Effects of Lake Bottom Channelization on Invertebrate Fish Food Organisms in Lake Tohopekaliga, Florida

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Abstract: The relationship between the decline of macroinvertebrate standing crop and the loss of aquatic habitat due to box-cut access channel construction was assessed on Lake Tohopekaliga. Channelization of natural lake bottom had an adverse effect on benthic productivity by increasing both taxon richness and numbers of organisms routinely utilized by sportfish. For this study, channel substrate supported only 54% of the total standing crop of fish food organisms found in littoral substrate. Macroinvertebrates associated with vegetation were eliminated by the destruction of rooted macrophytes; approximately 420 fish food organisms were lost for every cubic meter of vegetated water column altered by channelization. It was estimated that an average standing crop of 840,000 fish food organisms would be lost due to the construction of a "standard" 200 × 10 × 2 m box-cut access channel.

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Florida has been one of the most rapidly growing states in the nation for the past decade. An image of boundless natural resources and favorable climate has been promoted by developmental interests. Waterfront property, in particular, has been characterized as an unlimited part of the "Florida Dream." To meet the heavy demand for waterfront property, developers have resorted to extensive dredge and fill and draglining of wetlands (Bellinger 1970). Physical alterations of these sensitive areas are destructive to their biological productivity (Kaplan et al. 1974, Darnell 1976, Clark 1978). Inadequate concern for Florida's fragile environment has caused serious water quality problems, extensive loss of aquatic habitat and severe declines in populations of fish and wildlife (Brada, W., and W. M. Partington. 1972. Report of the environmental effects of private waterfront canals. Unpub. rep.

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Lake Tohopekaliga, a prime largemouth bass fishing lake, has experienced accelerated deterioration of aquatic habitat due to water level stabilization, nutrient enrichment and upland development. Extreme drawdowns were implemented successfully to maintain quality aquatic habitat in Lake Tohopekaliga through the 1970's (Wegener and Williams 1974). Unfortunately, serious environmental problems continue. Recent attempts to dragline littoral areas of Lake Tohopekaliga have prompted further investigation and documentation of biological parameters necessary for maintenance of healthy sportfish populations.

This paper accesses the relationship between the decline of macroinvertebrate standing crops and loss of desirable aquatic habitat due to dredging or draglining box cut access channels across the littoral zone of Lake Tohopekaliga.

Methods

Lake Tohopekaliga is a 7,618 ha natural lake located in central Florida. It is a shallow basin lake with extensive littoral areas encompassing approximately 50% of the lake at high pool stage. The lake has an annual fluctuation schedule of 1.0 m and is regulated for flood control purposes by the U.S. Army Corps of Engineers. Lake Tohopekaliga is part of the Kissimmee Chain of Lakes which encompasses over 44,480 ha of water. The Kissimmee River basin extends from Orlando to Lake Okeechobee and serves as a major water source for south Florida.

Three box-cut access channels were selected for this study. Boyd's channel has not been altered since construction in 1971. Heavy organic deposits occurred along approximately 75% of the channel bottom and as the channel approached the distal edge of the littoral zone, deposits changed to a silt-sand mixture. The surface area of Boyd's channel encompassed approximately 1,436 m^2 (189 × 7.6 m), and was dug to a maximum depth of 1.9 m below the normal landward lake bottom elevation.

Olsen's channel was maintenance dredged in the spring of 1979 during an extreme drawdown of Lake Tohopekaliga. Organic deposits were present from the upland terminus midway to the mouth, and the remainder of the channel bottom was sand. Overall surface area was 10,166 m^2 (299 × 34 m). The channel was dug to a maximum depth of 2.3 m below the normal landward lake bottom elevation.

The third channel, Granada Road, was constructed in 1979 as a public access site. The sand bottom filled with silt and light organic material as the study progressed. This channel has a surface area of 1,859 m^2 (169 × 11 m), and was dug to a maximum depth of 2.2 m below the normal landward lake bottom elevation.

Undisturbed littoral areas adjacent to each channel were selected for assessment of natural macroinvertebrate standing crops both on littoral substrate and in rooted aquatic vegetation.

