INITIAL POWER PLANT EFFECTS ON FISH DISTRIBUTION IN A SMALL FLORIDA ESTUARY

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Abstract: The distributional responses of fishes to operation of a newly constructed power plant were assessed for indigenous populations of the Anclote Anchorage and River, Florida. Studies conducted during 1976 compared stations removed from potential plant effects with data collected from areas adjacent to plant intake and discharge. Comparisons were also made with preoperational information collected in the vicinity of the Anclote site.

Beach seine collections exhibited a marked seasonal pattern related to the inshore-offshore migration of nonresident species and the nursery function of the estuary. Abundance and species richness were greatest during the warmer months, as reported during preoperational surveys. Fishes at the shore zone station most affected by thermal discharges were more abundant during the coldest months and exhibited decreases during the hottest periods. This reversal of normally expected abundance was attributed to the thermal effluent.

Comparable trawl and trammel net sampling conducted in the discharge canal revealed few species similarities when compared to collections over seagrass beds. The abundance and number of species in the discharge canal remained low during all but the colder months with collections dominated by sheepshead (*Archosargus probatocephalus*), a species rarely taken over seagrass beds. The seagrass stations exhibited comparable catches except during colder months, when abundance and diversity were highest in affected areas. Noticeable decreases in summer collections at affected stations during 1976 were not recorded during baseline surveys. Suppressed summer diversity, though localized, was attributed to heat stress on the community.

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There is a great deal of concern over the potential detrimental effects on fishes attracted to or repelled from thermal discharges from power plants. Although species composition and thermal responses of fishes congregated in various discharge canals have been observed, little is known of the distribution of fishes in and around the thermal plumes. To document the potential effects of the Anclote Power Plant on the aquatic community and ecosystem of the Anclote Anchorage and the Anclote River, Florida Power Corporation (FPC) contracted with several research organizations to conduct studies throughout 1976 in the vicinity of the intake and in the areas of the Anchorage affected by the discharge.

The survey for fish was conducted by Texas Instruments Incorporated. The study program conformed to the format outlined in the Environmental Protection Agency (EPA), Region IV, document for design of 316 demonstrations and responded to stipulations set forth by EPA in a draft permit for the Anclote Plant, Unit I (NPDES No. FL0002992).

Fish populations at stations removed from potential plant effects were sampled monthly and compared with data from areas adjacent to plant intake and discharge. Comparisons were made between operational and preoperational information (Humm et al. 1971; Baird et al. 1972, 1973, 1974; Mayer and Maynard 1975) collected in the vicinity of the Anclote site. Finally, station comparisons of seasonal variations in species number, composition, and abundance aided in determining to what extent juvenile fish utilize the Anclote River as a route to upstream nursery grounds.

Estuarine fishes are highly mobile and are able to relocate rapidly and utilize available habitats. Alteration of the environment by changes in circulation patterns, currents, temperature gradients and the like involve rapid changes in temporal and spatial patterns of local ichtyofauna. Results reported in this study provide an evaluation of power plant effects during the first year and indicate initial patterns of ecological change during this period of environmental instability.

MATERIALS AND METHODS

Description of the study area

The Anclote Anchorage, in southwestern Pasco County, Florida, is considered a very productive estuarine system. It is a shallow coastal lagoon of about 23.3 km^2, separated from the Gulf of Mexico by a series of barrier islands called the Anclote Keys (Fig. 1). Tides are the predominant hydrodynamic force of the Anchorage with winds playing a secondary role. Currents are primarily tide and wind driven, the latter being dominant when winds exceed 16.1 km/hour (Wapora 1977). Temperature and salinity distributions are generally affected by tidal currents with solar radiation modifying temperature distributions, especially in the shallows.

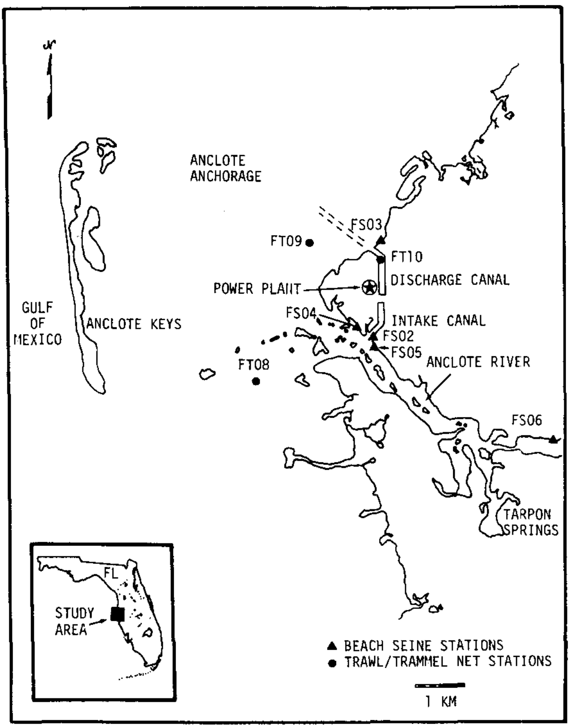


Fig. 1. Fish sampling stations at Anclote Power Plant site, 1976.

The Anclote River is the major stream discharging into the Anchorage. Average flow of the river is approximately 2.2 m^3/s but flow is characterized by long periods of low flow and short periods of high flow, dependent on seasonal variations in rainfall. The river has a base runoff of approximately 10% from aquifers.

