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A non-profit organization for protection and sustainable management of coral reefs

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Report to Joseph Ebanks, Cayman Turtle Farm

ALGAE IN THE FISH LAGOON AND CAYMAN TURTLE FARM EFFLUENT RECEIVING AREA: RECOMMENDATIONS FOR MONITORING OF WATER QUALITY IMPROVEMENTS

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INTRODUCTION

Effluents from the Grand Cayman Turtle Farm have released material high in total suspended solids (TSS), biochemical oxygen demand (BOD), bacteria, and nutrients (Nitrogen and Phosphorus) that have degraded water quality in the adjacent coastal zone for forty years. This has resulted in a visible plume of suspended white particulate organic mater and bacteria, and fertilized intensive growth of weedy algae that have smothered the shoreline, bottom, and coral reef habitat. The Turtle Farm is now taking the national lead in treating effluent water in order to improve water quality and restore coral reef and fisheries habitat, after decades in which the impacts were ignored. The planned installation of superior and low cost technologies to treat the effluents should result in dramatic decreases of TSS, BOD, harmful bacteria, and nutrients, so algae overgrowth of the coastal zone should die back, allowing recovery of the reef. The purpose of this report is to discuss the changes now underway and how they can best be documented.

Impacts of the Turtle Farm on the coastal waters were first documented by Dr. Michael Risk, who found large amounts of coliform bacteria, typical of faecal material, in the discharge along with an increase in red coral boring sponges Cliona delitrix, on the bottom, which filter bacteria from water polluted with organic matter (Rose, C.S. & Risk, M.J., 1985. Increase in *Cliona delitrix* infestation of *Montastrea cavernosa* heads on an organically polluted portion of the Grand Cayman fringing reef. Marine Ecology 6 (4), 345–363). In 2003, the Cayman Islands Department of the Environment asked the author of this report to look at the site, and videos were taken of the deep reef below the discharge site and along the shallow coastal zone. A small part of that documentation was used in a brief documentary on tourism, water quality, and coral reef health (http://www.biorock-thailand.com/tourismwaterquality512.html). These video transects clearly showed that the massive algae blooms were confined to the area receiving the effluents and areas just down-current of them.

In June 2008 the same area was revisited in connection with the Turtle Farm's Water Quality Improvement Program, and the algae in the breeding ponds and the Fish Lagoon were documented by photographs. Half a dozen other sites along the reef across North Sound, up current of the Turtle Farm were examined for comparison.

OBSERVATIONS

1. Fish Lagoon and Turtle Breeding Pond

The fish lagoon walls and bottom were covered in a dense blanket of fine filamentous greenish algae several centimeters thick. Due to problems with the vacuum system at the time the lagoon had not been cleaned recently, so it was worse than normal, but it is clear that this is a permanent recurring problem with the system, and that when vacuumed the algae grow right back in days. The algae is a uniform throughout the entire system but is especially brightly colored where it is growing on the inflow nozzles. The algae are very fine and cannot be identified to species without a microscope, but they appear to be primarily a mixture of the green alga Chaetomorpha with Cyanobacteria (blue green algae), which are indicators of very high levels of nutrients, especially phosphorus, and are very common around sewage outfalls. In addition to these, the water line in the Turtle Breeding Pond has growths of Enteromorpha, another green algae characteristic of very high nutrient pollution and typical of sewer outfalls.

As a result of the massive algae buildup, there is no marine life to be seen except for the fish, and the green surroundings are hardly what tourists hope to see, diminishing its attractiveness. It was noted that there were few algae eating fish in the ponds, only a few Blue Tangs and no parrotfish. Apparently the Ocean Surgeonfish that had been introduced had died from high temperatures in the lagoon, and parrotfish have not been introduced because they might scrape and damage the concrete. The bulk of the fishes are jacks, snappers, etc, which are fish eaters and surviving off fish food. The nutrients in the uneaten food and that passing through the fish are accumulating in the pond, and the flushing rate is not high enough to keep nutrients at low levels, so the high nutrients are causing permanent algae blooms. It is unlikely that enough surgeonfish could be introduced to control the algae. The dark color of the algae on the bottom and sides, and the green color of the water from phytoplankton (microscopic floating algae) greatly warms the water by increasing light absorption. The lack of sediments in the lagoon prevents the build up of natural microbial populations that might help absorb nutrients.

The long term solutions to get rid of the algae are to 1) get rid of the fish which would remove the entire purpose of the lagoon for visitors to enjoy swimming in clouds of attractive fish, 2) GREATLY increase the flushing rate with concomitant increases in energy costs that are already very high, 3) fill the lagoon with Diadema, the long black spiny sea urchin which grazes algae (although they could only get those on the bottom, not the sides), and their long venomous black spines would cause serious and unacceptable puncture wounds to visitors, or 4) greatly increase biological uptake of nutrients by algae and bacteria in a filter system from which they can be removed and recycled. Only the last option is consistent with the purposes and economic value of the system, and is the solution that will be implemented by the Biofilters that are proposed for installation under the advice of Henning Gatz.

2. Area in front of outfall

A) 2003

The 2003 video film documentation showed that the deep reef was nearly free of weedy algae buildup, but the entire shallow reef, which is separated from the deep reef by a sand plateau, had high levels of fleshy algae indicative of high nutrients, and that these increased towards the shore. It should be noted that there was no shallow coral reef framework on the limestone, which was a smooth old erosional surface. The Turtle Farm is located in a gap in the reef crest that fringes most of the Grand Cayman coastline, which is probably due to the high exposure of this portion of the coast to waves created by Northers. There are few large corals on this portion of the shallow reef, but there are many young head corals, 10-20 years old especially on the deeper portions and decreasing shoreward. However many corals were affected by coral disease, in particular the extremely fast spreading disease White Plague, which was more abundant here than any other site seen in Grand Cayman. The bottom area in front and down-current from the outfall were smothered in organic sludge, apparently the remnants of the white particles of organic matter and bacteria coming from the outfall, and by masses of weedy algae fertilized by the outfall nutrients. This sludge was not seen up-current of the outfall and disappeared with distance down-current.

Filmed documentation of the algae along the shoreline in 2003 showed a clear zonation of algae in the impacted area. The area in front of and immediately downcurrent of the outfall were smothered in dense growths of the dark green alga Bryopsis, which is often found in mangroves with very high pollution loading. Bryopsis was confined to the impacted area and did not occur up-current or sufficiently down-current of the outfall.

B) 2008

In 2008 the same algae zoning pattern at the shoreline and vertical rock walls was found around the outflow, but it was smaller in extent, and the blankets of algae and sludge on the bottom in front of the discharge had almost vanished.

At the edge of the Turtle Farm intake channel (where water is pumped into the facility, and which lies up-current of the outfall) the shoreline was marked by growth of green Zoanthus Sociatus, an animal related to corals and sea anemones, which is intolerant of high nutrients, when it gets replaced by weedy algae. The bottom was composed of white limestone with minor amounts of algae. There were very few Diadema, the long-spined black algae grazing sea urchin, but there were abundant populations of the small rock boring sea urchin Echinometra lucunter in a shallow band in waters less than about 10 feet deep and rare below that. These hide in burrows in the day time and feed on algae close by at night. Their grazing activity affects a well-defined zone since they don't go into very shallow water or deeper water. Shallow rock walls had growth of the brown algae Dictyota (at least three different species, probably pinnatifida, caribaea, bartayresiana). This alga is an indicator of moderate nutrients. It was uncommon on limestone surfaces deeper than around 10 feet depth. It was most dense on the vertical shallow wall due to higher land-based nutrient inputs into surface water and reduced grazing by urchins that avoid wave swept vertical surfaces.

On swimming towards the outfall from the up-current side (Note: this refers to the normal current direction from east to west, although at the time of these observations there was a rare current reversal which affected the white suspended solid distribution of matter from the outfall, while the algae patterns reflected the normal current patterns), the first noticeable changes were the decline and disappearance of Zoanthus just below the water line and an increase in density of Dictyota. The bottoms of the erosional grooves in the limestone, which had been white and fairly free of algae up-current of the outfall, began to take on a green hue, which became steadily thicker swimming towards the outfall. This color comes from Cyanobacteria mats, an indicator of nutrient pollution. Nearer the outfall the Dictyota on shallow rock surfaces was replaced completely by the very dark green alga Bryopsis. This is an indicator of high nutrients, and its almost greenish black color indicates high nutrients, since it is paler and greener and more sparsely branced at lower nutrient concentrations.

On a rock directly in front of the mouth of the outfall there was a dense growth of the green alga Ulva lactuca, an indicator of very high nutrients, especially phosphorus, and typically found in severely polluted areas such as the ends of sewer pipes entering the sea. The dense Bryopsis mat along the shoreline and shallow rocks gradually thinned with distance down current from the outfall and was replaced again first by Dictyota and then by Zoanthus.

On deeper surfaces, around 10 to 20 feet, there were clumps of finely branched red algae (indicative of high nitrogen levels) likely Ceramium or Wrangellia, whose density thinned with distance downcurrent from the outfall and then disappeared. The rocks deeper than 10 feet had little sludge, and beyond 15 feet depth there were few algae. No Diadema were seen, and the fish were predominantly fish eaters (snappers, jacks, and tarpon) with relatively few surgeonfish but some parrotfish in deeper waters on the bottom reef slope (25-40 feet).

There has been quite a bit of coral settlement on the outer part of the shallow reef rock formation, from about 20 feet to 40 feet depth. There are few large corals but many head corals up to about 10-20 years old. Many of them were old dead, many have bright white areas that have been killed by White Plague Disease (WPD) in the last few days to a week (any older and they would turn brown as algae grow on them), and many corals that are alive only on the upper portions since White Plague, which typically grows from the bottom up, stopped before the entire coral had died. One case of Black Band Disease (BBD) was seen. High abundance of WPD was only seen in this area, however this may be coincidental and have little relationship to the effluent, based on experience elsewhere. One more isolated case of BBD was seen in the much clearer waters of Barker's Cay. However the possibility of a link between coral disease and bacteria in the effluent cannot be completely ruled out, so it would be useful to see if there are changes in the abundance of the disease as water quality is improved. It would also be useful to compare the bacteria on the diseased corals with healthy corals in the same habitat, in the intake and effluent, and in upstream and downstream reef areas, but this would take genetic profiling of the bacteria populations.

3) Intake Area

The intake channel for the Turtle Farm had the pumps on when we went in and the water was very clear. On returning the pumps were off, and the water was very turbid with particulate material and small specks of floating oil. This was from the backflow of material in the pump lines that was draining back into the intake area. Apparently there is no check valve to prevent backflow. I don't know the on/off cycle times, which would indicate how frequent each condition is.

