Northeast Fisheries Science Center Reference Document 98-10

Seasonal Distribution and Abundance of 26 Species of Fish and Megainvertebrates Collected in the Hudson-Raritan Estuary, January 1992 - December 1997

by

Stuart J. Wilk, Robert A. Pikanowski,
Donald G. McMillan, and Eileen M. MacHaffie

October 1998

Northeast Fisheries Science Center Reference Document 98-10

Seasonal Distribution and Abundance of 26 Species of Fish and Megainvertebrates Collected in the Hudson-Raritan Estuary, January 1992 - December 1997

by

Stuart J. Wilk, Robert A. Pikanowski, Donald G. McMillan, and Eileen M. MacHaffie

James J. Howard Marine Science Lab., National Marine Fisheries Serv., Highlands, NJ 07732

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
Northeast Fisheries Science Center
Woods Hole, Massachusetts

October 1998

The *Northeast Fisheries Science Center Reference Document* series is an informal report series designed to assure the long-term documentation and to enable the timely transmission of research results emanating from various Center laboratories. The reports are reviewed internally before publication, but are not considered formal literature. The National Marine Fisheries Service does not endorse any proprietary material, process, or product mentioned in these reports. To obtain additional copies of this report, contact the senior Center author. Refer to the title page of this report for the senior Center author's name and mailing address.

This report may be cited as: Wilk, S.J.; Pikanowski, R.A.; McMillan, D.G.; MacHaffie, E.M. 1998. Seasonal distribution and abundance of 26 species of fish and megainvertebrates collected in the Hudson-Raritan Estuary, January 1992 - December 1997. *Northeast Fish. Sci. Cent. Ref. Doc.* 98-10; 145 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

The publication history of this report is as follows: manuscript submitted for review -- June 3, 1998; manuscript accepted through technical review -- September 8, 1998; manuscript accepted through policy review -- September 18, 1998; and camera-ready copy submitted for publication -- October 6, 1998.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Seasonal distribution and abundance maps, based on 1805 8.5-m otter trawl tows made in the Hudson-Raritan Estuary between January 1992 and December 1997, are presented for 26 species of fish and megainvertebrates. The 26 species illustrated are: clearnose skate, *Raja eglanteria*; little skate, *Raja erinacea*; winter skate, *Raja ocellata*; blueback herring, *Alosa aestivalis*; alewife, *Alosa pseudoharengus*; Atlantic herring, *Clupea harengus*; bay anchovy, *Anchoa mitchilli*; silver hake, *Merluccius bilinearis*; red hake, *Urophycis chuss*; spotted hake, *Urophycis regia*; northern searobin, *Prionotus carolinus*; striped searobin, *Prionotus evolans*; striped bass, *Morone saxatilis*; black sea bass, *Centropristis striata*; bluefish, *Pomatomus saltatrix*; scup, *Stenotomus chrysops*; weakfish, *Cynoscion regalis*; spot, *Leiostomus xanthurus*; butterfish, *Peprilus triacanthus*; summer flounder, *Paralichthys dentatus*; windowpane, *Scophthalmus aquosus*; winter flounder, *Pleuronectes americanus*; blue crab, *Callinectes sapidus*; Atlantic rock crab, *Cancer irroratus*; lady crab, *Ovalipes ocellatus*; and longfin squid, *Loligo pealeii*. These species dominated catches throughout the survey, accounting for greater than 90 percent of both total number and weight of all species collected.

INTRODUCTION

Background

The conflict among the various groups exploiting the Hudson-Raritan Estuary's shared resources involves approximately 40 million people and billions of dollars. Constituencies and agencies need appropriate and current information to make informed management decisions, e.g., site selection for dredge material disposal and widening and deepening of channels (US Army Corp of Engineers 1996, 1997). Therefore, this study was designed to provide: (1) a historical and timely baseline to measure natural as well as anthropogenic changes in fish distribution, abundance, ecology, and life history; (2) a means of identifying and describing habitat requirements and habits of selected species or species assemblages, e.g., temporal and spatial habitat utilization; (3) a statistically sound means of collecting synoptic physical, chemical, and biological information in a space and time framework, e.g., reproductive condition, food habits, incidence of disease, effects/distribution of body burdens of organic and inorganic compounds, benthic biomass, distribution of eggs and larvae, hydrography, etc.; (4) a basis to design and conduct directed field experiments, e.g., before and after dredging, before and after sand mining, etc.; and (5) a means to test laboratory experimental results and/or to identify parameters that can be tested in the laboratory.

Presently, the siting and associated impacts of contaminated dredged material placement, e.g., burrow pits and containment islands, are the focus of an Environmental Impact Statement to be promulgated by a multi-agency Dredge Material Management Plan (Long *et al.* 1995; US Army Corp of Engineers 1996, 1997). A portion of the siting area includes the Hudson-Raritan Estuary (Palermo *et al.* 1998). The information available from the aforementioned study conducted by NOAA/NMFS's, James J. Howard Laboratory, represents the only long term temporally comprehensive resource monitoring effort in the area (Wilk *et al.* 1996); and thus, must be included in this siting process. Therefore, it is the purpose of this document to illustrate the distribution and abundance of the 26 most abundant species of fish and megainvertebrate collected during the first six years of the study.

METHODS AND MATERIALS

Geographic Setting

The Hudson-Raritan Estuary (74°05′, 40°30′) is formed by the apex of Monmouth County, New Jersey, on the south and Staten Island and Brooklyn, New York, on the north (Figure 1). The Hudson, Raritan, and Shrewsbury-Navasink river systems feed into the estuary from the north, west, and south, respectively.

Station Selection

This study is based upon a stratified-random design. Detailed statistical descriptions and case study applications of this method can be found in Azarovitz (1980, 1994); Fogarty (1989); Grosslein (1969, 1974); Survey Working Group, Northeast Fisheries Science Center (1988) and Wilk *et al.* (1996). The design ensures both a statistically valid sample as well as comprehensive coverage of the possible ecological zones of the survey area.

The Hudson-Raritan Estuary was divided (stratified) into nine strata - the three main channels and the six non-channel areas naturally defined by the channels and the study area boundaries (Figure 2). Trawl tows could not be made in depths less than 3 m due to vessel draft. Each stratum was then divided into blocks of sufficient size to accommodate a trawl tow (Figure 3). The plan called for 40 tows to be made per cruise, 10 times per annum. However, some cruises were canceled and, on occasion, fewer than the planned 40 tows were made due to weather, vessel down-time, etc. Tows were allocated among strata in proportion to stratum surface area with the provision that at least two tows were made in each stratum. For each cruise and within each stratum the blocks towed were selected at random.

Sampling for Finfish and Megainvertebrates

Collections of fish and megainvertebrates were accomplished at randomly-selected stations from the 19.8-m (65-ft) NOAA R\V *Gloria Michelle.* The otter trawl deployed had an 8.5-m (28-ft) headrope and a 10.4-m (34-ft) footrope. The body of the trawl was constructed of 102-mm (4-inch) stretch mesh 21-thread knotted nylon. The cod end was constructed of 45-mm (1.75-inch) stretch mesh 30-thread knotted nylon and lined with 35-mm (1.375-inch) stretch mesh 18-thread knotted nylon. Three 203-mm (8-inch) diameter plastic trawl floats were equally spaced along the headrope with a sweepline constructed of 8-mm (0.313-inches) chain attached to the footrope at intervals of ≈356-mm (14-inches). Trawl doors weighing ≈36.3-kg (80-lb) were used to spread and hold the net open.

The trawl was towed for 10 minutes at ≈3.7 km/hr (2 kts) at each sampling location. If possible, trawl tows were made along isobaths to minimize sudden depth changes. Although tow time was kept constant, direction and distance of each tow were affected by current, tide, wind, and in some cases by the need to shift heading to avoid commercial and recreational vessel traffic. LORAN C coordinates and/or GPS positions, latitude, longitude, depth, and time were recorded at the beginning and end of each trawl tow.

After each tow, the trawl was retrieved and emptied on the deck. All fish and megainvertebrates were separated and identified. In addition, the more numerous crab species were segregated by sex and dealt with as separate entities. All specimens of each

species, as well as the sexed crabs, were weighed to the nearest 0.1 kg and individually measured to the nearest whole cm as follows: fish from the snout to the end of the middle caudal ray (i.e., either fork or total length depending on species); bivalves across the widest point of the shell; crabs across the widest point of the carapace; squid from the anterior margin to the posterior end of the dorsal mantle; and lobsters from the tip of the rostrum to the end of the carapace. All specimens of each species were usually measured except when large catches required subsampling. In such cases, an expansion factor (weight of total catch/weight of subsample) was applied to the number and length frequency of the subsample to estimate the number and length frequency of the total catch. All data were recorded at sea on forms designed for subsequent inclusion into a universal data management system which incorporates sorting, listing, graphical, and statistical systems to simplify data recall, analysis, and illustration.

DATA MAPPING

Cruises were conducted, when possible, each month between January 1992 and December 1997 with the exception of each May and September when the vessel was not available. A total of 1805 trawl stations were successfully sampled at randomly selected stations during 49 cruises. Twenty-six species of fish and megainvertebrates were selected for mapping: clearnose skate, *Raja eglanteria*; little skate, *Raja erinacea*; winter skate, *Raja ocellata*; blueback herring, *Alosa aestivalis*; alewife, *Alosa pseudoharengus*; Atlantic herring, *Clupea harengus*; bay anchovy, *Anchoa mitchilli*; silver hake, *Merluccius bilinearis*; red hake, *Urophycis chuss*; spotted hake, *Urophycis regia*; northern searobin, *Prionotus carolinus*; striped searobin, *Prionotus evolans*; striped bass, *Morone saxatilis*; black sea bass, *Centropristis striata*; bluefish, *Pomatomus saltatrix*; scup, *Stenotomus chrysops*; weakfish, *Cynoscion regalis*; spot, *Leiostomus xanthurus*; butterfish, *Peprilus triacanthus*; summer flounder, *Paralichthys dentatus*; windowpane, *Scophthalmus aquosus*; winter flounder, *Pleuronectes americanus*; blue crab, *Callinectes sapidus*; Atlantic rock crab, *Cancer irroratus*; lady crab, *Ovalipes ocellatus*; and longfin squid, *Loligo pealeii*.

Selected species fit into one or more of the following categories: (1) dominant, i.e., in the top 10, in terms of number, weight, or occurrence (e.g., little skate and spotted hake); (2) commercially and/or recreationally important, and in most cases, included in State, State/Federal, or Federal Fishery Management Plans (e.g., striped bass, Atlantic herring, and bluefish; and/or (3) ecologically important in the Hudson-Raritan Estuary (e.g., bay anchovy and alewife).

The analysis/map production for each species consisted of two layers. The first layer was a single map which provides overall distribution and abundance in the Hudson-Raritan Estuary, based on all trawl tows made (Figure 4). The second layer provides more detail by segregating the data by season as follows: *Winter* (Figure 5) = January-March; *Spring*

(Figure 6) = April and June (May is not sampled); *Summer* (Figure 7) = July-August (September is not sampled); and *Fall* (Figure 8) = October-December. Figures 9-138 illustrate the total as well as seasonal distribution and abundance for each species. Table 1 lists the *Total* and *Seasonal* figure numbers for each species. All maps were produced using SURFER® for Windows software. It should be noted that size, weight, and sex were not used as delineators in this *Reference Document*; however, they will be considered in subsequent individual species and species group publications.

ACKNOWLEDGMENTS

We thank all those NOAA Corp officers who expertly captained and crewed the R/V *Gloria Michelle* over the course of the study. In addition, we thank all reviewers for their critical comments that substantially improved this manuscript.

REFERENCES CITED

AZAROVITZ, T.R. 1981. A Brief Historical Review of the Woods Hole Laboratory Trawl Survey Time Series. *In:* W.G. Doubleday, and D. Rivard (eds.): Bottom Trawl Surveys (November 1980). Canadian Dept. Fish. and Oceans. Spec. Pub. Fish. and Aquatic Sciences No. 58. 273 p.

AZAROVITZ, T.R. 1994. Northeast Fisheries Science Center Bottom Trawl Surveys. *In:* T. Berger (ed.): Proceedings of a Workshop on the Collection and Use of Trawl Survey Data for Fisheries Management; August 1994; Charleston, SC; Atlantic States Marine Fisheries Commission, Special Report No. 35. 192 p.

FOGARTY, M.J. 1988. Trawl Survey Design - Random Versus Fixed Stations. *In:* T.R. Azarovitz, J. McGurrin, and R. Seagraves (eds.): Proceedings of Workshop on Bottom Trawl Surveys (August 1989). Atlantic States Marine Fisheries Commission, Spec. Rep. No. 17, 70 p.

GOSNER, K.L. 1978. A Field Guide to the Atlantic Seashore. Houghton Mifflin Co., Boston, MA. 329 p.

GROSSLEIN, M.G. 1969. Groundfish Survey Program of BCF Woods Hole. Comm. Fish. Rev. 31(8-9):22-35.

GROSSLEIN, M.G. 1974. Bottom Trawl Survey Methods of the Northeast Fisheries Center, Woods Hole, MA, USA. ICNAF Res. Doc. 74. 96 p.

LONG, E.R., D.A. WOLF, K.J. SCOTT, G.B. THURSBY, E.A. STERN, C. PEVEN, AND T. SCHWARTZ. 1995. Magnitude and Extent of Sediment Toxicity in the Hudson-Raritan Estuary. U.S. Dep. Commer., NOAA, NOS, ORCA, National Status and Trends Program, NOAA Tech. Memo. 88. 230 p.

PALERMO, M., B. EBERSOLE, L. PEYMAN-DOVE, D. LASHLEE, B. WISEMILLER, L. HOUSTON, AND R. WILL. 1998. Draft Report: Dredged Material Management Plan (DMMP) for the Port of New York and New Jersey - Siting of Island CDFs and Constructed CAD Pits. US Army Corp of Engineers, New York District, New York City, NY and Waterways Experiment Station, Vicksburg, MS. 43 p.

ROBINS, C.R., R.M. BAILEY, C.E. BOND, J.R. BROOKER, E.A. LACHNER, R.N. LEA, AND W.B. SCOTT. 1991. Common and Scientific Names of Fishes from the United States and Canada. Amer. Fish. Soc., Special Publication 20, Bethesda, MD. 183 p.

SURVEY WORKING GROUP, NORTHEAST FISHERIES CENTER. 1988. An Evaluation of the Bottom Trawl Survey Program of the Northeast Fisheries Center. U.S. Dep. Commer., NOAA, NMFS, NOAA Tech. Memo. NMFS-NE-52. 83 p. (NTIS Access. No. PB88-201983/AS).

TURGEON, D.D., A.E. BOGAN, E.V. COAN, W.K. EMERSON, W.G. LYONS, W.L. PRATT, C.F.E. ROPER, A. SCHELTEMA, F.G. THOMPSON, AND J.D. WILLIAMS. 1988. Common and Scientific Names of Aquatic Invertebrates from the United States and Canada: Mollusks. Amer. Fish. Soc., Special Publication 16, Bethesda, MD. 277 p.

US ARMY CORP OF ENGINEERS. 1996. Interim Report: Dredged Material Management Plan for the Port of New York and New Jersey. US Army Corp of Engineers, New York District, New York City, NY. 251 p.

US ARMY CORP OF ENGINEERS. 1997. Progress Report: Dredged Material Management Plan for the Port of New York and New Jersey. US Army Corp of Engineers, New York District, New York City, NY. 44 p.

WILK S.J., E.M. MACHAFFIE, D.G. MCMILLAN, A.J. PACHECO, R.A. PIKANOWSKI, AND L.L. STEHLIK. 1996. Fish, Megainvertebrates, and Associated Hydrographic Observations Collected in the Hudson-Raritan Estuary, January 1992 - December 1993. U.S. Dep. Commer., NOAA, NMFS, Northeast Fisheries Center Reference Document 96-14. 95 p.

WILLIAMS, A.B., L.G. ABELE, DL FELDER, H.H. HOBBS, JR., R.B.I. MANNING, P.A. MCLAUGHLIN, AND IP FARFANTE. 1989. Common and Scientific Names of Aquatic Invertebrates from the United States and Canada: Decapod Crustaceans. Amer. Fish. Soc. Spec. Pub. 17. 77 p.

Table 1.

Phylogenetic listing, including figure numbers, of the most common fish and megainvertebrates collected with an 8.5-m otter trawl in the Hudson-Raritan Estuary between January 1992 and December 1997. Fish are arranged according to Robins *et al.* (1991), and megainvertebrates according to Gosner (1978), Turgeon *et al.* (1988), and Williams *et al.* (1989).

Nomenclature	Figure Number				
Common Name / *Scientific Name*	**Total**	**Winter**	**Spring**	**Summer**	**Fall**
Clearnose Skate *Raja eglanteria*	9	10	11	12	13
Little Skate *Raja erinacea*	14	15	16	17	18
Winter Skate *Raja ocellata*	19	20	21	22	23
Blueback Herring *Alosa aestivalis*	24	25	26	27	28
Alewife *Alosa pseudoharengus*	29	30	31	32	33
Atlantic Herring *Clupea harengus*	34	35	36	37	38
Bay Anchovy *Anchoa mitchilli*	39	40	41	42	43
Silver Hake *Merluccius bilinearis*	44	45	46	47	48
Red Hake *Urophycis chuss*	49	50	51	52	53
Spotted Hake *Urophycis regia*	54	55	56	57	58
Northern Searobin *Prionotus carolinus*	59	60	61	62	63
Striped Searobin *Prionotus evolans*	64	65	66	67	68
Striped Bass *Morone saxatilis*	69	70	71	72	73
Black Sea Bass *Centropristis striata*	74	75	76	77	78
Bluefish *Pomatomus saltatrix*	79	80	81	82	83
Scup *Stenotomus chrysops*	84	85	86	87	88
Weakfish *Cynoscion regalis*	89	90	91	92	93
Spot *Leiostomus xanthurus*	94	95	96	97	98
Butterfish *Peprilus triacanthus*	99	100	101	102	103
Summer Flounder *Paralichthys dentatus*	104	105	106	107	108
Windowpane *Scophthalmus aquosus*	109	110	111	112	113
Winter Flounder *Pleuronectes americanus*	114	115	116	117	118
Blue Crab *Callinectes sapidus*	119	120	121	122	123
Atlantic Rock Crab *Cancer irroratus*	124	125	126	127	128
Lady Crab *Ovalipes ocellatus*	129	130	131	132	133
Longfin Squid *Loligo pealeii*	134	135	136	137	138

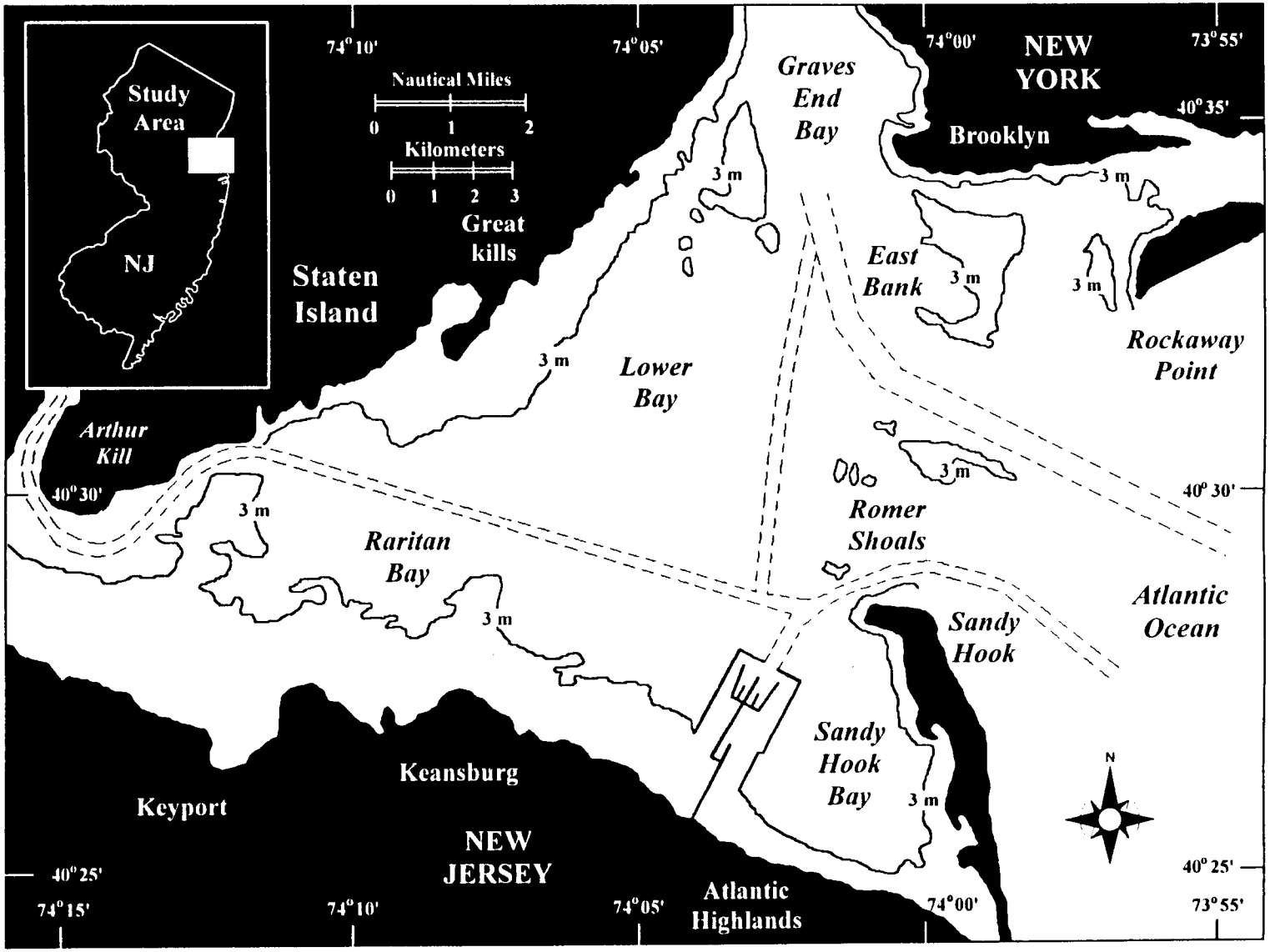

Figure 1. Location of the Hudson-Raritan Estuary; area in which a trawl survey was conducted between January 1992 and December 1997.

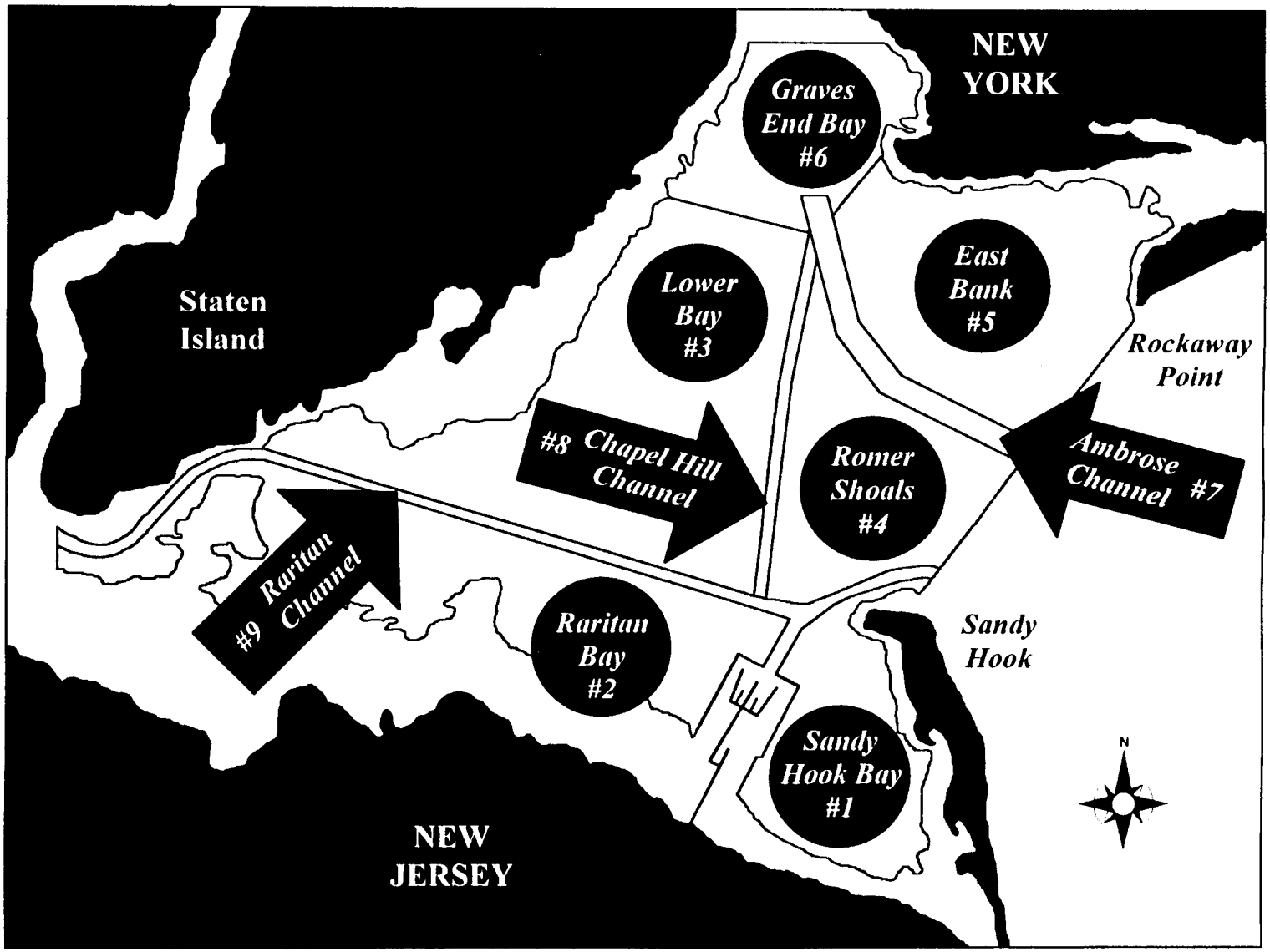

Figure 2. Hudson-Raritan Estuary divided into nine strata where fish and megainvertebrates were sampled with an 8.5-m otter trawl between January 1992 and December 1997.

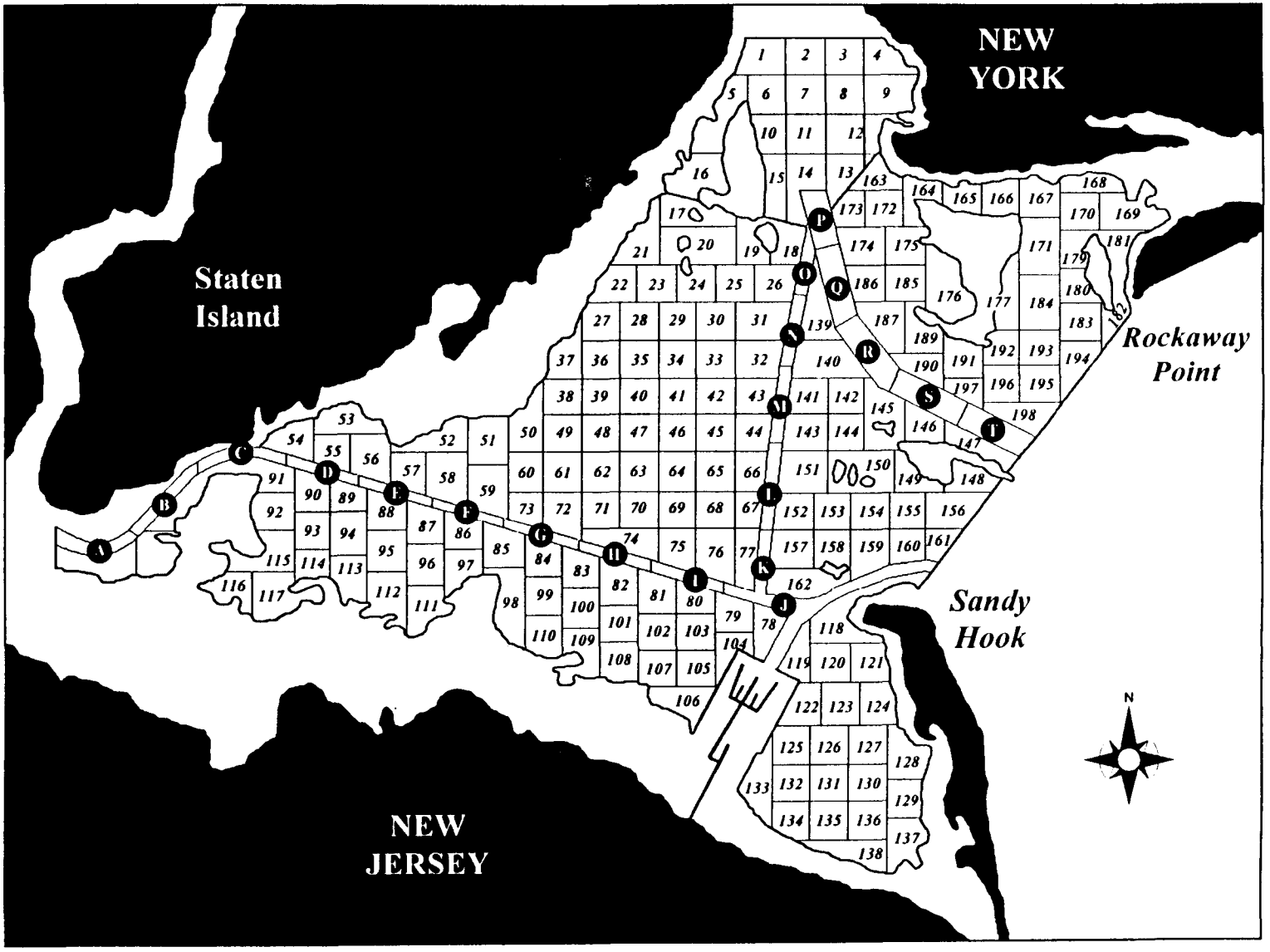

Figure 3. Hudson-Raritan Estuary divided into 217 blocks where fish and megainvertebrates were sampled with an 8.5-m otter trawl between January 1992 and December 1997.

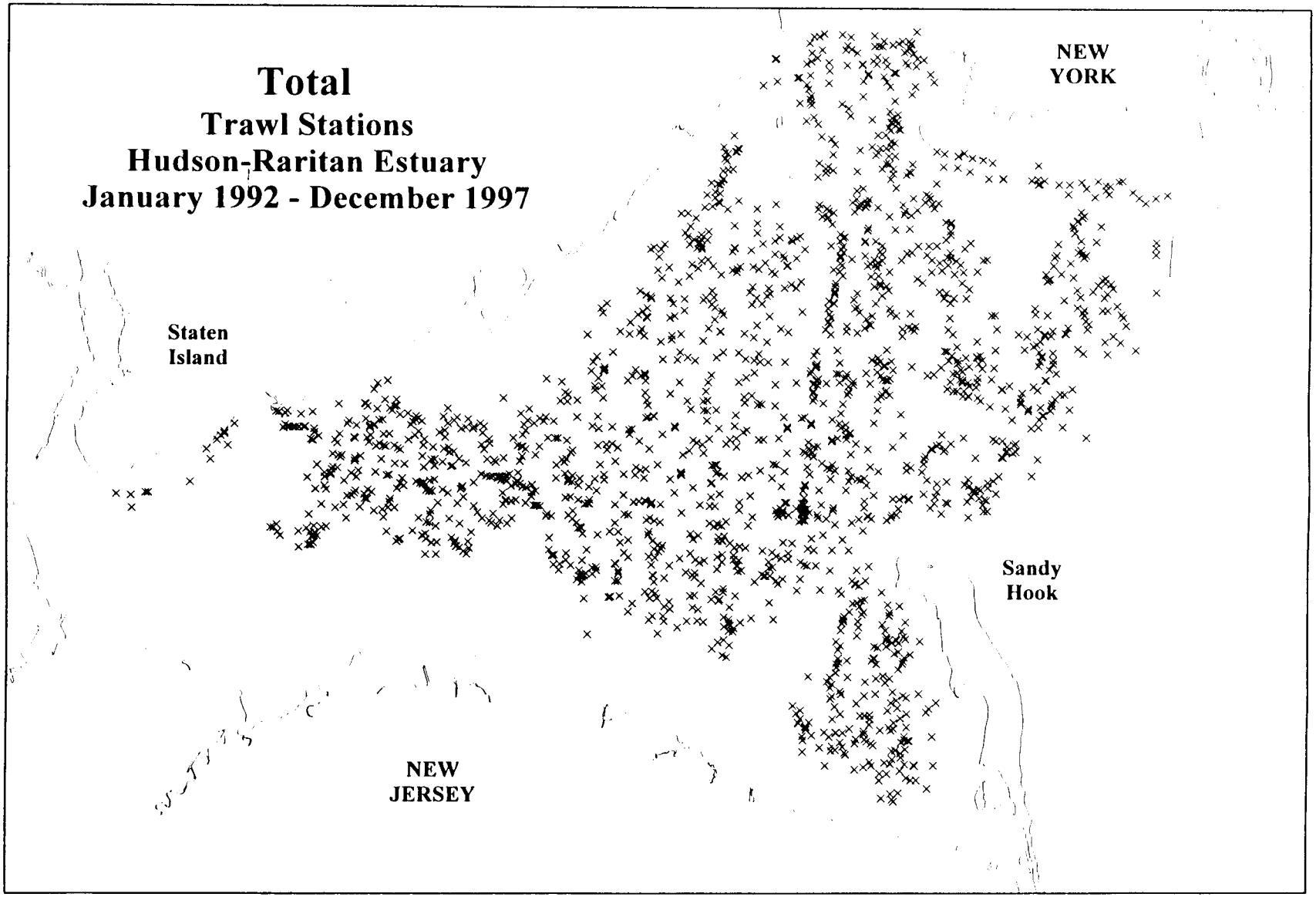

Figure 4. Location of all trawl stations sampled in the Hudson-Raritan Estuary between January 1992 and December 1997.

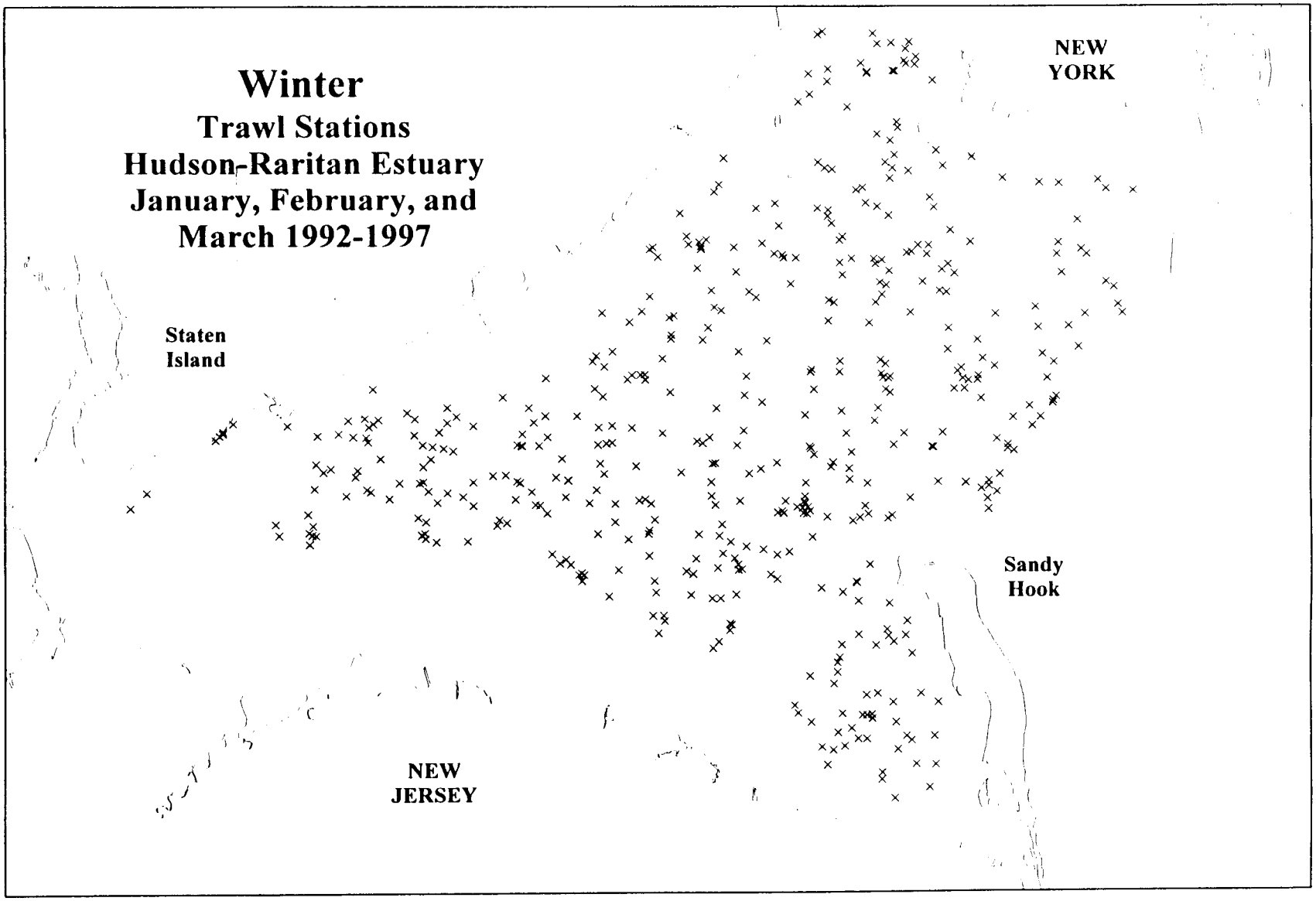

Figure 5. Location of trawl stations sampled during Winter (January, February, and March) in the Hudson-Raritan Estuary between 1992 and 1997.

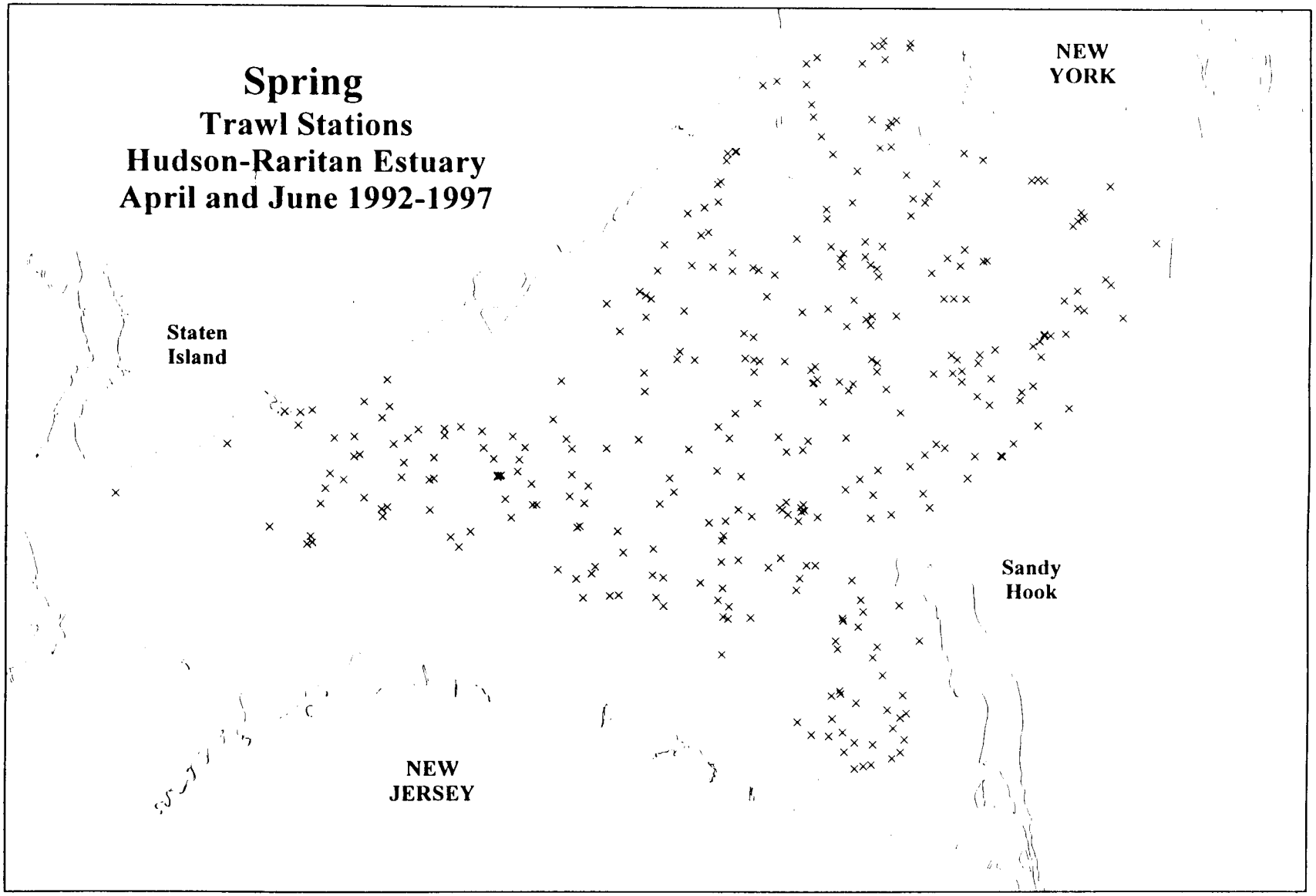

Figure 6. Location of trawl stations sampled during Spring (April and June) in the Hudson-Raritan Estuary between 1992 and 1997.

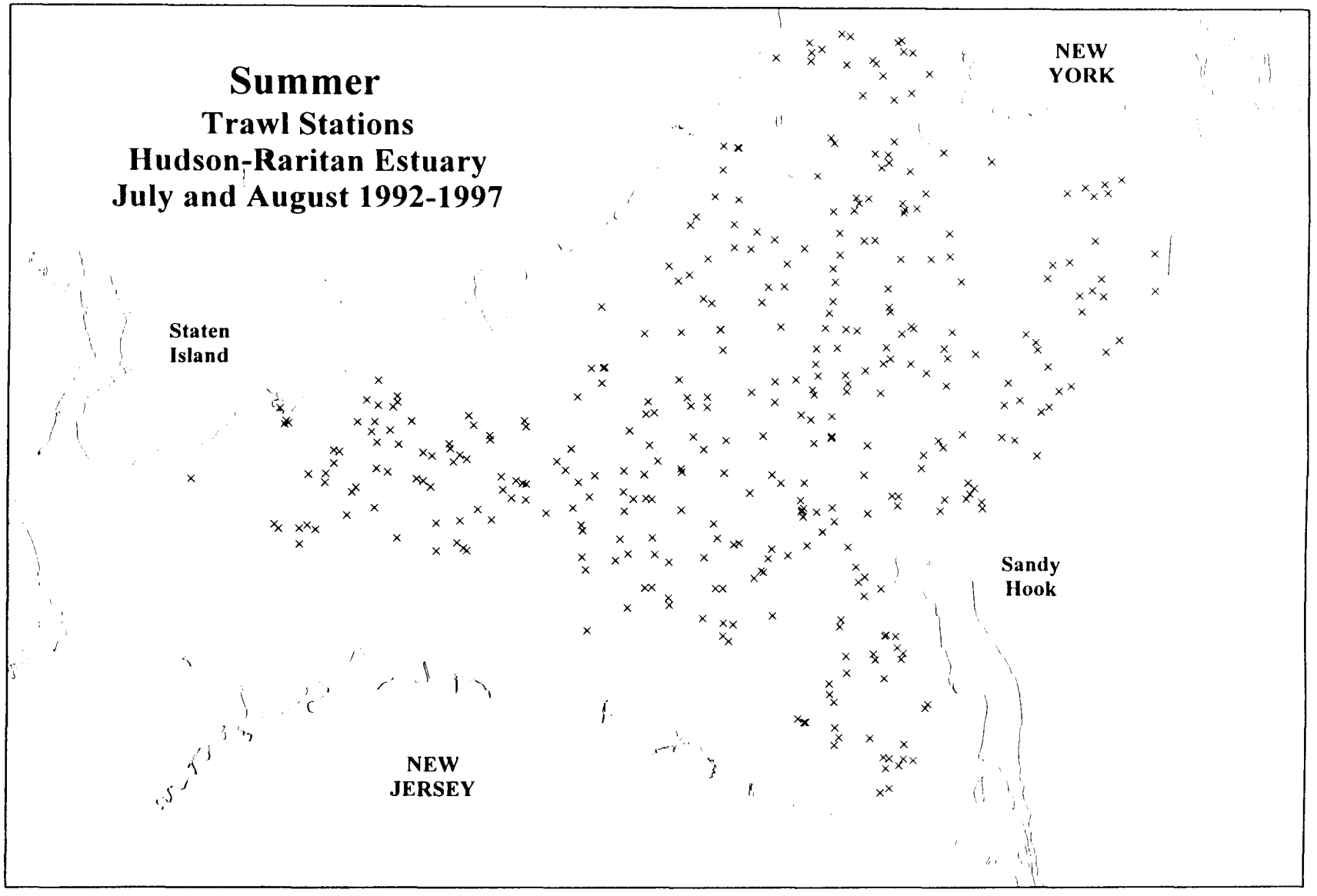

Figure 7. Location of trawl stations sampled during Summer (July and August) in the Hudson-Raritan Estuary between 1992 and 1997.

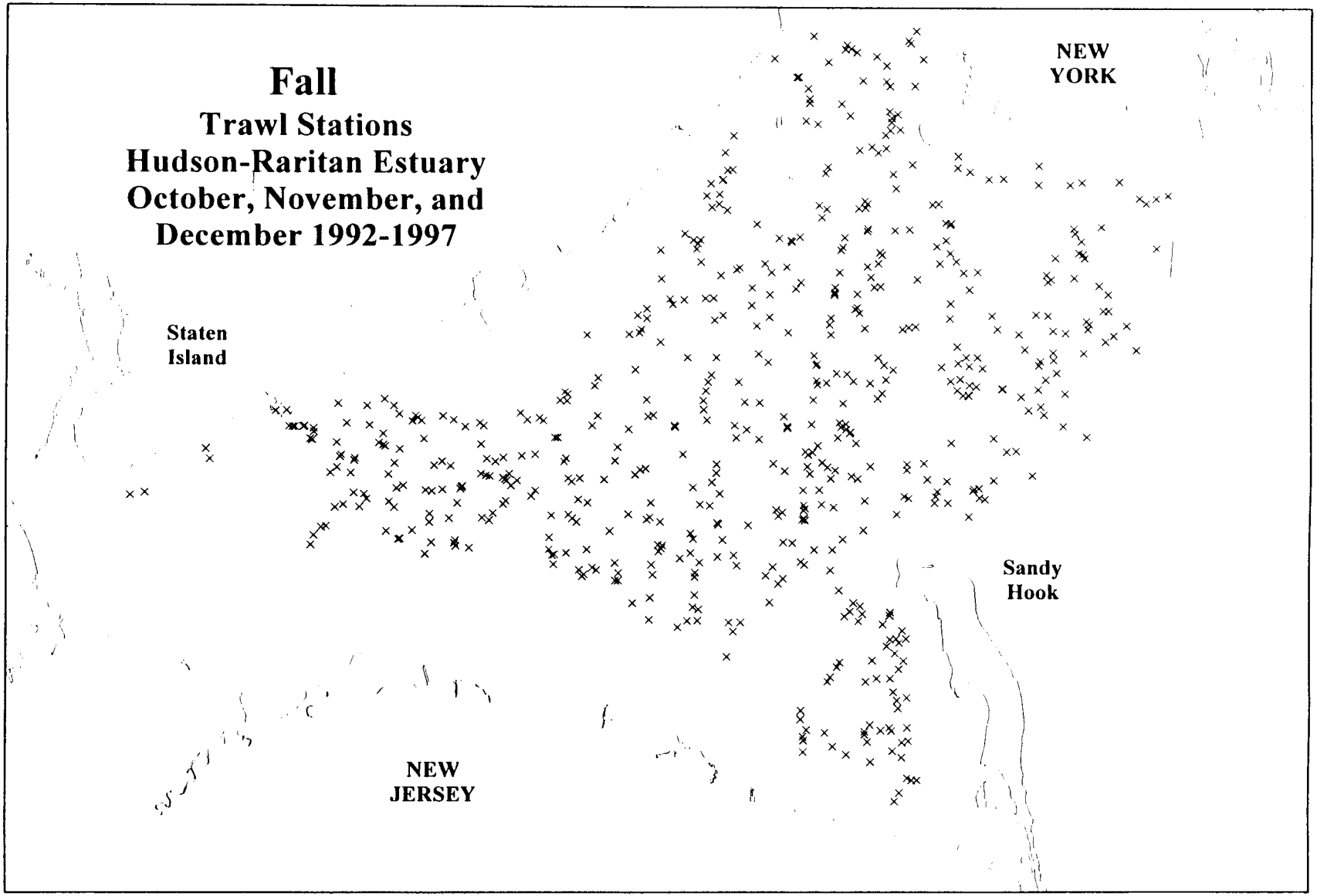

Figure 8. Location of trawl stations sampled during Fall (October, November, and December) in the Hudson-Raritan Estuary between 1992 and 1997.

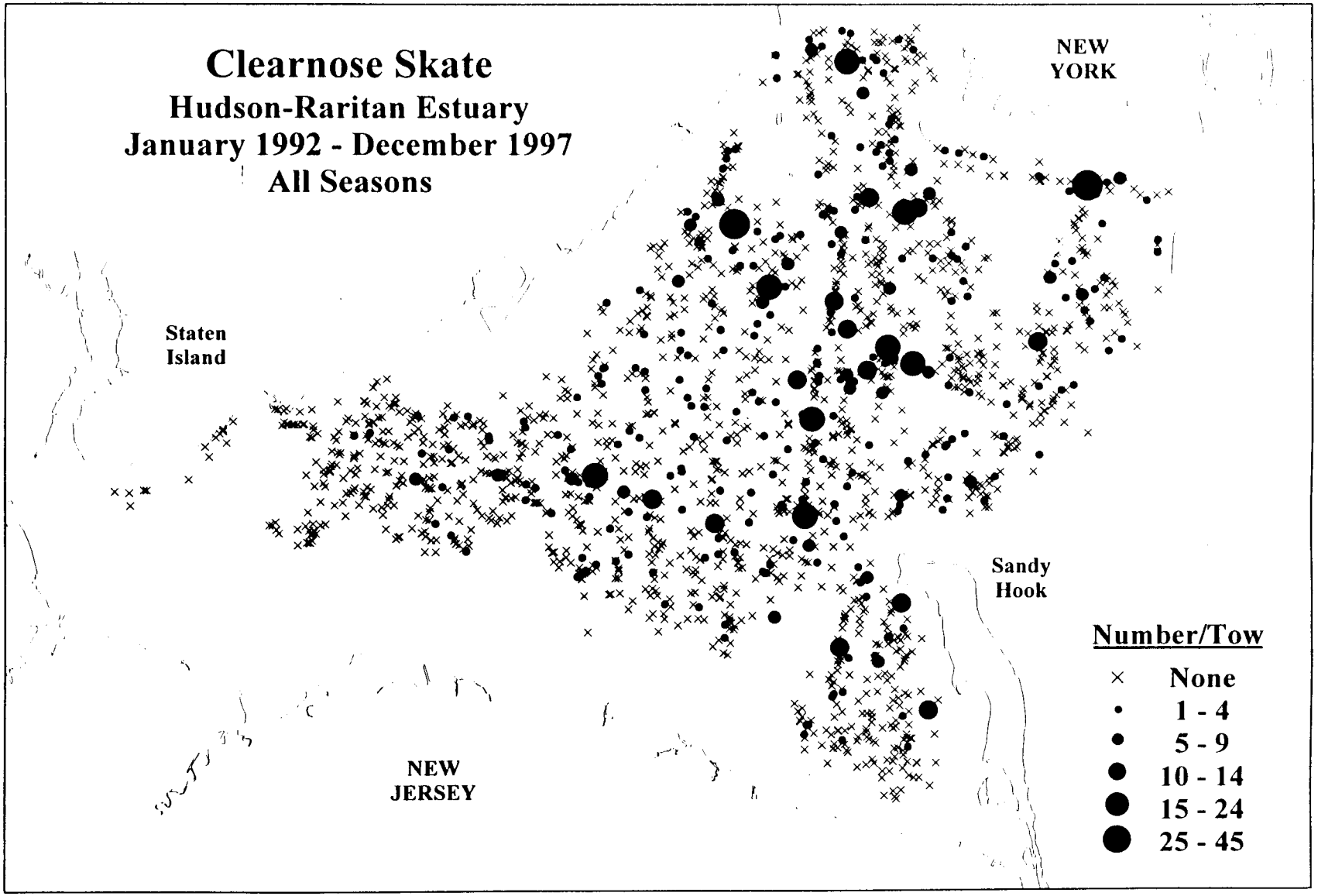

Figure 9. Distribution and abundance of all clearnose skate collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

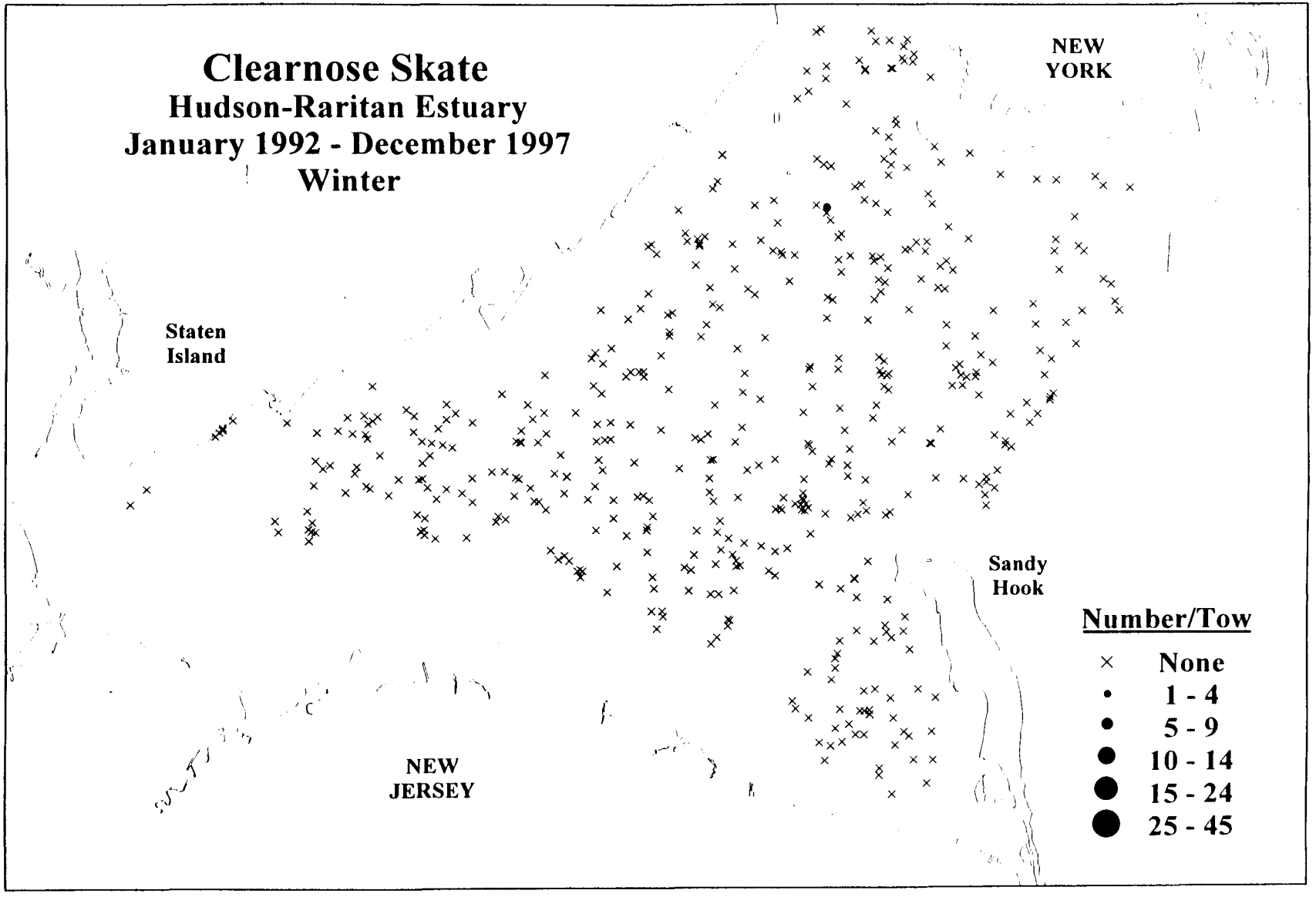

Figure 10. Distribution and abundance of all clearnose skate collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

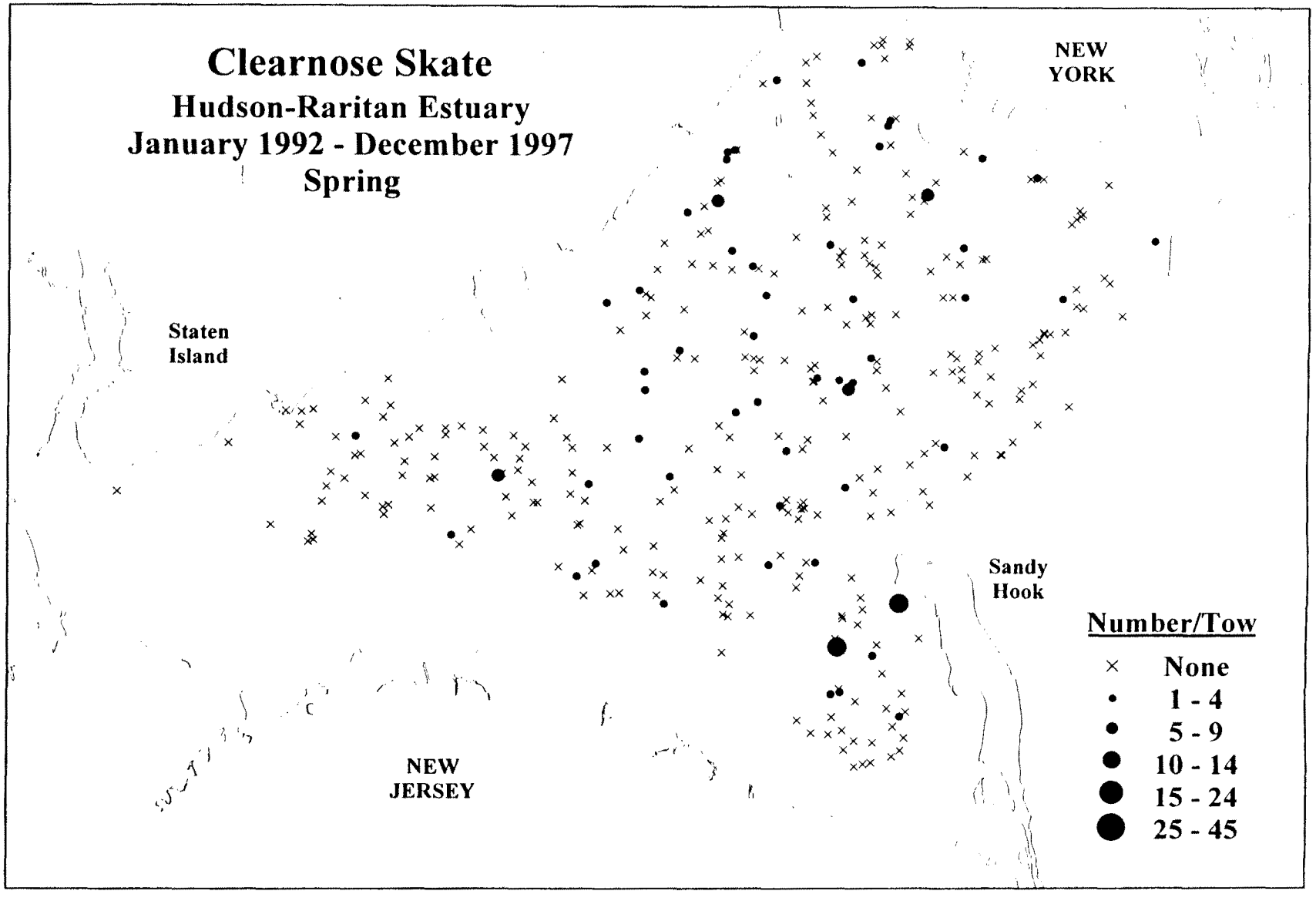

Figure 11. Distribution and abundance of clearnose skate collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

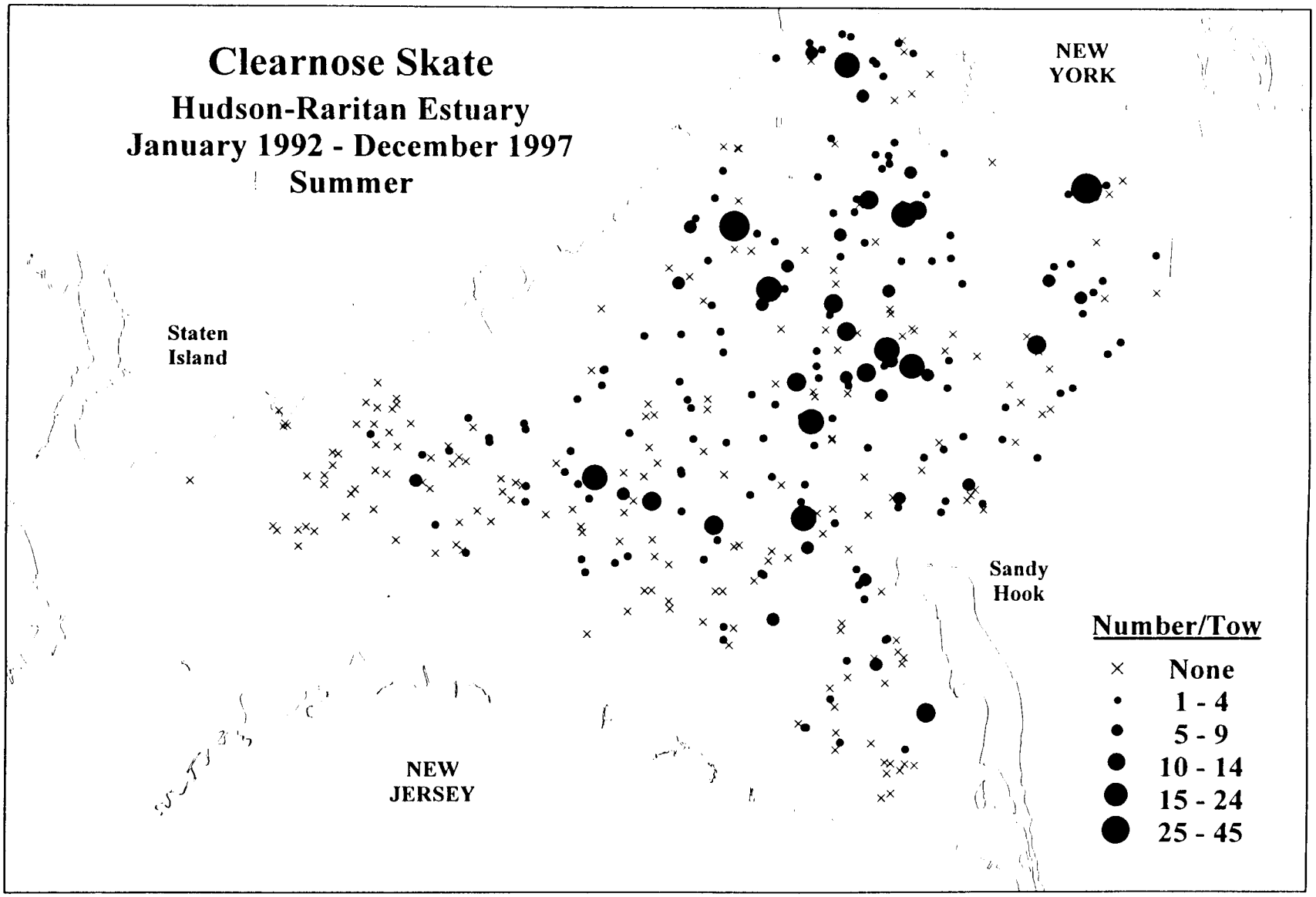

Figure 12. Distribution and abundance of clearnose skate collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

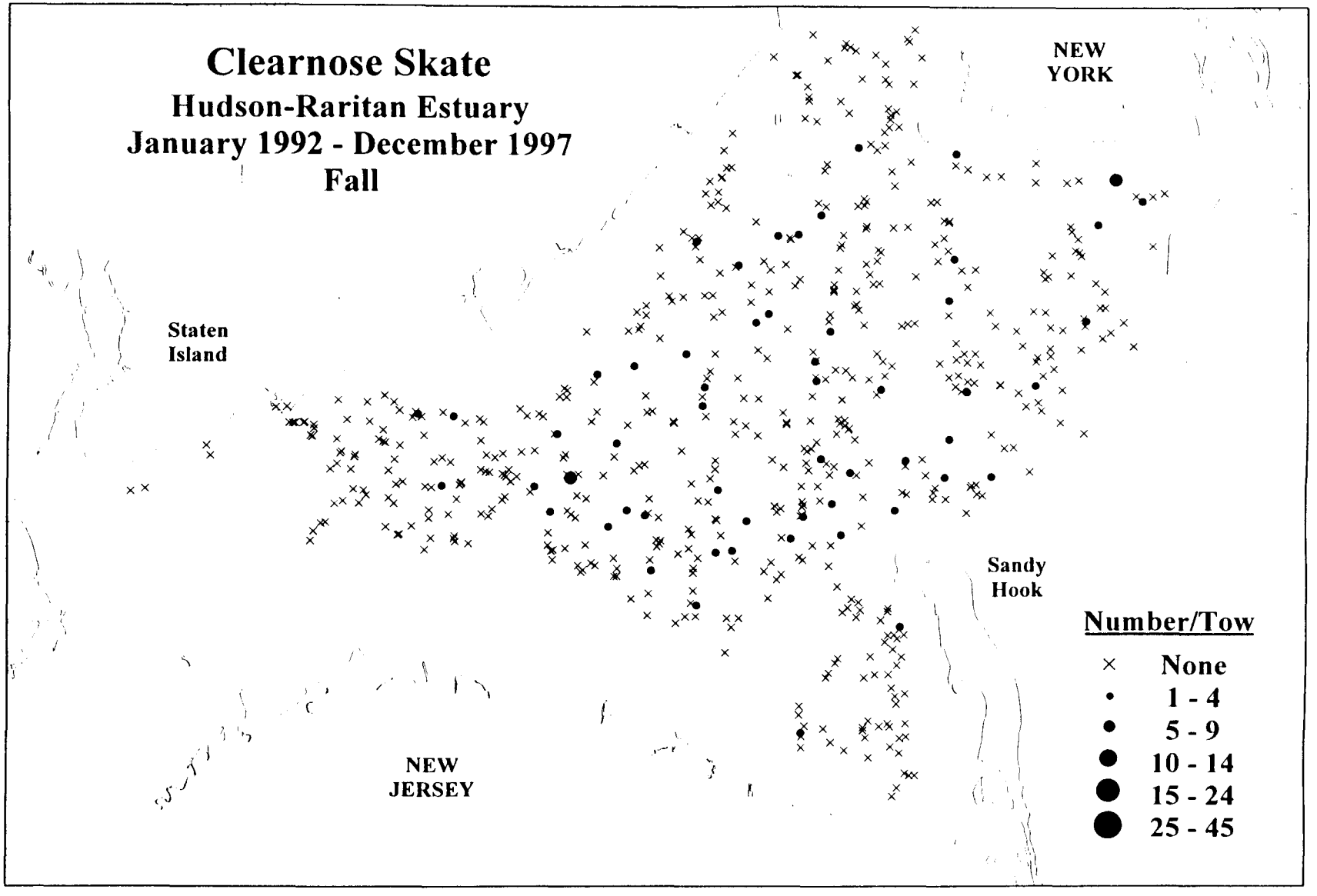

Figure 13. Distribution and abundance of clearnose skate collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

