14/1301

ATC MAKENA HOLDINGS, LLC
c/o Trinity Investments, LLC
55 Merchant Street, Suite 1560
Honolulu, HI 96813

RECEIVED
2014 MAR 18 A 11: 44
COUNTY OF MAUI
DEPT. OF PLANNING
ADMINISTRATION

TRANSMITTAL

March 13, 2014

Department of Planning
County of Maui
250 South High Street
Wailuku, Hawaii 96793

RECEIVED
MAR 12 2014
STATE OF HAWAII
LAND USE COMMISSION

SUBJECT: Sixteenth Annual Report for Land Use Commission Docket No. A97-721 (Makena Resort)

Via: USPS Mail

Dear Will Spence, Director:

Please find the following enclosed:

1 (one) Original	Sixteenth Annual Report for Land Use Commission Docket No. A97-721 (Makena Resort)

In compliance of Condition No. 19, the enclosed Annual Report is provided for your review. Condition No. 19 states

> *"Petitioner shall timely provide without any prior notice, annual reports to the Commission, the Office of Planning, and the County of Maui Planning Department in connection with the status of the subject project and Petitioner's progress in complying with the conditions imposed herein. The annual report shall be submitted in a form prescribed by the Executive Officer of the Commission."*

Should you have any questions or require additional information, do not hesitate to contact me at sarah@stanfordcarr.com or on by phone at (808)547-2276.

Sincerely,

Sarah Agnew-Miller

Sarah Agnew-Miller
Project Coordinator/Planner

ATC MAKENA HOLDINGS, LLC
c/o Trinity Investments, LLC
55 Merchant Street, Suite 1560
Honolulu, HI 96813

TRANSMITTAL

March 13, 2014

LAND USE COMMISSION
STATE OF HAWAII
2014 MAR 13 P 3:26

Land Use Commission
State of Hawaii
235 South Beretania Street, Suite 406
P. O. Box 2359
Honolulu, Hawaii 96804

SUBJECT: Sixteenth Annual Report for Land Use Commission Docket No. A97-721 (Makena Resort)

Via: Hand Delivery

Dear Chair and Members of the Commission:

Please find the following enclosed:

1 (one) Original	Sixteenth Annual Report for Land Use Commission Docket No. A97-721 (Makena Resort)

In compliance of Condition No. 19, the enclosed Annual Report is provided for your review. Condition No. 19 states

> *"Petitioner shall timely provide without any prior notice, annual reports to the Commission, the Office of Planning, and the County of Maui Planning Department in connection with the status of the subject project and Petitioner's progress in complying with the conditions imposed herein. The annual report shall be submitted in a form prescribed by the Executive Officer of the Commission."*

Should you have any questions or require additional information, do not hesitate to contact me at sarah@stanfordcarr.com or on by phone at (808)547-2276.

Sincerely,

Sarah Agnew-Miller

Sarah Agnew-Miller
Project Management and Planning

ATC MAKENA HOLDINGS, LLC
c/o Trinity Investments, LLC
55 Merchant Street, Suite 1560
Honolulu, HI 96813

TRANSMITTAL

March 13, 2014

Department of Planning
County of Maui
250 South High Street
Wailuku, Hawaii 96793

SUBJECT: Sixteenth Annual Report for Land Use Commission Docket No. A97-721 (Makena Resort)

Via: USPS Mail

Dear Will Spence, Director:

Please find the following enclosed:

1 (one) Original	Sixteenth Annual Report for Land Use Commission Docket No. A97-721 (Makena Resort)

In compliance of Condition No. 19, the enclosed Annual Report is provided for your review. Condition No. 19 states

> *"Petitioner shall timely provide without any prior notice, annual reports to the Commission, the Office of Planning, and the County of Maui Planning Department in connection with the status of the subject project and Petitioner's progress in complying with the conditions imposed herein. The annual report shall be submitted in a form prescribed by the Executive Officer of the Commission."*

Should you have any questions or require additional information, do not hesitate to contact me at sarah@stanfordcarr.com or on by phone at (808)547-2276.

Sincerely,

Sarah Agnew-Miller

Sarah Agnew-Miller
Project Coordinator/Planner

ATC MAKENA HOLDINGS, LLC
c/o Trinity Investments, LLC
55 Merchant Street, Suite 1560
Honolulu, HI 96813

March 7, 2014

Land Use Commission
State of Hawaii
235 South Beretania Street, Suite 406
P. O. Box 2359
Honolulu, Hawaii 96804

SUBJECT: Sixteenth Annual Report for Land Use Commission Docket No. A97-721 (Makena Resort)

Dear Chair and Members of the Commission:

On behalf of the ATC Makena Entities (identified below), we hereby submit this Sixteenth Annual Report for Docket No. A97-72.

I. INTRODUCTION

On February 19, 1998, the Land Use Commission of the State of Hawaii (the "**Commission**") filed its "Findings of Fact, Conclusions of Law and Decision and Order" (the "**1998 D&O**"), which reclassified 145.943 acres of land in Makena, Maui, Hawaii from the State Land Use Agricultural District into the State Land Use Urban District (hereinafter, the "**LUC Reclassified Property**").

The LUC Reclassified Property is currently owned by multiple owners, including Keaka LLC, ATC Makena N Golf LLC, ATC Makena S Golf LLC, ATC Makena Land SF1 LLC, ATC Makena Land MF1 LLC, ATC Makena Land MF2 LLC, ATC Makena Land MF3 LLC, ATC Makena Land C1 LLC, ATC Makena Land U1 LLC, ATC Makena Land B1 LLC, ATC Makena Land MF4 LLC, ATC Makena Land SF2 LLC, and ATC Makena Land AH1 LLC. All of the ATC entities listed above are Delaware limited liability companies and are hereinafter collectively referred to as the "ATC Makena Entities." The ATC Makena Entities purchased portions of the LUC Reclassified Property through a foreclosure action on August 27, 2010.

This Sixteenth Annual Report covers those portions of the LUC Reclassified Property that is owned by the ATC Makena Entities, identified by the following Tax Map Key Nos. 2-1-005: por. 90, 2-1-007: por. 108 and 2-1-005: por. 86 (formerly TMK 2-1-007:004), and does not address any properties owned by others, including those owned by Hawaii Development, LLC, e.g., the parcels identified by the following Tax Map Key Nos. 2-1-05:83, 84, and 85.

On August 27, 2012, the Commission filed an Order Granting With Modification Movant's Motion for Sixth Amendment to the Findings of Fact, Conclusions of Law, and Decision and Order, Filed on February 19, 1998, and for Release of Certain Conditions (the "2012 Amendment"). Pursuant to the 2012 Amendment, the Commission released the ATC Makena Entities from Conditions 4, 15 and 21, and amended Conditions 12 and 22, as further described herein. The 1998 Decision & Order was Amended and Restated on September 7, 2012 and filed with the Bureau of Conveyances (Doc. A-46330782).

III. STATUS OF COMPLIANCE WITH LUC CONDITIONS

The following are the conditions set forth in the **1998 D&O, as amended by the 2012 Amendment,** and a description of efforts that are being made to comply with each stated condition:

1. Petitioner shall provide affordable housing opportunities for low, low-moderate, and gap group income residents of the State of Hawai`i in accordance with applicable laws, rules, and regulations of the County of Maui. The location and distribution of the affordable housing or other provisions for affordable housing shall be under such terms as may be mutually agreeable between Petitioner and the County of Maui.

   Response: ATC Makena Entities acknowledge that the Petitioner is subject to the provisions of said condition.

2. Petitioner shall coordinate with the County of Maui Board of Water Supply to incorporate the proposed project into the County Water Use and Development Plan for the area. Prior to the granting of the first discretionary permit for the single-family and multi-family residential development described in paragraph 20 of the Decision and Order or the hotel described in paragraph 21 of the Decision and Order and by or before one year from the issuance date of this Decision and Order, Petitioner shall furnish the Commission with a letter from the County of Maui Board of Water Supply confirming that (a) the potable water allocation that will be credited to Petitioner will be available to and sufficient for the proposed project as it is described in the Petition, (b) the availability of potable water will not be an obstacle or impediment to the development of the proposed project as described in the Petition and (c) the proposed project as it is described in the Petition has been incorporated into the County Water Use and Development Plan for the area and that this plan will prevent the continued overpumping of the sustainable yield of the Iao aquifer.

Response: As provided in Petitioner's Second Annual Report, this condition was complied with as set forth in a letter from David Craddick, Director of the Department of Water Supply, County of Maui, dated February 18, 1999.

Additional letters regarding compliance with this condition, dated October 1, 2003 from Petitioner to the Department of Water Supply and the response from George Tengan, Director of Water Supply, dated October 7, 2003, were attached as Exhibit "A" and Exhibit "B" to the Sixth Annual Report.

ATC Makena Entities understand that this condition has been complied with.

3. Petitioner shall participate in the funding and construction of adequate water source, storage, and transmission facilities and improvements to accommodate the proposed project in accordance with the applicable laws, rules and regulations of the County of Maui, and consistent with the County of Maui water use and development plan.

Response: The ATC Makena Entities acknowledge this condition. Furthermore, the ATC Makena Entities understand that, in 1976, the Petitioner participated in the Central Maui Source Development Joint Venture and also the Central Maui Transmission Joint Venture, which developed water sources in Waiehu, Maui and a transmission line from the newly developed water sources down to the Wailea and Makena regions. Further, in 1985, Makena Resort constructed a 1.5 million gallon water storage tank at the Makena Resort.

4. Petitioner shall contribute to the development, funding, and/or construction of school facilities, on a pro rata basis for the residential developments in the proposed project, as determined by and to the satisfaction of the State Department of Education ("DOE"). Terms of the contribution shall be agreed upon by Petitioner and DOE prior to Petitioner acquiring county rezoning or prior to Petitioner applying for building permits if county zoning is not required.

Response: ATC Makena Entities understand that this condition has been complied with. Pursuant to an Educational Contribution Agreement for Makena Resort between Petitioner and the

Department of Education (DOE), dated August 17, 2000, the parties have agreed upon a cash contribution by Petitioner which shall represent a fair share payment for the development, funding and/or construction of school facilities by Petitioner

5. Petitioner shall participate in the pro rata funding and construction of adequate civil defense measures as determined by the State of Hawai`i and County of Maui civil defense agencies.

Response:

ATC Makena Entities has agreed to the two (2) locations for emergency sirens at the Makena Resort Wastewater Treatment Plant and near Big Beach consistent with the representations in the 2010 Annual Report. Final Right-Of-Entry and Non-Exclusive License Agreements dated May 25, 2012 have been fully executed between ATC Makena and the State of Hawaii, Department of Defense (DOD) was submitted with the Fifteenth Annual Report.

ATC Makena Entities has complied with the provisions of this condition. It is anticipated that the sirens will be installed by the State of Hawaii in 2014.

6. Should any human burials or any historic sites such as artifacts, charcoal deposits, stone platforms, pavings, or walls be found, Petitioner shall stop work in the immediate vicinity and contact SHPD. The significance of these finds shall then be determined and approved by SHPD, and an acceptable mitigation plan shall be approved by SHPD. SHPD must verify that the fieldwork portion of the mitigation plan has been successfully executed prior to work proceeding in the immediate vicinity of the find. Burials must be treated under specific provisions of Chapter 6E, Hawai`i Revised Statutes.

Response: ATC Makena Entities acknowledge that they are subject to provisions of said condition and will comply.

7. Petitioner shall follow the State DLNR recommendations for Petition Areas 1, 2 and 3, for archaeological data recovery and preservation. An archaeological data recovery plan (scope of work) must be approved by SHPD. That plan then must be successfully executed (to be verified in writing by the SHPD), prior to any grading, clearing, grubbing or other land alteration in these areas. In Petition Area 1, three significant historic sites (1969, 2563, 2569) are committed to preservation. A preservation plan must be approved by SHPD. This plan, or minimally its interim protection plan

phase, must be successfully executed (to be verified in writing by the SHPD), prior to any grading, clearing, grubbing or other land alteration in these areas.

Response: ATC Makena Entities acknowledge that they are subject to provisions of said condition and will comply.

8. Petitioner shall implement efficient soil erosion and dust control measures during and after the development process to the satisfaction of the State Department of Health and County of Maui.

Response: ATC Makena Entities acknowledge that they are subject to provisions of said condition and will comply at the appropriate time prior to commencement of construction.

9. Petitioner shall initiate and fund a nearshore water quality monitoring program. The monitoring program shall be approved by the State Department of Health in consultation with the U.S. Fish and Wildlife Service, the National Marine Fisheries Services, and the State Division of Aquatic Resources, DLNR. Petitioner shall coordinate this consultation process with the concurrence of the State Department of Health. Mitigation measures shall be implemented by Petitioner if the results of the monitoring program warrant them. Mitigation measures shall be approved by the State Department of Health in consultation with the above mentioned agencies.

Response: ATC Makena Entities understand that since August 1995, Petitioner (under prior ownership) has implemented and funded a nearshore water quality monitoring program. This program initially collected base line water samples and analyzed the same to determine turbidity, chemical compound contents and biota sampling. This monitoring program continues with semi-annual sampling at four separate nearshore sites.

ATC Makena Entities is providing the two most recent reports along with copies of their transmittals to State of Hawaii Department of Health: a.) dated August, 2013 for work conducted in May 2013 **See Exhibit "A"**, and b.) February 28, 2014for work conducted in January 2014**See Exhibit "B"**. ATC Makena Entities has contracted for this work with Marine Research Consultants, Inc.

ATC Makena Entities acknowledge that they are subject to provisions of said condition and will comply with said provisions.

10. Petitioner shall submit a Traffic Impact Analysis Report (TIAR) for review and approval by the State Department of Transportation and the County of Maui.

Response: As set forth in the Second Annual Report, a TIAR was prepared and submitted for review by the State Department of Transportation (DOT) and the County of Maui as part of the change in zoning application. Following certain comments by DOT, revisions were made to the TIAR which DOT agreed with as set forth in a letter from Kazu Hayashida, Director of Transportation, dated May 2, 2000, a copy of which was attached to the Third Annual Report.

In addition, as set forth in prior Annual Reports, the Petitioner prepared and submitted a Makena Resort Master Traffic Study, dated June 6, 2003 (Revised September 14, 2003), which was submitted to the SDOT and County of Maui, and approved by the County on September 26, 2003. *See* Sixth Annual Report.

ATC Makena Entities understand that this condition has been complied with.

11. (as amended) Petitioner shall participate in the pro rata funding and construction of local and regional transportation improvements and programs including dedication of rights-of-way as determined by the State Department of Transportation ("DOT") and the County of Maui. Agreement between Petitioner and DOT as to the level of funding and participation shall be obtained within fourteen (14) years from June 1, 2000.

Response: ATC Makena Entities acknowledge that they are subject to provisions of said condition.

ATC Makena Entities met with DOT on March 4, 2011, December 21, 2011, February 1, 2012, and May 8, 2012, regarding its participation in the design and construction of the four-lane widening of Piilani highway from Kilohana Drive to Wailea Ike Drive in order to satisfy Condition 12. ATC Makena Entities are presently formalizing an agreement with DOT that will satisfy Condition 12.

12. Petitioner shall fund the design and construction of drainage improvements required as a result of the development of the Property to the satisfaction of the appropriate State of Hawai`i and County of Maui agencies.

    Response: ATC Makena Entities acknowledge that they are subject to provisions of said condition.

    As reported in the Fifth Annual Report the Petitioner prepared a Drainage Master Plan, which was submitted to the County Department of Public Works and Environmental Management and Planning Department on July 1, 2003, and approved by the County on August 20, 2003.

13. The Petition Areas will be developed in accordance with the Kihei-Makena Community Plan.

    Response: ATC Makena Entities acknowledge that development of the Petition Areas is to be in accordance with the Kihei-Makena Community Plan.

14. Petitioner shall fund, design and construct all necessary traffic improvements necessitated by development of the Petition Areas as required by the State Department of Transportation and the County of Maui Department of Public Works and Waste Management.

    Response: ATC Makena Entities acknowledge that it is subject to the provisions of this said condition.

15. Petitioner shall develop the Property in substantial compliance with the representations made to the Commission. Failure to so develop the Property may result in a reversion of the Property to its former classification, a change to a more appropriate classification, or other reasonable remedy as determined by the Commission.

    Response: ATC Makena Entities acknowledges that it is subject to the provisions of this said condition.

16. Petitioner shall give notice to the Commission of any intent to sell, lease, assign, place in trust, or otherwise voluntarily alter the ownership interests in the Property, prior to development of the Property.

    Response: ATC Makena Entities acknowledges that it is subject to the provisions of this said condition.

17. Petitioner shall timely provide without any prior notice, annual reports to the Commission, the Office of Planning, and the County of Maui Planning Department in connection with the status of the subject project and Petitioner's progress in complying with the conditions imposed herein. The annual report shall be submitted in a form prescribed by the Executive Officer of the Commission.

    Response: The submittal of this Sixteenth Annual Report by ATC Makena Entities is in compliance with this condition.

18. The commission may fully or partially release or amend the conditions provided herein as to all or any portion of the petition area upon timely motion and upon the provision of adequate assurance of satisfaction of these conditions by Petitioner.

    Response: ATC Makena Entities acknowledges that it is subject to the provisions of this said condition.

19. (as amended) Petitioner shall record the conditions imposed herein by the Commission and every amendment thereto with the Bureau of Conveyances pursuant to Section 15-15-92, Hawai`i Administrative Rules.

    Response: ATC Makena Entities acknowledges that it is subject to the provisions of this said condition.

    ATC Makena Entities recorded in said Bureau that certain Amended and Restated Declaration of Conditions Applicable To An Amendment to District Boundary From Agricultural to Urban on September 7, 2012, as Document Number A-46330782, a copy of which was included with the Fifteenth Annual Report.

If you have any questions or require any further information, please contact Richard Riegels at (808)547-2239 or rbr@stanfordcarr.com.

Sincerely,	Sincerely,
Sean Hehir	Stanford S. Carr
Authorized Signor	Authorized Signor
ATC Makena Entities	ATC Makena Entities

SH:bbc

cc: State of Hawaii, Office of Planning
County of Maui, Department of Planning
Munekiyo & Hiraga, Inc.

Encl. **Exhibit "A"** Marine Monitoring Report with transmittal to State of Hawaii Department of Health dated August 2013, for work conducted in May 2013.
Exhibit "B" Marine Monitoring Report with transmittal to State of Hawaii Department of Health dated February 28, 2014, for work conducted in January 2041.

Exhibit A

ATC MAKENA HOLDINGS, LLC
c/o Stanford Carr Development, LLC
1100 Alakea St. 27th Floor
Honolulu, HI 96813

February 25, 2013

Mr. Watson Okubo
State of Hawaii, Department of Health
Clean Water Branch
919 Ala Moana Blvd. Room 301
Honolulu, HI 96814

Via PDF Only unless hardcopy is requested.

Re: State Land Use District Boundary Amendment Docket A9-721 Condition No. 10, County of Maui Zoning Ordinance 3613 Condition No. 19, Marine Water Quality Monitoring.

Dear Mr. Okubo

ATC Makena Holdings, LLC, in compliance with the above referenced conditions, respectfully submits the enclosed Marine Water Quality Monitoring Report prepared by Marine Research Consultants, Inc. dated February, 2013, for tests performed in December, 2012.

Should you have any questions, require a hardcopy, or require additional information please do not hesitate to contact me at (808) 547-2276, or by e-mail at sarah@stanfordcarr.com.

Sincerely,

STANFORD CARR DEVELOPMENT, LLC
For ATC MAKENA HOLDINGS, LLC

Sarah Agnew-Miller

Sarah Agnew-Miller
Project Management/Planning

MARINE WATER QUALITY MONITORING

MAKENA RESORT, MAKENA, MAUI

WATER CHEMISTRY

REPORT 1-2013

(December 2012)

Prepared for

ATC Makena Holdings, LLC
c/o Stanford Carr Development, LLC
1100 Alakea St. 27th Floor
Honolulu, HI 96813

By

Marine Research Consultants, Inc.
1039 Waakaua Pl.
Honolulu, Hawaii 96822

Submitted

February 2013

EXECUTIVE SUMMARY

The Makena Resort fronts approximately 5.4 miles of coastline of southeastern Maui, extending from Papanui Stream (Nahuna Point) on the north and Pu`u Olai (Ahihi Bay) on the south. However, only 0.58 miles of the Resort reaches to the actual shoreline. Within the Resort are two 18-hole golf courses (North and South Courses), as well as a hotel, sewage treatment plant and private residences. No part of the project involves direct alteration of the shoreline or nearshore marine environments. In the interest of assuring maintenance of the highest possible quality of the marine environment, condition No. 10 of the Declaration of Conditions pertaining to the Amendment of the District Boundary, as required by the Land Use Commission, dated April 17, 1998 stipulates the implementation of an ongoing marine monitoring program off the Makena Resort Development. Additionally, County of Maui Zoning Ordinance 3613 Condition 19 included requirements for similar monitoring. The primary goals of the program are twofold: 1) to assess the degree that materials used on land to enhance turf growth and landscaping, as well as other nutrient subsidies, leach to groundwater and subsequently reach the ocean, and 2) to determine the fate of these materials within the nearshore zone. In terms of determining fate, the question that is addressed is if the materials that originate from Resort activities disperse with little or no effect, or do they cause changes in water quality sufficient to alter marine biological community structure? The following report fulfills the requirements of these Conditions, and presents the results of water quality monitoring off the Makena Resort conducted on December 4, 2012. The report also incorporates the cumulative data from twenty-seven past water chemistry surveys conducted in the area.

Survey methodology includes collection of 62 ocean water samples on four transects spaced along the projects ocean frontage and on one control transect. Site 1 is located at the northern boundary of the project, Site 2 is located near the central part of the Makena North Golf Course in the center of Makena Bay, Site 3A (initiated during the June 2007 survey) is located near the southern boundary of Maluaka Bay, Site 3 was downslope from the part of Makena South Golf Course that comes closest to the shoreline, and Control Site 4 is located to the south of Makena Resort near the northern boundary of the 'Ahihi-Kina`u Natural Area Reserve. Water samples were collected at 7 stations spaced along transects that extended from the shoreline out to the open coastal ocean (about 500 feet). At sampling stations where water depth exceeded about 3 feet, samples were collected at the surface and just above the sea floor. Water samples were analyzed for chemical criteria specified by DOH water quality standards for open coastal waters, as well as several additional criteria. In addition, water samples were collected from nine irrigation wells located on the golf courses.

Results of analysis of water chemistry showed that constituents that occur in high concentration in groundwater (silica, nitrate-nitrogen) were found to be highest in ocean samples collected nearest to the shoreline, with progressively decreasing values moving away from shore into deeper water. While groundwater nutrient input was evident at all four sampling locations, it was highest in magnitude at Site 3A, located directly downslope from the Makena Resort. As Site 4 served as a control, and was not located in the vicinity of the Makena Resort, it is apparent that groundwater input is not solely a function of Resort land usage.

Vertical stratification of the water column was evident on transects with surface water generally having higher nutrient concentrations and lower salinities than samples from near the sea floor.

The observed patterns of distribution with respect to both distance from shore and depth in the water column indicate that physical mixing processes generated by tide, wind, waves and currents mix the water column from top to bottom.

Overall, measurements of turbidity and chlorophyll *a* were low throughout the sampling area, although values were slightly elevated close to the shoreline probably as a result of resuspension of fine-grained marine sediments (turbidity) and fragments of benthic algae washed up to the shoreline (Chl *a*). These results indicate that at the time of sampling, nutrient input from land was not resulting in increases in plankton populations in nearshore waters. Low turbidity in Makena Bay (transect Site 2) suggests mitigation of the effects of t a past episode of high runoff of upland soil from a flash flood in October 1999 that resulted in substantial impacts to water clarity within the Bay.

Other organic water chemistry constituents that do not occur in high concentrations in groundwater, such as ammonium nitrogen or organic nitrogen and phosphorus, were consistently low and did not show any distinctive patterns with respect to input from land.

Analyses that scale nutrient concentrations to salinity reveal that there were measurable increases of nitrate nitrogen above what is found in naturally occurring groundwater that enters the nearshore ocean at three survey sites (Sites 1, 3 and 3A). These subsidies, which are likely a result of land uses involving fertilizers, substantially increase the concentration of nitrate over natural groundwater flowing to the ocean. These subsidies were greatest in magnitude at Sites 3 and 3A, followed by Site 1, all of which are located off the Makena Golf Course and adjacent residential areas. No subsidies of nitrate were apparent at Site 2 (Makena Landing) or Site 4 ('Ahihi-Kina`u). The lack of distinguishable upward curvature of these data arrays indicates that the nutrients from groundwater that enter the ocean, both from natural and the human sources, are not being taken up by biotic communities in the nearshore zone. Rather, nutrients are mixed to background ocean values by physical processes including wind stirring and wave action.

Statistical tests of nutrient concentration scaled to salinity over time show no significant increases or decreases over the years of monitoring at any of the survey sites. The lack of such increases suggests that there has been no consistent change in nutrient input from land (either as an increase or decrease) to groundwater that enters the ocean over the past years.

Comparing values of water chemistry measured in the monitoring program to State of Hawaii Department of Health (DOH) water quality standards revealed that several measurements of nitrogen, phosphorus, turbidity and Chlorophyll *a* exceeded the DOH standards, particularly for "geometric mean" standards. Such exceedances occurred at all survey sites, including the control site that was removed from influences of the Makena Resort. The consistent exceedance of water quality standards is in large part a consequence of the natural effects of groundwater discharge to the nearshore ocean, as well as physical mixing processes that occur near the shorelines of all coastal areas. Revision of DOH standards to account for such natural input has been implemented for the West Coast of the Island of Hawaii, and will hopefully be extended to the rest of the State in the near future.

As in all past surveys, the results of the most recent increment of monitoring reveal that there is an increase over natural conditions of dissolved inorganic nutrients (e.g., nitrate and sometimes to a lesser extent phosphate) in groundwater that enters the nearshore ocean at sampling sites downslope from parts of the Makena Resort. Without question, such input is a consequence of various land use activities. However, none of these inputs have increased significantly over time during the 17-year course of the monitoring program. The regions where the highest elevations over natural inputs occur are restricted to narrow zone that extends from the shoreline to several meters offshore, and as such is restricted to an area that is not suitable for coral communities to occur owing to shallow water depth, wave impact and sand scour. Surveys of coral reef community structure that are also part of the ongoing monitoring program for the Makena Resort, as well as the continued lack of any nuisance algal accumulations in the nearshore area, indicate that the nutrient subsidies are presently not detrimental to marine community structure.

The next scheduled testing for the Makena Resort monitoring program is planned for the spring-summer season of 2013.

I. PURPOSE

The Makena Resort fronts approximately 5.4 miles of coastline of southeastern Maui, extending from Papanui Stream (Nahuna Point) on the north and Pu`u Olai (Ahihi Bay) on the south. However, only 0.58 miles of the Resort reaches to the actual shoreline. Within the Resort are two 18-hole golf courses (North and South Courses), as well as a hotel, sewage treatment plant and private residences. No part of the project involves direct alteration of the shoreline or nearshore marine environments.

Evaluations of other golf courses and other forms of resort development located near the ocean in the Hawaiian Islands reveal that there is detectable input to the coastal ocean of materials used for fertilization of turfgrass and landscaping (Dollar and Atkinson 1992). However, few, if any, effects that have been documented have been found to be detrimental to the marine ecosystem. Confirmation that the construction and responsible operation of the golf courses and other components of the Makena Resort does not cause any harmful changes to the marine environment requires rigorous and continual monitoring.

In the interest of assuring maintenance of excellent environmental quality in the Makena region, Condition No. 10, Declaration of Conditions pertaining to the Amendment of the District Boundary, as required by the Land Use Commission, dated April 17, 1998 stipulated the implementation of an ongoing marine monitoring program off the Makena Resort Development. In addition, County of Maui Zoning Ordinance 3613 Condition 19 included requirements for similar monitoring. The primary goals of the established monitoring program to satisfy these two requirements are twofold: 1) to assess the degree that materials used on land to enhance turf growth and landscaping, as well as other nutrient subsidies, leach to groundwater and subsequently reach the ocean, and 2) to determine the fate of these materials within the nearshore zone. In terms of determining fate, the question addressed is if the materials that originate from Resort activities disperse with little or no effect, or do they cause changes in water quality sufficient to alter marine biological community structure?

The rationale of the monitoring program is to conduct repetitive evaluations of water chemistry at the same locations at regular time intervals (twice per year). This strategy allows for determination of variations in effects from the Makena Resort in both space (at different locations along the shoreline) and time. It should be noted that water chemistry monitoring off the Makena area was initiated in 1995 on a voluntary basis, and has continued uninterrupted until the present. With the implementation of the Boundary Amendment and Zoning Conditions, it was determined that the ongoing voluntary monitoring protocol satisfied the stated requirements. Hence, the entire data set from 1995 onward is considered as part of the monitoring program. The following report presents the results of the twenty-eighth increment in the monitoring program, and contains data from water chemistry sampling conducted on December 4, 2012.

II. ANALYTICAL METHODS

Three survey sites directly downslope from the Makena Resort have been selected as sampling locations. A fourth site, located offshore of an area with minimal land-based development, particularly golf course operations, was selected as a control. During the June 2007 survey, another sampling location was added near the southern boundary of Maluaka Bay. It is anticipated that this station will remain part of the sampling protocol permanently. Figure 1 is a map showing the shoreline and topographical features of the Makena area, and the location of the North and South Golf Courses. All survey sites are depicted as transects perpendicular to the shoreline extending from the shoreline out to what is considered open coastal ocean (i.e., beyond the effects of activities on land). Survey Site 1 is located near the northern boundary of the project site off Nahuna Point; Survey Site 2 bisects Makena Bay near Makena Landing. Site 3 bisects the middle of the South course on the north side of Maluaka Point. Site 3A is on the southern corner of Maluaka Bay. Site 4, which is considered the Control site, is located near the northern boundary of the 'Ahihi-Kina`u natural area reserve north of the 1790 lava flow and approximately 1-2 miles south of the existing Makena Golf courses (Figure 1). The control site was located off a shoreline area with minimal land uses (i.e., residences near the shoreline and upslope ranchlands) rather than off the completely uninhabited 1790 lava flow. This location was selected as the most appropriate control site, as it is the farthest location from the Makena Resort with the same geophysical structural of the land area. The completely different geological structure of the lava flow off the natural reserve likely results in very different groundwater dynamics compared to the land area where the Makena Resort is located, hence making the lava flow an unsuitable control site.

In July of 2002, Site 3 was relocated from a location at the southern boundary of the project offshore of Oneloa Beach to the location directly off the Makena Golf Course, as described above. The relocation of Site 3 was deemed necessary as the original location consistently showed virtually no input of groundwater to the ocean. Such lack of groundwater discharge resulted in little potential for evaluating effects from the project. The new location of Site 3 is directly downslope from both the portion of the golf course nearest to the ocean, several newly constructed private residences, and a 3-acre recently restored wetland area. As a result, the new location represents an area that reflects the maximum influence on nearshore water quality from a variety of land uses and natural habitat.

All fieldwork for the present survey was conducted on December 4, 2012. Environmental conditions during sample collection consisted of mild on-shore winds (0-5 knots), sunny skies, and choppy shoreline swell. Sample collection at the shoreline occurred during a falling tide with a tidal range of 1.41 to +1.3 feet.

Water samples were collected at stations along transects that extend from the highest wash of waves to between 150-200 meters (m) offshore (about 500-650 feet), depending on the site. Such a sampling scheme is designed to span the greatest range of salinity with respect to freshwater efflux at the shoreline. Sampling was more concentrated in the nearshore zone because this area is most likely to show the effects of land-based activities. With the exception of the two stations closest to the shoreline (0 and 2 m offshore), samples were collected at two depths; a surface sample was collected within approximately 10 centimeters (cm) (~4 inches) of the sea surface, and a bottom sample was collected within one m (3 feet) of the sea floor.

Water samples from the shoreline to a distance of 10 m offshore were collected in triple-rinsed 1-liter polyethylene bottles by swimmers working from the shoreline. Water samples beyond 10 m from the shoreline were collected from a small boat using a 1.8-liter Niskin sampling bottle. This bottle was lowered to the desired depth in an open position where spring-loaded endcaps were triggered to close by a messenger released from the surface. Upon recovery, each sample was placed on ice until further processing in Honolulu. Water samples were also collected from nine golf course irrigation wells (No's 1, 2, 3, 4, 5, 6, 8, 10 and 11) on May 10, 2012.

Water quality parameters evaluated included the 10 specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Open Coastal waters) of the State of Hawaii Department of Health Water Quality Standards. These criteria include: total nitrogen (TN) which is defined as inorganic nitrogen [nitrate + nitrite nitrogen (NO_3^- + NO_2^-), ammonium (NH_4^+)], plus total organic nitrogen (TON), total phosphorus (TP) which is defined as inorganic phosphorus (PO_4^{3-}) plus total organic phosphorus, chlorophyll a (Chl *a*), turbidity, temperature, pH and salinity. In addition, orthophosphate phosphorus (PO_4^{3-}) and silica (Si) were reported because these constituents are sensitive indicators of biological activity and the degree of groundwater mixing, respectively.

Analyses for NO_3^- + NO_2^- (hereafter termed NO_3^-), NH_4^+ and PO_4^{3-}, were performed on filtered samples using a SEAL Analytical AA3 autoanalyzer according to standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983). TN and TP were analyzed in a similar fashion on unfiltered samples following digestion. Total organic nitrogen (TON) and Total organic phosphorus (TOP) were calculated as the difference between TN and inorganic N, and TP and inorganic P, respectively. Limits of detection for the dissolved nutrients are 0.01 μM (0.14 μg/L) for NO_3^- and NH_4^+, 0.01 μM (0.31 μg/L) for PO_4^{3-}, 0.1 μM (1.4 μg/L) for TN and 0.1 μM (3.1 μg/L) for TP.

Chl *a* was measured by filtering 300 ml of water through glass fiber filters; pigments on filters were extracted in 90% acetone in the dark at -5°C for 12-24 hours, and the fluorescence before and after acidification of the extract was measured with a Turner Designs fluorometer (level of detection 0.01 μg/L). Salinity was determined using an AGE Model 2100 laboratory salinometer with a precision of 0.003‰.

In situ field measurements included water temperature, pH, dissolved oxygen and salinity which were acquired using an RBR Model XR-420 CTD calibrated to factory specifications. The CTD has a readability of 0.001°C, 0.001pH units, 0.001% oxygen saturation, and 0.001 parts per thousand (‰) salinity. Shoreline salinity was measured in the field using an Atago PAL-06S digital refractometer.

Nutrient, turbidity, Chl *a* and salinity analyses were conducted by Marine Analytical Specialists located in Honolulu, Hawaii. This laboratory possesses acceptable ratings from EPA-compliant proficiency and quality control testing.

III. RESULTS and DISCUSSION

A. General Overview

Table 1 shows results of all marine water chemical analyses for samples collected off Makena on December 4, 2012 with nutrient concentrations reported in micromolar units (μM). Table 2 shows similar results with nutrient concentrations presented in units of micrograms per liter (μg/L). Tables 3 and 4 show geometric means of ocean samples at Sites 1, 2 and 4 for 28 surveys, 19 surveys at Site 3, and 10 surveys from Site 3A, with nutrient concentrations shown in μM and μg/L, respectively. Table 5 shows water chemistry measurements (in units of μM and μg/L) for samples collected from irrigation located on the Makena Resort Golf Courses. Concentrations of twelve chemical constituents in surface and deep-water samples from the December 2012 sampling are plotted as functions of distance from the shoreline in Figures 2 and 3. Mean concentrations ($\pm$standard error) of twelve chemical constituents in surface and deep water samples as functions of distance from the shoreline at Sites 1-4 collected since 1995 and from Site 3A collected since 2007are plotted in Figures 4-18. In addition, data from the most recent sampling in December 2012 are also plotted on Figures 4-18.

During the December 2012 sampling, nearshore concentrations of dissolved Si and NO_3^- on three of the five transects (1, 2, and 3-A) were elevated up to an order of magnitude compared to samples collected in the open coastal ocean farthest from shore (Figure 2, Tables 1 and 2). The horizontal gradient of Si was steeper on transect 2 than on transects 1 and 3-A, and was maintained for the entire length of the transect, out to a distance of 150 m from the shoreline. No horizontal gradients in Si or NO_3^- were evident at transects 3 and 4 during the December 2012 survey. Concentration of TN showed no distinct variation with distance offshore at any of the five transects (Figure 2, Tables 1 and 2).

At transects 1, 2 and 3-A, salinity was slightly lower in samples collected within 5 m of the shoreline compared to the samples collected farther from shore. The variation was not substantial with salinity values ranging between 34.88‰ and 35.22‰ for all transects in the December 2012 survey. The maximum change between the shoreline and offshore samples of 0.29‰ occurred at transect 1 (Figure 3 and Tables 1 and 2). Similar to the findings for dissolved nutrients, salinity was nearly constant along the entire transect as sites 3 and 4.

Surface concentrations of phosphate phosphorus (PO_4^{3-}) and TP were nearly constant along all five transects and horizontal gradients were not evident the December 2012 survey.

With no streams in the sampling area, nor heavy rainfall and subsequent surface runoff preceding sampling, patterns of elevated Si, NO_3^-, and TN with corresponding reduced salinity generally indicates groundwater entering the ocean near the shoreline. Low salinity groundwater, which contains high concentrations of Si, NO_3^-, TN and PO_4^{3-} (see values for well waters in Table 5), percolates to the ocean near the shoreline, resulting in a distinct zone of mixing in the nearshore region. The zone of mixing is discernible by distinct decreasing gradients of nutrients and increasing gradients of salinity with distance from shoreline. During periods of low tide when sea conditions are calm, the zone of mixing between groundwater and ocean water is most pronounced. The December 2012 sampling shows substantially smaller horizontal gradients than past surveys. These results are most likely a result of sampling during a higher tidal stand than normal, along with increased mixing near the shoreline caused by onshore winds and waves which diluted the groundwater signal. Comparing the results of surveys conducted during different sea conditions clearly indicates that tidal state, as well as wind and wave energy, greatly effect groundwater mixing in the nearshore zone.

Dissolved nutrient constituents that are not usually associated with groundwater input (NH_4^+, TON, TOP) did not exhibit distinct horizontal gradients across the sampling transects (Table 1, Figure 2). With the exception of a few shoreline samples at Site 4, NH_4^+, TON and TOP were relatively constant along all transect, and were of the same magnitude among the four transect sites (Table 1, Figure 2).

Turbidity was highest near the shoreline on all transects with distinctly higher concentrations at transects 2 and 3-A (Tables 1 and 2, Figure 3). Transect 2 bisects Makena Bay, which is semi-enclosed embayment with a silt/sand bottom rather than the predominantly "hard" reef or sand bottoms that occur at the other transect sites. In addition, it has been observed that during flash floods originating in the ranch lands upslope of the Makena Resort, terrigenous sediment may flow to the ocean in Makena Bay. As a result of wave-induced resuspension of the naturally occurring silt/sand substratum, as well as terrigenous runoff which may be partially retained within the embayment, turbidity has often been elevated on transect 2 relative to the other transect sites. It is important to note that in surveys conducted since July 2002, water clarity in Makena Bay has improved greatly compared to preceding surveys in 2001 which reflected conditions following substantial input of terrigenous materials from a flash-flood that occurred in October 1999. Since that time, a large retention basin has been constructed on the upper slopes of Makena Resort in the watershed that flows into Makena Bay.

In December 2012 concentrations of Chl *a* were higher near the shoreline compared to offshore values at all five survey sites. Values of Chl *a* within 50 m of the shoreline were distinctly higher at transect 2 compared to the other 4 transects (Figure 3). Surface water temperature was cool ranging between 23.5°C and 24.4°C among the five sites during the December 2012 survey (Figure 3 and Tables 1 and 2).

In many areas of the Hawaiian Islands, input of low salinity groundwater to the nearshore ocean creates a distinct buoyant surface lens that can persist for some distance offshore. Buoyant surface layers are generally found in areas where turbulent processes (primarily wave action) are insufficient to completely mix the water column in the nearshore zone. Figures 2 -18 and Tables 1 and 2 show concentrations of water chemistry constituents with respect to vertical stratification. During the December 2012 survey, there was no vertical stratification on any of the transects.

B. Temporal Comparison of Monitoring Results

Figures 4-18 show mean concentrations (±standard error) of water chemistry constituents from surface and deep samples at Transect Sites 1-4 from monitoring surveys conducted since 1995 and from Site 3A for monitoring surveys conducted since 2007. In addition, the results of the most recent survey in December 2012 are also shown on each plot.

Overall, means of surface concentrations of Si, NO_3^-, TN and PO_4^{3-} at sampling sites within 50 m of the shoreline were higher than values measured during the most recent survey in December 2012 (Figures 4, 7, 10, 13 and 16). The opposite pattern is evident for TOP and salinity where the December 2012 measurements were higher compared to the mean values along all five transects (Figures 5, 6, 8, 9, 11, 12, 14 and 15). The patterns comparing the concentrations measured in the most recent survey and the overall survey means are likely a result of conducting the recent sampling during a period of high tide and relatively high physical mixing of groundwater and ocean water in the nearshore zone. None of the comparisons of the most recent sampling results to the mean values calculated for the entire monitoring regime indicates any recent negative effects to nearshore water quality.

C. Conservative Mixing Analysis

A useful treatment of water chemistry data for interpreting the extent of material input from land is application of a hydrographic mixing model. In the simplest form, such a model consists of plotting the concentration of a dissolved chemical species as a function of salinity. Comparison of the curves produced by such plots with conservative mixing lines provides an indication of the origin and fate of the material in question (Officer 1979, Dollar and Atkinson 1992, Smith and Atkinson 1993).

Figure 19 shows plots of concentrations of four chemical constituents (Si, NO_3^-, PO_4^{3-}, and NH_4^+) as functions of salinity for samples collected in December 2012. Figures 20 and 21 show the same type of plot with data pooled by transect site for a composite of all past surveys, as well as for the most recent survey. Each graph also shows a conservative mixing line that is constructed by connecting the end member concentrations of open ocean water with irrigation well No. 4 located off the North Course of the Makena Resort (representative of groundwater upslope of the Makena Resort).

If the parameter in question displays purely conservative behavior (no input or removal from any process other than physical mixing), data points should fall on, or very near, the conservative mixing line. If, however, external material is added to the system through processes such as leaching of fertilizer nutrients to groundwater, data points will fall above the mixing line. If material is being removed from the system by processes such as uptake by biotic metabolic processes, data points will fall below the mixing line.

Dissolved Si represents a check on the model as this material is present in high concentration in groundwater, but is not a major component of fertilizer. In addition, Si is not utilized rapidly within the nearshore environment by biological processes. It can be seen in Figure 19 that when concentrations of Si are plotted as functions of salinity, most of the data points at salinities greater than 35‰ from all five sites fall in a linear array on the conservative mixing line. At salinities below 35‰, data points for transect site1 fall in a linear array slightly below the mixing line, while data points for transect site 2 lie above the mixing line. While there is some variation in the clustering of data points from different transect, the overall linearity of the data points indicates that marine waters at the five transect sites are primarily a mixture of groundwater flowing beneath the project and ocean water. These results indicate that the groundwater from upslope Well No. 4 provides a valid representation of groundwater that enters the ocean following flow through the

Makena development. Over the course of monitoring since 1995, the relationship between salinity and Si has remained nearly constant (Figure 20).

NO_3^- is the form of nitrogen most common in fertilizer mixes that are used for enhancing turf growth. When the concentrations of NO_3^- are plotted as functions of salinity, data from each transect prescribe similar patterns as that seen with Si (Figure 19). Most data points from each transect lies in a straight line. Data points from transects 2 and 4A fall on the mixing line The location of these data arrays indicates that the source of NO_3^- entering the ocean at these transect sites contains no subsidies from activities on land, and all NO_3^- can be attributed to natural inputs from groundwater. Inspection of the long-term mixing data (Figure 20) indicates that essentially all of the values of NO_3^- from Control Site 4 fall on, or very near, the conservative mixing line. Such a result validates that Site 4 is indeed a good "control" area that is not greatly affected by activities on land.

Conversely, data points from the nearshore samples at Transects 1 3 and 3A all fall above the conservative mixing line, indicating various subsidies of NO_3^- to the ocean from sources on land (Figure 19). Data points for Sites 3 and 3A are similar in slope, and are substantially steeper than data points from Site 1 (Figure 19). Such relationships indicate subsidies of NO_3^- at transect Sites 1, 3 and 3A that are likely a result of leaching of golf course fertilizers to the groundwater lens. In addition to the golf courses, however, residences near the shoreline at Site 1 include landscaping and lawns, while residences and a wetland lie directly inshore from Site 3. Sites 3 and 3A lies directly offshore of the golf course and a residential community clubhouse that is currently under construction.

Transect Site 1 has also been used as a monitoring station for a similar evaluation of the effects of the Wailea Golf Courses on water chemistry that commenced in 1989. The lowest concentrations of NO_3^- relative to salinity at Transect site 1 occurred during the initial two years of study, with subsequent higher concentrations increasing since 1992. Hence, there appears to have been an increase of NO_3^- in nearshore waters since 1992 that was not occurring in 1989-1991. Completion of the Wailea Gold Course occurred in December 1993, while completion of the Makena North Course occurred in November 1993. As the southern region of the Wailea Course and the northern part of the Makena Course abut each other in the makai-mauka direction landward of ocean Transect 1, the increased concentrations of NO_3^- evident in Figure 19 may be a result of leaching of fertilizer materials from the combined golf courses to groundwater that enters the ocean in the sampling area.

Mixing analyses also indicate an ongoing input of NO_3^- at the shoreline of Stations 3 and 3A located off the existing Makena Golf Course and several new residences that have been constructed adjacent to the Golf Course (Figures 19 and 20). Such subsidies have been noted in past surveys, as can be seen in Figure 20. When the slopes of the data points for the December 2012 survey (red symbols) are compared to the slopes of combined sets of data points from past surveys (black and maroon symbols) subsidies of NO_3^- have not increased during the most recent survey (Figure 20). Future monitoring will clarify if the trend of NO_3^- input to the ocean is indeed decreasing

While the data reveal a long-term subsidy to the concentration of NO_3^- in groundwater and the nearshore zone at several of the sampling sites, the concentrations of NO_3^- fall in clearly linear relationship as functions of salinity. The linearity of the data array indicates that there is little or no detectable uptake of this material by the marine environment. Such lack of uptake indicates that the nutrients are not being removed from the water column by metabolic reactions that could change the composition of the marine environment. Rather, the nutrient subsidies are diluted to background oceanic levels by physical processes of wind and wave mixing. As a result, the increased nutrients do not appear to have the potential to cause alteration in biological community composition or function.

Similar situations have also been observed in other locales in the Hawaiian islands where nutrient subsidies from golf course leaching result in excess NO_3^- in the nearshore zone. At Keauhou Bay on the Big Island, it was shown that owing to the distinct vertical stratification in the nearshore zone, the excess nutrients never come into contact with benthic communities, thereby limiting the potential for increased uptake by benthic algae. In addition, the residence time of the high nutrient water was short enough within the embayment to preclude phytoplankton blooms. As a result, while NO_3^- concentrations doubled as a result of golf course leaching for a period of at least several years, there was no detectable negative effect to the marine environment (Dollar and Atkinson 1992). Owing to the unrestricted nature of circulation and mixing off the Makena project (no confined embayments) it is reasonable to assume that the excess NO_3^- subsidies that are apparent in the present study will not result in alteration to biological communities.

Indeed, surveys of the nearshore marine habitats off of Makena reveal a generally healthy coral reef that does not appear to exhibit any negative effects from nutrient loading, particularly in the form of abundant algal biomass (Marine Research Consultants 2006). In addition to the lack of negative impacts to offshore coral communities, inspection of the entire shoreline fronting the Makena Resort revealed that there are no areas where excessive algal growth is presently occurring.

The other form of dissolved inorganic nitrogen, NH_4^+, does not show a linear pattern of distribution with respect to salinity for either the December 2012 survey (Figure 19) or the entire monitoring program (Figure 21). The lack of a correlation between salinity and concentration of NH_4^+ suggests that this form of nitrogen is not present in the marine environment as a result of mixing from groundwater sources. Rather, NH_4^+ is generated by natural biotic activity in the ocean waters off Makena.

PO_4^{3-} is also a major component of fertilizer, but is usually not found to leach to groundwater to the extent of NO_3^-, owing to a high absorptive affinity of phosphorus in soils. With the exception of data points from transect site 3A, all data points from December 2012 fell close to the mixing line. This result indicates that with the exception of site 3A the source of PO_4^{3-} to the ocean is from naturally occurring groundwater. At site 3A, the elevated PO_4^{3-} is likely a result of golf course and residential landscaping, reflecting similar subsidies of NO_3^-.

D. Time Course Mixing Analyses

While it is possible to evaluate temporal changes from repetitive surveys conducted over time in terms of concentrations of water chemistry constituents (See Section C), a more informative and accurate method of evaluating changes over time is to utilize the results of scaling nutrient concentrations to salinity. As discussed above, the simple hydrographic mixing model consisting of plotting concentrations of nutrient constituents versus salinity eliminates the ambiguity associated with comparing only the concentrations of samples collected during multiple samplings at different stages of tide and weather conditions. Figures 22 and 23 show plots of Si and NO_3^-, respectively, as functions of salinity collected during each year of sampling since 1995. Also shown in Figures 22 and 23 are straight lines that represent the least squares linear regression fitted through concentrations of Si and NO_3^- as functions of salinity at each monitoring site for each year. Tables 6-8 show the numerical values of the Y-intercepts, slopes, and respective upper and lower 95% confidence limits of linear regressions fitted through the data points for Si, NO_3^-, and PO_4^{3-} as functions of salinity for each year of monitoring.

The magnitude of the contribution of nutrients originating from land-based activities to groundwater will be reflected in both the steepness of the slope and the magnitude of the Y-intercept of the regression line fitted through the concentrations scaled to salinity (the Y-intercept can be interpreted as the concentration that would occur at a salinity of zero if the distribution of data points is linear). This relationship is valid because with increasing contributions from land, nutrient concentrations in any given parcel of water would increase with no corresponding change in salinity. Hence, if the contribution from land to groundwater nutrient composition is increasing over time, there would be progressive increases in the absolute value of the slopes, as well as the Y-intercepts of the regression lines fitted through each set of annual nutrient concentrations when plotted as functions of salinity. Conversely, if the contributions to groundwater from land are decreasing, there will be decreases in the absolute values of the slopes and Y-intercepts.

Plots of the values of the slopes (Figure 24) and Y-intercepts (Figure 25) of regression lines fitted though concentrations of Si, NO_3^- and PO_4^{3-} scaled to salinity during each survey year provide an indication of the changes that have been occurring over time in the nearshore ocean off the Makena Resort. As stated above, Si provides the best case for evaluating the effectiveness of the method, as Si is present in high concentration in groundwater but is not a component of fertilizers. NO_3^- and PO_4^{-3} are the forms of nitrogen and phosphorus that are found in high concentrations in groundwater relative to ocean water, and are the major nutrient constituents found in fertilizers.

Examination of Figures 24 and 25, as well as Tables 6-8 reveal that none of the slopes or Y-intercepts of Si, NO_3^- and PO_4^{3-} at any of the transect sites exhibit any indication of progressively increasing or decreasing values over the course of monitoring. The term "REGSLOPE" in Tables 6-8 denotes the values of the slopes and 95% confidence limits of linear regressions of the values of the yearly slopes and Y-intercepts as a function of time. For all sites, the span of the upper and lower 95% confidence limits of the REGSLOPE coefficients are not significantly different than zero, indicating that there is no statistically significant increase or decrease in the salinity-scaled concentrations of Si, NO_3^- and PO_4^{3-} over the course of the monitoring program (Tables 6-8).

For all three nutrients, there is little variation in either slopes or Y-intercepts during any single year at Site 1, located off the "5 Graves" area downslope from the juncture of the Wailea and Makena Resorts (Figures 24 and 25). Such lack of variation indicates relatively consistent concentrations of Si, NO_3^- and PO_4^{3-} in groundwater entering the ocean over the seventeen years of monitoring. Sites 2 (Makena Landing) and 4 ('Ahihi-Kina`u) also show relatively constant trends with time with the exception of 2001 which is marked by large spikes in Si and PO_4^{3-}. Such a fluctuation is not present for NO_3^- in 2001. Sampling in 2001 was conducted during a period of rough winter sea conditions marked by vigorous mixing of the water column. As a result, there was very weak linear relationship between nutrient concentrations and salinity.

At Site 3, located directly downslope for the point of the Makena Golf Course closest to the ocean, there is a trend of decreasing NO_3^- between 2002 and 2004, an increasing trend from 2004 to 2007, followed by another downturn in 2007 – 2009 (Figures 24 and 25). As a result of these reversing trends, there is no significant change over the seven-year period of monitoring. The multiple reversing trends may reflect changes in land use, such as variation in fertilizer application or construction-related activities in 2002-2004 versus 2004-2007. In June of 2008, the golf course fronting the ocean in this area was shut down for re-alignment and re-planting. Underground retention/filtration systems were also constructed to mitigate adverse affects of stormwater runoff. At the time of the December 2012 survey, new turf grass had been applied but the course remained closed. Construction has begun on the filtration systems but they were not yet operational.

E. Compliance with DOH Standards

Tables 1 and 2 also show samples that exceed DOH water quality standards for open coastal waters under "wet" and "dry" conditions. These criteria are applied depending upon whether the area is likely to receive less than (dry) or greater than (wet) 3 million gallons of groundwater and/or surface water input per mile per day. As it is not possible to accurately estimate groundwater and surface water discharge, both wet and dry standards are considered. DOH standards include specific criteria for three situations; criteria that are not to be exceeded during either 10% or 2% of the time, and criteria that are not to be exceeded by the geometric mean of samples. With only one or two samplings collected per year since 1995, comparison of the 10% or 2% of the time criteria for any sample is not statistically meaningful. However, comparing sample concentrations to these criteria provide an indication of whether water quality is near the stated specific criteria.

Boxed values in Tables 1 and 2 show instances where measurements exceed the DOH standards under dry conditions, while boxed and shaded values show instances where measurements exceed DOH standards under wet conditions.

Results from the December 2012 survey indicated numerous measurements of NO_3^-, two measurements of NH_4^+, and six measurements of turbidity exceeded the 10% DOH criteria under wet or dry conditions (Tables 1 and 2). No measurements of TP, TN or Chl *a* exceeded the 10% DOH criteria under dry conditions. It is of interest to note that at Transect Site 4, which is considered the control station beyond the influence of the Makena Resort, exceedance of DOH criteria occurred only for two instances of NH_4^+.

Tables 3 and 4 show geometric means of samples collected at the same locations during the 28 increments of the monitoring program at Sites 1, 2 and 4. Geometric means of samples collected over 19 increments of sampling at Site 3 and nine increments of sampling at Site 3A are also shown. These tables also specify the samples that exceed the DOH geometric mean limits for open coastal waters under "dry" (boxed) and "wet" (boxed and shaded) conditions. For NO_3^-, NH_4^+, and TN numerous dry and wet standards were exceeded on all transects. Eight samples of

TP and 21 samples of turbidity exceeded standards. All but seven samples exceed the geometric mean standards for Chl *a*.

Site 4 is considered a control transect, in that it is not located offshore of a resort, golf course or dense residential development. It can be seen in Tables 3 and 4, however, that the number of samples that exceed geometric mean criteria at Site 4 are comparable to the other four sites, all of which are located downslope from the Makena Resort. Hence, Resort activities, including golf courses cannot be attributed as the sole (or even major) factor causing water quality to exceed geometric mean standards.

Several comments can be made regarding the present DOH water quality standards and how they apply to the monitoring program at the Makena Resort. As noted above, the category of water quality standards that are applicable for the Makena Monitoring program are "Open Coastal Waters." As the name implies, these standards apply to "open" waters that can be reasonably defined as "waters beyond the direct influence of land." In order to evaluate the effects of land uses on the nearshore ocean off Makena, the selected sampling regime collects water within a zone that extends from the shoreline to the open coastal ocean. As a result, sampling takes place within the region of ocean that is directly influenced by land. If the monitoring protocol were changed to include only those sampling locations beyond 50-100 m from shore (i.e., open coastal waters), which is completely valid with respect to meeting DOH regulatory compliance, virtually none of the factors discussed above relating to the effects of activities on land to the nearshore ocean would not be observed.

