor of Florida's disaster declaration, which requested federal disaster assistance for Wakulla, Dixie and Levy Counties in addition to Franklin County**.** *See* JX-77, Sept. 6, 2012 Letter from Governor Scott to Secretary of Commerce Requesting Fishery Disaster Declaration, with Attachments. And the State of Florida's ultimate federal fisheries disaster declaration finding by NOAA found that the oyster fishery collapse was not confined to Apalachicola Bay but was more regional in nature. *See* FX-413, Aug. 12, 2013 Letter from NOAA Regional Administrator granting Florida's Disaster Request.

104. The evidence I reviewed suggests over-fishing drove the oyster decline in *both* Franklin County and Wakulla County, as measured by landings, effort, and catch-per-unit-effort in the years preceding the 2012 oyster population declines in Florida's Gulf oyster populations.

III. THE APALACHICOLA BAY OYSTER COLLAPSE WAS CAUSED BY UNSUSTAINABLE LEVELS OF OYSTER HARVESTING.

105. Given that there is no evidence that low water flows from the Apalachicola River caused the oyster collapse, I also evaluated whether fishery management and unsustainable levels of oyster harvesting could have been the cause. "Unsustainable levels of oyster harvesting," as that term is understood by marine scientists, includes both the amount of fishing pressure, as well as the attendant destruction and removal of oyster substrate caused by such fishing pressure. Based on the evidence I reviewed in this case, I can state to a high degree of scientific certainty that unsustainable levels of harvesting were the cause of the 2012-2013 oyster collapse.

A. Simultaneous Declines In Oyster Abundances On The Major Fished Reefs.

106. To evaluate over-harvesting's role in the 2012 oyster collapse, I used the same FDACS data from individual oyster bars taken during the months of August through October. I used these data to generate the mean densities of oysters at such bars for different years. Evaluating the data from these months provides the best estimates of annual mean oyster density because these months were consistently sampled in all years, providing a standardized index. As I described earlier, marine scientists routinely standardize fishery-independent data to assess underlying trends in marine species accurately.

107. There are two indications in the level of oyster abundance that might explain a population-wide collapse of an oyster fishery. If, for some reason, there were a significant decline in sublegal oysters in a given year, one might expect a significant decline in the adult population in the subsequent year, based on there not being sufficient oysters available to mature to legal size. As explained above, however, there is no evidence to indicate that such a decline in sublegal oysters occurred in the years prior to the collapse. And there is no evidence that some natural event or predation caused large-scale natural mortality of either sublegal or legal oysters.

108. Another logical explanation for a significant population-wide collapse of oysters is if there is excessive harvesting involving the removal of both legal and sublegal oysters. Such excessive harvesting would also be expected to remove the amount of dead shell material available for larval oysters to settle. That would mean there would be insufficient legal (adult) oysters to harvest, and insufficient sublegal (juvenile) oysters to "grow up" into legally harvestable oysters. That is what the scientific evidence strongly supports here, as explained below.

109. There is clear evidence of simultaneous declines in both legal and sublegal abundance in the years immediately preceding the 2012 collapse. This suggests that unsustainable levels of oyster harvesting, coupled with poor culling practices by fishermen in Apalachicola Bay (meaning they did not return juvenile oysters and shell to the oyster bars), left too little oyster habitat/substrate to allow the Apalachicola Bay oyster population to reproduce and generate future harvestable oyster populations.

110. An analysis of the FDACS fishery independent data, referenced earlier, reveals the following:

(a) A decline in sublegal abundance did not precede the drop in legal oyster abundance or in fishery landings; both legal and sublegal oysters declined simultaneously in 2012 prior to the 2013 fall in fishery landings, which is consistent with excessive removal of legal oysters, sublegal oysters, and shell substrate by the fishery.

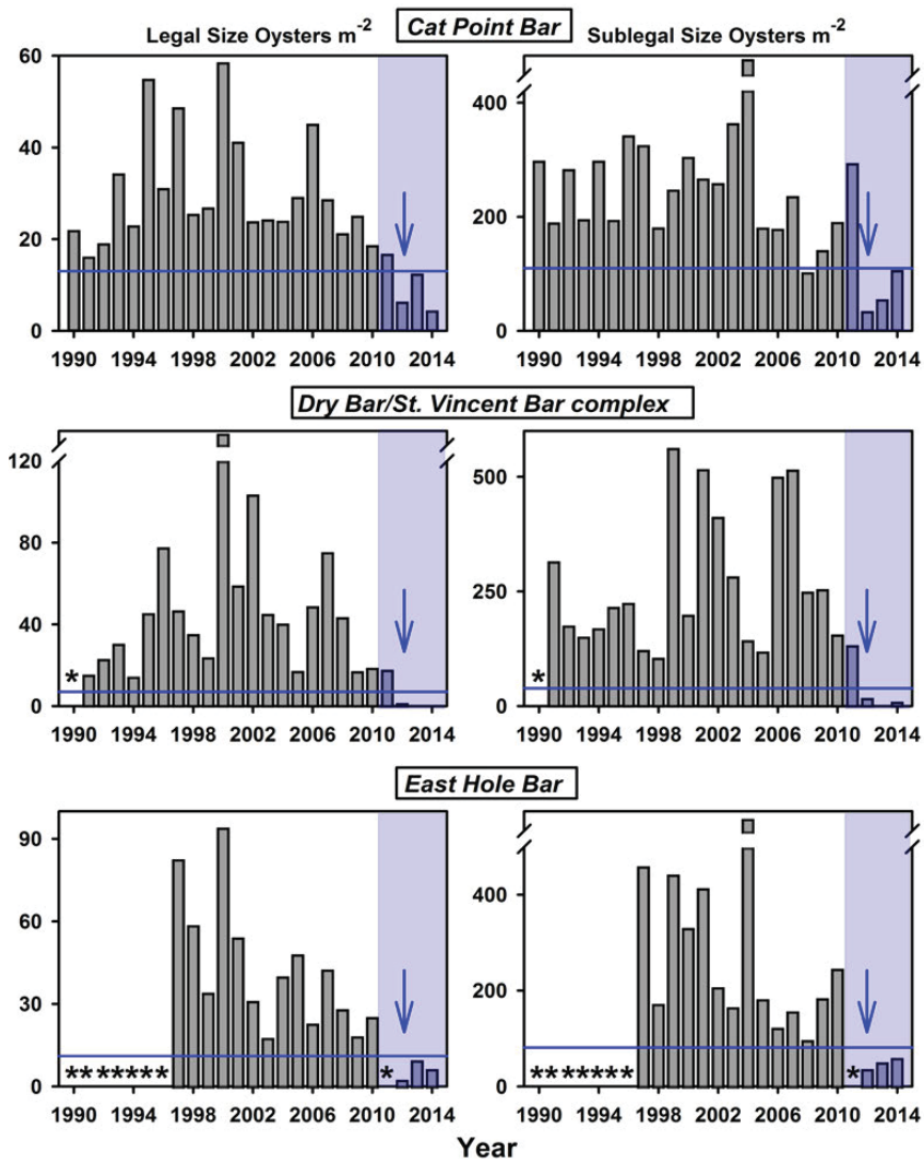
(b) The indices of both legal and sublegal oyster abundance concurrently dropped sharply on all three major oyster bars in 2012, and remained low through 2014.

