Appendix A

Acoustic-trawl estimates of sardine biomass off California during spring 2012

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This report summarizes results from the spring 2012 acoustic-trawl method (ATM) survey off central and southern California (**Fig. 1**). The survey was conducted from NOAA FSV *Bell M. Shimada* and chartered FV *Ocean Starr*. A cruise report and a manuscript including details of the ATM, these results, and the biomass estimates of other coastal pelagic fish species (CPS) are being finalized.

The ATM survey totaled 2 248 n.mi. of trackline spanning over 51 327 n.mi.^{2} and the expected distribution of the northern stock of Pacific sardine (**Fig. 1**). During daylight, from sunrise to sunset, multifrequency echosounders were used to sample acoustic backscatter from CPS. During nighttime, surface trawls were used to identify the proportions of CPS and their lengths. Due to their temporal-spatial proximity, data from trawl catches conducted each night were combined into clusters. Day and night, a continuous underway fish egg sampler (CUFES) was used to sample CPS eggs within 5 m of the sea-surface. Overall, only 14 catch clusters included CPS, and these clusters included a median of only 17 sardine.

Post-survey strata were defined with considerations to the sampling intensity, the presence of CPS in the echosounder and net samples, and the existence and abundance of sardine eggs in the CUFES samples (**Fig. 1**). The coastal region and the far offshore oceanic transects had no sardine (**Fig. 2**). The remaining offshore survey area was split into four strata (south-, mid-, central-, and north-offshore) for biomass estimations (**Table 1**). Within these stratum, the sparse trawl data were necessarily used to apportion the CPS backscatter to species (**Figs. 1 & 2**) and the sardine backscatter to length classes (**Figs. 3-5**).

The central-offshore stratum contained the largest concentration of CPS backscatter; trawl clusters with sardine; CUFES samples with sardine eggs (**Figs. 1 & 2**); about half of the area; and about 85% of the sardine (~0.421 million metric tons (Mt)). However, the CPS backscatter within this stratum was apportioned to species and sardine lengths based on nine trawl clusters that contained a total of only 175 sardine (**Table 1**), and, due to their proximity to high backscatter, mostly on only three clusters containing 37 fish (**Fig. 2**). The four strata (**Table 1**) contained a total sardine biomass of 0.470 Mt ($CI_{95\%}$ = [0.224; 0.750]; CV = 28.6%). The sardine abundance was comprised mostly of sardine with modal values of standard lengths (SL) at ~ 21 and 23 cm, corresponding to the putative 2009 cohort (**Table 2**).

Table 1. Sardine biomass by stratum for the spring 2012 survey.

Stratum		Transect		Trawls		Sardine		
Name	**Area (n.mi.)**	**Number**	**Distance (n.mi.)**	**CPS clusters**	**Number of sardine**	**Biomass (1000 tons)**	**95% confidence interval (1000 tons)**	***CV***
North-offshore	10283	3	236	1	61	31.63	0 - 68.91	95.6
Central-offshore	24846	12	1169	9	175	420.46	178.90 - 702.24	31.1
Mid-offshore[1]	4444	0	0	0	0	2.87	0.00 - 4.70	38.4
South-offshore	11754	4	609	4	261	14.52	9.41 - 19.65	20.5
Total	**51327**	**19**	**2248**	**14**	**497**	**469.48**	**223.83 - 749.56**	**28.6**

[1] The mean biomass density for the mid-offshore stratum was estimated from the densities of the bordering transects (i.e., the nearest transects from the central-offshore and south-offshore strata).

Table 2. Sardine abundance versus standard length for the spring 2012 survey using all positive sardine clusters, and sequentially removing clusters 12, 15, and 34 (see **Fig. 2**).

	Abundance			
Standard length (cm)	**All clusters (number);**	**No cluster 12 (number);**	**No cluster 15 (number);**	**No cluster 34 (number);**
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	63 911 373	0	63 911 373	65 641 845
18	0	0	0	0
19	57 833 499	103 898 256	104 630 872	57 833 499
20	602 555 207	630 934 637	594 249 915	612 144 909
21	750 656 682	871 142 584	780 843 471	643 559 792
22	369 584 592	397 825 774	412 229 319	210 278 827
23	700 811 155	555 210 916	726 845 298	709 986 816
24	576 472 913	448 673 208	415 317 565	528 773 022
25	185 021 711	167 175 095	231 819 084	90 717 682
26	407 022	407 022	407 022	407 022
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0

Figure 1. Acoustic backscatter from coastal pelagic fish species (CPS; left), proportions of CPS in trawl clusters (middle), and sardine egg densities from the continuous underway fish-egg sampler (CUFES).

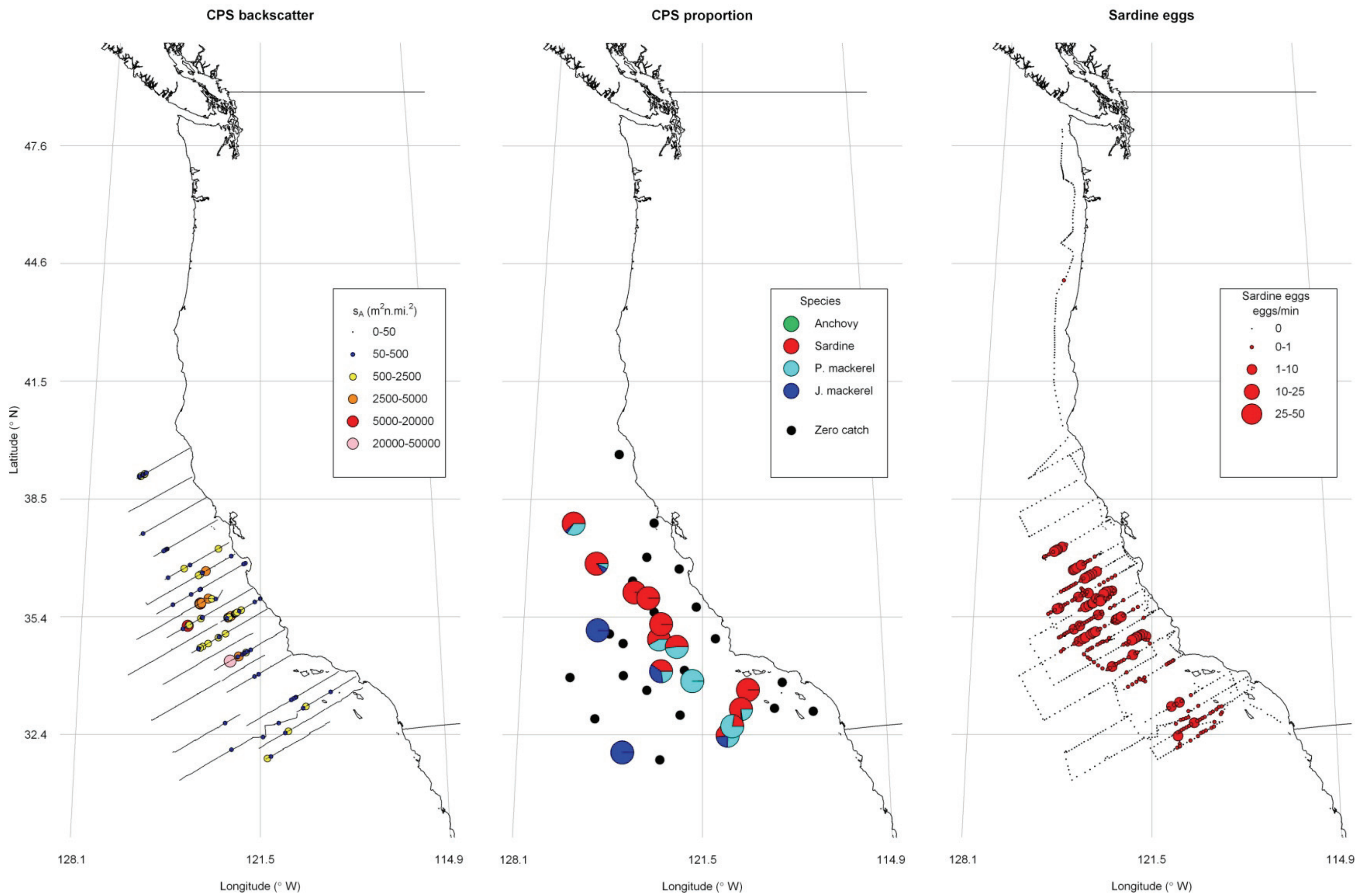


Figure 2. Sardine biomass densities versus stratum (**Table 1**) estimated using the acoustic-trawl method (ATM). The positions of trawl clusters containing sardine are indicated (numbers). Distributions of the density-weighted sardine lengths are shown in **Fig. 4**.

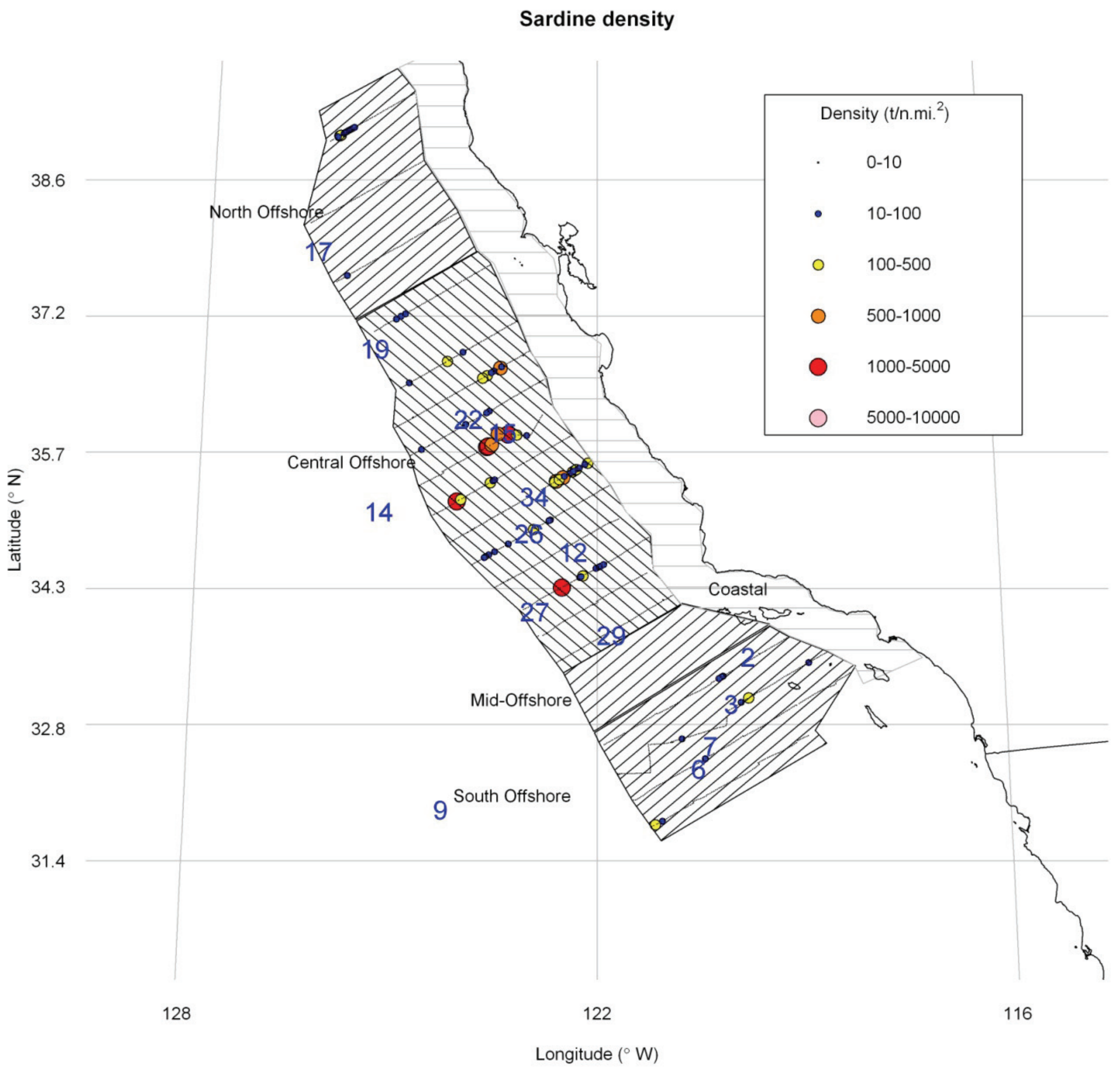


Figure 3. Distributions of sardine lengths versus trawl cluster, the total number of sardine caught in each cluster, and the proportions of the sardine abundances within each respective stratum represented by these data. The locations of the trawl clusters are shown in **Fig. 2**.

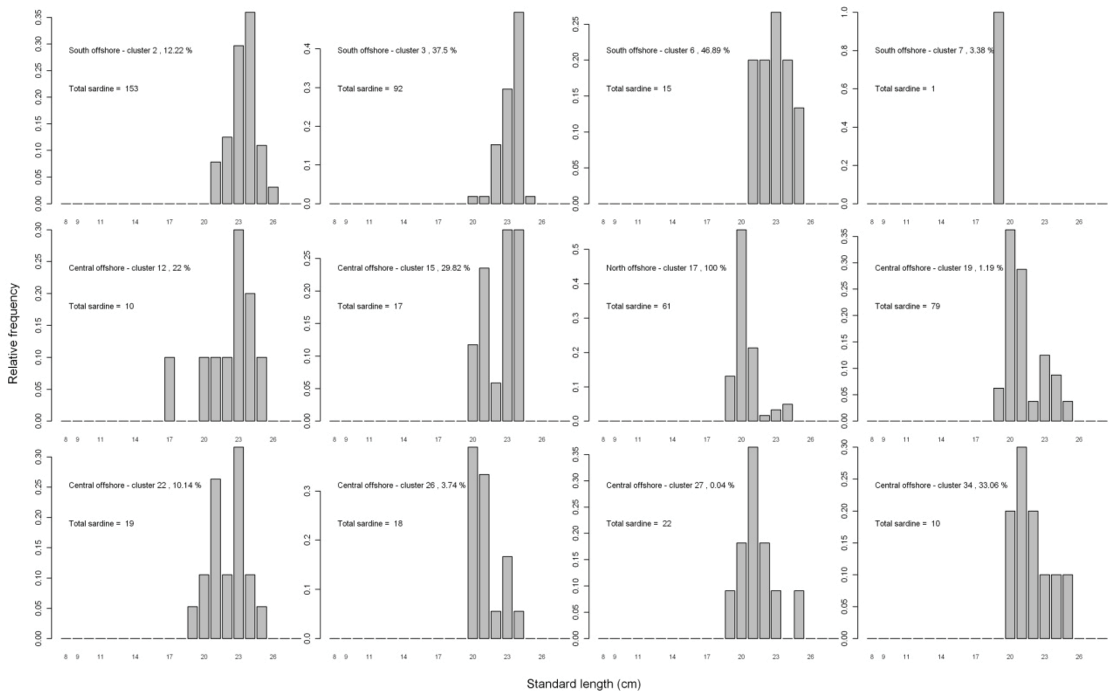


Figure 4. Sardine abundance versus standard length and stratum for the spring 2012 survey.

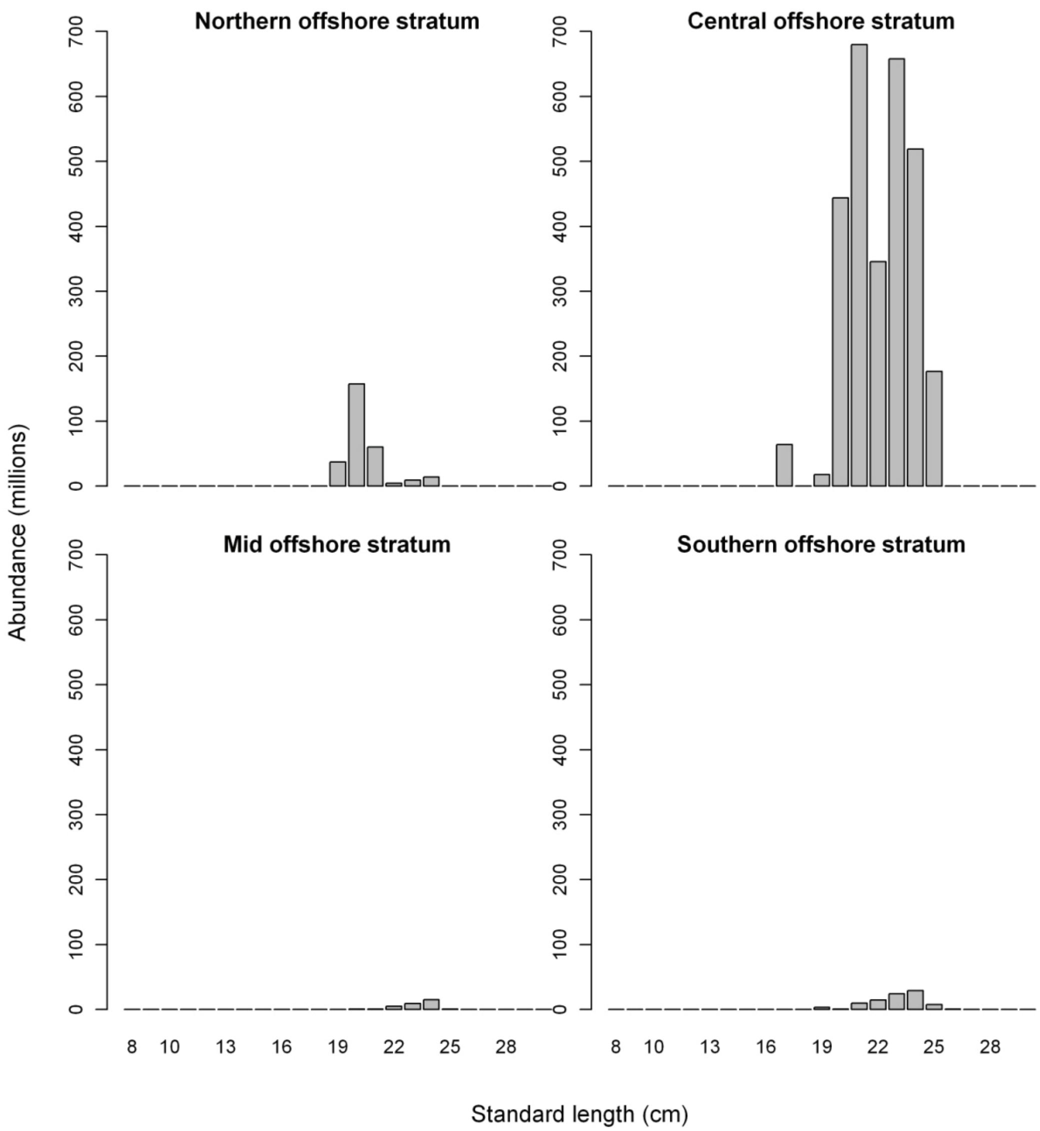
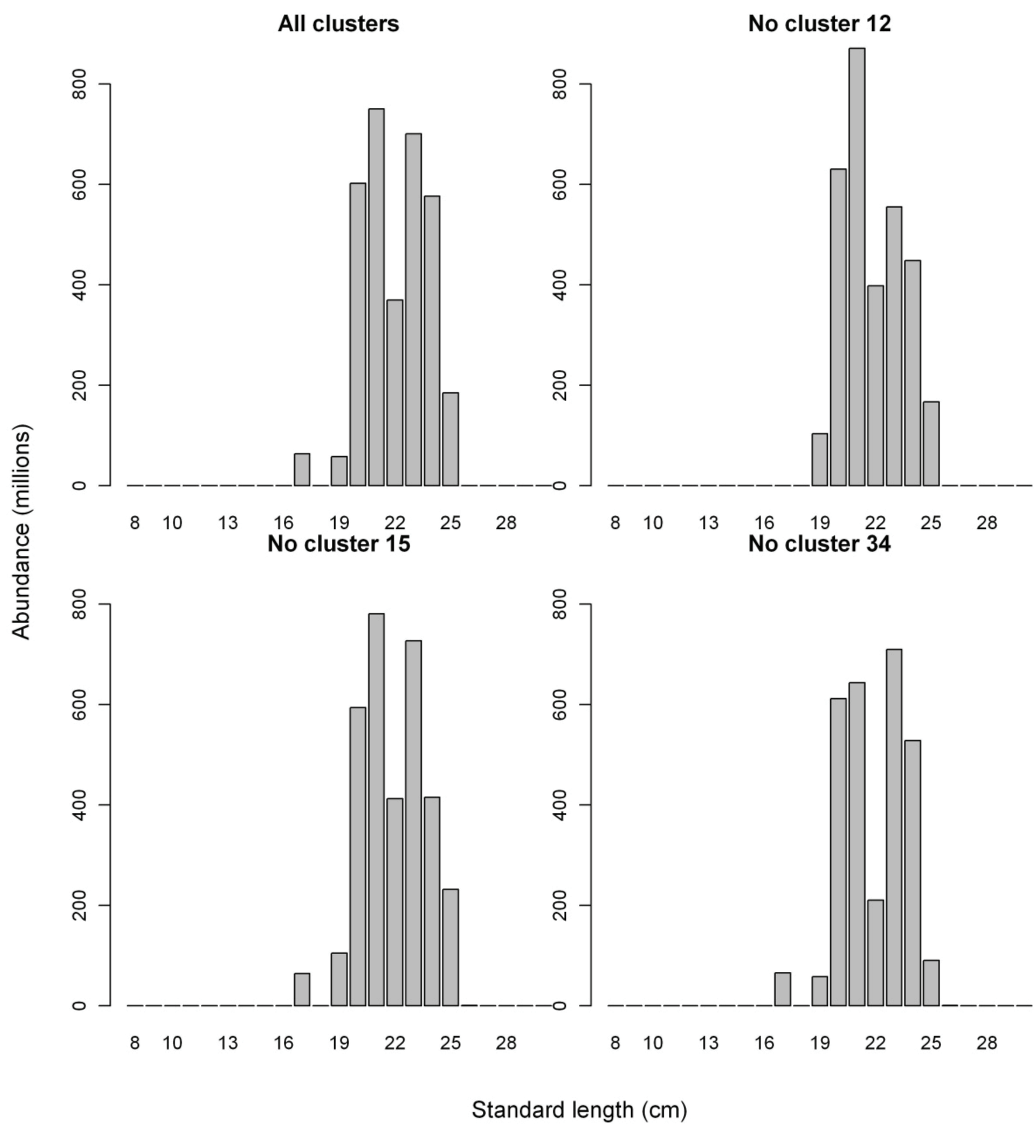


Figure 5. Sardine abundance versus standard length for the entire spring 2012 survey using all trawl clusters and sequentially removing clusters 12, 15 or 34 (**Figs. 2 & 3**) The data are provided in **Table 2**. This distribution and its bimodality are largely dependent on the catch locations and standard lengths of only 37 fish from the central stratum caught in those three clusters.



Acoustic-trawl estimates of sardine biomass off California during spring 2012.

