Supplemental Information for

Beach showers as sources of contamination for sunscreen pollution in marine protected areas and areas of intensive beach tourism in Hawaii, U.S.A.

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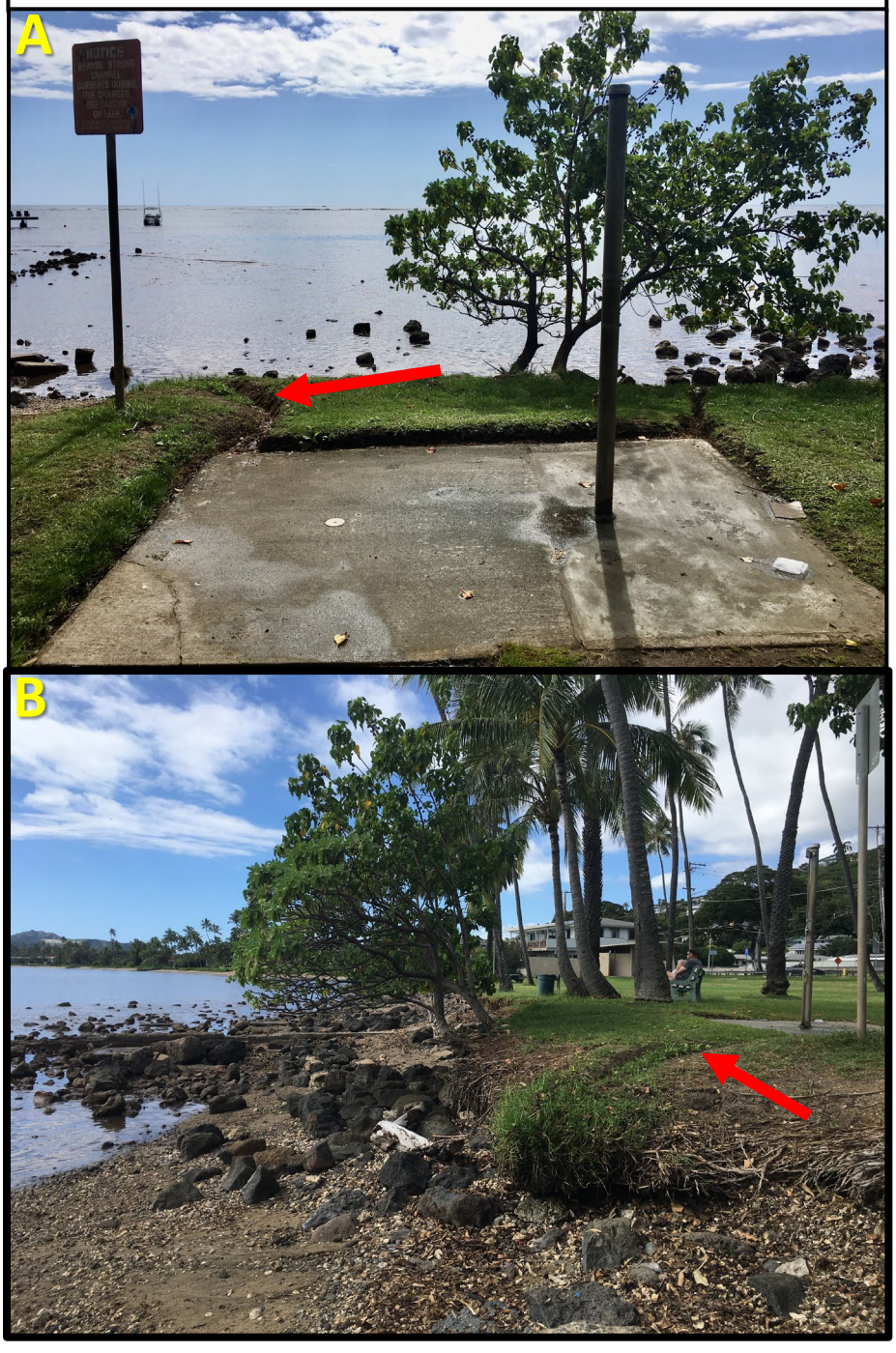
Supplemental Figure 1. Example of shampoo/body wash products that contain UV-filters, including benzophenone-3 (synonym of oxybenzone) and benzophenone-4. Photo courtesy of Professor Alex Rogers, PhD.

Supplemental Figure 2. Photo-documentation of Kuhio Beach Shower sampling site in Waikiki, Honolulu, Hawaii, U.S.A. Panel A is the shower platform (arrow). Panel B is the discharge pipe from the shower platform to the steps down to the beach (arrow). Panel C is the spillway from the shower discharge onto the beach. The arrow in Panel C indicates where the sediment sample was collected. Sample was collected Nov. 17, 2019 at 13:49 pm Hawaii Standard Time.

Supplemental Figure 3. Photo-documentation of Wailupe Beach Shower sampling site in Honolulu, Hawaii, U.S.A. Panel A is the shower platform with drainage culverts emanating from the shower platform. Panel B is the spillway from the shower (arrow) discharged onto the beach. The arrow in Panel A indicates where the sediment sample was collected. Sample collected Nov. 17, 2019 at 10:22 am Hawaii Standard Time



Supplemental Figure 4. Photo-documentation of beach shower sampling site at Kalama Park in Kihei, Maui County, Hawaii, U.S.A. The arrow indicates where the sediment sample was collected. Sample was collected Nov. 13, 2019 at 08:26 am HST

Supplemental Figure 5. Photo-documentation of Kamaole Beach Park 2 sampling site on South Kihei Road, Kihei, County of Maui, Hawaii, U.S.A. The arrow indicates where the sediment sample was collected. Sample was collected Nov. 13, 2019 at 09:03 am HST.

