A statistical and spatial analysis of chemical contaminants in Cocos Lagoon, Guam

Char'Mane Robinson

Introduction

Chemical hazardous waste has been a global problem since the early 1900's, although environmental regulations have been established such as the Environmental Protection Agency (EPA) scientists are still finding problems with hazardous waste. This is the case today in Coco Lagoon. Cocos lagoon, located on the southwestern side of Guam, is a water body known for being a thriving coral reef habitat and popular recreational site. Most importantly, Cocos Lagoon is an important food resource for local resident subsistence fishers who depend on the fish population to feed themselves and their families. Subsistence fishers are people who eat fish daily compared to recreational fishers who eat fish infrequently, perhaps once a month. Subsistence fisher screening values (2.45 ng/g) are lower than recreational fishers screening values (20 ng/g), as subsistence fishers consume fish at a higher rate, perhaps on a daily basis. Currently, local residents of Cocos Lagoon are very concerned about environmental contaminants, in particular, polychlorinated biphenyls PCBs which are present in Cocos Lagoon. I used the EPA screening values to determine concentrations of chemical contaminants that could negatively affect the health of local residents of Coco Lagoon.

PCBs belong to a family of man-made organic chemicals commonly known as chlorinated hydrocarbons. PCBs are extremely persistent in the environment and can be bioaccumulated and then biomagnified in organisms such as fish and humans (EPA, 2016). PCBs can cause a variety of adverse health effects in animals and in humans, ranging from immune system suppression, reproductive system impacts including birth defects and cancer (EPA,1996). One possible source of PCBs appears to be on Cocos Island, where there is a former US Coast Guard LORAN (Long Range Navigation) site. The station operated between 1944 and 1963 and was decommissioned in 1965. Hazardous materials, transformers, and capacitors containing PCBs may have been buried or dumped in nearby waters, exposing the waters and biota such as invertebrates and fish to PCBs. Local residents consume fish as part of their regular diet, and as such, there is concern about the health risks associated with consuming fish contaminated with PCBs.

Previous investigations by the military in 2005 conducted soil tests on Cocos Island and found PCB levels to be about 4,900 times higher than the federally recommended level (USCG,

2014). Although previous investigations have been done by the US Coast Guard, no previous investigations have tested the sediment and biota for the entire lagoon for any environmental contaminants. This lack of data sparked a debate to determine if there were any PCBs present in Cocos Lagoon and if so, could there be an impact on the health of the residents. To address these concerns, residents and the Guam government agencies requested NOAA to conduct additional testing (USCG, 2014).

Methods

Approximately 190 chemical contaminants, including 82 PCB congeners, were analyzed in sediment and fish tissue samples collected in May of 2015. For my project, we concentrated on PCBs in fish tissue, as this was one of the most prevalent contaminants found adjacent to Cocos Island. I conducted statistical analyses of PCBs from the samples taken from 25 sediments sites, along with 27 fish tissue samples collected from 16 sites throughout the entire Cocos Lagoon. I used programming software JMP (an SAS product) to conduct non-parametric Wilcoxon Tests to find significant differences between chemical contaminants and site areas. R-Studio was used to create graphical figures of the concentrations found in sediment and fish tissue. Lastly, I used ArcGIS to display the concentrations geographically and their relation to EPA screening values.

Results

Total PCB's concentrations, calculated as the sum of all 82 PCB congeners, in sediment were comparatively low (≤1.20ng/g). However, a significantly higher total concentration of PCB's in biota was found (Figure 1). The whole tissue concentrations of total PCB's for each local species in Cocos Lagoon in decreasing order was *Abudefduf sordidus* (≤1200ng/g), *Abudefduf septemfasciatus* (≤900 ng/g), *Epinephelus Merra* (≤700 ng/g), *Acanthurus triostegus* (≤200 ng/g), *Lethrinus obsoleta (*≤200ng/g), *and Epinephelus hexagonatus* (≤100ng/g), *Lutjanus fulvus* (≤20 ng/g), and *Lethrinus harrack* (≤20 ng/g) (Figure 2).

