

West Coast Aerial Sardine Survey

A Consortium of the Sardine Industry

Sampling Results in 2010



2010 EFP Components

- Summer Coastwide Aerial Sardine Survey
Research “Set-Aside”:
 - 2,100 mt in Northern Region (WA/OR) - NWSS
 - 2,100 mt in Southern Region (CA) - CWPA

- Fall California Pilot Study
Research “Set-Aside”:
 - 800 mt in S. CA Bight - CWPA

2010 Survey Design

- **Stage 1 Sampling: Aerial Survey Transects**

Systematic Random Sampling: Sampling Unit = Transect

Each Replicate SET: 26 Transects in Northern Region, 40 transects in Southern Region

Three SETs = 198 Planned Transects

Transects oriented E/W and spaced 15 nautical miles apart N/S

- **Stage 2 Sampling: At-Sea Point Sets**

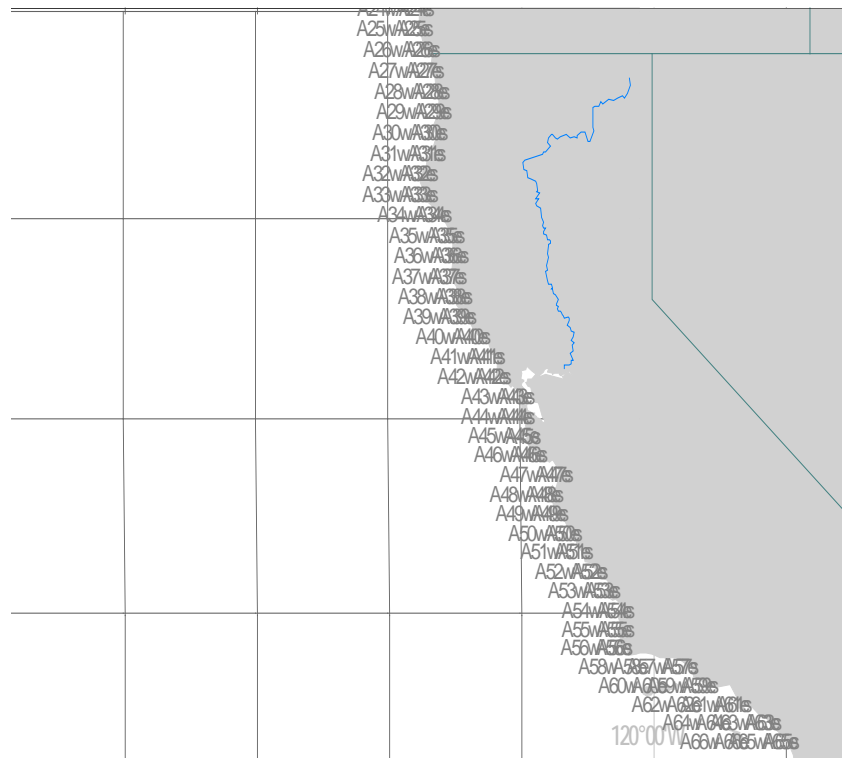
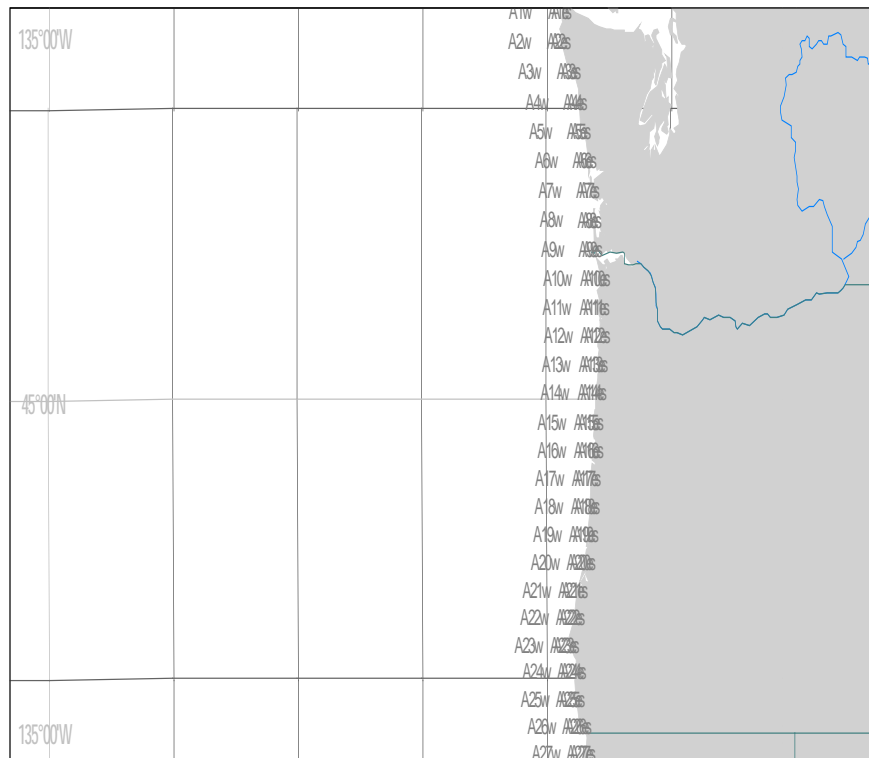
Distributed by Size: Size Bins Range from 100 m² to 10,000 m² (4-82 mt)

56 Planned Point Sets in Northern Region

56 Planned Point Sets in Southern Region

2010 Survey – Planned Transects

Cape Flattery to S.CA Bight – 66 Transects/SET



Northern Region (WA/OR) -- 26 Transects -- (NWSS)

Southern Region (CA) -- 40 Transects (CWPA)

Transect Logistics

At the nominal survey altitude of 4000 feet, the approximate width-swept by the camera with a 24 mm lens is about 1 mile. Digital images are collected with 60% overlap to ensure seamless photogrammetric coverage of the transects.



Data Collection and Reduction

Aerial Survey Data Acquisition

Manufacturer

Aerial Imaging Solutions
Don LeRoi

Canon EOS 1D Mark III

Digital AF/AE SLR
5616 x 3744 pixels
21 mega pixels
Lens 24mm

Laptop PC

Dell latitude D630



Acquires digital images at specified overlap rate (60%)
Logs: Altitude, GPS Position, Observer Comments

2010 Survey – Planned Point Sets

Size (m ²)	Weight (mt)	Total Weight	Number of Point Sets
100	3.8	31	8
500	10.6	85	8
1000	17.0	136	8
2000	26.5	212	8
4000	51.9	415	8
8000	70.5	564	8
10000	82.1	657	8
		2099	56

