Tampa Bay National Estuary Program
Technical Publication #04-92

OLIGOHALINE AREAS IN TAMPA BAY TRIBUTARIES: SPATIAL EXTENT AND SPECIES LISTS

FINAL REPORT

May 1992

OLIGOHALINE AREAS IN TAMPA BAY TRIBUTARIES:

SPATIAL EXTENT AND SPECIES LISTS

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FOREWORD

This report dated May 1992 and titled "Oligohaline Areas in Tampa Bay Tributaries: Spatial Extent and Species Lists" was prepared by Coastal Environmental Services, Inc. for the Tampa Bay National Estuary Program, as part of the Synthesis of Historical Biological Data project. All work was prepared under a contract entered into on 16 September 1991 by and between Tampa Bay Regional Planning Council on behalf of Tampa Bay National Estuary Program and Coastal Environmental Services, Inc. The final products of the project reflect adjustments to the original scope of work that were required by the availability of data and time and effort considerations. These adjustments have been made in consultation with the Tampa Bay National Estuary Program, and are described in a detailed work plan submitted on 21 September 1991, and in a revision to the work plan submitted on 17 January 1992.

This is Technical Publication #04-92 of the Tampa Bay National Estuary Program.

ACKNOWLEDGEMENTS

This project has benefitted from the work of many people. Dick Eckenrod and Holly Greening of the Tampa Bay National Estuary Program provided excellent advice, guidance, and assistance throughout the project. Roger Johansson of the City of Tampa Sewers Dept., Andy Squires of King Engineering Associates, Mark Simpson of Manatee County Public Works, and Richard Chinn of the West Coast Regional Water Supply Authority were very helpful in providing data and reports for water quality data. Thomas Lo of the Southwest Florida Water Management District provided the shoreline and hydrographic data we used in generating Geographic Information System (GIS) maps. This report was written by Sara Cairns of Coastal, based on work performed by the author and Bob Berardo, Peggy Derrick, Doug Heimbuch, Tony Janicki, Susan Janicki, John Seibel, and Dave Wade. Special thanks to those whose contributions went above and beyond the call of duty.

ABSTRACT

Three reports have been generated as products of the Synthesis of Historical Biological Data project of the Tampa Bay National Estuary Program (TBNEP): "Distribution of Selected Fish Species in Tampa Bay", "Database of Benthic Sampling Locations in Tampa Bay", and the current report, "Oligohaline Areas in Tampa Bay Tributaries: Spatial Extent and Species Lists". A summary of the spatial extent of oligohaline (low salinity) habitats in Tampa Bay tributaries was planned as part of the Synthesis of Historical Biological Data project. Three salinity zones were identified for each of the four major freshwater tributaries to Tampa Bay: the Hillsborough River, Alafia River, Little Manatee River, and Manatee River. Salinity zones were defined as areas where salinity was never less than 10 ppt, sometimes less than 10 ppt, or always less than 10 ppt. Maps of salinity zones, including shoreline and aquatic vegetation, were prepared and submitted to TBNEP. In addition, lists were prepared of plant, benthic, and fish species collected by field studies within each salinity zone.

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INTRODUCTION

Low-salinity (oligohaline) areas are believed to play a critical role in estuarine ecology, providing habitat for mangroves and possibly serving as nursery areas for a variety of fish species (e.g. Edwards 1991). Oligohaline areas provide important foraging areas for wading birds and other animals, especially when vegetated (Wolfe and Drew, 1990). During the Framework for Characterization workshops held by the Tampa Bay National Estuary Program (TBNEP) in June and July of 1991, the location and extent of oligohaline segments in the Tampa Bay tributaries was identified as one of the three priority areas for further study. Information on oligohaline habitats will be needed by resource managers to assess possible impacts of changes in freshwater flow. The other two priority areas identified by the Framework for Characterization workshops and included in the TBNEP's Synthesis of Historical Biological Data project were fish species distribution and trends (Coastal 1992a) and benthic communities in the Bay (Coastal 1992b).

The scope of work for the TBNEP's Synthesis of Historical Biological Data project called for the preparation of maps of oligohaline (defined as 10-2 ppt salinity) segments of Tampa Bay tributaries. For each identified oligohaline habitat, lists of the plant and aquatic animal species associated with the area were also to be prepared. The choice of a 10 ppt upper bound on the salinity range was based in part on a study of critical nursery habitats for fish, conducted in the Manatee River (Edwards 1990). The limited range of relatively low salinities over which juveniles of several commercially and recreationally important species were collected, relative to the wide range of values occurring within the river, indicates that as juveniles these fish require access to low-salinity habitat.

METHODS

Delineation of Salinity Zones

Coastal identified studies that have collected water quality data within each of the four major tributaries to Tampa Bay: the Hillsborough River, the Alafia River, the Little Manatee River, and the Manatee River (Table 1). Other, smaller tributaries may have oligohaline zones that play a similar ecological role to those in the major rivers. These locations may even be critical to certain species due to such factors as local water quality or the type of local vegetation. In terms of total habitat (surface area), however, the four major tributaries will account for the majority of the oligohaline habitat in Tampa Bay. For this reason, and due to a scarcity of data for the smaller tributaries, Coastal chose to examine only the four largest tributaries.

The Hillsborough County Environmental Protection Commission (HC EPC) has routinely monitored surface water quality in the Tampa Bay estuary since 1972. Coastal received computer files containing water quality data from the HC EPC (via King Engineering Associates) for the years 1986-1990. We identified stations located in the tributaries based on latitude and longitude, and confirmed their locations using maps in the 1988-1989 Surface Water Quality report (Boler 1990).

The West Coast Regional Water Supply Authority (WCRWSA) sponsored a study that collected water quality data in the lower Hillsborough River and Tampa Bypass Canal in 1991 (WAR 1991). Salinity and/or conductivity were measured at nine stations in the Hillsborough River, one in the Tampa Bypass Canal, and one in the Palm River. Richard Chinn of the WCRWSA supplied Coastal with preliminary data from this study from October and November 1991.

A project sponsored jointly by the U.S. Geological Society (USGS) and the Southwest Florida Water Management District (SWFWMD) collected water quality data in the lower Alafia River between April 1978 and September 1979 (Giovanelli 1981). Conductivity was measured monthly for a variety of tidal and stream flow conditions at 17 stations in the Alafia River (and 10 in nearby Bullfrog Creek).

Andy Squires of King Engineering supplied Coastal with water chemistry data collected by SWFWMD in the Little Manatee River estuary. Water chemistry stations were sampled between January 1988 and January 1990 at variable sampling locations. Additional data from as early as March 1985 came from fixed-site stations.

The Fisheries-Independent Monitoring Program operated by the Florida Marine Research Institute (FMRI) measured salinity at four fixed stations and a variable number of randomly selected sites in the Little Manatee River (FMRI 1990). Salinity was also collected at randomly chosen sites and two fixed stations in the Manatee River. Dr. Robert McMichael of the FMRI provided Coastal with computer files containing data for individual samples from 1988 to 1991.

Manatee County Utilities Department conducted a 22-month study of the Manatee River from February 1982 to December 1983 to identify factors controlling the salt profile of the river (Camp Dresser & McKee 1984). Weekly water quality sampling including conductivity measurements was conducted at 16 to 32 stations during the course of the study.

We used data from these six studies to delineate salinity zones in each tributary. We operationally defined oligohaline zones as having an upper limit of 10 ppt salinity. In each river, we then identified segments where salinity was never, sometimes, or always below a level of 10 ppt. Our approach was to plot observed salinity values against river mile (station location in the river), to obtain a summary

of the range of observed salinity values at each sampling site. We then drew a line across the river at each point where the observed salinity met our three classification criteria (never, sometimes, or always below 10 ppt). An illustration of our approach to delineating salinity zones is provided in Figure 1.

