NOAA Technical Memorandum NMFS-NE-129

Essential Fish Habitat Source Document:

Ocean Pout, *Macrozoarces americanus*, 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:

Ocean Pout, *Macrozoarces americanus*, Life History and Habitat Characteristics

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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 ocean pout (*Macrozoarces americanus*; Figure 1), also known as eel pout or muttonfish (previously *Zoarces anguillaris*), is a cool-temperate species found on the Atlantic continental shelf of North America between Labrador and the southern Grand Banks and Virginia, between 38-43.5^o latitude and 65-75^o longitude (Orach-Meza 1975; Clark and Livingstone 1982; Chang 1990; Brown *et al.* 1996). It can occur south of Cape Hatteras in deeper, cooler waters (Clemens and Clemens 1921; Orach-Meza 1975; Scott and Scott 1988). Ocean pout are caught in highest abundance in otter trawls off southern New England (Clark and Livingstone 1982; Chang 1990).

Jury *et al.* (1994) reported that all life stages of ocean pout were abundant in Passamaquoddy Bay, Maine-New Brunswick, but most of their information in the Gulf of Maine was based on "reasonable inference," except for the Sheepscot River estuary, New Hampshire, and Massachusetts and Cape Cod bays. In the Sheepscot Bay, Maine, Packer and Langton (in prep.) reported the species was co-dominant with American plaice (*Hippoglossoides platessoides*) at muddy stations. Ocean pout grow to 98 cm TL and weigh to 5.3 kg, although few grow longer than 75 cm TL (Bigelow and Schroeder 1953). At about 70 cm in length, ocean pout were estimated to be 18-20 years old (Hoenig 1982; Scott and Scott 1988), but some probably live longer based on reported lengths of nearly 100 cm.

LIFE HISTORY

The ocean pout is a bottom dweller in waters north of Cape Hatteras, North Carolina, using both open and rough habitats, where it feeds on benthic organisms. It spawns in protected habitats, such as rock crevices and man-made artifacts, where it lays eggs in nests that it guards. Ocean pout do not make extensive migrations (Table 1). It is currently considered as two stocks for management purposes.

EGGS

The eggs are demersal and laid in gelatinous masses in a sheltered place on the bottom, such as rocky crevices, where they are guarded either by one or both parents until hatching (White 1939; Bigelow and Schroeder 1953; Keats *et al.* 1985). Human artifacts, such as old rubber boots, can be used as spawning nests (Bigelow and Schroeder 1953). In the Gulf of Maine, there may be competition with wolffish for nesting sites (Scott and Scott 1988). Egg development is about 2-3 months, but incubation time is temperature dependent and is shorter in the warmer Middle Atlantic Bight (Olsen and Merriman 1946). Most of the population spawns in the fall and hatching occurs by mid-winter (Bigelow and Schroeder 1953). Egg size (diameter) varies seasonally and gradually increases from 1.11 mm in November to a peak of 5.88 mm in September (Olsen and Merriman 1946).

LARVAE

The larvae are about 30 mm long at hatching and are relatively advanced in development (Clark and Livingstone 1982; Methven and Brown 1991), although they can still have an external yolk sac that is soon withdrawn into the abdomen (White 1939). Length and weight at hatching are positively correlated with time of hatch and differ significantly for early- and late-hatched individuals; early-hatched larvae have larger yolk sacs and faster growth rates, suggesting a short larval phase. Bigelow and Schroeder (1953) suggest that the larvae stay on or near the bottom. Very few larvae (32-45 mm TL) were collected during the Northeast Fisheries Science Center (NEFSC) Marine Resources Monitoring, Assessment and Prediction (MARMAP) ichthyoplankton survey (1977-1992) and other surveys (Scherer 1984).

JUVENILES

Juveniles grow to 6-8 cm TL by their first summer (Olsen and Merriman 1946; Sheehy *et al.* 1977) and are about 10-12 cm TL at the end of their first year. The growth rate based on tag returns in Rhode Island waters was almost linear for juveniles to around 30 cm TL (Sheehy *et al.* 1977). Growth rates of the northern, Gulf of Maine population are less than growth rates on Georges Bank and farther south (Olsen and Merriman 1946).

ADULTS

Adult ocean pout remain demersal and are not known to form schools or aggregations. Natural mortality has been estimated at 0.25 based on a maximum age regression (Hoenig 1982).

Using Canadian and NEFSC bottom trawl data, Brown *et al.* (1996) found that ocean pout was associated with two species assemblages: (1) south-central, warm, shallow to mid depth assemblage concentrated in the Gulf of Maine, southern Scotian Shelf, outer edges of Georges Bank, and Middle Atlantic Bight with red hake (*Urophycis chuss*), cusk (*Brosme brosme*), pollock (*Pollachius virens*), spiny dogfish (*Squalus acanthias*), white hake (*Urophycis tenuis*), goosefish (*Lophius americanus*), haddock (*Melanogrammus aeglefinus*), and northern shortfin squid (*Illex illecebrosus*); and (2) central, medium temperature, shallow fragmented assemblage occurring on bank tops and coastal areas near southern New England with longhorn sculpin (*Myoxocephalus octodecemspinosus*), sea raven (*Hemitripterus americanus*), yellowtail flounder (*Limanda ferruginea*), and winter flounder (*Pseudopleuronectes americanus*).

From spring through fall, 1978-1980, ocean pout occurred inshore with yellowtail flounder, cod, and sea raven; in some seasons ocean pout occurred with spiny dogfish and American plaice (Phoel 1985). However, Colvocoresses and Musick (1984) reported that ocean pout were only weakly associated with species such as yellowtail flounder, longhorn sculpin, little skate (*Raja erinacea*), and windowpane (*Scophthalmus aquosus*) on the mid to outer continental shelf, in the spring. Both of these studies were based on NEFSC trawl data. In the Middle Atlantic Bight, ocean pout uses rocky habitats during some seasons. It becomes a member of an assemblage of temperate reef and wreck fish that includes black sea bass (*Centropristis striata*), tautog (*Tautoga onitis*), cunner (*Tautogolabrus adspersus*), scup (*Stenotomus chrysops)*, summer flounder (*Paralichthys dentatus*), triggerfish (*Balistes* spp.), conger eel (*Conger oceanicus*), and American lobster (*Homarus americanus*) (Briggs 1975; Eklund 1988).

REPRODUCTION

The size of sexual maturity differs between northern and southern populations and between studies. Northern males mature at a mean length of 30.3 cm and females at 26.2 cm; southern males mature at mean lengths of 31.9 cm (2+ yr) and females at 31.3 cm (O'Brien *et al.* 1993). Olsen and Merriman (1946) reported that the average sizes of sexual maturity for southern New England males was 25-39 cm TL and for females 45-65 cm TL. O'Brien *et al.* (1993) suggest the differences in estimated size at maturity of females between the two studies may be due to the difficulty of defining mature females. Immature female ocean pout may begin to produce eggs, but the eggs may not be spawned for two or more years, thus lowering the mean size at maturity estimate. Eklund (1988) reported that the female to male ratio was 1.2:1 for the species (n = 55) collected off Delaware. Eklund (1988) found no seasonal change in the gonado-somatic index (GSI) of females (0.3-0.4%), and males (0.2-0.4%) collected off Delaware suggesting that spawning did not occur at the southern limit of their range.

Spawning occurs in the late summer through early winter (peak in September-October) with earlier peaks (August-October) in the south (Wilk and Morse 1979). Spawning occurs on hard bottom, sheltered areas (Bigelow and Schroeder 1953), including artificial reefs and shipwrecks, at depths of < 50 m and temperatures of 10^{o}C or less (Clark and Livingstone 1982). These spawning/nesting habitats include the saline parts of New England estuaries (Jury *et al.* 1994). Eggs are fertilized internally (Mercer *et al.* 1993; Yao and Crim 1995). Multiple spawnings are unlikely, at least for Gulf of Maine population (Keats *et al.* 1985). It is unknown if mating pairs remain together throughout the year and if they breed every year.

Fecundity is size-dependent and relatively low; large, mature females (55-88 cm TL) produce about 1300 and 4200 eggs per spawning period (Clemens and Clemens 1921; Olsen and Merriman 1946). Prior to or during spawning, ocean pout cease or reduce feeding (Olsen and Merriman 1946; Sedberry 1983); some authors have suggested that "hibernation" may occur at this time (Orach-Meza 1975).

FOOD HABITS

MacDonald (1983) reported that ocean pout feed by sorting mouthfuls of sediments for infauna and do not use visual cues to stimulate feeding; they maintained that ocean pout were not very effective at capturing moving prey and rarely left the bottom to feed. Auster (1985) and Auster *et al.* (1995), however, considered ocean pout an "ambush predator" that waits in sediment depressions for prey to approach or drift by in the current.

The 0-group pout from Newfoundland hide in coarsely branched algae and feed on harpactacoid copepods (Keats and Steele 1993). Sedberry (1983) reported that juveniles were common during the summer on the sandy, mid- to outer-continental shelf (approximately 35-95 m) of the New York Bight and that they fed primarily on gammarid amphipods and polychaetes. This is consistent with data in the NEFSC Food Habits Data Base (Figure 2). Adult ocean pout feed on a variety of benthic invertebrates, including polychaetes, mollusks, crustaceans, and echinoderms (Clemens and Clemens 1921; Olsen and Merriman 1946; Orach-Meza 1975; Hacunda 1981; Clark and Livingstone 1982; Buzulutskaya 1983; Sedberry 1983; MacDonald and Green 1986). Ocean pout have short, blunt conical teeth that are ideal for preying on shelled organisms.

Sand dollars (*Echinarachnius parma*) are a primary prey in waters of coastal Maine, Georges Bank, southern New England, Block Island Sound, and Middle Atlantic Bight (Olsen and Merriman 1946; Smith 1950; Langton and Bowman 1980; Packer and Langton, in prep.); brittlestars and mollusks are also eaten. In the northern Gulf of Maine, ocean pout switch from crustaceans during the spring to mollusks and polychaetes during the summer and fall (Langton and Bowman 1980). Langton and Watling (1990) found ocean pout primarily ate bivalve mollusks off southern Maine. Buzulutskaya (1983) reported that Jonah crabs (*Cancer borealis*) constituted 76% of ocean pout diet (by total prey weight) off Nantucket shoals, while sand dollars and amphipods were dominant prey on Georges Bank. Many benthic species preyed upon by ocean pout are commercially valuable, including sea urchins, scallops, juvenile American lobsters, and crabs (Keats *et al.* 1987). Tyler (1971) reported that feeding was heaviest in the spring and ceased by the fall; this decline may be a response to high temperatures (Orach-Meza 1975) or a prelude to spawning. Fish are rarely eaten, although demersal sculpin eggs are consumed when encountered (Bigelow and Schroeder 1953; Orach-Meza 1975; Keats *et al.* 1987). MacDonald and Green (1986) reported that there was apparent prey competition between ocean pout and American plaice, in the Gulf of Maine.

