A comparison of two fishery-independent survey programs used to define the population structure of American lobster (*Homarus americanus*) in the Gulf of Maine

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Abstract—The population structure and abundance of the American lobster (*Homarus americanus*) stock in the Gulf of Maine are defined by data derived from a fishery-independent trawl survey program conducted by the National Marine Fisheries Service (NMFS). Few sampling stations in the survey area are located inshore, in particular along coastal Maine. According to statistics, however, more than two thirds of the lobster landings come from inshore waters within three miles off the coast of Maine. In order to include an inshore survey program, complementary to the NMFS survey, the Maine Department of Marine Resources (DMR) initialized an inshore survey program in 2000. The survey was modeled on the NMFS survey program, making these two survey programs comparable. Using data from both survey programs, we evaluated the population structure of the American lobster in the Gulf of Maine. Our findings indicate that lobsters in the Gulf of Maine tend to have a size-dependent inshore-offshore distribution; smaller lobsters are more likely to stay inshore and larger lobsters are more likely to stay offshore. The DMR inshore and NMFS survey programs focused on different areas in the Gulf of Maine and likely targeted different segments of the stock. We suggest that data from both survey programs be used to assess the lobster stock and to describe the dynamics of the stock in the Gulf of Maine.

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Many fish species experience size-dependent inshore-offshore movement at a certain stage (or stages) of their lives, resulting in size-dependent distribution. Shallow inshore waters along coasts in many parts of the world are primary nursery or spawning grounds (or both) for many commercially and recreationally important fish species (Taylor, 1953; Caddy, 1975). Juveniles of many fish species inhabit shallow inshore waters but migrate to deeper waters with increasing size (Chen et al., 1997). This size-dependent movement can also be observed in other life history stages such as when mature fish migrate to spawning grounds (Rowling, 1994). One consequence of such a size-dependent movement is that spatial distribution of fish becomes size-specific. Many ocean fish aggregate in their habitats according to size (Paloheimo and Dickie, 1964; Caddy, 1975; Hilborn and Walters, 1992).

The American lobster (*Homarus americanus*) is distributed throughout the northwest Atlantic from the Straight of Belle Isle, Newfoundland, to Cape Hatteras, North Carolina. It supports the most valuable commercial fishery in the Northeast United States (ASMFC, 2000). This lobster is most abundant in shallow coastal waters but can also be found in water depths of 700 meters (Cooper and Uzmann, 1980; Lawton and Lavalli, 1995). Various surveys and studies have indicated that there are large differences in lobster density among different areas and different water depths (Wahle and Steneck, 1992; Wilson, 1998; Palma et al., 1999).

Lobsters tend to move little during their first year on the bottom (Wahle, 1992; Palma et al., 1999). The daily and annual movement range increases with their sizes. After they reach harvestable size, their annual range of movement is about 2 to 3 kilometers (Krouse, 1980). Sublegal-size lobsters generally have small seasonal movements (<1 km/year) and are largely found near shore. Larger lobsters are more mobile (<20 km/year) and show progressively offshore deep