Initial steps have been taken by DOH to rectify this situation. During revision of the Department of Health water quality standards in 2004, a unique set of monitoring criteria was added for the West Coast of the Island of Hawaii (i.e., “Kona standards”). The rationale for these unique criteria was the recognition that existing numerical “standards” represent offshore coastal waters that are beyond the natural confluence of land and the nearshore ocean. As a result, the West Hawaii standards recognize that groundwater entering the ocean at the shoreline contains substantially elevated nutrients relative to open coastal waters. As a result, the Kona criteria provide the potential to meet water quality standards with elevated nutrient concentrations resulting from natural sources of groundwater input. As the same processes of groundwater discharge to the coastal ocean have been documented in Maui, it is hopeful that similar new provisions of the water quality standards with soon be applicable to the South Maui area.

IV. SUMMARY

- The twenty-eighth phase of water chemistry monitoring of the nearshore ocean off the Makena Resort was carried out on December 4, 2012. Sixty-two ocean water samples were collected on four transects spaced along the project ocean frontage and on one control transect. Site 1 was located at the northern boundary of the project, Site 2 was located near the central part of the Makena North Golf Course in the center of Makena Bay, Site 3A (initiated during the June 2007 survey) was located near the southern boundary of Maluaka Bay, Site 3 was downslope from the part of Makena South Golf Course that comes closest to the shoreline, and Control Site 4 was located to the south of Makena Resort near the northern boundary of the 'Ahihi-Kina`u Natural Area Reserve. Sampling transects extended from the shoreline out to the open coastal ocean. Water samples were analyzed for chemical criteria specified by DOH water quality standards, as well as several additional criteria.

- Water chemistry constituents that occur in high concentration in groundwater (Si and NO_3^-) displayed horizontal gradients with highest concentrations nearest to shore and decreasing concentrations moving seaward at three of the five sites. Groundwater input (based on salinity) was greatest at Site 2, followed by Site 3-A and 1. Horizontal gradients were not evident at Sites 3 and 4 during December 2012.

- Vertical stratification of the water column was not evident during December 2012, indicating that strong physical mixing processes generated by tidal exchange, wind stirring, and breaking waves were sufficient to mix the water column from surface to bottom throughout the sampling area at the time of the monitoring survey.

- Overall, values of Chl *a* and turbidity were elevated near the shoreline compared to offshore samples, with Site 2 having the highest values in nearshore samples. The elevated levels of Chl *a* and turbidity in the nearshore zone are likely a result of broken fragments of benthic plants that broken from the bottom by wave action and washed to the shoreline. The low concentrations of Chl *a* through the water column indicates the lack of plankton blooms in the area.

- Other organic water chemistry constituents that do not occur in high concentrations in groundwater (NH_4^+, TON, TOP) did not show any distinctive patterns with respect to horizontal gradients.

- Scaling nutrient concentrations to salinity indicates that there are measurable subsidies of NO_3^- to groundwater that enters the nearshore ocean at three Transect sites. No subsidies other than the chemical constituents of naturally occurring groundwater (particularly NO_3^-) were apparent at Site 2 (Makena Landing) or Control Site 4 ('Ahihi-Kina`u). These subsidies, which are without doubt a result of land uses involving fertilizers, substantially increase the concentration of NO_3^- with respect to salinity in groundwater flowing to the ocean compared to natural groundwater. The area shoreward of Site 1 includes the juncture of the southern part of the Wailea Gold Course and the northern part of the Makena North Course, as well as residential development. Sites 3 and 3A are directly downslope from the Makena South Course in an area were the golf course extends to the shoreline. In addition, private residences are near completion upslope of Transect 3, and it is possible that a cesspool remains from a house that was recently torn down. Hence, the subsidies of NO_3^- noted at these sites may result from a combination of sources.

- Linear regression statistics of nutrient concentration plotted as functions of salinity are useful for evaluating changes to water quality over time. When the regression values of nutrient concentrations versus salinity are plotted as a function of time, there are no statistically significant increases or decreases over the 18 years of monitoring at any of the survey sites. The lack of increase in these slopes and intercepts indicate that there has been no consistent change in nutrient input from land to groundwater that enters the ocean since 1995 (since 2002 at Site 2). At Site 3 off the Makena Resort South Golf Course, there was a progressive decrease in NO_3^- input between 2002 and 2004, followed by an increase between 2004 and

2007, and another decrease in 2008-2012. Further monitoring at this site will be of interest to note the future direction of the oscillating trends noted in the last seven years.

- Comparing water chemistry parameters to DOH standards revealed that several measurements of NO_3^- , two of NH_4^+, and a few of turbidity exceeded the DOH "not to exceed more than 10% of the time" criteria for dry and wet conditions of open coastal waters. It is apparent that the concentrations of NO_3^- in nearshore marine waters that contains a mixture of seawater and natural groundwater may exceed DOH criteria with no subsidies from human activities on land. Numerous values of NO_3^-, NH_4^+, TN, turbidity and Chl *a* exceeded specified limits for geometric means. Such exceedances occurred at all survey sites, including the control site that was far from any golf course influence. The consistent exceedance of water quality standards is in large part a consequence of the present DOH standards not accounting for the natural effects of groundwater discharge to the nearshore ocean.

- As in past surveys, there is a subsidy of dissolved inorganic nutrients (e.g., NO_3^- and sometimes to a lesser extent PO_4^{3-}) to groundwater that enters the nearshore ocean at sampling sites downslope from parts of the Makena Resort. Without question, such input is a consequence of various land use activities. However, none of these inputs have increased over time. Surveys of coral reef community structure that are part of the ongoing monitoring program for the Makena Resort, as well as the continued lack of any nuisance algal aggregations in the nearshore area indicate that the nutrient subsidies are not detrimental to marine community structure.

- The next scheduled testing for the Makena Resort monitoring program is planned for the spring-summer season of 2013.

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FIGURE 1. Aerial photograph of Makena Resort on southwest coastline of Maui. Also shown are locations of five water sampling transects that extend from the shoreline to 150-200 m from shore. The southern end of the Wailea golf course is visible at right.

TABLE 1. Water chemistry measurements from ocean water samples collected in the vicinity of the Makena Resort on December 4, 2012. Abbreviations as follows: DFS=distance from shore; S=surface; D=deep; BDL=below detection limit. Also shown are the State of Hawaii, Department of Health (DOH) "not to exceed more than 10% of the time" and "not to exceed more than 2% of the time" water quality standards for open coastal waters under "dry" and "wet" conditions. Boxed values exceed DOH 10% "dry" standards; boxed and shaded values exceed DOH 10% "wet" standards. For sampling site locations, see Figure 1.

TRANSECT SITE	DFS (m)	DEPTH (m)	PO_4^{3-} (μM)	NO_3^- (μM)	NH_4^+ (μM)	Si (μM)	TOP (μM)	TON (μM)	TP (μM)	TN (μM)	TURB (NTU)	SALINITY (ppt)	CHL a (μg/L)	TEMP (deg.C)	pH (std.units)	O2 % Sat
MAKENA 1	0 S	0.1	0.02	0.66	0.06	3.44	0.39	7.44	0.41	8.16	0.19	35.129	0.13	24.2	8.08	102.6
	2 S	0.1	0.07	0.99	0.08	3.49	0.51	6.42	0.58	7.49	0.23	35.119	0.15	24.3	8.09	102.5
	5 S	0.5	0.12	2.66	0.11	7.18	0.44	6.42	0.56	9.19	0.61	34.875	0.17	24.3	8.08	103.1
	5 D	1.5	0.09	1.78	0.13	5.36	0.43	6.56	0.52	8.47	0.49	35.012	0.15	24.3	8.08	103.0
	10 S	0.5	0.10	0.56	0.14	2.34	0.44	6.35	0.54	7.05	0.17	35.182	0.12	24.3	8.08	101.8
	10 D	2.4	0.08	0.83	0.15	3.06	0.47	6.72	0.55	7.70	0.22	35.149	0.10	24.3	8.09	102.6
	50 S	0.5	0.08	1.91	0.18	4.80	0.44	7.00	0.52	9.09	0.14	35.028	0.13	24.2	8.07	101.6
	50 D	4.1	0.07	0.44	0.20	2.53	0.45	6.63	0.52	7.27	0.12	35.174	0.17	24.5	8.08	101.5
	100 S	0.5	0.07	1.44	0.20	4.47	0.44	6.00	0.51	7.64	0.16	35.044	0.08	24.3	8.07	102.1
	100 D	5.5	0.07	0.15	0.16	1.70	0.43	6.76	0.50	7.07	0.08	35.222	0.07	24.5	8.10	102.0
	150 S	0.6	0.09	0.56	0.14	2.38	0.45	7.31	0.54	8.01	0.09	35.170	0.09	24.3	8.10	100.8
	150 D	10.4	0.09	0.11	0.16	1.77	0.45	9.03	0.54	9.30	0.05	35.204	0.10	24.5	8.10	101.6
MAKENA 2	0 S	0.1	0.20	1.18	0.23	8.80	0.43	5.56	0.63	6.97	0.63	34.988	0.42	24.0	8.09	99.3
	2 S	0.1	0.17	1.10	0.18	8.63	0.43	6.07	0.60	7.35	0.65	34.995	0.40	24.0	8.09	99.7
	5 S	0.6	0.17	1.16	0.19	8.01	0.45	6.07	0.62	7.42	0.52	34.964	0.48	24.0	8.09	97.5
	5 D	2.2	0.17	1.18	0.15	8.03	0.47	6.16	0.64	7.49	0.55	34.979	0.42	24.0	8.09	98.3
	10 S	0.5	0.15	1.02	0.06	6.30	0.44	6.29	0.59	7.37	0.29	35.018	0.37	24.0	8.09	99.7
	10 D	3.0	0.14	0.77	0.19	5.10	0.43	5.74	0.57	6.70	0.19	35.069	0.28	24.0	8.09	97.3
	50 S	0.6	0.11	0.59	0.22	3.73	0.45	7.22	0.56	8.03	0.12	35.124	0.10	24.3	8.09	100.3
	50 D	4.4	0.11	0.22	0.20	2.22	0.46	7.23	0.57	7.65	0.05	35.194	0.12	24.5	8.10	100.7
	100 S	0.6	0.09	0.40	0.06	2.88	0.46	6.11	0.55	6.57	0.08	35.154	0.10	24.3	8.09	98.5
	100 D	5.6	0.07	0.32	0.16	2.79	0.47	6.64	0.54	7.12	0.10	35.161	0.09	24.4	8.10	99.3
	150 S	0.5	0.06	0.27	0.22	2.80	0.46	6.48	0.52	6.97	0.11	35.166	0.07	24.2	8.09	100.7
	150 D	7.2	0.09	0.15	0.20	2.27	0.45	5.86	0.54	6.21	0.08	35.194	0.08	24.4	8.09	98.3
	200 S	0.6	0.05	0.19	0.09	2.48	0.48	6.51	0.53	6.79	0.13	35.182	0.06	24.3	8.10	101.3
	200 D	12.0	0.09	0.15	0.03	2.21	0.46	6.32	0.55	6.50	0.04	35.198	0.06	24.4	8.10	101.7
MAKENA 3-A	0 S	0.1	0.13	1.32	0.17	6.55	0.51	7.33	0.64	8.82	0.59	35.041	0.28	24.1	8.05	94.5
	2 S	0.1	0.13	1.26	0.22	5.75	0.51	9.39	0.64	10.87	0.30	35.052	0.20	24.1	8.04	94.7
	5 S	0.5	0.04	0.85	0.04	4.68	0.49	9.07	0.53	9.96	0.18	35.072	0.31	24.0	8.05	96.6
	5 D	1.1	0.06	0.86	BDL	4.51	0.51	7.83	0.57	8.69	0.18	35.091	0.23	24.0	8.05	96.0
	10 S	0.5	0.14	1.00	0.11	4.20	0.43	9.06	0.57	10.17	0.15	35.106	0.17	24.0	8.05	97.9
	10 D	2.9	0.13	0.96	0.15	4.33	0.43	8.60	0.56	9.71	0.12	35.080	0.30	23.5	8.05	102.2
	50 S	0.5	0.14	0.94	0.13	4.37	0.42	8.86	0.56	9.93	0.12	35.083	0.21	24.2	8.06	97.5
	50 D	4.5	0.12	0.65	0.18	3.54	0.42	8.71	0.54	9.54	0.09	35.137	0.22	24.3	8.07	97.7
	100 S	0.5	0.15	0.85	0.30	4.07	0.41	7.79	0.56	8.94	0.13	35.109	0.14	24.2	8.07	99.6
	100 D	5.0	0.13	0.81	0.23	3.21	0.44	9.01	0.57	10.05	0.14	35.153	0.17	24.3	8.04	99.0
	150 S	0.5	0.13	0.95	0.25	4.02	0.49	9.15	0.62	10.35	0.12	35.106	0.16	24.2	8.06	100.9
	150 D	10.4	0.14	0.56	0.23	3.13	0.43	9.43	0.57	10.22	0.10	35.170	0.13	24.3	8.07	103.2
MAKENA 3	0 S	0.1	0.13	0.60	0.25	3.41	0.47	9.35	0.60	10.20	0.21	35.179	0.16	24.1	8.03	97.0
	2 S	0.1	0.06	0.50	0.22	3.26	0.47	10.19	0.53	10.91	0.15	35.179	0.17	23.9	8.02	100.0
	5 S	0.5	0.10	0.55	0.20	3.12	0.45	9.02	0.55	9.77	0.12	35.163	0.12	23.9	8.03	96.7
	5 D	1.7	0.06	0.58	0.11	3.15	0.44	9.40	0.50	10.09	0.13	35.188	0.21	23.9	8.03	97.1
	10 S	0.5	0.07	0.64	0.24	3.34	0.44	7.76	0.51	8.64	0.12	35.174	0.12	23.8	8.03	97.6
	10 D	2.8	0.15	0.69	0.22	3.36	0.40	8.42	0.55	9.33	0.11	35.167	0.15	23.8	8.02	98.8
	50 S	0.5	0.07	0.79	0.16	3.40	0.47	7.90	0.54	8.85	0.11	35.166	0.09	24.1	8.03	98.0
	50 D	5.2	0.15	0.73	0.18	3.74	0.43	8.55	0.58	9.46	0.10	35.142	0.09	24.2	8.03	101.0
	100 S	0.5	0.14	0.64	0.19	3.14	0.44	9.31	0.58	10.14	0.10	35.176	0.09	24.1	8.05	97.7
	100 D	7.6	0.18	0.56	0.18	3.20	0.40	7.75	0.58	8.49	0.06	35.177	0.08	24.2	8.07	98.1
	150 S	0.5	0.11	0.16	0.12	2.19	0.44	8.11	0.55	8.39	0.03	35.216	0.06	24.3	8.10	98.6
	150 D	13.7	0.12	BDL	0.12	2.25	0.45	9.41	0.57	9.53	0.02	35.246	0.09	24.3	8.11	99.8
MAKENA 4	0 S	0.1	0.27	0.38	0.43	2.97	0.53	10.85	0.80	11.66	0.12	35.187	0.19	23.9	8.01	95.0
	2 S	0.1	0.09	0.40	0.53	2.91	0.45	9.61	0.54	10.54	0.17	35.195	0.17	23.9	8.00	97.2
	5 S	0.7	0.59	0.30	0.32	3.03	0.32	7.94	0.91	8.56	0.05	35.191	0.20	24.0	8.02	92.6
	5 D	2.7	0.14	0.28	BDL	2.54	0.44	7.35	0.58	7.63	0.14	35.194	0.24	23.9	8.02	98.9
	10 S	0.8	0.05	0.37	0.24	2.58	0.45	7.85	0.50	8.46	0.09	35.195	0.16	24.0	8.01	93.9
	10 D	2.5	0.13	0.32	0.15	2.52	0.43	8.16	0.56	8.63	0.11	35.182	0.19	23.9	8.01	96.2
	50 S	0.9	0.06	0.31	0.12	2.98	0.50	7.48	0.56	7.91	0.07	35.192	0.08	24.1	8.03	97.0
	50 D	4.5	0.06	0.30	0.06	3.32	0.50	6.50	0.56	6.86	0.07	35.156	0.16	24.1	8.03	99.2
	100 S	0.8	0.05	0.34	0.09	2.60	0.51	9.59	0.56	10.02	0.03	35.191	0.07	24.1	8.06	94.6
	100 D	7.0	0.25	0.26	0.28	2.51	0.46	8.84	0.71	9.38	0.04	35.184	0.12	24.2	8.06	100.9
	150 S	0.5	0.11	0.23	0.09	2.35	0.45	7.78	0.56	8.10	0.02	35.213	0.09	24.2	8.10	95.9
	150 D	9.7	0.08	0.12	0.06	2.76	0.47	6.62	0.55	6.80	0.02	35.181	0.07	24.2	8.10	98.2
DOH WQS		DRY	10%	0.71	0.36				0.96	12.86	0.50	*	0.50	**	***	****
			2%	1.43	0.64				1.45	17.86	1.00		1.00			
		WET	10%	1.00	0.61				1.29	17.85	1.25	*	0.90	**	***	****
			2%	1.78	1.07				1.93	25.00	2.00		1.75			

* Salinity shall not vary more than ten percent form natural or seasonal changes considering hydrologic input and oceanographic conditions.

** Temperature shall not vary by more than one degree C. from ambient conditions.

***pH shall not deviate more than 0.5 units from a value of 8.1.

****Dissolved Oxygen not to be below 75% saturation.

TABLE 2. Water chemistry measurements from ocean water samples (in μg/L) collected in the vicinity of the Makena Resort on January 4, 2013. Abbreviations as follows: DFS=distance from shore; S=surface; D=deep; BDL=below detection limit. Also shown are the State of Hawaii, Department of Health (DOH) "not to exceed more than 10% of the time" and "not to exceed more than 2% of the time" water quality standards for open coastal waters under "dry" and "wet" conditions. Boxed values exceed DOH 10% "dry" standards; boxed and shaded values exceed DOH 10% "wet" standards. For sampling site locations, see Figure 1.

TRANSECT SITE	DFS (m)	DEPTH (m)	PO_4^{3-} (μg/L)	NO_3^- (μg/L)	NH_4^+ (μg/L)	Si (μg/L)	TOP (μg/L)	TON (μg/L)	TP (μg/L)	TN (μg/L)	TURB (NTU)	SALINITY (ppt)	CHL a (μg/L)	TEMP (deg.C)	pH (std.units)	O2 % Sat
MAKENA 1	0 S	0.1	0.62	9.24	0.84	96.66	12.09	104.2	12.71	114.2	0.19	35.129	0.13	24.2	8.08	102.6
	2 S	0.1	2.17	13.86	1.12	98.07	15.81	89.88	17.98	104.9	0.23	35.119	0.15	24.3	8.09	102.5
	5 S	0.5	3.72	37.24	1.54	201.8	13.64	89.88	17.36	128.7	0.61	34.875	0.17	24.3	8.08	103.1
	5 D	1.5	2.79	24.92	1.82	150.6	13.33	91.84	16.12	118.6	0.49	35.012	0.15	24.3	8.08	103.0
	10 S	0.5	3.10	7.84	1.96	65.75	13.64	88.90	16.74	98.70	0.17	35.182	0.12	24.3	8.08	101.8
	10 D	2.4	2.48	11.62	2.10	85.99	14.57	94.08	17.05	107.8	0.22	35.149	0.10	24.3	8.09	102.6
	50 S	0.5	2.48	26.74	2.52	134.9	13.64	98.00	16.12	127.3	0.14	35.028	0.13	24.2	8.07	101.6
	50 D	4.1	2.17	6.16	2.80	71.09	13.95	92.82	16.12	101.8	0.12	35.174	0.17	24.5	8.08	101.5
	100 S	0.5	2.17	20.16	2.80	125.6	13.64	84.00	15.81	107.0	0.16	35.044	0.08	24.3	8.07	102.1
	100 D	5.5	2.17	2.10	2.24	47.77	13.33	94.64	15.50	98.98	0.08	35.222	0.07	24.5	8.10	102.0
	150 S	0.6	2.79	7.84	1.96	66.88	13.95	102.3	16.74	112.1	0.09	35.170	0.09	24.3	8.10	100.8
	150 D	10.4	2.79	1.54	2.24	49.74	13.95	126.4	16.74	130.2	0.05	35.204	0.10	24.5	8.10	101.6
MAKENA 2	0 S	0.1	6.20	16.52	3.22	247.3	13.33	77.84	19.53	97.58	0.63	34.988	0.42	24.0	8.09	99.3
	2 S	0.1	5.27	15.40	2.52	242.5	13.33	84.98	18.60	102.9	0.65	34.995	0.40	24.0	8.09	99.7
	5 S	0.6	5.27	16.24	2.66	225.1	13.95	84.98	19.22	103.9	0.52	34.964	0.48	24.0	8.09	97.5
	5 D	2.2	5.27	16.52	2.10	225.6	14.57	86.24	19.84	104.9	0.55	34.979	0.42	24.0	8.09	98.3
	10 S	0.5	4.65	14.28	0.84	177.0	13.64	88.06	18.29	103.2	0.29	35.018	0.37	24.0	8.09	99.7
	10 D	3.0	4.34	10.78	2.66	143.3	13.33	80.36	17.67	93.80	0.19	35.069	0.28	24.0	8.09	97.3
	50 S	0.6	3.41	8.26	3.08	104.8	13.95	101.1	17.36	112.4	0.12	35.124	0.10	24.3	8.09	100.3
	50 D	4.4	3.41	3.08	2.80	62.38	14.26	101.2	17.67	107.1	0.05	35.194	0.12	24.5	8.10	100.7
	100 S	0.6	2.79	5.60	0.84	80.93	14.26	85.54	17.05	91.98	0.08	35.154	0.10	24.3	8.09	98.5
	100 D	5.6	2.17	4.48	2.24	78.40	14.57	92.96	16.74	99.68	0.10	35.161	0.09	24.4	8.10	99.3
	150 S	0.5	1.86	3.78	3.08	78.68	14.26	90.72	16.12	97.58	0.11	35.166	0.07	24.2	8.09	100.7
	150 D	7.2	2.79	2.10	2.80	63.79	13.95	82.04	16.74	86.94	0.08	35.194	0.08	24.4	8.09	98.3
	200 S	0.6	1.55	2.66	1.26	69.69	14.88	91.14	16.43	95.06	0.13	35.182	0.06	24.3	8.10	101.3
	200 D	12.0	2.79	2.10	0.42	62.10	14.26	88.48	17.05	91.00	0.04	35.198	0.06	24.4	8.10	101.7
MAKENA 3-A	0 S	0.1	4.03	18.48	2.38	184.1	15.81	102.6	19.84	123.5	0.59	35.041	0.28	24.1	8.05	94.5
	2 S	0.1	4.03	17.64	3.08	161.6	15.81	131.5	19.84	152.2	0.30	35.052	0.20	24.1	8.04	94.7
	5 S	0.5	1.24	11.90	0.56	131.5	15.19	127.0	16.43	139.4	0.18	35.072	0.31	24.0	8.05	96.6
	5 D	1.1	1.86	12.04	BDL	126.7	15.81	109.6	17.67	121.7	0.18	35.091	0.23	24.0	8.05	96.0
	10 S	0.5	4.34	14.00	1.54	118.0	13.33	126.8	17.67	142.4	0.15	35.106	0.17	24.0	8.05	97.9
	10 D	2.9	4.03	13.44	2.10	121.7	13.33	120.4	17.36	135.9	0.12	35.080	0.30	23.5	8.05	102.2
	50 S	0.5	4.34	13.16	1.82	122.8	13.02	124.0	17.36	139.0	0.12	35.083	0.21	24.2	8.06	97.5
	50 D	4.5	3.72	9.10	2.52	99.47	13.02	121.9	16.74	133.6	0.09	35.137	0.22	24.3	8.07	97.7
	100 S	0.5	4.65	11.90	4.20	114.4	12.71	109.1	17.36	125.2	0.13	35.109	0.14	24.2	8.07	99.6
	100 D	5.0	4.03	11.34	3.22	90.20	13.64	126.1	17.67	140.7	0.14	35.153	0.17	24.3	8.04	99.0
	150 S	0.5	4.03	13.30	3.50	113.0	15.19	128.1	19.22	144.9	0.12	35.106	0.16	24.2	8.06	100.9
	150 D	10.4	4.34	7.84	3.22	87.95	13.33	132.0	17.67	143.1	0.10	35.170	0.13	24.3	8.07	103.2
MAKENA 3	0 S	0.1	4.03	8.40	3.50	95.82	14.57	130.9	18.60	142.8	0.21	35.179	0.16	24.1	8.03	97.0
	2 S	0.1	1.86	7.00	3.08	91.61	14.57	142.7	16.43	152.7	0.15	35.179	0.17	23.9	8.02	100.0
	5 S	0.5	3.10	7.70	2.80	87.67	13.95	126.3	17.05	136.8	0.12	35.163	0.12	23.9	8.03	96.7
	5 D	1.7	1.86	8.12	1.54	88.52	13.64	131.6	15.50	141.3	0.13	35.188	0.21	23.9	8.03	97.1
	10 S	0.5	2.17	8.96	3.36	93.85	13.64	108.6	15.81	121.0	0.12	35.174	0.12	23.8	8.03	97.6
	10 D	2.8	4.65	9.66	3.08	94.42	12.40	117.9	17.05	130.6	0.11	35.167	0.15	23.8	8.02	98.8
	50 S	0.5	2.17	11.06	2.24	95.54	14.57	110.6	16.74	123.9	0.11	35.166	0.09	24.1	8.03	98.0
	50 D	5.2	4.65	10.22	2.52	105.1	13.33	119.7	17.98	132.4	0.10	35.142	0.09	24.2	8.03	101.0
	100 S	0.5	4.34	8.96	2.66	88.23	13.64	130.3	17.98	142.0	0.10	35.176	0.09	24.1	8.05	97.7
	100 D	7.6	5.58	7.84	2.52	89.92	12.40	108.5	17.98	118.9	0.06	35.177	0.08	24.2	8.07	98.1
	150 S	0.5	3.41	2.24	1.68	61.54	13.64	113.5	17.05	117.5	0.03	35.216	0.06	24.3	8.10	98.6
	150 D	13.7	3.72	BDL	1.68	63.23	13.95	131.7	17.67	133.4	0.02	35.246	0.09	24.3	8.11	99.8
MAKENA 4	0 S	0.1	8.37	5.32	6.02	83.46	16.43	151.9	24.80	163.2	0.12	35.187	0.19	23.9	8.01	95.0
	2 S	0.1	2.79	5.60	7.42	81.77	13.95	134.5	16.74	147.6	0.17	35.195	0.17	23.9	8.00	97.2
	5 S	0.7	18.29	4.20	4.48	85.14	9.92	111.2	28.21	119.8	0.05	35.191	0.20	24.0	8.02	92.6
	5 D	2.7	4.34	3.92	BDL	71.37	13.64	102.9	17.98	106.8	0.14	35.194	0.24	23.9	8.02	98.9
	10 S	0.8	1.55	5.18	3.36	72.50	13.95	109.9	15.50	118.4	0.09	35.195	0.16	24.0	8.01	93.9
	10 D	2.5	4.03	4.48	2.10	70.81	13.33	114.2	17.36	120.8	0.11	35.182	0.19	23.9	8.01	96.2
	50 S	0.9	1.86	4.34	1.68	83.74	15.50	104.7	17.36	110.7	0.07	35.192	0.08	24.1	8.03	97.0
	50 D	4.5	1.86	4.20	0.84	93.29	15.50	91.00	17.36	96.04	0.07	35.156	0.16	24.1	8.03	99.2
	100 S	0.8	1.55	4.76	1.26	73.06	15.81	134.3	17.36	140.3	0.03	35.191	0.07	24.1	8.06	94.6
	100 D	7.0	7.75	3.64	3.92	70.53	14.26	123.8	22.01	131.3	0.04	35.184	0.12	24.2	8.06	100.9
	150 S	0.5	3.41	3.22	1.26	66.04	13.95	108.9	17.36	113.4	0.02	35.213	0.09	24.2	8.10	95.9
	150 D	9.7	2.48	1.68	0.84	77.56	14.57	92.68	17.05	95.20	0.02	35.181	0.07	24.2	8.10	98.2
DOH WQS		DRY	10%	10.00	5.00				30.00	180.00	0.50	*	0.50	**	***	****
			2%	20.00	9.00				45.00	250.00	1.00		1.00			
		WET	10%	14.00	8.50				40.00	250.00	1.25	*	0.90	**	***	****
			2%	25.00	15.00				60.00	350.00	2.00		1.75			

* Salinity shall not vary more than ten percent form natural or seasonal changes considering hydrologic input and oceanographic conditions.

** Temperature shall not vary by more than one degree C. from ambient conditions.

***pH shall not deviate more than 0.5 units from a value of 8.1.

****Dissolved Oxygen not to be below 75% saturation.

TABLE 3. Geometric mean data from water chemistry measurements (in µM) off the Makena Resort collected since August 1995 from Sites 1, 2, and 4 (N=28); since June 2002 from Site 3 (N=19) and since June 2007 from Site 3-A (N=10). For geometric mean calculations, detection limits were used in cases where sample was below detection limit. Abbreviations as follows: DFS=distance from shore; S=surface; D=deep. Also shown are State of Hawaii, Department of Health (DOH) geometric mean water quality standards for open coastal waters under "dry" and "wet" conditions. Boxed values exceed DOH GM 10% "dry" standards; boxed and shaded values exceed DOH GM 10% "wet" standards. For sampling site locations, see Figure 1.

TRANSECT SITE	DFS (m)	PO_4^{3-} (µM)	NO_3^- (µM)	NH_4^+ (µM)	Si (µM)	TOP (µM)	TON (µM)	TP (µM)	TN (µM)	TURB (NTU)	SALINITY (ppt)	CHL a (µg/L)	TEMP (deg.C)	pH	O2
MAKENA 1	0 S	0.20	36.13	0.33	65.41	0.24	7.78	0.54	53.14	0.34	26.185	0.79	25.6	8.13	102.6
	2 S	0.16	24.41	0.19	46.43	0.26	8.15	0.47	37.69	0.29	29.832	0.77	25.6	8.16	105.0
	5 S	0.12	11.26	0.13	25.12	0.25	7.90	0.41	23.49	0.25	32.185	0.51	25.5	8.16	105.1
	5 D	0.12	8.66	0.19	20.61	0.27	7.48	0.41	19.48	0.21	33.111	0.46	25.6	8.17	105.5
	10 S	0.10	3.77	0.15	10.30	0.26	7.35	0.38	13.07	0.19	34.071	0.32	25.6	8.15	104.5
	10 D	0.10	2.23	0.20	6.94	0.28	7.27	0.39	10.78	0.17	34.410	0.32	25.5	8.15	103.7
	50 S	0.08	2.38	0.20	7.04	0.26	7.17	0.37	10.81	0.16	34.453	0.27	25.6	8.14	100.3
	50 D	0.08	0.30	0.14	2.58	0.28	7.17	0.37	7.96	0.12	34.804	0.25	25.5	8.14	99.3
	100 S	0.09	0.88	0.16	4.54	0.27	6.67	0.37	9.19	0.13	34.596	0.22	25.5	8.14	98.4
	100 D	0.07	0.11	0.09	2.11	0.28	7.20	0.36	7.68	0.10	34.850	0.19	25.5	8.15	98.1
	150 S	0.08	0.27	0.16	2.93	0.27	7.16	0.37	8.32	0.12	34.764	0.18	25.7	8.14	97.4
	150 D	0.08	0.07	0.13	1.85	0.28	7.03	0.37	7.39	0.10	34.868	0.16	25.5	8.15	98.2
MAKENA 2	0 S	0.19	4.12	0.37	21.80	0.32	8.16	0.55	13.82	0.89	33.435	0.73	25.7	8.14	98.2
	2 S	0.18	3.70	0.25	19.12	0.32	7.78	0.53	12.75	0.65	33.615	0.72	25.8	8.14	100.3
	5 S	0.16	2.96	0.25	14.29	0.29	7.10	0.47	11.04	0.45	34.070	0.56	25.6	8.14	100.0
	5 D	0.17	2.77	0.29	14.25	0.31	7.33	0.50	11.34	0.42	34.117	0.68	25.6	8.14	99.3
	10 S	0.12	1.66	0.21	9.26	0.30	5.68	0.44	9.23	0.31	34.407	0.40	25.6	8.14	98.6
	10 D	0.11	0.98	0.25	7.54	0.30	7.05	0.44	8.94	0.27	34.528	0.43	25.6	8.14	97.4
	50 S	0.10	1.13	0.26	7.26	0.32	7.57	0.44	9.63	0.23	34.472	0.30	25.5	8.13	97.4
	50 D	0.11	0.21	0.23	3.14	0.30	7.40	0.43	8.09	0.17	34.816	0.33	25.5	8.14	96.9
	100 S	0.09	0.45	0.19	4.08	0.29	7.15	0.40	8.14	0.16	34.665	0.25	25.6	8.13	97.6
	100 D	0.08	0.13	0.18	2.37	0.29	7.06	0.39	7.58	0.13	34.845	0.24	25.5	8.14	97.0
	150 S	0.09	0.23	0.20	3.11	0.29	7.28	0.40	7.94	0.14	34.792	0.20	25.6	8.14	97.1
	150 D	0.08	0.08	0.15	2.08	0.30	7.32	0.39	7.69	0.10	34.868	0.20	25.5	8.15	97.3
	200 S	0.07	0.10	0.16	2.35	0.29	7.11	0.38	7.61	0.11	34.864	0.21	25.7	8.15	97.9
	200 D	0.08	0.04	0.18	1.71	0.29	7.58	0.38	7.90	0.10	34.893	0.21	25.5	8.16	97.6
MAKENA 3-A	0 S	1.14	110.1	0.34	231.8	0.21	10.11	1.60	141.7	0.34	15.525	0.27	24.9	7.89	97.1
	2 S	0.85	75.65	0.34	154.9	0.27	8.08	1.40	110.1	0.23	21.411	0.32	25.0	7.91	97.5
	5 S	0.30	26.21	0.38	57.58	0.34	8.56	0.77	50.34	0.20	29.565	0.29	25.0	8.00	98.1
	5 D	0.20	15.40	0.34	36.60	0.30	7.54	0.61	30.23	0.19	32.066	0.30	25.2	8.05	98.4
	10 S	0.10	5.26	0.22	15.93	0.28	7.63	0.44	17.81	0.14	33.625	0.18	25.2	8.08	98.7
	10 D	0.07	1.27	0.19	5.46	0.27	6.93	0.37	9.41	0.15	34.698	0.22	25.1	8.10	99.6
	50 S	0.09	1.75	0.20	7.68	0.27	7.60	0.40	11.64	0.12	34.528	0.14	25.5	8.10	98.8
	50 D	0.07	0.13	0.30	3.10	0.29	7.95	0.39	8.62	0.12	34.878	0.15	25.3	8.11	98.4
	100 S	0.09	0.79	0.13	4.79	0.28	7.01	0.39	8.71	0.12	34.790	0.14	25.5	8.10	97.9
	100 D	0.11	0.05	0.29	2.36	0.29	7.18	0.41	7.69	0.11	34.962	0.12	25.3	8.12	99.2
	150 S	0.07	0.12	0.14	3.19	0.32	7.80	0.41	8.81	0.13	34.887	0.12	25.4	8.12	98.5
	150 D	0.07	0.02	0.24	2.08	0.28	7.23	0.37	7.62	0.12	34.968	0.13	25.2	8.13	101.0
MAKENA 3	0 S	0.13	8.37	0.33	18.20	0.27	6.41	0.46	23.45	0.32	33.806	0.45	25.8	8.14	100.7
	2 S	0.15	12.33	0.26	22.90	0.27	6.04	0.47	26.93	0.29	33.813	0.49	25.7	8.12	101.6
	5 S	0.13	8.32	0.20	16.02	0.29	7.58	0.48	21.32	0.21	34.105	0.31	25.6	8.11	101.5
	5 D	0.13	5.90	0.18	12.36	0.28	6.97	0.45	17.68	0.21	34.318	0.38	25.6	8.11	100.2
	10 S	0.10	3.86	0.24	8.96	0.28	7.27	0.42	14.64	0.17	34.458	0.24	25.5	8.11	98.5
	10 D	0.09	1.95	0.16	5.98	0.29	7.61	0.40	11.74	0.15	34.691	0.25	25.4	8.11	97.9
	50 S	0.08	1.39	0.18	5.06	0.28	7.38	0.38	10.34	0.14	34.711	0.19	25.5	8.11	95.6
	50 D	0.09	0.32	0.17	2.88	0.29	7.61	0.39	8.45	0.10	34.876	0.19	25.4	8.12	94.1
	100 S	0.08	0.44	0.21	2.96	0.29	7.42	0.39	8.48	0.11	34.834	0.15	25.5	8.12	96.2
	100 D	0.07	0.11	0.23	2.04	0.29	6.92	0.38	7.47	0.09	34.882	0.16	25.5	8.13	96.0
	150 S	0.06	0.12	0.14	2.28	0.28	6.90	0.36	7.49	0.10	34.860	0.13	25.5	8.15	96.6
	150 D	0.07	0.06	0.12	1.83	0.28	7.03	0.37	7.35	0.09	34.911	0.16	25.5	8.16	97.9
MAKENA 4	0 S	0.20	36.13	0.33	65.41	0.24	7.78	0.54	53.14	0.34	26.185	0.79	25.6	8.13	100.8
	2 S	0.16	24.41	0.19	46.43	0.26	8.15	0.47	37.69	0.29	29.832	0.77	25.6	8.16	101.8
	5 S	0.12	11.26	0.13	25.12	0.25	7.90	0.41	23.49	0.25	32.185	0.51	25.5	8.16	102.5
	5 D	0.12	8.66	0.19	20.61	0.27	7.48	0.41	19.48	0.21	33.111	0.46	25.6	8.17	101.7
	10 S	0.10	3.77	0.15	10.30	0.26	7.35	0.38	13.07	0.19	34.071	0.32	25.6	8.15	100.1
	10 D	0.10	2.23	0.20	6.94	0.28	7.27	0.39	10.78	0.17	34.410	0.32	25.5	8.15	100.8
	50 S	0.08	2.38	0.20	7.04	0.26	7.17	0.37	10.81	0.16	34.453	0.27	25.6	8.14	94.8
	50 D	0.08	0.30	0.14	2.58	0.28	7.17	0.37	7.96	0.12	34.804	0.25	25.5	8.14	94.1
	100 S	0.09	0.88	0.16	4.54	0.27	6.67	0.37	9.19	0.13	34.596	0.22	25.5	8.14	94.9
	100 D	0.07	0.11	0.09	2.11	0.28	7.20	0.36	7.68	0.10	34.850	0.19	25.5	8.15	93.7
	150 S	0.08	0.27	0.16	2.93	0.27	7.16	0.37	8.32	0.12	34.764	0.18	25.7	8.14	96.4
	150 D	0.08	0.07	0.13	1.85	0.28	7.03	0.37	7.39	0.10	34.868	0.16	25.5	8.15	95.4
DOH WQS GEOMETRIC MEAN	DRY		0.25	0.14				0.52	7.86	0.20	*	0.15	**	***	
	WET		0.36	0.25				0.64	10.71	0.50		0.30			

* Salinity shall not vary more than ten percent form natural or seasonal changes considering hydrologic input and oceanographic conditions.

** Temperature shall not vary by more than one degree C. from ambient conditions.

***pH shall not deviate more than 0.5 units from a value of 8.1.

****Dissolved Oxygen not to be below 75% saturation.

TABLE 4. Geometric mean data (in μg/L) from water chemistry measurements (in μM) off the Makena Resort collected since August 1995 for Sites 1, 2, and 4 (N=28); since June 2002 from Site 3 (N=19) and since June 2007 from Site 3-A (N=10). For geometric mean calculations, detection limits were used in cases where sample was below detection limit. Abbreviations as follows: DFS=distance from shore; S=surface; D=deep. Also shown are State of Hawaii, Department of Health (DOH) geometric mean water quality standards for open coastal waters under "dry" and "wet" conditions. Boxed values exceed DOH GM 10% "dry" standards; boxed and shaded values exceed DOH GM 10% "wet" standards. For sampling site locations, see Figure 1.

TRANSECT SITE	DFS (m)	PO_4^{3-} (μg/L)	NO_3^- (μg/L)	NH_4^+ (μg/L)	Si (μg/L)	TOP (μg/L)	TON (μg/L)	TP (μg/L)	TN (μg/L)	TURB (NTU)	SALINITY (ppt)	CHL a (μg/L)	TEMP (deg.C)	pH	O2
MAKENA 1	0 S	6.10	506.0	4.60	1837	7.40	108.9	16.70	744.2	0.34	26.185	0.79	25.6	8.13	102.6
	2 S	4.90	341.8	2.60	1304	8.00	114.1	14.50	527.8	0.29	29.832	0.77	25.6	8.16	105.0
	5 S	3.70	157.7	1.80	705.6	7.70	110.6	12.60	329.0	0.25	32.185	0.51	25.5	8.16	105.1
	5 D	3.70	121.2	2.60	578.9	8.30	104.7	12.60	272.8	0.21	33.111	0.46	25.6	8.17	105.5
	10 S	3.00	52.80	2.10	289.3	8.00	102.9	11.70	183.0	0.19	34.071	0.32	25.6	8.15	104.5
	10 D	3.00	31.20	2.80	194.9	8.60	101.8	12.00	150.9	0.17	34.410	0.32	25.5	8.15	103.7
	50 S	2.40	33.30	2.80	197.8	8.00	100.4	11.40	151.4	0.16	34.453	0.27	25.6	8.14	100.3
	50 D	2.40	4.20	1.90	72.47	8.60	100.4	11.40	111.4	0.12	34.804	0.25	25.5	8.14	99.3
	100 S	2.70	12.30	2.20	127.5	8.30	93.40	11.40	128.7	0.13	34.596	0.22	25.5	8.14	98.4
	100 D	2.10	1.50	1.20	59.27	8.60	100.8	11.10	107.5	0.10	34.850	0.19	25.5	8.15	98.1
	150 S	2.40	3.70	2.20	82.30	8.30	100.2	11.40	116.5	0.12	34.764	0.18	25.7	8.14	97.4
	150 D	2.40	0.90	1.80	51.97	8.60	98.40	11.40	103.5	0.10	34.868	0.16	25.5	8.15	98.2
MAKENA 2	0 S	5.80	57.70	5.10	612.4	9.90	114.2	17.00	193.5	0.89	33.435	0.73	25.7	8.14	98.2
	2 S	5.50	51.80	3.50	537.1	9.90	108.9	16.40	178.5	0.65	33.615	0.72	25.8	8.14	100.3
	5 S	4.90	41.40	3.50	401.4	8.90	99.40	14.50	154.6	0.45	34.070	0.56	25.6	8.14	100.0
	5 D	5.20	38.70	4.00	400.3	9.60	102.6	15.40	158.8	0.42	34.117	0.68	25.6	8.14	99.3
	10 S	3.70	23.20	2.90	260.1	9.20	79.50	13.60	129.2	0.31	34.407	0.40	25.6	8.14	98.6
	10 D	3.40	13.70	3.50	211.8	9.20	98.70	13.60	125.2	0.27	34.528	0.43	25.6	8.14	97.4
	50 S	3.00	15.80	3.60	203.9	9.90	106.0	13.60	134.8	0.23	34.472	0.30	25.5	8.13	97.4
	50 D	3.40	2.90	3.20	88.20	9.20	103.6	13.30	113.3	0.17	34.816	0.33	25.5	8.14	96.9
	100 S	2.70	6.30	2.60	114.6	8.90	100.1	12.30	114.0	0.16	34.665	0.25	25.6	8.13	97.6
	100 D	2.40	1.80	2.50	66.57	8.90	98.80	12.00	106.1	0.13	34.845	0.24	25.5	8.14	97.0
	150 S	2.70	3.20	2.80	87.36	8.90	101.9	12.30	111.2	0.14	34.792	0.20	25.6	8.14	97.1
	150 D	2.40	1.10	2.10	58.43	9.20	102.5	12.00	107.7	0.10	34.868	0.20	25.5	8.15	97.3
	200 S	2.10	1.40	2.20	66.01	8.90	99.50	11.70	106.5	0.11	34.864	0.21	25.7	8.15	97.9
	200 D	2.40	0.50	2.50	48.03	8.90	106.1	11.70	110.6	0.10	34.893	0.21	25.5	8.16	97.6
MAKENA 3-A	0 S	35.30	1542	4.70	6512	6.50	141.6	49.50	1984	0.34	15.525	0.27	24.9	7.89	97.1
	2 S	26.30	1060	4.70	4352	8.30	113.1	43.30	1542	0.23	21.411	0.32	25.0	7.91	97.5
	5 S	9.20	367.0	5.30	1617	10.50	119.8	23.80	705.0	0.20	29.565	0.29	25.0	8	98.1
	5 D	6.10	215.6	4.70	1028	9.20	105.6	18.80	423.4	0.19	32.066	0.30	25.2	8.05	98.4
	10 S	3.00	73.60	3.00	447.5	8.60	106.8	13.60	249.4	0.14	33.625	0.18	25.2	8.08	98.7
	10 D	2.10	17.70	2.60	153.4	8.30	97.00	11.40	131.7	0.15	34.698	0.22	25.1	8.1	99.6
	50 S	2.70	24.50	2.80	215.7	8.30	106.4	12.30	163.0	0.12	34.528	0.14	25.5	8.1	98.8
	50 D	2.10	1.80	4.20	87.08	8.90	111.3	12.00	120.7	0.12	34.878	0.15	25.3	8.11	98.4
	100 S	2.70	11.00	1.80	134.6	8.60	98.10	12.00	121.9	0.12	34.790	0.14	25.5	8.1	97.9
	100 D	3.40	0.70	4.00	66.29	8.90	100.5	12.60	107.7	0.11	34.962	0.12	25.3	8.12	99.2
	150 S	2.10	1.60	1.90	89.61	9.90	109.2	12.60	123.3	0.13	34.887	0.12	25.4	8.12	98.5
	150 D	2.10	0.20	3.30	58.43	8.60	101.2	11.40	106.7	0.12	34.968	0.13	25.2	8.13	101.0
MAKENA 3	0 S	4.00	117.2	4.60	511.2	8.30	89.70	14.20	328.4	0.32	33.806	0.45	25.8	8.14	100.7
	2 S	4.60	172.6	3.60	643.3	8.30	84.50	14.50	377.1	0.29	33.813	0.49	25.7	8.12	101.6
	5 S	4.00	116.5	2.80	450.0	8.90	106.1	14.80	298.6	0.21	34.105	0.31	25.6	8.11	101.5
	5 D	4.00	82.60	2.50	347.2	8.60	97.60	13.90	247.6	0.21	34.318	0.38	25.6	8.11	100.2
	10 S	3.00	54.00	3.30	251.7	8.60	101.8	13.00	205.0	0.17	34.458	0.24	25.5	8.11	98.5
	10 D	2.70	27.30	2.20	168.0	8.90	106.5	12.30	164.4	0.15	34.691	0.25	25.4	8.11	97.9
	50 S	2.40	19.40	2.50	142.1	8.60	103.3	11.70	144.8	0.14	34.711	0.19	25.5	8.11	95.6
	50 D	2.70	4.40	2.30	80.90	8.90	106.5	12.00	118.3	0.10	34.876	0.19	25.4	8.12	94.1
	100 S	2.40	6.10	2.90	83.15	8.90	103.9	12.00	118.7	0.11	34.834	0.15	25.5	8.12	96.2
	100 D	2.10	1.50	3.20	57.30	8.90	96.90	11.70	104.6	0.09	34.882	0.16	25.5	8.13	96.0
	150 S	1.80	1.60	1.90	64.05	8.60	96.60	11.10	104.9	0.10	34.860	0.13	25.5	8.15	96.6
	150 D	2.10	0.80	1.60	51.40	8.60	98.40	11.40	102.9	0.09	34.911	0.16	25.5	8.16	97.9
MAKENA 4	0 S	6.10	506.0	4.60	1837	7.40	108.9	16.70	744.2	0.34	26.185	0.79	25.6	8.13	100.8
	2 S	4.90	341.8	2.60	1304	8.00	114.1	14.50	527.8	0.29	29.832	0.77	25.6	8.16	101.8
	5 S	3.70	157.7	1.80	705.6	7.70	110.6	12.60	329.0	0.25	32.185	0.51	25.5	8.16	102.5
	5 D	3.70	121.2	2.60	578.9	8.30	104.7	12.60	272.8	0.21	33.111	0.46	25.6	8.17	101.7
	10 S	3.00	52.80	2.10	289.3	8.00	102.9	11.70	183.0	0.19	34.071	0.32	25.6	8.15	100.1
	10 D	3.00	31.20	2.80	194.9	8.60	101.8	12.00	150.9	0.17	34.410	0.32	25.5	8.15	100.8
	50 S	2.40	33.30	2.80	197.8	8.00	100.4	11.40	151.4	0.16	34.453	0.27	25.6	8.14	94.8
	50 D	2.40	4.20	1.90	72.47	8.60	100.4	11.40	111.4	0.12	34.804	0.25	25.5	8.14	94.1
	100 S	2.70	12.30	2.20	127.5	8.30	93.40	11.40	128.7	0.13	34.596	0.22	25.5	8.14	94.9
	100 D	2.10	1.50	1.20	59.27	8.60	100.8	11.10	107.5	0.10	34.850	0.19	25.5	8.15	93.7
	150 S	2.40	3.70	2.20	82.30	8.30	100.2	11.40	116.5	0.12	34.764	0.18	25.7	8.14	96.4
	150 D	2.40	0.90	1.80	51.97	8.60	98.40	11.40	103.5	0.10	34.868	0.16	25.5	8.15	95.4
DOH WQS GEOMETRIC MEAN	DRY	3.50	2.00					16.00	110.00	0.20	*	0.15	**	***	
	WET	5.00	3.50					20.00	150.00	0.50		0.30			

* Salinity shall not vary more than ten percent form natural or seasonal changes considering hydrologic input and oceanographic conditions.

** Temperature shall not vary by more than one degree C. from ambient conditions.

***pH shall not deviate more than 0.5 units from a value of 8.1.

****Dissolved Oxygen not to be below 75% saturation.

TABLE 5. Water chemistry measurements in μM and μg/L (shaded) from irrigation wells and an irrigation lake collected in the vicinity of the Makena Resort on May 10, 2012. For sampling site locations, see Figure 1.

WELL	PO_4^{3-} (μM)	PO_4^{3-} (μg/L)	NO_3^- (μM)	NO_3^- (μg/L)	NH_4^+ (μM)	NH_4^+ (μg/L)	Si (μM)	Si (μg/L)	TOP (μM)	TOP (μg/L)	TON (μM)	TON (μg/L)	TP (μM)	TP (μg/L)	TN (μM)	TN (μg/L)	SALINITY (ppt)
1	2.10	65.10	124.6	1744.4	1.00	14.00	483.9	13597.6	0.55	17.05	6.80	95.20	2.65	82.15	132.4	1853.6	1.359
2	2.95	91.45	142.6	1996.4	0.80	11.20	648.4	18220.0	0.10	3.10	7.25	101.50	3.05	94.55	150.7	2109.1	1.827
3	3.10	96.10	137.2	1920.8	0.65	9.10	650.2	18270.6	0.15	4.65	12.95	181.30	3.25	100.75	150.8	2111.2	2.007
4	3.00	93.00	126.1	1765.4	0.60	8.40	612.5	17211.3	0.30	9.30	16.80	235.20	3.30	102.30	143.5	2009.0	1.739
5	2.70	83.70	161.4	2259.6	0.65	9.10	555.9	15620.8	0.60	18.60	10.70	149.80	3.30	102.30	172.8	2418.5	1.528
6	2.45	75.95	166.0	2323.3	0.35	4.90	523.8	14717.4	0.45	13.95	14.15	198.10	2.90	89.90	180.5	2526.3	1.611
8	2.80	86.80	111.3	1557.5	0.25	3.50	564.0	15847.0	0.30	9.30	14.55	203.70	3.10	96.10	126.1	1764.7	2.312
10	2.40	74.40	168.2	2354.8	4.75	66.50	578.2	16246.0	0.35	10.85	21.70	303.80	2.75	85.25	194.7	2725.1	1.829
11	2.45	75.95	117.1	1639.4	1.05	14.70	589.4	16562.1	0.65	20.15	17.80	249.20	3.10	96.10	136.0	1903.3	2.002

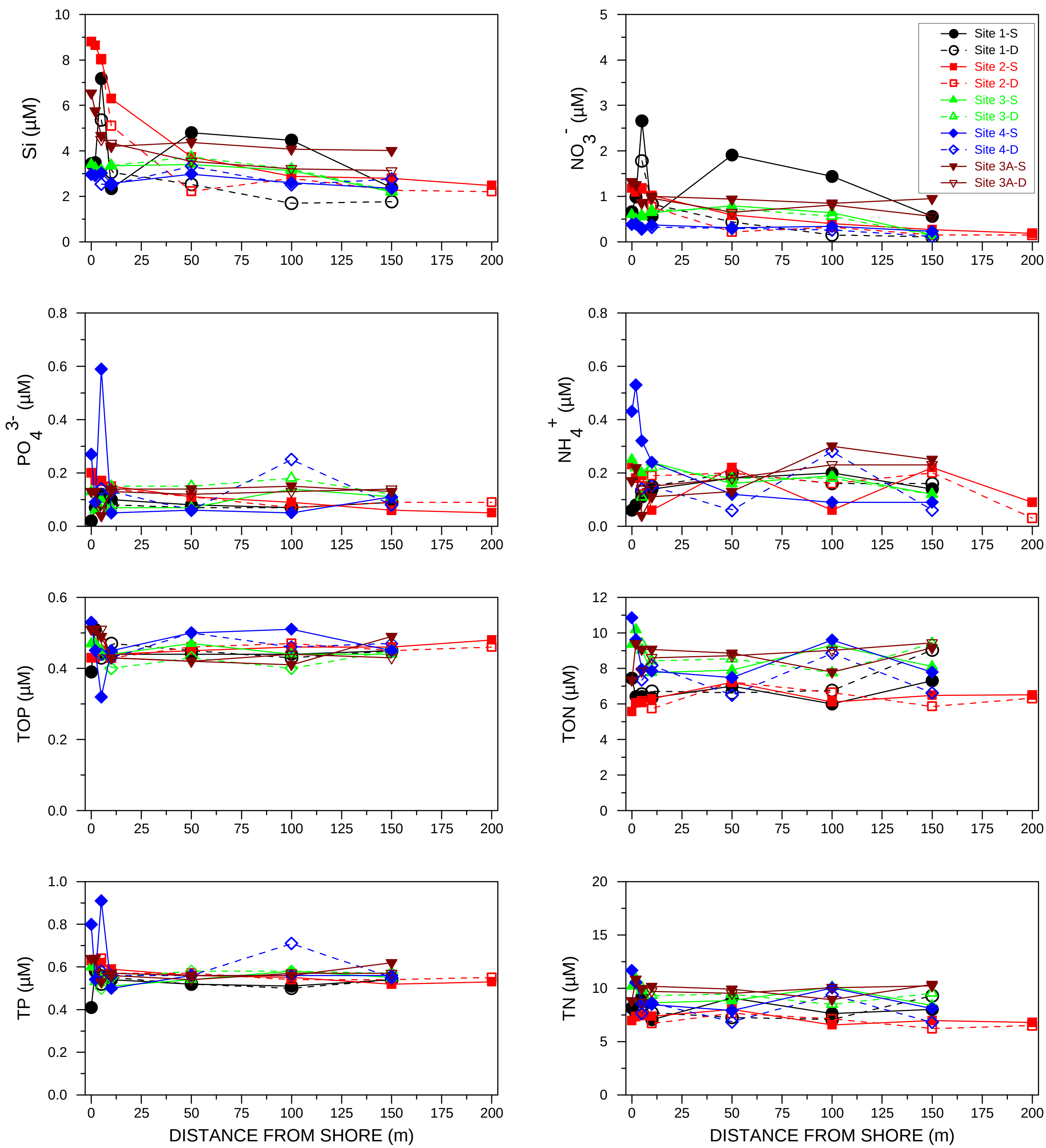

FIGURE 2. Plots of dissolved nutrients in surface (S) and deep (D) samples collected on December 4, 2012 as a function of distance from the shoreline in the vicinity of Makena Resort. For site locations, see Figure 1.

