NOAA Technical Memorandum NMFS-NE-132

Essential Fish Habitat Source Document:

Redfish, *Sebastes* spp., 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:

Redfish, *Sebastes* spp., Life History and Habitat Characteristics

Robert A. Pikanowski, Wallace W. Morse, Peter L. Berrien, Donna L. Johnson, and Donald G. McMillan

National Marine Fisheries Serv., James J. Howard Marine Sciences Lab., 74 Magruder Rd., Highlands, NJ 07732

U. S. DEPARTMENT OF COMMERCE
William Daley, Secretary
National Oceanic and Atmospheric Administration
D. James Baker, Administrator
National Marine Fisheries Service
Penelope D. Dalton, Assistant Administrator for Fisheries
Northeast Region
Northeast Fisheries Science Center
Woods Hole, Massachusetts

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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

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

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INTRODUCTION

The redfish (Figure 1) is a slow growing, long-lived, ovoviviparous species (Perlmutter and Clarke 1949; Kelly and Wolf 1959; Mayo 1980, 1995). In the current nomenclature, the common name redfish refers both to the Acadian redfish (*Sebastes fasciatus*) and the deepwater redfish (*Sebastes mentella*) (Klein-MacPhee and Collette, in prep.). The two species are difficult to discriminate at all life stages (Kenchington 1986) and as a matter of fisheries practice are usually combined (e.g., Templeman 1959; Mayo 1980).

Acadian redfish range from New Jersey to Iceland; deepwater redfish range from the Gulf of Maine to Europe (Klein-MacPhee and Collette, in prep.). The Acadian redfish predominates to the south and west of the Grand Bank, while the deepwater redfish predominates to the north and east (Ni and Sandeman 1984). Where the species overlap, S. *mentella* occurs in deeper water.

Once economically important, redfish are managed under the New England Fishery Management Councils Northeast Multispecies Management Plan (NEFMC 1993). This Essential Fish Habitat source document provides information on the life history and habitat requirements of redfish inhabiting U.S. waters, primarily in the Gulf of Maine.

LIFE HISTORY

The redfish is a slow-growing, long-lived, ovoviviparous species with an extremely low natural mortality rate. They are common in the deep waters of the North Atlantic (Perlmutter and Clarke 1949; Kelly and Wolf 1959; Mayo 1980, 1995).

EGGS

Redfish eggs are fertilized internally and develop into larvae within the oviduct and are released near the end of the yolk sac phase (Klein-MacPhee and Collette, in prep.).

LARVAE

Starting in April and continuing through August, females extrude 15,000-20,000 larvae about 5-7 mm long. The release of larvae lasts for 3-4 months with a peak in late May to early June (Kelly and Wolf 1959; Kelly *et al*. 1972; Kenchington 1984; Klein-MacPhee and Collette, in prep.). Flexion occurs at 8.5-10 mm (Klein-MacPhee and Collette, in prep.); this varies inter-annually (Anderson 1994). Anderson (1994) categorizes fish taken on the Flemish Cap as larval at < 9 mm, metamorphosing at 10-19 mm, and pelagic juveniles at > 19 mm. Newly spawned larvae occur in the upper 10 m of the water column; at 10-25 mm they occur within the thermocline (10-30 m) (Kelly and Barker 1961b). Larvae from various areas in North Atlantic have fairly constant relative growth rate of 1-1.5 % per day; they develop slowly and are planktonic for 4 months or more (Kenchington 1984).

JUVENILES

Post-larvae descend below the thermocline when they are about 25 mm. Young-of-the-year are pelagic until they reach 40-50 mm at 4-5 months old when they move to the bottom by early fall of their first year (Kelly and Barker 1961b). The duration of the pelagic stage would allow transport of larvae and young-of-the-year fish for hundreds of miles. However, the cylconic gyre in the Gulf of Maine keeps the larvae within the Gulf (Sherman *et al.* 1984). This mechanism may also maintain the cold pool of bottom water suitable for redfish allowing them to maintain their abundance at the southern end of their range. On the Scotian Shelf, redfish larvae are scattered widely and apparently subject to random planktonic drift (Kenchington 1984; O'Boyle *et al.* 1984).

ADULTS

In this report, redfish of 22 cm or greater are considered adults (O'Brien *et al.* 1993). As a general rule, the size of landed redfish is positively correlated with depth (e.g., Brown and Hennemuth 1965). The reason for this may involve differential growth rates of stocks, confused species identification (deepwater redfish are a larger species), size specific migration, gender specific migration (females are larger), or a combination of these factors. The depth distribution of redfish in the Western Gulf of St. Lawrence is positively correlated with the depth distribution of their primary euphausiid prey (Steele 1957).

More redfish are captured by bottom trawl during the day than at night, so the fishery for redfish has been primarily a daytime pursuit. Redfish make diurnal vertical migrations linked to their primary euphausiid prey (Steele 1957). By comparing catch-per-unit-effort of trawls with different vertical openings, Atkinson (1989) found that most redfish moved to about 3-7 m off the bottom at night; larger fish moved closer to the bottom in daytime and higher off the bottom at night than smaller fish. Redfish can be more readily taken at night when a lens of water of inappropriate temperature exists near to the bottom, thereby preventing the fish from rising off the bottom (Templeman 1959).

REPRODUCTION

Nothing is known about redfish breeding behavior, but fertilization is internal and fecundity is relatively low. Copulation probably occurs from October to January, but fertilization is delayed until February to April (Ni and Templeman 1985; Klein-MacPhee and Collette, in prep.). Larvae are released throughout the range of the adults, perhaps in mid-water, from April to August (Steele 1957; Kelly and Wolf 1959; Kelly *et al.* 1972; Kenchington 1984; Klein-MacPhee and Collette, in prep.).

Estimates of age and length at maturity vary among published studies and are functions of location, time, population size, and mensuration techniques. O'Brien *et al.* (1993) give the median age at maturity at 5.5 years for both sexes whereas Perlmutter and Clark (1949) give the median age at maturity was 8-9 years in the 1940s. It may be that redfish have responded to decreases in population size by maturing at younger ages. O'Brien *et al.* (1993) report the median length at maturity (L_{50}) as 20.9 cm for males and 22.3 cm for females whereas Ni and Sandeman (1984) report the L_{50} as 15.9 cm for males and 25.9 cm for females.

FOOD HABITS

Redfish larvae are released soon after the spring plankton bloom and through the summer production of zooplankton in the Gulf of Maine (Sherman *et al.* 1984) and the Gulf of St. Lawrence (Fortier *et al.* 1992). They feed on copepods, euphausiids, and fish and invertebrate eggs (Marak 1973). Redfish feed on the pelagic calanoid-euphausiid assemblage throughout ontogeny (Fortier *et al.* 1992; Sameoto *et al.* 1994) and prey size is proportional to fish size (Anderson, 1994). Small larvae eat larval copepods and eggs. Larger larvae and fry eat copepods and euphausiids. Planktonic redfish feed mostly during daylight and the development of gill rakers in postlarval fish enables them to access smaller prey items (Anderson 1994).

Juvenile and adult redfish eat euphausiids, mysids, and bathypelagic fish (Figure 2). They feed most actively at night when they rise off the bottom following the vertical migration of their primary euphausiid prey (Steele 1957). A positive correlation exists between the number of feeding redfish and the size of the catch, implying that redfish concentrate where their prey concentrate. The proportion of fish in the diet is positively correlated with body size (Yanulov 1962).

GROWTH

Based on the age-length curves for larvae collected on the Flemish Cap (Penney and Evans 1985), 10 mm fish are 5-20 day old and 20 mm fish are 65-95 day old. In the Gulf of Maine, redfish grew 15 mm (from 23.5 to 38.5 mm) in 42 days (Kelly and Barker 1961b). Perlmutter and Clarke (1949) and Kelly and Wolf (1959) report a growth rate of 20 mm per year during the first seven years for fish collected in the Gulf of Maine in the 1940s and 1950s. At about age 8, the growth rate slows and a marked sexual dimorphism develops; females grow about 10 mm per year while males grow about 5 mm per year (Kelly and Wolf 1959).

