## GET Committee

**From:** David Henkin <dhenkin@earthjustice.org>
**Sent:** Friday, May 17, 2019 11:59 AM
**To:** GET Committee
**Subject:** Earthjustice Testimony Re: GET-26 and CC-19-178
**Attachments:** 2019-5-20 Testimony re GET-26.pdf

To Whom It May Concern,

Please find attached Earthjustice's testimony on GET-26 and CC-19-178, which the GET Committee will take up at its meeting on May 20, 2019. Please distribute copies of this testimony to the Committee.

Thank you for your assistance.

Regards,

David Henkin
Staff Attorney
Earthjustice
850 Richards St., Suite 400
Honolulu, HI 96813
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EARTHJUSTICE

TESTIMONY REGARDING GET-26
HAWAII WILDLIFE, ET AL. V. COUNTY OF MAUI, CIVIL 12-00198 SOM BMK,
U.S. SUPREME COURT DOCKET 18-260,
AND REGARDING COMMUNICATION NO. 19-178
RESOLUTION "REQUIRING SETTLEMENT OFFERS IN HAWAII WILDLIFE, ET AL. V. COUNTY OF MAUI, RELATING TO THE CLEAN WATER ACT, TO BE TRANSMITTED TO THE COUNCIL FOR APPROVAL OR DISAPPROVAL"

Governance, Ethics and Transparency Committee Meeting
May 20, 2019
9:00 a.m.

Good morning Chair Molina, Vice-Chair Rawlins-Fernandez, and members of the GET Committee:

My name is David Lane Henkin, I am an attorney with Earthjustice, and I represented the plaintiffs in *Hawai'i Wildlife Fund, et al., v. County of Maui* in the proceedings before the federal district court and on appeal to the Ninth Circuit Court of Appeals. I continue to represent these Maui community groups—Hawai'i Wildlife Fund, Sierra Club-Maui Group, Surfrider Foundation and West Maui Preservation Association ("the Community Groups")—in the current proceedings before the U.S. Supreme Court.

We very much appreciate that the newly elected Maui County Council is taking up the question whether it is in the best interests of the County and its residents to continue litigating the *Hawai'i Wildlife Fund* case. I offer this testimony in the hopes of providing you with information that will be helpful to your deliberations.

As a threshold matter, we encourage the Council to adopt the resolution attached to CC-19-178, "Requiring Settlement Offers in *Hawaii Wildlife Fund, et al. v. County of Maui*, Relating to the Clean Water Act, to be Transmitted to the Council for Approval or Disapproval." Adopting this resolution would not require the Council to settle the case. Rather, it would simply ensure the Council has the opportunity to do so, should it deem settlement to be in the best interests of the County. This should not be a controversial proposition.

Should the Council wish to settle the case, we can assure you that the Community Groups would work cooperatively with the County of Maui to address the challenges posed by the injection wells at the Lahaina Wastewater Reclamation Facility ("LWRF") and the County's other facilities using injection wells. As discussed in greater detail below, we have never expressed or shown any interest in having the County spend money on litigation or pay Clean Water Act penalties to the federal treasury. On the contrary, the Community Groups have consistently sought to encourage the County to invest its taxpayer dollars to find solutions, including investments in infrastructure to increase re-use of treated wastewater from the LWRF to meet the irrigation needs of West Maui agriculture, golf courses and commercial landscaping.

## I. NEITHER EARTHJUSTICE NOR ANY OF THE PLAINTIFFS HAVE ANY INTEREST IN HAVING THE COUNTY PAY CIVIL PENALTIES; RATHER, WE JUST WANT THE COUNTY TO ADDRESS THE PROBLEM

In the past, some have expressed concerns that, if the County does not continue the litigation over the LWRF injection wells, the County will be subjected to hundreds of millions of dollars in fines for continued operation of its various wastewater treatment facilities. Please rest assured that the Community Groups have no interest in having the County subjected to civil penalties for its Clean Water Act violations. The memberships of all four Community Groups are made up of Maui taxpayers. They do not want their tax dollars sent to the U.S. Treasury in the form of penalties. Rather, they want the County to invest their tax dollars to fund projects to put treated wastewater to beneficial reuse (and, in the process, to help alleviate the County's chronic shortages of fresh water), rather than injecting that wastewater, where it ends up on the reef.

You don't have to take my word for it, because the record is very clear on this point. For four years before we headed to court, Earthjustice and our community clients tried to convince the County to address concerns about harm to the marine environment from the operation of the LWRF injection wells and to take steps to increase reuse of the facility's treated wastewater. In November 2011, after more than three years without making any headway, we sent the County the required notice of intent to sue under the Clean Water Act. Even then, we tried to get the County to commit to addressing the problems posed by the LWRF injection wells without going to court, waiting nearly ten months (rather than the 60 days required by law) before filing suit.

After we got to court and the court rejected the County's motion to dismiss our case, we welcomed the County's suggestion that the parties attempt to find a mutually acceptable settlement that would avoid the need to spend time and money on litigation, agreeing to put our case on hold for nearly a year and a half while the parties negotiated. All of our settlement proposals focused on identifying feasible projects to reuse treated wastewater from the LWRF. It was only when the County refused to fund any of those projects that we returned to active litigation.

After the district court ruled in our favor, holding that the County was violating the Clean Water Act, we again focused on trying to convince the County to fund wastewater reuse projects, not on seeking penalties. The settlement agreement we reached in September 2015 reflects that focus, with the agreement calling for the County to invest at least $2.5 million on wastewater reuse.

The September 2015 settlement does oblige the County to pay $100,000 in the form of a monetary penalty, but that is only because the Clean Water Act settlement policy requires at least a nominal fine as part of any settlement, not because we wanted to impose a fine. Please bear in mind that the settlement resolved over eight years of nearly daily Clean Water Act violations at each of four injection wells. The penalty in the settlement represents a fine of only a few dollars per violation, which is truly nominal.

The bottom line is that all the Community Groups want is for the County to invest in projects addressing the environmental concerns posed by the County's injection wells, not pay fines to the U.S. Treasury. This is reflected in the latest settlement communication attached to the May 10, 2019 correspondence from the Department of the Corporation Counsel (dated April 26, 2019, with May 9, 2019 edits), which (1) asks the County to make the previously agreed-upon investment in infrastructure to increase reuse of R-1 water from the LWRF (paragraph 2) and (2) provides assurances that the Community Groups will not bring litigation seeking any penalties based on the County's use of injection wells at the LWRF or other facilities as long as the County is making good faith efforts to address the concerns that use of injection wells raise (paragraphs 4 and 5).

## II. THE SETTLEMENT DOES NOT REQUIRE THE COUNTY TO PURSUE THIS APPEAL

In the past, some County leaders have suggested that the September 2015 settlement requires the County to pursue appeals. That is simply not the case. The settlement preserves the County's right to appeal the district court's rulings, but it does not *oblige* the County to do so. Thus, in urging the Council to settle the case, we are not "attempting to re-write the deal," as the County's special counsel would have it. Testimony of Colleen Doyle (Hunton Andrews Kurth) at 4 (May 16, 2019).[1] It is entirely up to you, the Council, to decide whether it is in the best interests of the County and its residents to continue to pursue this appeal, which threatens the County's national reputation as a champion of environmental quality and stewardship, or whether it is best to settle and focus on finding solutions to the problems posed by the injection wells.

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[1] As mentioned, it has always been our desire that the parties focus on finding solutions to environmental harm caused by using the LWRF injection wells, not on endless litigation. We have never urged the County to pursue appeals, as the County's special counsel suggests. *Id.*

## III. THE HAWAI'I DEPARTMENT OF HEALTH IS NOT REFUSING TO PROCESS THE COUNTY'S APPLICATION FOR A CLEAN WATER ACT PERMIT

In the past, County representatives have claimed the Hawai'i Department of Health (HDOH) refuses to issue a National Pollutant Discharge Elimination System (NPDES) permit under the Clean Water Act for the LWRF injection wells or even to process the County's permit application. This is untrue.

While the County's Department of Environmental Management did submit an application for an NPDES permit, HDOH made clear more than three years ago that the County's application was so deficient, lacking the most basic information, that HDOH could not process it. *See* 2/25/16 HDOH Letter (attached). HDOH identified a long list of missing, "required information" and set a deadline of May 31, 2016 for the County to provide it. *Id.* at 4.

Rather than comply with HDOH's information requests in a timely fashion, the County's Department of Environmental Management has asked for extension after extension of the deadline. *See* 5/16/16 DEM Letter (attached); 10/27/16 DEM Letter (attached). Most recently, the Department of Environmental Management asked for yet another extension, this time until the end of 2018. *See* 11/29/17 DEM Letter (attached); 12/5/17 DEM Letter (attached). Based on the information available on the HDOH permitting website, it appears that the County has yet to provide all of the information required to complete its application.

The County cannot fault HDOH for failing to take action on the County's NPDES permit application when the County has failed to provide all of the information HDOH identified over three years ago as essential to review of the County's application.

Once the County finalizes its permit application, we will work with you to encourage HDOH to process the application promptly. Moreover, as specified in our settlement letter (paragraph 4), as long as the County is making good faith efforts to secure a permit for the LWRF injection wells, we will not seek penalties for the lack of such a permit.

## IV. THE COUNTY CAN SECURE CLEAN WATER ACT PERMIT COVERAGE FOR INJECTION WELL DISCHARGES

Another major theme of past Council discussions is that it is allegedly impossible to secure an NPDES permit for the LWRF injection wells because, supposedly, no one knows how to design a permit for discharges via groundwater to navigable waters like the Pacific Ocean off Kahekili Beach. That is also untrue. The Environmental Protection Agency ("EPA") has issued such permits. *See, e.g.*, EPA, NPDES Permit #WA0023434 Fact Sheet (discussing permit for rapid infiltration basins at wastewater treatment plant that discharge to river via groundwater) (attached). Moreover, as recently retired EPA employee Wendy Wiltse confirms in her testimony to this committee, EPA has offered repeatedly to assist HDOH and the County to develop a legally adequate permit for the LWRF injections wells. Testimony of Wendy Wiltse at 2 (May 16, 2019) (attached).

The bottom line is that NPDES permits can be developed and issued to address discharges to navigable waters via hydrologically connected groundwater. The County is not, as many have alleged, in an impossible situation.

## V. PEOPLE WHO IRRIGATE WITH RECYCLED WATER FROM THE LAHAINA FACILITY WILL NOT BE SUBJECTED TO CIVIL PENALTIES

Some County representatives have claimed that, unless the County fights to overturn the Ninth Circuit's decision, businesses and others who irrigate with recycled water from the LWRF will be subjected to civil penalties for Clean Water Act violations, creating obstacles to increasing reuse of treated wastewater. This concern lacks any basis.

When businesses and other consumers irrigate their landscaping and golf courses, they are careful to use only as much water as is needed to soak into the root zone so their grass and other plants will stay alive. After all, they are paying for the water they use. Thus, there is no reason to believe that consumers of the LWRF's recycled water would overwater their landscaping and golf courses so as turn their properties into bogs, with a stream of excess irrigation water flowing into the ocean through the ground. There is simply no parallel with the LWRF injection wells, which were intentionally designed to dispose of millions of gallons of treated wastewater each day into the ocean via groundwater.

In the unlikely event that a business accidentally overwatered, such that large quantities of excess recycled water reached the ocean via groundwater, that business would have ample opportunity to correct the problem. The Clean Water Act requires 60-days advance, written notice before any citizen suit can be brought. The purpose of that notice requirement is to give people the chance to come into compliance, without any prospect for being subjected to penalties. Again, consumers of LWRF recycled water would have every incentive not to overwater—not just to avoid any pollution, but to also not to waste money paying for that water.

Finally, it bears emphasizing that Earthjustice and our community clients are deeply committed to increasing the amount of LWRF wastewater that is recycled, rather than injected. *That has been the sole focus of our advocacy for more than a decade.* We simply have no possible interest in creating any disincentive for business and others to use treated wastewater to meet their irrigation needs. To lay to rest any possible concerns, our latest settlement communication makes clear the Community Groups will not sue any end user of recycled water from the LWRF that is irrigating responsibly.

## VI. CONTINUING WITH BUSINESS AS USUAL AT THE LWRF IS DESTROYING THE REEF AT KAHEKILI

It is common in settlements for parties to reach agreement on the best path forward without necessarily agreeing on all the facts related to the case. For example, in this case, the County and the Community Groups entered into a settlement in 2015 regarding the proper remedy "without any admission of fact." 2015 Settlement at 3. Similarly, to resolve the pending appeal to the Supreme Court, the County would not have to acknowledge that the LWRF injection wells have an adverse effect on the nearshore marine environment. *See* Settlement Letter (dated April 26, 2019, with May 9, 2019 edits) at ¶ 7.

That said, we think it important that you know that every independent, peer-reviewed scientific study has concluded that the LWRF injection wells are harming the coral reef offshore of Kahekili Beach Park. In 2102, researchers from University of Hawai'i found that algae samples grown over freshwater seeps in Kahekili's nearshore waters contained the highest values of nitrogen associated with wastewater treatment facilities ($\delta^{15}N$) ever reported in the scientific literature (Dailer *et al.* 2012) (attached). Most recently, researchers at the U.S. Geological Survey, University of Hawai'i, Woods Hole Oceanographic Institution, and State of Hawai'i Division of Aquatic Resources published a peer-reviewed study confirming that discharges from the LWRF injection wells are literally eating the reef from the inside, contributing to rates of bioerosion that are orders of magnitude higher than one would otherwise expect (Prouty, et al., 2017) (attached).

As the testimony from former EPA staffer Wendy Wiltse makes clear, regulation under the state and federal underground injection control (UIC) program is entirely inadequate to protect Kahekili's fragile coral reefs from continued destruction. If it were, the existing UIC permits, which have been in effect for decades, would have brought an end to the harm to the reef at Kahekili. They have not.

## VII. CONCLUSION

I hope this information is helpful to this Council in refocusing on the available and necessary solutions in this case, rather than on counterproductive litigation. Earthjustice and its community clients would welcome the opportunity to work with the Council to find solutions to the challenges posed by the County's injection wells. I can be reached via email at dhenkin@earthjustice.org or via telephone at 808-599-2436, ext. 6614.

DAVID Y. IGE
GOVERNOR OF HAWAII

VIRGINIA PRESSLER, M.D.
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HI 96801-3378

In reply, please refer to:
EMD/CWB

02046PDCL.16

February 25, 2016

Mr. Stewart Stant
Director
Department of Environmental Management
County of Maui
2050 Main Street, Suite 1C
Wailuku, Hawaii 96793

Attention: Mr. Eric Nakagawa
Wastewater Division Chief

Dear Mr. Stant:

**Subject: Incomplete National Pollutant Discharge Elimination System (NPDES) Application for Lahaina Wastewater Reclamation Facility (WRF) Injection Wells 1-4**
**Permit No. HI 0021848**

The Department of Health (DOH), Clean Water Branch (CWB) has the following comments on your NPDES application:

1. Signatory and Certification Statement to National Pollutant Discharge Elimination System (NPDES) Permit Applications and NPDES Form 2A, Part C. Certification

   HAR 11-55-07(a)(3), identifies signatories to NPDES forms for a municipality, state, federal, or other public agency as a principal executive officer or ranking elected official. Please revise the application such that the certifying person meets the requirement of HAR 11-55-07(a)(3) (e.g., the Director).

2. NPDES Form 2A Application Overview, Part A.8

   The Yes choice should be checked if the treatment works discharges effluent to waters of the U.S and NPDES permit coverage is being requested. If the treatments works does not discharge effluent to waters of the U.S. (No choice selected in Part A.8), NPDES coverage is not required and your application should be withdrawn.

3. NPDES Form 2A Application Overview, Parts A.9 through A.12

   Any treatment works that discharges effluent to surface waters of the U.S. must answer questions A.9 through A.12. Please provide the required information for Parts A.9 through A.12 including: identification of a receiving water and effluent testing information.

4. NPDES Form 2A, Part B.6

   All treatment works that have a design flow greater than or equal to 0.1 MGD must complete questions B.1 through B.6. Applicants that discharge to waters of the U.S. must provide effluent testing data for the parameters listed in this part. Please provide the required information.

5. NPDES Form 2A, Part D

   A treatment works that discharges effluent to surface waters of the U.S. and has a design flow rate greater than or equal to 1 MGD must provide the expanded effluent testing data specified in this part. Please provide the required information.

6. NPDES Form 2A, Part E

   Per Part E of Form 2A, Publicly Owned Treatment Works (POTWs) with a design flow rate greater than or equal to 1.0 mgd must provide the results of whole effluent toxicity test for acute or chronic toxicity for each of the facility's discharge points. Please provide the required information.

7. Forms not received with the application submittal:

   a. An EPA Application Form 1 - General Information was not provided with the application. The CWB Individual NPDES Form has since replaced this form for NPDES submittals to the Clean Water Branch. Please complete and submit.

   b. Form 2S is required for Sewage sludge (biosolids) for new and existing treatment works treating domestic sewage. Please complete and submit Form 2S.

   c. Form B is required for discharges of storm water associated with industrial activities. NPDES permit coverage is required for discharges of storm water runoff associated with industrial activity(ies) as categorized in 40 CFR 122.26(b)(14)(i) through 122.26(b)(14)(ix) and 122.26(b)(14)(xi). If your facility is not covered under another permit for storm water, please verify your facility applicability and submit this form, as required.

d. Per HAR 11-54-9 Zone of Mixing (ZOM), every application for a ZOM shall be made on forms furnished by the director and shall be accompanied by a complete and detailed description of present conditions, how present conditions do not conform to standards, and other information as the director may prescribe. Please complete and submit the DOH Clean Water Branch ZOM Form to request a ZOM.

   i. Specify the specific pollutant parameters for which you are requesting a ZOM. Note: A ZOM for a specific pollutant cannot be granted if the receiving water does not have assimilative capacity for that pollutant.

   ii. Please also specify your minimum dilution, average dilution, and dilution at the edge of the ZOM. Provide your data and calculations used to derive the dilution values.

The various CWB NPDES application forms (including those specified in the preceding comments) are accessible through the e-Permitting Portal website at: https://eha-cloud.doh.hawaii.gov/epermit/View

8. Please be aware that HAR Section 11-54-4 requires dilution to be calculated using EPA approved models. Per HAR, Section 11-54-4(c)(1),

*"Dilution" means, for discharges through submerged outfalls, the average and minimum values calculated using the models in the EPA publication, Initial Mixing Characteristics of Municipal Ocean Discharges (EPA/600/3-85/073, November 1985), or in the EPA publication, Expert System for Hydrodynamic Mixing Zone Analysis of Conventional and Toxic Submerged Single Port Discharges (Cormix 1) (EPA/600/3-90/012), February, 1990.*

As the aforementioned models are older and there has been development of newer models, in some cases, the applicant has proposed to use the specified models for toxics and a newer 3-dimensional model for nutrients. EPA has okayed such models. In the past, EPA has requested more information (justification, appropriateness of the model for the particular situation, etc.) if the model is not one of the commonly used models. Other permittees have also proposed to evaluate both CORMIX 1 (for submerged diffusers) and CORMIX 3 (for surface discharge) and select the one shown to best represent the thermal plume dynamics.

A study (e.g., sampling, etc.) could then be used for confirmation of the modeled dilution.

9. HAR 11-54-1.1 provides the State's general policy of water quality antidegradation. U.S. EPA Region 9 Guidance on Implementing the Antidegradation Provisions of 40 CFR 131.12 dated June 3, 1987, includes adoption of a mixing zone as one of the actions which trigger an antidegradation analysis. Please provide an antidegradation analysis as part of your request for the adoption of a mixing zone.

10. In addition to listing Kaanapali (Kahekili Beach) as impaired for turbidity, the 2014 State of Hawaii Water Quality Monitoring and Assessment Report also identifies the following:

    - Honokowai Point to Kaanapali as impaired for total nitrogen and ammonia-nitrogen.
    - West Maui Coast-near shore waters to 60' from Honolua-Lahaina as impaired for total nitrogen, nitrate + nitrite nitrogen, total phosphorus, and TSS.

    Please verify if your discharge is in these areas. ZOMs are not allowed for pollutants for which the receiving water is impaired.

11. The federal CWA Section 307(b), and federal regulations, 40 CFR 403, require POTWs to develop an acceptable industrial pretreatment program. Please verify if your facility meets the applicability for the industrial pretreatment requirements.

12. Please clarify if the effluent from the seeps is only from the Lahaina WRF and natural groundwater. If there are other contributors to the effluent, please specify these sources.

In order to continue processing the NPDES Application, we request that you send us a transmittal letter (including your responses to our comments, **Permit No. HI 0021848**, the certification statement below, and your original signature) and a CD or DVD with the following information attached:

1. Revised NPDES Application in pdf format (minimum 300 dpi).
2. Attachments to support your submittal in pdf format (minimum 300 dpi).

The CWB expects to receive the required information by **May 31, 2016**. Additional time may be granted upon receipt of a valid written request from you or the Director of the Department of Environmental Management, County of Maui (COM). If the CWB does not receive the required information or a valid written request by **May 31, 2016**, we will assume that you are no longer interested in obtaining NPDES Permit coverage for the subject project. Consequently, the processing of your NPDES Permit Application will be automatically terminated. You may resubmit a complete NPDES Permit Application with the required filing fee.

Please include **Permit No. HI 0021848** and the following certification statement in all future correspondence with the DOH for the subject project:

> **"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."**

If you have any questions, please contact Mr. Darryl Lum or Mr. Shane Sumida of the Engineering Section, CWB, at (808) 586-4309.

Sincerely,

STUART YAMADA, P.E., CHIEF
Environmental Management Division

DCL:bk

c: Water Division (WTR-5), CWA Standards and Permits Office, EPA, Region 9
[via e-mail sablad.elizabeth@epamail.epa.gov only]
Mr. Eric Nakagawa, COM [via e-mail Eric.Nakagawa@co.maui.hi.us]
Mr. Scott Rollins, COM [via e-mail Scott.Rollins@co.maui.hi.us only]
Mr. Edward Bohlen, Deputy Attorney General [via e-mail only]

ALAN M. ARAKAWA
Mayor

STEWART STANT
Director

MICHAEL M. MIYAMOTO
Deputy Director

MICHAEL RATTE
Solid Waste Division

ERIC NAKAGAWA, P.E.
Wastewater Reclamation Division

2016 MAY 20 1:39PM

**COUNTY OF MAUI**
**DEPARTMENT OF ENVIRONMENTAL MANAGEMENT**

2050 MAIN STREET, SUITE 2B
WAILUKU, MAUI, HAWAII 96793

CERTIFIED MAIL RECEIPT
7010 1060 0000 7456 8784
Return Receipt Requested

May 16, 2016

Stuart Yamada, P.E. Chief
State of Hawaii
Department of Health
Environmental Management Division
P.O. Box 3378
Honolulu, Hi 9680-3378

Attention: Mr. Darryl Lum
Engineering Section, Clean Water Branch

Dear Mr. Yamada,

**SUBJECT: NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES) APPLICATION FOR LAHAINA WASTEWATER RECLAMATION FACILITY LAHAINA, ISLAND OF MAUI, HAWAII PERMIT NO. HI 0021848**

The County of Maui appreciates your staff meeting with us April 29, 2016 to discuss the comments in your February 25, 2016 letter regarding the subject permit application. Based on these discussions we have a clearer understanding of your department's goals and required revisions. The County of Maui through submission of this letter requests a six month time extension in order to plan necessary testing and compile the additional information needed to complete revisions to the subject application.