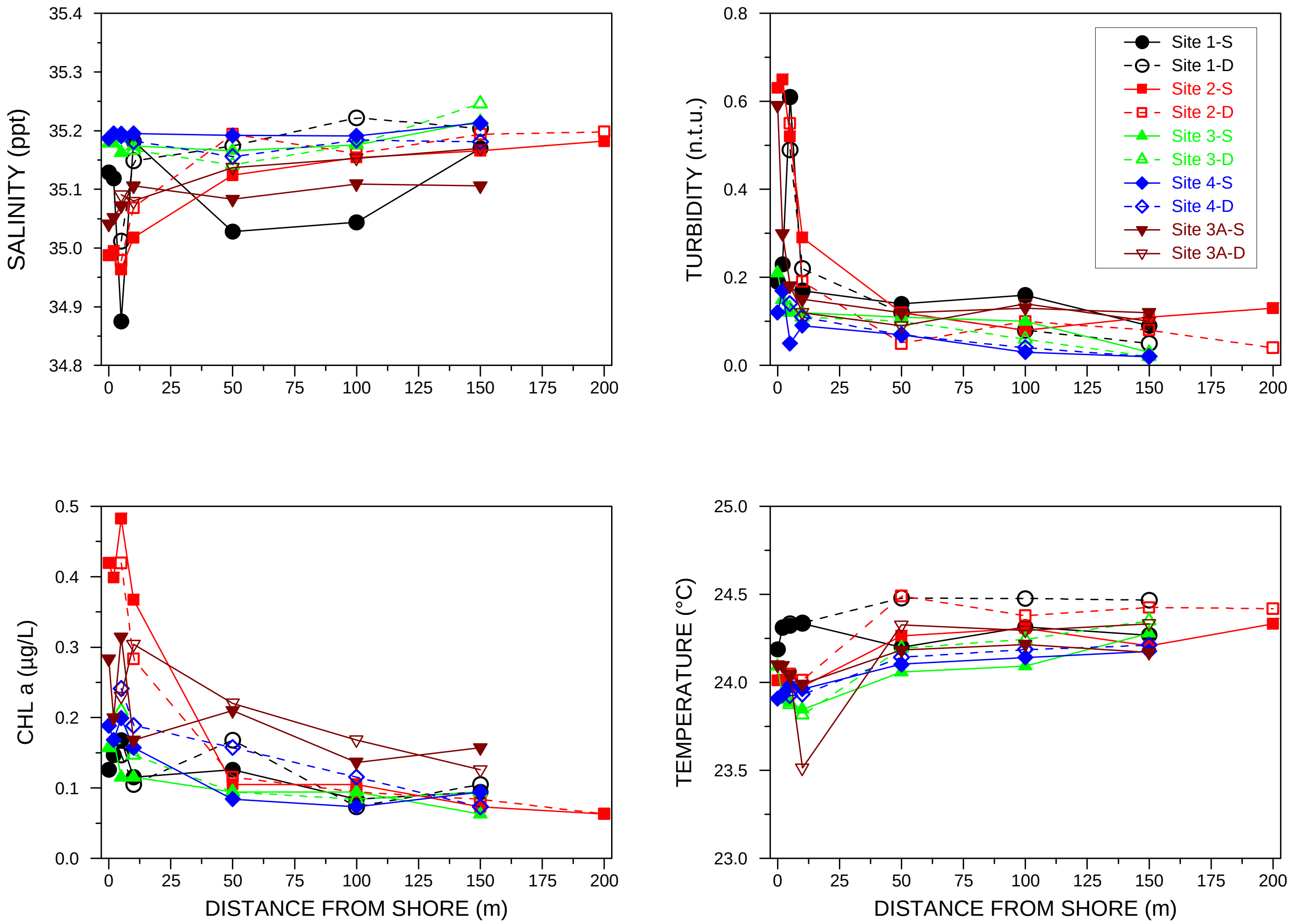

FIGURE 3. Plots of water chemistry constituents in surface (S) and deep (D) samples collected on December 4, 2012 as a function of distance from the shoreline in the vicinity of Makena Resort. For site locations, see Figure 1.

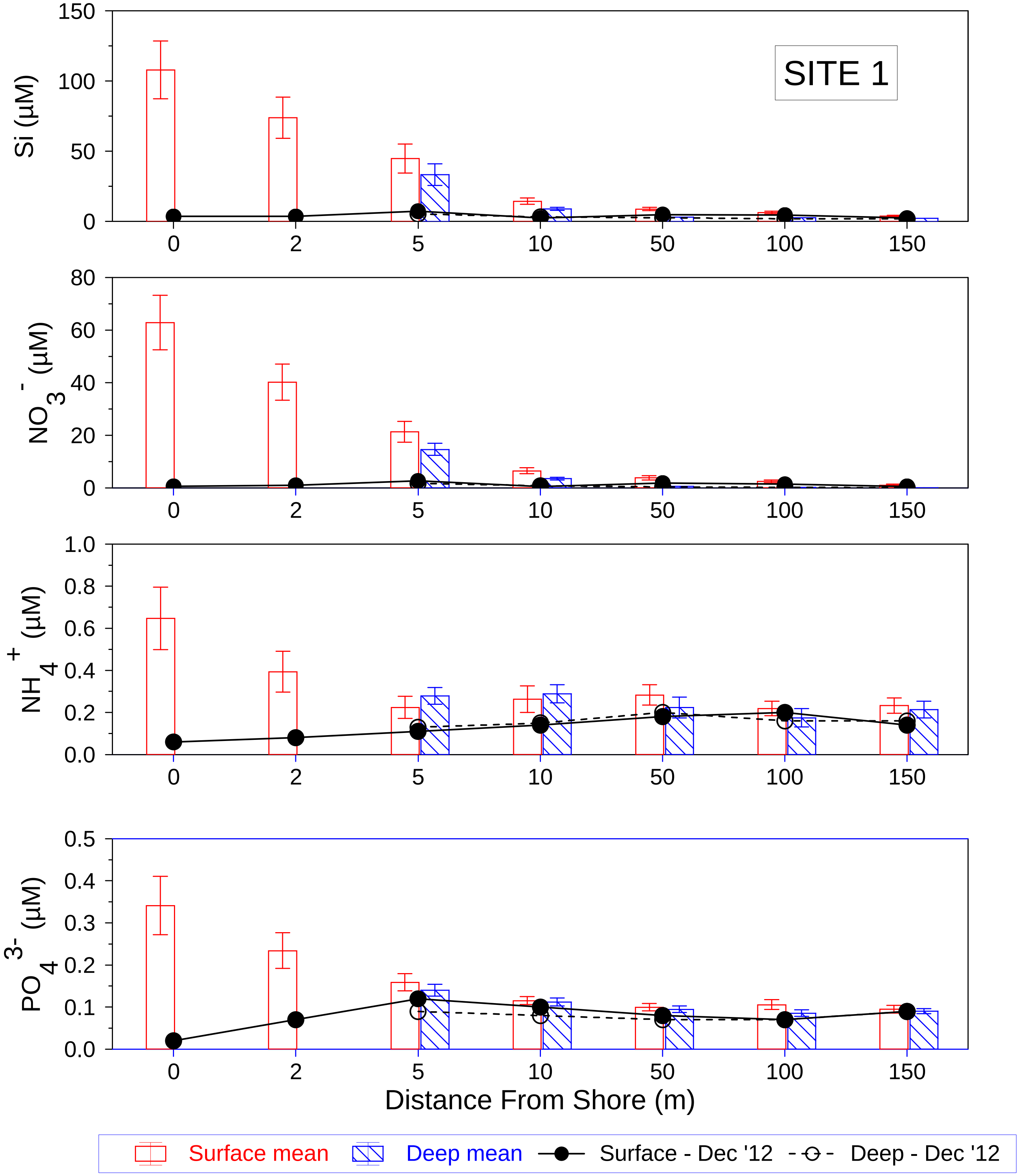

FIGURE 4. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=28). Error bars represent standard error of the mean. For site location, see Figure 1.

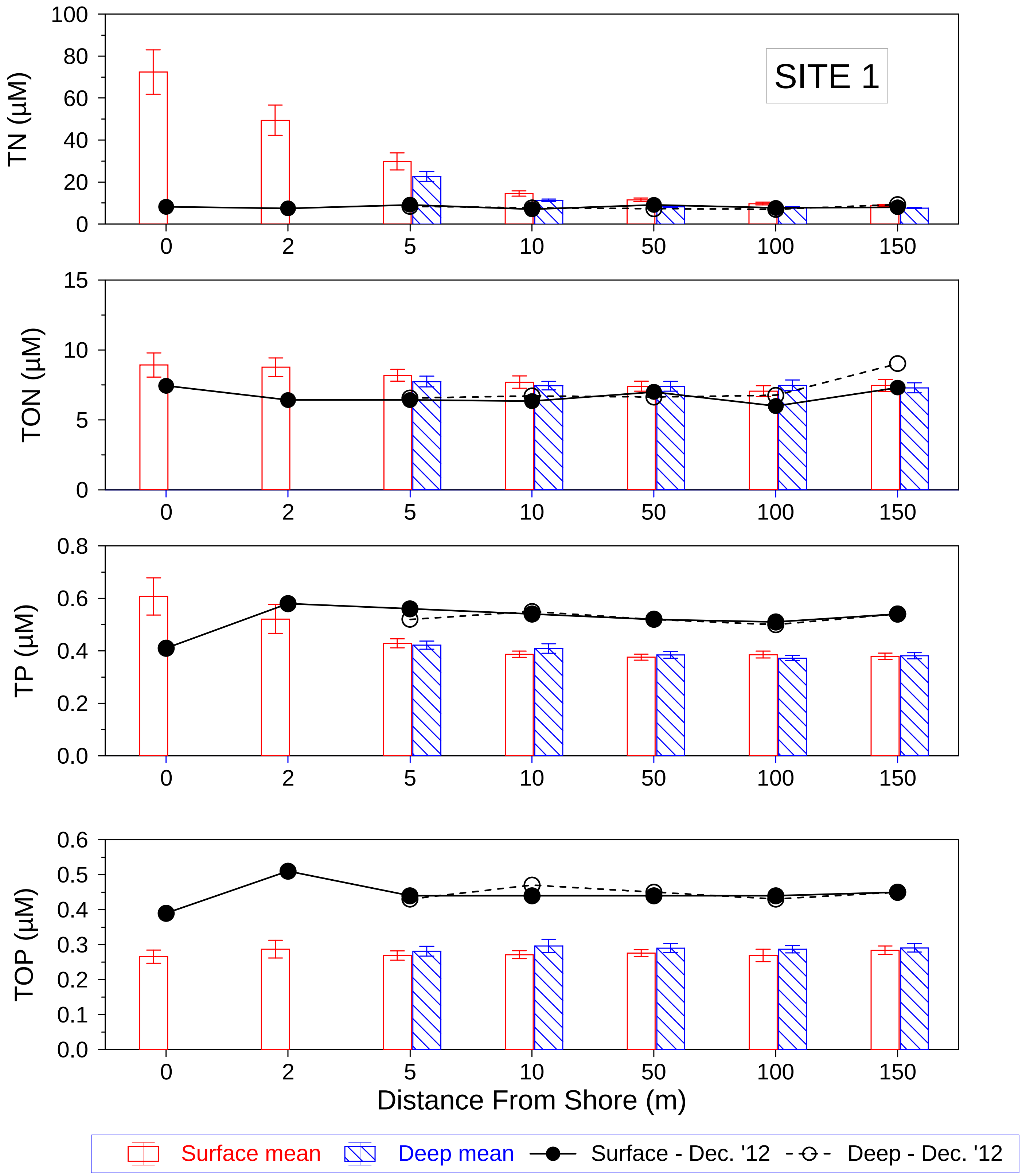

FIGURE 5. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=28). Error bars represent standard error of the mean. For site location, see Figure 1.

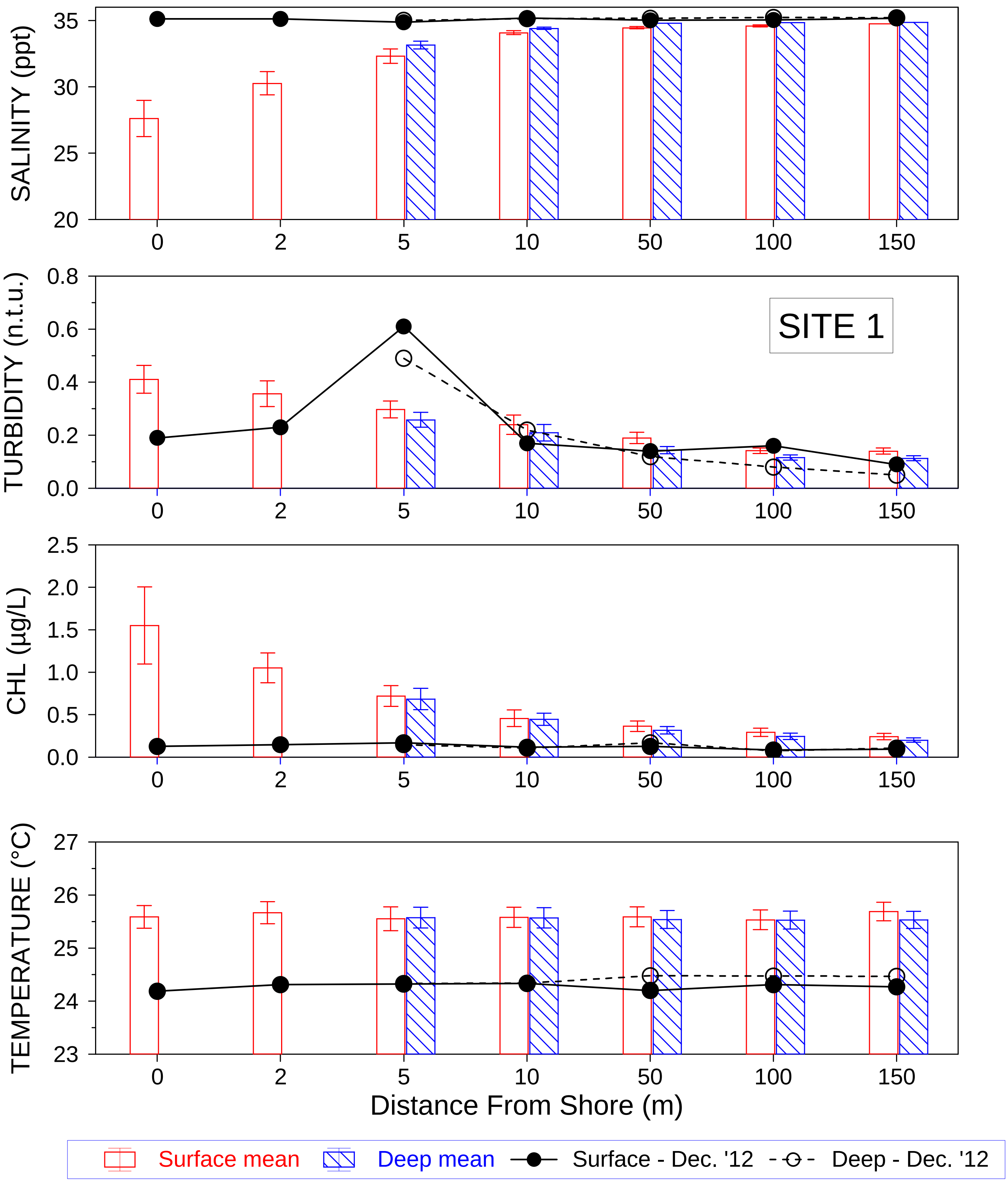

FIGURE 6. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=28). Error bars represent standard error of the mean. For site location, see Figure 1.

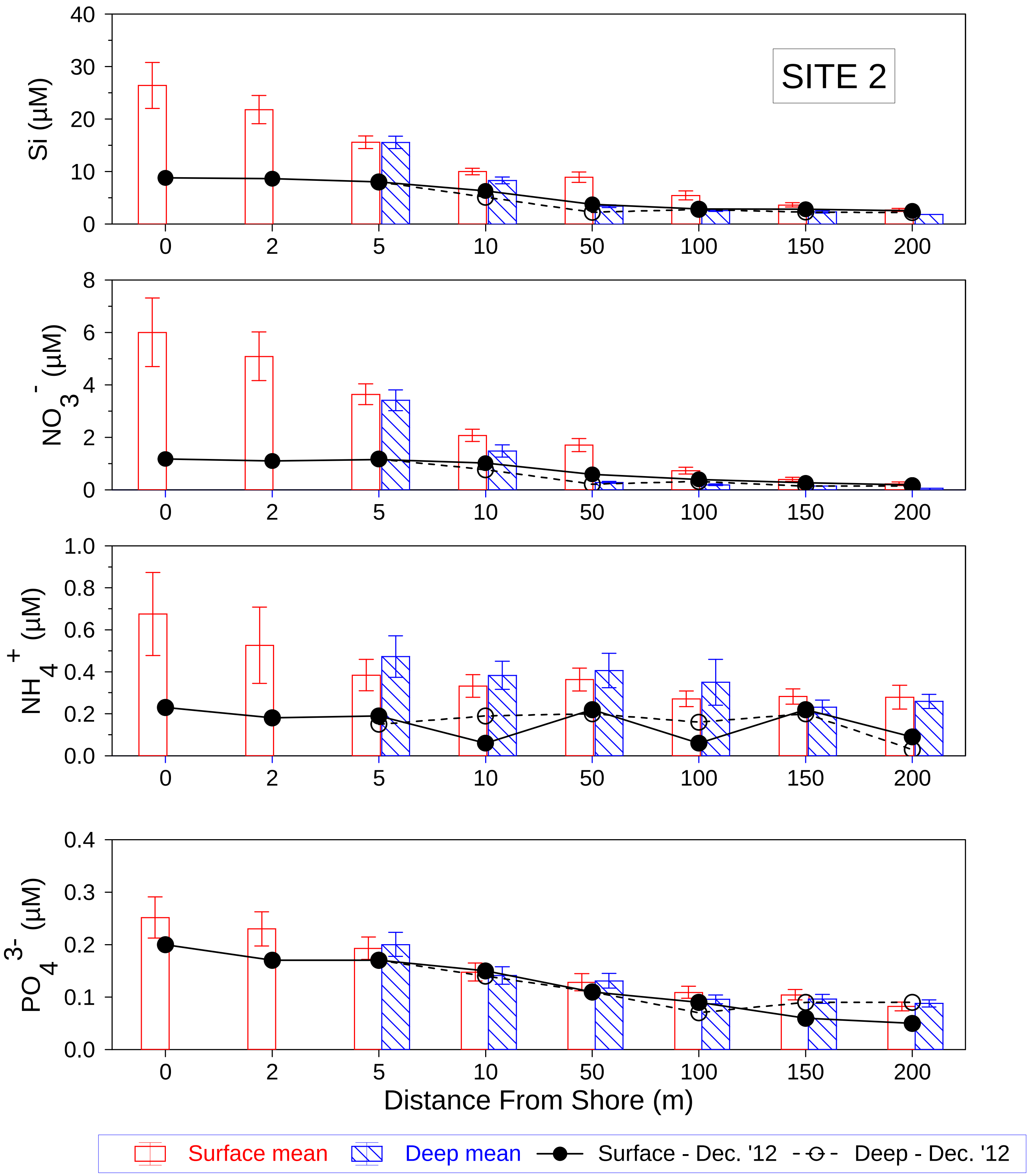

FIGURE 7. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=28). Error bars represent standard error of the mean. For site location, see Figure 1.

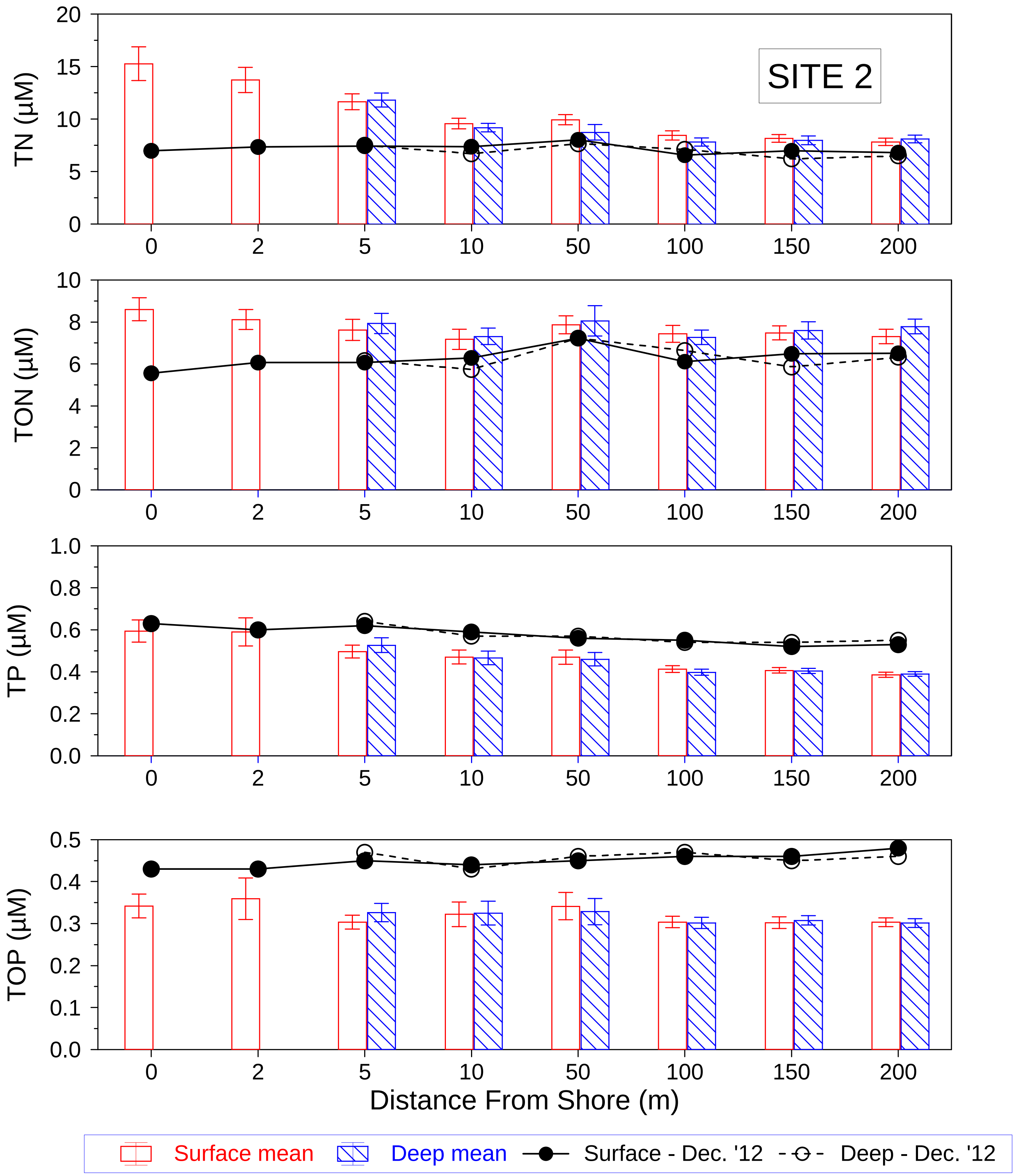

FIGURE 8. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=28). Error bars represent standard error of the mean. For site location, see Figure 1.

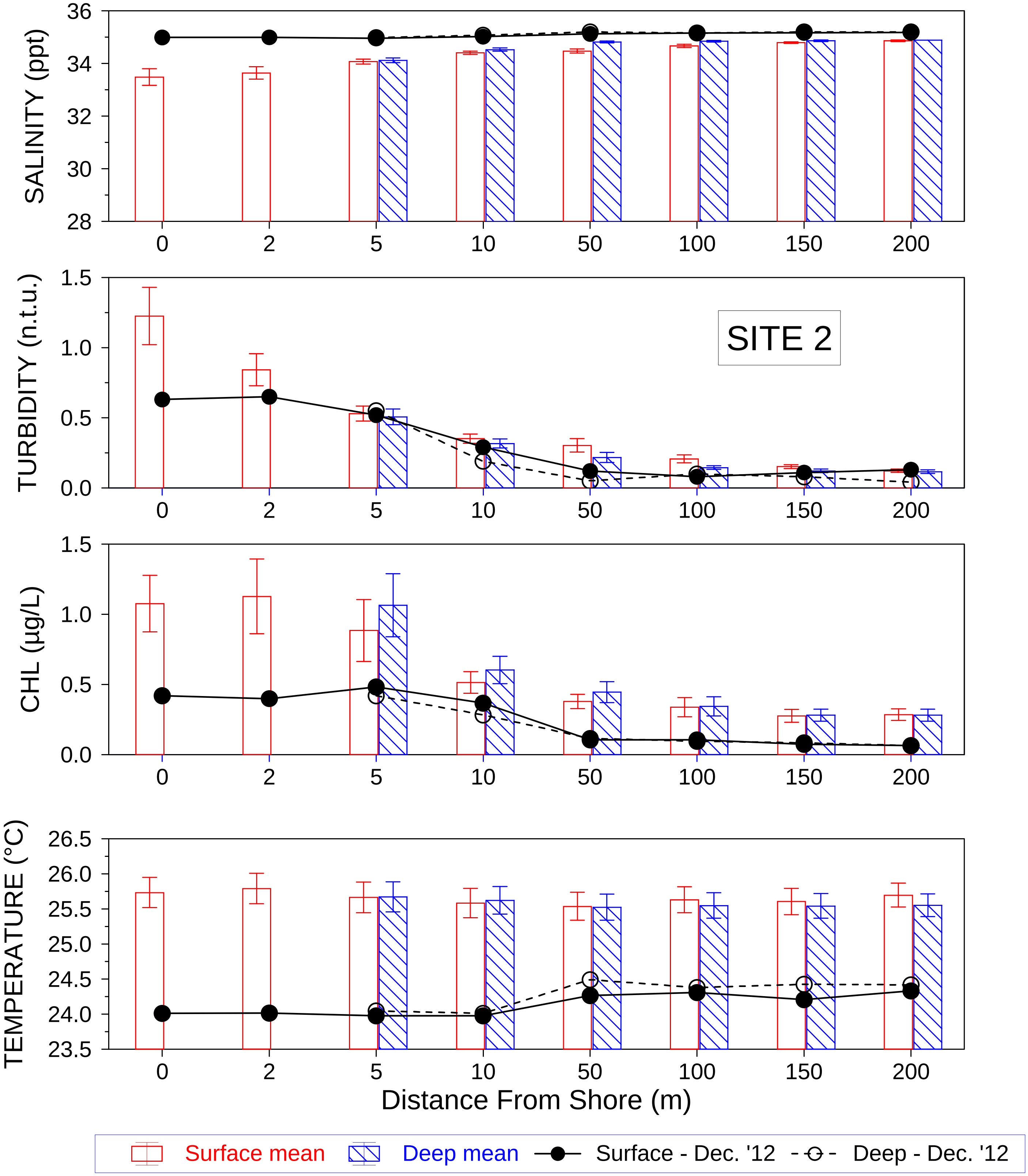

FIGURE 9. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey,bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=28). Error bars represent standard error of the mean. For site location, see Figure 1.

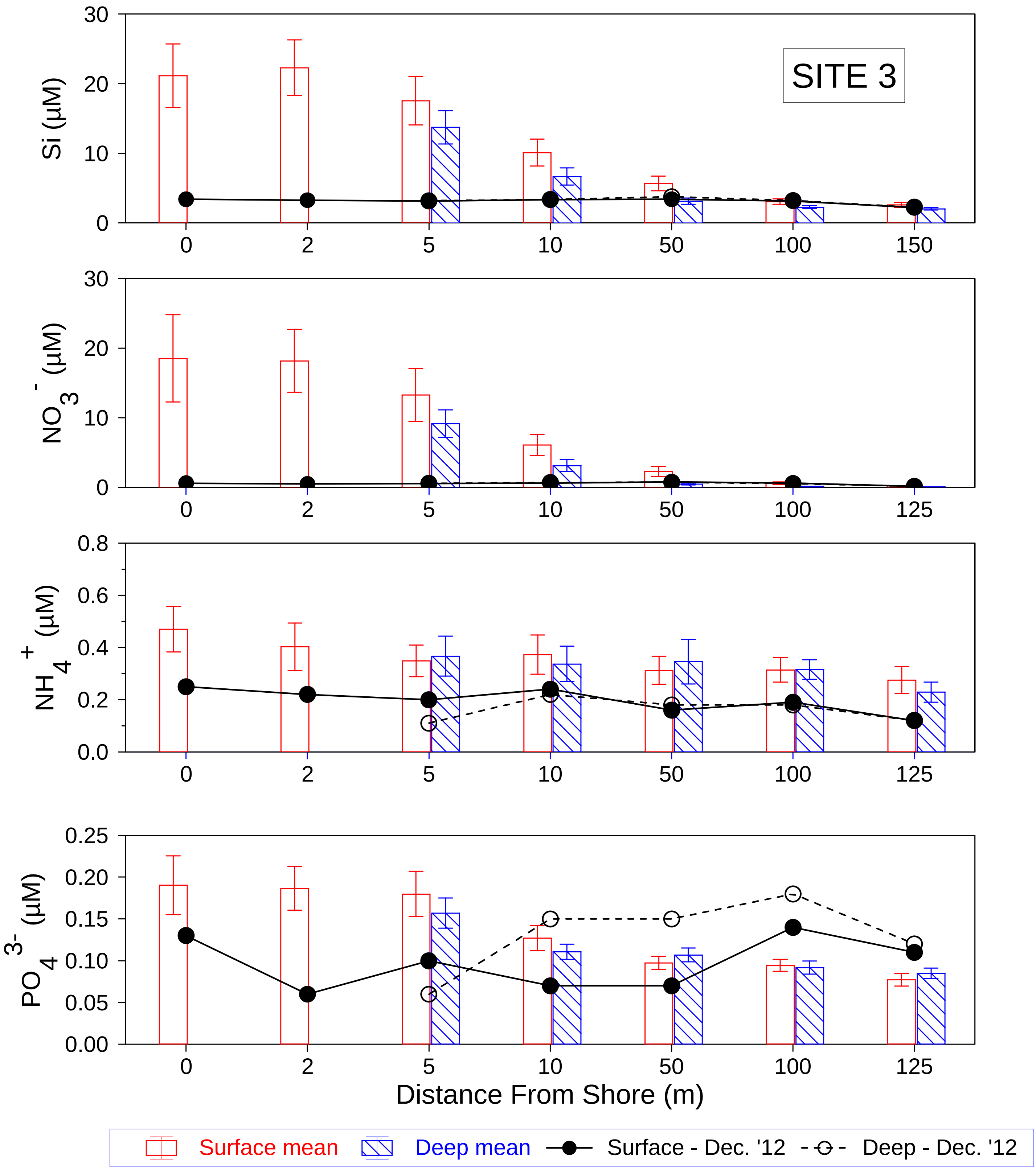

FIGURE 10. Plots of dissolved nutrient constituents measured in surface and deep water samples as functions of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=28). Error bars represent standard error of the mean. For site location, see Figure 1.

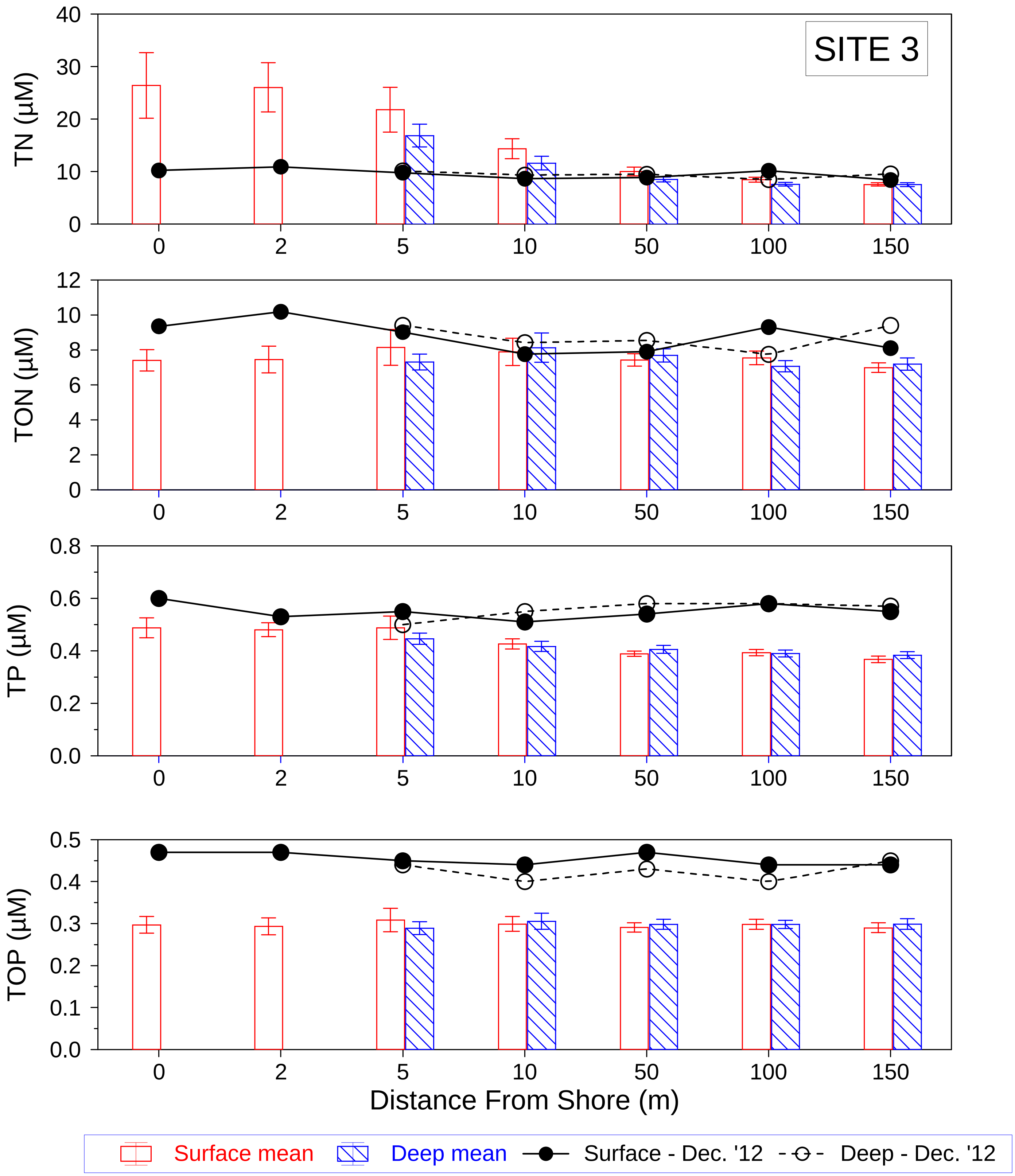

FIGURE 11. Plots of dissolved nutrient constituents measured in surface and deep water samples as functions of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=28). Error bars represent standard error of the mean. For site location, see Figure 1.

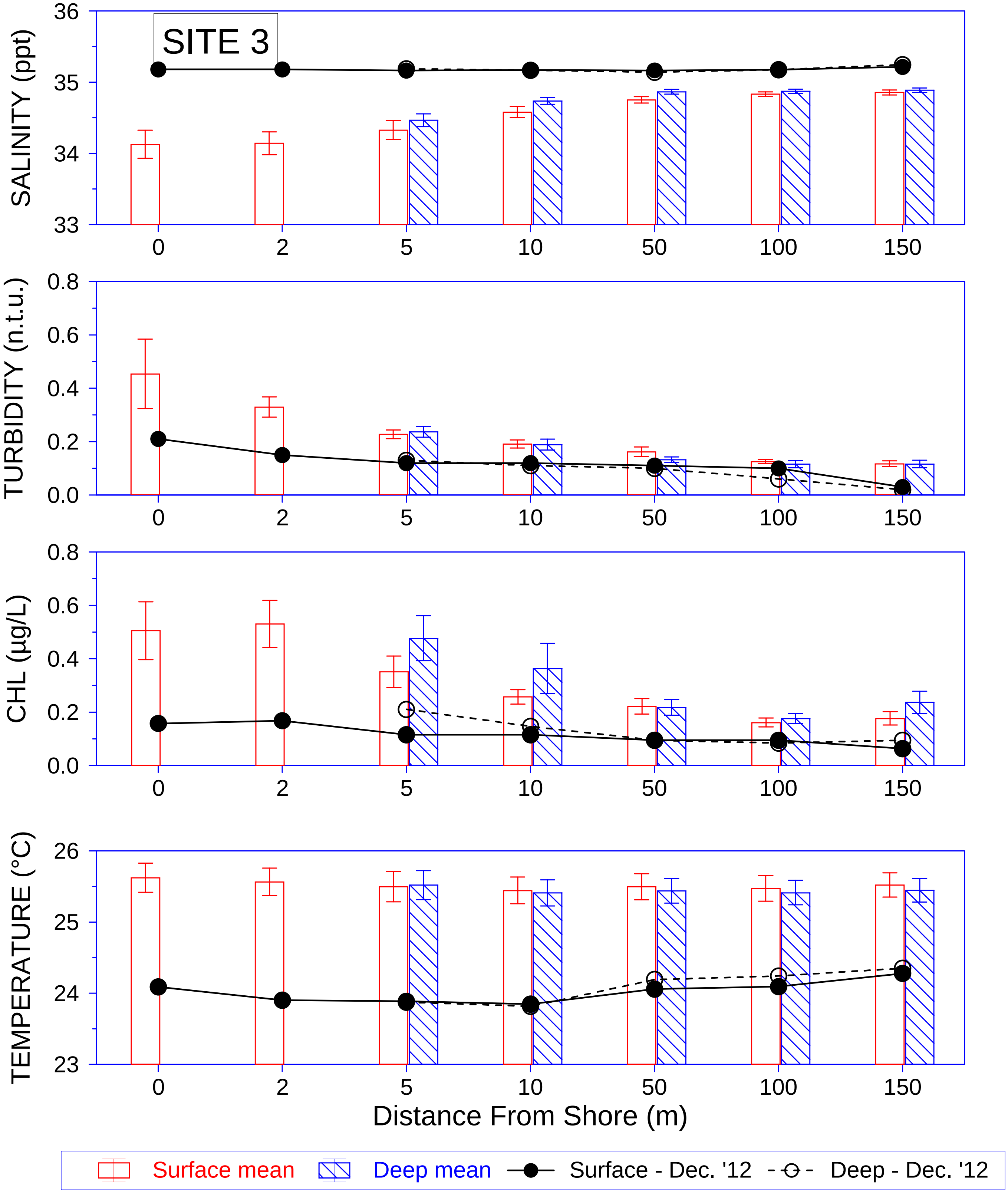

FIGURE 12. Plots of water chemistry constituents measured in surface and deep water samples as functions of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=28). Error bars represent standard error of the mean. For site location, see Figure 1.

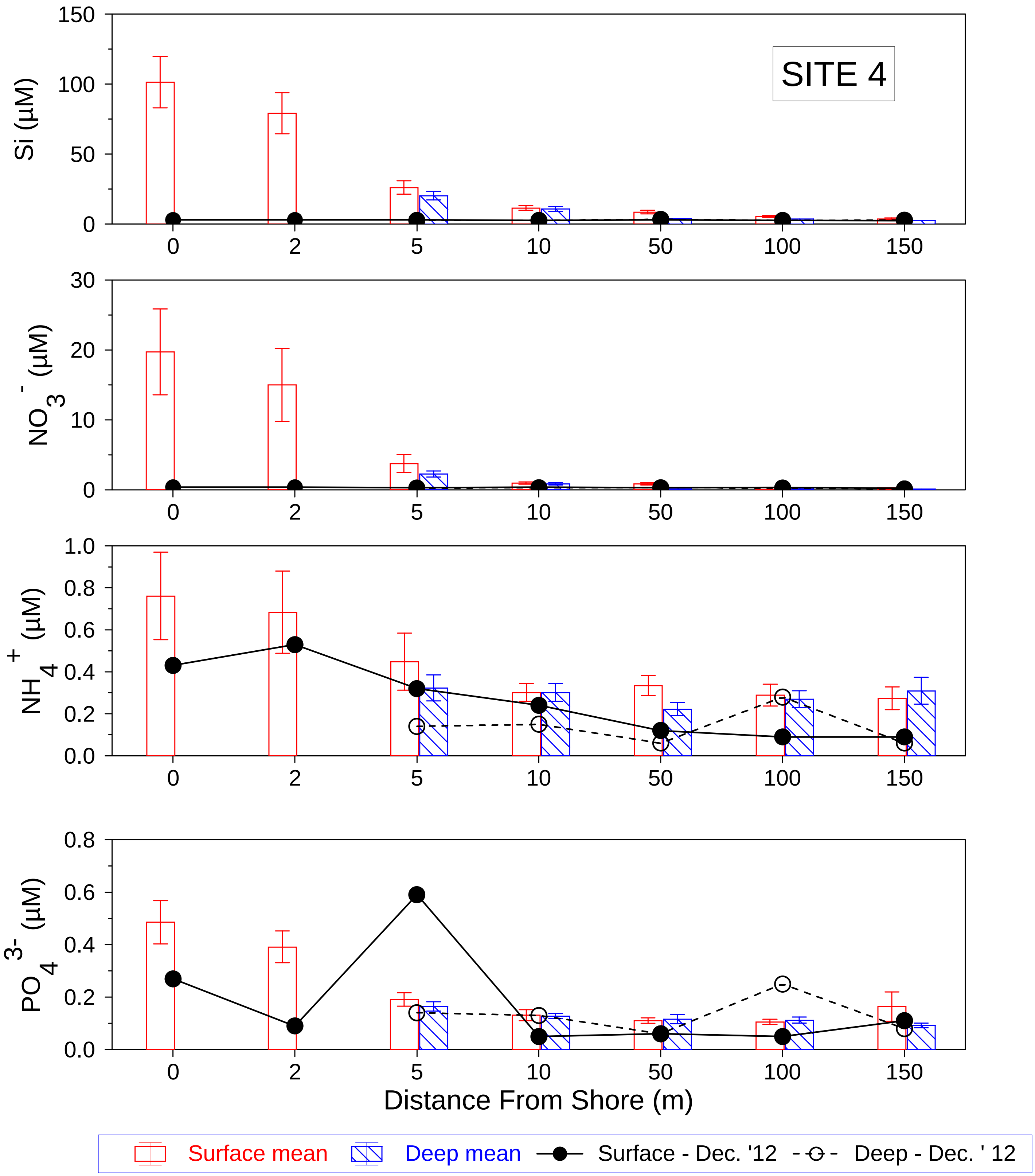

FIGURE 13. Plots of dissolved nutrient constituents measured in surface and deep water samples as functions of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=28). Error bars represent standard error of the mean. For site location, see Figure 1.

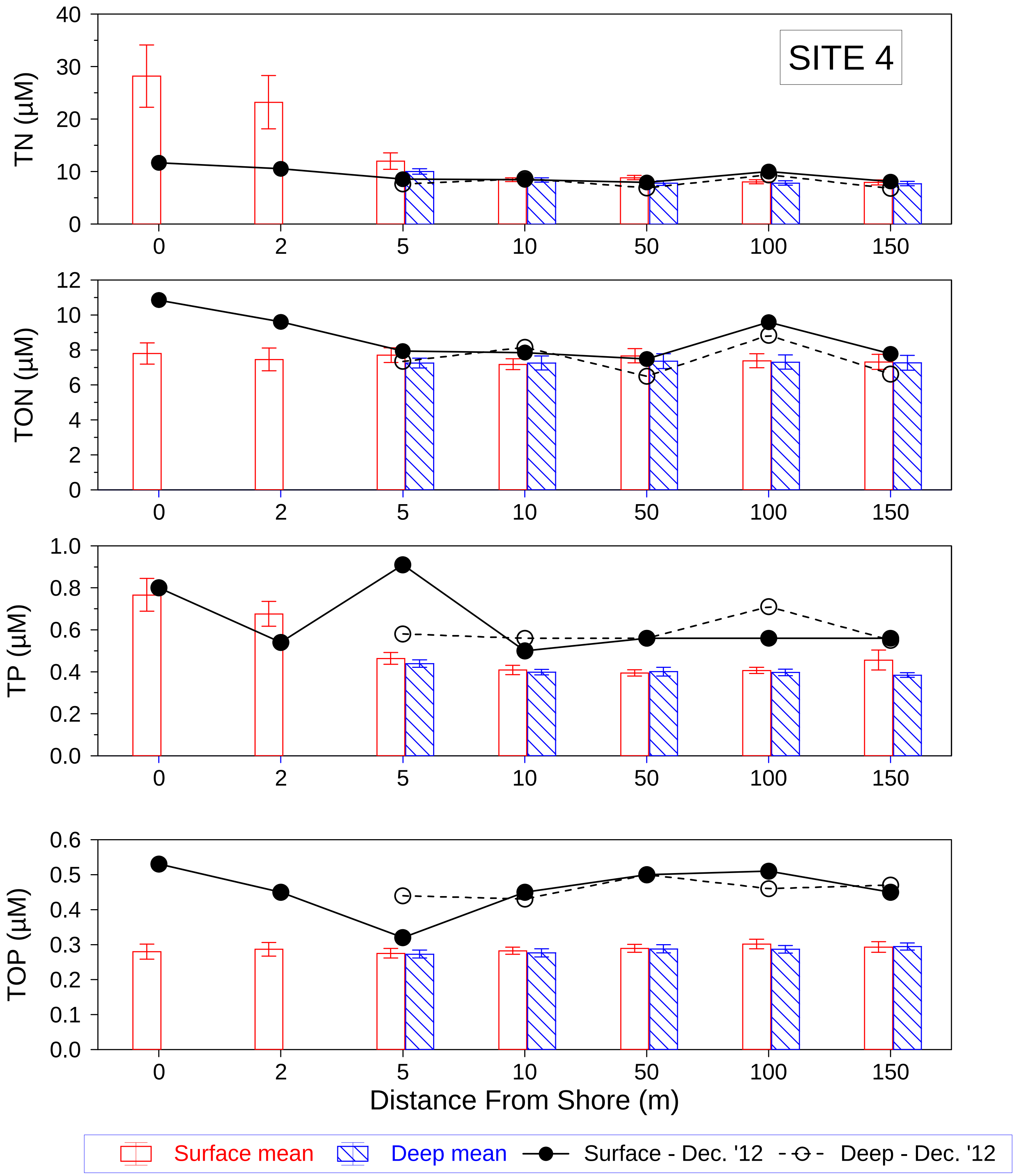

FIGURE 14. Plots of dissolved nutrient constituents measured in surface and deep water samples as functions of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=28). Error bars represent standard error of the mean. For site location, see Figure 1.

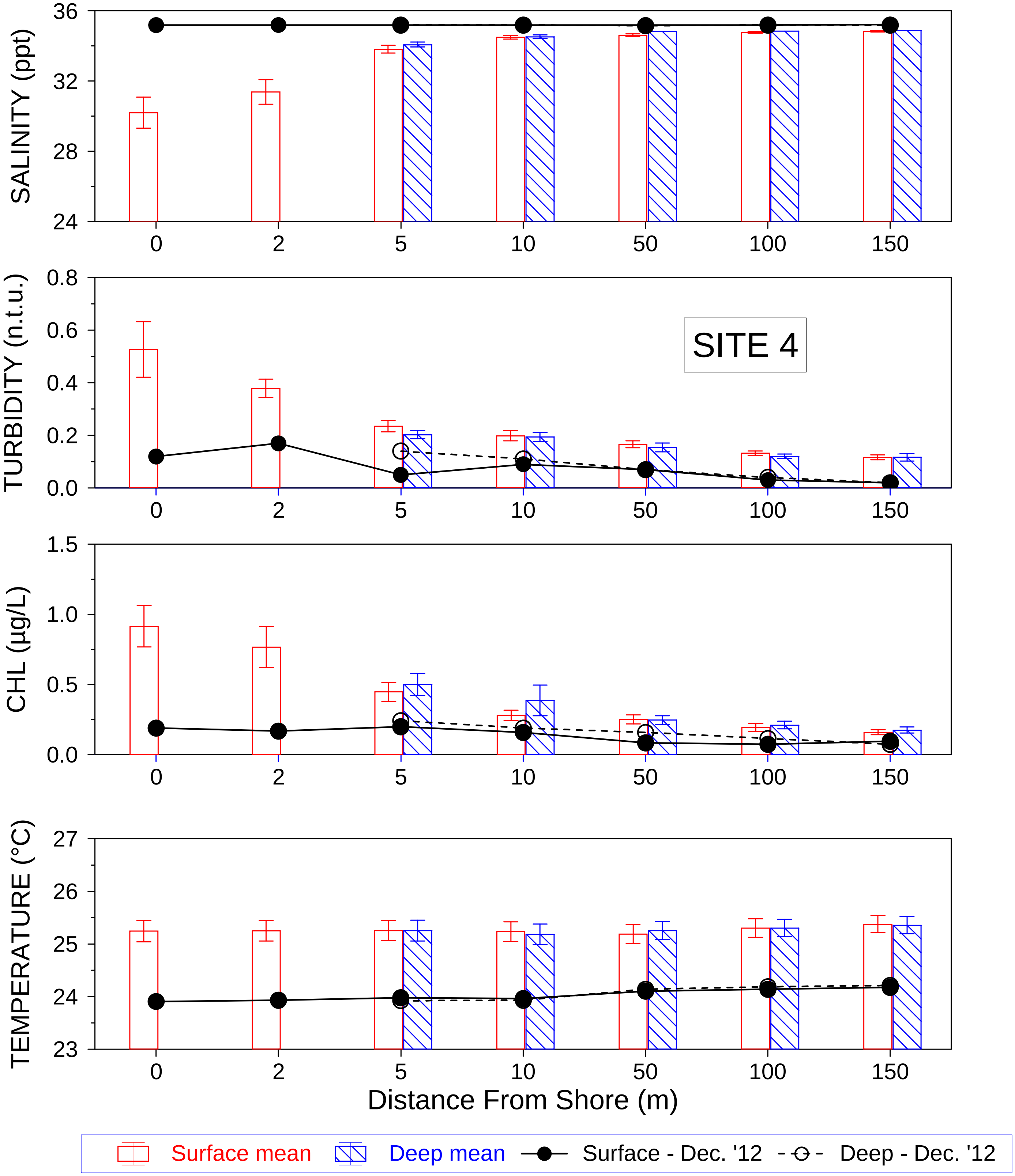

FIGURE 15. Plots of water chemistry constituents measured in surface and deep water samples as functions of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=28). Error bars represent standard error of the mean. For site location, see Figure 1.

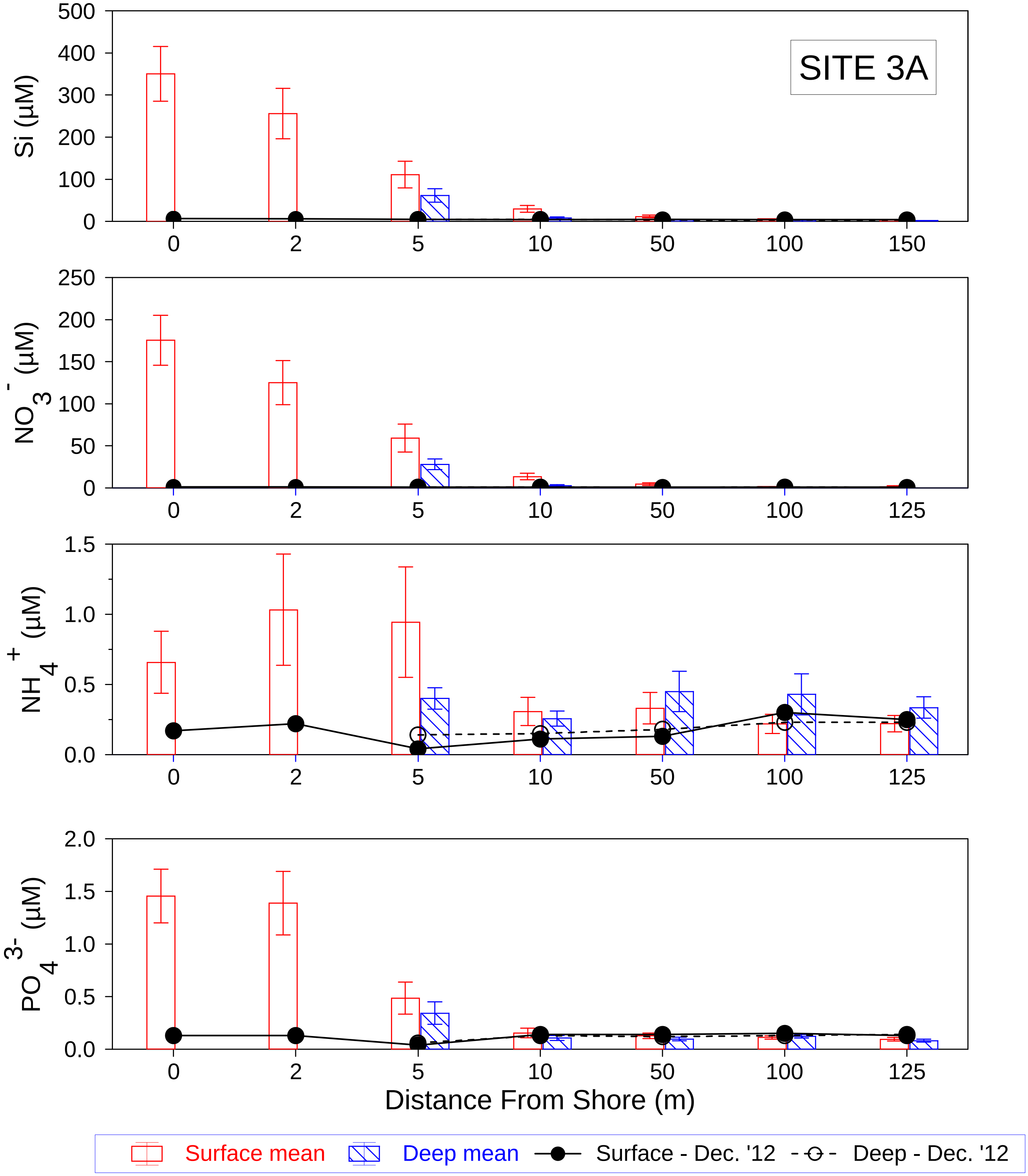

FIGURE 16. Plots of dissolved nutrient constituents measured in surface and deep water samples as functions of distance from the shoreline at Site 3A, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since June 2007 (N=10). Error bars represent standard error of the mean. For site location, see Figure 1.