Although Acadian redfish can exceed 45 cm, historically the mean commercial size in the Gulf of Maine has been about 26 cm for males and about 30 cm for females (Mayo 1980). Mayo reports L_∞ for Gulf of Maine redfish as 33.45 cm for males and 39.66 cm for females. Sandeman (1969), using the data of Kelly and Wolf (1959), calculated the L_∞ as 33.4 cm for males and 44.3 cm for females, which correspond to 30-50 year old fish. Ni and Sandeman (1984) report ranges of L_∞ across NAFO statistical areas of 16.3-21.8 cm for males and 24.4-34.6 cm for females. The NEFMC (1993) and Mayo *et al.* (1979) report extremely low instantaneous natural mortality coefficients of 0.05 and 0.1 respectively.

PREDATION

Redfish of all sizes are prey to larger piscivorous fish including goosefish, cod, pollock, and wolffish; young redfish are eaten by larger redfish and halibut (Klein-MacPhee and Collette, in prep.).

MIGRATION

Murawski (1993) found no evidence for latitudinal migration and classified redfish in the "deep-water sedentary" group in the Gulf of Maine. There is some evidence for a seasonal migration in the Gulf of Maine. During warm months, they occur deeper than 30 m in the southwestern part of the Gulf and they have been collected in Gloucester Harbor during the winter (Klein-MacPhee and Collette, in prep.). Kenchington (1984) found no evidence for seasonal change in the distribution of redfish on the Scotian Shelf; if redfish made migrations, they were only a few 10 to 100 km.

HABITAT CHARACTERISTICS

Although Acadian redfish (*S. fasciatus*) are found in shoal waters in the Gulf of Maine (Kelly and Barker 1961a), they are most common at depths of 128-366 m and have been collected down to 592 m. Deepwater redfish (*S. mentella*) are most common at depths of 350-700 m and have been collected down to 1,100 m (Klein-MacPhee and Collette, in prep.). Murawski (1993) reports mean seasonal depths for Acadian redfish on the northeast continental shelf of 171 m in spring, 153 m in summer, and 169 m in fall. He found no evidence for latitudinal migration and classified redfish in the "deep-water sedentary" group with white hake, witch flounder, pollock, and American plaice. Gulf of Maine redfish prefer a temperature range of 3-7^{o}C (Kelly *et al*. 1972); Scotian Shelf redfish prefer 5-9^{o}C. Both stocks can tolerate 0-13^{o}C (Kelly and Barker 1961a; Scott 1982b).

Scott (1982b) reports their salinity range as 31-34 ppt. The fish that Kelly and Barker (1961a) studied at Eastport, Maine probably tolerated lower salinities, but this was not reported.

Within the preferred depth and temperature zones, redfish are most abundant over silt, mud, or hard bottom; they are rarely taken over sand (Klein-MacPhee and Collette, in prep.). Redfish on the Scotian Shelf prefer finer grained bottom sediments and Scotian Shelf drift (a variable deposit of gravel, silts, clays, and boulders; Scott (1982b). Because redfish are bathypelagic, Templeman (1959) postulates that redfish are "stranded" in areas where there are current breaks (e.g., banks, ledges, depressions) and do not prefer a particular bottom type. There is evidence that redfish use boulders and anemones for cover (Shepard *et al.* 1986). Because redfish are not particularly active (Kelly and Barker 1961a), it is reasonable that they would be more exposed to predation over a featureless bottom than a structured bottom. A synopsis of the habitat characteristics of redfish by life history stages is presented in Table 1.

The following data sets were used to derive the habitat characteristics, distribution, and relative abundance of redfish: the National Marine Fisheries Service, Northeast Fisheries Science Center (NEFSC) groundfish survey (Azarovitz 1981) and the NEFSC Marine Resources Monitoring, Assessment and Prediction (MARMAP) survey (Sherman 1980). Methods and materials for these are found in Reid *et al*. (1999).

LARVAE

Larvae were collected from March through October in the NEFSC MARMAP survey at integrated water column temperatures ranging from 3-15^{o}C; most larvae were collected from 6-11^{o}C (Figure 3). Larvae collected in March and April occurred in relatively warm water on the continental slope. In May, the larval temperature distribution was well matched to the general survey temperature distribution; larvae were absent only from the few tows in water > 13^{o}C. From June through October, the larval temperature distribution was biased toward the cooler water temperatures; larvae were found only in water < 15^{o}C. Larvae were collected in surface waters (upper 200 m or within 5 m of bottom) in depths ranging from 30 to > 2000 m, but primarily in depths of 50-270 m (Figure 4). Larvae collected at the deepest stations (mostly in April and May) may have drifted seaward of continental slope.

JUVENILES

Juveniles were collected at bottom water temperatures ranging from 3-13^{o}C in spring and 4-14^{o}C in autumn; most juveniles were collected between 5-10^{o}C in both seasons (Figure 5). Proportionately more individuals were found at temperatures > 7^{o}C in the autumn. Juveniles were collected from 50 to 275 m deep in spring and 25 to 400 m deep in the autumn (Figure 5). In both seasons, most juveniles were collected from 50 to 200 m.

ADULTS

Adults were collected at bottom water temperatures ranging from 4-12^{o}C in spring and 4-13^{o}C in autumn; most adults were collected between 5-10^{o}C in both seasons (Figure 5). Adults were collected from 50-350 m deep in spring and 25-350 m deep in the autumn (Figure 5). In both seasons, most adults were collected from 125-200 m.

GEOGRAPHICAL DISTRIBUTION

Redfish in the northwest Atlantic were distributed from south of Cape Cod to Labrador during 1975-1994 (Figure 6). The areas of highest abundance of the species are the Gulf of St. Lawrence, the Continental Shelf northeast of Newfoundland, the southern edge of the Grand Bank and the Flemish Cap. In U.S. waters, redfish are common in the Gulf of Maine, in the deeper waters north and west of Georges Bank, and to a lesser extent on Browns Bank and the continental slope.

Although Acadian redfish can be found from shoal waters to nearly 600 m in the Gulf of Maine, they are most commonly found at depths of 128-366 m (Kelly and Barker 1961a; Klein-MacPhee and Collette, in prep.).

LARVAE

Larvae were collected on the continental slope south and east of Georges Bank and throughout the Gulf of Maine from March through October (Figure 7). Only a few larvae were collected in March on the slope southeast of Georges Bank. These larvae are possibly a mix of *S. fasciatus* and *S. mentella* [Kenchington (1984) reviewed evidence that larvae collected along the continental slope on the Scotian Shelf in early spring are *S. mentella*]. In April, larvae were more abundant on the slope and the first larvae appeared in the Gulf of Maine and in the Northeast Channel. In May, larvae were more dispersed on the slope and in the Gulf of Maine. In June and July, larvae were randomly distributed throughout the Gulf of Maine and in the Great South Channel. Larval abundance peaked in August, and by September, larvae were scarce and were found only in the Gulf of Maine. Only a few larvae were collected in October.

JUVENILES

Juvenile redfish (< 22 cm) were collected in all seasons in the channels north and west of Georges Bank, on the continental slope east of Georges Bank, on the southern Scotian Shelf, and in the Gulf of Maine (Figure 8). In spring and autumn, abundance was highest in the western Gulf of Maine.

ADULTS

Adult redfish (≥ 22 cm) were collected in all seasons in the channels north and west of Georges Bank, on the continental slope east of Georges Bank, on the southern Scotian Shelf, and in the Gulf of Maine (Figure 9). In spring, abundance was highest in the Georges and Wilkinson Basins.