**"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."**

Sincerely,

Stewart Stant, Director
Environmental Management

SS:sr (Lahaina NPDES Ext.docx)

DCL
S S

HI0021848

ALAN M. ARAKAWA
Mayor

STEWART STANT
Director

MICHAEL M. MIYAMOTO
Deputy Director

MICHAEL RATTE
Solid Waste Division

ERIC NAKAGAWA, P.E.
Wastewater Reclamation Division

**COUNTY OF MAUI**
**DEPARTMENT OF**
**ENVIRONMENTAL MANAGEMENT**
2050 MAIN STREET, SUITE 2B
WAILUKU, MAUI, HAWAII 96793

2016 OCT 28 10:47AM

October 27, 2016

Stuart Yamada, P.E. Chief
State of Hawaii
Department of Health
Environmental Management Division
P.O. Box 3378
Honolulu, Hi 96801-3378

Attention: Mr. Darryl Lum / Mr. Shane Sumida
Engineering Section, Clean Water Branch

Dear Mr. Yamada,

**SUBJECT: NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES) APPLICATION FOR LAHAINA WASTEWATER RECLAMATION FACILITY LAHAINA, ISLAND OF MAUI, HAWAII PERMIT NO. HI 0021848**

The County of Maui is proceeding with obtaining the requested data and revising the subject permit application per your previous correspondence. To that end, we have re-staffed our Wastewater Division laboratory and obtained funding in our fiscal year 2017 budget for sampling, required effluent analysis, toxicity testing and other field work necessary to fully complete the permit application.

We intend to make one submittal once our data is complete and not make partial submittals over time. We therefore, would like to request a one (1) year extension on the application process. This time will allow us to:

A. Complete the toxicity testing requested in the NPDES Application. The County would like to discuss issues related to the type of testing required and the effect on results.
B. Complete the sampling and analysis of effluent over a one year period in order to determine if there are any seasonal effects.
C. Perform field studies as necessary to provide the information requested by DOH related to the application.

We appreciate your consideration of this request and are available to meet if you wish to discuss further.

**"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."**

Sincerely,

for Stewart Stant, Director
Environmental Management

SS:sr (Lahaina NPDES Time Extension 2.docx)

SC HI 0021848

ALAN M. ARAKAWA
Mayor

STEWART STANT
Director

MICHAEL M. MIYAMOTO
Deputy Director

MICHAEL RATTE
Solid Waste Division

ERIC NAKAGAWA, P.E.
Wastewater Reclamation Division

COUNTY OF MAUI
**DEPARTMENT OF ENVIRONMENTAL MANAGEMENT**
2050 MAIN STREET, SUITE 2B
WAILUKU, MAUI, HAWAII 96793

2017 DEC 5 3:11PM

November 29, 2017

CERTIFIED MAIL
7014 2870 0001 3379 7386
Return Receipt Requested

Stuart Yamada, P.E. Chief
State of Hawaii
Department of Health
Environmental Management Division
P.O. Box 3378
Honolulu, Hi 96801-3378

Attention: Mr. Darryl Lum / Mr. Shane Sumida
Engineering Section, Clean Water Branch

Dear Mr. Yamada,

**SUBJECT: NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES) APPLICATION FOR LAHAINA WASTEWATER RECLAMATION FACILITY LAHAINA, MAUI, HAWAII PERMIT NO. HI 0021848**

The County of Maui is proceeding with obtaining the requested data and has revised the subject permit application per your February 25, 2016 and November 10, 2016 correspondences. We have amended the application by creating an e-form on your website, added or revised forms and exhibits based on your comments and new information gathered since our last submittal. We regret that we have been unable to gather all of the data required. We therefore, would like to request a second one (1) year extension on the application process. This time will allow us to complete the design and perform field studies for this complex disposal scenario.

Note the status of the items in your February correspondence below:

1. Signatory and Certification Statements – Have been updated to the current director.
2. NPDES Form 2A Part A.8 Discharges and Other Disposal Methods – We do not discharge wastewater to waters of the U.S. As a final component of our publicly owned treatment works, treated water is disposed via injection wells to groundwater, not to a surface water. It is hypothesized that after mixing with groundwater, some or all of the discharge may eventually reach the Pacific Ocean in a broad and diffuse manner. Please confirm whether you are concluding that this disposal method does not require an NPDES permit.

3. NPDES Form 2A Part A.9 through 12– Part A.9: We do not have an outfall, see number 2 above for type of discharge. We have completed Section A.10 through A.12
4. NPDES Form 2A, Part B.6 – Effluent Testing Data – We have added all of the required testing data of our effluent.
5. NPDES Form 2A, Part D – Effluent testing was completed and has been updated to reflect new data.
6. NPDES Form 2A, Part E – Toxicity tests were completed and results were included.
7. Forms not received with the application – a. & b. The CWB Individual NPDES Form and Form 2S were completed and included with this submittal. c. The sewer system is not combined; no storm water influent is received at the POTW. d. We are investigating the applicability of a ZOM as it may relate to the ultimate fate of recycled water/groundwater migration to the Pacific Ocean. Alternatively, we are considering other disposal possibilities.
8. Dilution studies have not been initiated pending ZOM analysis.
9. Anti-degradation studies have not been initiated pending ZOM analysis.
10. Discharge Area – It appears that many of the water bodies overlap with differing impairments. Please provide a map (or preferably a GIS layer) showing the extents of the various water bodies to aid in our interpretation. Additionally, should we follow the 2014 DOH WQ Monitoring and Assessment Report or is the 2016 report expected to be approved soon? Please see the response to Item 2 above for further information. The facility discharges to groundwater, which has been modeled to move in a broad and diffuse manner toward the coastline and enter the Pacific Ocean over approximately 2 miles. There is no current data on the outer extent of the groundwater migration.

    The Department of Health Water Quality Monitoring and Assessment Report indicates:

    a. Kaanapali (Kahekili Beach) (HI643627)
       2014 list: Turbidity 2016 list: $NO_3$+$NO_2$, $NH_4$, Turbidity
    b. Honokowai Point to Kaanapali (HIW00139)
       2014 List: TN, $NH_4$ 2016 List: TN, $NH_4$
    c. West Maui Coast-near shore waters to 60' from Honolua to Lahaina (HIW00060)
       2014 List: Turbidity 2016 List: Turbidity

11. Pretreatment Program – The County of Maui has a Pretreatment Program. We permit dischargers with grease waste interceptors and waste haulers related to operation of commercial food establishments. The County has not identified any other industrial users in the service area for the Lahaina WWRF.
12. There are multiple other possible contributors to the underground effluent mix, including mixed-use areas nearby that use septic systems and/or cesspools for sewage disposal, as well as several stream/gulch outlets. The Wahikuli-Honokowai Watershed Management Plan, available at http://www.westmauir2r.com/watershed-management-plans.html, prepared for the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, includes data and information on the land-based sources of pollution to near-shore waters via surface runoff or groundwater migration.

We revised the application and submitted via your e-permitting web-site. We do not anticipate paying any fees as this was a resubmittal. Attached are the signature sheets and the required disk copy of the recent submittal. We appreciate your consideration of this request and are available to meet if you wish to discuss further.

> **"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."**

Sincerely,

Stewart Stant, Director
Environmental Management

SS:sr (Lahaina NPDES Time Extension 3.docx)

# Fact Sheet

**The U.S. Environmental Protection Agency (EPA)
Proposes to issue a National Pollutant Discharge Elimination System (NPDES) Permit to Discharge Pollutants Pursuant to the Provisions of the Clean Water Act (CWA) to:**

## Taholah Wastewater Treatment Plant
## Quinault Indian Nation
## P.O. Box 189
## Taholah, Washington 99587

Public Comment Start Date: April 21, 2015
Public Comment Expiration Date: May 21, 2015

Technical Contact: Kai Shum
(206) 553-0060
800-424-4372, ext. 0060 (within Alaska, Idaho, Oregon and Washington)
Shum.Kai@epa.gov

**The EPA Proposes To Issue NPDES Permit**
The EPA proposes to issue the NPDES permit for the facility referenced above. The draft permit places conditions on the discharge of pollutants from the wastewater treatment plant to waters of the United States. In order to ensure protection of water quality and human health, the permit places limits on the types and amounts of pollutants that can be discharged from the facility.

This Fact Sheet includes:
- information on public comment, public hearing, and appeal procedures
- a listing of proposed effluent limitations and other conditions for the facility
- a map and description of the discharge location
- technical material supporting the conditions in the permit

**401 Certification**
The Quinault Indian Nation (QIN) has not yet taken on Section 401 certification under the CWA. Therefore, EPA is responsible for issuing 401 certification in this case.

**Tribal Coordination and Consultation**
In the course of issuing this NPDES Permit, EPA coordinated with the Quinault Indian Nation (QIN).

**Public Comment**
Persons wishing to comment on, or request a Public Hearing for the draft permit for this facility may do so in writing by the expiration date of the Public Comment period. A request for a Public Hearing must state the nature of the issues to be raised as well as the requester's name, address and telephone number. All comments and requests for Public Hearings must be in writing and should be submitted to the EPA as described in the Public Comments Section of the attached Public Notice.

After the Public Notice expires, and all comments have been considered, the EPA's regional Director for the Office of Water and Watersheds will make a final decision regarding permit issuance. If no substantive comments are received, the tentative conditions in the draft permit will become final, and the permit will become effective upon issuance. If substantive comments are received, the EPA will address the comments and issue the permit. The permit will become effective no less than 30 days after the issuance date, unless an appeal is submitted to the Environmental Appeals Board within 30 days pursuant to 40 CFR 124.19.

**Documents are Available for Review**
The draft NPDES permit and related documents can be reviewed or obtained by visiting or contacting the EPA's Regional Office in Seattle between 8:30 a.m. and 4:00 p.m., Monday through Friday at the address below. The draft permits, fact sheet, and other information can also be found by visiting the Region 10 NPDES website at "http://EPA.gov/r10earth/waterpermits.htm."

United States Environmental Protection Agency
Region 10
1200 Sixth Avenue, OWW-130
Seattle, Washington 98101
(206) 553-0523 or
Toll Free 1-800-424-4372 (within Alaska, Idaho, Oregon and Washington)

The fact sheet and draft permits are also available at:

The Quinault Indian Nation
1214 Aalis Drive
Taholah, Washington 98587
Attention: Dave Hinchen, (360) 276-0074

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## Acronyms

| | |
|---|---|
| 1Q10 | 1 day, 10 year low flow |
| 7Q10 | 7 day, 10 year low flow |
| 30B3 | Biologically-based design flow intended to ensure an excursion frequency of less than once every three years, for a 30-day average flow. |
| 30Q10 | 30 day, 10 year low flow |
| ACR | Acute-to-Chronic Ratio |
| AML | Average Monthly Limit |
| ASR | Alternative State Requirement |
| AWL | Average Weekly Limit |
| BA | Biological Assessment |
| BAT | Best Available Technology economically achievable |
| BCT | Best Conventional pollutant control Technology |
| BE | Biological Evaluation |
| BO or BiOp | Biological Opinion |
| $BOD_5$ | Biochemical oxygen demand, five-day |
| $BOD_{5u}$ | Biochemical oxygen demand, ultimate |
| BMP | Best Management Practices |
| BPT | Best Practicable |
| °C | Degrees Celsius |
| C $BOD_5$ | Carbonaceous Biochemical Oxygen Demand |
| CFR | Code of Federal Regulations |
| CFS | Cubic Feet per Second |
| COD | Chemical Oxygen Demand |
| CSO | Combined Sewer Overflow |
| CV | Coefficient of Variation |
| CWA | Clean Water Act |
| DMR | Discharge Monitoring Report |
| DO | Dissolved oxygen |
| EA | Environmental Assessment |
| EFH | Essential Fish Habitat |

| | |
|---|---|
| EIS | Environmental Impact Statement |
| EPA | U.S. Environmental Protection Agency |
| ESA | Endangered Species Act |
| FOTW | Federally Owned Treatment Works |
| FR | Federal Register |
| gpd | Gallons per day |
| HUC | Hydrologic Unit Code |
| IC | Inhibition Concentration |
| ICIS | Integrated Compliance Information System |
| I/I | Infiltration and Inflow |
| LA | Load Allocation |
| lbs/day | Pounds per day |
| LTA | Long Term Average |
| LTCP | Long Term Control Plan |
| mg/L | Milligrams per liter |
| ml | Milliliters |
| ML | Minimum Level |
| µg/L | Micrograms per liter |
| mgd | Million gallons per day |
| MDL | Maximum Daily Limit or Method Detection Limit |
| MF | Membrane Filtration |
| MPN | Most Probable Number |
| N | Nitrogen |
| NEPA | National Environmental Policy Act |
| NOAA | National Oceanic and Atmospheric Administration |
| NOEC | No Observable Effect Concentration |
| NOI | Notice of Intent |
| NPDES | National Pollutant Discharge Elimination System |
| NSPS | New Source Performance Standards |
| OWW | Office of Water and Watersheds |
| O&M | Operations and maintenance |
| POTW | Publicly owned treatment works |

| | |
|---|---|
| PSES | Pretreatment Standards for Existing Sources |
| PSNS | Pretreatment Standards for New Sources |
| QAP | Quality assurance plan |
| RP | Reasonable Potential |
| RPM | Reasonable Potential Multiplier |
| RIB(s) | Rapid Infiltration Basin(s) |
| SIC | Standard Industrial Classification |
| SPCC | Spill Prevention and Control and Countermeasure |
| SS | Suspended Solids |
| SSO | Sanitary Sewer Overflow |
| s.u. | Standard Units |
| TKN | Total Kjeldahl Nitrogen |
| TMDL | Total Maximum Daily Load |
| TOC | Total Organic Carbon |
| TRC | Total Residual Chlorine |
| TRE | Toxicity Reduction Evaluation |
| TSD | Technical Support Document for Water Quality-based Toxics Control (EPA/505/2-90-001) |
| TSS | Total suspended solids |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | United States Geological Survey |
| UV | Ultraviolet |
| WET | Whole Effluent Toxicity |
| WLA | Wasteload allocation |
| WQBEL | Water quality-based effluent limit |
| Water Quality Standards | Water Quality Standards |
| WWTP | Wastewater treatment plant |

# I. Applicant

## A. General Information

This fact sheet provides information on the draft NPDES permit for the following entity:

Physical Address:
Taholah Village Wastewater Treatment Plant
114 Quinault Street
Taholah, Washington 98587

Mailing Address:
Taholah Village Wastewater Treatment Plant
Quinault Indian Nation
P.O. Box 189
Taholah, Washington 99587

NPDES Permit Number: WA0023442

Contact:
Dave Hinchen
Wastewater Treatment Plant Supervisor
(360)276-0074

## B. Permit History

The most recent NPDES permit for the Taholah Village Wastewater Treatment Plant (WWTP) was issued on September 27, 2005, became effective on November 1, 2005, and expired on October 31, 2010. A complete NPDES application for permit issuance was submitted by the permittee on December 2, 2014.

# II. Facility Information

## A. Treatment Plant Description

### *Service Area*

The Quinault Indian Nation (QIN) owns and operates the Taholah Village Wastewater Treatment Plant (WWTP) located in Taholah, Grays Harbor County, Washington. The collection system has no combined sewers. The facility serves a resident population of 1500.

### *Treatment Process*

The WWTP was constructed and operational in 2006 with a design flow of 0.2 mgd. In a 2008 agreement between QIN and the U.S. Indian Health Service (IHS), the treatment system was improved in 2009 to include the addition of a UV disinfection system. At present, the treatment process consists of a four-celled lagoon system with UV disinfection and discharge into groundwater via a four celled Rapid Infiltration Basin (RIB) system. The four-celled lagoon system consists of three aerated cells, and one settling basin. Details about the wastewater treatment process and a map showing the location of the treatment facility and discharge are included in Appendix A. EPA regards facilities that have a design flow of less than 1.0 mgd as minor facilities. Because the design flow of the Taholah Village WWTP is 0.2 mgd, the facility is considered a minor facility.

### B. Outfall Description

The discharges from Outfall 001 go into a four celled RIB system that is approximately 505 feet from the banks of the Quinault River. The RIB system is believed to discharge into a likely tidally influenced brackish water table. The wastewater discharged into the RIB system is mixed and diluted into a groundwater plume prior to entering the Quinault River as surface water. The bottom of the RIB system is approximately 7 feet below surface, and the groundwater table is approximately 13 feet below surface. The RIBs are located at the following coordinates: 47° 20' 34" N, 124° 17' 00" W. Based on aerial mapping, the groundwater plume from the RIB system would travel at least 505 feet, the closest distance from the RIB system into the Quinault River, and from there, the distance to the mouth of the Quinault River is approximately 1.16 miles.

### C. Background Information

#### *Effluent Characterization*

In order to determine pollutants of concern for further analysis, EPA evaluated the application form, additional discharge data, and the nature of the discharge. The wastewater treatment process for this facility includes both primary and secondary treatment, as well as UV disinfection. Pollutants typical of a sewage treatment plant include five-day biochemical oxygen demand ($BOD_5$), total suspended solids (TSS), fecal coliform bacteria, pH, ammonia, temperature, and dissolved oxygen (DO).

The Taholah Village WWTP receives a small volume of process wastewater from a fish processing plant. According to QIN, the fish processing plant sends fish waste offsite, and the only wastewater directed to the WWTP consists of water used for washing equipment, and sanitary waste from the facility.

The concentrations of pollutants in the discharge were reported in the NPDES application and were used in determining reasonable potential for several parameters (see Appendix D).

#### *Compliance History*

The facility's last NPDES Permit expired on October 31, 2010. No new permit application was received until January 17, 2014. A complete NPDES application for permit issuance was submitted by the permittee on December 2, 2014.

The EPA conducted inspections at the facility in 2008, 2009, and 2010. The inspections revealed that there had been various exceedances of permit limits and incorrect reporting by the facility. The EPA made recommendations to QIN for improving compliance with its NPDES Permit.

On January 7, 2015, according to David Hinchen, QIN Wastewater Treatment Plant Supervisor, there has not been any citizen complaints concerning this WWTP.

### D. Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* directs each federal agency to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities." EPA is striving to enhance the ability of overburdened communities to participate fully and meaningfully in the permitting process for EPA-issued permits, including NPDES permits. "Overburdened" communities can include minority, low-income, tribal, and indigenous populations or communities that potentially experience disproportionate environmental harms and risks. As part of an agency-wide effort, EPA Region 10 will consider prioritizing enhanced public involvement opportunities for EPA-issued permits that may involve activities with significant public health or environmental impacts on already overburdened communities. For more information, please visit http://www.epa.gov/compliance/ej/plan-ej/.

As part of the permit development process, EPA Region 10 conducted an "EJSCREEN" to determine whether a permit action could affect overburdened communities. EJSCREEN is a nationally consistent geospatial tool that contains demographic and environmental data for the United States at the census block group level. As a pre-decisional tool, EJSCREEN is used to highlight permit candidates for additional review where enhanced outreach may be warranted.

The EPA also encourages permittees to review (and to consider adopting, where appropriate) Promising Practices for Permit Applicants Seeking EPA-Issued Permits: Ways To Engage Neighboring Communities (see https://www.federalregister.gov/articles/2013/05/09/2013-10945/epa-activities-to-promote-environmental-justice-in-the-permit-application-process#h-13). Examples of promising practices include: thinking ahead about community's characteristics and the effects of the permit on the community, engaging the right community leaders, providing progress or status reports, inviting members of the community for tours of the facility, providing informational materials translated into different languages, setting up a hotline for community members to voice concerns or request information, follow up, etc.

EPA's EJSCREEN tool identified the Quinault Indian Nation (QIN) as a potentially overburdened community because the WWTP discharges within the boundaries of the Quinault Indian Reservation. During the screening process, EPA considered specific case-by-case circumstances, and EPA concluded that there is no indication that the issuance of this permit would trigger significant environmental justice concerns. Separate from the environmental justice screening effort, EPA also conducted tribal coordination with QIN.

## III. Receiving Water

This facility discharges into groundwater via a RIBs system with expected hydrogeologic connection to the Quinault River. Wastewater discharged into the RIBs are initially diluted within the groundwater body, forming a groundwater plume prior to reaching the Quinault River. Based on aerial mapping, the groundwater plume from the RIBs system would travel at least 505 feet, the closest distance from the RIB system into the Quinault River, and from there, the distance to the mouth of the Quinault River is approximately 1.16 miles.

***Low Flow Conditions***

There is no information concerning the low flow conditions in the Quinault River perpendicular to the RIBs, accordingly, EPA estimated the low flow conditions based on an existing USGS Gauge that is 13.6 miles upstream.

The low flow conditions of the Quinault River is obtained from the upstream USGS Gauge #12039500, "Quinault River near Quinault Lake". This location is significantly upstream from the RIBs, where the Quinault River is a much smaller waterbody. The Quinault River above the RIBs is a gaining stream, but there is no gauge to measure the river flow rate near the RIBs. Therefore, low flow conditions can only be determined at the river near the Quinault Lake location. As a comparison, EPA expects that low flow are significantly higher on the river near the RIBs. The low flow values on Table 1 were obtained from USGS Gauge #12039500 and were used to determine dilution from the WWTP. In addition, because the WWTP discharges into the RIBs, the wastewater from the RIBs is first diluted in the groundwater plume prior to reaching the river. Accordingly, because of the location the low flow values were obtained and of the initial dilution in the groundwater plume prior to reaching the river, the dilution factors used are conservative.

The low flow conditions of a water body are used to assess the need for and develop water quality based effluent limits (see Appendix B of this fact sheet for additional information on flows). The EPA used ambient flow data collected at the Quinault River and the EPA's DFLOW 3.1b model to calculate the low flow conditions.