During the entry period it was clear that there were no fleshy algae on the walls or bottom of the intake channel, in contrast to the small patches of Dictyota on the rocky walls of the sea just outside the channel. The bottom and sides of the channel were covered with pink encrusting calcareous red algae, which are typical of low nutrient areas. The fact that they were more common inside the channel than just outside cannot be due to nutrient concentration differences. Instead it reflects the extremely high abundance of the black long spined sea urchin Diadema antillarum in the intake channel. While I did not try to count them, the photos indicate abundances roughly on the order of 5-10 per square meter. Diadema do not like wave surge, and were essentially absent outside the intake channel, while reaching extremely high densities inside the protected channel. Their intense grazing activity keeps the channel free of fleshy algae, and indeed they must be largely starving since there is little food for them. The lack of fleshy algae has led to a much higher density of corals on the walls of the channel than occur in the surrounding ocean slopes. These include very high amounts of young corals, primarily Porites astreoides and Agaricia agaricites, but also including half a dozen other species, including Diploria and Montastrea. Scraping of the surface by teeth of hungry Diadema searching for algae appears to kill many of the young corals but still the coral recruitment is very high.

The intake site, which is down-current from nutrient sources from soak away effluents from houses to the east of the site as well as from North Sound, can be usefully contrasted with a shallow site on the up current side of North Sound, with few local nutrient sources, examined in 2003. There the shallow rocks were completely free of weedy algae but there were no Diadema at all, so the lack of algae was due to lack of nutrients, while fleshy algae absence in the channel can be attributed to the ability of intense urchin grazing to cope with algae growth at low to moderate levels of nutrients. It can also be contrasted to areas in Jamaica and Barbados where Diadema densities are also similarly high. At those locations, where nutrient levels are much higher, Diadema are completely unable to control the algae except for a ring a few centimeters around each urchin, and masses of fleshy algae smother the bottom around them and overgrow and kill corals.

Below are brief notes on the ecological conditions of 6 more sites up current from the Turtle Farm intake subject to various mixtures of oceanic and land based influences, which provide some insight into the factors affecting the area and the changes that could take place if land based nutrients are reduced.

4) Barkers Cay

Barkers Cay, a small rocky island inside the north west corner of North Sound, has very different habitats on opposite sides, related to relative wave exposure, the distribution of sand and limestone bedrock, and exposure to open ocean flushing versus North Sound water. The western side of Barker's Cay appears to be primarily affected by clear blue ocean water transported over the reef crest by the trade winds. The bottom is clean and free of fleshy algae, being dominated by the calcareous sand producing algae that are normal of low-nutrient reef waters, mainly species of the green algae Halimeda, Udotea, and Penicillus, whose limestone skeletons make most of the white "coral" sand. There is high incidence of encrusting red calcareous algae, which are only dominant in low nutrient habitats. There is a high abundance of small corals, largely the finger coral, Porites divaricata, which is very common, and young to older corals of many kinds. No White Plague Disease was seen, but one case of Black Band Disease. There were few algae eating fish or sea urchins, but many snappers and jacks. The most dramatic feature of this site is the very high abundance of the red branching calcareous algae, Amphiroa rigida, which is characteristic of low nutrient habitats.

In sharp contrast, the waters at the eastern end of Barker's Cay are affected by the outflow of North Sound waters. These are distinctly green with phytoplankton and enriched in nutrients from the mangroves, garbage dump, golf courses, and septic effluents of development around the western and southern sides of North Sound. There were far less finger corals, and the Amphiroa and red algae were very low, being replaced by Dictyota, characterisitic of low to moderate nutrients, and dense clumps of Cladophoropsis, a green algae that is an indicator of high nutrients and which is very effective at overgrowing and killing corals. Many of the head corals had Cladophoropsis overgrowing their edges.

5) Inside reef by Sting Ray City

This area is the original Sting Ray City on the north west of North Sound. This area, which is even more affected by North Sound outflow, had very few young corals, an unhealthy coral reef appearance, and large amounts of fleshy algae, especially Cladophoropsis, along with red fleshy algae (probably Chondria and Heterosiphonia). Fish populations were dominated by algae-eating surgeonfish and parrotfish, but their grazing was clearly unable to control the algae abundance. Control of the nutrient effluents into North Sound will be needed for it to recover.

6) Outside Reef East of Sting Ray City Channel

This reef is exposed to ocean swells, and has much less North Sound water influence. There were numerous healthy looking elkhorn coral, and the algae was dominated by calcareous algae with only around 20% Dictoyota cover on hard ground. There were few herbivores, and unusual densities of the Black Durgeon Triggerfish.

7) Outside Reef North of Sand Bar

This was similar to the previous site with clear water, low fleshy algae, and few herbivores. There was roughly 30% cover of hardground by Dictyota.

8) Sand Bar Channel inside – West side

This site, in northeast North Sound, is widely and incorrectly called Sting Ray City. Conditions were similar to the original Sting Ray City, but with somewhat clearer water, and less fleshy algae, but with 70-80% cover of dead coral and hardground by Dictyota.

9) North of Rum Point Dock close to the reef

Similar to site 8 but with larger healthier corals and less fleshy algae.

DISCUSSION

Between 2003 and 2008 there was a marked decline in the number of turtles in the farm, and sometime around 2006 the waste materials from the turtle slaughterhouse for the commercial farm stopped being washed into the effluent and were transplanted to the sewage treatment. Along with the decrease in nutrient loading there has been a clear decrease in the severity and extent of algae impact on the receiving shoreline and waters. This strongly suggests that improvement of water quality from the planned installation of the biofilters should further greatly improve water quality, reduce nutrients, and the weedy algae should starve and die back. Depending on the extent of actual nutrient reduction we can expect a strong decrease and perhaps even an elimination of the weedy algae problem in the receiving waters, and a recovery in the coral populations.

Needless to say, such results depend on preventing further new nutrient sources from land-based sources of pollution. To this end the effluents from the dolphin pond under construction next door should also be fully treated with Biofilters to reduce TSS, BOD, and nutrients. Given the fact that the effluents from the expected 15 dolphins, each of which is equivalent to 4-6 people in terms of wastes produced, or 60-90 persons, will be far less than that produced by the 7-8,000 turtles, so it would make sense for the dolphin pond effluents to be treated together with those from the turtle farm.

RECOMMENDATIONS

1. Water Quality Monitoring

In order to improve the water quality assessment capability of the Turtle Farm and to determine the success of the water quality improvement steps the Farm will be taking it will be important to improve their capability to do in-house monitoring as much as possible. Samples that were collected and sent abroad to commercial labs provided reasonable looking data for Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), and Total Suspended Solids (TSS). However the values reported for nutrients were clearly artifacts of an inadequately sensitive analytical procedure and basically represented only the limits of detection of the procedures used. The real values are likely to be lower. If the values reported had in fact been real, the nutrients would have been well above those that trigger eutrophication (massive algae overgrowth of coral reefs). Without accurate nutrient measurements the success of the Biofilters in reducing nutrient loading to the coastal zone cannot be fully assessed directly.

It is suggested that the Turtle Farm should get the equipment needed to measure DO and BOD directly. The oxygen meters used for this can also be purchased in instrument packages in which temperature and salinity, variables of great importance in interpreting water quality, are also measured simultaneously. Some instruments allow simultaneous readings of pH (this is of limited use for sea water samples), chlorophyll (this is of great use, because it tells how green the water is from phytoplankton, and provides a measure of nutrients that have been taken up from the water by plankton), and turbidity (which is related to TSS). Good real time, continuous reading electrode instruments that measure all of these parameters simultaneously may be a good investment, providing more accurate data at lower cost than samples sent abroad, and allow much better awareness of fluctuations in the system due to variations in temperature, rainfall, and pumping rates, as well as changes within the tanks themselves, and provide useful information on the efficiency of the mechanical and biofilter processes.

In contrast to those water quality parameters, nutrients in seawater cannot be reliably measured with electrodes, and a chemical analysis is needed. The traditional procedure for nutrient analyses, namely sampling in a clean bottle, filtering and freezing or addition of a poison to stop microbial activity in the sample and preserve the original nutrients, storage, shipping, thawing, and analysis, produces many sampling, storage, and analytical artifacts. Since the analytical reagents used in different labs have different contamination backgrounds, comparing results made from different labs or even the same lab at different times can be problematic. Modern methods allow continuous real time measurements to be made, using equipment that pumps water samples through the instrument, reacts very small volumes with the appropriate chemicals, and uses battery powered fiber optic spectrophotometers to make instantaneous measurements of nitrate, nitrite, ammonium, and phosphate. Because the measurements are continuous, it is possible to map the distribution of nutrients in surface waters or their vertical profiles, and because they are nearly instantaneous (apart from a short lag for the chemical reactions to take place), nutrients can be tracked to their source, which is useful in identifying illegal outfalls, or unknown cracks and crevices that are sources of contaminated groundwater, and the measurements are free of sampling and storage artifacts. There is only instrument on the market that does this, which could be purchased and kept at the Department of the Environment (DoE) for national water quality monitoring, identification of sources, development of discharge control plans, and quantifying their success all around the Cayman Islands as well as at the Turtle Farm. Doing so would place the Cayman Islands in a leadership position in coastal zone management.

2. Algae Monitoring

The most effective environmental sign of improved water quality will be if the weedy algae in the Lagoon and the effluent zone die back. We would expect reduced nutrients to result in lower height and density of algae, a shift to paler colors in each species, and a change in the species zonation, with those algae that are indicators of high nutrients shrinking back closer to the source and then hopefully disappearing. It is very important to document such results because many people seem to think that there is nothing that can be done to get rid of algae and allow recovery of coral reef and fisheries habitat. Demonstration of a clear linkage between water quality improvements and coral reef health will have a huge impact on coastal zone management elsewhere, especially if this can be achieved at a reasonable cost.

It is recommended that selected sites be photographed at intervals starting before the installation of the Biofilters, and continuing until a new stable algae pattern is achieved. The sites should include a few representative sites on the side and bottom in the Fish Lagoon, as well as sites in front of the effluent discharge, and at sites along the coast in both directions. At each site photos should be taken just below the surface, and at various depths, say 5, 10, 20 and 40 feet deep. Wide-angle photos to show the overall algae coverage and close-ups to identify the algae should be included. One easy way to do this might be to include a frame, say one foot on a side, placed on the surface, and to photograph it from a distance and then close enough to include only the frame and the interior. In this way algae coverage, and the density and height of the algae might be estimated from photographs. These sites could be marked with tags, but tags can be lost, chewed by fish, or become substrate for algae growth. I have stainless steel nails that have been sharpened on a bench grinder to a sharp point, which can be driven into limestone rock and I can provide them as markers. The interval of photographing could be monthly, but doing it weekly in the two months might be useful if the response is rapid.

3. Reef restoration

Once water quality has been restored, coral reef recovery should ensue and active restoration can be started. It is proposed to grow Biorock coral reef structures to create habitat for fish and accelerate coral growth. At present the corals are all head corals, with no branching corals, and there are no naturally broken corals available in the area to be transplanted onto a Biorock reef. Corals could be transplanted from broken loose corals that are abundant around Barkers Cay and Sting Ray City. Another source of coral transplants could be the many young corals settling on the intake channel, many of which appear to be killed by Diadema grazing. The head corals can be connected to the Biorock reef by wires, which would give them the benefits of faster growth rate without being transplanted. The Biorock reef could be designed to provide coral and fish habitat and to be a valuable snorkeling and diving attraction, providing a unique new attraction for visitors, a new revenue stream for the Turtle Farm, and providing a valuable educational function in showing people how coral reefs can be restored.

