NOAA Technical Memorandum NMFS-NE-150

Essential Fish Habitat Source Document:

Spiny Dogfish, *Squalus acanthias*, 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

September 1999

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Essential Fish Habitat Source Document:

Spiny Dogfish, *Squalus acanthias*, Life History and Habitat Characteristics

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September 1999

Editorial Notes on Issues 122-152 in the *NOAA Technical Memorandum NMFS-NE* Series

Editorial Production

For Issues 122-152, 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 authors and acknowledgees of each issue, as well as those noted below in "Special Acknowledgments."

Special Acknowledgments

David B. Packer, Sara J. Griesbach, and Luca M. Cargnelli coordinated virtually all aspects of the preprinting editorial production, as well as performed virtually all technical and copy editing, type composition, and page layout, of Issues 122-152. Rande R. Cross, Claire L. Steimle, and Judy D. Berrien conducted the literature searching, citation checking, and bibliographic styling for Issues 122-152. Joseph J. Vitaliano produced all of the food habits figures in Issues 122-152.

Internet Availability

Issues 122-152 are being copublished, *i.e.*, both as paper copies and as web postings. All web postings are, or will soon be, available at: *www.nefsc.nmfs.gov/nefsc/habitat/efh*. Also, all web postings will be in "PDF" format.

Information Updating

By federal regulation, all information specific to Issues 122-152 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 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]).

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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.

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 30 EFH species reports (plus one consolidated methods report). The EFH species reports comprise 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 have understandably 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 30 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

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NORTHEAST FISHERIES SCIENCE CENTER

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INTRODUCTION

The spiny dogfish, *Squalus acanthias* (Figure 1), is a coastal squaloid shark with a circumboreal distribution. In addition to being the most abundant shark in the western North Atlantic, it is also one of the most highly migratory species (Bigelow and Schroeder 1953). Dogfish range from Labrador to Florida, but are most abundant from Nova Scotia to Cape Hatteras, North Carolina (Figure 2) (Rago *et al.* 1994).

The Mid-Atlantic Fishery Management Council adopted a draft Fishery Management Plan (FMP) for spiny dogfish in August 1998. The management unit in this FMP is the entire spiny dogfish population along the Atlantic coast of the United States (MAFMC 1998). The objective of this Essential Fish Habitat (EFH) source document is to provide a summary of the life history, habitat characteristics, geographical distribution, status of the stock, and research needs for spiny dogfish.

LIFE HISTORY

JUVENILES AND ADULTS

Estimates of the length when 50% of spiny dogfish females are mature have varied temporally and geographically (Table 1). For the purpose of this document, the median lengths at which 50% of individuals are mature are 83 cm for females and 60 cm for males.

Spiny dogfish school by size until they mature and then they school by size and sex. (Templeman 1944; Bigelow and Schroeder 1953; Saulson 1982; Nammack *et al.* 1985; Marques da Silva 1993; Rago *et al.* 1994). Schools are often composed of very large, mature females; medium-sized individuals, either all mature males or all immature females; or small immature individuals of both sexes in equal numbers (Bigelow and Schroeder 1953).

REPRODUCTION

Fertilization takes place internally and development is ovoviviparous. Early stage development shows that ova in each oviduct are encased in a membranous, horny capsule called a candle. This membrane breaks down about four to six months after fertilization and leaves the embryos without placental attachment to the uterine wall (Branstetter and Burgess, in prep.). The remaining internal development takes place over 18-22 months (Northeast Fisheries Science Center 1997). Parturition occurs offshore in the winter (Bigelow and Schroeder 1953; Soldat 1979; Azarovitz *et al.* 1980; McMillan and Morse, unpublished data). Young dogfish, referred to as "pups," are born head-first. Litter sizes range from 1-15 pups, but usually average 6-7 (Northeast Fisheries Science Center 1997; Branstetter and Burgess, in prep.). The size at birth for both sexes ranges from 20-33 cm. Ford (1921) and Templeman (1944) report a sex ratio of 1:1 among newborn pups.

Nammack *et al*. (1985) estimated that the maximum age of males was 35 years and the maximum age of females was 40 years in the northwest Atlantic Ocean. Females grow larger than males and may reach a maximum length of 125 cm and weight of 10 kg (Northeast Fisheries Science Center 1997).

FOOD HABITS

Spiny dogfish are well known for their voracious and opportunistic predatory behavior. Swimming in large "packs," they will attack schools of fishes smaller than themselves, including cod, haddock, capelin, mackerel, herring, and sand lance. Their opportunistic nature is supported by their consumption of flatfishes, blennies, sculpins, ctenophores, jellyfish, polychaetes, sipunculids, amphipods, shrimps, crabs, snails, octopods, squids, and sea cucumbers (Templeman 1944; Bigelow and Schroeder 1953; Jensen 1965; Branstetter and Burgess, in prep.).

The opportunistic feeding behavior of spiny dogfish is evident in several published studies. During inshore surveys in the early 1960s off South Carolina, Atlantic menhaden, *Brevoortia tyrannus*, was the dominant fish collected in most of the trawls in which spiny dogfish were taken. Many of the dogfish examined were gorged on young menhaden ranging from 75-130 mm total length (TL) (Bearden 1965). On the Scotian Shelf, the two most abundant species of zooplankton in Emerald and La Have basins are the copepod, *Calanus finmarchicus*, and the euphausiid, *Meganyctiphanes norvegica*. Sameoto *et al.* (1994) reported that stomachs of spiny dogfish from trawls on the Scotian Shelf in 1989 contained these zooplankton and there was no evidence that they were feeding on fish.

Fish, arthropods, and ctenophores dominated the stomachs of spiny dogfish collected during the Northeast Fisheries Science Center (NEFSC) bottom trawl surveys from 1973 through 1990 (Figure 3). More than 11,000 stomachs were analyzed and the diversity of prey selection supports observations from the literature.

MIGRATION

Spiny dogfish migrate northward in the spring and summer and southward in the fall and winter (Jensen 1965). Fish that spend the summer north of Cape Cod move south to Long Island in the fall and as far south as North Carolina in the winter (Branstetter and Burgess, in prep.). Winter catches in waters south of North Carolina were reported by Bearden (1965) and Hess (1966) and occurrences as far south as Cuba were reported by Bigelow and Schroeder (1953).

Seasonal inshore-offshore movements and coastal migrations are related to water temperature (Bigelow and Schroeder 1953; Jensen 1965). Generally, spiny dogfish spend summers in inshore waters and overwinter in deeper offshore waters. They are usually epibenthic, but occur throughout the water column and are found from nearshore shallows to offshore shelf waters to 900 m (Branstetter and Burgess, in prep.).

STOCK STRUCTURE

The population of spiny dogfish in the northwest Atlantic is managed as a unit stock under the authority of the Mid-Atlantic Fishery Management Council (MAFMC 1998).

HABITAT CHARACTERISTICS

Habitat characteristics for juvenile and adult spiny dogfish are summarized by survey and geographic area in Table 2. In the spring, juveniles and adults occur in deeper, generally warmer waters on the outer shelf from North Carolina to Georges Bank. In the fall, they occur in the shallower, moderately warm waters from southern New England into the Gulf of Maine. Their seasonal distribution is similar in coastal areas. Dogfish are transient visitors to estuaries where they prefer higher salinities.

GEOGRAPHICAL DISTRIBUTION

The geographical distribution of spiny dogfish is described below, based on NEFSC and various state trawl surveys [see Reid *et al*. (1999) for survey methodology]. Additional information provided by the NOAA National Ocean Service's (NOS) Estuarine Living Marine Resources Program (ELMR) is summarized in Table 3 (Jury *et al*., 1994; Stone *et al*., 1994).

JUVENILES

The seasonal distribution and abundance data for juvenile spiny dogfish in the NEFSC bottom trawl surveys were limited to those surveys where sex was determined. In the winter, juvenile spiny dogfish were widespread across the shelf from North Carolina to the eastern edge of Georges Bank (Figure 4). Juveniles were absent on the western portions of Georges Bank and rare on Nantucket Shoals. The Gulf of Maine was not adequately sampled to allow us to describe juvenile distribution during winter.