STATUS OF THE STOCKS

Exploitation of redfish began in the mid 1930s and peak landings (60,000 mt) were made in 1941. After the start-up period, the fishery stabilized yielding 7,000-19,000 mt from 1953 through 1980. The standard commercial catch per unit effort (CPUE; Mayo 1980) and the NEFSC fishery-independent biomass index began trending down in 1969 (Figure 10). Standard CPUE decreased from 6.4 mt/day in 1969 to 2.0 mt/day in 1978. The smoothed NEFSC index decreased from 30 kg/tow in 1969 to 5 kg/tow in 1984. Redfish landings decreased from 10,000 mt in 1980 to less than 1,000 mt in 1989 (Figure 10). Although the NEFSC index rose to 14 kg/tow in 1996, landings since 1989 have remained below 1,000 mt. Based on the overfishing criterion of current fishing mortality, redfish are not classified as overfished or approaching an overfished condition (National Marine Fisheries Service 1997).

RESEARCH NEEDS

- It is likely that redfish, particularly smaller individuals, are dependent on benthic structure to avoid predation. Due to the difficulty of making observations at depths where redfish occur, little is known about the extent of this dependency.
- The reasons for observed size correlations with depth are not clear and are likely a combination of factors: species and/or stock identification and differences in growth rates; size specific migration; gender specific migration; and seasonal mating migration.

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Table 1. Summary of life history and habitat parameters for redfish, *Sebastes* spp.

Life Stage	Size and Growth	Geographic Location	Habitat	Substrate	Temperature
Larvae [1]	5000-20000 larvae are extruded at 5-7 mm from April-August. Flexion at 8.5-10 mm. 10 mm fish are 5-20 days old, 20 mm fish are 65-95 days old. Fish at 10-19 mm are metamorphosing.	Northeast U.S. Continental Shelf, Flemish Cap, Scotian Shelf, Gulf of Maine.	Newly spawned fish are found in the upper 10 m. 10-25 mm fish are within the thermocline (10-30 m).		Preferred: 4-11^{o}C Range: 3-15^{o}C Within thermocline, range: 7-21^{o}C.
Juveniles [2]	Fish 19-50 mm are pelagic. Growth: 15 mm (23.5-38.5) in 42 days in Gulf of Maine; 2 cm/year growth in first 7 years.	Northeast U.S. Continental Shelf, Flemish Cap, Scotian Shelf, Gulf of Maine, Newfoundland, Labrador.	Fish 25 to 40-50 mm are pelagic below thermocline (> 30 m). Fish 40-50 mm (4-5 months) move to bottom. Preferred depth is 75-175 m, range is 25-400 m.	Associated with anthozoans in deepwater, available structure in Eastport, Maine. Observed associated with rock structure.	Preferred: 5-10^{o}C Range: 3-14^{o}C
Adults [3]	Maturation at 5.5-9 years at 16-21 cm for males, 22-26 cm for females. Mature females grow 10 mm/year, males 5 mm/year. L_4 is 16.3-33.45 cm for males, 21.8-44.3 cm for females.	Northeast U.S. Continental Shelf, Flemish Cap, Scotian Shelf, Gulf of Maine, Newfoundland, Labrador.	Bathypelagic fish show diurnal movement up in the water column at night. Preferred depth is 125-200 m, range is 25-350 m. Shoal water fish reported in Eastport, Maine.	Decreasing preference for LaHave clay, Scotian Shelf drift, Emerald silt, Sambro sand, Sable Island sand/gravel.	Preferred: 5-10^{o}C Range: 4-13^{o}C

[1] Size and Growth: Kelly and Wolf (1959), Kelly *et al.* (1972), Anderson (1994), Klein-MacPhee and Collette (in prep.); Habitat: Kelly and Barker (1961b); Temperature: Kelly and Barker (1961b), NEFSC Groundfish Survey.
[2] Size and Growth: Perlmutter and Clarke (1949), Kelly and Wolf (1959), Kelly and Barker (1961b); Habitat: Kelly and Barker (1961b), NEFSC Groundfish Survey; Substrate: Kelly and Barker (1961a), Shepard *et al.* (1986); Temperature: NEFSC Groundfish Survey.
[3] Size and Growth: Kelly and Wolf (1959), Sandeman (1969), Mayo (1980), Ni and Sandeman (1984); Habitat: Kelly and Barker (1961a), Atkinson (1989), NEFSC Groundfish Survey; Substrate: Scott (1982a); Temperature: NEFSC Groundfish Survey.

Table 1. cont'd.

Life Stage	Salinity	Light	Currents	Prey	Predators	Spawning
Larvae [1]		Larvae show no evidence of diurnal vertical migration.	The cyclonic gyre of the Gulf of Maine tends to hold larvae within the Gulf of Maine. Scotian Shelf larvae are subject to random planktonic drift.	Small larvae eat copepod eggs and larvae. Larger larvae eat copepods and euphausiids.		see Size and Growth
Juveniles [2]	Preferred: 32-34 ppt Mean: 33.4 ppt on Scotian Shelf	Juveniles show vertical diurnal migration off the bottom at night.	Fish may be "stranded" in areas where there are current breaks due to bathymetry.	Copepods, euphausiids, mysids and fish.	Redfish of all sizes are prey to larger piscivorous fish, including redfish.	
Adults [3]	Preferred: 32-34 ppt Mean: 33.4 ppt on Scotian Shelf	Adults show vertical diurnal migration off the bottom at night. Larger fish move higher and lower than smaller fish.	Fish may be "stranded" in areas where there are current breaks due to bathymetry.	Euphausiids, mysids and fish.		Copulation may occur between October and January. Fertilization is delayed until February through April. Spawning peaks in late May to early June. There may be spawning migration occurring within the Gulf of Maine. Larvae are likely released near the surface.

[1] Light: Kelly and Barker (1961b); Currents: O'Boyle *et al.* (1984), Sherman *et al.* (1984); Prey: Fortier *et al*. (1992), Anderson (1994), Sameoto *et al*. (1994).
[2] Salinity: Scott (1982b); Light: Atkinson (1989); Currents: Templeman (1959); Prey: Yanulov (1962), Fortier *et al.* (1992), Anderson (1994), Sameoto *et al.* (1994), NEFSC Groundfish Survey; Predators: Klein-MacPhee and Collette (in prep.).
[3] Salinity: Scott (1982b); Light: Atkinson (1989); Currents: Templeman (1959); Prey: Yanulov (1962), NEFSC Groundfish Survey; Spawning: Kelly and Wolf (1959), Kelly *et al.* (1972), Ni and Templeman (1985), Klein-MacPhee and Collette (in prep.).

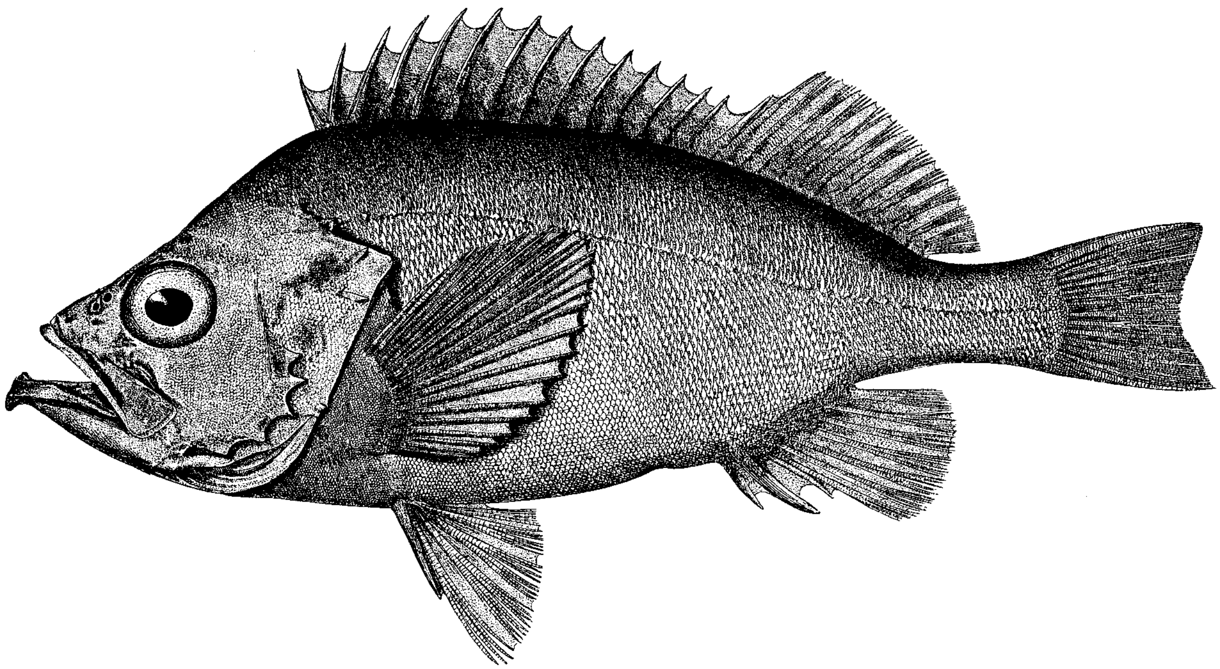


Figure 1. The Acadian redfish, *Sebastes fasciatus* (from Goode 1884).

