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Front Cover: The reef crest indicator species, *Acropora palmata*, on Gaulin's Reef, San Salvador Island. Gaulin's Reef is a classic bank-barrier reef that has shown remarkable resilience following two significant disturbances: El Niño-induced warming of the sea surface in 1998 and Hurricane Floyd in September, 1999 (see Peckol et al., this volume). Photo by Janet Lauroesch.

Back Cover: The oolite shoals of Joulter's Cay, north of Andros Island, Bahamas, site of the pre-meeting field trip. Photo by Ben Greenstein.

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ASSESSMENT OF THE HYDROLOGICAL IMPACT OF CONDUITS ON THE DISTRIBUTION OF BIOTA IN AN INLAND SALINE POND, SAN SALVADOR ISLAND, BAHAMAS.

Diana M. Whitelaw*
Department of Biology and Environmental Science
The University of New Haven
West Haven, CT 06516

*Currently at
The Goodwin-Niering Center for
Conservation Biology and Environmental Studies
Connecticut College
New London, CT 06320-4196

ABSTRACT

Crescent Pond is an inland saline pond fed by conduits on San Salvador Island. The objective of this research was to determine the hydrological impact of conduits on the pond's biota. Do conduits impact the underwater environment by tidal induced changes in temperature, water chemistry and turbulence? Do these environmental factors determine distribution of biota found in proximity to conduits? We chose five study sites based on a combination of interesting biota and distance from the main conduit. We measured water and sediment depths and tested water samples for salinity, conductivity and pH. Temperature data loggers were calibrated to record underwater temperature every two minutes. We counted algae (*Acetabularia, Batophora,* and *Caulerpa*); tunicates, sponges and lugworms; and mollusks (gastropods, bivalves), and found a unique assemblage of organisms at each site. Temperature changes reflect incoming flow from the conduit during higher high-tides but do not explain biotic distribution. Salinity, conductivity and pH measurements show minor differences between sites. Turbulence from the conduit disturbs the floc layer, removing it from some sites and increasing it in others. Hard substrate and shell hash near the conduit favor *Acetabularia, Batophora*, sponges, tunicates and bivalves. Deeper floc away from the conduit favors *Caulerpa* and lugworms. Gastropods are dispersed across substrate types. Conduits clearly impact biotic distribution and further research is needed to determine the exact nature of the relationship.

INTRODUCTION

San Salvador Island in the Bahamas is known as the "Land of Lakes". Inland lakes, ponds, holes and creeks cover almost half of its landmass (Diehl et al., 1988). Crescent Pond, located in the northeastern part of the island, is an inland saline pond fed by subsurface, solutional conduits. Pond biota include algae, gastropods and lugworms distributed widely across the bottom sediment, and sponges, tunicates and bivalves found in scattered patches near the conduits.

Purpose of Study

We found no previous work that reported on systematic data collected to examine the relationship between the conduits and the biota in Crescent Pond. In January 1999, we undertook such an investigation. Its objective was to determine if, in fact, there was any linkage between the distribution of organisms in the pond and the conduit hydrology. Our work tested the following hypotheses:

1. The location of conduits in Crescent Pond impacts the underwater environment by tidal induced changes in a) temperature, b) water chemistry (salinity, conductivity and pH), and c) turbulence (sediment and shell hash accumulation).
2. These environmental factors determine the distribution of organisms found in proximity to the conduits.

BACKGROUND

San Salvador Island is a typical carbonate platform island in the east central Bahamas approximately 600 km east of Miami. Edwards (1996) described the Bahamas as unique in the extent and purity of their carbonate rocks which, being soluble in normal rainwater, produce a karst landscape. With changing sea levels, conduits to the sea developed at different horizons with shafts connecting them. He noted that tides rose and fell within the limestone islands, producing inland saline waters as yet little studied or disturbed.

Inland Lakes of San Salvador Island

San Salvador Island is approximately 14 km north to south and 8 km east to west. Two of its major features are consolidated dune ridges and shallow, hypersaline lakes. The lakes cover a substantial portion of the island's interior. Maximum water depths are usually less than 2 m and the lakes have no direct surface connection to the ocean (Davis and Johnson, 1989). The salinity of water in the lakes can be slightly lower than seawater, to more than four times that of seawater. This varies with the seasons and from lake to lake. The island's subsurface contains large numbers of caves, conduits and vertical shafts (Davis and Johnson, 1989). Some of the interior lakes are connected to the sea by conduits, but many appear to be fed directly by ground water seeps and precipitation.