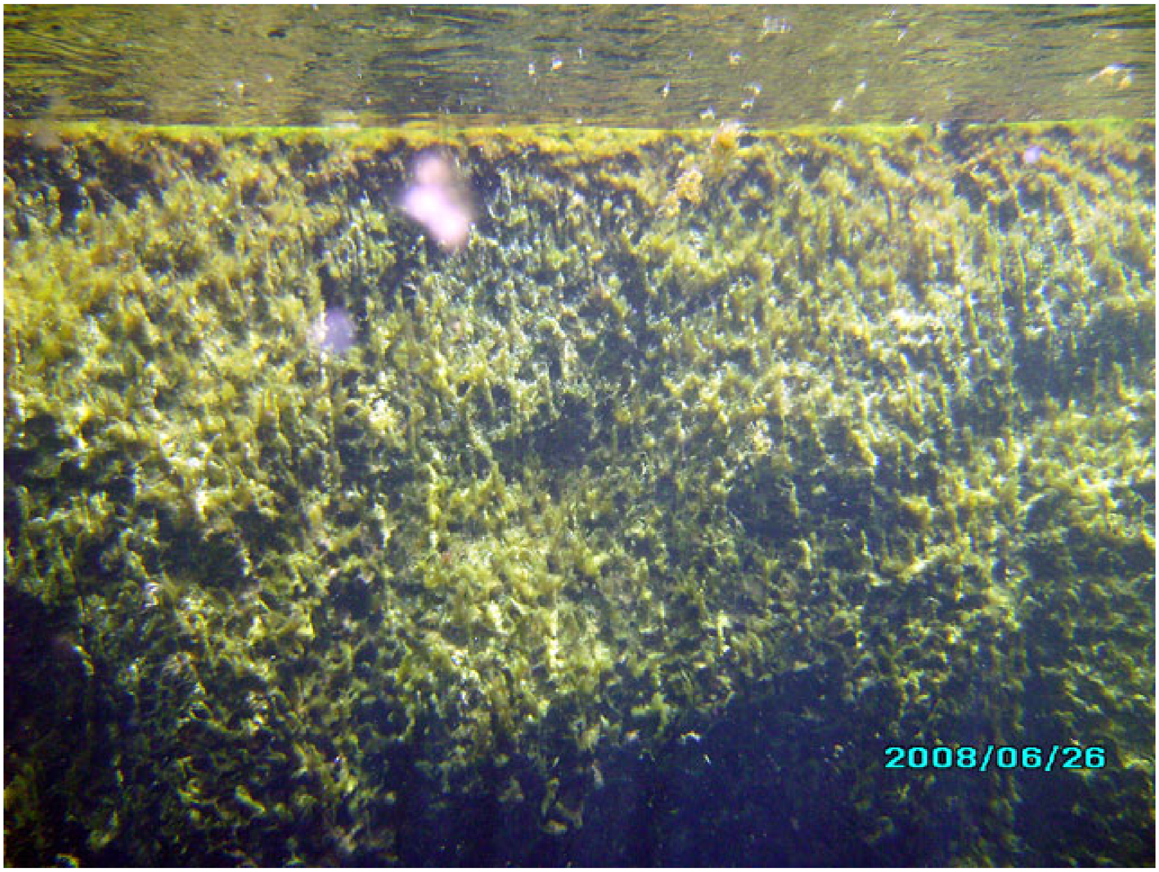
ACKNOWLEDGEMENTS

I thank Joseph Ebanks for the invitation to examine the turtle farm water quality impacts, Adam Mclaren for his thorough introduction to the workings of the turtle farm, Nancy Andryszak for her help with the water quality data and interpretation, Brian Andryszak and Phillip Admire for working with me in the water and helpful discussions, Henning Gatz for his insight into water treatment, the staff of the Department of Environment, especially Gina Ebanks-Petrie, Timothy Austin, and John Bothwell, for comments and information, Nancy and Jay Esterbrook for discussion, as well as many members of the public. Particular thanks also go to Billy Adam, for constant efforts to protect the Cayman environment, and for kindly providing use of his boat for looking at more reef sites.