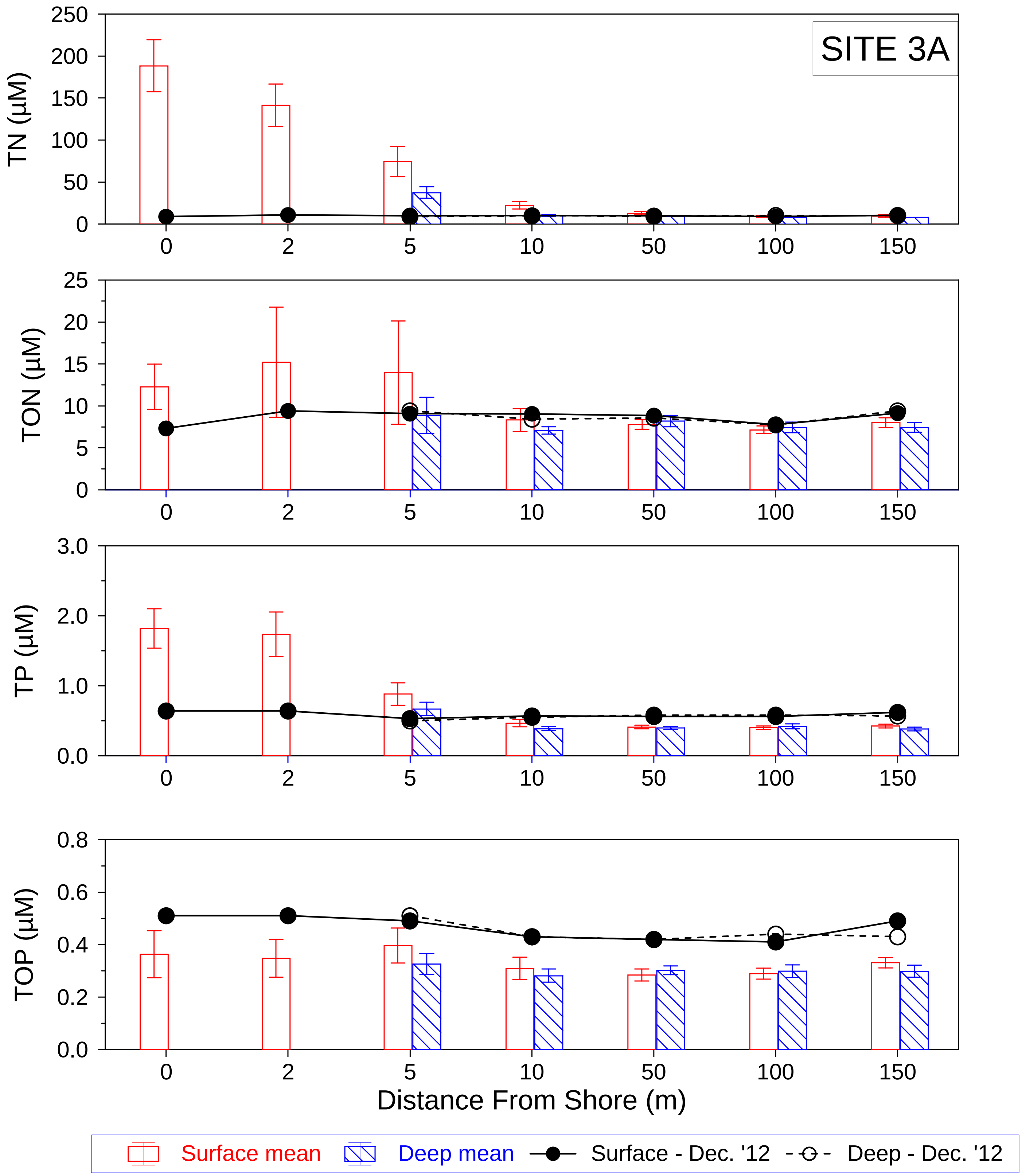

FIGURE 17. Plots of dissolved nutrient constituents measured in surface and deep water samples as functions of distance from the shoreline at Site 3A, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since June 2007 (N=10). Error bars represent standard error of the mean. For site location, see Figure 1.

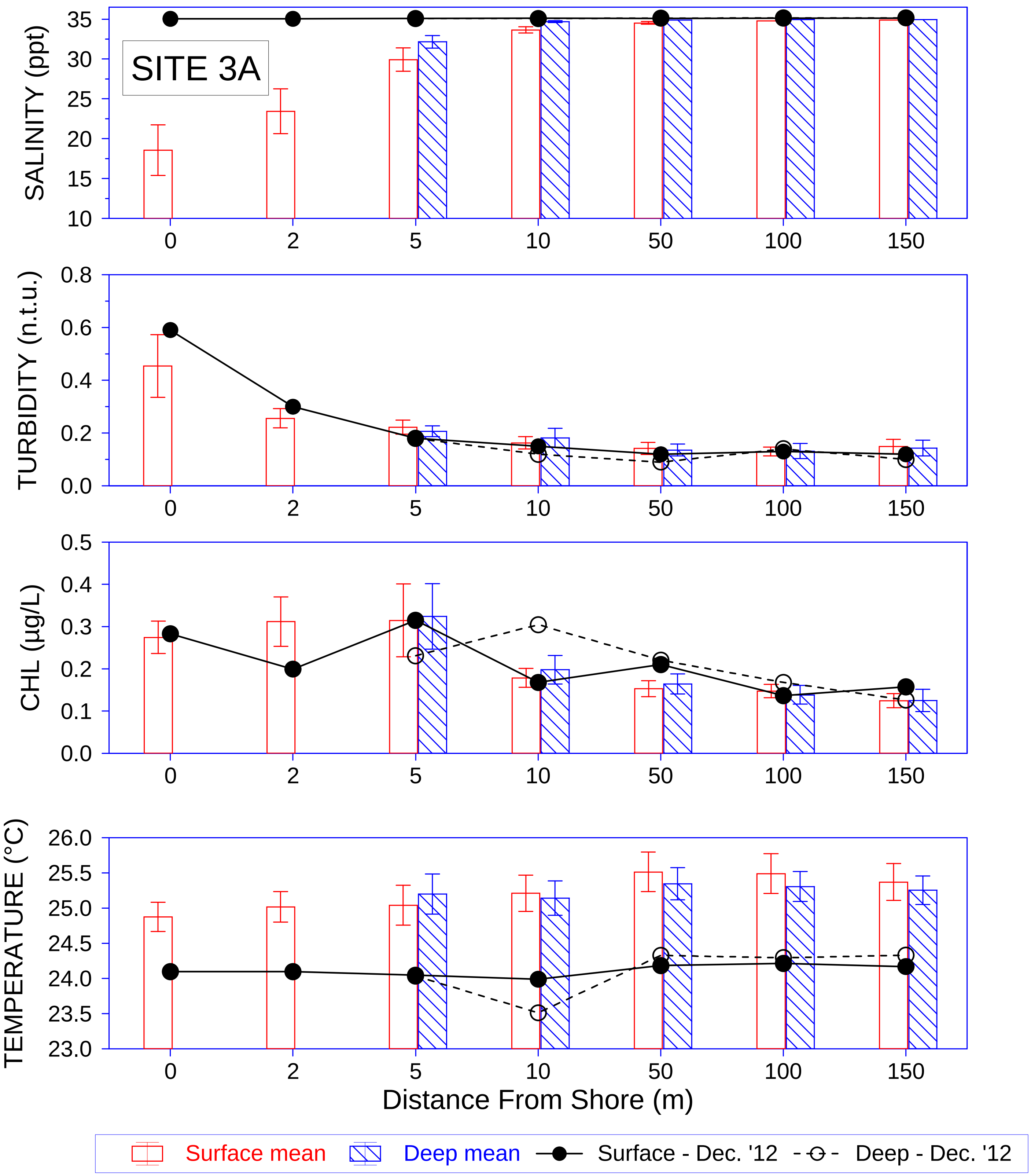

FIGURE 18. Plots of water chemistry constituents measured in surface and deep water samples as functions of distance from the shoreline at Site 3A, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since June 2007 (N=10). Error bars represent standard error of the mean. For site location, see Figure 1.

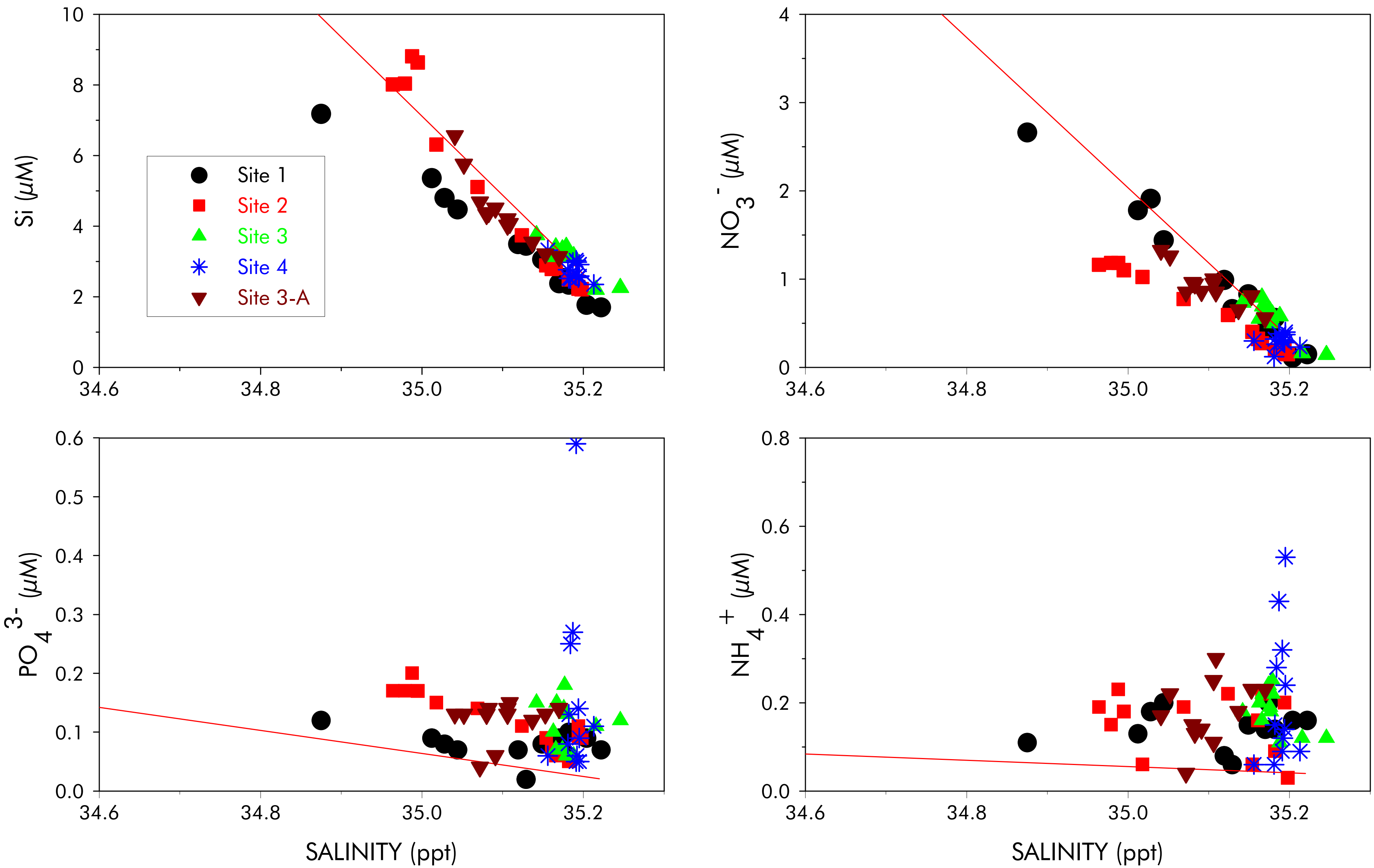

FIGURE 19. Mixing diagram showing concentration of dissolved nutrients from samples collected offshore of the Makena Resort on December 4, 2012 as functions of salinity. Solid red line in each plot is conservative mixing line constructed by connecting the concentrations in open coastal water with water from an irrigation well upslope of the Makena Golf Courses. For sampling site locations, see Figure 1.

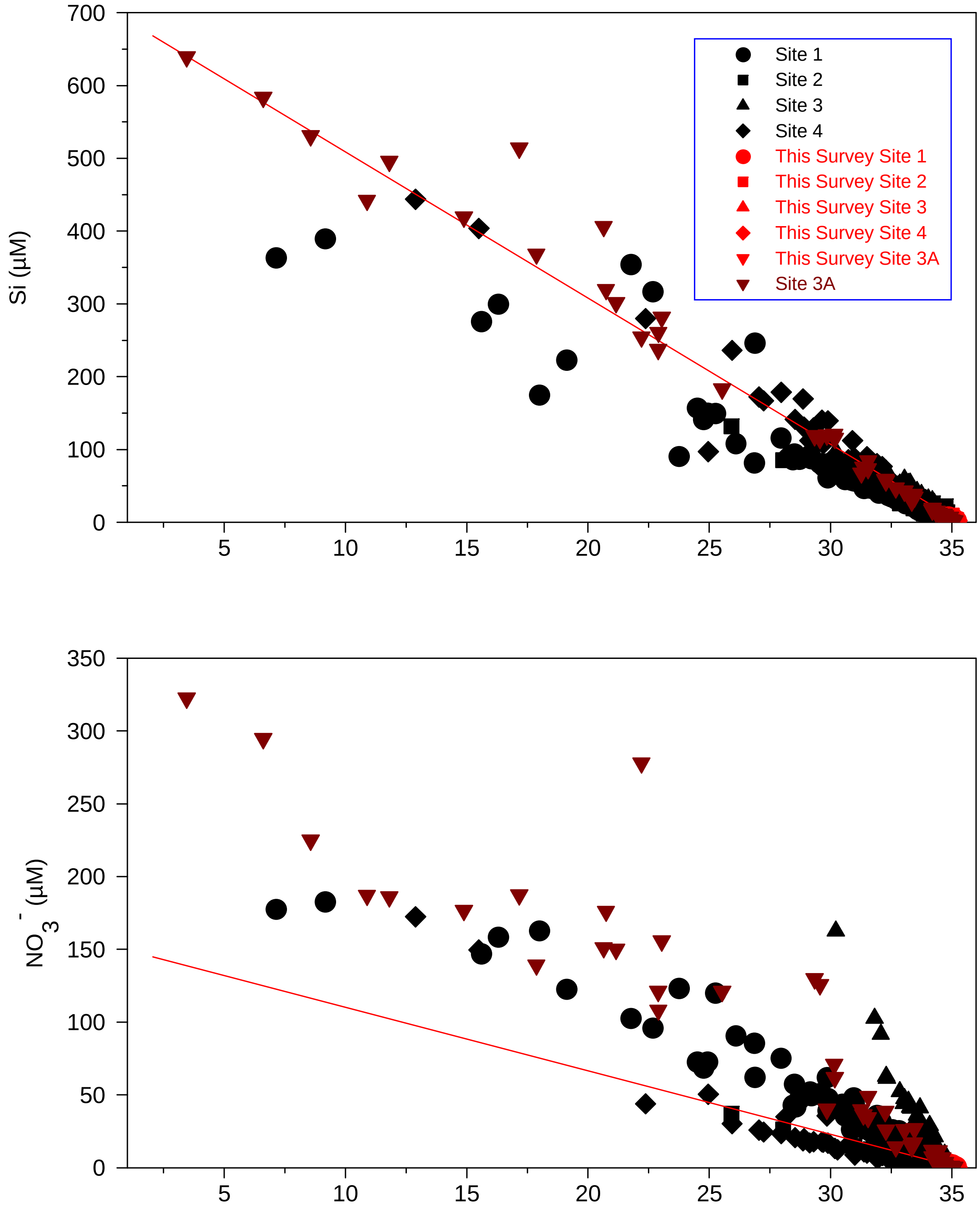

FIGURE 20. Silicate and nitrate, plotted as a function of salinity for surface samples collected since August 1995 at four sites offshore of the Makena Golf Course. Black symbols represent combined data from surveys conducted between August 1995 and April 2012. Green symbols represent data from surveys at Site 3A commencing in June 2007. Red symbols are data from most recent survey. Solid red line in each plot is conservative mixing line constructed by connecting the concentrations in open coastal water with water from golf course irrigation well #4. For sampling site locations, see Figure 1.

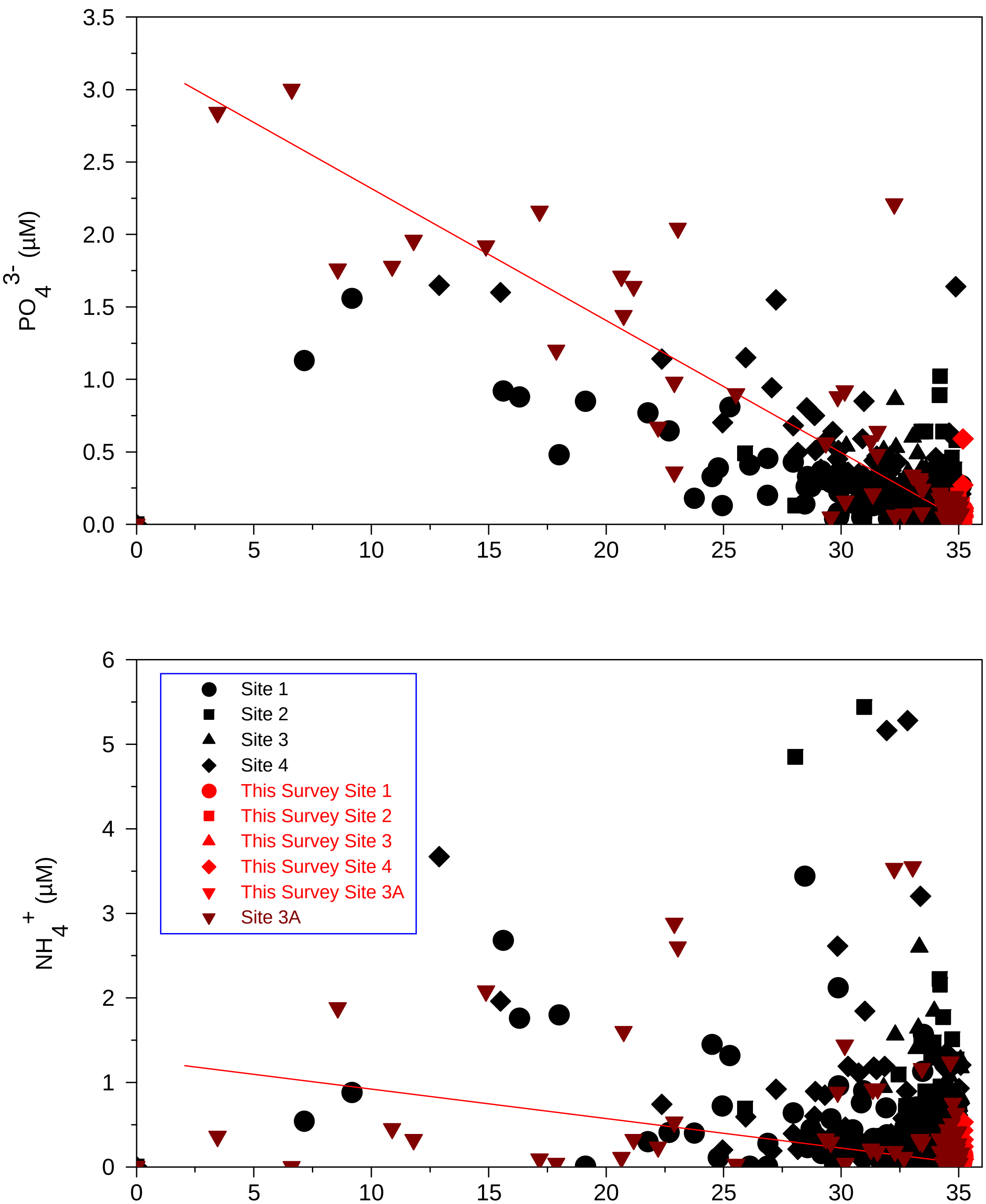

FIGURE 21. Phosphate and ammonium, plotted as a function of salinity for surface samples collected since August 1995 at four sites offshore of the Makena Golf Course. Black symbols represent combined data from surveys conducted between August 1995 and April 2012. Green symbols represent data from surveys at Site 3A commencing in June 2007. Red symbols are data from the most recent survey. Solid red line in each plot is conservative mixing line constructed by connecting the concentrations in open coastal water with water from golf course irrigation well #4. For sampling site locations, see Figure 1.

TABLE 6. Linear regression statistics (y-intercept and slope) of concentrations of silica as functions of salinity from four ocean transect sites off of the Makena Resort collected during monitoring surveys from 1995 to December 2012 (Transect Site 3 has been monitored since 2002; Trasect Site 3A since 2007). Also shown are standard errors and upper and lower 95% confidence limits around the y-intercepts and slopes."REGSLOPE" indicates regression statistics for slope of yearly coefficients as a function of time. For location of transect sites, see Figure 1.

SILICA -Y-INTERCEPT

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 1				
1995	522.34	12.18	491.03	553.66
1996	629.56	11.05	605.49	653.64
1997	504.17	2.83	496.89	511.46
1998	484.14	2.44	477.86	490.41
1999	479.11	9.89	457.55	500.66
2000	528.68	5.87	513.58	543.77
2001	625.85	10.91	597.82	653.88
2002	502.98	8.68	480.66	525.30
2003	625.85	10.91	597.82	653.88
2004	546.00	8.33	527.84	564.16
2005	466.59	11.09	442.42	490.75
2006	487.68	24.60	434.08	541.28
2007	491.19	34.99	414.95	567.42
2008	371.80	16.96	334.85	408.75
2009	457.28	10.01	431.54	483.02
2010	515.27	7.85	495.09	535.45
2011	464.80	5.70	452.37	477.22
2012	940.29	48.49	815.64	1064.94
2013	553.91	19.87	502.83	604.99
Regslope	2.37	4.99	-8.17	12.91
SITE 2				
1995	468.41	85.54	248.51	688.30
1996	549.09	177.83	164.91	933.28
1997	567.57	9.71	543.80	591.33
1998	563.20	37.23	472.10	654.30
1999	466.74	95.75	261.37	672.11
2000	770.15	27.32	703.31	837.00
2001	1254.31	74.17	1072.82	1435.81
2002	577.53	29.40	505.60	649.46
2003	505.05	20.10	461.94	548.15
2004	565.31	93.71	364.33	766.29
2005	339.08	33.78	266.64	411.52
2006	553.48	62.93	418.51	688.45
2007	443.05	17.15	406.27	479.84
2008	402.41	73.66	244.42	560.41
2009	501.76	9.02	479.69	523.82
2010	490.17	22.77	434.46	545.87
2011	501.35	17.35	464.13	538.56
2012	411.67	48.31	293.48	529.87
2013	1050.19	96.78	813.37	1287.01
Regslope	-1.24	9.64	-21.59	19.10
SITE 3A				
2007	714.10	5.58	701.94	726.27
2008	805.12	9.00	785.52	824.73
2009	646.37	7.80	626.32	666.43
2010	750.91	5.70	736.26	765.56
2011	715.44	5.06	704.42	726.45
2012	1005.34	28.55	931.95	1078.73
2013	1176.49	176.84	721.91	1631.08
Regslope	66.31	26.03	-0.59	133.21
SITE 3				
2002	931.92	27.54	861.13	1002.71
2003	984.76	41.58	894.16	1075.35
2004	632.75	127.62	354.68	910.82
2005	704.38	52.31	590.40	818.35
2006	928.22	64.18	788.40	1068.05
2007	722.80	15.07	689.97	755.63
2008	1058.06	48.59	952.18	1163.94
2009	943.91	40.06	840.94	1046.89
2010	962.57	74.39	771.34	1153.79
2011	880.51	26.78	822.17	938.85
2012	792.34	42.16	683.97	900.71
2013	757.70	185.71	280.33	1235.07
Regslope	-0.84	11.59	-26.67	24.99
SITE 4				
1995	710.45	8.83	687.74	733.15
1996	917.33	13.38	888.18	946.47
1997	776.74	3.53	767.66	785.82
1998	841.35	6.75	824.00	858.70
1999	823.63	24.78	769.63	877.62
2000	946.97	12.51	914.80	979.14
2001	1403.91	260.13	735.22	2072.61
2002	767.85	4.37	756.63	779.08
2003	854.37	29.88	789.26	919.48
2004	843.49	37.55	761.67	925.31
2005	703.97	14.00	673.47	734.46
2006	735.05	14.01	704.53	765.57
2007	710.11	7.14	694.56	725.66
2008	712.32	18.22	672.63	752.01
2009	715.30	7.99	694.75	735.84
2010	673.09	6.27	656.98	689.21
2011	688.21	7.10	672.74	703.68
2012	353.00	29.28	277.74	428.26
2013	835.40	315.71	23.83	1646.97
Regslope	-15.43	7.50	-31.26	0.39

SILICA - SLOPE

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 1				
1995	-15.08	0.38	-16.05	-14.12
1996	-18.05	0.32	-18.75	-17.34
1997	-14.43	0.08	-14.65	-14.21
1998	-13.83	0.07	-14.02	-13.64
1999	-13.63	0.29	-14.27	-12.99
2000	-15.08	0.18	-15.54	-14.62
2001	-17.76	0.32	-18.57	-16.94
2002	-14.38	0.26	-15.05	-13.72
2003	-17.76	0.32	-18.57	-16.94
2004	-15.68	0.25	-16.23	-15.14
2005	-13.31	0.33	-14.02	-12.61
2006	-13.88	0.76	-15.53	-12.23
2007	-14.11	1.14	-16.59	-11.62
2008	-10.46	0.52	-11.59	-9.33
2009	-12.98	0.30	-13.76	-12.20
2010	-14.78	0.28	-15.49	-14.06
2011	-13.13	0.18	-13.52	-12.74
2012	-26.98	1.61	-31.13	-22.84
2013	-15.68	0.57	-17.13	-14.22
Regslope	-0.06	0.14	-0.37	0.24
SITE 2				
1995	-13.47	2.51	-19.93	-7.00
1996	-15.62	5.15	-26.75	-4.49
1997	-16.26	0.29	-16.96	-15.56
1998	-16.11	1.08	-18.76	-13.45
1999	-13.21	2.78	-19.18	-7.23
2000	-22.06	0.80	-24.02	-20.11
2001	-35.68	2.12	-40.87	-30.49
2002	-16.54	0.86	-18.64	-14.44
2003	-14.37	0.59	-15.63	-13.11
2004	-16.23	2.73	-22.09	-10.38
2005	-9.61	0.98	-11.70	-7.52
2006	-15.82	1.83	-19.75	-11.89
2007	-12.54	0.51	-13.64	-11.45
2008	-11.41	2.14	-15.99	-6.83
2009	-14.32	0.27	-14.98	-13.66
2010	-13.97	0.67	-15.61	-12.33
2011	-14.24	0.50	-15.31	-13.16
2012	-11.62	1.41	-15.06	-8.18
2013	-29.79	2.76	-36.54	-23.03
Regslope	0.04	0.27	-0.54	0.62
SITE 3A				
2007	-20.35	0.19	-20.75	-19.94
2008	-22.96	0.28	-23.57	-22.36
2009	-18.28	0.26	-18.96	-17.61
2010	-21.44	0.19	-21.94	-20.94
2011	-20.35	0.17	-20.72	-19.99
2012	-29.01	0.94	-31.44	-26.59
2013	-33.40	5.04	-46.36	-20.44
Regslope	-1.90	0.75	-3.83	0.02
SITE 3				
2002	-26.75	0.81	-28.83	-24.68
2003	-28.10	1.21	-30.73	-25.47
2004	-18.19	3.69	-26.24	-10.14
2005	-20.11	1.51	-23.40	-16.83
2006	-26.56	1.89	-30.67	-22.46
2007	-20.60	0.44	-21.56	-19.63
2008	-30.22	1.41	-33.29	-27.14
2009	-26.90	1.17	-29.90	-23.91
2010	-27.56	2.19	-33.18	-21.93
2011	-25.06	0.77	-26.74	-23.37
2012	-22.57	1.24	-25.75	-19.39
2013	-21.45	5.28	-35.02	-7.88
Regslope	0.04	0.33	-0.70	0.78
SITE 4				
1995	-20.55	0.27	-21.25	-19.85
1996	-26.23	0.40	-27.10	-25.37
1997	-22.27	0.11	-22.55	-21.99
1998	-24.07	0.20	-24.58	-23.56
1999	-23.50	0.73	-25.10	-21.90
2000	-27.12	0.37	-28.08	-26.16
2001	-39.92	7.42	-58.99	-20.86
2002	-21.99	0.13	-22.34	-21.65
2003	-24.36	0.91	-26.34	-22.39
2004	-24.27	1.10	-26.66	-21.88
2005	-20.11	0.41	-21.00	-19.22
2006	-20.96	0.41	-21.86	-20.06
2007	-20.27	0.23	-20.77	-19.78
2008	-20.33	0.53	-21.49	-19.17
2009	-20.34	0.24	-20.95	-19.73
2010	-19.14	0.19	-19.62	-18.66
2011	-19.57	0.21	-20.03	-19.11
2012	-9.86	0.90	-12.17	-7.54
2013	-23.66	8.97	-46.72	-0.60
Regslope	0.46	0.21	0.01	0.90

TABLE 7. Linear regression statistics (y-intercept and slope) of concentrations of nitrate as functions of salinity from four ocean transect sites off of the Makena Resort collected during monitoring surveys from 1995 to December 2012 (Transect Site 3 has been monitored since 2002; Trasect Site 3A since 2007). Also shown are standard errors and upper and lower 95% confidence limits around the y-intercepts and slopes. "REGSLOPE" indicates regression statistics for slope of yearly coefficients as a function of time. For location of transect sites, see Figure 1.

NITRATE -Y-INTERCEPT

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 1				
1995	326.50	7.10	308.25	344.75
1996	336.49	4.62	326.41	346.56
1997	406.96	1.93	402.00	411.93
1998	268.90	1.55	264.91	272.89
1999	225.24	5.32	213.66	236.83
2000	309.77	3.36	301.14	318.41
2001	336.53	9.69	311.61	361.44
2002	278.21	17.43	233.40	323.03
2003	421.29	7.81	404.28	438.30
2004	442.33	4.89	431.68	452.99
2005	296.36	7.44	280.16	312.56
2006	361.76	7.20	346.08	377.45
2007	305.06	15.88	270.45	339.67
2008	330.95	7.18	315.29	346.60
2009	231.91	3.07	224.01	239.81
2010	253.63	4.57	241.88	265.38
2011	235.52	6.82	220.66	250.37
2012	272.66	0.94	270.26	275.07
2013	258.44	23.18	198.85	318.02
REGSLOPE	-4.12	2.56	-9.52	1.27
SITE 2				
1995	119.87	12.03	88.95	150.79
1996	106.36	18.44	66.53	146.19
1997	193.75	5.64	179.95	207.55
1998	166.93	5.33	153.89	179.97
1999	116.21	14.04	86.10	146.32
2000	142.07	2.83	135.13	149.01
2001	154.93	7.65	136.21	173.64
2002	180.82	58.78	36.98	324.66
2003	163.36	6.31	149.82	176.91
2004	145.36	10.55	122.74	167.99
2005	102.66	9.11	83.13	122.19
2006	124.74	4.89	114.26	135.22
2007	134.27	3.25	127.30	141.24
2008	108.01	12.87	80.41	135.61
2009	142.21	9.04	120.08	164.34
2010	135.27	10.49	109.60	160.94
2011	166.23	6.33	152.64	179.81
2012	180.39	4.91	168.38	192.41
2013	161.57	8.84	139.95	183.19
REGSLOPE	0.60	1.16	-1.85	3.06
SITE 3A				
2007	354.33	49.92	245.56	463.11
2008	448.07	7.75	431.19	464.95
2009	283.99	14.63	246.38	321.60
2010	283.25	1.86	278.48	288.02
2011	364.51	5.48	352.58	376.45
2012	369.69	1.88	364.84	374.53
2013	190.37	67.40	17.11	363.63
REGSLOPE	-20.29	14.52	-57.63	17.05
SITE 3				
2002	847.45	52.35	712.88	982.01
2003	693.24	39.54	607.10	779.38
2004	463.72	90.73	266.04	661.40
2005	535.53	47.19	432.72	638.34
2006	856.96	48.22	751.91	962.02
2007	1233.34	18.23	1193.63	1273.06
2008	899.91	41.92	808.57	991.25
2009	827.18	19.10	778.08	876.29
2010	924.44	35.54	833.09	1015.80
2011	936.86	87.11	747.07	1126.65
2012	527.25	5.85	512.22	542.28
2013	352.15	80.76	144.55	559.76
REGSLOPE	-7.37	21.79	-55.92	41.17
SITE 4				
1995	111.38	6.47	94.74	128.02
1996	118.34	1.63	114.79	121.89
1997	122.56	1.29	119.25	125.88
1998	112.77	1.87	107.97	117.57
1999	109.13	3.30	101.94	116.33
2000	118.51	0.75	116.58	120.43
2001	100.93	54.85	-40.08	241.94
2002	118.91	3.25	110.56	127.25
2003	113.78	2.76	107.77	119.79
2004	134.97	4.64	124.86	145.07
2005	114.59	4.47	104.85	124.33
2006	119.85	1.76	116.03	123.68
2007	269.24	10.13	247.16	291.32
2008	62.93	4.05	54.11	71.74
2009	107.17	1.51	103.30	111.04
2010	148.96	16.96	105.35	192.57
2011	126.90	2.74	120.94	132.87
2012	178.94	1.78	174.38	183.51
2013	169.16	77.79	-30.81	369.12
REGSLOPE	2.68	1.69	-0.88	6.24

NITRATE - SLOPE

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 1				
1995	-9.49	0.22	-10.05	-8.92
1996	-9.67	0.14	-9.97	-9.38
1997	-11.70	0.06	-11.85	-11.55
1998	-7.72	0.05	-7.84	-7.60
1999	-6.44	0.16	-6.79	-6.10
2000	-8.91	0.10	-9.17	-8.65
2001	-9.60	0.28	-10.32	-8.88
2002	-7.99	0.52	-9.31	-6.66
2003	-12.09	0.23	-12.60	-11.58
2004	-12.74	0.15	-13.06	-12.42
2005	-8.48	0.22	-8.96	-8.01
2006	-10.40	0.22	-10.89	-9.92
2007	-8.73	0.52	-9.86	-7.60
2008	-9.52	0.22	-10.00	-9.05
2009	-6.65	0.09	-6.89	-6.41
2010	-7.31	0.16	-7.72	-6.89
2011	-6.66	0.21	-7.12	-6.19
2012	-7.81	0.03	-7.89	-7.73
2013	-7.33	0.66	-9.03	-5.63
REGSLOPE	0.12	0.07	-0.03	0.28
SITE 2				
1995	-3.47	0.35	-4.38	-2.56
1996	-3.05	0.53	-4.20	-1.89
1997	-5.57	0.17	-5.97	-5.16
1998	-4.79	0.16	-5.17	-4.41
1999	-3.31	0.41	-4.19	-2.43
2000	-4.08	0.08	-4.29	-3.88
2001	-4.41	0.22	-4.95	-3.88
2002	-5.19	1.72	-9.40	-0.99
2003	-4.68	0.18	-5.07	-4.28
2004	-4.19	0.31	-4.84	-3.53
2005	-2.94	0.26	-3.50	-2.37
2006	-3.57	0.14	-3.88	-3.27
2007	-3.85	0.10	-4.06	-3.64
2008	-3.09	0.37	-3.89	-2.29
2009	-4.10	0.27	-4.76	-3.43
2010	-3.88	0.31	-4.64	-3.13
2011	-4.74	0.18	-5.14	-4.35
2012	-5.16	0.14	-5.51	-4.81
2013	-4.59	0.25	-5.20	-3.97
REGSLOPE	-0.02	0.03	-0.09	0.05
SITE 3A				
2007	-9.57	1.67	-13.20	-5.93
2008	-12.81	0.24	-13.33	-12.29
2009	-7.98	0.49	-9.25	-6.72
2010	-8.15	0.06	-8.32	-7.99
2011	-10.31	0.18	-10.71	-9.92
2012	-10.60	0.06	-10.76	-10.44
2013	-5.40	1.92	-10.34	-0.46
REGSLOPE	0.52	0.43	-0.58	1.62
SiTE 3				
2002	-24.49	1.53	-28.43	-20.56
2003	-19.86	1.15	-22.36	-17.35
2004	-13.37	2.63	-19.09	-7.64
2005	-15.33	1.36	-18.29	-12.37
2006	-24.61	1.42	-27.70	-21.52
2007	-35.51	0.54	-36.68	-34.34
2008	-25.78	1.22	-28.43	-23.12
2009	-23.65	0.56	-25.08	-22.22
2010	-26.57	1.05	-29.26	-23.88
2011	-26.75	2.51	-32.22	-21.28
2012	-15.09	0.17	-15.53	-14.65
2013	-9.99	2.30	-15.90	-4.09
REGSLOPE	0.23	0.63	-1.17	1.63
SITE 4				
1995	-3.26	0.20	-3.77	-2.75
1996	-3.40	0.05	-3.50	-3.29
1997	-3.53	0.04	-3.63	-3.43
1998	-3.24	0.05	-3.38	-3.10
1999	-3.13	0.10	-3.34	-2.92
2000	-3.40	0.02	-3.46	-3.34
2001	-2.87	1.56	-6.89	1.15
2002	-3.44	0.10	-3.70	-3.19
2003	-3.28	0.08	-3.46	-3.09
2004	-3.89	0.14	-4.18	-3.59
2005	-3.29	0.13	-3.57	-3.00
2006	-3.43	0.05	-3.54	-3.31
2007	-7.87	0.32	-8.58	-7.17
2008	-1.79	0.12	-2.05	-1.54
2009	-3.07	0.04	-3.18	-2.95
2010	-4.30	0.50	-5.60	-3.00
2011	-3.62	0.08	-3.79	-3.44
2012	-5.13	0.05	-5.27	-4.99
2013	-4.80	2.21	-10.48	0.88
REGSLOPE	-0.08	0.05	-0.18	0.03

TABLE 8. Linear regression statistics (y-intercept and slope) of concentrations of orthophosphate phosphorus as functions of salinity from four ocean transect sites off of the Makena Resort collected during monitoring surveys from 1995 to December 2012 (Transect site 3 has been monitored since 2002; Trasect Site 3A since 2007). Also shown are standard errors and upper and lower 95% confidence limits around the y-intercepts and slopes. For location of transect sites, see Figure 1.

PHOSPHATE -Y-INTERCEPT

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 1				
1995	1.04	0.14	0.68	1.39
1996	1.78	0.12	1.52	2.03
1997	1.40	0.12	1.10	1.69
1998	1.10	0.06	0.95	1.25
1999	1.07	0.12	0.80	1.34
2000	0.89	0.12	0.59	1.19
2001	2.16	0.76	0.22	4.11
2002	1.12	0.68	-0.64	2.88
2003	0.48	0.19	0.06	0.90
2004	2.71	0.17	2.33	3.08
2005	-0.02	0.14	-0.34	0.29
2006	1.36	0.13	1.08	1.65
2007	1.07	0.20	0.64	1.50
2008	0.89	0.13	0.61	1.16
2009	0.87	0.38	-0.12	1.85
2010	1.86	0.18	1.40	2.31
2011	1.47	0.11	1.24	1.70
2012	1.65	0.08	1.45	1.86
2013	4.31	4.19	-6.47	15.09
REGSLOPE	0.05	0.04	-0.03	0.13
SITE 2				
1995	0.15	0.63	-1.46	1.76
1996	2.03	1.59	-1.41	5.48
1997	3.70	0.25	3.10	4.31
1998	3.55	1.44	0.03	7.07
1999	3.68	5.55	-8.22	15.58
2000	12.78	1.18	9.89	15.66
2001	30.73	3.12	23.09	38.37
2002	6.67	1.68	2.57	10.77
2003	3.57	0.31	2.90	4.24
2004	5.76	0.53	4.62	6.91
2005	-0.95	2.96	-7.31	5.40
2006	1.88	0.57	0.67	3.10
2007	0.22	0.26	-0.34	0.78
2008	1.50	1.14	-0.95	3.95
2009	1.54	0.34	0.71	2.38
2010	1.70	1.31	-1.49	4.90
2011	2.46	0.37	1.66	3.26
2012	3.21	0.60	1.74	4.68
2013	20.71	2.42	14.79	26.63
REGSLOPE	0.02	0.34	-0.69	0.74
SITE 3A				
2007	2.39	0.24	1.86	2.93
2008	4.43	0.49	3.36	5.50
2009	2.60	0.15	2.21	2.99
2010	2.75	0.29	2.01	3.48
2011	3.42	0.41	2.53	4.31
2012	4.06	0.04	3.96	4.17
2013	-12.61	20.44	-65.16	39.95
REGSLOPE	-1.60	1.03	-4.24	1.04
SITE 3				
2002	4.62	2.31	-1.31	10.55
2003	7.38	0.99	5.24	9.53
2004	7.40	0.78	5.70	9.10
2005	3.17	0.53	2.03	4.32
2006	7.32	1.16	4.80	9.84
2007	4.46	0.46	3.47	5.45
2008	4.01	1.13	1.56	6.47
2009	3.12	2.67	-3.74	9.99
2010	6.25	2.27	0.41	12.09
2011	0.86	0.75	-0.79	2.50
2012	6.37	0.53	5.01	7.73
2013	-15.11	27.54	-85.90	55.69
REGSLOPE	-0.94	0.45	-1.94	0.06
SITE 4				
1995	2.44	0.15	2.04	2.84
1996	3.08	0.13	2.79	3.37
1997	2.95	0.09	2.71	3.19
1998	3.50	0.46	2.32	4.67
1999	3.26	0.14	2.96	3.55
2000	3.29	0.20	2.77	3.82
2001	-19.16	22.66	-77.41	39.09
2002	3.98	0.15	3.60	4.35
2003	4.13	1.29	1.33	6.93
2004	4.75	0.79	3.04	6.47
2005	2.12	0.38	1.28	2.95
2006	2.15	0.40	1.28	3.02
2007	2.65	0.09	2.46	2.83
2008	2.98	0.67	1.52	4.44
2009	1.51	0.65	-0.16	3.19
2010	0.76	0.47	-0.46	1.97
2011	2.15	0.30	1.51	2.80
2012	2.06	0.07	1.87	2.25
2013	225.51	356.16	-690.04	1141.05
REGSLOPE	3.56	2.05	-0.77	7.88

PHOSPHATE - SLOPE

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 1				
1995	-0.03	0.00	-0.04	-0.02
1996	-0.05	0.00	-0.06	-0.04
1997	-0.04	0.00	-0.05	-0.03
1998	-0.03	0.00	-0.03	-0.02
1999	-0.03	0.00	-0.03	-0.02
2000	-0.02	0.00	-0.03	-0.01
2001	-0.06	0.02	-0.12	0.00
2002	-0.03	0.02	-0.08	0.02
2003	-0.01	0.01	-0.02	0.00
2004	-0.08	0.01	-0.09	-0.06
2005	0.00	0.00	-0.01	0.01
2006	-0.04	0.00	-0.04	-0.03
2007	-0.03	0.01	-0.04	-0.02
2008	-0.02	0.00	-0.03	-0.02
2009	-0.02	0.01	-0.05	0.01
2010	-0.05	0.01	-0.07	-0.04
2011	-0.04	0.00	-0.05	-0.03
2012	-0.04	0.00	-0.05	-0.04
2013	-0.12	0.12	-0.43	0.19
REGSLOPE	0.00	0.00	0.00	0.00
SITE 2				
1995	0.00	0.02	-0.05	0.04
1996	-0.06	0.05	-0.16	0.04
1997	-0.10	0.01	-0.12	-0.09
1998	-0.10	0.04	-0.20	0.00
1999	-0.10	0.16	-0.44	0.25
2000	-0.36	0.03	-0.45	-0.28
2001	-0.87	0.09	-1.09	-0.65
2002	-0.19	0.05	-0.31	-0.07
2003	-0.10	0.01	-0.12	-0.08
2004	-0.16	0.02	-0.20	-0.13
2005	0.03	0.09	-0.15	0.21
2006	-0.05	0.02	-0.09	-0.02
2007	0.00	0.01	-0.02	0.01
2008	-0.04	0.03	-0.11	0.03
2009	-0.04	0.01	-0.07	-0.02
2010	-0.05	0.04	-0.14	0.05
2011	-0.07	0.01	-0.09	-0.04
2012	-0.09	0.02	-0.13	-0.05
2013	-0.59	0.07	-0.76	-0.42
REGSLOPE	0.00	0.01	-0.02	0.02
SITE 3A				
2007	-0.07	0.01	-0.09	-0.05
2008	-0.13	0.02	-0.16	-0.09
2009	-0.07	0.01	-0.09	-0.06
2010	-0.07	0.01	-0.10	-0.05
2011	-0.09	0.01	-0.12	-0.06
2012	-0.11	0.00	-0.12	-0.11
2013	0.36	0.58	-1.14	1.86
REGSLOPE	0.05	0.03	-0.03	0.12
SITE 3				
2002	-0.13	0.07	-0.30	0.04
2003	-0.21	0.03	-0.27	-0.15
2004	-0.21	0.02	-0.26	-0.16
2005	-0.09	0.02	-0.12	-0.06
2006	-0.21	0.03	-0.28	-0.13
2007	-0.13	0.01	-0.16	-0.10
2008	-0.11	0.03	-0.18	-0.04
2009	-0.09	0.08	-0.29	0.11
2010	-0.18	0.07	-0.35	-0.01
2011	-0.02	0.02	-0.07	0.03
2012	-0.18	0.02	-0.22	-0.14
2013	0.43	0.78	-1.58	2.44
REGSLOPE	0.03	0.01	0.00	0.06
SITE 4				
1995	-0.07	0.00	-0.08	-0.06
1996	-0.09	0.00	-0.09	-0.08
1997	-0.08	0.00	-0.09	-0.07
1998	-0.10	0.01	-0.13	-0.06
1999	-0.09	0.00	-0.10	-0.08
2000	-0.09	0.01	-0.10	-0.07
2001	0.55	0.65	-1.11	2.21
2002	-0.11	0.00	-0.12	-0.10
2003	-0.11	0.04	-0.19	-0.02
2004	-0.13	0.02	-0.18	-0.08
2005	-0.06	0.01	-0.08	-0.03
2006	-0.06	0.01	-0.08	-0.03
2007	-0.07	0.00	-0.08	-0.07
2008	-0.08	0.02	-0.13	-0.04
2009	-0.04	0.02	-0.09	0.01
2010	-0.02	0.01	-0.06	0.02
2011	-0.06	0.01	-0.08	-0.04
2012	-0.05	0.00	-0.06	-0.05
2013	-6.40	10.12	-32.42	19.61
REGSLOPE	-0.10	0.06	-0.22	0.02

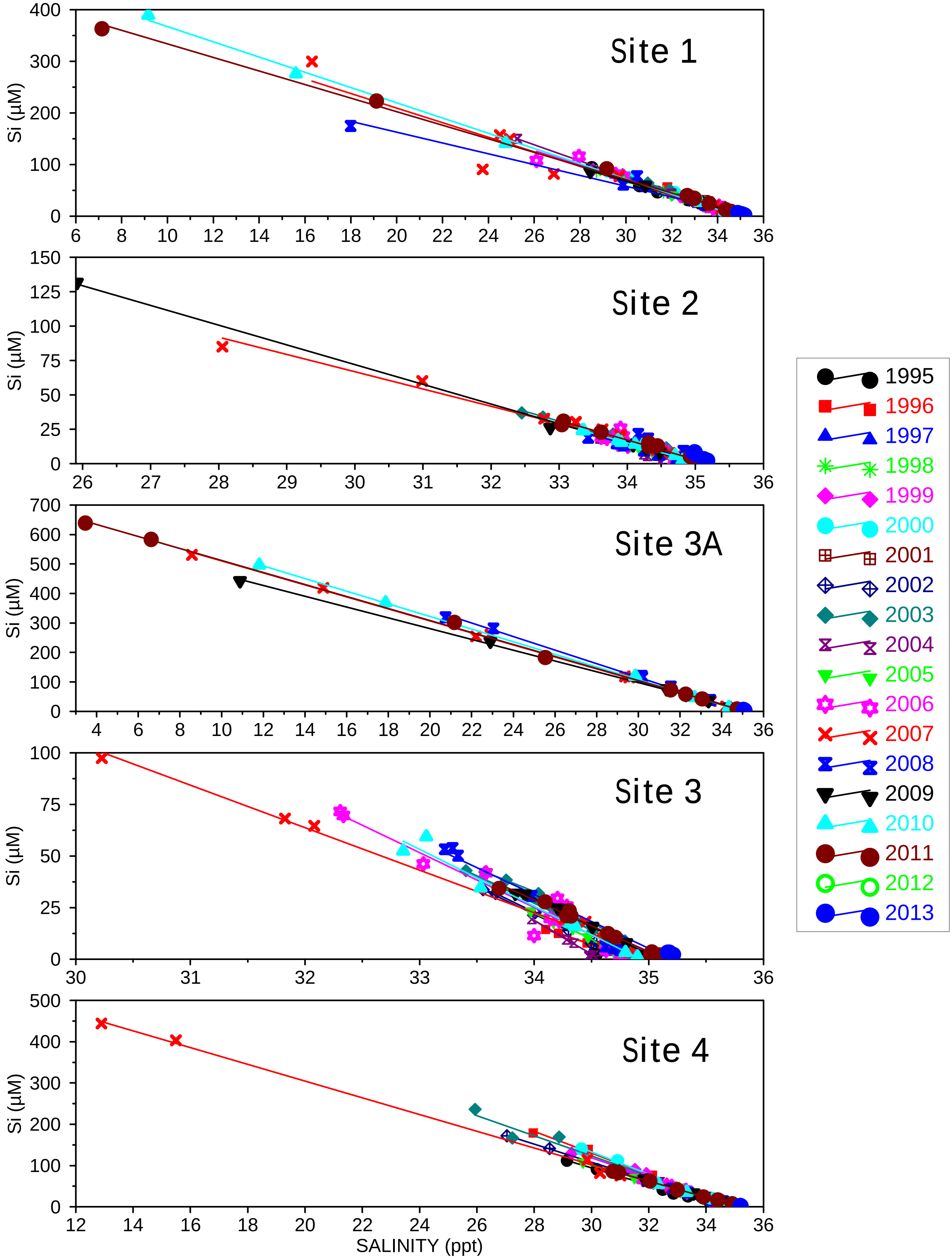

FIGURE 22. Mixing diagram showing yearly concentrations of silicate as functions of salinity from samples collected during annual monitoring surveys at five transect sites offshore of the Makena Resort (Site 3A since 2007). Note axis scale changes between sites. Straight lines are linear regressions through data points for each year. For sampling site locations, see Figure 1.

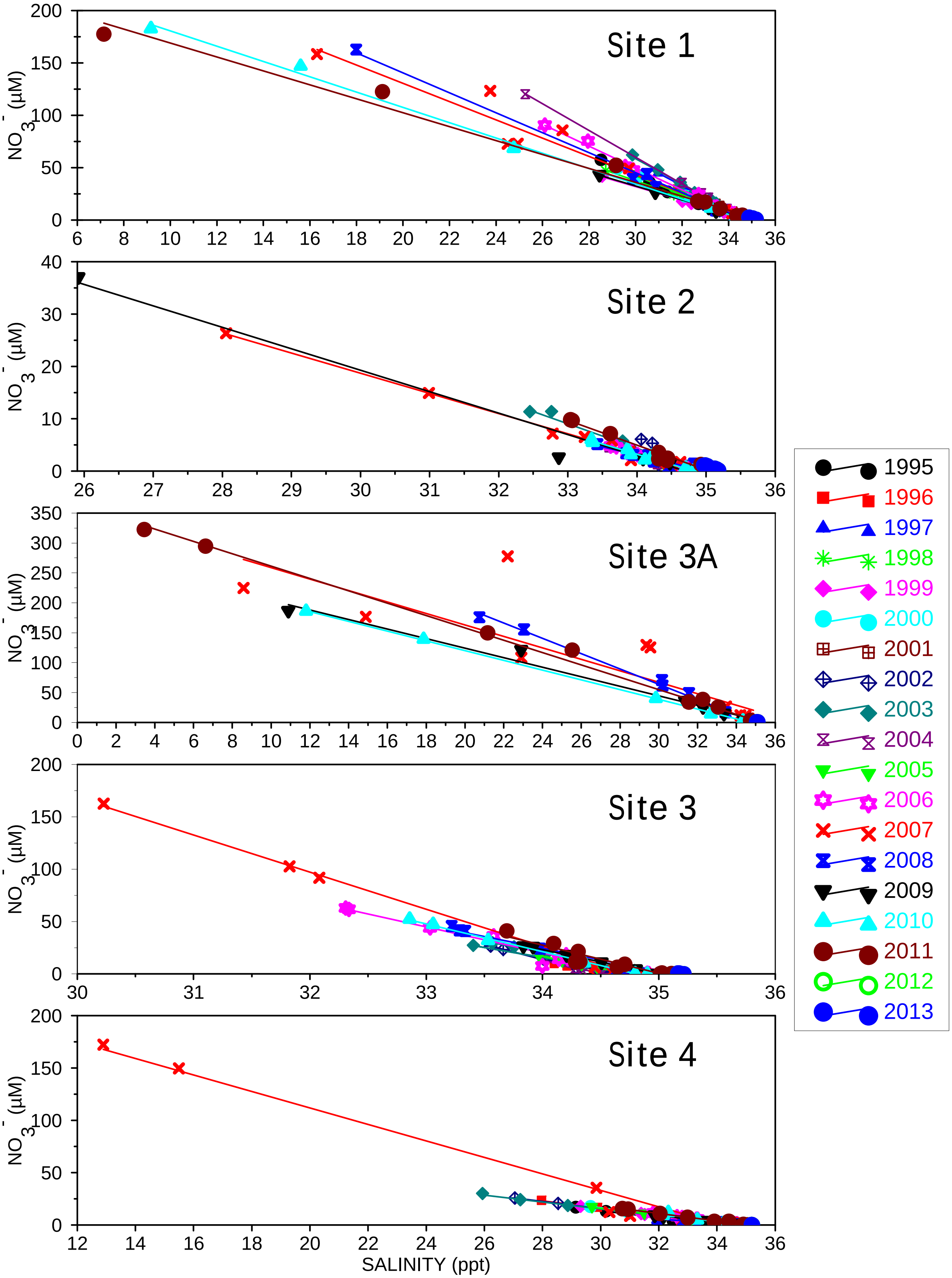

FIGURE 23. Mixing diagram showing yearly concentrations of nitrate as functions of salinity from samples collected during annual monitoring surveys at five transect sites offshore of the Makena Resort (Site 3A since 2007). Note axis scale changes between sites. Straight lines are linear regressions through data points for each year. For sampling site locations, see Figure 1.

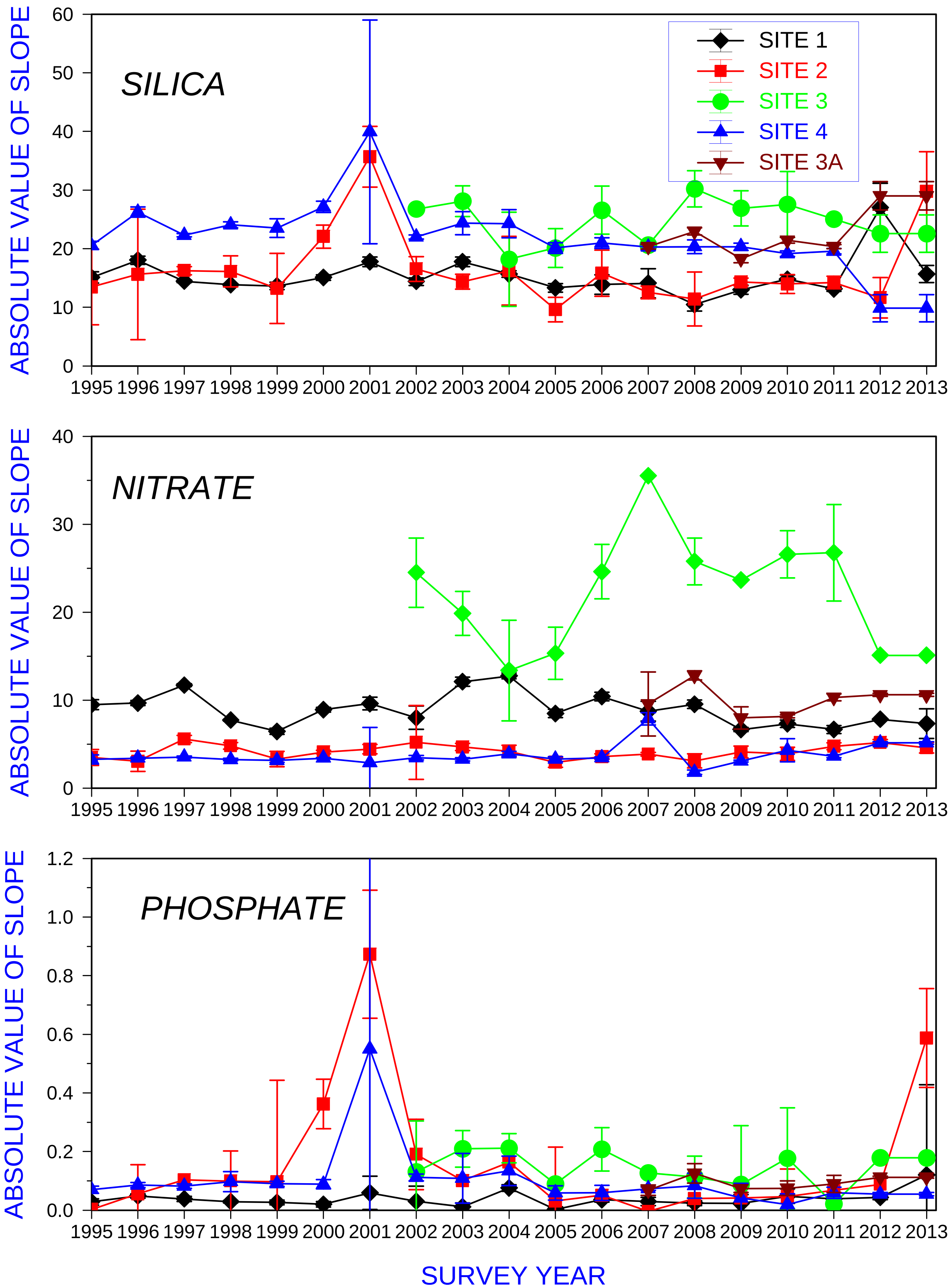

FIGURE 24. Time-course plots of absolute values of slopes of linear regressions of concentrations of silca, nitrate and phosphate as functions of salinity collected annually at each of the transect monitoring stations off the Makena Resort (Site 3A began in June 2007). Error bars are 95% confidence limits (Note error bar for Site 4 Phosphate is off scale). For locations of sampling transect sites, see Figure 1.

