HONUA LLC

March 26, 2008

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

Re: Tenth Annual Report for Land Use Commission (LUC) Docket No. A97-721
Makena Resort Corp.

Ladies and Gentlemen:

Pursuant to Condition 19 in the Decision and Order in the above-referenced docket matter, the following is submitted as the Tenth Annual Report on the status of this project.

As stated in the previous Annual Reports, Petitioner filed an application for change in zoning with the County of Maui affecting 603.303 acres of land in Makena, Maui, Hawai`i, including all of the 145.943 acres of the Petition Area. The majority of the change in zoning application included the zoning of approximately 437.085 acres of golf course into a new PK-4 zone that the County has established for golf courses. The change in zoning application was the subject of a public hearing before the Maui Planning Commission on July 25, 2000. Following the public hearing, the Maui Planning Commission voted to recommend to the Maui County Council approval of the change in zoning application subject to ten (10) conditions. The ten (10) conditions were set forth in Exhibit "A" attached to the Third Annual Report. On August 29, 2000, this recommendation by the Maui Planning Commission was sent to the Maui County Council. The application for change in zoning was subsequently referred to the Land Use Committee of the Maui County Council which held a meeting on the same on March 12, 2001, at which time further deliberation on the application was deferred pending the annual deliberations on the County budget. Following the budget deliberations, a review of the pending zoning application continued in June 2001, involving an additional eight (8) committee meetings before it was reported out to the full Council in December 2001. The Council then held a public hearing on January 24, 2002. Following the public hearing, the Council referred the application to its Land Use Committee and no additional meetings were held in 2002. The Land Use Committee referred the application to the newly elected 2003-2004 County Council and in January 2003, the Council referred the application to its new Planning and Land Use Committee. No meetings were held in 2003 by the Planning and Land Use Committee. The zoning application was reviewed by the Planning and Land Use Committee in March and April 2004. On April 14, 2004, the Planning and Land Use

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Committee recommended approval of the zoning application, subject to certain conditions. Petitioner had anticipated that the application would be reviewed by the County Council in June 2004, however, the review did not occur. By letter dated August 18, 2004, the Planning and Land Use Committee transmitted a draft bill on the change in zoning (with conditions) and requested that a Unilateral Agreement be executed. This letter was attached as Exhibit "A" to the Ninth Annual Report. A response dated September 17, 2004 was submitted to the Planning and Land Use Committee. This letter was attached as Exhibit "B" to the Ninth Annual Report. At the start of the subsequent County Council term (2005-2006), the application was referred to the new Land Use Committee. Although the Petitioner requested that the application be scheduled, no meetings were held in 2005 and 2006 by the Land Use Committee. These requests were submitted by letters dated January 11, 2005, September 19, 2005, January 12, 2006, February 7, 2006, and April 7, 2006. These letters were attached as Exhibits "C" through "G" to the Ninth Annual Report. At the start of this current County Council term (2007-2008), the application was referred to the Land Use Committee and remain pending with the Committee. The Land Use Committee did not review the application in 2007.

The following are the conditions set forth in the Decision and Order and 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: Petitioner will comply with this 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 lao aquifer.

Response: As set forth in detail in the 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. This letter was attached to said Second Annual Report.

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.

Petitioner has complied with this condition.

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: In 1976, 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. All necessary transmission lines to service the development at Makena has been developed by Petitioner. Petitioner shall continue to participate in the funding and construction of additional adequate storage and transmission facilities and improvements to accommodate the proposed project.

4. Petitioner shall participate in the funding and construction of adequate wastewater treatment, transmission and disposal facilities to accommodate the proposed project under such terms as are agreeable between Petitioner and the County of Maui.

Response: As set forth in detail in the Second Annual Report, Petitioner has commenced the construction of a wastewater system, comprising of collection lines, pump stations and wastewater reclamation plant at Makena. Construction commenced on February 10, 2000, and the entire wastewater reclamation system was completed and operable in October 2002.

Petitioner has complied with this condition.

5. 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: 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. A copy of said agreement was attached to the Third Annual Report.

Petitioner has complied with this condition.

6. 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: Petitioner will comply with this condition. Petitioner has had discussions with the State of Hawai`i and County of Maui civil defense agencies with regard to this condition. Both agencies have indicated to Petitioner that no civil defense measures are warranted for the property. A siren warning simulator for civil defense is installed in the 310-room Maui Prince Hotel security department which is manned 24 hours a day. For each new project in the development, Petitioner will contact the state and county civil defense agencies for their comments and requirements.

7. 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: Petitioner will comply with this condition.

8. 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: Petitioner will comply with this condition.

9. 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: Petitioner will comply with this condition.

10. 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: Since August 1995, Petitioner 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. Data analysis is submitted regularly to the State Department of Health (DOH).

The first 2007 report (Report 1-2007), dated September 15, 2007, attached as Exhibit "A" to this Tenth Annual Report was submitted to the Department of Health on December 12, 2007. The Department of Health reviewed and accepted the report on March 10, 2008. See Exhibit "A-1". The second 2007 report (Report 2-2007), dated February 22, 2008, attached as Exhibit "B" to this Tenth Annual Report was submitted to the Department of Health on March 15, 2008. The Department of Health review and acceptance is pending.

11. 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 further detail in the Second Annual Report, a TIAR was prepared and submitted for review by DOT and the County of Maui as part of the above-mentioned 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, Petitioner prepared and submitted a Makena Resort Master Traffic Study, dated June 6, 2003 (Revised September 14, 2003), which was submitted to the State Department of Transportation and County of Maui. This Master Traffic Study was attached as Exhibit "F" to the Sixth Annual Report. The County approved the study on September 26, 2003 as noted in Exhibit "G" attached to the Sixth Annual Report.

Petitioner has complied with this condition.

12. 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 prior to Petitioner acquiring county zoning or prior to Petitioner securing county building permits if county rezoning is not required.

Response: Following discussion with representatives of DOT relating to revisions to the TIAR as set forth in response to Condition No. 11 immediately above, on May 11, 2000, Petitioner filed Petitioner Makena Resort Corp.'s Motion for First Amendment to the Findings of Fact, Conclusions of Law and Decision and Order, filed on February 19, 1998 (D&O), requesting that this Condition No. 12 be amended. Said Motion was supported by the Affidavit of Roy Figueiroa, General Manager of then Petitioner. The County of Maui Planning Department filed a Response to Motion wherein it stated that it had no objections to the Motion. The Office of Planning (OP) filed a Response to Motion wherein it stated that DOT was satisfied by the fact that Petitioner had acknowledged responsibility for its pro rata share of the cost of the transportation improvements proposed in the Maui Long Range Land Transportation Plan for the Kihei-Makena region and that OP supported the position of DOT. Upon consideration of Petitioner's Motion, supporting affidavit, and the oral and written arguments presented by the parties, this Commission ordered that Condition No. 12 of the D&O, be amended as follows:

> "12. Petitioner shall participate in pro rata funding and the construction of local and regional transportation improvements and programs, including dedication of rights of way as determined by 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 two (2) years from June 1, 2000."

In complying with Condition No. 12, as amended, Petitioner has and continues to engage in discussions with the DOT relating to improvements to regional transportation infrastructure, specifically, with regard to the implementation of certain interim improvements to the State Piilani Highway from Mokulele Highway to Kilohana Drive. On July 16, 2001, Petitioner entered into an agreement with DOT to fund the planning and design of the restriping and other improvements to Piilani Highway to increase travel lanes from two (2) to four (4) lanes. As noted in the Fourth Annual Report, the planning and design work was ninety percent (90%) complete and the project was scheduled to begin construction in the summer 2002 and completed within one year. The improvements were completed in 2003.

As reported in the Second Annual Report, Petitioner continued in the development of the roadway and utility improvements to portions of Makena Alanui, Honoiki Street and Makena-Keoneoio Road, all within the Makena Resort. Construction commenced on January 10, 2000, and was completed in April, 2001.

On May 7, 2002, Petitioner filed a Motion for Second Amendment to the Findings of Fact, Conclusions of Law, and Decision and Order, filed on February 19, 1998 requesting that this Condition No. 12 be further amended. Said Motion was supported by the Affidavit of Roy Figueiroa, General Manager of then Petitioner. The County of Maui Planning Department filed a Response in Support of the Petitioner's Second Amendment on June 19, 2002. On June 20, 2002, the Motion came on hearing before this commission, with appearances by Petitioner, County and Office of Planning. Upon consideration of Petitioner's Motion, supporting affidavit, and the oral and written argument presented by the parties, this commission ordered that Condition No. 12 of the Amended Decision and Order dated February 19, 1998, be amended to impose a four-year agreement deadline from June 1, 2000, to read as follows:

> "12. 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 four (4) years from June 1, 2000."

On May 24, 2004, Petitioner filed a motion for third amendment to the Finding of Fact, Conclusions of Law, and Decision and Order requesting that Condition No. 12 be further amended to extend this agreement deadline beyond June 1, 2004. Said Motion was supported by the Affidavit of Roy Figueiroa, Vice-President of then Petitioner.

On June 4, 2004 the Motion came on hearing before this Commission with appearances by Petitioner, County of Maui, State Office of Planning and State Department of Transportation. The County of Maui stated no objections to Petitioner's request for an extension of time to satisfy Condition No. 12, however, questioned whether the two additional years would be an adequate amount of time to satisfy the condition. Upon consideration of Petitioner's Motion, supporting affidavit and written and oral argument presented by the parties, this Commission ordered that Condition No, 12 of the Amended Decision and Order dated February 19, 1998, be amended to read as follows:

> "12. 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 eight (8) years from June 1, 2000."

The Commission further ordered that the State Department of Transportation file written annual status reports detailing the status of the agreement between Petitioner and DOT as to the level of funding and other participation in constructing local and regional transportation improvements and programs.

Petitioner has met with the State Department of Transportation and has agreed to participate in design and construction of the four-lane widening of Piilani Highway from Kilohana Drive to Wailea Ike Drive.

Letters from the State Department of Transportation, dated September 12, 2007 and January 25, 2007, are attached as Exhibit "C" to this Tenth Annual Report.

13. 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 Hawaii and County of Maui agencies.

Response: As part of the proposed development described in Response No. 12 above and further described in the SMA use permit discussed in Response No. 12 as set forth in the Second Annual Report, Petitioner also proposed certain drainage improvements at the Makena Resort.

As reported in the Fifth Annual Report the Petitioner was preparing a Drainage Master Plan to be submitted to the County Department of Public Works and Environmental Management and Planning Department. The Master Plan was submitted on July 1, 2003 and approved by the County on August 20, 2003. Improvements to be designed and constructed will be in accordance with the approved Master Plan. Each new project will be consistent with the approved Master Plan.

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

Response: The Petition Areas shall be developed in accordance with Kihei-Makena Community Plan.

15. Petitioner shall obtain appropriate changes in zoning from the County of Maui for the Petition Areas.

Response: As stated previously, Petitioner has submitted a change in zoning application. The Council's Planning and Land Use Committee recommended approval of the application on April 14, 2004. It was anticipated that the application would be reviewed by the County Council in June 2004. However, this did not occur in 2004, as well as in 2005, 2006, and 2007. The change in zoning application is currently pending with the current Council's Land Use Committee.

16. 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: Petitioner will comply with this condition.

17. 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: Petitioner will comply with this condition.

18. 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: A July 11, 2000 letter from Eric T. Maehara, Esq., attached as Exhibit "H" to the Sixth Annual Report, notified the Commission of name changes to corporations holding property in the Petition Areas.

    By letter dated July 29, 2005, attached as Exhibit "D" to the Eighth Annual Report, Petitioner, through its attorney Christopher T. Kobayashi, notified the Commission of the sale of certain parcels of real property within the petition area to Keaka LLC, a Delaware limited liability company.

    By letter dated March 7, 2007, attached as Exhibit "K" to the Ninth Annual Report, Petitioner, through its attorney Burt T. Lau, notified the Commission of the intent to sell the remainder of the Makena Resort properties to Honua LLC, a Delaware limited liability company.

19. 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: This Tenth Annual Report complies with this condition.

20. 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: Petitioner will submit a timely motion to fully or partially release or amend the conditions upon compliance with the same.

21. Within seven (7) days of the issuance of the Commission's Decision and Order for the subject reclassification, Petitioner shall (a) record with the Bureau of Conveyances a statement that the Property is subject to conditions imposed herein by the Land Use Commission in the reclassification of the Property, and (b) shall file a copy of such recorded statement with the Commission.

    Response: Petitioner has complied with this condition.

22. Petitioner shall record the conditions imposed herein by the Commission with the Bureau of Conveyances pursuant to Section 15-15-92, Hawai`i Administrative Rules.

Response: Petitioner has complied with this condition.

If you have any questions or require any further information, please contact this office.

Very truly yours,

Don Fujimoto, Vice President
HONUA LLC

cc: State of Hawai`i, Office of Planning
County of Maui, Department of Planning

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MARINE WATER QUALITY MONITORING

MAKENA RESORT, MAKENA, MAUI

WATER CHEMISTRY

REPORT 1-2007

Prepared for

Dowling Company, Inc.

2005 Main St.

Wailuku, Maui, Hawaii 96793

By

Marine Research Consultants, Inc.

1039 Waakaua Pl.

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September 15, 2007

EXHIBIT "A"

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. Within the Resort are two 18-hole golf courses (North and South Courses), as well as a hotel 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, there are few, if any, effects that have been documented to be considered detrimental to the marine ecosystem. Thus, there is no *a priori* reason to suspect that the construction and responsible operation of the golf courses and other components of the Makena Resort will cause any harmful changes to the marine environment. Nevertheless, in the interest of assuring maintenance of environmental quality, and as a means of ensuring that proper procedures are set forth, a condition of the Land Use Commission District Boundary Amendment for the project was the implementation of an ongoing marine monitoring program off the Makena Resort Development. 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 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. These studies also fulfill 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. The following report presents the results of the nineteenth increment in the monitoring program, and contains data from water chemistry sampling conducted on June 29, 2007.

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 it was deemed appropriate to add an additional sampling location near the southern boundary of Maluaka Bay, downslope from the northern boundary of the Maluaka Residential project which had commenced construction at the time of the survey. 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 downslope from the northern boundary of the Maluaka Residential project. 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 large residences, and the southern boundary of the Maluaka project site. As a result, the new location represents an area that reflects the maximum influence on nearshore water quality from a variety of land uses.

All fieldwork for the present survey was conducted on June 29, 2007 using a 26-foot boat. Environmental conditions during sample collection consisted of mild winds (8-10 knots), sunny skies, and very little swell. Water samples were collected at stations along transects that extend from the highest wash of waves to approximately 125-200 meters (m) offshore at each 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 shoreline modification. 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) of the sea surface, and a bottom sample was collected within one m of the sea floor.

Water samples from the shoreline to a distance of 10 m offshore were collected by swimmers working from the boat. Water samples beyond 10 m from the shoreline were collected using a 1.8-liter Niskin-type oceanographic 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 transferred into a 1-liter polyethylene bottle until further processing. For nearshore samples within 10 m of the shoreline, water samples were collected in 1-liter polyethylene bottles by divers swimming to the shoreline from the boat.

Water samples were also collected from seven golf course irrigation wells (No's 1, 2, 3, 4, 5, 6, and 8) and one irrigation lakes on the same day as the ocean sampling. Samples were also collected from two monitoring wells drilled during the past six months downslope from the Maluaka project.

Subsamples for nutrient analyses from all water sources were immediately placed in 125-milliliter (ml) acid-washed triple rinsed, polyethylene bottles and stored on ice until returned to Honolulu. Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis.

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 dissolved inorganic nitrogen plus dissolved organic nitrogen, nitrate + nitrite nitrogen (NO_3^- + NO_2^-), ammonium (NH_4^+), total phosphorus (TP) which is defined as dissolved inorganic phosphorus plus dissolved 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 using a Technicon autoanalyzer according to standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983). TN and TP were analyzed in a similar fashion following digestion. Dissolved organic nitrogen (TON) and dissolved 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 was a readability of 0.001°C, 0.001pH units, 0.001% oxygen saturation, and 0.001 parts per thousand (‰) salinity.

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. Horizontal Stratification

Table 1 shows results of all marine water chemical analyses for samples collected off Makena on June 29, 2007 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 Sites 1-4 collected at the same sampling stations during the nineteen surveys to date from August 1995 to June 2007, with nutrient concentrations shown in μM and μg/L, respectively. Site 3-A was not included in the tables of geometric means, as only one sampling has been conducted to date. Table 5 shows water chemistry measurements (in units of μM and μg/L) for samples collected from irrigation wells and an irrigation lake located on the Makena Resort Golf Courses, and monitoring wells located at the Maluaka project site. Concentrations of twelve chemical constituents in surface and deep-water samples from the June 2007 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 collected from 1995 to 2007 are plotted in Figures 4-15. In addition, data from the most recent sampling in June 2007 are also plotted on Figures 4-15.

During the June 2007 sampling, concentrations of dissolved Si, NO_3^-, and TN were elevated by two to four orders of magnitude from the shoreline to farthest distance offshore on all five transects (Figure 2, Tables 1 and 2). Values of salinity display a mirror image with lowest values nearest the shoreline, and progressively increasing values with distance from shore (Figure 3, Tables 1 and 2). The horizontal gradients of nutrients were steepest on the recently added Transect 3-A, where NO_3^- at the shoreline (224.9 μM) was four orders of magnitude greater than that measured 150 m from the shoreline (0.03 μM). Salinity at Site 3-A was 8.6‰ at the shoreline and increased to 34.9‰ at the most offshore station. On Transect 1, similar steep gradients were evident where the peak values of NO_3^- (158.40 μM) at the shoreline were more than two orders of magnitude higher than the concentration 150 m from shore (~0.3μM). Salinity at the shoreline of Transect 1(16.3‰) was less than half the value at the most seaward sampling station (34.8‰) (Figure 3, Table 1). On Transects 2 and 4, horizontal gradients of Si, NO_3^- and salinity were also evident, but of a generally smaller magnitude than on Transects 1 and 3-A (Tables 1 and 2). Transect 3 had the smallest gradient with NO_3^- values of 1.31 μM in the shoreline sample compared to 0.06 μM in the offshore sample. Salinity at Site 3 showed only 0.28‰ difference between the shoreline and 150 m from the shoreline.

Horizontal gradients in the surface concentrations of phosphate phosphorus (PO_4^{3-}) were also evident on Transects 1 and 3-A with the highest values in the samples collected near the shoreline, and progressively lower concentrations with increasing distance from shore. While there were distinct gradients in the concentrations of PO_4^{3-}, the magnitude of the range in values was far less than for Si, NO_3^- and TN (Figure 2, Tables 1 and 2). The relative magnitude in concentration of Si, NO_3^-, TN and PO_4^{3-} were higher at Transects 1 and 3-A compared to the other three transects during the June 2007 survey (Table 1).

With no streams in the sampling area, the pattern of elevated Si, NO_3^-, PO_4^{3-} and TN with a corresponding reduced salinity 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, and can extend up to approximately 100 m from the shoreline. The June 2007 sampling was conducted during a period of falling tide (2.48 ft – 0.23 ft) and minimal winds and displayed a marked zone of mixing extending out to approximately 100 m from the nearshore area. Past monitoring surveys at Makena Resort conducted during periods of high tide and strong winds (e.g. December 2005) show substantially smaller horizontal gradients than the present survey. Comparing the results of surveys conducted during very different sea conditions clearly indicates how tidal state, as well as wind and wave mixing, affect groundwater dynamics in the nearshore zone.

Dissolved nutrient constituents that are not associated with groundwater input (NH_4^+, TP, TON, TOP) showed varying results with respect to distance from the shoreline (Figure 2). At all sites, NH_4^+ decreased with increasing distance from the shoreline with the most pronounced gradient at Site 2, where concentrations of NH_4^+ decreased from 5.44 μM at the shoreline to 0.38 μM 200 m from the shoreline (Table 1). Concentrations of TP were highest in the shoreline samples at Site 3-A and Site 1 compared to the offshore samples. Except for a high measurement at the 5 m from shore station at Site 3-A, measurements of TOP and TON were relatively constant along the length of each transect (Figure 2).

On all five transects, surface concentrations of turbidity were highest near the shoreline and decreased with increasing distance offshore (Table 1, Figure 3). With the exception of the samples collected within 5 m of the shoreline on Transect 2, turbidity values were of the same magnitude at all sites. In previous surveys, turbidity has generally been highest on Transect 2 compared to the other sites. Transect 2 bisects Makena Bay, which is semi-enclosed embayment with a silt/sand bottom rather than the predominantly "hard" reef bottoms that occur at the three 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 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 been elevated at 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.

Patterns in the concentrations of Chl *a* were similar to turbidity. Concentrations of Chl *a* were of the same magnitude along all transects, with the highest concentrations of Chl *a* occurring in the shoreline samples at Transect 2 (Figure 3).

Surface water temperature ranged between 25.3°C and 27.0°C during the June 2007 survey (Tables 1 and 2). Temperature measurements at Sites 2, 3 and 4 were ~ 0.3°C higher in the shoreline samples while at Site 1, the shoreline samples were ~ 0.8°C higher than that measured beyond 5 m of the shoreline (Tables 1 and 2). At Site 3-A, shoreline temperatures were lowest at the shoreline, increased to maximum values 50 m from the shoreline, then decreased with increasing distance offshore (Figure 3). The variation in temperature at Site 3-A was 1.1°C during the June 2007 survey.

B. Vertical Stratification

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 -15 and Tables 1 and 2 show concentrations of water chemistry constituents with respect to vertical stratification. During the June 2007 survey, vertical stratification was evident for Si, NO_3^-, TN and salinity along all the transects with the most pronounced gradients at Transects 1 and 3-A. Hence, the most pronounced vertical stratification occurred at the same locations with the steepest, and most pronounced horizontal gradients.

With respect to the other constituents of water chemistry, variations between surface and deep samples were generally small and no apparent trend with distance offshore (Figures 2-15).

C. Temporal Comparison of Monitoring Results

Figures 4-15 show mean concentrations (±standard error) of water chemistry constituents from surface and deep samples at four sites from the nineteen monitoring surveys conducted from 1995 to 2006. In addition, the results of the most recent survey in June 2007 are also shown on each plot. Because Site 3-A was not added to the sampling regime until June 2007, data from this site is not included in Figures 4–15.

On Transects 1 and 2, concentrations of Si, NO_3^-, PO_4^{3-}, TN, TP, NH_4^+ and temperature within 10 m of the shoreline are substantially higher than the mean values, while salinity is substantially lower than mean values. As discussed above, these variations are a result of sampling during a period of particularly low mixing of groundwater and ocean water in the nearshore zone. Thus, while the concentrations of Si, NO_3^- and PO_4^{3-} in June 2007 were higher than the means in nearshore samples, the elevated levels can be attributed to a greater proportion of groundwater in the samples relative to previous surveys. On Transect 3, NO_3^- and PO_4^{3-} and to a small extent Si, were lower during the June 2007 survey compared to the overall means. Comparison of the patterns of distributions of all other constituents reveals that the results of the June 2007 sampling are within the mean values from all previous studies (Figures 4-15).

D. 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 16 shows plots of concentrations of four chemical constituents (Si, NO_3^-, PO_4^{3-}, and $NH4^+$) as functions of salinity for samples collected in June 2007. Figures 17 and 18 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 four conservative mixing lines that are constructed by connecting the end member concentrations of open ocean water with three sources of groundwater: 1) irrigation well No. 4 located on the North Course of the Makena Resort (representative of unaltered groundwater), 2) the irrigation lake that is fed by irrigation wells 2, 3 and 4 and 3) two monitoring wells located adjacent to the golf course downslope from the Maluaka Residential Project.

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 16 that when concentrations of Si are plotted as functions of salinity, most of the data points from the five transects fall on the conservative mixing line created from water collected from the upslope irrigation wells and monitoring wells. In particular, the data points form Site 3-A located downslope of the Maluaka project fall very close to the mixing lines created from the monitoring wells downslope from the project. Such good agreement indicates that marine waters at Site 3-A are a mixture of groundwater flowing beneath the project and ocean water. In addition, data points from Transect Sites 1, 2 lie closer to the irrigation lake water mixing line. Data points from Site 4 also lie near the mixing lines from the irrigation and monitoring wells. The differences between the lines created by the data from Sites 1, 2, 3-A and 4 are likely a result of differences in irrigation water originating from lakes as opposed to wells. Even with these subtle differences between sampling locations, it appears that the groundwater endmembers from well No. 4 provides a valid representation of the effects of golf course operation on unaltered groundwater that enters the ocean following flow through the golf courses. Over the course of monitoring since 1995, the relationship between salinity and Si has remained nearly constant (Figure 17).

NO_3^- is the form of nitrogen most common in fertilizer mixes that are used for enhancing turf growth. There is a distinct difference in the mixing lines created for NO_3^- by connecting endpoint concentrations from monitoring wells, irrigation lakes and irrigation wells (Figure 16). These differences are likely a result of uptake of NO_3^- by plants in the irrigation lake that results is substantially lower concentrations than in the irrigation well. As the monitoring wells are located closer to the shoreline than the irrigation wells, the steeper NO_3^- mixing lines constructed from these wells are likely due to leaching of golf course fertilizers to groundwater.

Like Si, the plots of NO_3^- versus salinity reveal that data points from each transect lie in a distinctly different linear array. Data points from Transect 4, which is considered the control site with no influence from the Makena Resort, and Transect 2 lie close to the upslope well water mixing line. The position of these data arrays indicates that the source of NO_3^- entering the ocean at Transects 2 and 4 contains little or no subsidies from activities on land. Conversely, all of the data points from Transect 1and 3-A lie above the irrigation well mixing lines and close to the monitoring well mixing lines, indicating a subsidy of NO_3^- to the ocean from sources on land. In addition, the slopes of the lines created from the data points from Transects 1 and 3-A are similar, indicating similar sources of NO_3^- at the two sites. There is no apparent subsidy of NO_3^- at Site 3 (Figure 16).

Transect 1 is located directly downslope from the boundary between the Makena and Wailea Golf Courses, as well as numerous residences. Transect 3-A is located downslope from the area of the Makena South course that is closest to the ocean, as well as the Maluaka project presently under construction. It is possible that the apparent subsidy of NO_3^- at Transect sites 1 and 3-A are a result of leaching of golf course fertilizers to the groundwater lens. In addition to the golf courses, however, all of the residences near the shoreline at Site 1 include landscaping and lawns.

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 since 1992. Hence, there appears to have been an increase of NO_3^- in nearshore waters 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 overlap in the makai-mauka direction landward of ocean Transect 1, the increased concentrations of NO_3^- may be a result of leaching of fertilizer materials from the combined golf courses to groundwater that enters the ocean in the sampling area.

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, these subsidies have not been observed to affect the marine biota in the area. When nutrient subsidies are evident, the concentrations of NO_3^- fall in a clearly linear relationship as functions of salinity. The linearity of the data array indicates that there is 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 are not causing any 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 healthy coral reef that does not exhibit any negative effects from nutrient loading (Marine Research Consultants 2006). In addition to the lack of negative impacts to 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^+, generally does not show a linear pattern of distribution with respect to salinity for either the June 2007 survey (Figure 16) or the entire monitoring program (Figure 18). Some samples with near oceanic salinity also displayed the highest concentrations of NH_4^+. 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. Data points representing PO_4^{3-} vs. salinity show no distinct linearity, although several data points from samples collected near the shoreline at Sites 1 and 3-A had elevated concentrations relative to all other samples (Figure 16). Thus, the elevated NO_3^- at Sites 1 and 3-A, which is likely a result of golf course and residential landscaping, is reflected in similar subsidies of PO_4^{3-}.

Time Course Mixing Analyses

While it is possible to evaluate monitoring results 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 scale 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 19 and 20 show plots of Si and NO_3^-, respectively, as functions of salinity collected during each year of sampling (1995-2007). Also shown in Figures 19 and 20 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 yeqr of monitoring at study sites 1-4.

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 Y-intercept of the 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 true because with increasing contributions from land, nutrient concentrations in any given parcel of water will 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 21) and Y-intercepts (Figure 22) 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 it is present in high concentration in groundwater but is not a component of fertilizers. NO_3^- is the form of nitrogen found in high concentrations in groundwater relative to ocean water, and is the major constituent of nitrogen found in fertilizers. PO_4^{-3} is also a component of fertilizers, and is included in this analysis even thought elevated concentrations in nearshore waters have not been noted with regularity at the Makena sampling sites (Figure 18).

Examination of Figures 21 and 22, as well as Tables 6-8 reveal the time-course patterns of Si, NO_3^- and PO_4^{3-} from 1995 to 2007 at each of the Makena transect sites (2002 to 2007 at Site 3). None of the slopes or Y-intercepts 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. In no case is there a REGSLOPE that is 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.

For all three nutrients, there is little variation in either slopes or Y-intercepts during any year at Site 1, located off the "5 Graves" area downslope from the juncture of the Wailea and Makena Resorts (Figures 21 and 22). Such lack of variation indicates relatively consistent concentrations of Si, NO_3^- and PO_4^{3-} in groundwater entering the ocean over the thirteen years of monitoring. Sites 2 (Makena Landing) and 4 ('Ahihi-Kina`u) also show relative 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 2006, followed by a decrease in 2007 (Figures 21 and 22). As a result of these reversing trends there is no significant increase or decrease over the six-year period of monitoring. The reversing oscillations may reflect changes in land use, such as variation in fertilizer application or construction-related activities in 2002-2004 versus 2004-2006. The patterns for Si weakly mirror the pattern of NO_3^-, (except in 2007) suggesting that there may have been variations in the magnitude of materials used for fertilization and irrigation over the course of monitoring.

F. 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 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 nineteen samples collected to date from each sampling station, 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 June 2007 survey indicated that all measurements of NO_3^- from the shoreline to at least 10 m offshore at all five sites exceeded the 10% DOH criteria under wet or dry conditions. All but sixteen of the sixty-two measurements of NH_4^+, including all measurements from Sites 3 and 3-A exceeded the 10% DOH criteria for NH_4^+ under dry conditions. Four measurements of TP, sixteen measurements of TN, five measurements of turbidity and fifteen measurements of Chl a exceeded the 10% DOH criteria under dry conditions. Under "wet" criteria, only two measurements of TP, thirteen measurements of TN, two measurements of turbidity and eleven measurements of Chl *a* were exceeded. 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^- and NH_4^+ were similar to Sites 1-3, which were located off the Resort.

Tables 3 and 4 show geometric means of samples collected at the same locations during the nineteen increments of the monitoring program at all four sites. Also shown in these tables are 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 while only two samples of TP and seventeen samples of turbidity exceeded standards. All 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 three sites, all of which are located downslope from the Makena Resort. Hence, it appears that the 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 influenced by land. If the monitoring protocol were revised to include only those sampling locations beyond 50-100 m from shore (i.e., open coastal waters), only Site 3-A would show exceedances of the water quality standards during the June 2007 monitoring survey. As the DOH standards do not stipulate any monitoring procedures or sampling locations, such a monitoring scheme would be completely valid with respect to meeting regulatory compliance.

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 standards 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 Makena area.

III. SUMMARY

- The nineteenth phase of water chemistry monitoring of the nearshore ocean off the Makena Resort was carried out on June 29, 2007. 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 3-A (initiated during this survey) was located near the northern boundary of the Maluaka Residential project currently under construction, 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. In addition, water samples were collected from seven irrigation wells, and one irrigation lake on the Makena Golf Courses, and two recently drilled monitoring wells located at the Maluaka project site.

- Water chemistry constituents that occur in high concentration in groundwater (Si, NO_3^- and PO_4^{3-}) displayed distinct horizontal gradients with high concentrations nearest to shore and decreasing concentrations moving seaward. Based on salinity, groundwater input was greatest at Sites 1 and 3-A, followed by Sites 2 and 4, and to a much lesser extent at Site 3. As Site 4 was not located in the vicinity of the Makena Resort, it is apparent that groundwater input is not solely a response to Resort land usage.

- Vertical stratification of the water column was evident during June 2007, primarily at Sites 1 and 3-A, and beyond 10 m of the shoreline. The strong vertical and horizontal patterns of distribution indicate that physical mixing processes generated by tide, wind, waves and currents were insufficient to completely mix the water column at these sites.

- Turbidity and Chl *a* were elevated near the shoreline at all five sites, as has been the case in all previous surveys. Both turbidity and Chl *a* were distinctly elevated at Site 2 in the shoreline samples compared to the other sampling sites. Site 2 is located at the point where sediment-laden storm water runoff entered the ocean following a flash flood in October 1999. While the highly turbid conditions associated with the runoff event are no longer evident, normal processes of circulation (tidal exchange, wave mixing) and the silt/sand bottom have often resulted in slightly more turbid conditions in Makena Bay (Site 2) compared to the other sampling sites that occur in areas with predominantly hard reef substrata. During the June 2007 survey, Site 2 did not have turbidity levels any higher than the other sites beyond the shoreline.

- Concentrations of NH_4^+ at all transect sites showed patterns similar to Si and NO_3^- with highest levels near the shoreline and decreasing with increasing distance offshore. Other water chemistry constituents (TON, TOP) that do not occur in high concentrations in groundwater did not display any recognizable horizontal or vertical trends.

- Scaling nutrient concentrations to salinity indicates that there were measurable subsidies of NO_3^- to groundwater that enters the nearshore ocean at Transect sites 1 and 3-A. These subsidies, which are likely 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 an overlap of the southern part of the Wailea Gold Course and the northern part of the Makena North Course, as well as residential development. Site 3 is directly downslope from the Makena South Course in an area were the golf course extends to the shoreline. In addition, new 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 Sites 1 and 3-A 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 thirteen years of monitoring. The lack of increases in these slopes and intercepts indicate that there has been no consistent change in nutrient input from land to groundwater that enters the ocean from 1995 to 2006 (2002 to 2006 at Site 2). At Site 3 off the Makena Resort south golf course, there has been a progressive increase in NO_3^- between 2002 and 2004, followed by a decrease between 2004 and 2006 and an increase in 2007. These trends may be a result of changes in land use from the various activities that are occurring landward of the sampling transect. Further monitoring at this site will be of interest to note the future direction of the oscillating trends noted in the last four years.

- Comparing water chemistry parameters to DOH standards revealed that numerous measurements of NO_3^- and NH_4^+, several measurements of TN and Chl a, and a few measurements of 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^+, TP, TN, turbidity and all measurements of 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 standards not accounting for the natural effects of groundwater discharge to the nearshore ocean and resultant zones of mixing.

- As in past surveys, there appears to be a definite input of 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, that is a consequence of various land use activities. However, none of these inputs have significantly increased over time. Monitoring of coral reef community structure that is part of the ongoing monitoring, as well as the noted lack of any nuisance algal aggregations in the nearshore area indicate that the nutrient subsidies are not detrimental to marine community structure.

- The next phase of the Makena Resort monitoring program is scheduled for the second half of 2007.

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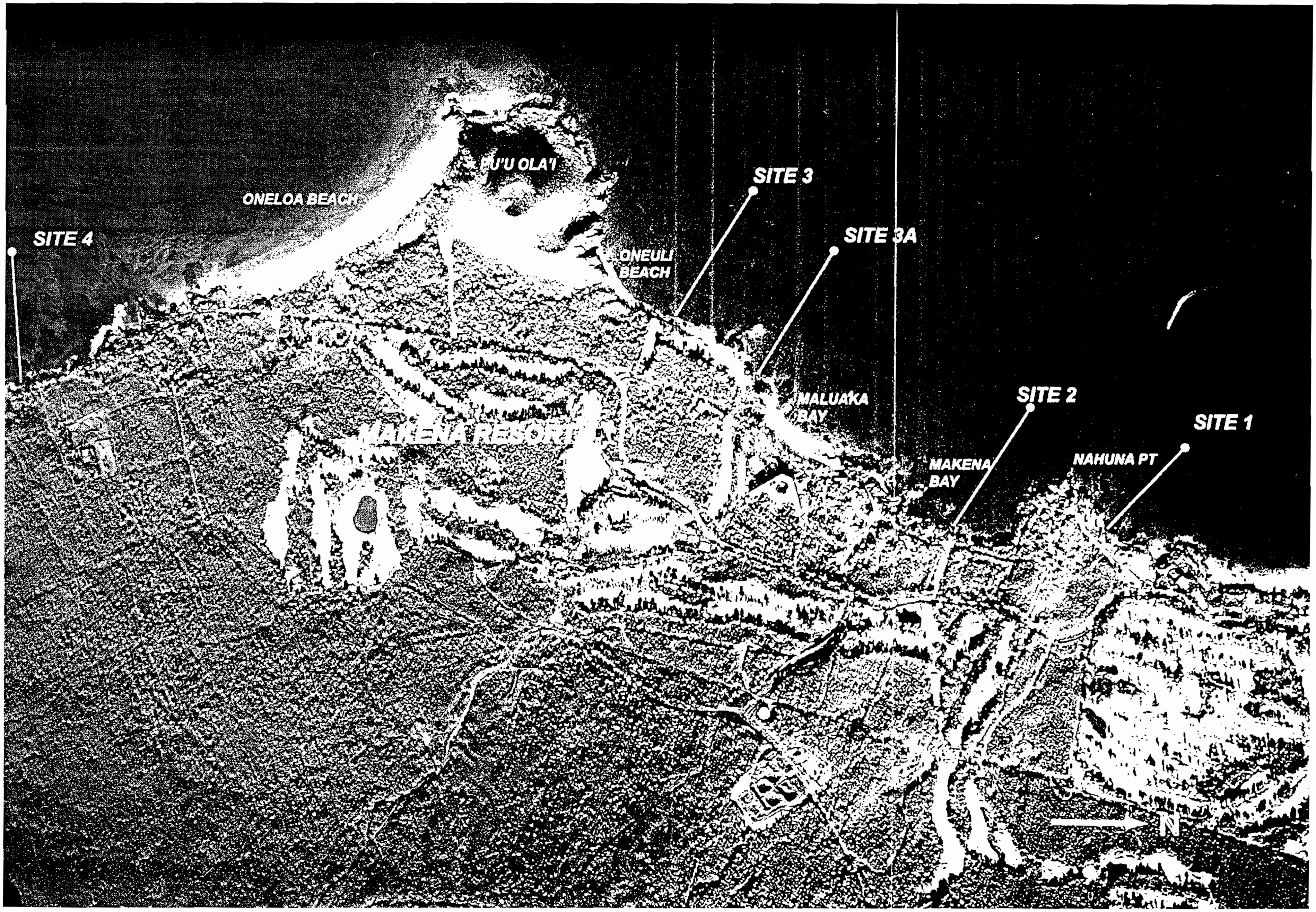

FIGURE 1. Aerial photograph of Makena Resort on southwest coastline of Maui. Also shown are locations of five water sampling transects that extend from the shoreline to 150-200 m from shore. The southern end of the Wailea golf course is visible at right.

