NOAA Technical Memorandum NMFS-NE-173

Essential Fish Habitat Source Document:

Barndoor Skate, *Dipturus laevis*, Life History and Habitat Characteristics

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

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Essential Fish Habitat Source Document:

Barndoor Skate, *Dipturus laevis*, Life History and Habitat Characteristics

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March 2003

Editorial Notes on Issues 122-152, 163, and 173-179 in the *NOAA Technical Memorandum NMFS-NE* Series

Editorial Production

For Issues 122-152, 163, and 173-179, staff of the Northeast Fisheries Science Center's (NEFSC's) Ecosystems Processes Division have largely assumed the role of staff of the NEFSC's Editorial Office for technical and copy editing, type composition, and page layout. Other than the four covers (inside and outside, front and back) and first two preliminary pages, all preprinting editorial production has been performed by, and all credit for such production rightfully belongs to, the staff of the Ecosystems Processes Division.

Internet Availability

Issues 122-152, 163, and 173-179 have been copublished, *i.e.*, both as paper copies and as Web postings. All Web postings are available at: *www.nefsc.noaa.gov/nefsc/habitat/efh*. Also, all Web postings are in "PDF" format.

Information Updating

By federal regulation, all information specific to Issues 122-152, 163, and 173-179 must be updated at least every five years. All official updates will appear in the Web postings. Paper copies will be reissued only when and if new information associated with Issues 122-152, 163, and 173-179 is significant enough to warrant a reprinting of a given issue. All updated and/or reprinted issues will retain the original issue number, but bear a "Revised (Month Year)" label.

Species Names

The NMFS Northeast Region's policy on the use of species names in all technical communications is generally to follow the American Fisheries Society's lists of scientific and common names for fishes (*i.e.*, Robins *et al.* 1991[a]), mollusks (*i.e.*, Turgeon *et al.* 1998[b]), and decapod crustaceans (*i.e.*, Williams *et al.* 1989[c]), and to follow the Society for Marine Mammalogy's guidance on scientific and common names for marine mammals (*i.e.*, Rice 1998[d]). Exceptions to this policy occur when there are subsequent compelling revisions in the classifications of species, resulting in changes in the names of species (*e.g.*, Cooper and Chapleau 1998[e]; McEachran and Dunn 1998[f]).

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[a]Robins, C.R. (chair); Bailey, R.M.; Bond, C.E.; Brooker, J.R.; Lachner, E.A.; Lea, R.N.; Scott, W.B. 1991. Common and scientific names of fishes from the United States and Canada. 5th ed. *Amer. Fish. Soc. Spec. Publ.* 20; 183 p.

[b]Turgeon, D.D. (chair); Quinn, J.F., Jr.; Bogan, A.E.; Coan, E.V.; Hochberg, F.G.; Lyons, W.G.; Mikkelsen, P.M.; Neves, R.J.; Roper, C.F.E.; Rosenberg, G.; Roth, B.; Scheltema, A.; Thompson, F.G.; Vecchione, M.; Williams, J.D. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks. 2nd ed. *Amer. Fish. Soc. Spec. Publ.* 26; 526 p.

[c]Williams, A.B. (chair); Abele, L.G.; Felder, D.L.; Hobbs, H.H., Jr.; Manning, R.B.; McLaughlin, P.A.; Pérez Farfante, I. 1989. Common and scientific names of aquatic invertebrates from the United States and Canada: decapod crustaceans. *Amer. Fish. Soc. Spec. Publ.* 17; 77 p.

[d]Rice, D.W. 1998. Marine mammals of the world: systematics and distribution. *Soc. Mar. Mammal. Spec. Publ.* 4; 231 p.

[e]Cooper, J.A.; Chapleau, F. 1998. Monophyly and interrelationships of the family Pleuronectidae (Pleuronectiformes), with a revised classification. *Fish. Bull. (U.S.)* 96:686-726.

[f]McEachran, J.D.; Dunn, K.A. 1998. Phylogenetic analysis of skates, a morphologically conservative clade of elasmobranchs (Chondrichthyes: Rajidae). *Copeia* 1998(2):271-290.

FOREWORD

One of the greatest long-term threats to the viability of commercial and recreational fisheries is the continuing loss of marine, estuarine, and other aquatic habitats.

Magnuson-Stevens Fishery Conservation and Management Act (October 11, 1996)

The long-term viability of living marine resources depends on protection of their habitat.

NMFS Strategic Plan for Fisheries Research (February 1998)

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), which was reauthorized and amended by the Sustainable Fisheries Act (1996), requires the eight regional fishery management councils to describe and identify essential fish habitat (EFH) in their respective regions, to specify actions to conserve and enhance that EFH, and to minimize the adverse effects of fishing on EFH. Congress defined EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity." The MSFCMA requires NMFS to assist the regional fishery management councils in the implementation of EFH in their respective fishery management plans.

NMFS has taken a broad view of habitat as the area used by fish throughout their life cycle. Fish use habitat for spawning, feeding, nursery, migration, and shelter, but most habitats provide only a subset of these functions. Fish may change habitats with changes in life history stage, seasonal and geographic distributions, abundance, and interactions with other species. The type of habitat, as well as its attributes and functions, are important for sustaining the production of managed species.

The Northeast Fisheries Science Center compiled the available information on the distribution, abundance, and habitat requirements for each of the species managed by the New England and Mid-Atlantic Fishery Management Councils. That information is presented in this series of 38 EFH species reports (plus one consolidated methods report). The EFH species reports are a survey of the important literature as well as original analyses of fishery-independent data sets from NMFS and several coastal states. The species reports are also the source for the current EFH designations by the New England and Mid-Atlantic Fishery Management Councils, and understandably have begun to be referred to as the "EFH source documents."

NMFS provided guidance to the regional fishery management councils for identifying and describing EFH of their managed species. Consistent with this guidance, the species reports present information on current and historic stock sizes, geographic range, and the period and location of major life history stages. The habitats of managed species are described by the physical, chemical, and biological components of the ecosystem where the species occur. Information on the habitat requirements is provided for each life history stage, and it includes, where available, habitat and environmental variables that control or limit distribution, abundance, growth, reproduction, mortality, and productivity.

Identifying and describing EFH are the first steps in the process of protecting, conserving, and enhancing essential habitats of the managed species. Ultimately, NMFS, the regional fishery management councils, fishing participants, Federal and state agencies, and other organizations will have to cooperate to achieve the habitat goals established by the MSFCMA.

A historical note: the EFH species reports effectively recommence a series of reports published by the NMFS Sandy Hook (New Jersey) Laboratory (now formally known as the James J. Howard Marine Sciences Laboratory) from 1977 to 1982. These reports, which were formally labeled as *Sandy Hook Laboratory Technical Series Reports*, but informally known as "Sandy Hook Bluebooks," summarized biological and fisheries data for 18 economically important species. The fact that the bluebooks continue to be used two decades after their publication persuaded us to make their successors – the 38 EFH source documents – available to the public through publication in the *NOAA Technical Memorandum NMFS-NE* series.

JAMES J. HOWARD MARINE SCIENCES LABORATORY
HIGHLANDS, NEW JERSEY
SEPTEMBER 1999

JEFFREY N. CROSS, (FORMER) CHIEF
ECOSYSTEMS PROCESSES DIVISION
NORTHEAST FISHERIES SCIENCE CENTER

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INTRODUCTION

The barndoor skate [*Dipturus laevis* (Mitchill 1817); formerly *Raja laevis*, see McEachran and Dunn (1998); Figure 1] occurs from Newfoundland, the Gulf of St. Lawrence, off Nova Scotia, the Gulf of Maine, and the northern sections of the Mid-Atlantic Bight down to North Carolina (Bigelow and Schroeder 1953, 1954; McEachran and Musick 1975; Scott and Scott 1988). A similar species, *Dipturus teevani* occurs along the coast south of Cape Hatteras, North Carolina (Bigelow and Schroeder 1962, 1968; Bullis and Thompson 1965; Struhsaker 1969). Barndoor skate is one of the largest skates in the northwest Atlantic. Bigelow and Schroeder (1953) reported one specimen to be 147.3 cm TL and 106.7 cm wide with a tail 68.8 cm long, and a female to be 127 cm TL and 84.5 cm wide with a 55.9 cm tail; unconfirmed reports have barndoor skate reaching 183 cm TL. Bigelow and Schroeder (1953) also state that they are about 1.8-2.7 kg when 71-76 cm TL, about 4.5-5.0 kg at 91 cm TL, and about 8.6-9.5 kg at 114-117 cm TL.

LIFE HISTORY

AGE, GROWTH, AND SIZE AT MATURITY

Barndoor skates are presumed to be a relatively long-lived, slow growing species, but no estimates of age and growth parameters are currently available. The closest relative to the barndoor skate is the common skate (*Dipturus batis*) in the northeast Atlantic. Casey and Myers (1998) expect similar characteristics for barndoor skate on Georges Bank, which has a similar temperature regime. By analogy, Casey and Myers (1998) suggested a L_{max} of 153 cm TL and an A_{mat} of 11 years for barndoor skate. Based on the predictive equations from Frisk *et al*. (2001) and the Northeast Fisheries Science Center (NEFSC) survey maximum observed length of 136 cm TL, L_{mat} is estimated at 102 cm TL and A_{mat} is estimated at 8 years (Northeast Fisheries Science Center 2000b). In another study, clasper length measurements on males from Georges Bank show that male sexual maturity occurs at approximately 100 cm TL (Gedamke and DuPaul 1999).

REPRODUCTION

Females containing fully formed egg capsules have been taken in December and January (Vladykov 1936; Bigelow and Schroeder 1953), although it is not known if egg capsule production and deposition is restricted to the winter (McEachran 2002).

Casey and Myers (1998) proposed that barndoor skate might have life history characteristics similar to European skate (*Dipturus batis*). By analogy, Casey and Myers (1998) suggest that maximum egg production for barndoor skate, which can be estimated from the inverse relation with the weight of the young at hatching, is about 47 eggs/yr.

EGGS

The single fertilized egg is encapsulated in a leathery yellowish or greenish egg capsule known as a "mermaid's purse." The capsules are rectangular in shape, 124-132 mm long and 68-72 mm wide with a short horn at each corner (Vladykov 1936; Bigelow and Schroeder 1953; Figure 2). The capsules are smooth but possess fine filaments along their anterior and posterior margins. The capsules are considerably larger and have shorter horns than those of other northwest Atlantic skates (McEachran 2002).

JUVENILES

Bigelow and Schroeder (1953) suggest that the young do not hatch until late spring or early summer (they assume the eggs are laid in winter). The young are thought to be 180-190 mm TL at hatching but small specimens are seldom captured (McEachran 2002).