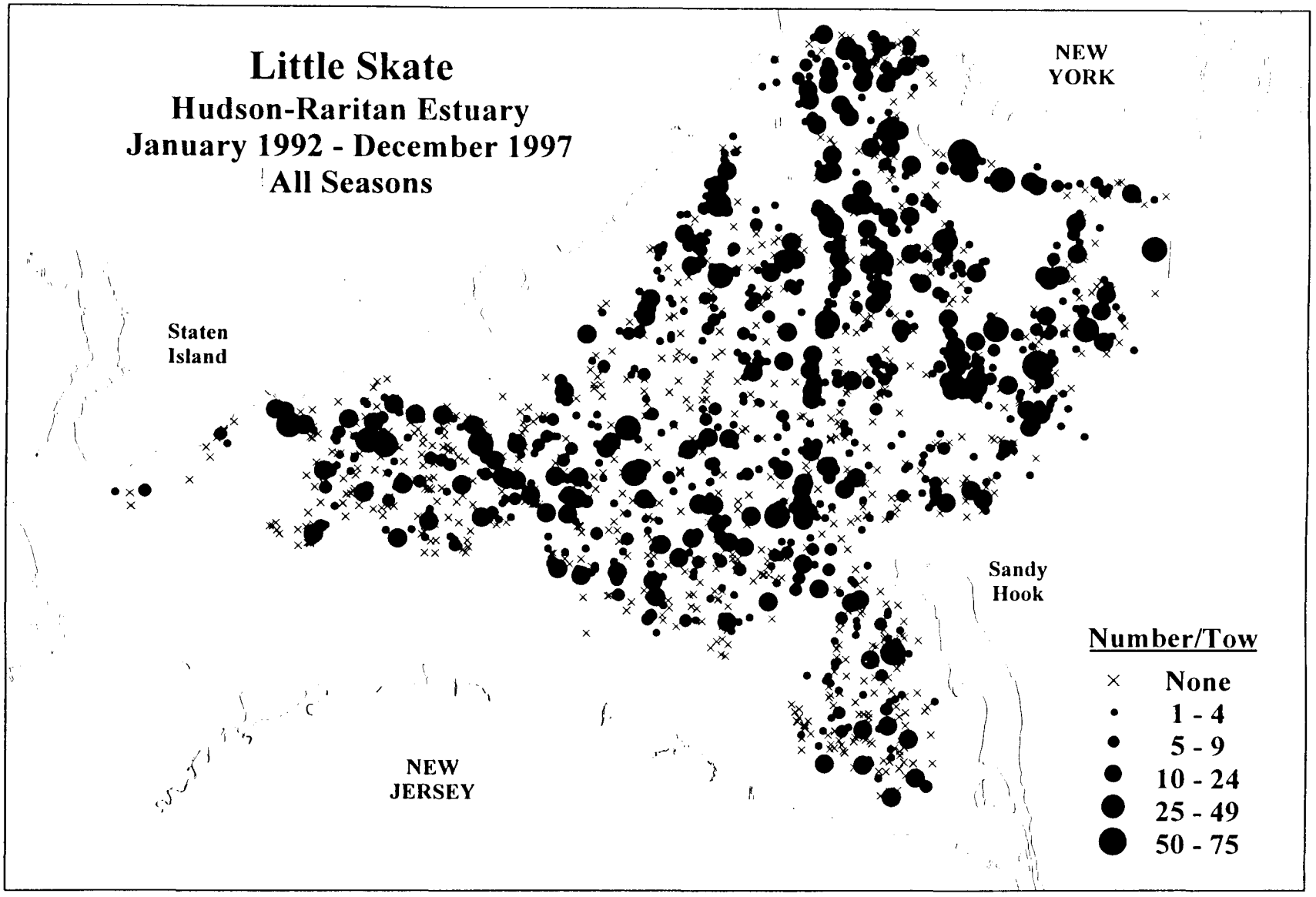

Figure 14. Distribution and abundance of all little skate collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

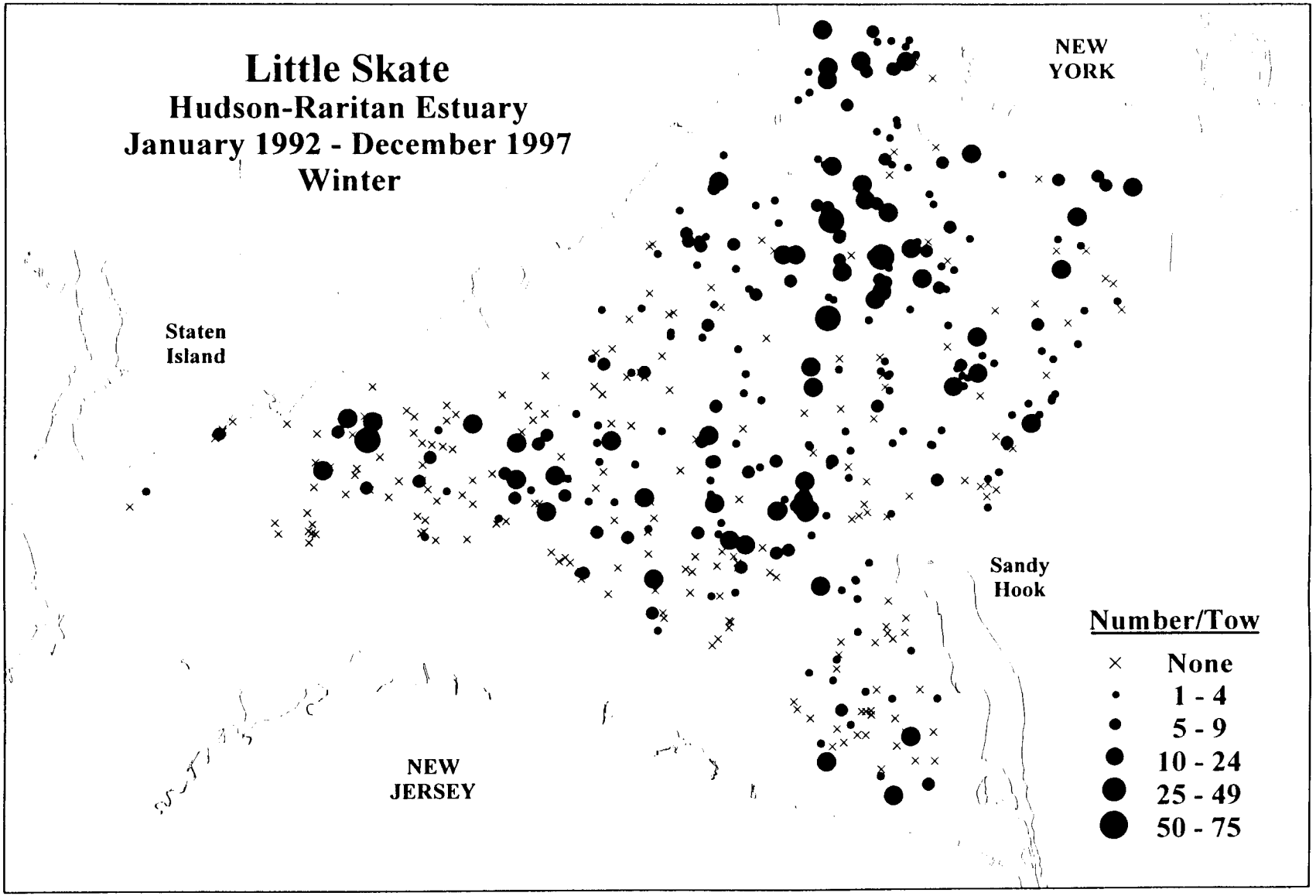

Figure 15. Distribution and abundance of all little skate collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

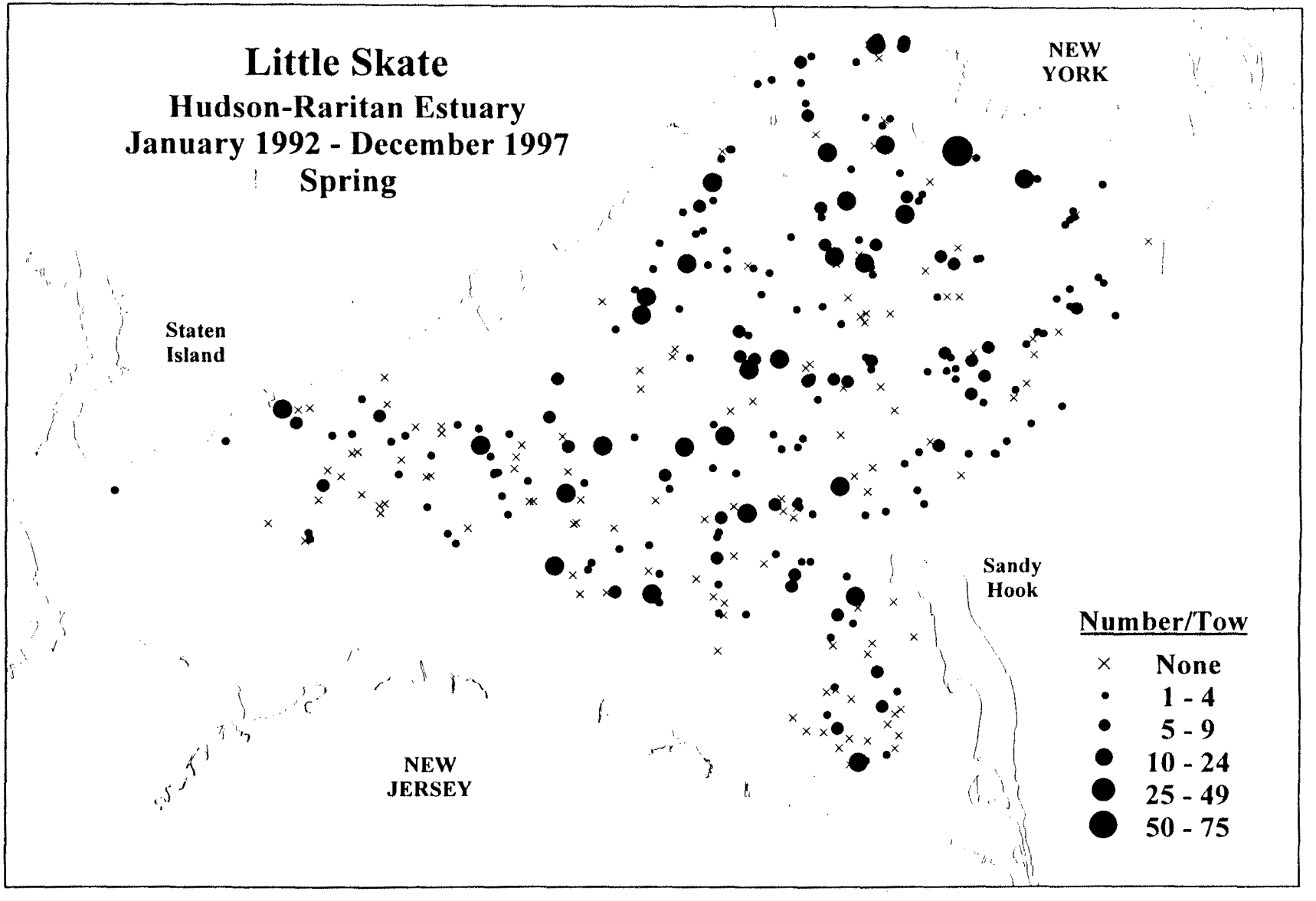

Figure 16. Distribution and abundance of little skate collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

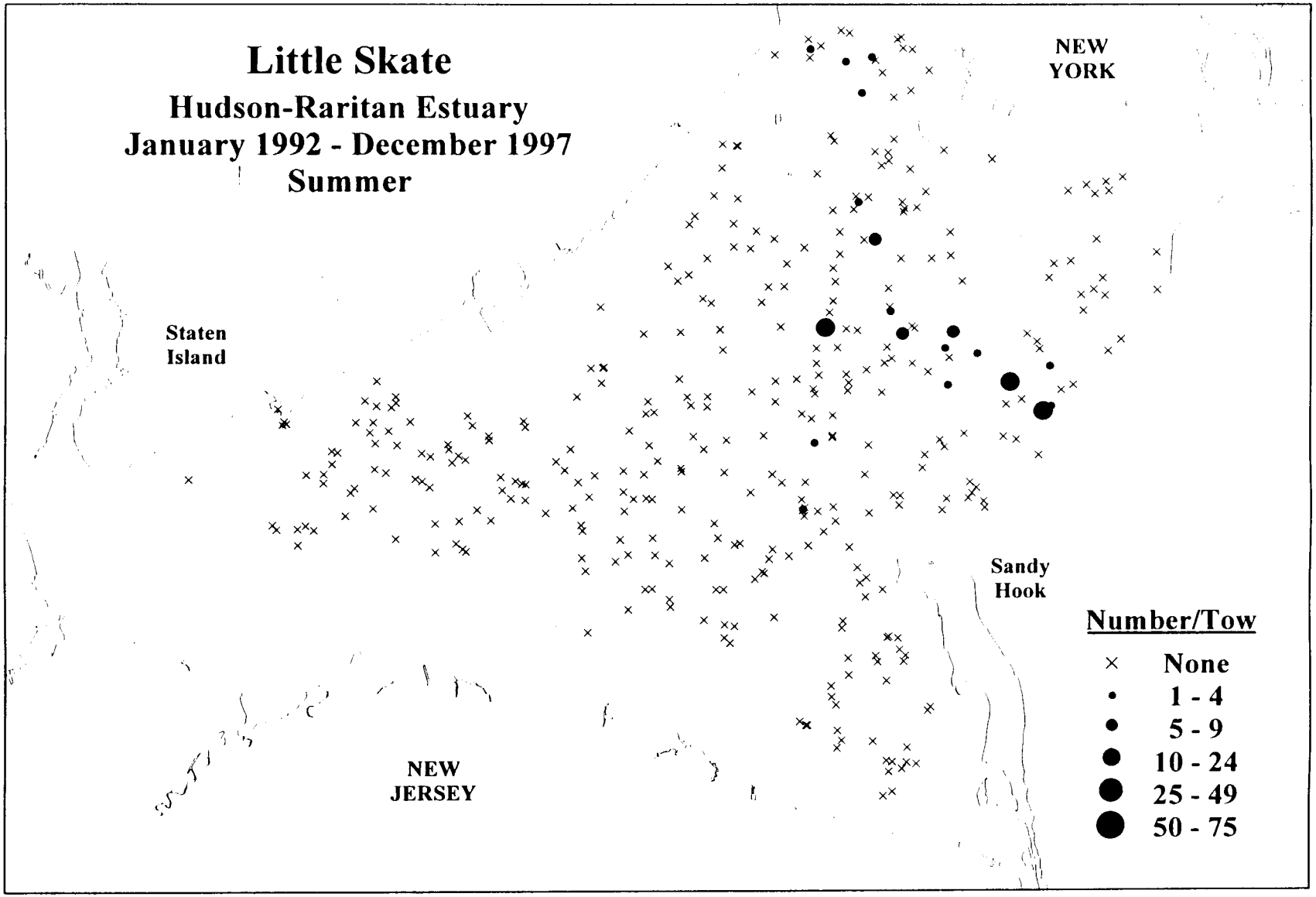

Figure 17. Distribution and abundance of little skate collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

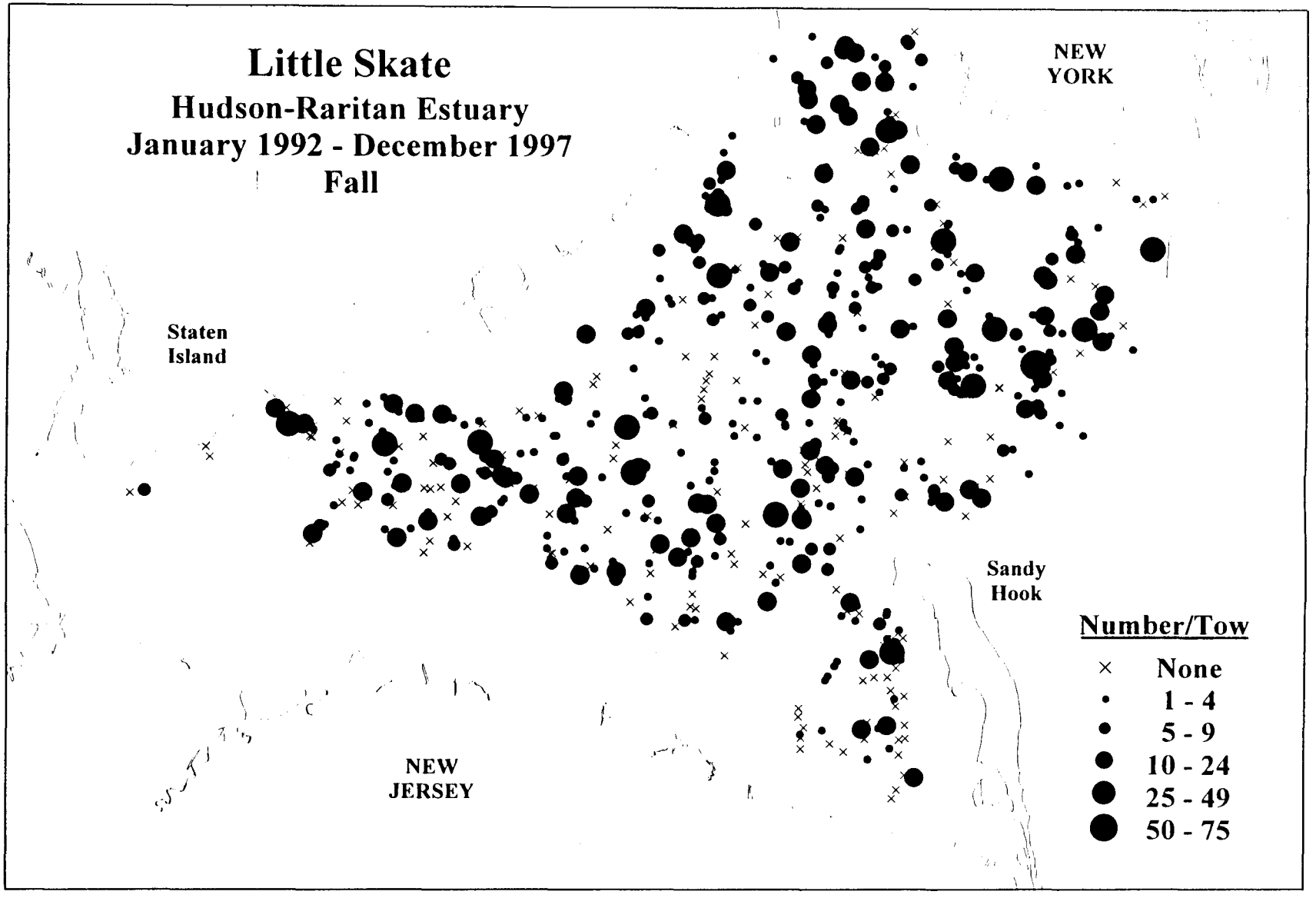

Figure 18. Distribution and abundance of little skate collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

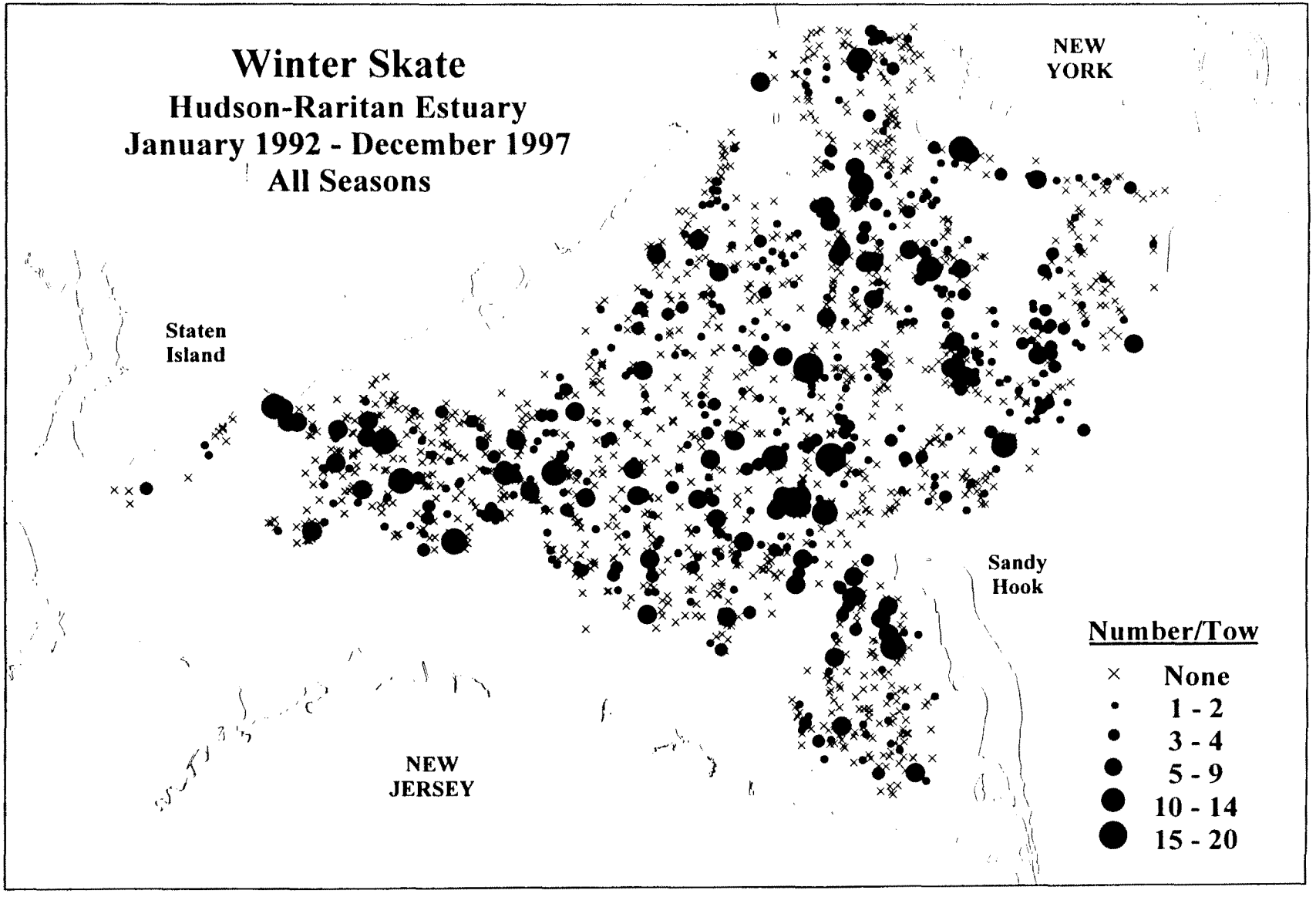

Figure 19. Distribution and abundance of all winter skate collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

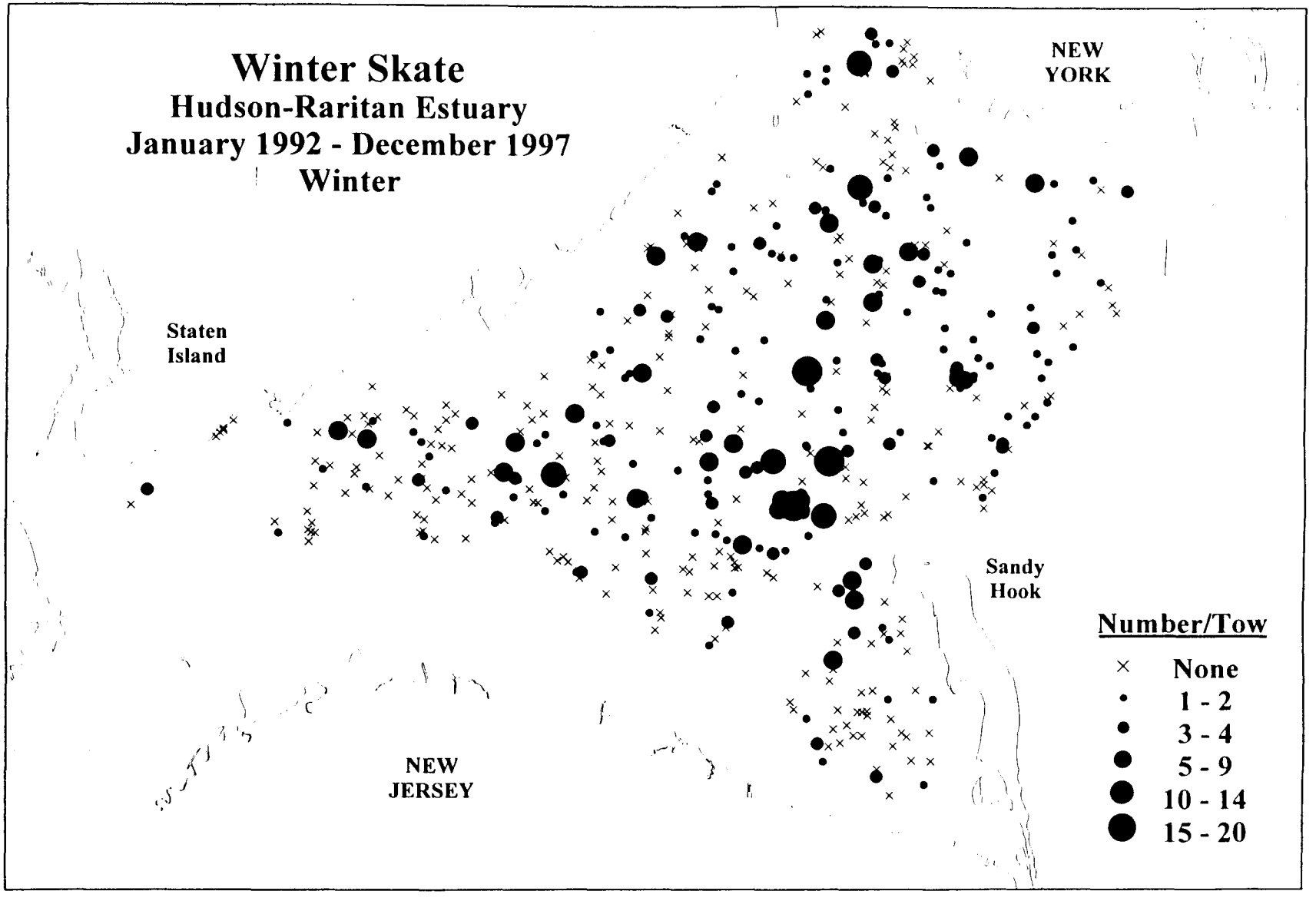

Figure 20. Distribution and abundance of all winter skate collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

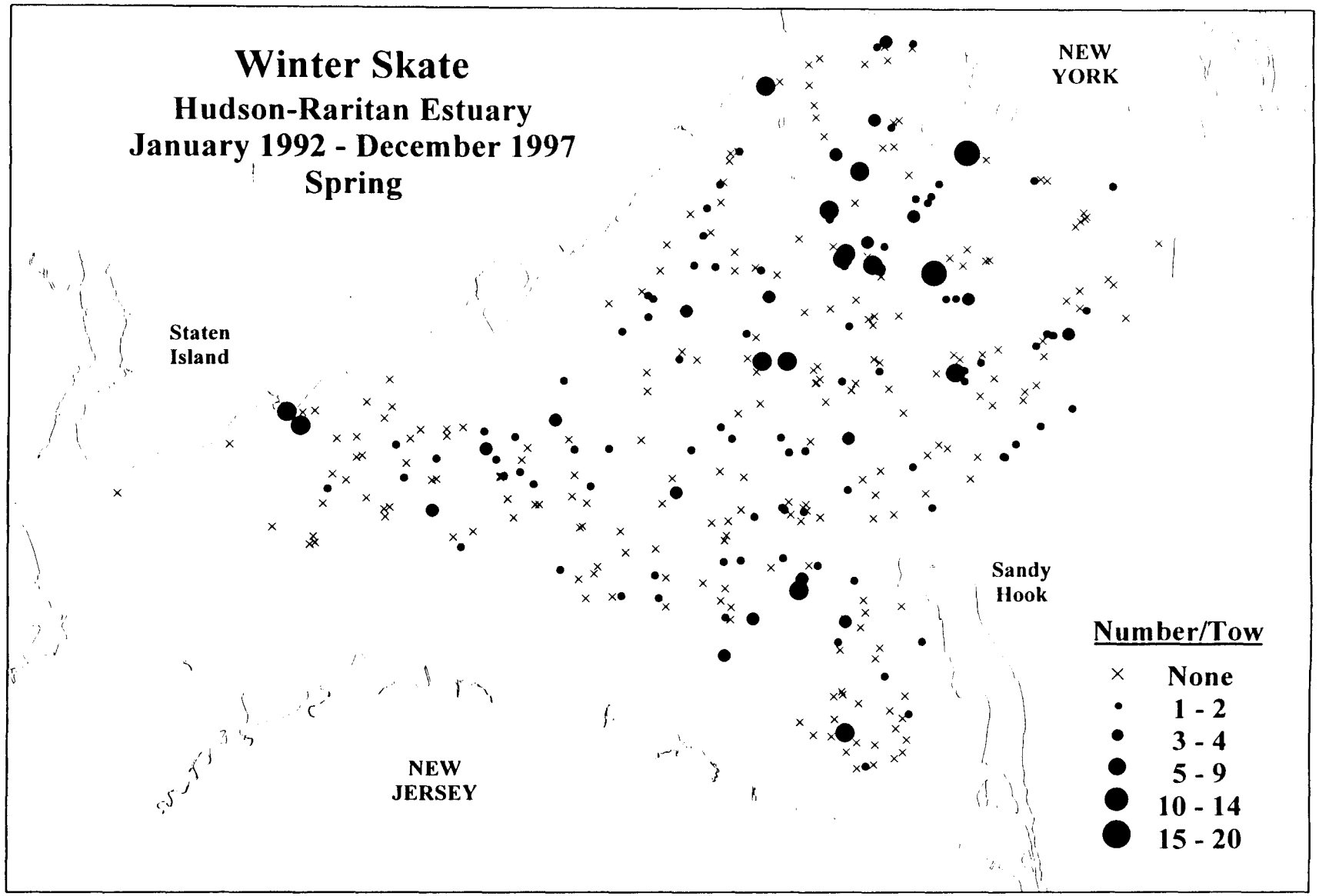

Figure 21. Distribution and abundance of winter skate collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

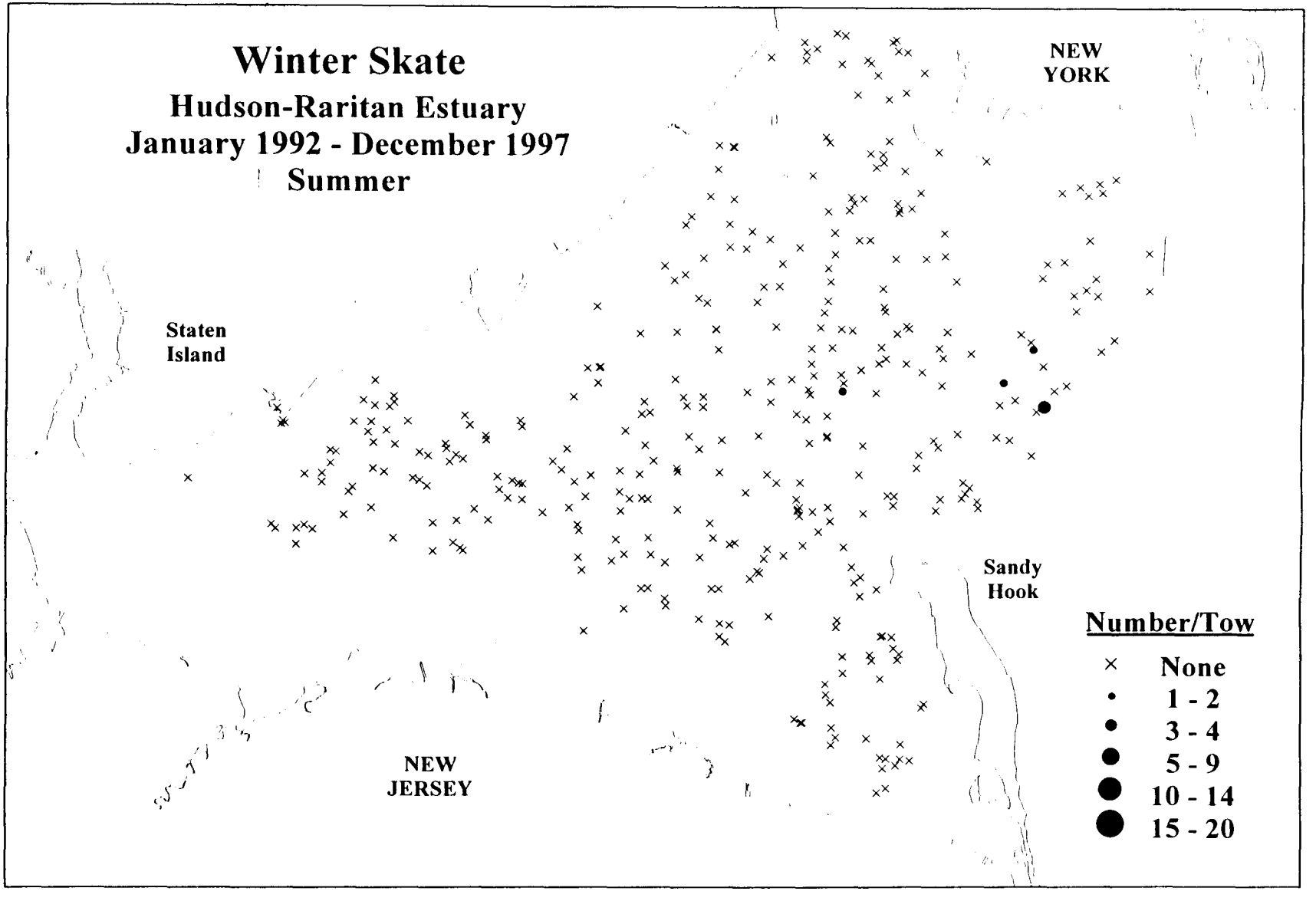

Figure 22. Distribution and abundance of winter skate collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

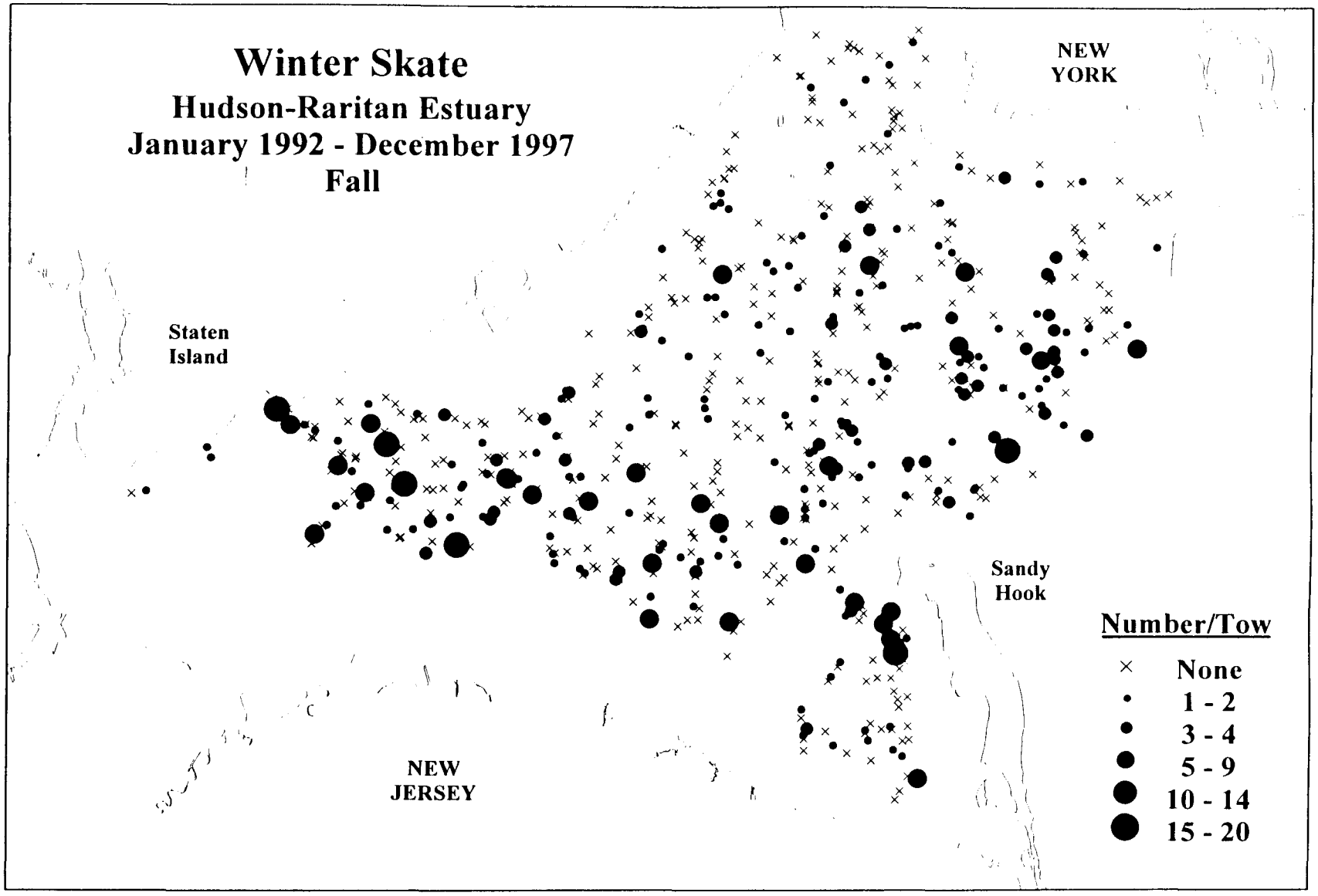

Figure 23. Distribution and abundance of winter skate collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

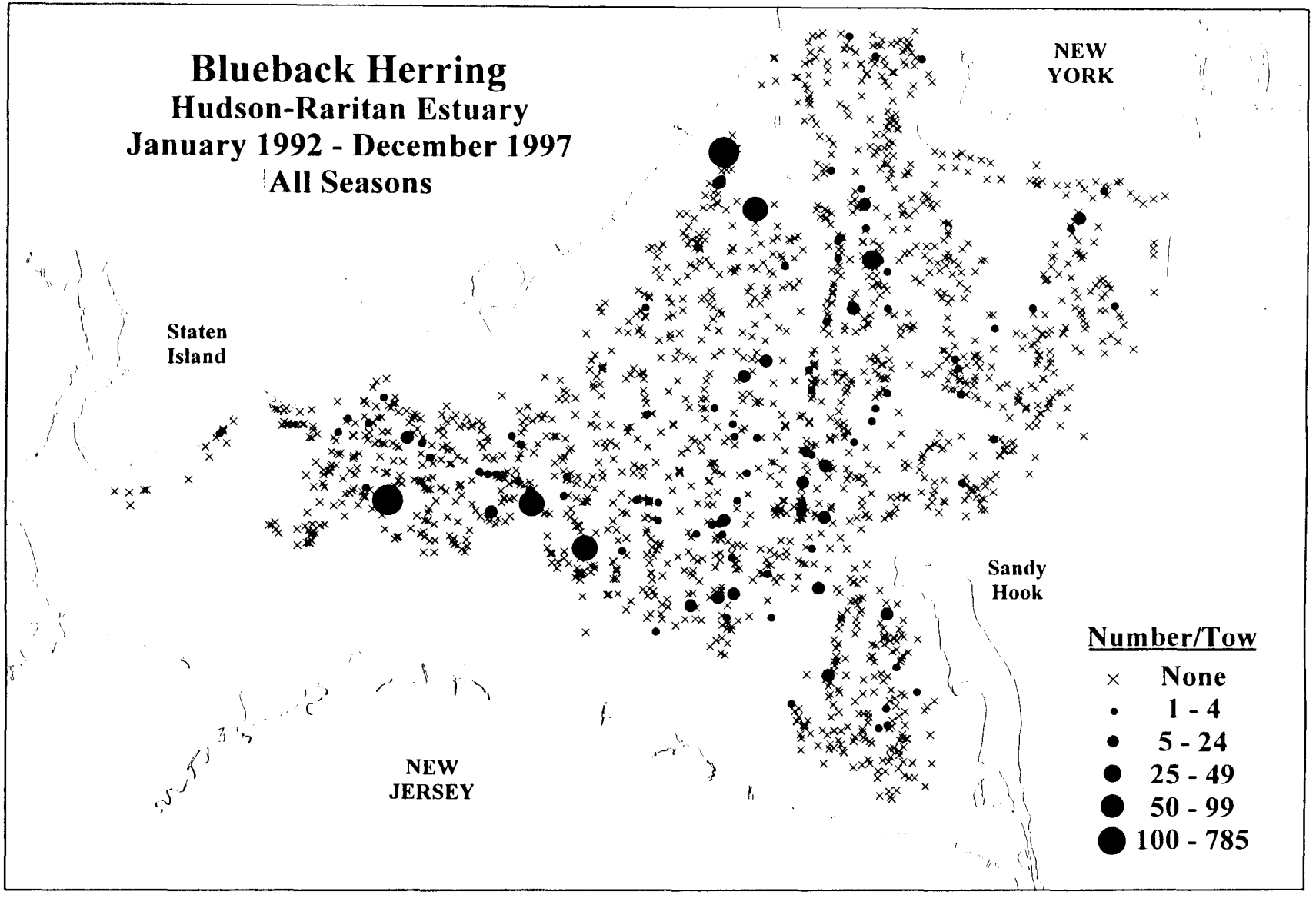

Figure 24. Distribution and abundance of all blueback herring collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

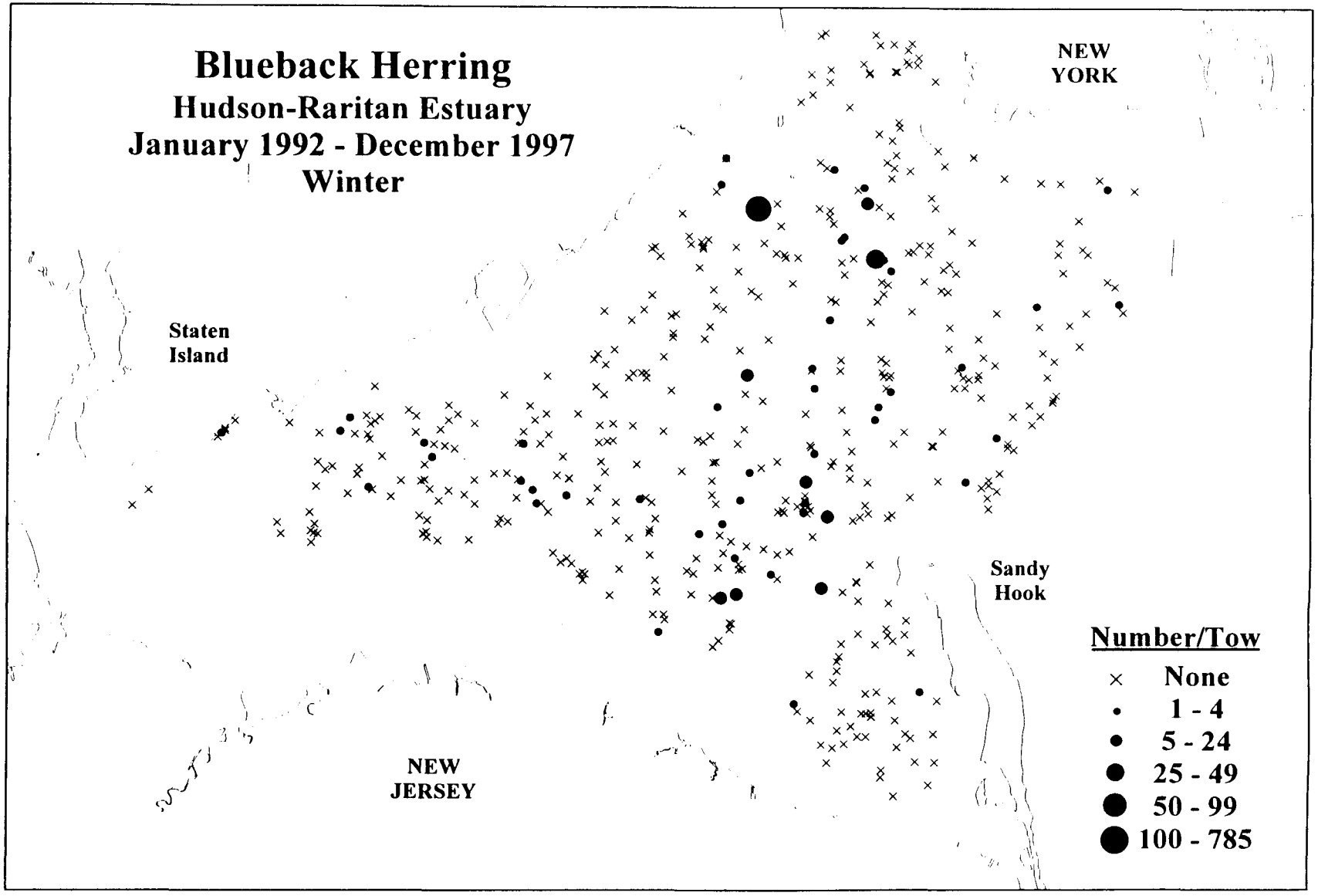

Figure 25. Distribution and abundance of all blueback herring collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

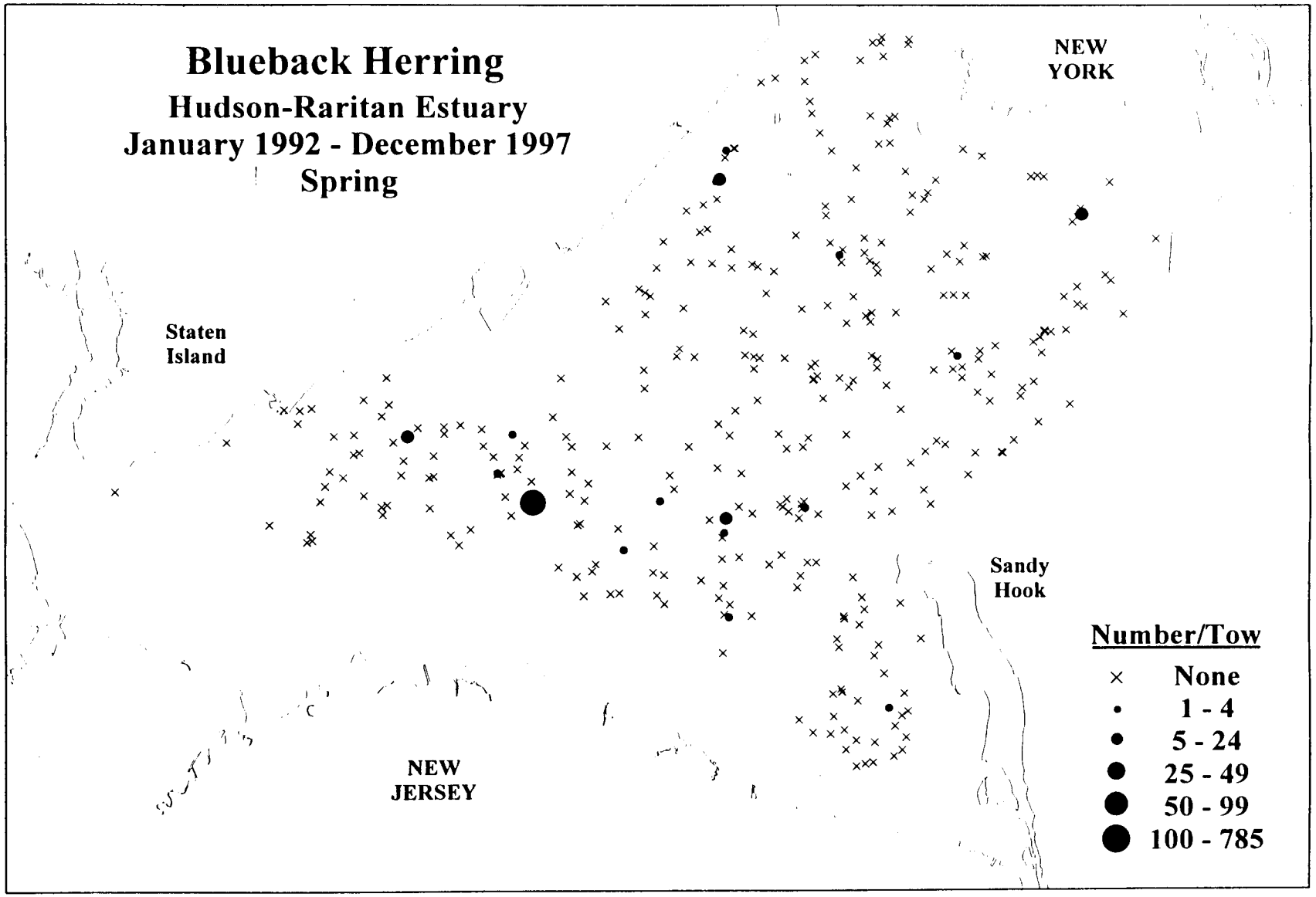

Figure 26. Distribution and abundance of blueback herring collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

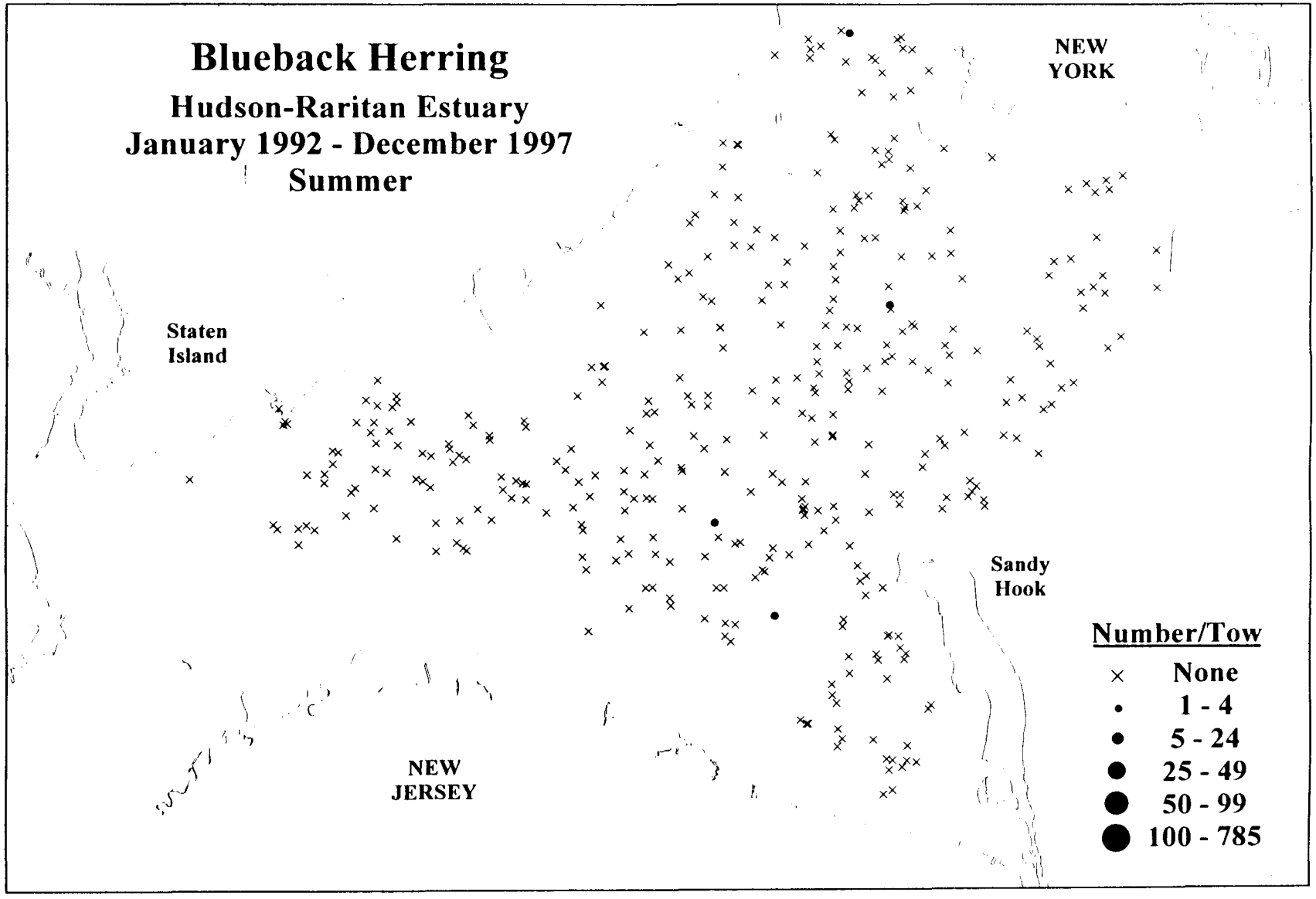

Figure 27. Distribution and abundance of blueback herring collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

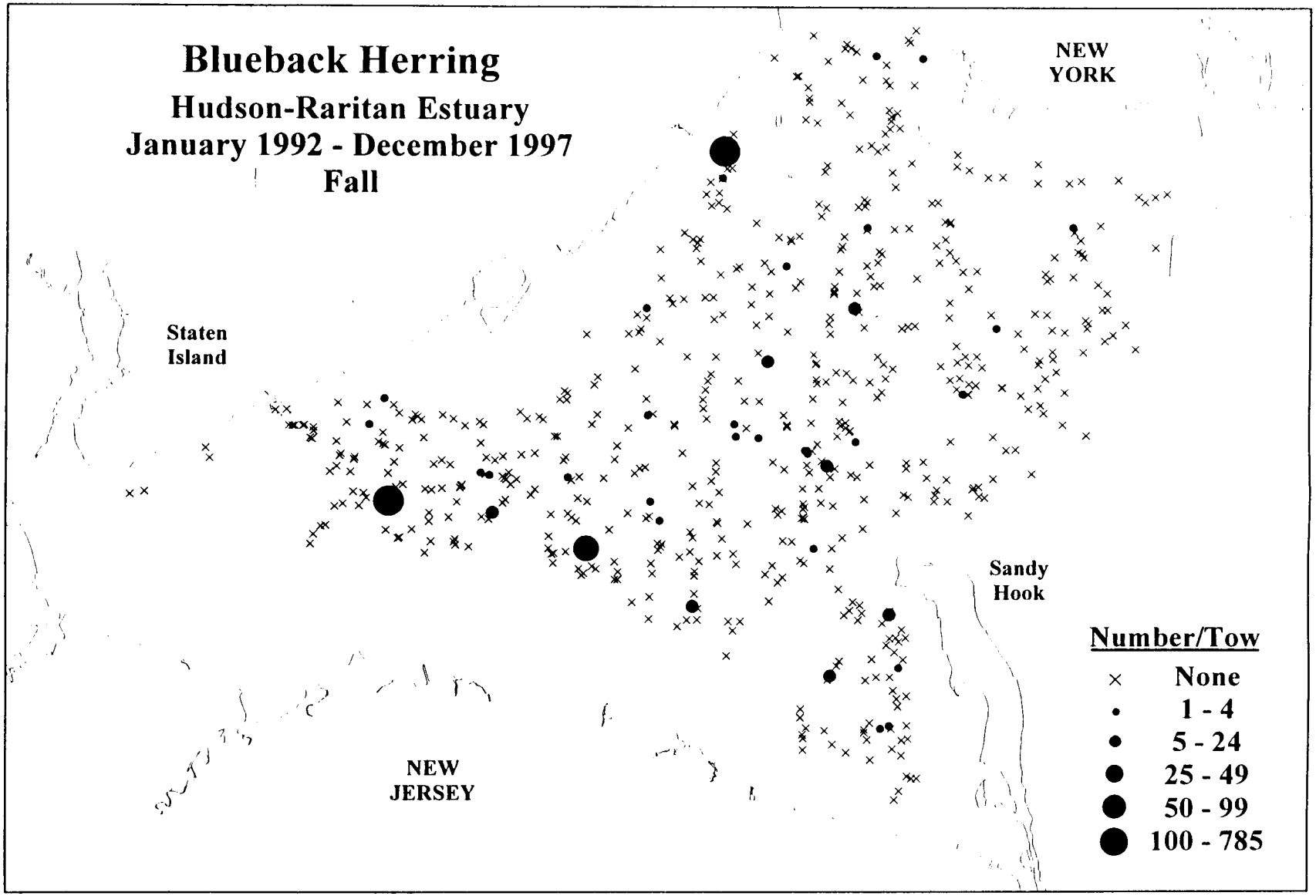

Figure 28. Distribution and abundance of blueback herring collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

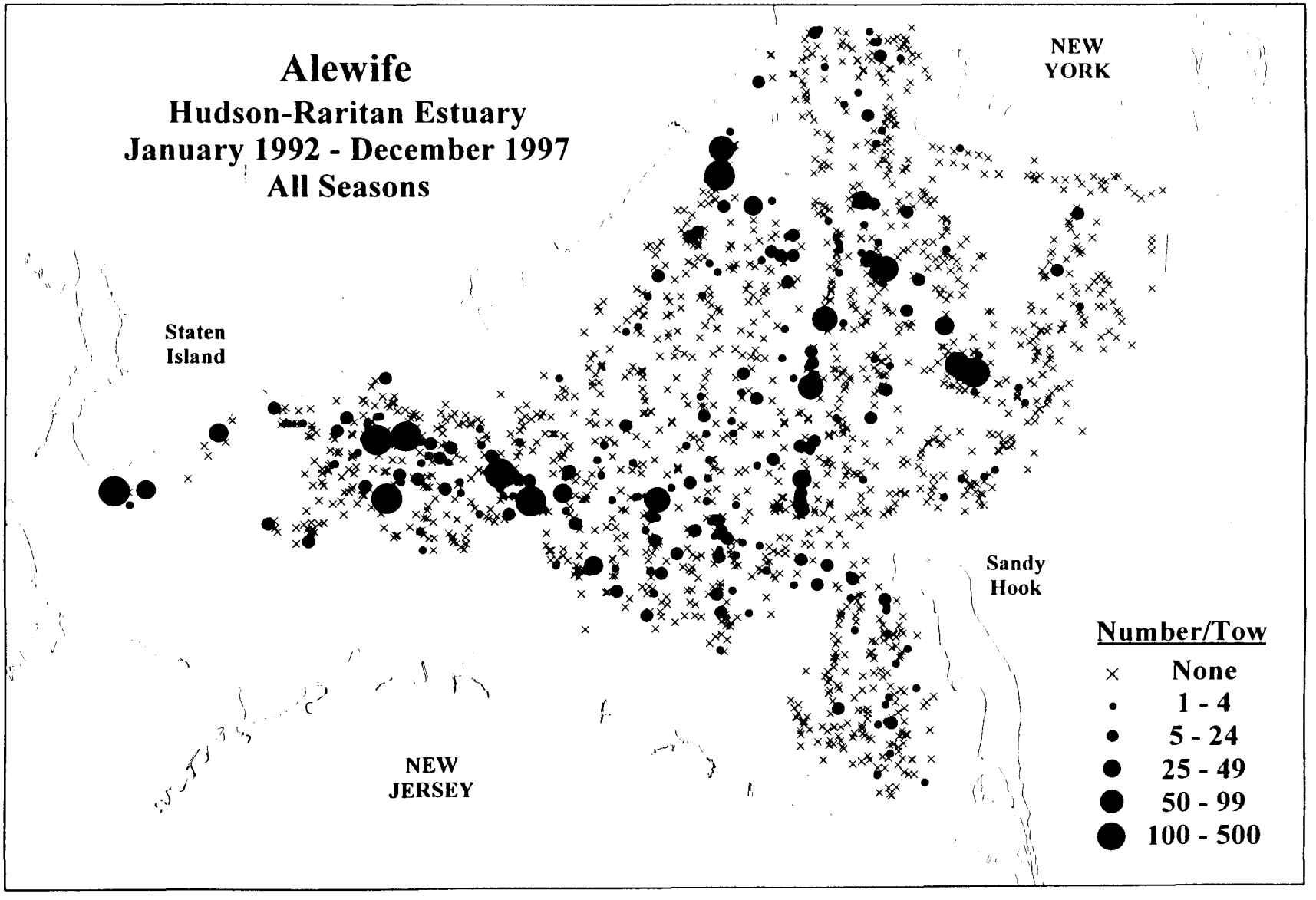

Figure 29. Distribution and abundance of all alewife collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

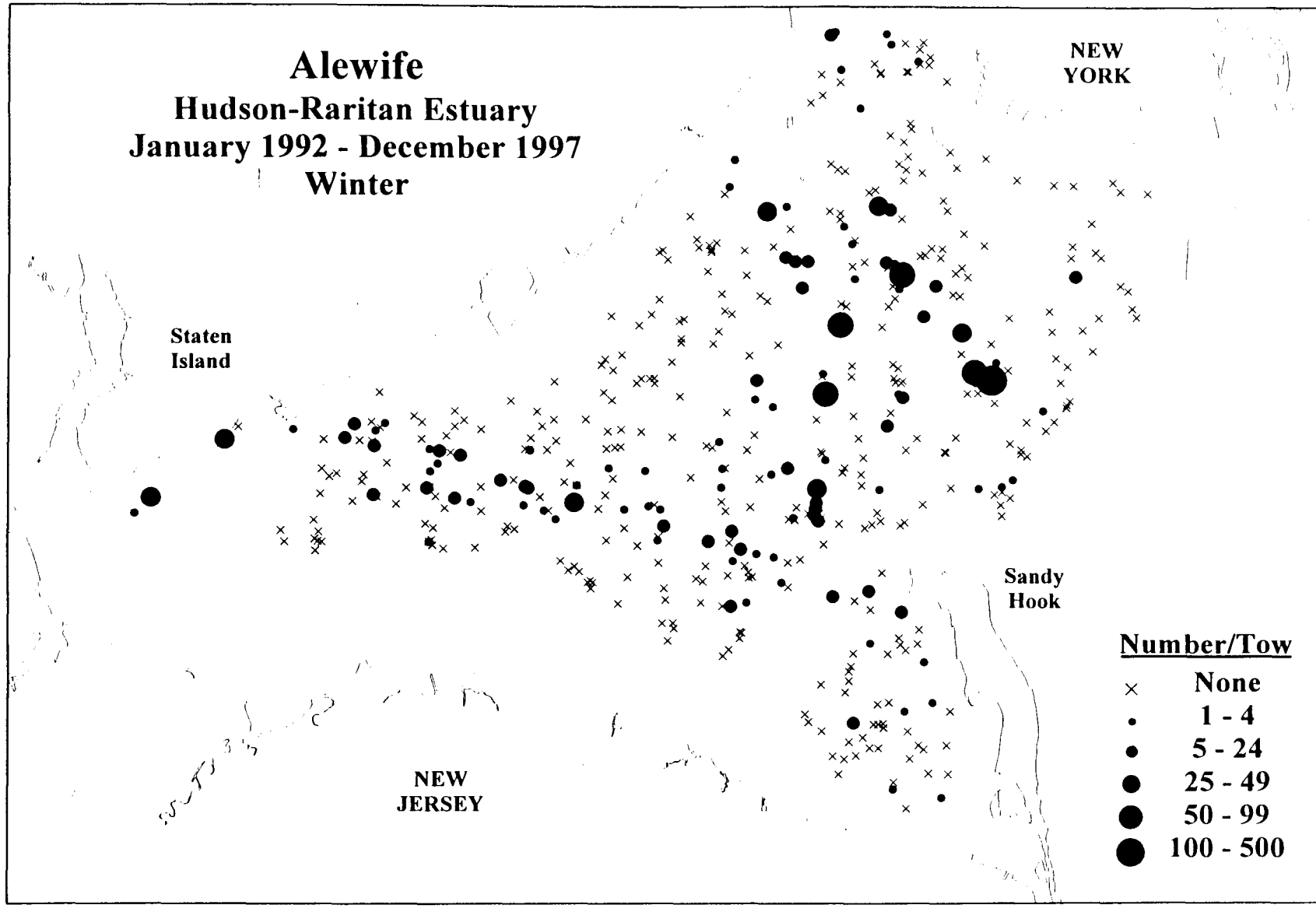

Figure 30. Distribution and abundance of all alewife collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

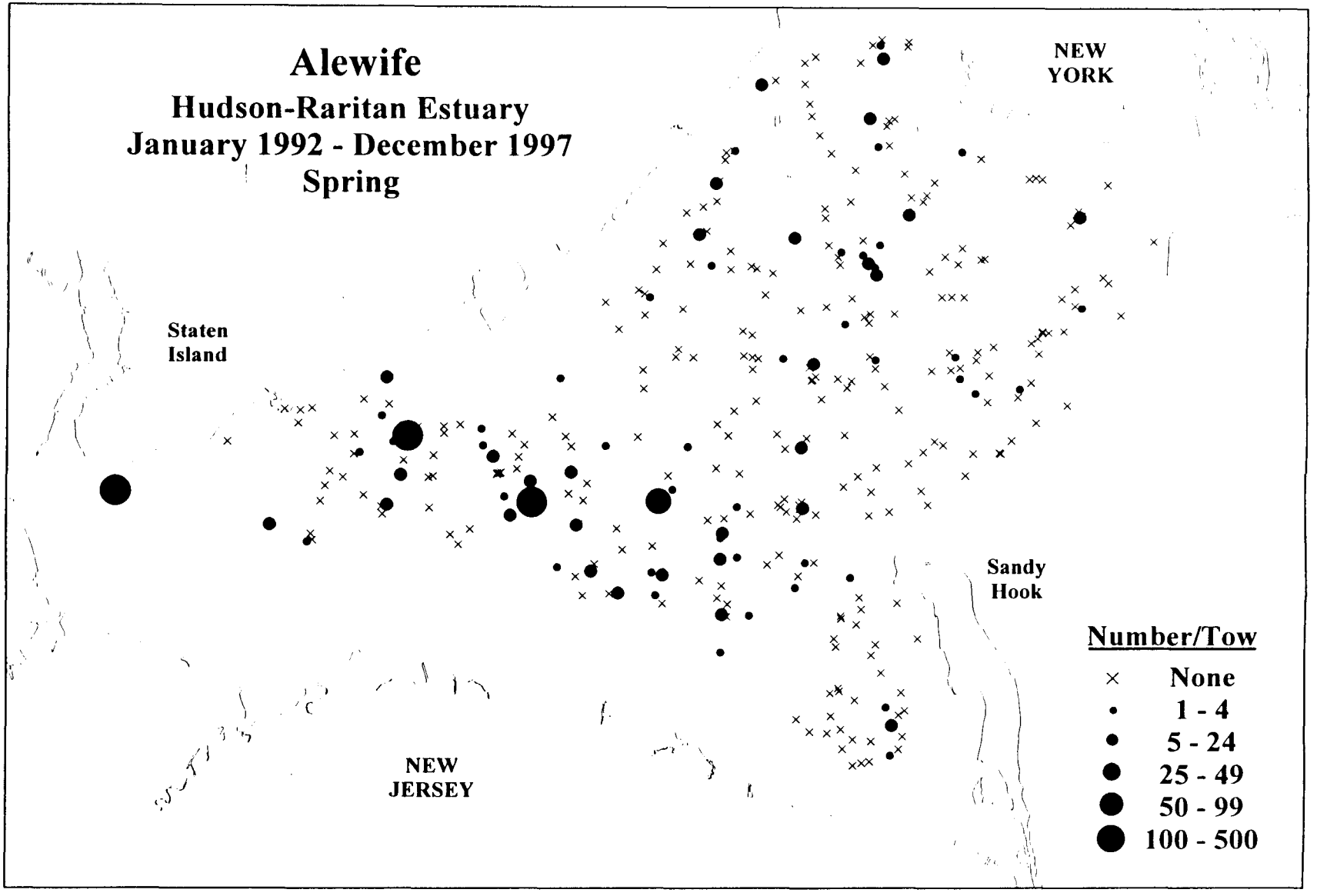

Figure 31. Distribution and abundance of alewife collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