TABLE 1. Water chemistry measurements from ocean water samples collected in the vicinity of the Makena Resort on June 29, 2007. Nutrient concentrations shown in micromolar (μM) units. 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 ($\mu g/L$)	TEMP (deg.C)	pH (std.units)	O2 % Sat
MAKENA 1	0 S	-	0.88	158.40	1.76	299.60	0.32	1.72	1.20	161.88	0.50	16.31	2.77	27.0	7.90	101.3
	2 S	0.1	0.13	72.72	0.72	149.89	0.25	6.82	0.38	80.26	0.33	24.94	1.09	26.8	8.03	100.2
	5 S	0.1	0.33	72.61	1.45	157.00	0.21	10.16	0.54	84.22	0.37	24.51	1.36	26.6	8.03	99.2
	5 D	0.2	0.11	42.99	0.58	85.64	0.29	4.96	0.40	48.53	0.29	29.34	1.25	26.4	8.11	99.8
	10 S	0.3	0.10	0.68	0.10	3.54	0.28	9.48	0.38	10.26	0.12	34.74	0.22	26.6	8.15	97.8
	10 D	3.1	0.09	0.18	0.09	1.51	0.25	9.32	0.34	9.59	0.09	34.90	0.18	26.0	8.11	97.9
	50 S	0.3	0.02	0.81	0.26	4.08	0.27	10.88	0.29	11.95	0.08	34.75	0.39	26.4	8.13	97.8
	50 D	5.3	0.02	0.04	0.10	1.12	0.29	10.03	0.31	10.17	0.07	34.92	0.20	25.8	8.11	97.1
	100 S	0.3	0.03	0.27	0.16	2.23	0.31	8.21	0.34	8.64	0.09	34.83	0.21	26.4	8.12	106.8
	100 D	4.6	0.04	0.04	0.22	6.69	0.32	10.51	0.36	10.77	0.08	34.95	0.22	26.0	8.12	102.5
	150 S	0.3	0.08	0.33	0.53	3.97	0.28	9.58	0.36	10.44	0.10	34.83	0.10	26.2	8.12	99.4
	150 D	9.3	0.09	BDL	0.33	8.84	0.36	9.22	0.45	9.55	0.08	34.91	0.08	25.7	8.12	97.0
MAKENA 2	0 S	-	0.03	14.92	5.44	60.08	0.41	10.79	0.44	31.15	3.00	30.99	3.99	26.8	8.03	100.3
	2 S	0.1	0.13	26.33	4.85	85.02	0.36	8.55	0.49	39.73	1.46	28.06	4.09	26.8	8.02	101.2
	5 S	0.3	0.03	7.17	0.72	32.78	0.31	11.39	0.34	19.28	0.91	32.78	5.85	26.6	8.05	100.5
	5 D	0.3	0.13	5.69	0.78	28.91	0.29	7.78	0.42	14.25	0.98	33.03	5.53	26.6	8.05	99.4
	10 S	0.3	0.06	1.77	0.23	10.18	0.28	9.06	0.34	11.06	0.28	34.31	0.39	26.6	8.12	99.2
	10 D	2.3	0.06	0.12	0.40	3.69	0.27	6.45	0.33	6.97	0.16	34.76	0.22	26.3	8.11	98.1
	50 S	0.3	0.15	1.38	0.67	8.55	0.24	11.08	0.39	13.13	0.15	34.51	0.24	26.6	8.10	98.5
	50 D	2.5	0.16	0.17	0.94	3.62	0.23	8.26	0.39	9.37	0.14	34.83	0.21	26.4	8.12	97.9
	100 S	0.3	0.03	0.70	0.28	7.74	0.29	9.65	0.32	10.63	0.26	34.50	0.23	26.6	8.11	98.0
	100 D	2.6	0.05	0.06	0.27	2.23	0.31	9.88	0.36	10.21	0.13	34.88	0.13	26.5	8.13	99.3
	150 S	0.3	0.09	0.58	0.74	5.50	0.27	8.04	0.36	9.36	0.22	34.72	0.17	26.5	8.11	98.3
	150 D	5.3	0.07	0.01	0.34	1.41	0.27	7.06	0.34	7.41	0.07	34.90	0.08	26.4	8.12	99.1
	200 S	0.3	0.03	0.03	0.38	2.06	0.34	9.22	0.37	9.63	0.08	34.88	0.10	26.5	8.12	99.8
	200 D	9.4	0.05	BDL	0.43	1.14	0.30	10.87	0.35	11.30	0.07	34.90	0.12	26.4	8.13	98.4
MAKENA 3-A	0 S	-	1.76	224.92	1.88	530.80	0.36	9.00	2.12	235.80	0.19	8.57	0.20	25.3	7.71	95.4
	2 S	0.1	1.92	176.56	2.08	419.12	0.32	4.16	2.24	182.80	0.25	14.89	0.70	26.0	7.68	95.8
	5 S	0.2	0.36	108.12	2.88	260.64	0.68	22.12	1.04	133.12	0.30	22.91	1.03	26.0	7.82	96.4
	5 D	0.3	0.49	42.21	0.68	105.30	0.23	5.63	0.72	48.52	0.24	29.71	0.87	26.1	7.98	97.3
	10 S	0.3	0.03	1.58	0.44	9.00	0.25	7.52	0.28	9.54	0.11	34.54	0.19	26.2	8.13	97.5
	10 D	5.2	0.06	0.23	0.50	2.14	0.28	8.20	0.34	8.93	0.08	34.95	0.10	25.8	8.12	97.4
	50 S	0.3	0.07	1.81	1.24	8.16	0.29	8.91	0.36	11.96	0.13	34.66	0.15	26.4	8.11	97.6
	50 D	4.4	0.04	0.03	0.42	3.12	0.27	8.04	0.31	8.49	0.07	34.91	0.23	25.8	8.12	97.0
	100 S	0.3	0.16	0.67	0.75	5.33	0.25	7.20	0.41	8.62	0.13	34.78	0.20	26.2	8.11	99.6
	100 D	8.2	0.17	0.02	0.62	2.99	0.27	7.55	0.44	8.19	0.08	34.92	0.14	25.7	8.13	95.7
	150 S	0.3	0.03	0.03	0.37	2.04	0.33	8.13	0.36	8.53	0.08	34.88	0.10	25.7	8.12	96.8
	150 D	8.6	0.04	0.02	0.42	1.12	0.31	7.99	0.35	8.43	0.07	34.91	0.12	25.7	8.13	97.0
MAKENA 3	0 S	-	0.02	1.31	1.07	9.57	0.28	7.84	0.30	10.22	0.41	34.60	0.53	26.0	8.14	101.3
	2 S	0.1	0.02	0.36	0.43	8.68	0.32	8.53	0.34	9.32	0.64	34.64	1.09	26.0	8.13	102.3
	5 S	0.2	BDL	3.97	0.42	11.12	0.27	7.00	0.27	11.39	0.21	34.63	0.24	25.9	8.14	100.3
	5 D	0.3	0.09	0.11	1.50	2.08	0.30	6.25	0.39	7.86	0.09	34.92	0.09	25.9	8.12	99.4
	10 S	0.3	0.01	1.56	0.78	6.46	0.29	8.21	0.30	10.55	0.10	34.72	0.12	25.8	8.12	99.9
	10 D	3.4	0.07	0.08	0.44	1.80	0.30	9.46	0.37	9.98	0.08	34.89	0.09	25.7	8.12	98.9
	50 S	0.3	0.08	1.38	0.56	5.88	0.29	7.87	0.37	9.81	0.10	34.72	0.21	26.0	8.12	99.1
	50 D	4.7	0.05	0.04	0.40	1.50	0.30	8.35	0.35	8.79	0.07	34.91	0.20	25.6	8.12	94.5
	100 S	0.3	0.06	0.20	0.42	3.31	0.30	8.13	0.36	8.75	0.08	34.83	0.14	25.8	8.11	97.0
	100 D	6.6	0.05	0.03	0.75	1.45	0.30	8.68	0.35	9.46	0.07	34.92	0.09	25.7	8.13	95.3
	150 S	0.3	0.02	0.06	0.54	1.68	0.30	9.17	0.32	9.77	0.07	34.89	0.07	25.7	8.13	96.8
	150 D	8.3	0.02	0.08	0.67	1.33	0.32	8.42	0.34	9.17	0.09	34.91	0.09	25.7	8.13	97.0
MAKENA 4	0 S	-	0.36	12.31	1.19	81.54	0.27	8.92	0.63	22.42	0.28	30.30	1.69	25.9	7.97	101.2
	2 S	0.1	0.33	8.79	1.84	76.11	0.19	7.77	0.52	18.40	0.19	31.01	0.66	25.9	8.03	102.2
	5 S	0.2	0.28	3.58	0.89	44.69	0.26	9.12	0.54	13.59	0.17	32.79	0.48	25.9	8.07	97.3
	5 D	0.2	0.34	1.31	1.57	26.99	0.21	7.41	0.55	10.29	0.16	33.65	0.44	25.9	8.08	96.5
	10 S	0.3	0.14	1.02	0.07	15.50	0.31	5.91	0.45	7.00	0.15	34.36	0.20	25.8	8.13	95.9
	10 D	3.4	0.16	0.16	0.40	5.55	0.23	8.08	0.39	8.64	0.12	34.85	0.17	25.7	8.11	94.9
	50 S	0.2	0.06	0.96	0.48	9.29	0.20	7.61	0.26	9.05	0.15	34.65	0.26	26.0	8.11	99.1
	50 D	4.7	0.06	0.08	0.07	4.08	0.20	6.51	0.26	6.66	0.11	34.89	0.17	25.6	8.08	94.5
	100 S	0.3	0.04	0.52	0.27	7.48	0.21	8.50	0.25	9.29	0.12	34.76	0.15	25.8	8.10	97.0
	100 D	6.6	0.25	0.10	0.03	5.03	0.19	8.90	0.44	9.03	0.11	34.94	0.15	25.7	8.11	95.3
	150 S	0.2	0.25	BDL	0.61	4.35	0.19	6.21	0.44	6.82	0.08	34.96	0.09	25.7	8.13	96.8
	150 D	8.3	0.13	0.01	0.45	3.87	0.27	10.27	0.40	10.73	0.08	34.96	0.10	25.7	8.13	97.0
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 June 29, 2007. Nutrient concentrations 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 ore 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	0.0	27.28	2217.60	24.65	8418.8	9.92	24.08	37.20	2266.32	0.50	16.31	2.77	27.0	7.90	101.3
	2 S	0.1	4.03	1018.08	10.08	4211.9	7.75	95.48	11.78	1123.64	0.33	24.94	1.09	26.8	8.03	100.2
	5 S	0.1	10.23	1016.54	20.31	4411.7	6.51	142.24	16.74	1179.08	0.37	24.51	1.36	26.6	8.03	99.2
	5 D	0.2	3.41	601.86	8.12	2406.5	8.99	69.44	12.40	679.42	0.29	29.34	1.25	26.4	8.11	99.8
	10 S	0.3	3.10	9.52	1.40	99.5	8.68	132.72	11.78	143.64	0.12	34.74	0.22	26.6	8.15	97.8
	10 D	3.1	2.79	2.52	1.26	42.4	7.75	130.48	10.54	134.26	0.09	34.90	0.18	26.0	8.11	97.9
	50 S	0.3	0.62	11.34	3.64	114.6	8.37	152.32	8.99	167.30	0.08	34.75	0.39	26.4	8.13	97.8
	50 D	5.3	0.62	0.56	1.40	31.5	8.99	140.42	9.61	142.38	0.07	34.92	0.20	25.8	8.11	97.1
	100 S	0.3	0.93	3.78	2.24	62.7	9.61	114.94	10.54	120.96	0.09	34.83	0.21	26.4	8.12	106.8
	100 D	4.6	1.24	0.56	3.08	188.0	9.92	147.14	11.16	150.78	0.08	34.95	0.22	26.0	8.12	102.5
	150 S	0.3	2.48	4.62	7.42	111.6	8.68	134.12	11.16	146.16	0.10	34.83	0.10	26.2	8.12	99.4
	150 D	9.3	2.79	BDL	4.62	248.4	11.16	129.08	13.95	133.70	0.08	34.91	0.08	25.7	8.12	97.0
MAKENA 2	0 S	0.0	0.93	208.88	76.19	1688.2	12.71	151.06	13.64	436.10	3.00	30.99	3.99	26.8	8.03	100.3
	2 S	0.1	4.03	368.62	67.93	2389.1	11.16	119.70	15.19	556.22	1.46	28.06	4.09	26.8	8.02	101.2
	5 S	0.3	0.93	100.38	10.08	921.1	9.61	159.46	10.54	269.92	0.91	32.78	5.85	26.6	8.05	100.5
	5 D	0.3	4.03	79.66	10.92	812.4	8.99	108.92	13.02	199.50	0.98	33.03	5.53	26.6	8.05	99.4
	10 S	0.3	1.86	24.78	3.22	286.1	8.68	126.84	10.54	154.84	0.28	34.31	0.39	26.6	8.12	99.2
	10 D	2.3	1.86	1.68	5.60	103.7	8.37	90.30	10.23	97.58	0.16	34.76	0.22	26.3	8.11	98.1
	50 S	0.3	4.65	19.32	9.38	240.3	7.44	155.12	12.09	183.82	0.15	34.51	0.24	26.6	8.10	98.5
	50 D	2.5	4.96	2.38	13.17	101.7	7.13	115.64	12.09	131.18	0.14	34.83	0.21	26.4	8.12	97.9
	100 S	0.3	0.93	9.80	3.92	217.5	8.99	135.10	9.92	148.82	0.26	34.50	0.23	26.6	8.11	98.0
	100 D	2.6	1.55	0.84	3.78	62.7	9.61	138.32	11.16	142.94	0.13	34.88	0.13	26.5	8.13	99.3
	150 S	0.3	2.79	8.12	10.36	154.6	8.37	112.56	11.16	131.04	0.22	34.72	0.17	26.5	8.11	98.3
	150 D	5.3	2.17	0.14	4.76	39.6	8.37	98.84	10.54	103.74	0.07	34.90	0.08	26.4	8.12	99.1
	200 S	0.3	0.93	0.42	5.32	57.9	10.54	129.08	11.47	134.82	0.08	34.88	0.10	26.5	8.12	99.8
	200 D	9.4	1.55	BDL	6.02	32.0	9.30	152.18	10.85	158.20	0.07	34.90	0.12	26.4	8.13	98.4
MAKENA 3-A	0 S	0.0	54.56	3148.88	26.33	14915.5	11.16	126.00	65.72	3301.20	0.19	8.57	0.20	25.3	7.71	95.4
	2 S	0.1	59.52	2471.84	29.13	11777.3	9.92	58.24	69.44	2559.20	0.25	14.89	0.70	26.0	7.68	95.8
	5 S	0.2	11.16	1513.68	40.34	7324.0	21.08	309.68	32.24	1863.68	0.30	22.91	1.03	26.0	7.82	96.4
	5 D	0.3	15.19	590.94	9.52	2958.9	7.13	78.82	22.32	679.28	0.24	29.71	0.87	26.1	7.98	97.3
	10 S	0.3	0.93	22.12	6.16	.252.9	7.75	105.28	8.68	133.56	0.11	34.54	0.19	26.2	8.13	97.5
	10 D	5.2	1.86	3.22	7.00	60.1	8.67	114.85	10.53	125.07	0.08	34.95	0.10	25.8	8.12	97.4
	50 S	0.3	2.17	25.34	17.37	229.3	8.99	124.74	11.16	167.44	0.13	34.66	0.15	26.4	8.11	97.6
	50 D	4.4	1.24	0.42	5.88	87.7	8.37	112.56	9.61	118.86	0.07	34.91	0.23	25.8	8.12	97.0
	100 S	0.3	4.96	9.38	10.50	149.8	7.75	100.80	12.71	120.68	0.13	34.78	0.20	26.2	8.11	99.6
	100 D	8.2	5.27	0.28	8.68	84.0	8.37	105.70	13.64	114.66	0.08	34.92	0.14	25.7	8.13	95.7
	150 S	0.3	0.93	0.42	5.18	57.3	10.23	113.82	11.16	119.42	0.08	34.88	0.10	25.7	8.12	96.8
	150 D	8.6	1.24	0.28	5.88	31.5	9.61	111.86	10.85	118.02	0.07	34.91	0.12	25.7	8.13	97.0
MAKENA 3	0 S	0.0	0.62	18.34	14.99	268.9	8.68	109.76	9.30	143.08	0.41	34.60	0.53	26.0	8.14	101.3
	2 S	0.1	0.62	5.04	6.02	243.9	9.92	119.42	10.54	130.48	0.64	34.64	1.09	26.0	8.13	102.3
	5 S	0.2	BDL	55.58	5.88	312.5	8.37	98.00	8.37	159.46	0.21	34.63	0.24	25.9	8.14	100.3
	5 D	0.3	2.79	1.54	21.01	58.4	9.30	87.50	12.09	110.04	0.09	34.92	0.09	25.9	8.12	99.4
	10 S	0.3	0.31	21.84	10.92	181.5	8.99	114.94	9.30	147.70	0.10	34.72	0.12	25.8	8.12	99.9
	10 D	3.4	2.17	1.12	6.16	50.6	9.30	132.44	11.47	139.72	0.08	34.89	0.09	25.7	8.12	98.9
	50 S	0.3	2.48	19.32	7.84	165.2	8.99	110.18	11.47	137.34	0.10	34.72	0.21	26.0	8.12	99.1
	50 D	4.7	1.55	0.56	5.60	42.2	9.30	116.90	10.85	123.06	0.07	34.91	0.20	25.6	8.12	94.5
	100 S	0.3	1.86	2.80	5.88	93.0	9.30	113.82	11.16	122.50	0.08	34.83	0.14	25.8	8.11	97.0
	100 D	6.6	1.55	0.42	10.50	40.7	9.30	121.52	10.85	132.44	0.07	34.92	0.09	25.7	8.13	95.3
	150 S	0.3	0.62	0.84	7.56	47.2	9.30	128.38	9.92	136.78	0.07	34.89	0.07	25.7	8.13	96.8
	150 D	8.3	0.62	1.12	9.38	37.4	9.92	117.88	10.54	128.38	0.09	34.91	0.09	25.7	8.13	97.0
MAKENA 4	0 S	0.0	11.16	172.34	16.66	2291.3	8.37	124.88	19.53	313.88	0.28	30.30	1.69	25.9	7.97	101.2
	2 S	0.1	10.23	123.06	25.76	2138.7	5.89	108.78	16.12	257.60	0.19	31.01	0.66	25.9	8.03	102.2
	5 S	0.2	8.68	50.12	12.46	1255.8	8.06	127.68	16.74	190.26	0.17	32.79	0.48	25.9	8.07	97.3
	5 D	0.2	10.54	18.34	21.98	758.4	6.51	103.74	17.05	144.06	0.16	33.65	0.44	25.9	8.08	96.5
	10 S	0.3	4.34	14.28	0.98	435.6	9.61	82.74	13.95	98.00	0.15	34.36	0.20	25.8	8.13	95.9
	10 D	3.4	4.96	2.24	5.60	156.0	7.13	113.12	12.09	120.96	0.12	34.85	0.17	25.7	8.11	94.9
	50 S	0.2	1.86	13.44	6.72	261.0	6.20	106.54	8.06	126.70	0.15	34.65	0.26	26.0	8.11	99.1
	50 D	4.7	1.86	1.12	0.98	114.6	6.20	91.14	8.06	93.24	0.11	34.89	0.17	25.6	8.08	94.5
	100 S	0.3	1.24	7.28	3.78	210.2	6.51	119.00	7.75	130.06	0.12	34.76	0.15	25.8	8.10	97.0
	100 D	6.6	7.75	1.40	0.42	141.3	5.89	124.60	13.64	126.42	0.11	34.94	0.15	25.7	8.11	95.3
	150 S	0.2	7.75	8DL	8.54	122.2	5.89	86.94	13.64	95.48	0.08	34.96	0.09	25.7	8.13	96.8
	150 D	8.3	4.03	0.14	6.30	108.7	8.37	143.78	12.40	150.22	0.08	34.96	0.10	25.7	8.13	97.0
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 (nutrients in μM) off the Makena Resort collected since August 1995 (N=19). 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)	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 ($\mu g/L$)	TEMP (deg.C)	pH
MAKENA 1	0 S	0.1	0.20	31.61	0.27	55.10	0.23	7.43	0.49	45.76	0.34	29.510	1.14	25.6	8.13
	2 S	0.1	0.14	22.05	0.19	39.80	0.24	7.85	0.41	33.36	0.29	31.570	0.95	25.6	8.16
	5 S	0.1	0.12	9.89	0.17	21.05	0.25	7.99	0.40	21.77	0.25	32.770	0.73	25.7	8.16
	5 D	2.5	0.12	8.32	0.23	18.57	0.27	7.45	0.40	19.55	0.21	33.230	0.64	25.7	8.17
	10 S	0.1	0.10	3.35	0.16	9.11	0.26	7.40	0.36	12.34	0.19	34.220	0.45	25.7	8.17
	10 D	3.0	0.10	2.20	0.18	6.57	0.28	7.54	0.40	10.86	0.18	34.420	0.46	25.6	8.16
	50 S	0.1	0.09	2.59	0.19	7.13	0.26	7.29	0.37	11.37	0.16	34.370	0.36	25.7	8.14
	50 D	4.1	0.08	0.37	0.12	2.61	0.27	7.34	0.37	8.03	0.12	34.750	0.31	25.6	8.15
	100 S	0.1	0.09	0.91	0.14	4.45	0.27	6.62	0.37	9.46	0.13	34.530	0.30	25.6	8.14
	100 D	6.4	0.08	0.11	0.09	2.04	0.27	7.14	0.36	7.49	0.10	34.810	0.26	25.6	8.16
	150 S	0.1	0.09	0.31	0.13	2.97	0.26	6.99	0.36	8.32	0.12	34.700	0.21	25.8	8.15
	150 D	10.5	0.08	0.07	0.10	1.81	0.27	6.90	0.36	7.18	0.10	34.820	0.20	25.7	8.16
MAKENA 2	0 S	0.1	0.20	3.65	0.38	20.68	0.32	8.57	0.57	13.76	1.05	33.740	0.91	25.7	8.14
	2 S	0.1	0.20	3.64	0.28	19.09	0.32	7.90	0.56	12.98	0.76	33.550	0.90	25.7	8.14
	5 S	0.1	0.17	3.06	0.29	15.13	0.28	7.19	0.48	11.43	0.49	33.990	0.69	25.7	8.14
	5 D	1.5	0.18	2.84	0.36	14.57	0.31	7.37	0.51	11.72	0.48	34.030	0.88	25.7	8.14
	10 S	0.1	0.14	1.76	0.20	9.88	0.30	5.17	0.46	9.26	0.35	34.330	0.48	25.6	8.15
	10 D	2.4	0.13	1.04	0.24	7.97	0.31	7.08	0.46	9.13	0.29	34.460	0.54	25.7	8.15
	50 S	0.1	0.12	1.13	0.28	7.09	0.32	7.50	0.47	9.47	0.26	34.460	0.39	25.6	8.14
	50 D	3.8	0.10	0.28	0.21	3.28	0.31	7.58	0.44	8.28	0.19	34.750	0.44	25.6	8.15
	100 S	0.1	0.09	0.46	0.20	3.90	0.29	7.34	0.39	8.33	0.17	34.650	0.31	25.7	8.14
	100 D	4.7	0.08	0.19	0.19	2.35	0.29	7.09	0.38	7.60	0.13	34.790	0.30	25.7	8.15
	150 S	0.1	0.09	0.26	0.24	2.98	0.28	7.42	0.39	8.07	0.14	34.750	0.25	25.7	8.15
	150 D	9.5	0.08	0.12	0.14	2.04	0.29	7.44	0.39	7.86	0.11	34.810	0.25	25.7	8.16
	200 S	0.1	0.08	0.15	0.16	2.27	0.29	7.25	0.38	7.87	0.11	34.810	0.27	25.8	8.16
	200 D	13.4	0.08	0.06	0.21	1.64	0.29	7.74	0.38	8.11	0.10	34.840	0.27	25.7	8.17
MAKENA 3	0 S	0.1	0.09	3.86	0.38	12.09	0.27	5.50	0.42	16.41	0.28	34.080	0.66	25.7	8.16
	2 S	0.1	0.15	8.77	0.23	19.85	0.25	5.72	0.47	22.59	0.32	33.870	0.70	25.9	8.14
	5 S	0.1	0.10	5.90	0.25	13.13	0.25	7.01	0.40	17.06	0.22	34.300	0.39	25.8	8.14
	5 D	1.5	0.12	3.48	0.34	9.61	0.27	6.34	0.43	14.36	0.20	34.390	0.49	25.8	8.14
	10 S	0.1	0.08	2.73	0.27	7.40	0.27	6.92	0.38	12.68	0.16	34.470	0.29	25.7	8.15
	10 D	2.5	0.08	1.53	0.21	5.37	0.28	6.96	0.38	10.87	0.15	34.610	0.31	25.7	8.15
	50 S	0.1	0.09	1.30	0.20	4.71	0.28	7.35	0.38	10.19	0.13	34.640	0.24	25.6	8.12
	50 D	5.9	0.07	0.42	0.17	2.88	0.28	7.55	0.36	8.43	0.09	34.780	0.24	25.6	8.15
	100 S	0.1	0.07	0.33	0.22	2.55	0.28	7.22	0.37	8.06	0.10	34.770	0.18	25.6	8.14
	100 D	6.0	0.07	0.10	0.24	1.81	0.27	6.56	0.35	7.12	0.08	34.800	0.20	25.7	8.15
	150 S	0.1	0.05	0.14	0.19	1.90	0.29	6.66	0.35	7.26	0.09	34.780	0.15	25.7	8.17
	150 D	7.4	0.06	0.09	0.12	1.77	0.28	6.60	0.35	6.97	0.09	34.830	0.17	25.7	8.18
MAKENA 4	0 S	0.1	0.20	31.61	0.27	55.10	0.23	7.43	0.49	45.76	0.34	29.510	1.14	25.6	8.13
	2 S	0.1	0.14	22.05	0.19	39.80	0.24	7.85	0.41	33.36	0.29	31.570	0.95	25.6	8.16
	5 S	0.1	0.12	9.89	0.17	21.05	0.25	7.99	0.40	21.77	0.25	32.770	0.73	25.7	8.16
	5 D	1.5	0.12	8.32	0.23	18.57	0.27	7.45	0.40	19.55	0.21	33.230	0.64	25.7	8.17
	10 S	0.1	0.10	3.35	0.16	9.11	0.26	7.40	0.36	12.34	0.19	34.220	0.45	25.7	8.17
	10 D	2.5	0.10	2.20	0.18	6.57	0.28	7.54	0.40	10.86	0.18	34.420	0.46	25.6	8.16
	50 S	0.1	0.09	2.59	0.19	7.13	0.26	7.29	0.37	11.37	0.16	34.370	0.36	25.7	8.14
	50 D	5.9	0.08	0.37	0.12	2.61	0.27	7.34	0.37	8.03	0.12	34.750	0.31	25.6	8.15
	100 S	0.1	0.09	0.91	0.14	4.45	0.27	6.62	0.37	9.46	0.13	34.530	0.30	25.6	8.14
	100 D	6.0	0.08	0.11	0.09	2.04	0.27	7.14	0.36	7.49	0.10	34.810	0.26	25.6	8.16
	150 S	0.1	0.09	0.31	0.13	2.97	0.26	6.99	0.36	8.32	0.12	34.700	0.21	25.8	8.15
	150 D	7.4	0.08	0.07	0.10	1.81	0.27	6.90	0.36	7.18	0.10	34.820	0.20	25.7	8.16
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 (N=19). 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)	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
MAKENA 1	0 S	0.1	6.10	442.70	3.70	1547.8	7.10	104.00	15.10	640.90	0.34	29.51	1.14	25.6	8.13
	2 S	0.1	4.30	308.80	2.60	1118.0	7.40	109.90	12.60	467.20	0.29	31.57	0.95	25.6	8.16
	5 S	0.1	3.70	138.50	2.30	591.3	7.70	111.90	12.30	304.90	0.25	32.77	0.73	25.7	8.16
	5 D	2.5	3.70	116.50	3.20	521.6	8.30	104.30	12.30	273.80	0.21	33.23	0.64	25.7	8.17
	10 S	0.1	3.00	46.90	2.20	255.9	8.00	103.60	11.10	172.80	0.19	34.22	0.45	25.7	8.17
	10 D	3.0	3.00	30.80	2.50	184.6	8.60	105.60	12.30	152.10	0.18	34.42	0.46	25.6	8.16
	50 S	0.1	2.70	36.20	2.60	200.3	8.00	102.10	11.40	159.20	0.16	34.37	0.36	25.7	8.14
	50 D	4.1	2.40	5.10	1.60	73.3	8.30	102.80	11.40	112.40	0.12	34.75	0.31	25.6	8.15
	100 S	0.1	2.70	12.70	1.90	125.0	8.30	92.70	11.40	132.40	0.13	34.53	0.30	25.6	8.14
	100 D	6.4	2.40	1.50	1.20	57.3	8.30	100.00	11.10	104.90	0.10	34.81	0.26	25.6	8.16
	150 S	0.1	2.70	4.30	1.80	83.4	8.00	97.90	11.10	116.50	0.12	34.70	0.21	25.8	8.15
	150 D	10.5	2.40	0.90	1.40	50.8	8.30	96.60	11.10	100.50	0.10	34.82	0.20	25.7	8.16
MAKENA 2	0 S	0.1	6.10	51.10	5.30	580.9	9.90	120.00	17.60	192.70	1.05	33.74	0.91	25.7	8.14
	2 S	0.1	6.10	50.90	3.90	536.2	9.90	110.60	17.30	181.70	0.76	33.55	0.90	25.7	8.14
	5 S	0.1	5.20	42.80	4.00	425.0	8.60	100.70	14.80	160.00	0.49	33.99	0.69	25.7	8.14
	5 D	1.5	5.50	39.70	5.00	409.3	9.60	103.20	15.70	164.10	0.48	34.03	0.88	25.7	8.14
	10 S	0.1	4.30	24.60	2.80	277.5	9.20	72.40	14.20	129.60	0.35	34.33	0.48	25.6	8.15
	10 D	2.4	4.00	14.50	3.30	223.9	9.60	99.10	14.20	127.80	0.29	34.46	0.54	25.7	8.15
	50 S	0.1	3.70	15.80	3.90	199.2	9.90	105.00	14.50	132.60	0.26	34.46	0.39	25.6	8.14
	50 D	3.8	3.00	3.90	2.90	92.1	9.60	106.10	13.60	115.90	0.19	34.75	0.44	25.6	8.15
	100 S	0.1	2.70	6.40	2.80	109.6	8.90	102.80	12.00	116.60	0.17	34.65	0.31	25.7	8.14
	100 D	4.7	2.40	2.60	2.60	66.0	8.90	99.30	11.70	106.40	0.13	34.79	0.30	25.7	8.15
	150 S	0.1	2.70	3.60	3.30	83.7	8.60	103.90	12.00	113.00	0.14	34.75	0.25	25.7	8.15
	150 D	9.5	2.40	1.60	1.90	57.3	8.90	104.20	12.00	110.00	0.11	34.81	0.25	25.7	8.16
	200 S	0.1	2.40	2.10	2.20	63.8	8.90	101.50	11.70	110.20	0.11	34.81	0.27	25.8	8.16
	200 D	13.4	2.40	0.80	2.90	46.1	8.90	108.40	11.70	113.50	0.10	34.84	0.27	25.7	8.17
MAKENA 3-A	0 S	0.1	54.50	3150.20	26.30	14910.2	11.10	126.00	65.60	3302.60	0.19	8.57	0.39	25.3	7.7
	2 S	0.1	59.40	2472.80	29.10	11773.1	9.90	58.20	69.30	2560.20	0.25	14.88	1.20	26.0	7.68
	5 S	0.1	11.10	1514.30	40.30	7321.4	21.00	309.80	32.20	1864.40	0.30	22.90	1.32	26.0	7.82
	5 D	3.0	15.10	591.10	9.50	2957.9	7.10	78.80	22.30	679.50	0.24	29.70	1.18	26.1	7.98
	10 S	0.1	0.90	22.10	6.10	252.8	7.70	105.30	8.60	133.60	0.11	34.53	0.30	26.2	8.13
	10 D	4.5	1.80	3.20	7.00	60.1	8.60	114.80	10.50	125.00	0.08	34.94	0.53	25.8	8.11
	50 S	0.1	2.10	25.30	17.30	229.2	8.90	124.70	11.10	167.50	0.13	34.66	0.16	26.4	8.11
	50 D	3.5	1.20	0.40	5.80	87.6	8.30	112.60	9.60	118.90	0.07	34.91	0.19	25.8	8.12
	100 S	0.1	4.90	9.30	10.50	149.7	7.70	100.80	12.60	120.70	0.13	34.77	0.22	26.2	8.1
	100 D	6.2	5.20	0.20	8.60	84.0	8.30	105.70	13.60	114.70	0.08	34.92	0.17	25.7	8.13
	150 S	0.1	0.90	0.40	5.10	57.3	10.20	113.80	11.10	119.40	0.08	34.87	0.17	25.7	8.11
	150 D	8.2	1.20	0.20	5.80	31.5	9.60	111.90	10.80	118.00	0.07	34.91	0.36	25.7	8.12
MAKENA 3	0 S	0.1	2.70	54.00	6.30	339.6	8.30	77.00	13.00	229.80	0.28	34.08	0.66	25.7	8.16
	2 S	0.1	4.60	122.80	3.20	557.6	7.70	80.10	14.50	316.30	0.32	33.87	0.70	25.9	8.14
	5 S	0.1	3.00	82.60	3.50	368.8	7.70	98.10	12.30	238.90	0.22	34.30	0.39	25.8	8.14
	5 D	1.5	3.70	48.70	4.70	269.9	8.30	88.70	13.30	201.10	0.20	34.39	0.49	25.8	8.14
	10 S	0.1	2.40	38.20	3.70	207.9	8.30	96.90	11.70	177.50	0.16	34.47	0.29	25.7	8.15
	10 D	2.5	2.40	21.40	2.90	150.8	8.60	97.40	11.70	152.20	0.15	34.61	0.31	25.7	8.15
	50 S	0.1	2.70	18.20	2.80	132.3	8.60	102.90	11.70	142.70	0.13	34.64	0.24	25.6	8.12
	50 D	5.9	2.10	15.80	2.30	80.9	8.60	105.70	11.10	118.00	0.09	34.78	0.24	25.6	8.15
	100 S	0.1	2.10	4.60	3.00	71.6	8.60	101.10	11.40	112.80	0.10	34.77	0.18	25.6	8.14
	100 D	6.0	2.10	1.40	3.30	50.8	8.30	91.80	10.80	99.70	0.08	34.80	0.20	25.7	8.15
	150 S	0.1	1.50	1.90	2.60	53.4	8.90	93.20	10.80	101.60	0.09	34.78	0.15	25.7	8.17
	150 D	7.4	1.80	1.20	1.60	49.7	8.60	92.40	10.80	97.60	0.09	34.83	0.17	25.7	8.18
MAKENA 4	0 S	0.1	6.10	442.70	3.70	1547.8	7.10	104.00	15.10	640.90	0.34	29.51	1.14	25.6	8.13
	2 S	0.1	4.30	308.80	2.60	1118.0	7.40	109.90	12.60	467.20	0.29	31.57	0.95	25.6	8.16
	5 S	0.1	3.70	138.50	2.30	591.3	7.70	111.90	12.30	304.90	0.25	32.77	0.73	25.7	8.16
	5 D	1.5	3.70	116.50	3.20	521.6	8.30	104.30	12.30	273.80	0.21	33.23	0.64	25.7	8.17
	10 S	0.1	3.00	46.90	2.20	255.9	8.00	103.60	11.10	172.80	0.19	34.22	0.45	25.7	8.17
	10 D	2.5	3.00	30.80	2.50	184.6	8.60	105.60	12.30	152.10	0.18	34.42	0.46	25.6	8.16
	50 S	0.1	2.70	36.20	2.60	200.3	8.00	102.10	11.40	159.20	0.16	34.37	0.36	25.7	8.14
	50 D	5.9	2.40	5.10	1.60	73.3	8.30	102.80	11.40	112.40	0.12	34.75	0.31	25.6	8.15
	100 S	0.1	2.70	12.70	1.90	125.0	8.30	92.70	11.40	132.40	0.13	34.53	0.30	25.6	8.14
	100 D	6.0	2.40	1.50	1.20	57.3	8.30	100.00	11.10	104.90	0.10	34.81	0.26	25.6	8.16
	150 S	0.1	2.70	4.30	1.80	83.4	8.00	97.90	11.10	116.50	0.12	34.70	0.21	25.8	8.15
	150 D	7.4	2.40	0.90	1.40	50.8	8.30	96.60	11.10	100.50	0.10	34.82	0.20	25.7	8.16
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 in μM and μg/L (shaded) from irrigation wells (1-6 and 8), and an irrigation lake (IL10)on the golf course collected on July 5, 2007. Also shown are results from two monitoring wells (M-1 and M-2) at the Maluaka project site collected on June 29, 2007.