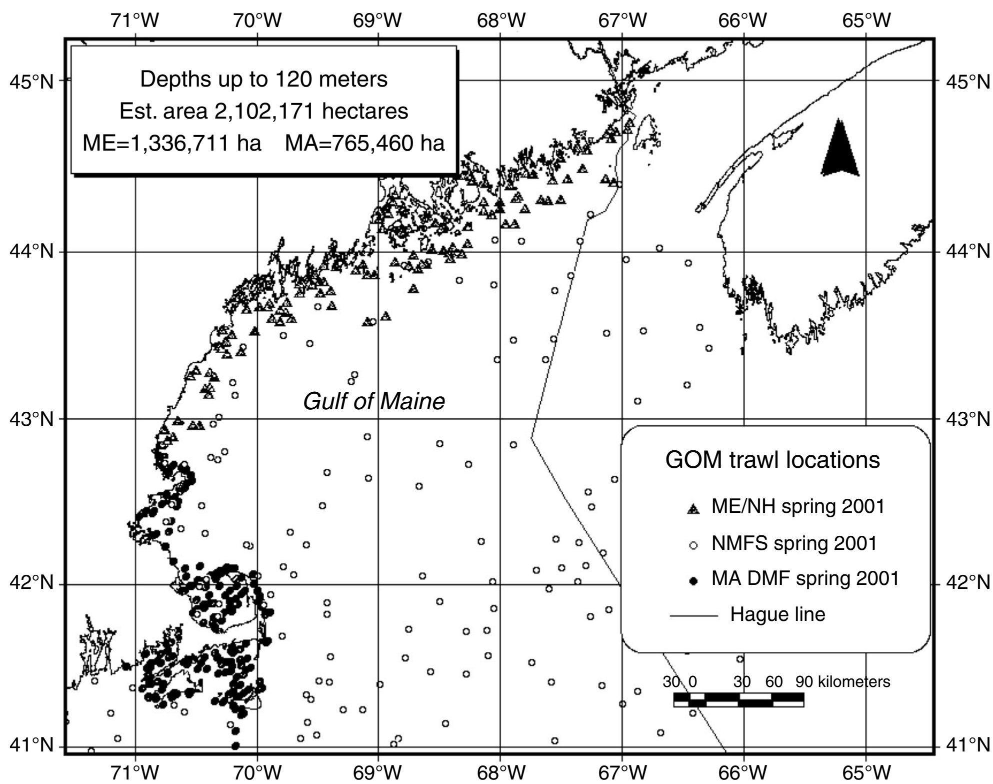

Figure 1

Geographical areas of the Maine Department of Marine Resources (DMF) inshore survey program and National Marine Fisheries Services NMFS survey program. ME/NH=Maine and New Hampshire; MA DMF=Massachusetts Department of Marine Fisheries.

movements in the fall, returning to inshore shallow areas in the spring.

The range of movement increases further after they reach maturity. However, there are large differences in migratory behaviors among individuals (Pezzack and Duggan, 1986). In general, mature legal-size lobsters are more abundant offshore and in deeper waters (Harding and Trites, 1989). Large egg-bearing lobsters have been shown to exhibit long migrations (>100 km) (Krouse, 1980; Campbell, 1983).

Size-dependent inshore-offshore distributions have been reported in many lobster studies (Skud, 1969; Cooper et al., 1975; Briggs, 1985; Campbell and Pezzack, 1986; Cobb et al., 1989; Harding and Trites, 1989). Information collected in commercial fisheries and scientific surveys has revealed that the spatial distribution of the American lobster may be size-dependent and that lobster of large sizes are more likely found in deep waters. This pattern has been identified but not quantified (Wilson, 1998). The spatial distribution of lobsters varies with seasons and scales with the size of lobsters.

The distribution and abundance of lobsters have been studied with a variety of techniques. Diver and submarine and ROV surveys are generally limited to nearshore areas or in temporal resolution. Tagging programs are often limited in area and time covered and in number of lobsters tagged and returned. A fisheries-dependent sea sampling program covers a limited number of fishing boats within limited areas and thus may not be able to provide an overall picture of lobster distribution and abundance within the lobster stock area in the Gulf of Maine. Until recently, the only comprehensive fishery-independent data were those obtained from the NMFS Gulf of Maine fall and spring trawl surveys. NMFS has conducted a randomized stratified survey since the mid 1960s, but this survey is limited to depths deeper than 50 meters. In fact, the majority of the sampling stations are located in waters deeper than 120 meters as a result of an increased proportion of untrawlable areas and problems with lobster gear in inshore waters. In the fall of 2000, the DMR began a coast-wide inshore trawl survey, which mainly covered waters shallower than 120 meters (Fig. 1).

The spatial distribution of lobsters is largely restricted to the nearshore areas. Although found throughout the Gulf of Maine, 80% of the landings are estimated to come within three miles from shore (ASMFC, 2000). Clearly the lobster fishery will follow the concentrations of lobsters, although seasonal changes in movements and trapability of lobsters may make less productive fishing areas desirable to limited portions of the fleet at certain times of the year. As the fishing effort for lobster has increased, the traditional inshore fishery has expanded to nearshore waters (from 4.8 km to 32.2 km from shore). There is also a deepwater fishery for lobster that occurs farther from shore.

An optimal and effective fisheries management plan requires a high-quality stock assessment, which, in turn, is dependent on data collected from fisheries-dependent and fisheries-independent survey programs. One of the most important pieces of information used in a lobster stock assessment is the abundance index which is derived from the fisheries-independent bottom trawl surveys conducted by NMFS. Because trawling is difficult in coastal waters, few sampling stations in the NMFS survey are located inshore, specifically along coastal Maine from which the majority of the lobster landings are landed. Previous studies have also indicated that inshore habitats are critical to the lobster fishery. Thus, it is critical to develop an inshore survey program that can cover the waters off coastal Maine. The data collected from such a program can overcome the problem of a lack of inshore coverage in the NMFS survey. An inshore survey and the NMFS survey can complement each other for a more complete abundance index of the lobster stock in the Gulf of Maine.

