Review of: Unprecedented disease-related coral mortality in Southeastern Florida

Rachel N. Silverstein, Ross Cunning, Andrew C. Baker

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Reply by Precht et al.

William F. Precht, Brooke E. Gintert, Ryan Fura, Martha L. Robbart

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Executive Summary

Silverstein et al. endeavored to replicate the results found in Precht et al. 2016 (https://jrcunning.github.io/pom-dredge/scirep/scirep_analysis.html). Their review was based on analysis they performed on Excel data files that we freely provided to them. However, they did not use the same analytical criteria (disease prevalence and definitions of bleaching) nor did they perform the same detailed review of the raw data with the available matching project photographs. Accordingly, they arrived at slightly different conclusions than we did in our Scientific Reports manuscript.

Specifically, Silverstein et al. did not use all the data that were available to them nor did they do the necessary due diligence to replicate our results. We used the same data in our analysis that we provided to Silverstein et al. However, we used the Excel spreadsheet data as a starting point in our interpretations, not an end point. This included using thousands of paired photographs that were taken at the same time the in situ data were collected. Just writing 'R Code' of an Excel data file without performing even minimal background research, or without using the available photographs may lead to a false trail as it did for Silverstein et al. in numerous instances throughout their review.

Our analysis for the Scientific Reports manuscript was based on thousands of underwater man-hours performed by multiple teams of trained Dial Cordy and Associates (DCA) scientific divers between September 2013 and July 2015, hundreds of pages of interviews, blog posts, press-releases, media coverage, and emails from our colleagues, as well as unpublished data from numerous other research (monitoring) teams collecting similar data from across the region. It should also be noted that one of the authors in Precht et al. 2016 (RF) was responsible for collecting a lion's share of the in situ field data while yet another (BEG) was responsible for the QA/QC analysis of all the collected field data which included comparing all the in situ field observations with their paired photographs. In addition, the four co-authors from DCA that were

involved in this analysis combined to perform well over 3,000 scientific dives throughout the region between Sept 2013 and July 2015.

Detailed answers are provided below in response to each of the points raised by Silverstein et al. The information below is presented in a comment-and-response style. For ease of reading, the original comment from Silverstein et al. is presented first and the response by Precht et al. follows immediately below and is indented.

Main issues raised by Silverstein et al.

This document attempts to replicate results presented in Precht et al. (2016) Scientific Reports, using the dataset provided to us by the authors.

> **Precht et al. Response**
>
> The comment above presumes that in order to replicate the results in Precht et al. (2016), all they require are the data files used in our analysis. This premise is false. The key to replicability is to perform the same analysis of <u>all of the underlying data</u> used in the original manuscript. While Silverstein et al. have these materials, by their own admission they do not use all the data at their disposal. Specifically, they stated the following "Please note that we conduct this review using the dataset provided by Precht et al. authors, and we did not independently verify the data through analysis of the photographs of each coral, nor do we present a complete reinterpretation of the data here."

Silverstein et al. comment:

In short, we are unable to reproduce many of Precht et al.'s findings, particularly with respect to disease prevalence… The authors define disease prevalence in the Methods section as "…the proportion of cases that were present in the population, at a given time."

It is also not made clear in the Methods that dead corals are counted in estimates of ongoing "disease prevalence." The description of "disease prevalence" in the Methods section is contradictory, vague, and obfuscated by the Results section that refers to disease prevalence results as, corals "infected with white plague" or "show[ing] outward signs of white plague."

> **Precht et al. Response:**
>
> Prevalence measures the proportion of individuals in a defined population that have a disease at a specified point in time (point prevalence) or during a specified period of time (period prevalence). Period prevalence is sometimes referred to as cumulative prevalence. In Precht et al. (2016) we used the general term 'prevalence' for determining the number (proportion) of corals (cases) with white-plague disease at the tagged coral sites "at a given time." The word 'given' here is the key as it indicates a 'certain time period.' The specified period of time in this instance are the dates from start to finish of the monitoring effort. Thus, any corals (cases) that died from the disease during the monitoring program

are included in the period prevalence because they obviously were infected with the disease at some point during the study. Had we meant 'point prevalence' instead of 'period prevalence' we would have said "at a point in time" not "at a given time." While this semantic debate might seem trivial, it appears to form the basic disconnect in Silverstein et al.'s analysis of our tagged coral results.

The timed-swim surveys, on the other hand, were all one-off surveys intended to capture a snapshot of the disease in space and time. Accordingly, these point prevalence data included recently dead corals in the prevalence calculation. We are not the first coral scientists to use recently dead corals to explain the burden of a disease on a given population. For instance, the AGRRA field monitoring protocol actually asks the observer to inventory all newly dead corals as that could indicate an ongoing disease outbreak or bleaching event (AGGRA 2016). As we previously shared with Silverstein et al., the inclusion of recently dead corals in the enumeration of white-plague disease prevalence was modeled after the work of Miller and Williams (2007), where both corals with active disease and those that had recently died were used to quantify the total impact of white-plague disease in Navassa. Miller and Williams (2007) stated: "(White Plague) disease state was scored as either 'active' disease signs, 'recent mortality', or unaffected. 'Active disease' designation was used for colonies with very bright white exposed skeleton with no (or very little) algal colonization and sharp corallite structure adjacent to live tissues. 'Recent mortality' included colonies with areas of skeleton having minimal to moderate colonization by algal turf but with intact corallite structure and including those colonies that had <u>undergone complete recent mortality</u>."

Other researchers throughout the region are presently using the same prevalence terminology, combing recently dead corals in their analysis. For instance, (Lunz et al. 2017, see also Ruzicka 2018) noted the following "In June and July 2016, additional disease outbreaks were reported from the Coral Reef Evaluation and Monitoring Project (CREMP) at historical sites in the upper Florida Keys. The CREMP team, part of FWC FWRI, conducted a directed sampling effort at Grecian Rocks targeting both apparently healthy and disease colonies for comparison and collected paired molecular and histology tissue samples for analysis. <u>Prevalence surveys conducted at the time of sampling</u> revealed that 100% of *Meandrina meandrites* colonies, 66.7% of *Diploria labyrinthiformis* colonies, 53.3% of *Montastraea cavernosa* colonies, 50% of *Dichocoenia stokesii* colonies, 50% of *Pseudodiploria strigosa* colonies, 42.3% of *Siderastrea siderea* colonies, 33.3% of *Colpophyllia natans* colonies, and 33.3% of *Eusmilia fastigiata* colonies <u>were actively diseased or recently dead.</u>"

We were forthcoming in the fact that we included recently dead corals in our prevalence calculations. The claim that we were intentionally contradictory and vague, and obfuscated the results is little more than an attack intended to besmirch our integrity. Unfortunately, these personal attacks do nothing to change the results of our study – the unprecedented and catastrophic effects of this coral killer on the reefs of south Florida in 2014-2015 and that continues to spread unabated to this day (see Epilogue below).

Silverstein et al. comment:

Silverstein et al. claim that our Scientific Report manuscript "describes the incidence, etiology, and epidemiology of the disease, and suggests that the disease is 'water-borne, infectious, and highly contagious'."

Precht et al. Response:

Our manuscript delves into the epidemiology of the white-plague coral disease outbreak by evaluating the prevalence of the disease at our study sites in space and time. Using these data we modeled the progressive, predictable spread of the disease away from a common area. Based upon these observations we noted that "The transmissibility of white-plague disease strongly implies that this particular strain (of white-plague disease) is water-borne, infectious, and highly contagious." However, we never evaluated the incidence of the disease (the rate of new cases during a specified time) nor did we attempt to decipher the etiology (root cause) of the disease. In fact, the word etiology never even appears in our Scientific Reports manuscript. Accordingly, we are confused by Silverstein et al's comment that these are two of the three main themes described in our manuscript. This general lack of understanding of the basic tenet of our manuscript is disquieting.

Silverstein et al. comment:

Background on data and sampling design

Precht et al. 2016 includes observations of coral condition from both timed swims and tagged corals. The tagged coral data are the focus of our analysis, as they were collected as a part of a FDEP permit-mandated compliance monitoring connected to the Port of Miami expansion project, which involved a large-scale dredging project offshore from October 2013 through March 2015.

Precht et al. Response:

The reason that Silverstein et al. 'focus' their analysis on the Port Miami tagged coral data is self-evident. Silverstein et al. represent "The Miami Waterkeeper" a NGO responsible for leading the charge on suing the US Army Corps of Engineers (USACE) over the Port Miami dredging project. https://www.miamiwaterkeeper.org/legal_actions

The Miami Waterkeeper has also recently sued the USACE over their proposed upcoming dredging project in Port Everglades.
https://www.miamiwaterkeeper.org/lawsuit_filed_over_coral_concerns_at_port_everglades

The three authors involved in the Silverstein et al. response are all affiliated with the Miami Waterkeeper. Specifically, Rachel Silverstein is the Executive Director, while Andrew Baker served as an expert witness for them in the Port Miami law suit filed against the USACE. We also understand that much of the analysis for this review was performed by Ross Cunning on behalf of the Miami Waterkeeper. Not disclosing this information in their review leads us to believe the motive behind their correspondence is not scientific inquiry but to personally sully the reputation of the authors in Precht et al. (2016). This was done with the clear intent of advancing one of the main missions of The Miami Waterkeeper: legal action. The Miami Waterkeeper, by its own account, exists to raise money for their legal fund and to use that money accordingly: "Miami Waterkeeper is one of the few environmental organizations in Miami that is willing to use one of the most powerful tools at our disposal to protect our Bay — the law" (see https://www.miamiwaterkeeper.org/legal_fund).

It is also important to point out that some organizations like the Miami Waterkeeper create "concerns" due to their ability to influence the media and internet in their favor. This often results in knee-jerk public actions and draws media attention away from real threats (like the 2014 coral bleaching event and subsequent disease outbreak) to fake or manufactured problems (see https://www.miamiwaterkeeper.org/tags/port_of_miami) that help to advance their cause.

In their letter to NMFS containing their review of Precht et al., Silverstein et al. explicitly stated "we believe that these analyses have introduced systematic bias into the data being used to describe the outbreak, and that this bias has been propagated to the datasets that the authors have made publicly available." Why is this important? We believe that if Silverstein et al. can make a case that the Precht et al. (2016) manuscript is somehow biased or deficient, especially the data collected as part of the Port Miami dredge project, they can make an argument that all data collected by DCA scientists should be dismissed. The reason this is important is the fact that the DCA data are the only data available for the Port Miami project. In addition, DCA performed a majority of the pre-project baseline studies and analysis at Port Everglades. Silverstein et al. have spent the last four years publically railing on DCA's reports with the clear intent of tarnishing the reputation of both the company and its scientists. This tactic of attacking the science and scientists that threaten their agenda is nothing more than a form of environmental bullying (see Lutcavage 2016). These attacks come right out of the playbook of the "Merchants of Doubt" written by Oreskes and Conway (2010). The doubt mongers (in this case Silverstein et al.) chip away at the edges, focusing on minor issues, amplifying uncertainties, and, most perniciously, attacking the motivations and honesty of the scientists involved (see Bradley 2011 for a similar dialog in a different context).

Hawaiian coral reef scientists, the late Rick Grigg and Steve Dollar (1984) noted that many similar lawsuits, especially where environmental NGO's are the plaintiffs against government entities, the NGO is banking on the fact that the case will settle long before it reaches trial (e.g. Staletovich 2018). We agree with Grigg and Dollar that legitimate differences in interpretation of the best scientific information may require legal tests in court. However, lawsuits based on technicalities for financial gain will ultimately undermine NGOs that are involved for clearly altruistic environmental reasons, will retard scientific discovery, significantly increase project costs to the taxpayers, divert critical resources, and will weaken - not strengthen - measures to protect coral reefs.

The breakdown of Silverstein et al.'s main issues regarding Precht et al. (2016) is little more than an ideologically motivated inquisition. It reminds us (almost verbatim) of the questions posed by Congress to Ray Bradley regarding his data and interpretations on global climate change that were also published in top tier journals (see Bradley 2011).

In a nutshell, it is clear that Silverstein et al. have a significant conflict of interest in this matter. This conflict does not mean they should not be able to comment on our paper – clearly they should – and we welcome the correspondence; especially if their comments help to clarify or illuminate our interpretations. However, when these attacks become trivial and personal they cease to serve a useful purpose. To quote Ray Bradley "We must resist all those who seek to suppress scientific results that do not fit their preconceived ideas, and we must defend those whose reputations are attacked…" (Bradley 2011). Through this rebuttal of the Silverstein et al. review we will attempt to do exactly that.

Silverstein et al. comment:

Observations reported in Precht et al. span the entire course of the active dredging, ending a few months after dredging concluded in July 2015. Four of five authors of Precht et al. are also employees of Dial Cordy and Associates, subcontractors of the dredging company Great Lakes Dredge and Dock, which conducted this compliance monitoring. This affiliation, which represents a significant potential conflict of interest, is not disclosed.

Precht et al. Response:

We will answer this question in two parts. The first pertains to our disclosure of any potential conflicts of interests with regards to our work for Great Lakes Dredge and Dock (GLDD) associated with the Port Miami dredge project. The second will discuss exactly what was published in Precht et al. and why the claim by Silverstein et al. about a "significant conflict of interest" is patently false.

In Precht et al. (2016) we state the following in the methods section under Tagged Coral Surveys: "Four permanent study sites were established in October 2013; two off Virginia Key and two off North Miami Beach. These four sites were originally designed as controls for <u>environmental compliance monitoring associated with the Port Miami deepening project</u> (DCA 2015a)."

In addition, in the Acknowledgements we stated the following: "This work was supported in-part to WFP, MLR, RF, and BEG by salaries from Dial Cordy and Associates (DCA), Inc. DCA <u>received funding under contract to Great Lakes Dredge and Dock Company, LLC sponsored by the US Army Corps of Engineers, Jacksonville District (FDEP Permit No. 0305721-001-BI)</u>. This contract provided partial support to the investigators to undertake <u>monitoring of coral populations in the vicinity of Port Miami</u> in Miami-Dade County (DCA 2015a). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript. RvW was not compensated for his contribution to this study."

Clearly, we fully disclosed the Port Miami dredging project, our role in it, and our relationship with both GLDD and the US Army Corps of Engineers (USACE) in the manuscript. Based upon this disclosure we are unsure of exactly what Silverstein et al. are trying to insinuate.

The goal of Precht et al. (2016) was to publish observations made in 2014 and 2015 in the waters off Miami-Dade County, Florida. Specifically while our team was monitoring the coral condition of tagged corals associated with the dredging of Port Miami by the USACE, we observed a number of phenomena that were unrelated to the project. The first was the observation of a mass coral bleaching event in the late summer of 2014 associated with a significant thermal anomaly that was recorded region-wide (NOAA 2014a, 2014b, Manzello 2015). The second was the observation of a white-plague disease-like outbreak that started in the wake of that bleaching event in the early fall of 2014.