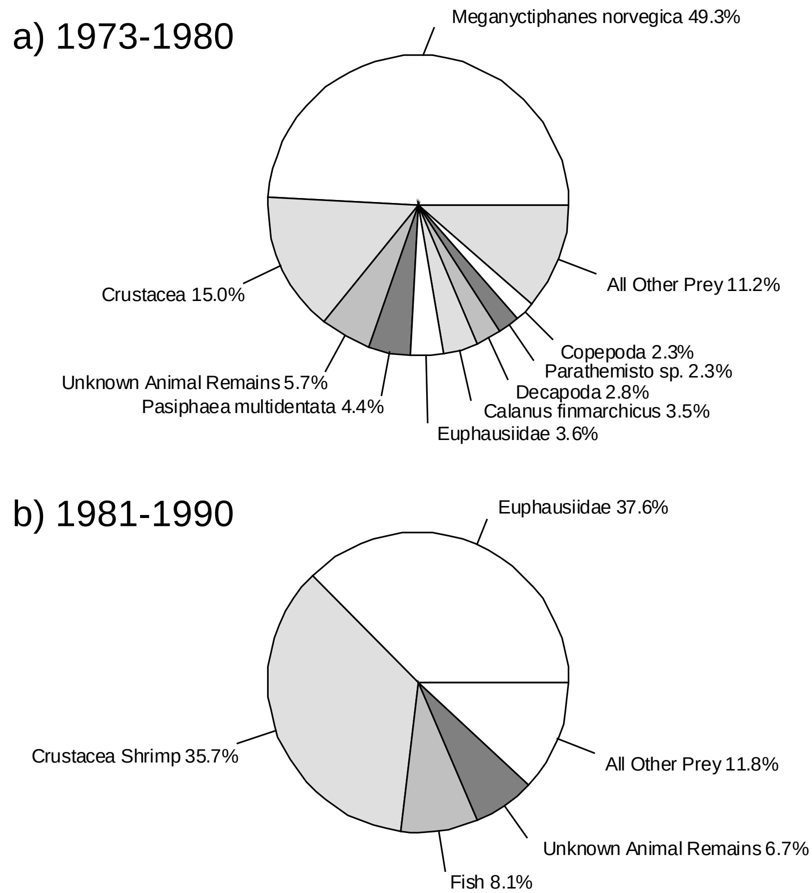


Figure 2. Abundance (% of total prey volume) of the major prey items of redfish collected during NEFSC bottom trawl surveys from 1973-1980 and 1981-1990. (a) 1973-1980, n = 644, (b) 1981-1990, n = 577. The category "unknown animal remains" refers to unidentifiable animal matter. Methods for sampling, processing, and analysis of samples differed between the time periods [see Reid *et al.* (1999) for details].

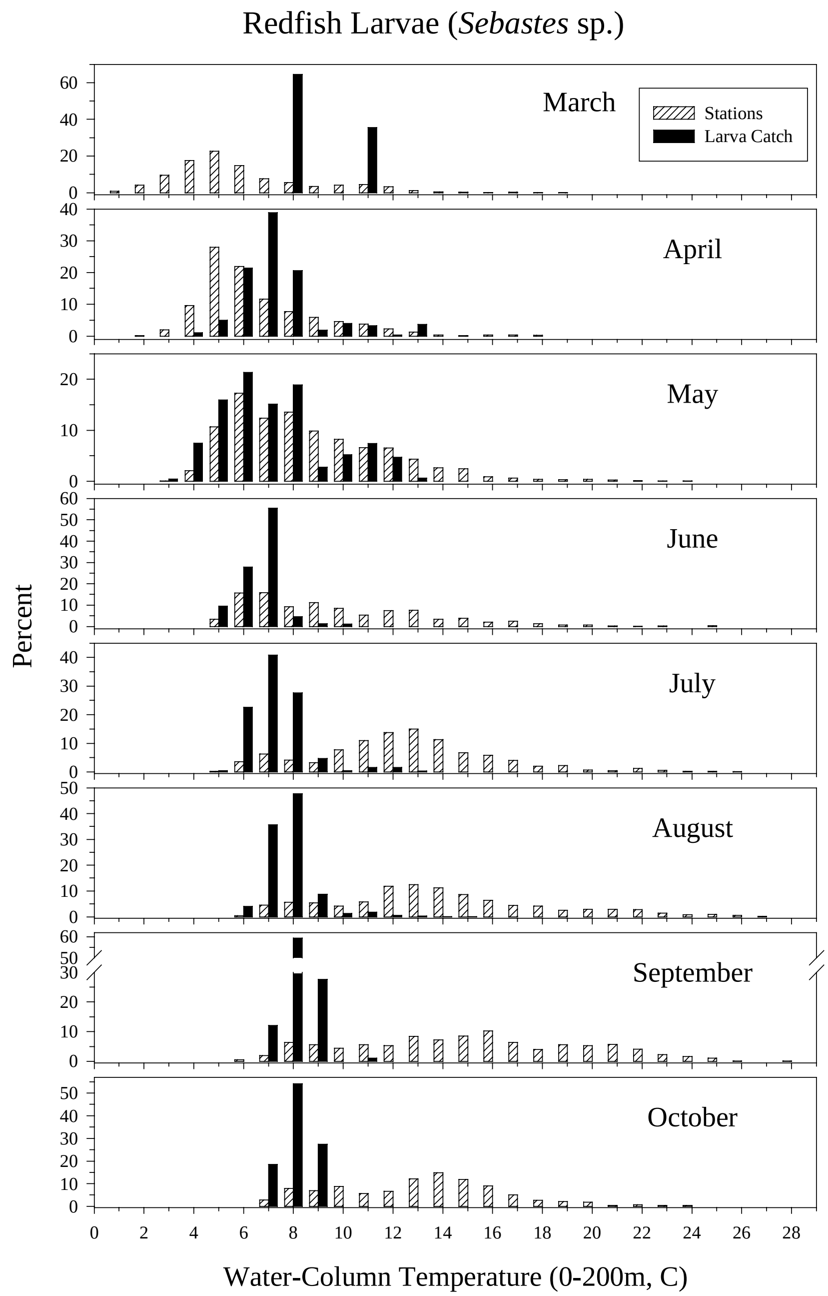


Figure 3. Abundance of redfish larvae relative to water column temperature (to a maximum of 200 m) from NEFSC MARMAP ichthyoplankton surveys, March to October, 1977-1987 (all years combined). Open bars represent the proportion of all stations surveyed, while solid bars represent the proportion of the sum of all standardized catches (number/10 m^2).

