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Coral Reefs

Well-point sampling of reef interstitial water

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Abstract. A technique is described for collecting reef interstitial water using manually-driven well points. This method does not require the use of hydraulic drills, and eliminates the problems associated with the casing of boreholes. The technique allows collection of samples from discrete depths within reef frameworks, and produces samples unaffected by atmospheric or surface seawater contamination. Data from Checker Reef, Oahu, Hawaii illustrate the utility of this approach.

Introduction

Biogeochemical studies have demonstrated the existence of nutrient-rich, oxygen-depleted, low pH interstitial water within the framework of coral reefs (DiSalvo 1971; Andrews and Müller 1983; Buddemeier et al. 1983; Risk and Müller 1983; Szmant-Froelich 1983; Sansone 1985; Buddemeier and Oberdorfer 1986; Tribble et al. 1986). These studies indicate that active anaerobic diagenesis is a common feature in these environments, and may be important in the biogeochemical cycling of elements in coral reef systems. Thus, there is an increasing interest in studying the details of internal reef processes.

This interest, however, has been tempered by a lack of convenient techniques for sampling reef interstitial water (RIW). Previously, hydraulic drill rigs were used to produce boreholes that were subsequently cased (e.g., Oberdorfer and Buddemeier 1986; Parnell 1986); this technique is both costly and time consuming, and causes significant disruption of the reef and the RIW during the water jetting used to install the casing. As an alternative, we have developed a sampling method that uses commercially available stainless steel well points that can be driven into the reef by hand, and that can be sampled using a battery powered peristaltic pump.

Material and methods

Well points used in this study were custom fabricated by Johnson Screen Co. (P.O. Box 64118, St. Paul, Minn. 55164, USA), although costs can be reduced by welding together separate screens and fittings obtained from Johnson. The well points were constructed of 1.25 inch (approx. 3.2 cm) diameter 304 stainless steel, although more expensive 316 stainless steel would provide greater corrosion resistance in saltwater.

The well points we have deployed consist of four stainless steel segments (Fig. 1 A) in different combinations to provide access to RIW at various depths; individual segments are joined with flush threads cut into the pipe. The stainless steel "Watermark" screens are 15 cm long, and are made with 0.015 inch (0.038 cm) slots that allow free flow of RIW into the well points with little clogging.

Lengths of $^1/_4$ inch (0.64 cm) o.d. polypropylene tubing extend from the screens (sealed on top and bottom by rubber stoppers) to the top of the well points, thereby allowing easy sampling of the RIW (Fig. 1 B). This design allows RIW to be collected from a number of discrete depth ranges in the reef with a single well point. In addition, the polypropylene tubing is in compression after the stainless steel segments are threaded together, thereby holding the stoppers in place and ensuring a leaktight fit between the stoppers and the inside wall of the well point. Underwater cement was used to seal the top of well points driven into reef plate (Fig. 1 B).

Short well points (1 and 2 m length) were driven into the reef using a sledge hammer; 2 m well points were installed in approximately 5 min. Well points longer than 2 m are more easily driven with a slide hammer (a pipe of approximately 5 cm diameter with a large weight bolted to the top), although a tripod with a drop weight can also be used. These longer well points can be assembled in the field so that only a single segment of the well point is above the reef surface at any time during installation.

In order to lessen the strain on the well points as they penetrated the reef's surface lithified layer, pilot holes were made with either a pneumatic drill operated with a SCUBA tank air supply, or a steel pipe equipped with a hardened steel drive point. This step may be essential in reefs with reef plates that are thicker and more lithified than those found on Checker Reef.

RIW was sampled by using a battery powered peristaltic pump connected to the polypropylene tubing; samples were collected in conventional sample containers. Flow rates of >500 ml min^{-1} were usually possible, although much slower rates were used in sampling. The upper ends of the polypropylene tubes were sealed with flexible endcaps between samplings.