On September 26, 2014, one of us (RF) specifically observed numerous corals with active disease signs at one of DCA's tagged coral far-field southern control sites (R2SC2). Following these initial observations we confirmed the disease to be a form of white-plague (some researchers are now referring to this regional disease outbreak as 'stony coral tissue-loss disease'). We noted the rapid spread of the disease to nearby corals (both on and off transect). Because the disease started at the far-field project controls south of the dredging operation, and the fact that we witnessed the spread of the disease away from this area (both south and north) and towards (not away) from the dredging operation (both in space and time), it was apparent to us at that time that the disease outbreak was unrelated to the construction project.

As a follow-up to the observations made by DCA in late September and October, on November 12, 2014 the senior author (WFP) dove the R2SC sites with the DCA dive team. Because it appeared that there were many more corals off our transect lines with white-plague disease-like signs, he performed an additional dive, performing a 60 min timed-swim survey due south of the R2SC2 site.

In an attempt to document the unprecedented nature and dynamics of this disease outbreak in time and space, the senior author performed a series of timed-swim coral disease surveys following the protocol he used during the November 12, 2014 timed-swim survey at R2SC2. Working with volunteers (including his daughters) and usually on weekends, he performed nine (9) timed-swim surveys throughout the waters of Miami-Dade County in 2015. These surveys confirmed the progressive, highly contagious nature of the outbreak and the near extirpation of many charismatic coral species throughout the region.

None of these nine surveys were performed near the area of impact of the Port Miami project. In fact, Precht et al. (2016) intentionally avoided areas within the impact area of the Port Miami dredge project so these data would not be potentially confounded by the construction activities.

Finally, regarding "potential conflicts of interest" it should be noted that at the time we were preparing the Scientific Reports manuscript, DCA was no longer under contract with GLDD. In fact, we waited until our obligations were complete, all reports had been submitted to the agencies and published on-line, and all the project data was released and in the public domain before submitting and publishing our results in Scientific Reports.

In addition, GLDD had no role in funding the acquisition of any of the timed-swim survey data performed in 2015 which was the major emphasis of our manuscript. These surveys were performed on personal time (usually weekends) and often at significant personal costs to the senior author. The manuscript was also written in its entirety by the team on their personal time (evenings, weekends and holidays) and none of the authors were compensated financially for their effort. Also, at no time during the preparation of the manuscript did the authors share their results or intent to publish with either GLDD, Port Miami, or the USACE. In fact, GLDD, Port Miami and the USACE did not receive a copy of the manuscript until after it was published. We believe we satisfied both our professional and ethical obligation to the readership by noting our relationship in the manuscript as described earlier, especially because this manuscript was about the unprecedented nature and regional dynamics of disease outbreak and not about the Port Miami dredge project, We also believe that our disclosure “The authors declare no competing financial interests” was and is both forthright and factual.

Unfortunately, it appears that Silverstein et al. see this as a simple dichotomy where dredging projects are pitted against the environment and those that are affiliated with the dredge project are somehow compromised and biased by this relationship. In their view those that oppose dredging projects wear ‘white hats’ while those that are affiliated with dredge projects, no matter what their views or motivations, wear ‘black hats.’ In our estimation, the intense disputatious and litigious nature of The Miami Waterkeeper makes conflict and bias more likely to be coming from their political and ideological agenda than from a personally funded science-based project performed by Precht et al. on their own time and dime.

Silverstein et al. comment:

Authors do not make clear that a large-scale dredging project was going on nearby their monitoring locations, nor do they describe the severe dredging-related impact to area corals captured in their compliance monitoring, nor do they explore whether any relationship exists between the dredging and the disease outbreak. Failing to include the data from the near-dredging locations also prevents others from exploring these alternative hypotheses.

As noted earlier, the intent of our manuscript was to publish observations made regarding a major regional coral bleaching event that was soon followed by a catastrophic disease outbreak in the waters off Miami-Dade County during 2014 and 2015. Specifically, our manuscript describes the unprecedented nature and regional dynamics of disease outbreak and not the effects of the Port Miami dredge project. This is precisely why we intentionally avoided confounding influences such as the Port Miami project.

Precht et al. (2016) only assessed coral condition on the inner reef tract (2nd Reef), and used these sites as a proxy for coral condition region-wide. All 10 of our independent timed-swim sites were located outside the area of potential sediment impacts from Port

Miami dredging. Precht et al. (2016) intentionally avoided areas near the dredge operation so their data would not be impacted by on-going construction activities.

In response to Silverstein et al's criticism, however, our team has produced a number of separate documents that fully describe the impacts of the Port Miami dredge project on the local coral communities and evaluates the regional coral bleaching and disease events within that context (DCA 2015a, 2015b, 2017). Precht et al. cite the DCA document in their Scientific Reports manuscript (DCA 2015a) and these Port Miami data are publically available for others to explore alternate hypotheses (e.g. Miller et al. 2016).

It should also be noted that we (Precht et al.) are currently preparing a number of new, follow-up peer-reviewed manuscripts that will answer the questions posed by Silverstein et al. regarding potential influences of the Port Miami project on local coral communities. In one study, we specifically address whether the dredging project, via sediment stress, locally contributed to the white-plague disease epizootic by increasing susceptibility, prevalence, and mortality. For that manuscript, we use the entire Port Miami project database and include additional data collected through 2017. In another, we are preparing a manuscript (with a number of other researcher's) detailing local versus regional dynamics of the disease outbreak. By using a number of disparate datasets collected by different groups we are trying to answer some basic questions about the etiology of the disease and why it started where and when it did. We are also working on a third manuscript that details the 2014 coral bleaching event in southeastern Florida. Finally, we are writing a manuscript on lessons learned from the Port Miami dredging where we specifically address both the direct and indirect effects of the project. All four manuscripts test a number of hypotheses using the full Port Miami coral database.

Silverstein et al. comment:

Precht et al. only report data from 2 control sites on the northern middle reef and 2 control sites on the southern middle reef, which represent only 4 of the 26 permanent monitoring stations for which these authors had tagged coral data. Precht et al. does not include data from any outer reef or inner reef "hardbottom" sites, or any sites near the shipping channel where dredging was occurring. Authors do not mention the existence of additional tagged coral data in Precht et al.

Precht et al. Response:

Much of this question was previously addressed. Specifically, estimates of species-specific white-plague disease susceptibility were initially assessed at 10 timed-swim survey sites throughout Miami-Dade County in 2014-2015 and published in Precht et al. (2016). This region-wide data is an independent source of disease prevalence and disease-related mortality estimates that occurred throughout southeast Florida reefs during Port Miami construction monitoring. The four tagged coral sites we used served as a direct control for our timed-swim survey sites. All 10 of these sites (plus the four project far-field tagged coral control sites) were outside of the area impacted by the Port Miami dredge project.

In our timed swim surveys, Precht et al. (2016) only assessed coral condition on the inner reef tract (2nd Reef), and used these 2nd Reef sites as a proxy for coral condition region-wide. Because all timed-swim survey sites were performed at 2nd Reef locations it was appropriate to only use the corresponding 2nd Reef Port Miami controls in our analysis and as a control for the timed-swim survey sites. Using 3rd Reef controls or Nearshore Hardbottom controls for our 2nd Reef timed-swim surveys would require comparing controls from different habitats and depths and thus would be like comparing apples to oranges.

As stated in Precht et al. (2016) in the Methods Section under Timed Swim Surveys (p. 9): "We used timed swims at ten sites along the inner-reef tract that were geographically widespread throughout the waters of Miami-Dade County."

We also noted the following under Study Sites (p. 8): "The coral assemblages documented in this study are all from the inner (second) reef terrace."

Based upon the above rationale, why we would include or mention these additional data from these additional 22 sites if they were not part of the Precht et al. (2016) study? It is for these reasons that they were not mentioned. There are also a number of other coral-related projects performed by other firms (Coastal Systems International) and agencies (Miami-Dade County DERM) working on various aspects of the Port Miami project. None of these additional studies were noted in the original Precht et al. (2016) manuscript for exactly the same reasons. However, all of these sites and data sets are presently being used in the manuscripts we are currently drafting.

Silverstein et al. comment:

Data issues that we have identified in this study are described in detail below. Please note that we conduct this review using the dataset provided by Precht et al. authors, and we did not independently verify the data through analysis of the photographs of each coral, nor do we present a complete reinterpretation of the data here.

Precht et al. Response:

We used the same data set in our analysis that we provided to Silverstein et al. However, we used the Excel spreadsheet data as a starting point to our interpretations, not an end point. Silverstein et al. state that they did not use the photographs of each coral (although they had these photos) to verify the data in the spreadsheets. We did! In fact, it formed the basis for many of our interpretations. We stated the following in the Methods Section of Precht et al. (2016): "In the laboratory, > 5,000 individual observations of in situ coral condition were compared to paired photographs." However, the analysis we performed for the Scientific Reports manuscript differed slightly than that for the Port Miami monitoring project. This was because the questions we were trying to answer were different. In one instance (Port Miami project) we were trying to evaluate the weekly effects of dredging on the corals in a restricted area, and in the other (Scientific Reports manuscript) we were trying to understand the dynamics of an active coral disease outbreak on corals regionally. Accordingly, we carefully re-evaluated and rigorously

QA/QC'd the data and photographs used in the Scientific Reports analysis. If Silverstein et al. were not willing to perform the full analysis with all the data that were available to them, including the photographs (that at a minimum matched the data we used in our analysis), how could they expect to replicate the results of Precht et al. (2016)?

Seven (7) specific issues posed by Silverstein et al.

1. Import and organize data provided by Precht et al.

Identify species ID errors for individual tagged corals and Change conflicting species assignments to reflect most frequently assigned species.

Out of 115 tagged corals, 23 have multiple species IDs associated with them across different points in time, indicative of some (unidentifiable) error in data entry.

Precht et al. Response:

We provided an answer to Silverstein earlier regarding both data entry errors and field ID issues. We expand on that response here.

Where species ID's may have changed on specific dates we included an Excel table showing 52 specific cases where inconsistencies were noted. Most importantly, as it pertains to the Precht et al. (2016) manuscript for just the 2nd Reef tagged coral project controls, there were some 6,535 actual in-situ coral observations made during the course of the project. These in situ observations were then matched with ~15,000 underwater photographs in the lab for verification. Thus, the accuracy rate of our in-water observations was 99.2%. Errors in a project of this size are inevitable, especially with so many moving parts (including alternating some 16 scientific divers working seven days a week for ~80 weeks). We are extremely proud of our exceptionally low error rate (<1%) and the performance of our scientific dive team in obtaining reliable data under often hostile field conditions (strong currents and low visibility). Also, species-specific information by week was never used in the Scientific Reports paper, so these minor weekly errors, where they occurred, had essentially no bearing on final data interpretation or any of the conclusions reached in the manuscript.

Had Silverstein et al. looked at the time series photographs of the 115 corals on the 2nd Reef Control Light-Table trim sheets (attached as separate PDF files to this letter) they would have noticed <u>that all photos document the correct tagged coral and the correct species ID's across all sites and dates</u>.

While not directly applicable to Silverstein et al.'s critique of the Precht et al. (2016) manuscript, we should note that for our Port Miami project, a third-party QA/QC analysis was performed during the one-year post-construction impact assessment surveys (DCA 2017). This QA/QC involved third-party observation of field techniques and evaluation of data acquisition procedures, verification that all data requirements were met according to the protocol, compared entered data to raw data sheets for the subset of sites where third-party in-field observation had taken place, and performed an overall 10% QA/QC analysis. It was noted that the error rate was <1% in all cases and no systematic errors were identified through the third-party QA/QC assessment and therefore no systematic re-analysis of the data was required or performed. It is worth noting here that on the entire project (all 26 sites), the DCA scientific dive team performed more than 10,865 dives between the fall of 2013 and the summer of 2017. As well, ~25,000 in situ coral observations were made and well more than 100,000 photographs were recorded by DCA divers.

Silverstein et al. comment:

2.0 Dataset summary

Precht *et al.*: "A total of 115 coral colonies, representing 13 coral species, were tagged for repeated monitoring at four sites on the inner reef tract in Miami-Dade County (Fig. 1). Coral colonies were monitored at least 40 times between October 19, 2013 and July 13, 2015."

Within the dataset provided, we confirm that 115 coral colonies of 13 different species were monitored. However, we found that individually tagged colonies were monitored between 31 and 45 times each. This is inconsistent with the Precht et al. statement that colonies were observed at least 40 times.

Precht et al. Response:

Based upon our data and photographs each tagged coral at all of our 2nd Reef Control Sites were actually visited and observed on average **49** times and a minimum of **46** times (see below).

At site R2SC1 all tagged corals along the three transects were visited and photographed **48** times and monitoring data for this site was recorded in the database **44** times.

At site R2SC2 all tagged corals along the three transects were visited and photographed **51** times and monitoring data for this site was recorded in the database **36** times.

At site R2NC1 all tagged corals along the three transects were visited and photographed **50** times and monitoring data for this site was recorded in the database **34** times.

At site R2NC2 all tagged corals along the three transects were visited and photographed **46** times and monitoring data for this was recorded in the database **37** times.

Note that there a discrepancy between the numbers of observations between the in situ monitoring data set and the photographic data set. This is because in several instances in situ coral data from control sites was collected in a given week but due to poor weather conditions or the position of the dredge (too close to the monitoring site), the scientific diving team was unable to safely dive at the paired channel-side locations later that week. As all compliance data for the environmental permit was specifically collected for weekly comparison of channel-side sites with their far-field control, in instances where far-field controls were collected with no channel-side comparison these data were excluded from the database. However, the raw field data sheets for these 'missing' field dates were catalogued and are available upon request. In addition, all the photographs of the control site corals that were collected on these dates were added to the compliance monitoring photographic database. Importantly, these photos were used to verify the presence of bleaching or white-plague disease that was active in periods within and between excluded paired surveys when preparing the Scientific Reports manuscript. Had Silverstein et al. used the photographic database (which they had) and just counted the number of photographs on each of the trim sheets, they would have seen that each of the four 2nd Reef control sites were observed at least 40 times.

Silverstein et al. comment:

3. Peak of coral bleaching

Precht *et al.*: "The peak of coral bleaching was recorded in September 2014. Specifically, the highest recorded bleaching prevalence occurred on September 12, 2014, when 84% (21 of 25 corals surveyed that day) showed signs of coral bleaching (Fig. 2)."

