NOAA Technical Memorandum NMFS-NE-140

Essential Fish Habitat Source Document:

Yellowtail Flounder, *Limanda ferruginea*, 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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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

Contents

Tables

Figures

INTRODUCTION

The yellowtail flounder, *Limanda ferruginea*, is a small-mouthed, thin bodied pleuronectid (Figure 1) that inhabits waters along the Atlantic coast of North America from the Gulf of St. Lawrence, Labrador, and Newfoundland to the Chesapeake Bay (Figure 2; Hildebrand and Schroeder 1928; Bigelow and Schroeder 1953; Royce *et al.* 1959; Lux 1964; Pitt 1970; Laurence and Howell 1981; Walsh 1992). Yellowtail are most abundant on the western half of Georges Bank, the western Gulf of Maine, east of Cape Cod, and southern New England. Yellowtail are rare in most North Atlantic estuaries and rivers although they are common in the Sheepscot River and Casco Bay and abundant in Boston Harbor (Jury *et al.* 1994).

Yellowtail flounder grow faster and mature earlier than most other flatfish (Scott 1954; Bowering and Brodie 1991). It was not until the mid-1930s that yellowtail was recognized as a valuable flatfish. Today it is in high demand in commercial fish markets. The primary fishing gear used to harvest yellowtail flounder is the otter trawl.

LIFE HISTORY

EGGS

In the northwest Atlantic, spawning occurs from March through August at temperatures of 5-12^{o}C (Fahay 1983). Yellowtail spawn buoyant, spherical, pelagic eggs that lack an oil globule. The diameter of live eggs averages 0.88 mm, and ranges from 0.79-1.01 mm. The egg membrane is smooth, clear, and colorless. The yolk is homogenous and there is a narrow perivitelline space. Eggs hatch approximately five days after fertilization at temperatures of 10-11^{o}C (Bigelow and Schroeder 1953; Hildebrand and Schroeder 1928; Miller *et al.* 1991).

LARVAE

Hatching times range from 14.5 days at 4^{o}C to 4.5 days at 14^{o}C (Yevseyenko and Nevinsky 1981; Walsh 1992). Larvae hatch with unpigmented eyes at lengths of 2.0-3.5 mm TL. Caudal rays develop at 10 mm. Body flexion begins at 5-10 mm notochord length (NL); transformation is completed at an average length of 14 mm (Fahay 1983). Larvae normally do not become benthic until ossification of fin rays is complete at approximately 14 mm SL (Bigelow and Schroeder 1953).

JUVENILES

As early larvae, yellowtail are indistinguishable from other bony fish with respect to body shape, but as development proceeds in the upper water column, the pelagic bilaterally symmetrical larvae become benthic asymmetrical juveniles. In the course of this transition, the most visible changes involve pigmentation patterns and migration of the left eye (usually) across the top of head. These changes are accompanied by the restructuring of nerves, blood vessels, skull bones, and muscles. Pelagic larvae are brief residents in the water column; transformation to the juvenile stage occurs at 11.6-16 mm SL (Fahay 1983).

ADULTS

Adults reach a maximum size of 60 cm. The body is compressed and ovate-elliptical with a low arching lateral line over the pectoral fin (Martin and Drewry 1978). Yellowtail have a small mouth with small conical teeth. They are generally found at depths between 37 and 73 m.

REPRODUCTION

The median age at maturity for females is 1.8 years on Georges Bank, 2.6 years off Cape Cod, and 1.6 years off southern New England (O'Brien *et al.* 1993). Females generally mature at 26-40 cm TL at 2-4 years of age in the southern part of their range and 5-8 years farther north (Table 1).

FOOD HABITS

The diet of yellowtail flounder consists chiefly of benthic macrofauna (Langton 1983; Bowman and Michaels 1984; Collie 1987b). Cohen and Grosslein (1981) found that the daily ration consumed by yellowtail decreased from 6.2% to 1.1% of body weight per day as the fish aged from young-of-the-year to age 4+. The prey consist primarily of amphipods (*Unicola inermis*, *Ericthonius fasciatus*, *Ampelisca agassizi*), polychaetes (*Chone infondibuliformis*, *Nephtys incisa*), and sand dollars (*Echinarachius parma*) (Hahm and Langton 1984; Collie 1987a). Yellowtail flounder adults eat mostly crustaceans while juveniles eat mostly polychaetes (Packer and Langton, in prep.). The most abundant prey in the stomachs of yellowtail flounder in the Northeast Fisheries Science Center (NEFSC) food habits database (1973-1990) [see Reid *et al.* (1999) for details] are shown in Figure 3.

PREDATION

Based on data from the NEFSC food habits database, yellowtail flounder are preyed on by spiny dogfish, winter skate, Atlantic cod, Atlantic halibut, fourspot flounder, goosefish, little skate, smooth skate, silver hake, bluefish, and sea raven.

MIGRATION

There are five relatively distinct stocks of yellowtail flounder with little migration occurring between them. These stocks are southern New England, Georges Bank, Cape Cod, Nova Scotia, and Grand Bank (Royce *et al.* 1959). Results from mark and recapture studies revealed that yellowtail stay primarily within those fishing grounds (Lux 1964). Minimal migration patterns show that the southern New England fish traveled eastward during spring and summer and westward in the fall and winter as a result of seasonal changes in temperature (Royce *et al.* 1959; Lux 1964). Walsh (1992) found that the distribution of juveniles and adults may be more depth dependent than temperature dependent.

STOCK STRUCTURE

Intermingling among the five relatively distinct stocks has not been confirmed. Yellowtail flounder are managed as four stocks (southern New England, Georges Bank, Cape Cod, Middle Atlantic Bight) under the Multispecies Fishery Management Plan of the New England Fishery Management Council (NEFMC 1993).

HABITAT CHARACTERISTICS

A summary of habitat characteristics of the various life stages of yellowtail flounder is presented in Table 2. Data from the following surveys were used to determine habitat characteristics: (1) Northeast Fisheries Science Center (NEFSC) Marine Monitoring Assessment and Prediction (MARMAP) ichthyoplankton survey, (2) NEFSC bottom trawl survey, (3) the Massachusetts Division of Marine Fisheries (MDMF) bottom trawl survey, and (4) the NEFSC Food Habits Investigation. A description of survey methods and materials is found in Reid *et al.* (1999).

EGGS

Yellowtail flounder eggs were collected at water temperatures ranging from 2^{o} to 15^{o}C (Figure 4). Egg catches displayed temperature shifts with time of year; most February to May catches occurred at 4-8^{o}C, June to August catches occurred at 7-10^{o}C, and September catches occurred at 11-12^{o}C. Most eggs were collected in water from 10 to 750 m deep; they were more frequently caught between 30 and 90 m (Figure 4).

LARVAE

Yellowtail flounder larvae were collected at water temperatures ranging from 5^{o} to 17^{o}C (Figure 5). Larval catches displayed temperature shifts with time of year; most larvae were collected at 6-10^{o}C from April to June, 10-14^{o}C from July to September, and 8-11^{o}C in October. No seasonal trends were obvious for bottom depth and catch relationships. The largest larval catches occurred in depths of 10 to 90 m while the overall range was 10 to 1250 m (Figure 5).

The length of the notochord was significantly different among individuals incubated at 8^{o}C and 10^{o}C compared to those incubated at 4^{o} and 12^{o}C (Howell 1980). Larvae reared at 4^{o}C and 12^{o}C had significantly larger yolk volumes and larvae reared at 12^{o}C grew significantly faster. A water temperature increase from 8^{o}C to 20^{o}C within 24 hours resulted in mortality of yellowtail flounder larvae in the field (Colton 1959).

JUVENILES

In the NEFSC spring bottom trawl survey, juvenile yellowtail flounder were not collected at temperatures > 11^{o}C and depths > 125 m (Figure 6). During the autumn survey, juveniles were concentrated in areas where temperatures ranged between 9 and 13°C. Juveniles were collected from 5 to 125 m in the spring and autumn surveys (Figure 6).

Temperature and depth relationships observed in the Massachusetts Division of Marine Fisheries bottom trawl survey was similar to patterns in the NEFSC survey (Figure 7). Juveniles were collected at temperatures ranging from 2-14^{o}C in spring and 5-17^{o}C in autumn; the largest catches occurred at 4-8^{o}C in spring and 8-11^{o}C in autumn. Juveniles were collected from 5-75 m in the spring and autumn surveys.

ADULTS

Yellowtail flounder prefer sand or sand-mud sediments (Bowering and Brodie 1991) where they find their demersal prey. Scott (1982b) calculated an index of preference based on percent frequency of occurrence on a particular bottom type. A high proportion of yellowtail flounder favored sand and gravel substrates, which are frequently found in shallow water.

In U.S. waters, yellowtail flounder are captured at depths ranging from 10-360 m, but are frequently found in < 100 m (Miller *et al.* 1991; Walsh 1992). In the NEFSC spring bottom trawl survey, adult yellowtail flounder were concentrated on Georges Bank, frequently along the Southern Flank and on the Northeast Peak in 60-100 m of water (Figure 6). Adults were collected at temperatures ranging from 2^{o}C to 12^{o}C. During autumn, adults were most abundant in areas with temperatures between 8°C and 14.0°C. The overall depth range was 15-100 m in the spring and autumn surveys.

In the Massachusetts Division of Marine Fisheries bottom trawl survey, adults were collected at 4-15°C in spring with the largest catches at 4-9°C (Figure 7). In the autumn survey, catches occurred from 5°C to 15°C with the largest catches at 8-11°C. The overall depth range was 5-75 m and the largest catches occurred from 20 to 50 m in spring and 20 to 40 m in autumn.

Based on 24 years of data from the NEFSC bottom trawl survey, Murawski and Finn (1988) reported that the depth preferences for age 0 yellowtail flounder ranged from 56.1 m in winter to 87.3 m autumn. Depth preferences for age 1+ ranged from 66.1 m in summer to 72.6 m in spring. The mean temperature range for age 0 (3.7-11.0°C) was slightly wider than for age 1+ (3.1-9.1°C). Yellowtail flounder can experience water temperatures that differ by as much as 20°C depending on season and location (Laurence and Howell 1981).

The relationship between yellowtail flounder catches and temperature has been documented (Royce *et al.* 1959; Lux 1964; Sissenwine 1974). Sissenwine (1974) found an inverse correlation between water temperature and year-class strength off southern New England. Helser and Brodziak (1996) found significant positive associations between yellowtail catch and bottom temperature in 20 of 27 years, and between catch and water depth in 25 out of 27 years during NEFSC spring trawl surveys. The number of significant associations in autumn trawl surveys occurred in only 5 of 32 years for bottom temperature and 18 of 32 years for water depth.

Relationships also exist between fish distributions and bottom depth on the Scotian Shelf (Scott 1976, 1982a). Scott (1982b) determined the following ranges for yellowtail flounder on the Scotian Shelf: 27-364 m, with 37-90 m preferred, 1-12°C, with 2-6°C preferred, and 31-34 ppt, with 32-33 ppt preferred. Yellowtail did not make extensive seasonal migrations and displayed higher selectivity for bottom type than for temperatures.

GEOGRAPHICAL DISTRIBUTION

Yellowtail flounder occur along the Atlantic coast of North America from the north shore of the Gulf of St. Lawrence, the Labrador side of the Strait of Belle Isle, northern Newfoundland, Newfoundland banks, and southward to the Chesapeake Bay (Figure 2; Hildebrand and Schroeder 1928; Bigelow and Schroeder 1953; Royce et al. 1959; Lux 1964; Pitt 1970; Laurence and Howell 1981; Walsh 1992). As stated previously, they are most abundant on western Georges Bank, western Gulf of Maine, east of Cape Cod, on Stellwagen Bank, and off southern New England. Yellowtail flounder are rare in most estuaries and rivers in the North Atlantic, although they are common in the Sheepscot River and Casco Bay and abundant in Boston Harbor (Table 3; Jury *et al.* 1994).