In order to identify the importance of the DMR inshore survey, we compared the differences between the NMFS survey and DMR inshore survey in 1) the size composition of survey catches and their temporal trends; 2) temporal trends in abundance indices; and 3) average size and weight of lobsters. From our comparative study, we determined whether the lobster stock in the Gulf of Maine has a size-dependent inshore-offshore distribution and whether it is essential to include both sampling programs in a stock assessment to adequately describe the population dynamics of lobsters in the Gulf of Maine.

Methods and materials

Like the NMFS surveys, the inshore trawl survey is conducted during the spring and fall of each year. It has a stratified random design modeled after the NMFS and Massachusetts Department of Marine Fisheries (MADMF) surveys. The design has four depth strata (9–37 m, 37–64 m, 64–100 m, >100 m [its outer boundary roughly delineated by the 12-mile or 22-km limit]) and five regions based on oceanographic, geologic, and biological features. The fourth stratum was added in the spring of 2003. It expands the coverage area to equal the area in federal waters covered by the Atlantic States Marine Fisheries Commission (ASMFC) and allows some overlaps between annual inshore trawl survey area and the NMFS survey area. It also slightly reduces the sampling pressure in the shallower strata, which has been of concern to fixed-gear fishermen in the past. To randomize the survey area (~13,720 km^2), each depth stratum is divided into 1-nmi (i.e., 1.852 km) sampling grids. A target of 100 stations is selected for sampling in each survey, resulting in a sampling density of about 1 station /137 km^2. This density compares to the sampling density of the NMFS survey (1 station/892 km^2) and Massachusetts' survey (1 station/65 km^2). The number of stations per stratum is allocated in proportion to the area of each stratum. When a station is encountered that cannot be towed, an alternate tow is selected nearby over similar depth.

Trawl design considerations for the survey included effectiveness of the gear for sampling the complex bottom in the Gulf of Maine and approximate comparability with previous and ongoing surveys, such as that performed by the NMFS. Net tapers are cut to permit the shape of the net to be of maximum height, while allowing the net to remain tight on the bottom. The net is shackled from the footrope to the frame by using two 0.95-cm shackles on a banded wire that runs parallel with the footrope. Heavy rubber wing bobbins retard bottom wing lift. The top leg is constructed of 5.1-cm mesh overall and has a 1.3-cm mesh liner in the codend. Doors are 7.5 Bison doors. Attached to the 21.3-m-long, 1.59-wide footrope is a roller frame. The 3.05-m-wide bosom section is made up of 20.3-cm rubber disks on 15.2-cm centers, and there are eight evenly spaced toggles. The spacing is maintained by small 10.2-cm cookies strung between the disks. Chain sweeps were not used. The headrope is 17.4 meter in length.

Environmental data, including temperature and salinity profiles, wind, sea state, and weather, were collected at each station. A standard trawl tow, 20 minutes in duration, was made at each station. Shorter tow times were accepted under certain circumstances, such as the presence of fixed gears or untrawlable bottom in the survey pathway. Tow speed was maintained at 2.1 to 2.3 knots (i.e., 3.9 km/h to 4.3 km/h) and tow direction was oriented toward the tidal current whenever possible. All sampling was conducted during the day. After each tow, the net was brought aboard and emptied onto a sorting table. All individuals were identified and sorted by species. All lobsters were immediately separated and processed while the rest of the catch was sorted. Total weights (by sex), carapace length (mm), shell condition, presence and stage of eggs, V-notch condition, and injuries to the lobsters caused by the trawl were recorded. All lobsters were measured and the data were recorded in electronic format for analysis and made available on compact disk (CD). The data were geo-referenced and incorporated into geographic information systems (GIS) for analysis.

A no. 36 Yankee bottom trawl has generally been used in NMFS bottom trawl surveys. The trawl net is towed at approximately 3.5 knots (i.e., 6.5 km/h) for 30 minutes at each station. The survey is based on a stratified random design. Strata are defined according to water depth, latitude, and historical fishing patterns. Within each stratum, stations are assigned randomly; the number of stations allotted to a stratum is in proportion to its area (approximately one station per 892 km^2). Specifications for NEFSC standard no. 36 Yankee bottom trawl are defined by the NMFS.[1]

[1] NMFS (National Marine Fisheries Service). Website: http://www.nefsc.noaa.gov/femad/ecosurvey/mainpage. [Accessed August 2004.]

