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ABSTRACT

Incidence of the picoplankter *Aureococcus anophagefferens* in eastern Long Island, NY, has been thoroughly documented since its blooms, or "brown tides", began there in1985. In contrast, definitive information on incidence of *A. anophagefferens* in the western or New Jersey side of the New York Bight lagged considerably. None was available until surveys along the northeast U. S. coast in 1988 and 1990 by other investigators detected the species in New Jersey bays and ocean coastal waters from the Hudson-Raritan estuary south to Great Bay (approximately central on the New Jersey coast). Confirmation of an *A. anophagefferens* bloom in New Jersey, this in the Barnegat Bay-Little Egg Harbor estuarine system, was delayed until 1995 although earlier episodes were suspected. To obtain more comprehensive and current information on *A. anophagefferens* distribution and potential for its blooms in the western Bight, we surveyed for it in coastal waters from Delaware Bay to the Hudson-Raritan estuary, and in western Long Island (Nassau County, NY) south shore locales, during 1997 to 2001. Results showed persistence of the species in New Jersey locales where found by the 1988,1990 surveys, and expansion of its range southward in New Jersey coastal waters since 1990. Year-to-year difference in incidence in waters south of Great Bay was noted, with much greater incidence in1999, a year when it bloomed primarily in the Barnegat Bay-Little Egg Harbor system and Great Bay, than in1998, a non-bloom year. Cell numbers in1999 in New Jersey southern estuarine waters were below reported detrimental level (3.5×10^4 cells ml^{-1}) at most sites surveyed, but at three sites to approximately six km south of Great Bay concentrations ranged $2\text{-}2.8 \times 10^6$ cells ml^{-1}. This was the first confirmed bloom occurrence south of Great Bay. Although having a history of intense blooms of other phytoplankton species, the Hudson-Raritan estuary does not appear to be a system where brown tide might be expected.

KEY WORDS: *Harmful algal blooms, brown tide distribution, New York Bight, Aureococcus anophagefferens*.

INTRODUCTION

Intense blooms of a previously unidentified picoplankter in New York Bight coastal waters were reported first in the mid-1980's in eastern Long Island bays, including the easternmost Gardiners Bay-Peconic Bay system, and bays along the southeastern shore including Shinnecock Bay, Moriches Bay, and Great South Bay (Nuzzi, 1995; Bricelj and Lonsdale, 1997). The causative picoplankter was described and named *Aureococcus anophagefferens* by Sieburth et al. (1988). Early recognition of severe detriment of the eastern Long Island blooms, or "brown tides", to bay scallop, *Argopecten irradians*, and other components of the biota (Bricelj and Kuenster, 1989) resulted in considerable timely attention to these blooms. Examination of brown tide as a regional phenomenon has been inadequate, however, despite a documented 1985 *A. anophagefferens* bloom in Narragansett Bay, RI (Smayda and Villareal, 1989). *A. anophagefferens* incidence information for the western or New Jersey side of the New York Bight was lacking completely until Anderson et al.(1993) provided limited data. A 1995 brown tide episode was the first confirmed in the western Bight (Nuzzi et al., 1996); such confirmation may have been delayed for a decade. New Jersey possibly experienced *A. anophagefferens* blooms in 1985-1987 but the dominant picoplankter was not identified definitively (Olsen, 1989). *A. anophagefferens* could not be distinguished reliably from similar picoplankters using light microscopy. Means for positive identification of the species was not available to monitoring agencies until Anderson et al.(1989) developed an immunofluorescence protocol for this.

The goal of the Anderson et al. (1993) surveys for *A. anophagefferens* along the northeast U. S. coast in1988 and 1990 was to determine its distribution beyond the eastern Long Island embayments bloom loci. The southerly limit of the 1988 survey was Barnegat Bay at Manahawkin, New Jersey; their 1990 survey extended to Chesapeake Bay. They found the species in New Jersey bays and ocean coastal waters from the Hudson-Raritan estuary south to the Barnegat Bay-Great Bay sector (approximately central on the New Jersey coast). In 1988, New Jersey samples were collected on September 20, well past the usual time for primary bloom development and maxima (May-June). Nevertheless, alarming levels of *A. anophagefferens* (3.5-14.1 x 10^4 cells ml^{-1}) were detected in southern Barnegat Bay. Brownish water discoloration characteristic of an *A. anophagefferens* bloom was not observed in the bay in 1988 (Olsen, unpublished data). Such discoloration is evident when *A. anophagefferens* cell numbers are $\geq$ ~2.0 x 10^5 ml^{-1} (Nuzzi, personal communication). If a low level bloom occurred there in 1988 it likely was masked, because total picoplankton concentrations (likely dominated by *Nannochloris atomus*) approximated 2.0 x 10^6 cells ml^{-1} and *A. anophagefferens* when assessed comprised only ~7.5% of the picoplankton (Olsen, 1989). The Anderson et al.1990 survey sampling again was post-bloom maximum time, August 29, and when water temperature likely was unfavorably high for *A. anophagefferens* (i.e. $\geq$26˚C). They detected the species in low numbers (highest, 216 cells ml^{-1}) in several Barnegat Bay locales and in Great Bay, but not between Great Bay and Chesapeake Bay.

Anderson et al. (1993) concluded that the widespread distribution of *A. anophagefferens* they found in waters far from the eastern Long Island, New York, population "center" suggests that numerous areas have the potential for destructive brown tides. They recommended continued monitoring for the species. We conducted surveys for *A. anophagefferens* in 1997 to 2001 from Delaware Bay to western Long Island, to update and expand information on distribution of the species in this area, and to identify additional locales where its blooms might be expected. We report the initial *A. anophagefferens* distribution information for western Long Island; Nuzzi (personal communication) had advised there was a dearth of such information. This report excludes *A. anophagefferens* incidence information for the brown tide-prone Barnegat Bay-Little Egg Harbor system (Mahoney et al., 1999) which will be reported separately.

MATERIALS AND METHODS

The New York Bight is bounded by easternmost Long Island on the north and southernmost New Jersey on the west. Surveys for *A. anophagefferens* were conducted on an irregular basis in coastal ocean waters, embayments, and intracoastal waters of New Jersey and western Long Island during 1997-2001. The initial survey, in July 1998, was of bay and intracoastal waterway sites from Delaware Bay to the Hudson-Raritan estuary, excluding the Barnegat Bay-Little Egg Harbor system. Survey of such sites from Delaware Bay to Great Bay was repeated on September 30, 1998, June 14-16, 1999, and May 31, 2000. Samples were collected occasionally at nine New Jersey intracoastal and bay sites and thirteen New Jersey coastal ocean sites between 1995 and 2000. A total of 14 western Long Island estuarine and coastal ocean sites were sampled in June 2001. Survey sites are shown in Figure 1 (survey area with sites numbered), and Figures 1A, 1B, 1C, and1D (survey area regions with sites numbered and named). Combined letter/number designations in parentheses denote standard U. S. Environmental Protection Agency (EPA) sampling stations. Figure site numbers correspond to site numbers in Tables 1, 2 and 3.

Bay water samples primarily were collected from docks along shore with a Niskin bottle at ~0.5 m depth. Offshore bay samples were collected by helicopter (EPA, Region II) with a Kemmerer bottle at ~1.0 m depth. Helicopter collections (same depth and method) also provided coastal ocean samples, from ~0.4 km to ~1.6 km from shore. Water salinity and temperature measurements were made by personnel of various agencies and by different means. Salinity was measured by Yellow Springs Instrument Co. meter or refractometer, and is expressed as practical salinity units (PSU), equivalent to parts per thousand ($^{0}/_{00}$). Water temperature measurements were made variously by meter (Orion Model 265; Hanna Model HI 9060) and thermometer.