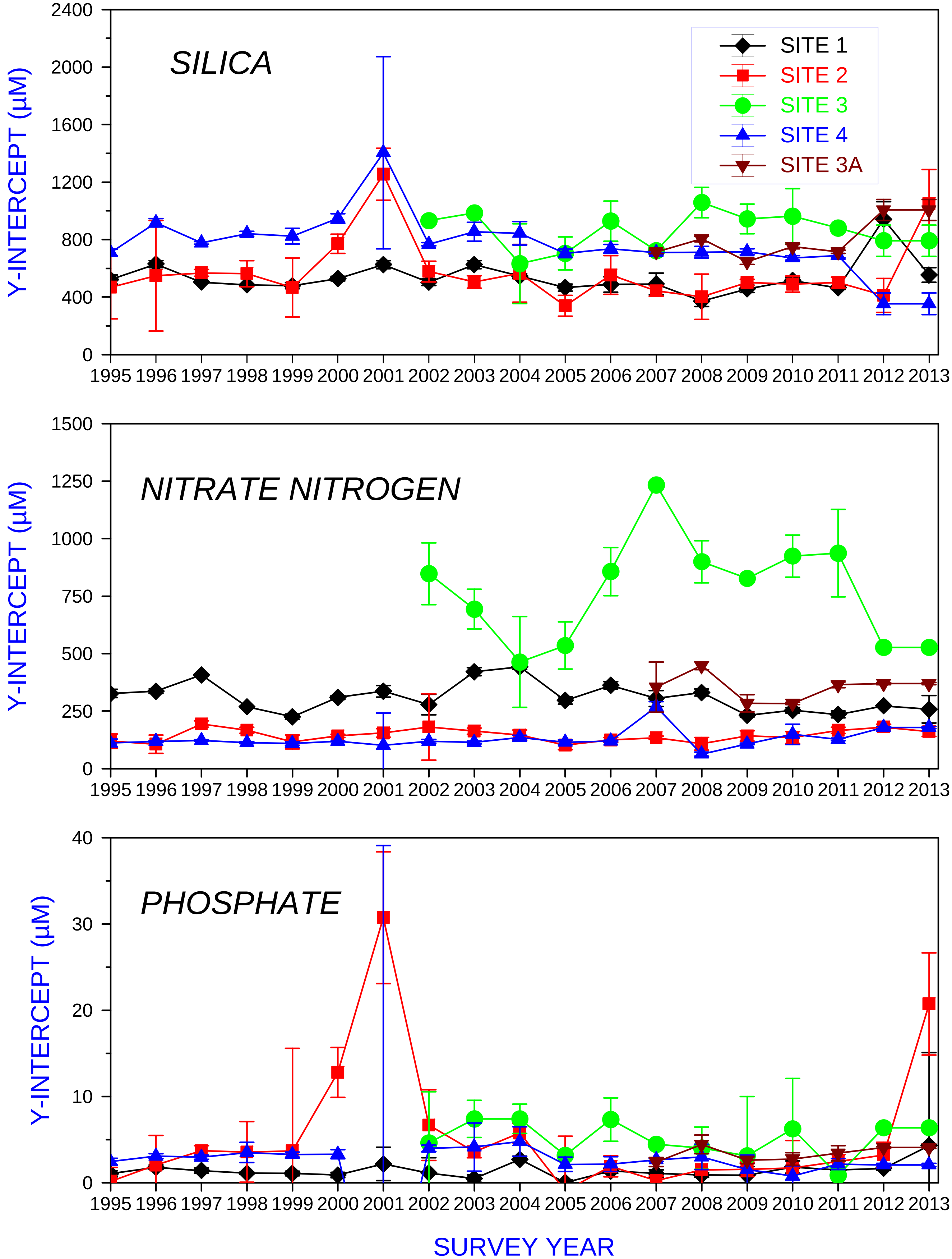

FIGURE 25. Time-course plots of Y-intercepts of linear regressions of concentrations of silca, nitrate and phosphorus as functions of salinity collected annually at each of the transect monitoring stations off the Makena Resort (Site 3A began in June 2007). Error bars are 95% confidence limits. For locations of sampling transect sites, see Figure 1.

Exhibit B

ATC MAKENA HOLDINGS, LLC
c/o Stanford Carr Development, LLC
1100 Alakea St. 27th Floor
Honolulu, HI 96813

March 5, 2014

Mr. Watson Okubo
State of Hawaii, Department of Health
Clean Water Branch
919 Ala Moana Blvd. Room 301
Honolulu, HI 96814

Via PDF Only unless hardcopy is requested.

Re: State Land Use District Boundary Amendment Docket A9-721 Condition No. 10, County of Maui Zoning Ordinance 3613 Condition No. 19, Marine Water Quality Monitoring.

Dear Mr. Okubo,

ATC Makena Holdings, LLC, in compliance with the above referenced conditions, respectfully submits the enclosed Marine Water Quality Monitoring Report prepared by Marine Research Consultants, Inc. dated February 28, 2014, for tests performed on January 5, 2014. It should be noted that the present survey constitutes the second required survey of 2013. However, owing to unforeseen problems with logistics, MRCI was unable to conduct field sampling until January 5, 2014.

The next scheduled testing for the Makena Resort monitoring program is planned for the spring-summer season of 2014.

Should you have any questions, require a hardcopy, or require additional information please do not hesitate to contact me at (808) 547-2276, or by e-mail at sarah@stanfordcarr.com.

Sincerely,

STANFORD CARR DEVELOPMENT, LLC
For ATC MAKENA HOLDINGS, LLC.

Sarah Agnew-Miller

Sarah Agnew-Miller
Project Management/Planning

MARINE WATER QUALITY MONITORING

MAKENA RESORT, MAKENA, MAUI

WATER CHEMISTRY

REPORT 2-2013

(January 2014)

Prepared for:

ATC Makena Holdings, LLC
c/o Stanford Carr Development, LLC
1100 Alakea St. 27th Floor
Honolulu, HI 96813

By:

MRCI
MARINE RESEARCH CONSULTANTS, INC.

1039 Waakaua Pl.
Honolulu, Hawaii 96822

Submitted

February 28, 2014

EXECUTIVE SUMMARY

The Makena Resort fronts approximately 5.4 miles of coastline of southeastern Maui, extending from Papanui Stream (Nahuna Point) on the north and Pu`u Olai (Ahihi Bay) on the south. However, only 0.58 miles of the Resort reaches to the actual shoreline. Within the Resort are two 18-hole golf courses (North and South Courses), as well as a hotel, sewage treatment plant and private residences. No part of the project involves direct alteration of the shoreline or nearshore marine environments. In the interest of assuring maintenance of the highest possible quality of the marine environment, condition No. 10 of the Declaration of Conditions pertaining to the Amendment of the District Boundary, as required by the Land Use Commission, dated April 17, 1998 stipulates the implementation of an ongoing marine monitoring program off the Makena Resort Development. Additionally, County of Maui Zoning Ordinance 3613 Condition 19 included requirements for similar monitoring. The primary goals of the program are twofold: 1) to assess the degree that materials used on land to enhance turf growth and landscaping, as well as other nutrient subsidies, leach to groundwater and subsequently reach the ocean, and 2) to determine the fate of these materials within the nearshore zone. In terms of determining fate, the question that is addressed is if the materials that originate from Resort activities disperse with little or no effect, or do they cause changes in water quality sufficient to alter marine biological community structure? The following report fulfills the requirements of these Conditions, and presents the results of water quality monitoring off the Makena Resort conducted on January 5, 2014. The report also incorporates the cumulative data from 29 past water chemistry surveys conducted in the area.

Survey methodology includes collection of 62 ocean water samples on four transects spaced along the projects ocean frontage and on one control transect. Site 1 is located at the northern boundary of the project, Site 2 is located near the central part of the Makena North Golf Course in the center of Makena Bay, Site 3A (initiated during the June 2007 survey) is located near the southern boundary of Maluaka Bay, Site 3 was downslope from the part of Makena South Golf Course that comes closest to the shoreline, and Control Site 4 is located to the south of Makena Resort near the northern boundary of the 'Ahihi-Kina`u Natural Area Reserve. Water samples were collected at 7 stations spaced along transects that extended from the shoreline out to the open coastal ocean (about 500 feet). At sampling stations where water depth exceeded about 3 feet, samples were collected at the surface and just above the sea floor. At shallower stations, only surface water was collected. Water samples were analyzed for chemical criteria specified by DOH water quality standards for open coastal waters, as well as several additional criteria. In addition, water samples were collected from nine irrigation wells located on the golf courses.

Results of analysis of water chemistry showed that constituents that occur in high concentration in groundwater (silica, nitrate-nitrogen) were found to be highest in ocean samples collected nearest to the shoreline, with progressively decreasing values moving away from shore into deeper water. While groundwater nutrient input was evident at all four sampling locations, it was highest in magnitude at Sites 1 (located off the northern boundary of the Makena Resort property), and 3A, (located directly downslope from the Makena Resort). As Site 4 served as a control, and was not located in the vicinity of the Makena Resort, it is apparent that groundwater input is not solely a function of Resort land usage.

Vertical stratification of the water column was not evident on transects with no substantial differences between surface and bottom water. The observed patterns of distribution with respect to both distance from shore and depth in the water column indicate that physical mixing processes generated by tide, wind, waves and currents mix the water column from top to bottom.

Overall, measurements of turbidity and chlorophyll *a* were low throughout the sampling area, although values were slightly elevated close to the shoreline probably as a result of resuspension of fine-grained marine sediments (turbidity) and fragments of benthic algae washed up to the shoreline (Chl *a*). These results indicate that at the time of sampling, nutrient input from land was not likely resulting in increases in plankton populations in nearshore waters. Low turbidity in Makena Bay (transect Site 2) suggests mitigation of the effects of a past episode of high runoff of upland soil from a flash flood in October 1999 that resulted in substantial impacts to water clarity within the Bay.

Other organic water chemistry constituents that do not occur in high concentrations in groundwater, such as ammonium nitrogen or organic nitrogen and phosphorus, were consistently low and did not show any distinctive patterns with respect to input from land.

Analyses that scale nutrient concentrations to salinity reveal that there were measurable increases of nitrate nitrogen above what is found in naturally occurring groundwater that enters the nearshore ocean at three survey sites (Sites 1, 3 and 3A). These subsidies, which are likely a result of land uses involving fertilizers, substantially increase the concentration of nitrate over natural groundwater flowing to the ocean. These subsidies were greatest in magnitude at Sites 3 and 3A, followed by Site 1, all of which are located off the Makena Golf Courses and adjacent residential areas. No subsidies of nitrate were apparent at Site 2 (Makena Landing) or Site 4 ('Ahihi-Kina`u). The lack of distinguishable upward curvature of these data arrays indicates that the nutrients from groundwater that enter the ocean, both from natural and the human sources, are not being taken up by biotic communities in the nearshore zone. Rather, nutrients are mixed to background ocean values by physical processes including wind stirring and wave action.

Statistical tests of nutrient concentration scaled to salinity over time show no significant increases or decreases over the years of monitoring at any of the survey sites. The lack of such increases suggests that there has been no consistent change in nutrient input from land (either as an increase or decrease) to groundwater that enters the ocean over the past years.

Comparing values of water chemistry measured in the monitoring program to State of Hawaii Department of Health (DOH) water quality standards revealed that several measurements of nitrogen, phosphorus, turbidity and Chlorophyll *a* exceeded the DOH standards, particularly for "geometric mean" standards. Such exceedances occurred at all survey sites, including the control site that was removed from influences of the Makena Resort. The consistent exceedance of water quality standards is in large part a consequence of the natural effects of groundwater discharge to the nearshore ocean, as well as physical mixing processes that occur near the shorelines of all coastal areas. Revision of DOH standards to account for such natural input has been implemented for the West Coast of the Island of Hawaii, and will hopefully be extended to the rest of the State in the near future.

As in all past surveys, the results of the most recent increment of monitoring reveal that there is an increase over natural conditions of dissolved inorganic nutrients (e.g., nitrate and phosphate) in groundwater that enters the nearshore ocean at sampling sites downslope from parts of the Makena Resort. Without question, such input is a consequence of various land use activities.

However, none of these inputs have increased significantly over time during the 18-year course of the monitoring program. The regions where the highest elevations over natural inputs occur are restricted to narrow zone that extends from the shoreline to several meters offshore, and as such is restricted to an area that is not suitable for coral communities to occur owing to shallow water depth, wave impact and sand scour. Surveys of coral reef community structure that are also part of the ongoing monitoring program for the Makena Resort, as well as the continued lack of any nuisance algal accumulations in the nearshore area, indicate that the nutrient subsidies are presently not detrimental to marine community structure.

The next scheduled testing for the Makena Resort monitoring program is planned for the spring-summer season of 2014.

I. PURPOSE

The Makena Resort fronts approximately 5.4 miles of coastline of southeastern Maui, extending from Papanui Stream (Nahuna Point) on the north and Pu`u Olai (Ahihi Bay) on the south. However, only 0.58 miles of the Resort reaches to the actual shoreline. Within the Resort are two 18-hole golf courses (North and South Courses), as well as a hotel, sewage treatment plant and private residences. No part of the project involves direct alteration of the shoreline or nearshore marine environments.

Evaluations of other golf courses and other forms of resort development located near the ocean in the Hawaiian Islands reveal that there is detectable input to the coastal ocean of materials used for fertilization of turfgrass and landscaping (Dollar and Atkinson 1992). However, few, if any, effects that have been documented have been found to be detrimental to the marine ecosystem. Confirmation that the construction and responsible operation of the golf courses and other components of the Makena Resort does not cause any harmful changes to the marine environment requires rigorous and continual monitoring.

In the interest of assuring maintenance of excellent environmental quality in the Makena region, Condition No. 10, Declaration of Conditions pertaining to the Amendment of the District Boundary, as required by the Land Use Commission, dated April 17, 1998 stipulated the implementation of an ongoing marine monitoring program off the Makena Resort Development. In addition, County of Maui Zoning Ordinance 3613 Condition 19 included requirements for similar monitoring. The primary goals of the established monitoring program to satisfy these two requirements are twofold: 1) to assess the degree that materials used on land to enhance turf growth and landscaping, as well as other nutrient subsidies, leach to groundwater and subsequently reach the ocean, and 2) to determine the fate of these materials within the nearshore zone. In terms of determining fate, the question addressed is if the materials that originate from Resort activities disperse with little or no effect, or do they cause changes in water quality sufficient to alter marine biological community structure?

The rationale of the monitoring program is to conduct repetitive evaluations of water chemistry at the same locations at regular time intervals (twice per year). This strategy allows for determination of variations in effects from the Makena Resort in both space (at different locations along the shoreline) and time. It should be noted that water chemistry monitoring off the Makena area was initiated in 1995 on a voluntary basis, and has continued uninterrupted until the present. With the implementation of the Boundary Amendment and Zoning Conditions, it was determined that the ongoing voluntary monitoring protocol satisfied the stated requirements. Hence, the entire data set from 1995 onward is considered as part of the monitoring program. The following report presents the results of the 30th increment in the monitoring program, and contains data from water chemistry sampling conducted on January 5, 2014. It should be noted that the present survey constitutes the second required survey of 2013. However, owing to unforeseen problems with logistics field sampling was not conducted until the January 5, 2014.

II. ANALYTICAL METHODS

Three survey sites directly downslope from the Makena Resort have been selected as sampling locations. A fourth site, located offshore of an area with minimal land-based development, particularly golf course operations, was selected as a control. During the June 2007 survey, another sampling location was added near the southern boundary of Maluaka Bay. It is anticipated that this station will remain part of the sampling protocol permanently.

Figure 1 is a map showing the shoreline and topographical features of the Makena area, and the location of the North and South Golf Courses. All survey sites are depicted as transects perpendicular to the shoreline extending from the shoreline out to what is considered open coastal ocean (i.e., beyond the effects of activities on land). Survey Site 1 is located near the northern boundary of the project site off Nahuna Point; Survey Site 2 bisects Makena Bay near Makena Landing. Site 3 bisects the middle of the South course on the north side of Maluaka Point. Site 3A is on the southern corner of Maluaka Bay. Site 4, which is considered the Control site, is located near the northern boundary of the 'Ahihi-Kina`u natural area reserve north of the 1790 lava flow and approximately 1-2 miles south of the existing Makena Golf courses (Figure 1).

The control site was located off a shoreline area with minimal land uses (i.e., residences near the shoreline and upslope ranchlands) rather than off the completely uninhabited 1790 lava flow. This location was selected as the most appropriate control site, as it is the farthest location from the Makena Resort with the same geophysical structural of the land area. The completely different geological structure of the lava flow off the natural reserve likely results in very different groundwater dynamics compared to the land area where the Makena Resort is located, hence making the lava flow an unsuitable control site.

In July of 2002, Site 3 was relocated from the southern boundary of the project offshore of Oneloa Beach to the location directly off the Makena Golf Course, as described above. The relocation of Site 3 was deemed necessary as the original location consistently showed virtually no input of groundwater to the ocean. Such lack of groundwater discharge resulted in little potential for evaluating effects from the project. The present location of Site 3 is directly downslope from both the portion of the golf course nearest to the ocean, several newly constructed private residences, and a 3-acre recently restored wetland area. As a result, the new location represents an area that reflects the maximum influence on nearshore water quality from a variety of land uses and natural habitat.

All fieldwork for the present survey was conducted on January 5, 2014. Environmental conditions during sample collection consisted of moderate Kona winds (15-20 knots), sunny skies, and wind-chopped ocean conditions. Surf breaking on the shoreline was negligible. Sample collection at the shoreline occurred during a period closest to low tide with a tidal range of ~+0.40 to +0.24 feet.

Water samples were collected at stations along transects that extend from the highest wash of waves to between 150-200 meters (m) offshore (about 500-650 feet), depending on the site. Such a sampling scheme is designed to span the greatest range of salinity with respect to freshwater efflux at the shoreline. Sampling was more concentrated in the nearshore zone because this area is most likely to show the effects of land-based activities. With the exception of the two stations closest to the shoreline (0 and 2 m offshore), samples were collected at two depths; a surface sample was collected within approximately 10 centimeters (cm) (~4 inches) of the sea surface, and a bottom sample was collected within one m (3 feet) of the sea floor.

Water samples from the shoreline to a distance of 10 m offshore were collected in triple-rinsed 1-liter polyethylene bottles by swimmers working from the shoreline. Water samples beyond 10 m from the shoreline were collected from a small boat using a 1.8-liter Niskin sampling bottle. This bottle was lowered to the desired depth in an open position where spring-loaded endcaps were triggered to close by a messenger released from the surface. Upon recovery, each sample was placed on ice until further processing in Honolulu. Water samples were also collected from nine golf course irrigation wells (No's 1, 2, 3, 4, 5, 6, 8, 10 and 11) on May 10, 2012.

Water quality parameters evaluated included the 10 specific criteria designated for open coastal waters in Chapter 11-54, Section 06 (Open Coastal waters) of the State of Hawaii Department of Health Water Quality Standards. These criteria include: total nitrogen (TN) which is defined as inorganic nitrogen [nitrate + nitrite nitrogen (NO_3^- + NO_2^-), ammonium (NH_4^+)], plus total organic nitrogen (TON), total phosphorus (TP) which is defined as inorganic phosphorus (PO_4^{3-}) plus total organic phosphorus, chlorophyll a (Chl *a*), turbidity, temperature, pH and salinity. In addition, orthophosphate phosphorus (PO_4^{3-}) and silica (Si) were reported because these constituents are sensitive indicators of biological activity and the degree of groundwater mixing, respectively.

Analyses for NO_3^- + NO_2^- (hereafter termed NO_3^-), NH_4^+ and PO_4^{3-}, were performed on filtered samples using a Technicon Analytical AA3 autoanalyzer according to standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983). TN and TP were analyzed in a similar fashion on unfiltered samples following digestion. Total organic nitrogen (TON) and Total organic phosphorus (TOP) were calculated as the difference between TN and inorganic N, and TP and inorganic P, respectively. Limits of detection for the dissolved nutrients are 0.01 μM (0.14 μg/L) for NO_3^- and NH_4^+, 0.01 μM (0.31 μg/L) for PO_4^{3-}, 0.1 μM (1.4 μg/L) for TN and 0.1 μM (3.1 μg/L) for TP.

Chl *a* was measured by filtering 300 ml of water through glass fiber filters; pigments on filters were extracted in 90% acetone in the dark at -5°C for 12-24 hours, and the fluorescence before and after acidification of the extract was measured with a Turner Designs fluorometer (level of detection 0.01 μg/L). Salinity was determined using an AGE Model 2100 laboratory salinometer with a precision of 0.003‰.

In situ field measurements included water temperature, pH, dissolved oxygen and salinity which were acquired using an RBR Model XR-420 CTD calibrated to factory specifications. The CTD has a readability of 0.001°C, 0.001pH units, 0.001% oxygen saturation, and 0.001 parts per thousand (‰) salinity. Shoreline salinity was measured in the field using an Atago PAL-06S digital refractometer.

Nutrient, turbidity, Chl *a* and salinity analyses were conducted by Marine Analytical Specialists located in Honolulu, Hawaii. This laboratory possesses acceptable ratings from EPA-compliant proficiency and quality control testing.

III. RESULTS and DISCUSSION

A. General Overview

Table 1 shows results of all marine water chemical analyses for samples collected off Makena on January 5, 2014 with nutrient concentrations reported in micromolar units (μM). Table 2 shows similar results with nutrient concentrations presented in units of micrograms per liter (μg/L). Tables 3 and 4 show geometric means of ocean samples at Sites 1, 2 and 4 for 30 surveys, 21 surveys at Site 3, and 12 surveys from Site 3A, with nutrient concentrations shown in μM and μg/L, respectively. Table 5 shows water chemistry measurements (in units of μM and μg/L) for samples collected from irrigation wells located on the Makena Resort Golf Courses. Concentrations of twelve chemical constituents in surface and deep-water samples from the January 2014 sampling are plotted as functions of distance from the shoreline in Figures 2 and 3. Mean concentrations (±standard error) of twelve chemical constituents in surface and deep water samples as functions of distance from the shoreline at Sites 1-4 collected since 1995 and from Site 3A collected since 2007are plotted in Figures 4-18. In addition, data from the most recent sampling in January 2014 are also plotted on Figures 4-18.

During the January 2014 sampling, nearshore concentrations of dissolved Si, NO_3^- and TN on all five transects were elevated by one to two orders of magnitude compared to samples collected in the open coastal ocean at stations located farthest from shore (Figure 2, Tables 1 and 2). The horizontal gradient of Si, NO_3^- and TN was steepest on Transects 1 and 3A and least evident on Transects 2 and 4. In all cases, the horizontal gradients were maintained out to a distance of at least ten meters from the shoreline.

At all survey sites, surface salinity was lower than ocean values (~35‰) within ten meters of the shoreline. The gradient of salinity was greatest on Transect 1, where values increased from 26.25‰ at the shoreline to 35.17‰ in the surface sample collected farthest from shore (Tables 1 and 2). Similar horizontal gradients in salinity at the other four sites varied between the shoreline and the offshore area by ~ 5.5‰ (Site 3-A) and ~1.5 ‰ (Sites 2, 3 and 4).

On all transects, concentrations of phosphate phosphorus (PO_4^{3-}) and TP were generally only slightly higher at the shoreline compared with offshore values. The steep horizontal gradients evident in concentrations of Si and NO_3^- were not replicated with PO_4^{3-} and TP (Figure 2 and Tables 1 and 2). However, among the five transect sites, horizontal gradients of PO_4^{3-} and TP were distinctly higher at Transect site 3-A compared to the other four sites.

With no streams in the sampling area, nor heavy rainfall and subsequent surface runoff preceding sampling, patterns of elevated Si, NO_3^-, TN and PO_4^{3-} with corresponding reduced salinity generally indicates groundwater entering the ocean near the shoreline. Low salinity groundwater, which contains high concentrations of Si, NO_3^-, TN and PO_4^{3-} (see values for well waters in Table 5), percolates to the ocean near the shoreline, resulting in a distinct zone of mixing in the nearshore region. The zone of mixing is discernible by distinct decreasing gradients of nutrients and increasing gradients of salinity with distance from shoreline. During periods of low tide when sea conditions are calm, the zone of mixing between groundwater and ocean water is most pronounced. When a higher than normal tidal stand exists, along with onshore winds and waves, increased mixing near the shoreline tends to dilute the groundwater signal. While the January 2014 sampling was conducted during a period of low tide, moderately strong Kona winds and choppy sea conditions were not sufficient to coastal waters to the extent that gradients of groundwater nutrients were eliminated. Comparing the results of the repetitive surveys conducted during different wind and sea conditions clearly indicates that tidal state, as well as wind and wave energy, greatly effect groundwater mixing in the nearshore zone.

Dissolved nutrient constituents that are not usually associated with groundwater input (NH_4^+, TON, TOP) did not exhibit distinct horizontal gradients across the sampling transects (Table 1, Figure 2). Surface concentration of TON and TOP were relatively constant along all transects (Table 1, Figure 2). Surface concentrations of NH_4^+ varied with distance offshore and among the five transects, however, no distinct pattern was evident (Figure 2).

Turbidity was highest near the shoreline on all transects with distinctly higher concentrations at Transects 2, 3-A and 4 (Tables 1 and 2, Figure 3). Transect 2 bisects Makena Bay (Makena Landing), which is a semi-enclosed embayment with a silt/sand bottom rather than the predominantly "hard" reef or sand bottoms that occur at the other transect sites. In addition, it has been observed that during flash floods originating in the ranch lands upslope of the Makena Resort, terrigenous sediment will flow to the ocean at Makena Bay. As a result of wave-induced resuspension of the naturally occurring silt/sand substratum, as well as terrigenous runoff which may be partially retained within the embayment, turbidity has often been elevated on Transect 2 relative to the other transect sites. It is important to note that in surveys conducted since July 2002, water clarity in Makena Bay has improved greatly compared to preceding surveys in 2001 which reflected conditions following substantial input of terrigenous materials from a flash-flood that occurred in October 1999. Since that time, a large retention basin has been constructed on the upper slopes of Makena Resort in the watershed that flows into Makena Bay. Beyond the shoreline, turbidity was constant and of the same magnitude at all five transect sites (Tables 1 and 2).

In January 2014 concentrations of Chl *a* were higher near the shoreline and steadily decreased with distance offshore (Figure 3). Values of Chl *a* at the shoreline were higher at Transect sites 2 and 3-A compared to the other three sites. Beyond the shoreline, the magnitude in Chl *a* concentrations were similar among all five sites (Tables 1 and 2). Excluding the low value for temperature measured at Transect site 3-A, surface water temperature ranged between 23.6°C and 24.8°C among the five sites during the January 2014 survey (Figure 3 and Tables 1 and 2). Temperature was relatively constant along each of the transect sites with a maximum variation along any one transect of 1.0°C (Tables 1 and 2).

In many areas of the Hawaiian Islands, input of low salinity groundwater to the nearshore ocean creates a distinct buoyant surface lens that can persist for some distance offshore. Buoyant surface layers are generally found in areas where turbulent processes (primarily wave action) are insufficient to completely mix the water column in the nearshore zone. Figures 2 -18 and Tables 1 and 2 show concentrations of water chemistry constituents with respect to vertical stratification. During the January 2014 survey, differences were detected between surface and deep samples collected within 50 m of the shoreline, however no distinct pattern emerged from the data (Figures 2 and 3, Tables 1 and 2).

B. Temporal Comparison of Monitoring Results

Figures 4-18 show mean concentrations (±standard error) of water chemistry constituents from surface and deep samples at Transect Sites 1-4 from monitoring surveys conducted since 1995 and from Site 3A for monitoring surveys conducted since 2007. The results of the most recent survey in January 2014 are also shown on each plot.

The long-term means of concentrations of groundwater nutrients (Si, NO_3^-, and PO_4^{3-}), salinity, NH_4^+, Chl *a* and turbidity show an overall trend of increasing nutrients and decreasing salinity with distance offshore. Additionally, differences between surface and deep concentrations show vertical stratification within 50 meters of the shoreline with nutrient concentrations higher and salinity lower in the surface water compared to the deep water. Mean concentrations of TON, TOP and temperature remain constant along the length of each transect. The exception to the general trends is evident at Site 3A where mean values for NH_4^+ and Chl *a* were higher in a zone within 5 meters of the shoreline and lowest in a zone between 10–150 meters offshore. Temperature at Site 3A also increased with increasing distance offshore, a finding dissimilar from the other sites where temperature was fairly constant (Figures 16 and 18).

Comparing the most recent survey with the overall dataset revealed that surface concentrations of Si, NO_3^-, and PO_4^{3-} measured during January 2014 at sampling sites within 50 m of the shoreline were both higher (Transects 1, 2 and 3) and lower (Transects 3-A and 4) than the mean values (Figures 4, 7, 10, 13 and 16). Salinity exhibited the opposite trends, with lower nearshore values at the transects with higher nutrients, and vice versa. Concentrations of TN and TP measured during the present survey were similar to the long-term means (Figures 5, 8, 11, 14 and17). Turbidity and measured in the most recent survey along the shoreline were also similar to mean values, with the exceptions of Transect 4, which showed slightly higher values in January 2014. Values of Chl *a* were higher than the means on Transects 2, 3 and 3-A (Figures 6, 9, 12, 15 and18). The patterns comparing the concentrations measured in the most recent survey to the mean values over all survey dates are likely a reflection of the presence or absence of physical mixing processes in the nearshore zone. None of the comparisons of the most recent sampling results to the mean values calculated for the entire monitoring regime indicates any recent negative effects to nearshore water quality.

C. Conservative Mixing Analysis

A useful treatment of water chemistry data for interpreting the extent of material input from land is application of a hydrographic mixing model. In the simplest form, such a model consists of plotting the concentration of a dissolved chemical species as a function of salinity. Comparison of the curves produced by such plots with conservative mixing lines provides an indication of the origin and fate of the material in question (Officer 1979, Dollar and Atkinson 1992, Smith and Atkinson 1993).

Figure 19 shows plots of concentrations of four chemical constituents (Si, NO_3^-, PO_4^{3-}, and NH_4^+) as functions of salinity for samples collected in January 2014. Figures 20 and 21 show the same type of plot with data pooled by transect site for a composite of all past surveys, as well as for the most recent survey. Each graph also shows a conservative mixing line that is constructed by connecting the end member concentrations of open ocean water with irrigation well No. 4 located off the North Course of the Makena Resort (representative of groundwater upslope of the Makena Resort).

If the parameter in question displays purely conservative behavior (no input or removal from any process other than physical mixing), data points should fall on, or very near, the conservative mixing line. If, however, external material is added to the system through processes such as leaching of fertilizer nutrients to groundwater, data points will fall above the mixing line. If material is being removed from the system by processes such as uptake by biotic metabolic processes, data points will fall below the mixing line.

Dissolved Si represents a check on the model as this material is present in high concentration in groundwater, but is not a major component of fertilizer. In addition, Si is not utilized rapidly within the nearshore environment by biological processes. It can be seen in Figure 19 that when concentrations of Si are plotted as functions of salinity, most of the data points from all five sites fall in a linear array on, or close to the conservative mixing line. Data points for Transect 1 fall slightly below the mixing line, while points for the other four sites lie consistently on the line. The overall linearity of the data points indicates that marine waters at the five transect sites are primarily a mixture of groundwater flowing beneath the project and ocean water. These results indicate that the groundwater from upslope Well No. 4 provides a valid representation of groundwater that enters the ocean following flow through the Makena development. Over the course of monitoring since 1995, the relationship between salinity and Si has remained nearly constant (Figure 20).

NO_3^- is the form of nitrogen most common in fertilizer mixes that are used for enhancing turf growth. When the concentrations of NO_3^- are plotted as functions of salinity, data from each transect prescribe a distinct linear pattern (Figure 19). With the exception of Transect 4, data points from all the other sites fall far above the mixing line. The location of all data points from Control Transect 4 on or below the mixing line indicate that there are no external subsidies of NO_3^- to the ocean at this location (Figure 19). Inspection of the long-term mixing data indicates that essentially all of the values of NO_3^- from Control Site 4 fall on, or very near, the conservative mixing line (Figure 20). Such a result validates that Site 4 is indeed a good "control" area that is not greatly affected by activities on land.

Conversely, data points from the nearshore samples at Transects 1, 2, 3 and 3-A all fall above the conservative mixing line, indicating various subsidies of NO_3^- to the ocean from sources on land (Figure 19). The mixing line prescribed from data points for Transect 3 is steeper than that from Sites 1 and 3A (Figure 19). Transect sites 3 and 3A lie directly offshore of the golf course, residences and a wetland. Transect Site 1 lies offshore of a shoreline area populated by numerous residences, and is downslope from the northern end of the Makena Golf Courses. The mixing line relationships from Figures 19 and 20 indicate subsidies of NO_3^- at these areas that are likely a result of leaching of fertilizers to the groundwater lens. The source of fertilizer nutrients is likely from both golf course and residential landscaping. Although the Makena South Course has been closed for an extended time, the greens and fairways continue to be maintained at the time of this survey.

Transect Site 1 has also been used as a monitoring station for a similar evaluation of the effects of the Wailea Golf Courses on water chemistry that commenced in 1989. The lowest concentrations of NO_3^- relative to salinity at Transect site 1 occurred during the initial two years of study, with subsequent higher concentrations increasing since 1992. Hence, there appears to have been an increase of NO_3^- in nearshore waters since 1992 that was not occurring in 1989-1991. Completion of the Wailea Gold Course occurred in December 1993, while completion of the Makena North Course occurred in November 1993. As the southern region of the Wailea Course and the northern part of the Makena Course abut each other in the makai-mauka direction landward of ocean Transect 1, the increased concentrations of NO_3^- evident in Figure 19 may be a result of leaching of fertilizer materials from the combined golf courses to groundwater that enters the ocean in the sampling area.

Mixing analyses also indicate an ongoing input of NO_3^- at the shoreline of Stations 3 and 3A located off the existing Makena Golf Course and several residences that have been constructed over the course of monitoring adjacent to the Golf Course (Figures 19 and 20). Such subsidies have been noted in past surveys, as can be seen in Figure 20. When the slopes of the data points for the January 2014 survey (red symbols) are superimposed over the slopes of combined sets of data points from past surveys (black and maroon symbols) it can be seen that subsidies of NO_3^- lie in the approximate midpoint of the overall data set (Figure 20). Thus, it can be inferred that over the course of the monitoring program, results from the most recent survey do not indicate a increase, or decrease in subsidies of NO_3^- to the ocean from human activities. Future monitoring will continue to provide information on any directions of trends of NO_3^- input to the ocean.

While the data reveal a long-term subsidy to the concentration of NO_3^- in groundwater and the nearshore zone at several of the sampling sites, the concentrations of NO_3^- fall in clearly linear relationship as functions of salinity. The linearity of the data array indicates that there is little or no detectable uptake of this material by the marine environment. Such lack of uptake indicates that the nutrients are not being removed from the water column by metabolic reactions that could change the composition of the marine environment. Rather, the nutrient subsidies are diluted to background oceanic levels by physical processes of wind and wave mixing. As a result, the increased nutrients do not appear to have the potential to cause alteration in biological community composition or function.

Similar situations have also been observed in other locales in the Hawaiian islands where nutrient subsidies from golf course leaching result in excess NO_3^- in the nearshore zone. At Keauhou Bay on the Big Island, it was shown that owing to the distinct vertical stratification in the nearshore zone, the excess nutrients never come into contact with benthic communities, thereby limiting the potential for increased uptake by benthic algae. In addition, the residence time of the high nutrient water was short enough within the embayment to preclude phytoplankton blooms. As a result, while NO_3^- concentrations doubled as a result of golf course leaching for a period of at least several years, there was no detectable negative effect to the marine environment (Dollar and Atkinson 1992). Owing to the unrestricted nature of circulation and mixing off the Makena project (no confined embayments) it is reasonable to assume that the excess NO_3^- subsidies that are apparent in the present study will not result in alteration to biological communities.

Indeed, surveys of the nearshore marine habitats off of Makena reveal a generally healthy coral reef that does not appear to exhibit any negative effects from nutrient loading, particularly in the form of abundant algal biomass (Marine Research Consultants 2006). In addition to the lack of negative impacts to offshore coral communities, inspection of the entire shoreline fronting the

Makena Resort revealed that there are no areas where excessive algal growth is presently occurring.

The other form of dissolved inorganic nitrogen, NH_4^+, does not show a linear pattern of distribution with respect to salinity for either the January 2014 survey (Figure 19) or the entire monitoring program (Figure 21). The lack of a correlation between salinity and concentration of NH_4^+ suggests that this form of nitrogen is not present in the marine environment as a result of mixing from groundwater sources. Rather, NH_4^+ is generated by natural biotic activity in the ocean waters off Makena. The reversed gradient of increasing concentrations of NH_4^+ with increasing salinity on Transect 3A indicates that the source of NH_4^+ is not from groundwater entering the nearshore zone (Figure 19).

PO_4^{3-} is also a major component of fertilizer, but is usually not found to leach to groundwater to the extent of NO_3^-, owing to a high absorptive affinity of phosphorus in soils. However, as with NO_3^-, when concentrations of PO_4^{3-} are plotted as functions of salinity, samples from each transect fall in distinct linear arrays. Of interest is that while all data points from Transects 2, 3 and 3-A located downslope from substantial land uses, data points for Control Transect 4 also lie above the mixing line.

D. Time Course Mixing Analyses

While it is possible to evaluate temporal changes from repetitive surveys conducted over time in terms of concentrations of water chemistry constituents (See Section C), a more informative and accurate method of evaluating changes over time is to utilize the results of scaling nutrient concentrations to salinity. As discussed above, the simple hydrographic mixing model consisting of plotting concentrations of nutrient constituents versus salinity eliminates the ambiguity associated with comparing only the concentrations of samples collected during multiple samplings at different stages of tide and weather conditions. Figures 22 and 23 show plots of Si and NO_3^-, respectively, as functions of salinity collected during each year of sampling since 1995. Also shown in Figures 22 and 23 are straight lines that represent the least squares linear regression fitted through concentrations of Si and NO_3^- as functions of salinity at each monitoring site for each year. Tables 6-8 show the numerical values of the Y-intercepts, slopes, and respective upper and lower 95% confidence limits of linear regressions fitted through the data points for Si, NO_3^-, and PO_4^{3-} as functions of salinity for each year of monitoring.

The magnitude of the contribution of nutrients originating from land-based activities to groundwater will be reflected in both the steepness of the slope and the magnitude of the Y-intercept of the regression line fitted through the concentrations scaled to salinity (the Y-intercept can be interpreted as the concentration that would occur at a salinity of zero if the distribution of data points is linear). This relationship is valid because with increasing contributions from land, nutrient concentrations in any given parcel of water would increase with no corresponding change in salinity. Hence, if the contribution from land sources to groundwater nutrient composition is increasing over time, there would be progressive increases in the absolute value of the slopes, as well as the Y-intercepts of the regression lines fitted through each set of annual nutrient concentrations when plotted as functions of salinity. Conversely, if the contributions to groundwater from land are decreasing, there will be decreases in the absolute values of the slopes and Y-intercepts.

Plots of the values of the slopes (Figure 24) and Y-intercepts (Figure 25) of regression lines fitted though concentrations of Si, NO_3^- and PO_4^{3-} scaled to salinity during each survey year provide an indication of the changes that have been occurring over time in the nearshore ocean off the Makena Resort. As stated above, Si provides the best case for evaluating the effectiveness of the method, as Si is present in high concentration in groundwater but is not a component of fertilizers. NO_3^- and PO_4^{-3} are the forms of nitrogen and phosphorus that are found in high concentrations in groundwater relative to ocean water, and are the major nutrient constituents found in fertilizers.

Examination of Figures 24 and 25, as well as Tables 6-8 reveal that none of the slopes or Y-intercepts of Si, NO_3^- and PO_4^{3-} at any of the transect sites exhibit any indication of progressively increasing or decreasing values over the course of monitoring. The term "REGSLOPE" in Tables 6-8 denotes the values of the slopes and 95% confidence limits of linear regressions of the values of the yearly slopes and Y-intercepts as a function of time. For all sites, the span of the upper and lower 95% confidence limits of the REGSLOPE coefficients are not significantly different than zero, indicating that there is no statistically significant increase or decrease in the salinity-scaled concentrations of Si, NO_3^- and PO_4^{3-} over the course of the monitoring program (Tables 6-8).

For all three nutrients, there is little variation in either slopes or Y-intercepts during any single year at Site 1, located off the "5 Graves" area downslope from the juncture of the Wailea and Makena Resorts (Figures 24 and 25). Such lack of variation indicates relatively consistent concentrations of Si, NO_3^- and PO_4^{3-} in groundwater entering the ocean over the entire course of monitoring since 1995. Sites 2 (Makena Landing) and 4 ('Ahihi-Kina`u) also show relatively constant trends with time. The single exception occurred in 2001 which is marked by spikes in Si and PO_4^{3-}, although not for NO_3^-. Sampling in 2001 was conducted during a period of rough winter sea conditions marked by vigorous mixing of the water column. As a result, there was very weak linear relationship between nutrient concentrations and salinity.

At Site 3, located directly downslope for the point of the Makena Golf Course closest to the ocean, there is a trend of decreasing NO_3^- between 2002 and 2004, an increasing trend from 2004 to 2007, followed by another downturn from 2007 to 2013 (Figures 24 and 25). As a result of these reversing trends, there is no significant change over the seven-year period of monitoring. The multiple reversing trends may reflect changes in land use, such as variation in fertilizer application or construction-related activities in 2002-2004 versus 2004-2007. In June of 2008, the golf course fronting the ocean in this area was shut down for re-alignment and re-planting. Underground retention/filtration systems were also constructed to mitigate adverse affects of stormwater runoff. At the time of the January 2014 survey, new turf grass had been applied but the course remained closed. Construction has been completed on the filtration systems but they are not yet operational.

E. Compliance with DOH Standards

Tables 1 and 2 also show samples that exceed DOH water quality standards for open coastal waters under "wet" and "dry" conditions. These criteria are applied depending upon whether the area is likely to receive less than (dry) or greater than (wet) 3 million gallons of groundwater and/or surface water input per mile per day. As it is not possible to accurately estimate groundwater and surface water discharge, both wet and dry standards are considered. DOH standards include specific criteria for three situations; criteria that are not to be exceeded during either10% or 2% of the time, and criteria that are not to be exceeded by the geometric mean of samples. With only one or two samplings collected per year since 1995, comparison of the 10% or 2% of the time criteria for any sample is not statistically meaningful. However, comparing sample concentrations to these criteria provide an indication of whether water quality is near the stated specific criteria.

Boxed values in Tables 1 and 2 show instances where measurements exceed the DOH standards under dry conditions, while boxed and shaded values show instances where measurements exceed DOH standards under wet conditions.

Results from the January 2014 survey indicated that numerous measurements of NO_3^-, TN and Chl *a* exceeded the 10% DOH criteria under wet or dry conditions (Tables 1 and 2). Only four measurements of NH_4^+, one measurement of TP, seven measurements of turbidity exceeded the 10% DOH criteria under any conditions. It is of interest to note that at Transect site 4, which is considered the control station beyond the influence of the Makena Resort, exceedance of DOH criteria for NO_3^- occurred at a similar number of sampling sites as for the transects located directly offshore of the golf courses.

Tables 3 and 4 show geometric means of samples collected at the same locations during the 30 increments of the monitoring program at Sites 1, 2 and 4. Geometric means of samples collected over 21 increments of sampling at Site 3 and 12 increments of sampling at Site 3A are also shown. These tables also specify the samples that exceed the DOH geometric mean limits for open coastal waters under “dry” (boxed) and “wet” (boxed and shaded) conditions. For NO_3^-, NH_4^+, and TN numerous dry and wet standards were exceeded on all transects at sampling stations within 50 m of the shoreline. Seven samples of TP and 21 samples of turbidity exceeded standards. All but six samples exceed the geometric mean standards for Chl *a*.

As noted above, Site 4 is considered a control transect, in that it is not located offshore of the Makena Resort or dense residential development. It can be seen in Tables 3 and 4, however, that the number of samples that exceed geometric mean criteria at Site 4 are comparable to the other four sites, all of which are located downslope from the Makena Resort. Hence, Resort activities, including golf courses cannot be attributed as the sole (or even major) factor causing water quality to exceed geometric mean standards.

Several comments can be made regarding the present DOH water quality standards and how they apply to the monitoring program at the Makena Resort. As noted above, the category of water quality standards that are applicable for the Makena Monitoring program are "Open Coastal Waters." As the name implies, these standards apply to "open" waters that can be reasonably defined as "waters beyond the direct influence of land.” In order to evaluate the effects of land uses on the nearshore ocean off Makena, the selected sampling regime collects water within a zone that extends from the shoreline to the open coastal ocean. As a result, sampling takes place within the region of ocean that is indeed directly influenced by land. If the monitoring protocol were changed to include only those sampling locations beyond 50-100 m from shore (i.e., open coastal waters), which is completely valid with respect to meeting DOH regulatory compliance, virtually none of the factors discussed above relating to the effects of activities on land to the nearshore ocean would not be observed.

Initial steps have been taken by DOH to rectify this situation. During revision of the Department of Health water quality standards in 2004, a unique set of monitoring criteria was added for the West Coast of the Island of Hawaii (i.e., "Kona standards"). The rationale for these unique criteria was the recognition that existing numerical "standards" represent offshore coastal waters that are beyond the natural confluence of land and the nearshore ocean. As a result, the West Hawaii standards recognize that groundwater entering the ocean at the shoreline contains substantially elevated nutrients relative to open coastal waters. As a result, the Kona criteria provide the potential to meet water quality standards with elevated nutrient concentrations resulting from natural sources of groundwater input. As the same processes of groundwater discharge to the coastal ocean have been documented in Maui, it is hopeful that similar new provisions of the water quality standards with soon be applicable to the South Maui area.

IV. SUMMARY

- The 30th phase of water chemistry monitoring of the nearshore ocean off the Makena Resort was carried out on January 5, 2014. Sixty-two ocean water samples were collected on four transects spaced along the project ocean frontage and on one control transect. Site 1 was located at the northern boundary of the project, Site 2 was located near the central part of the Makena North Golf Course in the center of Makena Bay, Site 3A (initiated during the June 2007 survey) was located near the southern boundary of Maluaka Bay, Site 3 was downslope from the part of Makena South Golf Course that comes closest to the shoreline, and Control Site 4 was located to the south of Makena Resort near the northern boundary of the 'Ahihi-Kina`u Natural Area Reserve. Sampling transects extended from the shoreline out to the open coastal ocean. Water samples were analyzed for chemical criteria specified by DOH water quality standards, as well as several additional criteria.

- Water chemistry constituents that occur in high concentration in groundwater (Si, NO_3^- and TN) displayed horizontal gradients with highest concentrations nearest to shore and decreasing concentrations moving seaward at all of the five sites. Groundwater input (based on salinity) was greatest at Transect sites 1 and 3A, followed by sites 3, 2 and 4.

- Vertical stratification of the water column was not evident during January 2014, indicating that physical mixing processes generated by tidal exchange, wind stirring, and breaking waves were insufficient to mix the water column from surface to bottom throughout the sampling area at the time of the monitoring survey.

- Overall, values of Chl *a* and turbidity were elevated near the shoreline compared to offshore samples, with Sites 2 and 4 having the highest values of turbidity in nearshore samples. The elevated levels of Chl *a* in the nearshore zone are likely a result of broken fragments of benthic plants that broken from the bottom by wave action and washed to the shoreline. The low concentrations of Chl *a* through the water column indicates the lack of plankton blooms in the area. Elevated values of turbidity in the nearshore samples is likely a result of wave resuspension of fine-grained particulate material in the surf zone.

- Other organic water chemistry constituents that do not occur in high concentrations in groundwater (NH_4^+, TON, TOP) did not show any distinctive patterns with respect to horizontal gradients.

- Scaling nutrient concentrations to salinity indicates that there are measurable subsidies of NO_3^- to groundwater that enters the nearshore ocean at three Transect sites (1, 3, 3-A). No subsidies of NO_3^- other than the chemical constituents of naturally occurring groundwater (particularly were apparent at Site 2 (Makena Landing) or Control Site 4 ('Ahihi-Kina`u). These subsidies, which are without doubt a result of land uses involving fertilizers, substantially increase the concentration of NO_3^- with respect to salinity in groundwater flowing to the ocean compared to natural groundwater. The area shoreward of Site 1 includes the juncture of the southern part of the Wailea Gold Course and the northern part of the Makena North Course, as well as residential development. Sites 3 and 3A are directly downslope from the Makena South Course in an area were the golf course extends to the shoreline. In addition, private residences and a wetland are present upslope of Transect 3 and 3A. Hence, the subsidies of NO_3^- noted at these sites may result from a combination of sources.

- Linear regression statistics of repetitive slopes and Y-intercepts of nutrient concentration plotted as functions of salinity over time are useful for evaluating changes to water quality over time. When the regression values of nutrient concentrations versus salinity are plotted as a function of time, there are no statistically significant increases or decreases over the 18 years of monitoring at any of the survey sites. The lack of increase in these slopes and intercepts indicate that there has been no consistent change in nutrient input from land to groundwater that enters the ocean since 1995 (since 2002 at Site 2). At Site 3 off the Makena Resort South Golf Course, there was a progressive decrease in NO_3^- input between 2002 and 2004, followed by an increase between 2004 and 2007, with progressive decreases from 2008 through 2013. Further monitoring at this site will be of interest to note the future direction of the oscillating trends noted in the last ten years.

- Comparing water chemistry parameters to DOH standards revealed that several measurements of NO_3^- and TN and Chl *a*, a few of NH_4 TP and turbidity exceeded the DOH "not to exceed more than 10% of the time" criteria for dry and wet conditions of open coastal waters. It is apparent that the concentrations of NO_3^- in nearshore marine waters that contains a mixture of seawater and natural groundwater may exceed DOH criteria with no subsidies from human activities on land. Numerous values of NO_3^-, NH_4^+, TN, turbidity and Chl *a* exceeded specified limits for geometric means. Such exceedances occurred at all survey sites, including the control site that was far from any golf course influence. The consistent exceedance of water quality standards is in large part a consequence of the present DOH standards not accounting for the natural effects of groundwater discharge to the nearshore ocean.

- As in past surveys, there is a subsidy of dissolved inorganic nutrients (e.g., NO_3^- and to a lesser extent PO_4^{3-}) to groundwater that enters the nearshore ocean at sampling sites downslope from parts of the Makena Resort. Without question, such input is a consequence of various land use activities. However, none of these inputs have increased over time. Surveys of coral reef community structure that are part of the ongoing monitoring program for the Makena Resort, as well as the continued lack of any nuisance algal aggregations in the nearshore area indicate that the nutrient subsidies are not detrimental to marine community structure.

- The next scheduled testing for the Makena Resort monitoring program is planned for the spring-summer season of 2014

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FIGURE 1. Aerial photograph of Makena Resort on southwest coastline of Maui. Also shown are locations of five water sampling transects that extend from the shoreline to 150-200 m from shore. The southern end of the Wailea golf course is visible at right.

TABLE 1. Water chemistry measurements from ocean water samples collected in the vicinity of the Makena Resort on January 5, 2014. Nutrient concentrations are shown as micromoles (μM). Abbreviations as follows: DFS=distance from shore; S=surface; D=deep; BDL=below detection limit. Also shown are the State of Hawaii, Department of Health (DOH) "not to exceed more than 10% of the time" and "not to exceed more than 2% of the time" water quality standards for open coastal waters under "dry" and "wet" conditions. Boxed values exceed DOH 10% "dry" standards; boxed and shaded values exceed DOH 10% "wet" standards. For sampling site locations, see Figure 1.