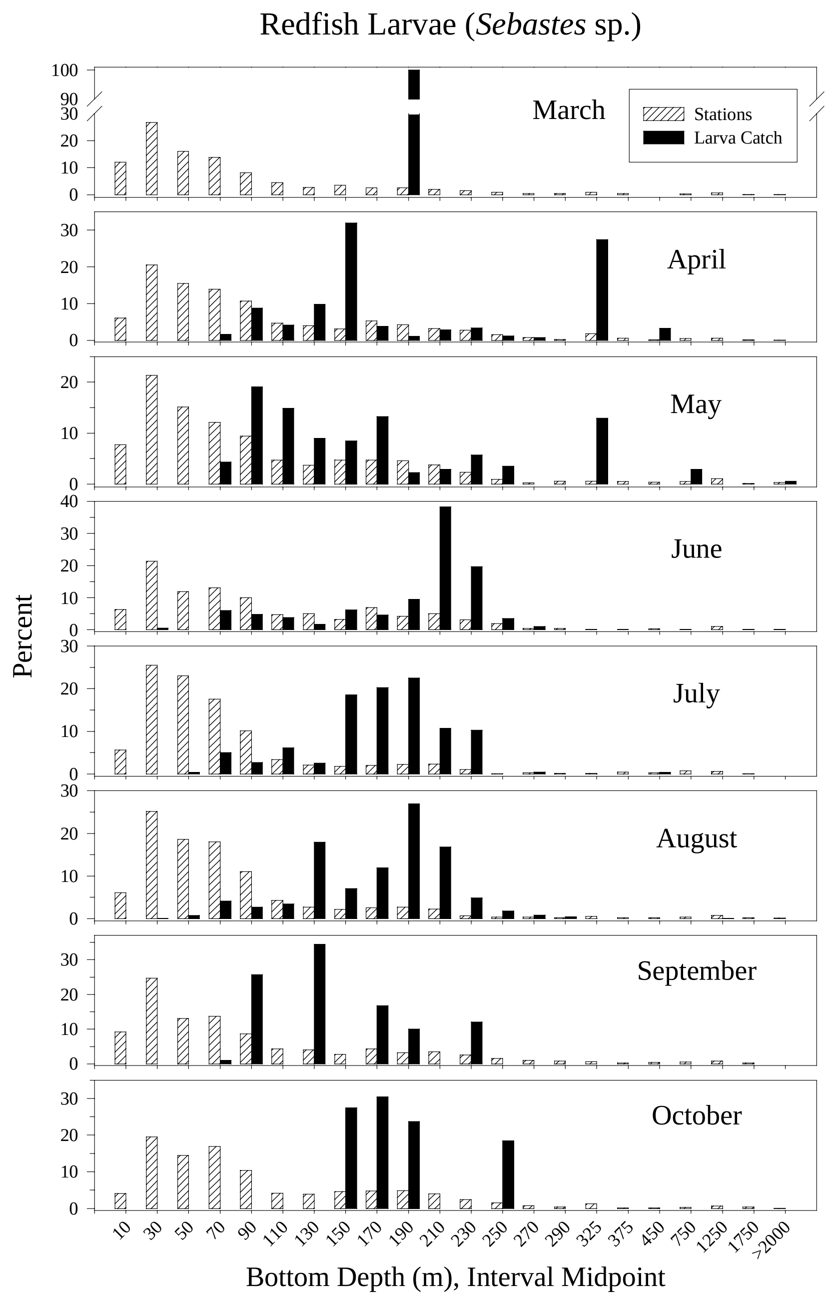


Figure 4. Abundance of redfish larvae relative to bottom depth from NEFSC MARMAP ichthyoplankton surveys, March to October, 1977-1987 (all years combined). Open bars represent the proportion of all stations surveyed, while solid bars represent the proportion of the sum of all standardized catches (number/10 m^2).

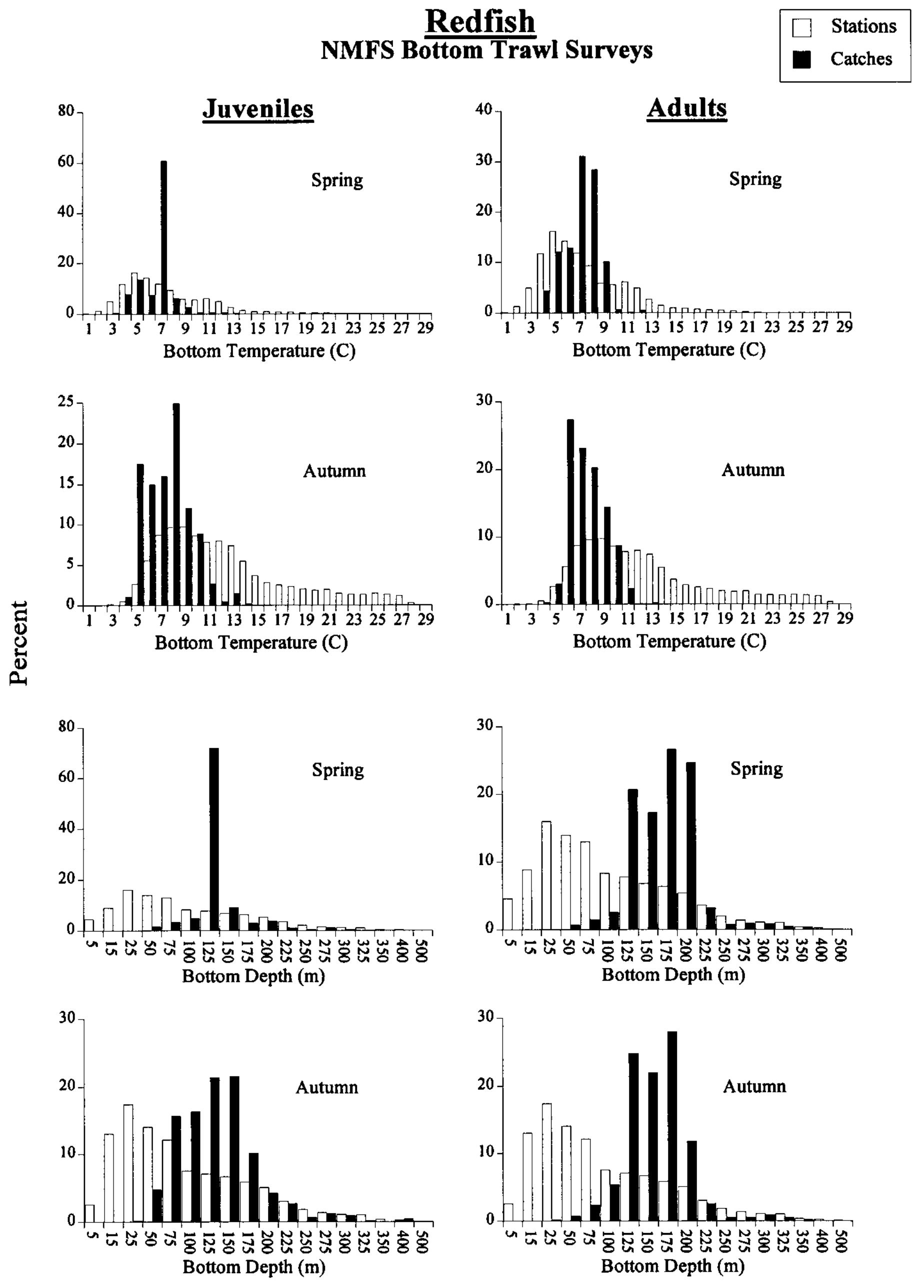
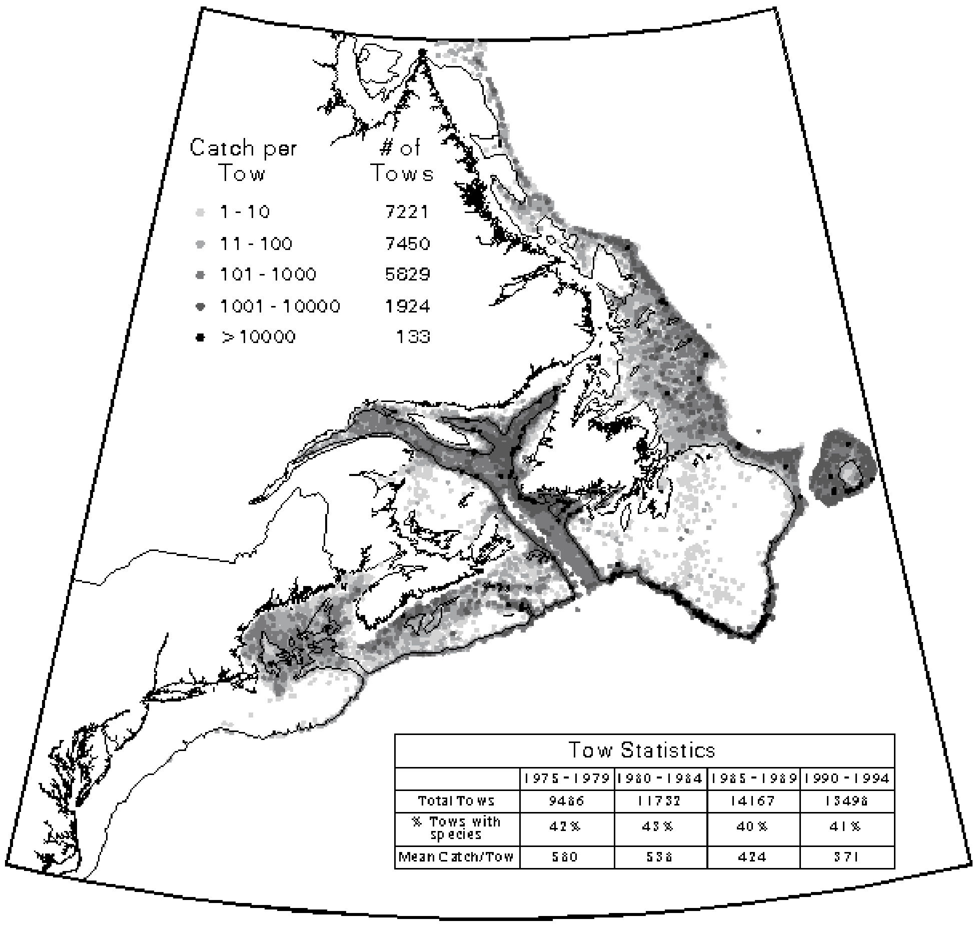