The trawl used in the DMR survey is similar in design, but smaller than that used in NMFS, although the size of the mesh liner in the codend is the same. The DMR survey trawl net is also towed for less time (20 minutes versus 30 minutes for NMFS).

The data collected in the inshore survey were analyzed according to the methods described below. The stratified mean number of lobsters per tow, $\bar{X}$, can be calculated as

$$\bar{X} = \frac{1}{A}\sum_{k=1}^{g} A_k \bar{}_k,$$

where g = the number of stratum in the survey;
A_k = the survey area in stratum k;
A = the total area covered by the survey $X(A = \frac{1}{A}\sum_{k=1}^{g} A_k)$;$_k$, and
$\bar{X}_k$ = the average catch per tow in stratum k.

The $\bar{X}_k$ can be calculated as

$$\bar{X}_k = \frac{1}{T_k}\sum_{t=1}^{T_k} X_{k,t},$$

where $X_{k,t}$ = catch in tow t, stratum k; and
T_k = the total number of tow in stratum K.

The variance for the stratified mean, $S^2(\bar{X})$, can be estimated as

$$S^2(\bar{X}) = \frac{1}{A^2}\sum_{k=1}^{g} A_k^2 S^2(\bar{X}_k),$$

where $S_2(\bar{X}_k)$ = the variance for the mean number per tow in stratum k, which can be estimated as

$$S^2(\bar{X}_k) = \frac{\sum_{t=1}^{T_k}(X_{k,t} - \bar{X}_k)^2}{n_k(n_k - 1)}.$$

The mean length of the lobster population is estimated as

$$\bar{L} = \frac{\sum_{k=1}^{g} A_k \bar{}_k}{\sum_{k=1}^{g} A_k \bar{}_k}.$$

The average length fish per tow, $\bar{C}_k$, in the above equation is calculated as

$$\bar{C}_k = \frac{\sum_{t=1}^{T_k}\sum_{j=1}^{200} L_j X_{j,t,k}}{T_k},$$

where L_j = the lobster carapace size ranging from 1 to 200; and
$X_{j,t,k}$ = the number of the lobsters in size j, tow t, and stratum k.

The stratified mean number of lobsters of length j per tow, $\bar{X}_j$, can be estimated as

$$\bar{X}_j = \frac{1}{A}\sum_{k=1}^{g} A_k \bar{X}_{j,k},$$

where the mean number of lobsters of size j per tow, $\bar{X}_{j,k}$, is estimated as

$$\bar{X}_{j,k} = \sum_{t=1}^{T_k}\frac{X_{j,t,k}}{T_k}.$$

The above equations were used for both the original data (without any transformation) and the data transformed by using log(x+1). For results derived from the log (x+1) transformed data, a retransformation was done to retransform the log-based results to the results of the original scale by using the following equation:

$$U = \exp(Y + \sigma_U^2 / 2),$$

where Y = the statistics derived from log(x+1) transformed data;
U = is the re-transformed statistics; and
σ_U^2 = the population variance estimates as

$$\sigma_U^2 = \frac{1}{\sum_{k=1}^{T_k} A_k}\sum_{k=1}^{T_k}\left[A_k \;{}^{2}_{Y_k} + A_k\left(\bar{Y}_k - \frac{\sum_{k=1}^{T_k} A_k \bar{}_k}{\sum_{k=1}^{T_k} A_k}\right)^2\right],$$

where $S_{Y_k}^2$ and $\bar{Y}_k$ = the variance and mean value of log(x+1) transformed data in stratum k, respectively.

Using the above equations, we estimated the stratified mean number of lobsters per tow for original and log(x+1) transformed data, the stratified mean size frequency, and the stratified mean size of lobsters for the Maine inshore surveys. The average weight of lobsters for each tow was also calculated and then plotted against the average depth of the tow to identify if there was any size-depth dependent distribution. It should be noted that observations of zero lobsters occurred only for a small number of tows in the years covered in our study. Thus for the DMR inshore survey, there was no need to use methods such as delta transformation, which is often used in dealing with zero-inflated survey data with a large number of zero lobster catches.

The stratified mean number of lobsters per tow, stratified mean size frequency, and stratified mean size of lobsters for the NMFS survey program were obtained from the NMFS (Idoine[2]). Because of the large number

[2] Idoine, J. 2004. Personal commun. Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA 02543-1026.

