

**Local pollution factors reduce the resiliency
of coral reefs:
what they are and what to do about them.**

Fighting to Save Hawaii's Coral Reefs

**Craig A. Downs, PhD.
Executive Director
Haereticus Environmental
Laboratory**



What is at risk?

- Tourism Industry
- Restaurant Industry
- Recreational Industry
- Property Values
- Tax Revenue
- Cultural History/Identity
- Reputation
- Feedback Corruption
- Legacy



Carysfort Reef 1975



Carysfort Reef 1985



Carysfort Reef 2004



Carysfort Reef 2014

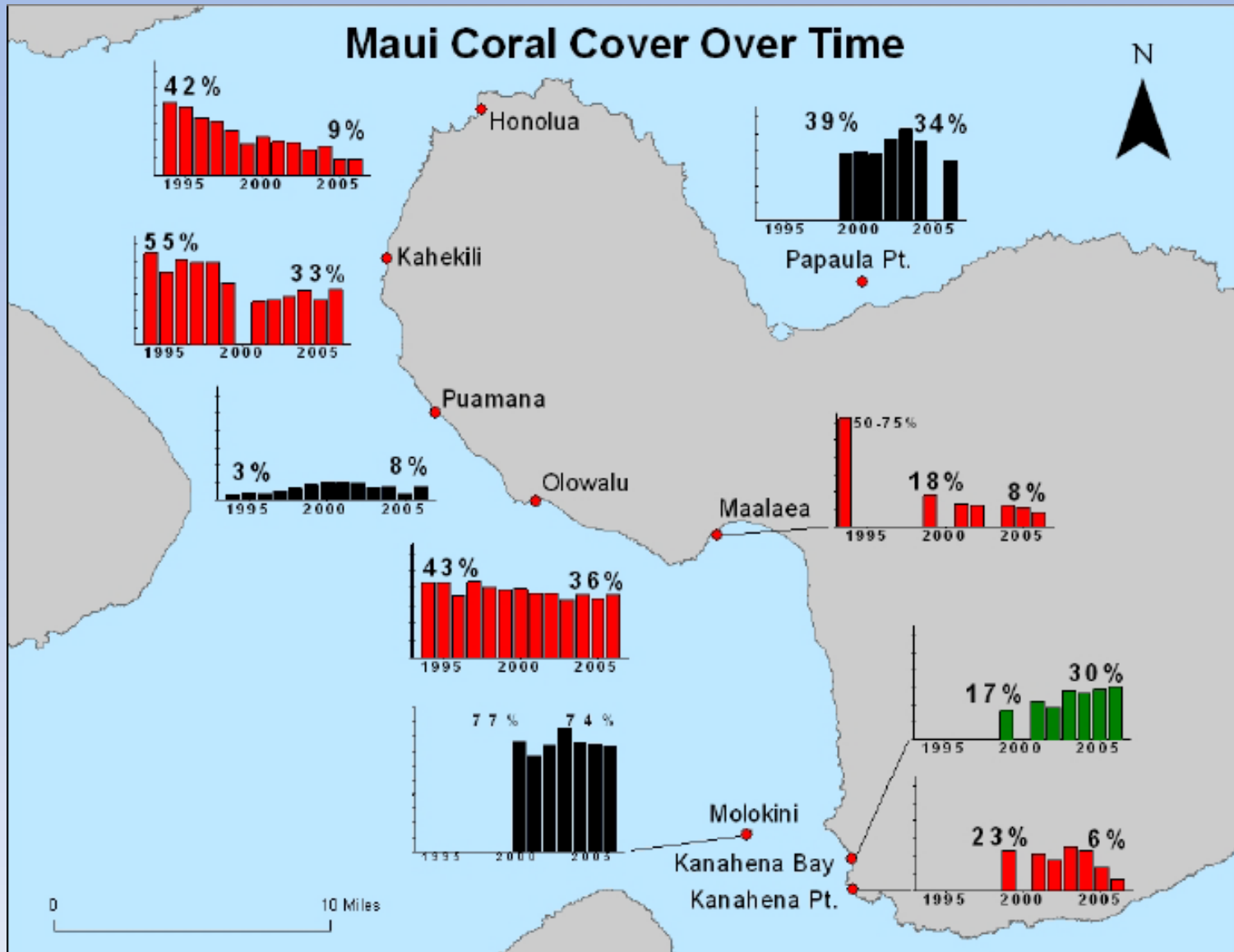


Photos courtesy of Dr. Phil Dustan



Disappearing Coral Reefs

Slow, almost imperceptible decline



Big Mama

Olowalu, Maui





Healthy

Recruitment/Growth



Death Rate

Coastal Reefs near populated areas

Death Rate



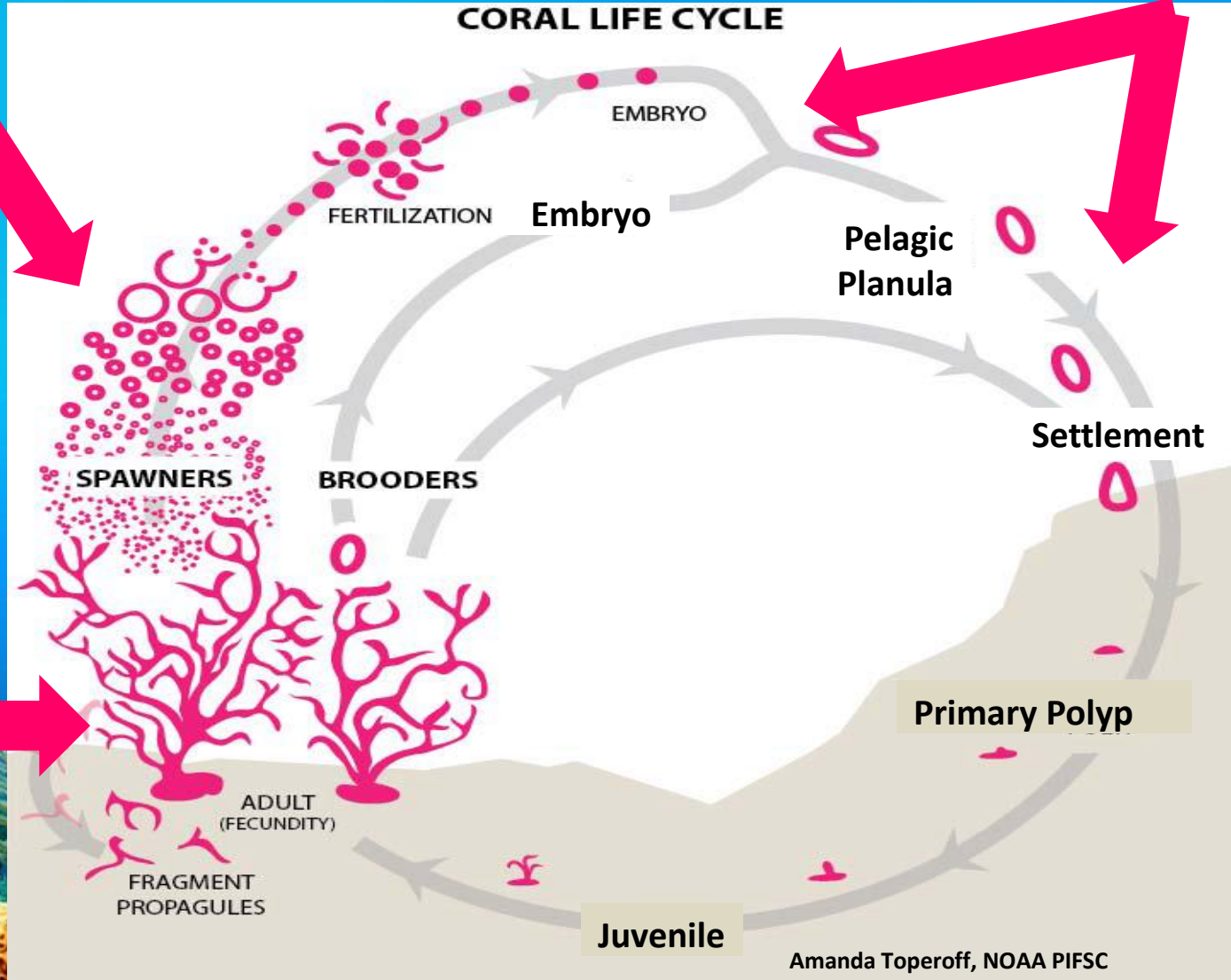
Recruitment/Growth



Reproductive Failure

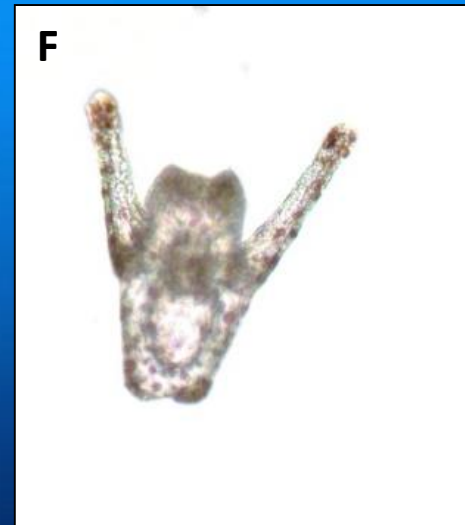
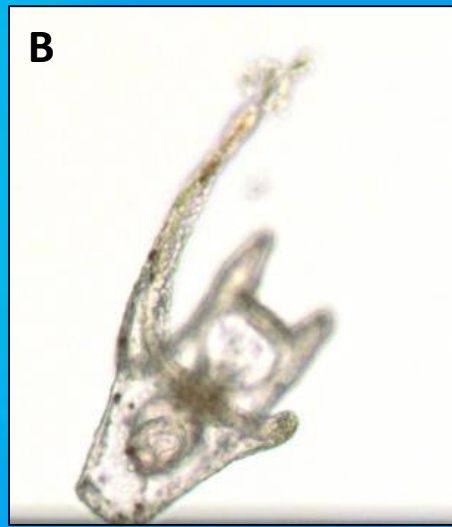
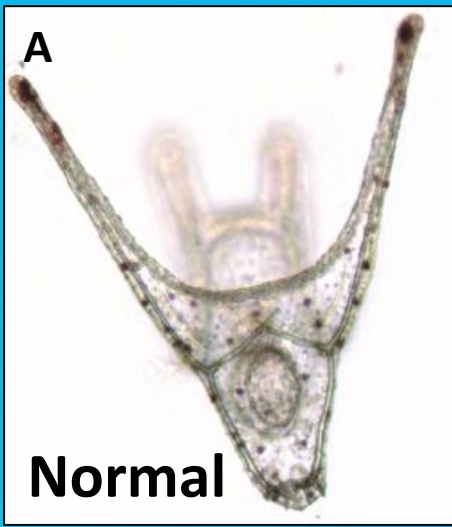
Developmental Defects

CORAL LIFE CYCLE



Allee Effect

Amanda Toperoff, NOAA PIFSC



From a demographic and evolutionary perspective, populations with little to no recruitment are the 'living dead'---

Coral Reef Zombies



- Sea urchins
- Fish
- Shrimp/crabs
- Sea grass

Carysfort Reef 1975



Carysfort Reef 1985



Carysfort Reef 2004



Carysfort Reef 2014



Photos courtesy of Dr. Phil Dustan

Disappearance of reefs

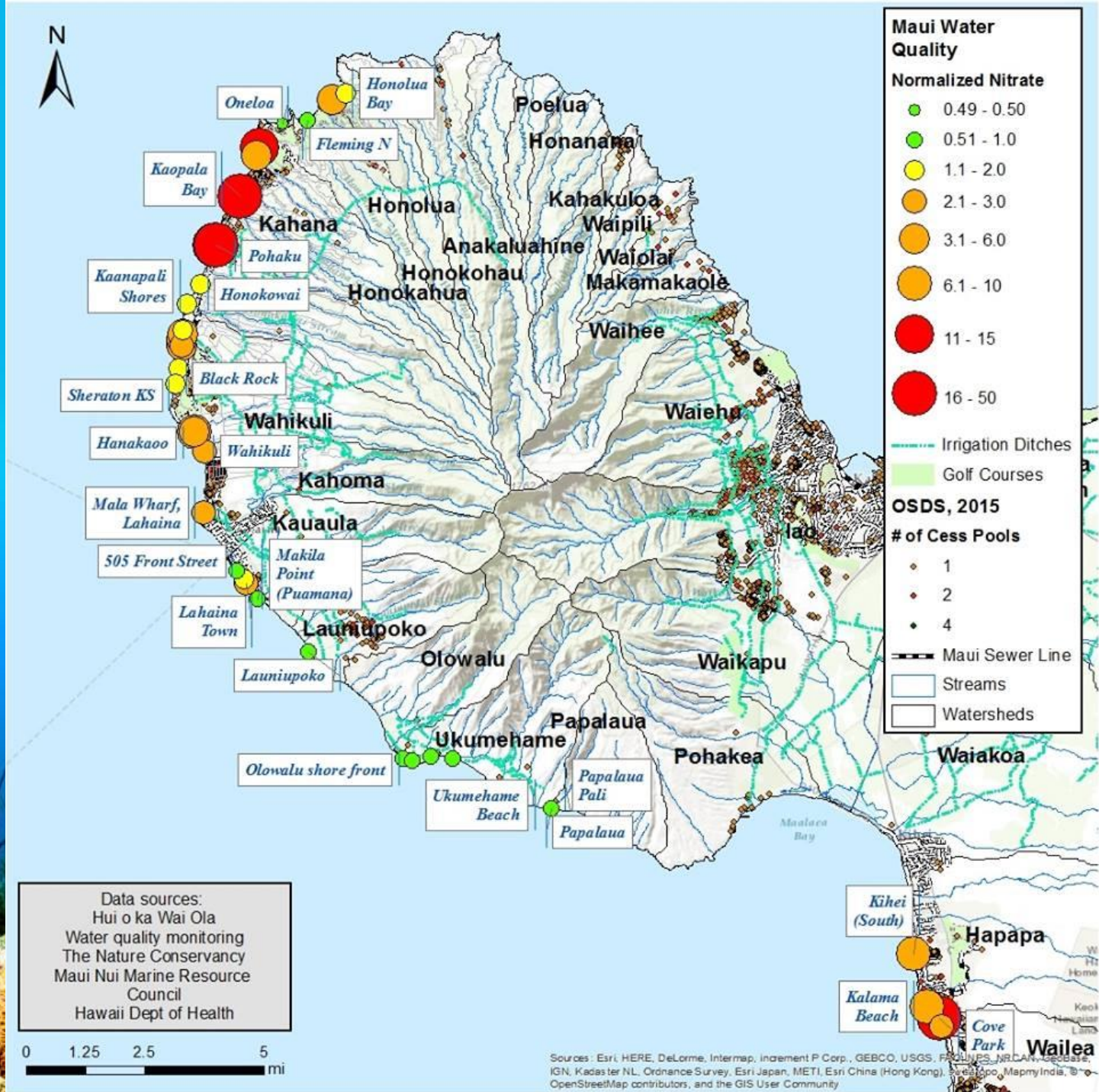
Understanding how it is happening will allow us to:

1. Identify the Stressors
2. Mitigate the Stressors
3. Restore Coral Reefs



Hawaii's Local Pollution Factors that could be Impacting Coral Reefs

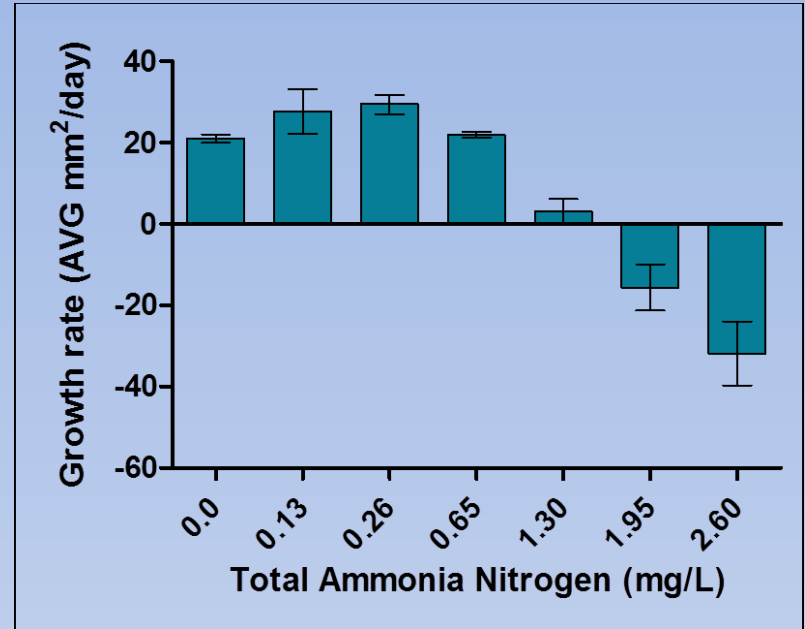




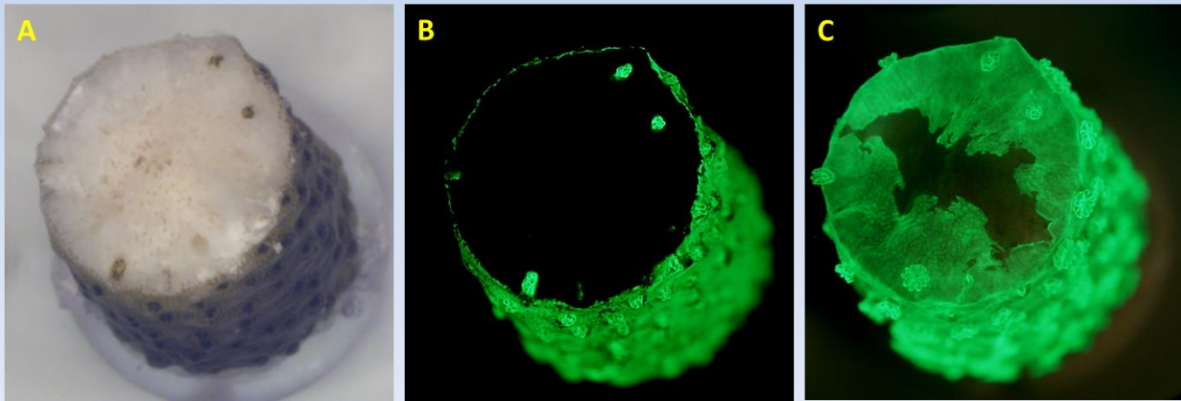
Factors that reduce coral homeostasis (resiliency) to heat stress events (e.g., El Niño event)