(c) Sublegal oyster abundance did not decline in 2011, the year preceding the significant drop in legal abundance in 2012. On the contrary, sublegal abundance actually increased in 2011, which was the first full year of the extended drought from 2010-2012. This result is flatly inconsistent with Florida's hypothesis.

(d) The only time-period in which the FDACS fisheries-independent survey data reflect a simultaneous drop in abundance for both legal and sublegal oysters in Apalachicola Bay occurred from 2012-2014.

111. These results – which strongly indicate over-harvesting – are reflected in Lipcius, Demo. 10, below. Data represent the annual mean density from samples taken during August through October each year. Asterisks denote years when samples were not taken.

Lipcius, Demo. 10: Indices of abundance for legal and sublegal oysters on the three major oyster bars in Apalachicola Bay over time.



B. Fishing Pressure Increased Dramatically In The Years Immediately Preceding The Oyster Collapse.

112. Marine scientists routinely consider fishery-independent data in assessing why any significant change in a relevant population might have occurred.

113. One well-established measure regularly analyzed by marine scientists is what is called "fishing pressure." To the extent data are available – as they are here – assessment of fishing pressure involves the analysis of (i) fishery landings, (ii) fishing effort represented by the number of fishing trips, (iii) fishing effort represented by the number of licensed fishers, and (iv) fishing mortality.

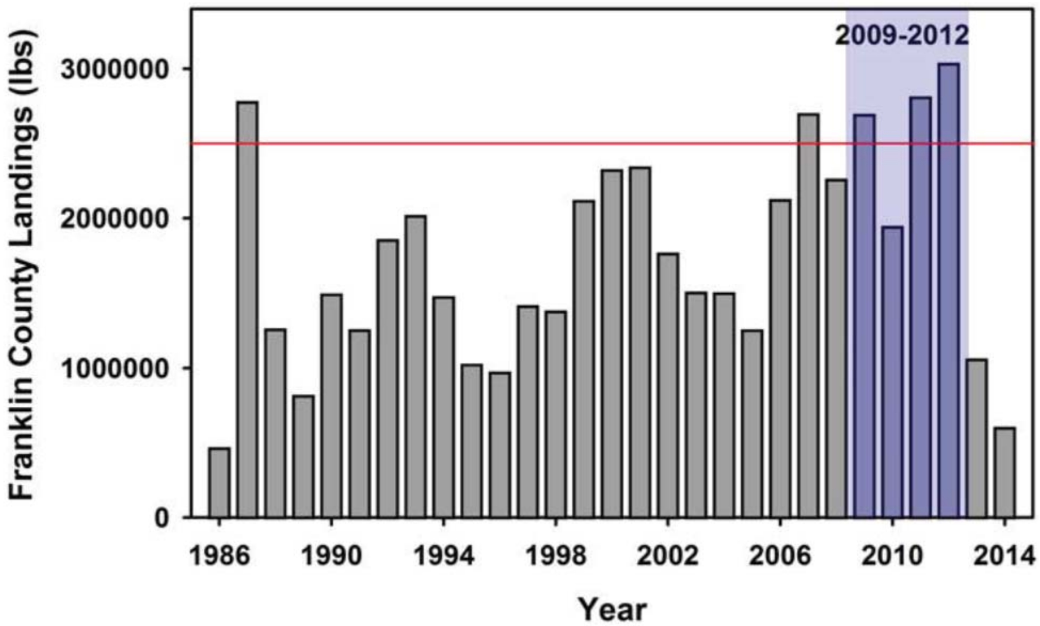
114. In addition, I analyzed the amount of shell replacement that the State of Florida conducted, and whether it was sufficient to replenish the oyster population in the Bay relative to the fishing pressure that occurred.

115. The contemporaneous data (generated by agencies from the State of Florida) indicate that fishing pressure and harvest practices used on the oyster population in Apalachicola Bay were excessive, unprecedented, and unsustainable, and collectively caused the collapse of the Apalachicola Bay oyster population in 2012, as discussed in more detail below.

1. Apalachicola Bay Landings 1986-2014.

116. Lipcius, Demo. 11, below, is based on GX-1129, referenced earlier, which contains Apalachicola Bay fishery landings for the years 1986 through 2014, Lipcius, Demo. 11 shows that landings in Apalachicola Bay were at the highest levels of the contemporary reporting period (1986-2014) in the two years immediately preceding the fishery collapse.

Lipcius, Demo. 11: Annual oyster landings from Franklin County Apalachicola Bay reflected by Florida Fish and Wildlife Conservation Commission data. The red line is a reference at 2,500,000 lbs.



2. **CPUE And Fishing Trips.**

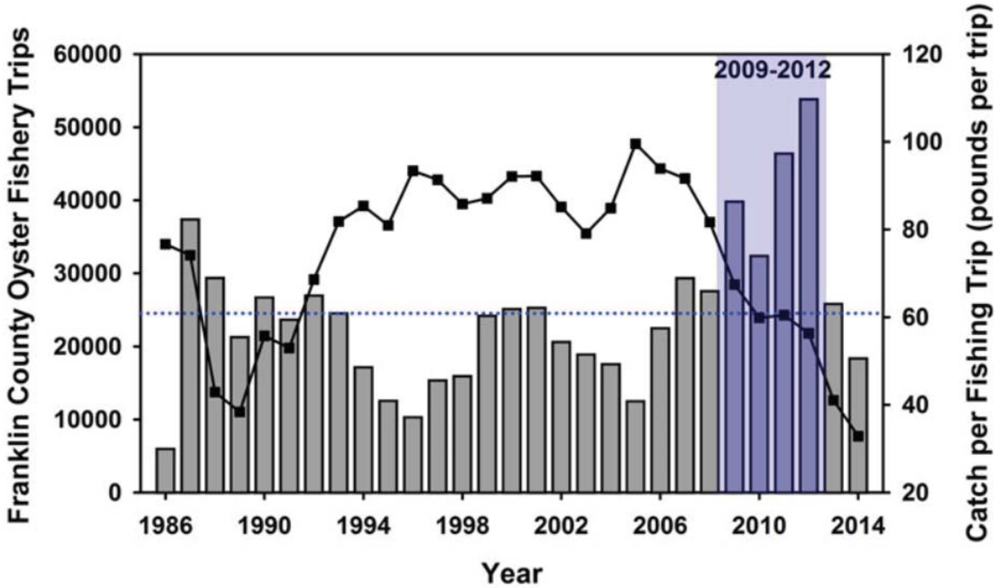
117. Catch Per Unit Effort (CPUE), which measures fishing efficiency calculated as oyster landings harvested per one fishing trip, began to decline precipitously in 2009, eventually dropping and remaining at the lowest numbers of the historical time period through 2014. What this means is that fishermen were making more trips, but "catching" fewer and fewer oysters per trip. Marine scientists routinely monitor CPUE of various species, as it informs the level of fishing effort of a particular species.

118. The significant, persistent decline in CPUE is a tell-tale warning sign for marine fisheries that often precedes fishery collapse, and should have triggered risk-averse management actions for the fishery. It is common knowledge in oyster fisheries management that successive years of abnormally high fishing effort combined with a sharp and consistent decline in CPUE risks a fisheries collapse, *especially* if such effort is not accompanied by proportionally high amounts of substrate restoration.