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	2.08	64.48	119.4	1672.2	2.32	32.48	524.2	14728.9	0.40	12.40	21.12	295.68	2.48	76.88	142.9	2000.3	1.377
2	2.96	91.76	134.6	1885.0	2.72	38.08	692.5	19458.7	0.48	14.88	16.00	224.00	3.44	106.64	153.4	2147.0	1.852
3	3.04	94.24	126.7	1774.1	6.00	84.00	695.9	19555.4	0.32	9.92	14.24	199.36	3.36	104.16	147.0	2057.4	2.004
4	3.28	101.68	133.2	1864.8	5.04	70.56	662.0	18602.2	0.08	2.48	2.88	40.32	3.36	104.16	141.1	1975.7	2.150
5	2.32	71.92	182.6	2557.0	3.84	53.76	565.6	15893.4	0.48	14.88	4.80	67.20	2.80	86.80	191.3	2677.9	1.547
6	2.88	89.28	165.3	2313.9	4.24	59.36	545.4	15326.9	0.40	12.40	23.68	331.52	3.28	101.68	193.2	2704.8	1.525
8	3.04	94.24	107.8	1509.8	6.96	97.44	606.5	17042.1	0.24	7.44	5.92	82.88	3.28	101.68	120.7	1690.1	1.906
IL10	4.80	148.80	63.0	882.6	73.92	1034.88	444.9	12501.1	0.56	17.36	21.04	294.56	5.36	166.16	158.0	2212.0	2.099
M-1	11.20	347.20	312.2	4371.4	7.04	98.56	685.7	19267.6	0.24	7.44	2.72	38.08	11.44	354.64	322.0	4508.0	4.971
M-2	4.72	146.32	387.8	5428.6	3.68	51.52	693.9	19499.2	0.08	2.48	4.40	61.60	4.80	148.80	395.8	5541.8	2.816

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 June 2007 (Transect site 3 has been monitored since 2002). 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. All REGSLOPES bound zero indicating there is no significant change over time at any of the transect sites. 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	548.55	9.14	525.04	572.05
REGSLOPE	**-1.37**	**4.48**	**-11.23**	**8.50**
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	441.73	19.61	393.73	489.72
REGSLOPE	**-6.38**	**17.21**	**-44.27**	**31.51**
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	1084.54	128.10	755.25	1413.84
REGSLOPE	**19.00**	**45.27**	**-106.69**	**144.70**
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	608.00	17.70	562.50	653.49
REGSLOPE	**-10.60**	**14.57**	**-42.66**	**21.47**

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	-15.71	0.30	-16.49	-14.93
REGSLOPE	**0.05**	**0.13**	**-0.23**	**0.33**
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	-12.55	0.59	-13.99	-11.10
REGSLOPE	**0.19**	**0.49**	**-0.89**	**1.27**
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	-31.05	3.69	-40.53	-21.56
REGSLOPE	**-0.54**	**1.29**	**-4.12**	**3.05**
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	-17.25	0.53	-18.62	-15.89
REGSLOPE	**0.32**	**0.41**	**-0.59**	**1.22**

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 June 2007 (Transect site 3 has been monitored since 2002). 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. All REGSLOPES bound zero indicating there is no significant change over time at any of the transect sites. 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	282.52	11.27	253.54	311.50
REGSLOPE	**1.65**	**4.93**	**-9.20**	**12.51**
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	135.29	2.07	130.23	140.34
REGSLOPE	**-0.61**	**2.20**	**-5.45**	**4.23**
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	254.57	161.65	-160.97	670.11
REGSLOPE	**-68.61**	**52.80**	**-215.22**	**78.00**
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	85.32	6.53	68.54	102.10
REGSLOPE	**-0.57**	**0.89**	**-2.53**	**1.38**

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	-8.16	0.37	-9.12	-7.20
REGSLOPE	**-0.05**	**0.14**	**-0.36**	**0.27**
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	-3.89	0.06	-4.04	-3.74
REGSLOPE	**0.02**	**0.06**	**-0.12**	**0.16**
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	-7.30	4.66	-19.26	4.67
REGSLOPE	**1.99**	**1.52**	**-2.22**	**6.21**
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	-2.45	0.20	-2.95	-1.94
REGSLOPE	**0.02**	**0.03**	**-0.04**	**0.08**

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 June 2007 (Transect site 3 has been monitored since 2002). 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	1.34	0.25	0.68	1.94
REGSLOPE	**-0.01**	**0.05**	**-0.13**	**0.11**
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	0.23	0.27	-0.42	0.88
REGSLOPE	**-0.10**	**0.64**	**-1.51**	**1.31**
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	-2.74	3.82	-12.56	7.07
REGSLOPE	**-0.12**	**0.88**	**-3.62**	**1.27**
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	2.02	0.57	0.55	3.49
REGSLOPE	**-0.02**	**0.48**	**-1.08**	**1.03**

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	-0.06	-0.02
REGSLOPE	**0.00**	**0.00**	**0.00**	**-0.06**
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
REGSLOPE	**0.00**	**0.16**	**-0.04**	**0.04**
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	0.08	0.01	-0.20	0.36
REGSLOPE	**0.00**	**0.03**	**-0.04**	**0.10**
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	-0.05	0.02	-0.10	-0.01
REGSLOPE	**0.00**	**0.01**	**-0.03**	**0.03**

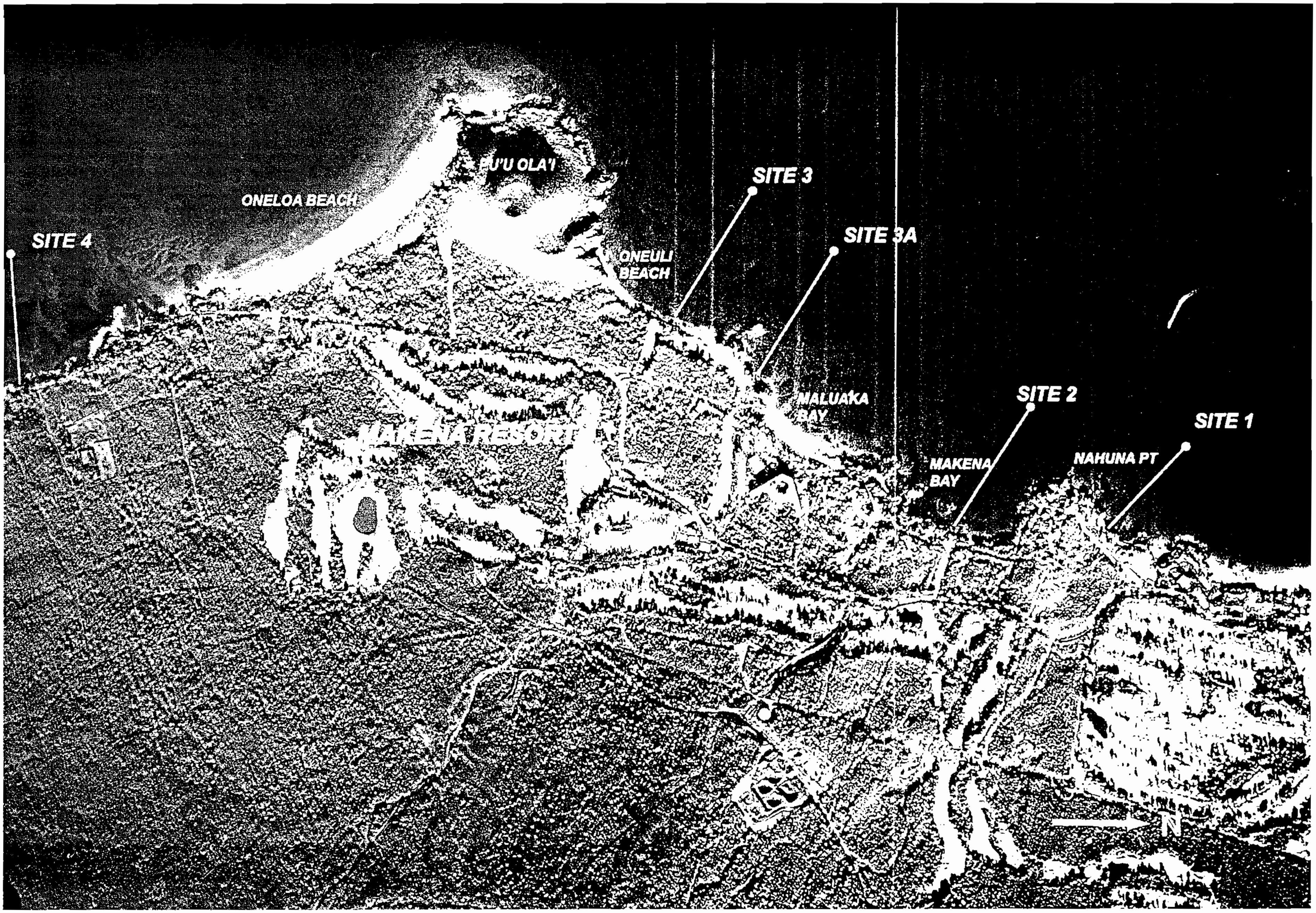

FIGURE 1. Aerial photograph of Makena Resort on southwest coastline of Maui. Also shown are locations of five water sampling transects that extend from the shoreline to 150-200 m from shore. The southern end of the Wailea golf course is visible at right.

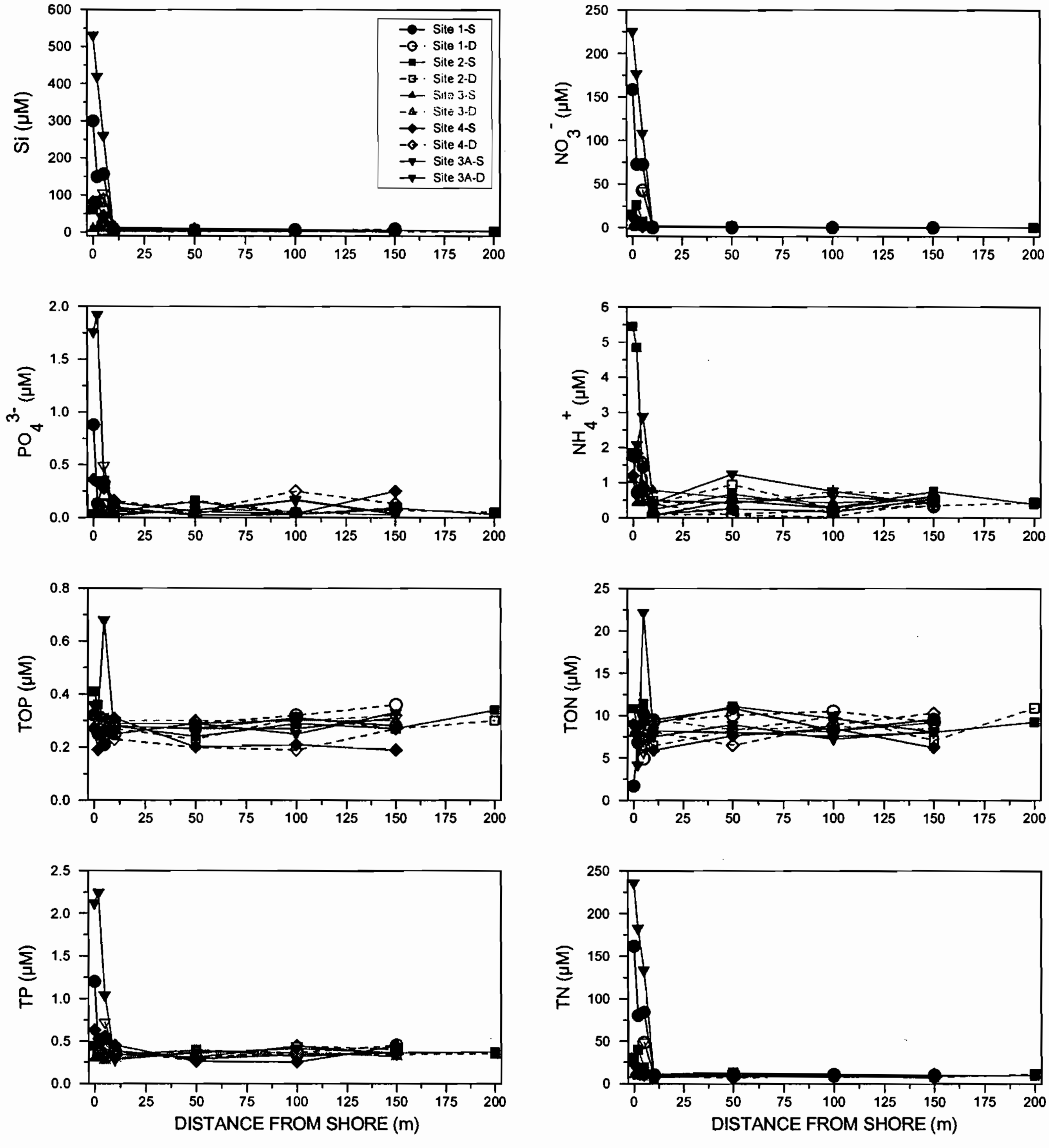

FIGURE 2. Plots of dissolved nutrients in surface (S) and deep (D) samples collected on June 29, 2007 as a function of distance from the shoreline in the vicinity of the Makena Resort. For site locations, see Figure 1.

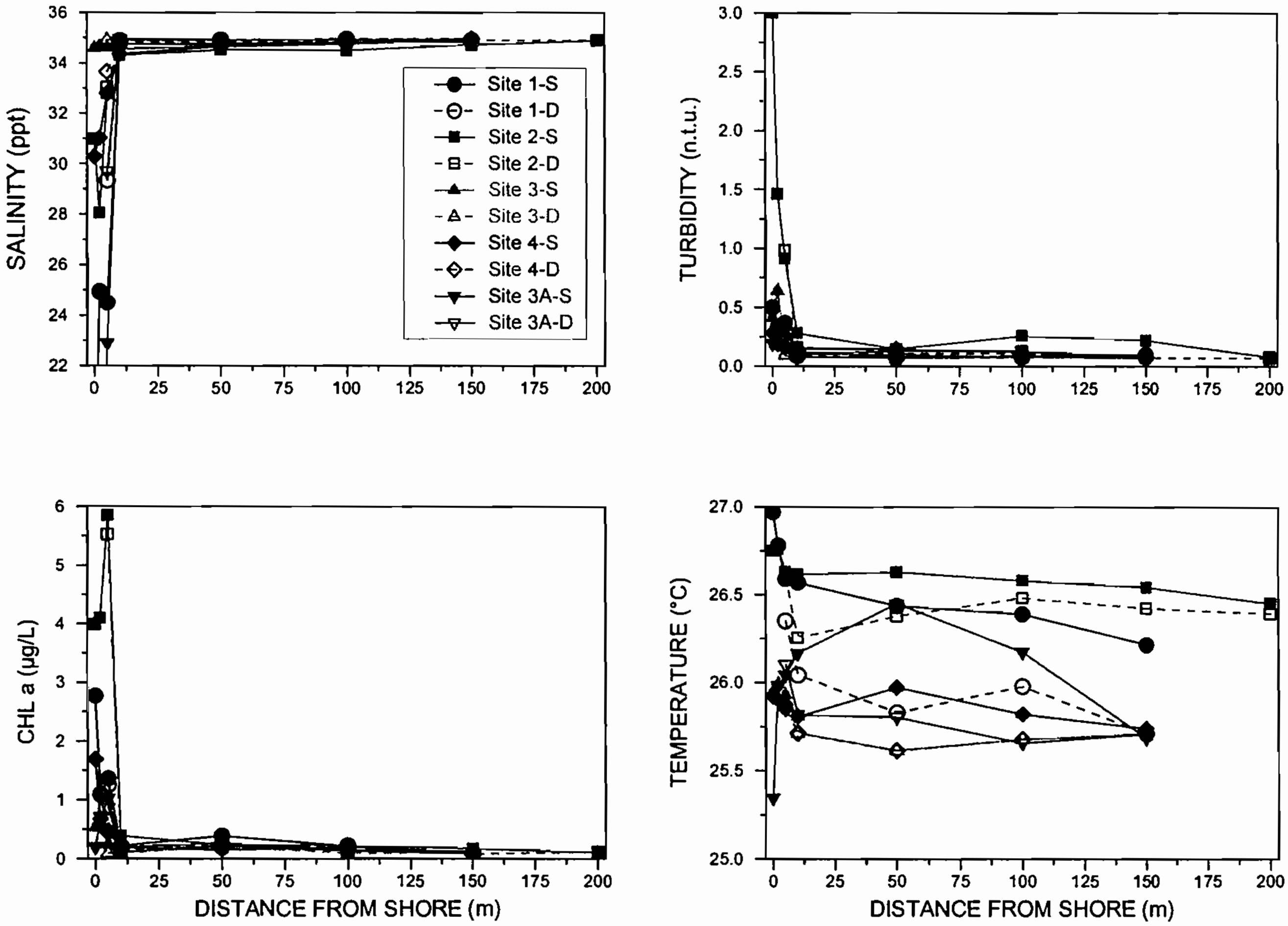

FIGURE 3. Plots of water chemistry constituents in surface (S) and deep (D) samples collected on June 29, 2007 as a function of distance from the shoreline in the vicinity of Makena Resort. For site locations, see Figure 1.

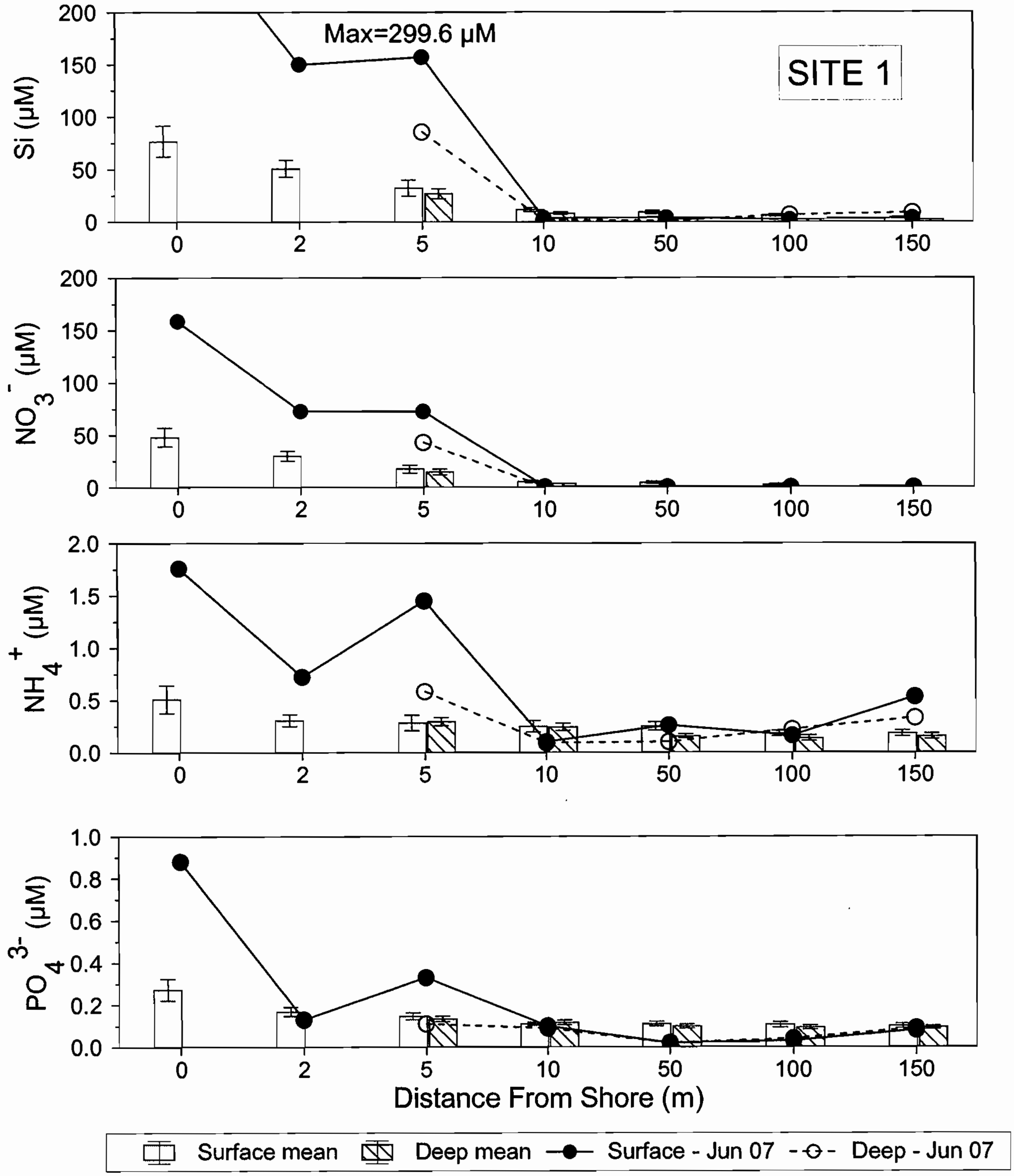

FIGURE 4. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

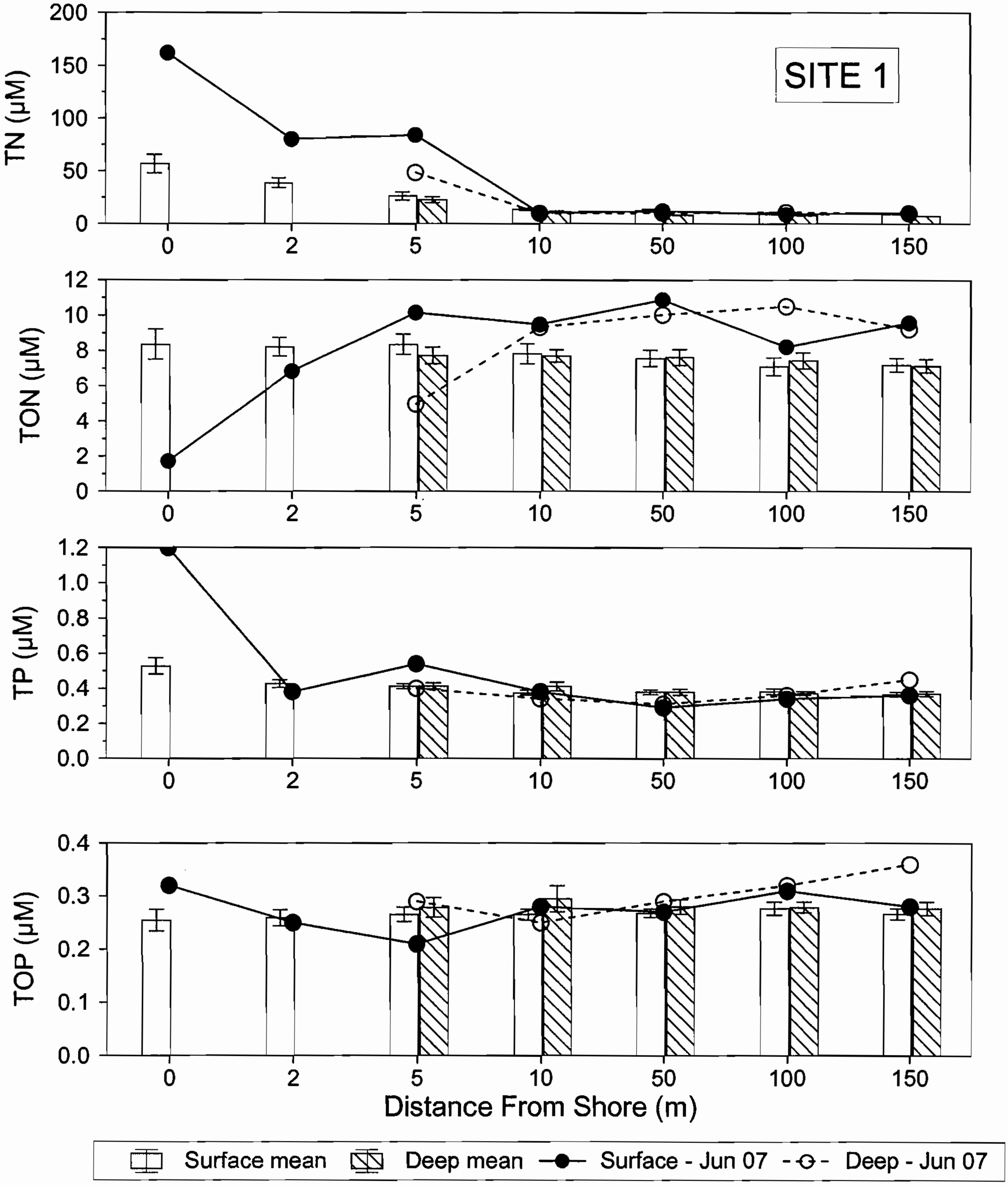

FIGURE 5. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

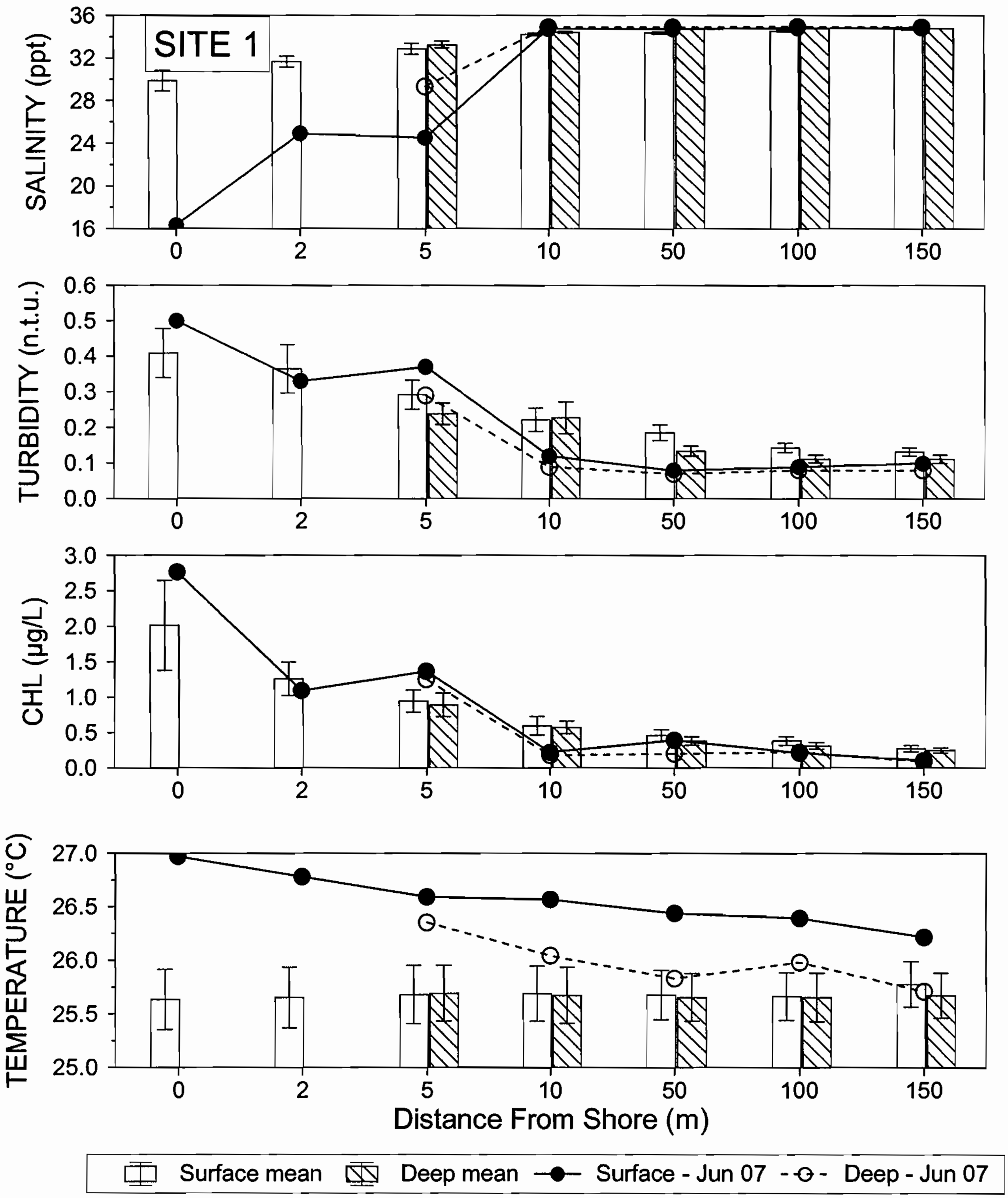

FIGURE 6. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

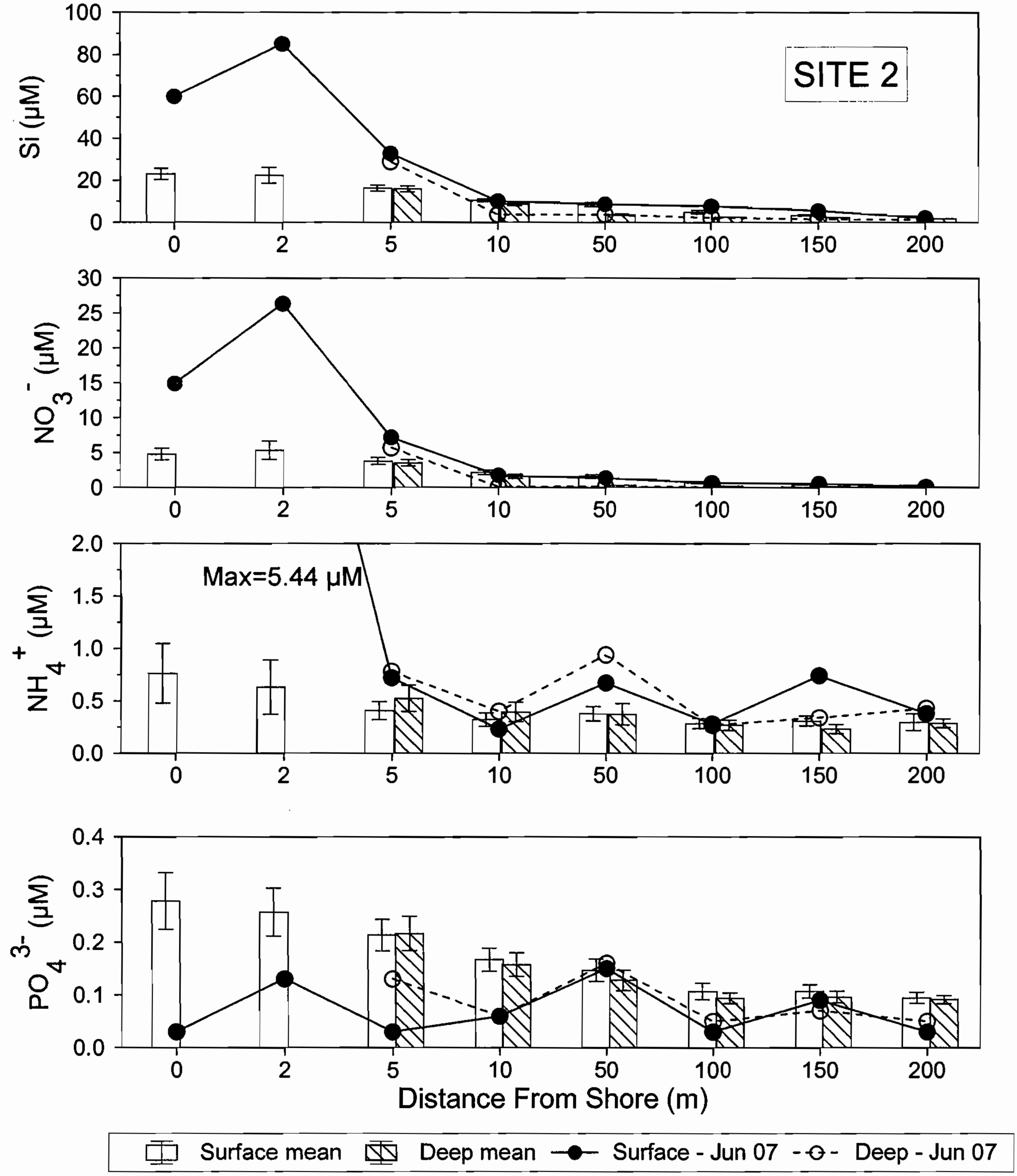

FIGURE 7. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

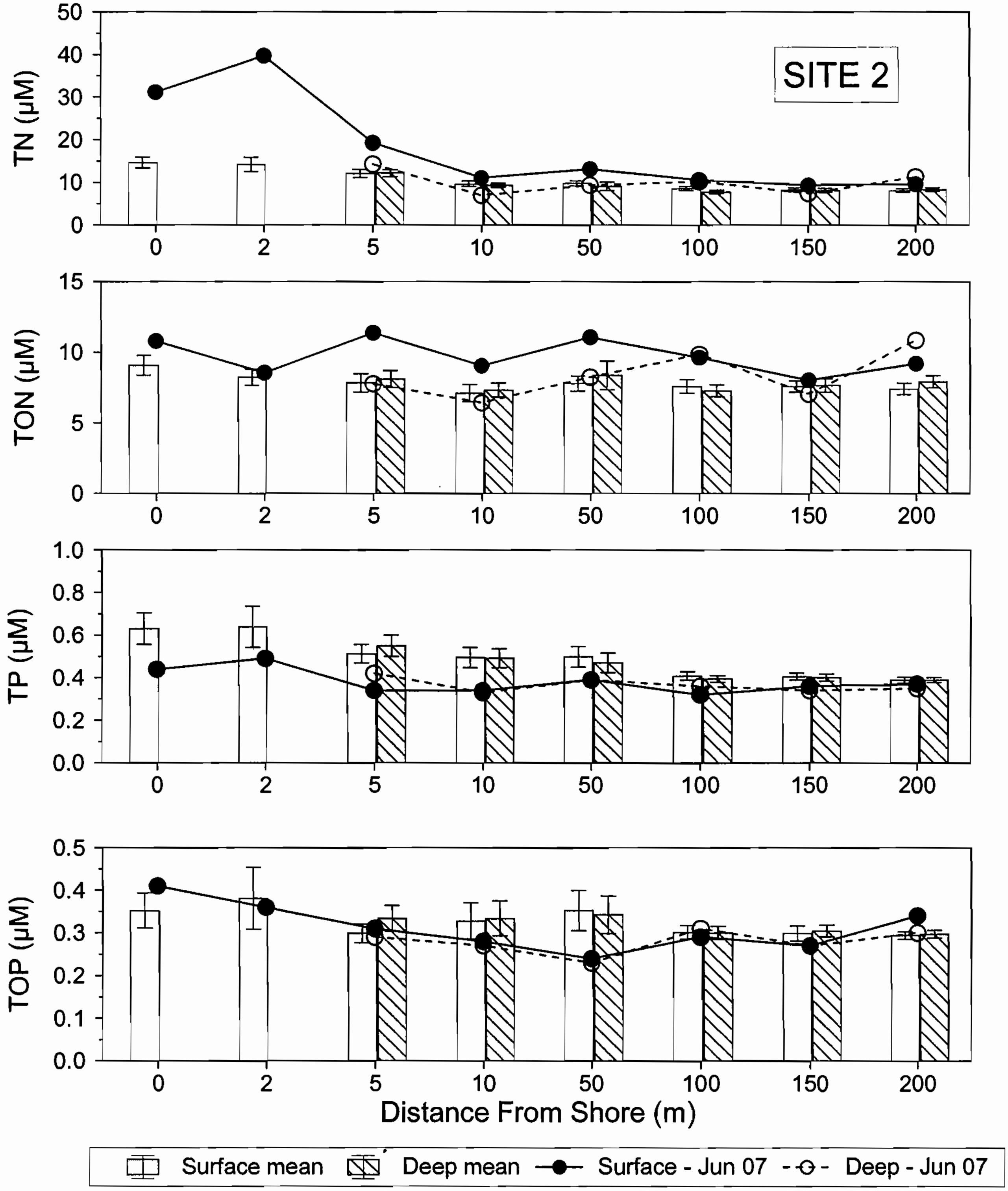

FIGURE 8. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

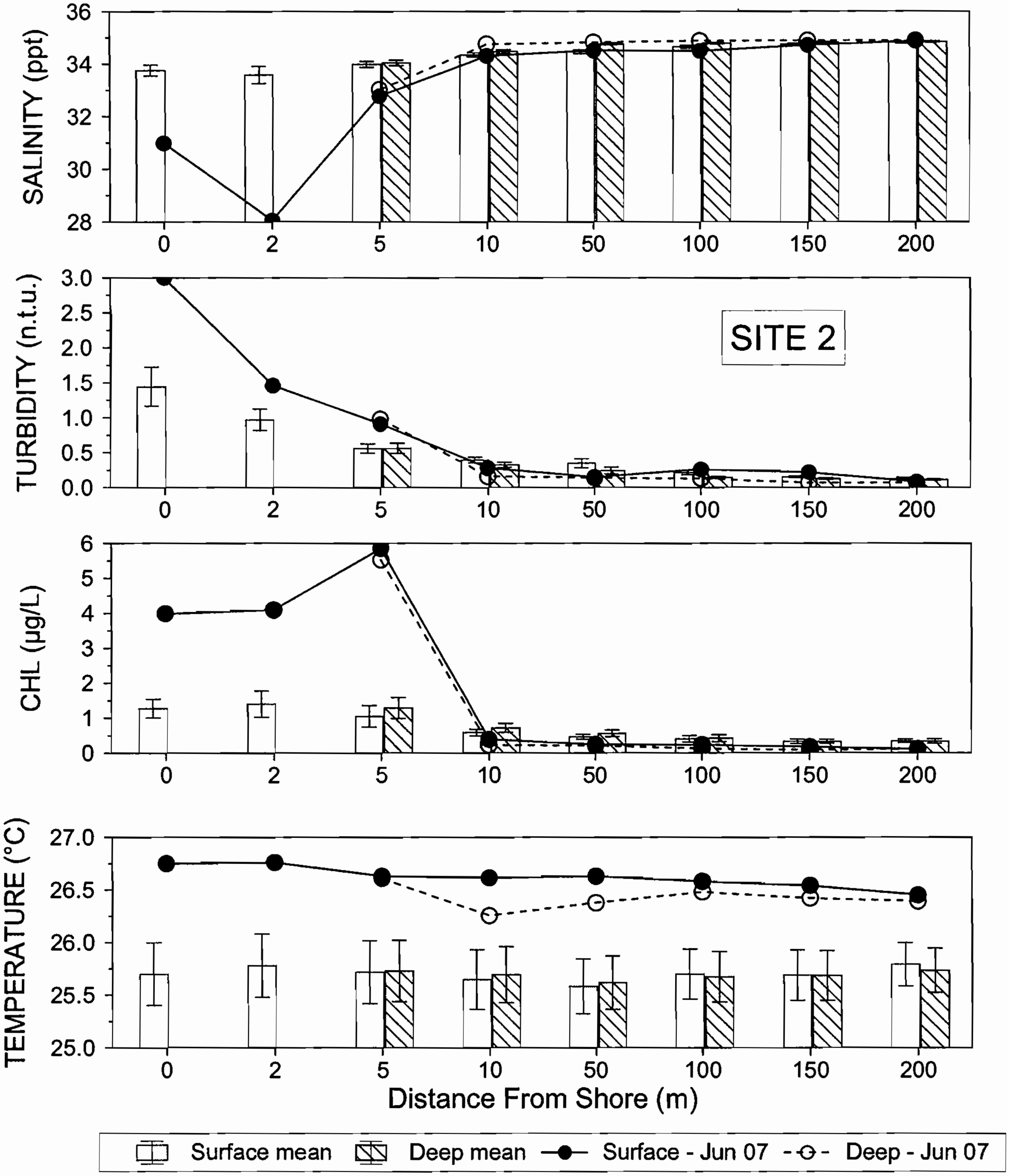

FIGURE 9. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey,bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