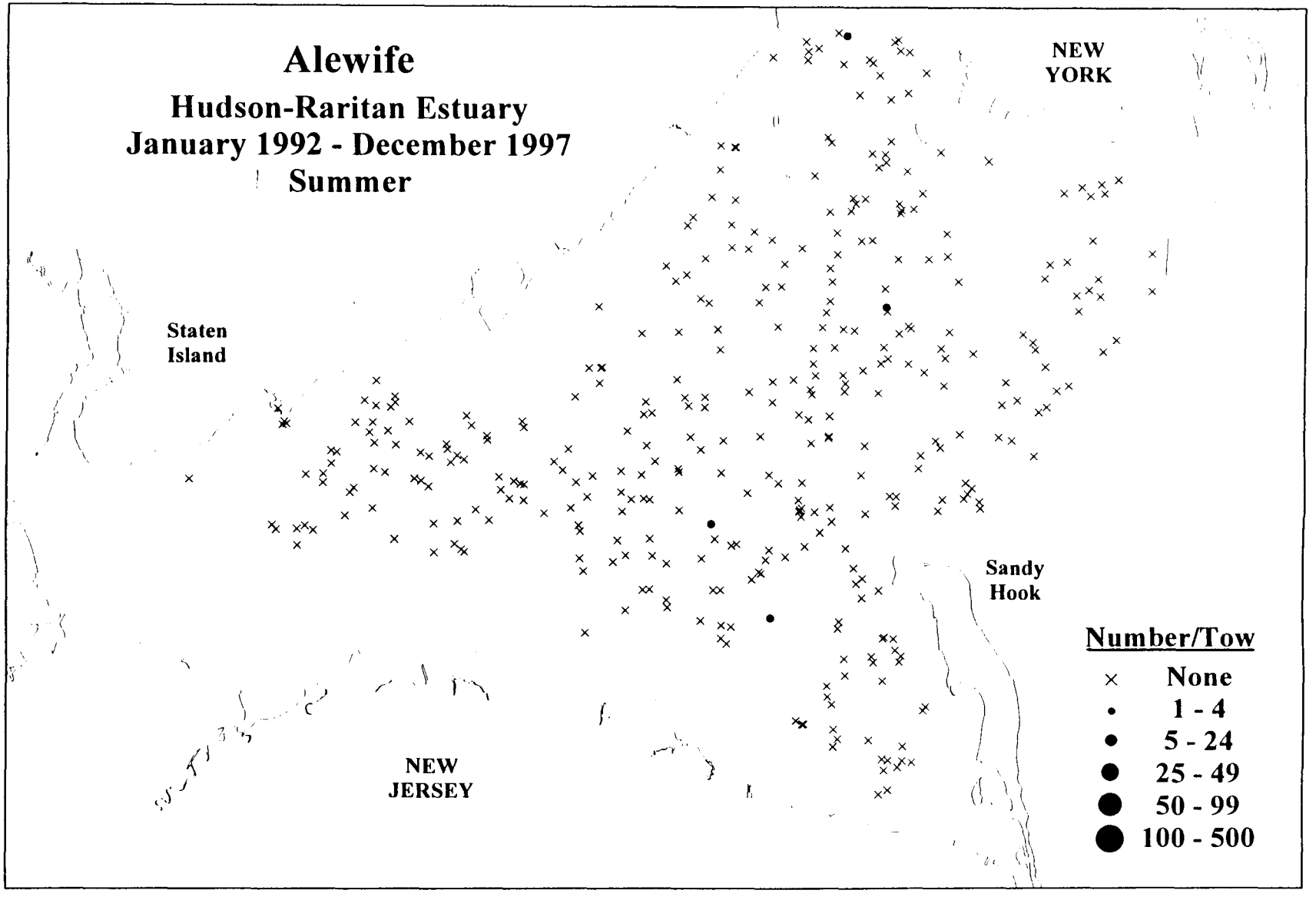

Figure 32. Distribution and abundance of alewife collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

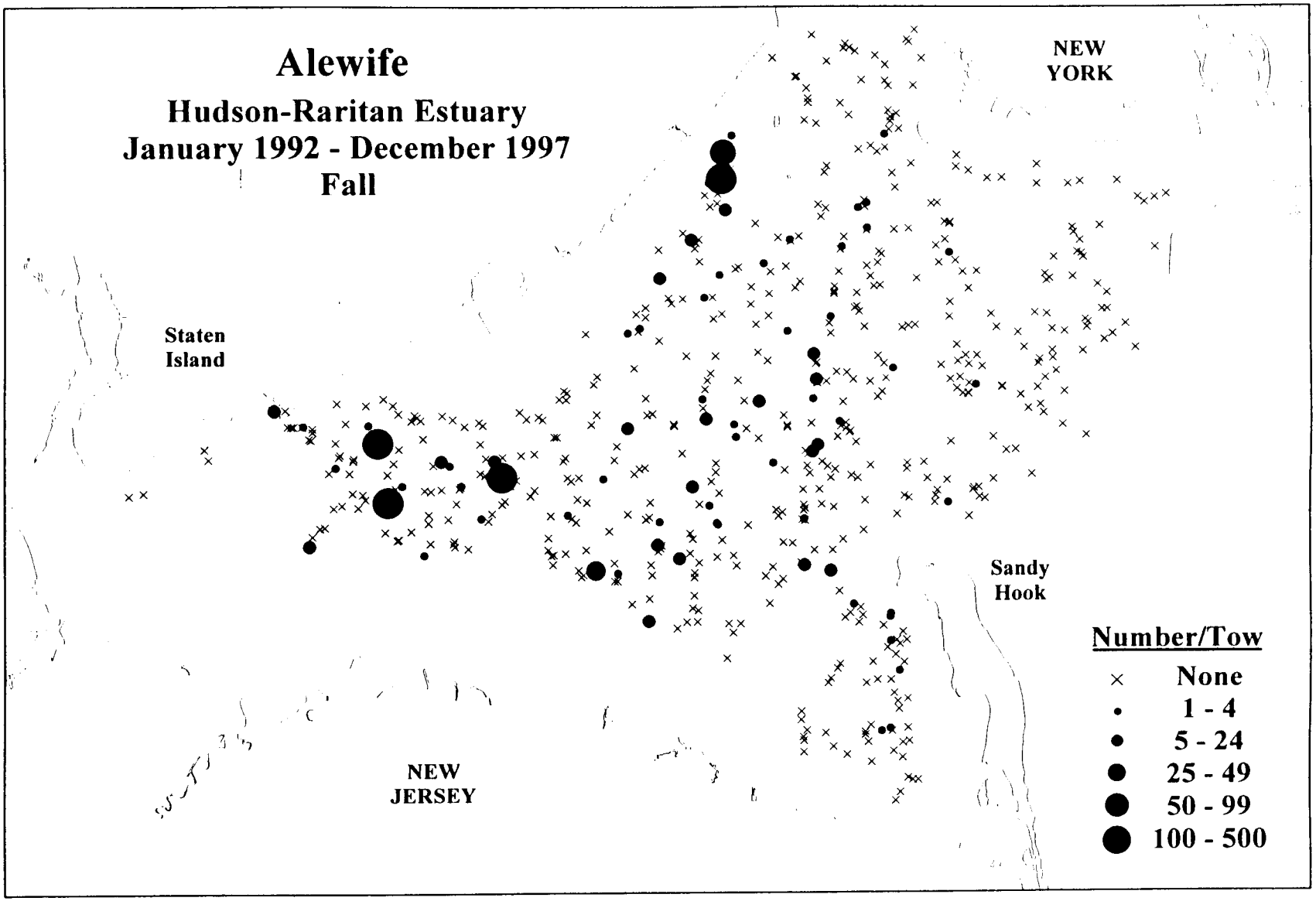

Figure 33. Distribution and abundance of alewife collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

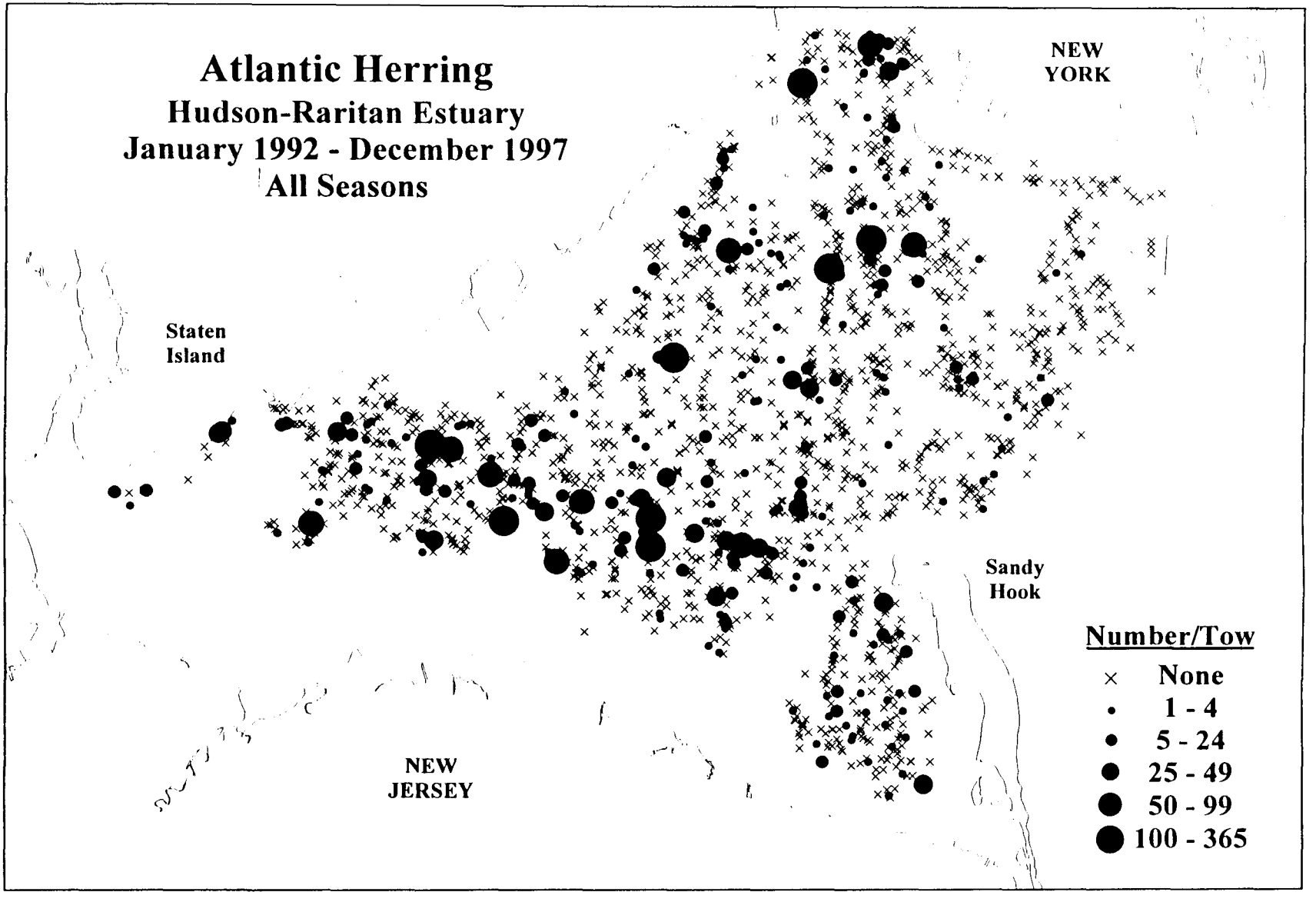

Figure 34. Distribution and abundance of all Atlantic herring collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

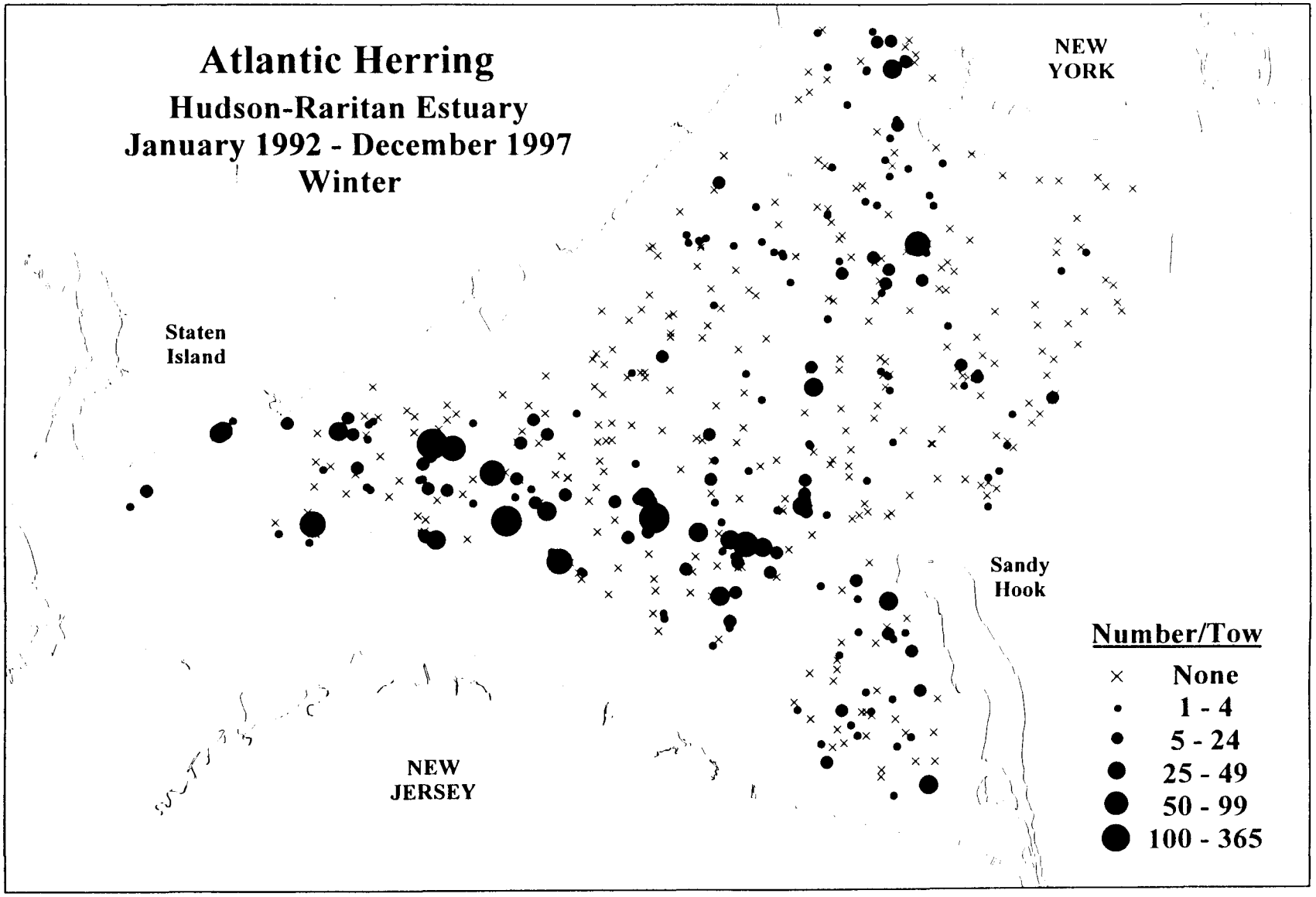

Figure 35. Distribution and abundance of all Atlantic herring collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

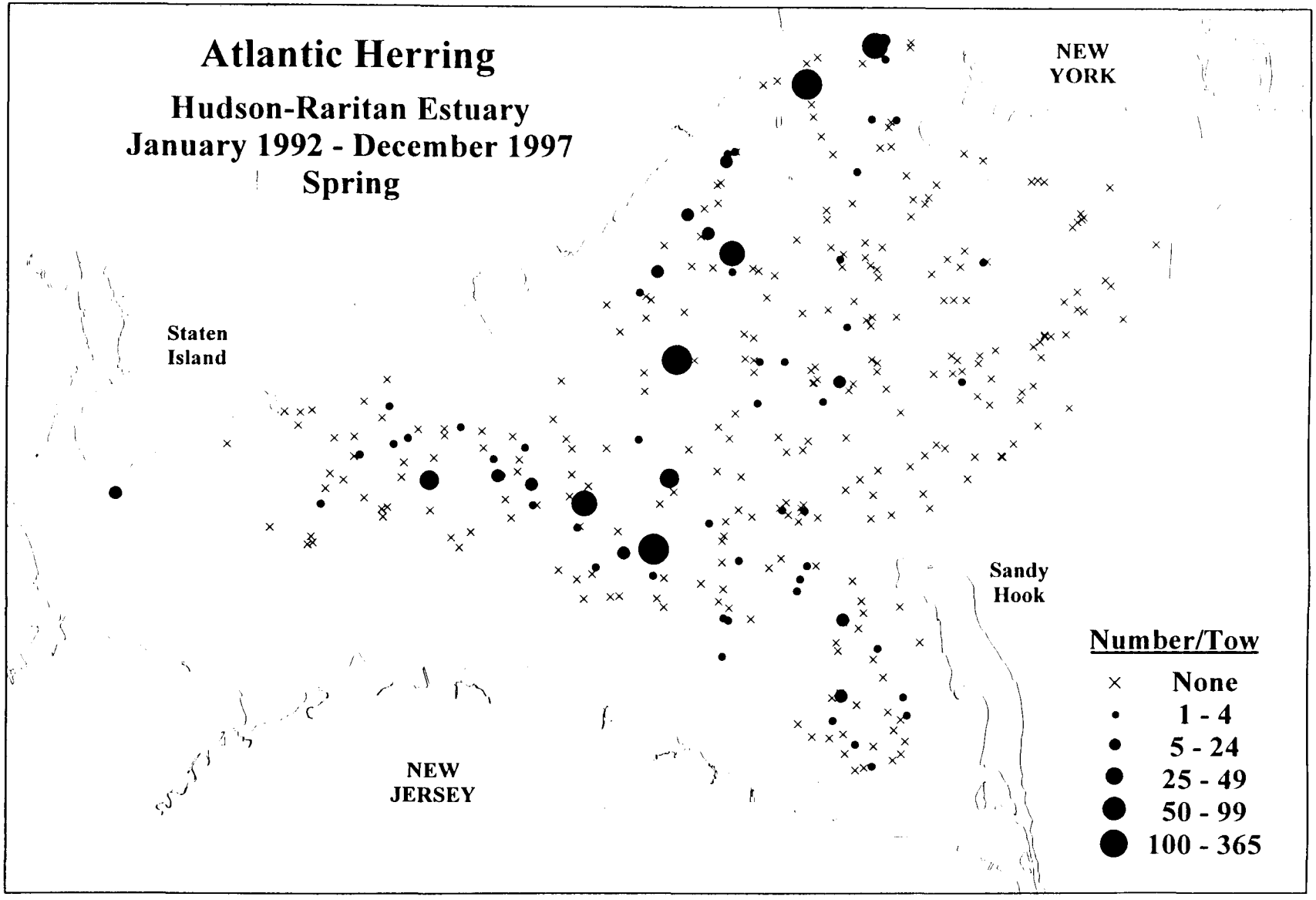

Figure 36. Distribution and abundance of Atlantic herring collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

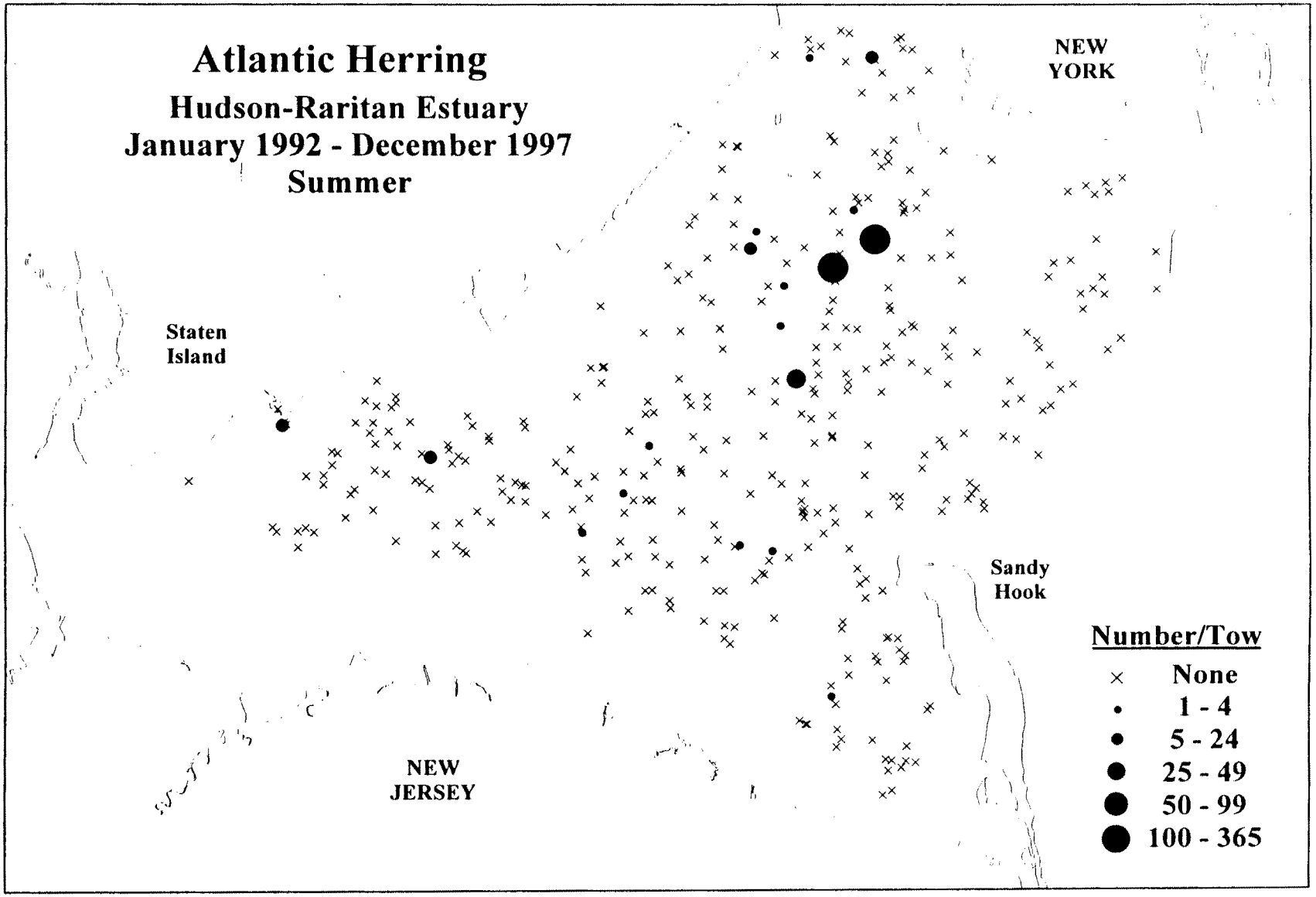

Figure 37. Distribution and abundance of Atlantic herring collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

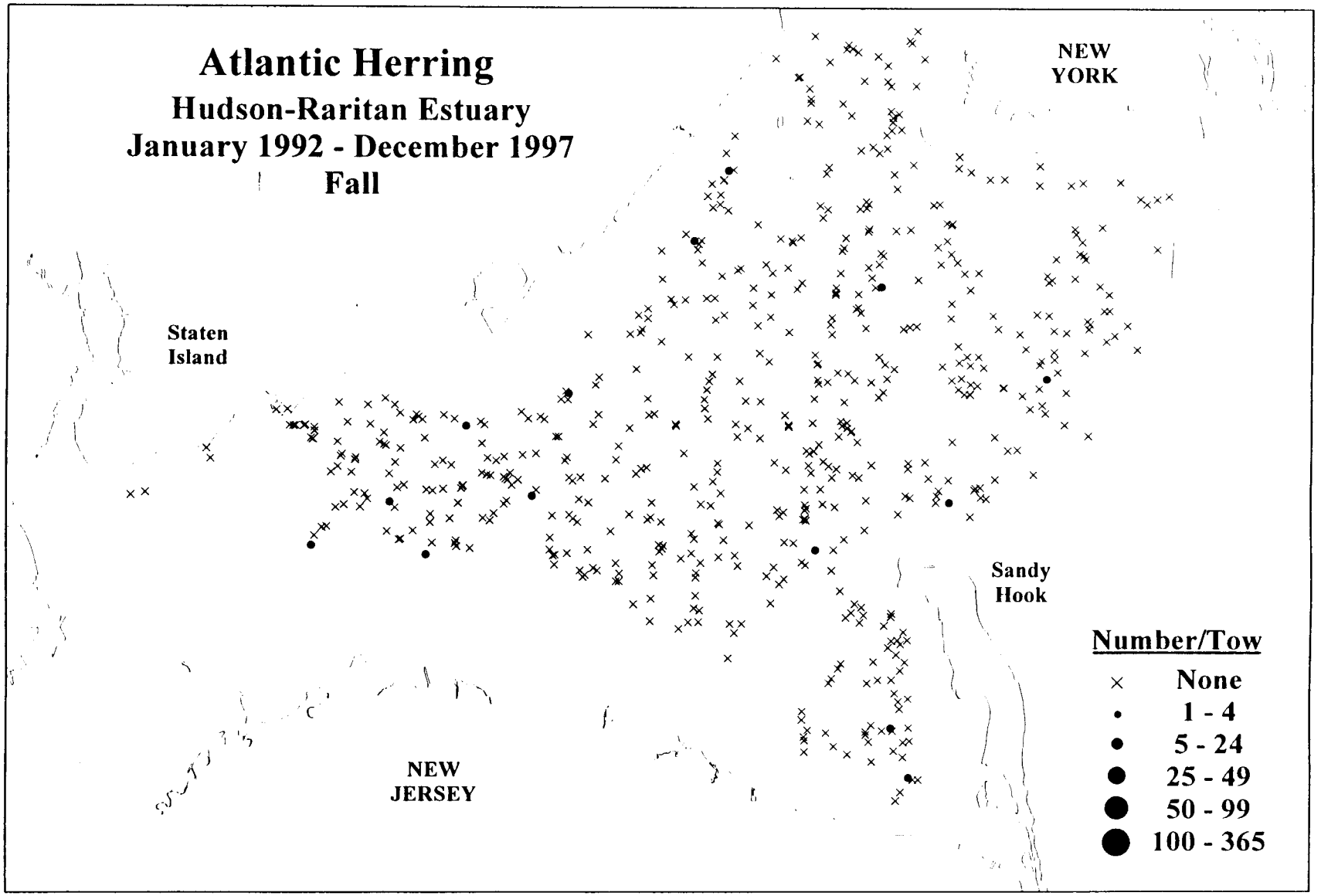

Figure 38. Distribution and abundance of Atlantic herring collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

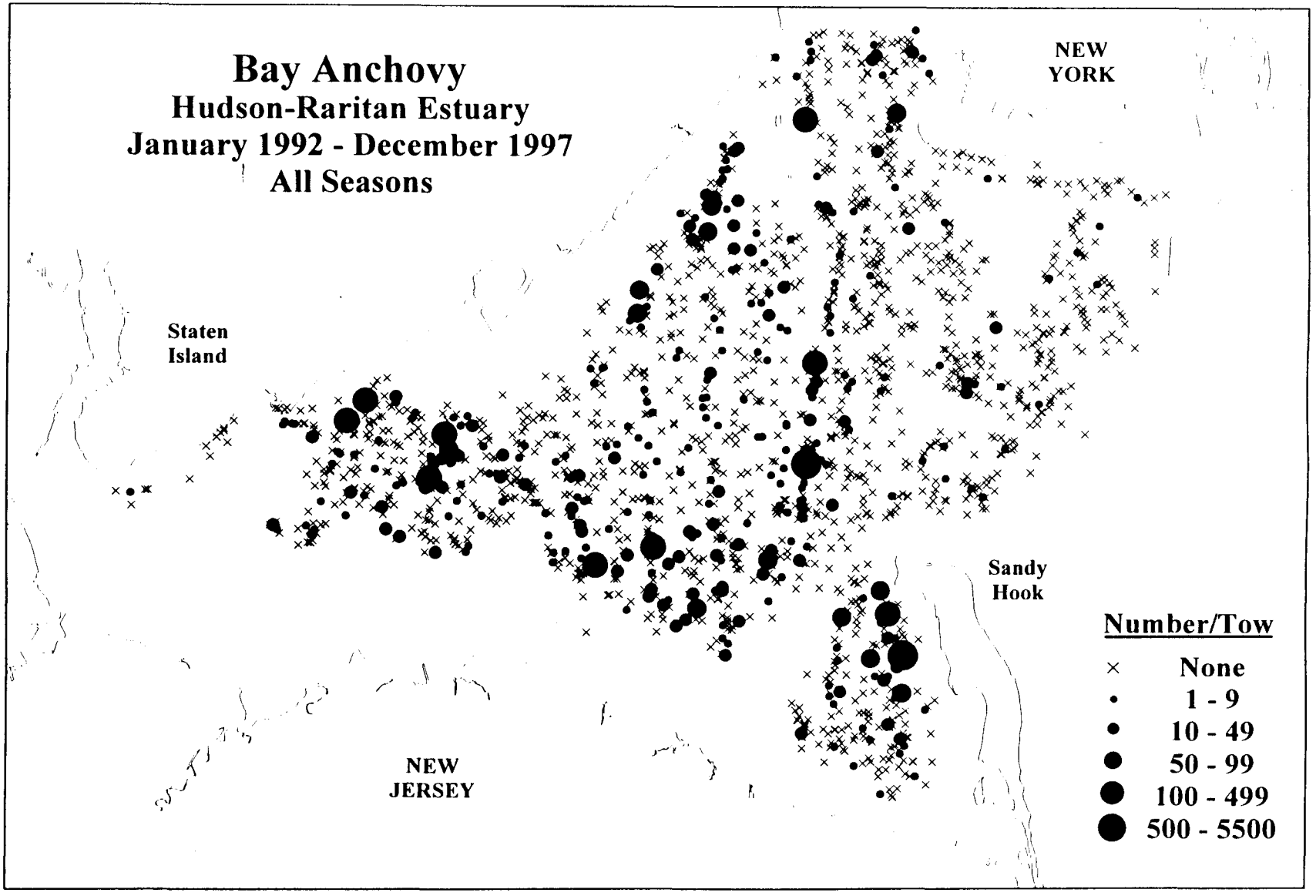

Figure 39. Distribution and abundance of all bay anchovy collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

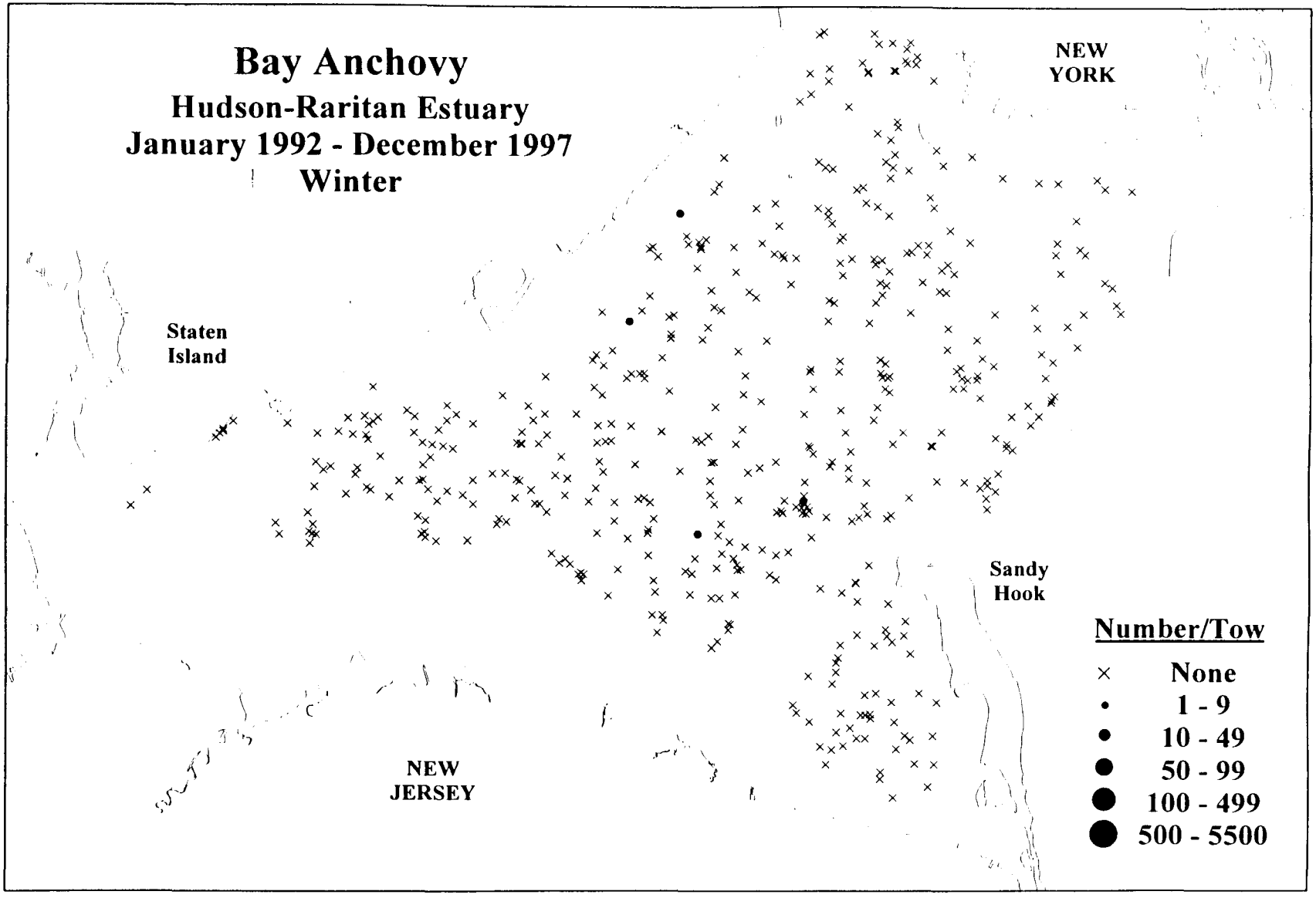

Figure 40. Distribution and abundance of all bay anchovy collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

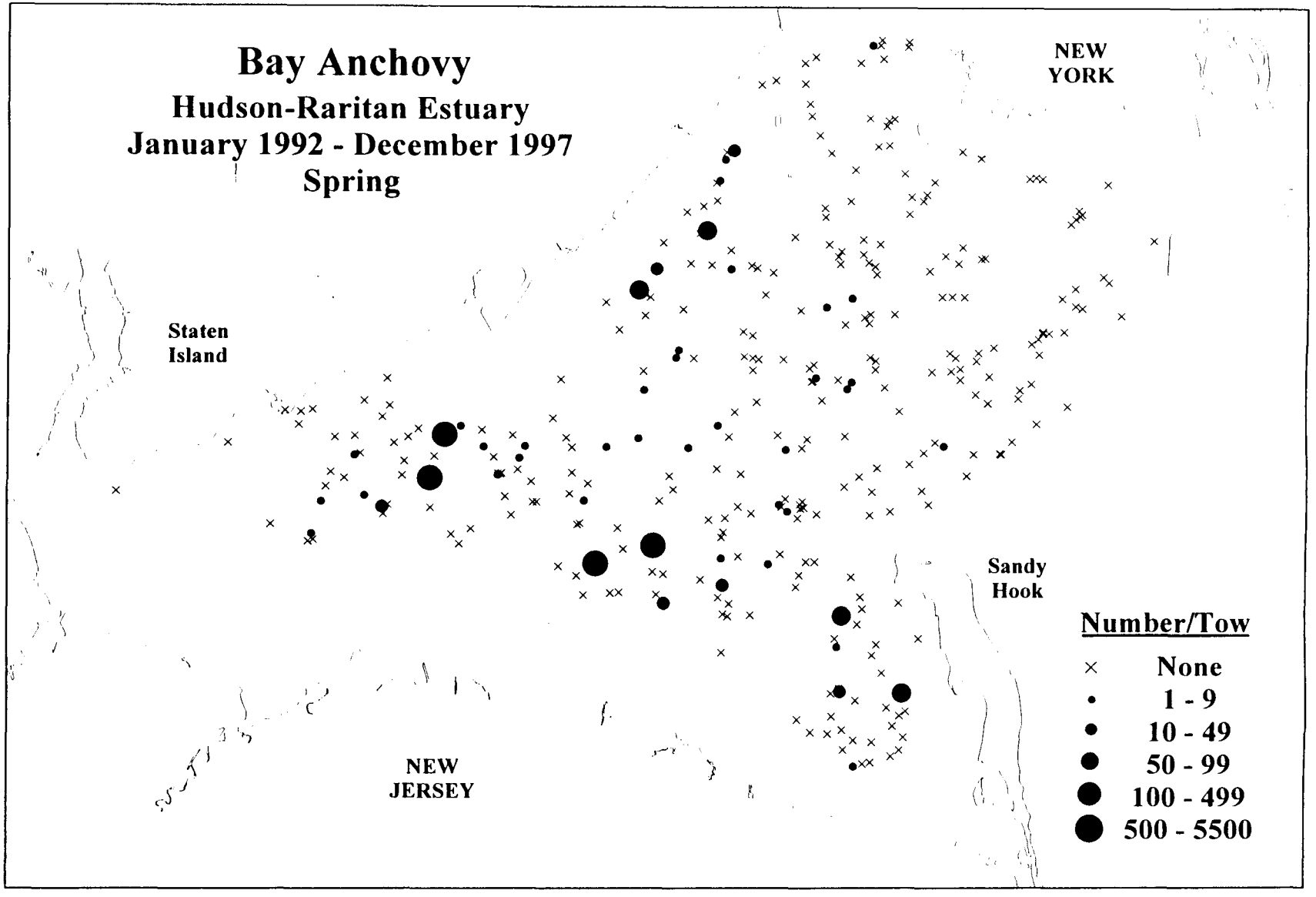

Figure 41. Distribution and abundance of bay anchovy collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

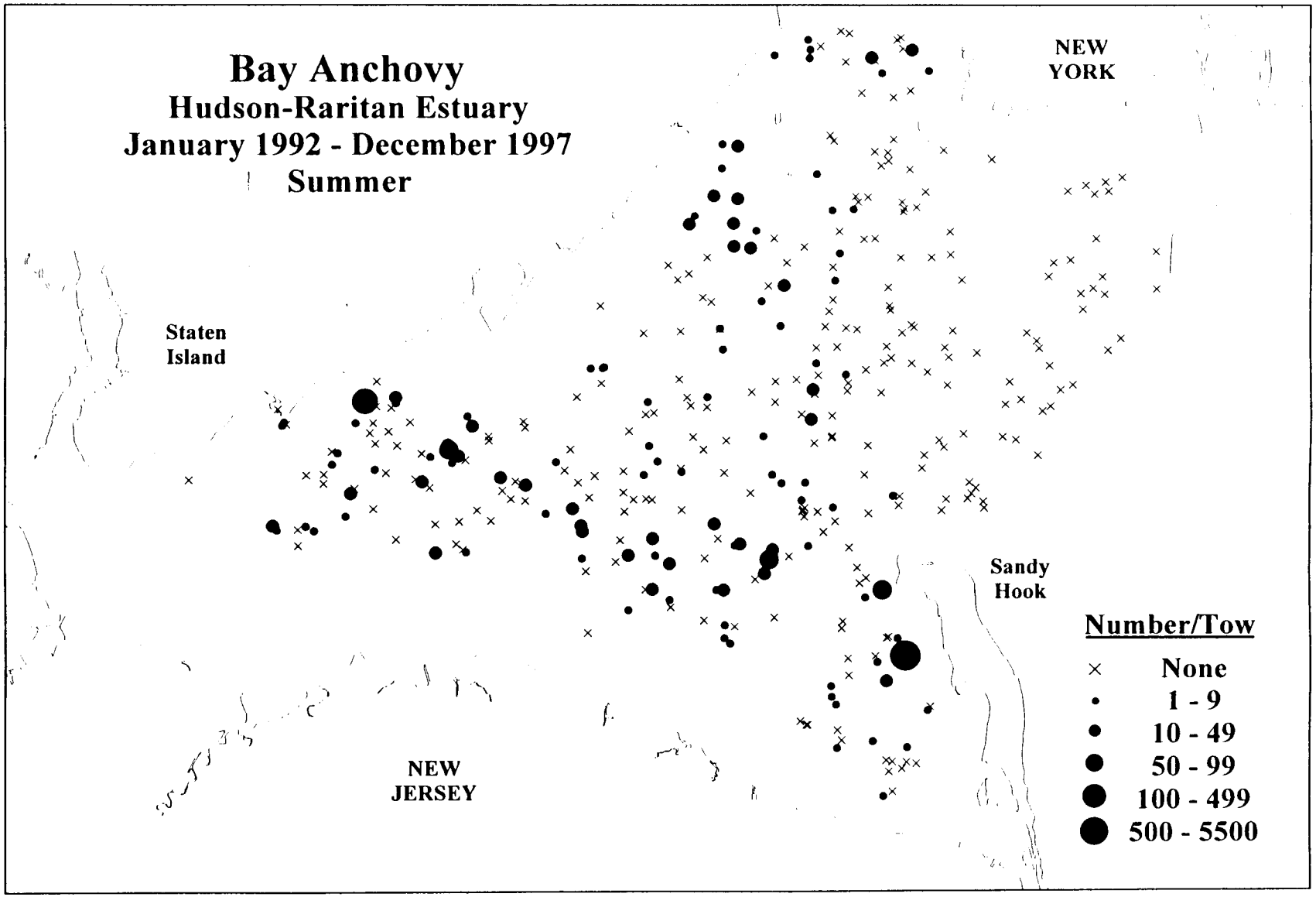

Figure 42. Distribution and abundance of bay anchovy collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

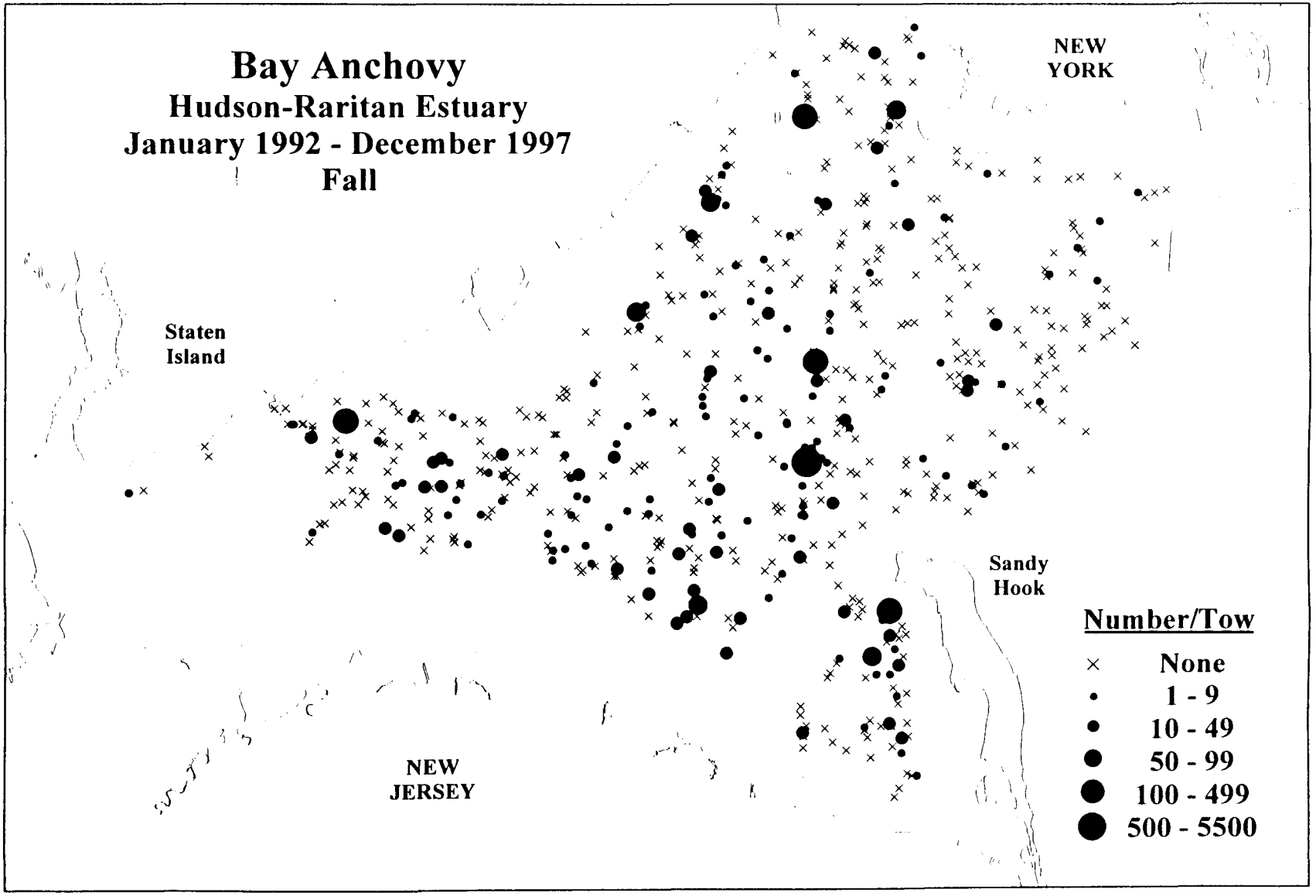

Figure 43. Distribution and abundance of bay anchovy collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

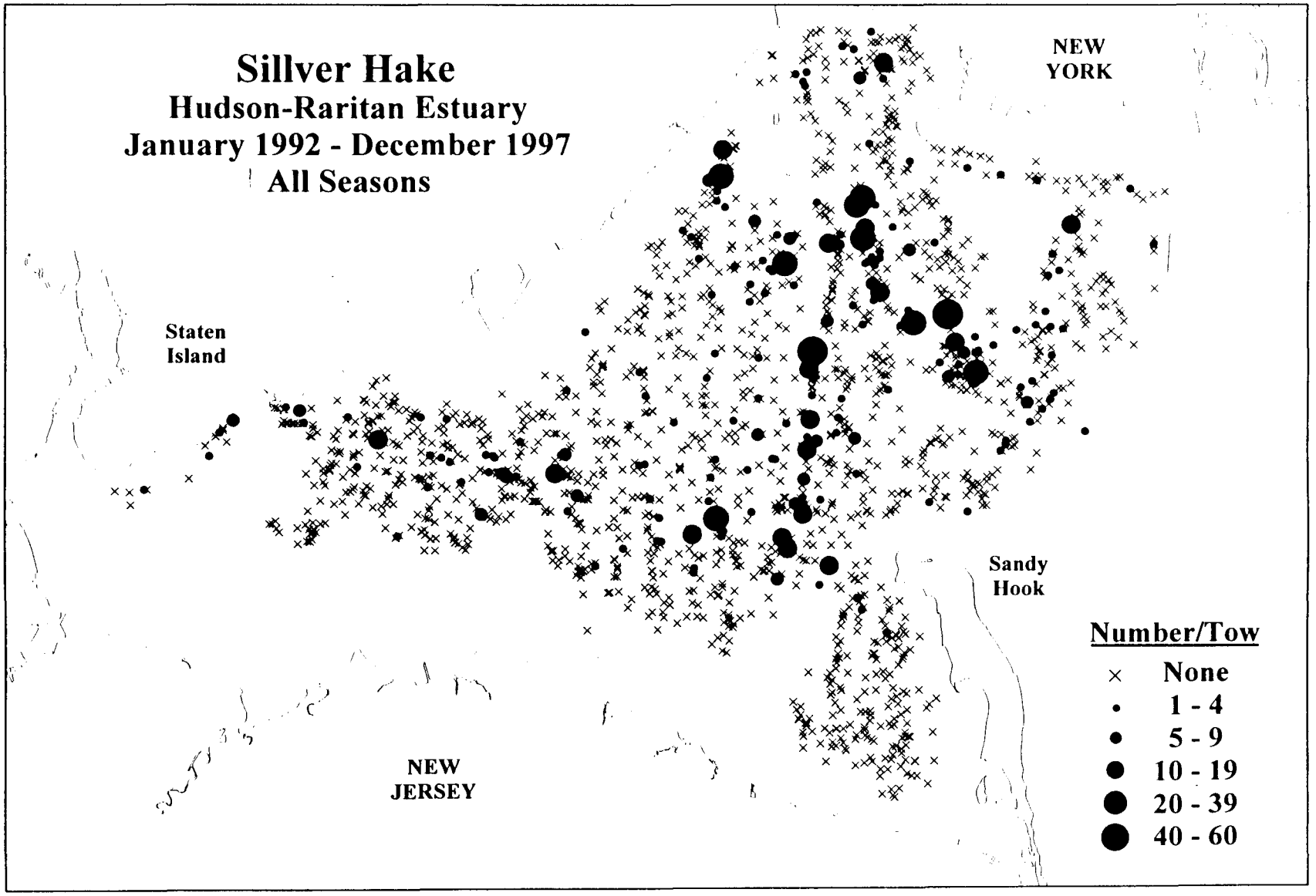

Figure 44. Distribution and abundance of all silver hake collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

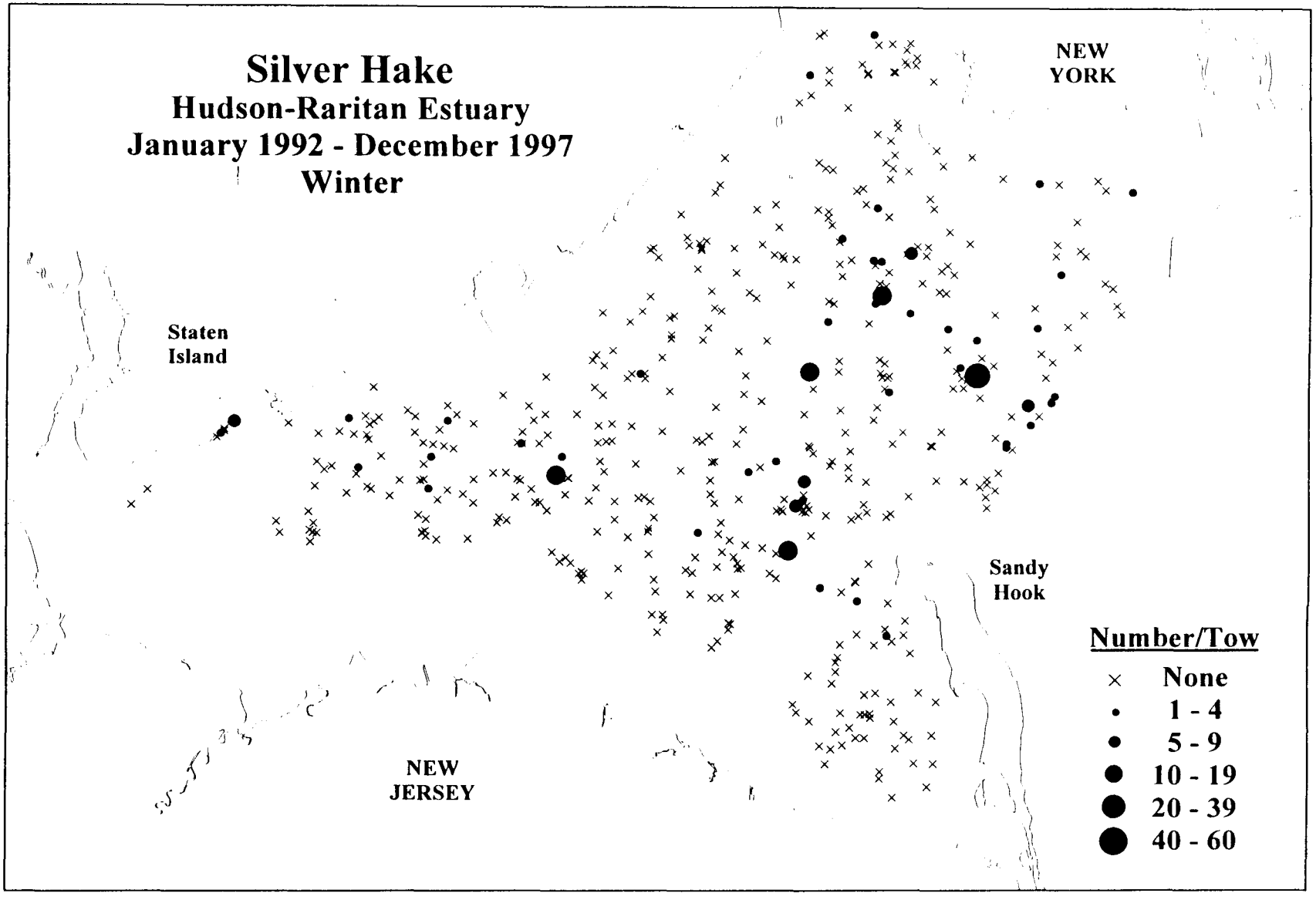

Figure 45. Distribution and abundance of all silver hake collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

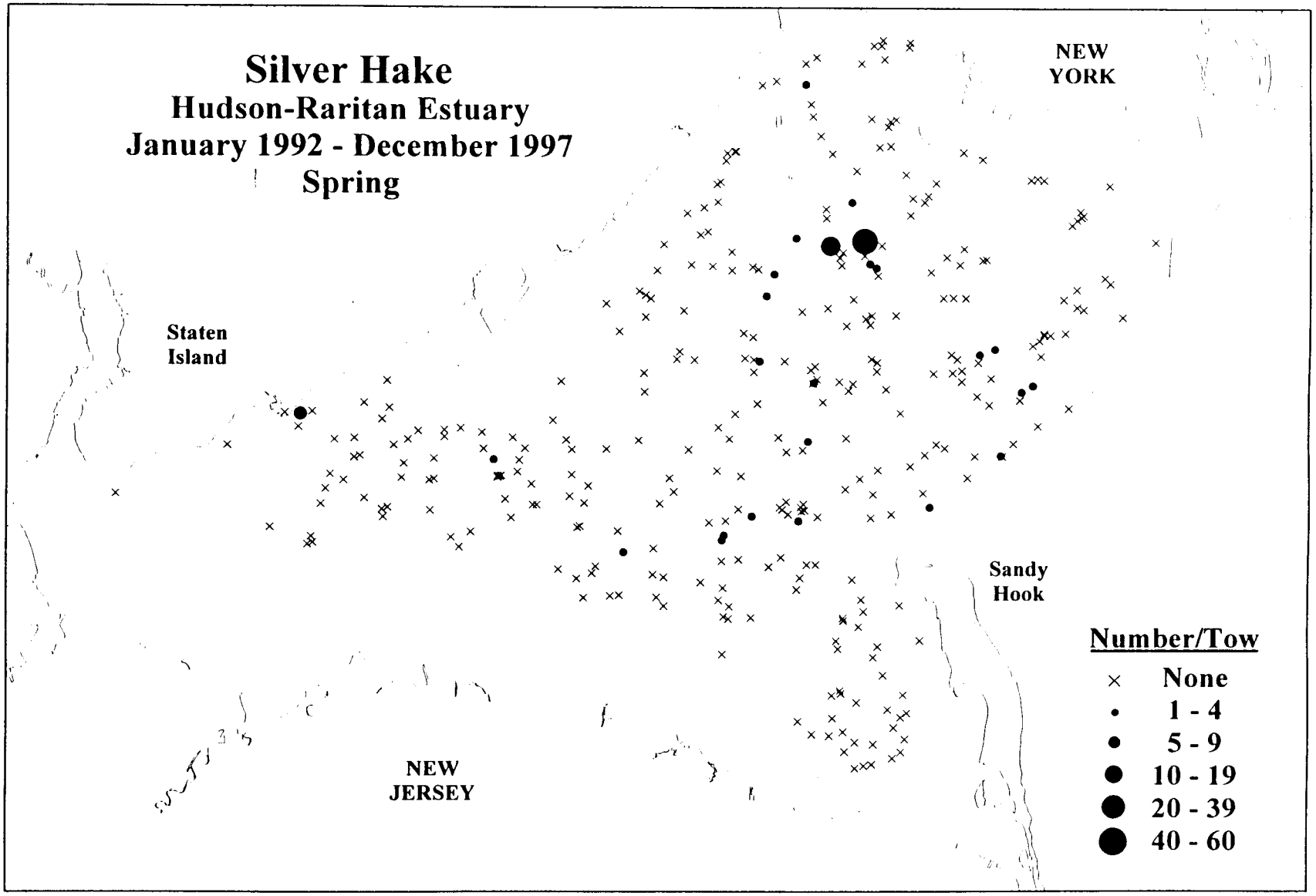

Figure 46. Distribution and abundance of silver hake collected during the Spring (April and June) in the Hudson- Raritan Estuary between January 1992 and December 1997.

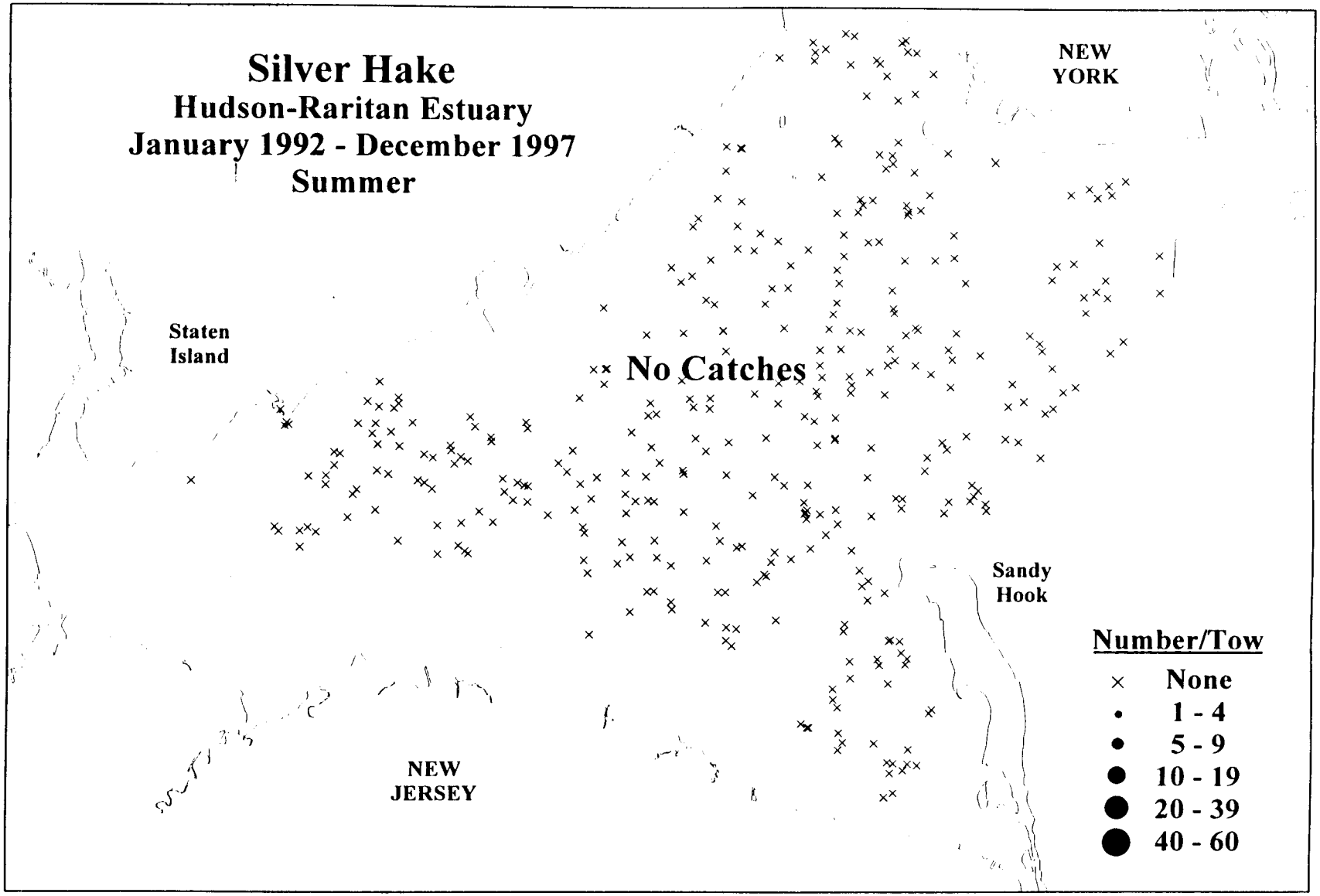

Figure 47. Distribution and abundance of silver hake collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

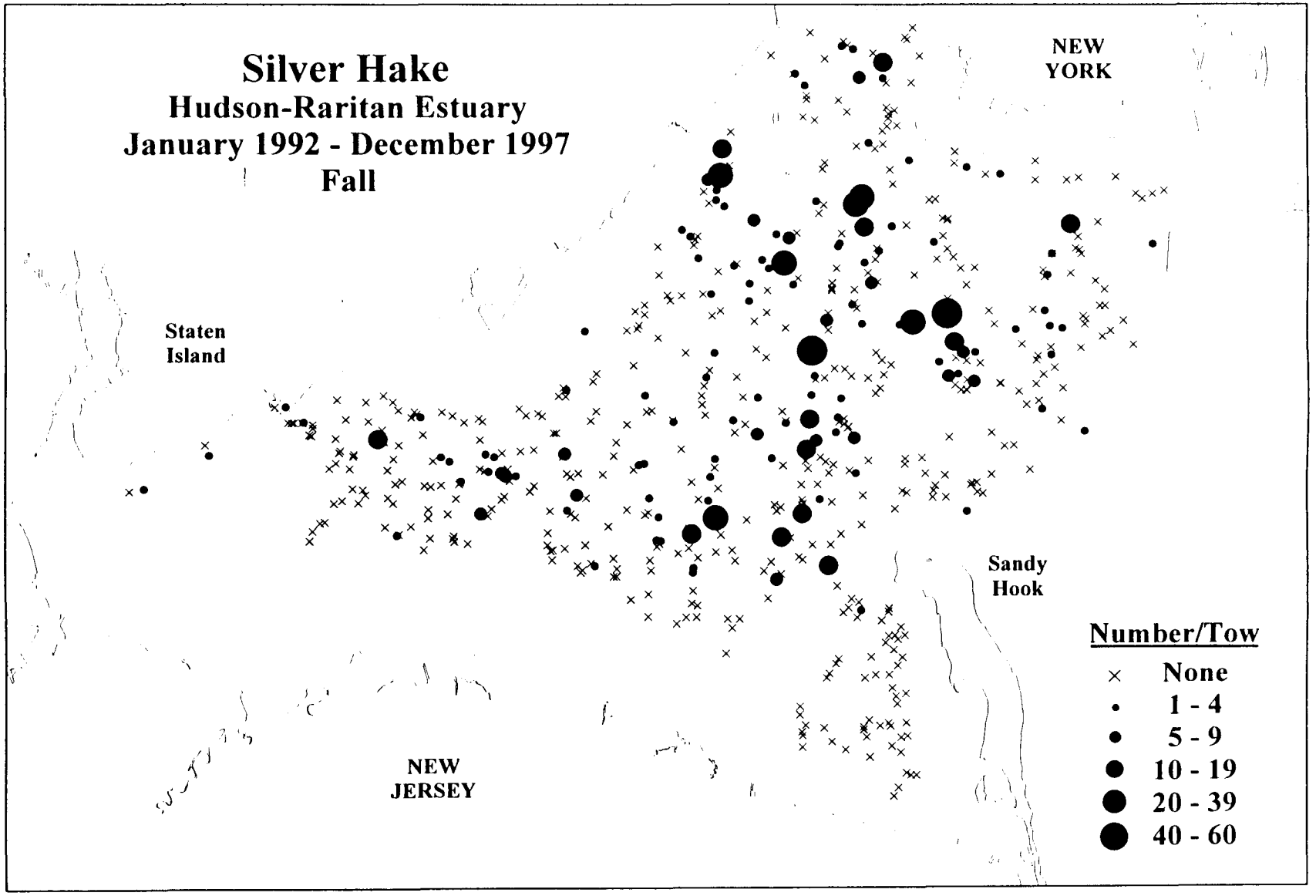

Figure 48. Distribution and abundance of silver hake collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

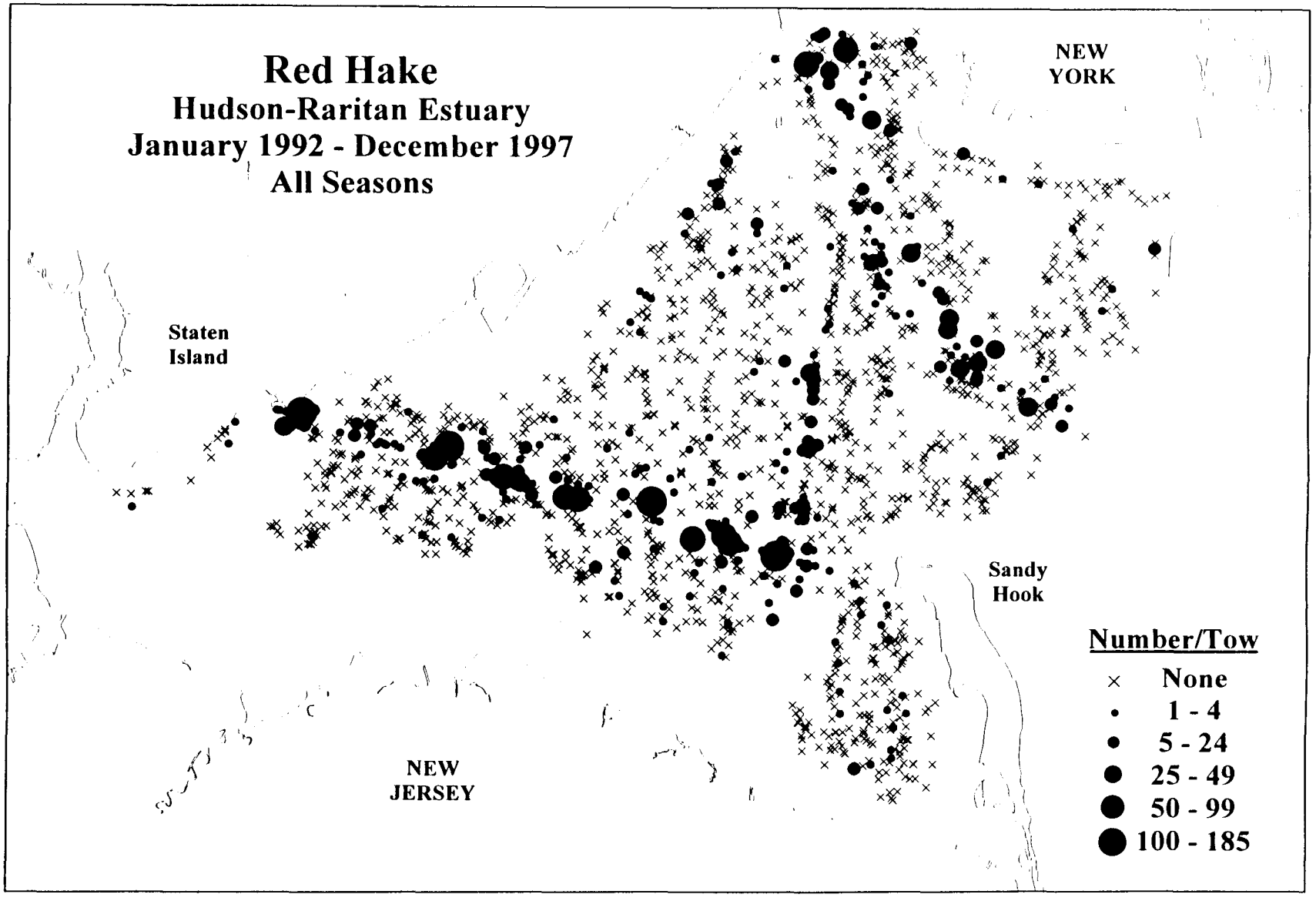

Figure 49. Distribution and abundance of all red hake collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