The following methods were used for RIW analysis: inorganic nutrients and pH (Smith et al. 1981); dissolved oxygen and sulfide (Ingvorsen and Jorgensen 1979); titration alkalinity (corrected for sulfide) (Edmond 1970); and dissolved methane (Brooks et al. 1981).

RIW samples from 1 and 2 m depths were collected from well points deployed along a transect on Checker Reef, a patch reef located immediately leeward of the main inlet to Kaneohe Bay, Oahu (Fig. 2). This reef is described in detail by Morrissey (1985).

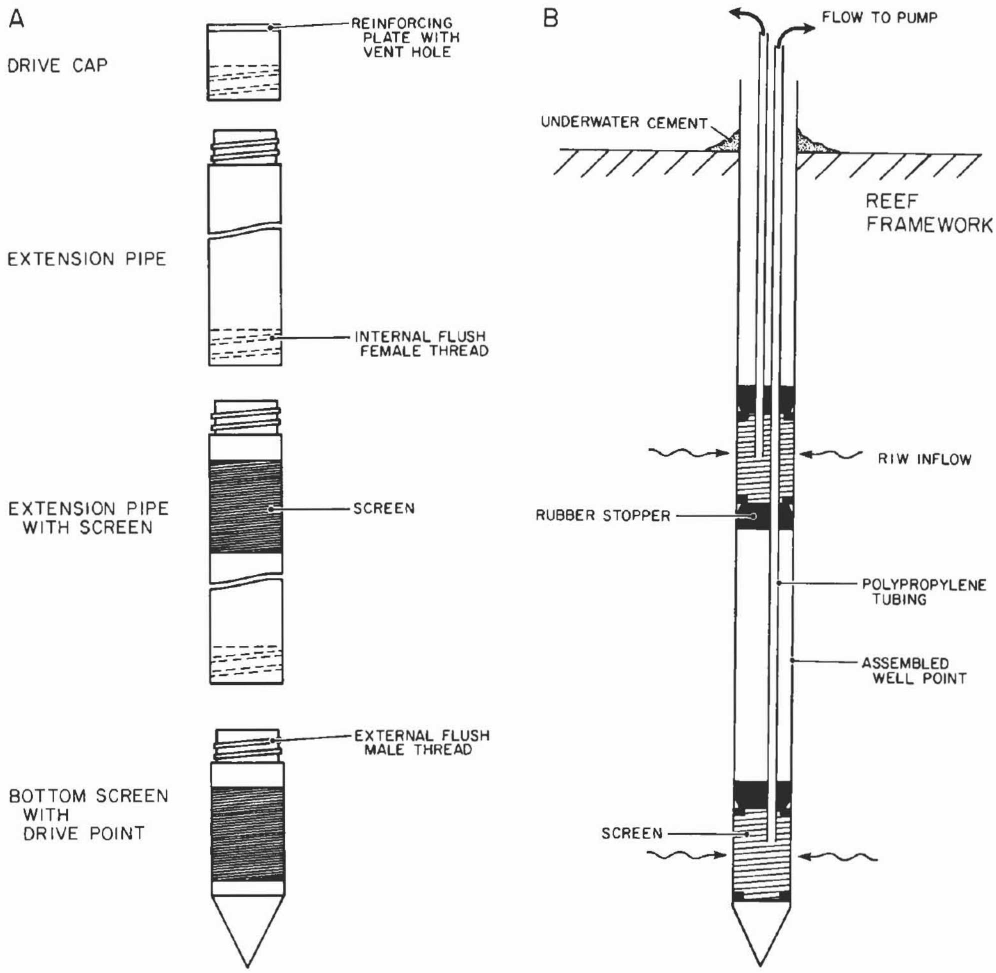

Fig. 1. A Schematic diagram of the well point components.
B Cross section view of an assembled well point used for sampling at two depths