We are able to reproduce the 84% metric reported in the paper, but only if all corals recorded with the condition codes for "paling" (P), "partial bleaching" (PB), or "bleaching" (BL) are combined together.

The proportion of true "bleaching" (BL) in the condition code data was 4 corals out of 25 (16%). Partial bleaching (PB) condition code accounts for an additional 3 corals out of 25. The majority of the 84% "bleaching" reported here, therefore, is due to paling alone. Paling is a common seasonal phenomenon that often occurs in late summer and may not be indicative of stress (see e.g. Gates 1990 *Coral Reefs*). Therefore, combining these condition codes to describe "bleaching" is misleading and serves to inflate the apparent bleaching prevalence.

Precht et al. Response:

While Gates (1990) noted that some species of corals appeared to darken and pale with respect to annual temperature variations, she also stated the following "*A coral was considered to be exhibiting a bleaching response if one or more areas of the colony were pale in comparison to the rest of the colony.*"

Numerous authors have shown seasonal variations in zooxanthellae densities related to temperature, however, only under extreme losses in symbiont density does bleaching (paling) occur (Fitt et al. 2000, Warner et al. 2002, Enriquez et al. 2005, Thornhill et al. 2011). Reporting on the 2005 mass coral bleaching event in the Caribbean, Eakin et al.

(2010) stated the following "*Also, because any visible bleaching probably indicated a loss of most of the zooxanthellae originally present, <u>it was appropriate to include any degree of bleaching, from pale and partially bleached to fully bleached colonies, as an indicator of significant stress in the corals</u>.*"

More recently, Lesser (2011) stated the following: "*Coral bleaching results in a <u>paling</u> or whitening of the colony*… and …*Coral bleaching is distinct from the seasonal cycling of zooxanthellae densities in reef corals*." This is contrary to what Silverstein et al. would have you believe in their comment above. Proof texting of the Gates (1990) manuscript by Silverstein et al. shows either a pedestrian understanding of the coral bleaching literature, or worse, an insidious attempt at dogmatic eisegesis.

Photographs showing the three different types of bleaching response. Left to right include paling (P), partial bleaching (PB), and bleaching (BL) (from DCA 2017).

In our data collection we specifically used the FRRP bleaching protocol (FRRP 2011). This methodology is currently used by most ecologists working on reef communities in Florida.

The FRRP protocol states the following:

"*Characterize any BLEACHED tissues as approximate severity of discoloration:*

P = Pale (discoloration of coral tissue)

PB = Partly Bleached (patches of fully bleached or white tissue)

BL = Bleached (tissue is totally white, no zooxanthellae visible)"

The AGRRA reef monitoring protocol (AGRRA 2016) also uses the same three categories for bleaching condition. The protocol asks the observer to "qualitatively record the severity of any discoloration as P (pale), and/or PB (partly bleached, i.e., some polyps are fully bleached) and/or BL (all polyps are fully bleached)" in their analysis.

Using this general criteria, the categories for "paling" (P), "partial bleaching" (PB), or "bleaching" (BL) were combined (binned) together in our analysis following FRRP (2011). Based on our combined analysis, the proportion of corals that were "bleached" is 84%, exactly as reported in Precht et al. (2016). This was not done to be 'misleading' or to 'inflate' the apparent bleaching prevalence, but was done to follow well established field identification protocols for coral bleaching.

Most importantly, Silverstein et al. through their intentional omission of 'paled' colonies, deflate the bleaching prevalence in their analysis. This flies in the face of accepted terminology as well as the scientific consensus of the severity and significance of the 2014 thermal anomaly and regional bleaching event (NOAA 2014a, 2014b, FRRP 2015, Manzello 2015).

Silverstein et al. comment:

Here, we tally and plot the prevalence of all three of these condition codes over time for the Precht et al. dataset:

We find that the maximum prevalence of bleaching indicated by the BL condition code was September 15th (20% of observed colonies), and the maximum prevalence of bleaching and partial bleaching (BL or PB condition codes) was on September 27th (43% of observed colonies.

Precht et al. Response:

Intentionally omitting paled colonies as bleached is inconsistent with accepted bleaching terminology. For our analysis, their point is moot because we combined the three bleaching conditions per the FRRP (and AGRRA) protocols. Using this combined bleaching metric the date of peak bleaching was September 12, 2014 exactly the same as recorded in Precht et al. (2016). The difference of parsing out the individual bleaching codes by Silverstein et al. shifts the peak bleaching date by 3 days or 15 days accordingly. These minor shifts make little difference to any of the interpretations put forth in Precht et al. (2016). Mainly that peak summertime sea surface temperatures were recorded in late August and peak bleaching occurred in mid-to-late September.

Silverstein et al. comment:

4. First signs of white plague disease

Precht *et al.*: "The first sign of a white-plague disease outbreak (prevalence > 5%) was noticed at the southern monitoring sites, near Virginia Key, on September 26, 2014."

Using the data provided by Precht et al., we find that the prevalence of white plague disease ("WP") on Sept. 26, 2014 was not greater than 5% at the southern monitoring sites. Disease prevalence was only 4% at site R2SC2 (N=1 out of 25 corals) and was 0% at R2SC1 (R2SC2 and R2SC1 are the southern monitoring sites referenced in the Precht et al. Results statement above). Neither reached the "5% prevalence" threshold (defined by Precht et al. as representative of an "outbreak") on that date.

In response to our inquiry regarding this discrepancy, the Precht et al. authors responded, "This was a typo and was not caught in the galley stage. The original statement should have read "< 5%" not "> 5%."" This explanation, however, makes little logical sense. This apparent typographical error fundamentally changes the conclusions of the paper, the abstract, and the contagion-based model presented.

Precht et al. Response:

Our original response to Silverstein was incorrect. There was not a typographical error but an actual change in text between our original submission to Scientific Reports and the text in the final publication.

Original text submitted to Scientific Reports (12/23/15 version)

"*The first sign of a white-plague disease outbreak was noticed at the southern monitoring sites offshore of Virginia Key on September 26, 2014. By the week of November 15, 2014, epidemic levels were observed at the sites off Virginia Key, with 15% of tagged colonies showing outward signs of white-plague disease (Figure 2).*"

Revision sent to Scientific Reports (4/8/16 final)

"*The first sign of a white-plague disease outbreak (prevalence >5%) was noticed at the southern monitoring sites, near Virginia Key, on September 26, 2014 and by November 18, 15% of the tagged colonies showed outward signs of white-plague disease (Figure 2).*"

Based on this clarification, we in fact, stand behind the statement in Precht et al. (2016) that "*The first sign of a white-plague disease outbreak (prevalence > 5%) was noticed at the southern monitoring sites, near Virginia Key, on September 26, 2014.*" (See detailed explanation below)

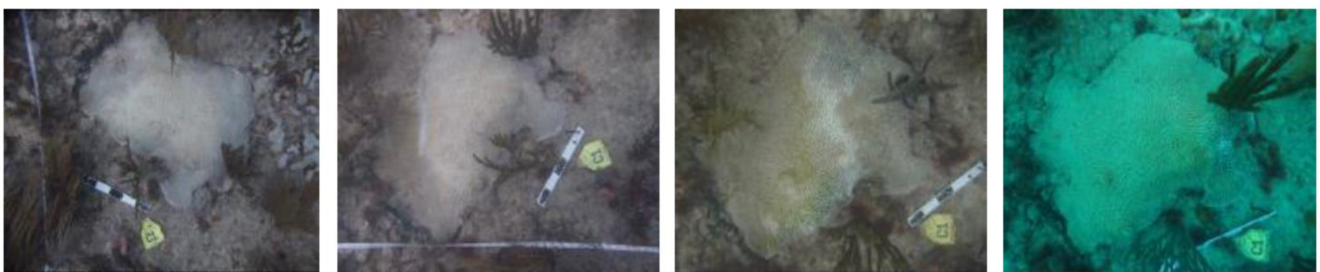
Silverstein et al. comment:

The Precht et al. authors' response, confusingly, goes on to support the original ">5% white plague" claim as stated, citing as support: 1) off-transect, untagged corals that were observed informally and without documentation or reference, 2) multiple colonies at the southern monitoring sites for which WP condition codes were applied retroactively and which are not noted as such in the dataset. (It is not clear if other sites received the same *post hoc* re-examination and additional scoring of WP condition codes.) We therefore queried the Precht *et al.* dataset to determine the earliest date that we find white plague disease appears at a >5% prevalence. In the Precht et al. dataset, we find that the first time >5% white plague prevalence (defined as occurrence of the "WP" condition code) was documented was on October 17, 2014 at R2SC2, when the proportion was 8% (N=2 out of 25 colonies).

Precht et al. Response:

The first evidence of a possible white-plague disease epidemic was noted at the 2nd Reef southern control site (R2SC2-LR) on September 26, 2014 some three weeks earlier than noted for the same site by Silverstein et al. On that day, three corals that were side-by-side all showed a malady that was first coded as an "unknown condition" (UC) by our scientific divers.

On that day tagged coral R2SC2-LR-T2-C1 was still bleached from high summer temperatures but recent mortality was evident with lines of necrotic tissue. Subsequent visits confirmed active, progressing signs of white-plague disease (see photos below).

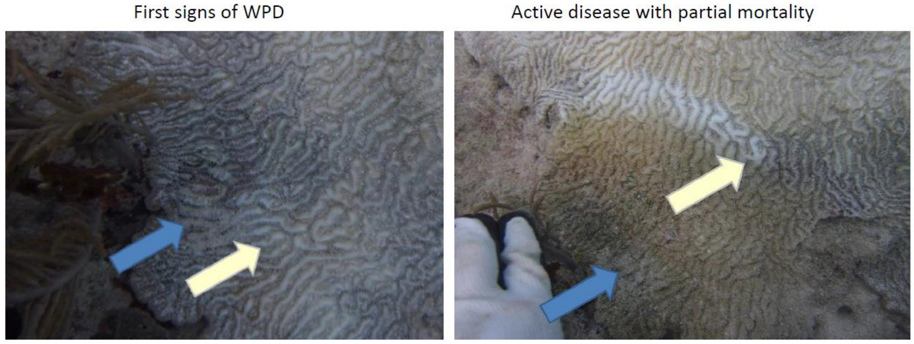


R2SC2 CW45 T2 C-1 September 26, 2014 | R2SC2 CW47 T2 C-1 October 08, 2014 | R2SC2 CW49 T2 C-1 October 22, 2014 | R2SC2 CW50 T2 C-1 October 31, 2014

Progressive expansion of white-plague disease across colony of *M. meandrites*. First sign of disease was noted on September 26, 2014.

Originally coded as "UC"
First signs of WPD

Two weeks later
Active disease with partial mortality

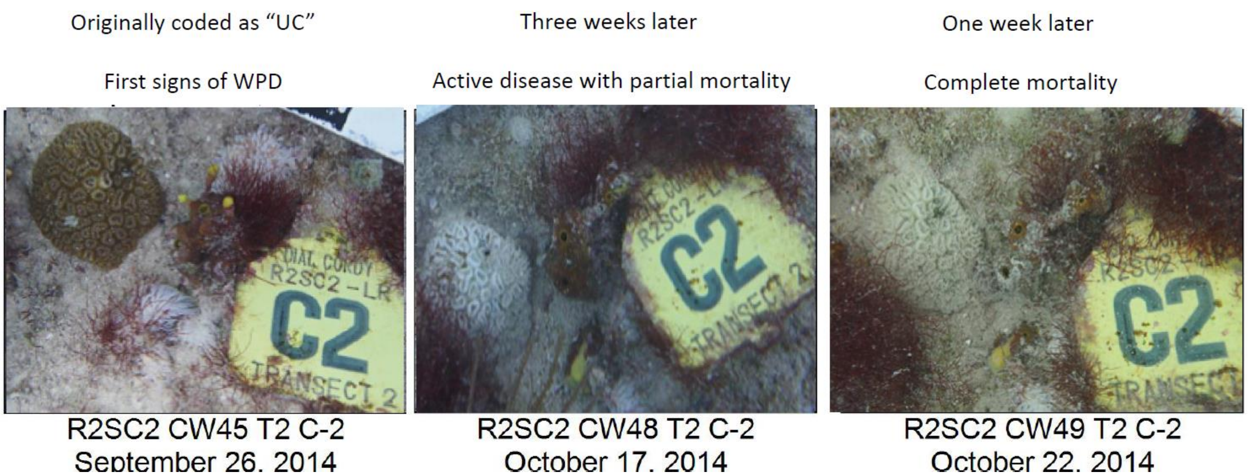


September 26, 2014 | October 8, 2014

Close-up of initial observation of partial mortality (blue arrow) and first appearance of the white disease line (light yellow arrow) from tagged *M. meandrites* coral located at R2SC2-LR-T2-C1 on September 26, 2014 (left) and again with well-defined white-plague disease line (light yellow arrow) and continued partial mortality from initial location of mortality

(blue arrow) on October 8, 2014 (right) (from DCA 2017). Note that in photo on right that the bleached portion of the colony has regained color (zooxanthellae) in response to cooler water temperatures.

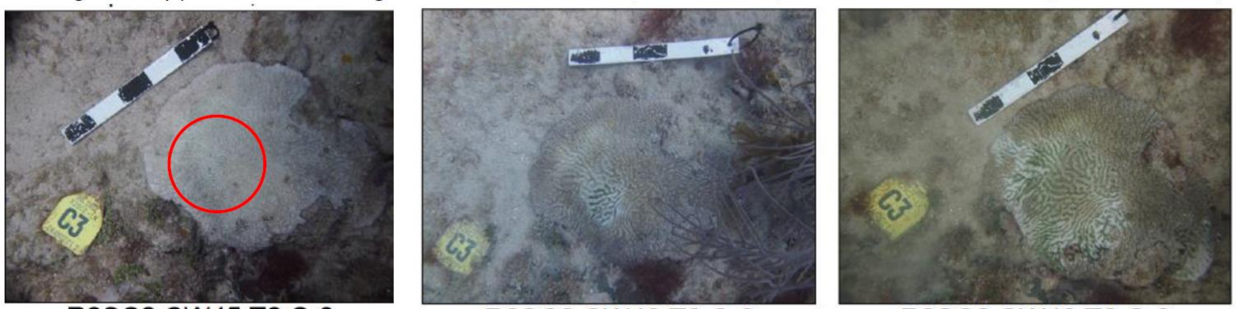
Two adjacent corals also showed initial signs of disease on September 26, 2014 and these too were also later confirmed with the disease (see below). Disease progression was rapid and all corals died soon after contracting the disease.