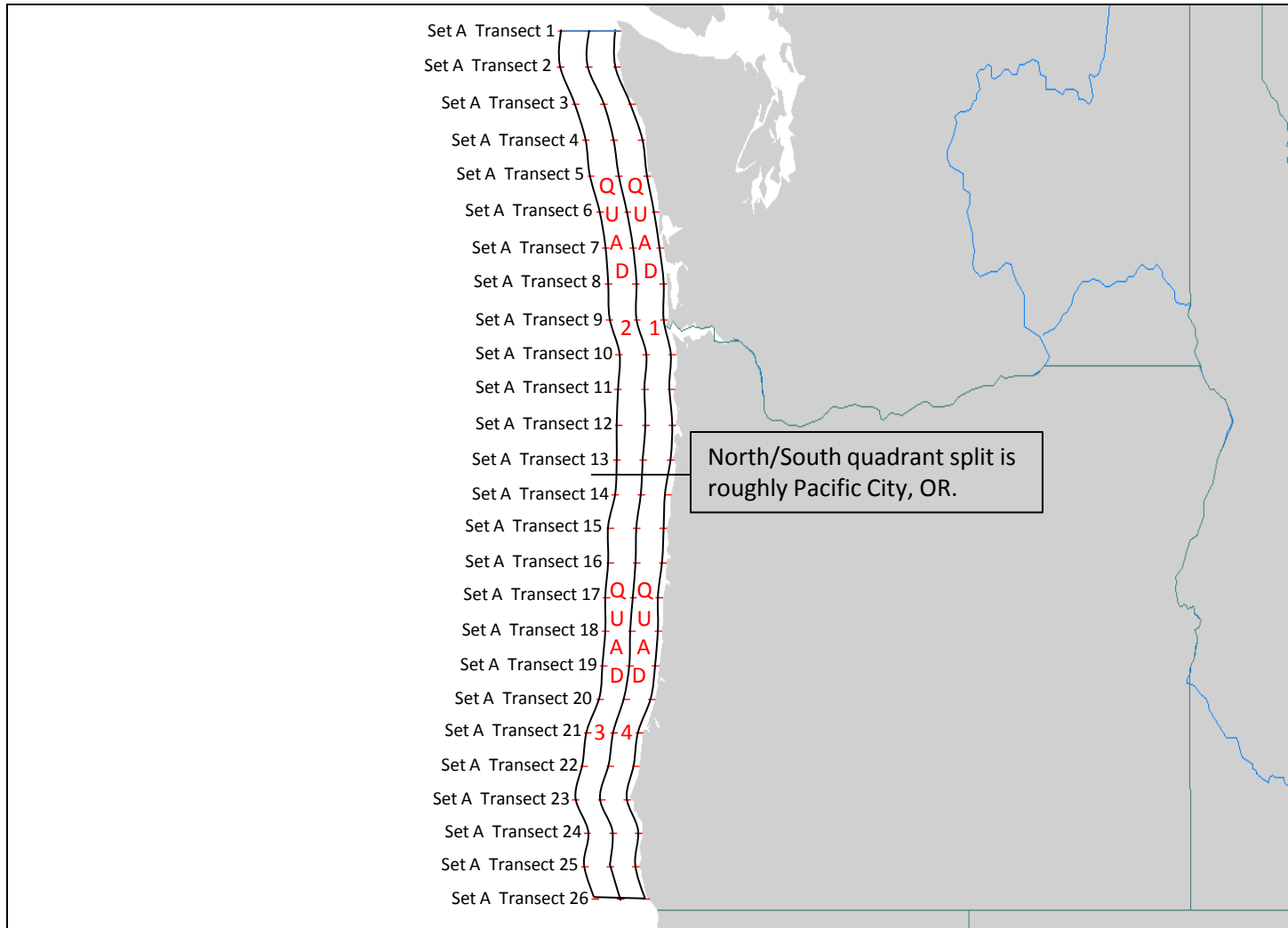


Table 1. Northern Region Point Set Quadrants – Set A

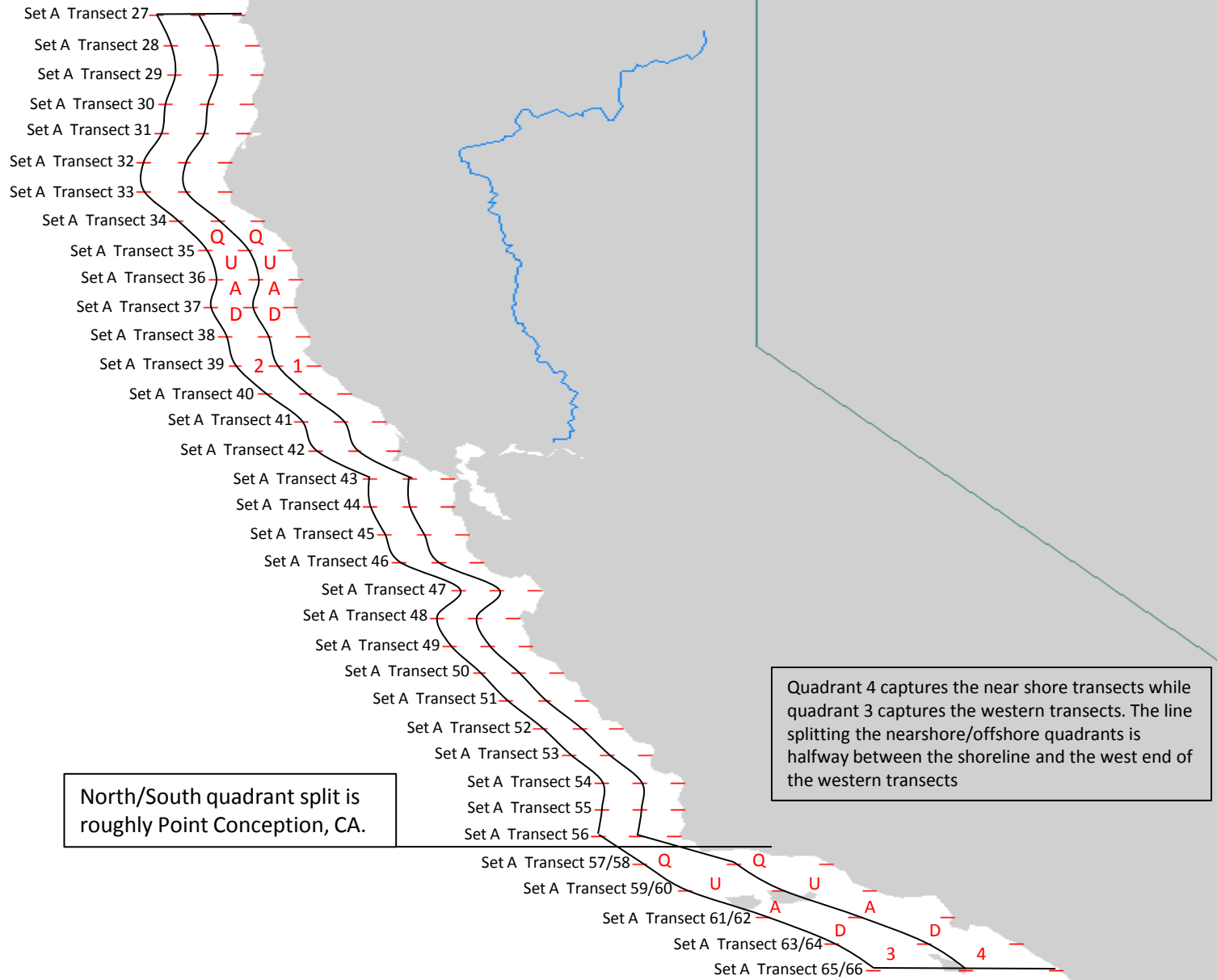


Table 2. Southern Region Point Set Quadrants – Set A

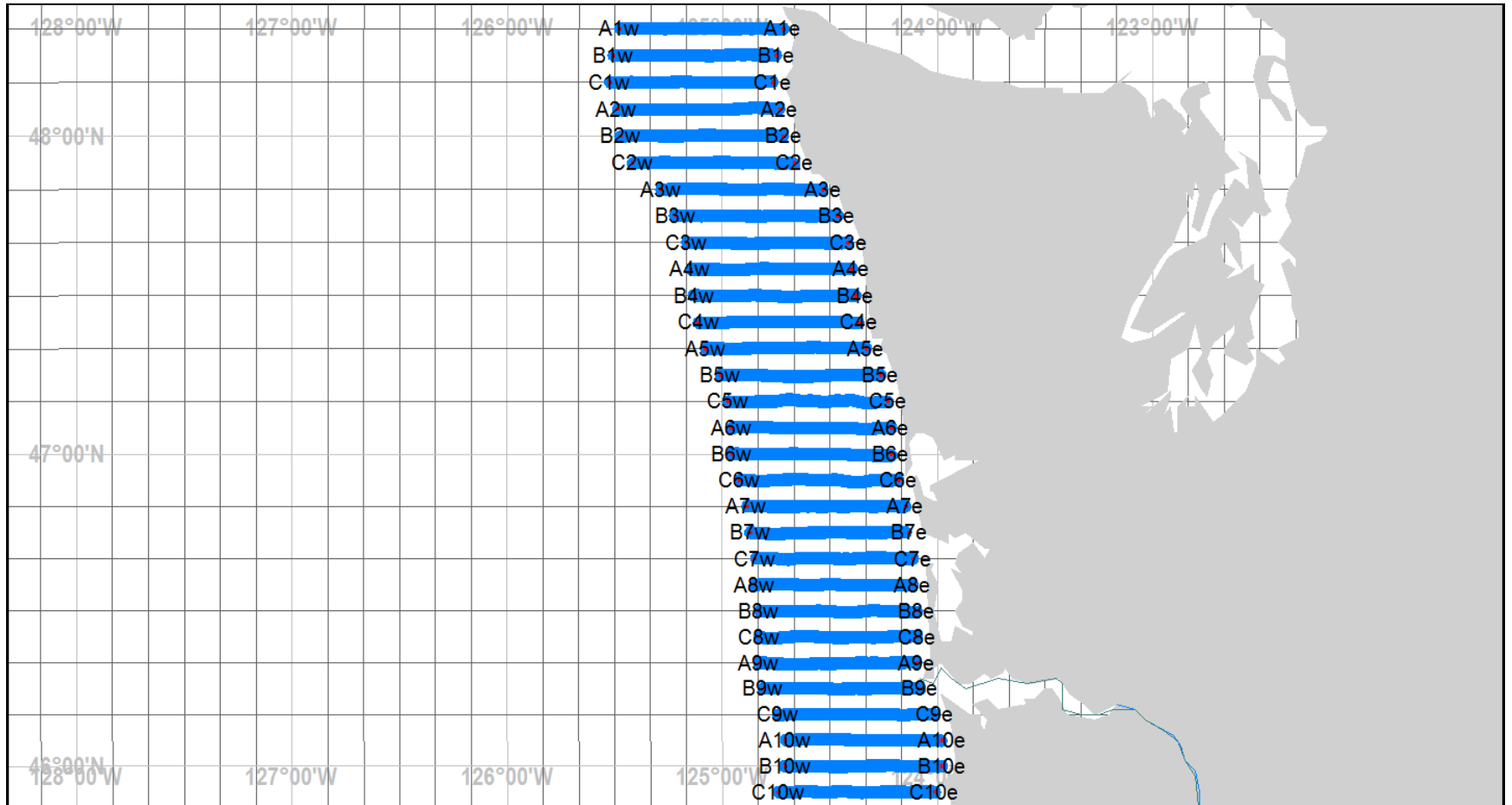
Analytical Methods

- Estimation of Biomass from Stage 1 and Stage 2 Sampling
- Estimation of Coefficient of Variation of Biomass Estimate (CV)