EGGS

Collections from the NEFSC MARMAP ichthyoplankton survey (1977-1987) showed little or no spawning activity during January and February (Figure 8). By March and April, eggs appeared on the continental shelf off New Jersey and Long Island, on Georges Bank, northwest of Cape Cod, and on Browns Bank. The distribution and abundance of eggs expanded in southern New England in May. On Georges Bank, the distribution and abundance of eggs expanded in June and declined thereafter; spawning ended in August. The densest egg concentrations occurred on the northeast and southwest part of Georges Bank, west from Nantucket Shoals to New Jersey, northwest of Cape Cod along western Gulf of Maine, and off southwest Nova Scotia.

LARVAE

In the NEFSC MARMAP ichthyoplankton survey, yellowtail flounder larvae (< 7.0 mm NL) first appeared on the shelf in April from the New York Bight south to the Delmarva peninsula (Figure 9). Larvae were collected more frequently from May through July. Their numbers increased in May along the 365 m (200 fm) contour of Georges Bank. The highest larval concentrations occurred in the mixed layer on southwest Georges Bank, off southern New England, and in the New York Bight during May-July. In June, larvae were most abundant from Georges Bank to Hudson Canyon. Abundance declined during July and August when the larvae were caught on southwest Georges Bank and northwest of Cape Cod.

JUVENILES AND ADULTS

Based on the NEFSC bottom trawl survey, yellowtail flounder occur from Nova Scotia south to Chesapeake Bay. Catches are high around Cape Cod during spring and autumn. However, adults and juveniles migrate away from coastal areas off southern New England, especially around Long Island and the New York Bight, during autumn (Figure 10). During the spring surveys, dense concentrations of adults appear on Georges Bank, frequently along the Southern Flank and Northeast Peak. During the winter, yellowtail adults are present over most of Georges Bank, southern New England, and the Middle Atlantic Bight. Adults extend as far south as Maryland while juveniles reach the southern tip of New Jersey. Throughout most of the nearshore areas of southern New England, populations are found from New Jersey, extending south as far as Delaware Bay. Few fish were collected in the Northeast Channel, south of Nova Scotia, Cape Cod, and the Gulf of Maine. Only during the summer did adults appear along the coastal Gulf of Maine.

In the Massachusetts Division of Marine Fisheries bottom trawl survey, yellowtail adults and juveniles concentrate seasonally in coastal waters east of Cape Cod and from northwestern Cape Cod Bay to Ipswich Bay (Cape Cod stock) (Figure 11). In Cape Cod Bay, juveniles appear to redistribute shoreward in fall. Small numbers of mostly juvenile fish are caught seasonally in shoal waters south of Martha's Vineyard and Nantucket Island (southern New England stock).

STATUS OF THE STOCK

Yellowtail flounder became a key constituent of the U.S. demersal fishery in the early 1930s when the stock of winter flounder declined (Royce *et al.* 1959). Twenty-four years later, landings suffered a dramatic decline; however landings peaked in the late 1960s due in large part to an increase in fishing effort (Lux 1964). Yellowtail flounder landings and abundance indices (stratified mean catch per tow) for four principal fishing grounds are presented in Figure 12.

From 1973 to 1975, the spawning stock biomass (SSB) for southern New England dropped 10,000 mt. By 1982, it increased to 22,000 mt due to the strong 1980 year-class and then declined to a low of 2,400 mt in 1984 due to heavy fishing. Numbers increased again to 22,000 mt due to a strong year-class in 1987. It was heavily fished and SSB dropped to 1,057 mt in 1993. Large numbers of discards were generated because of minimum size regulations. The SSB slowly rose during the mid 1990s to < 10,000 mt in autumn 1997. Recruitment from the 1990 year class increased total landings by 1,000 mt from 1991 to 1992 (Northeast Fisheries Science Center 1994b).

In the Georges Bank stock, the four strongest year classes with the highest estimated recruitment at age 1 were 1973, 1974, 1977, and 1980. All cohorts after 1973 were < 25 million at age 1. The 1995 cohort was the weakest since 1986. The SSB was 21,000 mt in 1973 and declined to < 4,000 mt from 1984 to 1988. From 1989 to 1994, SSB remained < 6,000 mt and increased to 11,700 mt in 1996 (Northeast Fisheries Science Center 1997).

During the 1980s, the abundance of New England groundfish declined by 65% when haddock, redfish, and yellowtail flounder reached record low levels (Northeast Fisheries Science Center 1991). Commercial indices of catch-per-unit-effort (CPUE) and standardized research trawl survey indices indicate that yellowtail flounder underwent substantial fluctuations and dramatic declines over a twenty year span (Northeast Fisheries Science Center 1994a, 1994b).

The abundance index for yellowtail flounder was high in 1963-1967 and low in 1984-1988 (Figure 13). During 1963-1967, adult and juvenile yellowtail were abundant along the 60 m contour in southern New England and between at 60-100 m on Georges Bank during autumn. During 1984-1988, yellowtail abundance declined significantly in these areas. According to a recent report to Congress from the Secretary of Commerce (National Marine Fisheries Service 1997), yellowtail flounder are no longer considered overfished on Georges Bank and in southern New England; the status for the Cape Cod and Middle Atlantic Bight stocks is unknown.

RESEARCH NEEDS

- In spite of its commercial importance, relatively little is know about the early life history and development of yellowtail flounder.
- A spatial and temporal comparison of early-life history characteristics based on otolith microstructure.
- Analysis of current age and length at maturity contrasted against historic information on age and length at maturity.
- Habitat specific examination of biotic and abiotic factors, which ultimately affect adult recruitment.

ACKNOWLEDGMENTS

Special acknowledgment and appreciation goes to the reviewers from the Woods Hole Laboratory, Michael Pentony, members of the New England Fishery Management Council, and Dr. Jeffrey Cross for their critical reviews and comments. We also thank librarians Judy Berrien, Rande Ramsey-Cross, and Claire Steimle for their invaluable assistance with literature searches and style suggestions. Thanks also to Michael P. Fahay for his helpful suggestions in preparation of this document.

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Table 1. The length (L) and age (A) at which 50% of the female yellowtail flounder, *Limanda ferruginea*, in the northwest Atlantic Ocean are mature.

Area	**L_{50}** (cm)	**A_{50}** (yrs)	**Source**
Nova Scotia	40	-	Scott (1954)
Cape Cod	32	2.0	Royce *et al.* (1959)
East of 72°	27	-	Morse and Morris (1981)
West of 72°	25	-	Morse and Morris (1981)
Scotian Shelf (1970-1974)	24	3.1	Beacham (1983)
Scotian Shelf (1975-1979)	29	2.9	Beacham (1983)
Georges Bank	25.8	1.8	O'Brien *et al.* (1993)
Cape Cod	27.3	2.6	O'Brien *et al.* (1993)
Southern New England	25.5	1.6	O'Brien *et al.* (1993)

Table 2. Summary of life history and habitat parameters for yellowtail flounder, *Limanda ferruginea*. (NTS = NEFSC Trawl Survey; MITS = Massachusetts Inshore Trawl Survey).

Life Stage	Size Range	Time of Year Distribution	Habitat/Location	Substrate	Temperature
Spawning Adults	see Table 1	mid-March to September, peaks in April to June in southern New England, late June to July in Canada. [1]	Along continental shelf waters of Georges Bank, northwest of Cape Cod, southern New England and nearshore along NJ and southern Long Island.		Estimated range 2.0-17°C
Eggs	0.76-1.01 mm (avg. 0.88 mm)	mid-March to July, peaks in April to June in southern New England, late June to July in Canada.	Pelagic, near surface, along continental shelf waters of Georges Bank, northwest of Cape Cod, southern New England and nearshore along NJ and southern Long Island.		range 2.0-15°C
Larvae	up to 16 mm	March through April (< 7.0mm NL) in NY Bight. Peak during May-July in southern New England and southeastern Georges Bank.	Pelagic, movement limited to water current		range 5.0-17°C
Juveniles	17 mm to < 26 cm	January to December	Spring: In Gulf of Maine concentrations occur between Mass. Bay, Cape Cod, and along the outer perimeter of Cape Cod. Southern edge of Georges Bank. [2] Autumn: In Gulf of Maine concentrations occur between Mass. Bay, Cape Cod, and along the outer perimeter of Cape Cod. Northern shift towards Great South Channel, in deeper waters along the Southern Flank of Georges Bank. [2]	sand or sand and mud sand or sand and mud	NTS 2.0-13°C (most 3.0-10°C) MITS 2.0-16°C (most 4.0-7°C) NTS 5.0-18°C (most 7.0-15°C) MITS 5.0-17°C (most 8.0-11°C)
Adults	≥ 26 to 60 cm	January to December	Overall distributions include the Strait of Belle Isle down to the Chesapeake Bay. High concentrations around Cape Cod for both spring and autumn seasons. Concentrations pull away from coastal southern New England, Long Island, and the NY Bight during autumn months.	sand or sand and mud	For NTS same as Juvenile above; MITS spring: > 2-17°C (most 5-8°C), autumn: > 5-17°C (most 8-12°C)

[1] Martin and Drewry (1978);
[2] Wigley and Gabriel (1991)

Table 2. cont'd.

Life Stage	Salinity	Depth (m)	Estuarine Use	Notes
Spawning Adults	32.44-33.49 ppt (southern New England); 32.75-33.35 ppt (Georges Bank)	Estimated range 10-1250 m	Largely an oceanic nursery (see Table 3).	
Eggs	32.44-33.49 ppt (southern New England); 32.75-33.35 ppt (Georges Bank)	range 10-750 m (most 30-90 m)	Largely an oceanic nursery (see Table 3).	Buoyant pelagic spheres, lack an oil globule. Shell is smooth, clear and colorless, yolk is homogenous.
Larvae	32.44-33.49 ppt (southern New England); 32.75-33.35 ppt (Georges Bank)	Vertical abundance peak 10 m at night, 20 m in the daytime. [1] Range 10-1250 m (most 10-90 m)	Largely an oceanic nursery (see Table 3).	Transformation occurs between 11.6-16.0 mm. [2]
Juveniles	Spring: 32.44-33.49 ppt (southern New England); 32.75-33.35 ppt (Georges Bank) Autumn: 32.44-33.49 ppt (southern New England); 32.75-33.35 ppt (Georges Bank)	9.0-179 m (mean 47.3 m) [3] MITS 5-60 m (most 30-50 m) 14-287.0 m (mean 63 m) [3] MITS 5-60 m (most 20-40 m)	Largely an oceanic nursery (see Table 3). Largely an oceanic nursery (see Table 3).	Significant juvenile mortality found in the southern New England region with unregulated mesh size. [3] (Trawl Surveys 1968-1986)
Adults	32.44-33.49 ppt (southern New England); 32.75-33.35 ppt (Georges Bank)	9.0-238 m concentrated at 37-73 m. During spring and summer trawl surveys found between 15-100 m. MITS spring: 5.0-75m (most 20-50 m); autumn: > 5.0-65 m (most 20-40 m)	Largely an oceanic nursery (see Table 3).	

[1] Smith *et al*. 1975;
[2] Fahay 1983;
[3] Wigley and Gabriel 1991

Table 3. Distribution of life history stages of yellowtail flounder in estuaries and rivers of the northwest Atlantic Ocean (from Jury *et al*. 1994). *** = Highly Certain; ** = Moderately Certain; * = Reasonable Inference.

