June 19th, 2019

Dear Ms. Tonioli and members of the Sustainability and Resiliency Committee,

First, I would like to introduce myself, I am Carys Mitchelmore, a Professor at the University of Maryland Center for Environmental Science. I am an aquatic toxicologist with over 25 years of scientific research experience and have published over 70 peer-reviewed scientific papers, book chapters and technical reports, served on several committees at the National Academies of Sciences and testified before Congress and other state and federal regulatory bodies about my research. We currently face huge challenges to protect our coastal and oceanic ecosystems. Thousands of chemical contaminants enter our oceans and so my research focuses on understanding how these chemicals and other stressors, interact with and impact organisms. I am very concerned about the declining health of our coral reefs which is why I having been working with corals for over 20 years now, investigating the impacts of chemical contaminants on them, researching novel antioxidant pathways and determining causes of oxidative stress and damage in the host coral and their symbionts.

As a coral toxicologist I have been following the science and legislative activities regarding the organic UV filters, oxybenzone and octinoxate and their potential impacts to coral. I understand that the Sustainability and Resiliency Committee is collecting information on this subject. As a Professor who is actively conducting research in this area and as an educator and advocate for science I would like to offer any help you need in gathering the scientific data on the impact of UV filters to coral. The enclosed PowerPoint includes some of the material that I have presented at recent scientific meetings and in the letter below I highlight a few of the main points regarding coral reef health and the organic UV filters oxybenzone and octinoxate.

**First, corals are in serious decline, and the scientific consensus is that major threats are increased temperatures due to climate change, and disease, while the sunscreen components oxybenzone and octinoxate are currently implicated essentially by a single study.**

Many coral threats are due to people and include implications of climate change, physical damage, biological changes, increased inputs of sediment, nutrients and many different organic and inorganic chemical pollutants. In comparison to the large number of studies investigating increased temperatures on coral there are very few that have looked at the effect of chemical contaminants, with even fewer published on the impact of UV filters to coral. Essentially, the research that was presented during the legislative activity on UV filters in Hawaii came from one primary study. This single study does not provide sufficient evidence to determine the environmental risk of oxybenzone to coral, and it does not even examine or provide any evidence for octinoxate.

**Second, there is very limited scientific data on oxybenzone and octinoxate concentrations in seawater and their impacts on corals; not enough data to conduct a risk assessment. It is an emerging field of research.**

Determining the environmental risk of a chemical contaminant to coral requires two sets of scientific data; the concentration of the chemical in seawater coupled with coral toxicity studies. During the Hawaii legislation, there were no published concentrations of octinoxate in seawater from Hawaii and data in the primary publication mentioned earlier showed that only 1 of 7 seawater samples from Hawaii contained a measurable level of oxybenzone. Recently my laboratory together with colleagues significantly expanded the data set on the concentration of UV filters in seawater near Hawaii's coral reefs. We collected seawater at 19 sites in Oahu, Hawaii, finding low parts per trillion concentrations of oxybenzone but no measurable levels of octinoxate in any of the 57 samples, even those collected at the high tourist sites along Waikiki Beach.

A graph in the PowerPoint presentation enclosed summarizes all of the oxybenzone concentrations reported in seawater from around the world's coral reefs. These studies highlight that oxybenzone concentrations are very variable between sites/locations, water depths, distance from the

shoreline and time of year etc., but overall the majority of samples are in the parts per trillion concentration range.

There are even fewer studies looking at the impacts (toxicity) of oxybenzone and octinoxate on corals. During the Hawaii legislation two limited toxicity studies were available, although data was mainly reported from the one primary paper mentioned earlier. However, as an emerging field of research, more studies on oxybenzone and octinoxate toxicity to corals are being conducted and published. Currently there are five publications in total (two were just published in 2019 so there are now four for oxybenzone and two for octinoxate although some studies are limited as they are looking at products not single UV filters).

**Third, the mere presence of oxybenzone or octinoxate in seawater does not imply toxicity and there are substantial methodological limitations to the primary study being leveraged.**

With advances in analytical chemistry we can now detect chemicals at extremely low levels but that does not equate to harm. All chemicals are toxic at some concentration, which is why it is important to conduct risk assessments to determine if the concentrations of the chemical found in seawater are at levels that may cause harm.

Using the most conservative and appropriate toxicity threshold from the primary study (i.e. the LC50 (lethal concentration that results in 50% mortality of the population) for the longest exposure time of 24 hours in the light) the PowerPoint presentation graph shows that most oxybenzone seawater concentrations reported globally are below this toxicity threshold, except for the seawater concentration data points from that primary study.

In addition to the low number of oxybenzone and/or octinoxate toxicity studies in coral, there are also many limitations in the data provided in the primary publication used. This primary study does not provide any toxicity data on octinoxate and there are also many other methodological limitations, which are too numerous to list but I would be happy to expand upon and explain them at a later time. Thus, the research in the primary study is not sufficient to conclude a link between oxybenzone and octinoxate and coral decline.

