Relationships among Climate, Water Quality and Toxic Blooms of Golden Alga in Texas

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Webinar Transcript

Ashley Fortune: Good afternoon from the U.S. Fish and Wildlife Service's National Conservation Training Center in Shepherdstown, West Virginia. My name is Ashley Fortune, and I would like to welcome you to today's broadcast of the NCCWSC Climate Change Science and Management webinar series. This series is held in partnership with the U.S. Geological Survey's National Climate Change and Wildlife Science Center. Today's webinar, "Relationships among Climate, Water Quality, and Toxic Blooms of Golden Alga in Texas," will be presented by Reynaldo Patino with the USGS Texas Cooperative Fish and Wildlife Research Unit.

I would like to welcome Dr. Shawn Carter to introduce our speaker. Shawn?

Shawn Carter: Thanks, Ashley. Thank you, everyone, for joining today. Today, I'm pleased to introduce Reynaldo Patino, who's our leader at the USGS Texas Cooperative Fish and Wildlife Research Unit. He's also Professor of the Departments of Natural Resource Management and Biological Sciences at Texas Tech University. Reynaldo has degrees from Tokyo University of Marine Science and Technology and also Master's and PhD degrees from Fisheries Science in Oregon State University. He's also done postdoctoral work at the Texas Marine Science Institute.

Reynaldo has 30 years of research experience in the fields of comparative and reproductive physiology and toxicology. Over the past several years, his lab has focused much of their attention on the area of water quality, especially harmful algal blooms and impacts to fish populations, which you'll hear about today.

Without further ado, it's my pleasure to introduce our speaker, Reynaldo Patino. It's yours.

Reynaldo Patino: Thank you, Shawn. First, I'd like to thank the Center, Shawn, and others for the invitation to give this webinar on the work we've been doing. Also, I'd like to thank the audience for taking the time to listen to this presentation. Hopefully, you'll find some useful information in it. As usual, I'd like to start with the disclaimer that you see on this first slide that this work has been recently completed. We're analyzing data and interpreting it. The conclusions are not final. We're still looking at things and trying to understand what we found.

In fact, if anybody has any suggestions or comments, I'd be very appreciative if you share those with me at the end of this webinar or a later time. What I'd like to do first is, let's see if this works, it was working a while ago. There you go.

For those of you who may not be too familiar with golden alga, the first record of a toxic bloom was recorded in a Texas river back in 1985. Also, a large range expansion occurred in 2001, when multiple major reservoirs in the Red, Brazos and Colorado Rivers were hit with the alga. So this was kind of a key year in terms of the expansion of this alga. Now, blooms of the alga, toxic blooms, have been reported in, last time I counted, at least 20 states.

In Texas, the majority of golden alga populations have been determined to be genetically related to Scottish strains of this Alga. So it is believed that what we have in Texas, the strains we have in Texas and have in Oregon, is in Scotland.

The other thing thing to keep in mind as I'll be giving some data later is that the blooms typically occur in Winter. A typical bloom would probably start in late Fall and continue through the Winter or early Spring. Sometimes they may be long-lasting in certain places; sometimes they may last for a couple or three weeks. But they normally happen during the colder times of the year.

One question and I will expand on this later. But one question in our mind when we started doing this work is, was the 2001 expansion of the alga, in Texas in particular, due to a novel introduction into pre-existing habitat that was favorable to the alga, or was this more of something, conditions that existed for a while, or is this the result of changing conditions that made it possible for the alga to become established and bloom around 2001. These gradual changes could have happened as the result of human development or climate change. Again, we'll come back to this question later.

Just a brief synopsis of what the current understanding of how climate change relates to harmful alga blooms. In general, there's a number of review papers listed here that state that development or climate will increase eutrophication, salinity, in some cases temperature, and so forth. That's how this will then influence the incidents and also severity of harmful alga blooms.

In particular, my understanding is that how people view that climate change may worsen the incidents of HABs is primarily by changes in water quality. Again, that includes eutrophication and salinity. But specifically for golden alga, the relationships between water quality and bloom events are not very clear yet.