The *Technical Support Document for Water Quality-Based Toxics Control* (hereafter referred to as the TSD) (EPA, 1991) and the State of Washington Water Quality Standards (WQS) recommend the flow conditions for use in calculating water quality-based effluent limits (WQBELs) using steady-state modeling. The TSD and the Washington State WQS state that WQBELs intended to protect aquatic life uses should be based on the lowest seven-day average flow rate expected to occur once every ten years (7Q10) for chronic criteria and the lowest one-day average flow rate expected to occur once every ten years (1Q10) for acute criteria. The flow data in Table 1 below is generated from the USGS data from April 1, 2001 to April 1, 2014, and analyzed by EPA's DFLOW program.

**Table 1: Calculated Low Flow Values**

| Units | 1Q10 | 7Q10 | 30B3 |
|---|---|---|---|
| USGS data in cfs | 238 | 291 | 428 |
| In mgd | 153.5 | 187.7 | 276.1 |

### A. Receiving Water Quality

The EPA reviews receiving water quality data when assessing the need for and developing water quality based effluent limits. In granting assimilative capacity of the receiving water, the EPA must account for the amount of the pollutant already present in the receiving water. In situations where some of the pollutant is actually present in the upstream waters, an assumption of "zero background" concentration overestimates the available assimilative capacity of the receiving water and could result in limits that are not protective of applicable water quality standards.

The existing permit required the permittee to perform upstream receiving water monitoring on the Quinault River. Table 2 below summarizes the receiving water data reported by the WWTP during the last permit cycle.

| Table 2: Receiving Water Quality Data | | | | |
|---|---|---|---|---|
| **Parameter** | **Units** | **Percentile** | **Value** | **Source** |
| Temperature | °C | 95th | 14.94 | Facility |
| pH | Standard units | 5th – 95th | 6.54 – 7.47 | Facility |
| Phosphorus | mg/L | maximum | 0.4 | Facility |
| Ammonia | mg/L | maximum | 0.3 | Facility |

### B. Water Quality Standards

The Quinault Indian Nation does not currently have EPA-approved water quality standards. Until they establish their own regulations for water quality, Washington State's standards will be used as a reference to protect downstream uses in Washington waters.

The State of Washington's Water Quality Standards are composed of use classifications, numeric and/or narrative water quality criteria, and an anti-degradation policy. The use classification system designates the beneficial uses (such as cold water aquatic life communities, contact recreation, etc.) that each water body is expected to achieve. The numeric and/or narrative water quality criteria are the criteria deemed necessary to support the beneficial use classification of each water body. The anti-degradation policy represents a three tiered approach to maintain and protect various levels of water quality and uses.

Section 301(b)(1)(C) of the Clean Water Act (CWA) requires the development of limitations in permits necessary to meet water quality standards. Federal regulations at 40 CFR 122.4(d) require that the conditions in NPDES permits ensure compliance with the water quality standards of all affected States. A State's water quality standards are composed of use classifications, numeric and/or narrative water quality criteria and an anti-degradation policy.

The use classification system designates the beneficial uses that each water body is expected to achieve, such as drinking water supply, contact recreation, and aquatic life. The numeric and narrative water quality criteria are the criteria deemed necessary by the State to support the beneficial use classification of each water body. The anti-degradation policy represents a three-tiered approach to maintain and protect various levels of water quality and uses.

The Quinault River is located within the Washington State Department of Ecology's "Queets/Quinault Water Resources Inventory Area (WRIA) #21". The Quinault River is specifically named on Department of Ecology's use designation for fresh waters found at WAC 173-201A-602, Table 602. These designations are described below.

***Designated Beneficial Uses***

EPA considered WAC 173-201A-602, Table 602: Use designations for fresh waters by water resource inventory area (WRIA). For "WRIA 21 Queets-Quinault", and the applicable segment is described as, "Quinault River and tributaries from mouth to the confluence with the North Fork Quinault River", the following water quality use designations apply:

Aquatic Life Uses: Core Summer Habitat;
Recreational Uses: Extraordinary Primary Contact
Water Supply Uses: Domestic Water; Industrial Water; Agricultural Water; Stock Water
Misc. Uses: Wildlife Habitat; Harvesting; Commerce/Navigation; Boating; and Aesthetics.

In reference to WAC 173-201A-600(1)(a)(iv), because the groundwater table is believed to be brackish beneath the RIB, and the designation of extraordinary quality marine waters off the Pacific coast, this segment of the Quinault River should also be protected for Core Summer Salmonid Habitat and Extraordinary Primary Contact recreation.

The point of discharge appears to be to an estuary and the receiving water is believed to be brackish from tidal flow carrying salt water up the Quinault River.

WAC 173-201A-260 Natural conditions and other water quality criteria and applications states:

"(e) In brackish waters of estuaries, where different criteria for the same use occurs for fresh and marine waters, the decision to use the fresh water or the marine water criteria must be selected and applied on the basis of vertically averaged daily maximum salinity, referred to below as "salinity."

(i) The fresh water criteria must be applied at any point where ninety-five percent of the salinity values are less than or equal to one part per thousand, except that the fresh water criteria for bacteria applies when the salinity is less than ten parts per thousand; and
(ii) The marine water criteria must apply at all other locations where the salinity values are greater than one part per thousand, except that the marine criteria for bacteria applies when the salinity is ten parts per thousand or greater."

EPA does not currently have salinity data to make a determination if applying marine water criteria would be appropriate. Therefore, EPA is requiring the collection of salinity data during this permit cycle so that a determination can be made for the next permit cycle. For the proposed permit, EPA is applying Washington State Water Quality Standards for freshwater.

If marine water quality standards apply the EPA may apply WAC 173-201A-612, Table 612 — Use designations for marine waters and the applicable segment is described as "Coastal waters: Pacific Ocean from Ilwaco to Cape Flattery". The following water quality use designations would apply:

Aquatic Life Uses: Extraordinary, Shellfish harvesting
Recreational Uses: Primary Contact
Misc. Uses: Wildlife Habitat, Harvesting, Commerce/Navigation; Boating; and Aesthetics

WAC 173-201A-610, Use designations — Marine waters, assigns the following aquatic life uses under Extraordinary:

Salmonid and other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing and spawning.

Salinity surface water monitoring is added to determine if the receiving water is brackish.

The criteria for the State of Washington Water Quality Standards to protect the beneficial uses for the Quinault River off the reservation, and the State's anti-degradation policy are summarized below.

***Antidegradation***

The proposed issuance of an NPDES permit triggers the need to ensure that the conditions in the permit ensure that Tier I, II, and III of the State's antidegradation policy are met. An anti-degradation analysis was conducted by EPA (see Appendix D), which concluded that the permit would not result in deterioration of water quality. This is because there is no measurable change caused to the water quality of the Quinault River, and the analysis concluded that a Tier 2 review is not warranted. In addition, there is no loss of beneficial uses in the Quinault River.

### C. Water Quality Limited Waters

Any waterbody for which the water quality does not, and/or is not expected to meet, applicable water quality standards is defined as a "water quality limited segment."

Section 303(d) of the CWA requires states to develop a Total Maximum Daily Load (TMDL) management plan for water bodies determined to be water quality limited segments. A TMDL is a detailed analysis of the water body to determine its assimilative capacity. The assimilative capacity is the loading of a pollutant that a water body can assimilate without causing or contributing to a violation of water quality standards. Once the assimilative capacity of the water body has been determined, the TMDL will allocate that capacity among point and non-point pollutant sources, taking into account natural background levels and a margin of safety. Allocations for non-point sources are known as "load allocations" (LAs). The allocations for point sources, known as "waste load allocations" (WLAs), are implemented through effluent limitations in NPDES permits. Effluent limitations for point sources must be consistent with applicable TMDL allocations.

The area where the WWTP discharges is categorized by Ecology at Water Resource Inventory Area 21 (WRIA 21). Ecology on January 12, 2015, stated by email there are no TMDLs completed in this area; accordingly, there are no WLA applicable to this NPDES Permit in WRIA 21. However, Ecology has identified the area where this facility is discharging as having one 303(d) listing for PCB in fish tissue (Ecology listing #52686). Ecology listing #52686 can be found at: http://apps.ecy.wa.gov/wats/ViewListing.aspx?LISTING_ID=52686 ; a screen shot from this Ecology webpage is shown below. On January 15, 2015, EPA approached QIN about possible sources of PCB that may be the cause of this PCB listing. QIN responded that it has no information of local sources of PCB pertaining to Ecology's listing.

On January 15, 2015, in tribal consultation with QIN concerning possible sources of PCBs in fish tissue from Quinault River, Mr. Dave Bingaman, Quinault Nation's Director of Natural Resources. The QIN does not know of any sources of PCBs in the watershed. In addition, the WWTP is not a source of PCBs. Accordingly the EPA is not proposing PCB monitoring at the WWTP.

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| | | | |
|---|---|---|---|
| **Listing ID:** | 52686 | **2012 Category:** | 5 |
| **Medium:** | Tissue | **2008 Category:** | 5 |
| **Parameter:** | PCB | **2004 Category:** | 3 |
| **CAS:** | 1336-36-3 | **On 1998 303(d) List?:** | N |
| **Waterbody Name:** | QUINAULT RIVER | **On 1996 303(d) List?:** | N |
| **Waterbody Type:** | Rivers | **County:** | Grays Harbor |
| **Waterbody Class:** | RAA | **Township/Range/Section:** | 22N-13W-36 |
| **Collection Date:** | N/A | **Grid Cell:** | None |
| **WRIA:** | 21 - Queets-Quinault | **Grid Cell Latitude:** | None |
| **PSAA:** | None | **Grid Cell Longitude:** | None |
| **WASWIS:** | None | **LLID:** | 1242991473493 |
| **WASWIS Upper Route:** | None | **LLID Upper Route:** | 1.526 |
| **WASWIS Lower Route:** | None | **LLID Lower Route:** | 0.816 |

**Basis:**

Data from 2004 :
User Location ID [QuinaultR-F] - Fillet samples of chinook salmon exceeded the National Toxics Rule criterion for Total PCBs based on the sum of PCB aroclors.

User Location ID [QuinaultR-F] - Fillet samples of chinook salmon did not exceed the National Toxics Rule criterion for Total PCBs based on the sum of PCB congeners.

**Remarks:**

The water quality assessment category 5 was based on results indicating an exceedance of Total PCBs based on the sum of PCB aroclors in fillet samples of chinook salmon.

**EIM:**

| EIM Study ID: | EIM Location ID: |
|---|---|
| WSTMP04 | QuinaultR-F |

# IV. Effluent Limitations

## A. Basis for Effluent Limitations

In general, the CWA requires that the effluent limits for a particular pollutant be the more stringent of either technology-based limits or water quality-based limits. Technology-based limits are set according to the level of treatment that is achievable using available technology. A water quality-based effluent limit is designed to ensure that the water quality standards applicable to a waterbody are being met and may be more stringent than technology-based effluent limits. The basis for the effluent limits proposed in the draft permit is provided in Appendix B.

## B. Proposed Effluent Limitations

The following summarizes the proposed effluent limits that are in the draft permit.

1. The permittee must not discharge floating, suspended, or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that may impair designated beneficial uses.
2. The pH range shall be between 6.5 to 8.5 standard units.

*Numeric Limitations*

Table 3 below presents the proposed effluent limits for $BOD_5$, TSS, and fecal coliform.

**Table 3: Proposed Effluent Limits**

| Parameter | Units | Effluent Limits | | |
|---|---|---|---|---|
| | | Average Monthly Limit | Average Weekly Limit | Maximum Daily Limit |
| Five-Day Biochemical Oxygen Demand ($BOD_5$) | mg/l | 30 | 45 | |
| | lb/day | 50 | 75 | |
| $BOD_5$ Removal | percent | 85 minimum | | |
| Total Suspended Solids (TSS) | mg/l | 30 | 45 | |
| | lb/day | 50 | 75 | |
| TSS Removal | percent | 85 minimum | | |
| Fecal coliform bacteria (geometric mean) | #/100 ml | 50[1] | | 100 |

1. Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies/100 ml.

## C. Changes in Effluent Limits From the Previous Permit

**Table 4. Changes in Permit Effluent Limits**

| Parameter | Previous Permit | Draft Permit | Reason |
|---|---|---|---|
| Bacteria, colonies/100ml (Geometric Mean) | E.coli bacteria Ave. Monthly Limit, 126 | Fecal Coliform bacteria, Ave. Monthly Limit, 50 | Compliance with current Washington State Water Quality Standards for Extraordinary Primary Contact Recreation, WAC 173.201A.200 (2), Table 200(2) (b) |
| | E.coli bacteria Max. Daily Limit, 576 | See Footnote 1 | |
| pH, standard units | 6.0 to 9.0 | 6.5 to 8.5 | Compliance with current Washington State Water Quality Standards, for pH criteria for Core summer salmonid habitat, WAC173.201A.200(1)(g) |
| Footnote: | | | |

1. Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 ml, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies/100 ml.

# V. Monitoring Requirements

## A. Basis for Effluent and Surface Water Monitoring

Section 308 of the CWA and federal regulation 40 CFR 122.44(i) require monitoring in permits to determine compliance with effluent limitations. Monitoring may also be required to gather effluent and surface water data to determine if additional effluent limitations are required and/or to monitor effluent impacts on receiving water quality.

The permit also requires the permittee to perform effluent monitoring required by the NPDES Form 2A application, so that these data will be available when the permittee applies for a renewal of its NPDES permit.

The permittee is responsible for conducting the monitoring and for reporting results on DMRs or on the application for renewal, as appropriate, to the EPA.

## B. Effluent Monitoring

Monitoring frequencies are based on the nature and effect of the pollutant, as well as a determination of the minimum sampling necessary to adequately monitor the facility's performance. Permittees have the option of taking more frequent samples than are required under the permit. These samples must be used for averaging if they are conducted using the EPA-approved test methods (generally found in 40 CFR 136) or as specified in the permit.

Table 5, below, presents the proposed effluent monitoring requirements in the draft permit. The sampling location must be after the last treatment unit and prior to discharge to the receiving water. The samples must be representative of the volume and nature of the monitored discharge. If no discharge occurs during the reporting period, "no discharge" shall be reported on the DMR.

**Table 5: Effluent Monitoring Requirements**

| Parameter | Units | Sample Location | Sample Frequency | Sample Type |
|---|---|---|---|---|
| Flow | Mgd | Effluent | Continuous | recording |
| Temperature | °C | Effluent | 1/week | grab |
| $BOD_5$ | mg/L | Influent & Effluent | 1/week | 24-hour composite |
| | lb/day | Influent & Effluent | 1/week | calculation[1] |
| | % Removal | -- | 1/month | calculation[2] |
| TSS | mg/L | Influent & Effluent | 1/week | 24-hour composite |
| | lb/day | Influent & Effluent | 1/week | calculation[1] |
| | % Removal | -- | 1/month | calculation[2] |
| pH | standard units | Effluent | 5/week | grab |
| Fecal coliform bacteria | #/100 ml | Effluent | 5/month | grab |
| Total Ammonia as N | mg/L | Effluent | 1/quarter | 24-hour composite |
| | lb/day | Effluent | | calculation[1] |
| Copper, Total Recoverable | µg/l | Effluent | 1/quarter | grab |
| Zinc, Total Recoverable | µg/l | Effluent | 1/quarter | grab |

| Table 5: Effluent Monitoring Requirements | | | | |
|---|---|---|---|---|
| **Parameter** | **Units** | **Sample Location** | **Sample Frequency** | **Sample Type** |
| NPDES Application Form 2A (Part B.6) Effluent Testing Data | mg/l | Effluent | 3 times[3] | 24-hour composite |

Notes:
1. Loading is calculated by multiplying the concentration (in mg/l) by the flow (in mgd) on the day sampling occurred and a conversion factor of 8.34.
2. The monthly average percent removal must be calculated from the arithmetic mean of the influent values and the arithmetic mean of the effluent values for that month, i.e.:.
   (average monthly influent – average monthly effluent) ÷ average monthly influent.
   Influent and effluent samples must be taken over approximately the same time period.
3. In accordance with instructions in NPDES Application Form 2A, Part B.6, Part D, and where a minimum of one scan for each test to be conducted during years 2015, 2016, and 2017.

### *Monitoring Changes from the Previous Permit*

Monitoring frequencies for certain parameters have been changed, relative to the previous permit. Table 6, below, summarizes the changes in monitoring.

| Table 6: Changes in Monitoring Requirements | | |
|---|---|---|
| **Parameter** | **Previous Permit** | **Draft Permit** |
| Flow | Continuous recording, influent | Continuous recording, effluent |
| $BOD_5$ and TSS | 1/week, grab sampling | 1/week, 24-hour composite |
| Temperature | 5/month, grab | 1/week, grab |
| pH | 1/week, grab sampling | 5/week, grab |
| Bacteria | E.coli, 5/month, grab sampling | Fecal coliform, 5/month, grab sampling |
| Total Ammonia as N | 1/month, grab | 1/quarter 24-hour composite |
| Copper, Total Recoverable | None | 1/quarter, grab |
| Zinc, Total Recoverable | None | 1/quarter, grab |

## C. Surface Water Monitoring

Table 7 presents the proposed surface water monitoring requirements for the draft permit. The EPA requires the permittee to conduct surface water monitoring at an upstream station at the Quinault River. Surface water monitoring must be conducted for the duration of the permit. Surface water monitoring results must be submitted with the DMR in the month following the monitoring period.

| Table 7: Surface Water Monitoring Requirements | | | | |
|---|---|---|---|---|
| **Parameter** | **Units** | **Upstream Sample Locations** | **Sample Frequency** | **Sample Type** |
| Temperature | °C | Quinault River | 1/quarter | Grab |

| Table 7: Surface Water Monitoring Requirements | | | | |
|---|---|---|---|---|
| **Parameter** | **Units** | **Upstream Sample Locations** | **Sample Frequency** | **Sample Type** |
| Total Ammonia as N | mg/l | | 1/quarter | Grab |
| pH | standard units | | 1/quarter | Grab |
| Salinity | Part per Thousand | | 1/quarter | Grab |
| Hardness | mg/L | | 1/quarter | Grab |

### D. Electronic Submission of Discharge Monitoring Reports

The draft permit includes new provisions to allow the permittee the option to submit DMR data electronically using NetDMR. NetDMR is a national web-based tool that allows DMR data to be submitted electronically via a secure Internet application. NetDMR allows participants to discontinue mailing in paper forms under 40 CFR § 122.41 and § 403.12. The permittee may use NetDMR after requesting and receiving permission from the EPA Region 10.

Under NetDMR, all reports required under the permit are submitted to the EPA as an electronic attachment to the DMR. Once a permittee begins submitting reports using NetDMR, it is no longer required to submit paper copies of DMRs or other reports to the EPA.

The EPA encourages permittees to sign up for NetDMR, and currently conducts free training on the use of NetDMR. Further information about NetDMR, including upcoming trainings and contacts, is provided on the following website: http://www.EPA.gov/netdmr.

## VI. Sludge (Biosolids) Requirements

The EPA Region 10 separates wastewater and sludge permitting. The EPA has authority under the CWA to issue separate sludge-only permits for the purposes of regulating biosolids. The EPA may issue a sludge-only permit to each facility at a later date, as appropriate.

Until future issuance of a sludge-only permit, sludge management and disposal activities at each facility continue to be subject to the national sewage sludge standards at 40 CFR Part 503 and any requirements of the State's biosolids program. The Part 503 regulations are self-implementing, which means that facilities must comply with them whether or not a permit has been issued.

## VII. Other Permit Conditions

### A. Quality Assurance Plan

In order to ensure compliance with the federal regulation at 40 CFR 122.41(e) for proper operation and maintenance, the draft permit requires the permittee to develop procedures to ensure that the monitoring data submitted is accurate and to explain data anomalies if they occur. The permittee is required to develop or update the Quality Assurance Plan within 180 days of the effective date of the final permit. The Quality Assurance Plan must include standard operating procedures the permittee must follow for collecting, handling, storing and shipping samples, laboratory analysis, and data reporting. The plan must be retained on site and be made available to the EPA upon request.

### B. Operation and Maintenance Plan

The proposed permit requires the permittee to properly operate and maintain all facilities and systems of treatment and control. Proper operation and maintenance is essential to meeting discharge limits, monitoring requirements, and all other permit requirements at all times. The permittee is required to develop and implement an operation and maintenance plan for their facility within 180 days of the effective date of the final permit. The plan must be retained on site and made available to the EPA upon request.

### C. Sanitary Sewer Overflows and Proper Operation and Maintenance of the Collection System

Untreated or partially treated discharges from separate sanitary sewer systems are referred to as sanitary sewer overflows (SSOs). SSOs may present serious risks of human exposure when released to certain areas, such as streets, private property, basements, and receiving waters used for drinking water, fishing and shellfishing, or contact recreation. Untreated sewage contains pathogens and other pollutants, which are toxic. SSOs are not authorized under this permit. Pursuant to the NPDES regulations, discharges from separate sanitary sewer systems authorized by NPDES permits must meet effluent limitations that are based upon secondary treatment. Further, discharges must meet any more stringent effluent limitations that are established to meet the EPA-approved state water quality standards.

The permit contains language to address SSO reporting and public notice and operation and maintenance of the collection system. The permit requires that the permittee identify SSO occurrences and their causes. In addition, the permit establishes reporting, record keeping and third party notification of SSOs. Finally, the permit requires proper operation and maintenance of the collection system. The following specific permit conditions apply:

**Immediate Reporting** – The permittee is required to notify the EPA of an SSO within 24 hours of the time the permittee becomes aware of the overflow. (See 40 CFR 122.41(l)(6)).

**Written Reports** – The permittee is required to provide the EPA a written report within five days of the time it became aware of any overflow that is subject to the immediate reporting provision. (See 40 CFR 122.41(l)(6)(i)).

**Third Party Notice** – The permit requires that the permittee establish a process to notify specified third parties of SSOs that may endanger health due to a likelihood of human exposure; or unanticipated bypass and upset that exceeds any effluent limitation in the permit or that may endanger health due to a likelihood of human exposure. The permittee is required to develop, in consultation with appropriate authorities at the local, county, tribal and/or state level, a plan that describes how, under various overflow (and unanticipated bypass and upset) scenarios, the public, as well as other entities, would be notified of overflows that may endanger health. The plan should identify all overflows that would be reported and to whom, and the specific information that would be reported. The plan should include a description of lines of communication and the identities of responsible officials. (See 40 CFR 122.41(l)(6)).