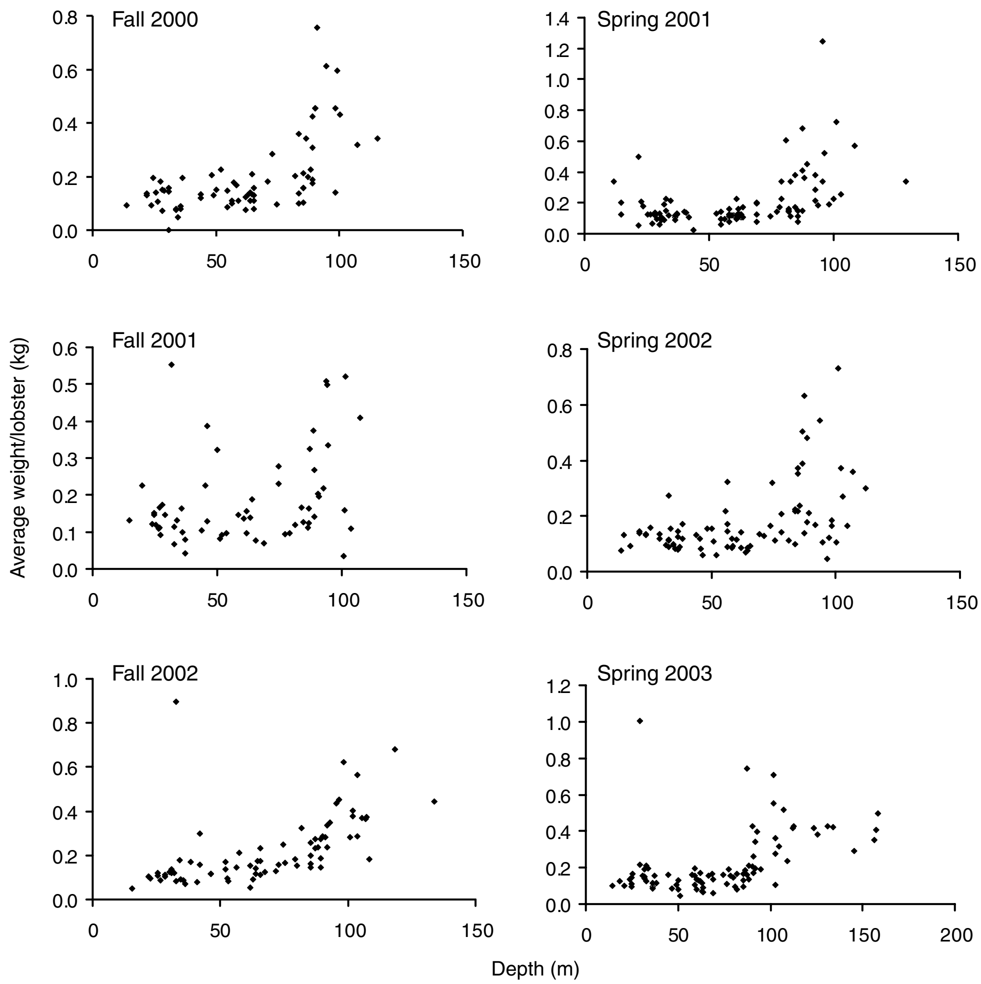

Figure 2

The changes in the average weight of American lobster (*Homarus americanus*) with the average depth of survey for each tow in each sampling season and year.

of tows with zero lobsters in the NMFS survey, a delta transformation was used to estimate the stratified mean of lobsters per tow. Because the DMR inshore survey program began in fall 2000, we used data from the NMFS survey program for the same time period only for our comparison of data. Currently the stock assessment uses only female data because females and males exhibit similar pattern; therefore we report results for females only in the present study.

Results

The average weight per lobster tended to be low and relatively constant for lobsters caught in the tows conducted in waters shallower than 73 m but increased greatly with increased depths (Fig. 2). The average carapace length for the first two depth strata, which were shallower than 72 m, were similar for each year and sampling season, but were much smaller than the average carapace length of lobsters in the third depth stratum which was deeper than 73 m (Table 1). For example, for the 2000 fall survey, the average lobster size for depth strata I and II were 61.9 and 64.4 mm—much smaller than 80 mm for stratum III. These distributional patterns in the lobster average weight and average size were consistent among years and seasons, indicating that lobsters inhabiting waters shallower than 73 m were mainly small individuals, whereas lobsters in waters deeper than 73 m were much larger than those in the shallow waters. A fourth depth stratum was used in the 2003 spring survey, where the average towing depth was 125 m. The average size of lobsters sampled in this stratum was 99.5 mm, which was similar to the stratified mean size of lobsters estimated in the NMFS survey program (Fig. 3).