Prof. Wiegner et al., UH-Hilo



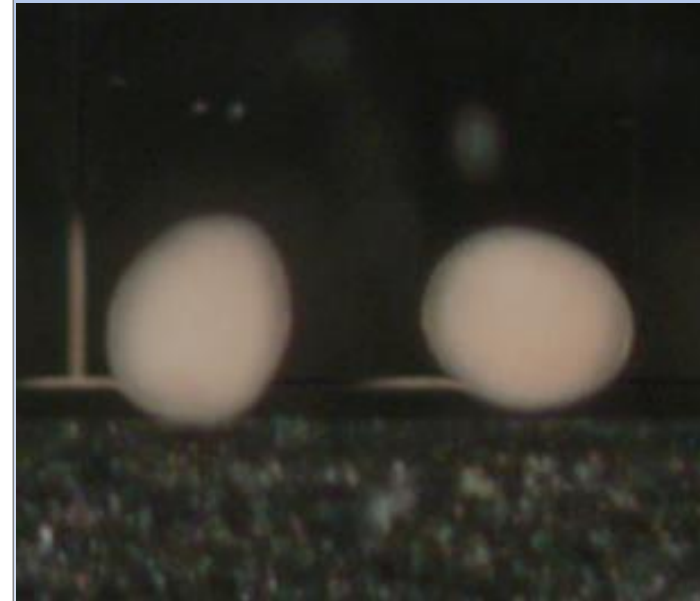
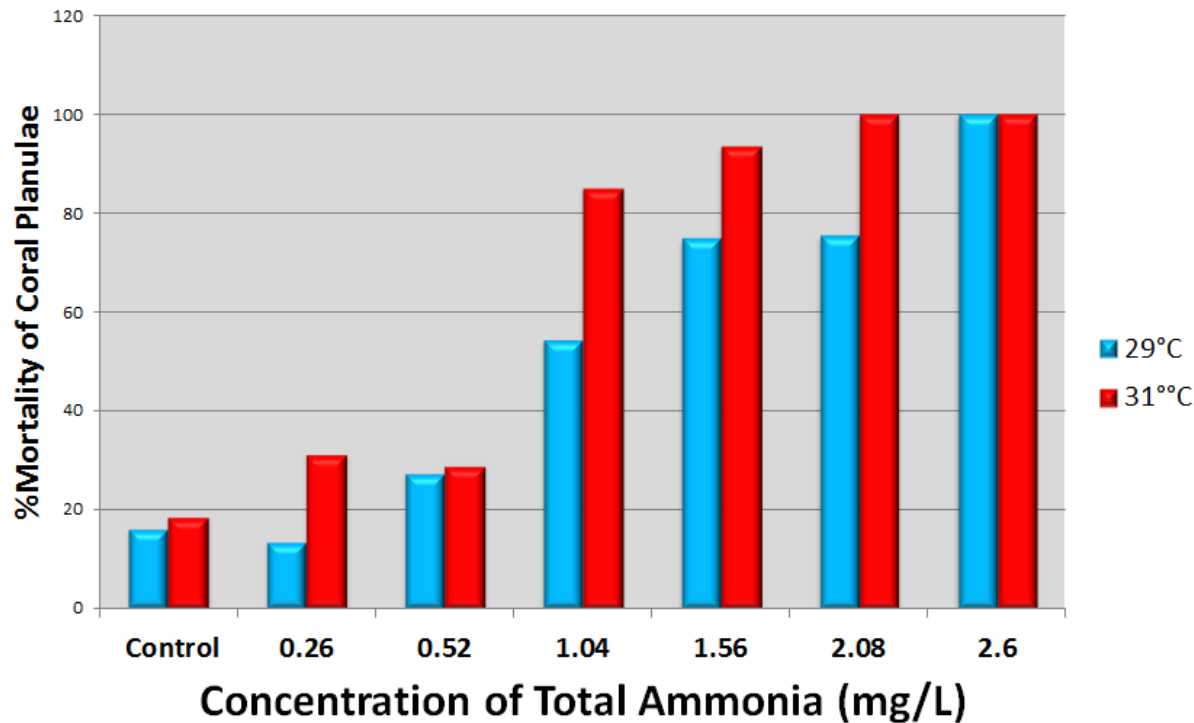
Sewage (Ammonia Nitrogen) at high concentrations reduces the ability of coral to heal or grow



Factors that reduce coral homeostasis (resiliency) to heat stress events (e.g., El Niño event)

El Niño thermal sea-surface temp. events induces significantly more mortality when exposed to Total Ammonia

Acropora palmata Planula Toxicity Test



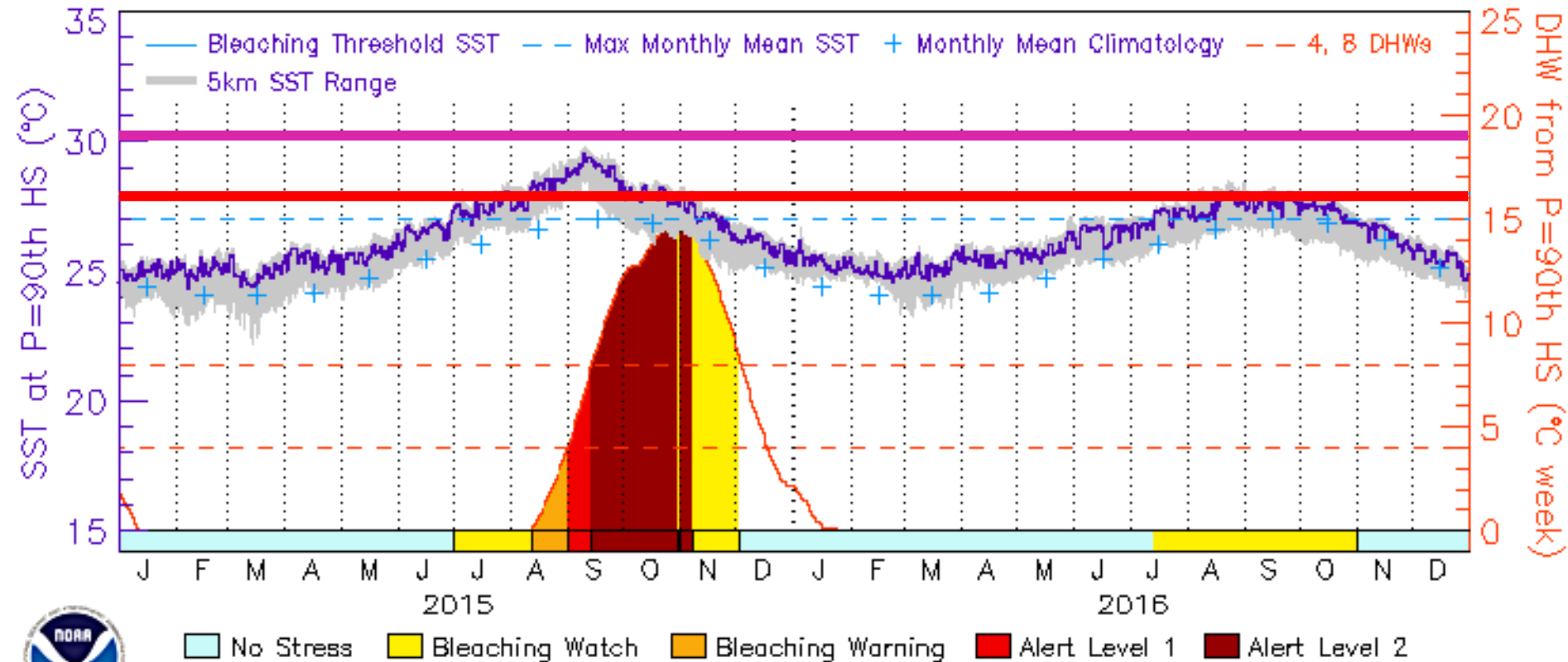
NOAA Bleaching Alert

NOAA's Definition of Bleaching Threshold:

When corals start to become stressed when the SST is 1°C warmer than the highest monthly mean temperature

Glynn & D'Croz, 1990. Experimental evidence for high temperature stress as the cause of El Niño coincident coral mortality. *Coral Reefs*, 8, 181-191.

Main Hawaiian Islands





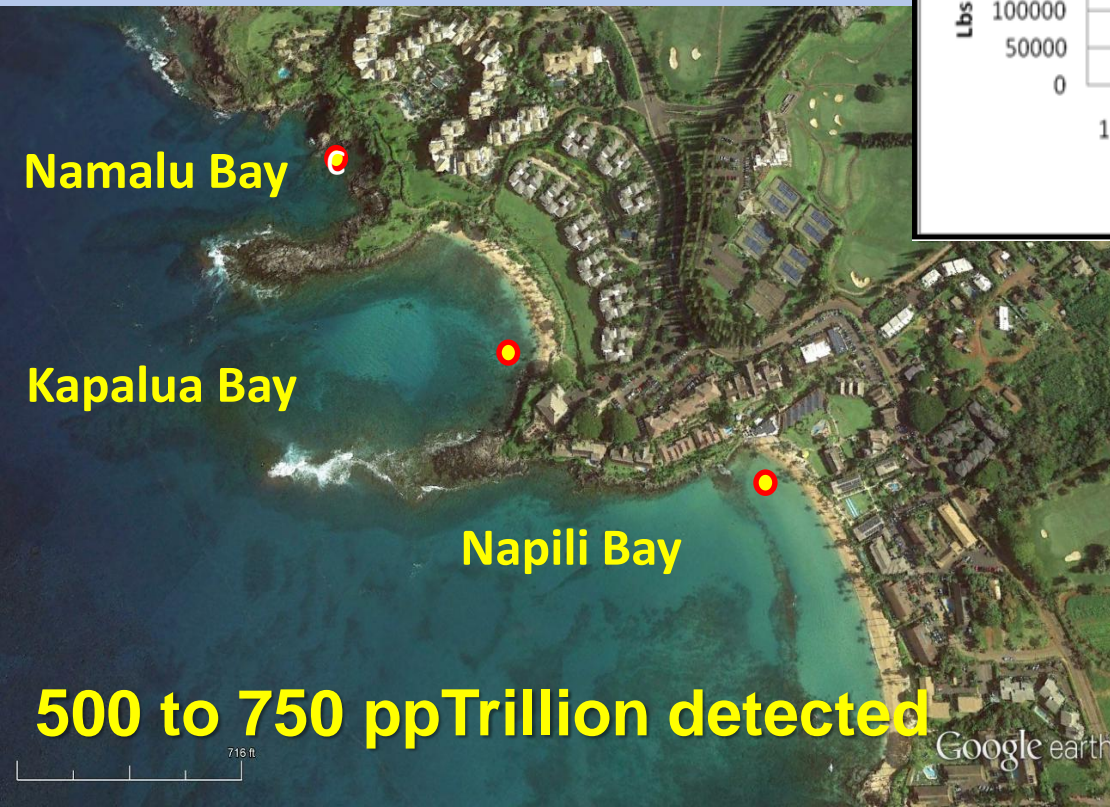
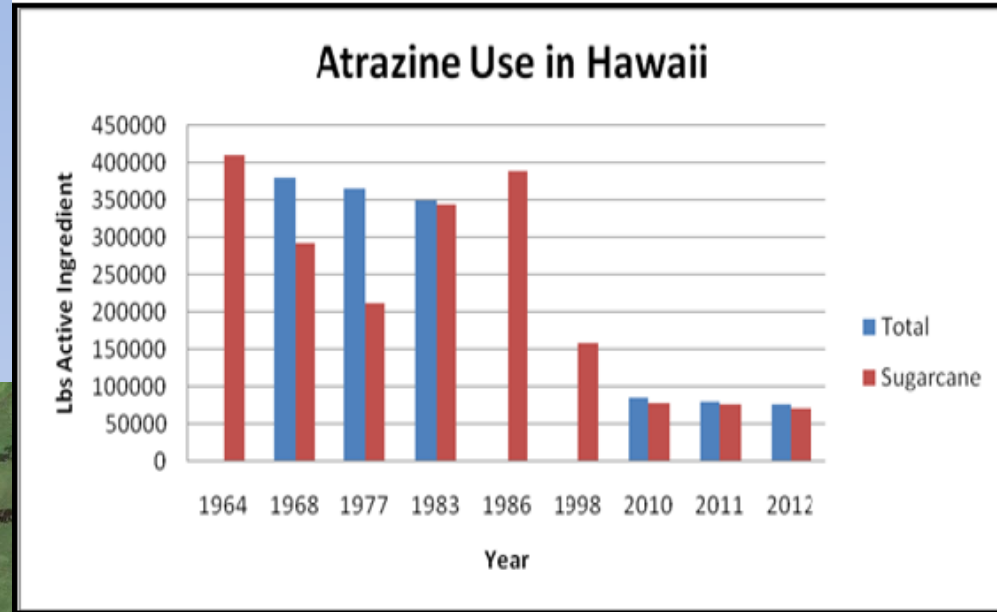
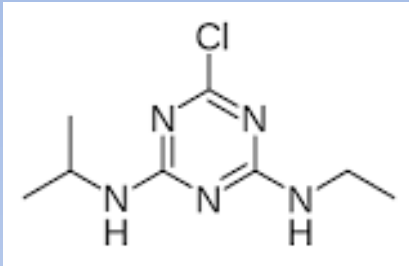
Coral bleaching has been attributed to a variety of disturbances:

- high and low temperature,
- subaerial exposure,
- calm sea conditions,
- freshwater dilution,
- High and low turbidity,
- sedimentation,
- high and low light levels & UV radiation,
- parasite infections, and
- **pollutants**

(Brown 1987; Ogden and Wicklund 1988; Williams and Bunkley-Williams 1988; Coffroth et al., in press).

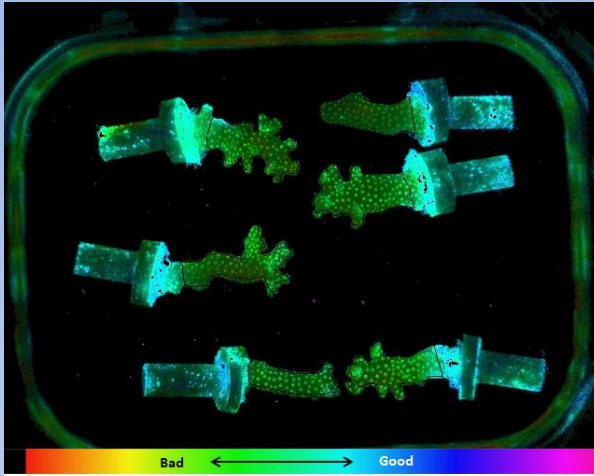
Factors that reduce coral homeostasis (resiliency) to heat stress events (e.g., El Niño event)

Atrazine Pollution

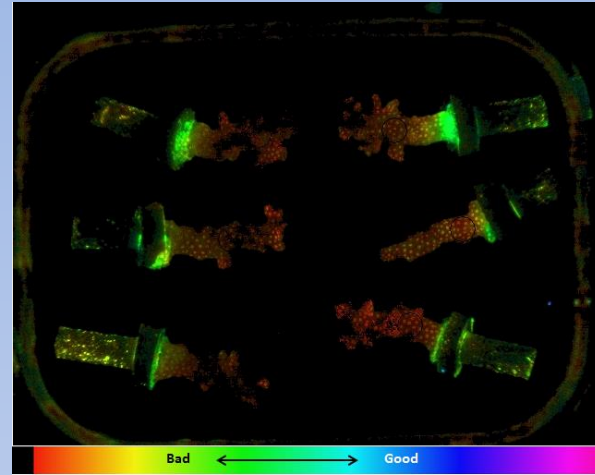


Factors that reduce coral homeostasis (resiliency) to heat stress events (e.g., El Niño event)

Control



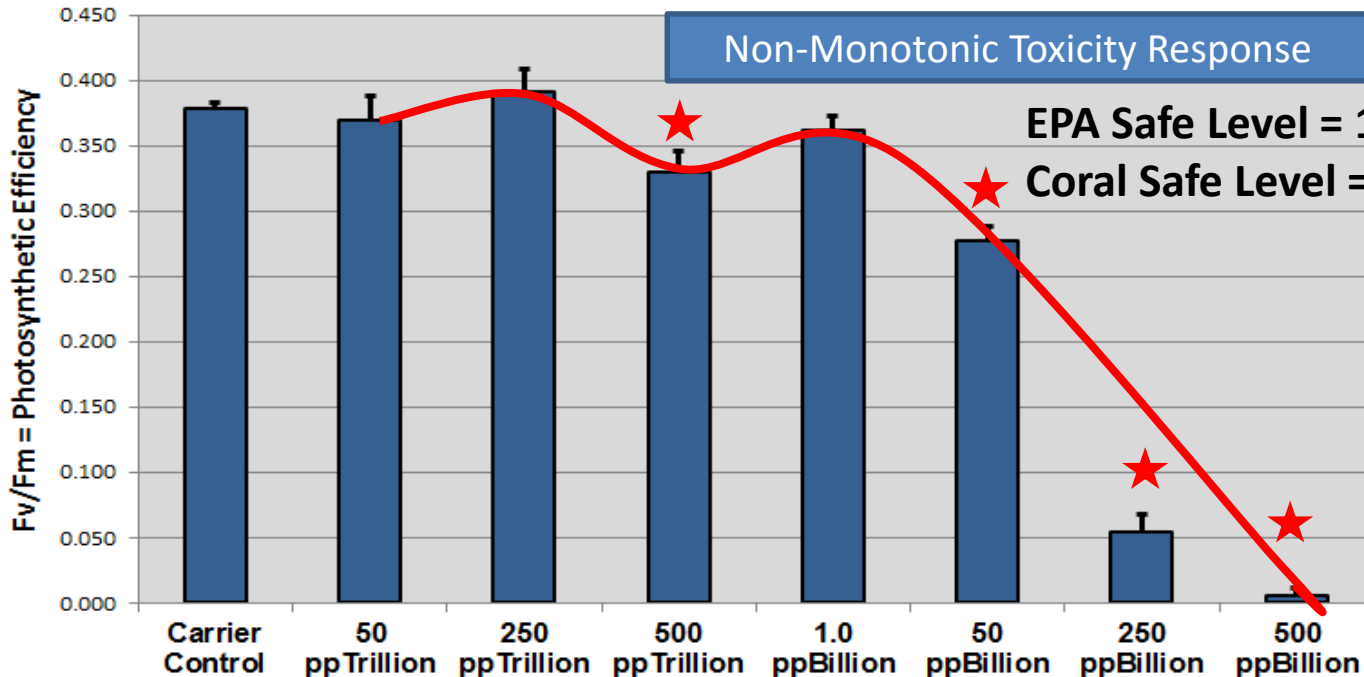
Atrazine



25°C

Atrazine Exposure - *Pocillopora damicornis*

96 hours



What can we do to mitigate these factors?

Do we *even try* to mitigate these factors?

or

Do we ignore the pollution and the reef decline?

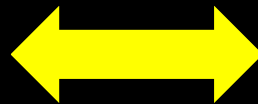
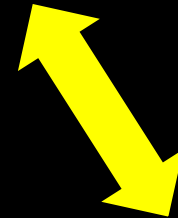
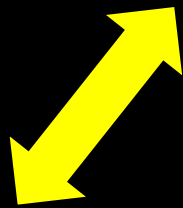
“A claimed lack of a specific proof on the issue has led to a policy of no response. As such, “science” is used as an excuse to postpone management and mitigation responses”

-Dr. Robert Richmond





**(Forensics)
Natural Resource
Damage
Assessment**



Anti-foulant Booster Biocides:

Irgarol 1051

- Herbicide
- Water-soluble
- Triazine compound, related to atrazine

West Marine
We make boating more fun!