PREDATION

Juvenile ocean pout are consumed by squid (*Illex* spp.), spiny dogfish *(Squalus acanthias)*, sea raven, cod, barndoor skate *(Raja laevis)*, harbor seals, and cormorants (Froerman 1984; Scott and Scott 1988; Cairns 1998). Some predation may occur when ocean pout are caught on long-lines (Clemens and Clemens 1921). Adult ocean pout were preyed upon by sandbar shark *(Carcharhinus plumbeus*) in the Middle Atlantic Bight, but do not appear to be a major dietary item (Stillwell and Kohler 1993). During nesting, excessive stress or attacks on egg masses may induce egg cannibalism (Yao and Crim 1995).

Ocean pout are host to a number of parasites in Canadian and New England waters, including protozoans, myxosporideans, trematodes, cestodes, nematodes, acanthocephalans, leaches, and copepods (Olsen and Merriman 1946; Nigrelli 1946; Sheehy *et al.* 1974; Scott and Scott 1988). In the past, parasitism has reduced consumer acceptance of pout as a food fish (Bigelow and Schroeder 1953). Despres-Patanjo *et al.* (1982) noted that there were only a few instances where ocean pout were affected with fin rot and ulcers, conditions associated with degraded habitats.

MIGRATION

Although ocean pout moves seasonally among habitats within a region, this species is considered non-migratory (Bigelow and Schroeder 1953), a conclusion supported by tagging studies (Sheehy *et al.* 1977). Seasonal inshore/offshore movements are not extensive (Wigley 1998).

STOCK STRUCTURE

Most stock identification studies have suggested that there are two ocean pout stocks: a northern population in the Gulf of Maine (Bay of Fundy-northern Gulf of Maine, east of Cape Elizabeth), and a southern population in Cape Cod Bay, on Georges Bank, and south to Delaware (Olsen and Merriman 1946; Clark and Livingstone 1982; Wigley 1998). The population in United States waters is currently managed as two stocks: northern Gulf of Maine and south of this area (Wigley 1998).

Orach-Meza (1975), however, suggested that there are up to five stocks of ocean pout delineated on the basis of vertebral counts, growth rates, condition factors, and aggregations. These include: (1) the Scotian shelf (Bay of Fundy to Sable Bank); (2) Gulf of Maine (including Cape Cod Bay); (3) Georges Bank (east of southern Cape Cod – the Koons and Franklin Swells – to the Great South Channel); (4) southern New England (coastal southeastern Cape Cod, Nantucket Shoals, and Great South Channel to southern New Jersey); and (5) Mid Atlantic (southern New Jersey to Cape Hatteras).

HABITAT CHARACTERISTICS

Ocean pout is a bottom-dwelling species that occurs in cool waters (< 10^{o}C) across the continental shelf from Labrador to Cape Hatteras (Table 1). It is non-migratory, but it will move seasonally to remain at preferred temperatures.

EGGS

Ocean pout eggs are deposited in sheltered nests where they are protected by one or both parents. Ocean pout eggs were not collected in the NEFSC MARMAP ichthyoplankton survey and thus information on habitat characteristics of the egg nests are unknown, although they might be extrapolated from adult distribution during the spawning period.

LARVAE

Because it has a relatively short larval stage (some authors suggest there is no true larval stage), hatchlings remain near the nest shelter. There is little information on the habitats associated with this life stage. Jury *et al.* (1994) reported that larvae occurred in most coastal and saline (> 25 ppt) estuarine waters of the Gulf of Maine in the cooler months (October-April).

JUVENILES

In the Gulf of Maine, juveniles occur in shallow coastal waters around rocks and attached algae, and in rivers with saline bottom waters (Bigelow and Schroeder 1953). Sheehy *et al.* (1977) reported that juveniles (< 8 cm TL) use scallops shells in about 90 m of water southeast of Block Island (southern New England) and Auster *et al.* (1995) reported that ocean quahog shell aggregates are also used for cover. Juvenile ocean pout were commonly found in the > 25 ppt saline parts of most major estuaries or coastal areas from Passamaquoddy Bay south to Cape Cod Bay throughout the year, except in New Hampshire (Jury *et al.* 1994).

On the continental shelf, juvenile ocean pout are commonly collected in bottom water temperatures between 3°C and 14°C at water depths < 100 m (Figure 3). Off Massachusetts, juvenile ocean pout prefer bottom temperatures < 11°C, with about a 3°C shift (from 6°C to 9°C) in the peak abundance mode from spring to autumn (Figure 4). Off Rhode Island, only a few juveniles were collected in the trawl survey in winter and spring when they occurred at bottom temperatures between 3-7°C at the deeper (> 25 m) stations (Figure 5). In Long Island Sound, ocean pout were only collected in the spring and about half of these were juveniles (< 31 cm TL; Figure 7). They were collected where bottom temperatures were 3-13°C, depths were 14-40 m, and salinities were 23-30 ppt.

Based on the species seasonal use of sheltered habitats and the inefficiency of otter trawls in sampling these habitats, the range of habitats occupied may be broader than reported herein.

ADULTS

Adult ocean pout occur from the intertidal across the continental shelf and on the upper continental slope to about 200 m on Georges Bank and in the Gulf of Maine (Bigelow and Schroeder 1953; Orach-Meza 1975; Clark and Livingstone 1982; Keats *et al.* 1985; Scott and Scott 1988; Jury *et al.* 1994). In Canadian waters, adults occur between 55-108 m (Scott and Scott 1988). Higher temperatures apparently restrict ocean pout distribution south of Delaware Bay, although the species was observed on artificial reefs off Delaware throughout the year (Eklund 1988). Ocean pout were not observed on artificial reefs off Virginia (Adams 1993).

The bottom temperature and depth preference of the adults is similar to that of the juveniles. Adults are more abundant in cooler (3-14°C) waters (Figures 3 and 4). They can tolerate temperatures up to 25°C and fatal stress occurs at and above 30°C (Britton 1942). Adults are commonly collected at depths < 100 m, in coastal waters of New England and in saline estuaries during most months (Jury *et al.* 1994; Figures 3 and 4), but some adults have been collected at depths > 300 m (Orach-Meza 1975). More adults than juveniles were collected in the Rhode Island trawl survey and they were caught mostly in the winter-spring between 2-10°C at deeper stations (> 25 m) (Figures 5, 6). In Long Island Sound, adult and juvenile ocean pout were only collected in the spring (Figure 7) when bottom temperatures were 3-13°C and salinities were 23-30 ppt at depths between 14-40 m.

Adult ocean pout occur on most sediment types, including shell patches (Bigelow and Schroeder 1953; Auster *et al.* 1991, 1995). However, there appears to be seasonal variability in the use of certain habitats; rocky shelter is especially important for spawning adults in the autumn (Smith 1898). In softer sediments, ocean pout may burrow tail first and leave a depression on the sediment surface. After they leave the site, the depressions were used by other species, such as juvenile scup (Stanley 1971; Auster *et al.* 1995).

Adults may move seasonally among different habitats and water depths to remain within their preferred temperature range (2-10°C). In the winter and spring, adults were found in sand and gravel substrates (Olsen and Merriman 1946), while in the summer and at other seasons, they were found in rock and hard substrate, such as artificial reefs and wrecks in the New York Bight (Able *et al.* 1987; Eklund 1988). This seasonal use of hard bottom by ocean pout reduces its catchability by otter trawls.

Although ocean pout have been reported to be quite hardy (Sheehy *et al.* 1977), they appear to have limited tolerance of hypoxic and anoxic conditions; they are common victims of these conditions which occasionally occur in the New York Bight (Ogren and Chess 1969; Azarovitz *et al.* 1979). Haedrich and Haedrich (1974) reported a few occurrences of ocean pout in the then degraded Mystic River (Boston, Massachusetts), but they could have been brought in with a strong tide. Ocean pout are sluggish swimmers (Beamish 1966), which can explain their inability to avoid stressful conditions, such as hypoxia.

GEOGRAPHICAL DISTRIBUTION

Ocean pout are found in marine waters, across the continental shelf and on the upper continental slope from Labrador, Canada to south of Cape Hatteras (Figure 8). They are also found in coastal areas and estuaries from southern New England and north.

EGGS

Because ocean pout eggs are demersal and deposited in sheltered nests, they were not collected during NEFSC MARMAP and other ichthyoplankton surveys. Data are not available on egg occurrence and distribution from other sources.

LARVAE

Collections of this benthic life stage are rare; they occurred in only 0.3% of NEFSC MARMAP ichthyoplankton tows. But available data suggest that larvae are widely distributed north and south of Cape Cod across the continental shelf (Figure 9).

JUVENILES

The NEFSC bottom trawl survey collected juvenile ocean pout south and west of Cape Cod in the winter (Figure 10), but they were also collected within the Gulf of Maine and on Georges Bank in the other seasons. Juvenile ocean pout are not commonly found in Middle Atlantic Bight estuaries, e.g., they were not collected in a monthly survey of the Hudson-Raritan Estuary from 1992 to 1997 (R. Pickanowski, National Marine Fisheries Service, Highlands, NJ, personal communication). In Long Island Sound, most ocean pout (juveniles and adults) were collected in the western portion (Figure 7). This is a silty basin, but there is a larger silty basin in the central Sound (Reid *et al.* 1979) where they were not commonly collected. In Rhode Island waters, juvenile ocean pout were infrequently collected only at the mouth of Narragansett Bay in the winter-spring (Figure 11). In Massachusetts waters, juvenile ocean pout were abundant in spring and autumn in Cape Cod Bay and around Cape Ann; few were collected south of Cape Cod (Figure 12). Juvenile ocean pout (< 16 cm) were abundant in the Gulf of Maine during the 1970s, but trawl collections never exceeded 10 fish per tow (Bowman *et al.* 1987).

ADULTS

The seasonal distribution of adult ocean pout is similar to that of the juveniles. In the winter, they were collected from Georges Bank to the Middle Atlantic Bight (Figure 10). They were also collected in the Gulf of Maine during other seasons. Adult ocean pout are among the most abundant fish collected in coastal Cape Cod and Massachusetts Bay during the spring; the abundance and size of the fish decreased during summer and fall (Lux and Kelly 1982; Lawton *et al.* 1984). This seasonal abundance pattern is evident in Massachusetts inshore survey data (Figure 12) and in Passamaquoddy Bay, Maine (Tyler 1971). Adults were relatively common in the Rhode Island trawl survey at the mouth of Narragansett Bay in the winter-spring (mean 7.6-27.0 fish per tow) (Figure 11). Merriman and Warfel (1948) reported that ocean pout were a winter seasonal occupant of Block Island Sound. It was reported in Long Island Sound by Olsen and Merriman (1946), but not by Richards (1963). It is common in more recent trawl surveys in Long Island Sound, but only in the spring (Figure 7). It is not common in Narragansett Bay (Oviatt and Nixon 1973) or Raritan Bay (R. Pickanowski, National Marine Fisheries Service, Highlands, NJ, personal communication), nor is it found in other shallow bays to the south (Orach-Meza 1975). Higher temperatures apparently restrict the distribution of ocean pout south of Delaware Bay (Eklund 1988).