Estuaries and Rivers	**Life Stage**	**Distribution and Relative Abundance**		**Months of Occurrence**	**Data Reliability**
		Mixing	**Seawater**		
Passamaquoddy Bay	**A**dults (A)		Rare	Jan - Dec	**
	Spawning adults (S)		Rare	April - Aug	*
	Juveniles (J)		Rare	Jan - Dec	**
	Larvae (L)		Rare	April - Aug	*
	Eggs (E)		Rare	April - Aug	*
Englishman / Machias Bay	**A**		Rare	Jan - Dec	**
	S		Rare	April - Aug	*
	J		Rare	Jan - Dec	**
	L		Rare	April - Aug	*
	E		Rare	April - Aug	*
Narraguagus Bay	**A**		Rare	Jan - Dec	**
	S		Rare	April - Aug	*
	J		Rare	Jan - Dec	**
	L		Rare	April - Aug	*
	E		Rare	April - Aug	*
Blue Hill Bay	**A**		Rare	Jan - Dec	**
	S		Rare	April - Aug	*
	J		Rare	Jan - Dec	**
	L		Rare	April - Aug	*
	E		Rare	April - Aug	*
Penobscot Bay	**A**		Rare	Jan - Dec	**
	S		Rare	April - Aug	*
	J		Rare	Jan - Dec	**
	L		Rare	April - Aug	*
	E		Rare	April - Aug	*
Muscongus Bay	**A**		Rare	Jan - Dec	**
	S		Rare	April - Aug	*
	J		Rare	Jan - Dec	**
	L		Rare	April - Aug	*
	E		Rare	April - Aug	*
Damariscotta River	**A**		Rare	Jan - Dec	**
	S		Rare	April - Aug	*
	J		Rare	Jan - Dec	**
	L		Rare	April - Aug	*
	E		Rare	April - Aug	*
Sheepscot River	**A**		Common	Jan - Dec	***
	S		Rare	April - Aug	***
	J		Common	Jan - Dec	***
	L		Rare	April - Aug	***
	E		Rare	April - Aug	***
Kennebec / Androscoggin Rivers	**A**		Rare	Jan - Dec	**
	S		Rare	April - Aug	*
	J		Rare	Jan - Dec	**
	L		Rare	April - Aug	*
	E		Rare	April - Aug	*
Casco Bay	**A**		Common	Jan - Dec	*
	S		Common	April - Aug	*
	J		Common	Jan - Dec	*
	L		Common	April - Aug	*
	E		Common	April - Aug	*

Table 3. cont'd.

Estuaries and Rivers	Life Stage	Distribution and Relative Abundance		Months of Occurrence	Data Reliability
		Mixing	Seawater		
Saco Bay	**A**		Rare	Jan - Dec	*
	S		Rare	April - Aug	*
	J		Rare	Jan - Dec	*
	L		Rare	April - Aug	*
	E		Rare	April - Aug	*
Wells Harbor	**A**		Not Present		*
	S		Not Present		*
	J		Rare	April - Nov	**
	L		Rare	April - Aug	*
	E		Not Present		*
Great Bay	**A**		Not Present		**
	S		Not Present		***
	J		Not Present		**
	L		Rare	April - Sept	**
	E		Rare	April - Sept	**
Merrimack River	**A**		Not Present		**
	S		Not Present		**
	J		Not Present		**
	L	Rare	Not Present	April - Sept	*
	E	Rare	Not Present	April - Sept	*
Massachusetts Bay	**A**		Abundant	Jan - Dec	***
	S		Abundant	April - Sept	*
	J		Abundant	Jan. - Dec	***
	L		Abundant	April - Oct	*
	E		Abundant	April - Sept	*
Boston Harbor	**A**		Abundant	Jan - Dec	**
	S		Abundant	April - Sept	*
	J		Abundant	Jan - Dec	**
	L		Abundant	April - Oct	*
	E		Abundant	April - Sept	*
Cape Cod Bay	**A**		Common	Jan - Dec	**
	S		Common	April - Sept	*
	J		Common	Jan - Dec	**
	L		Common	April - Oct	**
	E		Common	April - Sept	**

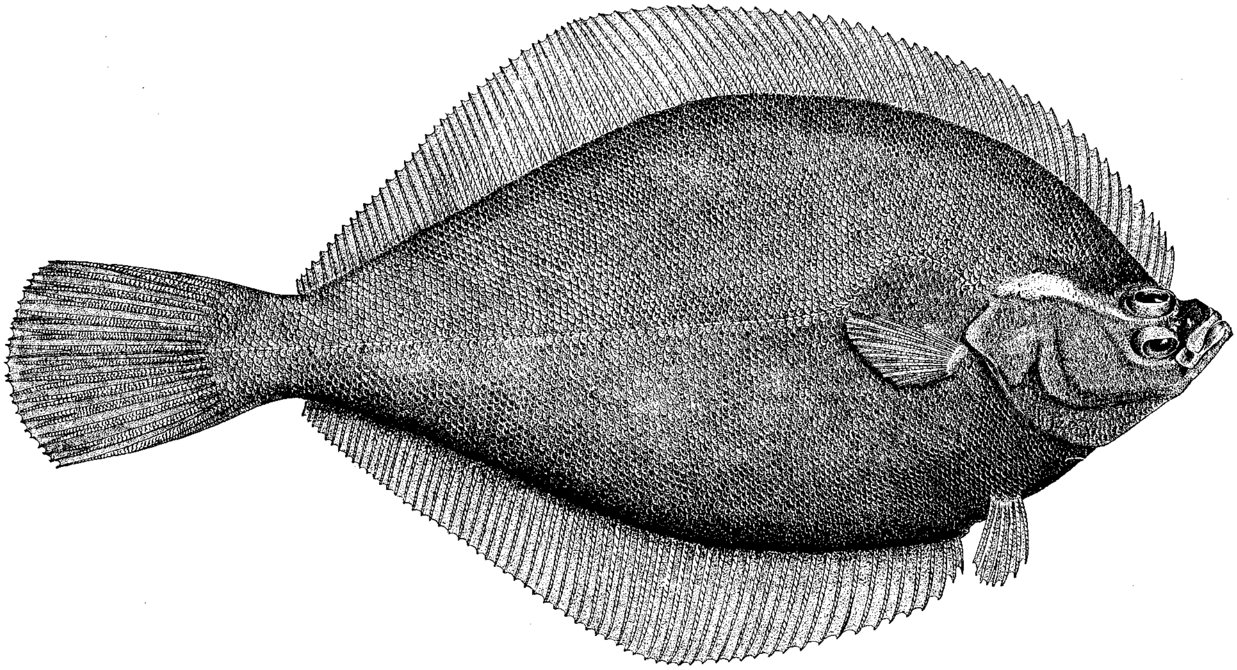
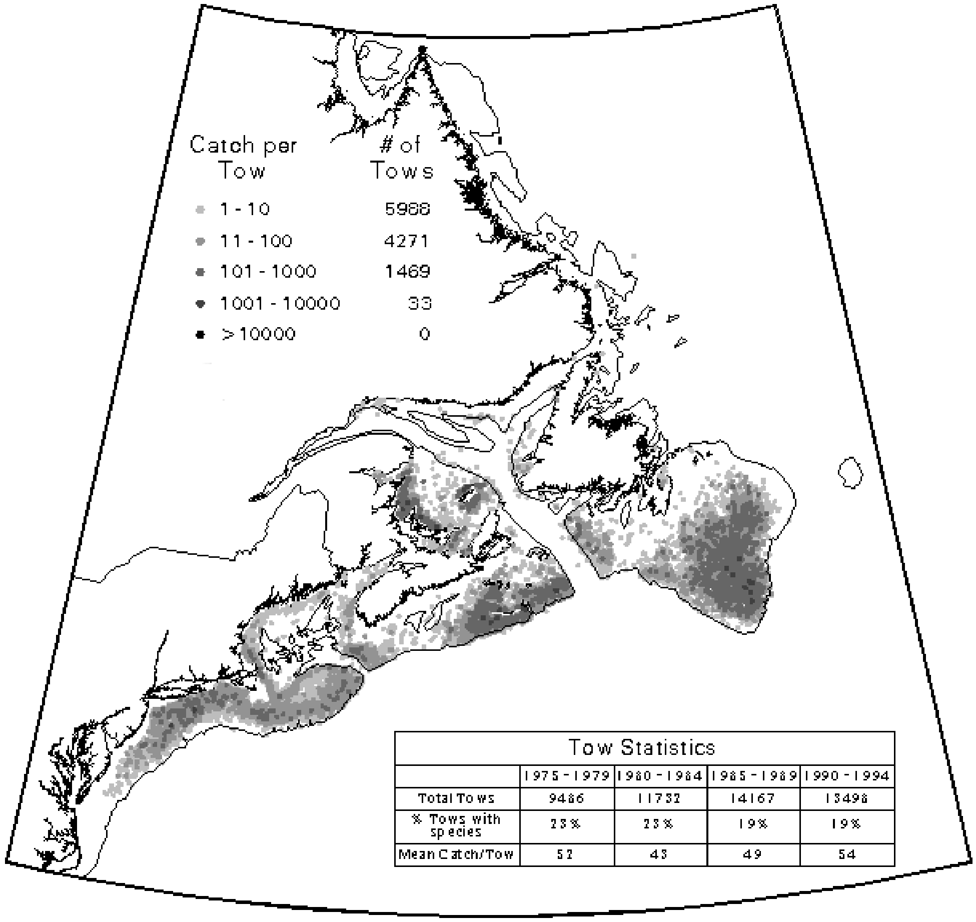


Figure 1. The yellowtail flounder, *Limanda ferruginea* (from Goode 1884).



	1975 - 1979	1980 - 1984	1985 - 1989	1990 - 1994
Total Tows	9486	11732	14167	13498
% Tows with species	23%	23%	19%	19%
Mean Catch/Tow	52	43	49	54

Figure 2. Distribution and abundance of Yellowtail flounder from Newfoundland to Cape Hatteras based on research trawl surveys 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).