3 DAY SALE!
FRI-SUN, MARCH 22ND-24TH
\$20 OFF ALL BOTTOM PAINT

PETTIT
marine paint
154⁹⁹ /gal.
Trinidad SR Antifouling Paint
Dual-biocide, modified-epoxy paint with 2% Ciba Irgarol to prevent slime growth and 70% CuOx content. Available in blue, black and red. Gallon.
Ref. Model 143474



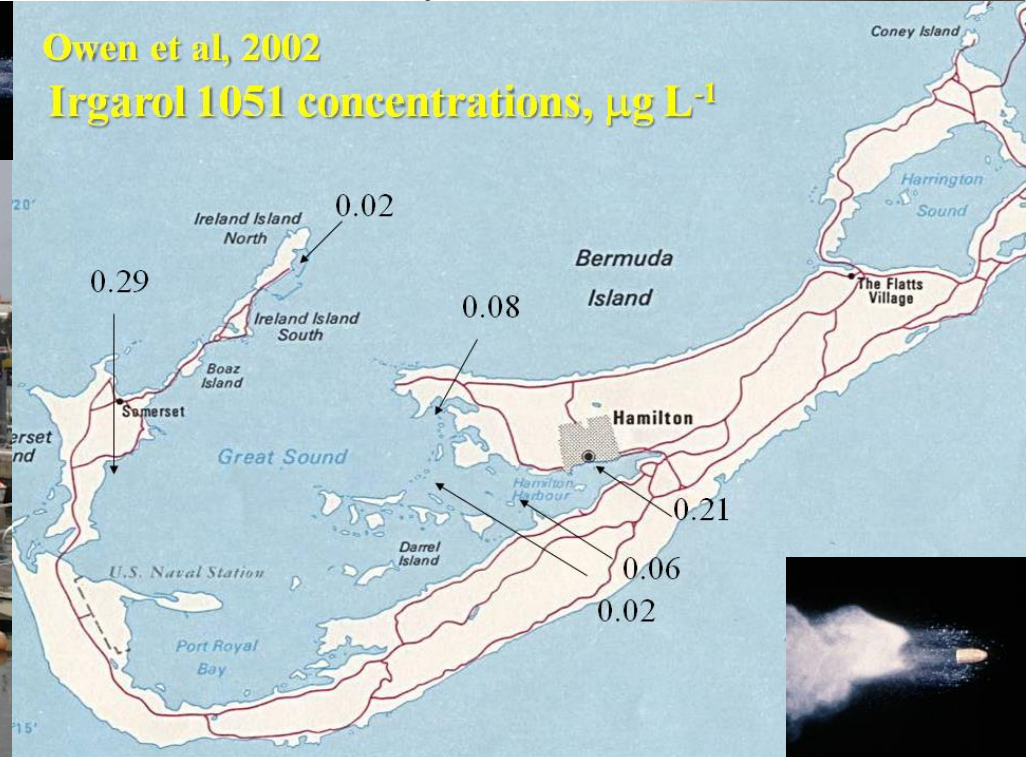
Interlux
174⁹⁹ /gal.
CSC Plus
Combines Biolux slime-blocker along with 39% cuprous oxide (CuOx) to achieve ablative protection against shell, weed and slime fouling. CSC Plus offers multi-season protection. In blue and black. Gallon.
Ref. Model 2674521



Hamilton,
Bermuda

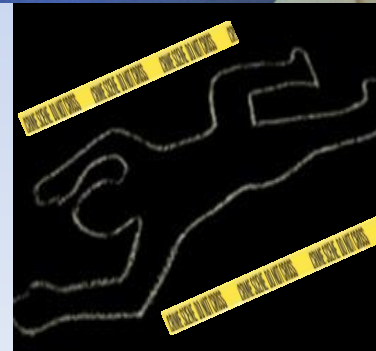
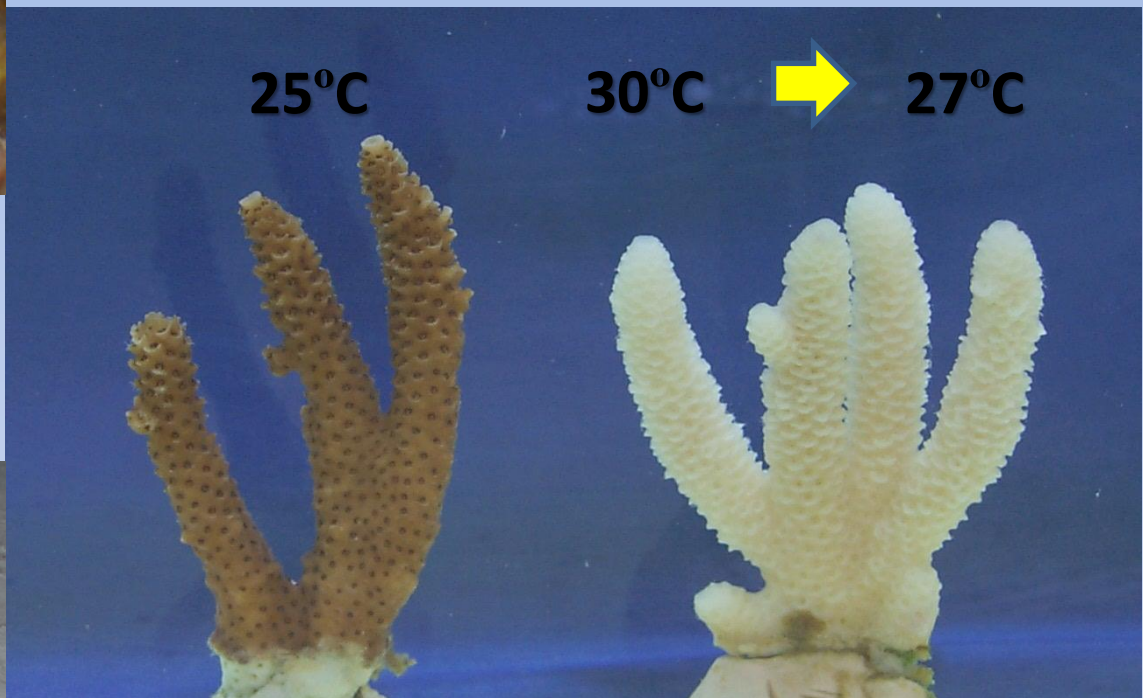


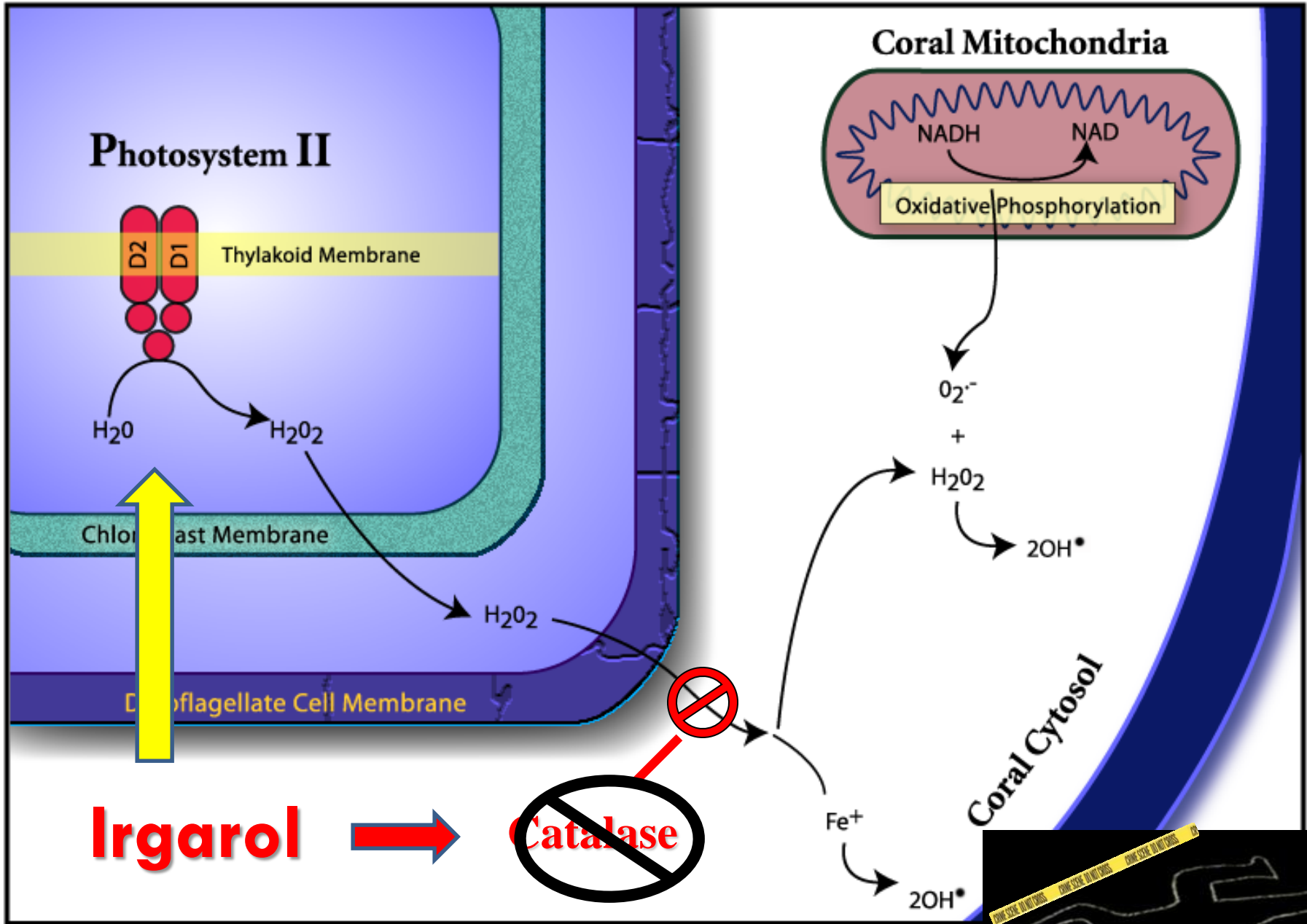
Owen et al, 2002
Irgarol 1051 concentrations, $\mu\text{g L}^{-1}$





Irgarol lowers the temperature in which corals bleach





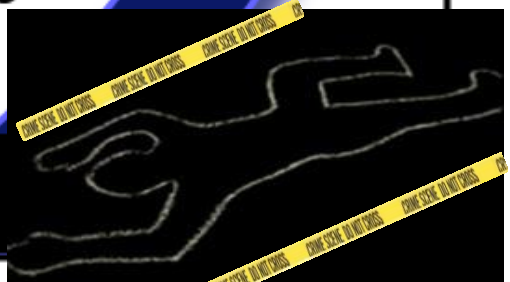
Irgarol

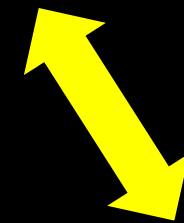
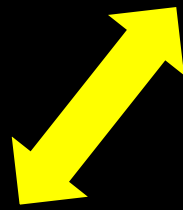


Catalase



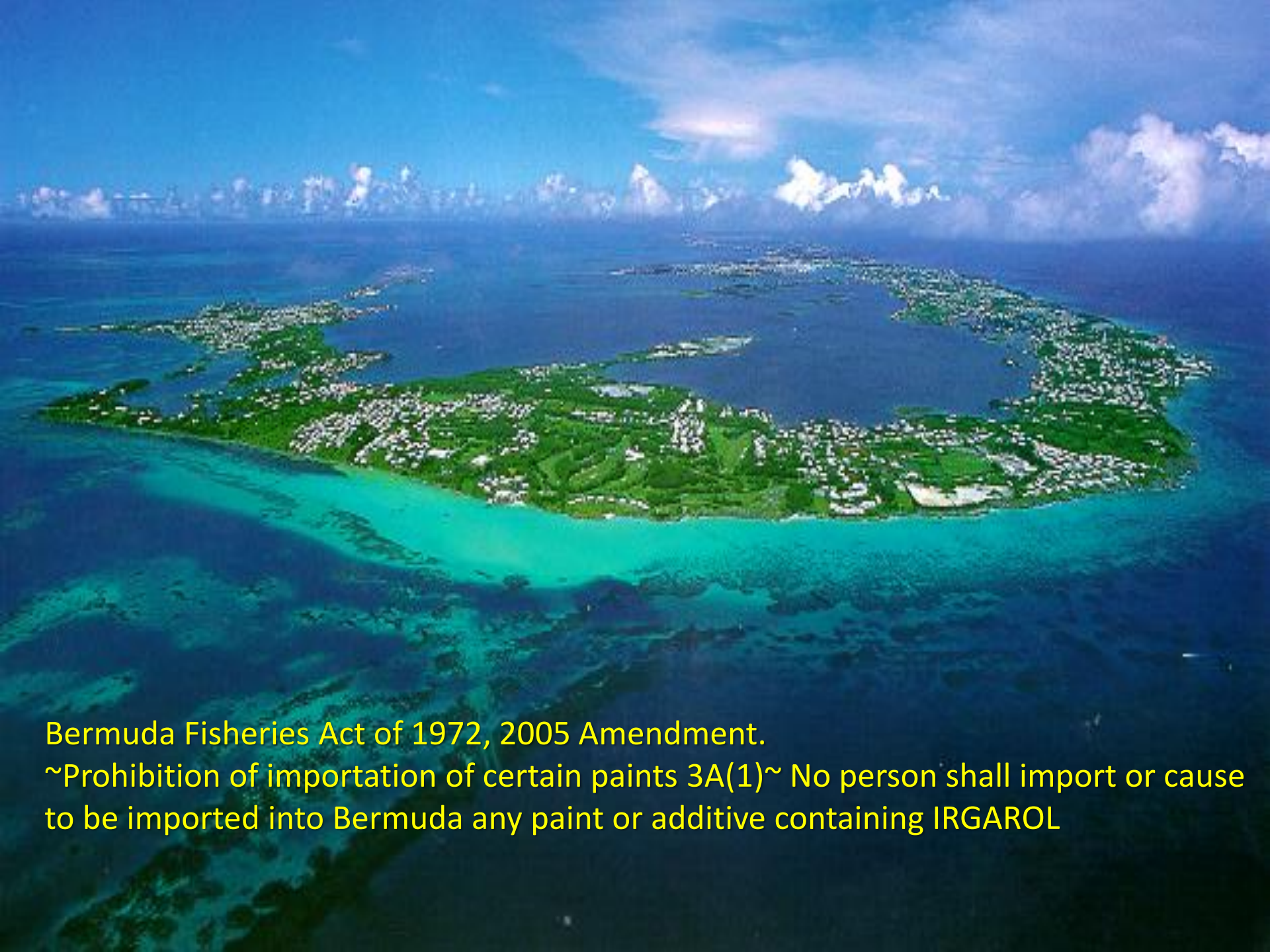
Oxidative Theory of Coral Bleaching





Crime Scene Investigation Coral Reefs



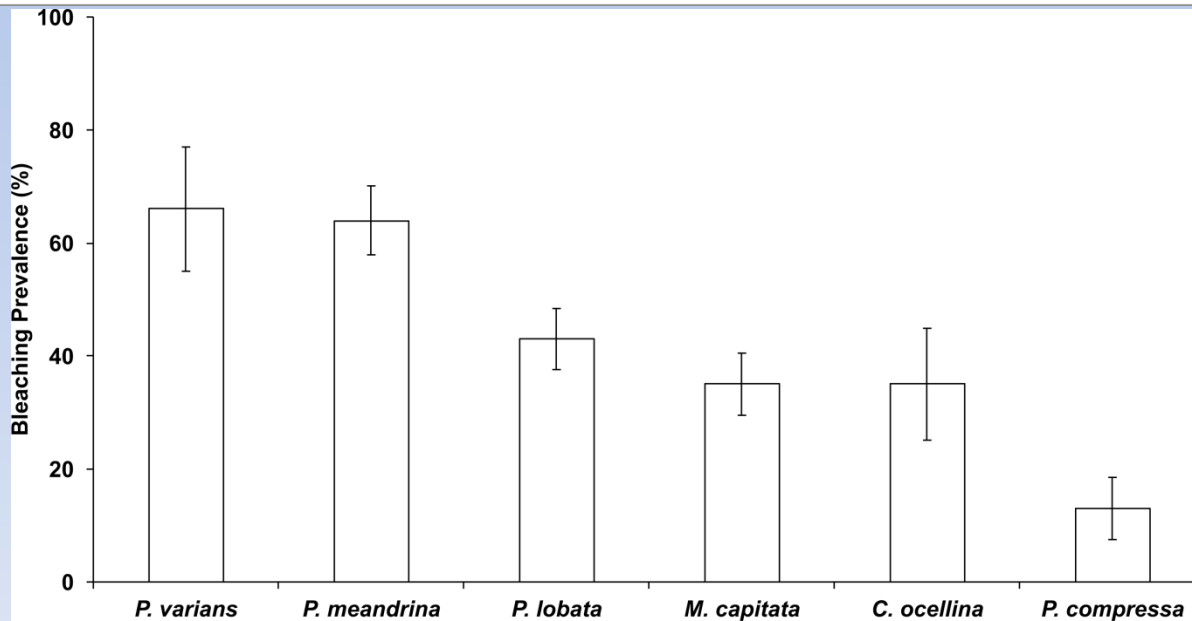
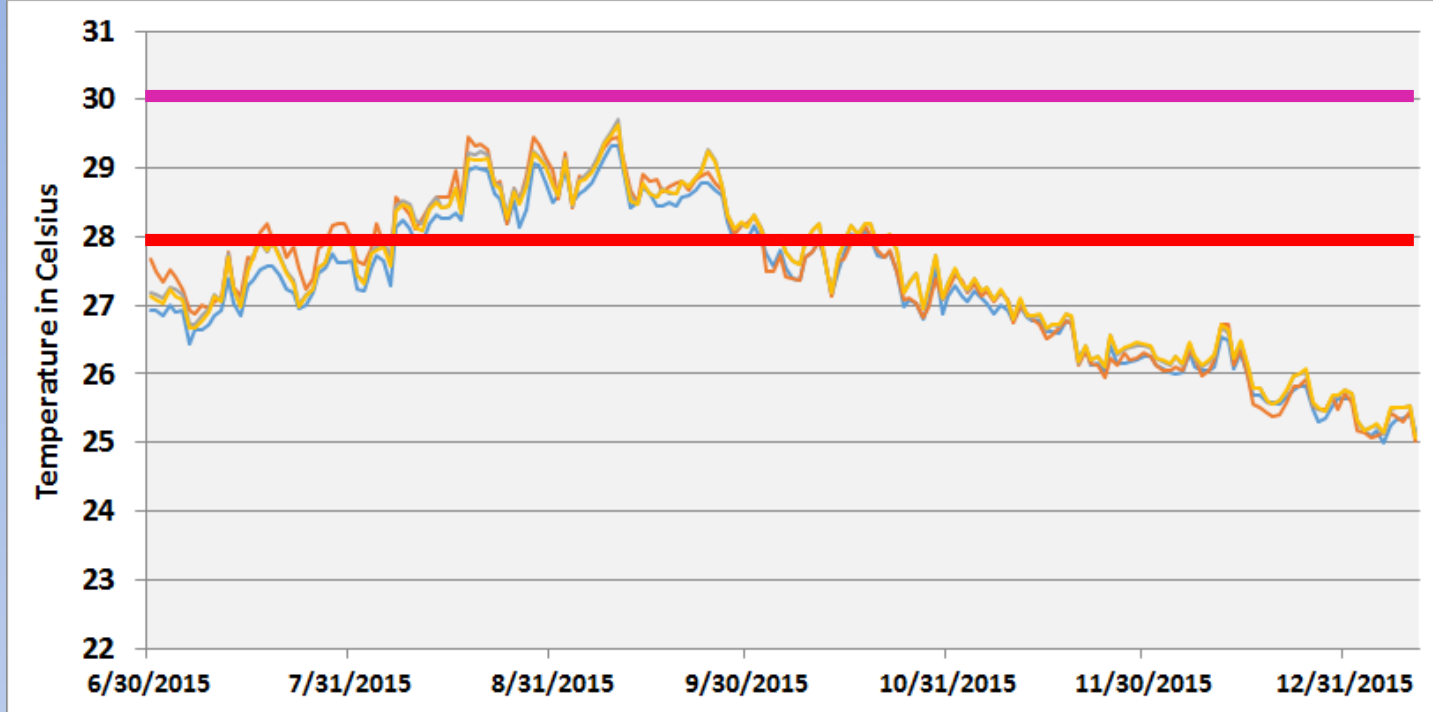


Bermuda Fisheries Act of 1972, 2005 Amendment.

