

Ciguatera Fish Poisoning in the Caribbean

*Patricia A. Tester, Rebecca L. Feldman,
Amy W. Nau, Maria A. Faust,
and R. Wayne Litaker*

ABSTRACT. Ciguatera fish poisoning (CFP) is a significant illness in the Caribbean. Local fishers and natives attempt to avoid CFP by applying traditional knowledge concerning where and when certain fish species are likely to be ciguatoxic, but this knowledge is incomplete. Evidence gathered over the past decades indicates that CFP events are increasing and becoming more unpredictable, thereby posing a greater threat to local inhabitants as well as tourists. The current understanding of CFP distribution is from studies nearly a decade old and generated largely by self-reported CFP incidents to a call-in "hotline" in Miami, Florida. To better guide resource allocation and focus future research, an active survey method was used to uniformly query public health professionals and fisheries officials on the occurrence of CFP. Points of contact from each of these two groups were compiled for the 24 Caribbean island countries and territories and 9 mainland countries bordering the Caribbean. An outcome of this project will be to provide public health agencies, resource managers, and others with information they can use in developing CFP tracking systems and effective public education programs. The long-term goal of associated efforts is to provide accurate and affordable monitoring tools for predicting the onset of CFP events.

PREFACE

Ciguatera fish poisoning (CFP) occurs in tropical regions worldwide and is globally the most common nonbacterial food-borne illness (Tester, 1994; CDC, 2007; Figure 1A). The toxic organisms most commonly associated with CFP are benthic dinoflagellates reported to produce ciguatoxins or maitotoxins (Yasumoto et al., 1977; Durand-Clement, 1987; Satake, 2007). Ciguatoxins bioconcentrate in the food chain and reach their highest levels in top predators such as barracuda or other tropical reef fish. These toxins have been found in more than 400 fish species, including groupers, snappers, jacks, mackerels, triggerfish, and surgeonfish (Bagnis et al., 1970). Consumption of tainted fish can lead to gastrointestinal distress followed by neurological (perioral numbness, tingling, temperature sensory reversal) and cardiovascular (arrhythmia, bradycardia, tachycardia, reduced blood pressure) symptoms and, in rare cases, death. The chronic phase of CFP can persist for weeks, months, or years (Freudenthal, 1990), and repeated exposure to ciguatoxins exacerbates the symptoms.

Patricia A. Tester, Amy W. Nau, and R. Wayne Litaker, National Ocean Service, NOAA, 101 Pivers Island Road, Beaufort, North Carolina 28516, USA. Rebecca L. Feldman, RLF Environmental, 2220 Shefflin Court, Baltimore, Maryland 21209, USA. Maria A. Faust, Department of Botany, National Museum of Natural History, Smithsonian Institution, 4210 Silver Hill Road, Suitland, Maryland 20746, USA. Corresponding author: P. Tester (pat.test@noaa.gov). Manuscript received 9 June 2008; accepted 20 April 2009.