In the NEFSC spring surveys, juveniles were concentrated in offshore waters from North Carolina to the eastern edge of Georges Bank (Figure 4). The largest catches were made along the outer shelf (60-200 m). Juveniles were nearly absent in the northwestern Gulf of Maine. During spring surveys, bottom water temperatures ranged from 1-22^{o}C and juvenile spiny dogfish occurred from 3-17^{o}C; most were captured between 8^{o} and 13^{o}C (Figure 5). Trawl stations occupied during the spring ranged from 5-439 m deep and juveniles were captured from 7-390 m; most were caught between 50 and 150 m.

In the summer, the NEFSC surveys where sex was determined were limited to 1993-1995 in the Gulf of Maine, so the distribution cannot be summarized during this season.

In the autumn NEFSC surveys, the highest catches were made around Nantucket Shoals, on Georges Bank, and in waters between Lurcher Shoal and German Bank off the coast of Nova Scotia. Juveniles were widespread throughout the Gulf of Maine (Figure 4). During the autumn surveys, bottom water temperatures ranged from 5-28^{o}C and juvenile spiny dogfish occurred from 5-20^{o}C; most were captured at 10-15^{o}C. Trawl stations occupied during autumn ranged from 5-481 m deep and juveniles were captured from 12-366 m; most were caught between 25 and 75 m (Figure 5).

In the spring Massachusetts bottom trawl surveys, juvenile spiny dogfish were not captured in the Gulf of Maine and were rarely captured in Buzzards Bay and Nantucket Sound (Figure 6). They were more abundant around the southwest part of Martha's Vineyard, south of Nantucket Island, along the northeast edge of Cape Cod, and north of Cape Cod Bay. In the spring, juveniles were six times more abundant than adults in trawl catches.

The northward migration of juveniles was evident in the spring and autumn Massachusetts bottom trawl surveys (Figure 6). The only noteworthy abundance south of Cape Cod occurred on Great Round Shoal, just northeast of Nantucket Island. Juveniles were captured along the eastern shore of Cape Cod from Nauset Beach northward around the tip of the Cape and into Cape Cod Bay. Juveniles were caught in large numbers around Cape Ann, throughout Ipswich Bay, and north and offshore of Plum Island. Adults were about twice as abundant as juveniles in the autumn.

During the spring Massachusetts bottom trawl surveys, bottom water temperatures ranged from 1-15^{o}C (Figure 7). Juvenile spiny dogfish occurred in waters with bottom temperatures of 2-14^{o}C; most were caught at temperatures of 7-10^{o}C. Trawl stations occupied during this season had bottom depths ranging from 5-82 m. Juveniles occurred at bottom depths ranging from 7-64 m; most were caught at depths between 10 and 44 m.

During the autumn Massachusetts bottom trawl surveys, bottom water temperatures were bimodal and ranged from 4-23^{o}C (Figure 7). Juveniles occurred at bottom temperatures ranging from 4-20^{o}C with peaks at 8-10^{o}C and 13-16^{o}C. Autumn trawl depths ranged from 4-82 m. Juvenile dogfish occurred between 8-82 m; most were caught at depths between 15 and 34 m.

ADULTS

In the NEFSC bottom trawl surveys, the distribution of adult spiny dogfish in the winter was similar to the distribution of juveniles (Figure 4). Adults occurred across the shelf from Cape Hatteras to the eastern edge of Georges Bank. Adults were rare in the New York Bight, on Nantucket Shoals, and absent from the western portion of Georges Bank.

In the spring, the distribution and relative abundance of adults were somewhat similar to that of the juveniles. Adults were abundant along the outer shelf from North Carolina to the Northeast Peak of Georges Bank and onto Browns Bank (Figure 4). Lesser numbers occurred inshore from Cape Hatteras to Long Island, the western portion of Georges Bank, and central Gulf of Maine.

In the summer, the NEFSC surveys where sex was determined were limited to 1993-1995 in the Gulf of Maine, so the distribution cannot be summarized during this season.

In autumn, adults were not collected on the shelf from North Carolina to just south of Hudson Canyon. Low numbers were captured south of Long Island (Figure 4). The highest catches occurred off Nantucket Shoals, along the eastern edge of Cape Cod, and in Cape Cod and Massachusetts Bays. Adults were also abundant southwest of Nova Scotia. Adults were collected sporadically throughout the Gulf of Maine and along the northwest edge of Georges Bank, although to a lesser degree than the juveniles.

During the spring NEFSC surveys, bottom water temperatures ranged from 1-22^{o}C. Adult spiny dogfish were captured at bottom temperatures between 3-17^{o}C; most individuals were caught between 7-11^{o}C (Figure 5). Trawl stations occupied during the spring ranged in depth from 5-439 m. Adults occurred from 7-439 m; most were caught between 50 and 149 m.

During the autumn NEFSC surveys, bottom temperature ranged from 5-28^{o}C (Figure 5). Adult spiny dogfish were captured at bottom temperatures between 5-19^{o}C; the majority were caught at bottom temperatures between 10-15^{o}C. Trawl stations occupied during autumn ranged in depth from 5-481 m. Adults occurred from 12-344 m; the majority were caught between 10 and 49 m.

In the spring Massachusetts bottom trawl surveys, adult spiny dogfish were collected in the southern portions of the survey area and were most abundant on the south shores of Nantucket Island, northeast of Cape Cod, and in Cape Cod Bay (Figure 6). Adult were absent north of Cape Cod Bay, which was due to their seasonal migration patterns.

In the autumn Massachusetts surveys, the highest catches of adults occurred along the eastern shore of Cape Cod near Nauset Beach, near the tip of the Cape, and within Cape Cod Bay (Figure 6). They were also caught near Cape Ann, Ipswich Bay, and Plum Island, but were rare in the southern portion of the survey area except northeast of Nantucket Island.

During the spring Massachusetts surveys, bottom water temperatures ranged from 1-15^{o}C. Adult spiny dogfish were caught at bottom water temperatures between 1-14^{o}C; most were caught between 6-12^{o}C (Figure 7). Bottom depths during the spring surveys ranged from 5-82 m. Adults were captured at depths ranging from 6-64 m; most were caught in less than 45 m of water.

During autumn Massachusetts surveys, bottom temperatures ranged from 4-23^{o}C. Adult spiny dogfish were caught at bottom water temperatures between 4-20^{o}C; most were caught from 9-15^{o}C (Figure 7). Bottom depths during the autumn surveys ranged from 4-82 m. Adults were captured at depths ranging from 6-82 m; most were caught between 10 and 34 m.

OTHER SURVEYS

In the Long Island Sound survey, sexes and sizes were not recorded, so adults and juveniles are considered together.

Spiny dogfish entered Long Island Sound in May and June and departed by early August (Gottschall *et al.*, in review) (Figure 8). They were found in waters deeper than 27 m with sandy and transitional sand-mud bottoms. Spiny dogfish returned to the sound in the fall, with the largest catches and widest distribution during November. These autumn transients preferred mud and/or transition bottoms and waters deeper than 27 m.

In the Hudson-Raritan estuary survey, although sizes were recorded, sexes were not, so adults and juveniles are considered together.

Spiny dogfish were transient visitors to the Hudson-Raritan estuary (Figure 9). Spiny dogfish were not caught during the 1992 and 1993 surveys. From 1994 to 1996, spiny dogfish were caught in small numbers in December and were not caught in January. In 1997, spiny dogfish were caught in November in small numbers and were absent in December and January.

Spiny dogfish were caught at bottom depths of 13-20 m, at bottom water temperatures between 7.1-11.3^{o}C, at bottom dissolved oxygen levels between 8.2-11.2 mg/L, and at bottom salinities between 30.7-32.2 ppt (Figure 9).

STATUS OF THE STOCKS

The total commercial landings of spiny dogfish increased from 1968 through 1974, due largely to the foreign fleet harvest, most notably the former USSR (Figure 10). [The combined commercial landings of spiny dogfish (1963-1996) include U.S., Canada, foreign, and U.S. recreational catches. The U.S. recreational catch data is not included from 1968-1980.] Foreign fishing continued through 1977. With the advent of the Exclusive

Economic Zone, the foreign harvest dwindled to a low in 1979, but landings by the U.S. and Canada have been steadily increasing since then. A sharp intensification of the U.S. commercial fishery began in 1990. Estimated landings for 1996, in excess of 28,000 metric tons, represent the highest landings since 1962.

As of August 1998, spiny dogfish are classified as overfished as a result of an increased directed fishery (MAFMC 1998). The increased effort to harvest spiny dogfish is due to the ongoing decline in the abundance of traditional groundfish. With this increase in effort comes an increase in fishing mortality, especially on adult females that are targeted because of their larger size. There has been a six-fold increase in commercial landings of spiny dogfish in the last seven years.