119. As with Franklin County landings and CPUE, the number of fishing trips executed by Franklin County oystermen in 2011 and 2012 were the two highest in the time

series. The third highest value in the time series was in 2009 and fifth highest was in 2010, indicating that fishing pressure (as measured by fishing trips) on oysters in Apalachicola Bay was extreme for the contemporary period in the years immediately prior to the collapse. This is reflected in Lipcius, Demo. 12, derived from GX-1129. The blue-shaded rectangle encompasses the three highest numbers of fishing trips (2009, 2011, 2012) in the contemporary historical record from 1986 through 2014. The blue dotted line is the average of the trips time series.

Lipcius, Demo. 12: Number of fishing trips per year (grey bars) and CPUE as catch per fishing trip (square symbols connected by line) by the oyster fishery in Franklin County.



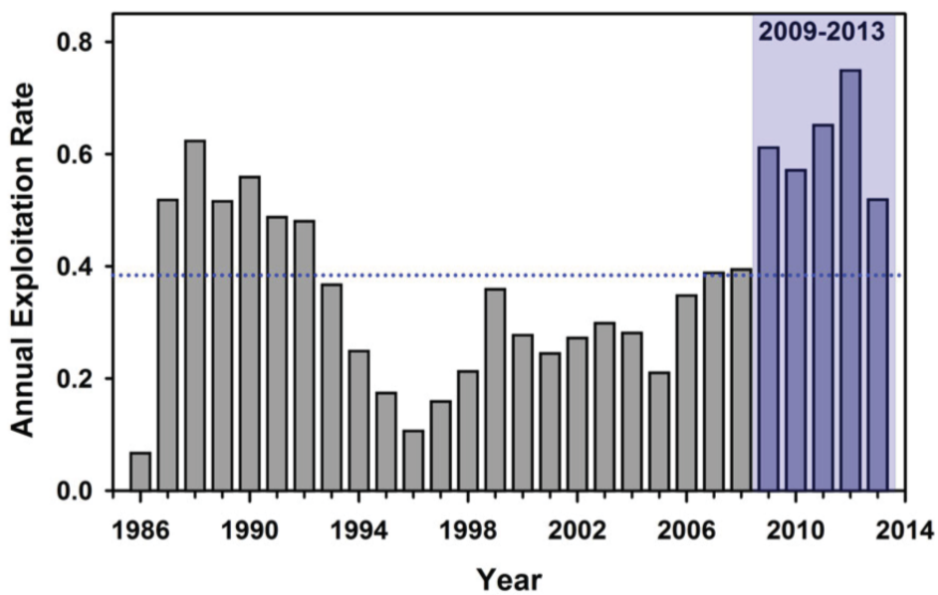
3. <u>Exploitation Rate</u>.

120. Exploitation rate is the fraction of the fishable population harvested by the fishery per unit of time. It is another common reference point that marine scientists routinely use to assess the causes of a significant decline in population of a harvested species.

121. The published academic literature suggests that the ideal annual exploitation rate to maintain sustainable oyster populations in the Gulf of Mexico should be around 20 percent; higher levels risk collapse of the fishery. *See* Powell, et al., *The Rise and Fall of Crassotrea Virginica Oyster Reefs: The Role of Disease and Fishing in their Demise and a Vignette on their Management*, J. of Marine Res. (2012). Marine scientists routinely rely on such literature in studying the underlying trends in marine fisheries populations, and I did so as part of my expert analysis in this case.

122. As shown below in Lipcius, Demo. 13, annual fishery exploitation rates in Apalachicola Bay increased spectacularly from 2009 through 2012. In addition, monthly rates (from which the annual rates were derived) in 2011 and 2012 were in the top six percent of those in the *336 months* from 1986 to 2014, and annual rates ranged from 45 to as high as 73 percent. This is additional strong evidence indicating excessive harvesting pressure. The blue shaded rectangle encompasses 2009 through 2013, immediately before and during the fishery collapse. The blue dotted line is the average of the time series. Annual exploitation rates were derived from the data contained in GX-1167, produced by the University of Florida in connection with this litigation, and referenced earlier.

Lipcius, Demo. 13: Annual exploitation rate, the fraction of the legal population harvested by the oyster fishery per year, in Apalachicola Bay from 1986 through 2013.



123. As Lipcius, Demo. 13 also shows, as the population declined through 2012, oyster fishers were catching a higher fraction of oysters. This is known as depensatory fishing, which is well-recognized in the academic literature as relevant to a collapse and as limiting the potential recovery of the oyster resource.

124. Overfishing of oyster populations usually also involves the degradation or destruction of oyster reef habitat through the destruction of the physical profile of reef and removal of substrate. When there is insufficient substrate, the oyster larvae may not settle successfully and can suffer high mortality in subsequent juvenile and adult stages.

125. Oyster tonging – the harvesting method used in Apalachicola Bay – involves the process of grabbing both shell and live oysters from the oyster bar. Thus, when oysters are harvested, the shell which makes up the substrate for oyster spat is often removed along with the live product. Oystermen are supposed to put the shell back, but if poor harvesting practices are being used they do not do so. This degrades oyster substrate, preventing oyster larvae from settling and developing into juvenile and adult oysters. There is a direct correlation between harvesting levels and loss of oyster substrate, which can be especially strong in years of low oyster abundance, as Dr. Bill Pine explained in his deposition in this case. (Pine Dep. Tr. 208-211). This relationship between harvesting and substrate is considered common knowledge by marine scientists who study oyster populations.

126. This also was described by the 2013 UF Sea Grant Apalachicola Bay Oyster Situation Report, GX-568, at pg. 15: "Both substrate and the number of oyster spat available may be influenced by the number of oysters harvested each year. In this way feedbacks are created between the oysters that are harvested, the shell that is available for spat to settle, and the spat that are produced each year."

127. Annual exploitation rates for the time period of the Apalachicola Bay collapse calculated from the estimated monthly rates derived by University of Florida scientists (see Pine III, *et al.* (2015), GX-789, GX-1167, and GX-1168), ranged from 45 percent to as high as 73 percent per year, well above any sustainable level for an oyster population, and more than *3 times* the recommend annual exploitation rates in Powell, et al., *The Rise and Fall of Crassotrea Virginica Oyster Reefs: The Role of Disease and Fishing in their Demise and a Vignette on their Management,* J. of Marine Res. (2012).

128. The conclusion that there was excessive removal of substrate is further supported by the additional finding that that the subset of Apalachicola Bay oyster reefs that Florida did re-shell from 2010-2012 had significant amounts of harvestable and sublegal oysters relative to reefs that were not re-shelled. *See* JX-52 (In 2011, recently re-shelled bars were healthy – showing new growth, a good spat set, and high numbers of live oysters). JX-52 is a report created by the principal Florida agency in charge of oyster reef restoration at the time - FDACS. Marine scientists routinely rely on such official state documents, as it represents fishery-

independent data and observations made by scientific personnel to assess underlying marine fishery population trends.

129. As the principal FDACS official responsible for oyster reef re-shelling (restoration) testified, the major harvested oyster bars in Apalachicola Bay were never re-shelled in the years immediately prior to the oyster collapse, due to opposition from the fishery. Berrigan Dep. Tr. pgs. 117-118. (Cat Point and East Hole were not re-shelled because of opposition from community that did not want them closed from harvesting).

130. In fact, in 2012, as reflected in his contemporaneous communications, Florida's chief oyster expert, Dr. David Kimbro, noted the deleterious effects of unsustainable harvesting practices and the excessive removal of substrate. Specifically, he emailed Dr. Pill Pine after surveying oyster bars in October 2012: "I was out with FDACS surveying a lot of their subtidal bars this week. . .In Apalachicola, the subtidal patterns are completely different mostly because ***there is nothing left . . . the "open" bars look like gravel parking lots because they've been harvested so much."*** GX-486, Oct. 25, 2012 e-mail from Dr. Kimbro to Dr. Pine. (emphasis added).

