BSAI yellowfin sole stock structure report

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Introduction

A Stock Structure Working Group (SSWG), consisting of members of the North Pacific Fisheries Management Council's (NPFMC) Scientific and Statistical Committee (SSC), Groundfish Plan Teams, geneticists, and assessment scientists, was formed in 2009 to develop a set of guidelines to facilitate a rigorous and consistent procedure for making management decisions on stock structure for Alaska stocks. The committee produced a template (Table 1) that identifies various scientific data from which stock structure may be inferred. At the September, 2011, meeting of the joint Groundfish Plan Team, it was recommended the stock structure template be applied to several stocks, including BSAI yellowfin sole.

Rationale for the analysis

Extensive tagging studies of eastern Bering Sea yellowfin sole by Japanese scientists in the 1970s indicated that there may be separate spawning areas and spawning groups of fish on the shelf (Fig. 1). It is unknown to what extent fish co-mingle between spawning areas/groups or how much fidelity there is for an individual fish to spawn in a certain area during its life. However, migration patterns from the tagging study suggest possible stock structure along a northwest to southeast axis. The shelf survey strata is also analyzed by subareas that make it convenient to make this comparison (Fig. 2), where the diagonal line from south of Nunivak Island to the Pribilof Islands separates southeast subareas 10, 31, 32 and 50 from the northwestern subareas. Survey biomass, length composition and fisheries catch from 2001-2011 is used to analyze stock structure.

I. Application of stock structure template

Harvest and Trends

Fishing mortality (relative to target reference point)

Spatial concentration of harvest relative to abundance

Yellowfin sole catch primarily occurs in the SE subarea of the Bering Sea (Fig. 3). Except for two years, exploitation rates for the northwest (NW) and the southeastern (SE) Bering Sea shelf were less than 0.08 and indicate that the exploitation pattern in the SE area was usually higher than in the NW subarea in most years (Fig. 3).

Population trends

Yellowfin sole biomass and population number were examined relative to the northwest and southeast divisions of the eastern Bering Sea shelf using the annual shelf survey results (Fig. 3). Comparisons indicate that 1) the biomass is much higher in the southeast strata, 2) trends in biomass and population number are non-synchronous between the two areas, 3) the CV of the biomass estimates is higher in the northwest area (Fig 4). Normalized plots of biomass and population number (Fig. 4) also indicate that the estimates for the NW area are more variable. The NW area is more shallow with less annual survey sampling than the SE area and may contain more young fish (see Fig. 6). The population variability in the NW may be a result of recruitment

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pulses that are less directly observed in the SE area (SE area is observing the adult and sub-adult populations).

Barriers and phenotypic characters

Generation time
Mean generation time for yellowfin sole is calculated at 14.3 years from life-history information for the whole survey area. This calculation is not available for each subarea.

Physical limitations (clear physical inhibitors to movement)
There are no obvious physical limitations to yellowfin sole movements on the eastern Bering Sea shelf.

Differences in length-weight relationships
Fish condition differences between the SE and NW areas were examined by the available length-weight data. Plots of length-weight data from 6,330 fish, fit with the allometric growth equation, indicate that fish from both areas have about the same weight for a given length up to about 30 cm when fish in the NW subarea have a higher weight at length (Fig. 5). This analysis did not consider differences in length at age between the areas.

Age/size structure
Survey size compositions were computed for the SE and NW subareas (2001-2011) to compare the population size structure and abundance. Plots for the 2007-2011 estimates are shown in figure 6 and their normalized values in figure 7. These plots indicate that the differences in size composition between the two subareas was small in 2007 and 2008 but was quite different in 2010 and 2011. The increase in the proportion of young fish in the NW in 2010 and 2011 is caused by recruitment in the nursery grounds of the NW area that have not made their way to the SE yet as older fish.

A mixed model ANOVA was performed on the data set and resulted in a finding of significance between subareas and for each year.

Behavior and movement
See figure 1.

Genetics
No genetics work has been completed for BSAI yellowfin sole.