GIS Maps of Salinity Zones and Associated Veaetation

We identified three salinity zones on each river, as described in the previous section. The demarcation line between each zone was drawn on GIS maps generated from the SWFWMD's ARC/INFO hydrographic coverage for Tampa Bay (at a scale of 1:100,000), and each zone was then digitized into a GIS coverage. We also digitized the shoreline and riverine vegetation zones from National Wetlands Inventory (NWI) maps into an ARC/INFO coverage. (The aerial photography dates for the NWI maps were 1972-1973, except for one quad on the Hillsborough River with a date of 1984.) By combining the salinity and vegetatinn coverages we generated a GIS map depicting the extent of salinity zones and the location and type of associated vegetation in each of the four major Tampa Bay tributaries. These maps were submitted to TBNEP as one of the products of this project. Small-scale versions of the maps, showing the salinity zones but not the vegetation coverages, are provided in Figures 2-6.

For the Little Manatee River we prepared two maps of salinity zones (Figures 4 and 5). Data from two different studies were used for each of the four tributaries, but for the Little Manatee the results from the two studies placed the salinity zone boundaries in different locations in the river. One data source (the Fisheries-Independent Monitoring Program) was conducted seasonally, in spring and fall, rather than year-round. Seasonal differences in freshwater flow will affect the location of salinity zone boundaries. The Fisheries-Independent data were also used for the Manatee River, but in that case the bulk of the data came a 22-month Manatee County study with weekly sampling (Camp Dresser & McKee 1984).

Zones in which salinity was never observed to be less than 10 ppt are the portion of the river downriver of the oligohaline zone. Any significant changes in freshwater flow will tend to shift this zone either up- or down-river, depending on whether the flow decreases or increases. Such shifts could have major effects on existing vegetation, especially for plant species such as mangrove and submerged aquatic plants that cannot quickly shift their distribution. The combined map of salinity zones and vegetated habitat can be used to identify areas where changes in freshwater flow are particularly likely to have a major impact on oligohaline vegetation.

Species Lists for Salinity Zones

The importance of oligohaline zones to estuarine ecology is strongly suspected, but much remains to be discovered regarding what species rely on these areas at what times in their life cycles. Having identified the spatial extent of different salinity regimes in the Tampa Bay tributaries, Coastal then prepared lists of species that have actually been collected within each zone.

The potential number of studies that could be used to compile species lists is large, but time and budget constraints required that the lists be representative rather than comprehensive. For three major taxonomic groups (vegetation, benthos, and fish) we prepared lists of species collected in each salinity zone for at least one of the major tributaries. The lists are based on presence/absence, and do not reflect relative or absolute abundance.

For vegetation, we used a botanical survey conducted along the Little Manatee River between February 1982 and May 83 (Fernandez 1985). The locations where species were found are classified by salinity zone in Table 2. For benthos, we used a study from the Manatee River, which sampled 20 stations throughout the freshwater to saline gradient. Data were collected in October 1982 (Culter and Mahadevan 1982). Those species collected from stations located in each of the three salinity zones are listed in Table 3. For fish, we used the Fisheries-Independent Monitoring Program data from 1988 - 1991. Extensive sampling was conducted in the lower reaches of the Alafia, Little Manatee, and Manatee rivers (FMRI 1990). Species presence and absence is summarized by salinity zone for the Alafia, Little Manatee, and Manatee rivers in Table 4.

RESULTS

The GIS maps indicate that the Hillsborough River below the Tampa Reservoir Dam is primarily low-saline (sometimes or always < 10 ppt) but has little or no riverside vegetation. The low-salinity zones in the Alafia River are similarly sparse in vegetation, except for the upper freshwater reaches. In contrast, both the Little Manatee and Manatee rivers have extensive areas of emergent estuarine vegetation along the banks in the lower salinity zones.

Relatively few plant species found along the Little Manatee River are adapted to a high-saline environment: only 4 out of 32 species (black mangrove, white buttonwood, white mangrove, and red mangrove) were found in the "Never < 10 ppt" zone (Table 2). The majority (26 species) were found within the "Always < 10 ppt" zone, and 17 species did not occur outside of that zone.

Benthic invertebrates collected in the Manatee River were typically associated with only one of the salinity zones (Table 3). Out of 87 genera collected, 55 were found exclusively in one type of zone: 12 in "Never < 10 ppt", 28 in "Sometimes < 10 ppt", and 15 in "Always < 10 ppt". Only one genus was found in all three salinity zones.

The Fisheries-Independent Monitoring Program collected 74 different fish species from the Alafia River between 1988 and 1991, not including catches identified only to genus (Table 4). Of these, 43% were collected in a low-salinity zone ("Sometimes < 10 ppt"). A total of 95 species were collected in the Little Manatee River, 76% occurring in low-salinity zones. (The Little Manatee River was the only river where fish sampling occurred within a zone where salinity was "Always < 10 ppt". Only 2 of the 95 species were collected exclusively in this zone, however.) A total of 90 species were collected in the Manatee River, 69% in a low-salinity zone.

These results indicate that a majority of species collected in the tributaries utilize low-salinity habitats. Relatively few species were collected exclusively in low-salinity zones: 3 species in the Manatee River and 14 species in the Little Manatee River were never collected in the "Never < 10 ppt" zone. These data do not distinguish, however, between juvenile and older fish. In an extensive study in the Manatee River juvenile snook were always collected in water under 11 ppt salinity, and 95% were collected at less than 7 ppt (Edwards 1991).

SUMMARY

Coastal prepared maps of salinity zones for the four major tributaries to Tampa Bay. We identified those areas in the Hillsborough River, Alafia River, Little Manatee River, and Manatee River where salinity readings were always < 10 ppt, sometimes < 10 ppt, or never < 10 ppt. The locations of these zones, and the riverside vegetation associated with each zone, were summarized in the form of GIS maps submitted to the TBNEP. We also prepared lists of plant, benthic, and fish species collected by field studies within the different salinity zones in the Alafia, Little Manatee, and Manatee rivers. Low-salinity habitats support a diversity of species within each of these major tributaries.

Table 1. Data sources used in developing maps of salinity zones in four tributaries to Tampa Bay.

Hillsborough River Tampa Bypass Canal and Hillsborough River Biological Monitoring and Assessment Program (WCRWSA), October - November 1991 Surface Water Quality Monitoring Program (HC EPC), 1986 - 1990
Alafia River Surface Water Quality Monitoring Program (HC EPC), 1986 - 1990 Alafia River and Bullfrog Creek Freshwater Flow Study (USGS and SWFWMD), April 1978 - September 1979
Little Manatee River (2 maps) A. Little Manatee River Study (SWFWMD), January 1988 - January 1990. B. Fisheries Independent Monitoring Program (FL DNR-MRI), 1988-1991
Manatee River Fisheries Independent Monitoring Program (FL DNR-MRI), 1988-1991 Study of Downstream Effects of Withdrawals from the Lake Manatee Reservoir (SWFWMD), February 1982 - December 1983

Table 2. Riverside vegetation found in a botanical survey of the Little Manatee River. Presence (1) or absence (0), in zones with salinity never < 10 ppt (N), sometimes < 10 ppt (S), or always < 10 ppt (A). Source: Fernandez (1985).