There's a number of labs where they're working on this, but the relationships are not really well understood. Also, projections of increased bloom frequency and severity due to climate change are based on essentially conceptual scenarios, and there is limited empirical data to support those scenarios.

Another thing maybe worth keeping in mind, and this may be specific for Texas, but most reservoirs in Texas, at least those that are known, or 90 percent of the reservoirs, are already classified as eutrophic to hypereutrophic. In our opinion, it seems unlikely that further increases or changes in eutrophication will be a major factor that would influence the spread of golden alga in the future, because they’re already up there in levels of nutrients. Basically, salinity is one factor of interest.

I'm sure some of you know this far better than I do, but this is an excerpt, an image of a page that I took from Karl et al. in 2009, that shows that the temperature, this is the Great Plains, which includes down there, the bottom is Texas, the temperature is projected to continue to increase.

Precipitation will change according to this scenario. It may become wetter in the north, but drier in the south. There will be an increase in extreme events as well. This is what the climate is projected to be in the next 100 years or so. To give you an idea of the situation in Texas in terms of precipitation, this is data compiled by the USGS that shows the yearly average for between '61 and 1990 of the gradient of precipitation from Eastern to Western Texas.

You can see it's wetter in the east and becomes drier as you go to the west. This slide essentially reflects that. The colors here represent reservoirs in Texas and their status, essentially how much water they have. As you can see, they're fuller, more to capacity, in the east than they are in the west. This reflects the precipitation gradient that is naturally observed in this area in Texas.

One answer that we're trying to address in order to understand how climate and golden alga may be associated in reservoirs is, one specific question we're asking is, has the quality of reservoir water in Texas changed over the years, and also in a manner that is consistent with being rooted in climate change?

A “yes” answer to this would be consistent with a scenario where, as climate continues to change, so will be the spread or severity of golden alga blooms. A “no” answer would not rule out future influence of climate change, but perhaps would also suggest that there are maybe other factors that also play important roles.

With that question in mind, the specific research objective of this part of our research is, we would like to first, based on water quality, define what is the golden alga habitat at the landscape scale. The next question is, what are the variables, they may be the same, they may be different, that are associated with actual bloom events.

Then also third, to determine trends in water quality. We've chosen a period of 20 years, bracketing the period of the first appearance of blooms in 2001 in major Texas reservoirs. These are our three specific research objectives that essentially I'll be talking about today.

The information gathered from this study can obviously be used to develop water quality criteria for management or maybe mitigation purposes, but it also can be used to understand golden alga dispersal mechanisms, and also to more accurately project how climate change may influence the future spacial distribution of golden alga. The last two are the ones that I'll be focusing on today in terms of the application this data.

The data sources that we've used. We've used some of our own data that we've collected during the course of short-term studies. They range from some ongoing studies of two years to five years. But primarily, we used a data set that was put together by our colleagues from the Texas Water Science Center, Burley et al., where they collected data from, I believe it was up to 59 reservoirs in Texas, and put it all in one place.

This is a very useful resource in order to study the spatiotemporal distribution of water quality in these reservoirs. Reservoirs we've chosen for most of our studies include reservoirs from the

Brazos and Colorado river basins. We also looked at other basins, but primarily these are the two basins. We're looking at both golden alga impact, as you can see here with the asterisks here, those that are impacted and also non-impacted reservoirs as reference.

The date of the first toxic bloom in all of these impacted reservoirs, or majority of them, was in 2001. First question, our first objective, what are the water quality variables that define golden alga habitat? For this purpose, we used both short-term and medium-term data sets. Again, short-term is our ongoing study and medium-term there does include up to the time, in 2001, when golden alga bloom first began.

We use a multivariable analysis to describe patterns and distribution of water quality. Not only, but essentially principal component analysis. You see here the number of the variables that we included. The number of variables depends on the source of data or the reservoir. Sometimes the data for certain variables is very limited for certain reservoirs, or sometimes non-existent.

Included in our list is four variables that I'm showing here, depending on the study or the reservoir also are the variables. One thing to know and I wanted to note, that specific conductance of chlorine and sulfate, both in the Brazos and the Colorado, are highly correlated with each other. Therefore, we feel we can use either one of them as proxy for salinity in terms of patterns, assessing temporal patterns.