Recommendations
This analysis does not provide information to warrant a split in the allocation of ABC and OFL between the NW and SE subareas of the Bering Sea shelf for yellowfin sole. Most of the biomass and the catch are present in the SE subarea, and differential exploitation patterns do not exist between the two areas that would cause concern even if there were separate stocks in the NW and SE subareas. Although the designated areas used in the analysis provide an interesting comparison based on the Japanese tagging studies, the choice of the diagonal line separating the Bering Sea shelf NW and SE subareas was largely based on the survey stratification scheme and convenience of analysis. If there are two stocks in the eastern Bering Sea that need management protection, then this study would benefit from a genetics analysis to determine the overlap between stocks since the Bering Sea shelf does not have an obvious physical barrier for this species.

Future Work

Collection of tissue for a genetics study would be useful to determine if there are two spawning stocks.

HARVEST AND TRENDS	
Factor and criterion	Available information
Fishing mortality (5-year average percent of F_{abc} or F_{ofl})	Recent catch in the BSAI are approximately ¾ the ABC level
Spatial concentration of fishery relative to abundance (Fishing is focused in areas << management areas)	Most of the catch comes from the SE subarea, where most of the biomass exists.
Population trends (Different areas show different trend directions)	Population trends do not appear to have been different between areas for the time-series. Recent years may show a divergence.
Barriers and phenotypic characters	
Generation time (e.g., >10 years)	The generation time is calculated at 14.3 years
Physical limitations (Clear physical inhibitors to movement)	There are no obvious physical limitations for yellowfin sole on the Bering Sea shelf.
Growth differences (Significantly different LAA, WAA, or LW parameters)	Differences in length-weight fits were observed between the NW and SE subareas for fish larger than 30 cm.
Age/size-structure (Significantly different size/age compositions)	Significant year and area effects were found from an ANOVA examining size composition estimates between the two subareas.
Spawning time differences (Significantly different mean time of spawning)	none
Maturity-at-age/length differences (Significantly different mean maturity-at-age/ length)	Unknown
Morphometrics (Field identifiable characters)	Unknown
Meristics (Minimally overlapping differences in counts)	Unknown
Behavior & movement	
Spawning site fidelity (Spawning individuals occur in same location consistently)	Unknown
Mark-recapture data (Tagging data may show limited movement)	See figure 1.
Natural tags (Acquired tags may show movement smaller than management areas)	Unkown
Genetics (for blackspotted rockfish only)	
Isolation by distance (Significant regression)	unknown
Dispersal distance (<<Management areas)	unknown
Pairwise genetic differences (Significant differences between geographically distinct collections)	unknown

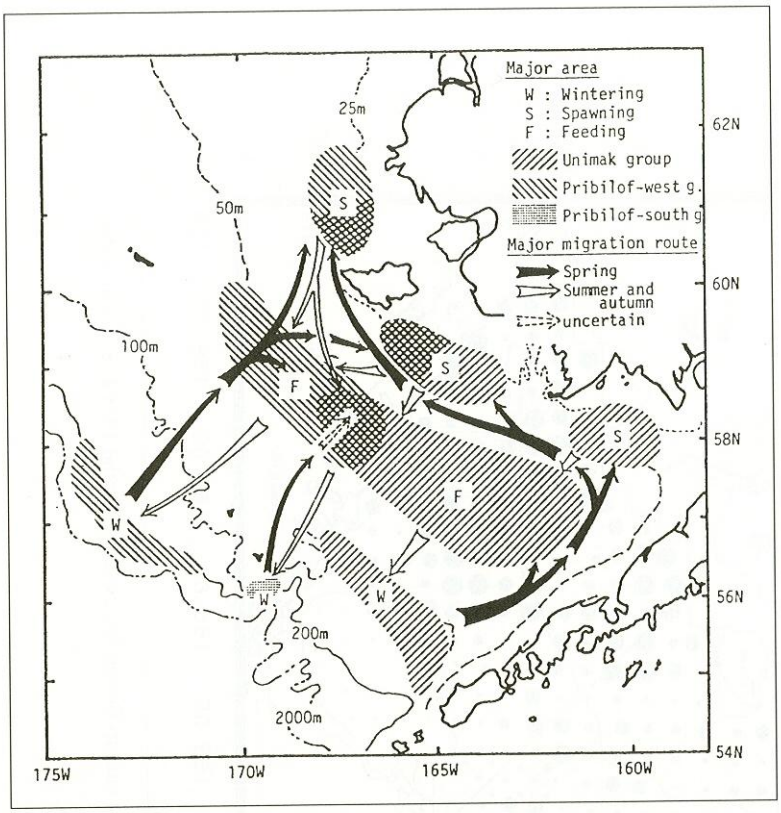

Figure 1- Hypothesized yellowfin sole spawning, feeding and migration areas in the eastern Bering Sea suggesting rationale for a stock structure analysis between the northwest and southeast subareas.