Scientific Name	Common name	N	S	A
Acer rubrum	Southern red maple	0	0	1
Avicennia gerrnenans	Black mangrove	1	1	0
Baccharis halirnifolia	Saltbush	0	0	1
Casuarina equisetifolia	Australian pine	0	1	0
Cladiurn jarnaicensis	Sawgrass	0	0	1
Conocorpus erecta	White buttonwood	1	1	0
Distichilis spicata	Saltgrass	0	1	1
Epidindrurn conopseurn	Butterfly orchid	0	0	1
Fraxirnus coroliniana	Water ash	0	0	1
Juncus roernerianus	Blackrush	0	1	1
Juniperus silicicola	Red cedar	0	0	1
Laguncularia racernosa	White mangrove	1	1	0
Ludwigia peruviana	Primrose willow	0	0	1
Myrica cerifera	Wax murtle	0	1	1
Nupbar luteurn	Spatterdock	0	0	1
Osrnunda regalis	Royal fern	0	0	1
Phragmites cornmunis	Reed	0	0	1
Phlebodium aureurn	Golden polypody	0	0	1
Pinus clausa	Sand pine	0	1	0
Pinus elliotii	Slash pine	0	0	1
Quercus sp.	Oak	0	0	1
Rhizophora mangle	Red mangrove	1	1	0
Rhynchelytrurn repens	Natal grass	0	0	1
Sabal palmetto	Cabbage palm	0	1	1
Schinus terebinthifolius	Florida holly	0	1	1
Serenoa repens	Saw palmetto	0	1	1
Spartina alterniflora	Smooth cordgrass	0	1	1
Spartina patens	Slender cordgrass	0	1	1
Taxodiurn distichurn	Bald cypress	0	0	1
Thelypteris sp.	Thelypteris fern	0	0	1
Typha dorningensis	Cattail	0	1	1
Typha latifolia	Cattail	0	0	1

Table 3. Benthic invertebrates and bycatch from samples collected in three salinity zones in the Manatee River. Presence (1) or absence (0) in zones with salinity never < 10 ppt, sometimes < 10 ppt, or always < 10 ppt. Source: Culter and Mahadevan (1982).

Phylum Class	Scientific Name	Never	Sometimes	Always
Cnidaria				
Hydrozoa	*Hydra* sp.	0	1	0
Platyhelminthes				
Turbellaria	*Stylochus* sp.	0	1	0
Nemertinea	Unidentified species	0	1	1
Nematoda	Unidentified species	1	1	0
Annelida				
Polychaeta	Ampharetidae (1 species)	0	1	0
	Amphioteis gunneri	0	1	0
	Brania wellfleetensis	0	1	0
	Laeonereis culveri	0	1	0
	Neanthes acuminata	0	1	0
	Parahesione luteola	0	1	0
	Pectinaria gouldii	0	1	0
	Pseudopolydora sp.	0	1	0
	Sphaerosyllis brevifrons	0	1	0
	Travisia hobsonae	0	1	0
	Ehlersileanira incisa	1	0	0
	Fabriciola sabella	1	0	0
	Goniadides carolinae	1	0	0
	Minuspio cirrifera	1	0	0
	Sphaerosyllis taylori	1	0	0
	Brania sp.	1	1	0
	Cirrophorus americanus	1	1	0
	Exogone lourei	1	1	0
	Glycinde nordmanni	1	1	0
	Mediomastus ambiseta	1	1	0
	Parapionosyllis longicirrata	1	1	0
	Paraprionospio pinnata	1	1	0
	Streblospio benedicti	1	1	0
	Streptosyllis pettiboneae	1	1	0
	Tharyx annulosus	1	1	0

Table 3 (continued). Benthic invertebrates and bycatch from samples collected in three salinity zones in the Manatee River. Presence (1) or absence (0) in zones with salinity never < 10 ppt, sometimes < 10 ppt, or always < 10 ppt. Source: Culter and Mahadevan (1982).

Phylum Class	Scientific Name	Never	Sometimes	Always
Annelida (cont.)				
Oligochaeta	*Dero trifida*	0	0	1
	Dero flabellinger	0	0	1
	Limnodrilus hoffmeisteri	0	0	1
	Pristima longiseta	0	0	1
	Tubificidae (w/ capillary)	0	0	1
	Aulodrilus piqueti	0	1	1
	Pelescoles benedeni	1	0	0
	Lumbricillus codensis	1	1	0
	Smithsondrilus rnarinus	1	1	0
	Tubificidae (no capillary)	1	1	1
Mollusca				
Gastropoda	Viviparidae (juv.)	0	1	0
	Acetocina canaliculata	1	0	0
	Eulirnastorna cf. *weberi*	1	0	0
Bivalvia	*Pisidiurn puncteriferurn*	0	0	1
	Amygdalum papyrium	0	1	0
	Musculus sp.	0	1	0
	Tellina spp.	0	1	0
	Tellina texana	0	1	0
	Corbicula rnaxiliensis	0	1	1
	Mulinia lateralis	1	1	0
Arthropoda				
Arachnida	*Lirnnochares* sp.	0	0	1
Crustacea				
(Ostracoda)	*Podocepida* spp.	0	0	1
	Sarsiella spp.	0	1	0
(Malacostraca)	*Aegathora oculata*	0	0	1
	Alrnyracurna sp.	0	0	1
	Acanthohaustorius rnillsi	0	1	0
	Callianassa sp.	0	1	0
	Corophium louisianurn	0	1	0
	Leptognathia sp.	0	1	0
	Leucothoe sp.	0	1	0

Table 3 (continued). Benthic invertebrates and bycatch from samples collected in three salinity zones in the Manatee River. Presence (1) or absence (0) in zones with salinity never < 10 ppt, sometimes < 10 ppt, or always < 10 ppt. Source: Culter and Mahadevan (1982).

Phylum Class	Scientific Name	Never	Sometimes	Alwavs
Arthropoda (cont.)				
(Malacostraca)	*Oxyurostylis smithi*	0	1	0
	Xenanthura brevitelson	0	1	0
	Cyathura polita	0	1	1
	Edotea montosa	0	1	1
	Grandidierella bonnieroides	0	1	1
	Cyclaspis sp.	1	0	0
	Listriella barnardi	1	0	0
	Platyischnopus sp.	1	0	0
	Trichophoxus sp.	1	0	0
	Acuminodeutopus naglei	1	1	0
	Ampelisca abdita	1	1	0
	Cyclaspis varians	1	1	0
	Leucon acutirostris	1	1	0
	Munna renoldsi	1	1	0
	Mysidopsis bahia	1	1	1
Insecta				
	Coelotanypedini (1 species)	0	0	1
	Coelotanypus sp.	0	0	1
	Dubiraphia sp.	0	0	1
	Lepidoptera *(1* species)	0	0	1
	Marnischia sp.	0	0	1
	Palpomyia tibialis	0	0	1
	Palpomyia sp .	0	0	1
	Stempellina sp.	0	0	1
	Tanytarsus sp.	0	0	1
	/so tomurus palustris	0	1	0
	Micropsecta sp.	0	1	0
	Procladius sp.	0	1	0
	Chironominae (pupae)	0	1	1
	Cladotanytarsus sp.	0	1	1
	Clinotanypus sp.	0	1	1
	Cryptochiromus sp.	0	1	1
	Polypedilum sp.	0	1	1
	Stictechironornus sp.	0	1	1
	Pyralididae *sp.*	1	0	0

Table 4. Fish and bycatch from samples collected in three salinity zones in the Alafia, Little Manatee, and Manatee rivers. Presence (1) or absence (·), in zones with salinity never < 10 ppt (N), sometimes < 10 ppt (S), or always < 10 ppt (A). NODC codes used to sort the table taxonomically. Source of data: Fisheries-Independent Monitoring Program data from 1988 - 1991 (FMRI 1990).