Local species found above the EPA recreational screening values (concentrations ranged from 20.15 to 338.47 ng/g) were *Acanthurus triostegus, Epinephelus merra, Abudefduf sordidus, Abudefduf septemfasciatus, and Lethrinus obsoleta.* Local species found above the EPA subsistence screening values (concentrations ranged from 3.84 to 18.81) were *Epinephelus merra, Epinephelus hexagonatus, and Lutjanus fulvus* (Figure 3).

Discussion

Sediment:

In Cocos Lagoon the sediment composition consists of 90% of sand and 10% of silt, gravel, and clay. Sand naturally has a small surface area making it difficult for organic contaminants such as PCB's to attach to. This is one possible explanation as to why there is a low total PCB's concentration in sediment (≤ 1.20 ng/g) as compared to tissue.

Biota:

Higher levels of PCBs were found in biota samples at sites closest to the former LORAN station. Based on my results, I wanted to determine why and where the local fish were bio-accumulating PCB's. To make this determination, I looked at what the concentrations were for each of the local species in Cocos Lagoon. My results show that the *Abudefduf sordidus* fish species had the highest concertation of total PCB's (≤ 1,000 ng/g). The *Abudefduf sordidus* fish is an extremely territorial fish and mostly feeds on benthic and small vertebrates. This particular fish species was only found adjacent to Cocos Island and not anywhere else in the lagoon. It's feeding strategy, and territorial behavior may be influencing how PCBs are accumulating. The fish species with the third highest total PCB's was *Epinephelus merra* (≤700 ng/g). The *Epinephelus merra* is a relatively mobile fish, so it could possibly be bioaccumulating contaminants from Cocos Island and transporting them throughout Cocos Lagoon.

Public Health:

I compiled all my previous results into a single map to show the distribution of total PCB's accumulated in fish species throughout Cocos Lagoon. The concentrations of total PCB's were categorized by EPA screening value exceedances in an attempt to address the concerns of public health. Some concentrations of PCBs fell above the EPA subsistence screening value and even the recreational fishers screening value (SV) for some fish species around Cocos Island. These values indicate there could be a risk to humans, particularly subsistence fishers consuming fish from around Cocos Island. Because of the presence of PCBs in the tissues of fish, there is a chance that people who consumes these fish as part of their daily diets could be accumulating PCBs in their bodies.

Implications

Based on my results, scientists now know that bioaccumulation is occurring in the local fish species and in not the sediment. However, how the fish are being exposed to the chemical contaminants has not been determined. Next spring a team of researchers will be conducting water quality testing in Cocos Lagoon in an attempt to determine if water is the source of exposure. Overall, the implications of this study could be that Cocos Lagoon will remain shut down imposing economic and recreational losses on the adjacent communities. There are ongoing debates about opening up a current natural reserve adjacent to Cocos Lagoon for new fishing in an effort to offset the economic loss. However human health may still be at risk as there is almost no data currently available about the presence or absence of contaminants in this new area. The information conducted in this project will be published next fall so that it can be used by government agencies, researchers, and the general public to provide key information needed to make effective decisions for the health of Cocos Lagoon and also gauge the efficacy of restoration activities.

Literature Cited

1. U.S. EPA. (1996) PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures. U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, Washington Office, Washington, DC, EPA/600/P-96/001F 74pp.

2. U.S. EPA. (2016) Learn about Polychlorinated Biphenyls (PCBs). Environmental Protection Agency. Web. 13 July 2016.

3. U.S. EPA. (2000) PCBs: Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Office of Science and Technology Office of Water, U.S. Environmental Protection Agency, Washington, DC, EPA 823-B-00-007pp.

4. U.S. Coast Guard (USCG). (2014) *Final Report* Follow-On Environmental Site Investigation Former LORAN Station Cocos Island *Cocos Island, Guam.* Civil Engineering Unit, Honolulu, HI. 289pp.