STATUS OF THE STOCKS

Ocean pout were discarded from catches until the 1930s (Orach-Meza 1975; Clark and Livingstone 1982). Since then, there has been an inconsistent US commercial fishery for ocean pout. It was initially used as food fish during WW II, then as an industrial fish (fish meal), and most recently, as a food fish marketed as fresh fillets. Until recently the species has been considered "under-utilized" partially because of reduced marketing caused by harmless parasitic lesions (e.g., Sheehy *et al.* 1974, 1977). During the late 1960s and early 1970s, distant-water, foreign fishing vessels heavily exploited the species (Orach-Meza 1975). Although the population is considered to consist of two stocks, only the southern stock supports the commercial fishery (Wigley 1998). The species is also used extensively for physiological studies, and Canadians are investigating its aquaculture potential (Brown *et al.* 1992); successful culturing can affect fishery and demand for wild-caught fish. There is no directed recreational fishery for in this species (NEFMC 1993); however, when caught, anglers often keep ocean pout as food.

The abundance of ocean pout in US waters has fluctuated from highs in the late 1960s to lows in the mid-1970s and rose to record high levels in the early 1980s (Figure 13). Although ocean pout abundance has fluctuated around the long-term average, recent estimates suggest that abundance has declined. The population is considered fully exploited (National Marine Fisheries Service 1997; Wigley 1998). The variability in population abundance does not appear to have affected the spatial distribution of the species (Brown *et al.* 1996).

RESEARCH NEEDS

- More information is needed about the diets of larval and early juvenile ocean pout.
- Ocean pout may create or expand sheltering habitat via burrowing or evacuating of holes. What is the effect on other species? The effect of intensive trawling on the persistence and use of this modified habitat should also be studied.
- Winter surveys of the abundance and distribution of juvenile and adult ocean pout in the Gulf of Maine are needed, especially in regard to habitat use.
- The interactions between ocean pout and other species that use or compete for the seasonal shelter needs study. How does predation on ocean pout eggs by lobster and Jonah crab affect recruitment? How does predation by ocean pout on juvenile American lobster and other shellfish affect their recruitment?
- An assessment of ocean pout use of reef habitats is needed to better characterize the relative value of this habitat (Orach-Meza 1975).
- The role that the expanding use of artificial reefs in

the northeast plays in the relative abundance, distribution, and productivity of this seasonal, shelter-using, or possibly shelter-dependent species needs to be evaluated.

- The stock structure of ocean pout needs to be reexamined (Orach-Meza 1975; Wigley 1998).
- Are adult females more vulnerable to trawls than males because of their wider girth (Sheehy *et al.* 1977)? If so, what are the management consequences?
- The age-fecundity relationship of this species needs to be better defined (Sheehy *et al.* 1977).
- The exposure source and etiology of the microsporidean parasite that infects ocean pout and reduces its marketability needs additional research (Sheehy *et al.* 1974).

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Table 1. Summary of life history and habitat parameters for ocean pout, *Macrozoarces americanus.* (NS = northern stock; SS = southern stock; GOM = Gulf of Maine; MAB = Middle Atlantic Bight; GB = Georges Bank; SNE = southern New England; NYB = New York Bight).

Life Stage	Time of Year	Size and Growth	Geographic Location	Habitat	Substrate
Spawning	Late summer-fall; peak Sept - Oct	NS: females mature at ~26 cm TL; SS: females mature at ~31 cm TL.	Continental shelf, GOM-NYB; saline estuaries in New England.	Demersal, < 50 m.	Rough bottom, nests in holes, crevices, etc.
Eggs	Fall-winter	Incubate for 2-3 months	As above, in nests.	Within nests.	As above.
Larvae	Late fall -spring	30 mm at hatching.	As above, near nests.	Near bottom.	As above.
Juveniles	Throughout	≤ 29 cm TL Linear growth to ~10-12 cm TL (yr 1); NS slower growth.	Inner-middle shelf; GOM, GB, MAB; saline estuaries in SNE and GOM.	Demersal, 1-200 m, mainly 20-75 m.	Sheltered under rocks, mollusk shells, and algae.
Adults	Throughout	> 29 cm TL Grow up to 98 cm TL and 5.3 kg; long-lived, > 20 years.	Continental shelf, GOM- to North Carolina; mostly north of Delaware; winters mostly south of GB; other seasons, more widespread.	Demersal, seasonally variable, 1-300+ m; prefer ~ 15-110 m.	Variable, sand, gravel, rough bottom, but rarely mud.

Table 1. cont'd.

Life Stage	Temperature	Salinity	Prey	Predators	Notes
Spawning	< 10°C	Mostly 32-34 ppt	Feeding ceased/ reduced.		Internal fertilization, oviparous.
Eggs	< 10°C	Mostly 32-34 ppt			Laid in gelatinous masses, guarded by parents.
Larvae		> 25 ppt	Harpacticoid copepods		Brief yolk-sac stage.
Juveniles	3-14°C; mostly < 11°C	> 25 ppt	Small benthic organisms, such as amphipods and polychaetes.	Squid, dogfish, sea raven, cod, barndoor skate, other fish, harbor seals.	Not common in estuaries south of Long Island; juveniles and adults not migratory except for seasonal, local movements.
Adults	3-14°C, prefer 2-10°C.	Mostly, 32-34 ppt	Benthic organisms, especially shelled, e.g., mollusks, crustaceans, echinoderms, especially sand dollars.	Sandbar sharks, among others.	Hypoxia sensitive; moves seasonally to different habitats; temps > 30°C can be fatal; digs depressions in soft sediments that are used by other species. Two stocks divided by central GB

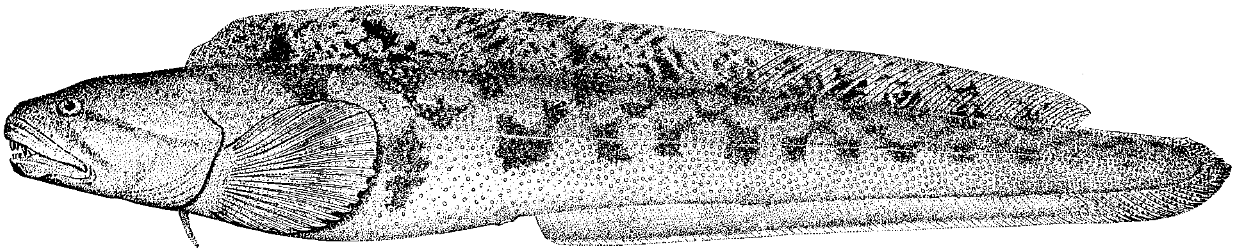


Figure 1. The ocean pout, *Macrozoarces americanus* (Schneider 1801) (from Goode 1884).

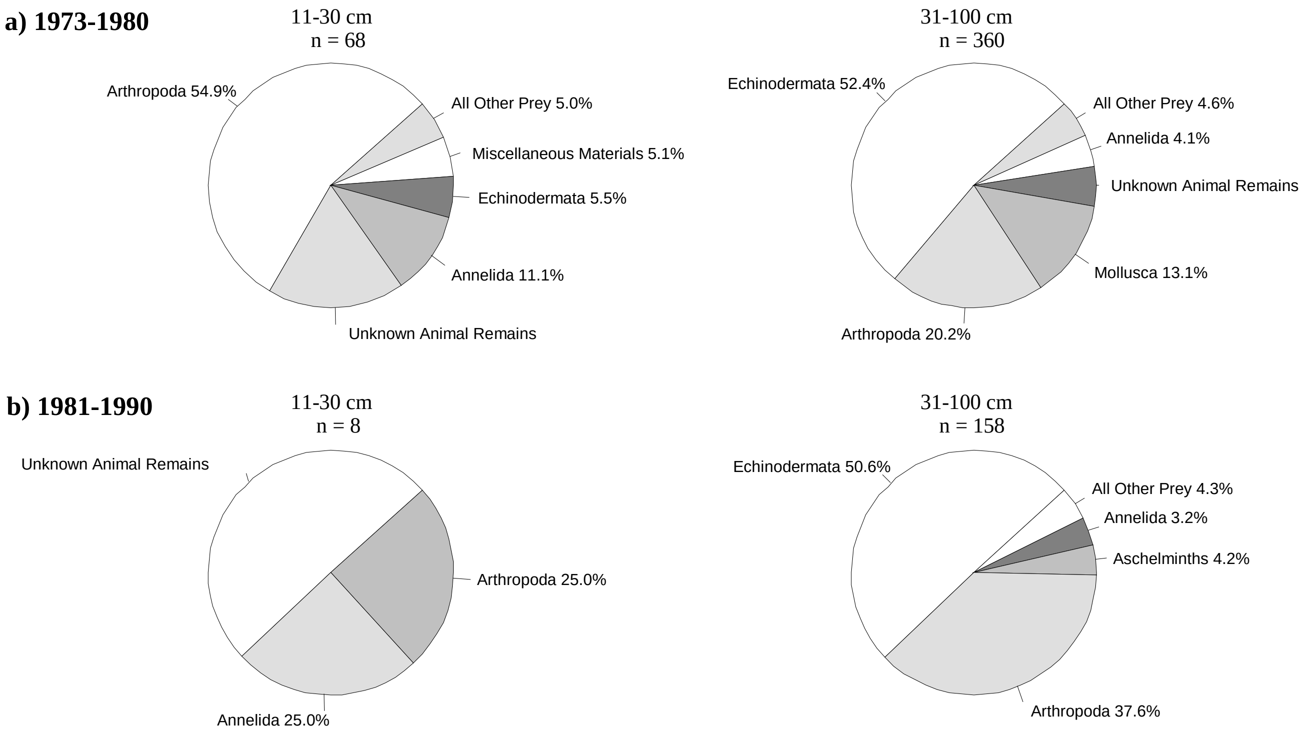


Figure 2. Abundance (percent occurrence) of the major prey items of ocean pout collected during NEFSC bottom trawl surveys from 1973-1980 and 1981-1990. The 11-30 cm size range corresponds, at least roughly, to juveniles, and the 31-100 cm size class corresponds to adults. The category “animal remains” 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].