**Finally, many more robust scientific studies are needed to determine the risk of these chemicals to corals, so that management decisions can prioritize the stressors that are the most damaging to Florida's coral reefs.**

Much more research is needed to determine the risk of UV filters to corals. Scientists from academia, government, and industry need to work together to conduct additional environmental monitoring and toxicology studies. As an emerging field of research many more studies are already being conducted to look into this issue in more detail. In fact, since the primary publication was highlighted during the Hawaii legislation there has been a doubling of research papers looking at oxybenzone and octinoxate toxicity in corals. The new oxybenzone study shows toxicity thresholds (i.e. impact concentrations) at much higher levels in two species of coral, both in larvae and adults, compared to the original primary paper. Furthermore, the new recently published Hawaii UV-filter monitoring study reported very low parts per trillion concentrations of oxybenzone and no measurable concentrations of octinoxate in seawater.

I have provided a list of references at the end of the PowerPoint presentation. I would be happy to send you any of these publications and expand on any of the above topics in detail with you at a later date.

Yours sincerely,

Dr. Carys Mitchelmore
Professor,
mitchelmore@umces.edu

# Overview on the State of the Science regarding the Sunscreen organic UV-filters Oxybenzone and Octinoxate and Coral Reef Health


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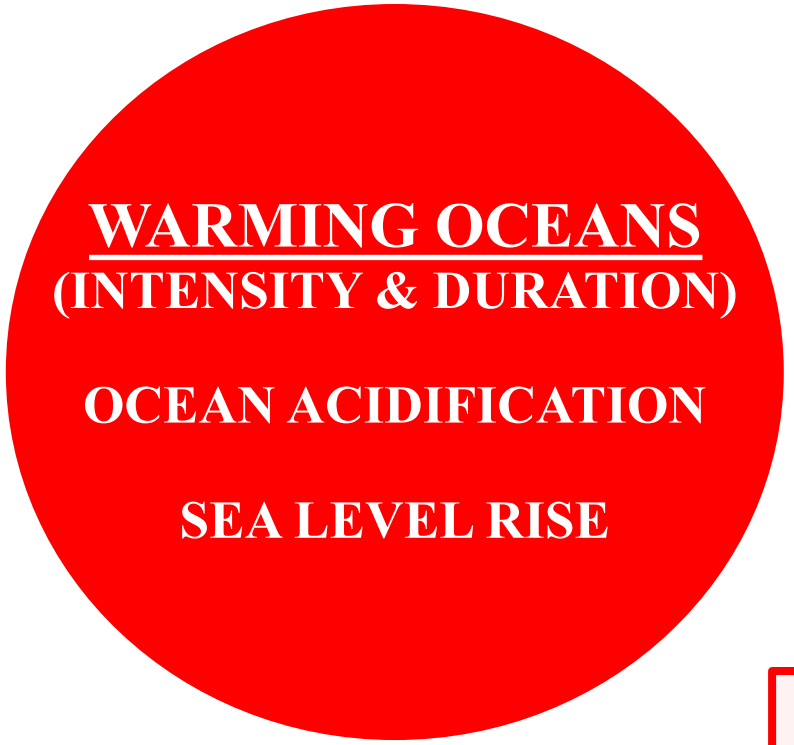
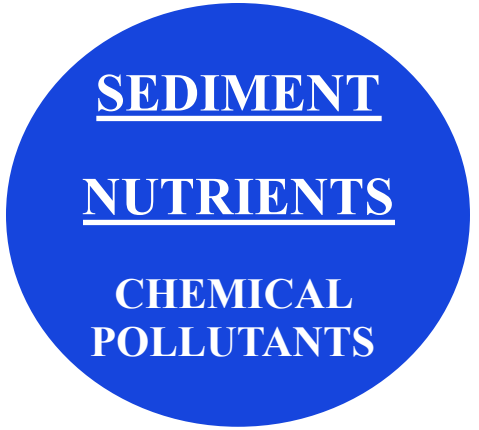
# Many Threats to Coral Reefs