This is the first data slide. This shows some work, this is an ongoing survey of water quality of the Double Mountain Fork, which essentially is the Upper Brazos River. This is the Lubbock right here, where I am right now, so this is the Double Mountain Fork here, Alan Henry and other places.

Anyway, we've been collecting data from several sites for a number of years. This plot here shows is that after ordination or PCA, the water quality data sort out, you can see here that are labeled according to whether the observations came from non-golden alga sites or golden alga sites, and you can see that they completely separate according to salinity.

This is the salinity vector here. These are the variable vectors. The X or the PC1 vectors capture salinity-associated variables, and the Y, or PC2 axis, this reflects seasonality. This is data that we collected year-round, this is the vertical distribution. It's influenced by season.

The one thing that I wanted to point out here more than anything is that there's one site, it's a stream site, it's not a lake, where you can occasionally see extreme high levels of salinity, but it is a non-golden alga site. Keep this in mind. This finding will come back up later.

Another recently completed study, short-term but year-round, of the Upper Colorado River. You can see this is the area where the lakes were located in Texas. This is the Colorado River here. Again, you can see that the lakes, whether they are golden alga or non-golden alga, they're separated primarily, but not exclusively, by variables, specific conductance, hardness, both of chloride, but variables from other that are related to salinity.

Now, this is actually data from the project I'm presenting today, funded by the center. This is basinwide. We're looking at a total of 12 reservoirs in the Brazos and Colorado, also including golden alga and non-golden alga. It is winter data. Remember I said golden alga blooms in winter, so we wanted to look at the specific conditions in winter that define the golden alga habitat.

We've removed season effects from this data set, or from this plot. You can see, again, primarily, data, this is non-golden alga sites and these are golden alga sites, in terms of habitat. Again, they're primarily separated by specific conductance, sulfates, chloride. Again, all proxies are related to salinity.

But you can see here they also tended to be associated with slightly, and I must emphasize that word, slightly higher pH values, slightly higher dissolved oxygen values, slightly lower temperature values in winter. That was so far about habitat. Now, how about, what are variables that are associated with the actual, essentially, real-time, so to speak, bloom events? Is there Is there anything that stands out?

For this purpose we used classification/regression tree analysis where we use water quality variables as the predictor variables, and either a toxic bloom or presence of golden alga cells as the dependent variable. And to show you golden-corrected data this is the short-term data year round, and almost, I guess, no surprise, in the upper Colorado River, the main predictor for incidence of blooms either B here, the Graph B is here where the association is with lethal ichthyotoxicity. Levels are lethal.

And A is more related to golden alga cells, numbers of cells. But either way we got a very essentially identical pattern where specific conductance is a primary predictor variable, and you can see that salinities above 3,700 or so, which is roughly, estimated is about 2 psu's resulted in much higher cell densities than salinities lower than that level.

But if its salinity was higher -- remember this is year-round data. It includes summer, winter, spring, and so forth – temperature, was also a predictor variable. Essentially levels that were below about 21, 22 resulted in higher cell numbers than temperature levels that were above. And, again, the same pattern held up when we were using ichthyotoxicity as the response variable.

The reason temperature is here is because, as I said, it's year-round data. Essentially this is telling us that temperature when they start becoming warmer this is probably in the upper Colorado, these are long lasting blooms in the upper Colorado River. That is kind of unique for this site. But when they are starting to get very warm, higher then cell levels and ichthyotoxicity is lower.

Now this is data using a longer term data set, basin-wide winter data alone so we've removed the season influence here, so this resulted in much simpler trees, and, again, either chloride or a specific conductance in the Colorado where the top split in variable both obviously, as I said earlier, they are both related to salinity. A chloride level of about 2,028 more or less is according to a specific conductance is about 1,184 which more or less -- and this is all approximations -- a psu of about .6. In this case, specific conductance of 2,000 microSiemens per centimeter is about one psu.

