

Motivation and plan for a coastwide stock assessment

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The figures in this paper make heavy use of color, which will not appear in the print version. To view the figures in color, see the version posted in the complete 2007 IPHC Report of Research and Assessment Activities at www.iphc.washington.edu/halcom/pubs/rara/IPHCRARA.htm.

Abstract

The closed-area assessments that have been standard for some years assume that the stock in each area is a closed population. There is now considerable evidence of a continuing west-to-east migration of legal-sized fish that violates the assumption. A coastwide assessment does not require any assumptions about migration, so this year the staff undertook to perform one. This paper summarizes the reasons for questioning the closed-area assessments and outlines a plan for compiling the necessary data and running the coastwide assessment.

Problems with the present closed-area assessments

Since the staff began doing closed-area assessments for Areas 3B, 4A, and 4B in 2003, there has been a growing divergence between the distribution of exploitable biomass as estimated by the stock assessment and as indicated by our survey data taken at face value. For example, Area 3B is twice the size of Area 2C and has a higher survey CPUE, but the assessment says there is more biomass in Area 2C. Here are the two biomass distributions from the 2005 assessment:

	Assessment	Survey CPUE x bottom area
Area 2A	0.020	0.009
Area 2B	0.160	0.071
Area 2C	0.160	0.083
Area 3A	0.374	0.373
Area 3B	0.118	0.208
Area 4A	0.050	0.074
Area 4B	0.024	0.041
Area 4CDE	0.094	0.141

On the whole, the assessment sees about twice as much biomass in Area 2 as the survey, and a bit more than half as much in Areas 3B and 4. This can happen because the assessment estimates different catchabilities and selectivities in each area, and in particular it estimates that setline catchability in Areas 3B and 4A is 2-3 times what it is in Areas 2 and 3A (Fig.1).

The high catchability estimates result from the high apparent rates of total mortality in Areas 3B and 4A (Fig. 2). The difference between the high apparent values of Z and M is taken to be fishing mortality, meaning that the present catches must be exerting a fishing mortality equal to or greater than the target. In 2005, the assessment estimates that approximately equal amounts of catch resulted in a higher fishing mortality rate in Area 3B than in Area 2C, so the Area 3B biomass had to be lower.

There are other indications that the high apparent mortality rates in Areas 3B and 4A are due in part to net emigration, in which case the assessment estimates of fishing mortality and setline catchability are too high, and estimates of biomass are too low. The indications are:

(i) Relative to trawl survey catch rates at length, setline survey catch rates at length in Areas 3B and 4A are no higher than in Area 3A (Fig. 3). This is strong evidence that the assessment estimates of much higher setline catchability in Areas 3B and 4A are wrong, and that setline survey catchability is in fact equal in the three areas.

(ii) While the PIT tag recovery data on the whole are puzzling, they do show a high proportion of out-of-area recoveries from Area 3B and 4A releases, and a high proportion of out-of-area releases among Area 2B recoveries.

The standard closed-area stock assessment assumes that net migration is negligible among fish older than six years. It now appears that this assumption is probably wrong, and that the closed-area estimates of biomass distribution among regulatory areas are probably also wrong. It is therefore necessary to conduct the assessment in a way that does not rely on the closed-population assumption. Because we do not have the kind and amount of data that would allow us to estimate migration rates reliably, we are obliged to consider the feasibility of a single coastwide assessment.

Checks for heterogeneity among areas

A coastwide assessment will estimate a single, average survey catchability and selectivity. For the purpose of estimating total biomass it is not necessary to assume that these parameters are in fact equal in all areas, but for the purpose of estimating the distribution of biomass it is necessary to assume equal survey catchability. NMFS trawl survey data provide some support for this assumption as regards Areas 3A, 3B, and 4A (Figure 3), but at this point we have no way to check it in Area 2.

Because of the need for survey data to estimate the sex composition of commercial catches, the assessment will be limited to the years beginning with 1996, like the recent closed-area assessments in western areas. With a simple length-specific model and a lot of data for each year, the parameters should be well determined with eleven years of data.

The catch at age will be summed over areas. If there were large, systematic differences among areas in age composition, one would be worried about the model's ability to predict the coastwide data, particularly if the distribution of effort varied substantially among years. But the area-specific commercial and survey age compositions (Fig. 4) are quite similar in most areas in most years. The major differences relate to the timing of the appearance of large year-classes (e.g., 1987 and 1994). These tend to appear in strength first in Areas 4A, 2B, and 2C, next in Areas 3B and 4B, and last in Area 3A. The coastwide estimated selectivities will be averages over areas and years.

Coastwide averages of mean length at age by sex in survey catches will be used to predict coastwide length-specific selectivities. This will involve averaging over some large differences in length at age among areas (Fig. 5) but that should not cause any new problems; we average over large differences among individuals within areas now. A subtle problem is that, strictly speaking, the coastwide mean length used to predict survey selectivity should be weighted by abundance in each area, while the mean length used to predict commercial selectivity should be weighted by catch in each area. Calculations show that the two means never differ by more than a few percent, so this issue can be ignored.

Unfortunately, there are some large and persistent differences in sex ratio among areas (Fig. 6). The overall proportion female in recent survey catches is about 60%, but for unknown reasons it drops steadily from about 70% in Area 2 to 40% in Area 4B. This may cause some problems in predicting commercial catch at age/sex. If so, estimating sex-specific selectivities may solve the problems.

If we assume survey catchability is the same in all areas, we have to recognize differences in commercial catchability, because the relative values differ. In Area 2C, for example, survey and commercial CPUE are the same, while next door in Area 2B commercial CPUE is twice survey CPUE. This is surely the result of lower commercial catchability in Area 2C. In each area, survey and commercial CPUE bear approximately the same ratio over time (Fig. 7), so it would be possible to standardize commercial CPUE among areas by multiplying commercial CPUE by the area-specific ratio of survey to commercial CPUE. Because the distribution of effort among areas has not changed greatly in recent years, we do not intend to standardize commercial CPUE.

Data elements

In the following sections, the term “area-weighted average” refers to the weighted average of area-specific values with bottom areas used as weights. The term “abundance-weighted average” refers to the weighted average of area-specific values with the weights calculated as bottom area times smoothed survey CPUE in total number.

Commercial catch at age/sex

This will be the sum of all the area-specific estimates, including Areas 2A and 4CDE. Variances will also add.