Sample handling, preservation and immunofluorescence protocol for *A. anophagefferens* identification and enumeration basically were that of Anderson et al. (1989, 1993). Bureau of Marine Research, Suffolk County, NY, Department of Health Services (SCDHS) enumerated *A. anophagefferens* in 1995 samples and some 1997 samples. Otherwise, *A. anophagefferens* enumerations were done at the James J. Howard Marine Sciences Laboratory (HL). SCDHS provided initial training and continuing advice in the immunofluorescence protocol to HL personnel. *A. anophagefferens* identification and enumeration was confirmed periodically between the two labs. *A. anophagefferens* population levels at collection sites are provided in Tables 1, 2 and 3, along with associated water temperature and salinity when available. Sample immunofluorescence preparations were scanned for presence of *A. anophagefferens* prior to enumeration. When the species was seen during the scan but not during enumeration its presence "P" is tabulated. Bricelj et al. (2001) reported that *A. anophagefferens* concentrations as low as 3.5 x 10^4 cells ml^{-1} reduced feeding of juvenile hard clam, *Mercenaria mercenaria.* This level will be referred to in regard to relevance of *A. anophagefferens* population levels detected.

RESULTS

New Jersey Coastal Ocean Sites

Atlantic Ocean coastal waters, from off Cape May Point, southernmost on the New Jersey ocean shore, to the northern ocean shore off Monmouth Beach (Figure 1), were sampled irregularly during May through August, 1997 to 2000. One site also was sampled in 1995. Sites included some ~1.6 km from shore as well as the majority which were ~0.4 km from shore. Results are shown in Table 1. *A. anophagefferens* was found at least part of the time at all sites; levels ranged to 4.6 x 10^3 cells ml^{-1} (site 3, off Cape May Point, Figure 1A) but predominantly were ≤300 cells ml^{-1} over the several years of the study. Highest levels of the species were found in southern coast and mid-coast sites (sites 3, 39, 45) in 1999. This was concurrent with or shortly after an intense bloom in the Barnegat Bay-Little Egg Harbor system, Great Bay, and some contiguous bays to the south (Figure 1B). Sites sampled in multiple years (sites 3, 49, 54), with the exception of site 3 in1995, had presence of *A. anophagefferens* each year. The greatest year-to-year change in abundance was at site 3. Sites 49 and 54, sampled multiple times during particular years, had varied same-year *A. anophagefferens* presence, i.e., from 0 to ~300 cells ml^{-1}. Comparison of geometric means of cell levels (multiple enumerations for individual sites were averaged) at southern shore sites (Cape May to Atlantic City - sites 3, 5, 12, 13, 17, 19) and northern shore sites (Manasquan to Monmouth Beach - sites 49, 50, 54) shows comparable levels, 149 vs. 151cells ml^{-1}.

New Jersey Bay and Intracoastal Sites

Survey for *A. anophagefferens* in New Jersey bay or intracoastal waters, excluding the Barnegat Bay-Little Egg Harbor system and Great Bay (excepting southern shore) (Figure 1B), primarily was done irregularly during May-September, 1997-2000. Results are shown in Table 2. The species was present from Delaware Bay to the Hudson-Raritan estuary at most sites, most of the time. It was detected more in the southern region, from Delaware Bay to the southern shore of Great Bay (Figure 1A), than in the northern region, from Shark River to the Hudson-Raritan estuary (Figure 1C). *A. anophagefferens* was found at 16 of 20 sites in the southern region (sites 1-26), whereas in the northern region (sites 51-71) the species was found at only eight (sites 51, 55, 62, 63, 64, 66, 69, 71) of 20 sites. However, 17 of the latter were sampled only in1998, a non-bloom year, but15 of 20 southern sites were sampled in one or more bloom years, i.e., 1995, 1997, 1999, 2000. Instances of non-detection in the southern region during the course of the surveys were associated with sites sampled only in1998 (sites 8, 12, 20, 22). In 1998, the species was found at only six (sites 1, 6, 14, 15, 23, 24) of 15 sites sampled in the southern region, although at site 15, Great Egg Inlet, it was found in three samplings over a month. In contrast, in 1999 it was present at all southern region sites. Cell levels at seven of 10 southern region sites (sites 6, 9, 10, 14, 15, 18, 24) sampled in 1999 and at least one other bloom year, e.g. 2000, were highest in 1999; at two sites (sites 4,16) levels were higher in 2000, and at one site (site 5) levels for 1999 and 2000 were low and comparable. Sites in the Hudson-Raritan estuary (Fig.1C, Table 2, sites 62 to 71) primarily were sampled in May through August, 1997, 1998. We confirm presence of the species in Sandy Hook Bay (sites 62-64, 66, 69) reported by Anderson et al.(1993) and also report its presence in Raritan Bay (site 71).

Data for Oyster Creek at the south shore of Great Bay (Site 27) are included in Table 2, although this bay is considered in the central region. Shown is that *A. anophagefferens* was undetected there in a single September 1998 sample, a high level (1.7×10^6 cells ml^{-1}) was present in June 1999, and low levels $\leq$ 1000 cells ml^{-1} were present in June-August 2000.

A. anophagefferens population levels in1999 were below reported minimum detrimental level (3.5×10^4 cells ml^{-1}) at most sites, but three sites to approximately six km south of Great Bay, i.e., Reed Bay, Perch Cove and Obes Thorofare, Brigantine (Fig. 1A; Table 2, sites 24, 25, 26) had concentrations ranging 2-2.8×10^6 cells ml^{-1}.

Western Long Island South Shore Sites

A. anophageffens was present at all 14 western Long Island south shore sites (Table 3, sites 72-85) sampled during the first three weeks of June, 2001. At 13 of these sites, sampled multiple times, cell levels increased slightly during the month. Highest cell levels (~1000-2000 cells ml^{-1}) were found in coastal ocean samples from the vicinity of Jones Inlet (sites 3, 74, 75); considerably lower levels were found in this Inlet (site 78).

Salinity and Temperature Conditions

Encompassing open ocean and estuarine locations from Portsmouth, New Hampshire to the Chesapeake Bay, Anderson et al. (1993) detected *A. anophageffens* in waters having salinities ranging from18-32 PSU. In our western New York Bight surveys we detected it in a similar salinity range: 18.5-34 PSU; the temperatures of waters we found it in ranged 14.1-28.3˚C.

DISCUSSION

Prior to the surveys we report, the only available *A. anophagefferens* incidence information for the western New York Bight was that of Anderson et al. (1993) who provided data from single samplings of five sites in September 1988 and eight sites in August 1990. Our results are insufficiently comprehensive to support conclusions about *A. anophagefferens* population dynamics in western New York Bight waters, but are a substantial increase in incidence information. It is clear now that the species is distributed along the whole coast of New Jersey, in coastal ocean waters, and especially in certain embayments. It appears to be firmly established in some embayments as a constituent of the phytoplankton community. *A. anophagefferens* does not flourish unless environmental conditions are suitable. Comparison of 1998 and 1999 incidences shows that distribution of the species, and suitability of a body of water to support high concentrations of the species, are best gauged when regional environmental conditions are favorable. Our results also show that single assessments of incidence can be unreliable, and multiple assessments through a growing season are necessary.

