SEASONAL DISTRIBUTION AND ABUNDANCE OF LOBSTER (HOMARUS AMERICANUS) POSTLARVAE IN THE NEW YORK BIGHT AND AN ADJACENT ESTUARY

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ABSTRACT: There is virtually no information on the pelagic early life history stages of American lobster, Homarus americanus, in the New York Bight despite the fishery for this species in the region. We present data on the distribution and abundance of postlarvae (Stage IV) on the continental shelf and in the polyhaline portion of an adjacent estuary in order to elucidate aspects of their presettlement distribution. The postlarvae were collected with a frame net (5 m², 3 mm mesh) during six cruises in 1988 and 1990 and in the Great Bay, New Jersey estuary under nighttime with dip nets from 1986–1992. They were common in surface waters of the New York Bight in June and July, and from June to August in Great Bay. In both areas most collections occurred at temperatures of 17–24°C. On the continental shelf, postlarvae occurred throughout the spatial limits of the sampling from the eastern tip of Long Island to the mouth of Delaware Bay. They were most abundant inshore, especially off the eastern tip of Long Island and off Great Bay. Despite the large number of postlarvae collected in Great Bay there is no evidence of successful settlement there, and there are no data on the early benthic phase for the continental shelf in the New York Bight, thus the habitat for recently settled individuals is unknown and should receive further attention.

Key Words: Homarus americanus, lobster, Stage IV, postlarvae, New York Bight

INTRODUCTION

The natural history and population dynamics of American lobster, Homarus americanus, in the New York Bight are poorly known despite the value of this species in inshore and offshore fisheries elsewhere in the northeastern United States (Grosslein and Azaroritz, 1982; MacKenzie, 1992). In a review of the life history and recruitment processes of lobsters, larval supply, including that of the pelagic postlarvae (Stage IV), was identified as a focus for further research (Cobb and Wahle, 1994). The issue of larval supply is a particularly complex problem for H. americanus because both inshore and offshore populations (Uzmann et al. 1977, Andrews, 1980; Incze et al., 2000a) may contribute larvae, and extensive movement of adults, including ovigerous females, are common (Cooper and Uzmann, 1971; Cooper, 1980; Campbell, 1986; Watson et al., 1999). Larval supply in the New York Bight is virtually unstudied (see Clark and Hughes, 1965 for the only prior record) although there are numerous field studies of larval distribution and abundance in New England and the Gulf of Maine (Fogarty, 1983; Harding et al., 1987; Harding and Trites, 1988; Cobb et al. 1989; Incze and Wahle, 1991; Katz et al., 1994; Incze et al., 1997, 2000a; Incze and Naime, 2000).

In this paper we have concentrated on the distribution and relative abundance of postlarval lobsters on the continental shelf of the New York Bight and in an adjacent estuary in order to provide an improved understanding of their presettlement distribution. These studies were facilitated because the pelagic postlarvae are accessible in surface collections due to their abundance in the top one meter of water (Bibb et al., 1983; Fogarty, 1983; Hudon et al., 1986; Harding et al., 1987).

MATERIALS AND METHODS

Samples of postlarval lobster (Stage IV) were collected incidentally to other extensive studies designed to collect larval fishes in continental shelf water of the New York Bight and in an adjacent estuary (Fig. 1). All postlarval lobsters were easily identified based on their similarity to the adults (Herrick, 1911). Terminology for the postlarval stage of development follows Lavalli and Lawton (1996).

Continental Shelf Sampling

Postlarval lobsters were collected during two years of intensive plankton sampling in the New York Bight. During 1988, eight cruises were conducted from May through August. Five transects were run perpendicular from shore between Cape May, New Jersey and Montauk, New York with stations (n=327) placed approximately every 18 km from 3 to 200 km offshore (Fig. 1). During 1990, three cruises were conducted from mid-June to mid-July. Stations (n = 106) were placed every 18 km along six evenly spaced transects between 3 and 120 km offshore (i.e. to the shelf edge) within the same region as the 1988 sampling, with the addition of one transect to the south of Cape May, New Jersey. All larvae were sampled using a 5 m² Methot frame net with 3 mm mesh (Methot, 1986). The net was towed at the surface (approximately the upper 2 m). Standard tows were of 10 minute duration at a speed of ca 1.5 m s⁻¹, number of postlarvae collected per tow are reported as catch-per-unit-effort (CPUE). Samples were preserved in 95% ethanol. Measurements of temperature and salinity were recorded at each station with an internal recording STD (Applied Microsystems Inc., Model AMS-STD 12).
Fig. 1. Distribution (CPUE, number per tow) of postlarval lobsters (*Homarus americanus*) in 1988 and 1990 frame net collections in the New York Bight. The dotted line represents the edge of the continental shelf at the 200 m contour. The arrow in the upper left box indicates the approximate location of the Rutgers University Marine Field Station in Great Bay, New Jersey.
Estuarine Sampling
Postlarval lobsters were collected in the semi-enclosed boat basin of Rutgers University Marine Field Station (RUMFS) in southern New Jersey. This location in Great Bay is < 2 km from the Atlantic Ocean inside Little Egg Inlet at approximately 39°30' N, 74°20' W. The basin is surrounded by naturally occurring Spartina alterniflora marshes at the mouth of a subtidal creek. At this location in the estuary strong tidal currents (Charlesworth, 1968) bring flooding waters from Little Egg Inlet and the adjacent ocean. The semidiurnal tides in this estuary are approximately 1 m (Able et al., 1992). All collections were made at night with a dip net (0.3 mm mesh) under a light suspended above the water surface. Postlarvae were easily detected and captured. Sampling occurred irregularly during 1986–1992 (Table 1). The timing of sampling relative to time of night and tide was haphazard. Temperature and salinity were recorded daily at midday at a site approximately 200 m from the sampling location (Able et al., 1992). Additional details of this sampling site are available (Able et al., 1997, Able and Fahay, 1998).

