Northwest Aerial Sardine Survey

Sampling Results in 2013

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March 12, 2014

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Introduction

Advisory bodies of the Pacific Fishery Management Council (PFMC), including the Coastal Pelagic Species Advisory Subpanel (CPSAS), Coastal Pelagic Species Management Team (CPSMT) and the Scientific and Statistical Committee (SSC), have recommended that additional fishery-independent indices of abundance be developed for the assessment of Pacific Sardine. Aerial survey methods have been used previously in S. Africa to assess sardine stock abundance (Misund et al. 2003), and Hill et al. (2007) described how aerial survey indices were developed from spotter pilot logs and a contracted line transect survey conducted in 2004 and 2005 for sardine in Southern California.

To meet the need for a credible comparative index of abundance, a coastwide aerial survey was developed by a consortium formed by the West Coast sardine industry (Northwest Sardine Survey, LLC - NWSS). The methods employed by this survey were initially developed through pilot study work conducted in the northwest in 2008 (Wespestad et al. 2008) and were reviewed at Stock Assessment Review (STAR) panels in May and September of 2009. Full-scale surveys were subsequently performed jointly by NWSS and the California Wetfish Producers Association (CWPA) coastwide in 2009 and 2010, and then by NWSS alone in the coastal waters of Washington and Oregon in 2011, 2012, and 2013. These surveys were conducted under Exempted Fishery Permits (EFPs) approved by PFMC and granted by the National Marine Fisheries Service (NMFS). Results from the 2009, 2010, 2011, and 2012 aerial sardine surveys were incorporated into the Pacific sardine stock assessment models that were used to set harvests for the 2010, 2011, 2012, and 2013 fishing years, respectively (Hill et al 2009, 2010, 2011, 2012).

This report describes work conducted in 2013 by NWSS off the coasts of Washington and Oregon, using the same methods that were applied in the aerial surveys conducted from 2009-2012 (Jagielo et al 2009; 2010; 2011; 2012). The survey employs a two-part approach, involving: 1) quantitative photographs collected on planned, randomly sampled aerial transects to estimate sardine school surface areas, and 2) fishing vessels operating at sea to capture a sample of photographed and measured schools to determine the relationship between sardine school biomass and school surface area.

Materials and Methods

I. Survey Design

A two-stage survey sampling design was employed. Stage 1 consisted of aerial transect sampling to estimate the surface area (and ultimately the biomass) of individual sardine schools from quantitative aerial photogrammetry; Stage 2 involved at-sea sampling to quantify the relationship between individual school surface area and biomass. Additional logistical details of the survey are provided in a Field Operational Plan document, which is substantially unchanged since the 2012 survey (NWSS 2012).

Stage 1: Aerial Transect Survey

Transect Logistics

The aerial survey employs the belt transect method using systematic random sampling; with each transect comprising a single sampling unit (Elzinga et al. 2001). Three alternative fixed starting points five miles apart were established, and from these points, three sets of transects were planned for the survey. The order of conducting the three replicate sets was chosen by randomly picking one set at a time without replacement. The starting and ending positions for each these transect sets are given in the Field Operational Plan (NWSS 2012).

Planned survey transects were parallel and were aligned in an east-west orientation. To fully encompass the expected westward (offshore) extent of the sardine school distribution, transects originated three miles from the shoreline and extended westward for 35 miles. Additionally, the segment from the coastline to the transect east end (3 miles offshore) was to be photo-documented for future evaluation. Two strata were established for sampling: 1) a northern zone from Cape Flattery, WA to the Newport, OR area, and 2) a southern zone from the Newport area to the Oregon/California border. Planned transects were spaced 7.5 nautical miles apart in the northern stratum (n = 31 transects); spacing was 15 nautical miles apart in the southern stratum (n = 10 transects) (NWSS 2012).

The survey plane was equipped with the same Aerial Imaging Solutions photogrammetric aerial digital camera mounting system and data acquisition system as used in the 2008-2012 work (NWSS 2012). This integrated system was used to acquire digital images and to log transect data. The system recorded altitude, GPS position, and spotter observations, which were directly linked to the time stamped quantitative digital imagery. At the nominal survey altitude of 4000 feet, the approximate transect width-swept by the camera with a 24 mm lens was 1829 m (1.13 mi). Digital images were collected with 80% overlap to ensure seamless photogrammetric coverage.

Transect Data Collection and Reduction

Photogrammetric calculations. Digital images were analyzed to determine the number, size, and shape of sardine schools on each transect. Adobe *Photoshop Lightroom 3.0* software was used to bring the sardine schools into clear resolution and measurements of sardine school size (m^2) and shape (circularity) were made using Adobe *Photoshop CS5-Extended* software. Transect width was determined from the digital images using the basic photogrammetric relationship:

$$\frac{I}{F} = \frac{GCS}{A}$$

and solving for *GCS*:

$$GCS = \frac{I}{F} A$$

where *I* = Image width of the camera sensor (e.g. 36 mm), *F* = the focal length of the camera lens (e.g. 24mm), *A* = altitude, and *GCS* = “ground cover to the side” or width of the field of view of the digital image. Transect width was obtained by taking the average of *GCS* for all images collected.

Photogrammetric Calibration. In order to provide ground truth information, digital imagery of an object of known size (i.e. a circular helicopter landing pad at the US Coast Guard base, Astoria, OR) was collected at a series of altitudes ranging from 1000 ft. to 4000 ft. The observed vs. actual size of the object was subsequently compared to evaluate photogrammetric error. Deviation ranged from 0.57% to 4.16% and averaged 2.73% (Table 1).