ADULTS

FOOD HABITS

Food of the barndoor skate consists of benthic invertebrates and fishes. Prey includes polychaetes, gastropods, bivalve mollusks, squids, crustaceans, hydroids, and fishes (Bigelow and Schroeder 1953; Scott and Scott 1988; Bowman *et al*. 2000; Avent *et al*. 2001). Smaller individuals apparently subsist mainly on benthic invertebrates, such as polychaetes, copepods, amphipods, isopods, the shrimp *Crangon septemspinosa*, and euphausids, while larger skate eat larger and more active prey such as razor clams (*Ensis directus*), large gastropods, squids, crabs (*Cancer* spp. and spider crabs), lobsters and fishes (McEachran 2002). Fish prey includes spiny dogfish, alewife, Atlantic herring, menhaden, hakes, sculpins, cunner, tautog, sand lance, butterfish, and various flounders (Bigelow and Schroeder 1953).

PREDATORS AND SPECIES ASSOCIATIONS

McEachran (2002) states that nothing is known of the predators of barndoor skate, but it is probably eaten by sharks, and a similar species in the eastern North Pacific is preyed upon by sperm whales.

Based upon 1967-1970 surveys from Nova Scotia to Cape Hatteras, McEachran and Musick (1975) noted that barndoor skate was associated with both little skate (*Leucoraja erinacea*) and winter skate (*Leucoraja ocellata*). Barndoor skate was found in the same areas as the above species pair but had a wider substratum and depth tolerance.

GEOGRAPHICAL DISTRIBUTION

Barndoor skate occurs from the banks of Newfoundland [although the only recent research survey catches of barndoor skate in the Newfoundland area have been very deep (> 1000 m) and in an area north of the reported range of the species (Casey and Myers 1998)], the southern Gulf of St. Lawrence, and along the northeastern coast and offshore banks of Nova Scotia down to North Carolina (Bigelow and Schroeder 1953, 1954; McEachran and Musick 1975; Scott and Scott 1988). It has been found throughout the Gulf of Maine including off Nova Scotia, in St. Mary Bay, in the Bay of Fundy and Passamaquoddy Bay, from Eastport, Casco Bay, and the remainder of the coast of Maine, and from various localities in Massachusetts Bay (Bigelow and Schroeder 1953; Macdonald *et al*. 1984; Collette and Hartel 1988). It also occurs on Georges Bank and Nantucket Shoals (Bigelow and Schroeder 1953). However, McEachran and Musick (1975), based on surveys from Nova Scotia to Cape Hatteras during 1967-1970, found that barndoor skate was most abundant in the eastern Gulf of Maine and on the eastern section of Georges Bank, but none were found in the western Gulf of Maine. McEachran and Musick (1975) also declared that the barndoor skate was the most widespread of the skate species they studied, but too few were taken to elaborate on its distribution.

In the Gulf of Maine part of the population of barndoor skate moves into shallow water during the summer (Bigelow and Schroeder 1953). Huntsman (1922) stated that it is often stranded on the beach, and they quote Huntsman as saying it comes into Passamaquoddy Bay from May to November and slightly longer in the Bay of Fundy. However, some are found at depths of 37-110 m on Georges Bank and off Cape Cod throughout the year (Bigelow and Schroeder 1953). South of Cape Cod barndoor skate occurs in relatively shallower water during the spring and autumn (Bigelow and Schroeder 1953) although Merriman and Warfel (1948) note that it is most abundant in southern New England during the summer. Hildebrand and Schroeder (1928) state that it only occurs in Chesapeake Bay during the spring.

JUVENILES

NEFSC bottom trawl surveys [see Reid *et al*. (1999) for details] captured low numbers or concentrations of juvenile ($\leq$ 101 cm TL) barndoor skate year-round (Figures 3-6). (Note that winter and summer distributions are presented as presence/absence data, precluding a discussion of abundances.) In winter, juveniles were found mostly on Georges Bank, near the 200 m depth contour, as well as in the Gulf of Maine, southern New England, and the Mid-Atlantic Bight down to the Hudson Canyon (Figure 3). In spring, they were found in the same areas and were not very abundant (Figure 4), while in summer they were mostly concentrated on or near Georges Bank (Figure 5), in contradiction to Merriman and Warfel's (1948) observation about barndoor skate being most abundant in southern New England during the summer. In fall they were again widely distributed throughout the previously mentioned areas, especially on Georges Bank, and in greater numbers than in the spring (Figure 6). Lower abundances and narrower distributions during spring and summer may be due to their moving into shallow water, as noted previously.

Contrary to previous records, none were found as far south as North Carolina. In agreement with McEachran and Musick (1975), few were found in the western Gulf of Maine, but contrary to those same authors, they were often relatively abundant throughout Georges Bank, not just in the eastern portion.

Only two juvenile barndoor skate was found near Martha's Vineyard during the spring 1978-2002 Massachusetts inshore trawl surveys (Figure 7).

ADULTS

NEFSC bottom trawl surveys [see Reid *et al*. (1999) for details] captured adult barndoor skate ($\geq$ 102 cm TL) during all seasons (Figures 8-11), although the overall numbers of adults collected were even lower than those for juveniles. (Again, winter and summer distributions are presented as presence/absence data, precluding a discussion of abundances.) In winter, a few were present in the Gulf of Maine, on Georges Bank near the 200 m isobath, and in southern New England and the Mid-Atlantic Bight down to the Hudson Canyon between the 60 m and 200 m isobaths (Figure 8). The few that were caught in spring were found mostly on Georges Bank near the 200 m isobath and in the Northeast Channel (Figure 9). Few were present in summer, and were found either on central Georges Bank or near the Bay of Fundy (Figure 10). In the fall they were again found in the Gulf of Maine and on Georges Bank, although they were not confined to near the 200 m isobath; some were also found a little farther south as well as in or near the Bay of Fundy (Figure 11). As with the juveniles, lower abundances and narrower distributions during spring and summer may be due to their moving into shallow water, as noted previously.

No adults were found as far south as North Carolina, contrary to previous records. In agreement with McEachran and Musick (1975), few were found in the

western Gulf of Maine, but contrary to those same authors, they were often found throughout Georges Bank, not just in the eastern portion.

HABITAT CHARACTERISTICS

Information on the habitat requirements and preferences of barndoor skate (based on both the pertinent literature and the most recent NEFSC surveys) are presented here and summarized in Table 1.

Barndoor skate is found on mud bottoms as well as on sand and gravel (Bigelow and Schroeder 1953) and occurs from the shoreline to about 750 m, although it is most abundant at depths < 150 m (Bigelow and Schroeder 1953, 1954; McEachran and Musick 1975; Scott and Scott 1988) and around Newfoundland the only recent catches of barndoor skate have been at depths > 1000 m (Casey and Myers 1998). McEachran and Musick (1975), during trawl surveys conducted from Nova Scotia to Cape Hatteras, found it to be widespread from 38-351 m. Bigelow and Schroeder (1953) state that it is widespread (but not numerous) to a depth of 183 m both in the open trough of the Gulf of Maine and in the bowl west of Jeffreys Ledge, but is perhaps more plentiful at 46-64 m on Georges Bank and Nantucket Shoals than deeper, and has been reported as deep as 430 m off Nantucket. The spring and fall 1963-2002 NEFSC trawl surveys from the Gulf of Maine to Cape Hatteras (see below) indicated that the juveniles were generally widespread from approximately 21-400 m, with most from about 61-140 m (Figure 12). The adults were found from approximately 31-400 m, and often at depths greater than approximately 70 m in spring and 40 m in fall (Figure 13).

Barndoor skate has a relatively broad temperature range, which may explain its wide depth distribution. Bigelow and Schroeder (1953, 1954) stated that its full temperature range is from 1.2-20°C. In the Gulf of St. Lawrence it is reported from waters as cold as 1.2°C. Off the east coast of Nova Scotia it has been reported at depths of 24-375 m and at temperatures of 1.2-10.7°C and from Nova Scotia to Cape Hatteras it has been reported at temperatures of 3-20°C (McEachran and Musick 1975; Scott and Scott 1988). The spring and fall 1963-2002 NEFSC trawl surveys from the Gulf of Maine to Cape Hatteras (see below) collected juvenile barndoor skate over a temperature range of about 3-18°C, with most found around 3-8°C in spring and 6-11°C (with a peak at 9°C) in fall (Figure 12). Adults were found over a temperature range of about 4-16°C (Figure 13).

The barndoor skate's salinity preference ranges from 32-36 ppt (spring and fall 1963-2002 NEFSC trawl survey data; Figures 12-13)**,** although it has been reported from the mouth of Chesapeake Bay where salinities range from 21-24 ppt, and from the Delaware River near Philadelphia in brackish water (McEachran 2002).

JUVENILES

The spring and fall distributions of juvenile barndoor skate relative to bottom water temperature, depth, and salinity based on 1963-2002 NEFSC bottom trawl surveys from the Gulf of Maine to Cape Hatteras are shown in Figure 12. In spring, they were found in waters between 3-13°C, with most between 3-8°C. Their depth range during that season was between 41-400 m, with most spread between about 61-140 m. They were found over a salinity range of 32-36 ppt, with around 50% found at 33 ppt. In the fall they were found over a temperature range of about 3-18°C, with most found between 6-11°C and with around 25% found at 9°C. Their depth range during that season was between 21-400 m with the majority between approximately 61-140 m. They were found over a salinity range of 32-36 ppt, with about 50-60% found at 33 ppt.

ADULTS

The spring and fall distributions of adult barndoor skate relative to bottom water temperature, depth, and salinity based on 1963-2002 NEFSC bottom trawl surveys from the Gulf of Maine to Cape Hatteras are shown in Figure 13. In spring, they were found in temperatures of between 4-12°C, with about 50% between 7-8°C. Their depth range during spring was spread between 71-400 m, with a few at 31-40 m and many between 201-400 m. Their salinity range was between 33-36 ppt, with close to 60% at 35 ppt. In the fall they were found over a temperature range of 5-16°C, with a peak at 7°C and another lower peak at 11°C. Their depth range during that season was between 31-400 m with the highest catches and occurrences between about 61-100 m and 121-140 m. They were found at salinities between 32-35 ppt, with about 70% between 32-33 ppt.

STATUS OF THE STOCKS

The following section is based on Northeast Fisheries Science Center (2000a, b).

The principal commercial fishing method used to catch all seven species of skates [little, barndoor, winter, thorny (*Amblyraja radiata*), clearnose (*Raja eglanteria*), rosette (*Leucoraja garmani*), smooth (*Malacoraja senta*)] is otter trawling. Skates are frequently taken as bycatch during groundfish trawling and scallop dredge operations and discarded recreational and foreign landings are currently insignificant, at < 1% of the total fishery landings.

Skates have been reported in New England fishery landings since the late 1800s. However, commercial fishery landings, primarily from off Rhode Island, never exceeded several hundred metric tons until the advent of

distant-water fleets during the 1960s. Landings are not reported by species, with over 99% of the landings reported as "unclassified skates." Skate landings reached 9,500 mt in 1969, but declined quickly during the 1970s, falling to 800 mt in 1981 (Figure 14). Landings have since increased substantially, partially in response to increased demand for lobster bait, and more significantly, to the increased export market for skate wings. Wings are taken from winter and thorny skates, the two species currently used for human consumption. Bait landings are presumed to be primarily from little skate, based on areas fished and known species distribution patterns. Landings for all skates increased to 12,900 mt in 1993 and then declined somewhat to 7,200 mt in 1995. Landings have increased again since 1995, and the 1998 reported commercial landings of 17,000 mt were the highest on record (Figure 14).