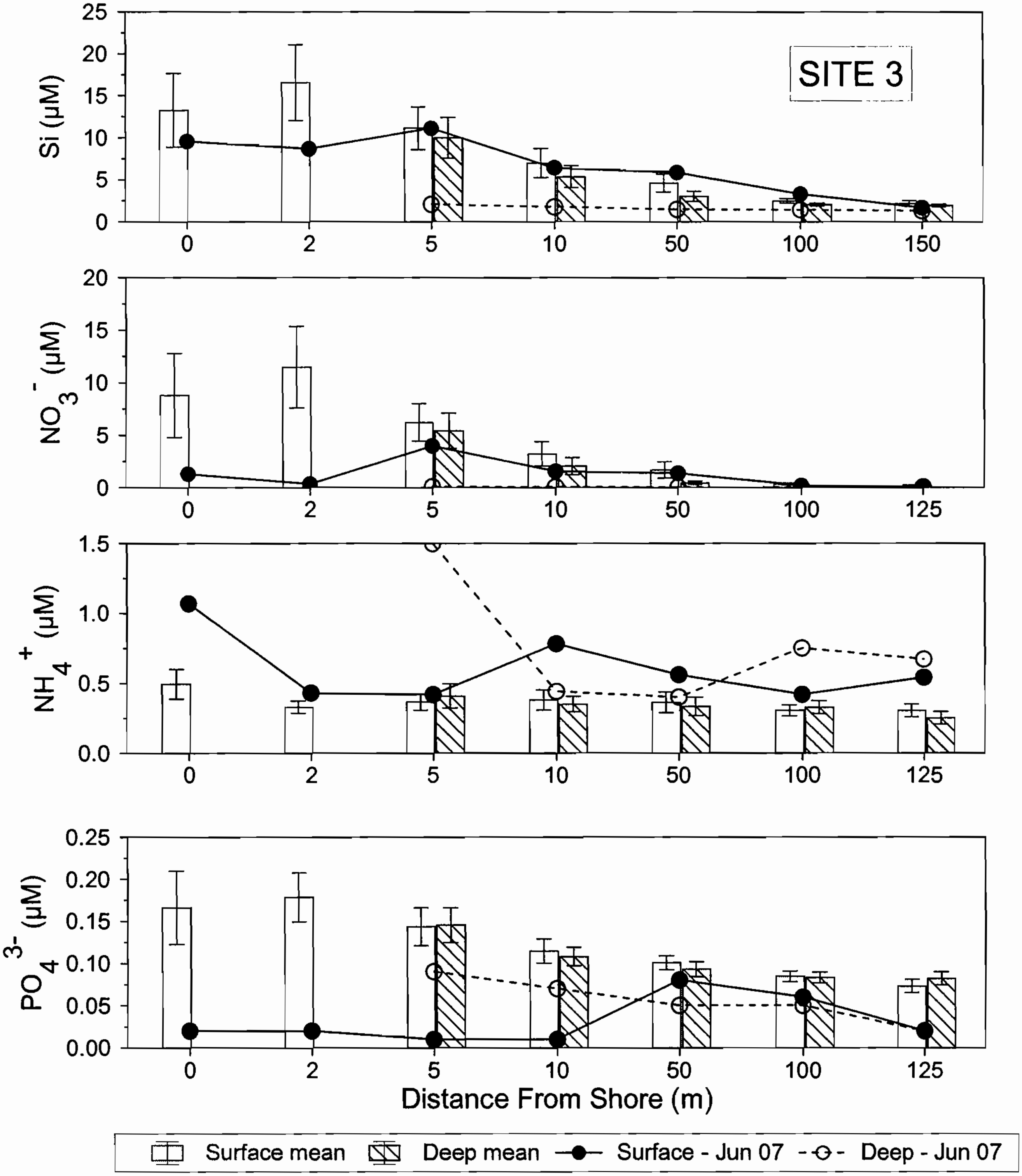

FIGURE 10. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

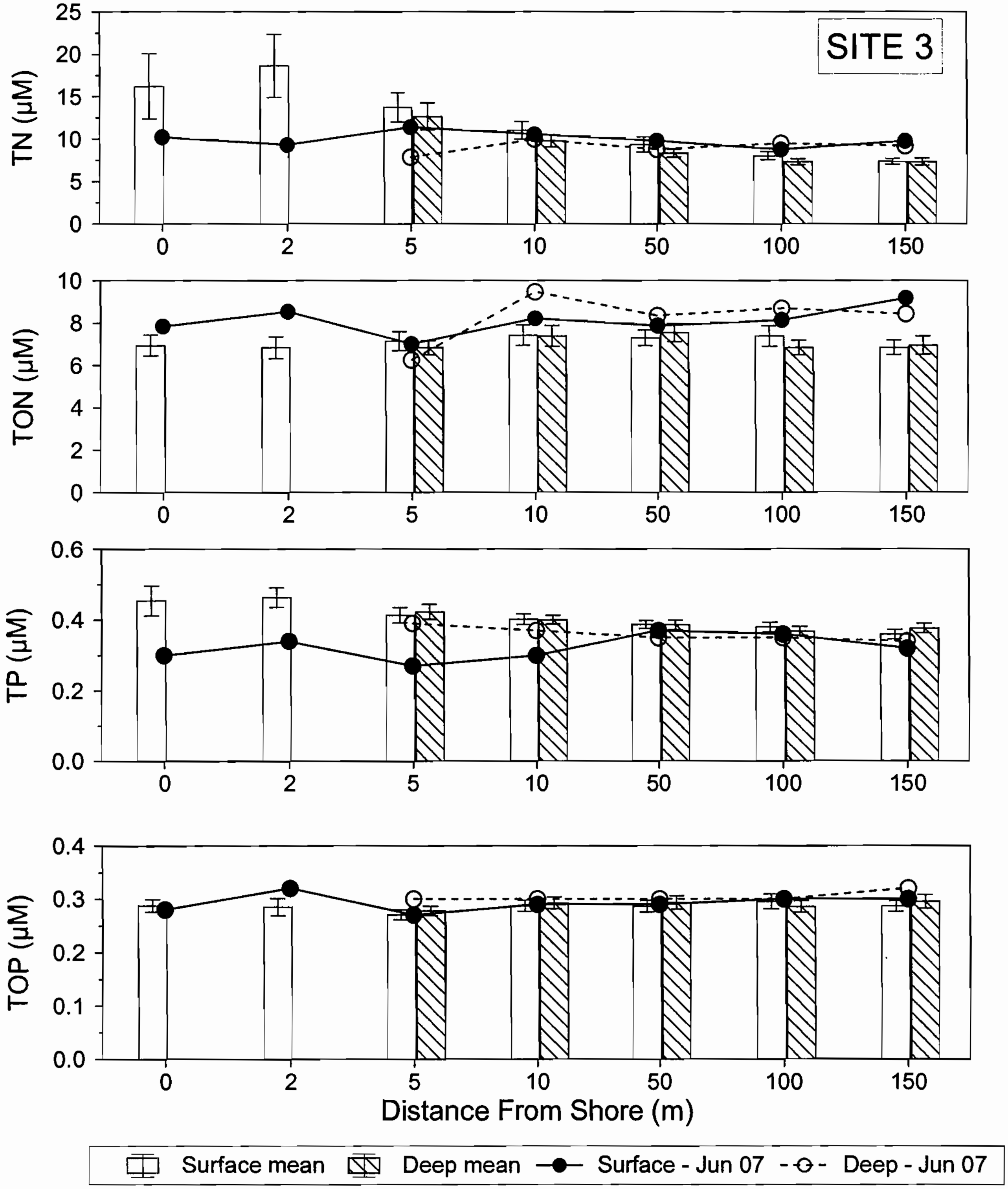

FIGURE 11. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

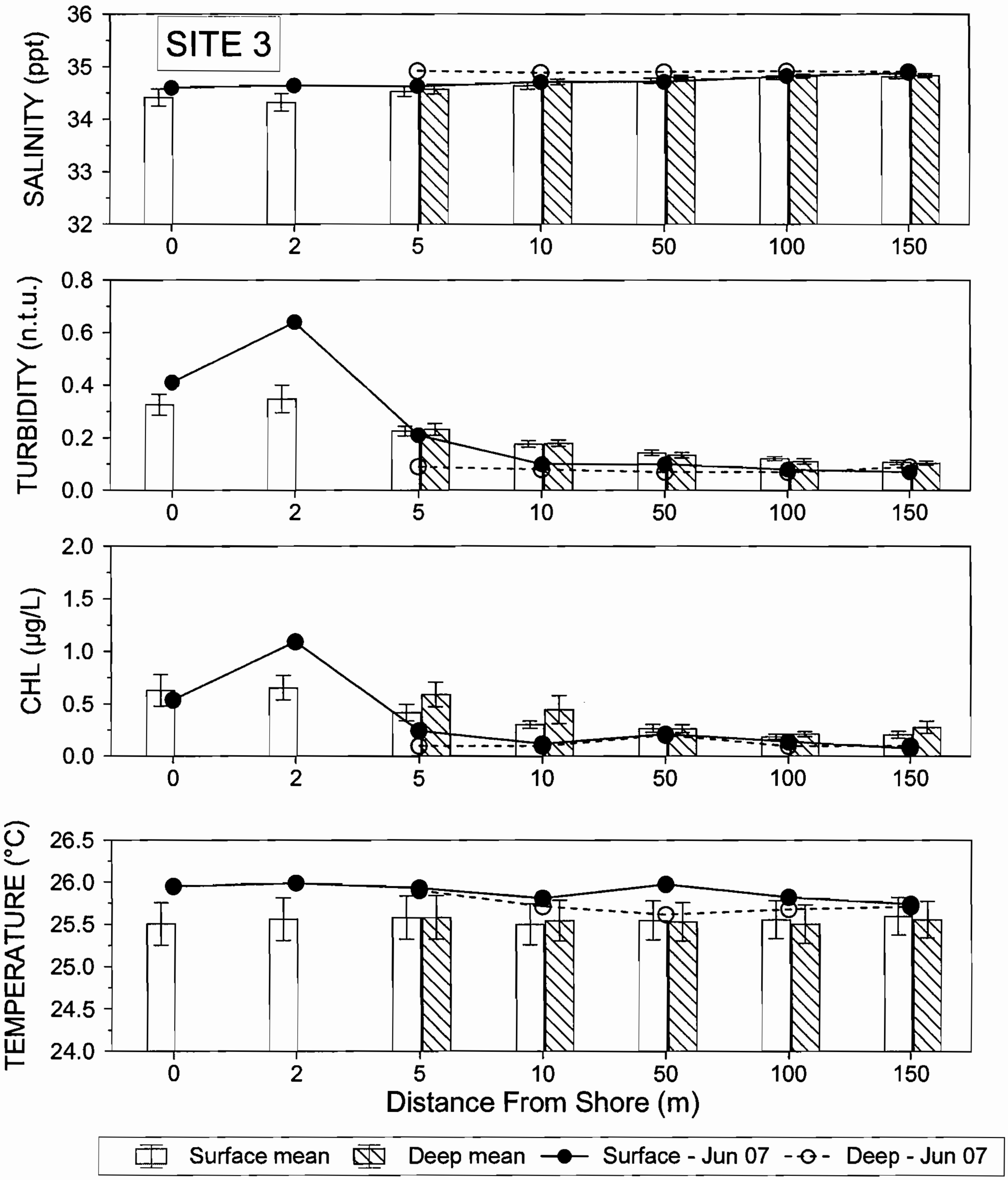

FIGURE 12. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

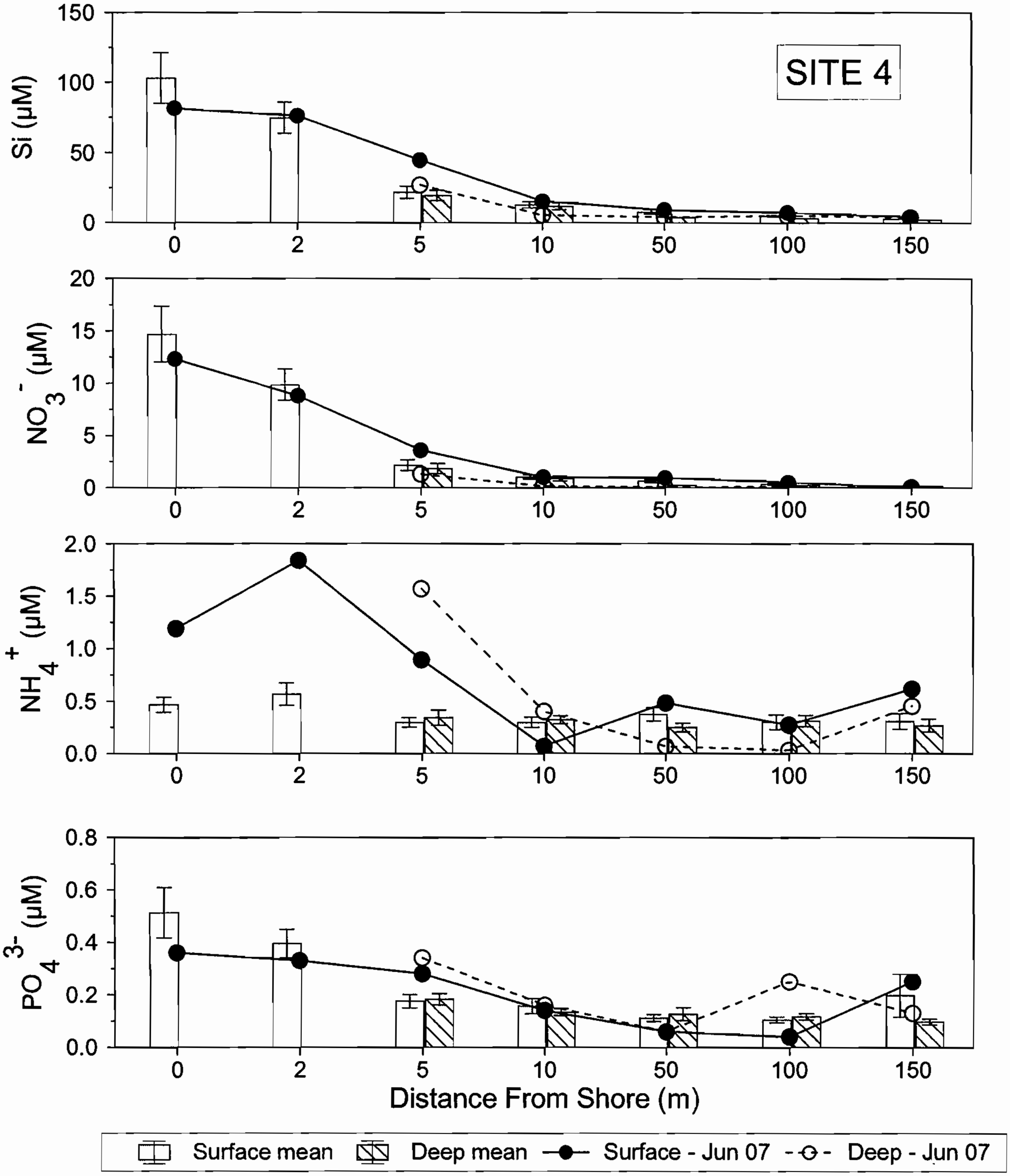

FIGURE 13. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

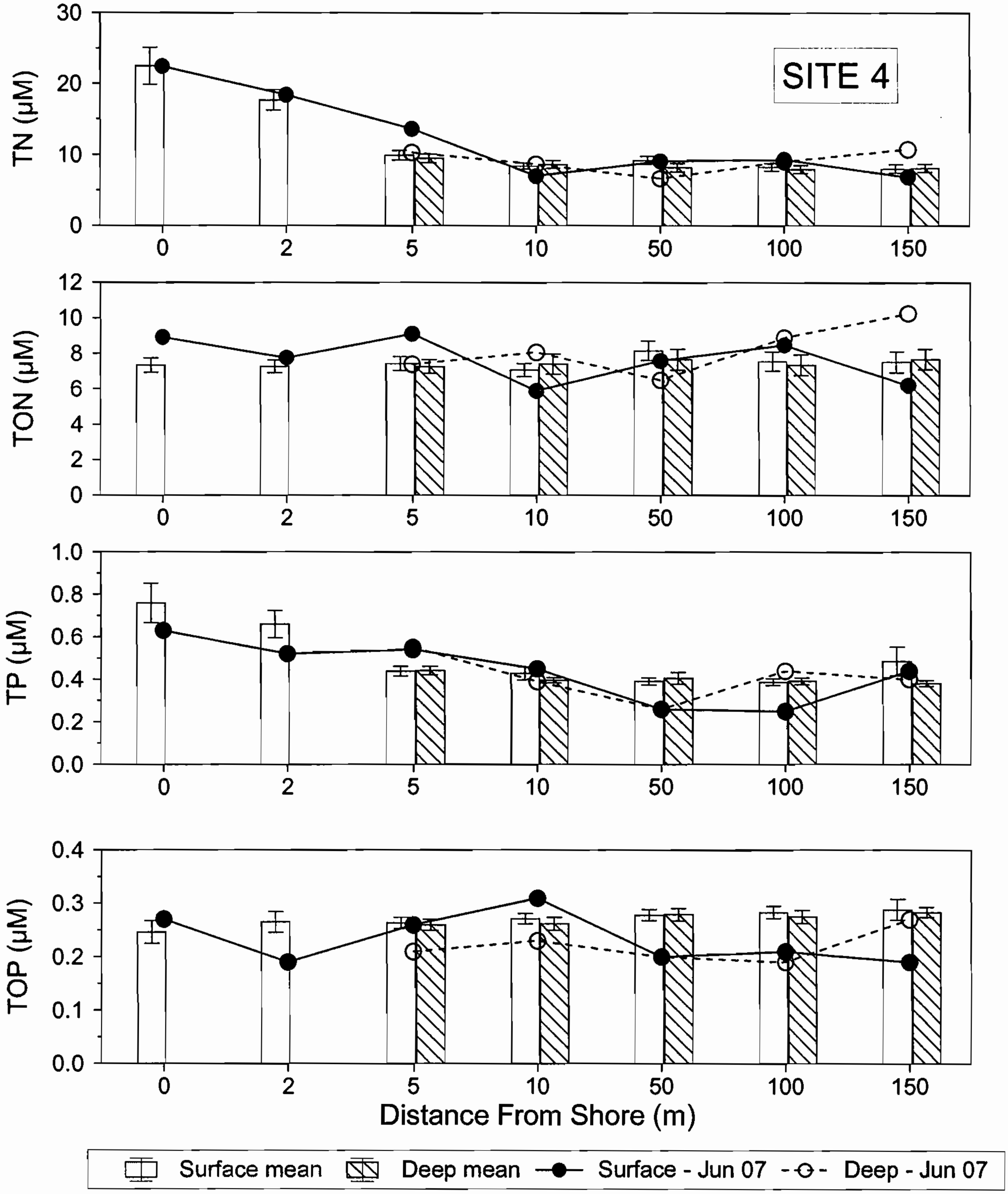

FIGURE 14. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

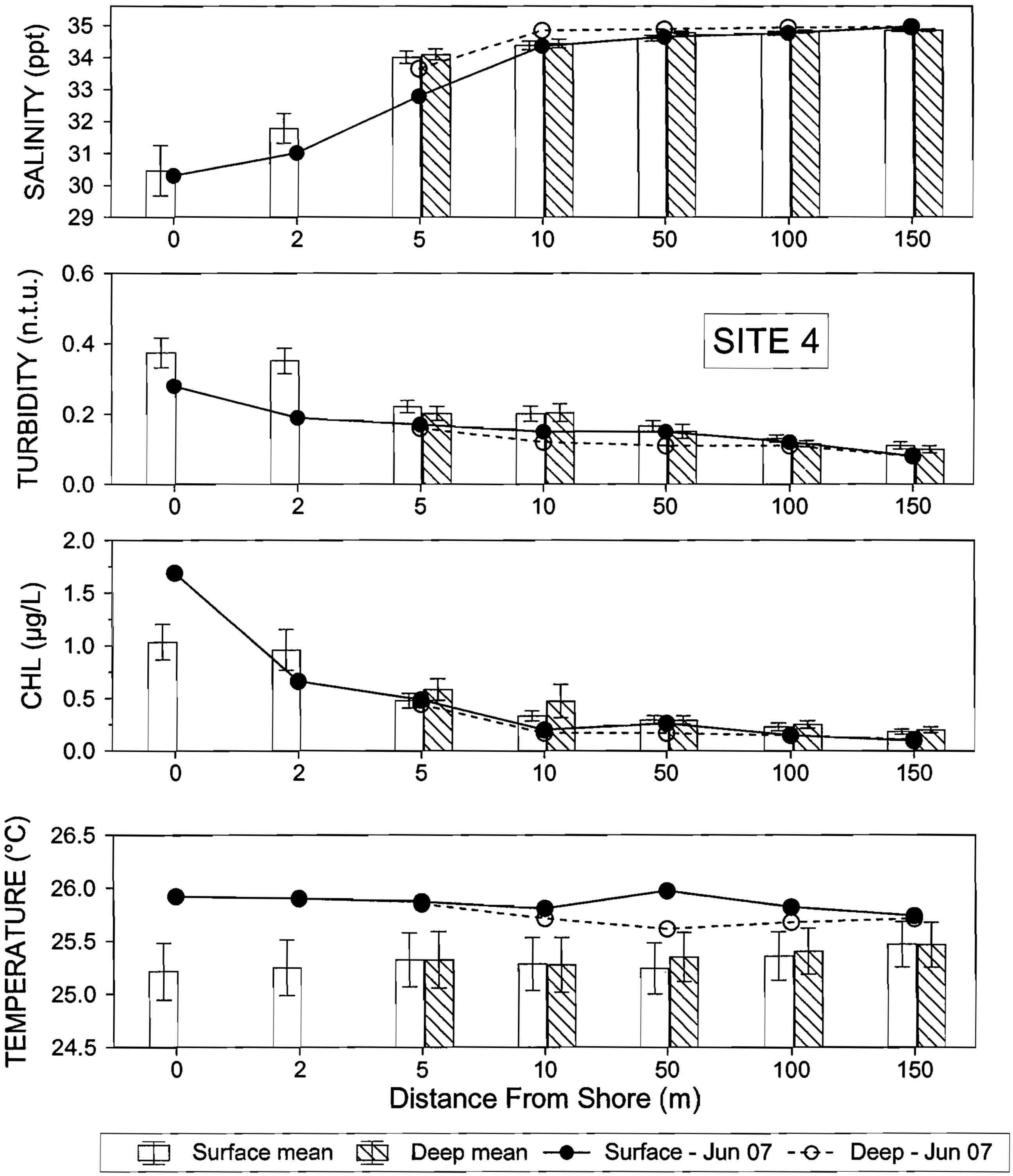

FIGURE 15. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

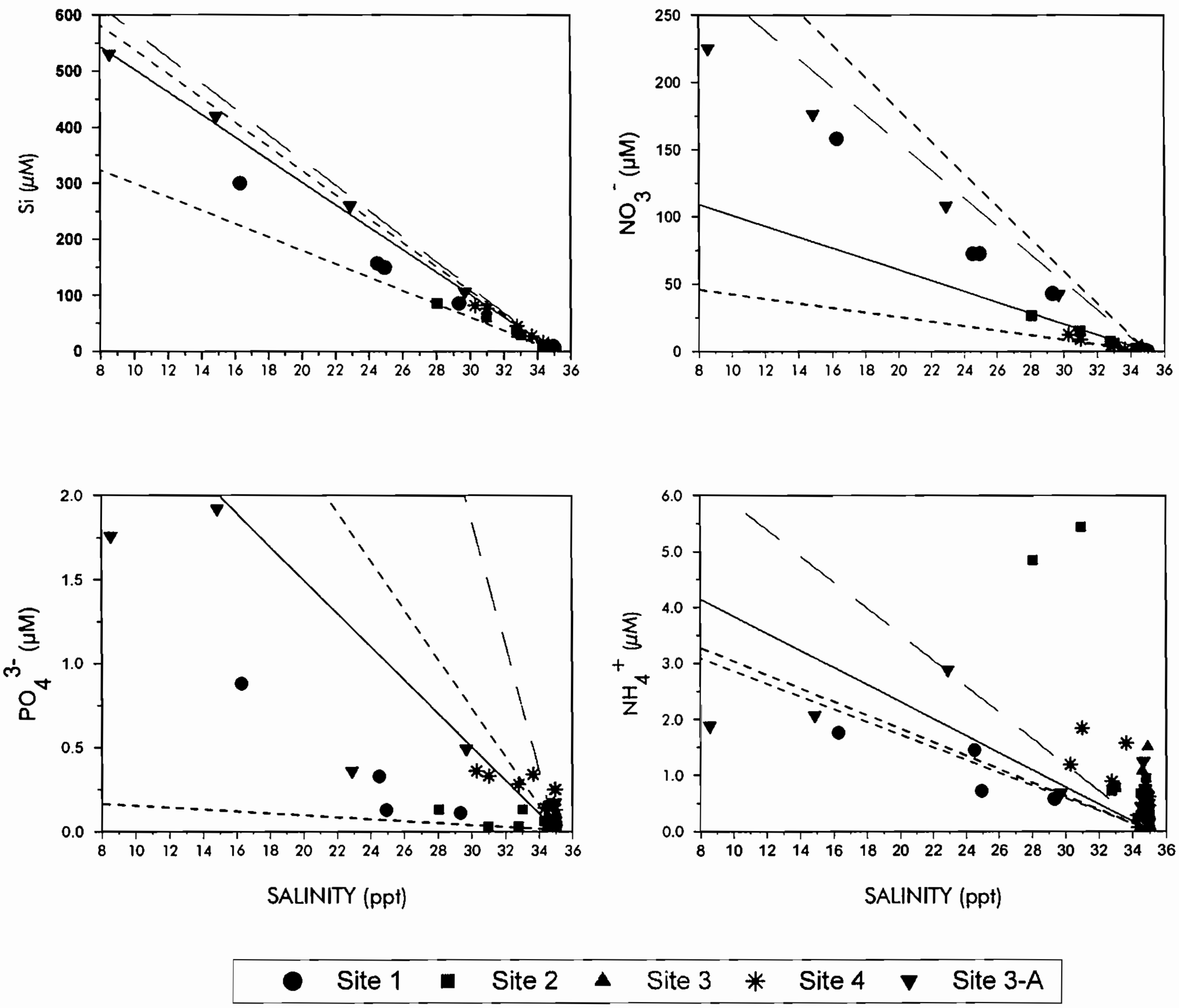

FIGURE 16. Mixing diagram showing concentration of dissolved nutrients from samples collected offshore of the Makena Resort on June 29, 2007 as functions of salinity. Solid red line in each plot is conservative mixing line constructed by connecting the concentrations in open coastal water with water from a golf course irrigation well. Dotted black line is mixing line constructed from open coastal water with water from irrigation lake 10 used to feed both North and South golf courses. Green and blue lines were constructed by connecting the concentrations in open coastal water with water from two monitoring wells sampled in June 2007. For sampling site locations, see Figure 1.

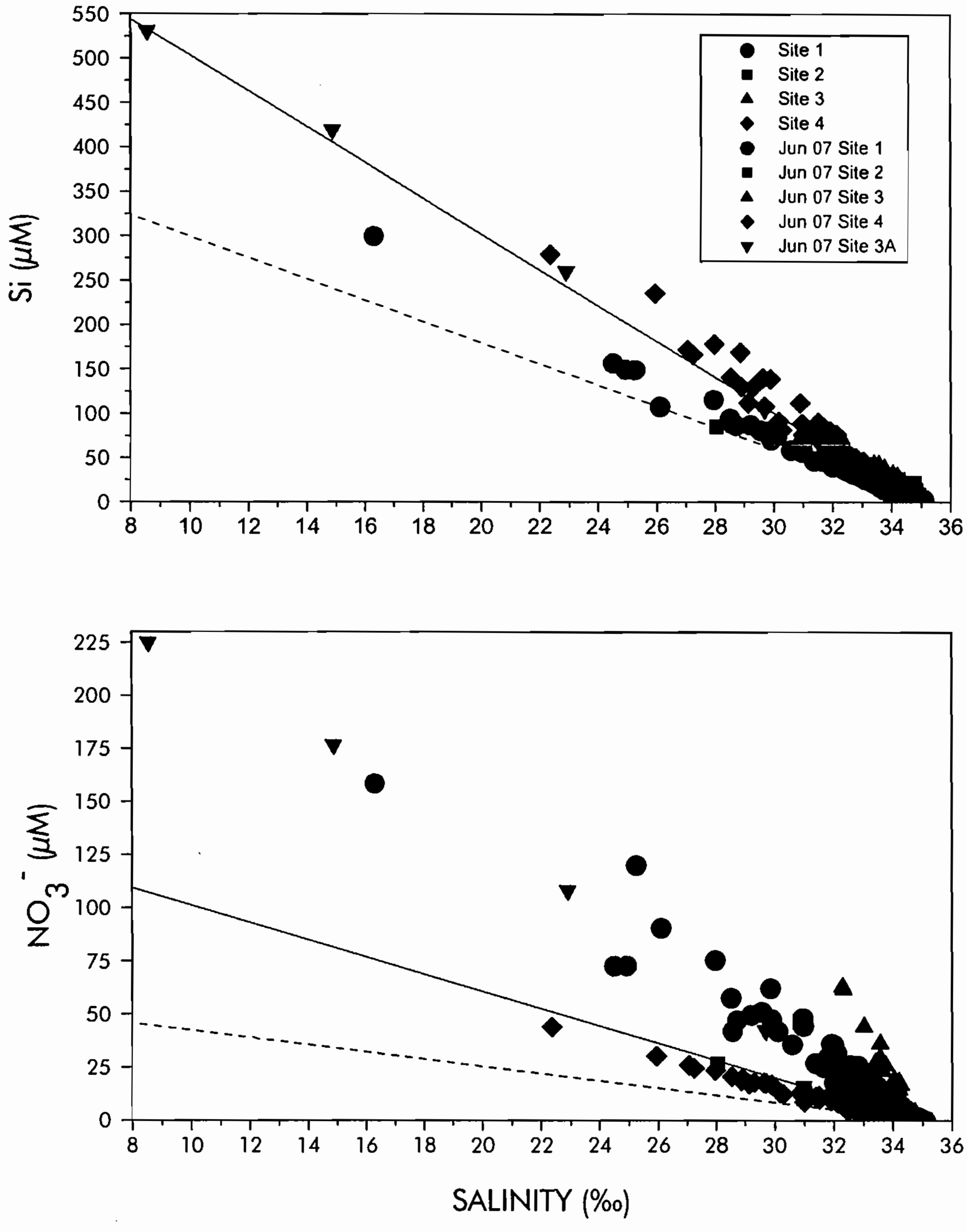

FIGURE 17. Silicate and nitrate, plotted as a function of salinity for surface samples collected since August 1995 at four sites offshore of the Makena Golf Course. Black symbols represent combined data from surveys conducted between August 1995 and June 2007. Red symbols are data from most recent survey. Solid red line in each plot is conservative mixing line constructed by connecting the concentrations in open coastal water with water from a golf course irrigation well. Dotted black line is mixing line constructed from open coastal water with water from irrigation lake 10 used to feed both North and South golf courses. For sampling site locations, see Figure 1.

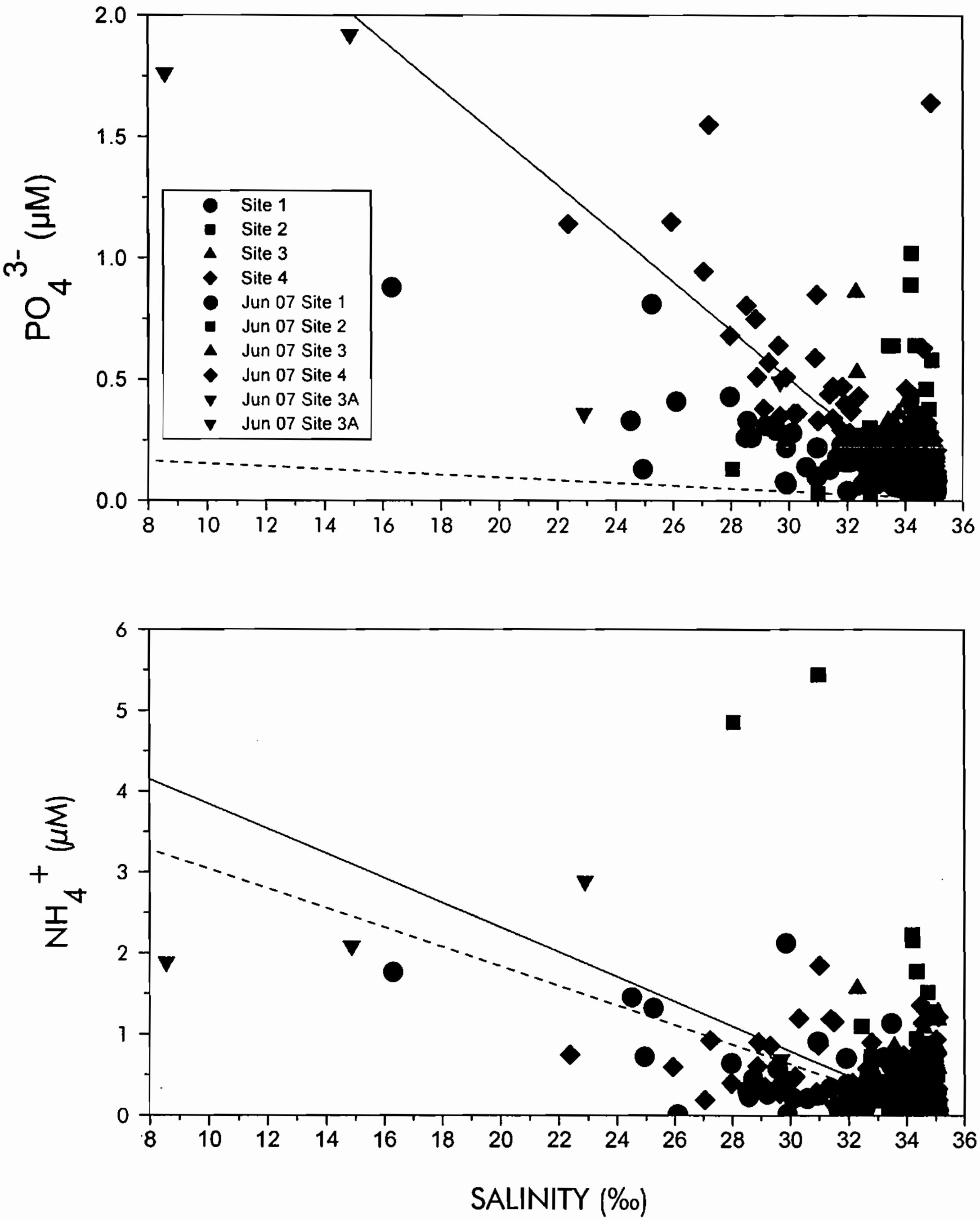

FIGURE 18. Phosphate and ammonium, plotted as a function of salinity for surface samples collected since August 1995 at four sites offshore of the Makena Resort. Black symbols represent combined data from surveys conducted between August 1995 and June 2007. Red symbols are data from current survey. Solid red line in each plot is conservative mixing line constructed by connecting the concentrations in open coastal water with water from a golf course irrigation well. Dotted black line is mixing line constructed from open coastal water with water from irrigation lake 10 used to feed both North and South golf courses. For sampling site locations, see Figure 1.

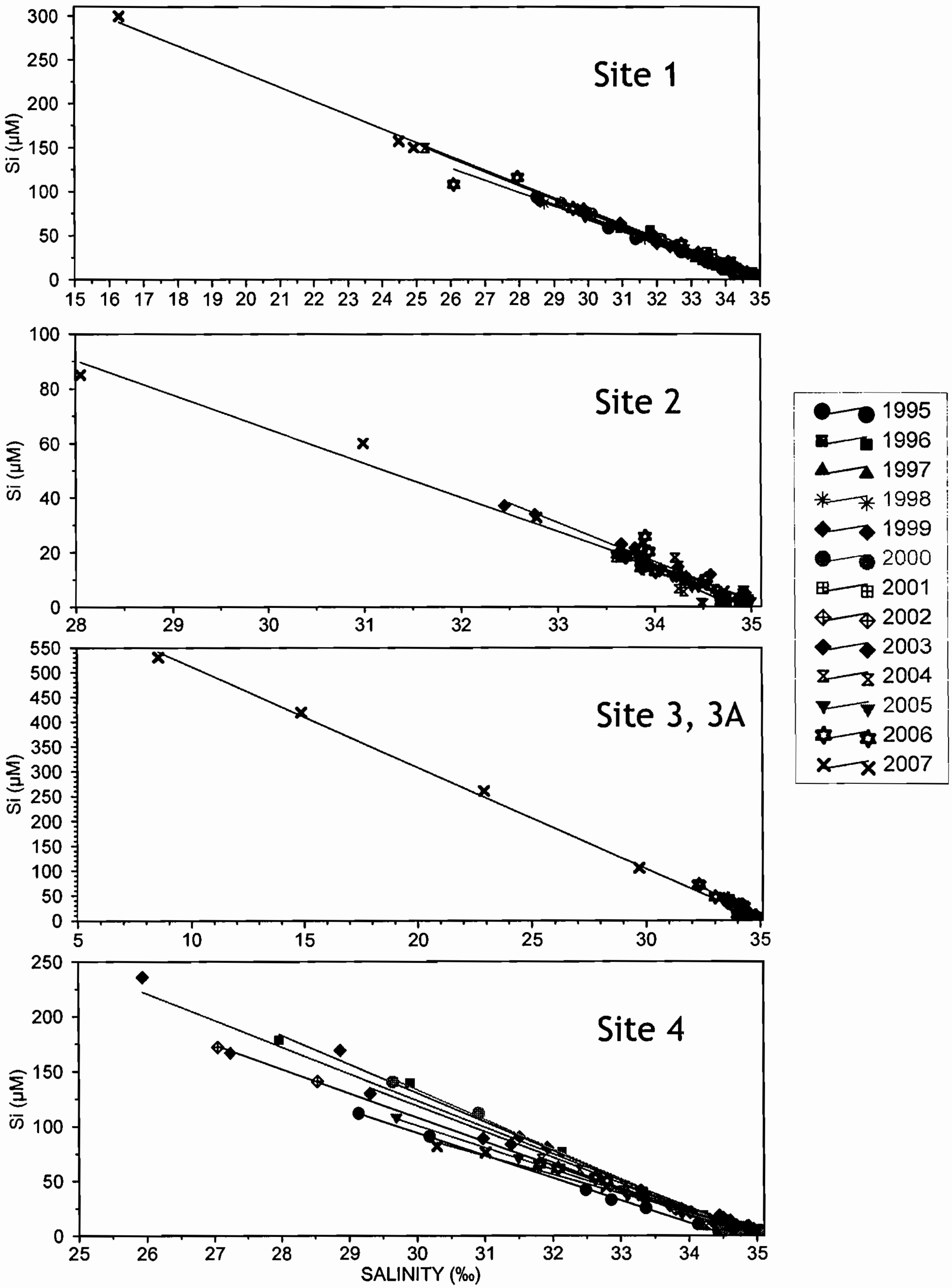

FIGURE 19. Mixing diagram showing yearly concentrations of silica as functions of salinity from samples collected during annual monitoring surveys at four transect sites offshore of the Makena Resort. Note axis scale changes between sites. Straight lines are linear regressions through data points for each year. For sampling site locations, see Figure 1.

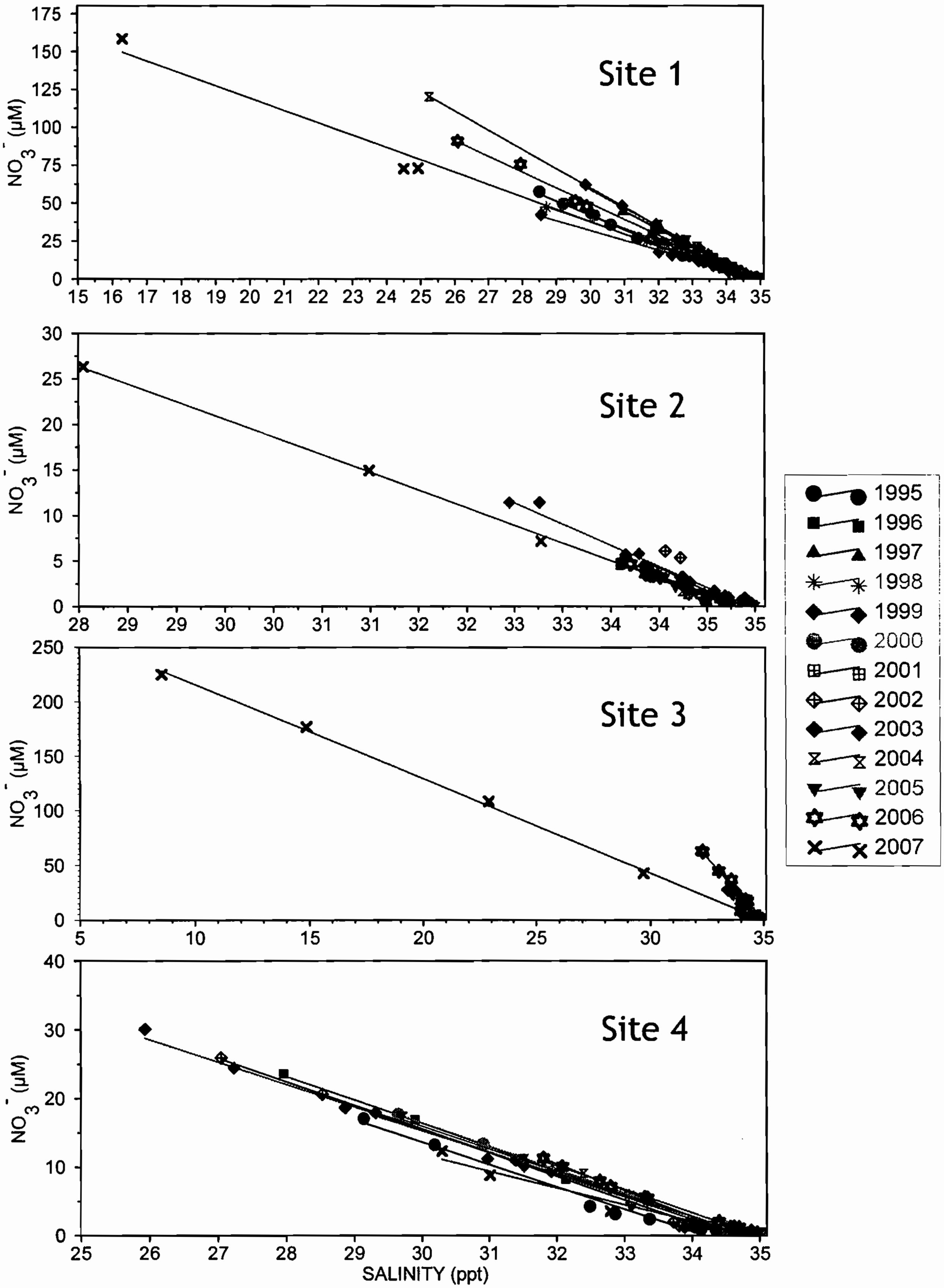

FIGURE 20. Mixing diagram showing yearly concentrations of nitrate as functions of salinity from samples collected during annual monitoring surveys at four transect sites offshore of the Makena Resort. Note axis scale changes between sites. Straight lines are linear regressions through data points for each year. For sampling site locations, see Figure 1.