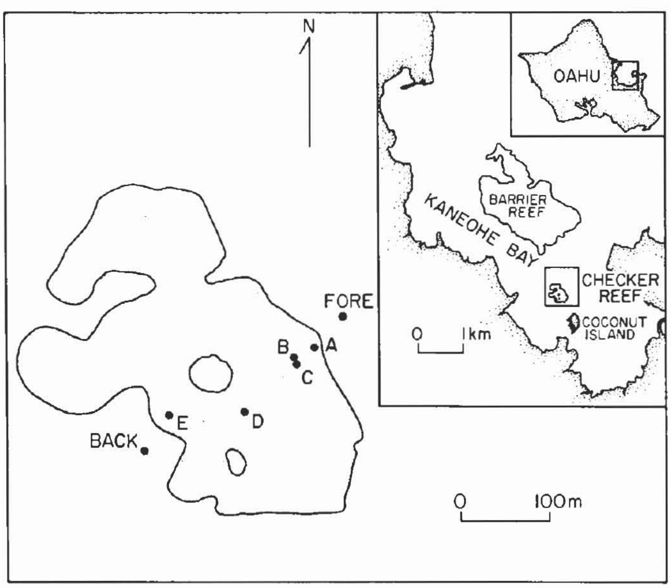

Fig. 2. Location of Checker Reef, Kaneohe Bay, Oahu, Hawaii. Well point stations are identified by letters A–E. "Fore" and "Back" are surface seawater stations

Results

Results from one sampling of the Checker Reef well points and overlying seawater are shown in Fig. 3. These samples were collected approximately 2 weeks after the last Checker Reef well point was installed, and are shown here to illustrate the utility of well point sampling.

Dissolved oxygen values are much depleted in the RIW as compared to the overlying seawater, with lowest values in the center of the reef. Methane, sulfide, phosphate, ammonium, and alkalinity show trends opposite to that of oxygen. Values of pH are noticeably depressed in the RIW.

We are in the process of collecting samples at roughly 6-week intervals for a period of a year, and have found similar values to those reported here throughout the first half-year. Complete data on the Checker Reef sampling program will be reported later, including results from a 4 m deep well point successfully deployed at site "D" after this paper was submitted for publication.