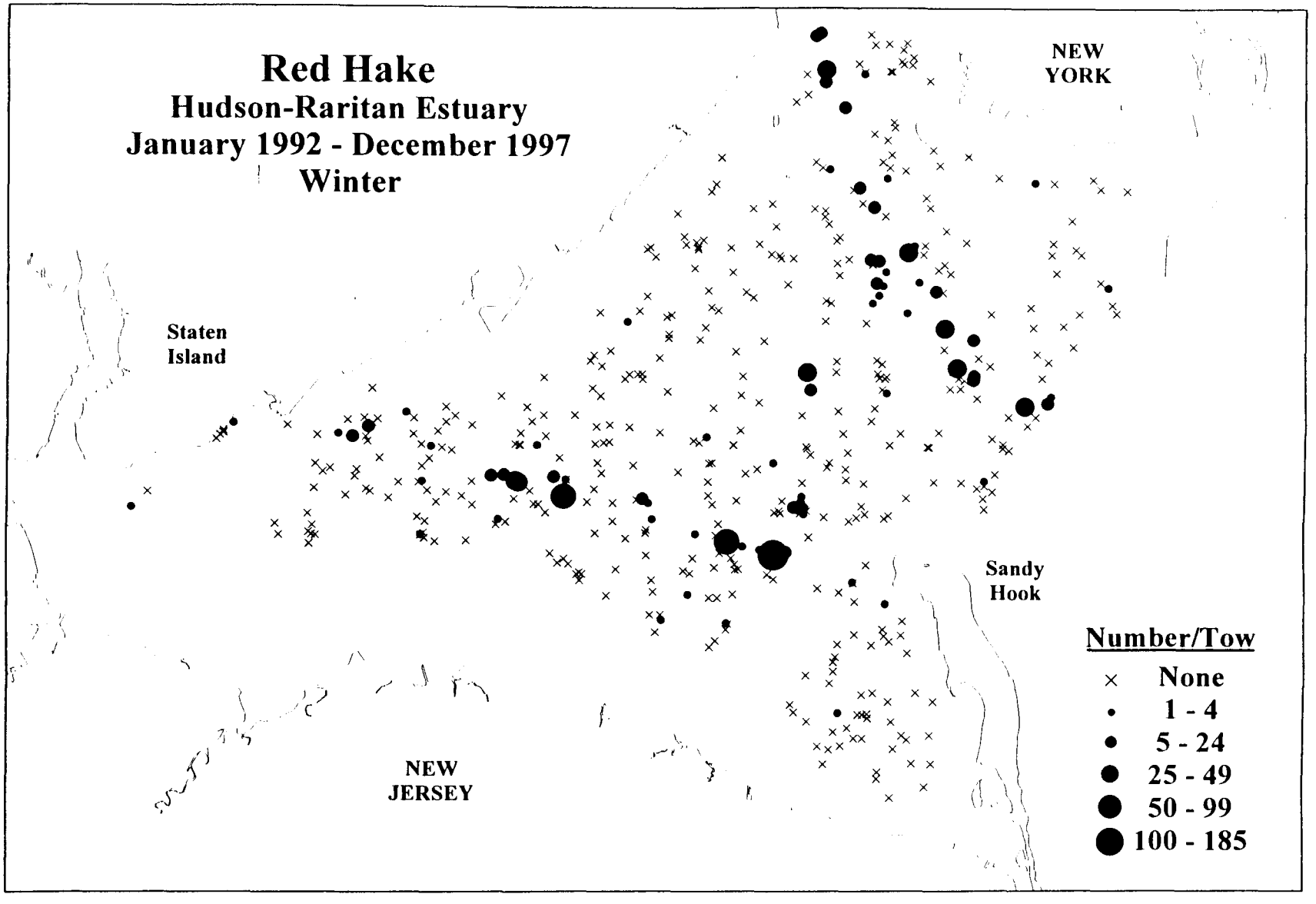

Figure 50. Distribution and abundance of all red hake collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

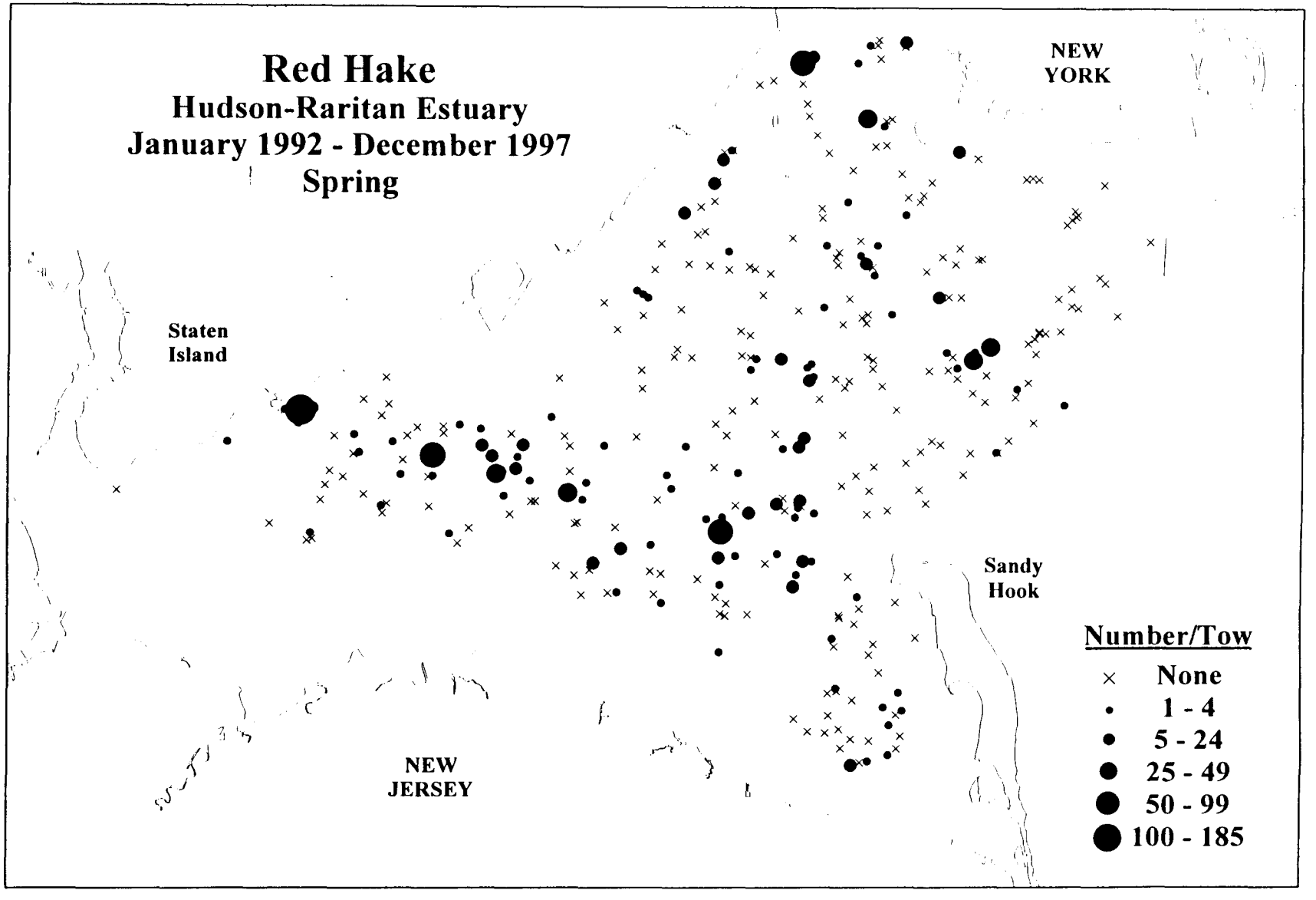

Figure 51. Distribution and abundance of red hake collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

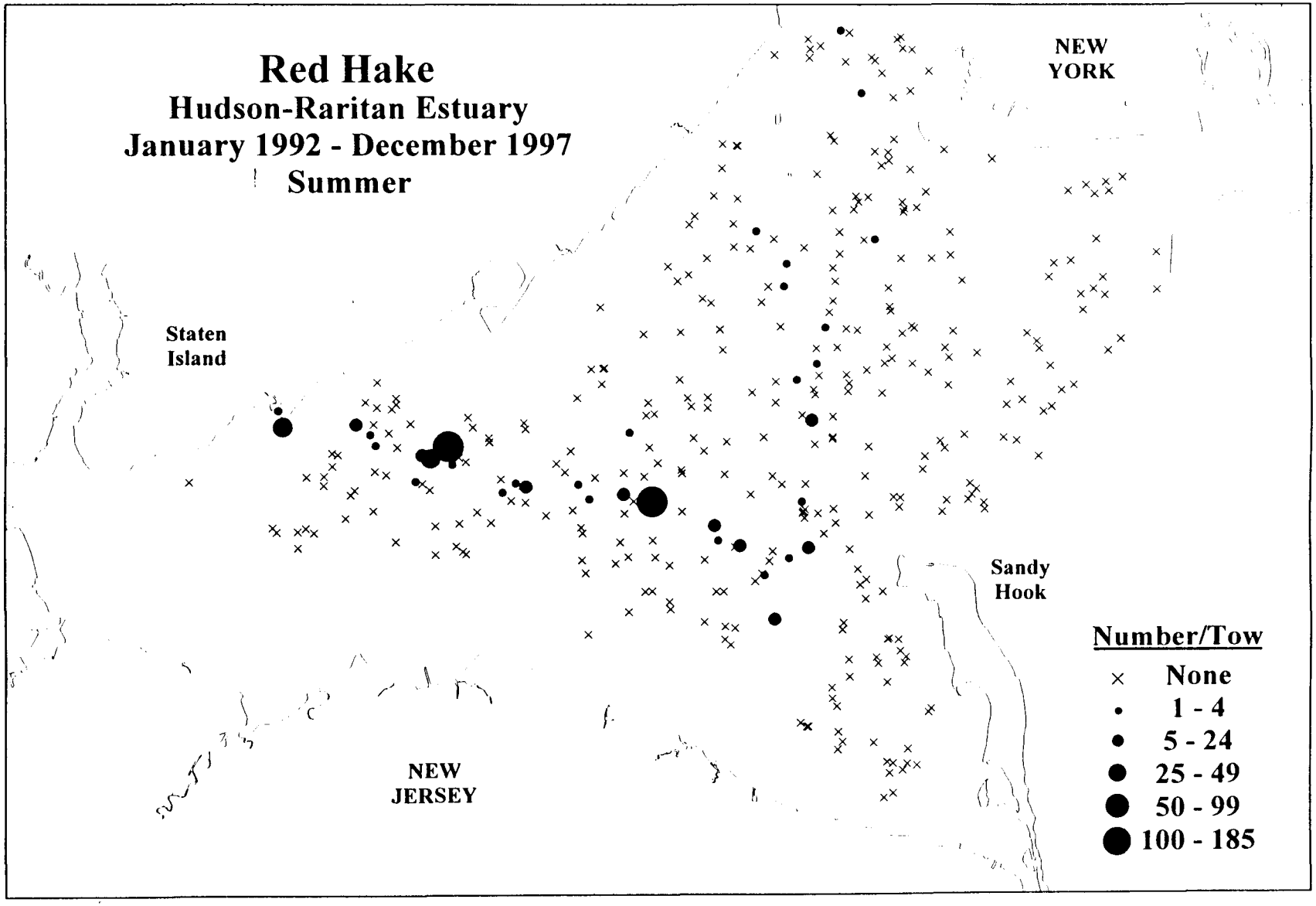

Figure 52. Distribution and abundance of red hake collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

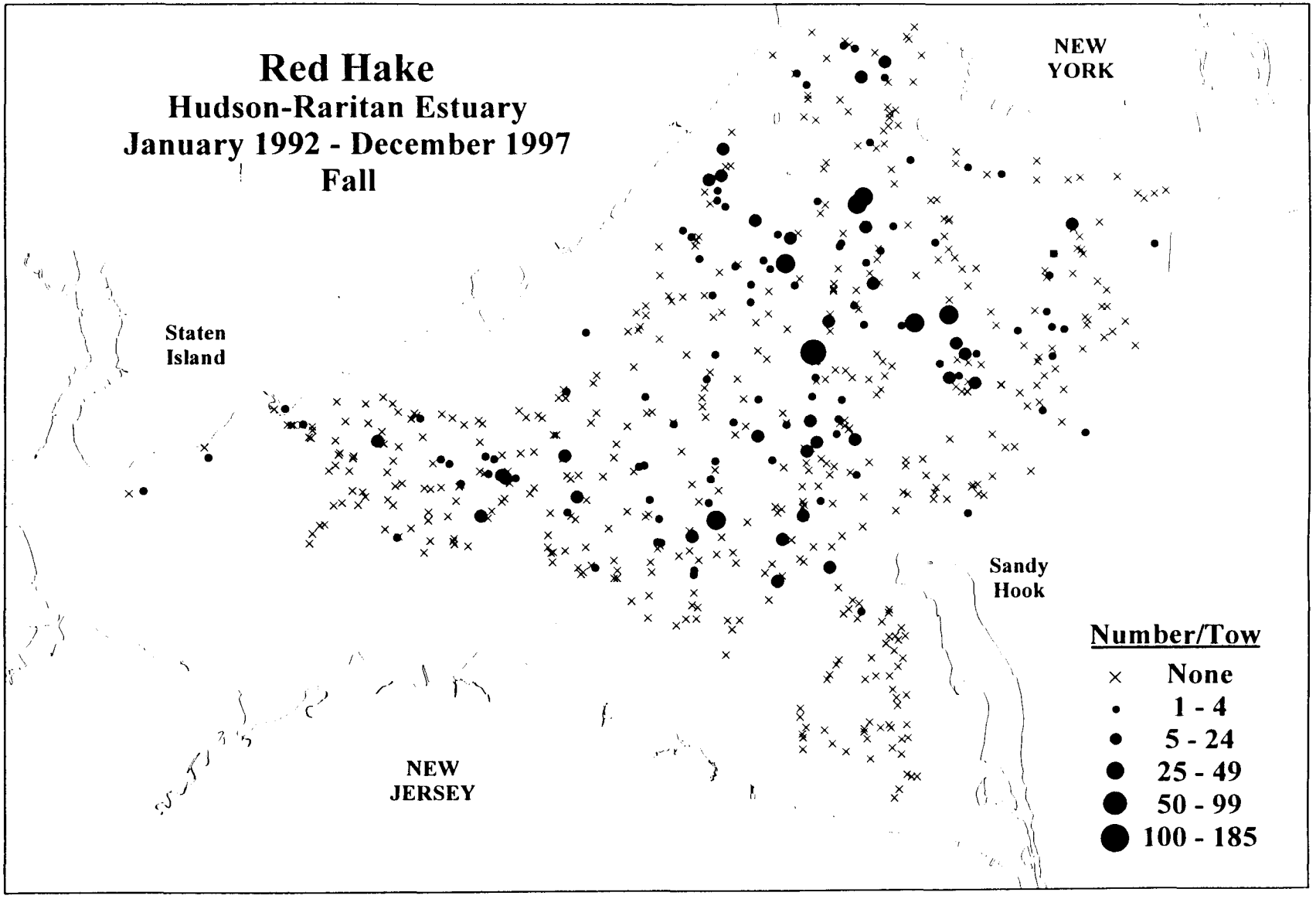

Figure 53. Distribution and abundance of red hake collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

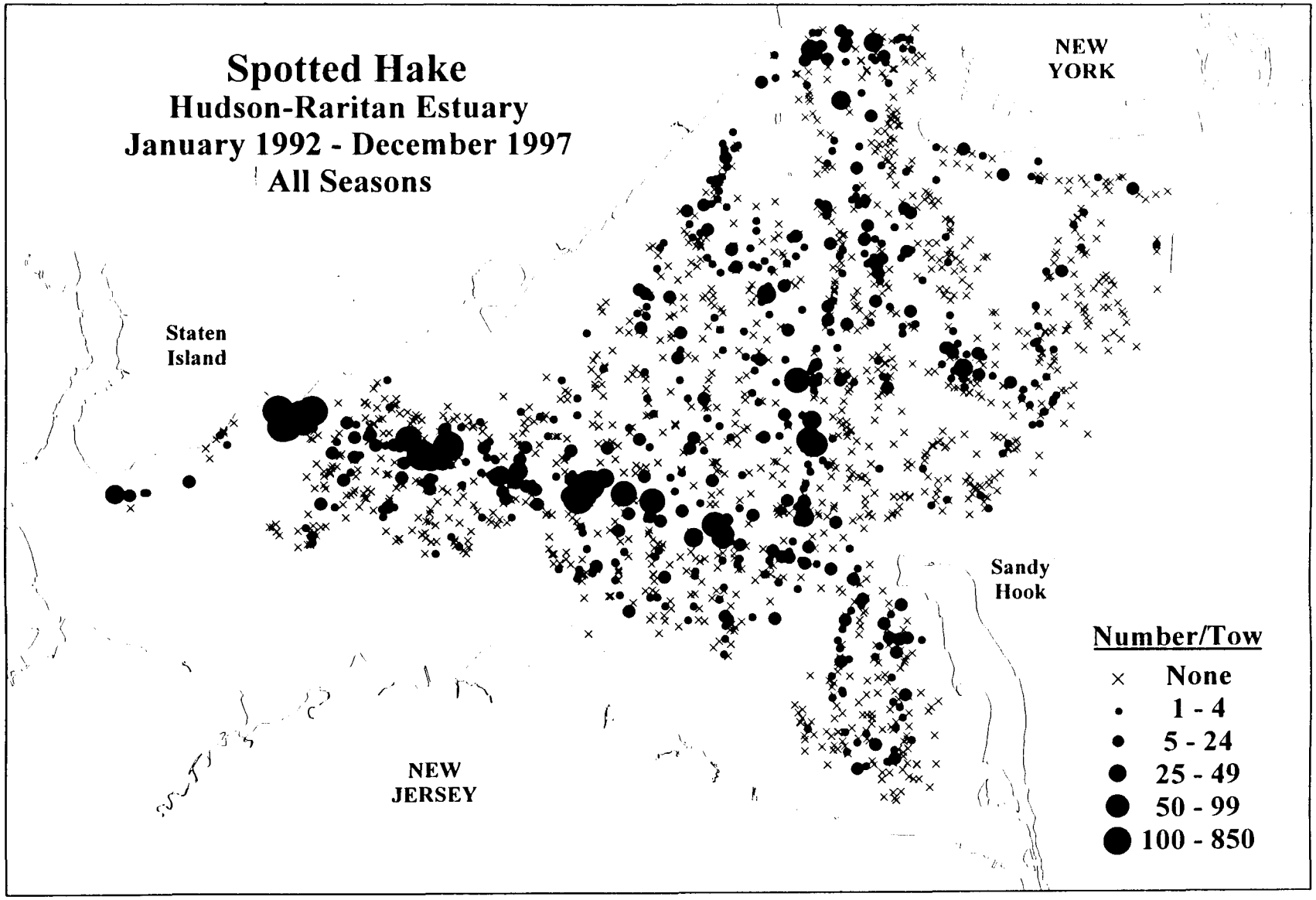

Figure 54. Distribution and abundance of all spotted hake collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

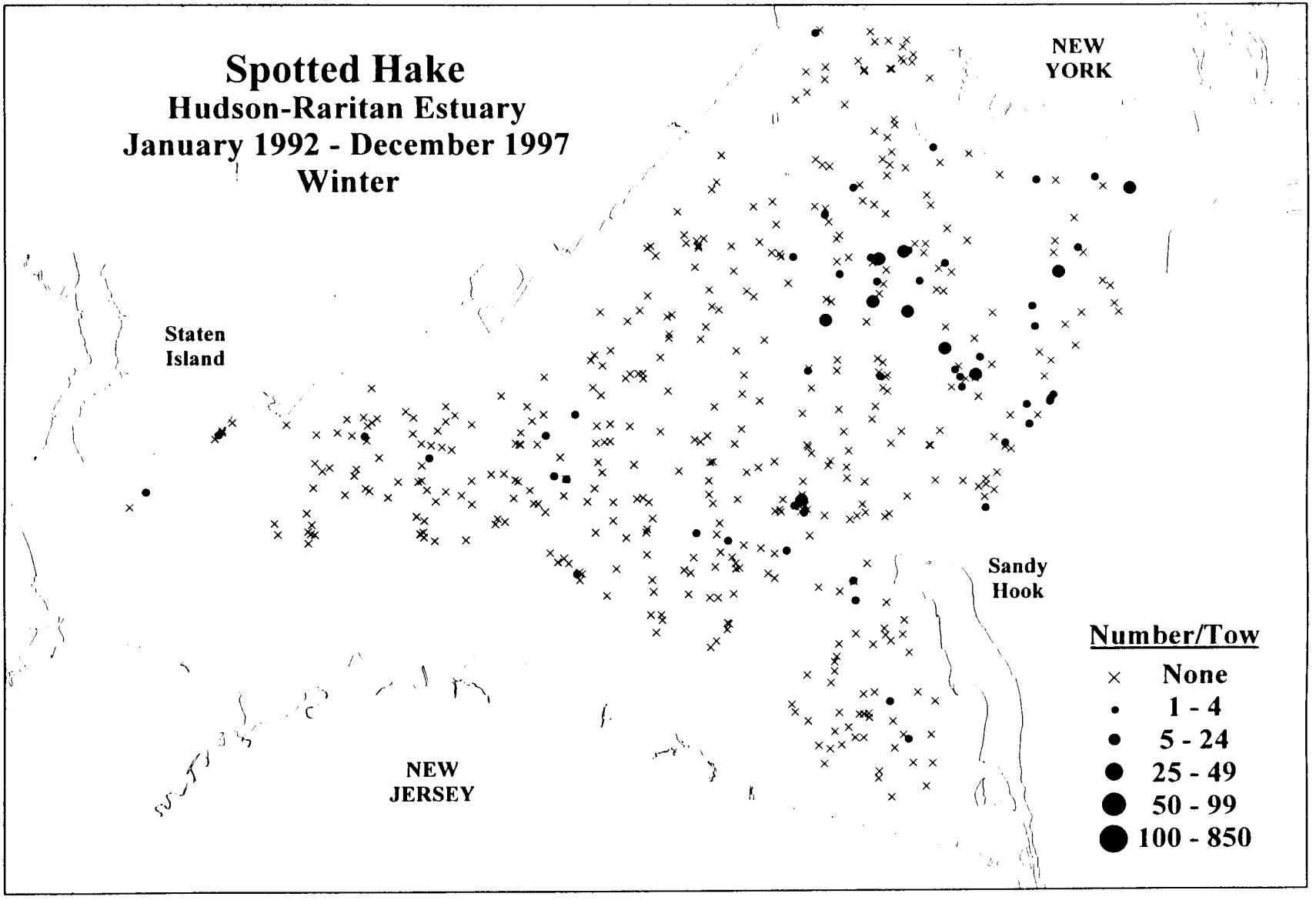

Figure 55. Distribution and abundance of all spotted hake collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

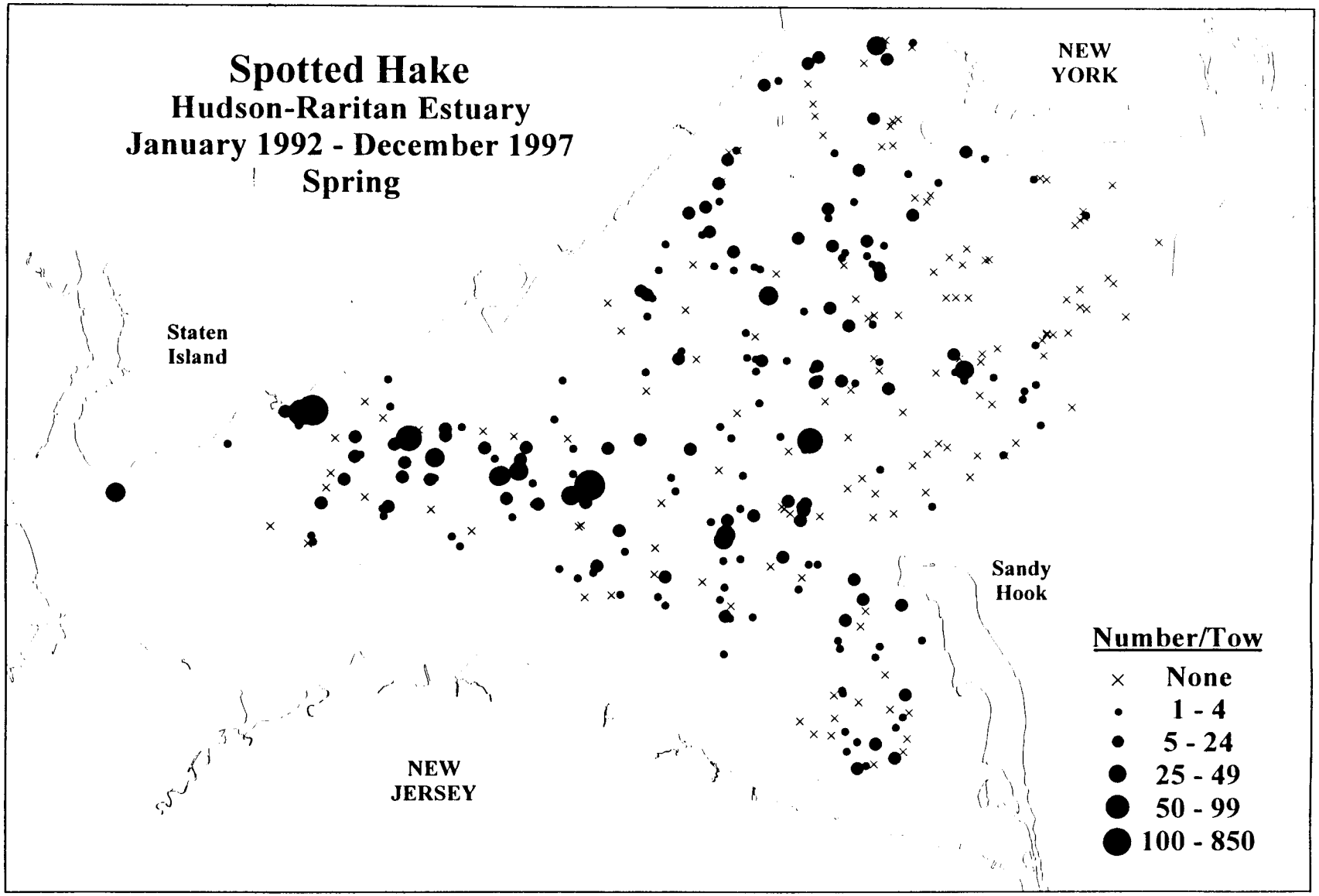

Figure 56. Distribution and abundance of spotted hake collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

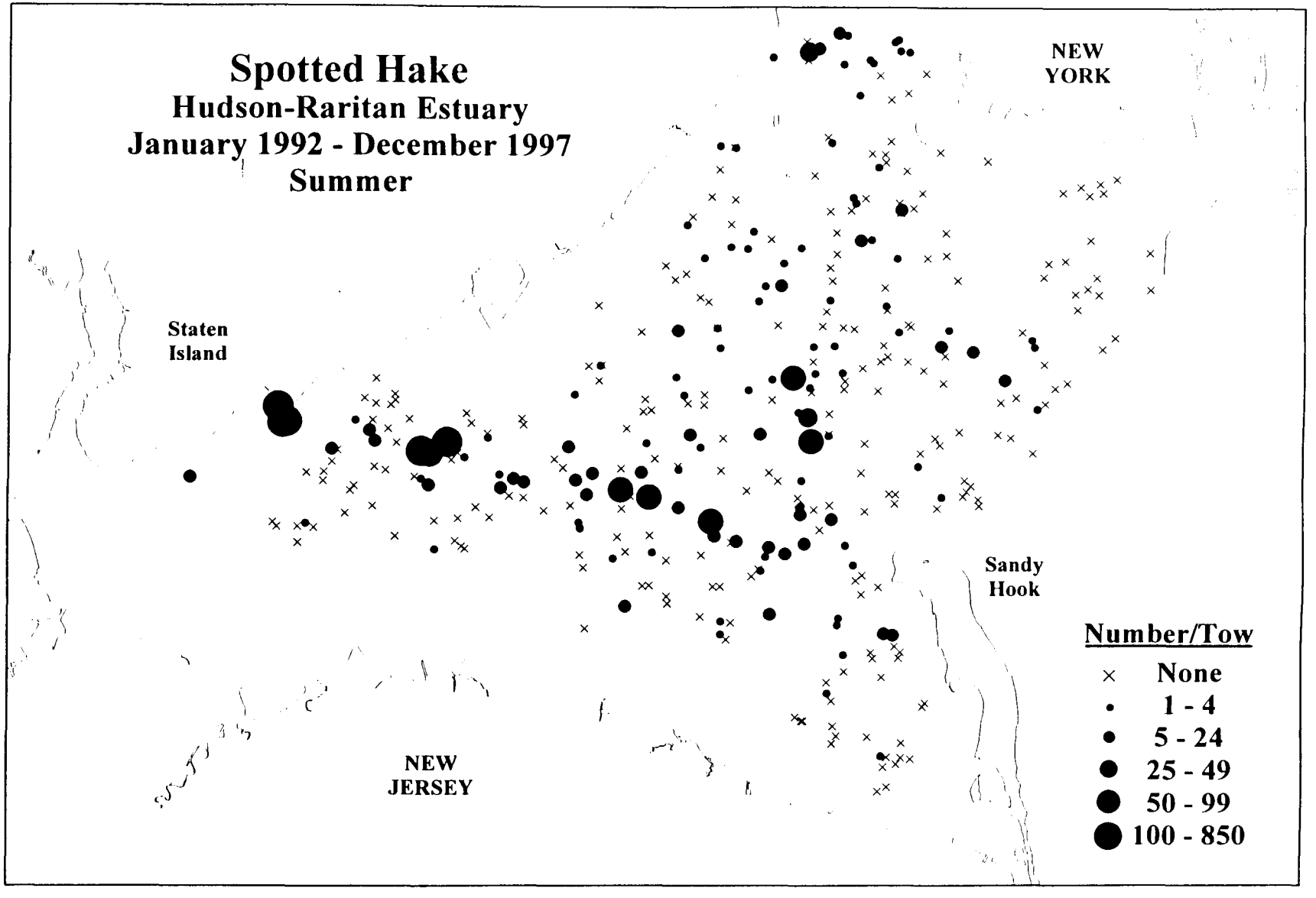

Figure 57. Distribution and abundance of spotted hake collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

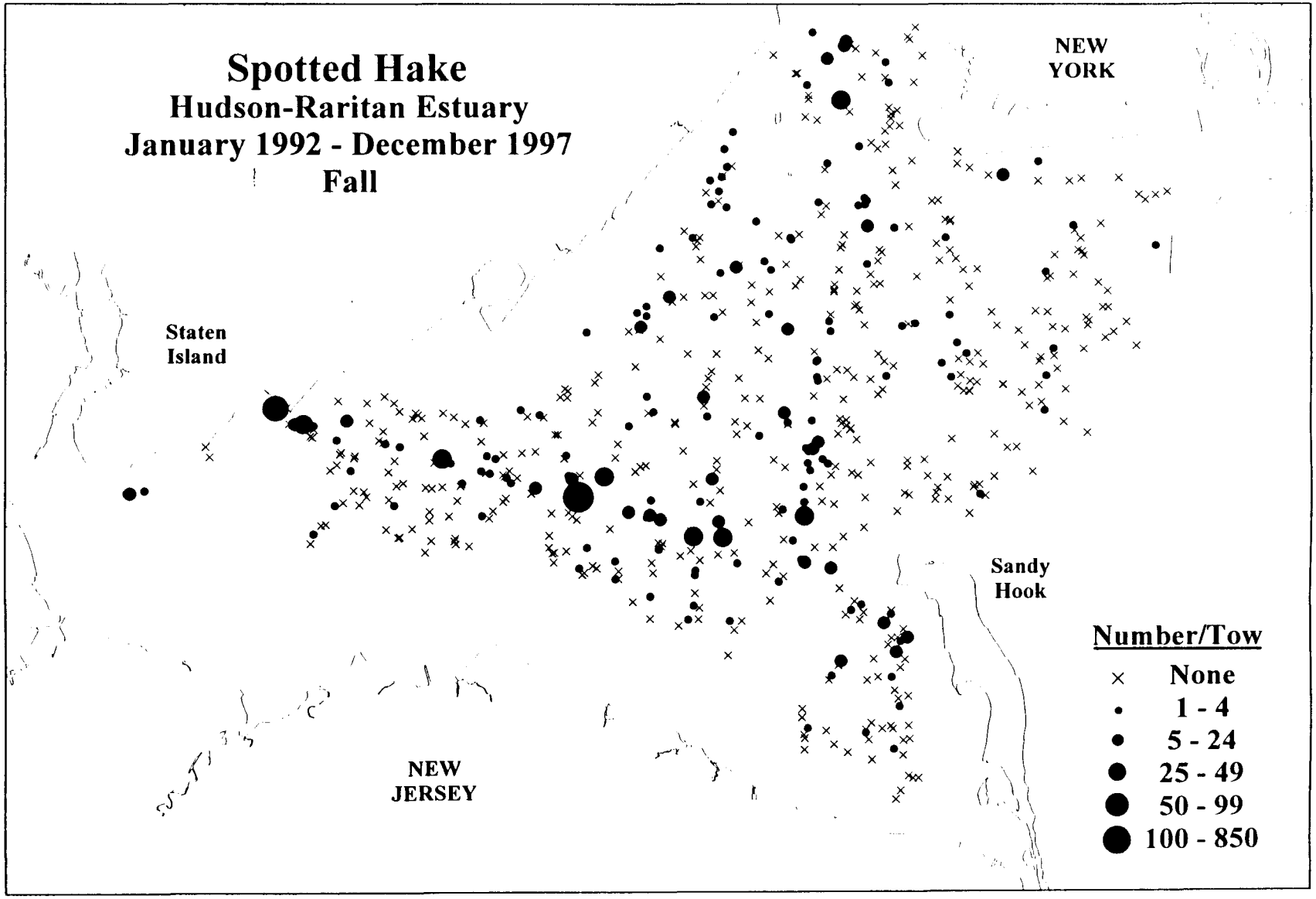

Figure 58. Distribution and abundance of spotted hake collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

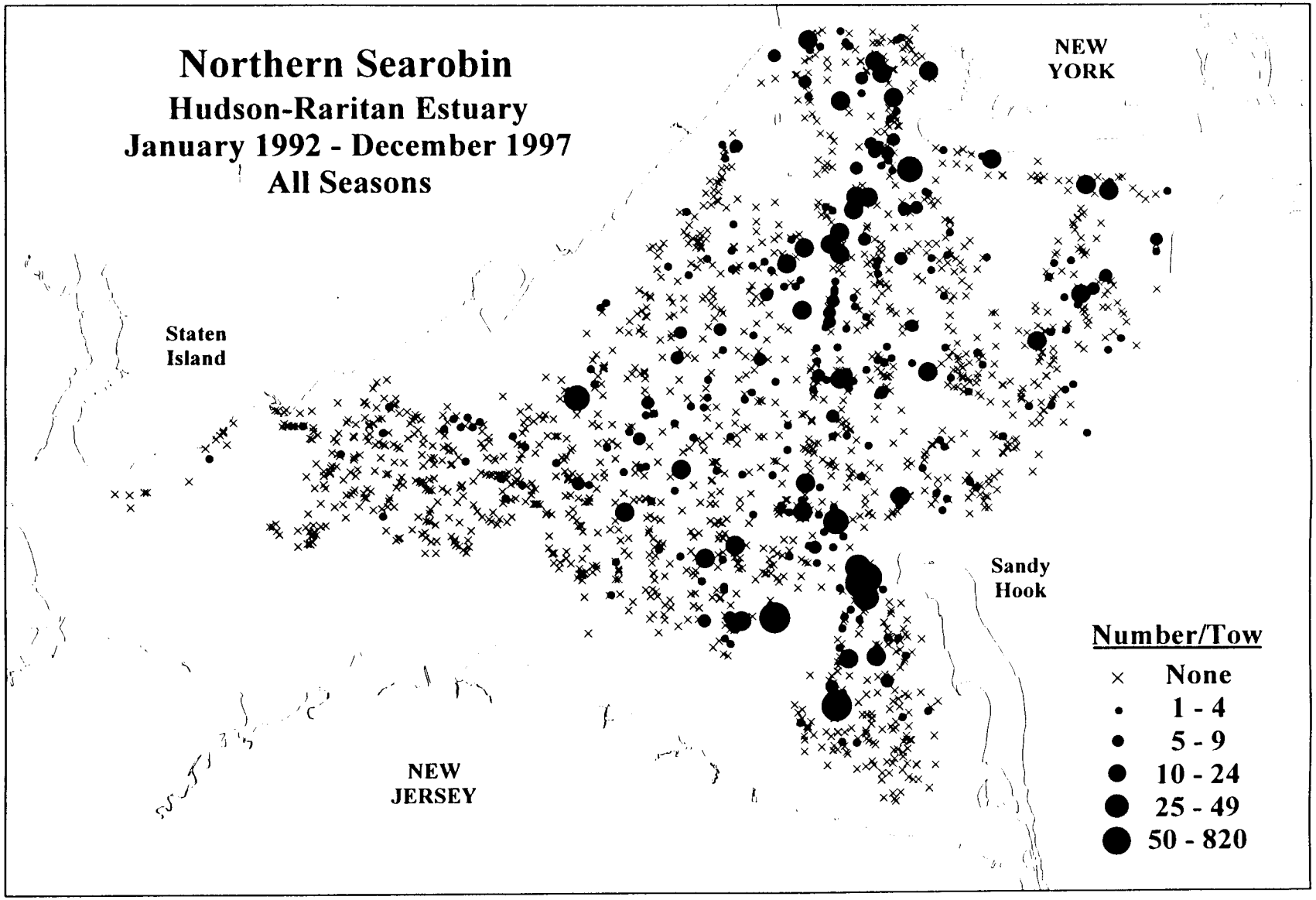

Figure 59. Distribution and abundance of all northern searobin collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

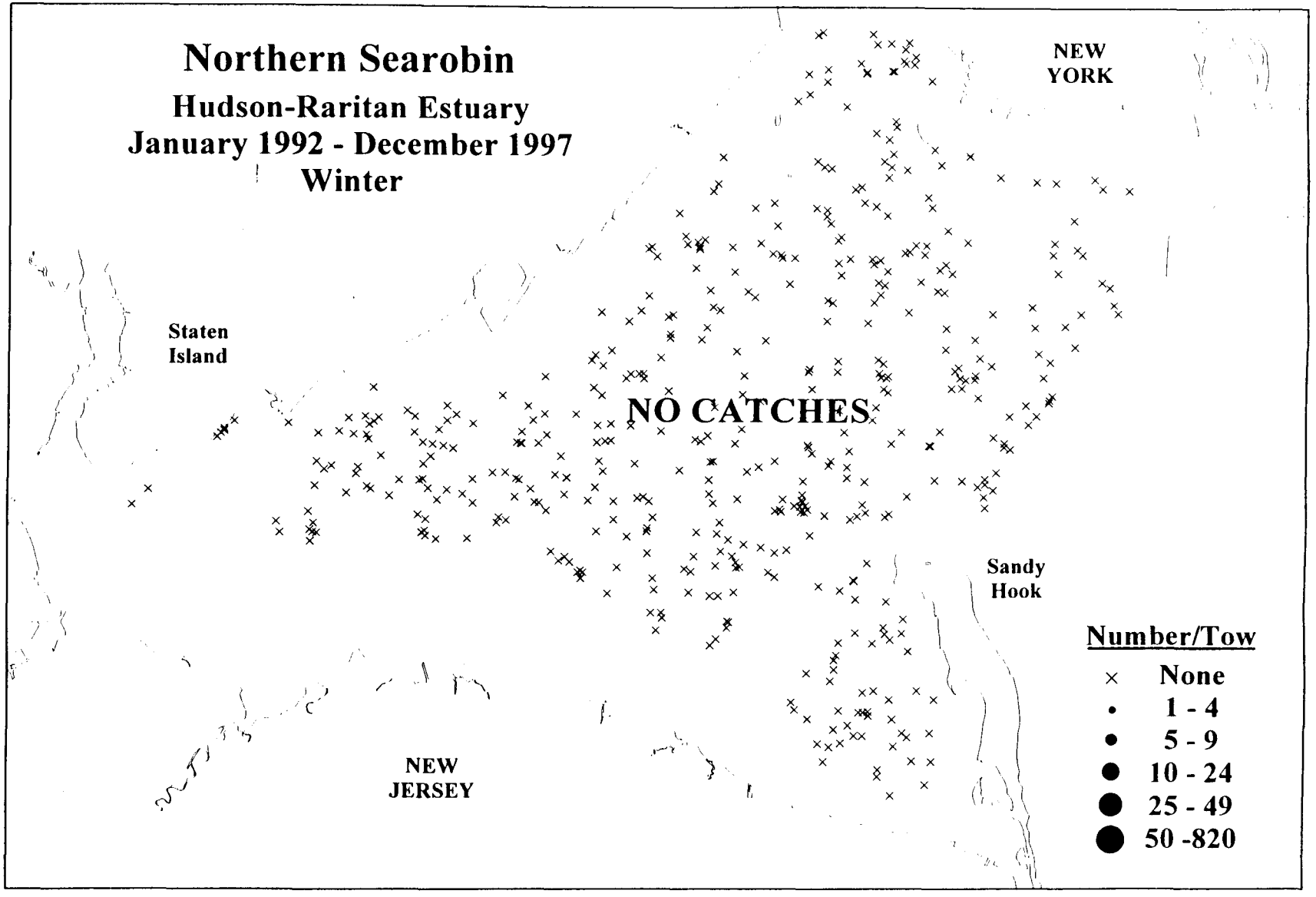

Figure 60. Distribution and abundance of all northern searobin collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

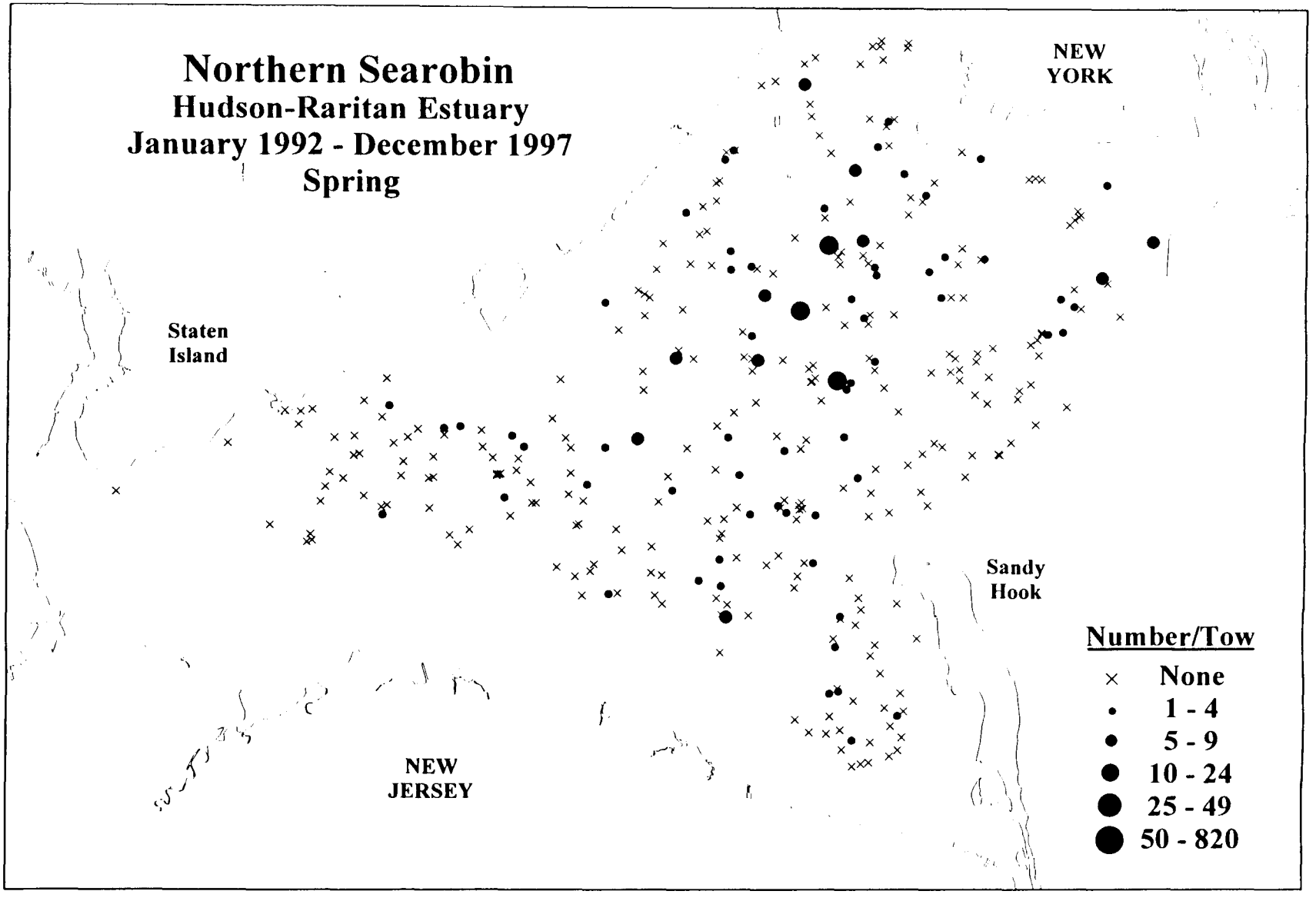

Figure 61. Distribution and abundance of northern searobin collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

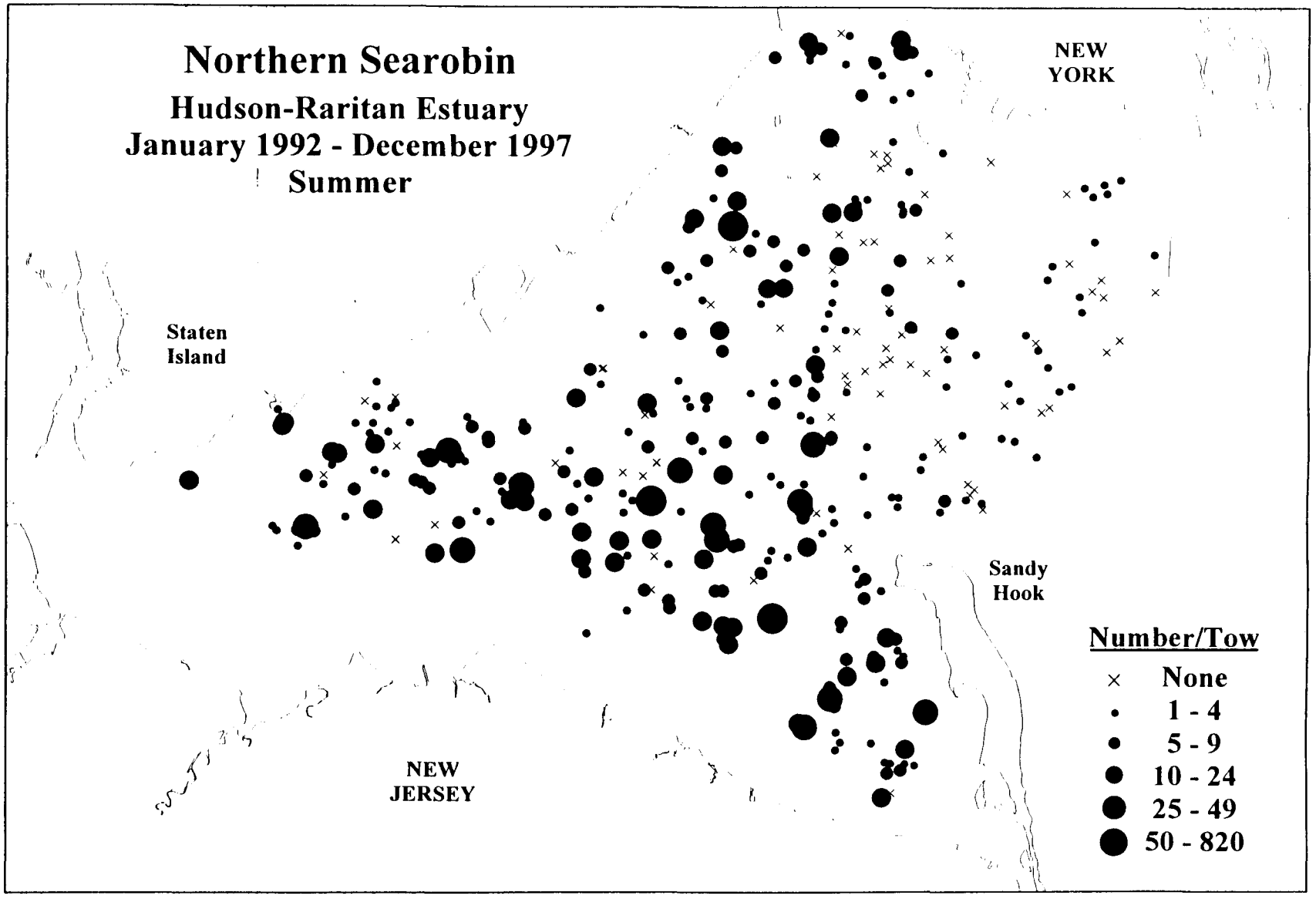

Figure 62. Distribution and abundance of northern searobin collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

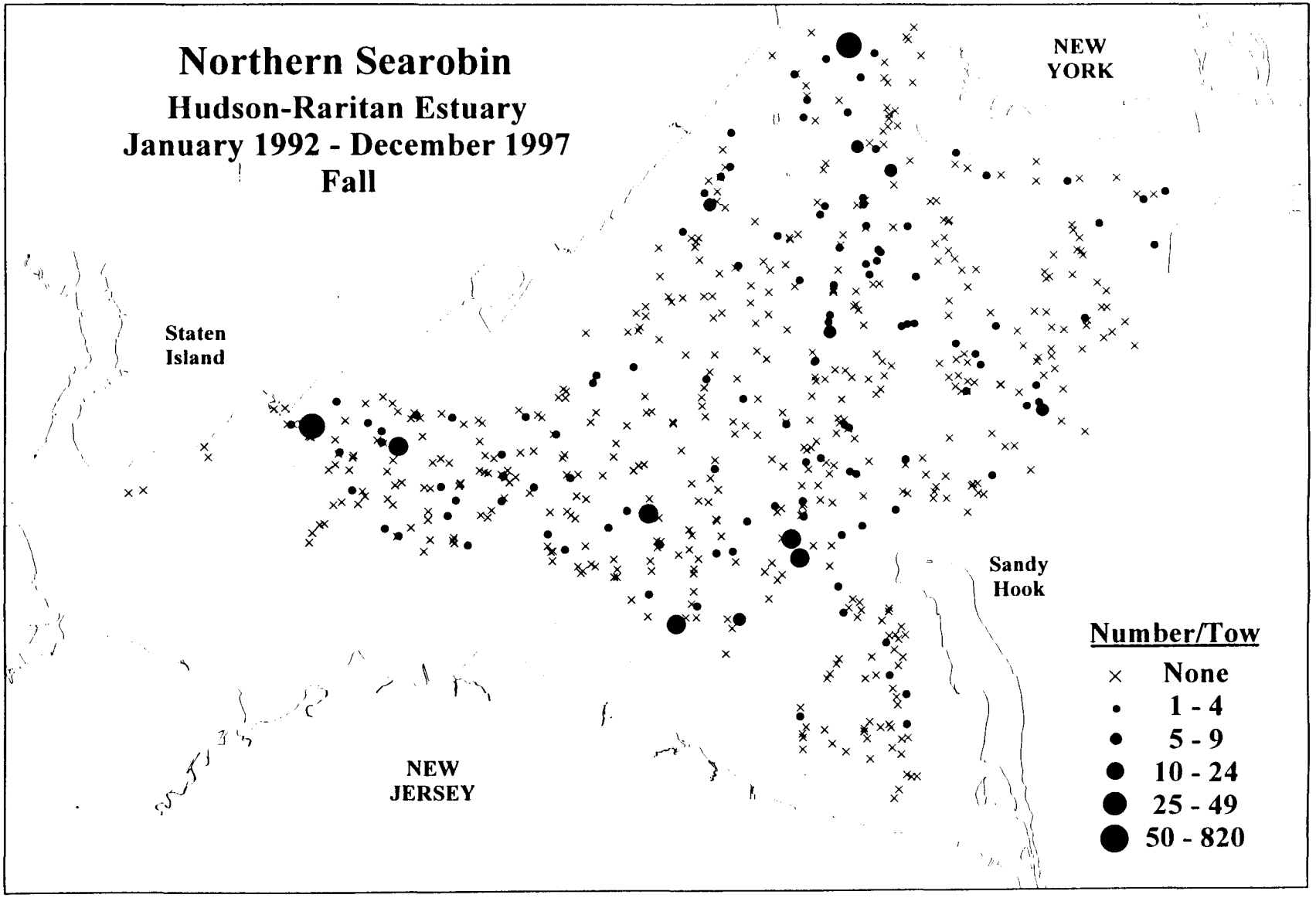

Figure 63. Distribution and abundance of northern searobin collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

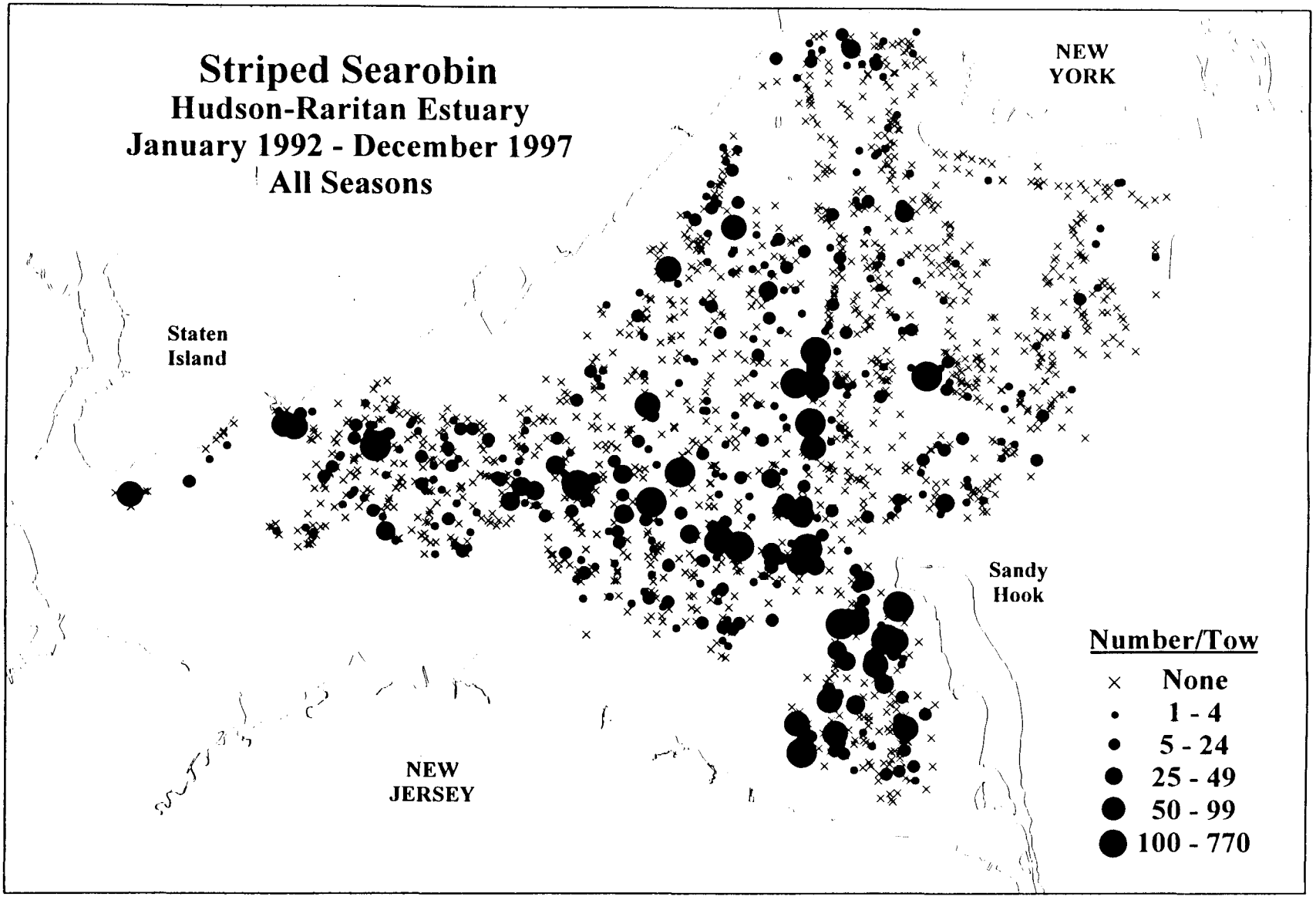

Figure 64. Distribution and abundance of all striped searobin collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

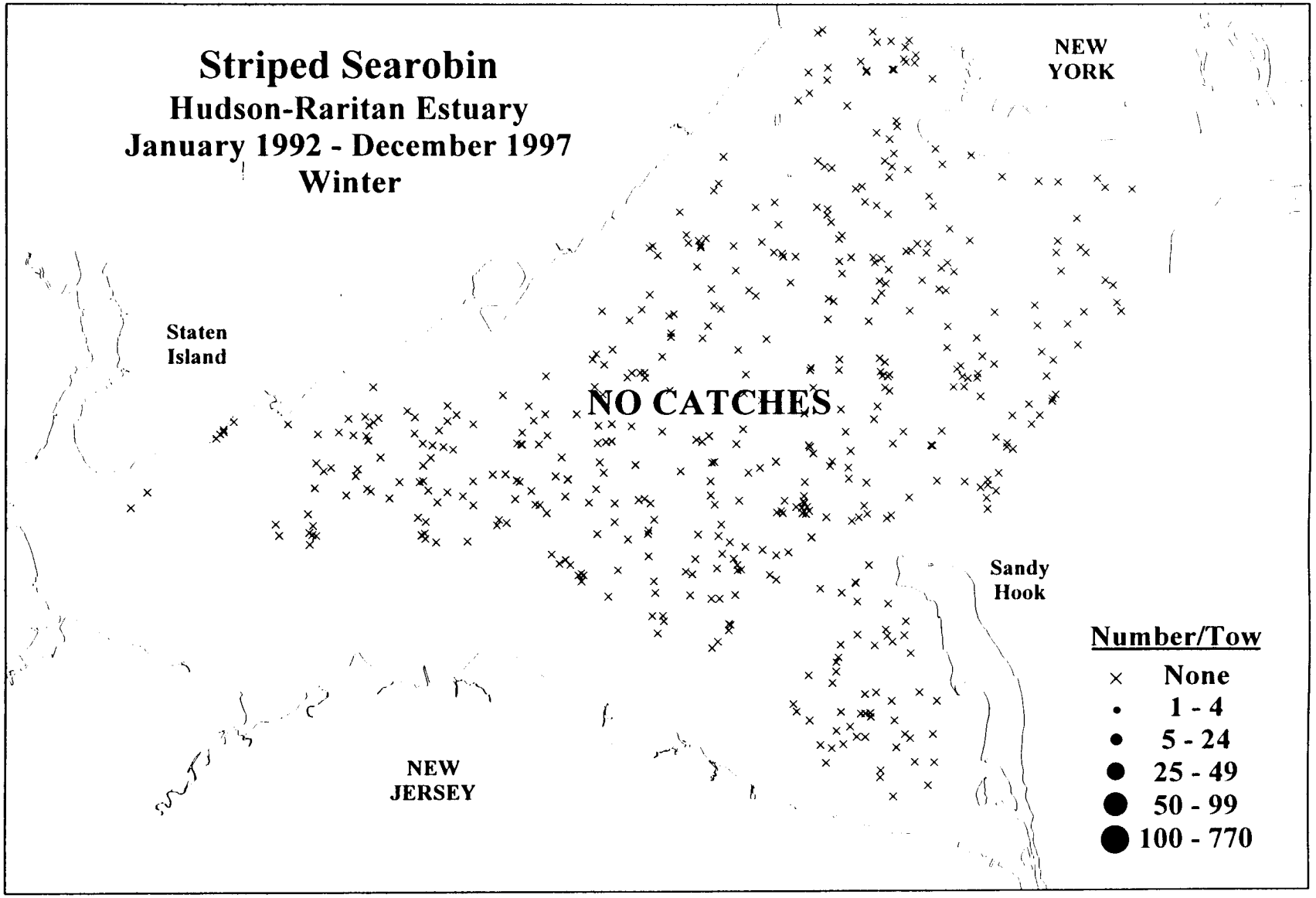

Figure 65. Distribution and abundance of all striped searobin collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

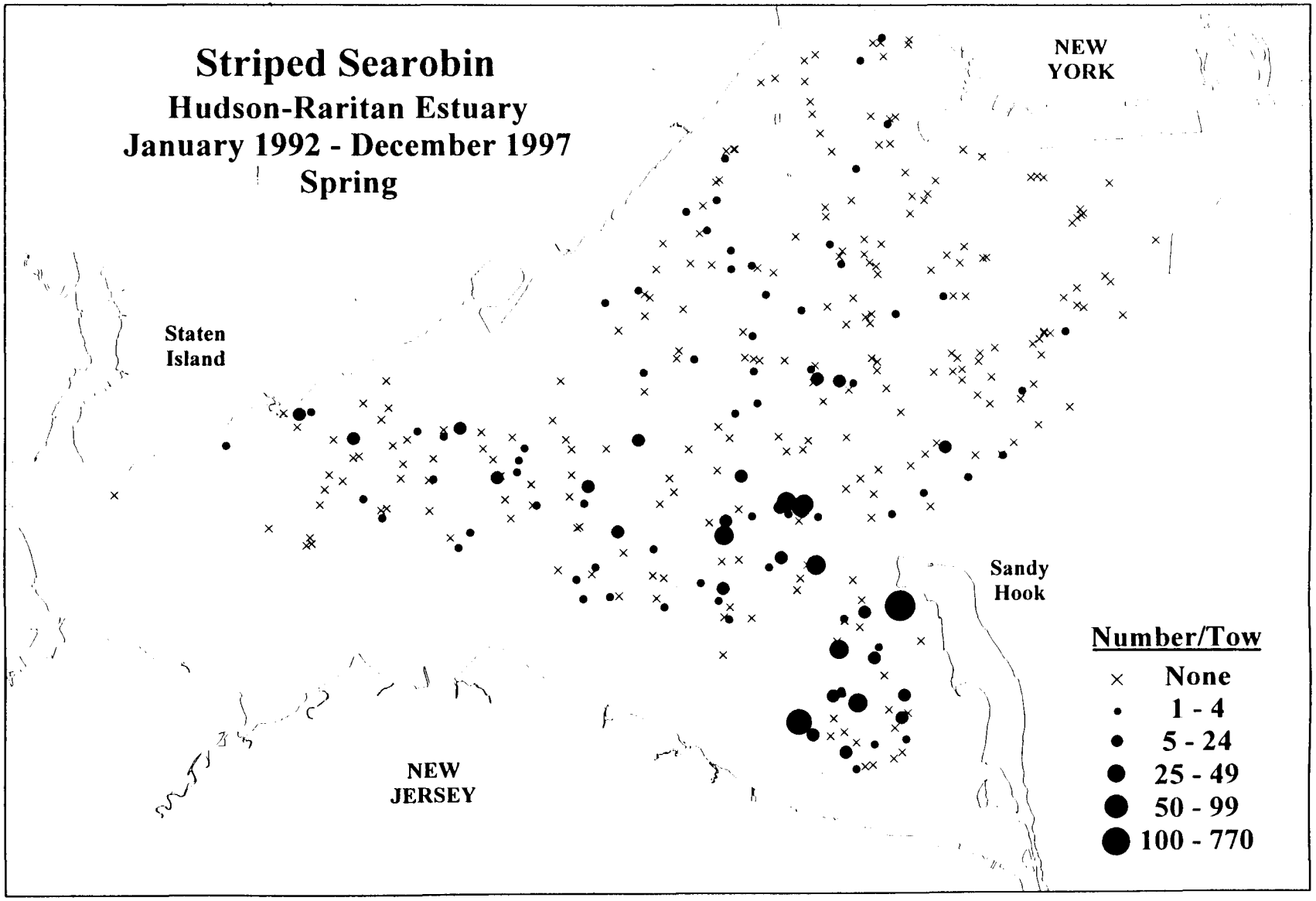

Figure 66. Distribution and abundance of striped searobin collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

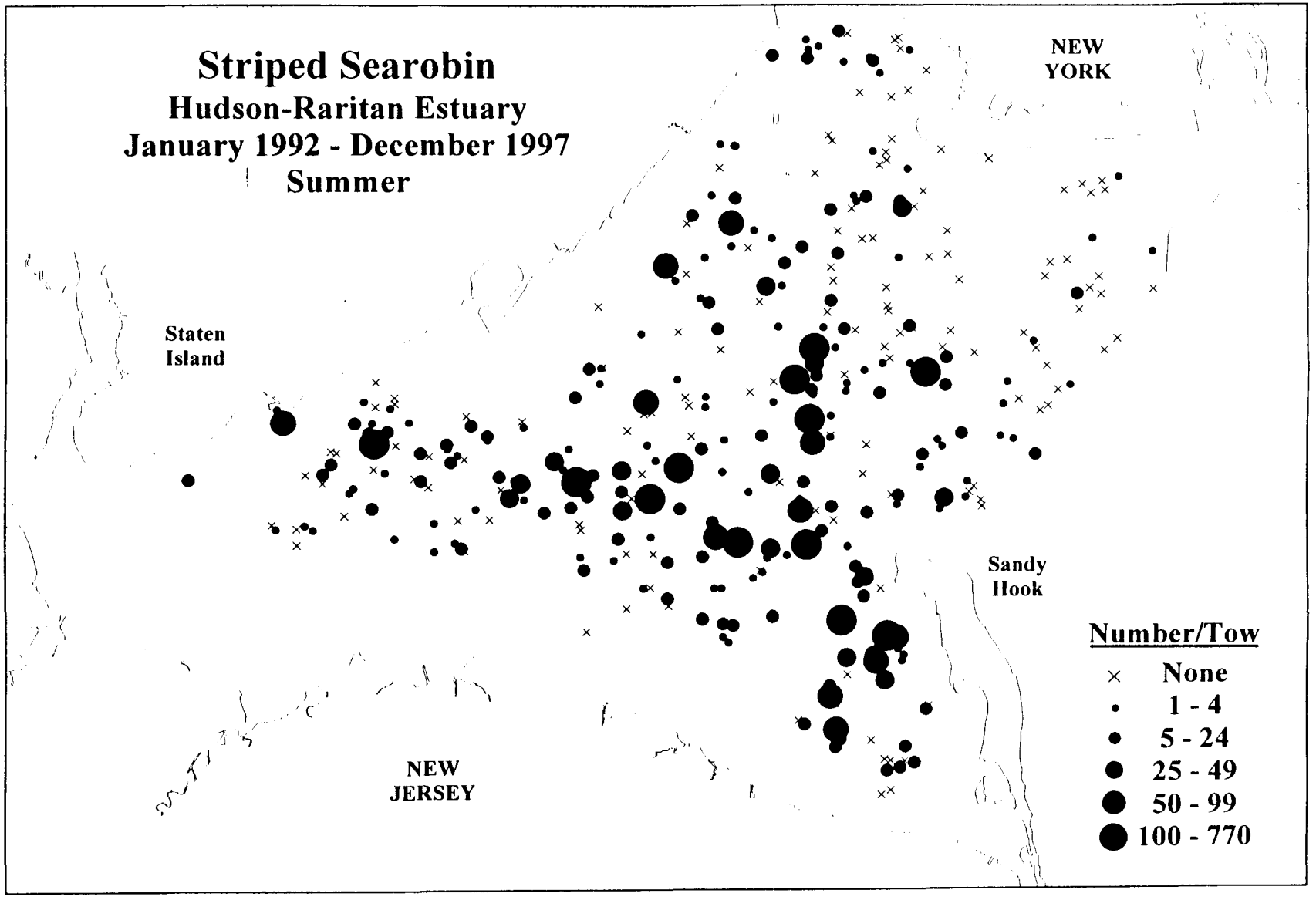

Figure 67. Distribution and abundance of striped searobin collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