~Prohibition of importation of certain paints 3A(1)~ No person shall import or cause to be imported into Bermuda any paint or additive containing IRGAROL

Hanauma Bay Nature Preserve





Rodgers KS, Bahr KD, Jokiel PL, Richards Donà A. (2017) Patterns of bleaching and mortality following widespread warming events in 2014 and 2015 at the Hanauma Bay Nature Preserve, Hawai'i. PeerJ 5:e3355 <https://doi.org/10.7717/peerj.3355>



Honour Booth survey - > 1,500 pptrillion Oxybenzone



source: bridgemedia

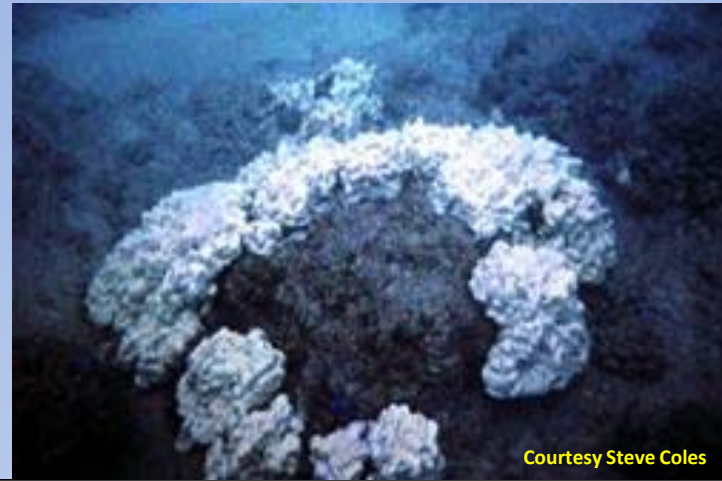
Hanauma Bay

(2015 averaged 2,600 swimmers/day)

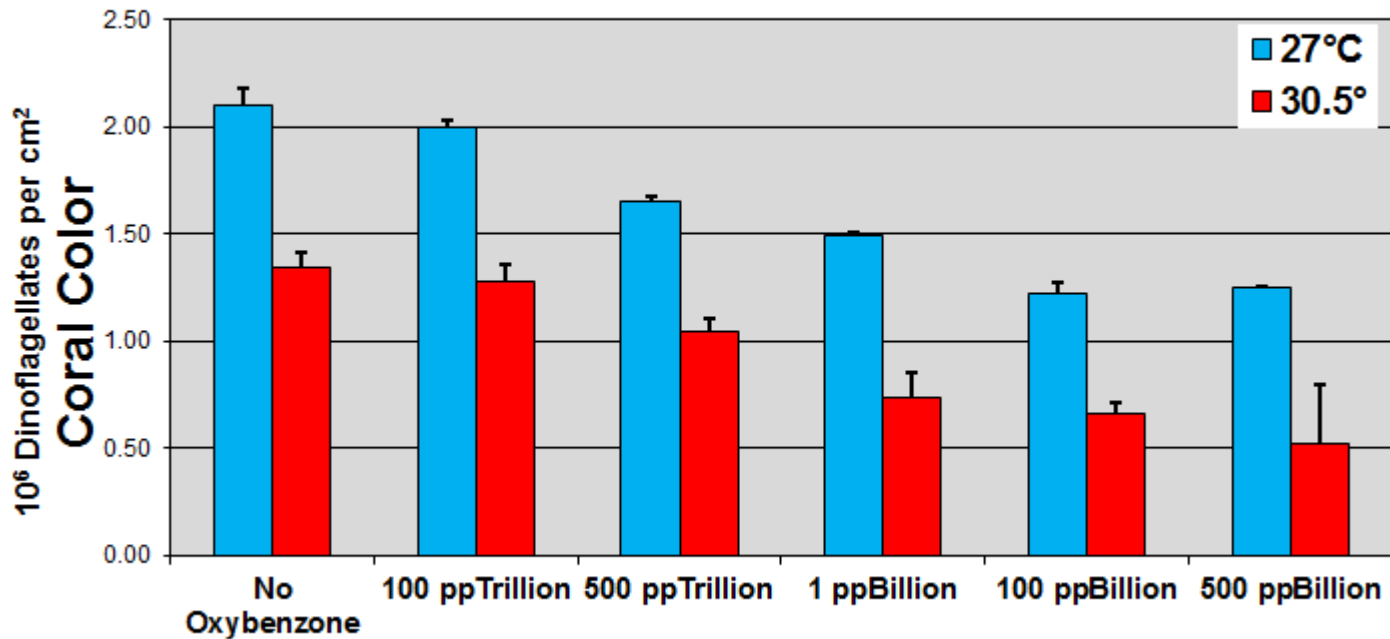


- = 187 kilograms of sunscreen lotion a day. 78 grams per person**
- = 5.61 kilograms of oxybenzone a day (3% oxybenzone).**
- = 168 kilograms of oxybenzone per month (~370 pounds per month)**
- = 68,255 kilograms of sunscreen product per year (150,476 lbs/year)**
- = 2,048 kilograms of oxybenzone per year (4,515 pounds /year)**

Factors that reduce coral homeostasis (resiliency) to heat stress events (e.g., El Niño event)



Coral Bleaching in the presence/absence of Oxybenzone



Drug Facts

Active Ingredients

Avobenzone 2.0%, Homosalate 10.0% }
Octisalate 5.0%, Octocrylene 2.0%, Oxybenzone 5.0% }

Use

• helps prevent sunburn

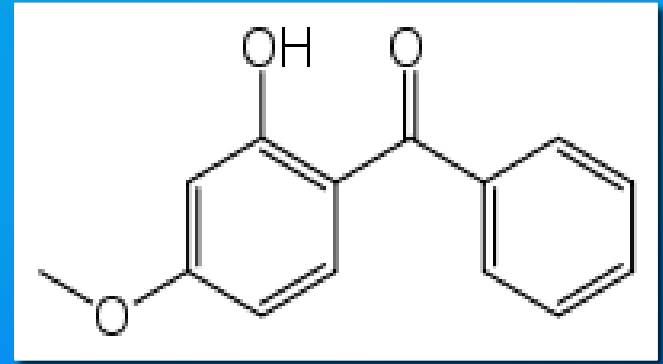
• if used as directed with other sun protection measures (see Directions)



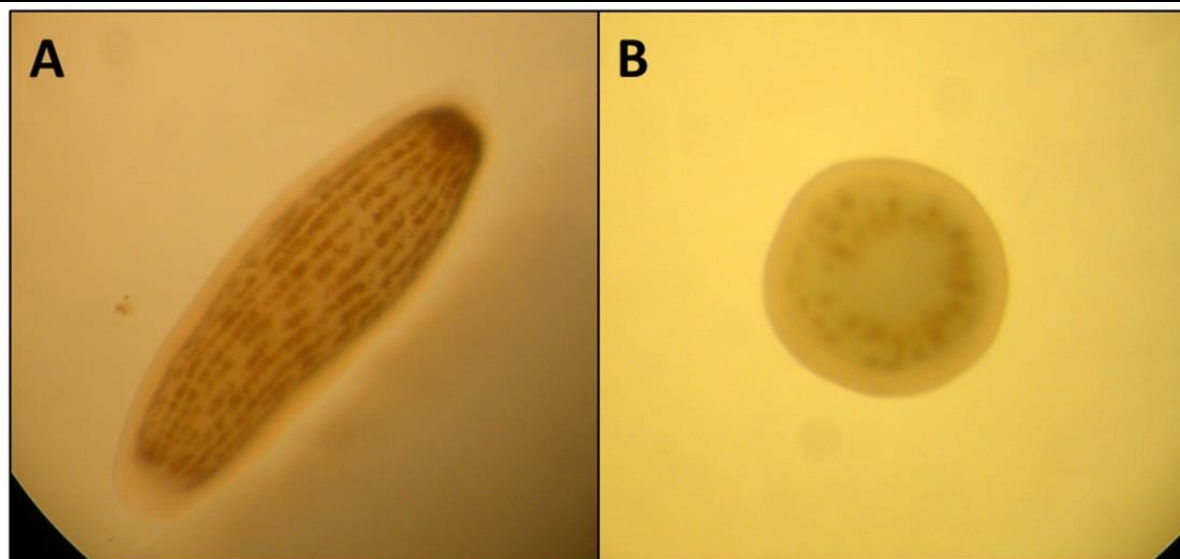
FDA Monograph Sunscreen Ingredients Drug Label Name (INCI/Common Name)	Amount of Ray Protection		Chemical (C) or Physical (P)
	UVA	UVB	
Aminobenzoic acid (PABA)	Minimal	Extensive	C
Avobenzone (Butyl Methoxydibenzoylmethane)	Extensive	Limited	C
Cinoxate	Limited	Extensive	C
Dioxybenzone (Benzophenone-8)	Considerable	Extensive	C
Ecamsule (Terephthalylidene Dicamphor Sulfonic Acid)	Extensive	limited	C
Homosalate	Minimal	Extensive	C
Menthyl anthranilate	Considerable	Extensive	C
Octocrylene	Limited	Extensive	C
Octinoxate (Ethylhexyl methoxycinnamate)	limited	Extensive	C
Octisalate (Ethylhexyl salicylate)	Minimal	Extensive	C
Oxybenzone (Benzophenone-3)	Considerable	Extensive	C
Padimate O (Ethylhexyl Dimethyl PABA)	Minimal	Extensive	C
Ensulizole (Phenylbenzimidazole Sulfonic Acid)	Minimal	Extensive	C
Sulisobenzene (Benzophenone-4)	Considerable	Extensive	C
Titanium dioxide	Considerable	Extensive	P
Trolamine salicylate (TEA-Salicylate)	Minimal	Extensive	C
Zinc oxide	Extensive	Extensive	P

Oxybenzone Impacts

- Endocrine Disruptor
 - Reduced sperm count
 - Reduced gonad tissue
 - Reduced thyroid function
 - Reduced neurological function
- Developmental disruptor
- Cancer cell proliferator
- Causes DNA damage
- Causes oxidative stress (damage to cells) in the presence of sunlight



Coral Reef Ecotoxicology of Oxybenzone



Panel A is a normal, healthy juvenile coral (also called a planula). It is about 5 mm in length. Panel B is a coral exposed to oxybenzone for 8 hours. *Used with permission from Archives of Environmental Contamination and Toxicology.*

- DNA Damage 8h EC₂₀ = 129 ppTrillion
- Bleaching 8h EC₂₀ = 695 ppTrillion
- Skeletal Endocrine Disruption

Coral Planula LOEC = 62 parts per trillion



Clownfish (*Amphiprion ocellaris*)

Fish Embryo Acute Toxicity Test



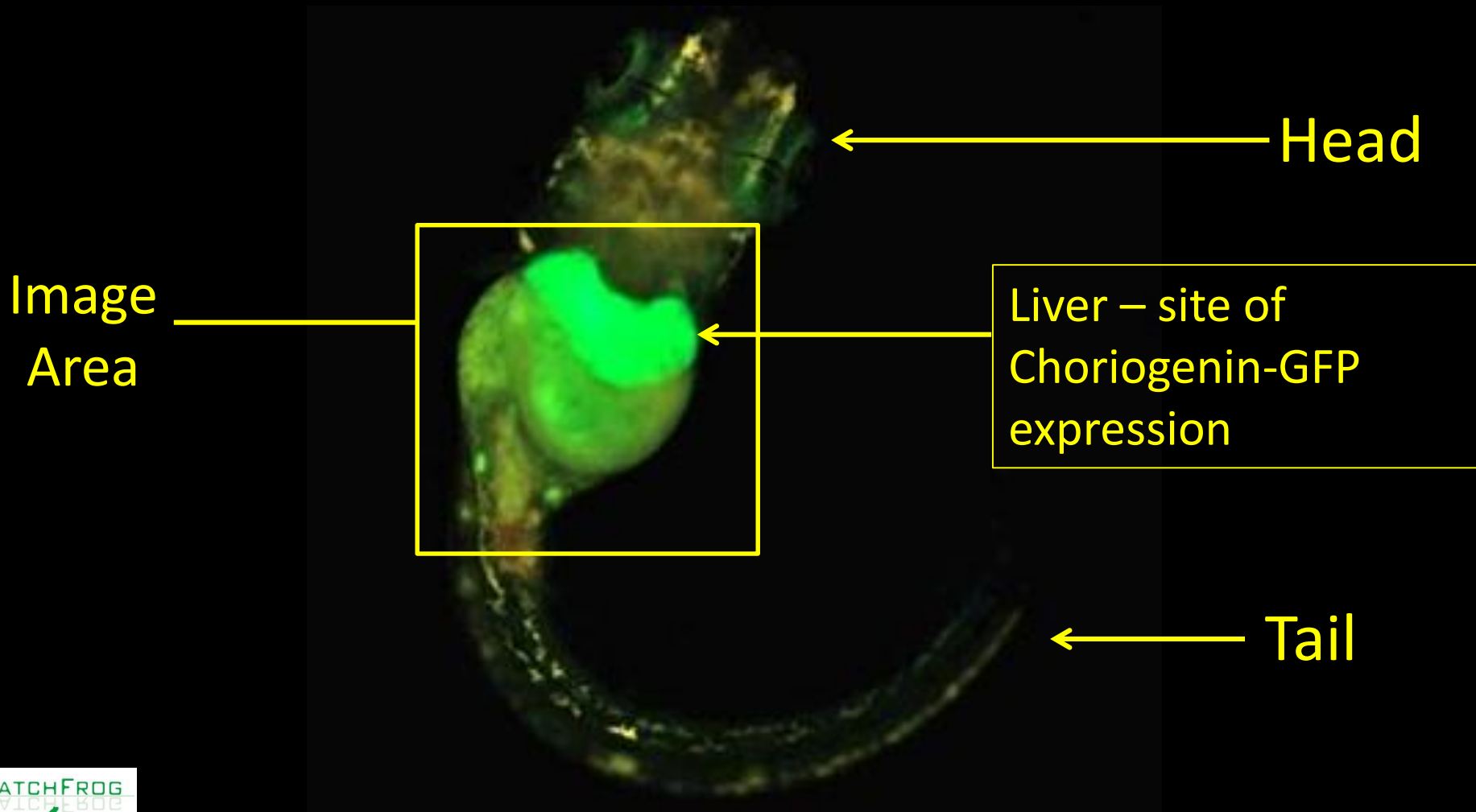
Control
48-hr exposure

1 ppbillion oxybenzone
48-hr exposure

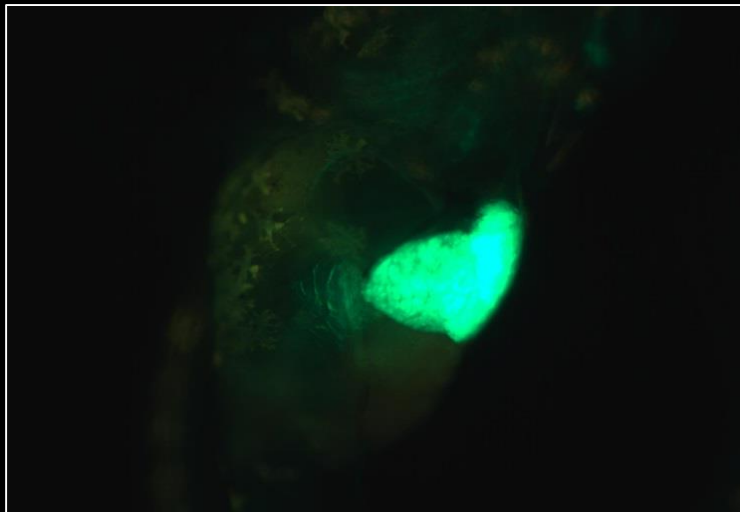
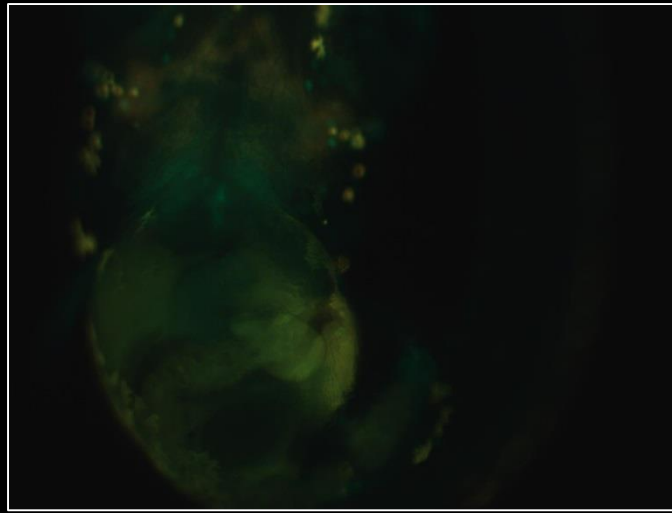
Genetically Modified Medaka

Estrogen Endocrine Axis Disruption

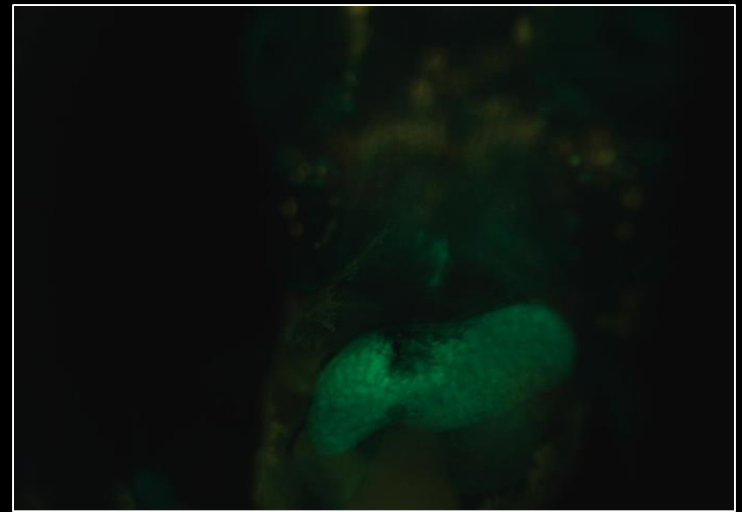
Inappropriate induction of choriogenin



Control →



Benzophenone - 1



**Oxybenzone
(Benzophenone-3)**

Sequential Hermaphroditism

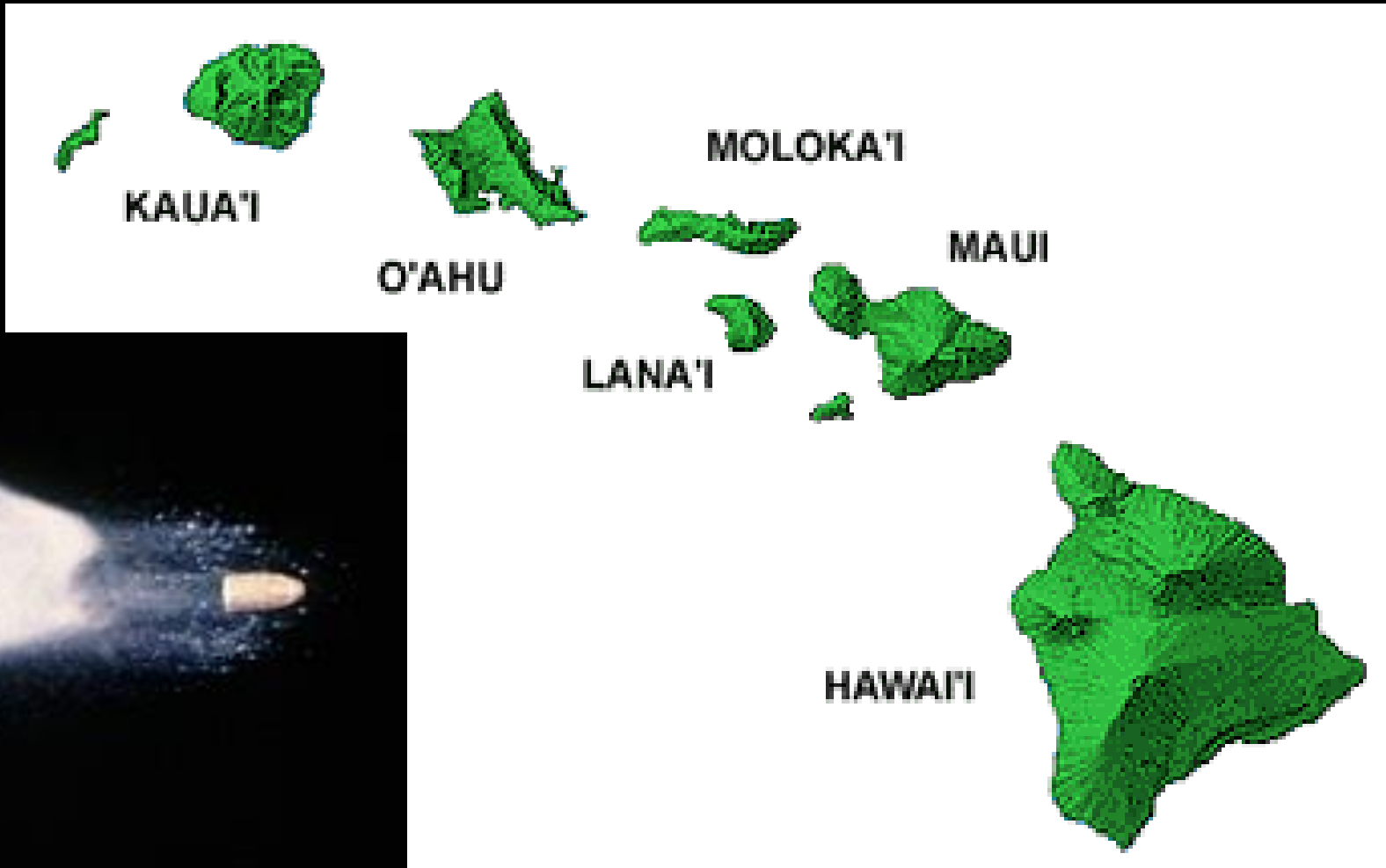
- Males turn into Females
- No Males
- Clown Fish
- Wrasses
- Moray Eels
- Gobies
- Parrot Fish