**Record Keeping** – The permittee is required to keep records of SSOs. The permittee must retain the reports submitted to the EPA and other appropriate reports that could include work orders associated with investigation of system problems related to a SSO, that describes the steps taken or planned to reduce, eliminate, and prevent reoccurrence of the SSO. (See 40 CFR 122.41(j)).

**Proper Operation and Maintenance** – The permit requires proper operation and maintenance of the collection system. (See 40 CFR 122.41(d) and (e)). SSOs may be indicative of improper operation and maintenance of the collection system. The permittee may consider the development and implementation of a capacity, management, operation and maintenance (CMOM) program.

The permittee may refer to the Guide for Evaluating Capacity, Management, Operation, and Maintenance (CMOM) Programs at Sanitary Sewer Collection Systems (EPA 305-B-05-002). This guide identifies some of the criteria used by the EPA inspectors to evaluate a collection system's management, operation and maintenance program activities. Owners/operators can review their own systems against the checklist (Chapter 3) to reduce the occurrence of sewer overflows and improve or maintain compliance.

## D. Design Criteria

The permit includes design criteria requirements. This provision requires the permittee to compare influent flow and loading to the facility's design flow and loading and prepare a facility plan for maintaining compliance with NPDES permit effluent limits when the annual average flow or loading exceeds 85% of the design criteria values for three consecutive months.

## E. Industrial Waste Management Requirements

EPA implements and enforces the National Pretreatment Program regulations of 40 CFR 403, per authority from sections 204(b)(1), 208(b)(2)(C)(iii), 301(b)(1)(A)(ii), 301(b)(2)(A)(ii), 301(h)(5) and 301(i)(2), 304(e ) and (g), 307, 308, 309, 402(b), 405, and 501(a) of the Federal Water Pollutant Control Act as amended by the CWA of 1977. Because QIN does not have an approved pretreatment program per 40 CFR 403.10, EPA is the Approval Authority for QIN's POTWs. In addition, because the QIN does not have an approved POTW pretreatment program per 40 CFR 403.8, the EPA is also the Control Authority of industrial users that might introduce pollutants into the Taholah Village Wastewater Treatment Plant.

Per 40 CFR 122.44(j)(1), all POTWs need to identify, in terms of character and volume of pollutants, any significant industrial users (SIUs) discharging into the POTW. This condition is included as Special Condition C.1 of the draft permit with a due date 90 days following the effective date of the POTW permit.

Since the QIN does not have an approved pretreatment program, Special Condition C.2 of the permit reminds the City that it cannot authorize discharges which may violate the national specific prohibitions of the General Pretreatment Program, which are applicable to all industrial users introducing pollutants into a publicly owned treatment works (40 CFR 403.5(b)).

Consequently, Special Condition C.5 requires the Permittee to develop legal authority enforceable in Federal, State or local courts which authorizes or enables the POTW to apply and to enforce the requirement of sections 307 (b) and (c) and 402(b)(8) of the Clean Water Act, as described in 40 CFR 403.8(f)(1). The draft legal authority shall be submitted to EPA for review and comment, and then shall be adopted and enforced by the POTW.

### F. Standard Permit Provisions

Sections III, IV and V of the draft permit contain standard regulatory language that must be included in all NPDES permits. The standard regulatory language covers requirements such as monitoring, recording, and reporting requirements, compliance responsibilities, and other general requirements.

## VIII. Other Legal Requirements

### A. Endangered Species Act

The Endangered Species Act requires federal agencies to consult with National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries) and the U.S. Fish and Wildlife Service (USFWS) if their actions could beneficially or adversely affect any threatened or endangered species. A review of the threatened and endangered species located in the Quinault Indian Nation finds that there is NO EFFECT caused by the discharge from the Taholah Village Wastewater Treatment Plant (see Appendix E).

### B. Essential Fish Habitat

Essential fish habitat (EFH) is the waters and substrate (sediments, etc.) necessary for fish to spawn, breed, feed, or grow to maturity. The Magnuson-Stevens Fishery Conservation and Management Act (January 21, 1999) requires the EPA to consult with NOAA Fisheries when a proposed discharge has the potential to adversely affect EFH (i.e., reduce quality and/or quantity of EFH). A review of the Essential Fish Habitat documents shows that there is no effect to essential fish habitat.

The EFH regulations define an adverse effect as any impact which reduces quality and/or quantity of EFH and may include direct (e.g. contamination or physical disruption), indirect (e.g. loss of prey, reduction in species' fecundity), site specific, or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions.

For the same reasons as listed for endangered species the EPA has determined that issuance of this permit would have no effect to EFH in the vicinity of the discharge. The EPA has provided NOAA Fisheries with copies of the draft permit and fact sheet during the public notice period. Any comments received from NOAA Fisheries regarding EFH will be considered prior to issuance of this permit.

### C. State Certification

The state in which the discharge originates is typically responsible for issuing the certification pursuant to CWA Section 401(a)(1). In the case where the state has no authority to give 401 certification, such as for a discharge located within the boundaries of an Indian Reservation, EPA provides the certification. The point of discharge of the outfall is also located within boundaries of the Quinault Indian Reservation. Indian Tribes may issue 401 certification for discharges within their boundaries if the Tribe has been approved by the EPA pursuant to CWA Section 518(e) and 40 CFR Section 131.8 to administer a water quality standards program. The Quinault Indian Nation has not yet taken on § 401 certification; therefore, EPA is responsible for issuing 401 certification in this case. However, in the course of issuing this NPDES Permit, EPA has coordinated and consulted with the Quinault Indian Nation.

### D. Permit Expiration

The permit will expire five years from the effective date.

## IX. References

EPA. 1991. *Technical Support Document for Water Quality-based Toxics Control.* US Environmental Protection Agency, Office of Water, EPA/505/2-90-001.

Water Pollution Control Federation. Subcommittee on Chlorination of Wastewater. *Chlorination of Wastewater.* Water Pollution Control Federation. Washington, D.C. 1976.

EPA. 2010. *NPDES Permit Writers' Manual.* Environmental Protection Agency, Office of Wastewater Management, EPA-833-K-10-001.

# Appendix A: Facility Information

| **General Information** | |
|---|---|
| NPDES ID Number: | WA0023434 |
| Physical Address: | Taholah Village Wastewater Treatment Plant<br>114 Quinault Street<br>Taholah, Washington 98587 |
| Mailing Address: | Taholah Village Wastewater Treatment Plant<br>Quinault Indian Nation<br>P.O. Box 189<br>Taholah, Washington 98587 |
| Facility Background: | Wastewater Treatment Plant for Sanitary Wastes and process waste stream for a fish processing plant. |
| **Facility Information** | |
| Type of Facility: | Small tribally owned and operated wastewater treatment plant. |
| Treatment Train: | Four celled lagoon system; 4 aerators in the first lagoon, 2 aerators in the second lagoon, 2 aerators in the third lagoon, covered fourth lagoon, UV disinfection, dosing tank, discharge to 4-celled Rapid Infiltration Basins into groundwater. |
| Flow: | Designed flow rate: 0.2 mgd |
| Outfall Location: | 47° 20' 34" N, 124° 17' 00" W. |
| **Receiving Water Information** | |
| Receiving Water: | Discharge into groundwater then into Quinault River due to hydrogeologic connection to the Quinault River. |
| Watershed as designated by Washington State Dept of Ecology: | Queets/Quinault Water Resources Inventory Area (WRIA) #21, segment: Quinault River and tributaries from mouth to the confluence with the North Fork Quinault River. |
| Beneficial Uses: | The following water quality use designations apply:<br>Aquatic Life Uses: Core Summer Habitat;<br>Recreational Uses: Extraordinary Primary Contact<br>Water Supply Uses: Domestic Water; Industrial Water; Agricultural Water; Stock Water<br>Misc. Uses: Wildlife Habitat; Commerce/Navigation; Boating; and Aesthetics. |
| Impairments | None. No applicable TMDL or WLA |

Figure A1: Area Map of Taholah Village WWTP

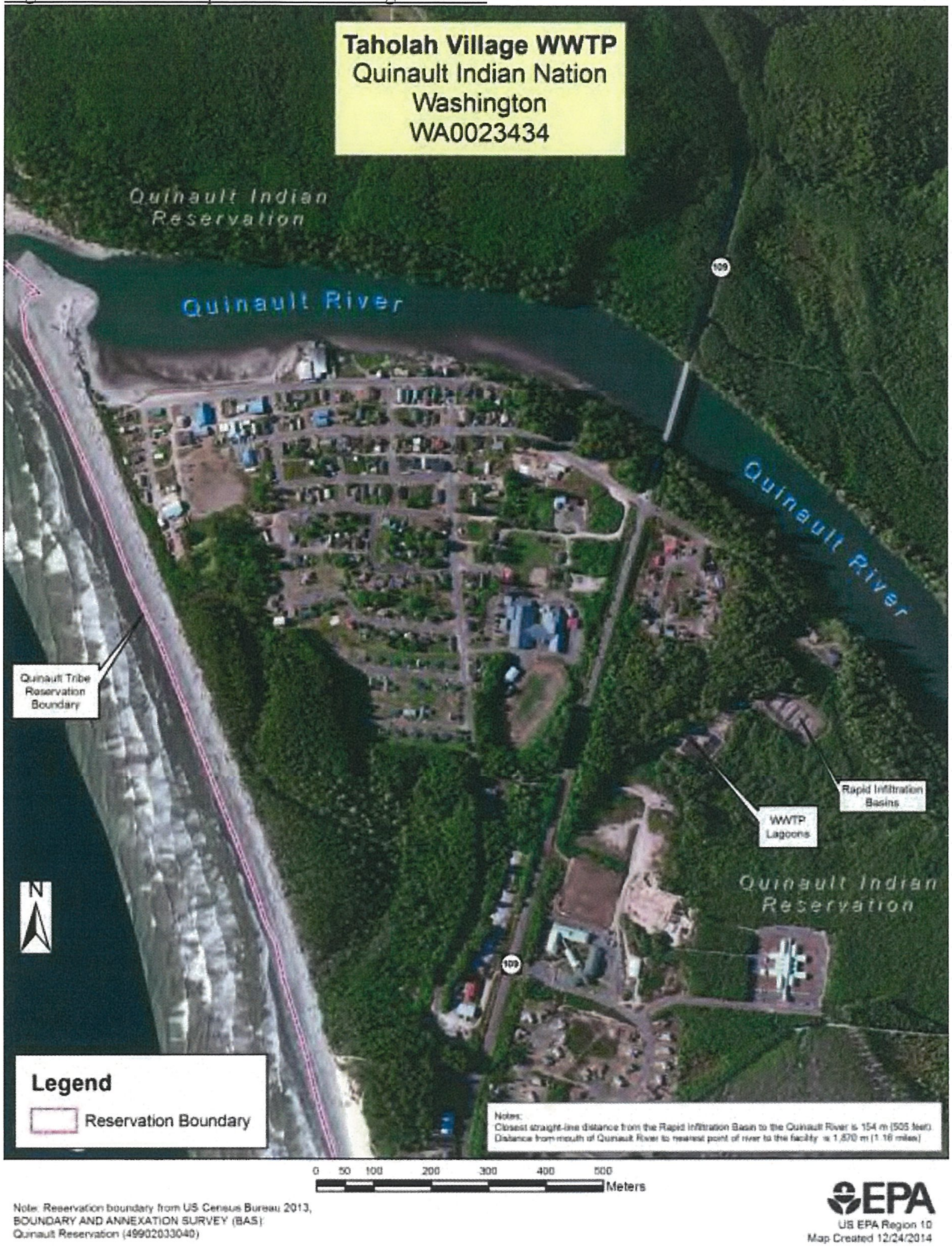
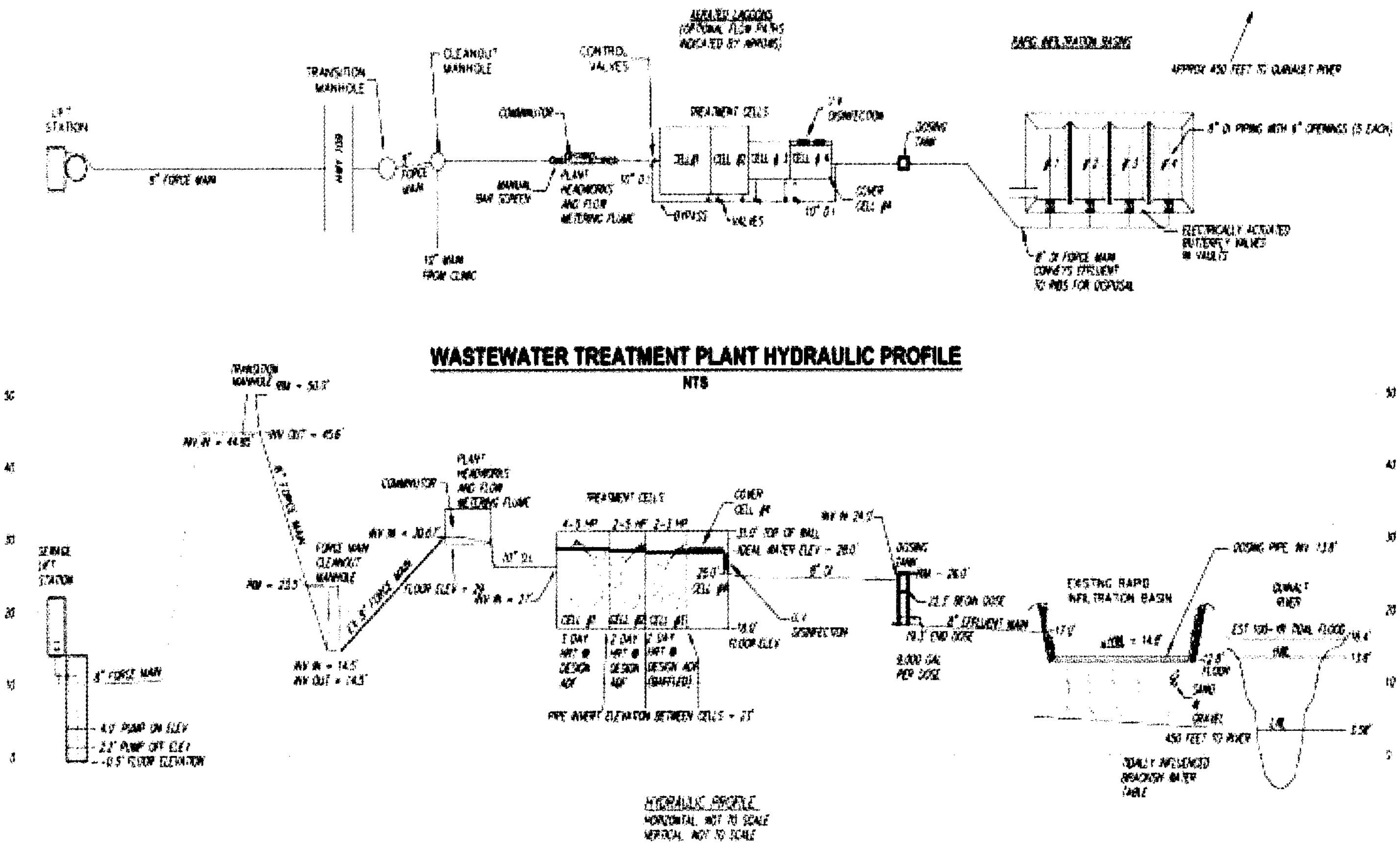


**Figure A-2: Schematic of Taholah Village WWTP**



## GET Committee

**From:** Wendy Wiltse <420keani@gmail.com>
**Sent:** Thursday, May 16, 2019 9:22 PM
**To:** GET Committee; County Clerk
**Subject:** Testimony on Hawaii Wildlife v. Maui County
**Attachments:** Lahaina testimony.docx

Please see attached testimony on Hawaii Wildlife Fund, et al. V County of Maui, Civil 12-00198 SOM (GET-26).

Aloha,
Wendy Wiltse, Ph.D,
Oahu Waterkeeper

OAHU WATERKEEPER

From: Wendy Wiltse, Ph.D. (420keani@gmail.com)
Date: May 16, 2019
To: Governance, Ethics and Transparency Committee
Chair Mike Molina
Vice Chair Keani Rawlins-Fernandez
And Committee members
RE: HAWAII WILDLIFE FUND, ET AL. V. COUNTY OF MAUI, CIVIL 1 2-00198 SOM (GET-26) BMK, U.S. SUPREME COURT DOCKET 18-260 (GET-26)

I am writing in reference to recent discussions at Maui County regarding settlement of Claims and Lawsuits in Hawaii Wildlife Fund, et al., vs. County of Maui. I worked for the US Environmental Protection Agency (EPA) for 32 years; I was stationed in Hawaii for 24 years until I retired two years ago. Now I serve as President of Oahu Waterkeeper's Board of Directors, working for clean water in Hawaii.

I worked in Lahaina from 1993-1997 on detail to Hawaii Department of Health (DOH). My position was "West Maui Watershed Coordinator" similar to the position now held by Tova Callender. At the time, nuisance macroalgal blooms along West Maui shores caused noxious odors and hurt resort occupancy. Our watershed project worked to reduce sediment and nutrient inputs to the coastal ocean. I coordinated with Maui County Wastewater Department to start reclaimed water irrigation at Kaanapali Resort and to successfully adjust the treatment process at Lahaina Wastewater Reclamation Facility (LWRF) to reduce nitrogen loads in the treated wastewater.

During my years working at EPA's Honolulu Office after 1997, I frequently participated in discussions related to the Lahaina wastewater injection wells. I participated in internal EPA meetings and meetings with DOH, and reviewed correspondence to and from Maui County and DOH regarding the Lahaina Wastewater Injection Wells and EPA's UIC permits for Lahaina. I also helped design and provided review comments on the Lahaina Tracer Study conducted by Dr. Craig Glenn of University of Hawaii.

I support the very doable proposed settlement of this lawsuit. I have followed this issue with great interest for 26 years through many Maui County administrations. It's time to stop fighting and using hyperbole to scare people about the projected implications of NPDES. It's time to work on the solutions to managing Maui's wastewater in ways that protect the reefs and coastal waters.

Speculations are being made about the ramifications of a NPDES permit for LWRF. Below I address the speculations about (1) the feasibility of drafting a NPDES permit, (2) the ability of UIC permits to protect marine life, and (3) the likelihood that that an NPDES for Lahaina will lead to new cesspool regulation. My comments are based on my historical first hand perspective and knowledge of the issues.

1. An appropriate NPDES permit can be developed for LWRF's injection wells and EPA offered help.

   An NPDES permit for a point source discharge to groundwater that eventually flows into coastal surface waters would be an unusual NPDES permit but not impossible to prepare. The notion that this permit is difficult and not formulaic is not a reason to avoid NPDES. The NPDES program in Hawaii is delegated to DOH but EPA retains oversight authority. One of EPA's regular roles is providing DOH with training and technical assistance on the application of NPDES for Hawaii. EPA has offered multiple times to provide technical assistance to help DOH prepare a NPDES permit for LWRF.

   There is much recent and relevant data available to inform calculations of assimilative capacity and zones of mixing. EPA and DOH's UIC permits require regular effluent monitoring; DOH collected several years of water quality monitoring data from the wastewater seeps in the ocean, and for nearby ambient waters near the seeps, and at control sites. All of these data will be helpful in drafting an appropriate NPDES permit.

2. Underground Injection Program (UIC) permits cannot adequately address concerns about coastal water quality.

   The UIC program falls under the Safe Drinking Water Act (SDWA) and is intended to protect underground sources of drinking water from underground injection. It does not address protection of surface waters or the aquatic life that lives in waters the injected chemicals may reach. The LWRF has for decades been regulated by UIC permits for wastewater discharge from both DOH and EPA. The poor water quality, algal blooms, and degradation of corals reported by scientists at Kahekili have all occurred under existing UIC permit regulations, so the UIC permits currently lack adequate protection for Maui's coastal waters.

   The NPDES program is a component of the Clean Water Act (CWA). The objective of the CWA is to restore and maintain the chemical, physical and biological integrity of the nations waters (Sec 101(a)). The CWA made it unlawful to discharge any pollutant from a point source into navigable surface waters without a Clean Water Act permit.

   The concentration limits used in permits for various pollutants are based on standards promulgated by EPA. SDWA/UIC and NPDES/CWA permits use different standards because these programs are designed to protect different uses of water. UIC permit limits founded in the SDWA protect human health from chemical exposure through drinking. NPDES permits under the CWA use limits that are protective of the aquatic and marine life living in streams and rivers, wetlands, and coastal and marine waters. In many cases the CWA limits are far more stringent than the SDWA limits.

I provide two ecologically important examples of these differences to show that the UIC permits are inadequate to protect marine life. Nitrate is a nutrient that fuels plant growth and is also toxic to aquatic life at some concentrations. The SDWA's MCL or maximum safe contaminant concentration for nitrate in drinking water is 10mg/L. Marine and aquatic life are far more sensitive than humans to nitrogen and nitrate concentrations in water. Hawaii's water quality standard for nitrate that cannot be exceeded in open coastal waters is 0.005 mg/L (5 ug/L). In another example, the EPA action level for copper in tap water is 1.3 mg/L whereas the maximum allowed concentration to protect marine life is 0.0029 mg/L. Copper is highly toxic to many marine organisms. Obviously the drinking water MCLs used to set pollutant limits in UIC permits do not protect sensitive marine organisms.

Public concern over former nuisance algal blooms in West Maui led EPA to propose stricter nitrate limits in previous draft versions of their UIC permit for Lahaina. Maui County successfully challenged EPA's authority to impose stricter limits under the UIC program. These limits were removed from the final permit. An NPDES permit can regulate discharges of chemicals to levels that are safe for marine organisms.

3. An NPDES permit for LWRF will NOT lead to NPDES permits for cesspools.

The LWRF injection wells and the fate of the effluent are uniquely well studied. Top scientists from UH and the US Geological Survey have used indigenous wastewater chemicals and dye tracers to identify the travel path, travel time, biological degradation, and exit points (seeps) in the ocean for Lahaina's treated wastewater effluent. Scientists have also documented exceedances of Hawaii's water quality standards for marine life, and direct harm to corals in the vicinity of the wastewater seeps. These studies were highly technical, time consuming, and costly. Similar convincing bodies of facts do not currently exist for other injection wells in Hawaii. Further application of NPDES to injection wells in Hawaii would likely require a high bar of site-specific information.

Onsite wastewater systems such as cesspools and septic systems are regulated as Class V UIC wells and differ in significant ways from the Class 1 municipal waste disposal injection wells at LWRF. According to EPA's NPDES website, NPDES permits are NOT required for individual homes that use onsite wastewater systems or do not have a surface discharge. EPA and DOH have limited resources and far higher priorities for the

NPDES program including major dischargers and municipal stormwater. Speculation about NPDES regulation of cesspools is unfounded.