Figure 5. Abundance of juvenile and adult redfish relative to bottom water temperature and depth based on NEFSC bottom trawl surveys for spring and autumn, 1963-1997 (all years combined). Open bars represent the proportion of all stations surveyed, while solid bars represent the proportion of the sum of all standardized catches (number/10 m^2).



Tow Statistics				
	1975 - 1979	1980 - 1984	1985 - 1989	1990 - 1994
Total Tows	9486	11732	14167	13498
% Tows with species	42%	43%	40%	41%
Mean Catch/Tow	580	538	424	371

Figure 6. Distribution and abundance of redfish (*Sebastes* spp.) from Newfoundland to Cape Hatteras during 1975-1994. Data are 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).

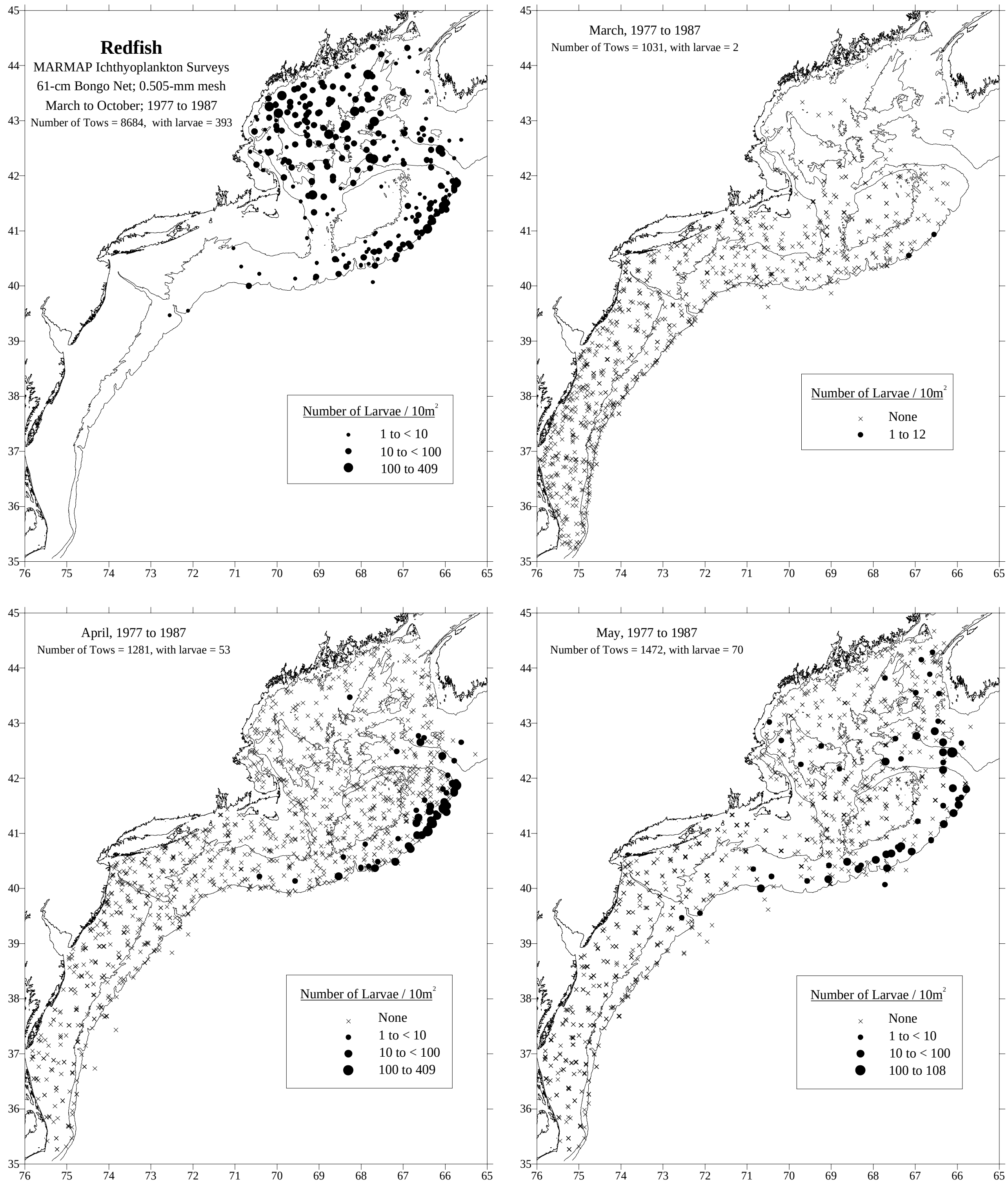


Figure 7. Distribution of redfish larvae collected during NEFSC MARMAP ichthyoplankton surveys (March to October, 1977-1987). Larval densities are represented by dot size [see Reid *et al.* (1999) for details].