Appendix B

Acoustic-trawl estimates of sardine biomass off the west coasts of the United States of America and Canada during summer 2012

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This report summarizes acoustic-trawl method (ATM) estimates of the sardine distribution and abundance from the summer 2012 survey (SaKe 2012) off the west coasts of the USA and Vancouver Island, Canada (**Fig. 1**). The survey was conducted from NOAA FSV *Bell M. Shimada*. A cruise report and a manuscript including details of the ATM, these results, and the biomass estimates of other coastal pelagic fish species (CPS) are being finalized.

The ATM survey totaled 3632 n.mi. of trackline spanning over 39 614 n.mi.^{2} and the expected distribution of the northern stock of Pacific sardine (**Fig. 1**). During daylight, from sunrise to sunset, multi-frequency echosounders were used to sample acoustic backscatter from CPS. During nighttime, surface trawls were used to identify the proportions of CPS and their lengths. Due to their temporal-spatial proximity, data from trawl catches conducted each night were combined into clusters. Overall, 31 catch clusters included CPS and these clusters included an average catch of 274 sardine (median = 7).

For biomass estimation, the survey area was split into three strata, each having relatively homogeneous species composition and density (Fig. 1; **Table 1**). The Oregon-California stratum contained the largest concentration of CPS backscatter and trawl clusters with sardine (**Figs. 1 & 2**). Sardine were concentrated north of San Francisco, off northern California and southern Oregon (**Fig. 2**).

The three strata (**Table 1**) contained a total sardine biomass of 0.341 Mt ($CI_{95\%}$ = [0.188; 0.688]; *CV* = 33.4%). The sardine abundance was comprised mostly of sardine with modal standard length (*SL*) ~ 21 cm, corresponding to the putative 2009 cohort (**Table 2**).

Table 1. Sardine biomass by stratum for the summer 2012 survey.

Stratum		Transect		Trawls		Sardine		
Name	Area (n.mi.)	Number	Distance (n.mi.)	CPS clusters (number)	Sardine (number)	Biomass (1000 tons)	95% confidence interval (1000 tons)	*CV* (%)
Vancouver Island	7370	15	698	8	1051	18.675	2.661 - 54.017	61.9
Washington-Oregon	10 832	20	915	9	3516	13.335	3.918 - 27.559	42.9
Oregon-California	17 295	39	1614	14	3920	308.821	150.872 - 650.235	37.3
Central California	4169	11	390	0	0	0	NA	NA
Total	**39 666**	**85**	**3632**	**31**	**8487**	**340.8311**	**187.666 - 687.523**	**33.4**

Table 2. Sardine abundance versus standard length for the summer 2012 survey using all positive sardine clusters (see **Fig. 2**).

Standard length (cm)	All clusters (number);
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	1906030
19	10394493
20	732568840
21	1160073971
22	372313768
23	243284246
24	148308909
25	15833336
26	1290773
27	0
28	0
29	0
30	0

Figure 1. Acoustic backscatter from coastal pelagic fish species (CPS; left); and proportions of CPS in trawl clusters (right).

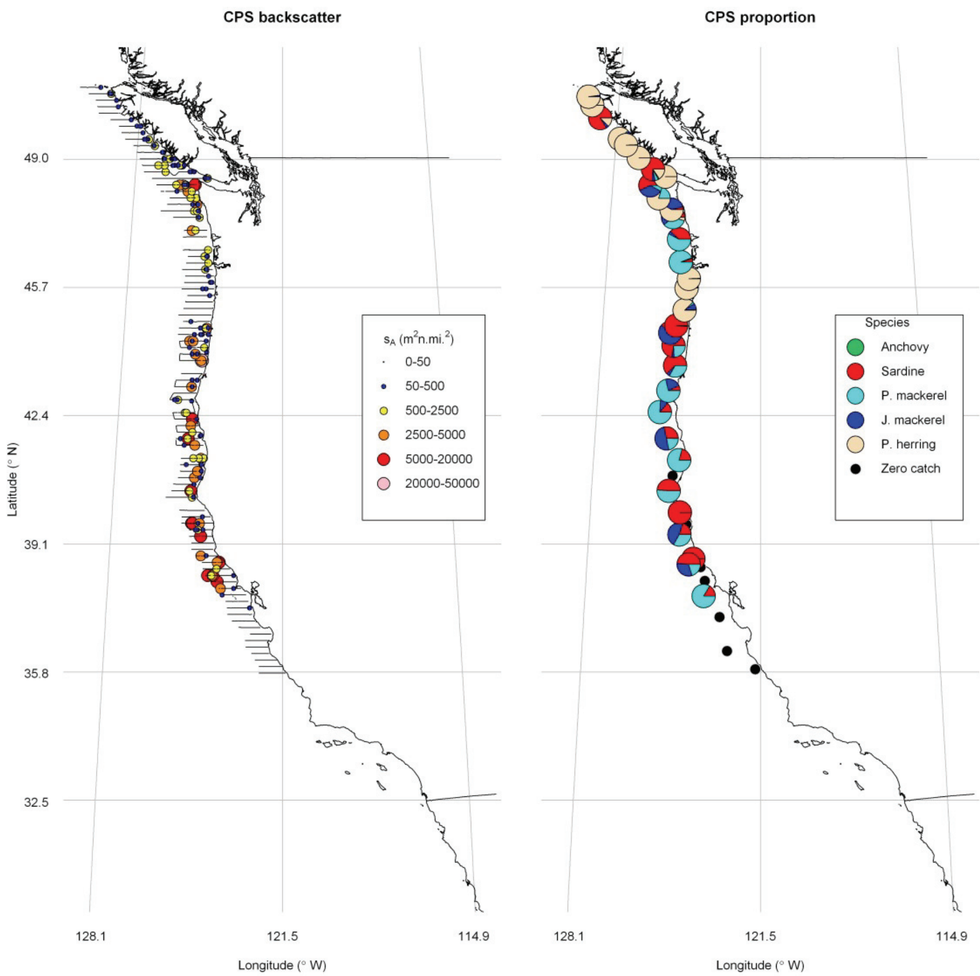


Figure 2. Sardine biomass densities versus stratum (**Table 1**) estimated using the acoustic-trawl method (ATM).

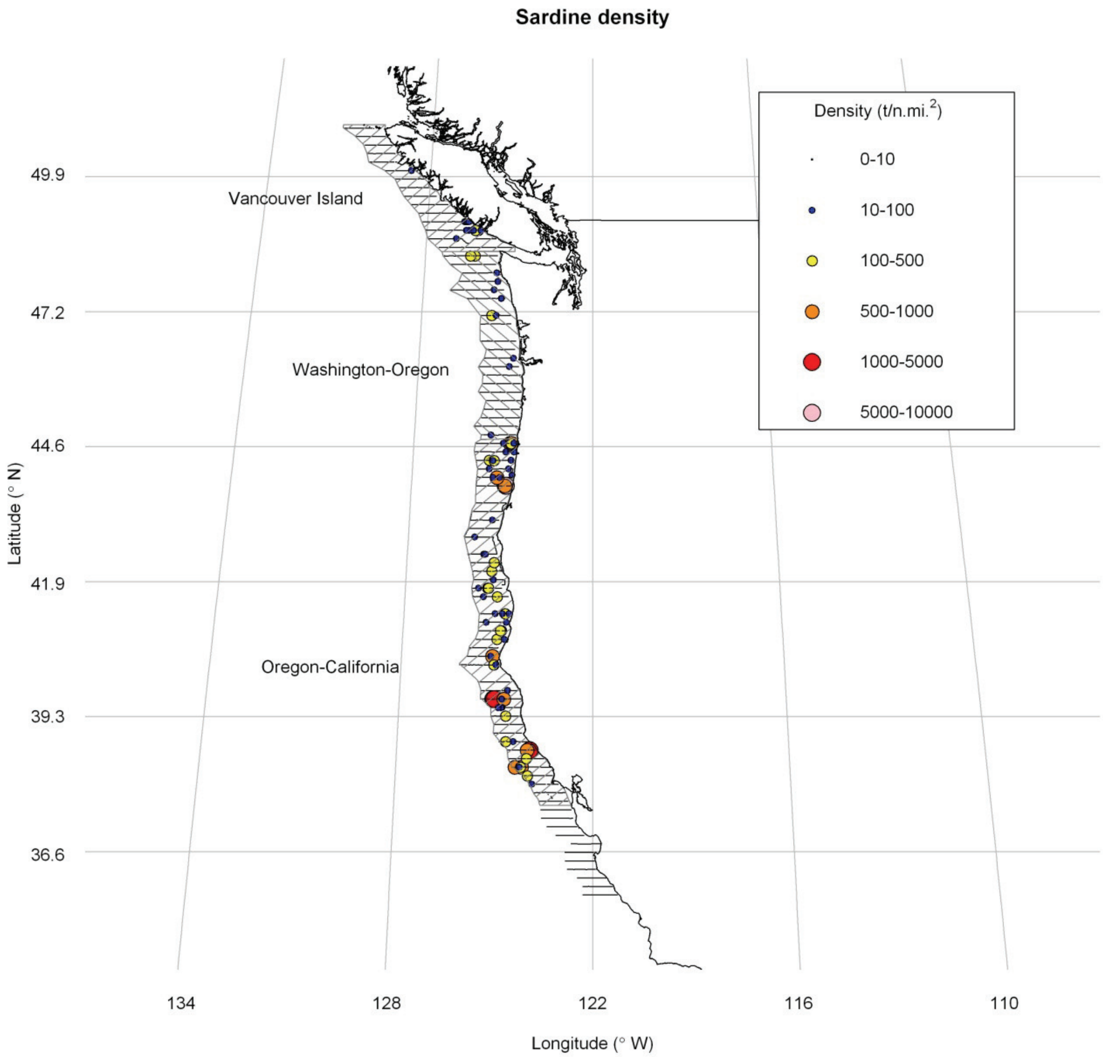
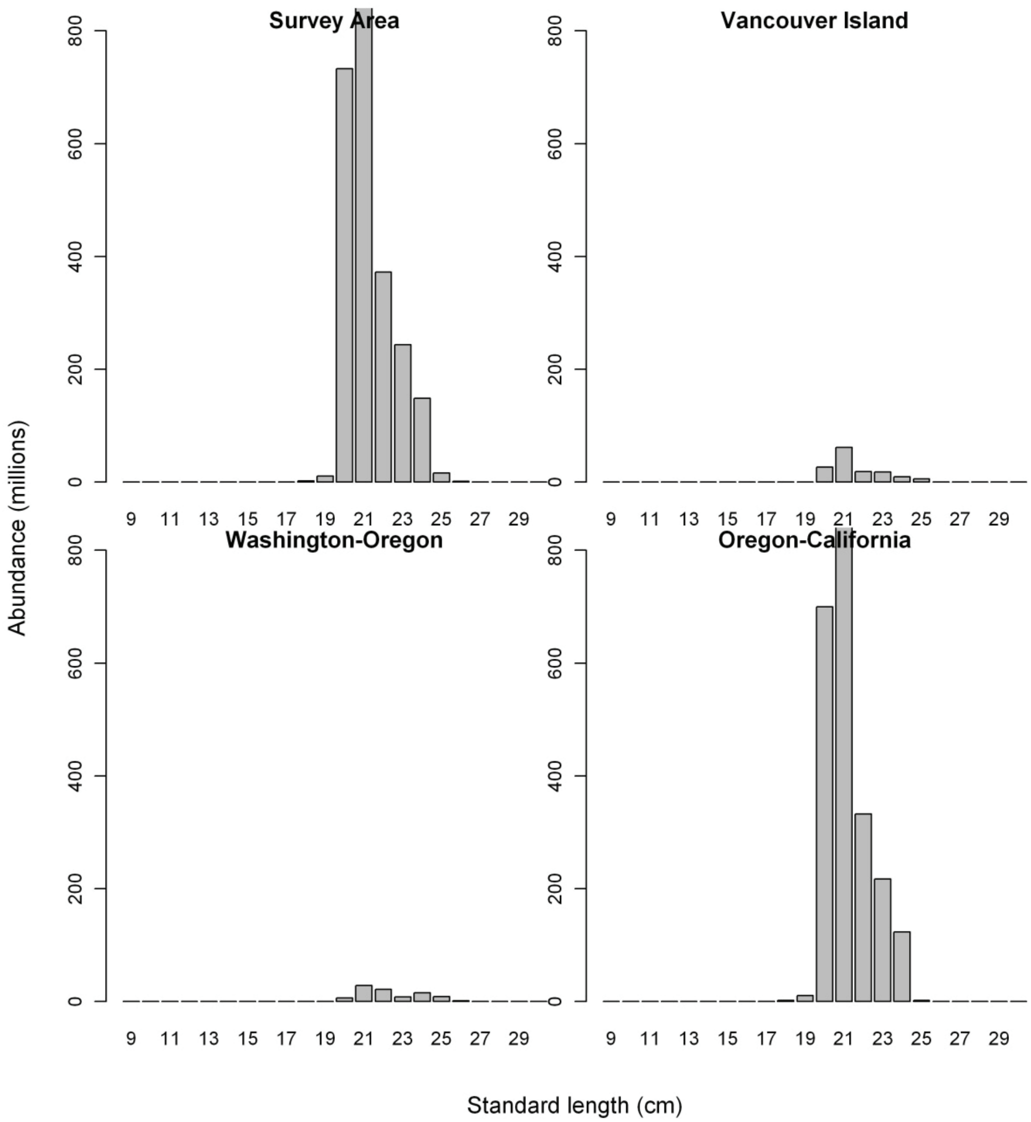


Figure 3. Sardine abundance versus standard length for the summer 2012 survey (SaKe 2012). Data for the entire survey are provided in **table 2**.



Appendix C – SS files for update model X6e

STARTER.SS

```
#V3.21a-win64
#Model X6e:
PS12_X6e.DAT
PS12_X6e.CTL
0 # 0=use init values in control file; 1=use ss3.par
1 # run display detail (0,1,2)
2 # detailed age-structured reports in REPORT.SSO (0,1,2)
1 # write detailed checkup.sso file (0,1)
3 # write parm values to ParmTrace.sso (0=no,1=good,active; 2=good,all; 3=every_iter,all_parms; 4=every,active)
2 # write to cumreport.sso (0=no,1=like&timeseries; 2=add survey fits)
0 # Include prior_like for non-estimated parameters (0,1)
1 # Use Soft Boundaries to aid convergence (0,1) (recommended)
1 # Number of datafiles to produce: 1st is input, 2nd is estimates, 3rd and higher are bootstrap
10 # Turn off estimation for parameters entering after this phase
10 # MCeval burn interval
2 # MCeval thin interval
0 # jitter initial parm value by this fraction
-1 # min yr for sdreport outputs (-1 for styr)
-1 # max yr for sdreport outputs (-1 for endyr; -2 for endyr+Nforecastyrs
0 # N individual STD years
#vector of year values
0.00001 # 0.00001 final convergence criteria (e.g. 1.0e-04)
0 # retrospective year relative to end year (e.g. -4)
1 # min age for calc of summary biomass
1 # Depletion basis:  denom is: 0=skip; 1=rel X*B0; 2=rel X*Bmsy; 3=rel X*B_styr
1 # Fraction (X) for Depletion denominator (e.g. 0.4)
4 # SPR_report_basis:  0=skip; 1=(1-SPR)/(1-SPR_tgt); 2=(1-SPR)/(1-SPR_MSY); 3=(1-SPR)/(1-SPR_Btarget);
4=rawSPR
4 # F_report_units: 0=skip; 1=exploitation(Bio); 2=exploitation(Num); 3=sum(Frates); 4=true F for range of ages
0 13 #COND 10 15 #_min and max age over which average F will be calculated with F_reporting=4
2 # F_report_basis: 0=raw; 1=F/Fspr; 2=F/Fmsy ; 3=F/Fbtgt
999 # check value for end of file
```

FORECAST.SS

```
#V3.21a-win64
# for all year entries except rebuilder; enter either: actual year, -999 for styr, 0 for endyr, neg number for
rel. endyr
1 # Benchmarks: 0=skip; 1=calc F_spr,F_btgt,F_msy
2 # MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt); 4=set to F(endyr)
0.4 # SPR target (e.g. 0.40)
0.4 # Biomass target (e.g. 0.40)
#_Bmark_years: beg_bio, end_bio, beg_selex, end_selex, beg_relF, end_relF (enter actual year, or values of 0 or
-integer to be rel. endyr)
 0 0 0 0 0 0
#  2010 2010 2010 2010 2010 2010 # after processing
1 #Bmark_relF_Basis: 1 = use year range; 2 = set relF same as forecast below
#
0 # Forecast: 0=none; 1=F(SPR); 2=F(MSY) 3=F(Btgt); 4=Ave F (uses first-last relF yrs); 5=input annual F scalar
0 # N forecast years
0 # F scalar (only used for Do_Forecast==5)
#_Fcast_years:  beg_selex, end_selex, beg_relF, end_relF  (enter actual year, or values of 0 or -integer to be
rel. endyr)
 9.09362e+223 1.9911e+209 6.21814e+175 2.28885e+243
#  1180631052 1667592815 7631713 1936290657 # after processing
0 # Control rule method (1=catch=f(SSB) west coast; 2=F=f(SSB) )
0 # Control rule Biomass level for constant F (as frac of Bzero, e.g. 0.40); (Must be > the no F level below)
0 # Control rule Biomass level for no F (as frac of Bzero, e.g. 0.10)
0 # Control rule target as fraction of Flimit (e.g. 0.75)
14 #_N forecast loops (1=OFL only; 2=ABC; 3=get F from forecast ABC catch with allocations applied)
0 #_First forecast loop with stochastic recruitment
0 #_Forecast loop control #3 (reserved for future bells&whistles)
0 #_Forecast loop control #4 (reserved for future bells&whistles)
0 #_Forecast loop control #5 (reserved for future bells&whistles)
0  #FirstYear for caps and allocations (should be after years with fixed inputs)
0 # stddev of log(realized catch/target catch) in forecast (set value>0.0 to cause active impl_error)
0 # Do West Coast gfish rebuilder output (0/1)
0 # Rebuilder:  first year catch could have been set to zero (Ydecl)(-1 to set to 1999)
0 # Rebuilder:  year for current age structure (Yinit) (-1 to set to endyear+1)
1 # fleet relative F:  1=use first-last alloc year; 2=read seas(row) x fleet(col) below
# Note that fleet allocation is used directly as average F if Do_Forecast=4
0 # basis for fcast catch tuning and for fcast catch caps and allocation  (2=deadbio; 3=retainbio; 5=deadnum;
6=retainnum)
# Conditional input if relative F choice = 2
# Fleet relative F:  rows are seasons, columns are fleets
#_Fleet:  ENS SCA_S1 SCA_S2 CCA_S1 CCA_S2 ORWA BC
#  0 0 0 0 0 0 0
#  0 0 0 0 0 0 0
# max totalcatch by fleet (-1 to have no max) must enter value for each fleet

# max totalcatch by area (-1 to have no max); must enter value for each fleet

# fleet assignment to allocation group (enter group ID# for each fleet, 0 for not included in an alloc group)
```

```
#_Conditional on >1 allocation group
# allocation fraction for each of: 0 allocation groups
# no allocation groups
0 # Number of forecast catch levels to input (else calc catch from forecast F)
0 # basis for input Fcast catch:  2=dead catch; 3=retained catch; 99=input Hrate(F) (units are from fleetunits; note new codes in SSV3.20)
# Input fixed catch values
#Year Seas Fleet Catch(or_F)

#
999 # verify end of input
```

