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Tony A. Lowery
National Oceanic and Atmospheric Administration

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THE DERIVATION AND USE OF GULF COAST ESTUARY WATERSHED POPULATION ESTIMATES (1960-2010)

Tony A. Lowery

National Oceanic and Atmospheric Administration
Strategic Environmental Assessments Division
N/ORCA 1, SSMC 4
1305 East West Highway
Silver Spring, MD 20910

ABSTRACT: Reaggregation of county population data to hydrologic units was used to produce estuarine watershed population estimates. Estuarine watershed population estimates are presented for the following estuaries: Charlotte Harbor, FL; Tampa Bay, FL; Apalachicola Bay, FL; St. Andrews Bay, FL; Choctawhatchee Bay, FL; Pensacola Bay, FL; Perdido Bay, AL; Mobile Bay, AL; Calcasieu Lake, LA; Sabine Lake, TX; Galveston Bay, TX; Matagorda Bay, TX; San Antonio Bay, TX; Aransas Bay, TX; Corpus Christi Bay, TX. These estimates are for the years 1960, 1970, 1980, 1990, 2000, 2010. The methodology and data sets used to develop the estuarine watershed population estimates can be applied to most estuaries in the contiguous United States. A series of estuarine comparators (density per land area; per capita estuary volume) are developed from the watershed population estimates in order to underscore the utility of basin-wide comparators.

Anthropogenic impacts are major causes of estuarine ecosystem degradation and are intrinsically tied to human populations within estuarine watersheds. Hence, human population estimates per watershed can be used as surrogate indicators of anthropogenic impacts (Biggs 1986, Nixon 1983). However, historical population estimates per estuarine watershed have not been available for many estuaries. This paper presents a means of producing these estimates from existing data sets.

Estuarine watersheds are defined by basin topography and drainage patterns. The National Oceanic and Atmospheric Administration's (NOAA) Strategic Assessment Branch (SAB) has identified estuarine watersheds in terms of United States Geological Survey (USGS) hydrologic unit mappings. As a result, consistently developed estuarine watershed bounds are available.

Census data are most easily acquired for the county level. However, counties are often divided by estuary watershed bounds. Hence, compiling population data for counties within an estuarine watershed overestimates watershed population via the inclusion of portions of the counties not within the estuary's watershed (Figure 1). This misalignment of the two spatial entities requires compensatory adjustment of the county population data for the counties divided by estuary watershed bounds.

Recently, geographic information systems (GIS) and data base managment systems (DBMS) have been used to develop population weightings for county/hydrologic unit combinations (Lanfear and Knopman 1988). These weightings make reaggregation of county population to estuarine watershed estimates possible on a consistant basis. County population data can be compiled for the counties completely within an estuarine watershed. Counties divided by the estuarine watershed bounds can have