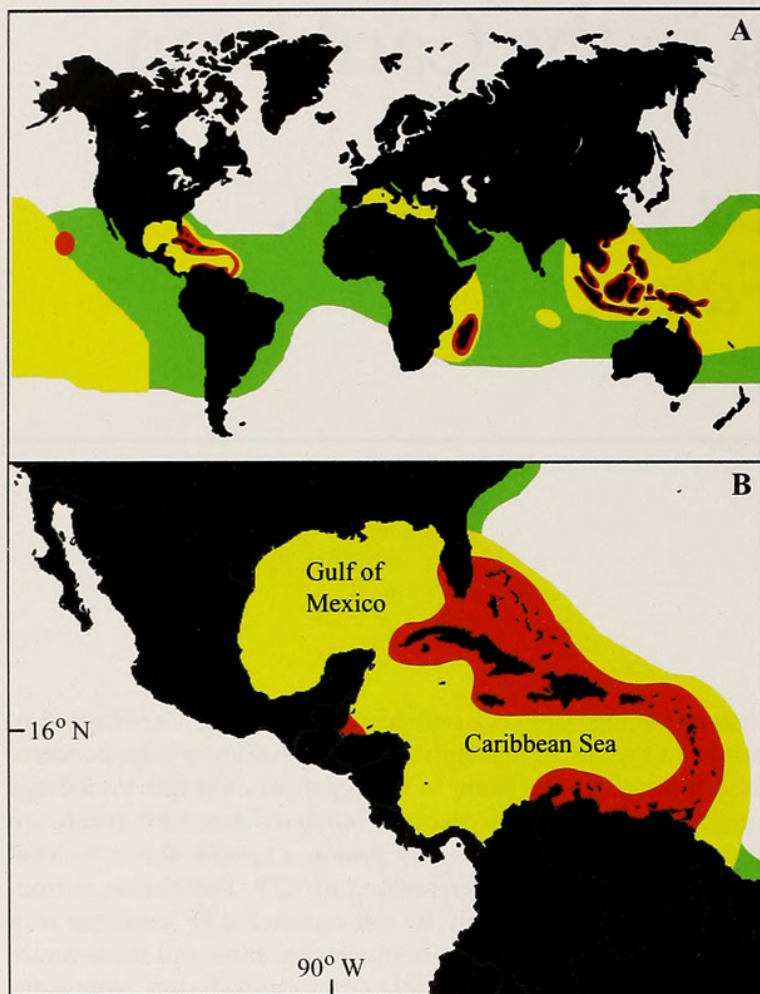


FIGURE 1. A, Potential global distribution of ciguatera fish poisoning (CFP). Red areas indicate regions with a high CFP prevalence, yellow indicates moderate potential exposure, and green indicates regions where the dinoflagellates responsible for the disease are found and represent a potential problem. This map represents a composite of the data obtained from an aquatic biotoxins review by Huss et al. (2003), the CFP distribution map maintained by the journal *Harmful Algae* (WHOI, 2008), and Lewis (2006). B, Potential distribution map of CFP in the Caribbean, as modified from Stinn et al. (2000), combined with some recent incident reports showing the presumed distribution of ciguatera fish poisoning in the Caribbean, mostly collected by passive means; that is, a self-reporting CFP hot-line in Miami (“Cigualine” at 1-888-232-8635). Red areas indicate high frequency of CFP reports; yellow indicates regions where CFP is reported less frequently; green indicates infrequent reports of CFP. These maps may not accurately portray the actual CFP distribution because many cases go unreported.

This paper provides the justification for and an overview of our recent efforts to conduct an active survey of public health officials and fishery management professionals on the incidence of CFP in the Caribbean. We currently lack an accurate picture of CFP in the Caribbean

because of the difficulty in diagnosing CFP and the absence of uniform reporting criteria or any entity responsible for maintaining this information. Previous information gathered on the incidence of CFP in the Caribbean has relied heavily on self-reporting mechanisms, such as calls to a “hot-line” in Miami, Florida. Because people living closer to Miami are more likely to know about the hot-line, the reported incidence rates could reflect a geographic bias (Figure 1B). Another important aspect of this research has been to focus the joint research efforts of the National Oceanic and Atmospheric Administration (NOAA) and Smithsonian Institution scientists who are working on the molecular and morphological characterization of the toxic dinoflagellates responsible for CFP. Both groups have strong interests in understanding how changes in the distribution and abundance of ciguatera-associated dinoflagellate species relate to the occurrence and severity of CFP.

An important outcome of this project will be to provide public health agencies, resource managers, and others with information that they can use in developing CFP tracking systems and effective public education programs. The long-term goal of associated efforts is to provide accurate and affordable monitoring tools for predicting the onset of CFP events.

INTRODUCTION AND BACKGROUND

Ciguatera fish poisoning is a common disease in the Caribbean, caused by the ingestion of a wide variety of fishes that contain toxins accumulated from the marine food web (Lewis and Holmes, 1993) (Figure 1B). The ultimate sources of these toxins (ciguatoxins and maitotoxins) are small benthic microalgae belonging to the dinoflagellate genera *Gambierdiscus*, *Coolia*, *Ostreopsis*, and *Prorocentrum* (Figure 2) (Steidinger and Baden, 1984). Although ciguatera fish poisoning (CFP) is a threat to public health throughout the Caribbean, it is generally managed by local, traditional knowledge of the native fishers. However, their knowledge of the seasonality of occurrence and locations of ciguatoxic reefs may no longer be accurate because of changing environmental conditions (Tester, 1994; Tosteson, 2004). These environmental changes in turn alter the distribution and abundance patterns of the cells that cause CFP. Some evidence exists that ciguatoxicity may vary seasonally, but not all studies support this view (de Fouw et al., 2001). Tosteson (2004) argued that seasonality of CFP and the correlation of dinoflagellate abundance with CFP intoxications evident before 1990