RESEARCH NEEDS

The following list of research needs is based on the current review and analyses of spiny dogfish data. For a more detailed list of research needs, see Northeast Fisheries Science Center (1994, 1997).

- Update age and growth estimates.
- Update length at maturity estimates.
- Update and investigate food habits of young-of-the-year (< 35 cm) and recruits (> 35 cm).
- Improve estimates of discards by non-directed fisheries.
- Investigate potential databases from coastal states regarding estuarine use, particularly the ELMR mid-Atlantic region.
- Increase the frequency of sex determination for all surveys and seasons.

ACKNOWLEDGMENTS

We wish to thank C. Steimle and R. Ramsey-Cross for their expertise and assistance in the literature search; P. Rago for review of the manuscript; J. Cross for manuscript review and editing and for providing the status of the stock analyses; and J. Vitaliano for providing food habits analyses.

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Table 1. Estimates of spiny dogfish size at 50% maturity for females from 1944 to 1993.

Study	Years	Area	Age	Length
Templeman 1944	1940s	Newfoundland	7-8 years	74 cm
Bigelow & Schroeder 1953	1950s	Gulf of Maine		75 cm
Nammack *et al*. 1985	1980 – 1981	Mid-Atlantic & Southern New England	12.1 years	79.9 cm
Marques da Silva 1993	1980 – 1981	Northwest Atlantic	12 years	80.6 cm
Marques da Silva 1993	1985 – 1986	Northwest Atlantic		85.9 cm
Marques da Silva 1993	1987 – 1988	Northwest Atlantic		82.2 cm
Marques da Silva 1993	1991	Northwest Atlantic		84.1 cm
Marques da Silva 1993	1968 – 1990	Northwest Atlantic		83.1 cm*

* Mean length calculated from Figure 4.4 in Marques da Silva (1993).

Table 2. Summary of life history and habitat characteristics for spiny dogfish, *Squalus acanthias*.[1] Abbreviations: NEFSC = Northeast Fisheries Science Center; OR = observed range; OA = occurred at; PR = preferred range.

Life Stage and Study	Geographic Location	Spatial/Temporal Distribution	Bottom Depth/ Bottom Type	Bottom Temperature	Salinity	Estuarine Use	Prey
JUVENILES NEFSC Bottom Trawl Surveys	Northwest Atlantic	WINTER: across the shelf from North Carolina (NC) to Georges Bank (GB). SPRING: across shelf from NC. GB, more abundant offshore. SUMMER: inadequate sampling. AUTUMN: Nantucket Island, GB, between Lurcher Shoal and German Bank.	SPRING: OR: 5-439 m OA: 7-390 m PR: 50-150 m AUTUMN OR: 5-481 m OA: 12-366 m PR: 25-75 m	SPRING OR: 1-22°C OA: 3-17°C PR: 8-13°C AUTUMN OR: 5-28°C OA: 5-20°C PR: 10-15°C		Estuaries not sampled	Major predators on some commercially important species, mainly herring, Atlantic mackerel, squids, and to a lesser extent, haddock and cod.
Massachusetts Inshore Trawl Survey	Inshore from Vineyard Sound to Cape Ann	SPRING: southwest Martha's Vineyard, southern Nantucket Island, northeast Cape Cod, northern Cape Cod Bay. AUTUMN: northeast Nantucket Island, Cape Cod and Cape Cod Bay, Cape Ann.	SPRING: OR: 5-82 m OA: 7-64 m PR: 10-44 m AUTUMN: OR: 4-82 m OA: 8-82 m PR: 15-34 m	SPRING OR: 1-15°C OA: 2-14°C PR: 7-10°C AUTUMN OR: 4-23°C OA: 4-20°C PR: 8-10°C 13-16°C* * Bimodal preference		Estuaries not sampled	
ADULTS NEFSC Bottom Trawl Surveys	Northwest Atlantic	WINTER: across the shelf from NC to GB. SPRING: outer shelf from NC to northeast peak of GB, Browns Bank. SUMMER: Inadequate sampling AUTUMN: Nantucket Shoals, eastern Cape Cod, Cape Cod and Massachusetts Bays.	SPRING OR: 5-439 m OA: 7-439 m PR: 50-149 m AUTUMN OR: 5-481 m OA: 12-344 m PR: 10-49 m	SPRING OR: 1-22°C OA: 3-17°C PR: 7-11°C AUTUMN OR: 5-28°C OA: 5-19°C PR: 10-15°C			See above
Massachusetts Inshore Trawl Survey	Inshore from Vineyard Sound to Cape Ann	SPRING: southern Nantucket Island, northeast Cape Cod, Cape Cod Bay. Absent in the Gulf of Maine. AUTUMN: Eastern Cape Cod, northern Cape Cod, Cape Cod Bay, Cape Ann, Ipswich Bay, Plum Island.	SPRING OR: 4-82 m OA: 6-64 m PR: < 45 m AUTUMN OR: 4-82 m OA: 6-82 m PR: 10-34 m	SPRING OR: 1-15°C OA: 1-14°C PR: 6-12°C AUTUMN OR: 4-23°C OA: 4-20°C PR: 9-15°C			
Connecticut Bottom Trawl Survey (Gottschall *et al.*, in review)	Long Island Sound	Enter the Sound in May and June and depart by early August. Return in Sept-Nov with highest numbers in Nov.	May-June: prefer waters > 27 m; sand to transitional sand-mud bottoms. Sept-Nov: prefer waters > 27 m; mud and/or transitional bottoms.				
Hudson-Raritan Estuary Trawl Surveys (Reid *et al*. 1999)	Hudson-Raritan estuary	Nov-Dec 1994-1997. Found on Romer Shoals, East Bank, and Ambrose channel.	OA: 12-18 m	OA: 7.1 - 11.3°C	OA: 30.7 - 32.2 ppt		Crabs, eels, various small fishes

[1] In addition to the references cited in the text, the following references were used to construct this table: Cohen (1982), Jensen (1961), Jensen *et al.* (1961), Schwartz (1964), Scott (1982a,b), and Woodhead *et al.* (1976).

Table 3. Summary of the distribution and relative abundance of spiny dogfish, *Squalus acanthias*, in North Atlantic and Mid-Atlantic estuaries by salinity zone [based on Estuarine Living Marine resources (ELMR) data in Jury *et al*. (1994) and Stone *et al*. (1994)]. Salinity zone**:** T = tidal fresh, 0.0-0.5 ppt; M = mixing zone, 0.5-25 ppt; S = Seawater Zone, > 25 ppt. Relative abundance: h = highly abundant, a = abundant, c = common, r = rare, blank = not present, n = no data presented, * = no data available, nz = salinity zone not present. Data reliability: highly certain = bold and underlined text, moderately certain = bold italicized text, reasonable inference = normal text.