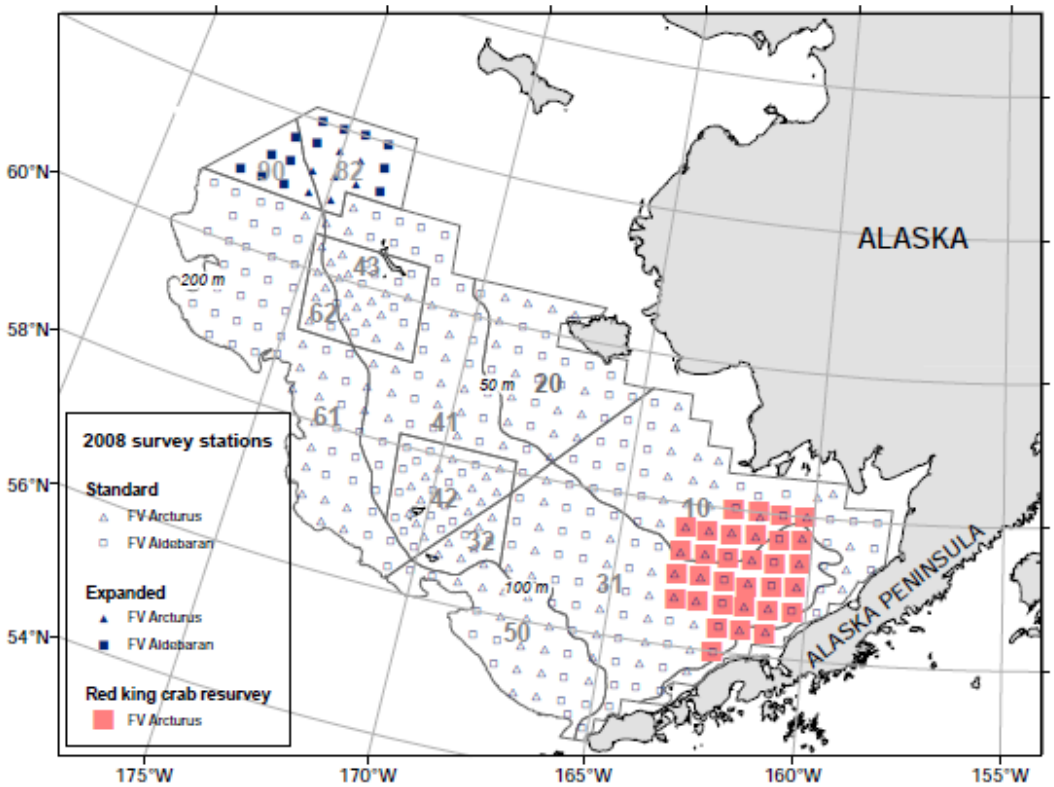

Figure 2. -- Sampled survey stations by vessel and the stratification scheme used for data analysis of the 2008 eastern Bering Sea bottom trawl survey.