RESULTS

Temporal Occurrence and Abundance
Postlarval lobsters (Stage IV) were frequent components of surface waters in the New York Bight during the summer. Sampling during these years found the postlarvae in surface plankton collections during July and early August of 1988 and late June and July in 1990 (Fig. 1, 2A). An overlapping pattern of seasonal occurrence is evident for nighttime collections in Great Bay, New Jersey (Fig. 2B) even though these collections occurred during all months of the year (Table 1). In these estuarine collections postlarvae occurred from early June through the third week of July in 1986 and 1990. In 1992, they were collected later, from the last week of June to the second week of August.

Postlarvae appeared to be relatively more abundant in collections on the continental shelf in 1990 than in 1988 (Fig. 1). In Great Bay the annual variation in abundance is difficult to compare because effort was not quantified. However, postlarvae were most abundant in 1986 and 1990 based on the total number collected and the per-
percentage of nights in which they were captured (Table 1). In 1992, in a one-night intensive effort, over 167 individuals were collected at this single location.

Spatial Distribution and Abundance
The postlarvae were collected throughout the spatial limits of the continental shelf sampling program (Fig. 1). In 1988, they were found as far east as the outer continental shelf. In 1990 they were found as far south as the mouth of Delaware Bay. In 1992, when sampling extended into the deeper waters of the continental slope (> 200 m), postlarvae were restricted to the continental shelf. The frequency of occurrence of postlarvae in each 1988 cruise was low relative to 1990. In 1988, the frequency of occurrence in the three cruises early and late July and August was 52%, 45%, and 18% of the stations, respectively. In 1990, when postlarvae did not always extend to the edge of the shelf on each transect, postlarvae were collected at most stations. In both late June and early July cruises, the postlarvae were encountered at a very high percentage of the stations (72% and 74%) dropping off to only 15% by August. In both years the largest collections (>10 individuals / tow) were at the most inshore stations in 4 of the 6 cruises (Fig. 1). These occurred off the eastern tip of Long Island and off Great Bay, New Jersey.

Collections were most frequent and largest from 18-24°C, both on the continental shelf and in the estuary (Fig. 3). In 1988, postlarvae on the continental shelf were collected over a surface temperature range of 18-24°C; in 1990, they occurred over a similar range with the exception of a large collection at 13°C. The later occurred off eastern Long Island. In Great Bay the larvae were collected at temperatures of 17-27°C over 1986-1992 (Table 1) and most extensively at 17-22°C during 1990 and 1992 when they were more frequently collected (Fig. 3). At this estuarine site, the salinities for positive collections ranged from 25-32%.

DISCUSSION
Our collections of postlarvae, which are the first extensively reported from the New York Bight, are almost the most southern records for the postlarvae of this species. The timing of occurrence for postlarval lobsters in the New York Bight is earlier than many other more-northern areas off the east coast of North America. The peak occurrence in June and July over several years in the New York Bight is concurrent with southern New England waters, earlier than Cape Cod Bay, and earlier than Gulf of Maine and Canadian waters (see Fig. 4 in Cobb and Wahle, 1994; Incze et al. 1997, 2000a). The distribution of postlarvae in the New York Bight relative to temperature and salinity is in agreement with previous observations (Phillips and Sastry, 1980).