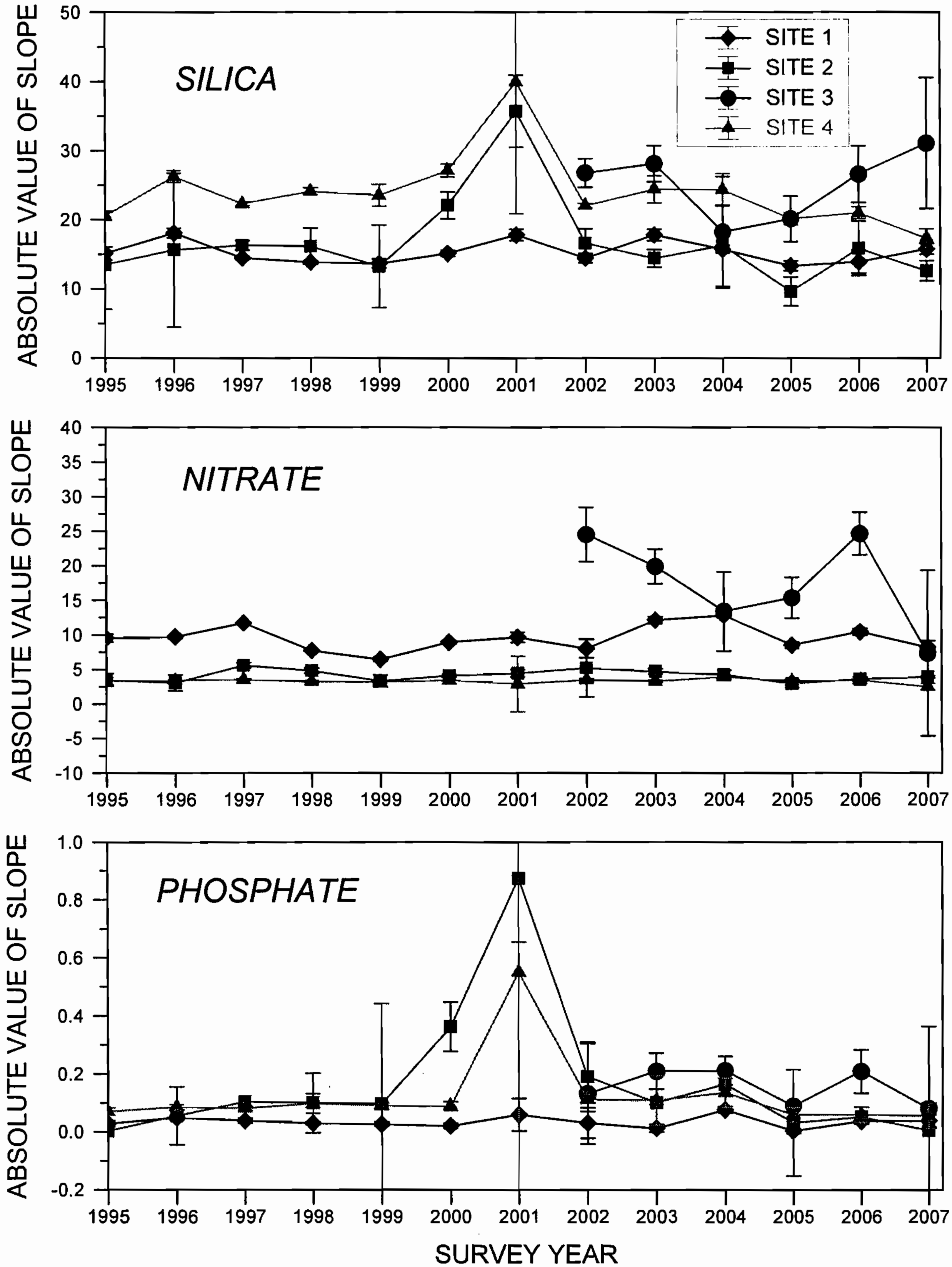

FIGURE 21. Time-course plots of absolute values of slopes of linear regressions of concentrations of silica, nitrate and phosphate as functions of salinity collected annually at each of the four transect monitoring stations off the Makena Resort. Error bars are 95% confidence limits. For locations of sampling transect sites, see Figure 1.

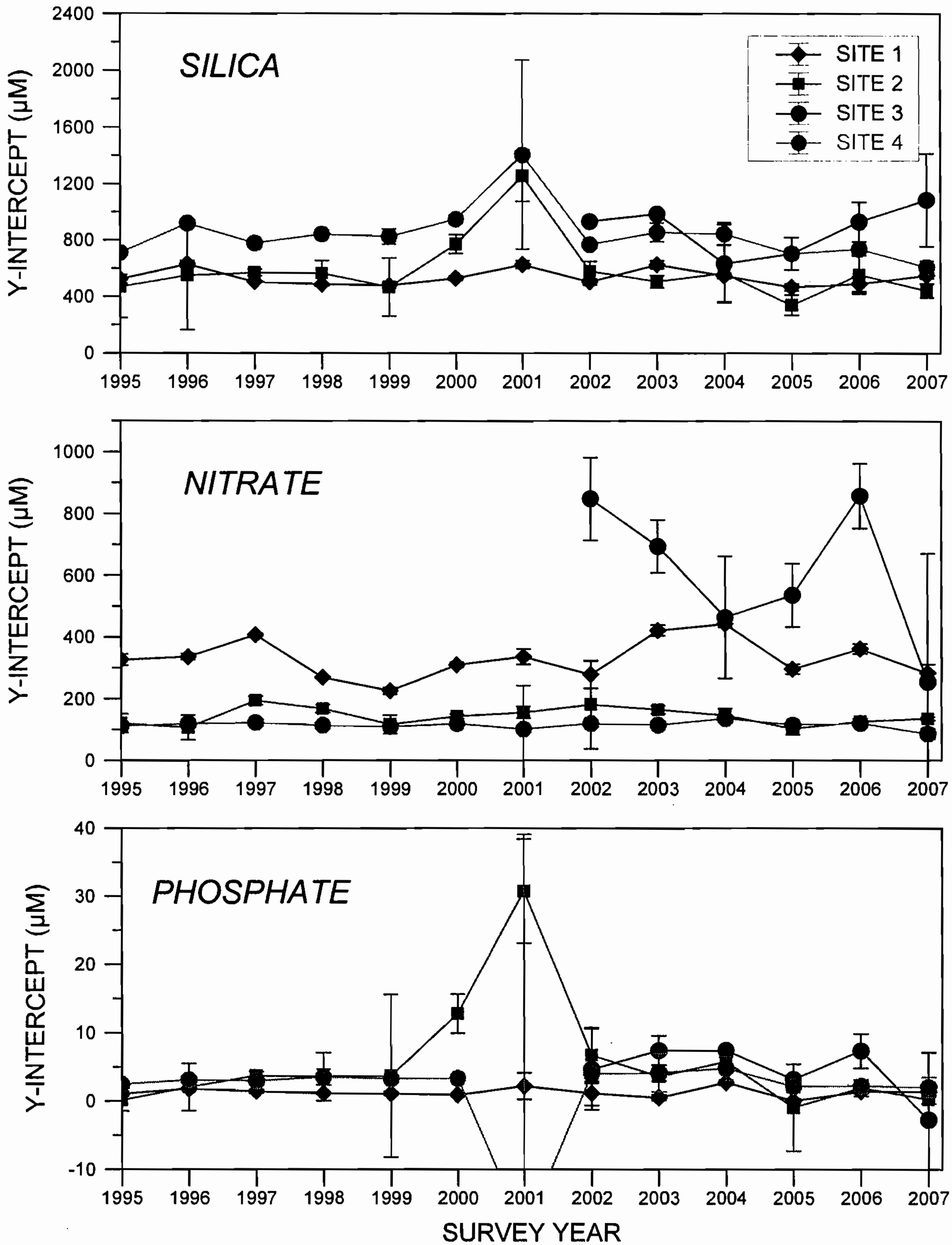

FIGURE 22. Time-course plots of Y-intercepts of linear regressions of concentrations of silica, nitrate and phosphorus as functions of salinity collected annually at each of the four transect monitoring stations off the Makena Resort. Error bars are 95% confidence limits. For locations of sampling transect sites, see Figure 1.

LINDA LINGLE
GOVERNOR OF HAWAII

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

CHIYOME L. FUKINO, M.D.
DIRECTOR OF HEALTH

In reply, please refer to:
DOH/CWB

RECEIVED
MAR 13 2008
Dowling Company, Inc.

March 10, 2008

03029MWO.08

Mr. Don Fujimoto
Dowling Company, Inc.
2005 Main Street
Wailuku, Maui, Hawaii 96793

Dear Mr. Fujimoto:

Subject: **Letter of Acceptance for Makena Resort Marine Water Quality Monitoring Reports dated September 15, 2007 and March 5, 2007, in compliance with Condition No. 10 of the State Land Use Commission Decision and Order LUC Docket No. A97-721**

We have reviewed and accepted the subject reports transmitted to the Department of Health, Clean Water Branch (CWB), on December 12, 2007.

The CWB will be utilizing the information in the reports for our 2008 Integrated 303d/305b Report to the U.S. Environmental Protection Agency.

We thank you for this opportunity to review your reports.

Sincerely,

ALEC WONG, P.E., CHIEF
Clean Water Branch

WTO:rg

EXHIBIT "A-1"

MARINE WATER QUALITY MONITORING
MAKENA RESORT, MAKENA, MAUI
WATER CHEMISTRY
REPORT 2-2007

Prepared for

Makena Land LLC

2005 Main St.

Wailuku, Maui, Hawaii 96793

By

Marine Research Consultants, Inc.

1039 Waakaua Pl.

Honolulu, Hawaii 96822

February 22, 2008

EXHIBIT "B"

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. 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, there are few, if any, effects that have been documented to be considered detrimental to the marine ecosystem. Thus, there is no a *priori* reason to suspect that the construction and responsible operation of the golf courses and other components of the Makena Resort will cause any harmful changes to the marine environment. Nevertheless, in the interest of assuring maintenance of environmental quality, and as a means of ensuring that proper procedures are set forth, a condition of the Land Use Commission District Boundary Amendment for the project was the implementation of an ongoing marine monitoring program off the Makena Resort Development. 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 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. These studies also fulfill 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. The following report presents the results of the twentieth increment in the monitoring program, and contains data from water chemistry sampling conducted on December 9, 2007.

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 9, 2007, three days after a major storm front moved through the South Maui area. Rainfall was recorded at 2.95 inches in a 24-hour period between Wednesday, December 5, 2007 and Thursday, December 6, 2007, which represented the peak of the storm. The 13-year averaged rainfall data for Makena in the month of December is 3.9 inches. A significant amount of rain (1.72 inches) was also recorded on December 4, 2007, five days before sampling. The storm had subsided by the day of the survey and environmental conditions during sample collection consisted of mild winds (8-10 knots), sunny skies, and very little swell. Rainfall to the area on December 8th was recorded as 0.95 inches.

Water samples were collected at stations along transects that extend from the highest wash of waves to between125-200 meters (m) offshore, 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) of the sea surface, and a bottom sample was collected within one m of the sea floor.

Water samples from the shoreline to a distance of 10 m offshore were collected into polyethylene bottles by swimmers working from the shoreline. A refractometer was used to pinpoint the location of maximum groundwater flux to the ocean for each transect site. Water samples beyond 10 m from the shoreline were collected from a small boat using a 1.8-liter Niskin-type oceanographic 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 transferred into a 1-liter polyethylene bottle until further processing. Water samples were also collected from eight golf course irrigation wells (No's 1, 2, 3, 4, 5, 8, 10 and 11) and two irrigation lakes on the same day as the ocean sampling.

Subsamples for nutrient analyses from all water sources were immediately placed in 125-milliliter (ml) acid-washed triple rinsed, polyethylene bottles and stored on ice until returned to Honolulu. Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis.

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 dissolved inorganic nitrogen plus dissolved organic nitrogen, nitrate + nitrite nitrogen ($NO_3^- + NO_2^-$), ammonium (NH_4^+), total phosphorus (TP) which is defined as dissolved inorganic phosphorus plus dissolved 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 autoanalyzer according to standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983). TN and TP were analyzed in a similar fashion following digestion. Dissolved organic nitrogen (TON) and dissolved 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.

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 9, 2007 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 Sites 1-4 collected at the same sampling stations during the twenty surveys to date from August 1995 to December 2007, with nutrient concentrations shown in μM and μg/L, respectively. Site 3-A was not included in the tables of geometric means, as only two samplings have been conducted to date. Table 5 shows water chemistry measurements (in units of μM and μg/L) for samples collected from irrigation wells and two irrigation lakes located on the Makena Resort Golf Courses. Concentrations of twelve chemical constituents in surface and deep-water samples from the December 2007 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 from 1995 to 2007 are plotted in Figures 4-15. In addition, data from the most recent sampling in December 2007 are also plotted on Figures 4-15.

During the December 2007 sampling, nearshore concentrations of dissolved Si, NO_3^-, and TN on all five transects were elevated up to three orders of magnitude compared to samples collected farthest from shore (Figure 2, Tables 1 and 2). Values of salinity display a mirror image with lowest values nearest the shoreline, and progressively increasing values with distance from shore (Figure 3, Tables 1 and 2). The horizontal gradients of nutrients were steepest on Transects 1, 3, 3A and 4,where the peak values of NO_3^- at the shoreline were between 123 and 277 μM. In contrast, at the seaward ends of these transects, concentrations of NO_3^- in surface waters ranged from 0.08 to 11.5 μM. (Figure 2, Table 1). Salinity displayed a mirror image, with lowest salinity at the shoreline (13 - 30‰), and rapidly increasing values with increasing distance from shore to near oceanic values (34.4 - 34.7‰) at the ends of the transects (Figure 3, Table 1). At Sites 1, 3, 3-A and 4, horizontal gradients extended the entire length of each transect, from the shoreline out to the station farthest offshore. On Transect 2, horizontal gradients of Si, NO_3^- and salinity were also evident, but of a generally smaller magnitude than on the other four transects and dissipated within 150 m of the shoreline(Tables 1 and 2). Salinity gradients were also the smallest on Transect 2 with only a 1.70‰ difference between the shoreline and 150 m from the shoreline.

Horizontal gradients in the surface concentrations of phosphate phosphorus (PO_4^{3-}) were also evident on Transects 3, 3-A and 4 with the highest values in the samples collected near the shoreline, and progressively lower concentrations with increasing distance from shore. While there were distinct gradients in the concentrations of PO_4^{3-}, the magnitude of the range in values was far less than for Si, NO_3^- and TN (Figure 2, Tables 1 and 2).

With no streams in the sampling area, the pattern of elevated Si, NO_3^-, PO_4^{3-} and TN with a corresponding reduced salinity 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 2007 sampling was conducted during a period of falling tide (2.02 ft – 0.58 ft) and minimal winds and displayed a marked zone of mixing extending approximately 150 m from shore. Past monitoring surveys at Makena Resort conducted during periods of high tide and strong winds (e.g. December 2005) show substantially smaller horizontal gradients than the present survey. Comparing the results of surveys conducted during very different sea conditions clearly indicates how tidal state, as well as wind and wave mixing, affect groundwater dynamics in the nearshore zone.

Dissolved nutrient constituents that are not associated with groundwater input (NH_4^+, TP, TON, TOP) showed varying results with respect to distance from the shoreline (Figure 2). With the exception of Site 4, NH_4^+ concentrations in the surface waters did not show any distinct patterns with respect to distance from the shoreline and was relatively constant within any one transect. At Site 4, NH_4^+ decreased with increasing distance from the shoreline from 3.7 μM at the shoreline to 0.66 μM at the farthest offshore station (Table 1). Concentrations of TP were highest in the shoreline samples at Sites 3-A, 3 and Site 4 compared to the offshore samples. Measurements of TP in the shoreline samples at Site 4 were more than double that measured at Sites 3-A and 3 (Tables 1 and 2). Measurements of TON were relatively constant along the length of each transect except for a distinctly higher measurement at the shoreline at Site 3-A and lower measurements at the shoreline at Sites 1, 3 and 4 (Figure 2).

Surface concentrations of turbidity were highest within 5 m of the shoreline on Transects 1, 2 and 4, while at Transects 3 and 3-A turbidity was constant along the length of the transect (Table 1, Figure 3). Turbidity values were of the same magnitude at all sites except for samples collected within 5 m of the shoreline on Transect 4 which had values an order of magnitude greater than the other sites. In previous surveys, turbidity has generally been highest on Transect 2 compared to the other sites. 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 at 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.

Patterns in the concentrations of Chl a showed higher shoreline values compared to offshore values at Sites 1, 2 and 4. Beyond the shoreline, concentrations of Chl a were of the same magnitude along 4 of the 5 transects, with slightly higher concentrations of Chl a occurring along the transect at Site 2 (Figure 3).

Surface water temperature ranged between 24.3°C and 26.6°C during the December 2007 survey (Tables 1 and 2). Temperature measurements in the shoreline samples varied between transect sites. At Site 2, shoreline temperature was ~ 1.0°C higher than that measured at Sites 1, 3 and 3-A while at Site 4, temperature in the shoreline was ~ 1.0°C lower than Sites 1, 3 and

3-A (Tables 1 and 2). At all sites except Site 2, temperatures were lowest at the shoreline and steadily increased with distance offshore (Figure 3). The greatest variation in temperature within any one transect occurred at Site 4 where temperature increased by 1.6°C between the shoreline and offshore waters.

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 -15 and Tables 1 and 2 show concentrations of water chemistry constituents with respect to vertical stratification. During the December 2007 survey, vertical stratification was evident for Si, NO_3^-, TN and salinity along all the transects with the most pronounced gradients at Transects 4 and 3-A.

With respect to the other constituents of water chemistry, variations between surface and deep samples were generally small and no apparent trend with distance offshore (Figures 2-15). Only temperature showed any vertical stratification with the deeper waters ~0.5°C lower than the surface water (Figure 3).

B. Temporal Comparison of Monitoring Results

Figures 4-15 show mean concentrations (±standard error) of water chemistry constituents from surface and deep samples at Transect Sites 1-4 from the twenty monitoring surveys conducted from 1995 to 2007. In addition, the results of the most recent survey in December 2007 are also shown on each plot. Because Site 3-A was not added to the sampling regime until June 2007, data from this site is not included in Figures 4–15.

On all four transects, surface concentrations of Si, NO_3^-, and TN within 10 m of the shoreline were substantially higher during the most recent survey compared to the surface mean values, while salinity was substantially lower than mean values at Site 1, 3 and 4. Concentrations of PO_4^{3-} were higher compared to the mean values at Sites 3 and 4 (Figures 10 and 13). As discussed above, these variations can be a result of sampling during a period of particularly low mixing of groundwater and ocean water in the nearshore zone. Thus, while the concentrations of Si, NO_3^- and PO_4^{3-} in December 2007 were higher than the means in nearshore samples, the elevated levels can be attributed to a greater proportion of groundwater in the samples relative to previous surveys. Turbidity on Transects 1, 2 and 3 was lower than the mean values suggesting that runoff from the recent storm was not significant, and did not impact this area to the same extent as the Control site (Site 4) where turbidity in the shoreline area was three-fold higher than the mean values (Figure 15). Distinctions between the mean values and Chl a, TP, TN, TON, TOP and temperature were also visible at Site 4 during the December 2007 survey. Comparison of the patterns of distributions of all other constituents reveals that the results of the December 2007 sampling are within the mean values from all previous studies (Figures 4-15).

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 16 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 2007. Figures 17 and 18 show the same type of plot with data pooled by transect site for a composite of all past surveys at Sites 1-4, the initial survey at Site 3-A, as well as for the most recent survey at all sites. Each graph also shows four conservative mixing lines that are constructed by connecting the end member concentrations of open ocean water with irrigation well No. 4 located on the upper 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 16 that when concentrations of Si are plotted as functions of salinity, most of the data points from Transects 2, 3, 3A and 4 fall on the conservative mixing line created from water collected from the upslope irrigation well. Such good agreement indicates that marine waters at these four transect sites are a mixture of groundwater flowing beneath the project and ocean water. However, three low salinity data points from Transect Site 1 deviate substantially from the upslope mixing line, indicating a different source of groundwater is mixing with ocean water in this area. Over the course of monitoring, data points from Site 1 have consistently been below the Si mixing lines in a similar manner as noted in December 2007. These results indicate that with the exception of Transect 1, groundwater endmembers from 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 17).

NO_3^- is the form of nitrogen most common in fertilizer mixes that are used for enhancing turf growth. Inspection of the data points in the plot of NO_3^- as a function of salinity indicates that there are distinct difference in the mixing lines for each transects (Figure 16). Data points from Transect 2 lie close to the upslope well water mixing line. The position of these data arrays indicates that the source of NO_3^- entering the ocean at Transect 2 contains little or no subsidies from activities on land. Conversely, all of the data points from Transects 1, 3, 3-A and 4 lie above the irrigation well mixing lines, indicating a subsidy of NO_3^- to the ocean from sources on land. In addition, the slopes of the lines created from the data points from Transects 3 and 3-A are similar, indicating similar sources of NO_3^- at the two sites. Such relationships indicate a subsidy of NO_3^- at Transect sites 1, 3 and 3-A that are likely a result of leaching of golf course fertilizers to the groundwater lens. In addition to the golf courses, however, all of the residences near the shoreline at Site 1 include landscaping and lawns.

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 since 1992. Hence, there appears to have been an increase of NO_3 in nearshore waters 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 overlap in the makai-mauka direction landward of ocean Transect 1, the increased concentrations of NO_3^- may be a result of leaching of fertilizer materials from the combined golf courses to groundwater that enters the ocean in the sampling area. The subsidy of NO_3^- at Transect 4, which is considered the control site with no influence from Makena Resort, during the December 2007 survey may be the result of runoff events from the storms that preceded the sampling (Figure 17).

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 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 healthy coral reef that does not exhibit any negative effects from nutrient loading (Marine Research Consultants 2006). In addition to the lack of negative impacts to 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^+, generally does not show a linear pattern of distribution with respect to salinity for either the December 2007 survey (Figure 16) or the entire monitoring program (Figure 18). Some samples with near oceanic salinity also displayed the highest concentrations of NH_4^+. 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. During the December 2007 survey, the highest measurements for NH_4^+ occurred in the lowest salinity water at Site 4, the control site. As mentioned above, this anomaly could be the result of increased runoff during the recent rainfall event.

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. Data points representing PO_4^{3-} vs. salinity show indications of linearity with samples concentrations falling near the mixing lines. Thus, the elevated NO_3^- which is likely a result of golf course and residential landscaping, is not reflected in similar subsidies of PO_4^{3-}.

D. Time Course Mixing Analyses

While it is possible to evaluate monitoring results 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 scale 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 19 and 20 show plots of Si and NO_3^-, respectively, as functions of salinity collected during each year of sampling (1995-2007). Also shown in Figures 19 and 20 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 at Transect Sites 1-4. Because Site 3-A has only been sampled twice, data from Site 3-A is not included in this comparison.

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 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 will 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 21) and Y-intercepts (Figure 22) 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 is the form of nitrogen found in high concentrations in groundwater relative to ocean water, and is the major constituent of nitrogen found in fertilizers. PO_4^{3} is also a component of fertilizers, and is included in this analysis even though elevated concentrations in nearshore waters have not been noted with regularity at the Makena sampling sites (Figure 18).

Examination of Figures 21 and 22, as well as Tables 6-8 reveal that none of the slopes or Y-intercepts of Si, NO_3^- and PO_4^{3-} from 1995 to 2007 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 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 year at Site 1, located off the "5 Graves" area downslope from the juncture of the Wailea and Makena Resorts (Figures 21 and 22). Such lack of variation indicates relatively consistent concentrations of Si, NO_3^- and PO_4^{3-} in groundwater entering the ocean over the thirteen years of monitoring. Sites 2 (Makena Landing) and 4 ('Ahihi-Kina`u) also show relative 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 (Figures 21 and 22). As a result of these reversing trends, there is no significant increase or decrease over the six-year period of monitoring. The reversing trend may reflect changes in land use, such as variation in fertilizer application or construction-related activities in 2002-2004 versus 2004-2007.

F. 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 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 twenty samplings collected to date, 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 2007 survey indicated that nearly all measurements of NO_3^- along all five transect sites exceeded the 10% DOH criteria under wet or dry conditions (Tables 1 and 2). Only eighteen of the sixty-two samples collected did not exceed the DOH criteria for NO_3^- and those instances were mostly from deep waters beyond 50 m of the shoreline. Fifteen measurements of NH_4^+, mostly from Site 4 exceeded the 10% DOH criteria for NH_4^+ under dry conditions. Two measurements of TP, thirty-six measurements of TN, three measurements of turbidity and eleven measurements of Chl a exceeded the 10% DOH criteria under dry conditions. Under "wet" criteria, seven measurements of NH_4^+, two measurements of TP, nineteen measurements of TN, one measurement of turbidity and eight measurements of Chl *a* were exceeded. 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^- and NH_4^+ were similar to Sites 1-3 and 3-A, which were located directly offshore of the Resort.

Tables 3 and 4 show geometric means of samples collected at the same locations during the twenty increments of the monitoring program at Sites 1-4. Also shown in these tables are 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 while only two samples of TP and sixteen samples of turbidity exceeded standards. All 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 three 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 influenced by land. If the monitoring protocol were revised to include only those sampling locations beyond 50-100 m from shore (i.e., open coastal waters), the monitoring scheme would be completely valid with respect to meeting regulatory compliance since the DOH standards do not stipulate any monitoring procedures or sampling locations.

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 standards 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.

III. SUMMARY

- The twentieth phase of water chemistry monitoring of the nearshore ocean off the Makena Resort was carried out on December 9, 2007. 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 3-A (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. In addition, water samples were collected from eight irrigation wells,. Of note is that the survey was conducted within days of substantial storm events that resulted in abnormally high levels of rainfall throughout South Maui.

- Water chemistry constituents that occur in high concentration in groundwater (Si, NO_3^- and PO_4^{3-}) displayed distinct horizontal gradients with high concentrations nearest to shore and decreasing concentrations moving seaward. Groundwater input (based on salinity) was greatest at Site 4 and decreased progressively from Site 3-A, 1, 3, and 2. As Site 4 was not located in the vicinity of the Makena Resort, it is apparent that groundwater input is not solely a response to Resort land usage.

- Vertical stratification of the water column was also evident on all transects during December 2007, with the surface samples displaying higher nutrient and lower salinities than bottom samples. The strong vertical and horizontal patterns of distribution indicate that physical mixing processes generated by tide, wind, waves and currents were insufficient to completely mix the water column throughout the sampling area.

- Turbidity and Chl *a* were elevated near the shoreline at Sites 1, 2 and 4 but not at Sites 3 and 3-A. Turbidity was elevated at Site 4 and Chl *a* at Site 2 in the shoreline samples compared to the other sampling sites. Site 2 is located at the point where sediment-laden storm water runoff entered the ocean following a flash flood in October 1999. While the highly turbid conditions associated with the runoff event are no longer evident, normal processes of circulation (tidal exchange, wave mixing) and the silt/sand bottom have often resulted in slightly more turbid conditions in Makena Bay (Site 2) compared to the other sampling sites that occur in areas with predominantly hard reef substrata. During the December 2007 survey, Site 2 did not have turbidity levels any higher than the other sites beyond the shoreline.

- With the exception of anomalously elevated concentrations at Site 4, concentrations of NH_4^+ were similar throughout the length of transects. Other organic water chemistry constituents that do not occur in high concentrations in groundwater (TON, TOP) also did not display any recognizable horizontal or vertical trends.

- Scaling nutrient concentrations to salinity indicates that there were measurable subsidies of NO_3^- to groundwater that enters the nearshore ocean on all Transect sites, with the exception of Site 2 (Makena Bay). These subsidies, which are likely 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 an overlap 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 thirteen years of monitoring at Sites 1, 2 and 4. The lack of increases in these slopes and intercepts indicate that there has been no consistent change in nutrient input from land to groundwater that enters the ocean from 1995 to 2007 (2002 to 2007 at Site 2). At Site 3 off the Makena Resort South Golf Course, there has been a progressive decrease in NO_3^- input between 2002 and 2004, followed by an increase between 2004 and 2007. Further monitoring at this site will be of interest to note the future direction of the oscillating trends noted in the last four years.

- Comparing water chemistry parameters to DOH standards revealed that numerous measurements of NO_3^- and NH_4^+, several measurements of TN and Chl a, and a few measurements of 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^+, TP, TN, turbidity and all measurements of 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 standards not accounting for the natural effects of groundwater discharge to the nearshore ocean and resultant zones of mixing.

- 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, that is a consequence of various land use activities. However, while none of these inputs have increased significantly over time, there is a steady increase of NO_3^- over the last three years at the site directly offshore of the Makena Resort. Monitoring of coral reef community structure that is part of the ongoing monitoring, as well as the noted lack of any nuisance algal aggregations in the nearshore area indicate that the nutrient subsidies are not detrimental to marine community structure.

- Results of the present survey, which occurred several days after a period of unusually heavy rainfall, indicates that nutrient levels in the nearshore ocean were slightly higher than in previous surveys conducted during drier periods. The elevated nutrient, were most evident at the control site (Transect 4), located to the south of the Makena Resort.

- The next phase of the Makena Resort monitoring program is scheduled for the June of 2008.

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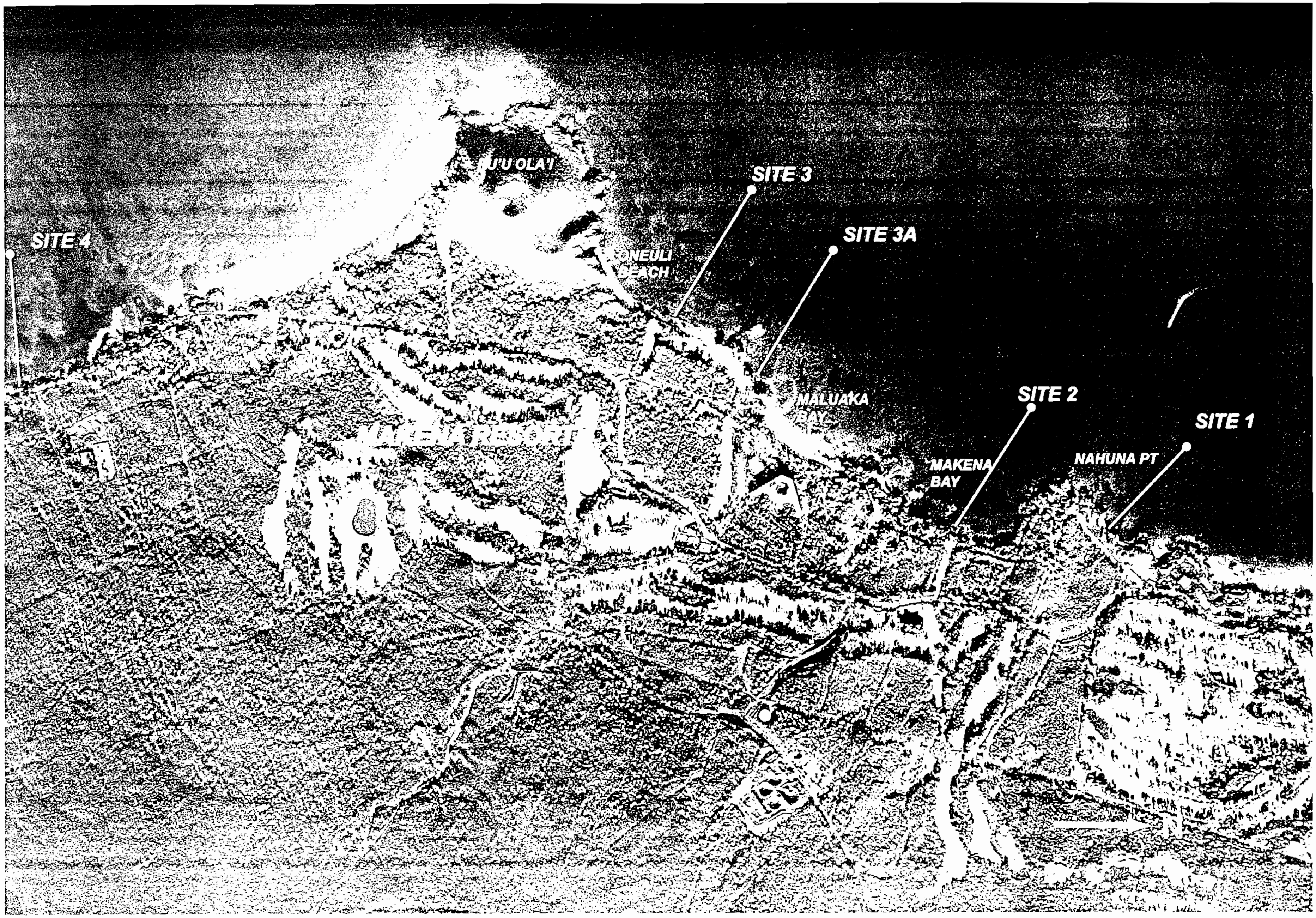

FIGURE 1. Aerial photograph of Makena Resort on southwest coastline of Maui. Also shown are locations of five water sampling transects that extend from the shoreline to 150-200 m from shore. The southern end of the Wailea golf course is visible at right.