Sampling was conducted during July and December of 1979 and 1980, and in July 1981. Littoral samples were taken along 3 transect lines established adjacent and parallel to the channels. Each transect began at the water's edge and ran lakeward to the outermost limit of rooted vegetation. Samples were collected with a sweepnet (for vegetation) and core sampler (for littoral benthos) at every 0.3-m contour that was inundated. Bottom samples consisted of 4 cores combined per littoral station, representing the same total surface area (15 × 15 cm) as a single Ekman dredge grab. Benthic data collected by the Ekman dredge and core sampler were comparable, as described by Wegener and Williams (1976); the Ekman dredge was found most efficient in non-vegetated habitat, whereas the core sampler was more effective in vegetated littoral areas. Aquatic vegetation at littoral stations was sampled with a sweepnet to collect invertebrate organisms associated with plant communities. The rectangular sweepnet rim measured 20 × 46 cm, and webbing was standard #30 mesh. One sweepnet sample consisted of 10 1.5 m long sweeps and approximated 1.5 m^3. Numerical data for the sweepnet sampler was expressed and tabulated as organisms/m^3. Channel sampling stations were located at the upland terminus, midpoint, and lakeward terminus of all 3 channels. A single 15- × 15-cm Ekman dredge grab was collected at each station per sampling period. Standard sweepnet samples were collected during July 1981 in the water column at open water channel stations for comparison with littoral sweepnet samples.

Samples were immediately rinsed in a wash bucket having a bottom of standard #30 mesh screen, and preserved in formalin stained with Rose Bengal solution. Preserved invertebrates were sorted into taxonomic groups and counted.

Results and Discussion

Benthic Sampling

Estimates of total numbers of macroinvertebrates collected from both channel and littoral substrate were comparable for the duration of the study, although the number of organisms collected per sampling period varied greatly (Table 1). This variability was due in part to an extreme drawdown of Lake Tohopekaliga conducted in early 1979 to restore quality aquatic habitat. Water levels began to recede in January and declined until the lake's littoral zone was exposed. The drawdown schedule enabled water levels to

Table 1. Invertebrates Collected in Lake Transects and Channels from July 1979 to July 1981 at Lake Tohopekaliga, Florida. (Expressed as numbers per square meter)

	Sampling Periods											
	7–79		12–79		7–80		12–80		7–81		Average	
Taxon	Channel	Lake	Channel	Lake	Channel	Lake	Channel	Lake	Channel	Lake	Channel	Lake
Turbellaria				72		65				3		28
Nematoda	334	990	813	1,298	655	406	4	3		18	361	543
Oligochaeta	4,372	2,118	8,342	3,682	2,213	859	1,413	1,537	546	792	3,377	1,798
Hirudinea	10	114	4	81	33	72		22		43	10	66
Cladocera		25		689				11				145
Copepoda	1,310	33	115	571	211	58	4	3	22		332	133
Cypridae			10								2	
Talitridae	4	172	18	40	569	51	4	40		3	119	61
Palaemonidae	4	8	4	5		4			4	3	3	4
Araneae		26		3		4						7
Ephemeridae					10	10	4				3	2
Baetidae	133	767	9	74	244	68		8	4		78	183
Libellulidae		11										2
Gomphidae		8		1		28		8				9
Coenagrionidae		42		9	4	72		3			1	25
Hydrometridae		3										1
Gerridae		4										1
Corixidae		40						3				9
Leptoceridae		15			10	33					2	10
Limnephilidae	4		4	29							2	6
Lepidoptera		8										2
Dytiscidae						33						7
Hydrophilidae		23		8				3				7
Curculionidae		3		113								23
Psychodidae		3										1
Culicidae	168	8	1,452	132	171	66	70				372	41
Tendipedidae	1,925	6,436	215	3,487	1,796	1,967	315	1,233	120	172	874	2,659
Ceratapogonidae	115	39	1,093		850	176			4		413	43

Table 1. Continued.