Commercial CPUE

This will be the area-weighted average of area-specific CPUE, with only the fished part of Area 4D (5000 sq nmi) counted, and Areas 2A, 4C, and 4E excluded because of unique features of the fisheries in those areas. A coefficient of variation will be assigned as in the closed-area assessments.

Survey age/sex composition and mean length at age/sex

This will be the abundance-weighted average of the area-specific values from all surveyed areas except 2A and 4D. The survey data from 2A and 4D are too spotty and sparse to allow for the calculation of smoothed area-specific values in the first place. For Area 2A, a dataset comprising 2A plus 2B data will be used; for Area 4D; a dataset comprising 4D plus 4A data. Trawl survey age/length data from Area 4CDE, when adjusted for setline survey selectivity, is very close to Area 4A data (Fig. 8), so that can be used for Area 4CDE.

Survey CPUE

This will be the area-weighted average of area-specific values, with ad hoc adjustments for missing data in Areas 2A, 4A, and 4D. For Area 4CDE, the swept-area estimate of biomass from the trawl survey can provide an index of setline survey CPUE that can be scaled by the ratio of the 2006 trawl and setline survey results. The ad hoc adjustments made to supply missing data are:

(i) In Area 2A, where no survey was done in 1996, 1998, and 2000, the missing values will be simply interpolated.

(ii) In Area 4A, where only the southern part was surveyed in 1999, the 1999 value was multiplied by 0.76 on the basis of a regression of the all-area CPUE on southern-area CPUE in years when the whole area was surveyed (Fig. 9a).

(iii) In Area 4D, where no survey was done in 1998 and 1999, the Area 4A values were used on the basis of a similar regression of Area 4D on Area 4A values that had a slope of 0.99 (Fig. 9b).

Sport and subsistence catch

The coastwide total poundage will be handled as in the closed-area assessments, by estimating a fishing mortality rate and applying the survey selectivity schedule.

Bycatch

The coastwide total poundage will be handled as in the closed-area assessments, by estimating a fishing mortality rate and applying the average bycatch selectivity schedule, which increases linearly from the origin to one at 40 cm and stays there.

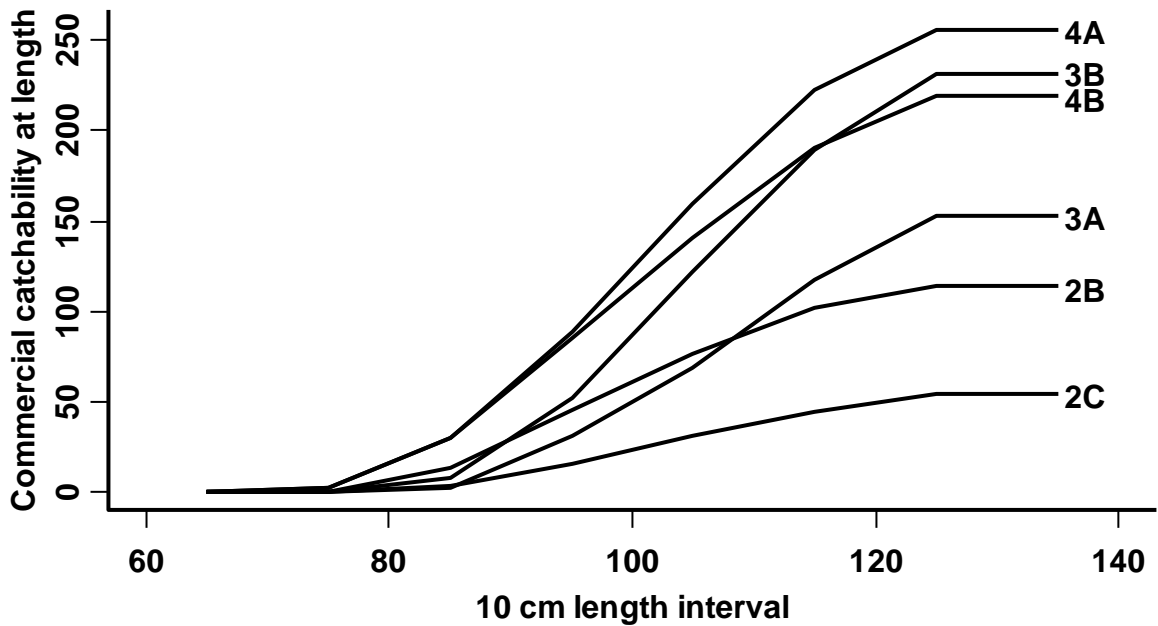
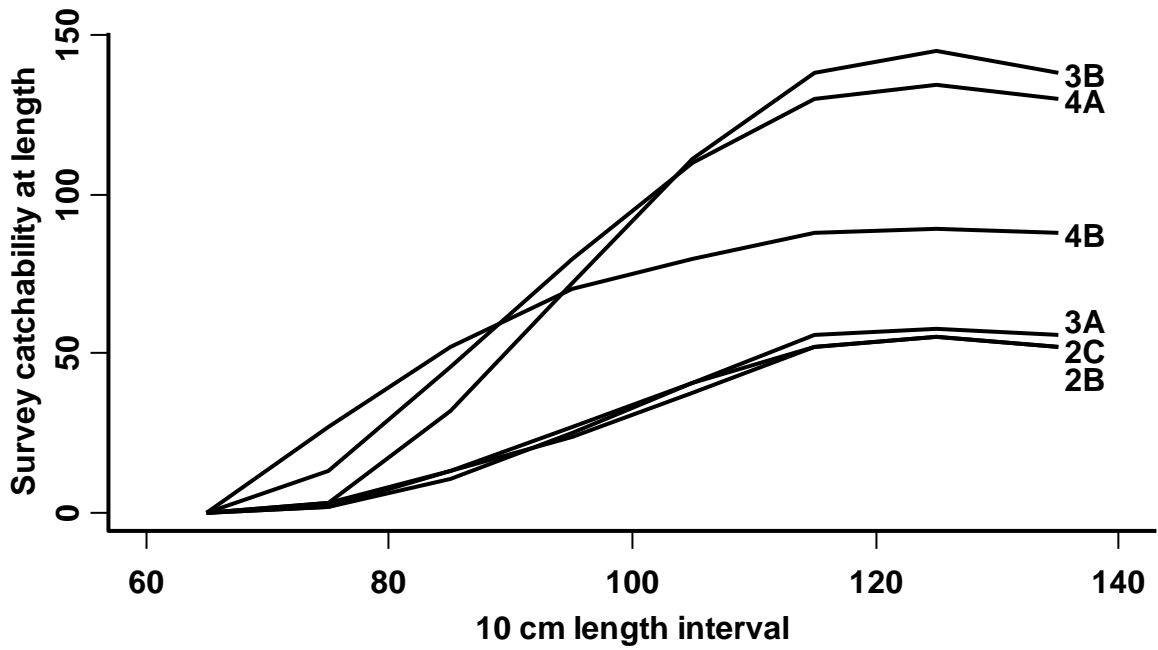


Figure 1. Estimates of survey (above) and commercial (below) catchability at length as estimated in the 2005 closed-area assessments. The values plotted are the assessment estimates multiplied by bottom area so that they all relate to stock density. The vertical scale is not meaningful.