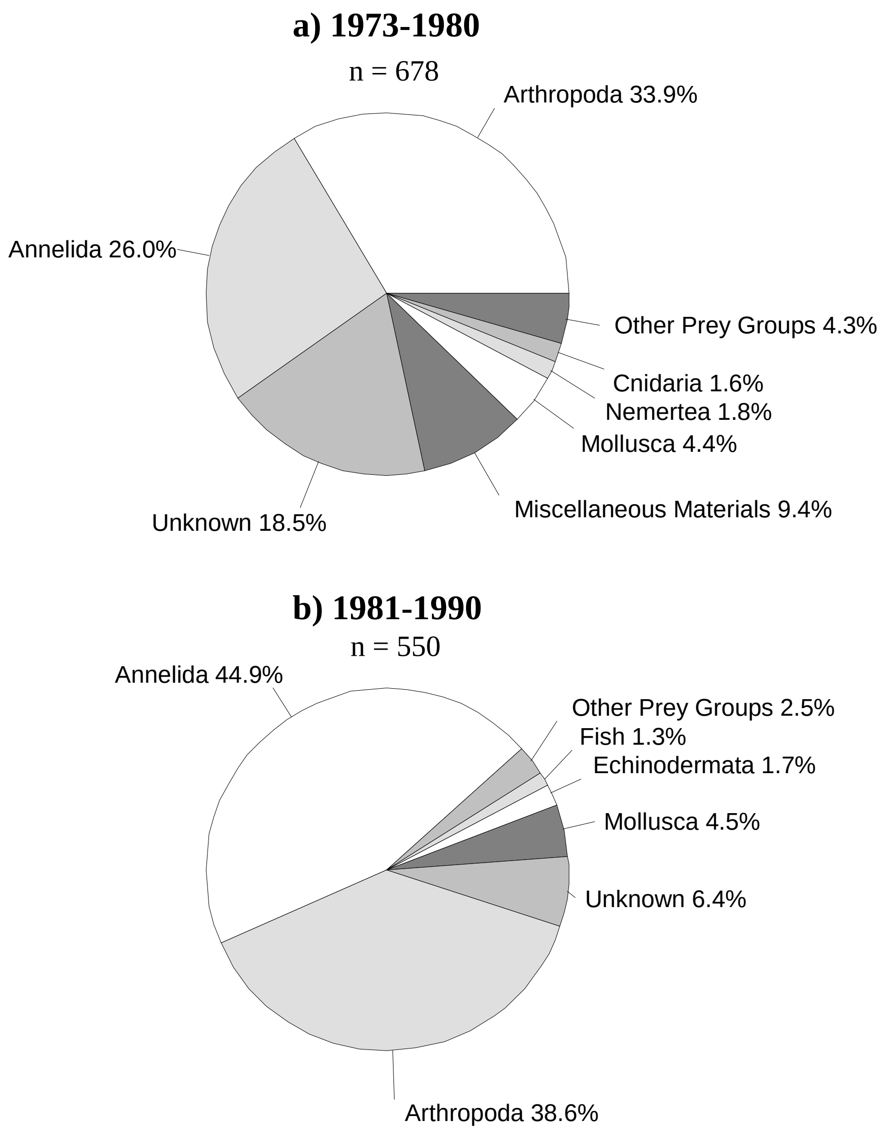
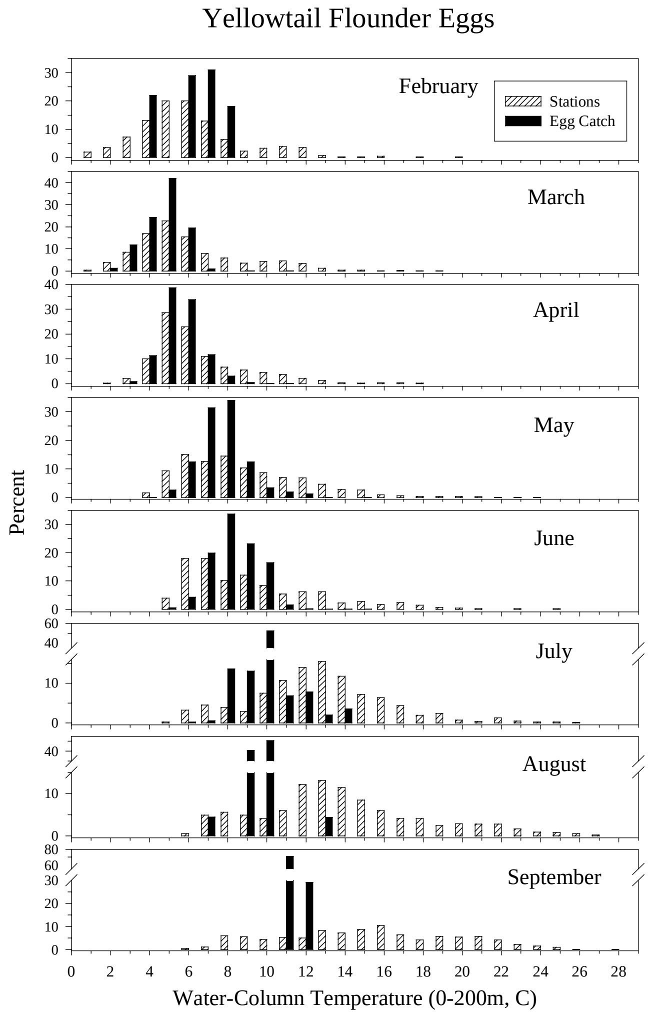


Figure 3. Abundance (% occurrence) of the major prey items in the diet of yellowtail flounder collected during NEFSC bottom trawl surveys from 1973-1980 and 1981-1990. The category “unknown” refers to unidentifiable animal matter. Methods for sampling, processing, and analysis of samples differed between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



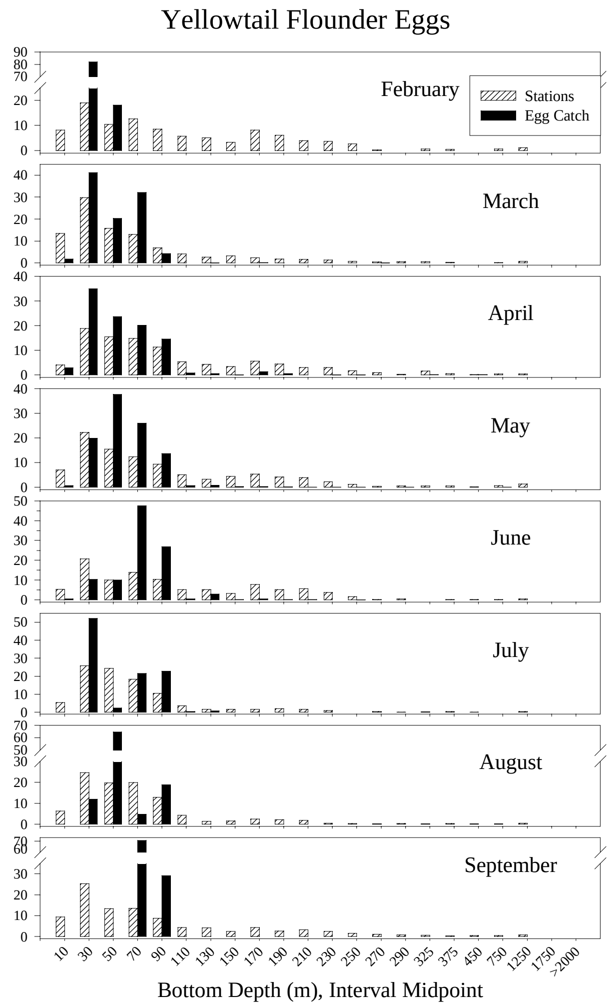


Figure 4. Abundance of yellowtail flounder eggs relative to water column temperature (to a maximum of 200 m) and bottom depth from NEFSC MARMAP ichthyoplankton surveys (1977-1987) by month for all years combined. Open bars represent the proportion of all stations surveyed, while solid bars represent the proportion of the sum of all standardized catches (number/10 m^2).

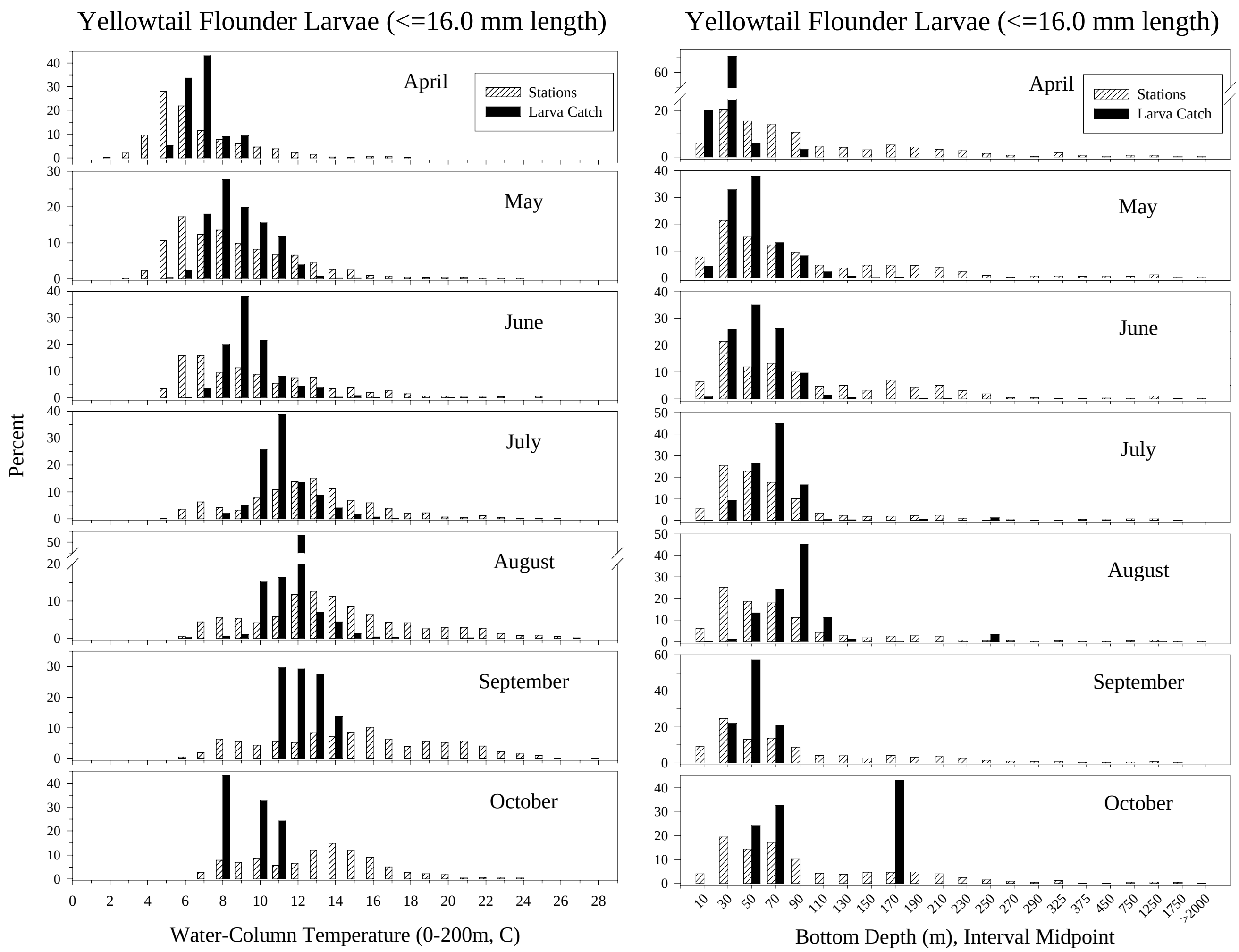


Figure 5. Abundance of yellowtail flounder larvae relative to water column temperature (to a maximum of 200 m) and bottom depth from NEFSC MARMAP ichthyoplankton surveys (1977-1987) by month for all years combined. Open bars represent the proportion of all stations surveyed, while solid bars represent the proportion of the sum of all standardized catches (number/10 m^2).