Closing the 88,000 cesspools in Hawaii is a priority for EPA and DOH but NPDES is not the right tool. The legislature already required replacement of all cesspools by 2050 and the agencies are working to develop appropriate affordable technologies and funding mechanisms to assist homeowners with upgrades.

I appreciate the opportunity to provide testimony relative to the NPDES regulation of the LWRF's injection wells. My long employment by EPA Region IX provides useful perspective and history on the important decisions before Maui County. If you wish to discuss my comments further, I can be reached at (808) 358-6206 and email at 420keani@gmail.com.

With sincere aloha,
Wendy Wiltse, Ph.D,
Oahu Waterkeepers
President, Board of Directors

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# Algal $\delta^{15}N$ values detect a wastewater effluent plume in nearshore and offshore surface waters and three-dimensionally model the plume across a coral reef on Maui, Hawai'i, USA

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ABSTRACT

The coral reef at Kahekili, Maui is located ~300 m south of the Lahaina Wastewater Reclamation Facility which uses four Class V injection wells to dispose of 3–5 million gallons of wastewater effluent daily. Prior research documented that the wastewater effluent percolates into the nearshore region of Kahekili. To determine if the wastewater effluent was detectable in the surface waters offshore, we used algal bioassays from the nearshore region to 100 m offshore and throughout the water column from the surface to the benthos. These algal bioassays documented that significantly more wastewater effluent was detected in the surface rather than the benthic waters and allowed us to generate a three-dimensional model of the wastewater plume in the Kahekili coastal region. Samples located over freshwater seeps had the highest $\delta^{15}N$ values (~30–35‰) and the effluent was detected in surface samples 500 m south and 100 m offshore of the freshwater seeps (~8–11‰).



## 1. Introduction

Anthropogenic nutrient loading of coastal waters has had major impacts on the receiving ecosystems worldwide. For example, in response to heavy nitrogen (N) loads large scale blooms of opportunistic macroalgae have formed in tropical and temperate regions in coral reef and estuarine systems (Lapointe, 1997; Paerl, 1997; Valiela et al., 1997; McCook, 1999; Stimson et al., 2001; Lapointe et al., 2005; Morand and Merceron, 2005; Viaroli et al., 2005; Pinon-Gimate et al., 2009). Algal blooms have various negative affects on ecosystems, including reduced oxygen levels via the decomposition of algal tissue, increased microbial abundance, and emigration of fish from the impacted area (Rosenberg, 1985; Alber and Valiela, 1994; Morand and Briand, 1996; Lapointe, 1997). Specifically, on coral reefs in tropical regions, N-driven algal blooms growing over corals can affect their nutrition, growth and survival by smothering and limiting light levels (Smith et al., 1981). Coral mortality has also resulted from high phosphate concentrations from sewage-derived wastewater effluent (wastewater effluent) through the inhibition of calcification and localized bacterial infection (Kinsey and Davies, 1979; Walker and Ormond, 1982).

Nutrient sources of fertilizer and sewage can be differentiated through the use of stable isotopes of N ($^{15}N$:$^{14}N$, expressed as $\delta^{15}N$; Eq. (1)) because natural (atmospheric) and fertilizer N sources have generally low values ranging from 0‰ to 4‰ and −4 to 4‰, respectively (Owens, 1987; Macko and Ostrom, 1994) and sewage N sources are enriched in $^{15}N$ ranging from 7‰ to 38‰ (Kendall, 1998; Gartner et al., 2002; Savage and Elmgren, 2004). The elevated $\delta^{15}N$ values found in sewage N arises from the denitrification of nitrate and nitrification of ammonia during which fractionation occurs by microbes for the easier to metabolize, lighter isotope ($^{14}N$) (Heaton, 1986). The volatilization of $^{14}N$-ammonia also enriches the sewage N source in $^{15}N$ relative to $^{14}N$ (Heaton, 1986). The release of $N_2$ into the atmosphere from the natural, microbe driven processes of nitrification and denitrification (Biological Nitrogen Removal (BNR)) is now used by some wastewater treatment facilities to reduce N levels in the effluent (Wiesmann, 1994; Zumft, 1997). Therefore, the wastewater effluent from facilities using BNR for N removal will likely have highly elevated $\delta^{15}N$ values.

Because algae assimilate N from their surrounding environment into their tissues, algal $\delta^{15}N$ values have been used worldwide to discriminate between anthropogenic and natural N sources and map the presence of anthropogenic N in a variety of coastal environments (Lapointe, 1997; Riera et al., 2000; Gartner et al., 2002; Umezawa et al., 2002; Savage and Elmgren, 2004; Steffy and Kilham, 2004; Barlie and Lapointe, 2005; Deutsch and Voss, 2006; Lin et al., 2007; Thornber et al., 2008; Pitt et al., 2009; Dailer

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et al., 2010). The $\delta^{15}N$ values of algae growing adjacent to wastewater outfalls have ranged from 8‰ to 19‰ (Costanzo et al., 2001; Gartner et al., 2002; Barlie and Lapointe, 2005; Lin et al., 2007; Thornber et al., 2008; Pitt et al., 2009). To date, the highest reported algal $\delta^{15}N$ value is 50.1‰ from samples deployed over warm freshwater seeps on a coral reef suspected to be affected by wastewater effluent at Kahekili on the island of Maui (Dailer et al., 2010). In agreement with other studies (Costanzo et al., 2001, 2005) Dailer et al. (2010), verified that the $\delta^{15}N$ values of transplanted algae express the integration of new N sources over short time intervals of less than one week and can be used to map the presence of wastewater effluent. Thus, considering the findings from Dailer et al. (2010), and the likelihood that non-saline wastewater effluent would rise to the surface waters as a buoyant plume, this study aimed to use algal bioassays to (1) determine if there is a difference in the presence of the wastewater effluent in the surface versus the benthic waters and (2) map the wastewater effluent plume as a three-dimensional model, across the coral reef at Kahekili.

## 2. Study area

The study area is within the Kahekili Herbivore Fisheries Management Area (HFMA) that was established to restore a healthy grazing population in July 2009 by the State of Hawai'i, Department of Land and Natural Resources, Division of Aquatic Resources (http://Hawaii.gov/dlnr/dar/regulated_areas_maui.html). The Kahekili HFMA spans approximately 1.5 km of coastline and is closed to the taking of herbivorous fishes and sea urchins in an attempt to battle prolific algal growth associated with the area's decline in coral cover from 55% to 33% over the past decade (http://Hawaii.gov/dlnr/dar/pubs/MauireefDeclines.pdf). The Lahaina Wastewater Reclamation Facility (WWRF) is located about 300 m north of the study area approximately 900 m from the coastline. This facility uses BNR to reduce N concentrations in the wastewater effluent (Parabocoli, personnel communication) and operates four Class V injection wells for wastewater effluent disposal. An injection well is a bored, drilled or driven shaft, whose depth is greater than its largest surface dimension; or a subsurface fluid distribution system used to discharge fluids underground (Code of Federal Regulations, Chapter 40 Part 144.3). The shallow forereef at Kahekili (~1.5–10 m offshore) has had algal blooms (primarily of *Ulva fasciata*) in the summer months when the wave action is negligible in the area (MD pers. obs.). The shallow forereef also has warm, continuously flowing freshwater seeps that are surrounded by rocks and coral rubble with black precipitates. Although these black, powdery and impregnating minerals have not been chemically analyzed yet, we believe that they are likely manganese oxides and/or iron oxyhydroxides which oxidatively precipitate from the solution exiting the seeps upon encountering normally oxygenated benthic waters (Glenn, personnel communication; Roden et al., 2004; Konhauser, 2007). The most persistent current in the area flows from the north to the south (Storlazzi and Field, 2008).

## 3. Material and methods

### 3.1. Three-dimensional algal bioassay deployments

In our previous study, we aimed to determine the two-dimensional extent of the Lahaina WWRF wastewater effluent plume across the coral reef at Kahekili and used nearshore and offshore sites (32 total) for algal bioassay deployments of *U. fasciata* 0.5 m from the benthos (Dailer et al., 2010). Those experiments revealed that the nearshore sites in the south were still located within the wastewater effluent plume and that the offshore sites (at 6.0 m depth) probably underestimated the plume boundaries because the non-saline wastewater effluent is likely more buoyant than the surrounding saltwater. Building on our previous field experiments, we expanded the experimental area by adding one transect in the north, two transects in the south and extending the array to the surface (at sites deeper than 1.5 m) with algal samples stratified throughout the water column (Fig. 1). The expanded array consisted of 45 sites total. Nine transects extended offshore each with four sites A–D at the following depths (m): A ~1.5, B ~2.0, C ~3.0 and D ~6.0 (Fig. 1); and an additional nine sites (S1–S8 and NS) were located in the shallow (~1.5 m depth) nearshore area containing the warm freshwater seeps (Fig. 2). Two sites, B4 and NS, were located directly over warm, freshwater seeps.

Samples of *U. fasciata* were collected from a bloom location at Waipuilani Beach Park (with initial $\delta^{15}N$ values ~5‰) and acclimated to low nutrient seawater for seven days to deplete internal N stores. After acclimation, samples were placed in 10 × 10 cm cages enclosed in plastic mesh and attached to float lines at the specified locations ($n = 3$ per site, per depth) (Figs. 1 and 2). The perimeter of the array consisted of large (0.5 m × 0.5 m) Aqua Lantern bouys equipped with solar panels to charge four AA batteries during the day that would automatically turn on five internal LED bulbs at night to provide a lit perimeter for boaters. The array was deployed for seven days in February, April, May and June 2010. In February, the array consisted of 261 samples and the results from the most northern and southern transects indicated that the wastewater effluent was still strongly present at these locations; we therefore, further expanded the array by adding one transect in the north and shifting the two most southern transects farther south. The algal bioassay deployments for April, May and June consisted of 291 samples and spanned 900 m of the Kahekili HFMA. A total of 1098 samples were deployed across all deployment periods, of which 951 samples were recovered (a recovery rate of ~87%). Some samples were not recovered because they were disintegrated in large unexpected wave events.

### 3.2. Algal sample preparation

Field and acclimated samples were prepared in triplicate to obtain the initial and acclimated $\delta^{15}N$ values. Recovered samples from each deployment (per site, per depth) were prepared for final $\delta^{15}N$ values. Samples were rinsed in deionized water, dried at 60 °C to a constant weight, and ground with mortar and pestle into a powder. Powdered samples were then sent for tissue $\delta^{15}N$ determinations to the Biogeochemical Stable Isotope Laboratory,

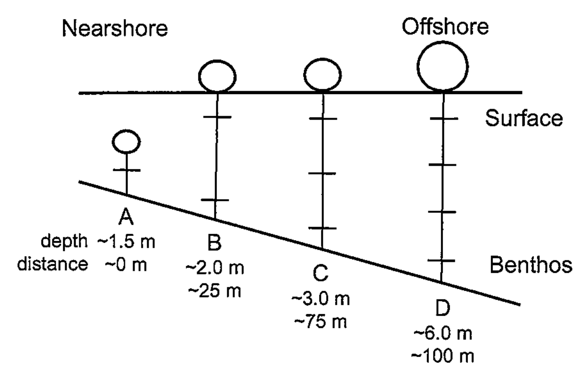


**Fig. 1.** Schematic of one transect for the algal bioassay deployments extended from the benthos to the surface. Sites A–D are shown from nearshore to offshore with accompanying approximate depths (m) and distances (m) from shore. Each horizontal dash represents a cluster of three mesh cages with one sample of acclimated *Ulva fasciata* per cage.

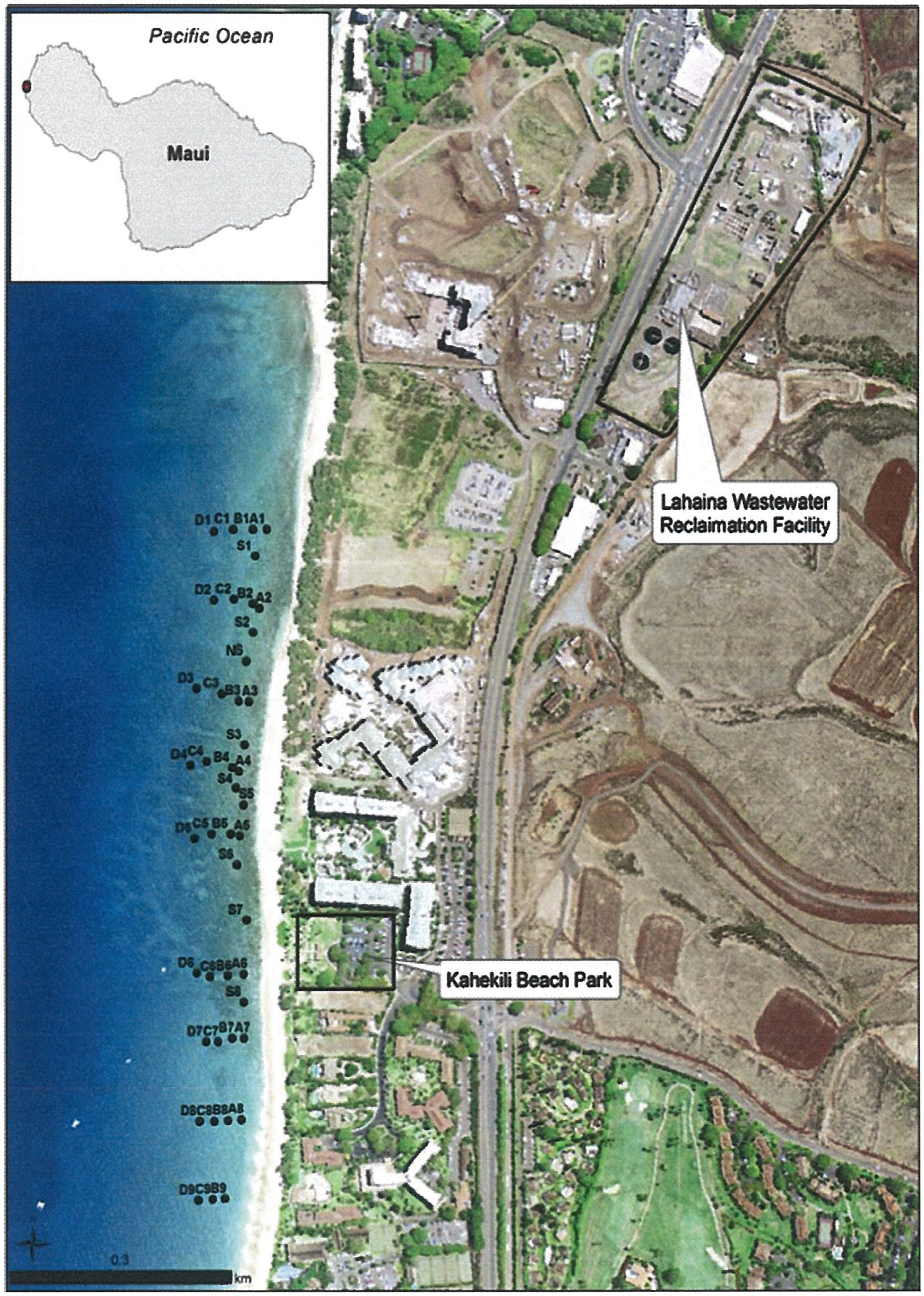


**Fig. 2.** Algal bioassay deployment sites across the coral reef at Kahekili. Aerial imagery was acquired through the Hawai'i Coastal Geology Group, School of Ocean and Earth Sciences and Technology (2007). <http://www.soest.hawaii.edu/coasts/erosion/maui/aerials.php>.

University of Hawai'i at Manoa. Samples were weighed then analyzed with a Carlo Erba NC 2500 Elemental Analyzer, Finnigan MAT ConFloII, and Finnigan MAT DeltaS. Ratios of $^{15}N$:$^{14}N$ were expressed relative to atmospheric nitrogen and calculated as (Sweeney et al., 1978):

$$\delta^{15}\mathrm{N}\ (‰) = \{(R_{\mathrm{sample}}/R_{\mathrm{standard}}) - 1\} \times 10^3, \text{ where } R = {}^{15}\mathrm{N}/{}^{14}\mathrm{N} \quad (1)$$

*3.3. Statistical analyses*

Data from the algal bioassays were not normally distributed and had unequal sample sizes per site, per depth by the end of the deployments due to unexpected large wave events that disintegrated some of the samples; therefore the data were analyzed with a General Linear Model with Type III error. After a significant result (see below for results by deployment for surface and benthic locations) an Unequal N post hoc test was performed to determine significance of algal $\delta^{15}N$ values within deployment sites and initial levels (field and acclimated samples) (performed with Satistica 6.0). Sites with only one remaining sample were not included in statistical analyses. Simple linear regressions were used to determine if there were significant relationships in the $\delta^{15}N$ values from the surface to the benthos per offshore location (B, C and D) per deployment (performed with SigmaPlot 9.0).

### 3.4. Three-dimensional modeling of the Lahaina WWRF wastewater effluent plume

The Lahaina WWRF wastewater effluent plumes for February, April, May and June 2010 were created with EnviroInsite, which is a three-dimensional groundwater visualization software. A Garmin GPS 76CS Plus was used to obtain the GPS coordinates in WGS 84 for algal bioassay deployment sites. The wastewater effluent plumes were modeled using an Inverse Distance Weighting algorithm with the following parameters: Z scale = 0.5 (>1 for anisotropy), exponent ($n$) = 1.5, smooth distance = 1, and search radius = 850 m (the extent of all sites). The modeled wastewater effluent plumes cover an area of approximately 80,275 $m^2$ with resolution or cell size of approximately 2.0 m × 17.0 m.

## 4. Results

A significant effect of site was found for each deployment month for the surface and benthos (GLM ANOVA): February surface, $F_{39,74} = 44.7$, $P < 0.00001$; February benthos, $F_{39,67} = 59.0$, $P < 0.00001$; April surface, $F_{42,64} = 27.8$, $P < 0.00001$; April benthos, $F_{40,58} = 44.1$, $P < 0.00001$; May surface, $F_{42,72} = 40.8$, $P < 0.00001$; May benthos, $F_{42,71} = 87.7$, $P < 0.00001$; June surface, $F_{43,68} = 17.4$, $P < 0.00001$; June benthos, $F_{43,65} = 58.5$, $P < 0.00001$. Regardless of deployment month, all samples deployed over warm freshwater seeps drastically and significantly ($P < 0.0002$) increased in $\delta^{15}N$ values from ~5‰ initially to 30.7 ± 1.1‰ in February, 35.4 ± 0.5‰ in April, 31.0 ± 1.2‰ in May and 32.7 ± 0.1‰ in June (Fig. 3). For all deployments, significantly ($P < 0.02$) increased algal $\delta^{15}N$ values were observed throughout the shallow nearshore region (sites A, B and S1–S8; Fig. 3). Ranges of algal $\delta^{15}N$ values for this region (excluding values from freshwater seep sites) were as follows per month: February ~22‰ to ~9.0‰, April ~29‰ to ~8.0‰, May ~24‰ to ~8.0‰, and June ~20‰ to ~8.0‰ (Fig. 3). Significantly higher than initial $\delta^{15}N$ values were continually found in samples that were deployed at the surface and benthic locations of site B9, which was ~500 m to the south of the warm freshwater seep site B4 ($P < 0.0002$, Fig. 3). In general for all deployments, the $\delta^{15}N$ values from algae deployed in the shallow sites to the south were higher than those from S1 and transect 1 to the north (Fig. 3).

For all deployments, the $\delta^{15}N$ values of samples deployed at the surface of sites C and D (~75 and ~100 m offshore, respectively) were significantly ($P < 0.05$) increased from initial values (~5‰). More specifically, this occurred at the following sites with the accompanying range of algal $\delta^{15}N$ values per deployment: February C3–9 (~19‰ to ~10‰) and D3–9 (~12‰ to ~9‰); April C3, C6–8 (~15‰ to ~12‰) and D8–9 (~12‰ to ~11‰); May C2–3, C5–9 (~17.0‰ to ~11‰) and D3, D5, D7–9 (~11‰ to ~9‰); and June C2–7, C9 (~17‰ to ~11‰) and D2 (~11‰) (Fig. 3). However, the $\delta^{15}N$ values of samples deployed at the benthos of C and D locations generally increased but were not significantly elevated from initial values (Fig. 3). The $\delta^{15}N$ values of algae deployed at B sites located ~25 m offshore were significantly ($P < 0.04$) elevated from initial values for the following months in the surface and the benthos, respectively: April B4, B6–9 and B8–9; May B2–9 and B3–5, B9; and June B2–4, B6–9 and B2–5, B9 (Fig. 3). In February, all B sites were significantly ($P < 0.03$) elevated from initial values in both the surface and the benthos (Fig. 3). The three-dimensional models of the wastewater effluent plumes show that the highest $\delta^{15}N$ values were located in the nearshore warm freshwater seep zone and that the effluent was detected on the most southern transect, regardless of deployment month (Fig. 4).

For each deployment, a significant ($P < 0.0009$) decreasing relationship was found in the $\delta^{15}N$ values of algae deployed at the surface through the water column to the benthos for all of the offshore locations (B, C and D) except for site B4 (Table 1). B4 was the only offshore site located directly over a warm freshwater seep. The pooled data from site B4 across deployment months for the surface and benthos, separately, showed a significant ($P < 0.0008$) increasing relationship from the surface to the benthos (Table 1). This shows that regardless of deployment month, the wastewater effluent was more detectable in the surface than the benthos waters at all offshore sites except for B4 where a warm freshwater seep was located. In summary, these data demonstrate that the Lahaina WWRF effluent plume (1) affected the majority of the shallow region at Kahekili, (2) rose to the surface waters in the area and (3) generally flowed south with the most predominant current in the area (Fig. 3 and 4).

## 5. Discussion

Algae with high N uptake rates generally quickly respond to pulses of nutrients (Wallentinus, 1984) and can be used as an additional method to assess water quality in coastal environments. Algal bioassays can be deployed in an area of concern to integrate water column N over short time periods to examine dominant source(s) of N in the area (Costanzo et al., 2001, 2005). Although no macroalgal specific evidence of isotopic preference (fractionation) exists (Cohen and Fong, 2005), it is possible that algal $\delta^{15}N$ values may be lowered in N rich environments (Pennock et al., 1996). However, algal $\delta^{15}N$ values have been used globally to detect sources of anthropogenic N in coastal systems and in all cases where algal tissue has been used to trace wastewater effluent, the $\delta^{15}N$ values nearest the outfalls or treatment facilities were elevated relative to natural signatures (Risk et al., 2009 and references therein). High wastewater loadings have been associated with elevated $\delta^{15}N$ values in harmful algal blooms where the wastewater effluent discharged through injection wells quickly rose to the surface likely affecting coral reefs in the area (Lapointe et al., 2005).

