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Abstract

A Preliminary Biological Study of the Link Port Canal

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I. Introduction

Few ecological studies have been published about artificial canals in Florida, but it is generally agreed that most Florida canals have poor flushing rates that can produce eutrophic conditions. Eutrophication can be greatly accelerated by increased biological oxygen demand from domestic and industrial runoff, which can result in a paucity of desirable aquatic life (Barada and Partington 1972). The purpose of this study is to obtain a generalized idea of conditions in the Link Port canal. This investigation is by no means complete but it is hoped that it may stimulate more detailed studies.

II. Mehtods and procedures.

The Link Port canal was divided into 8 transverse sections by concrete markers placed on each bank (Fig. 1). Station 0 is at the headof the canal and station 8 is at the mouth of the canal which connects to the Intracoastal Waterway.

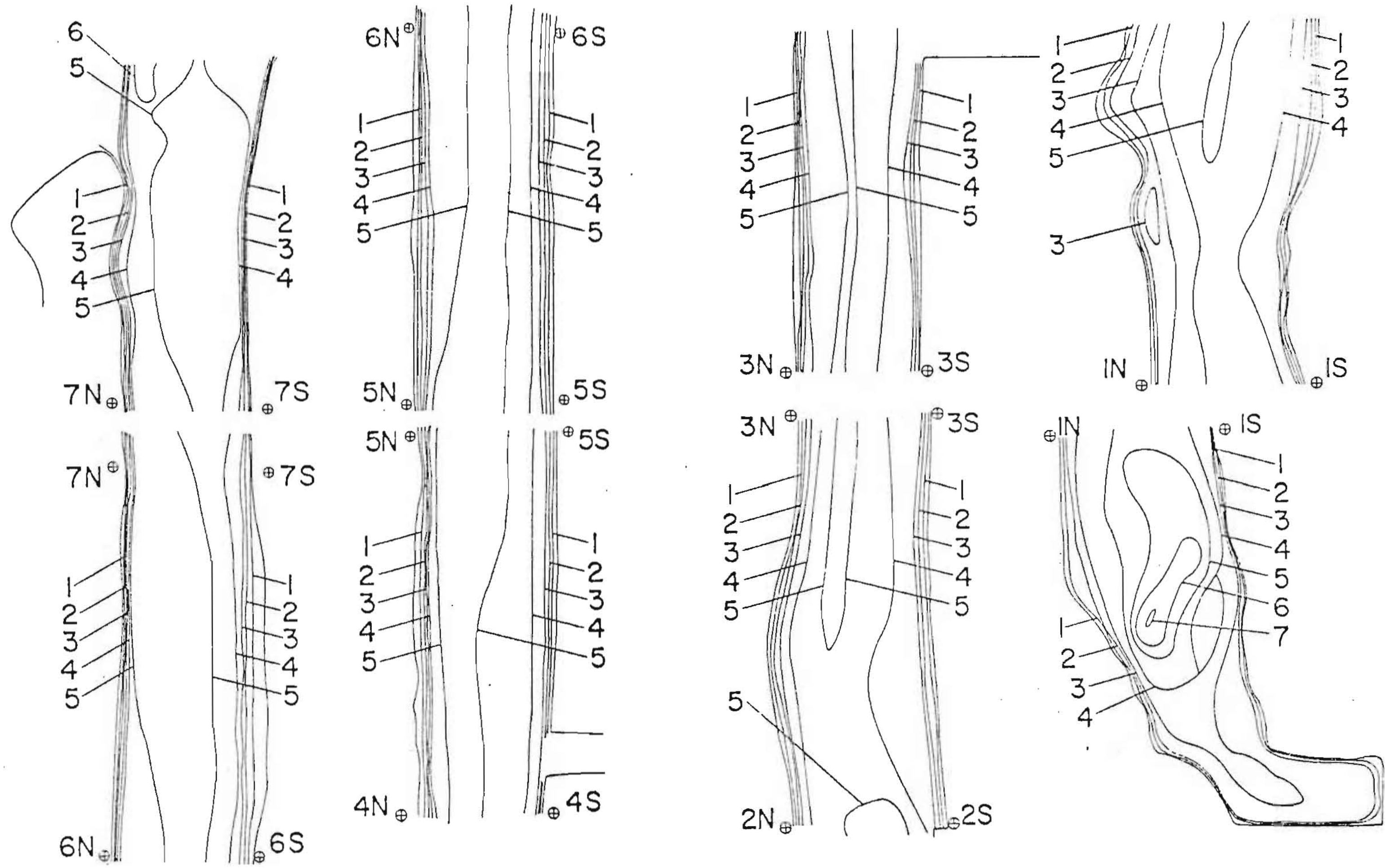
Depth was measured with a depth recorder mounted on a boat moving at a constant speed. Three or four transverse sections were made between each set of transect markers and three lateral transects were made the length of the canal. The depths were plotted on a map of the canal and isobaths drawn for each meter of depth.