PS12_X6E.CTL

```
#V3.21d-win64
#C - Sardine 2012 Update Model X6e
#_SS-V3.21d-safe-win64;_04/23/2011;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB
1 #_N_Growth_Patterns
1 #_N_Morphs_Within_GrowthPattern
#_Cond 1 #_Morph_between/within_stdev_ratio (no read if N_morphs=1)
#_Cond  1 #vector_Morphdist_(-1_in_first_val_gives_normal_approx)
#
1 # number of recruitment assignments (overrides GP*area*seas parameter values)
0 # recruitment interaction requested
# GP seas area for each recruitment assignment
1 1 1
#
#_Cond 0 # N_movement_definitions goes here if N_areas > 1
#_Cond 1.0 # first age that moves (real age at begin of season, not integer) also cond on do_migration>0
#_Cond 1 1 1 2 4 10 # example move definition for seas=1, morph=1, source=1 dest=2, age1=4, age2=10
#
1 #_Nblock_Patterns
1 #_blocks_per_pattern
# begin and end years of blocks
1999 2012 #_MexCal_selex
#
0.5 #_fracfemale
0 #_natM_type:_0=1Parm; 1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate
  #_no additional input for selected M option; read 1P per morph
1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=not implemented; 4=not implemented
0.5 #_Growth_Age_for_L1
999 #_Growth_Age_for_L2 15 (999 to use as Linf)
0 #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)
0 #_CV_Growth_Pattern:  0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A); 4 logSD=F(A)
1 #_maturity_option:  1=length logistic; 2=age logistic; 3=read age-maturity matrix by growth_pattern; 4=read age-fecundity; 5=read fec and wt from wtatage.ss
#_placeholder for empirical age-maturity by growth pattern
0 #_First_Mature_Age
1 #_fecundity option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b; (4)eggs=a+b*L; (5)eggs=a+b*W
0 #_hermaphroditism option:  0=none; 1=age-specific fxn
1 #_parameter_offset_approach (1=none, 2= M, G, CV_G as offset from female-GP1, 3=like SS2 V1.x)
1 #_env/block/dev_adjust_method (1=standard; 2=logistic transform keeps in base parm bounds; 3=standard w/ no bound check)
#
#_growth_parms
#_LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
 0.3 0.7 0.4 0 -1 99 -3 0 0 0 0 0 0 0 # NatM_p_1_Fem_GP_1
 3 15 10 0 -1 99 3 0 0 0 0 0 0 0 # L_at_Amin_Fem_GP_1
 20 30 25 0 -1 99 3 0 0 0 0 0 0 0 # L_at_Amax_Fem_GP_1
 0.05 0.99 0.4 0 -1 99 3 0 0 0 0 0 0 0 # VonBert_K_Fem_GP_1
 0.05 0.3 0.14 0 -1 99 3 0 0 0 0 0 0 0 # CV_young_Fem_GP_1
 0.01 0.1 0.05 0 -1 99 3 0 0 0 0 0 0 0 # CV_old_Fem_GP_1
 -3 3 1.68384e-005 0 -1 99 -3 0 0 0 0 0 0 0 # Wtlen_1_Fem
 -3 5 2.948247 0 -1 99 -3 0 0 0 0 0 0 0 # Wtlen_2_Fem
 9 19 15.88 0 -1 99 -3 0 0 0 0 0 0 0 # Mat50%_Fem
 -20 3 -0.90461 0 -1 99 -3 0 0 0 0 0 0 0 # Mat_slope_Fem
 0 10 1 0 -1 99 -3 0 0 0 0 0 0 0 # Eggs/kg_inter_Fem
 -1 5 0 0 -1 99 -3 0 0 0 0 0 0 0 # Eggs/kg_slope_wt_Fem
 -4 4 0 0 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_GP_1
 -4 4 1 0 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_Area_1
 -4 4 1 0 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_Seas_1
 -4 4 0 0 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_Seas_2
 1 1 1 0 -1 99 -3 0 0 0 0 0 0 0 # CohortGrowDev
#
#_Cond 0  #custom_MG-env_setup (0/1)
#
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no MG-environ parameters
#
# 1 #_custom_MG-block_setup (0/1)
#_Cond No MG parm trends
#
#_seasonal_effects_on_biology_parms
 0 0 0 0 0 0 0 0 0 0 #_femwtlen1,femwtlen2,mat1,mat2,fec1,fec2,Malewtlen1,malewtlen2,L1,K
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no seasonal MG parameters
#
#_Cond -4 #_MGparm_Dev_Phase
#
#_Spawner-Recruitment
2 #_SR_function: 1=B-H_flattop; 2=Ricker; 3=std_B-H; 4=CAA; 5=Hockey; 6=Shepard_3Parm
#_LO HI INIT PRIOR PR_type SD PHASE
3 25 16 0 -1 99 1 # SR_R0
```

```
0.2 4 2.5 0 -1 99 6 # SR_steep Ricker
0 2 0.727 0 -1 99 -3 # SR_sigmaR (FINAL_X5=0.622)
-5 5 0 0 -1 99 -3 # SR_envlink
-15 15 0 0 -1 99 2 # SR_R1_offset
0 0 0 0 -1 99 -3 # SR_autocorr
0 #_SR_env_link
0 #_SR_env_target_0=none;1=devs;_2=R0;_3=steepness
1 #do_recdev:  0=none; 1=devvector; 2=simple deviations
1993 #_first year of main recr_devs; early devs can preceed this era (FINAL_X5=1993)
2010 #_last year of main recr_devs; forecast devs start in following year (FINAL_X5=2008)
1 #_recdev phase
1 # (0/1) to read 13 advanced options
-6 # -6 _recdev_early_start (0=none; neg value makes relative to recdev_start)
2 # 2 _recdev_early_phase
0 # 0 _forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)
1 # 1 _lambda for Fcast_recr_like occurring before endyr+1
1987 #_last_early_yr_nobias_adj_in_MPD (FINAL_X5=1987)
1994 #_first_yr_fullbias_adj_in_MPD (FINAL_X5=1994)
2010 #_last_yr_fullbias_adj_in_MPD (FINAL_X5=2008)
2011 #_first_recent_yr_nobias_adj_in_MPD (FINAL_X5=2009)
0.9 # 1 0.9 _max_bias_adj_in_MPD (-1 to override ramp and set biasadj=1.0 for all estimated recdevs)
0 #_period of cycles in recruitment (N parms read below)
-5 #min rec_dev
5 #max rec_dev
0 #_read_recdevs
#_end of advanced SR options
#
#_placeholder for full parameter lines for recruitment cycles
# read specified recr devs
#_Yr Input_value
#
#
#Fishing Mortality info
0.1 # F ballpark for tuning early phases
-2006 # F ballpark year (neg value to disable)
3 # F_Method:  1=Pope; 2=instan. F; 3=hybrid (hybrid is recommended)
4 # max F or harvest rate, depends on F_Method
# no additional F input needed for Fmethod 1
# if Fmethod=2; read overall start F value; overall phase; N detailed inputs to read
# if Fmethod=3; read N iterations for tuning for Fmethod 3
10  # N iterations for tuning F in hybrid method (recommend 3 to 7)
#
#_initial_F_parms
#_LO HI INIT PRIOR PR_type SD PHASE
0 4 0 0 -1 99 -1 # InitF_1MexCal_S1
0 4 0 0 -1 99 -1 # InitF_2MexCal_S2
0 4 0 0 -1 99 -1 # InitF_3PacNW
#
#_Q_setup
 # Q_type options:  <0=mirror, 0=median_float, 1=mean_float, 2=parameter, 3=parm_w_random_dev,
4=parm_w_randwalk, 5=mean_unbiased_float_assign_to_parm
 #_Den-dep  env-var  extra_se  Q_type
0 0 0 0 # 1 MexCal_S1
0 0 0 0 # 2 MexCal_S2
0 0 0 0 # 3 PacNW
0 0 0 2 # 4 DEPM
0 0 0 2 # 5 TEP
0 0 0 2 # 6 TEP_all
0 0 0 2 # 7 Aerial
0 0 0 2 # 8 Acoustic
#
#_Cond 0 #_If q has random component, then 0=read one parm for each fleet with random q; 1=read a parm for each
year of index
#_Q_parms(if_any)
# LO HI INIT PRIOR PR_type SD PHASE
-3 3 -1.39 0 -1 99 5 # Q_base_8_DEPM
-3 3 -0.69 0 -1 99 5 # Q_base_9_TEP
-3 3 -0.69 0 -1 99 5 # Q_base_9_TEP_all
-3 3 0 0 -1 99 5 # Q_base_10_Aerial
-3 3 0 0 -1 99 -5 # Q_base_11_Acoustic
#
#_size_selex_types
#_Pattern Discard Male Special
24 0 0 0 # 1 MexCal_S1
24 0 0 0 # 2 MexCal_S2
1 0 0 0 # 3 PacNW
30 0 0 0 # 4 DEPM
30 0 0 0 # 5 TEP
30 0 0 0 # 6 TEP_full
24 0 0 0 # 7 Aerial 15 0 0 3
24 0 0 0 # 8 Acoustic
#
#_age_selex_types
#_Pattern ___ Male Special
11 0 0 0 # 1 MexCal_S1
11 0 0 0 # 2 MexCal_S2
11 0 0 0 # 3 PacNW
11 0 0 0 # 4 DEPM
11 0 0 0 # 5 TEP
11 0 0 0 # 6 TEP_full
11 0 0 0 # 7 Aerial
11 0 0 0 # 8 Acoustic
```

```
#_LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
#_MexCal_S1_Baseline_Selex
 10 28 18 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_2P_1_MexCal_S1
 -5 3 3 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_2P_2_MexCal_S1
 -1 9 2.5 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_2P_3_MexCal_S1
 -1 9 4 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_2P_4_MexCal_S1
 -10 10 -10 0 -1 99 -4 0 0 0 0 0 1 2 # SizeSel_2P_5_MexCal_S1
 -10 10 10 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_2P_6_MexCal_S1
#_MexCal_S2_Baseline_Selex
 10 28 18 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_2P_1_MexCal_S2
 -5 3 -4.9 0 -1 99 -4 0 0 0 0 0 1 2 # SizeSel_2P_2_MexCal_S2
 -1 9 2.5 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_2P_3_MexCal_S2
 -1 9 4 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_2P_4_MexCal_S2
 -10 10 -10 0 -1 99 -4 0 0 0 0 0 1 2 # SizeSel_2P_5_MexCal_S2
 -10 10 10 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_2P_6_MexCal_S2
#_PacNW_Baseline_Selex
 10 28 18 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_6P_1_PacNW_logistic
 1 16 4 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_6P_2_PacNW_logistic
#_Aerial_Baseline_Selex
 10 28 18 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_2P_1_Aerial
 -5 3 3 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_2P_2_Aerial
 -1 9 2.5 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_2P_3_Aerial
 -1 9 4 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_2P_4_Aerial
 -10 10 -10 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_2P_5_Aerial
 -10 10 10 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_2P_6_Aerial
#_Acoustic_Baseline_Selex
 10 28 18 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_8P_1_Acoustic
 -5 3 3 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_8P_2_Acoustic
 -1 9 2.5 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_8P_3_Acoustic
 -1 9 4 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_8P_4_Acoustic
 -10 10 -10 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_8P_5_Acoustic
 -10 10 10 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_8P_6_Acoustic
#_Age_Selex_Basline
 0 15 0 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_2P_1_MexCal_S1
 0 15 15 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_2P_2_MexCal_S1
 0 15 0 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_3P_1_MexCal_S2
 0 15 15 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_3P_2_MexCal_S2
 0 15 0 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_6P_1_PacNW
 0 15 15 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_6P_2_PacNW
 0 15 0 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_8P_1_DEPM
 0 15 15 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_8P_2_DEPM
 0 15 0 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_9P_1_TEP
 0 15 15 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_9P_2_TEP
 0 15 0 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_9P_1_TEP_full
 0 15 15 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_9P_2_TEP_full
 0 15 0 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_10P_1_Aerial
 0 15 15 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_10P_2_Aerial
 0 15 0 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_11P_1_Acoustic
 0 15 15 0 -1 99 -4 0 0 0 0 0 0 0 # AgeSel_11P_2_Acoustic
#
#_Cond 0 #_custom_sel-env_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no enviro fxns
1 #_custom_sel-blk_setup (0/1)
#_MexCal_S1_Block_2_Selex
 10 28 18 0 -1 99 4 # SizeSel_1P_1_MexCal_S1_BLK2repl_1999
 -5 3 -5 0 -1 99 -4 # SizeSel_1P_2_MexCal_S1_BLK2repl_1999
 -1 9 2.5 0 -1 99 4 # SizeSel_1P_3_MexCal_S1_BLK2repl_1999
 -1 9 4 0 -1 99 4 # SizeSel_1P_4_MexCal_S1_BLK2repl_1999
 -10 10 -10 0 -1 99 -4 # SizeSel_1P_5_MexCal_S1_BLK2repl_1999
 -10 10 10 0 -1 99 4 # SizeSel_1P_6_MexCal_S1_BLK2repl_1999
#_MexCal_S2_Block_2_Selex
 10 28 18 0 -1 99 4 # SizeSel_2P_1_MexCal_S2_BLK2repl_1999
 -5 3 -5 0 -1 99 -4 # SizeSel_2P_2_MexCal_S2_BLK2repl_1999
 -1 9 2.5 0 -1 99 4 # SizeSel_2P_3_MexCal_S2_BLK2repl_1999
 -1 9 4 0 -1 99 4 # SizeSel_2P_4_MexCal_S2_BLK2repl_1999
 -10 10 -10 0 -1 99 -4 # SizeSel_2P_5_MexCal_S2_BLK2repl_1999
 -10 10 10 0 -1 99 4 # SizeSel_2P_6_MexCal_S2_BLK2repl_1999
#
#_Cond No selex parm trends
#_Cond -4 # placeholder for selparm_Dev_Phase
1 #_env/block/dev_adjust_method (1=standard; 2=logistic trans to keep in base parm bounds; 3=standard w/ no
bound check)
#
# Tag loss and Tag reporting parameters go next
0  # TG_custom:  0=no read; 1=read if tags exist
#_Cond -6 6 1 1 2 0.01 -4 0 0 0 0 0 0 0  #_placeholder if no parameters
#
1 #_Variance_adjustments_to_input_values
#_fleet: 1 2 3 4 5 6 7 8
0.000000 0.000000 0.000000 0.404505 0.347977 0.000000 0.349533 0.221872 #_add_to_survey_CV
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_discard_stddev
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 #_add_to_bodywt_CV
1.860953 1.722981 0.602769 1.000000 1.000000 1.000000 0.584194 3.197891 #_mult_by_lencomp_N
0.800000 0.800000 0.250000 1.000000 1.000000 1.000000 1.000000 0.250000 #_mult_by_agecomp_N
1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 1.000000 #_mult_by_size-at-age_N
#
1 #_maxlambdaphase
1 #_sd_offset
#
17 # number of changes to make to default Lambdas (default value is 1.0)
# Like_comp codes:  1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage; 8=catch;
```

```
# 9=init_equ_catch; 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-
negbin
#like_comp fleet/survey  phase  value  sizefreq_method
 1 4 1 1 1       #_DEPM
 1 5 1 1 1       #_TEP
 1 6 1 0 1       #_TEP_full
 1 7 1 1 1       #_Aerial
 1 8 1 1 1       #_Acoustic
 4 1 1 1 1       #_MexCal-S1_lengths
 4 2 1 1 1       #_MexCal-S2_lengths
 4 3 1 1 1       #_PacNW_lengths
 4 7 1 1 1       #_Aerial_lengths
 4 8 1 1 1       #_Acoustic_lengths
 5 1 1 1 1       #_MexCal-S1_CondAL
 5 2 1 1 1       #_MexCal-S2_CondAL
 5 3 1 1 1       #_PacNW_CondAL
 5 8 1 1 1  #_Acoustic_CondAL
 9 1 1 0 1  #_init_equ_catch_MexCal-S1
 9 2 1 0 1  #_init_equ_catch_MexCal-S2
 9 3 1 0 1  #_init_equ_catch_PacNW
#
0 # (0/1) read specs for more stddev reporting
 # 0 1 -1 5 1 5 1 -1 5 # placeholder for selex type, len/age, year, N selex bins, Growth pattern, N growth
ages, NatAge_area(-1 for all), NatAge_yr, N Natages
 # placeholder for vector of selex bins to be reported
 # placeholder for vector of growth ages to be reported
 # placeholder for vector of NatAges ages to be reported
999
```