The biomass for the seven skate species is at a medium level of abundance. For the aggregate complex, the NEFSC spring survey index of biomass was relatively constant from 1968-1980, then increased significantly to peak levels in the mid- to late 1980s. The index of skate complex biomass then declined steadily until 1994, but has recently increased again. The large increase in skate biomass in the mid- to late 1980s was dominated by little and winter skate. The recent increase in aggregate skate biomass has been due to an increase in small sized skates (< 100 cm max. length: little, clearnose, rosette, and smooth), primarily little skate. The biomass of large size skates (> 100 cm max. length: barndoor, winter, and thorny) has steadily declined since the mid-1980s.

The abundance of barndoor skate declined continuously through the 1960s due to historic lows during the early 1980s (Figure 14). Since 1990, the abundance of barndoor skate has increased slightly on Georges Bank, the western Scotian Shelf, and in southern New England, although the 1999 current NEFSC autumn survey biomass index is < 5% of the peak observed in 1963 (Northeast Fisheries Science Center 2000a, b). It should be noted however that barndoor skate also occurs in waters deeper than those covered by the NEFSC and state surveys and it is likely that these surveys underrepresent the abundance of larger barndoor skate (Northeast Fisheries Science Center 2000a, b). Barndoor skate is considered to be overfished (Northeast Fisheries Science Center 2000a, b).

RESEARCH NEEDS

Imprecise reporting of fishery statistics where several skate species are lumped together under one category (e.g., "unclassified skates" or "skates spp.") can mask basic changes in community structure and profound reduction in populations of larger, slower growing species (Dulvy *et al*. 2000; Musick *et al*. 2000). Thus, it is important to have fishery-independent data on skates where the individual species are reported.

Northeast Fisheries Science Center (2000b) also suggests the following research needs:

- More life history studies (including studies on age, growth, maturity, and fecundity) are necessary.
- Studies of stock structure are needed to identify unit stocks; stock identification studies are also necessary.
- Explore possible stock-recruit relationships by examination of NEFSC survey data.
- Investigate trophic interactions between skate species in the complex, and between skates and other groundfish.
- Investigate the influence of annual changes in water temperature or other environmental factors on shifts in the range and distribution of the species in the skate complex, and establish the bathymetric distribution of the species in the complex in the northwest Atlantic.
- Investigate historical NEFSC survey data from the R/V Albatross III during 1948-1962 when they become available, as they may provide valuable historical context for long-term trends in skate biomass.

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Table 1. Summary of habitat parameters for barndoor skate, based on the pertinent literature and the most recent NEFSC surveys.

Life Stage	Depth	Substrate	Salinity	Temperature
Juveniles [1]	Occurs from the shoreline to about 750 m, although widespread from 38-351 m and most abundant at depths < 150 m. Reported to be widespread (but not numerous) to 183 m both in the open trough of the Gulf of Maine and in the bowl west of Jeffreys Ledge, but may be more plentiful at 46-64 m on Georges Bank and Nantucket Shoals than deeper; has been reported as deep as 430 m off Nantucket. Off the east coast of Nova Scotia it has been reported at depths of 24-375 m and around Newfoundland the only recent catches have been at depths > 1000 m. The spring and fall 1963-2002 NEFSC trawl surveys from the Gulf of Maine to Cape Hatteras indicated that the juveniles were generally widespread from approximately 21-400 m, with most from about 61-140 m. In the Gulf of Maine part of the population moves into shallow water during summer; however, some are found at a depth of 37-110 m on Georges Bank and off Cape Cod throughout the year. South of Cape Cod barndoor skate occurs in relatively shallower water during the spring and autumn.	Found on mud bottoms as well as on sand and gravel.	Salinity preference ranges from 32-36 ppt, although it has been reported from the mouth of Chesapeake Bay where salinities range from 21-24 ppt, and from the Delaware River near Philadelphia in brackish water.	Barndoor skate has a relatively broad temperature range of 1.2-20°C, which may explain its wide depth distribution. In the Gulf of St. Lawrence it has been reported from waters as cold as 1.2°C. Off the east coast of Nova Scotia it has been reported at temperatures of 1.2-10.7°C and from Nova Scotia to Cape Hatteras it has been reported at temperatures of 3-20°C. The spring and fall 1963-2002 NEFSC trawl surveys from the Gulf of Maine to Cape Hatteras collected juveniles over a temperature range of about 3-18°C, with most found around 3-8°C in spring and 6-11°C (with a peak at 9°C) in fall.
Adults [2]	Same as for the juveniles. The spring and fall 1963-2002 NEFSC trawl surveys from the Gulf of Maine to Cape Hatteras indicated that the adults were found from approximately 31-400 m, and often at depths greater than approximately 70 m in spring and 40 m in fall.	Same as for the juveniles.	Same as for the juveniles.	Same as for the juveniles. The spring and fall 1963-2002 NEFSC trawl surveys from the Gulf of Maine to Cape Hatteras show that adults were found over a temperature range of about 4-16°C.

[1] Bigelow and Schroeder (1953, 1954); McEachran and Musick (1975); Scott and Scott (1988); Casey and Myers (1998); McEachran (2002); 1963-2002 NEFSC trawl surveys.
[2] Bigelow and Schroeder (1953, 1954); McEachran and Musick (1975); Scott and Scott (1988); Casey and Myers (1998); McEachran (2002); 1963-2002 NEFSC trawl surveys.

Table 1. cont'd.

Life Stage	Prey	Predators/Species Associations
Juveniles [1]	Prey includes polychaetes, gastropods, bivalve mollusks, squids, crustaceans, hydroids, and fishes. Smaller individuals apparently subsist mainly on benthic invertebrates, such as polychaetes, copepods, amphipods, isopods, the shrimp *Crangon septemspinosa*, and euphausids.	Probably preyed upon by sharks and whales. Barndoor skate associated with both little skate (*Leucoraja erinacea*) and winter skate (*Leucoraja ocellata*); barndoor skate found in the same areas as the above species pair but has wider substratum and depth tolerance.
Adults [2]	Prey includes polychaetes, gastropods, bivalve mollusks, squids, crustaceans, and fishes. Larger skate eat larger and more active prey such as razor clams (*Ensis directus*), large gastropods, squids, crabs (*Cancer* spp. and spider crabs), lobsters and fishes. Fish prey includes spiny dogfish, alewife, Atlantic herring, menhaden, hakes, sculpins, cunner, tautog, sand lance, butterfish, and various flounders.	Same as for juveniles.

[1] Bigelow and Schroeder (1953); McEachran and Musick (1975); Scott and Scott (1988); Bowman *et al*. 2000; Avent *et al*. (2001); McEachran (2002).
[2] Bigelow and Schroeder (1953); McEachran and Musick (1975); Scott and Scott (1988); Bowman *et al*. 2000; Avent *et al*. (2001); McEachran (2002).

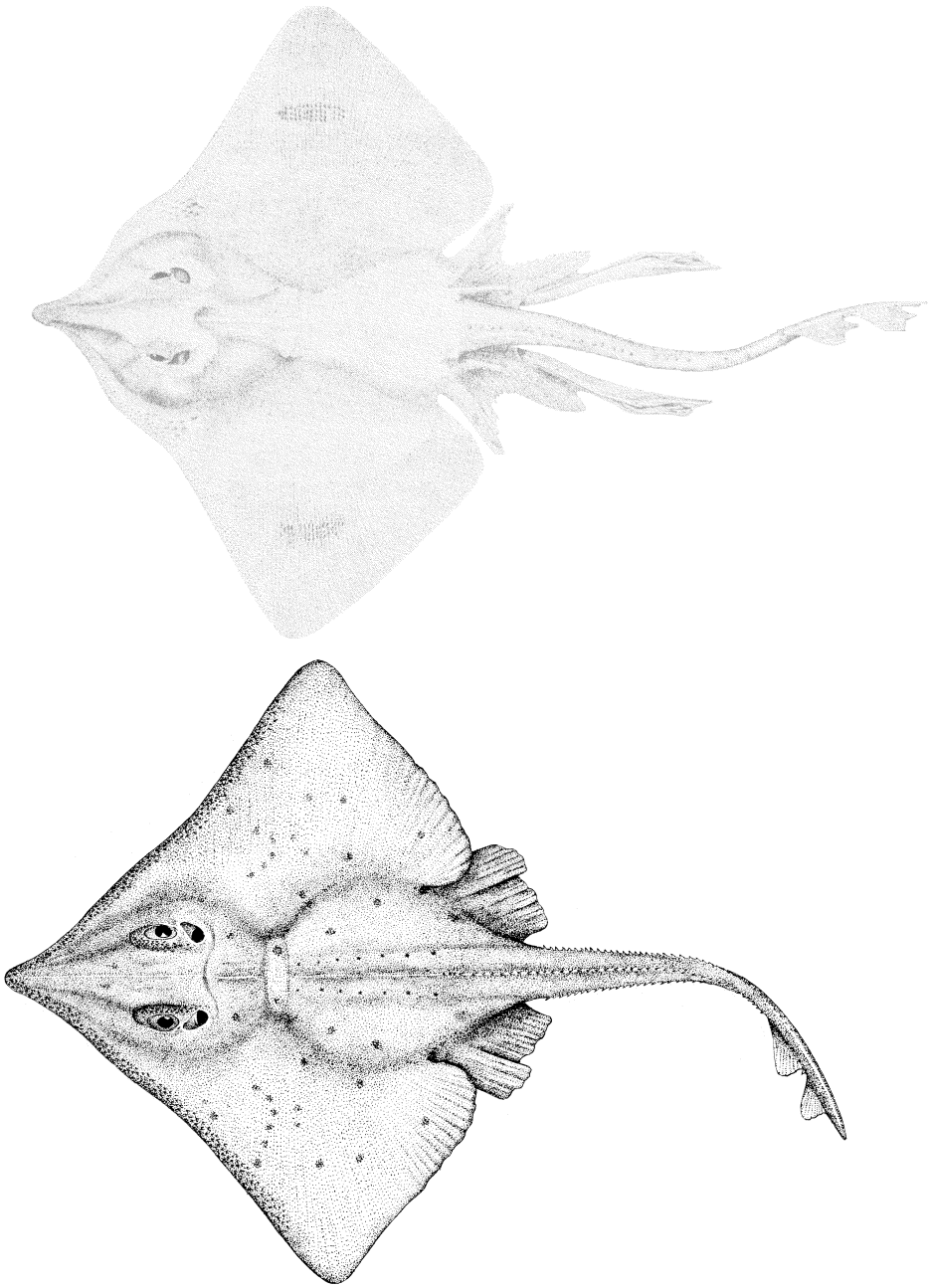

Figure 1. The barndoor skate, *Dipturus laevis* (Mitchill 1817). Top: male, from Murdy *et al*. (1997). Bottom: female, from Scott and Scott (1988).

Figure 2. Egg case of barndoor skate. Photograph by Jim Simon (from <http://www.mscs.dal.ca/~myers/barndoor.html>).