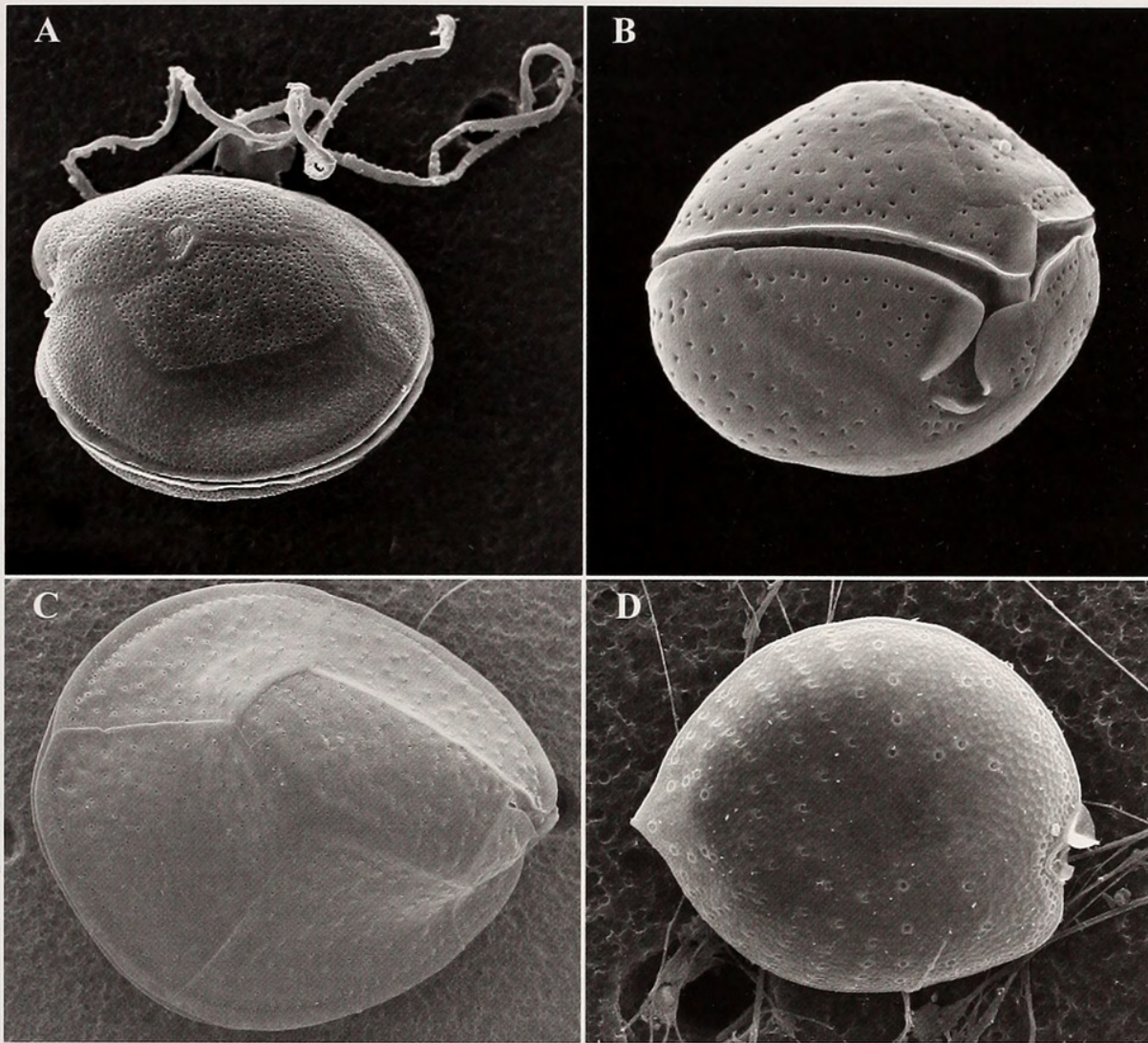


FIGURE 2. Scanning electron micrographs of ciguatera-associated dinoflagellates: A, *Gambierdiscus*; B, *Coolia*; C, *Ostreopsis*; D, *Prorocentrum*.

was not observed in data from 1990–2000. He suggested these changes appeared to be associated with increasing periods of elevated sea-surface temperatures in the Caribbean. Further, the potential for a greater number of people to be exposed to CFP has increased because of more intense exploitation of fisheries and the depersonalization of markets (Olsen et al., 1984). Both trends have been accelerated by tourism and rapidly growing resident populations (CIA, 2008).

The average number of tourist days (excluding ships' passengers) in the Caribbean, 174 million, dwarfs the 38.8 million residents and represents a significant exposure of a naive population to CFP. The most common route of exposure is through consumption of locally harvested fish. Currently, the annual total Caribbean fishery landings exceed 1.6 million metric tons (CRFM, 2008; FAO, 2005,

2008; WRI, 2007), making a strong argument for focused studies on CFP occurrence and on the environmental factors that affect the distribution and abundance of CFP-associated organisms.

As part of its commitment to understand and characterize the diversity, distribution, and abundance of organisms throughout the Caribbean, the Smithsonian Institution has carried out extensive studies on dinoflagellates over the past 20 years (Faust and Gullede, 2002). Because of this pioneering work, much of the background information and expertise needed to characterize the diversity of ciguatera-causing dinoflagellates are already in place. During the past five years, NOAA (National Oceanic and Atmospheric Administration) and Smithsonian scientists have collaborated to isolate, identify, and genetically characterize the ciguatera-causing dinoflagellates

of the Caribbean, as well as to develop species-specific molecular assays for assessing their abundance. As part of this work, four new *Gambierdiscus* species have been discovered and are being described (Tester et al., 2008; Litaker et al., in press).

We are now in a position to begin systematic studies of the incidence of CFP and distribution and abundance of CFP-causing dinoflagellates throughout the Caribbean. To identify areas of concern from both public health and marine resource perspectives, and to focus the effectiveness of environmental sampling, we needed to identify areas where CFP was most common. Consequently, we initiated active surveys of local fishery managers and public health officials. By examining the CFP incidences among the 24 islands and the 9 mainland countries surrounding

the Caribbean, additional insights can be gained into factors that govern the spatial and temporal variations in the prevalence of CFP.

