The Lionfish Invasion!

Thinking Like a Scientist

So you want to chase invasive species?

Paula Whitfield has been chasing lionfish since they were first discovered in U.S. waters in 2000. Paula is a fisheries biologist at NOAA's Center for Coastal Fisheries and Habitat Research in Beaufort, North Carolina. We spoke to Paula about her work with the invasive lionfish. Here is what she had to say:

Profile of a Lionfish Chaser *- Click here to learn more about the early influences and career of Paula Whitfield.*

Interviewer:
When did you first become aware of the problem of lionfish in the Atlantic Ocean?

Paula Whitfield:
I first became aware that lionfish were in the Atlantic when one was sighted by a group of recreational divers in August 2000. They were exploring a shipwreck off the coast of North Carolina when they saw it. Although the divers did not bring back any solid evidence (like photos, video, or an actual

Click the filmstrip to view underwater footage of the beautiful but venomous lionfish, and the scientists who study them!

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specimen), there was little doubt in my mind that they had indeed seen a lionfish. Lionfish are very distinctive in their coloration and posture, and nothing native to the Atlantic could be mistaken for a lionfish.

As a fisheries biologist, I immediately knew that lionfish in the Atlantic were going to be a big story. First, lionfish are exotic and beautiful. Second, the possibility of divers or fishermen getting stung by lionfish gave the whole story a sensational aspect. In fact, numerous newspapers, as well as TV and radio stations, have interviewed me in the past few years. I knew that once word got out, a lot of attention would be paid to the presence of lionfish off the East Coast—both in the popular press and among biologists.

Soon after the first report, other reports from recreational divers and commercial diving companies began coming in—it was clear that the first sighting was no fluke! I began keeping a log of all the sightings, including all the information I could get about it—location, how many, size, etc. So far, virtually all lionfish sightings have been in waters of 100 ft or deeper, and in coral reef or other hard-bottom habitats, or near shipwrecks.

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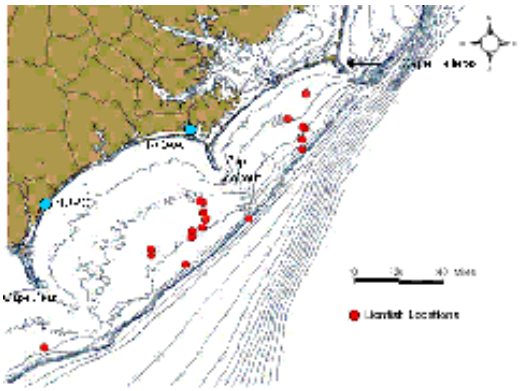
Interviewer:
In your research with lionfish, what was the first question you wanted to answer?



A map of Paula Whitfield's study area in the Three Capes region off the coast of North Carolina. The red dots represent known lionfish populations. ***Click on image*** for larger view and further deails.

Paula Whitfield:
The first question that came to mind was, "*What will be the ecological impact of lionfish on ecosystems in the Atlantic?*" In other words, *how will the presence of lionfish affect other organisms living in the Atlantic?* I immediately realized that this would be a difficult question to answer. After doing a bit of research and reading, I learned that very little was known about the hard-bottom habitats and other areas in the Atlantic where lionfish were reported. As a result, there is nothing to compare the present situation to. It would have been nice to be able to do a "before and after" comparison, but it is not possible.

Interviewer:
How did you go about deciding how you would answer this question?

Paula Whitfield:
First, we assumed that we should not expect lionfish in the Atlantic to behave the same as those in their native habitats in the Pacific and Indian Oceans. The Atlantic Ocean off the coast of the southeastern USA is vastly different from the tropical Pacific. The Atlantic's community of organisms is very different from the lionfish's native tropical waters, which means that the lionfish may occupy a very different niche in the Atlantic than it does in the Pacific. For example, in their native habitats, lionfish are considered one of the top predators, with no known predators of their own. To say it another way, they are often the top dog in the food chain! It was entirely unclear whether this would be the case in the Atlantic.