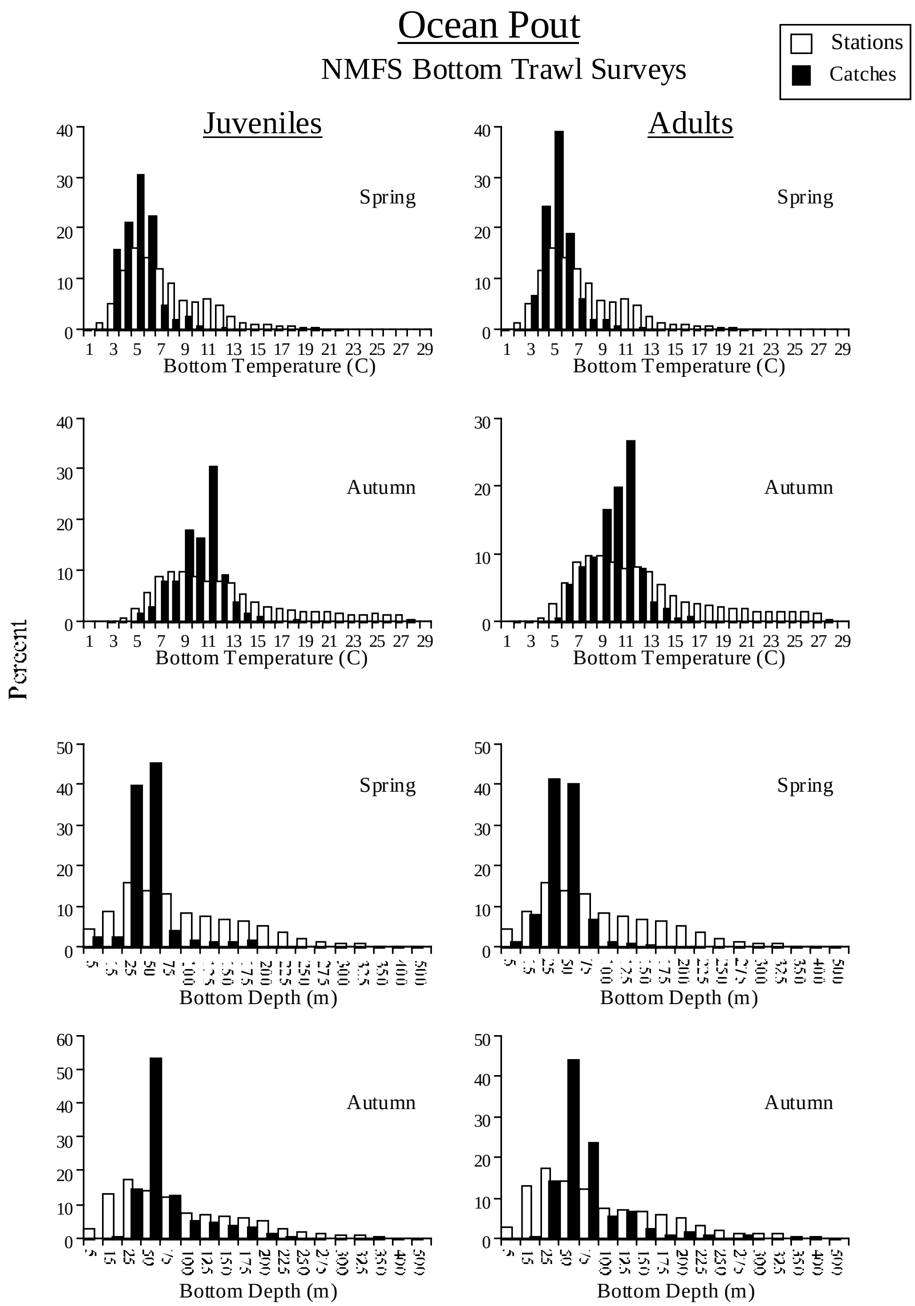


Figure 3. Abundance of juvenile and adult ocean pout relative to bottom water temperature and depth based on NEFSC bottom trawl surveys for spring (1968-1997) and autumn (1963-1996), all years combined. Open bars represent the proportion of all stations surveyed, while solid bars represent the proportion of the sum of all standardized catches (number/10 m^2).

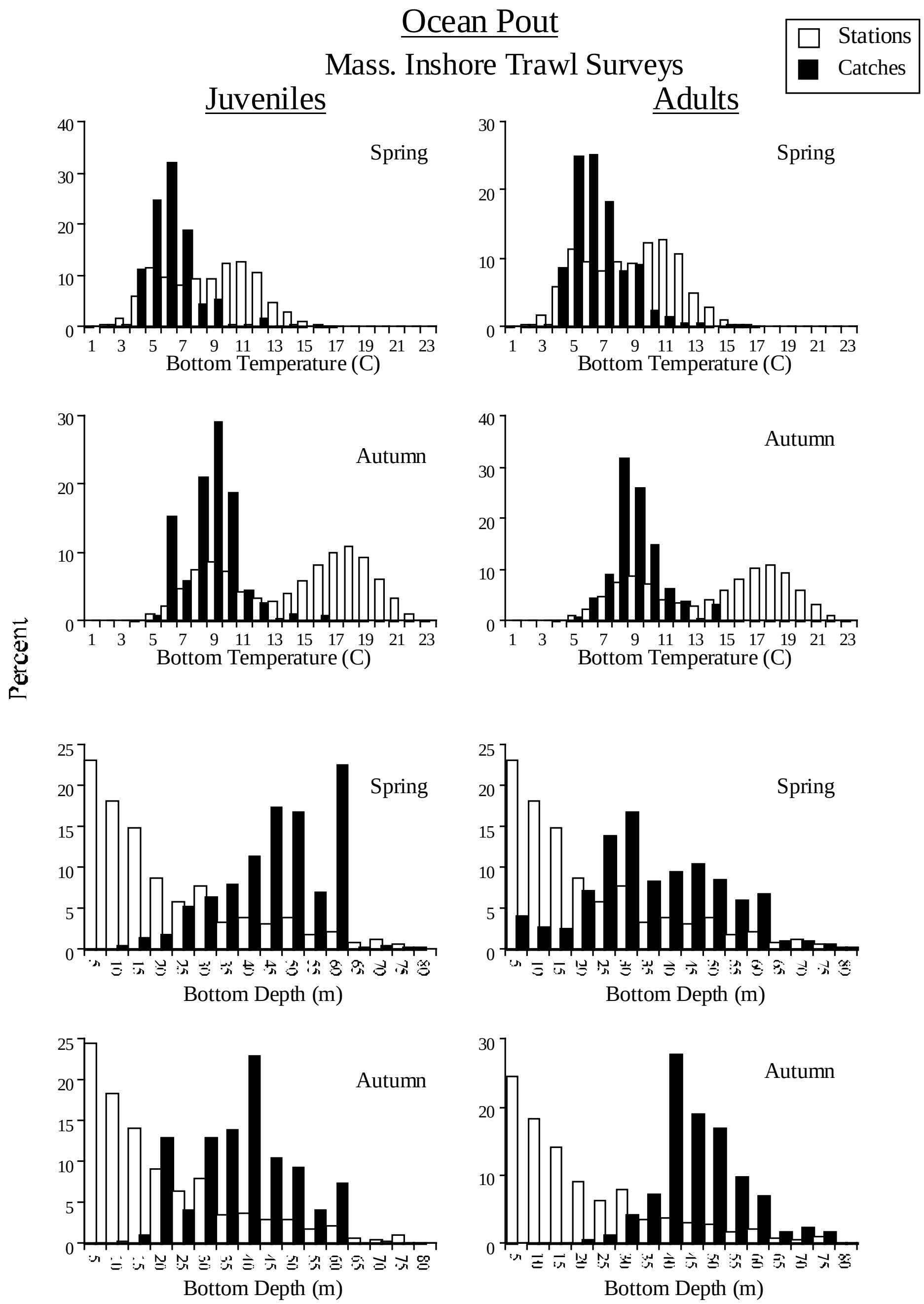


Figure 4. Abundance of juvenile and adult ocean pout relative to bottom water temperature and depth based on Massachusetts inshore bottom trawl surveys (spring and autumn 1978-1996) for all years combined. Open bars represent the proportion of all stations surveyed, while solid bars represent the proportion of the sum of all standardized catches (number/10 m^2).

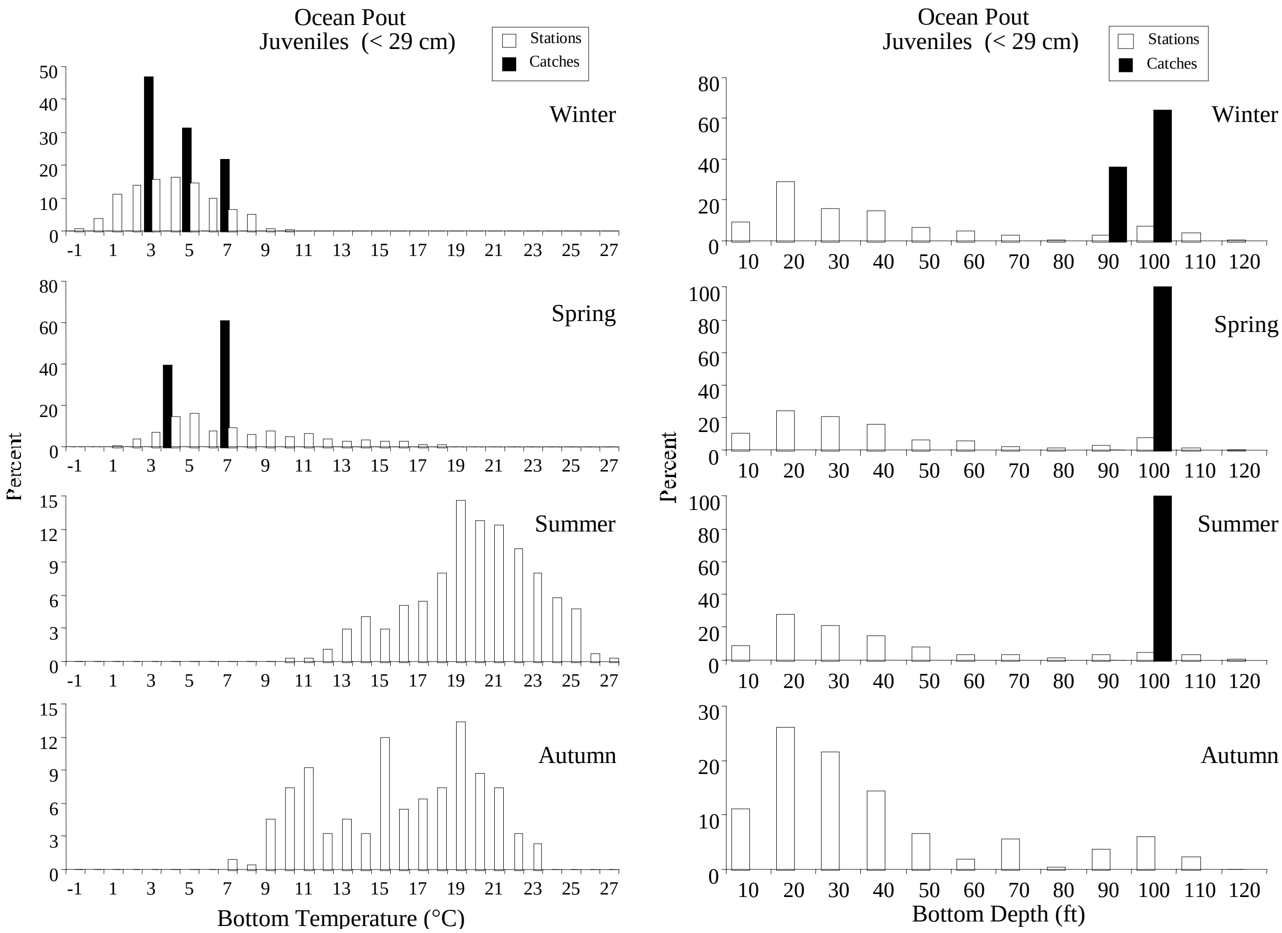


Figure 5. Abundance of juvenile and adult ocean pout relative to bottom water temperature and depth based on Rhode Island Narragansett Bay inshore bottom trawl surveys (1990-1996) by season for all years combined. Open bars represent the proportion of all stations surveyed, while solid bars represent the proportion of the sum of all standardized catches (number/10 m^2).