Estuary	**Adults**			**Mating**			**Juveniles**			**Parturition**		
	T	**M**	**S**	**T**	**M**	**S**	**T**	**M**	**S**	**T**	**M**	**S**
Passamaquoddy Bay		***c***	***a***			na		***c***	***a***	*	*	na
Englishman/Machias Bays		c	a			na		c	a	*	*	na
Narragaugus Bay		c	a			na		c	a	*	*	na
Blue Hill Bay		c	a			na		c	a	*	*	na
Penobscot Bay		c	a			na		c	c	*	*	na
Muscongus Bay		***c***	***c***			na		***c***	***c***	*	*	na
Damariscotta Bay		***c***	***c***			na		***c***	***c***			na
Sheepscot Bay		***c***	***c***			na		***c***	***c***			na
Kennebec/Androscoggin Rivers		***c***	***c***			na		***c***	***c***			na
Casco Bay		r	c					r	c			
Saco Bay		r	c					r	c			
Wells Harbor	nz			nz			nz			nz		
Great Bay												
Merrimack River			nz			nz			nz			nz
Massachusetts Bay	nz	nz	***a***	nz	nz	na	nz	nz	***a***	nz	nz	na
Boston Harbor	nz	r	r	nz			nz	r	r	nz		
Cape Cod Bay	nz	r	a	nz		na	nz	r	a	nz		na
Waquoit Bay	n	n	n	n	n	n	n	n	n	n	n	n
Buzzards Bay	n	n	n	n	n	n	n	n	n	n	n	n
Narragansett Bay	n	n	n	n	n	n	n	n	n	n	n	n
Connecticut River	n	n	n	n	n	n	n	n	n	n	n	n
Gardiners Bay	n	n	n	n	n	n	n	n	n	n	n	n
Long Island Sound	n	n	n	n	n	n	n	n	n	n	n	n
Great South Bay	n	n	n	n	n	n	n	n	n	n	n	n
Hudson River/Raritan Bay	n	n	n	n	n	n	n	n	n	n	n	n
Barnegat Bay	n	n	n	n	n	n	n	n	n	n	n	n
New Jersey Inland Bays	n	n	n	n	n	n	n	n	n	n	n	n
Delaware Bay	n	n	n	n	n	n	n	n	n	n	n	n
Delaware Inland Bays	n	n	n	n	n	n	n	n	n	n	n	n
Chincoteague Bay	n	n	n	n	n	n	n	n	n	n	n	n
Chesapeake Bay Mainstem	n	n	n	n	n	n	n	n	n	n	n	n
Chester River	n	n	n	n	n	n	n	n	n	n	n	n
Choptank River	n	n	n	n	n	n	n	n	n	n	n	n
Patuxent River	n	n	n	n	n	n	n	n	n	n	n	n
Potomac River	n	n	n	n	n	n	n	n	n	n	n	n
Tangier/Pocomoke Sounds	n	n	n	n	n	n	n	n	n	n	n	n
Rappahannock River	n	n	n	n	n	n	n	n	n	n	n	n
York River	n	n	n	n	n	n	n	n	n	n	n	n
James River	n	n	n	n	n	n	n	n	n	n	n	n

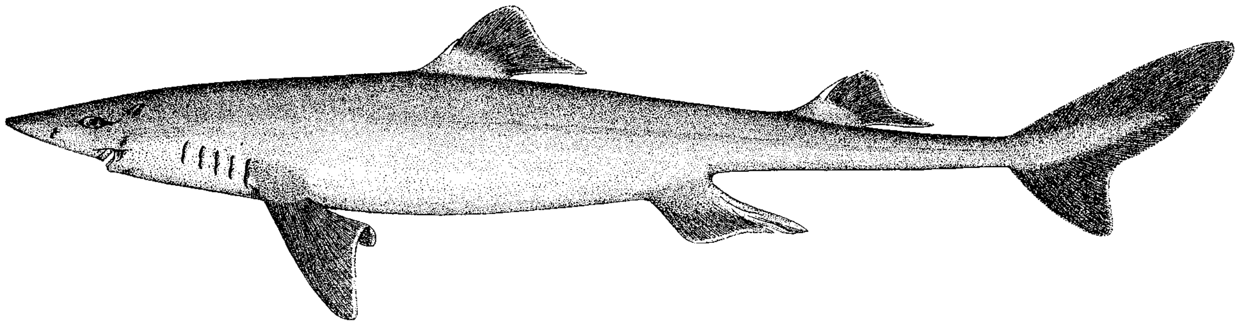
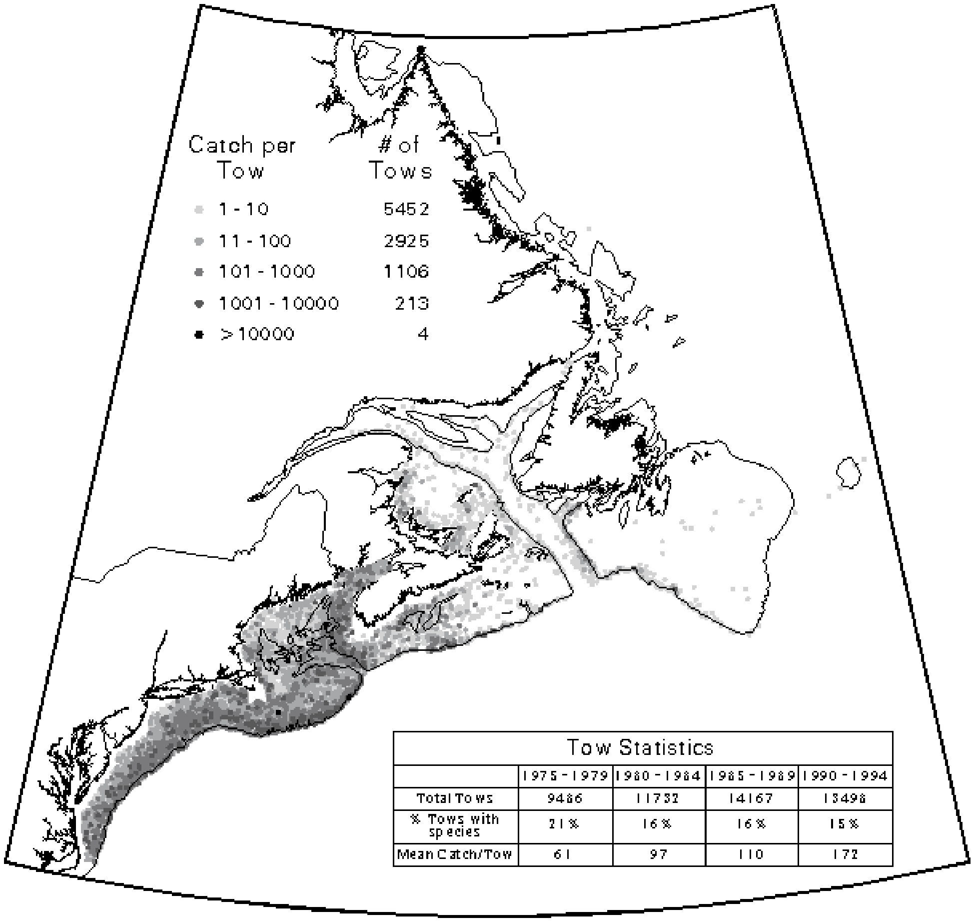


Figure 1. The spiny dogfish, *Squalus acanthias* (from Goode 1884).



Tow Statistics

	1975 - 1979	1980 - 1984	1985 - 1989	1990 - 1994
Total Tows	9486	11732	14167	13498
% Tows with species	21%	16%	16%	15%
Mean Catch/Tow	61	97	110	172

Figure 2. Distribution and abundance of spiny dogfish in the northwest Atlantic Ocean during 1975-1994, from the U.S. NOAA/Canada DFO East Coast of North America Strategic Assessment Project (http://www-orca.nos.noaa.gov/projects/ecnasap/ecnasap_table1.html).