There were no significant differences in size distributions among years in a given sampling season (i.e.,

Table 1

Summary of the mean carapace length of lobsters (*Homarus americanus*) and average survey depth for different depth strata in the inshore surveys. Roman numerals stand for depth strata: I=9–37 m; II=37–64 m; III=64–100 m; IV=>100 m). na=not available.

		Mean carapace length (mm)				Average depth (m)			
Year	Season	I	II	III	IV	I	II	III	IV
2000	fall	61.9	64.4	80.0	na	28.6	57.9	89.2	na
2001	fall	63.6	63.0	78.0	na	28.2	53.7	88.8	na
2002	fall	63.6	69.9	84.4	na	29.8	57.1	93.0	na
2001	spring	66.1	63.7	79.9	na	29.5	59.2	89.0	na
2002	spring	61.5	61.1	78.6	na	29.7	56.4	89.7	na
2003	spring	68.6	64.0	74.9	99.5	29.3	59.0	87.7	125.4

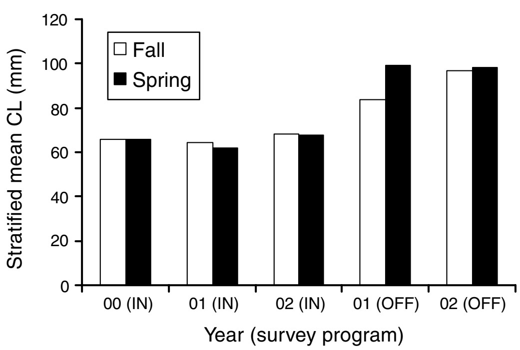

Figure 3

The stratified mean carapace length (CL) for American lobsters (*Homarus americanus*) for each sampling season and year for the Maine Department of Marine Resources inshore (IN) and the National Marine Fisheries Service offshore (OFF) survey programs. 00=2000; 01=2001; 02=2002.

either fall or spring survey) for the inshore survey (Fig. 4). For the NMFS survey, however, significant differences were found in size distributions between 2001 and 2002 in the fall surveys, but not between the two years in the spring surveys. The seasonal differences (i.e., spring vs. fall) in size distribution within a year were much larger than the between-year differences for the inshore fall or spring survey. For the NMFS survey, however, the seasonal differences in size distributions were large in 2001, but small in 2002 (Fig. 4). The large seasonal differences in a year compared to the between-year differences in a season in size distributions for the inshore survey indicate that seasonal factors are important in determining the size distribution of lobsters in the inshore waters. Such seasonal variability was not so clear for the offshore waters.

Large differences in size distributions were observed between the DMR inshore and NMFS surveys; the NMFS surveys consisted of lobsters of much larger sizes than those sampled inshore (Fig. 4). This finding may indicate that the inshore survey program had a limited coverage of the lobsters of large sizes, whereas the NMFS survey program had a limited coverage of the lobsters of small sizes. The size composition of lobsters from the NMFS survey had large variations. This result was probably due to the small number of lobsters caught in the NMFS survey. An increase in sample size could make the size composition curve smoother, and thus better defined. Compared with size composition of Amercan lobsters from the NMFS survey, size composition for the inshore survey was better defined, probably as a result of the larger number of lobsters caught in the inshore survey.

The stratified mean sizes of lobsters were similar among years for the same sampling season in the inshore survey (Fig. 3). For 2001, the stratified mean size in the fall survey was almost the same as that in the spring survey. For 2002, however, the stratified mean size in the fall survey was about 7 mm larger than that in the spring survey (Fig. 3). The stratified mean size of the 2001 fall survey was about 16 mm smaller than that of the 2001 spring survey (Fig. 3). The stratified mean size of lobsters in the NMFS survey was much larger than that of the inshore survey. This reconfirms the results derived from the comparisons of size distributions between the inshore and NMFS surveys (Fig. 4).

The abundance index derived from the inshore survey program revealed a consistent temporal pattern with original data or retransformed data (Table 2). For the original data and retransformed data, the fall inshore survey abundance index was the highest in 2001, followed closely by 2002, and the abundance index in 2000 was the lowest. For the log-transformed data, however, the differences among the three years were small (Table 2). For the spring survey, the abundance index in 2002 was much higher than the abundance indices in 2001 and 2003, and the abundance indices in 2001 and 2003 were similar (Table 2). The delta mean abundance indices of the NMFS survey program were higher in 2002