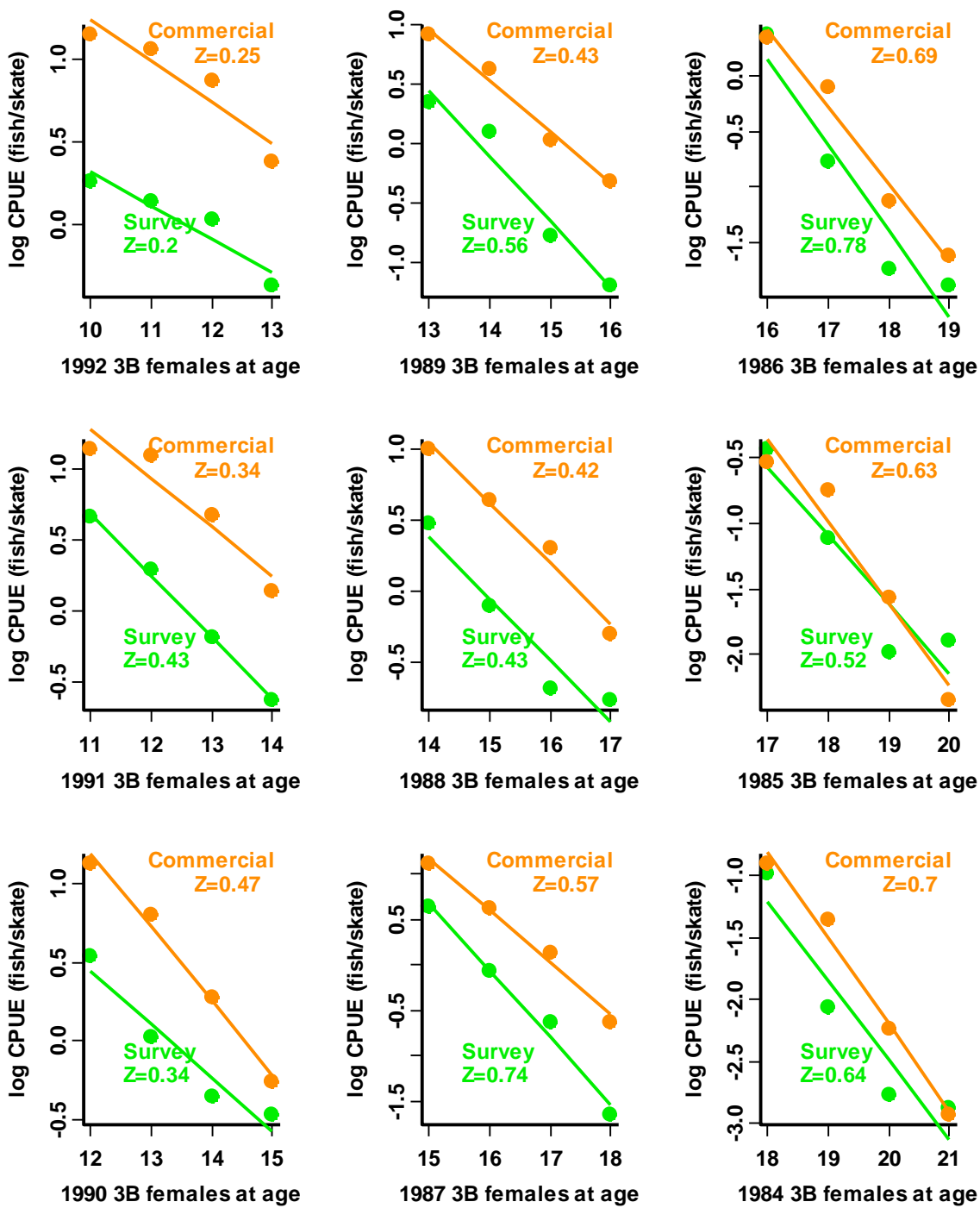


Figure 2. Model-free estimates of total mortality of Area 3B females. All graphs refer to the years 2002-2005.