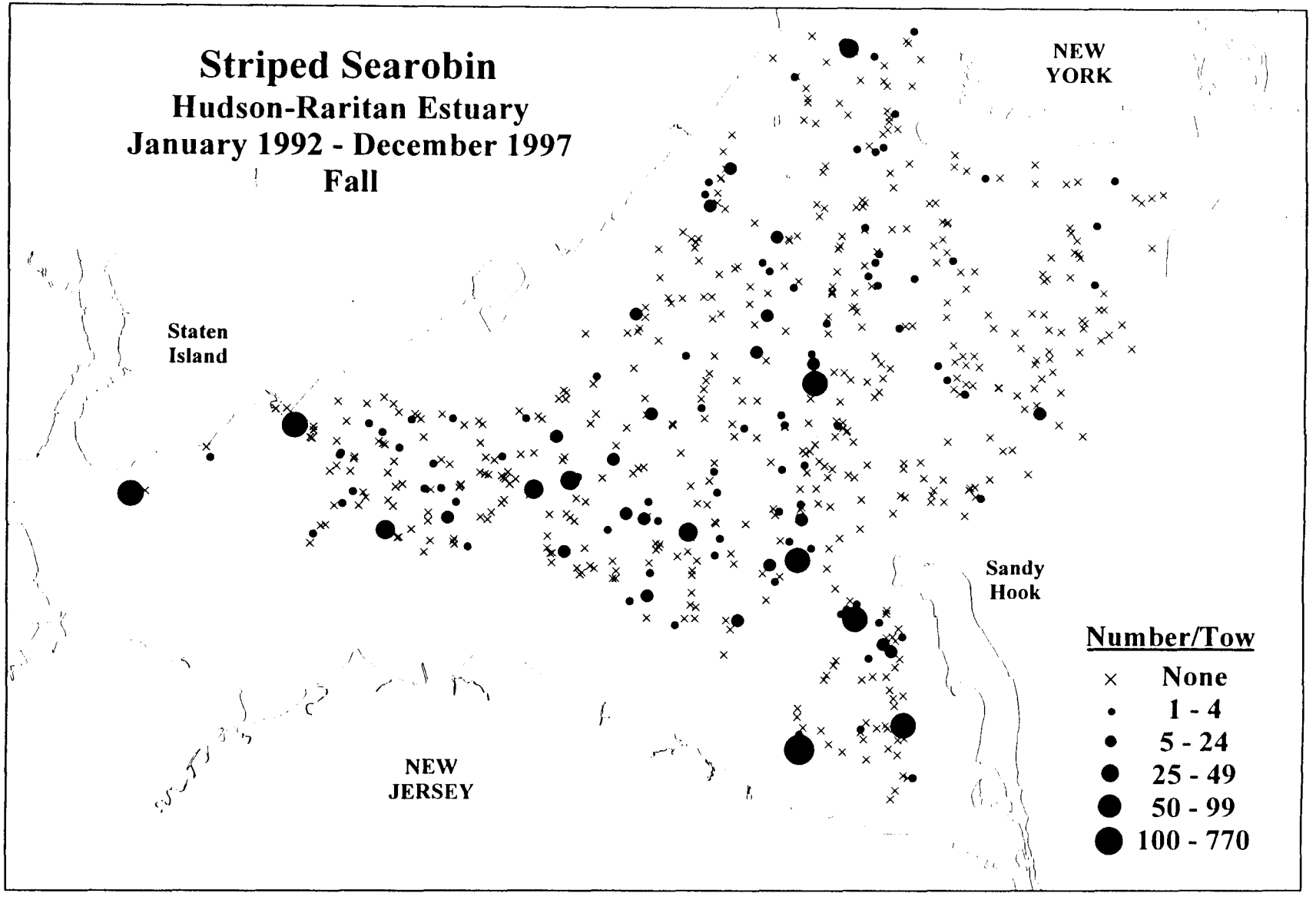

Figure 68. Distribution and abundance of striped searobin collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

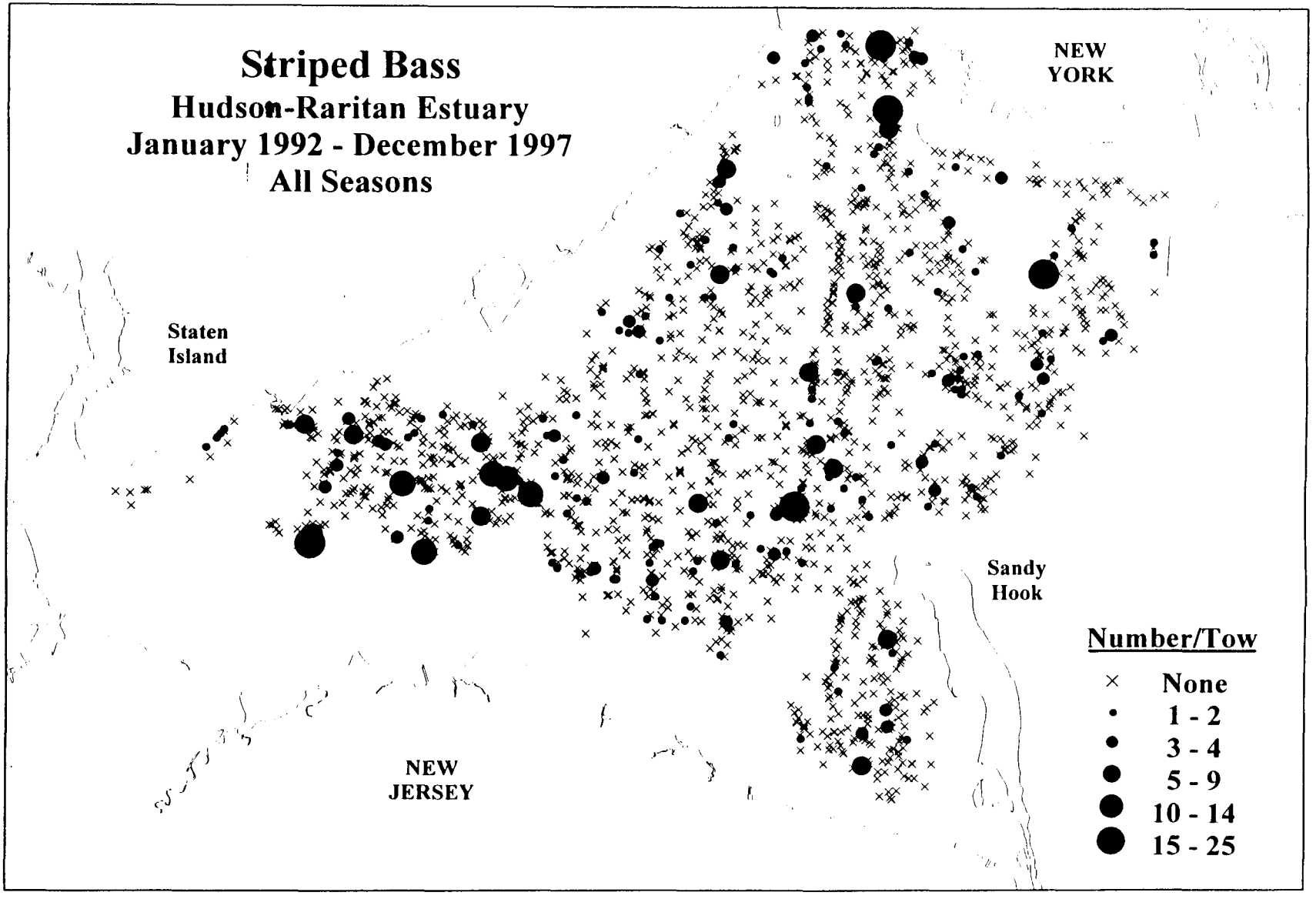

Figure 69. Distribution and abundance of all striped bass collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

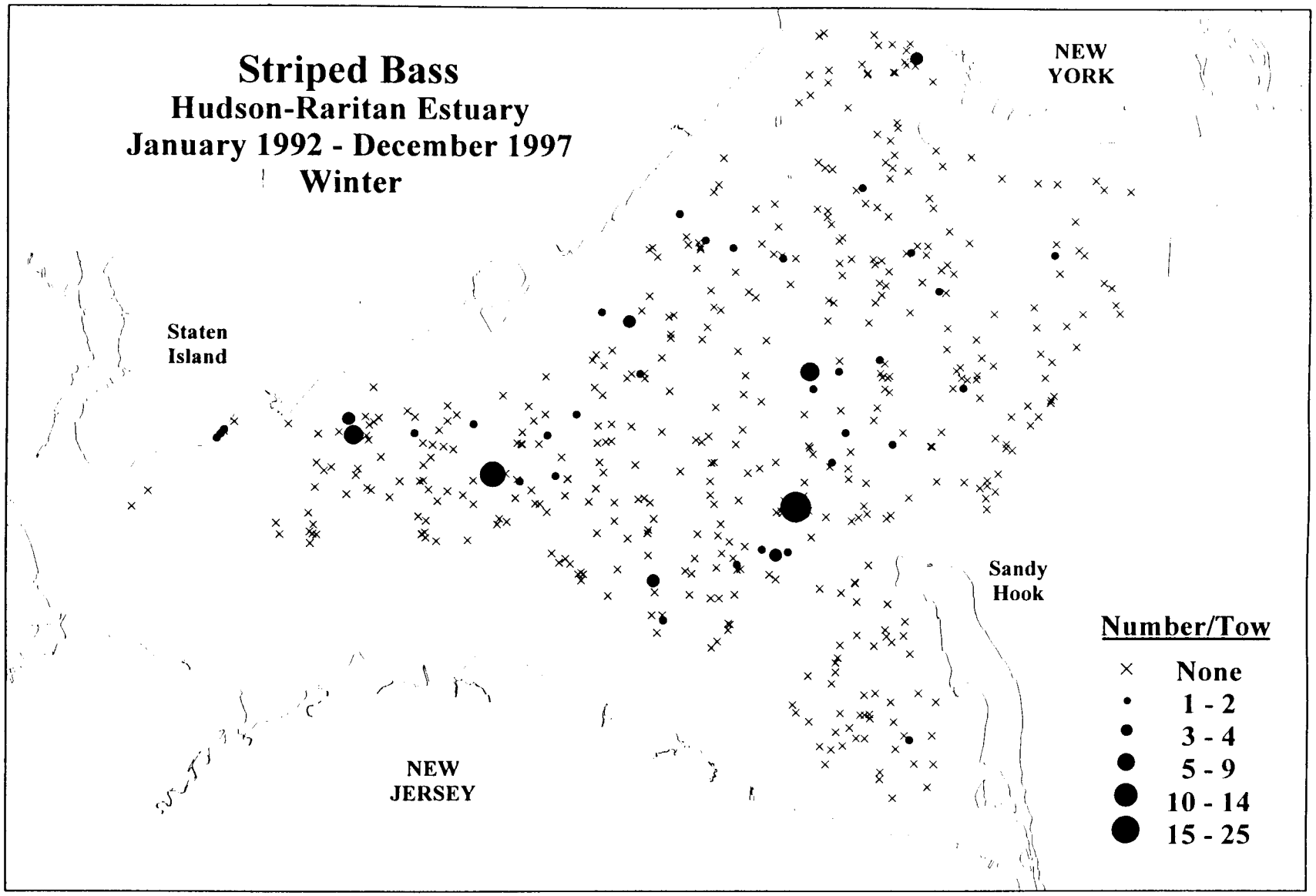

Figure 70. Distribution and abundance of all striped bass collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

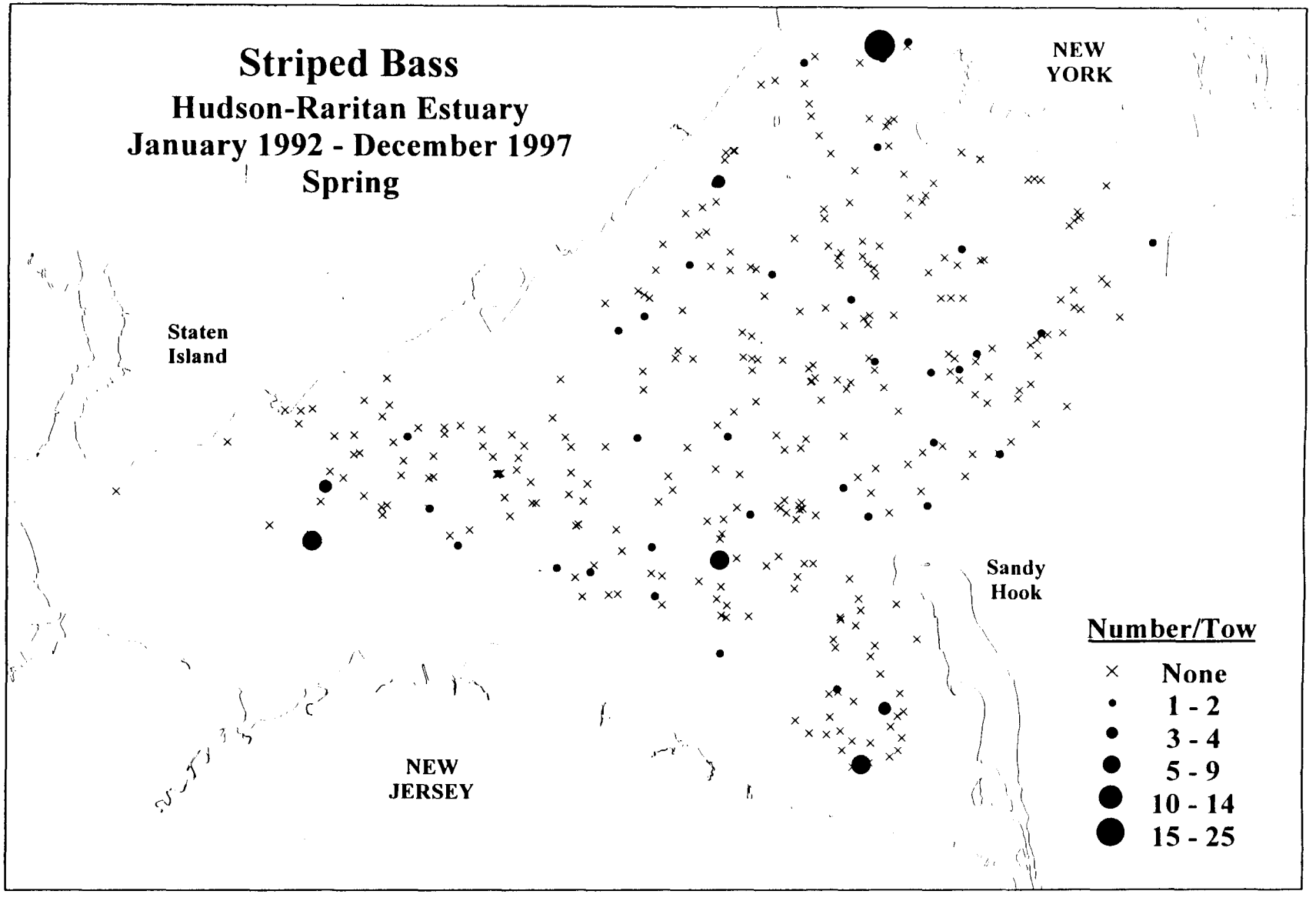

Figure 71. Distribution and abundance of striped bass collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

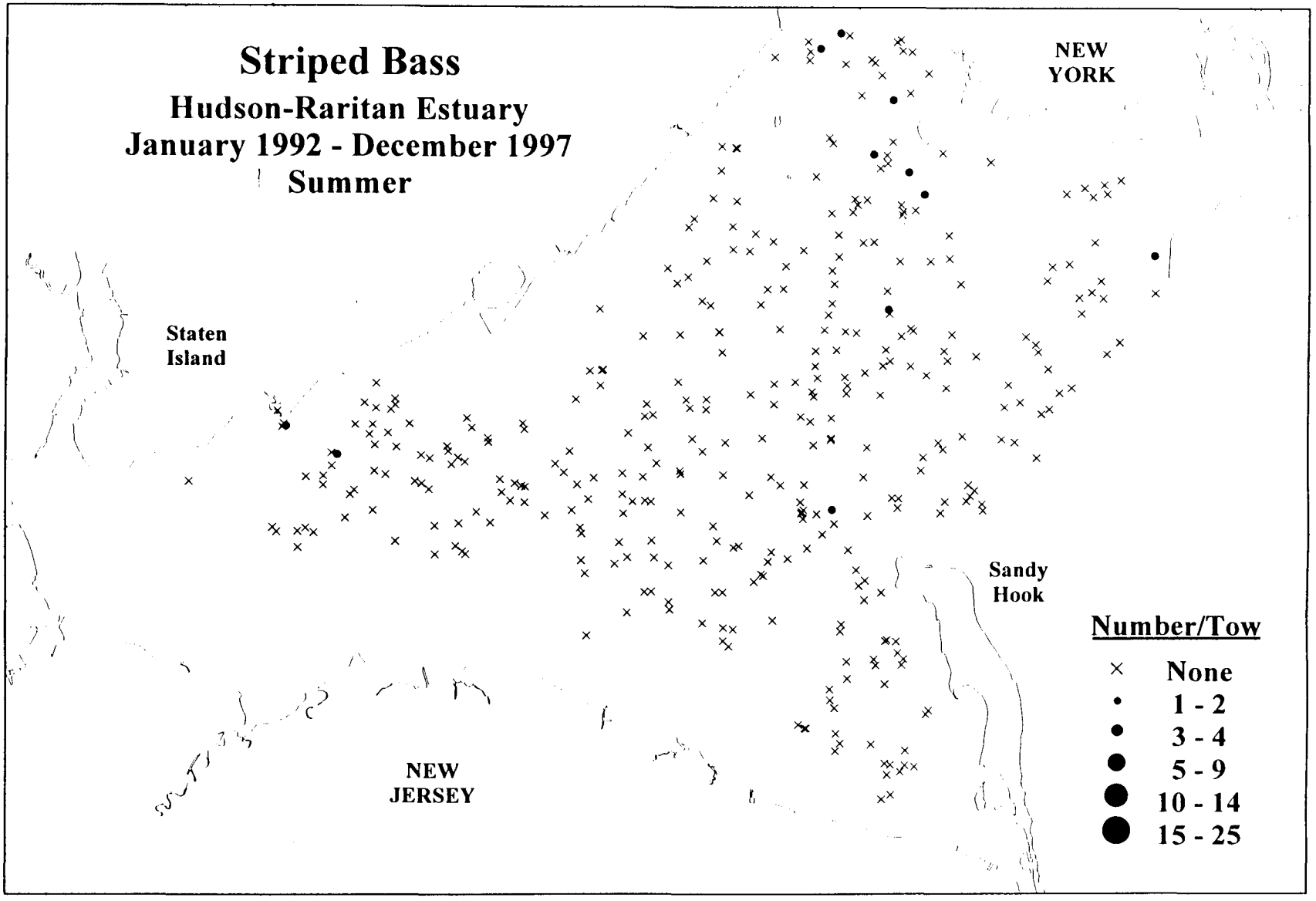

Figure 72. Distribution and abundance of striped bass collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

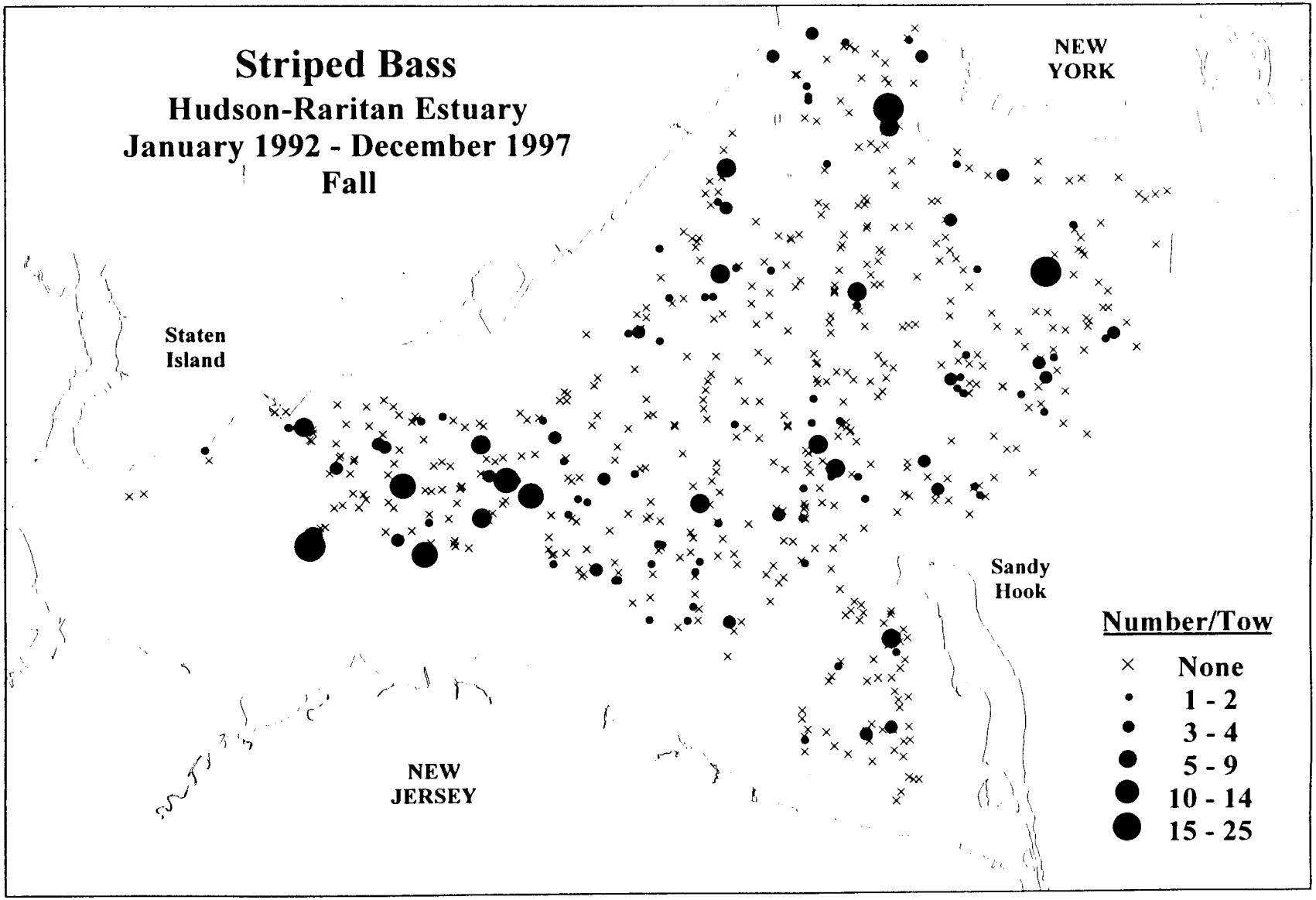

Figure 73. Distribution and abundance of striped bass collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

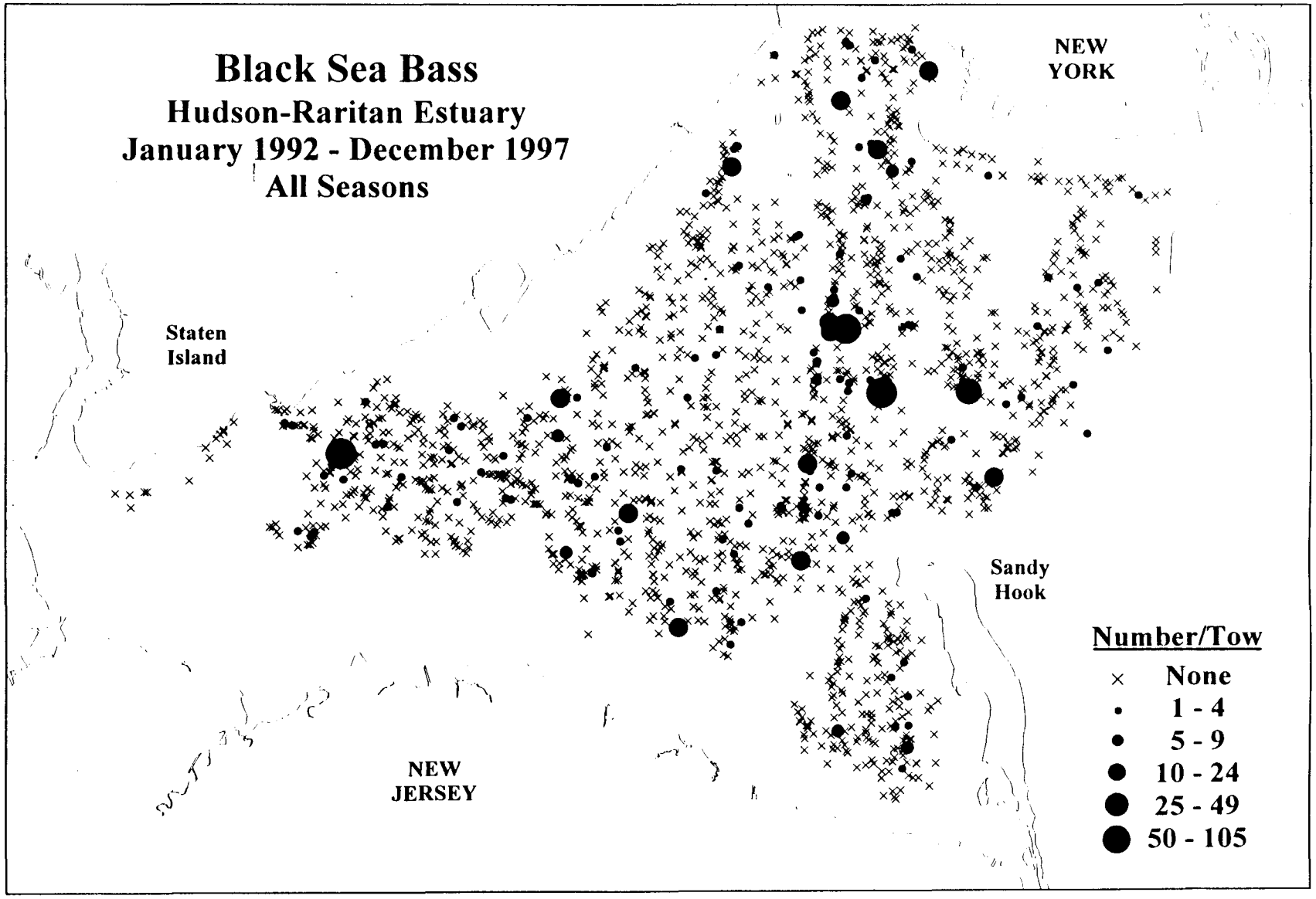

Figure 74. Distribution and abundance of all black sea bass collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

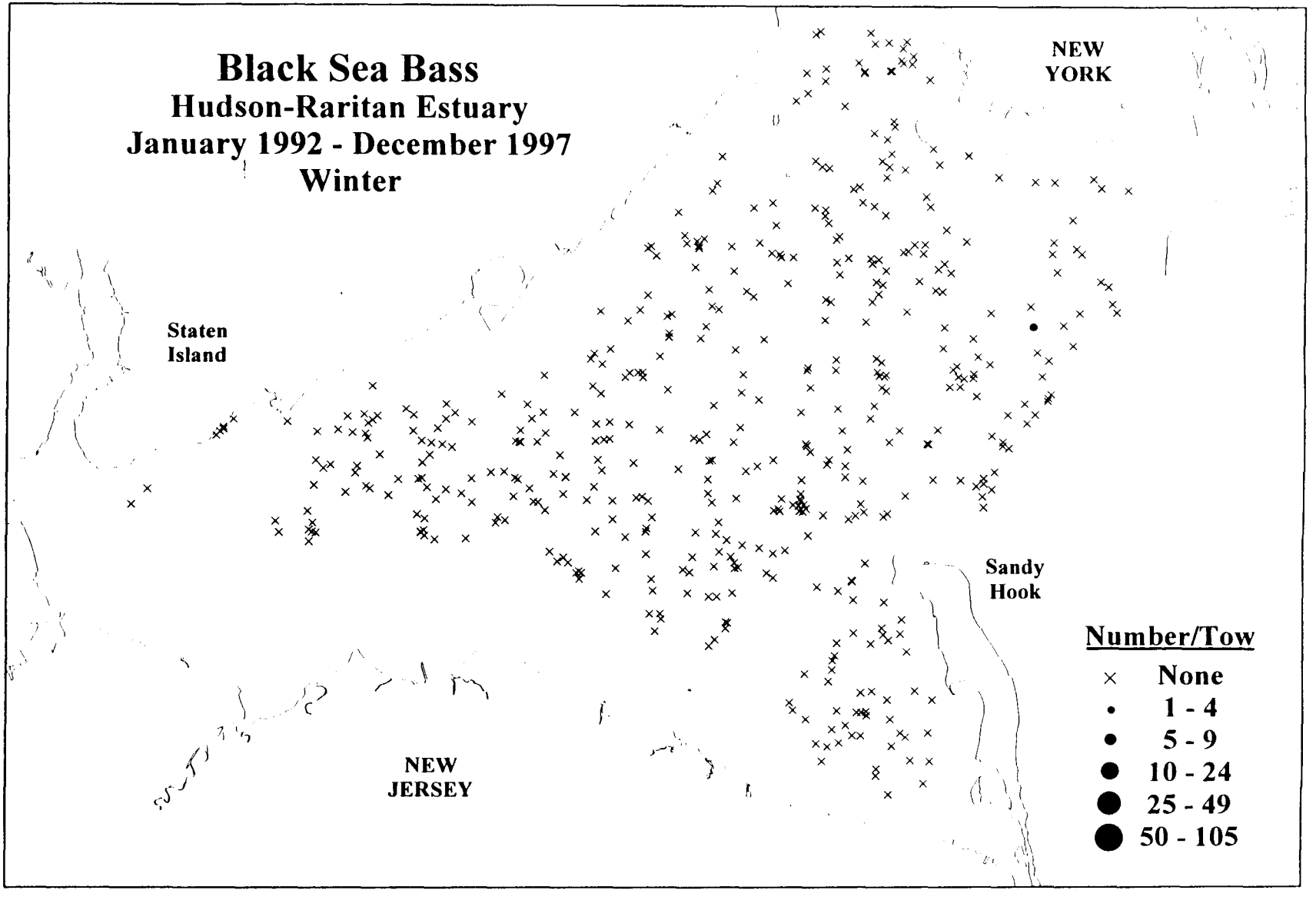

Figure 75. Distribution and abundance of all black sea bass collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

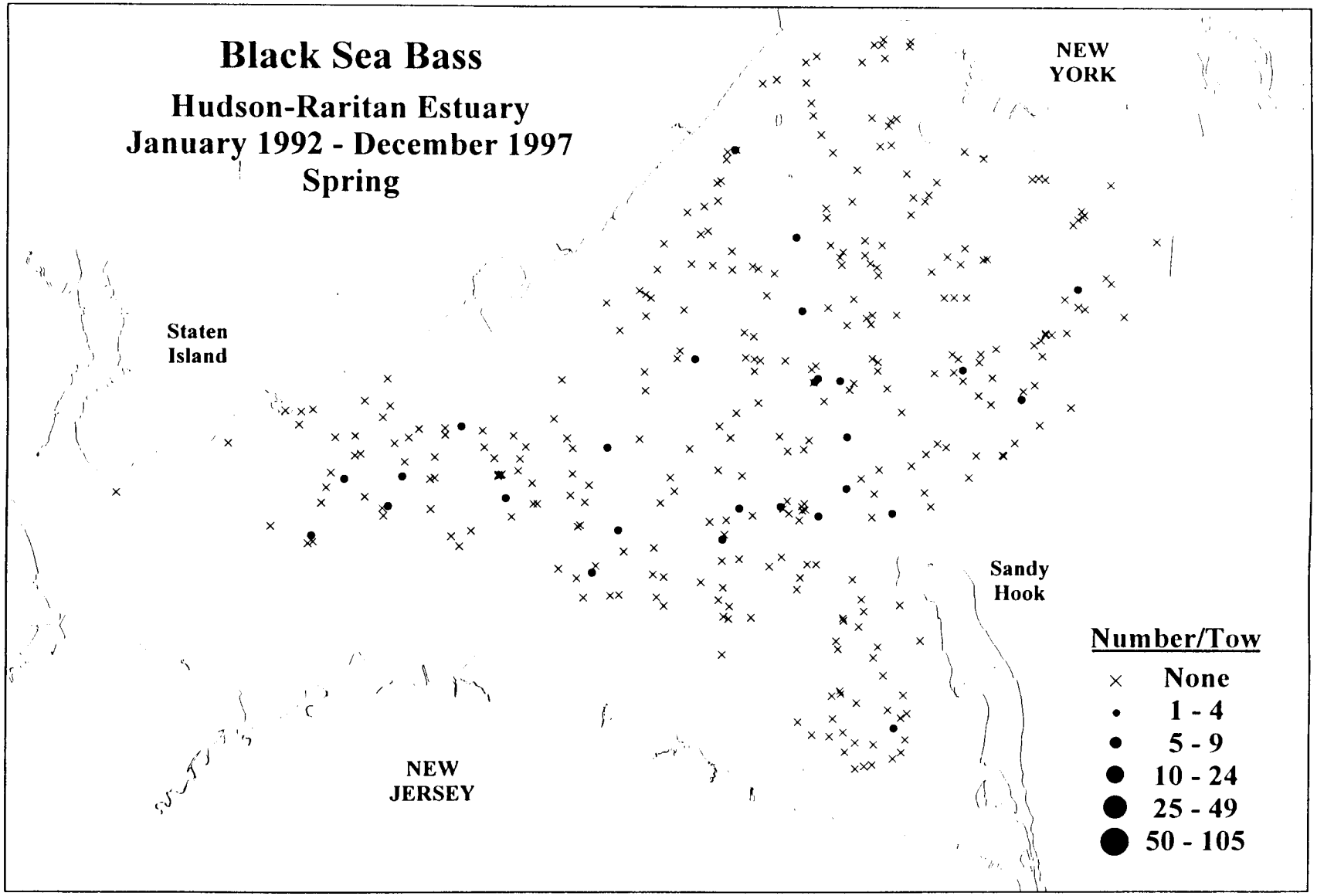

Figure 76. Distribution and abundance of black sea bass collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

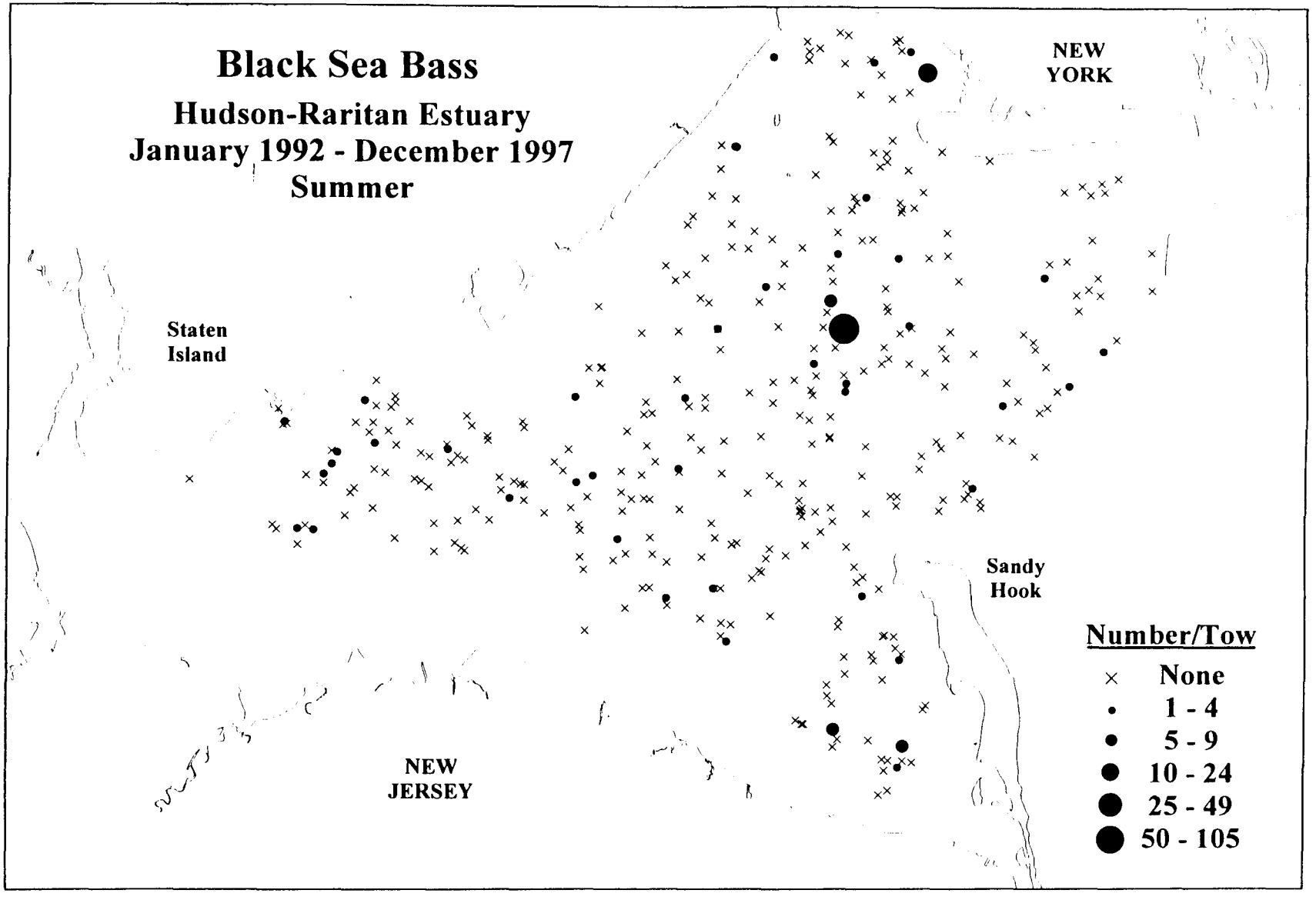

Figure 77. Distribution and abundance of black sea bass collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

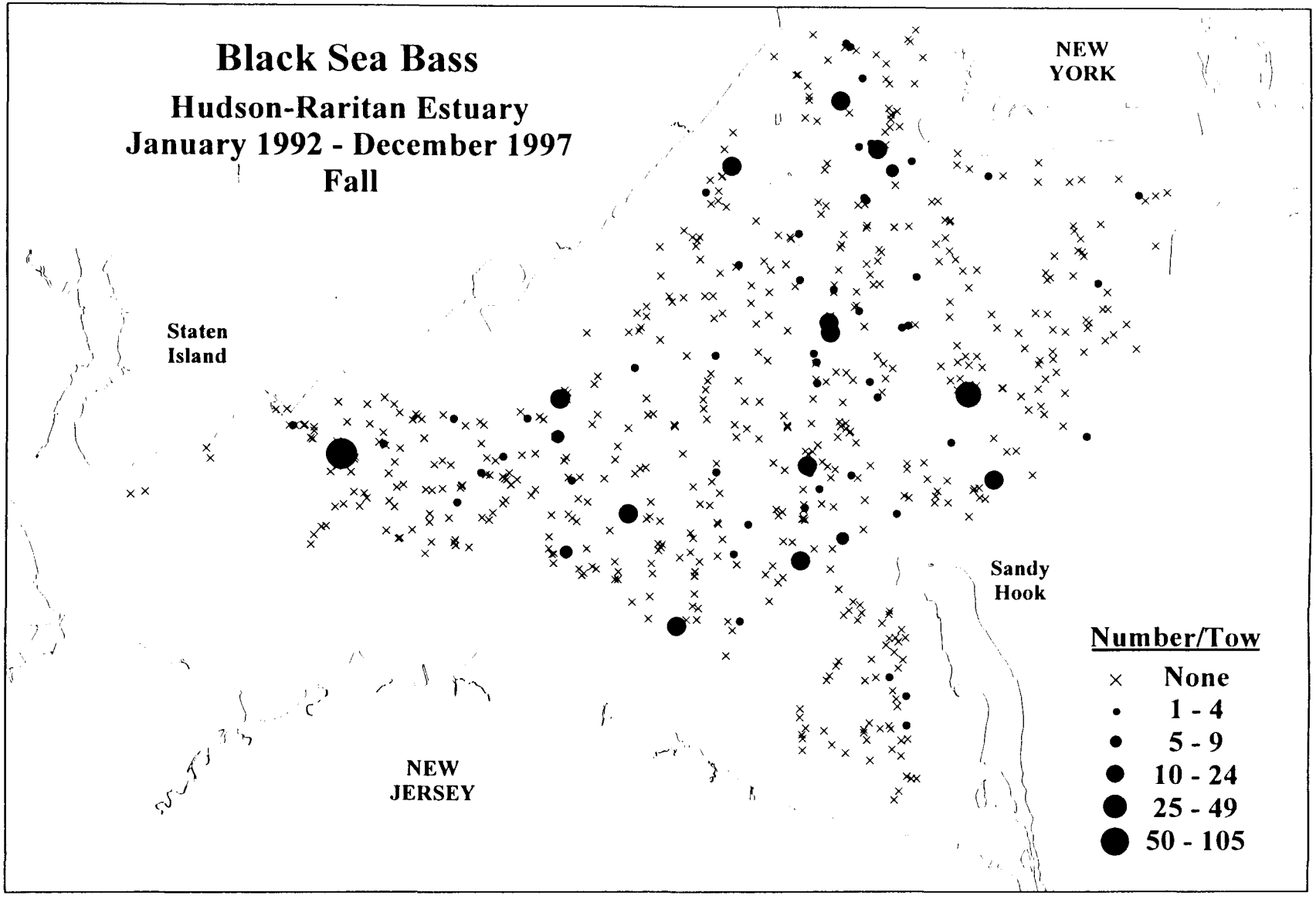

Figure 78. Distribution and abundance of black sea bass collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

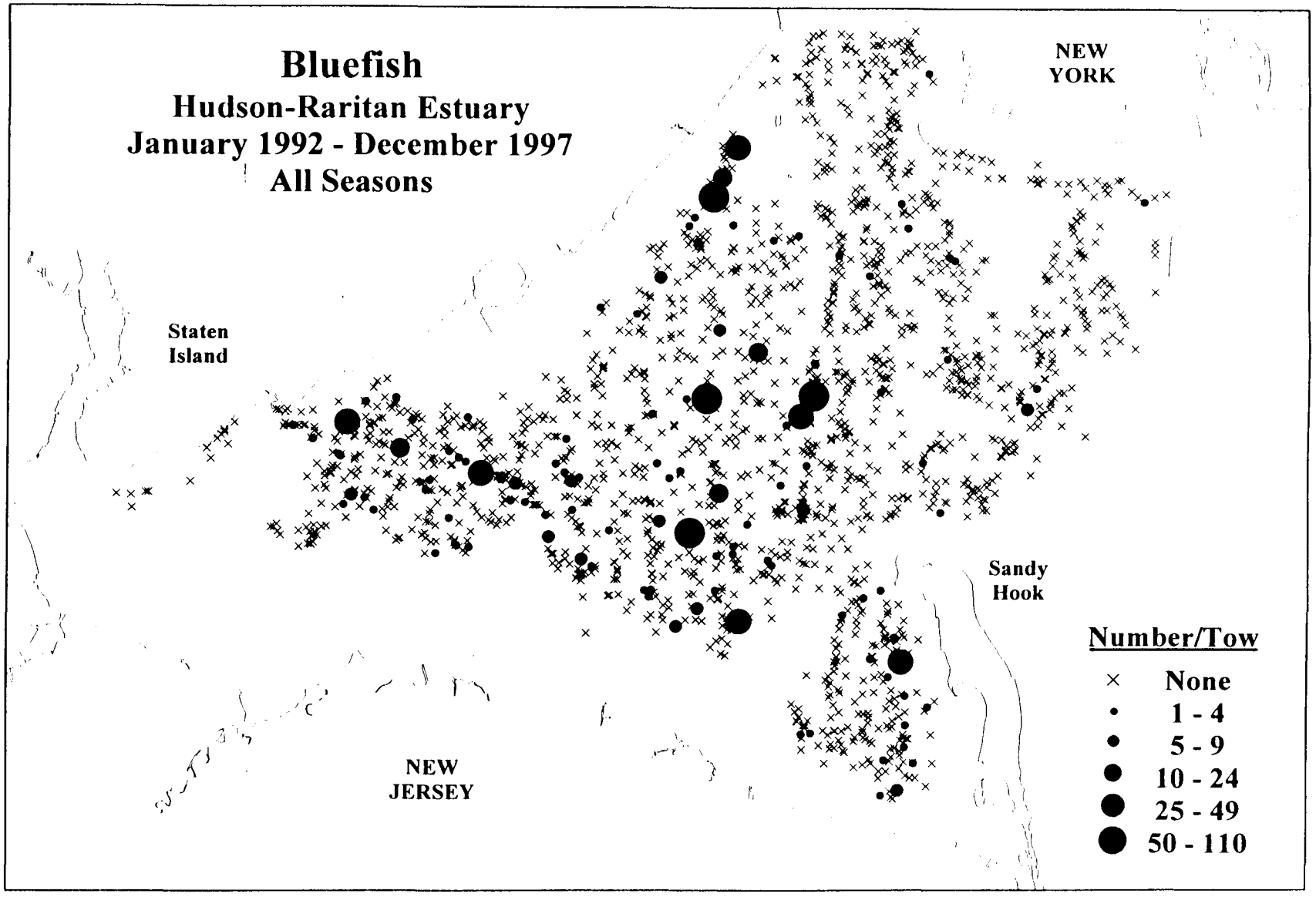

Figure 79. Distribution and abundance of all bluefish collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

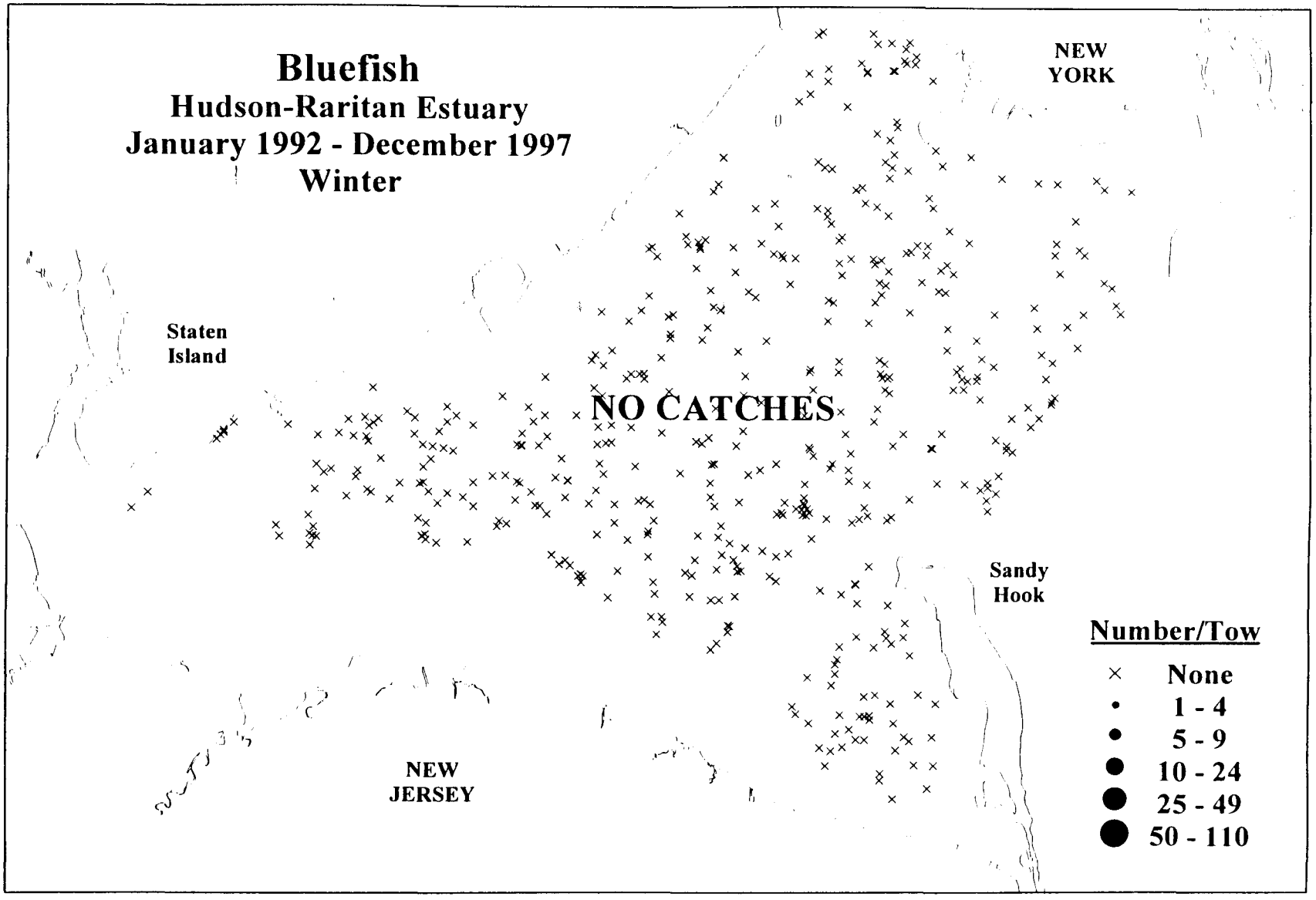

Figure 80. Distribution and abundance of all bluefish collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

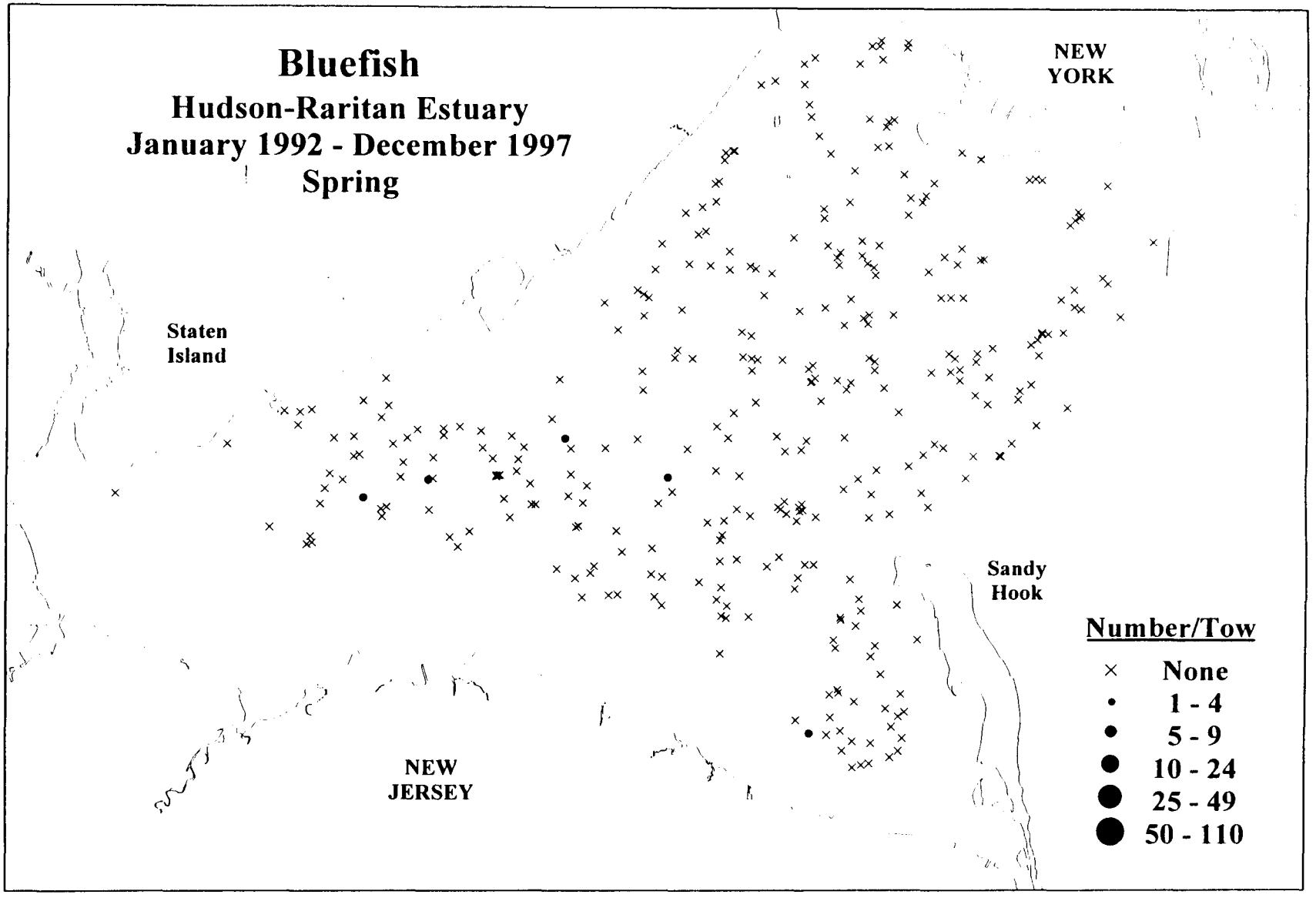

Figure 81. Distribution and abundance of bluefish collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

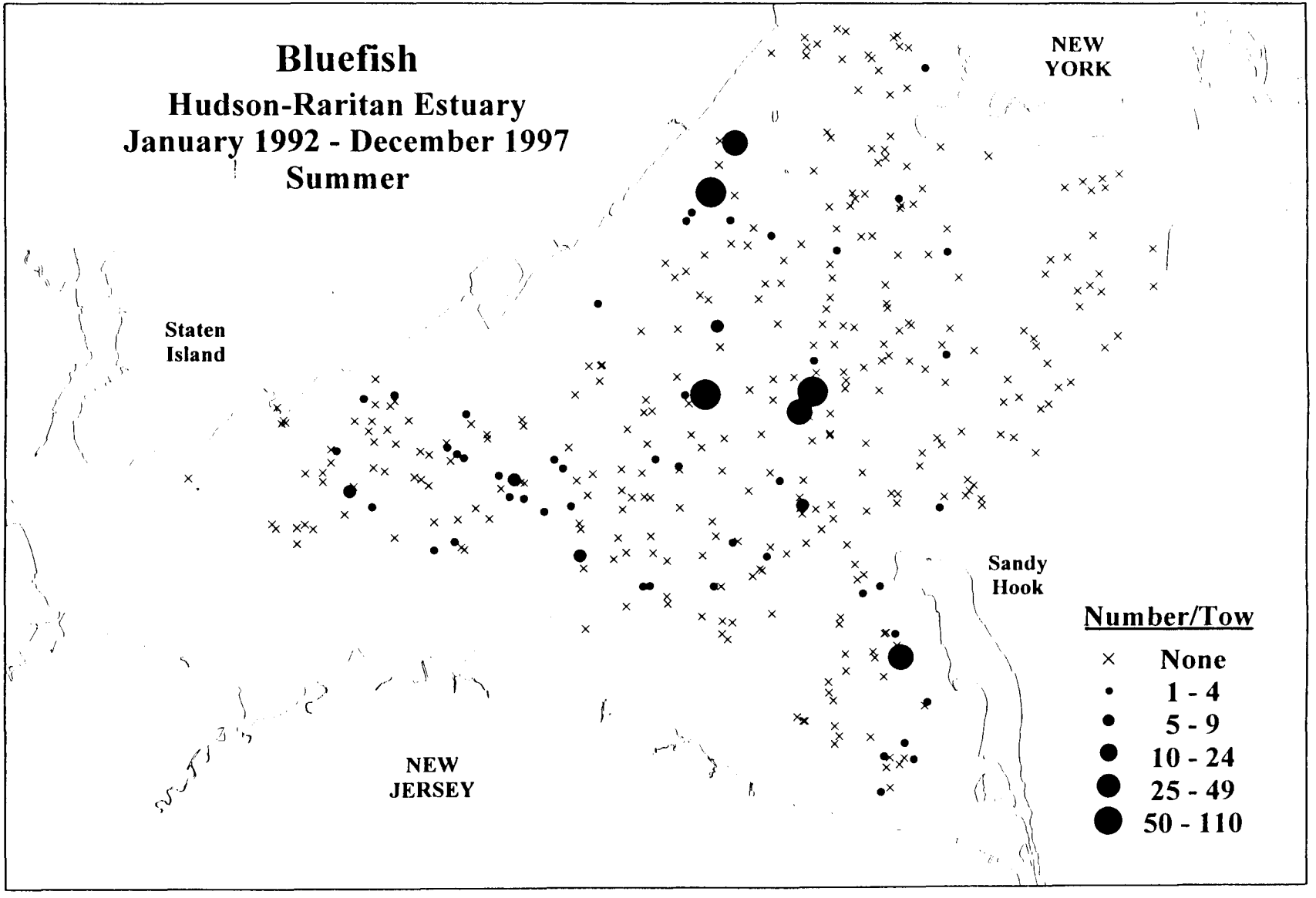

Figure 82. Distribution and abundance of bluefish collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

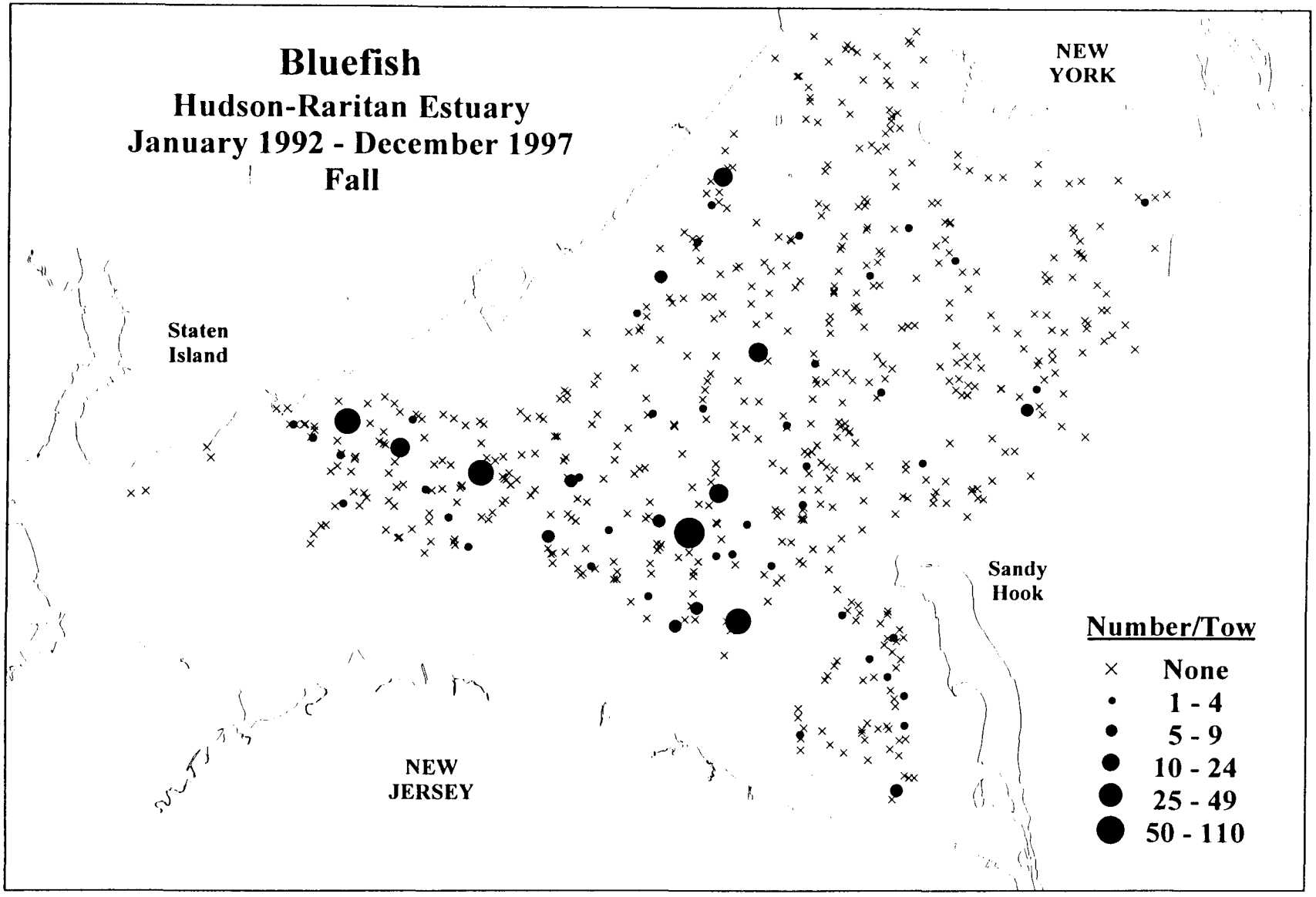

Figure 83. Distribution and abundance of bluefish collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

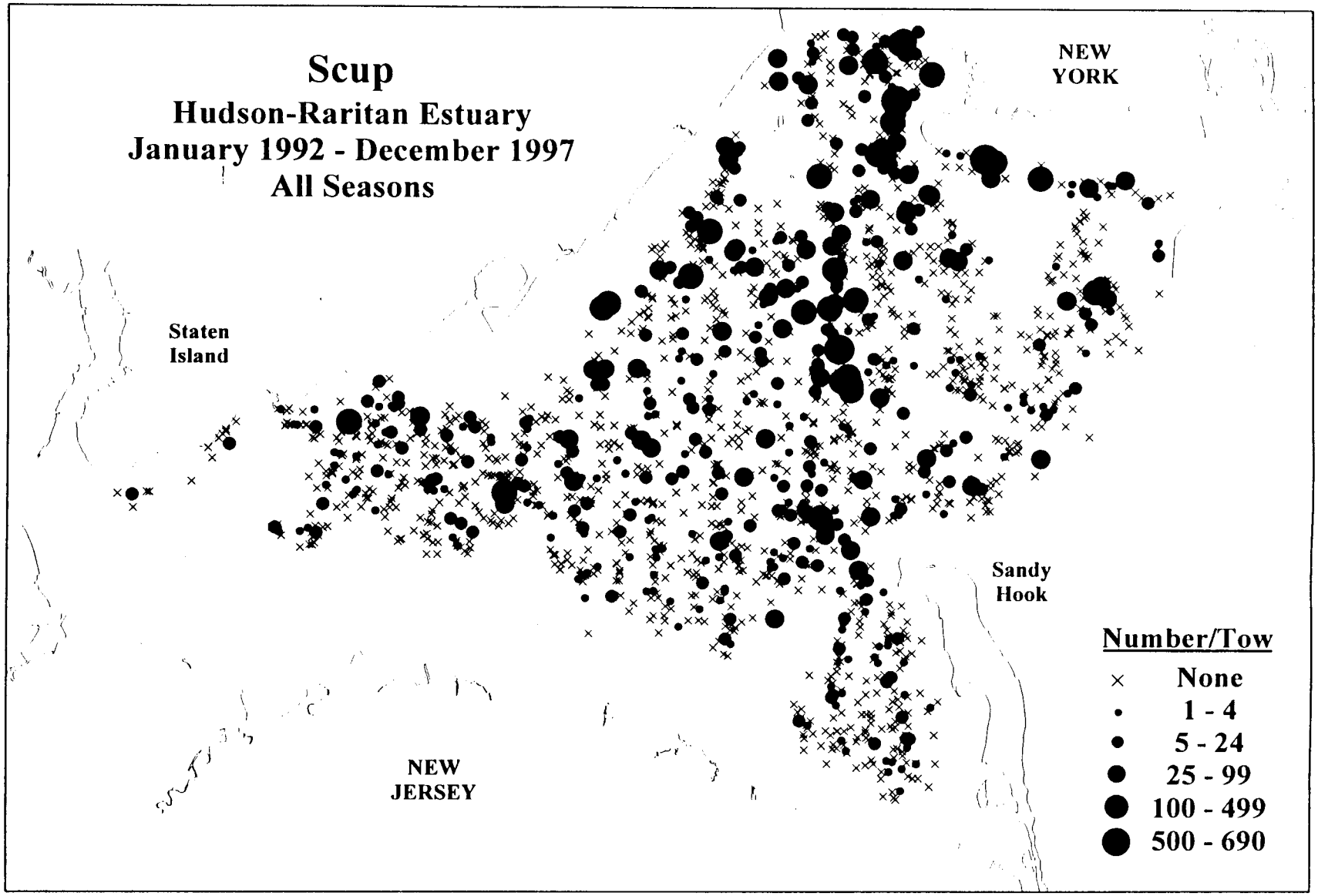

Figure 84. Distribution and abundance of all scup collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

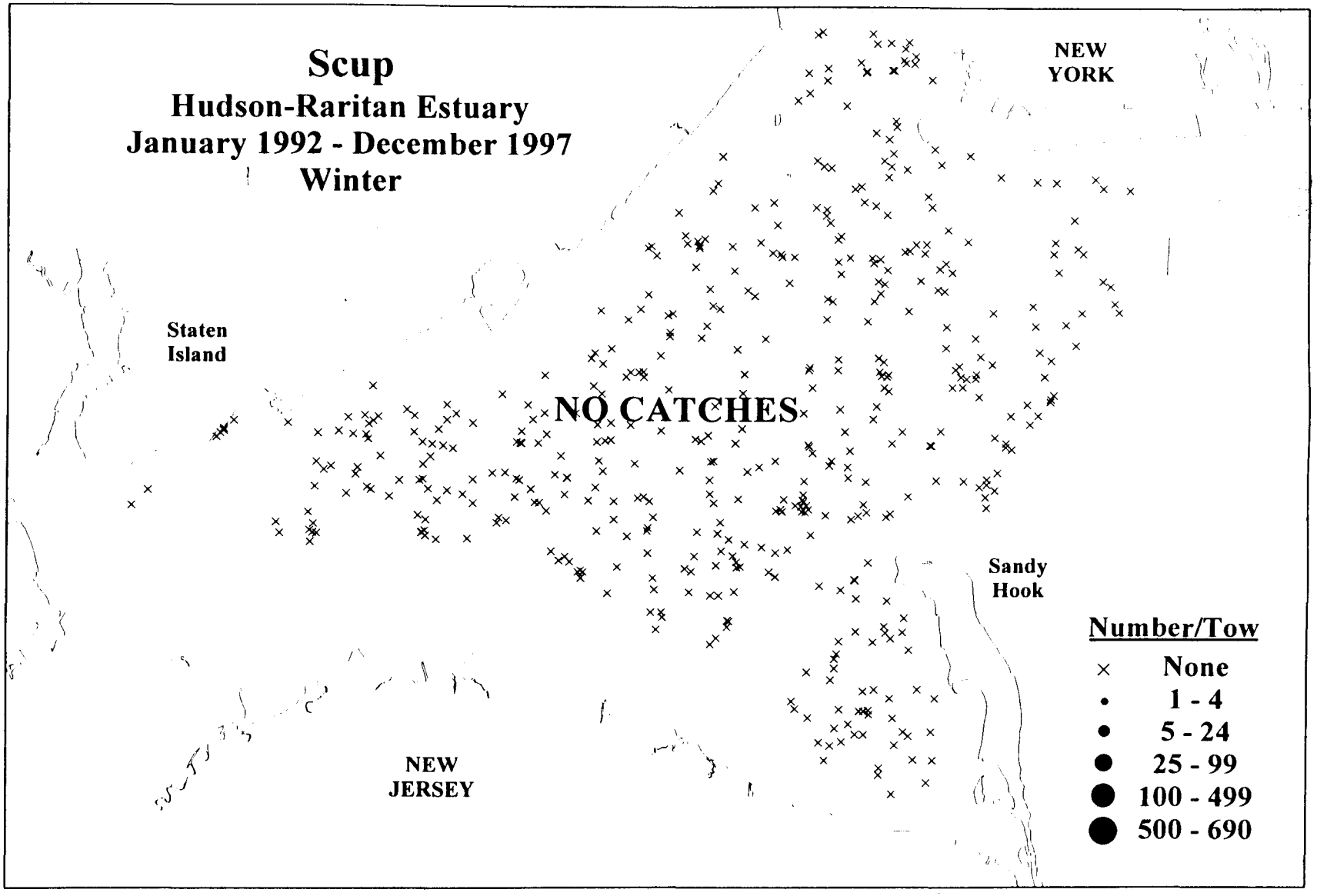

Figure 85. Distribution and abundance of all scup collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