Conduit-fed Lakes

Davis and Johnson (1989) described two general types of lakes. Seep-fed lakes were very muddy and had substantial colonies of cyanobacteria, which appeared red due to nutrient deprivation. The salinity of the lakes ranged from (36,000 to 90,000 mg/L), and water temperatures were usually very high, exceeding 30° C. These lakes received water from three sources: direct precipitation, seeps, and saline ground water flow. Conduit-fed lakes were clear, with salinity and water temperatures similar to those of ocean water. They received water from the same sources as the seep-fed lakes, but in addition received fresh seawater through conduits during most high tides. The water chemistry in conduit-fed lakes was close to that of seawater and remained fairly constant throughout the year.

Carew and Mylroie (1994) described lake drains as conduits that carried water into and out of lakes in a pattern related to tides. Their presence resulted in lakes that maintained marine salinity despite climatic conditions that might favor freshwater, such as in the northwestern Bahamas, or hypersaline water, such as in the more arid southeastern Bahamas. On the coast, the height of the ocean tides varies considerably from day to day. The elevation of many of the inland lakes is above that of the low high-tide. Therefore, conduit flow into them only occurs during the higher high-tide. At these times the flow is especially vigorous (Davis and Johnson, 1989).

Crescent Pond.

Two studies included Crescent Pond in their descriptions. Edwards et al. (1990) found that the salinity in Crescent Pond ranged from 36,000 to 38,000 mg/L, and that the tidal range was from 20 to 30 cm. This tidal range and salinity suggested the presence of conduits, but in 1990 they had not yet been discovered. At the west end of the pond, however, where it was deepest, several conduits were later found and explored (Davis, 1999; personal communication). Cave divers tried to enter them in 1992, but the conduits pinched out after a very short distance. Godfrey et al. (1994) noted that flow on incoming tides was very strong and a boil could be seen on the pond surface above the largest conduit. They described three small conduits located in the mud at the northeast corner of the pond, but they observed little flow there. Neither study attempted to relate the distribution of organism populations to the presence of conduits in the pond.

Biota in Ponds on San Salvador Island

Diehl et al. (1988) stated that overall, the inland lakes of San Salvador were not as rich in organisms as were adjacent ocean sites. However, they suggested that these lakes offered a good model ecosystem in which to study adaptations and relationships of specialized forms in stressed environments. Each pond had its own endemic population of organisms. Salinity and water temperatures varied greatly from lake to lake and from season to season, usually creating a stressed environment. They found that this resulted in low species diversity but that those organisms that did thrive showed a rather high density.

Edwards (1996) described dense communities of planktonic microorganisms occurring as a living floc layer overlying the muddy substrate of inland saline waters, both tidal and non-tidal. Such assemblages, often amounting to a "false bottom", could not persist in the face of coastal ebbs and flows of the tides, much less currents and waves.

Plants.

Acetabularia, *Caulerpa* and *Batophora* are three species of algae that were found in Crescent Pond by Godfrey et al. (1994). Richardson and Mitchell (1994) described these and other species of chlorophyta found in the Bahamas. They reported that individuals of *Acetabularia* are very distinct, calcified, green algae, often growing in clusters in shallow water attached to rocks, shells and coral rubble. Single cell stalks reach 5-7 cm tall with green, funnel-shaped disks of 1-1.5 cm in diameter on the end. *Caulerpa* species are adapted to living on soft bottoms by growing horizontal, cylindrical stolens over or just below the sediment surface. Upright, erect portions grow and support forked branches. Filament–like rhizoids grow downward into the sediment to provide anchorage. *Batophora*, short green fuzzy club-shaped individuals, often grow in clusters on shallow rocks and shells, 3 – 6 cm tall.

Mollusks.

In surveys of the inland saline ponds, Edwards et al. (1990) described a typical assemblage of just five ecologically little known mollusks: three gastropods and two pelecypods. Among the gastropods, either *Batillaria minima* or *Cerithidea costata* overwhelmingly dominated brackish sites. The snail that was scarce in brackish waters, *Cerithium lutosum*, dominated in fully marine ponds (Edwards, 1996). Edwards et al. (1990) noted that the pelecypods *Anomalocardia auberiana* and *Polymesoda maritima* tolerated salinity from approximately 20,000 – 65,000 mg/L. They found the living molluscan assemblage in Crescent Pond to be atypical. Although it contained the three gastropods characteristic of lake assemblages, *Batillaria minima*, *Cerithidea costata* and *Cerithium lutosum*, and one of the pelecypods, *Anomalocardia auberiana*, it also contained *Pinctada imbricata*, *Isognomon alatus* and *Tellina mera*, more typical of marine assemblages. Hagey

(1991) describes these lake and marine assemblages in detail. Godfrey et al. (1994) found these same species in Crescent Pond.

Other Invertebrates.