A second objective of this study was to determine how CFP was being monitored and reported throughout the Caribbean, where more than 46% of the tourists are from the United States (United Nations Statistics Division, 2004; CTO, 2008; Figure 3) and the average length of stay is 8.7 days (United Nations Statistics Division, 2004; CTO, 2008; Figure 4). This project represents the first steps toward an assessment of community vulnerability by the identification of susceptible populations and serves as a framework for developing human dimensions research as a cross-cutting priority of ecosystem science supporting marine resource management (Bauer, 2006).

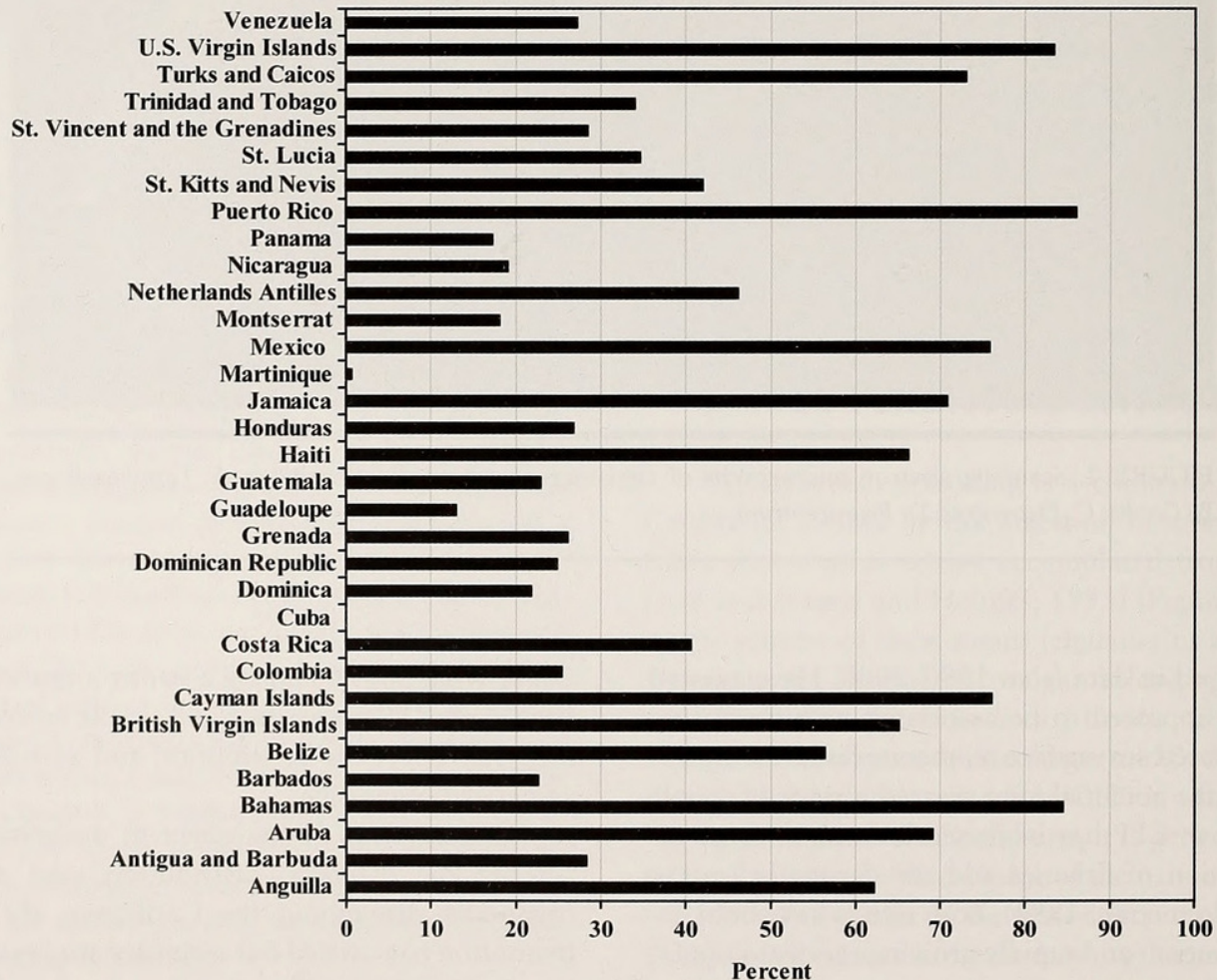


FIGURE 3. Average percentage of American tourists visiting the Caribbean by country (1996–2005). Only data from Cancun and Cozumel were used for Mexico. On average, 46% of tourists who visited all Caribbean countries came from the United States. On average, not counting visits from passengers on cruise ships, tourists spend over 174 million tourist days in this region each year (OAS, 1997; ACS-AEC, 2003; UNSD, 2004; CIA, 2008; CTO, 2008).