Also, it was entirely possible that lionfish would **compete** for food and habitat with a different set of organisms in the Atlantic than in the Pacific. So, we needed to answer some basic questions about the natural history of lionfish in the Atlantic before we could even begin to understand their ecological impact there.

One assumption we made from the beginning of our research was that the impact of lionfish in the Atlantic was most likely related to their abundance, which is often the case with invasive species. So, the first question we asked was, *"How many lionfish are in the Atlantic?"* Our next question naturally followed. *"Are lionfish reproducing in the Atlantic?"* Ultimately, we hope that the answers to these two questions will begin to shed light on the impact of lionfish in the Atlantic.

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Interviewer:
What are the some of the field methods you use to estimate the abundance of lionfish or whether or not they are present?

Paula Whitfield:
You might think that determining the number of lionfish in the Atlantic would be a fairly easy task,

except that lionfish are living in waters about 100-260 ft deep and perhaps even deeper! Many physical and physiological constraints come into play when people work in water this deep. In scuba diving, there are depth and time limits for the divers. In fact, recreational scuba diving has a maximum limit of 130 ft. Much of the time, we were working slightly beyond that depth. So, automatically, answering our two simple questions about the natural history of lionfish became very difficult. We were limited to two 30-minute dives each day. This is not much time to do our work. So we had to be very organized and know exactly what we were going to do when we got there.

NOAA scientists Christine Addison (foreground) and Paula Whitfield (in back holding the underwater video camera) decompress after one of their lionfish research dives. . ***Click on image*** for larger view and further deails.

At each site we visited, two teams of divers were deployed. One team was called the “lionfish observer team” and the other was the “hunter/gatherer team.” The observer team was responsible for conducting surveys to estimate the number of lionfish (i.e., their abundance) at the site. The hunter/gatherer team went in afterward to collect as many lionfish specimens as they could and bring them to the surface. Also, at the water’s surface, a chase boat with a safety diver followed the divers to help them if anything were to go wrong on the ocean floor below.

To determine the abundance of lionfish at each site, we did visual transect counts using teams of divers. We established transects, or survey lines, on the ocean bottom. As the divers swam, they measured a predetermined distance using a tape measure. We recorded every lionfish we saw along each transect. We also recorded the numbers of grouper and snapper, two predatory fish species that potentially compete with lionfish for food and habitat. We did this because we

wanted to know how many grouper and snapper there were in comparison to lionfish at that location. We used waterproof paper and pencils to record data, and hand signals to communicate. Later, we will use these counts to estimate lionfish abundance in the different habitats and locations that we surveyed.

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Interviewer:
What are some of the other questions you are asking about lionfish in the Atlantic? How did you go about answering these questions?

Paula Whitfield:
Another question we asked was, *"Does temperature limit the distribution of lionfish in the Atlantic?"* At several locations where we counted lionfish, we also installed sensors to record the water temperature. These sensors will record the temperature every 30 minutes for the next year. We will retrieve them when we return in the summer of 2005. From the temperature data, we will test the prediction that cold-water temperatures at the ocean bottom limit the distribution of the tropical lionfish in the Atlantic.

We also asked: *Is the diet of lionfish in the Atlantic different from that of lionfish in the native Pacific range? What kind of prey organisms are they eating in the Atlantic, and how many? What is the size (or age) of the fish in their diet?* We dissected some of the lionfish specimens that we collected and examined their stomach contents to determine what they were eating (this is called a diet analysis). In general, we found that lionfish are voracious predators. The stomachs of most of the specimens we collected were full of small fish!

The R/V *Cape Fear*, an oceanographic research vessel, was home to Paula Whitfield and her research crew for several one-week research expeditions to study the lionfish in August 2004. ***Click on image*** for larger view and further details.

We also examined each specimen's reproductive status and sex. We have questions like: *What is their reproductive*

potential in the Atlantic? When do they spawn? Where are they spawning? This kind of "life history" information isn't well known for the lionfish even in its native habitat!

We also brought back some live lionfish to our laboratory so we could conduct growth and breeding experiments. By doing so, we hoped to learn how fast the populations in the Atlantic might grow, as well as learn more about lionfish reproduction: when breeding occurs, how often they breed, how many eggs are produced, how many eggs ultimately develop into fingerlings (i.e., baby fish), etc.