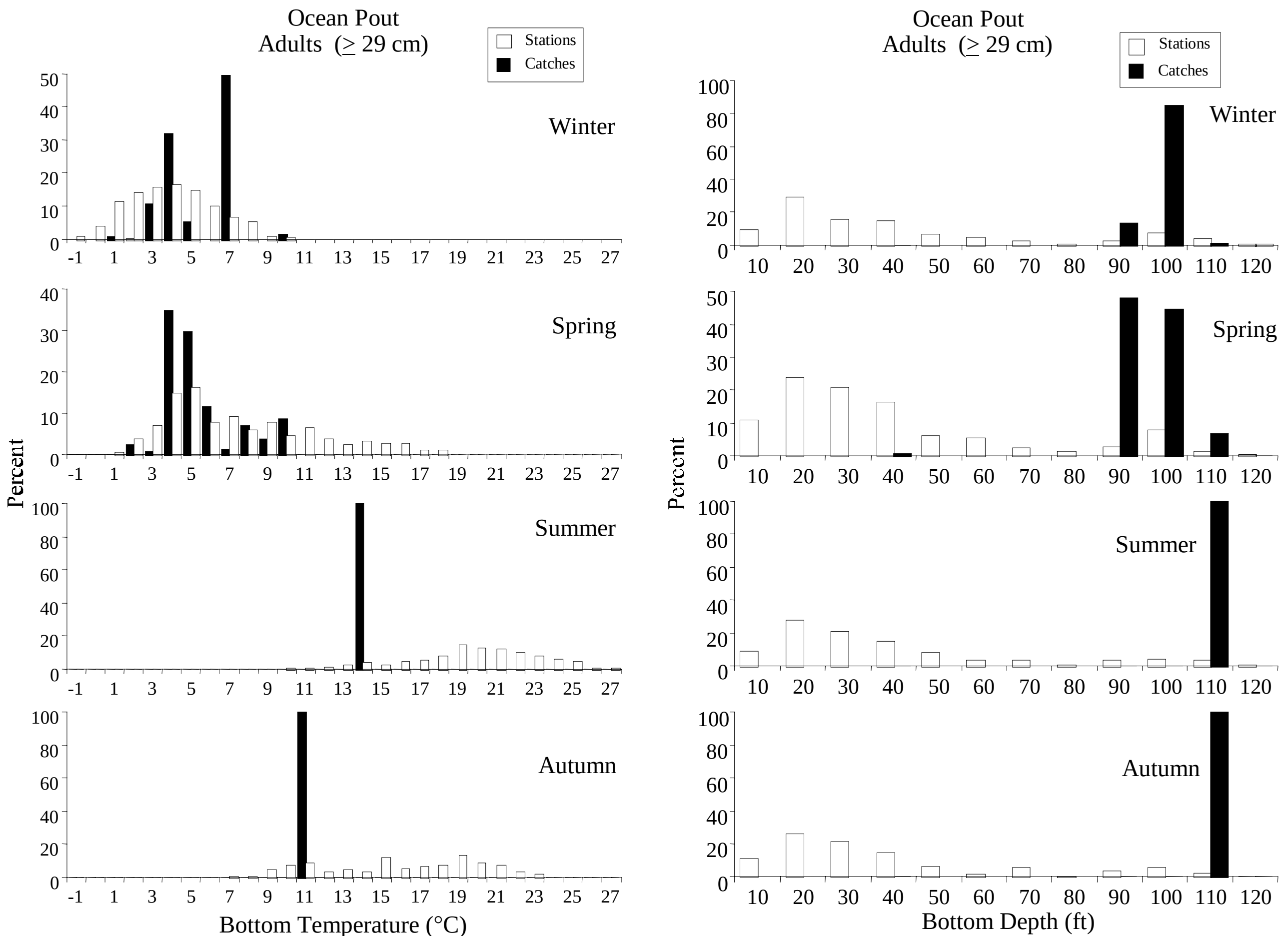


Figure 5. cont'd.

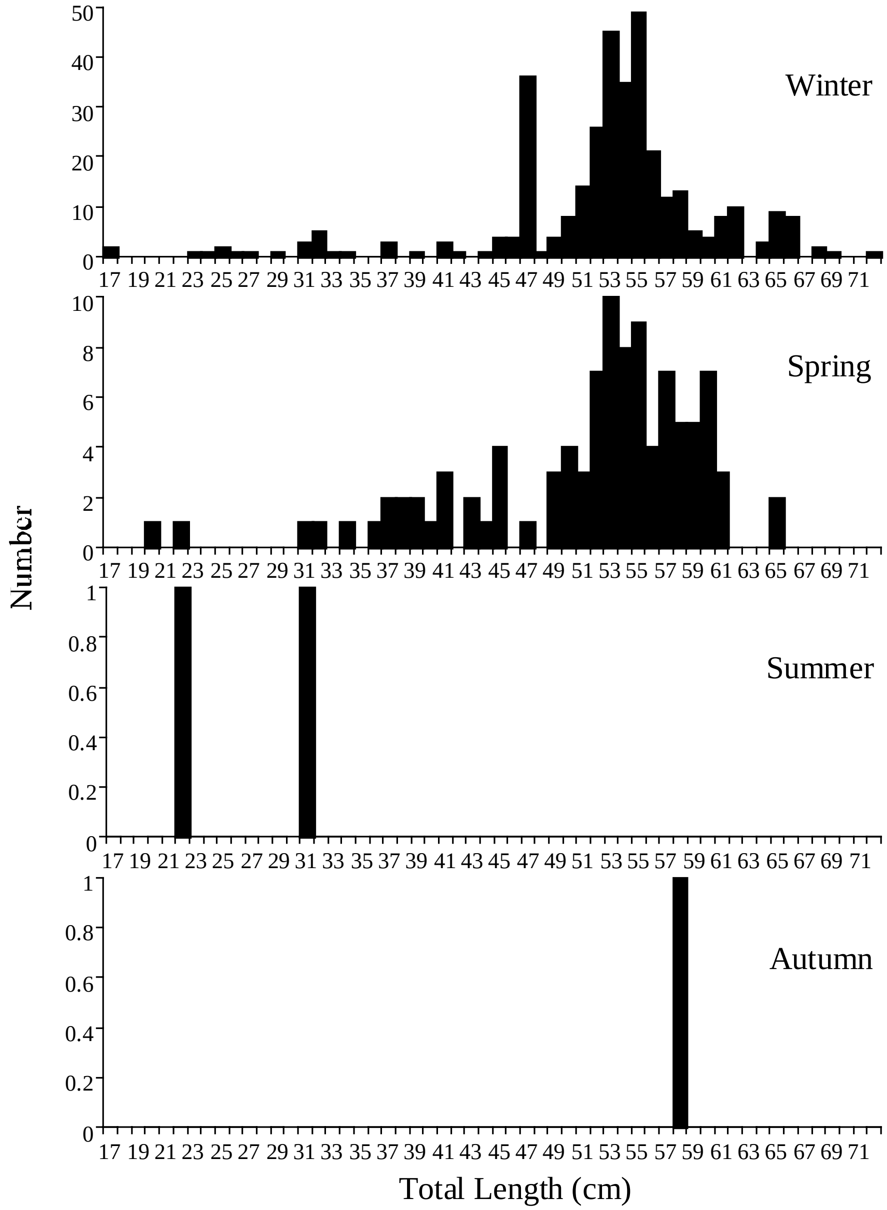


Figure 6. Size frequency distribution of ocean pout collected during all seasons in Narragansett Bay, during Rhode Island Narragansett Bay inshore bottom trawl surveys (1990-1996, all years combined).

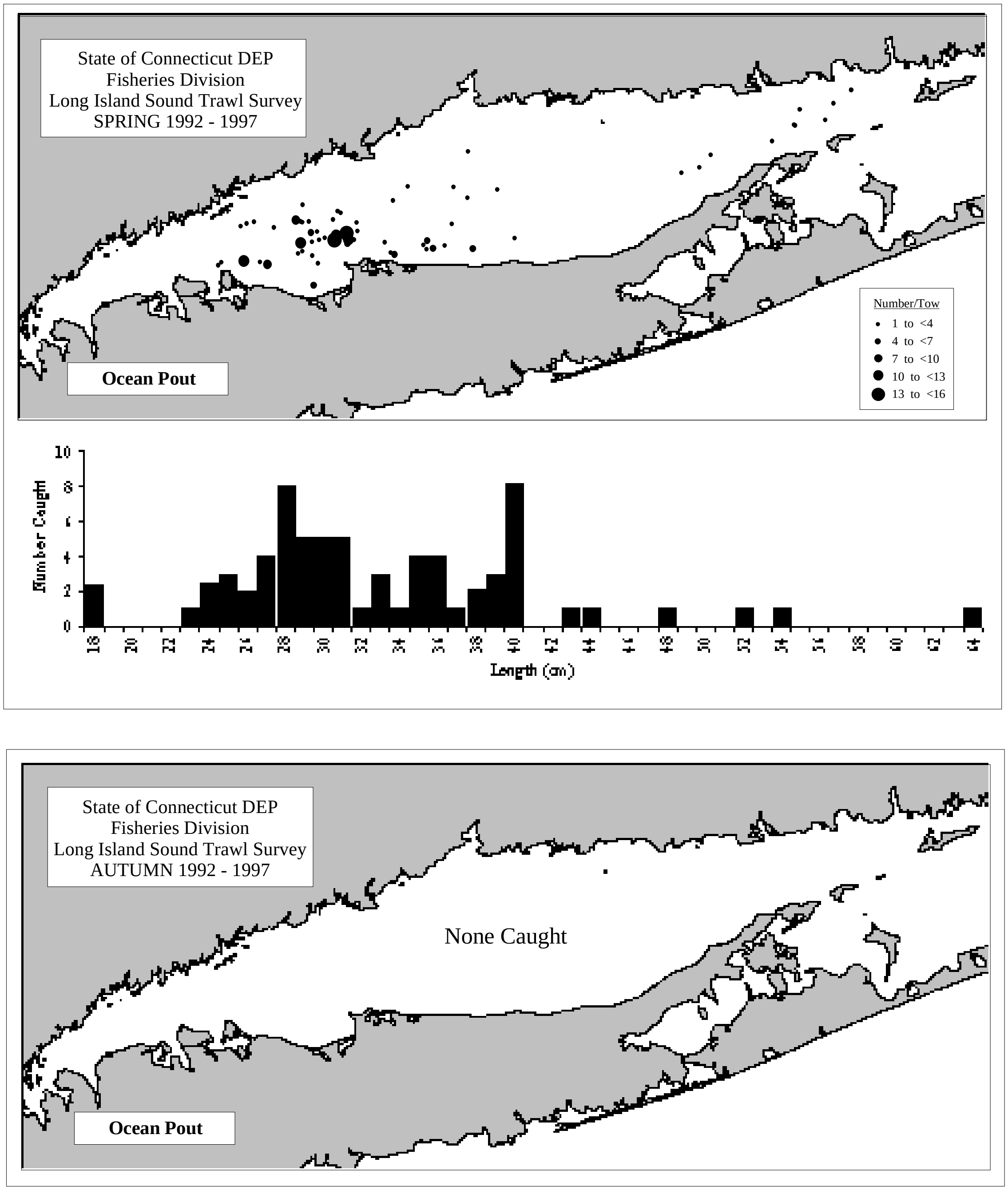


Figure 7. Distribution and abundance of juvenile and adult ocean pout collected in Long Island Sound during spring and autumn, from the Connecticut bottom trawl surveys, 1992-1997 [see Reid *et al.* (1999) for details].