Godfrey et al. (1994) found marine organisms in Crescent Pond which included the seaweed cucumber (*Synaptula hydriformis*), chicken liver sponge (*Chrondrilla nucula*), anemones, polychaetes, sponges and tunicates. Edwards et al. (1990) described the sediment on the bottom of Crescent Pond as over 1 m thick along the north shore, and noted that it contained a multitude of microscopic organisms. Godfrey et al. (1994) described subtidal organisms living in these organic sediments just as they did in a mineral-based mud bottom. They reported the most common large animal was the Atlantic lugworm (*Arenicola cristata*) whose bag-like egg masses floated in the pond. Edwards (1996) and Diehl et al. (1988) noted the presence of the reddish-orange shrimp *Barbouria cubensis* in a blue hole.

Vertebrates.

Edwards (1996) and Diehl et al. (1988) reported that virtually all lakes and ponds in San Salvador regardless of size, location, or salinity (brackish to ≤ 60,000 mg/L) had two species of fish, the sheepshead minnow, *Cyprinodon variegatus*, and the mosquito fish, *Gambusia puncticulata*.

DESCRIPTION OF STUDY AREA

Figure 1 shows northeastern San Salvador Island and the location of Crescent Pond in relation to other ponds in the area south of the Bahamian Field Station. Crescent Pond is approximately 500 m in length, 80 m in width, and crescent in shape as its name implies. It lies between two branches of a large, complex dune. It is reached by following the trail that skirts the shore of Reckly Hill Settlement Pond to the east end of Crescent Pond. The study area is reached by continuing on Crescent Pond Trail to Bee Sting Cut-off, where a rock ledge allows for easy access to the water. Although species diversity is generally low in Crescent Pond it increases near the conduits. The triangles in Figure 1 indicate the approximate location of the conduits approximately 100 m from the west end of the pond where it is deepest.

Pond Bottom Conditions

Sediment on the bottom is over 1 m thick, soft, dark greenish gray to brown, and easily disturbed. Several vertical and horizontal underwater formations, habitat for a variety of biota, are located in the general vicinity of the conduits. Deep channels have formed in the sediment at all the conduit exits, each different in shape and size. Shell hash is mounded at the conduit exits. Bedrock is not generally visible except near the conduits where the flow of water moves the floc, creating channels and exposing a flat substrate with some small algae-covered knobs.

Pond Biota

Numerous fish populate the pond incuding *Cyprinodon* and *Gambusia* species and several unidentified species. The floc covering the bottom of the pond is inhabited primarily by gastropods (*Batillaria, Cerithidea* and other species), pelecypods (*Anomalocardia auberiana* and other species), and lugworms (*Arenicola*). While gastropods move freely over the surface, bivalves are found buried in the organic sediment. Oysters and mussels also attach to rocks, shells and hard substrate and the mangrove oyster (*Isognomon alatus*)