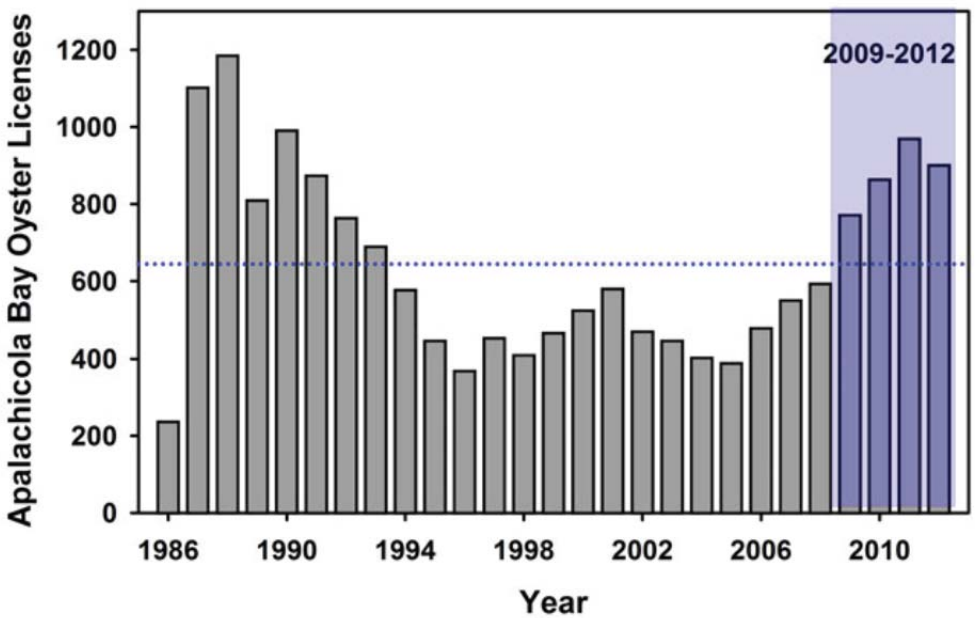
131. Contemporaneous observations such as reflected in GX-486 are a form of evidence which is commonly relied upon by marine fisheries experts, and is in a category called fishery-independent data and observations by scientific personnel. In this case, GX-486 reflects Dr. Kimbro's contemporaneous assessment of the state of Apalachicola Bay's oyster bars *at the time the collapse of the oyster fishery was occurring*. It is therefore entirely consistent with the other available evidence showing that unsustainable harvesting was the cause of the collapse of the oyster fishery in 2012-2013.

4. Increase in the Number of Fishing License Holders

132. Another indicator of fishing effort I analyzed was to track the number of licensed oyster fishers in Apalachicola Bay over time using the State of Florida's own data. As reflected in Lipcius, Demo. 14**,** below, there was a marked increase in licensed fishermen from 2009-2012, the years immediately prior to the collapse. This demonstrative was based on GX-1014, which includes licensing information from Apalachicola Bay during the relevant time frame. Experts in my field routinely rely on this sort of data to assess underlying trends in marine

populations and their fisheries. Blue shaded rectangle encompasses the period immediately before the fishery collapse and blue dotted line is the average of the time series.

Lipcius, Demo. 14: Number of licensed fishers per year in the Apalachicola Bay oyster fishery.



133. As Lipcius, Demo. 14 shows, the number of licensed fishers per year in Apalachicola Bay from 2009-2012 ranged from 774-972 licenses. Such a high number of licenses issued for Apalachicola Bay oyster harvesting had not been observed since the early 1990s. And all these values in the 2009-2012 time period were well above the 1986-2012 average of 644 licensed fishers. This is another source of data that may indicate high nominal fishing effort, in conjunction with the data on fishing trips shown in Lipcius, Demo. 12, which are more signs of potential unsustainable harvesting.

C. <u>Lack Of Adequate Re-Shelling To Restore Apalachicola Bay's Oyster Reefs.</u>

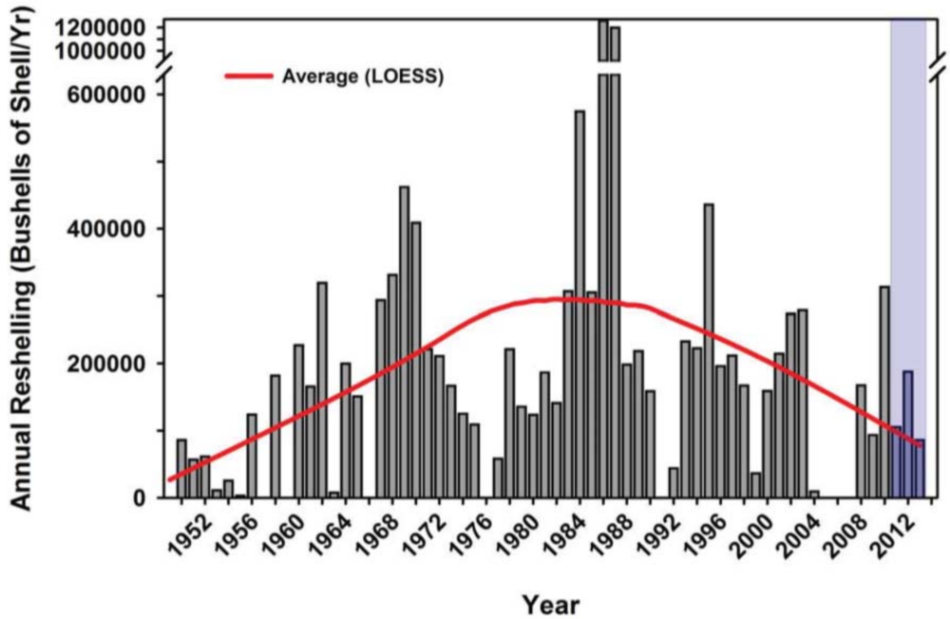
134. Oyster fisheries are unique among the world's fisheries in that they require management not just of the spawning stock, but also of the shell resource, because, as described above, oyster harvest removes not just living oysters but also the shell resource for future generations.

135. As every oyster scientist and Florida state official responsible for managing the Apalachicola Bay oyster resource recognizes, stable shell resource is an essential substrate for larval settlement, juvenile growth and survival, and adult growth, survival and reproduction. *See* Knickerbocker Dep. Tr. pgs. 96–100; Shields Dep. Tr. pgs. 36-37; Berrigan Dep. Tr. pgs. 117-122; Sutton 30(b)(6) Dep. Tr. pgs. 166-167. This dual management responsibility (*i.e.*, stock abundance and shell resource) has been recognized throughout the range of the eastern oyster since the early part of the 20th Century as critical to sustaining oyster fisheries.

136. During the years immediately preceding the collapse, however, Florida's re-shelling activity reached its lowest levels since 1986. This is especially significant, because the high fishing pressure in 2010-2102, coupled with low stock abundance and CPUE should have induced Florida to dramatically increase its level of re-shelling if there was to be any hope of sustaining the oyster population. This did not happen.