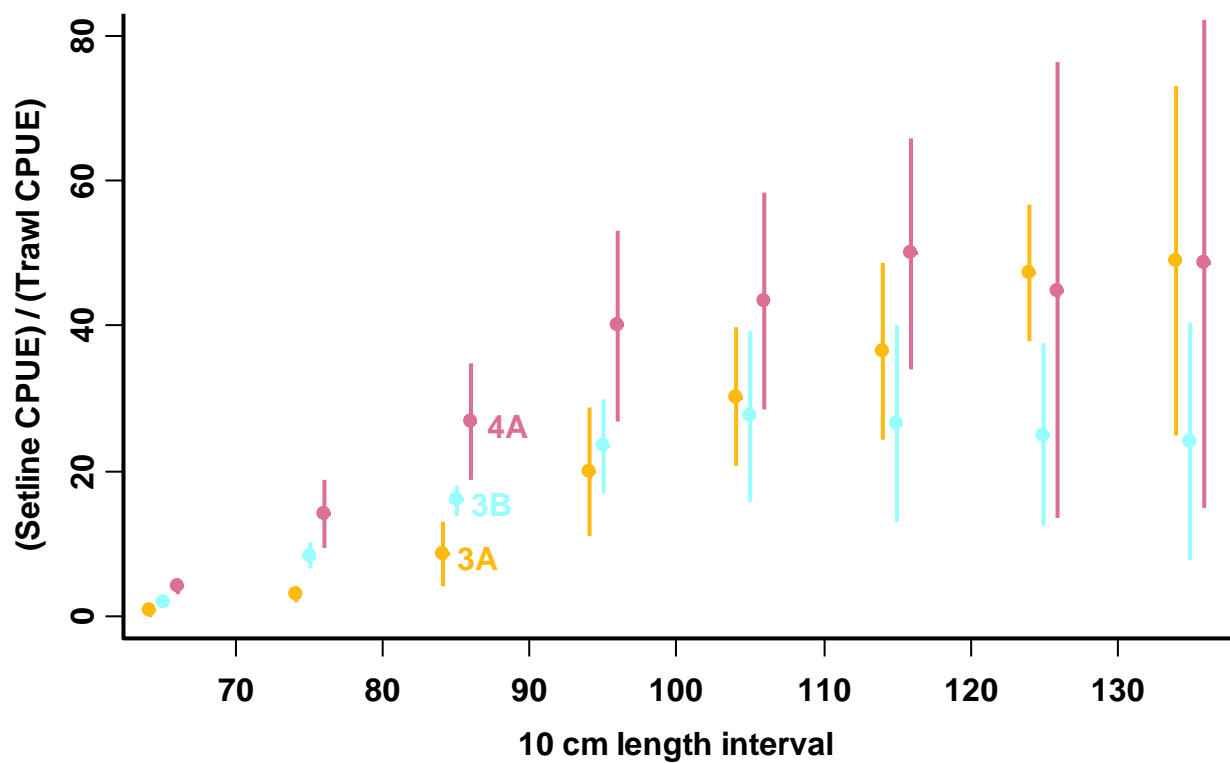


Figure 3. Ratio of setline survey catch rates at length (fish/skate) to trawl survey catch rates at length (fish/ha swept).

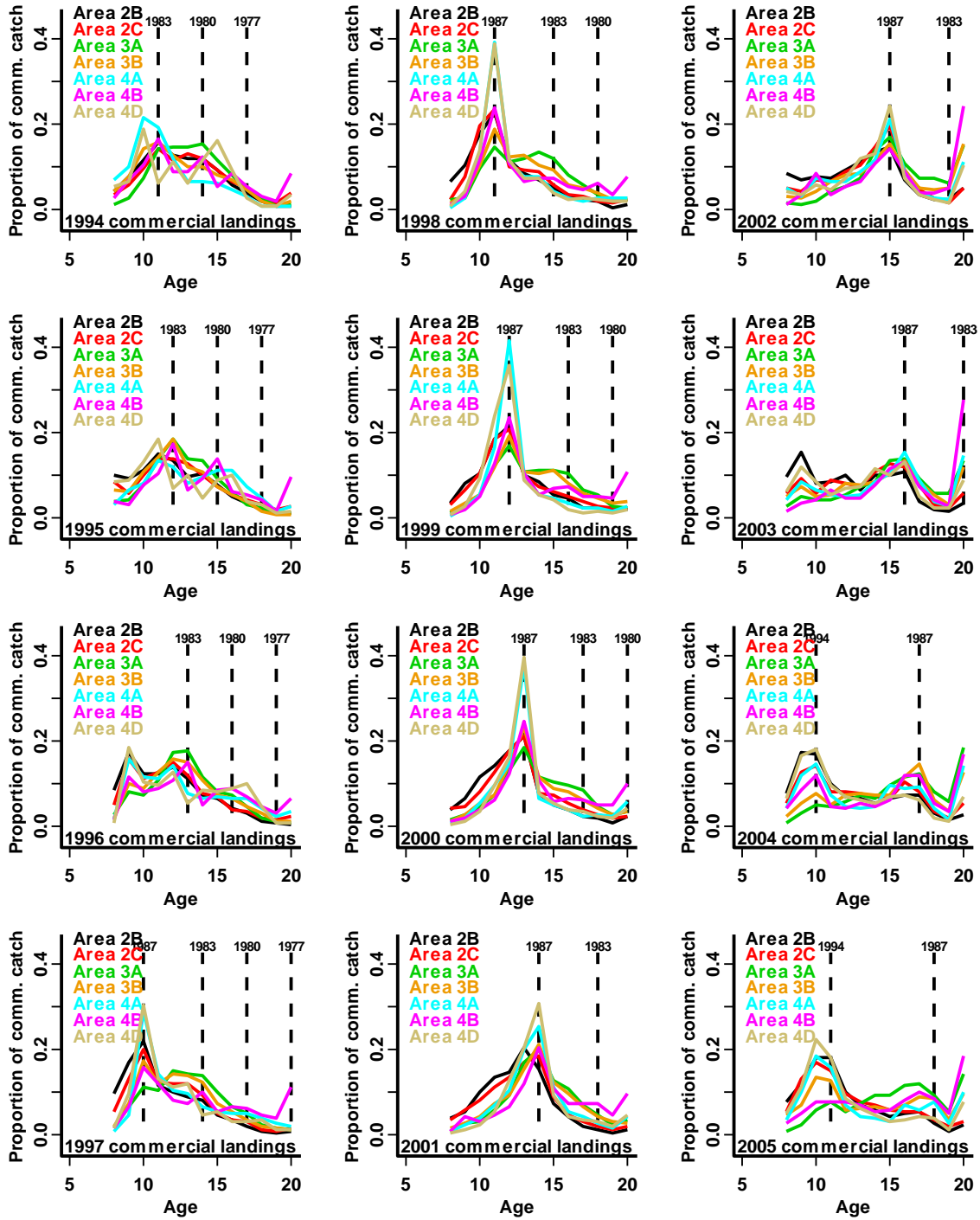


Figure 4a. Commercial age compositions by area, 1994-2005.