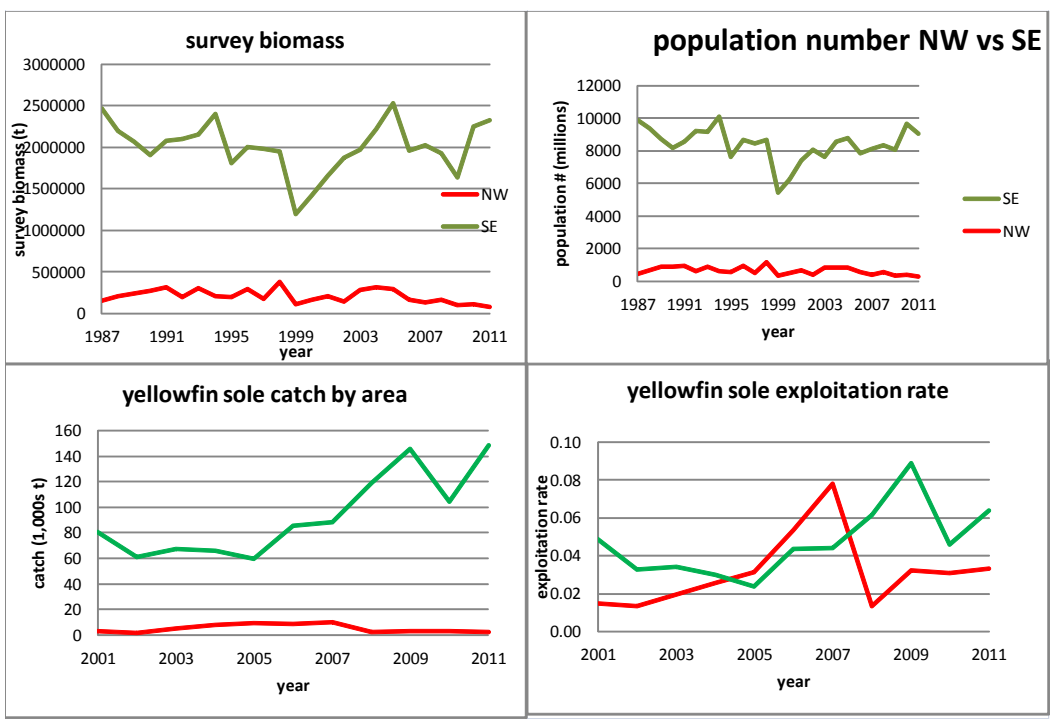

Figure 3- Yellowfin sole survey biomass estimates by NW and SE subareas (top left panel), catch (t) by subarea (bottom left panel), exploitation rate by subarea (bottom rightpanel) and population number by subarea (top right panel).