Above is the time series photographs the second of the three adjacent corals coded with an "Unknown Condition" (UC) on September 26, 2014 (R2SC2-LR-T2-C2). Repeated monitoring revealed that the UC was actually white-plague disease.

Time series of a *Dichocoenia stokesi* colony off Marathon in the middle Florida Keys in 2018. Note the exact pattern and spread of white-plague disease as in the colony R2SC2-LR-T2-C2 from 2014 in the panel above. Photo sequence with interpretation furnished by Florida Fish and Wildlife Conservation Commission.

Originally coded as "UC" | Three weeks later | One week later
First signs of WPD | Active disease with partial mortality | Active disease with significant mortality
Still significantly paled from bleaching



R2SC2 CW45 T2 C-3 September 26, 2014 | R2SC2 CW48 T2 C-3 October 17, 2014 | R2SC2 CW49 T2 C-3 October 22, 2014

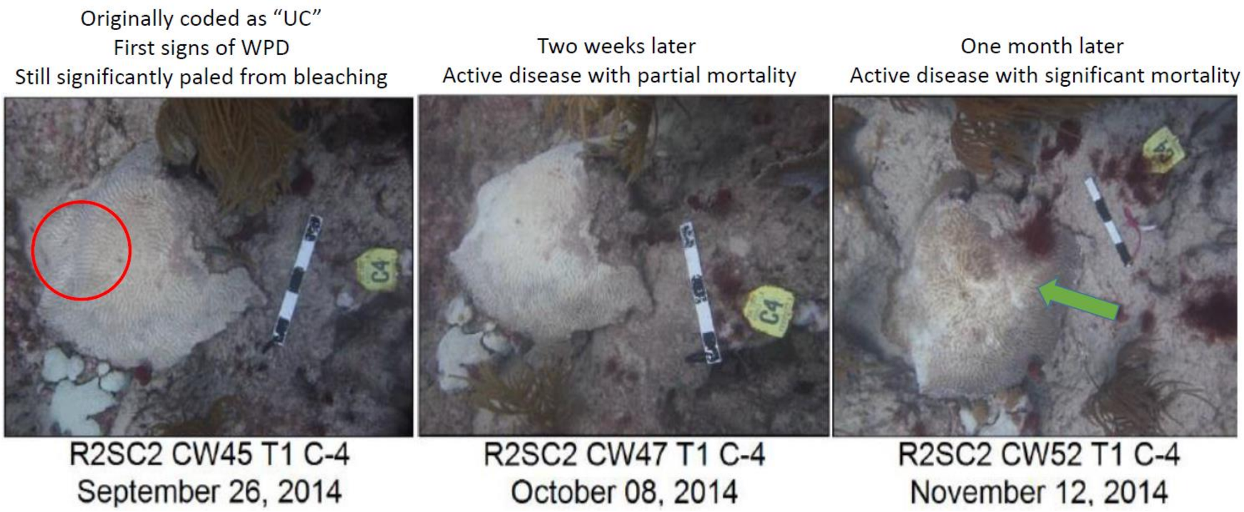
Above is the time series photographs the third of the three adjacent corals coded with an "Unknown Condition" (UC) on September 26, 2014 (R2SC2-LR-T2-C3). Repeated monitoring revealed that the UC had outward signs resembling white-plague disease. Note that in photo taken on October 22, 2014 that the bleached portion of the colony has also regained color (zooxanthellae) in response to cooler water temperatures and a clear line of white-plague disease is progressing outwards from it point of origin across this colony.

Thus, applying this confirmation of white-plague disease retroactively back to September 26, 2014 changes the actual prevalence to 12% (3 out of 25 corals). This was the first time we saw epidemic levels of this disease at one site. Unbeknownst to us at the time (September – October 2014), we were about to witness the rapid spread of the disease away from this general area (2nd Reef – South Control off Virginia Key) of what was to become one of the most aggressive, contagious coral diseases ever recorded. This also confirms why the inclusion of the underwater photographs is essential for interpreting the temporal sequence of events and not just the raw data in the Excel database.

It should also be noted that on September 26, 2014 another coral at site R2SC2 had a condition that was coded as "UPM (unknown partial mortality), BL (bleached), and UC (unknown condition)." However, subsequent photos reveal that it too was probably infected with white-plague disease on that date, thus the UC code (see below). If we add this colony to the white-plague infected corals at site R2SC2 on September 26th it increases the disease prevalence at this site to 16% (4 out of 25 corals).

The temporal sequence was similar for all four (4) corals labeled as UC in the field on September 26, 2014 at R2SC2. The only differences noted were the species specific signs of how the disease presents itself and the rate of progression of the disease across each of the colonies. When combining disease prevalence for both southern 2nd Reef Control Sites (R2SC1 and R2SC2) on September 26, 2014 we find that 4 out of 55 corals showed initial signs of white-plague disease, a prevalence of 7% (which is >5%).

It was the observation of these four (4) corals with active disease that led to our statement regarding prevalence >5%. Thus, our support of this statement should not be confusing at all. The rapid spread of the disease to nearby corals (both on and off transect) and then to other sites, led us to identify the area near this site off Virginia Key as the likely start of the disease epidemic.



Above is the time series photographs of coral R2SC2-LR-T1-C4. Repeated monitoring revealed that the mottled residual bleaching and mortality pattern observed on September 26, 2014 was likely the initiation of white-plague disease. Note that in photo taken on November 12, 2014 that the bleached portion of the colony has also regained color (zooxanthellae) in response to cooler water temperatures and a clear line of white-plague disease is progressing across this colony (green arrow). The colony was completely dead by December 12, 2014.

Whether we use 3 out of 55 (5.5 %) or 4 out of 55 (7%) our disease prevalence for both southern control sites on September 26, 2014 does not change the results reported in the manuscript - that the first sign of epidemic levels of white-plague disease (>5%) was observed at the southern control sites (specifically R2SC2) and that it spread away from this general area.

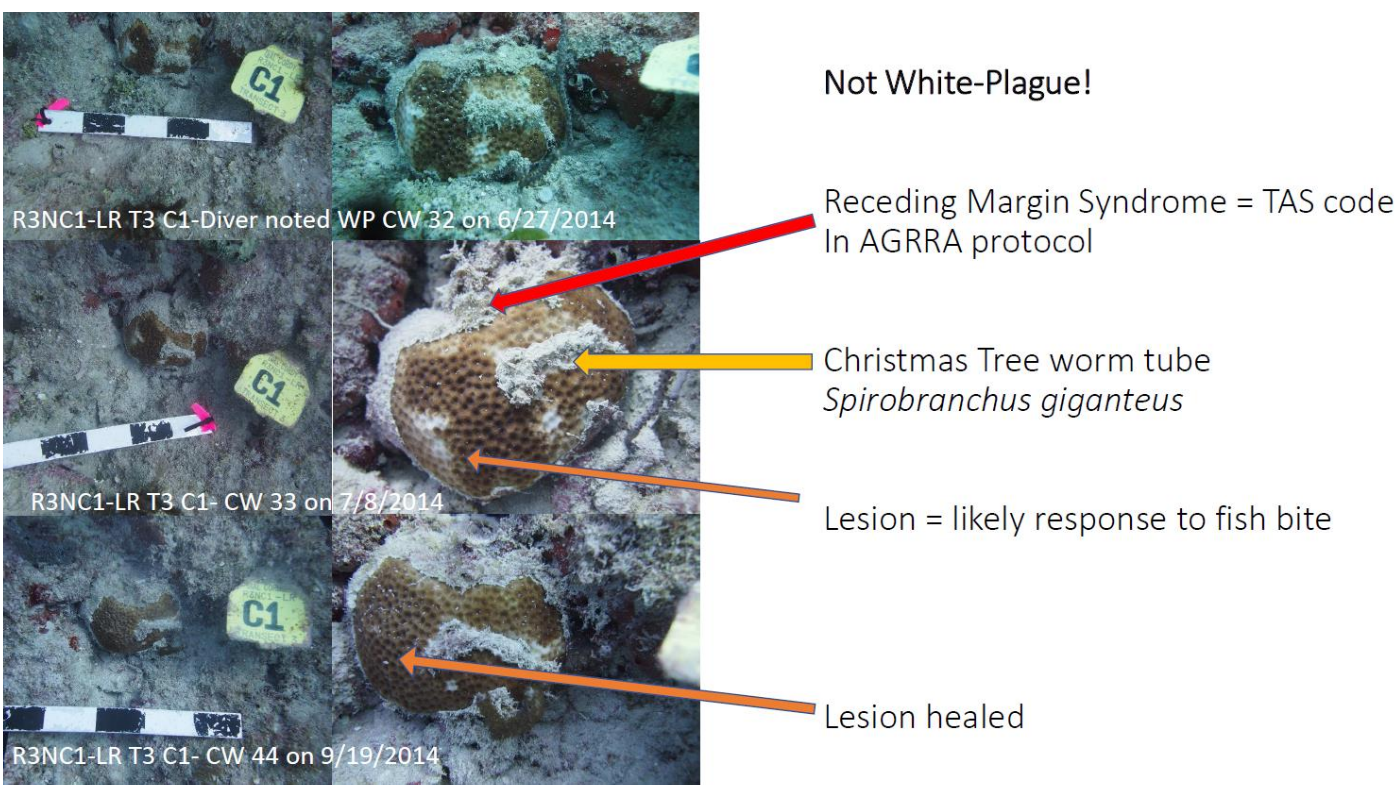
Silverstein et al. comment:

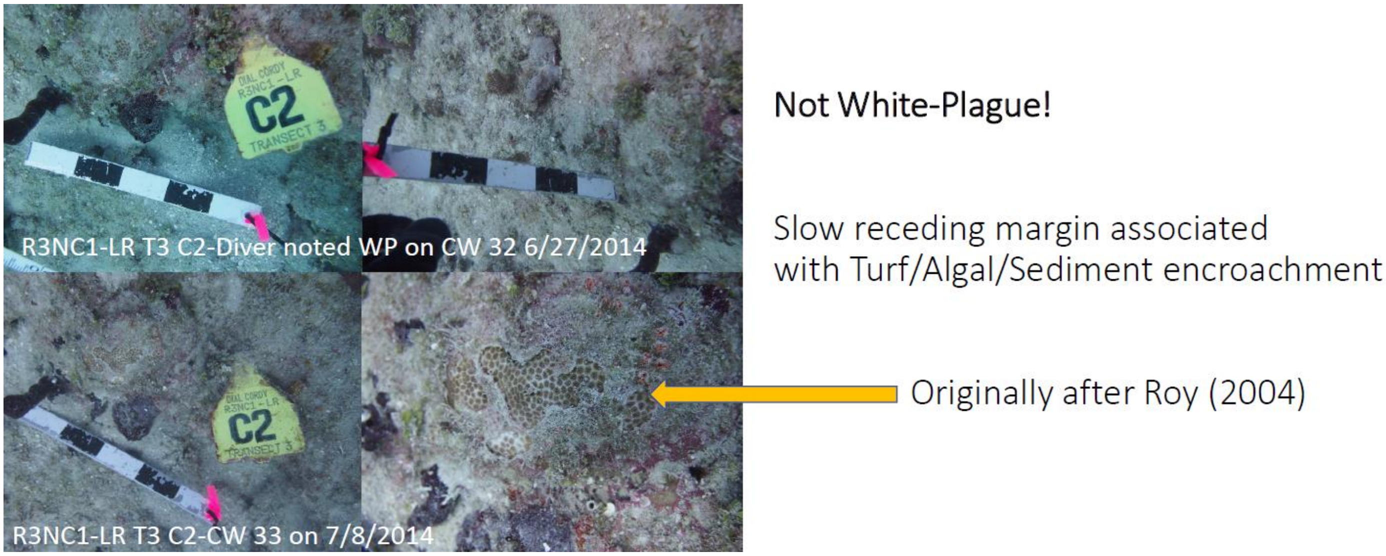
We then queried the FDEP dataset including all middle and outer reef permanent monitoring locations (submitted by the authors working for Dial Cordy as part of compliance monitoring), and we find that the first prevalence >5% WP at a single site was actually on June 27th, 2014 at R3NC1 (the northern control site from the outer reef, see Figure 1), which was omitted from Precht et al. analyses. This puts the 'start of the outbreak' (defined by the authors' >5% disease prevalence threshold) months earlier, north of the channel, and before bleaching had yet occurred.

Precht et al. Response:

We previously explained why the 3rd Reef data were omitted from the Scientific Reports paper. It is, however, important to specifically address the Silverstein et al. comment, that on June 27, 2014 at site R3NC1 two corals were coded by our divers with white-plague disease (WP). These 3rd Reef northern control site corals specifically had a number of stress conditions resulting in white lesions and partial mortality of the colony. However, subsequent QA/QC analysis using both close-up and time-series photographs confirmed that the lesions were in-fact not associated with white-plague disease.

Another hint to Silverstein et al. that this was probably not white-plague disease should have been the fact that neither of these two corals were white-plague disease susceptible species (SSID and SINT) at sites in Miami-Dade County. We have included time series photo panels of the corals in question below. Because the actual conditions observed and photographed were not white-plague disease, the comment by Silverstein et al. that the disease outbreak started months earlier, north of the channel, and before bleaching had occurred is simply incorrect. In fact, had this been the case, the disease 'outbreak' would have actively radiated out from this northern location, it also would have started to spread month's earlier, and it would have had to initiate in non-disease susceptible species. There is no evidence from other monitoring stations or studies by other researchers that reveal any of these patterns anywhere in the waters of Miami-Dade County between the end of June and early October, 2014.





While we can't know for sure the exact location of ground zero or the precise date when this catastrophic epizootic started, however, the most parsimonious explanation is that the disease initiated somewhere off Virginia Key or Key Biscayne sometime in late September, 2014.

Silverstein et al. comment:

5. White plague prevalence and dynamics

Precht *et al.*: "…by November 18, 15% of the tagged colonies showed outward signs of white-plague disease (Fig. 2)."

We find that only 6 of 55 colonies (10.9%) observed on November 18th were actually recorded with the WP condition code.

If we also include corals recorded with white plague that had died by November 18 (12.7%, 7 out of 55 colonies observed), we still do not find a 15% disease prevalence. Based on communication with the authors, it appears that the remaining discrepancy of 2.3% is due to the authors' inclusion of additional corals that were assumed to have died from WP that do not appear in their initial dataset. Therefore, the reported value does not accurately describe the colonies that "showed outward signs of white plague" on this date.

Precht et al. Response:

We used corals that were actively diseased and those which had recently died in our prevalence calculations. Revisiting our data and photographs we stand by our calculation of 15%. However, their point is little more than a semantic quibble. Importantly, the difference between 11% (6 out of 55 corals; 10.9%), 13% (7 out of 55 colonies; 12.7%) and 15% (8 out of 55 colonies; 14.5%) is only two corals (2 out of 55%; 3.6%). Even if we do not use the single coral that died between survey events, this does not alter the "accurate description" of this outbreak as stated by Silverstein et al.