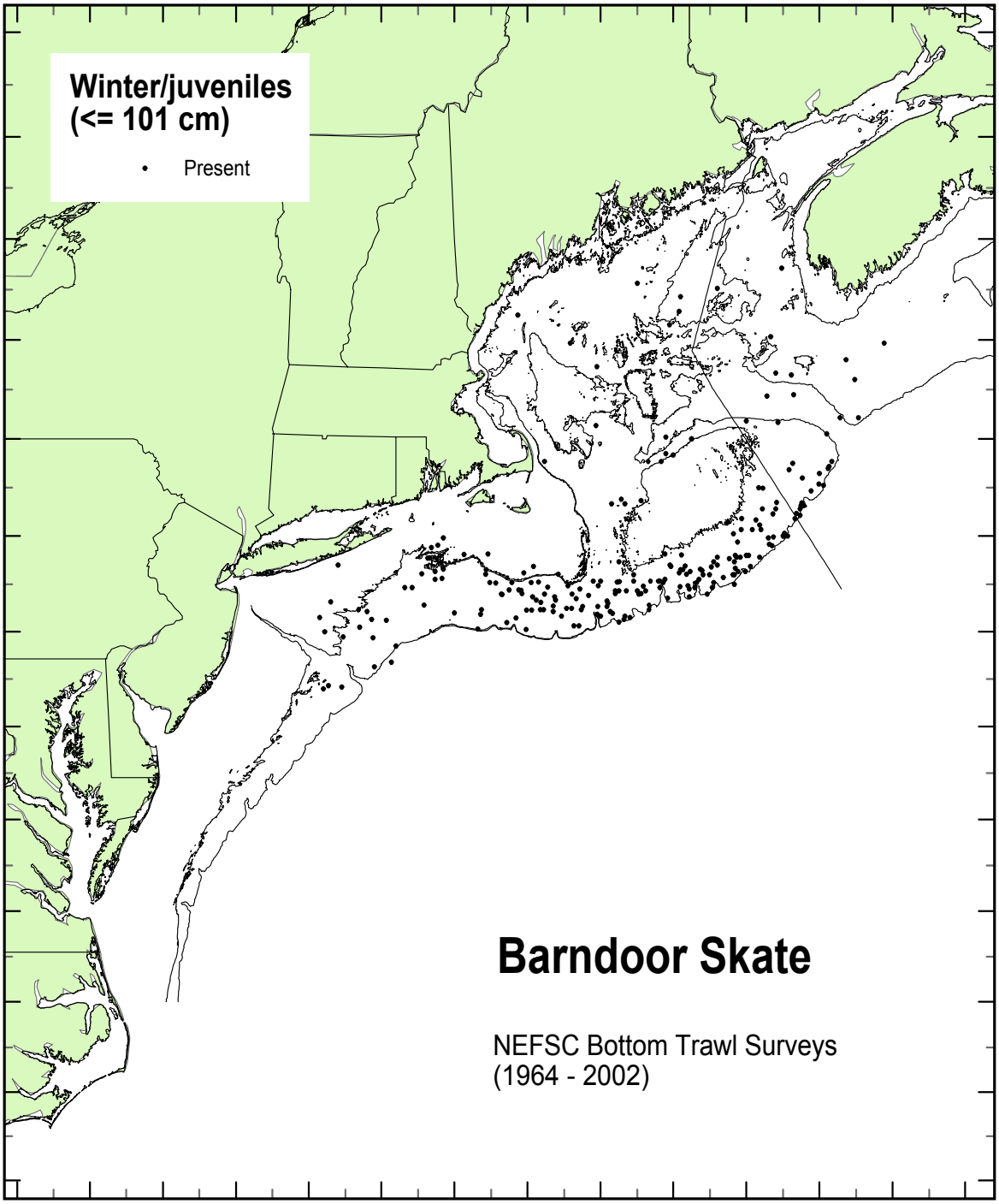

Figure 3. Distribution of juvenile barndoor skate collected during winter NEFSC bottom trawl surveys [1964-2002, all years combined; see Reid *et al.* (1999) for details]. Survey stations where juveniles were not found are not shown.

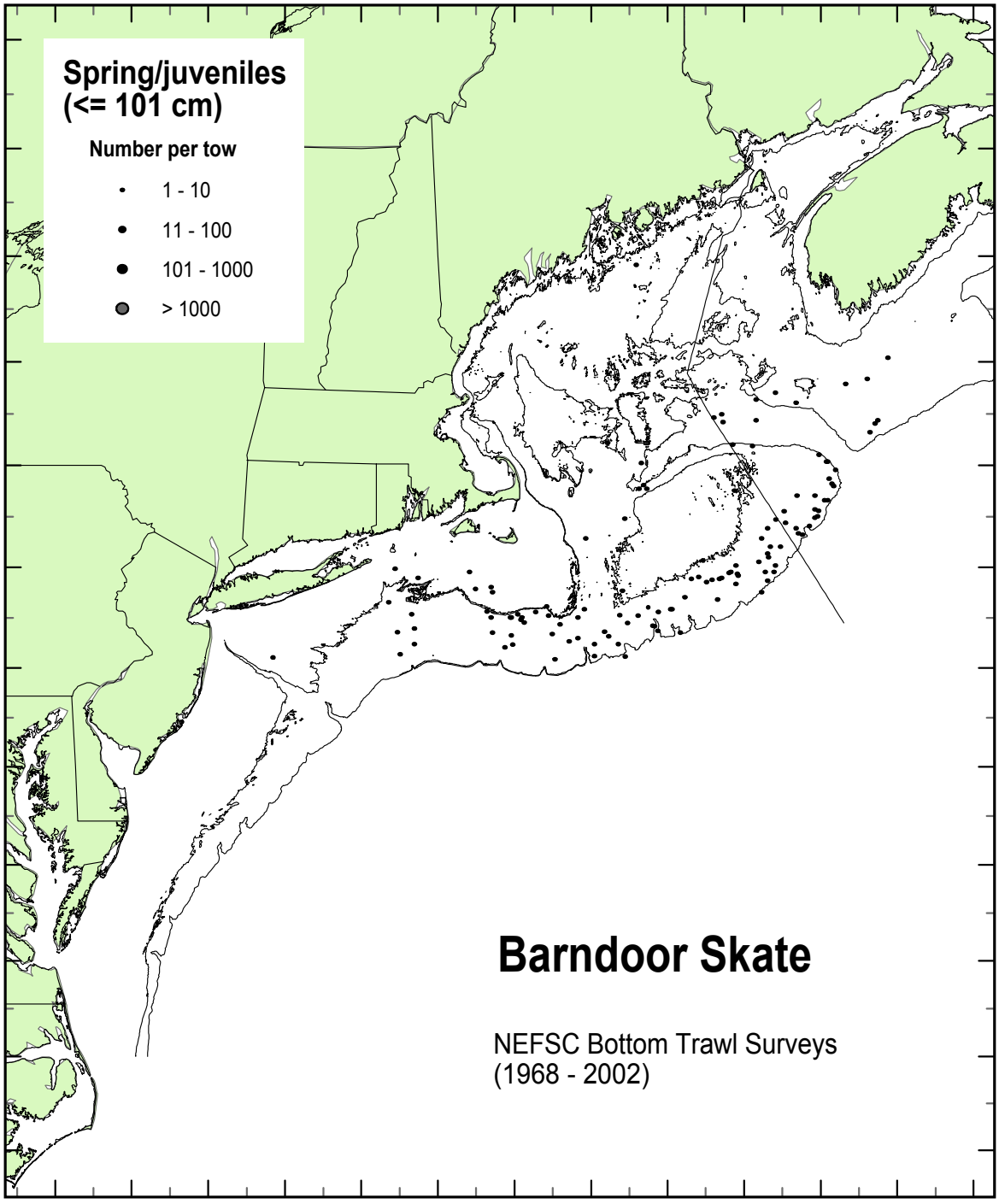

Figure 4. Distribution and abundance of juvenile barndoor skate collected during spring NEFSC bottom trawl surveys [1968-2002, all years combined; see Reid *et al.* (1999) for details].

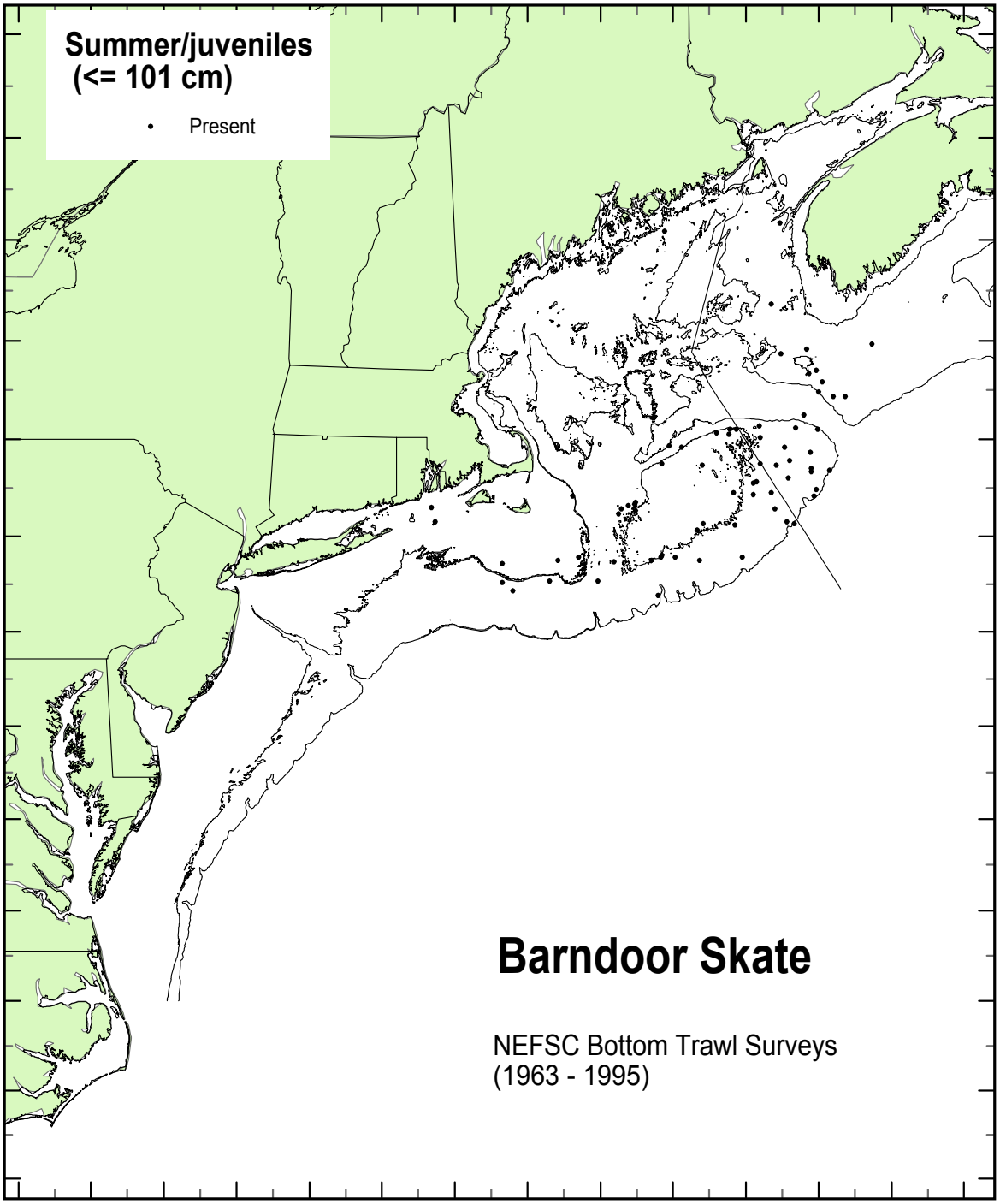

Figure 5. Distribution of juvenile barndoor skate collected during summer NEFSC bottom trawl surveys [1963-1995, all years combined; see Reid *et al.* (1999) for details]. Survey stations where juveniles were not found are not shown.