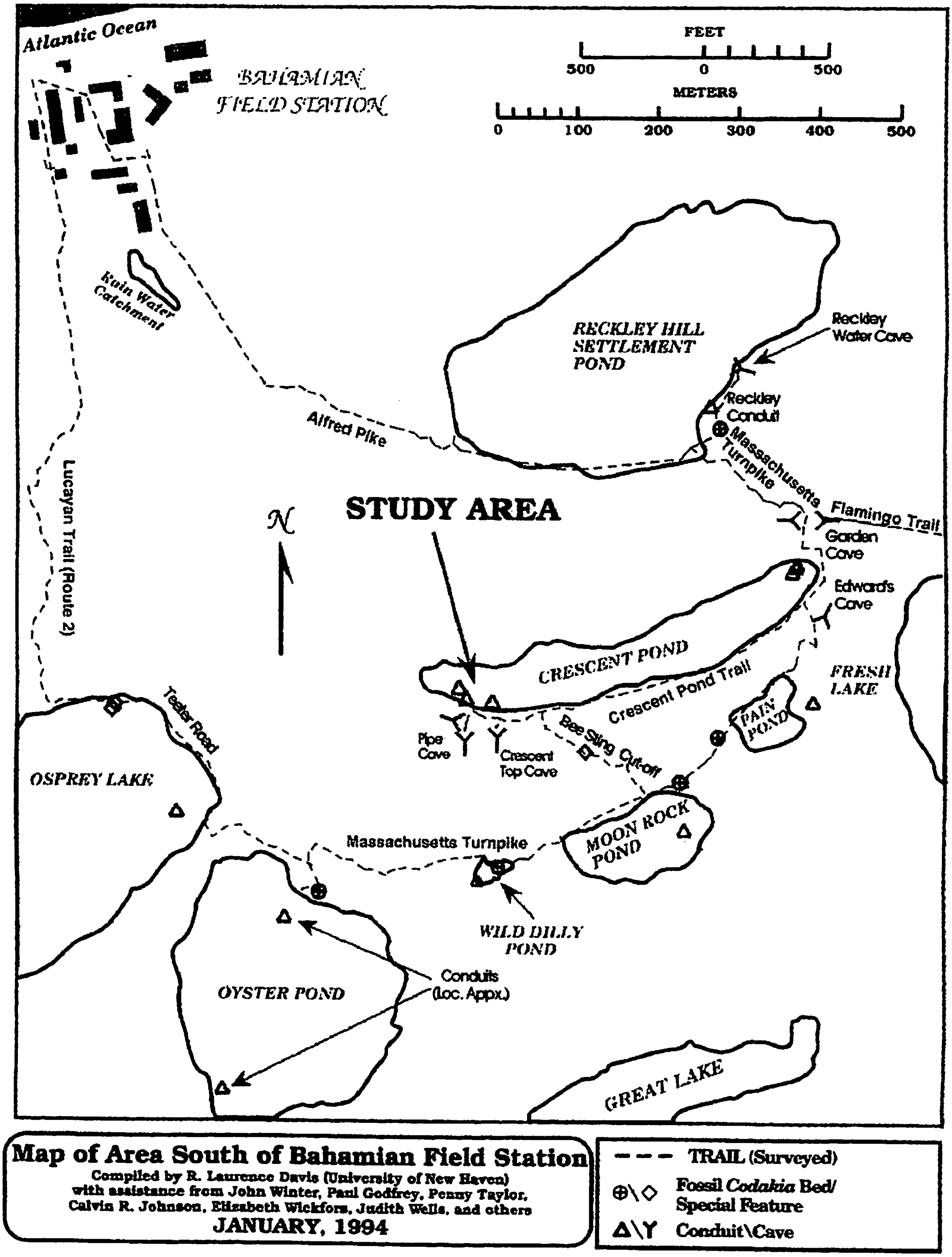

Figure 1. The study area is located in the west end of Crescent Pond. The three triangles represent the location of the conduits.

is common on the rocks and mangrove roots surrounding the pond. Lugworms reside in U-shaped burrows in the sediment. Bag-like egg masses inflate above the openings to their burrows, or float freely on the water surface.

Sponges and tunicates are located near the conduits. *Acetabularia* and *Batophora* are the dominant algae near the south shore and *Caulerpa* dominates near the north shore where the floc layer is deeper.

STUDY METHODS

The objective of this study was to discover if any linkage existed between the distribution of biota in the pond and conduit hydrology. If so, we wanted to determine which environmental factors controlled the distribution of biota found in proximity to the conduits.

Setup of Sites

We chose five sites based on a combination of interesting biota and distance from the main conduit. At each site we positioned a one meter square quadrat at a depth of approximately 2 m, and a buoy to mark its location. In order to develop a map of the pond environment in proximity to the conduits, we took compass bearings to all sites from the shore and tape measurements to the site and conduit locations. Figure 2 shows the approximate position of the study sites, numbered 1 through 5, in relation to the three conduits in Crescent Pond. Site 1 is located upflow, directly in front and to the northeast of the main conduit, at a distance of 6.5 m. Site 2 is located at the exit of the main conduit. Site 3 is located southwest of the conduit, away from the direction of flow, at a distance of 5.5 m. Sites 4 and 5 are west and northwest of the main conduit at distances of 13.2 m and 22 m respectively.

The main conduit, which is the largest, has an extensive accumulation of shell hash, primarily consisting of large bivalves such as

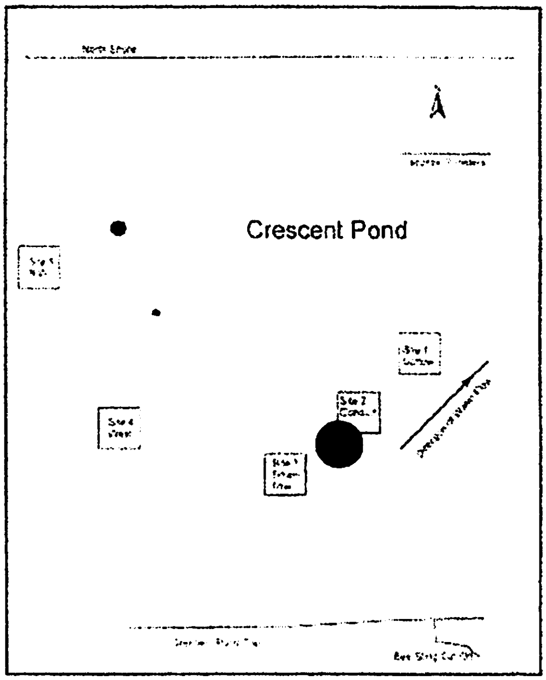

Figure 2. The approximate positions of the study sites, numbered 1 through 5, are shown in relation to the conduits in Crescent Pond.

oysters and mussels, piled up at the exit. This conduit had a very strong flow during the morning high tides, creating a current that was difficult to swim against. The smallest conduit had no visible flow at any time during the study and no shell hash accumulation. The medium conduit has two exits, the smaller one with a stronger flow than the larger. The shell hash accumulations outside the two exits consist primarily of gastropod species including *Batillaria* and *Cerithidea*. Water entering the pond flows northeast from the exits of the conduits. We were never present when there was flow into the conduits from the pond. There are several fish species including *Cyprinodon* and *Gambusia* feeding at the conduits at high tide. Polychaete worms swim in the water flow, and large red shrimps, possibly *Barbouria cubensis*, crawl on the shell hash.