Silverstein et al. comment:

In their response to us regarding this issue, Precht et al. authors responded, "We also stated the following in our in our Scientific Reports paper: "Disease prevalence includes colonies with both active signs of white-plague disease and those that were identified as recently killed as a direct result of the disease. The strong coupling between disease prevalence and total coral mortality suggests that disease prevalence was a useful proxy of mortality." But this statement is in a legend describing timed swim coral data, not tagged coral data. The Tagged Coral Methods' description of "disease prevalence" values are contradictory and obfuscated by the presentation of these findings in the Results section.

Precht et al. Response:

Silverstein et al. are not satisfied with the fact that we used recently dead corals in our calculations. However, that doesn't change the fact that we used these methodologies for the tagged coral and timed-swim data. As we discussed earlier we used period prevalence for the tagged corals and point prevalence for the timed-swim surveys. This was predicated by questions being addressed by these different survey methods. Their charge of obfuscation (the act of concealing something making it more difficult to understand) is unfounded. We describe our rationale for combining actively diseased and recently dead corals above (*sensu* Miller and Williams 2007).

Silverstein et al. comment:

While authors provided us with "qa/qc'd" timed swim data on April 4, 2018, we have no way to verify or to double check the timed swim data, since no photos, video, or alternative datasets were provided or are available, and Mr. Precht alone appears to have collected this data.

Precht et al. Response:

Unless they were in the water with Precht when he performed the timed-swim surveys, there is essentially no way to perform a *post hoc* QA/QC analysis on this type of ecological field data. The key to successfully performing timed-swim survey data is to have a trained observer do the data collection and for that observer to use the same protocol on all surveys for data consistency within and between sites. Precht has more than 40 years' experience performing in-water ecological coral surveys and has taught these field techniques in a graduate level coral reef ecology class for Northeastern University's Three Seas Marine Biology Program for the past 31 years. The comment by Silverstein et al. is little more than an *ad hominem* attack on the senior author. The fact that other researchers are now replicating the results presented in Precht et al. (2016) validates the accuracy of the data collected by Precht in his timed-swim surveys.

It should also be known that when Silverstein originally requested an Excel spreadsheet of the timed-swim data she never asked for any corresponding photos. For nine of the ten timed-swim survey sites underwater photographs were recorded (at one site the underwater camera failed). This was described in the Methods section: “At each site, the diver slowly swam at a height of approximately 1 m above the substrate, stopping occasionally to take notes and photographs…” and “Corals that were bleached, visibly diseased, or recently dead during the surveys were photographed…” Detailed PowerPoint presentations were made from these underwater photos and were shared with the Florida Disease Consortium. Of course these PowerPoint files (in PDF format) are available upon request.

Silverstein et al. comment:

Precht *et al.*: “White-plague disease did not impact the northern monitoring sites (14 km north) until June 2015.”

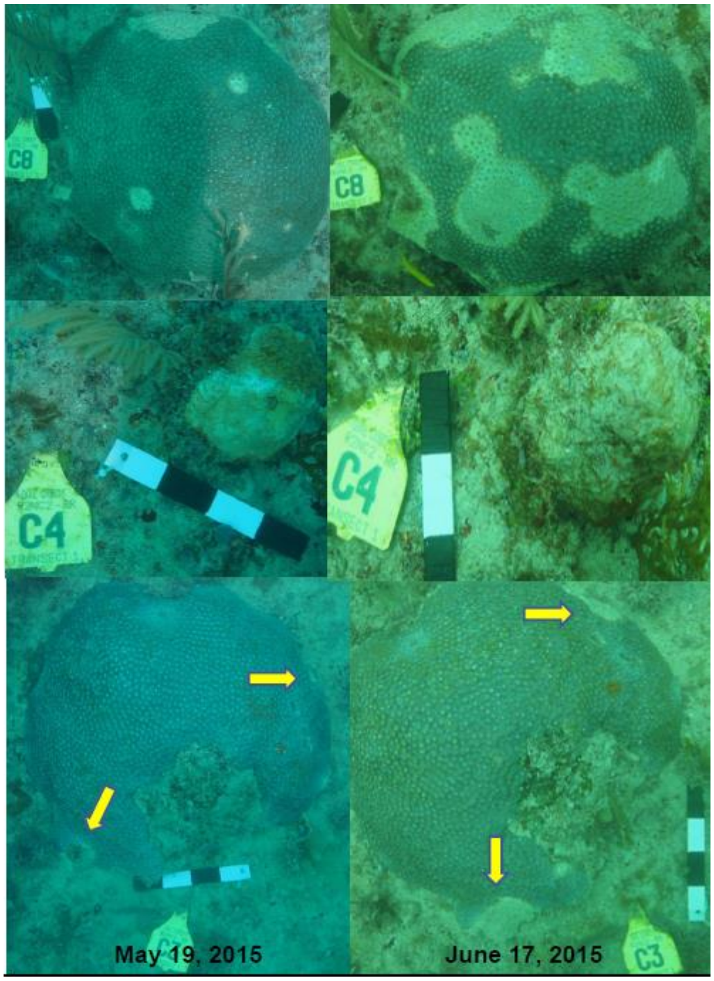
We also find that WP was first observed ≥5% at the northern sites in June 2015 within the dataset provided by Precht et al. However, analyzing the same tagged corals at the same 4 sites included in Precht et al, but querying the dataset provided by the authors to the FDEP for compliance monitoring, we find that the northern control site (R2NC2) was observed to have a 10% WP prevalence on May 19, 2015. From this comparison, we determined that Precht et al. excludes observations collected from May 2015 in their analysis. Therefore, this study not only excludes certain sites from analysis, but also dates.

Precht et al. Response:

We previously responded to this question of Silverstein et al. and we repeat and expand on our earlier response here.

The May 19th date that Silverstein et al. are referring were part of a separate set of “impact assessment” surveys performed by DCA (DCA 2015b). These surveys were <u>not</u> part of our weekly FDEP permit compliance monitoring program (DCA 2015a) and was a separate task assigned to DCA as part of the Port Miami project. These surveys employed different field methods and were designed to answer a different question from those posed in the weekly compliance monitoring program. Because the data associated with these surveys were not part of or included in the compliance monitoring results they were not entered into the compliance monitoring Excel database. Since these data were not entered into the database they were not used by Precht et al. in the Scientific Reports manuscript.

In reviewing the DCA’s impact assessment spreadsheets, it was noted that there were three colonies with signs of white-plague disease at site R2NC2, a prevalence of 10% (3 out of 30 colonies) on May 19, 2015. White-plague –like disease was corroborated for these three corals using the matching photographs. All three of these corals were counted as diseased in the June/July 2015 post construction surveys (DCA 2015a). However, even if these May 2015 impact assessment surveys had been included in our compliance monitoring database, they would have shown that the diseased progressed north arriving at the northern control sites (R2NC2) in mid-May 2015 and not June 2015. This difference in arrival time of the disease by a few weeks would not have changed the interpretation of the point of origin of the outbreak, the direction of its spread, the total number or species of disease impacted corals, or the overall impact of the disease on the coral community in the Precht et al. (2016) manuscript.



Three colonies with first signs of white-plague disease at R2NC2 site on May 19, 2015 (left of panel) and same colony less than one-month later on June 17, 2015 (right panel). While we use the term 'white-plague' to describe the outward signs of this disease, more recently the Florida Disease Advisory Committee is now referring to all affected Floridian corals as having "tissue-loss disease." This is due to the fact that the disease in the Florida Keys is now impacting more species than originally observed in Miami-Dade County.

Silverstein et al. comment:

Precht *et al.*: "During the week of June 17 [2015], 17% of the tagged coral colonies at the northern monitoring sites were infected with white-plague disease."

We find that, out of 60 corals at the northern monitoring sites, six (10%) were directly observed with active white plague on June 17th, 2015. In order reproduce the 17% prevalence reported here, Precht et al. must have included corals that were found dead and were then assumed to have died from white plague disease, but without direct observation. Therefore, this result is not reproducible– almost half of these corals were not actually "infected with white-plague disease" on this date.

Precht et al. Response:

As we have repeatedly stated we did exactly that. Using that combined methodology the results are clearly reproducible.

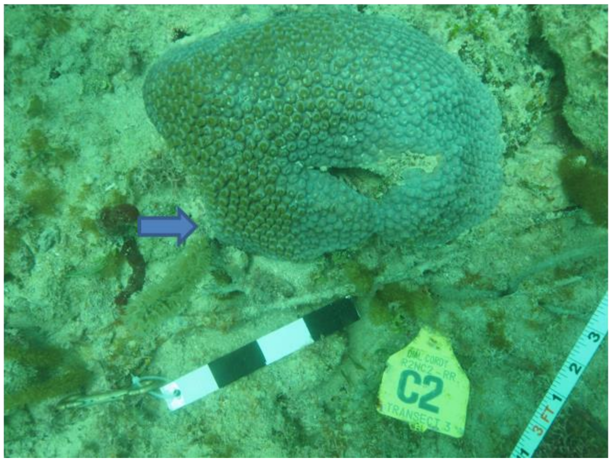
A total of six (6) corals were observed with active white plague on June 17, 2015. However, four (4) corals that had recently died from white plague were also surveyed on this date. The total (six infected) and four recently dead is equivalent to 10/60 corals which is 16.6% (rounded to 17% prevalence), identical with that reported in Precht et al. (2016).

Below are photographs of the six corals that had active white-plague and the four corals that suffered recent mortality likely as a direct result of the disease. The six corals with active white-plague were from two locations, R2NC1-LR and R2NC2-RR. The two species affected on this survey date were *Montastrea cavernosa* and *Dichocoenia stokesi.* The four corals that suffered recent mortality consistent with white-plague were *Dichocoenia stokesi* or *Meandrina meandrites.* These two species have among the highest prevalence and mortality rates associated with this outbreak region-wide. The inclusion of recently dead corals whose mortality is consistent with the white-plague disease epidemic was done to prevent significant underestimation of the effects of the disease. Of the four corals included in this estimation, all species were extremely white-plague susceptible, all had rapid tissue loss within the 3 months between surveys, and all corals died at sites with active white-plague at the time of their death.

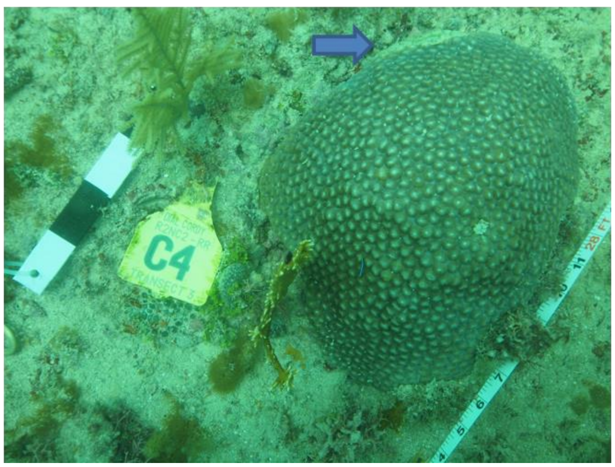
If the mortality of these corals were *not* attributable to the white-plague disease we would have to assume there was a second coral disease or mortality event that affected only white-plague susceptible species, and which was not visible by divers or in photographs during the 40 some visits of these monitoring locations. There is absolutely no reason to believe any other factor was responsible for the mortality of these corals at these reference (control) locations besides the obvious presence of the high mortality white-plague disease event. We know of no other reports of other coral diseases or disturbances during this time period that would have resulted in the total coral mortality observed from these corals *except* white-plague disease. In fact, this example shows exactly why we only used 2nd Reef Control Sites in this manuscript (and not the entire Port Miami data set) as there were no outside confounding influences such as the Port Miami dredging project that could conflate the interpretation. Because the control sites were not impacted by the dredging the cause of this mortality could not be attributed to the project (see similar discussion in Miller et al. 2016 below).

Here are photographs of the six corals with active white plague taken on 6/17/2015.

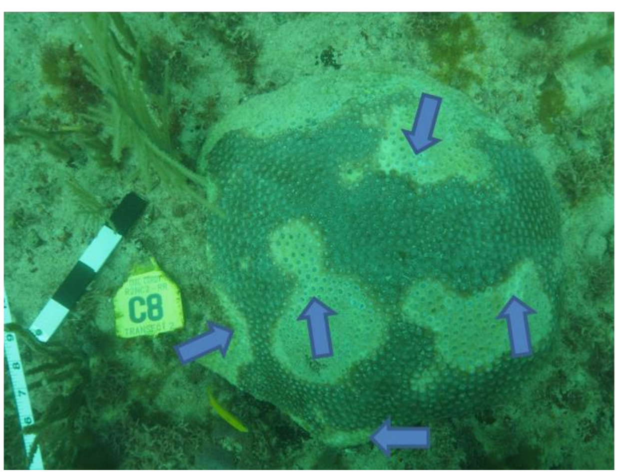
1) R2NC2-RR T3 C2 6/17/2015 with active white-plague