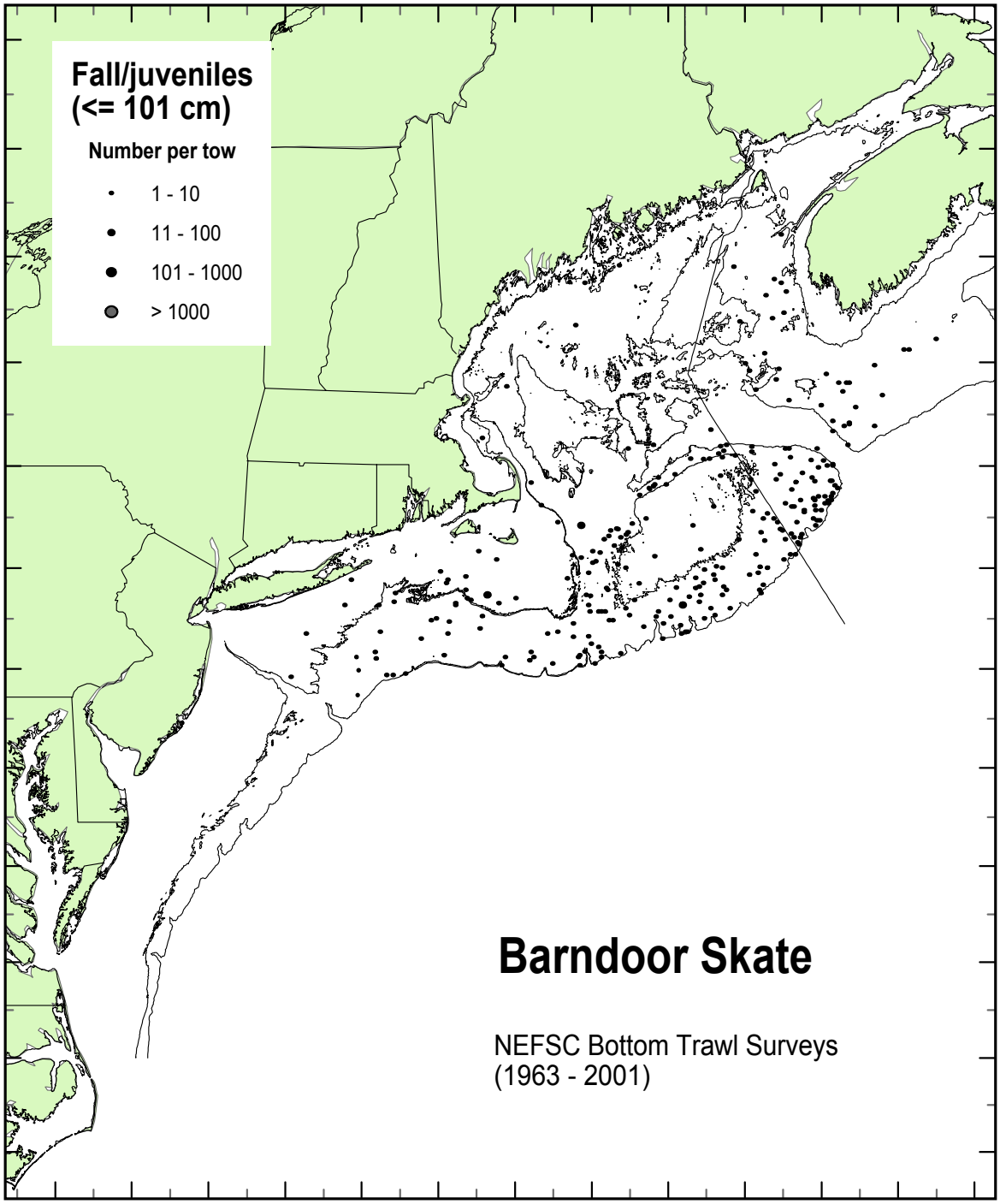

Figure 6. Distribution and abundance of juvenile barndoor skate collected during fall NEFSC bottom trawl surveys [1963-2001, all years combined; see Reid *et al.* (1999) for details].

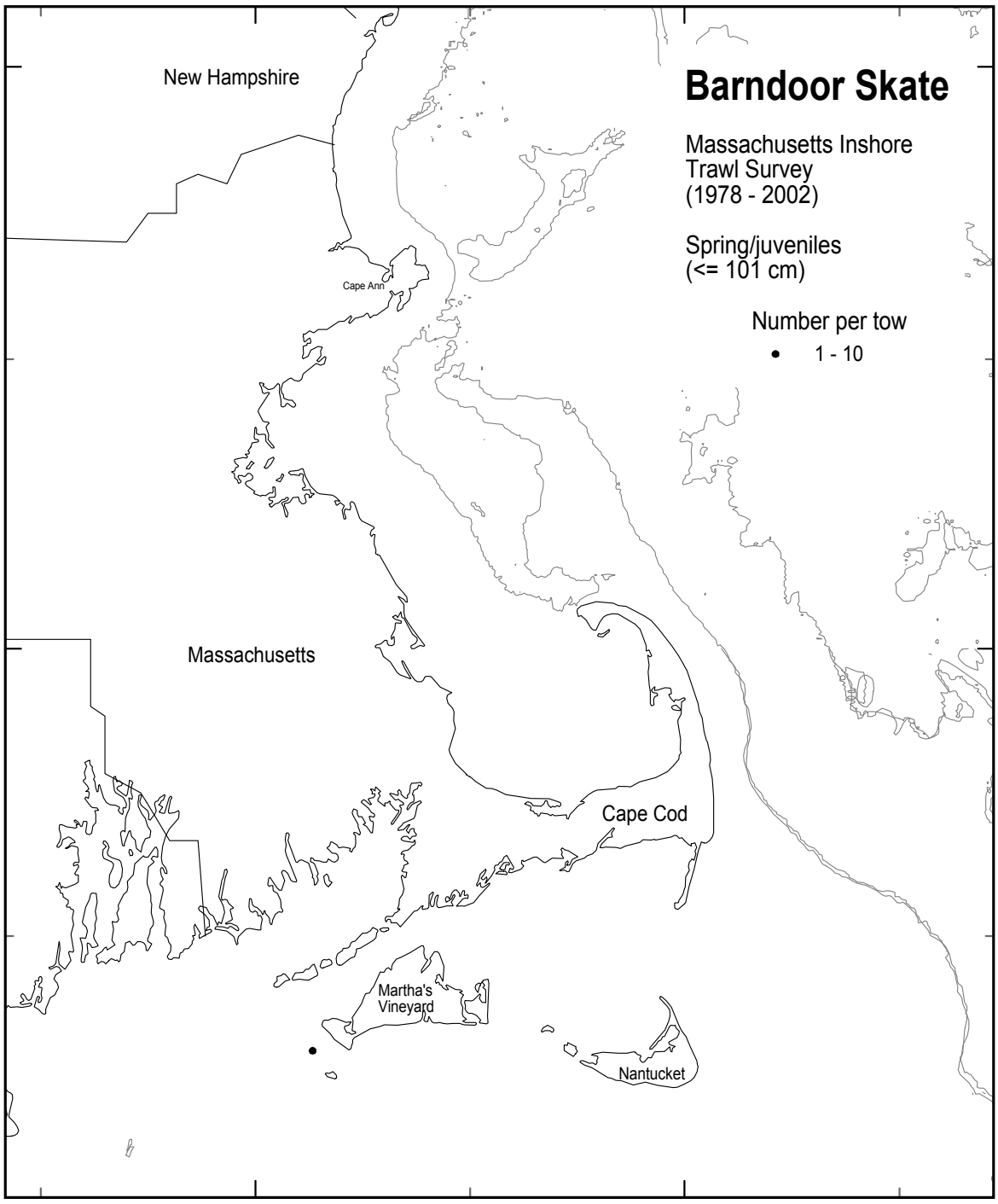

Figure 7. Distribution and abundance of juvenile barndoor skate in Massachusetts coastal waters collected during the spring Massachusetts inshore trawl surveys [1978-2002, all years combined; see Reid *et al.* (1999) for details].