Appendix

Figures:

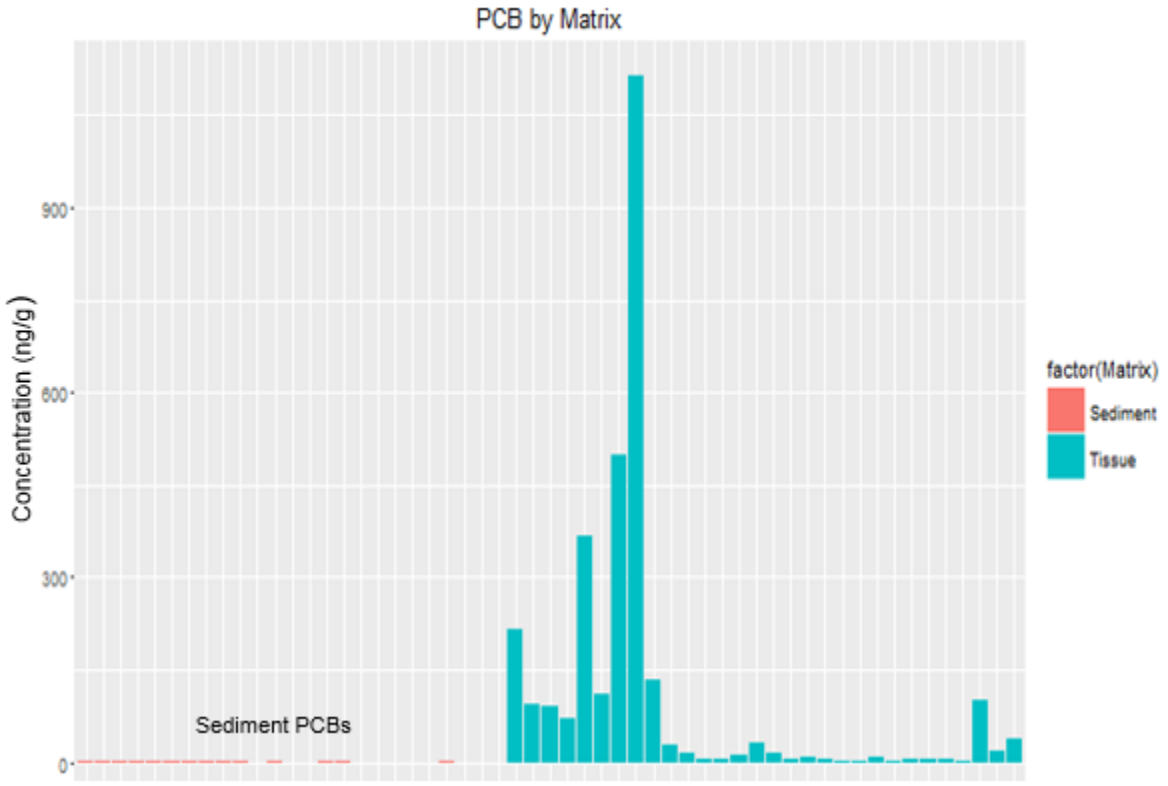

Figure 1: PCBs were found to be the most prevalent contaminants. Total PCBs in sediments (< 1.20ng/g) was much lower than in fish samples.

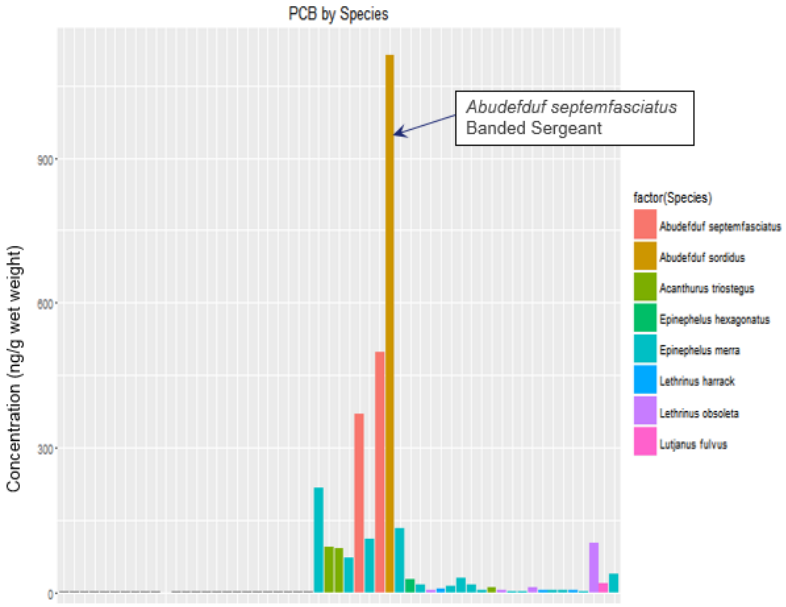

Figure 2: Total PCBs in each fish species samples.