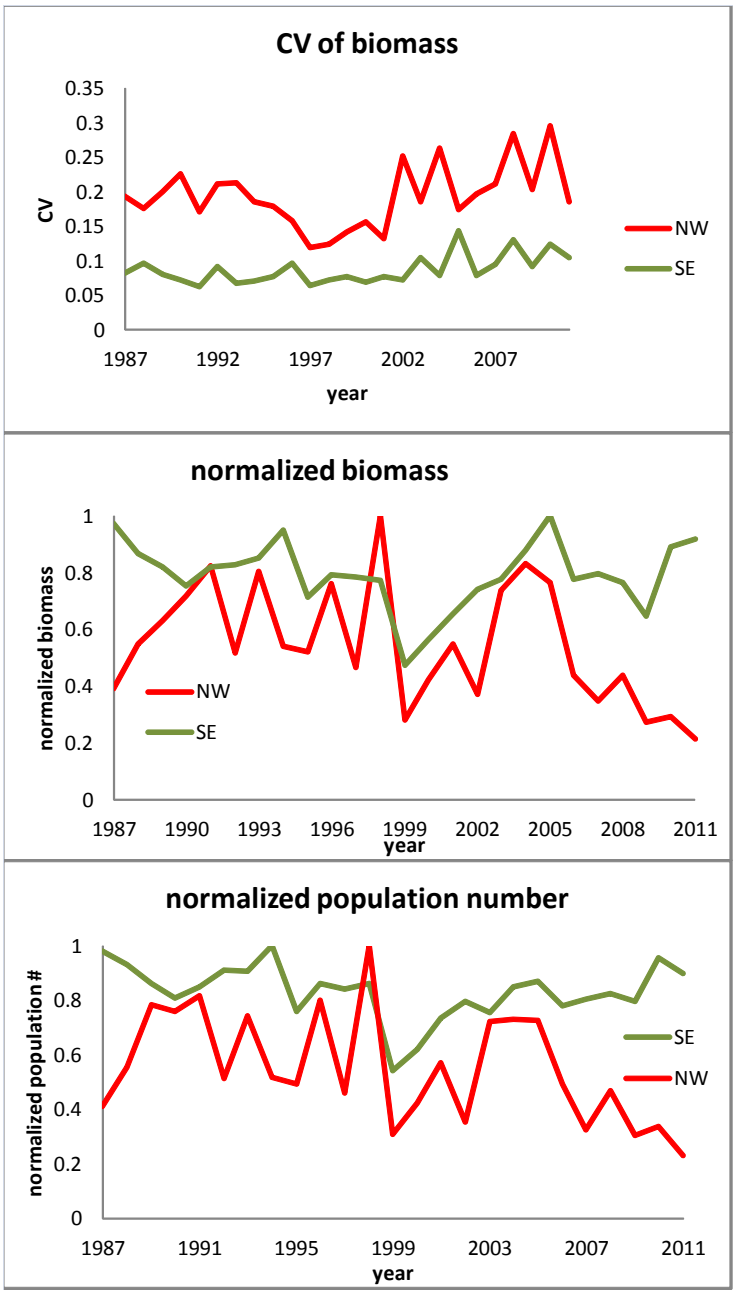

Figure 4-CV of biomass by subarea (top panel) and normalized biomass (center panel) and population number (bottom panel) by subarea.

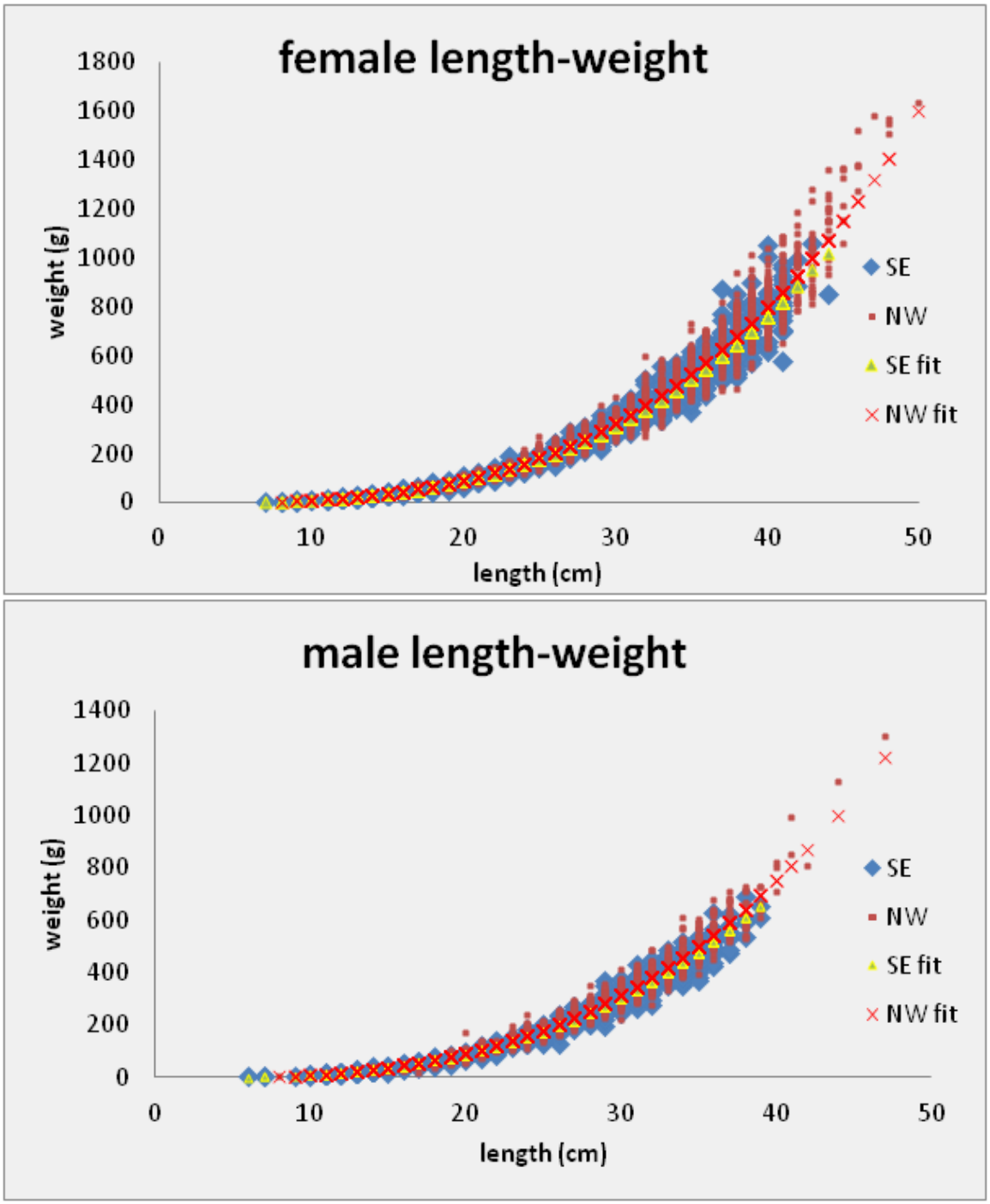

Figure 5- Length-weight data of female and male yellowfin sole by subarea and allometric model fit to the data (from 6,330 observations).