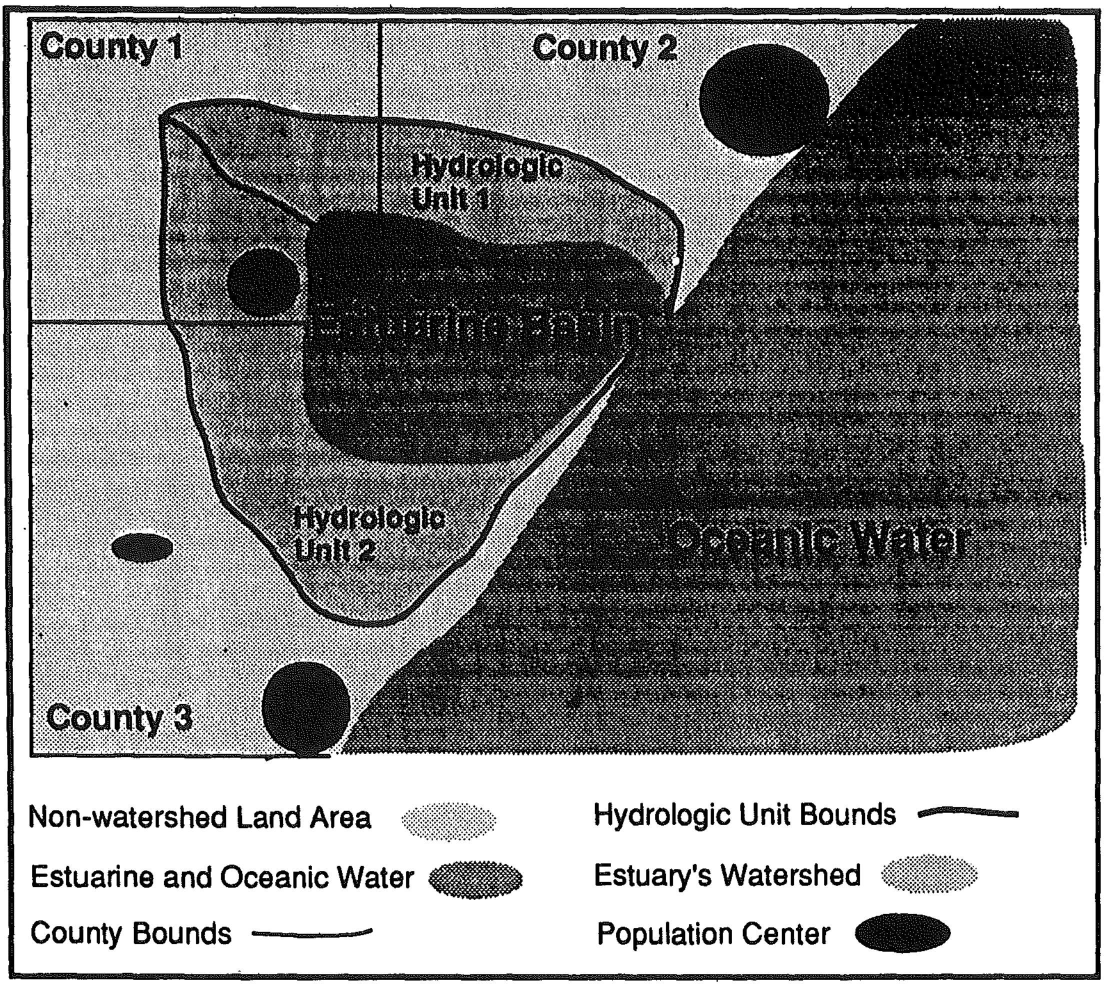

Figure 1. Example of county and hydrologic unit bounds in relation to estuarine watersheds. Note population centers outside of estuarine watershed potentially bias estimates of estuarine watershed population if only a county perspective is used.

the "within watershed" portion of their population estimated by use of the weightings.

Concurrently, historical series of county population data have been developed for coastal states of the contiguous United Stated (NOAA 1990). Since most estuarine watersheds are within coastal states, county population data sets can be reaggregated to yield estuarine watershed estimates by use of the county/hydrologic unit weightings. The estuaries used in this paper were selected based on the amount of available information and the author's familiarity with these estuaries. The comparators used in this paper were selected based on NOAA (1985) physical and hydrologic characteristics. The remainder of this paper presents the methodology used to develop a representative set of estuarine watershed population estimates and uses these estimates to develop a series of estuarine comparators.

METHODS

Two data sets were used to develop population estimates for estuarine watersheds. The first data set contains county population estimates for coastal states of the contiguous United States (NOAA 1990). The data set consists of census data for 1960, 1970, and 1980, and projections for 1990, 2000 and 2010. The other data set contains population weightings per county/USGS hydrologic unit combination. This data set was developed using 1985 census data.

NOAA (1985) mappings were used to identify estuarine watersheds in terms of USGS hydrologic units. The USGS hydrologic unit maps were used to identify counties and county segments within estuarine watersheds. The USGS hydrologic unit maps were also used to determine the hydrologic unit codes, county codes, and county segments within the estuarine watersheds.

The counties and county segment/hydrologic unit combinations were compiled for each estuarine watershed and entered into a data base management system. Population weightings per sounty/hydrologic unit combination (Lanfear and Knopman 1988) and county population data (NOAA 1990) were added to the records containing corresponding hydrologic unit code/county equivalent code combinations. The population weightings were applied to the county population data to develop population estimates for the county segments and counties. These county and county segment population estimates were summed to produce estuarine watershed population estimates (watershed method).

In order to assess the watershed method estimates' improvement over the traditional compilation of county population for all counties overlapping the watershed (county method), county method estimates were produced for comparative purposes. The watershed population estimates (watershed method) were divided by watershed land area (NOAA 1985) resulting in population density estimates developed per mi² of watershed land area. Estuary volume (NOAA 1985) was divided by the watershed population estimates to produce per capita estuary volume (1,000m³) estimates.

RESULTS

The county method consistently overestimates watershed population when compared to the watershed method. The county method's percentage of overestimation is presented in Figure 2. Perdido Bay has the greatest average overestimate at 1,687%, while Galveston Bay has the least average overestimate at 29%. The average overestimate for the fifteen estuarine watersheds is 338%. Based on these results, the watershed method's population estimates were determined to be more accurate and were used to develop the estuarine comparators presented in the remainder of this section.