Transect Photograph Analysis. The procedure for analyzing the transect photographs involved three steps: 1) preliminary analysis, 2) double-blind analysis, and 3) resolution.

In the first step (preliminary analysis), a review of all transect photographs was conducted by a well-seasoned member of the analysis team. The presence or absence of schools was noted for each transect photograph for the purpose of determining which photographs would be used for collecting sardine school measurements.

In the second step (double-blind analysis), transect photographs were assigned to two separate analysts (Reader 1 and Reader 2) for independent school detection and measurement. The two individuals worked independently and did not confer with each other regarding their work.

Finally, in the third step (resolution), a school-by-school comparison of between-reader differences in school detection was conducted. The two sets of transect school measurement readings (for Reader 1 and Reader 2) were examined side-by-side the resolver, to identify discrepancies in school detection between Reader 1 and Reader 2 for each transect. For cases where both readers successfully identified and measured a sardine school, no changes were made to the sets of measurements. In cases where schools were either: 1) missed, 2) mis-identified, or 3) double counted, the set of Reader 1 and Reader 2 measurements readings was corrected by adding new measurements or deleting existing school measurements, accordingly. The final result of the resolution process was two sets of school measurement readings that 1) accounted for all schools identified, and 2) reflected reader variability in the process of measuring school size.

School Species Identification. We utilized real-time observations made by experienced fishery spotter pilots for the species identification of schools on the transects. The spotter pilots recorded their observations on a Transect Flight Log Form (NWSS 2012). The pilots also documented general conditions to aid in the subsequent interpretation of the transect photographs, including factors such as sea state, weather, and sea surface anomalies (e.g. tidal rips, bodies of fresh water or turbidity plumes).

Stage 2: At-Sea Point Set Sampling

<u>Point Set Logistics</u>

Empirical measurements of biomass were obtained by conducting research hauls or “point sets” at sea. Point sets were the means used to determine the relationship between individual school surface area (as documented with quantitative aerial photographs, described above) and the biomass of individual fish schools.

Point sets are defined as sardine schools first identified by a survey pilot and subsequently captured in their entirety by a survey purse seine vessel. The protocol for conducting point sets, and the specific criteria used for determining the acceptability of point sets for analysis of the school area-biomass relationship are given in the Field Operational Plan (NWSS 2012).

The point set sampling design was stratified by school size, with the goals of obtaining: 1) a range of sizes representative of schools photographed on the transects (keeping within a size range consistent with the safe operation of the vessels participating in the survey) and 2) a geographic distribution of schools that would be representative of schools found on the transects (to the extent logistically possible given operational constraints). Point sets were generally not attempted for schools larger than approximately 130 mt. Using the EFP set-aside amount of 3,000 mt, a total of n = 82 point sets were planned for 2013 (PFMC 2013).

Point Set Data Collection and Reduction

School height information was collected at sea using purse-seine vessel sonar and down-sounder equipment, and was recorded by vessel skippers on a Point Set Vessel Log Form (NWSS 2012). The total weight of the school was determined from measurements made at the dock of landed weight.

School Surface Area. The method used to obtain measurements of surface areas for the point set schools was the same as that described above for measuring on transect photographs. For each point set, a series of photographs was taken to document the target school prior to the approach of the fishing vessel. Point set school size measurements were made using the best quality image available, prior to any observable influence by the vessel during the process of school capture. Observations by the spotter pilot were recorded on the Point Set Flight Log Form (NWSS 2012).

II. Analytical Methods

Total Biomass

Estimation of total sardine biomass for the survey area was accomplished in a 3 step process that required: 1) measurements of individual school surface area on sampled transects, 2) estimation of individual school biomass (from the estimated surface area – biomass relationship), and 3) transect sampling design theory for estimation of a population total. The calculations described below were implemented using the R statistical programming language. Computer algorithms used for the analysis are included as Appendix I of this document.

Individual school surface area (a_i) was measured on the photo-documented transects using the *measurement tool* feature of *Adobe Photoshop*, and employed the photogrammetric relationships described above. Individual school surface area density (d_i) is specific to school size and was determined from the empirical relationship between surface area and biomass obtained from Stage 2 (point set) sampling (described below). Individual school biomass (b_i) was estimated as the product of school surface area density and surface area ($b_i = d_i a_i$). The sum of individual school biomass (b_u) was then determined for each transect (u). The mean sampled biomass for the study area ($\bar{b}$) was computed as

$$\bar{b} = \sum_{u=1}^{n} b_u \ / n \ ,$$

where n = the number of transects sampled. Total biomass for the study area $(\hat{B})$ was estimated using the unbiased estimator for a population total (Stehman and Salzer 2000),

$$\hat{B} = N\bar{b} \ ,$$

where N = the total number of transects that could possibly be sampled in the survey area without overlap.

The school measurement process described above was conducted by two independent readers; thus two estimates of total biomass were obtained. The two separate estimates of biomass were then averaged to obtain the final biomass estimate.

Individual School Biomass

The biomass of individual schools observed on the transects (b_i) was calculated using 1) measurements of school surface area, and 2) the relationship between school surface area and biomass, obtained from point sets. The three parameter Michaelis-Menten (MM) model assuming log-normal error was used to describe the sardine surface area – biomass relationship:

$$d_i = (yz + xa_i)/(z + a_i)$$

where

d_i = school surface area density (mt/m^2)
a_i = school surface area (m^2)
y = y intercept
x = asymptote as x approaches infinity
x/z = slope at the origin.