Seagrasses are the predominant benthic plants in the estuary. A major portion of the bottom is covered by one or more of several species: *Thalassia testudinium, Syringodium filiforme, Ruppia maritima, Halodule wrightii,* and *Halophila* spp. The combination of shallow waters (with depths generally less than 3 m), rich and widespread grass beds, input of fresh water from the Anclote River, and flushing action of the tides make the Anchorage a very productive nursery area for sport and commercially important species.

The Anclote Power Plant is located on a 164 ha site just north of the mouth of the Anclote River and adjacent to the Anclote Anchorage (Fig. 1). The generating facility currently consists of 1 oil-fired steam-electric generating unit with a rated net capacity of approximately 515,000 KWe. Operating at design capacity, cooling water circulated through the condensers is mixed with dilution water resulting in a combined flow of 62.8 m^3/s and a temperature increase of 2.8 C at the point of discharge. Both cooling water and dilution flow are withdrawn from the Anclote River at a point near the river mouth. The heated water is discharged to the Anchorage through a dredged channel extending offshore from the bulkhead line to the 1.8 m depth contour.

Samplng gear and stations

A 22.8 m x 1.8 m nylon-bag seine with 3 mm delta mesh was used to monitor juvenile and small fishes at 5 stations in the vicinity of the plant's discharge and intake canals and Anclote River (Fig. 1). Replicate collections were taken monthly at beaches near the intake (Station FS02) and the thermal discharge (Station FS03) with other shore stations sampled monthly during summer and bimonthly at other times.

To maintain maximum comparability with previously collected baseline data, materials and techniques used to monitor ichthyofauna of seagrass beds and the discharge canal conformed to those described by Barid et al. (1972). The bimonthly program consisted of sampling twice day and night with both trammel net and trawl at three permanent stations (Fig. 1). At each seagrass station, a 91.4 m x 1.2 m trammel net with 5 cm stretch inner mesh and 30.5 cm stretch outer mesh walls, was fished for 45 min. During this time, a 3.1 m commercial try trawl, with 3.5 cm stretch mesh, was towed parallel to the trammel net on each side at a distance of approximately 76 m from the trammel net. Comparable sampling was conducted at a station located near the midpoint of the discharge canal. A 2.4 m deep trammel net was used to adequately sample the discharge canal. Because of spatial constraints, modified trawl sampling was conducted in front of the trammel net.

Data collection and analytical procedures

The total number and weight of each fish species was recorded for each sample. Standard length and weight were determined for all individuals, or a random subsample of at least 25 specimens per species. Lengths were recorded to the nearest 1.0 mm, and weights to the nearest 0.1 g.

Physical data expected to influence fish distribution were routinely recorded in situ. A Weston and Stack oxygen analyzer system, with temperature compensation and readout, was used in coordination with a YSI Model 33 induction salinometer to obtain measurements of temperature, dissolved oxygen, and salinity. An IL 175 Porto-matic pH meter was used to measure hydrogen ion concentration.

Catch-per-unit-effort data were used to describe seasonal variations in species number, composition, abundance, and community structure, while day-night sampling supplied information on short-term diel variations. Catch per unit effort (C/f) for beach seines and trawls was defined as the number of individuals per haul. For trammel nets, C/f was defined as the number of individuals per 45-min net set. The mean C/f by gear was calculated as follows:

where:

$\bar{x}$ = simple mean of C/f over catches

x_i = number collected for i^{th} catch

T_1 = unit of effort

T_2 = actual number of efforts for i^{th} catch

n = number of "observations" or catches

To test hypotheses about spatial and temporal distribution, analysis of variance (ANOVA) was performed on mean total weights, mean total numbers, and species richness (i.e. number of species). Duncan's Multiple Range procedure was used to explore the nature of the differences indicated in each ANOVA for those variables significant at the 0.05 level. The statistical analyses were performed by J. McClave and his staff, University of Florida.

RESULTS AND DISCUSSION

Environmental setting

The year 1976 was extremely dry (Buzick 1977). Mean discharge from the Anclote River during 1976 was 1.2 m^3/s, compared with an annual mean 30-yr discharge of 2.2m^3/s (U.S. Geological Survey 1977). Largest discharges from the Anclote River occurred from May through October, with a maximum in June of 6.1m^3/s. Dissolved oxygen and pH were variable with season and tide. Dissolved oxygen concentrations, most affected by photosynthetic activity, exhibited early morning lows and mid-afternoon highs. Relatively constant pH values were noted, with river waters slightly lower than those in Anchorage. Salinity for the study area was high throughout the summer and during March, and lowest in December (Fig. 2). Seasonal and annual changes in rainfall, river discharge, and occurrence of storms added much variability to the system.

Stations in the Anclote River were most influenced by the runoff of fresh water. As river discharge increased salinity decreased greatly upriver at Station FS06, and to a lesser extent at stations farther downstream. Limited movement of this low salinity water through the power plant to the discharge area was detected. The decreased winter ("dry") season salinities in the Anchorage were caused by low evaporation rates and maximum subsurface discharge from the limestone aquifer.

Passage ot water through the plant, either through the condensers or as dilution water, had little effect on most physical and chemical features (Texas Instruments 1977a). Mean annual increase in temperature (intake to mouth of discharge canal) was 1.2 C. Maximum observed temperature increase never exceeded 4.5 C and no thermal multiplication was observed during this study. The shallowness of the Anchorage and the resulting high insolation made differentiation between naturally heated and thermal-plume influenced areas difficult.