PS12_X6E.DAT

```
#V3.21d-win64
#_SS-V3.21d-safe-win64;_04/23/2011;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB
#_Start_time: Mon May 09 12:25:15 2011
#_Number_of_datafiles: 1
#C Stock Synthesis 3.21d (R. Methot)
#C Pacific sardine stock assessment update for 2012 (K. Hill)
#C PS12_X6e.DAT
#_observed data:
1993 #_styr (July 1993)
2012 #_endyr
2 #_nseas
6 6 #_months/season
2 #_spawning_season (Spring semester)
3 #_N_fleets
5 #_N_surveys
1 #_N_areas
MexCal_S1%MexCal_S2%PacNW%DEPM%TEP%TEP_full%Aerial%Acoustic
0.5 0.5 0.5 0.58 0.58 0.58 0.2 0.58 #_surveytiming_in_season
1 1 1 1 1 1 1 1 #_area_assignments_for_each_fishery_and_survey
1 1 1 #_units of catch:  1=bio; 2=num
0.05 0.05 0.05 #_se of log(catch) only used for init_eq_catch and for Fmethod 2 and 3
1 #_Ngenders
15 #_Nages
0 0 0 #_init_equil_catch_for_each_fishery (lambda=0)
64 #_N_lines_of_catch_to_read
#_catch_biomass(mtons):_columns_are_fisheries,year,season
5.78     0.00     0.00     1981     1
0.00     57.15    0.00     1981     2
73.94    0.00     0.00     1982     1
0.00     412.76   0.00     1982     2
213.19   0.00     0.00     1983     1
0.00     159.12   0.00     1983     2
75.39    0.00     0.00     1984     1
0.00     3495.80  0.00     1984     2
819.44   0.00     0.00     1985     1
0.00     1018.99  0.00     1985     2
387.70   0.00     0.00     1986     1
0.00     2278.90  0.00     1986     2
2247.30  0.00     0.00     1987     1
0.00     3639.76  0.00     1987     2
2179.91  0.00     0.00     1988     1
0.00     2614.75  0.00     1988     2
7290.45  0.00     0.00     1989     1
0.00     8031.52  0.00     1989     2
6158.41  0.00     0.00     1990     1
0.00     14443.49 0.00     1990     2
24698.02 0.00     0.00     1991     1
0.00     10323.52 0.00     1991     2
43433.31 0.00     3.90     1992     1
0.00     30776.37 0.18     1992     2
17460.78 0.00     0.00     1993     1
0.00     14078.85 0.00     1993     2
19503.00 0.00     0.00     1994     1
0.00     46792.12 0.00     1994     2
30093.29 0.00     22.68    1995     1
0.00     32561.24 0.00     1995     2
40559.48 0.00     0.00     1996     1
0.00     25364.55 43.54    1996     2
89272.03 0.00     27.22    1997     1
0.00     42079.67 0.82     1997     2
```

```
46787.92 0.00     488.25   1998     1
0.00     66550.51 74.39    1998     2
48765.83 0.00     725.20   1999     1
0.00     69337.59 429.59   1999     2
56709.77 0.00     15586.16 2000     1
0.00     46662.67 2336.90  2000     2
54311.70 0.00     22545.99 2001     1
0.00     45617.11 3136.84  2001     2
64671.88 0.00     35525.69 2002     1
0.00     40979.60 597.29   2002     2
38099.55 0.00     37242.26 2003     1
0.00     28590.55 2618.43  2003     2
61008.15 0.00     46730.80 2004     1
0.00     32857.28 1016.32  2004     2
60658.00 0.00     54152.62 2005     1
0.00     36791.15 101.70   2005     2
71474.68 0.00     41220.90 2006     1
0.00     46338.25 0.00     2006     2
71489.22 0.00     48237.10 2007     1
0.00     50130.29 0.00     2007     2
74536.03 0.00     39800.10 2008     1
0.00     46113.91 0.00     2008     2
47373.39 0.00     44841.15 2009     1
0.00     35325.50 1369.73  2009     2
55153.61 0.00     54085.91 2010     1
0.00     33753.60 0.09     2010     2
64296.47 0.00     39750.49 2011     1
0.00     34239.84 5844.40  2011     2
66624.62 0.00     80508.00 2012     1
0.00     34239.84 5844.40  2012     2
#
53 #_N_cpue_and_surveyabundance_observations
#_Units:  0=numbers; 1=biomass; 2=F
#_Errtype:  -1=normal; 0=lognormal; >0=T
#_Fleet Units Errtype
1 1 0 # MexCal_S1
2 1 0 # MexCal_S2
3 1 0 # PacNW
4 1 0 # DEPM
5 1 0 # TEP
6 1 0 # TEP_full
7 1 0 # Aerial_N
8 1 0 # Acoustic
#_year seas index obs err
1986     1        4        4061     0.60     #_DEPM_8608
1987     1        4        8661     0.56     #_DEPM_8707
1993     2        4        69065    0.29     #_DEPM_9404
2003     2        4        145274   0.23     #_DEPM_0404
2004     2        4        459943   0.55     #_DEPM_0504
2006     2        4        198404   0.30     #_DEPM_0704
2007     2        4        66395    0.27     #_DEPM_0804
2008     2        4        99162    0.24     #_DEPM_0905
2009     2        4        58447    0.40     #_DEPM_1004
2010     2        4        219386   0.27     #_DEPM_1104
2011     2        4        113178   0.27     #_DEPM_1204
1987     2        5        17266    0.35     #_TEP_8805
1995     2        5        97923    0.40     #_TEP_9604
1996     2        5        482246   0.21     #_TEP_9704
1997     2        5        369775   0.33     #_TEP_9804
1998     2        5        332177   0.34     #_TEP_9904
1999     2        5        1252539  0.39     #_TEP_0004
2000     2        5        931377   0.38     #_TEP_0104
2001     2        5        236660   0.17     #_TEP_0204
2002     2        5        556177   0.18     #_TEP_0304
2005     2        5        651994   0.25     #_TEP_0604
1986     1        6        11220    0.73     #_TEPall_8608
1987     1        6        24883    0.48     #_TEPall_8707
1987     2        6        17266    0.35     #_TEPall_8805
1993     2        6        73374    0.21     #_TEPall_9404
1995     2        6        97923    0.40     #_TEPall_9604
1996     2        6        482246   0.21     #_TEPall_9704
1997     2        6        369775   0.33     #_TEPall_9804
1998     2        6        332177   0.34     #_TEPall_9904
1999     2        6        1252539  0.39     #_TEPall_0004
2000     2        6        931377   0.38     #_TEPall_0104
2001     2        6        236660   0.17     #_TEPall_0204
2002     2        6        556177   0.18     #_TEPall_0304
2003     2        6        307795   0.24     #_TEPall_0404
2004     2        6        486950   0.40     #_TEPall_0504
2005     2        6        651994   0.25     #_TEPall_0604
2006     2        6        306297   0.26     #_TEPall_0704
2007     2        6        128118   0.21     #_TEPall_0804
2008     2        6        162188   0.22     #_TEPall_0904
2009     2        6        97838    0.39     #_TEPall_1004
2010     2        6        364798   0.26     #_TEPall_1104
2011     2        6        227632   0.27     #_TEPall_1204
2009     1        7        1236911  0.90     #_Aerial_09N
2010     1        7        173390   0.40     #_Aerial_10N
2011     1        7        201888   0.29     #_Aerial_11N
2012     1        7        696251   0.37     #_Aerial_12N
2005     2        8        1947063  0.30     #_Acoustic_0604
2007     2        8        751075   0.09     #_Acoustic_0804
```

```
2008    1       8       801000  0.30    #_Acoustic_0807
2009    2       8       357006  0.41    #_Acoustic_1004
2010    2       8       493672  0.30    #_Acoustic_1104
2011    2       8       469480  0.28    #_Acoustic_1204
2012    1       8       340831  0.33    #_Acoustic_1208
#
0 #_N_fleets_with_discard
#_discard_units (1=same_as_catchunits(bio/num); 2=fraction; 3=numbers)
#_discard_errtype:  >0 for DF of T-dist(read CV below); 0 for normal with CV; -1 for normal with se; -2 for
lognormal
#Fleet Disc_units err_type
0 #N discard obs
#_year seas index obs err
#
0 #_N_meanbodywt_obs
100 #_DF_for_meanbodywt_T-distribution_like

2 # length bin method: 1=use databins; 2=generate from binwidth,min,max below; 3=read vector
0.5 # binwidth for population size comp
8 # minimum size in the population (lower edge of first bin and size at age 0.00)
30 # maximum size in the population (lower edge of last bin)

-0.0001 #_comp_tail_compression
0.0001 #_add_to_comp
0 #_combine males into females at or below this bin number
39 #_N_LengthBins
 9 9.5 10 10.5 11 11.5 12 12.5 13 13.5 14 14.5 15 15.5 16 16.5 17 17.5 18 18.5 19 19.5 20 20.5 21 21.5 22 22.5
23 23.5 24 24.5 25 25.5 26 26.5 27 27.5 28
95 #_N_Length_obs
#Yr Seas Flt/Svy Gender Part Nsamp datavector(female-male)
1981    1       1       0       0       7.16    0.01484956      0.00000000      0.00371239
        0.00000000      0.00000000      0.01059504      0.02753060      0.07362315      0.07787767
        0.03124299      0.00688265      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.03814443      0.05314352      0.07216263      0.06335617
        0.03692413      0.03634891      0.04966195      0.04223717      0.04223717      0.04486040
        0.12175717      0.10110922      0.02421245      0.01376530      0.00688265      0.00688265
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1982    1       1       0       0       14.44   0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.02929626      0.02107766      0.06247351      0.14551868
        0.16192081      0.10854351      0.06164664      0.03447696      0.04939521      0.06554510
        0.06436408      0.07884345      0.05378302      0.03365010      0.01481689      0.00732406
        0.00000000      0.00732406      0.00000000      0.00000000      0.00000000      0.00000000
1983    1       1       0       0       16.84   0.00010000      0.00187768      0.00075107
        0.00037554      0.00037554      0.00012518      0.00112661      0.00552454      0.00039086
        0.00568036      0.02239448      0.00555518      0.00025036      0.01753400      0.05493949
        0.05212797      0.05396474      0.00602525      0.04948431      0.03960425      0.05712430
        0.05217038      0.06639215      0.08421796      0.08040515      0.03481751      0.00814070
        0.00740317      0.00012518      0.00292233      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1985    1       1       0       0       15.00   0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00551492      0.01811125      0.01937734      0.09389666      0.07578540      0.06549965
        0.07103958      0.14212149      0.14101305      0.10906458      0.08189415      0.06823210
        0.05966281      0.01368725      0.01713147      0.00469950      0.00428464      0.00585115
        0.00313300      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1986    1       1       0       0       20.20   0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00616313      0.01386704      0.01540782      0.00000000
        0.00154078      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00021255      0.00154078      0.00234481
        0.01417509      0.06784718      0.08371505      0.12675030      0.16127035      0.22070112
        0.13588124      0.07198028      0.04649567      0.01157162      0.01540760      0.00000000
        0.00000000      0.00312759      0.00000000      0.00000000      0.00000000      0.00000000
1987    1       1       0       0       29.40   0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00235959
        0.00330682      0.01575054      0.02432356      0.02777470      0.06436425      0.09996834
        0.13984439      0.19144865      0.13300410      0.04121332      0.03241437      0.03758516
        0.06964660      0.05157932      0.03856749      0.01563735      0.00829264      0.00291879
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1988    1       1       0       0       22.76   0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00395131      0.00000000      0.00195829
        0.00590960      0.01762461      0.01910706      0.03947840      0.03079151      0.02392604
        0.02333000      0.07643028      0.11050425      0.16258680      0.15424512      0.14644944
        0.08546717      0.05005023      0.01996970      0.01562267      0.00451948      0.00355857
        0.00451948      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1989    1       1       0       0       12.65   0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00004926      0.00000000      0.00037039
        0.00166667      0.02627693      0.00989771      0.04386157      0.06196975      0.11209574
        0.13522328      0.16657270      0.08405352      0.06556757      0.11092387      0.08723008
        0.03641874      0.05551307      0.00212660      0.00018253      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1990    1       1       0       0       16.11   0.00000000      0.00000000      0.00000000
        0.00004919      0.00014757      0.00014757      0.00022135      0.00017216      0.00029513
        0.00104947      0.00090190      0.00362556      0.00057035      0.00426920      0.00380236
        0.00484519      0.00208566      0.00641450      0.01880919      0.01127935      0.01412415
        0.01035632      0.01876826      0.14219400      0.09175071      0.15087323      0.16178891
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	0.13033895	0.09953868	0.05536229	0.03955230	0.00680348	0.00569918
	0.00286161	0.01125414	0.00002404	0.00002404	0.00000000	0.00000000
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	0.03231462	0.01154319	0.02694888	0.04275312	0.06152849	0.05973348
	0.05912893	0.07578256	0.08149112	0.09224337	0.08819169	0.15633075
	0.06340067	0.03636108	0.02511698	0.01407484	0.00332283	0.00028678
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
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	0.12370043	0.11421111	0.08900276	0.06994105	0.06036575	0.05439107
	0.04625813	0.02798518	0.02235592	0.00922742	0.00601169	0.00452736
	0.00387575	0.00250130	0.00175651	0.00113082	0.00052993	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
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	0.00463876	0.00417488	0.00373452	0.00327065	0.00512615	0.02802067
	0.06602880	0.12334864	0.19706625	0.18881199	0.14355881	0.10976281
	0.05905231	0.02651354	0.00943403	0.00564154	0.00186000	0.00046387
	0.00000450	0.00000450	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
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	0.07058380	0.07693263	0.10024725	0.11272863	0.10135839	0.07086814
	0.04307455	0.01356492	0.00575959	0.00296204	0.00007494	0.00000000
	0.00007494	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
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	0.18312667	0.16935996	0.18316509	0.09855926	0.06139729	0.02572781
	0.01466323	0.01211805	0.00278032	0.00111213	0.00055607	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
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	0.04810660	0.06716504	0.08405646	0.09316402	0.09338781	0.10206335
	0.09107056	0.11092918	0.11402608	0.05956644	0.03485381	0.01237661
	0.00472432	0.00135423	0.00144851	0.00000000	0.00000000	0.00010176
	0.00010176	0.00000000	0.00010176	0.00000000	0.00000000	0.00000000
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	0.00088600	0.00359328	0.00513131	0.00874090	0.02664693	0.05109290
	0.06387748	0.06766987	0.07409647	0.06853287	0.09439870	0.09061933
	0.10039371	0.11987944	0.10453417	0.07038100	0.02785320	0.01576992
	0.00286513	0.00147837	0.00008452	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1998	1 1	0 0	67.85	0.00000000	0.00004705	0.00000000
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	0.04970289	0.05777902	0.06378212	0.05466526	0.06180209	0.04071198
	0.04185828	0.02927103	0.04564241	0.05567713	0.06796882	0.07337549
	0.09087017	0.08564151	0.05507811	0.02635638	0.01806399	0.00629265
	0.00271092	0.00076412	0.00057309	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1999	1 1	0 0	44.67	0.00000000	0.00000000	0.00000000
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	0.13968191	0.12407610	0.06295814	0.05176260	0.02287701	0.01023445
	0.00798720	0.00771018	0.00481621	0.00120405	0.00060203	0.00239361
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2000	1 1	0 0	53.24	0.00000000	0.00000000	0.00000000
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	0.00474920	0.00690367	0.00844581	0.01362315	0.02804889	0.05707431
	0.07737624	0.08644725	0.08397418	0.09461817	0.11440859	0.11960159
	0.12381242	0.08604373	0.05355463	0.03214253	0.00466724	0.00000000
	0.00000000	0.00048772	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2001	1 1	0 0	58.90	0.00057197	0.00095218	0.02712915
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	0.00232433	0.00202475	0.00257832	0.01286708	0.03805012	0.05344231
	0.05591429	0.08031976	0.10297294	0.12212423	0.10754679	0.09162344
	0.05219503	0.04087607	0.02959570	0.02261711	0.01920680	0.01508908
	0.00506016	0.00378819	0.00180539	0.00181057	0.00114030	0.00041607
	0.00025939	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2002	1 1	0 0	73.64	0.00266457	0.00000000	0.00025942
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	0.01875338	0.02407949	0.03765499	0.07010071	0.09466222	0.11429467
	0.12472299	0.11097433	0.10553060	0.10320511	0.08375941	0.05680869
	0.03047152	0.00406449	0.00120510	0.00118393	0.00032929	0.00118432
	0.00050619	0.00000000	0.00000000	0.00000000	0.00013160	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2003	1 1	0 0	50.43	0.00277981	0.00015765	0.00042073
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	0.01184669	0.01280630	0.01835263	0.01590922	0.04227579	0.05008598
	0.06218838	0.06105123	0.07833376	0.08864727	0.09187423	0.08632483
	0.10370733	0.09782327	0.06357319	0.02783622	0.01976241	0.00677658

	0.00245614	0.00012456	0.00000000	0.00000000	0.00000000	0.00000000
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2004	1 1	0 0	149.06 0.00000000	0.00000000	0.00024623	
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	0.05712753	0.09939158	0.12256186	0.14571263	0.13156927	0.12554599
	0.08281947	0.07282526	0.04363738	0.03007620	0.01464121	0.01506060
	0.01670913	0.00844771	0.00711333	0.00032787	0.00039852	0.00000000
	0.00037395	0.00000000	0.00000000	0.00037395	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1 1	0 0	108.68 0.00193470	0.00022519	0.00323104	
	0.00304557	0.00588404	0.00734152	0.00998155	0.00644322	0.01456475
	0.02943337	0.03914779	0.04814759	0.06142719	0.06501332	0.08754971
	0.12044423	0.12701609	0.13282524	0.10749765	0.06992057	0.03918980
	0.00894531	0.00571821	0.00408001	0.00027147	0.00007357	0.00000000
	0.00014714	0.00007357	0.00000000	0.00035304	0.00007357	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2006	1 1	0 0	78.73 0.00126598	0.00038116	0.00102634	
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	0.01766474	0.04055878	0.07395192	0.11421666	0.12956466	0.13307404
	0.13343058	0.10168666	0.09006022	0.06043566	0.03808969	0.02071229
	0.00458588	0.00239223	0.00169079	0.00069944	0.00009863	0.00009863
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2007	1 1	0 0	109.86 0.00342080	0.00513120	0.00744004	
	0.00587535	0.00227271	0.00289339	0.00446225	0.01298850	0.02137569
	0.02898517	0.04185486	0.04810869	0.06925907	0.09596944	0.13036217
	0.15193221	0.13507403	0.09628356	0.05789959	0.03139757	0.01029151
	0.01123851	0.00492664	0.00113647	0.00113647	0.00102624	0.00186428
	0.00171040	0.00376288	0.00342080	0.00342080	0.00239456	0.00068416
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	0.00143318	0.00176861	0.00477100	0.01221751	0.01693650	0.02419813
	0.02875578	0.04320828	0.05850512	0.06568445	0.07526991	0.11266934
	0.12093960	0.11349677	0.09825216	0.07731113	0.04470080	0.02657355
	0.01857655	0.01169440	0.01771420	0.00896050	0.00657205	0.00435700
	0.00271677	0.00105177	0.00096382	0.00000000	0.00000000	0.00000000
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2009	1 1	0 0	36.00 0.00000000	0.00000000	0.00000000	
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	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	1 1	0 0	38.00 0.00000000	0.00000000	0.00000000	
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	0.07724581	0.04519083	0.02234872	0.00522683	0.00202406	0.00084533
	0.00202406	0.00000000	0.00160139	0.00000000	0.00160139	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
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	0.12404446	0.22379100	0.21880308	0.11415475	0.03360562	0.01007733
	0.00433701	0.00063817	0.00000000	0.00167433	0.00000000	0.00000000
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	0.01574749	0.00847728	0.00339091	0.00000000	0.00000000	0.00000000
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	0.04090004	0.07710371	0.04708260	0.02047974	0.01747763	0.00436941
	0.01872604	0.04726095	0.08453467	0.06099337	0.04993609	0.05885325
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1982	2 2	0 0	23.32 0.00000000	0.00000000	0.00000000	
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	0.00393489	0.00000000	0.00000000	0.00000000	0.00000000	0.00786978
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	0.08999555	0.18771542	0.22467716	0.19362188	0.08360123	0.05287586
	0.04065799	0.03577425	0.01106387	0.01314369	0.00210956	0.00393489
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1983	2 2	0 0	7.52 0.00000000	0.00000000	0.00000000	
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	0.01316522	0.00000000	0.02940664	0.00842831	0.02876048	0.04746268
	0.05416835	0.09809378	0.14872302	0.19677016	0.14681479	0.08831027
	0.03494293	0.02805307	0.00473691	0.00473691	0.00000000	0.00000000
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1984	2 2	0 0	8.64 0.00000000	0.00000000	0.00000000	
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	0.05235745	0.10612598	0.12213463	0.14012787	0.13814328	0.14695143

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	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1985	2 2	0 0	33.40	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
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	0.00000000	0.00131840	0.00010163	0.00669388	0.01710975	0.02415533
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	0.14408914	0.07590716	0.02481579	0.01449698	0.00792752	0.00308319
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	0.00463096	0.01700021	0.04013232	0.09014523	0.16819054	0.19272019
	0.19108334	0.11055003	0.05771905	0.01622154	0.00823406	0.00216127
	0.00116005	0.00018137	0.00045387	0.00045387	0.00000000	0.00000000
1987	2 2	0 0	87.72	0.00080506	0.00000000	0.00000000
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	0.00035065	0.00205047	0.00508633	0.01985322	0.06486613	0.08420574
	0.06821583	0.09473885	0.10246251	0.12938656	0.10419184	0.08840682
	0.06964671	0.04868916	0.02922919	0.01583587	0.00537524	0.00188258
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	0.02361299	0.02408992	0.00958245	0.01283679	0.01615761	0.04130164
	0.02460793	0.05520461	0.08278055	0.10323603	0.14070264	0.14736675
	0.13313655	0.05418899	0.05216054	0.02646659	0.01715723	0.00257962
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	0.00000000	0.00716243	0.00026888	0.01467734	0.00256638	0.01532452
	0.07917171	0.17701230	0.37268290	0.10756034	0.12759557	0.04062899
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	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1990	2 2	0 0	64.03	0.00000000	0.00000000	0.00000000
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	0.00022232	0.00024251	0.00275118	0.00484713	0.01189466	0.02059758
	0.01939717	0.01606975	0.00581443	0.00699338	0.00452519	0.01009643
	0.01098561	0.03768127	0.07701301	0.10377742	0.15370524	0.15803354
	0.13571389	0.08495925	0.06409418	0.03598720	0.02016837	0.00883532
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	0.00788828	0.01516930	0.01898239	0.02540698	0.02062991	0.02254313
	0.01296508	0.01314172	0.01876992	0.03902738	0.03603072	0.04460787
	0.04346361	0.06268591	0.06534050	0.07444044	0.08153105	0.10986582
	0.09543977	0.08060247	0.05639323	0.02876966	0.01255328	0.00823300
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	0.03787993	0.02871215	0.02027659	0.01405220	0.00690711	0.00791724
	0.00630235	0.00374008	0.00167745	0.00135070	0.00000000	0.00046224
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	0.07315222	0.08758657	0.08721873	0.07926404	0.04565867	0.03164984
	0.01919190	0.01296081	0.00690469	0.00601175	0.00244018	0.00176944
	0.00151644	0.00244920	0.00220644	0.00095330	0.00015289	0.00090616
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	0.04320883	0.01928648	0.02230967	0.00359658	0.00075974	0.00042601
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	0.11460112	0.10766407	0.07852197	0.03336299	0.02042397	0.00933447
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	0.03895383	0.03885556	0.06291080	0.05221076	0.05714851	0.07685111
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	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1 3	0 0	67.68	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000553	0.00001355	0.00159531	0.00039392	0.00020755
	0.00004066	0.00020755	0.00020258	0.00270103	0.02291847	0.05924987
	0.09616749	0.20727817	0.18328761	0.12443673	0.05097571	0.01877167
	0.01515760	0.00998755	0.00942919	0.01080600	0.01243740	0.01347518
	0.01891349	0.02806092	0.03110144	0.04082612	0.02108261	0.01447999
	0.00282130	0.00249264	0.00027437	0.00014659	0.00002710	0.00002710
2006	1 3	0 0	27.00	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00385525	0.01151585	0.04782390	0.16295078	0.33602885
	0.24986185	0.11243519	0.01737664	0.00466226	0.00994350	0.00193035
	0.00122605	0.00686819	0.00826354	0.01135211	0.00487000	0.00864962
	0.00000000	0.00000000	0.00038607	0.00000000	0.00000000	0.00000000
2006	2 3	0 0	3.00	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.01333333	0.00000000	0.06666667	0.06666667
	0.20000000	0.16000000	0.09333333	0.09333333	0.05333333	0.02666667
	0.05333333	0.00000000	0.08000000	0.04000000	0.02666667	0.02666667
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2007	1 3	0 0	87.86	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000737	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00001639
	0.00061942	0.00255561	0.01442330	0.07011329	0.13161223	0.21383784
	0.23707687	0.18219854	0.07220975	0.02287642	0.01307278	0.00799927
	0.00556329	0.00684479	0.00802636	0.00410422	0.00215245	0.00214591
	0.00115543	0.00071927	0.00011042	0.00050099	0.00001250	0.00004528
2008	1 3	0 0	129.64	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00004054	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00041928	0.00000000
	0.00000000	0.00058332	0.00460794	0.03193930	0.06132653	0.11715864
	0.14270701	0.15921219	0.11117985	0.07109068	0.04339494	0.04764464
	0.06409722	0.06209469	0.04086420	0.02147774	0.01039633	0.00450936
	0.00253737	0.00106315	0.00059479	0.00056213	0.00027694	0.00022122
2009	1 3	0 0	159.41	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000722	0.00000000	0.00000000
	0.00000000	0.00000000	0.00036834	0.00036834	0.00000722	0.00002165
	0.00000722	0.00001443	0.00385185	0.02385351	0.05630274	0.13546005
	0.16896254	0.15574778	0.09681599	0.06985591	0.04410210	0.07537644
	0.06582272	0.05197468	0.02553117	0.01450460	0.00584005	0.00330284
	0.00143161	0.00023704	0.00012583	0.00002508	0.00004879	0.00003229
2009	2 3	0 0	5.36	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.01798295	0.00000000	0.00000000
	0.00000000	0.00000000	0.00926034	0.00215512	0.03969015	0.07032977
	0.20107522	0.16721988	0.20166429	0.13155969	0.07237361	0.05072363
	0.01798242	0.00899121	0.00899174	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	1 3	0 0	159.59	0.00000000	0.00000000	0.00000000
	0.00000000	0.00001446	0.00001446	0.00001446	0.00001446	0.00001446
	0.00001446	0.00044360	0.00000000	0.00000122	0.00000000	0.00180862
	0.00201059	0.00163823	0.00255405	0.00742189	0.02909014	0.09064297
	0.14163734	0.15765569	0.10927082	0.08730225	0.06801394	0.09160221
	0.07800250	0.06283037	0.03622525	0.02043204	0.00627469	0.00354811
	0.00108430	0.00019300	0.00002444	0.00005434	0.00002891	0.00012173
2011	1 3	0 0	214.20	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00003236	0.00000000	0.00000000
	0.00001345	0.00000000	0.00095709	0.00004035	0.00057654	0.00017484
	0.00011306	0.00300540	0.00074600	0.00445332	0.00603542	0.01683443
	0.02585907	0.08792317	0.12395570	0.11948856	0.07901055	0.12219928
	0.12866145	0.11115942	0.08709386	0.04678383	0.02031662	0.00905944
	0.00348268	0.00110194	0.00056892	0.00018600	0.00013491	0.00003236
2012	1 3	0 0	114.88	0.00000000	0.00000000	0.00000000
	0.00011643	0.00135664	0.00040244	0.00045559	0.00040244	0.00000000
	0.00011643	0.00000000	0.00023286	0.00016958	0.00000000	0.00011643
	0.00000000	0.00000000	0.00043912	0.00358880	0.01738868	0.08553096
	0.14807548	0.18699420	0.14419229	0.12451846	0.10484095	0.09190027
	0.05196396	0.02388299	0.00871040	0.00346663	0.00070319	0.00030071
	0.00006704	0.00004578	0.00000000	0.00002126	0.00000000	0.00000000
2009	1 7	0 0	33.20	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00052810	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00057622	0.00495836	0.03103000	0.09960013	0.16374495
	0.20219759	0.22838807	0.15886180	0.07916015	0.02095343	0.00615335
	0.00086496	0.00258641	0.00000000	0.00039648	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	1 7	0 0	24.00	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00080160	0.00000000	0.00000000	0.00000000
	0.00051869	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00101947	0.00144396	0.00068636	0.00132264	0.00518994	0.02150013
	0.09853051	0.21071417	0.29173440	0.18574131	0.11417842	0.04092949
	0.01770211	0.00669268	0.00000000	0.00129411	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	1 7	0 0	50.00	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00032391	0.00048844	0.00090264	0.00004834
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00067671	0.00000000	0.00017503	0.00058270	0.00081600
	0.00639086	0.02291477	0.10158366	0.24939403	0.26460441	0.20025064

```
        0.09328675        0.03327509        0.01190588        0.00477899        0.00363973        0.00294363
        0.00000000        0.00101779        0.00000000        0.00000000        0.00000000        0.00000000
2012    1       7         0         0       23.00   0.00000000        0.00000000        0.00000000
        0.00096182        0.00000000        0.00000000        0.00325589        0.00292761        0.00000000
        0.00000000        0.00080840        0.00000000        0.00000000        0.00000000        0.00000000
        0.00000000        0.00000000        0.00000000        0.00000000        0.00198040        0.04085942
        0.12161069        0.32194293        0.25935231        0.10149073        0.05042019        0.03717053
        0.03715582        0.01294936        0.00496227        0.00104007        0.00111157        0.00000000
        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000
2005    2       8         0         0       10.00   0.00000000        0.00000000        0.00000000
        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000        0.00270862
        0.00270862        0.00000000        0.00000000        0.01100873        0.01100873        0.12353364
        0.12353364        0.06453880        0.06453880        0.15773170        0.15773170        0.06426980
        0.06426980        0.05009669        0.05009669        0.01516183        0.01516183        0.00505394
        0.00505394        0.00000000        0.00000000        0.00168465        0.00168465        0.00336930
        0.00336930        0.00168465        0.00000000        0.00000000        0.00000000        0.00000000
2007    2       8         0         0       12.00   0.00000000        0.00000000        0.00000000
        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000
        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000        0.01871052
        0.01871052        0.04456086        0.04456086        0.07885461        0.07885461        0.07720993
        0.07720993        0.09196321        0.09196321        0.10803940        0.10803940        0.06881783
        0.06881783        0.00321240        0.00321240        0.00825866        0.00825866        0.00037258
        0.00037258        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000
2008    1       8         0         0       27.00   0.01700544        0.01700544        0.02210707
        0.02210707        0.00680218        0.00680218        0.00000000        0.00000000        0.00000000
        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000        0.00680218
        0.00680218        0.02009720        0.02009720        0.02164783        0.02164783        0.08951514
        0.08951514        0.10939327        0.10939327        0.14029251        0.14029251        0.05385909
        0.05385909        0.01118376        0.01118376        0.00129435        0.00129435        0.00000000
        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000
2009    2       8         0         0       19.00   0.00000000        0.00000000        0.00000000
        0.00000000        0.00071913        0.00071913        0.00036184        0.00036184        0.00000000
        0.00000000        0.00121512        0.00121512        0.00265337        0.00265337        0.00332081
        0.00332081        0.00555546        0.00555546        0.00224440        0.00224440        0.00833426
        0.00833426        0.05506318        0.05506318        0.17107802        0.17107802        0.16580872
        0.16580872        0.06954074        0.06954074        0.01153821        0.01153821        0.00243023
        0.00243023        0.00027301        0.00000000        0.00000000        0.00000000        0.00000000
2010    2       8         0         0       18.00   0.00000000        0.00000000        0.00000000
        0.00000000        0.00000000        0.00000000        0.00000449        0.00000449        0.00000000
        0.00000000        0.00000000        0.00000000        0.00015121        0.00015121        0.08020558
        0.08020558        0.22135962        0.22135962        0.08918809        0.08918809        0.04535153
        0.04535153        0.00957193        0.00957193        0.00287216        0.00287216        0.01710648
        0.01710648        0.02239309        0.02239309        0.00960401        0.00960401        0.00139900
        0.00139900        0.00158562        0.00000000        0.00000000        0.00000000        0.00000000
2011    2       8         0         0       12.00   0.00000000        0.00000000        0.00000000
        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000
        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000
        0.00000000        0.00966230        0.00966230        0.00000000        0.00000000        0.00874343
        0.00874343        0.09109599        0.09109599        0.11348639        0.11348639        0.05587484
        0.05587484        0.10595060        0.10595060        0.08715280        0.08715280        0.02797210
        0.02797210        0.00006153        0.00006153        0.00000000        0.00000000        0.00000000
2012    1       8         0         0       26.00   0.00000000        0.00000000        0.00000000
        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000
        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000        0.00000000
        0.00000000        0.00000000        0.00000000        0.00035481        0.00035481        0.00193496
        0.00193496        0.13636929        0.13636929        0.21595031        0.21595031        0.06930702
        0.06930702        0.04528789        0.04528789        0.02760803        0.02760803        0.00294741
        0.00294741        0.00024028        0.00024028        0.00000000        0.00000000        0.00000000
#
10 #_N_age_bins
0 1 2 3 4 5 6 7 8 11
9  #_N_ageerror_definitions