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Interviewer:
Is it possible to predict the future abundance and distribution of lionfish in the Atlantic?

Paula Whitfield:
I think it is difficult to estimate future abundance, but we have some ideas. Predicting lionfish distribution in the future is easier, so let me start with that. We have predicted that the minimum temperatures at the ocean bottom in the winter will limit lionfish distribution in the Atlantic. Tropical fish like the lionfish simply cannot tolerate water temperatures below a certain minimum. We hope to test this prediction with the temperature data we are collecting with the sensors we set up this past summer.

Except for low winter temperatures, overall conditions in the Atlantic Ocean are excellent for lionfish. For that reason, we think that where lionfish are found in the Atlantic, they will be just as abundant there as they are in their native habitats in the Pacific. At least that is our assumption. In other words, in the warmer waters of the Atlantic, where lionfish are able to live, we predict that they will be just as abundant as in the Pacific. So, one way to forecast their eventual abundance in the Atlantic is to determine their abundance in their native habitat and extrapolate those numbers to the Atlantic. Eventually, the Atlantic should have a similar number of lionfish per unit area as the Pacific. Until we have more accurate information about the reproductive potential and death rates of lionfish in the Atlantic, this is the best we can do.

Interviewer:
What are some of the challenges you face in conducting your research on lionfish?

Paula Whitfield:
As I mentioned before, the biggest challenge is getting to where the lionfish live on the ocean bottom. These depths are

at the edge of our current diving technology. Diving at these depths can be dangerous, and even potentially life-threatening. We have to be very careful not to return to the surface too quickly; otherwise "decompression sickness" can occur. In fact, we must surface as slowly as possible. We use time and depth tables that we strap to our arms, and wrist computers and stopwatches to time ourselves. For the same reason, we must severely limit the amount of time we spend at greater depths.

Diving specialist and research technician Jay Styron *carefully* captures a lionfish off the coast of North Carolina for later study. ***Click on image*** for larger view and further deails.

Instead of diving, we could have used remotely operated vehicles (ROVs) or submersibles, but these have their limitations. For example, it is not feasible to collect lionfish using the arms of ROVs or submersibles. Some have tried, but the technology isn't quite there yet. So we were left with using scuba gear.

The logistics of ocean research like mine are also quite challenging. I have no problems finding people to spend a week or two on a research ship to help me gather data. The hard part is scheduling space on the research ship, which is in very high demand. "Ship time" is also very expensive (thousands of dollars per day), as is the equipment that we use.

Then there's the ever-challenging Atlantic weather, which never seems to cooperate. This past summer, for example, we had to cut our expedition short by several days, courtesy of Hurricanes Alex and Charlie!

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Interviewer: What is the present (summer 2004) status of lionfish populations in U.S. waters? Were there any changes in the past year?

Paula Whitfield:
Unfortunately, lionfish sightings have increased over the past year. Reports have come in from Florida all the way up the coast to North Carolina. Of course, these reports are helpful to

us, but they represent what scientists call "anecdotal" information. In other words, they are observational and there is nothing systematic or consistent about how the observations of lionfish were made. Neither are they quantitative. From a report of a sighting, we know someone saw a lionfish in a particular location, but that's about it.

However, these reports from everyday citizens have helped us locate areas that lionfish might use for overwintering (i.e., places warm enough for lionfish to survive there through the winter). We targeted these locations for further study - in fact, many of the locations we visited this past summer were mentioned in citizens' reports. It is clear that lionfish are widespread along the North Carolina coast between Cape Fear and Cape Lookout. If fact, by the end of our studies in the summer of 2004, we were surprised if we did *not* see lionfish when we checked out a new location. Prior to our expedition, I never suspected that this would be the case.

The abundance of lionfish along the South Carolina, Georgia and Florida coasts is less clear, simply because no one has systematically looked, at least to my knowledge. Again, we know lionfish are there from citizen reports, but we don't know how many, whether they are reproducing, etc.