TABLE 1. Water chemistry measurements from ocean water samples collected in the vicinity of the Makena Resort on December 9, 2007. Abbreviations as follows: DFS=distance from shore; S=surface; D=deep. 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)	O_2 % Sat
MAKENA 1	0 S	0.1	0.18	123.21	0.40	90.52	0.22	2.04	0.40	125.65	0.25	23.751	0.13	25.2	8.11	99.4
	2 S	0.1	0.20	85.58	0.01	81.67	0.22	3.81	0.42	89.40	0.24	26.861	1.08	25.3	8.12	100.4
	5 S	0.1	0.04	49.15	0.03	77.05	0.25	9.76	0.29	58.94	0.16	29.711	0.19	25.4	8.14	101.3
	5 D	1.0	0.04	8.26	0.11	17.75	0.25	10.55	0.29	18.92	0.06	33.954	0.16	25.3	8.16	102.3
	10 S	0.1	0.09	6.14	0.16	13.96	0.25	7.93	0.34	14.23	0.08	34.156	0.17	25.6	8.13	107.4
	10 D	1.7	0.04	1.76	0.10	5.50	0.26	8.51	0.30	10.37	0.06	34.616	0.14	25.3	8.10	104.2
	50 S	0.1	0.05	5.38	0.14	11.32	0.26	8.41	0.31	13.93	0.10	34.325	0.14	25.6	8.12	108.4
	50 D	4.4	0.06	0.11	0.18	2.48	0.30	8.30	0.36	8.59	0.06	34.866	0.17	25.3	8.11	104.3
	100 S	0.1	0.16	9.15	0.27	20.40	0.24	8.03	0.40	17.45	0.06	33.842	0.12	25.9	8.11	106.5
	100 D	6.2	0.08	0.08	0.19	3.46	0.27	10.25	0.35	10.52	0.07	34.889	0.14	25.2	8.10	102.5
	150 S	0.1	0.18	0.53	0.67	4.61	0.31	14.87	0.49	16.07	0.32	34.754	0.68	26.1	8.06	104.4
	150 D	11.7	0.06	0.03	0.18	2.40	0.29	11.26	0.35	11.47	0.07	34.852	0.15	25.2	8.10	101.0
MAKENA 2	0 S	0.1	0.07	6.54	0.24	30.21	0.30	10.55	0.37	17.33	0.27	33.247	0.79	26.2	8.13	100.4
	2 S	0.1	0.04	6.55	0.19	30.38	0.28	10.16	0.32	16.90	0.20	33.244	0.67	26.2	8.13	102.3
	5 S	0.1	0.20	5.87	0.27	25.04	0.27	11.00	0.47	17.14	0.34	33.636	2.45	26.1	8.08	101.2
	5 D	1.2	0.12	4.54	0.24	19.99	0.29	11.10	0.41	15.88	0.27	33.914	2.49	26.1	8.08	101.2
	10 S	0.1	0.04	1.39	0.26	9.80	0.30	11.77	0.34	13.42	0.19	34.461	1.49	26.1	8.09	101.8
	10 D	1.5	0.02	0.91	0.38	7.56	0.29	9.82	0.31	11.11	0.12	34.611	1.07	26.1	8.08	102.4
	50 S	0.1	0.02	3.73	0.27	20.89	0.27	10.63	0.29	14.63	0.11	33.893	0.26	26.0	8.13	103.2
	50 D	2.8	0.08	0.25	0.30	3.10	0.30	12.19	0.38	12.74	0.08	34.790	0.30	25.3	8.10	104.9
	100 S	0.1	0.05	2.13	0.29	19.49	0.34	9.63	0.39	12.05	0.12	33.912	0.47	26.0	7.90	104.6
	100 D	4.7	0.07	0.14	0.33	3.47	0.28	10.78	0.35	11.25	0.07	34.810	0.44	25.2	8.09	102.6
	150 S	0.1	0.11	1.78	0.31	7.81	0.26	9.44	0.37	11.53	0.11	34.629	0.36	25.8	8.06	100.3
	150 D	11.4	0.10	0.10	0.32	2.31	0.27	11.87	0.37	12.29	0.07	34.855	0.21	25.2	8.11	100.3
	200 S	0.1	0.05	0.08	0.35	2.77	0.24	9.20	0.29	9.63	0.12	34.950	0.47	26.6	8.10	102.3
	200 D	16.0	0.09	0.03	0.31	3.08	0.25	10.64	0.34	10.98	0.07	34.890	0.22	25.2	8.10	100.5
MAKENA 3A	0 S	0.1	0.67	277.83	0.23	254.34	0.11	25.53	0.78	303.59	0.10	22.209	0.19	24.9	7.88	97.4
	2 S	0.1	0.05	125.59	0.29	115.05	0.25	2.84	0.30	128.72	0.11	29.567	0.16	25.3	7.95	93.2
	5 S	0.1	0.56	129.69	0.33	118.99	0.14	2.85	0.70	132.87	0.10	29.354	0.18	25.3	7.95	95.3
	5 D	1.0	0.09	29.25	0.47	37.98	0.26	10.34	0.35	40.06	0.09	33.366	0.15	25.2	8.03	96.3
	10 S	0.1	0.24	26.76	0.29	34.45	0.20	10.79	0.44	37.84	0.09	33.471	0.17	25.8	8.04	100.2
	10 D	1.8	0.14	7.91	0.38	12.71	0.22	8.18	0.36	16.47	0.07	34.400	0.16	25.2	8.05	101.1
	50 S	0.1	0.18	12.00	0.33	16.65	0.22	10.46	0.40	22.79	0.07	34.205	0.14	25.8	8.10	102.3
	50 D	4.3	0.10	0.17	0.41	10.78	0.26	12.34	0.36	12.92	0.10	34.290	0.12	25.2	8.09	104.2
	100 S	0.0	0.12	6.65	0.36	8.98	0.23	9.91	0.35	16.92	0.07	34.619	0.13	25.7	8.06	103.1
	100 D	5.0	0.10	0.03	0.33	3.58	0.24	9.65	0.34	10.01	0.05	34.890	0.09	25.2	8.09	102.9
	150 S	0.1	0.07	11.47	0.31	12.00	0.25	10.45	0.32	22.23	0.09	34.470	0.16	25.7	8.06	102.7
	150 D	11.5	0.06	0.05	0.37	2.35	0.25	10.39	0.31	10.81	0.08	34.910	0.09	25.2	8.10	101.3
MAKENA 3	0 S	0.1	0.54	162.58	0.36	97.42	0.16	4.95	0.70	167.89	0.14	30.227	0.12	25.2	7.99	99.4
	2 S	0.1	0.51	102.62	0.94	68.13	0.20	11.81	0.71	115.37	0.15	31.825	0.14	25.5	8.02	100.2
	5 S	0.1	0.47	91.74	0.18	64.57	0.18	11.73	0.65	103.65	0.15	32.081	0.13	25.5	8.03	101.2
	5 D	1.0	0.19	23.55	0.02	24.88	0.21	10.50	0.40	34.07	0.14	34.065	0.14	25.2	8.07	100.2
	10 S	0.1	0.13	17.23	0.20	19.41	0.22	8.52	0.35	25.95	0.10	34.260	0.10	25.9	8.08	102.4
	10 D	1.9	0.18	8.52	0.14	11.51	0.23	9.19	0.41	17.85	0.09	34.547	0.14	25.2	8.09	102.1
	50 S	0.1	0.04	6.19	0.26	18.07	0.27	10.61	0.31	17.06	0.19	34.449	0.10	26.0	8.08	103.8
	50 D	2.3	0.08	0.14	0.07	2.50	0.26	10.93	0.34	11.14	0.08	34.819	0.12	25.2	8.09	103.2
	100 S	0.1	0.17	3.03	0.36	10.32	0.25	9.95	0.42	13.34	0.14	34.612	0.17	25.5	8.07	100.9
	100 D	6.3	0.13	0.34	0.21	3.01	0.35	11.72	0.48	12.27	0.07	34.805	0.08	25.2	8.09	101.4
	150 S	0.1	0.18	1.86	0.08	6.73	0.21	8.57	0.39	10.51	0.16	34.699	0.17	25.9	8.08	100.4
	150 D	9.2	0.11	0.03	0.07	1.81	0.23	8.61	0.34	8.71	0.17	34.856	0.12	25.2	8.11	101.0
MAKENA 4	0 S	0.1	1.65	172.31	3.67	443.97	0.19	0.31	1.84	176.29	1.35	12.896	2.80	24.3	8.03	89.4
	2 S	0.1	1.60	149.62	1.96	403.46	0.11	2.02	1.71	153.60	0.80	15.500	1.14	24.8	8.03	90.2
	5 S	0.1	0.45	35.64	2.61	113.59	0.19	11.65	0.64	49.90	0.54	29.856	1.59	24.9	8.09	100.4
	5 D	1.0	0.14	3.32	0.79	16.67	0.21	9.58	0.35	13.69	0.25	34.198	0.30	24.9	8.14	101.2
	10 S	0.1	0.11	1.67	0.31	8.39	0.20	8.16	0.31	10.14	0.17	34.605	0.13	25.3	8.07	102.3
	10 D	2.0	0.13	1.70	0.57	9.25	0.19	7.06	0.32	9.33	0.16	34.592	0.31	25.1	8.06	102.1
	50 S	0.1	0.07	1.48	0.44	12.03	0.21	7.48	0.28	9.40	0.29	34.474	0.21	25.4	8.17	109.0
	50 D	4.4	0.06	0.07	0.31	2.58	0.22	7.69	0.28	8.07	0.12	34.809	0.14	25.1	8.11	106.3
	100 S	0.1	0.12	0.11	0.22	8.57	0.23	8.05	0.35	8.38	0.17	34.514	0.15	26.0	8.10	108.6
	100 D	6.4	0.16	2.05	0.24	13.58	0.22	8.47	0.38	10.76	0.22	34.451	0.08	25.1	8.15	102.2
	150 S	0.1	0.20	2.16	0.66	11.85	0.19	8.51	0.39	11.33	0.16	34.529	0.14	25.9	8.09	104.4
	150 D	7.7	0.16	0.02	0.31	1.81	0.24	6.99	0.40	7.32	0.10	34.855	0.12	25.1	8.11	100.7
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 December 9, 2007. Abbreviations as follows: DFS=distance from shore; S=surface; D=deep. 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)	O_2 % Sat
MAKENA 1	0 S	0.1	5.58	1724.94	5.60	2543.6	6.82	28.56	12.40	1759.10	0.25	23.751	0.13	25.2	8.11	99.4
	2 S	0.1	6.20	1198.12	0.14	2294.9	6.82	53.34	13.02	1251.60	0.24	26.861	1.08	25.3	8.12	100.4
	5 S	0.1	1.24	688.10	0.42	2165.1	7.75	136.64	8.99	825.16	0.16	29.711	0.19	25.4	8.14	101.3
	5 D	1.0	1.24	115.64	1.54	498.8	7.75	147.70	8.99	264.88	0.06	33.954	0.16	25.3	8.16	102.3
	10 S	0.1	2.79	85.96	2.24	392.3	7.75	111.02	10.54	199.22	0.08	34.156	0.17	25.6	8.13	107.4
	10 D	1.7	1.24	24.64	1.40	154.6	8.06	119.14	9.30	145.18	0.06	34.616	0.14	25.3	8.10	104.2
	50 S	0.1	1.55	75.32	1.96	318.1	8.06	117.74	9.61	195.02	0.10	34.325	0.14	25.6	8.12	108.4
	50 D	4.4	1.86	1.54	2.52	69.7	9.30	116.20	11.16	120.26	0.06	34.866	0.17	25.3	8.11	104.3
	100 S	0.1	4.96	128.10	3.78	573.2	7.44	112.42	12.40	244.30	0.06	33.842	0.12	25.9	8.11	106.5
	100 D	6.2	2.48	1.12	2.66	97.2	8.37	143.50	10.85	147.28	0.07	34.889	0.14	25.2	8.10	102.5
	150 S	0.1	5.58	7.42	9.38	129.5	9.61	208.18	15.19	224.98	0.32	34.754	0.68	26.1	8.06	104.4
	150 D	11.7	1.86	0.42	2.52	67.4	8.99	157.64	10.85	160.58	0.07	34.852	0.15	25.2	8.10	101.0
MAKENA 2	0 S	0.1	2.17	91.56	3.36	848.9	9.30	147.70	11.47	242.62	0.27	33.247	0.79	26.2	8.13	100.4
	2 S	0.1	1.24	91.70	2.66	853.7	8.68	142.24	9.92	236.60	0.20	33.244	0.67	26.2	8.13	102.3
	5 S	0.1	6.20	82.18	3.78	703.6	8.37	154.00	14.57	239.96	0.34	33.636	2.45	26.1	8.08	101.2
	5 D	1.2	3.72	63.56	3.36	561.7	8.99	155.40	12.71	222.32	0.27	33.914	2.49	26.1	8.08	101.2
	10 S	0.1	1.24	19.46	3.64	275.4	9.30	164.78	10.54	187.88	0.19	34.461	1.49	26.1	8.09	101.6
	10 D	1.5	0.62	12.74	5.32	212.4	8.99	137.48	9.61	155.54	0.12	34.611	1.07	26.1	8.08	102.4
	50 S	0.1	0.62	52.22	3.78	587.0	8.37	148.82	8.99	204.82	0.11	33.893	0.26	26.0	8.13	103.2
	50 D	2.8	2.48	3.50	4.20	87.1	9.30	170.66	11.78	178.36	0.08	34.790	0.30	25.3	8.10	104.9
	100 S	0.1	1.55	29.82	4.06	547.7	10.54	134.82	12.09	168.70	0.12	33.912	0.47	26.0	7.90	104.6
	100 D	4.7	2.17	1.96	4.62	97.5	8.68	150.92	10.85	157.50	0.07	34.810	0.44	25.2	8.09	102.6
	150 S	0.1	3.41	24.92	4.34	219.5	8.06	132.16	11.47	161.42	0.11	34.629	0.36	25.8	8.06	100.3
	150 D	11.4	3.10	1.40	4.48	64.9	8.37	166.18	11.47	172.06	0.07	34.855	0.21	25.2	8.11	100.5
	200 S	0.1	1.55	1.12	4.90	77.8	7.44	128.80	8.99	134.82	0.12	34.950	0.47	26.6	8.10	102.3
	200 D	16.0	2.79	0.42	4.34	86.5	7.75	148.96	10.54	153.72	0.07	34.890	0.22	25.2	8.10	100.5
MAKENA 3-A	0 S	0.1	20.77	3889.62	3.22	7147.0	3.41	357.42	24.18	4250.26	0.10	22.209	0.19	24.9	7.88	97.4
	2 S	0.1	1.55	1758.26	4.06	3232.9	7.75	39.76	9.30	1802.08	0.11	29.567	0.16	25.3	7.95	93.2
	5 S	0.1	17.36	1815.66	4.62	3343.6	4.34	39.90	21.70	1860.18	0.10	29.354	0.18	25.3	7.95	95.3
	5 D	1.0	2.79	409.50	6.58	1067.2	8.06	144.76	10.85	560.84	0.09	33.366	0.15	25.2	8.03	96.3
	10 S	0.1	7.44	374.64	4.06	968.0	6.20	151.06	13.64	529.76	0.09	33.471	0.17	25.8	8.04	100.2
	10 D	1.8	4.34	110.79	5.32	357.0	6.81	114.57	11.15	230.68	0.07	34.400	0.16	25.7	8.05	101.1
	50 S	0.1	5.58	168.00	4.62	467.9	6.82	146.44	12.40	319.06	0.07	34.205	0.14	25.8	8.10	102.5
	50 D	4.3	3.10	2.38	5.74	302.9	8.06	172.76	11.16	180.88	0.10	34.290	0.12	25.2	8.09	104.2
	100 S	0.0	3.72	93.10	5.04	252.3	7.13	138.74	10.85	236.88	0.07	34.619	0.13	25.7	8.06	103.1
	100 D	5.0	3.10	0.42	4.62	100.6	7.44	135.10	10.54	140.14	0.05	34.890	0.09	25.2	8.09	102.9
	150 S	0.1	2.17	160.58	4.34	337.2	7.75	146.30	9.92	311.22	0.09	34.470	0.16	25.7	8.08	102.7
	150 D	11.5	1.86	0.70	5.18	66.0	7.75	145.46	9.61	151.34	0.08	34.910	0.09	25.2	8.10	101.3
MAKENA 3	0 S	0.1	16.74	2276.12	5.04	2737.5	4.96	69.30	21.70	2350.46	0.14	30.227	0.12	25.2	7.99	99.4
	2 S	0.1	15.81	1436.68	13.17	1914.5	6.20	165.34	22.01	1615.18	0.15	31.825	0.14	25.5	8.02	100.2
	5 S	0.1	14.57	1284.36	2.52	1814.4	5.58	164.22	20.15	1451.10	0.15	32.081	0.13	25.5	8.03	101.2
	5 D	1.0	5.89	329.70	0.28	699.1	6.51	147.00	12.40	476.98	0.14	34.065	0.14	25.2	8.07	100.2
	10 S	0.1	4.03	241.22	2.80	545.4	6.82	119.28	10.85	363.30	0.10	34.260	0.10	25.9	8.08	102.4
	10 D	1.9	5.58	119.28	1.96	323.4	7.13	128.66	12.71	249.90	0.09	34.547	0.14	25.2	8.09	102.1
	50 S	0.1	1.24	86.66	3.64	507.8	8.37	148.54	9.61	238.84	0.19	34.449	0.10	26.0	8.08	103.8
	50 D	2.3	2.48	1.96	0.98	70.3	8.06	153.02	10.54	155.96	0.08	34.819	0.12	25.2	8.09	103.2
	100 S	0.1	5.27	42.42	5.04	290.0	7.75	139.30	13.02	186.76	0.14	34.612	0.17	25.5	8.07	100.9
	100 D	6.3	4.03	4.76	2.94	84.6	10.85	164.08	14.88	171.78	0.07	34.805	0.08	25.2	8.09	101.4
	150 S	0.1	5.58	26.04	1.12	189.1	6.51	119.98	12.09	147.14	0.16	34.699	0.17	25.9	8.08	100.4
	150 D	9.2	3.41	0.42	0.98	50.9	7.13	120.54	10.54	121.94	0.17	34.856	0.12	25.2	8.11	101.0
MAKENA 4	0 S	0.1	51.15	2412.34	51.38	12475.6	5.89	4.34	57.04	2468.06	1.35	12.896	2.80	24.3	8.03	89.4
	2 S	0.1	49.60	2094.68	27.44	11337.2	3.41	28.28	53.01	2150.40	0.80	15.500	1.14	24.8	8.03	90.2
	5 S	0.1	13.95	498.96	36.54	3191.9	5.89	163.10	19.84	698.60	0.54	29.856	1.59	24.9	8.09	100.4
	5 D	1.0	4.34	46.48	11.06	468.4	6.51	134.12	10.85	191.66	0.25	34.198	0.30	24.9	8.14	101.2
	10 S	0.1	3.41	23.38	4.34	235.8	6.20	114.24	9.61	141.96	0.17	34.605	0.13	25.3	8.07	102.3
	10 D	2.0	4.03	23.80	7.98	259.9	5.89	98.84	9.92	130.62	0.16	34.592	0.31	25.1	8.06	102.1
	50 S	0.1	2.17	20.72	6.16	338.0	6.51	104.72	8.68	131.60	0.29	34.474	0.21	25.4	8.17	109.0
	50 D	4.4	1.86	0.98	4.34	72.5	6.82	107.66	8.68	112.98	0.12	34.809	0.14	25.1	8.11	106.3
	100 S	0.1	3.72	1.54	3.08	240.8	7.13	112.70	10.85	117.32	0.17	34.514	0.15	26.0	8.10	108.6
	100 D	6.4	4.96	28.70	3.36	381.6	6.82	118.58	11.78	150.64	0.22	34.451	0.08	25.1	8.15	102.2
	150 S	0.1	6.20	30.24	9.24	333.0	5.89	119.14	12.09	158.62	0.16	34.529	0.14	25.9	8.09	104.4
	150 D	7.7	4.96	0.28	4.34	50.9	7.44	97.86	12.40	102.48	0.10	34.855	0.12	25.1	8.11	100.7
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 from four sites since August 1995 (N=20). 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 ($\mu g/L$)	TEMP (deg.C)	pH
MAKENA 1	0 S	0.20	33.84	0.28	56.48	0.23	6.97	0.49	48.13	0.33	29.190	1.02	25.6	8.13
	2 S	0.14	23.59	0.16	41.25	0.24	7.57	0.41	35.05	0.29	31.320	0.95	25.6	8.16
	5 S	0.12	10.72	0.15	22.47	0.25	8.07	0.39	22.88	0.24	32.610	0.68	25.6	8.16
	5 D	0.11	8.31	0.22	18.53	0.26	7.58	0.40	19.52	0.20	33.270	0.60	25.6	8.17
	10 S	0.10	3.45	0.16	9.31	0.26	7.43	0.36	12.43	0.18	34.220	0.43	25.7	8.16
	10 D	0.10	2.17	0.17	6.51	0.28	7.58	0.39	10.84	0.17	34.430	0.44	25.6	8.16
	50 S	0.09	2.68	0.19	7.30	0.26	7.35	0.36	11.49	0.16	34.360	0.35	25.7	8.14
	50 D	0.08	0.34	0.13	2.60	0.27	7.38	0.37	8.05	0.11	34.760	0.30	25.6	8.14
	100 S	0.09	1.03	0.15	4.80	0.26	6.68	0.37	9.75	0.12	34.500	0.29	25.7	8.14
	100 D	0.08	0.11	0.09	2.09	0.27	7.27	0.36	7.62	0.09	34.820	0.25	25.6	8.16
	150 S	0.09	0.32	0.14	3.04	0.26	7.26	0.36	8.60	0.12	34.700	0.22	25.8	8.14
	150 D	0.08	0.07	0.10	1.84	0.27	7.07	0.36	7.35	0.10	34.820	0.19	25.6	8.16
MAKENA 2	0 S	0.19	3.76	0.37	21.07	0.32	8.66	0.56	13.92	0.98	33.710	0.90	25.7	8.14
	2 S	0.19	3.75	0.27	19.53	0.32	8.00	0.54	13.15	0.71	33.540	0.89	25.8	8.13
	5 S	0.18	3.16	0.28	15.51	0.28	7.34	0.48	11.66	0.48	33.970	0.74	25.7	8.14
	5 D	0.18	2.91	0.35	14.80	0.31	7.52	0.51	11.90	0.47	34.030	0.93	25.7	8.14
	10 S	0.13	1.73	0.21	9.87	0.30	5.39	0.46	9.43	0.34	34.340	0.51	25.6	8.15
	10 D	0.12	1.03	0.25	7.95	0.30	7.19	0.45	9.22	0.27	34.470	0.56	25.7	8.15
	50 S	0.11	1.20	0.28	7.48	0.32	7.63	0.46	9.68	0.25	34.430	0.38	25.6	8.14
	50 D	0.10	0.28	0.21	3.27	0.31	7.76	0.43	8.46	0.19	34.760	0.43	25.6	8.15
	100 S	0.08	0.50	0.20	4.22	0.29	7.44	0.39	8.48	0.17	34.610	0.31	25.7	8.13
	100 D	0.08	0.19	0.20	2.39	0.29	7.24	0.38	7.75	0.12	34.790	0.31	25.6	8.15
	150 S	0.09	0.29	0.25	3.13	0.28	7.51	0.39	8.22	0.13	34.740	0.26	25.7	8.15
	150 D	0.08	0.12	0.15	2.05	0.29	7.62	0.39	8.04	0.11	34.810	0.25	25.6	8.16
	200 S	0.08	0.14	0.16	2.29	0.28	7.35	0.37	7.96	0.11	34.810	0.28	25.8	8.15
	200 D	0.08	0.06	0.21	1.70	0.29	7.88	0.38	8.25	0.10	34.840	0.27	25.7	8.17
MAKENA 3	0 S	0.11	5.43	0.37	14.61	0.26	5.45	0.44	20.27	0.26	33.710	0.60	25.7	8.15
	2 S	0.17	10.96	0.26	22.21	0.25	6.11	0.48	26.20	0.30	33.680	0.65	25.8	8.13
	5 S	0.11	7.57	0.24	15.17	0.24	7.35	0.42	20.10	0.21	34.090	0.37	25.8	8.13
	5 D	0.13	4.14	0.26	10.48	0.26	6.63	0.43	15.53	0.20	34.360	0.46	25.7	8.13
	10 S	0.08	3.22	0.26	8.08	0.27	7.06	0.38	13.53	0.15	34.450	0.28	25.7	8.14
	10 D	0.09	1.79	0.20	5.76	0.28	7.14	0.38	11.37	0.14	34.600	0.29	25.7	8.14
	50 S	0.09	1.50	0.20	5.33	0.27	7.60	0.37	10.68	0.13	34.620	0.23	25.7	8.12
	50 D	0.07	0.38	0.16	2.84	0.28	7.81	0.36	8.64	0.09	34.780	0.23	25.6	8.14
	100 S	0.08	0.41	0.23	2.89	0.28	7.43	0.37	8.44	0.10	34.750	0.18	25.6	8.13
	100 D	0.07	0.11	0.23	1.90	0.28	6.92	0.36	7.48	0.08	34.800	0.19	25.6	8.14
	150 S	0.06	0.18	0.17	2.13	0.28	6.82	0.35	7.51	0.10	34.780	0.15	25.7	8.16
	150 D	0.06	0.08	0.11	1.78	0.27	6.76	0.35	7.11	0.09	34.830	0.17	25.6	8.17
MAKENA 4	0 S	0.20	33.84	0.28	56.48	0.23	6.97	0.49	48.13	0.33	29.190	1.02	25.6	8.13
	2 S	0.14	23.59	0.16	41.25	0.24	7.57	0.41	35.05	0.29	31.320	0.95	25.6	8.16
	5 S	0.12	10.72	0.15	22.47	0.25	8.07	0.39	22.88	0.24	32.610	0.68	25.6	8.16
	5 D	0.11	8.31	0.22	18.53	0.26	7.58	0.40	19.52	0.20	33.270	0.60	25.6	8.17
	10 S	0.10	3.45	0.16	9.31	0.26	7.43	0.36	12.43	0.18	34.220	0.43	25.7	8.16
	10 D	0.10	2.17	0.17	6.51	0.28	7.58	0.39	10.84	0.17	34.430	0.44	25.6	8.16
	50 S	0.09	2.68	0.19	7.30	0.26	7.35	0.36	11.49	0.16	34.360	0.35	25.7	8.14
	50 D	0.08	0.34	0.13	2.60	0.27	7.38	0.37	8.05	0.11	34.760	0.30	25.6	8.14
	100 S	0.09	1.03	0.15	4.80	0.26	6.68	0.37	9.75	0.12	34.500	0.29	25.7	8.14
	100 D	0.08	0.11	0.09	2.09	0.27	7.27	0.36	7.62	0.09	34.820	0.25	25.6	8.16
	150 S	0.09	0.32	0.14	3.04	0.26	7.26	0.36	8.60	0.12	34.700	0.22	25.8	8.14
	150 D	0.08	0.07	0.10	1.84	0.27	7.07	0.36	7.35	0.10	34.820	0.19	25.6	8.16
DOH WQS		DRY	0.25	0.14				0.52	7.86	0.20	*	0.15	**	***
GEOMETRIC MEAN		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 (N=20). 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
MAKENA 1	0 S	6.10	473.90	3.90	1586.5	7.10	97.60	15.10	674.10	0.33	29.190	1.02	25.6	8.13
	2 S	4.30	330.40	2.20	1158.7	7.40	106.00	12.60	490.90	0.29	31.320	0.95	25.6	8.16
	5 S	3.70	150.10	2.10	631.2	7.70	113.00	12.00	320.40	0.24	32.610	0.68	25.6	8.16
	5 D	3.40	116.30	3.00	520.5	8.00	106.10	12.30	273.30	0.20	33.270	0.60	25.6	8.17
	10 S	3.00	48.30	2.20	261.5	8.00	104.00	11.10	174.00	0.18	34.220	0.43	25.7	8.16
	10 D	3.00	30.30	2.30	182.9	8.60	106.10	12.00	151.80	0.17	34.430	0.44	25.6	8.16
	50 S	2.70	37.50	2.60	205.1	8.00	102.90	11.10	160.90	0.16	34.360	0.35	25.7	8.14
	50 D	2.40	4.70	1.80	73.0	8.30	103.30	11.40	112.70	0.11	34.760	0.30	25.6	8.14
	100 S	2.70	14.40	2.10	134.8	8.00	93.50	11.40	136.50	0.12	34.500	0.29	25.7	8.14
	100 D	2.40	1.50	1.20	58.7	8.30	101.80	11.10	106.70	0.09	34.820	0.25	25.6	8.16
	150 S	2.70	4.40	1.90	85.4	8.00	101.60	11.10	120.40	0.12	34.700	0.22	25.8	8.14
	150 D	2.40	0.90	1.40	51.7	8.30	99.00	11.10	102.90	0.10	34.820	0.19	25.6	8.16
MAKENA 2	0 S	5.80	52.60	5.10	591.9	9.90	121.20	17.30	194.90	0.98	33.710	0.90	25.7	8.14
	2 S	5.80	52.50	3.70	548.6	9.90	112.00	16.70	184.10	0.71	33.540	0.89	25.8	8.13
	5 S	5.50	44.20	3.90	435.7	8.60	102.80	14.80	163.30	0.48	33.970	0.74	25.7	8.14
	5 D	5.50	40.70	4.90	415.7	9.60	105.30	15.70	166.60	0.47	34.030	0.93	25.7	8.14
	10 S	4.00	24.20	2.90	277.2	9.20	75.40	14.20	132.00	0.34	34.340	0.51	25.6	8.15
	10 D	3.70	14.40	3.50	223.3	9.20	100.70	13.90	129.10	0.27	34.470	0.56	25.7	8.15
	50 S	3.40	16.80	3.90	210.1	9.90	106.80	14.20	135.50	0.25	34.430	0.38	25.6	8.14
	50 D	3.00	3.90	2.90	91.9	9.60	108.60	13.30	118.40	0.19	34.760	0.43	25.6	8.15
	100 S	2.40	7.00	2.80	118.5	8.90	104.20	12.00	118.70	0.17	34.610	0.31	25.7	8.13
	100 D	2.40	2.60	2.80	67.1	8.90	101.40	11.70	108.50	0.12	34.790	0.31	25.6	8.15
	150 S	2.70	4.00	3.50	87.9	8.60	105.10	12.00	115.10	0.13	34.740	0.26	25.7	8.15
	150 D	2.40	1.60	2.10	57.6	8.90	106.70	12.00	112.60	0.11	34.810	0.25	25.6	8.16
	200 S	2.40	1.90	2.20	64.3	8.60	102.90	11.40	111.40	0.11	34.810	0.28	25.8	8.15
	200 D	2.40	0.80	2.90	47.8	8.90	110.30	11.70	115.50	0.10	34.840	0.27	25.7	8.17
MAKENA 3	0 S	3.40	76.00	5.10	410.4	8.00	76.30	13.60	283.90	0.26	33.710	0.60	25.7	8.15
	2 S	5.20	153.50	3.60	623.9	7.70	85.50	14.80	366.90	0.30	33.680	0.65	25.8	8.13
	5 S	3.40	106.00	3.30	426.1	7.40	102.90	13.00	281.50	0.21	34.090	0.37	25.8	8.13
	5 D	4.00	57.90	3.60	294.4	8.00	92.80	13.30	217.50	0.20	34.360	0.46	25.7	8.13
	10 S	2.40	45.00	3.60	227.0	8.30	98.80	11.70	189.50	0.15	34.450	0.28	25.7	8.14
	10 D	2.70	25.00	2.80	161.8	8.60	100.00	11.70	159.20	0.14	34.600	0.29	25.7	8.14
	50 S	2.70	21.00	2.80	149.7	8.30	106.40	11.40	149.50	0.13	34.620	0.23	25.7	8.12
	50 D	2.10	5.30	2.20	79.8	8.60	109.30	11.10	121.00	0.09	34.780	0.23	25.6	8.14
	100 S	2.40	5.70	3.20	81.2	8.60	104.00	11.40	118.20	0.10	34.750	0.18	25.6	8.13
	100 D	2.10	1.50	3.20	53.4	8.60	96.90	11.10	104.70	0.08	34.800	0.19	25.6	8.14
	150 S	1.80	2.50	2.30	59.8	8.60	95.50	10.80	105.10	0.10	34.780	0.15	25.7	8.16
	150 D	1.80	1.10	1.50	50.0	8.30	94.60	10.80	99.50	0.09	34.830	0.17	25.6	8.17
MAKENA 4	0 S	6.10	473.90	3.90	1586.5	7.10	97.60	15.10	674.10	0.33	29.190	1.02	25.6	8.13
	2 S	4.30	330.40	2.20	1158.7	7.40	106.00	12.60	490.90	0.29	31.320	0.95	25.6	8.16
	5 S	3.70	150.10	2.10	631.2	7.70	113.00	12.00	320.40	0.24	32.610	0.68	25.6	8.16
	5 D	3.40	116.30	3.00	520.5	8.00	106.10	12.30	273.30	0.20	33.270	0.60	25.6	8.17
	10 S	3.00	48.30	2.20	261.5	8.00	104.00	11.10	174.00	0.18	34.220	0.43	25.7	8.16
	10 D	3.00	30.30	2.30	182.9	8.60	106.10	12.00	151.80	0.17	34.430	0.44	25.6	8.16
	50 S	2.70	37.50	2.60	205.1	8.00	102.90	11.10	160.90	0.16	34.360	0.35	25.7	8.14
	50 D	2.40	4.70	1.80	73.0	8.30	103.30	11.40	112.70	0.11	34.760	0.30	25.6	8.14
	100 S	2.70	14.40	2.10	134.8	8.00	93.50	11.40	136.50	0.12	34.500	0.29	25.7	8.14
	100 D	2.40	1.50	1.20	58.7	8.30	101.80	11.10	106.70	0.09	34.820	0.25	25.6	8.16
	150 S	2.70	4.40	1.90	85.4	8.00	101.60	11.10	120.40	0.12	34.700	0.22	25.8	8.14
	150 D	2.40	0.90	1.40	51.7	8.30	99.00	11.10	102.90	0.10	34.820	0.19	25.6	8.16
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 in µM and µg/L (shaded) from irrigation wells and two irrigation lakes collected in the vicinity of the Makena Resort on December 9, 2007. Also shown are results from samples collected from two monitoring wells (M-1 and M-3) located near the Maluaka development site on December 22, 2007. 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	129.1	1806.7	0.10	1.40	540.1	15176.8	0.35	10.85	13.05	182.70	2.45	75.95	142.2	1990.8	1.341
2	2.80	86.80	137.6	1925.7	0.70	9.80	702.6	19741.7	0.30	9.30	8.35	116.90	3.10	96.10	146.6	2052.4	1.906
3	2.45	75.95	114.7	1605.1	1.40	19.60	690.8	19411.5	0.45	13.95	12.35	172.90	2.90	89.90	128.4	1797.6	1.909
4	2.60	80.60	140.0	1960.0	0.45	6.30	655.2	18411.1	0.35	10.85	12.90	180.60	2.95	91.45	153.4	2146.9	2.076
5	2.20	68.20	197.4	2762.9	1.00	14.00	570.2	16021.2	0.30	9.30	4.70	65.80	2.50	77.50	203.1	2842.7	1.542
8	2.30	71.30	113.3	1585.5	0.15	2.10	622.1	17481.0	0.35	10.85	12.70	177.80	2.65	82.15	126.1	1765.4	1.683
10	2.00	62.00	207.8	2909.2	0.70	9.80	637.7	17918.0	0.40	12.40	11.20	156.80	2.40	74.40	219.7	3075.8	2.023
11	2.40	74.40	115.6	1617.7	0.55	7.70	622.0	17476.8	0.25	7.75	15.90	222.60	2.65	82.15	132.0	1848.0	1.970
IL10	0.30	9.30	1.3	17.5	1.50	21.00	640.1	17986.8	2.00	62.00	58.65	821.10	2.30	71.30	61.4	859.6	1.788
IL-B	77.75	2410.25	44.4	621.6	14.20	198.80	405.0	11379.1	0.25	7.75	62.50	875.00	78.00	2418.00	121.1	1695.4	1.822

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 2007 (Transect Site 3 has been monitored since 2002). 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. All REGSLOPES bound zero indicating there is no significant change over time at any of the transect sites. 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
REGSLOPE	-3.26	4.47	-13.11	6.59
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
REGSLOPE	-6.34	17.21	-44.22	31.54
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
REGSLOPE	-32.67	35.96	-132.53	67.18
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	14.0	704.53	765.57
2007	710.11	7.14	694.56	725.66
REGSLOPE	-7.23	14.10	-38.25	23.79

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
REGSLOPE	0.10	0.13	-0.18	0.38
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
REGSLOPE	0.19	0.49	-0.89	1.27
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
REGSLOPE	0.96	1.02	-1.88	3.80
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
REGSLOPE	0.22	0.40	-0.66	1.09

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 2007 (Transect Site 3 has been monitored since 2002). 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. All REGSLOPES bound zero indicating there is no significant change over time at any of the transect sites. 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
REGSLOPE	**2.40**	**4.82**	**-8.20**	**13.00**
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
REGSLOPE	**-0.65**	**2.20**	**-5.49**	**4.20**
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
REGSLOPE	**71.21**	**64.82**	**-108.77**	**251.20**
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
REGSLOPE	**5.49**	**2.90**	**-0.90**	**11.88**

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
REGSLOPE	**-0.06**	**0.14**	**-0.37**	**0.24**
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
REGSLOPE	**0.02**	**0.06**	**-0.12**	**0.16**
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
REGSLOPE	**-2.04**	**1.88**	**-7.24**	**3.17**
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
REGSLOPE	**-0.16**	**0.09**	**-0.35**	**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 June 2007 (Transect site 3 has been monitored since 2002). 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
REGSLOPE	-0.02	0.05	-0.14	0.10
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
REGSLOPE	-0.10	0.64	-1.52	1.31
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
REGSLOPE	-0.15	0.49	-1.52	1.22
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
REGSLOPE	0.00	0.48	-1.07	1.06

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
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
REGSLOPE	0.00	0.02	-0.04	0.04
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
REGSLOPE	0.00	0.01	-0.03	0.04
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
REGSLOPE	0.00	0.01	-0.03	0.03

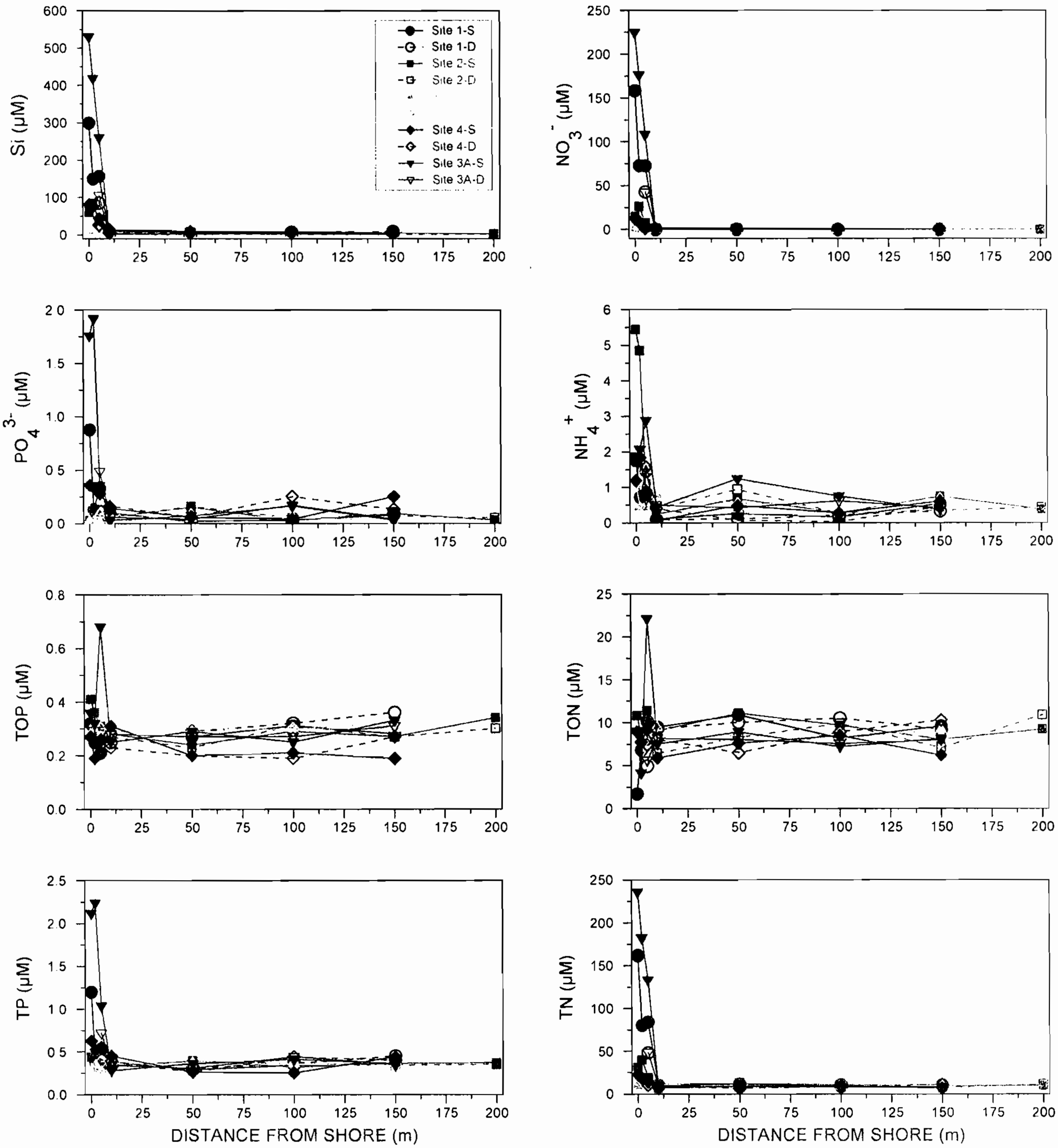

FIGURE 2. Plots of dissolved nutrients in surface (S) and deep (D) samples collected on June 29, 2007 as a function of distance from the shoreline in the vicinity of the Makena Resort. For site locations, see Figure 1.

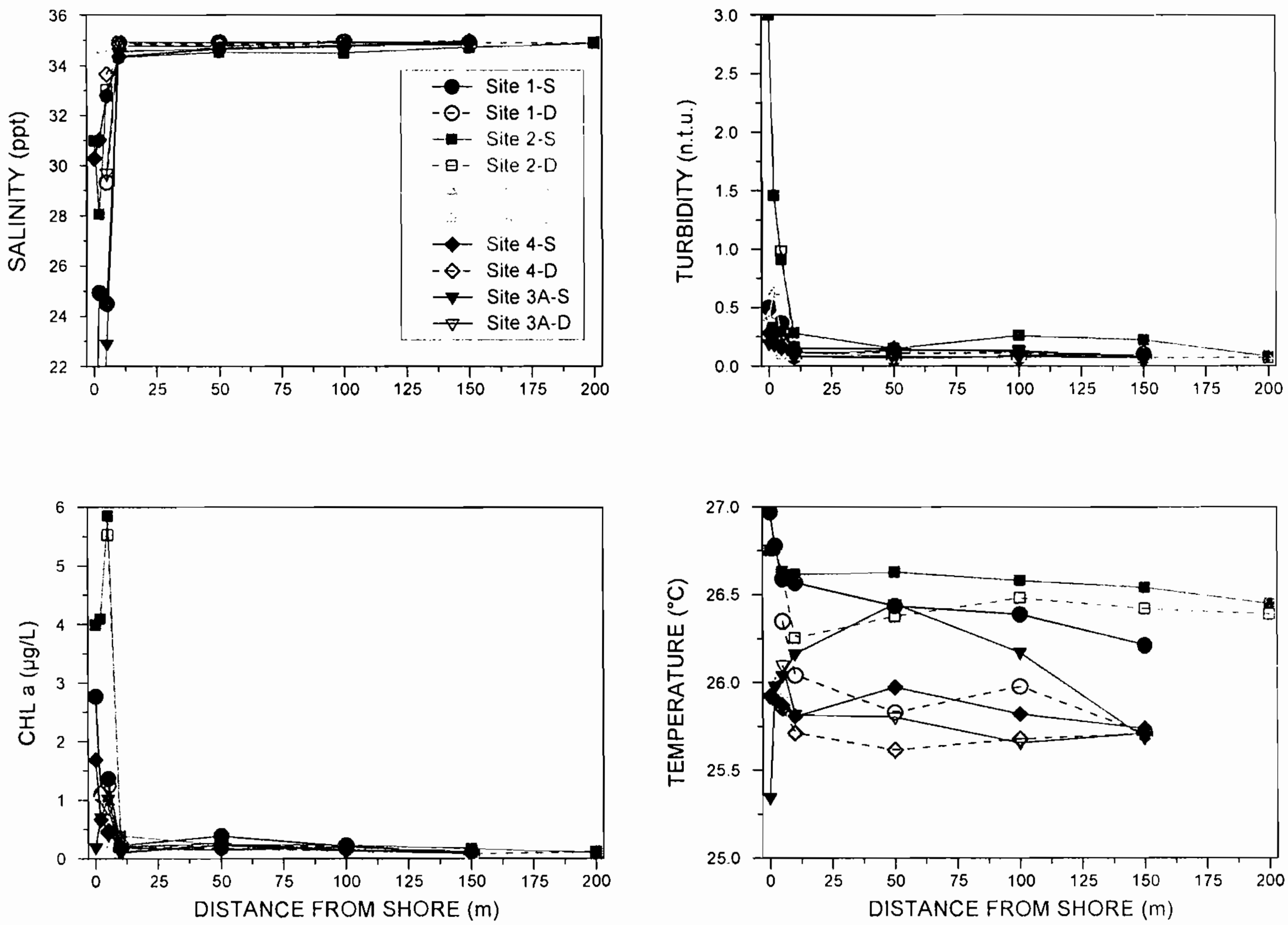

FIGURE 3. Plots of water chemistry constituents in surface (S) and deep (D) samples collected on June 29, 2007 as a function of distance from the shoreline in the vicinity of Makena Resort. For site locations, see Figure 1.

