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A COMPARISON OF DREDGE AND PATENT TONGS FOR ESTIMATION OF OYSTER POPULATIONS

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ABSTRACT Exploited oyster stocks on public grounds in Virginia waters are subject to regular surveys effected using a traditional oyster dredge and, more recently, patent tongs. Dredges provide semiquantitative data, have been used with consistency over extended periods (decades), and provide data on population trends. Surveys with patent tongs provide absolute quantification (number of individuals per unit area) of oyster stocks but are more labor intensive. Absolute quantification of dredge data is difficult in that dredges accumulate organisms as they move over the bottom, may not sample with constancy throughout a single dredge haul, and may fill before completion of the haul thereby providing biased sampling. Selectivity of dredges versus patent tongs with respect to oyster demographics has not been rigorously examined. The objective of this study is to compare demographic oyster data collected at the same sites in the same years from both gear types. Data for the study were taken from 1993 to 2001 surveys conducted in the James River, Virginia, by the Virginia Institute of Marine Science and the Virginia Marine Resources Commission wherein the same stations were sampled by both techniques. Dredge surveys give data in oysters per bushel and assume no selective retention of live oysters with respect to shell substrate by the dredge. Patent tong surveys provide data as per tong estimates of oysters by size class and shell by volume. The hydraulically operated, 1-m square tong used in VMRC/VIMS surveys is designed to sample on and below the reef surface and include elements of buried shell that are probably not well sampled by a dredge, although the sampling ensures collection of all oysters within the tong mouth. Oysters collected by both gear types were classified as small (25–75 mm) or market (>75 mm SL) for comparisons across methods. Shell volumes collected in patent tong surveys were standardized to bushel increments assuming 35.28 L of shell per bushel. The summary plots of mean values from 1993 to 2001 and 1998 to 2001 illustrate differences related to sampling gear. More shell per unit oyster (lower bushel counts) are observed in a patent tong sample. The appropriate model for attempting to fit a predictive line is open to debate, and will be influenced by patent tong penetration as determined by the degree of consolidation of the underlying substrate. The available data do not strongly support the ability to predict a relationship between dredge and patent tong population estimates at this time.

KEY WORDS: *Crassostrea virginica*, Eastern oyster, recruitment, survey methods, Chesapeake Bay

INTRODUCTION

The Chesapeake 2000 agreement (Chesapeake Bay Program, 2000) established a 10-fold increase in the Chesapeake Bay oyster population by 2010 as one of the principal goals of Bay restoration. The baseline for this goal is the population biomass that existed at the beginning of 1994, as assessed by surveys in fall 1993. A collaborative research effort between researchers in Maryland and Virginia was performed between 2000 and 2003 to develop the baseline value. Historical data in both states was collected in support of fishery management although differences existed in details of the assessment methods preventing a singular approach to stock estimation from the accumulated data sets. Dredge surveys have been used for oyster stock assessment in Virginia for over 50 years. The Virginia Institute of Marine Science (VIMS) began annual dredge surveys at a limited number of sites in Virginia's subestuaries in 1946 and this sampling program has continued through the present with recent dredge surveys conducted in collaboration with the Virginia Marine Resources Commission (VMRC) Shellfish Replenishment Program. More recently, dredge stock assessments have been supplemented by annual patent tong surveys based on a stratified random sampling design. Patent tong sampling began in the James River in 1993 and has since expanded to include the Piankatank River (1998 to present), Great Wicomico River (1998 to present), Rappahannock River (1993, 1995– 1997, 1998 to present), Tangier Sound (2001 to present) and Pocomoke Sound (2002 to present). Here we focus exclusively on data from the James River, Virginia.

Dredge data is semiquantitative. The data exist as numbers of oysters per bushel, not bushels per unit area. Patent tong data are absolute density data (numbers of oysters per unit area). Given both the extensive historical and spatial coverage of dredge assessment, the question was posed as to the possibility of developing a conversion function relating dredge to patent tong data, thus allowing hindcasting of absolute densities of oyster populations using historical dredge data sets. This, in turn would facilitate description of historical oyster populations including estimation of the 1994 baseline for the previously described 10-fold increase goal. In this note we compare oyster density estimates from both dredge and patent tong sampling for a limited suite of observations, 1993 to 2001 surveys conducted in the James River, where both sampling approaches were used on the same populations.