0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5
        13.5    14.5    15.5    #_1_ENS_all_years
0.2043  0.2043  0.2792  0.3067  0.3169  0.3606  0.3933  0.4261  0.4589  0.4916  0.5244  0.5571  0.5899
        0.6227  0.6554  0.6882  #_1_ENS_all_years
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5
        13.5    14.5    15.5    #_2_CA_1981-2006
0.2832  0.2832  0.2890  0.8009  0.8038  0.9597  1.1156  1.2715  1.4274  1.5833  1.7392  1.8951  2.0510
        2.2069  2.3627  2.5186  #_2_CA_1981-2006
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5
        13.5    14.5    15.5    #_3_CA_2007
0.2539  0.2539  0.3434  0.9205  0.9653  1.1743  1.3832  1.5922  1.8011  2.0101  2.2190  2.4280  2.6369
        2.8459  3.0548  3.2638  #_3_CA_2007
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5
        13.5    14.5    15.5    #_4_CA_2008-09
0.4032  0.4032  0.4995  0.5800  0.6902  0.8246  0.9727  1.0165  1.1144  1.2123  1.3102  1.4082  1.5061
        1.6040  1.7020  1.7999  #_4_CA_2008-09
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5
        13.5    14.5    15.5    #_5_CA_2010-11
0.2825  0.2825  0.2955  0.3125  0.3347  0.3637  0.4017  0.4046  0.4245  0.4445  0.4645  0.4844  0.5044
        0.5243  0.5443  0.5643  #_5_CA_2010-11
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5
        13.5    14.5    15.5    #_6_ORWA_all_years
0.26655 0.30145 0.3149  0.3615  0.3847  0.3961  0.4018  0.4047  0.4061  0.4352  0.4487  0.4622  0.4756
        0.4891  0.5026  0.5160  #_6_ORWA_all_years
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5
        13.5    14.5    15.5    #_Vector_7_CalCOFI_C
0.5386  0.5386  0.7547  0.8341  0.8634  0.8741  0.8781  0.8796  0.8801  0.8801  0.8801  0.8801  0.8801
        0.8801  0.8801  0.8801  #_7_CalCOFI_C_updated
```