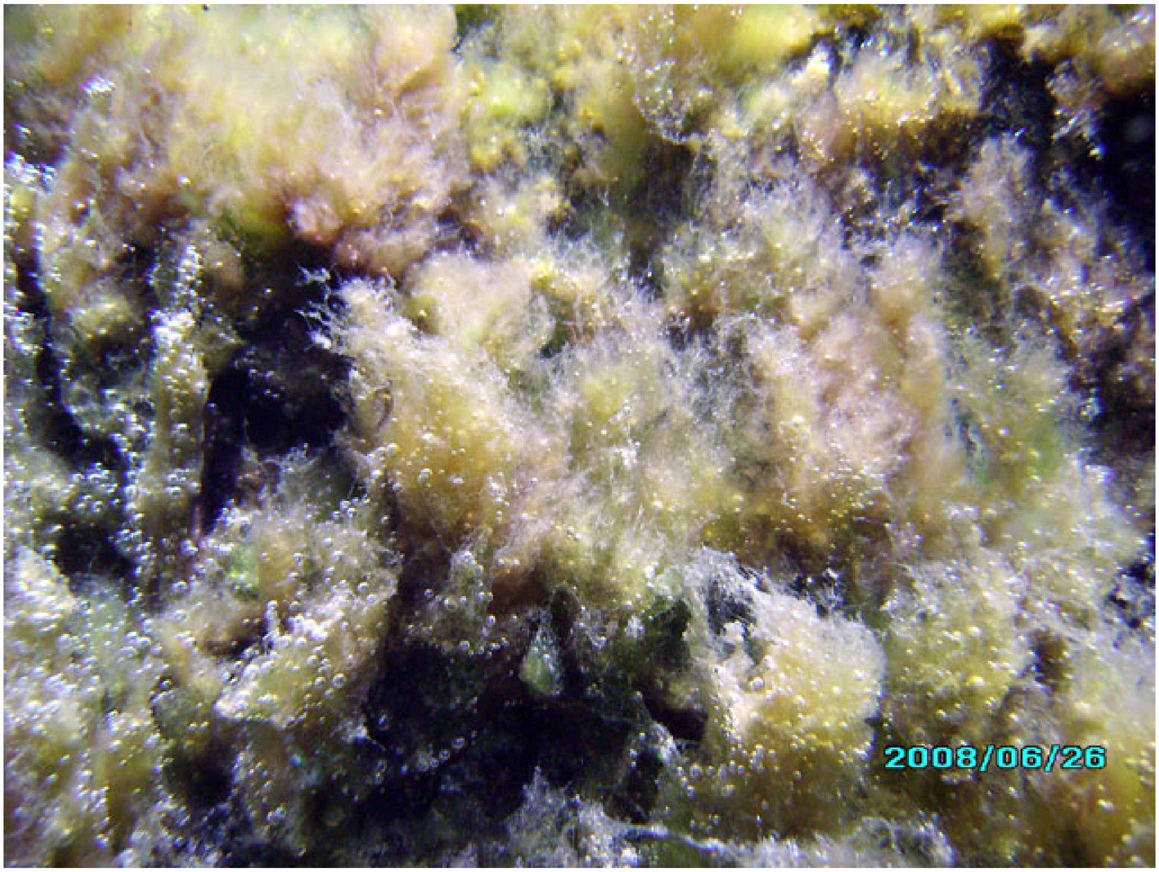
PHOTOGRAPHS

Fish in the Fish Lagoon

The bottom is covered with algae

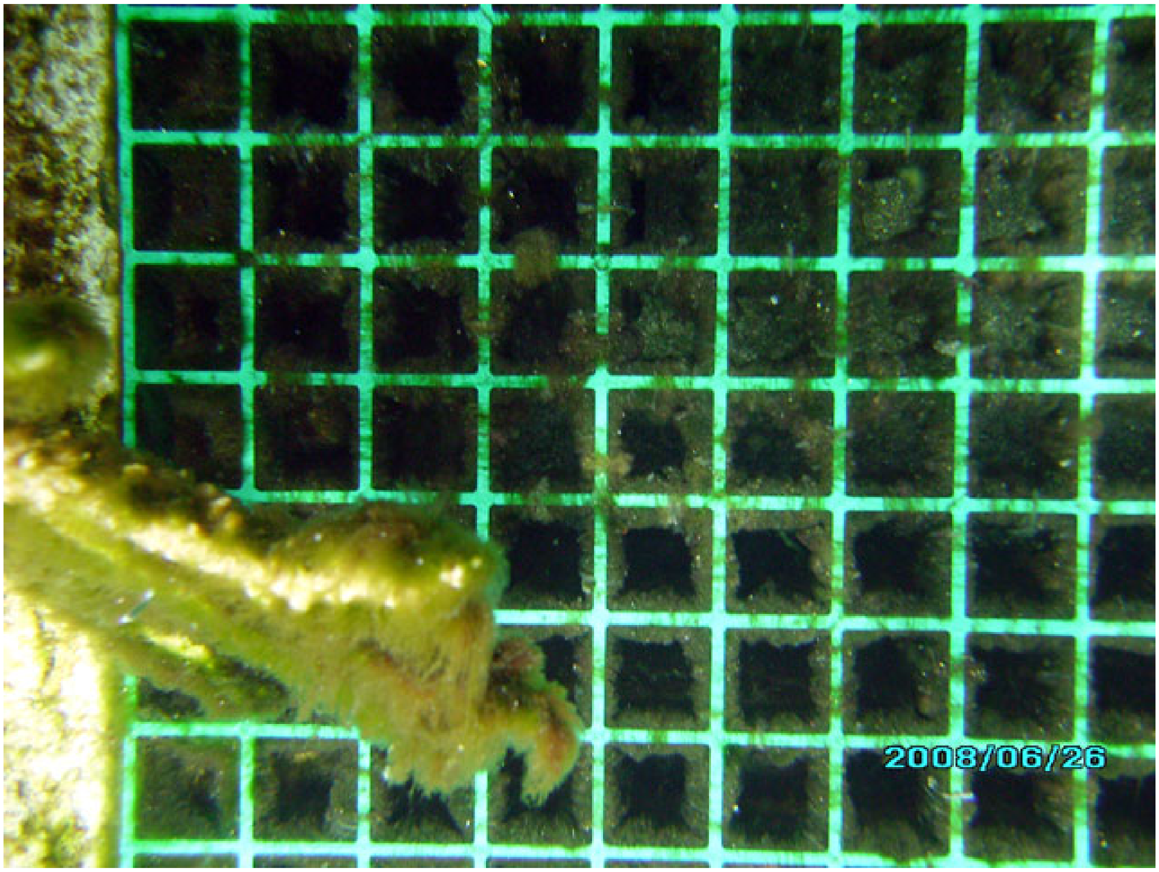


The sides are covered with algae to the water line



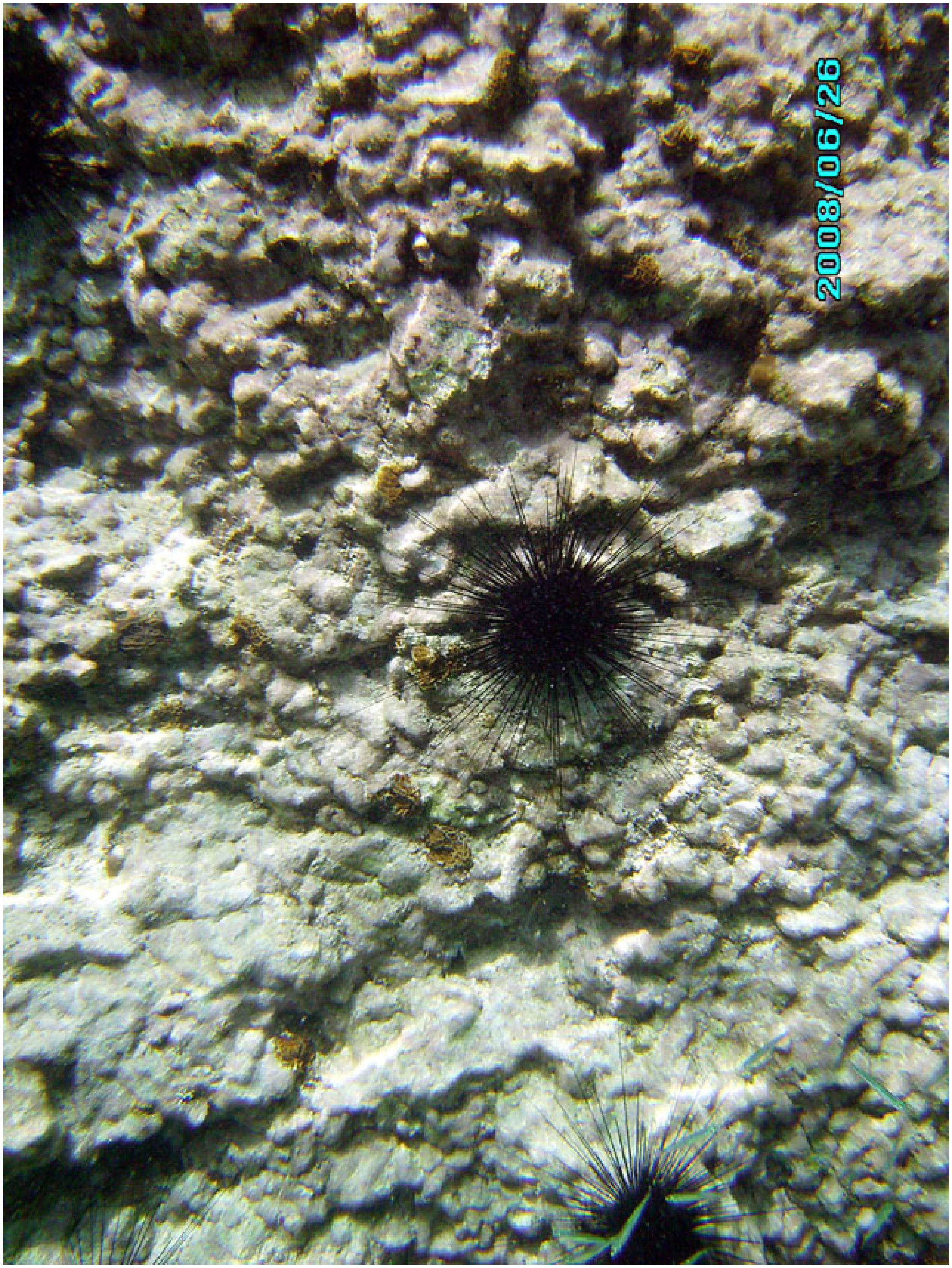
Closeup reveals fine filaments of high nutrient indicating algae

Large amounts of algae float in the water

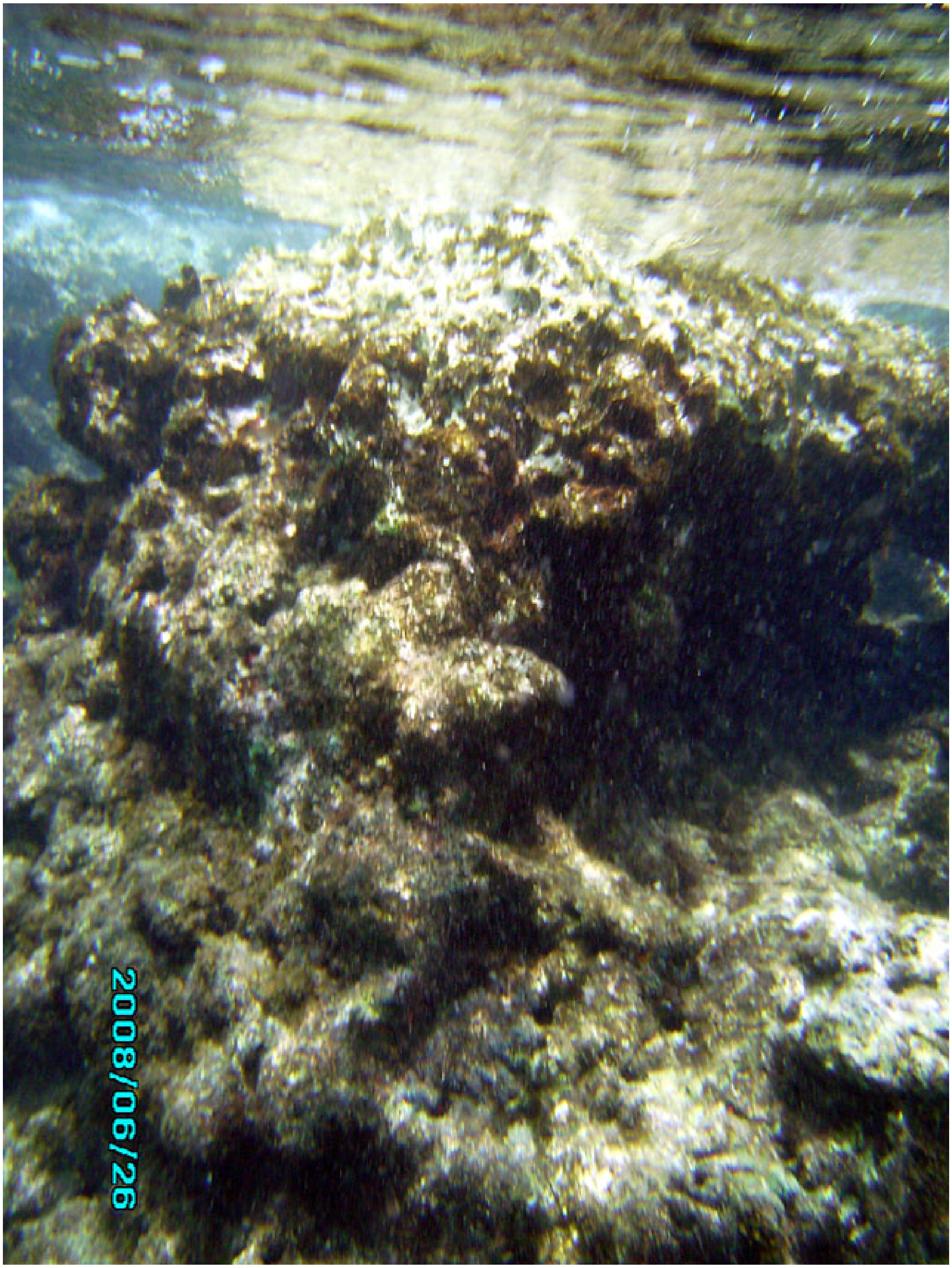


Algae clog the recirculating drains

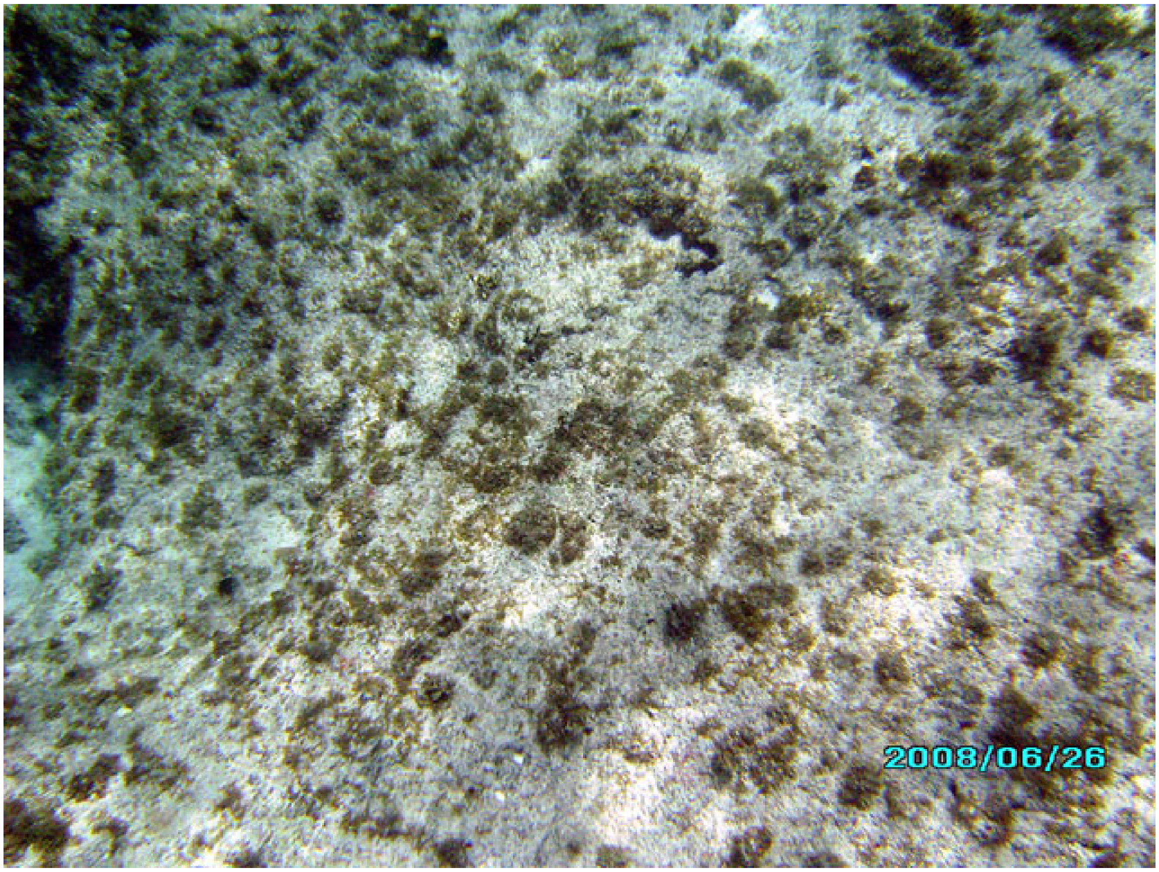
The inflow channel has clear water and large numbers of black long spined sea urchins