Beach seining for juvenile and small fishes

Fifty-six fish species representing 30 families were seined during the January-December 1976 study period. Species occurring along the shore varied by station throughout the year (Table 1). Young-of-the-year spot (*Leiostomus xanthurus*) and tidewater silverside (*Menidia beryllina*) numerically dominated yearly beach seine collections, while silver jenny (*Eucinostomus gula*) and pinfish (*Lagodon rhomboides*) dominated total biomass collections (Table 2).

Species numbers were highest from June through October owing to migratory influx of juveniles and to a small degree to adventitious species (Fig. 3). The total number of species during this period was significantly ($p < 0.05$) greater than February, March, April, and December collections. Numbers of individuals generally followed the same

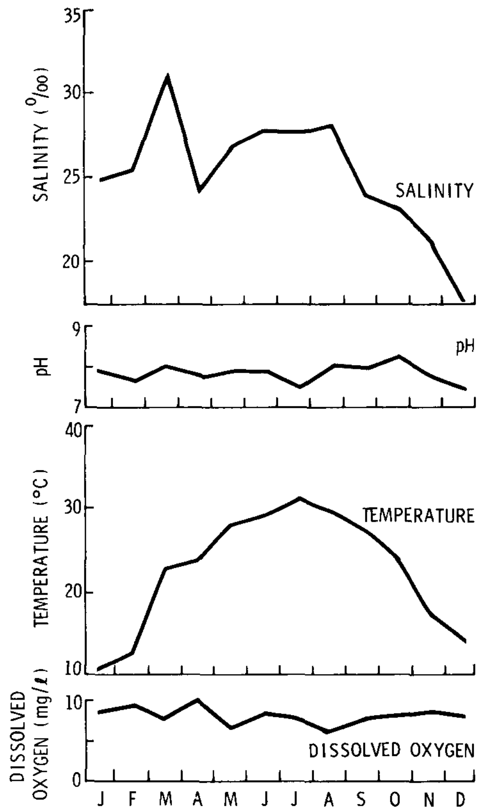


Fig. 2. Monthly means for salinity, temperature, dissolved oxygen and pH, Anclote site, 1976.

seasonal pattern as species numbers except for January and February, when total numbers of individuals were significantly ($p < 0.05$) greater than all months but June, July, and August.

Analysis of variance for beach seine sampling results indicated that mean total numbers differed significantly ($p < 0.05$) by month and by station, but a significant month-station interaction indicated that the pattern of differences among stations was not consistent from month to month. Results were similar for mean total weights, although the trends were not quite the same as for numerical abundance (Fig. 3).

Large catches of young-of-the-year fish such as spot and tidewater silverside, emphasized the nursery function of the shore zones. The schoolng nature of the young of these and many other fish species accounted for the monthly fluctuations at the stations, characterized by large single catches of individual species. During winter, beach seining generally produced higher catches and greater species diversity at Station FS03, a gently sloped, shallow grass area near the discharge canal (Fig. 3). Trends in species numbers and abundance at FS03 fluctuated greatly, probably in response to thermal discharge influence. Collections at FS03 during the summer were frequently lower than those at Station FS02 and other river stations, indicating that species avoided the thermal plume during this period.

Table 1. Fishes taken during seining, Anclote site, January-December 1976 (Numbers in columns correspond to station designations).

Scientific Name	Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dasyatis sabina	Atlantic stingray						4	2					
Harengula pensacolae	Scaled sardine						2					3	
Anchoa mitchilli	Bay anchovy		4,5		4		3,4	2,6	4		4		
Synodus foetens	Inshore lizardfish		6		2		4,5		4,5	2	2,3,4,5,6		
Arius felis	Sea catfish										2		
Hyporhamphus unifasciatus	Halfbeak				5	2	2,3,5				3	2	
Strongylura marina	Atlantic needlefish		3,4	2	2,3,4,5			2		2,3			
Strongylura notata	*Redfin needlefish*	3	2,3,4	3	3	2,3	2,3,4,5	2,3,4,5,6	2,3,4,5	2,3	2,3,4,5	2,3	2,3,4,5,6
Strongylura timucu	Timucu					2,3	2,3,4,5,6	2,3,4,5,6	2,3,4,5,6	2,3	3,4,5,6	2,3	2,3,4,5,6
Cyprinodontidae	Killifish				2								
Cyprinodon variegatus	Sheepshead minnow	2	3					6	3,4,6				4
Floridichthys carpio	Goldspotted killifish	2,3	2,3,4,5	2,3	3,5	2	2,3,4,5	2,3,4,5,6	2,3,4,5,6	2,3	3,5,6	2,3	2,3,4,6
Fundulus confluentus	Marsh killifish		2										
Fundulus grandis	Gulf killifish							6	3,4,5,6	3	5		
Fundulus similis	Longnose killifish	2	5	2	2,3		3,4,6	3,6	2,3,4,6	3	3,4,5	3	2,3,5
Lucania parva	Rainwater killifish	3	2,3	2,3	3,4	2	2,4,6	4	4,5		3		2
Poecilia latipinna	Sailfin molly							6					
Menidia beryllina	Tidewater silverside	2,3	2,3,4,5	3	2,3,4,5	2,3	2,3,4,5,6	3,6	2,4,5,6	3	3,5		2,5
Hippocampus zosterae	Dwarf seahorse	2											
Syngnathus floridae	Dusky pipefish						4,5	5					
Syngnathus louisianae	Chain pipefish				3								
Syngnathus scovelli	Gulf pipefish				3,4,5	2	2,4,5,6	2,4,5	2,4,5		3,4	2	
Centropomus undecimalis	Snook							2					
Caranx hippos	Crevalle jack							3			3		
Chloroscombrus chrysurus	Atlantic bumper									3			
Oligoplites saurus	Leatherjacket						3,5	2,3,5	3,4,6	2,3	3		
Trachinotus falcatus	Permit							2		3	2,3	2	
Lutjanus griseus	Gray snapper										3		