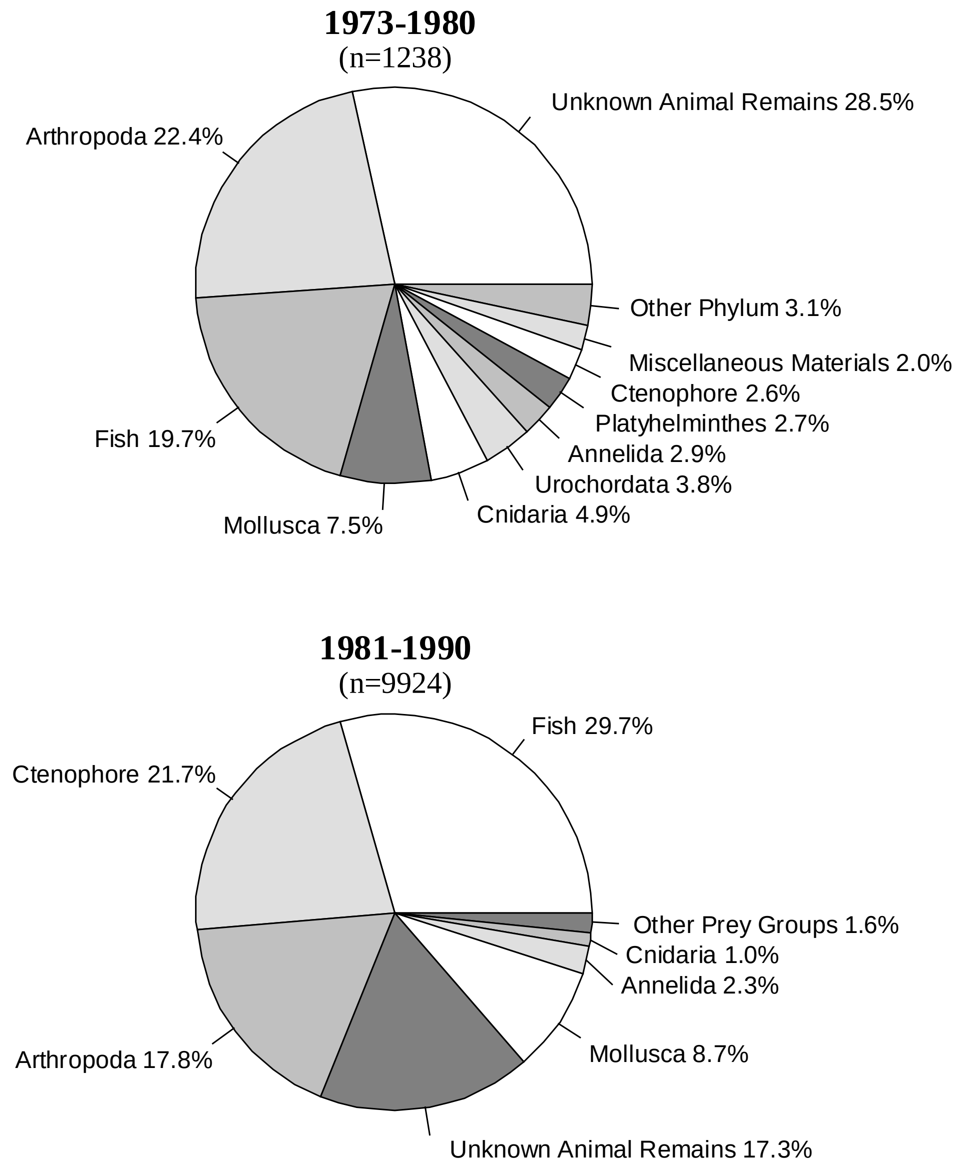


Figure 3. Abundance (percent occurrence) of the major items in the diet of spiny dogfish collected during NEFSC bottom trawl surveys from 1973-1980 and 1981-1990. The category “unknown animal remains” refers to unidentifiable animal matter. Methods for sampling, processing, and analysis of samples differed between the time periods [see Reid *et al.* (1999) for details].

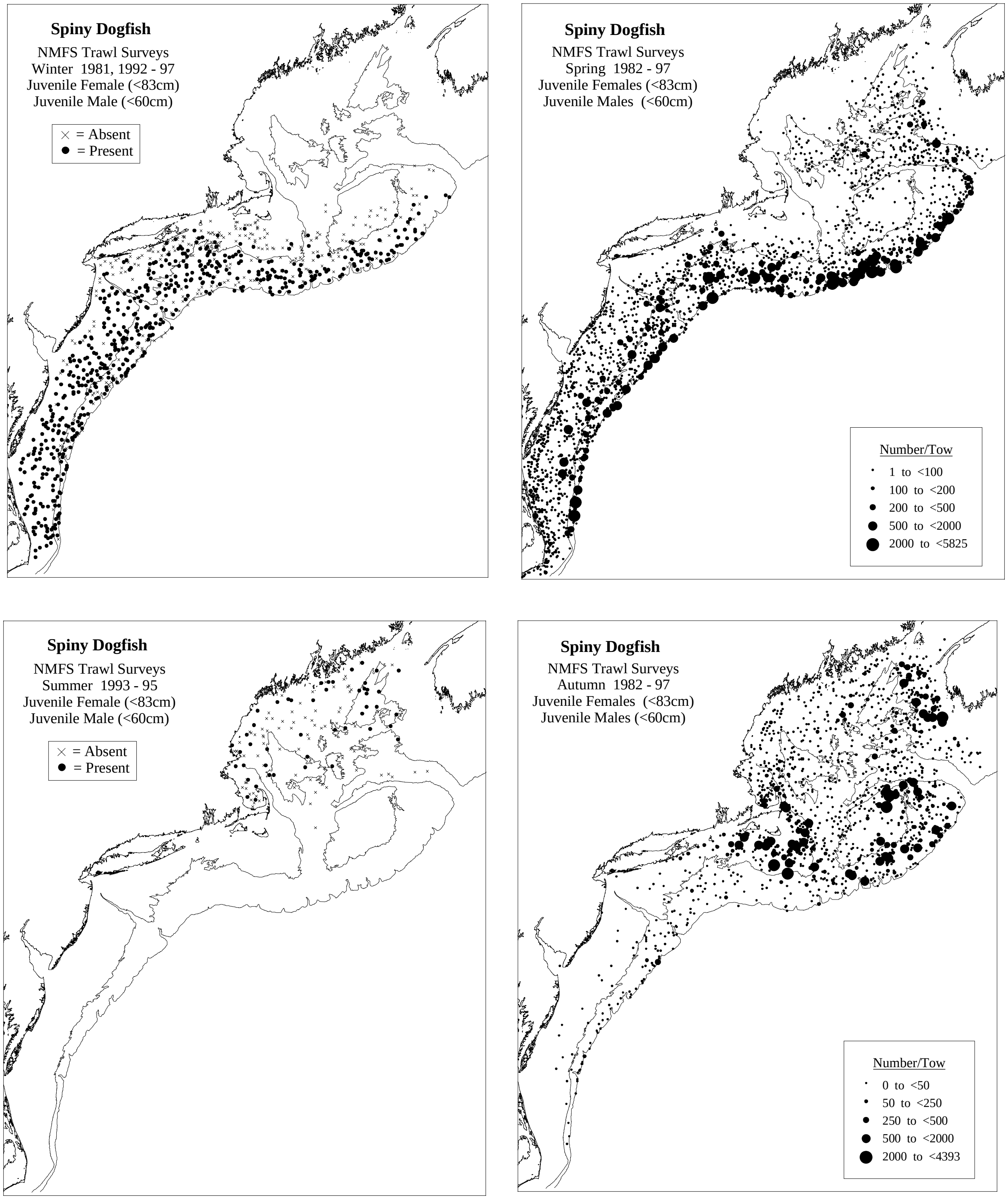
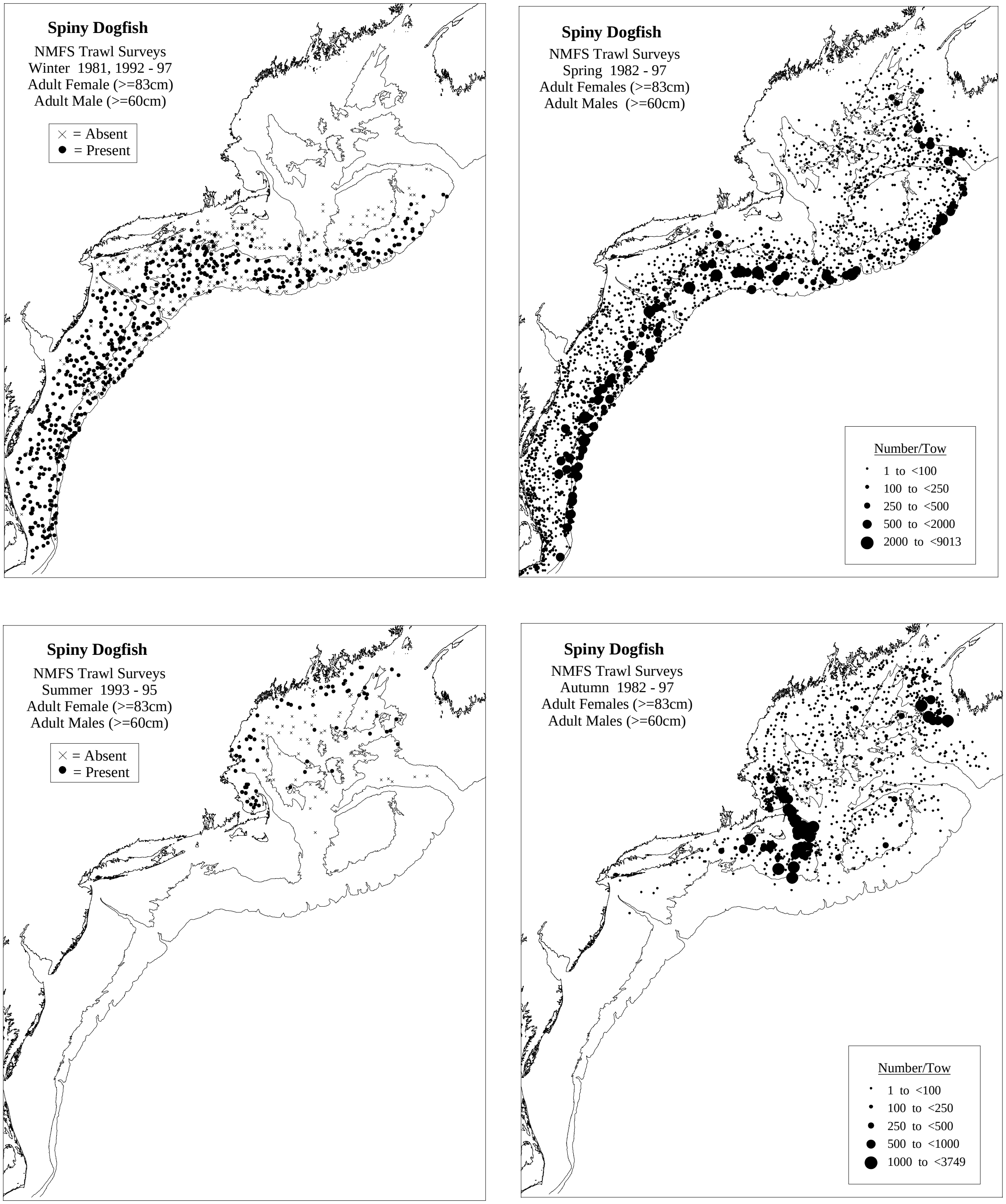