© LemonTYK

© LemonTYK

wiseGEEK



**Oxybenzone Concentrations
Oahu, Hawaii, U.S.A.
Summer 2015**

**Waimea Bay
4,780 ppTrillion**



**Ko Olina Cove
568 ppTrillion**

**Ala Moana
230 ppTrillion**

**Waikiki (Kuhio Park)
11,300 ppTrillion**

11.35 mi

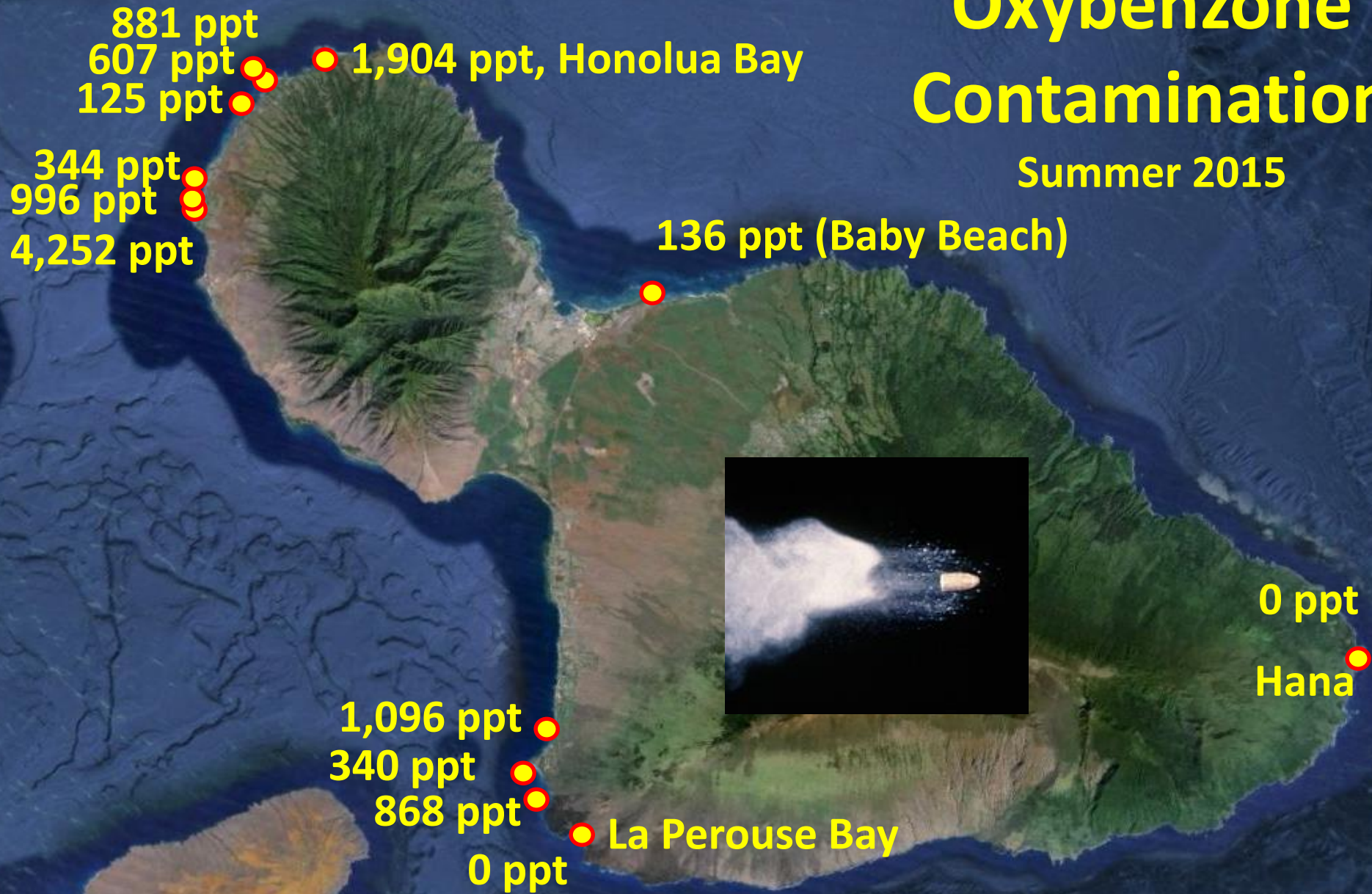
Image USGS
Data USGS
Data SOEST/UHM

Google earth

©2016 Haereticus

Oxybenzone Contamination

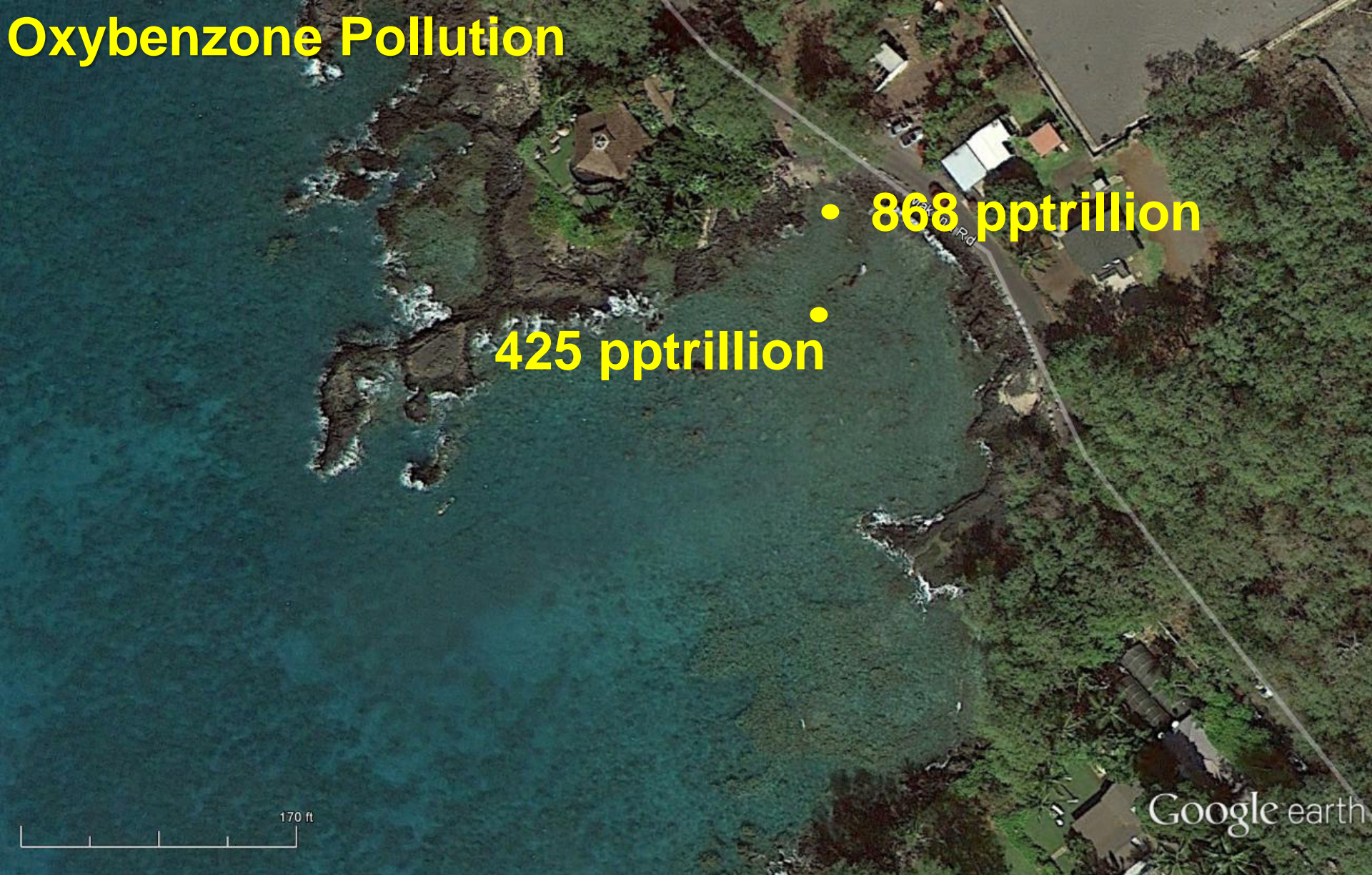
Summer 2015



13.38 mi

Data MBARI
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
Data LDEO-Columbia, NSF, NOAA

Oxybenzone Pollution

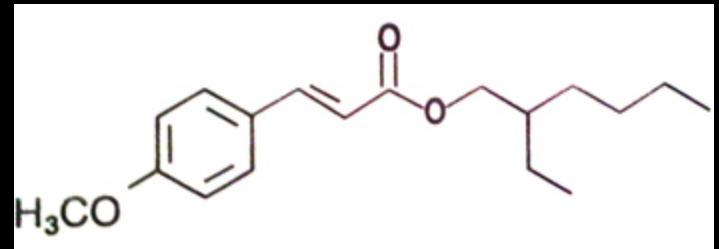


July 27, 2015, 15:00 HST

Special Use Permit, Natural Areas Reserve, 'Ahihi Kina'u, 6/2015-6/2016

Octyl methoxycinnamate (octinoxate)

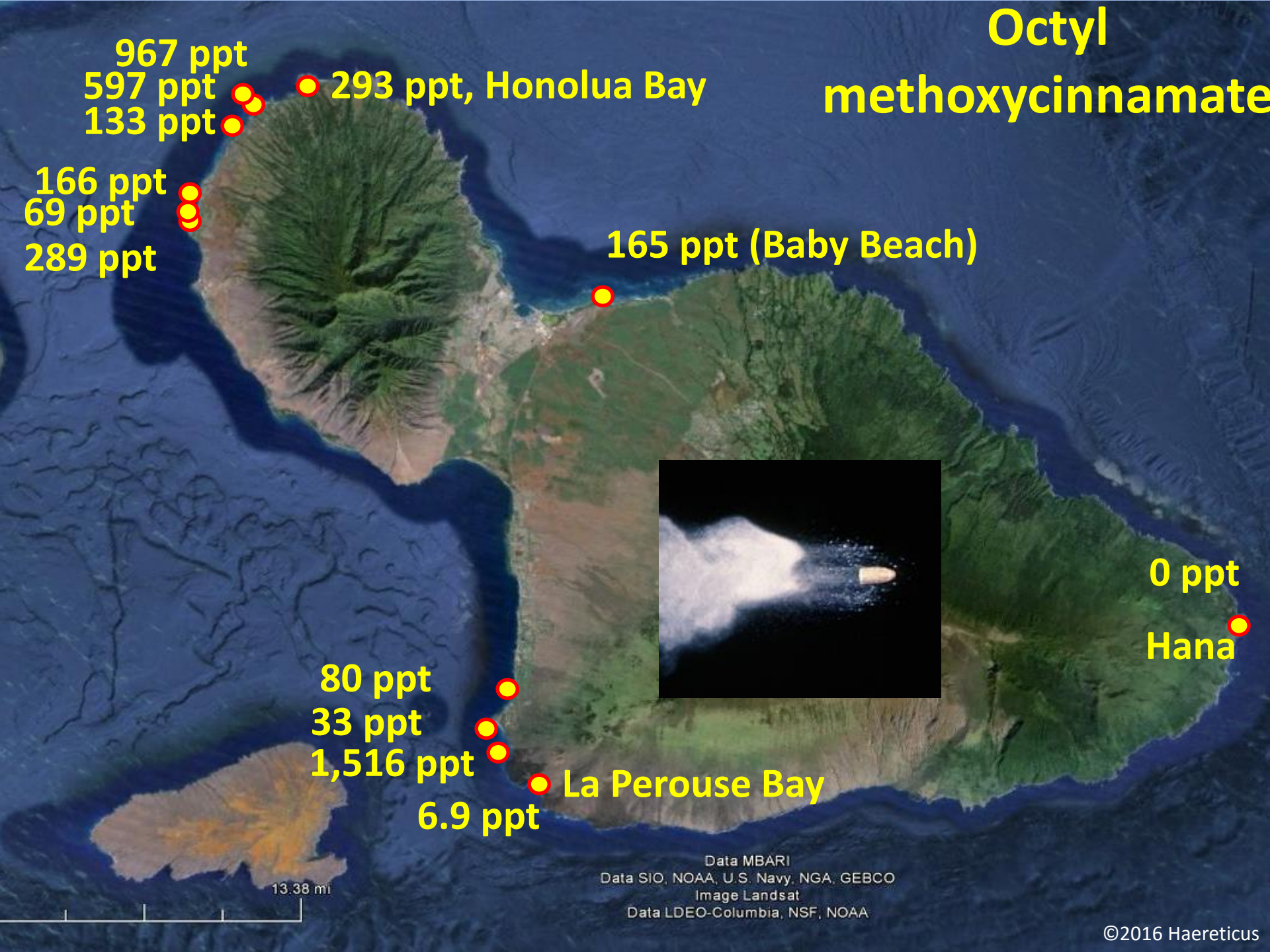
- **Endocrine Disruptor**
 - Reduced sperm count
 - Reduced gonad tissue
 - Reduced thyroid function
 - Reduced neurological function
- **Developmental Disruptor**
- **Sea urchin Embryo EC_{20} = 900-49,000 ppTrillion**
- **Clown Fish Embryo EC_{20} = 223 ppTrillion**



**Sunscreen chemical
in sunscreen lotions**

Octyl

methoxycinnamate



13.38 mi

Data MBARI
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
Data LDEO-Columbia, NSF, NOAA

Source of Contamination



Aerosol-spray Sunscreen Products

**Source of
Contamination**

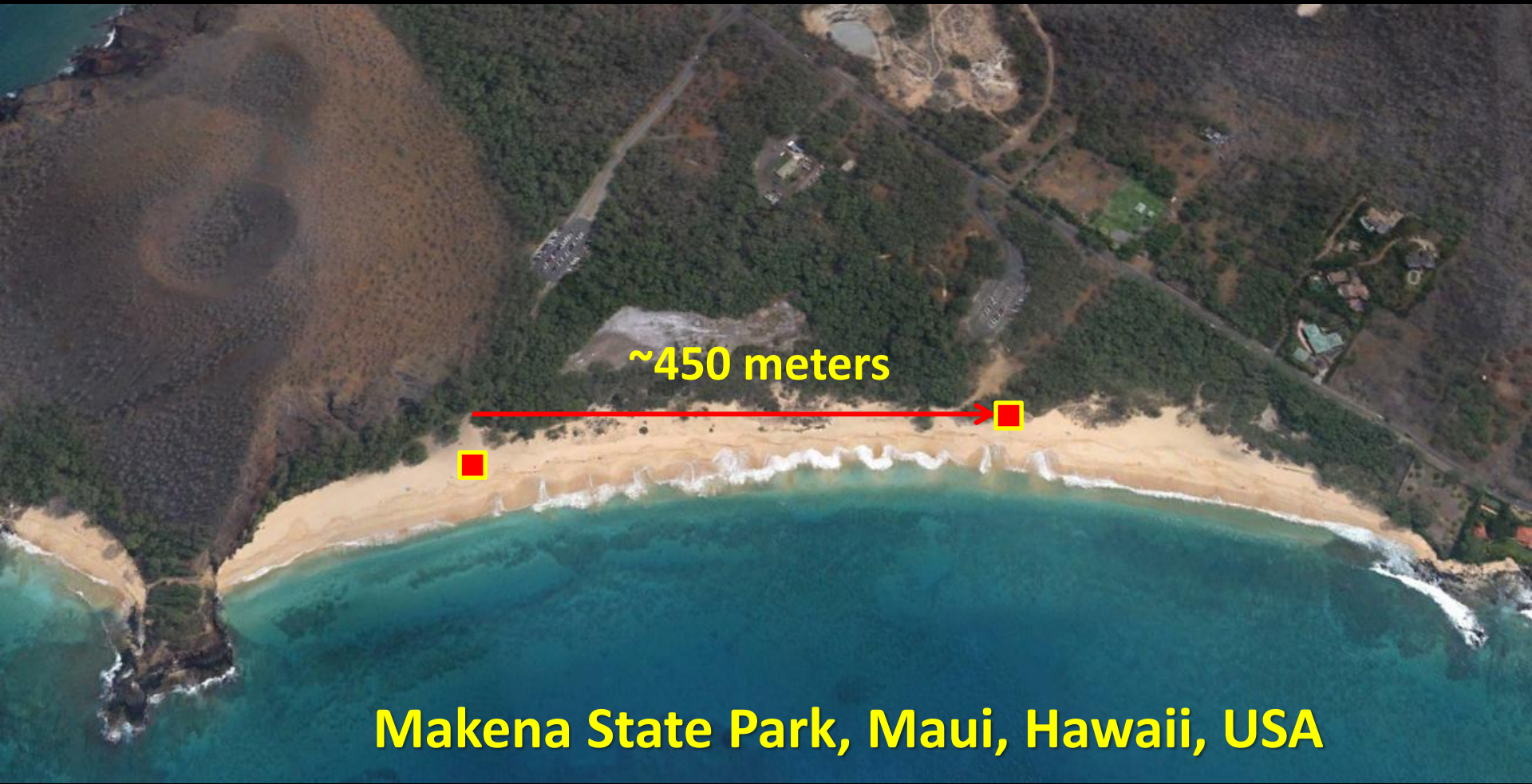


**Aerosol-spray
Sunscreen Products**

As Seen on Shark Tank...



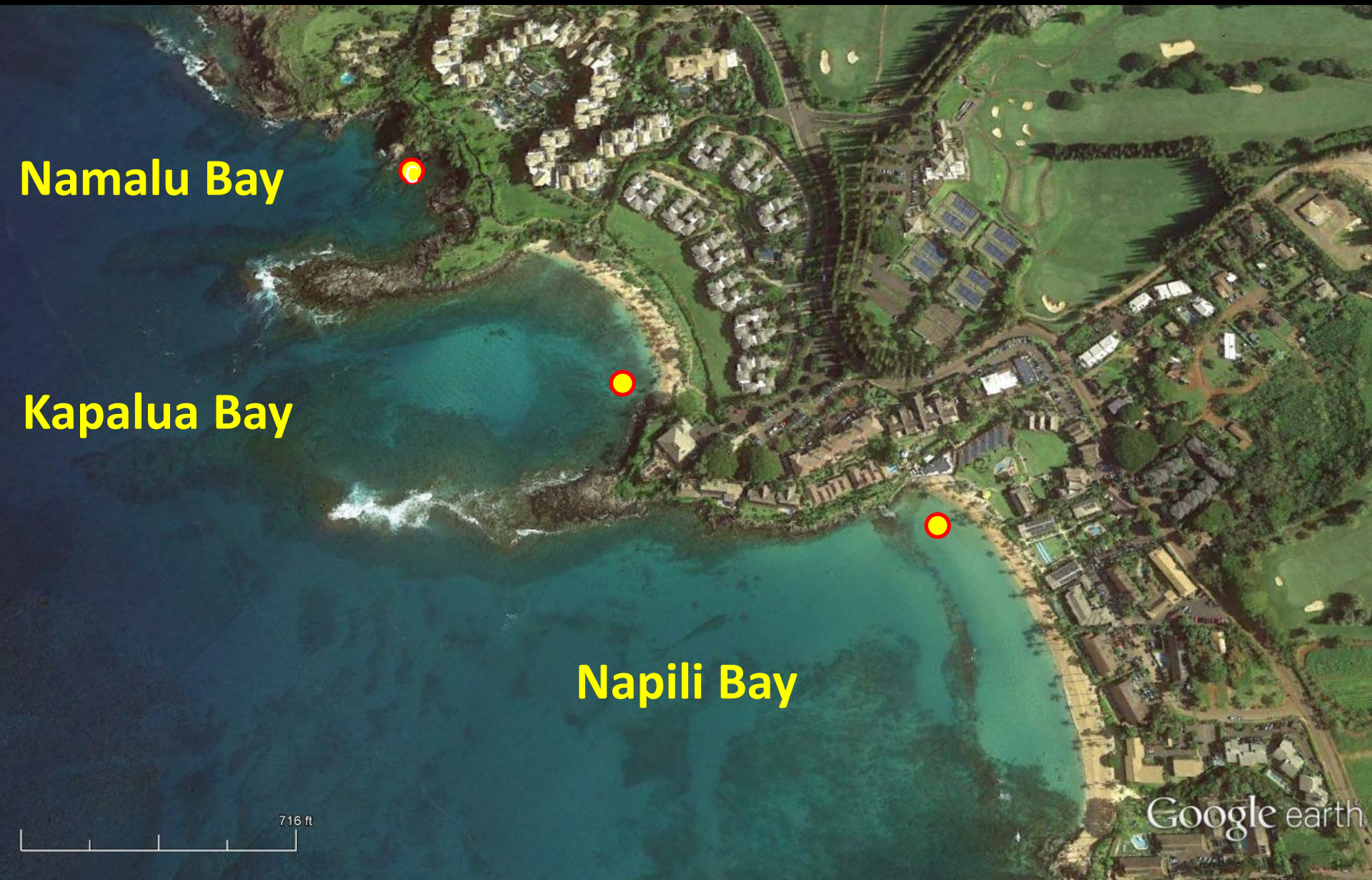
How far does aerosol sunscreen mist carry?