(Table 1. continued)

Scientific Name	Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gerreidae	Mojarras										3		
Diapterus plumieri	Striped mojarra						6	2,5					
Eucinostomus argenteus	Spotfin mojarra					2		2,3,5,6	2,3,4,5,6	2,3		2,3	3,4,5,6
Eucinostomus gula	Silver jenny	3	3,6	3	3,6	2,3	2,3,4,5,6	2,3,4,5	2,3,4,5,6	2,3	2,3,4,5,6	2,3	2,5
Orthopristis chrysoptera	Pigfish				5	2	2,4,5	2,4,5	2,5		3		
Archosargus probatocephalus	Sheepshead						3,4	2,4,6	4,5	3			
Lagodon rhomboides	Pinfish	2,3	2,3,4,5,6	2,3	2,3,4,5	2,3	2,3,4,5,6	2,3,4,5	2,4,5,6	2,3	3,4,5	2,3	2,3,5
Bairdiella chrysura	Silver perch						2,3,4,5	2,5	2,5		4		
Cynoscion spp.	Seatrouts	3											
Cynoscion nebulosus	Spotted seatrout						4,5	2	2,5		3		
Leiostomus xanthurus	Spot	2,3	2,3,4,5	2	3,5	2	2,3,4,5	3					
Menticirrhus littoralis	Gulf kingfish						6						
Micropogon undulatus	Atlantic croaker	3											
Sciaenops ocellata	Red drum		6										
Chaetodipterus faber	Atlantic spadefish							5					
Mugilidae	Mullets	3	3						3		3		3
Mugil cephalus	Striped mullet		3				3	6					
Mugil trichodon	Fantail mullet		3	3			3,6	3		3	3,5	3	
Astroscopus y-graecum	Southern stargazer												5
Chasmodes saburrae	Florida blenny							2					
Hypsoblennius hentzi	Feather blenny						2						
Gobiosoma robustum	Code goby				5								
Microgobius gulosus	Clown goby				3,4		2,6	6					
Prionotus scitulus	Leopard searobin										2		
Prionotus tribulus	Bighead searobin										2		
Paralichthys albigutta	Gulf flounder			2	5								
Achirus lineatus	Lined sole									2			
Trinectes maculatus	Hogchoker								6				
Symphurus plagiusa	Blackcheek tonguefish				5				4				
Monacanthus hispidus	Planehead filefish						3						
Sphoeroides nephelus	Southern puffer	3	5	3	2,3,4,5	2,3	2,3,4,5	2,3	2		2,3,4,5	2,3	3,4,5
Chilomycterus schoepfi	Striped burrfish									2	4		
	Total No. Species	14	18	12	21	13	29	33	23	18	28	13	13
	No. Samples	4	10	4	12	4	12	12	12	4	12	4	10

Table 2. Species composition of dominant fishes collected by beach seine at Anclote, 1976.

INTAKE STATION FS02
(Number samples = 24)

Numerical			Gravimetric		
Species	No.	%	Species	Wt (g)	%
Tidewater silverside	10208	43.6	Silver jenny	11296.0	31.6
Spot	5158	22.0	Pinfish	7196.5	20.2
Pinfish	3289	14.1	Redfin needlefish	4455.1	12.5
Silver jenny	2444	10.4	Spotfin mojarra	4009.8	11.2
Spotfin mojarra	1277	5.4	Tidewater silverside	1600.8	4.5
Goldspotted killifish	368	1.6	Goldspotted killifish	1279.9	3.6
Redfin neeldefish	280	1.2	Timucce	1278.4	3.6
Longnose killifish	78	0.3	Spot	824.0	2.3
Silver perch	55	0.2	Striped mojarra	354.6	1.0
Gulf pipefish	46	0.2	Longnose killifish	166.2	0.5
Other	194	0.8	Other	3234.8	9.0
Total	23397		Total	35696.1	

DISCHARGE STATION FS03
(Number samples = 36)

Numerical			Gravimetric		
Species	No.	%	Species	Wt (g)	%
Spot	18543	60.4	Tidewater silverside	6368.5	17.0
Tidewater silverside	4171	13.6	Silver jenny	5848.2	15.8
Mullet spp.	1976	6.4	Fantail mullet	5632.9	15.1
Silver jenny	1862	6.1	Pinfish	4024.9	10.8
Goldspotted killifish	1420	4.6	Redfin needlefish	3888.7	10.4
Pinfish	1022	3.3	Goldspotted killifish	2938.7	7.9
Faintail mullet	376	1.2	Spot	1964.8	5.2
Spotfin mojarra	365	1.2	Spotfin mojarra	1630.6	4.4
Redfin needlefish	263	0.8	Timucce	1277.3	3.4
Longnose killifish	189	0.6	Longnose killifish	873.5	2.3
Other	538	1.8	Other	2895.1	7.7
Total	30725		Total	37393.2	

RIVER STATIONS FS04-FS06
(Number samples = 36)

Numerical			Gravimetric		
Species	No.	%	Species	Wt (g)	%
Spot	10782	38.5	Pinfish	10918.0	26.6
Pinfish	4481	16.0	Silver jenny	9368.2	22.9
Silver jenny	4317	15.4	Tidewater silverside	4451.5	10.9
Tidewater silverside	3423	12.2	Spotfin mojarra	3578.4	8.7
Spotfin mojarra	1835	6.5	Timucce	2550.8	6.2
Goldspotted killifish	940	3.4	Goldspotted killifish	2117.4	5.2
Mojarra spp.	728	2.6	Spot	1281.8	3.1
Pigfish	262	0.9	Pigfish	853.0	2.1
Gulf pipefish	244	0.9	Redfin needlefish	809.7	2.0
*Red drum	156	0.6	Longnose killifish	705.7	1.7
Other	859	3.0	Other	4364.1	10.6
Total	28027		Total	40998.6	

*Taken only at Station FS06

Table 3. Fishes taken during trammel net and trawl sampling, Anclote site, 1976 (Numbers in columns represent station designations).