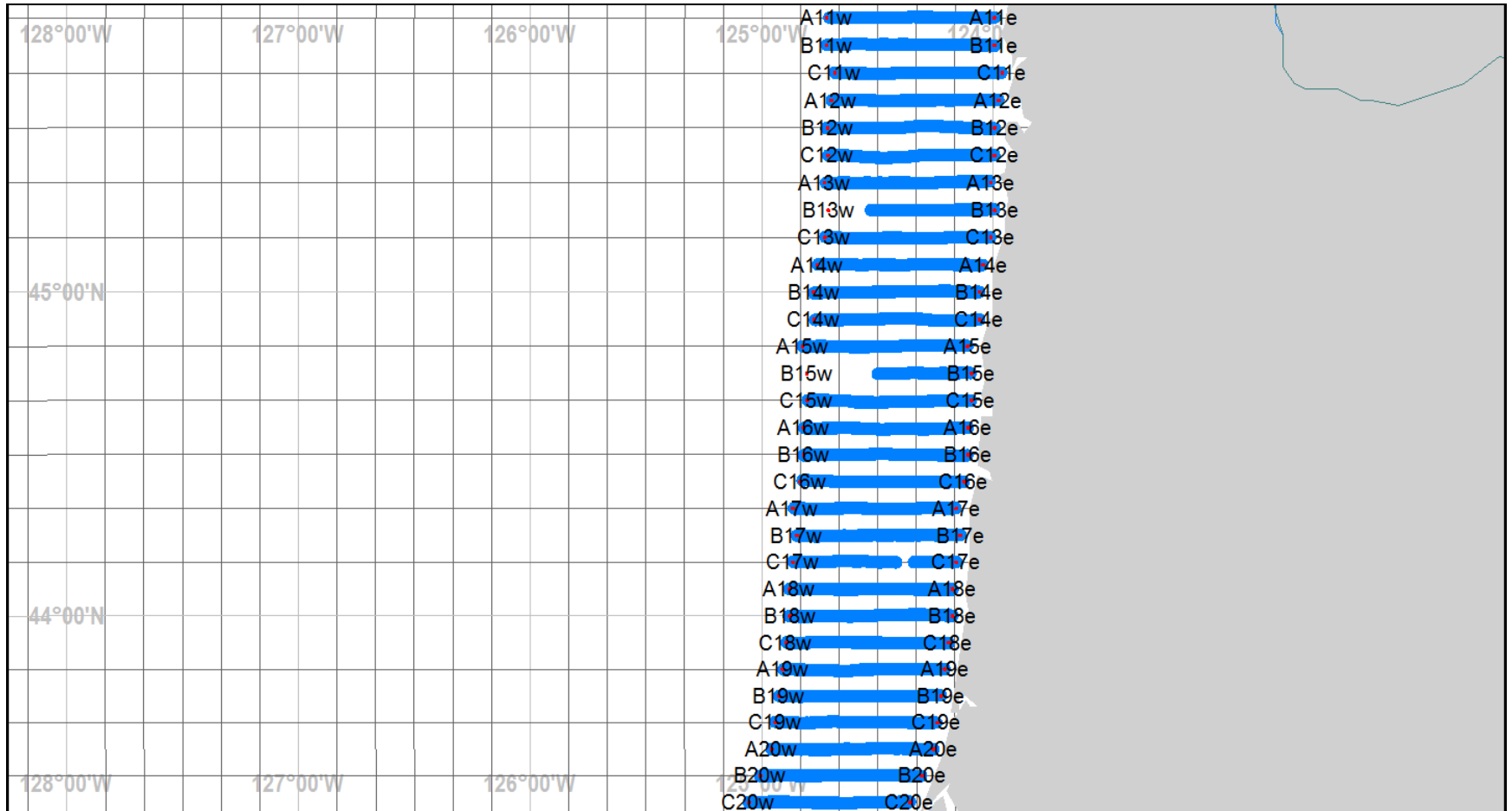
2010 Survey Results

- Transects:
Three Replicates – 182 Transects Sampled
- Point Sets:
71 Landed – 51 qualified for area-biomass analysis