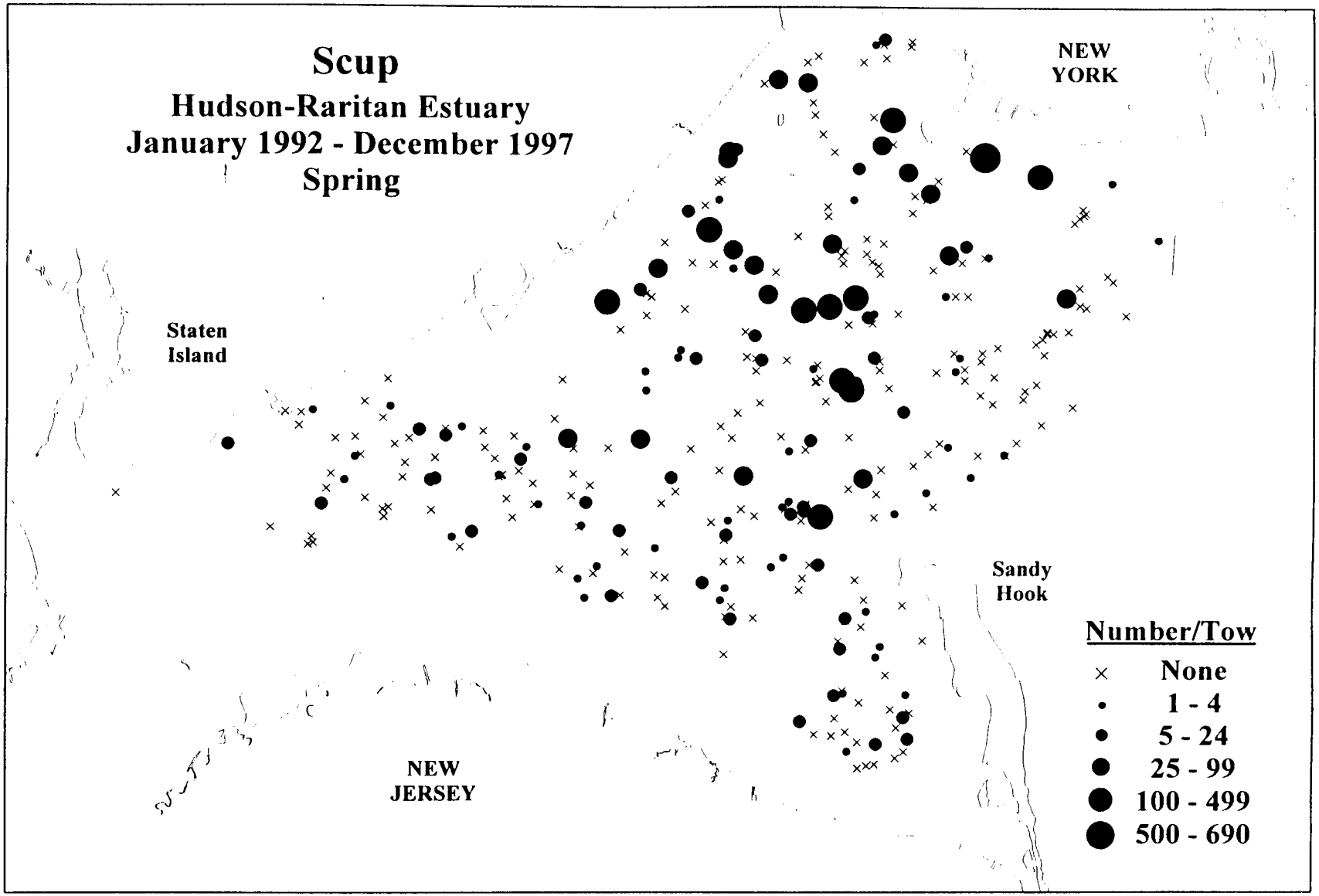

Figure 86. Distribution and abundance of scup collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

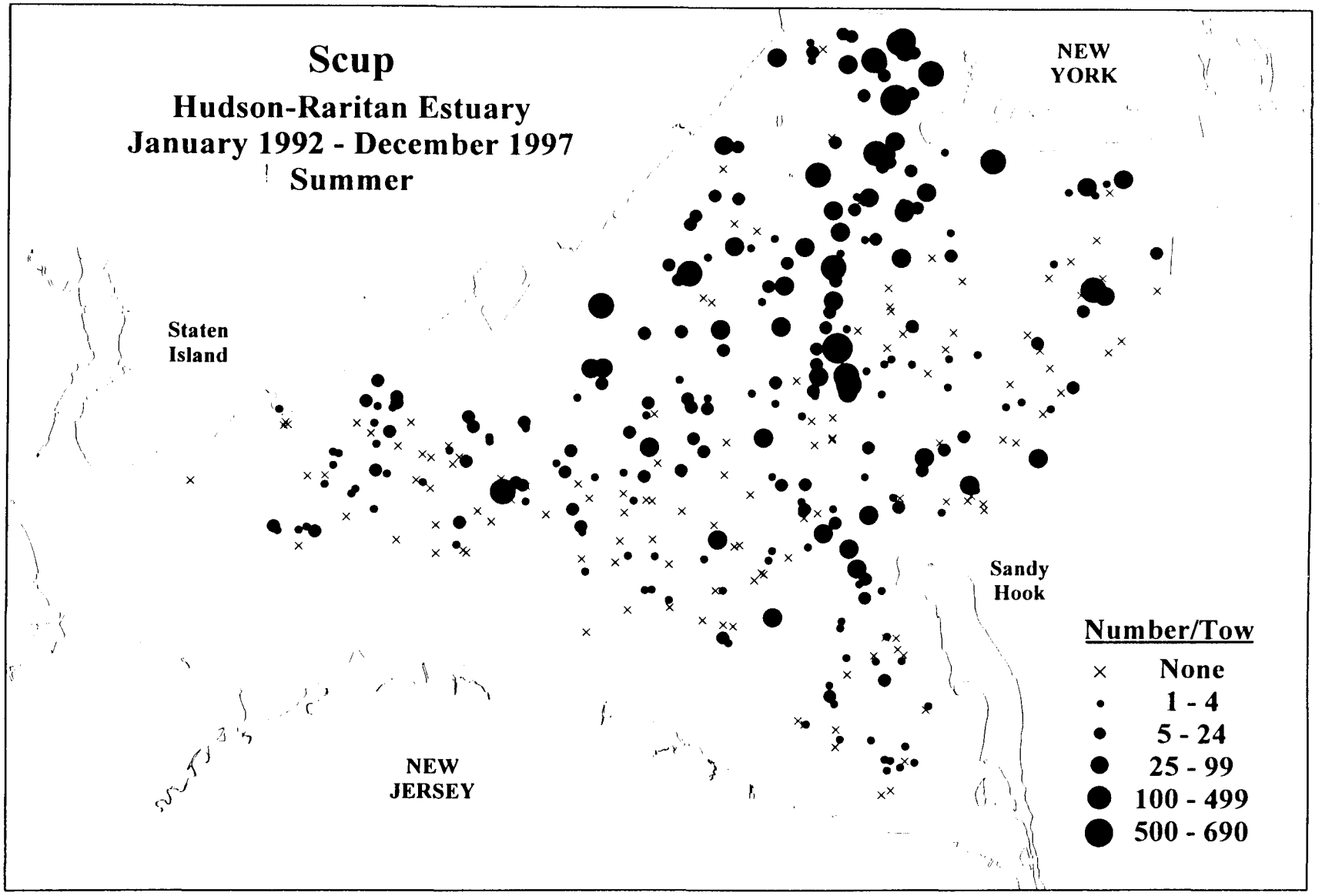

Figure 87. Distribution and abundance of scup collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

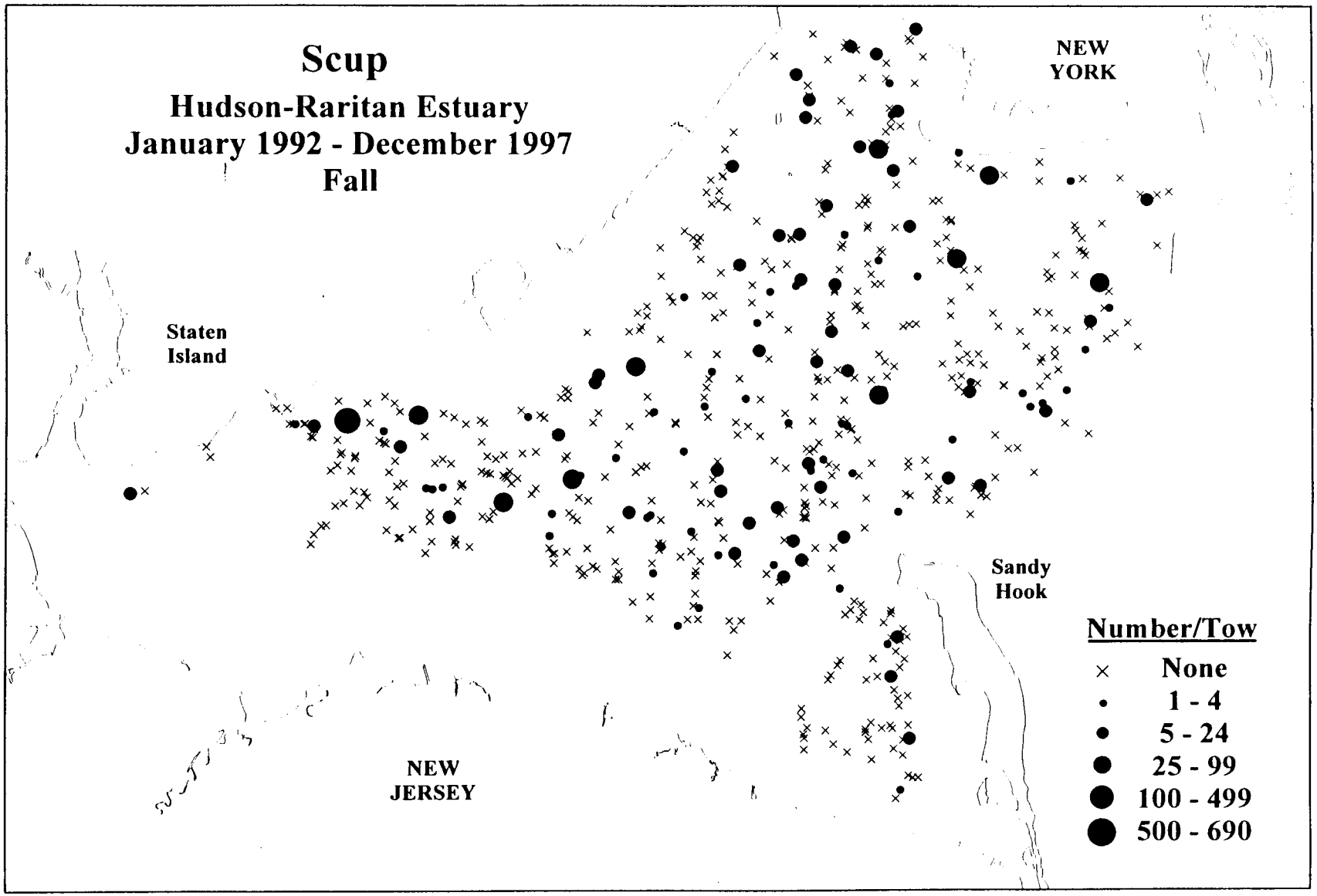

Figure 88. Distribution and abundance of scup collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

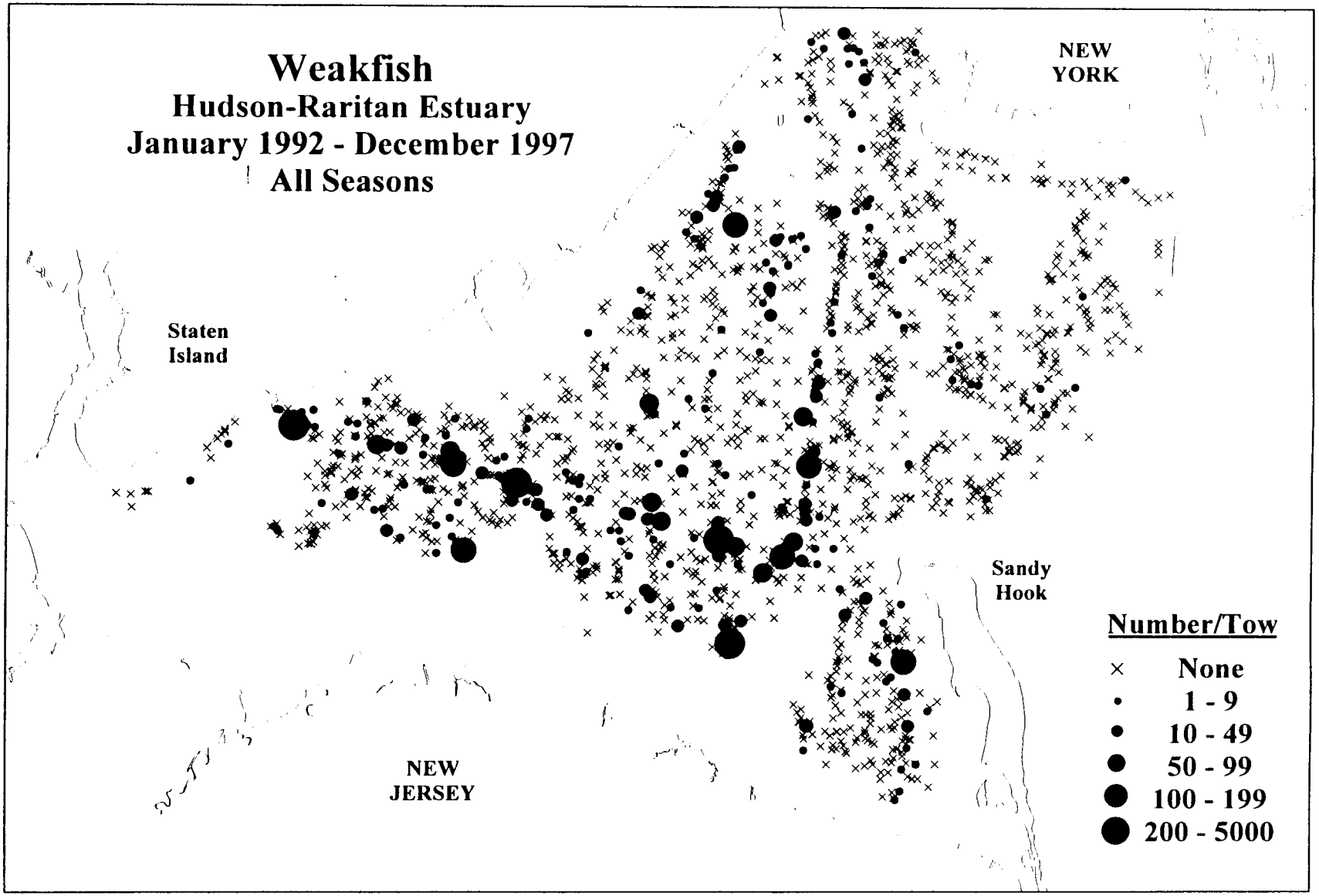

Figure 89. Distribution and abundance of all weakfish collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

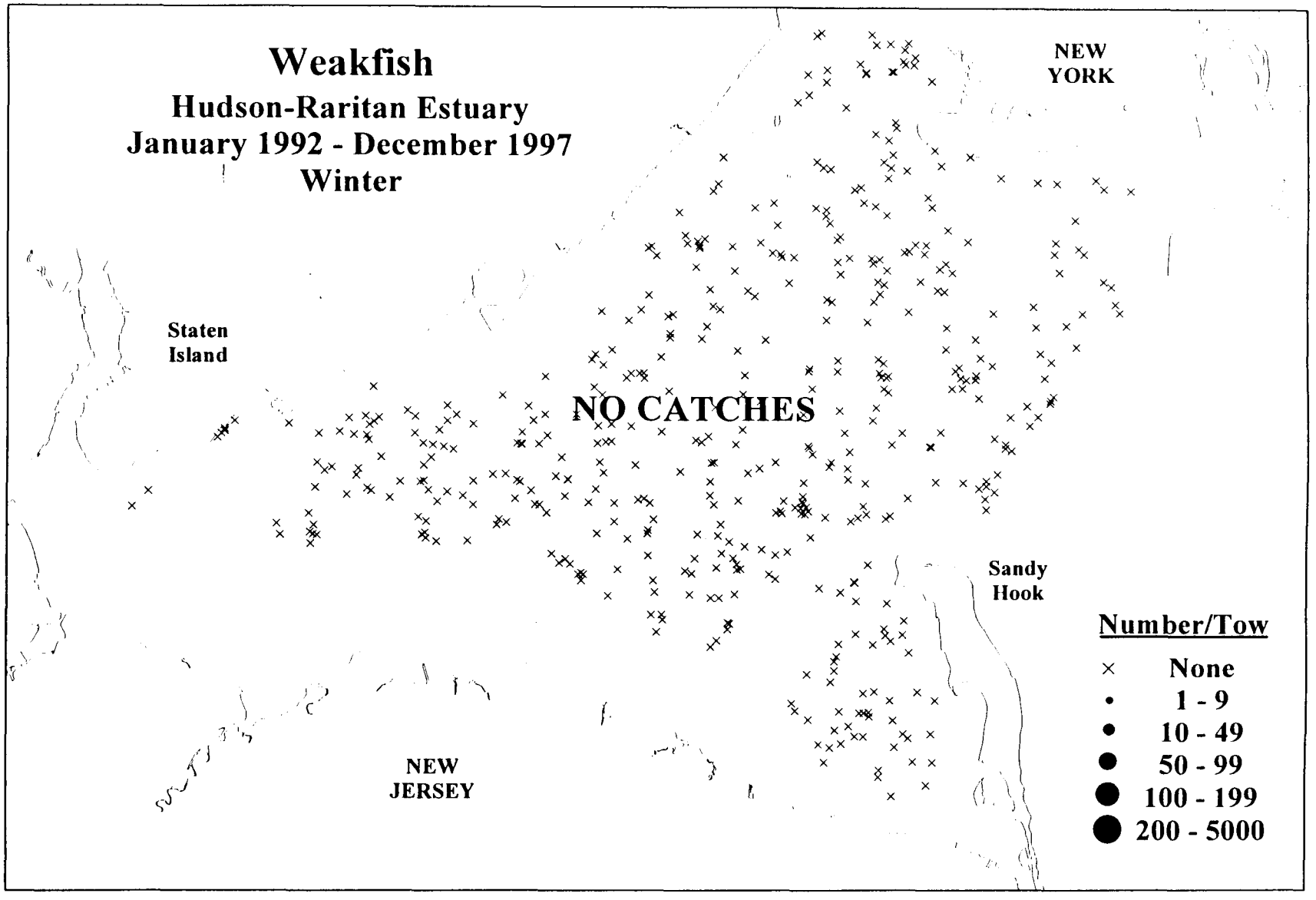

Figure 90. Distribution and abundance of all weakfish collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

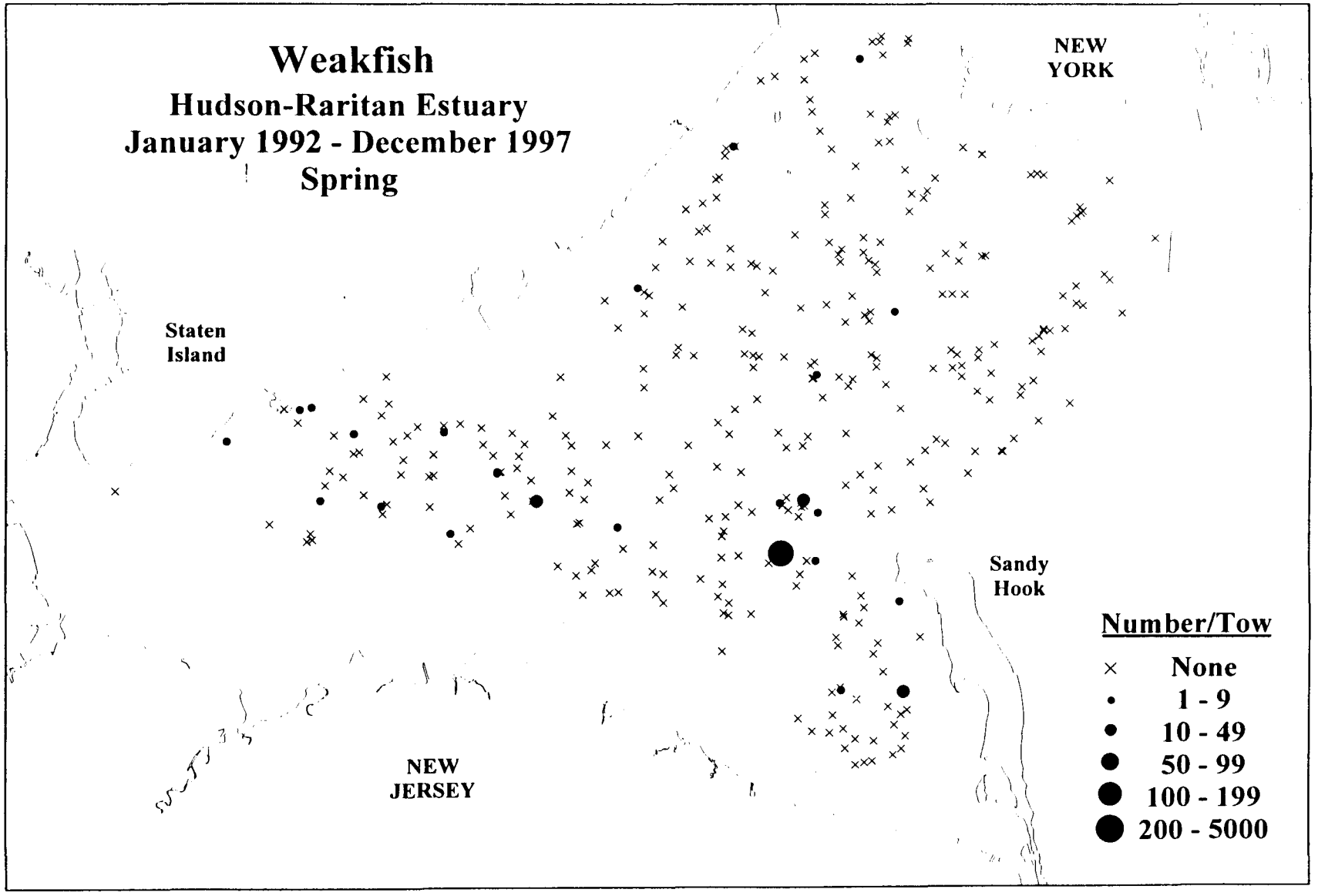

Figure 91. Distribution and relative of weakfish collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

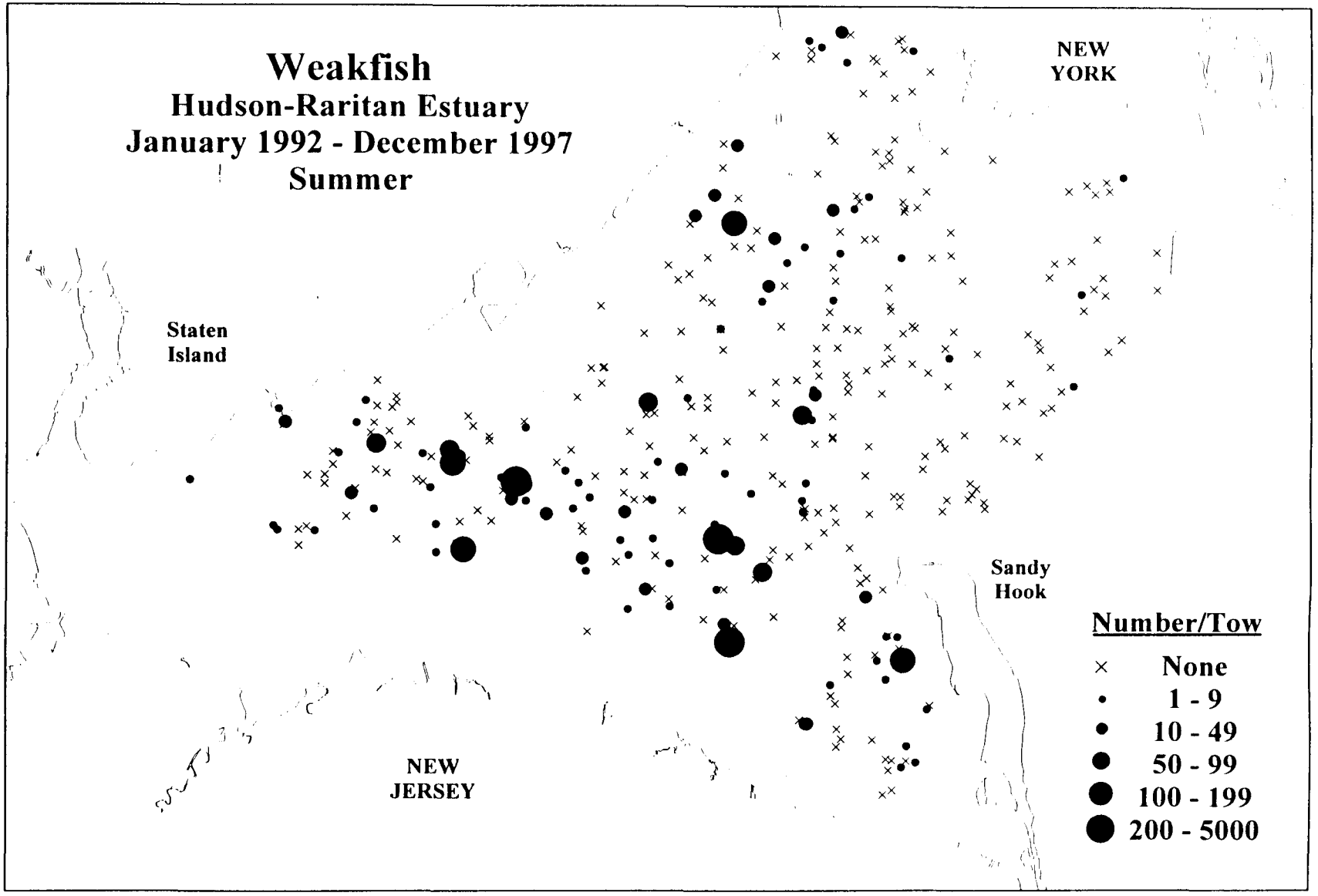

Figure 92. Distribution and abundance of weakfish collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

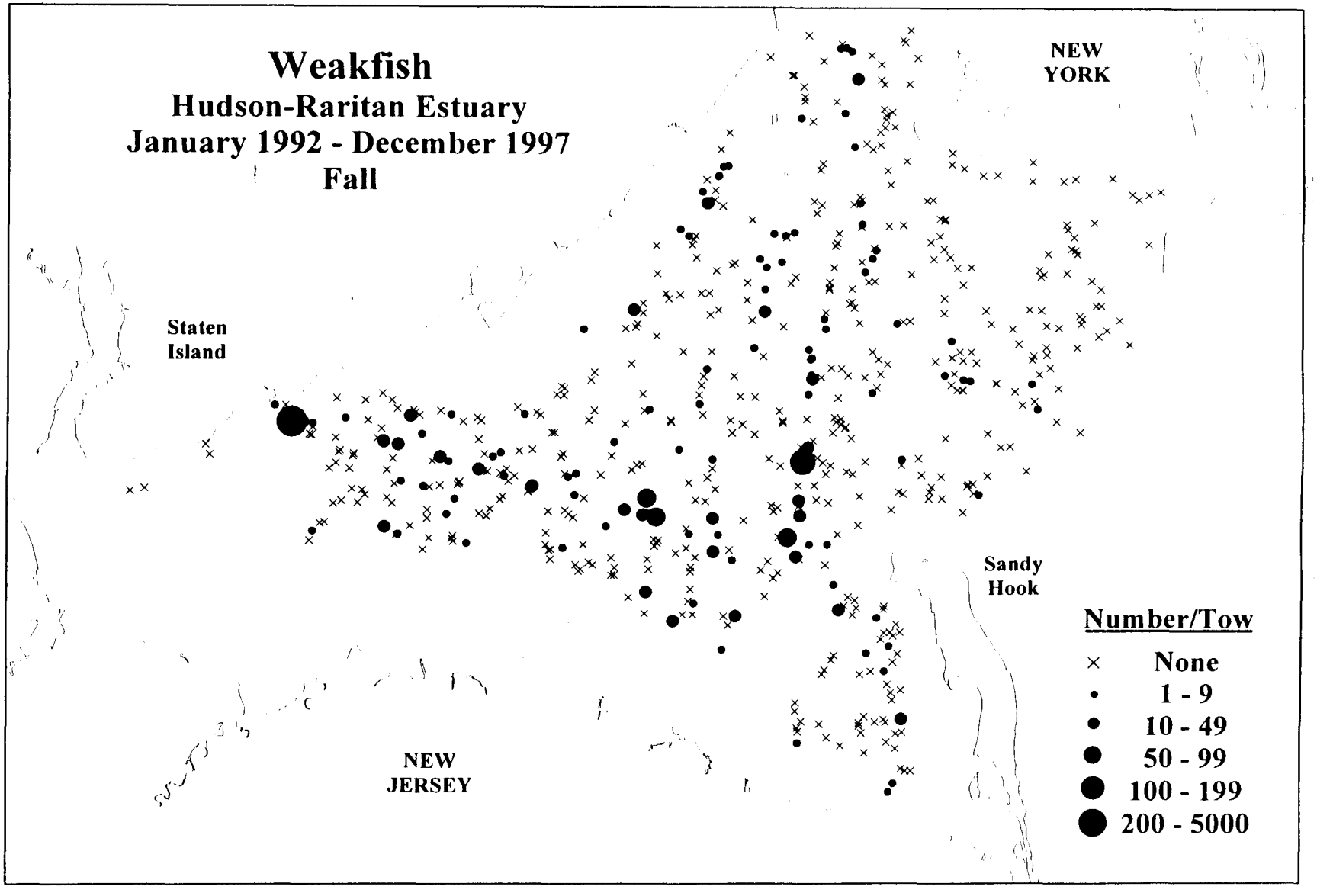

Figure 93. Distribution and abundance of weakfish collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

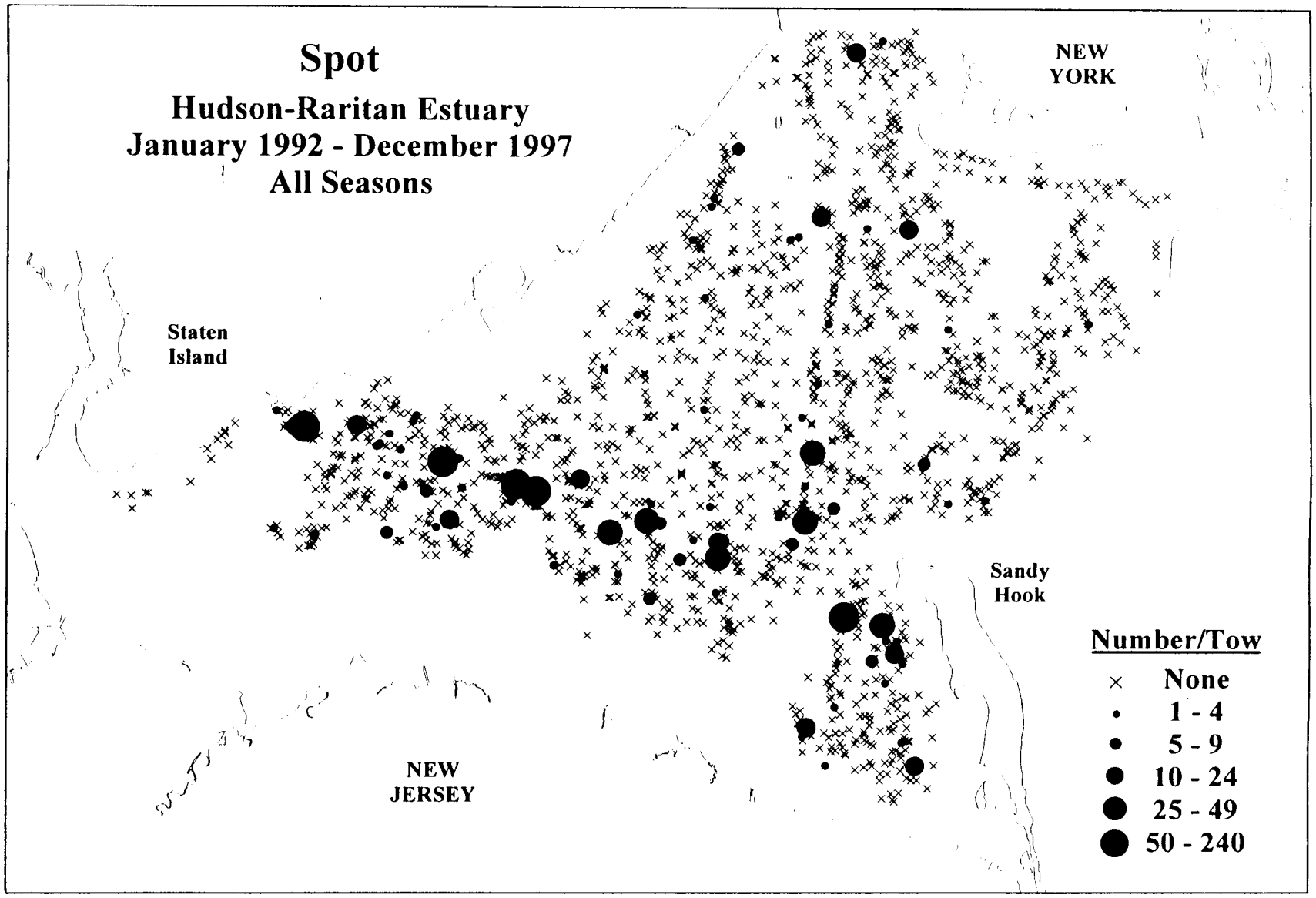

Figure 94. Distribution and abundance of all spot collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

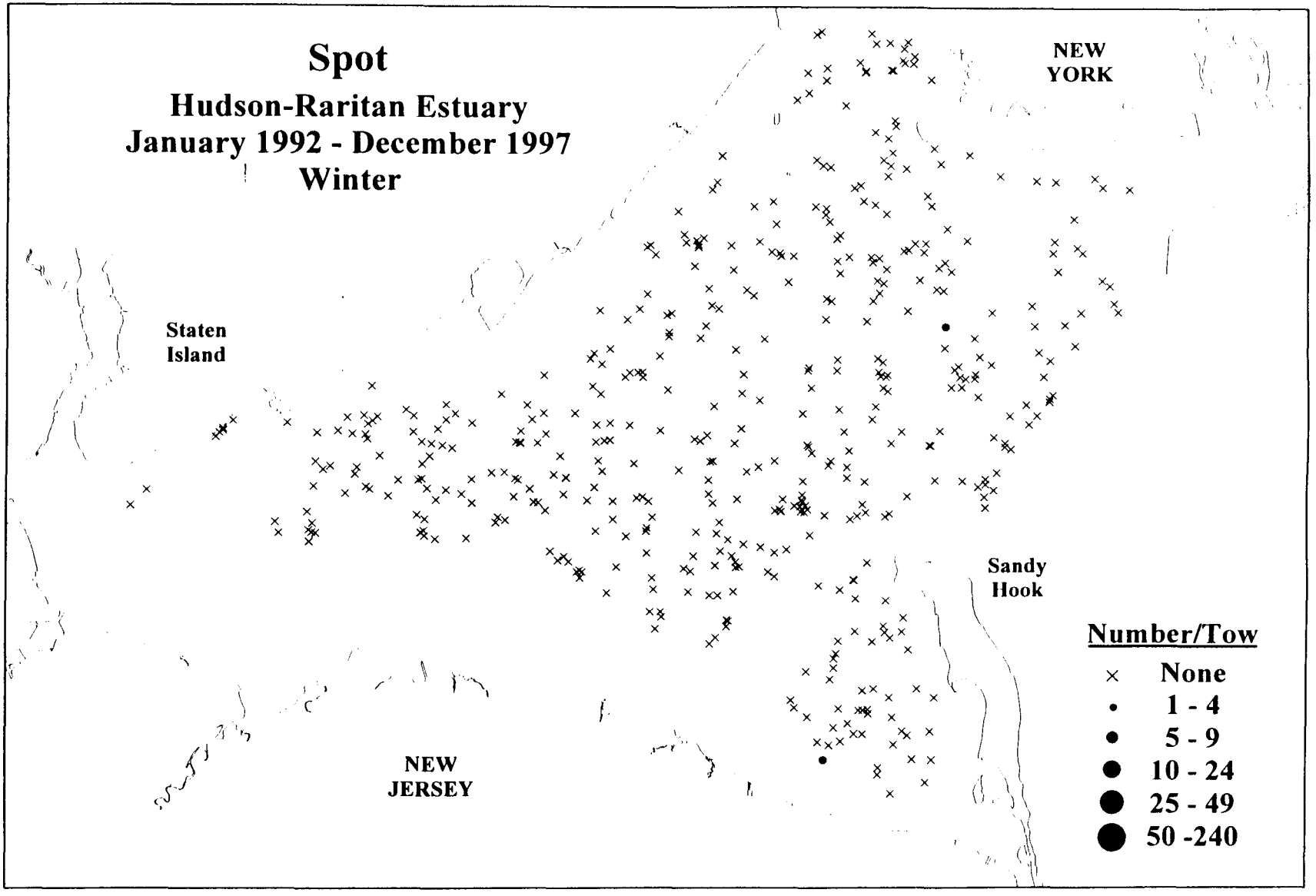

Figure 95. Distribution and abundance of all spot collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

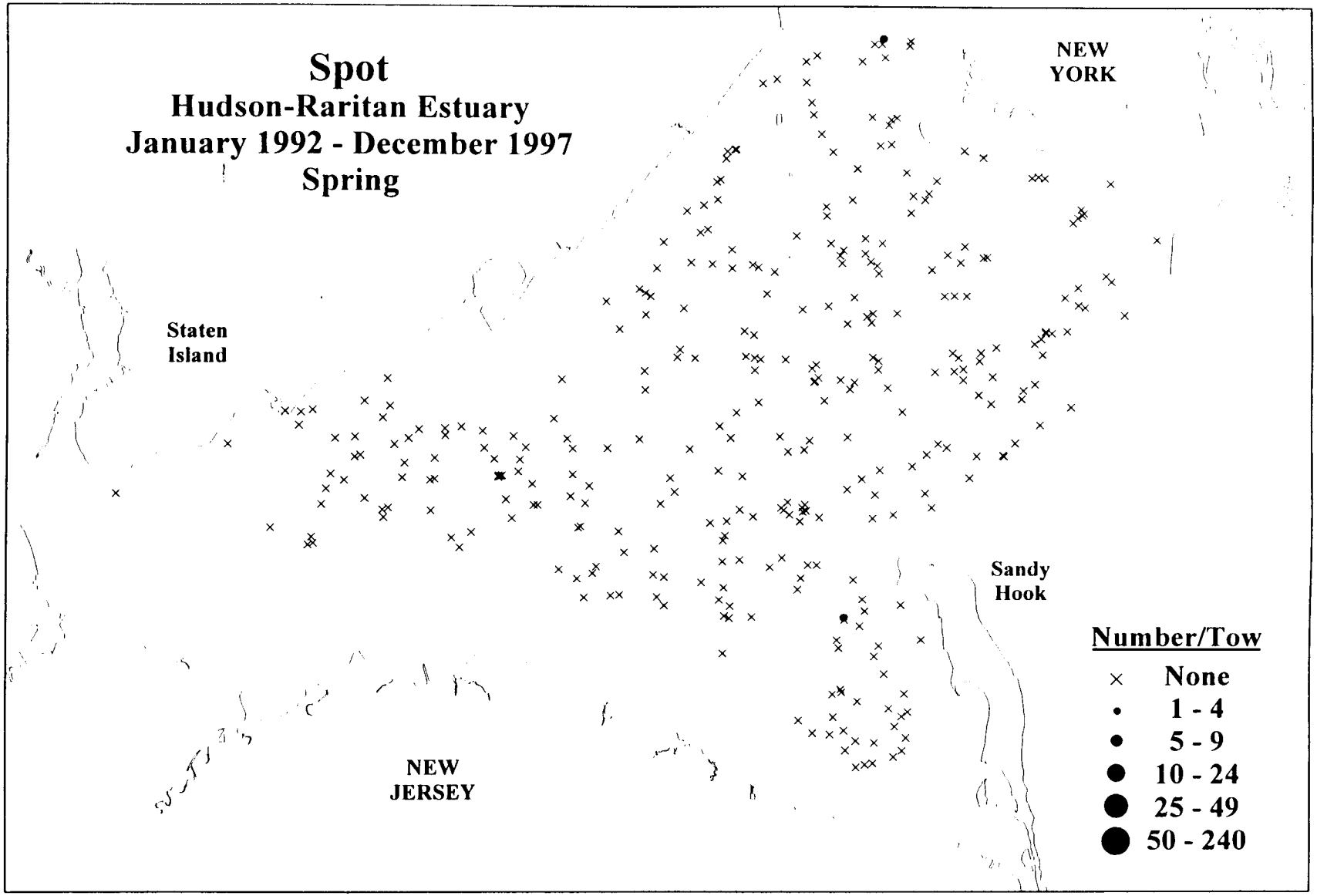

Figure 96. Distribution and abundance of spot collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

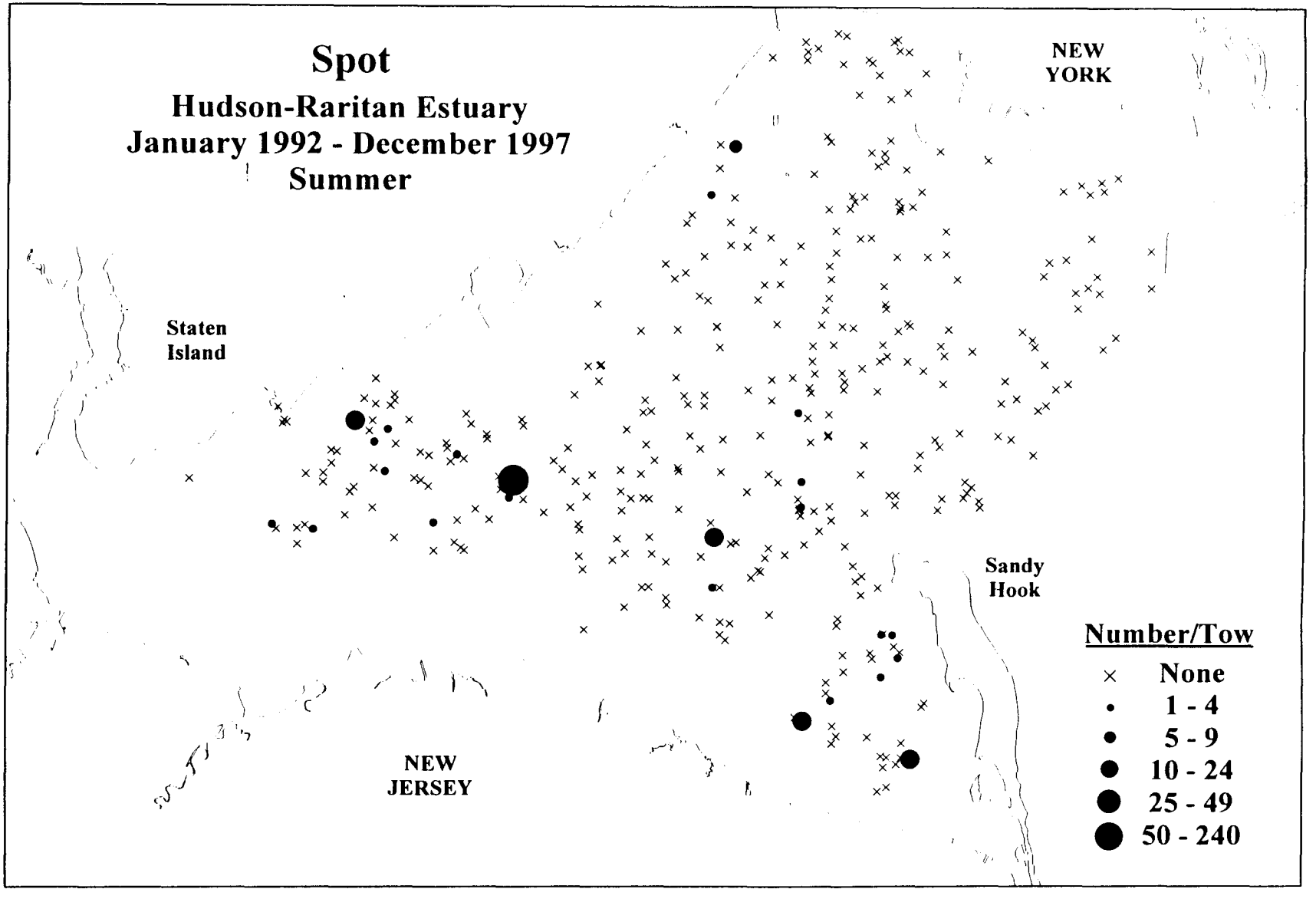

Figure 97. Distribution and abundance of spot collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

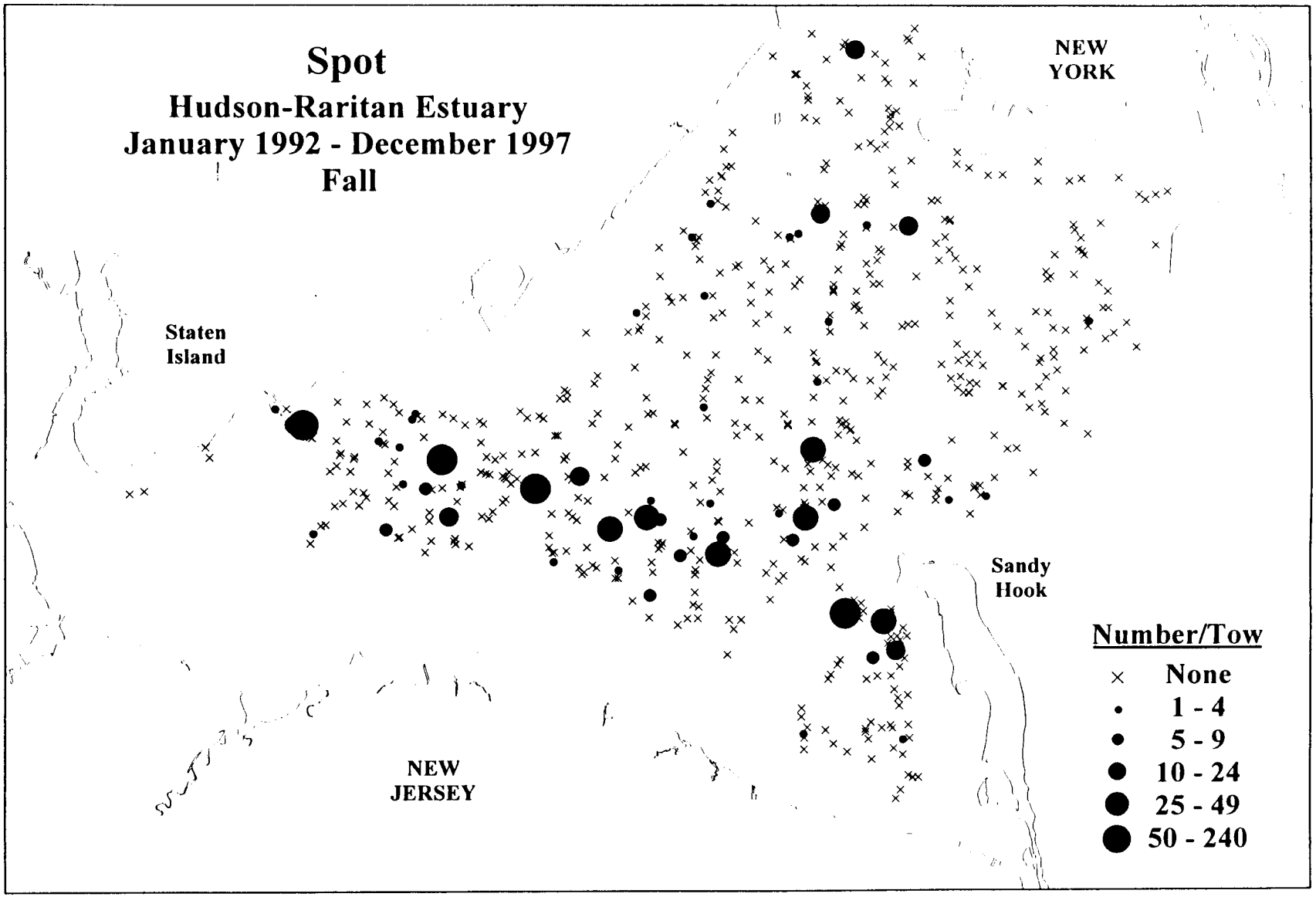

Figure 98. Distribution and abundance of spot collected during the Fall (October, November, and December) in the Hudson- Raritan Estuary between January 1992 and December 1997.

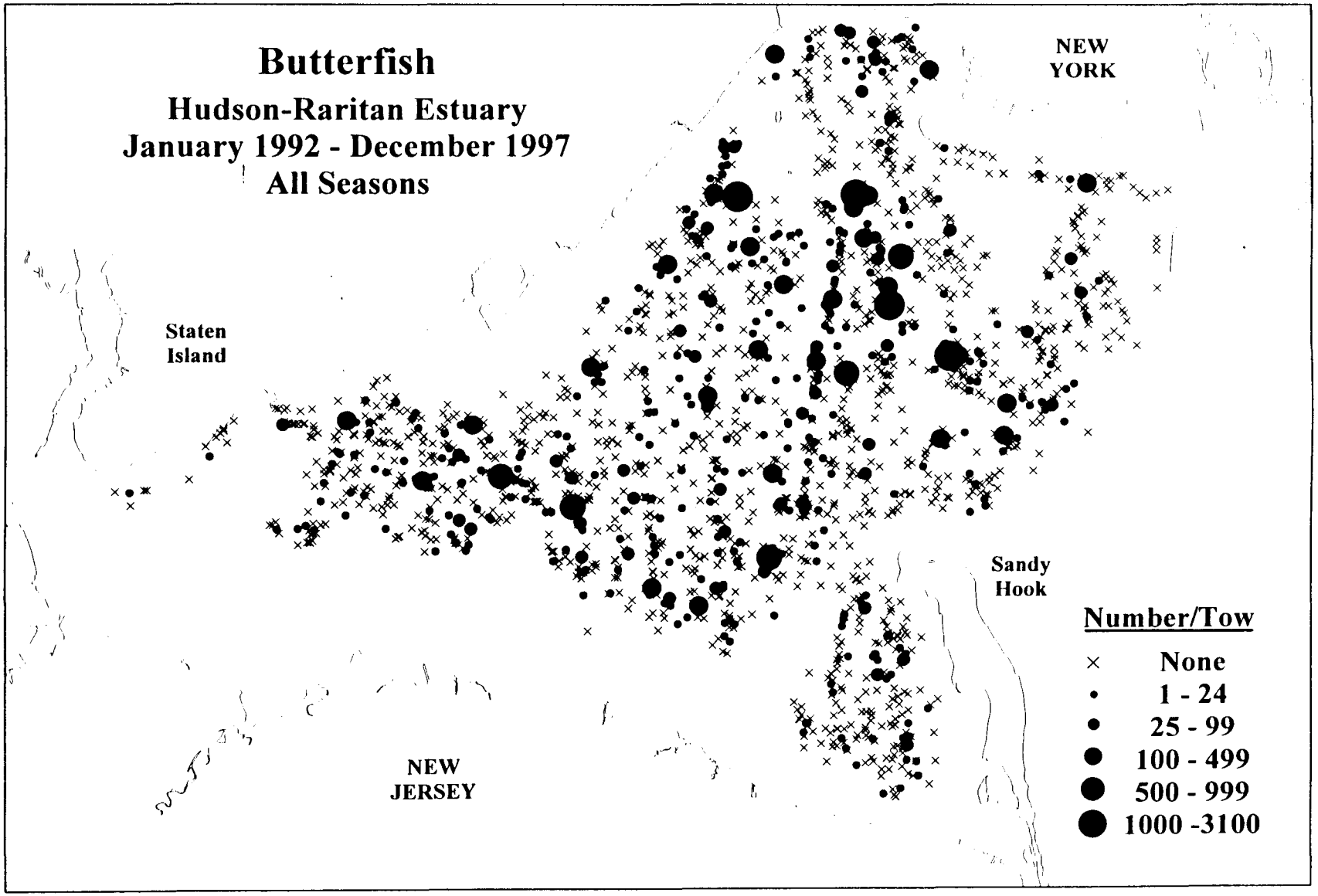

Figure 99. Distribution and abundance of all butterfish collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

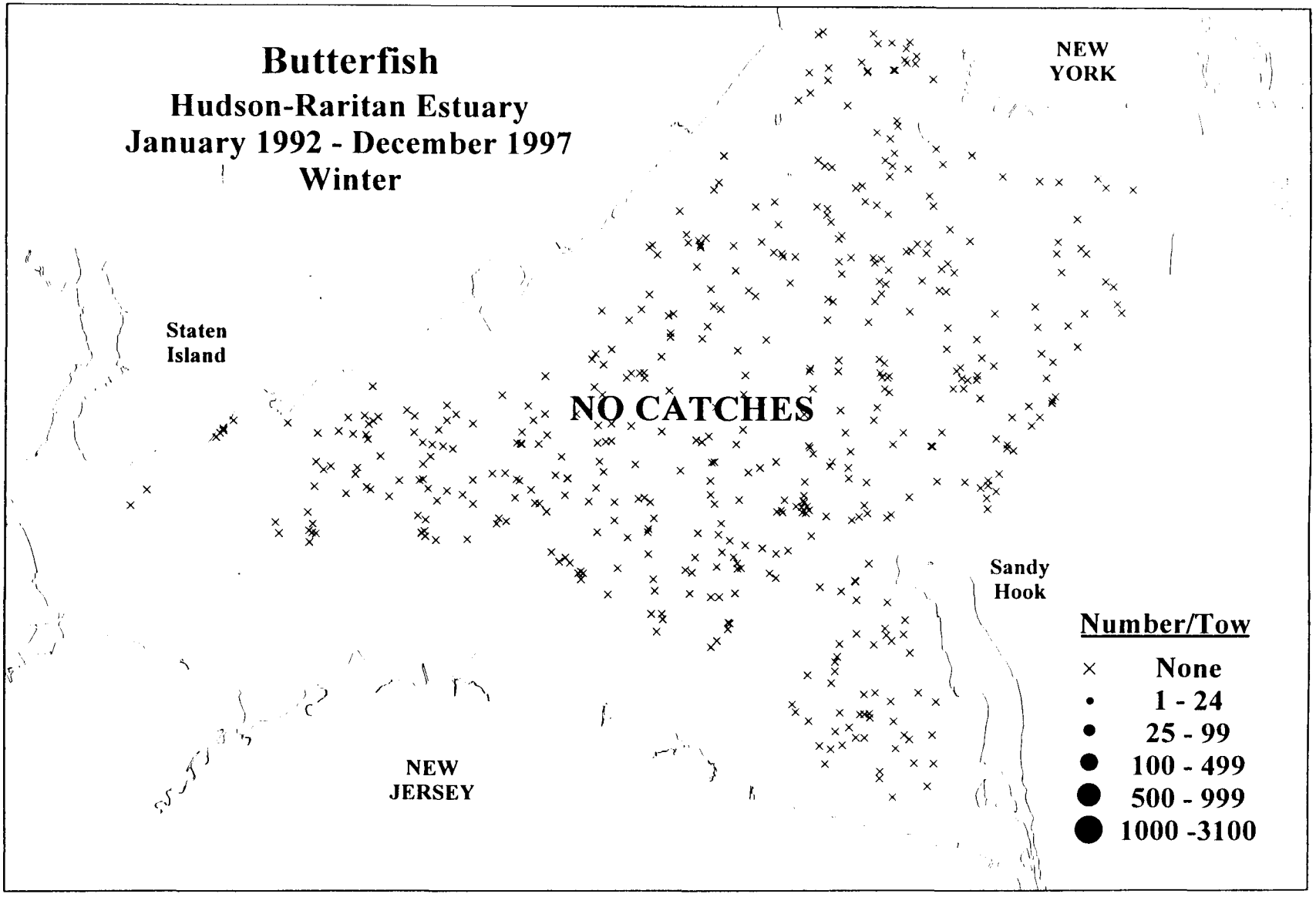

Figure 100. Distribution and abundance of all butterfish collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

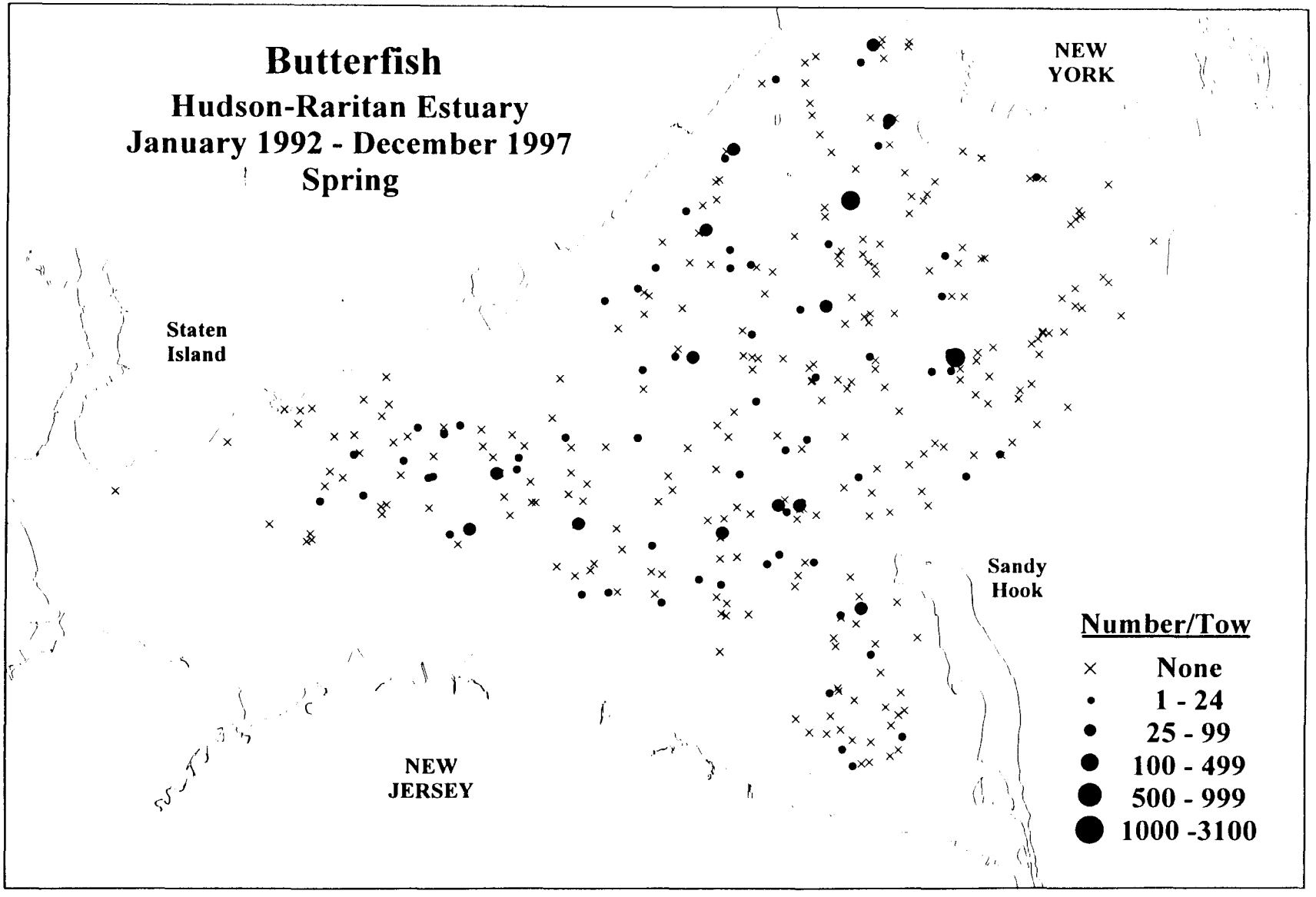

Figure 101. Distribution and abundance of butterfish collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

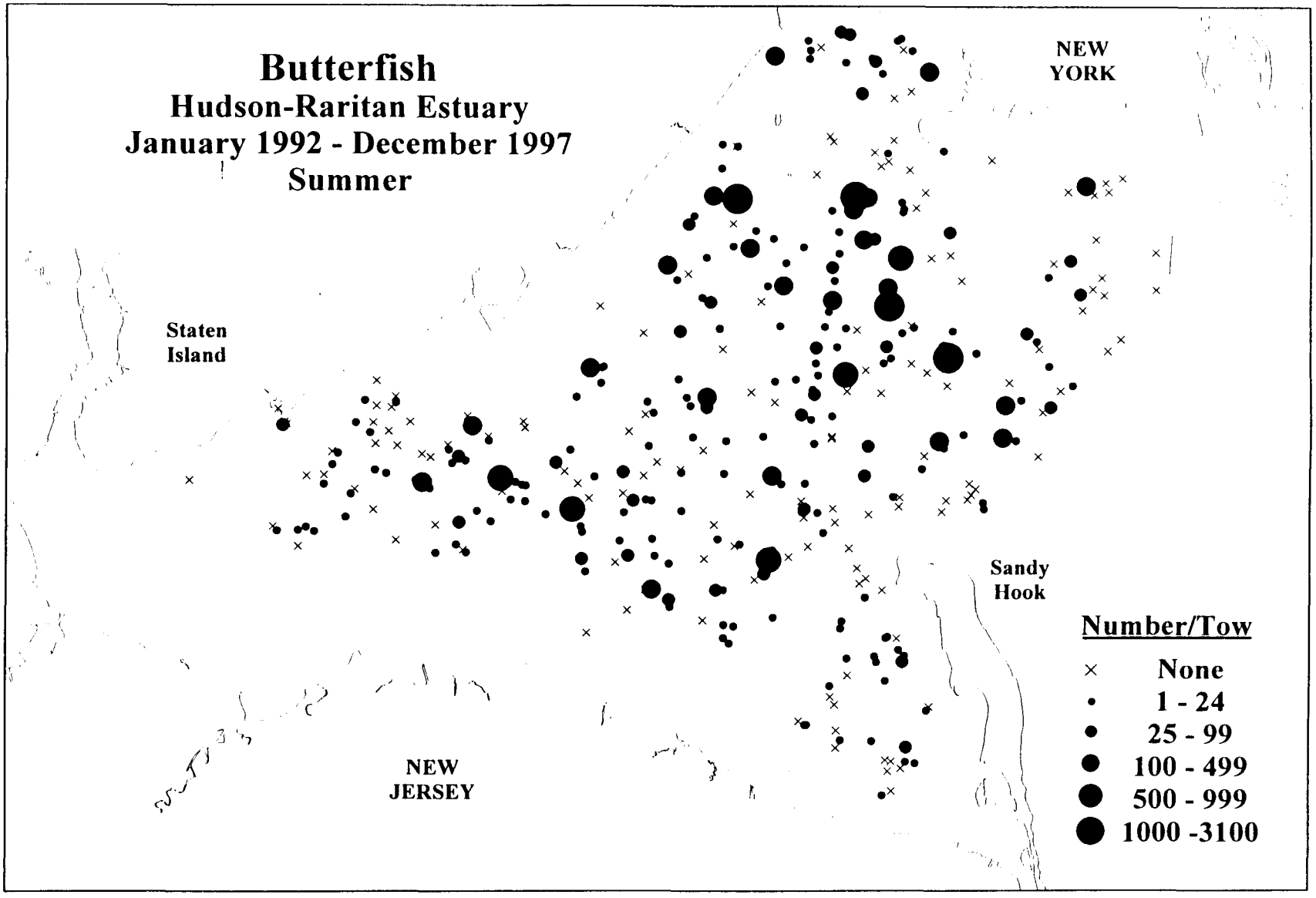

Figure 102. Distribution and abundance of butterfish collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