In New Jersey coastal ocean waters *A. anophagefferens* evidenced consistent presence in relatively low abundance (usually $\leq$ 300 cells ml^{-1}). Although detected at ~5000 cells ml^{-1} at a coastal ocean site in June, 1999 - when it bloomed intensely in the Barnegat Bay-Little Egg Harbor system, Great Bay, and some contiguous bays to the south - it was never found in high abundance in ocean waters. Difference in mean levels between New Jersey southern and northern coastal ocean waters was not apparent. Comparison of limited data available from a decade earlier suggests little change in levels of the species; Anderson et al.(1993) reported levels of 49 and 243 cells ml^{-1}, respectively, at two New Jersey coastal ocean sites in their 1990 survey. Presence of *A. anophagefferens* along the northern half of the New Jersey ocean shore detected by Anderson et al. (1993) in their 1990 survey, is confirmed to the year 2000. Anderson et al. (1993) did not detect the species south of Great Bay, NJ. The present study, therefore, extends its known range in western New York Bight coastal ocean waters south to Delaware Bay. It is noted that in 1998, a non-bloom year, all five coastal sites south of Atlantic City sampled had presence of *A. anophagefferens* (range 36-118 cells ml^{-1}), whereas only one of six intracoastal sites in this area had it present, and this below detection level for enumeration.

Sampling the southern region in bloom years (1995, 1997, 1999, 2000) and sampling the northern region primarily in1998, a non-bloom year, likely skewed results but, nevertheless, the data do suggest greater incidence in the southern region. Supporting this is that there are more bodies of water potentially of high suitability for the species in the southern coastal region than in the northern coastal region. Central on the New Jersey coast, the Barnegat Bay-Little Egg Harbor estuarine system, New Jersey's principal barrier island system, has a history of brown tide occurrence. South of this system, a similar complex of bays or "sounds"connected by intracoastal channels (including the Intracoastal Waterway) extends along the New Jersey coast. In contrast, to the north, the Metedeconk River, Manasquan River and Shark River are the only sizeable estuarine waters between Barnegat Bay and the Hudson-Raritan estuarine system. Generally higher incidence of *A. anophagefferens* in the southern region in1999, relative to other bloom years, suggests especially favorable conditions that year. Higher incidence and occurrence of its blooms in certain New Jersey embayments follows a similar pattern of its incidence and blooms on Long Island. Paralleling its distribution in abundance on Long Island being limited to embayments and barrier island systems in the eastern region, at distance from the Hudson-Raritan estuary and adjacent waters, greatest incidence and abundance in New Jersey was found in the central and southern coast regions.

During the June1999 *A. anophagefferens* bloom, high levels (2-2.8 x 10^6 cells ml^{-1}) were detected, to approximately six km south of Great Bay, in Reed Bay, Perch Cove and Obes Thorofare, Brigantine. This was the first confirmed bloom occurrence south of Great Bay. These cell levels are comparable to the maximum reported for eastern Long Island (Bricelj and Lonsdale, 1997). Because Absecon Bay is directly contiguous with Reed Bay, the bloom likely was present there also, but Absecon Bay unfortunately was not sampled at the time. A June 1999 level of 2.5 x 10^4 cells ml^{-1} detected in Beach Thorofare at Atlantic City (Table 2, site 21), about 13 km south of Great Bay, is further evidence of southward occurrence of the bloom. This population was below reported detrimental level when sampled. However, *A. anophagefferens* concentration can approximately double in a day (Dzurica et al., 1989). Beach Thorofare is contiguous with Absecon Bay on its south side; the elevated level detected in the Thorofare supports suspicion that the species bloomed in Absecon Bay. The comparably high *A. anophagefferens* level (1.7 x 10^6 cells ml^{-1}) at Oyster Creek at the south shore of Great Bay at this time suggests continuity of the bloom in the Barnegat Bay-Little Egg Harbor system with bloom occurrence to the south.

The Hudson-Raritan estuary, where high primary productivity is characteristic (O'Reilly et al., 1976), and where intense blooms of various phytoplankton species have recurred over the last several decades (Olsen and Mahoney, 2001), does not appear to be a system where brown tide might be expected. *A. anophagefferens* has been present in the estuary for at least nine years (Anderson et al.,1993) and was detected there only in relatively low numbers in years when it was blooming in the Barnegat Bay-Little Egg Harbor system. Its long term-presence but apparent inability to bloom in the Hudson-Raritan estuary, suggests water quality unfavorable to the species may be a factor. Steele et al. (1989) found *A. anophagefferens* to be among the most sensitive species of marine flora and fauna tested to organic and metal toxicants, e.g., it is very sensitive to copper. Bioassay studies in 1982 indicated that this estuary is not generally suitable for the toxic dinoflagellate *Gonyaulax tamarensis* (=*Alexandrium tamarense*) (Mahoney et al., 1988).

Comparison of *A. anophagefferens* incidence from a non-bloom year and a bloom year suggests that *A. anophagefferens* regulation can be general from Barnegat Bay south to Cape May at least, and not specific to the Barnegat Bay-Little Egg Harbor-Great Bay system where it flourishes best. The western Long Island incidence data are limited but serve to begin to close an information gap. A possible explanation for the higher June, 2001 levels in western Long Island coastal ocean sites (74. 75, 76) relative to estuarine sites is that a minor bloom (cell concentration to 4.6 x 10^5 cells ml^{-1}; Nuzzi, unpublished data) occurred at the same time in mid- to western Great South Bay and bloom water may have flowed westward from Fire Island Inlet. Levels of *A. anophagefferens* in Long Island and New Jersey coastal ocean waters were roughly comparable.

Recommendations

Because an intense bloom of *A. anophagefferens* is not necessary for detrimental effects, in addition to bloom centers monitoring should be conducted in areas that have history or apparent potential for supporting levels of the species $\geq 3.5 \times 10^4 < 2.0 \times 10^5$ cells ml^{-1}.

The Hudson-Raritan estuary and western Long Island bays apparently have never experienced brown tides but are proximal to areas where brown tides recur. Because at least some of these waters characteristically support high primary productivity and factors regulating bloom occurrence may change, regular survey of these waters is recommended.

IN MEMORIAM

One of the authors, Christine Zetlin, is recently deceased. She is missed by her colleagues. Typical of her research dedication, she contributed to this report while seriously ill.

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Table 1. *A. anophagefferens* presence at Atlantic Ocean sites along the coast of New Jersey. Temperature data indicated to be approximate (~) were provided by Monmouth County, NJ, Department of Health for sampling sites in the general area and within two days of USEPA sampling for *A. anophagefferens*. "P" indicates present but not detected during enumeration.

(Site #)/Shore Location	EPA Sta.#	Latitude	Longitude	Date (m/d/yr)	Salinity (PSU)	Temp. (˚C)	Cells ml^{-1}
(3) Atl. Oc. off Cape May Point	JC99	38 55 48.9	74 57 33.1	8-23-95			0
"	"	"	"	7-30-98		21.7	118
"	"	"	"	6-16-99	33.0	19.6	4682
(5) Atl. Oc. off Avalon	JC89	39 05 30.8	74 43 2.3	7-30-98	32.0	23.0	44
(12) Atl. Oc. off Peck Beach	JC83	39 14 4.9	74 37 21.6	8-12-98		24.6	80
(13) "	JC85A	39 14 3.4	74 35 37.5	5-31-00	31.5	14.8	143
(17) Atl. Oc. off Ventnor City	JC77A	39 19 43	74 28 37.5	8-13-98			103
"	"	"	"	8-27-98			36
(19) Atl. Oc. off Atlantic City	JC75	39 21 7.6	74 26 13.2	7-7-99		19.5	214
(35) Atl. Oc off Ship Bottom	JC54B	39 38 0.42	74 08 52.5	5-31-00	27.5	14.9	86
(39) Atl. Oc. off Barnegat	JC61	39 45 26.8	74 05 37	7-7-99	32.0	24.4	2421
(45) Atl. Oc. off Seaside Heights	JC53	39 56 16.8	74 04 11.9	6-30-99	33.0		1076
(49) Atl. Oc. off Manasquan	JC35	40 06 9.6	74 01 53.9	5-21-97	29.0		65
"	"	"	"	6-5-97	28.9		0
"	"	"	"	6-18-97	29.0		253
"	"	"	"	7-17-97	30.7	23.4	100
"	"	"	"	7-30-97	29.7	~22	287
"	"	"	"	8-20-97	30.3	21.1	P
"	"	"	"	8-27-97	31.5	22.5	0
"	"	"	"	7-30-98	31.5	17.3	287
"	"	"	"	8-12-98	29.5	23.3	258
"	"	"	"	8-27-98	28.7	22.9	264