Taxon	7–79		12–79		7–80		12–80		7–81		Average	
	Channel	Lake	Channel	Lake	Channel	Lake	Channel	Lake	Channel	Lake	Channel	Lake
Stratiomyiidae								3				1
Tabanidae	4	8								3	1	2
Physidae		4		9								3
Planorbidae		23		8		8			4	3	1	8
Ancylidae	4		4	108		65	15	8			5	36
Viviparidae		14						8		11		7
Amicolidae	4			1			4	3	4		3	1
Unionidae	4	3									1	1
Spaeriidae		3		1								1
Corbiculidae					4						1	
Totals	8,395	10,951	12,083	10,421	6,770	4,045	1,833	2,896	708	1,051	5,961	5,876
Taxons Present	15	30	13	22	13	19	9	16	8	10	21	36
No. of Samples	9	11	9	17	9	10	9	12	9	12	45	62

recede 2.0 m below regulated high pool stage. The littoral zone was reflooded by mid-May. Beneficial results of the extreme drawdown included oxidation and consolidation of bottom sediments, improved littoral substrate, development of desirable aquatic plant communities, and increased invertebrate standing crops. Drying and compaction of sediments occurred along the sides but not the bottoms of the 3 channel sites.

Macroinvertebrates recolonized the littoral zone rapidly after reflooding. Hale and Bayne (1980) observed a similar occurrence in Alabama's West Point Reservoir, and Hepworth (1976) documented like results for Lake Powell, on the Utah-Arizona border. High numbers of littoral benthic organisms were sampled throughout 1979, averaging approximately 10,700 organisms/m^2. Densities of benthic organisms collected from channels ranged from 8,400 to 12,100/m^2 in 1979. These organisms showed a trend similar to littoral benthos and declined steadily throughout the study. Macroinvertebrate data collected in conjunction with the first extreme drawdown of Lake Tohopekaliga in 1971 (Wegener et al. 1974) showed that littoral benthos nearly doubled following reflooding. Invertebrate numbers subsequently decreased to predrawndown estimates within 2 years.

Species composition of benthic organisms in channels and lake transects differed greatly (Fig. 1). Fish food organisms had been previously determined by assessing stomach contents of sportfish from lakes Tohopekaliga and Kissimmee, a 14,154 ha sister lake located 19.3 km to the south (Barwick 1973, Williams et al. 1979). Several of the most numerous groups of macroinvertebrates collected in channel benthos, such as aquatic earthworms (Oligochaeta), round worms (Nematoda), and biting midges (Ceratopogonidae) were seldom utilized by sportfish. Data collected since 1975 has demonstrated that the above invertebrate groups contribute less than 0.4% of the food items consumed by bluegill (*Lepomis macrochirus*), redear sunfish (*Lepomis microlophus*) and largemouth bass (*Micropterus salmoides*).

Littoral substrate supported a standing crop of fish food organisms 2 to 3 times greater than channel substrate for the July and December 1979 and December 1980 sampling periods. For the study duration, the standing crop of fish food organisms in channel bottoms was 54% of that found in littoral bottom habitat. Greater taxon richness (number of taxons) was documented in littoral substrate than channel substrate for the entire study. Taxon richness of littoral benthos ranged from 45 to 100% greater than channel benthos in 4 of 5 sampling periods (Table 1). Data collected from sportfish food habit studies was based on identification at various taxonomic levels above genus. Because the same held true for this study, the use of standard diversity indices such as Shannon-Weaver were not possible, since these are based on identification to species level. In Lake Kissimmee, a preliminary short term study (Moyer 1980) showed littoral lake bottom supported 5