MATERIALS AND METHODS

Intensive sampling of the areas within the James River, Virginia that are actively fished for oysters (Fig. 1) is completed each fall as part of a collaborative program between VMRC and VIMS. Patent tong surveys use a stratified random sampling design with historical reefs (Baylor 1894, Haven et al. 1981) forming the basis of strata delineation. Individual samples were collected by a hydraulic patent tong with a one square meter sample capability. The patent tong used in VMRC/VIMS surveys is designed to sample on and below the reef surface, and include elements of buried shell

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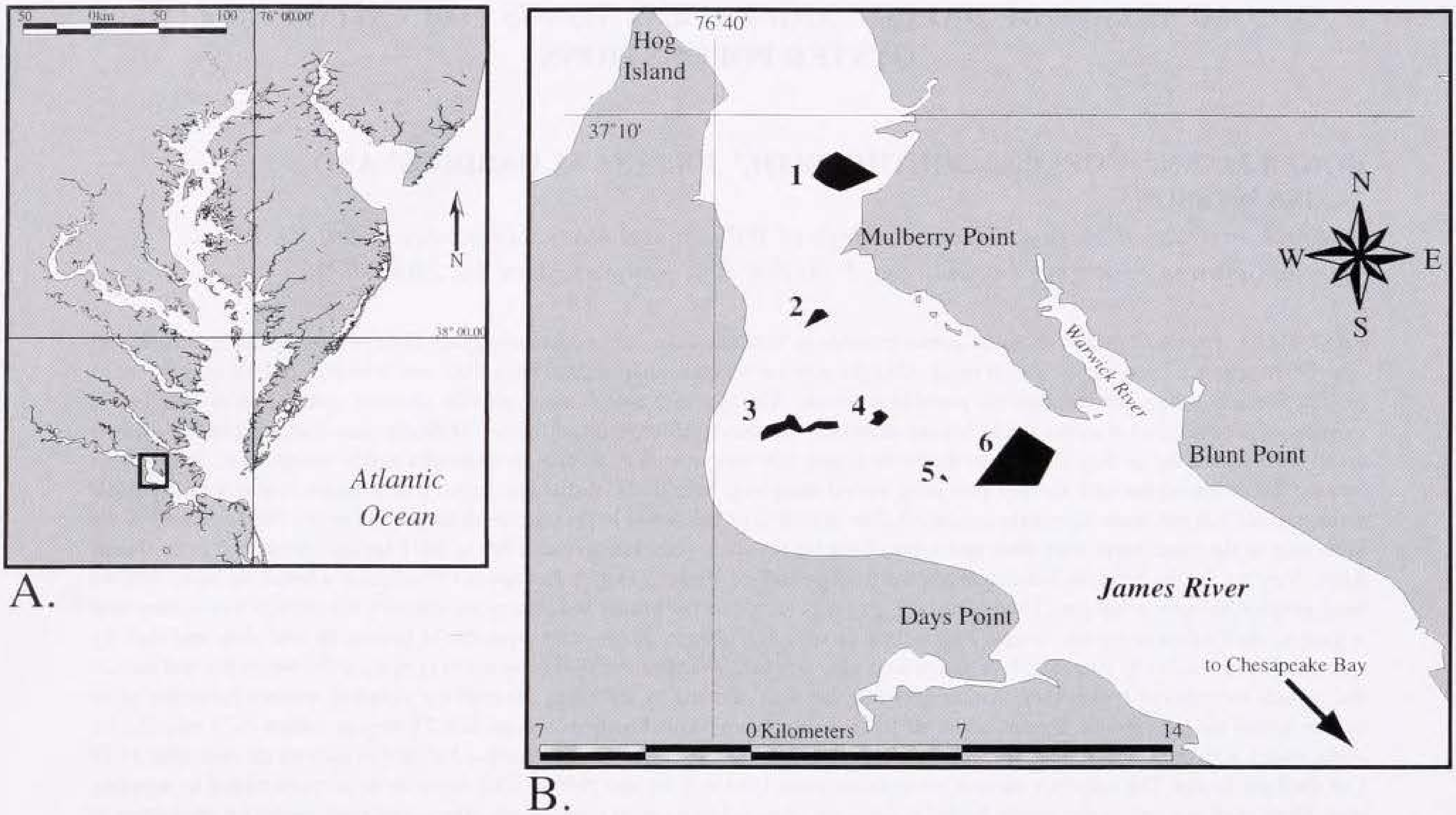

Figure 1. Map of Chesapeake Bay, USA (A) and the James River, Virginia (B) showing the reefs used for sample collection in this study: (1) Deep Water Shoal, (2) Horse Head, (3) Point of Shoals, (4) Cross Rock, (5) Dry Lumps, and (6) Wreck Shoals.

that are probably not well sampled by a dredge, although the sampling insures collection of all oysters within the tong mouth. Since 1998, all oysters collected on the patent tong survey have been measured in the field and length-frequency data have been collected at 5-mm size intervals. Prior to 1998, oysters were simply characterized as small (25–75 mm SL) and market (SL >75 mm). Total shell volume (liters) is also recorded for each patent tong grab.