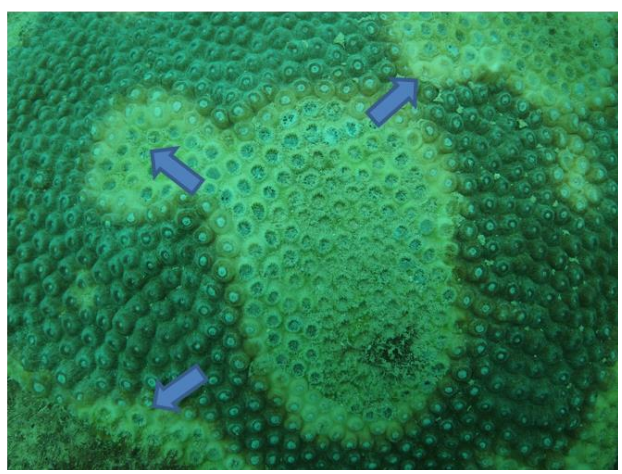


2) R2NC2-RR T3 C4 6/17/2015 with active white-plague

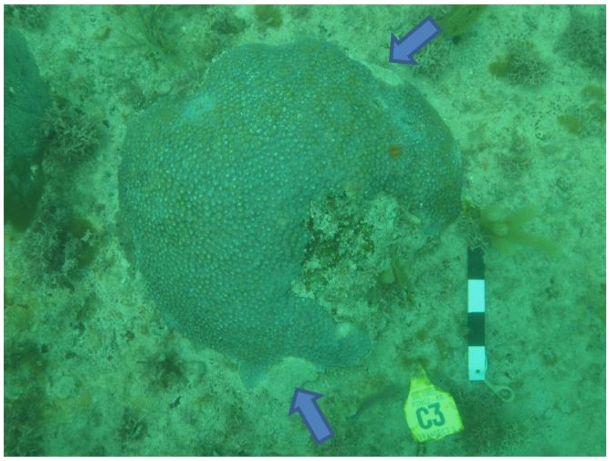


3) R2NC2-RR T2 C8 6/17/2015 with active white-plague

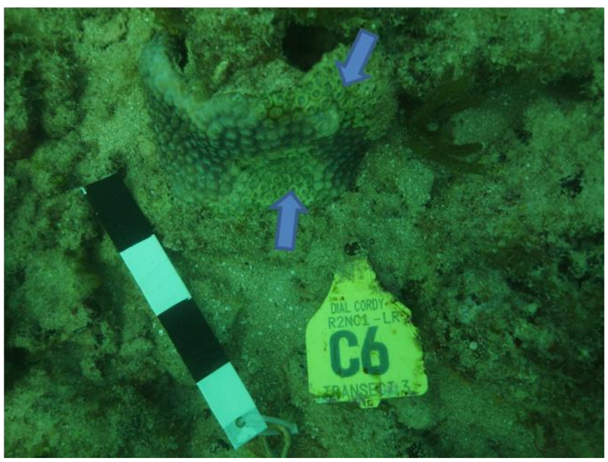


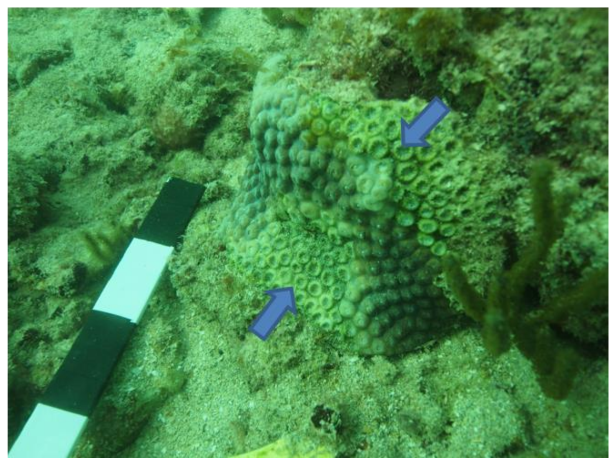


4) R2NC2-RR T1 C3 6/17/2015 with active white-plague

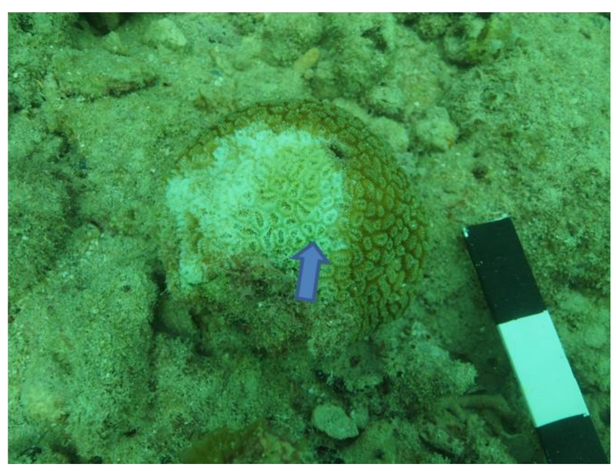


5) R2NC1-LR T3 C6 6/17/2015 with active white-plague



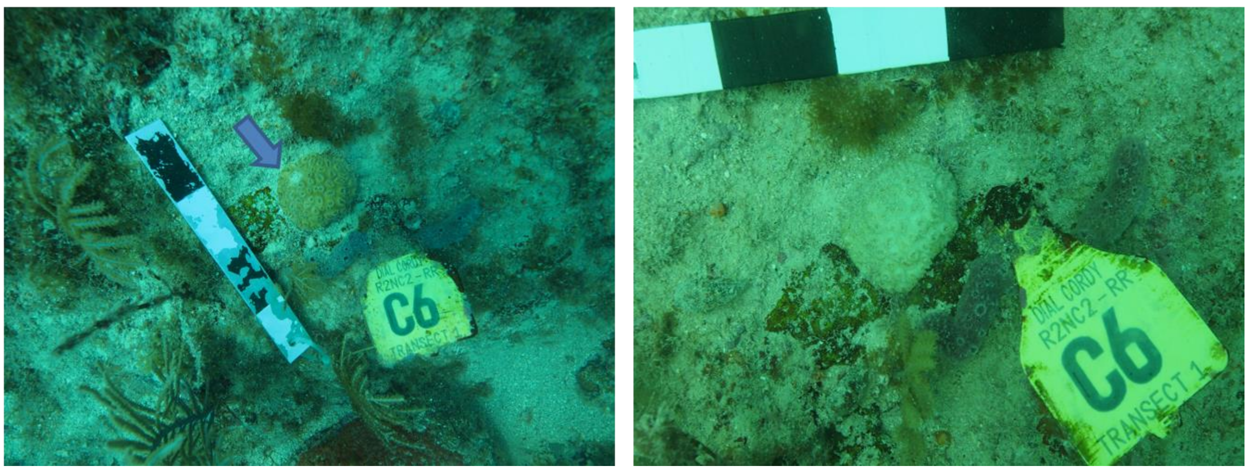


6) R2NC1-LR T3 C8 6/17/2015 with active white-plague



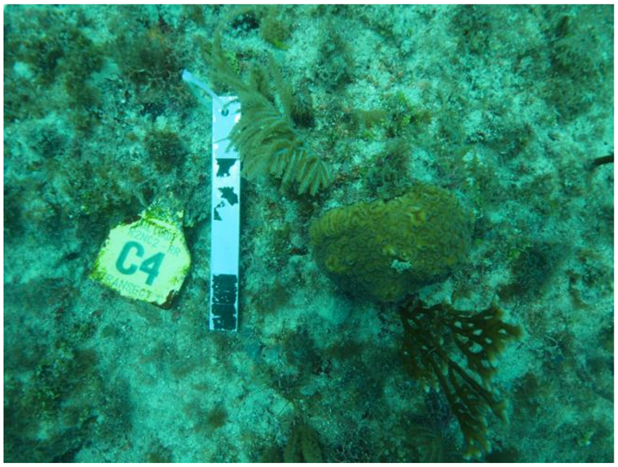
Below are the examples of the four corals that suffered rapid complete mortality (sudden death), but on which active white-plague was not observed. Please note that all colonies are from white-plague susceptible species, that active white-plague was documented during the same surveys on other corals, and that there is no indication of other sources of the coral mortality (no bleaching, no competitive mortality, no predation, etc.). The fact that death occurred between March 2015 and June 2015 is also consistent with the rapid tissue loss of other white-plague infected corals. In fact, as noted in the previous question, if the outbreak had arrived a few weeks earlier than we originally reported (May 2015) at R2NC2, is further evidence which helps to assist in validating that the mortality pattern observed in the four colonies detailed below was associated with white-plague disease and not some chimerical or illusory cause.

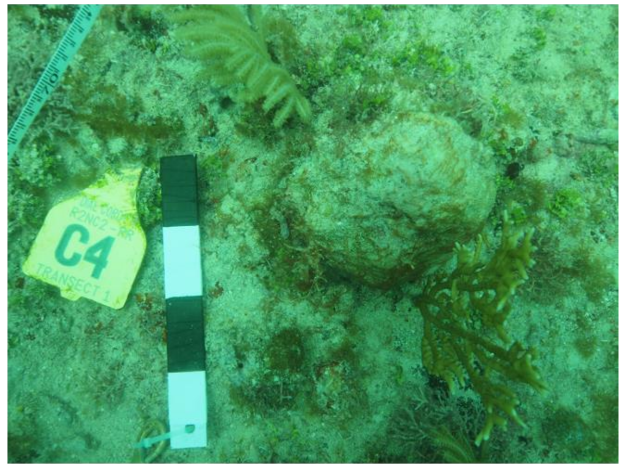
1) R2NC2-RR T1 C6 died between 3/17/2015 (left) and 6/17/2015 (right). The colony mortality is consistent with white-plague.



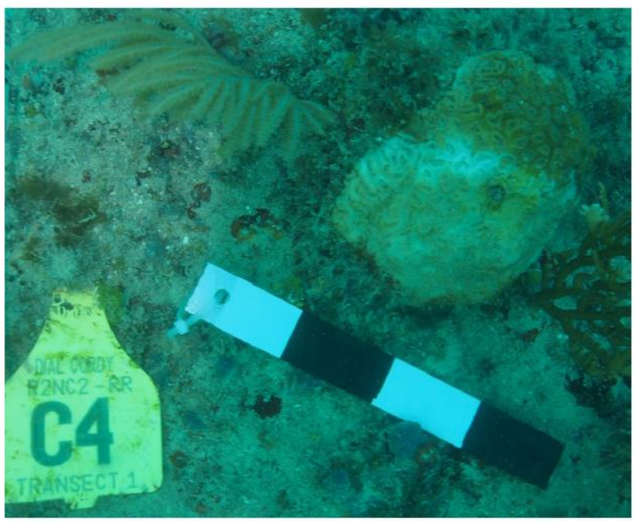
While originally coded as unknown partial mortality (UPM) on the March 17, 2015 field data sheets, the lesion (see blue arrow) resembles the initial sign of white-plague disease commonly observed on colonies of *D. stoksei* during this outbreak.

2) R2NC2-RR T1 C4 died between 3/17/2015 (left) and 6/17/2015 (right). The colony mortality is consistent with white-plague.



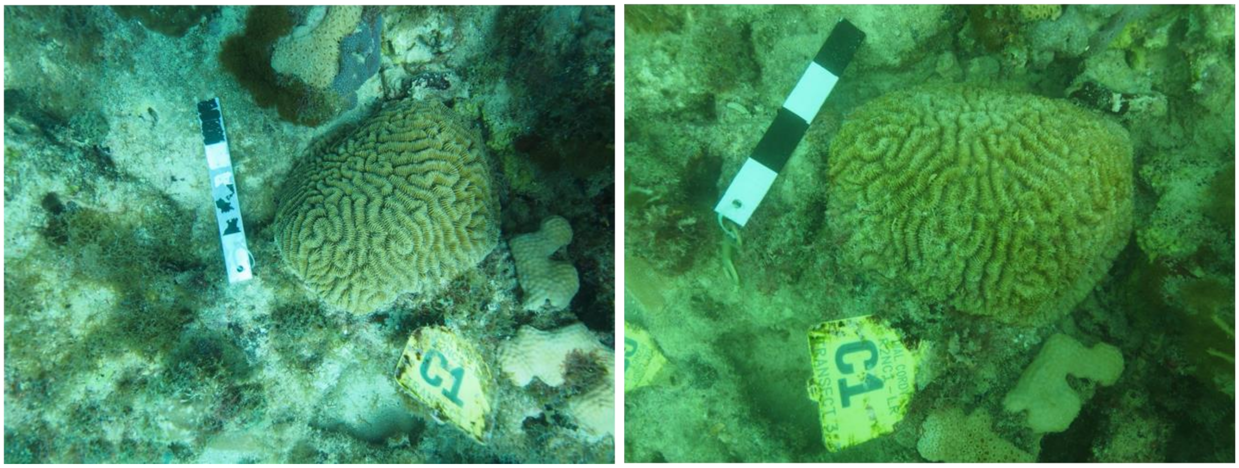


R2NC2-T1-C4 (DSTO)

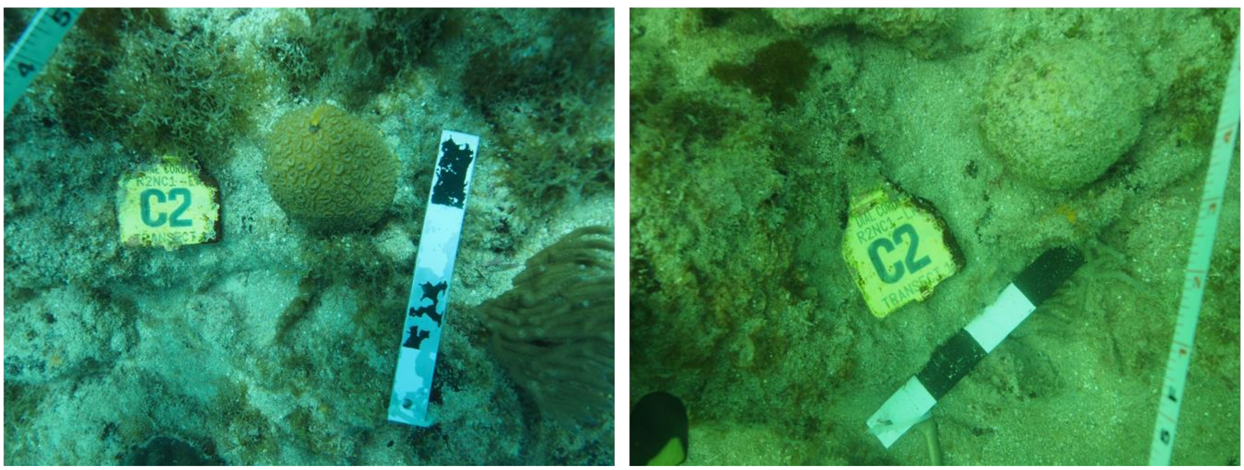


Active white-plague disease noted on May 19, 2015 during our impact assessment surveys (DCA 2015b) revealed that what we had originally reported as a "sudden death" coral (see photos above for colony R2NC2-T1-C4) was actually killed by white-plague disease. This corroborates that the sudden death corals were lost to this disease and not some other unknown cause.

3) R2NC1-LR T3 C1 died between 3/17/2015 (left) and 6/17/2015 (right). The colony mortality is consistent with white-plague.



4) R2NC1-LR T1 C2 died between 3/17/2015 (left) and 6/17/2015 (right). The colony mortality is consistent with white-plague.



We do not understand why Silverstein et al. have difficulty with combining actively diseased and recently dead corals in the analysis, as it most accurately describes the impact of this disease outbreak. The AGRRA field monitoring protocol actually asks the observer to inventory all newly dead corals as that could indicate ongoing disease outbreak or bleaching event (AGGRA 2016). As well, Miller et al. (2016) coined the term "sudden death" for these very corals. However, they stated the following: "`sudden death' (the complete mortality of a colony between sequential photos in the time series, presumably attributable to disease, though no active disease signs were observable) were recorded in sequence. We included `sudden death' in a category of disease impact given consistency with described patterns of mortality (i.e., complete colony mortality over a period of weeks) associated with a regional outbreak of `White Plague' disease affecting most species of mounding corals during this time frame, a lack of other known disturbances such as storms, and the presumption that the longer interval of images during which most of the `sudden death' occurred (winter 2014 - 2015) was during a period when dredging activities were distant according to permit requirements (hence transient sediment burial unlikely)."