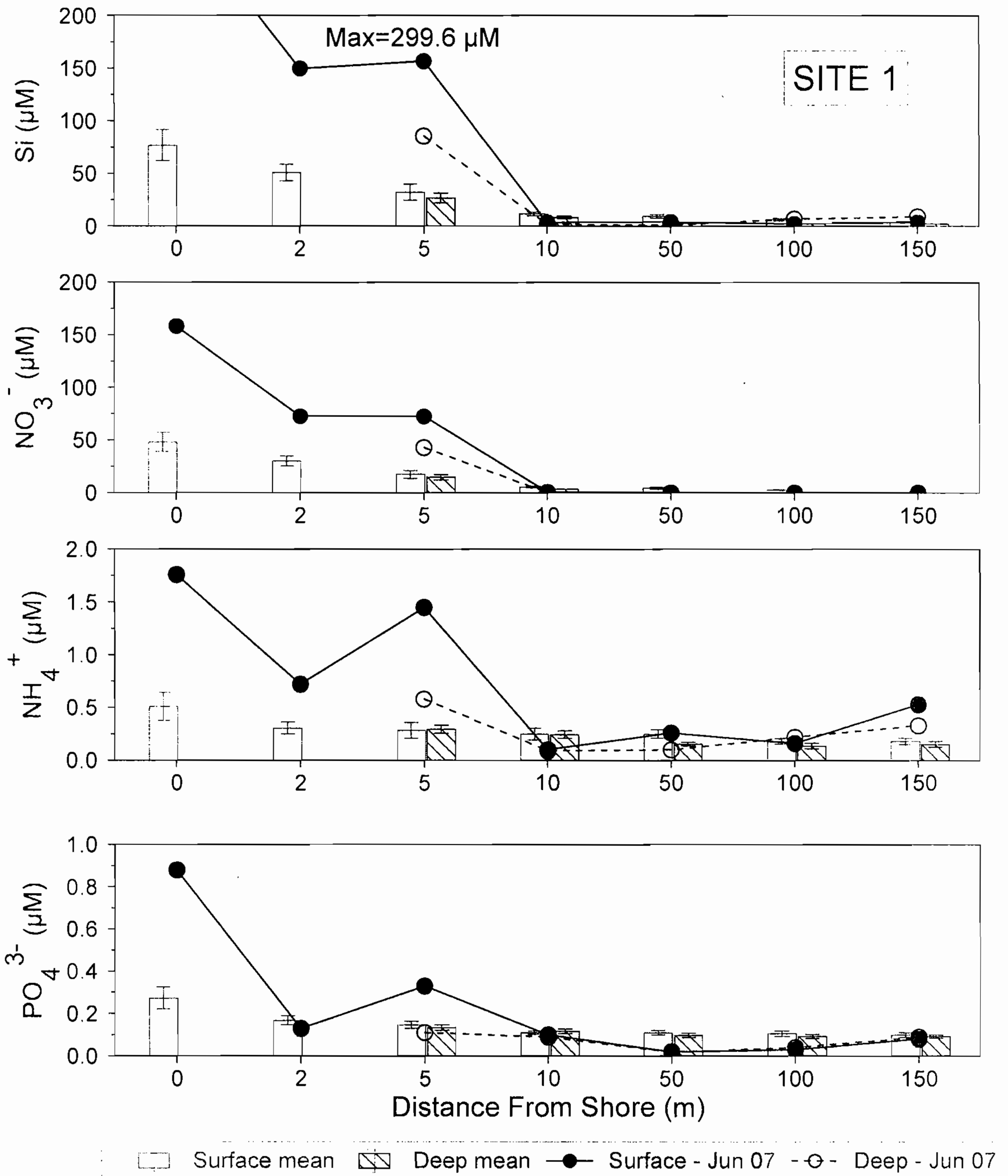

FIGURE 4. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

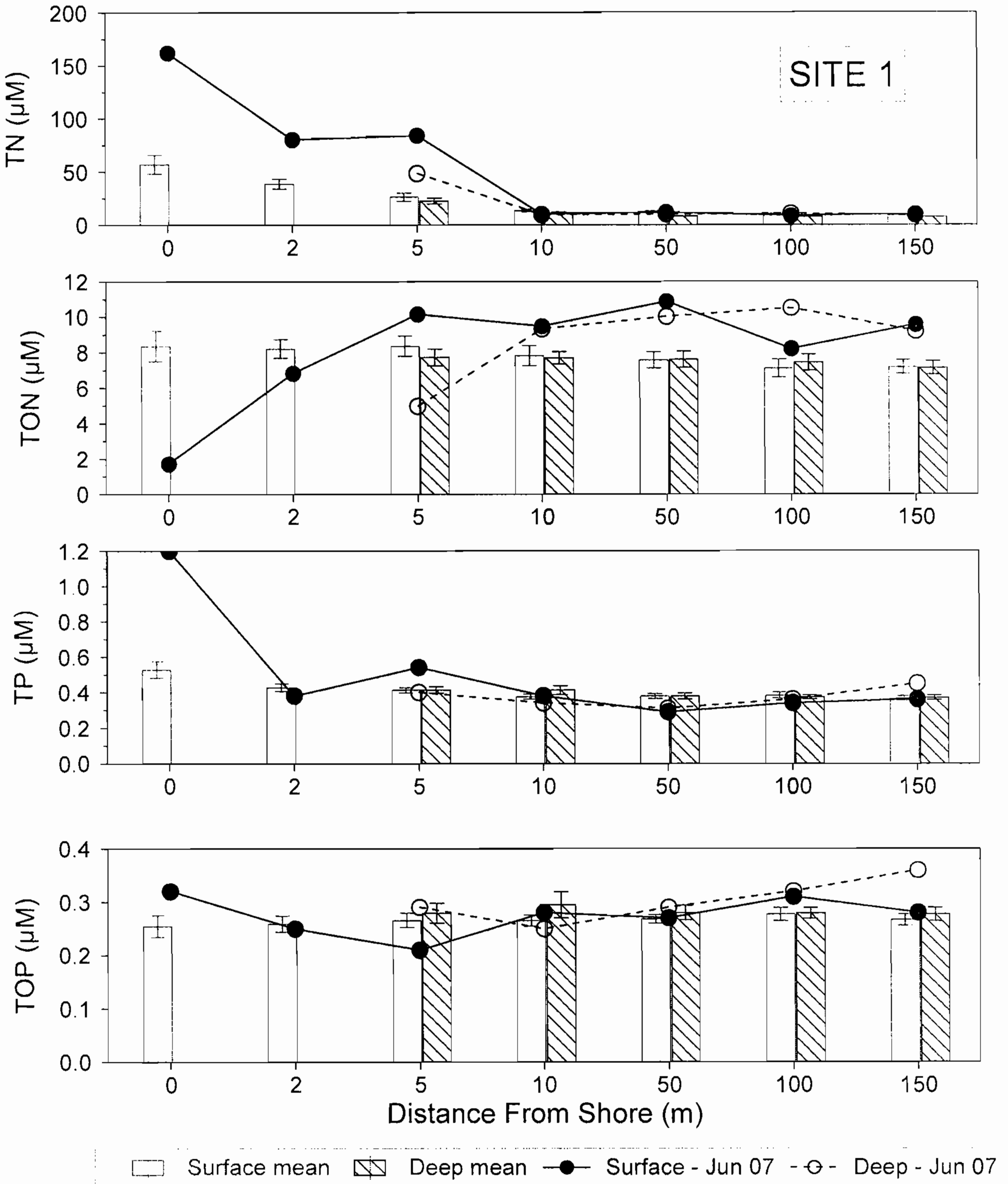

FIGURE 5. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

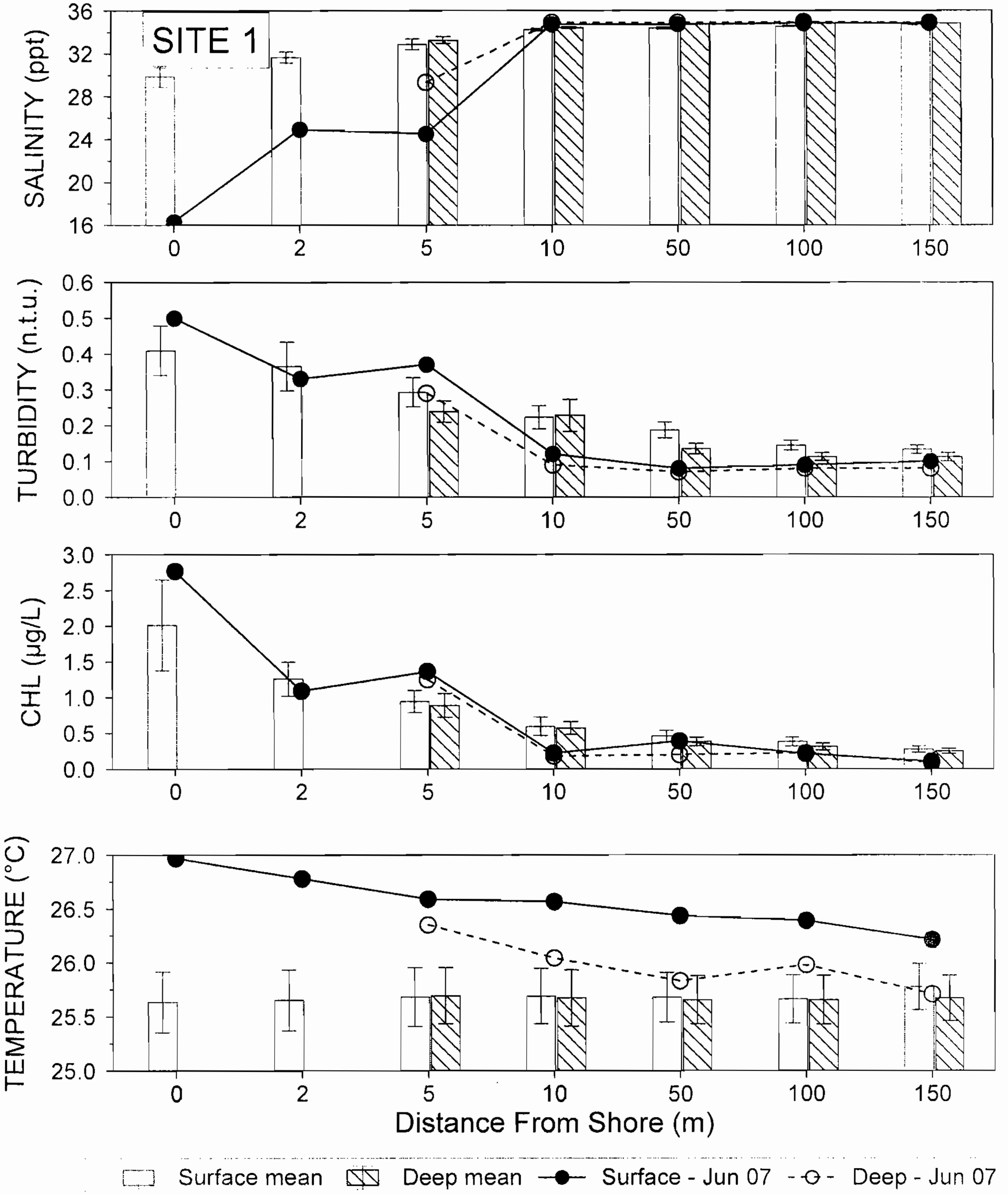

FIGURE 6. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 1, offshore of the Makena Resort. Data points and connected lines from samples collected during the most survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

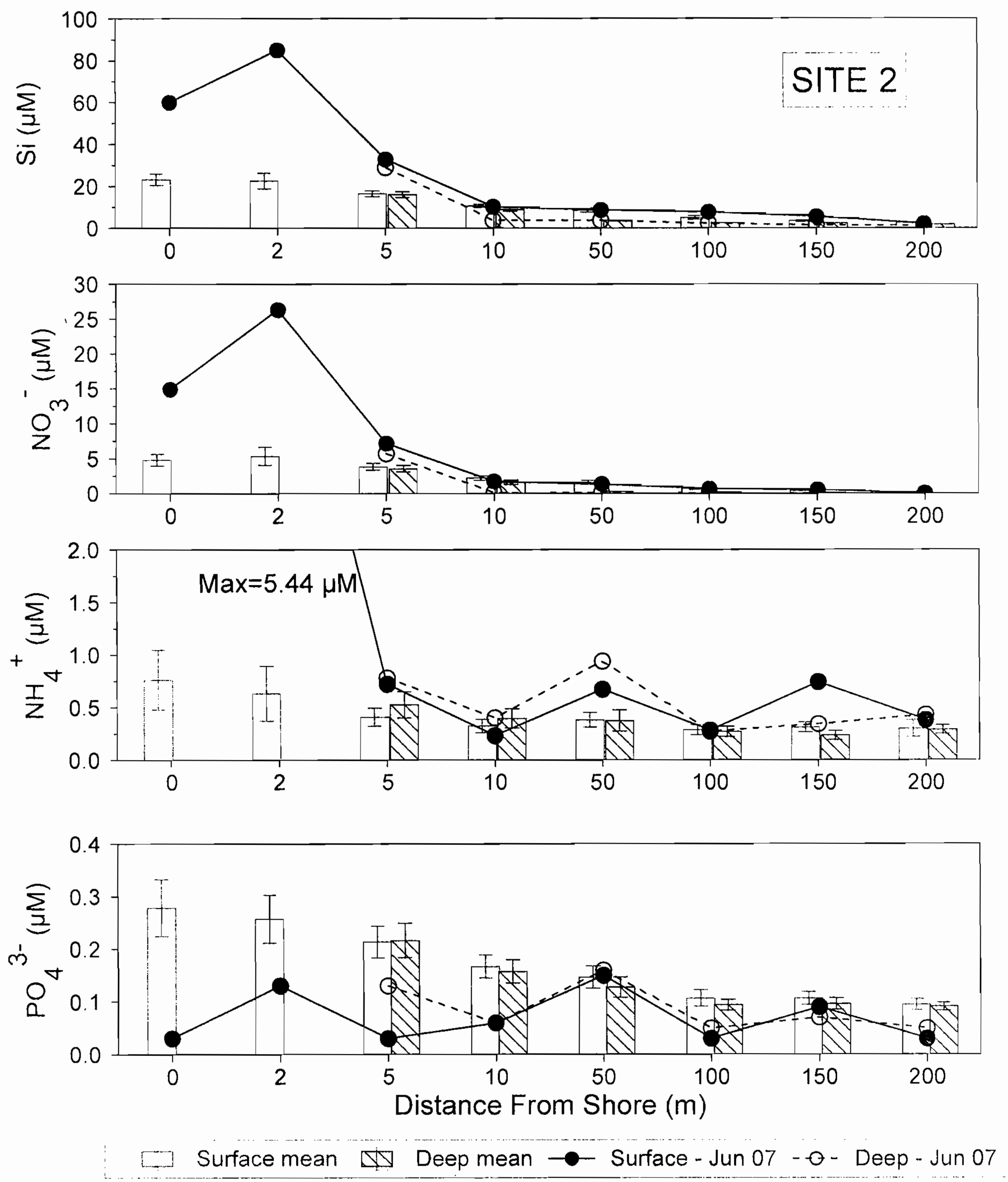

FIGURE 7. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

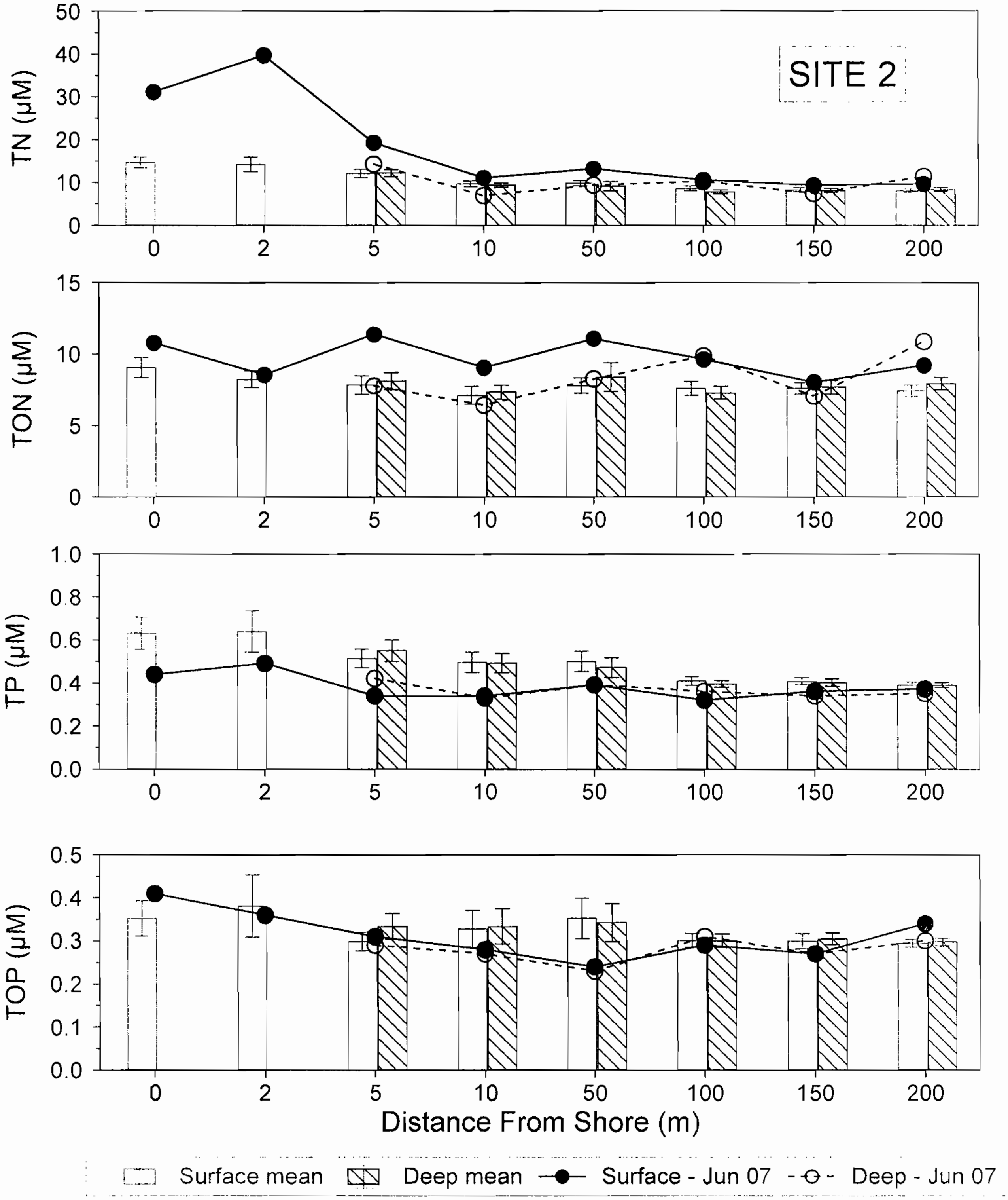

FIGURE 8. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

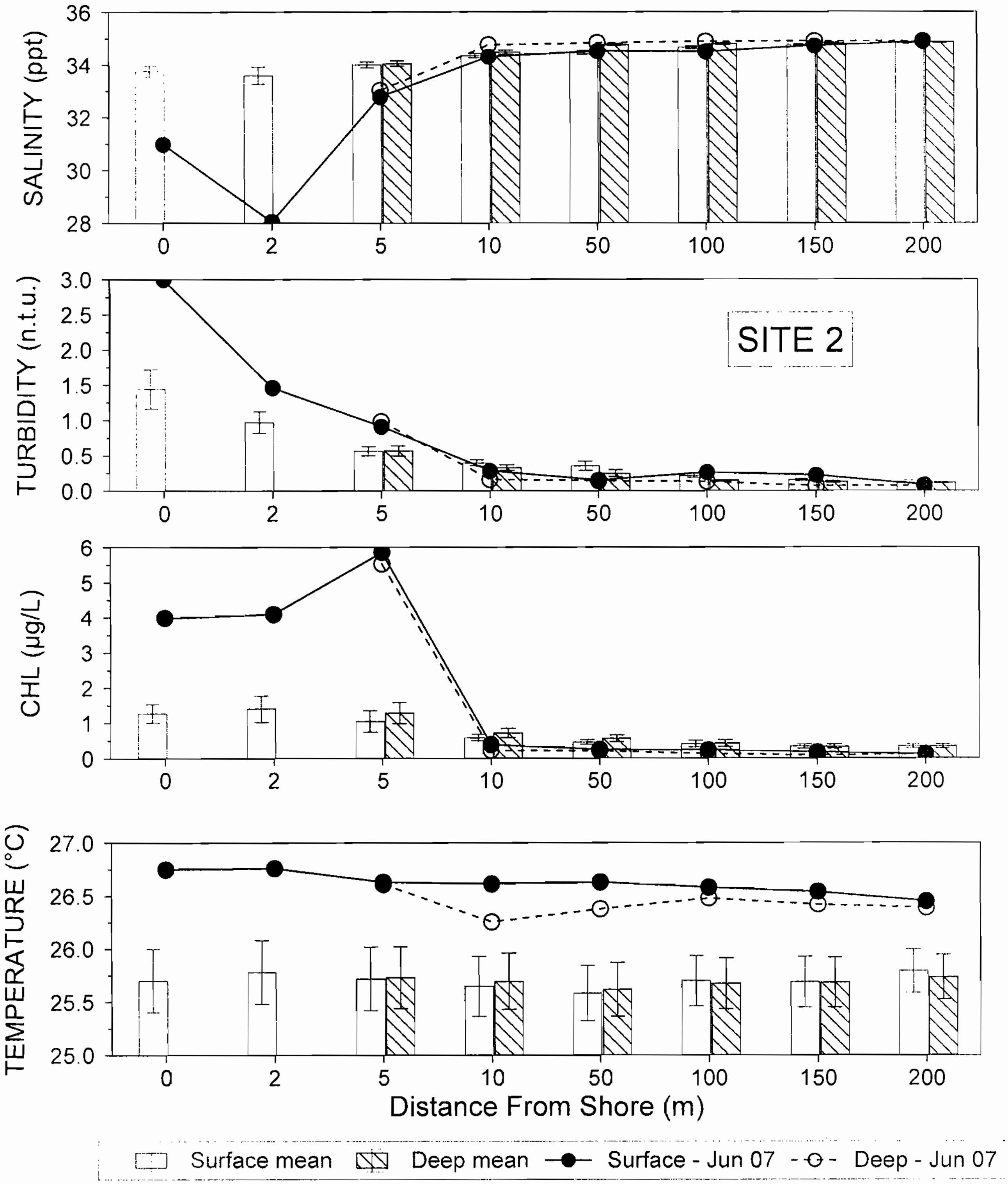

FIGURE 9. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 2, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey,bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

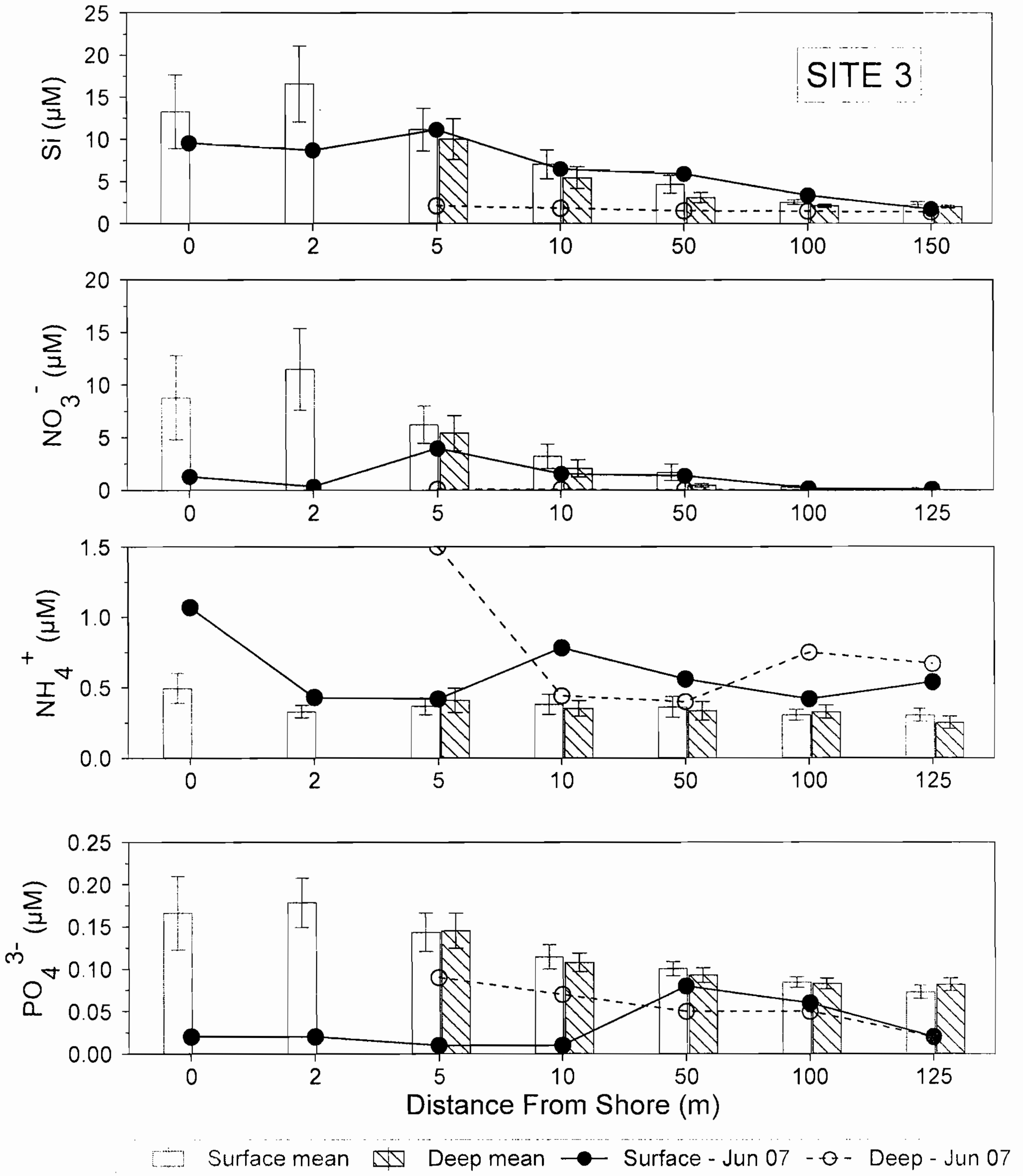

FIGURE 10. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

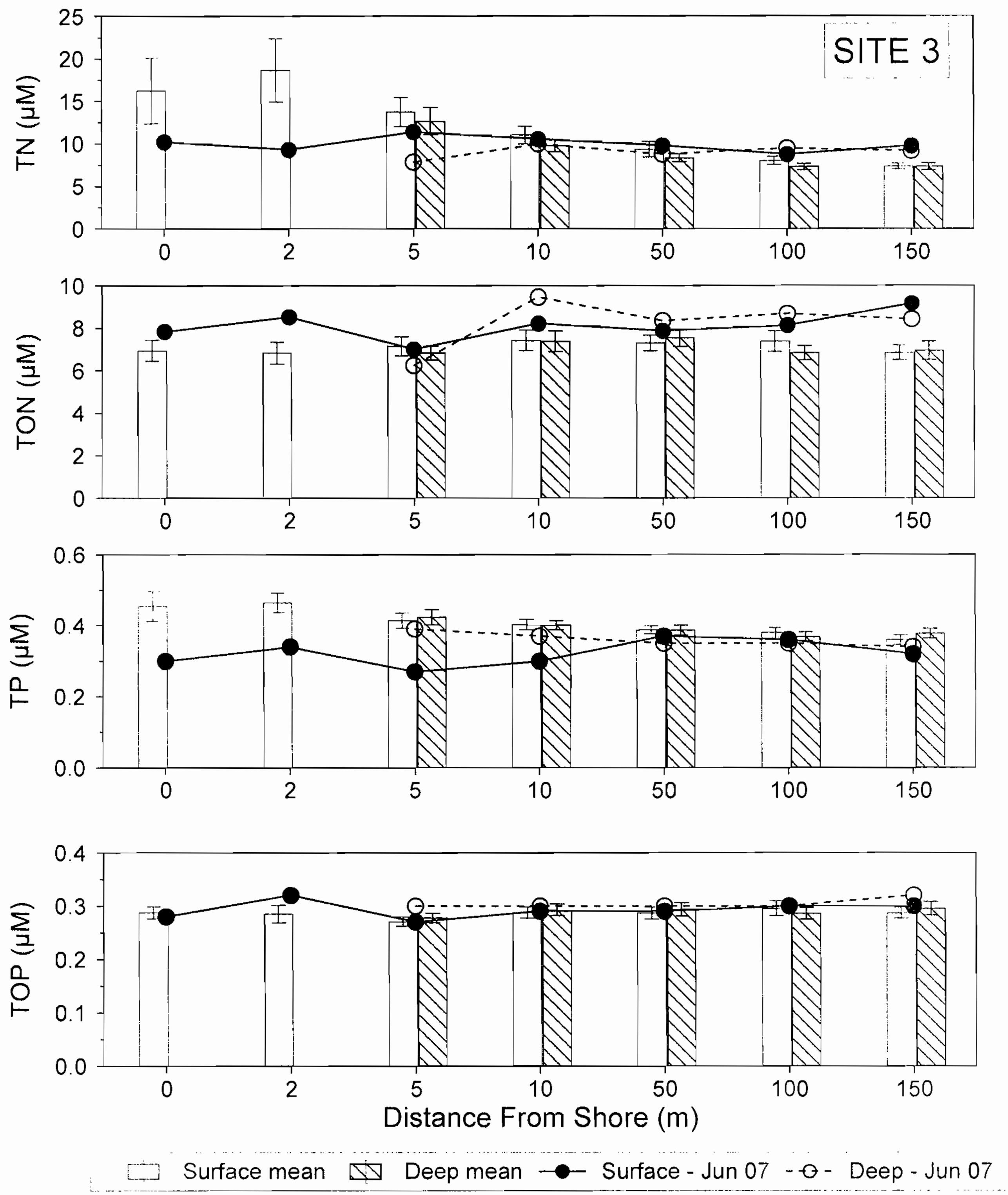

FIGURE 11. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

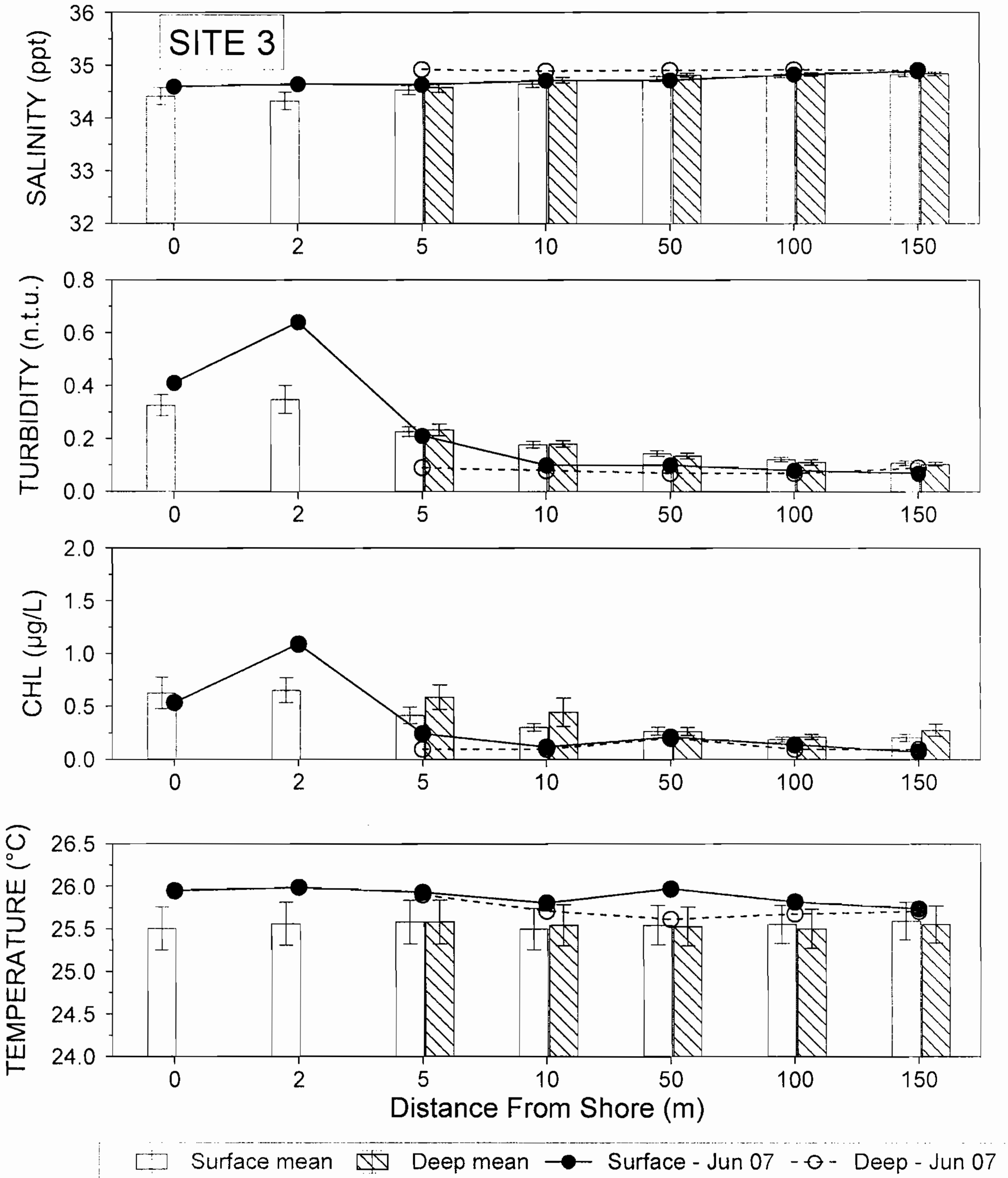

FIGURE 12. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 3, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

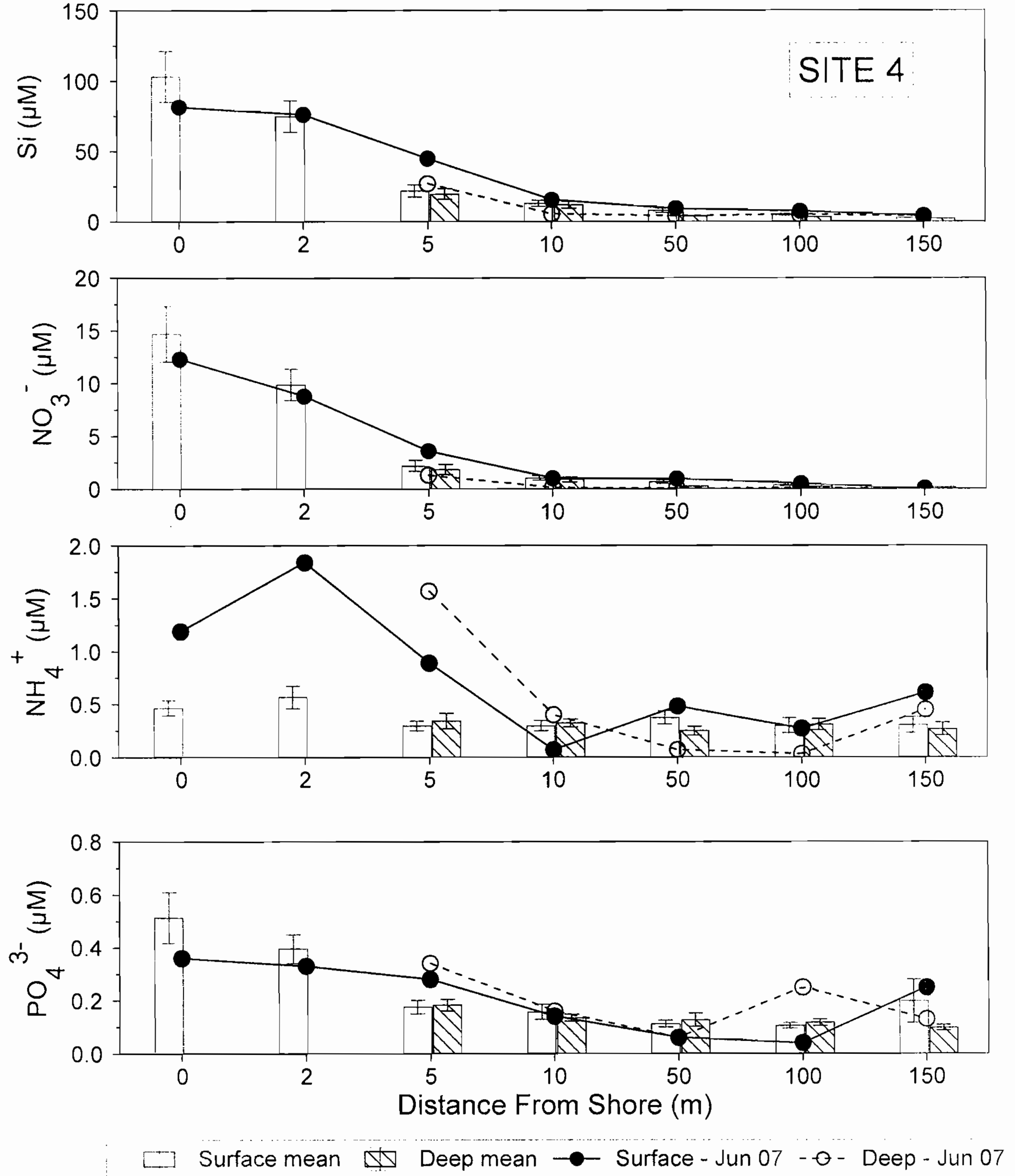

FIGURE 13. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

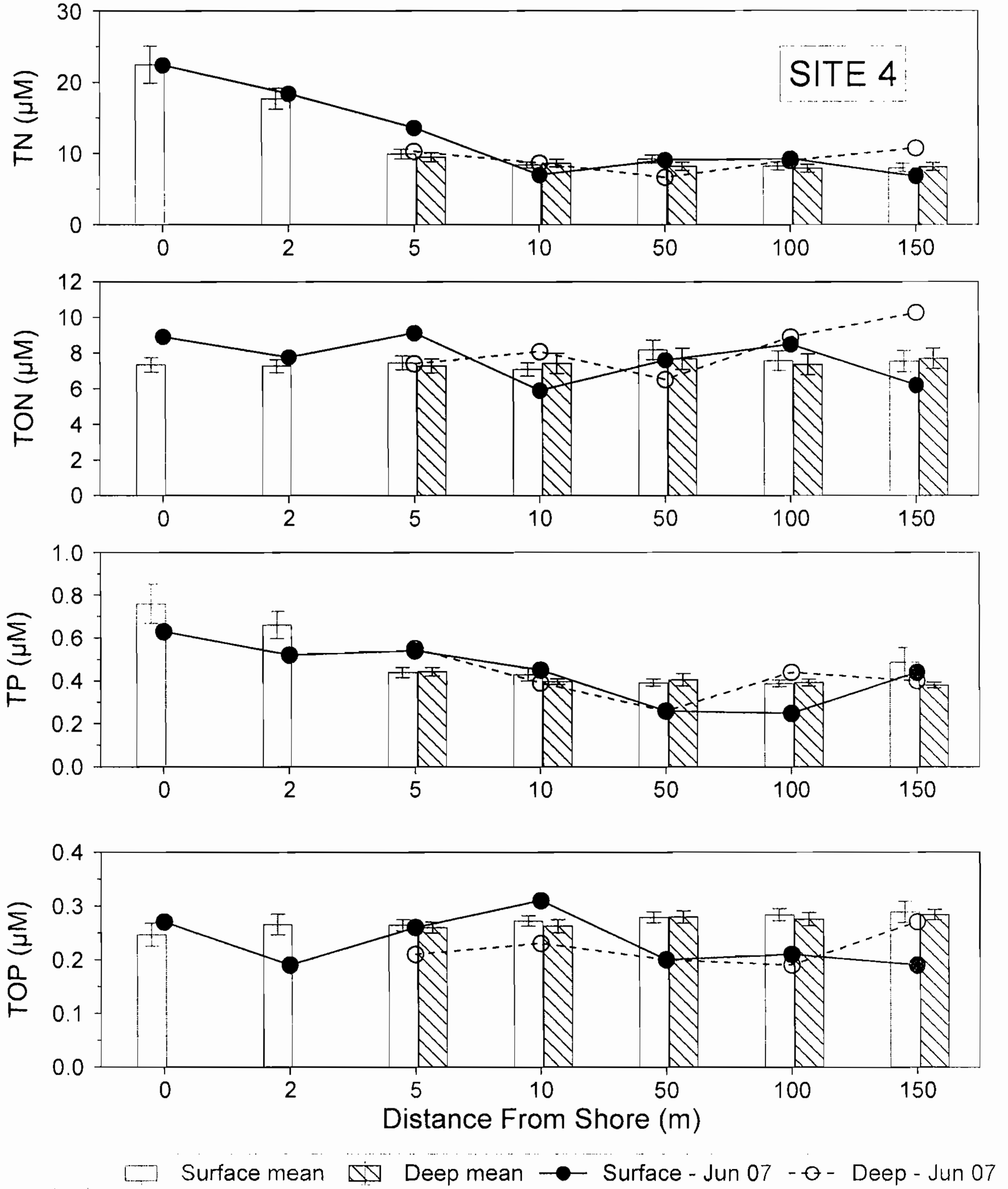

FIGURE 14. Plots of dissolved nutrient constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