137. But, as set forth below in Lipcius, Demo. 15, annual re-shelling during the year before the collapse (2011) through the two years of the collapse (2012-2013) averaged 128,407 bushels per year -- the lowest average going back to the 1960's. Lipcius, Demo. 15 is based on GX-1183 and GX-1184, and reflects annual amounts of oyster re-shelling Apalachicola Bay. The red curve depicts the smoothed average over the time series.

Lipcius, Demo. 15: Complete record of re-shelling in Apalachicola Bay from 1949- 2013.



138. As the above graph demonstrates, the re-shelling activities by Florida in the years leading up to the collapse were not sufficient to replenish the concurrent spike in the exploitation rate for oyster harvest, thus causing the oyster collapse.

139. Dr. Kimbro mischaracterizes my analysis of Florida's re-shelling program, which is shown in Figure 35 of my expert report. He accuses me of having arbitrarily selected the time periods I used to display average amounts of re-shelling per year. That criticism is incorrect. As I expressly explained in my expert report, the time periods I analyzed were the exact same ones that the Florida Fish and Wildlife Conservation Commission (FWC) used in connection with their report. *See* JX-96, 2013 FWC Disaster Report, at 20. They selected the time periods, not myself.

140. The purpose of Figure 35 was to include the two time periods that were "arbitrarily" omitted by FWC, which were 1982-1989 and 2011-2013. By adding back these omitted time periods, the data clearly demonstrates that the amount of re-shelling Florida did in the years immediately preceding and during the collapse (2011-2013) was substantially lower than the time periods selected by FWC.

141. Next, Dr. Kimbro states that he conducted a "more rigorous analysis of the same data" by selecting five-year time bins from 1970-2015, and then comparing the average of the 2010-2014 time bin with the long-term average. Kimbro Direct ¶ 105(a-b). From this analysis, he concludes that "the amount of shell deployed in 2010–2014 does not differ statistically from the long-term average" and that, therefore it was "invalid" for me "to conclude that the years just prior to and during the 2012 collapse represent a period of anomalously low shelling by the State of Florida." Kimbro Direct ¶ 150(d-e).

142. This is demonstrably false. Dr. Kimbro's analysis, in addition to using arbitrary time periods, reflects a fundamentally flawed analysis.

143. In particular, Dr. Kimbro's selection of time periods is arbitrary because he selects a starting date (1970) and a bin interval (five years) indiscriminately. He provides no logical explanation for these selections, which can have a major effect on the results. In contrast, I presented re-shelling data from 2011-2013 because these were the years immediately before and during the fishery collapse, and which provides a logical basis for their selection. Had Dr. Kimbro selected three-year time intervals that included 2011-2013 as an interval – the time period FWC omitted from its report -- he would have gotten the same results as I did.

144. Dr. Kimbro's analysis is further fundamentally flawed because he uses inappropriate data that skew the results in favor of his conclusion. Specifically, Dr. Kimbro includes re-shelling data from 2014 and 2015 in his analysis and data presentation.

145. The year prior to the fishery collapse was 2011, and the years of the actual fishery collapse were 2012 and 2013, when the population and fishery declined dramatically. This terminology is that used by fishery scientists worldwide, and is a scientifically valid means of identifying the time period when a fishery "collapse" actually occurs.

146. After a fishery collapse, unless it recovers, the population will remain at a consistently low level of abundance and is considered "depleted," "in decline" or "collapsed." Thus, the years 2014 and 2015 were *post-collapse* years, not the years of the collapse. It is true that, in sharp contrast to the years of the collapse (and the year prior), Florida has conducted relatively more aggressive re-shelling. Notably, Florida did not itself fund this re-shelling

activity; rather it was conducted with federal funds from the fishery disaster declaration, after the collapse, to promote recovery of the fishery.

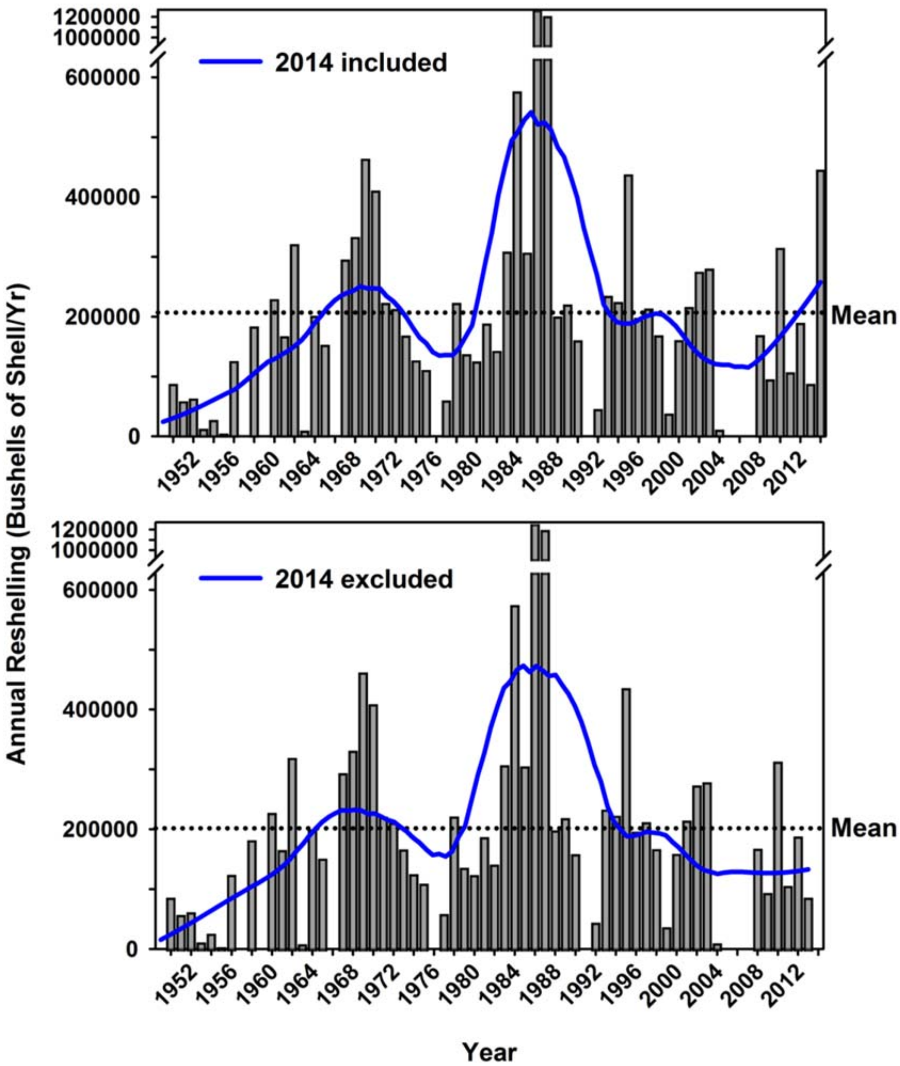
147. Elimination of re-shelling data for 2014 and 2015 from Dr. Kimbro's analysis would lead to the same conclusion reached in my report, that the State of Florida significantly reduced its re-shelling program in the years immediately preceding and during the collapse.

148. Dr. White also uses re-shelling data from 2014 in his criticism of my analysis and presentation of Florida's re-shelling data in my Expert Report Figure 36. White Direct ¶¶ 69-71 and Figure 2. This results in a flawed analysis for the same reasons presented above for Dr. Kimbro's analysis. It is therefore also inaccurate and misleading for him to state as he does that his Figure 2 "is an accurate representation of the shelling data [I] provided with [my] report."