The collections of postlarvae in Great Bay are the first reported from estuarine waters of the New York Bight. The catches of postlarvae on the continental shelf off Great Bay (Fig. 1) may account for the relatively large numbers of larvae that were taken in the nighttime collections within the bay. The distance from the inner shelf collecting sites are short enough (7 km) and the current speeds strong enough (Charlesworth, 1968) that they could have been transported there on a single flood tide. The larvae in Great Bay occurred at salinities higher than 25%; lower salinities are presumed to negatively affect survival rates (Templeman, 1936). A prior investigation of recruitment of early benthic phase lobsters along the estuarine gradient in Narragansett Bay indicated declining numbers from the open coast to the upper bay (Wahle, 1993). He suggested that lack of available settlement substrate and high temperatures may preclude successful settlement there.

The sources of postlarvae for the continental shelf and Great Bay may be varied. First, ovigenous females have been collected in nearshore waters in the New York Bight (Andrews, 1980). It is not clear if these are from local populations or migrants. In addition, in the same region, there are seasonally large numbers of offshore lobsters that are the basis of an extensive fishery (Uzmann et al., 1977; Andrews, 1980; Grosslein and Azarovits, 1982). Thus, it is also possible that larvae are released from ovigenous females offshore or from the inshore migration of ovigenous females (Uzmann et al., 1977; Andrews, 1980). It would require an analysis of the location of the earlier larval stages (Stage 1-3; Herrick, 1911) in order to determine the source of the postlarvae; such an attempt has occurred off Massachusetts and Rhode Island (Katz et al., 1994).

The consistent occurrence of the greatest numbers of postlarval lobsters in nearshore areas may be related to physical oceanographic features such as wind induced transport (Wahle and Incze, 1997). However, models developed for larval distribution data off Massachusetts and Rhode Island suggested that directional swimming from offshore hatching areas could account for a great number of postlarval individuals in inshore areas (Katz et al., 1994). These data were for the same year (1988) as our earliest observations and in an immediately adjacent area (Fig. 1), suggesting that the pattern of more postlarvae inshore, that we observed, may have extended from off Massachusetts to at least the eastern end of Long Island during that year.

The distribution of postlarval lobsters is especially relevant to settlement and the location of potential nursery areas because this stage is relatively short in duration (12 days at 20°C, Herrick 1911) and coincident with becoming benthic (Scarratt, 1973; Botera and Atema, 1982; Katz et al., 1994; Incze et al., 1997; Wahle and Incze 1997; Incze et al., 2000b). The nursery areas in the New York Bight are unknown although the harvesting of small sublegal lobsters is a tradition in Raritan Bay (MacKenzie, 1992) and juvenile lobsters are frequently taken in deep holes (burrow pits) there (National Marine Fisheries Service, Sandy Hook Laboratory, unpublished data). Small lobsters (50-80 mm CL) also occur in the apex of the New York Bight where rocky reefs, shipwrecks and rubble may provide appropriate habitat (Andrews, 1980). While juvenile lobsters have been reported in estuarine waters of the Middle Atlantic Bight in Massachusetts (Able et al., 1988) and Rhode Island (Wahle, 1993; Incze et al., 1997), and the postlarval individuals were sometimes abundant in Great Bay, the juveniles have not been collected in this New Jersey estuary. Intensive collections during the spring, summer and fall over a six-year period (1987-1992), with a variety of gears (throwtrap, seines, otter trawls, beam trawls; Sogard and Able, 1991; Rountree and Able, 1992; Szedlmayer and Able, 1996) including benthic suction sampling in a variety of habitats (Zostera marina, Ulva lactuca, unvegetated sand and mud, including marsh creeks) (K.A. Wilson and K.W. Able, unpublished data) have not collected a single benthic juvenile. Thus, currently there is no evidence that successful settlement occurs in Great Bay. The same may be true on the adjacent continental shelf.
where sampling for decapod crustaceans with beam trawls in the vicinity of Beach Haven Ridge (10–20 m depth) have failed to collect a single juvenile lobster (Viscido et al., 1997) even though shell accumulations there (Hales et al., 1995) would appear to provide habitat similar to the cobble that is preferred in other areas (Wahle and Steneck, 1991). Perhaps the warm summer temperatures in Great Bay (typically >23°C, occasionally > 25°C in summer, Able et al., 1992) and on the inner shelf near Beach Haven Ridge (Able and Fahay 1998) may preclude survival after settlement as suggested by laboratory studies (MacKenzie 1988). Additionally, the increased relative abundance of some types of predators in Great Bay, such as mud crabs (Lavalli and Barshaw, 1986; Barshaw and Able, 1990), may contribute to mortality during and immediately after settlement. Others have argued that subtidal cobble habitat is critical to survival (Wahle and Steneck, 1991). This habitat is lacking from Great Bay and much of New Jersey although peat reef habitat, which has been demonstrated to be a nursery habitat (Able et al., 1988), is abundant (K.W. Able, pers. observ.).

In summary, the large number of postlarval lobsters collected in the New York Bight suggests that this area provides appropriate habitat for reproduction and larval development. The location of the habitat for the early benthic phase individuals remains to be determined.

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