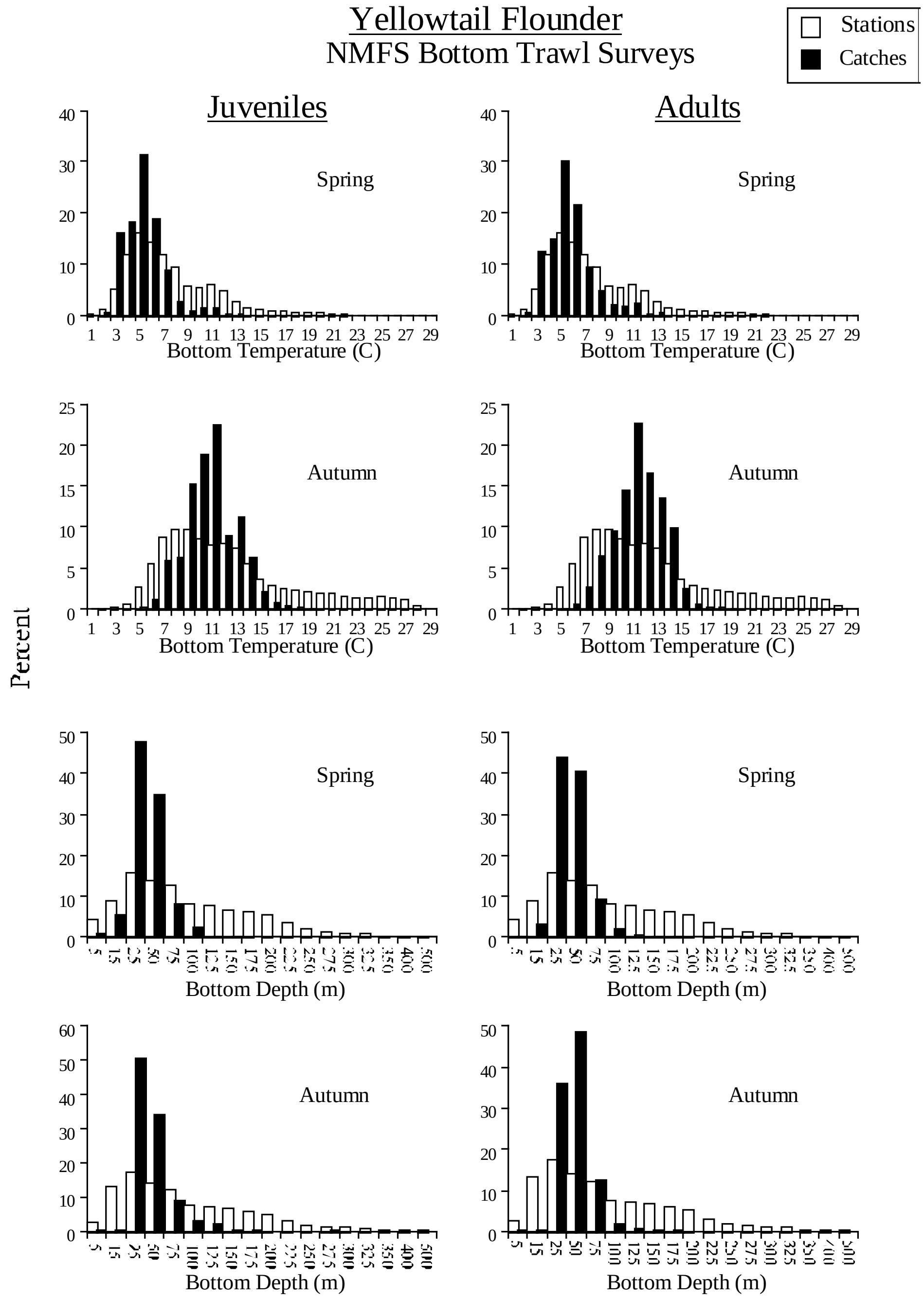


Figure 6. Abundance of juvenile and adult yellowtail flounder relative to bottom water temperature and depth based on spring (1968-1997) and autumn (1963-1996) NEFSC bottom trawl surveys. Open bars represent the proportion of all stations surveyed, while solid bars represent the proportion of the sum of all standardized catches (number/10 m^2).

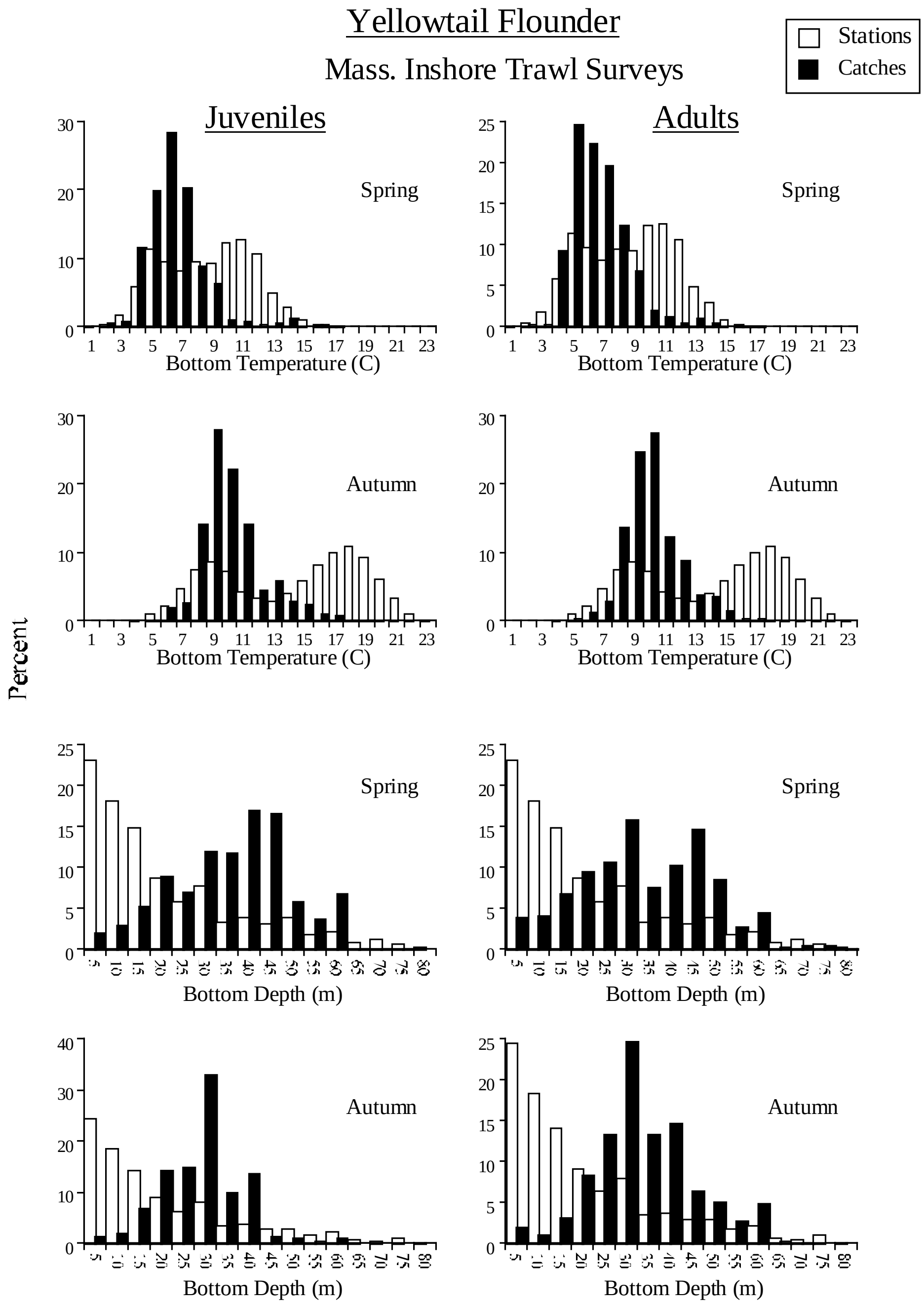


Figure 7. Abundance of juvenile and adult yellowtail flounder relative to bottom water temperature and depth based on Massachusetts inshore bottom trawl surveys (spring and autumn 1978-1996) for all years combined. Open bars represent the proportion of all stations surveyed, while solid bars represent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

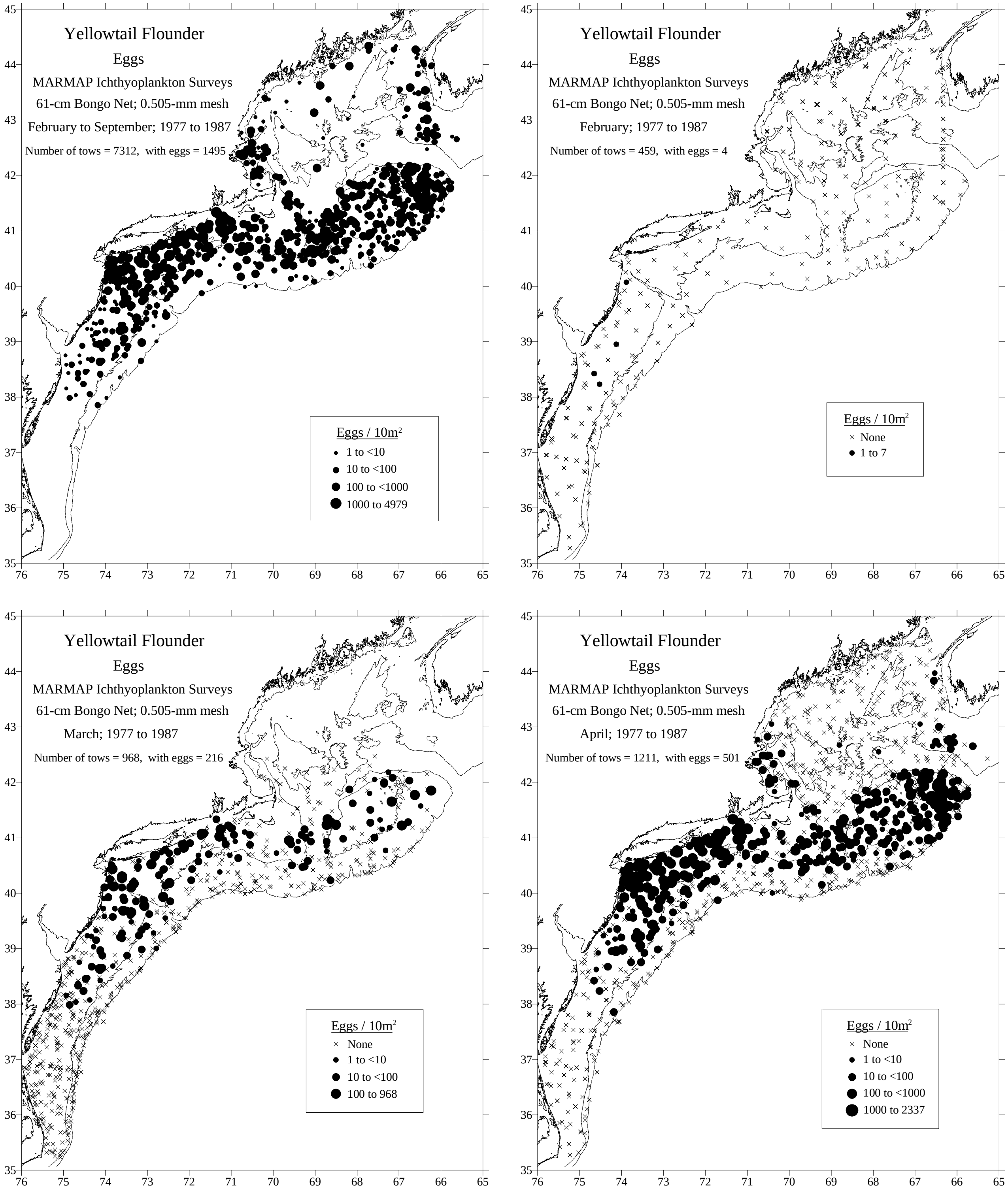
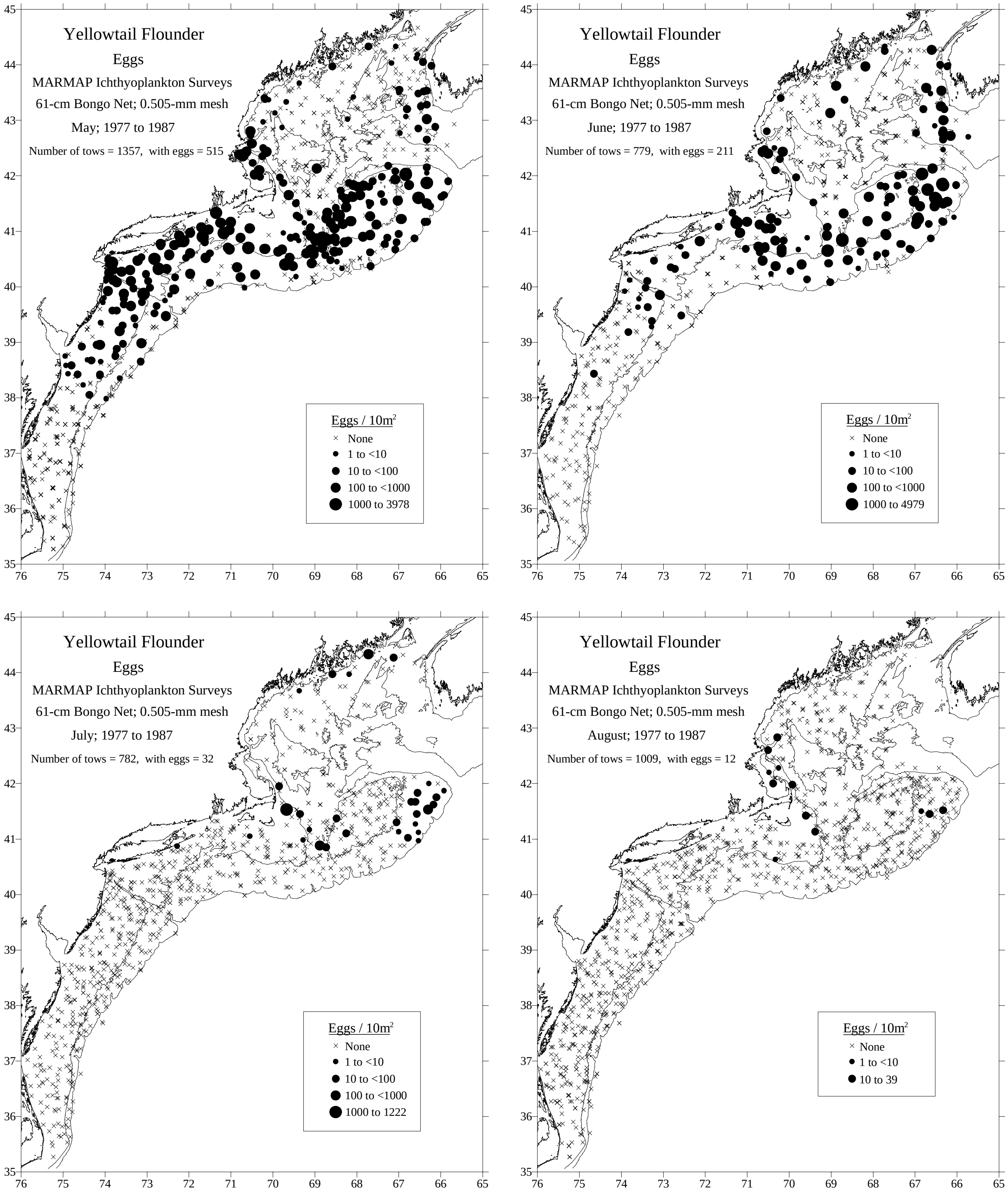