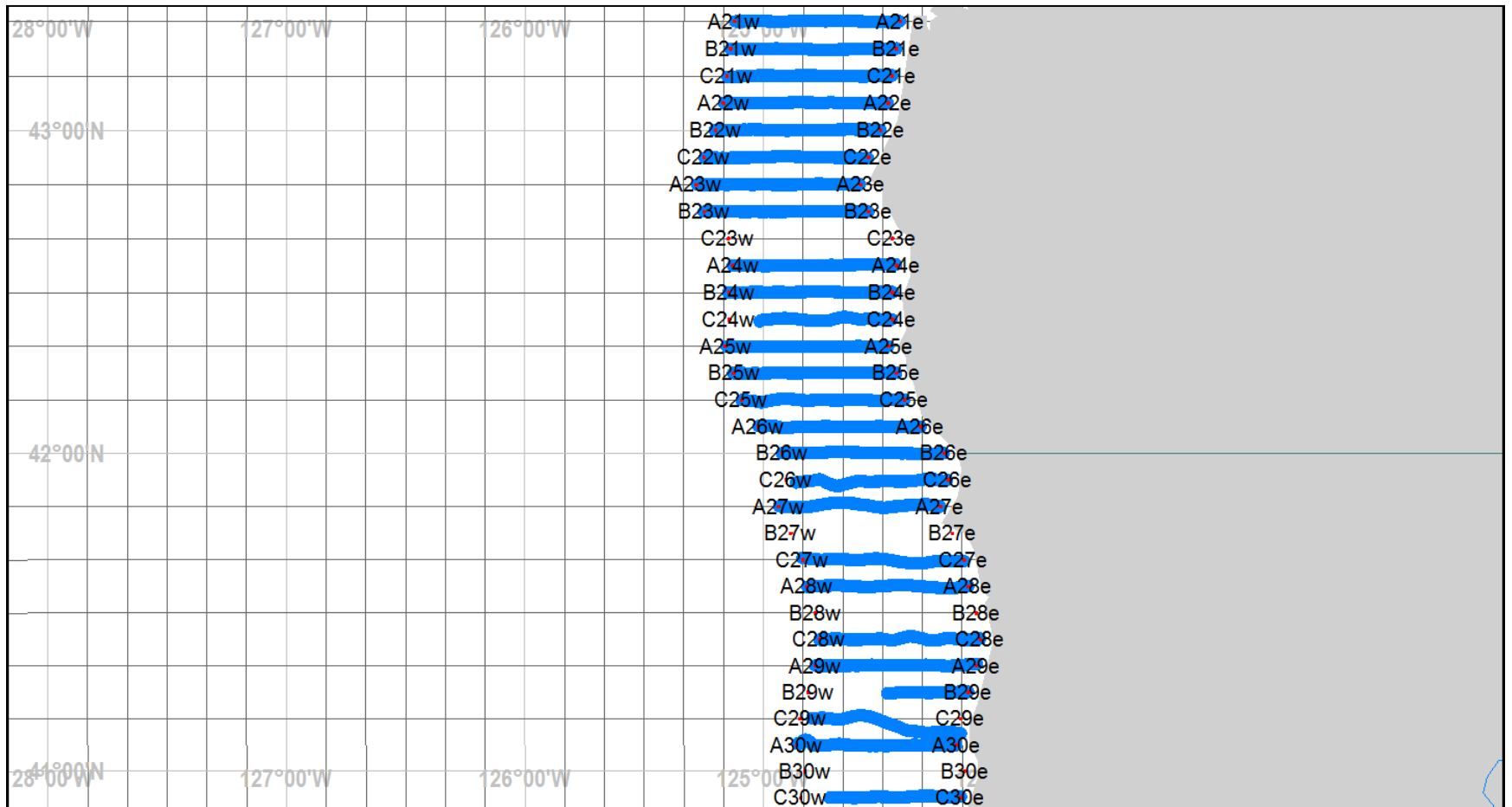
Transect SET A,B,C Transects 1-10



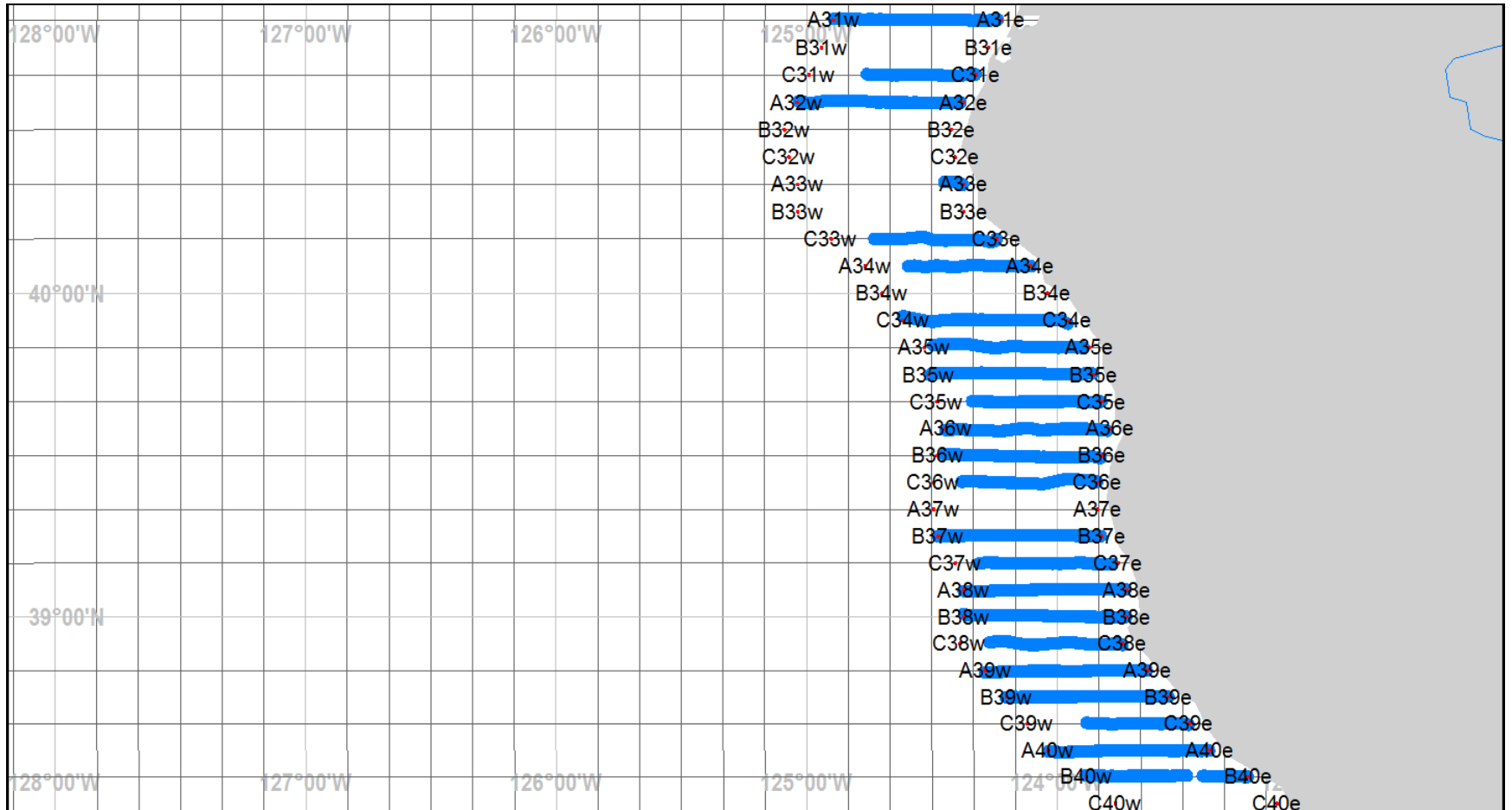
Transect SET A,B,C Transects 11-20



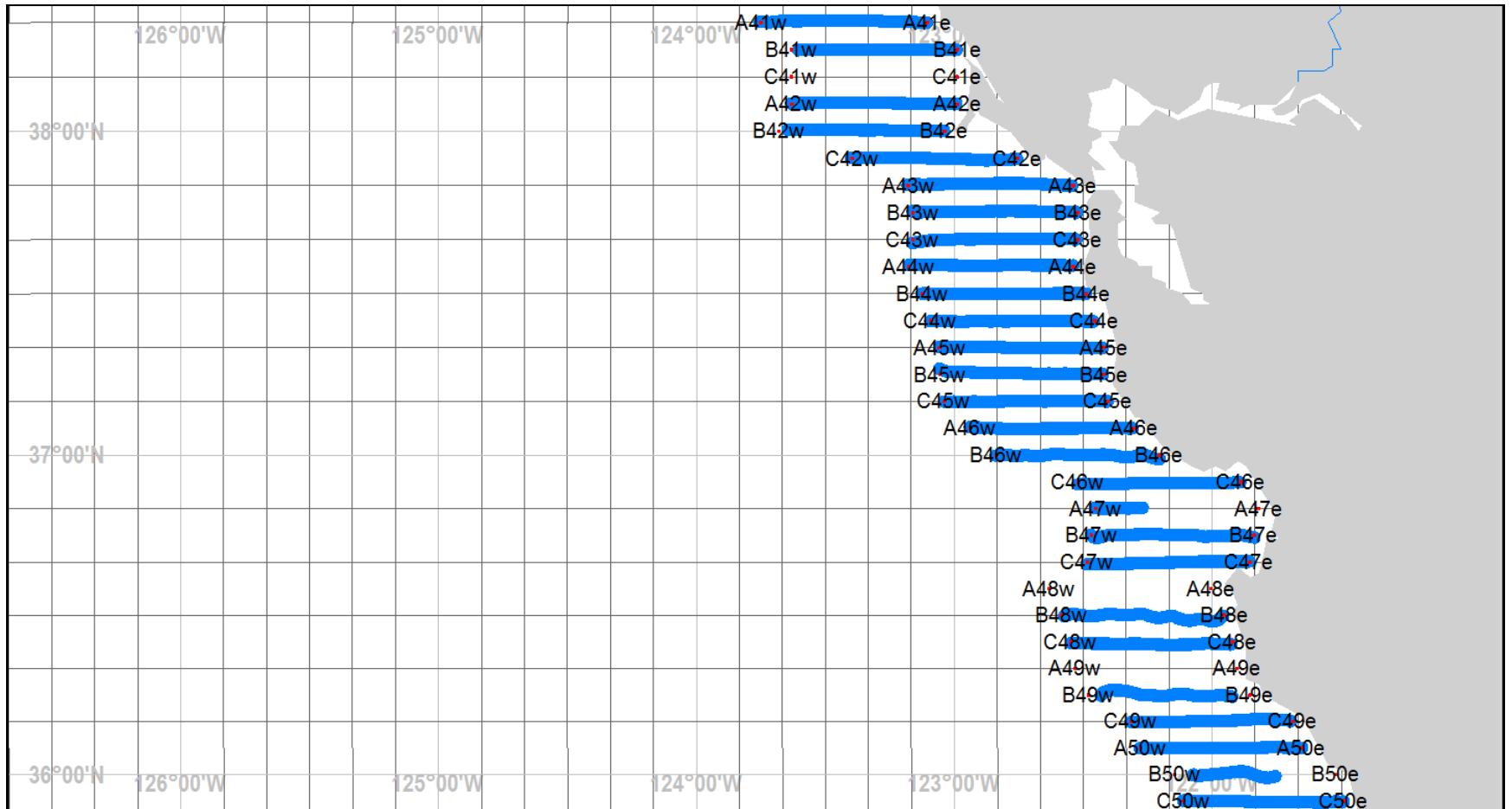
Transect SET A,B,C Transects 21-30



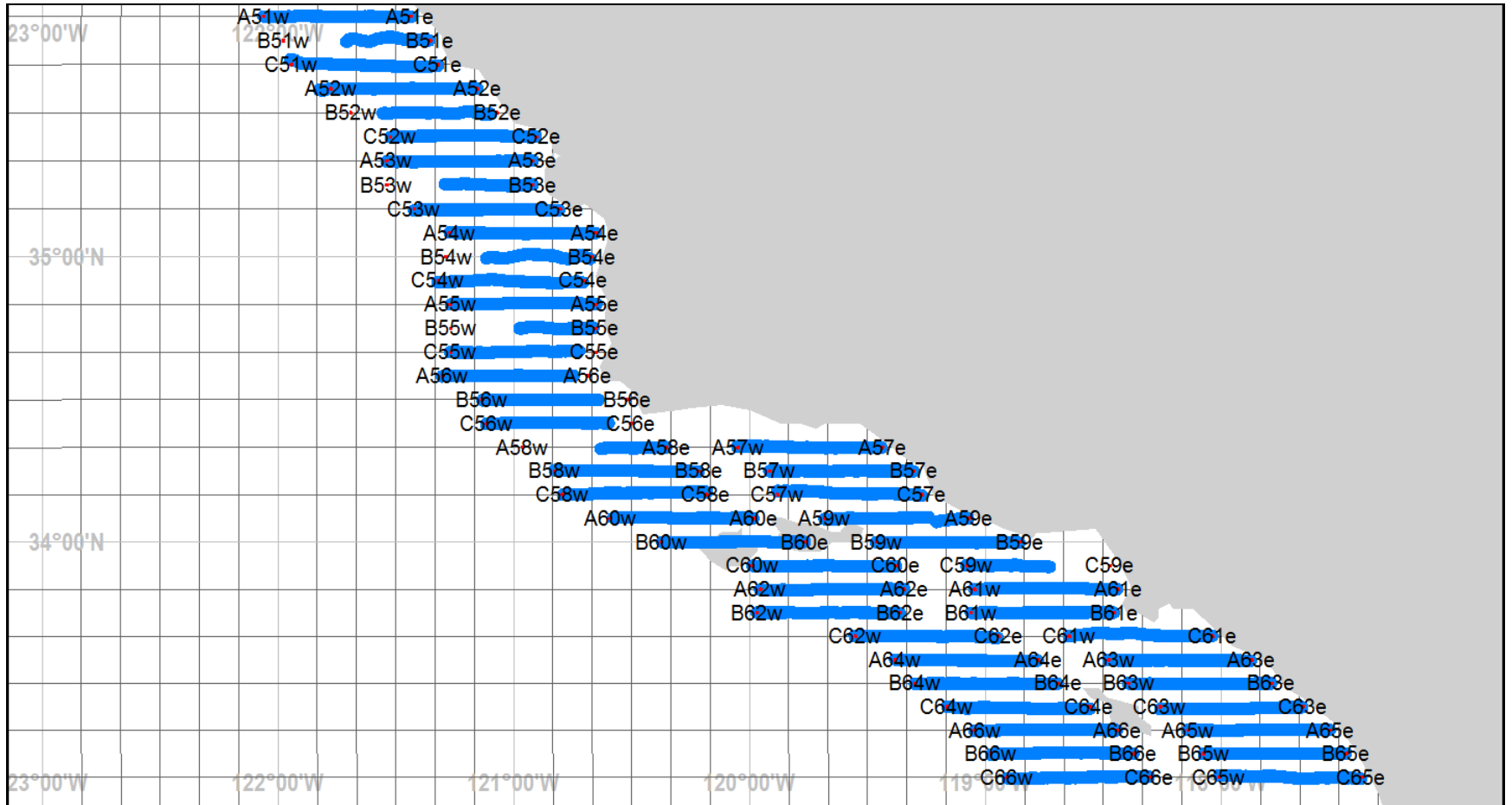
Transect SET A,B,C Transects 31-40



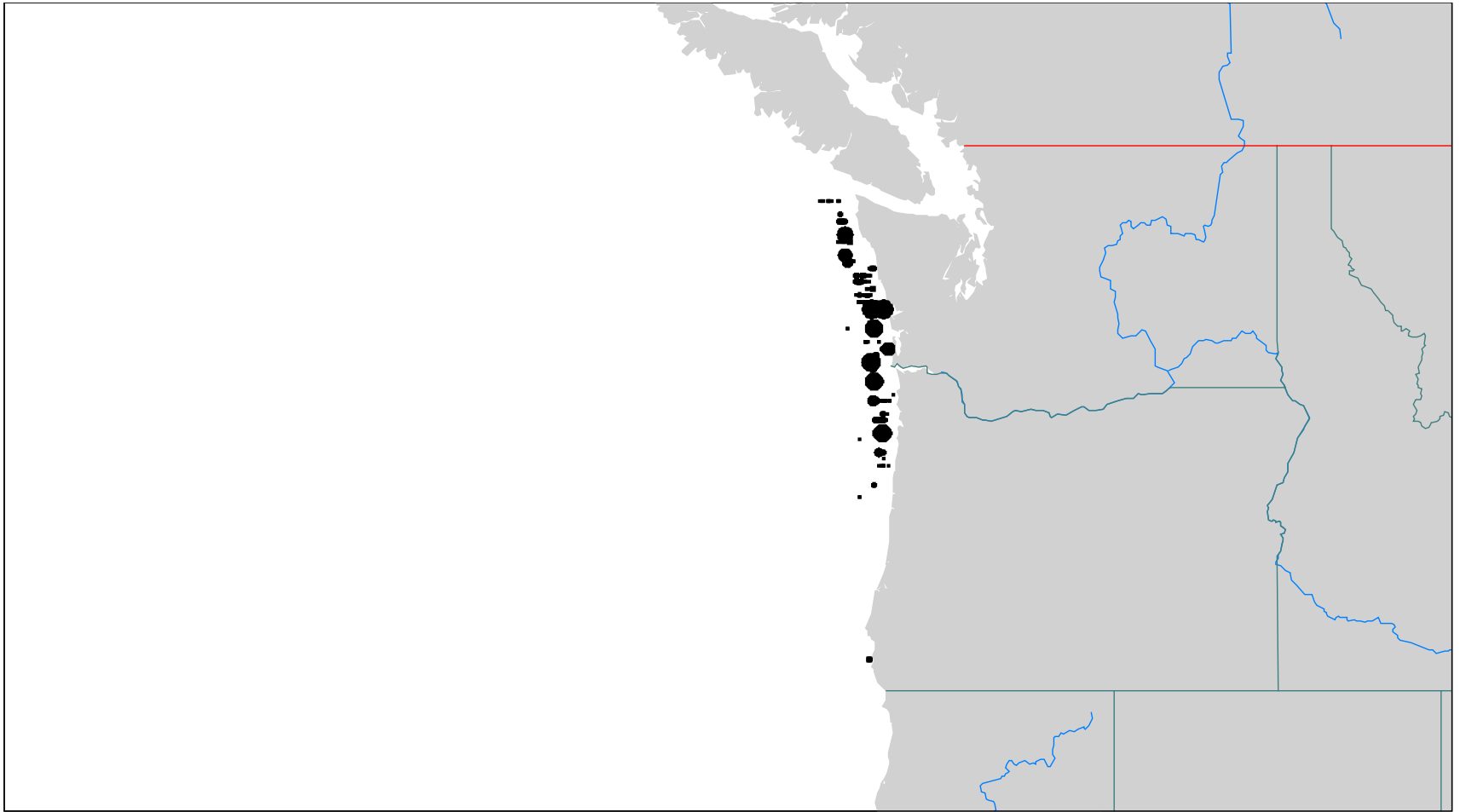
Transect SET A,B,C Transects 41-50



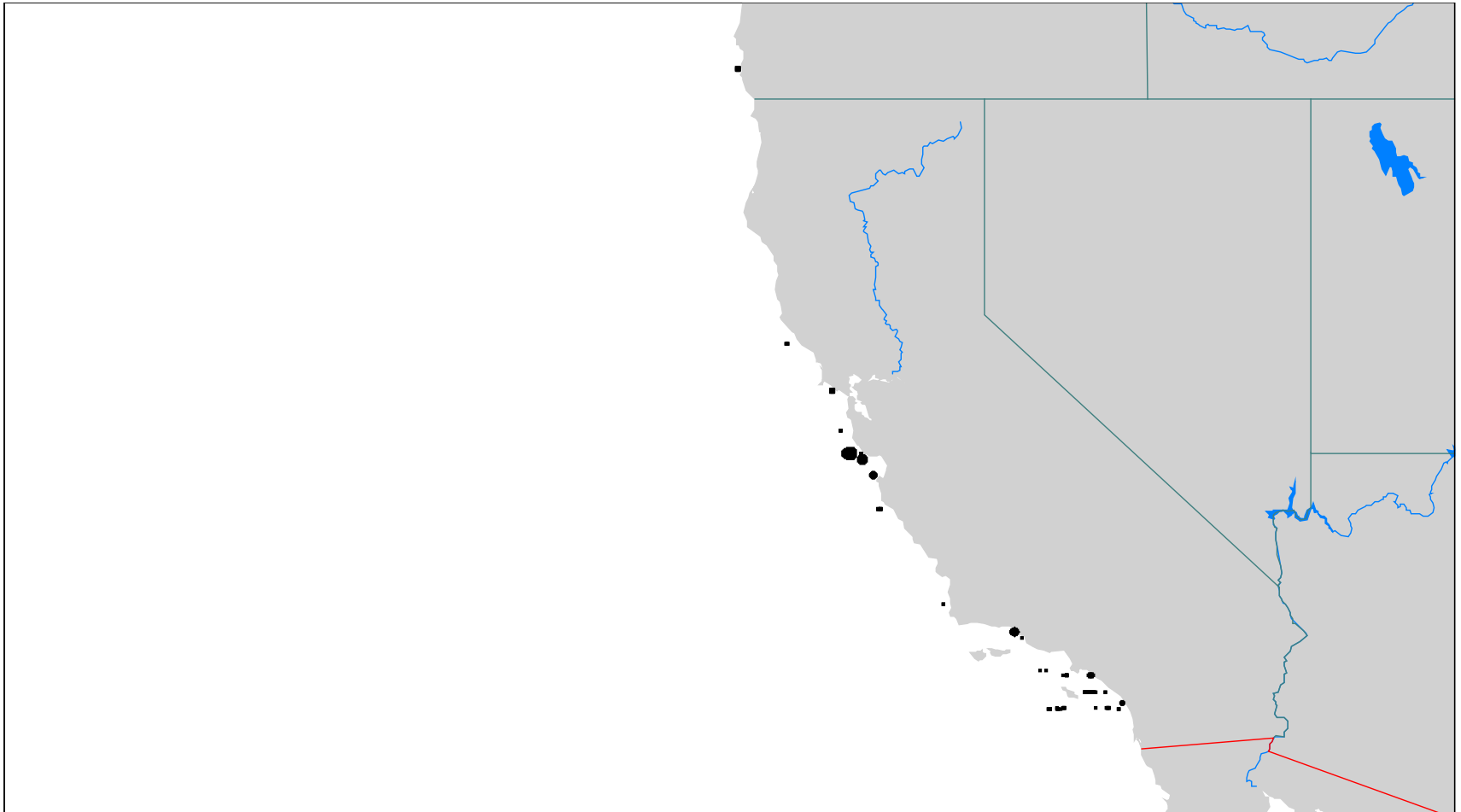
Transect SET A,B,C Transects 51-66



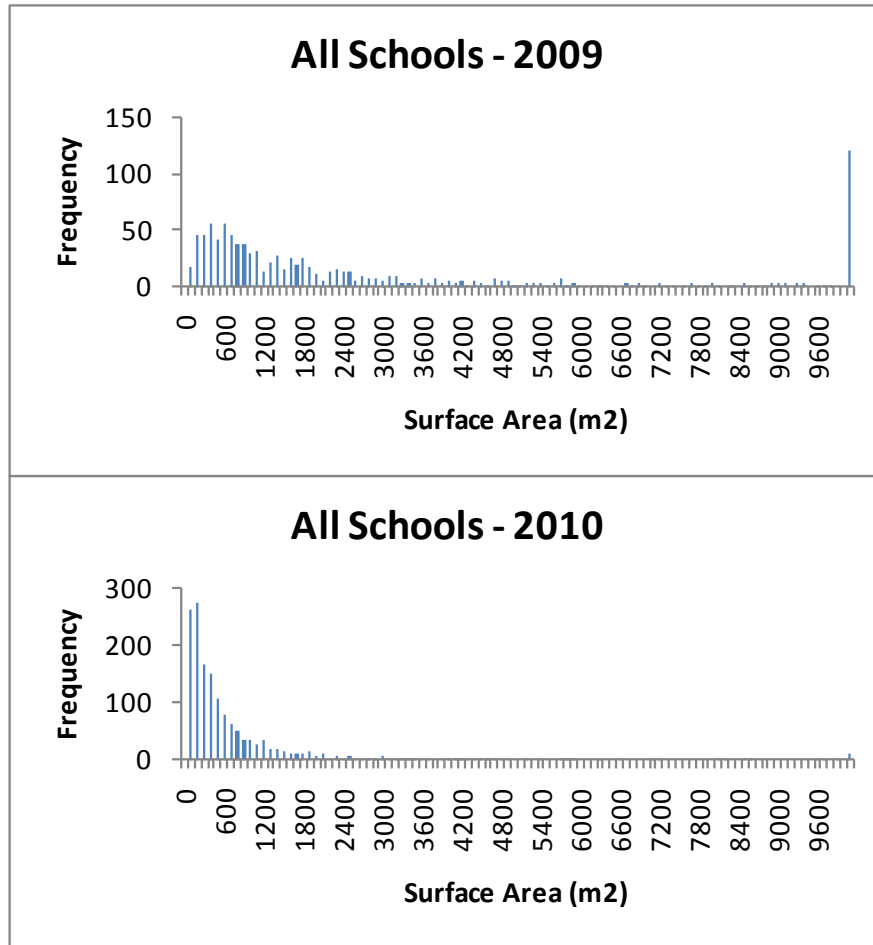
2010 School Locations - North



2010 School Locations - South



Size of Schools on Transects



Transect Summary Results

Coastwide		No. of Transects Sampled	No. of Schools	Avg. School Area (m2)	Total School Area (m2)	Total School Biomass (mt)
2009		41	1,033	9,853	10,178,228	85,371
2010	Rep A	63	642	775	497,841	12,597
	Rep B	59	230	1,198	275,467	5,719
	Rep C	60	618	572	353,198	9,633
	2010 Total	182	1,490	756	1,126,506	27,949
North		No. of Transects Sampled	No. of Schools	Avg. School Area (m2)	Total School Area (m2)	Total School Biomass (mt)
2010	Rep A	26	504	868	437,607	10,698
	Rep B	26	177	1,348	238,645	4,818
	Rep C	25	281	902	253,482	6,235
	2010 Total	77	962	966	929,734	21,752
South		No. of Transects Sampled	No. of Schools	Avg. School Area (m2)	Total School Area (m2)	Total School Biomass (mt)
2010	Rep A	37	138	436	60,234	1,899
	Rep B	33	53	695	36,822	901
	Rep C	35	337	296	99,716	3,398
	2010 Total	105	528	373	196,772	6,198