Supplemental Figure 6. Photo-documentation of Polo Beach Park shower sampling site off of Kaukahi street, Wailea-Makena, County of Maui, Hawaii, U.S.A. The arrow indicates where the sediment sample was collected. Sample was collected on Nov. 13, 2019 at 10:49 am HST. There are two beach showers at this location. The shower sampled is the higher elevation shower and is farther from the beach in reference to a second beach shower that is much closer to the beach. The second shower is predominantly used by Fairmont Resort guests, and the authors were not sure if that shower was located on private property. Hence, the Public beach shower was the only shower sampled.

Supplemental Figure 7. Photo-documentation of beach sampling site at Kihei Boat Beach in Kihei, Maui County, Hawaii, U.S.A. The arrow indicates where the sediment sample was collected. Sample collected on Nov. 13, 2019 at 09:14 am HST

Supplemental Figure 8. Photo-documentation of Mauna Lani Beach Club Beach Shower sampling site in Makaiwa Bay, Puako, Hawaii, U.S.A. Panel A is the shower platform with view of the shower and its proximity to the beach and water. Panel B is the spillway from the shower discharged onto the beach. The RED arrows in Panels A and B indicates where the sediment samples were collected. Sample collected on Nov. 11, 2019 at 08:04 am Hawaii Standard Time

Supplemental Figure 9. Photo-documentation of 49 Black Sand Beach Shower sampling site in Honokaope Bay, Puako, Hawaii, U.S.A. Panel A is the shower platform with view of the shower and its proximity to the beach and water. Panel B is the spillway from the shower discharged onto the beach. The RED arrow in Panel B indicates where the sediment sample was collected. Sample collected on Nov. 11, 2019 at 08:47 am Hawaii Standard Time

Supplemental Figure 10. Photo-documentation of Kahalu'u Bay Beach Park, Hawaii, U.S.A. The RED arrows indicate where the sediment samples were collected.

Supplemental Figure 11. Photo-documentation of Kapahukapu (Manini Beach), Hawaii, U.S.A. Panel A is the narrow beach area. Manini Beach is at the southern end of Kealakekua Bay Marine and Land Conservation District. Panel B is the sign of rules for visitors to help conserve Kapahukapu. The RED arrow in Panel A indicates where the sediment sample was collected. Sample collected on Nov. 12, 2019 at 11:27 am HST

Supplemental Figure 12. Prohibition of U.S. FDA petrochemical SPF active ingredients

Division of State Parks, Department of Land and Natural Resources

Vessel Special Use Permit (SUP) - Commercial

Kealakekua Bay State Historical Park (KBSHP)

Permit Number (to be filled out by DSP staff)
KBSHP-
EXPIRATION: DEC 31, 2022
e/t/m: Ins:

Note: Required information marked with (*). Any changes to your application information must be submitted to Hawaii District office with a NEW VESSEL SUP request.

- Blue numbers below correspond to those on the Page 2 instruction sheet.

1. Permit Status (click box)*	2. Permittee (owner or manager of business; name as shown on driver's license or official identification) *
☐ New Permit ☐ Renewal	Name (First, Middle, Last)*

3. Vessel Name (If applicable)		4. Registration #* (If applicable)	
5. Vessel Document Type: (If applicable, USCG reference #)		6. Vessel Type:* (1 permit per vessel type)	
7. Vessel Document # (If applicable)			
8. Overall Vessel Length:*		9. Vessel Passenger Capacity:*	
10. Total Number of Vessels* (covered by permit)			

Business Name:*		Email Address:*			
Mailing Address*		City*		State*	Zip Code*
Business Phone #*		Mobile #*		Mobile Accepts Texts: (Used only when needed)	☐
Business Contact Name*		Alternate Contact Name*		FAX #	

The following permit conditions apply to those using the waters at Kealakekua Bay State Historic Park (KBSHP) (conditions subject to change):

1. This permit only applies to transiting the water. No tying off to any objects and/or mooring without a mooring permit.
2. **No launching or landing of vessels at Nāpō'opo'o Wharf (Landing) is allowed unless authorized by separate DLNR written approval.**
3. **This permit is nontransferable to any other individual or party.**
4. Vessels shall not be used to transport people to land at Ka'awaloa Flats or to traverse any portion of Ka'awaloa Flats, including the Captain Cook Monument (See attached map) unless authorized by separate DLNR written approval.
5. No auxiliary vessels shall be launched from a permitted vessel. Swimmers are allowed in the water but shall not access the shoreline or land at Ka'awaloa Flats unless authorized by separate DLNR written approval.
6. Motorized vessels are to operate at a "no wake" speed.
7. Only reef safe sunscreen, which does not contain oxybenzone, octinoxate, octisalate, avobenzone, octocrylene, homosalate, and nanoparticles, shall be allowed to be used by all visitors to Kealakekua Bay as stipulated under the MLCD rules below. It is encouraged that the wearing of sun protective clothing be utilized instead of sunscreen when practical. Commercial operators shall ensure that their customers follow these guidelines.
8. All motorized vessels shall have a self-contained human waste system on board their vessel for use by their passengers and will encourage the use of the system.
9. Damaging live coral and tampering or interfering with other marine life and mammals is prohibited. Legal distances must be maintained from marine mammals.
10. If an emergency landing is required within KBSHP, please notify the DLNR Hawaii State Park Office at 808-961-9540 within 24 hours of the landing and report the nature of the emergency and the need to land.
11. This permit does not authorize any business operation related to soliciting for customers, renting equipment or otherwise promoting a business within KBSHP. Doing so is in violation of the following:
    HAR §13-146-66 Business operations. No person shall engage in or solicit any business, except in accordance with the provisions of a permit, contract, license, lease, concession, or other written agreement with the Board or its authorized representative, or as allowed by HAR Chapter 13-7.
    HAR §13-146-68 Commercial activities. No person shall engage in commercial activities of any kind, without a written permit from the board [Board of Land and Natural Resources] or its authorized representative.
    Hawaii County Code §22-2.5. Commercial use of County streets. Except as otherwise permitted by law, no person shall use any portion of a County street for the purpose of displaying, vending, hawking, selling, renting or leasing any goods, wares, food, merchandise or other kinds of property. (2002, Ord. No. 02-67, sec. 2.) 22
12. **The Permittee shall abide by these permit conditions and all County, State and Federal laws and regulations.** Any violation of these laws and regulations may result in immediate suspension of this permit and the permittee may be subject to civil and criminal penalties.
13. Please submit the following:
    - Current marine general liability insurance certificate for minimum of $1,000,000.00 per occurrence and$2,000,000.00 in the aggregate naming the State of Hawaii, Department of Land and Natural Resources, as additional insured.
    -Current General Excise Tax (GET) License