Table 1 continued

(50) Atl. Oc. off Sea Girt	JC24A	40 07 48.4	74 01 4.5	5-31-00	27.5	14.2	393
(54) Atl. Oc. off Monmouth Bch.	JC11	40 19 55.1	73 58 17.9	5-21-97	29.5		0
“	”	“	”	6-5-97	28.3		187
“	“	”	“	6-18-97	28.5		294
“	”	“	”	7-17-97	29.0	24.2	0
“	”	“	”	8-27-97	31.3	~23	0
“	”	“	”	6-18-98	28.4	17.7	294
“	”	“	”	7-15-98	31.0	18.1	0
“	“	”	“	7-30-98	30.0	21.2	220
“	”	“	”	8-12-98	29.5	23.7	31
“	”	“	”	8-27-98	27.5	23.2	0
“	”	“	”	5-31-00	26.0	14.1	73

Table 2. *A. anophagefferens* incidence at Delaware Bay (DB) sites, intracoastal waterway sites south of Little Egg Harbor, and sites in the Hudson-Raritan estuary and some contiguous rivers. “P” indicates present but not detected during enumeration. GB = Great Bay; SR = Shrewsbury River; NR = Navesink River; SHB = Sandy Hook Bay; RB = Raritan Bay. Temperature data indicated to be approximate (~) were provided by Monmouth County NJ Dept. of Health for sites in the general area and within two days of sampling for *A. anophagefferens*.

(Site. #)/Location	EPA Sta. #	Latitude	Longitude (m/d/yr)	Date	Salinity (PSU)	Temp. (˚C)	Cells ml^{-1}
(1) DB off Pierces Point	DB1	39 04 58.8	74 54 47.4	8-23-95			0
“	”	“	”	6-18-97	24.0		1634
“	”	“	”	7-15-98	27.5	25.6	0
“	”	“	”	7-30-98	27.9	24.8	290
“	”	“	”	8-12-98	26.2	26.0	129
“	”	“	”	5-31-00	20.0	17.1	651
“	”	“	”	6-22-00	20.0	25.6	1421
(2) DB off Cape May Pt.	DB3	38 55 48.4	74 59 22.6	5-31-00	30.0	15.5	1654
“	”	“		6-22-00	32.0	21.6	2870
(4) Del. Bay Canal		38 58 04.2	74 57 45.0	9-30-98	29.0	21.9	0
“	”	“		6-14-99	33.0	20.4	226
“	”	“		5-31-00	32.0	15.5	1654
(5) Wildwood Crest		38 59 23.4	74 49 59.7	7-7-98	31.5	26.3	0
“		”	“	9-30-98	33.0	21.6	0
“		”	“	6-14-99	34.0	21.5	161
“		”	“	5-31-00	32.5	15.4	164
(6) Stone Harbor		39 03 29.0	74 45 57.5	7-7-98	31.5	27.4	P
“		”	“	9-30-98	33.0	21.2	P
“		”	“	6-14-99	33.5	22.4	226
“		”	“	5-31-00	32.0	15.5	129

Table 2 continued

(8) Avalon		39 06 35.0	74 44 30.0	7-7-98	31.5	25.6	0
(9) DB Reeds Beach		39 07 38.4	74 53 24.0	6-14-99	22.5	24.0	460
"		"	"	5-31-00	18.5	16.0	89
(10) Sea Isle City		39 09 25.3	74 42 01.4	7-7-98	32.0	26.5	0
"		"	"	9-30-98	32.8	22.0	0
"		"	"	6-14-99	34.0	22.5	1679
"		"	"	5-31-00	32.5	16.0	129
(12) Corson's Inlet		39 12 55.0	74 38 50.0	7-7-98	32.0	24.1	0
(14) Ocean City		39 15 13.6	74 37 42.7	7-7-98	29.5	26.0	P
"		"	"	9-30-98	33.0	21.6	0
"		"	"	6-14-99	33.0	23.4	2970
"		"	"	5-31-00	28.5	16.0	114
(15) Great Egg Inlet (GEI)	GE1	39 17 25.2	74 34 25.2	8-23-95			681
"	"	"	"	7-15-98	31.3	22.0	106
"	"	"	"	7-30-98	32.1	20.6	339
"	"	"	"	8-13-98	30.9	24.6	89
"	"	"	"	6-16-99	32.5	20.1	2583
"	"	"	"	6-14-00	30	22.9	258
"	"	"	"	6-28-00	28.5		807
(16) GEI Broad Thorofare		39 18 48.4	74 33 41.4	9-30-98	31.0	21.5	0
"		"	"	6-14-99	33.0	22.6	646
"		"	"	5-31-00		18.0	64
"		"	"	6-22-00	32.5	23.7	2098
(18) Margate		39 21 12.7	74 32 20.6	7-7-98	30.5	25.6	0
"		"	"	9-30-98	33.0	21.4	0
"		"	"	6-14-99	34.0	23.5	936
"		"	"	5-31-00	31.5	17.0	185
(20) Clam Creek (Atl. City)		39 22 38.8	74 25 35	7-7-98	31.5	22.5	0
(21) Beach Thorofare (Atl. City)		39 22 38.8	74 27 10	6-14-99	33.5	22.5	25,089
(22) Newfound Thorofare (Atl. City)		39 23 9	74 27 55.5	7-7-98	31.0	25.6	0
"		"	"	9-30-98	33.0	21.9	0
(23) Pleasantville		39 23 00.1	74 31 05.4	7-7-98	30.0	28.3	P
"		"	"	9-30-98	32.2	21.4	0

Table 2 continued

(24) Obes Thorofare, Brigantine		39 25 23.9	74 22 02.0	7-7-98	30.5	24.0	P
"		"	"	9-30-98	33.0	21.3	93
"		"	"	6-14-99	33.0	22.4	2.81KK
"		"	"	5-31-00	30.5	15.5	377
(25) Perch Cove		39 27 22	74 26 00	6-22-99			2.1KK
(26) Reed Bay		39 27 30	74 26 00	6-22-99			2.01KK
(27) Oyster Creek (GB)		39 30 20	74 24 45	9-30-98	29.5	21.4	0
"		"	"	6-22-99			1.74KK
"		"	"	5-31-00		15.9	839
"		"	"	6-14-00	32.5	21.9	1032
"		"	"	6-22-00	31	23.5	409
"		"	"	6-28-00	32		484
"		"	"	7-5-00	31	25.8	258
"		"	"	7-26-00	28.5	25.6	253
"		"	"	8-2-00	29	26.3	220
"		"	"	8-9-00	29	28.3	256
"		"	"	8-16-00	29.5	23.2	292
(51) Shark River at Belmar		40 10 45.9	74 1 50.2	7-14-98	29.5	19.0	P
(52) Pleasure Bay (SR)		40 18 45.8	74 00 12	7-9-98	20.0	26.0	0
(53) Parker Creek (SR)		40 19 30.1	74 01 17	7-9-98	19.5	25.5	0
(55) Monmouth Beach (SR)		40 20 10.3	73 58 50.4	7-9-98	22.0	24.0	P
(56) Little Silver Creek (SR)		40 20 14	74 01 50.2	7-9-98	22.5	26.0	0
(59) Red Bank (NR)		40 21 16.9	74 03 52.9	7-9-98	17.0	25.0	0
(57) Oyster Bay (SR)		40 21 33.8	73 58 56	7-9-98	21.5	25.5	0
(58) Sea Bright (SR)		40 21 53.9	73 58 30	7-9-98	22.0	23.0	0
(60) Oceanic (NR)		40 22 37.1	74 00 45.7	7-9-98	20.5	23.2	0
(61) Claypit Creek (NR)		40 23 37	74 01 20.4	7-9-98	19.0	23.0	0
(62) Highlands (SHB)		40 23 49.7	73 58 52.1	7-9-98	24.5	20.0	P
(63) Sandy Hook Bay (inner)	SH1	40 25 15.4	74 00 16.5	5-31-00	24.0	14.8	711
(64) Leonardo (SHB)		40 26 20.2	74 03 35.1	7-9-98	24.0	20.0	P
(65) Keyport (RB)		40 26 20.3	74 11 55.1	7-9-98	21.5	23.0	0