		Alafia		Little Manatee			Manatee	
Scientific name	Common name	N	S	N	S	A	N	S
Penaeidae		1	1	1	1	.	1	1
Penaeus spp.	COMMERCIAL SHRIMP	1	.	1	.	.	1	.
Menippe spp.		1	.	.	.	.	1	.
Menippe mercenaria		1	.	.	.	.	.	.
Callinectes sapidus us	BLUE CRAB UNSEXED	1	1	1	1	.	1	1
Callinectes sapidus m	BLUE CRAB MALE	1	1	1	1	1	1	1
Callinectes sapidus f	BLUE CRAB FEMALE	1	1	1	1	1	1	1
Callinectes sapidus lt	BLUE CRAB PARASIT.	1	.	.	.	.	1	1
Sphyrna tiburo	BONNETHEAD	.	.	.	.	.	1	.
Rhinobatos lentiginosus		.	.	.	.	.	1	.
Dasyatis americana	SOUTHERN STINGRAY	.	.	1	1	.	1	.
Dasyatis sabina	ATLANTIC STINGRAY	1	.	1	1	.	1	1
Dasyatis sayi	BLUNTNOSE STINGRAY	1	.	.	.	.	1	.
Gymnura micrura	SMOOTH BUTTERFLY RAY	1	.	.	.	.	1	.
Rhinoptera bonasus	COWNOSE RAY	1	1	.	.	.	1	1
Lepisosteus spp.		.	.	1	1	1	.	1
Lepisosteus osseus	LONGNOSE GAR	1	.	1	1	.	1	1
Lepisosteus spatula	ALLIGATOR GAR	.	.	.	1	.	.	.
Lepisosteus platyrhincus	FLORIDA GAR	.	.	1	1	.	.	.
Elops saurus	LADYFISH	1	.	1	1	.	1	1
Megalops atlanticus	TARPON	1	.	1	.	1	.	.
Anguilla rostrata	AMERICAN EEL	.	.	.	1	.	.	.
Myrophis punctatus	SPECKLED WORM EEL	1	.	.	.	.	1	.

Table 4 (continued). Fish and bycatch from samples collected in three salinity zones in the Alafia, Little Manatee, and Manatee rivers. Presence (1) or absence (·), in zones with salinity never < 10 ppt (N), sometimes < 10 ppt (S), or always < 10 ppt (A). Source: Fisheries-Independent Monitoring Program data from 1988 - 1991 (FMRI 1990).

		Alafia		Little Manatee			Manatee	
Scientific name	Common name	N	S	N	S	A	N	S
Brevoortia spp.		1	1	1	1	·	1	1
Brevoortia patronus	GULF MENHADEN	1	·	1	1	·	·	1
Brevoortia smithi	YELLOWFIN MENHADEN	1	·	1	1	·	1	1
Dorosoma		1	·	·	·	·	·	·
Dorosoma cepedianum	GIZZARD SHAD	·	·	·	1	·	·	·
Dorosoma petenense	THREADFIN SHAD	1	·	·	1	·	·	·
Opisthonema oglinum	ATLANTIC THREAD HERR	1	·	1	1	·	1	·
Harengula jaguana	SCALED SARDINE	1	1	1	·	·	1	1
Anchoa spp.		1	·	1	1	·	1	1
Anchoa hepsetus	STRIPED ANCHOVY	1	1	1	1	·	1	1
Anchoa mitchilli	BAY ANCHOVY	1	1	1	1	1	1	1
Synodus foetens	INSHORE LIZARDFISH	1	·	1	·	·	1	1
Cyprinus		·	·	·	1	·	·	·
Notemigonus crysoleucas	GOLDEN SHINER	·	·	·	1	·	·	·
Ictaluridae		·	·	·	1	1	·	·
Ictalurus spp.		·	·	·	1	·	·	·
Ictalurus catus	WHITE CATFISH	·	·	1	1	·	·	·
Ictalurus natalis	YELLOW BULLHEAD	·	·	·	1	·	·	·
Ictalurus punctatus	CHANNEL CATFISH	·	·	1	1	·	·	·
Bagre marinus	GAFFTOPSAIL CATFISH	1	·	1	1	·	1	1
Arius felis	HARDHEAD CATFISH	1	1	1	1	1	1	1
Opsanus beta	GULF TOADFISH	1	·	·	·	·	1	·
Gobiesox strumosus	SKILLETFISH	1	1	·	·	·	1	·

Table 4 (continued). Fish and bycatch from samples collected in three salinity zones in the Alafia, Little Manatee, and Manatee rivers. Presence (1) or absence (·), in zones with salinity never < 10 ppt (N), sometimes < 10 ppt (S), or always < 10 ppt (A). Source: Fisheries-Independent Monitoring Program data from 1988 - 1991 (FMRI 1990).

		Alafia		Little Manatee			Manatee	
Scientific name	Common name	N	S	N	S	A	N	S
Urophycis floridana	SOUTHERN HAKE	·	·	·	·	·	1	1
Strongylura spp.		1	1	1	·	·	1	1
Strongylura marina	ATLANTIC NEEDLEFISH	1	·	·	·	·	1	·
Strongylura notata	REDFIN NEEDLEFISH	1	·	1	1	·	1	1
Strongylura timucu	TIMUCU	1	·	1	1	·	1	1
Cyprinodon variegatus	SHEEPSHEAD MINNOW	1	·	1	1	·	1	1
Fundulus spp.	ASSORTED KILLIFISH	1	1	1	1	·	·	·
Fundulus confluentus	MARSH KILLIFISH	1	·	1	1	·	·	·
Fundulus grandis	GULF KILLIFISH	1	1	1	1	·	1	1
Fundulus similis	LONGNOSE KILLIFISH	1	1	1	1	·	1	1
Fundulus seminolis	SEMINOLE KILLIFISH	1	1	·	1	1	·	·
Lucania parva	RAINWATER KILLIFISH	1	1	1	1	1	1	1
Lucania goodei	BLUEFIN KILLIFISH	·	·	1	1	·	·	·
Adinia xenica	DIAMOND KILLIFISH	1	·	1	·	·	·	1
Floridichthys carpio	GOLDSPOTTED KILLIFIS	1	1	1	1	·	1	·
Jordanella floridae	FLAGFISH	·	·	·	1	·	·	·
Gambusia affinis	MOSQUITOFISH	1	1	1	1	1	1	1
Poecilia latipinna	SAILFIN MOLLY	1	1	1	1	1	·	1
Heterandria formosa	LEAST KILLIFISH	·	·	·	1	·	·	·
Membras martinica	ROUGH SILVERSIDE	1	·	1	1	·	1	1
Menidia spp.		1	1	1	1	·	1	1
Menidia beryllina	INLAND SILVERSIDE	1	1	1	1	1	1	1
Menidia peninsulae	TIDEWATER SILVERSIDE	1	·	1	1	·	1	1
Labidesthes sicculus	BROOK SILVERSIDE	1	·	1	1	·	·	·

Table 4 (continued). Fish and bycatch from samples collected in three salinity zones in the Alafia, Little Manatee, and Manatee rivers. Presence (1) or absence (·), in zones with salinity never < 10 ppt (N), sometimes < 10 ppt (S), or always < 10 ppt (A). Source: Fisheries-Independent Monitoring Program data from 1988 - 1991 (FMRI 1990).