Measurements

We took measurements at the pond over a period of five days. Temperature data loggers were calibrated to record the underwater temperature every two minutes. We attached one to each of the five quadrats, at a depth of approximately 2 m, at 15:00 on January 2. We removed the data loggers at 11:00 on January 6. Water depth and sediment thickness are potential variables in biotic distribution and were measured at all sites using a meterstick.

We collected water samples from each site on the afternoon of January 3, 1999, during low tide, and again during the morning high tide on January 6, to provide a basis for comparison of water chemistry in relation to tides. These samples were tested in the lab for pH, salinity and conductivity.

We recorded the biota present at each site on January 5. Each square meter quadrat was divided into 25 sections. We counted the number of sections inhabited by each species. We chose this method because it was not possible to count individuals of algae (*Acetabularia, Batophora* and *Caulerpa).*

Conditions

Table 1 shows the weather, height and time of the higher high-tides, lowest and highest water temperatures, and observed water inflow at the conduits over the five-day study period. The weather started warm but gradually deteriorated, with wind and heavy rain, then decreasing temperatures by the end of the study-period.

RESULTS

Data were analyzed to determine the impact of conduits on the underwater environment by tidal induced changes in temperature, water chemistry and turbulence. This was followed by an analysis of the distribution of biota.

Temperature

Temperature data were analyzed and charted for the study sites across the five days of recordings. Table 2 shows temperature means and ranges for each site. The highest mean temperature of 25.67 ^{0}C is at Site 2 (main conduit) and the lowest mean temperature of 25.26 ^{0}C is at Site 3. Temperatures at

Date and Time of Site Visit	Jan 2 p.m.	Jan 3 p.m.	Jan 4 N/A	Jan 5 a.m.	Jan 6 a.m.
Weather	Rain, windy	Warm, sunny	Warm, sunny	Rain, Windy	Cloudy, windy
Higher High-Tides	07.43 1.43 m	08.33 1.40 m	09.21 1.37 m	10.08 1.31 m	10.55 1.21 m
Lowest Water Temperature	N/A	24.78 ^{0}C	25.56 ^{0}C	25.56 ^{0}C	23.24 ^{0}C
Highest Water Temperature	25.56 ^{0}C	26.73 ^{0}C	26.73 ^{0}C	25.78 ^{0}C	N/A
Water Inflow:					
Main Conduit	No	No	N/A	Yes	Yes
Small Conduit	No	No	N/A	No	No
Medium Conduit	No	No	N/A	Yes	Yes

Table 1. Weather and water conditions at Crescent Pond during the five-day study period.

Site #	Count	Mean (^{0}C)	Standard Deviation	Minimum	Maximum	Range
All	13655	25.62 ^{0}C				
1 (upflow)	2731	25.63 ^{0}C	1.595083	22.47 ^{0}C	27.12 ^{0}C	4.65 ^{0}C
2 (main conduit)	2731	25.67 ^{0}C	1.568756	22.47 ^{0}C	26.73 ^{0}C	4.26 ^{0}C
3 (downflow)	2731	25.56 ^{0}C	1.651325	22.47 ^{0}C	26.73 ^{0}C	4.26 ^{0}C
4 (far west)	2731	25.58 ^{0}C	1.711169	22.47 ^{0}C	27.12 ^{0}C	4.65 ^{0}C
5 (far northwest)	2731	25.66 ^{0}C	1.740699	22.86 ^{0}C	27.12 ^{0}C	4.26 ^{0}C

Table 2. Mean temperatures and ranges at each study site in Crescent Pond. Temperatures were logged every two minutes for five days.

Sites 1, 2 and 5 are slightly above the study area mean of 25.62 ^{0}C. Temperatures at Sites 3 and 4 are below the mean. Sites 2, 3 and 5 range 4.26 ^{0}C in temperature and Sites 1 and 4 have a larger range of 4.65 ^{0}C.

Figure 3 shows the impact of tides on the water temperature over three days from January 3 to January 5, 1999, with trends of warming and cooling at the main conduit. There is a clear warming trend as water flows into the pond each day at the morning high tide, the higher of the two high tides. Fluctuations also relate to day and night air temperatures, with a cooling off as the weather turned rainy and cold at the end of the study period.