Dailer et al. (2010) detected the presence of the Lahaina WWRF wastewater effluent in the nearshore area of Kahekili through elevated $\delta^{15}N$ values in attached intertidal algae and algal bioassays. Since the non-saline, wastewater effluent plume is likely more buoyant than saltwater, this study extended the algal bioassay array to the surface waters at sites 25–100 m offshore. The extension to the surface waters was necessary to determine if the wastewater plume was detectable in the offshore surface waters while remaining undetected in the benthic waters (~6.0 m depth) until water column mixing occurs from large wave events.

All samples placed over warm freshwater seeps drastically and significantly increased in $\delta^{15}N$ value (from ~5‰ to ~30‰ to 35‰), regardless of deployment month. These $\delta^{15}N$ values are higher than those reported from the Lahaina WWRF (~20‰) (Hunt and Rosa, 2009). The increased difference in $\delta^{15}N$ values might be caused by continual denitrification processes in the wastewater effluent as it flows to the ocean and/or variable $\delta^{15}N$ values of the effluent. $\delta^{15}N$ values from ~30‰ to 35‰ are comparable to values reported from a wastewater treatment facility using BNR (38.0‰ Savage and Elmgren, 2004) and are higher than those reported of algae with anthropogenic exposure (25.7‰ Riera et al., 2000; 19.6‰ Jones et al., 2001).

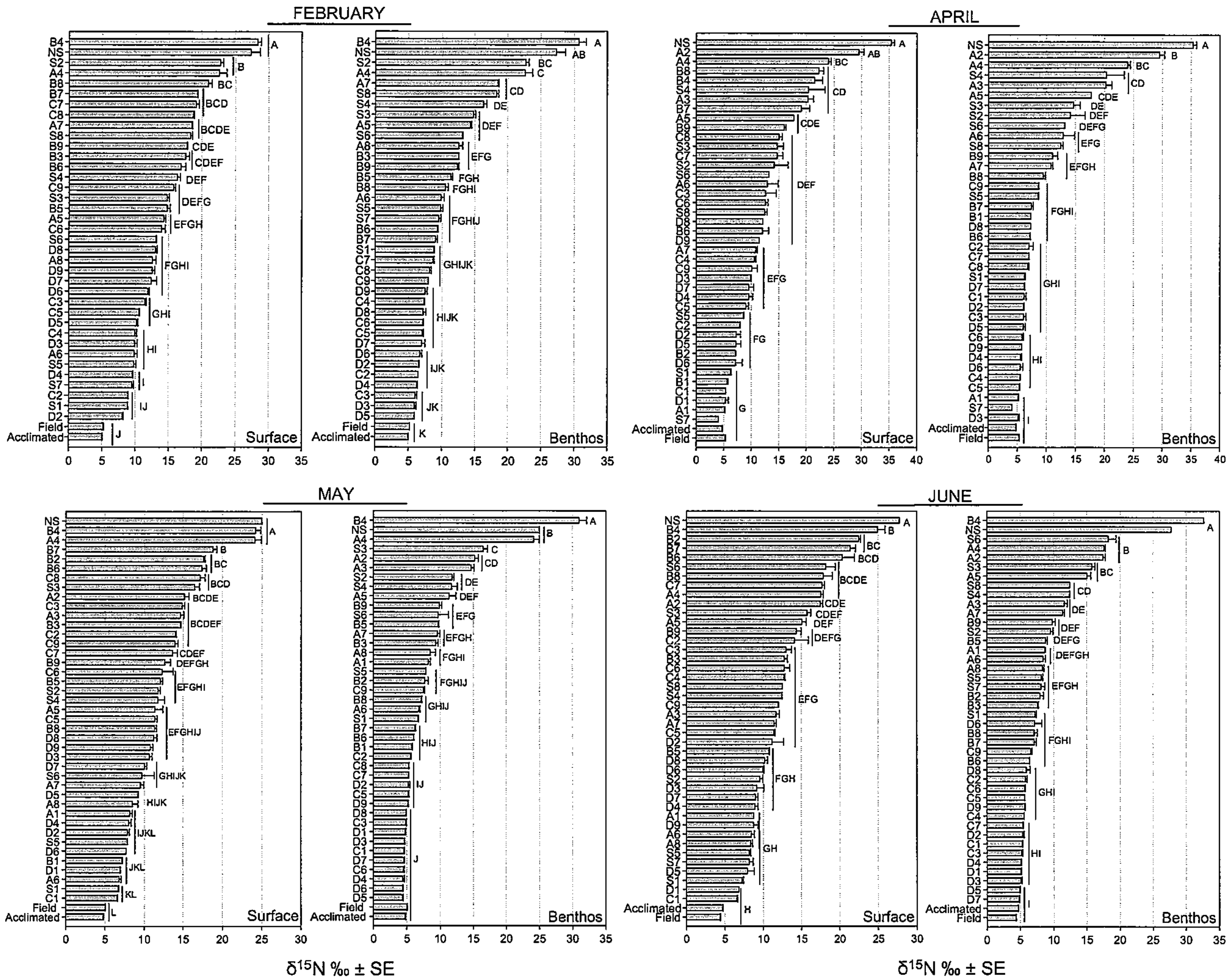


**Fig. 3.** February, April, May and June 2010 $\delta^{15}N$ values (average ± SE) of *Ulva fasciata* for field, acclimated, and deployed samples at Kahekili at the respective sites for surface and benthic locations. Significant differences are represented by different letters; note the change in scale on the x-axis.

In general for all deployment months, $\delta^{15}N$ values of algae deployed at the shallow southern sites were higher than those from the most northern sites. This study agrees with the consideration that the promontory landmass of Honokowai Point likely diverts the wastewater effluent plume to the south over the coral reef at Kahekili (Dailer et al., 2010). In addition, increased $\delta^{15}N$ values to the south are consistent with the findings of Dailer et al. (2010) and research conducted by the US Geological Survey which documented that the most dominant nearshore current in the area flows from north to south (Storlazzi and Field, 2008). The $\delta^{15}N$ values of surface samples at sites ~75 m and ~100 m offshore were significantly increased from initial values (ranging from 9‰ to 19‰ across all deployments), whereas those of the benthic samples were elevated but not significantly increased. This study shows that the surface array is a successful method for the detection of wastewater effluent and that, for the Kahekili area, the wastewater signal is stronger in the surface waters than in the benthic waters when the water column is stratified from calm conditions. During large wave events however, the water column becomes well mixed and the presence of the effluent can be strongly detected at the benthic locations of the offshore sites (Dailer et al., 2010).

These results confirm that the wastewater effluent flows through the coral reef at Kahekili into the surface waters, where most of the recreational users (swimmers, snorkelers, canoe paddlers, etc.) are active, and then flows to the south. The confirmation of the wastewater effluent encompassing the nearshore and the majority of the surface waters at Kahekili potentially threatens the health of those using the ocean and marine life (e.g. fish, sea turtles, and marine mammals) in this area. This is because wastewater effluent will normally contain an assortment of microbial (bacterial and viral) assemblages (Tree et al., 2003) prior to disinfection. Radiation from ultraviolet light (UV, 254 nm) disinfects wastewater effluent by killing more than 99% of the coliform, fecal coliform, fecal streptococci and heterotrophic bacteria found in wastewater (Oliver and Cosgrove, 1975). The Lahaina WWRF is currently capable of disinfecting about 1.0 million gallons of wastewater effluent per day with UV radiation and processes an average of ~3.4 million gallons of wastewater effluent per day with an accompanying mass load estimate of 79–97 kg (174–215 lbs) per day of total nitrogen (Dailer et al., 2010). The remaining ~2.4 million gallons of wastewater per day is directed into the injection wells prior to full disinfection. Therefore, to protect the health of the recreational users and marine life of this area from

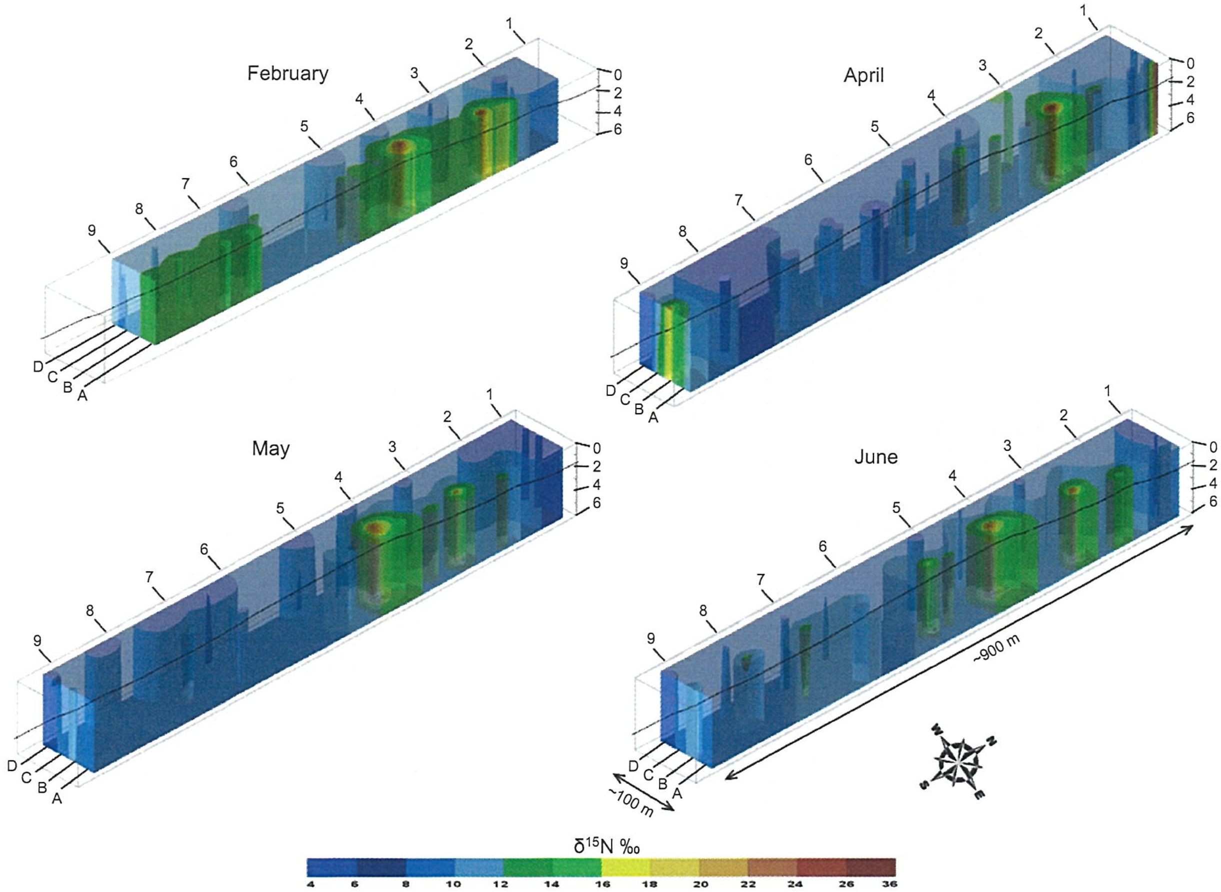


**Fig. 4.** Three-dimensional models of the wastewater effluent plume spanning the coral reef at Kahekili. The models were generated with EnviroInsite software from the $\delta^{15}N$ values of deployed algae in February, April, May and June 2010. Algal bioassay transects 1 through 9 are shown from north to south with deployment locations A–D from nearshore to offshore and the depth is shown from the surface (0 m) to the benthos (6 m).

**Table 1**
Relationships between $\delta^{15}N$ values of deployed algal samples from the surface through the benthos for all offshore sites per deployment month. For site B4, data were pooled across deployments for the surface and benthos, separately.

| | Site | Equation | $F$ | $r^2$ | $P$ |
|---|---|---|---|---|---|
| February | B | $y = -6.83x + 24.7$ | 102.6 | 0.76 | <0.0001 |
| | C | $y = -3.11x + 16.0$ | 61.4 | 0.48 | <0.0001 |
| | D | $y = -1.39x + 11.6$ | 98.5 | 0.52 | <0.0001 |
| April | B | $y = -7.17x + 23.0$ | 13.8 | 0.32 | 0.0009 |
| | C | $y = -2.27x + 12.7$ | 46.4 | 0.41 | <0.0001 |
| | D | $y = -0.91x + 8.97$ | 41.7 | 0.33 | <0.0001 |
| May | B | $y = -2.88x + 14.5$ | 46.2 | 0.52 | <0.0001 |
| | C | $y = -1.64x + 11.9$ | 92.8 | 0.59 | <0.0001 |
| | D | $y = -0.74x + 8.45$ | 174.3 | 0.63 | <0.0001 |
| June | B | $y = -4.23x + 17.9$ | 58.9 | 0.63 | <0.0001 |
| | C | $y = -1.60x + 12.0$ | 75.0 | 0.56 | <0.0001 |
| | D | $y = -0.60x + 8.68$ | 53.8 | 0.44 | <0.0001 |
| All months freshwater seep site B4 | | $y = 6.72x + 17.7$ | 17.7 | 0.54 | 0.0008 |

the potential microbial assemblages associated with the wastewater effluent, the Lahaina WWRF should have the capacity to disinfect the total volume of effluent processed.

In the US, injection wells are regulated under the Safe Drinking Water Act, by the Underground Injection Control (UIC) Program which manages the subsurface injection of waste fluids below, into, and above underground drinking water sources. Correspondingly, the UIC permit conditions are designed to protect underground drinking water sources (not coastal waters) from injectate pollutants. The Clean Water Act, however, prohibits the discharge of pollutants from point sources into the waters of the US without a National Pollution Discharge Elimination System permit that implements minimum wastewater treatment standards through technology-based effluent limits. We hope that this study will help guide regulatory authorities toward improving wastewater treatment standards for the Lahaina WWRF, especially full disinfection of all effluent, to consequently enhance the water quality of the Kahekili area for the benefit of the people, as well as, the environment.

## Acknowledgements

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Research Article

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# Vulnerability of coral reefs to bioerosion from land-based sources of pollution

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**Ocean acidification (OA), the gradual decline in ocean pH and [$CO_3^{2-}$] caused by rising levels of atmospheric $CO_2$, poses a significant threat to coral reef ecosystems, depressing rates of calcium carbonate ($CaCO_3$) production, and enhancing rates of bioerosion and dissolution. As ocean pH and [$CO_3^{2-}$] decline globally, there is increasing emphasis on managing local stressors that can exacerbate the vulnerability of coral reefs to the effects of OA. We show that sustained, nutrient rich, lower pH submarine groundwater discharging onto nearshore coral reefs off west Maui lowers the pH of seawater and exposes corals to nitrate concentrations 50 times higher than ambient. Rates of coral calcification are substantially decreased, and rates of bioerosion are orders of magnitude higher than those observed in coral cores collected in the Pacific under equivalent low pH conditions but living in oligotrophic waters. Heavier coral $\delta^{15}N$ values pinpoint not only site-specific eutrophication, but also a sewage nitrogen source enriched in $^{15}N$. Our results show that eutrophication of reef seawater by land-based sources of pollution can**

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**magnify the effects of OA through nutrient driven-bioerosion. These conditions could contribute to the collapse of coastal coral reef ecosystems sooner than current projections predict based only on ocean acidification.**

## 1. Introduction

Coral reefs occupy less than 1% of the world's seafloor yet support hundreds of thousands of animal and plant species (Reaka-Kudla, 1987), sustain the livelihoods of hundreds of millions of people around the world, and protect thousands of kilometers of coastline from coastal hazards (Hughes *et al.*, 2003; Ferrario *et al.*, 2014). Yet coral reefs are facing increasing stress from global climate change, such as increasing temperatures, sea levels, and ocean acidification (OA), combined with local stresses from over-fishing, sedimentation, and land-based sources of pollution including coastal acidification (Knowlton and Jackson, 2008). As discussed in early work by Stearn et al. (1977), and Scoffin et al. (1980) on carbonate budgets, the carbonate accretion of coral reefs depends on two overarching processes: production of calcium carbonate ($CaCO_3$) skeletons by plants and animals on the reef and cementation of sand and rubble, and $CaCO_3$ breakdown and removal that occurs through bioerosion, dissolution, and offshore transport (e.g., Perry *et al.*, 2013; Glynn and Manzello, 2015). Accretion of $CaCO_3$ must exceed removal for modern reefs to be in a state of net growth. However, any factor facilitating the decrease of carbonate production could tip this balance, causing reefs to shift to a state of net loss. There is now strong evidence that calcification rates tend to decrease, and bioerosion and dissolution rates tend to increase with declining seawater pH and [$CO_3^{2-}$] (Hughes *et al.*, 2007; Anthony *et al.*, 2008; Enochs *et al.*, 2016). Under elevated aqueous $p$$CO_2$ (750 µatm) treatments, biogenic dissolution by euendolith (microborers) communities were found to yield a dissolution rate of 39 g $CaCO_3$ $m^{-2}$ $mo^{-1}$ (468 m□□□□□□ □□□□□ (Tribollet *et al.*, 2009). This is consistent with field observations from Oahu where bioerosion rates were highly sensitive to ocean pH (Silbiger *et al.*, 2014; Silbiger *et al.*, 2016). Nutrient loading can also accelerate bioerosion rates (Holmes *et al.*, 2000;

Carreiro-Silva *et al.*, 2005, 2009), as revealed at sites that were exposed to inorganic nutrient loading in the absence of macrograzers having bioerosion rates enriched by a factor of 10 (Carreiro-Silva *et al.*, 2005). Therefore, past studies indicate that both OA and nutrient loading separately can increase bioerosion rates. However, there is now compelling evidence that sensitivity to bioerosion is much magnified under multiple stressors, including stressors from nutrient and sediment loading, along with overfishing (Ban *et al.*, 2014; Vega Thurber *et al.*, 2014; DeCarlo *et al.*, 2015). Recently, DeCarlo et al. (2015) found macrobioerosion rates 10 times greater under high-nutrient conditions. Bioerosion rates of corals collected from naturally low pH environments were 10 times faster under nutrient rich (eutrophic) conditions compared with nutrient poor (oligotrophic) conditions. Although this observation was made on pristine, unpolluted reef systems, it highlights the potential dangers of nutrients to magnifying OA effects. This is of particular concern to coral reefs adjacent to densely inhabited shorelines, where nutrient fluxes can be high due to upstream fertilized, agricultural lands, treated wastewater injection, and leakage from leech field and septic systems close to shore.

Situated in the North Pacific Subtropical Gyre, the coral reef islands of Hawaii occupy a tropical, oligotrophic region with naturally occurring, low nutrient concentrations. On the Hawaiian island of Maui, however, anthropogenic nutrient loading to coastal waters via sustained submarine groundwater discharge (SGD) has been well documented (Dailer *et al.*, 2010; Dailer *et al.*, 2012; Bishop *et al.*, 2015; Amato *et al.*, 2016; Fackrell *et al.*, 2016). SGD consists of both terrestrial groundwater and recirculated seawater that is influenced by tides and waves (Dimova *et al.*, 2012). In Hawaii, where rivers are not abundant and permeability is high within the basaltic bedrock, SGD is an important water-borne transport vector for nutrients into the coastal ocean (Bienfang, 1980; Parsons *et al.*, 2008; Hunt and Rosa, 2009; Peterson *et al.*, 2009; Swarzenski *et al.*, 2012; Nelson *et al.*, 2015; Amato *et al.*, 2016; Fackrell *et al.*, 2016; Swarzenski *et al.*, 2016). As a result, SGD can impact the structure of marine biotic communities by delivering elevated nutrient loads that may lead to eutrophication, harmful algal blooms (Anderson *et al.*, 2002), decreased coral abundance and diversity, and increased macroalgal abundance (Fabricius, 2005; Lapointe *et al.*, 2005), as well as low pH water that can cause coastal acidification (Wang *et al.*, 2014). Eutrophication, for example, from nitrogen and phosphorous pollution of land-based sources, such as septic leachate and fertilizers, can alter ecosystem function and structure by shifting reefs from being dominated by corals to being dominated by algae (Howarth *et al.*, 2000; Andrefouet *et al.*, 2002; Hughes *et al.*, 2007) and increasing the vulnerability of reefs to coral disease (Bruno *et al.*, 2003; Redding *et al.*, 2013).

"Dead zones," areas of clustered patches of variable degrees of degradation with discrete coral cover loss of nearly 100% have been observed for decades (Wiltse, 1996; Ross *et al.*, 2012) along the shallow coral reef at Kahekili in Kaanapali, west Maui, Hawaii, USA (Fig. 1). This area has a long history of macro-algal blooms (Smith *et al.*, 2005) and a decrease in herbivorous fishes attributed to overfishing (Williams *et al.*, 2016). As a result, there has been a shift over the past decades in benthic cover from abundant corals to turf- or macro-algae (Cochran *et al.*, 2014). Currently, only 51% of the hardbottom at Kahekili is covered with at least 10% live coral (Cochran *et al.*, 2014). Excessive algae growth has been a concern since the late 1980s, with potential links to input of nutrient-rich water via wastewater injection wells (Dailer *et al.*, 2010; Dailer *et al.*, 2012). Fluorescent dye tracer studies now confirm that there is a direct hydrologic link between the nearby Lahaina Wastewater Reclamation Facility (LWRF) and SGD, where treated wastewater is injected into groundwater that then flows towards the coast to emerge through a network of small seeps and vents (Glenn *et al.*, 2013; Swarzenski *et al.*, 2016). Changes in coastal water quality observed off west Maui can ultimately impact the balance between reef accretion and bioerosion, with reef degradation occurring through both the biological breakdown of the skeleton from microborers (e.g., alga and bacteria) and macroborers (e.g., bivalves and sponges; Osorno *et al.*, 2005) via mechanical and chemical bioerosion (see reviews by Tribollet and Golubic, 2011; Schönberg, 2017) as well as dissolution of $CaCO_3$ due to changes in the aragonite saturation state ($\Omega_{arag}$) from both natural (Crook *et al.*, 2012; Crook *et al.*, 2013; Shamberger *et al.*, 2014; Silbiger *et al.*, 2014) and anthropogenic activities (Kleypas *et al.*, 1999; Hoegh-Guldberg *et al.*, 2007; Fabricius *et al.*, 2011).