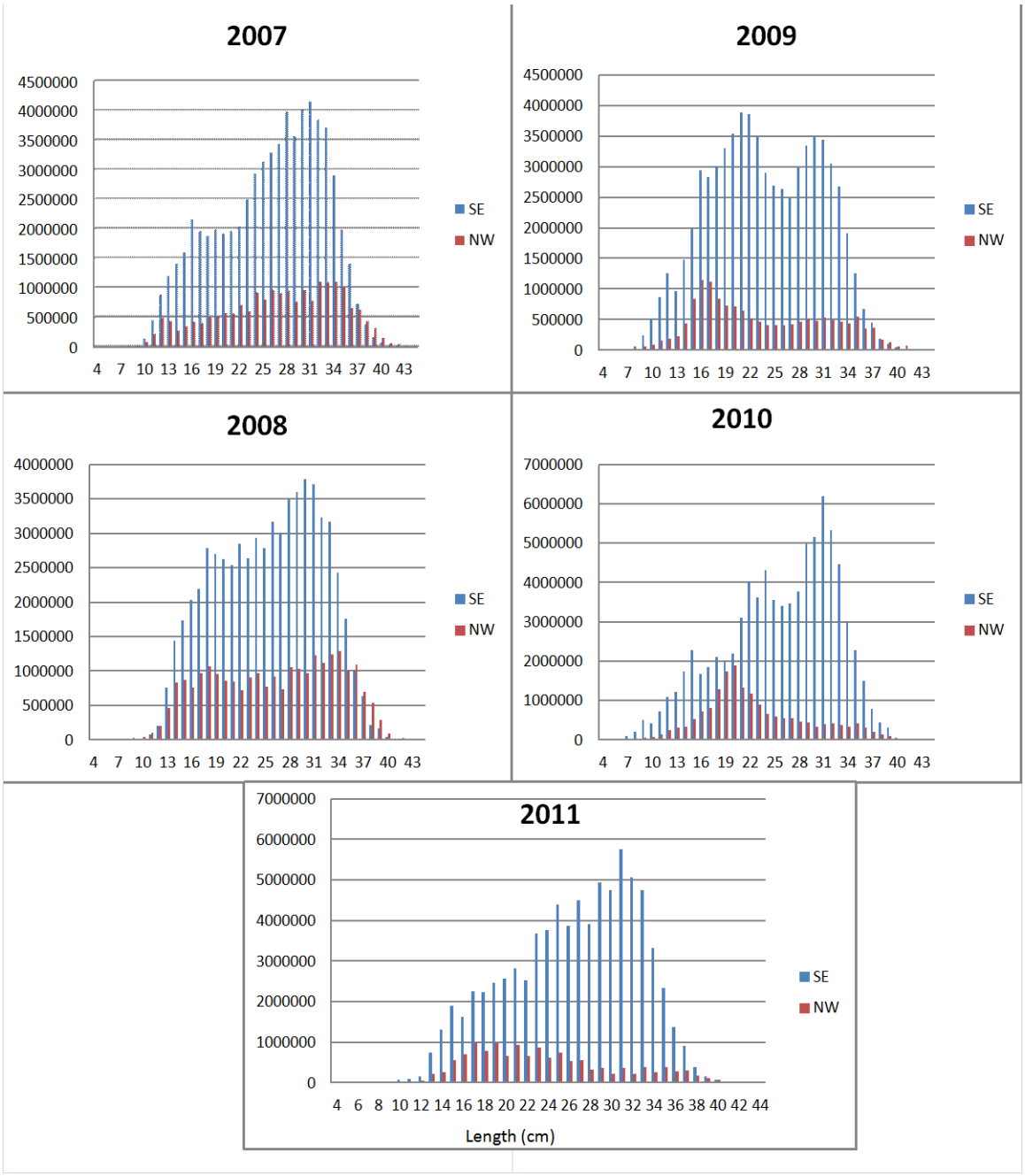

Figure 6- Survey estimates of population size composition for the NW and SE subareas for 2007-2011.