Surface and bottom temperature ($\pm 0.1^{o}C$ accuracy) and dissolved oxygen ($\pm$0.1 mg/liter accuracy) were measured in the center of the canal at each transect with a Martek water quality monitor. Surface water samples were taken by dipping a container in the water; bottom water samples were taken with a van Dorn bottle. Salinity was measured with a refractometer ($\pm$1 o/oo accuracy).

Chlorophyll a was extracted from 500 ml of sample and calculated by methods outlined by Strickland and Parsons (1968). Phytoplankton was concentrated from a 10 ml aliquot of each sample by a centrifuge (Wood 1962).

Zooplankton were collected by towing a 0.25 m net (35 μ mesh) for about 10 m on the surface. Tows were made midway

Fig. 1. Depth contours of Link Port canal in meter increments. The canal was divided into 8 sections by sets of concrete posts implanted on the north and south banks. Stations 0 and 1 are at the head of the canal (west end) and stations 7 and 8 are at the mouth of the canal (east end) which connects to the Intracoastal Waterway. Diver's Training Academy is located at station 1s; the Harbor Branch Foundation Laboratory building is between marker 3s and 4s.



LINK PORT CANAL
DEPTH SURVEY
DEPTH IN METERS

between transects 0 and 1, 2 and 3, 4 and 5, and 6 and 7. The samples were preserved in 5% formalin. Aliquots of 0.2 ml of each sample were examined under a dissecting microscope. Major taxonomic groups were identified and counted.

Benthic samples were collected at transects 1, 3, and 7 on the north shore of the canal. Various habitats at each station were sampled. All material within a 10 cm^2 area was collected and placed into jars. The samples were placed in dissecting trays and allowed to settle. The clear water was decanted off and isotonic $MgCl_2$ added, mixed with the sediment, and allowed to stand for about 10 minutes to narcotize the invertebrates. The trays were then agitated and their contents poured through a geological sieve (0.250 mm opening) and all organisms picked from the sieve. This process was repeated until all macrofauna and algae were recovered. All plants and animals were preserved in 10% formalin. Animals were identified to major taxonomic groupings. The organisms were placed in tared aluminum weighing boats, dried at 100° C for 7 days, weighed, ashed at 550° C for 4 hours, and reweighed. Mid-canal bottom samples were taken in several placed in the canal with a 15.2 cm Ekman grab and examined in the field.

Nutrient limitation was determined by enriching 1 liter of canal water with 1 ml of f5, f10, and f20, NO_2^-, NH_3^+, and PO_4^{-3} solutions (Guillard and Ryther 1962). One hundred ml of each solution was placed in covered finger bowls and the bowls exposed to fluorescent light for 14 days. The bowls were rotated each day to assure that each container received an equal amount of light. After 14 days, each bowl was stirred for 2 min and the contents mixed with a Waring Blender for 20 sec. Relative chlorophyll was measured with a fluorometer at door 10 (Strickland and Parsons 1967).