Table 2 continued

(66) Sandy Hook Bay (mid)	RB15	40 26 42	74 00 48	8-23-95			136
“	”	“	”	5-21-97	24.5		39
“	”	“	”	6-4-97	24.4		85
“	”	“	”	6-18-97	25.5	22.0	170
“	”	“	”	7-2-97	27.4	22.7	27
“	”	“	”	7-17-97	26.7	26.1	28
“	”	“	”	7-30-97	23.8		0
“	”	“	”	8-20-97	27.3	~24	P
“	”	“	”	8-27-97	27.7	26.1	27
“	”	“	”	7-15-98	25.0	23.6	64
“	”	“	”	7-30-98	25.5	25.8	68
“	”	“	”	8-12-98	25.1	25.4	241
(69) Sandy Hook Bay (outer)	RB51A	40 26 48	74 04 24	5-21-97	21.2		19
“	”	“	”	6-4-97	24.6		25
“	“	”	“	6-10-97	24.2		348
“	”	“	”	7-2-97	25.5	22.9	62
“	”	“	”	7-30-97	24.7	22.9	20
“	”	“	”	8-20-97	26.9	~25	P
“	”	“	”	8-27-97	27.3	~23	P
“	”	“	”	7-15-98	25.5	22.4	196
“	”	“	”	7-30-98	26.5	24.3	101
“	”	“	”	8-12-98	23.3	25.3	116
“	”	“	”	8-27-98	24.3	25.5	66
(67) Horseshoe Cove (SHB)		40 26 50	73 59 55.2	7-9-98	24.0	23.0	0
(68) Keansburg (SHB)		40 26 55.1	74 07 8.5	7-9-98	23.0	22.0	0
(70) Cheesequake (RB)		40 27 45.2	74 15 30.4	7-9-98	21.5	22.2	0
(71) Raritan Bay (Outer)	RB1	40 28 30.4	74 10 38.5	5-31-00	21.5	15.8	246

Table 3. *A. anophagefferens* incidence at Nassau County, NY, estuarine and coastal sites in June 2001. A range of salinities is given for some 6-5-01 samples because of salinity sample identification difficulty.

(Site #)/Location	EPA Sta. #	Latitude	Longitude	Date (m/d/yr)	Salinity (PSU)	Temp. (˚C)	Cells ml^{-1}
(72) Atl. Oc. off Rockaway	LIC02	40 33 40.2	73 52 39	6-19-01	33	20.5	194
(73) Rockaway Inlet, Beach Chan.		40 34 41	73 52 12	6-5-01	30	18.1	64
“	”	“	“	6-11-01	30	17.2	64
“	”	“	”	6-19-01	28.5	22.5	97
(74) Atl. Oc. off Short Beach	LIC12	40 34 46.2	73 33 35.4	6-19-01	33.5	20.6	1905
(75) Atl. Oc. off Long Beach	LIC09	40 34 57.6	73 38 8.4	6-19-01	32.5	21.1	1033
(76) Atl. Oc off Far Rockaway	LIC05	40 35 23.4	73 45 57.6	6-19-01	33	20.2	678
(77) Jamaica Bay, Beach Ch.		40 35 28	73 49 03	6-11-01	30	19.1	97
“		“	”	6-19-01	28	23.7	205
(78) Jones Inlet		40 35 39	73 33 19	6-5-01	28-34.5	13.6	32
“		”	“	6-11-01	34	14.4	64
“		”	“	6-19-01	33	21.2	323
(79) Reynolds Ch. off Lg. Mead. Is.		40 35 45	73 35 34	6-5-01	28-34.5	18.1	64
“		“	“	6-11-01	33	14.8	97
“		“	”	6-19-01	30	23.0	161
(80) ” off Cinder Is.		40 35 45	73 36 41	6-11-01	34	16.1	32
“		“	”	6-19-01	30	22.8	64
(81) ” off Est. Ch. Is.		40 35 48	73 37 48	6-11-01	33	17.9	97
”		“	“	6-19-01	30.5	22.5	194
(82) Sloop Channel		40 36 00	73 32 00	6-11-01	33	15.1	64
”		“	”	6-19-01	31	22.6	355
(83) Zachs Bay		40 36 05	73 29 20	6-5-01	28-34.5	16.2	0
“		”	“	6-11-01	34	18.4	64
“		“	”	6-19-01	31	23.3	452

Table 3 continued

(84) Sth. Oyster Bay off West Is.	40 37 52	73 27 00	6-5-01	28-34.5	17.8	64
“	“	”	6-11-01	33.5	20.2	226
“	”	”	6-19-01	31	23.5	226
(85) Gt. Sth. Bay off Amityville	40 39 07	73 24 55	6-5-01	28-34.5	19.3	97
”	“	”	6-11-01	32.5	21.8	258
”	“	”	6-19-01	29	24.8	0