So in both basins salinity is the best predictor of bloom appearance after removing the seasonal influences, and these particular results here are similar to the short-term data, results over the short-term data, that I showed you in the previous slide.

So this is an ongoing study, and the reason I'm showing it in the Pecos River...it's not related to the center-funded project that I'm reporting on today, but it's interesting in that we have found that -- this is presence or absence of golden alga, not toxicity.

We have found that that there seems to be an upper limit of salinity where above that level you have, upward of about 18,000, you have very little incidence of golden alga occurrence, whereas as at a lower level you have hardness having some influence here, but what I wanted to point out is that when you have even lower levels of specific conductance here, that's when you have the higher levels of golden alga appearance.

So the take-home message from our Pecos River ongoing study is that there seems to be an upper limit, which is somewhat odd, because this alga is supposed to be a coastal or estuarine species, but there seems to be, at least in inland Texas, this working to some sites in Mexico as well, but there seems to be an upper limit of salinity for golden alga to be present.

And it seems that the salinity as it gets lower from about 11 psu to about 5 psu that's where you have most of the appearances of golden alga. Now I should point out, base salinity is still much higher than the salinities in the Brazos or Colorado River. Again, remember we're talking here about the Pecos River. This study is still ongoing, so conclusions are preliminary, but I thought this was of interest to the topic of this presentation so that's why I'm showing it to you. There seems to be an upper limit of salinity for golden alga to occur.

So to summarize so far we have that golden alga habitat in Texas surface waters. It's primarily characterized by moderate salinity if it's correctly defined as moderate. Salinities of .6 to 11 psu approximately, represented primarily by specific conducts fluorides and sulfates. And in reservoirs -- this may not apply for streams -- but in reservoirs also slightly higher winter pH and dissolved oxygen, and slightly lower winter temperature.

Now, again, we're defining habitat here. We do believe, obviously, and we're not the only ones, that salinity is important for golden alga. We do not know if there are differences in golden alga and non-golden alga lakes in terms of pH, in the dissolved oxygen, or temperature having a biological relevance. Here we're just reporting results of our classification or definition of habitat where golden alga occurs.

The results of the classifications tree analysis then also suggest the same thing essentially that golden alga events, bloom events, are associated with more moderate salinity. So essentially habitat and conditions for blooms are one and the same, at least given the variables that we have measured in the study.

Now the apparent upper limit on salinity would be a novel finding, but, again, this is our conclusion. This conclusion is based primarily on observations of a still ongoing study of the Pecos River, and we're not done there yet, but it kind of matches somewhat the results we found for the upper Brazos River as well where we had a high salinity site that has never had golden alga blooms.

So trend, trend analysis -- have changes occurred? And, again, we chose a 20-year period bracketing the alga blooms in 2001. The variables we used for this analysis are essentially the same as already mentioned. We use stream analysis, Kendall tau if it's seasonally grouped data, or

Seasonal Kendall Tau when we're using also monthly averages for some of the analysis and the data is from Burley et al. primarily.

So this table shows the results for the Brazos River watershed, and I'm highlighting in yellow the golden alga, the lakes that have had golden alga events in the past, and the ones that are not highlighted, in this case for the Brazos, are reference lakes, and these are the various variables. And to make it easier for you, I'll just tell you there are no trends. None of those variables during that 20-year period underwent significant trends. That's for the Brazos.

For the Colorado, again, these are the golden alga lakes that we had in the Colorado River. The rest are reference lakes. We did find some trends, but those were for two of the reference lakes, not the golden alga lakes. For decreasing salinity, you can see chloride, specific conductance in this case, and sulfate in these two lakes, all of those three variables significantly decrease during that period suggesting a slight decrease in salinity, but nothing else.

Now we did also do long-term, obviously, using the full period of record represented in Burley et al. I'm showing here a relevant summary from those analyses. The only consistent trend that we observed across reservoirs for both golden alga and non-golden alga, was an increase in total phosphorus or eutrophication.

There was only one exception, and that was E.V. Spence. This over a longer period of time than we used for the other analysis, shorter term, our midterm analysis did show an increase in total phosphorus. This is consistent, obviously, with natural/cultural eutrophication as reservoirs age, and one thought we have is that the reason it expands, is the natural trend because it's been the target of restoration efforts to reduce total dissolved solids, and this could potentially have reduced the nutrient inputs.