**CLIMATE CHANGE**


**BIOLOGICAL CHANGES**




**WATER QUALITY**


**PHYSICAL DAMAGE**

## Take Home Messages

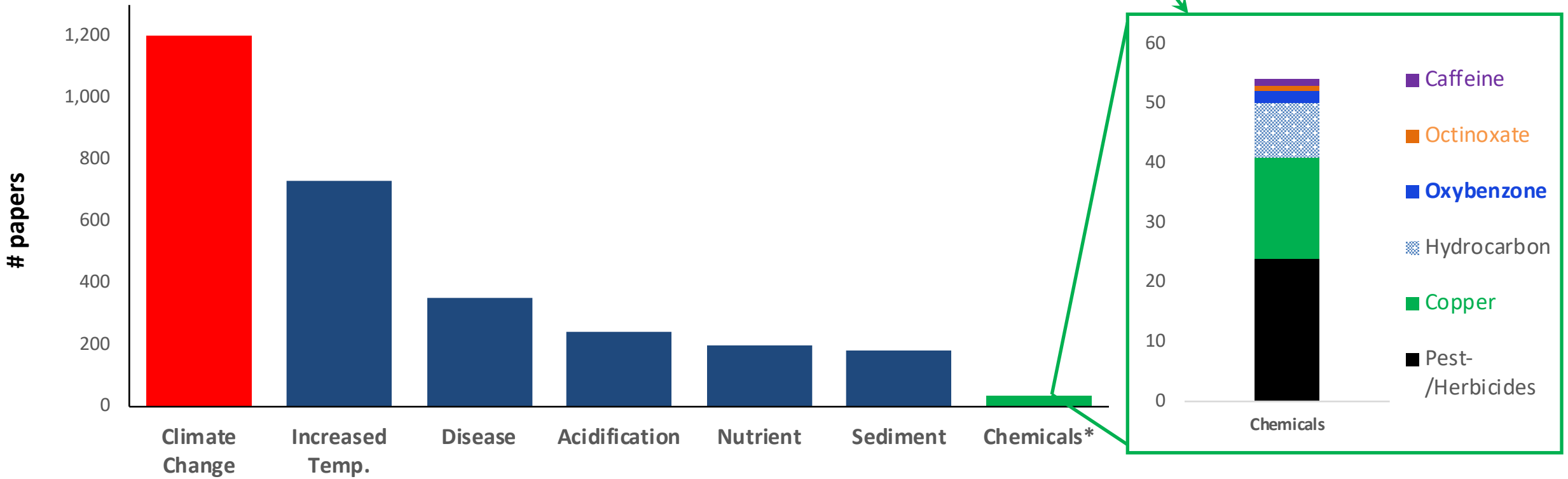
- Climate Change is the biggest threat to Coral Reefs, Globally
- Additional major concerns: diseases, over-fishing, water quality

**Management approach:**

- Multiple biological, physical and chemical stressors
- Conduct risk assessments to identify and prioritize problems

# What is the Scientific Literature on Coral Health?

**1,222** studies have investigated the impact of **climate change** on coral
**54** studies have investigated the impact of **chemicals*** on coral
**2** studies on the impact of **oxybenzone** on coral# (**1** for **octinoxate**) – **VERY LITTLE DATA**




Citations generated from a 'Topic' search in the Web of Science that included the terms: "coral bleaching" AND "climate change" (or the other column categories in the graphs) as of 05/02/19 *; pesticides/herbicides, copper, hydrocarbon and oxybenzone

**#: In total there are 3 papers for oxybenzone and 2 papers for octinoxate in intact corals (two of these papers are from 2019)**

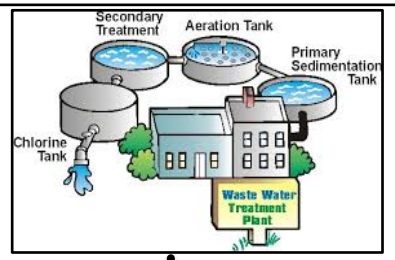
# UV filters: Sources and Exposure Routes to the Environment

**SUNCREEN UV-FILTER TYPES:**

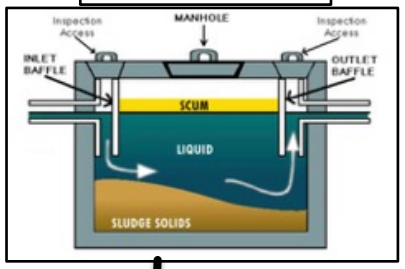
- Organic (UV absorbers)
- Mineral based (physical barriers)

Wastewater

Sewage / Wastewater Treatment Plant (WWTP)




Septic Tank




Groundwater

**SURFACE WATERS**

Sediment

**ORGANISM EXPOSURE**

**Point exposure from anthropogenic sources (e.g. bathers) is an important exposure pathway of UV filters**

**POINT EXPOSURE**

**OTHER UV-FILTER SOURCES:**

- **Storm-water and land run off**
- Industry; production of numerous products
- Landfill (from many products e.g. paints, plastics)
- Natural (plants and fungi), other?