13a. Expiration* _____ (mm/dd/yyyy)

14. License #* _____

I have reviewed, understand, and agree to abide by all the above special conditions and regulations:

Permittee Signature:* /s/ _____ (Please sign or type name above) Date:* _____ (mm/dd/yyyy)

This application, when approved and issued by an authorized Department of Land and Natural Resources agent, shall serve as the official permit:

Division of State Parks Approval: /s/ _____ Administrator/Island Superintendent Approval Date: _____

Page 1 of 2 (Revised 6/23/21)

Supplemental Figure 13. Fairwind and State of Hawaii Department of Land and Natural Resources education banner

Supplemental Figure 14. An example of public education regarding the mitigation of petrochemical UV-filters contamination in Kahalu'u Bay (Kona, Hawaii, U.S.A).

Choosing a safe sunscreen

Determining whether a sunscreen is reef-friendly or not is simple: **just look at the active ingredients.** The only two active ingredients the U.S. Food and Drug Administration considers "safe and effective" are **zinc oxide** and **titanium dioxide.**

Look for these active ingredients:
✓ Zinc oxide ✓ Titanium dioxide

Be careful:
Many sunscreens labeled as "reef-friendly" or "reef-safe" actually aren't. Always check the active ingredients to be sure!

Avoid these active ingredients:
✗ Oxybenzone ✗ Octisalate
✗ Avobenzone ✗ Octocrylene
✗ Homosalate ✗ Nanoparticles
✗ Octinoxate

Visit koha.la/reef-friendly for an up-to-date list of recommended sunscreen products and retailers.

Always remember...
- Don't stand on, step on, or touch coral: Stay afloat when snorkeling or swimming.
- Give marine life plenty of space: Never touch, chase, feed, or harass.

Produced by THE KOHALA CENTER
kohalacenter.org

Updated: November 25, 2019

Why does it matter?

Coral reefs in Hawai'i are facing many threats. Research confirms that chemicals found in many common sunscreens, such as oxybenzone, octinoxate, and octocrylene, are harming our marine ecosystems. These chemicals damage coral DNA and larvae, contribute to coral bleaching, and affect the health of algae, fish, shellfish, urchins, and marine mammals.

Chemicals from sunscreens, other pollutants, and rising ocean temperatures are causing the health of coral reef ecosystems to decline at an accelerated pace.

By wearing as much protective clothing as possible, then applying limited amounts of **reef-friendly, mineral-based sunscreens** where needed, we can all help Hawai'i's coral and marine ecosystems flourish and remain healthy for generations to come.

It's easy to go reef-friendly!

Follow this guide to reduce your impact on coral reefs while protecting yourself from the sun.

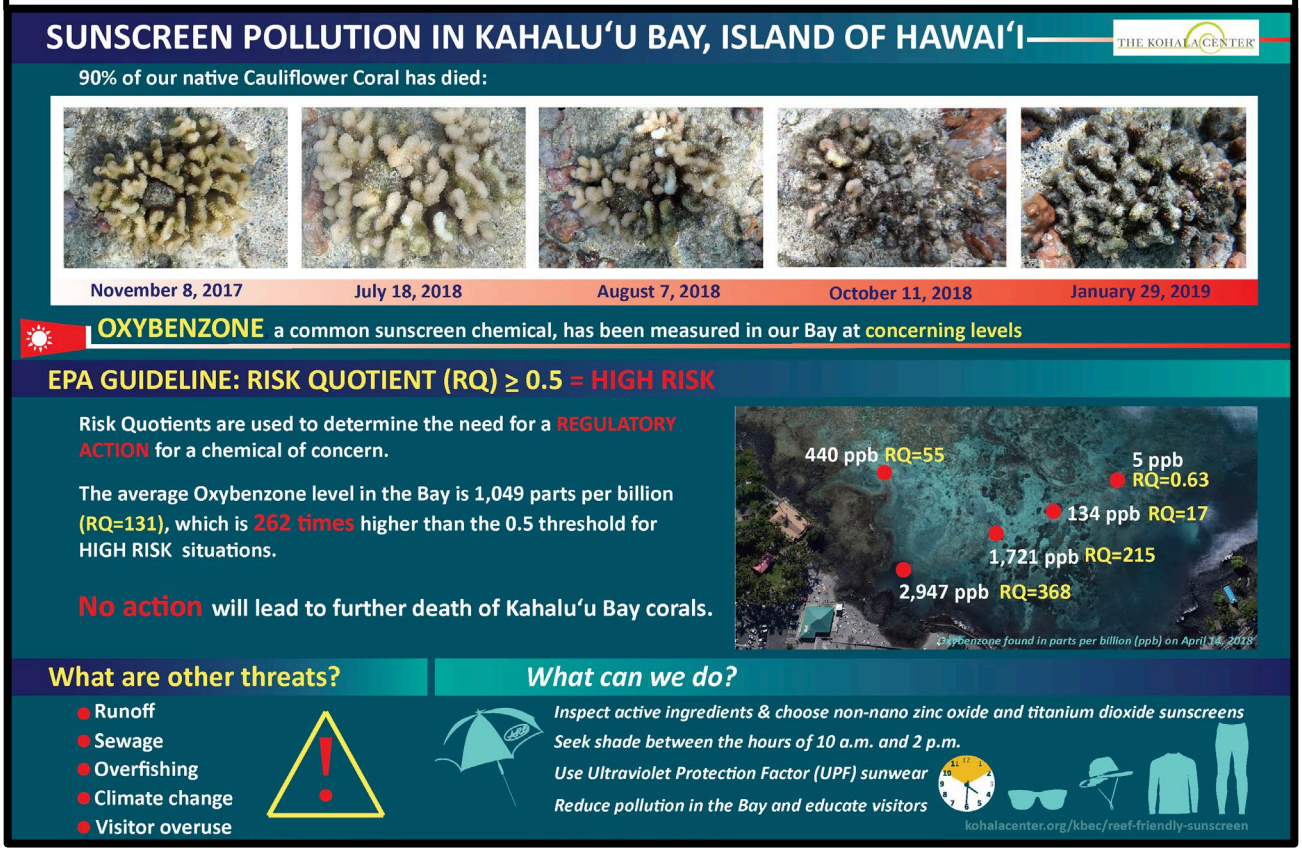
BEST
Hats, sunwear shirts and rash guards, wraps, and board shorts