Figure 4. Seasonal distribution and abundance of juvenile and adult spiny dogfish collected during NEFSC bottom trawl surveys. Densities are represented by dot size in spring and fall plots, while only presence and absence are represented in winter and summer plots [see Reid *et al.* (1999) for details].



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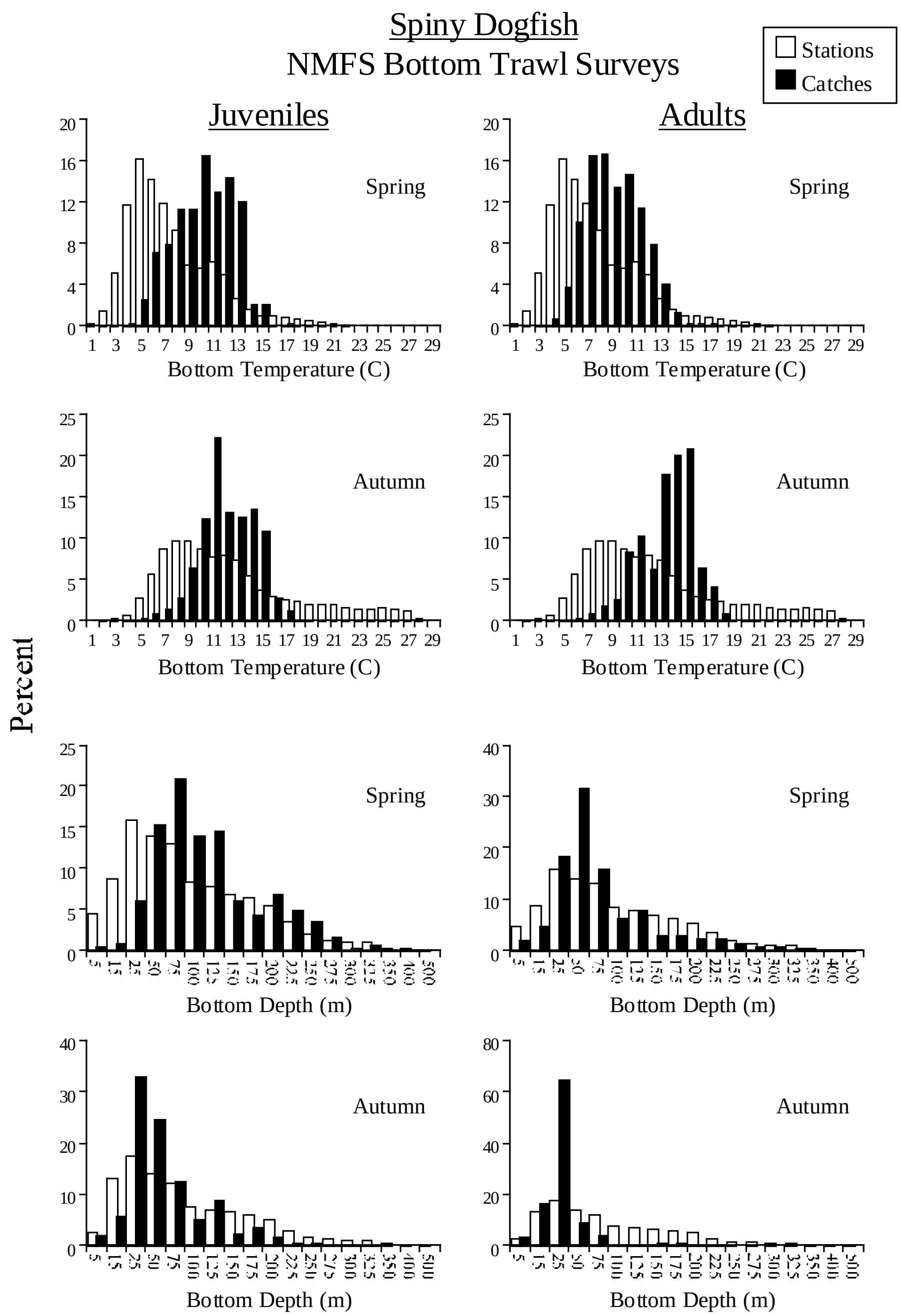


Figure 5. Abundance of juvenile and adult spiny dogfish relative to bottom water temperature and depth based on NEFSC spring and autumn bottom trawl surveys (all years combined). Open bars represent the proportion of all stations surveyed, while solid bars represent the proportion of the sum of all standardized catches (number/10 m^2).