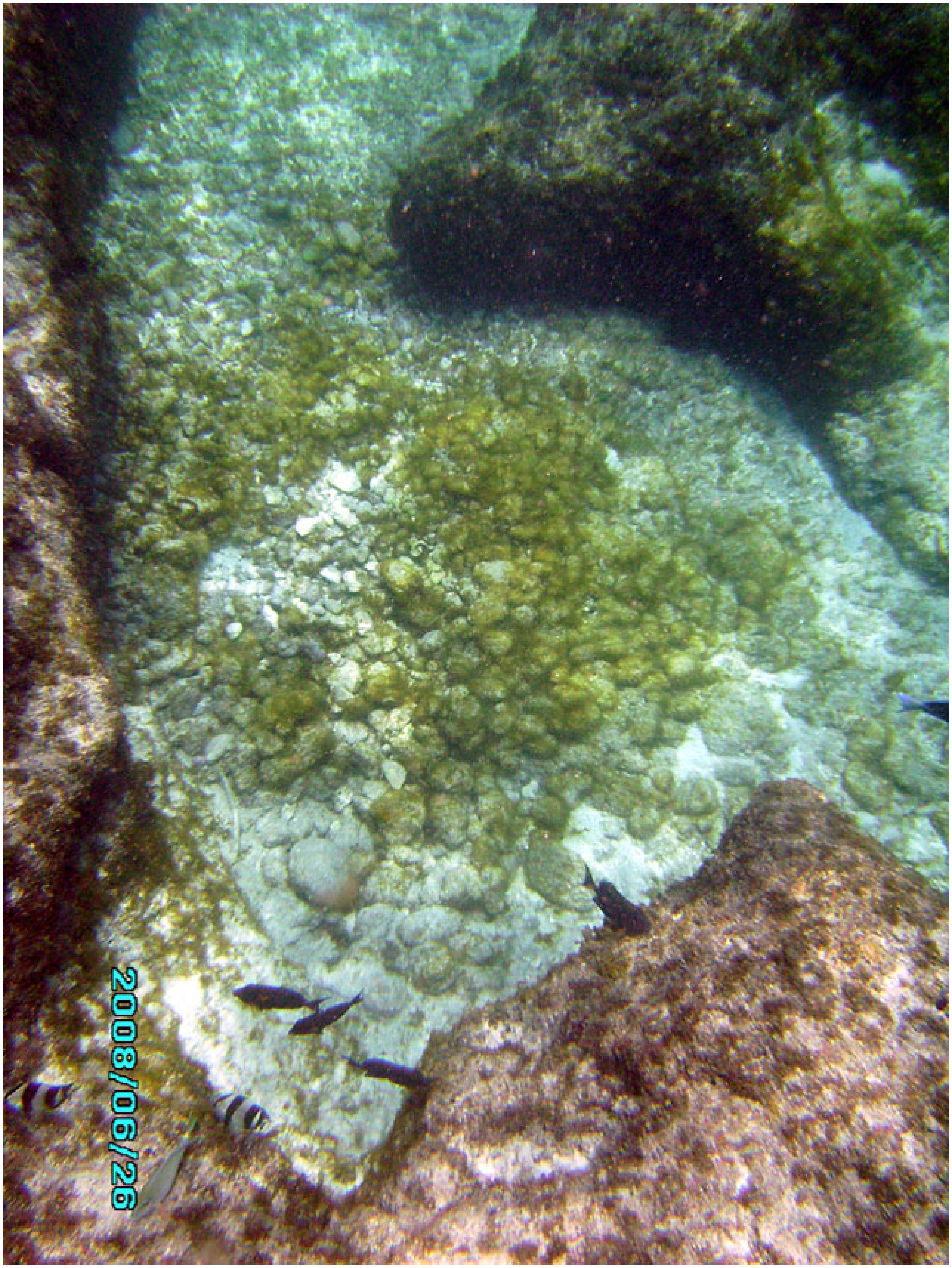
Urchin grazing keeps the walls clean and allows baby coral settlement (small brown patches), but many die from scraping by hungry urchins searching for algae



The rocks in front of the inflow channel have a thin coating of brown algae

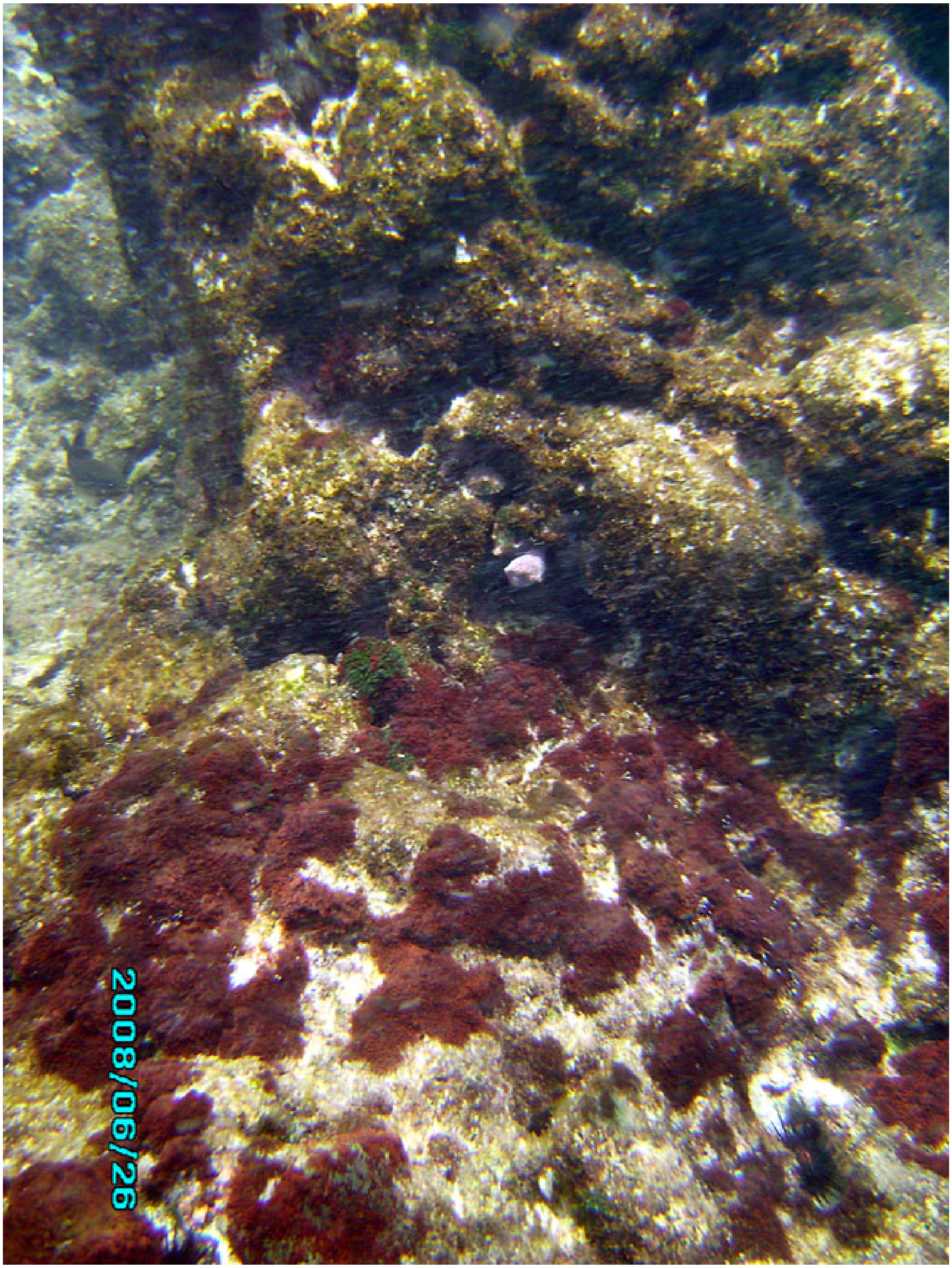


At 10 feet there are sparse brown algae clumps



In front of the dolphin tank area green cyanobacteria start to appear on the channel bottoms

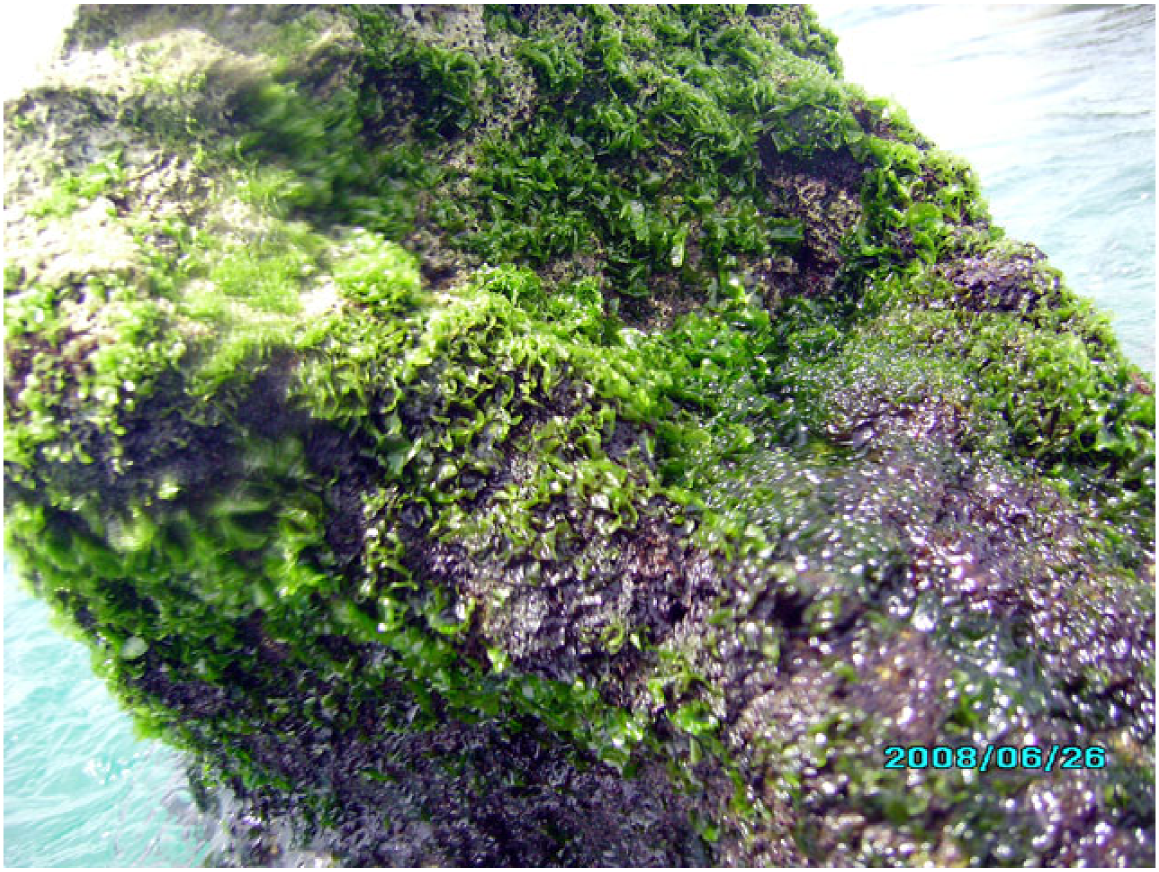
Closer to the outfall the algae growth on the bottom increases