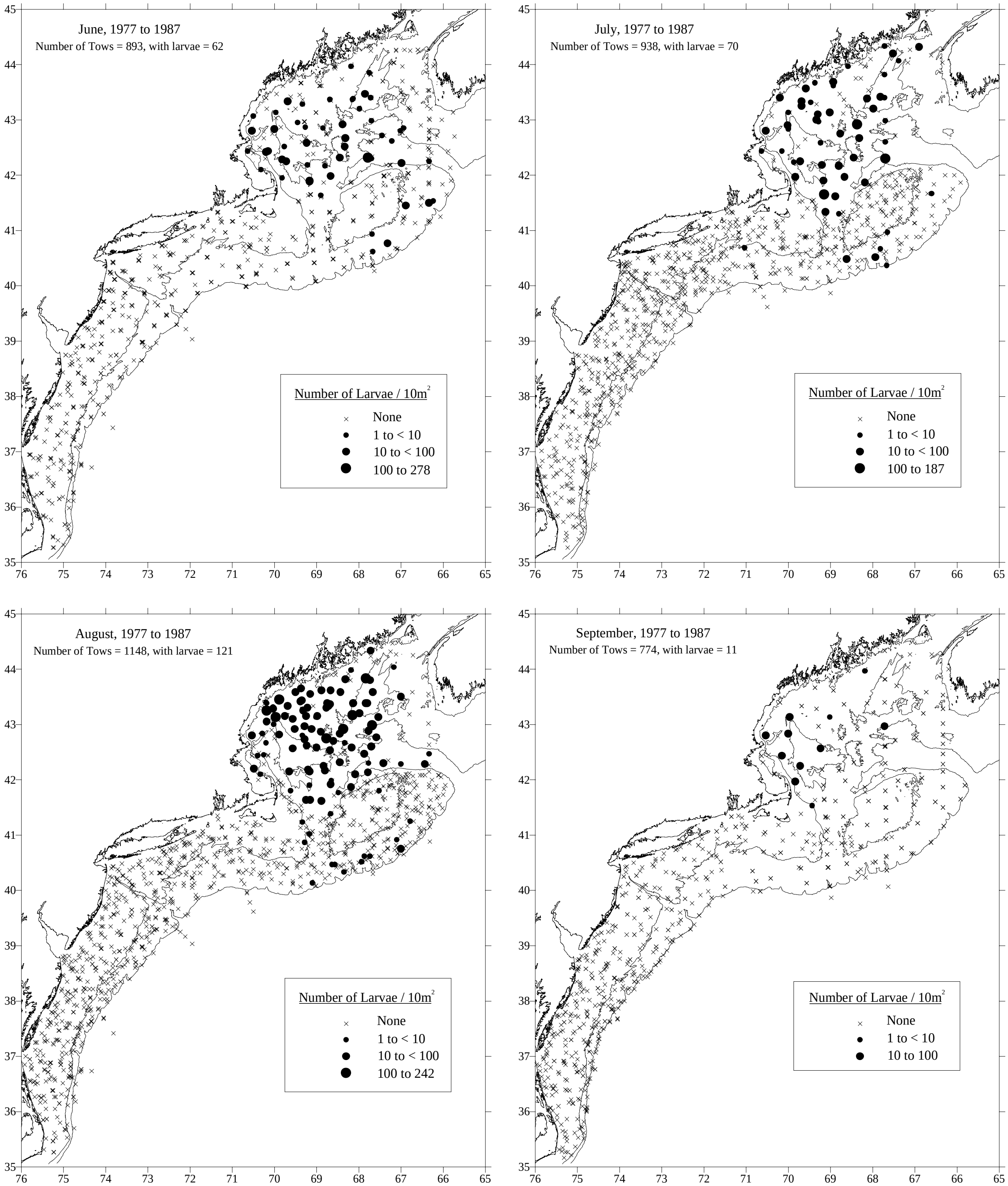
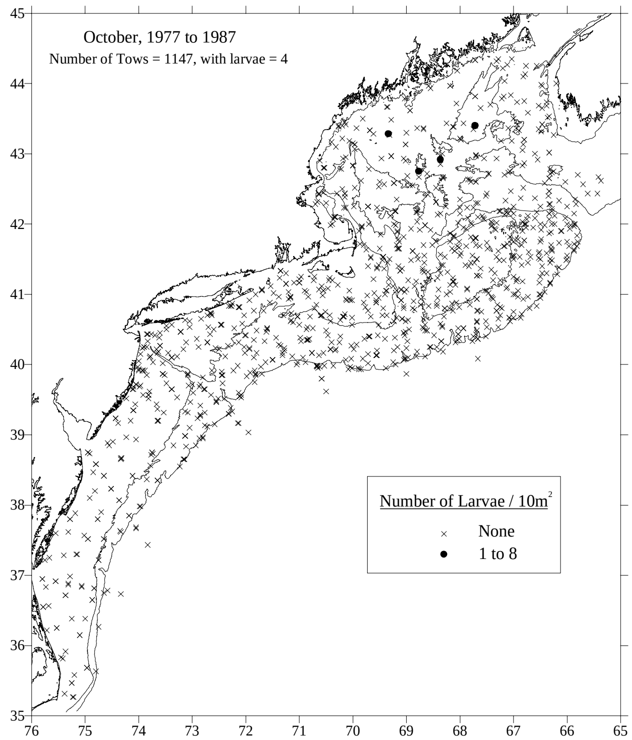


Figure 7. cont'd.



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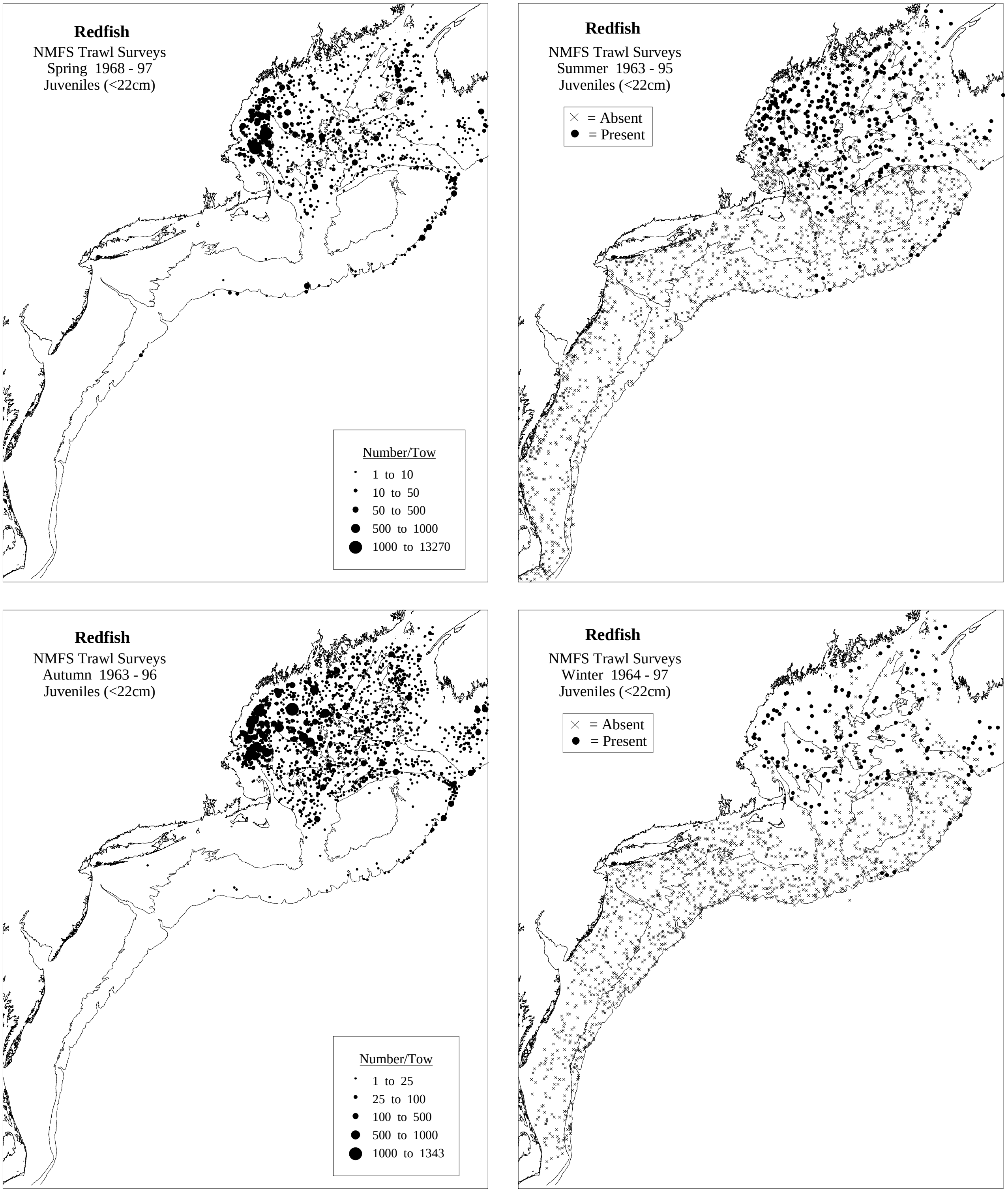

Figure 8. Distribution of juvenile redfish collected during NEFSC bottom trawl surveys during all seasons during 1963-1997. Densities are represented by dot size in spring and fall plots, while only presence and absence are represented in winter and summer plots [see Reid *et al.* (1999) for details].