Figure 8. Distribution and abundance of yellowtail flounder eggs collected during NEFSC MARMAP ichthyoplankton surveys, February to September, 1977-1987 [see Reid *et al.* (1999) for details].



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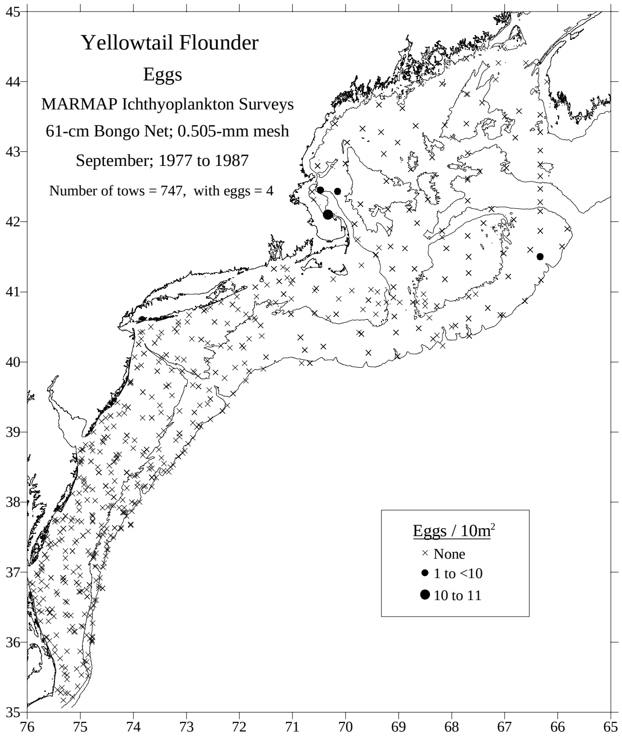

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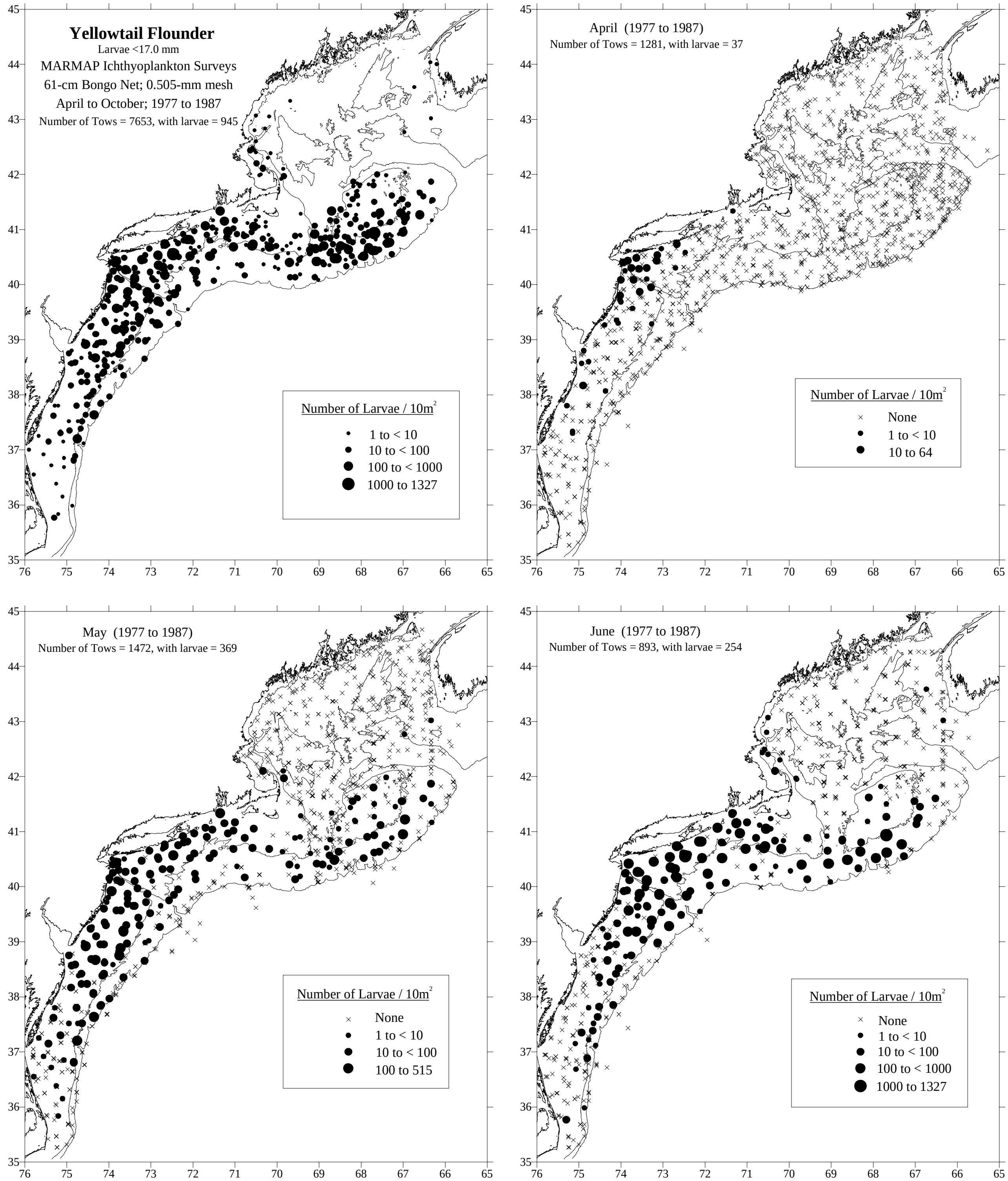
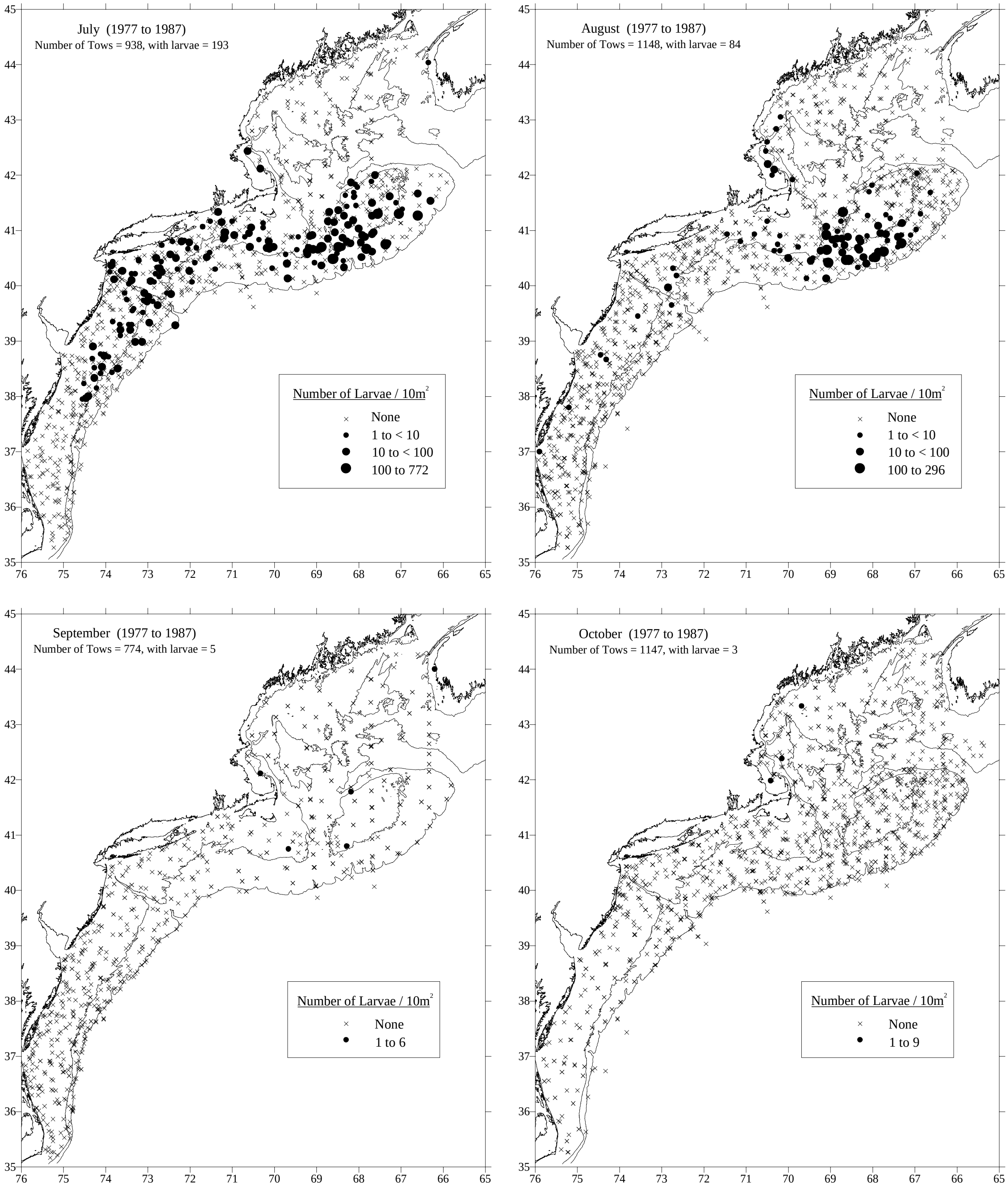


Figure 9. Distribution and abundance of yellowtail flounder larvae collected during NEFSC MARMAP ichthyoplankton surveys, April to October, 1977-1987 [see Reid *et al.* (1999) for details].