As noted above, individual school biomass (b_i) was then estimated as the product of school surface area density and surface area ($b_i = d_i a_i$).

Total Biomass - Coefficient of Variation (CV)

The CV of the total biomass estimate was obtained by employing a bootstrapping procedure implemented with the R statistical programming language (Appendix I). The intent of the procedure was to propagate error through the entire process of biomass estimation, incorporating variability due to error in: 1) the surface area - biomass relationship, 2) reader measurements, and 3) transect random sampling. The steps of the procedure were:

1) The MM model was fit to the point set data.
2) A variance-covariance matrix was derived for the MM model fit to the data, using the R library “MSBVAR”.
3) A matrix of simulated MM parameters was derived from the MSBVAR output, using the R function “rmultnorm”.
4) For j = 100,000 bootstraps:
   a. One realization of the MM parameters was selected from the matrix of simulated parameters.

b. The predicted MM curve was calculated.
c. Biomass was estimated for the transects (Reading 1 and Reading 2).
d. For each of the n transects, either Reading 1 or Reading 2 was selected at random.
e. The set of selected transects was randomly sampled with replacement.
f. Total biomass for the study area was calculated from the sampled transects and stored as the bootstrap estimate of biomass.

5) The standard error (SE) was calculated from the stored bootstrap estimates of biomass (4e).
6) CV was calculated as $CV = SE/\hat{B}$.

Survey Results

I. Aerial Transect Sampling

Transect Coverage in 2013

One pilot (SP3) participated in the 2013 survey, operating a Cessna model 180 single engine airplane.

Exceedingly poor weather conditions during the summer of 2013 (persistent fog) precluded execution of the originally planned transect sets. Instead, the survey pilot took an ad-hoc approach in an attempt to get essentially complete coverage of a portion of the coast that was clear on 8-12-2013 and 8-13-2013. Working from the Columbia River in the north to Garibaldi, OR in the south, the survey pilot conducted 42 closely-spaced East-West transects (Figure 1). Due to overlap in coverage between the closely spaced (ad-hoc) transects, a subset of 21 transects were selected for estimation of biomass (see below).

Transect School Measurements

Two sets of measurements of individual sardine schools were completed independently by photo-analysts for the 21 transects used in the analysis in 2013. A comparison of frequency histograms of individual school size measurements (surface area in m^2) is given in Figure 2 for sampling from 2009-2013. The shape of the distribution of school sizes in 2013 was similar to that observed in 2010, 2011, and 2012. A summary of estimated biomass totals, by transect, is given in Table 2.

II. Point Set Sampling

Point Set Coverage

No new point sets were conducted in 2013. Thus, no new additional point set biological or surface area data are available for 2013.

Sardine School Surface Area - Biomass Relationship

A plot of the sardine school surface area - biomass relationship for acceptable point sets collected from 2008-2012 is shown in Figure 3, and the MM fit to the data is shown in Figure 4. These data were used for biomass estimation in 2013.

III. Quantities for Input to the Pacific Sardine Stock Assessment

As noted above, no new biological sampling data were collected in 2013. Thus, a new length composition data set could not be provided for the assessment. In previous years, we observed good agreement between length composition data from the fishery and the point sets sampled. In general, both activities operate in the same area using the same gear. This suggests that fishery length composition data could serve as a proxy for estimating selectivity for the survey, depending what fishery data are available for 2013.

Lacking new point set surface area and catch data, the biomass estimate was derived using the same point set data relationship that was used last year (n=123 collected from 2008-2012; Figure 4). The biomass estimate for 2013 was 160,763 mt (Table 3). A set of 100,000 simulations (Figure 5) resulted in a coefficient of variation (CV) of 0.35 .

Discussion

Point set and transect sampling activities in 2013 were virtually shut-down during most of the summer of 2013, due to thick and persistent fog. In an attempt to salvage something useful from a largely failed sampling season, the survey pilot conducted an ad-hoc sampling approach on two marginally clear days in August. Starting at the Columbia River in the north on 8-12-2013, closely spaced parallel transects were conducted proceeding to the south and ending in the vicinity of Garibaldi, OR on 8-13-2013. Subsequent examination of the area-swept by these photographed transects revealed that many overlapped in coverage. Thus, a sub-set of the transects (odd numbered) was used for analysis (n = 21). Additionally, since no new point sets were collected in 2013, it was not possible to compare the surface area-biomass relationship, or the size frequency distribution of sardine with other years.

Acknowledgements

This work is the result of efforts put forth by members of the sardine industry (Northwest Sardine Survey - Jerry Thon, Principal) operating under an EFP and harvest set-aside approved by PFMC and granted by NMFS. Our team of dedicated photo-analysts, (Meghan Mikesell, and Pat McCall) were essential to the project’s completion.

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Figure 1. Map of transects flown on 8-12-2013 and 8-13-2013. These transects were re-numbered from 1 to 42 and the odd numbered transects were then used in the analysis (see text).