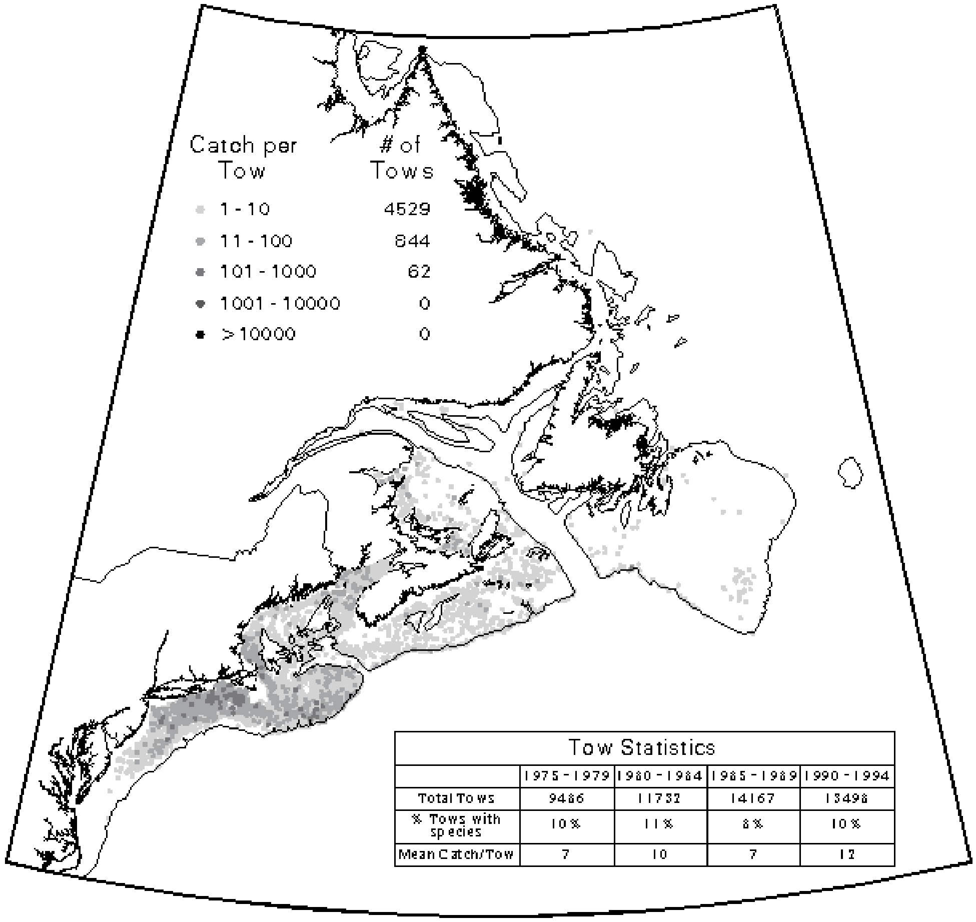


Figure 8. Distribution and abundance of ocean pout from Newfoundland to Cape Hatteras during 1975-1994. Data are from the U.S. NOAA/Canada DFO East Coast of North America Strategic Assessment Project (http://www-orca.nos.noaa.gov/projects/ecnasap/ecnasap_table1.html).

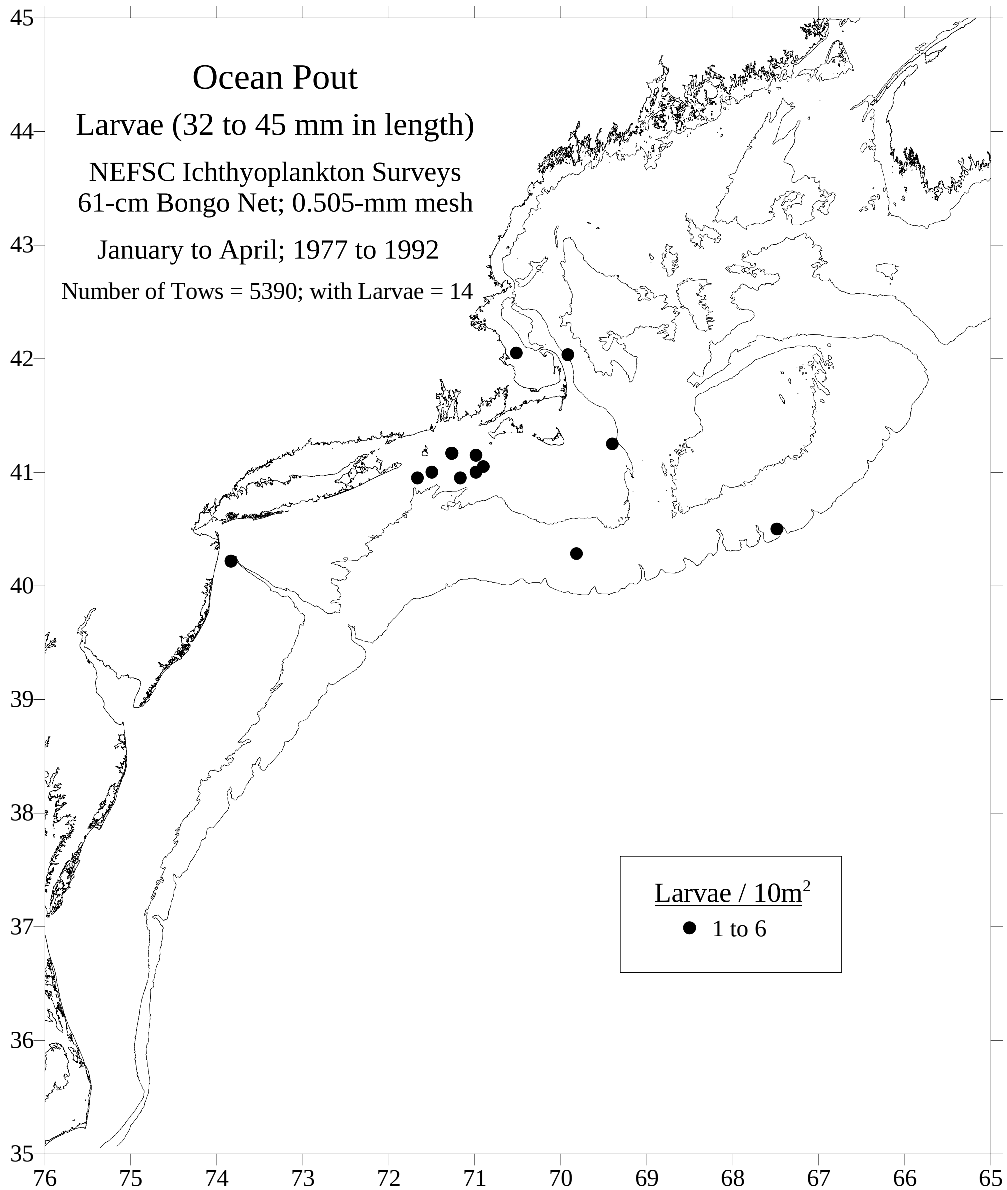


Figure 9. Distribution and abundance of ocean pout larvae collected during NEFSC MARMAP ichthyoplankton surveys from January to April, 1977-1992 [see Reid *et al.* (1999) for details].