Makena State Park, Maui, Hawaii, USA

**Is beach contamination and tidal
flux a source of sunscreen
pollution?**

Northwest coast of Maui, Hawaii, USA



Namalu Bay

Kapalua Bay

Napili Bay

716 ft

Google earth

Kapalua Bay

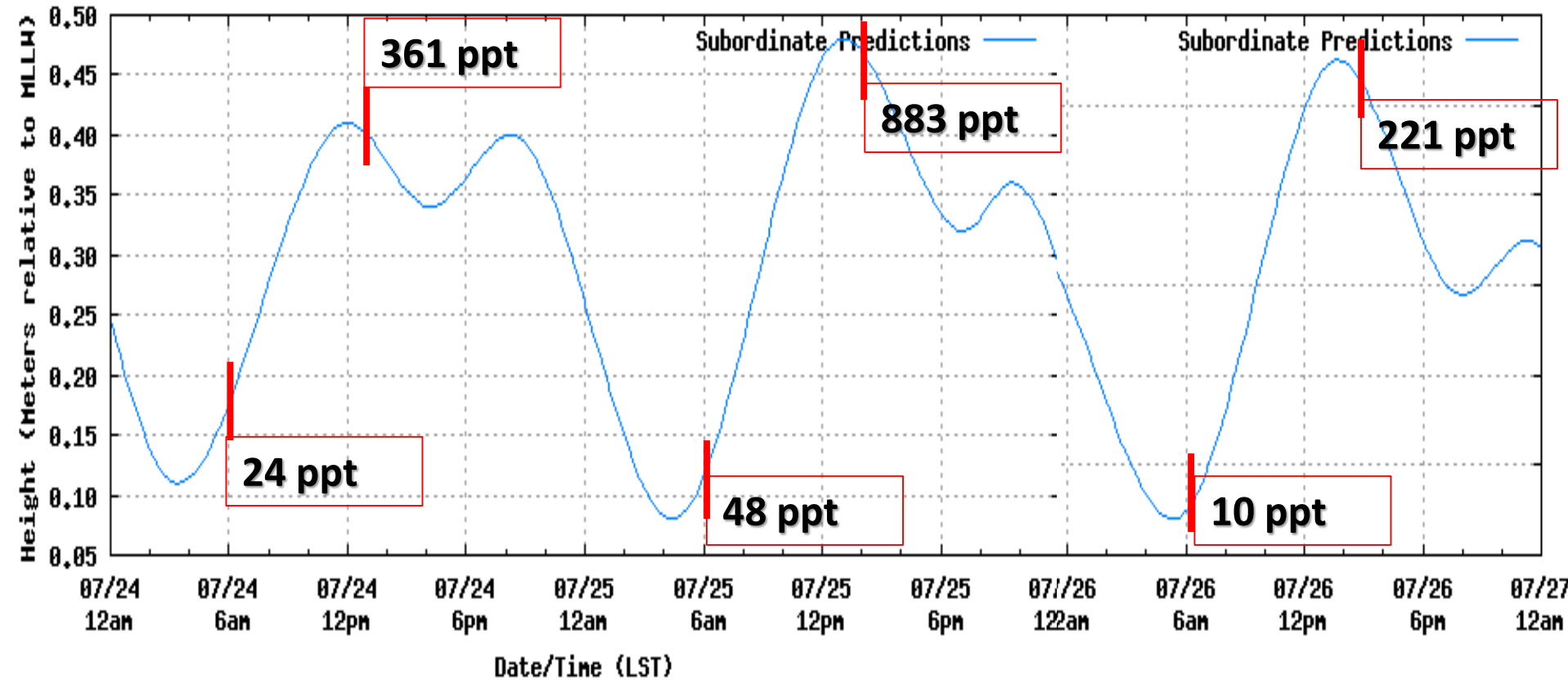


Napili Bay



Kapalua Bay

(Maui, Hawaii)

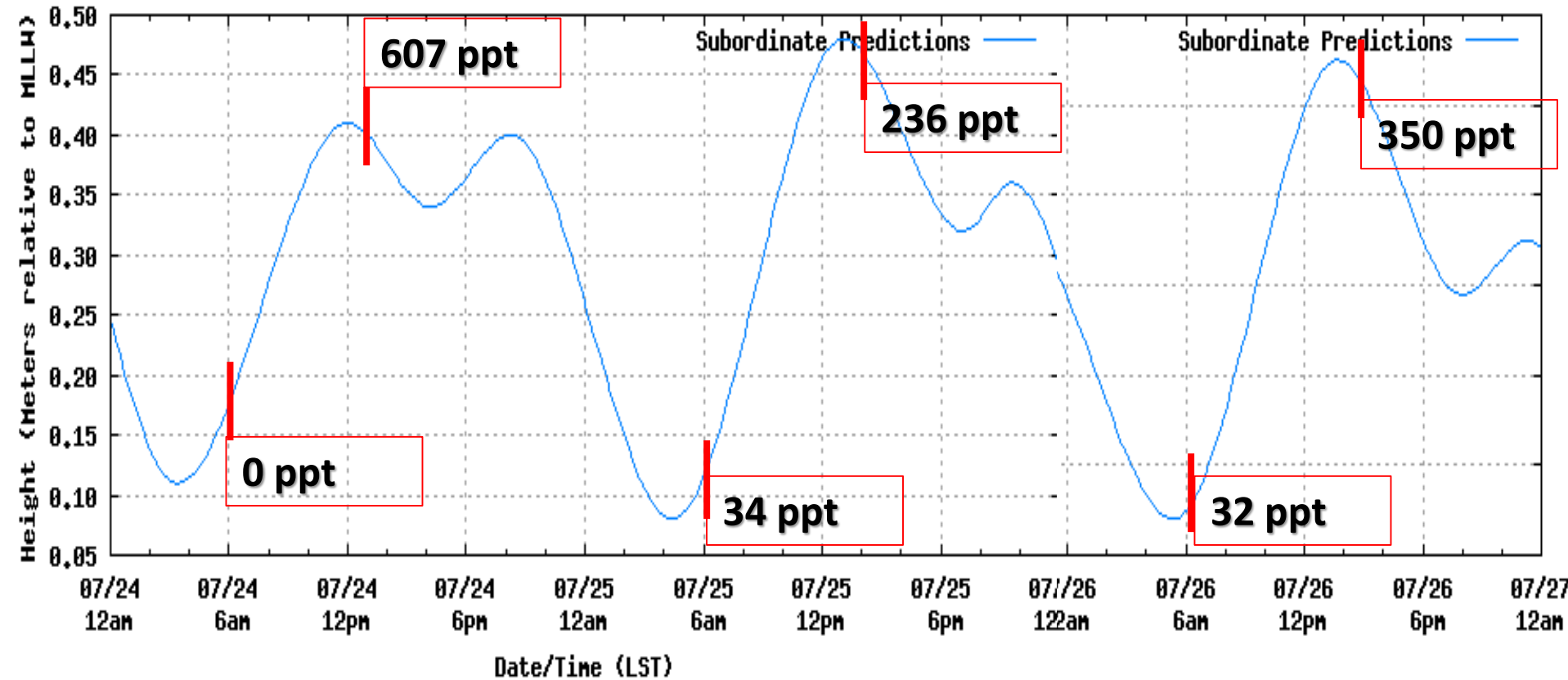


Tidal fluctuations of Oxybenzone Concentration

Correlation = 0.7698, $p = 0.0034$

Napili Bay

(Maui, Hawaii)



Tidal fluctuations of Oxybenzone Concentration

Is Oxybenzone Found in Beach Sand?

Yes!

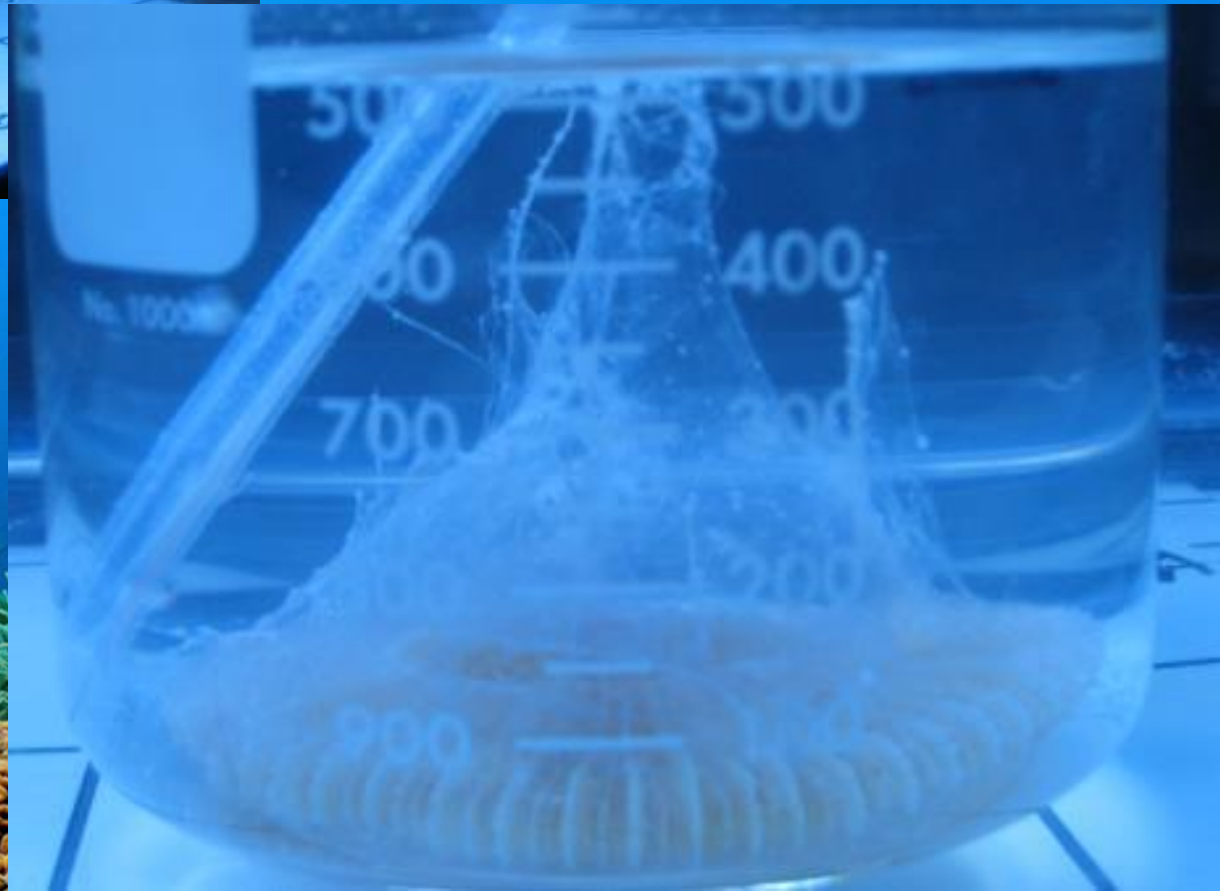
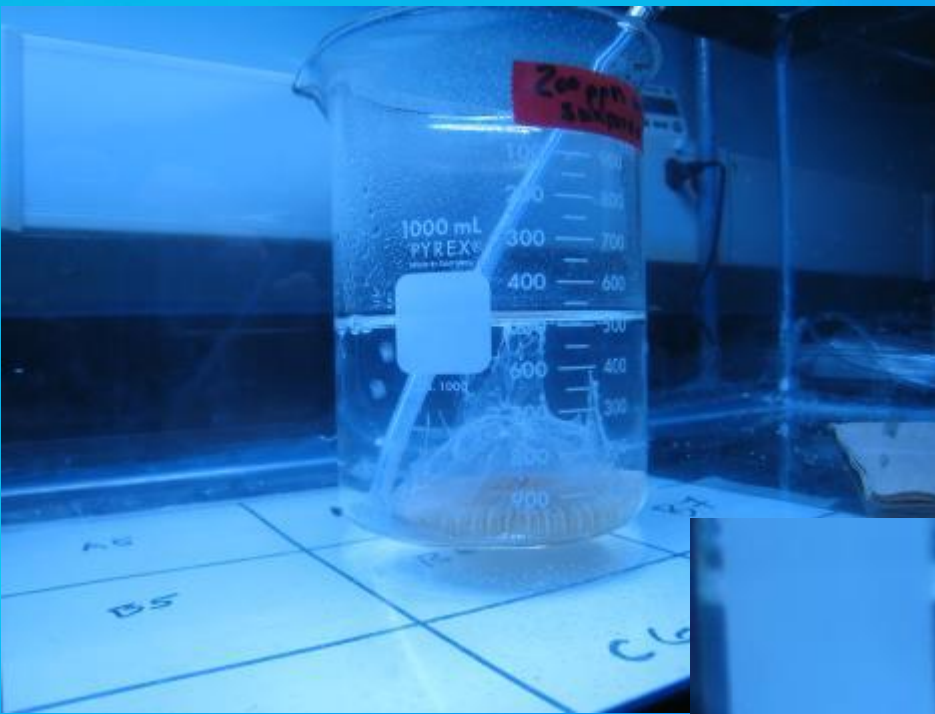
Napili Bay = 478 ng/kg Oxybenzone

Kapalua Bay = 1,004 ng/kg Oxybenzone

Sea Turtle Nests?



23 hour incubation after
placing in Sunscreen
WAF 200 ppm

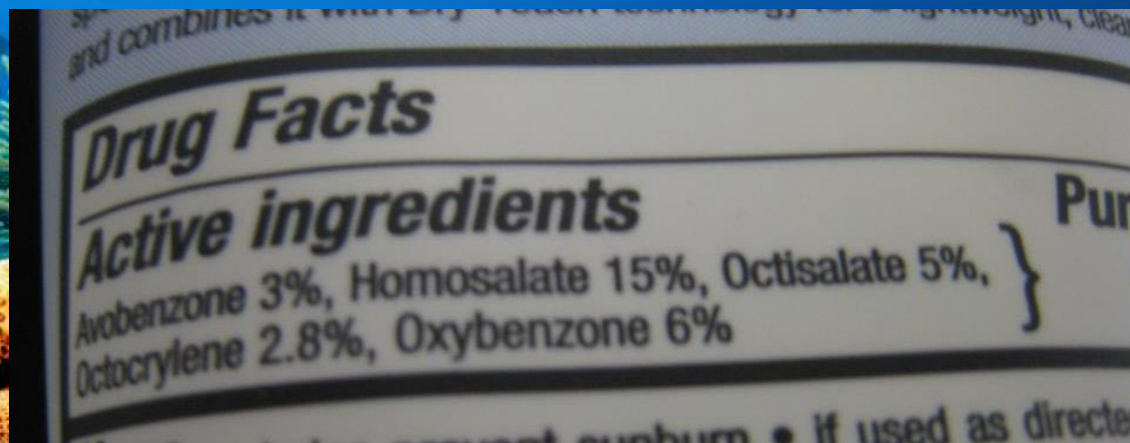


WAF-Sunscreen Lotion Exposure

23 hours

<u>Oxybenzone</u>	<u>Benzophenone-1</u>	<u>Benzophenone-2</u>	<u>4,4DHbenzophenone</u>
220.70	0.2	0	10.4
	<u>Avobenzone</u>	<u>Octocrylene</u>	
	10.2	0?	

Extraction from one *Fungia* polyp 60 mm in diameter
 All concentrations in parts per trillion



Article

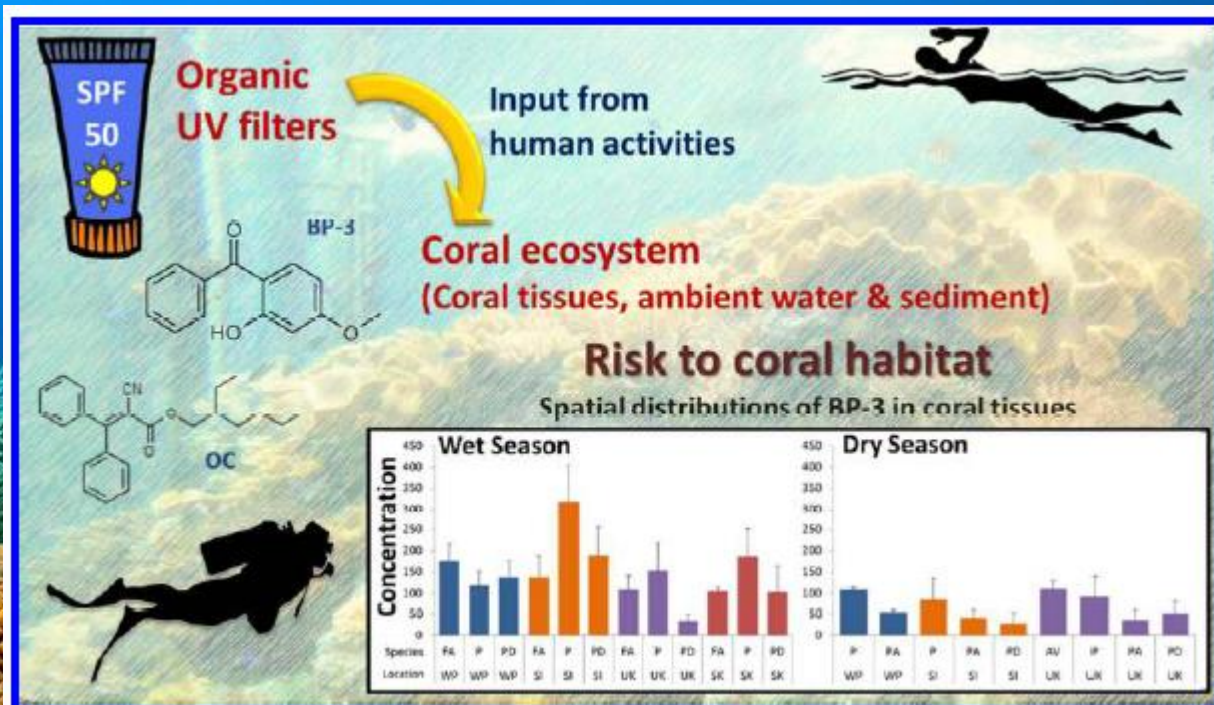
Occurrence, distribution and fate of organic UV filters in coral communities

Mirabelle M.P. Tsui, James C.W. Lam, Tsz Yan Ng, Put O. Ang, Margaret B. Murphy, and Paul Kwan-Sing Lam