To determine if there were any trends related to the height of the tide, data from the main conduit were reanalyzed from two hours before to two hours after both high tides on three consecutive days. Table 3 shows the height of these morning and evening tides. Morning tides decreased from 1.40 m to 1.31 m and evening tides from 1.09 m to 1.06 m over the three-day period.

Table 3 also shows the change in temperature at the main conduit over the four-hour period coincidental with each high tide. The largest temperature increase of 1.17

Date	Height and Time of High Tides		Temperature Range		Temperature Increase	
			a.m.	p.m.	a.m.	p.m.
Jan 3	1.40 m 8:33	1.09 m 20:54	24.78 - 25.95 ^{0}C	26.34 – 26.34 ^{0}C	+1.17 ^{0}C	0.00 ^{0}C
Jan 4	1.37 m 9:21	1.06 m 21:46	25.56 - 26.34 ^{0}C	26.73 – 26.34 ^{0}C	+0.78 ^{0}C	-0.39 ^{0}C
Jan 5	1.31 m 10:08	1.06 m 22:38	25.95 - 26.34 ^{0}C	25.17 – 25.17 ^{0}C	+0.39 ^{0}C	0.00 ^{0}C

Table 3. Height of tides and temperature increases at the main conduit in Crescent Pond over a four-hour period coincidental with each high tide for three consecutive days.

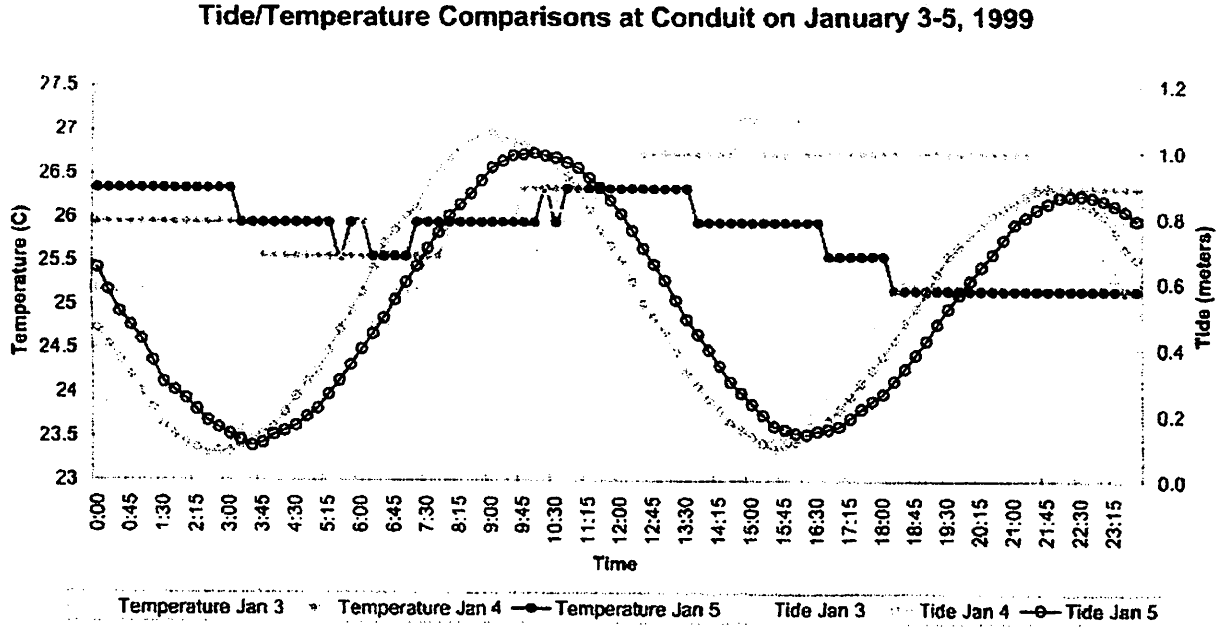

Figure 3. The impact of the tide on water temperatures is shown over three days from January 3 to January 5, 1999.

Table 3 also shows the change in temperature at the main conduit over the four-hour period coincidental with each high tide. The largest temperature increase of 1.17 ^{0}C was recorded on January 3, at the highest tide of 1.40 m. Increases in temperature only occur at high tides above 1.31 m. At tides of 1.09 m or below there were no temperature increases, perhaps indicating a pond elevation higher than that.