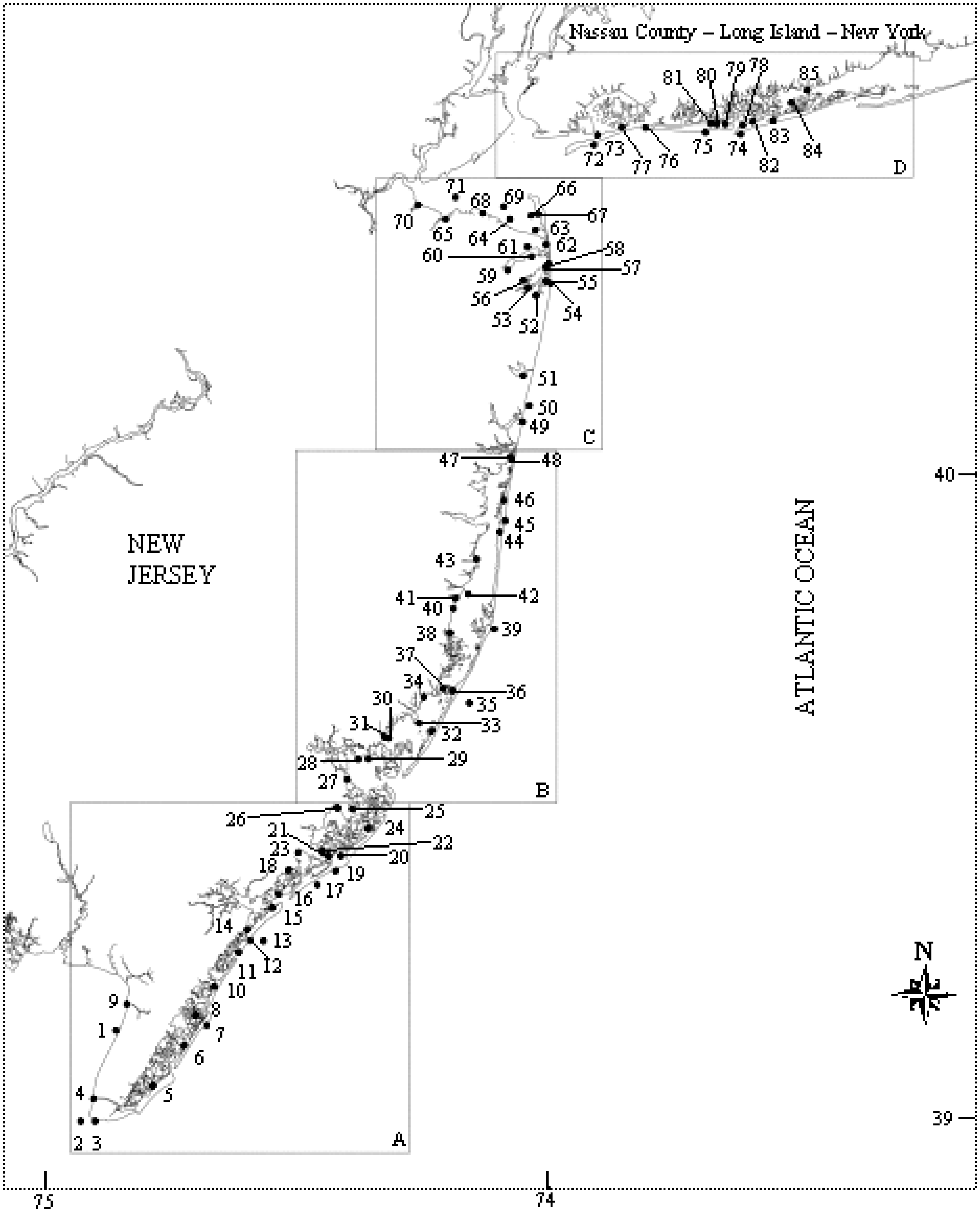
Figure 1. Map of western New York Bight showing locations of sampling sites; site numbers are the same as those in Tables 1-3. Numbers are assigned by latitude, from south to north.

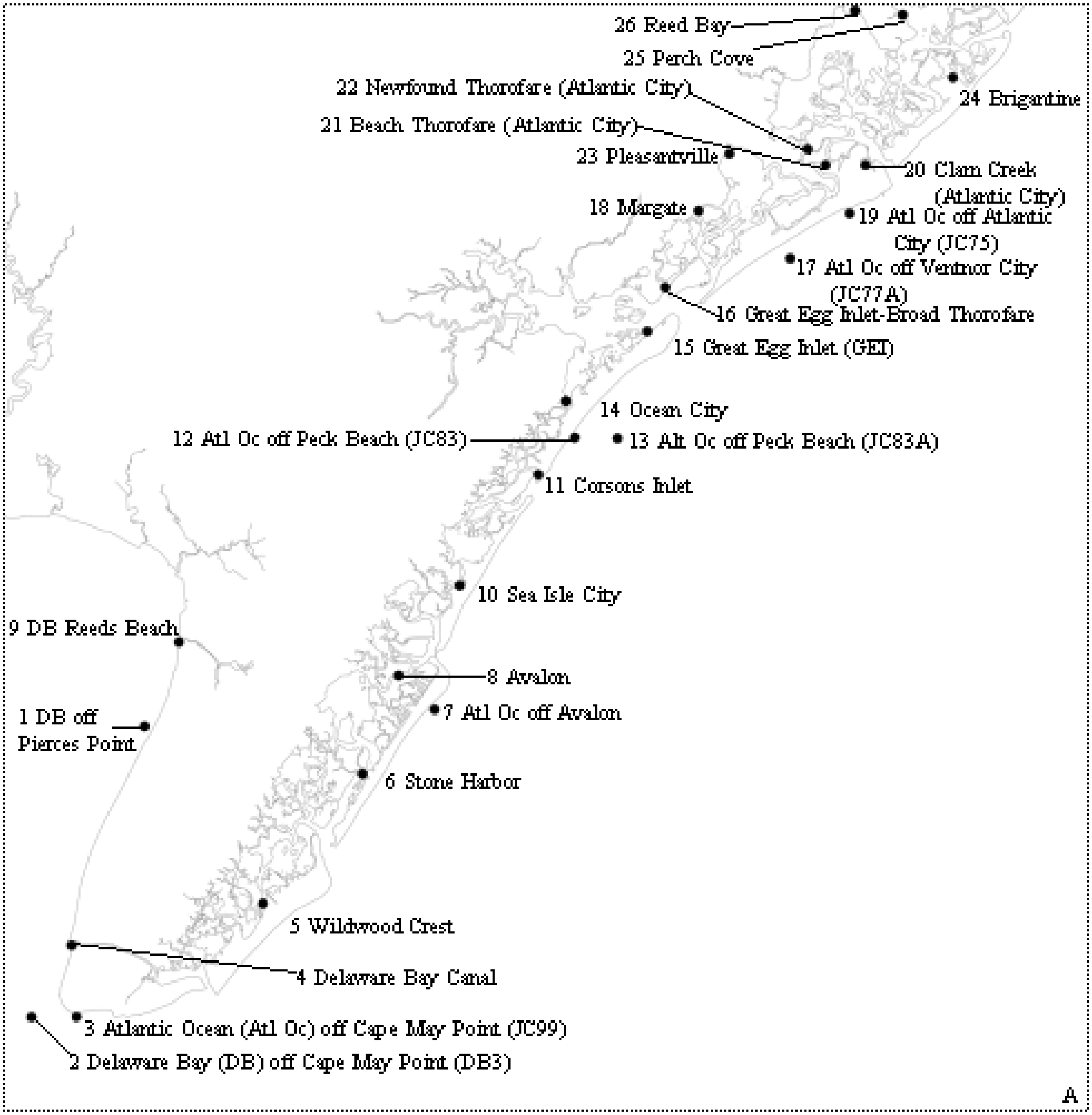
Figure 1A. Map of southern New Jersey coastal region, from Delaware Bay to the southern shore of Great Bay, sampling sites named.