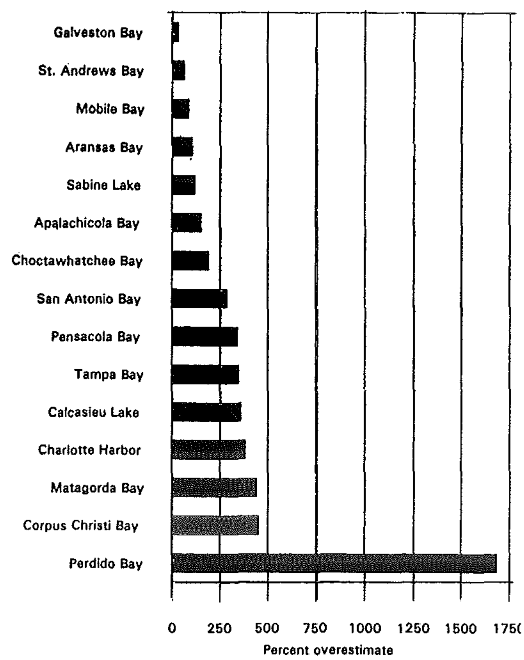

Figure 2. Overestimate of watershed population by county method versus watershed method (sorted ascending). The overestimates presented have been averaged for years 1960-2010 for the estuaries indicated.

Estuarine watershed population estimates based on the watershed method are presented in Table 1. Figure 3 depicts watershed population trends from 1960 to 2010. Charlotte Harbor has the greatest percent change at 240%. Calcasieu Lake has the least percent change at 19%. Galveston Bay has the greatest population with 3.38 million (1960) and 9.61 million (2010). Perdido Bay has the least population with 25,514 (1960) and 52,776 (2010).

Table 2 presents population density per mi² of watershed land area. Figure 4 depicts population density per watershed land area from 1960 to 2010. Tampa Bay has the greatest density, ranging from 228 (1960) to 603 (2010). Matagorda Bay has the least density ranging from 1 (1960) to 2 (2010).

Table 3 presents per capita estuary volume. Figure 5 depicts per capita estuary volume from 1960 to 2010. Matagorda Bay has the highest per capita volume at 28,100 m³ (1960) and 21,900 m³ (2010). Galveston Bay has lowest per capital volume at 800 m³ (1960) and 300 m³ (2010).

DISCUSSION

The obvious point to make is that these watershed population estimates provide the basis for comparative analyses of estuaries on regional scales in historical terms. The methodologies presented in this paper can be used to generate consistent watershed population estimates and comparators for most estuaries in the contiguous United States. However, the county weightings were developed from 1985 census data (Lanfear and Knopman 1988) and are

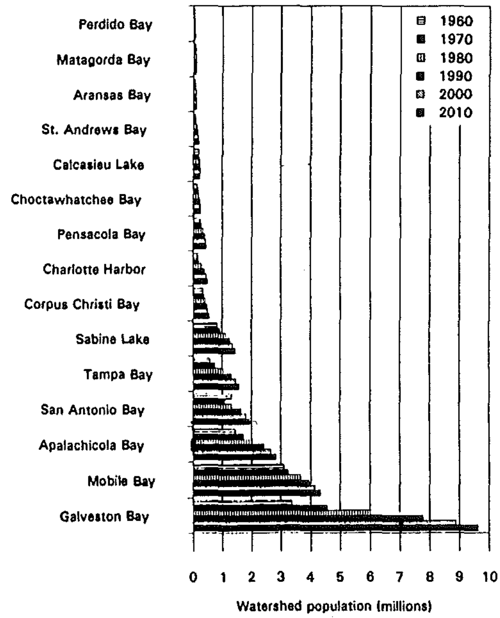

Figure 3. Estuarine watershed population (1960-2010) based on watershed method (sorted on year 2010 in ascending order).

Table 1. Watershed population estimates based on watershed method.

Watershed	1960	1970	1980	1990	2000	2010
Galveston Bay	3,374,632	4,566,445	6,005,611	7,771,203	8,877,473	9,614,677
Mobile Bay	3,091,414	3,228,890	3,660,054	3,934,443	4,147,948	4,337,426
Apalachicola Bay	1,447,098	1,714,351	2,023,065	2,421,667	2,667,177	2,837,519
San Antonio Bay	1,309,910	1,084,861	1,317,989	1,641,191	1,810,883	1,934,747
Tampa Bay	592,945	752,092	1,032,374	1,311,410	1,455,978	1,566,128
Sabine Lake	837,873	929,179	1,121,693	1,260,669	1,363,252	1,441,295
Corpus Christi Bay	341,289	355,341	413,379	469,620	506,830	537,459
Charlotte Harbor	148,737	189,452	289,632	394,782	461,155	505,570
Pensacola Bay	227,915	280,254	330,522	395,730	433,108	461,606
Choctawhatchee Bay	140,888	174,536	194,185	224,062	240,813	254,283
Calcasieu Lake	187,918	200,956	230,019	240,451	251,414	223,163
St. Andrews Bay	72,919	81,092	103,691	140,153	159,563	172,750
Aransas Bay	73,111	71,865	84,454	90,716	97,249	102,941
Matagorda Bay	73,941	72,276	81,312	85,809	90,016	94,787
Perdido Bay	25,514	30,343	37,561	45,755	49,801	52,776