Silverstein et al. comment:

Precht *et al.*: "In total, white-plague disease was observed on seven of the 13 coral species identified at the four permanent monitoring sites (Table 1)."

Based on the Precht et al. dataset, only six species are shown to have WP at the four permanent monitoring sites. The tagged coral data do not contain any reports of WP for *Colpophyllia natans*, as reported by Precht et al. in their Table 1. Photographs provided by FDEP show that the single tagged *C. natans* colony was indeed diseased on Dec. 12, 2014, but data from this date are excluded from the Precht et al. dataset. Precht et al.'s finding is therefore not reproducible from the dataset provided.

Precht et al. Response:

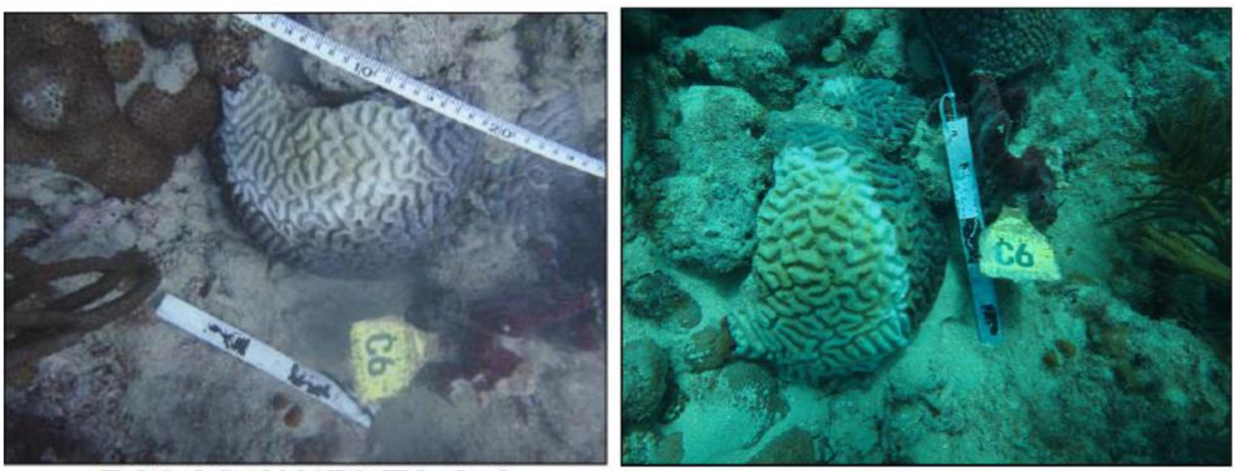
Prior to their dissemination of this review, Silverstein et al. asked us the following question: "R2SC1 T3 C6 has no data recorded for Dec. 12 and 17, 2014, but it was photographed. Can you help us determine why these observations was not entered into the datasheets?"

Our answer was as follows: "based upon our records there was data recorded for R2SC1-T3-C6 on December 12th and this is in the file we provided. However, no data was provided for this same coral on December 17th, 2014. This was due to the fact that the paired channel-side could not be monitored that week due to 'poor environmental conditions and the proximity of… all middle reef channel-side sites to active dredge equipment' per our Compliance Report 57."

However, a subsequent re-evaluation of Silverstein et al.'s question we find that they were specifically looking for the data of coral R2SC2-T3-C6 not R2SC1-T3-C6. The coral in question was a colony of *Colpophyllia natans* that became infected with white-plague disease in December 2014. It appears that Silverstein et al. unwittingly (because of a typo in their original request) had asked us to respond to missing data from the wrong site.

Checking our records (weekly compliance reports) for the week in question, December 12, 2014, biological monitoring was completed once at all sites within 750 m of an active dredge except for sites R2N1, R2N2, and R2S2 which were too close to active dredge equipment for safe dive operations. In addition, adverse environmental conditions (e.g., excessive wind speeds, wave heights, extreme currents, and/or low visibility) made conditions unsafe for offshore dive operations for portions of four out of seven (4/7) days in compliance week 56.

Because compliance data was specifically collected for weekly comparison of channel-side sites with their far-field controls, in those instances where far-field controls were collected with no channel-side comparison these data were excluded from the database. However, the photographs of the control site corals (as Silverstein et al. indicated) were added to the photographic database. This was done for all data collected during compliance monitoring. Thus, according to project protocol, data from R2SC2 were not entered into the project database for the two weeks in question. However, photographs of the coral in question were recorded on both December 12th and December 17th. This explains the discrepancy reported by Silverstein et al. for why those sites on those dates are not in the database. More importantly, it also shows that by using the available photos (which Silverstein et al. have) these data and results are still easily reproduced. You have to ask the question, why would we purposefully try to obfuscate the data by eliminating certain dates or sites, especially when they reveal exactly what we say in our manuscript?



R2SC2 CW56 T3 C-6
December 12, 2014

R2SC2 CW57 T3 C-6
December 17, 2014

Photographs of active white-plague disease noted on a colony of *Colpophyllia natans* on December 12 and December 17, 2014. These photos were used in our calculation of white-band disease infected colonies at our tagged 2nd Reef control sites.

Silverstein et al. comment:

Precht *et al.*: "The highest recorded prevalence of white-plague disease occurred on July 7, 2015, when 40% (22 of 55 corals surveyed that day) showed signs of white-plague disease infection (Fig. 2)."

We find that on July 7, 2015, only 3 out of 55 corals observed (5.5%) were actually recorded in the data as "WP". If we also include corals that were recorded as having WP *and* corals that were previously recorded as having WP and are now recorded as dead ("WPdead"), the total is 15 out of 55 corals, or 27.3%. We are unable to reproduce the result reported in the paper with the provided data. Therefore, the 40% disease prevalence reported by Precht et al. does not represent the number of corals "showing signs of white plague infection" on July 7, 2015, but must acutally represent the cumulative sum of corals that were recorded with WP, that had WP and then died, and/or that were assumed by authors to have died from WP at any time before July 7, 2015 (also the end of the reported data period).

Precht et al. Response:

That is correct, it is the combined totals of actively diseased and recently dead tagged corals (period prevalence as described earlier).

Silverstein et al. comment:

This is, perhaps, the most dramatic example of how the stated methods for calculating disease prevalence produce different results than the methods actually employed in Precht et al., which systematically overinflate the apparent disease prevalence.

Precht et al. Response:

We employed different methods as described earlier, we used period prevalence for our tagged coral surveys and point prevalence for the timed-swim surveys. We did NOT systematically overinflate the apparent disease prevalence (see below).

Silverstein et al. comment:

We then queried the Precht et al. dataset to determine the highest recorded prevalence of active white plague ("WP" condition code):

We found that, of the tagged corals included in Precht et al. directly observed to have white plague disease on a given date, the highest active disease prevalence only ever reaches 15% (9 out of 60 colonies observed on July 5, 2015).

We can also show the cumulative impact of white plague disease by plotting the number of corals with active white plague combined with corals that had previously been observed with white plague disease and are now dead:

If we count corals that have active white plague disease ("WP") *and* corals that previously had WP disease and are now dead ("WPdead"), we find that the highest prevalence on any date is just 15 out of 55 (27.3%) on July 7th, 2015.

Precht et al. Response:

Silverstein et al.'s result of 15 of 55 (27.3%) is incorrect. We have reviewed our files and photographs and still show 22 out of 55 corals to have either active white-plague disease or to have recently died from WPD; a total combined disease prevalence of 40%. This is the same proportion as reported in Precht et al. (2016). We have enclosed the tables below to show the exact species and location of the 22 colonies in question. We agree with Silverstein et al. that on July 7th, 2015 only three (3) corals were actively identified with disease signs, however, 19 others had previously succumbed to the disease outbreak at our southern control sites (R2SC1 and R2SC2). Again, failure to use the photographic database limited Silverstein et al.'s ability to reproduce our results or to understand the significance of this disease outbreak in space and time.

On July 7, 2015 R2SC1 and R2SC2 were surveyed. The dataset and photographs for that date show that three (3) corals were identified with active white plague disease during the surveys.

Site	Transect	Colony #	Species	Code on 7/7/15	Date ID'd with WP	Date ID'd as DEAD
R2SC1	1	2	PSTR	WP	6/8/15	N/A
R2SC1	1	4	MCAV	WP	3/6/15	N/A
R2SC1	3	1	SBOU	WP	6/25/15	N/A

An additional 17 colonies were identified as dead during the July 7, 2015 surveys, but historically had displayed symptoms of active white plague.

Site	Transect	Colony #	Species	Code on 7/7/15	Date ID'd with WP	Date ID'd as DEAD
R2SC1	1	3	MMEA	DEAD	11/18/14	12/12/14
R2SC1	1	9	PSTR	DEAD	6/18/15	6/25/15
R2SC1	2	6	MCAV	DEAD	3/6/15	6/18/15
R2SC1	3	5	DSTO	DEAD	12/12/14	3/6/15
R2SC2	1	1	MMEA	DEAD	11/18/14	2/24/15
R2SC2	2	1	MMEA**	DEAD	9/26/14	2/24/15
R2SC2	2	3	MMEA**	DEAD	10/17/14	11/18/14
R2SC2	2	7	MMEA	DEAD	11/18/14	2/24/15
R2SC2	3	9	MMEA	DEAD	11/18/14	2/24/15
R2SC2	3	10	PSTR	DEAD	2/24/15	3/17/15
R2SC2	3	6	CNAT*	DEAD	12/12/14	2/24/15
R2SC2	1	4	MMEA**	DEAD	9/26/14	12/12/14
R2SC2	2	2	DSTO**	DEAD	9/26/14	10/31/14
R2SC2	1	5	DSTO*	DEAD	12/12/14	2/24/15
R2SC1	1	5	SBOU	DEAD	12/12/14	6/18/15
R2SC1	1	6	DSTO	DEAD	12/12/14	2/24/15
R2SC1	3	8	PSTR	DEAD	12/12/14	2/24/15

*** For these two colonies we used the field sheets and photographs to verify that they had been affected by white-plague disease. Note the date of December 12, 2014 and our previous response to data collected and photographed for site R2SC2 on that date.**

**** These four colonies were part of the original outbreak – initially coded as "UC" at R2SC2.**

Another two (2) colonies were also identified as dead during the July 7, 2015 surveys. These colonies were never recorded as having white-plague because they died rapidly between monitoring visits (sudden death). Both of these colonies were disease susceptible, small in size, and died during the midst of the white-plague outbreak at the southern control sites.

Site	Transect	Colony #	Species	Code on 7/7/15	Date ID'd with WP	Date ID'd as DEAD
R2SC1	3	10	DSTO	DEAD	N/A	2/24/15
R2SC2	1	7	MMEA	DEAD	N/A	2/24/15

Failure to report these 19 dead corals by Precht et al. (2016) would have grossly underestimated the impact (burden) of this regional coral killer (40% vs. 5.5%). This is because the disease-susceptible species were being culled rapidly by the impact of this outbreak (mortality rate often exceeding incidence rate with time). Incidence (rate of new infections) should not be confused with period prevalence (total number of diseased individuals through time).

In addition, when we look at the prevalence and mortality of individual species collected by other observers from across the region the numbers are essentially identical to those reported in Precht et al. (2016). Clearly, we did not systematically overinflate the apparent disease prevalence. Had we done so these other recently published surveys by other researchers (FRRP 2014, FRRP 2016, Carsey et al. 2016, CSi 2016, DERM 2016, Hayes et al. 2017, USCRTF 2017, Ruzicka 2018, Sharp & Maxwell 2018) would have served as a 'correction' to our data and not as a confirmation of it!

Silverstein et al. comment:

Precht *et al.*: "Of the white-plague impacted species, the overall disease prevalence was 51% (35 of 69 corals surveyed)."

We find that, analyzing just the species that Precht et al. determined to be white plague susceptible, the dataset provided shows that only 28 out of 69 colonies (40.6%) were recorded as having WP at any point in time (cumulative disease total).

Precht et al. Response:

Silverstein et al. calculation of 41% is incorrect. Based upon a re-analysis of our data, the overall disease prevalence was 51% of disease susceptible species (35 of 69 disease susceptible corals surveyed). This is identical to the results published in Precht et al. (2016). See attached table below that shows the actual records for the 35 corals in question. Again, if Silverstein et al. had used the corresponding photos, they would have been able to calculate exactly how many white-plague susceptible corals were impacted. Silverstein et al. also refuse to accept the fact of using the 'sudden death' corals in their analysis (although others do not, see Miller et al. 2016). As long as they do this, they will always have trouble being able to reproduce "many of Precht et al.'s findings, particularly with respect to disease prevalence."