		Alafia		Little Manatee			Manatee	
Scientific name	Common name	N	S	N	S	A	N	S
Syngnathus floridae	DUSKY PIPEFISH	1	·	1	·	·	1	·
Syngnathus louisianae	CHAIN PIPEFISH	1	·	1	·	·	1	1
Syngnathus scovelli	GULF PIPEFISH	1	1	1	·	·	1	·
Hippocampus zosterae	DWARF SEAHORSE	·	·	1	·	·	·	·
Prionotus scitulus	LEOPARD SEAROBIN	1	·	1	·	·	1	1
Prionotus tribulus	BIGHEAD SEAROBIN	1	·	1	1	·	1	1
Centropomus undecimalis	SNOOK	1	1	1	1	1	1	1
Centropristis striata	BLACK SEA BASS	·	·	·	·	·	1	·
Diplectrum formosum	SAND PERCH	·	·	·	·	·	1	·
Lepomis spp.		1	·	1	1	·	·	·
Lepomis macrochirus	BLUEGILL	1	·	1	1	1	·	·
Lepomis microlophus	REDEAR SUNFISH	·	·	·	1	1	·	·
Lepomis punctatus	SPOTTED SUNFISH	·	·	·	·	1	·	·
Micropterus salmoides	LARGEMOUTH BASS	·	·	1	1	1	·	·
Carangidae		·	·	·	·	·	1	·
Caranx spp.		1	·	·	·	·	·	·
Caranx hippos	CREVALLE JACK	1	·	·	·	1	1	1
Caranx latus	HORSE-EYE JACK	·	·	1	·	·	·	·
Chloroscombrus chrysurus	ATLANTIC BUMPER	1	1	1	·	·	1	1
Oligoplites saurus	LEATHERJACKET	1	1	1	1	·	1	1
Selene vomer	LOOKDOWN	·	·	·	·	·	1	·
Trachinotus falcatus	PERMIT	·	·	·	·	·	1	·
Hemicaranx amblyrhynchus	BLUNTNOSE JACK	1	·	1	·	·	1	·

Table 4 (continued). Fish and bycatch from samples collected in three salinity zones in the Alafia, Little Manatee, and Manatee rivers. Presence (1) or absence (•), in zones with salinity never < 10 ppt (N), sometimes < 10 ppt (S), or always < 10 ppt (A). Source: Fisheries-Independent Monitoring Program data from 1988 - 1991 (FMRI 1990).

		Alafia		Little Manatee			Manatee	
Scientific name	Common name	N	S	N	S	A	N	S
Lutjanus griseus	GRAY SNAPPER	.	.	1	.	.	1	1
Lutjanus synagris	LANE SNAPPER	.	.	.	.	.	1	.
Eucinostomus spp.		1	1	1	1	1	1	1
Eucinostomus argenteus	SPOTFIN MOJARRA	.	.	1	.	.	.	.
Eucinostomus gula	SILVER JENNY	1	.	1	1	.	1	1
Eucinostomus harengulus	TIDEWATER MOJARRA	1	1	1	1	1	1	1
Diapterus spp.		1	.	.	.	.	.	.
Diapterus plumieri	STRIPED MOJARRA	1	1	1	1	1	1	1
Orthopristis chrysoptera	PIGFISH	1	1	1	.	.	1	1
Lagodon rhomboides	PINFISH	1	1	1	1	1	1	1
Archosargus probatocephalus	SHEEPSHEAD	1	1	1	1	.	1	1
Sciaenidae		.	.	.	.	.	1	.
Cynoscion spp.		.	.	.	.	.	1	.
Cynoscion nebulosus	SPOTTED SEATROUT	1	1	1	1	.	1	1
Cynoscion arenarius	SAND SEATROUT	1	1	1	1	.	1	1
Bairdiella chrysoura	SILVER PERCH	1	1	1	1	1	1	1
Leiostomus xanthurus	SPOT	1	1	1	1	1	1	1
Menticirrhus spp.		1	.	1	1	.	1	1
Menticirrhus americanus	SOUTHERN KINGFISH	1	1	1	1	.	1	1
Menticirrhus saxatilis	NORTHERN KINGFISH	1	.	1	.	.	1	1
Micropogonias undulatus	ATLANTIC CROAKER	1	.	.	1	.	.	.
Pogonias cromis	BLACK DRUM	1	.	1	1	.	1	1
Sciaenops ocellatus	RED DRUM	1	1	1	1	1	1	1

Table 4 (continued). Fish and bycatch from samples collected in three salinity zones in the Alafia, Little Manatee, and Manatee rivers. Presence (1) or absence (·), in zones with salinity never < 10 ppt (N), sometimes < 10 ppt (S), or always < 10 ppt (A). Source: Fisheries-Independent Monitoring Program data from 1988 - 1991 (FMRI 1990).

		Alafia		Little Manatee			Manatee	
Scientific name	Common name	N	S	N	S	A	N	S
Chaetodipterus faber	ATLANTIC SPADEFISH	1	1	1	.	.	1	1
Tilapia spp.		1	.	1	1	.	.	.
Tilapia melanotheron	BLACKCHIN TILAPIA	.	.	1	1	.	.	.
Mugil spp.		1	.	1	1	.	1	1
Mugil cephalus	STRIPED MULLET	1	.	1	1	1	1	1
Mugil curema	WHITE MULLET	.	.	.	1	.	.	.
Mugil trichodon	FANTAIL MULLET	1	.	1	.	.	1	1
Sphyraena barracuda	GREAT BARRACUDA	.	.	.	.	.	1	.
Chasmodes saburrae	FLORIDA BLENNY	1	.	.	.	.	1	.
Gobiidae		1	.	.	.	.	.	1
Gobionellus boleosoma	DARTER GOBY	1	.	.	.	.	1	.
Gobionellus hastatus	SHARPTAIL GOBY	.	.	1	.	.	.	.
Gobiosoma spp.		1	.	1	1	1	1	1
Gobiosoma bosci	NAKED GOBY	1	.	1	1	1	1	1
Gobiosoma robustum	CODE GOBY	1	1	1	1	.	1	1
Microgobius spp.		.	.	1	.	.	.	.
Microgobius gulosus	CLOWN GOBY	1	.	1	1	1	1	1
Microgobius thalassinus	GREEN GOBY	1	.	1	1	.	1	1
Bathygobius soporator	FRILLFIN GOBY	1	.	1	.	.	1	1
Citharichthys spilopterus	BAY WHIFF	.	.	.	.	.	1	.
Etropus spp.		.	.	.	.	.	1	.
Etropus crossotus	FRINGED FLOUNDER	.	.	.	.	.	1	.

Table 4 (continued). Fish and bycatch from samples collected in three salinity zones in the Alafia, Little Manatee, and Manatee rivers. Presence (1) or absence (·), in zones with salinity never < 10 ppt (N), sometimes < 10 ppt (S), or always < 10 ppt (A). Source: Fisheries-Independent Monitoring Program data from 1988 - 1991 (FMRI 1990).

		Alafia		Little Manatee			Manatee	
Scientific name	Common name	N	S	N	S	A	N	S
Paralichthys albigutta	GULF FLOUNDER	1	·	1	·	·	1	1
Ancylopsetta quadrocellata	OCELLATED FLOUNDER	·	·	·	·	·	1	·
Trinectes		·	·	·	1	·	·	·
Trinectes maculatus	HOGCHOKER	1	1	1	1	1	1	1
Trinectes inscriptus	SCRAWLED SOLE	·	1	·	·	·	·	·
Achirus lineatus	LINED SOLE	1	1	1	1	·	1	1
Symphurus plagiusa	BLACKCHEEK TONGUEFIS	1	·	1	·	·	1	1
Monacanthus hispidus	PLANEHEAD FILEFISH	·	·	1	·	·	1	·
Lactophrys quadricornis	SCRAWLED COWFISH	·	·	·	·	·	1	·
Sphoeroides nephelus	SOUTHERN PUFFER	1	·	1	1	·	1	1
Chilomycterus schoepfi	STRIPED BURRFISH	·	·	1	·	·	1	1