2010 Point Sets - North



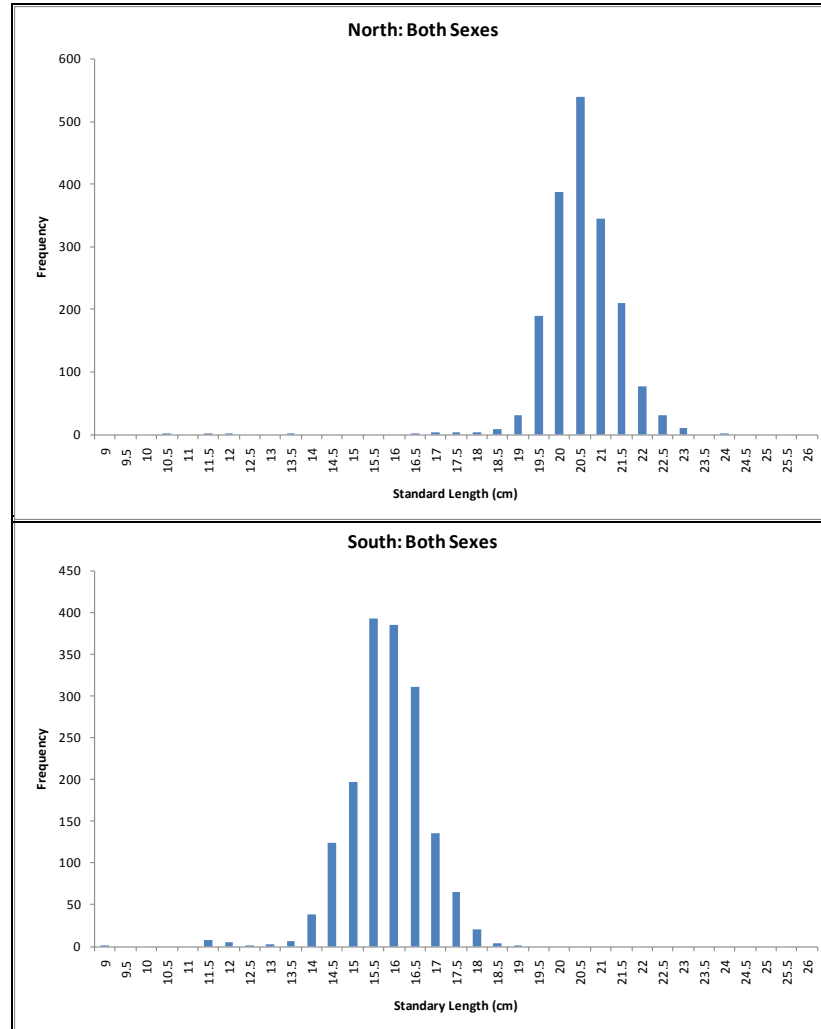
2010 Point Sets - South



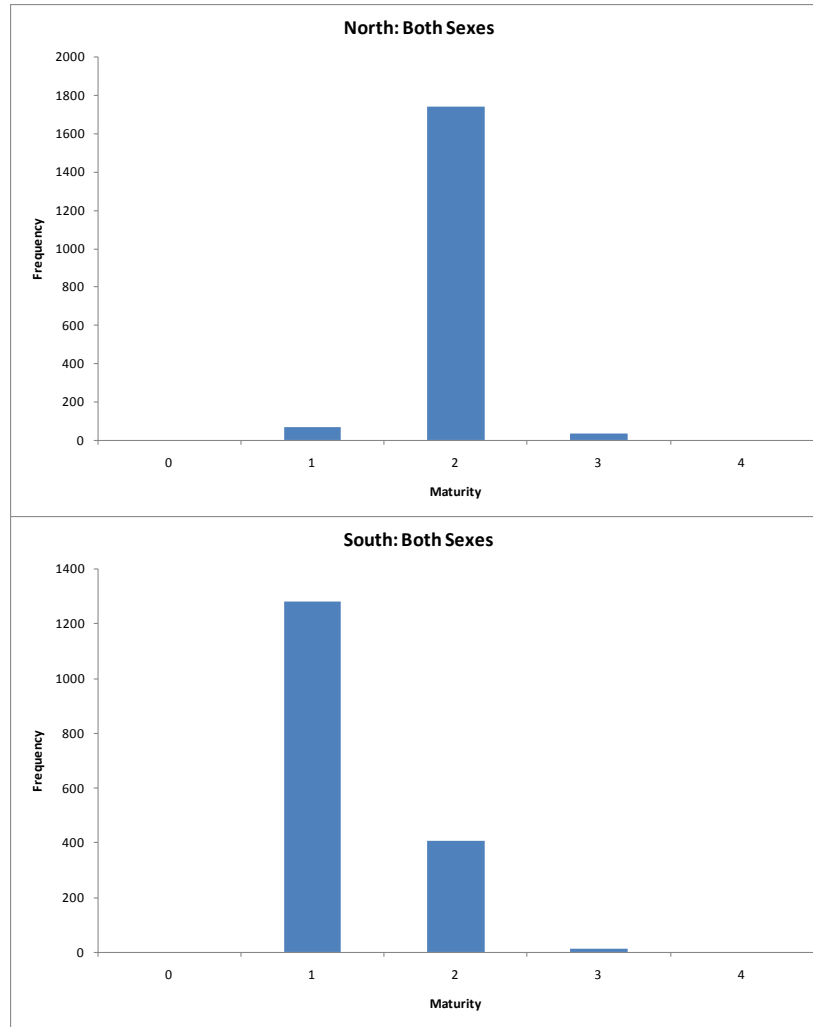
Size of Point Sets Landed

Weight (mt)	No. Planned	North	South
3.8	8	0	1
10.6	8	0	3
17.0	8	1	6
26.5	8	0	6
51.9	8	19	9
70.5	8	7	4
82.1	8	7	3
95.0	0	0	2
115.0	0	2	0
140.0	0	1	0
	56	37	34