Site	Coral ID	Species	ID'd w/WP in database	Date	Comments	
R2NC1-LR-1	2	DSTO			coral died between surveys 3/17 and 6/17	
R2NC1-LR-3	1	MMEA			coral died between sueveys 3/17 and 6/17	
R2NC1-LR-3	5	DCLI	1	6/24/2015		
R2NC1-LR-3	6	MCAV	1	6/17/2015		
R2NC1-LR-3	8	DSTO	1	6/17/2015		
R2NC2-RR-1	3	MCAV	1	6/17/2015	WPD was noted during impact assessment surveys on May 19, 2018	
R2NC2-RR-1	4	DSTO			coral died between compliance surveys 3/17 and 6/17; was noted with WPD on May 19th during impact surveys	
R2NC2-RR-1	6	DSTO			Originally coded UPM on 3/17/15 looks like start of WPD - coral died between surveys 3/17 and 6/17	
R2NC2-RR-1	9	DSTO	1	7/5/2015		
R2NC2-RR-2	8	MCAV	1	6/17/2015	WPD was noted during impact assessment surveys on May 19, 2018	
R2NC2-RR-3	2	MCAV	1	6/17/2015		
R2NC2-RR-3	4	MCAV	1	6/17/2015		
R2NC2-RR-3	10	MCAV	1	7/13/2015		
R2SC1-RR-1	2	DSTR	1	6/18/2015		
R2SC1-RR-1	3	MMEA	1	11/18/2014		
R2SC1-RR-1	4	MCAV	1	3/6/2015		
R2SC1-RR-1	5	SBOU			progressive mortality from WPD noted on 12/12/2014 - initially coded as UPM	
R2SC1-RR-1	6	DSTO	1	12/12/2014		
R2SC1-RR-1	9	DSTR	1	3/6/2015		
R2SC1-RR-2	6	MCAV	1	3/6/2015		
R2SC1-RR-3	1	SBOU	1	6/25/2015		
R2SC1-RR-3	5	DSTO	1	12/12/2014		
R2SC1-RR-3	8	DSTR		12/17/2014	WPD clear on on 12/17/14 - originally coded as UPM 12/12/14	
R2SC1-RR-3	10	DSTO			coral died between surveys 12/17/14 and 2/24/15	
R2SC2-LR-1	1	MMEA	1	11/18/2014		
R2SC2-LR-1	4	MMEA	1	11/12/2014	Photos confirm active WPD on 11/12/14 - Disease may have started as early as 9/26/14	
R2SC2-LR-1	5	DSTO	1	11/18/2014		
R2SC2-LR-1	7	MMEA			coral died between surveys 12/17/14 and 2/24/15	
R2SC2-LR-2	1	MMEA	1	9/26/2014	Original coded as UC - follow-up photos confirm WPD	
R2SC2-LR-2	2	DSTO		9/26/2014	PM 10/17/14 - Original coded as UC - follow-up photos confirm WPD	
R2SC2-LR-2	3	MMEA	1	9/26/2014	10/17/2014 - Original coded as UC on 9/26/14 - follow-up photos confirm WPD	
R2SC2-LR-2	7	MMEA	1	11/18/2014		
R2SC2-LR-3	6	CNAT		12/12/2014	not in database - Active WPD noted in photographs on 12.12/14 and 12/17/14	
R2SC2-LR-3	9	MMEA	1	11/18/2014		
R2SC2-LR-3	10	DSTR	1	2/24/2015		

Silverstein et al. comment:

6. Testing for a relationship between bleaching and disease

Precht *et al.*: "The majority (81%) of white-plague susceptible corals bleached, prior to becoming infected with the disease (Table 1). *Meandrina meandrites*, *Dichocoenia stokesi*, *Colpophyllia natans*, and *Pseudodiploria strigosa* were the most heavily impacted coral species, with 100% of tagged colonies being afflicted with white-plague disease. All colonies that showed signs of disease died, regardless of species."

This is a key finding, yet we cannot reproduce it. We find that only 3 out of 28 corals (10.7%) that had WP were recorded as bleached (BL) at some time prior to becoming infected. 20 out of 28 (71%) were recorded as partially bleached (PB) prior to infection, while 28 out of 28 (100%) were recorded as pale (P) prior to infection. We cannot combine these three condition codes (as appears to have happened for the earlier report of bleaching prevalence) to replicate the reported 81% prior “bleaching” for WP-infected corals.

Precht et al. Response:

The bleaching data used to calculate the 81% of white-plague-susceptible corals were taken from a single survey day on Sept. 17, 2014 and compared with the data collected from the last week of surveys (July 8-15, 2015) which we used to calculate the final number of WP affected corals. The bleaching data was used from this day because it was the only single day where all four 2nd Reef control sites were surveyed during the peak of bleaching prevalence. The data table used to generate the 81% is included below. This table was used to produce Table 1 in Precht et al. (2016).

Species	Colonies (n)	BL Colonies	% BL	WP Colonies	% WP
Dichocoenia stokesi	10	4	40	10	100
Meandrina meandrites	9	8	88.89	9	100
Pseudodiploria strigosa	4	3	75	4	100
Colpophyllia natans	1	1	100	1	100
Montastrea cavernosa	27	24	88.89	8	29.63
Pseudodiploria clivosa	6	5	83.33	1	16.67
Solenastrea bournoni	12	11	91.67	2	16.67
Siderastrea siderea	17	14	82.35	0	0
Porites astreoides	17	14	82.35	0	0
Stephanocoenia intersepta	5	5	100	0	0
Acropora cervicornis	4	2	50	0	0
Orbicella faveolata	2	0	0	0	0
Agaricia agaricites	1	1	100	0	0
Total	115	92	80	35	30.43
WP Infected Species Only	69	56*	**81.16***	35	50.72

Combined data for all tagged corals at the four permanent monitoring stations, where BL indicates bleached, and WP indicates white-plague. Total corals, n = 115. * 81% of white-plague-susceptible corals were taken from a single survey day on Sept. 17, 2014

We used the 81% figure to be conservative in our estimate directly contrary to the claim of Silverstein et al. that we overinflated our results.

We agree with Silverstein et al. that in our Excel database 100% of the WP affected corals had exhibited paling, partial bleaching, and/or bleaching at some point during the monitoring program. We found three corals displayed paling or partial beaching only once (R2SC2-T1-C5 and R2NC2-T3-C4) or twice (R2SC2-T1-C7). For these corals we did additional research by looking and comparing the in situ code to their paired photographs in a time series both before and after they had been coded as bleached (Siebeck et al. 2006). Based upon this analysis we determined that they had not paled or bleached. Accordingly, these corals were not included in our bleaching analysis.

Interestingly, had we added these corals to the overall tally would have increased the proportion of corals showing some form of bleaching stress from 81% to 100% before having become infected with white-plague disease. Ironically, using all corals (100% bleaching prevalence) would strengthen, not weaken, our conclusion that the majority of white-plague susceptible corals bleached prior to becoming infected with the disease. Clearly, if we were trying to inflate or exaggerate our claims we would have used the raw Excel data files and not the revised totals that used the paired photographs to validate our in situ observations.

Silverstein et al. comment:

However, to statistically test whether there is a relationship between bleaching and disease, the number of corals that bleached and did *not* get disease must also be considered (which Precht *et al.* authors also did not test).

Precht et al. Response:

Silverstein et al. are claiming that we stated that there was a statistical relationship between bleaching and disease. We never said that. We were very careful in our wording and actually stated the following: "The unprecedented disease outbreak in 2014 to 2015 appears to have been associated with the unusually warm-winter and spring temperatures followed by an anomalously warm summer. These conditions caused widespread bleaching, which was most likely a precursor of the lethal white-plague outbreak that followed." We also noted "Muller et al. showed that the prevalence of coral disease increased following the 2005 thermal-stress event, but they also showed that disease-associated mortality was only apparent when the coral host had bleached prior to the disease outbreak. In a similar study, Brandt and McManus documented that colonies with white-plague disease experienced the most extensive bleaching during the 2005 thermal anomaly. Together, these results reflect a clear and consistent relationship between bleaching and disease prevalence. The results of the 2014–2015 white-plague outbreak are similar, but in the present study bleaching was not a prerequisite of infection."

Silverstein et al. comment:

We do not consider "paling" to be descriptive of bleaching.

Precht et al. Response:

We strongly disagree with Silverstein et al.'s interpretation that paling is not "descriptive of bleaching." This is contrary to essentially every coral reef ecologist visually describing the effects of coral bleaching in the field today. Paling is also used and accepted in every major bleaching monitoring protocol discussed above (FRRP, AGRRA).

Silverstein et al. comment:

Therefore, we considered BL and PB only in this analysis. We find that 50 of the 69 disease-susceptible corals 'bleached' (BL or PB), and of these, 20 got WP disease (40%), but 30 did not (60%). We find a similar incidence of disease among corals that did not bleach, with 8 out of 19 (42%) having the disease, and 11 (58%) not having disease. With Fisher's exact test, we find no relationship between bleaching (BL or PB) and disease (WP) (p-value=1).

Precht et al. Response:

Their analysis of the bleaching data is disingenuous. Obviously, if Silverstein et al. are not counting paled corals as bleached they automatically bias their analysis and lower the total number of bleached corals. Using this biased methodology they will never find a relationship between bleaching and disease because they do not even show that a majority of the corals of white-plague susceptible corals bleached prior to becoming infected with the disease; the point we made in Precht et al. (2016).

In addition, from their comment above it is also evident that Silverstein et al. do not understand the difference in terminology between incidence and prevalence. This may be the root of their problem in understanding and validating the prevalence results published in Precht et al. (2016).

Silverstein et al. comment:

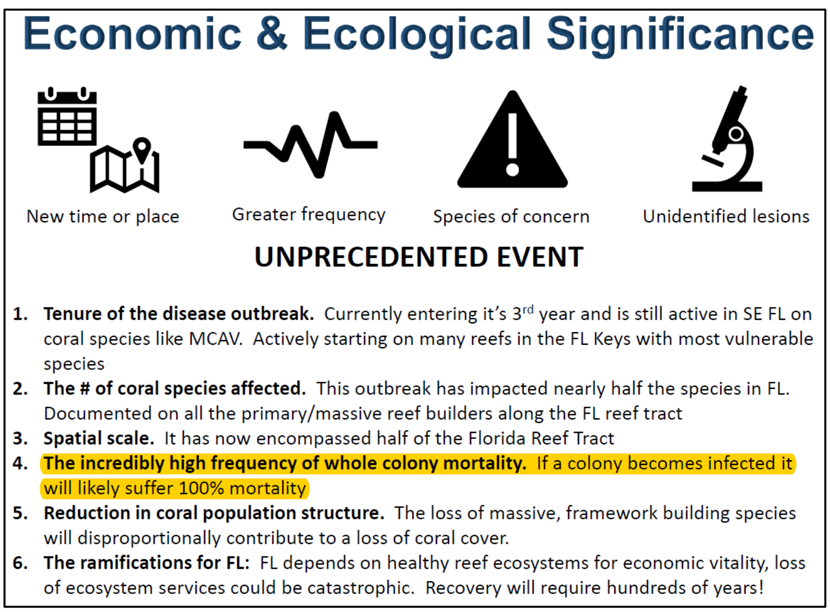
7. Evaluating the relationship between disease and death

Precht *et al.*: "All colonies that showed signs of disease died, regardless of species."

In the Precht et al dataset, we find that 15 coral colonies recorded with WP were still alive on 7/15/15, while 13 corals were dead. This is a mortality rate of 46%. Therefore, the data do not support the claim of 100% mortality following disease infection.

Precht et al. Response:

The claim of 100% mortality was obviously for corals that had run the course of the disease. However, at the time of our last survey (July 15, 2015) the disease was still active. This was especially true for some *Montastrea cavernosa* colonies at our northern control sites. Clearly, if a coral had just recently become infected and the disease was still active it would not be coded as "dead". How could the disease be active and all corals dead at the same time? However, if a coral became infected with this virulent disease it did eventually die! Subsequent surveys to these sites following publication of Precht et al. (2016) have confirmed these observations (DCA 2017). Importantly, at the time we wrote the manuscript, we had not witnessed any corals associated with the regional epizootic to go into remission (the progression and outward signs of the disease disappearing) as had happened in earlier white-plague disease outbreaks in Florida (Richardson et al. 1998). Another important aspect of the white-plague outbreak among southeast Florida coral populations is that susceptibility patterns (which species became infected first and to what extent) varied according to coral species, and that those patterns were conserved across the studied region. Other researchers throughout south Florida have been observing exactly what was reported in Precht et al. (2016). Thus, infection essentially leads to a death sentence! Subsequent researchers have noted exactly the same pattern on corals at their sites related to this white-plague disease epizootic (see below).



Slide from USCRTF (2017) showing the significance of the impacts associated with this regional coral disease. Highlighted text shows likelihood of 100% mortality of infected colonies. Data from Karen Bohnsack (FDEP).

Based on subsequent analysis performed over the last few years it is clear we did not exaggerate, overinflate, or obfuscate any of our data or interpretations in the 2016 Scientific Reports manuscript (see DCA 2017). Also, in carefully re-analyzing the data associated with all the points raised by Silverstein et al. in their critique, we stand by all of the data, interpretations, and conclusions reached in that manuscript. Based on our individual answers to Silverstein et al. in this rebuttal, it should also be clear that our results did not "fundamentally change the apparent severity, lethality, location, and timing of the reported disease outbreak." All we did was to sound the first alarm of this horrific coral conflagration. Subsequent studies by other researchers have affirmed the results and conclusions proffered in Precht et al. (2016).

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Epilogue

Letter from Sen. Bill Nelson (FL) attached below

United States Senate

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

WASHINGTON, DC 20510–6125

WEBSITE: http://commerce.senate.gov

February 28, 2018

The Honorable Alex Azar
Secretary
Department of Health and Human Services
200 Independence Ave., SW
Washington, DC 20201

The Honorable Sonny Perdue
Secretary
Department of Agriculture
1400 Independence Ave., SW
Washington, DC 20250

The Honorable Wilbur Ross
Secretary
Department of Commerce
1401 Constitution Ave., NW
Washington, DC 20230

Dear Secretary Ross, Secretary Azar, and Secretary Perdue,

I am writing because your departments have the combined expertise necessary to help address an environmental crisis in the Florida Reef Tract, where an unprecedented disease outbreak – the most serious coral disease epidemic on record globally – is ravaging reefs.

The outbreak began in 2014, when isolated diseased coral colonies were reported near Key Biscayne off the coast of Miami-Dade County. It has since spread north and south without interruption. To date, over half of the Florida Reef Tract – the only living coral barrier reef in the continental United States – has been affected. The disease has been shown to affect at least 23 species of reef-building corals. Once infected, coral colonies typically die within weeks to months. Despite efforts from Florida scientists and regional managers, the disease remains yet to be identified.

To adequately address the outbreak, we must have a correct diagnosis as soon as possible. And this is more than just an environmental concern. Florida's coral reefs attract over 16 million visitors each year, are estimated to bring in over $6 billion of revenues to the state, and provide over 71,000 local jobs. The 360-mile-long Florida Reef Tract is the third largest barrier reef in the world. These ecosystems are referred to as the rainforests of the sea for their biodiversity. They serve as the base of the food web for economically valuable fish stocks and a tourism draw for divers and snorkelers. That's why it is so important to figure out what's threatening the viability of these corals.

Hurricane Irma further damaged this invaluable natural resource. After the storm, divers surveyed more than 50 sites and reported significant shifting of sand and sediment accumulation, as well as structural damage to individual corals. This can cause serious harm to healthy coral reefs, but for vulnerable coral already exposed to disease, this type of damage can be catastrophic.

I believe that the agencies within your departments – specifically the National Oceanic and Atmospheric Administration, the Centers for Disease Control and Prevention and the Animal and Plant Health Inspection Service – have the expertise and tools to diagnose this disease and mitigate the outbreak. I urge you to establish an interagency epidemiological strike team to quickly deploy experts to the Florida Reef Tract to assist ongoing local efforts, to sample the corals to determine the mechanism of the disease and to perform field trials of intervention techniques to identify the most effective treatments for saving the remaining colonies.

Time is of the essence for Florida's coral reefs. Thank you in advance for your consideration. I look forward to your response.

Sincerely,

Bill Nelson

BILL NELSON
Ranking Member

cc: The Honorable John Thune, Chairman