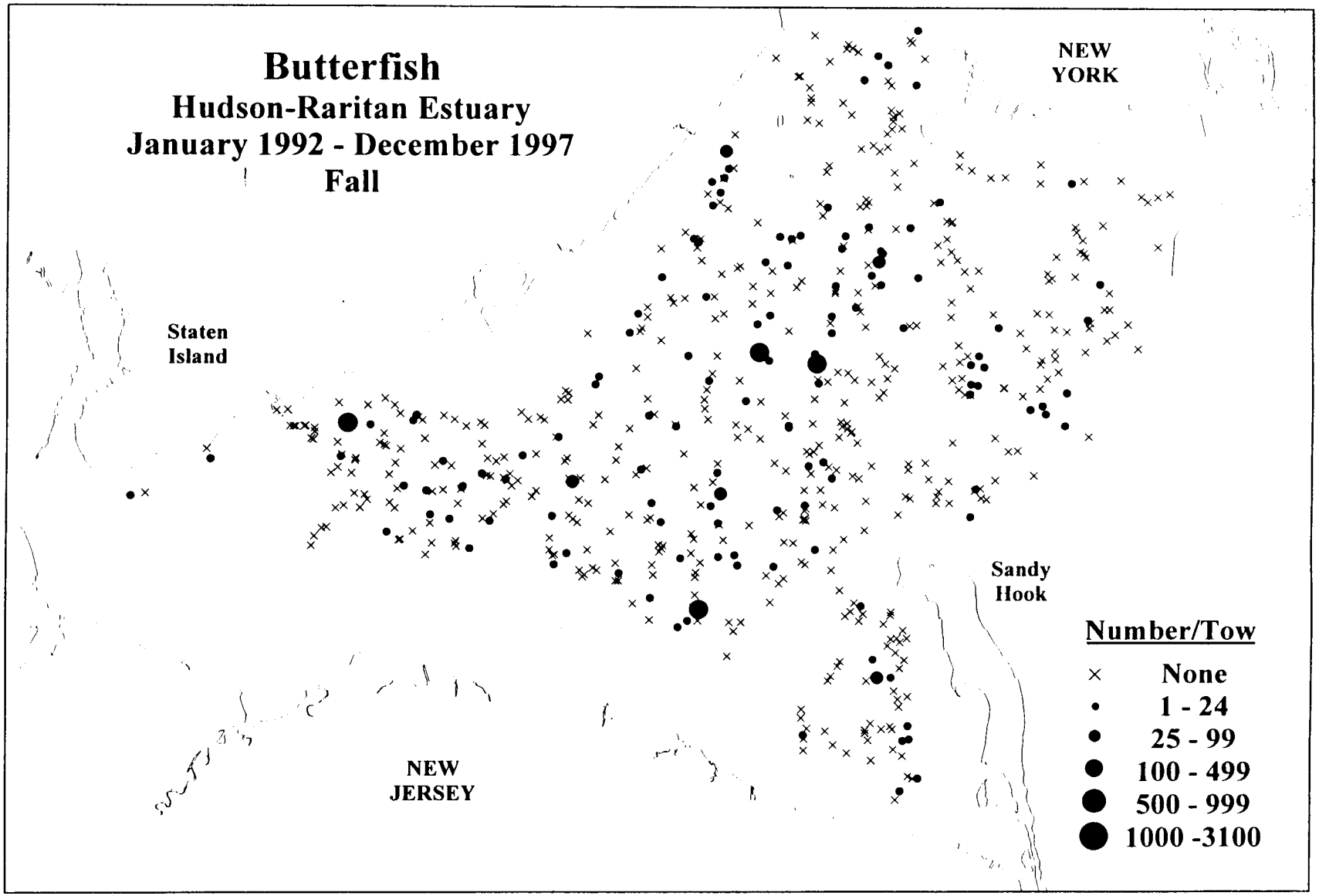

Figure 103. Distribution and abundance of butterfish collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

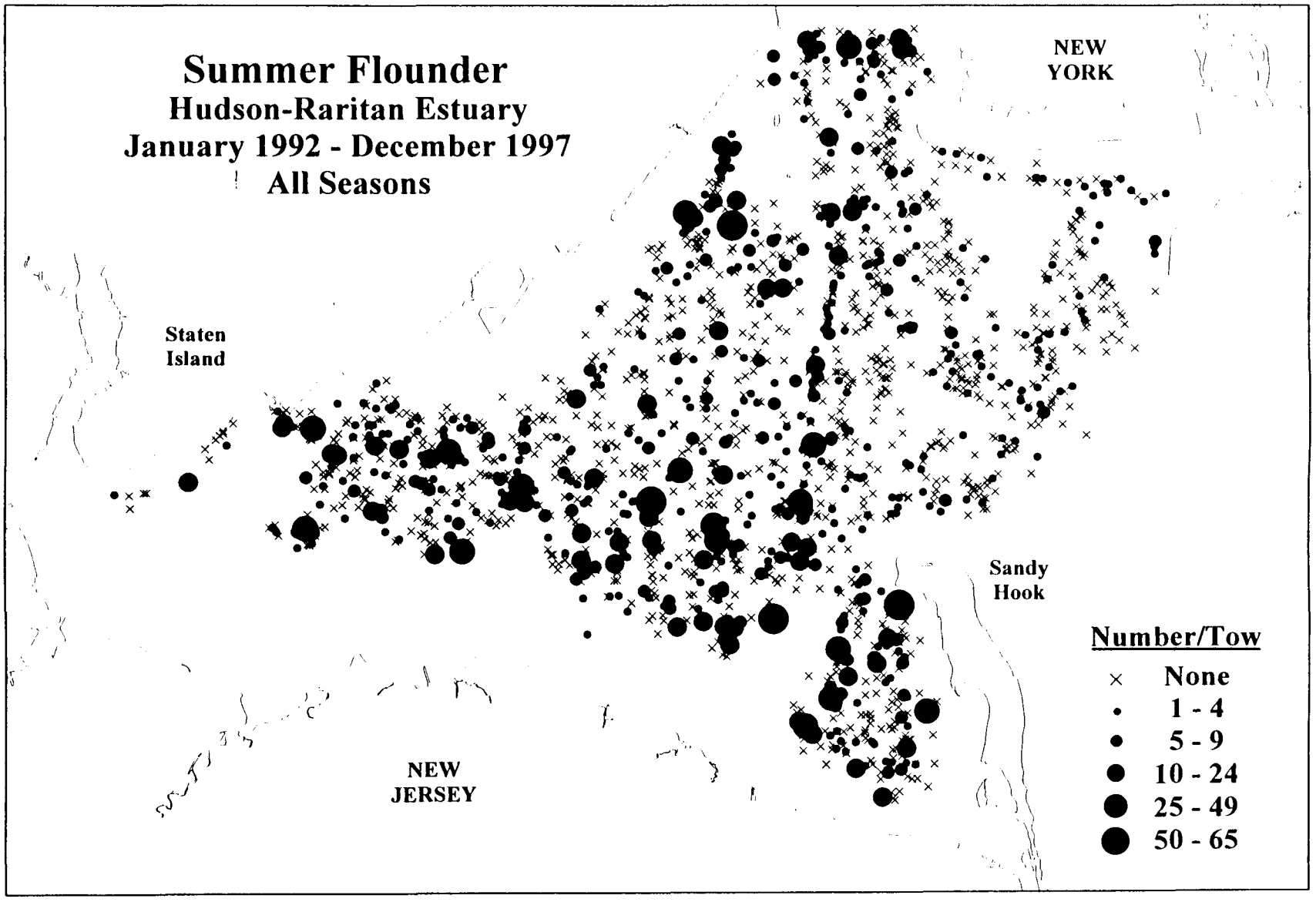

Figure 104. Distribution and abundance of all summer flounder collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

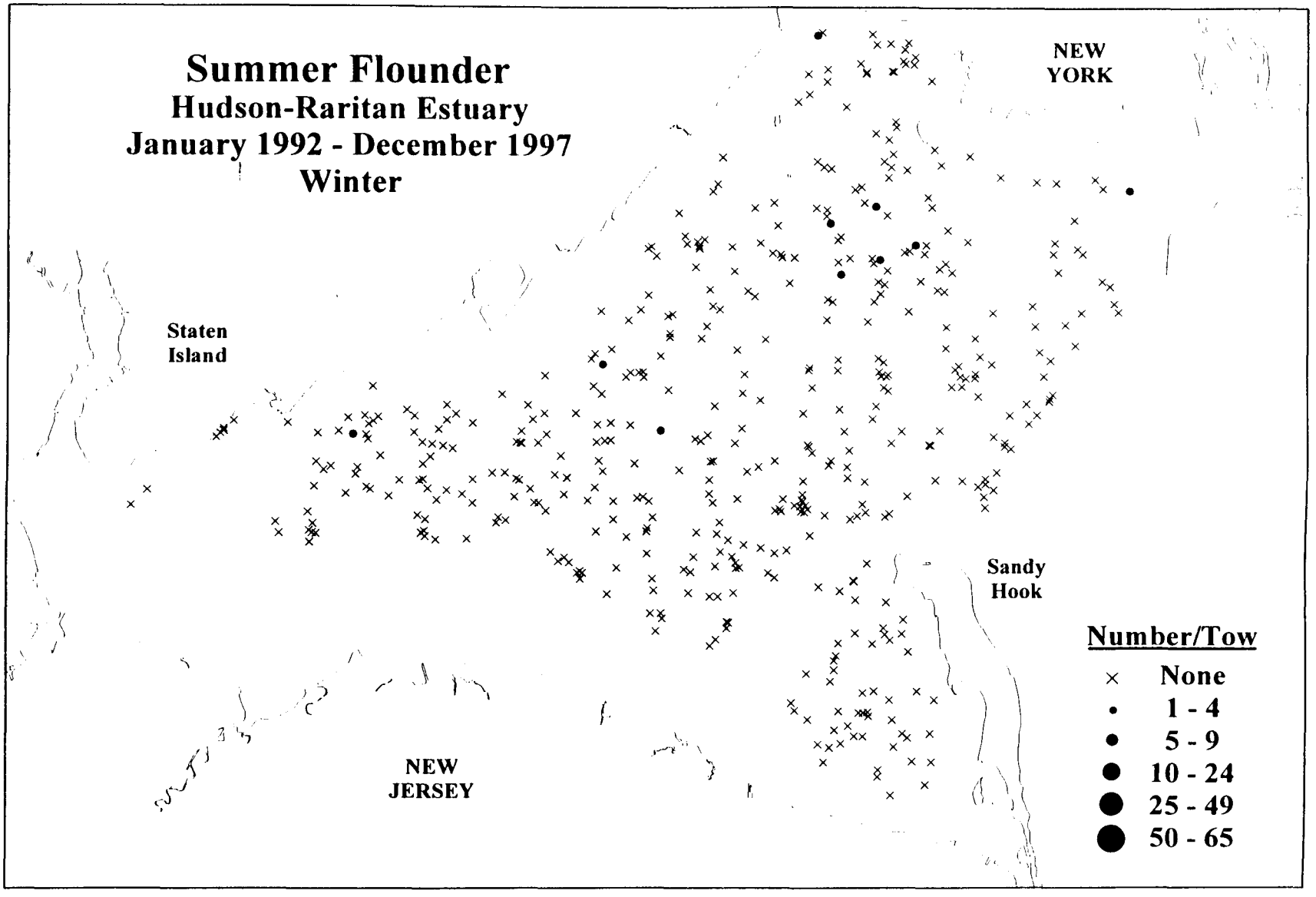

Figure 105. Distribution and abundance of all summer flounder collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

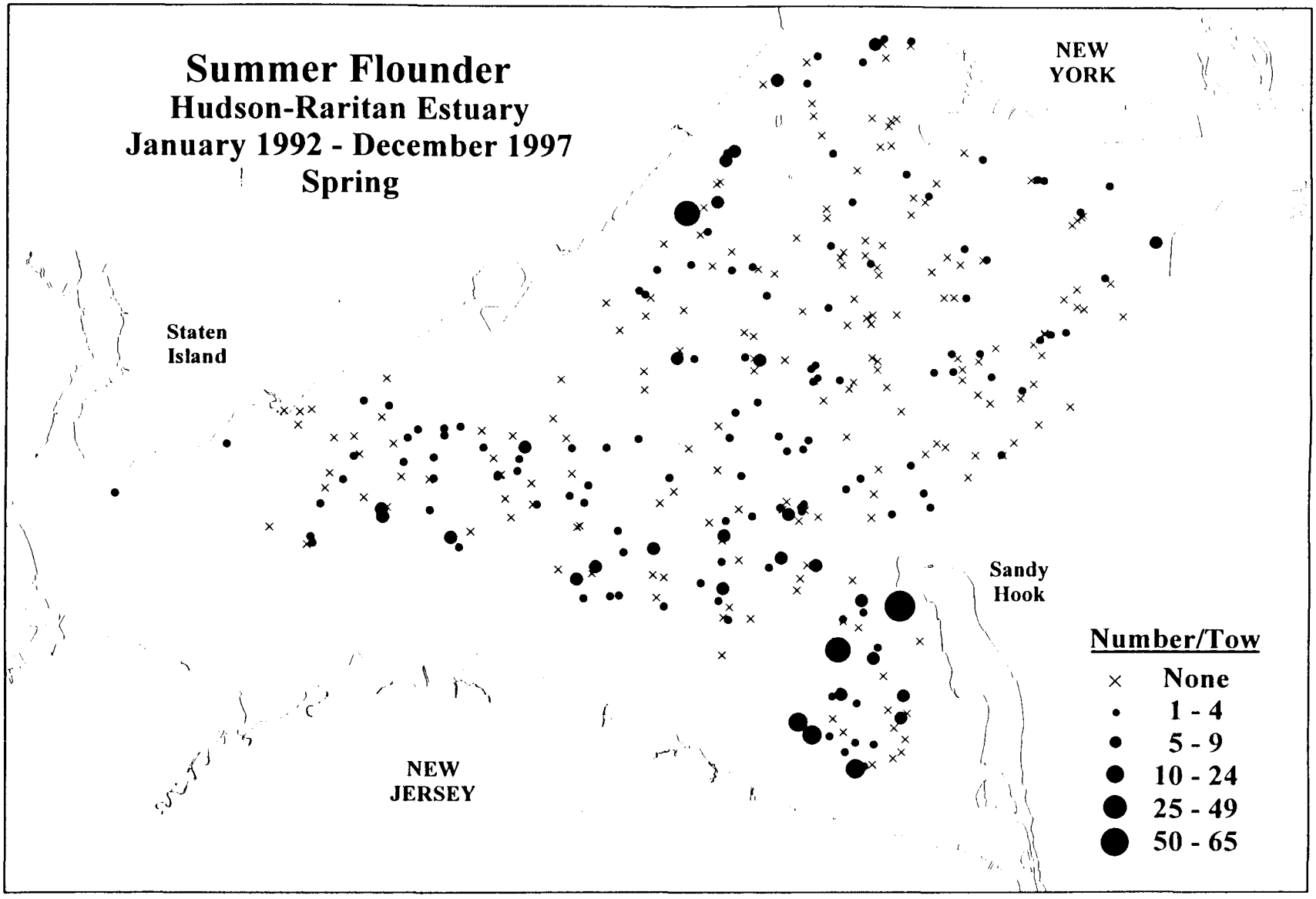

Figure 106. Distribution and abundance of summer flounder collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

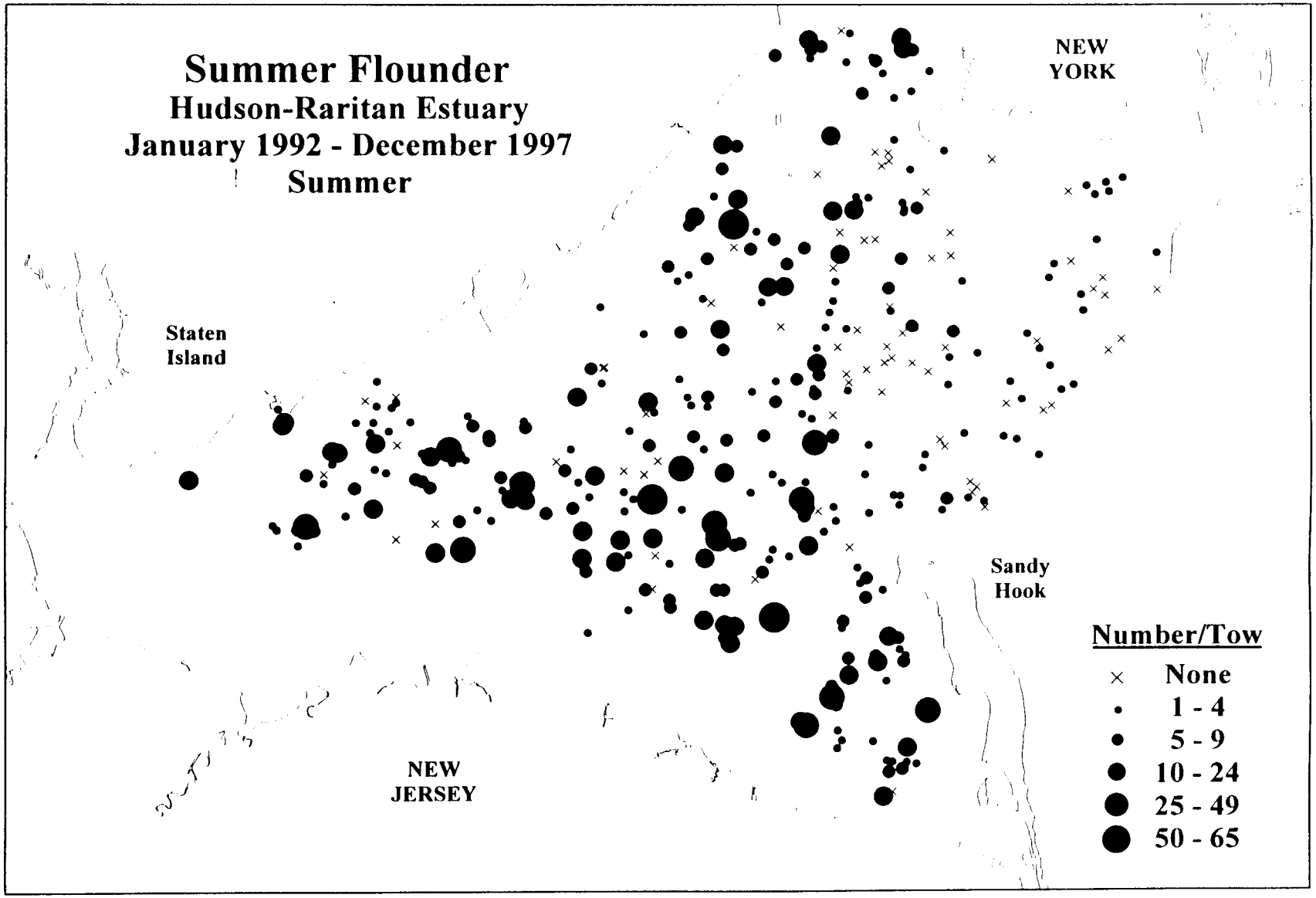

Figure 107. Distribution and abundance of summer flounder collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

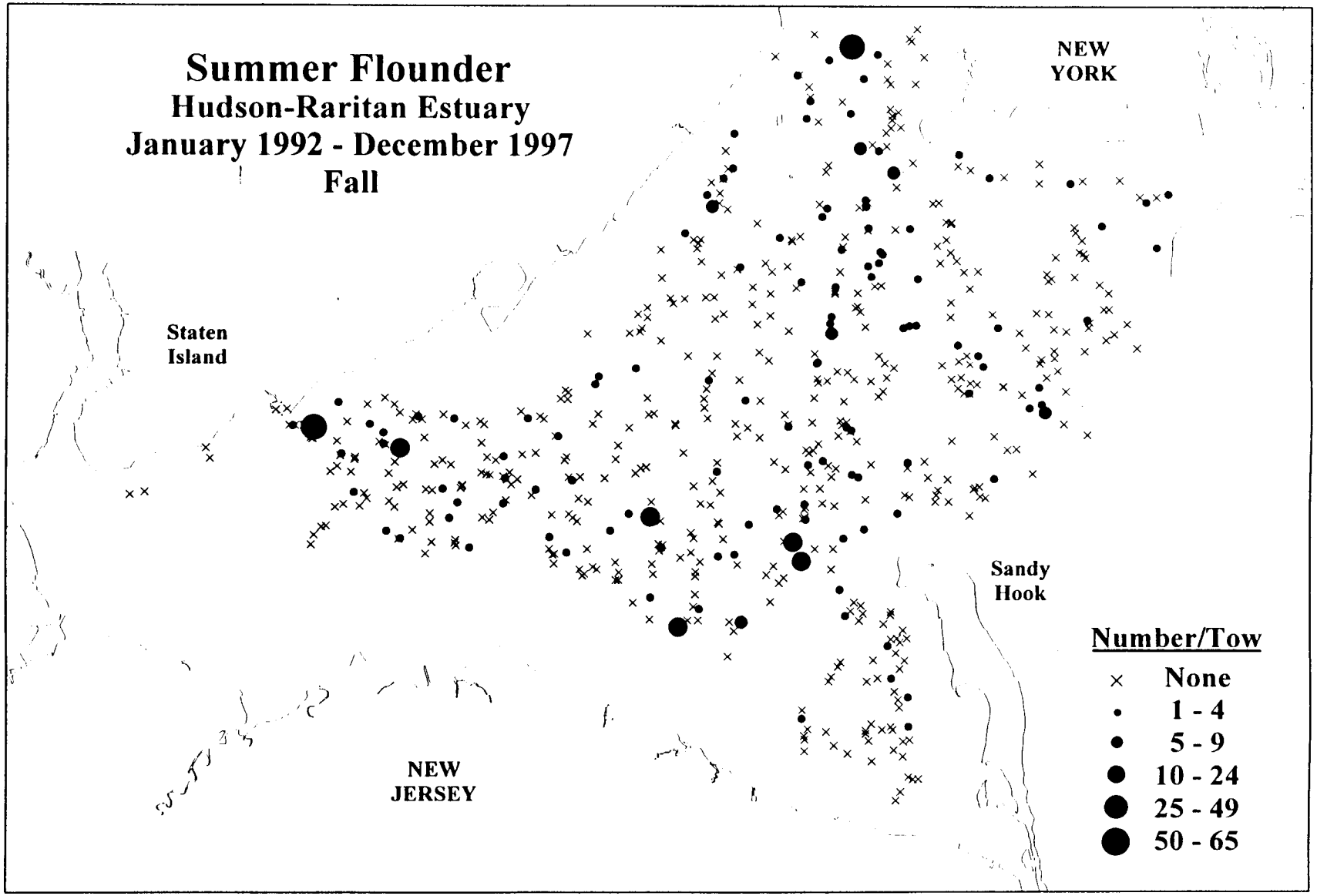

Figure 108. Distribution and abundance of summer flounder collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

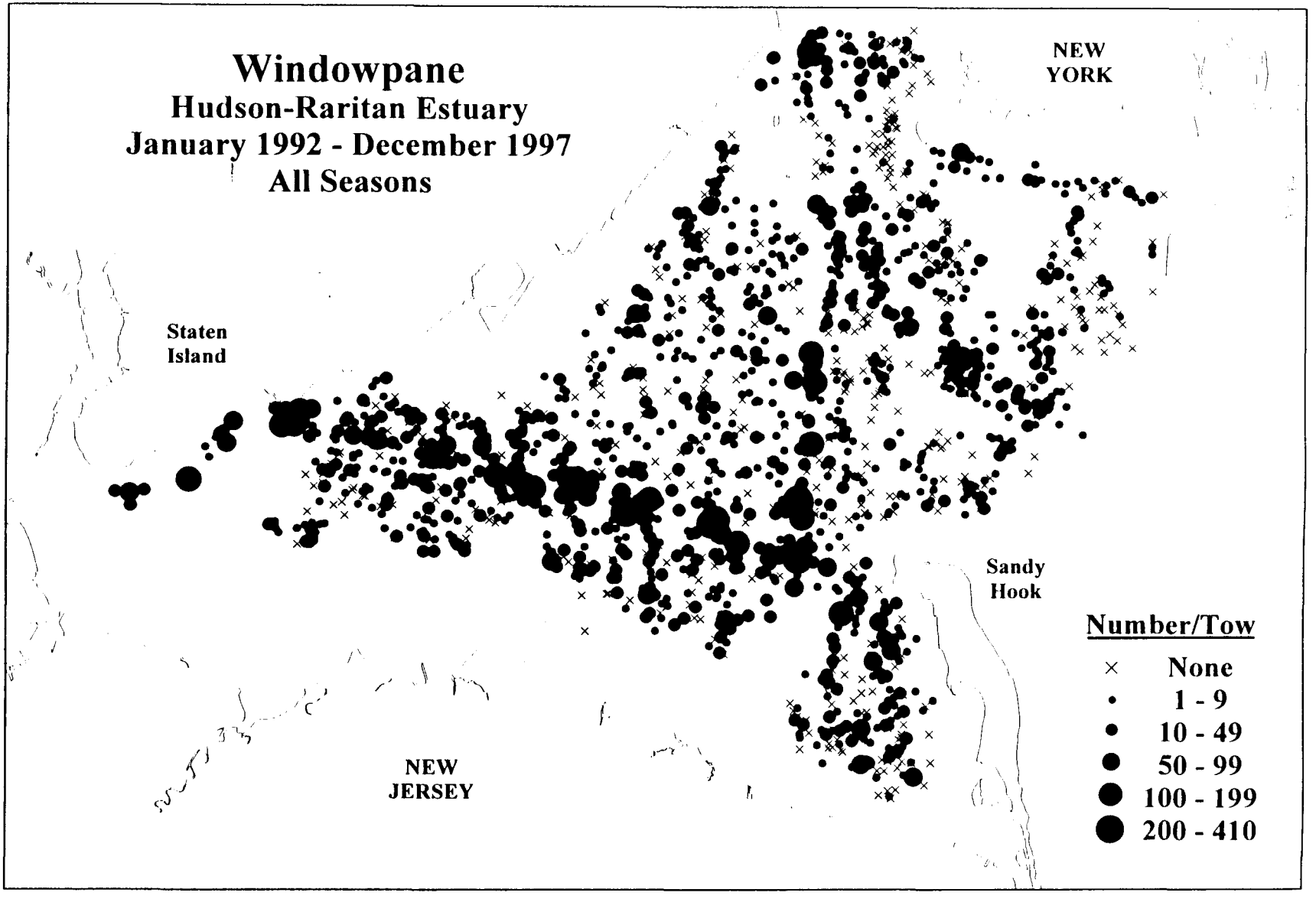

Figure 109. Distribution and abundance of all windowpane collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

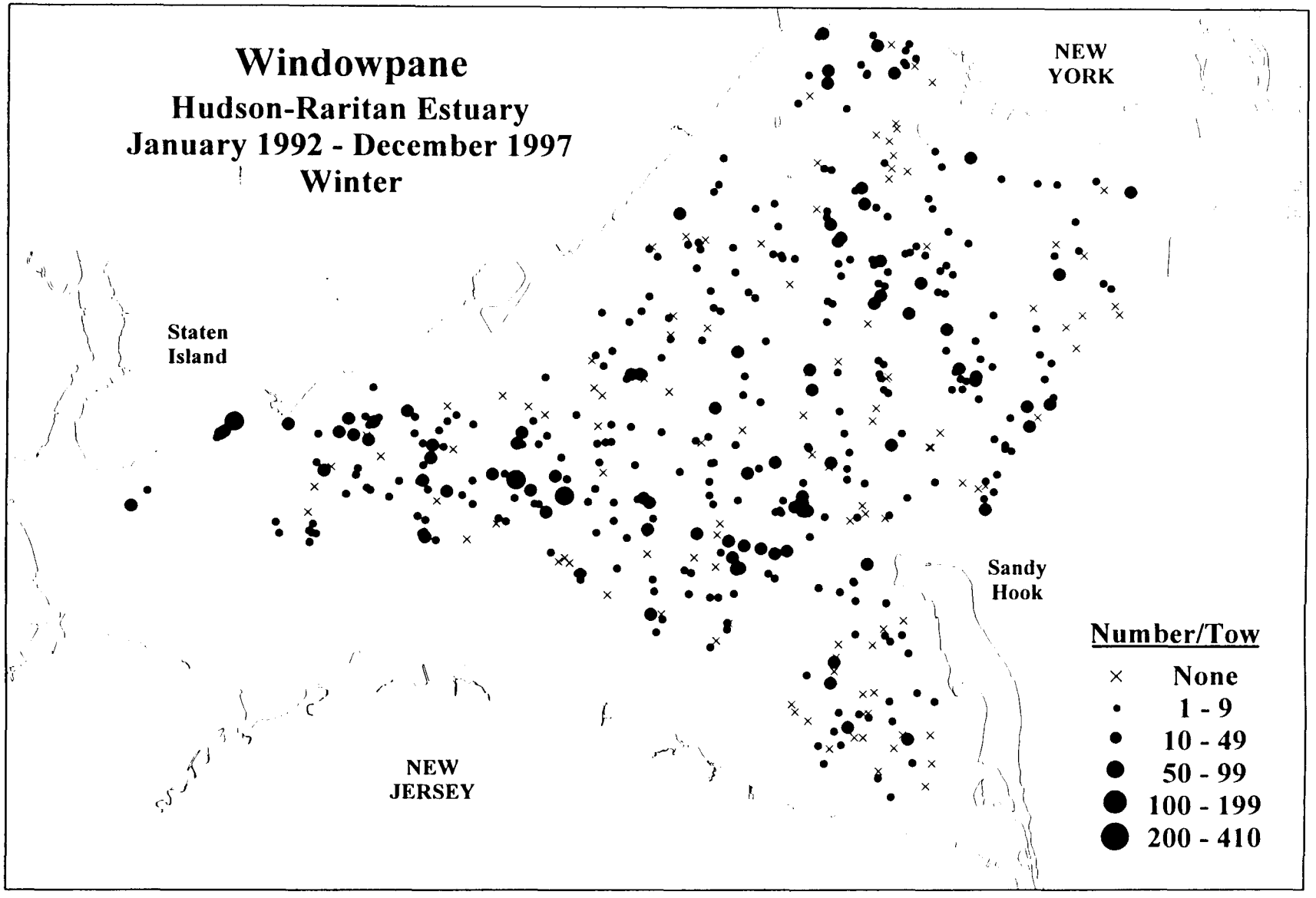

Figure 110. Distribution and abundance of all windowpane collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

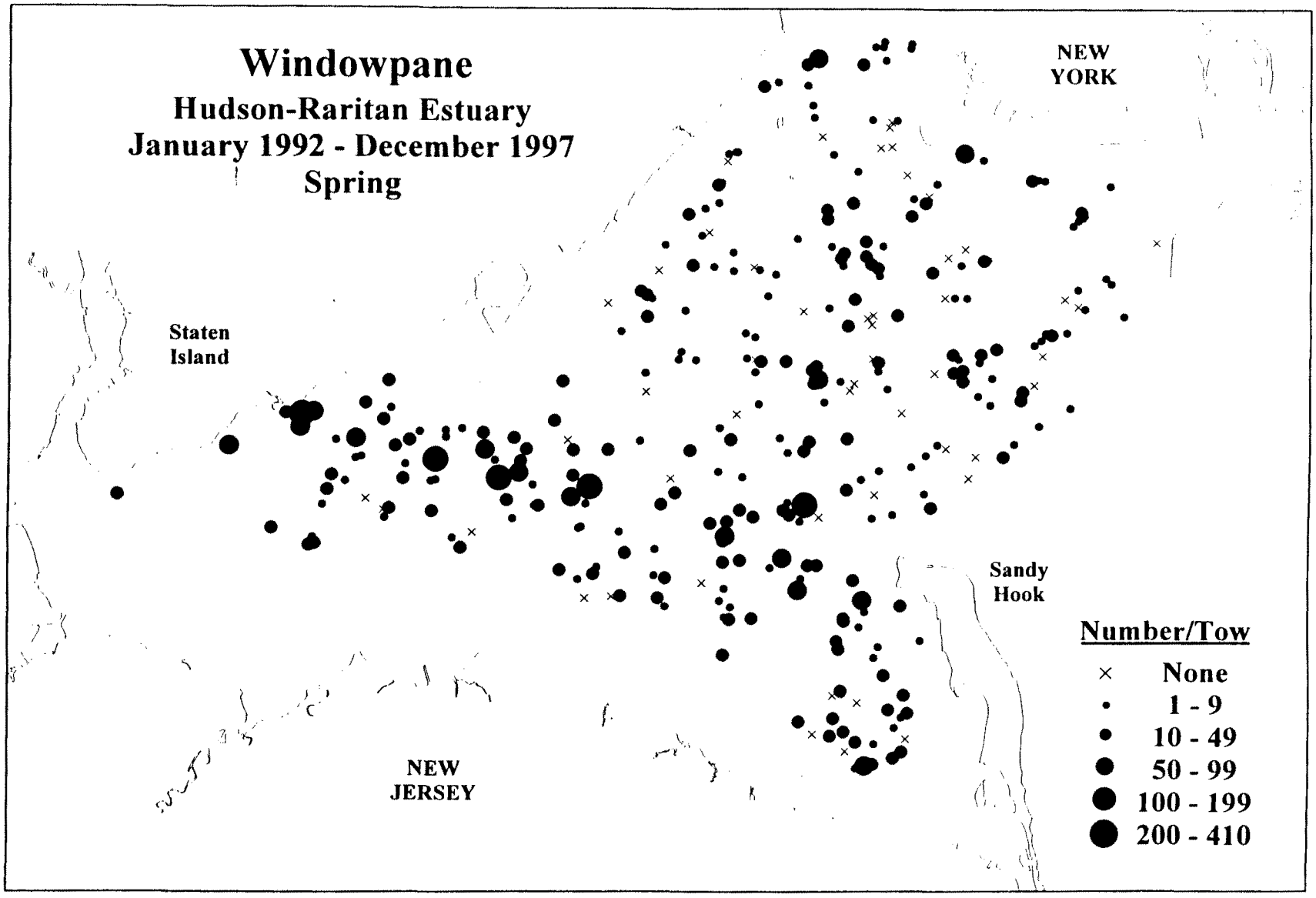

Figure 111. Distribution and abundance of windowpane collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

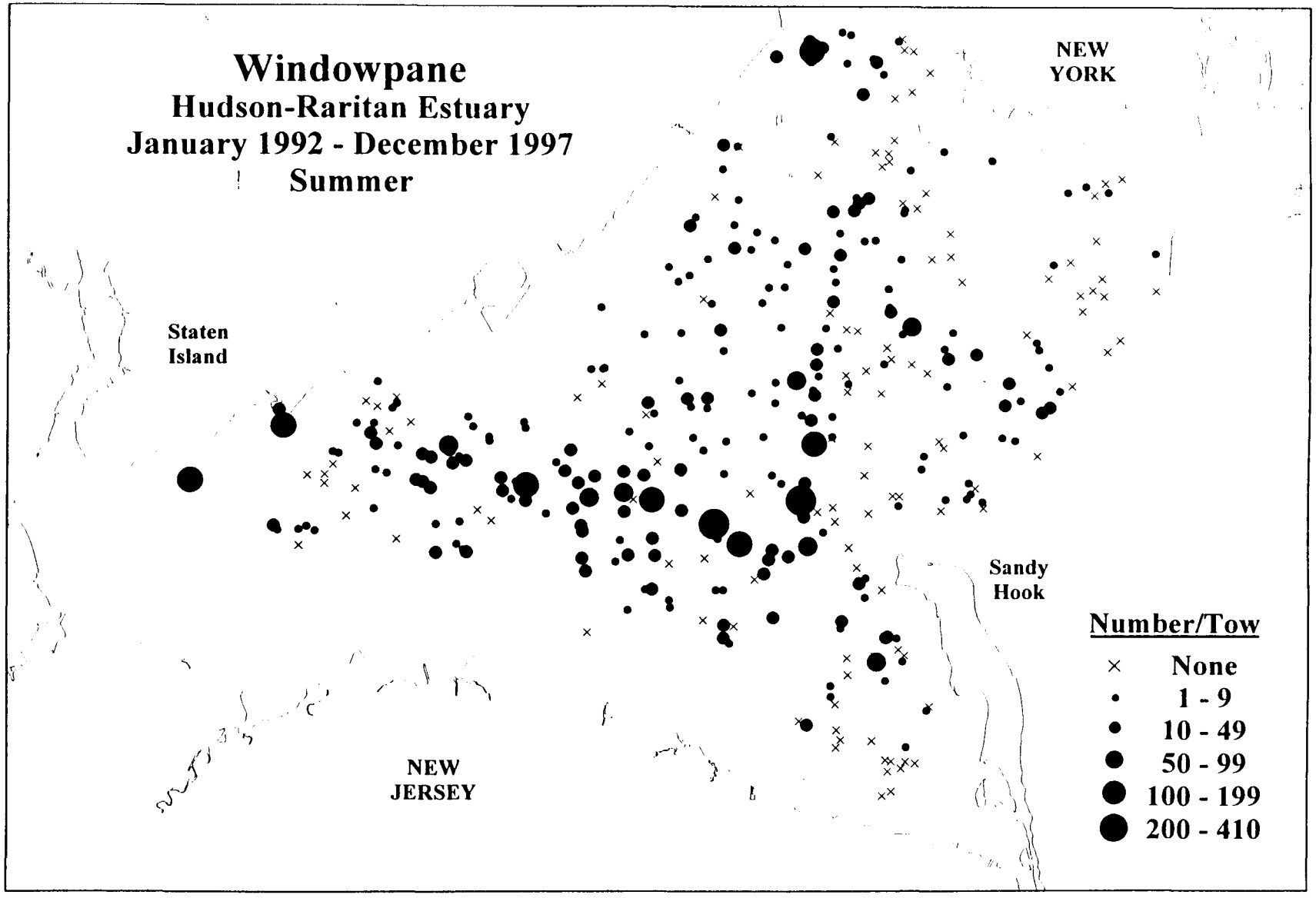

Figure 112. Distribution and abundance of windowpane collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

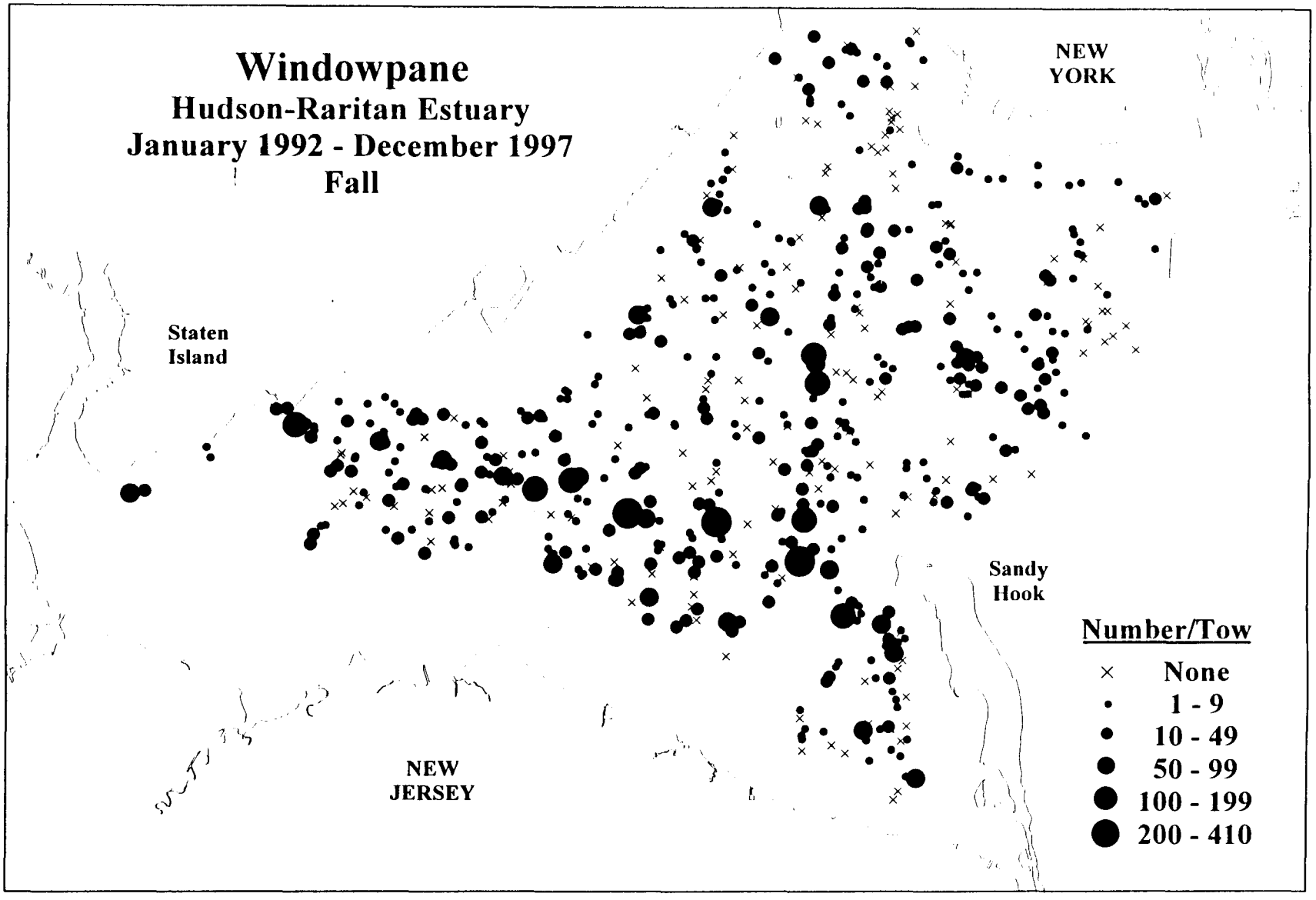

Figure 113. Distribution and abundance of windowpane collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

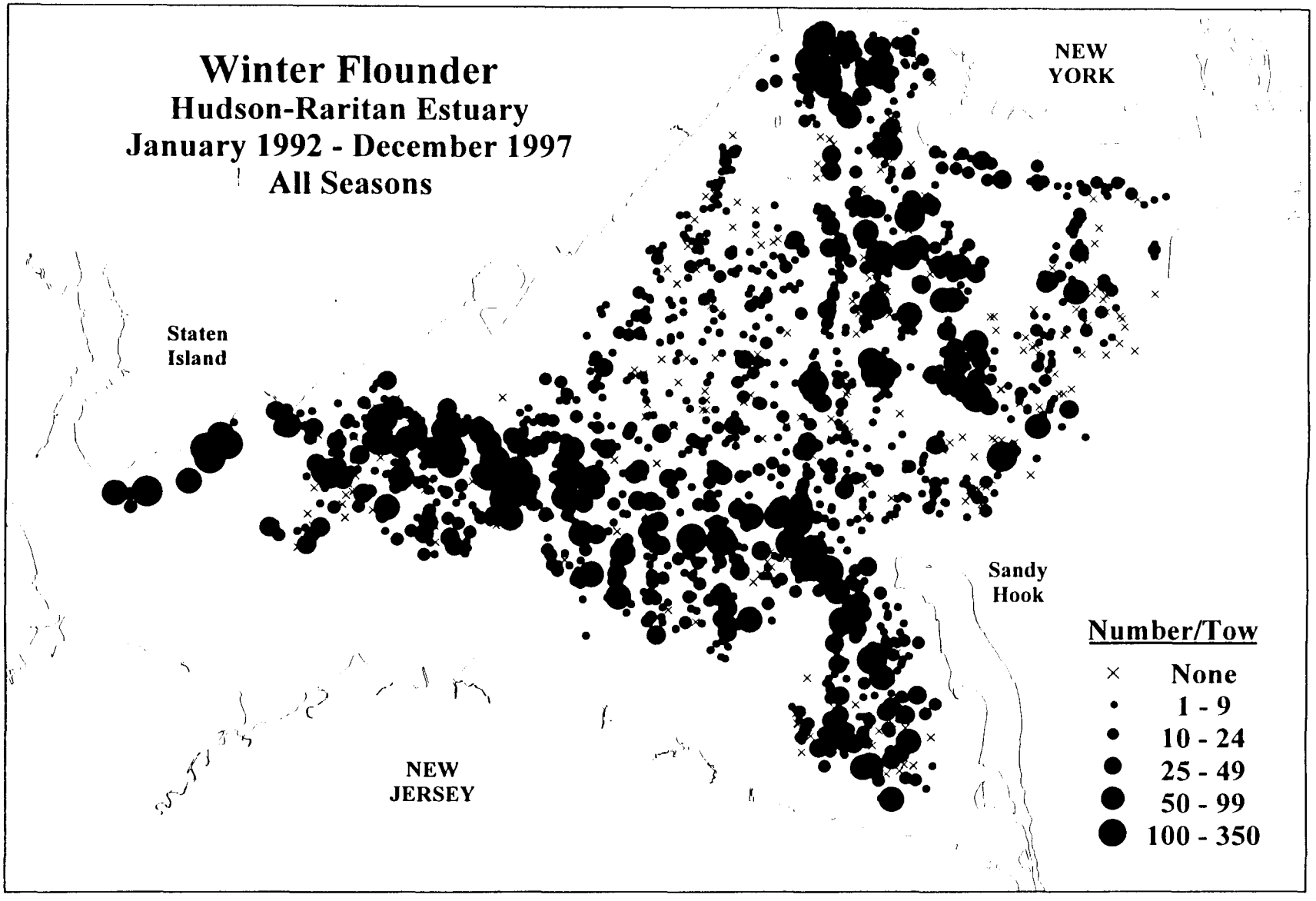

Figure 114. Distribution and abundance of all winter flounder collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

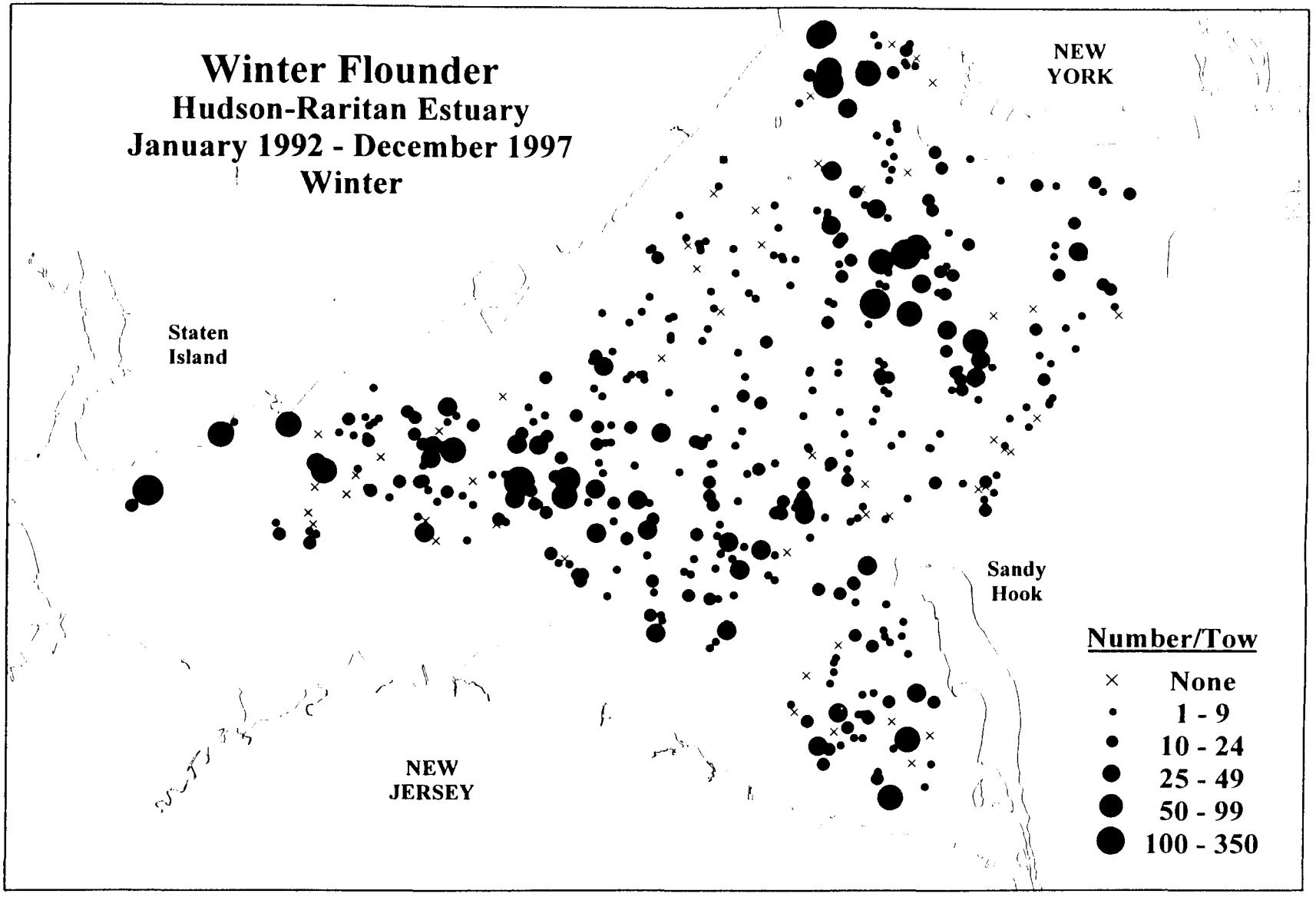

Figure 115. Distribution and abundance of all winter flounder collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

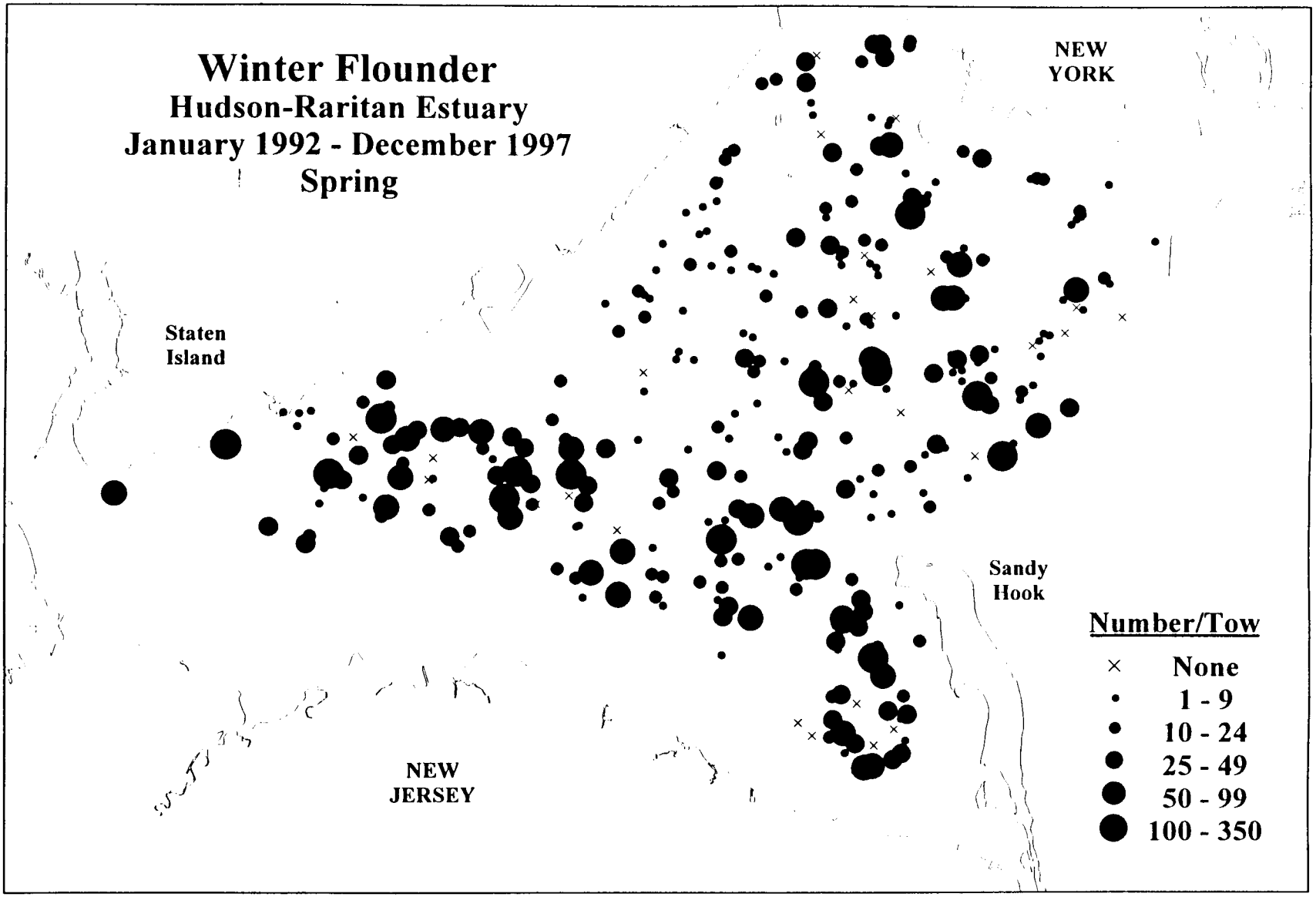

Figure 116. Distribution and abundance of winter flounder collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

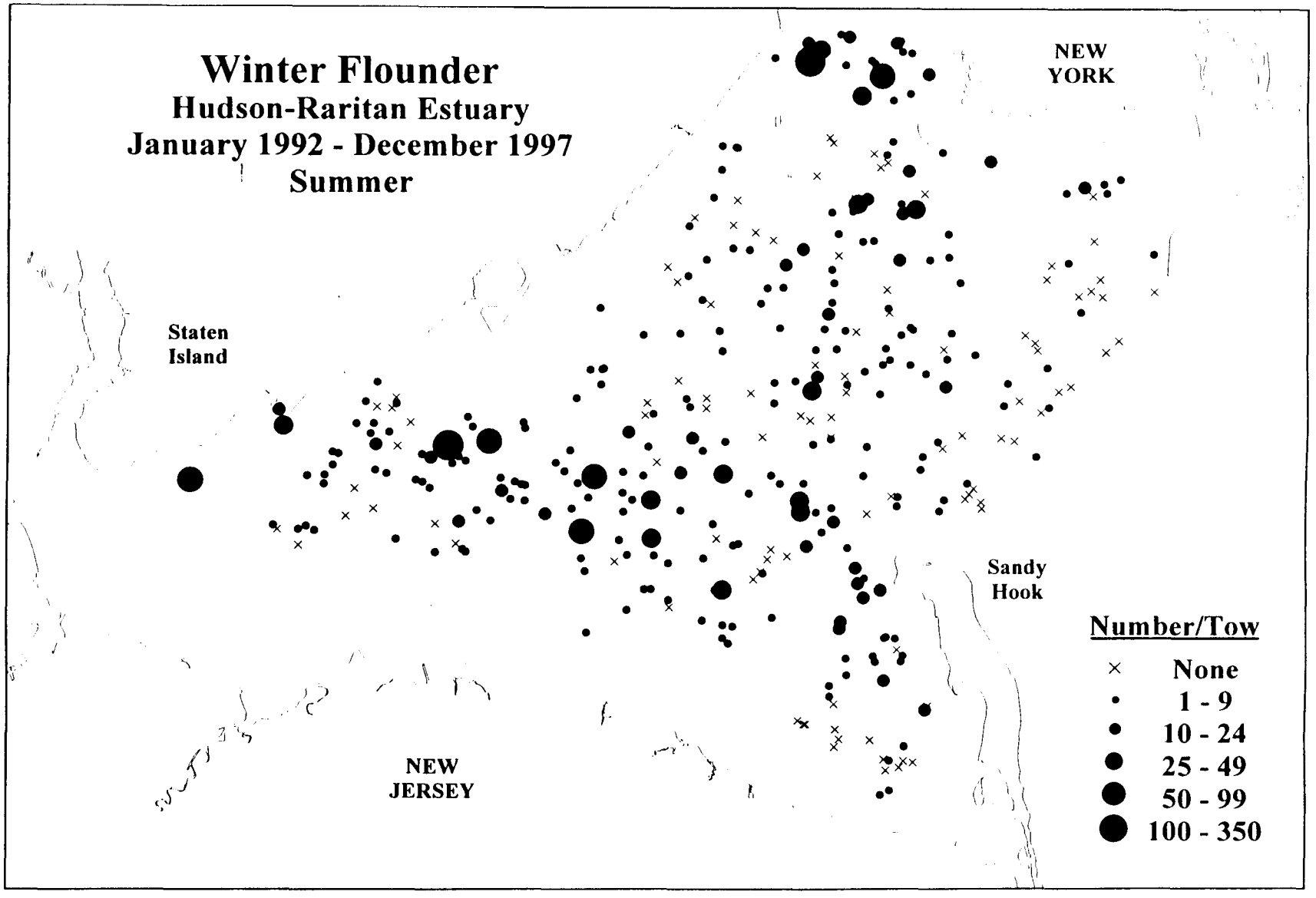

Figure 117. Distribution and abundance of winter flounder collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

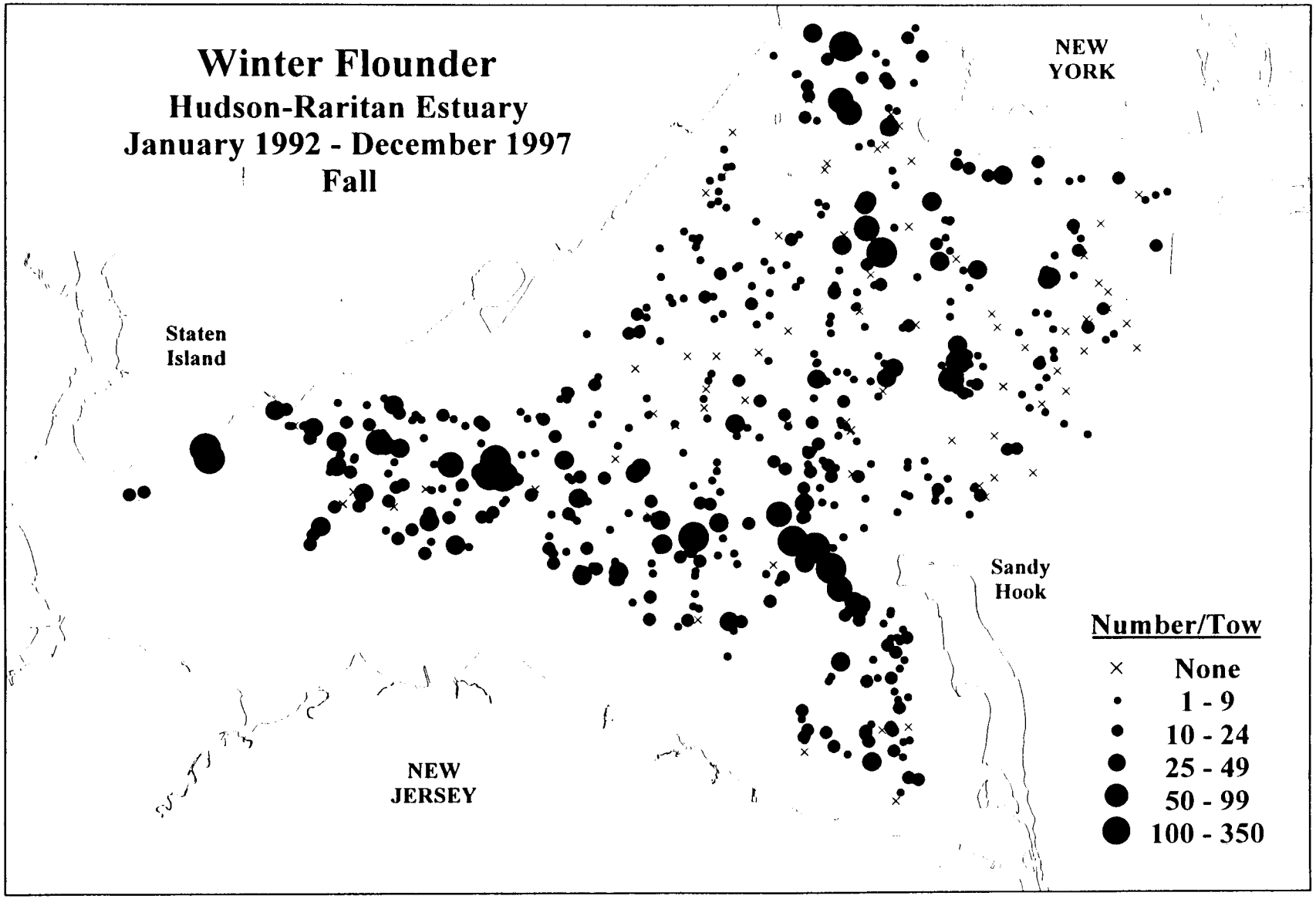

Figure 118. Distribution and abundance of winter flounder collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

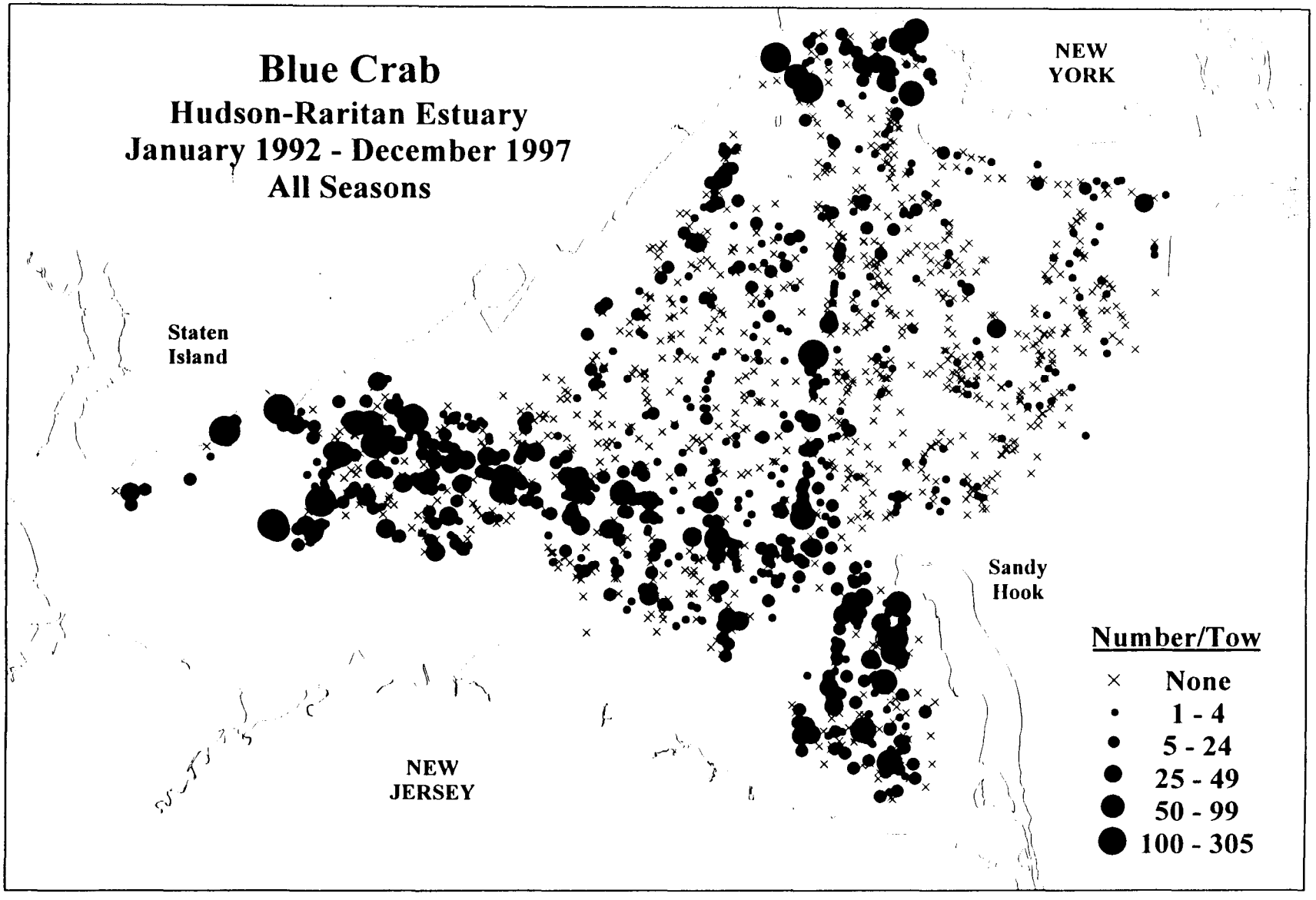

Figure 119. Distribution and abundance of all blue crab collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

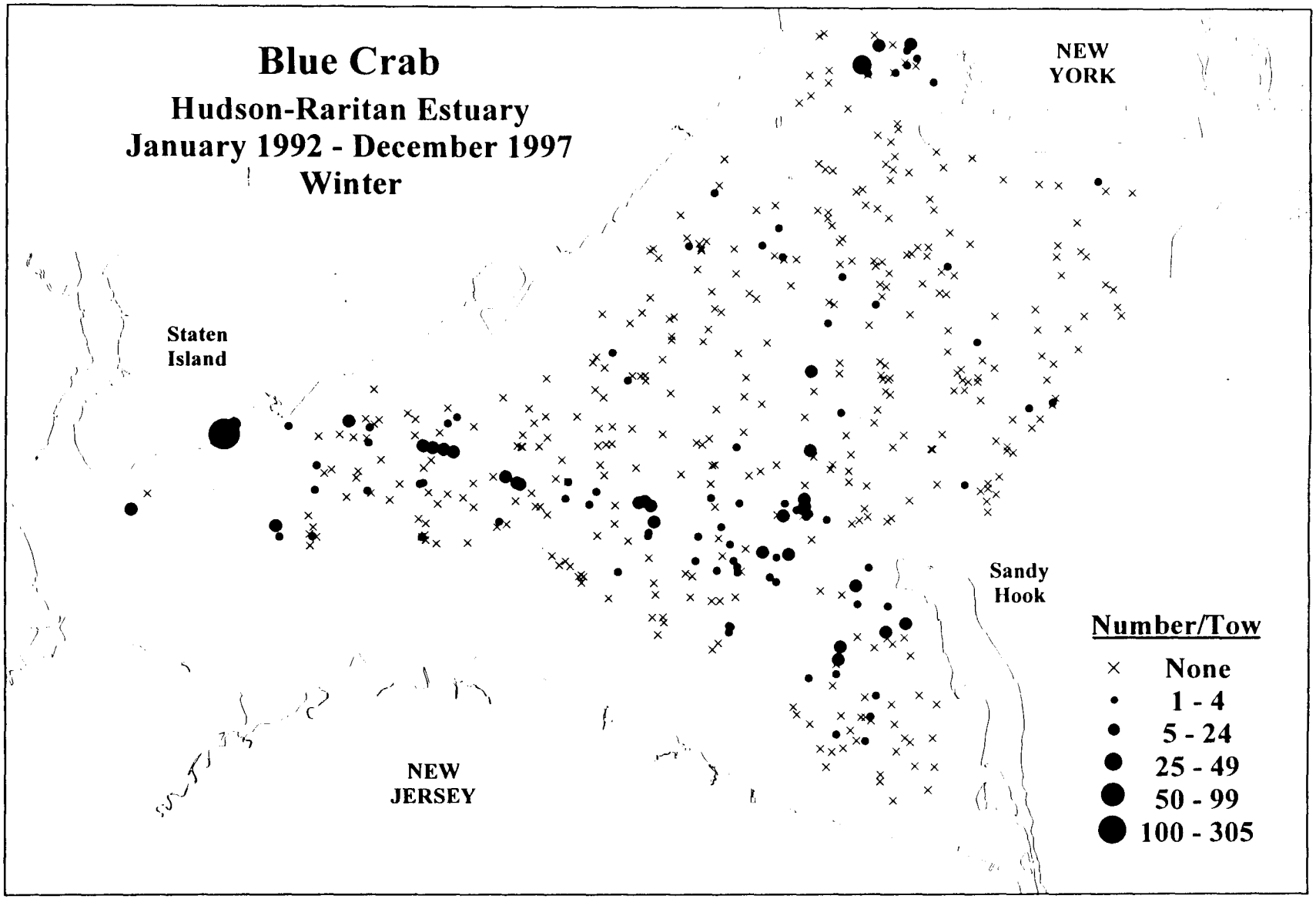

Figure 120. Distribution and abundance of all blue crab collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