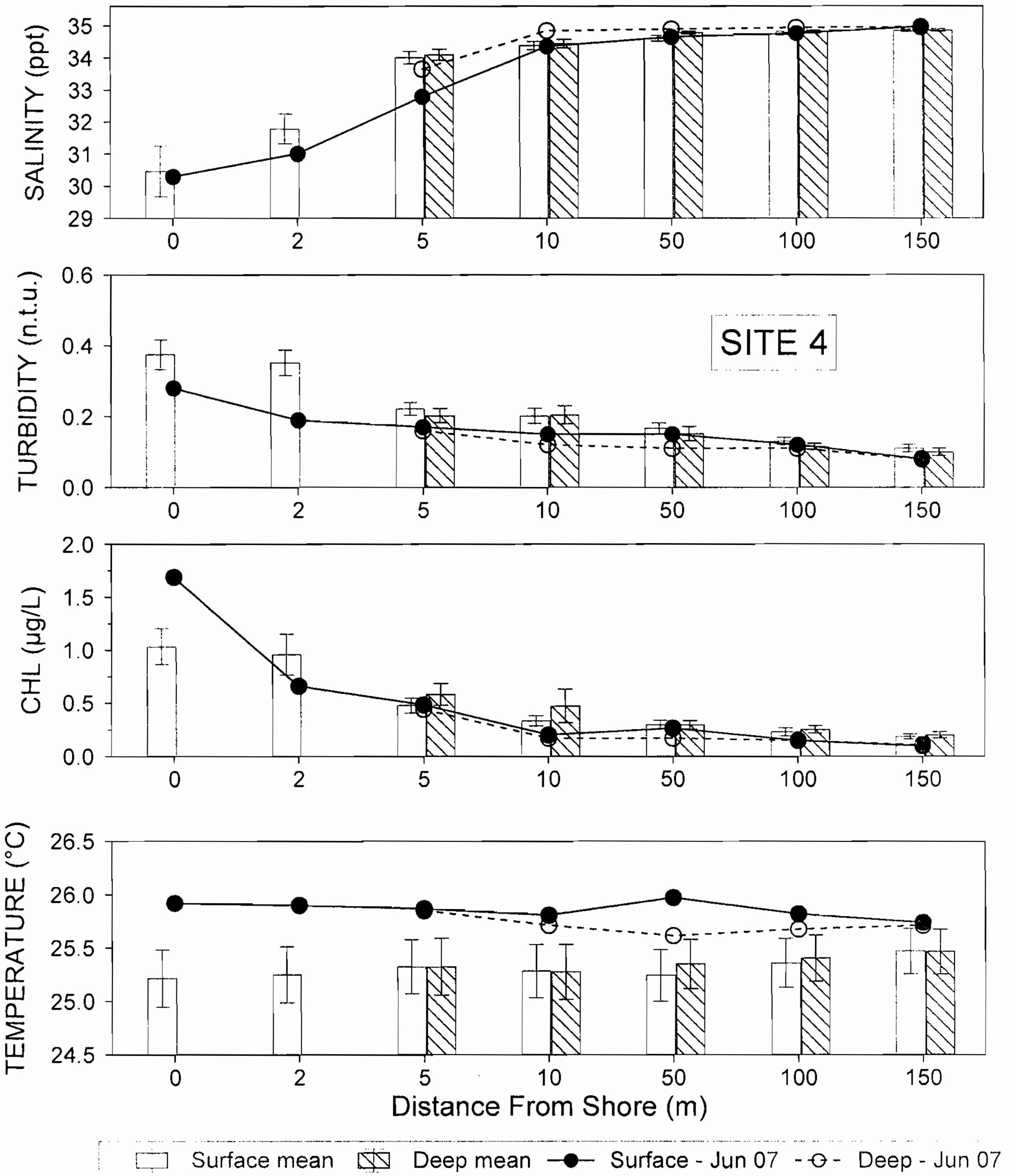

FIGURE 15. Plots of water chemistry constituents measured in surface and deep water samples as a function of distance from the shoreline at Site 4, offshore of the Makena Resort. Data points and connected lines from samples collected during the most recent survey, bar graphs represent mean values at each sampling station for surveys conducted since August 1995 (N=19). Error bars represent standard error of the mean. For site location, see Figure 1.

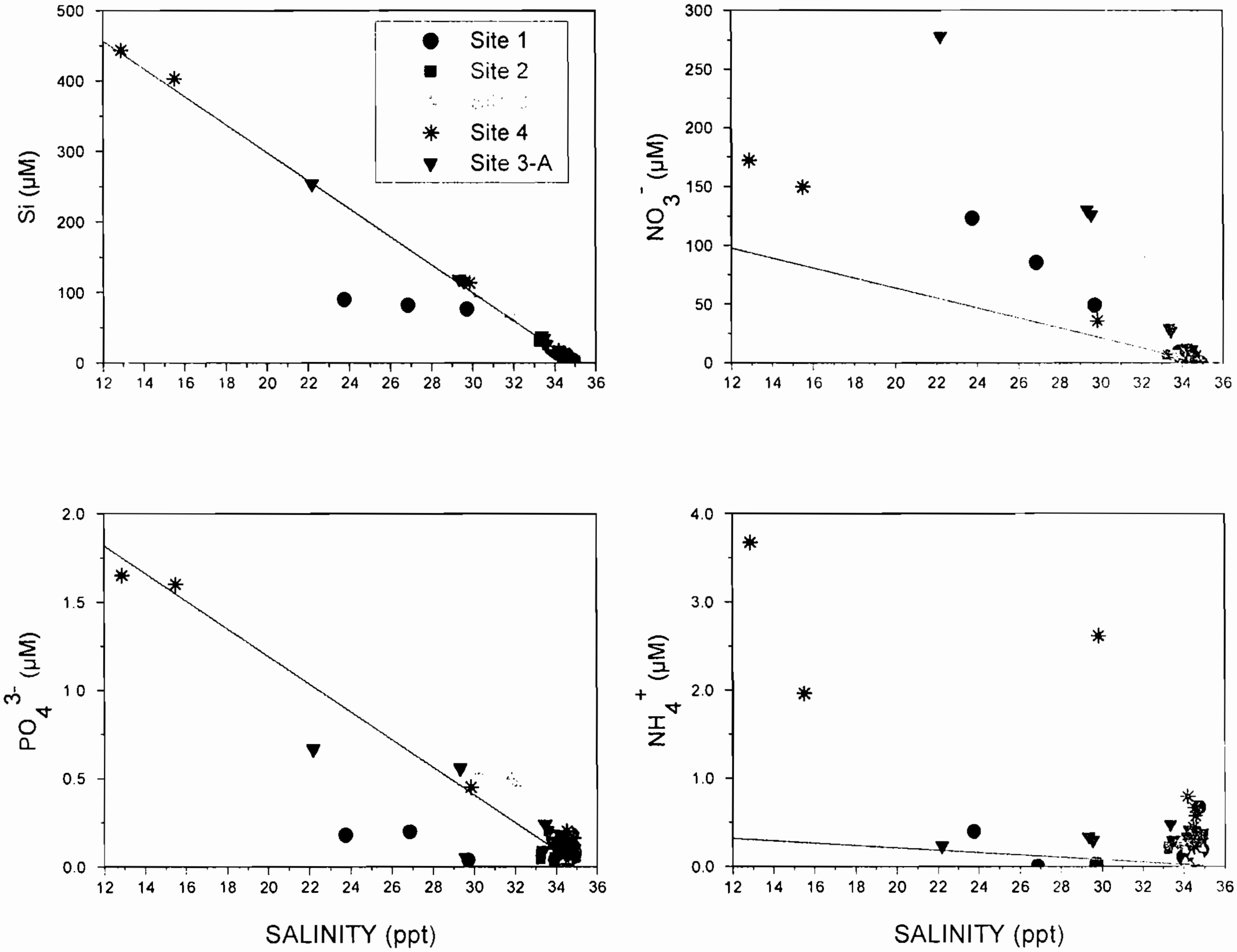

FIGURE 16. Mixing diagram showing concentration of dissolved nutrients from samples collected offshore of the Makena Resort on December 9, 2007 as functions of salinity. Solid red line in each plot is conservative mixing line constructed by connecting the concentrations in open coastal water with water from an irrigation well upslope of the Makena Golf Courses. For sampling site locations, see Figure 1.

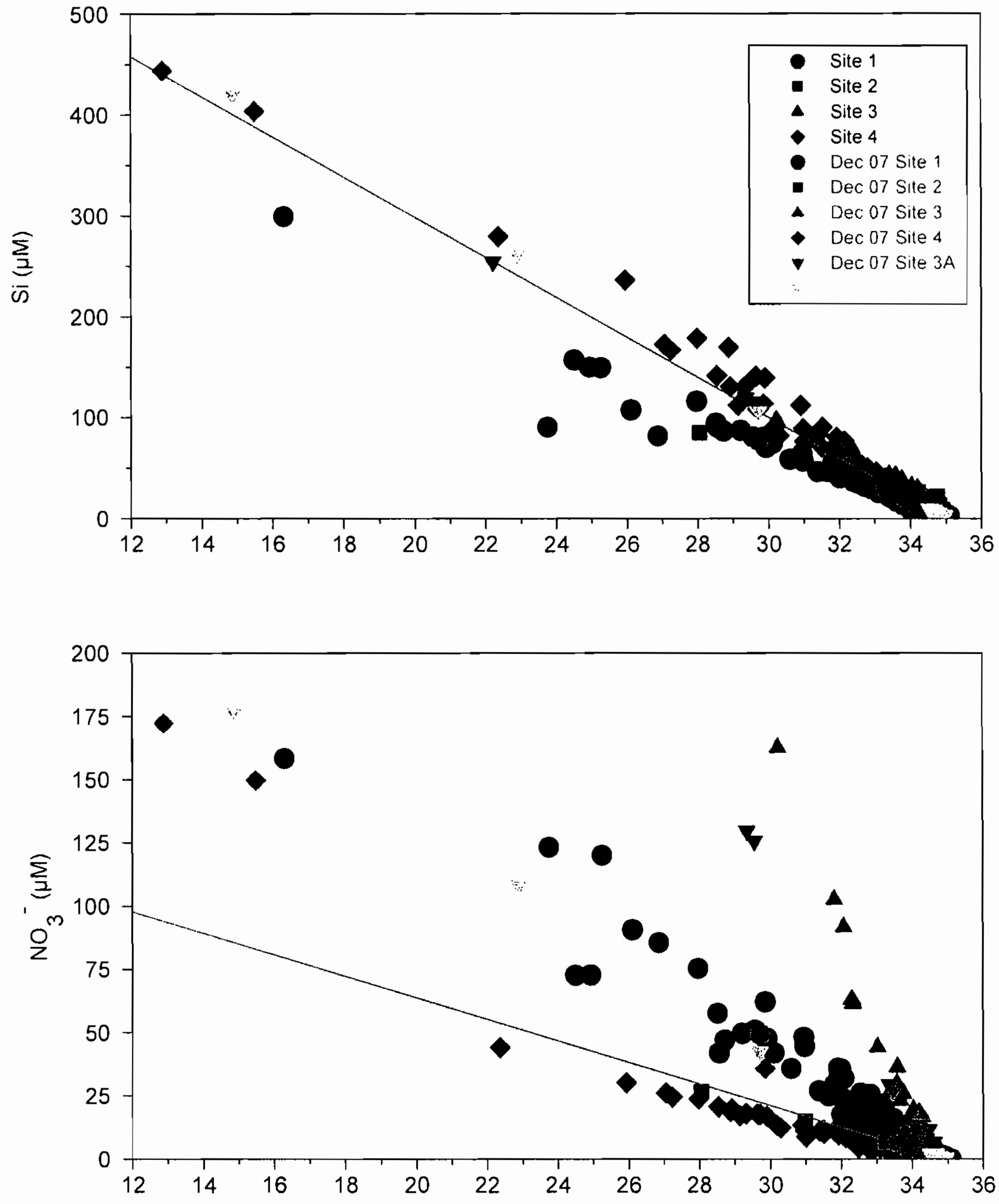

FIGURE 17. Silicate and nitrate, plotted as a function of salinity for surface samples collected since August 1995 at four sites offshore of the Makena Golf Course. Black symbols represent combined data from surveys conducted between August 1995 and December 2007. Green symbols represent data from the first survey at Site 3A 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.

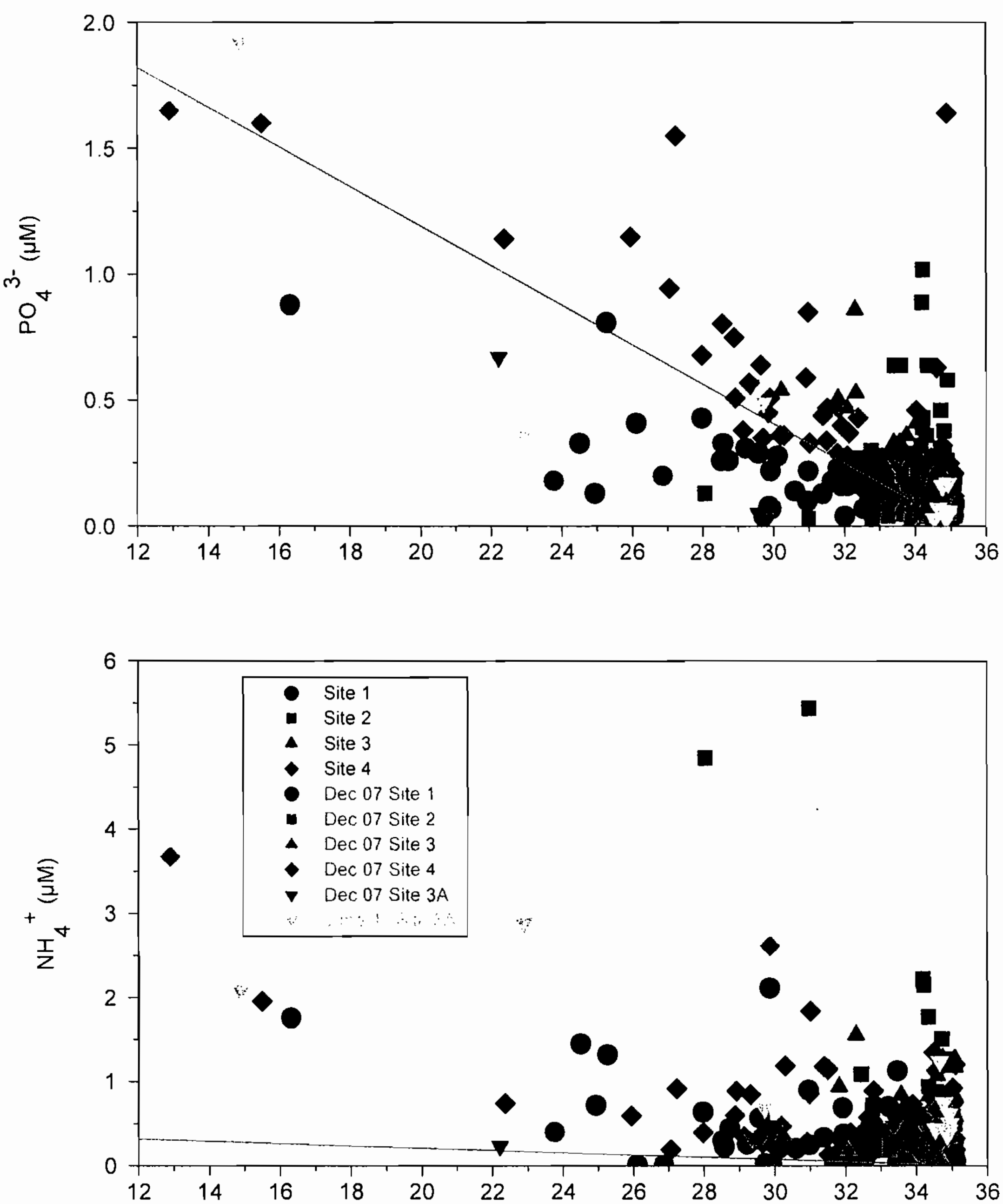

FIGURE 18. Phosphate and ammonium, plotted as a function of salinity for surface samples collected since August 1995 at four sites offshore of the Makena Golf Course. Black symbols represent combined data from surveys conducted between August 1995 and December 2007. Green symbols represent the first set of data from Site 3A (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.

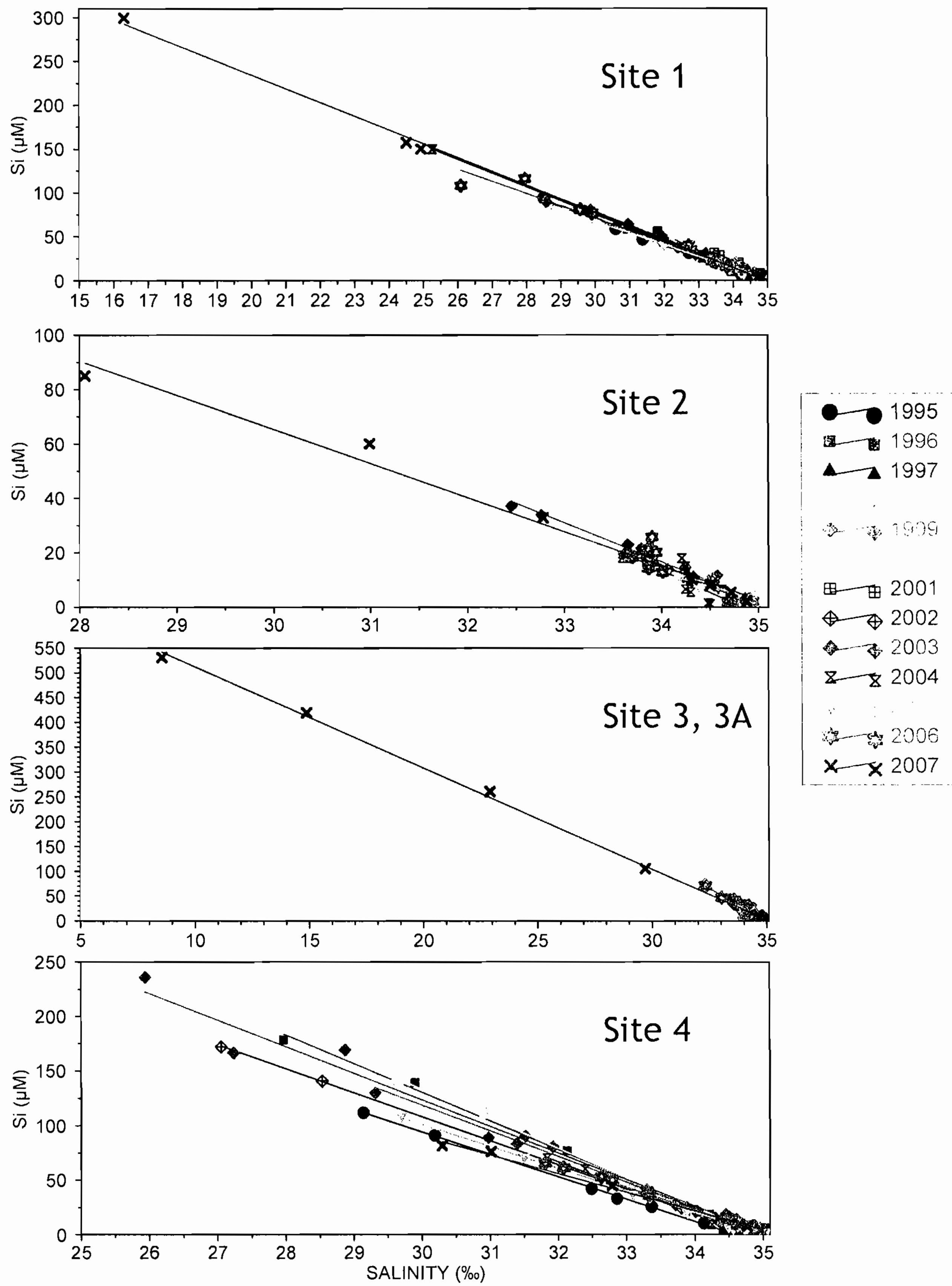

FIGURE 19. Mixing diagram showing yearly concentrations of silica as functions of salinity from samples collected during annual monitoring surveys at four transect sites offshore of the Makena Resort. Note axis scale changes between sites. Straight lines are linear regressions through data points for each year. For sampling site locations, see Figure 1.

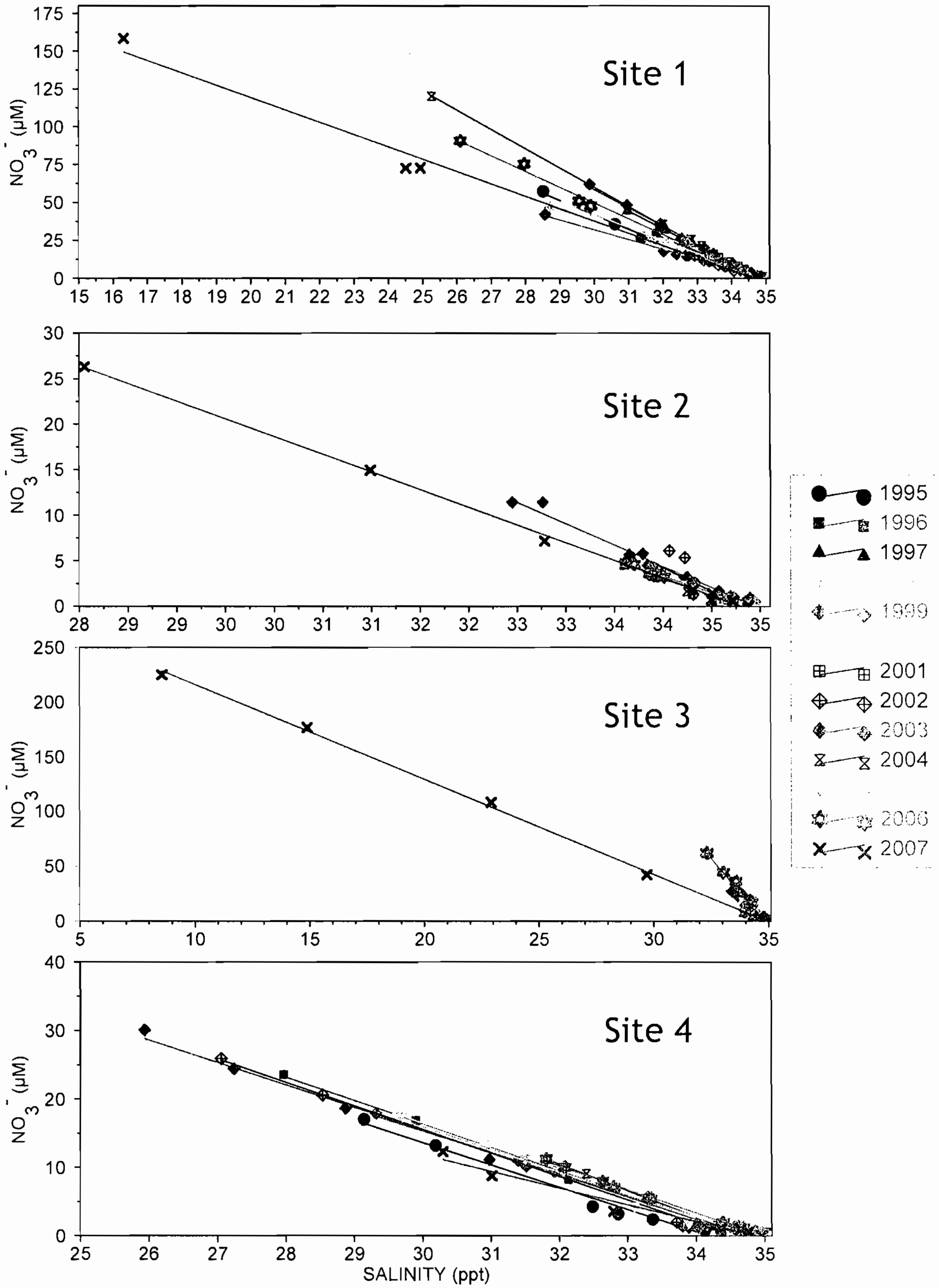

FIGURE 20. Mixing diagram showing yearly concentrations of nitrate as functions of salinity from samples collected during annual monitoring surveys at four transect sites offshore of the Makena Resort. Note axis scale changes between sites. Straight lines are linear regressions through data points for each year. For sampling site locations, see Figure 1.

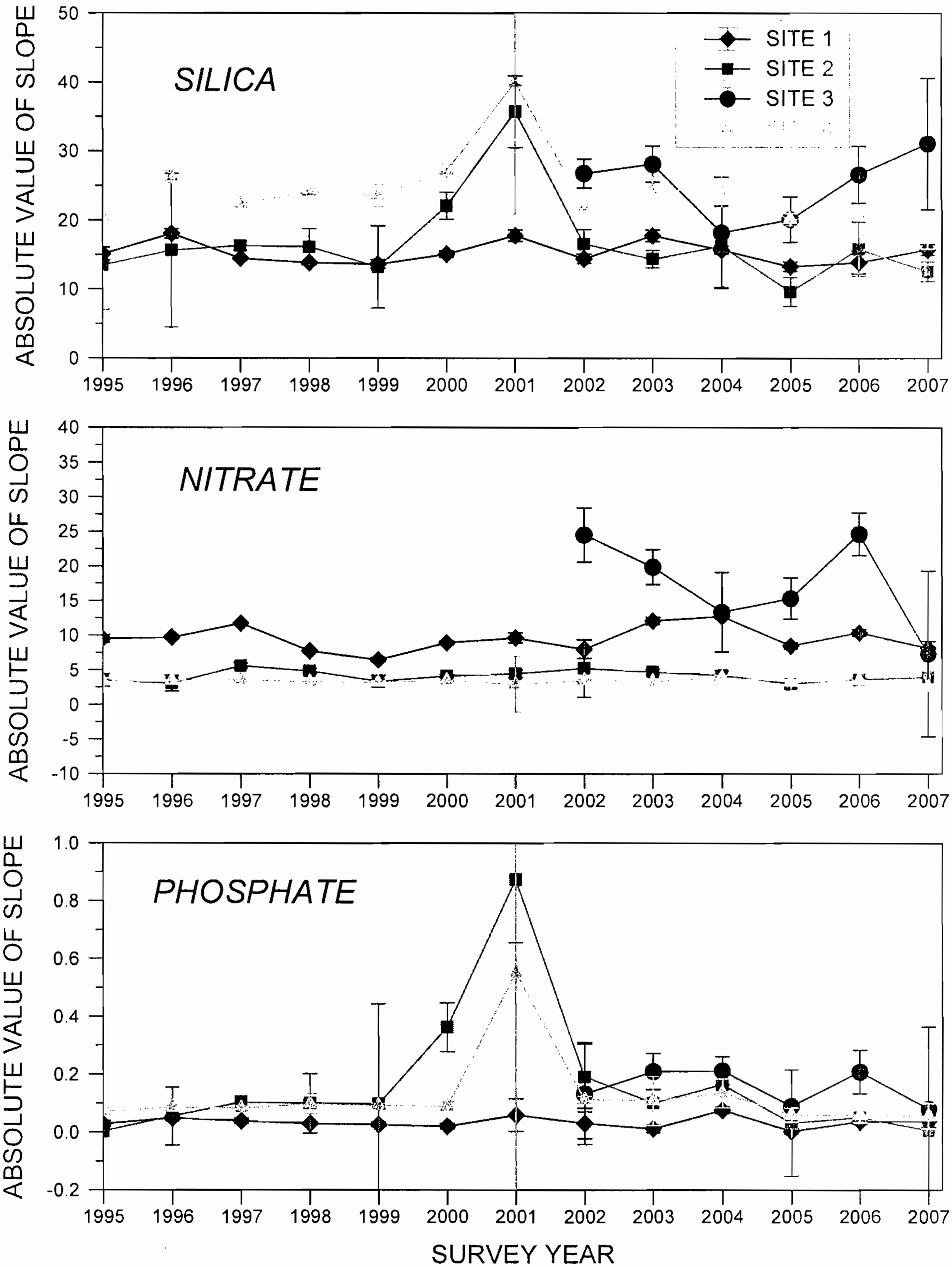

FIGURE 21. Time-course plots of absolute values of slopes of linear regressions of concentrations of silica, nitrate and phosphate as functions of salinity collected annually at each of the four transect monitoring stations off the Makena Resort. Error bars are 95% confidence limits. For locations of sampling transect sites, see Figure 1.

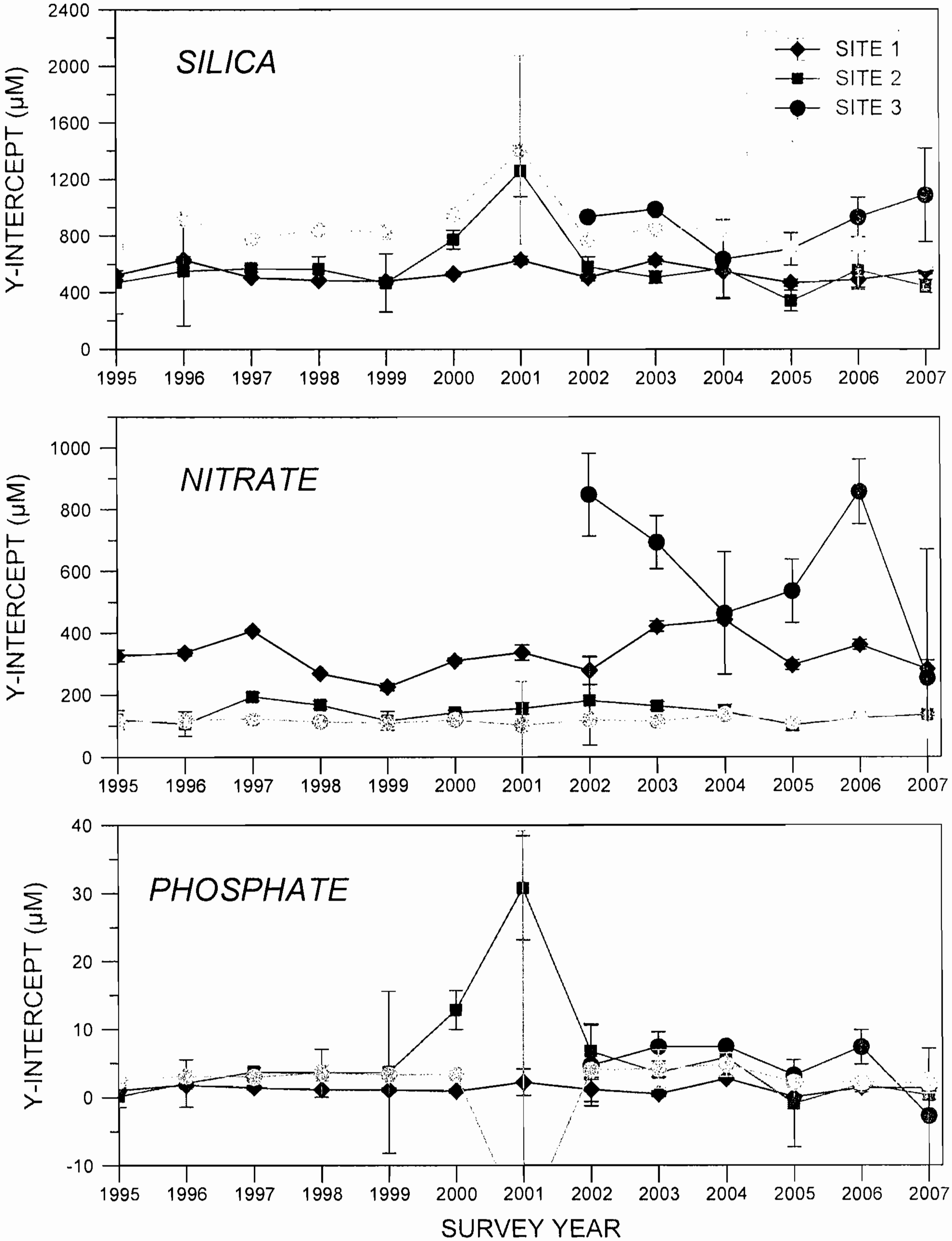

FIGURE 22. Time-course plots of Y-intercepts of linear regressions of concentrations of silica, nitrate and phosphorus as functions of salinity collected annually at each of the four transect monitoring stations off the Makena Resort. Error bars are 95% confidence limits. For locations of sampling transect sites, see Figure 1.

LINDA LINGLE
GOVERNOR

BARRY FUKUNAGA
DIRECTOR

Deputy Directors
MICHAEL D. FORMBY
FRANCIS PAUL KEENO
BRENNON T MORIOKA
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:
HWY-PS
2.5613

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

SEP 12 2007

The Honorable Michael J. Molina, Chair
Land Use Committee
County Council
County of Maui
200 South High Street
Wailuku, Maui, Hawaii 96793

Dear Councilmember Molina:

Subject: Change in Zoning for Various Parcels of Land in the Makena Resort Area, Makena, Maui, Hawaii (LU-37); Change in Zoning and Project District Phase I approval for Honua'ula/Wailea 670 Residential Development (LU-38)

This supplements our attached HWY-PS 2.3496 letter dated January 25, 2007.

Based on a July 2007 traffic study for the Makena Resort, we believe that Piilani Highway will need two additional lanes from Kilohana Drive to Wailea Ike Drive if a zone change is approved for the Makena Resort, Honua'ula, or both. We would have no objection to approval of the Makena Resort zone change, the Honua'ula zone change, or both, provided that zoning conditions require one or both developers to design, acquire right-of-way, obtain permits, and construct two additional lanes and intersection improvements on Piilani Highway from Kilohana Drive to Wailea Ike Drive at no cost to the State or County.

Our understanding is that the developers of the Makena Resort, Honua'ula, and A&B Wailea are willing to negotiate a cost-sharing agreement and privately construct needed improvements of Piilani Highway if both zone changes are approved. Although not required, if the proposed cost-sharing agreement includes private extension of Piilani Highway as a County road south of Wailea Ike Drive, we will support the extension and allow use of existing unimproved State highway right-of-way.

EXHIBIT "C"

If there are any questions, please contact Ronald Tsuzuki, Head Planning Engineer, Highways Division at (808) 587-1830.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Deputy Director – Highways

Attachment: HWY-PS 2.3496

c: Jeff Hunt
Don Fujimoto
Charles Jencks
Clyde Murashige

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
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BARRY FUKUNAGA
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BRENNON T. MORIOKA
BRIAN H. SEKIGUCHI

IN REPLY REFER TO:

HWY-PS
2.3496

JAN 25 2007

Mr. Michael J. Molina
Land Use Committee
County Council
County of Maui
200 South High Street
Wailuku, Maui, Hawaii 96793

Dear Mr. Molina:

Subject: Change in Zoning and Project District Phase I Approval for Honua'ula / Wailea 670 Residential Development (LU-38)

Thank you for your January 12, 2007 letter and for allowing HDOT to share our perspective on the Honua'ula traffic study.

As stated in their September 29, 2006 and January 22, 2007 letters to your Committee, the Honua'ula developer (WCPT/GW Land Associates, LLC) has offered to design, acquire necessary right-of-way, obtain necessary permits, and construct two additional lanes and intersection improvements to Piilani Highway from Kilohana Drive to Wailea Ike Drive at no cost to the State or County. We would have no objection to approval of the Honua'ula zone change and project district applications provided this offer were imposed as a condition of approval. In simple terms, such a zoning/permit condition would relieve us of the burden of negotiating a cost-sharing agreement between South Maui developers to ensure that required highway improvements would be provided when needed.

We do not believe that a revised Piilani Highway traffic study, which reflects updated plans of all major South Maui developers, is necessary for the Maui Council to require the Honua'ula developer to widen and improve Piilani Highway as a zoning/permit condition. Such a traffic study will be provided at a later date as part of the design process for highway improvements. We assume that an updated traffic study would also help in the negotiation of cost-sharing arrangements between South Maui developers.

If there are any questions, please contact Ronald Tsuzuki, Head Planning Engineer, Highways Division at 587-1830.

Very truly yours,

BRENNON T. MORIOKA, Ph.D., P.E.
Deputy Director - Highways

DM:dn

c: Charles Jencks