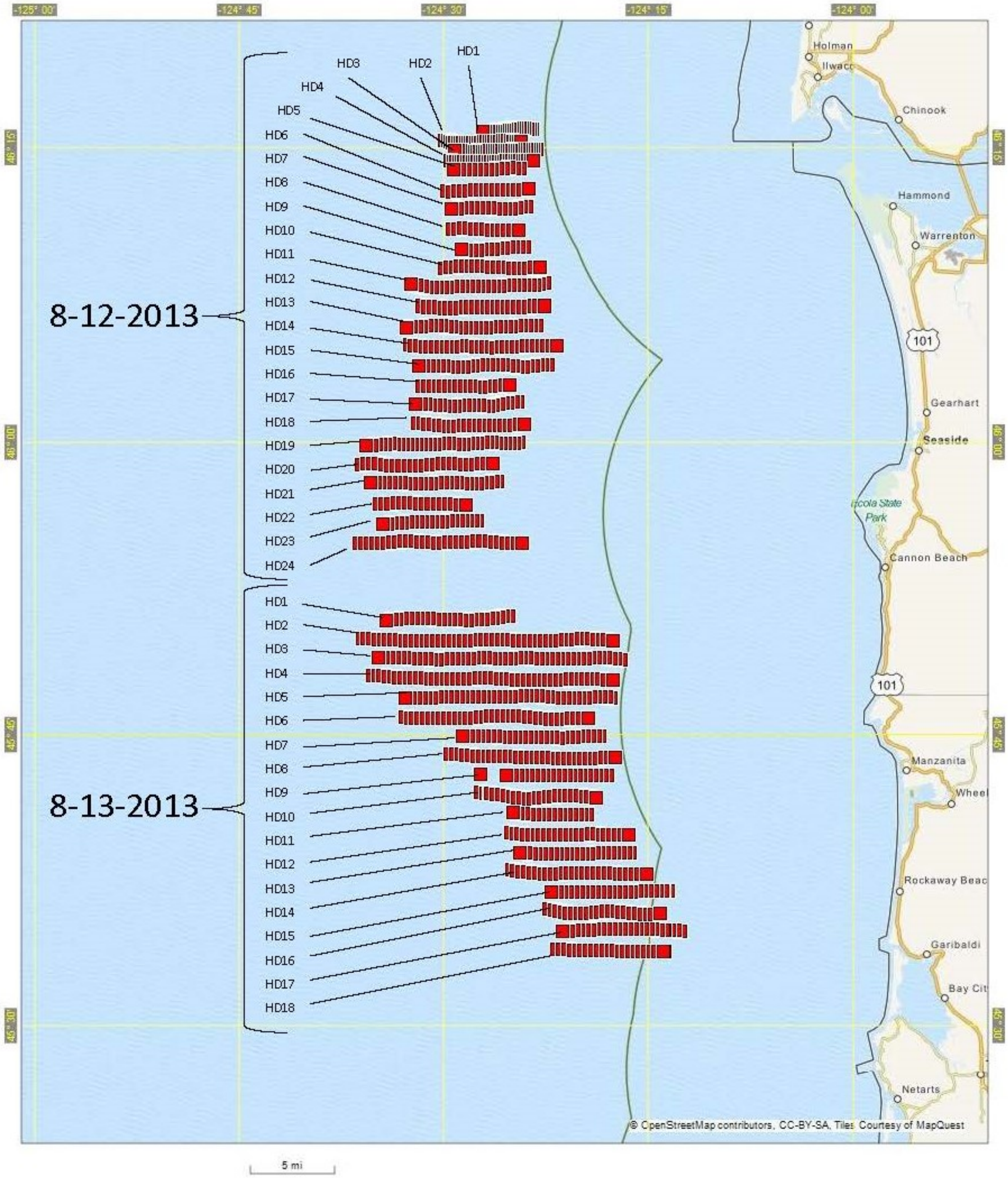

Figure 2. Size distribution of individual schools (area in m^2) on transects, 2009-2013.