Table 2. Population density per watershed land area (mi²). Population estimates from Table 1 divided by watershed land area (NOAA 1985).

		Year					
Watershed	land area mi²	1960	1970	1980	1990	2000	2010
Tampa Bay	2,598	228	289	397	505	560	603
Galveston Bay	24,300	139	188	247	320	365	396
San Antonio Bay	10,857	121	101	121	151	167	178
St. Andrews Bay	1,130	65	72	92	124	141	153
Apalachicola Bay	20,500	71	84	99	118	130	138
Charlotte Harbor	5,030	30	38	58	78	92	101
Mobile Bay	44,600	69	72	82	88	93	97
Sabine Lake	20,900	40	44	54	60	65	69
Pensacola Bay	6,990	33	40	47	57	62	66
Calcasieu Lake	4,332	43	46	53	56	58	52
Choctawhatchee Bay	5,369	26	33	36	42	45	47
Perdido Bay	1,205	21	25	31	38	41	44
Aransas Bay	2,768	26	26	31	33	35	37
Corpus Christi Bay	17,621	19	20	23	27	29	31
Matagorda Bay	49,670	1	1	2	2	2	2

most accurate for generating the 1980 and 1990 estimates. Applying these 1985 based weightings to 1960, 1970, 2000 and 2010 is inherently less accurate. The development and use of county weightings based on census data for the years 1960, 1970, 1990, 2000 and 2010 (as they become available) would be desirable. In the meantime, the use of the 1985 based county weightings greatly improves the accuracy of estuarine watershed population estimates.

Nixon (1983) and Biggs (1986) used watershed population data as a surrogate indicator of anthropogenic impact on "estuarine health". The premise being that some yet to be identified nutrient and toxin concentration ranges correspond to various states of estuarine health (EPA 1982, EPA 1988, Goldsmith 1976, Shepherd et. al. 1989). The watershed population estimates and associated methodologies presented in this paper are intended to provide the basis for the development of population based anthropogenic surrogates for assessing estuarine health questions. However, the evaluation of the relationship of anthropogenic surrogates to estuarine health is beyond the scope of this paper.

Table 3. Per capita estuary volume (1,000m³). Estuary volume (m³) (NOAA 1985) divided by population estimates in Table 1.

		Year					
Estuary	estuary vol m³	1960	1970	1980	1990	2000	2010
Galveston Bay	2.57E+09	0.8	0.6	0.4	0.3	0.3	0.3
San Antonio Bay	6.97E+08	0.5	0.6	0.5	0.4	0.4	0.4
Sabine Lake	6.06E+08	0.7	0.7	0.5	0.5	0.4	0.4
Apalachicola Bay	1.52E+09	1.1	0.9	0.8	0.6	0.6	0.5
Mobile Bay	3.20E+09	1.0	1.0	0.9	0.8	0.8	0.7
Corpus Christi Bay	1.19E+09	3.5	3.3	2.9	2.5	2.3	2.2
Tampa Bay	3.48E+09	5.9	4.6	3.4	2.7	2.4	2.2
Pensacola Bay	1.43E+09	6.3	5.1	4.3	3.6	3.3	3.1
Calcasieu Lake	7.33E+08	3.9	3.7	3.2	3.1	2.9	3.3
Charlotte Harbor	1.97E+09	13.2	10.4	6.8	5.0	4.3	3.9
St. Andrews Bay	8.86E+08	12.1	10.9	8.6	6.3	5.6	5.1
Perdido Bay	2.74E+08	10.7	9.0	7.3	6.0	5.5	5.2
Choctawhatchee Bay	1.44E+09	10.3	8.3	7.4	6.4	6.0	5.7
Aransas Bay	8.66E+08	11.8	12.0	10.3	9.5	8.9	8.4
Matagorda Bay	2.08E+09	28.1	28.9	25.6	24.2	23.1	21.9