In addition to patent tong sampling the exploited James River oyster stocks are subject to regular examination within surveys effected using a traditional oyster dredge (e.g., dredge mouth 1.2 m wide, 0.1 m long teeth, bag volume of 147.87 L or 4.19 bushels). Oysters from either sample type were described as 1 of 2 size classes (small, market) on the basis of length. Oyster abundances from patent tong surveys were converted to numbers of oysters using the conversion factors of 1000 oysters bushel^{-1} for small oysters (25–75 mm SL), and 500 oysters bushel^{-1} for oysters of marketable size (SL > 75 mm). This allows an estimation of the number of oysters bushel^{-1}, the unit given by dredge data, and for patent tong data by dividing the converted abundance values for each size class by the total shell volume bushel^{-1} recorded at that patent tong grab site. The resulting abundance estimates (oysters of a size class bushel^{-1}) were summed within a single patent tong grab and then all of the grabs within 1 site in 1 year were averaged to provide estimates of average numbers of small, market, and total oysters bushel^{-1} with standard errors of the mean.

Quantification of dredge data is more difficult than patent tong data in that dredges accumulate organisms as they move over the bottom, may not sample with constancy throughout a single dredge haul, and may fill before completion of the haul, thereby providing biased sampling in favor of the "early" portion of the haul. Although Powell et al. (2002) describe bias against shell in oyster dredge samples, these samples were collected during 1 minute tows in which the dredge never filled. The samples described in this study were all collected by tows of longer duration where the dredge filled completely before the end of the tow. For this study we assume no selective retention of live oysters with respect to shell substrate by the dredge due to the method in which the dredge was fished. Selectivity of dredges versus patent tongs with respect to demographics has not been rigorously examined in Virginia waters, especially in shell-poor substrates where tongs dig deeply into buried shell material. Conversely, dredges provide semiquantitative data, have been used with consistency over extended periods (decades), and thus provide data on population trends. The challenge in the current objective of estimating absolute numbers of oysters is to use dredge data in a consistent quantitative approach.

RESULTS AND DISCUSSION

Within the 1993 to 2001 comparison, we have used the same stations for both dredge and patent tong surveys. Pre 1998 data may well have suffered from subjective distinction of the small versus spat categories in the field. Given the annual abundance of spat, this may have led to inconsistent distinctions of these size categories and occasional large discrepancies in the resulting plot of total oysters per bushel as estimated by dredge and patent tong methods (Figs. 2A, 2C, and 2E). Examination of the data collected at 5-mm size intervals for 1998 to 2001 is illustrated in Figures 2B, 2D, and 2F.

Recalling that both figures give points that are mean values, the plotted relationships represent a considerable body of individual