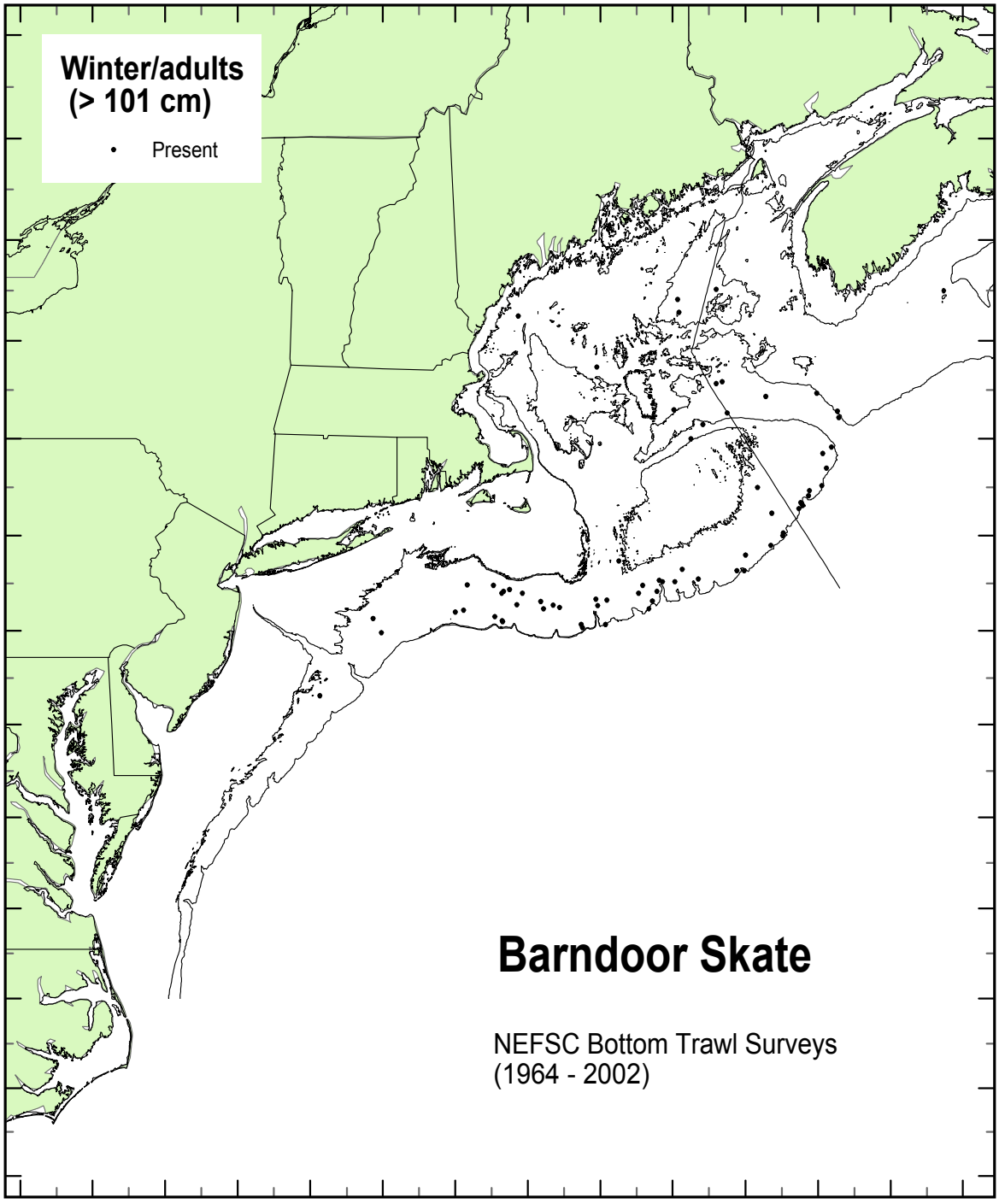

Figure 8. Distribution of adult barndoor skate collected during winter NEFSC bottom trawl surveys [1964-2002, all years combined; see Reid *et al.* (1999) for details]. Survey stations where adults were not found are not shown.

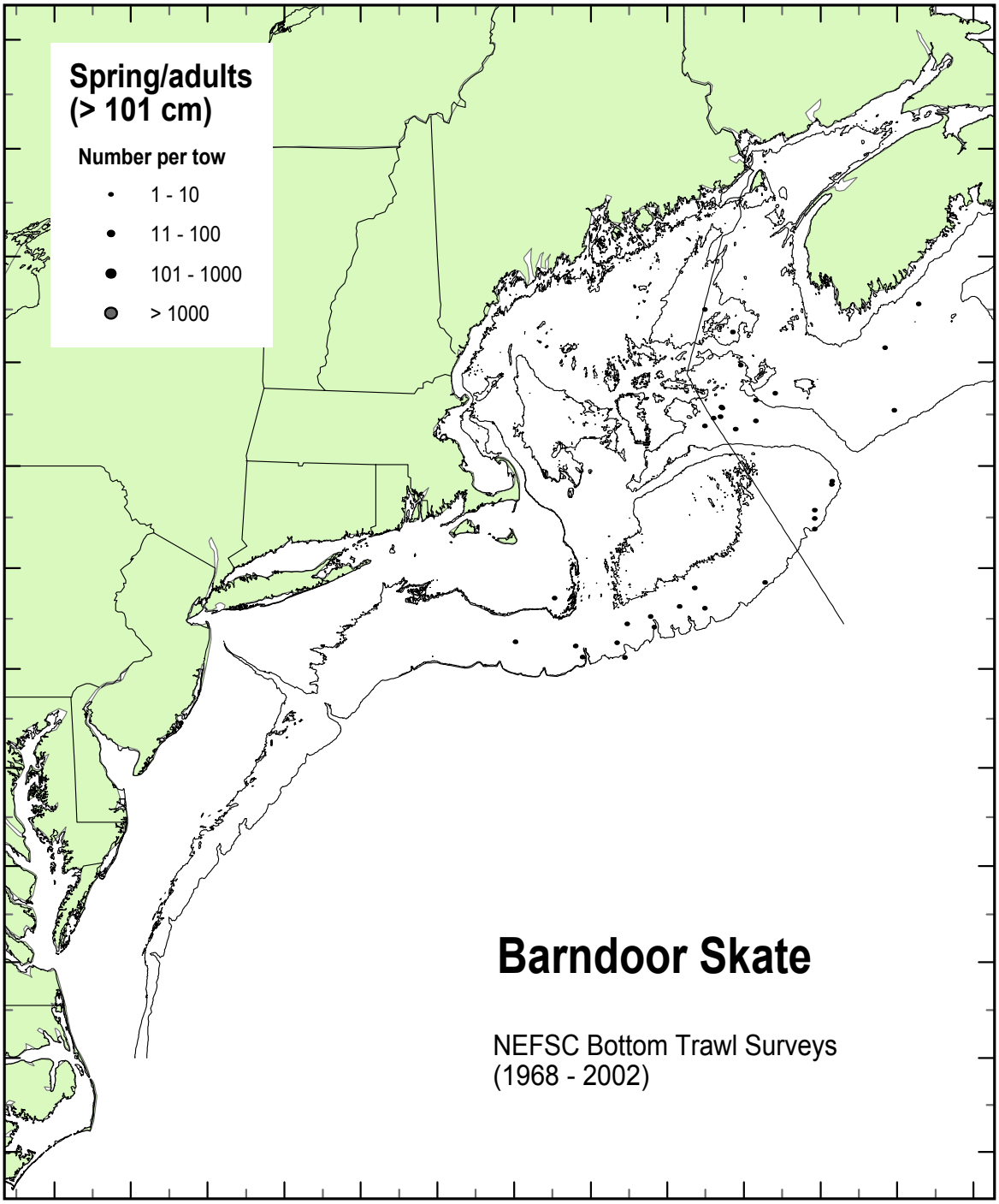

Figure 9. Distribution and abundance of adult barndoor skate collected during spring NEFSC bottom trawl surveys [1968-2002, all years combined; see Reid *et al.* (1999) for details].

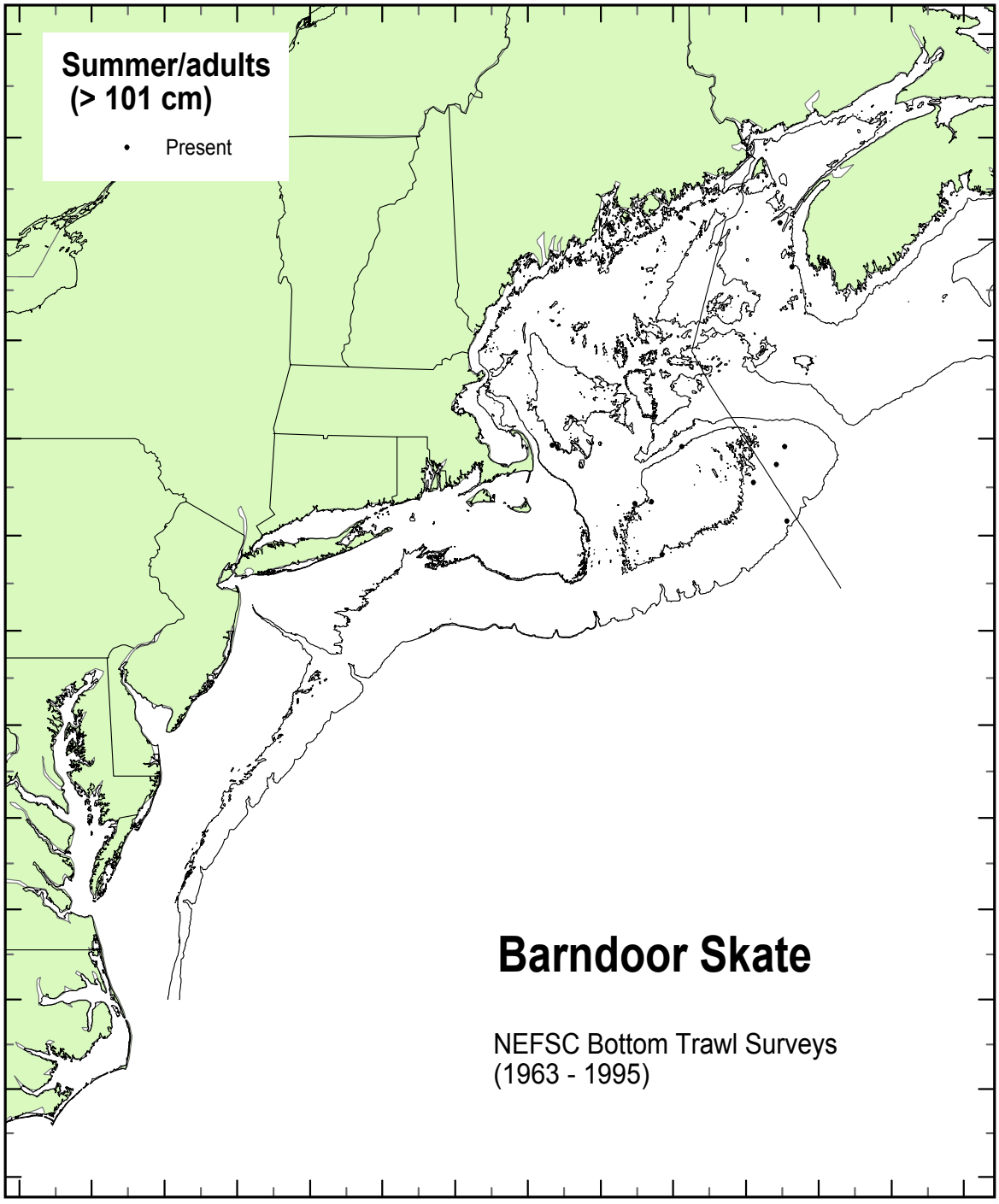

Figure 10. Distribution of adult barndoor skate collected during summer NEFSC bottom trawl surveys [1963-1995, all years combined; see Reid *et al.* (1999) for details]. Survey stations where adults were not found are not shown.