Scientific Name	Common Name	February Trawl	February Trammel	April Trawl	April Trammel	June Trawl	June Trammel	August Trawl	August Trammel	October Trawl	October Trammel	December Trawl	December Trammel
Carcharhinus leucas	Bull shark						9						10
Carcharhinus limbatus	Blacktip shark		8		9								
Mustelus canis	Smooth dogfish												8
Sphyrna tiburo	Bonnethead shark				8,9		8,9		8,9		8,9		
Rhinobatos lentiginosus	Atlantic guitarfish				8,9		8						
Dasyatis americana	Southern stingray		8		10		8,9,10		8,9				
Dasyatis sabina	Atlantic stingray		8,10		9,10		9	8,10	8,9,10		8,9	8	8
Dasyatis sayi	Bluntnose stingray								9				
Gymnura micrura	Smooth butterfly ray				8		8						8
Rhinoptera bonasus	Cownose ray		8								9		8
Lepisosteus spatula	Alligator gar		8								9		
Elops saurus	Ladyfish	10	10										
Brevoortia sp.	Menhaden		8										
Brevoortia smithi	Yellowfin menhaden										8		8
Synodus foetens	Inshore lizardfish			8,9						9			
Bagre marinus	Gafftopsail catfish				10		8				8,9		
Arius felis	Sea catfish		9		8,9	9	8	10		9	8,9		8,9
Opsanus beta	Gulf toadfish	8		9,10		8,9		8,9		8,9			
Urophycis floridanus	Southern hake	8,9		8								8	
Ophidion holbrooki	Bank cusk-eel											8	
Lucania parva	Rainwater killifish							9					
Hippocampus erectus	Lined seahorse			8									
Hippocampus zosterae	Dwarf seahorse			8		8							
Micrognathus crinigerus	Fringed pipefish	9		8									
Syngnathus floridae	Dusky pipefish	8,9		8,9		8,9				8		8,9	
Syngnathus louisianae	Chain pipefish											8,9	
Syngnathus scovelli	Gulf pipefish			8,9		8,9		9				8,9	
Centropristis melana	Southern sea bass	8											
Diplectrum formosum	Sand perch	8		8									
Epinephelus itajara	Jewfish					10							
Pomatomus saltatrix	Bluefish	10	10										

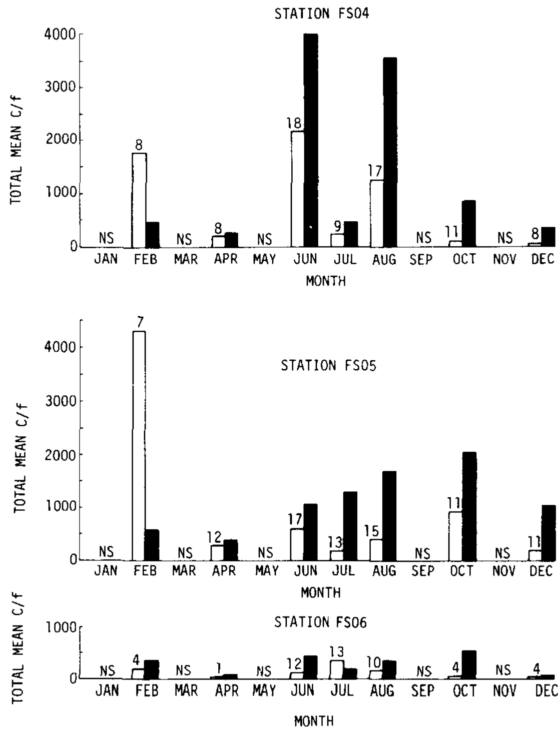
(Table 3. continued)