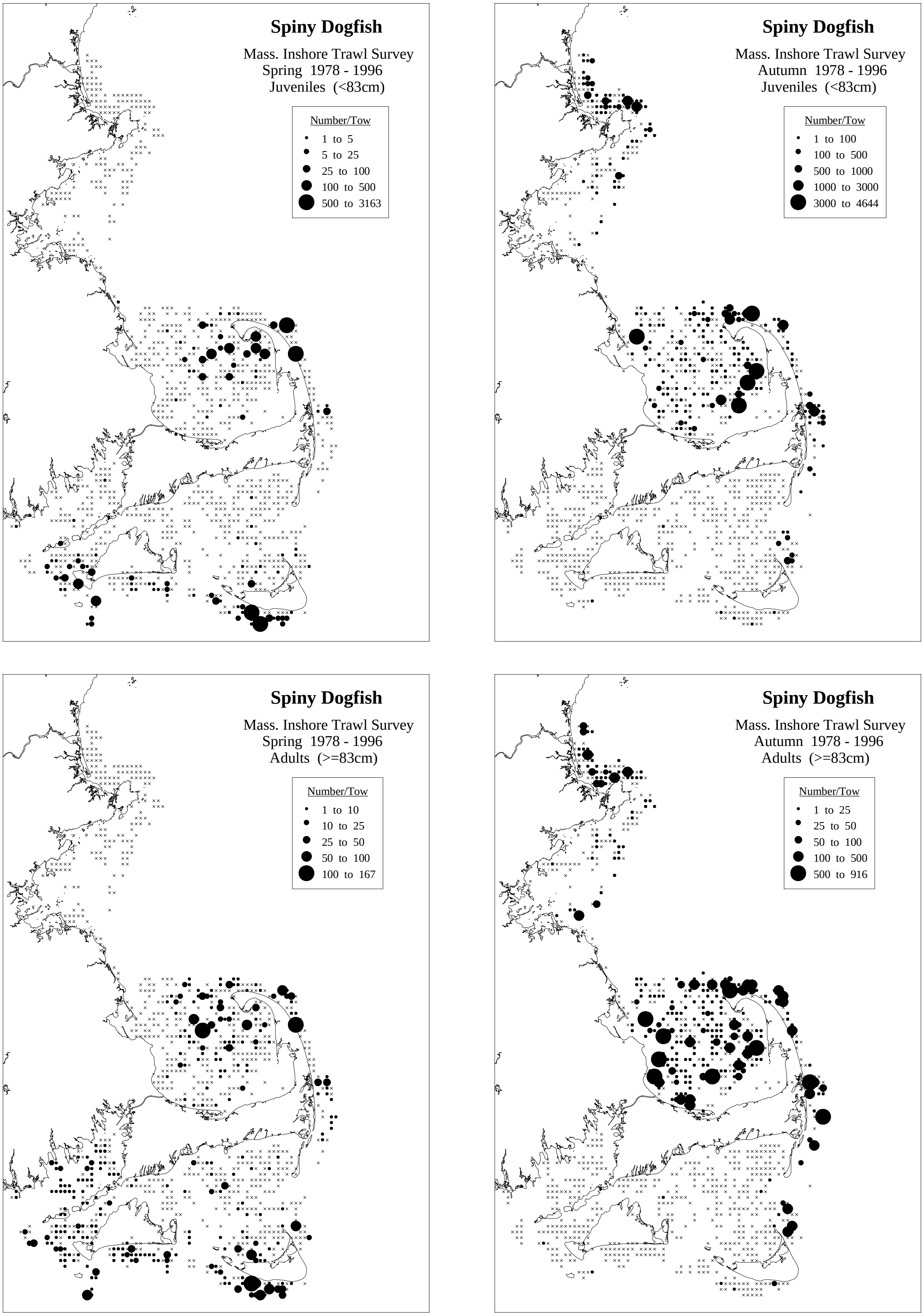


Figure 6. Distribution and abundance of juvenile and adult spiny dogfish in Massachusetts coastal waters during spring and autumn Massachusetts trawl surveys, 1978-1996 [see Reid *et al.* (1999) for details].

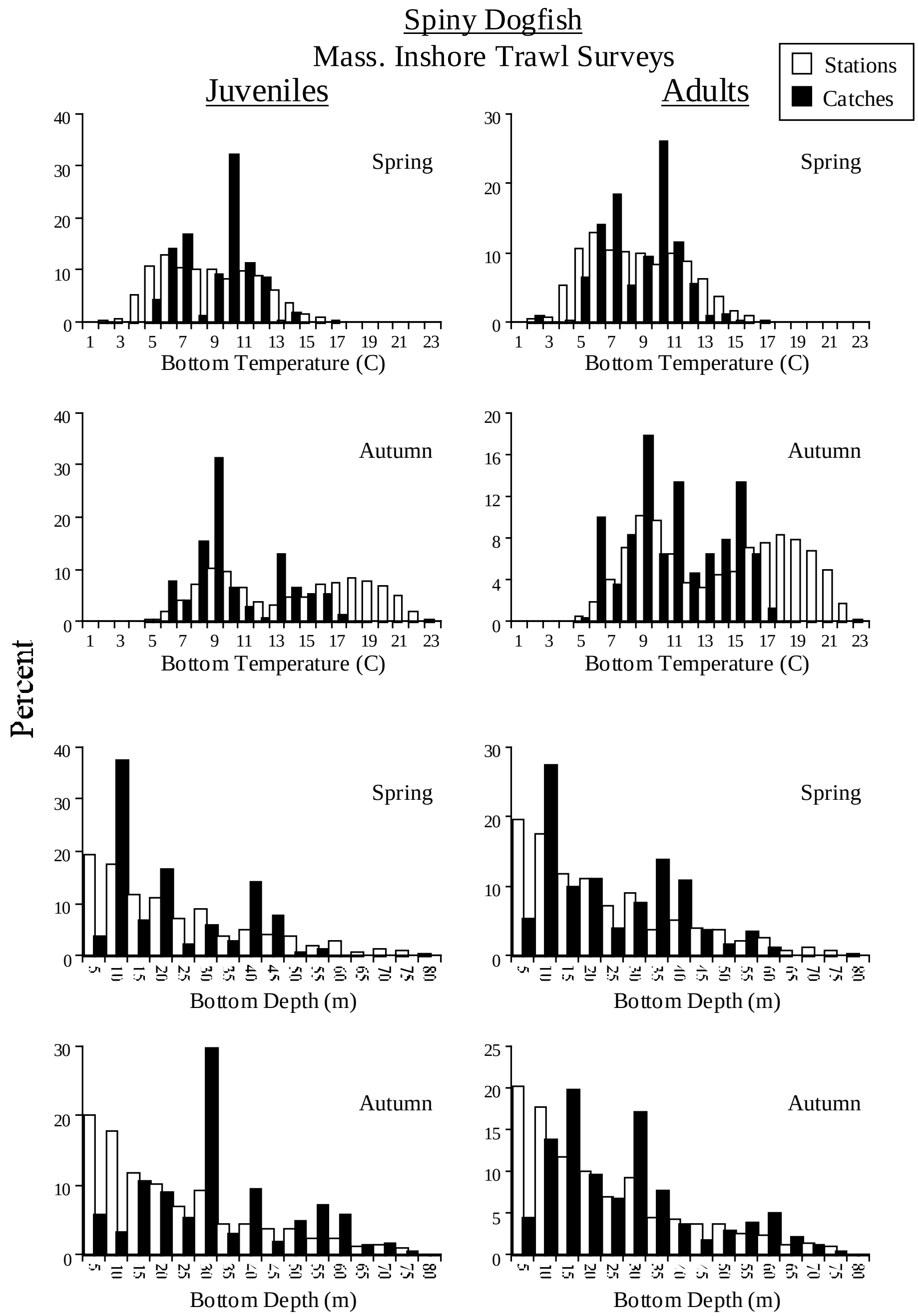
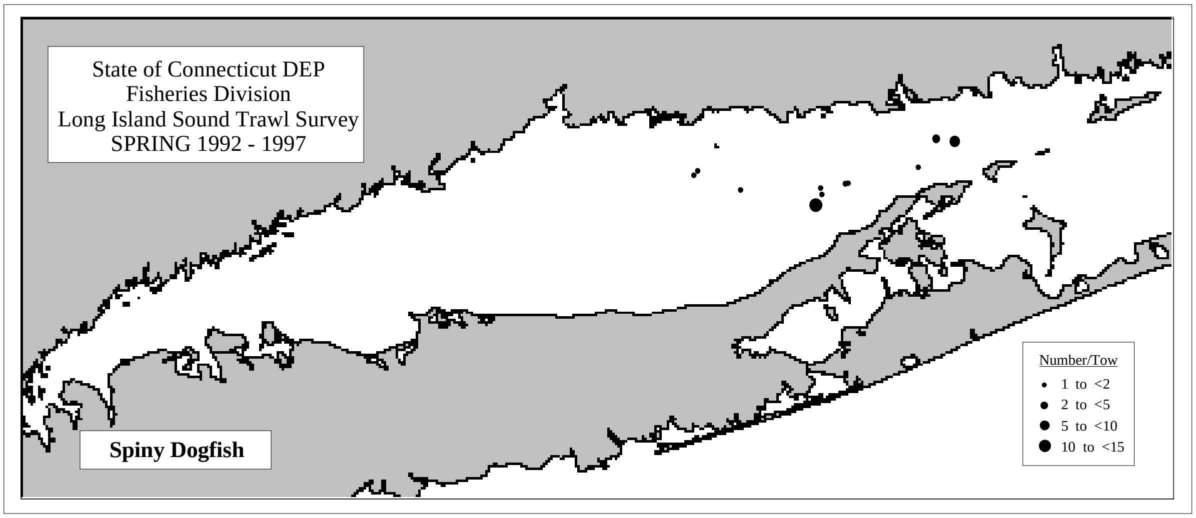


Figure 7. Abundance of juvenile and adult spiny dogfish relative to bottom water temperature and depth based on Massachusetts spring and autumn inshore bottom trawl surveys, 1978-1996 (all years combined). Open bars represent the proportion of all stations surveyed, while solid bars represent the proportion of the sum of all standardized catches (number/10 m^2).