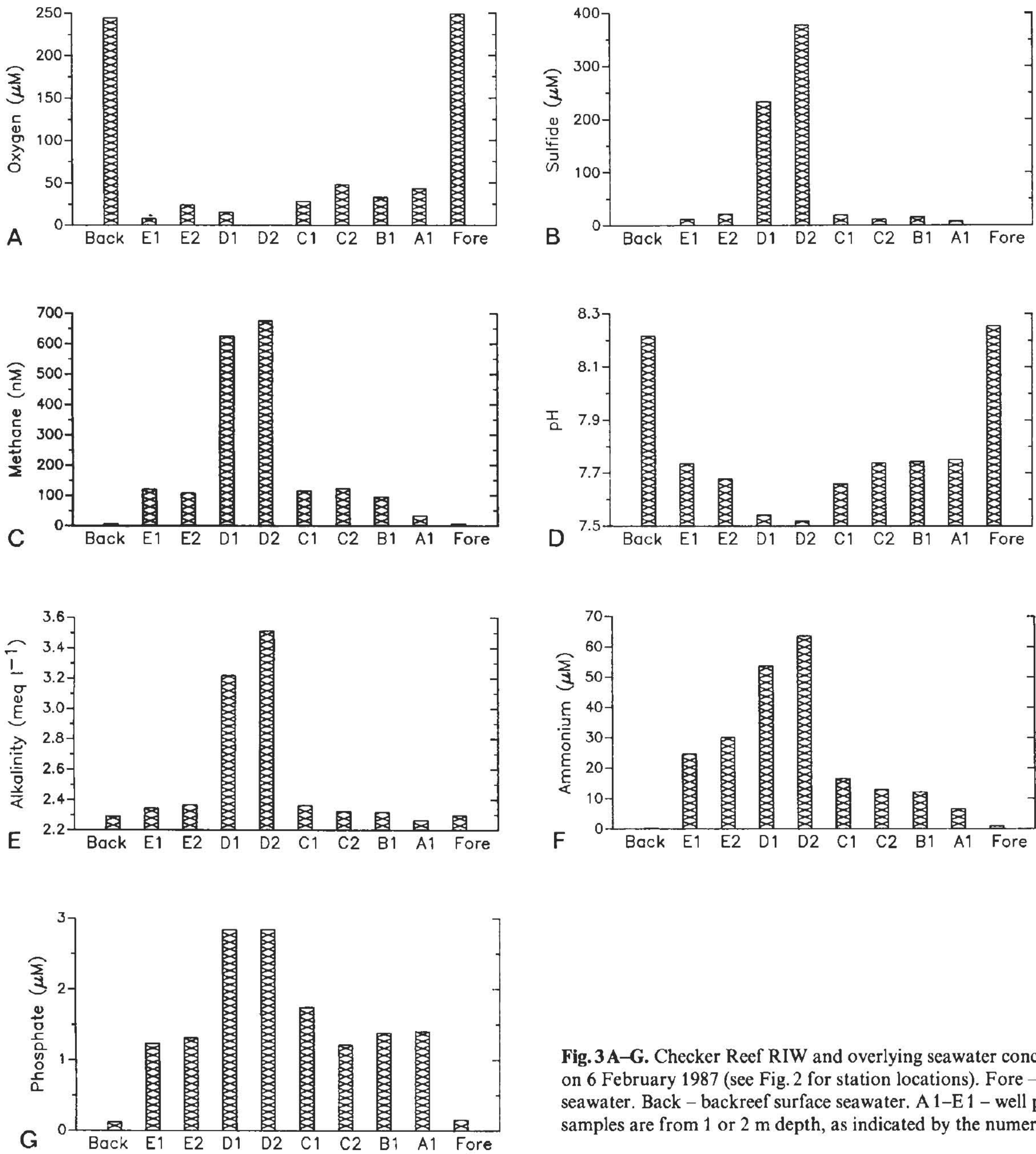

Fig. 3 A–G. Checker Reef RIW and overlying seawater concentrations measured on 6 February 1987 (see Fig. 2 for station locations). Fore – forereef surface seawater. Back – backreef surface seawater. A 1–E 1 – well point stations; samples are from 1 or 2 m depth, as indicated by the numeric suffixes

Discussion

The RIW concentrations observed in Fig. 3 indicate active organic matter oxidation occurring within the reef framework: the decomposition of organic matter results in the consumption of oxygen, the release of inorganic phosphorus and nitrogen, an increase in alkalinity, and a lowering of pH (e.g., Froelich et al. 1979). The depletion of oxygen leads to sulfide production due to sulfate reduction, and ultimately to the production of methane (e.g., Sansone 1985).

The very low oxygen concentrations found in Checker Reef RIW suggest that there is little atmospheric or surface seawater contamination of the RIW during well point sampling. In addition, the values reported here are comparable to those found in Davies Reef, Great Barrier Reef using conventionally drilled and cased wells (Buddemeier et al. 1983; Sansone 1985).

The results presented here illustrate the utility of reliable methods for collecting RIW in a simple and uncontaminating fashion. The methods described here offer a considerable advantage over conventional techniques for sampling RIW by eliminating the need for hydraulic drilling and the difficult process of borehole casing in typically poorly consolidated coral reef frameworks. The component approach presented here allows fabrication of well points specific for each sample location: several depths can be sampled at a given location with a single well point, with variation possible in the vertical spacing of the collection depths. In addition, well points can be removed and reconfigured as needed for additional sampling at other locations.

It is hoped that, by simplifying access to RIW, well point sampling of RIW will lead to an increase in research in this area. In light of the very high concentrations observed in RIW, it seems likely that further investigation will lead to significant advances in our understanding of the biogeochemical cycling of coral reef systems.

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