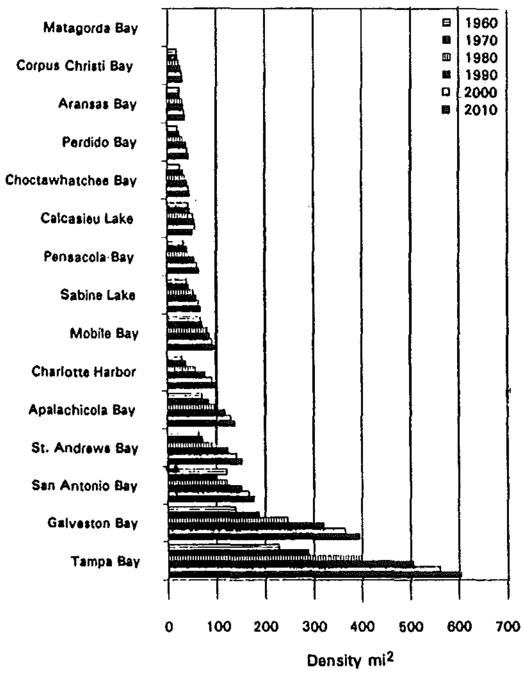

Figure 4. Population density per land area (mi²) (sorted on year 2010 in ascending order).

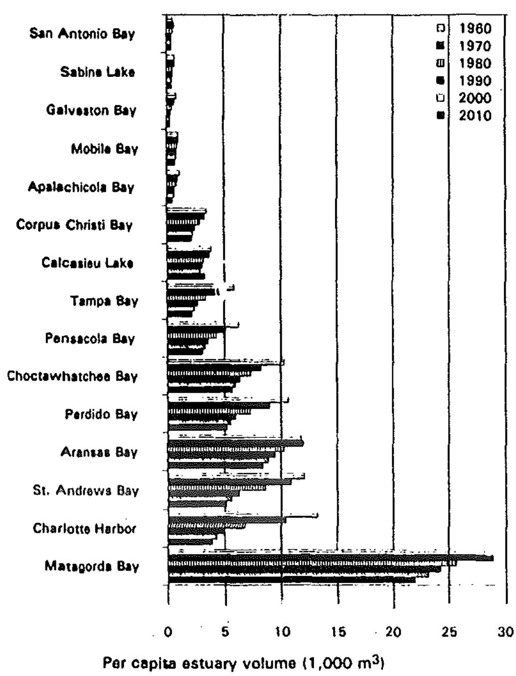

Figure 5. Per capita estuary volume (1,000 m³) (sorted on year 1960 in ascending order).

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LITERATURE CITED

Biggs, R. 1986. Susceptibility of United States Estuaries to Anthropogenic Impacts. Office of Marine and Estuarine Protection, Environmental Protection Agency, Washington, D.C. 57 p.

EPA. 1982. Chesapeake Bay Program Technical Studies: a Synthesis. Chesapeake Bay Program, Environmental Protection Agency, Washington, D.C. 635 p.

_________. Baywide Nutrient Reduction Strategy: Agreement Commitment Report. Cheasapeake Executive Council, Chesapeake Bay Program, Environmental Protection Agency, Annapolis, Maryland. 136 p.

Goldsmith, J.C. 1976. Identification of nitrogen as a growth-limiting nutrient in wastewaters and coastal marine waters through continuous culture algal assays. Water Research 10:97-104.

Lanfear, K.J. and D.S. Knopman. 1988. Use of a Geographic Information System for Reaggregating Water-Use Data from Counties to Hydrologic Units, p. 217-222. *In* M. Waterstone and R. Burt (eds.) Proceedings of the Symposium on Water Use Data for Water Use. American Water Resource Association, Bethesda, MD.

Nixon, S.W. 1983. Estuarine Ecology; a Comparative and Experimental

Analysis using 14 Estuaries and the MERL Misrocosms. Chesapeake Bay Program, Environmental Protection Agency, Annapolis, Maryland. 44 p.

NOAA. 1985. National Estuarine Inventory Data Atlas, Volume 1: Physical and Hydrologic Characteristics. Strategic Assessment Branch, National Oceanic and Atmospheric Administration, Rockville, Maryland. 103 p.

NOAA. 1990. 50 Years of Population Change Along the Nation's Coasts. Strategic Assessment Branch, National Oceanic and Atmospheric Administration, Rockville, Maryland. 41 p.

Shepherd, S.A., A.J. McComb, D.A. Bulthuis, V. Neverauskas, D.A. Steffensen, and R. West. 1989. Decline of seagrasses, p. 346-392. *In* A.W.D. Larkum, A.J. McComb and S.A. Shepherd (eds.), Biology of Seagrasses. Elsevier, New York.