We investigated the influence of SGD on reef biogeochemistry and growth of massive reef-building corals on a shallow reef at Kahekili in Kaanapali, west Maui, Hawaii, USA (Fig. 1), where the existence of numerous low salinity seeps provide a direct vector for low pH, nutrient-rich groundwater onto the reef (Glenn *et al.*, 2013; Swarzenski *et al.*, 2016). Sampling to characterize seawater chemistry at the primary seep site and in adjacent coastal waters was conducted in September 2014 and March 2016. Water samples were collected and analyzed for salinity, dissolved inorganic nutrients, and seawater carbonate system parameters (pH (total scale), total alkalinity (TA), and dissolved inorganic carbon (DIC)). The full seawater $CO_2$ system was calculated using the carbonate speciation program CO2SYS (Table S1; see methods). To investigate the response of corals to the combined effects of coastal acidification and nutrient loading associated with SGD, skeletal cores were extracted from *Porites lobata* corals located around the discharge seep (Fig. 1; Table 1), and to the north and south of its influence, and Computerized Tomography (CT) scanned at the Woods Hole Oceanographic Institution's Computerized Tomography Scanning Facility (Crook *et al.*, 2013). The scan images were analyzed for annual calcification and bioerosion rates using coralCT (DeCarlo and Cohen, 2016). With global warming and ocean acidification projected to compromise carbonate accretion (Hoegh-Guldberg *et al.*, 2007; Fabricius *et al.*, 2011; Gattuso *et al.*, 2015), managing the compounding effects from local stressors is a top priority in reef-management. Results from this work can therefore be used to estimate changes in coral reef health under future OA and shifting off continent material flux scenarios.

## 2. Methods

### 2.1 Coral growth parameters

Coral cores ($n = 7$) were collected in July 2013 from the shallow reef at Kahekili in Kaanapali, west Maui, Hawaii, from scleractinian *Porites lobata* (Fig. 1) in water depths of between 1 to 3 m and in the vicinity of brackish submarine groundwater discharge (SGD) "seeps" near Kahekili Beach Park (Glenn *et al.*, 2013), approximately 0.5 km southwest of the Lahaina Wastewater Reclamation Facility (LWRF) (Table 1). All cores were collected from living *Porites sp.*, except for adjacent to the vent where the coral colony was dead upon collection. Colonies were selected based on several criteria including distance from shore, distance from seep, coral shape, and water depth. Metrics of coral reef health (bioerosion, calcification, and growth rate) were quantified at the Woods Hole Oceanographic Institution's Computerized Tomography (CT) Scanning Facility (Crook *et al.*, 2013) where CT scan images (Fig. S1) were used to calculate the proportion of the skeleton eroded (>1 mm boring diameter) by boring organisms and calculated as the total volume of $CaCO_3$ removed relative to the total volume of the individual *Porites* coral core (Barkley *et al.*, 2015; DeCarlo *et al.*, 2015) using coralCT (DeCarlo and Cohen, 2016). The average growth rate reported in this study is the average linear extension rate and respective standard deviation for the length of cores analyzed per site. Pearson correlation coefficients and respective p-values were calculated in Excel. Significance levels were tested at the 95% and 90% confidence level. The number of years for analysis ranged from the upper 10 to 26 yr and was calculated as linear extension (mm) per yr. The range (i.e., length of core analyzed) reflects the fact that the quality/preservation of banding was not consistent across the collection sites due to differences in boring and erosion (Fig. S1). In comparison to measured bioerosion rates, predicted bioerosion rates were calculated using the equation from DeCarlo *et al.* (2015) where bioerosion rate = $-11.96 * \Omega_{arag} + 43.52$. Coral life spans were calculated based on annual growth rate and core length. Coral life span for the dead specimen was determined by comparing bomb-derived radiocarbon ($^{14}C$) values measured at 5 depth intervals to reference bomb-curves from Hawaii (Andrews *et al.*, 2016). Samples were prepared for Accelerator Mass Spectrometry (AMS) radiocarbon ($^{14}C$) dating at the National Ocean Sciences Accelerator Mass Spectrometry (NOSAMS) facility.

## 2.2 Carbonate geochemistry

Coral nitrogen isotope ($\delta^{15}N$) values were determined by collecting skeletal material (~300 mg) from the upper 4.0-5.6 mm of growth. Approximately 18 mg of material was placed into tin capsules with an approximately equivalent mass of vanadium oxide ($V_2O_5$) catalyst to ensure complete combustion for analysis using a Costech elemental analyzer - Isotope Ratio Mass Spectrometry (EA-IRMS) at the University of California at Santa Cruz and the USGS Stable Isotope Lab to determine $\delta^{15}N$ composition. Analytical uncertainty of 0.16 ‰ is reported based on replicate analysis of the international nitrogen standard, acetanilide.

## 2.3 Water sample collection and analysis

Sampling for water at the primary vent site and in adjacent coastal waters was conducted in September 2014 and March 2016. In 2014, sampling of the submarine springs was conducted using a piezometer point directly inserted into the primary vent site (Swarzenski *et al.*, 2012) and a 12V peristaltic pump during both high and low tide (Table S1). At each sampling site, the salinity and temperature of the vent water and bottom water was recorded using calibrated YSI multi-probes. Seawater sampling in March 2016 was conducted near the coral sites every 4-hr over a 6-d period for nutrients and carbonate chemistry variables. A peristaltic pump was used to pump seawater from the seafloor and temperature and salinity were recorded using a calibrated YSI multimeter. In-situ temperatures were also recorded from Solonist CTD Divers installed at each sampling tube (Prouty *et al.*, 2017).

Water samples were collected for the dissolved nutrients $NH_4^+$, Si, $PO_4^{3-}$, and [$NO_3^-$+$NO_2^-$] in duplicate, filtered with an in-line 0.45-µm filter (and 0.20 µm syringe filter for time-series sample), and kept frozen until analysis. Nutrients were analyzed at the Woods Hole Oceanographic Institution nutrient laboratory and University of California at Santa Barbara's Marine Science Institute Analytical

Laboratory via flow injection analysis for $NH_4^+$, Si, $PO_4^{3-}$, and [$NO_3^-$+ $NO_2^-$], with precisions of 0.6-3.0 %, 0.6-0.8 %, 0.9-1.3 %, and 0.3 %-1.0 % relative standard deviations, respectively. Nitrate isotope ($\delta^{15}N$ and $\delta^{18}O$) analyses were done at the University of California at Santa Cruz using the chemical reduction method (McIlvin and Altabet, 2005; Ryabenko *et al.*, 2009) and University of California at Davis' Stable Isotope Facilities using the denitrifier method (Sigman *et al.*, 2001). Using a Thermo Finnigan MAT 252 coupled with a GasBench II interface, isotope values are presented in per mil (‰) with respect to AIR for $\delta^{15}N$ and VSMO for $\delta^{18}O$ with a precision of 0.3-0.4‰ and 0.5-0.6‰ for $\delta^{15}N$-nitrate and $\delta^{18}O$-nitrate, respectively.

Measurement for carbonate chemistry parameters from the March 2016 collection were collected and analyzed for pH (total scale), TA, and DIC. A peristaltic pump was used to pump seawater from sampling sites through a 0.45-μm filter. Samples for pH were filtered into 30 mL optical glass cells, and were analyzed within 1 h of collection using spectrophotometric methods (Zhang and Byrne, 1996), an Ocean Optics USB2000 spectrometer and thymol blue indicator dye. Samples for TA (±1 μmol $kg^{-1}$) and DIC (±2 μmol $kg^{-1}$) were filtered into 300 ml borosilicate glass bottles, preserved by adding 100 uL saturated $HgCl_2$ solution, and bottles were pressured sealed with ground glass stoppers coated with Apiezpon grease. TA samples were analyzed using spectrophotometric methods of Yao and Byrne (1998) with an Ocean Optics USB2000 spectrometer and bromocresol purple indicator dye. DIC samples were analyzed using a UIC carbon coulometer model CM5014 and CM5130 acidification module fitted with a sulfide scrubber, and methods of Dickson *et al.* (2007). Dissolved oxygen (±0.1 mg $L^{-1}$), temperature (± 0.01°C), and salinity (± 0.01) were measured using a YSI multimeter calibrated daily. However, due to temperature change during water transit time within the sampling tube, in-situ temperatures as recorded from Solonist CTD Divers were reported and used to temperature corrected pH and perform CO2SYS calculations.

Certified reference materials (CRM) for TA and DIC analyses were from the Marine Physical Laboratory of Scripps Institution of Oceanography (person. Comm. A. Dickson). Duplicate or triplicate analyses were performed on at least 10 % of samples, yielding a mean precision of ~1 μmol $kg^{-1}$ and ~2 μmol $kg^{-1}$ for TA and DIC analyses, respectively. For low salinity (<10) water samples collected directly from the vent, discrete DIC samples were measured on an Apollo SciTech AS-C3 DIC autoanalyzer via sample acidification followed by non-dispersive infrared $CO_2$ detection using a LiCOR 7000. The instrument was calibrated with certified reference material (CRM) from Dr. A.G. Dickson at the Scripps Institution of Oceanography. A modified Gran titration procedure by Wang and Cai (2004) was used to determine TA with an Apollo SciTech AS-ALK2 automated titrator and CRM-calibrated HCl at 25.0°C. The full seawater $CO_2$ system was calculated with measured salinity, temperature, nutrients (phosphate and silicate), TA, and pH data using an Excel Workbook Macro translation of the original CO2SYS program (Pierrot *et al.*, 2006). The CO2SYS 2.0 program was run with dissociation constants $K_1$ and $K_2$ from Mehrbach *et al.* (1973) refit by Dickson and Millero (1987) and KSO4 from Dickson (1990). The aragonite saturation state ($\Omega_{arag}$) was defined as the ratio of $[CO_3^{2-}]$ and $[Ca^{2+}]$ divided by the aragonite solubility product ($K_{sp}$). The concentration of calcium $[Ca^{2+}]$ was assumed to be proportional to the salinity, and the carbonate concentration was calculated from DIC, pH, and the values of $K_1$ and $K_2$ (Pierrot *et al.*, 2006).

## 3. Results

### 3.1 Seawater carbonate chemistry

The 6-d continuous sampling in March 2016 revealed dynamic changes in the chemistry of seawater adjacent to the primary seep site, and captured the level of exposure of corals to variable pH and nutrient conditions (Fig 2; Table S1). From 16-19 March 2016, salinity increased and nutrient concentrations steadily declined, while pH values increased. From 21-24 March 2016, salinity decreased and nutrient concentrations increased by five orders of magnitude as pH fell, reaching values as low as 7.36 at the primary vent site (Fig. 2a,b). During this time, DIC and TA values increased, and $\Omega_{arag}$ fell below saturation for approximately 15 % of the time at the primary vent site (Fig. 2c, Table

S1). All carbonate parameters adjacent to the primary seep site behaved conservatively with respect to salinity (Fig. S2), demonstrating the tight coupling between nutrients and pH and freshened seep water input, consistent with earlier work documenting lower pH, nutrient enriched SGD derived seep water (Swarzenski *et al.*, 2012; Glenn *et al.*, 2013; Swarzenski *et al.*, 2016). Nutrients, TA, and DIC continued to covary with salinity at values greater than 33, suggesting that these stressors may have greater potential to impact those corals away from the vent. Although the salinity was extremely low at the vent, by the time affected waters reach corals only meters away, it had become well mixed with respect to salinity, and most corals in the vicinity of the vent were experiencing salinities ranging from 34 to 36 (Table S1). However, nutrients can impact the corals "downstream" because they are assimilated rapidly, fueling productivity that was likely driving the bioerosion (e.g., Carreiro-Silva *et al.*, 2005, 2009). These conditions clearly demonstrate that SGD is the primary source of elevated bottom water nutrient concentrations and dramatically under-saturated seawater ($\Omega_{arag} < 1$), corresponding to seawater $p\mathrm{CO_2}$ values greater than 1500 μatm (Fig 2).

### 3.2 Coral cores

Measured bioerosion rates and percent volume erosion were highest at the coral site adjacent to the active SGD seep, and lowest at the coral site furthest from the seep, with bioerosion rates ranging between 23-99 mg $cm^{-2}$ $yr^{-1}$ (Table 2). However, the bioerosion rate of LobataHead06 may be an overestimate given that the core was collected from a dead specimen. The correlation between coral bioerosion rates and percent volume erosion relative to distance to the vent ($r$ = -0.69 and -0.62; respectively) was significant at the 90% confidence level (Table 3). In addition, correlations between bioerosion rate and percent bioerosion volume and seawater parameters ($\Omega_{arag}$, pH, and nitrate) were statistically significant ($p < 0.05$). Growth rates ranged from 0.69±0.10 cm $yr^{-1}$ to 1.17±0.26 cm $yr^{-1}$, and calcification rates ranged from 0.67 to 1.10 g $cm^{-2}$ $yr^{-1}$ (Table 2). Calcification rates were correlated to distance from shore ($r = 0.72$; $p \leq 0.05$; Table 3). Neither growth parameter, however, was statistically correlated to bioerosion rates or seawater parameters.

To investigate whether the corals assimilate SGD nitrate, the nitrogen isotope ($\delta^{15}N$) composition of the coral tissue from the upper 4.0-5.6 mm of coral growth was analyzed. Coral $\delta^{15}N$ values were highest closest to the seep site (17.08 ± 0.40 ‰; Table 2), and decreased with distance away from the vent ($r = -0.58$; $p = 0.09$) and from shore ($r = -0.88$; $p < 0.05$; Table 3). With the exception of one coral head, all tissue $\delta^{15}N$ collected from corals near the primary seep zone, referred to as the "dead zone," were enriched relative to the north and south coral sites according to a one-way analysis of variance (ANOVA; $F_{(6,50)} = 136.1$; $p < 0.0001$; Fig. S3). Coral $\delta^{15}N$ values were also positively correlated to percent volume bioerosion ($r = 0.68$, $p = 0.07$; Fig. S3), and inversely correlated with calcification rates ($r = -0.70$, $p = 0.06$; Table 3).

**4. Discussion**

At the Kahekili site off the west coast of Maui, sustained SGD is rich in nutrients and also has lower pH (average 7.5±1.7). As a result of this SGD, the surrounding corals are exposed to multiple associated stressors, including nitrate concentrations up to 50 times higher than ambient seawater, and lower pH bottom water. Additional stressors from SGD, including reduced salinity at the primary vent site, and elevated TA and DIC concentrations can impact the corals by changes in photosynthesis, respiration, as well as increased bleaching and mortality (e.g. Ferrier-Pages *et al.*, 1999). We did not observe, however, the salinity extremes away from the vent that would have caused physiological stress/tissue loss/damage, yet increased rates of bioerosion were observed. An increase in TA and DIC can drive a shift from positive net community calcification to net negative community calcification, or net dissolution relative to calcification (Deffeyes, 1965). With expected reductions in calcification rates predicted under higher $pCO_2$ conditions (Shamberger *et al.*, 2011; Shaw *et al.*, 2012; Bernstein *et* *al.*, 2016), the interplay of bioeroding organisms under reduced community calcification could enhance both chemical and mechanical bioerosion rates.

Bioerosion rates from dead pieces of the massive coral *Porites* sp. skeleton from along a natural pH gradient in Kāne'ohe Bay, Oahu, reported rates from 2 to 91 g $cm^{-2}$ $yr^{-1}$ (Silbiger *et al.*, 2016), with the upper range in rates comparable to those observed closet to the SGD vent at Kahekili. Comparing bioerosion rates remains difficult, however, due to heterogeneity in bioeroding communities (e.g., chemical vs. mechanical, internal vs. external, micro- vs. macrobioeroders), as well as differences in environmental factors (e.g., hydrodynamics, temperature, etc.) and analytical approaches (e.g., SEM, grazing scars). For example, comparing bioerosion rates from carbonate blocks may not be an appropriate comparison given different bioeroding communities of dead versus alive substrate (e.g., (Hutchings, 1986; Sammarco *et al.*, 1987). In order to reduce uncertainty that could be an artifact from different field and/or analytical approach, rates derived by the same techniques as reported here were compared. Bioerosion rates from 15 sites across the tropical Pacific range from 0 to 68 mg $cm^{-2}$ $yr^{-1}$ (Table S2), with bioerosion rates at Kahekili up to 30 mg $cm^{-2}$ $yr^{-1}$ higher than measured elsewhere in the basin. Elevated bioerosion rates at Kahekili are consistent with findings from Sylbiger *et al.* (2017) that reported the highest average bioerosion rate and lowest net accretion rate across the Hawaiian Archipelago at the Kahekili study site. In comparison to measured bioerosion rates, we calculated predicted bioerosion rates using the equation from DeCarlo *et al.* (2015) where bioerosion rate = -11.96 * $\Omega_{arag}$ + 43.52. Based on this computation, greater-than-predicted bioerosion rates for an oligotrophic setting in the Pacific were measured at Kahekili (Fig. 3). In other words, measured coral bioerosion rates at Kahekili are up to 8 times greater than expected for corals growing away from land-based sources of pollution (DeCarlo *et al.*, 2015) (Table 2).

Although our study did not quantify bioerosion rates by microborers *per se*, chemical bioerosion by microborers will contribute to net bioerosion rates by weakening of coral skeleton (Tribollet *et al.*, 2009) as well as by grazing from by fish and echinoids (Perry *et al.*, 2014). Given the elevated nutrient concentrations at Kahekili, the data appear to indicate that eutrophication is driving elevated bioerosion rates at Kahekili. This finding is consistent with previous work showing increased bioeroding communities with increased nutrient concentrations and declining water quality (e.g., (Edinger *et al.*, 2000; Holmes *et al.*, 2000; Carreiro-Silva *et al.*, 2005, 2009). At Kahekili, large-scale ephemeral blooms of green alga (Smith *et al.*, 2005) can act to stimulate bioeroders, with both filter feeders and photoautotrophs capitalizing on nutrients in both the dissolved and particulate form. Microbioeroders can therefore interact with different bioeroding communities and contribute to the bioerosion loop (Schönberg, 2017). It is also important to point out the succession dynamics of bioeroders on marine carbonate budgets, whereby one taxon group prepares the substrate for the next bioeroder community (e.g., Hutchings 1986, 2011; Kiene and Hutchings, 1994; Scott 1988), including providing crevices for the intrusion of bivalves (e.g., Morton and Scott, 1980; Morton 1983). In addition, endolithic algae play an important role in erosive and early digenetic process (e.g., Kobluk and Risk, 1977; Kobluk and James, 1979). Vulnerability to physical erosion is further enhanced by bioerosion whereby the coral colony's ability to withstand wave shock and storm waves is reduced (e.g., Hein and Risk, 1975; Tunnicliffe 1979; 1981; Highsmith et al., 1980; Scott and Risk 1988). The degree of degradation and coral mortality has been linked to turf algal competition, with the "dead zone" characterized by clustered patches of variable degrees of degradation along the length of the reef at Kahekili Beach Park (Ross *et al.*, 2012). Increased mortality will therefore further facilitate bioerosion by increasing exposed carbonate structure on the corals. The decrease in abundance of reef grazing herbivores at Kahekili (Williams *et al.*, 2016) may also be a contributing factor to the establishment of certain bioeroders (Paddack *et al.*, 2006).

Elevated coral $\delta^{15}N$ values indicate not only eutrophication, but also a sewage nitrogen source enriched in $^{15}N$ (Heaton, 1986). Input of such an effluent to Maui's coral reef ecosystem has been documented by elevated algae $\delta^{15}N$ values, with the highest algae $\delta^{15}N$ values found adjacent to the

LWRF, yielding values of up to 43.3 ± 0.08‰, indicative of wastewater effluent (Dailer *et al.*, 2010). Those results are consistent with seawater $\delta^{15}$N-nitrate values measured near the seep that were typically greater than 65‰ (Fig. 2a). The elevated coral and nitrate $\delta^{15}$N ratios are therefore a function of both denitrification processes within the SGD pathway and an elevated $\delta^{15}$N signature of the effluent source (Kendall, 1998; Fackrell *et al.*, 2016). The LWRF processes approximately 12.8 million L $d^{-1}$ of wastewater effluent with estimated nitrogen loading of 79-97 kg $d^{-1}$ (Glenn *et al.*, 2013). Based on SGD rates derived for the primary vent site (Swarzenski *et al.*, 2016) and nitrate concentrations measured directly from the discharging seep water (Table S1), the freshened seep water is estimated to deliver approximately 714 mol $d^{-1}$ nitrate. Although seawater above the seep is an admixture of SGD and ambient seawater, exposure of nutrient-laden/low pH freshwater occurred approximately 8 hr $d^{-1}$, during the semidiurnal low tides when salinity values typically dropped below 10 and maximum SGD rates were observed (Glenn *et al.*, 2013). To exacerbate the exposure to contaminated nutrient-enriched effluent, the direction of maximum flow during the transition from high to low tide were dominantly offshore (Swarzenski *et al.*, 2016), transporting nutrient-rich water from the nearshore seeps towards the reef.

The elevated coral $\delta^{15}$N values not only indicate that coral $\delta^{15}$N appears to be a reliable tracer of nutrient loading and nitrate assimilation, but also further demonstrates a link between exposure to elevated nutrient levels and coral health given the observed increased bioerosion rates and decreased calcification rates at sites closest to the primary seep. In comparison, coral bioerosion rates and $\delta^{15}$N values were lower at sites away from the primary seep, consistent with a decrease in nitrate flux (245 mol $dy^{-1}$) 85 m offshore from the primary seep site where measured SGD rates decreased to 30 cm $d^{-1}$ (Swarzenski *et al.*, 2016). Enhanced nutrient loading from greater SGD nitrate fluxes can therefore increase abundance of bioeroding communities (Edinger *et al.*, 2000; Holmes *et al.*, 2000; Carreiro-Silva *et al.*, 2005, 2009). Teasing apart the different stressors from SGD is difficult given that pH, nutrients, TA, and DIC covary with salinity. Any stressor that reduces live tissue coverage can ultimately increase bioerosion rates due to increased area of exposed substrate. At a salinity greater than 33, however, the relation between pH and salinity seems to break down, whereas TA, DIC, and nutrients continue to covary with salinity (Fig. S2), indicating that these stressors may have greater potential to impact corals growing away from the vent. Mesocosm experiments that can manipulate these individual stressors in a controlled environment (Wiedenmann *et al.*, 2013) therefore represent important complimentary studies to the field-based results presented here.