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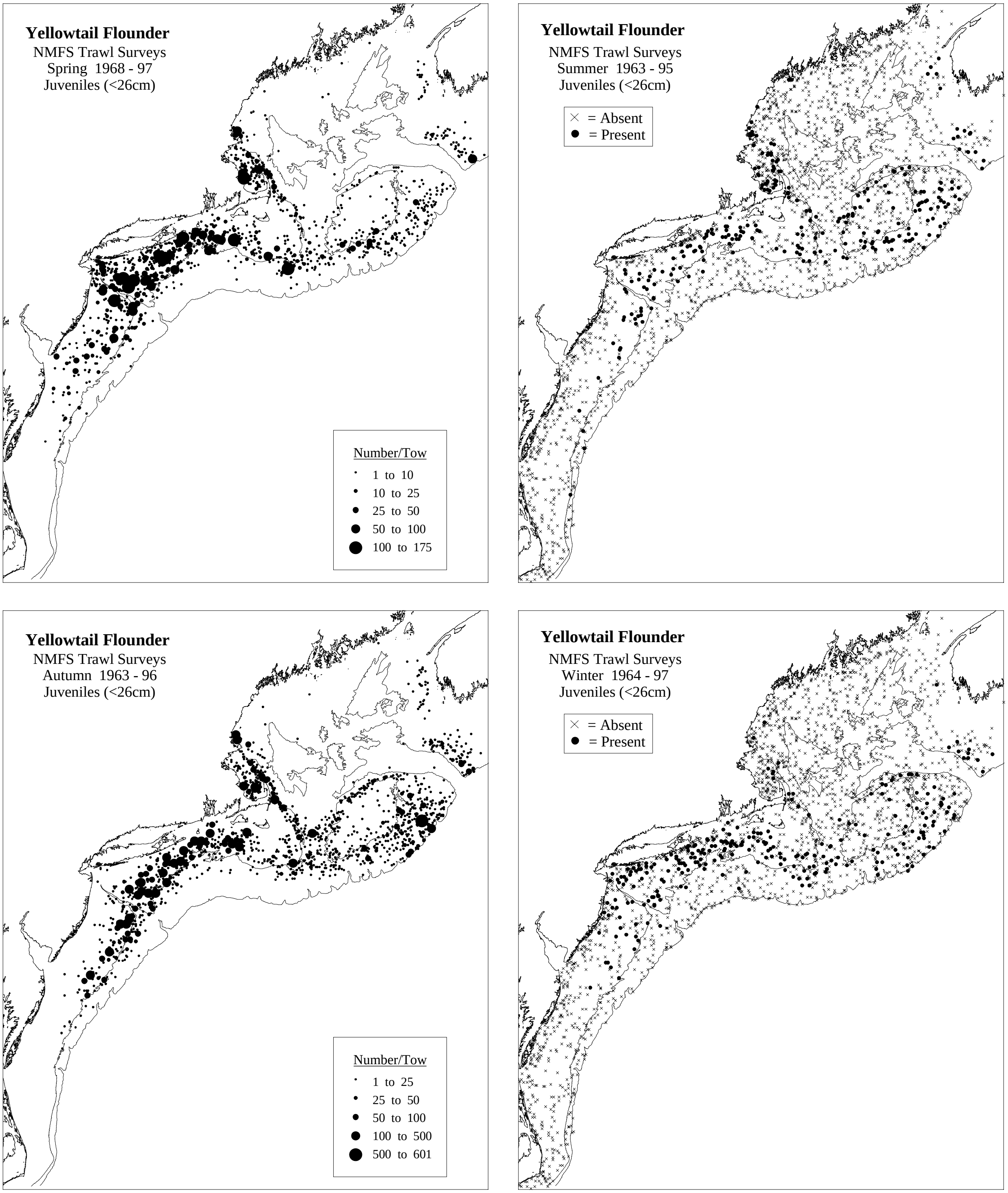
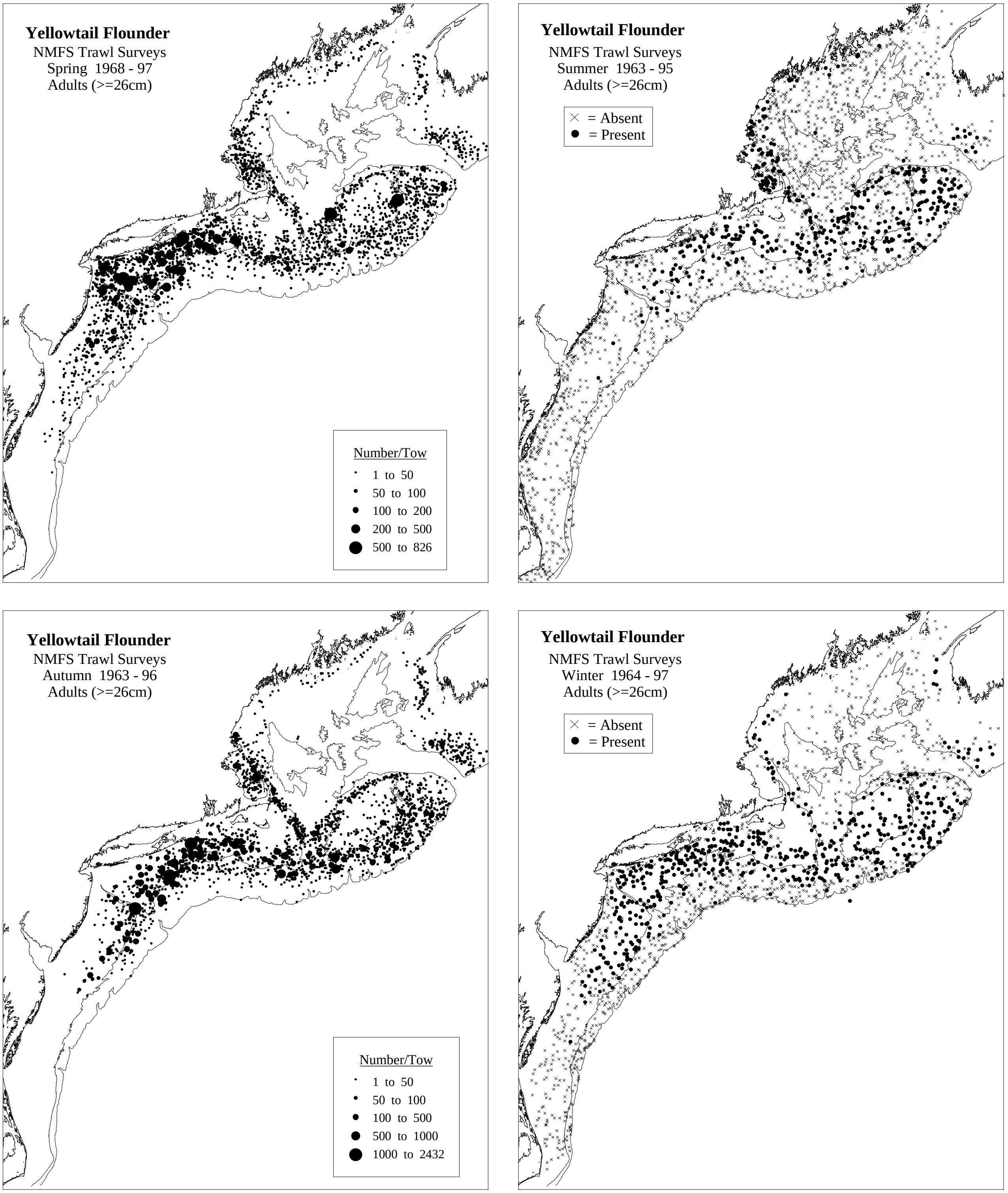


Figure 10. Distribution and abundance of juvenile and adult yellowtail flounder collected during NEFSC bottom trawl surveys during all seasons during 1963-1997. Densities are represented by dot size in spring and fall plots, while only presence and absence are represented in winter and summer plots [see Reid *et al.* (1999) for details].



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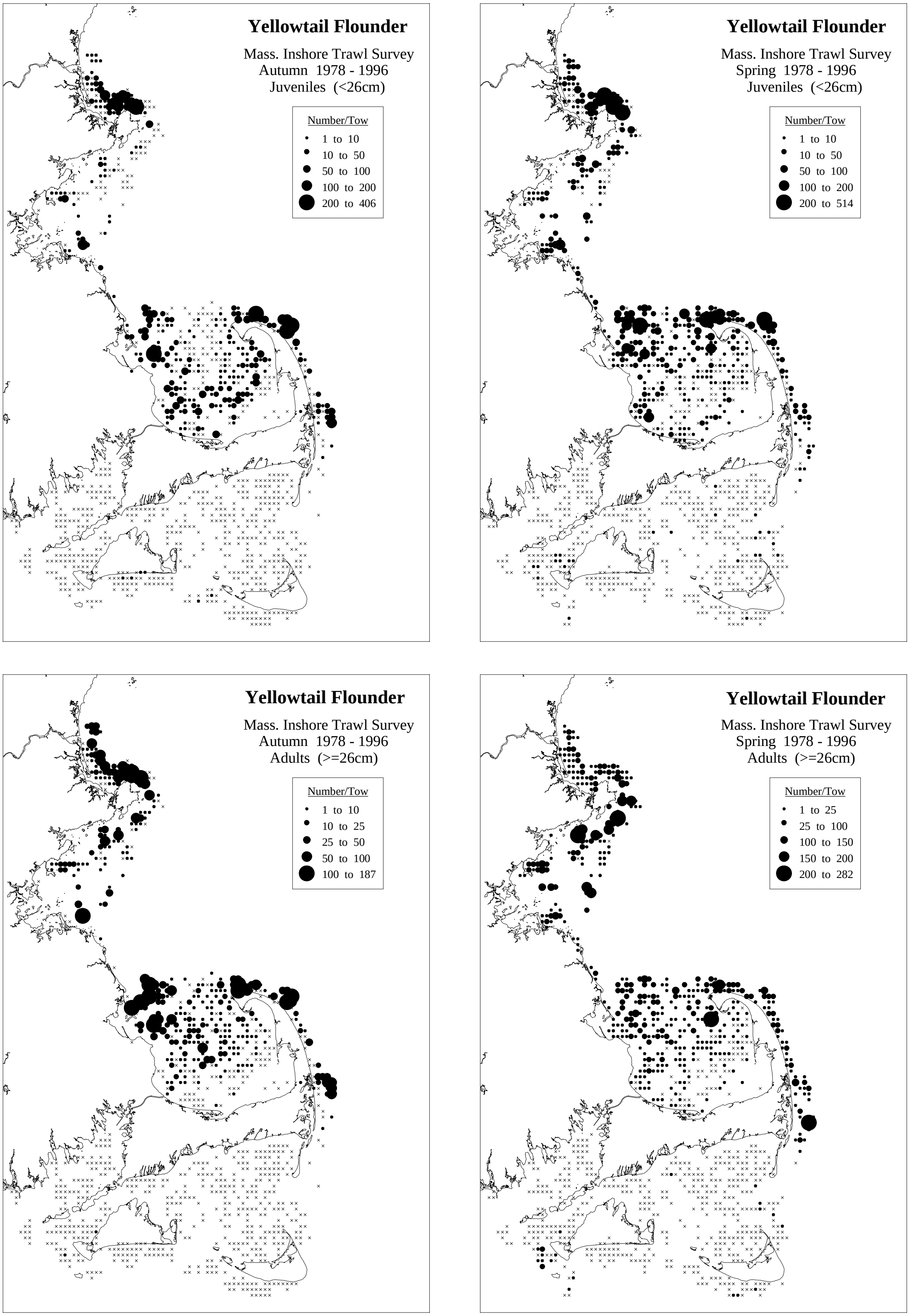


Figure 11. Distribution and abundance of juvenile and adult yellowtail flounder in Massachusetts coastal waters during spring and autumn Massachusetts trawl surveys, 1978-1996 [see Reid *et al.* (1999) for details].