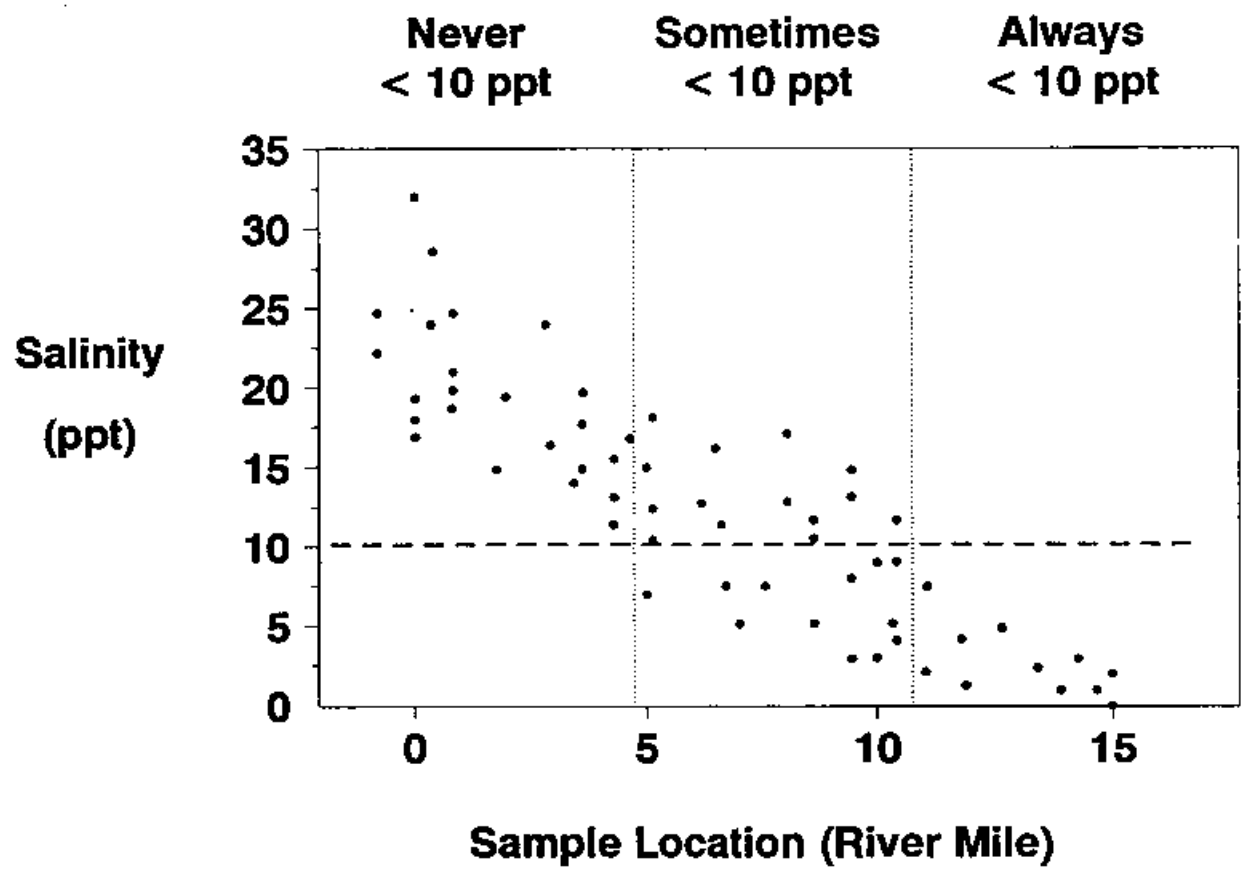

Figure 1. Example of approach used to delineate salinity zones. Based on a plot of observed salinity against river mile, zones where salinity was always, sometimes, or never less than 10 ppt were identified.