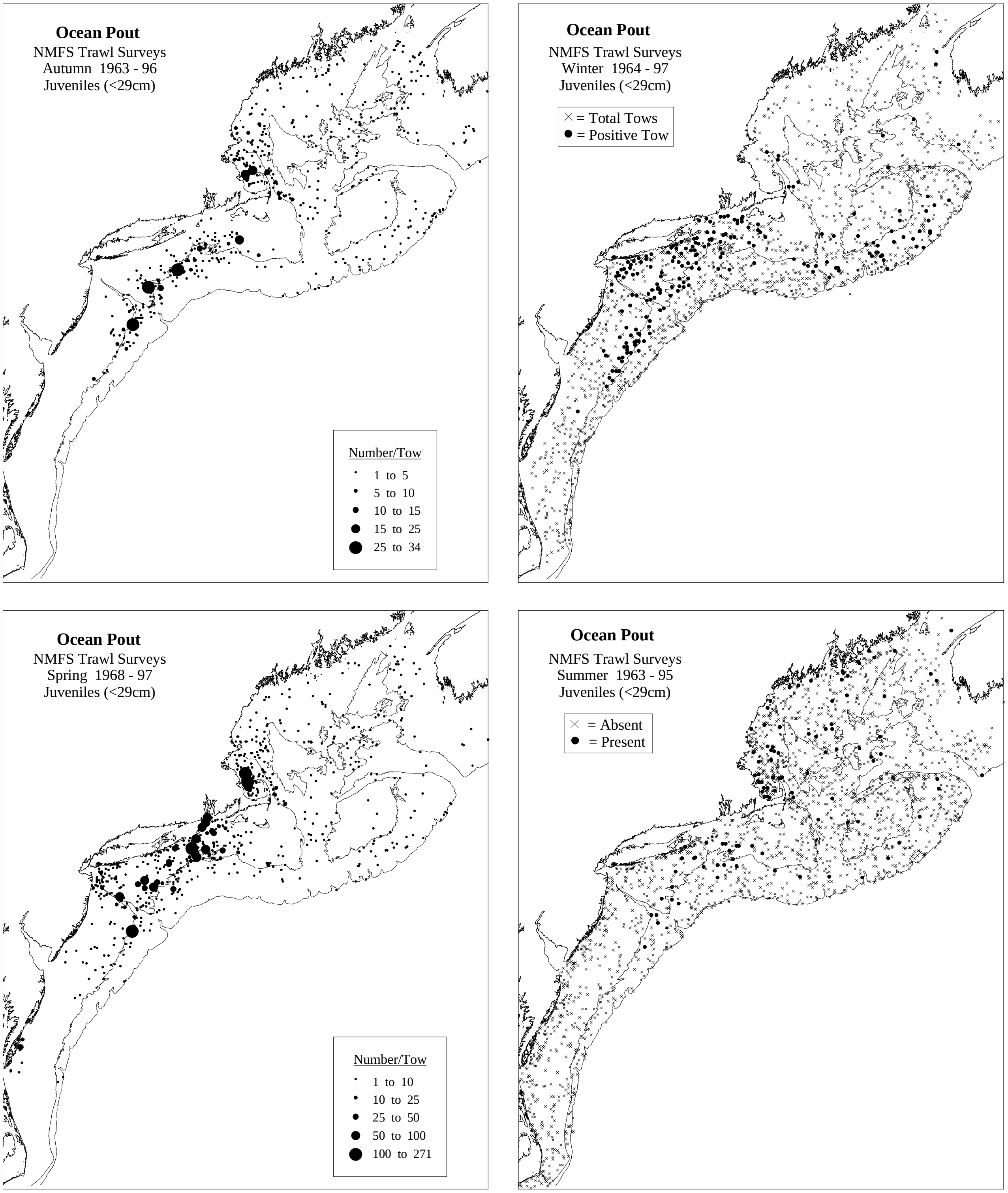
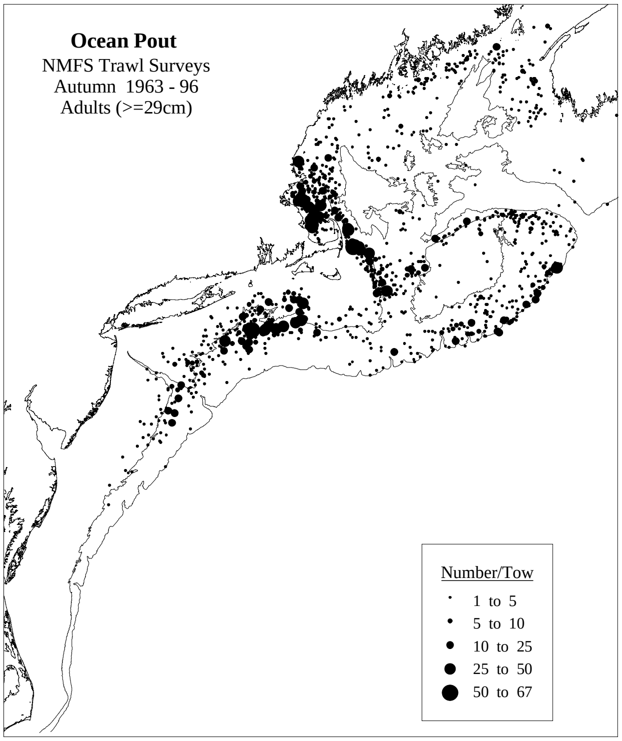
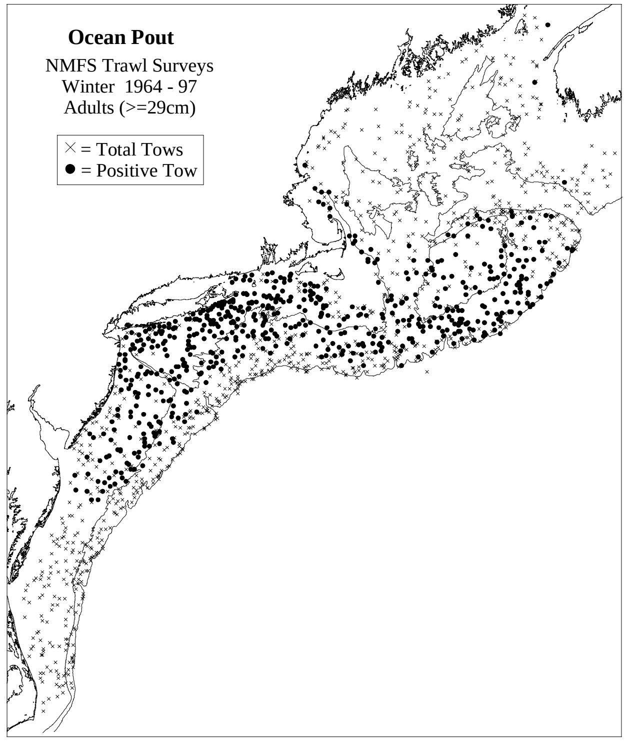
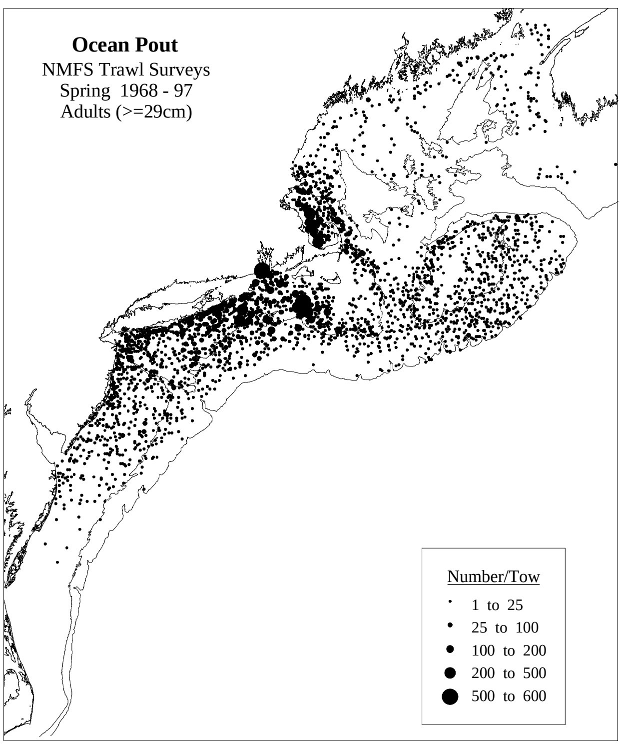


Figure 10. Distribution and abundance of juvenile and adult ocean pout collected in each season during NEFSC bottom trawl surveys, 1963-1997. Densities are represented by dot size in spring and fall plots, while only presence and absence are represented in winter and summer plots [see Reid *et al.* (1999)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







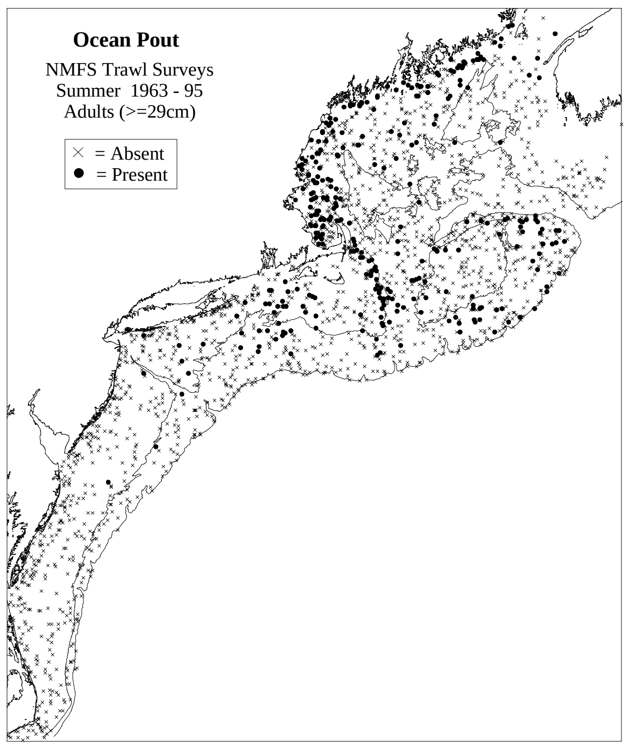


Figure 10. cont'd.

Ocean Pout Juveniles (< 29 cm)

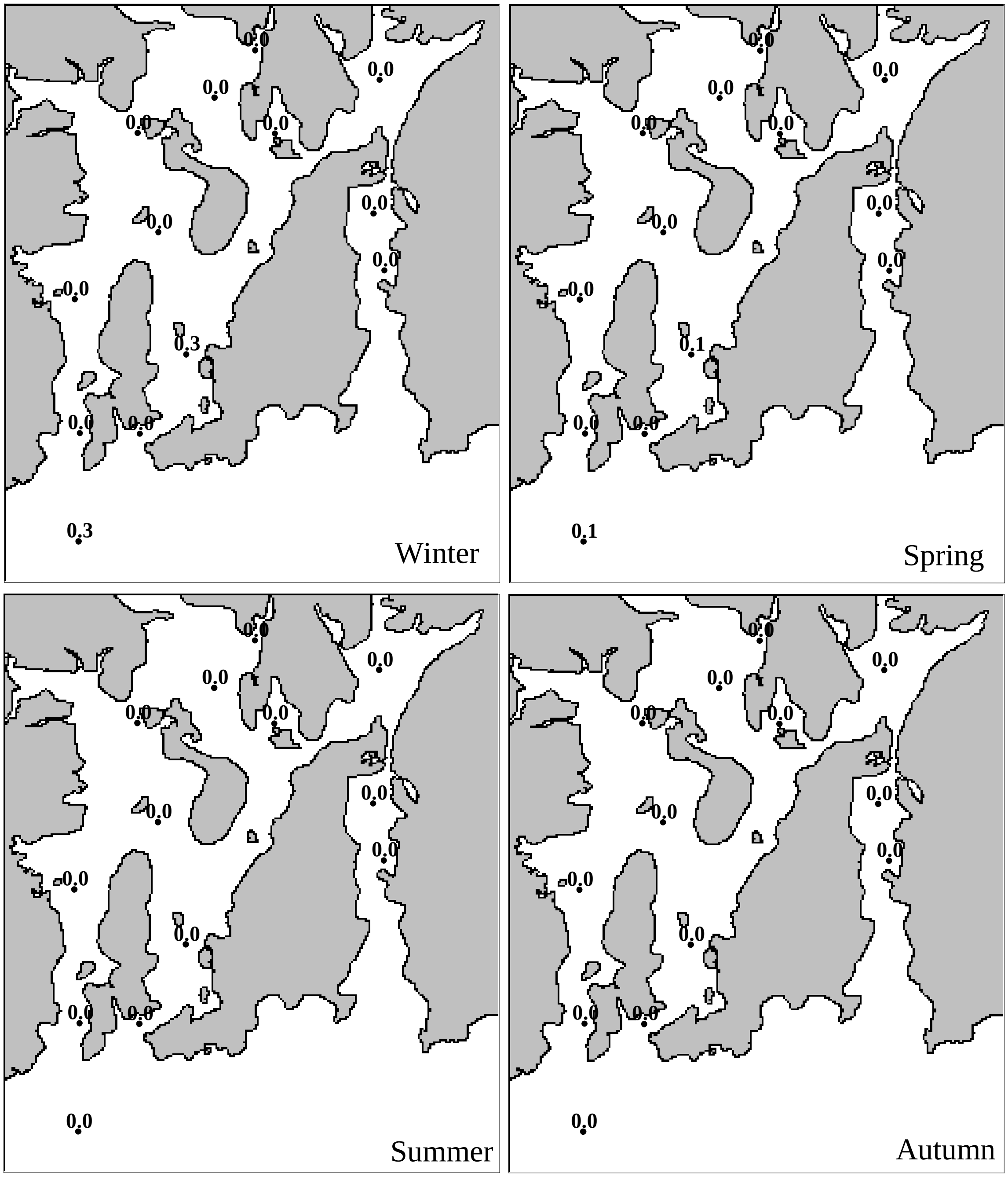


Figure 11. Distribution and abundance of juvenile and adult ocean pout collected during all seasons in Narragansett Bay during 1990-1996 Rhode Island inshore bottom trawl surveys. The numbers shown at each station are the average catch per tow rounded to one decimal place [see Reid *et al.* (1999) for details].