```
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5
        13.5    14.5    15.5    #_8_SWFSC_2_2008_DataSetB
0.4972  0.4972  0.7284  0.8233  0.8622  0.8782  0.8847  1.0328  1.1063  1.1798  1.2533  1.3268  1.4004
        1.4739  1.5474  1.6209  #_8_SWFSC_2_2008_DataSetB
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5
        13.5    14.5    15.5    #_9_SWFSC_3_2010_CalCOFI_A_Reader12
0.7043  0.7043  0.7875  0.8912  1.0205  1.1816  1.3823  1.6324  1.9440  1.9073  2.0610  2.2147  2.3684
        2.5222  2.6759  2.8296  #_9_SWFSC_3_2010_CalCOFI_A_Reader12
#
1104 #_N_Agecomp_obs
3 #_Lbin_method: 1=poplenbins; 2=datalenbins; 3=lengths
-1 #_combine males into females at or below this bin number
#Yr Seas Flt/Svy Gender Part Ageerr Lbin_lo Lbin_hi Nsamp datavector(female-male)
1981    1       1       0       0       2       9       9.5     0.16    1.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1982    1       1       0       0       2       17      17.5    0.32    0.00000000      0.00000000
        1.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1982    1       1       0       0       2       18      18.5    1.08    0.00000000      0.07069299
        0.92930701      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1982    1       1       0       0       2       19      19.5    4.24    0.00000000      0.06153205
        0.85865723      0.07349847      0.00631224      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1982    1       1       0       0       2       20      20.5    2.92    0.00000000      0.03391161
        0.76420432      0.20188408      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1982    1       1       0       0       2       21      21.5    1.48    0.00000000      0.00000000
        0.33098127      0.59859631      0.07042242      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1982    1       1       0       0       2       22      22.5    1.76    0.00000000      0.02818917
        0.00000000      0.77058950      0.11665380      0.05637835      0.02818917      0.00000000
        0.00000000      0.00000000
1982    1       1       0       0       2       23      23.5    1.88    0.00000000      0.00000000
        0.00000000      0.58926127      0.35551548      0.02761162      0.02761162      0.00000000
        0.00000000      0.00000000
1982    1       1       0       0       2       24      24.5    0.60    0.00000000      0.00000000
        0.00000000      0.27019396      0.57869153      0.15111452      0.00000000      0.00000000
        0.00000000      0.00000000
1982    1       1       0       0       2       25      25.5    0.08    0.00000000      0.00000000
        0.00000000      0.00000000      1.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1982    1       1       0       0       2       26      26.5    0.08    0.00000000      0.00000000
        0.00000000      0.00000000      0.50000000      0.50000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       9       9.5     5.64    1.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       10      10.5    0.36    0.44444444      0.55555556
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       11      11.5    0.16    1.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       12      12.5    0.40    1.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       13      13.5    0.32    0.97685790      0.02314210
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       14      14.5    0.48    0.59407734      0.40592266
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       15      15.5    0.32    0.00000000      1.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       16      16.5    1.64    0.00000000      0.97027141
        0.02972859      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       17      17.5    0.96    0.00000000      0.90373568
        0.09626432      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       18      18.5    1.04    0.00000000      0.83630042
        0.16369958      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       19      19.5    1.36    0.00000000      0.57690290
        0.42309710      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       20      20.5    2.08    0.00000000      0.18904164
        0.81095836      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       21      21.5    1.76    0.00000000      0.12838091
        0.74118410      0.13043499      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       22      22.5    0.24    0.00000000      0.00000000
        0.51567079      0.48432921      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
1983    1       1       0       0       2       23      23.5    0.08    0.00000000      0.00000000
        0.00000000      1.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000
```

1985	1 1	0 0	2 16	16.5 0.08	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	1 1	0 0	2 17	17.5 0.56	0.00000000	0.78935373
	0.21064627	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	1 1	0 0	2 18	18.5 2.28	0.00000000	0.86518855
	0.13481145	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	1 1	0 0	2 19	19.5 2.44	0.00000000	0.57408299
	0.38429634	0.04162067	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	1 1	0 0	2 20	20.5 3.52	0.00000000	0.40699674
	0.59300326	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	1 1	0 0	2 21	21.5 2.68	0.00000000	0.06638286
	0.87987775	0.05373939	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	1 1	0 0	2 22	22.5 2.16	0.00000000	0.03394619
	0.85201343	0.10492387	0.00911651	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	1 1	0 0	2 23	23.5 0.80	0.00000000	0.00000000
	0.31820794	0.64442381	0.03736824	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	1 1	0 0	2 24	24.5 0.24	0.00000000	0.00000000
	0.17436281	0.69745123	0.12818596	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	1 1	0 0	2 25	25.5 0.24	0.00000000	0.00000000
	0.34872561	0.52308842	0.12818596	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	1 1	0 0	2 11	11.5 0.16	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	1 1	0 0	2 12	12.5 0.76	0.83333333	0.16666667
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	1 1	0 0	2 13	13.5 0.04	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	1 1	0 0	2 18	18.5 0.08	0.00000000	0.12122764
	0.87877236	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	1 1	0 0	2 19	19.5 0.32	0.00000000	0.76428217
	0.23571783	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	1 1	0 0	2 20	20.5 2.76	0.00000000	0.38495347
	0.61504653	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	1 1	0 0	2 21	21.5 5.76	0.00000000	0.08028763
	0.76847033	0.15124204	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	1 1	0 0	2 22	22.5 7.16	0.00000000	0.02493386
	0.73259767	0.24246848	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	1 1	0 0	2 23	23.5 2.36	0.00000000	0.00000000
	0.39924485	0.60075515	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	1 1	0 0	2 24	24.5 0.76	0.00000000	0.00000000
	0.23510574	0.52978851	0.23510574	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	1 1	0 0	2 16	16.5 0.16	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	1 1	0 0	2 17	17.5 1.96	0.00000000	0.98744217
	0.01255783	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	1 1	0 0	2 18	18.5 4.28	0.00519359	0.96789217
	0.02691424	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	1 1	0 0	2 19	19.5 7.72	0.00000000	0.91466673
	0.08533327	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	1 1	0 0	2 20	20.5 7.20	0.00000000	0.77509708
	0.21757710	0.00000000	0.00732581	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	1 1	0 0	2 21	21.5 1.84	0.00000000	0.25252277
	0.69894313	0.04853411	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	1 1	0 0	2 22	22.5 3.04	0.00000000	0.00000000
	0.77408665	0.19780355	0.02810980	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	1 1	0 0	2 23	23.5 2.52	0.00000000	0.00000000
	0.18340837	0.81033957	0.00625206	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	1 1	0 0	2 24	24.5 0.60	0.00000000	0.00000000
	0.26018904	0.48076499	0.25904597	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	1 1	0 0	2 25	25.5 0.08	0.00000000	0.00000000
	0.00000000	0.80841664	0.19158336	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

1988	1 1	0 0	2 15	15.5 0.08	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1988	1 1	0 0	2 16	16.5 0.16	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1988	1 1	0 0	2 17	17.5 0.76	0.00000000	0.78580079
	0.21419921	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1988	1 1	0 0	2 18	18.5 1.44	0.00000000	0.65091128
	0.34908872	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1988	1 1	0 0	2 19	19.5 1.00	0.00000000	0.43423099
	0.56576901	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1988	1 1	0 0	2 20	20.5 4.20	0.00000000	0.05313130
	0.91203048	0.03483821	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1988	1 1	0 0	2 21	21.5 7.12	0.00000000	0.02510010
	0.87180146	0.08330622	0.01979222	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1988	1 1	0 0	2 22	22.5 5.36	0.00000000	0.00866820
	0.63861370	0.30936948	0.04334863	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1988	1 1	0 0	2 23	23.5 1.72	0.00000000	0.00000000
	0.24458249	0.56761063	0.16253246	0.02527442	0.00000000	0.00000000
	0.00000000	0.00000000				
1988	1 1	0 0	2 24	24.5 0.64	0.00000000	0.00000000
	0.00000000	0.32160253	0.52648318	0.15191429	0.00000000	0.00000000
	0.00000000	0.00000000				
1988	1 1	0 0	2 25	25.5 0.28	0.00000000	0.00000000
	0.00000000	0.06603427	0.62121055	0.31275518	0.00000000	0.00000000
	0.00000000	0.00000000				
1989	1 1	0 0	2 16	16.5 0.20	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1989	1 1	0 0	2 17	17.5 0.56	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1989	1 1	0 0	2 18	18.5 2.16	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1989	1 1	0 0	2 19	19.5 3.72	0.00000000	0.91397849
	0.06451613	0.01075269	0.01075269	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1989	1 1	0 0	2 20	20.5 5.28	0.00000000	0.63636364
	0.34090909	0.02272727	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1989	1 1	0 0	2 21	21.5 5.04	0.00000000	0.18253968
	0.67460317	0.09523810	0.03968254	0.00793651	0.00000000	0.00000000
	0.00000000	0.00000000				
1989	1 1	0 0	2 22	22.5 2.16	0.00000000	0.07407407
	0.81481481	0.09259259	0.01851852	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1989	1 1	0 0	2 23	23.5 0.52	0.00000000	0.07692308
	0.23076923	0.61538462	0.07692308	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1989	1 1	0 0	2 24	24.5 0.12	0.00000000	0.00000000
	0.00000000	0.33333333	0.66666667	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	1 1	0 0	2 13	13.5 0.04	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	1 1	0 0	2 14	14.5 0.24	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	1 1	0 0	2 15	15.5 0.56	0.00000000	0.78571429
	0.21428571	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	1 1	0 0	2 16	16.5 1.56	0.00000000	0.53846154
	0.41025641	0.05128205	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	1 1	0 0	2 17	17.5 0.48	0.00000000	0.41666667
	0.25000000	0.25000000	0.08333333	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	1 1	0 0	2 18	18.5 0.60	0.00000000	0.73333333
	0.06666667	0.20000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	1 1	0 0	2 19	19.5 0.76	0.00000000	0.47368421
	0.26315789	0.26315789	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	1 1	0 0	2 20	20.5 2.44	0.01639344	0.16393443
	0.44262295	0.26229508	0.09836066	0.01639344	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	1 1	0 0	2 21	21.5 6.64	0.01204819	0.12650602
	0.37951807	0.27710843	0.12048193	0.06024096	0.02409639	0.00000000
	0.00000000	0.00000000				
1990	1 1	0 0	2 22	22.5 4.64	0.00000000	0.04310345
	0.28448276	0.40517241	0.18965517	0.05172414	0.02586207	0.00000000
	0.00000000	0.00000000				

1990	1	1	0	0	2	23	23.5	2.20	0.00000000	0.01818182	0.10909091	0.38181818	0.21818182	0.18181818	0.09090909	0.00000000	0.00000000	0.00000000
1990	1	1	0	0	2	24	24.5	0.48	0.00000000	0.00000000	0.08333333	0.25000000	0.33333333	0.25000000	0.08333333	0.00000000	0.00000000	0.00000000
1990	1	1	0	0	2	25	25.5	0.20	0.00000000	0.00000000	0.00000000	0.00000000	0.20000000	0.40000000	0.20000000	0.20000000	0.00000000	0.00000000
1990	1	1	0	0	2	26	26.5	0.04	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1990	1	1	0	0	2	27	27.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1991	1	1	0	0	2	9	9.5	0.04	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1991	1	1	0	0	2	12	12.5	0.08	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1991	1	1	0	0	2	13	13.5	0.12	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1991	1	1	0	0	2	14	14.5	0.80	0.30000000	0.70000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1991	1	1	0	0	2	15	15.5	3.48	0.34482759	0.65517241	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1991	1	1	0	0	2	16	16.5	2.00	0.36000000	0.58000000	0.06000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1991	1	1	0	0	2	17	17.5	4.60	0.03478261	0.66956522	0.28695652	0.00869565	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1991	1	1	0	0	2	18	18.5	8.32	0.00480769	0.58653846	0.36538462	0.04326923	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1991	1	1	0	0	2	19	19.5	12.92	0.00928793	0.37151703	0.57894737	0.03715170	0.00309598	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1991	1	1	0	0	2	20	20.5	20.92	0.00000000	0.17399618	0.67877629	0.11854685	0.02868069	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1991	1	1	0	0	2	21	21.5	16.00	0.00000000	0.10000000	0.48750000	0.28250000	0.08000000	0.03250000	0.00500000	0.00750000	0.00500000	0.00000000
1991	1	1	0	0	2	22	22.5	10.28	0.00000000	0.03112840	0.26848249	0.38910506	0.19066148	0.06614786	0.04280156	0.01167315	0.00000000	0.00000000
1991	1	1	0	0	2	23	23.5	4.72	0.00000000	0.00000000	0.16101695	0.34745763	0.25423729	0.16101695	0.05084746	0.02542373	0.00000000	0.00000000
1991	1	1	0	0	2	24	24.5	1.16	0.00000000	0.00000000	0.06896552	0.44827586	0.31034483	0.13793103	0.00000000	0.00000000	0.03448276	0.00000000
1991	1	1	0	0	2	25	25.5	0.24	0.00000000	0.00000000	0.00000000	0.16666667	0.33333333	0.33333333	0.00000000	0.16666667	0.00000000	0.00000000
1991	1	1	0	0	2	26	26.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1992	1	1	0	0	2	13	13.5	0.32	0.12500000	0.87500000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1992	1	1	0	0	2	14	14.5	4.24	0.01886792	0.92452830	0.05660377	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1992	1	1	0	0	2	15	15.5	9.84	0.00000000	0.84959350	0.15040650	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1992	1	1	0	0	2	16	16.5	14.76	0.00271003	0.74525745	0.24661247	0.00542005	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1992	1	1	0	0	2	17	17.5	20.60	0.00000000	0.53398058	0.45048544	0.01553398	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1992	1	1	0	0	2	18	18.5	18.48	0.00000000	0.35064935	0.60173160	0.04112554	0.00649351	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1992	1	1	0	0	2	19	19.5	17.88	0.00000000	0.07829978	0.70693512	0.19239374	0.01789709	0.00447427	0.00000000	0.00000000	0.00000000	0.00000000
1992	1	1	0	0	2	20	20.5	9.72	0.00000000	0.02057613	0.59670782	0.31687243	0.05761317	0.00823045	0.00000000	0.00000000	0.00000000	0.00000000
1992	1	1	0	0	2	21	21.5	3.24	0.00000000	0.01234568	0.37037037	0.35802469	0.14814815	0.09876543	0.01234568	0.00000000	0.00000000	0.00000000

1992	1 1	0 0	2 22	22.5 2.20	0.00000000	0.00000000
	0.05454545	0.41818182	0.30909091	0.14545455	0.07272727	0.00000000
	0.00000000	0.00000000				
1992	1 1	0 0	2 23	23.5 1.48	0.00000000	0.00000000
	0.00000000	0.21621622	0.27027027	0.35135135	0.10810811	0.02702703
	0.02702703	0.00000000				
1992	1 1	0 0	2 24	24.5 0.36	0.00000000	0.00000000
	0.00000000	0.33333333	0.44444444	0.22222222	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	1 1	0 0	2 14	14.5 0.04	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	1 1	0 0	2 15	15.5 0.08	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	1 1	0 0	2 16	16.5 1.84	0.02173913	0.06521739
	0.73913043	0.15217391	0.02173913	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	1 1	0 0	2 17	17.5 6.88	0.00581395	0.09302326
	0.67441860	0.22674419	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	1 1	0 0	2 18	18.5 5.64	0.00000000	0.02127660
	0.38297872	0.55319149	0.04255319	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	1 1	0 0	2 19	19.5 4.12	0.00000000	0.00970874
	0.28155340	0.58252427	0.09708738	0.02912621	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	1 1	0 0	2 20	20.5 0.64	0.00000000	0.00000000
	0.25000000	0.43750000	0.25000000	0.00000000	0.06250000	0.00000000
	0.00000000	0.00000000				
1993	1 1	0 0	2 21	21.5 0.16	0.00000000	0.00000000
	0.00000000	0.50000000	0.25000000	0.00000000	0.25000000	0.00000000
	0.00000000	0.00000000				
1993	1 1	0 0	2 22	22.5 0.04	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	1 1	0 0	2 23	23.5 0.04	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1994	1 1	0 0	2 14	14.5 0.60	0.06666667	0.93333333
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1994	1 1	0 0	2 15	15.5 3.32	0.01204819	0.93975904
	0.04819277	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1994	1 1	0 0	2 16	16.5 6.32	0.00632911	0.88607595
	0.08860759	0.01898734	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1994	1 1	0 0	2 17	17.5 9.32	0.04291845	0.54935622
	0.30472103	0.09012876	0.01287554	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1994	1 1	0 0	2 18	18.5 8.96	0.02678571	0.21875000
	0.45535714	0.26339286	0.03125000	0.00446429	0.00000000	0.00000000
	0.00000000	0.00000000				
1994	1 1	0 0	2 19	19.5 6.08	0.03947368	0.09868421
	0.42105263	0.40131579	0.03947368	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1994	1 1	0 0	2 20	20.5 1.28	0.00000000	0.03125000
	0.28125000	0.59375000	0.09375000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1994	1 1	0 0	2 21	21.5 0.36	0.00000000	0.00000000
	0.55555556	0.44444444	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1994	1 1	0 0	2 22	22.5 0.04	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1994	1 1	0 0	2 25	25.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	1 1	0 0	2 12	12.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	1 1	0 0	2 13	13.5 0.20	0.40000000	0.60000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	1 1	0 0	2 14	14.5 0.68	0.52941176	0.41176471
	0.05882353	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	1 1	0 0	2 15	15.5 5.48	0.06569343	0.70072993
	0.21897810	0.01459854	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	1 1	0 0	2 16	16.5 15.92	0.04522613	0.65326633
	0.28391960	0.01507538	0.00251256	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	1 1	0 0	2 17	17.5 15.00	0.04800000	0.51200000
	0.40000000	0.03733333	0.00266667	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	1 1	0 0	2 18	18.5 6.64	0.07831325	0.30120482
	0.55421687	0.06024096	0.00602410	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

1995	1 1	0 0	2 19	19.5 1.88	0.14893617	0.21276596
	0.42553191	0.12765957	0.08510638	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	1 1	0 0	2 20	20.5 1.04	0.00000000	0.03846154
	0.50000000	0.30769231	0.15384615	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	1 1	0 0	2 21	21.5 0.24	0.00000000	0.00000000
	0.66666667	0.16666667	0.16666667	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	1 1	0 0	2 22	22.5 0.04	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	1 1	0 0	2 27	27.5 0.04	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 13	13.5 0.04	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 14	14.5 0.28	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 15	15.5 4.68	0.00854701	0.65811966
	0.32478632	0.00000000	0.00854701	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 16	16.5 14.68	0.01362398	0.46594005
	0.46049046	0.05994550	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 17	17.5 26.60	0.00150376	0.26766917
	0.56090226	0.15187970	0.01654135	0.00150376	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 18	18.5 36.60	0.00327869	0.08852459
	0.61202186	0.26229508	0.03169399	0.00218579	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 19	19.5 30.32	0.00131926	0.03166227
	0.51319261	0.39577836	0.05277045	0.00527704	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 20	20.5 13.72	0.00291545	0.03206997
	0.47521866	0.38483965	0.08454810	0.02040816	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 21	21.5 5.08	0.00000000	0.03937008
	0.45669291	0.32283465	0.18110236	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 22	22.5 1.28	0.00000000	0.06250000
	0.46875000	0.21875000	0.21875000	0.03125000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 23	23.5 0.12	0.00000000	0.00000000
	0.66666667	0.33333333	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 24	24.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 25	25.5 0.08	0.00000000	0.00000000
	0.00000000	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 26	26.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000				
1997	1 1	0 0	2 9	9.5 0.08	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	1 1	0 0	2 11	11.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	1 1	0 0	2 12	12.5 0.16	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	1 1	0 0	2 13	13.5 0.76	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	1 1	0 0	2 14	14.5 4.48	0.00000000	0.95535714
	0.04464286	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	1 1	0 0	2 15	15.5 9.28	0.00000000	0.90948276
	0.08620690	0.00000000	0.00431034	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	1 1	0 0	2 16	16.5 19.28	0.00414938	0.81742739
	0.17219917	0.00622407	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	1 1	0 0	2 17	17.5 25.20	0.00317460	0.56666667
	0.40317460	0.02063492	0.00634921	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	1 1	0 0	2 18	18.5 24.64	0.00000000	0.21266234
	0.68344156	0.09577922	0.00811688	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	1 1	0 0	2 19	19.5 18.80	0.00212766	0.04680851
	0.52127660	0.33617021	0.07872340	0.00851064	0.00638298	0.00000000
	0.00000000	0.00000000				
1997	1 1	0 0	2 20	20.5 11.76	0.00000000	0.01700680
	0.25850340	0.46598639	0.21088435	0.02721088	0.02040816	0.00000000
	0.00000000	0.00000000				

1997	1	1	0	0	2	21	21.5	6.20	0.00000000	0.02580645	0.18064516	0.51612903	0.20645161	0.07096774	0.00000000	0.00000000	0.00000000	0.00000000
1997	1	1	0	0	2	22	22.5	1.16	0.00000000	0.06896552	0.17241379	0.37931034	0.27586207	0.10344828	0.00000000	0.00000000	0.00000000	0.00000000
1997	1	1	0	0	2	23	23.5	0.28	0.00000000	0.00000000	0.28571429	0.42857143	0.14285714	0.14285714	0.00000000	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	9	9.5	0.04	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	10	10.5	0.08	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	11	11.5	0.72	0.55555556	0.44444444	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	12	12.5	4.92	0.37398374	0.62601626	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	13	13.5	15.76	0.07106599	0.90609137	0.02284264	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	14	14.5	25.24	0.00316957	0.97781300	0.01901743	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	15	15.5	23.56	0.00169779	0.85059423	0.14770798	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	16	16.5	11.36	0.00000000	0.51056338	0.48943662	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	17	17.5	8.52	0.00000000	0.12206573	0.81220657	0.04694836	0.01877934	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	18	18.5	7.40	0.00000000	0.01621622	0.72972973	0.22162162	0.03243243	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	19	19.5	6.56	0.00000000	0.00609756	0.35975610	0.40243902	0.21951220	0.00609756	0.00609756	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	20	20.5	4.88	0.00000000	0.02459016	0.11475410	0.42622951	0.35245902	0.04918033	0.03278689	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	21	21.5	1.92	0.00000000	0.00000000	0.08333333	0.45833333	0.31250000	0.10416667	0.02083333	0.02083333	0.00000000	0.00000000
1998	1	1	0	0	2	22	22.5	0.36	0.00000000	0.11111111	0.00000000	0.11111111	0.55555556	0.11111111	0.11111111	0.00000000	0.00000000	0.00000000
1998	1	1	0	0	2	23	23.5	0.32	0.00000000	0.00000000	0.00000000	0.37500000	0.25000000	0.37500000	0.00000000	0.00000000	0.00000000	0.00000000
1999	1	1	0	0	2	11	11.5	0.04	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1999	1	1	0	0	2	12	12.5	0.16	0.75000000	0.25000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1999	1	1	0	0	2	13	13.5	3.80	0.13684211	0.81052632	0.05263158	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1999	1	1	0	0	2	14	14.5	17.32	0.01385681	0.86605081	0.12009238	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1999	1	1	0	0	2	15	15.5	20.16	0.00000000	0.72023810	0.26190476	0.01587302	0.00198413	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1999	1	1	0	0	2	16	16.5	10.52	0.00380228	0.42965779	0.42965779	0.09505703	0.02661597	0.01140684	0.00380228	0.00000000	0.00000000	0.00000000
1999	1	1	0	0	2	17	17.5	4.68	0.00000000	0.30769231	0.47863248	0.13675214	0.05982906	0.00854701	0.00854701	0.00000000	0.00000000	0.00000000
1999	1	1	0	0	2	18	18.5	1.64	0.00000000	0.19512195	0.48780488	0.12195122	0.17073171	0.02439024	0.00000000	0.00000000	0.00000000	0.00000000
1999	1	1	0	0	2	19	19.5	0.36	0.00000000	0.00000000	0.55555556	0.11111111	0.33333333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1999	1	1	0	0	2	20	20.5	0.36	0.00000000	0.00000000	0.44444444	0.44444444	0.11111111	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1999	1	1	0	0	2	21	21.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1999	1	1	0	0	2	22	22.5	0.12	0.00000000	0.00000000	0.33333333	0.00000000	0.00000000	0.33333333	0.33333333	0.00000000	0.00000000	0.00000000

2000	1 1	0 0	2 12	12.5 0.28	0.85714286	0.00000000
	0.14285714	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	1 1	0 0	2 13	13.5 0.72	0.83333333	0.16666667
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	1 1	0 0	2 14	14.5 1.48	0.75675676	0.02702703
	0.13513514	0.08108108	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	1 1	0 0	2 15	15.5 4.72	0.01694915	0.24576271
	0.35593220	0.36440678	0.01694915	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	1 1	0 0	2 16	16.5 21.20	0.00188679	0.09433962
	0.49811321	0.39433962	0.00943396	0.00000000	0.00188679	0.00000000
	0.00000000	0.00000000				
2000	1 1	0 0	2 17	17.5 19.80	0.00202020	0.15151515
	0.46060606	0.36767677	0.01616162	0.00202020	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	1 1	0 0	2 18	18.5 10.96	0.00000000	0.35401460
	0.33941606	0.26642336	0.03649635	0.00364964	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	1 1	0 0	2 19	19.5 5.40	0.00000000	0.44444444
	0.39259259	0.14074074	0.01481481	0.00740741	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	1 1	0 0	2 20	20.5 3.00	0.00000000	0.48000000
	0.33333333	0.13333333	0.04000000	0.01333333	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	1 1	0 0	2 21	21.5 0.48	0.00000000	0.33333333
	0.25000000	0.25000000	0.08333333	0.08333333	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	1 1	0 0	2 23	23.5 0.08	0.00000000	0.00000000
	0.00000000	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 9	9.5 0.40	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 10	10.5 2.48	0.96774194	0.03225806
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 11	11.5 4.32	0.99074074	0.00925926
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 12	12.5 3.24	0.96296296	0.03703704
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 13	13.5 1.80	0.97777778	0.02222222
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 14	14.5 0.64	0.43750000	0.50000000
	0.06250000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 15	15.5 4.24	0.06603774	0.63207547
	0.27358491	0.02830189	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 16	16.5 12.68	0.00946372	0.48580442
	0.39747634	0.09779180	0.00946372	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 17	17.5 25.36	0.01261830	0.29652997
	0.46372240	0.20031546	0.02523659	0.00157729	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 18	18.5 19.28	0.00207469	0.22614108
	0.33195021	0.39211618	0.04149378	0.00622407	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 19	19.5 6.16	0.00000000	0.11038961
	0.27922078	0.50649351	0.09090909	0.01298701	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 20	20.5 4.20	0.00000000	0.08571429
	0.29523810	0.49523810	0.07619048	0.04761905	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 21	21.5 7.56	0.00000000	0.01058201
	0.10582011	0.66137566	0.19576720	0.02645503	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 22	22.5 4.92	0.00000000	0.01626016
	0.08943089	0.52032520	0.28455285	0.06504065	0.01626016	0.00813008
	0.00000000	0.00000000				
2001	1 1	0 0	2 23	23.5 1.80	0.00000000	0.00000000
	0.02222222	0.22222222	0.35555556	0.26666667	0.11111111	0.02222222
	0.00000000	0.00000000				
2001	1 1	0 0	2 24	24.5 0.96	0.00000000	0.00000000
	0.00000000	0.08333333	0.41666667	0.45833333	0.04166667	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 25	25.5 0.20	0.00000000	0.00000000
	0.00000000	0.00000000	0.20000000	0.40000000	0.20000000	0.20000000
	0.00000000	0.00000000				
2002	1 1	0 0	2 9	9.5 2.20	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 1	0 0	2 11	11.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

2002	1 1	0 0	2 13	13.5 0.64	0.31250000	0.68750000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 1	0 0	2 14	14.5 2.84	0.16901408	0.77464789
	0.05633803	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 1	0 0	2 15	15.5 10.64	0.18421053	0.75563910
	0.06015038	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 1	0 0	2 16	16.5 12.36	0.22330097	0.66343042
	0.09385113	0.01941748	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 1	0 0	2 17	17.5 8.36	0.10526316	0.51674641
	0.35885167	0.01913876	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 1	0 0	2 18	18.5 3.40	0.09411765	0.27058824
	0.45882353	0.15294118	0.02352941	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 1	0 0	2 19	19.5 1.40	0.00000000	0.40000000
	0.45714286	0.05714286	0.08571429	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 1	0 0	2 20	20.5 0.52	0.00000000	0.30769231
	0.46153846	0.15384615	0.07692308	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 1	0 0	2 21	21.5 0.20	0.00000000	0.40000000
	0.20000000	0.20000000	0.20000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 1	0 0	2 22	22.5 0.24	0.00000000	0.00000000
	0.16666667	0.16666667	0.50000000	0.16666667	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 1	0 0	2 24	24.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 9	9.5 0.40	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 10	10.5 0.96	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 11	11.5 5.16	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 12	12.5 3.40	0.98791332	0.01208668
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 13	13.5 1.96	0.99323425	0.00676575
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 14	14.5 1.52	0.38713785	0.59261133
	0.02025082	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 15	15.5 7.12	0.02548793	0.74464426
	0.22986782	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 16	16.5 17.32	0.00140916	0.64027960
	0.35640250	0.00190874	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 17	17.5 17.44	0.00599124	0.51397996
	0.46442091	0.01560789	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 18	18.5 10.24	0.00000000	0.22596727
	0.69045357	0.08357916	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 19	19.5 2.56	0.00000000	0.00000000
	0.71002730	0.28997270	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 20	20.5 1.08	0.00000000	0.01515160
	0.39644094	0.39544547	0.19296199	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 21	21.5 0.04	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 22	22.5 0.08	0.00000000	0.00000000
	0.00000000	0.48419650	0.00000000	0.51580350	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 23	23.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 1	0 0	2 10	10.5 0.08	0.85724164	0.14275836
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 1	0 0	2 11	11.5 0.20	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 1	0 0	2 12	12.5 0.64	0.08048017	0.82743070
	0.09208913	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 1	0 0	2 13	13.5 12.52	0.00956258	0.95122903
	0.03920839	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

2004	1	1	0	0	2	14	14.5	21.76	0.00359058	0.95739276	0.03466519	0.00435147	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	1	1	0	0	2	15	15.5	25.40	0.00000000	0.94091359	0.05742835	0.00000000	0.00165806	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	1	1	0	0	2	16	16.5	19.40	0.00202978	0.86090953	0.13192873	0.00513197	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	1	1	0	0	2	17	17.5	7.68	0.00000000	0.69924154	0.26060917	0.03108951	0.00905978	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	1	1	0	0	2	18	18.5	3.40	0.00000000	0.15186875	0.68818996	0.12145801	0.03848328	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	1	1	0	0	2	19	19.5	1.64	0.00000000	0.07207820	0.62049830	0.28369307	0.02373042	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	1	1	0	0	2	20	20.5	0.12	0.00000000	0.00000000	0.15864740	0.00000000	0.84135260	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	1	1	0	0	2	21	21.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	1	1	0	0	2	22	22.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
2004	1	1	0	0	2	24	24.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	9	9.5	0.56	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	10	10.5	1.76	0.98053090	0.01946910	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	11	11.5	3.56	0.88990152	0.11009848	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	12	12.5	4.08	0.84988920	0.15011080	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	13	13.5	12.08	0.22818318	0.69264963	0.07916718	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	14	14.5	23.44	0.06733006	0.75052503	0.16993421	0.00732642	0.00488428	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	15	15.5	23.28	0.00939555	0.49792816	0.48303236	0.00964393	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	16	16.5	16.52	0.00000000	0.10627283	0.86028527	0.03344190	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	17	17.5	8.56	0.00000000	0.05795213	0.84600344	0.09604443	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	18	18.5	2.04	0.00000000	0.00000000	0.86649676	0.13350324	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	19	19.5	1.16	0.00000000	0.04098077	0.81345481	0.13020836	0.01535606	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	20	20.5	0.12	0.00000000	0.00000000	0.25406824	0.74593176	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	21	21.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	22	22.5	0.08	0.00000000	0.00000000	0.00000000	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	23	23.5	0.04	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	1	1	0	0	2	24	24.5	0.12	0.00000000	0.00000000	0.00000000	0.00000000	0.65509747	0.17245126	0.17245126	0.00000000	0.00000000	0.00000000
2006	1	1	0	0	2	9	9.5	0.96	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2006	1	1	0	0	2	10	10.5	1.40	0.88701076	0.11298924	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2006	1	1	0	0	2	11	11.5	1.32	0.98568238	0.01431762	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2006	1	1	0	0	2	12	12.5	1.32	0.88006038	0.10052698	0.01941265	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

2006	1 1	0 0	2 13	13.5 3.00	0.21940014	0.76161037
	0.01898949	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	1 1	0 0	2 14	14.5 21.32	0.01304065	0.90358890
	0.07851261	0.00485784	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	1 1	0 0	2 15	15.5 37.72	0.01095136	0.84253949
	0.14033226	0.00617688	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	1 1	0 0	2 16	16.5 28.40	0.00611224	0.63583488
	0.33683104	0.02122184	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	1 1	0 0	2 17	17.5 15.56	0.00450101	0.27867060
	0.64420885	0.07172864	0.00089091	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	1 1	0 0	2 18	18.5 6.36	0.00000000	0.16801225
	0.62027621	0.20965932	0.00205223	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	1 1	0 0	2 19	19.5 1.48	0.00000000	0.11597262
	0.51746858	0.33087053	0.03568828	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	1 1	0 0	2 20	20.5 0.32	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	1 1	0 0	2 21	21.5 0.08	0.00000000	0.00000000
	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	1 1	0 0	2 22	22.5 0.04	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 10	10.5 0.32	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 11	11.5 1.32	0.94287247	0.05712753
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 12	12.5 2.92	0.59384550	0.33348688
	0.07266763	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 13	13.5 9.68	0.14502383	0.79833549
	0.05664069	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 14	14.5 15.92	0.00617587	0.80915906
	0.17251095	0.01215412	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 15	15.5 25.12	0.00383211	0.46621895
	0.50989604	0.02005290	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 16	16.5 42.60	0.00021225	0.13963974
	0.75198026	0.10624223	0.00192553	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 17	17.5 31.44	0.00221231	0.04880480