## Take Home Messages

- UV filters are not just in sunscreens
- Multiple routes of UV filters into the Ocean

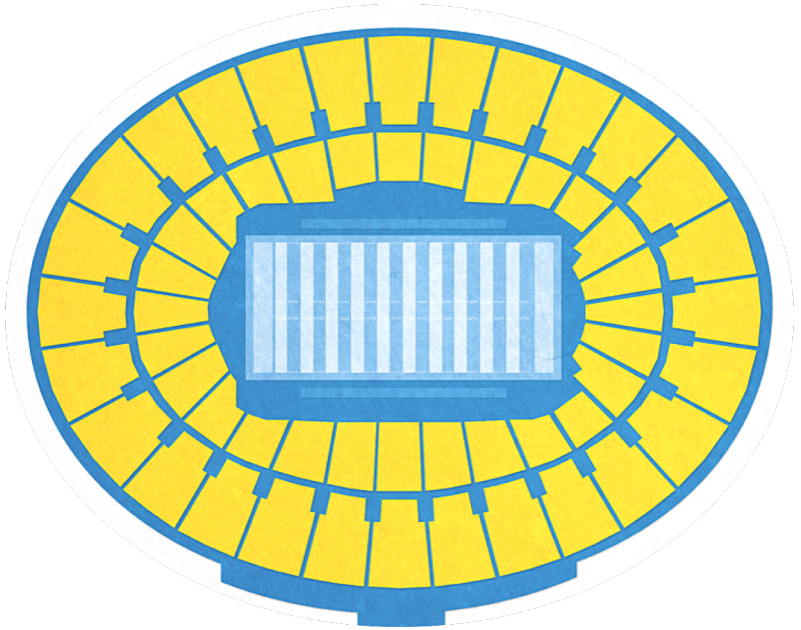
# How Does Science Measure Environmental Risk?

- Detection or presence of a chemical does **NOT** mean harm
- **Concentration and time** (duration) of exposure is critical to determine harm
- **Every chemical** is **TOXIC** at some concentration/dose
- So the **REAL question** to ask is: Does the coral get exposed to UV filters at toxic concentrations?

## WHAT IS A PART PER TRILLION?

nanograms/liter (ng $L^{-1}$)

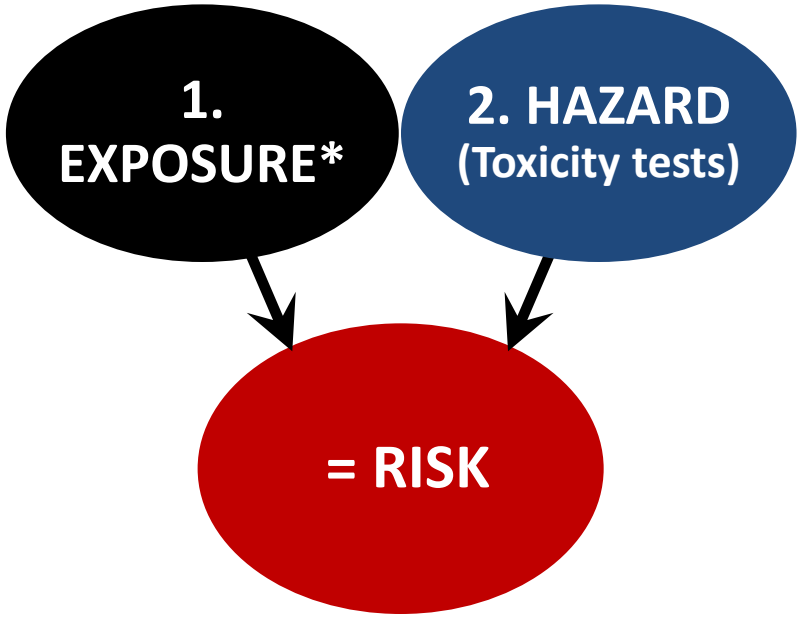
**= 10 drops added to the Rose Bowl**
(filled with water)



## HOW DO WE KNOW IF A CHEMICAL IS A PROBLEM?

## CONDUCT A RISK ASSESSMENT

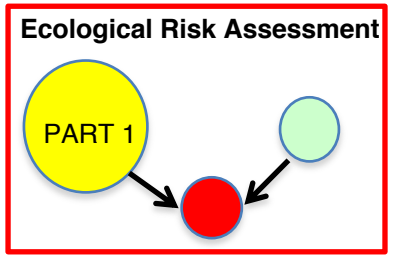
**(2 data sets needed)**




***: Environmental concentration (e.g. in seawater)**

# State of the Science for UV filters – Exposure Summary

**QUESTION:** What are the concentrations of oxybenzone (BP-3) and octinoxate (EHMC) in seawater near coral reefs?




- A few (<10) global studies on various UV filter concentrations in seawater, one study in coral
- Some show a link with/reflect recreational activity

## For Hawaii specifically:

- BP-3 one study, Oahu/Maui (Downs et al. 2016): 6 of 7 samples <Limit of quantitation (LOQ), one sample at 19,200 ng $L^{-1}$
- EHMC or other UV filters: no published studies
- No data on levels of UV filters in sediment or corals