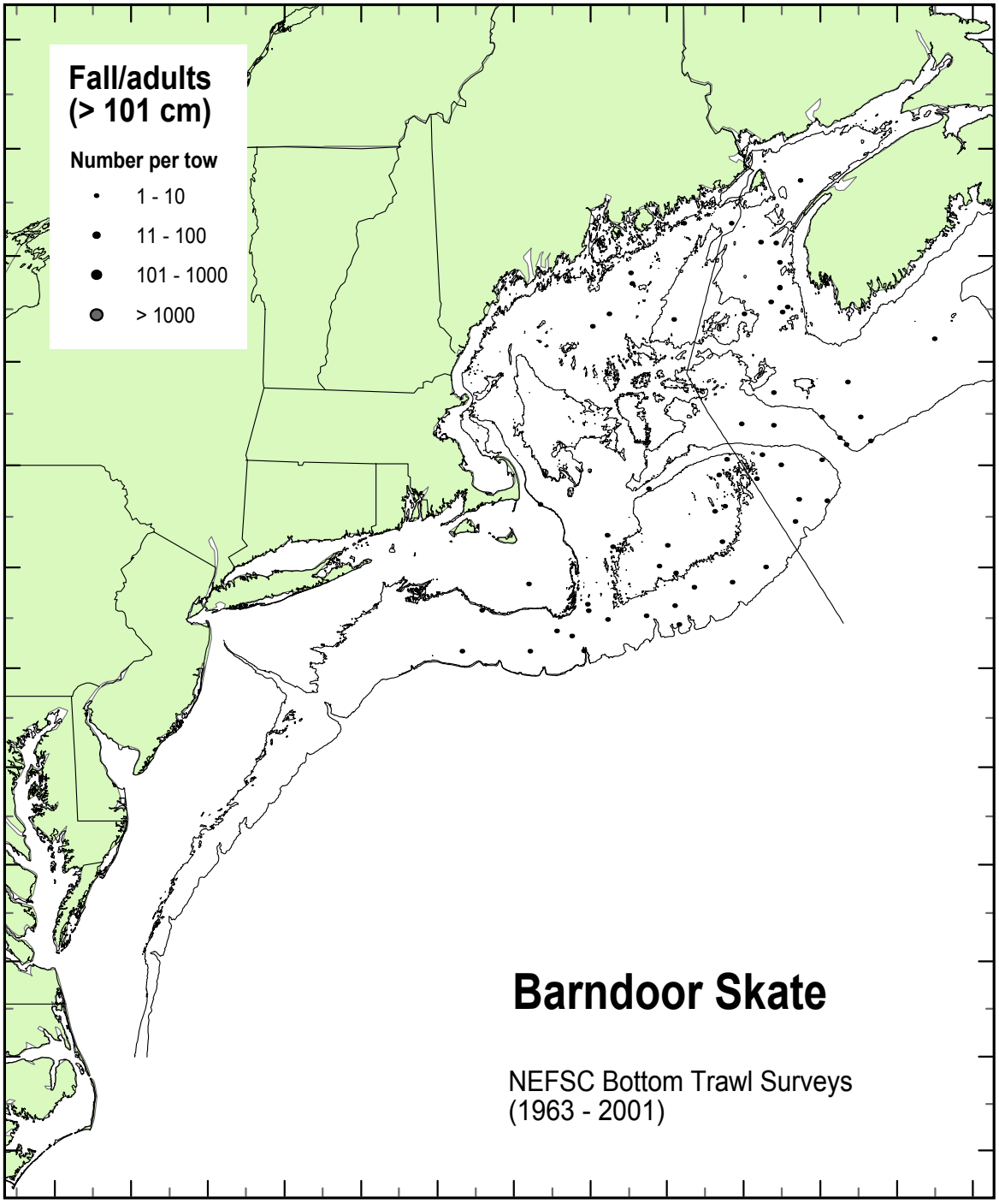

Figure 11. Distribution and abundance of adult barndoor skate collected during fall NEFSC bottom trawl surveys [1963-2001, all years combined; see Reid *et al.* (1999) for details].

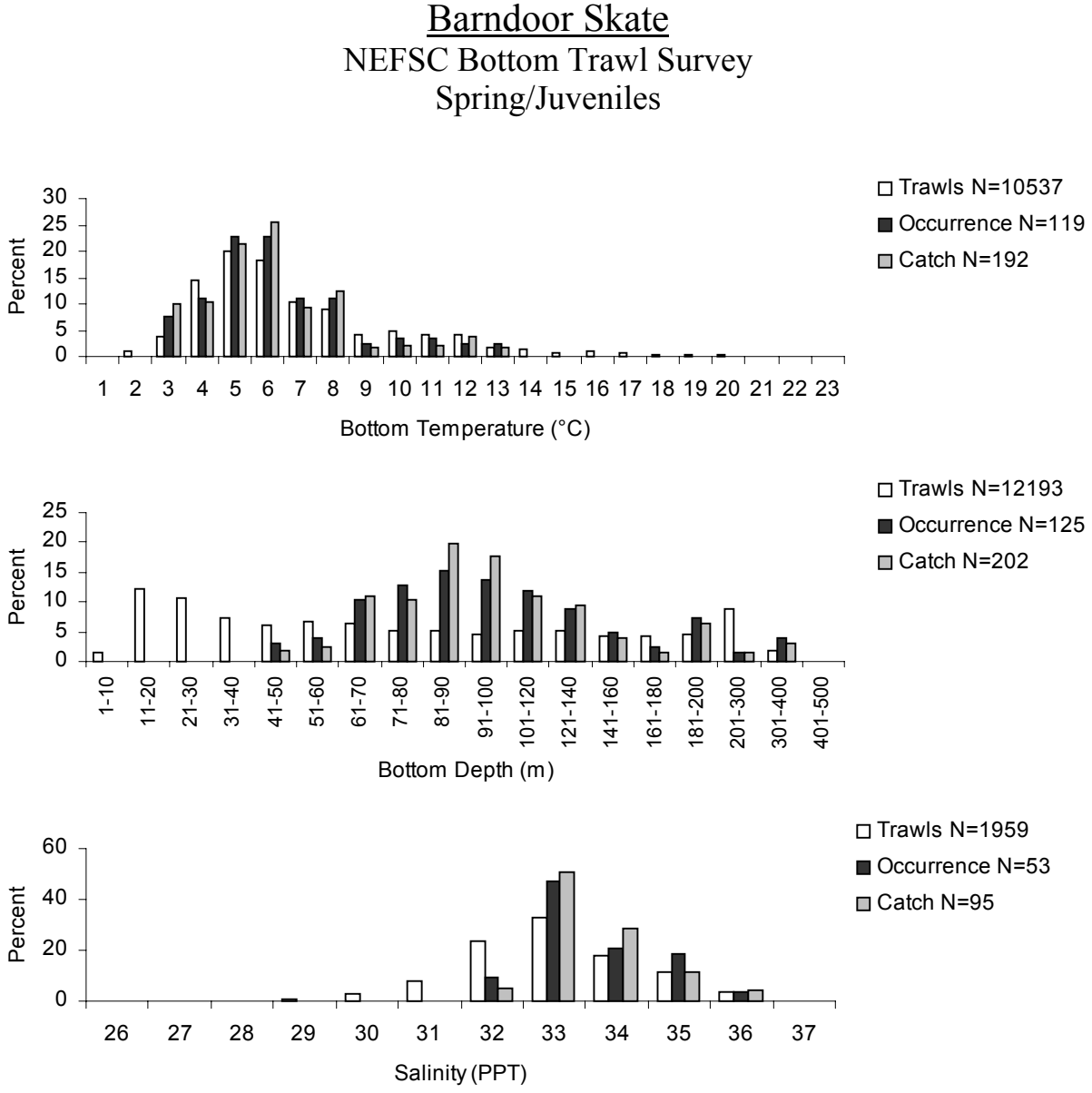

Figure 12. Spring and fall distributions of juvenile barndoor skate and trawls relative to bottom water temperature, depth, and salinity based on NEFSC bottom trawl surveys (1963-2002; all years combined). White bars give the distribution of all the trawls, black bars give the distribution of all trawls in which barndoor skate occurred, and gray bars represent, within each interval, the percentage of the total number of barndoor skate caught.

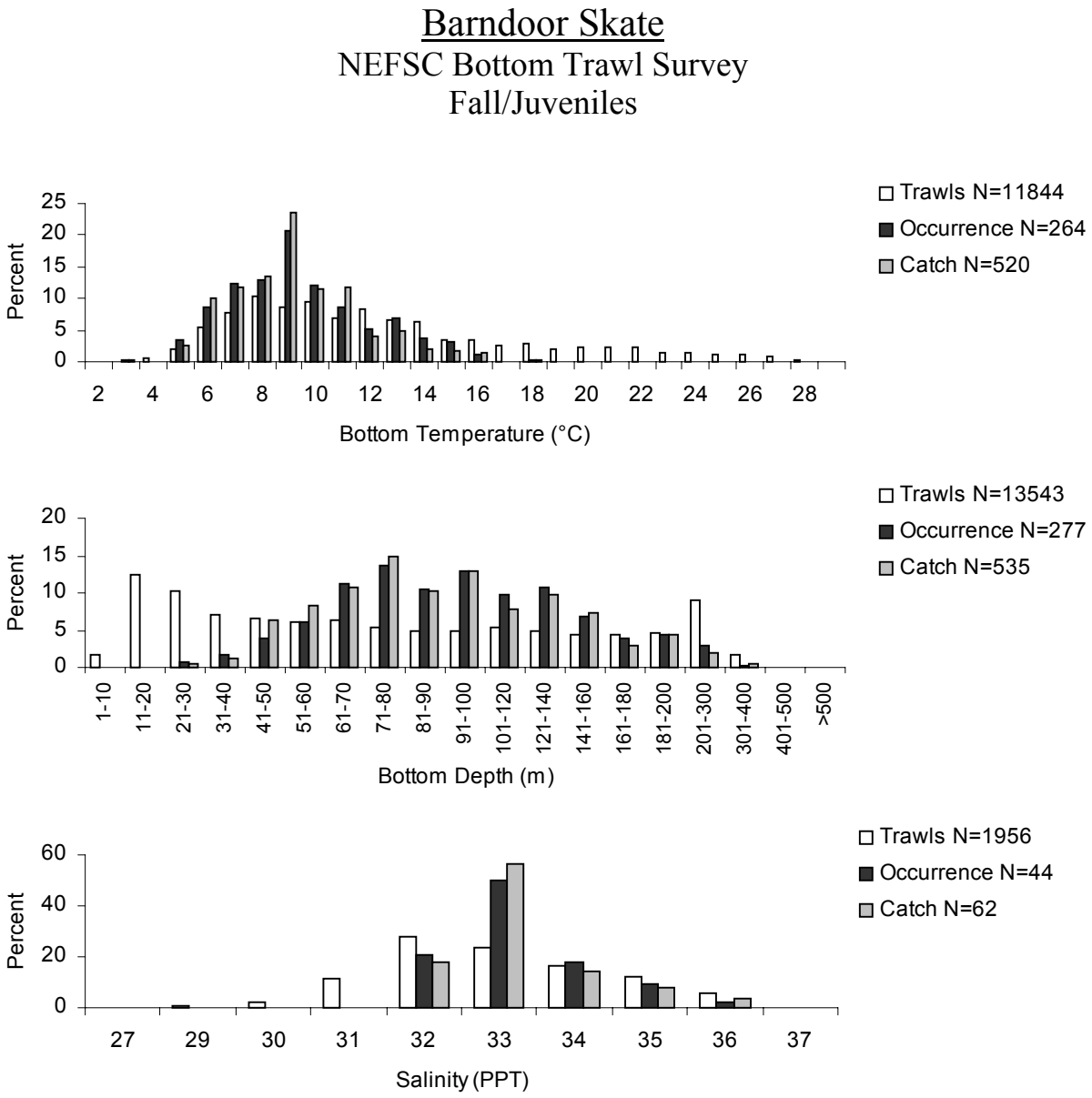

Figure 12. cont'd.