Zinc oxide
Titanium dioxide

OK
Zinc oxide and titanium dioxide-based sunscreens made without nanoparticles

NEVER
Products containing oxybenzone, avobenzone, homosalate, octinoxate, octisalate, octocrylene, or nanoparticles

Supplemental Figure 15. Oxybenzone concentrations of five sample sites in Kahalu'u Bay, Island of Hawai'i, Hawaii, U.S.A. Water samples were collected 30 cm before the surface of the water on April 14, 2018. ppb = parts per billion = micrograms/liter. Risk Quotient was calculated by Dr. Cheryl Woodley of the U.S. National Oceanic & Atmospheric Administration using the same method as described in the Materials & Methods section in this manuscript.



Supplemental Figure 16. Hawaii Act 104 of 2018
https://governor.hawaii.gov/newsroom/latest-news/office-of-the-governor-news-release-governor-david-ige-signs-bill-making-hawaii-first-in-the-world-to-ban-certain-sunscreens/

EXECUTIVE CHAMBERS
HONOLULU

DAVID Y. IGE
GOVERNOR

July 3, 2018 **GOV. MSG. NO. 1205**

The Honorable Ronald D. Kouchi,
President
and Members of the Senate
Twenty-Ninth State Legislature
State Capitol, Room 409
Honolulu, Hawai'i 96813

The Honorable Scott K. Saiki,
Speaker and Members of the
House of Representatives
Twenty-Ninth State Legislature
State Capitol, Room 431
Honolulu, Hawai'i 96813

Dear President Kouchi, Speaker Saiki, and Members of the Legislature:

This is to inform you that on July 3, 2018, the following bill was signed into law:

SB2571 SD2 HD2 CD1 RELATING TO WATER POLLUTION
ACT 104 (18)

Sincerely,

DAVID Y. IGE
Governor, State of Hawai'i

Approved by the Governor
on JUL 03 2018

ACT 104

THE SENATE
TWENTY-NINTH LEGISLATURE, 2018
STATE OF HAWAII

S.B. NO. 2571 S.D. 2 H.D. 2 C.D. 1

A BILL FOR AN ACT

RELATING TO WATER POLLUTION.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF HAWAII:

SECTION 1. The legislature finds that two chemicals contained in many sunscreens, oxybenzone and octinoxate, have significant harmful impacts on Hawaii's marine environment and residing ecosystems, including coral reefs that protect Hawaii's shoreline. Oxybenzone and octinoxate cause mortality in developing coral; increase coral bleaching that indicates extreme stress, even at temperatures below 87.8 degrees Fahrenheit; and cause genetic damage to coral and other marine organisms. These chemicals have also been shown to degrade corals' resiliency and ability to adjust to climate change factors and inhibit recruitment of new corals. Furthermore, oxybenzone and octinoxate appear to increase the probability of endocrine disruption. Scientific studies show that both chemicals can induce feminization in adult male fish and increase reproductive diseases in marine invertebrate species (e.g., sea urchins), vertebrate species (e.g., fish such as wrasses, eels, and parrotfish), and mammals (in species similar to the Hawaiian monk seal). The chemicals also induce

deformities in the embryonic development of fish, sea urchins, coral, and shrimp and induce neurological behavioral changes in fish that threaten the continuity of fish populations. In addition, species that are listed on the federal Endangered Species Act and inhabit Hawaii's waters, including sea turtle species, marine mammals, and migratory birds, may be exposed to oxybenzone and octinoxate contamination.

The legislature further finds that environmental contamination of oxybenzone and octinoxate persists in Hawaii's coastal waters, as the contamination is constantly refreshed and renewed every day by swimmers and beachgoers. Swimming and other water activities cause these chemicals to pollute Hawaii's water unless they are actively mitigated. Sewage contamination of coastal waters is another source of oxybenzone and octinoxate environmental contamination, as these chemicals are not removed by the State's wastewater treatment system. Oxybenzone and octinoxate are also discharged to the ground and surface waters from cesspools, leaking septic systems, and municipal wastewater collection and treatment systems. The legislature additionally finds that elevated levels of oxybenzone and octinoxate have been detected at popular swimming beaches and critical coral

reef areas throughout the State, including Waimea bay, Hanauma bay, and Waikiki beach on Oahu, and Honolua bay and 'Ahihi-Kina'u natural area reserve on Maui.

Accordingly, the purpose of this Act is to preserve marine ecosystems, including coral reefs, by, beginning January 1, 2021, prohibiting the sale, offer for sale, and distribution in Hawaii of sunscreen containing oxybenzone and octinoxate without a prescription from a licensed healthcare provider.

SECTION 2. Chapter 342D, Hawaii Revised Statutes, is amended by adding a new section to part I to be appropriately designated and to read as follows:

"**§342D- Sale and distribution of sunscreen containing oxybenzone or octinoxate, or both; prohibition.** (a) Beginning January 1, 2021, it shall be unlawful to sell, offer for sale, or distribute for sale in the State any sunscreen that contains oxybenzone or octinoxate, or both, without a prescription issued by a licensed healthcare provider.