Scientific Name	Common Name	February Trawl	February Trammel	April Trawl	April Trammel	June Trawl	June Trammel	August Trawl	August Trammel	October Trawl	October Trammel	December Trawl	December Trammel
Caranx hippos	Crevalle jack		9										
Lutjanus griseus	Gray snapper							9					
Eucinostomus argenteus	Spotfin mojarra									9			
Eucinostomas gula	Silver jenny					8,9		8,9		8,9,10		8,9	
Haemulon plumieri	White grunt	8				9				8,9		8,9	
Orthopristis chrysoptera	Pigfish	8		8,9		8,9		8,9		8,9,10		8,9	
Archosargus probatocephalus	Sheepshead	10	10		10	9,10	10	9,10	10	8,9	9,10	9	10
Calamus arctifrons	Grass porgy					8				8			
Diplodus holbrooki	Spottail pinfish			8						9		8,9	
Lagodon rhomboides	Pinfish	8,9		8,9		8,9		8,9		8,9		8,9	
Sciaenidae	Drums			9									
Bairdiella chrysura	Silver perch	9		8,9		8,9		8,9,10		8,9		8,9	
Cynoscion nebulosus	Spotted seatrout		10			8,9		9	9	9			10
Leiostomus xanthurus	Spot					10				10			
Pogonias cromis	Black drum		10			10	10		10		9,10		10
Chaetodipterus faber	Atlantic spadefish	9,10	9,10		9	10	8,9,10		9,10	9	9,10		9,10
Lachnolaimus maximus	Hogfish					8,9		8					
Nicholsina usta	Emerald parrotfish	8		8									
Mugil cephalus	Striped mullet	10											
Sphyraena borealis	Northern sennet					8							
Hypsoblennius hentzi	Feather blenny			9									
Gobiosoma robustum	Code goby			9									
Scorpaena brasiliensis	Barbfish			8						8			
Prionotus scitulus	Leopard searobin	8											
Paralichthys albigutta	Gulf flounder	8	8	8,9	10		8	8,9,10		9	8,9,10		8,9
Anclyopsetta quadrocellata	Ocellated flounder		9							9			9
Trinectes maculatus	Hogchoker		9							9			
Monacanthus ciliatus	Fringed filefish	8		8		8,9				8		8,9	
Monacanthus hispidus	Planehead filefish	8		8		8,9		8		8,9		8,9	
Lactophrys quadricornis	Scrawled cowfish	8,9,10	8,9		8,10	8,9	9	8		8,9	9,10	9	
Sphoeroides nephelus	Southern puffer	9		8		9		9		8,9		8,9	
Chilomycterus schoepfi	Striped burrfish	8,9	8,9	8	8,9	8,9	8,9	8,9	9	8,9		8,9	
Total No. Species		23	17	23	13	24	14	18	9	24	12	18	13

Variations in species composition were least among the intake-canal station (FS02) and river stations FS04 and FS05 on either side of the intake canal. Spot, pinfish, tidewater silverside, silver jenny, spotfin mojarra (*Eucinostomus argenteus*), and goldspotted killifish (*Floridichthys carpio*) represented the more prominent species. Station FS06, located farther upriver, consistently produced lower catches and low species richness. The station's species composition was unique, being represented by such species as gulf kingfish (*Menticirrhus littoralis*) and red drum (*Sciaenops ocellata*) that were not taken at any of the other stations. Since only young spotfin mojarra and tidewater silverside were taken at Station FS06 in any quantity, it appears that the majority of young of the year do not travel much beyond the month of the Anclote River in search of nursery grounds.

Trammel netting and trawling at the seagrass beds and discharge canal

Sixty-one fish species representing 38 families were collected by trammel nets and bottom trawls during the 1976 study period. The occurrence of these species varied by station and method of collection (Table 3). Of the 61 species collected, only 13 were taken at all 3 stations, and only 12 were collected by both trammel net and bottom trawl. The species composition of the discharge canal (Station FT10) was quite different from stations FT08 and FT09 located at the seagrass beds.



NS = No Sample
NC = No Catch

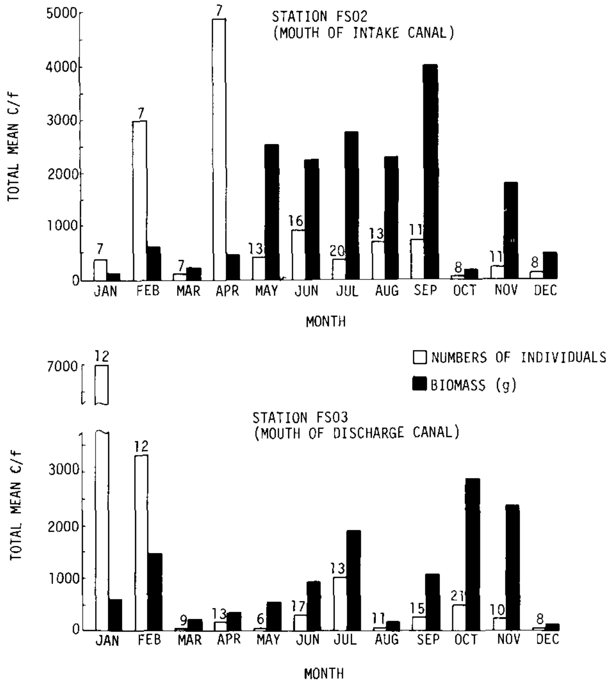


Fig. 3. Total mean catch per unit effort (C/f) for fish collected by beach seine, Anclote site, 1976 (Numbers above bars represent numbers of species).

Sheepshead (*Archosargus probatocephalus*) and spotted seatrout (*Cynoscion nebulosus*), rarely collected at the seagrass stations, dominaed trammel net collections in the discharge canal both by number and weight (Table 4). Trammel net collections at the seagrass beds were typically light; Atlantic spadefish (*Chaetodipterus faber*) and Atlantic stingray (*Dasytis sabina*) were collected in greatest numbers, while southern stingray (*D. americana*) and bonnethead shark (*Sphyra tiburo*) ranked highest by biomass (Table 4).

Pinfish overwhelmingly dominated trawl collections at the seagrass beds both by number and weight (Table 5). Trawling was most productive at the seagrass beds owing to the shelter seagrasses afforded species susceptible to this gear. Trawl collections in the discharge canal were low. The absence of vegetation and increased predator pressure in the discharge canal made this habitat unsuitable for juvenile and small fishes.

Interpretation of statistical analyses was complicated by differences in species inhabiting the discharge canal and seagrass beds, as previously discussed. Station differences compounded the problem as the nature of these differences varied with month, diel period, and tidal cycle. Typically, day-night differences existed; collections at night were significantly greater than day for species numbers and mean total number of individuals taken by trammel net and for mean total numbers and biomass taken by trawls.