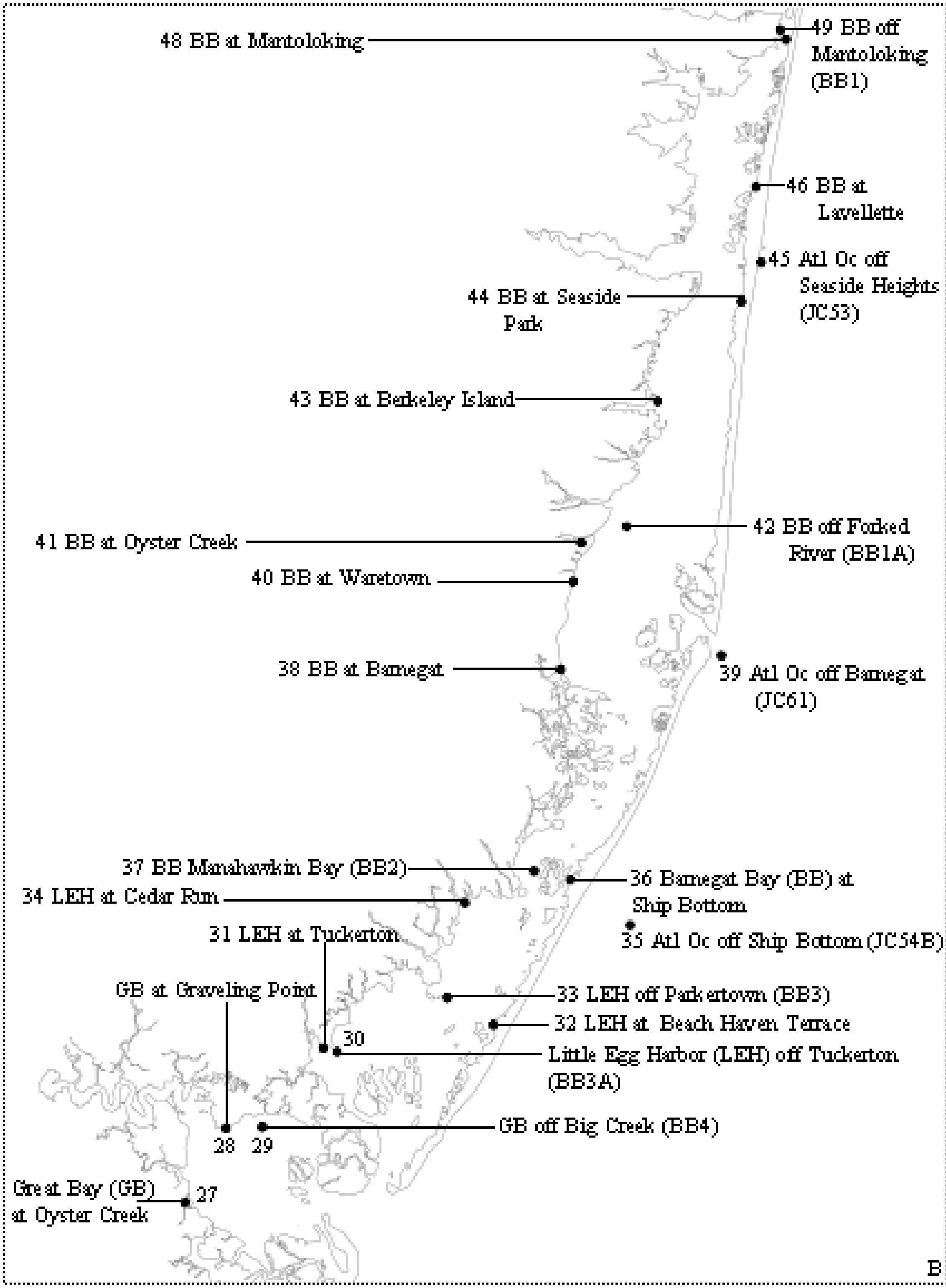
Figure 1B. Map of central New Jersey coastal region, south shore of Great Bay to Mantoloking, sampling sites named.

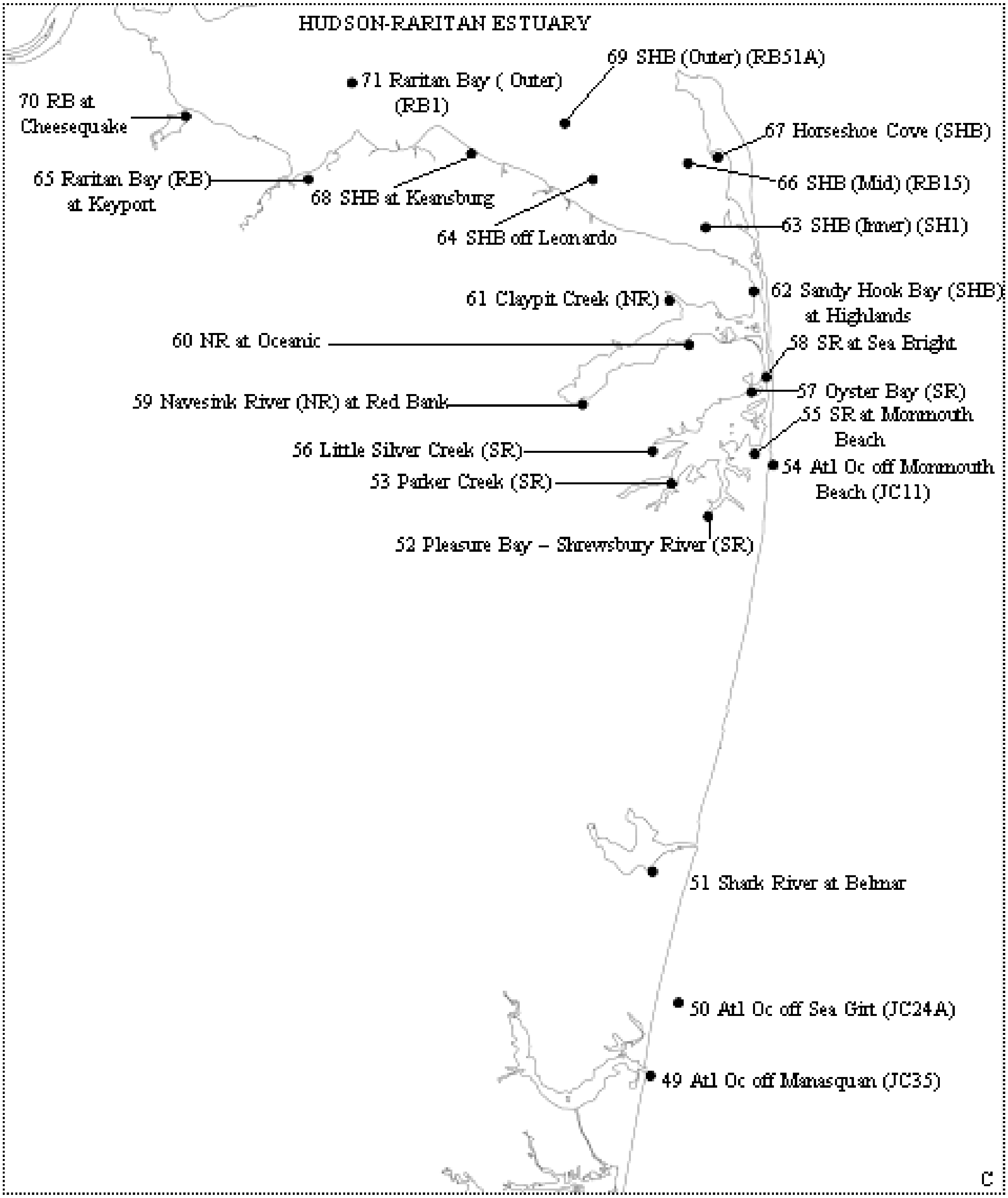
Figure 1C. Map of northern New Jersey coastal region, from Shark River to the Hudson-Raritan estuary, sampling sites named.