(b) No county shall enact any ordinance or regulatory restriction to prohibit the sale, use, labeling, packaging, handling, distribution, or advertisement of sunscreens

containing oxybenzone or octinoxate, or both, prior to January 1, 2021.

(c) For purposes of this section:

"Licensed healthcare provider" means a physician or osteopathic physician licensed pursuant to chapter 453, or an advanced practice registered nurse licensed pursuant to chapter 457.

"Octinoxate" refers to the chemical (RS)-2-Ethylhexyl (2E)-3-(4-methoxyphenyl)prop-2-enoate under the International Union of Pure and Applied Chemistry chemical nomenclature registry; that has a chemical abstract service registry number 5466-77-3; the synonyms of which include but are not limited to ethylhexyl methoxycinnamate, octyl methoxycinnamate, Eusolex 2292, Neo Heliopan AV, NSC 26466, Parsol MCX, Parsol MCX, and Uvinul MC80; and is intended to be used as protection against ultraviolet light radiation with a spectrum wavelength from 370 nanometers to 220 nanometers in a sunscreen.

"Oxybenzone" refers to the chemical (2-Hydroxy-4-methoxyphenyl)-phenylmethanone under the International Union of Pure and Applied Chemistry chemical nomenclature registry; that has a chemical abstract service registry number 131-57-7; the

synonyms of which include but are not limited to benzophenone-3, Escalol 567, Eusolex 4360, KAHSCREEN BZ-3, Uvasorb MET/C, Syntase 62, UV 9, Uvinul 9, Uvinul M-40, Uvistat 24, USAF Cy-9, Uniphenone-3U, 4-methoxy-2-hydroxybenzophenone and Milestab 9; and is intended to be used as protection against ultraviolet light radiation with a spectrum wavelength from 370 nanometers to 220 nanometers in a sunscreen.

"Prescription" means an order for medication, that is dispensed to or for an ultimate user. "Prescription" shall not include an order for medication that is dispensed for immediate administration to the ultimate user, such as a chart order to dispense a drug to a bed patient for immediate administration in a hospital. "Prescription" includes an order for a sunscreen.

"Sunscreen" means a product marketed or intended for topical use to prevent sunburn. Sunscreen does not include products marketed or intended for use as a cosmetic, as defined in section 328-1, for the face."

SECTION 3. This Act does not affect rights and duties that matured, penalties that were incurred, and proceedings that were begun before its effective date.

SECTION 4. New statutory material is underscored.

Supplemental Figure 17. 2021 Maui County Ordnance No. 5306

ORDINANCE NO. 5306

BILL NO. 135 (2021)

A BILL FOR AN ORDINANCE ESTABLISHING CHAPTER 20.42, MAUI COUNTY CODE, TO PROHIBIT THE SALE, USE, OR DISTRIBUTION OF NON-MINERAL SUNSCREENS

BE IT ORDAINED BY THE PEOPLE OF THE COUNTY OF MAUI:

SECTION 1. The Council finds that to preserve the State's marine ecosystems, the State banned the sale, offer of sale, and distribution in the State of any sunscreen that contains oxybenzone or octinoxate, or both, without a prescription issued by a licensed healthcare provider, through the enactment of Act 104, Session Laws of Hawai'i 2018, which is codified in Section 342D-21, Hawai'i Revised Statutes.

The Council further finds that while Section 342D-21, Hawai'i Revised Statutes, temporarily prohibited any county from enacting ordinances to prohibit the sale, use, or distribution of sunscreens containing oxybenzone or octinoxate, that prohibition expired January 1, 2021.

The Council further finds that Section 342D-19(b), Hawai'i Revised Statutes permits any county to adopt ordinances and rules governing any matter relating to water pollution control that is not governed by a rule of the State Department of Health adopted pursuant to Chapter 342D, Hawai'i Revised Statutes.

The Council further finds that coral reefs are essential for the livelihood of many residents of the County of Maui, both through the provision of food from subsistence fishing and from tourism and commercial fisheries.

The Council further finds that coral reefs dissipate wave energy and thereby protect coastal infrastructure, beaches, and communities.

The Council further finds that sunscreens are considered by the United States Food and Drug Administration (FDA) to be nonprescription, over-the-counter drugs that require specific testing to demonstrate that the sunscreen is generally recognized as safe and effective (GRASE) for its intended use before being sold to consumers. On September 24, 2021, the FDA issued a proposed order concerning nonprescription sunscreen drug products. In the proposed order, the FDA proposes that of the sixteen active ingredients currently used as UV filters in sunscreen products, zinc oxide and titanium dioxide ("mineral sunscreens") are deemed GRASE. Two of the chemical compounds used in sunscreen products — aminobenzoic acid (PABA) and trolamine salicylate — are proposed as not GRASE for use in sunscreens. The FDA has also proposed that the because the public record does not currently contain sufficient data to support positive GRASE determinations for avobenzone, cinoxate, dioxybenzone, ensulizole, homosalate, meradimate, octinoxate, octisalate, octocrylene, oxybenzone, padimate O, and sulisobenzone, these twelve ingredients are not GRASE because they require additional data.

The Council further finds that once the FDA finalizes the GRASE determinations for over-the-counter sunscreen products listed in the proposed order, the Council may revise its list of permitted sunscreens..

The Council further finds that action must be taken to prevent any potential harmful impacts of sunscreens certain harmful chemical compounds.

The Council finds that a number of non-mineral sunscreen products have recently been demonstrated to pose intolerable toxicologic threats, such as:

- Environmental contamination in coastal waters, including significant harmful impacts on the marine environment.
- Mortality in coral planula and gametes.
- Coral bleaching at temperatures lower than 87.8 degrees Fahrenheit.
- Damage to coral and other marine organisms' genomic integrity.
- Harm to humans including birth defects caused by Hirschsprung's disease.