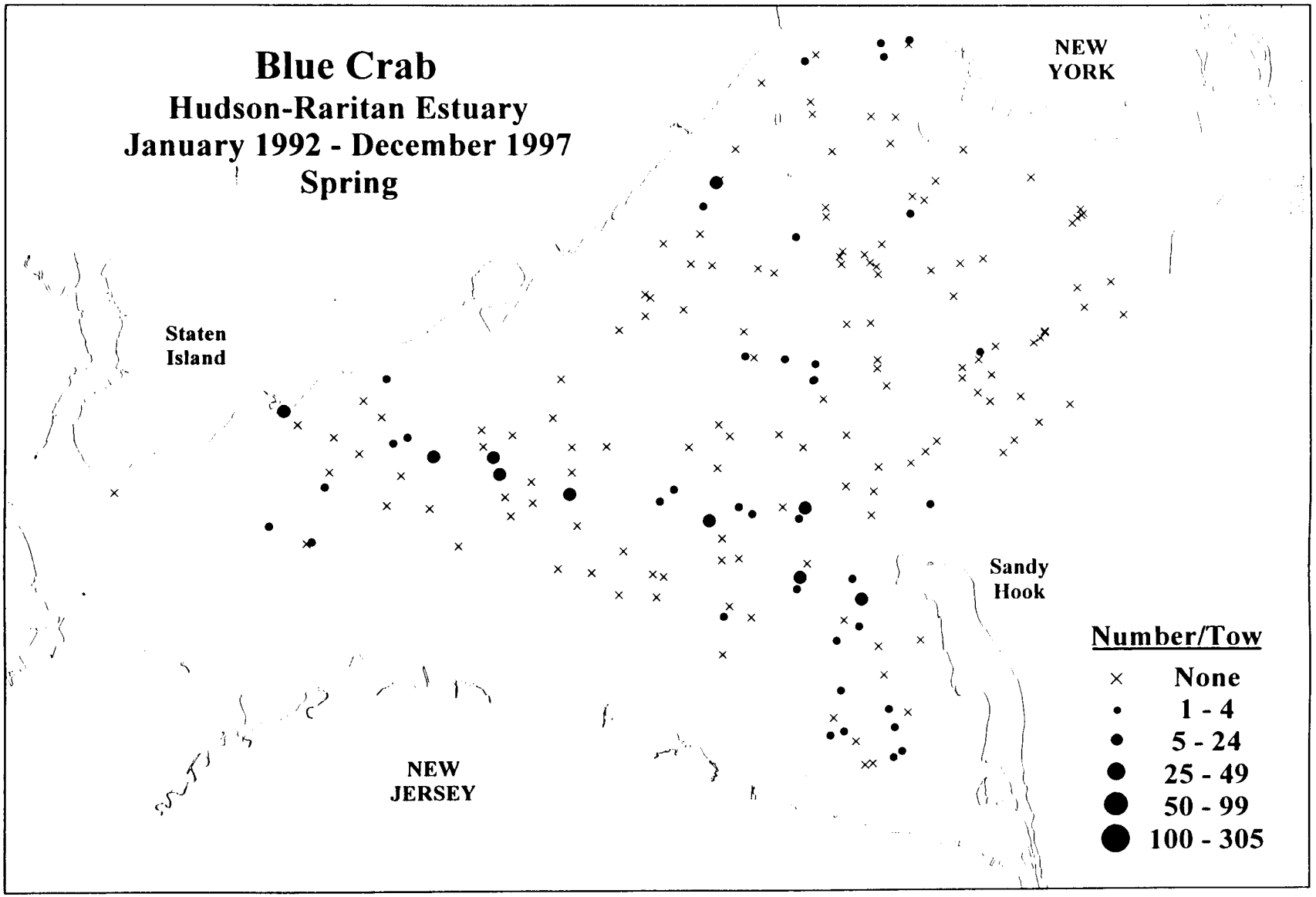

Figure 121. Distribution and abundance of blue crab collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

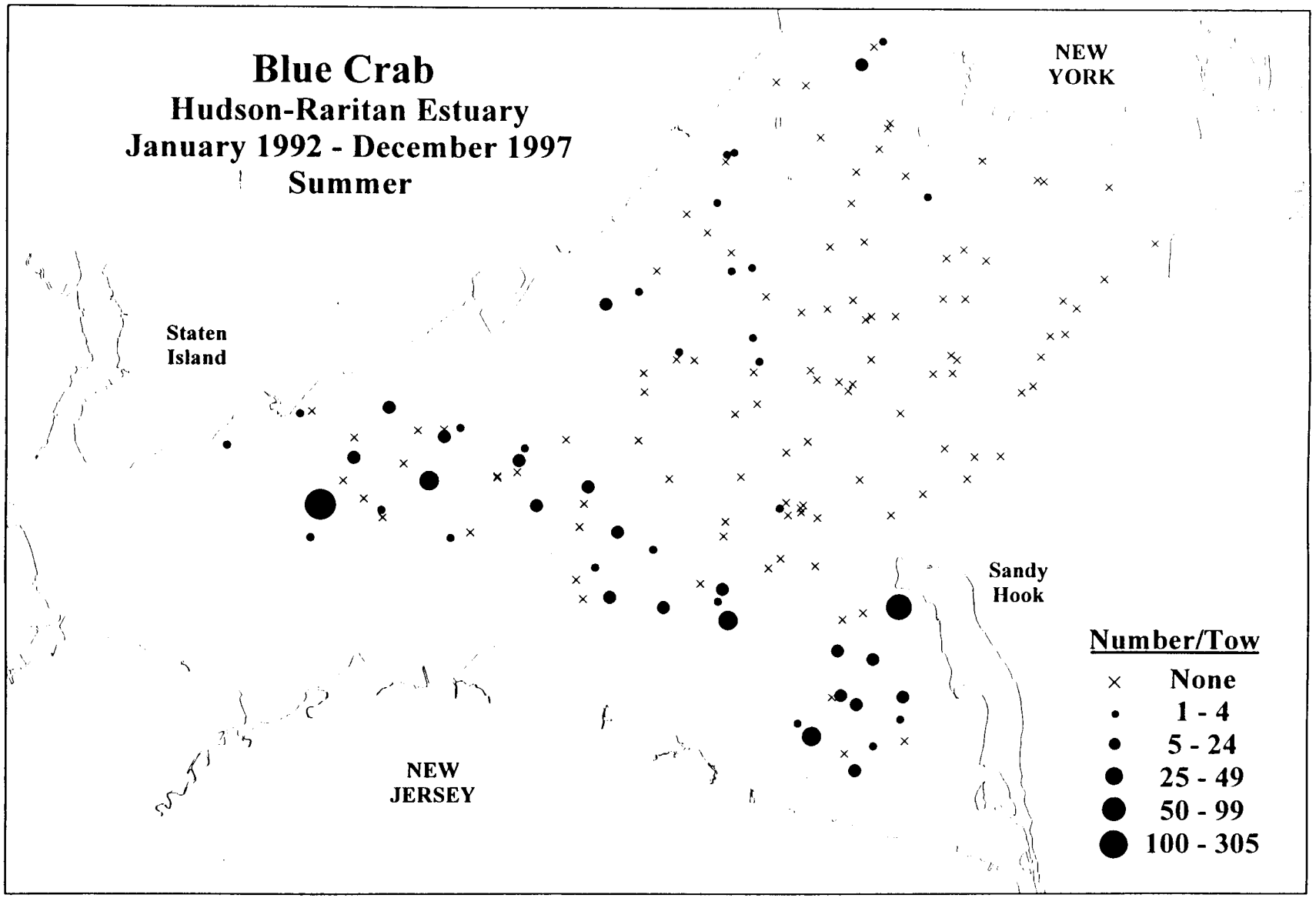

Figure 122. Distribution and abundance of blue crab collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

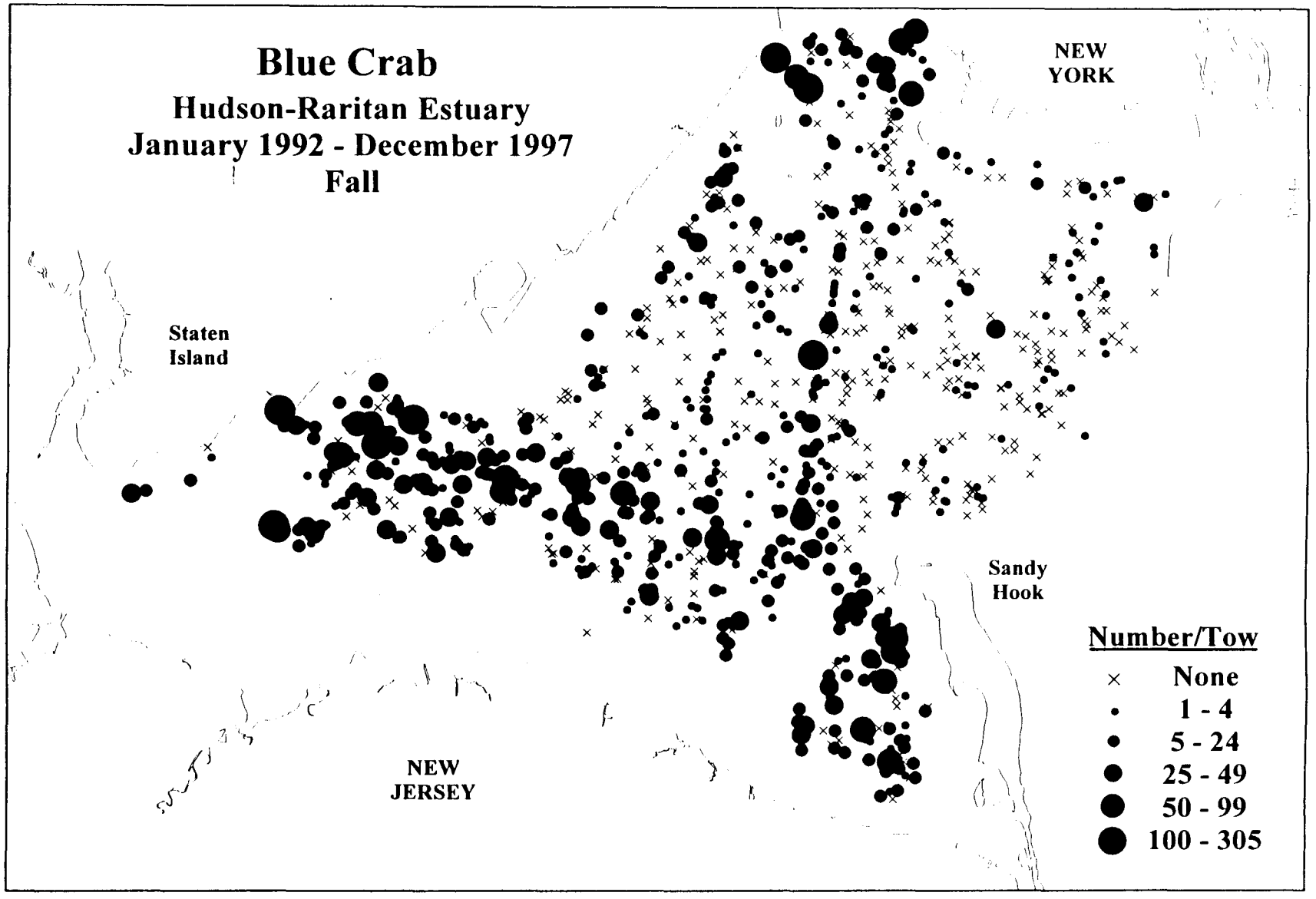

Figure 123. Distribution and abundance of blue crab collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

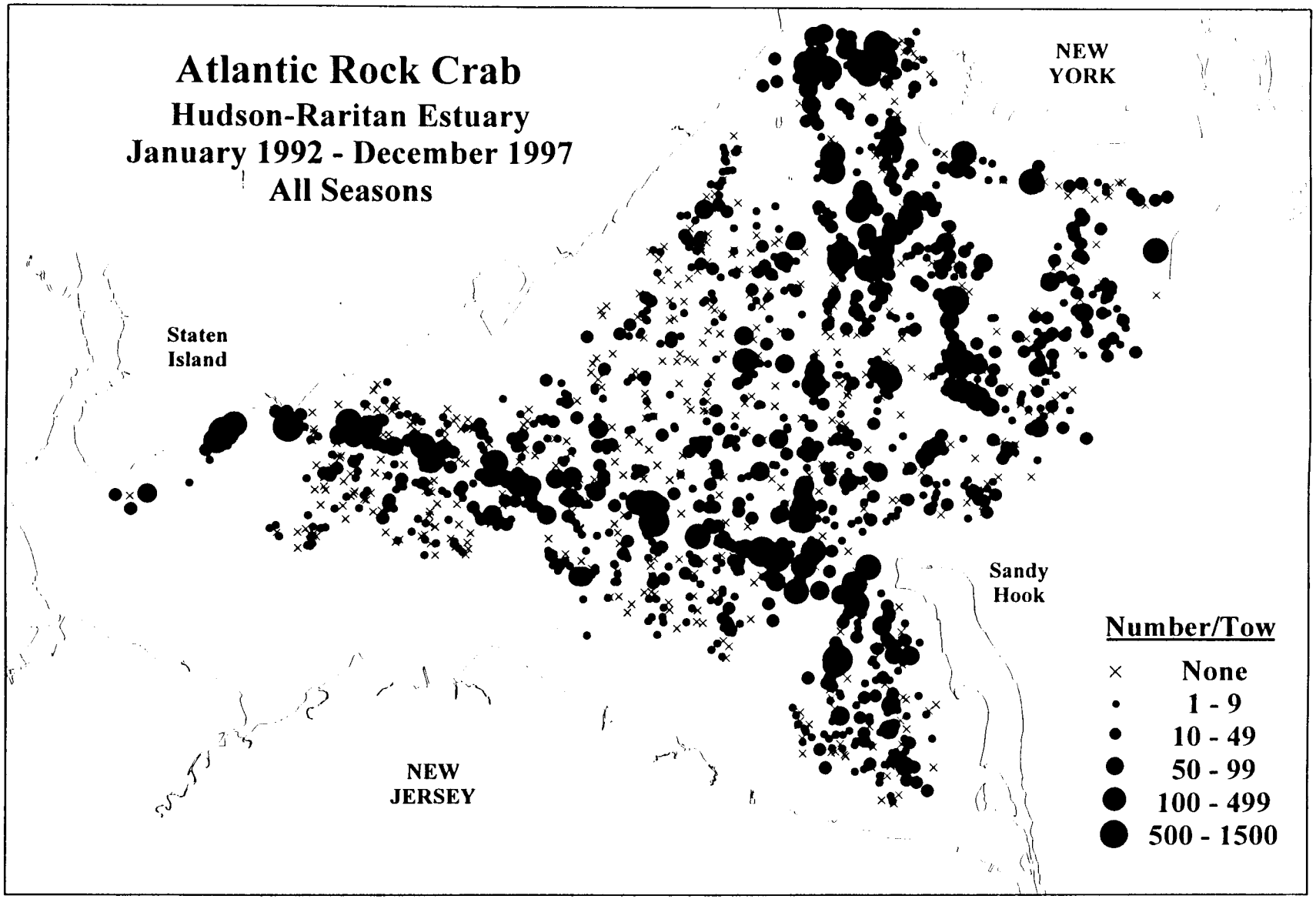

Figure 124. Distribution and abundance of all Atlantic rock crab collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

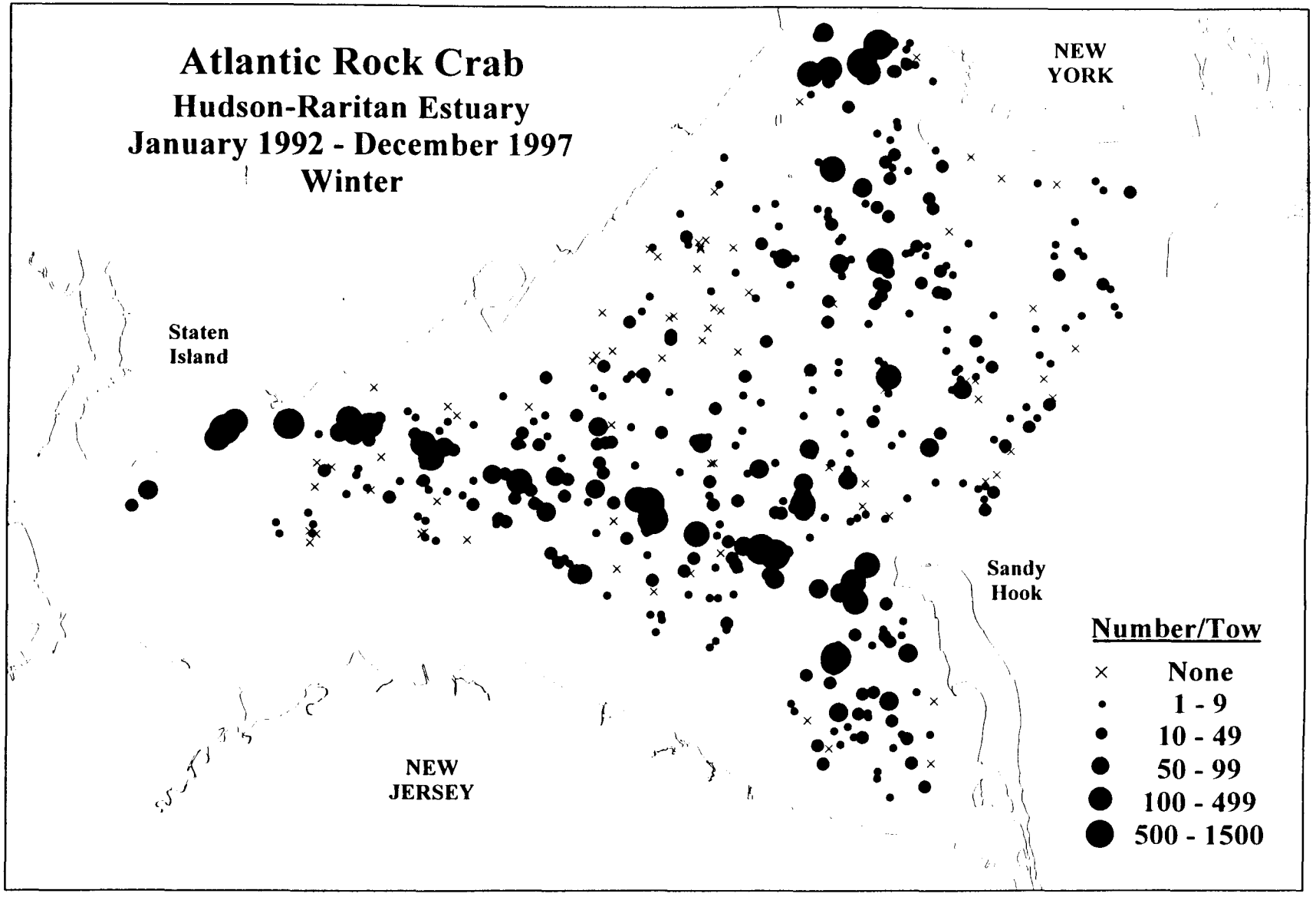

Figure 125. Distribution and abundance of all Atlantic rock crab collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

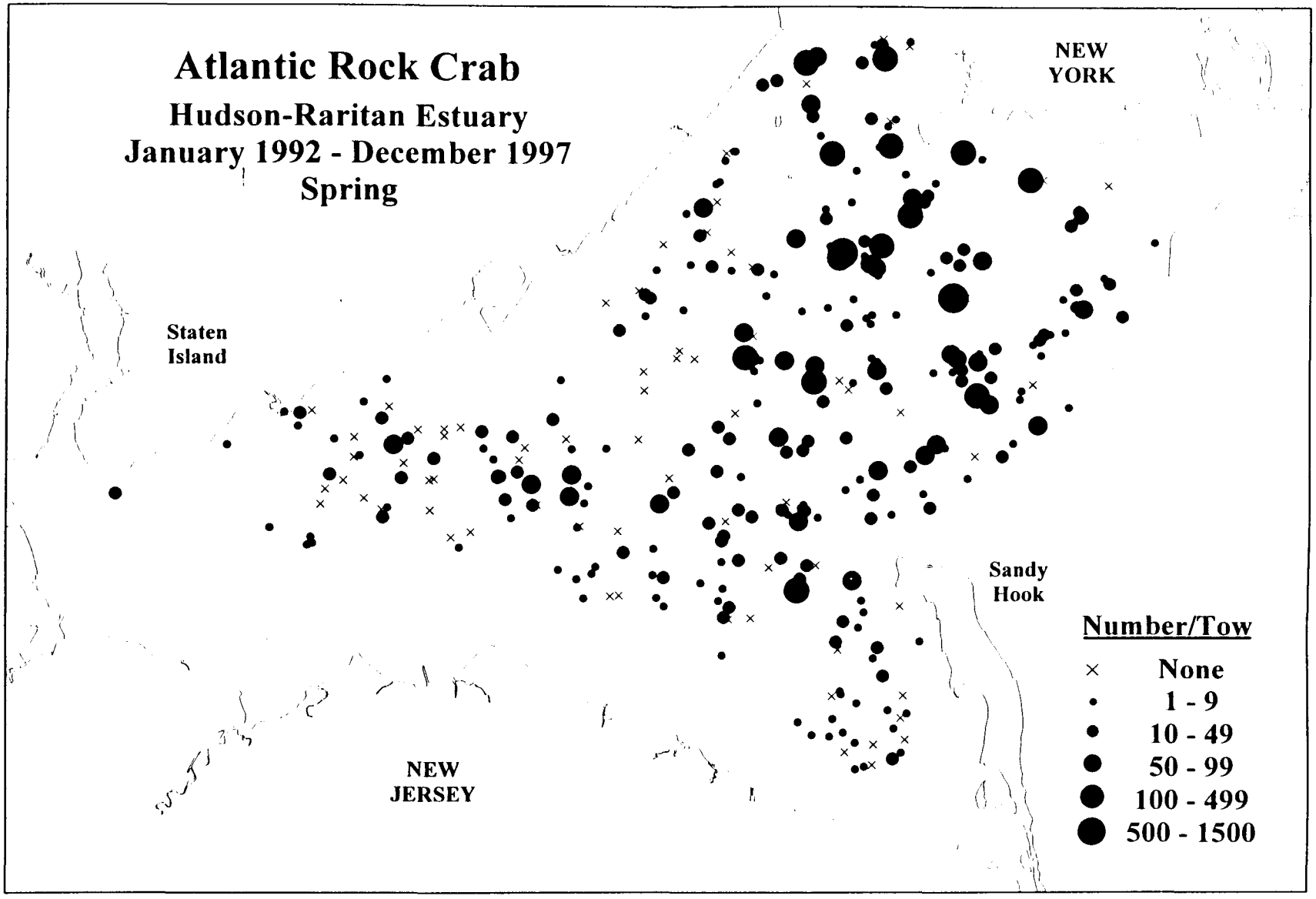

Figure 126. Distribution and abundance of Atlantic rock crab collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

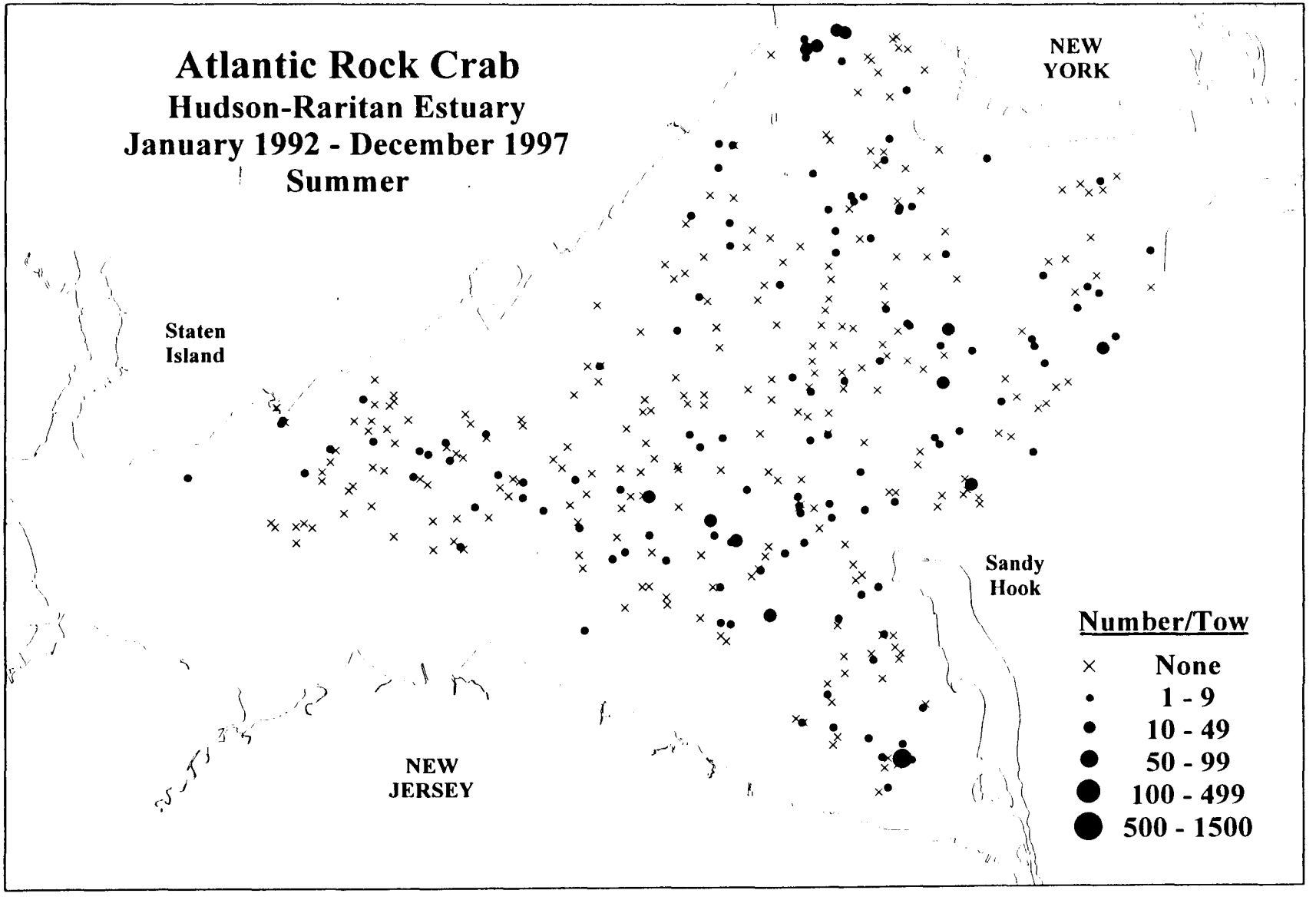

Figure 127. Distribution and abundance of Atlantic rock crab collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

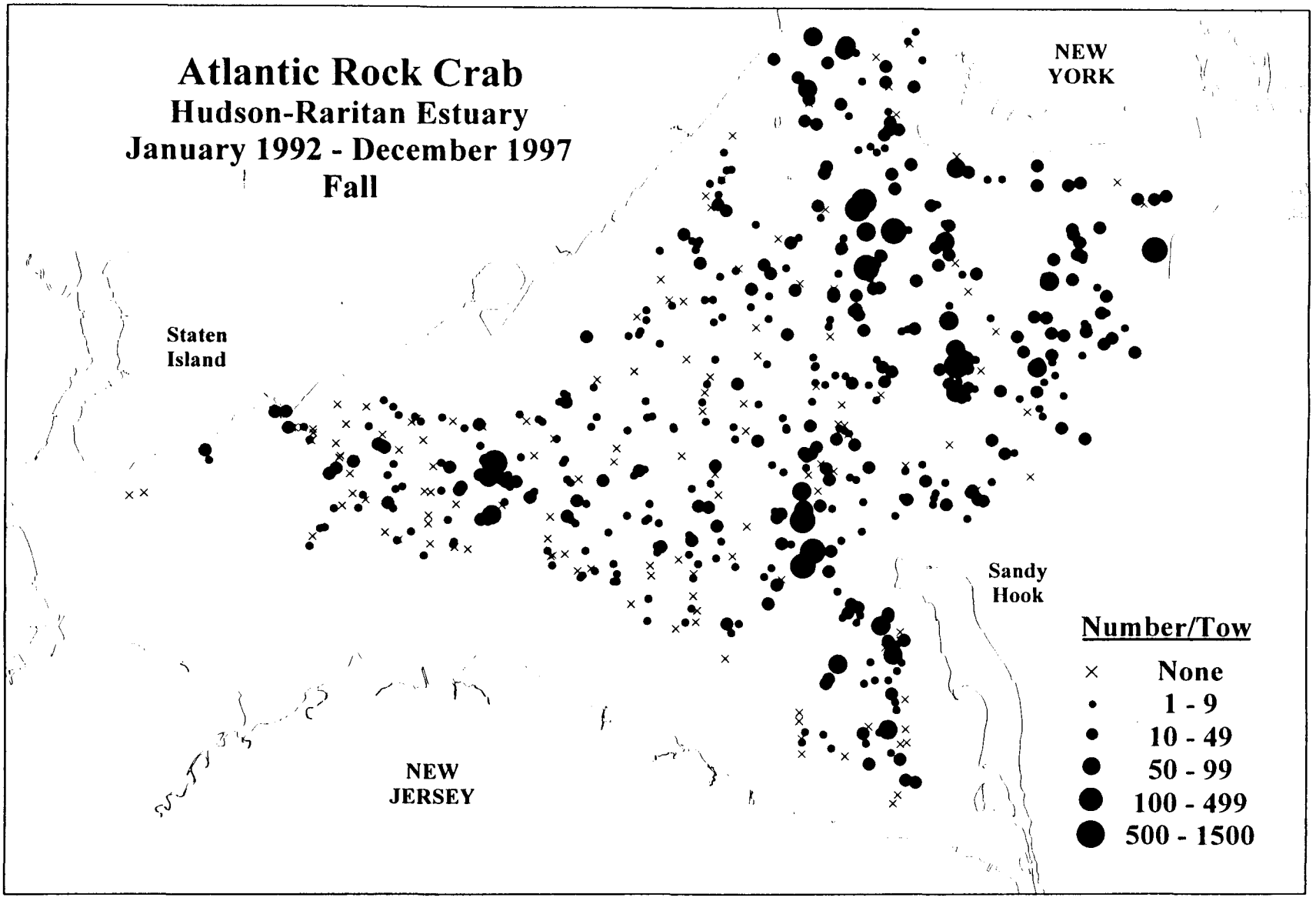

Figure 128. Distribution and abundance of Atlantic rock crab collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

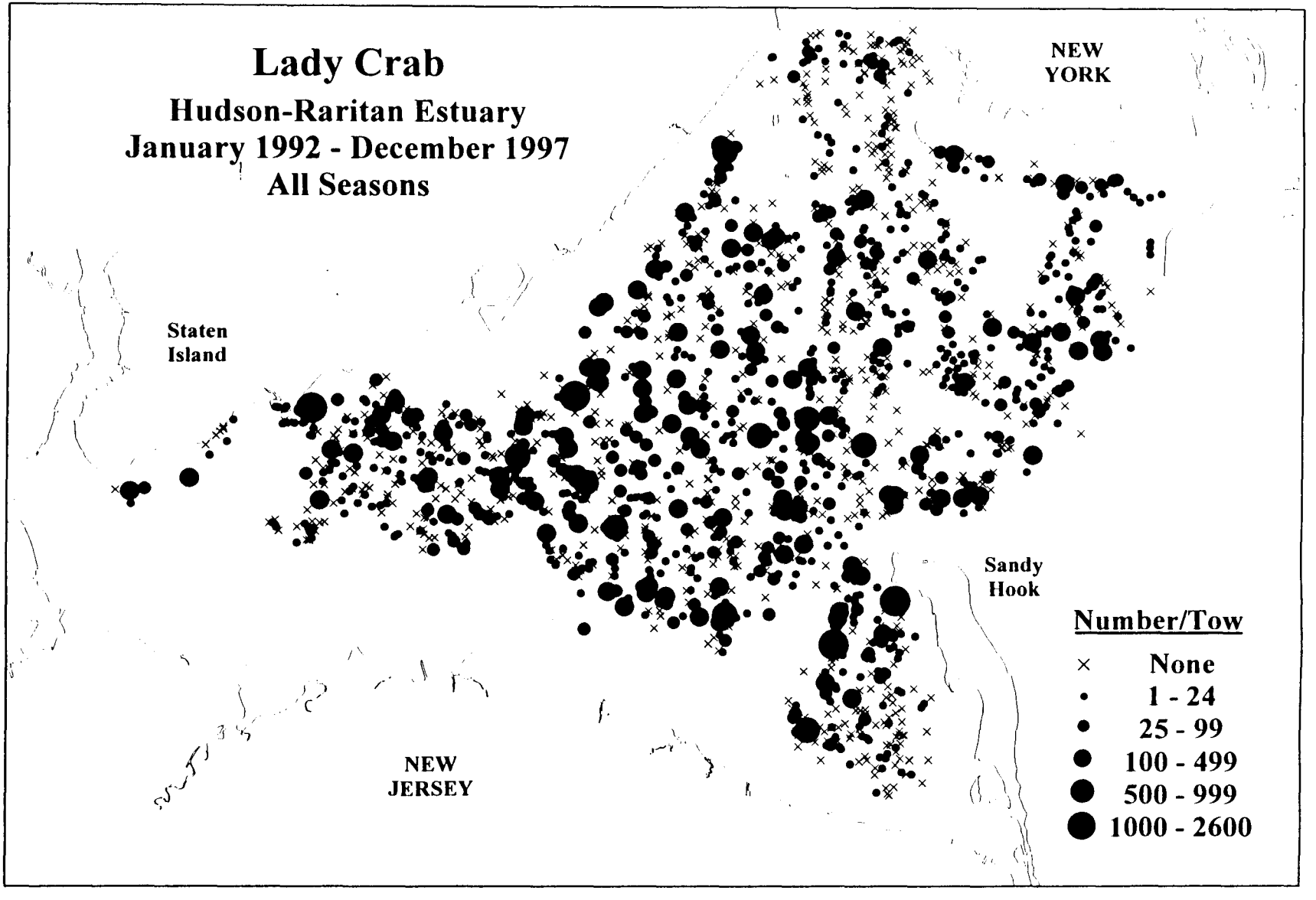

Figure 129. Distribution and abundance of all lady crab collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

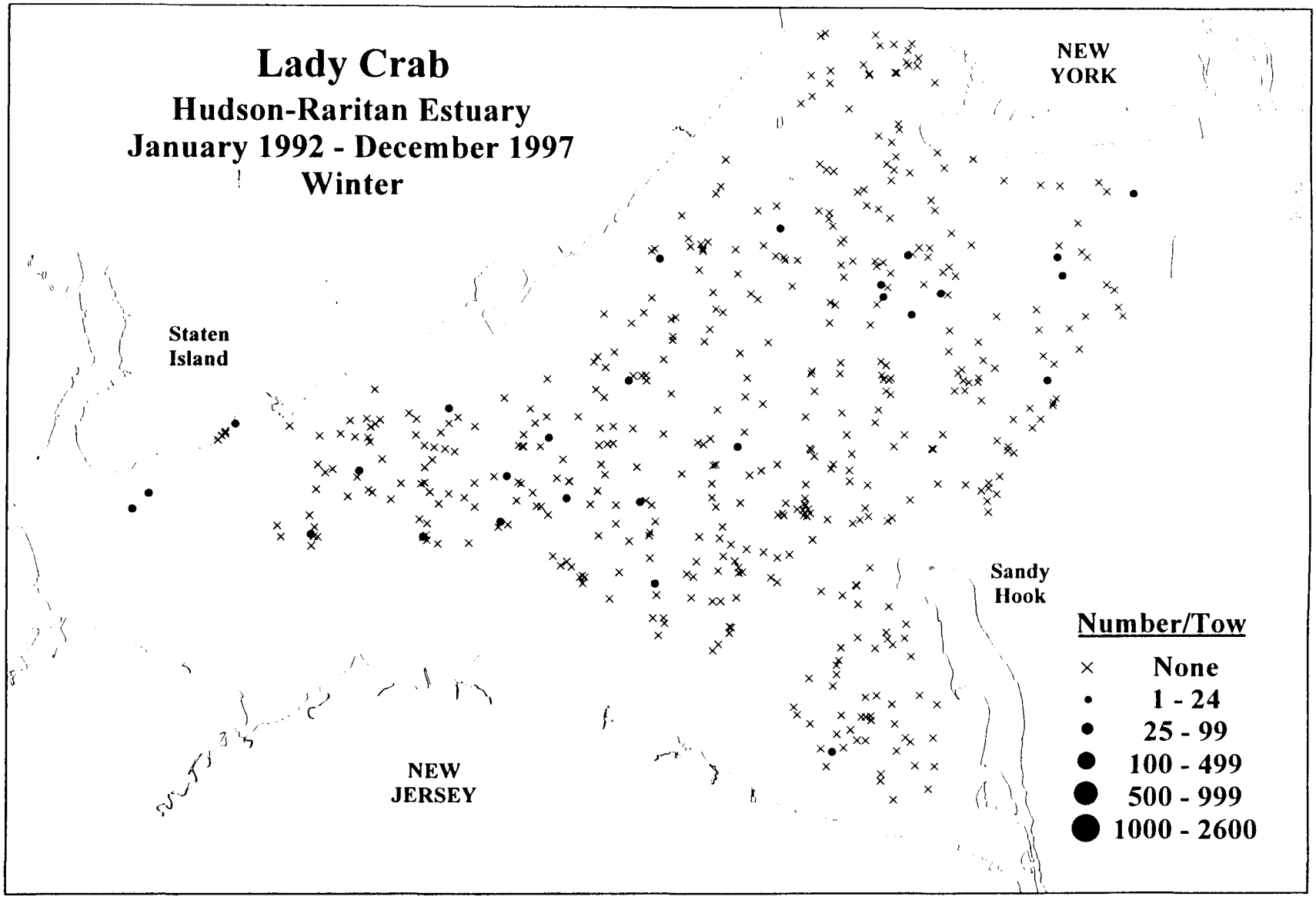

Figure 130. Distribution and abundance of all lady crab collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

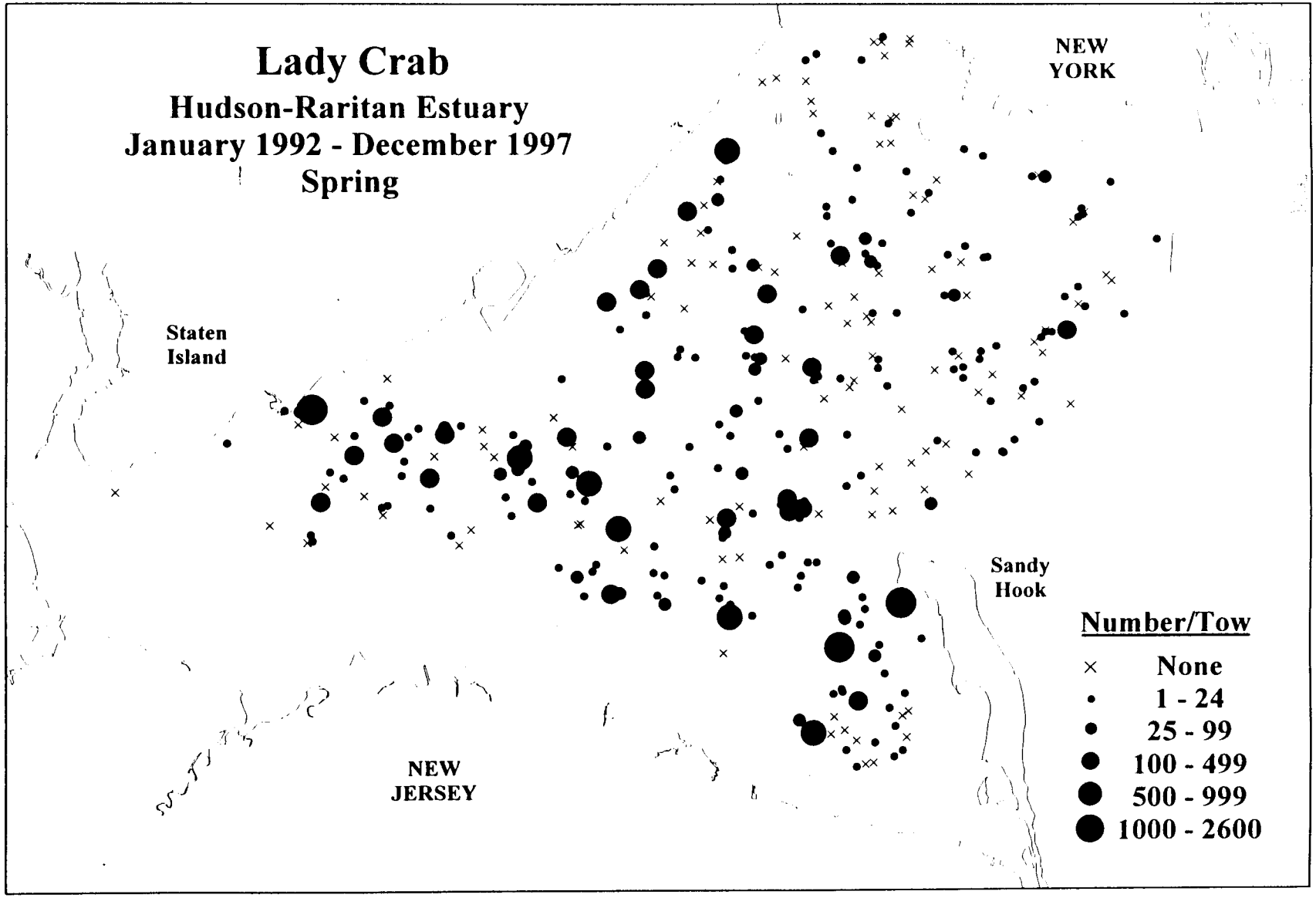

Figure 131. Distribution and abundance of lady crab collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

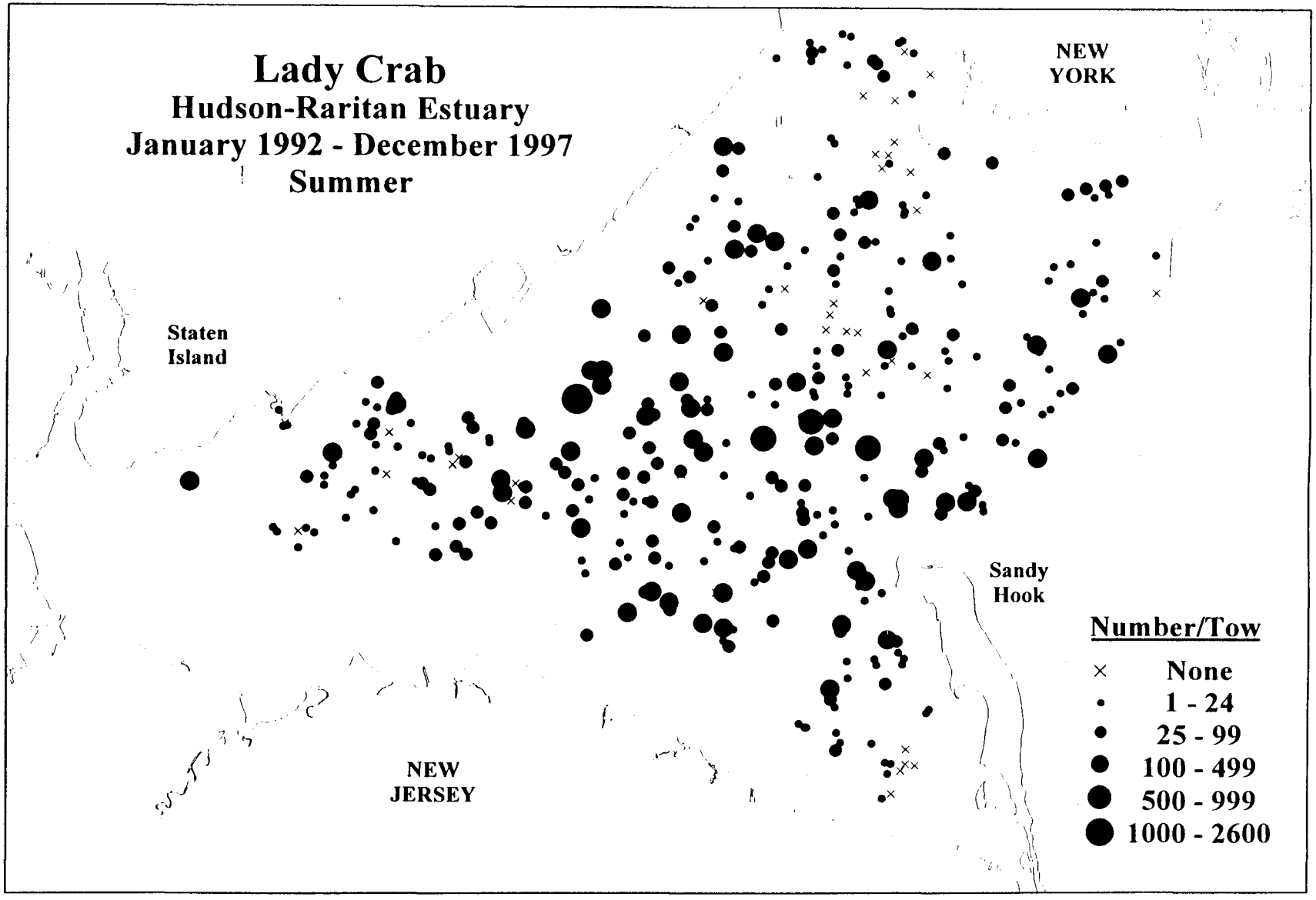

Figure 132. Distribution and abundance of lady crab collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

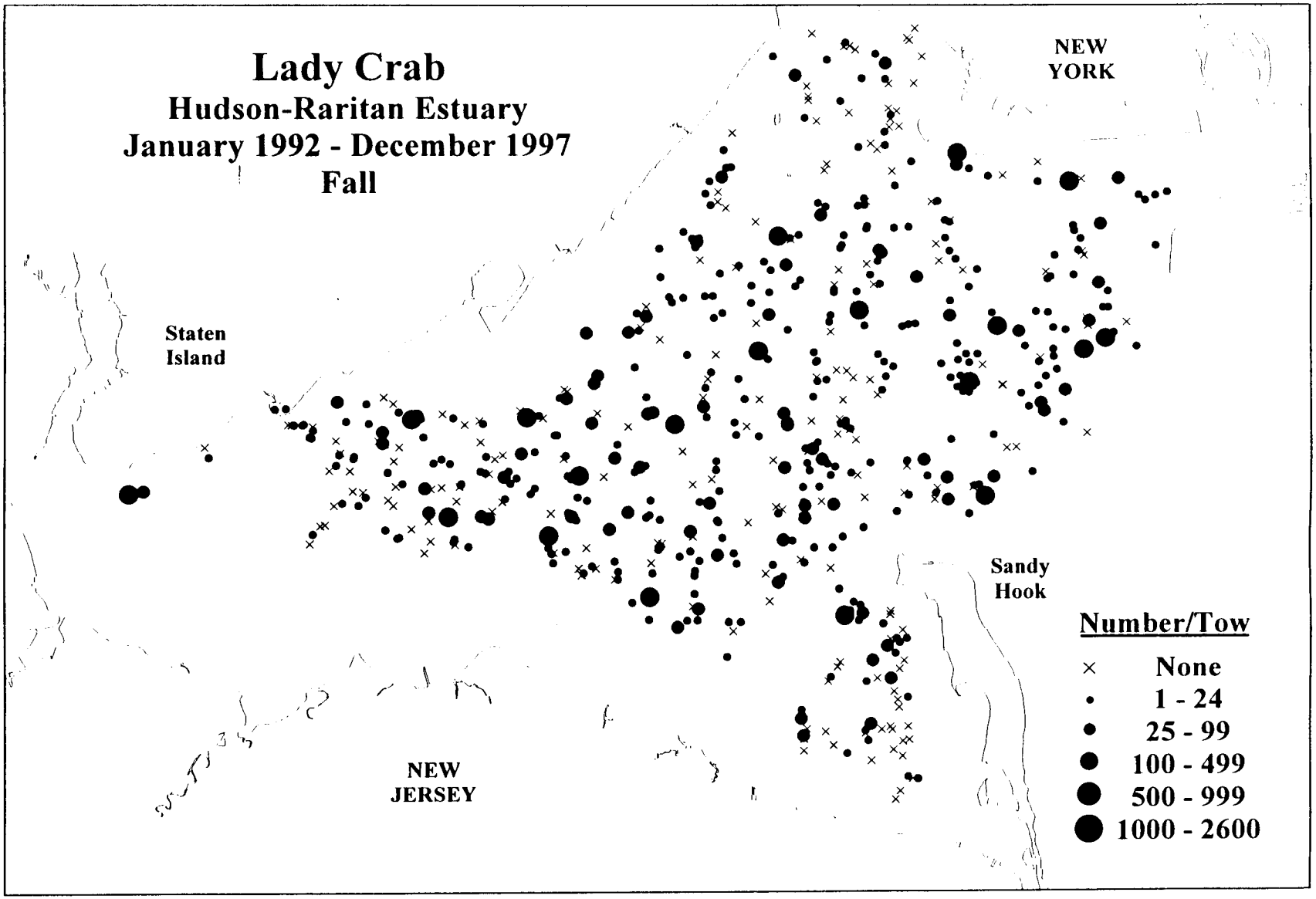

Figure 133. Distribution and abundance of lady crab collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.

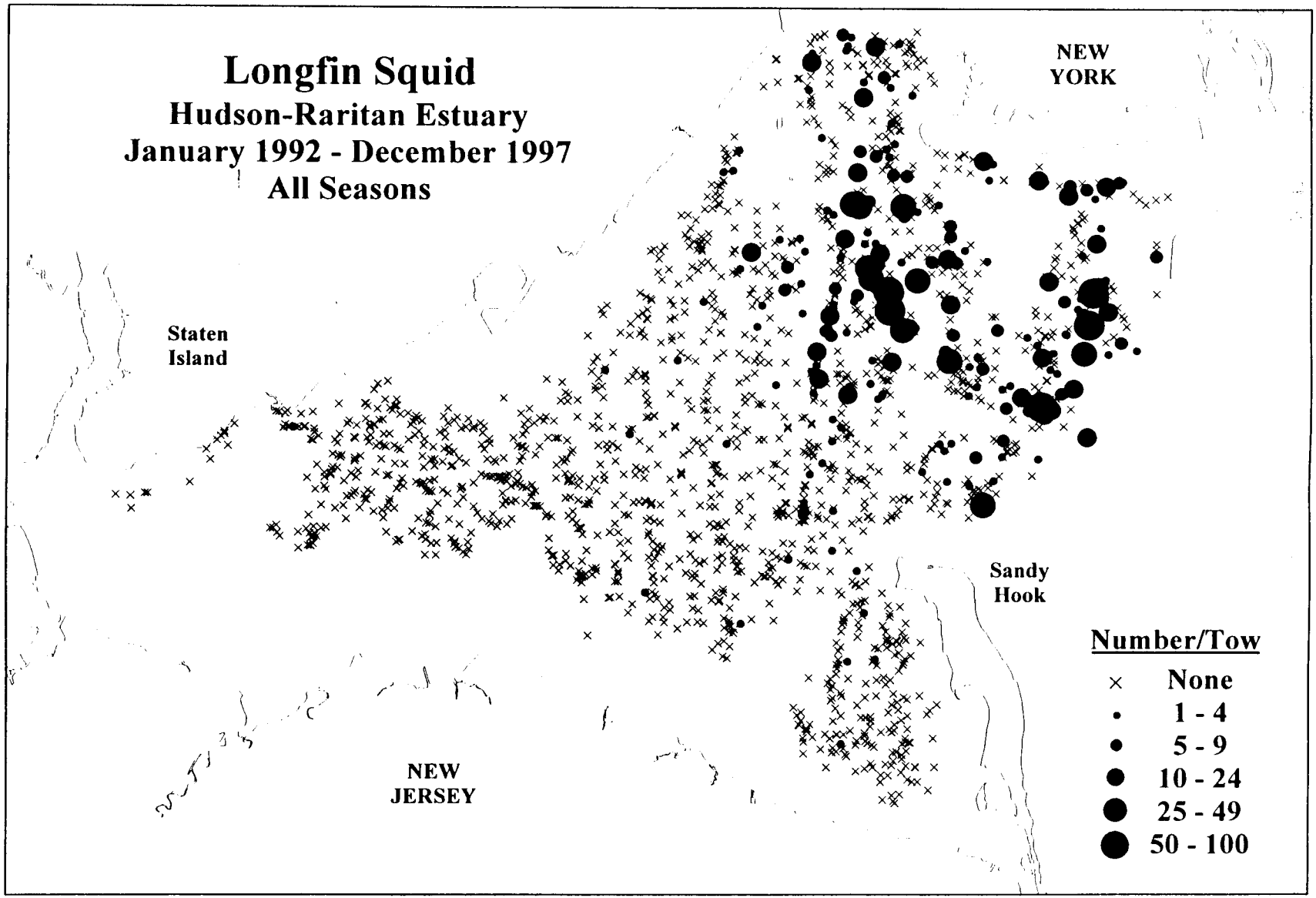

Figure 134. Distribution and abundance of all longfin squid collected in the Hudson-Raritan Estuary between January 1992 and December 1997.

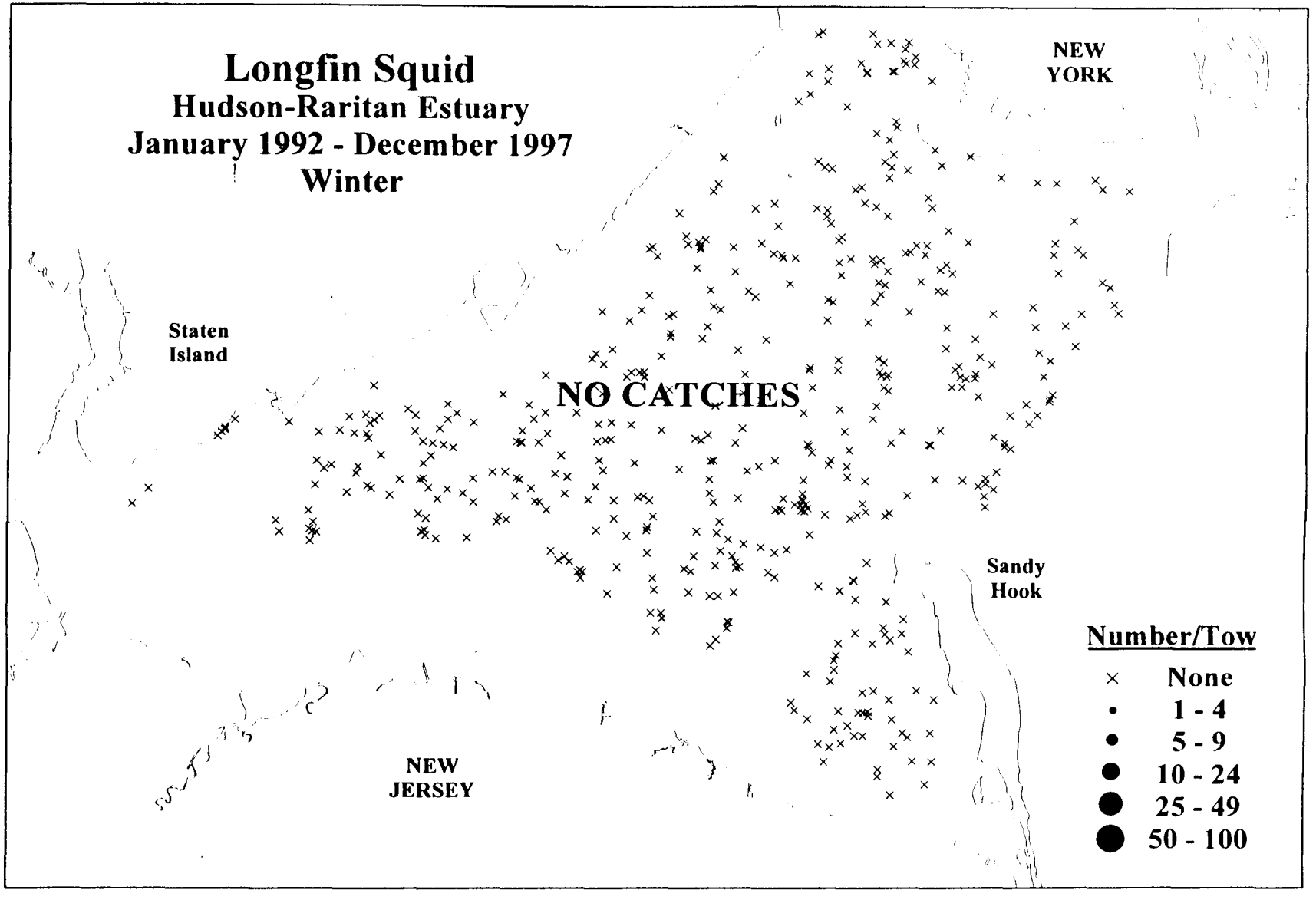

Figure 135. Distribution and abundance of all longfin squid collected during the Winter (January, February, and March) in the Hudson-Raritan Estuary between January 1992 and December 1997.

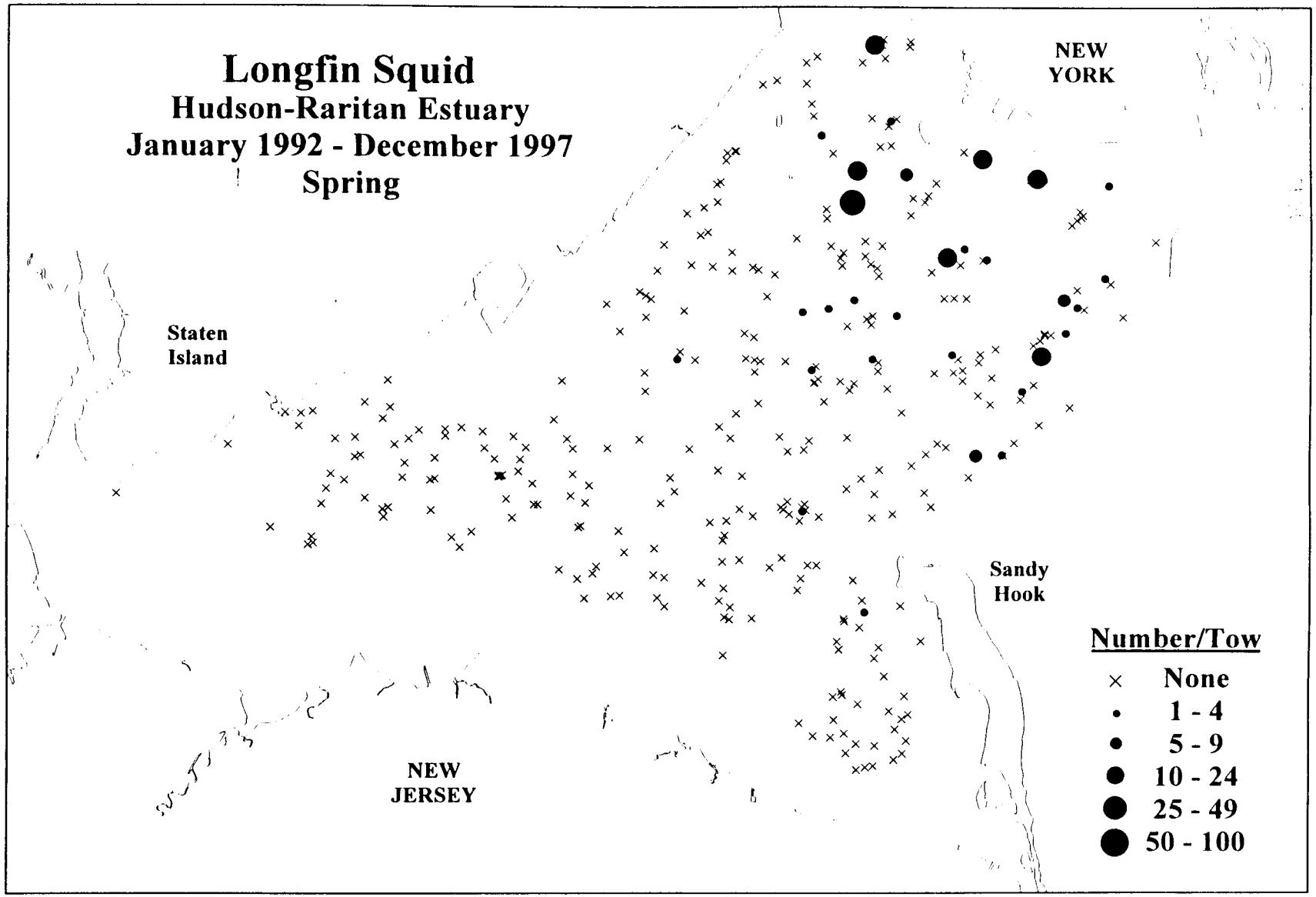

Figure 136. Distribution and abundance of longfin squid collected during the Spring (April and June) in the Hudson-Raritan Estuary between January 1992 and December 1997.

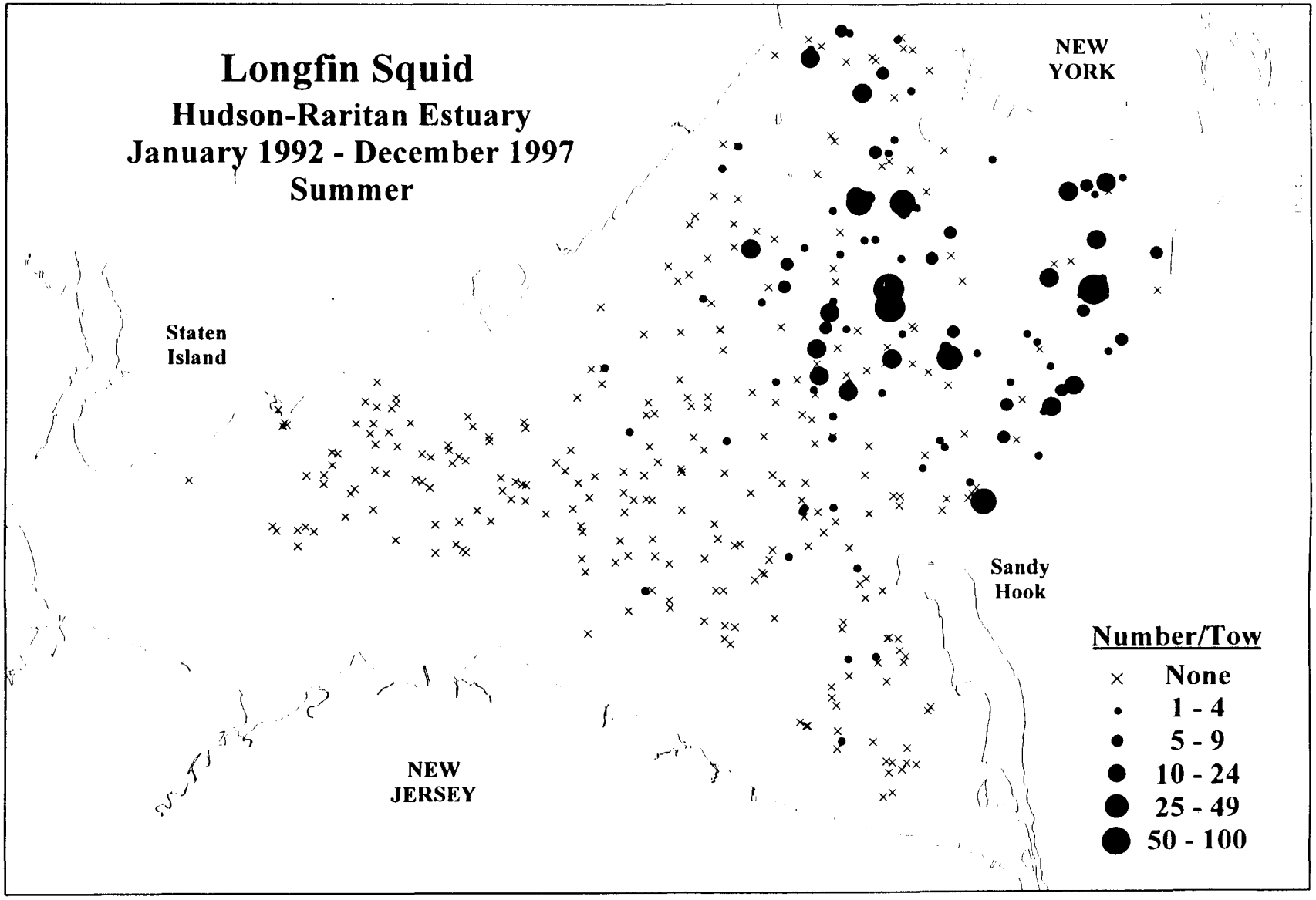

Figure 137. Distribution and abundance of longfin squid collected during the Summer (July and August) in the Hudson-Raritan Estuary between January 1992 and December 1997.

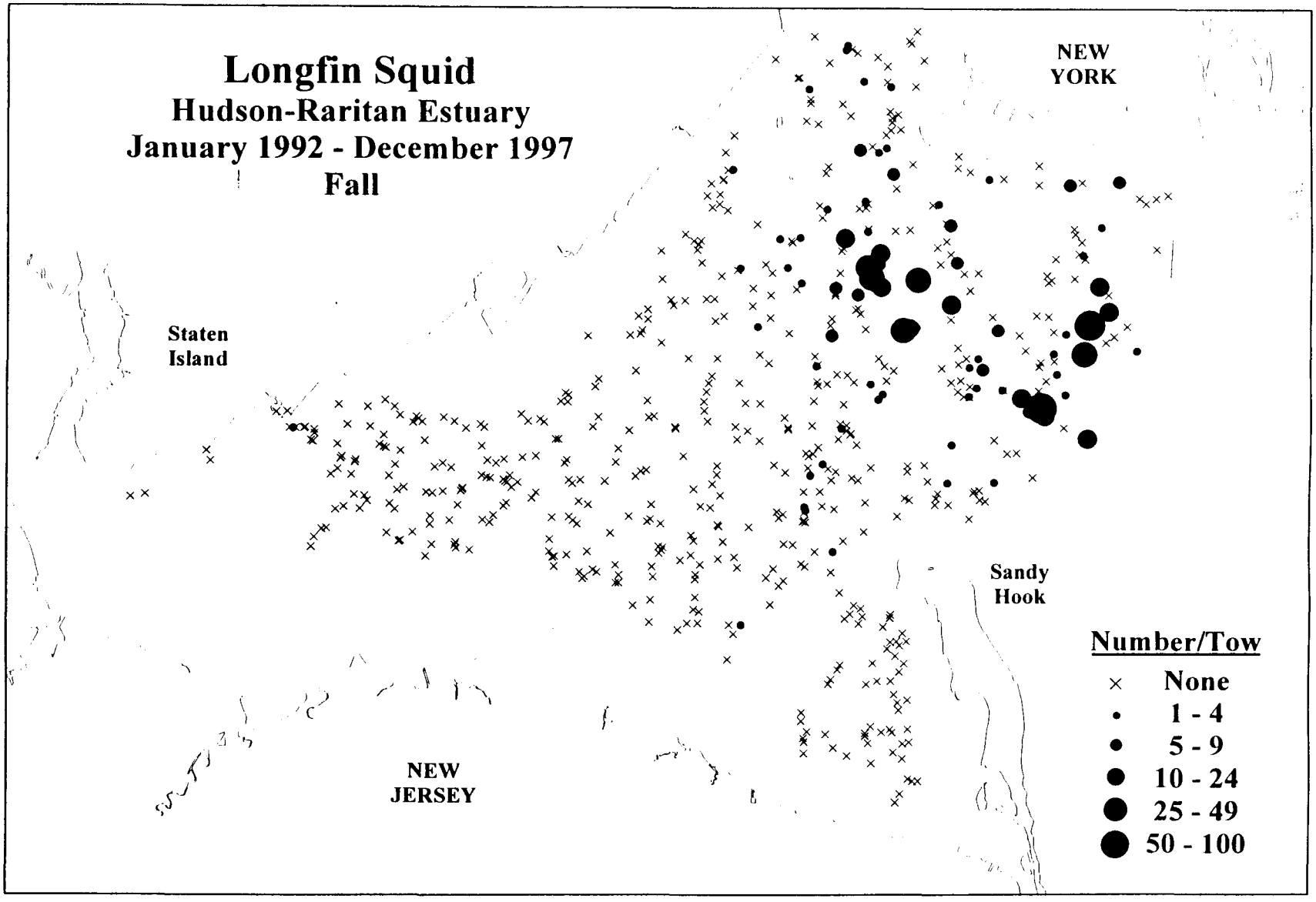

Figure 138. Distribution and abundance of longfin squid collected during the Fall (October, November, and December) in the Hudson-Raritan Estuary between January 1992 and December 1997.