## Take Home Messages:

- **Oxybenzone (BP-3):** Most concentrations in the ng $L^{-1}$ (**parts per trillion**), some µg $L^{-1}$ (parts per billion; ppb), one sample in US Virgin Island (USVI; at 1.395 mg $L^{-1}$ (ppm) from Downs et al. 2016).
- **Octinoxate (EHMC):** Very little data; most concentrations are non-detects or at ng $L^{-1}$ levels.
- **Variable concentrations** with;
  - Location (Vertical/horizontal)
  - Season (time of year/day)
  - Distance from shoreline
  - Depth (e.g. 30 times lower at coral depth than surface measurements; Tsui et al. 2017)
- Most studies are surface seawater, also n=1; **no replicates** (except one study is n=2).
- **Limited data for Hawaii** on BP-3 (one sample), **no** published data for EHMC : **SEVERE LACK OF DATA**

# JUST PUBLISHED (Mitchelmore et al. 2019): First COMPREHENSIVE Study ON UV FILTERS in Hawaii

- Robust, comprehensive sampling design; multiple and replicated samples; 19 sites measured in triplicate
- Measured UV filters in seawater, sediment and coral tissue (looked for 13 UV filters)
- Found very low levels of oxybenzone in seawater across all the sites – low parts per trillion concentrations (ng $L^{-1}$)
- Found **NO** measurable octinoxate levels in any of the 57 seawater samples

Science of the Total Environment 670 (2019) 398–410

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

## Occurrence and distribution of UV-filters and other anthropogenic contaminants in coastal surface water, sediment, and coral tissue from Hawaii

Carys L. Mitchelmore [a,*,1], Ke He [b,c,1], Michael Gonsior [a], Ethan Hain [b], Andrew Heyes [a], Cheryl Clark [a], Rick Younger [d], Philippe Schmitt-Kopplin [e,f], Anna Feerick [b], Annaleise Conway [a], Lee Blaney [b]

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[b] University of Maryland Baltimore County, Department of Chemical, Biochemical, and Environmental Engineering, 1000 Hilltop Circle, Engineering 314, Baltimore, MD 21250, USA
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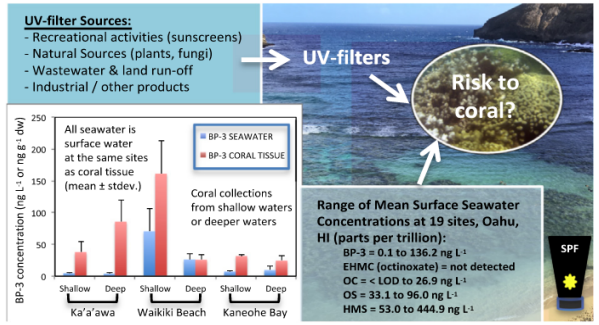
[f] Analytical Food Chemistry, Technische Universität München, Freising-Weihenstephan D-85354, Germany