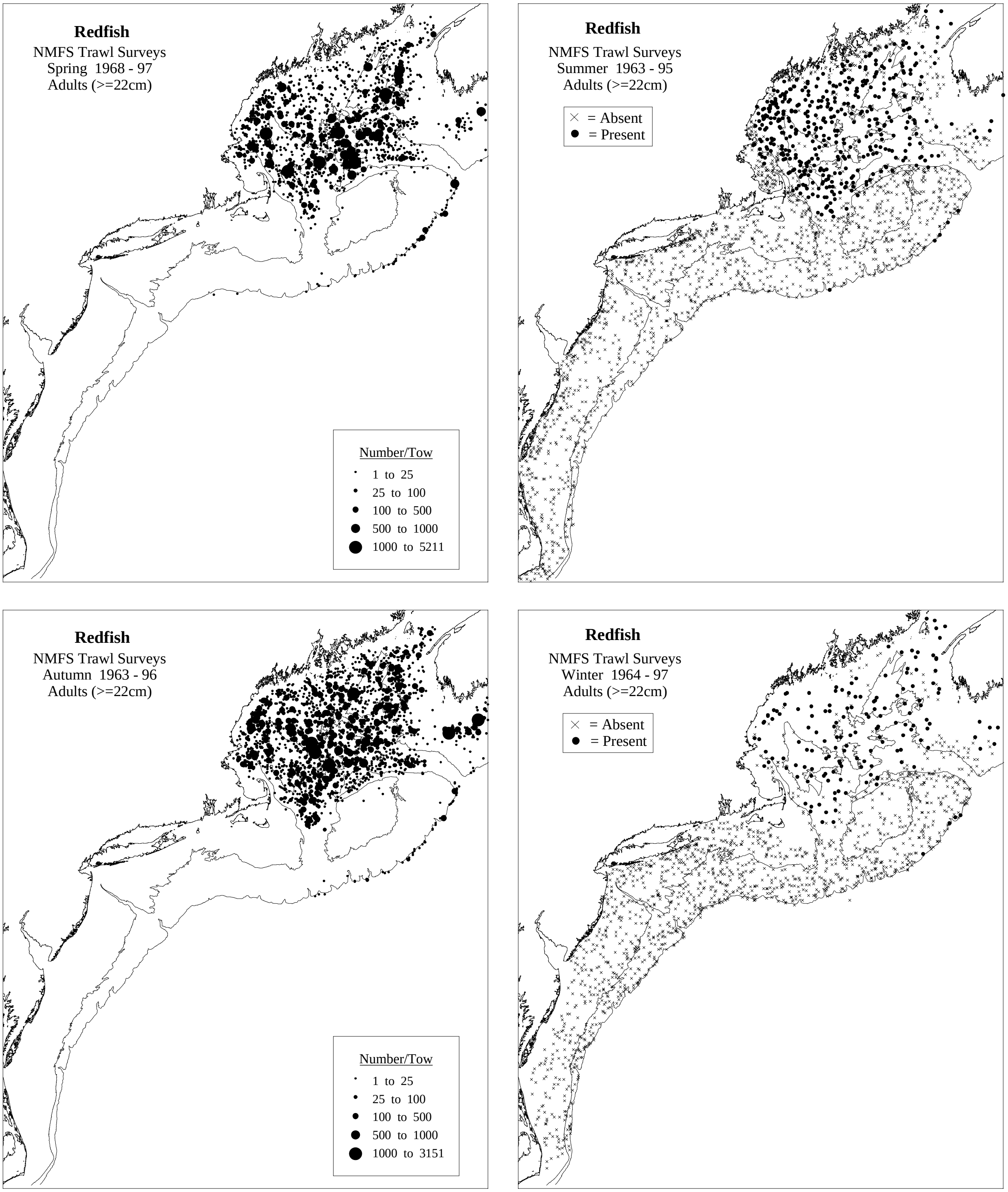

Figure 9. Distribution of adult redfish collected during NEFSC bottom trawl surveys during all seasons during 1963-1997. Densities are represented by dot size in spring and fall plots, while only presence and absence are represented in winter and summer plots [see Reid *et al.* (1999) for details].

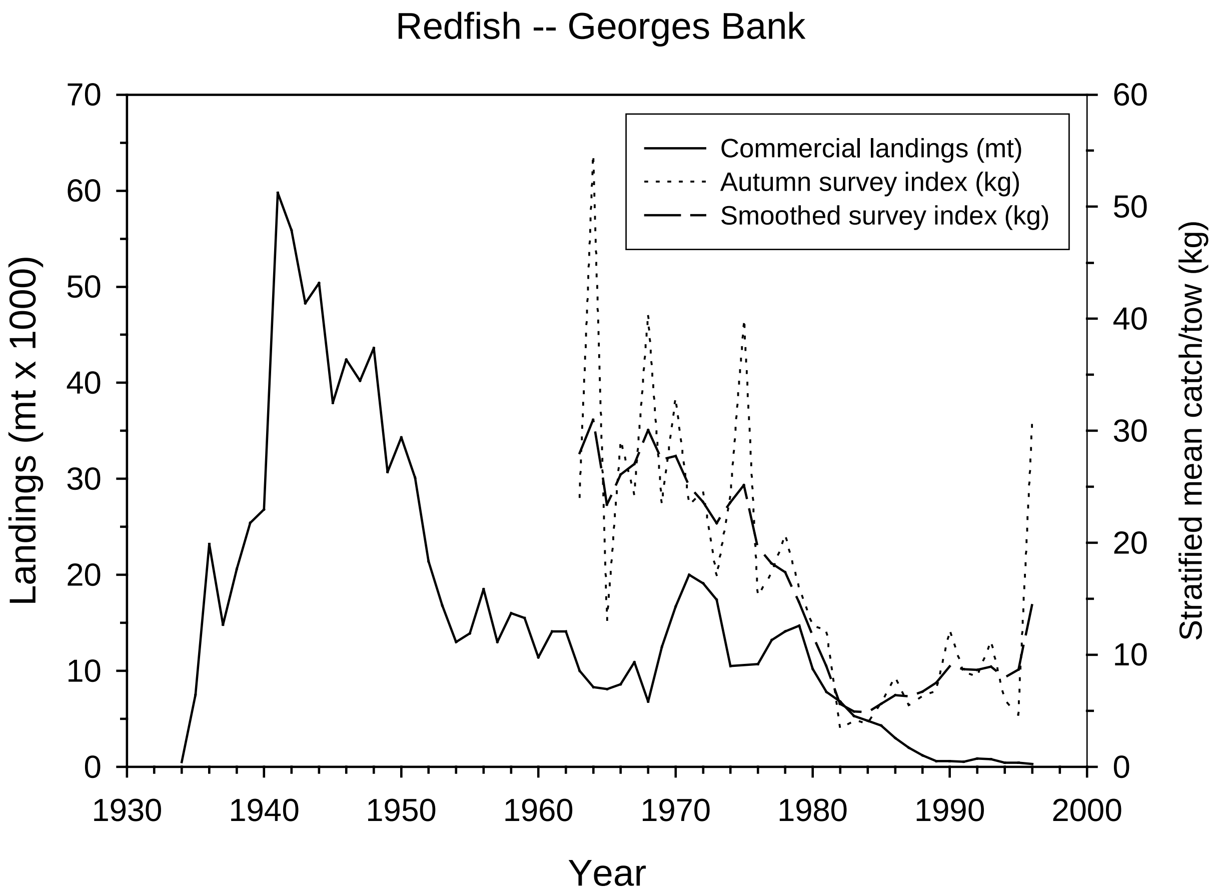

Figure 10. Commercial landings and abundance indices (from the NEFSC bottom trawl surveys) for redfish from Georges Bank.

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National Marine Fisheries Service
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