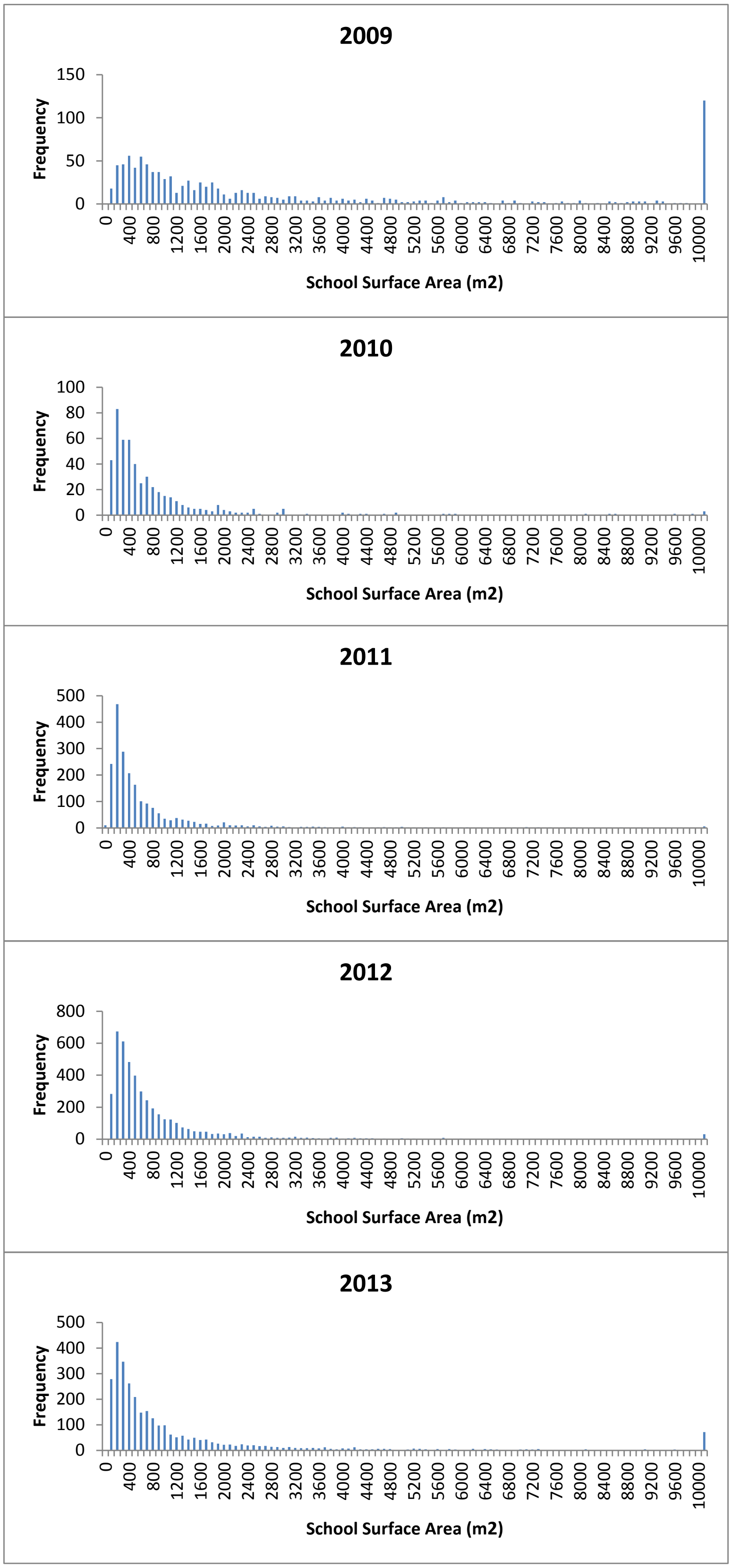

Figure 3. Plot showing sardine point set surface area-biomass relationship (mt/m^2 vs m^2), 2008-2012. Red – 2008; Green – 2009; Blue – 2010; Orange – 2011; Black (open squares) – 2012.

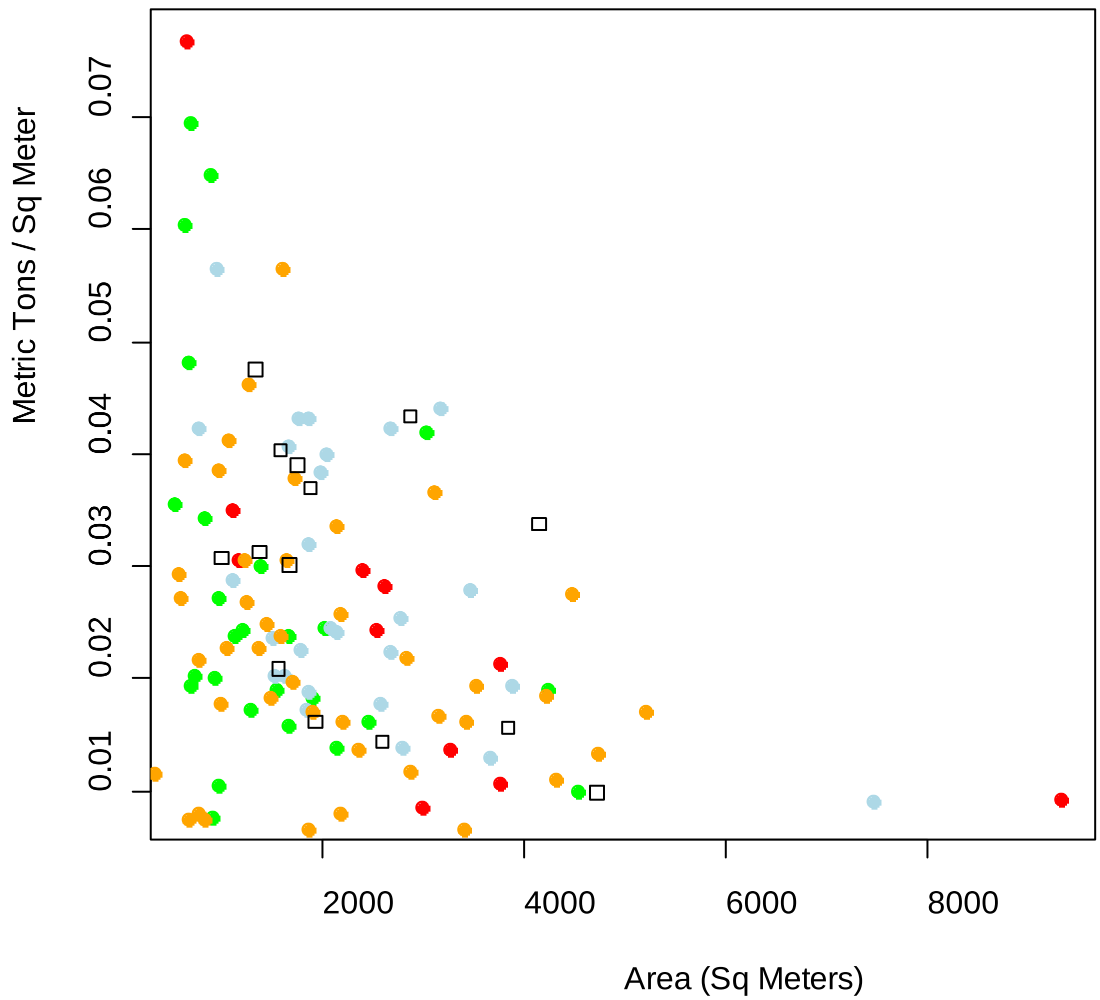

Figure 4. Plot showing fit of MM curve to point set data. 2008-2012 data pooled (green dots; solid black line). 2012 data alone (black squares; dashed black line). The biomass estimate was derived using the solid black line.