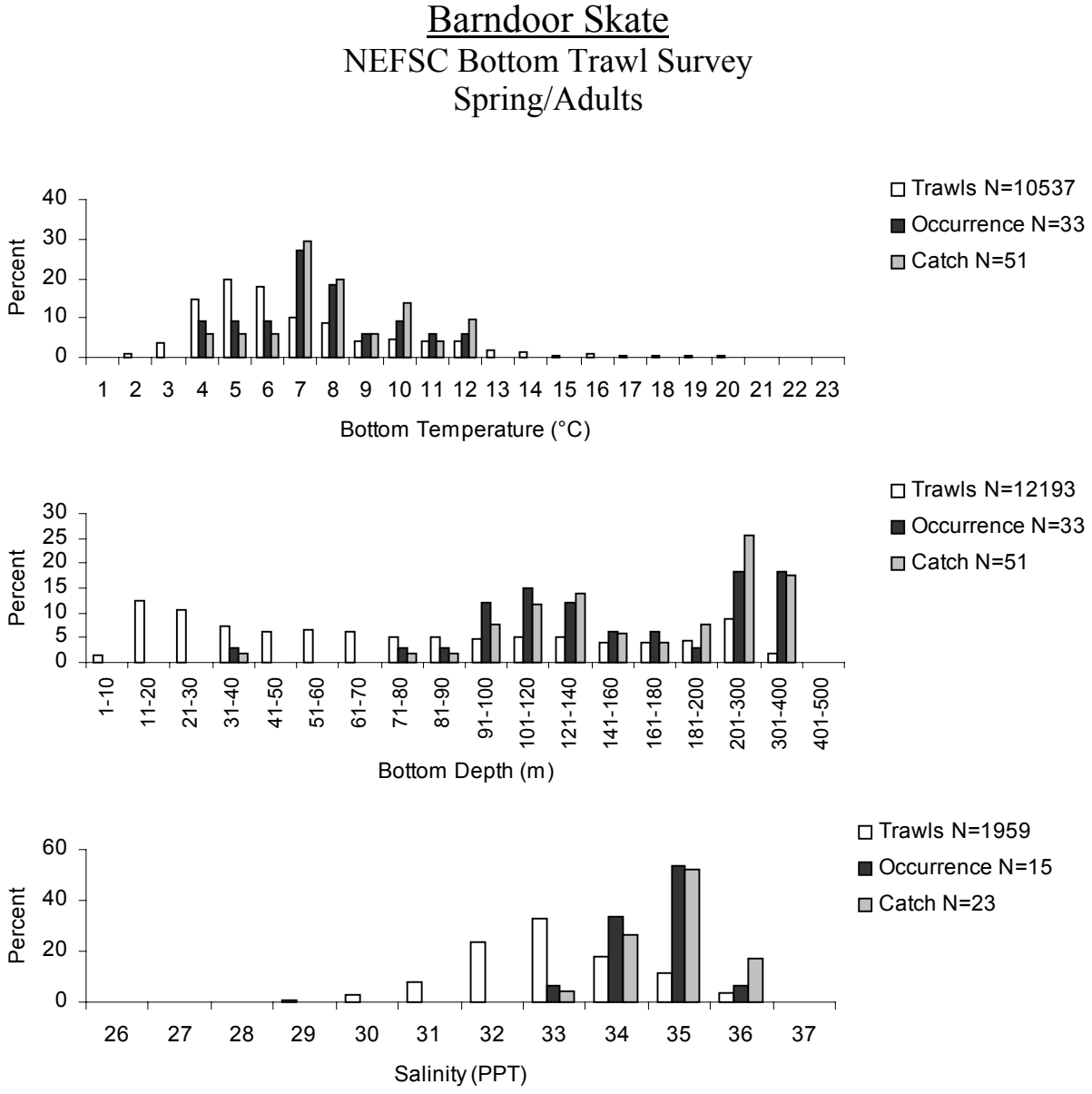

Figure 13. Spring and fall distributions of adult barndoor skate and trawls relative to bottom water temperature, depth, and salinity based on NEFSC bottom trawl surveys (1963-2002; all years combined). White bars give the distribution of all the trawls, black bars give the distribution of all trawls in which barndoor skate occurred, and gray bars represent, within each interval, the percentage of the total number of barndoor skate caught.

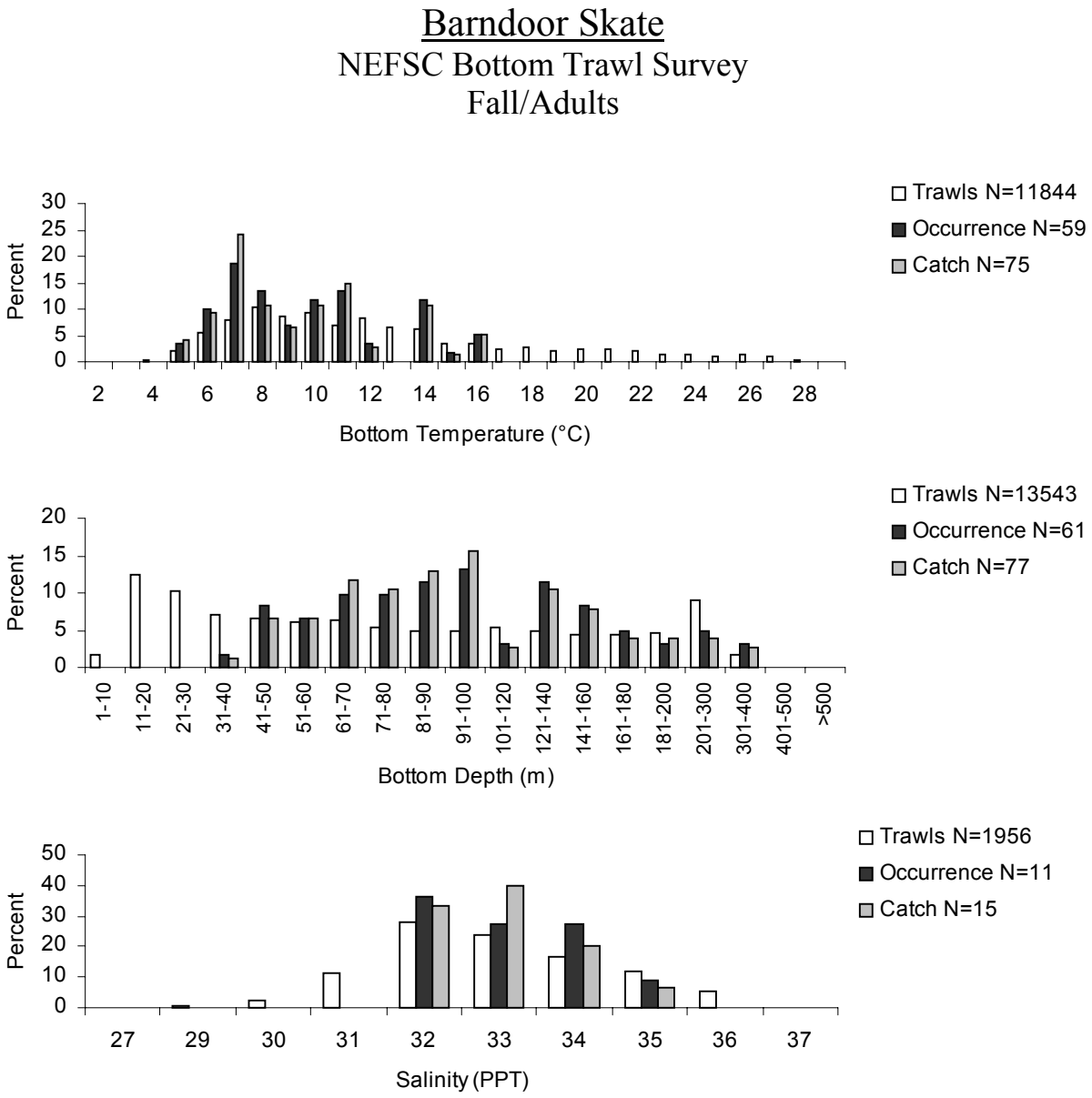

Figure 13. cont'd.

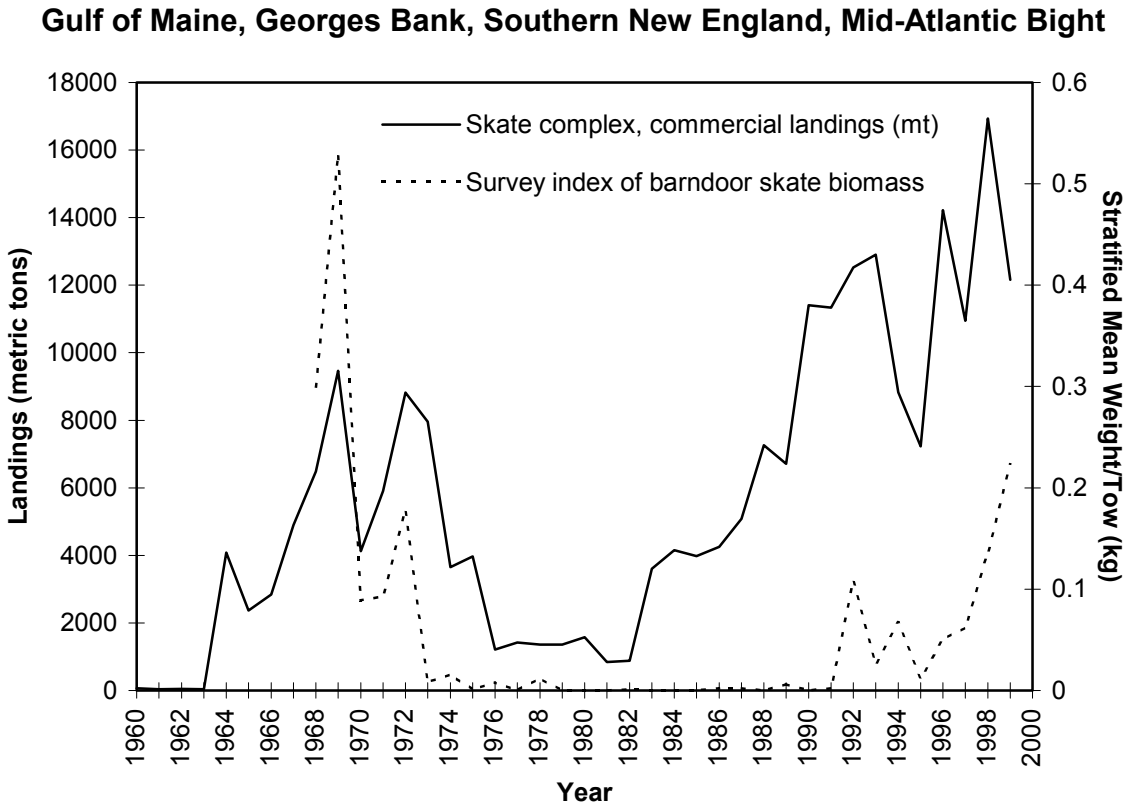

Figure 14. NEFSC spring survey index of barndoor skate biomass and commercial landings of the seven species skate complex from the Gulf of Maine to the Mid-Atlantic Bight.

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