III. Results.

Depth soundings (Fig. 1) show that the Link Port canal is relatively steep sided with a fairly level bottom. Average depths in the center are about 5-6 m with one spot slightly deeper than 7 m. Sediments consist of sand, gravel, shells, and small stones along the shore at the mouth of the canal. Fine sand and mud are at the inland (west) end of the canal. The deeper areas of the canal are covered with a layer of anoxic silt.

Daytime dissolved oxygen levels (Table 1) ranged from 8.9 mg/liter on the surface to bottom values of 1.8 mg/liter in the deeper parts of the canal. Nighttime dissolved oxygen levels were slightly lower than daytime levels. Surface dissolved oxygen levels were generally higher than bottom dissolved oxygen levels.

Salinity (Table 2) varied from 23-32 o/oo. Bottom salinities were slightly higher than surface values. Surface temperatures (Table 3) were higher than bottom temperatures.

Chlorophyll a (Table 4) levels varied markedly in parts of the canal, but surface readings were generally higher than those on the bottom. Chlorophyll a levels were generally highest in the inland (west) end of the canal.

When canalwater samples were enriched with nutrients (Table 5), NH_4^+ and NO_3^- encouraged algal growth more than PO_4^{-3}.

Skeletonema, *Chaetoceros*, and *Rhizosolenia* sp. were the most abundant phytoplankters (Table 6). Phytoplankton appeared most abundant at the landward end of the canal. Common zooplankters were copepods, nauplii, and gastropod veligers (Table 7). The zooplankton standing crop was highest at the mouth of the canal.

Benthic organisms (Table 8) were most numerous at station 7 (east end of the canal). The fewest number of animals were found at the head of the canal (station 0). Macroalgae (Table 9) were most abundant at station 7. No macroalgae were collected at station 3 and only a small amount collected at station 1.

Table 1. Dissolved oxygen (mg/liter) for surface and bottom stations located in Link Port canal. The sampling time in hrs is beneath the date. Jul. 1973.

Station		2 Jul. 0900	18 Jul. 1100	23 Jul. 1300	24 Jul. 0000
0	s	8.9	8.9	7.0	6.7
	b	5.9	6.6	3.3	4.4
1	s	7.2	8.5	6.5	8.0
	b	4.8	5.9	1.8	1.6
2	s	6.4	6.8	6.5	7.8
	b	4.4	4.6	3.0	2.4
3	s	5.8	7.4	5.4	6.9
	b	4.0	4.2	2.8	1.8
4	s	5.8	6.2	5.1	6.0
	b	4.1	4.8	2.7	1.7
5	s	6.0	5.5	4.9	5.4
	b	4.5	5.9	3.0	1.8
6	s	5.4	5.6	5.1	5.4
	b	4.0	4.3	3.0	2.0
7	s	6.1	5.6	4.9	5.4
	b	3.8	5.9	2.8	1.7
8	s	5.7	---	5.3	5.5
	b	4.2	---	2.7	2.0

Table 2. Salinity (o/oo) for surface and bottom stations located in Link Port canal. The sampling time in hrs is beneath the date. Jul. 1973.

Station	2 Jul. 0900	18 Jul. 1100	23 Jul. 1300	24 Jul. 0000
0 s	23	25	28	25
b	25	--	30	29
1 s	26	25	29	27
b	28	--	30	29
2 s	25	27	28	27
b	26	--	28	28
3 s	26	25	27	28
b	29	--	28	30
4 s	25	24	27	27
b	30	--	28	28
5 s	26	25	28	28
b	32	--	27	26
6 s	26	24	28	27
b	32	--	28	28
7 s	25	25	27	30
b	31	--	28	28
8 s	25	26	28	29
b	29	--	29	28

Table 3. Temperature (^{o}C) for surface and bottom stations located in Link Port canal. The sampling time in hrs is beneath the date. Jul. 1973.