Water Chemistry

Table 4 shows the salinity, on the afternoon of January 3 and at high tide on the conductivity and pH measurements recorded at low tide morning of January 6 after heavy rain the day before. Salinity ranges from 35,500 mg/L at Site 3 to 35,700 mg/L at Sites 1 and 5 at low tide. It decreases to a range from 33,100 mg/L at Site 3 to 33,700 mg/L at Site 1 at high tide. Ocean salinity is approximately 35,000 mg/L. Conductivity ranges from 53.8 mS at Site 3 to 54.1 mS at Site 1 at low tide, and from 50.7 mS at Site 2 to 51.4 mS at Site 1 at high tide. The pH ranges from 7.8 at Sites 1 and 2 to 7.9 at Sites 3, 4 and 5 at low tide. At high tide the pH is 7.7 at all sites.

Site #	Salinity (mg/L)		Conductivity (mS)		pH	
	Low Tide 1/3/99 p.m.	High Tide 1/6/99 a.m.	Low Tide 1/3/99 p.m.	High Tide 1/6/99 a.m.	Low Tide 1/3/99 p.m.	High Tide 1/6/99 a.m.
1 (upflow)	35,700	33,700	54.1	51.4	7.8	7.7
2 (main conduit)	35,600	33,400	54.0	50.7	7.8	7.7
3 (downflow)	35,500	33,100	53.8	50.8	7.9	7.7
4 (far west)	35,600	33,500	53.9	50.8	7.9	7.7
5 (far northwest)	35,700	33,300	54.0	50.9	7.9	7.7

Table 4. Salinity, conductivity and pH recordings at low and high tide at each study site in Crescent Pond. Water samples were collected once at each tide level.

Site #	Water Depth (m)	Sediment (Floc) Thickness (cm)
1 (upflow)	1.37	60+
2 (main conduit)	2.40	0.0 (50.0 at side of shell hash)
3 (downflow)	1.94	3.0
4 (far west)	1.32	15.0
5 (far northwest)	1.39	10.0

Table 5. Water depth and sediment thickness at each study site in Crescent Pond.

Turbulence

The sediment consists primarily of a layer of dark greenish gray to brown floc. At incoming tides, flow from the conduits pushes the floc away from the exits and mounds it higher along the north shore of the pond. This forceful flow creates deep channels found on the pond bottom at the exit of each conduit. Mounds of shell hash have formed outside all but the smallest conduit. Shell hash consists primarily of gastropods at the two exits of the medium conduit. At the main conduit it consists of larger bivalves and has formed into a steep incline. Here the floc on each side of the shell hash is 50 cm deep. Table 5 shows a range in floc thickness from 0 cm at Site 2, the main conduit exit, to over 60 cm at Site 1, upflow of the conduit. Downflow the floc depth is just 3.0 cm. West of the conduits the floc settles out at 10 to 15 cm.

Distribution of Biota

Populations were analyzed by examining the number of the 25 sections of square meter inhabited by each taxon. Table 6 shows the distribution of biota at each site. Of the three algae surveyed, *Acetabularia* are dominant at four sites and absent at Site 2 where *Batophora* dominates. *Caulerpa* are present only at Site 1. Sponges are found mostly at Sites 2 and 3. Tunicates are found mostly at Site 4 and lugworms mostly at Site 5. Of the mollusks surveyed, gastropods dominate bivalves at all sites except the main conduit.

Site #	1 (Upflow)	2 (Main Conduit)	3 (Downflow)	4 (West)	5 (Northwest)
Acetabularia	24	0	25	25	25
Batophora	4	25	9	1	7
Caulerpa	1	0	0	0	0
Sponges	4	7	7	2	0
Tunicates	2	0	1	16	0
Lugworms	0	0	3	2	15
Gastropods	25	24	25	25	25
Bivalves	13	25	13	0	6

Table 6. Distribution of biota at study sites in Crescent Pond. Counts refer to the number of the 25 sections of square meter inhabited by each species.