	0.70318270	0.22906363	0.01673656	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 18	18.5 8.40	0.00000000	0.01098498
	0.64039056	0.32013968	0.02848478	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 19	19.5 1.92	0.00000000	0.00000000
	0.20575525	0.76614876	0.02809599	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 20	20.5 0.40	0.00000000	0.00000000
	0.24239144	0.66239227	0.09521629	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 21	21.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 22	22.5 0.04	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 10	10.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 11	11.5 0.36	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 12	12.5 1.60	0.95862309	0.04137691
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 13	13.5 1.44	0.80969928	0.19030072
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 14	14.5 8.04	0.08352459	0.85871898
	0.05473401	0.00000000	0.00302242	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 15	15.5 10.60	0.02228641	0.80904227
	0.16867132	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 16	16.5 13.44	0.01314588	0.39706905
	0.57489769	0.01488738	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

2008	1 1	0 0	4 17	17.5 12.08	0.01443762	0.20951006
	0.71505274	0.06099959	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 18	18.5 5.24	0.01151620	0.19437510
	0.70333613	0.09077257	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 19	19.5 1.36	0.00000000	0.19981514
	0.49211523	0.25835256	0.04971707	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 20	20.5 0.60	0.00000000	0.00000000
	0.21969045	0.58469287	0.19561668	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 21	21.5 0.40	0.00000000	0.00000000
	0.10728223	0.57087110	0.32184668	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 22	22.5 0.08	0.00000000	0.00000000
	0.19645556	0.00000000	0.80354444	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 23	23.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	1 1	0 0	4 13	13.5 0.12	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	1 1	0 0	4 14	14.5 1.24	0.00596642	0.82827338
	0.16576019	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	1 1	0 0	4 15	15.5 5.04	0.01703981	0.56400035
	0.41895984	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	1 1	0 0	4 16	16.5 10.16	0.00000000	0.43444470
	0.55297108	0.01258422	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	1 1	0 0	4 17	17.5 14.96	0.00000000	0.13659213
	0.72556147	0.12329127	0.01455513	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	1 1	0 0	4 18	18.5 4.28	0.00000000	0.03133328
	0.60766805	0.33294139	0.02805729	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	1 1	0 0	4 19	19.5 0.20	0.00000000	0.00000000
	0.25074000	0.74926000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 1	0 0	5 10	10.5 0.16	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 1	0 0	5 11	11.5 0.88	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 1	0 0	5 12	12.5 1.48	0.46167897	0.53832103
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 1	0 0	5 13	13.5 3.68	0.00805442	0.94498800
	0.04695758	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 1	0 0	5 14	14.5 7.24	0.00178965	0.89145422
	0.10210396	0.00465217	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 1	0 0	5 15	15.5 11.84	0.00312532	0.78440500
	0.21246967	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 1	0 0	5 16	16.5 10.12	0.00447208	0.61519943
	0.34820481	0.03212367	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 1	0 0	5 17	17.5 2.12	0.00000000	0.18606884
	0.55430142	0.25962973	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 1	0 0	5 18	18.5 0.24	0.00000000	0.00000000
	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 1	0 0	5 19	19.5 0.16	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 1	0 0	5 20	20.5 0.04	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 1	0 0	5 21	21.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000				
2011	1 1	0 0	5 11	11.5 0.36	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2011	1 1	0 0	5 12	12.5 0.28	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2011	1 1	0 0	5 13	13.5 0.12	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2011	1 1	0 0	5 14	14.5 0.64	0.00000000	0.93941461
	0.06058539	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

2011	1 1	0 0	5 15	15.5 7.52	0.00000000	0.66143896
	0.31944032	0.01912072	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2011	1 1	0 0	5 16	16.5 10.52	0.00000000	0.50490178
	0.38630133	0.10879689	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2011	1 1	0 0	5 17	17.5 15.12	0.00000000	0.32876650
	0.50782148	0.16341202	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2011	1 1	0 0	5 18	18.5 7.92	0.00000000	0.11111186
	0.46436282	0.40729327	0.01723205	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2011	1 1	0 0	5 19	19.5 0.76	0.00000000	0.00000000
	0.32112782	0.60508088	0.07379130	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2011	1 1	0 0	5 20	20.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2011	1 1	0 0	5 21	21.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 10	10.5 0.20	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 12	12.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 13	13.5 0.28	0.42857143	0.57142857
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 14	14.5 0.96	0.38888889	0.61111111
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 15	15.5 1.48	0.22198353	0.77801647
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 16	16.5 0.92	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 17	17.5 1.20	0.00000000	0.96941293
	0.03058707	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 18	18.5 0.36	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 19	19.5 0.24	0.00000000	0.23333333
	0.76666667	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 20	20.5 1.16	0.00000000	0.00000000
	0.84464661	0.15535339	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 21	21.5 0.96	0.00000000	0.00000000
	0.81422594	0.12887029	0.05690377	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 22	22.5 1.00	0.00000000	0.10834671
	0.74799358	0.14365971	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 23	23.5 0.48	0.00000000	0.00000000
	0.22023810	0.68253968	0.09722222	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 24	24.5 0.12	0.00000000	0.00000000
	0.00000000	0.69052632	0.30947368	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 25	25.5 0.08	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 26	26.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	2 2	0 0	2 10	10.5 0.04	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	2 2	0 0	2 11	11.5 0.04	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	2 2	0 0	2 12	12.5 0.04	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	2 2	0 0	2 13	13.5 0.04	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	2 2	0 0	2 16	16.5 0.08	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	2 2	0 0	2 18	18.5 0.16	0.00000000	0.24635771
	0.75364229	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	2 2	0 0	2 19	19.5 3.64	0.00000000	0.70323381
	0.28808754	0.00867865	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

1982	2 2	0 0	2 20	20.5 10.32	0.00000000	0.67689091
	0.30757488	0.01553421	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	2 2	0 0	2 21	21.5 5.56	0.00000000	0.29096469
	0.64576781	0.06326750	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	2 2	0 0	2 22	22.5 2.04	0.00000000	0.04574610
	0.59299210	0.36126181	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	2 2	0 0	2 23	23.5 0.96	0.00000000	0.00000000
	0.34613383	0.65386617	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	2 2	0 0	2 24	24.5 0.36	0.00000000	0.00000000
	0.25797076	0.41490727	0.32712197	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	2 2	0 0	2 25	25.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1983	2 2	0 0	2 14	14.5 0.04	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1983	2 2	0 0	2 15	15.5 0.20	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1983	2 2	0 0	2 16	16.5 0.16	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1983	2 2	0 0	2 17	17.5 0.16	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1983	2 2	0 0	2 18	18.5 0.24	0.00000000	0.90157160
	0.09842840	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1983	2 2	0 0	2 19	19.5 0.72	0.00000000	0.46731445
	0.53268555	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1983	2 2	0 0	2 20	20.5 1.80	0.00000000	0.26570016
	0.72482790	0.00947194	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1983	2 2	0 0	2 21	21.5 2.80	0.00000000	0.09409231
	0.86759048	0.02453050	0.01378671	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1983	2 2	0 0	2 22	22.5 1.12	0.00000000	0.03843233
	0.94259994	0.01896773	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1983	2 2	0 0	2 23	23.5 0.24	0.00000000	0.00000000
	0.34145960	0.65854040	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1983	2 2	0 0	2 24	24.5 0.04	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1984	2 2	0 0	2 14	14.5 0.04	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1984	2 2	0 0	2 16	16.5 0.28	0.00000000	0.85714286
	0.14285714	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1984	2 2	0 0	2 17	17.5 0.64	0.27755920	0.72244080
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1984	2 2	0 0	2 18	18.5 1.04	0.00000000	0.75308147
	0.24691853	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1984	2 2	0 0	2 19	19.5 0.80	0.00000000	0.58731421
	0.39226218	0.02042360	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1984	2 2	0 0	2 20	20.5 1.56	0.03025239	0.31452206
	0.63849962	0.01672593	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1984	2 2	0 0	2 21	21.5 2.08	0.00000000	0.05916880
	0.87483749	0.06599372	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1984	2 2	0 0	2 22	22.5 1.68	0.00000000	0.07116822
	0.85302285	0.07580893	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1984	2 2	0 0	2 23	23.5 0.52	0.00000000	0.08479459
	0.33917834	0.57602707	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	2 2	0 0	2 15	15.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	2 2	0 0	2 16	16.5 0.08	0.20354671	0.79645329
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	2 2	0 0	2 17	17.5 0.08	0.92843389	0.07156611
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	2 2	0 0	2 18	18.5 0.76	0.00000000	0.93323994
	0.06676006	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

1985	2 2	0 0	2 19	19.5 1.96	0.00000000	0.73704598
	0.21255300	0.05040102	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	2 2	0 0	2 20	20.5 7.68	0.00000000	0.44114657
	0.51618302	0.04267040	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	2 2	0 0	2 21	21.5 10.36	0.00000000	0.14891157
	0.82291396	0.02817448	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	2 2	0 0	2 22	22.5 8.12	0.00000000	0.03064221
	0.88380250	0.08555529	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	2 2	0 0	2 23	23.5 3.40	0.00000000	0.03335505
	0.48462921	0.48201574	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	2 2	0 0	2 24	24.5 0.80	0.00000000	0.00000000
	0.12060857	0.78234396	0.09704746	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	2 2	0 0	2 25	25.5 0.12	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 9	9.5 0.12	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 14	14.5 1.76	0.37500000	0.62500000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 15	15.5 1.00	0.12994393	0.87005607
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 16	16.5 0.68	0.07590847	0.92409153
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 17	17.5 0.08	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 18	18.5 0.28	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 19	19.5 0.40	0.00000000	0.68125154
	0.31874846	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 20	20.5 2.96	0.00000000	0.40831098
	0.58747531	0.00421371	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 21	21.5 12.28	0.00000000	0.08215714
	0.79523239	0.11814516	0.00446531	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 22	22.5 16.24	0.00000000	0.03090581
	0.79749546	0.17034075	0.00062899	0.00062899	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 23	23.5 7.04	0.00000000	0.00000000
	0.29123092	0.68753585	0.02123323	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 24	24.5 1.00	0.00000000	0.00000000
	0.06895176	0.64116293	0.28988531	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 25	25.5 0.16	0.00000000	0.00000000
	0.24684621	0.05460697	0.69854681	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 26	26.5 0.08	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 27	27.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	2 2	0 0	2 9	9.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	2 2	0 0	2 11	11.5 0.20	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	2 2	0 0	2 12	12.5 2.32	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	2 2	0 0	2 13	13.5 0.32	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	2 2	0 0	2 14	14.5 0.24	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	2 2	0 0	2 15	15.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	2 2	0 0	2 16	16.5 0.12	0.50000000	0.50000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	2 2	0 0	2 17	17.5 0.64	0.05695696	0.94304304
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

1987	2	2	0	0	2	18	18.5	6.08	0.00000000	0.92227802	0.07772198	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1987	2	2	0	0	2	19	19.5	12.92	0.00000000	0.92599879	0.07400121	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1987	2	2	0	0	2	20	20.5	17.52	0.00000000	0.65930960	0.32334658	0.01734382	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1987	2	2	0	0	2	21	21.5	20.24	0.00000000	0.12638084	0.79687099	0.07594739	0.00080078	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1987	2	2	0	0	2	22	22.5	14.64	0.00157500	0.03258990	0.69330996	0.25157650	0.02094863	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1987	2	2	0	0	2	23	23.5	8.76	0.00000000	0.00000000	0.16066324	0.71579062	0.12354613	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1987	2	2	0	0	2	24	24.5	2.96	0.00000000	0.00000000	0.04698771	0.43069403	0.45011679	0.06303248	0.00916899	0.00000000	0.00000000	0.00000000
1987	2	2	0	0	2	25	25.5	0.64	0.00000000	0.00000000	0.00000000	0.37713168	0.31623182	0.30663650	0.00000000	0.00000000	0.00000000	0.00000000
1988	2	2	0	0	2	13	13.5	0.08	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1988	2	2	0	0	2	14	14.5	0.72	0.61111111	0.38888889	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1988	2	2	0	0	2	15	15.5	1.56	0.33333333	0.58974359	0.05128205	0.02564103	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1988	2	2	0	0	2	16	16.5	2.12	0.15094340	0.83018868	0.00000000	0.01886792	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1988	2	2	0	0	2	17	17.5	2.24	0.01785714	0.89285714	0.07142857	0.01785714	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1988	2	2	0	0	2	18	18.5	1.84	0.00000000	0.91304348	0.08695652	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1988	2	2	0	0	2	19	19.5	2.56	0.01562500	0.82812500	0.14062500	0.01562500	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1988	2	2	0	0	2	20	20.5	5.48	0.01459854	0.35036496	0.62043796	0.00729927	0.00729927	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1988	2	2	0	0	2	21	21.5	9.56	0.00000000	0.05857741	0.92050209	0.01673640	0.00418410	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1988	2	2	0	0	2	22	22.5	10.56	0.00000000	0.01893939	0.86742424	0.09090909	0.01893939	0.00378788	0.00000000	0.00000000	0.00000000	0.00000000
1988	2	2	0	0	2	23	23.5	5.00	0.00000000	0.01600000	0.49600000	0.41600000	0.05600000	0.00800000	0.00800000	0.00000000	0.00000000	0.00000000
1988	2	2	0	0	2	24	24.5	2.28	0.00000000	0.01754386	0.15789474	0.43859649	0.36842105	0.01754386	0.00000000	0.00000000	0.00000000	0.00000000
1988	2	2	0	0	2	25	25.5	0.24	0.00000000	0.16666667	0.00000000	0.33333333	0.16666667	0.16666667	0.16666667	0.00000000	0.00000000	0.00000000
1989	2	2	0	0	2	12	12.5	0.04	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1989	2	2	0	0	2	13	13.5	0.44	0.36363636	0.63636364	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1989	2	2	0	0	2	14	14.5	0.40	0.40000000	0.60000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1989	2	2	0	0	2	15	15.5	0.32	0.62500000	0.37500000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1989	2	2	0	0	2	16	16.5	0.04	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1989	2	2	0	0	2	17	17.5	0.16	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1989	2	2	0	0	2	18	18.5	1.56	0.02564103	0.92307692	0.05128205	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1989	2	2	0	0	2	19	19.5	8.56	0.00000000	0.92056075	0.07476636	0.00467290	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1989	2	2	0	0	2	20	20.5	14.52	0.00550964	0.82644628	0.14876033	0.01652893	0.00275482	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

1989	2 2	0 0	2 21	21.5 12.20	0.00000000	0.35409836
	0.58032787	0.06229508	0.00327869	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1989	2 2	0 0	2 22	22.5 6.08	0.00000000	0.15131579
	0.72368421	0.11184211	0.01315789	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1989	2 2	0 0	2 23	23.5 1.88	0.00000000	0.00000000
	0.40425532	0.59574468	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1989	2 2	0 0	2 24	24.5 0.28	0.00000000	0.00000000
	0.28571429	0.57142857	0.14285714	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	2 2	0 0	2 13	13.5 1.00	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	2 2	0 0	2 14	14.5 1.92	0.81250000	0.18750000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	2 2	0 0	2 15	15.5 4.16	0.51923077	0.48076923
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	2 2	0 0	2 16	16.5 8.92	0.19730942	0.79372197
	0.00896861	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	2 2	0 0	2 17	17.5 3.56	0.24719101	0.70786517
	0.04494382	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	2 2	0 0	2 18	18.5 2.64	0.15151515	0.68181818
	0.13636364	0.03030303	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	2 2	0 0	2 19	19.5 4.96	0.01612903	0.62903226
	0.27419355	0.06451613	0.00806452	0.00000000	0.00806452	0.00000000
	0.00000000	0.00000000				
1990	2 2	0 0	2 20	20.5 20.80	0.01346154	0.22884615
	0.49230769	0.18269231	0.03846154	0.02692308	0.01346154	0.00384615
	0.00000000	0.00000000				
1990	2 2	0 0	2 21	21.5 31.48	0.00000000	0.14104193
	0.42439644	0.26683609	0.09911055	0.03557814	0.02414231	0.00762389
	0.00127065	0.00000000				
1990	2 2	0 0	2 22	22.5 21.40	0.00000000	0.07289720
	0.36448598	0.31028037	0.17943925	0.03364486	0.03364486	0.00373832
	0.00186916	0.00000000				
1990	2 2	0 0	2 23	23.5 6.88	0.00000000	0.07558140
	0.26744186	0.24418605	0.27325581	0.05813953	0.05232558	0.02325581
	0.00581395	0.00000000				
1990	2 2	0 0	2 24	24.5 1.16	0.00000000	0.00000000
	0.20689655	0.34482759	0.17241379	0.10344828	0.13793103	0.03448276
	0.00000000	0.00000000				
1990	2 2	0 0	2 25	25.5 0.12	0.00000000	0.00000000
	0.33333333	0.00000000	0.33333333	0.33333333	0.00000000	0.00000000
	0.00000000	0.00000000				
1991	2 2	0 0	2 11	11.5 0.08	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1991	2 2	0 0	2 12	12.5 0.12	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1991	2 2	0 0	2 13	13.5 0.44	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1991	2 2	0 0	2 14	14.5 1.32	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1991	2 2	0 0	2 15	15.5 2.64	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1991	2 2	0 0	2 16	16.5 3.04	0.86842105	0.11842105
	0.01315789	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1991	2 2	0 0	2 17	17.5 3.64	0.31868132	0.61538462
	0.05494505	0.01098901	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1991	2 2	0 0	2 18	18.5 8.04	0.08457711	0.77611940
	0.13432836	0.00497512	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1991	2 2	0 0	2 19	19.5 12.64	0.00949367	0.78481013
	0.17721519	0.02531646	0.00316456	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1991	2 2	0 0	2 20	20.5 13.76	0.00000000	0.57848837
	0.34593023	0.05232558	0.02034884	0.00290698	0.00000000	0.00000000
	0.00000000	0.00000000				
1991	2 2	0 0	2 21	21.5 11.52	0.00000000	0.22916667
	0.42013889	0.24652778	0.07291667	0.01041667	0.01041667	0.00347222
	0.00694444	0.00000000				
1991	2 2	0 0	2 22	22.5 12.52	0.00000000	0.04153355
	0.31309904	0.34824281	0.18530351	0.07667732	0.01597444	0.01277955
	0.00638978	0.00000000				
1991	2 2	0 0	2 23	23.5 10.04	0.00000000	0.01593625
	0.15537849	0.40637450	0.21115538	0.16334661	0.02390438	0.02390438
	0.00000000	0.00000000				

1991	2 2	0 0	2 24	24.5 2.40	0.00000000	0.00000000
	0.11666667	0.30000000	0.35000000	0.15000000	0.06666667	0.00000000
	0.01666667	0.00000000				
1991	2 2	0 0	2 25	25.5 0.24	0.00000000	0.16666667
	0.00000000	0.16666667	0.16666667	0.33333333	0.00000000	0.16666667
	0.00000000	0.00000000				
1991	2 2	0 0	2 26	26.5 0.36	0.00000000	0.00000000
	0.00000000	0.11111111	0.44444444	0.33333333	0.00000000	0.00000000
	0.11111111	0.00000000				
1991	2 2	0 0	2 27	27.5 0.28	0.00000000	0.00000000
	0.00000000	0.00000000	0.14285714	0.42857143	0.28571429	0.14285714
	0.00000000	0.00000000				
1991	2 2	0 0	2 28	28.5 0.12	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.66666667	0.00000000	0.33333333
	0.00000000	0.00000000				
1992	2 2	0 0	2 10	10.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 11	11.5 0.16	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 12	12.5 0.64	0.93750000	0.06250000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 13	13.5 1.60	0.85000000	0.15000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 14	14.5 5.00	0.56800000	0.40000000
	0.03200000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 15	15.5 12.80	0.32812500	0.65625000
	0.01562500	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 16	16.5 17.64	0.17006803	0.77097506
	0.05668934	0.00226757	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 17	17.5 15.04	0.02925532	0.79521277
	0.16755319	0.00797872	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 18	18.5 8.68	0.00460829	0.77419355
	0.18433180	0.03686636	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 19	19.5 4.88	0.00819672	0.44262295
	0.47540984	0.07377049	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 20	20.5 3.20	0.01250000	0.18750000
	0.61250000	0.13750000	0.05000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 21	21.5 1.48	0.00000000	0.05405405
	0.45945946	0.35135135	0.10810811	0.02702703	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 22	22.5 1.24	0.00000000	0.03225806
	0.09677419	0.61290323	0.19354839	0.00000000	0.06451613	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 23	23.5 0.28	0.00000000	0.14285714
	0.00000000	0.14285714	0.57142857	0.14285714	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 24	24.5 0.08	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 25	25.5 0.08	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 26	26.5 0.08	0.00000000	0.00000000
	0.00000000	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1992	2 2	0 0	2 27	27.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	2 2	0 0	2 9	9.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	2 2	0 0	2 13	13.5 0.28	0.71428571	0.28571429
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	2 2	0 0	2 14	14.5 2.60	0.52307692	0.47692308
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	2 2	0 0	2 15	15.5 6.12	0.31372549	0.67973856
	0.00653595	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	2 2	0 0	2 16	16.5 7.04	0.35227273	0.48295455
	0.15909091	0.00568182	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	2 2	0 0	2 17	17.5 11.12	0.07553957	0.58992806
	0.30935252	0.02158273	0.00359712	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1993	2 2	0 0	2 18	18.5 7.04	0.01136364	0.41477273
	0.55113636	0.02272727	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

1993	2	2	0	0	2	19	19.5	3.04	0.00000000	0.10526316	0.67105263	0.18421053	0.01315789	0.01315789	0.01315789	0.00000000	0.00000000	0.00000000
1993	2	2	0	0	2	20	20.5	1.04	0.00000000	0.03846154	0.42307692	0.42307692	0.07692308	0.03846154	0.00000000	0.00000000	0.00000000	0.00000000
1993	2	2	0	0	2	21	21.5	0.56	0.00000000	0.00000000	0.21428571	0.50000000	0.28571429	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1993	2	2	0	0	2	22	22.5	0.52	0.00000000	0.00000000	0.23076923	0.30769231	0.23076923	0.07692308	0.15384615	0.00000000	0.00000000	0.00000000
1993	2	2	0	0	2	23	23.5	0.52	0.00000000	0.00000000	0.07692308	0.30769231	0.38461538	0.23076923	0.00000000	0.00000000	0.00000000	0.00000000
1993	2	2	0	0	2	24	24.5	0.16	0.00000000	0.00000000	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1993	2	2	0	0	2	25	25.5	0.20	0.00000000	0.00000000	0.00000000	0.20000000	0.00000000	0.60000000	0.20000000	0.00000000	0.00000000	0.00000000
1993	2	2	0	0	2	26	26.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	9	9.5	0.08	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	11	11.5	0.80	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	12	12.5	1.96	0.95918367	0.04081633	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	13	13.5	6.84	0.87719298	0.11695906	0.00584795	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	14	14.5	15.40	0.84935065	0.14805195	0.00259740	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	15	15.5	24.88	0.63344051	0.33922830	0.02572347	0.00160772	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	16	16.5	33.84	0.26122931	0.67730496	0.05673759	0.00354610	0.00000000	0.00118203	0.00000000	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	17	17.5	25.28	0.09968354	0.67879747	0.15348101	0.06170886	0.00632911	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	18	18.5	13.84	0.04624277	0.42196532	0.32080925	0.19075145	0.01734104	0.00289017	0.00000000	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	19	19.5	5.56	0.02158273	0.17266187	0.43884892	0.30935252	0.05035971	0.00719424	0.00000000	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	20	20.5	1.32	0.00000000	0.09090909	0.42424242	0.45454545	0.00000000	0.03030303	0.00000000	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	21	21.5	0.36	0.00000000	0.11111111	0.22222222	0.44444444	0.11111111	0.00000000	0.11111111	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	23	23.5	0.04	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1994	2	2	0	0	2	24	24.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1995	2	2	0	0	2	9	9.5	0.04	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1995	2	2	0	0	2	12	12.5	0.48	0.41666667	0.58333333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1995	2	2	0	0	2	13	13.5	3.04	0.42105263	0.56578947	0.01315789	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1995	2	2	0	0	2	14	14.5	6.24	0.55769231	0.42948718	0.01282051	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1995	2	2	0	0	2	15	15.5	12.64	0.55379747	0.31329114	0.12974684	0.00316456	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1995	2	2	0	0	2	16	16.5	21.60	0.33148148	0.44629630	0.20740741	0.01481481	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
1995	2	2	0	0	2	17	17.5	18.68	0.08993576	0.57815846	0.30192719	0.02783726	0.00000000	0.00214133	0.00000000	0.00000000	0.00000000	0.00000000
1995	2	2	0	0	2	18	18.5	9.48	0.04219409	0.55696203	0.35864979	0.04219409	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

1995	2 2	0 0	2 19	19.5 3.72	0.00000000	0.40860215
	0.52688172	0.05376344	0.01075269	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	2 2	0 0	2 20	20.5 1.24	0.00000000	0.16129032
	0.58064516	0.09677419	0.16129032	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	2 2	0 0	2 21	21.5 0.56	0.00000000	0.07142857
	0.50000000	0.21428571	0.21428571	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	2 2	0 0	2 22	22.5 0.08	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	2 2	0 0	2 23	23.5 0.04	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	2 2	0 0	2 25	25.5 0.04	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 10	10.5 0.40	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 11	11.5 0.64	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 12	12.5 3.32	0.90361446	0.07228916
	0.02409639	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 13	13.5 9.28	0.81896552	0.13362069
	0.04741379	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 14	14.5 11.28	0.59574468	0.37588652
	0.02836879	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 15	15.5 8.12	0.50246305	0.46798030
	0.02955665	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 16	16.5 4.40	0.16363636	0.52727273
	0.28181818	0.02727273	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 17	17.5 6.08	0.03289474	0.50000000
	0.40131579	0.06578947	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 18	18.5 6.84	0.00000000	0.25146199
	0.66666667	0.07602339	0.00584795	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 19	19.5 7.80	0.00512821	0.13846154
	0.61025641	0.18974359	0.01025641	0.04615385	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 20	20.5 4.96	0.00000000	0.10483871
	0.50000000	0.26612903	0.07258065	0.05645161	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 21	21.5 2.04	0.00000000	0.03921569
	0.37254902	0.41176471	0.05882353	0.09803922	0.01960784	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 22	22.5 0.68	0.00000000	0.17647059
	0.29411765	0.35294118	0.17647059	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 25	25.5 0.08	0.00000000	0.00000000
	0.00000000	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 9	9.5 0.08	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 10	10.5 0.88	0.95454545	0.04545455
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 11	11.5 1.40	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 12	12.5 1.60	0.95000000	0.05000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 13	13.5 4.28	0.94392523	0.05607477
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 14	14.5 4.40	0.71818182	0.27272727
	0.00909091	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 15	15.5 5.72	0.16083916	0.79020979
	0.04195804	0.00699301	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 16	16.5 6.68	0.01197605	0.85029940
	0.13173653	0.00598802	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 17	17.5 7.96	0.02010050	0.64321608
	0.28643216	0.04522613	0.00502513	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 18	18.5 7.84	0.01530612	0.40816327
	0.46938776	0.09693878	0.01020408	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

1997	2 2	0 0	2 19	19.5 6.56	0.00609756	0.10365854
	0.50000000	0.31097561	0.06707317	0.01219512	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 20	20.5 9.48	0.00000000	0.02531646
	0.37552743	0.43881857	0.14767932	0.01265823	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 21	21.5 7.52	0.00000000	0.01595745
	0.20744681	0.57978723	0.17021277	0.02659574	0.00000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 22	22.5 3.84	0.00000000	0.01041667
	0.16666667	0.42708333	0.30208333	0.08333333	0.01041667	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 23	23.5 1.00	0.00000000	0.00000000
	0.04000000	0.40000000	0.44000000	0.08000000	0.04000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 24	24.5 0.20	0.00000000	0.00000000
	0.00000000	0.00000000	0.80000000	0.00000000	0.20000000	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 25	25.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 9	9.5 0.08	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 10	10.5 1.00	0.92000000	0.08000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 11	11.5 2.76	0.95652174	0.04347826
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 12	12.5 7.20	0.76111111	0.22777778
	0.01111111	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 13	13.5 11.84	0.53378378	0.41891892
	0.04391892	0.00337838	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 14	14.5 16.68	0.36211031	0.59712230
	0.03597122	0.00479616	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 15	15.5 16.16	0.18316832	0.65594059
	0.14603960	0.00990099	0.00000000	0.00495050	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 16	16.5 12.60	0.02857143	0.56825397
	0.36825397	0.02222222	0.00952381	0.00317460	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 17	17.5 10.04	0.02788845	0.31872510
	0.60557769	0.03984064	0.00398406	0.00398406	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 18	18.5 4.40	0.01818182	0.21818182
	0.66363636	0.10000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 19	19.5 3.20	0.01250000	0.12500000
	0.55000000	0.25000000	0.05000000	0.01250000	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 20	20.5 1.24	0.00000000	0.06451613
	0.35483871	0.41935484	0.12903226	0.03225806	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 21	21.5 0.92	0.00000000	0.08695652
	0.13043478	0.26086957	0.43478261	0.08695652	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 22	22.5 0.20	0.00000000	0.20000000
	0.20000000	0.20000000	0.40000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 23	23.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 24	24.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	2 2	0 0	2 10	10.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	2 2	0 0	2 12	12.5 0.20	0.40000000	0.60000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	2 2	0 0	2 13	13.5 5.00	0.30400000	0.59200000
	0.09600000	0.00800000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	2 2	0 0	2 14	14.5 15.12	0.42063492	0.48412698
	0.07407407	0.01058201	0.00793651	0.00264550	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	2 2	0 0	2 15	15.5 23.12	0.33737024	0.45847751
	0.18512111	0.01384083	0.00519031	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	2 2	0 0	2 16	16.5 16.28	0.16216216	0.51597052
	0.29729730	0.01719902	0.00737101	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	2 2	0 0	2 17	17.5 5.92	0.02702703	0.51351351
	0.41216216	0.04054054	0.00675676	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

1999	2 2	0 0	2 18	18.5 2.76	0.00000000	0.39130435
	0.52173913	0.07246377	0.01449275	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	2 2	0 0	2 19	19.5 1.12	0.00000000	0.39285714
	0.57142857	0.03571429	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	2 2	0 0	2 20	20.5 0.24	0.00000000	0.33333333
	0.50000000	0.00000000	0.00000000	0.00000000	0.16666667	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 9	9.5 0.08	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 11	11.5 0.72	0.88888889	0.11111111
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 12	12.5 2.28	0.71929825	0.26315789
	0.00000000	0.01754386	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 13	13.5 6.56	0.56097561	0.39024390
	0.04268293	0.00609756	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 14	14.5 15.56	0.32904884	0.63239075
	0.03598972	0.00257069	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 15	15.5 17.84	0.30941704	0.56726457
	0.10313901	0.01793722	0.00224215	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 16	16.5 11.08	0.09025271	0.42238267
	0.39711191	0.07581227	0.01444043	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 17	17.5 12.00	0.03333333	0.32000000
	0.54666667	0.09000000	0.01000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 18	18.5 8.12	0.01970443	0.31527094
	0.58620690	0.05911330	0.01970443	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 19	19.5 3.92	0.04081633	0.35714286
	0.44897959	0.12244898	0.03061224	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 20	20.5 1.88	0.04255319	0.44680851
	0.34042553	0.14893617	0.02127660	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 21	21.5 0.08	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 22	22.5 0.12	0.00000000	0.00000000
	0.00000000	0.66666667	0.00000000	0.00000000	0.00000000	0.33333333
	0.00000000	0.00000000				
2000	2 2	0 0	2 26	26.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000				
2001	2 2	0 0	2 9	9.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	2 2	0 0	2 10	10.5 2.00	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	2 2	0 0	2 11	11.5 7.68	0.98437500	0.01562500
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	2 2	0 0	2 12	12.5 14.60	0.93698630	0.06027397
	0.00000000	0.00273973	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	2 2	0 0	2 13	13.5 16.96	0.91273585	0.08254717
	0.00471698	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	2 2	0 0	2 14	14.5 13.28	0.69879518	0.27409639
	0.02409639	0.00301205	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	2 2	0 0	2 15	15.5 11.84	0.48310811	0.44594595
	0.06756757	0.00337838	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	2 2	0 0	2 16	16.5 4.84	0.22314050	0.65289256
	0.11570248	0.00826446	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	2 2	0 0	2 17	17.5 4.80	0.05000000	0.61666667
	0.26666667	0.05833333	0.00833333	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	2 2	0 0	2 18	18.5 4.12	0.01941748	0.33980583
	0.49514563	0.11650485	0.02912621	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	2 2	0 0	2 19	19.5 2.76	0.02898551	0.34782609
	0.44927536	0.17391304	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	2 2	0 0	2 20	20.5 1.96	0.06122449	0.14285714
	0.42857143	0.28571429	0.06122449	0.02040816	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	2 2	0 0	2 21	21.5 0.56	0.00000000	0.00000000
	0.14285714	0.64285714	0.07142857	0.14285714	0.00000000	0.00000000
	0.00000000	0.00000000				