Many non-mineral sunscreen ingredients also have been shown to degrade coral physiology and coral reef community integrity, which reduce acclimation and resiliency to climate change factors and degrade coral reefs by inhibiting recruitment. These ingredients have been shown to increase the probability of endocrine disruption in marine invertebrate species, such as sea urchins; vertebrate species, including fish such as wrasses, eels, and parrotfish; and mammals, such as in species similar to the endangered Hawaiian monk seal.

The active ingredients used in non-mineral sunscreen products in Maui County coastal waters acts as a pollutant, with environmental contamination levels refreshed and renewed, every day, by swimmers and beachgoers.

The Council finds that, to preserve the health, safety, and welfare of humans and the environment, as well as scenic underwater and natural beauty of Maui County, only mineral sunscreens may be sold, offered for sale, used, or distributed in the County.

SECTION 2. Title 20, Maui County Code, is amended by adding a new chapter to be appropriately designated and to read as follows:

"**Chapter 20.42**

SUNSCREEN

Sections:

20.42.010 Prohibitions. A. A person must not sell, offer for sale, or distribute for sale any non-mineral sunscreen without a prescription issued by a licensed healthcare provider.

B. Any non-mineral sunscreen must not be sold, provided, or offered for use at any County facility, County-authorized concession, County-sponsored or County-permitted event, or County program, without a prescription issued by a licensed healthcare provider.

C. Any non-mineral sunscreen must not be used or applied by any person, unless the sunscreen is from a prescription issued by a licensed healthcare provider.

20.42.020 Permit-application forms. Each agency must express this chapter's prohibitions on all permit-application forms for County facilities, County-managed concessions, County-sponsored and County-permitted events, and County programs.

20.42.030 Definitions. Whenever used in this chapter, unless the context otherwise requires:

"Sunscreen," "licensed healthcare provider," and "prescription" mean the same as defined in section 342D-21, Hawai'i Revised Statutes.

"Non-mineral sunscreen" means any sunscreen that uses an active ingredient other than zinc oxide and titanium dioxide.

"Titanium dioxide" means the chemical Titanium (IV) oxide under the International Union of Pure and Applied Chemistry chemical nomenclature registry, has a chemical abstract service registry number 13463-67-7, and whose synonyms include TiO2, Titania, Rutile, Anatase, Brookite, akaogiite, titanium white, Pigment White 6 (PW6), Colour Index (CI) 77891, oxido de titanio (IV), and Titandioxid, and is intended to be used as protection against ultraviolet light radiation with a spectrum wavelength from four hundred nanometers to two hundred twenty nanometers in an epidermal sunscreen-protection personal-care product.

"Zinc oxide" means the chemical Oxozinc under the International Union of Pure and Applied Chemistry chemical nomenclature registry, has a chemical abstract service registry number 1314-13-2, and whose synonyms include ZnO, zinc white, calamine, Chinese White, flowers of zinc, and zinc oxide, and is intended to be used as protection against ultraviolet light radiation with a spectrum wavelength from four hundred nanometers to two hundred twenty nanometers in an epidermal sunscreen-protection personal-care product.

20.42.040 Exceptions. This section does not apply to the sale, distribution, or offer of sale of sunscreens banned by State law, to the extent such ban is governed by a rule of the State department of health under chapter 342D, Hawai'i Revised Statutes.

20.42.050 Administration. The department of environmental management must administer this chapter and may adopt administrative rules in accordance with chapter 91, Hawai'i Revised Statutes.

20.42.060 Penalties. A. Violations of this chapter are subject to the penalties and enforcement procedures of section 19.530.030.

B. Money from fines collected for violation of this chapter must be deposited into the environmental protection and sustainability fund.

20.42.070 No conflict with State or federal law. Nothing in this chapter may be interpreted or applied so as to create any requirement or duty in conflict with any State or federal law."

SECTION 3. Section 3.55.040, Maui County Code, is amended to read as follows:

"**3.55.040 Deposits to the fund.** [There shall] The following must be deposited into the environmental protection and sustainability fund:

1. [Monies] Money transferred from the wastewater reclamation division of the department of environmental management related to the processing, handling, or disposal of sewage sludge.
2. Any fees or portions [thereof] of fees as set forth in the annual budget ordinance.
3. Supplemental transfers as set forth in the annual budget ordinance.
4. Money from fines collected for violations of chapter 20.42."

SECTION 4. This Ordinance takes effect on October 1, 2022.

APPROVED AS TO FORM AND LEGALITY:

KEOLA R. WHITTAKER
Deputy Corporation Counsel
Department of the Corporation Counsel
County of Maui
LF 2021-0007
2021-10-11 Ord Est Ch 20.42 (PAF 21-144) (KK)

Supplemental Figure 18. An example of policy regulation to mitigate sunscreen chemical contamination of a coral reef habitat during a coral spawning event.

Harry Kim
Mayor

Wil Okabe
Managing Director

Roxcie L. Waltjen
Director

Maurice C. Messina
Deputy Director

County of Hawai`i
DEPARTMENT OF PARKS AND RECREATION
101 Pauahi Street, Suite 6 • Hilo, Hawai'i 96720
(808) 961-8311 • Fax (808) 961-8411
Email: parks_recreation@hawaiicounty.gov
http://www.hawaiicounty.gov/parks-and-recreation/

April 27, 2018

NEWS RELEASE

PARTIAL CLOSURE OF KAHALU'U BEACH PARK DUE TO CORAL SPAWNING

Hawai'i County Department of Parks and Recreation is informing the public that Kahalu'u Beach Park will be closed from 7am – 12pm on May 1, May 2, May 31, and June 1, 2018 due to anticipated coral spawning events.