But I also wanted to point out one thing. I said this earlier, but about 90 percent of Texas reservoirs are already classified as eutrophic or hypereutrophic. These trends that we measured here including some cases from the beginning when the reservoirs were first filled up so that's why we're seeing trends here, but today most of the reservoirs in Texas are already eutrophic or hypereutrophic.

So just as an overall summary, habitat for golden alga in Brazos, Colorado, and Pecos Rivers is characterized by waters of moderate range of salinities with an apparent -- again, this pending the completion of our study -- but an apparent upper limit and obviously also a lower limit, that's well known for golden alga. They need a certain level of salinity to grow. But what may be novel from our studies here is that there seems to be, at least in inland waters, potentially a higher limit to their growth.

And, again this is habitat bloom events themselves. There's almost no difference, as I said earlier, at least in Brazos and Colorado is associated. The only variable we could see associated with bloom events was salinity when we use only winter data. If we use year-round data than we also see temperature having an influence.

In terms of the results of trend analysis we found no significant monotonic trends in winter water quality in reservoirs from these two river basins, Brazos and Colorado, including salinity, during the 20-year period bracketing the 2001 onset of toxic blooms. The long-term analysis that we've also done confirmed the lack of consistent trends across reservoirs except for total phosphorous.

So, conclusions: we believe that our data shows that habitat that is favorable to GA, golden alga in Texas reservoirs, defined primarily as waters of moderate salinity, predates the onset of toxic blooms by more than 10 years, and in some cases several decades.

We believe, based on this data, we can propose two patterns or mechanisms of how golden alga may colonize and lead to bloom formation in reservoirs. One is, the traditional novel introduction into pre-existing favorable habitat, leading then within a relatively short period of time to toxic bloom occurrence. Now this is consistent with what has already been proposed, for golden alga based on genetic or the lack of strong genetic divergence among Texas golden alga strains, and between Texas golden alga strains and Scottish strains.

But we also believe that there could be...I'm sorry something's happening here with my computer...there's another potential scenario, but before I explain that I'd like to provide a little more background information. And that is, it is known that several non-golden alga reservoirs of the Colorado, that includes the ones mentioned here which I've introduced, and at least Waco and the Brazos River, contain golden alga populations that have never formed toxic blooms, despite the fact that golden alga is present.

So it is possible to envision that as ambient conditions change due to either land use or climate change or other, golden alga populations in these reservoirs could develop toxic blooms. However, another important piece of information is, that it is being shown by some other colleagues here in Texas, Roelke et al., that increased salinity by itself in the case of Waco lake water, is unable to overcome the inability of water from this lake to support golden alga bloom. So, salinity itself did not do the trick.

So for a change in these various reservoirs that contain golden alga blooms, normally they are lower salinity than golden alga reservoirs, the change may include but not necessarily be limited to, increased salinity, there may be other variables, other constituents of water that may also change.

In other words salinity is necessary but not sufficient. So given that the other scenario may be what I've just said that golden alga could be introduced into a habitat that allowed its establishment or colonization of the area or the habitat, but not for toxic blooms then following a gradual change through time, including as I said but not limited to increased salinity, then blooms may develop. And we see that these two scenarios have not been mutually exclusive.

The lack of consistent trends across reservoirs, especially salinity, suggest that any past impact of climate change on reservoir water quality -- and I should limit this to the Brazos and Colorado because thats where most of the studies have been done -- may have been obscured by either reservoir water management options, and remember that reservoirs are highly managed water bodies, or land use changes within reservoirs that may have a more prominent impact than climate change, or both.

So if climate change, let's assume, has influenced somehow the expansion of golden blooms in Texas reservoirs generally, it does not appear to have been due to changes in salinity. So going forward, as I said at the beginning, were not suggesting at all that climate change may not have any impact, going forward, on the future distribution of golden alga.