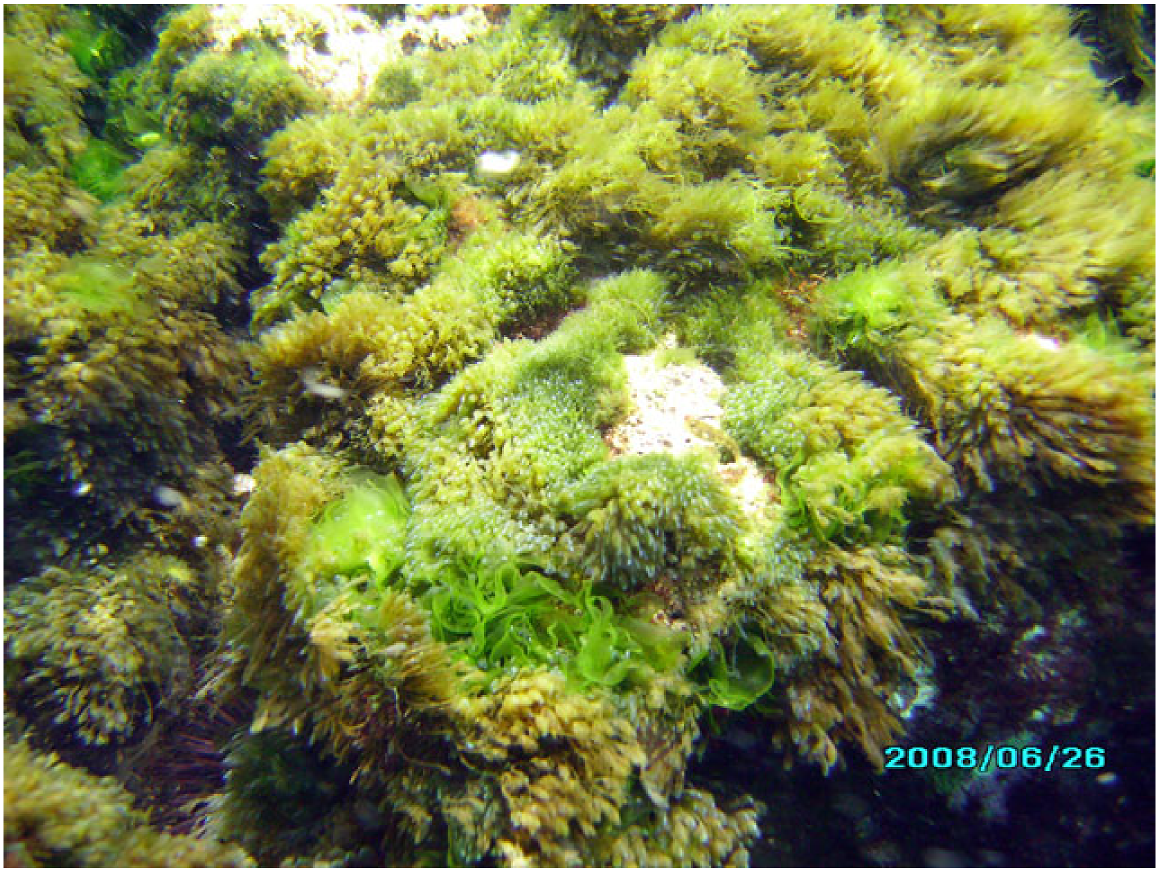
At 10 feet depth in front of the outfall there are masses of red algae on the bottom

Tarpons swim in the white particulate matter in front of the outfall

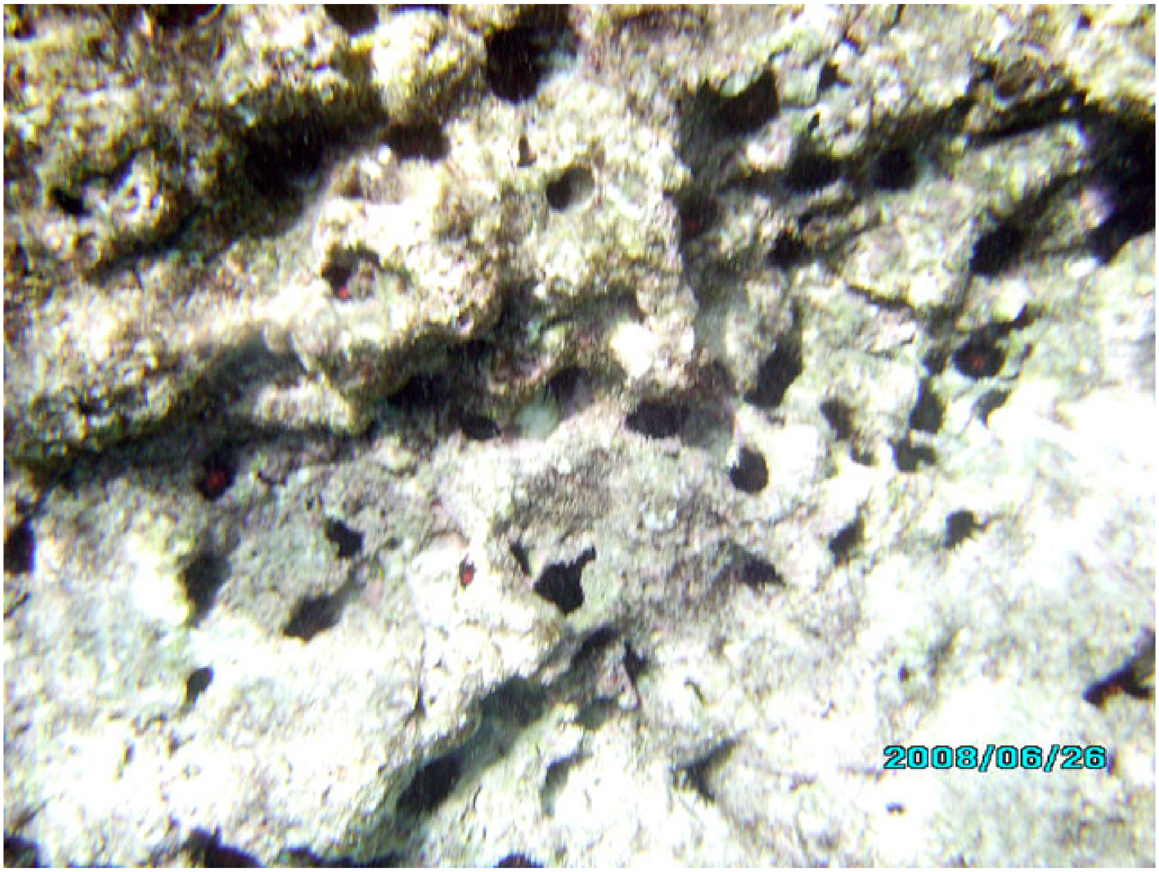
Directly in front of the outfall (square black hole in the wall) a rock reaches the surface



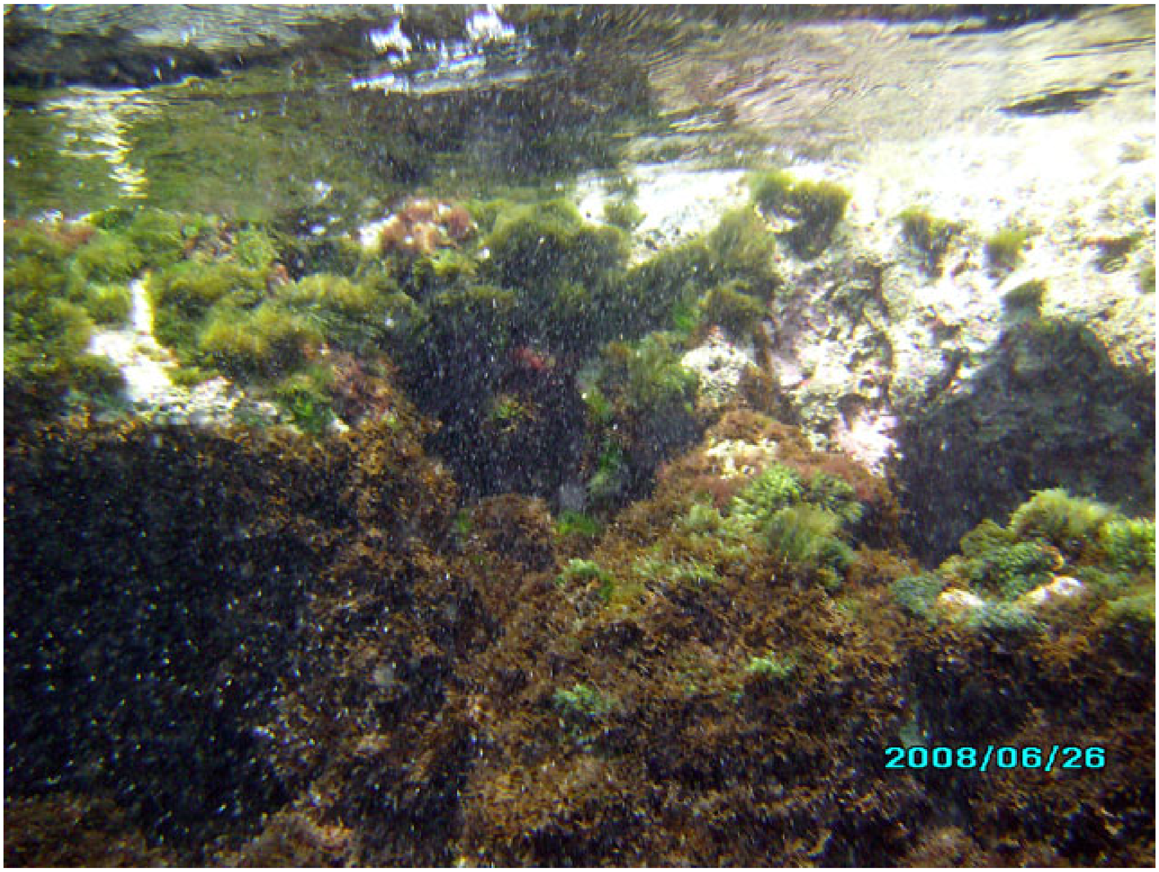
The top of the rock is covered with bright green Ulva, a sewage indicator, the dark material below is Bryopsis lying flat