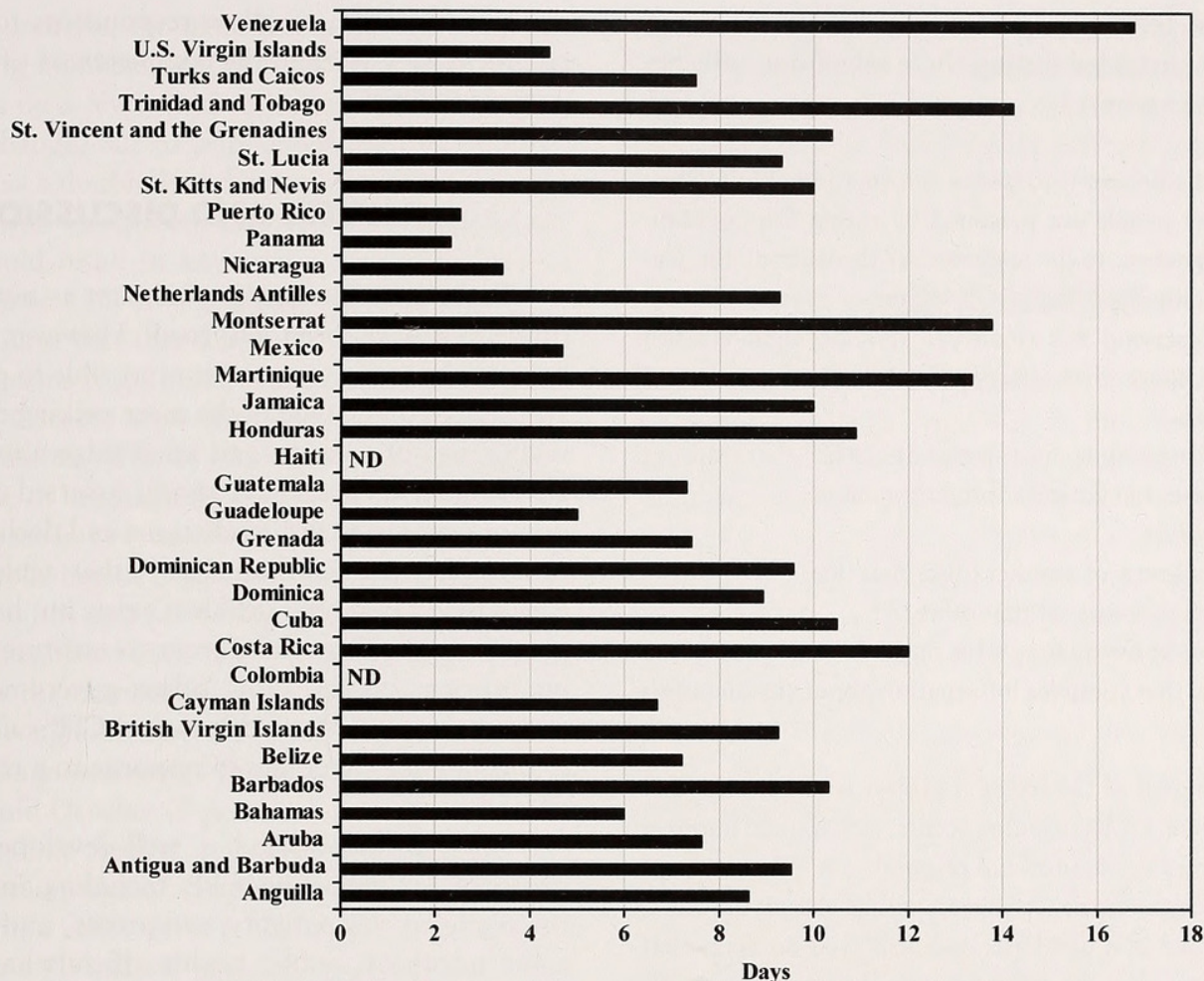


FIGURE 4. Average length of stay for all tourists visiting the Caribbean during 1996–2005, by country. Only data from Cancun and Cozumel were used for Mexico. The average length of stay for all tourists was 8.7 days (OAS, 1997; ACS-AEC, 2003; UNSD, 2004; CIA, 2008; CTO, 2008). ND = no data.

Our ultimate goal is a comprehensive assessment of the environmental, sociocultural, and economic impacts of CFP in the Caribbean and the development of effective detection and monitoring tools to support management decisions and improve inter-island communications among public health officials, marine resource managers, Caribbean residents, and tourists.

METHODS

Based on published cases and self-reporting, it appears that CFP is more prevalent in the eastern Caribbean than the western Caribbean (Stinn et al., 2000; see Figure 1B). To assess whether this is the case or whether the pattern derives from reporting bias, we used an ac-

tive method to query public health officials and fisheries managers about the occurrence of CFP from 1996 through 2006 in 24 Caribbean island nations and territories and 9 mainland countries bordering the Caribbean. Fisheries and public health officials were contacted separately. One or both agencies could be involved in the surveillance of and response to CFP, although often within different administrative units. Querying two separate agencies was intended to allow corroboration of the data and to measure information-sharing between agencies. The questionnaires used in this study were vetted by a panel of experts with experience in designing human health surveys (see Acknowledgments).