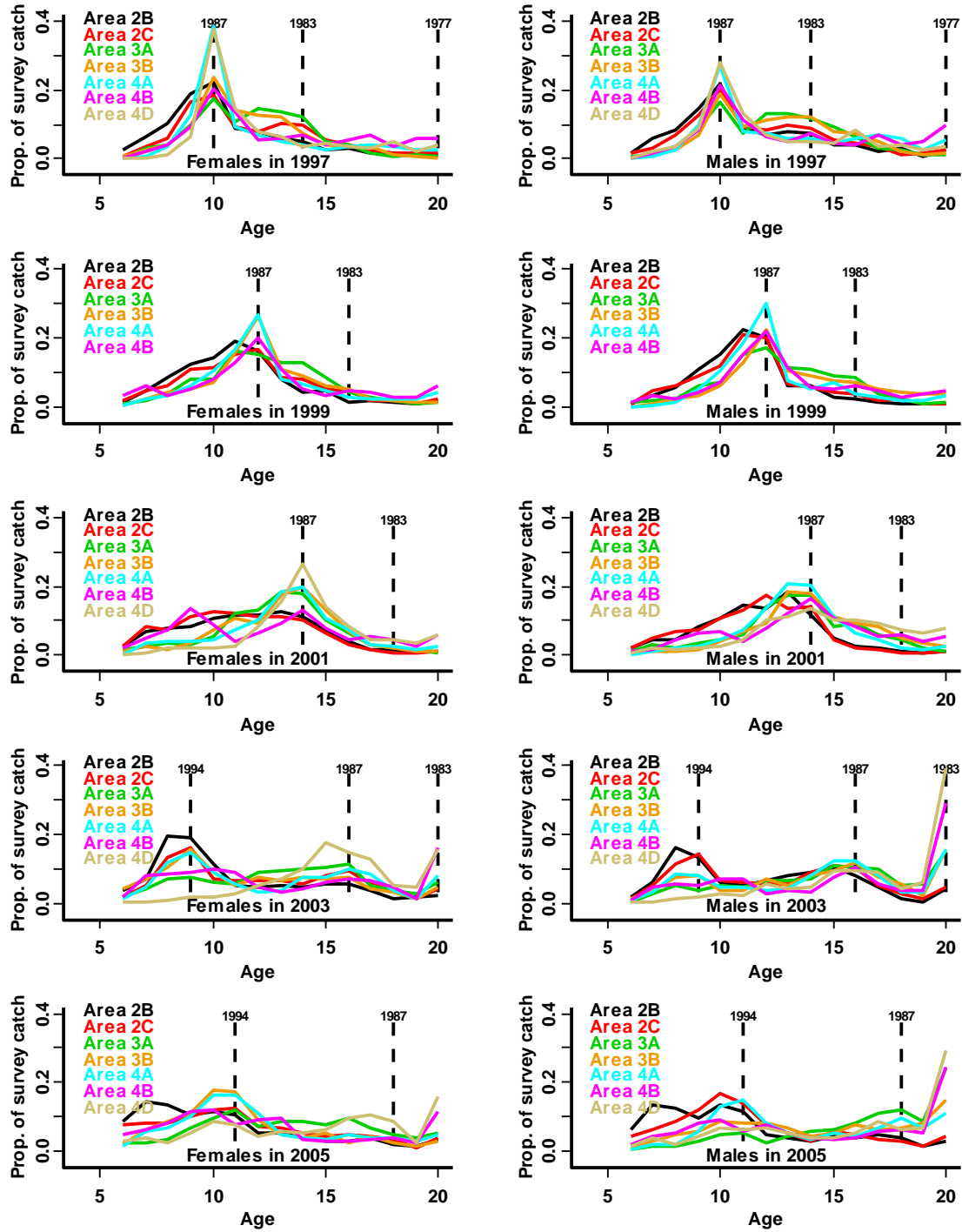


Figure 4b. Survey age compositions by area and sex, 1997-2005.

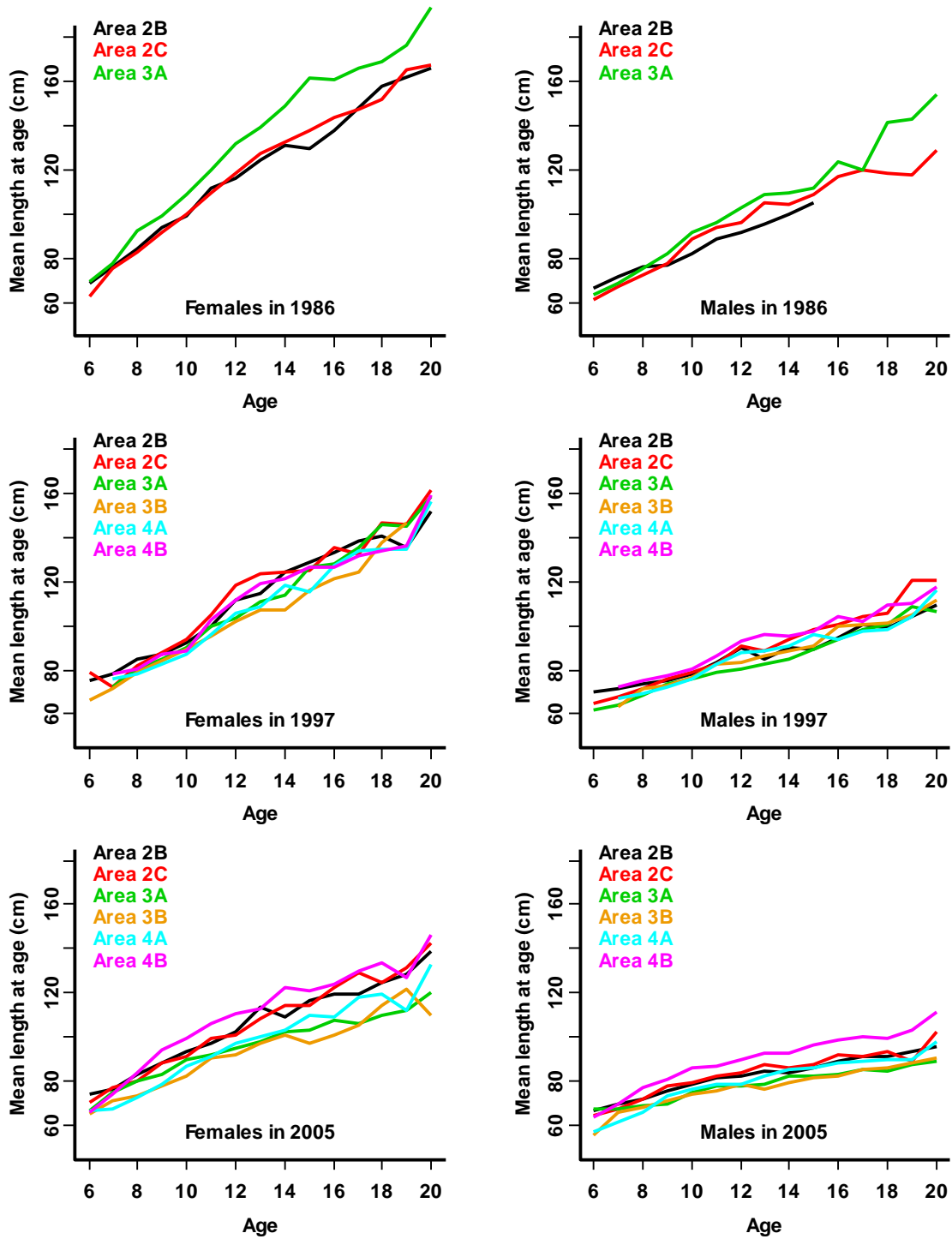


Figure 5. Mean length at age in survey catches, by area, year, and sex.