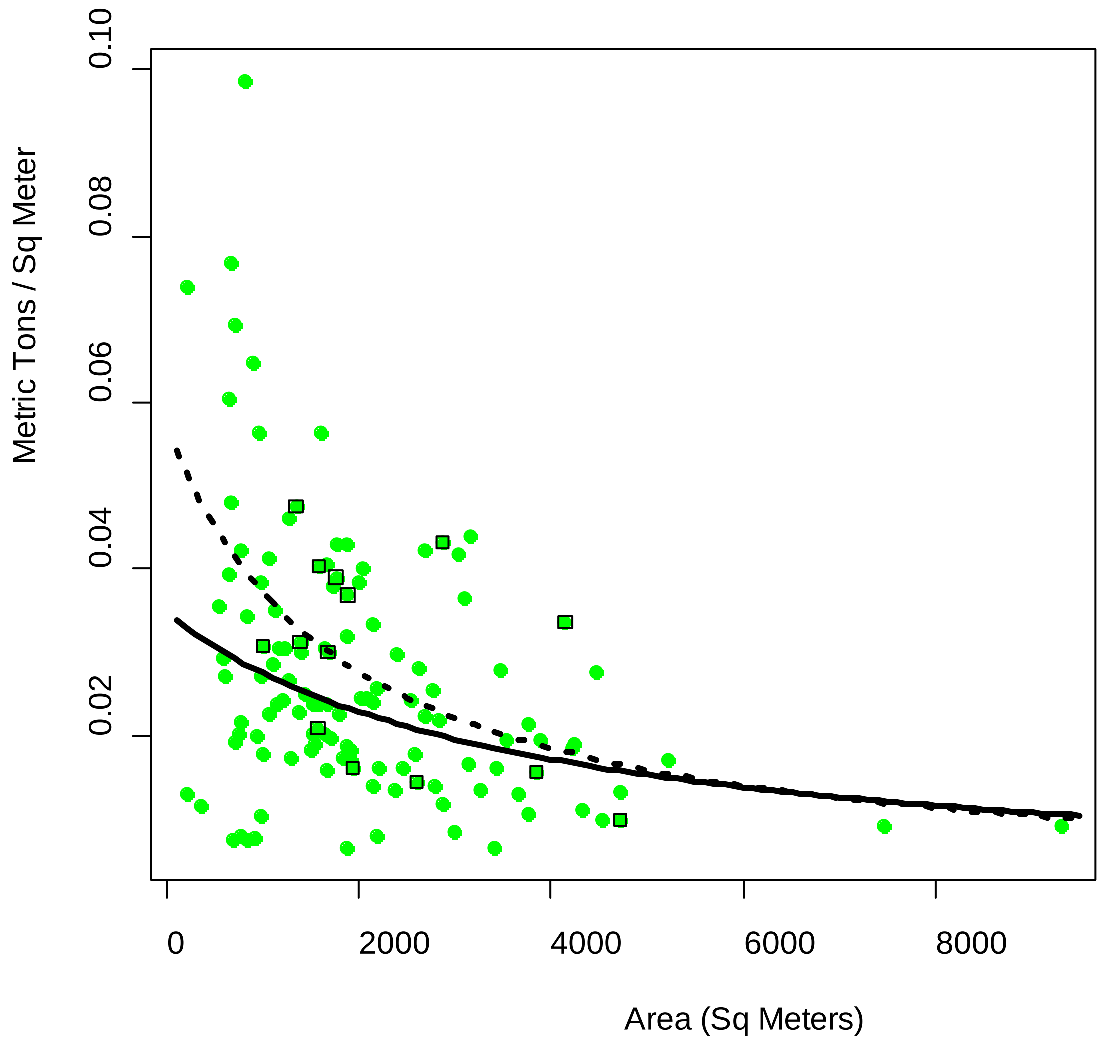

Figure 5. Distribution of biomass from 100,000 simulations; used to derive estimate of Biomass CV.