Initial contact was made with public health and fisheries department staff persons by telephone. Introductory conversations were conducted in English, Spanish, or French, depending on the preference of the official

contacted. The following preliminary information and questions were provided during these telephone calls before sending the survey:

- The focus of the project is to gather information about where and how many people are poisoned by eating fish contaminated with ciguatera toxin (ciguatoxin) throughout the Caribbean, including in _____ (*name of country*). People who eat fish carrying this toxin can develop ciguatera fish poisoning, an illness that affects primarily the digestive and nervous systems.
- Does your office compile information about fish that transmit ciguatera or cases of ciguatera fish poisoning in _____ (*name of country*)?
(If No) Do you know of another office that does?
(If Yes) What is the name of that office?
(If No) Do you know anyone who might be able to help me locate an office that compiles information about ciguatera fish poisoning?

A long-term goal of the research project is to better understand where ciguatera fish poisoning occurs, which could improve the use of resources to monitor and respond to it. The results of our research throughout the Caribbean will be summarized in a report, documented in a database, and displayed on maps that will be available to you and others interested in the project. We will not be collecting names, addresses, or other personal information from people who have ciguatera fish poisoning.

- Are you the best person in your office to provide information about ciguatera in _____ (*name of country*)?
(If referred to another person or agency) Do you have any contact information for the person you recommend I speak with?

We are asking for your voluntary assistance with our research.

- Would you be willing to answer a few questions?
(If Yes) Thank you! I would greatly appreciate being able to e-mail you some specific questions I have. May I do so?
(If No) Why not?

Once an appropriate contact was identified, a written copy of the questionnaire was provided in the appropriate language (or languages, as some participants received the questionnaire in both Spanish and English or French and English). Both questionnaires (the fisheries department version and the public health department version) included the 11 core questions listed in Appendix I, as well as 4 questions that applied to only the fisheries department (Appendix II) or the public health department (Appendix III). Efforts were made, in designing

the questionnaire, to allow respondents to qualify how confident they were of the completeness of the data they were providing.

RESULTS AND DISCUSSION

To date, results are preliminary, as not all the questionnaires have been returned. However, some trends have begun to emerge, and it is possible to provide a brief synopsis of these. One of the most striking results was the wide range of concern and knowledge about CFP. Some government agencies have simply asserted that CFP cases do not occur in their jurisdictions and declined to receive or complete the questionnaire. Other agencies acknowledged that a potential problem exists but have been hampered by insufficient resources to institute an organized monitoring system. Still other governments reported making progress toward bringing CFP surveillance programs online, sometimes in response to a recent outbreak of CFP cases.

Some countries had a well-developed mandatory protocol for reporting CFP, including information on the name of the patients, symptoms, and diagnosis. In some instances, public health officials have a high degree of confidence that they are finding 90% or more of the cases, but most public health officials who have responded to date are less confident in their statistics. In some countries, when clusters of CFP cases are observed, the health department issues a press release. At the same time, the department may do a public service announcement for radio and TV about the risk of consuming barracuda.

A wide range of opinions were offered about how aware and concerned local populations and fishers are about the risk that eating certain types of locally caught fish could result in developing CFP. These responses ranged from "Not aware" or "Not concerned," to "Somewhat aware" or "Somewhat concerned," to "Very aware" or "Very concerned." One respondent commented that native-born citizens had a higher level of awareness and concern than people who recently moved to the region. Perceived levels of risk might depend more on being educated about the problem rather than an actual risk of exposure. At least in some regions where CFP is well known, most people seem to understand that if they feel tingling or prickling on their tongues when they are eating fish, they should stop eating it to minimize the risk of becoming sick.

In some countries, the data also suggest a trend toward increasing numbers of CFP cases with time. Public health officials on a few islands attributed this not to environmental change, but to population growth, in some cases as rapid as a doubling of the population in 20 years. As the population has grown, so too has the demand for fish, which could result in an increase in the number of people exposed to CFP. It is generally agreed that CFP is underreported and that this lack could be attributable to a variety of reasons (e.g., because its symptoms resemble those of other diseases when the poisoning is mild). This apparent increase may also be attributable to increased reporting because of heightened awareness, or it may reflect an actual increase in new cases of CFP.

Several public health departments have compiled and reported the months and years when people ate ciguatoxic fish and were diagnosed with CFP. From these limited data it appears that the number of CFP episodes was distributed evenly throughout the year but that the number of cases (people diagnosed with CFP) per episode was greater in September and October (Figure 5).