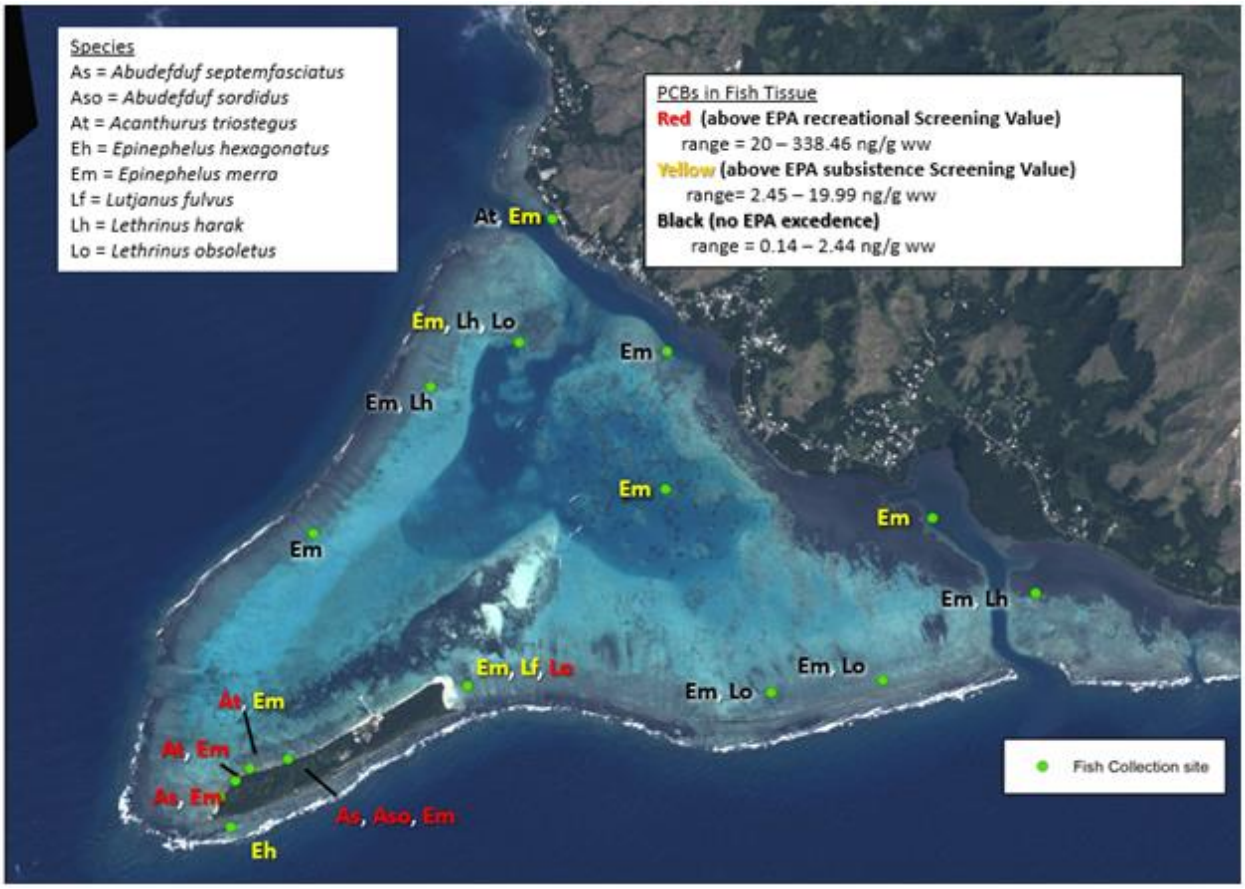

Figure 3: The concentrations of polychlorinated biphenyls (PCBs) in relation to EPA screening values.