Point Set Sampling – Length Frequency

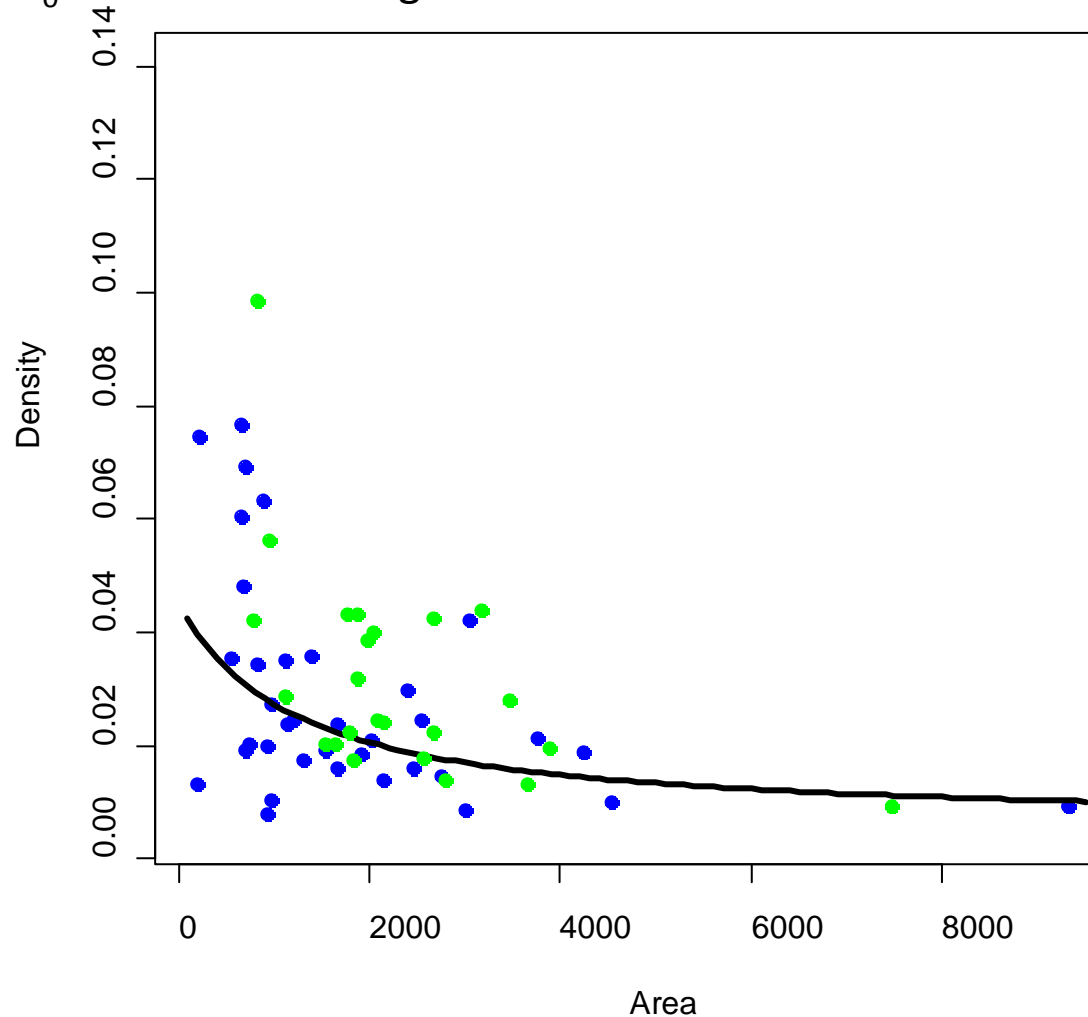


Point Set Sampling – Maturity



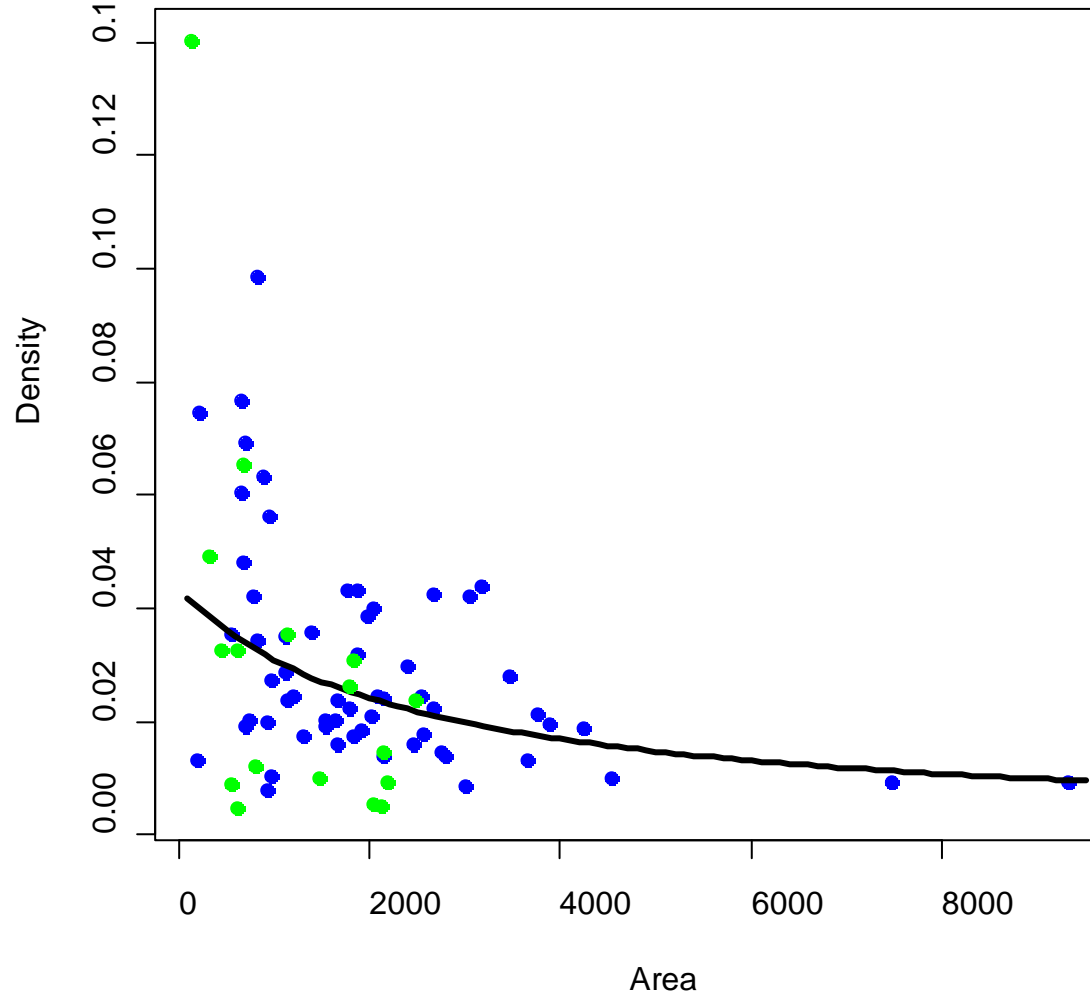
Plot of point set data – Density (mt/m²) vs. Area (m²):

- Data from the 2009 analysis (blue points – solid line)
- New data from the north in 2010 (green points – dashed line)
- Likelihood ratio test $P = 0.189$
- Fail to reject H_0 at 0.05 level of significance



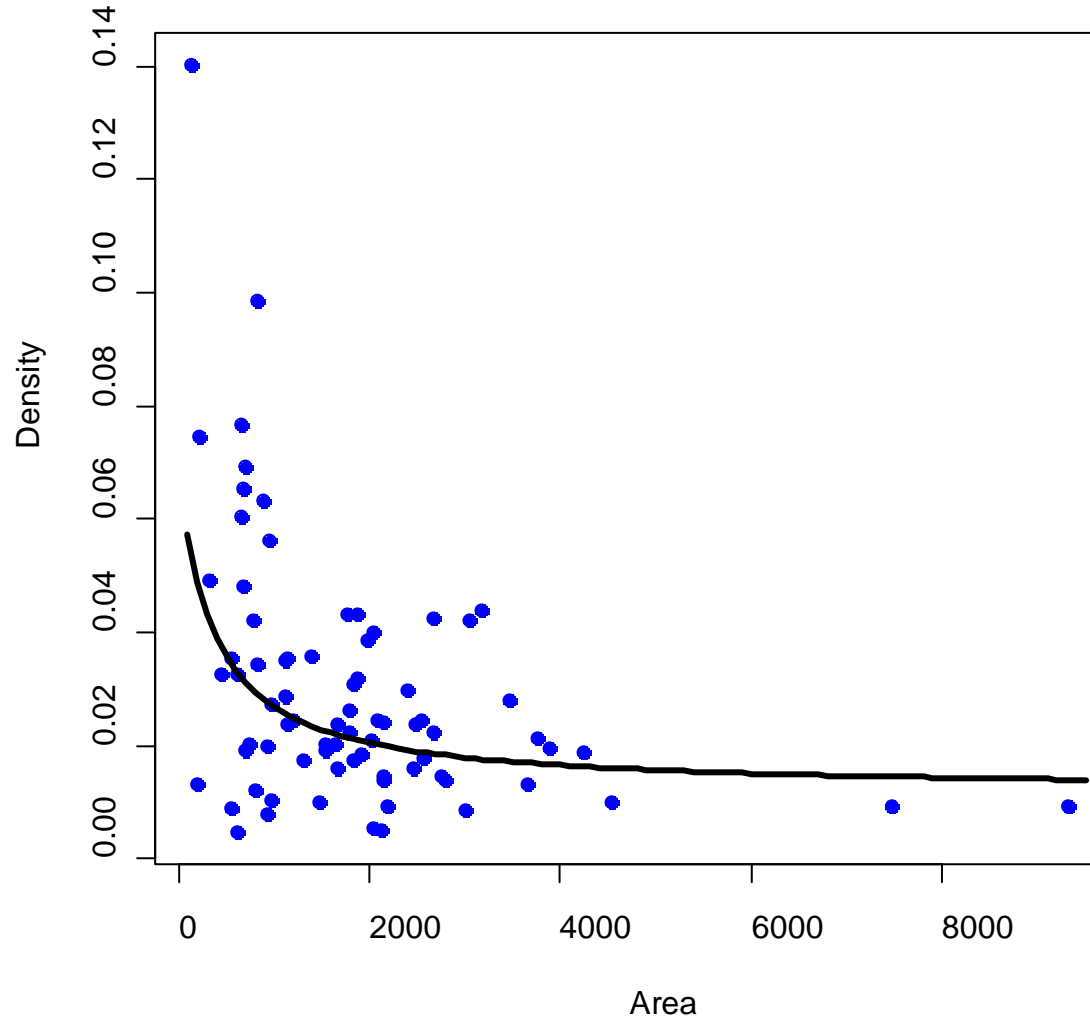
Plot of point set data – Density (mt/m²) vs. Area (m²):

- All years pooled from the north (blue points – solid line)
- New data from the south in 2010 (green points – dashed line)
- Likelihood ratio test $P = 0.029$
- Reject H_0 at 0.05 level of significance



Plot of point set data – Density (mt/m²) vs. Area (m²):

- All years and regions pooled



Biomass Estimates

Region	Point Set Data File	Biomass Estimate (mt)		CV	Area-Biomass Calibration Parameters		
					asyp	yint	cc
Runs conducted at the STAR panel meeting 10-5-2010							
North	cdata2010n	Total	173,390	0.42	0.0057	0.2020	257.5
		Rep A	263,331				
		Rep B	100,626				
		Rep C	156,214				
South	cdata2010s	Total	27,695	0.56	0.0061	0.1392	100.0 (bound)
		Rep A	21,511				
		Rep B	10,767				
		Rep C	50,806				

Estimation of School Density

Michaelis-Menten model with log-normal error

$$= (y_{\text{int}} * cc + \text{asymp} * x) / (cc + x)$$

where

x = school density (mt/m²)

cc = school area (m²)

y_{int} = y intercept

asymp = asymptote as $x \rightarrow$ infinity

asymp/cc = slope at the origin .

Estimation of Total Biomass

Where:

- = school biomass (mt)
- = school density (mt/m²)
- = school area (m²)

Where:

- = mean sampled biomass for the study area
- = sum of school biomass on a transect
- = number of transects sampled

Where:

- = total biomass for the study area
- N = total number of transects possible

Bootstrapping Procedure to Estimate CV

- 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 $n = 100,000$ bootstraps:
 - a. One realization of the MM parameters was selected from the matrix of simulated parameters.
 - b. The predicted MM curve was calculated.
 - c. Total biomass for the study area was estimated for each of the three replicate transect sets.
 - d. One of the three replicate estimates of total biomass was selected at random and stored.
- 5) The standard error (SE) was calculated from the stored bootstrap estimates of biomass (4d).
- 6) CV was calculated as $CV = SE/$.

Figure 4. NWSS point sets conducted during the Aerial Sardine Survey in 2010.