What we have done here so far, and we have limited our conclusions to say that, historically or what has happened in the last 10 to 13 years since Golden Alga appeared in most of the reservoirs here in Texas, it doesn't seem that trends in water quality have had at least, and I need to qualify this too at least for the variables that we have measured, doesn't seem to have played a major role in the expansion of or the range expansion of bloom golden alga that we have seen in the last 10 to 15 years.

So with that I was told to keep it sweet and short. So that's the main message I wanted to convey, but the other very important thing is to acknowledge the contributors to this study. Those include my colleagues from the Texas Water Science Center, William Asquith, Tom Burly, Donald Brooks; Texas Tech, some of my students and postdocs have been involved, other colleagues from the university Chris Taylor, Katherine Hayhoe and other people that work in Katherine's lab.

We have had a lot of contributions, idea sharing and so forth, with a number of individuals from Texas Parks and Wildlife. And also we've been fortunate to be able to work with Shawn Denny from the New Mexico Department of Game and Fish, who has helped us collect samples and also provided historical data on golden alga and water quality for the state of New Mexico. So with that I am done and if anybody has any questions or comments, I'll be happy to try and respond.

Ashley: Yes, Barry Rosen.

Barry: I have a question about have you looked at turbidity in these lakes? Don't forget these are organisms that need sunlight to grow. And also residence time, they'll flush out fairly easily if the water coming into the reservoir is moving quickly, they won't get a chance to build up.

Reynaldo: The answer is, the first question about turbidity, the answer is yes, but only for the short term data set. That parameter -- I'm trying to remember -- I don't think the data density for turbidity is, or the variable is in a historical data set put together by Burley et al. I don't believe that was a major variable, or not a variable that you could associate with any number of significant reservoirs. Or if it was there the data density was so poor that we couldn't use it. We have in the short term studies, that's our own studies, our own data, water quality measurements, we always measured turbidity. It has not come out that -- now this is for short term data set not historical -- not come out as an important factor, at least not to define golden alga habitat or to influence it's bloom events. I forget what the other question was. Oh, flushing, flow? Yes

Just broadly speaking, flows have been shown to be, or flushing events, if there is a big flow into a reservoir in the Brazos, I'm talking about more than the central portion of the Brazos, Possum Kingdom, Banbury, Whitney, the work done by others, has shown that flows or inflows after a rain event or flushing can influence the, for example, can cut short a bloom event.

That could happen via a number of mechanisms, the most central one is a dilution event. The reservoirs in the Upper Colorado, there's a whole lot less rain in that part of the state. And other than when there's a rain event to bring the levels of the reservoir up, there's very little flushing going on, nobody's losing water, so to speak, from one reservoir to the next because there's no water, or little water. I don't know if that answered your question.

Barry: Yes it’s fine thank you.

Reynaldo: OK.

Ashley Fortune: Then we have a couple of questions from Brendlyn Faison? You can go ahead and ask your questions over the phone by pressing star six.

Brendlyn: I have two questions. Can you hear me now?

Reynaldo: Yes.

Brendlyn: I have two questions. First, do you know whether this microorganism is able to use nitrogen from the atmosphere?

Reynaldo: Good question, I don't know. I know that it has been shown that phosphorus can come, or one of the sources of phosphorus in a lake or surface waters could be atmospheric, from atmospheric deposition, I would imagine that the same applies to nitrogen. But I'm not a geochemist, I couldn't tell you for sure but I suspect the answer is maybe yes.

Barry: It can't fix atmospheric nitrogen, however. It can take nitrates that might fall out of the atmosphere, it can't fix like a blue-green can.

Brendlyn: Thank you, and that leads to the second question that I posted. How is the land near the water bodies you sampled used? Is it agricultural, ranching, something else?

Reynaldo: It depends. Around some of the upper Brazos, the first slide I showed you, there is both. There's a city, Lubbock, that is associated with the upper Brazos, at least one of the branches of the double mountain fork, and another fork that we also included in that study which is more rural ranching that goes on there. Lower in the Brazos, as you get near Waco and that area there is a lot of human development there but there's also agriculture. So both the Brazos and the Colorado pass through a number of different types of landscape including rural and urban.