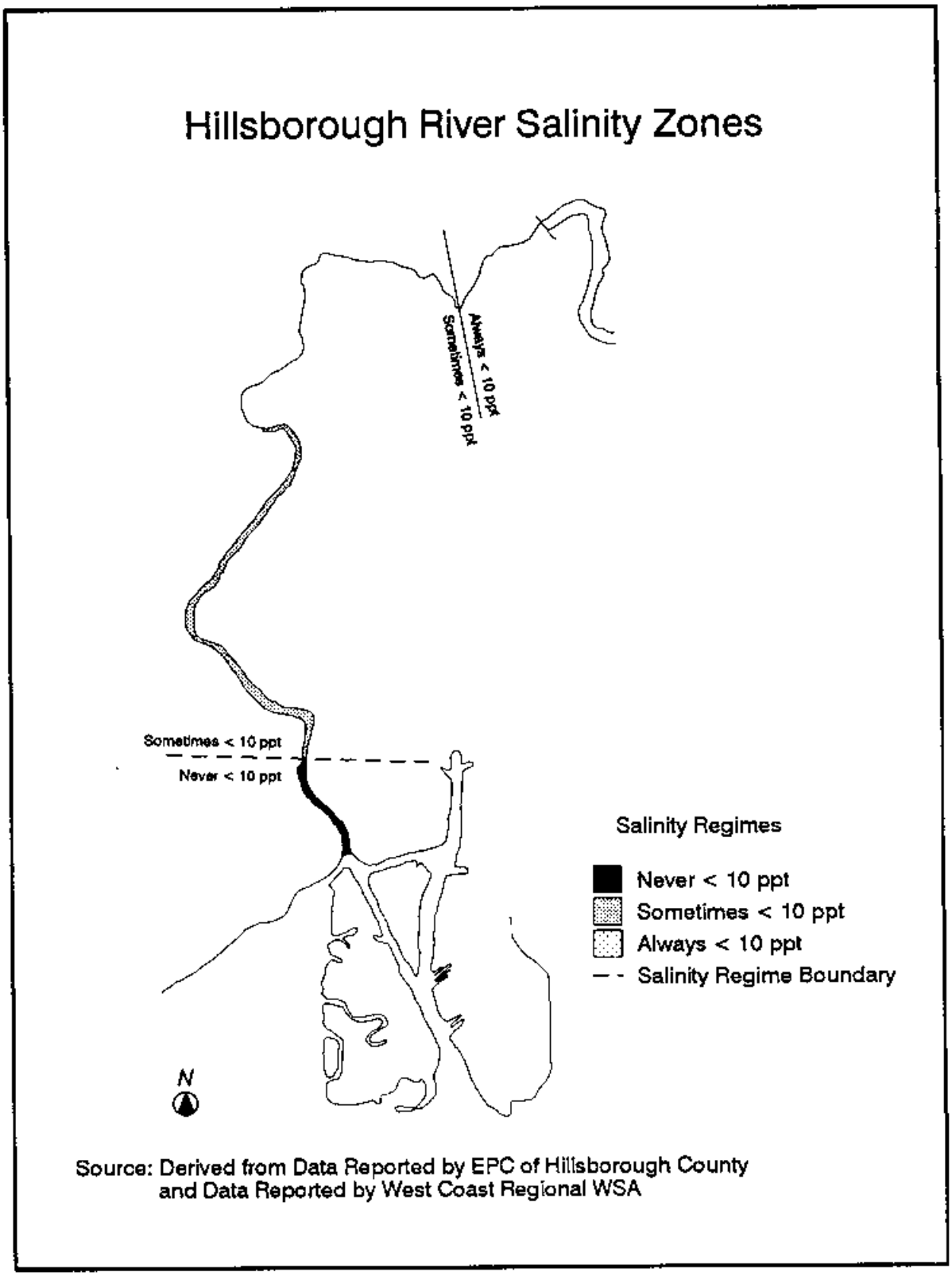

Figure 2. Salinity zones for the Hillsborough River

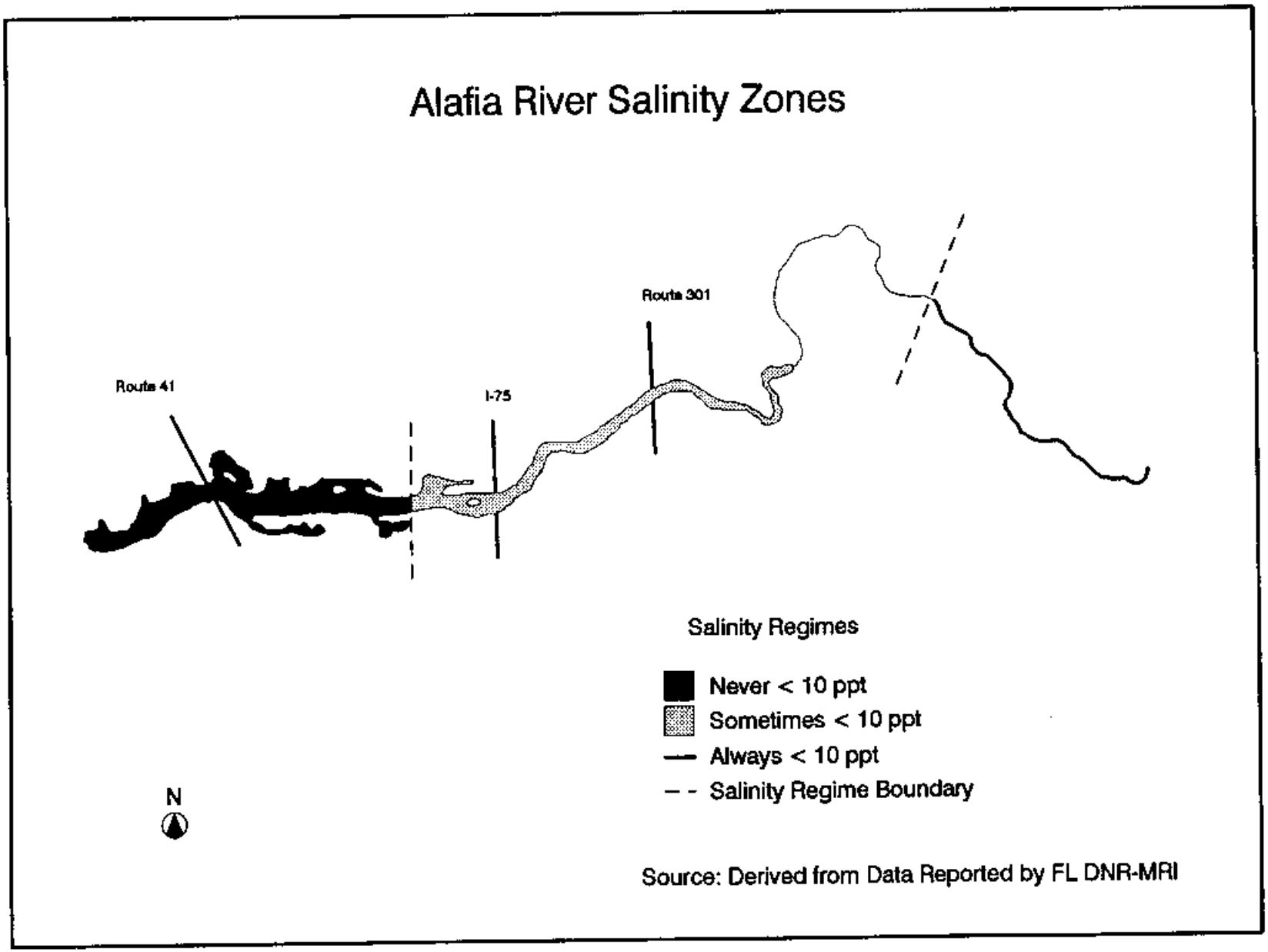

Figure 3. Salinity zones for the Alafia River

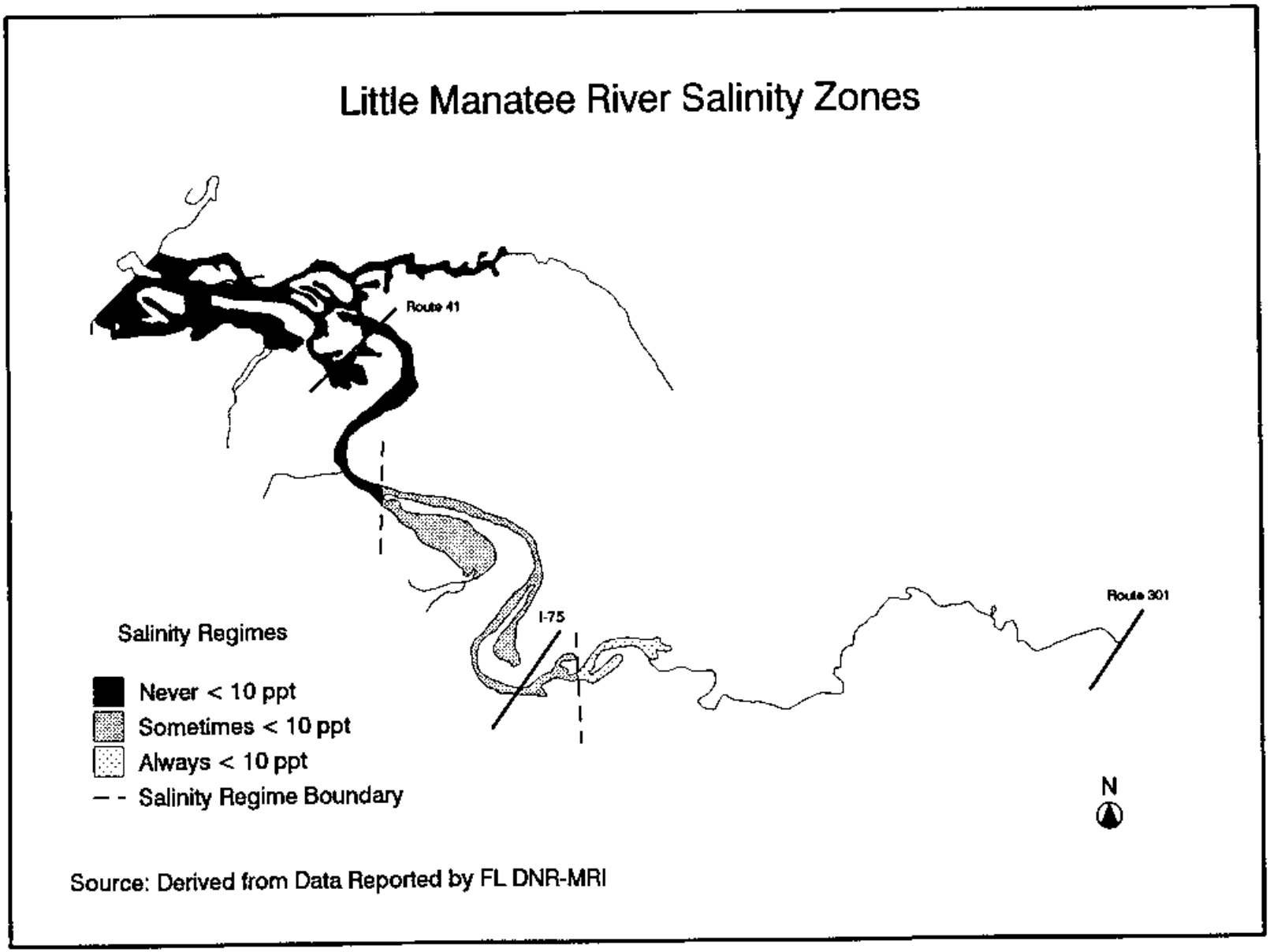

Figure 4. Salinity zones for the Little Manatee River, based on FL DNR-MRI data.