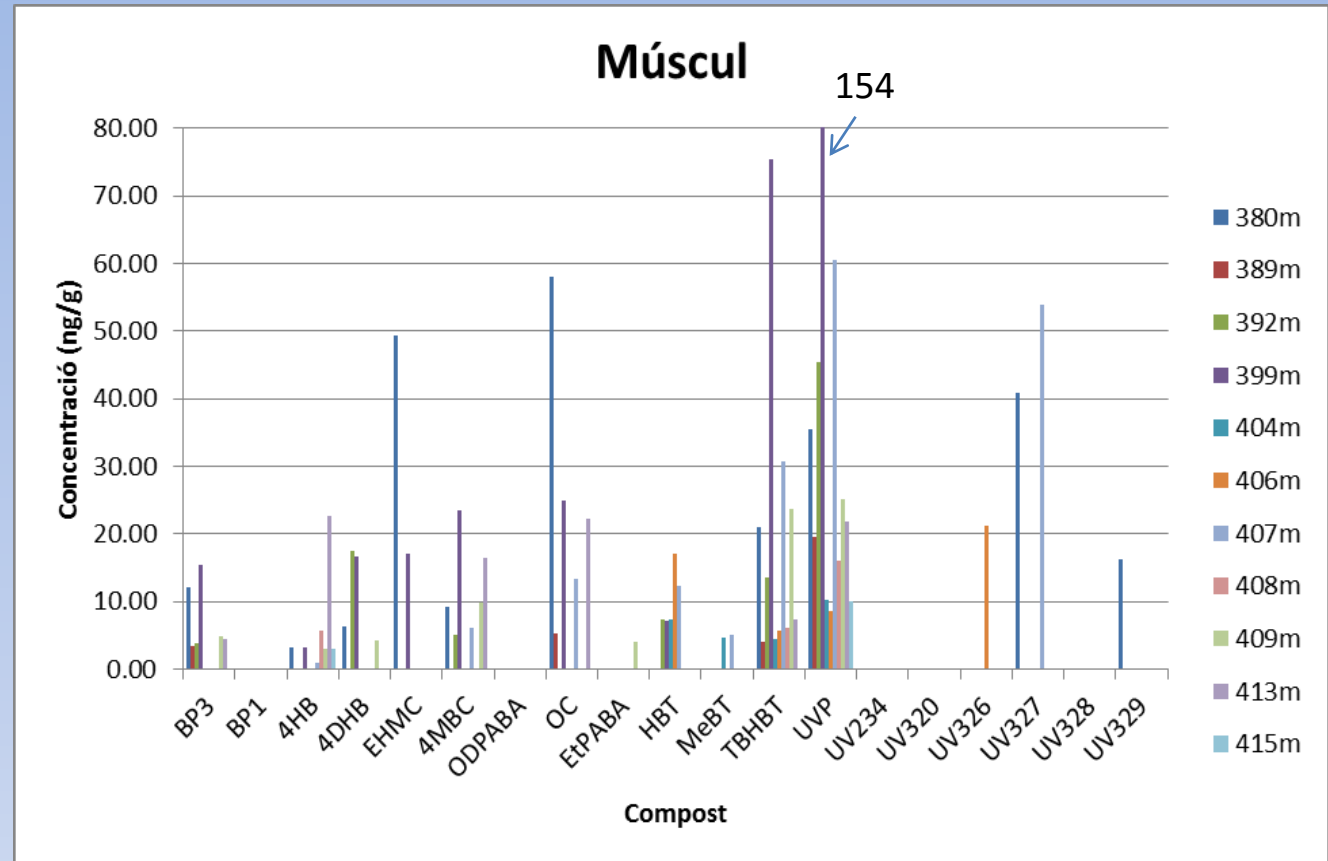
Environ. Sci. Technol., **Just Accepted Manuscript** • DOI: 10.1021/acs.est.6b05211 • Publication Date (Web): 29 Mar 2017

Downloaded from <http://pubs.acs.org> on April 4, 2017

“The results of a preliminary risk assessment indicated that over 20% of coral samples from the study sites contained OXYBENZONE concentrations exceeding the threshold values for causing larval deformities and mortality... Higher probabilities of negative impacts of OXYBENZONE on coral communities are predicted to occur in wet season.”



Muscle analysis



- BP3 = oxybenzone. BP1, 4HB, & 4DHB are metabolites of oxybenzone. OC = octocrylene; EHMC = methoxycinnamate; **ng/g = parts per billion**

→ This is the edible part of the fish

Sunscreen Pollution



Toxicity Testing of Sunscreen Products using **Shrimp Larvae** and **Sea Urchin Embryos**



100 ppBillion WAF, 24-hour exposure

<u>Product Name</u>	<u>% Mortality</u>	<u>Species</u>
Hawaiian Tropic Sheer Touch Ultra Radiance SPF 30	70%	Shrimp Larvae (7-day old)
	100%	Sea Urchin Embryo Assay
Neutrogena Ultra Sheer Dry Touch SPF 55	100%	Shrimp Larvae (7-day old)
	100%	Sea Urchin Embryo Assay
Aveeno Baby Continuous Protection SPF 55	33%	Shrimp Larvae (7-day old)
	100%	Sea Urchin Embryo Assay
Reef Safe Sprayable Sunscreen 30+	100%	Shrimp Larvae (7-day old)
	100%	Sea Urchin Embryo Assay
Blue Lizard SPF 30	13%	Shrimp Larvae (7-day old)
	80%	Sea Urchin Embryo Assay
Coppertone Sport Lotion SPF 30	27%	Shrimp Larvae (7-day old)
	35%	Sea Urchin Embryo Assay

Drug Facts

Active ingredients

	Purpose
Avobenzone 3%.....	Sunscreen
Homosalate 15%.....	Sunscreen
Octisalate 5%.....	Sunscreen
Octocrylene 5%.....	Sunscreen
Oxybenzone 6%.....	Sunscreen

Uses • helps prevent sunburn • if used as directed with other sun protection measures (see **Directions**), decreases the risk of skin cancer and early skin aging caused by the sun

Warnings

For external use only

Do not use on damaged or broken skin

When using this product keep out of eyes. Rinse with water to remove.

Stop use and ask a doctor if rash occurs

Keep out of reach of children. If swallowed, get medical help or contact a Poison Control Center right away.

Directions For sunscreen use: • apply generously 15 minutes before sun exposure • reapply: • after 80 minutes of swimming or sweating • immediately after towel drying • at least every 2 hours
• **Sun Protection Measures.** Spending time in the sun increases your risk of skin cancer and early skin aging. To decrease this risk, regularly use a sunscreen with a Broad Spectrum SPF value of 15 or higher and other sun protection measures including: • limit time in the sun, especially from 10 a.m. – 2 p.m. • wear long-sleeved shirts, pants, hats, and sunglasses. • children under 6 months of age: Ask a doctor

Other information • protect the product in this container from excessive heat and direct sun

Inactive ingredients water, dimethicone, isododecane, styrene/acrylates copolymer, propanediol, glycerin, silica, isononyl isononanoate, inulin lauryl carbamate, nylon-12, caprylyl methicone, synthetic wax, poly C10-30 alkyl acrylate, PEG-8 laurate, stearyl alcohol, dimethicone, triethanolamine, isoeugenol, fragrance, vit. vinifera (grape) fruit extract, phenoxyethanol, p-anisic acid, ammonium acryloyldimethyltaurate/stearate-25 methacrylate crosspolymer, chlorphenesin, disodium EDTA, tocopherol, sucrose tristearate, xanthan gum, polymethyl methacrylate

Phenoxyethanol

- Used as a cosmetic preservative
- Insect repellent
- Antiseptic
- Lubricant
- Anesthetic for fish aquaculture

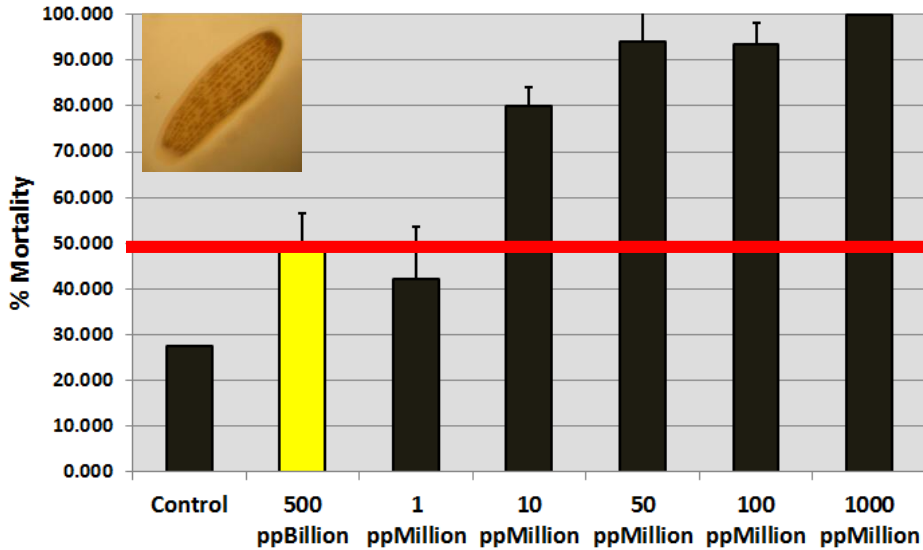
Genotoxic & Allergen

- Natl. Toxicol. Program Tech Rep Ser. 2010, p1-178

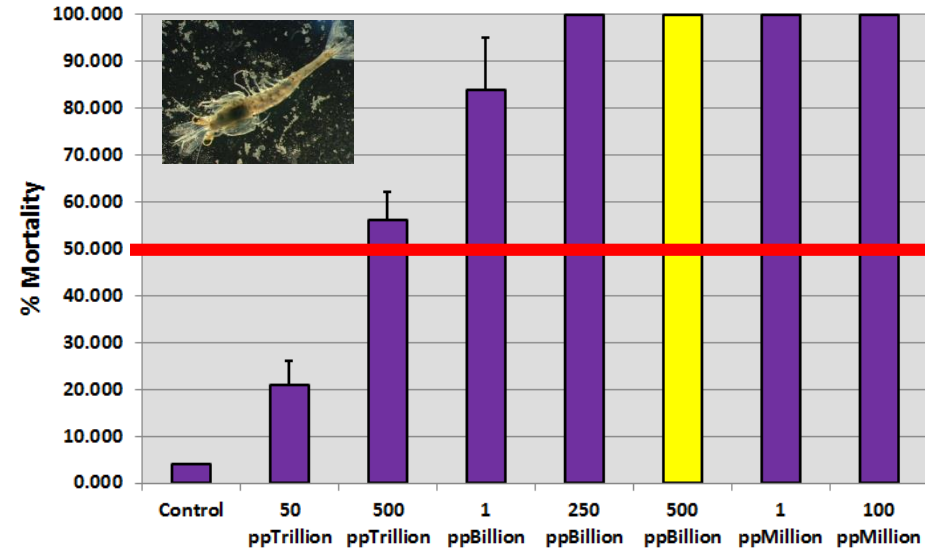
Different Reef Species Respond Differently to the Same Chemical

Technical Term: Species Sensitivity Distribution

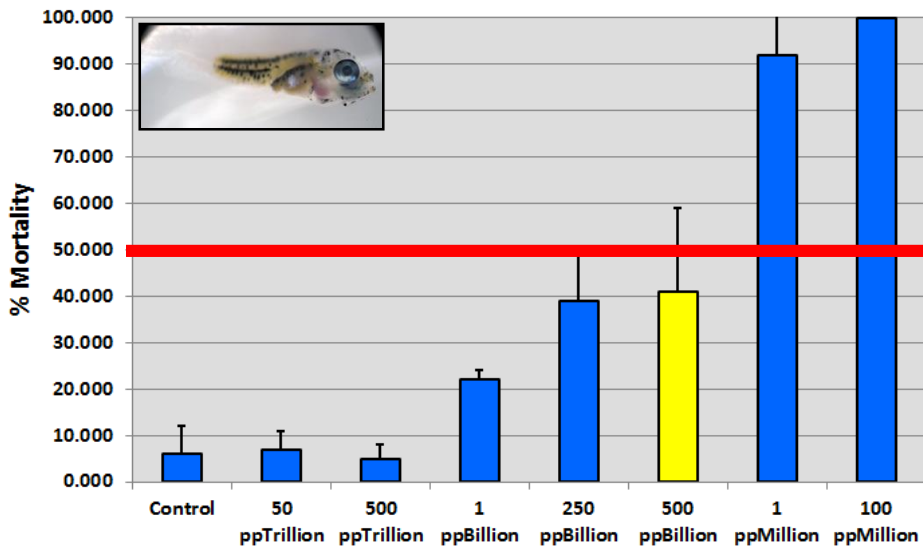
Phenoxyethanol - Coral Planula Toxicity Assay



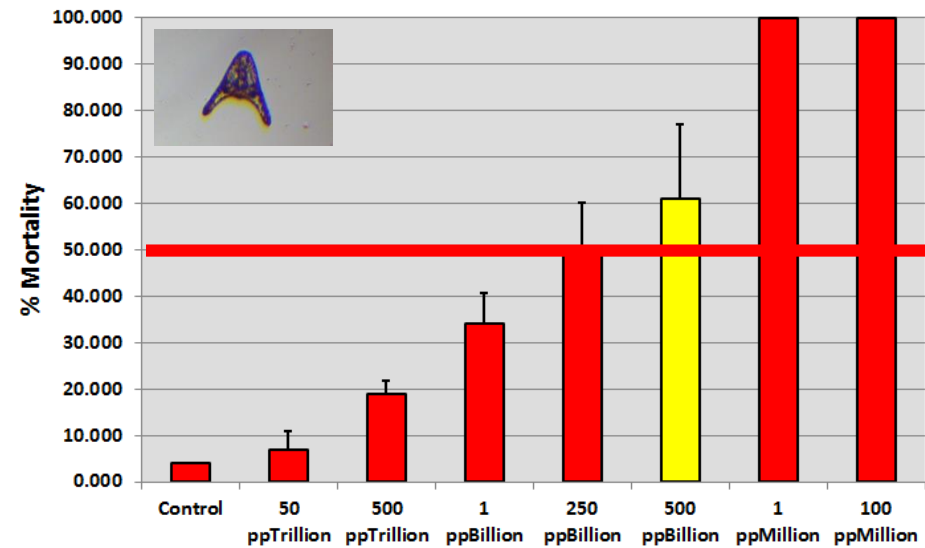
Phenoxyethanol - Shrimp Larvae Toxicity Assay

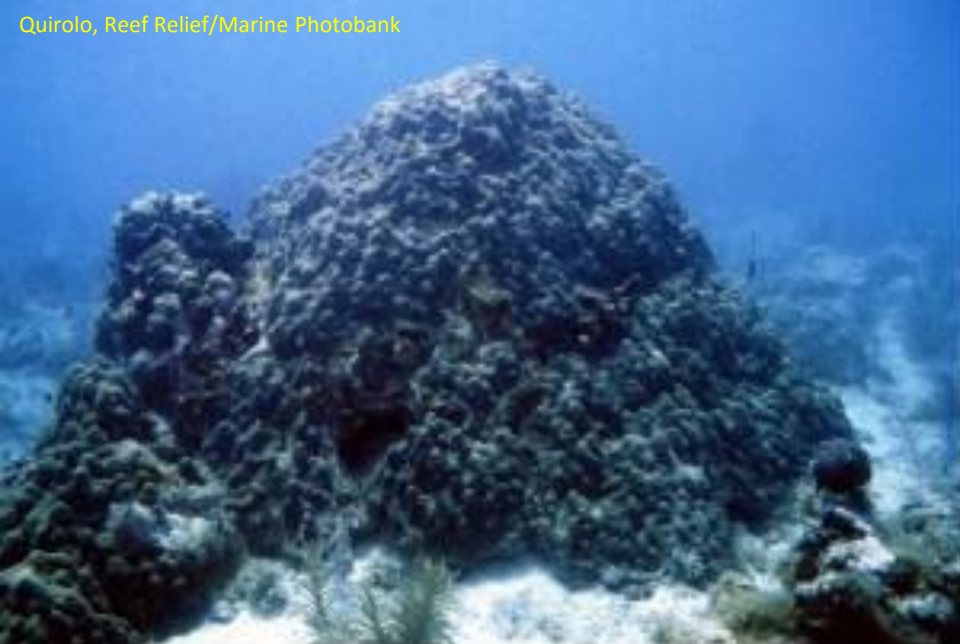


Phenoxyethanol - Clown Fish Embryo Toxicity Assay



Phenoxyethanol - Sea Urchin Planula Toxicity Assay





1996 - Healthy



1997 - Bleached



2000 - Dead/Overgrown



2005 - Dead/Overgrown

Sewage

- 30min after application, detect in urine
- Stay on skin, wash off in shower



Take Home Message

We've got problems (zombies)....

Poor water quality a root cause

- Natural products (i.e. algal)
- Anthropogenic chemicals

It is a cause that can be managed

- Protection
- Investigation—Mitigation—Restoration



Sunscreen Pollution Mitigation

- Consumer Education & Choice (*haereticus*)
 - Govt outreach, NGO campaign, Industry marketing
- Sun clothes/Sun Wear - consumer education and marketing
- Formulation of Eco-Safer Sunscreen Products
- Regulation of consumer access (Distribution & Sales)
 - **Ban Sale of Targeted-Chemical Products**
 - **Higher Tax on Targeted-Chemical Products**
- Natural Resource Management

Government & NGO Public Education General and Natural Resource Targeted

National Park Service

National Park Service
U.S. Department of the Interior



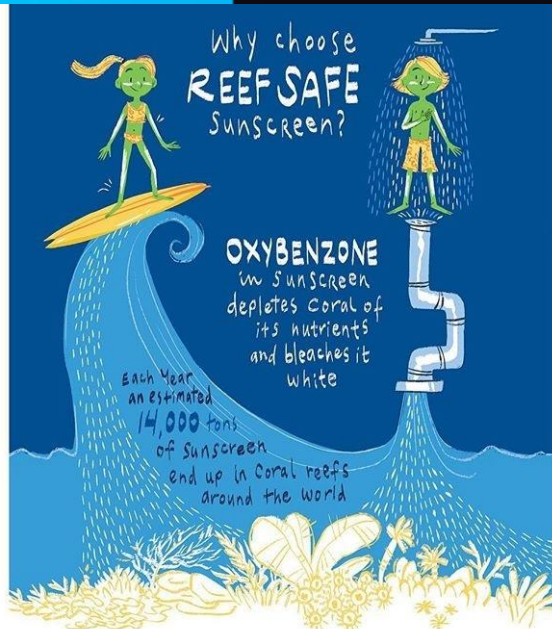
South Florida, Hawaii, U.S. Virgin Islands,
American Samoa

Protect Yourself, Protect The Reef!



NPS Photos by Thomas W. Strom

The impacts of sunscreens on our coral reefs



wear protective clothing and choose **REEF SAFE** sunscreen

‘Āhihi-Kīna‘u Natural Area Reserve

State of Hawai‘i
Department of Land and Natural Resources
Division of Forestry and Wildlife



If You Can't Say It, Don't Spray It!

New studies have shown that several common sunscreen ingredients known as **OXYBENZONES** are killing our coral reefs. No corals = no fish + no surf. These compounds have been banned in Mexico, Australia and Europe but are in over 3,500 products in the U.S. Please stop buying and using any sunscreens or products with the following:

**OXYBENZONE / AVOBENZINE / AVOBENZONE
OCTINOXATE / ETHYLHEXLY METHOXYCINNAMATE
HOMOSALATE / OCTISALATE / OCTOCRYLENE**

Your dermatologist is right! Sunscreens are important tools in protecting your skin, but you don't have to sacrifice coral reefs to stay sun-safe.

Zinc and titanium oxide sunscreens are safe for corals and work well, if they don't also have oxybenzones in them. Sun/ocean shirts ("rash guards") also work well.

Read the ingredients label for yourself. Labeling claims such as "reef safe," "organic," and "cruelty-free" can be found on many products that still contain oxybenzones - these claims are not monitored or tested by any oversight agency. Brand loyalty doesn't help: one formula may be oxybenzone-free, while another formula of the same brand, and almost all of the aerosols, have them. In one test, 20 minutes after people applied these sunscreens, oxybenzones appeared in their urine.

It matters: each time and everyone who gets into the ocean.