Station	2 Jul. 0900	18 Jul. 1100	23 Jul. 1300	24 Jul. 0000
0 s	30.0	31.0	27.0	30.0
b	30.0	30.0	27.5	28.0
1 s	31.0	29.2	26.5	27.0
b	29.0	29.2	26.0	26.5
2 s	31.0	29.2	26.0	26.5
b	29.5	29.0	25.5	26.0
3 s	30.0	28.7	26.0	25.5
b	29.5	28.7	25.5	25.5
4 s	30.0	28.5	26.0	25.5
b	29.5	28.5	25.5	25.5
5 s	30.0	29.0	25.5	25.5
b	29.5	28.5	25.0	25.0
6 s	30.0	29.1	25.5	25.0
b	30.0	28.5	25.0	25.5
7 s	30.0	29.0	25.5	25.0
b	29.5	28.8	25.0	25.0
8 s	30.0	29.0	25.0	24.5
b	30.0	29.0	25.5	25.0

Table 4. Chlorophyll a (mg/liter) for surface and bottom stations located in Link Port canal. The sampling time in hrs is beneath the date. Jul. 1973.

Station	2 Jul. 0900	18 Jul. 1100	23 Jul. 1300	24 Jul. 0000
0 s	7.1	7.4	33.9	11.3
b	8.9	24.6	12.1	14.2
1 s	11.7	17.9	26.1	34.9
b	8.8	9.8	10.4	10.3
2 s	8.0	10.6	23.9	4.0
b	4.8	6.6	7.7	9.5
3 s	8.0	10.1	9.5	9.1
b	3.5	6.4	6.4	18.3
4 s	8.7	21.0	5.8	7.9
b	4.6	10.7	9.8	6.9
5 s	11.6	10.5	6.4	6.3
b	4.4	13.5	8.8	7.8
6 s	10.1	10.4	6.8	4.9
b	5.2	8.3	8.4	8.6
7 s	9.0	8.5	7.2	7.4
b	4.9	10.4	8.2	8.1

Table 5. Relative fluorescense of canal water samples that were enriched with different concentrations of NH_4^+, NO_3^-, and PO_4^{-3} according to Guillard and Ryther (1962).

	Nutrient			
Concentration	NH_4^+	NO_3^-	PO_4^{-3}	Control
f20	48	53	17	--
f10	38	41	15	--
f5	40	50	14	--
control	--	--	--	13

Table 6. Major phytoplankton groups (organisms per liter X 10^6) found at the surface and bottom stations of the Link Port canal. Jul. 1973.

Station		Skeletonema	Perdinium	Chaetoceros	Rhizosolenia	Asterionella	Thallassiasiria
0	s	2.25	0.15		0.15		1.50
	b	3.15		1.50		2.25	
1	s	19.8	5.85		11.7	3.15	
	b	0.45		0.90			8.30
2	s			8.25			
	b	12.1			0.45		
3	s	1.80		2.70	0.15		
	b	6.30		2.25			
4	s						
	b						
5	s			3.15	0.90		
	b	11.7	0.45	1.80	0.45		
6	s						
	b						
7	s	2.70		1.80			
	b	10.8		0.54	8.50		

Table 7. Major zooplankton groups (animals per $m^3 \times 10^3$) collected between various stations in the Link Port canal. Jul. 1973.

Station	Copepods	Gastropod veligers	Nauplii	Cladocerans	total
0-1	15.6		15.6		30.2
2-3	4.20	8.40	12.6	8.40	33.6
4-5	24.0	4.00	20.0		48.0
6-7	66.3	42.9	3.80		113.

Table 8. Benthic invertebrates (individuals/m^2) collected at stations 1, 3, and 7 in the Link Port canal. Jul. 1973.