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Interviewer:
Do you still think the aquarium trade is the vector for the introduction of lionfish into the Atlantic Ocean? What is the evidence to support this hypothesis? Is there any evidence to refute this hypothesis?

Paula Whitfield:
Yes, in my opinion, the aquarium trade is the vector for the introduction of lionfish into the Atlantic. There is no absolute proof, but all of the evidence points to the aquarium trade as the vector. There is no evidence that lionfish entered the Atlantic by swimming over from the Pacific or that they were released in ballast water. We know for sure that a seaside aquarium in Key Biscayne Bay, Florida, broke during Hurricane Andrew in 1992, releasing six lionfish. In addition, thousands of lionfish are imported into the United States every year! It is very likely that their owners released some proportion of these lionfish either on purpose or by accident. There are many other examples of the introduction (and spread) of aquarium fish by their owners into Florida waters - so why not lionfish?

Interviewer:
Assuming lionfish are here to stay, what steps do you recommend to stop their further spread? Are regulations in place in the United States to control marine invasive species

like lionfish? If so, what are they?

Paula Whitfield:
I'm afraid that lionfish are here to stay. I don't believe there is any way to stop their spread throughout the warmer Atlantic waters. The broad geographic area that they have already colonized - from Florida all the way up the Eastern Seaboard to North Carolina - and the depths at which we are finding them, from 85 to 300 ft - makes it very difficult to remove them. Short of establishing a lionfish fishery and asking people to fish for them, I don't think there is a solution. But even this would be prohibitive because the lionfish's spines make it difficult to collect them without stinging incidents.

Another complicating factor is that there are people who actually want the lionfish in the Atlantic! Recreational divers want to see interesting and exotic sea creatures, and lionfish are certainly exotic. The charter companies that take people out to dive don't want to see the lionfish killed or removed because they are good for business. I would hope that if they were educated on the devastating effects of invasive species, they might think again...but probably not.

Also, lionfish are big business in the aquarium trade and I don't see the importation of lionfish slowing down or stopping. There are no federal or state regulations that prohibit the importation of lionfish, period. However, some states, like Florida, do have regulations that prohibit certain organisms from being released into native waters. Obviously, these regulations are not enforced very well.

In contrast to lionfish, it was fairly easy to halt the importation of snakeheads to the USA. They are rather ugly creatures and people can see and understand the devastating effects they have in ponds and other waterways in their own neighborhoods. Therefore, lawmakers were able to quickly stop snakeheads from being imported. Lionfish are different, though. They are attractive animals that people want to look at *and* they are found in rather remote locations off the coast, so they are "out of sight, out of mind" to the public. Snakeheads have a very low likeability factor, whereas lionfish are very charismatic. I don't anticipate that the importation of lionfish will slow down any time soon, so new releases are likely to continue.

Lastly, because lionfish eggs and larvae are "free-floating," water currents rapidly spread them to new areas. This is now the main way lionfish are spreading up and down the East Coast. There is just no way to stop this from happening.

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Some Lionfish Reading Material:

The following is a list of Paula Whitfield's publications that relate to her research on lionfish:

Hare, Jonathan A. and Paula E. Whitfield. 2003. An Integrated Assessment of the Introduction of the Lionfish (*Pterois volitans/miles complex*) to the Western Atlantic Ocean. NOAA NOS Technical Memorandum CCFHR 1 (available online at: http://shrimp.ccfhrb.noaa.gov/lionfish/lionfish_ia.pdf).

Whitfield, P.E., T. Gardner, S.P. Vives, M.R. Gilligan, W.R. Courtenay, Jr., G.C. Ray, and J.A. Hare. 2002. Biological invasion of the Indo-Pacific lionfish *Pterois volitans* along the Atlantic Coast of North America. Marine Ecology Progress Series 235: 289-297 (for copies contact paula.whitfield@noaa.gov or available online at: http://www.int-res.com/abstracts/meps/v235/p289-297.html).