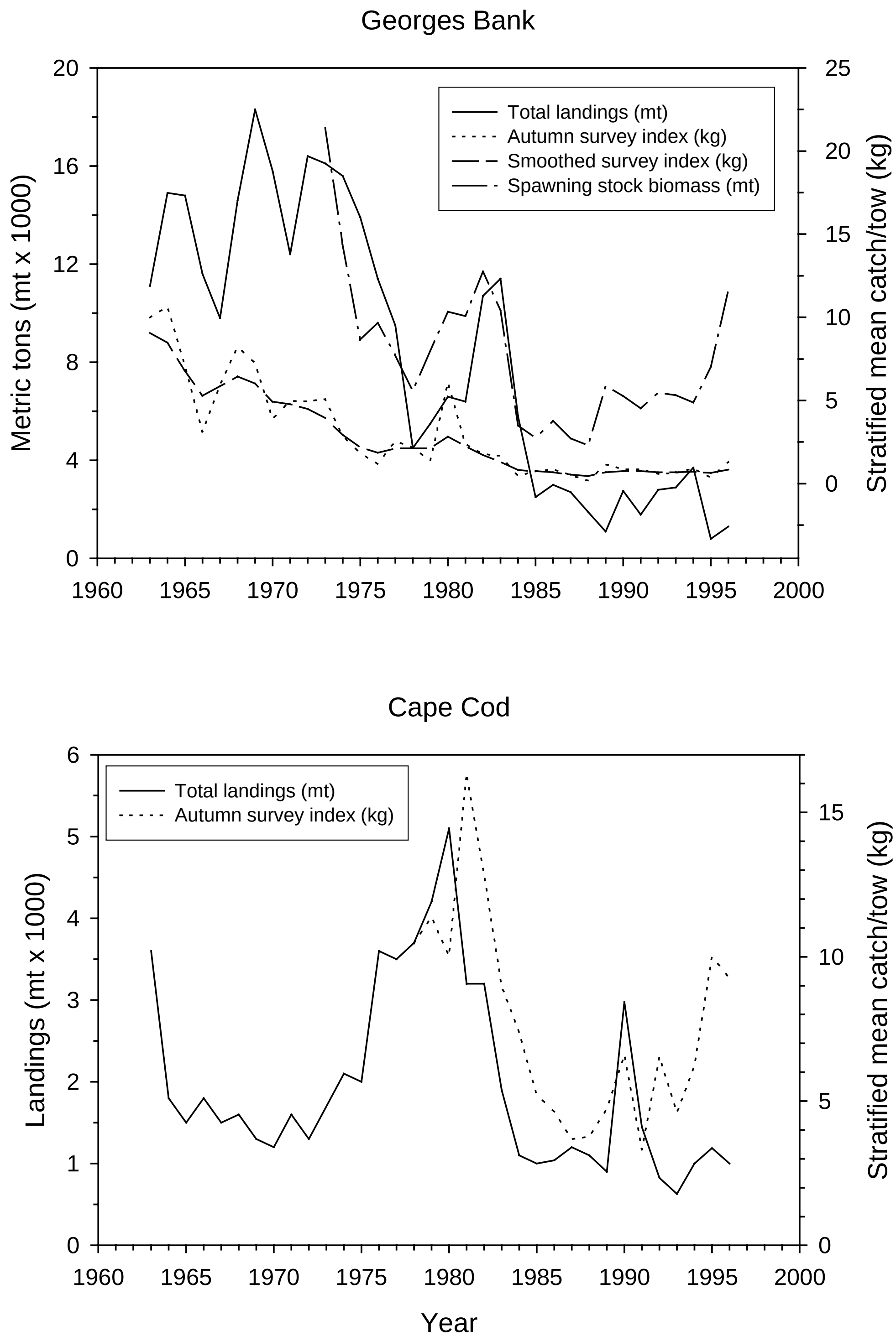
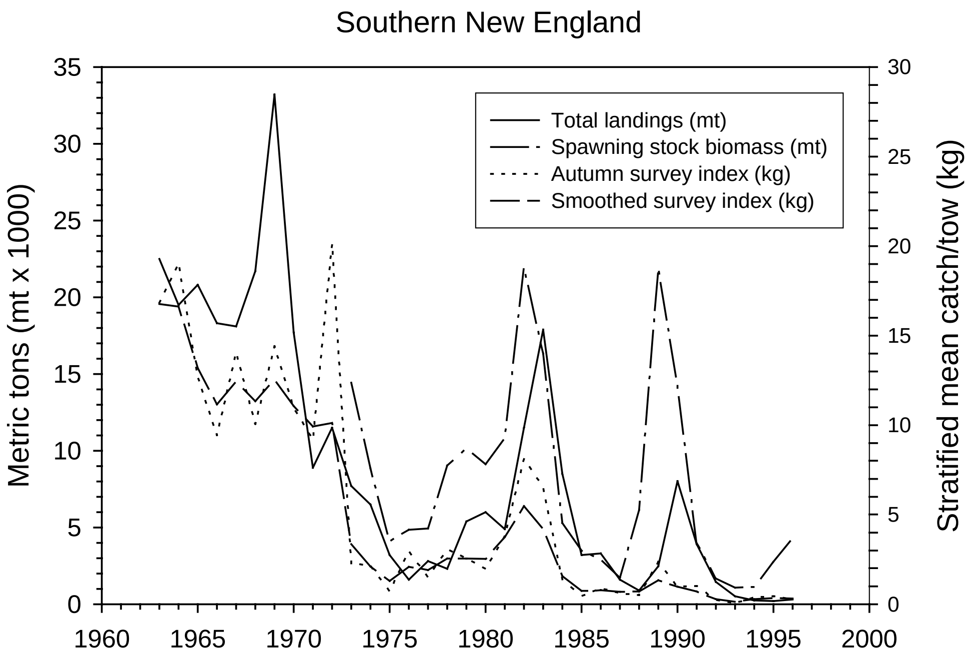
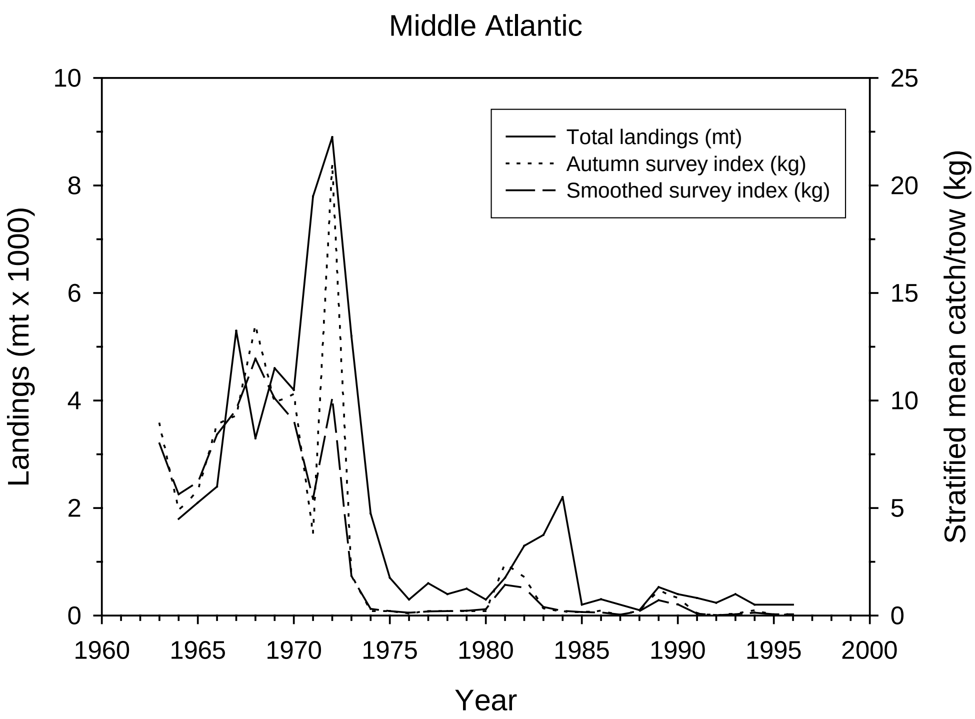


Figure 12. Commercial landings, survey indices, and spawning stock biomass (from the NEFSC bottom trawl surveys) for yellowtail flounder from Georges Bank, Cape Cod, southern New England, and the Middle Atlantic Bight.





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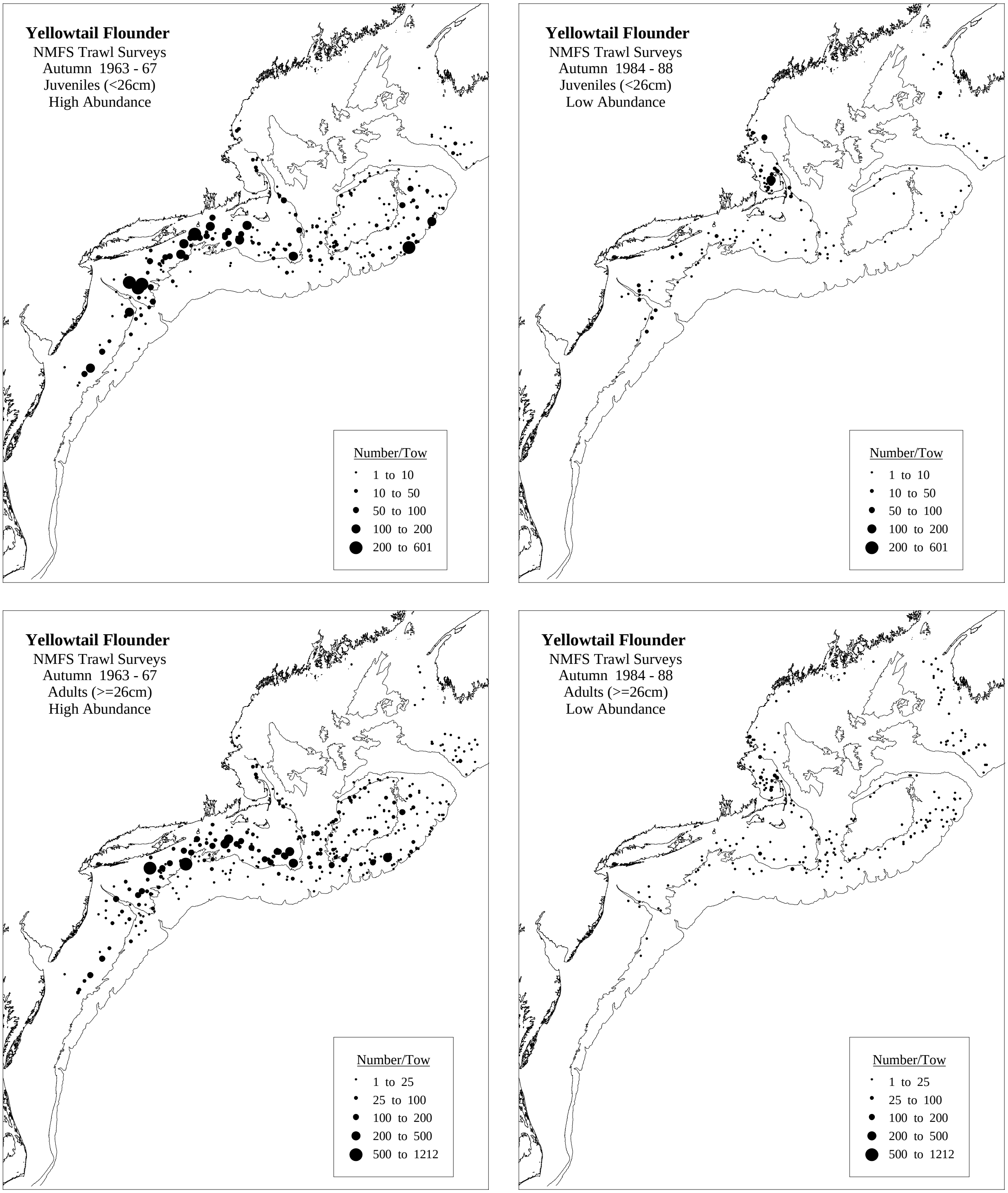

Figure 13. Distribution and abundance of juvenile and adult yellowtail flounder during a period of high abundance (1963-1967) and during a period of low abundance (1984-1988), from autumn NEFSC bottom trawl surveys.

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