Overall, public health and fisheries officials indicated that consumption of contaminated barracuda was the most common cause of CFP. Other species frequently identified with CFP include jack, grouper, snapper, hogfish, and mackerel. Some fishermen discard barracuda that do not "put up a fight" when caught, believing that if a fish does not fight, it is sick. However, it should be noted that ciguatoxic status cannot be discerned visually; seem-

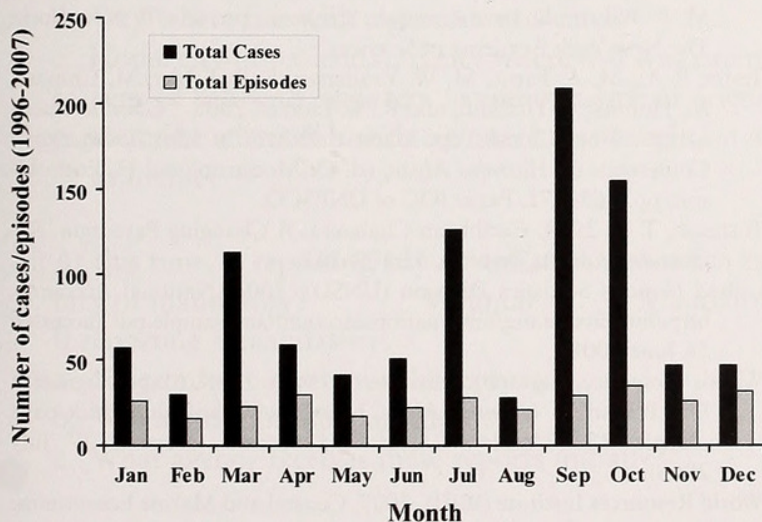


FIGURE 5. Ciguatera episodes and cases in the Caribbean by month from 1996 to 2007. Episodes indicate multiple cases (usually defined by zip code) during the same week.

ingly healthy fish can be quite toxic. One positive outcome of this research was that some countries provided data indicating geographic locations where ciguatoxic fish were frequently found. This information will guide future sampling efforts.

CONCLUSIONS

The data currently available from Caribbean countries suggest there is wide variability in the amount of attention given to CFP. This variability is probably not entirely attributable to how prevalent CFP is in various areas. The reasons for this include differences in (1) how significant a problem CFP is thought to pose, (2) awareness of the risk of CFP, (3) whether central reporting of CFP cases is mandatory, and (4) resources available for CFP monitoring and education.

Active surveys, such as the one described in this study, can help countries quantify potential risks and establish training and monitoring systems for CFP. This study also provides unique insights into human dimensions of CFP, including perceptions of how significant the risks are in different areas and how frequently health and fisheries departments exchange information concerning CFP. The data from this study were also detailed enough, in some cases, to suggest specific regions in the Caribbean where CFP occurrences are elevated or are relatively rare. This information will facilitate identification of specific sampling sites for future investigations of the factors that affect the temporal and spatial variability in exposure to CFP. The fruitful partnership between the Smithsonian Institution and NOAA continues the Smithsonian's tradition of documenting the diversity of life on earth and NOAA's mission to bring state-of-the-art management tools to the marine community.

ACKNOWLEDGMENTS

We thank Drs. Nathalie Valette-Silver, David Johnson, and Michael Dowgiallo and Mr. Joseph Schittone of the National Ocean Service (NOS), NOAA, for facilitating this study. Dr. Richard Appledorn, Director of the Caribbean Coral Reef Institute, provided guidance for field sampling. Mr. Michael Carpenter, National Museum of Natural History (NMNH), kindly provided logistic support. Mr. Scott Whittaker (Head) and Mr. Don Hurlbert of the Smithsonian's NMNH Imaging and Photography Department generously gave us technical assistance. We

appreciate the guidance from Leonard Young, Public Health Scientist, Eastern Research Group; Dr. MaryBeth Bauer, NOAA National Centers for Coastal Ocean Science; Dr. Chris Ellis and Ms. Lauren Smith, Human Dimensions Program, NOAA Coastal Services Center; and Dr. Janna Shakeroff, Duke University Marine Laboratory, in the development of the questionnaire used in this study. We are especially grateful to Dr. Klaus Ruetzler and the Caribbean Coral Reef Ecosystem Program and the NOS International Program Office for funding. This is contribution number 851 of the Caribbean Coral Reef Ecosystems Program (CCRE), Smithsonian Institution, supported in part by the Hunterdon Oceanographic Research Fund.

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APPENDIX 1

The following core questions were used in both fisheries and health department questionnaires:

1. a. What information does your office compile about cases of ciguatera fish poisoning (for example, number of people diagnosed, locations of people diagnosed, locations where fish were caught, etc.)?
 - b. If your office does not compile such information, is there another governmental office or agency that does, and what is its name? Yes No I'm not sure
Name of other office or agency: _____
 - c. If yes, what types of information do you think that office might have?
 - d. Please provide contact information for someone in that office, if possible (contact name, e-mail address, phone number, and fax number).

2. If you receive reports of ciguatera fish poisoning, from whom do the reports come? (*Please check ALL that apply.*)
 Doctors Clinics and Hospitals Fisheries Department [for the health department survey] Fishermen
 Health Department [for the fisheries department survey]/Other Health Agencies [for the health department survey] (please specify jurisdiction represented and contact person, if available) Restaurants Hotels
 Individual Citizens Other Sources (please list)

3. Please indicate the total number of reported ciguatera fish poisoning cases per calendar year from January 1, 1996, through December 31, 2006.
 [A table containing one line for each year, a column for the number of cases reported, and a column for any comments was provided here.]