Whitfield, P.E., J. Hare, and D. Kesling. 2004. Dive operations plan for the assessment of the status and risk posed by the invasive lionfish in North Carolina hard-bottom communities. Accessed on September 20, 2004 at: http://www.uncwil.edu/nurc/research/cruise_plan_whitfield.pdf.

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Profile of a NOAA Scientist: Paula Whitfield

Paula Whitfield is a fisheries biologist at NOAA's Center for Coastal Fisheries and Habitat Research in Beaufort, North Carolina. We talked to Paula about how she came to be a scientist, her career as a scientist at NOAA, and how she came to study lionfish. Here is what she had to say:

Paula Whitfield looks for lionfish! Paula is a NOAA fisheries biologist studying and tracking the lionfish invasion in the Atlantic. ***Click on image*** for larger view and further details.

Interviewer:
Can you tell us how you became interested in a career in science? Can you trace your interest in science back to a childhood experience, a favorite teacher or a favorite course?

Paula Whitfield:
I first became interested in the ocean when I was a kid. I couldn't get enough of "The Undersea World of Jacque Cousteau." It sounds kind of corny because this Cousteau show influenced so many of today's marine scientists, but it's true! It was my favorite TV show and I never missed it. It was today's equivalent to the Discovery Channel. The underwater footage was something very new when I was a kid—it was cutting-edge and exciting. I loved the water as a kid, too. I loved to swim, and I grew up on an island in Puget Sound in Washington State. So, being in the water and working around the water came naturally to me.

I didn't get interested in pursing a career in marine science until I went to college. I took Biology 101 during my freshman year at George Mason University in Virginia. From the start, I thought studying life was very cool. I also had the opportunity to go on an extended field trip to Costa Rica, a country in Central America that has nature reserves with amazing biodiversity. I saw how science was done by observing scientists in the field collecting data and interacting with each other and with students. It was great! I thought, "This would be a great life." That's when I decided to pursue a career in biology.

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Interviewer:
Tell us about your career at NOAA.What is your job title? What are your duties?

Paula Whitfield:
I started at NOAA even before I graduated with my bachelor's in biology from George Mason University. While in college, I was a part-time biological technician at the National Marine Fisheries Service. Most of my time was spent in the field assisting senior scientists with their research projects. I collected data, but also was in charge of making sure we had the proper supplies and equipment on hand, entering and analyzing data, etc. This got my foot in the door, and when I graduated, NOAA hired me full-time. Over the past 10 years, I have climbed the ladder to a professional biologist position and now have much more responsibility. Being promoted to a scientist position required that I have a master's degree. While I worked as a technician, NOAA allowed me time to go back to school to earn a master's in marine science from the University of North Carolina at Wilmington.

Paula Whitfield collects lionfish data onboard the R/V *Seward Johnson*. (Photo credit: Christine Addison)

Now, I am a fisheries biologist with the Center for Fisheries and Habitat Research, an office of NOAA's National Ocean Service in Beaufort, North Carolina. My job is to design and carry out ecological studies on marine fish and their habitats. So now, instead of working to help others with their research projects, I get to design, plan and carry out my own. This involves a lot of responsibility and requires much more creativity on my part. Now, I am very much in tune with the "big picture"—I can see how my research makes a difference—and that is very satisfying. Sometimes I get to choose my own questions (in the context of the NOAA mission) and sometimes my bosses assign me a question.

On a day-to-day basis, my work might seem fairly mundane. I actually spend most of my time behind a computer entering and analyzing data, planning research projects and logistics, writing grants to obtain money to do my research, and writing scientific papers. For me, the most difficult aspect of my job is writing. Although I find writing grants and research papers difficult, taking a research project from it beginning to its culmination as a publication that other scientists read is quite enjoyable. But, the 25 to 30% of my time that I spend in the field collecting data is why I am a scientist. It's what I enjoy most, and it happens to be the most glamorous and fun part of science, too.

In my work, I mostly use observations to try to answer questions, but sometimes I'm able to do an actual experiment. Doing experiments (that is, manipulating variables) is preferred, but often very difficult, so we count our lucky stars when an experiment is possible. As you might imagine, it is difficult to find ways to do experiments in the vastness of the ocean, so sometimes we are left with doing more observational research until more is understood about the system.