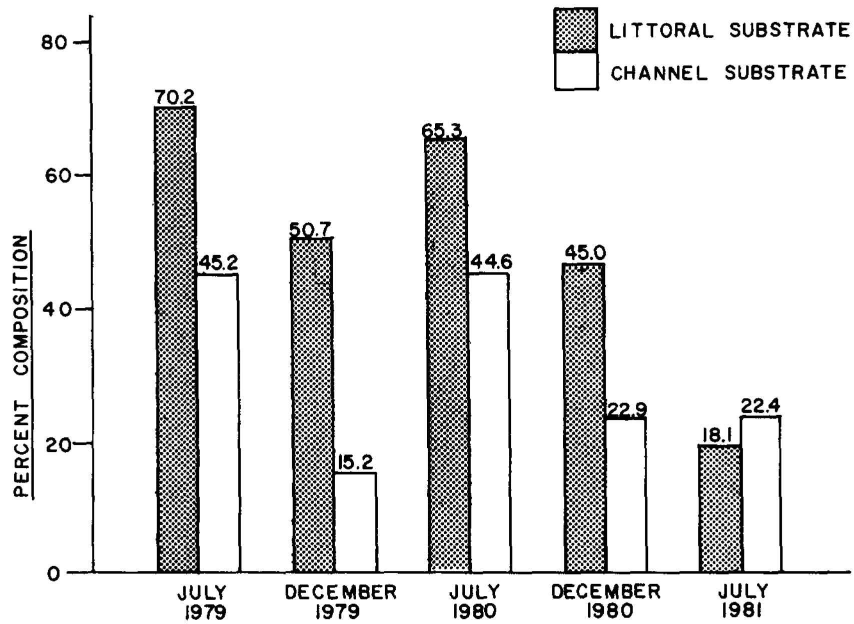

Figure 1. Comparison of percentage composition of fish food organisms per square meter of channel and lake substrate for 5 sampling periods.

times as many macroinvertebrates and 4 times the taxon richness per square meter as channel bottom. Kaplan et al. (1974) found that standing crop and taxon richness of an estuarine channel were reduced to small fractions of predredging levels eleven months after dredging occurred.

Previous work on Lake Tohopekaliga (Wegener et al. 1974) indicated that increased predation due to expanding sportfish populations could sharply decrease standing crops of littoral benthic fish food organisms. Sportfish populations responded positively to the 1979 drawdown, and this factor is probably responsible for the significant decline of prime fish food items such as midges (Tendipedidae) and scuds (Talitridae) throughout the study. In addition, predator cropping of desirable forage such as dragonflies (Libellulidae, Gomphidae), damselflies (Coenagrionidae) and mayflies (Ephemeridae, Baetidae) eliminated these families from littoral benthos by July 1981.

During the 1979 drawdown sediments along the sides of these shallow channels were exposed, oxidized and consolidated. This improvement could be responsible for the relatively high numbers of organisms which initially utilized channel habitat upon reflooding. There was little difference in total standing crop among the 3 channels for the duration of the study.

Sweepnet Sampling

Macroinvertebrates responded rapidly to inundation of rejuvenated littoral habitat by producing high standing crops within 3 months (Table 2). The taxon richness of organisms associated with vegetation was 2 to 3 times greater per sampling period than that of channel benthos. McLachlan (1975) reported that taxon richness of invertebrates found in aquatic vegetation was 3.5 times greater than that of bottom muds.

Fish food organisms comprised between 70 to 100% of the total numbers of macroinvertebrates associated with vegetation in all but the summer 1981 sampling period. During summer 1981, after fish predation had decreased overall numbers, fish food organisms collected in the littoral zone remained high. Grass shrimp (Palaemonidae), an important forage item for

Table 2. Invertebrates Collected in Littoral Sweepnet Samples from July 1979 to July 1981 at Lake Tohopekaliga, Florida. (Expressed as Average Numbers Per Cubic Meter)

	Sampling Periods					
Taxon	7–79	12–79	7–80	12–80	7–81	Average
Turbellaria		5.3	2.5	15.8		4.7
Nematoda	0.6	200.3	0.9			40.4
Oligochaeta	137.9	43.2	14.2	362.5	0.7	111.7
Hirudinia	0.2	26.8		0.2		5.4
Cladocera		5.0	8.4	36.8	1.2	10.3
Copepoda	0.3	16.6	0.2			3.4
Talitridae	25.2	46.9	29.7	242.1	3.7	69.5
Astacidae			0.3		0.2	0.1
Palaemonidae	5.8	80.9	28.8	16.9	34.3	33.3
Araneae	30.2	22.8	12.8	8.8	0.8	15.1
Collembola	0.2			20.8		4.2
Ephemeridae					2.7	0.5
Baetidae	88.3	20.7	16.6	5.6	0.2	26.3
Libellulidae	10.4	0.4		0.7	1.7	2.6
Gomphidae	0.2	12.3	2.5	0.7	0.4	3.2
Coenagrionidae	52.1	36.6	39.7	19.2	0.4	29.6
Hebridae	1.8					0.4
Hydrometridae	7.8	0.2				1.6
Mesoveliidae	0.2					<.1
Gerridae	42.2					8.4
Vellidae	5.8	42.0	19.6			13.5
Notonectidae		0.2				<.1
Naucoridae	0.2			0.4	1.7	0.5
Nepidae	3.1	0.6	8.8	0.2		2.5
Belostomatidae	9.6	4.1	3.2	0.1	0.1	3.4
Corixidae	11.3	21.3	0.2	2.0	25.2	12.0
Psychomyiidae			0.1	0.2	0.1	0.1
Hydroptilidae	0.1	13.2	0.2	0.5		2.8
Leptoceridae	8.3		2.0			2.1
Lepidoptera	1.8					0.4