Taxa	Station 7 (n = 9)	Station 3 (n = 1)	Station 1 (n = 2)
Amphipoda	100		
Isopoda	22	100	
Decapoda	78	400	
Bivalvia	33		50
Gastropoda	33	200	
Terebellidae	144	100	
Neridae	133		100
Maldanidae	133		
Sabellidae	266	1500	
Pectinaridae	11		
Nephidae	11		
Spionidae	11		
Phylodocidae	11		
Orbiniedae	11		
Insect larvae		200	100
Sponges	11		
Fragments	700	700	350
Total	1708	3200	600

Table 9. Dry and ash weights of benthic plants and animals (g/m^2) taken in the Link Port canal at stations 7, 3, and 1. Jul. 1973.

	Station 7	Station 3	Station 1
Animals			
dry	11.28	4.21	6.16
ash	4.68	----	5.09
Plants			
dry	145.25	none	3.12
ash	116.09		2.40

IV. Discussion.

The variations in salinity and temperature are not unusual occurrences in esturaine areas, especially when they are distant from the source of oceanic water as the Link Port canal (Emery and Stevenson 1957). The slightly cooler and more saline water near the bottom could indicate that little mixing is occurring in the canal. Temperature stratifications have been noted in salt-water canals of excessive depth and inadequate circulation (Barada and Partington 1972). Since July is a time of frequent and heavy rains in Florida, further studies would be necessary to determine if these temperature and salinity stratifications are due to rainfall or poor circulation.

The lower dissolved oxygen levels on the bottom and the release of hydrogen sulfide by the deeper sediments indicate that anoxic conditions are present in the deeper portions of the canal. Barada and Partington (1972) reported similar conditions in other Florida canals but they did not give any data for comparison.

Enrichment experiments (Table 5) indicate that nitrogen is probably one of the limiting factors for algal growth in the canal. Data collected simultaneously by Wang (unpublished) demonstrates higher nitrogen concentrations in the head of the canal. The higher standing phytoplankton crop at the landward end of the canal (Tables 4 and 6) may be due either to the higher nitrogen concentrations or simply to the patchy nature of phytoplankton populations (Hopkins 1963).

The higher zooplankton standing crop at the mouth of the canal could be a result of recruitment from the Indian River, while the zooplankton at the landward end of the canal could be limited by low dissolved oxygen. The Indian River contains many grass flats and is bordered by salt marshes and mangrove swamps. In estuaries, sea grasses are a far more important link in the food chain than phytoplankton (Odum 1970) and shoreline marshes also contribute a great amount of nutrients to estuaries (Rogotzke 1959). Since mangrove swamps and sea grasses are rare in the canal, the canal may have a lower standing crop of zooplankton than the Indian River, and thus a higher standing crop of zooplankton could be expected as the river is approached. More studies of canal and river zooplankton are required to verify this observation.

More data is required to ascertain if biomass and diversity decreases as the canal is ascended. Since the sample sizes at the different stations are not identical, comparison is difficult (Sanders 1968), but the large differences observed are probably not due to sampling variation alone. The fewer types of benthic habitats (Pianka 1965) coupled with a possible decrease in water quality (Stickney and Stringer 1957) could explain the decrease in benthic fauna as the canal is ascended. A more intensive benthic survey would be necessary in order to ascertain the benthic community structure of Link Port canal.

V. Summary.

The Link Port canal is a steep sided, flat bottomed canal. The deeper sediments are largely anaerobic but the shoreline areas are inhabited by a variety of animals and plants. As the canal is ascended, fewer numbers and species of benthic organisms are found. This could be a result of decreasing water quality or a decreasing diversity of habitats. The phytoplankton standing crop is highest at the head of the canal, and nitrogen may be the limiting factor for algal growth. Zooplankton may be limited by low dissolved oxygen in the canal but recruitment from the Indian River probably maintains a higher standing crop of zooplankton at the mouth of the canal.

This brief study indicates that the Link Port canal has not been reduced to the abiotic conditions of many Florida canals. Unless great care is taken in the development of the Link Port complex, increases in domestic and industrial pollutants will cause a degradation the water quality of the Link Port canal.

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