Though the species composition and size of individuals collected by trammel net and trawl were considerably different, both gear revealed similar seasonal trends that were related to well-documented inshore (spring) and off-shore (winter) migrations of Gulf of Mexico fishes (Reid 1954; Springer and Woodburn 1960). The abundance of fishes inhabiting the seagrass beds was generally low during winter, increased nearly 3-fold during spring, decreased into the summer, and was highest in the fall (Figs. 4 and 5). Seasonal trends in species numbers revealed lows during winter and summer, as highest values were recorded during spring owing to the migratory influx of offshore overwintering species. Shifts in adventitious species, possibly in response to higher temperatures during August, were responsible for the drop in numbers of individuals and species during midsummer. The increased variety of species taken during fall was attributed to local shifts in resident species and an influx of adventitious species, probably in response to the warmer waters in the vicinity of the power plant. Abundance and number of species in the discharge canal remained low during all but the colder months.

Seagrass stations FT08 and FT09 generally exhibited comparable catches and species richness in all but the colder months. During October, the number of species taken in trammel net collections at Station FT09 was significantly greater than at Station FT08, as were trawl collections for total fish number and biomass. Station FT09 is located in a shallow grass area approximately 0.8 km from the discharge canal and is thereby influenced to a greater extent by the effluent. With the exception of discharge canal Station FT10, mean temperatures at Station FT09 were significantly higher than at all other stations. Station FT08, on the southeastern shore of Rabbit Key and just south of the Anclote River channel, is protected by the intervening deeper waters of the Anchorage, which help buffer the effects of thermal loading.

It is likely that increased water temperatures in the immediate vicinity of the power plant delayed offshore winter migrations of many species to deeper and warmer waters. Apparently the concentration or overwintering of fish in deeper water areas is not fixed, and fish may accept an increase in water temperature instead of depth (McErlean et al. 1973). As temperatures continued to drop with the approach of winter, however, fish sought deeper waters to avoid the temperature fluctuations characteristic of inshore shallow areas such as Station FT09. It was during this period that migrating fishes found their way into the discharge and intake canals, resulting in increased impingement rates (Texas Instruments 1977b) and significantly greater trammel net collections in the discharge.

Comparisons with preoperational data, though limited, revealed similar seasonal trends, with number of individuals and number of species declining during winter (Baird et al. 1974; Rolfes and Mayer 1975). However, noticeable decreases in summer abundance and species numbers as observed during 1976 were not observed during baseline surveys. In fact, Baird et al. (1974) reported that the maximum number of fish and species per unit effort was taken in trawls during August (summer).

Seasonal patterns of the present study closely resemble those reported by Grimes and Mountain (1971) at FPC's Crystal River power facility. These authors reported a seasonal alternation of diversity and abundance associated with the thermal effluent that was characterized by winter increases and summer decreases. Water quality data do not substantiate any significant increases in temperature or other profound parameter changes from those measured during preoperational Anclote surveys. Admittedly, seasonal patterns of fish distribution in the estuary may be incompletely defined owing to shortcomings in sampling frequency during present and past surveys. Thus, it could not be determined whether seasonal patterns observed during 1976 were short-term movements or redistribution of a more permanent nature.

In concluding, thermal discharges from the Anclote Power Plant had a very localized effect on the Gulf fishes of the Anchorage. Abundance and diversity were slightly altered during the colder months, and avoidance of the thermal plume during the hottest months

Table 4. Species composition of dominant fishes collected by trammel net at Anclote, 1976.

SEAGRASS BEDS
(Number samples = 48)

Numerical			Gravimetric		
Species	No.	%	Species	Wt (g)	%
Atlantic spadefish	36	18.5	Southern stingray	36945.6	21.1
Atlantic stingray	27	13.8	Bonnethead shark	33374.1	19.0
Bonnethead shark	23	11.8	Cownose ray	18088.8	10.3
Sea catfish	18	9.2	Atlantic stingray	12753.8	7.3
Striped burrfish	15	7.7	Bluntnose stingray	11360.0	6.5
Southern stingray	11	5.6	Smooth butterfly ray	9070.0	5.2
Gulf flounder	10	5.1	Sea catfish	8566.7	4.9
Menhaden	9	4.6	Smooth dogfish	7498.4	4.3
Scrawled cowfish	9	4.6	Alligator gar	6702.4	3.8
Atlantic guitarfish	6	3.1	Atlantic spadefish	6378.2	3.6
Other	31	16.0	Other	24509.5	14.0
Total	195		Total	175247.5	

DISCHARGE CANAL
(Number samples = 24)

Numerical			Gravimetric		
Species	No.	%	Species	Wt (g)	%
Sheepshead	78	50.0	Spotted seatrout	46604.9	41.4
Spotted seatrout	37	23.7	Sheepshead	29839.0	26.5
Atlantic spadefish	13	8.3	Southern stingray	15989.4	14.2
Black drum	8	5.2	Black drum	4311.0	3.8
Atlantic stingray	7	4.5	Atlantic spadefish	4150.6	3.7
Scrawled cowfish	4	2.6	Atlantic stingray	3569.3	3.2
Southern stingray	3	1.9	Bull shark	3558.8	3.2
Gulf flounder	2	1.3	Scrawled cowfish	1192.8	1.0
Bull shark	1	0.6	Gulf flounder	1022.4	0.9
Bluefish	1	0.6	Bluefish	1008.6	0.9
Other	2	1.3	Other	1409.4	1.2
Total	156		Total	112674.6	

of summer was evident. Since fish are mobile and can generally avoid unfavorable conditions, the possibility of fish kills is low in all but the coldest months, when entrapment in the thermal plume combined with sudden drops in temperature could pose problems. Since the estuary in the vicinity of the Anclote Power Plant is an open system, the abundance of fishes in the area is influenced by the migration of individuals into and out of the estuary. Consequently, any available habitat temporarily vacated because of transient man-induced effects at Anclote could be filled by migrant individuals from adjacent areas.