Brendlyn: In my limited experience, when microorganisms proliferate and then stop growing and start releasing strange compounds, it's because there starved for nitrogen. That is the biggest problem that animals and plants and fungi face on this planet. And I'm wondering where the nitrogen may have come from and/or what, when and why it stopped. Any thoughts?

Reynaldo: Yes well, a couple of different ways of answering the question, the historical database, Burley et al., that we use has very little unfortunately, it's just a fact there not a whole of data on nitrates and nitrites and so forth, so the only proxy for eutrophication was to use, there was total phosphorus. There's not a whole lot of nitrogen or nitrogen compounds information. In the shorter term studies, at least some but not all of them that we have done, we have measured nutrients, different fractions of nitrogen, phosphorus. And we are still digesting our own data, now generally speaking it is shown that deviations either high or low ratios of nitrogen, phosphorus may make the cells angry and start producing toxins.

That work has been done by others, so that is known for golden alga as well. But I imagine all the sources of nitrogen, if I were to guess, we have not done that study but if I were to guess from what

I know of the landscape are rural there is agriculture going on in much of the areas, there's also urban waste water effluent. So that's where I would guess that most of the nitrates, organic as well as inorganic sources of nitrogen, are coming from. Fertilizers and waste water.

Brendlyn: Thank you.

Ashley: Aright thank you. We have a text chat question from Rebecca Baldwin, and she says "is there a prediction of what the lower limit is for winter temperature for golden alga to survive?"

Reynaldo: Not that I know. I can share some of my random knowledge. We have, and this is not medians or averages, but I do know that we once were actually measuring golden alga cells out in the field, in Lubbock Lakes, when the temperature in one of the lakes that was at the time very highly toxic, we didn't measure cells, but it was very highly toxic in biological terms. The temperature was around -- off the top of my head, take this with a grain of salt -- but I think it was somewhere around six or seven degrees Celsius. So that's on the low side. Most blooms, based on what I've read in the literature, cannot occur somewhere around 10 or 20 degrees Celsius. We've shown a limit in the Upper Colorado of about 21, 22. But 10 to 20 or so, but we have seen individual blooms happening at much lower temperature. Now I don't know enough to be able to say what the low is, but there's organisms that survive freezing, but I don't know for golden alga, sorry.

Ashley: Rebecca says thanks. We have another question in the chat box and it says "have you looked at zoo-plankton composition for potential predators?". And this is from Barbara Dorf.

Reynaldo: That's a very easy answer. No we haven't. Now others have, colleagues from Texas A&M and Baylor have done that work. I can't off the top of my head remember the details of that work.

Ashley: And Reynaldo is there a specific...

Reynaldo: I know there's work also done at the University of Oklahoma, Lake Texoma. But that's not our studies I don't remember the details to be honest with you. We have not done those studies. We are interested primarily in aspects of abiotic habitat, but that's not to say we don't realize biotic interactions are also very important.

Ashley: OK. Thank you. We have another question from Hyeok Choi, that says "are you interested in monitoring biological toxins in water generated from these golden alga?"

Reynaldo: Am I what? I'm sorry?

Ashley: It says "are you interested in monitoring biological toxins in water generated from those golden alga?"

Reynaldo: Of course, I think as soon as the toxin or toxins are definitely identified, we'll be able to do that. At the moment there's a number of ideas as to what those toxins might be. Yes, there may be a resolution to that, based on some recent publications, but until recently at least, it's been a major problem to measure toxins when we don't know what to measure. Because there's been a debate going on as to, or an on-going attempt to positively identify what the actual toxic compounds are, that are being produced by golden alga.

Ashley: Alright, thank you. And that's last question I'm seeing, are there any more questions out there? [pause] Aright Reynaldo, do you have any closing remarks?

Reynaldo: No, just maybe say thank you again to everybody for taking your time to listen to this presentation, and I said if anybody offline later has any comments or suggestions, even to tell me if something I said was wrong, I welcome that. As I said we are still digesting this information, it has not been fully peer reviewed yet. So again thank you everybody. Thank you to the Center for inviting me to give this seminar, and I hope it was worth your time.

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