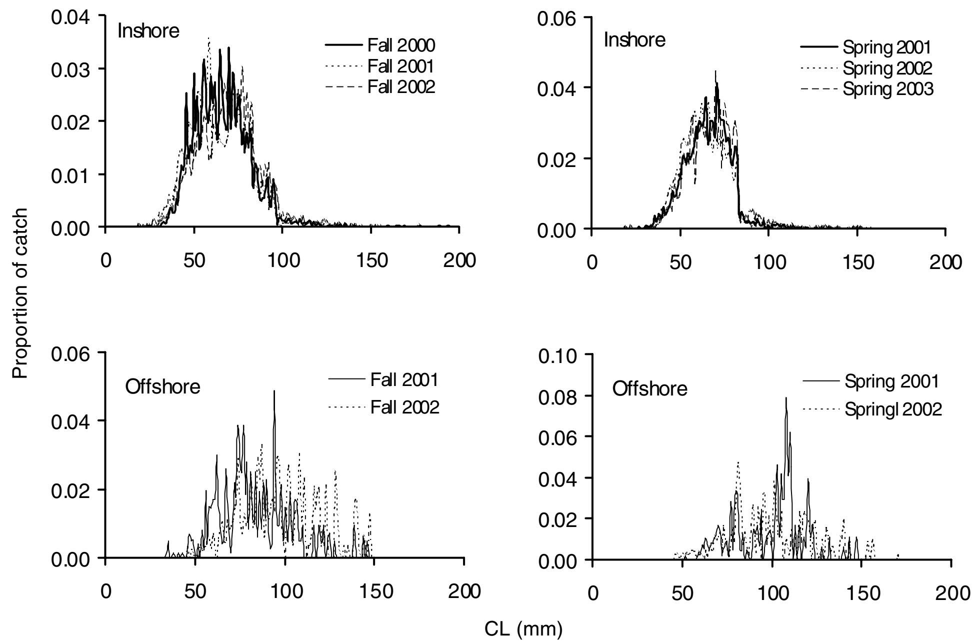

Figure 4

The size (of carapace [CL]) distributions for American lobsters (*Homarus americanus*) for each sampling season and year for the Maine Department of Marine Resources inshore and the National Marine Fisheries Service offshore survey programs.

Table 2

Estimates of the survey abundance index obtained from the original data and log(x+1) transformed data, and the retransformed abundance index derived from log(x+1) transformed data. "Lower B" and "upper B" are the lower and upper boundaries of the 95% confidence intervals.

		Statistics		Fall		Spring	
Index		2000	2001	2002	2001	2002	2003
Original (inshore)	Mean	55.5	68.5	64.1	22.6	49.2	21.2
	Lower B	32.7	45.1	51.7	16.4	34.7	15.8
	Upper B	78.2	91.9	76.5	28.8	63.6	26.7
Log(x+1) transformed (inshore)	Mean	2.9	2.9	3.1	2.1	2.7	2.2
	Lower B	2.6	2.5	2.8	1.9	2.4	1.8
	Upper B	3.2	3.3	3.5	2.4	3.0	2.6
Retransformed (inshore)	Mean	54.5	119.6	88.8	25.1	62.4	24.3
	Lower B	39.5	81.5	62.4	19.6	45.9	16.1
	Upper B	75.2	175.1	126.3	32.0	84.7	36.5
Delta mean (NMFS)	Mean		1.52	2.67	1.63	2.53	

than those in 2001 for both the fall and spring surveys. Thus, for fall, DMR inshore survey program had a different temporal pattern between 2001 and 2002, compared with the NMFS surveys, whereas for spring, the temporal pattern of 2001 and 2002 was same for the two sampling programs.

Discussions

Large differences were found in size compositions and mean sizes of lobsters between the DMR inshore and NMFS surveys. Such differences indicated that large lobsters are more likely to appear in the NMFS survey, and small lobsters are more likely to appear in the inshore survey. This is true for both sampling seasons, fall and spring. Two possible hypotheses can be developed to explain such patterns: one is that large differences in size compositions exist in lobsters inhabiting the areas covered by the inshore and NMFS survey programs, and the other is that the observed differences in size compositions between the DMR inshore and NMFS surveys result from differences in gear selectivity for lobsters of different sizes. The first hypothesis implies that lobsters have size-dependent inshore-offshore distribution, namely that large lobsters tend to inhabit deep waters and small lobsters inhabit shallow waters. The second hypothesis implies that although lobsters may have no size-dependent inshore-offshore distribution, the NMFS survey gears are selective for large lobsters and the inshore survey gears are selective for small lobsters in the population. Such a difference in gear selectivity between the two programs may result from differences between the two sampling programs not only in sampling gears but in towing speed and duration.