According to the Division of Aquatic Resources and Eyes of the Reef Network, Cauliflower coral (*Pocillopora meandrina*) was once abundant on shallow coral reefs along West Hawai'i, including Kahalu'u Bay. However, a global thermal stress event resulting in very high ocean temperatures struck West Hawai'i in the fall of 2015, and caused catastrophic bleaching and mortality for more than 90% of the regional population of cauliflower coral. To recover from this event, natural reproductive and replenishment activities of corals are critically important. For more than a decade, researchers have observed annual broadcast spawning events for cauliflower corals, and can now accurately predict when they will likely occur based on season, solar, tidal, and lunar cycles.

During broadcast spawning events, corals emit reproductive materials ("gametes") into the water column, and these materials are carried by the tides to mix and generate planktonic coral larvae. During this time, physical disturbance of corals and pollutants in the water (e.g. oxybenzone in many sunscreens) must be minimized to help ensure that corals are successful.

The Department of Parks & Recreation and the Kahalu'u Bay Education Center appreciates the public's understanding and respect of this important coral recovery and replenishment process at Kahalu'u Bay. We also apologize for any inconvenience with closure may cause.

For more information, please contact the Kahalu'u Bay Education Center at (808) 887-6411.

Supplemental Table 1. Estimation of mass of sunscreen shed from swimmers' skin at a location per day, per month, and per year

- 36 grams of sunscreen on average person for a two-hour treatment of a swimmer wearing modest bathing clothing.
- Reapplication of 36 grams of sunscreen after 90 minutes.
- Average length of time at a beach setting: 3 hours
- Assumption: 50% of sunscreen applied to a swimmer body is shed into the water during a 30 minute swimming period.

(36 grams)(2 applications) = 72 grams

72 grams x 50% shed into water = 36 grams

1,000 swimmers per day at a location

36 grams of shed sunscreen x 1,000 people =
36,000 grams of sunscreen in the water/day

(30-day month)(36 kg sunscreen/day) =
1,080 kg per month for 1,000 visitors per day

(12 months)(1,080 kg/month) =
12,960 kg/year for 1K visitors/day

Supplemental Table 2. Physicochemical properties of UV filters and sex hormones (ChemSpider | Search and share chemistry, © Royal Society of Chemistry 2022, Registered charity number: 207890). na, not applicable; Kow, partition constant octanol-water; Koc, partition constant organic carbon; Ka, dissociation constant.

Compound	Acronym	CAS Nº	Log Kow	Log Koc	pKa	Solubility (mg/l, in water, 25ºC)
UV FILTERS						
2,4-dihydroxybenzophenone, Benzophenone 1	BP1	92092-63-2	2.96	3.46	7.09	390
2,2',4,4'-Tetrahydroxybenzophenone, Benzophenone 2	BP2	131-55-5	2.78	3.89	6.75	98
2-hydroxy-4-methoxybenzophenone, Benzophenone 3 (oxybenzone)	BP3	131-57-7	3.79	3.10	7.56	210
2-Hydroxy-4-Methoxy-5-sulfonylbenzophenone (Benzophenone 4, Sulisobenzone)	BP4	4065-45-6	0.37	1.96	-2.42	650
2,2'-Dihydroxy-4-methoxybenzophenone (Benzophenone 8, dioxybenzone)	BP8, DHMB	131-53-3	3.82	3.32	6.78	52
4-Hydroxybenzophenone (p-benzoylphenol)	4HB	1137-42-4	3.02	3.24	7.85	410
4,4'-Dihydroxybenzophenone	4DHB	611-99-4	2.55	3.45	7.55	600
2-Ethylhexyl-p-metoxycinnamate	EHMC	5466-77-3	5.80	4.09	8.13	0.1548
3-(4-Methyl)benzyliden camphor)	4MBC	36861-47-9	5.92	4.09	na	0.1966
Octocrylene	OC	6197-30-4	6.88	5.61	na	0.003808
Ethyl-PABA, ethyl-4-aminobenzoate (benzocaine)	Et-PABA	94-09-7	1.86	1.59	2.51	1671
Avobenzone	AVO	70356-09-1	4.51	3.23	3.23	1.517
Homosalate	HMS	118-56-9	6.16	4.03	8.1	0.4195
Octisalate (2-Ethylhexyl salicylate)	OS	118-60-5	5.97	3.93	9.72	0.7171
1,2,3-Benzotriazole	BZT	95-14-7	1.44	3.00	8.37	5957
5-Methyl-1-H-benzotriazole (5-Tolyltriazole)	MeBZT	136-85-6	1.71	3.21	8.85	3069
5,6-Dimethyl-1H-benzotriazole	DMBZT	4184-79-6	2.26	3.43	8.92	914.2
2-(2-Hydroxy-5-methylphenyl) benzotriazole	UVP	2440-22-4	4.31	5.00	8.15	25.59
Sex Hormones						
Estrone	E1	53-16-7	3.13	4.48	10.33	146.8
Estriol	E3	50-27-1	2.45	2.90	10.54	440.8
Isotopically-labelled standards						
Benzophenone-^{13}C (Surrogate Standard)	BP-^{13}C	32488-48-5				
2-Hydroxy-4-methoxybenzophenone-d_5 (Internal Standard)	BP3-d_5	1219798-54-5				
3-(4-methylbenzylidine-d_4) camphor (Internal standard)	4MBC-d_4	1219806-41-3				
1H-Benzotriazole-d_4 (Internal Standard)	BZT-d_4	1185072-03-0				

Supplemental Table 3. Validation parameters for the analysis of UV filters in sand.