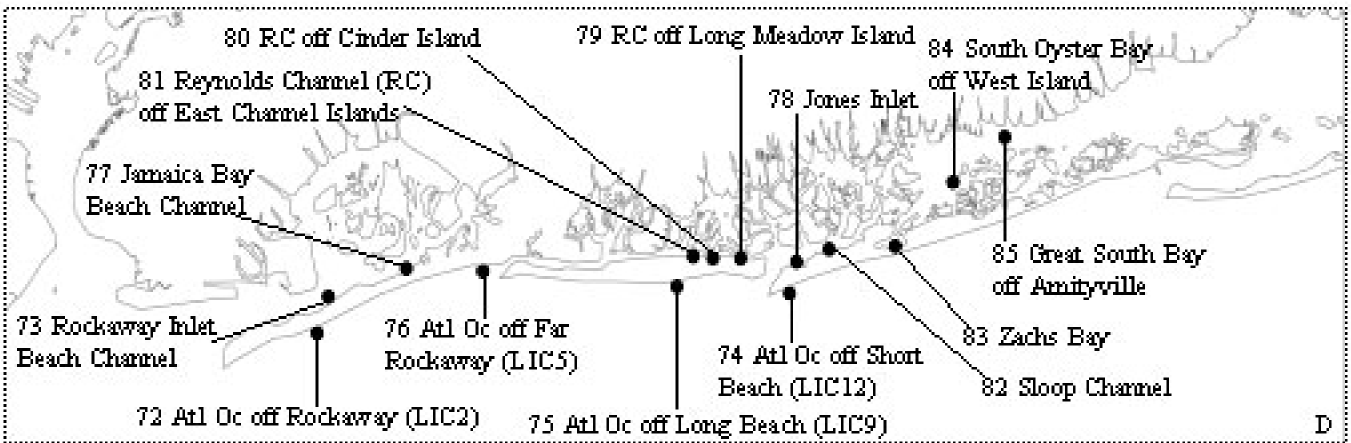
Figure 1D. Map of southern shore of western Long Island, NY, sampling sites named.


Nassau County – Long Island – New York
NEW JERSEY
ATLANTIC OCEAN
N
A
B
C
D
40
39
75
74


26 Reed Bay
25 Perch Cove
22 Newfound Thorofare (Atlantic City)
24 Brigantine
21 Beach Thorofare (Atlantic City)
23 Pleasantville
20 Clam Creek (Atlantic City)
18 Margate
19 Atl Oc off Atlantic City (JC75)
17 Atl Oc off Ventnor City (JC77A)
16 Great Egg Inlet-Broad Thorofare
15 Great Egg Inlet (GEI)
14 Ocean City
12 Atl Oc off Peck Beach (JC83)
13 Alt Oc off Peck Beach (JC83A)
11 Corsons Inlet
10 Sea Isle City
9 DB Reeds Beach
8 Avalon
1 DB off Pierces Point
7 Atl Oc off Avalon
6 Stone Harbor
5 Wildwood Crest
4 Delaware Bay Canal
3 Atlantic Ocean (Atl Oc) off Cape May Point (JC99)
2 Delaware Bay (DB) off Cape May Point (DB3)
A


48 BB at Mantoloking
49 BB off Mantoloking (BB1)
46 BB at Lavellette
45 Atl Oc off Seaside Heights (JC53)
44 BB at Seaside Park
43 BB at Berkeley Island
42 BB off Forked River (BB1A)
41 BB at Oyster Creek
40 BB at Waretown
38 BB at Barnegat
39 Atl Oc off Barnegat (JC61)
37 BB Manahawkin Bay (BB2)
36 Barnegat Bay (BB) at Ship Bottom
34 LEH at Cedar Run
35 Atl Oc off Ship Bottom (JC54B)
31 LEH at Tuckerton
GB at Graveling Point
33 LEH off Parkertown (BB3)
32 LEH at Beach Haven Terrace
30
Little Egg Harbor (LEH) off Tuckerton (BB3A)
28
29
GB off Big Creek (BB4)
Great Bay (GB) at Oyster Creek
27
B


HUDSON-RARITAN ESTUARY
69 SHB (Outer) (RB51A)
71 Raritan Bay (Outer) (RB1)
70 RB at Cheesequake
67 Horseshoe Cove (SHB)
65 Raritan Bay (RB) at Keyport
68 SHB at Keansburg
66 SHB (Mid) (RB15)
64 SHB off Leonardo
63 SHB (Inner) (SH1)
61 Claypit Creek (NR)
62 Sandy Hook Bay (SHB) at Highlands
60 NR at Oceanic
58 SR at Sea Bright
59 Navesink River (NR) at Red Bank
57 Oyster Bay (SR)
55 SR at Monmouth Beach
56 Little Silver Creek (SR)
54 Atl Oc off Monmouth Beach (JC11)
53 Parker Creek (SR)
52 Pleasure Bay – Shrewsbury River (SR)
51 Shark River at Belmar
50 Atl Oc off Sea Girt (JC24A)
49 Atl Oc off Manasquan (JC35)
C


80 RC off Cinder Island
79 RC off Long Meadow Island
84 South Oyster Bay off West Island
81 Reynolds Channel (RC) off East Channel Islands
78 Jones Inlet
77 Jamaica Bay Beach Channel
85 Great South Bay off Amityville
73 Rockaway Inlet Beach Channel
76 Atl Oc off Far Rockaway (LIC5)
74 Atl Oc off Short Beach (LIC12)
83 Zachs Bay
82 Sloop Channel
72 Atl Oc off Rockaway (LIC2)
75 Atl Oc off Long Beach (LIC9)
D

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MEDIA MAIL

Publications and Reports of the Northeast Fisheries Science Center

The mission of NOAA's National Marine Fisheries Service (NMFS) is "stewardship of living marine resources for the benefit of the nation through their science-based conservation and management and promotion of the health of their environment." As the research arm of the NMFS's Northeast Region, the Northeast Fisheries Science Center (NEFSC) supports the NMFS mission by "planning, developing, and managing multidisciplinary programs of basic and applied research to: 1) better understand the living marine resources (including marine mammals) of the Northwest Atlantic, and the environmental quality essential for their existence and continued productivity; and 2) describe and provide to management, industry, and the public, options for the utilization and conservation of living marine resources and maintenance of environmental quality which are consistent with national and regional goals and needs, and with international commitments." Results of NEFSC research are largely reported in primary scientific media (*e.g.*, anonymously-peer-reviewed scientific journals). However, to assist itself in providing data, information, and advice to its constituents, the NEFSC occasionally releases its results in its own media. Those media are in four categories:

NOAA Technical Memorandum NMFS-NE -- This series is issued irregularly. The series typically includes: data reports of long-term field or lab studies of important species or habitats; synthesis reports for important species or habitats; annual reports of overall assessment or monitoring programs; manuals describing program-wide surveying or experimental techniques; literature surveys of important species or habitat topics; proceedings and collected papers of scientific meetings; and indexed and/or annotated bibliographies. All issues receive internal scientific review and most issues receive technical and copy editing.

Northeast Fisheries Science Center Reference Document -- This series is issued irregularly. The series typically includes: data reports on field and lab studies; progress reports on experiments, monitoring, and assessments; background papers for, collected abstracts of, and/or summary reports of scientific meetings; and simple bibliographies. Issues receive internal scientific review, but no technical or copy editing.

Resource Survey Report (formerly *Fishermen's Report*) -- This information report is a quick-turnaround report on the distribution and relative abundance of selected living marine resources as derived from each of the NEFSC's periodic research vessel surveys of the Northeast's continental shelf. There is no scientific review, nor any technical or copy editing, of this report.

The Shark Tagger -- This newsletter is an annual summary of tagging and recapture data on large pelagic sharks as derived from the NMFS's Cooperative Shark Tagging Program; it also presents information on the biology (movement, growth, reproduction, etc.) of these sharks as subsequently derived from the tagging and recapture data. There is internal scientific review, but no technical or copy editing, of this newsletter.

OBTAINING A COPY: To obtain a copy of a *NOAA Technical Memorandum NMFS-NE* or a *Northeast Fisheries Science Center Reference Document*, or to subscribe to the *Resource Survey Report* or the *The Shark Tagger*, either contact the NEFSC Editorial Office (166 Water St., Woods Hole, MA 02543-1026; 508-495-2228) or consult the NEFSC webpage on "Reports and Publications" (*http://www.nefsc.noaa.gov/nefsc/publications/*).

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