In order to determine which hypothesis is more plausible, we evaluated size composition for a depth stratum covered by both the DMR inshore and NMFS surveys. In the 2003 spring inshore survey, the fourth depth stratum had an average depth of 125 m which overlapped depth ranges in the NMFS surveys. The average size of lobsters in the fourth depth stratum in the 2003 spring inshore survey was almost identical to the average size of lobsters in the NMFS survey (Table 1 and Fig. 3). This finding indicates that the inshore survey gears can, like the NMFS survey gears, catch large lobsters if they are present in the areas covered by the survey program. Likewise, the differences in the average size between the first three strata and the fourth stratum (Table 1) in the 2003 spring inshore survey are likely to result from a lack of large lobsters in the first three strata in the inshore surveys, rather than from gear selectivity. Thus, the differences in size composition of lobsters between the DMR and NMFS surveys are likely the result of the differences in the size composition of the lobster population between the areas covered by the inshore and NMFS surveys, rather than the result of sampling methods. Although our study could not exclude the impacts of possible differences in gear selectivity on the survey size compositions, the results of our study seem to support the first hypothesis that the lobsters have a size-dependent inshore-offshore distribution, where large lobsters are more likely to be found in deep waters and small lobsters are to be found in shallow inshore waters. Thus, the two sampling programs tend to cover different segments of the stock in the Gulf of Maine. In order to have an adequate representation of the lobster population, it is necessary to include data from both sampling programs to describe the lobster population dynamics in the Gulf of Maine.

The temporal changes in the abundance index in the spring surveys were rather consistent between the DMR and NMFS surveys and for data on the original and log scales. However, for the fall survey, the delta mean of the NMFS survey was consistent only with the mean of log-transformed data, but not with the mean of the original data and the mean retransformed data from the mean of log-transformed data (Table 2). This finding raises an interesting question regarding the type of data transformation we should choose and the potential impacts of each type on detecting temporal changes in the population abundance. A different choice of data transformation methods may lead to different interpretations of temporal variations in stock abundance.

If the size-dependent inshore-offshore distribution pattern is not taken into consideration in making stock assessments, the entire stock will not be managed. We may need a separate set of abundance indices and size compositions for the lobsters in the inshore and offshore waters to describe the population dynamics of lobsters of different size groups more accurately. The inclusion of only NMFS survey data or inshore survey data in the stock assessment may lead to errors in determining the status of the lobsters if the population dynamics of large lobsters is different from that of small lobsters. The blending of DMR and NMFS data into a single set of data may be a solution. However, whether such a set of data can describe the dynamics of the whole population depends upon whether the lobster population dynamics are consistent among different size classes and whether there is a large difference in gear selectivity and in catchability of the trawl gear. Large differences in the population dynamics of large and small lobsters and in the gear selectivity and catchability of DMR and NMFS trawls may make such blended data less desirable for describing the population dynamics with DMR-NMFS blended data. For example, a significant increase or decrease in the abundance of lobsters of prerecruiting sizes may not be well defined with the NMFS surveys or DMR-NMFS blended data. We recommend both sets of data from the DMR inshore and the NMFS surveys be used separately in the stock assessment to define the population dynamics of the lobsters in the Gulf of Maine more accurately.

Many fish species in the world exhibit a size-dependent distribution pattern similar to that of the American lobster in the Gulf of Maine. Their population abundance and size structure are often assessed by fisheries-independent survey programs. The information is then used in the assessment and management of these fish species. Because it is often difficult with large trawls to survey inshore areas where the majority of stocks are present, the fishery-independent survey may not provide adequate coverage of inshore areas that are productive and critical, in particular, to recruitment. Thus, it is highly likely that fish in inshore areas are not adequately represented in an offshore-focused survey, and this misrepresentation would lead to errors in data on stock-size structure. Such an error may, in turn, result in large errors in a stock assessment if an age- or length-based stock assessment model is used. We suggest that two sampling programs with different spatial focuses may help identify the problems associated with a sampling program that does encompass fish size-dependent inshore-offshore distribution (or a size-dependent distribution that is related to depth or other environmental variables). The two sampling programs can greatly improve the quality and quantity of data collected in a fishery-independent program, leading to the improved assessment and management of fisheries. In the case where only one survey program can be conducted (e.g., due to budget limitation or time constraints, or both), we suggest that area-specific fishery landing data, together with depth or other environmental variables that influence fish distributions, be used in allocating sampling efforts in a random stratified survey.

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