149. To demonstrate how Dr. White's inclusion of 2014 in his analysis skews his results, I recreated Dr. White's analysis that produced the blue curve in his Figure 2 using the data I presented in Figure 36 of my report. The blue curve differs from the red curve in my Expert Report Figure 36 because the blue curve uses a shorter time frame for the LOESS spline that generates the curves (25-year time frame for the blue curve vs. 56-year time frame for my red curve). This allows a shorter subset of the data to have greater influence on the form of the curve. Because Dr. White includes 2014 as a data point in his analysis – when there was a higher amount of re-shelling *after* the collapse – it affects the form of the blue curve significantly, and forces the blue curve to rise during 2008-2014 to make it appear that Florida was increasing their re-shelling program.

150. Lipcius, Demo 16 recreates Dr. White's analysis both with and without 2014 data. Note the sharp difference in the curves from 2008-2013 if one includes or excludes 2014. If one includes 2014, the blue curve rises above the long-term average during 2012 and 2013. In contrast, when one excludes 2014, the curve now shows what actually occurred before and during the collapse—after 1997, re-shelling decreased below the average of the time series, and remained well below the average in 2011, 2012 and 2013.

Lipcius, Demo. 16: Complete record of re-shelling in Apalachicola Bay from 1949-2014 (top) and 1949-2013 (bottom).



151. Consequently, my conclusion that Florida reduced their re-shelling program immediately before and during the fishery collapse remains valid and scientifically justified.

D. <u>Restoration Experiments Conducted by Dr. Kimbro</u>

152. In his testimony, Dr. Kimbro also takes issue with my conclusion that the addition of shell material to oyster bars significantly reduces mortality of oysters due to predation. He discusses the results of one of his restoration experiments conducted from October 2015 through

January 2016. Kimbro Direct ¶ 89. The experiment had three treatments with varying amounts of shell added to oyster bars, either (i) no shell added, (ii) addition of 200 cubic yards per ¼ acre of oyster bar, and (iii) addition of 400 cubic yards per ¼ acre of oyster bar of shell. At each treatment oysters were placed on the bars and their survival monitored. Kimbro Direct ¶ 89(a).

153. Dr. Kimbro offers the opinion that the amount of reef structure does not impact predation, describing the results of his experiment as follows: "In this experiment, predation occurred. But oyster survivorship due to predation did not differ among the reefs. … As illustrated in Figure 11, the survivorship of oysters was relatively constant across the different types of reefs. Therefore, the amount of background reef structure does not influence the degree to which snails consumes oysters in my experiments." Kimbro Direct ¶ 89(b).

154. As a threshold matter, contrary to standards of professional scientific analysis, Dr. Kimbro does not present the statistical analysis supporting his conclusion. Accordingly, I reviewed the underlying data myself and determined that his conclusion is unsupported and, in fact, is directly contradicted by the data underlying his experiment.

155. First, Dr. Kimbro's conclusion in his direct testimony is directly opposite to what he presents in the Expert Report he provided in this case. In that report, Appendix pg. 36, Dr. Kimbro described the results of the same experiment as follows: "… in agreement with the laboratory experiment, restored reefs significantly reduced the intensity of predation ($p = 0.03$), with additional reef structure increasing overall survivorship from 79% (+9.0) in the nonrestored treatment to 92% (+4.0) in the moderately restored treatment and 84% (+7.0) survival in the highly restored treatment."

156. Dr. Kimbro's expert report also found a significant effect of shell structure on oyster survival through his laboratory experiment, as stated on pg. 36 of his expert report: "In laboratory experiments, an increasing amount of restored reef (dead shell material) significantly decreased daily rate of snail predation on oysters by physically inhibiting encounters between snails and living oysters in the interior of the restored reef, with an average of 1.89 oysters eaten per day on reefs with high reef structure and 3.0–3.44 oysters eaten per day on reefs with low and moderate reef structure."

157. To verify the statistical analysis discussed in Dr. Kimbro's expert report, I used Dr. Kimbro's experimental data provided in Exhibit "847_FL-ACF-04142700.CSV," and conducted a statistical analysis of oyster survival as a function of the shell restoration treatments. The results are presented, below, in Lipcius, Demo. 17, as "Restoration Experiment 1."

158. The results of my statistical analysis are completely inconsistent with Dr. Kimbro's direct testimony submitted in this case. Oyster survival was 42-106% higher at the two bars with shell added, either at 200 or 400 cubic yards per ¼ acre, than survival at the oyster bar with no shell added. Furthermore, survival of oysters on the bars with shell added were statistically higher than survival of oysters on the bar without shell in three of the four cases (Lipcius, Demo. 17, $p < 0.05$). Even in the one shell addition case that was not statistically significant ($p = 0.18$), survival of oysters was still 42 percent higher than survival on the bar without shell added.

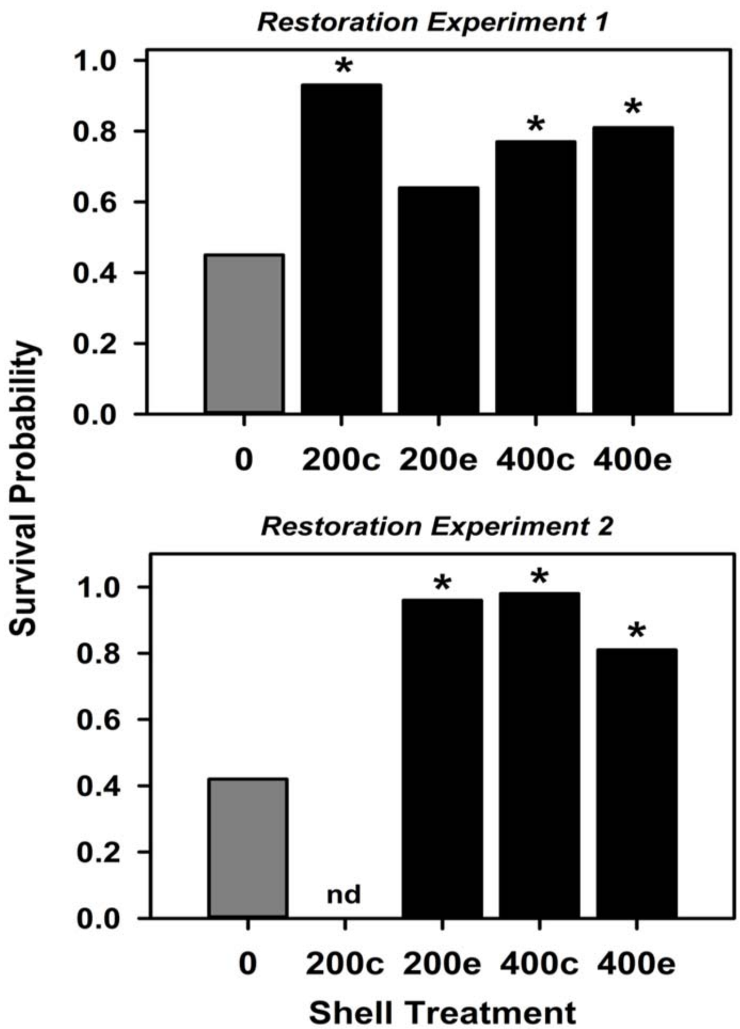
159. I also analyzed the data from Dr. Kimbro's second restoration experiment, which was conducted similarly as experiment 1, but from February – May 2016. The results of this experiment were provided by the State of Florida in Exhibit "842_FL-ACF-04142734_image.pdf," but the results of this second restoration experiment were neither presented nor discussed in Dr. Kimbro's testimony. The data for this experiment and analysis are in Exhibit "847_FL-ACF-04142700.CSV."