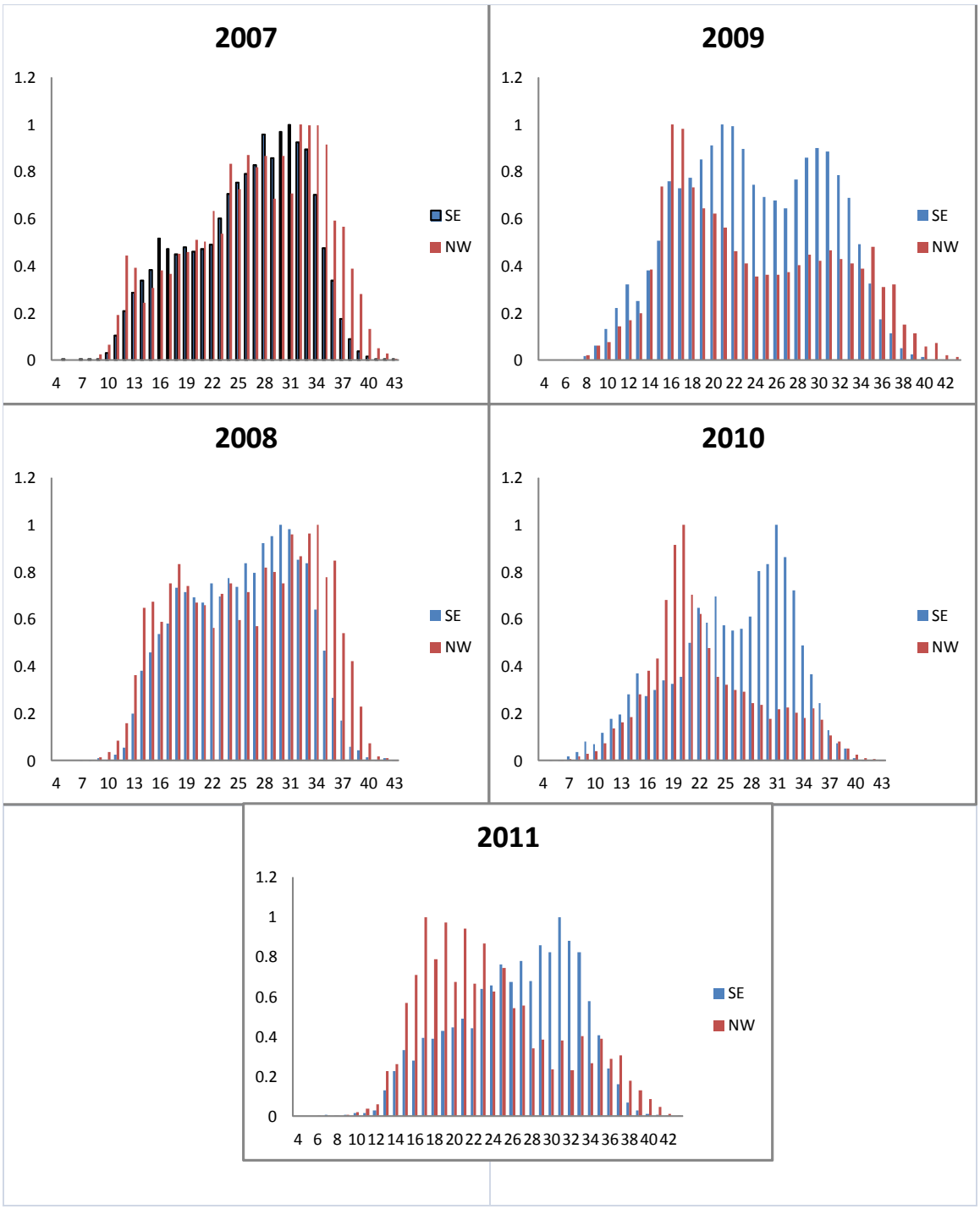

Figure 7- Normalized survey estimates of population size composition for the NW and SE subareas for 2007-2011.