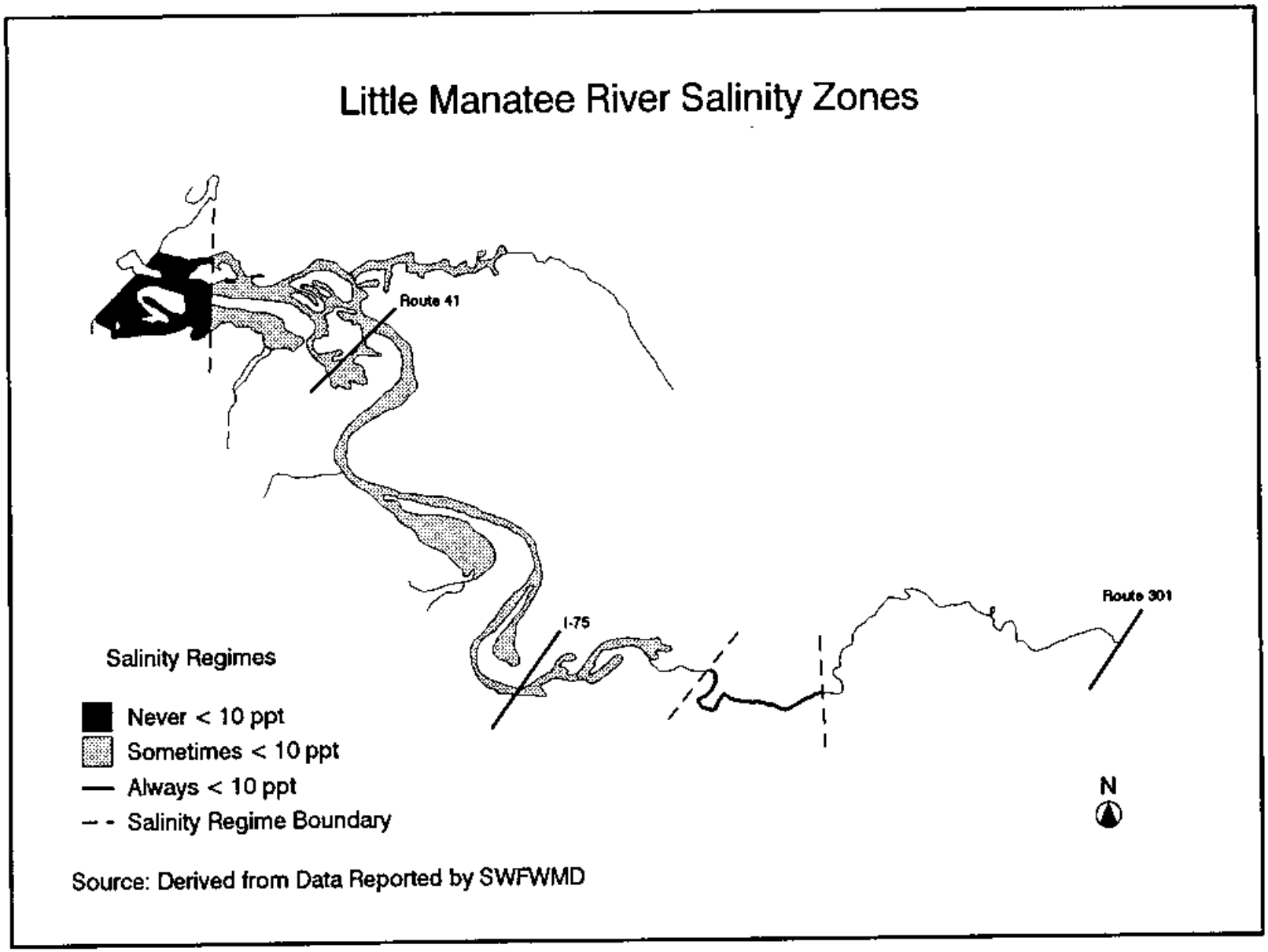

Figure 5. Salinity zones for the Little Manatee River, based on data from SWFWMD.

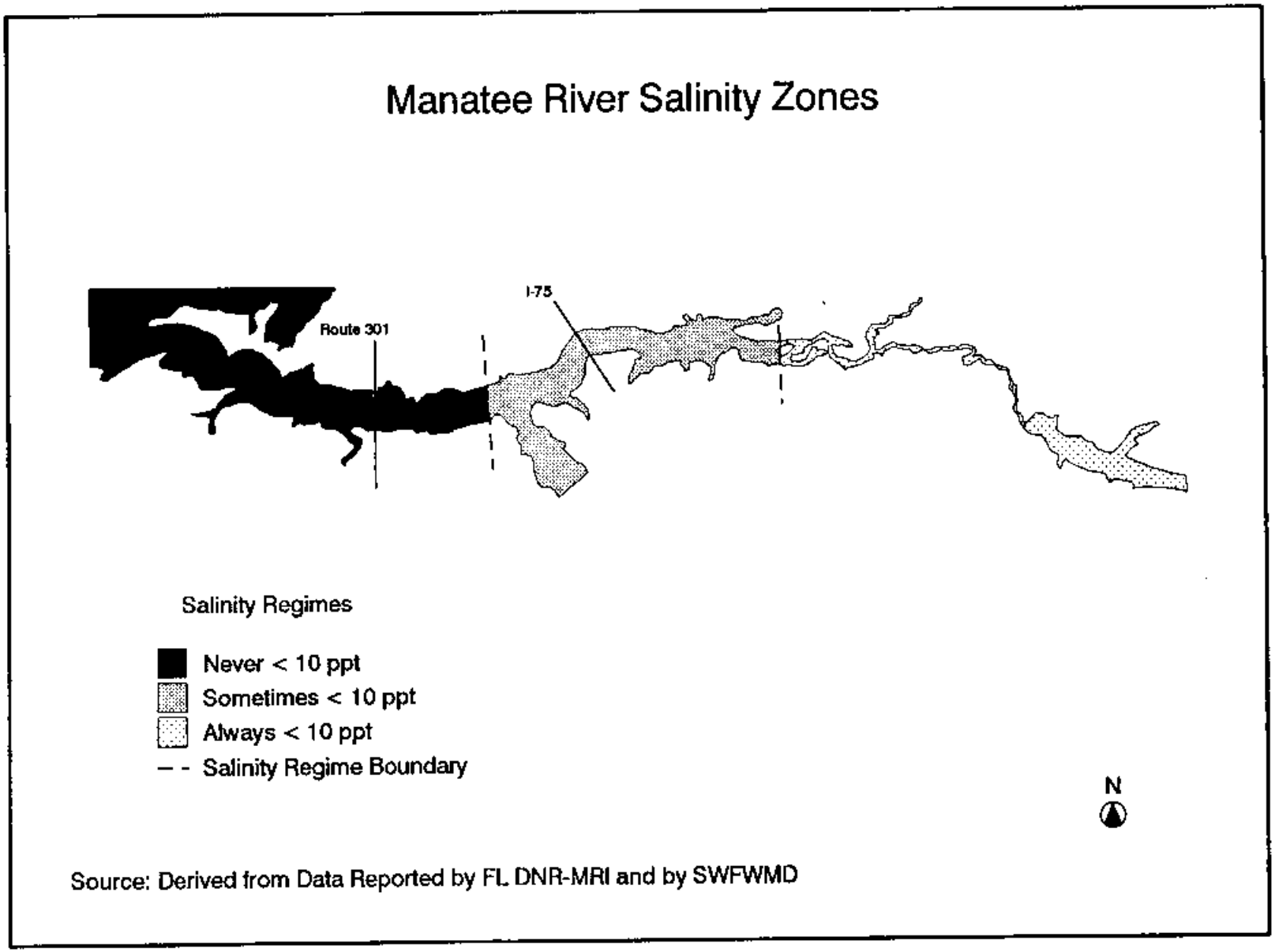

Figure 6. Salinity zones for the Manatee River.

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