160. The results of the second restoration experiment are displayed in Lipcius, Demo. 17 under "Kimbro Restoration Experiment 2." As Lipcius, Demo. 17 reflects, Dr. Kimbro's second experiment results are even more striking than those of his first experiment. Oyster survival was 93-133% higher at the two bars with shell added (200 or 400 cubic yards per ¼ acre) than survival at the oyster bar with no shell added. In this experiment, survival on the bars with shell added was always statistically higher than survival on the unshelled bar (Lipcius, Demo. 17, $p < 0.05$).

161. Lipcius, Demo. 17-Restoration Experiment 2 reflects the following: survival probability represents the fraction of oysters surviving in each of the shell addition treatments. 0 = no shell addition; 200 = 200 cubic yards per ¼ acre added to the oyster bar; 400 = 400 cubic yards per ¼ acre added to the oyster bar; c = survival measured at the center of the oyster bar; e

= survival measured at the edge of the oyster bar. Asterisks (*) denote values that are statistically higher than the value for no shell added. Finally, "nd" means that there were no data for 200 cubic yards per ¼ acre added to the oyster bar in experiment 2.

Lipcius, Demo. 17: Results of analysis of the two restoration experiments conducted by Dr. Kimbro.



162. This collective information is entirely consistent with the conclusions I presented in my expert report and that I present in my testimony here: (i) the addition of shell to oyster bars significantly reduces mortality of oysters due to predation, and (ii) the reduction of re-shelling of oyster bars by the State of Florida in the years immediately preceding and during the

oyster fishery collapse was a major contributor to the collapse. The statements and conclusions in Dr. Kimbro's written testimony are, therefore, misleading and scientifically unreliable.

E. Lack Of Enforcement Against Illegal And Sublegal Harvesting.

163. In the course of my analysis of the deposition testimony and trial record evidence in this case, several documents captured contemporaneous reports of over-harvesting and illegal harvesting. Contemporaneous observations by those in the field and from state officials are commonly considered by marine scientists in their analyses of marine fisheries, in addition to the documents and data mentioned above.

164. These contemporaneous official State documents and comments of Florida officials also indicate that law enforcement efforts to prevent harvesting of illegal and sublegal oysters were lacking at the same time that such illegal fishing was widespread. This illegal harvesting escalated particularly after the Deepwater Horizon oil spill event in April 2010, and continued through the fishery collapse of 2012 and into 2014.

165. As mentioned above, in requesting the federal fishery disaster declaration, Governor Scott attached the August 2012 official FDACS Report to his letter to the Secretary of Commerce Requesting Fishery Disaster Declaration. JX-77. This report stated that harvesting pressure contributed to declining stocks of "juvenile, sub-legal, and market-size oysters" due to "continuous harvesting" of Apalachicola Bay's primary oyster bars, Cat Point and East Hole. (FDACS August 2012 Assessment at pg. 7.) Governor Scott himself also attributed the collapse, in part, to over-harvesting.

166. The 2012 FDACS Report explained that the "excessive harvesting of sub-legal oysters" contributed to declines in legal size oysters, and that this "excessive harvesting" started after the Deepwater Horizon oil spill event, but then continued through at least August 2012. JX-77, at pg. 7.

167. Contemporaneous analyses by official Florida agencies repeatedly documented the fact of extremely high fishing pressure in the years immediately preceding the 2012 oyster fisheries collapse. For example, even earlier, in its 2011 Resource Assessment Report, FDACS noted that "Fishing effort throughout the winter and spring of 2011 placed added pressure on Cat

Point and East Hole Bars, which, in conjunction with fishing effort that was placed on these reefs during the summer of 2010 in response to the oil spill event, resulted in a cumulative increase in harvesting pressure from a relatively limited resource." GX-368 at pg. 3. Marine scientists routinely rely on this type of information produced by official state agencies tasked with monitoring state fisheries. Such reports reflect contemporaneous knowledge from people who have the most interaction with the resource and fishery, and thus capture critical information that is not otherwise reflected in abundance surveys.

168. Based on the evidence I reviewed in this case, it is clear that enforcement efforts to prevent harvesting of illegal and sublegal oysters were not boosted at a time when such illegal fishing was widespread. For instance, Florida did not put check stations in place to stop illegal harvesting until November 2015, even though it was documented as early as 1988 by Florida's own officials that check-stations were effective at preventing over-harvesting and poor culling practices. JX-2, M. Berrigan, Management of Oyster Resources in Apalachicola Bay Following Hurricane Elena, J. Shellfish Research (1988); FX-407, November 2015 Executive Order Establishing Check-Stations in Apalachicola Bay. And reports of illegal harvesting did not stimulate increased monitoring by Florida officials until after the collapse was already occurring or had already occurred.

169. These documents fill in gaps in knowledge of what is happening "on the ground" at the time that a specific fishery is experiencing population declines. These contemporaneous discussions of the state of the fishery must be read with caution, but they are important pieces of information that are commonly used by scientists to understand underlying causes of fisheries trends.

170. The following statements in documents provided in this case, which are no means exhaustive, reflect precisely the type of "on the ground" discussion that informs scientific analysis about what causal mechanisms contributed to fisheries collapse. These contemporaneous observations examined in tandem with the fishery-dependent and fishery-independent data, collectively provide overwhelming evidence that unsustainable harvest, and not low river flows, caused the Apalachicola Bay oyster fisheries collapse in 2012. GX-459 (Sept. 19, 2012 email from Beaton to Cooper: "Illegal harvest is really exploding. We may need

to expand our detail and bring in some out of area folks."); GX-677 (Sept. 11, 2013 email from FWC Marine Fisheries Manager Heil to FWC Asst. Executive Director Estes: "For what it is worth, Mark Berrigan told me that one of the Apalachicola Dealers told him that there is indeed large scale harvest of 1 inch oysters occurring."); JX-53 and JX-134 (Oct. 2013: "Since the beginning of the year there has been an exceptional increase in illegal harvest from shellfish. These violations seem to be on the rise with extreme and gross malice.").

171. Finally, I note that Dr. Kimbro cites the Florida Fish and Wildlife Conservation Commission's 2013 Disaster Report ("FWC Report") submitted in support of their disaster declaration request, which found that over-harvesting did not play a role in the collapse. *See* Kimbro Direct ¶ 5(c). The Fish and Wildlife Conservation Commission (2013) report opined that there was no evidence that overharvesting contributed to the oyster collapse (pgs. 13-14, 16-17, 30-31), most prominently because of the following finding: "It is FWC's contention that while harvest of sub-legal oysters does occur, the fact that the Apalachicola oyster satisfies the half-shell oyster market at competitive prices is testament to the conclusion that this practice is not unregulated, and that it is not occurring at rates that substantially differ from the past." The Fish and Wildlife Conservation Commission (2013) report also relied on oyster assessment reports drafted by FDACS and FWC landings data, as well as from the UF Sea Grant Apalachicola Bay Oyster Situation Report, which was published a few months before the Fish and Wildlife Conservation Commission (2013) report. See GX-568.