TRANSECT SITE	DFS (m)	DEPTH (m)	PO_4^{3-} (μM)	NO_3^- (μM)	NH_4^+ (μM)	Si (μM)	TOP (μM)	TON (μM)	TP (μM)	TN (μM)	TURB (NTU)	SALINITY (ppt)	CHL a (μg/L)	TEMP (deg.C)	pH (std.units)	O2 % Sat
MAKENA 1	0 S	0.1	0.06	74.01	0.01	131.6	0.17	5.06	0.23	79.08	0.32	26.256	1.00	24.6	7.98	107.7
	2 S	0.1	0.29	29.93	0.22	54.61	0.19	7.49	0.48	37.64	0.31	31.745	1.07	24.6	8.12	110.4
	5 S	0.5	0.24	20.42	0.18	36.65	0.20	6.10	0.44	26.70	0.35	32.945	1.23	24.7	8.14	110.7
	5 D	1.5	0.23	21.13	0.14	38.09	0.18	5.75	0.41	27.02	0.44	32.860	1.13	24.6	8.15	108.3
	10 S	0.5	0.13	0.69	0.15	3.11	0.25	7.50	0.38	8.34	0.13	35.137	0.96	24.0	8.09	101.5
	10 D	2.4	0.14	0.54	0.22	3.17	0.22	6.92	0.36	7.68	0.15	35.123	1.10	24.6	8.08	106.1
	50 S	0.5	0.21	0.08	0.21	1.85	0.18	7.26	0.39	7.55	0.05	35.189	0.53	23.9	8.05	100.0
	50 D	4.1	0.16	0.10	0.16	2.32	0.19	6.83	0.35	7.09	0.05	35.153	0.65	24.6	8.06	102.1
	100 S	0.5	0.18	0.06	0.23	1.89	0.24	6.38	0.42	6.67	0.03	35.185	0.44	24.4	8.06	100.6
	100 D	5.5	0.20	0.03	0.26	1.80	0.17	6.16	0.37	6.45	0.05	35.173	0.40	24.8	8.05	102.6
	150 S	0.6	0.19	0.01	0.27	1.87	0.23	7.03	0.42	7.31	0.06	35.173	0.40	24.8	8.05	102.2
	150 D	10.4	0.21	0.01	0.27	2.86	0.17	6.80	0.38	7.08	0.05	35.114	0.39	24.9	8.05	103.3
MAKENA 2	0 S	0.1	0.28	7.05	0.24	28.93	0.30	6.64	0.58	13.93	0.64	33.499	1.77	24.4	8.12	106.4
	2 S	0.1	0.29	7.16	0.29	28.74	0.18	6.66	0.47	14.11	0.53	33.472	2.12	24.4	8.12	106.3
	5 S	0.6	0.30	7.88	0.23	29.60	0.20	5.70	0.50	13.81	0.38	33.428	1.40	24.4	8.10	105.0
	5 D	2.2	0.30	7.74	0.26	29.72	0.17	5.88	0.47	13.88	0.39	33.440	1.42	24.4	8.10	105.8
	10 S	0.5	0.17	0.21	0.23	3.16	0.19	6.33	0.36	6.77	0.25	35.145	0.41	24.0	8.05	101.0
	10 D	3.0	0.23	0.25	0.23	3.63	0.16	6.50	0.39	6.98	0.48	35.134	0.81	24.6	8.04	101.4
	50 S	0.6	0.21	0.11	0.20	2.84	0.17	6.11	0.38	6.42	0.09	35.126	0.77	24.1	8.05	101.7
	50 D	4.4	0.24	0.03	0.20	3.10	0.17	6.30	0.41	6.53	0.03	35.121	0.75	24.7	8.05	102.4
	100 S	0.6	0.21	0.01	0.14	2.24	0.20	6.87	0.41	7.02	0.06	35.163	0.58	24.3	8.05	101.3
	100 D	5.6	0.20	0.10	0.16	2.56	0.16	6.32	0.36	6.58	0.06	35.133	0.56	24.5	8.05	103.5
	150 S	0.5	0.20	0.11	0.12	2.54	0.16	6.62	0.36	6.85	0.08	35.170	0.48	24.6	8.05	101.3
	150 D	7.2	0.20	0.13	0.10	2.81	0.21	6.40	0.41	6.63	0.08	35.175	0.69	24.6	8.05	103.1
	200 S	0.6	0.15	0.01	0.08	2.05	0.19	6.43	0.34	6.52	0.19	35.154	0.48	24.5	8.06	101.4
	200 D	12.0	0.16	BDL	0.09	2.27	0.23	6.08	0.39	6.17	0.09	35.133	0.49	24.6	8.05	102.3
MAKENA 3-A	0 S	0.1	0.77	53.55	0.35	116.2	0.25	3.76	1.02	57.66	0.52	29.473	1.34	24.0	7.98	101.9
	2 S	0.1	0.70	47.04	0.39	103.4	0.13	4.72	0.83	52.15	0.43	30.212	1.53	24.0	8.00	101.1
	5 S	0.5	0.59	41.89	0.21	91.25	0.15	5.06	0.74	47.16	0.27	30.802	1.17	24.0	8.00	102.3
	5 D	1.1	0.46	24.83	0.21	56.64	0.15	6.67	0.61	31.71	0.23	32.600	1.76	24.0	8.06	102.2
	10 S	0.5	0.17	0.33	0.16	3.14	0.25	7.97	0.42	8.46	0.12	35.103	0.61	21.2	8.06	98.0
	10 D	2.9	0.19	0.25	0.12	2.62	0.26	6.58	0.45	6.95	0.16	35.130	0.64	24.4	8.05	100.7
	50 S	0.5	0.14	0.10	0.13	1.79	0.21	6.70	0.35	6.93	0.11	35.134	0.65	24.3	8.05	101.0
	50 D	4.5	0.17	0.16	0.17	2.12	0.25	7.45	0.42	7.78	0.07	35.111	0.62	24.8	8.06	102.3
	100 S	0.5	0.14	0.05	0.11	1.84	0.23	6.61	0.37	6.77	0.35	35.131	0.46	23.8	8.06	101.1
	100 D	5.0	0.15	0.01	0.05	2.06	0.22	6.63	0.37	6.69	0.06	35.110	0.57	24.9	8.06	102.2
	150 S	0.5	0.15	BDL	0.02	1.57	0.22	6.54	0.37	6.56	0.02	35.126	0.35	24.4	8.06	100.1
	150 D	10.4	0.14	0.01	0.07	1.66	0.24	6.63	0.38	6.71	0.02	35.117	0.44	24.5	8.06	99.9
MAKENA 3	0 S	0.1	0.36	24.19	0.08	37.81	0.21	5.27	0.57	29.54	0.32	33.605	0.83	24.5	8.07	99.8
	2 S	0.1	0.35	16.90	0.09	28.58	0.17	6.19	0.52	23.18	0.30	34.111	0.73	24.5	8.08	100.7
	5 S	0.5	0.19	5.51	0.10	12.42	0.22	5.85	0.41	11.46	0.15	34.841	0.79	24.5	8.10	100.8
	5 D	1.7	0.23	5.75	0.09	13.41	0.20	7.17	0.43	13.01	0.14	34.804	1.04	24.5	8.10	100.7
	10 S	0.5	0.21	0.28	0.41	2.42	0.21	9.38	0.42	10.07	0.11	35.135	0.83	24.2	8.06	100.5
	10 D	2.8	0.10	0.15	0.18	2.39	0.28	6.62	0.38	6.95	0.09	35.116	0.60	24.3	8.05	102.2
	50 S	0.5	0.17	0.11	0.17	1.88	0.23	6.40	0.40	6.68	0.07	35.131	0.50	24.5	8.05	100.4
	50 D	5.2	0.14	0.10	0.38	3.00	0.22	5.99	0.36	6.47	0.07	35.073	0.48	24.6	8.05	102.0
	100 S	0.5	0.06	0.09	0.13	2.25	0.21	5.54	0.27	5.76	0.05	35.124	0.49	24.5	8.05	101.1
	100 D	7.6	0.15	0.12	0.16	2.57	0.21	5.71	0.36	5.99	0.07	35.116	0.48	24.3	8.05	100.9
	150 S	0.5	0.15	0.03	0.16	1.78	0.24	6.35	0.39	6.54	0.07	35.105	0.37	24.1	8.06	100.7
	150 D	13.7	0.03	0.03	0.12	1.89	0.27	6.51	0.30	6.66	0.08	35.101	0.36	24.7	8.06	103.6
MAKENA 4	0 S	0.1	0.26	4.94	0.07	32.43	0.21	6.67	0.47	11.68	0.74	33.776	0.88	24.6	8.13	103.4
	2 S	0.1	0.26	4.57	0.19	31.74	0.17	6.20	0.43	10.96	0.77	33.804	0.95	24.6	8.13	103.2
	5 S	0.7	0.26	3.46	0.26	26.67	0.20	7.35	0.46	11.07	0.59	34.045	0.91	24.6	8.13	101.5
	5 D	2.7	0.14	3.31	0.07	23.92	0.20	7.97	0.34	11.35	0.58	34.200	1.05	24.5	8.13	100.5
	10 S	0.8	0.20	0.32	0.11	3.51	0.20	7.39	0.40	7.82	0.11	35.059	0.56	23.6	8.04	100.4
	10 D	2.5	0.14	0.14	0.08	3.03	0.22	6.69	0.36	6.91	0.08	35.068	0.50	24.3	8.03	105.1
	50 S	0.9	0.13	0.05	0.08	1.89	0.22	7.19	0.35	7.32	0.05	35.094	0.37	23.8	8.05	100.5
	50 D	4.5	0.11	0.18	0.03	3.17	0.20	7.37	0.31	7.58	0.09	35.062	0.44	24.3	8.03	104.1
	100 S	0.8	0.21	0.01	0.02	1.88	0.19	6.76	0.40	6.79	0.04	35.085	0.44	24.6	8.06	100.6
	100 D	7.0	0.20	BDL	0.03	1.77	0.19	7.75	0.39	7.78	0.03	35.078	0.33	24.3	8.06	100.6
	150 S	0.5	0.15	0.01	0.07	1.56	0.22	7.57	0.37	7.65	0.06	35.083	0.33	24.6	8.06	100.7
	150 D	9.7	0.21	0.03	0.01	2.31	0.20	7.21	0.41	7.25	0.10	35.071	0.32	24.4	8.05	99.0
DOH WQS	DRY	10%	0.71	0.36					0.96	12.86	0.50	*	0.50	**	***	****
		2%	1.43	0.64					1.45	17.86	1.00		1.00			
	WET	10%	1.00	0.61					1.29	17.85	1.25	*	0.90	**	***	****
		2%	1.78	1.07					1.93	25.00	2.00		1.75			

* Salinity shall not vary more than ten percent form natural or seasonal changes considering hydrologic input and oceanographic conditions.

** Temperature shall not vary by more than one degree C. from ambient conditions.

***pH shall not deviate more than 0.5 units from a value of 8.1.

****Dissolved Oxygen not to be below 75% saturation.

TABLE 2. Water chemistry measurements from ocean water samples collected in the vicinity of the Makena Resort on January 5, 2014. Nutrient concentrations are shown in units of micrograms per liter (µg/L). Abbreviations as follows: DFS=distance from shore; S=surface; D=deep; BDL=below detection limit. Also shown are the State of Hawaii, Department of Health (DOH) "not to exceed more than 10% of the time" and "not to exceed more than 2% of the time" water quality standards for open coastal waters under "dry" and "wet" conditions. Boxed values exceed DOH 10% "dry" standards; boxed and shaded values exceed DOH 10% "wet" standards. For sampling site locations, see Figure 1.

TRANSECT SITE	DFS (m)	DEPTH (m)	PO_4^{3-} (µg/L)	NO_3^- (µg/L)	NH_4^+ (µg/L)	Si (µg/L)	TOP (µg/L)	TON (µg/L)	TP (µg/L)	TN (µg/L)	TURB (NTU)	SALINITY (ppt)	CHL a (µg/L)	TEMP (deg.C)	pH (std.units)	O2 % Sat
MAKENA 1	0 S	0.1	1.86	1036	0.14	3698	5.27	70.84	7.13	1107	0.32	26.256	1.00	24.6	7.98	107.7
	2 S	0.1	8.99	419.0	3.08	1535	5.89	104.9	14.88	527.0	0.31	31.745	1.07	24.6	8.12	110.4
	5 S	0.5	7.44	285.9	2.52	1030	6.20	85.40	13.64	373.8	0.35	32.945	1.23	24.7	8.14	110.7
	5 D	1.5	7.13	295.8	1.96	1070	5.58	80.50	12.71	378.3	0.44	32.860	1.13	24.6	8.15	108.3
	10 S	0.5	4.03	9.66	2.10	87.39	7.75	105.0	11.78	116.8	0.13	35.137	0.96	24.0	8.09	101.5
	10 D	2.4	4.34	7.56	3.08	89.08	6.82	96.88	11.16	107.5	0.15	35.123	1.10	24.6	8.08	106.1
	50 S	0.5	6.51	1.12	2.94	51.99	5.58	101.6	12.09	105.7	0.05	35.189	0.53	23.9	8.05	100.0
	50 D	4.1	4.96	1.40	2.24	65.19	5.89	95.62	10.85	99.26	0.05	35.153	0.65	24.6	8.06	102.1
	100 S	0.5	5.58	0.84	3.22	53.11	7.44	89.32	13.02	93.38	0.03	35.185	0.44	24.4	8.06	100.6
	100 D	5.5	6.20	0.42	3.64	50.58	5.27	86.24	11.47	90.30	0.05	35.173	0.40	24.8	8.05	102.6
	150 S	0.6	5.89	0.14	3.78	52.55	7.13	98.42	13.02	102.3	0.06	35.173	0.40	24.8	8.05	102.2
	150 D	10.4	6.51	0.14	3.78	80.37	5.27	95.20	11.78	99.12	0.05	35.114	0.39	24.9	8.05	103.3
MAKENA 2	0 S	0.1	8.68	98.70	3.36	812.9	9.30	92.96	17.98	195.0	0.64	33.499	1.77	24.4	8.12	106.4
	2 S	0.1	8.99	100.2	4.06	807.6	5.58	93.24	14.57	197.5	0.53	33.472	2.12	24.4	8.12	106.3
	5 S	0.6	9.30	110.3	3.22	831.8	6.20	79.80	15.50	193.3	0.38	33.428	1.40	24.4	8.10	105.0
	5 D	2.2	9.30	108.4	3.64	835.1	5.27	82.32	14.57	194.3	0.39	33.440	1.42	24.4	8.10	105.8
	10 S	0.5	5.27	2.94	3.22	88.80	5.89	88.62	11.16	94.78	0.25	35.145	0.41	24.0	8.05	101.0
	10 D	3.0	7.13	3.50	3.22	102.0	4.96	91.00	12.09	97.72	0.48	35.134	0.81	24.6	8.04	101.4
	50 S	0.6	6.51	1.54	2.80	79.80	5.27	85.54	11.78	89.88	0.09	35.126	0.77	24.1	8.05	101.7
	50 D	4.4	7.44	0.42	2.80	87.11	5.27	88.20	12.71	91.42	0.03	35.121	0.75	24.7	8.05	102.4
	100 S	0.6	6.51	0.14	1.96	62.94	6.20	96.18	12.71	98.28	0.06	35.163	0.58	24.3	8.05	101.3
	100 D	5.6	6.20	1.40	2.24	71.94	4.96	88.48	11.16	92.12	0.06	35.133	0.56	24.5	8.05	103.5
	150 S	0.5	6.20	1.54	1.68	71.37	4.96	92.68	11.16	95.90	0.08	35.170	0.48	24.6	8.05	101.3
	150 D	7.2	6.20	1.82	1.40	78.96	6.51	89.60	12.71	92.82	0.08	35.175	0.69	24.6	8.05	103.1
	200 S	0.6	4.65	0.14	1.12	57.61	5.89	90.02	10.54	91.28	0.19	35.154	0.48	24.5	8.06	101.4
	200 D	12.0	4.96	BDL	1.26	63.79	7.13	85.12	12.09	86.38	0.09	35.133	0.49	24.6	8.05	102.3
MAKENA 3-A	0 S	0.1	23.87	749.7	4.90	3264	7.75	52.64	31.62	807.2	0.52	29.473	1.34	24.0	7.98	101.9
	2 S	0.1	21.70	658.6	5.46	2907	4.03	66.08	25.73	730.1	0.43	30.212	1.53	24.0	8.00	101.1
	5 S	0.5	18.29	586.5	2.94	2564	4.65	70.84	22.94	660.2	0.27	30.802	1.17	24.0	8.00	102.3
	5 D	1.1	14.26	347.6	2.94	1592	4.65	93.38	18.91	443.9	0.23	32.600	1.76	24.0	8.06	102.2
	10 S	0.5	5.27	4.62	2.24	88.23	7.75	111.6	13.02	118.4	0.12	35.103	0.61	21.2	8.06	98.0
	10 D	2.9	5.89	3.50	1.68	73.62	8.06	92.12	13.95	97.30	0.16	35.130	0.64	24.4	8.05	100.7
	50 S	0.5	4.34	1.40	1.82	50.30	6.51	93.80	10.85	97.02	0.11	35.134	0.65	24.3	8.05	101.0
	50 D	4.5	5.27	2.24	2.38	59.57	7.75	104.3	13.02	108.9	0.07	35.111	0.62	24.8	8.06	102.3
	100 S	0.5	4.34	0.70	1.54	51.70	7.13	92.54	11.47	94.78	0.35	35.131	0.46	23.8	8.06	101.1
	100 D	5.0	4.65	0.14	0.70	57.89	6.82	92.82	11.47	93.66	0.06	35.110	0.57	24.9	8.06	102.2
	150 S	0.5	4.65	BDL	0.28	44.12	6.82	91.56	11.47	91.84	0.02	35.126	0.35	24.4	8.06	100.1
	150 D	10.4	4.34	0.14	0.98	46.65	7.44	92.82	11.78	93.94	0.02	35.117	0.44	24.5	8.06	99.9
MAKENA 3	0 S	0.1	11.16	338.7	1.12	1062	6.51	73.78	17.67	413.6	0.32	33.605	0.83	24.5	8.07	99.8
	2 S	0.1	10.85	236.6	1.26	803.1	5.27	86.66	16.12	324.5	0.30	34.111	0.73	24.5	8.08	100.7
	5 S	0.5	5.89	77.14	1.40	349.0	6.82	81.90	12.71	160.4	0.15	34.841	0.79	24.5	8.10	100.8
	5 D	1.7	7.13	80.50	1.26	376.8	6.20	100.4	13.33	182.1	0.14	34.804	1.04	24.5	8.10	100.7
	10 S	0.5	6.51	3.92	5.74	68.00	6.51	131.3	13.02	141.0	0.11	35.135	0.83	24.2	8.06	100.5
	10 D	2.8	3.10	2.10	2.52	67.16	8.68	92.68	11.78	97.30	0.09	35.116	0.60	24.3	8.05	102.2
	50 S	0.5	5.27	1.54	2.38	52.83	7.13	89.60	12.40	93.52	0.07	35.131	0.50	24.5	8.05	100.4
	50 D	5.2	4.34	1.40	5.32	84.30	6.82	83.86	11.16	90.58	0.07	35.073	0.48	24.6	8.05	102.0
	100 S	0.5	1.86	1.26	1.82	63.23	6.51	77.56	8.37	80.64	0.05	35.124	0.49	24.5	8.05	101.1
	100 D	7.6	4.65	1.68	2.24	72.22	6.51	79.94	11.16	83.86	0.07	35.116	0.48	24.3	8.05	100.9
	150 S	0.5	4.65	0.42	2.24	50.02	7.44	88.90	12.09	91.56	0.07	35.105	0.37	24.1	8.06	100.7
	150 D	13.7	0.93	0.42	1.68	53.11	8.37	91.14	9.30	93.24	0.08	35.101	0.36	24.7	8.06	103.6
MAKENA 4	0 S	0.1	8.06	69.16	0.98	911.3	6.51	93.38	14.57	163.5	0.74	33.776	0.88	24.6	8.13	103.4
	2 S	0.1	8.06	63.98	2.66	891.9	5.27	86.80	13.33	153.4	0.77	33.804	0.95	24.6	8.13	103.2
	5 S	0.7	8.06	48.44	3.64	749.4	6.20	102.9	14.26	155.0	0.59	34.045	0.91	24.6	8.13	101.5
	5 D	2.7	4.34	46.34	0.98	672.2	6.20	111.6	10.54	158.9	0.58	34.200	1.05	24.5	8.13	100.5
	10 S	0.8	6.20	4.48	1.54	98.63	6.20	103.5	12.40	109.5	0.11	35.059	0.56	23.6	8.04	100.4
	10 D	2.5	4.34	1.96	1.12	85.14	6.82	93.66	11.16	96.74	0.08	35.068	0.50	24.3	8.03	105.1
	50 S	0.9	4.03	0.70	1.12	53.11	6.82	100.7	10.85	102.5	0.05	35.094	0.37	23.8	8.05	100.5
	50 D	4.5	3.41	2.52	0.42	89.08	6.20	103.2	9.61	106.1	0.09	35.062	0.44	24.3	8.03	104.1
	100 S	0.8	6.51	0.14	0.28	52.83	5.89	94.64	12.40	95.06	0.04	35.085	0.44	24.6	8.06	100.6
	100 D	7.0	6.20	BDL	0.42	49.74	5.89	108.5	12.09	108.9	0.03	35.078	0.33	24.3	8.06	100.6
	150 S	0.5	4.65	0.14	0.98	43.84	6.82	106.0	11.47	107.1	0.06	35.083	0.33	24.6	8.06	100.7
	150 D	9.7	6.51	0.42	0.14	64.91	6.20	100.9	12.71	101.5	0.10	35.071	0.32	24.4	8.05	99.0
DOH WQS		DRY	10%	10.00	5.00				30.00	180.00	0.50	*	0.50	**	***	****
			2%	20.00	9.00				45.00	250.00	1.00		1.00			
		WET	10%	14.00	8.50				40.00	250.00	1.25	*	0.90	**	***	****
			2%	25.00	15.00				60.00	350.00	2.00		1.75			

* Salinity shall not vary more than ten percent form natural or seasonal changes considering hydrologic input and oceanographic conditions.

** Temperature shall not vary by more than one degree C. from ambient conditions.

***pH shall not deviate more than 0.5 units from a value of 8.1.

****Dissolved Oxygen not to be below 75% saturation.

TABLE 3. Geometric mean data from water chemistry measurements off the Makena Resort collected since August 1995 from Sites 1, 2, and 4 (N=30); since June 2002 from Site 3 (N=21) and since June 2007 from Site 3-A (N=12). Nutrient concentrations are shown as micromoles (µM). For geometric mean calculations, detection limits were used in cases where sample was below detection limit. Abbreviations as follows: DFS=distance from shore; S=surface; D=deep. Also shown are State of Hawaii, Department of Health (DOH) geometric mean water quality standards for open coastal waters under "dry" and "wet" conditions. Boxed values exceed DOH GM 10% "dry" standards; boxed and shaded values exceed DOH GM 10% "wet" standards. For sampling site locations, see Figure 1.

TRANSECT SITE	DFS (m)	PO_4^{3-} (µM)	NO_3^- (µM)	NH_4^+ (µM)	Si (µM)	TOP (µM)	TON (µM)	TP (µM)	TN (µM)	TURB (NTU)	SALINITY (ppt)	CHL a (µg/L)	TEMP (deg.C)	pH	O2
MAKENA 1	0 S	0.20	38.03	0.29	69.15	0.22	7.72	0.53	54.83	0.34	26.064	0.77	25.5	8.11	102.9
	2 S	0.17	24.92	0.19	47.54	0.26	8.08	0.47	37.89	0.29	29.895	0.75	25.6	8.15	105.2
	5 S	0.13	11.76	0.13	26.09	0.25	7.81	0.42	23.80	0.25	32.197	0.51	25.5	8.16	105.1
	5 D	0.12	9.20	0.19	21.69	0.27	7.38	0.41	19.95	0.22	33.062	0.46	25.5	8.16	105.4
	10 S	0.10	3.73	0.16	10.35	0.26	7.38	0.38	13.14	0.19	34.062	0.33	25.5	8.15	104.1
	10 D	0.10	2.27	0.21	7.15	0.28	7.25	0.39	10.93	0.17	34.381	0.33	25.5	8.14	103.6
	50 S	0.08	2.13	0.20	6.81	0.26	7.21	0.37	10.69	0.15	34.490	0.27	25.5	8.13	100.3
	50 D	0.08	0.29	0.14	2.63	0.28	7.18	0.37	7.94	0.12	34.828	0.25	25.5	8.13	99.6
	100 S	0.08	0.79	0.16	4.43	0.27	6.66	0.38	9.03	0.12	34.635	0.22	25.5	8.13	98.6
	100 D	0.07	0.10	0.10	2.14	0.27	7.16	0.37	7.62	0.10	34.874	0.19	25.5	8.14	98.3
	150 S	0.08	0.24	0.16	2.92	0.27	7.13	0.37	8.22	0.12	34.793	0.18	25.6	8.14	97.8
	150 D	0.08	0.06	0.13	1.93	0.27	7.01	0.37	7.36	0.10	34.888	0.16	25.5	8.15	98.6
MAKENA 2	0 S	0.19	4.25	0.37	22.17	0.32	8.16	0.55	13.91	0.88	33.440	0.73	25.6	8.13	98.9
	2 S	0.19	3.86	0.24	19.60	0.31	7.69	0.52	12.81	0.63	33.608	0.72	25.7	8.14	100.6
	5 S	0.17	3.14	0.24	14.94	0.28	7.03	0.47	11.20	0.44	34.030	0.56	25.6	8.14	100.3
	5 D	0.18	2.95	0.30	14.91	0.30	7.30	0.50	11.53	0.41	34.075	0.67	25.6	8.13	99.8
	10 S	0.12	1.62	0.21	9.23	0.29	5.76	0.44	9.27	0.30	34.406	0.38	25.5	8.14	98.8
	10 D	0.12	1.00	0.24	7.66	0.29	7.07	0.44	9.02	0.27	34.518	0.43	25.6	8.14	97.8
	50 S	0.10	1.08	0.26	7.22	0.31	7.50	0.44	9.53	0.22	34.485	0.30	25.5	8.13	97.8
	50 D	0.11	0.21	0.23	3.16	0.30	7.35	0.43	8.03	0.16	34.835	0.33	25.5	8.14	97.4
	100 S	0.09	0.40	0.18	4.01	0.29	7.16	0.40	8.11	0.16	34.695	0.25	25.6	8.12	98.0
	100 D	0.09	0.12	0.17	2.37	0.28	7.04	0.39	7.53	0.13	34.865	0.24	25.5	8.14	97.5
	150 S	0.09	0.22	0.18	3.10	0.28	7.24	0.40	7.86	0.13	34.816	0.20	25.6	8.14	97.4
	150 D	0.08	0.08	0.14	2.12	0.29	7.31	0.40	7.67	0.10	34.888	0.20	25.5	8.15	97.7
	200 S	0.07	0.10	0.14	2.38	0.29	7.08	0.38	7.57	0.11	34.883	0.21	25.6	8.14	98.2
	200 D	0.08	0.04	0.17	1.74	0.29	7.53	0.38	7.84	0.10	34.912	0.21	25.5	8.15	98.0
MAKENA 3-A	0 S	1.18	105.7	0.29	225.1	0.16	8.81	1.60	131.6	0.34	16.536	0.30	24.6	7.88	97.7
	2 S	0.90	75.05	0.33	156.0	0.20	7.49	1.38	103.9	0.24	22.066	0.35	24.9	7.91	98.0
	5 S	0.34	28.98	0.36	63.77	0.32	7.85	0.79	50.82	0.20	29.611	0.32	24.9	8.00	98.6
	5 D	0.24	17.55	0.34	41.54	0.29	7.35	0.64	31.80	0.19	31.910	0.33	25.1	8.05	98.8
	10 S	0.13	4.94	0.23	16.14	0.28	7.52	0.46	18.13	0.15	33.467	0.20	24.8	8.07	98.7
	10 D	0.08	1.38	0.20	6.12	0.27	6.83	0.38	9.94	0.15	34.596	0.23	25.1	8.09	99.7
	50 S	0.10	1.51	0.20	7.18	0.27	7.45	0.40	11.19	0.12	34.581	0.15	25.4	8.10	99.1
	50 D	0.08	0.15	0.26	3.02	0.29	7.78	0.39	8.44	0.11	34.919	0.16	25.3	8.10	98.8
	100 S	0.10	0.67	0.13	4.55	0.27	6.91	0.39	8.48	0.13	34.835	0.15	25.3	8.10	98.4
	100 D	0.11	0.05	0.26	2.39	0.28	7.17	0.40	7.69	0.10	34.989	0.13	25.3	8.12	99.6
	150 S	0.08	0.10	0.12	2.93	0.31	7.58	0.41	8.43	0.11	34.930	0.12	25.3	8.12	98.8
	150 D	0.07	0.02	0.21	2.05	0.28	7.13	0.37	7.49	0.10	35.000	0.14	25.2	8.12	100.9
MAKENA 3	0 S	0.14	9.28	0.32	19.84	0.27	6.13	0.48	23.95	0.32	33.761	0.44	25.6	8.13	100.5
	2 S	0.16	12.97	0.25	24.11	0.26	5.92	0.48	26.89	0.28	33.792	0.48	25.6	8.11	101.5
	5 S	0.14	8.74	0.20	16.94	0.28	7.19	0.48	21.32	0.22	34.059	0.31	25.5	8.10	101.3
	5 D	0.15	6.42	0.18	13.43	0.27	6.82	0.46	18.13	0.21	34.252	0.39	25.5	8.10	100.1
	10 S	0.11	3.77	0.24	9.24	0.28	7.14	0.43	15.03	0.17	34.403	0.25	25.4	8.10	98.7
	10 D	0.10	1.94	0.17	6.33	0.29	7.31	0.41	11.94	0.15	34.645	0.26	25.4	8.10	98.3
	50 S	0.08	1.21	0.18	4.88	0.28	7.28	0.39	9.98	0.14	34.751	0.19	25.5	8.10	96.2
	50 D	0.09	0.32	0.18	2.97	0.29	7.46	0.40	8.29	0.10	34.897	0.19	25.4	8.12	94.9
	100 S	0.08	0.41	0.21	2.94	0.29	7.22	0.38	8.23	0.10	34.862	0.15	25.4	8.12	96.6
	100 D	0.07	0.12	0.22	2.10	0.29	6.76	0.38	7.29	0.09	34.905	0.16	25.4	8.13	96.5
	150 S	0.06	0.12	0.14	2.31	0.28	6.81	0.36	7.38	0.10	34.884	0.13	25.4	8.14	97.0
	150 D	0.07	0.06	0.12	1.86	0.28	6.92	0.36	7.23	0.09	34.934	0.16	25.4	8.16	98.3
MAKENA 4	0 S	0.20	38.03	0.29	69.15	0.22	7.72	0.53	54.83	0.34	26.064	0.77	25.5	8.11	101.0
	2 S	0.17	24.92	0.19	47.54	0.26	8.08	0.47	37.89	0.29	29.895	0.75	25.6	8.15	101.9
	5 S	0.13	11.76	0.13	26.09	0.25	7.81	0.42	23.80	0.25	32.197	0.51	25.5	8.16	102.2
	5 D	0.12	9.20	0.19	21.69	0.27	7.38	0.41	19.95	0.22	33.062	0.46	25.5	8.16	101.5
	10 S	0.10	3.73	0.16	10.35	0.26	7.38	0.38	13.14	0.19	34.062	0.33	25.5	8.15	100.0
	10 D	0.10	2.27	0.21	7.15	0.28	7.25	0.39	10.93	0.17	34.381	0.33	25.5	8.14	101.0
	50 S	0.08	2.13	0.20	6.81	0.26	7.21	0.37	10.69	0.15	34.490	0.27	25.5	8.13	95.4
	50 D	0.08	0.29	0.14	2.63	0.28	7.18	0.37	7.94	0.12	34.828	0.25	25.5	8.13	95.0
	100 S	0.08	0.79	0.16	4.43	0.27	6.66	0.38	9.03	0.12	34.635	0.22	25.5	8.13	95.4
	100 D	0.07	0.10	0.10	2.14	0.27	7.16	0.37	7.62	0.10	34.874	0.19	25.5	8.14	94.2
	150 S	0.08	0.24	0.16	2.92	0.27	7.13	0.37	8.22	0.12	34.793	0.18	25.6	8.14	96.8
	150 D	0.08	0.06	0.13	1.93	0.27	7.01	0.37	7.36	0.10	34.888	0.16	25.5	8.15	95.9
DOH WQS GEOMETRIC MEAN	DRY	0.25	0.14					0.52	7.86	0.20	*	0.15	**	***	
	WET	0.36	0.25					0.64	10.71	0.50		0.30			

* Salinity shall not vary more than ten percent form natural or seasonal changes considering hydrologic input and oceanographic conditions.
** Temperature shall not vary by more than one degree C. from ambient conditions.
***pH shall not deviate more than 0.5 units from a value of 8.1.

TABLE 4. Geometric mean data (in μg/L) from water chemistry measurements (in μM) off the Makena Resort collected since August 1995 for Sites 1, 2, and 4 (N=29); since June 2002 from Site 3 (N=20) and since June 2007 from Site 3-A (N=11). Nutrient concentrations are shown in units of micrograms per liter (μg/L). For geometric mean calculations, detection limits were used in cases where sample was below detection limit. Abbreviations as follows: DFS=distance from shore; S=surface; D=deep. Also shown are State of Hawaii, Department of Health (DOH) geometric mean water quality standards for open coastal waters under "dry" and "wet" conditions. Boxed values exceed DOH GM 10% "dry" standards; boxed and shaded values exceed DOH GM 10% "wet" standards. For sampling site locations, see Figure 1.

TRANSECT SITE	DFS (m)	PO_4^{3-} (μg/L)	NO_3^- (μg/L)	NH_4^+ (μg/L)	Si (μg/L)	TOP (μg/L)	TON (μg/L)	TP (μg/L)	TN (μg/L)	TURB (NTU)	SALINITY (ppt)	CHL a (μg/L)	TEMP (deg.C)	pH	O2
MAKENA 1	0 S	6.10	532.6	4.00	1942	6.80	108.1	16.40	767.9	0.34	26.064	0.77	25.5	8.11	102.9
	2 S	5.20	349.0	2.60	1335	8.00	113.1	14.50	530.6	0.29	29.895	0.75	25.6	8.15	105.2
	5 S	4.00	164.7	1.80	732.9	7.70	109.3	13.00	333.3	0.25	32.197	0.51	25.5	8.16	105.1
	5 D	3.70	128.8	2.60	609.3	8.30	103.3	12.60	279.4	0.22	33.062	0.46	25.5	8.16	105.4
	10 S	3.00	52.20	2.20	290.7	8.00	103.3	11.70	184.0	0.19	34.062	0.33	25.5	8.15	104.1
	10 D	3.00	31.70	2.90	200.8	8.60	101.5	12.00	153.0	0.17	34.381	0.33	25.5	8.14	103.6
	50 S	2.40	29.80	2.80	191.3	8.00	100.9	11.40	149.7	0.15	34.490	0.27	25.5	8.13	100.3
	50 D	2.40	4.00	1.90	73.88	8.60	100.5	11.40	111.2	0.12	34.828	0.25	25.5	8.13	99.6
	100 S	2.40	11.00	2.20	124.4	8.30	93.20	11.70	126.4	0.12	34.635	0.22	25.5	8.13	98.6
	100 D	2.10	1.40	1.40	60.11	8.30	100.2	11.40	106.7	0.10	34.874	0.19	25.5	8.14	98.3
	150 S	2.40	3.30	2.20	82.02	8.30	99.80	11.40	115.1	0.12	34.793	0.18	25.6	8.14	97.8
	150 D	2.40	0.80	1.80	54.21	8.30	98.10	11.40	103.0	0.10	34.888	0.16	25.5	8.15	98.6
MAKENA 2	0 S	5.80	59.50	5.10	622.8	9.90	114.2	17.00	194.8	0.88	33.440	0.73	25.6	8.13	98.9
	2 S	5.80	54.00	3.30	550.6	9.60	107.7	16.10	179.4	0.63	33.608	0.72	25.7	8.14	100.6
	5 S	5.20	43.90	3.30	419.7	8.60	98.40	14.50	156.8	0.44	34.030	0.56	25.6	8.14	100.3
	5 D	5.50	41.30	4.20	418.8	9.20	102.2	15.40	161.4	0.41	34.075	0.67	25.6	8.13	99.8
	10 S	3.70	22.60	2.90	259.3	8.90	80.60	13.60	129.8	0.30	34.406	0.38	25.5	8.14	98.8
	10 D	3.70	14.00	3.30	215.2	8.90	99.00	13.60	126.3	0.27	34.518	0.43	25.6	8.14	97.8
	50 S	3.00	15.10	3.60	202.8	9.60	105.0	13.60	133.4	0.22	34.485	0.30	25.5	8.13	97.8
	50 D	3.40	2.90	3.20	88.76	9.20	102.9	13.30	112.4	0.16	34.835	0.33	25.5	8.14	97.4
	100 S	2.70	5.60	2.50	112.6	8.90	100.2	12.30	113.5	0.16	34.695	0.25	25.6	8.12	98.0
	100 D	2.70	1.60	2.30	66.57	8.60	98.60	12.00	105.4	0.13	34.865	0.24	25.5	8.14	97.5
	150 S	2.70	3.00	2.50	87.08	8.60	101.4	12.30	110.0	0.13	34.816	0.20	25.6	8.14	97.4
	150 D	2.40	1.10	1.90	59.55	8.90	102.3	12.30	107.4	0.10	34.888	0.20	25.5	8.15	97.7
	200 S	2.10	1.40	1.90	66.85	8.90	99.10	11.70	106.0	0.11	34.883	0.21	25.6	8.14	98.2
	200 D	2.40	0.50	2.30	48.88	8.90	105.4	11.70	109.8	0.10	34.912	0.21	25.5	8.15	98.0
MAKENA 3-A	0 S	36.50	1480	4.00	6324	4.90	123.3	49.50	1842	0.34	16.536	0.30	24.6	7.88	97.7
	2 S	27.80	1051	4.60	4383	6.10	104.9	42.70	1455	0.24	22.066	0.35	24.9	7.91	98.0
	5 S	10.50	405.8	5.00	1791	9.90	109.9	24.40	711.7	0.20	29.611	0.32	24.9	8	98.6
	5 D	7.40	245.8	4.70	1167	8.90	102.9	19.80	445.3	0.19	31.910	0.33	25.1	8.05	98.8
	10 S	4.00	69.10	3.20	453.4	8.60	105.3	14.20	253.9	0.15	33.467	0.20	24.8	8.07	98.7
	10 D	2.40	19.30	2.80	171.9	8.30	95.60	11.70	139.2	0.15	34.596	0.23	25.1	8.09	99.7
	50 S	3.00	21.10	2.80	201.7	8.30	104.3	12.30	156.7	0.12	34.581	0.15	25.4	8.1	99.1
	50 D	2.40	2.10	3.60	84.83	8.90	108.9	12.00	118.2	0.11	34.919	0.16	25.3	8.1	98.8
	100 S	3.00	9.30	1.80	127.8	8.30	96.70	12.00	118.7	0.13	34.835	0.15	25.3	8.1	98.4
	100 D	3.40	0.70	3.60	67.14	8.60	100.4	12.30	107.7	0.10	34.989	0.13	25.3	8.12	99.6
	150 S	2.40	1.40	1.60	82.30	9.60	106.1	12.60	118.0	0.11	34.930	0.12	25.3	8.12	98.8
	150 D	2.10	0.20	2.90	57.58	8.60	99.80	11.40	104.9	0.10	35.000	0.14	25.2	8.12	100.9
MAKENA 3	0 S	4.30	129.9	4.40	557.3	8.30	85.80	14.80	335.4	0.32	33.761	0.44	25.6	8.13	100.5
	2 S	4.90	181.6	3.50	677.2	8.00	82.90	14.80	376.6	0.28	33.792	0.48	25.6	8.11	101.5
	5 S	4.30	122.4	2.80	475.8	8.60	100.7	14.80	298.6	0.22	34.059	0.31	25.5	8.1	101.3
	5 D	4.60	89.90	2.50	377.2	8.30	95.50	14.20	253.9	0.21	34.252	0.39	25.5	8.1	100.1
	10 S	3.40	52.80	3.30	259.6	8.60	100.0	13.30	210.5	0.17	34.403	0.25	25.4	8.1	98.7
	10 D	3.00	27.10	2.30	177.8	8.90	102.3	12.60	167.2	0.15	34.645	0.26	25.4	8.1	98.3
	50 S	2.40	16.90	2.50	137.1	8.60	101.9	12.00	139.7	0.14	34.751	0.19	25.5	8.1	96.2
	50 D	2.70	4.40	2.50	83.43	8.90	104.4	12.30	116.1	0.10	34.897	0.19	25.4	8.12	94.9
	100 S	2.40	5.70	2.90	82.58	8.90	101.1	11.70	115.2	0.10	34.862	0.15	25.4	8.12	96.6
	100 D	2.10	1.60	3.00	58.99	8.90	94.60	11.70	102.1	0.09	34.905	0.16	25.4	8.13	96.5
	150 S	1.80	1.60	1.90	64.89	8.60	95.30	11.10	103.3	0.10	34.884	0.13	25.4	8.14	97.0
	150 D	2.10	0.80	1.60	52.25	8.60	96.90	11.10	101.2	0.09	34.934	0.16	25.4	8.16	98.3
MAKENA 4	0 S	6.10	532.6	4.00	1942	6.80	108.1	16.40	767.9	0.34	26.064	0.77	25.5	8.11	101.0
	2 S	5.20	349.0	2.60	1335	8.00	113.1	14.50	530.6	0.29	29.895	0.75	25.6	8.15	101.9
	5 S	4.00	164.7	1.80	732.9	7.70	109.3	13.00	333.3	0.25	32.197	0.51	25.5	8.16	102.2
	5 D	3.70	128.8	2.60	609.3	8.30	103.3	12.60	279.4	0.22	33.062	0.46	25.5	8.16	101.5
	10 S	3.00	52.20	2.20	290.7	8.00	103.3	11.70	184.0	0.19	34.062	0.33	25.5	8.15	100.0
	10 D	3.00	31.70	2.90	200.8	8.60	101.5	12.00	153.0	0.17	34.381	0.33	25.5	8.14	101.0
	50 S	2.40	29.80	2.80	191.3	8.00	100.9	11.40	149.7	0.15	34.490	0.27	25.5	8.13	95.4
	50 D	2.40	4.00	1.90	73.88	8.60	100.5	11.40	111.2	0.12	34.828	0.25	25.5	8.13	95.0
	100 S	2.40	11.00	2.20	124.4	8.30	93.20	11.70	126.4	0.12	34.635	0.22	25.5	8.13	95.4
	100 D	2.10	1.40	1.40	60.11	8.30	100.2	11.40	106.7	0.10	34.874	0.19	25.5	8.14	94.2
	150 S	2.40	3.30	2.20	82.02	8.30	99.80	11.40	115.1	0.12	34.793	0.18	25.6	8.14	96.8
	150 D	2.40	0.80	1.80	54.21	8.30	98.10	11.40	103.0	0.10	34.888	0.16	25.5	8.15	95.9
DOH WQS GEOMETRIC MEAN	DRY	3.50	2.00					16.00	110.00	0.20	*	0.15	**	***	
	WET	5.00	3.50					20.00	150.00	0.50		0.30			

* Salinity shall not vary more than ten percent form natural or seasonal changes considering hydrologic input and oceanographic conditions.

** Temperature shall not vary by more than one degree C. from ambient conditions.

***pH shall not deviate more than 0.5 units from a value of 8.1.

TABLE 5. Water chemistry measurements and (shaded) from irrigation wells and an irrigation lake collected in the vicinity of the Makena Resort on May 10, 2012. Nutrient concentrations are shown in micromolar units (μM) in top panel, and in units of micrograms per liter (μg/L) in bottom panel. For sampling site locations, see Figure 1.

WELL	PO_4^{3-} (μM)	NO_3^- (μM)	NH_4^+ (μM)	Si (μM)	TOP (μM)	TON (μM)	TP (μM)	TN (μM)	SALINITY (ppt)
1	2.10	124.6	1.00	483.9	0.55	6.80	2.65	132.4	1.359
2	2.95	142.6	0.80	648.4	0.10	7.25	3.05	150.7	1.827
3	3.10	137.2	0.65	650.2	0.15	12.95	3.25	150.8	2.007
4	3.00	126.1	0.60	612.5	0.30	16.80	3.30	143.5	1.739
5	2.70	161.4	0.65	555.9	0.60	10.70	3.30	172.8	1.528
6	2.45	166.0	0.35	523.8	0.45	14.15	2.90	180.5	1.611
8	2.80	111.3	0.25	564.0	0.30	14.55	3.10	126.1	2.312
10	2.40	168.2	4.75	578.2	0.35	21.70	2.75	194.7	1.829
11	2.45	117.1	1.05	589.4	0.65	17.80	3.10	136.0	2.002

WELL	PO_4^{3-} (μg/L)	NO_3^- (μg/L)	NH_4^+ (μg/L)	Si (μg/L)	TOP (μg/L)	TON (μg/L)	TP (μg/L)	TN (μg/L)	SALINITY (ppt)
1	65.10	1744.4	14.00	13,598	17.05	95.20	82.15	1853.6	1.359
2	91.45	1996.4	11.20	18,220	3.10	101.50	94.55	2109.1	1.827
3	96.10	1920.8	9.10	18,271	4.65	181.30	100.75	2111.2	2.007
4	93.00	1765.4	8.40	17,211	9.30	235.20	102.30	2009.0	1.739
5	83.70	2259.6	9.10	15,621	18.60	149.80	102.30	2418.5	1.528
6	75.95	2323.3	4.90	14,717	13.95	198.10	89.90	2526.3	1.611
8	86.80	1557.5	3.50	15,847	9.30	203.70	96.10	1764.7	2.312
10	74.40	2354.8	66.50	16,246	10.85	303.80	85.25	2725.1	1.829
11	75.95	1639.4	14.70	16,562	20.15	249.20	96.10	1903.3	2.002

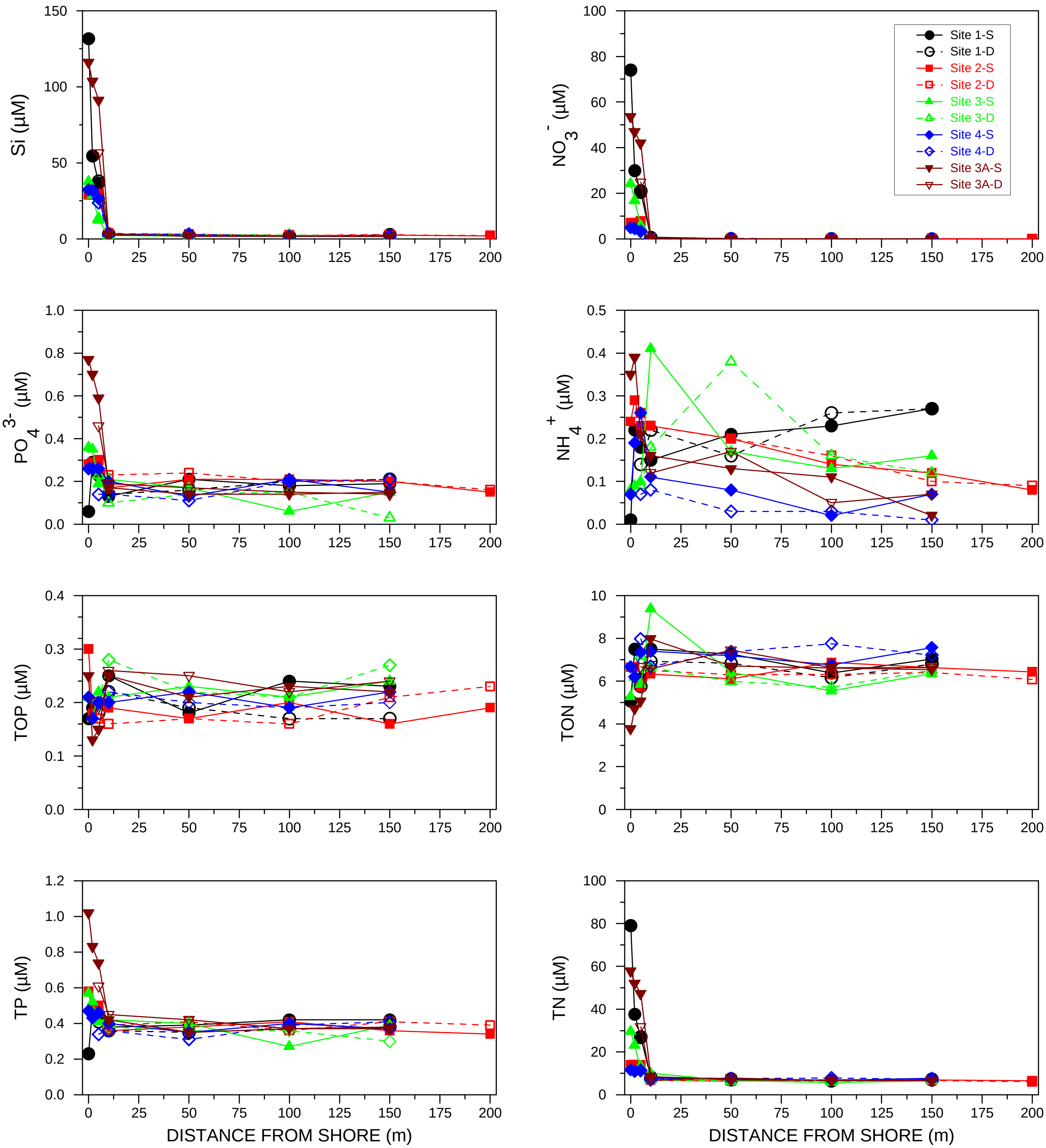


FIGURE 2. Plots of dissolved nutrients in surface (S) and deep (D) samples collected on January 5, 2014 as a function of distance from the shoreline in the vicinity of Makena Resort. For site locations, see Figure 1.

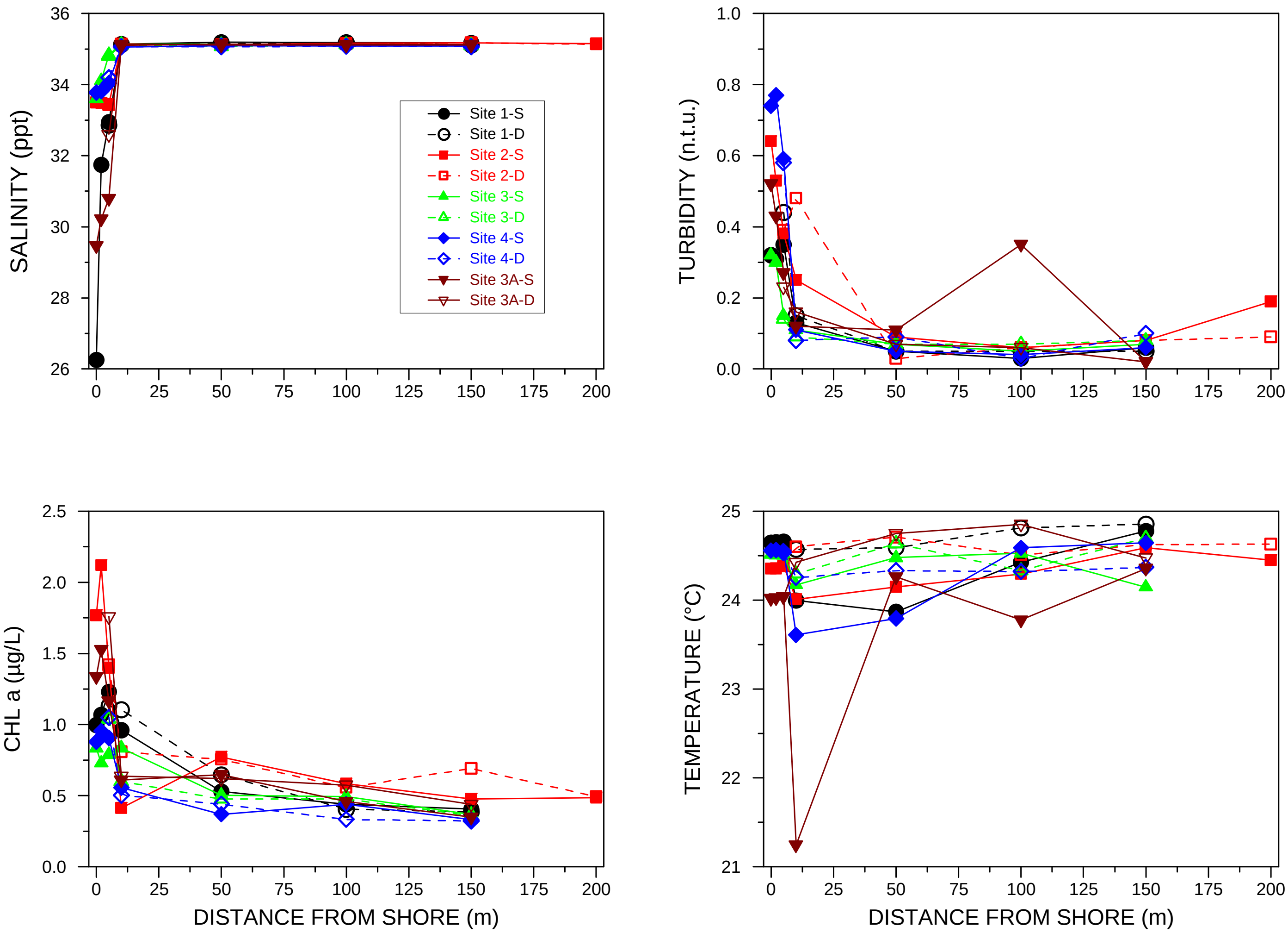


FIGURE 3. Plots of water chemistry constituents in surface (S) and deep (D) samples collected on January 5, 2014 as a function of distance from the shoreline in the vicinity of Makena Resort. For site locations, see Figure 1.

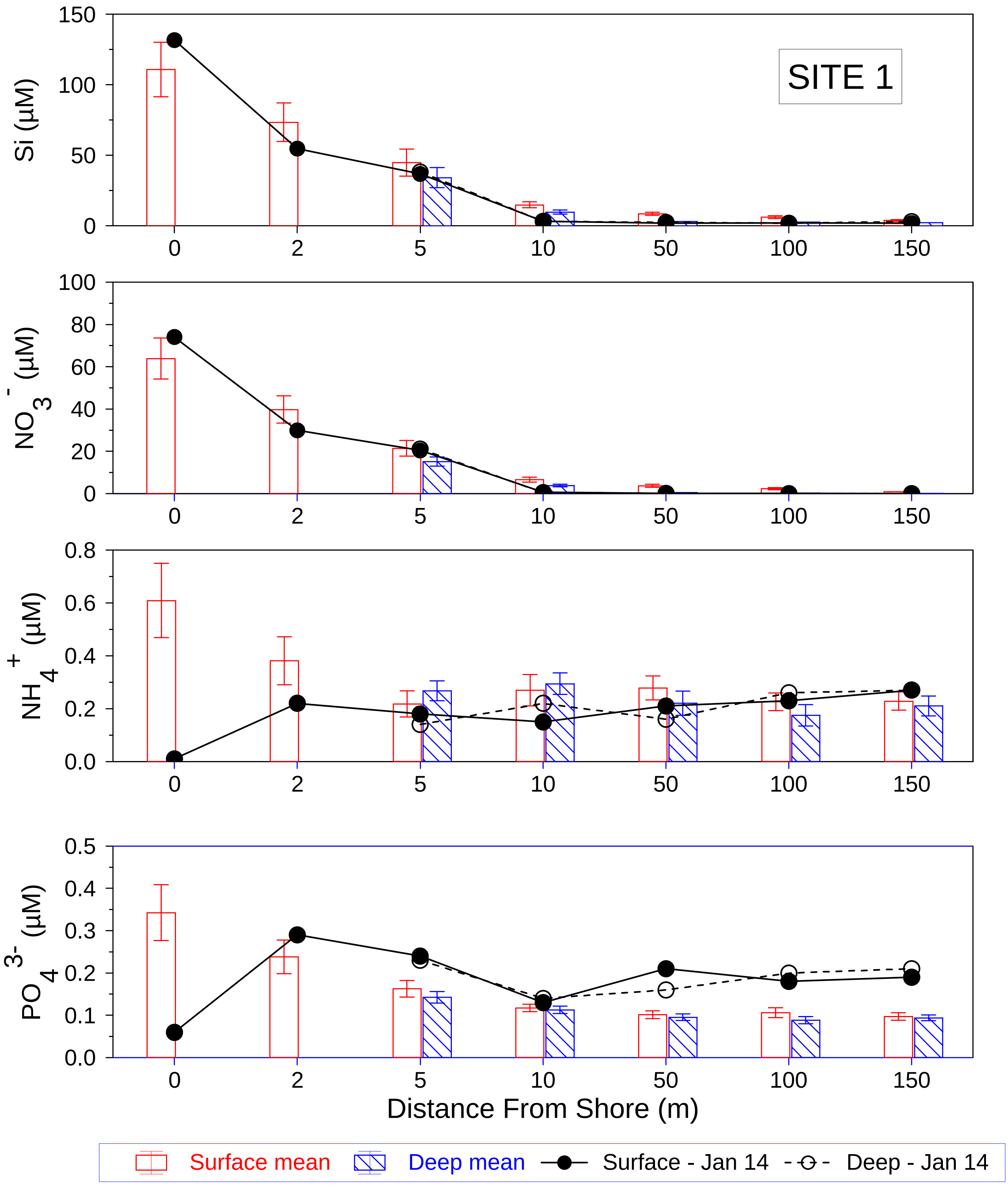


FIGURE 4. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=30). Error bars represent standard error of the mean. For site location, see Figure 1.