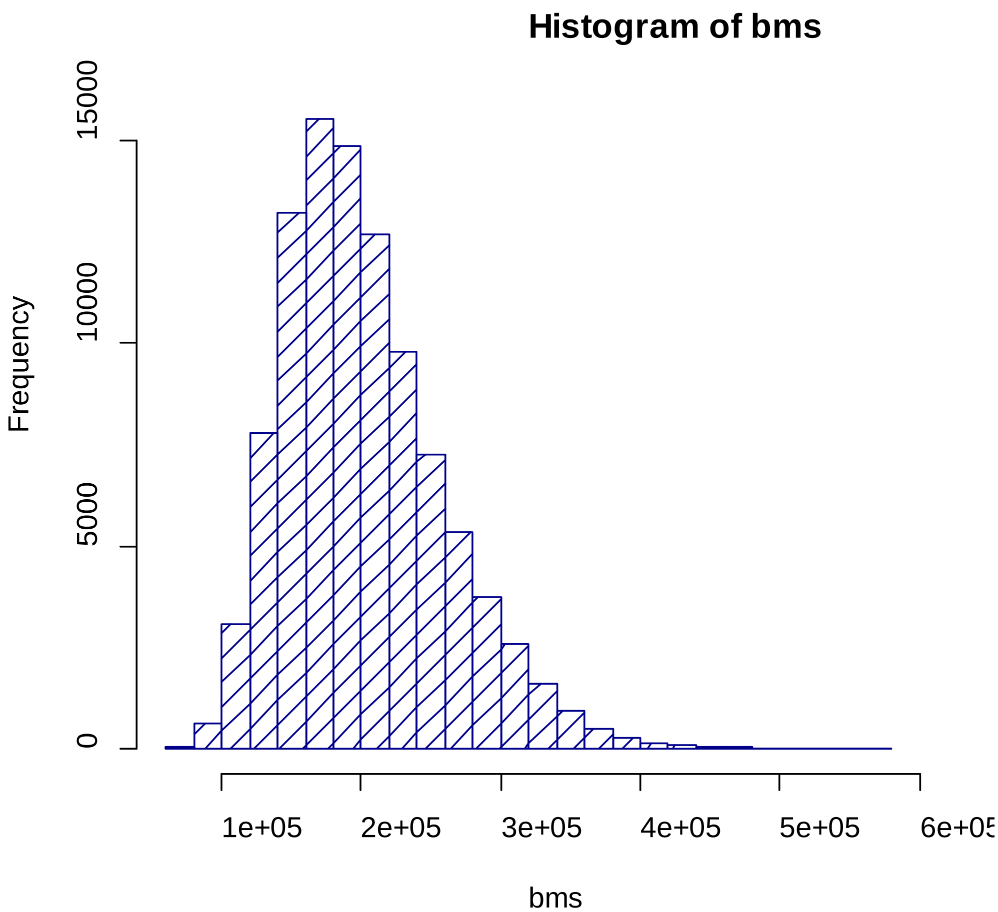

Table 1. Aerial photograph calibration measurements conducted in 2013. The target object was a large yellow circle (helicopter landing pad) at the USCG base, Astoria, OR.

Photo no.	Object	Area measured (m²)	Actual Area (m²)	Nominal Altitude (ft)	Actual Altitude (ft)	Actual Alt. - elevation (ft)	% Deviation
SP3_0093	Large yellow circle	466.74	454.69	4000	4073	4064.06	2.65%
SP3_0121	Large yellow circle	470.85	454.69	3000	2999	2990.06	3.55%
SP3_0206	Large yellow circle	473.6	454.69	2000	2012	2003.06	4.16%
SP3_0338	Large yellow circle	457.29	454.69	1000	920	911.06	0.57%

Table 2. Transect Summary, 2013.

Survey_Date	Transect_ID	Begin_Latitude	Begin_Longitude	End_Latitude	End_Longitude	Biomass_Reading_1_mt	Biomass_Reading_2_mt
8/12/2013	1	46.2686	-124.3945	46.2665	-124.4549	706.2	716.7
8/12/2013	3	46.2513	-124.3896	46.2505	-124.4888	1049.2	1119.9
8/12/2013	5	46.2348	-124.4100	46.2341	-124.4904	3842.6	4225.4
8/12/2013	7	46.2030	-124.4014	46.2005	-124.4938	2740.2	2801.5
8/12/2013	9	46.1686	-124.4047	46.1660	-124.4815	4781.7	5264.8
8/12/2013	11	46.1366	-124.3800	46.1356	-124.5424	9398.3	9248.8
8/12/2013	13	46.1015	-124.3897	46.0999	-124.5488	5352.9	4814.3
8/12/2013	15	46.0680	-124.3757	46.0673	-124.5332	1643.0	1545.4
8/12/2013	17	46.0364	-124.4122	46.0344	-124.5372	2475.2	2162.3
8/12/2013	19	46.0023	-124.4104	45.9988	-124.5972	900.0	824.9
8/12/2013	21	45.9684	-124.4370	45.9672	-124.5930	1017.6	1095.4
8/12/2013	23	45.9348	-124.4614	45.9318	-124.5778	575.2	559.7
8/13/2013	25	45.8532	-124.4234	45.8501	-124.5732	11304.5	11428.2
8/13/2013	27	45.8160	-124.2866	45.8175	-124.5830	10336.4	10807.8
8/13/2013	29	45.7837	-124.2983	45.7831	-124.5503	4321.0	5053.9
8/13/2013	31	45.7504	-124.3120	45.7505	-124.4794	2228.9	2494.7
8/13/2013	33	45.7169	-124.3032	45.7167	-124.4256	4591.6	4632.1
8/13/2013	35	45.6838	-124.3277	45.6850	-124.4185	877.1	850.9
8/13/2013	37	45.6506	-124.2745	45.6504	-124.4095	4876.0	5034.7
8/13/2013	39	45.6179	-124.2296	45.6173	-124.3712	2135.0	2114.9
8/13/2013	41	45.5834	-124.2152	45.5831	-124.3571	709.7	797.4

Table 3. Estimate of total biomass in 2013.

	Metric Tons	**CV**
Reading 1 Biomass	158,950	
Reading 2 Biomass	162,577	
Estimated Biomass	160,763	0.35

Appendix I.