Table 5. Species composition of dominant fishes collected by trawl at Anclote, 1976.

SEAGRASS BEDS
(Number samples = 48)

Numerical			Gravimetric		
Species	No.	%	Species	Wt (g)	%
Pinfish	3533	75.4	Pinfish	38230.9	58.2
Silver perch	409	8.7	Striped burrfish	7273.6	11.1
Pigfish	306	6.5	Pigfish	5525.6	8.4
Striped burrfish	72	1.5	Silver perch	3166.3	4.8
Silver jenny	55	1.1	Scrawled cowfish	2668.2	4.1
Gulf toadfish	36	0.8	Gulf toadfish	1766.0	2.7
Dusky pipefish	32	0.7	Atlantic stingray	1470.2	2.2
Gulf pipefish	25	0.5	Southern puffer	1098.1	1.7
Scrawled cowfish	24	0.5	Gulf flounder	641.2	1.0
Fringed filefish	21	0.4	Sea catfish	446.8	0.7
Other	169	3.7	Other	3379.1	5.1
Total	4682		Total	65666.0	

DISCHARGE CANAL
(Number samples = 24)

Numerical			Gravimetric		
Species	No.	%	Species	Wt (g)	%
Sheepshead	12	30.8	Ladyfish	4537.2	30.0
Southern hake	6	15.4	Sheepshead	3259.1	21.5
Atlantic spadefish	3	7.7	Jewfish	1760.8	11.6
Silver jenny	2	5.1	Atlantic spadefish	1412.2	9.3
Ladyfish	2	5.1	Bluefish	1400.0	9.2
Bluefish	2	5.1	Striped mullet	656.1	4.3
Spot	2	5.1	Black drum	482.8	3.2
Black drum	1	2.6	Spot	470.1	3.1
Striped mullet	1	2.6	Atlantic stingray	312.4	2.1
Jewfish	1	2.6	Scrawled cowfish	282.5	1.9
Other	7	17.9	Other	558.1	3.8
Total	39		Total	15131.3	

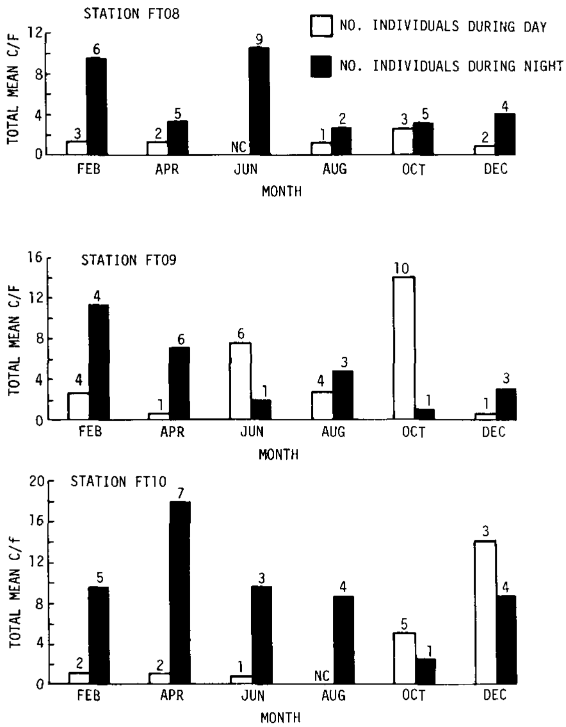


Fig. 4. Total mean catch per unit effort (C/f) for fish collected by trammel net, Anclote site, 1976 (Numbers above bars represent numbers of species).

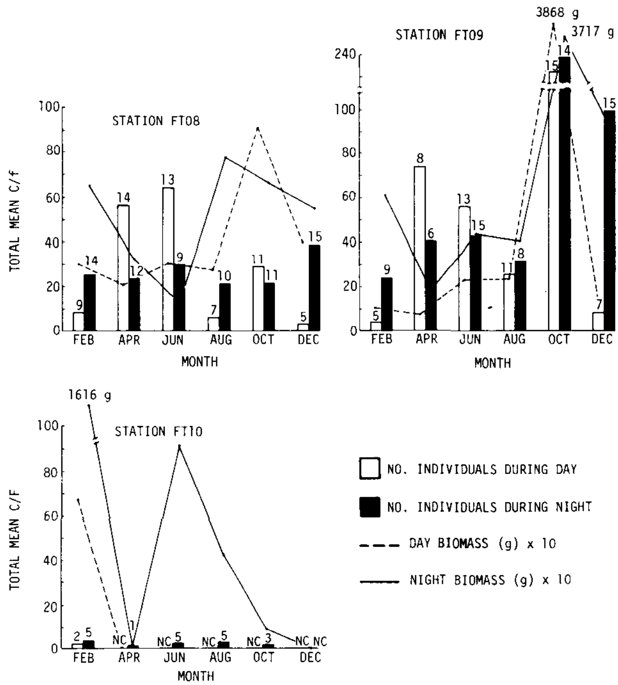


Fig. 5. Total mean catch per unit effort (C/f) for fish collected by trawl, Anclote site, 1976 (Numbers above bars represent numbers of species).

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