were prevalent in 2015, but an extreme northern distribution was not observed by the survey. More Pacific Hake were observed in Canadian waters, but a large amount of backscatter was observed off Oregon and Washington during the period of time that the survey took place.

During the acoustic surveys, mid-water trawls are made opportunistically to determine the species composition of observed acoustic sign and to obtain the length data necessary to scale the acoustic backscatter into biomass (see Table 6 for the number of trawls in each survey year). Biological samples collected from these trawls were post-stratified, based on similarity in size composition, and the composite length frequency was used to characterize the hake size distribution along each transect and to predict the expected backscattering cross section for hake based on the fish size-target strength (TS) relationship. Any potential biases that might be caused by factors such as alternative TS relationships are partially accounted for in catchability, but variability in the estimated survey biomass due to uncertainty in target strength is not explicitly accounted for.

Text replacing the existing paragraph on page 11

Acoustic survey data from 1995 onward have been analyzed using geostatistical techniques (kriging), which accounts for spatial correlation to provide an estimate of total biomass as well as an estimate of the year-specific sampling variability due to patchiness of hake schools and irregular transects (Petitgas, 1993; Rivoirard et al., 2000; Mello and Rose, 2005; Simmonds and MacLennan, 2006). Advantages to the kriging approach are discussed in the 2013 stock assessment (Hicks et al., 2013).

For this assessment, the data from all surveys since 1998 were scrutinized and reanalyzed using the same geostatistical techniques as in the 2015 assessment (Taylor et al., 2015), but with more robust assumptions and some corrections. These include:

- fixing the minimum ($k_{\min}$) and maximum ($k_{\max}$) number of points used to calculate the value in a cell;
- standardizing the search radius to be three times the length scale that is estimated from the variogram;
- when extrapolating biomass beyond the end of a transect, using a function that decays with distance from the end of the transect;
- correcting spurious off-transect zeros that were erroneously generated in previous exportation of data;
- re-analyzing data using an updated version of the EchoPro software with consistent data input files.

The net result of these changes is a consistent approach applied to all survey years from 1998 onwards (Table 1). Therefore, the biomass indices (Table 6 and Figure 8) and age compositions (Figure 7, top) are new for this assessment and differ from the 2015 assessment (Taylor et al., 2015).

Table 1. Summary of key kriging parameters for the acoustic survey as used in the 2015 and 2016 assessments. Search radius is the distance in the transformed space from which observations are drawn to calculate weights in the kriging. Parameters $k_{\min}$ and $k_{\max}$ are the minimum and maximum number of data points used to calculate a kriged value. Length scale is a parameter estimated from the variogram for each year. [**Table will be moved to the Tables section]

Year	Search radius	$k_{\min}$	$k_{\max}$
2015 assessment			
1995	0.03	1	10
1998	0.03	1	10
2001	0.03	1	10
2003	0.03	1	10
2005	0.03	1	10
2007	0.03	1	10
2009	0.03	1	10
2011	0.30	10	30
2012	0.30	10	30
2013	0.30	10	30
2016 assessment			
1998-2015	3 $\times$ length scale	1	10

End of extra text

Results from research done in 2010 and 2014 on representativeness of the biological data (i.e. repeated trawls at different depths and spatial locations on the same aggregation of hake) and sensitivity analyses of stratified data showed that trawl sampling and post-stratification is only a small source of variability among all of the sources of variability inherent to the acoustic analysis (see Stewart et al. 2011).

Estimated age-2+ biomass in the survey has increased steadily over the four most recent surveys conducted in 2011-2013 and 2015. The 2015 survey biomass estimate is 2.156 million metric tons, which is 1.69 times the 2012 survey biomass estimate and 3.19 times the 2011 acoustic survey biomass estimate (Table 6 and Figure 8). The 2015 survey age composition was made up of 58.98% age-5 fish from the 2010 year-class.

The acoustic survey biomass index included in the base model (Table 6) includes an estimate of biomass outside the survey area that is expected to be present due to the occurrence of fish at or near the western end of some survey transects. The method of extrapolation has been the subject of some debate in recent reviews, hence the reanalysis of the entire time series using a more robust parameterization in the kriging analysis. However, a time series without extrapolation is used as a sensitivity. The series without extrapolation is shown in Table 7 and Figure 9 along with the extrapolated time series. The largest percentage of extrapolated biomass in any year occurred in 2005 and was 25.18% (with a minimum of 0.52% in 2011 and an average of 8.89%).

The extrapolated survey time series was used in this assessment for a number of reasons. First, some surveys have observed hake at or near the western (offshore) edge of some transects. Second, in 2014 and 2015, the U.S. at-sea fishery has caught a significant amount of hake farther offshore