With thousands of people surfing/swimming/snorkeling, about one 55-gallon drum of sunscreen is going into the near-shore waters of Maui each and every day, one person at a time. Levels of these compounds in the waters off Maui have been found 10-20 times higher than the "safe" levels for corals.



Please do your part to protect our reefs:
**Before You Buy or Apply,
Read the Labels.**
Everyone, Every Day, for Every Reef.

Businesses
Community Groups
NGOs
Cosmetic Industry
Scientists

CORAL REEFS ARE DYING

and those in the
waters of Hawai'i
are among the
most at risk

Sunscreen pollution, especially the chemical **oxybenzone**, plays a role in that loss. The toxicity of **oxybenzone** can cause both coral bleaching and coral death, as well as induce reproductive diseases in fish. Oxybenzone can play a destructive role in **preventing** the natural restoration of a damaged reef—ultimately leaving the seascape barren and desolate. Sunscreen pollution's worst impacts occur on reefs where locals and tourists love to swim and experience the ocean.

To learn more about sunscreen pollution and coral reefs, and to see a short film, visit

ReefsAtRisk.org



To learn more about what Hawai'i and its elected representatives are doing, go to **bantoxicsunscreens.com** or **bereefsafe.com**

PHOTO COURTESY OF SARAH LEE AT WWW.SARAHLEE.PHOTO

AQUA-ASTON
HOSPITALITY



As a community of businesses, scientists, and non-profits, we are asking you to learn more about this issue, and like us, become part of the solution in rebuilding healthy coral reefs.

BUSINESSES:

808 Boards, Inc.
Hawaiian Paddle Sports
Hawaii Mermaid Adventures
Valley Isle Excursions
Maui Marketing
Maui Standup
Maui Surf Lessons LLC
Snorkel Depot
Waterworks Sports
Sunrise Surf Lessons Kauai
BeReefSafe.com
Rainbow Kayaks
Maui Kayak Adventures
Kai Kanani Sailing Charters
Tuga Sunwear
Pakaloha Bikinis
Snorkel Bob's
Hale Napili
Napili Shores Resort
Nalu Koa Maui
Napili Kai Resort
Napili Surf Resort
The Mauian
Napili Sunset
Ozone by Outrigger Resorts
Aqua-Aston Hospitality

SCIENTISTS:

Dr. Robert Richmond, University of Hawaii
Dr. Michael J Risk, McMaster University
Dr. Abbas Haghshenas, University of Tehran
Dr. Eugene Shinn, University of South Florida
Dr. Ariel Kushmaro, Ben Gurion University
Dr. Esti Winter-Kramarsky, Weizmann Institute
Dr. John Fauth, University of Central Florida
Dr. Silvia Diaz Cruz, Spanish Council for Scientific Research
Dr. Omri Bronstein, Natural History Museum of Vienna, Austria
Dr. Kim Sheehan, University of Oregon
Dr. Heather Hamlin, University of Maine
Dr. Craig A. Downs, Haereticus Environmental Laboratory

COSMETIC COMPANIES:

Joe Dinaro, (ret) VP, Revlon-Almay
Raw Elements USA
All Good
Stream2Sea
Sea & Summit
Suntegrity Skincare
Mama Kuleana

NGOs:

Napili Bay and Beach Foundation
Friends of Hanauma Bay
Hawaii Ocean Ambassadors For the Fishes
Hawai'i Wildlife Fund
Sustainable Coastlines Hawaii
Maui Huliau Foundation
Malama O Puna
Pacific Whale Foundation
Humane Society of the US
Maui Nui Marine Resource Council
Boxerwood Education Assoc.
Humane Society International
Save the Waves
Hawaii Ecotourism Association
Save Honolulu Coalition
KUPU
Colorado Ocean Coalition
Inland Ocean Coalition
Hawaii Association for Marine Education & Research
Conservation Council for Hawai'i
Coral Restoration Foundation
Hui O Ka Wai Ola
Hui O Ho'ohouua
Toxic Free NC
Hui o Koolaulupoko
Haereticus Environmental Laboratory

Ua Mau ke Ea o ka 'Āina i ka Pono
(The Life of the Land is Perpetuated in Righteousness)

**ONE
RECOMMENDED
APPLICATION OF
CONVENTIONAL
SUNSCREEN ON A
BIKINI-CLAD
WOMAN IS EQUAL
TO DAILY
HORMONAL
THERAPY FOR
MENOPAUSE.**

More info on REAL sun safety at
KitchenStewardship.com



BETTER Formulation of Products



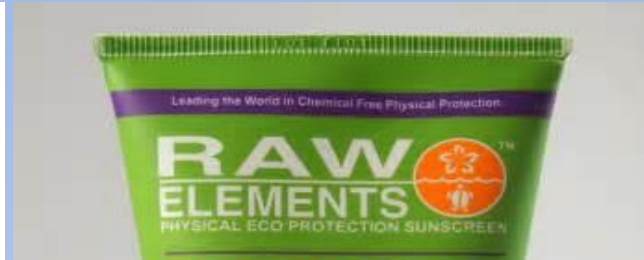
"IF WE BAN OXYBENZONE THERE WILL BE NO OPTIONS"

Reef Friendly: Sunscreen Criteria



No-Oxybenzone Companies

NO Chemical Sunscreens
 Oxybenzone, Octinoxate, Octocrylene, PABA, Encacamene, Octisalate, Homosalate, and Avobenzone - the Ugly Eight!



Goddess Garden Sunscreen: REEF SAFE AND BIODEGRADABLE

NO Toxic Preservatives or Additives
 Parabens, Phthalates, Triclosan & Microbeads

YES to Zinc Oxide
 Just Make Sure It Is Non-Nano Zinc Oxide



PROTECT THE REEFS
use coral safe sunscreen!

YES to 3rd Party Testing
 Don't take our word for it - or theirs - make sure the sunscreen is 3rd party tested!

Are Badger Sunscreens safe for the environment?

Oxybenzone-Free Sunscreens
 Tested - Non-Harmful to Coral Reef and Fish

Join the campaign to promote Reef Friendly!
allgoodproducts.com/reeffriendly
 #ReefFriendly

BIO THERM WATER LOVERS:
A PROUD PARTNER OF
SYLVIA EARLE'S MISSION BLUE
 IN ITS MISSION TO PROTECT THE HOPE SPOTS



Sunscreen Swaps

Donations for Conservation Efforts

Eco-responsible Marketing

Your sunscreen
 is destroying our
 coral reefs

DOES YOUR SUNSCREEN HARM CORALS?

Philippine Beaches.org

HARMONY REEF TRADING POST
 Your One-Stop Shop for TOP RATED Reef-Friendly Biodegradable Sunscreens!
 BIG SELECTION, SHOP NOW!
20% OFF

A Killer Combo
 Sunscreen and Coral Reefs

A recent study found oxybenzone, a common chemical ingredient in sunscreens, is toxic to corals even at low concentrations. Sunscreens from swimmers and municipal and residential wastewater discharges are likely contributing to coral reef deaths around the world.

What is Oxybenzone?

- A common ingredient in sunscreens and other personal care products like body fragrance, soap and makeup
- Helps protect against the damaging effects of ultraviolet light
- From public swimming and wastewater effluents, this chemical is released into the ocean and toxic to coral reefs

Effect on Corals

- Causes deformities in the oosa, even in the larval form (planula)
- A skeletal endocrine disruptor that can affect the growth and reproduction of corals
- Increases the risk of coral bleaching, where stress causes the coral to expel algae, turn white and at a higher risk of dying

How much?

Between 100,000 and 1,000,000 tons of sunscreen absorbed into the ocean each year

- 10% of global coral reefs at risk
- 40% of coral reefs along coastal areas at higher risk of exposure

Importance of Corals

Economic Value of Coral Reefs

Coral reefs are diverse, vibrant ecosystems that provide habitats and food resources for over 4,000 species of fish, 800 types of coral, and hundreds of other organisms

Worldwide, healthy reefs also contribute to tourism and recreation, coastal protection, and fisheries

"If it's on your skin, it's on the reef"

Protect Where You Play

Helping Save the Reefs,
ONE BOTTLE
 of sunscreen
AT A TIME

Healthy Coral vs **Bleached Coral**

What causes coral bleaching?

- Chemical sunscreens
- Pollution in oceans
- Fishing practices that use cyanide or dynamite
- Ocean acidification from greenhouse gases
- Temperature increase

What can you do?

- Check the labels
- Look for sunscreens that are "reef friendly" with ingredients as safe as water and in zinc oxide or titanium dioxide
- Cover up your face and legs with clothing to protect your skin

THIS IS NOT AN ENDORSEMENT & NO FINANCIAL CONFLICT OF INTEREST

Massive Marketing Push

Acknowledgements

- Friends of Hanauma Bay
- Senator Will Espero & Office
- Dr. Robert Richmond, UH-Manoa
- Hawaii Dept. Land and Natural Resources
- Napili Bay and Beach Foundation



History of the Over-the-Counter (OTC) Drug Review Program

- In 1972, FDA finalized rules for the OTC Review that utilize a monograph process to determine the basis of therapeutic categories.
- Expert panels reviewed data and issued reports that FDA publishes in the Federal Register, which include recommendations for claims, dosages, and active ingredients for approximately 20 therapeutic categories.

In 1978 the FDA OTC panel concluded “oxybenzone is an effective sunscreen ingredient for OTC use” based on the following data:

- Oxybenzone “Neat”:
 - LD50 > 12.8g/Kg in rats and IP injection > 1.6 g/Kg in mice
 - Draize rabbit skin irritation and ocular irritation testing = non-irritating
 - Sub-chronic 15 day rabbit dermal toxicity - no signs of toxicity.
- Product Containing 6% Oxybenzone and 12% Homosalate:
 - 2 – Draize ocular irritation test = practically non-Irritating
 - Rabbit repeat insult patch photosensitivity test = non-photosensitizing
 - 4 hr 14 Subject patch test = non-irritating
- Product Containing 3% Oxybenzone and 3% Padimate A and 4% Padimate O:
 - 48 hr 100 subject patch test = non-irritating
 - Repeat insult patch test 200 subjects = non-sensitizing
 - 25 subject repeat insult patch photosensitivity test = non-photosensitizing
- Product Containing 3% Oxybenzone and 7% Padimate O:
 - 2 - 150 Subject repeat insult patch test = minor skin irritation, no allergic reactions
 - 25 Subject phototoxicity test = non-phototoxic
- SPF Efficacy (UVB only) was based on the 2 products:
 - One product contained 3% Oxybenzone and 3% Dioxybenzone and the another with just 3% Oxybenzone. Both products were found to protect against UV exposure.
 - UVA testing (critical wavelength - analytical method) did not occur until many years later.

2011 FDA communication

- A large ratio could result if one or more ingredients absorb radiation in the shorter wavelength UVA II region but not at all or only minimally in the longer wavelength UVA I region. For example, oxybenzone absorbs radiation at 340–360 nm, and inclusion of this ingredient at higher concentrations might result in a high ratio *even though it does not provide true broad spectrum protection.*

The FDA is demanding more studies and safety data from manufacturers, despite decades of world-wide experience. The latest batch of rejections is particularly notable because one of the ingredients, ecamsule, has been approved by the FDA since 2006 as a prescription drug. Sunscreen makers simply want FDA permission to use it in over-the-counter products.

The FDA is hung up on what it called “the riddle of dermal absorption” in a September 2014 presentation to its outside science advisory board. The fear is the new sunscreens will seep into the skin and pose some speculative and so-far-unspecified health risk over the long run, and thus the agency wants manufacturers to conduct randomized controlled pharmacokinetic trials.

The FDA also notes that earlier sunscreens had been approved in a “paleoregulatory” period characterized by a “lack of adequate analytical methods.” In other words, the FDA would have rejected the older sunscreens too if it had known better.

Wall Street Journal
March 13, 2015

Ecotox Methods

- **Creation of Water-Accommodated Fraction**
 - OECD Guidance document on aquatic toxicity testing of difficult substances and mixtures (ENV/JM/MONO(2000)6)
- **Use Teflon Exposure Vessels**
- **No Serial Dilutions!**
- **Natural Light for Photo-toxicity**
- **Artificial Seawater – Need to be able to replicate. Pharma/ACS-grade water and salts**

IS THIS POLLUTION A THREAT?

Old U.S. EPA Method

- Oxybenzone in USVI

HQ = 10, YES

- Honolulu Bay in Hawaii

HQ = 0.1, NO

Ecological Risk Assessment

- Oxybenzone in USVI

RA = 63, Yes

- Honolulu Bay in Hawaii

RA = 21, YES

Used EC₅₀ 24-h deformity at 20% PAR
17 ppbillion

Sea Urchin Embryo Tox assay (*Tripneustes gratilla*): 24h EC50 = 439 ppbillion ($\mu\text{g/L}$) (single cell embryo to prizm).

Evaluation of the developmental toxicity of 2-phenoxyethanol and clove oil anaesthetics using the Frog Embryo Teratogenesis Assay: *Xenopus* (FETAX)

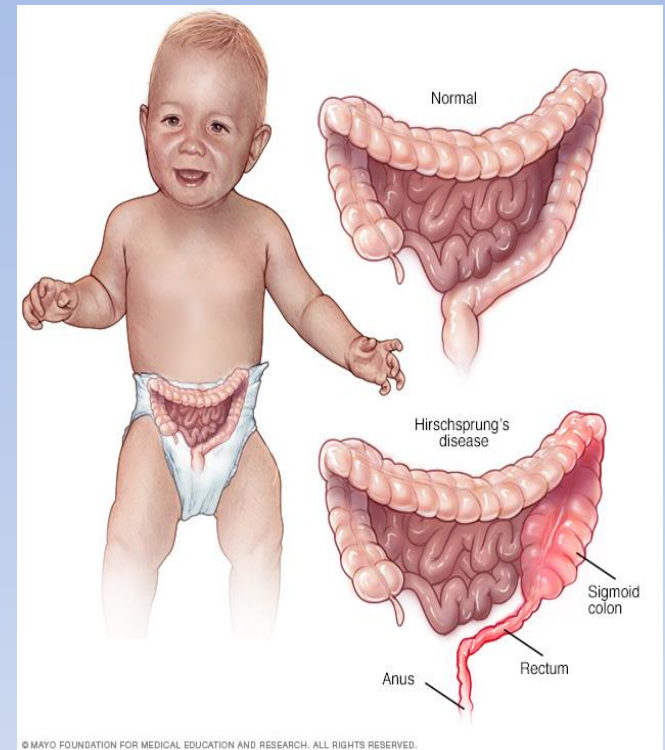
D. VRŠKOVÁ, H. MODRA

University of Veterinary and Pharmaceutical Sciences, Brno, Czech Republic

ABSTRACT: The developmental toxicity of two anaesthetics, 2-phenoxyethanol and clove oil, used in aquaculture was evaluated using the Frog Embryo Teratogenesis Assay: *Xenopus* (FETAX) and the results were compared to outcomes in fish. *Xenopus laevis* embryos were exposed to 50, 100, 300, 500, 700 and 1000 mg/l of 2-phenoxyethanol or 1, 5, 10, 20, 30 and 40 mg/l of clove oil. Values of 96 h LC50, 96 h EC50 (malformation) and teratogenic index (ratio of 96 h LC50 and 96 h EC50) were determined and the types and severities of the induced malformations and minimal concentration inhibiting the growth of embryos were estimated. Teratogenic index values for 2-phenoxyethanol and clove oil were estimated at 1.69 and 0.61 respectively. The most frequently observed malformations produced by 2-phenoxyethanol were axial flexure and oedema and for clove oil, axial flexure, gut malformation, microphthalmia and oedema. 2-phenoxyethanol was found to induce growth inhibition of frog embryos at concentrations above 300 mg/l and clove oil at concentrations above 20 mg/l. In summary, both 2-phenoxyethanol and clove oil affected the growth of *Xenopus* embryos, while only 2-phenoxyethanol represented a teratogenic risk.

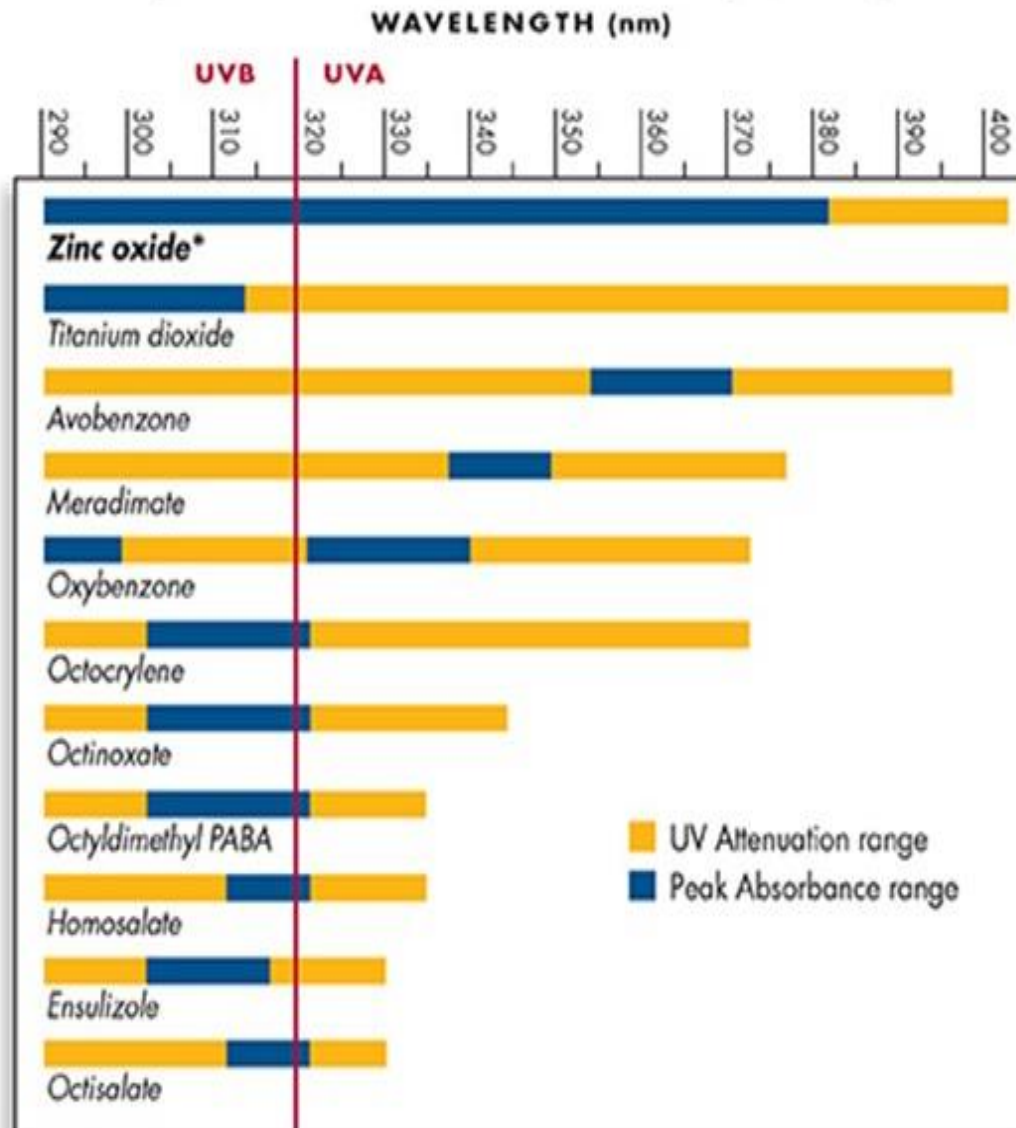
Oxybenzone & Hirschsprung's Disease

- Oxybenzone impairs migration of embryonic enteric neural crest cells (important role in pathogenesis of disease)
- Dose-response relationship between oxybenzone concentration and cell pathology
- Between 1980-1984 in Maryland, 1 in 5,000 births with HD
- In some municipalities, estimates are as high as 1:300 with HD



Huo et al. (2016) The relationship between prenatal exposure to oxybenzone and Hirschsprung's disease. *Chemosphere* 144:1091-1097

Comparison of how the most widely used U.S. sunscreen ingredients attenuate (reduce the intensity of) UV light



Data provided by F&G Beauty & Grooming