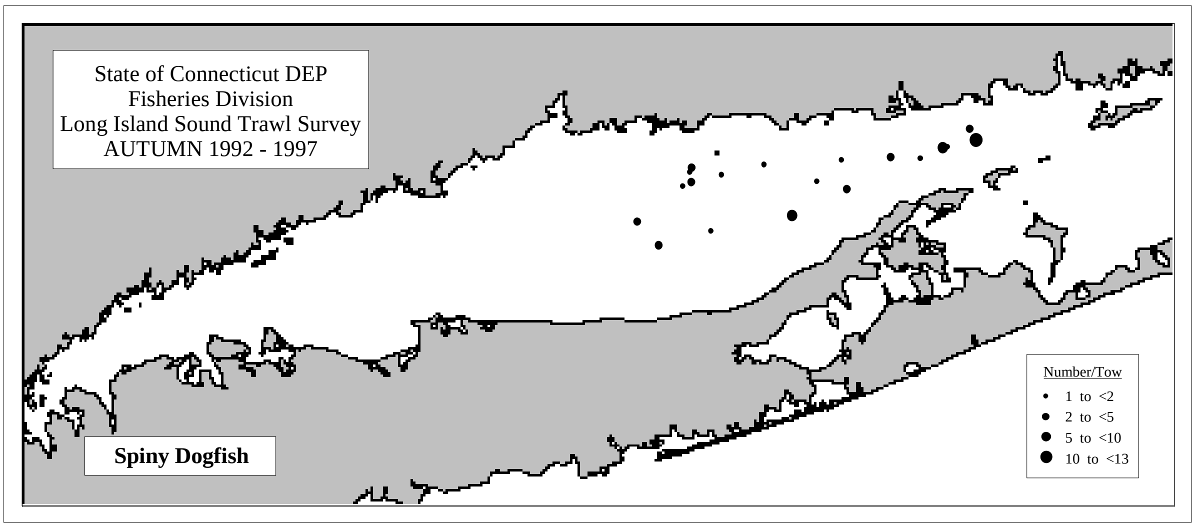
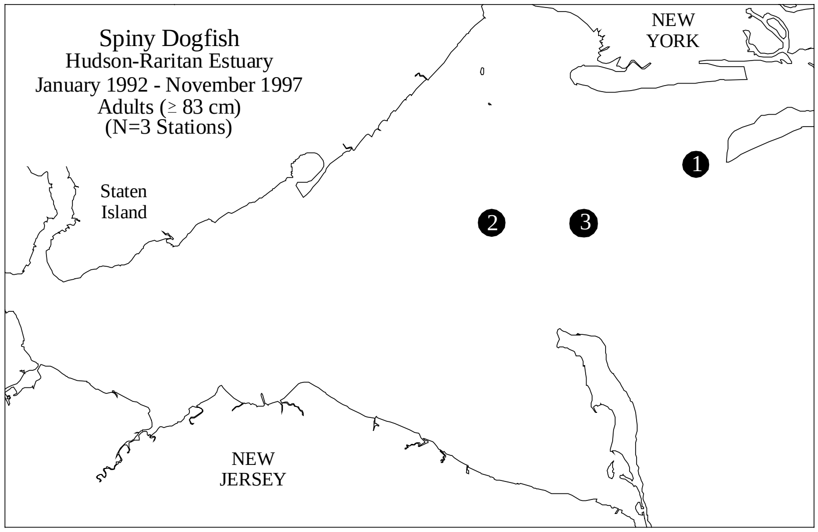


Figure 8. Distribution and abundance of spiny dogfish (all lengths) in Long Island Sound during spring and autumn, from the Connecticut bottom trawl surveys, 1992-1997 [see Reid *et al.* (1999) for details].



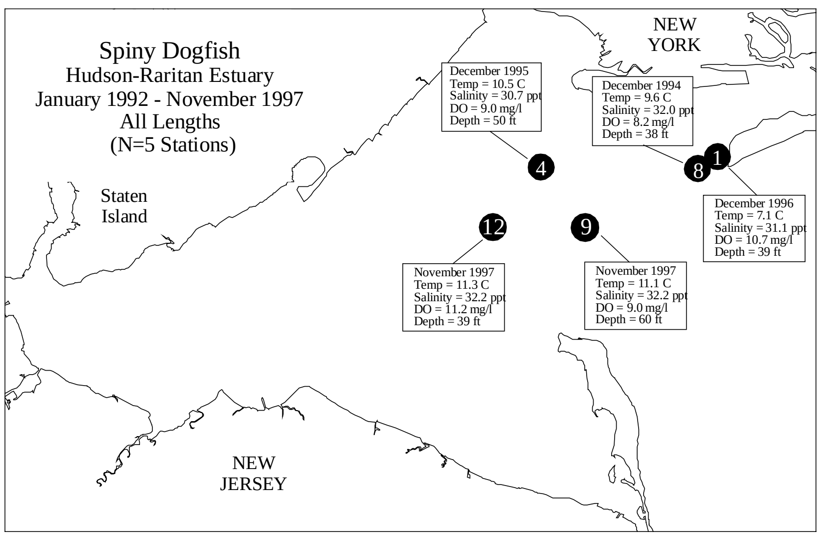


Figure 9. Distribution and abundance of adult (≥ 83 cm) and all lengths of spiny dogfish in the Hudson-Raritan estuary, based on Hudson-Raritan trawl surveys, 1992-1997 [see Reid *et al.* (1999) for details].

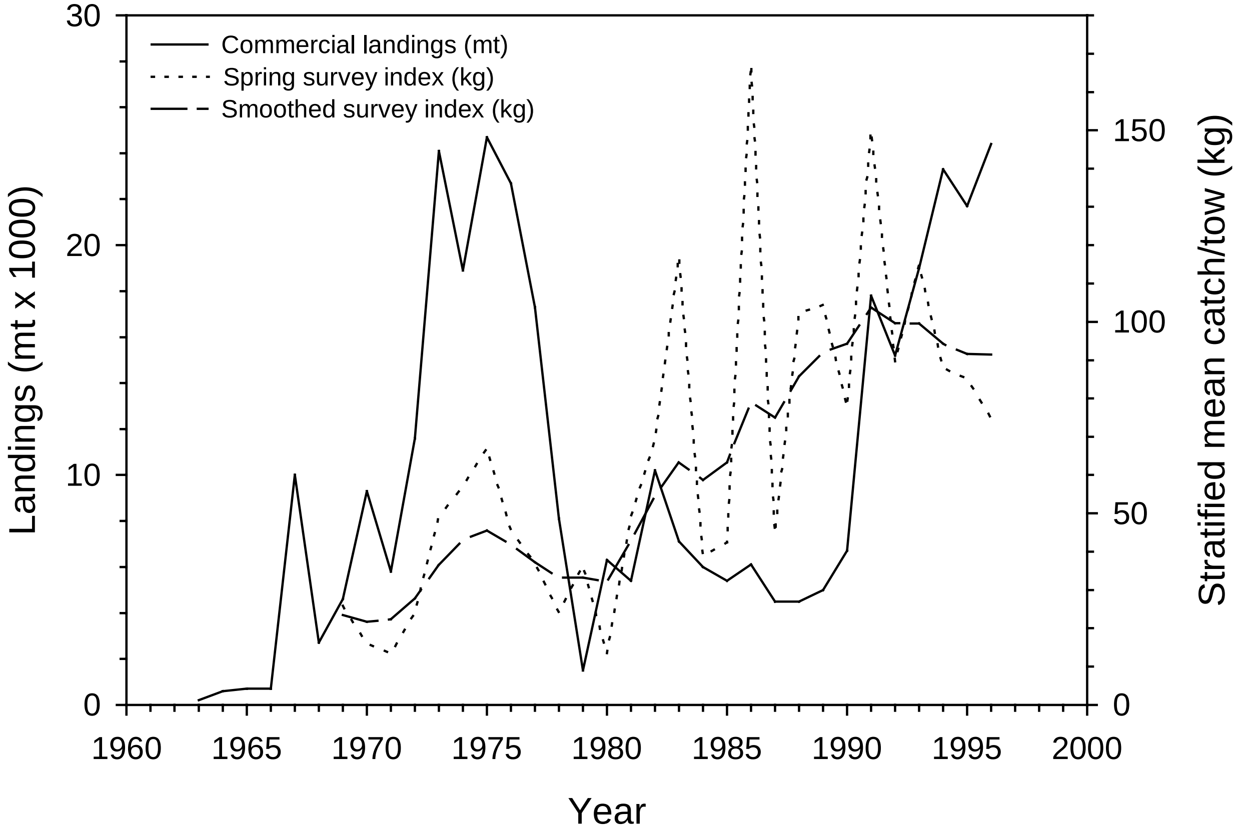


Figure 10. Commercial landings (United States, foreign, and United States recreational) and NEFSC trawl survey indices (stratified mean catch per tow in kg) of spiny dogfish, 1963-1996.

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