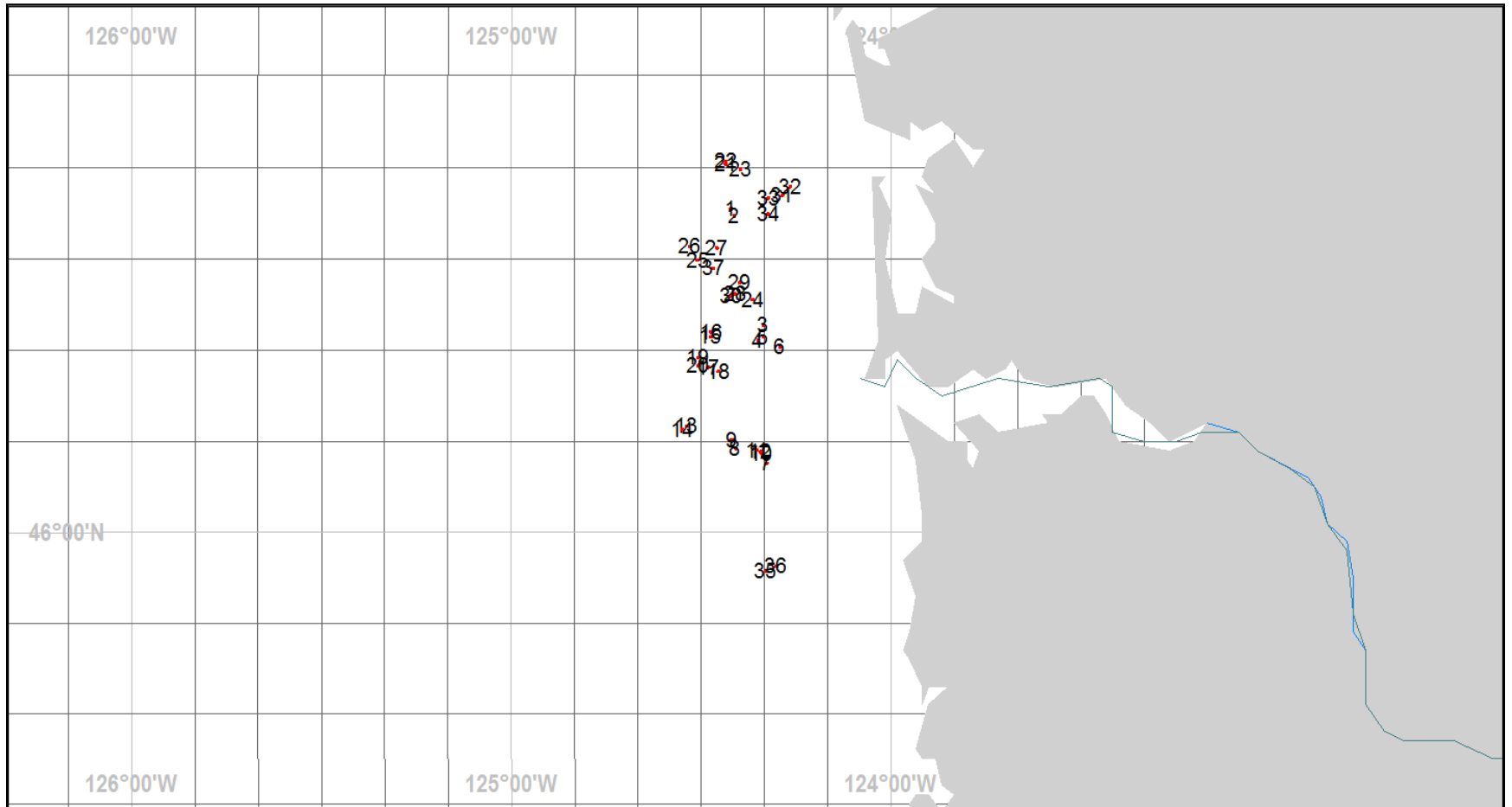
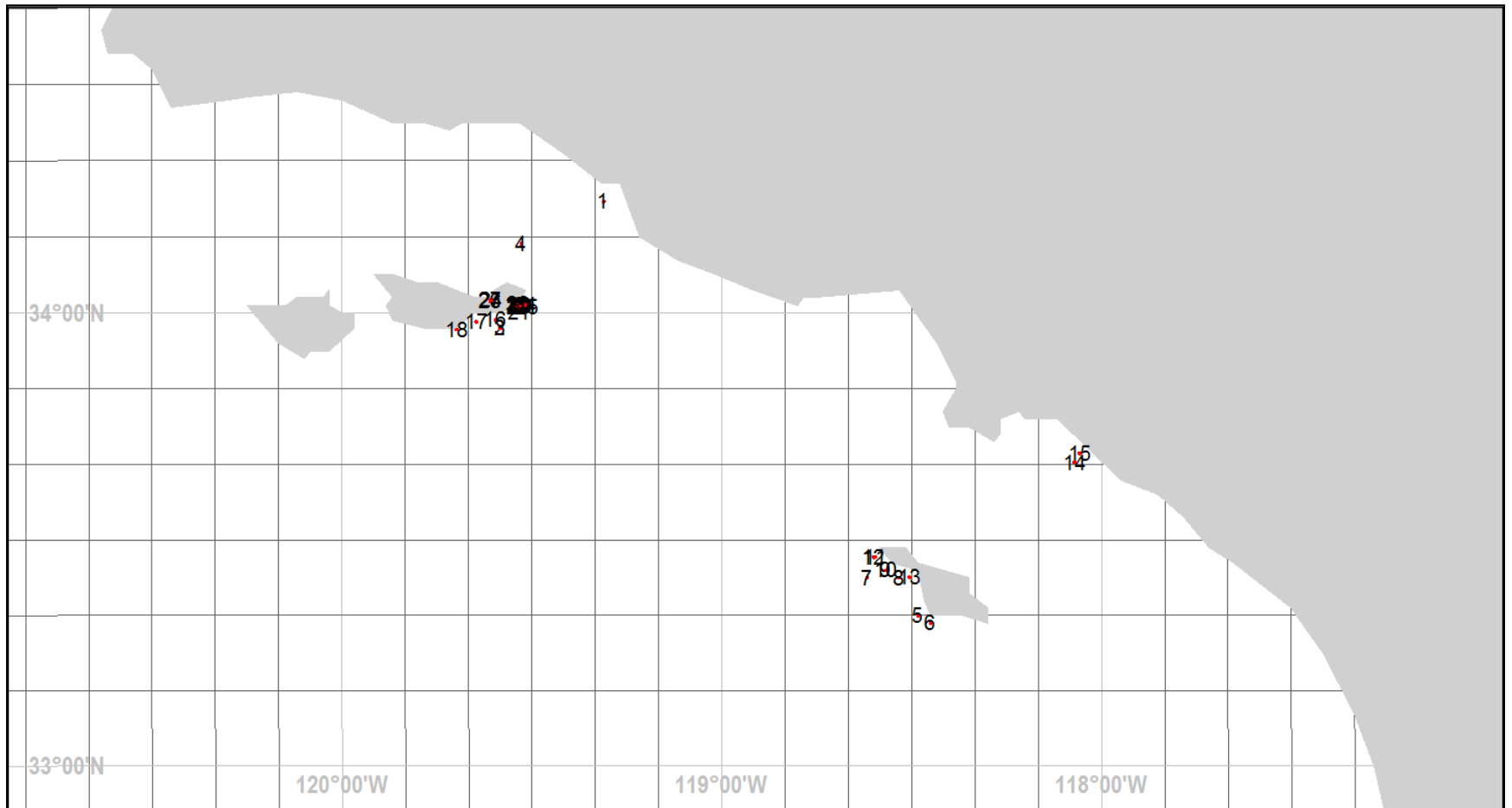


Figure 5. CWPA point sets conducted during the Aerial Sardine Survey in 2010.



Point Set Data - Likelihood Ratio Tests

Comparison of data from the north used in the 2009 analysis with the new 2010 data from the north:				
Model Data	Data File Name	Model Name	Log Likelihood	df
(north 2008;2009 pooled)	cdata	mmfit	-28.26	33
(north 2010)	cdata2010n	mmfita	-11.46	21
(north 2008;2009;2010 pooled)	cdata2010np	mmfitb	-44.50	57
		LLcombined	-44.50	57
		LLseparate	-39.73	54
(LLseparate - LLcombined) =		4.76996845		
Chi Sq (df=3) P =		0.189	->Fail to reject H ₀ at 0.05 significance level.	
Comparison of all data from the north (pooled) with the new 2010 data from the south:				
Model Data	Data File Name	Model Name	Log Likelihood	df
(north 2008;2009;2010 pooled)	cdata2010np	mmfitb	-44.50	57
(south 2010)	cdata2010s	mmfitc	-19.75	14
(all data pooled)	cdata2010nsp	mmfitd	-73.28	74
		LLcombined	-73.28	74
		LLseparate	-64.24	71
(LLseparate - LLcombined) =		9.03413383		
Chi Sq (df=3) P =		0.029	->Reject H ₀ at 0.05 significance level.	

Region	Point Set Data File	Biomass Estimate (mt)		CV	Area-Biomass Calibration Parameters		
					asymp	yint	cc
Coastwide	cdata2010nsp	Total	138,379	0.30	0.0119	0.0707	338.0
		Rep A	176,561				
		Rep B	86,850				
		Rep C	151,726				
North (asymp = 0.001)	cdata2010np	Total	105,738	0.44	0.001 (bound)	0.0435	2375.5
		Rep A	157,749				
		Rep B	62,314				
		Rep C	97,150				
North (asymp = 0.005)	cdata2010np	Total	108,851	0.40	0.005 (bound)	0.0464	1649.4
		Rep A	161,448				
		Rep B	66,656				
		Rep C	98,450				
South	cdata2010s	Total	27,695	0.72	0.0061	0.1392	100.0 (bound)
		Rep A	21,511				
		Rep B	10,767				
		Rep C	50,806				
2009 (asymp = 0.001)	cdata2010np		794,159	2.08	0.001 (bound)	0.0435	2375.5
2009 (asymp = 0.005)	cdata2010np		1,247,250	1.12	0.005 (bound)	0.0464	1649.4
2009	cdata2010nsp		2,000,618	0.66	0.0119	0.0707	338.0
2009	cdata (2009)		1,236,911	1.12	0.0057	0.0455	1187.5