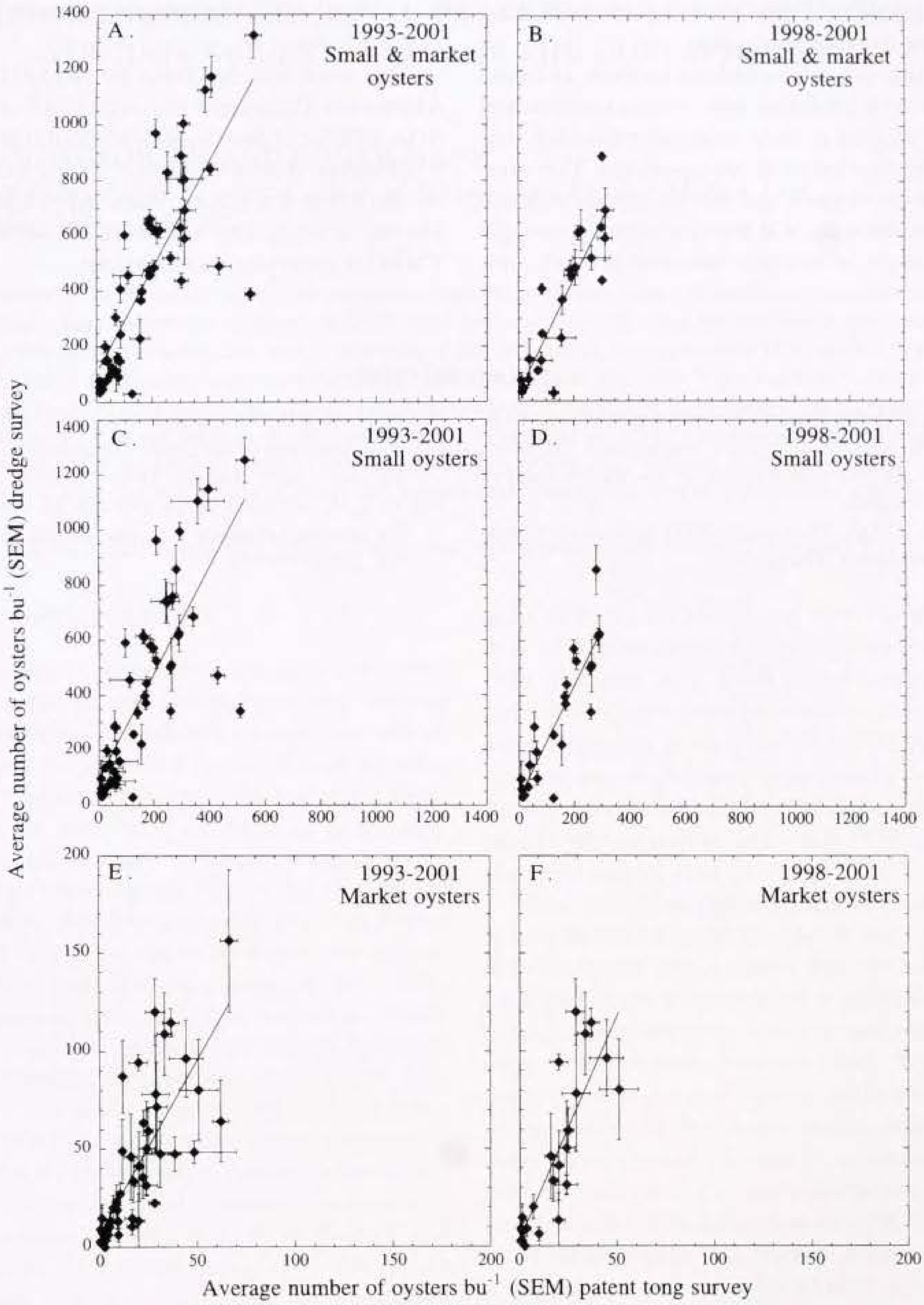

Figure 2. Average total number of oysters (A, B), small oysters (C, D), and market oysters (E, F) bu^{-1} collected from 6 reefs in the James River with patent tongs in comparison to dredge data. Error bars indicate standard error of the mean. Note the difference in scale between plots A–D and plots E and F. (A) $y = 104.17 + 1.9x$, $R^2 = 0.65$, (B) $y = 27.46 + 2.08x$, $R^2 = 0.79$, (C) $y = 99.31 + 1.91x$, $R^2 = 0.62$, (D) $y = 27.92 + 2.05x$, $R^2 = 0.78$, E) $y = 6.79 + 1.77x$, $R^2 = 0.62$, and (F) $y = 4.07 + 2.28x$, $R^2 = 0.70$.

data points (annual dredge survey $n > 24$, annual patent tong $n > 130$). All plots illustrate the different results obtained by tong and dredge respectively. These data show that the assumption of no selective retention of live oysters with respect to shell substrate by the dredge due to the method in which the dredge was fished is not correct. The dredge samples appear to be biased towards live oysters with an enrichment of live oysters versus cultch on the order of a factor 2. Similar patterns of dredge sample enrichment have been reported by Powell et al. (2002) for oyster dredges with 1-min tows.

Enrichment in dredge samples may occur because dredging takes the top layer of shell whereas the patent tong also includes a buried layer of shell where it occurs. So more shell per unit oyster can be expected in a tong sample with a concomitant lower bushel count of oysters—again the historical unit of record. On the other hand, a plot of the grand means of a very large amount of data on a single plot suggests that a line might be fitted to this data. Any attempt to fit a line for predictive purposes through these data would not pass through the origin unless a nonlinear fit was used. The appropriate model for such a fit is open to debate, and may be influenced by the nature of the underlying substrate in many locations—for example oyster reefs in the productive part of the James River have a hard base into which the patent tong does not sink easily. Universal application of a fitted "predicative" relationship may; however, be tenuous. In contrast to the James River, oyster reefs in the Rappahannock River may be less consolidated resulting in deeper penetration of the underlying substrate. Site-specific application may be more appropriate.

Clearly, annual surveys using standardized methods and sampling designs can provide a wealth of relevant stock assessment information, provided caution is used when extrapolating site-specific data beyond regions that have been surveyed. This exercise demonstrates, different methods and provide slightly different estimates of the available resources, and these estimates are strongly affected by modest changes in available substrate per unit area.

ACKNOWLEDGMENTS

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