4. To the extent available, please provide the following information for each episode of ciguatera fish poisoning. (For this study, an episode is defined as an occasion when one or more people were poisoned on the same day by one or multiple fish of the same variety, caught in the same place.)
 - a. Number of people poisoned
 - b. Date of episode (list season and year if date or month is not known)
 - c. Date of diagnosis, if date of poisoning (B) is not known
 - d. City where fish with ciguatera was eaten
 - e. Home city of patient(s), if city where fish was eaten (D) is not known
 - f. Type of fish with ciguatera (common name or scientific name)
 - g. Describe where fish with ciguatera was caught, in as much detail as possible (with latitudes and longitudes, if available)

5. At this time, is reporting any information about fish transmitting ciguatera or cases of ciguatera fish poisoning voluntary or mandatory? Voluntary Mandatory I'm not sure
 If reporting is mandatory:
 - a. What information must be reported?
 - b. When did it become mandatory?
 - c. What agency receives these reports initially?

6. a. What percentage of ciguatera fish poisoning cases diagnosed each year in _____ (*name of country or territory*) do you think are reported to your office?
 - b. How confident are you of this estimate? Very confident Somewhat confident Slightly confident
 Not at all confident I'm not sure

continued

Appendix 1 continued

7. a. To your knowledge, has your agency or another governmental agency issued any advisory warnings related to consuming fish that might carry ciguatera, such as barracuda or large reef fish?
 Yes No I'm not sure
- b. If yes, please indicate which office issued the advisory.
- c. If applicable, please include or attach the wording of each such advisory and indicate when it was issued. Attach additional pages, if necessary.
- d. If your agency has not issued an advisory, who or what agency would be most appropriate to consult for information on advisories? (Please list the agency name and the following, if available: a contact name, e-mail address, phone number, and fax number.)
8. How often do your department and fisheries department officials [for the health department survey]/health department officials [for the fisheries department survey] exchange information about episodes of ciguatera fish poisoning?
 As cases occur Every month Every 3 months Every 6 months Every year Never
 Other (please specify):
9. How aware do you think local citizens are of the risk that eating certain types of fish could cause them to develop ciguatera fish poisoning? Very aware Somewhat aware Not very aware Not aware
 I'm not sure
10. To what extent do you think local citizens are concerned about ciguatera fish poisoning?
 Very concerned Somewhat concerned Slightly concerned Not concerned I'm not sure
11. Please provide your contact information for future reference. Thanks again for your assistance!
- Government represented:
 Agency and office:
 Name and title of person completing questionnaire:
 Telephone number, with city code:
 Fax number, with city code:
 e-mail address:
 Date information provided:
 Would you like to receive notification of the results of the study? Yes No

APPENDIX 2

The following questions were directed only to officials representing fisheries departments:

1. a. Is information usually communicated to you about where fish suspected of carrying ciguatera were caught?
 Yes No
- b. Is information usually communicated to you about what types of fish have carried ciguatera?
 Yes No
- c. If yes to either (a) or (b), and if you do not have information in the format provided in Question 4, please provide any information you have about the types of fish, and the locations involved in episodes of ciguatera fish poisoning reported to you, for the years 1996 to 2006. [A table was provided with the following headings: Year, Common or scientific names of fish reported, Locations of fish reported (latitudes/longitudes, if possible, or place names, in as much detail as possible).]

2. Please provide any information you have on economic losses resulting from ciguatera fish poisoning, either quantitative or qualitative (for example, if fishing had ceased at a particular reef because of the suspected presence of ciguatera toxins, there might be an annual loss of \$10,000 to the fishing industry). Please include the year(s) your data reflects and note your data sources.
3. To what extent do you think fishermen are aware of the risk of catching certain types of fish that could cause people to develop ciguatera fish poisoning? Very aware Somewhat aware Not very aware
 Not aware I'm not sure
4. To what extent do you think fishermen are concerned about catching certain types of fish that could cause ciguatera fish poisoning? Very concerned Somewhat concerned Slightly concerned Not concerned
 I'm not sure

APPENDIX 3

The following questions were directed only to officials representing health departments:

1. Is any information available to you on the cost per year to your government of monitoring or documenting the incidence of ciguatera fish poisoning? Yes No
 If yes, please provide the information below and note your data sources.
2. Is any information available to you on the cost per year of medical treatments in _____ (*name of country or territory*) for ciguatera fish poisoning, as an average per person affected by ciguatera fish poisoning and/or annually for _____ (*name of country or territory*)? Yes No
 If yes, please provide it below, specify whether it reflects a total or an average per person, and note your data sources.
3. Is any information available to you related to the number of days people have been unable to work due to ciguatera fish poisoning per year in _____ (*name of country or territory*)? Yes No
 If yes, please provide it below, specify whether it reflects a total or an average per person, and note your data sources.
4. Would you rank ciguatera fish poisoning as one of the 10 most severe food-borne illnesses in _____ (*name of country or territory*)? Yes No I'm not sure
 If yes, would it rank in the top 1 to 5 or 6 to 10?



Tester, Patricia A. et al. 2009. "Ciguatera Fish Poisoning in the Caribbean." *Proceedings of the Smithsonian Marine Science Symposium* 38, 301–311.

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