Sand matrix										
	Linearity (ng/g)	r2	ILOD (pg)	ILOQ (pg)	MLOD (ng/g)	MLOQ (ng/g)	Intraday	Interday	Recovery	RSD (%)
Oxybenzone	1-700	0.994	0.0657	0.219	0.0106	0.0353	1	22	95	10
Benzophenone-1	1-700	0.992	0.2310	0.770	0.0562	0.1870	0.5	5	78	10
Benzophenone-2	1-700	0.991	0.3760	1.250	0.0634	0.2110	2	14	84	12
4HB	1-700	0.994	0.3380	1.130	0.0156	0.0520	8	23	114	18
4DHB	1-700	0.966	0.1350	0.451	0.0147	0.0490	4	9	104	15
DHMB	1-700	0.998	0.1890	0.629	0.0111	0.0370	8	13	85	12
Avobenzone	1-700	0.995	0.2310	0.770	0.0319	0.1060	11	9	92	11
4MBC	1-700	0.998	0.0836	0.279	0.0227	0.0756	10	16	44	6
Octinoxate	1-700	0.997	0.0302	0.101	0.0320	0.1067	3	16	103	19
EtPABA	1-700	0.998	1.7300	5.760	0.0140	0.0468	0.1	7	95	19
BZT	1-700	0.992	1.8300	6.100	0.0065	0.0216	3	13	113	15
MeBZT	1-700	0.988	1.1700	3.910	0.0150	0.0500	12	15	112	9
DMeBZT	1-700	0.996	1.2100	4.020	0.0097	0.0325	3	14	89	15
UVP	1-700	0.994	0.2010	0.671	0.0096	0.0320	1	4	89	14
Octocrylene	1-700	0.992	0.2480	0.825	0.0258	0.0858	4	8	125	22
BP4 (-)	1-700	0.988	0.0936	0.312	0.0134	0.0446	6	5	68	21
Homosalate (-)	1-700	0.981	0.5340	1.780	0.0257	0.0858	4	9	110	7
Octisalate (-)	1-700	0.984	0.4680	1.560	0.0124	0.0412	6	7	102	15

Supplemental Table 4. Validation parameters for the analysis of UV filters in water

	Water matrix									
	Linearity (ng/L)	r2	ILOD (pg)	ILOQ (pg)	MLOD (ng/mL)	MLOQ (ng/mL)	Intraday	Interday	Recovery	RSD (%)
Oxybenzone	1-700	0.999	0.00792	0.0264	0.00142	0.00472	3	5	99	6
Benzophenone-	1-700	0.999	0.00728	0.0243	0.00211	0.00703	3	6	97	9
Benzophenone-	1-700	0.999	0.0194	0.0648	0.00647	0.02150	2	5	101	13
4HB	1-700	0.999	0.00697	0.0232	0.00242	0.00805	4	5	103	9
4DHB	1-700	0.999	0.0139	0.0464	0.00378	0.01260	3	5	99	13
DHMB	1-700	0.999	0.0077	0.0257	0.00170	0.00565	4	6	110	15
Avobenzone	1-700	0.999	0.00778	0.0259	0.00189	0.00630	4	6	66	8
4MBC	1-700	0.997	0.0189	0.0630	0.00641	0.02130	3	6	82	12
Octinoxate	1-700	0.998	0.00604	0.0201	0.00255	0.00851	3	5	69	5
EtPABA	1-700	0.999	0.0205	0.0684	0.00660	0.02200	5	7	59	11
BZT	1-700	0.999	0.02	0.0666	0.00614	0.02050	5	6	74	12
MeBZT	1-700	0.999	0.0135	0.0451	0.00336	0.01120	3	5	56	11
DMeBZT	1-700	0.999	0.0081	0.0270	0.00120	0.00400	4	8	45	11
UVP	1-700	0.999	0.0128	0.0428	0.00333	0.01110	3	7	73	10
Octocrylene	1-700	0.999	0.00793	0.0264	0.00248	0.00828	4	8	81	10
BP4 (-)	1-700	0.991	0.0207	0.0693	0.00715	0.02383	7	16	86	16
Homosalate (-)	1-700	0.996	0.0119	0.0396	0.00188	0.00627	5	8	78	9
Octisalate (-)	1-700	0.997	0.00745	0.0249	0.00142	0.00472	3	7	82	8

Supplemental Table 5. Risk Quotient for Acute Toxicity for 4MBC in beach sand samples collected in Hawaii using European Union method for Cnidarian, invertebrates (non-Cnidarian), plant and algae species, and fish species. Color chart: RED= Severe condition for a potential toxic effect ≥1; Orange = Moderate threat condition for a potential toxic effect = 0.5 to 1.0; Yellow = Condition of concern 0.1 to 0.5.

4-Methylbenzylidene camphor				Wailupe Beach	Kuhio Beach	Kalama Beach	Kamaola Beach	Polo Beach	Waialea Bay Site 1	Waialea Bay Site 2	Mauna Lani Site 1	Mauna Lani Site 2	Black Sand Site 1	Black Sand Site 2	Kahalu'u Site 1	Kahalu'u Site 2	
				3.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Environ. Concen. ng/g
SPECIES			Toxicity Reference Value ng/g														References for Toxicity Reference Values
Arthropoda																	
Sericostoma vittatum	Reduced feeding rate (6 days)	NOEC	1350.00	2.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Campos et al 2017a
Sericostoma vittatum	Decreased carbohydrates content 6 days	NOEC	2,570.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Campos et al 2017a
Sericostoma vittatum	Increased total glutathione levels 6 days	PNEC	675.00	4.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Campos et al 2017a
Chironomus riparius	Larval growth inhibition 28 days	NOEC	800.00	4.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Campos et al 2017b
Chironomus riparius	Delayed development time of females 28 days	NOEC	800.00	4.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Campos et al 2017b
Chironomus riparius	Reduced male adults bodyweight 28 days	NOEC	2,050.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Campos et al 2017b
Chironomus riparius	Increased GST levels, 48 h	NOEC	1,120.00	2.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Campos et al 2017b
Chironomus riparius	Increased catalyase activity, 48 h	NOEC	1,120.00	2.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Campos et al 2017b
Chironomus riparius	Decreased Acetylcholinestrase activity, 48 h	PNEC	45.00	73.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Campos et al 2017b
Annelida																	
Lumbriculus variegatus	Decreased in reproduction rate 28 days	NOEC	1,470.00	2.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Schmitt et al 2008