Programming used to estimate biomass and CV in 2013, coded in the R statistical programming language.

```
#SetHD2013: Computes biomass and CV estimate for Set HD (ad hoc)
# of the 2013 Survey (Transects 1-42). Uses pooled point set data 2008-2012
# Bootstraps two readings of school size
# Covariance on pointset data obtained from library 'MSVBAR'

cdata <- read.csv(file="cdataALL.csv")              #file of point set data

#Transects 1-42 Omitting even numbered transects due to overlap (n = 21)

#file of transect surface area data, reading 1
transectdata <- read.csv(file="transectdata2013sethdR1.csv")
#file of transect surface area data, reading 2
transectdata2 <- read.csv(file="transectdata2013sethdR2.csv")

 sethd2013 = function(nboots,cdata,transectdata,transectdata2){
  convert = function(yint, asymp, cc, x) {
    #defines function to convert area to bms - yint = y intercept
    return((yint*cc+asymp*x)/(cc+x))}
    #asymp = asymptote as x->infty, asymp/c = slope at orgin
  nls.control(maxiter = 5000,tol = 2e-6)
    #control parameters for nonlinear fitting
  ntransects <- 21
  xpanfactor  <- 44
  dimcdata <-  dim(cdata)
  npdata <- dimcdata[1] #number of point sets
  larea <- log(cdata$Area) #logs of areas of point sets
  parea <- cdata$Area  #point set areas
  obs <- cdata$ObsDens
  lobs <- log(cdata$ObsDens) #log of observed densities of point sets
  mmfit <- nls(lobs~log(convert(exp(lyint),exp(lasymp),exp(lcc),parea)),
    start = list(lyint= log(0.045), lasymp= log(0.0057), lcc= log(1187)),
    upper=list(lyint= log(1.0), lasymp= log(0.1),lcc= log(100000)),
    lower=list(lyint= log(0.001), lasymp= log(0.002),lcc= log(100)),
    algorithm="port")  #fit point set data
  mmcoef <- coef(mmfit)
  yint <- exp(mmcoef[1])  #fitted coef a
  asymp <- exp(mmcoef[2])  #fitted coef b
  cc <- exp(mmcoef[3])  #fitted coef c
  predobs <- convert(yint,asymp,cc,cdata$Area)
  res <- predobs - obs  #residuals of point sets
  windows()
```

```
plot(ObsDens~Area,data = cdata,ylab="Metric Tons / Sq Meter",
       xlab="Area (Sq Meters)",pch=19) #plots point set data
areas <- 100*(1:95)
pdens0 <-  convert(yint,asymp,cc,areas)#predicted curve
lines(pdens0~areas,col='dark red',lwd=3)  #plots predicted curve

Density <- convert(yint,asymp,cc,transectdata$sarea)
Density2 <- convert(yint,asymp,cc,transectdata2$sarea)
transectdata$bms <- Density*transectdata$sarea
      #estimated bms of schools - reading 1
transectdata2$bms <- Density2*transectdata2$sarea
      #estimated bms of schools - reading 2

transectbms1 <- tapply(transectdata$bms,transectdata$transect,sum)
    #calc bms on transect by summing over schools reading1
transectbms1R2 <- tapply(transectdata2$bms,transectdata2$transect,sum)
    #calc bms on transect by summing over schools reading2

tbmsR1 = xpanfactor*sum(transectbms1)/ntransects
    #calculate total bms - reading 1
tbmsR2 = xpanfactor*sum(transectbms1R2)/ntransects
    #calculate total bms - reading 2
tbms0 = (tbmsR1+tbmsR2)/2
print(paste("R1 bms = ",round(tbmsR1)),quote=F)
print(paste("R2 bms = ",round(tbmsR2)),quote=F)
print(paste("Est bms = ",round(tbms0)),quote=F)

write.csv(transectbms1,file="bmsStratum1Reading1.csv")
write.csv(transectbms1R2,file="bmsStratum1Reading2.csv")

bms <- rep(0,nboots) #set up bootstraps

library('MSBVAR')
covmatrix <- vcov(mmfit)
meanparams <- coef(mmfit)
newcoef <- rmultnorm(nboots,vmat=covmatrix,mu=meanparams)
Rselect <- transectbms1
for (i in 1:nboots){
  nyint <- exp(newcoef[i,1])
  nasymp <- exp(newcoef[i,2])
  nasymp <- min(nasymp,0.02)
  nc <- exp(newcoef[i,3])   #simulated coefficients
#   if (i < 20){ #draw refitted lines on pointset plot
#      pdens <- convert(nyint,nasymp,nc,areas)
#      lines(pdens~areas,col=i,lwd=0.05)
#       }
```

```
 Density <- convert(nyint,nasymp,nc,transectdata$sarea)
 Density2 <- convert(nyint,nasymp,nc,transectdata2$sarea)

 transectdata$bms <- Density*transectdata$sarea
      #estimated bms of schools - reading 1
 transectdata2$bms <- Density2*transectdata2$sarea
      #estimated bms of schools - reading 2

 transectbms1 <- tapply(transectdata$bms,transectdata$transect,sum)
      #calc bms on transect by summing over schools reading1
 transectbms1R2 <- tapply(transectdata2$bms,transectdata2$transect,sum)
      #calc bms on transect by summing over schools reading2

 #randomly select reading 1 or reading 2 for each transect
 readings <- matrix(nrow=ntransects,c(transectbms1,transectbms1R2))
 ii <- sample(seq(from=1,to=2),size=ntransects,replace=T)
  for (j in 1:ntransects){
    Rselect[j] <- readings[j,ii[j]]
     }

 tresample <- sample(1:ntransects,replace=T)  #sample the transect indicies
 retransect <- Rselect[tresample] #bootstrap of transects

 bms[i] <- xpanfactor*sum(retransect)/ntransects
   #calculated bms of this bootstrap
}
write.csv(bms,file="2013bms.csv")
windows()
hist(bms,breaks=20,density=10,col='dark blue')
 #histogram of bootstrapped biomasses
print(paste("yint = ",yint),quote=F)
print(paste("asymp = ",asymp),quote=F)
print(paste("cc = ",cc),quote=F)
print(paste("SE = ",round(sd(bms,na.rm=TRUE))),quote=F)
print(paste("CV = ",round(sd(bms,na.rm=TRUE))/tbms0), quote=F)
#mbms <- mean(bms)
#print(paste("mean bms = ",mbms),quote=F)

}
```