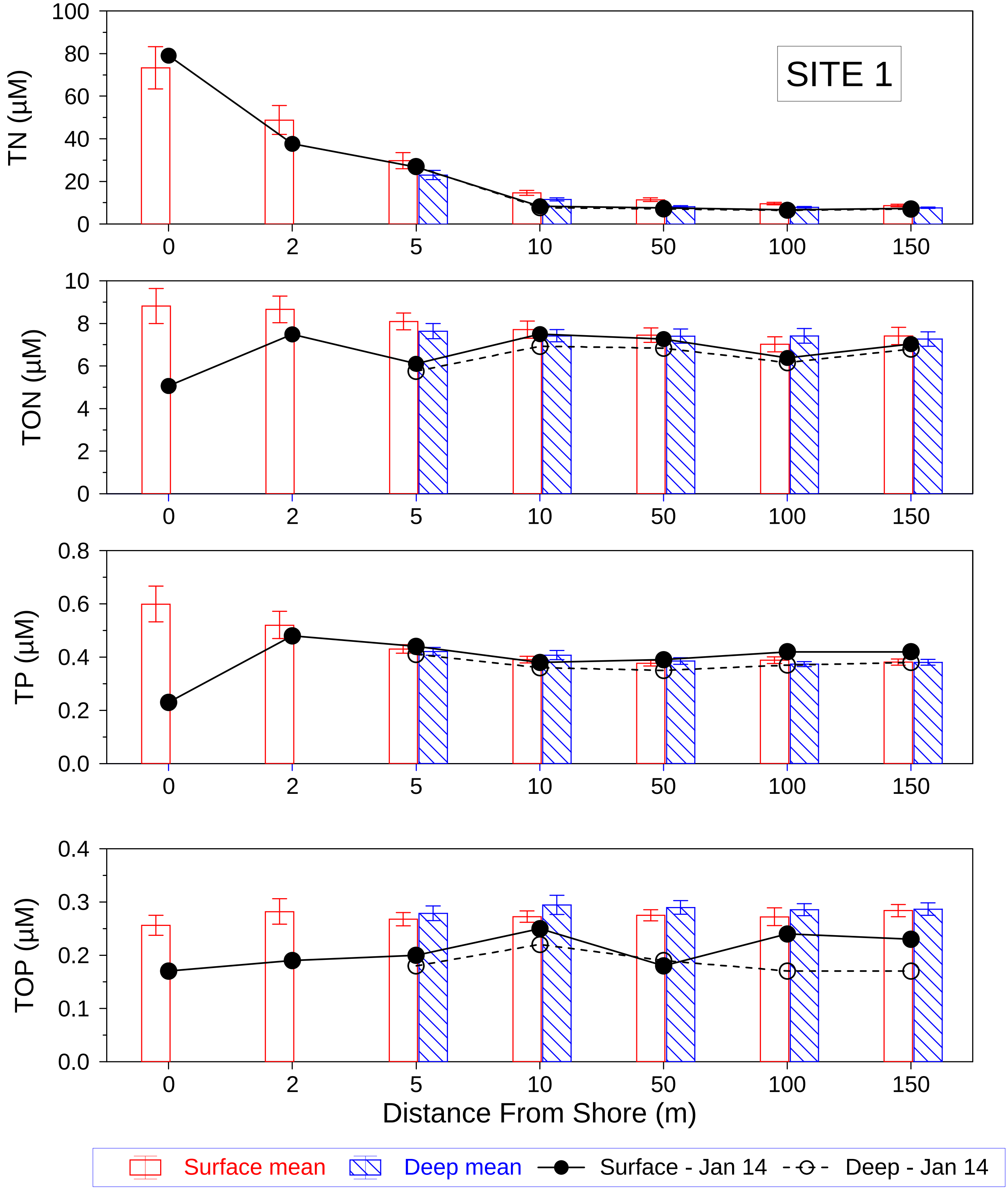


FIGURE 5. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=30). Error bars represent standard error of the mean. For site location, see Figure 1.

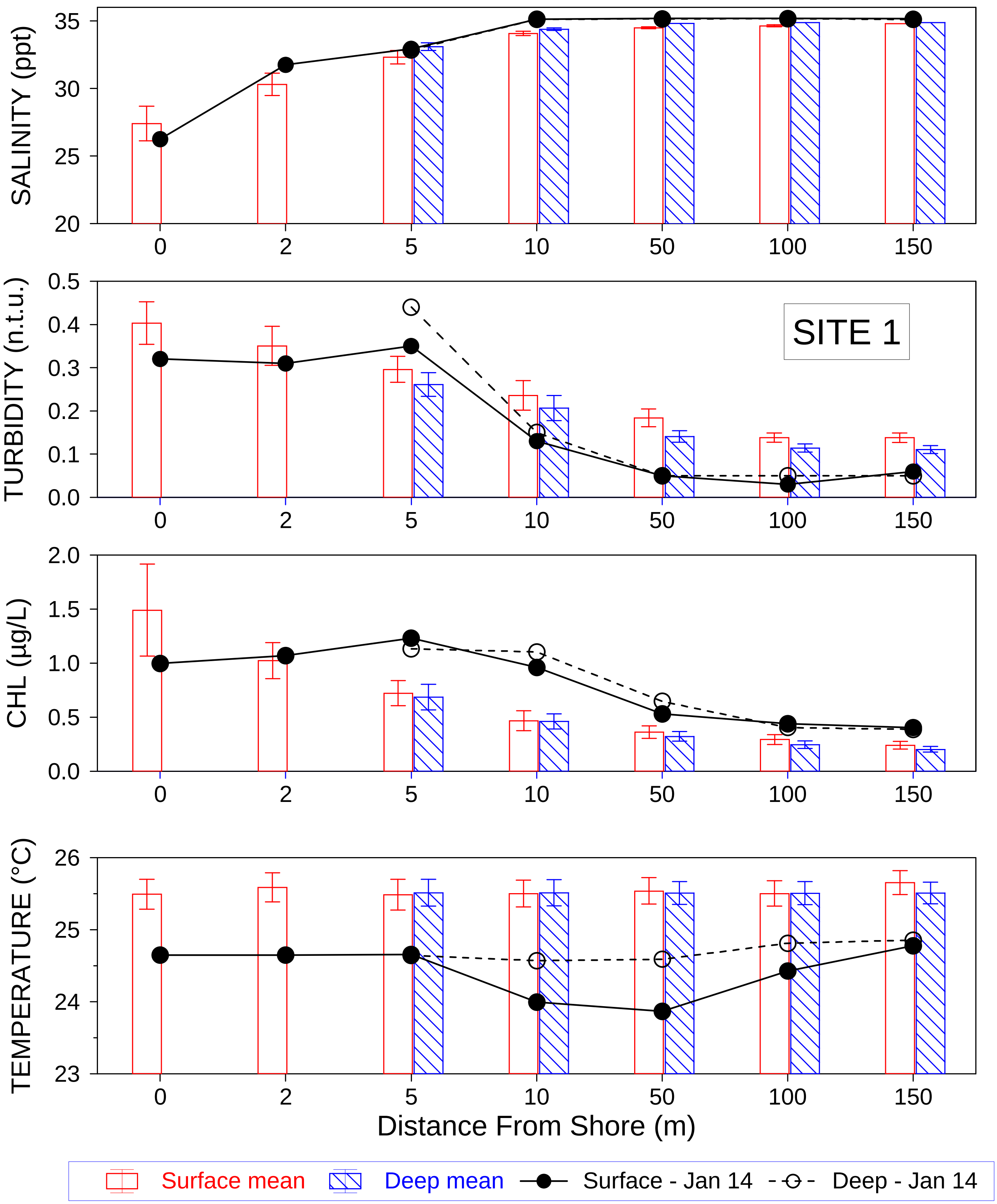


FIGURE 6. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=30). Error bars represent standard error of the mean. For site location, see Figure 1.

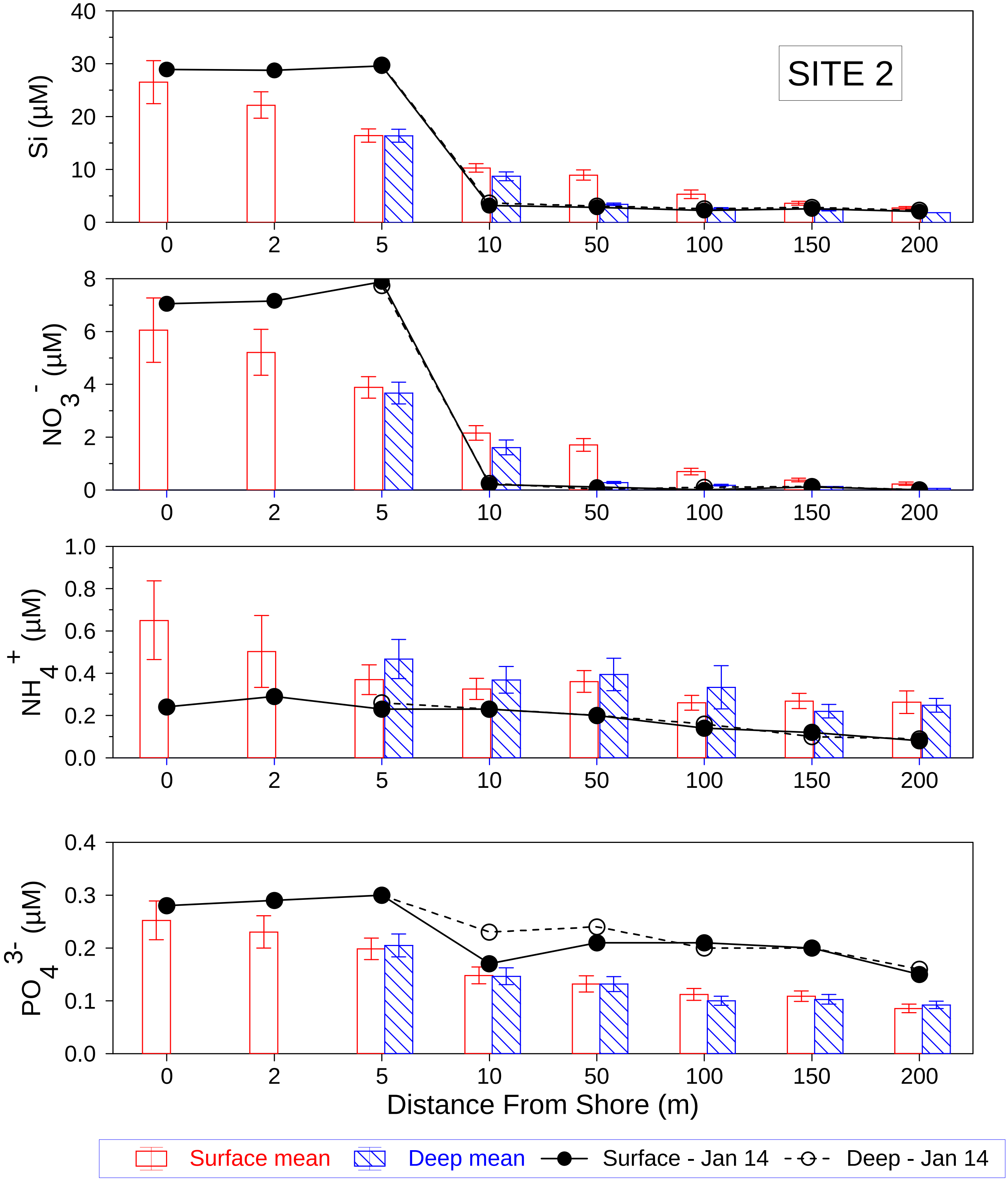


FIGURE 7. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=30). Error bars represent standard error of the mean. For site location, see Figure 1.

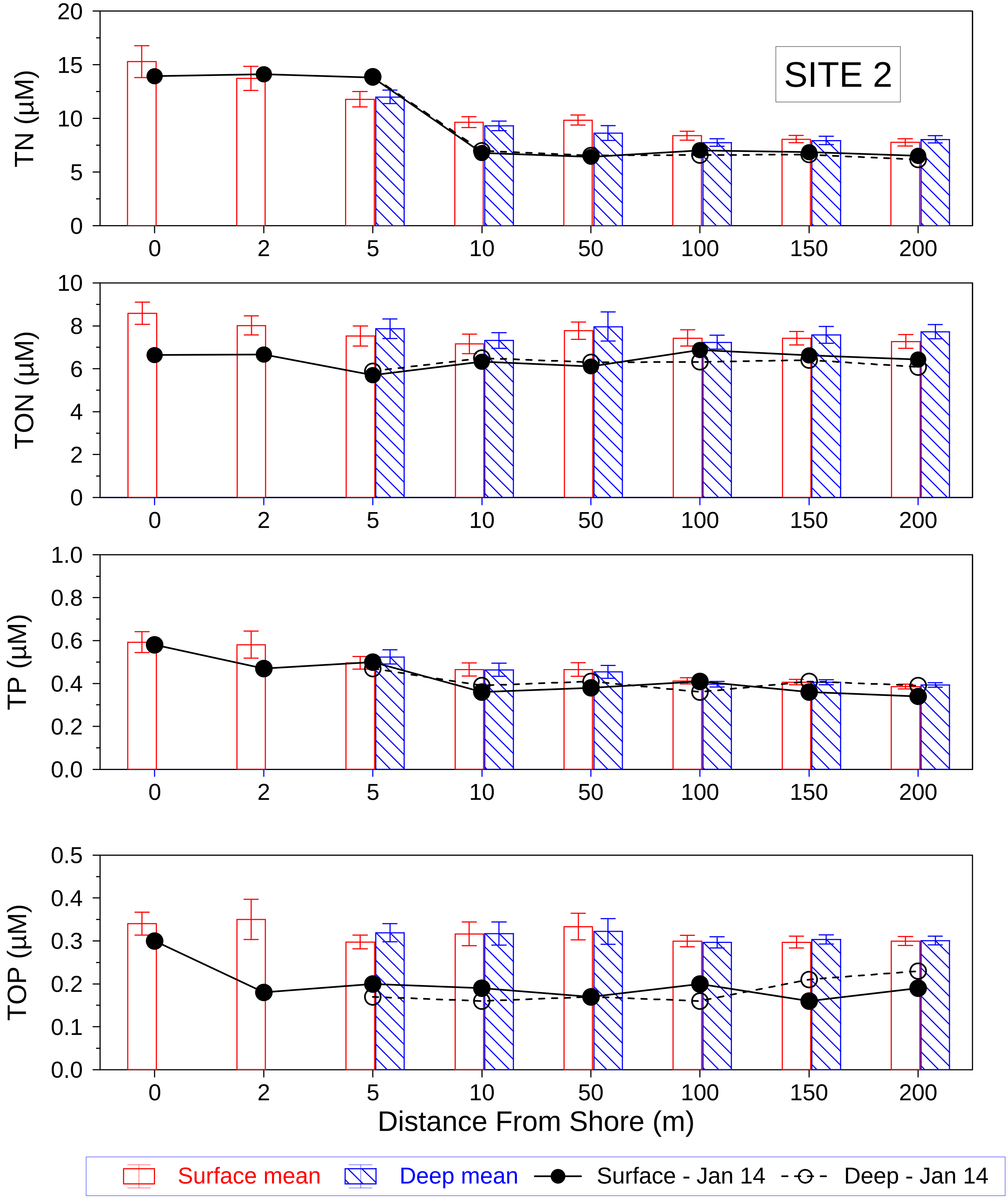


FIGURE 8. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=30). Error bars represent standard error of the mean. For site location, see Figure 1.

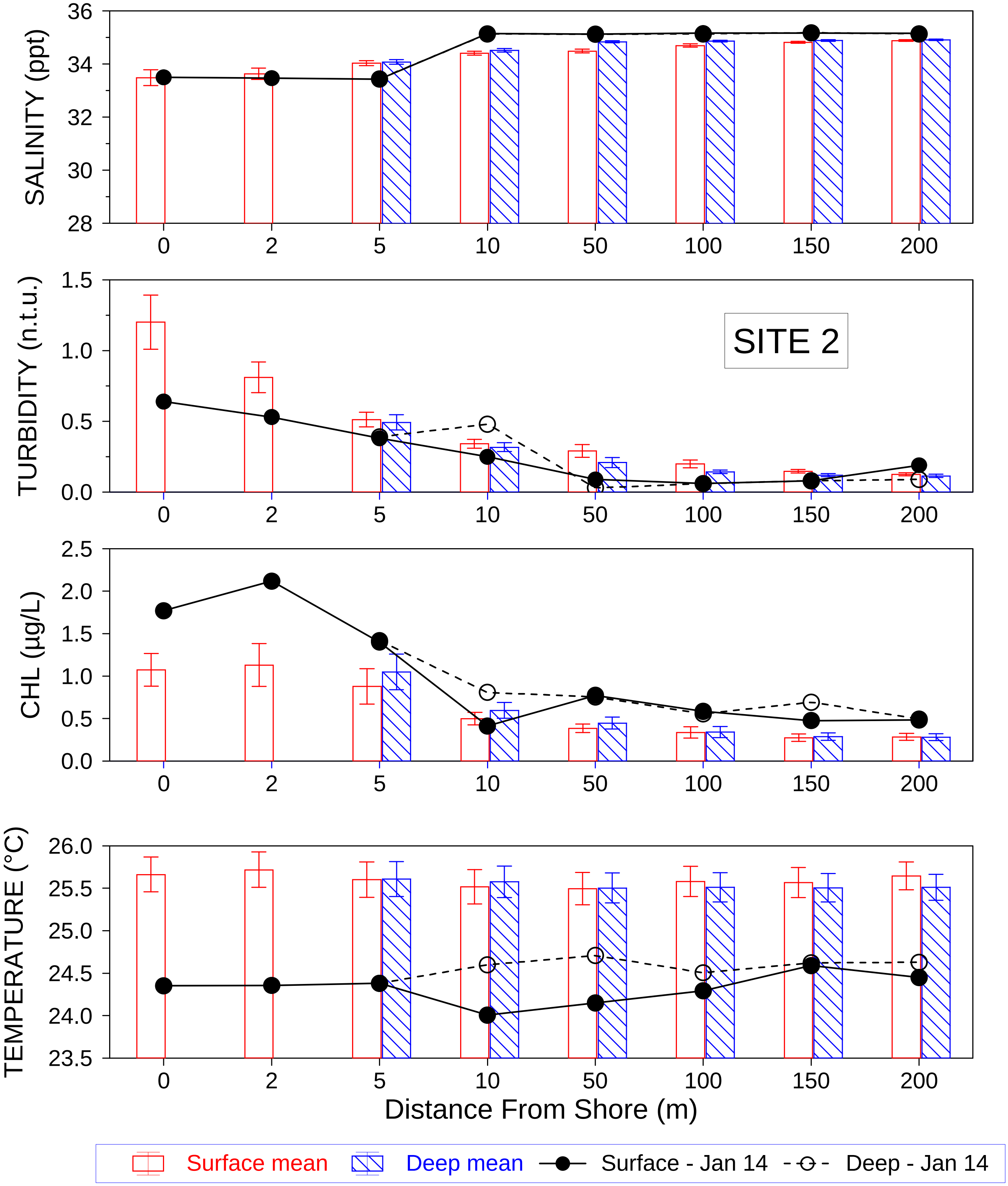


FIGURE 9. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey,bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=30). Error bars represent standard error of the mean. For site location, see Figure 1.

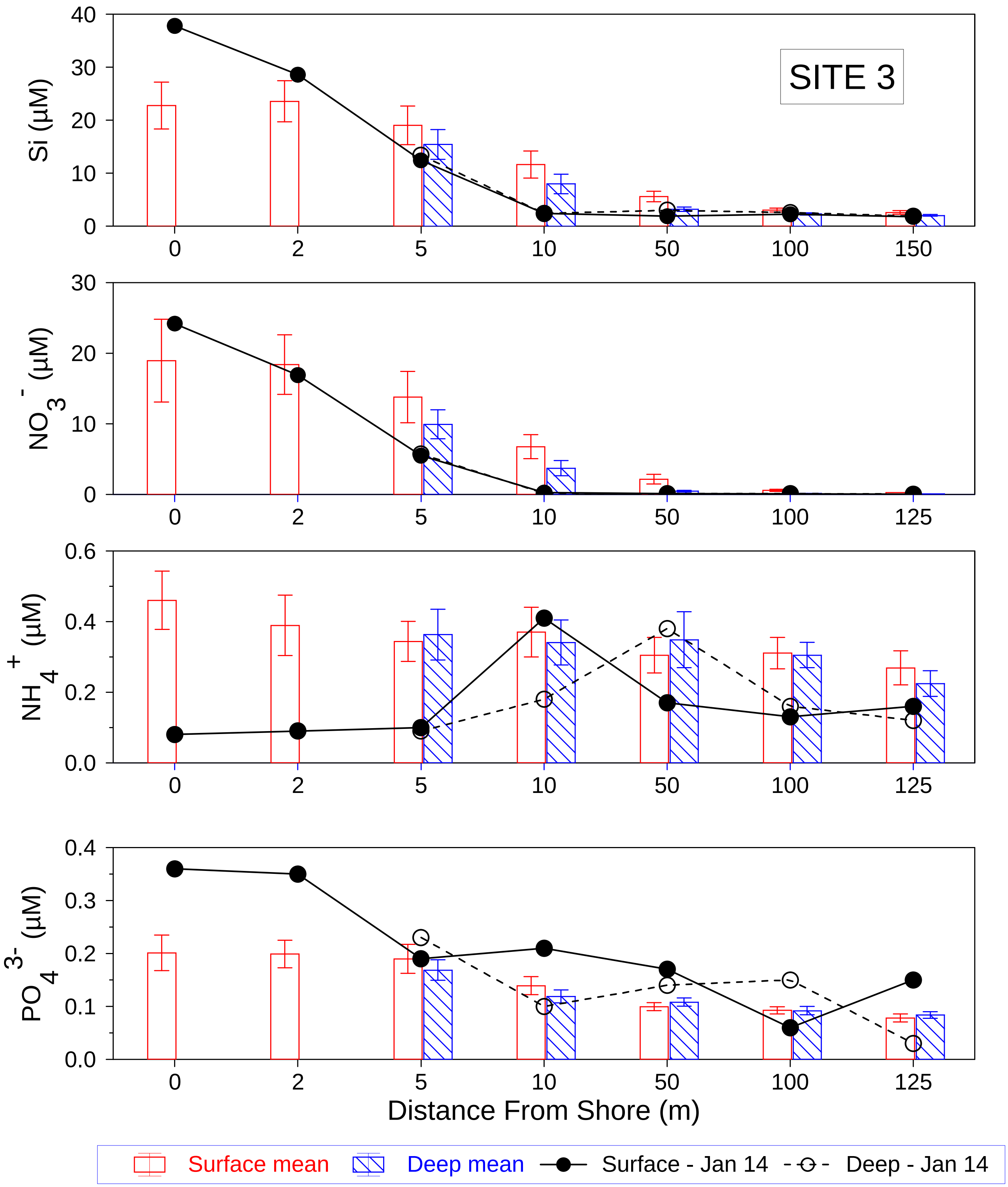


FIGURE 10. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=30). Error bars represent standard error of the mean. For site location, see Figure 1.

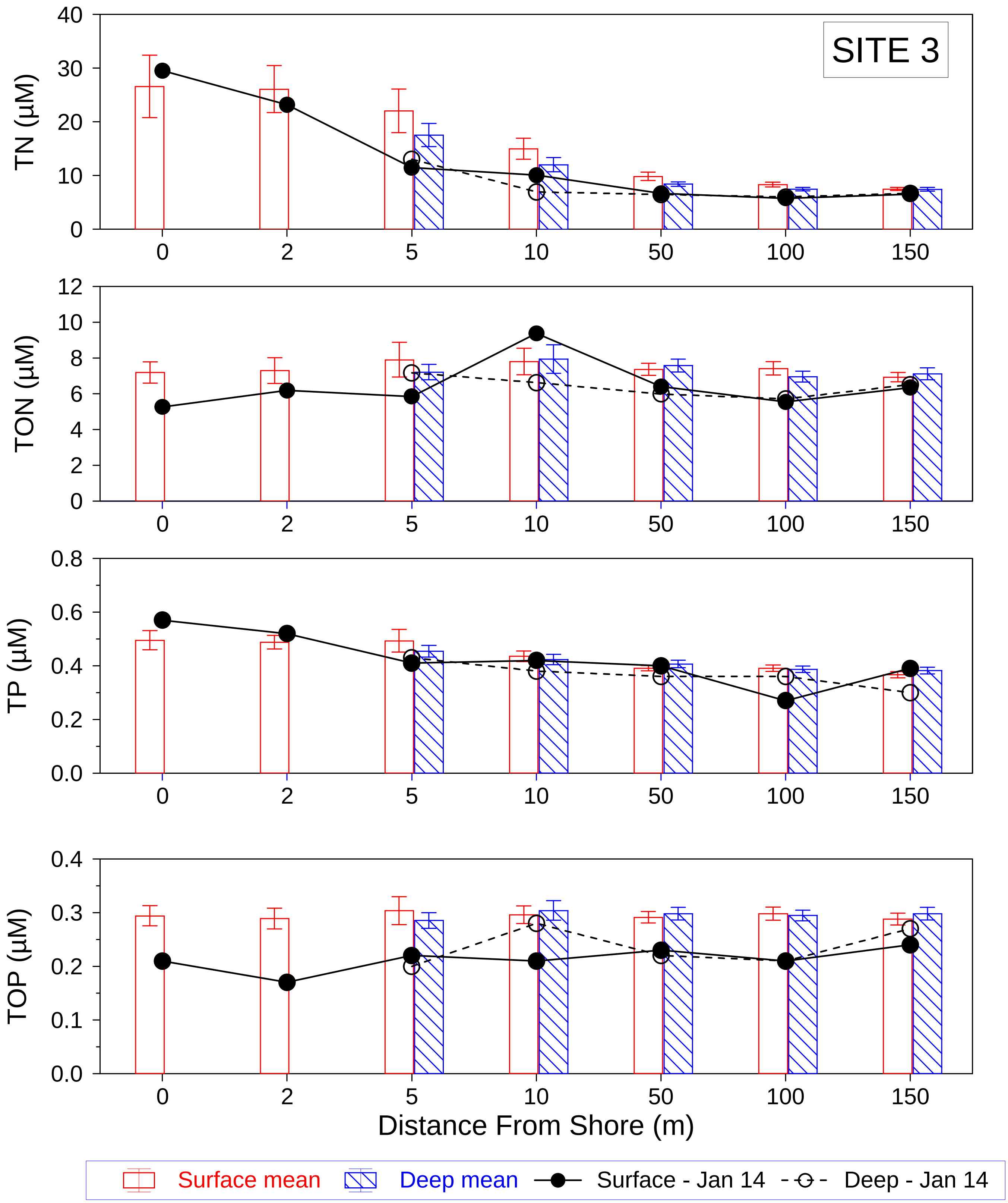


FIGURE 11. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=30). Error bars represent standard error of the mean. For site location, see Figure 1.

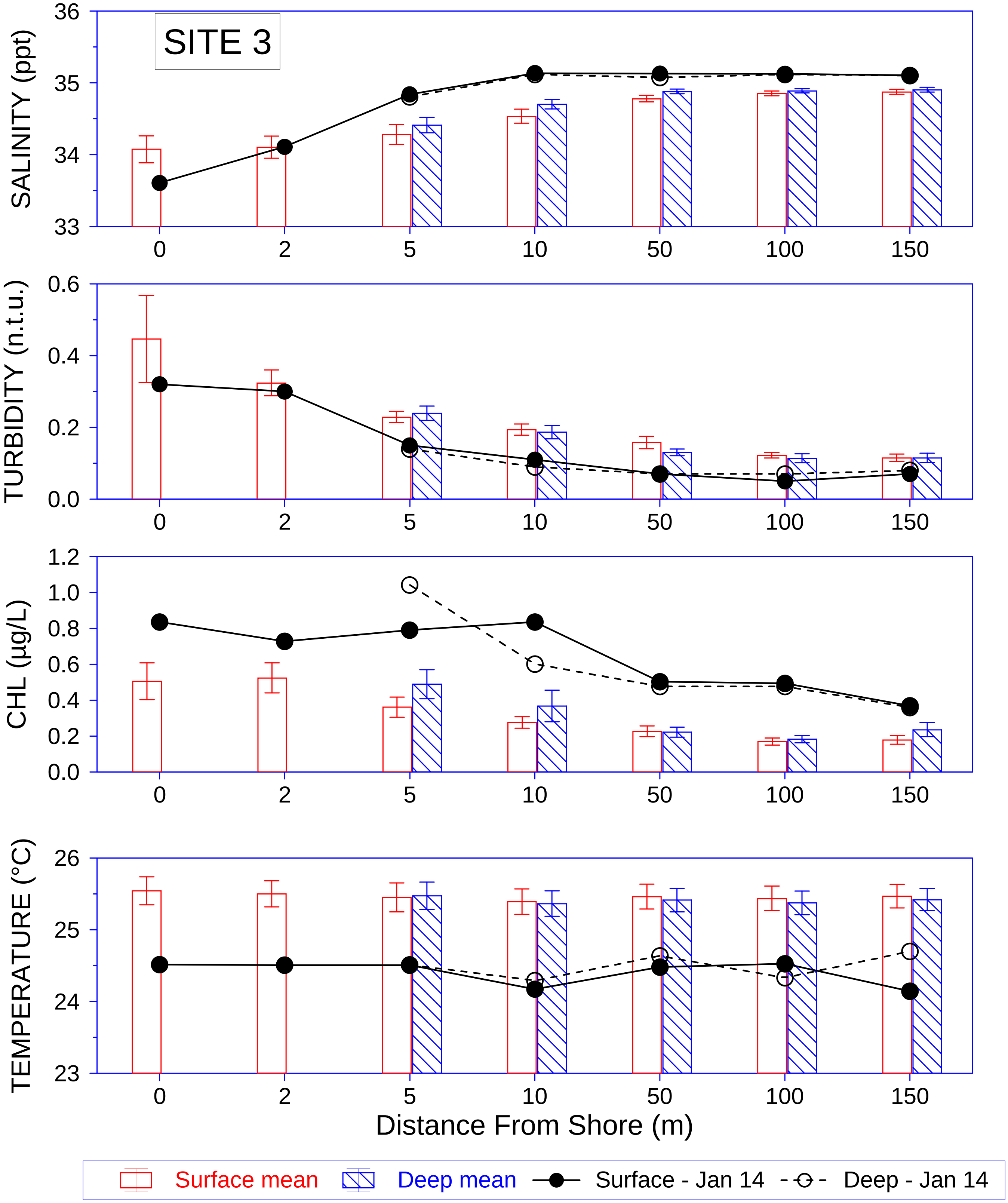


FIGURE 12. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=30). Error bars represent standard error of the mean. For site location, see Figure 1.

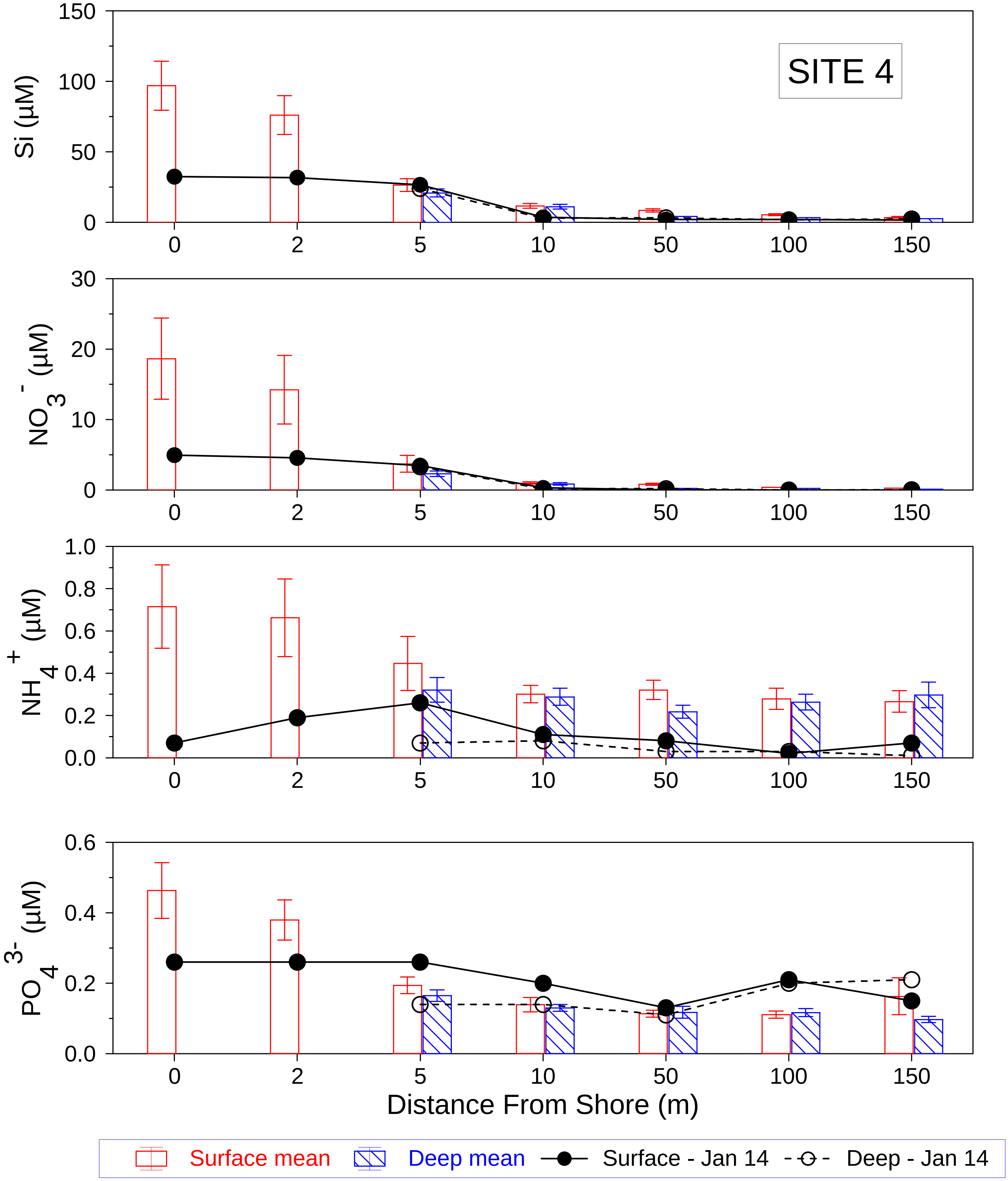


FIGURE 13. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=30). Error bars represent standard error of the mean. For site location, see Figure 1.

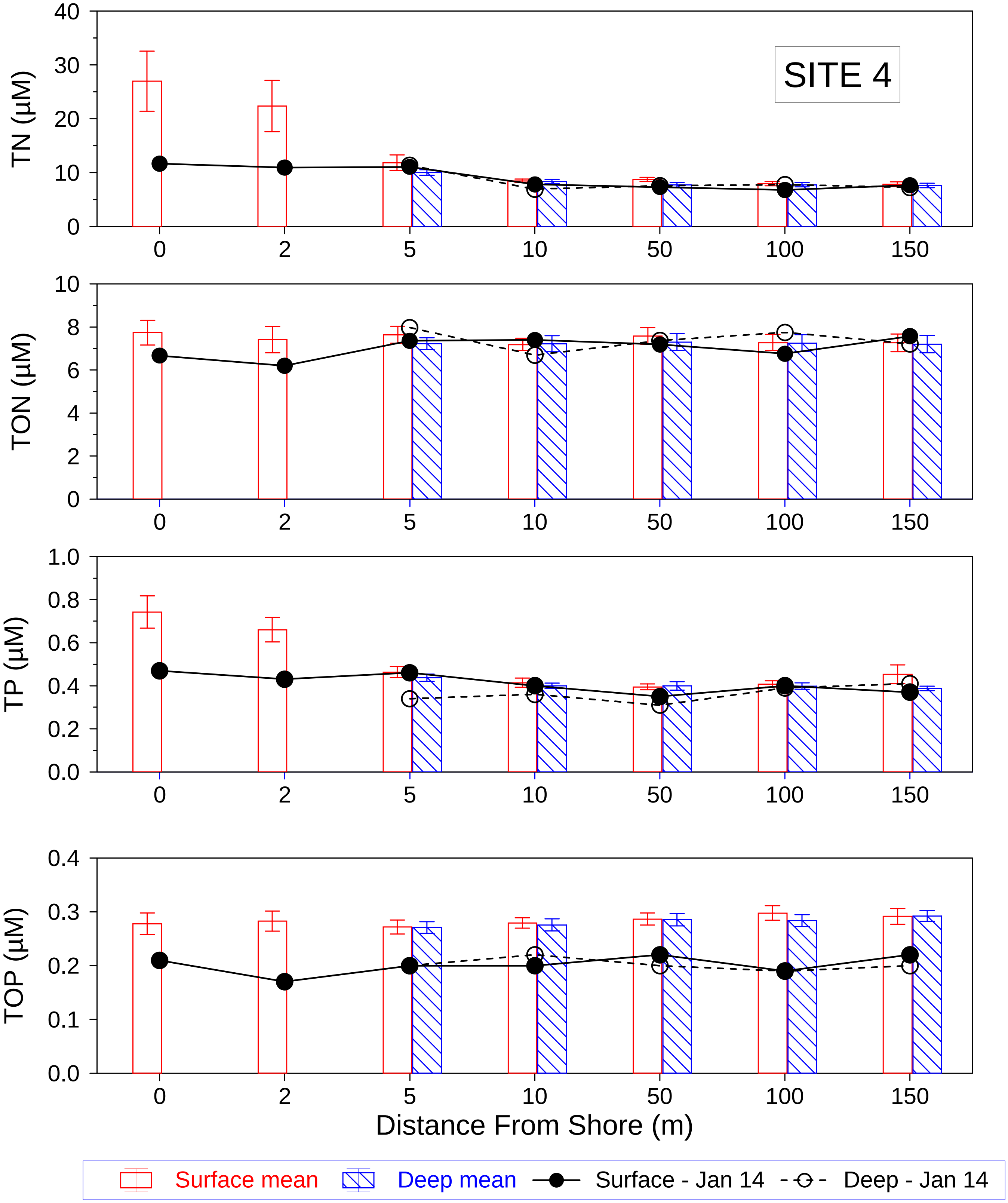


FIGURE 14. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=30). Error bars represent standard error of the mean. For site location, see Figure 1.

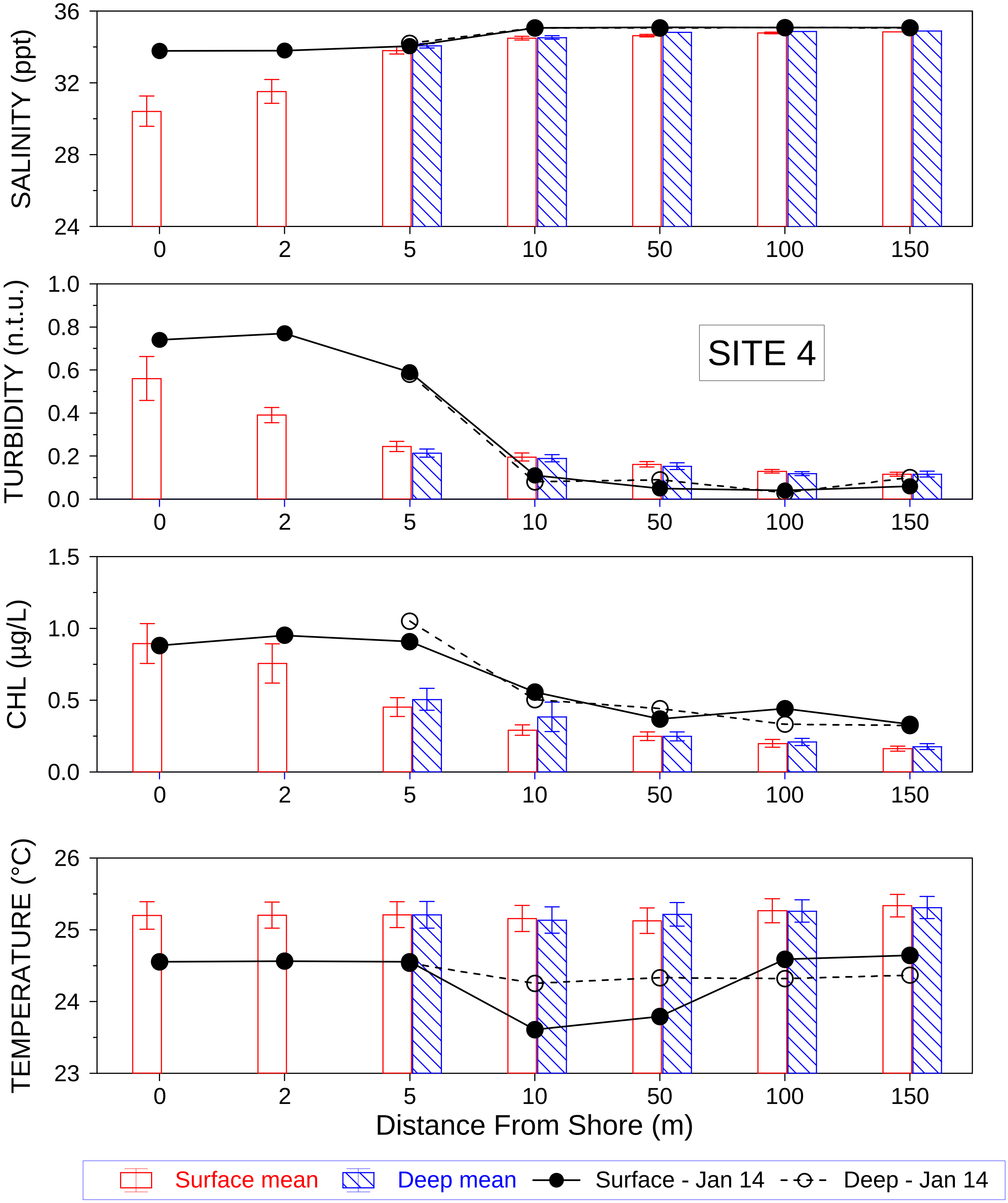


FIGURE 15. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=30). Error bars represent standard error of the mean. For site location, see Figure 1.

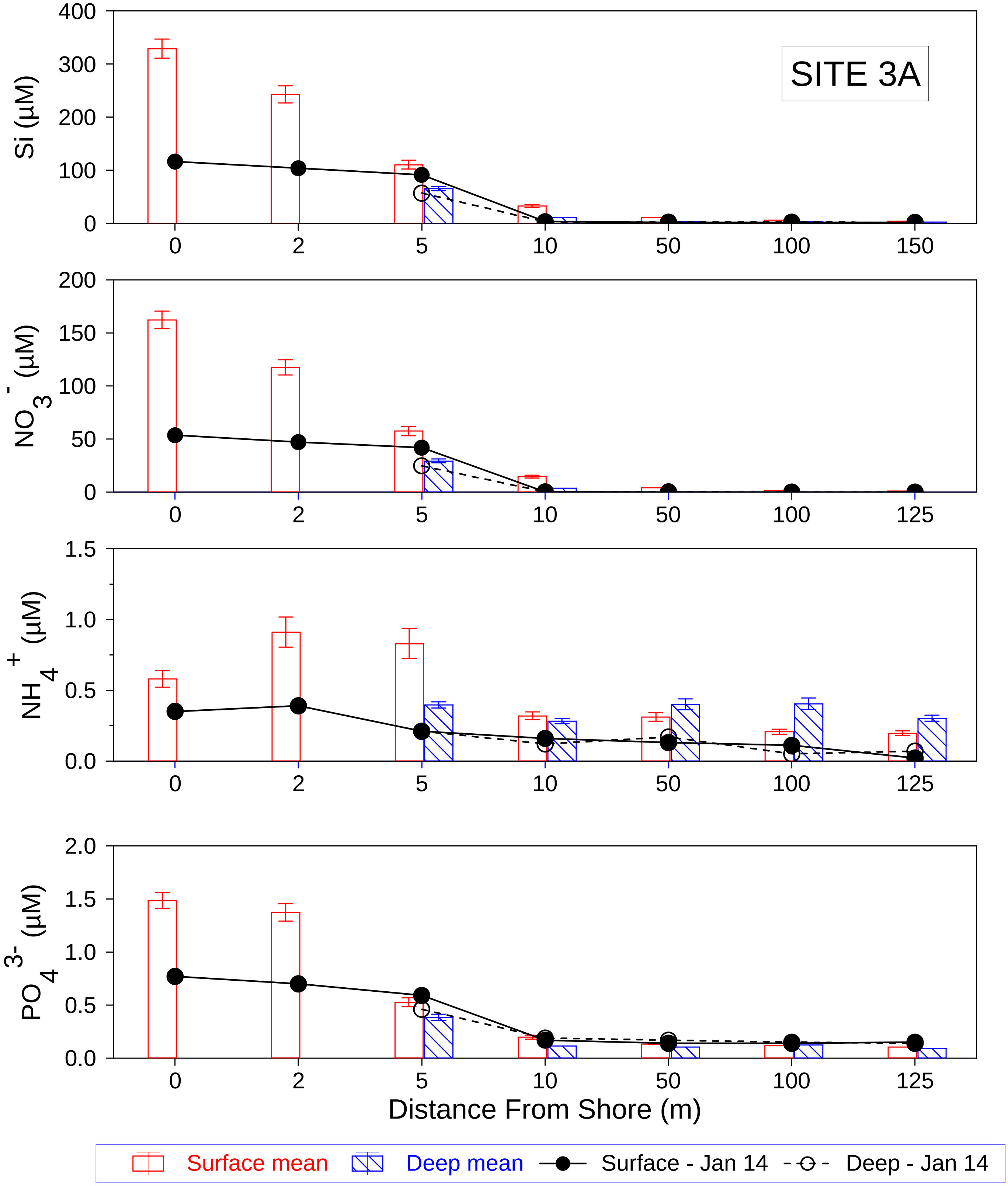


FIGURE 16. Plots of dissolved nutrient constituents measured in surface and deep water samples as af unction of distance from the shoreline at Site 3A, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since June 2007 (N=12). Error bars represent standard error of the mean. For site location, see Figure 1.

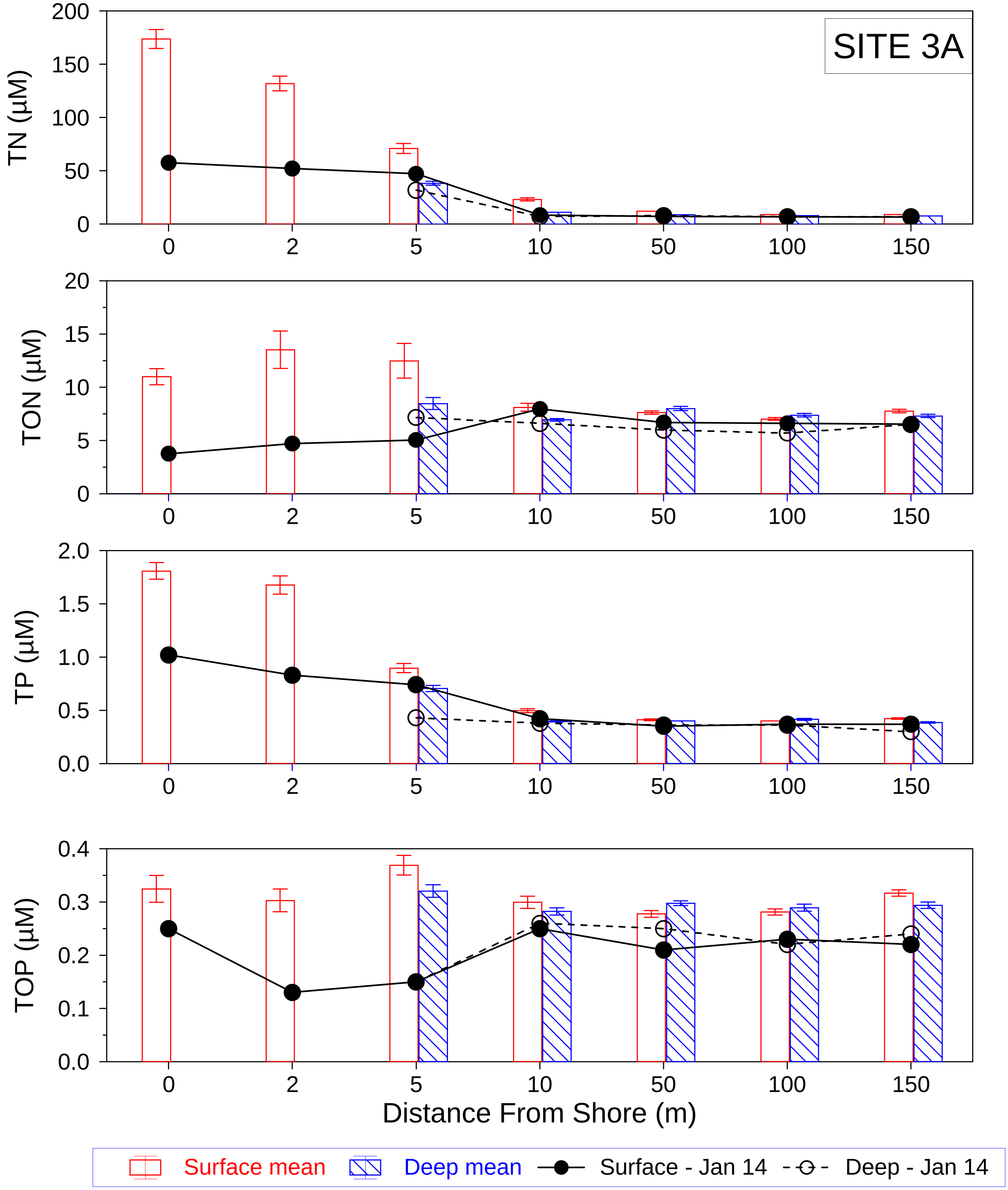


FIGURE 17. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3A, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since June 2007 (N=12). Error bars represent standard error of the mean. For site location, see Figure 1.

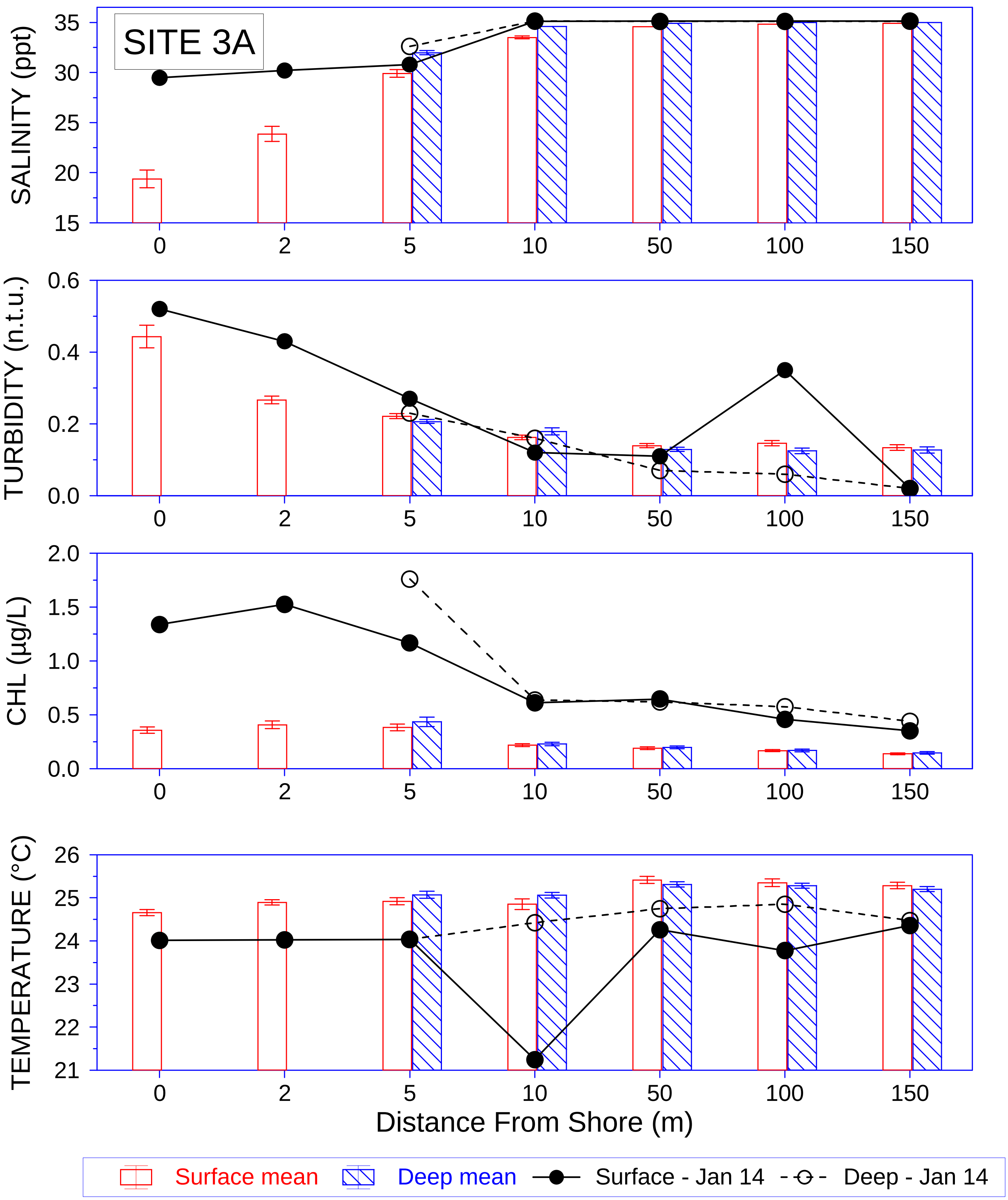


FIGURE 18. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3A, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since June 2007 (N=12). Error bars represent standard error of the mean. For site location, see Figure 1.

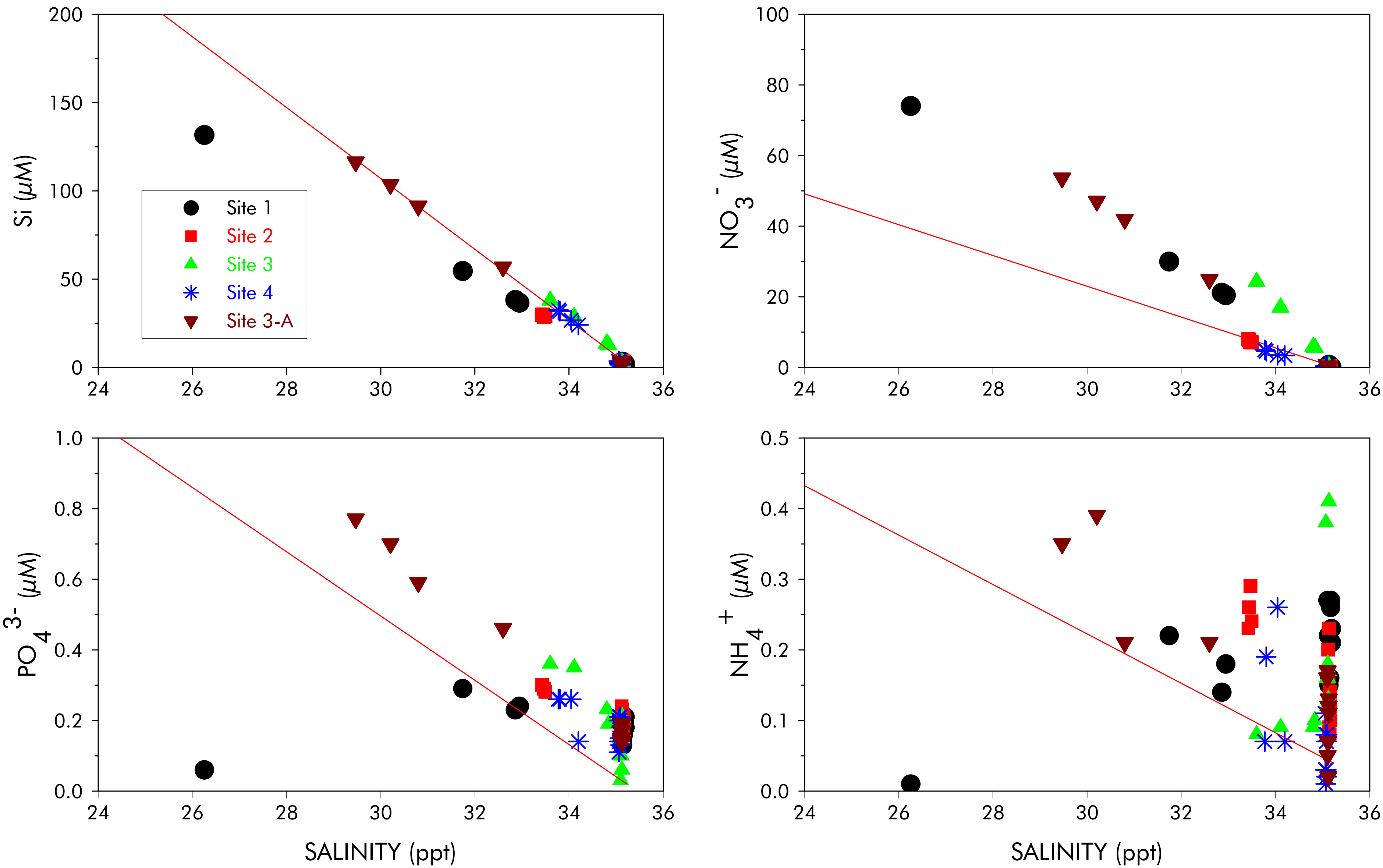
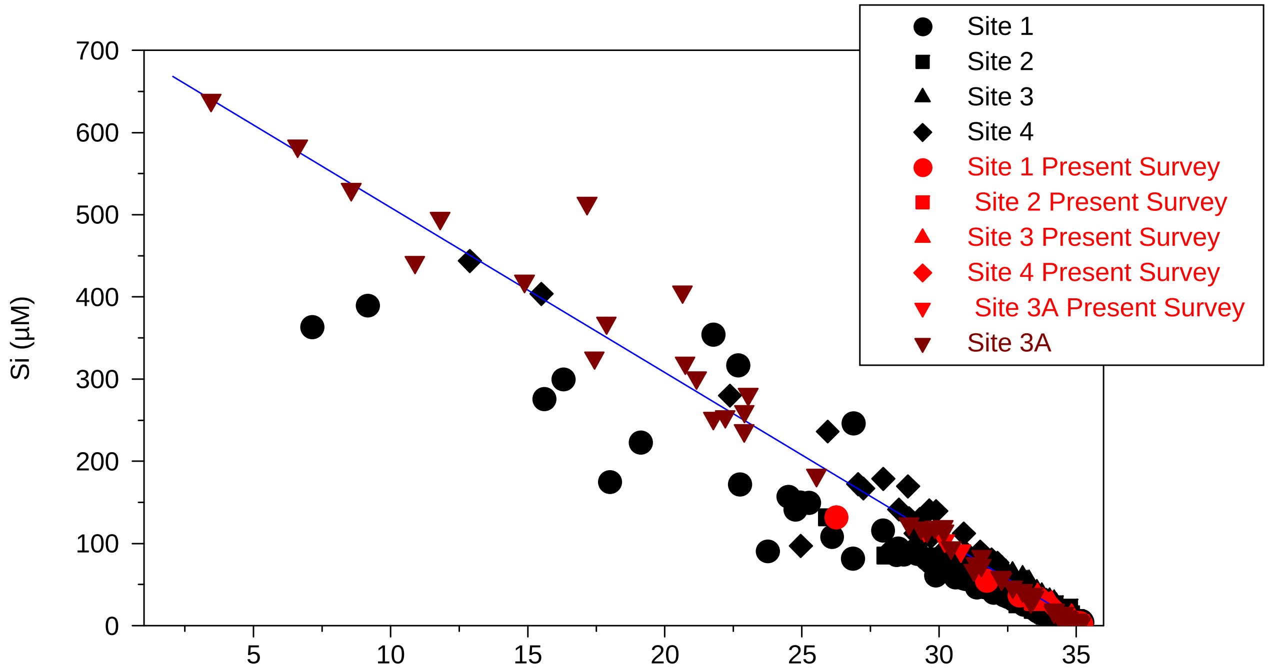


FIGURE 19. Mixing diagram showing concentration of dissolved nutrients from samples collected offshore of the Makena Resort on January 5, 2014 as functions of salinity. Solid red line in each plot is conservative mixing line constructed by connecting the concentrations in open coastal water with water from an irrigation well upslope of the Makena Golf Courses. For sampling site locations, see Figure 1.