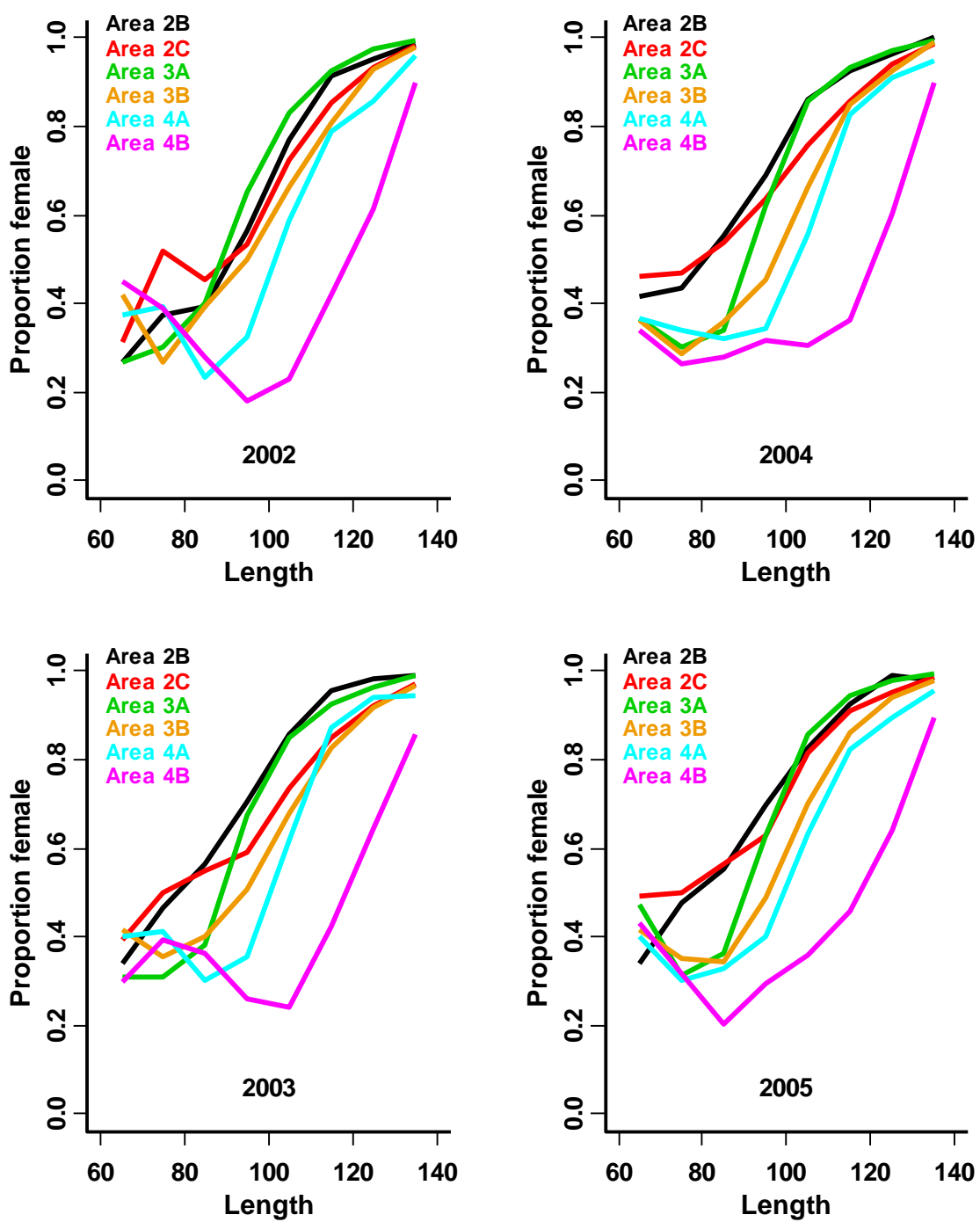


Figure 6. Sex ratio of survey catches, by area and year.