### HIGHLIGHTS

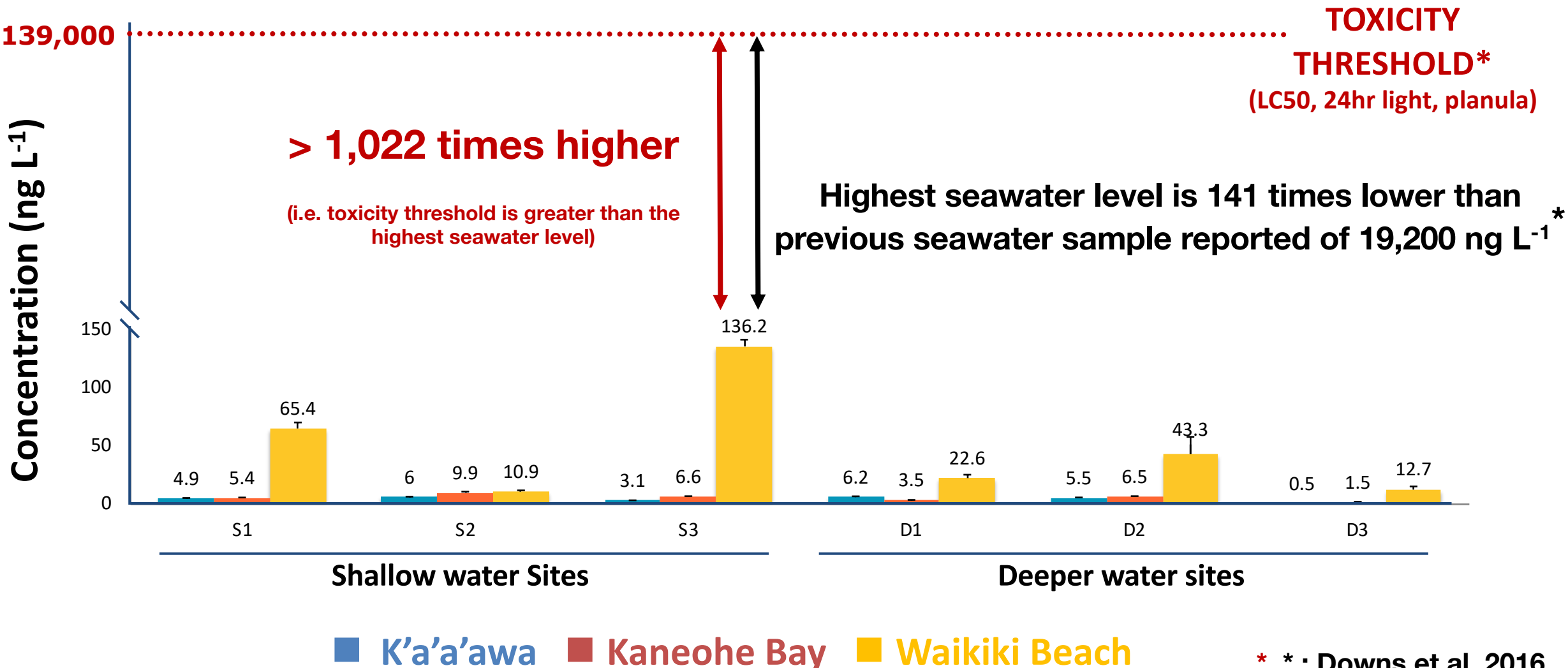
- First report of UV-filters in coral tissue from a USA coral reef.
- At least 8 UV-filters detected in matched surface seawater, sediment and coral tissue from 19 sites in Oahu, Hawaii.
- UV-filter concentrations in the parts per trillion (ng $L^{-1}$) in surface seawater and in ng $g^{-1}$ dw. in sediment and corals.
- Octinoxate, 11 hormones and sucralose were not detected in surface seawater but surfactant degradation products were.
- Overall highest UV-filter concentrations in all matrices were for homoslate and octisalate.

### GRAPHICAL ABSTRACT



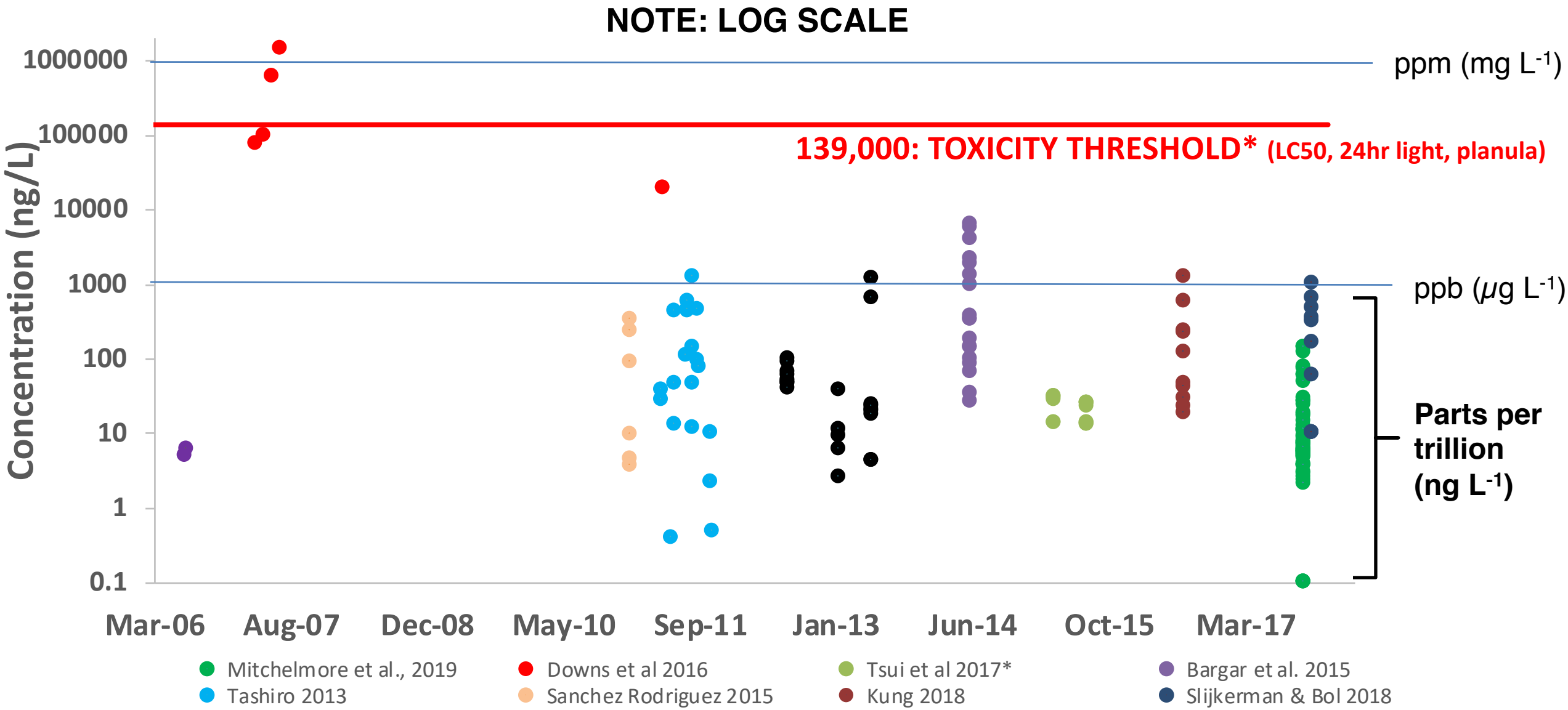
# VERY LOW LEVELS OF OXYBENZONE IN OAHU, HI SEAWATER: well below REPORTED harmful level TO CORAL