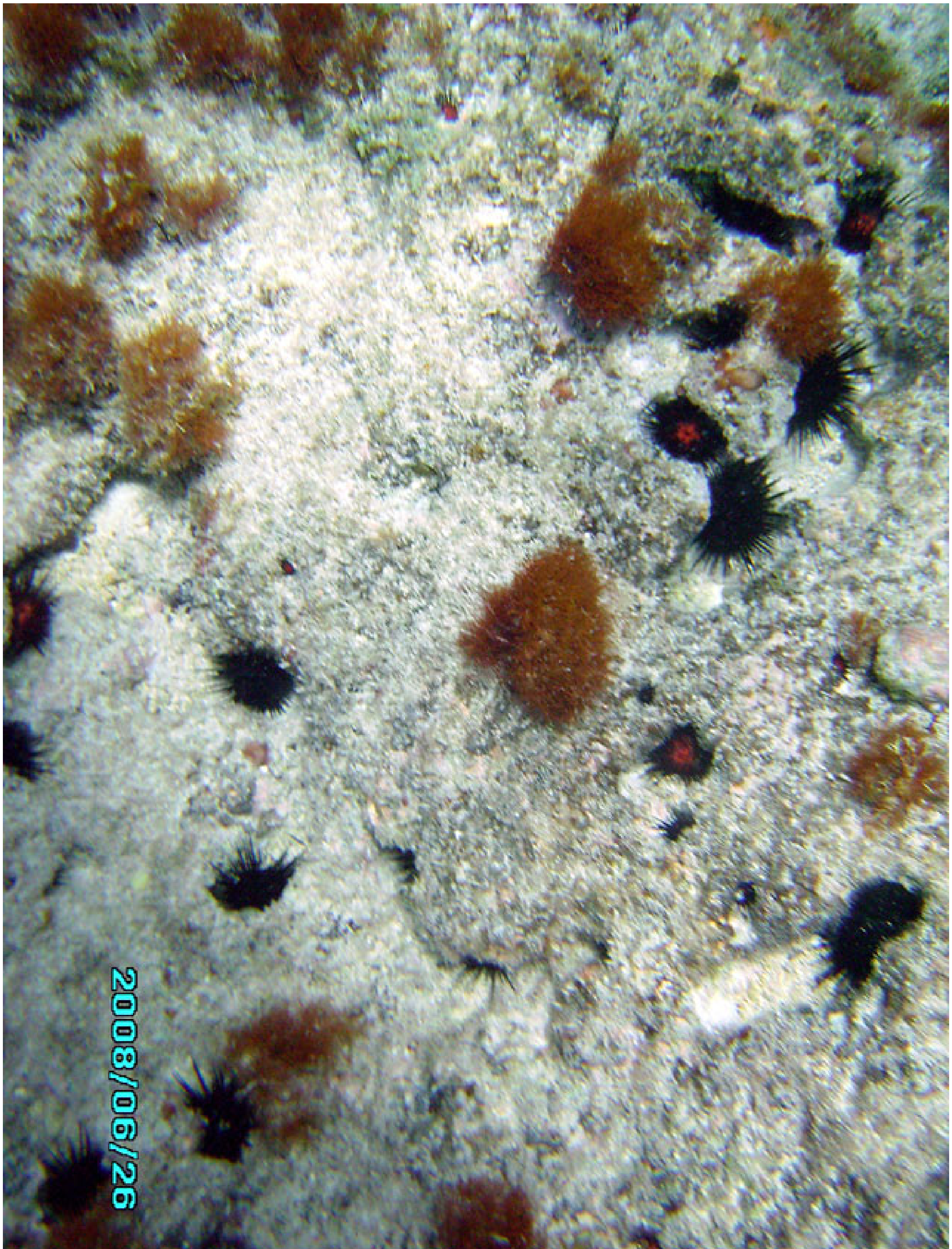
Underwater the Bryopsis on the rock looks like feathery plumes, the Ulva is bright green



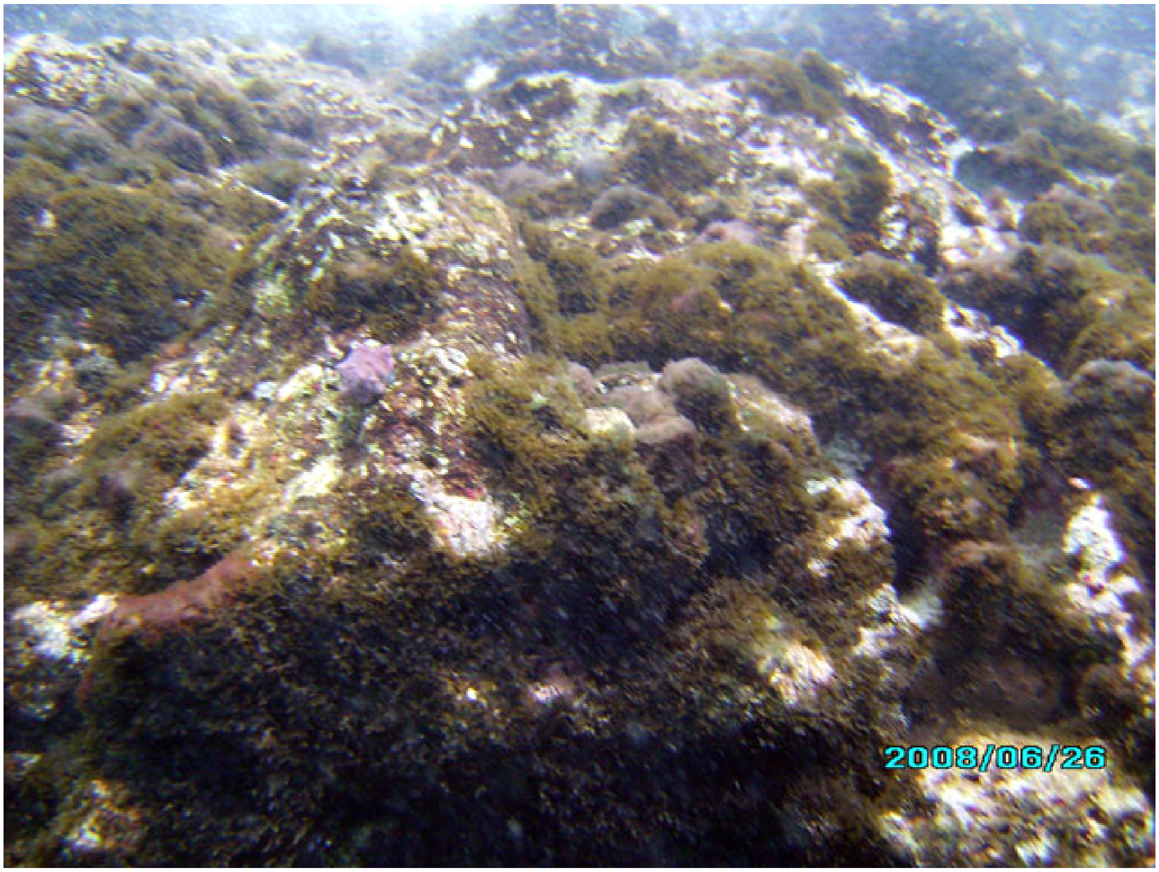
Deeper down burrowing urchins living in a narrow depth band eat the algae around them at night



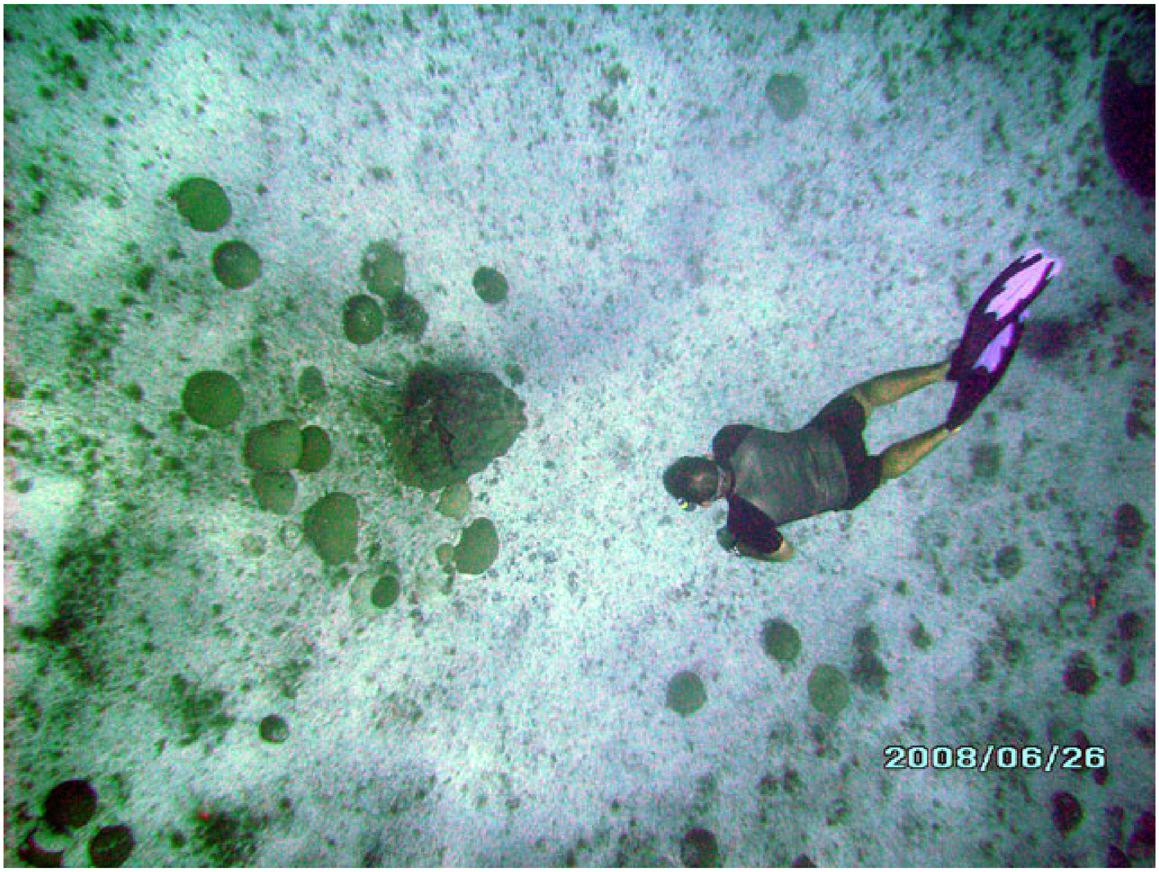
Down-current from the outfall the green Bryopsis on the rocks is paler and is gradually replaced by brown algae