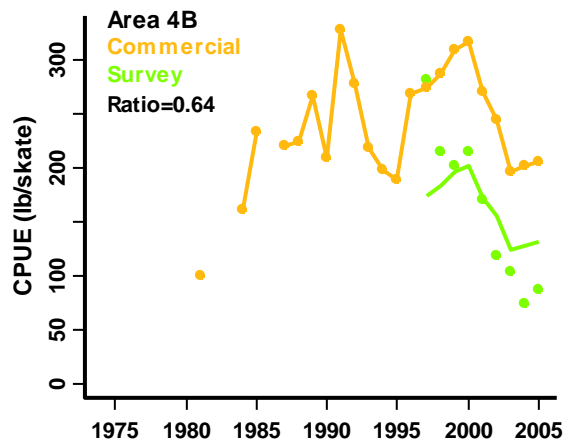
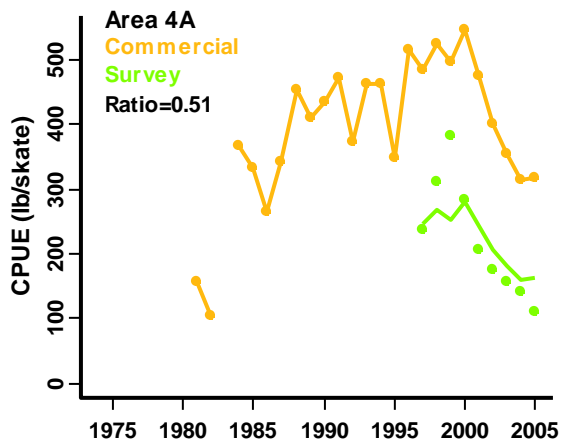
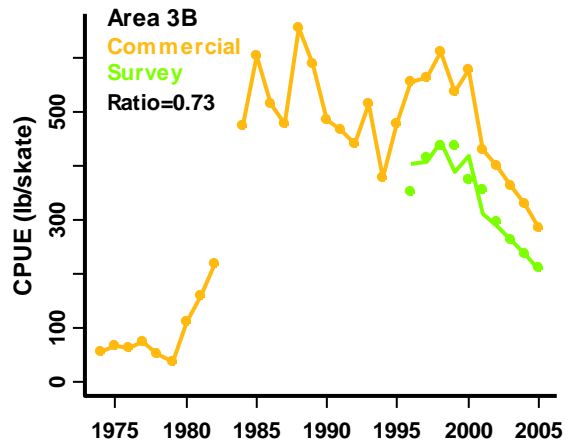
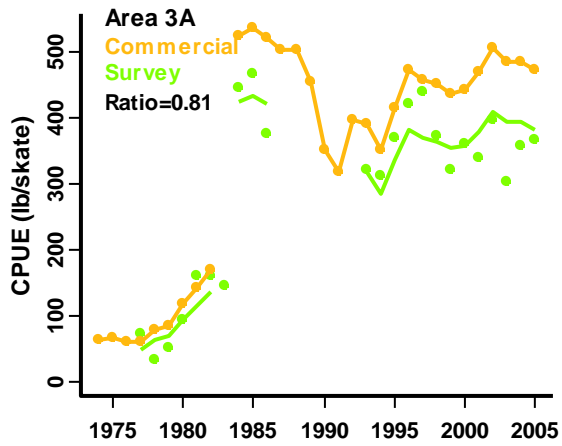
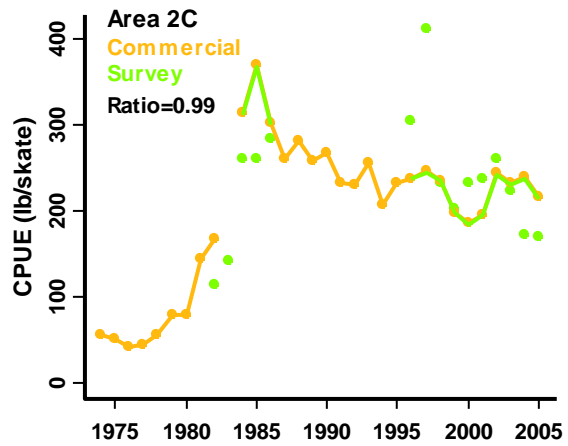
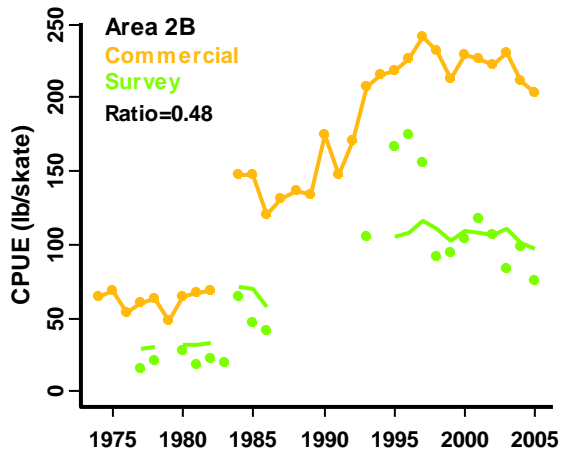


Figure 7. Commercial and survey CPUE by area and year. The green line is the overall ratio of survey to commercial CPUE, multiplied by each year's commercial CPUE.

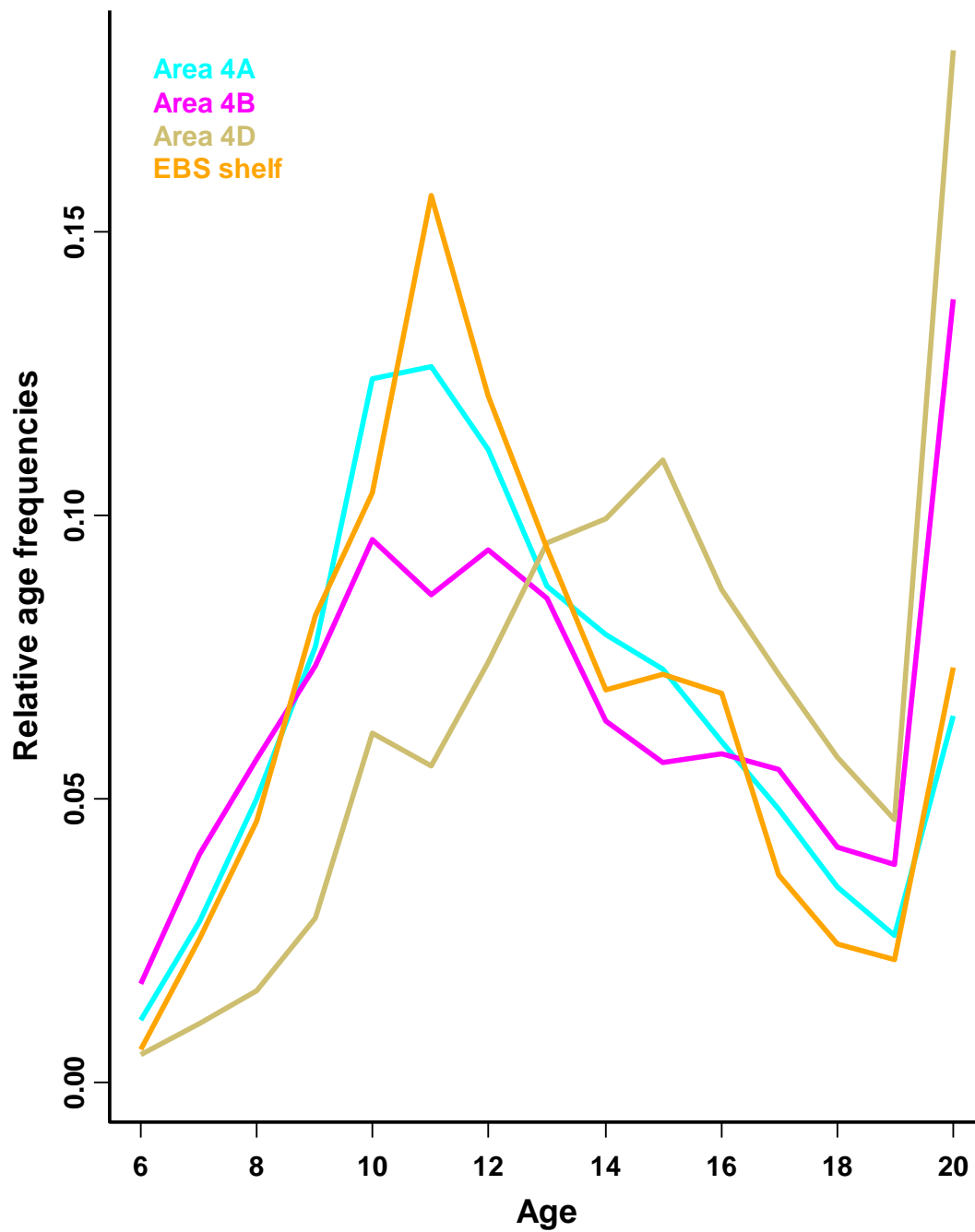


Figure 8. Setline survey age compositions in Areas 4A, 4B, 4D edge, and eastern Bering Sea shelf. The latter is estimated by applying the setline survey selectivity to age/length data from the NMFS trawl survey.