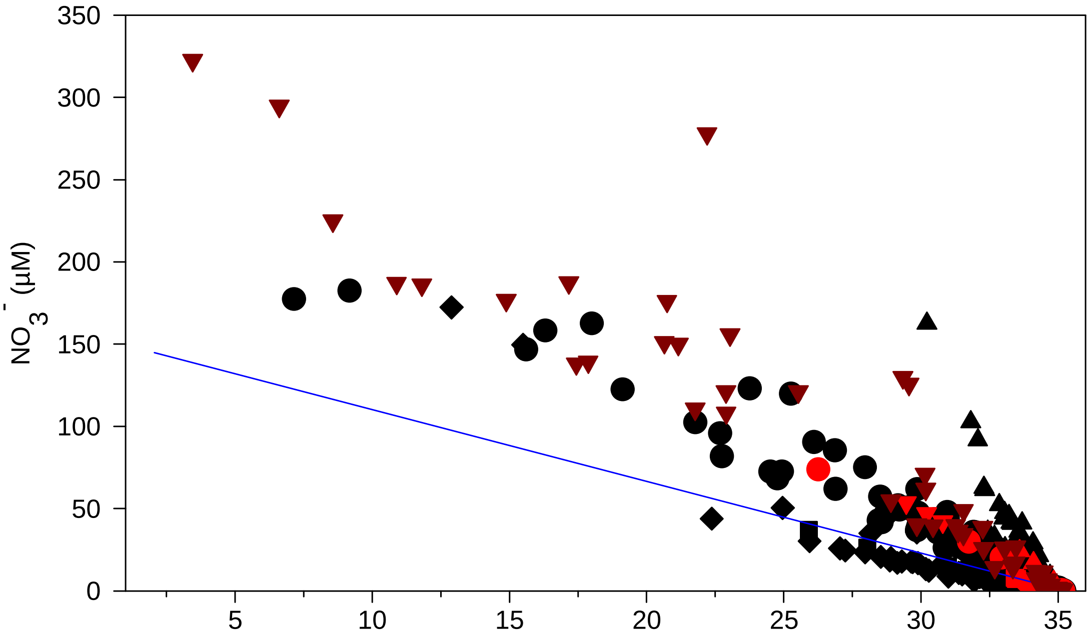
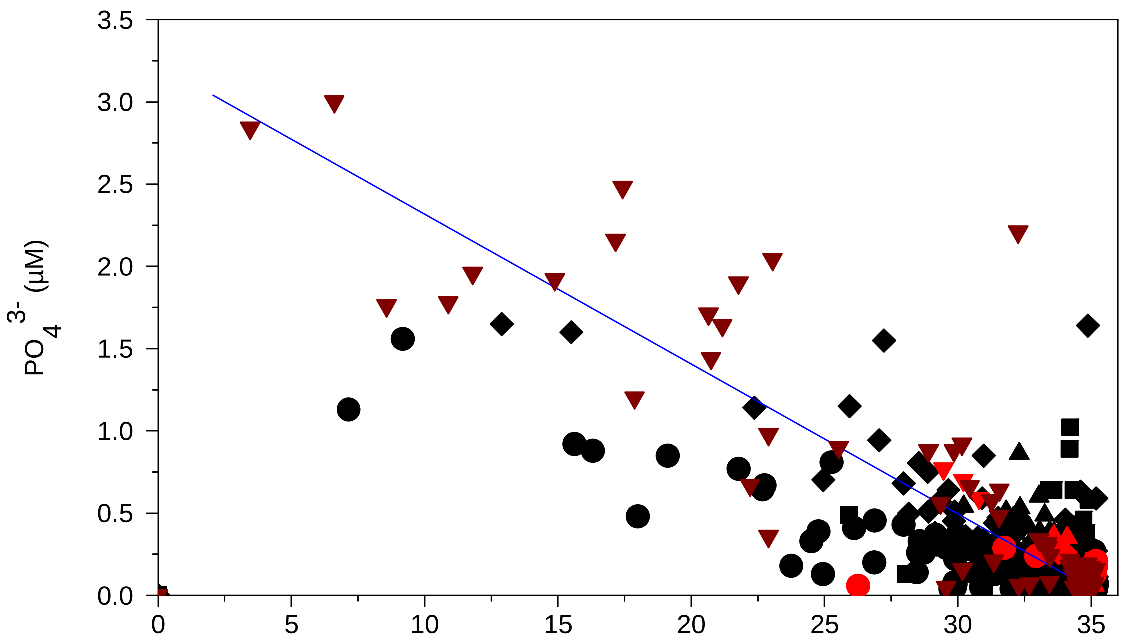


FIGURE 20. Silicate and nitrate, plotted as a function of salinity for surface samples collected since August 1995 at four sites offshore of the Makena Golf Course. Black symbols represent combined data from surveys conducted between August 1995 and May 2013. Brown symbols represent data from surveys at Site 3A commencing in June 2007. Red symbols are data from most recent survey. Solid blue line in each plot is conservative mixing line constructed by connecting the concentrations in open coastal water with water from golf course irrigation well #4. For sampling site locations, see Figure 1.



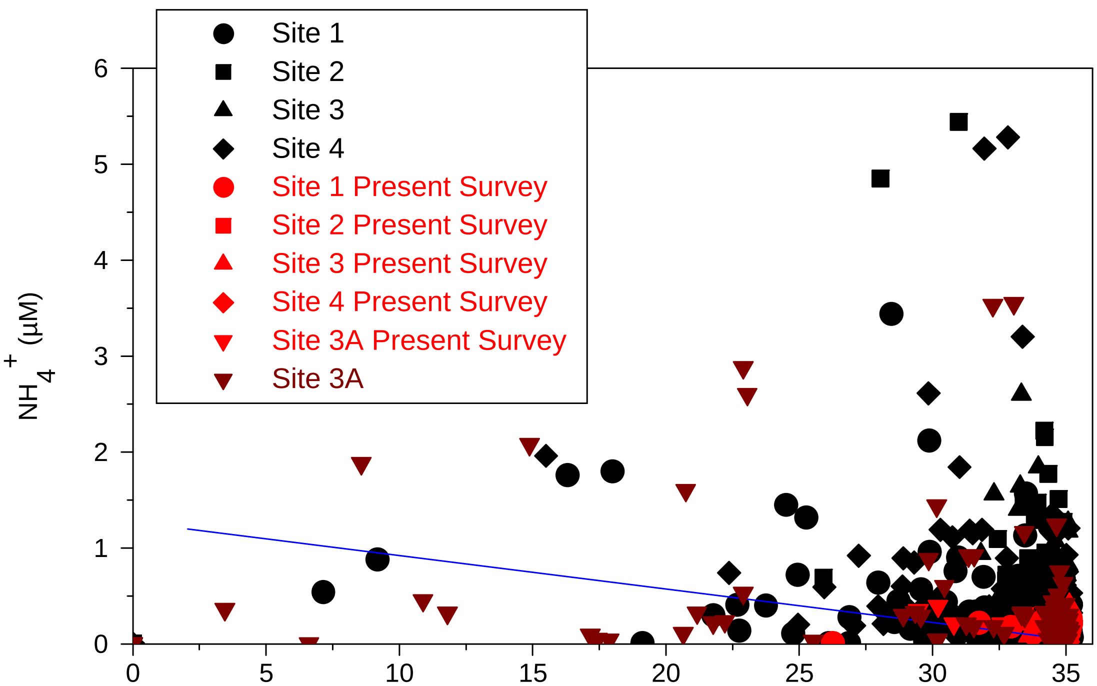


FIGURE 21. Phosphate and ammonium, plotted as a function of salinity for surface samples collected since August 1995 at four sites offshore of the Makena Golf Course. Black symbols represent combined data from surveys conducted between August 1995 and May 2013. Brown symbols represent data from surveys at Site 3A commencing in June 2007. Red symbols are data from the most recent survey. Solid blue line in each plot is conservative mixing line constructed by connecting the concentrations in open coastal water with water from golf course irrigation well #4. For sampling site locations, see Figure 1.

TABLE 6. Linear regression statistics (y-intercept and slope) of concentrations of silica as functions of salinity from four ocean transect sites off of the Makena Resort collected during monitoring surveys from 1995 to January 2014 (Transect Site 3 has been monitored since 2002; Trasect Site 3A since 2007). Also shown are standard errors and upper and lower 95% confidence limits around the y-intercepts and slopes."REGSLOPE" indicates regression statistics for slope of yearly coefficients as a function of time. For location of transect sites, see Figure 1.

SILICA -Y-INTERCEPT

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 1				
1995	522.34	12.18	491.03	553.66
1996	629.56	11.05	605.49	653.64
1997	504.17	2.83	496.89	511.46
1998	484.14	2.44	477.86	490.41
1999	479.11	9.89	457.55	500.66
2000	528.68	5.87	513.58	543.77
2001	625.85	10.91	597.82	653.88
2002	502.98	8.68	480.66	525.30
2003	625.85	10.91	597.82	653.88
2004	546.00	8.33	527.84	564.16
2005	466.59	11.09	442.42	490.75
2006	487.68	24.60	434.08	541.28
2007	491.19	34.99	414.95	567.42
2008	371.80	16.96	334.85	408.75
2009	457.28	10.01	431.54	483.02
2010	515.27	7.85	495.09	535.45
2011	464.80	5.70	452.37	477.22
2012	940.29	48.49	815.64	1064.94
2013	486.60	5.46	474.70	498.50
2014	515.44	5.37	501.64	529.24
Regslope	0.87	4.54	-8.67	10.40

SILICA -Y-INTERCEPT

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 2				
1995	468.41	85.54	248.51	688.30
1996	549.09	177.83	164.91	933.28
1997	567.57	9.71	543.80	591.33
1998	563.20	37.23	472.10	654.30
1999	466.74	95.75	261.37	672.11
2000	770.15	27.32	703.31	837.00
2001	1254.31	74.17	1072.82	1435.81
2002	577.53	29.40	505.60	649.46
2003	505.05	20.10	461.94	548.15
2004	565.31	93.71	364.33	766.29
2005	339.08	33.78	266.64	411.52
2006	553.48	62.93	418.51	688.45
2007	443.05	17.15	406.27	479.84
2008	402.41	73.66	244.42	560.41
2009	501.76	9.02	479.69	523.82
2010	490.17	22.77	434.46	545.87
2011	501.35	17.35	464.13	538.56
2012	411.67	48.31	293.48	529.87
2013	495.00	16.53	459.56	530.45
2014	555.71	5.39	542.52	568.89
Regslope	-8.48	7.21	-23.62	6.66

SILICA -Y-INTERCEPT

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 3A				
2007	714.10	5.58	701.94	726.27
2008	805.12	9.00	785.52	824.73
2009	646.37	7.80	626.32	666.43
2010	750.91	5.70	736.26	765.56
2011	715.44	5.06	704.42	726.45
2012	1005.34	28.55	931.95	1078.73
2013	651.22	3.75	643.05	659.40
2014	719.70	4.65	707.74	731.65
Regslope	3.70	19.06	-42.94	50.34
SITE 3				
2002	931.92	27.54	861.13	1002.71
2003	984.76	41.58	894.16	1075.35
2004	632.75	127.62	354.68	910.82
2005	704.38	52.31	590.40	818.35
2006	928.22	64.18	788.40	1068.05
2007	722.80	15.07	689.97	755.63
2008	1058.06	48.59	952.18	1163.94
2009	943.91	40.06	840.94	1046.89
2010	962.57	74.39	771.34	1153.79
2011	880.51	26.78	822.17	938.85
2012	792.34	42.16	683.97	900.71
2013	840.08	7.86	822.95	857.22
2014	847.10	40.22	743.71	950.48
Regslope	1.23	9.53	-19.75	22.22

SILICA -Y-INTERCEPT

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 4				
1995	710.45	8.83	687.74	733.15
1996	917.33	13.38	888.18	946.47
1997	776.74	3.53	767.66	785.82
1998	841.35	6.75	824.00	858.70
1999	823.63	24.78	769.63	877.62
2000	946.97	12.51	914.80	979.14
2001	1403.91	260.13	735.22	2072.61
2002	767.85	4.37	756.63	779.08
2003	854.37	29.88	789.26	919.48
2004	843.49	37.55	761.67	925.31
2005	703.97	14.00	673.47	734.46
2006	735.05	14.01	704.53	765.57
2007	710.11	7.14	694.56	725.66
2008	712.32	18.22	672.63	752.01
2009	715.30	7.99	694.75	735.84
2010	673.09	6.27	656.98	689.21
2011	688.21	7.10	672.74	703.68
2012	353.00	29.28	277.74	428.26
2013	642.86	7.88	625.69	660.03
2014	818.28	10.73	790.70	845.87
Regslope	-15.29	6.75	-29.46	-1.12

SILICA - SLOPE

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 1				
1995	-15.08	0.38	-16.05	-14.12
1996	-18.05	0.32	-18.75	-17.34
1997	-14.43	0.08	-14.65	-14.21
1998	-13.83	0.07	-14.02	-13.64
1999	-13.63	0.29	-14.27	-12.99
2000	-15.08	0.18	-15.54	-14.62
2001	-17.76	0.32	-18.57	-16.94
2002	-14.38	0.26	-15.05	-13.72
2003	-17.76	0.32	-18.57	-16.94
2004	-15.68	0.25	-16.23	-15.14
2005	-13.31	0.33	-14.02	-12.61
2006	-13.88	0.76	-15.53	-12.23
2007	-14.11	1.14	-16.59	-11.62
2008	-10.46	0.52	-11.59	-9.33
2009	-12.98	0.30	-13.76	-12.20
2010	-14.78	0.28	-15.49	-14.06
2011	-13.13	0.18	-13.52	-12.74
2012	-26.98	1.61	-31.13	-22.84
2013	-13.72	0.16	-14.07	-13.37
2013	-14.58	0.16	-14.99	-14.16
Regslope	-0.02	0.13	-0.29	0.26

SILICA - SLOPE

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 2				
1995	-13.47	2.51	-19.93	-7.00
1996	-15.62	5.15	-26.75	-4.49
1997	-16.26	0.29	-16.96	-15.56
1998	-16.11	1.08	-18.76	-13.45
1999	-13.21	2.78	-19.18	-7.23
2000	-22.06	0.80	-24.02	-20.11
2001	-35.68	2.12	-40.87	-30.49
2002	-16.54	0.86	-18.64	-14.44
2003	-14.37	0.59	-15.63	-13.11
2004	-16.23	2.73	-22.09	-10.38
2005	-9.61	0.98	-11.70	-7.52
2006	-15.82	1.83	-19.75	-11.89
2007	-12.54	0.51	-13.64	-11.45
2008	-11.41	2.14	-15.99	-6.83
2009	-14.32	0.27	-14.98	-13.66
2010	-13.97	0.67	-15.61	-12.33
2011	-14.24	0.50	-15.31	-13.16
2012	-11.62	1.41	-15.06	-8.18
2013	-13.97	0.48	-14.99	-12.95
2013	-15.74	0.16	-16.12	-15.35
Regslope	0.25	0.21	-0.18	0.68

SILICA - SLOPE

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 3A				
2007	-20.35	0.19	-20.75	-19.94
2008	-22.96	0.28	-23.57	-22.36
2009	-18.28	0.26	-18.96	-17.61
2010	-21.44	0.19	-21.94	-20.94
2011	-20.35	0.17	-20.72	-19.99
2012	-29.01	0.94	-31.44	-26.59
2013	-18.41	0.12	-18.66	-18.16
2013	-20.43	0.14	-20.79	-20.07
Regslope	-0.11	0.57	-1.50	1.29

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 3				
2002	-26.75	0.81	-28.83	-24.68
2003	-28.10	1.21	-30.73	-25.47
2004	-18.19	3.69	-26.24	-10.14
2005	-20.11	1.51	-23.40	-16.83
2006	-26.56	1.89	-30.67	-22.46
2007	-20.60	0.44	-21.56	-19.63
2008	-30.22	1.41	-33.29	-27.14
2009	-26.90	1.17	-29.90	-23.91
2010	-27.56	2.19	-33.18	-21.93
2011	-25.06	0.77	-26.74	-23.37
2012	-22.57	1.24	-25.75	-19.39
2013	-23.79	0.23	-24.29	-23.29
2013	-24.04	1.16	-27.02	-21.06
Regslope	-0.02	0.27	-0.62	0.58

SILICA - SLOPE

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 4				
1995	-20.55	0.27	-21.25	-19.85
1996	-26.23	0.40	-27.10	-25.37
1997	-22.27	0.11	-22.55	-21.99
1998	-24.07	0.20	-24.58	-23.56
1999	-23.50	0.73	-25.10	-21.90
2000	-27.12	0.37	-28.08	-26.16
2001	-39.92	7.42	-58.99	-20.86
2002	-21.99	0.13	-22.34	-21.65
2003	-24.36	0.91	-26.34	-22.39
2004	-24.27	1.10	-26.66	-21.88
2005	-20.11	0.41	-21.00	-19.22
2006	-20.96	0.41	-21.86	-20.06
2007	-20.27	0.23	-20.77	-19.78
2008	-20.33	0.53	-21.49	-19.17
2009	-20.34	0.24	-20.95	-19.73
2010	-19.14	0.19	-19.62	-18.66
2011	-19.57	0.21	-20.03	-19.11
2012	-9.86	0.90	-12.17	-7.54
2013	-18.19	0.23	-18.69	-17.70
2013	-23.26	0.31	-24.06	-22.46
Regslope	0.45	0.19	0.05	0.85

TABLE 7. Linear regression statistics (y-intercept and slope) of concentrations of nitrate as functions of salinity from four ocean transect sites off of the Makena Resort collected during monitoring surveys from 1995 to January 2014(Transect Site 3 has been monitored since 2002; Trasect Site 3A since 2007). Also shown are standard errors and upper and lower 95% confidence limits around the y-intercepts and slopes. "REGSLOPE" indicates regression statistics for slope of yearly coefficients as a function of time. For location of transect sites, see Figure 1.

NITRATE -Y-INTERCEPT

YEAR	*Coefficients*	*Std Err*	*Lower 95%*	*Upper 95%*
SITE 1				
1995	326.50	7.10	308.25	344.75
1996	336.49	4.62	326.41	346.56
1997	406.96	1.93	402.00	411.93
1998	268.90	1.55	264.91	272.89
1999	225.24	5.32	213.66	236.83
2000	309.77	3.36	301.14	318.41
2001	336.53	9.69	311.61	361.44
2002	278.21	17.43	233.40	323.03
2003	421.29	7.81	404.28	438.30
2004	442.33	4.89	431.68	452.99
2005	296.36	7.44	280.16	312.56
2006	361.76	7.20	346.08	377.45
2007	305.06	15.88	270.45	339.67
2008	330.95	7.18	315.29	346.60
2009	231.91	3.07	224.01	239.81
2010	253.63	4.57	241.88	265.38
2011	235.52	6.82	220.66	250.37
2012	272.66	0.94	270.26	275.07
2013	232.39	1.37	229.40	235.37
2014	292.86	3.49	283.90	301.82
REGSLOPE	-4.12	2.34	-9.03	0.79

NITRATE -Y-INTERCEPT

YEAR	*Coefficients*	*Std Err*	*Lower 95%*	*Upper 95%*
SITE 2				
1995	119.87	12.03	88.95	150.79
1996	106.36	18.44	66.53	146.19
1997	193.75	5.64	179.95	207.55
1998	166.93	5.33	153.89	179.97
1999	116.21	14.04	86.10	146.32
2000	142.07	2.83	135.13	149.01
2001	154.93	7.65	136.21	173.64
2002	180.82	58.78	36.98	324.66
2003	163.36	6.31	149.82	176.91
2004	145.36	10.55	122.74	167.99
2005	102.66	9.11	83.13	122.19
2006	124.74	4.89	114.26	135.22
2007	134.27	3.25	127.30	141.24
2008	108.01	12.87	80.41	135.61
2009	142.21	9.04	120.08	164.34
2010	135.27	10.49	109.60	160.94
2011	166.23	6.33	152.64	179.81
2012	180.39	4.91	168.38	192.41
2013	135.18	3.15	128.41	141.94
2014	151.91	2.85	144.94	158.87
REGSLOPE	0.29	1.05	-1.91	2.48

NITRATE -Y-INTERCEPT

YEAR	*Coefficients*	*Std Err*	*Lower 95%*	*Upper 95%*
SITE 3A				
2007	354.33	49.92	245.56	463.11
2008	448.07	7.75	431.19	464.95
2009	283.99	14.63	246.38	321.60
2010	283.25	1.86	278.48	288.02
2011	364.51	5.48	352.58	376.45
2012	369.69	1.88	364.84	374.53
2013	281.00	3.14	274.17	287.83
2014	334.97	1.65	330.73	339.20
REGSLOPE	-7.53	9.10	-29.79	14.73
SITE 3				
2002	847.45	52.35	712.88	982.01
2003	693.24	39.54	607.10	779.38
2004	463.72	90.73	266.04	661.40
2005	535.53	47.19	432.72	638.34
2006	856.96	48.22	751.91	962.02
2007	1233.34	18.23	1193.63	1273.06
2008	899.91	41.92	808.57	991.25
2009	827.18	19.10	778.08	876.29
2010	924.44	35.54	833.09	1015.80
2011	936.86	87.11	747.07	1126.65
2012	527.25	5.85	512.22	542.28
2013	444.28	6.57	429.97	458.60
2014	561.79	11.23	532.91	590.66
REGSLOPE	-9.74	17.89	-49.11	29.64

NITRATE -Y-INTERCEPT

SITE 4				
1995	111.38	6.47	94.74	128.02
1996	118.34	1.63	114.79	121.89
1997	122.56	1.29	119.25	125.88
1998	112.77	1.87	107.97	117.57
1999	109.13	3.30	101.94	116.33
2000	118.51	0.75	116.58	120.43
2001	100.93	54.85	-40.08	241.94
2002	118.91	3.25	110.56	127.25
2003	113.78	2.76	107.77	119.79
2004	134.97	4.64	124.86	145.07
2005	114.59	4.47	104.85	124.33
2006	119.85	1.76	116.03	123.68
2007	269.24	10.13	247.16	291.32
2008	62.93	4.05	54.11	71.74
2009	107.17	1.51	103.30	111.04
2010	148.96	16.96	105.35	192.57
2011	126.90	2.74	120.94	132.87
2012	178.94	1.78	174.38	183.51
2013	40.48	3.63	32.58	48.39
2014	124.13	4.06	113.69	134.56
REGSLOPE	0.58	1.76	-3.11	4.27

NITRATE - SLOPE

YEAR	*Coefficients*	*Std Err*	*Lower 95%*	*Upper 95%*
SITE 1				
1995	-9.49	0.22	-10.05	-8.92
1996	-9.67	0.14	-9.97	-9.38
1997	-11.70	0.06	-11.85	-11.55
1998	-7.72	0.05	-7.84	-7.60
1999	-6.44	0.16	-6.79	-6.10
2000	-8.91	0.10	-9.17	-8.65
2001	-9.60	0.28	-10.32	-8.88
2002	-7.99	0.52	-9.31	-6.66
2003	-12.09	0.23	-12.60	-11.58
2004	-12.74	0.15	-13.06	-12.42
2005	-8.48	0.22	-8.96	-8.01
2006	-10.40	0.22	-10.89	-9.92
2007	-8.73	0.52	-9.86	-7.60
2008	-9.52	0.22	-10.00	-9.05
2009	-6.65	0.09	-6.89	-6.41
2010	-7.31	0.16	-7.72	-6.89
2011	-6.66	0.21	-7.12	-6.19
2012	-7.81	0.03	-7.89	-7.73
2013	-6.59	0.04	-6.68	-6.50
2013	-8.31	0.10	-8.58	-8.04
REGSLOPE	0.12	0.07	-0.02	0.27

NITRATE - SLOPE

YEAR	*Coefficients*	*Std Err*	*Lower 95%*	*Upper 95%*
SITE 2				
1995	-3.47	0.35	-4.38	-2.56
1996	-3.05	0.53	-4.20	-1.89
1997	-5.57	0.17	-5.97	-5.16
1998	-4.79	0.16	-5.17	-4.41
1999	-3.31	0.41	-4.19	-2.43
2000	-4.08	0.08	-4.29	-3.88
2001	-4.41	0.22	-4.95	-3.88
2002	-5.19	1.72	-9.40	-0.99
2003	-4.68	0.18	-5.07	-4.28
2004	-4.19	0.31	-4.84	-3.53
2005	-2.94	0.26	-3.50	-2.37
2006	-3.57	0.14	-3.88	-3.27
2007	-3.85	0.10	-4.06	-3.64
2008	-3.09	0.37	-3.89	-2.29
2009	-4.10	0.27	-4.76	-3.43
2010	-3.88	0.31	-4.64	-3.13
2011	-4.74	0.18	-5.14	-4.35
2012	-5.16	0.14	-5.51	-4.81
2013	-3.84	0.09	-4.03	-3.64
2013	-4.32	0.08	-4.52	-4.12
REGSLOPE	-0.01	0.03	-0.07	0.06

NITRATE - SLOPE

YEAR	*Coefficients*	*Std Err*	*Lower 95%*	*Upper 95%*
SITE 3A				
2007	-9.57	1.67	-13.20	-5.93
2008	-12.81	0.24	-13.33	-12.29
2009	-7.98	0.49	-9.25	-6.72
2010	-8.15	0.06	-8.32	-7.99
2011	-10.31	0.18	-10.71	-9.92
2012	-10.60	0.06	-10.76	-10.44
2013	-7.97	0.10	-8.18	-7.76
2013	-9.53	0.05	-9.66	-9.40
REGSLOPE	0.17	0.27	-0.48	0.82
SiTE 3				
2002	-24.49	1.53	-28.43	-20.56
2003	-19.86	1.15	-22.36	-17.35
2004	-13.37	2.63	-19.09	-7.64
2005	-15.33	1.36	-18.29	-12.37
2006	-24.61	1.42	-27.70	-21.52
2007	-35.51	0.54	-36.68	-34.34
2008	-25.78	1.22	-28.43	-23.12
2009	-23.65	0.56	-25.08	-22.22
2010	-26.57	1.05	-29.26	-23.88
2011	-26.75	2.51	-32.22	-21.28
2012	-15.09	0.17	-15.53	-14.65
2013	-12.62	0.19	-13.03	-12.20
2013	-15.99	0.32	-16.82	-15.15
REGSLOPE	0.30	0.52	-0.84	1.43

NITRATE - SLOPE

YEAR	*Coefficients*	*Std Err*	*Lower 95%*	*Upper 95%*
SITE 4				
1995	-3.26	0.20	-3.77	-2.75
1996	-3.40	0.05	-3.50	-3.29
1997	-3.53	0.04	-3.63	-3.43
1998	-3.24	0.05	-3.38	-3.10
1999	-3.13	0.10	-3.34	-2.92
2000	-3.40	0.02	-3.46	-3.34
2001	-2.87	1.56	-6.89	1.15
2002	-3.44	0.10	-3.70	-3.19
2003	-3.28	0.08	-3.46	-3.09
2004	-3.89	0.14	-4.18	-3.59
2005	-3.29	0.13	-3.57	-3.00
2006	-3.43	0.05	-3.54	-3.31
2007	-7.87	0.32	-8.58	-7.17
2008	-1.79	0.12	-2.05	-1.54
2009	-3.07	0.04	-3.18	-2.95
2010	-4.30	0.50	-5.60	-3.00
2011	-3.62	0.08	-3.79	-3.44
2012	-5.13	0.05	-5.27	-4.99
2013	-1.14	0.10	-1.37	-0.91
2013	-3.54	0.12	-3.84	-3.23
REGSLOPE	-0.02	0.05	-0.12	0.09

TABLE 8. Linear regression statistics (y-intercept and slope) of concentrations of orthophosphate phosphorus as functions of salinity from four ocean transect sites off of the Makena Resort collected during monitoring surveys from 1995 to January 2014(Transect site 3 has been monitored since 2002; Trasect Site 3A since 2007). Also shown are standard errors and upper and lower 95% confidence limits around the y-intercepts and slopes. For location of transect sites, see Figure 1.

PHOSPHATE -Y-INTERCEPT

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 1				
1995	1.04	0.14	0.68	1.39
1996	1.78	0.12	1.52	2.03
1997	1.40	0.12	1.10	1.69
1998	1.10	0.06	0.95	1.25
1999	1.07	0.12	0.80	1.34
2000	0.89	0.12	0.59	1.19
2001	2.16	0.76	0.22	4.11
2002	1.12	0.68	-0.64	2.88
2003	0.48	0.19	0.06	0.90
2004	2.71	0.17	2.33	3.08
2005	-0.02	0.14	-0.34	0.29
2006	1.36	0.13	1.08	1.65
2007	1.07	0.20	0.64	1.50
2008	0.89	0.13	0.61	1.16
2009	0.87	0.38	-0.12	1.85
2010	1.86	0.18	1.40	2.31
2011	1.47	0.11	1.24	1.70
2012	1.65	0.08	1.45	1.86
2013	1.73	0.08	1.56	1.90
2014	-0.14	0.30	-0.91	0.64
REGSLOPE	-0.01	0.03	-0.07	0.05

PHOSPHATE -Y-INTERCEPT

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 2				
1995	0.15	0.63	-1.46	1.76
1996	2.03	1.59	-1.41	5.48
1997	3.70	0.25	3.10	4.31
1998	3.55	1.44	0.03	7.07
1999	3.68	5.55	-8.22	15.58
2000	12.78	1.18	9.89	15.66
2001	30.73	3.12	23.09	38.37
2002	6.67	1.68	2.57	10.77
2003	3.57	0.31	2.90	4.24
2004	5.76	0.53	4.62	6.91
2005	-0.95	2.96	-7.31	5.40
2006	1.88	0.57	0.67	3.10
2007	0.22	0.26	-0.34	0.78
2008	1.50	1.14	-0.95	3.95
2009	1.54	0.34	0.71	2.38
2010	1.70	1.31	-1.49	4.90
2011	2.46	0.37	1.66	3.26
2012	3.21	0.60	1.74	4.68
2013	2.12	0.57	0.90	3.34
2014	2.32	0.33	1.50	3.14
REGSLOPE	-0.26	0.27	-0.82	0.29

PHOSPHATE -Y-INTERCEPT

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 3A				
2007	2.39	0.24	1.86	2.93
2008	4.43	0.49	3.36	5.50
2009	2.60	0.15	2.21	2.99
2010	2.75	0.29	2.01	3.48
2011	3.42	0.41	2.53	4.31
2012	4.06	0.04	3.96	4.17
2013	4.76	0.07	4.61	4.91
2014	3.97	0.09	3.73	4.20
REGSLOPE	0.21	0.12	-0.09	0.51
SITE 3				
2002	4.62	2.31	-1.31	10.55
2003	7.38	0.99	5.24	9.53
2004	7.40	0.78	5.70	9.10
2005	3.17	0.53	2.03	4.32
2006	7.32	1.16	4.80	9.84
2007	4.46	0.46	3.47	5.45
2008	4.01	1.13	1.56	6.47
2009	3.12	2.67	-3.74	9.99
2010	6.25	2.27	0.41	12.09
2011	0.86	0.75	-0.79	2.50
2012	6.37	0.53	5.01	7.73
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2014	5.62	1.25	2.39	8.84
REGSLOPE	-0.12	0.15	-0.44	0.21

PHOSPHATE -Y-INTERCEPT

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 4				
1995	2.44	0.15	2.04	2.84
1996	3.08	0.13	2.79	3.37
1997	2.95	0.09	2.71	3.19
1998	3.50	0.46	2.32	4.67
1999	3.26	0.14	2.96	3.55
2000	3.29	0.20	2.77	3.82
2001	-19.16	22.66	-77.41	39.09
2002	3.98	0.15	3.60	4.35
2003	4.13	1.29	1.33	6.93
2004	4.75	0.79	3.04	6.47
2005	2.12	0.38	1.28	2.95
2006	2.15	0.40	1.28	3.02
2007	2.65	0.09	2.46	2.83
2008	2.98	0.67	1.52	4.44
2009	1.51	0.65	-0.16	3.19
2010	0.76	0.47	-0.46	1.97
2011	2.15	0.30	1.51	2.80
2012	2.06	0.07	1.87	2.25
2013	0.20	1.93	-4.02	4.41
2014	2.69	0.66	1.01	4.37
REGSLOPE	0.02	0.20	-0.40	0.43

PHOSPHATE - SLOPE

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 1				
1995	-0.03	0.00	-0.04	-0.02
1996	-0.05	0.00	-0.06	-0.04
1997	-0.04	0.00	-0.05	-0.03
1998	-0.03	0.00	-0.03	-0.02
1999	-0.03	0.00	-0.03	-0.02
2000	-0.02	0.00	-0.03	-0.01
2001	-0.06	0.02	-0.12	0.00
2002	-0.03	0.02	-0.08	0.02
2003	-0.01	0.01	-0.02	0.00
2004	-0.08	0.01	-0.09	-0.06
2005	0.00	0.00	-0.01	0.01
2006	-0.04	0.00	-0.04	-0.03
2007	-0.03	0.01	-0.04	-0.02
2008	-0.02	0.00	-0.03	-0.02
2009	-0.02	0.01	-0.05	0.01
2010	-0.05	0.01	-0.07	-0.04
2011	-0.04	0.00	-0.05	-0.03
2012	-0.04	0.00	-0.05	-0.04
2013	-0.05	0.00	-0.05	-0.04
2013	0.01	0.01	-0.01	0.03
REGSLOPE	0.00	0.00	0.00	0.00

PHOSPHATE - SLOPE

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 2				
1995	0.00	0.02	-0.05	0.04
1996	-0.06	0.05	-0.16	0.04
1997	-0.10	0.01	-0.12	-0.09
1998	-0.10	0.04	-0.20	0.00
1999	-0.10	0.16	-0.44	0.25
2000	-0.36	0.03	-0.45	-0.28
2001	-0.87	0.09	-1.09	-0.65
2002	-0.19	0.05	-0.31	-0.07
2003	-0.10	0.01	-0.12	-0.08
2004	-0.16	0.02	-0.20	-0.13
2005	0.03	0.09	-0.15	0.21
2006	-0.05	0.02	-0.09	-0.02
2007	0.00	0.01	-0.02	0.01
2008	-0.04	0.03	-0.11	0.03
2009	-0.04	0.01	-0.07	-0.02
2010	-0.05	0.04	-0.14	0.05
2011	-0.07	0.01	-0.09	-0.04
2012	-0.09	0.02	-0.13	-0.05
2013	-0.06	0.02	-0.09	-0.02
2013	-0.06	0.01	-0.08	-0.04
REGSLOPE	0.01	0.01	-0.01	0.02

PHOSPHATE - SLOPE

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 3A				
2007	-0.07	0.01	-0.09	-0.05
2008	-0.13	0.02	-0.16	-0.09
2009	-0.07	0.01	-0.09	-0.06
2010	-0.07	0.01	-0.10	-0.05
2011	-0.09	0.01	-0.12	-0.06
2012	-0.11	0.00	-0.12	-0.11
2013	-0.13	0.00	-0.14	-0.13
2013	-0.11	0.00	-0.12	-0.10
REGSLOPE	-0.01	0.00	-0.01	0.00
SITE 3				
2002	-0.13	0.07	-0.30	0.04
2003	-0.21	0.03	-0.27	-0.15
2004	-0.21	0.02	-0.26	-0.16
2005	-0.09	0.02	-0.12	-0.06
2006	-0.21	0.03	-0.28	-0.13
2007	-0.13	0.01	-0.16	-0.10
2008	-0.11	0.03	-0.18	-0.04
2009	-0.09	0.08	-0.29	0.11
2010	-0.18	0.07	-0.35	-0.01
2011	-0.02	0.02	-0.07	0.03
2012	-0.18	0.02	-0.22	-0.14
2013	-0.13	0.01	-0.15	-0.12
2013	-0.16	0.04	-0.25	-0.06
REGSLOPE	0.00	0.00	-0.01	0.01

PHOSPHATE - SLOPE

YEAR	Coefficients	Std Err	Lower 95%	Upper 95%
SITE 4				
1995	-0.07	0.00	-0.08	-0.06
1996	-0.09	0.00	-0.09	-0.08
1997	-0.08	0.00	-0.09	-0.07
1998	-0.10	0.01	-0.13	-0.06
1999	-0.09	0.00	-0.10	-0.08
2000	-0.09	0.01	-0.10	-0.07
2001	0.55	0.65	-1.11	2.21
2002	-0.11	0.00	-0.12	-0.10
2003	-0.11	0.04	-0.19	-0.02
2004	-0.13	0.02	-0.18	-0.08
2005	-0.06	0.01	-0.08	-0.03
2006	-0.06	0.01	-0.08	-0.03
2007	-0.07	0.00	-0.08	-0.07
2008	-0.08	0.02	-0.13	-0.04
2009	-0.04	0.02	-0.09	0.01
2010	-0.02	0.01	-0.06	0.02
2011	-0.06	0.01	-0.08	-0.04
2012	-0.05	0.00	-0.06	-0.05
2013	0.00	0.06	-0.12	0.12
2013	-0.07	0.02	-0.12	-0.02
REGSLOPE	0.00	0.01	-0.01	0.01

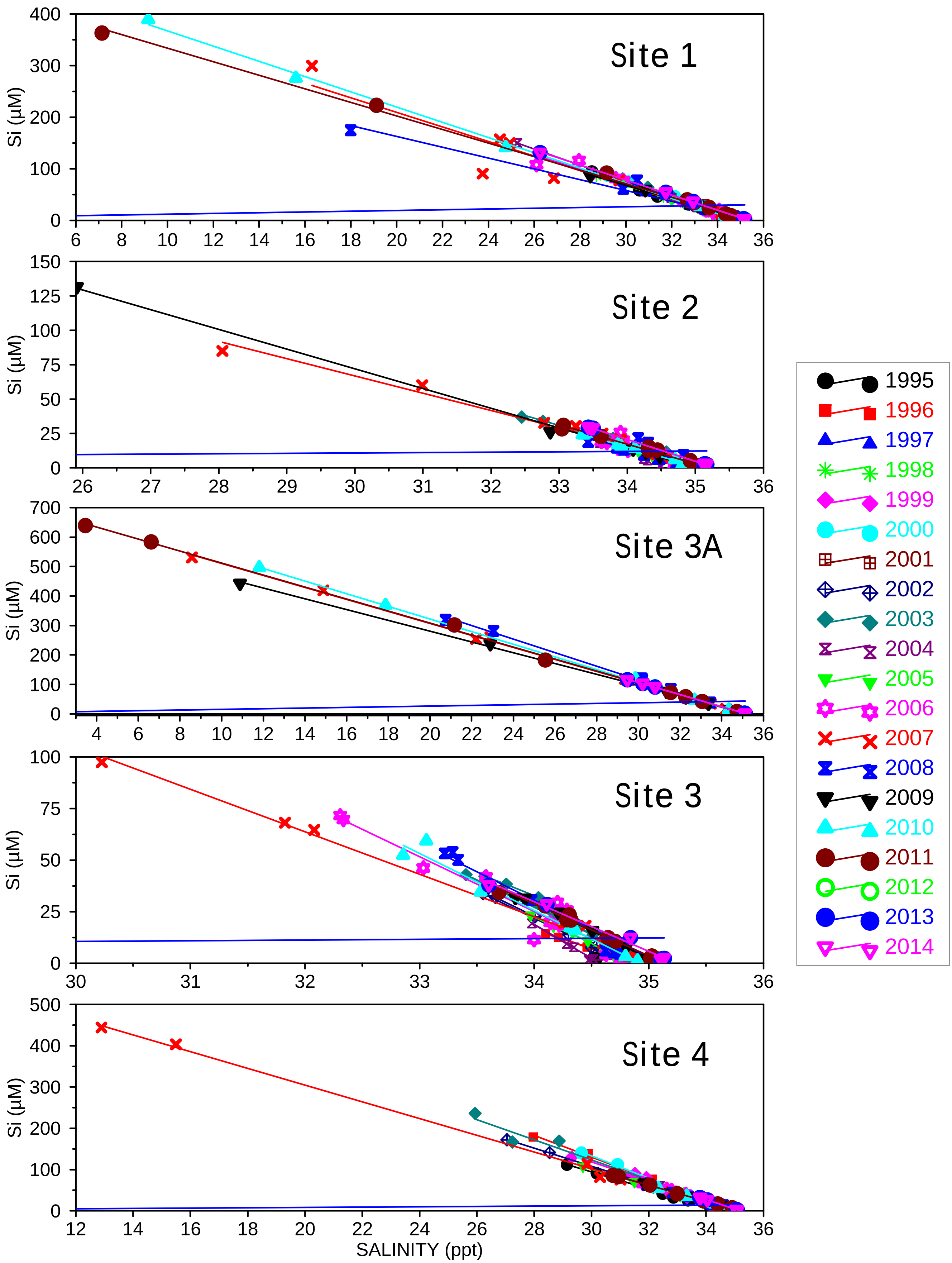


FIGURE 22. Mixing diagram showing yearly concentrations of silicate as functions of salinity from samples collected during annual monitoring surveys at five transect sites offshore of the Makena Resort (Site 3A since 2007). Note axis scale changes between sites. Straight lines are linear regressions through data points for each year. For sampling site locations, see Figure 1.

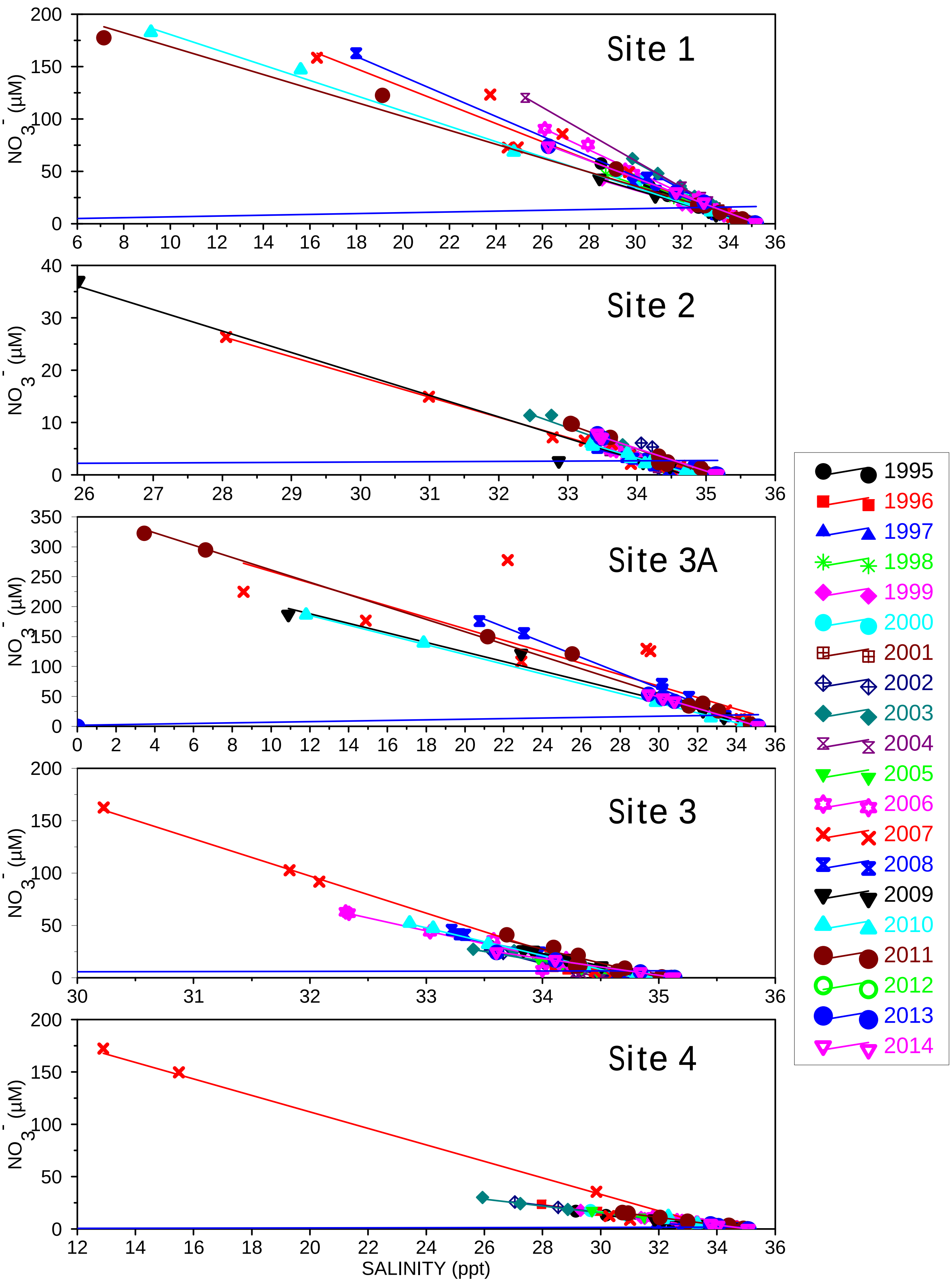


FIGURE 23. Mixing diagram showing yearly concentrations of nitrate as functions of salinity from samples collected during annual monitoring surveys at five transect sites offshore of the Makena Resort (Site 3A since 2007). Note axis scale changes between sites. Straight lines are linear regressions through data points for each year. For sampling site locations, see Figure 1.

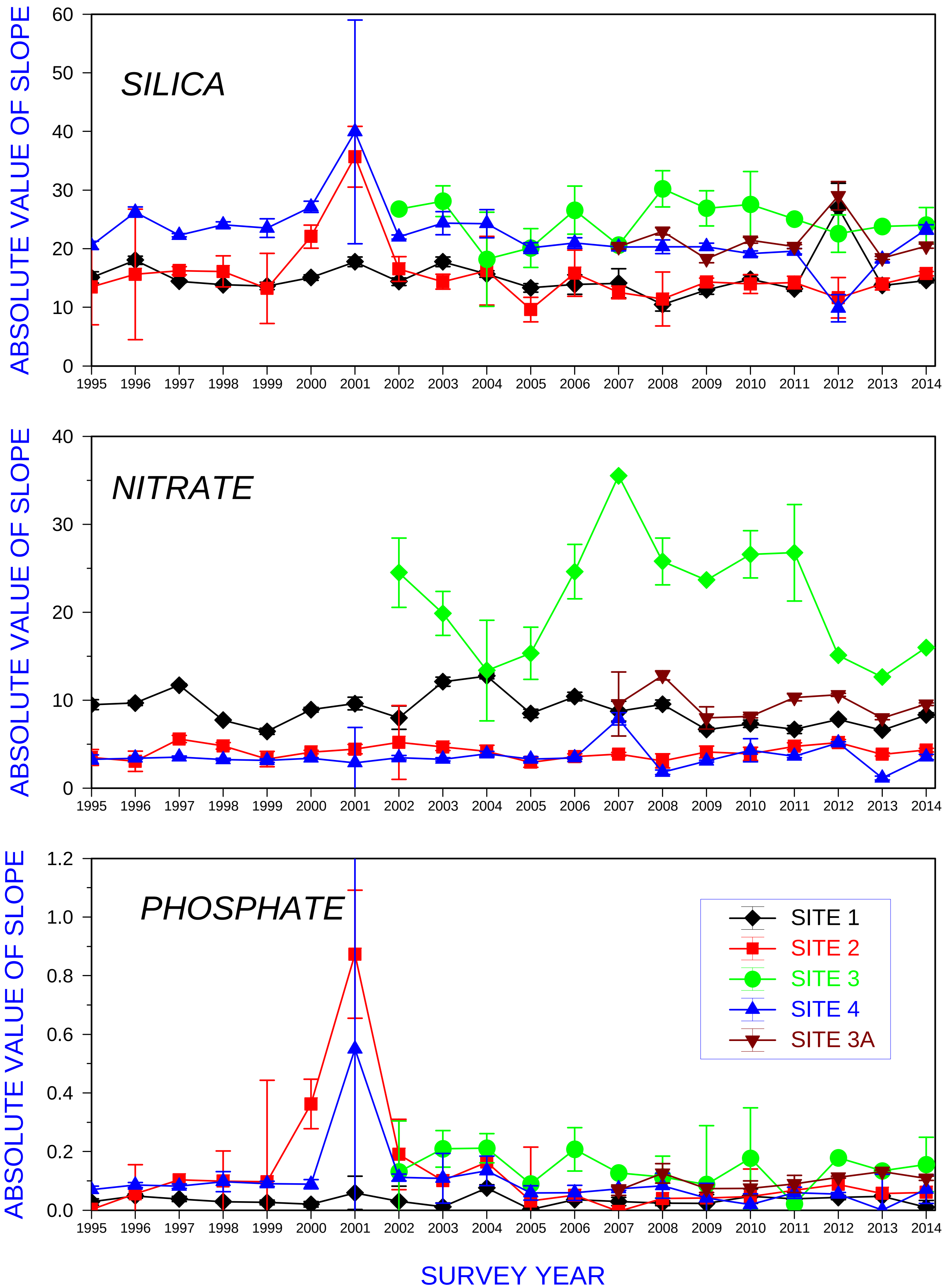


FIGURE 24. Time-course plots of absolute values of slopes of linear regressions of concentrations of silca, nitrate and phosphate as functions of salinity collected annually at each of the transect monitoring stations off the Makena Resort (Site 3A began in June 2007). Error bars are 95% confidence limits (Note error bar for Site 4 Phosphate is off scale). For locations of sampling transect sites, see Figure 1.

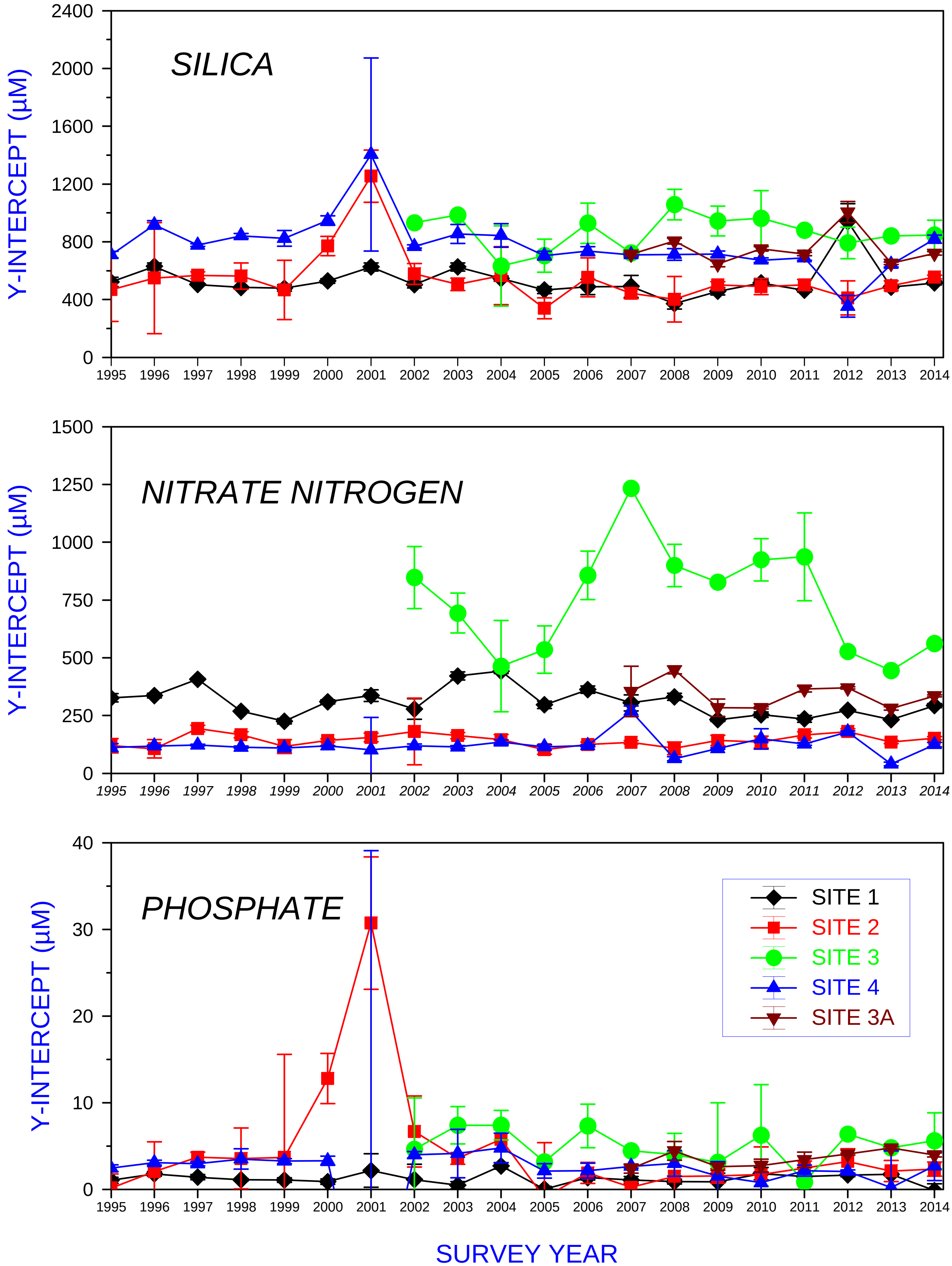


FIGURE 25. Time-course plots of Y-intercepts of linear regressions of concentrations of silca, nitrate and phosphorus as functions of salinity collected annually at each of the transect monitoring stations off the Makena Resort (Site 3A began in June 2007). Error bars are 95% confidence limits. For locations of sampling transect sites, see Figure 1.