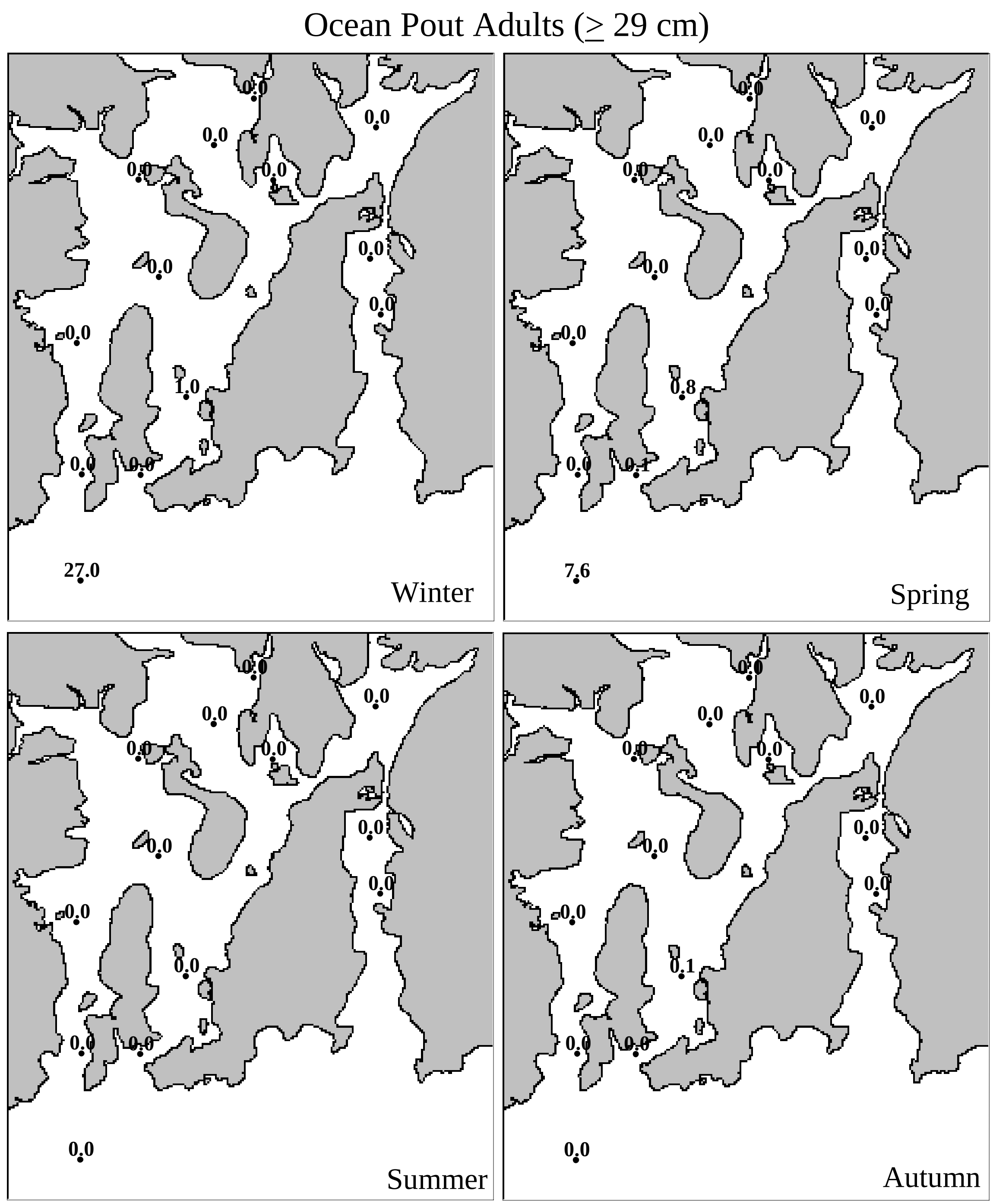


Figure 11. cont'd.

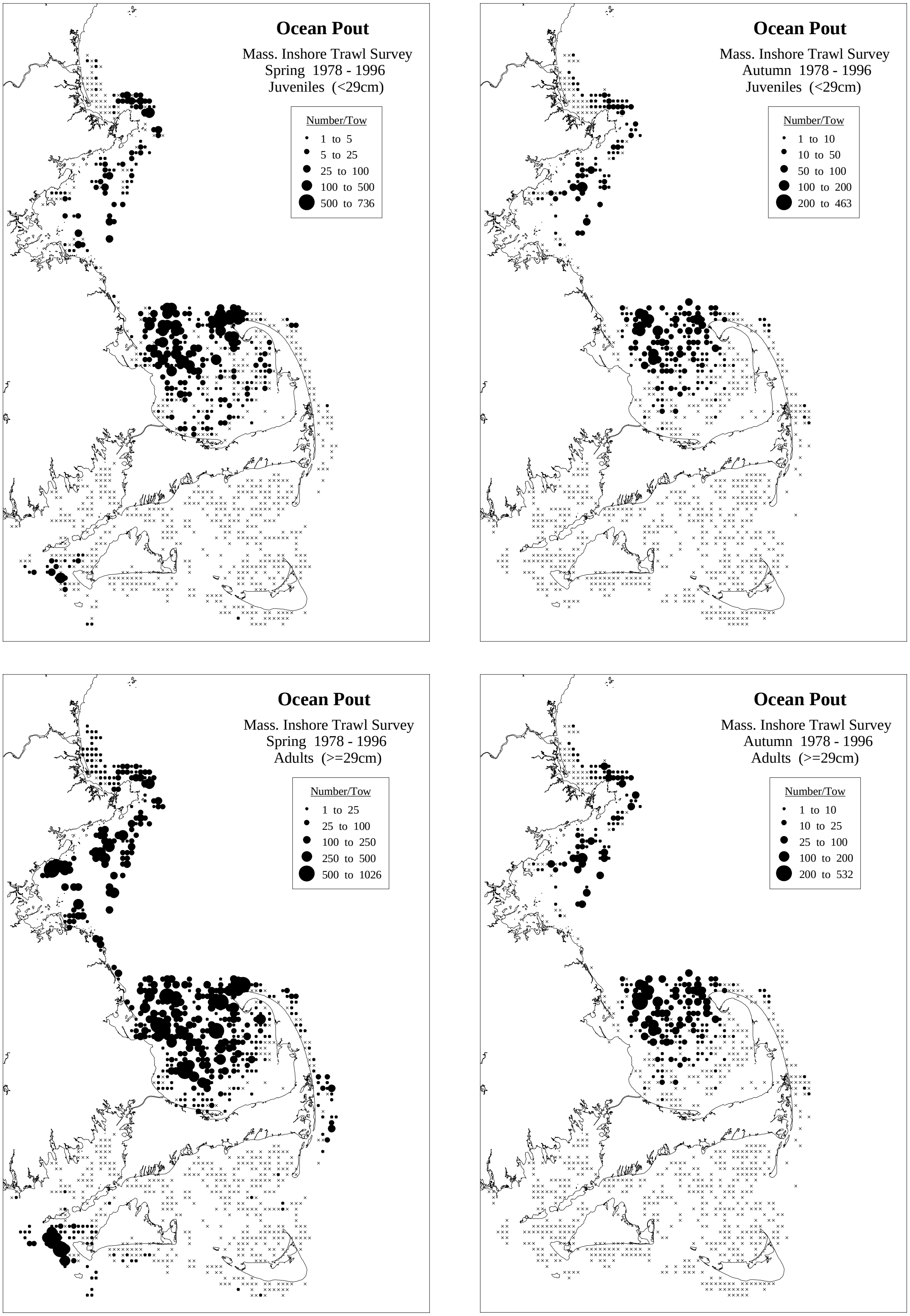


Figure 12. Distribution and abundance of juvenile and adult ocean pout in Massachusetts coastal waters during spring and autumn Massachusetts trawl surveys, 1978-1996 [see Reid *et al.* (1999) for details].

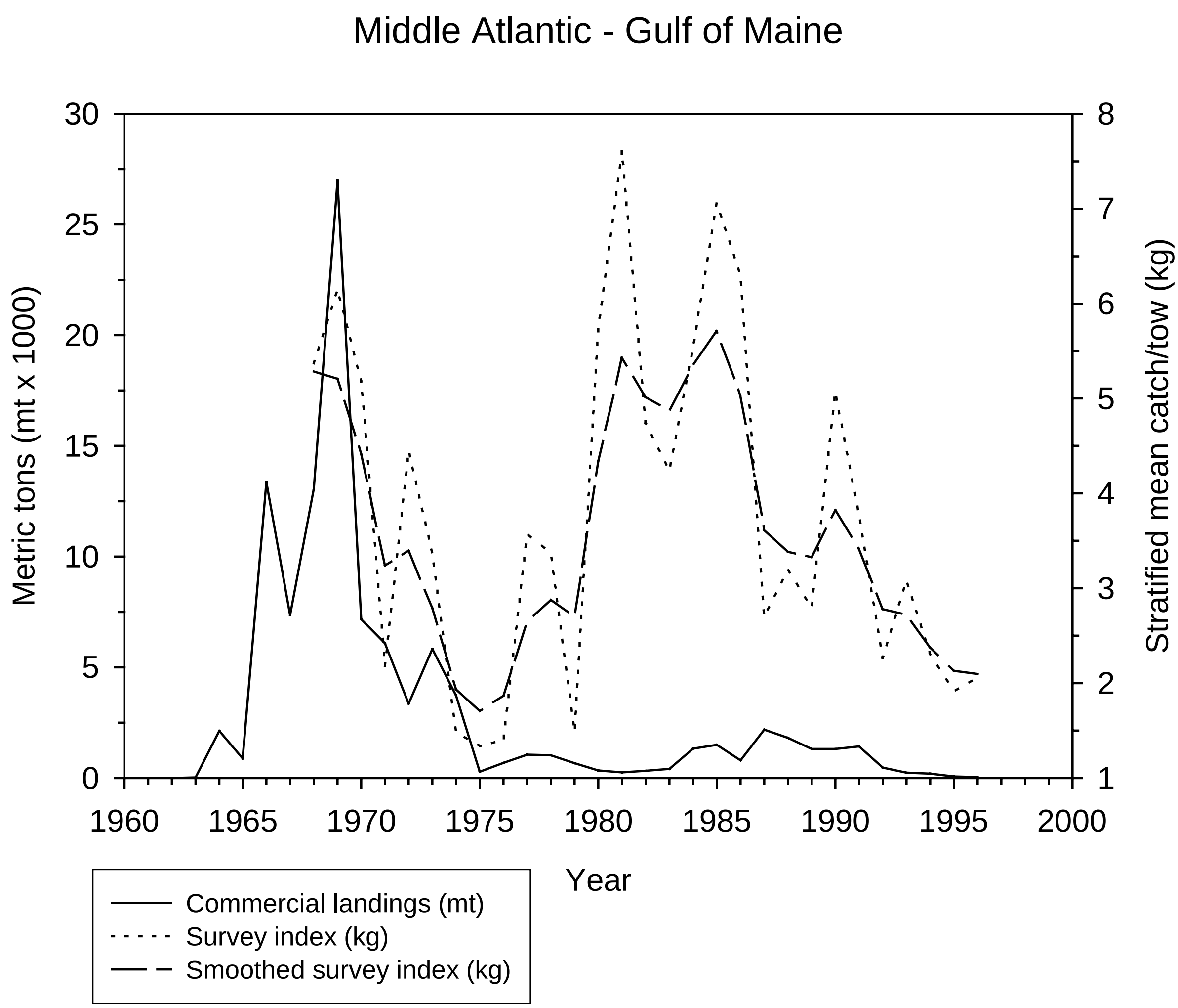


Figure 13. Commercial landings and survey indices (stratified mean catch per tow from the NEFSC bottom trawl surveys) for ocean pout from the Gulf of Maine to the Middle Atlantic Bight.

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