Table 2. Continued.

Taxon	7–79	12–79	7–80	12–80	7–81	Average
			Sampling Periods			
Haliplidae	0.1			0.5		0.1
Dytiscidae	3.0	12.8	2.4	0.9	1.5	4.1
Gyrinidae	0.1	1.5	0.1			0.3
Hydrophilidae	23.0			0.5		4.7
Dryopidae	0.2					<.1
Elmidae		0.2			0.2	0.1
Helodidae	1.3					0.3
Curculionidae	0.7					0.1
Tipulidae		1.2				0.2
Psychodidae		0.2				<.1
Culicidae	7.0	0.3				1.5
Tendipedidae	362.8	395.5	159.1	120.6	5.8	208.8
Ceratopogonidae	145.6	5.2	3.1	1.7	0.2	31.2
Stratiomyiidae		12.2		5.5	1.4	3.8
Tabanidae	3.2	3.1	0.2	1.1		1.5
Syrphidae		0.2				<.1
Neritidae		1.2				0.2
Physidae	1.7	4.7	0.5			1.4
Planorbidae	1.5	17.5	2.9	16.0	3.6	8.3
Ancylidae		13.1	0.3	0.1	0.2	2.7
Viviparidae	0.2				0.2	0.1
Amnicolidae					0.1	<.1
Corbiculidae	0.1					<.1
Totals	994.1	1,068.3	359.3	880.4	86.6	677.4
Taxons Present	39	35	27	27	24	54
No. of Samples	11	16	10	11	12	60

largemouth bass, were well represented in summer 1981 sweepnet samples. By contrast, channel samples showed grass shrimp as an incidental item. Trent et al. (1976) found that 5 species of macrocrustaceans were more abundant in a natural marsh than in an upland canal at West Bay, Texas.

Macroinvertebrates associated with vegetation were eliminated by the destruction of aquatic plants in the channels sampled. In July 1981, sweepnet samples were collected at channel stations. Approximately 2 organisms/m^3 were collected from the 3 channels, as compared to an average for the entire study of 677 organisms/m^3 in adjacent littoral areas. Fish food organisms comprised nearly 62% of the total number of invertebrate organisms associated with aquatic vegetation for the study duration. An average of 420 fish food organisms were lost for each cubic meter of vegetated water column altered by channelization.

There is an important relationship between loss of vegetation and fish food organisms. In terms of standing crop, this can be determined by multiplying the number of organisms per unit volume times the volume of the water column which had been previously occupied by aquatic vegetation before channelization. A "standard" 200- × 10- × 2-m box-cut access channel would have eliminated an average standing crop of 840,000 fish food organisms for this study. It must be emphasized that this is a loss estimate for standing crop only. Annual productivity could be more than 17 times this standing crop estimate (Hayne and Ball 1956).

In summary, construction of private access channels has an adverse effect on benthic organisms utilized by sportfish, and associated fish populations by decreasing both taxon richness and numbers of invertebrate fish food organisms. Macroinvertebrates associated with vegetation were eliminated by destruction of rooted macrophytes.

Dredging and filling activities within wetlands associated with Florida lakes cause severe permanent damage to aquatic habitat. Declines in sportfish populations are anticipated should this activity increase. It is hoped that the results of this investigation will assist regulatory agencies in formulating policies and enforcing existing statutes and rules pertaining to wetlands protection.

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