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

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Background

- Cocos Lagoon is located on the southwestern corner of Guam, a U.S. island territory in Micronesia.
- US Coast Guard operated had a LORAN navigation site on Cocos Island inside the Lagoon from 1944 to 1963.
- Hazardous materials, including polychlorinated biphenyls (PCBs), were disposed of on land and in nearshore ocean exposing surrounding waters, sediment, fish species and also humans to these and other chemicals.
- Local residents consume the fish as part of their regular diet, therefore there is concern about the health risks associated with consuming fish contaminated with PCBs.
Background: PCBs

- PCBs belong to a family of man-made organic chemicals known as chlorinated hydrocarbons.

- Transformers and capacitors containing PCBs on Cocos Island were buried or dumped in the ocean, exposing the sediment and biota throughout Cocos Lagoon to these chemical contaminants.

- PCBs are extremely persistent in the environment causing bioaccumulation by fish species.

- PCBs biomagnification the PCBs in people who have ingest these fish.

- PCBs can cause a variety of adverse health effects:
  - immune system suppression
  - reproductive system impacts (including birth defects)
  - cancer (EPA, 1996)
Previous Research

- In 2014, the US Coast Guard have indicated the presence of chemical contaminants, particularly PCBs, on and in the area adjacent to Cocos Island.

- In May 2015, NOAA’s National Centers for Coastal Ocean Science (NCCOS) scientists, and local NOAA Coral Reef Conservation Program (CRCP) and sampled sediments and fish throughout Cocos Lagoon.

- Samples collected were analyzed for approximately 190 chemical contaminants, including 82 PCB congeners.
Objectives

This study used the data generated from the NOAA sampling in Cocos Lagoon to:

• Conduct statistical analyses of PCBs in sediments from 25 aquatic sites, along with 27 fish tissue samples from 16 sites of these 25 sites

• Develop charts and tables displaying the results of the analyses to be incorporated into future NOAA reports and manuscripts

• Assess the human health risks associated with the chemical contaminants present
Methodology

• ArcGIS: used to display the concentrations of PCBs in relation to EPA screening values

• Statistical Analysis Tools such as JMP (SAS product) and R to preform Non-parametric Wilcoxon test
Results

- PCBs in sediments were much lower, than in the fish samples ($\leq 1.20$ ng/g)
Results: Fish Species Analyzed

- Abudefduf septemfasciatus (As) = Banded Sergeant
- Abudefduf sordidus (Aso) = Blackspot Sergeant
- Acanthurus triostegus (At) = Convict Tang
- Epinephelus hexagonatus (Eh) = Starspotted Grouper
- Epinephelus merra (Em) = Honeycomb Grouper
- Lutjanus fulvus (Lf) = Blacktail Snapper
- Lethrinus harak (Lh) = Thumbprint Emperor
- Lethrinus obsoletus (Lo) = Orange-striped Emperor

Photos courtesy D. Burdick/
http://www.guamreeflife.com/
PCBs Results by Fish Species

![Graph showing PCB concentrations by fish species.](image)

- **Abudefduf septemfasciatus** (Banded Sergeant)
- **Acanthurus triostegus**
- **Abudefduf sordidus**
- **Abudefduf septemfasciatus**
- **Lutjanus fulvus**
- **Lethrinus obsoleta**
- **Lethrinus harrack**
- **Epinephelus hexagonatus**
- **Epinephelus Merra**
- **Lethrinus harrack**

**Axes:**
- **Y-axis:** Concentration (ng/g dry weight)
- **X-axis:** Sample Locations

**Legend:**
- Red: **Abudefduf septemfasciatus**
- Brown: **Abudefduf sordidus**
- Green: **Acanthus triostegus**
- Blue: **Epinephelus hexagonatus**
- Teal: **Epinephelus Merra**
- Light Blue: **Lethrinus harrack**
- Purple: **Lethrinus obsoleta**
- Pink: **Lutjanus fulvus**

**Note:** The graph illustrates the PCB concentration levels for various fish species, with a significant peak for **Abudefduf septemfasciatus** (Banded Sergeant).
Results: EPA Screening Values

- Screening values (SV) have been developed by the USEPA to define the risk resulting from the consumption of fish by subsistence and recreational fishers.

- SVs (concentration values in fish tissues) have been developed for both recreational fishers and subsistence fishers for total PCBs.

- Subsistence fisher screening values are lower than recreational fishers, as subsistence fishers consume fish at a higher rate, perhaps on a daily basis.

- Exceedance of these SVs should be taken as an indication that more intensive site-specific studies are needed.

EPA screening value of PCBs for subsistence fishers = 2.45 ng/g (ppb)

EPA screening value of PCBs for recreational fishers = 20 ng/g (ppb)
Species
As = Abudefduf septemfasciatus
Aso = Abudefduf sordidus
At = Acanthurus triostegus
Eh = Epinephelus hexagonatus
Em = Epinephelus merra
Lf = Lutjanus fulvus
Lh = Lethrinus harak
Lo = Lethrinus obsoletus

PCBs in Fish Tissue
Red (above EPA recreational Screening Value)
range = 20 – 338.46 ng/g ww
Yellow (above EPA subsistence Screening Value)
range= 2.45 – 19.99 ng/g ww
Black (no EPA excedence)
range = 0.14 – 2.44 ng/g ww

p-value = < 0.0001
Summary

- PCBs in sediments (≤ 1.20 ng/g) were much lower indicating no concern compared in the fish samples.

- Concentrations of polychlorinated biphenyls (PCBs) in biota were above the EPA subsistence screening value, and even the recreational fishers screening value (SV) for some fish species around Cocos Island.

- Indicates risk to humans, particularly subsistence fishers consuming fish, particularly from around Cocos Island.

- Based on my results Cocos Lagoon has been shut down imposing economic and recreational losses on the adjacent communities.
Next Steps

- To better protect human health and the environment further work by the USEPA, USCG, and Guam EPA may include additional remediation of the former USCG LORAN site, and/or the monitoring of chemical contaminant concentrations in water and biota adjacent to Cocos Island.

- In conjunction with recent biota testing results, the NOAA results will be used to assess the current fishing advisory area within Cocos Lagoon.

- During the Fall, I will write the results of my analyses that will be included in report and submit for publication as a NOAA tech memo, and journal article.

- My future aspirations are to attend UC Davis for graduate school to pursue a Ph.D in water science.
Literature Cited


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