(average of n=3 samples / site, 19 sites; total 57 samples; October 2017: **Mitchelmore et al. 2019**)




* ,* : Downs et al. 2016

# Most Oxybenzone Seawater Concentrations From Global Reefs: Also well below reported harmful level to coral



# In summary: Oxybenzone risk to Hawaii Corals

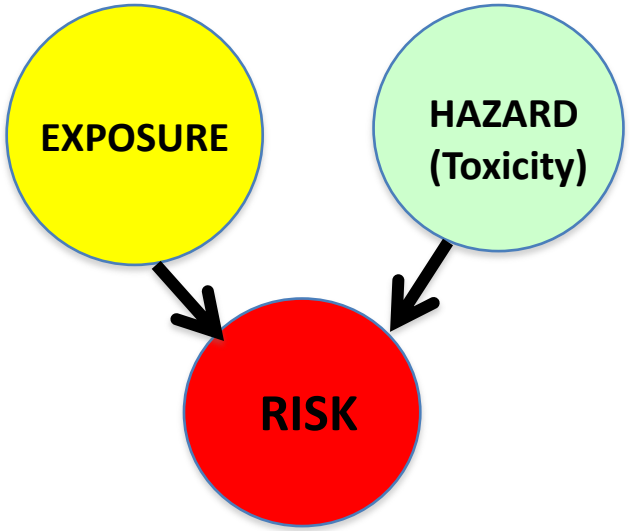
**HI Seawater Concentrations:**

(1) Mitchelmore et al. 2019

**0.2 to 136 ng $L^{-1}$ (n=19 in triplicate)**

(2) Downs et al. 2016

**19,200 ng $L^{-1}$ (n=1**; 6 other sites were < LOQ)




**Toxicity thresholds (2 studies):**

(1) Downs et al. 2016 (24 or 4 hour exposures)

**LC50 Planula: 139,000 ng $L^{-1}$**
(LC50 cell culture: 8,000 – 340,000 ng $L^{-1}$)

(2) He et al. 2019a (7 and 14-day exposures)

**LC50 larvae and nubbins ≥ 1,000,000 ng $L^{-1}$**
(2 coral species)

**Maximum Seawater concentrations:**
**136 to 19,200 ng $L^{-1}$**

**Toxicity Threshold values:**
**139,000 to ≥ 1,000,000 ng $L^{-1}$**

## TAKE HOME MESSAGE:

Using the highest oxybenzone level in seawater from Oahu, HI from Mitchelmore et al. 2019:

Seawater concentrations are at least **1,022 to 7,352 times LOWER** than reported harmful levels to intact coral (toxicity thresholds)

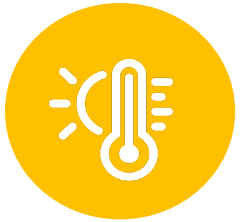
# UV FILTERS AND CORAL REEFS: KEY CONCLUSIONS

Coral reefs are in decline, **we need to protect them**

**Hundreds of chemicals are in seawater near reefs** ; many more toxic than UV filters

Major problems are **climate change, disease, excess sediments and nutrients**

**Very little evidence** that sunscreen UV filters are harming coral health, especially at environmentally relevant concentrations in seawater



**UV filters are not a priority risk** compared with other coral stressors (most studies show low and variable levels in seawater)

**Much more research is needed for an accurate environmental risk assessment** on UV filters and corals (and other chemicals too)

Questions? Please contact me: **mitchelmore@umces.edu**

# References for PART 1: Environmental Exposure

## (i.e. seawater concentrations of oxybenzone, octinoxate near corals)


**1. Bargar, T.A., et al. 2015.** Synthetic ultraviolet light filtering chemical contamination of coastal waters of Virgin Islands national park, St. John, U.S. Virgin Islands. Marine Pollution Bulletin, 101, 1, 193-199.