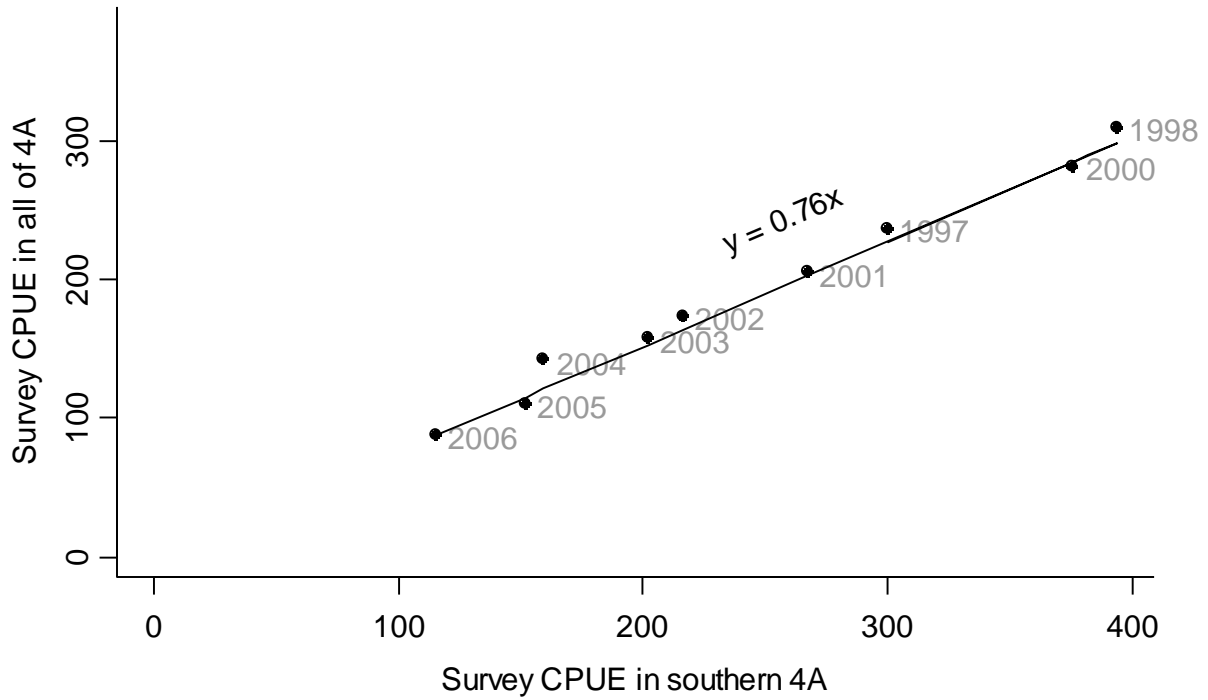


Figure 9a. Survey CPUE in all of Area 4A predicted from CPUE in southern Area 4A.

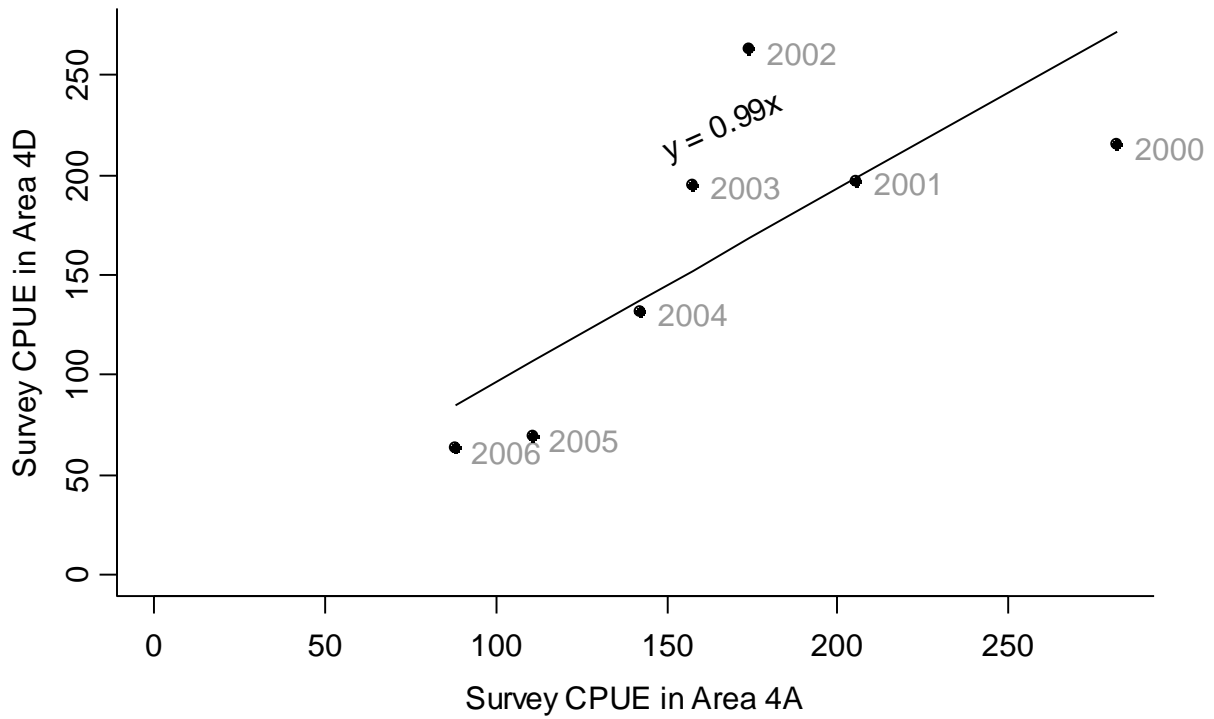


Figure 9b. Survey CPUE in Area 4D predicted from survey CPUE in Area 4A.