**5. Conclusion**

Based on observations from this site off west Maui, land-based sources of pollution, in synergy with changing ocean conditions on a global scale, interact to deleteriously influence coral reef health in the nearshore environment. Our results confirm how valuable nearshore coral reef ecosystems – the cornerstone of Hawaiian tourism, shoreline protection, and local fisheries – are affected by land-based sources of pollution that are also magnified by effects of coastal acidification. The range of exposure of reefs living in the vicinity of the SGD vents at Kahekili are comparable to end of century $pCO_2$ projections (Fabricius *et al.*, 2011) (Fig. 2c). With the largest decrease in Ω projected for the tropics (Gattuso *et al.*, 2015), coral reefs are extremely vulnerable to $CO_2$-related threats given the synergistic drivers responsible for present day coral degradation. Bioerosion rates at our study site, however, are much greater than predicted for an oligotrophic setting, suggesting that eutrophication exacerbates ocean acidification and bioerosion of corals, causing coral reef collapse much sooner in the future than currently predicted (van Hooidonk *et al.*, 2014). With many of Maui's coral reefs in significant decline (Rodgers *et al.*, 2015; Yates *et al.*, 2017) and recent coral bleaching events leading to increased coral mortality (Sparks *et al.*, 2016), reducing any stressors at a local scale – especially ones that can be readily attenuated with proactive resource management of nutrients – is imperative to sustaining future coral reef ecosystems and planning for resiliency.

## Figures

**Figure 1** Location map of the island of Maui, Hawaii, USA, and the study area at Kahekili along west Maui. Bathymetric map (5-m contours) of study area showing coral coring locations and seawater sampling sites (blue triangles) along Kahekili, primary seep site (red circle), superimposed on distribution of percent coral cover versus sand. Computerized tomography (CT) images and respective photographs of coral cores collected at the primary seep site and north of the primary seep site, approximately 780 m north of the primary seep cluster at Kahekili.

**Figure 2** Results of time-series of seawater chemistry variables over a 6-d period collected from bottom water near the seep site on the nearshore reef (20°56.31660', -156°41.59080') every 4 hr. (a) Dissolved nutrient (nitrate+nitrite, phosphate, and silicate) concentrations (μmol $L^{-1}$), and nitrate stable nitrogen isotopes ($\delta^{15}$N-nitrate; ‰); (b) temperature corrected pH (total scale); and (c) calculated carbonate parameters for aragonite saturation state ($\Omega_{arag}$) and $pCO_2$ (μatm; inverted) based on TA-pH pairwise and measured salinity, temperature, nutrients (phosphate and silicate) data. End-of-century projections according to the "business as usual" RCP8.5 scenario for pH (reduction by 0.4 units), $\Omega_{arag}$ (2.0), and $pCO_2$ (750 μatm) (Fabricius *et al.*, 2011).

**Figure 3** Relationship between aragonite saturation state ($\Omega_{arag}\pm1\sigma$; inverted axis) measured in March 2016 and coral bioerosion (mg $cm^{-2}$ $yr^{-1}$) from west Maui exposed to anthropogenic nutrient loading (black circles), naturally high- (open circles) and low-nutrient (grey diamonds) reefs across the Pacific Basin (Barkley *et al.*, 2015; DeCarlo *et al.*, 2015). The predicted bioerosion rate for Maui (black cross) was calculated using the equation bioerosion rate = -11.96* $\Omega_{arag}$ + 43.52 (DeCarlo *et al.*, 2015) and a calculated Ω value of 3.06 based on offshore sampling site (~70 m), south of the seep (~150 m) site with nitrate concentrations <0.20 μmol $L^{-1}$.

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**Additional Information**

**Supplementary information** accompanies this paper.

**Competing financial information:** The authors declare no competing financial interests.

| Coral ID | Core Length (cm) | Water Depth (m) | Lat | Long | Lifespan | Tissue thickness (mm) | Distance offshore (m) | Distance from seep (m) | Direction from seep (°) |
|---|---|---|---|---|---|---|---|---|---|
| LobataHead01 | 50 | <2 | 20° 56.317'N | 156° 41.598'W | 1970-2013 | 5.13 | 38 | 15 | 264 |
| LobataHead02 | 18 | <2 | 20° 56.320'N | 156° 41.605'W | 1992-2013 | 5.63 | 52 | 29 | 279 |
| LobataHead03 | 19 | <2 | 20° 56.324'N | 156° 41.594'W | 1987-2013 | 4.63 | 33 | 15 | 324 |
| LobataHead04 | 21 | <2 | 20° 56.326'N | 156° 41.587'W | 1983-2013 | 4.00 | 20 | 16 | 16 |
| LobataHead05 | 28 | <2 | 20° 56.708'N | 156° 41.590'W | 1984-2013 | 4.63 | 58 | 783 | 0 |
| LobataHead06 | 22 | <1 | 20° 56.318'N | 156° 41.589'W | 1978-2008[1] | n/a | 23 | *at seep* | *at seep* |
| LobataHead07 | 50 | 3 | 20° 56.236'N | 156° 41.611'W | n/a | 5.13 | 68 | 156 | 194 |

1 - Age of death determined by bomb-derived $^{14}C$ value

**Table 1** Location and physical characteristics of coral coring locations off Kahekili Beach Park collected in July 2013 from *Porites lobata*.

| Coral Head | Growth Rate | Density | Calcification | Volume Bioerosion | Bioerosion Rate | Predicted bioerosion Rate | $\delta^{15}N$ | $\Omega_{arag}$ | pH | Salinity | Nitrate |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LobataHead01 (n=24 yrs) | 1.17±0.26 | 1.04 | 1.10 | 6.57 | 72.32 | n/a | 11.29 ± 1.76 (n=9) | n/a | n/a | n/a | n/a |
| LobataHead02 (n=21 yrs) | 0.88±0.06 | 1.08 | 0.94 | 5.94 | 56.03 | 7.04 | 8.44 ± 0.12 (n=12) | 3.05±0.10 | 8.00±0.02 | 35.19±0.87 | 0.16±0.10 |
| LobataHead03 (n=26 yrs) | 0.72±0.10 | 0.99 | 0.71 | 12.48 | 89.07 | n/a | 10.87 ± 0.45 (n=9) | n/a | n/a | n/a | n/a |
| LobataHead04 (n=20 yrs) | 0.72±0.16 | 1.01 | 0.67 | 5.92 | 39.87 | 7.04 | 14.62 ± 0.23 (n=9) | 3.05±0.17 | 8.01±0.03 | 34.98±0.99 | 0.41±0.18 |
| LobataHead05 (n=13 yrs) | 0.95±0.11 | 1.15 | 1.02 | 2.20 | 22.58 | 6.92 | 7.50 ± 0.19 (n=9) | 3.06±0.11 | 8.01±0.02 | 35.36±1.10 | 0.19±0.11 |
| LobataHead06 (n=10 yrs) | 0.69±0.10 | 1.07 | 0.68 | 14.63 | 99.15 | 16.37 | 17.08 ± 0.40 (n=3) | 2.27±0.81 | 7.85±0.17 | 28.57±7.79 | 20.35±23.32 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LobataHead07 | n/a | n/a | n/a | n/a | n/a | n/a | 8.17 ± 0.19 (n=6) | n/a | n/a | n/a | n/a |

**Table 2** Coral growth parameters quantified by computerized tomography (CT) for growth rate (±SD; (cm $yr^{-1}$), density (g $cm^{-3}$), and calcification rates (g $cm^{-2}$ $yr^{-1}$), percent volume erosion (%), measured bioerosion rate (mg $cm^{-2}$ $yr^{-1}$), predicted bioerosion rate (mg $cm^{-2}$ $yr^{-1}$) based on (DeCarlo *et al.*, 2015); bioerosion rate = -11.96* $\Omega_{arag}$ + 43.52), and average (±STD) coral tissue nitrogen isotope ($\delta^{15}N$; (‰) values. LobataHead07 was not analyzed for growth parameters prior to subsectioning for geochemical analysis. Seawater chemistry parameters ($\Omega_{arag,}$ temperature corrected-pH, salinity, and nitrate (μmol $L^{-1}$) are reported as average (±SD; $n$ = 37) based on 6-d sampling period in March 2016.

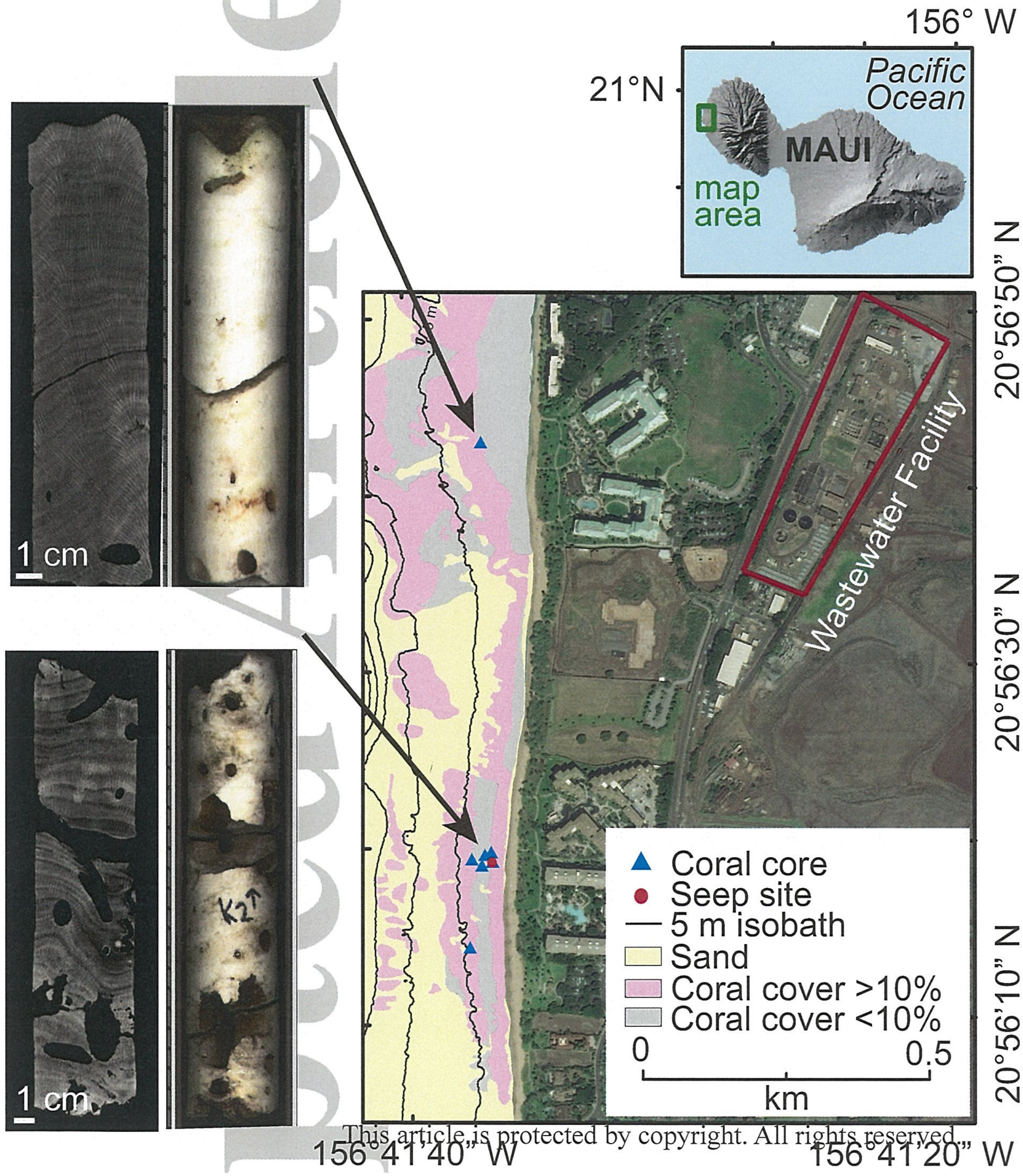
| | Coral Tissue $\delta^{15}N$ | Growth Rate | Density | % Volume bioerosion | Calcification | Bioerosion rate | Lifespan | Distance from shore | Distance from seep | $\Omega_{arag,}$ | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Growth Rate | **-0.53** | | | | | | | | | | |
| Overall density | **-0.45** | **0.33** | | | | | | | | | |
| Bioerosion % volume | ***0.68*** | **-0.57** | **-0.51** | | | | | | | | |
| Average Calcification | ***-0.70*** | 0.95 | **0.54** | ***-0.66*** | | | | | | | |
| Bioerosion Rate | **0.55** | **-0.27** | **-0.51** | 0.94 | **-0.39** | | | | | | |
| Lifespan | **0.29** | ***0.60*** | **-0.09** | **0.02** | **0.38** | **0.20** | | | | | |
| Distance from shore | -0.88 | **0.49** | 0.81 | ***-0.68*** | 0.72 | ***-0.61*** | **-0.22** | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Distance from seep | ***-0.58*** | **0.26** | 0.80 | ***-0.62*** | **0.44** | ***-0.69*** | **-0.08** | 0.83 | | | |
| $\Omega_{arag,}$ | **-0.66** | **0.64** | **0.05** | -0.95 | **0.57** | -0.91 | **-0.55** | **0.53** | **0.37** | | |
| pH | **-0.72** | **0.62** | **0.05** | -0.95 | **0.54** | -0.93 | **-0.50** | **0.50** | **0.39** | 0.99 | |
| Nitrate | **0.74** | **-0.64** | **-0.05** | 0.94 | **-0.57** | 0.91 | **0.56** | **-0.53** | **0.36** | 0.99 | 0.99 |

**Table 3** Pearson-product correlation coefficients (r; bold p≤0.05; italics p≤0.10) between average coral reef growth parameters (growth rate, density, %volume bioerosion, calcification, and lifespan), location (distance from shore and primary seep site), average coral $\delta^{15}$N-nutrient loading proxy, and average seawater variables ($\Omega_{arag,,}$ pH, and nitrate).

Figure 1.

Figure 1



156° W
21°N
Pacific
Ocean
MAUI
map
area
20°56'50" N
20°56'30" N
20°56'10" N
Wastewater Facility
Coral core
Seep site
5 m isobath
Sand
Coral cover >10%
Coral cover <10%
0
0.5
km
1 cm
1 cm
K2↑
156°41'40" W
156°41'20" W

**Figure 2.**

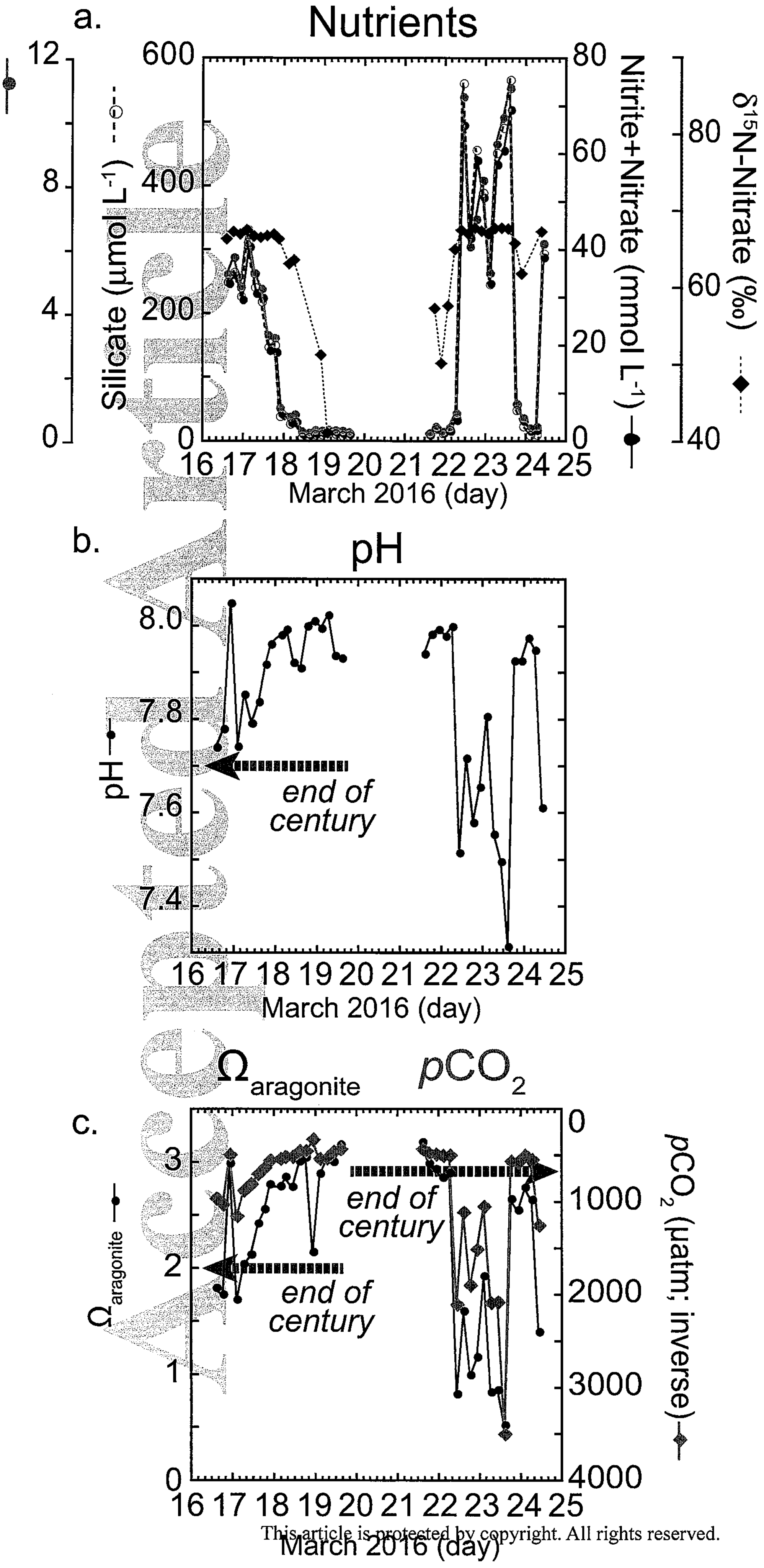
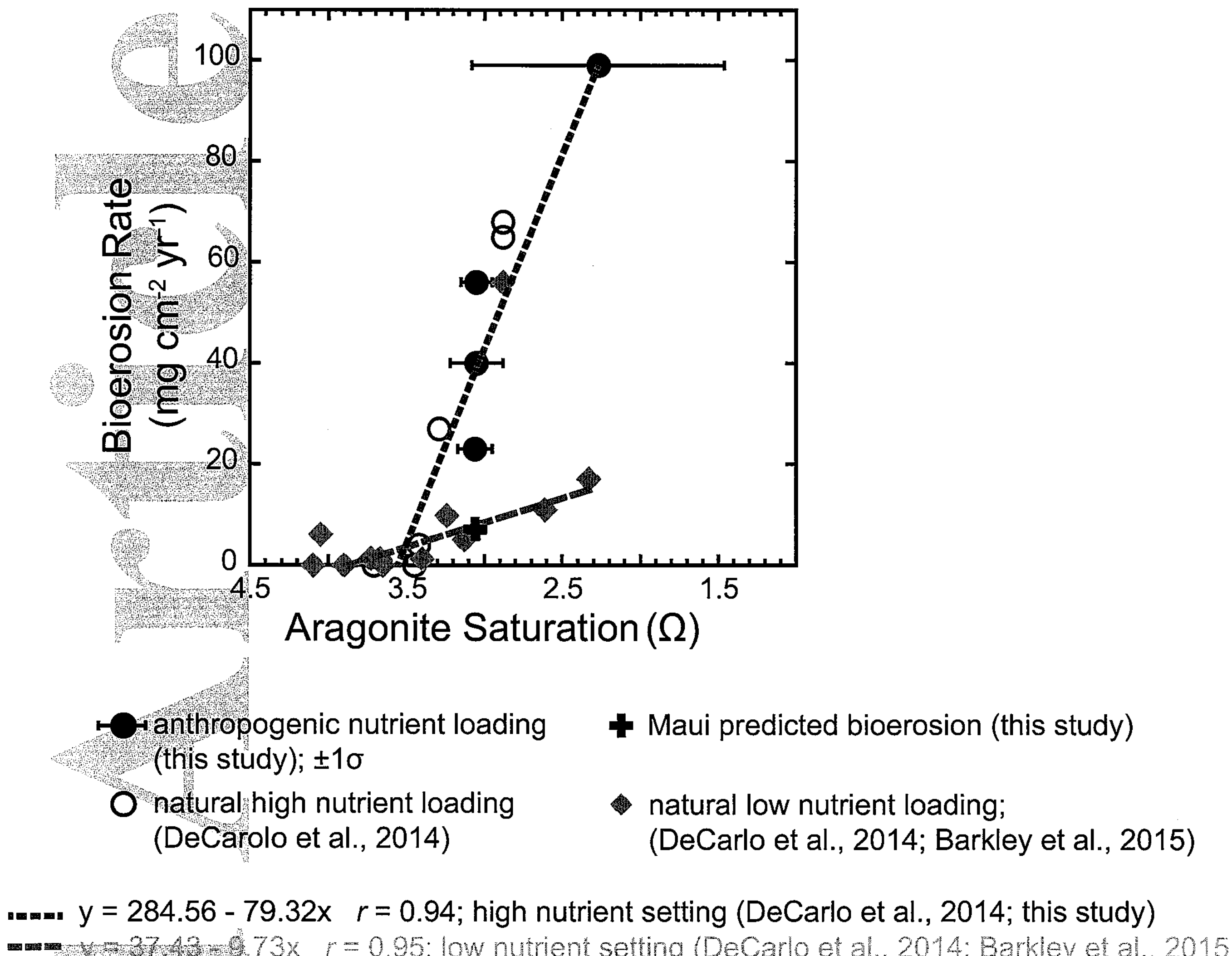

a.
Nutrients
Silicate (µmol L-1)
Nitrite+Nitrate (mmol L-1)
δ15N-Nitrate (‰)
March 2016 (day)
b.
pH
end of century
March 2016 (day)
c.
Ωaragonite
pCO2
end of century
end of century
pCO2 (µatm; inverse)
March 2016 (day)

**Figure 3.**

Figure 3



Bioerosion Rate (mg cm$^{-2}$ yr$^{-1}$)
100
80
60
40
20
0
4.5
3.5
2.5
1.5
Aragonite Saturation (Ω)
anthropogenic nutrient loading (this study); ±1σ
natural high nutrient loading (DeCarolo et al., 2014)
Maui predicted bioerosion (this study)
natural low nutrient loading; (DeCarlo et al., 2014; Barkley et al., 2015)
y = 284.56 - 79.32x r = 0.94; high nutrient setting (DeCarlo et al., 2014; this study)
y = 37.43 - 9.73x r = 0.95; low nutrient setting (DeCarlo et al., 2014; Barkley et al., 2015)