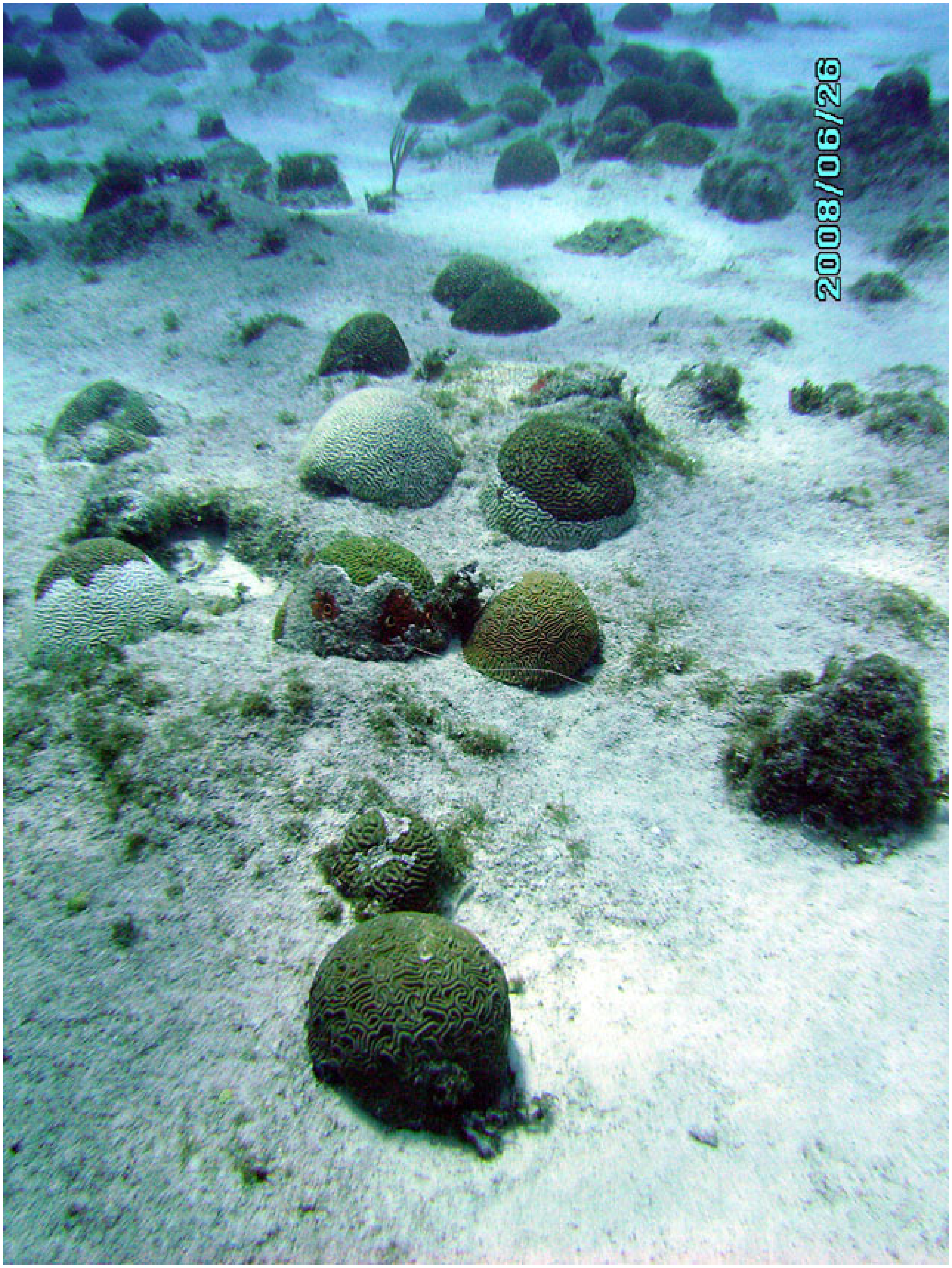
Below are large clumps of red algae, which grow faster than the urchins can eat them if the nutrients are elevated



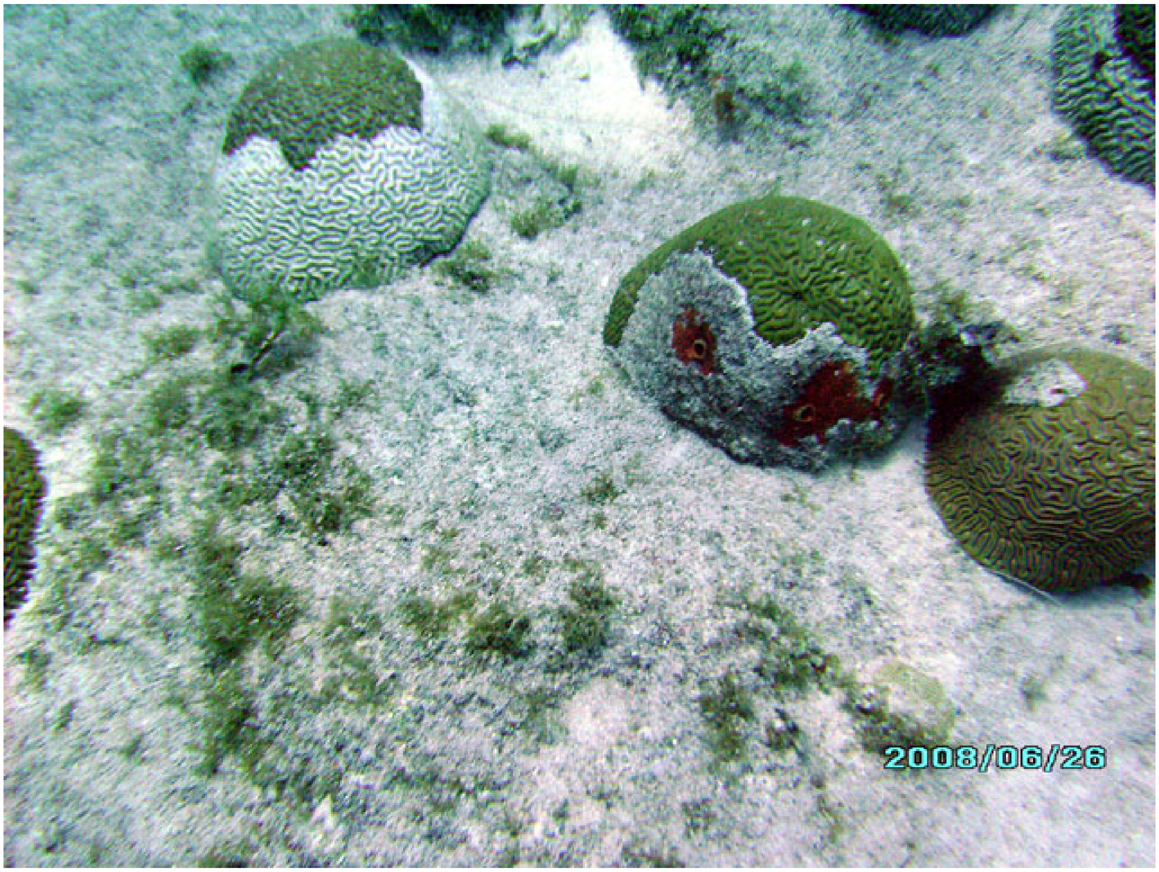
Further away from the outfall the green and red algae are replaced by brown algae, indicating lower nutrients



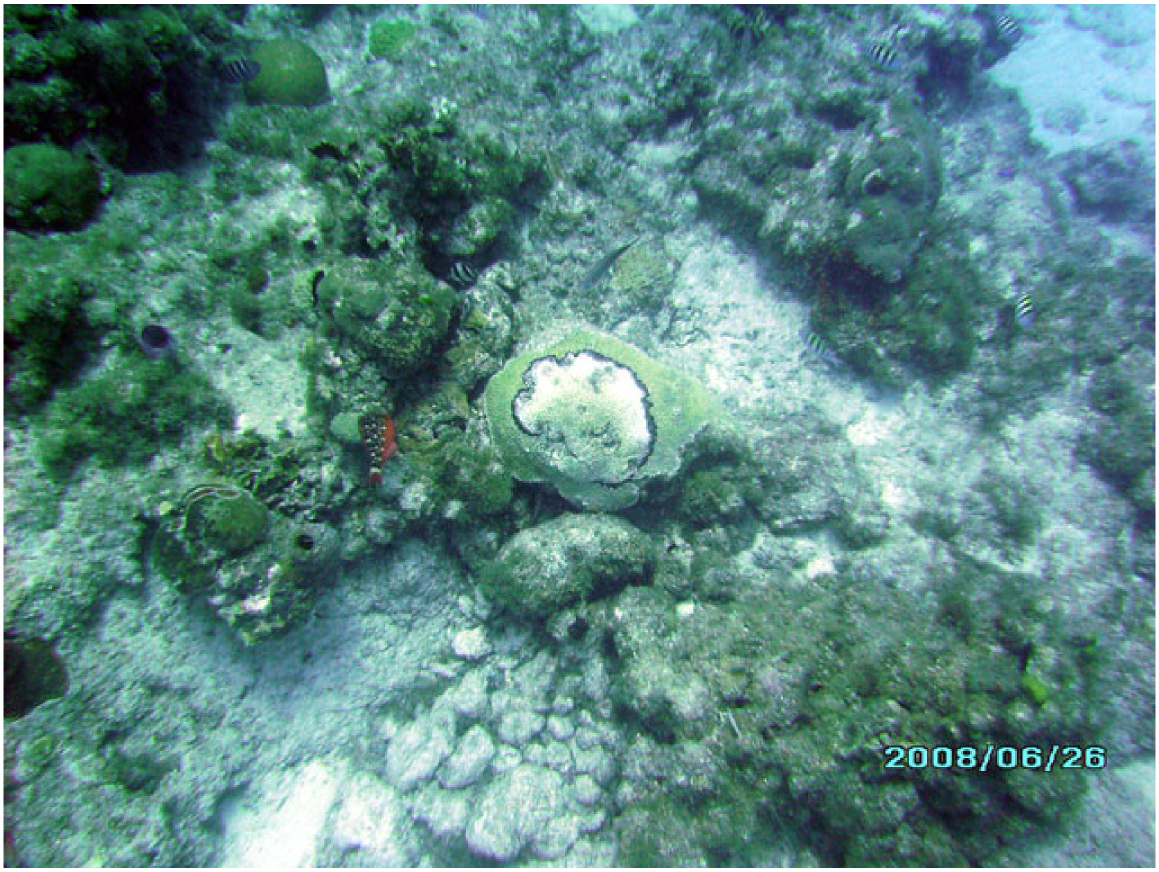
At 20 feet or deeper there are less nutrients and algae and urchins, and corals are re-colonizing the bottom



Many of the corals are white because they have died very recently from White Plague Disease



The red areas on the central coral are the boring sponge, Cliona delitrix, which is found where there is a lot of organic material falling on the bottom. This has probably gotten much less since it was noted in the 1980s, when there were more turtles, but the coral disease was not present at that time.



An isolated case of Black Band Disease in front of the Turtle Farm effluent at around 30 feet. This is likely not related to the pollution, another case was seen at Barker's Cay. Most of the corals here are old dead heads.