**2. Downs C.A., et al. 2016.** Toxicopathological effects of the sunscreen UV filter, Oxybenzone (benzophenone-3), on coral planulae and cultured primary cells and its environmental contamination in Hawaii and the U.S. Virgin Islands. Arch. Environ. Contam. Toxicol. 70, 2, 265-288.

**3. Goksoyr, A., et al. 2009.** Balsa Raft Crossing the Pacific Finds Low Contaminant Levels. ES&T, 43, 13, 4783-4790.

**4. Kung, T.A. et al. 2018.** Survey of selected personal care products in surface water of coral reefs in Kenting National Park, Taiwan. STOTEN, 635, 1302-1307.

**5. Sánchez Rodríguez, A. et al. 2015.** Occurrence of eight UV filters in beaches of Gran Canaria (Canary Islands). An approach to environmental risk assessment. Chemosphere, 131, 85–90.

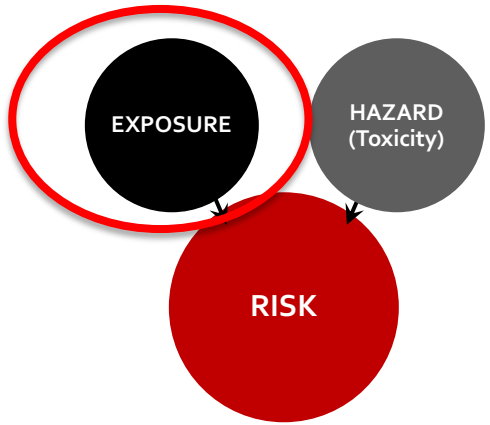
**6. Tashiro Y. & Kameda, Y. 2013.** Concentration of organic sun-blocking agents in seawater of beaches and coral reefs of Okinawa Island, Japan. Mar. Pollut. Bull. 77, (1-2), 333-340.

**7. Tsui M.M.P., et al. 2017.** Occurrence, distribution and fate of organic UV filters in coral communities. Environmental Science and Technology. 51, 8, 4182-4190.

**8. Tsui M.M. et al. 2014**. Occurrence, distribution and ecological risk assessment of multiple classes of UV filters in surface waters from different countries. Water Res. 67, 55-65.

**NEW STUDY:**

**9. Mitchelmore et al. 2019.** Occurrence and distribution of UV-filters and other anthropogenic contaminants in coastal surface water, sediment, and coral tissue from Hawaii. Science of the Total Environment, 670, 398-410.


References as of February, 2019

# References for PART 2: Hazard (Toxicity)

## (i.e. toxicity studies of oxybenzone and octinoxate in corals)


**1. Danovaro R., et al. 2008.** Sunscreens cause coral bleaching by promoting viral infections. Environ. Health. Perspect. 116 (4), 441-447. (oxybenzone and octinoxate; also products*)

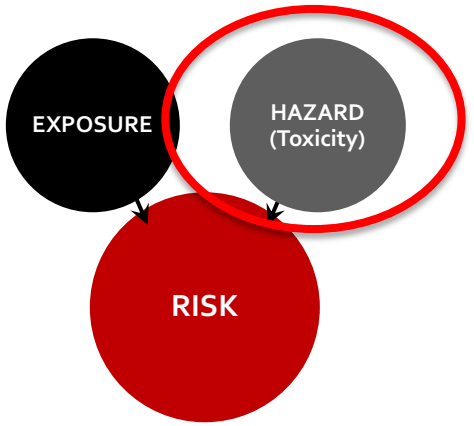
**2. Downs C.A., et al. 2016.** Toxicopathological effects of the sunscreen UV filter, Oxybenzone (benzophenone-3), on coral planulae and cultured primary cells and its environmental contamination in Hawaii and the U.S. Virgin Islands. Arch. Environ. Contam. Toxicol. 70, 2, 265-288. (oxybenzone)

**3. He, T., et al. 2019a**. Comparative toxicities of four benzophenone ultraviolet filters to two life stages of two coral species. STOTEN, 651, 2391–2399. (oxybenzone)

**4. He, T., et al. 2019b.** Toxicological effects of two organic ultraviolet filters and a related commercial sunscreen product in adult corals. Environ. Pollut., 245, 462-471. (octinoxate; also products*)

NOTE: also a study in soft coral (Xenia sp.) but product only (contains oxybenzone and other UV filters:

**5. *McCoshum, S. M. et al. 2016.** Direct and indirect effects of sunscreen exposure for reef biota. Hydrobiologia, 776, (1), 139–146. (product contains oxybenzone)


*: Sunscreen Product (not individual UV filter)

References as of February, 2019