172. This document, in my opinion, is not supported by sound scientific analysis, but rather appears to have been directed toward a pre-requisite to obtain a fisheries disaster declaration, which "has to be beyond the scope and control of management." JX-96 (FWC Report at Appendix 3). The Report's conclusions included that "the oyster decline is a lack of freshwater flow into rivers and estuaries," pg. 5 and that "harvesting levels were not excessive under normal environmental conclusions." JX-96 at pg. 30.

173. The contemporaneous documents I reviewed relating to the FWC Disaster Report suggest that Florida was concerned that the federal government – through the National Oceanic and Atmospheric Administration – flagged over-harvesting as a significant impediment to Florida receiving a disaster declaration. For example, in GX-569, David Heil, the FWC marine

fisheries management leader charged with drafting the Report, e-mailed other FWC personnel, after speaking with a NOAA official, Steve Branstetter, who confirmed that Florida had significant concerns that its disaster application was vulnerable to being rejected on the basis of fisheries mis-management. *See* GX-569.

174. However, I have seen no evidence that there was any actual additional scientific analysis done to support the report's conclusions. The Report's Appendices do include the 2012 FDACS Oyster Resource Assessment Report, as well as the full-text of the UF Sea Grant Report I discussed earlier, GX-568. But these publications do not support the report's conclusions. The University of Florida team did not draw any conclusions about over-harvesting oysters in Apalachicola Bay. It stated: "there is no evidence that harvest of sub-legal oysters in the catch has caused the trends we see in the data unless the sub-legal harvest has been unregulated and extremely high." GX-568. In short, the report did not attempt to study the amount of sub-legal harvest in the Bay in the time period preceding the collapse, instead simply emphasizing that its modeling data suggested that "lack of compliance with current regulations could greatly reduce the likelihood of Apalachicola Bay oyster populations returning to historic population levels, regardless of management action taken." GX-568 at pg. 6.

175. FDACS, Department of Aquaculture officials who were deposed in this case stated that they "could not support the FWC conclusions" and that the available data did not support the argument that overharvesting was not a contributing factor to the collapse. Kal Knickerbocker, current FDACS Aquaculture director, stated the following to an FWC official, the agency who drafted the report: "Also I expressed our concern regarding the FWC Oyster Damage Report. Told him that we could not support the FWC conclusions [no evidence of overharvesting contributing to the oyster resource collapse] based upon the FDACS 2012 Oyster Assessment Report. Our report very clearly did not indicate that kind of a conclusion to be true." GX-596.

176. In short, the FWC Report, which was generated by the State of Florida and submitted to the federal government in support of Florida's request for an oyster disaster declaration in the Florida panhandle, is not credible scientific evidence that low river flows caused the 2012 oyster collapse in Apalachicola Bay.

IV. THERE IS NO SCIENTIFIC EVIDENCE OF A GENERAL DECLINE IN ECOSYSTEM PRODUCTIVITY OF APALACHICOLA BAY DUE TO LOW RIVER FLOWS.

177. In its complaint in this lawsuit, Florida also asserts that Georgia's water use and low water flows from the Apalachicola river caused a generalized decline in overall ecosystem productivity in the Bay. To analyze this claim, I examined whether the CPUE of other fished species dropped significantly at the same time (2011-2013) as lower river flows and the oyster fishery collapse. I compared these data to those for the oyster and stone crab fisheries.

178. The official Florida landings data and CPUE for white shrimp, pink shrimp and blue crab – other species harvested in Apalachicola Bay – show that there was no generalized decline in ecosystem productivity. Indeed, the data show that during and immediately after the years of lower flow and the oyster fishery collapse:

(a) CPUE of white shrimp, pink shrimp and blue crab did not exhibit a significant reduction;

(b) landings of these species were either positively correlated or not correlated with river flow at 0 or 1 year time lags;

(c) the patterns in CPUE over time differed significantly from those of oyster and stone crab;

(d) CPUE for shrimp species in Apalachicola Bay (white and pink shrimp) did not differ from those of the brown rock shrimp, which inhabits deeper waters outside of Apalachicola Bay; and,

(e) CPUE of all four of these species from 2011 through 2013 varied about the average of the contemporary time series from 1986-2014, and never fell below 1 standard deviation of the mean (Figure 34). Of the 11 values of CPUE, 7 were above and 4 were below the mean.

179. What this means is that the official Florida state data show that these species were not negatively impacted in any noticeable manner by lower river flows during the drought. Consequently, there was not a significant reduction in ecosystem production of crustaceans

during and immediately after the years of lower flows during drought and the oyster fishery collapse from 2011 through 2013, which is entirely opposite Florida's assertions.

V. RECOVERY OF THE APALACHICOLA BAY OYSTER FISHERY IS POSSIBLE WITH RESPONSIBLE FISHERY MANAGEMENT AND SUFFICIENT HABITAT RESTORATION.

180. The Eastern oyster is a remarkably resilient species. In fact, Florida's experience in the early 1980's after Hurricane Elena – when the Apalachicola Bay oyster fishery was decimated – shows that, with responsible fishery management practices, recovery of the oyster population is possible.

181. What Florida did after the fishery disaster occasioned by the hurricane was to immediately adopt fishery management practices that: i) stringently restricted harvesting – in fact the entire fishery was closed for a period, ii) ramped up enforcement efforts against harvesting through the institution of check stations, and iii) implemented a substantially increased re-shelling program. These are exactly the type of responsible fishery management practices Florida should have employed at that time – and the once-decimated Apalachicola oyster fishery recovered quickly.

182. Changes in the level of freshwater flows, which overall cause relatively minor and temporary changes in salinity, have little to do with the timing of recovery of an oyster fishery after a collapse, such as the one here. Larval oysters cannot settle and grow to juveniles and then to adults without substrate – regardless of salinity levels. Nor can they be replaced if removed by excessive fishing.

183. The academic literature supports this. An example of the viability of population and fishery recovery of exploited oyster populations was presented by Wilberg, *et al.* (2013). They modeled the effects of reef quality and quantity upon recovery rates of depleted oyster populations (Figure 37). In these simulations, the recovery time of a depleted oyster population was possible and much faster when the shell resource was of better quality, such as occurs after substantial re-shelling of fished oyster bars.

184. In contrast, recovery was either impossible or took much longer when oyster reef habitat was of poor quality, such as when the shell resource is not consistently replenished.

Consequently, resumption of a vibrant re-shelling program, along with risk-averse fishery management, is the optimal approach for stimulating recovery of the oyster fishery.

185. A responsible, risk-averse strategy for rehabilitation of the Apalachicola Bay oyster fishery will necessarily involve (i) reductions in fishing pressure and shell (substrate) removal, (ii) enhancement of re-shelling of the oyster fishery grounds to rehabilitate the habitat, including magnification of the re-shelling program, (iii) intensified enforcement to prevent harvest of illegal and sublegal oysters, and (iv) lowering the fishery harvest to sustainable levels that will allow for persistence of the spawning stock and sufficient shell substrate for juvenile recruitment, growth and survival. With such efforts, there is no reason the Apalachicola Bay should not recover relatively quickly, just as it did in the 1980s after being decimated by Hurricane Elena.

CONCLUSION

I conclude to a high degree of scientific certainty that low flows in the Apalachicola river due to Georgia water consumption did *not* cause the collapse of the Apalachicola Bay oyster fishery in 2012-2013. There simply is no scientific evidence to support that assertion. I also conclude to a high degree of scientific certainty that the oyster fishery collapse was caused by unsustainable harvesting practices taking place during the years immediately preceding and during the collapse. The scientific evidence in support of this is substantial.