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Interviewer:
What kind of educational background would someone need to get a job like yours?

Paula Whitfield:
To work as a technician requires at least a bachelor's degree in a science related to the work you are being hired to do. A master's degree would make you even more competitive for these types of positions. However, these days, most professional scientists have PhDs in their fields. The exceptions are people like me who climbed up the ladder over many years. I am actually considering returning to graduate school to earn a PhD, which is required for me to get any further promotions. More importantly, a PhD would help make me more competitive for grants I wish to apply for to fund my research projects.

Paula Whitfield waits to dive. Note her deep-water diving gear, and the underwater videocamera she carrys. (Photo credit: Christine Addison)

Interviewer:
Besides your work with lionfish, what other research projects have you been involved in as a NOAA scientist?

Paula Whitfield:
Until I began studying lionfish, most of my research had to do with the disturbance and restoration of seagrass beds. I ask questions about how seagrass beds are damaged or disturbed by human activities or natural processes, and how they recover from damage. On a practical level, I try to find ways that damaged seagrass beds can be repaired so that their function in the ecosystem can be restored. Seagrass beds suffer from numerous types of insults from human activities, including poor water quality, severe damage from motorboat propellers, etc. Actually, I'm still very much involved with the restoration ecology of seagrass beds, but lionfish have been taking up most of my time lately!

Interviewer:
What are some other career options for people with a background like yours?

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Paula Whitfield:
There are many career options for someone with a bachelor's or master's in biology. The opportunities may be more limited for someone with a more specialized degree (especially a bachelor's) in marine science or marine biology. Even though I eventually

went into marine biology, I'm glad that I decided to get the more general biology degree, because it gave me a broader perspective and opened up more avenues for me in the end.

One option for someone with a bachelor's or master's is to start as a technician, like I did—assisting scientists in carrying out their research. All kinds of institutions hire research technicians, including universities, state and local governments, agencies of the federal government like the National Ocean and Atmospheric Administration (NOAA), the National Park Service, the United States Geological Survey (USGS) and the Environmental Protection Agency (EPA). There are also private research institutions like Moss Landing Marine Laboratories (CA), Woods Hole Oceanographic Institution (MA) and Mote Marine Laboratory (FL).

With a master's degree, there is also the option of teaching high school or community college. High school science teachers are in great demand and supply these days. Many school districts are willing to give bonuses and other incentives to attract young people to their schools.

Another option is to work as a professor at a university or college. This usually requires a PhD in your area of expertise, but it depends on the institution. Most professors spend part of their time doing scientific research and the rest teaching classes and supervising the research of graduate students who are working on their own masters and PhDs.

Interviewer:
What advice would you give to a high school student who would like to pursue a career similar to yours, say in biology or marine science?

Paula Whitfield:
I advise students to take as many science and math courses as they can, including biology, chemistry and physics. Not only will it prepare you for what is to come in college, it will help you figure out what you like and don't like, and what you are good at. I have found that my broad background in the sciences has benefited me tremendously in my career—and that started back in high school. What I didn't learn in high school, I had to learn later anyway, and believe me, it will be much harder when you are older.

NOAA scientist Paula Whitfield and NURC diving specialist Jay Styron after a dive during their August 2004 expedition to study lionfish. (Photo credit: Christine Addison)

I wasn't a very good student in high school. I wasn't focused on my schoolwork because I didn't understand how important it would be later on. Also, I was very intimidated by math, or at least I thought I was. I encourage students to get help at the first sign of problems in a math class—get a tutor, a study buddy, or ask the teacher for help. Doing nothing and just trying to struggle though is a big mistake. I know from experience!

For a while, I let my anxiety about math discourage me from pursuing a career in

science. When I got to college, I thought I couldn't do math or anything that required working with numbers. Later, I realized that I would need to overcome my anxiety if I was going to be a scientist. In the end, I overcame my shaky background in math by seeking help from others and keeping my eye on the goal. Don't let a fear or deficiency in math or any other subject discourage you from pursuing a career in science!

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