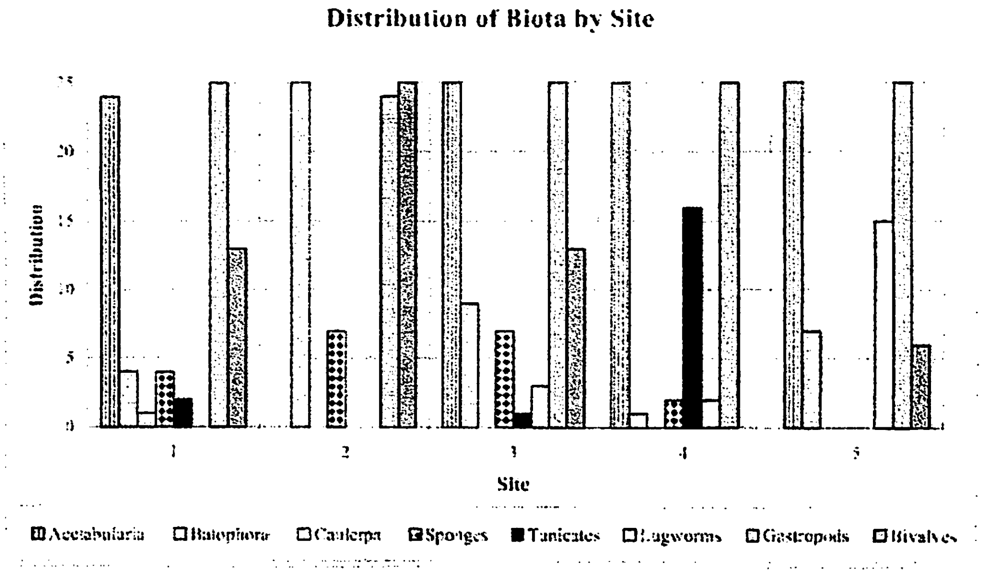

Figure 4. The distribution of biota is shown at each study site in Crescent Pond.

Each study site represents a unique microhabitat, as shown by the distribution of biota graphed in Figure 4.

- At 60 cm of floc, Site 1 has the deepest layer and is directly in line of water flow from the main conduit exit. The dominant algae are *Acetabularia*. It is the only site where *Caulerpa* are found. The dominant mollusks are gastropods. A few sponges and tunicates are present but there are no lugworms.
- Site 2 is at the main conduit exit and has a bottom surface consisting of shell hash with no floc. The only algae are *Batophora*. It is the only site where bivalves are widespread. Several sponges are present but no tunicates or lugworms.
- Site 3, located downflow and to the west of the main conduit, has some bare hard substrate and only 3 cm of floc. The only algae are *Acetabularia* and some *Batophora*. Gastropods outnumber bivalves. Sponges, tunicates and lugworms are all present in small numbers.
- At 20 cm of floc, Site 4 has a layer of intermediate thickness and is the furthest away from the influence of any conduits. Here *Acetabularia* are clearly the dominant algae. This is the only site where no bivalves are found although gastropods are widespread. Tunicates outnumber sponges and lugworms.
- Site 5 has a floc layer of 10 cm. Though the farthest from the main conduit, this site is closest to the medium conduit. Both *Acetabularia* and *Batophora* are present, and gastropods far outnumber bivalves. Lugworms are found in the highest numbers at this site but there are no sponges or tunicates.

ANALYSIS AND CONCLUSIONS

The conduits in Crescent Pond impact the underwater environment and increase species diversity in their vicinity. However, causal relationships are not easy to pinpoint.

Temperature and Chemistry of Inflow

Temperature recordings and flow observations reflect incoming seawater at the main conduit during higher high-tides. We were not present during low high-tides which occurred during the late evening. While differences in temperature do occur over time at all sites, and to some extent between sites, they do not appear sufficient to explain the differences in biota distribution. Salinity readings at the main conduit (35,600 at low tide decreasing to 33,400 mg/L at high tide after the rain) reflect typical seawater salt content. Salinity, conductivity and pH measurements show only minor differences between sites and are not a likely explanation for biota distribution.

Turbulence and Biota Distribution

Turbulence from the conduits disturbs the floc layer, removing it from some areas and increasing its thickness in others. It provides a surface of hard substrate and shell hash near the main conduit which favors *Acetabularia* and *Batophora*, also sponges, tunicates and bivalves, such as mussels and oysters, all of which are sessile and need a firm substrate to flourish. A thicker layer of floc away from the conduits favors *Caulerpa*, which is adapted to living on soft bottoms, and lugworms, which bury in its depth. Gastropods are more evenly dispersed across surface types, but fewest are found at Site 2 (main conduit), which is the most turbulent.

An additional impact of turbulence, in the form of nutrients and oxygen in the incoming water flow, cannot be overlooked. It can be expected to favor the sedentary species such as the bivalves that dominate Site 2 (main conduit). Sponges and tunicates may benefit from proximity to the conduits. Fish are seen actively feeding at the conduit exits during times of water inflow and other biota such as polychaetes and shrimps, possibly brought in by the tides, also feed there.

Overall Conclusions

Unique assemblages of organisms are found at each site. The physical effects of the conduits are more important than are any chemical effects. The conduits clearly impact the distribution of organisms in Crescent Pond and further research is needed to determine the exact nature of this relationship.

RECOMMENDATIONS

This preliminary study suggests opportunities for several more extensive explorations than were possible under present study restraints and time limitations. Would research over a larger area of the pond support our findings? Comparison with other conduit-fed ponds would be informative. What causes the presence and distinctive shapes of the underwater formations? A much wider variety of fish species was observed than expected from a review of previous research. Why? A systematic identification of fish species and other biota found could be enlightening. How many of these marine species are able to colonize inland saline ponds because of the presence of conduits?

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