```
2001    2        2    0        0    2       22    22.5    0.08    0.00000000    0.00000000
        0.00000000    0.50000000    0.50000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2001    2        2    0        0    2       23    23.5    0.04    0.00000000    0.00000000
        0.00000000    1.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2001    2        2    0        0    2       24    24.5    0.04    0.00000000    0.00000000
        0.00000000    0.00000000    1.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2        9    9.5     0.04    1.00000000    0.00000000
        0.00000000    0.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       10    10.5    0.04    1.00000000    0.00000000
        0.00000000    0.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       11    11.5    0.32    1.00000000    0.00000000
        0.00000000    0.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       12    12.5    0.60    0.94090198    0.05909802
        0.00000000    0.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       13    13.5    1.20    0.86776363    0.13223637
        0.00000000    0.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       14    14.5    3.20    0.48202583    0.45861108
        0.05936309    0.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       15    15.5    14.36   0.31363030    0.63047762
        0.05228755    0.00360452    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       16    16.5    27.68   0.15968705    0.71509268
        0.11910650    0.00588729    0.00000000    0.00000000      0.00000000    0.00000000
        0.00022648    0.00000000
2002    2        2    0        0    2       17    17.5    26.04   0.10238038    0.62706992
        0.23076059    0.03345566    0.00633345    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       18    18.5    8.36    0.04824437    0.46107866
        0.36726539    0.11233367    0.01107791    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       19    19.5    4.40    0.00000000    0.19801612
        0.46919353    0.26671983    0.06607053    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       20    20.5    1.88    0.00000000    0.03799019
        0.50165190    0.35401946    0.10633845    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       21    21.5    0.40    0.00000000    0.00000000
        0.49698119    0.18994595    0.17934567    0.13372720      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       22    22.5    0.28    0.00000000    0.00000000
        0.00000000    0.25326971    0.20511461    0.54161568      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       23    23.5    0.20    0.00000000    0.00000000
        0.00000000    0.05517814    0.05517814    0.88964373      0.00000000    0.00000000
        0.00000000    0.00000000
2002    2        2    0        0    2       24    24.5    0.04    0.00000000    0.00000000
        0.00000000    0.00000000    0.00000000    0.00000000      1.00000000    0.00000000
        0.00000000    0.00000000
2003    2        2    0        0    2       10    10.5    0.52    1.00000000    0.00000000
        0.00000000    0.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2003    2        2    0        0    2       11    11.5    7.52    1.00000000    0.00000000
        0.00000000    0.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2003    2        2    0        0    2       12    12.5    11.24   1.00000000    0.00000000
        0.00000000    0.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2003    2        2    0        0    2       13    13.5    26.12   0.99216013    0.00783987
        0.00000000    0.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2003    2        2    0        0    2       14    14.5    15.68   0.97074099    0.02925901
        0.00000000    0.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2003    2        2    0        0    2       15    15.5    3.96    0.76533365    0.21262370
        0.02204265    0.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2003    2        2    0        0    2       16    16.5    1.24    0.08207484    0.51377819
        0.40414697    0.00000000    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2003    2        2    0        0    2       17    17.5    1.24    0.03396623    0.34689388
        0.57761967    0.04152022    0.00000000    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2003    2        2    0        0    2       18    18.5    2.68    0.00000000    0.00000000
        0.74075755    0.23570895    0.02353350    0.00000000      0.00000000    0.00000000
        0.00000000    0.00000000
2003    2        2    0        0    2       19    19.5    2.24    0.00000000    0.05383938
        0.46209001    0.42658630    0.04311323    0.01437108      0.00000000    0.00000000
        0.00000000    0.00000000
2003    2        2    0        0    2       20    20.5    0.64    0.00000000    0.00000000
        0.28011714    0.46931240    0.19601734    0.05455312      0.00000000    0.00000000
        0.00000000    0.00000000
```

2003	2	2	0	0	2	21	21.5	0.64	0.06615850	0.00000000	0.18886008	0.42216843	0.27713679	0.04567620	0.00000000	0.00000000	0.00000000	0.00000000
2003	2	2	0	0	2	22	22.5	0.60	0.00000000	0.00000000	0.00000000	0.25966959	0.36244571	0.31296731	0.06491740	0.00000000	0.00000000	0.00000000
2003	2	2	0	0	2	23	23.5	0.52	0.00000000	0.00000000	0.00000000	0.00000000	0.69230769	0.07692308	0.15384615	0.07692308	0.00000000	0.00000000
2003	2	2	0	0	2	24	24.5	0.40	0.00000000	0.00000000	0.00000000	0.10000000	0.30000000	0.00000000	0.50000000	0.10000000	0.00000000	0.00000000
2003	2	2	0	0	2	25	25.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	2	2	0	0	2	11	11.5	0.24	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	2	2	0	0	2	12	12.5	1.76	0.76554318	0.23445682	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	2	2	0	0	2	13	13.5	7.48	0.34723179	0.65276821	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	2	2	0	0	2	14	14.5	17.64	0.05703625	0.93734365	0.00562010	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	2	2	0	0	2	15	15.5	22.36	0.03039504	0.95822333	0.01138163	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	2	2	0	0	2	16	16.5	14.52	0.02602538	0.88287281	0.09110181	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	2	2	0	0	2	17	17.5	4.92	0.00625618	0.79552493	0.17853943	0.01967945	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	2	2	0	0	2	18	18.5	1.88	0.00000000	0.22090829	0.66786799	0.11122372	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	2	2	0	0	2	19	19.5	0.72	0.00000000	0.00000000	0.76369633	0.23630367	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	2	2	0	0	2	20	20.5	0.16	0.00000000	0.00000000	0.62829972	0.37170028	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	2	2	0	0	2	21	21.5	0.12	0.00000000	0.00000000	0.28698906	0.00000000	0.71301094	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	2	2	0	0	2	22	22.5	0.12	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2004	2	2	0	0	2	23	23.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	2	0	0	2	9	9.5	0.28	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	2	0	0	2	10	10.5	2.92	0.94666048	0.05333952	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	2	0	0	2	11	11.5	10.96	0.96530725	0.03469275	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	2	0	0	2	12	12.5	10.60	0.81288846	0.18711154	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	2	0	0	2	13	13.5	18.48	0.59898274	0.37869156	0.02232571	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	2	0	0	2	14	14.5	21.16	0.42406796	0.52373122	0.05220082	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	2	0	0	2	15	15.5	17.36	0.40038006	0.43837061	0.16124933	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	2	0	0	2	16	16.5	7.40	0.21345200	0.38980902	0.37901947	0.01771952	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	2	0	0	2	17	17.5	4.36	0.00144527	0.22691882	0.64385726	0.10039887	0.02737979	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	2	0	0	2	18	18.5	2.60	0.00000000	0.14090830	0.64748177	0.13670520	0.07490474	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	2	0	0	2	19	19.5	1.80	0.00000000	0.19741650	0.58508024	0.21750326	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	2	0	0	2	20	20.5	0.40	0.00000000	0.15375206	0.18540616	0.35333766	0.15375206	0.15375206	0.00000000	0.00000000	0.00000000	0.00000000

2005	2 2	0 0	2 21	21.5 0.16	0.00000000	0.00000000
	0.15773106	0.84226894	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2005	2 2	0 0	2 23	23.5 0.16	0.00000000	0.00000000
	0.00000000	0.00000000	0.03206035	0.32264655	0.32264655	0.00000000
	0.32264655	0.00000000				
2005	2 2	0 0	2 24	24.5 0.32	0.00000000	0.00000000
	0.16132328	0.00000000	0.00000000	0.16132328	0.19338362	0.32264655
	0.16132328	0.00000000				
2005	2 2	0 0	2 25	25.5 0.08	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.50000000	0.50000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 9	9.5 0.60	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 10	10.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 11	11.5 1.00	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 12	12.5 3.16	0.99618663	0.00381337
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 13	13.5 7.20	0.80038619	0.19961381
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 14	14.5 17.76	0.39831158	0.59728109
	0.00440732	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 15	15.5 28.84	0.10293259	0.88159937
	0.01546804	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 16	16.5 26.64	0.05447037	0.87580402
	0.06972561	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 17	17.5 17.44	0.00844991	0.62947182
	0.35031023	0.01176804	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 18	18.5 10.32	0.00000000	0.16951243
	0.71893833	0.11154923	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 19	19.5 5.88	0.00000000	0.06548842
	0.77827178	0.15623980	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 20	20.5 2.16	0.00000000	0.01675148
	0.59447024	0.33123465	0.05754363	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 21	21.5 0.20	0.00000000	0.00000000
	0.58226221	0.41773779	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 22	22.5 0.08	0.00000000	0.00000000
	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	2 2	0 0	3 23	23.5 0.08	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 9	9.5 0.08	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 10	10.5 0.52	0.81161422	0.18838578
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 11	11.5 3.56	0.81748933	0.16948738
	0.01302330	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 12	12.5 7.96	0.80789846	0.18543433
	0.00666722	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 13	13.5 13.60	0.58443765	0.40077974
	0.01478262	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 14	14.5 12.40	0.35239361	0.57909543
	0.06851095	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 15	15.5 8.40	0.13962133	0.67446158
	0.18591708	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 16	16.5 5.72	0.04265578	0.60969432
	0.34455928	0.00309062	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 17	17.5 4.52	0.13907978	0.44035193
	0.35454781	0.06602048	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 18	18.5 3.24	0.00000000	0.25882826
	0.41917676	0.32199498	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 19	19.5 1.72	0.13230410	0.04936132
	0.24787050	0.54753177	0.02293231	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

2007	2 2	0 0	4 20	20.5 2.76	0.10336144	0.05906368
	0.25102064	0.48319280	0.10336144	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 21	21.5 2.16	0.01919929	0.09599643
	0.17973905	0.56372476	0.11519571	0.02614477	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 22	22.5 0.56	0.07484045	0.07484045
	0.10191455	0.44904273	0.22452136	0.07484045	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 23	23.5 0.16	0.00000000	0.00000000
	0.00000000	0.75000000	0.25000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 24	24.5 0.08	0.50000000	0.00000000
	0.00000000	0.00000000	0.50000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	2 2	0 0	4 25	25.5 0.08	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 10	10.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 11	11.5 0.84	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 12	12.5 2.80	0.98557929	0.01442071
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 13	13.5 2.80	0.85459472	0.14540528
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 14	14.5 1.92	0.21852994	0.75404580
	0.02742427	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 15	15.5 7.56	0.02649326	0.84675852
	0.12433842	0.00240980	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 16	16.5 11.56	0.03125844	0.83304051
	0.12357623	0.01212482	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 17	17.5 5.56	0.01343018	0.47528389
	0.49238317	0.01890276	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 18	18.5 4.44	0.00380832	0.15793925
	0.63661667	0.20163576	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 19	19.5 1.24	0.00000000	0.22595676
	0.28517288	0.48887036	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 20	20.5 0.60	0.00000000	0.09286446
	0.27321611	0.60214765	0.03177178	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 21	21.5 0.32	0.00000000	0.24674396
	0.08441868	0.50000000	0.16883736	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 22	22.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	2 2	0 0	4 23	23.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 2	0 0	5 10	10.5 0.04	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 2	0 0	5 11	11.5 0.44	0.83689127	0.16310873
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 2	0 0	5 12	12.5 5.88	0.68363000	0.30445839
	0.01191161	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 2	0 0	5 13	13.5 22.88	0.68889728	0.29909058
	0.01201214	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 2	0 0	5 14	14.5 31.40	0.50150025	0.41038623
	0.08811352	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 2	0 0	5 15	15.5 24.72	0.24521747	0.58333748
	0.17108762	0.00035743	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 2	0 0	5 16	16.5 10.56	0.06829203	0.66014805
	0.25919930	0.01236061	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 2	0 0	5 17	17.5 2.20	0.01583498	0.50300787
	0.45519484	0.02596231	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 2	0 0	5 18	18.5 0.48	0.00000000	0.15593280
	0.65023873	0.19382847	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 2	0 0	5 19	19.5 0.16	0.00000000	0.00000000
	0.35870468	0.05263820	0.58865712	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

2009	2	2	0	0	5	20	20.5	0.12	0.00000000	0.00000000	0.47300504	0.42438989	0.10260507	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2009	2	2	0	0	5	21	21.5	0.08	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2009	2	2	0	0	5	22	22.5	0.04	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	10	10.5	0.04	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	11	11.5	0.12	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	12	12.5	1.40	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	13	13.5	4.36	0.97937875	0.02062125	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	14	14.5	7.96	0.67156961	0.32843039	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	15	15.5	6.84	0.34889782	0.65110218	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	16	16.5	1.92	0.07429875	0.88299211	0.04270913	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	17	17.5	0.72	0.00000000	0.66645819	0.24824745	0.08529436	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	18	18.5	0.48	0.00000000	0.36847266	0.51480434	0.11672300	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	19	19.5	0.32	0.00000000	0.14639383	0.14639383	0.41442469	0.14639383	0.14639383	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	20	20.5	1.40	0.00000000	0.00000000	0.08571429	0.37142857	0.42857143	0.08571429	0.02857143	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	21	21.5	3.60	0.00000000	0.00000000	0.03333333	0.15555556	0.40000000	0.40000000	0.01111111	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	22	22.5	2.72	0.00000000	0.00000000	0.00000000	0.04411765	0.33823529	0.58823529	0.02941176	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	23	23.5	0.92	0.00000000	0.00000000	0.00000000	0.00000000	0.08695652	0.65217391	0.21739130	0.00000000	0.04347826	0.00000000
2010	2	2	0	0	5	24	24.5	0.12	0.00000000	0.00000000	0.00000000	0.33333333	0.00000000	0.00000000	0.66666667	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	5	25	25.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000
2011	2	2	0	0	5	11	11.5	0.16	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	5	12	12.5	3.52	0.87215345	0.12784655	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	5	13	13.5	6.28	0.59088204	0.40911796	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	5	14	14.5	6.20	0.30685411	0.65950540	0.03364049	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	5	15	15.5	5.44	0.07295659	0.81515839	0.11188502	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	5	16	16.5	7.04	0.00891596	0.56660164	0.40843139	0.01605101	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	5	17	17.5	7.52	0.00827203	0.39661205	0.57670891	0.01840702	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	5	18	18.5	9.28	0.00000000	0.29387555	0.56963232	0.13258364	0.00390849	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	5	19	19.5	7.28	0.00000000	0.14220005	0.42277049	0.36060242	0.07020416	0.00422289	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	5	20	20.5	4.28	0.00000000	0.00177857	0.18041040	0.36546157	0.31767374	0.10499112	0.02968460	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	5	21	21.5	2.80	0.00000000	0.00000000	0.03219035	0.21732442	0.12490489	0.31241213	0.28719892	0.02596928	0.00000000	0.00000000

2011	2 2	0 0	5 22	22.5 2.40	0.00000000	0.00000000
	0.01180748	0.21224463	0.15255710	0.26888587	0.19530660	0.14159287
	0.01760545	0.00000000				
2011	2 2	0 0	5 23	23.5 0.56	0.00000000	0.00000000
	0.00000000	0.02033793	0.34405479	0.06101380	0.26946132	0.21020075
	0.09493141	0.00000000				
2011	2 2	0 0	5 24	24.5 0.12	0.00000000	0.00000000
	0.00000000	0.00000000	0.66666667	0.00000000	0.33333333	0.00000000
	0.00000000	0.00000000				
1999	1 3	0 0	6 16	16.5 0.32	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	1 3	0 0	6 17	17.5 0.56	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	1 3	0 0	6 18	18.5 0.80	0.00000000	0.00000000
	0.78519341	0.21480659	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	1 3	0 0	6 19	19.5 0.28	0.00000000	0.00000000
	0.28571429	0.71428571	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	1 3	0 0	6 20	20.5 0.28	0.00000000	0.00000000
	0.00000000	0.69739439	0.30260561	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	1 3	0 0	6 21	21.5 0.32	0.00000000	0.00000000
	0.00000000	0.25000000	0.37500000	0.37500000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	1 3	0 0	6 22	22.5 0.28	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	1 3	0 0	6 23	23.5 0.16	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.69162500	0.30837500	0.00000000
	0.00000000	0.00000000				
1999	1 3	0 0	6 25	25.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000				
2000	1 3	0 0	6 11	11.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	1 3	0 0	6 16	16.5 0.24	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	1 3	0 0	6 17	17.5 3.16	0.00000000	0.02971019
	0.81568211	0.15460770	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2000	1 3	0 0	6 18	18.5 6.28	0.00000000	0.01663748
	0.69778813	0.22384006	0.05787131	0.00000000	0.00386302	0.00000000
	0.00000000	0.00000000				
2000	1 3	0 0	6 19	19.5 7.88	0.00000000	0.01003458
	0.26631129	0.57918797	0.11595072	0.02075920	0.00775624	0.00000000
	0.00000000	0.00000000				
2000	1 3	0 0	6 20	20.5 12.44	0.00000000	0.00000000
	0.12132936	0.62061646	0.19578829	0.04921868	0.01167967	0.00000000
	0.00136755	0.00000000				
2000	1 3	0 0	6 21	21.5 18.92	0.00000000	0.00000000
	0.07301902	0.43689008	0.28873359	0.13664039	0.05036686	0.00394759
	0.01040247	0.00000000				
2000	1 3	0 0	6 22	22.5 13.52	0.00000000	0.00376028
	0.04421478	0.24078300	0.31639225	0.25016788	0.09655734	0.03249653
	0.01562794	0.00000000				
2000	1 3	0 0	6 23	23.5 4.56	0.00000000	0.00996131
	0.02853334	0.11903465	0.33924029	0.19843023	0.21097310	0.08115465
	0.01267242	0.00000000				
2000	1 3	0 0	6 24	24.5 0.60	0.00000000	0.08604282
	0.00000000	0.09553265	0.03549035	0.35597674	0.35597674	0.07098070
	0.00000000	0.00000000				
2000	1 3	0 0	6 25	25.5 0.16	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.44069022	0.21415281	0.00000000
	0.34515697	0.00000000				
2001	1 3	0 0	6 13	13.5 0.56	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 3	0 0	6 14	14.5 0.44	0.00000000	0.78526625
	0.21473375	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 3	0 0	6 15	15.5 0.16	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 3	0 0	6 16	16.5 0.04	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 3	0 0	6 18	18.5 1.12	0.00000000	0.18051209
	0.33614455	0.37483373	0.03610242	0.04280481	0.02960240	0.00000000
	0.00000000	0.00000000				
2001	1 3	0 0	6 19	19.5 8.60	0.00000000	0.01925963
	0.21266479	0.54224992	0.19662330	0.02920235	0.00000000	0.00000000
	0.00000000	0.00000000				
2001	1 3	0 0	6 20	20.5 29.88	0.00000000	0.00422791
	0.14436947	0.54004602	0.27399952	0.03365278	0.00370430	0.00000000
	0.00000000	0.00000000				

2001	1 3	0 0	6 21	21.5 24.20	0.00000000	0.00526833
	0.05438869	0.44296758	0.35803980	0.09663834	0.02718394	0.01385955
	0.00165377	0.00000000				
2001	1 3	0 0	6 22	22.5 11.32	0.00000000	0.00000000
	0.02739324	0.27709108	0.31245259	0.20449538	0.14091520	0.03370418
	0.00394833	0.00000000				
2001	1 3	0 0	6 23	23.5 4.20	0.00000000	0.00000000
	0.00000000	0.09938270	0.26174016	0.29696200	0.25522179	0.06547067
	0.02122267	0.00000000				
2001	1 3	0 0	6 24	24.5 1.36	0.00000000	0.00000000
	0.00000000	0.00000000	0.11400278	0.29653276	0.41151161	0.11324999
	0.06470286	0.00000000				
2001	1 3	0 0	6 25	25.5 0.20	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.42632700	0.57367300	0.00000000
	0.00000000	0.00000000				
2002	1 3	0 0	6 16	16.5 0.32	0.00000000	0.61079433
	0.00000000	0.00000000	0.38920567	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 3	0 0	6 17	17.5 1.00	0.00000000	0.05397122
	0.33719811	0.60883067	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 3	0 0	6 18	18.5 2.40	0.00000000	0.36692199
	0.47794134	0.13307801	0.01102933	0.01102933	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	1 3	0 0	6 19	19.5 2.64	0.00000000	0.08124207
	0.44744620	0.37831800	0.00351850	0.06096807	0.00000000	0.02850716
	0.00000000	0.00000000				
2002	1 3	0 0	6 20	20.5 8.84	0.00000000	0.00096806
	0.16028495	0.29077515	0.43336995	0.08898633	0.00974430	0.01587127
	0.00000000	0.00000000				
2002	1 3	0 0	6 21	21.5 54.32	0.00000000	0.00138445
	0.03422952	0.20205619	0.45716363	0.23106171	0.05486628	0.01522131
	0.00401691	0.00000000				
2002	1 3	0 0	6 22	22.5 64.20	0.00000000	0.00120007
	0.00769523	0.10957576	0.40541534	0.26660646	0.13228271	0.05251317
	0.02390997	0.00080130				
2002	1 3	0 0	6 23	23.5 30.20	0.00000000	0.00027504
	0.00304354	0.07014138	0.23002191	0.30895891	0.22516891	0.11658483
	0.04580547	0.00000000				
2002	1 3	0 0	6 24	24.5 8.00	0.00000000	0.00000000
	0.00000000	0.03031816	0.15396709	0.22605776	0.19593474	0.18364555
	0.20308000	0.00699671				
2002	1 3	0 0	6 25	25.5 1.92	0.00000000	0.00000000
	0.00000000	0.00000000	0.03411823	0.03411823	0.29486547	0.38081541
	0.22892806	0.02715461				
2002	1 3	0 0	6 26	26.5 0.36	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.40176012
	0.59823988	0.00000000				
2003	1 3	0 0	6 13	13.5 0.08	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 3	0 0	6 14	14.5 0.72	0.00000000	0.29858794
	0.70141206	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 3	0 0	6 15	15.5 0.36	0.00000000	0.62500000
	0.25000000	0.12500000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 3	0 0	6 16	16.5 0.08	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 3	0 0	6 17	17.5 2.96	0.00000000	0.02889942
	0.59388085	0.29995467	0.07726506	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 3	0 0	6 18	18.5 11.68	0.00000000	0.04616065
	0.48016399	0.39541509	0.05770609	0.02055417	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 3	0 0	6 19	19.5 15.92	0.00000000	0.04240543
	0.42650319	0.36282959	0.09436512	0.04293923	0.02108421	0.00987323
	0.00000000	0.00000000				
2003	1 3	0 0	6 20	20.5 17.92	0.00000000	0.01717434
	0.29797336	0.31388293	0.13396078	0.11909413	0.05801164	0.05330315
	0.00659966	0.00000000				
2003	1 3	0 0	6 21	21.5 20.92	0.00000000	0.00954034
	0.17388137	0.21066391	0.16657494	0.20443598	0.15382380	0.05487018
	0.02620948	0.00000000				
2003	1 3	0 0	6 22	22.5 35.72	0.00000000	0.00433987
	0.02139465	0.05261509	0.10155920	0.29939189	0.26100106	0.14053815
	0.11045422	0.00870587				
2003	1 3	0 0	6 23	23.5 27.04	0.00000000	0.00000000
	0.00581401	0.03606881	0.09759893	0.22299494	0.22855432	0.20015732
	0.18504891	0.02376276				
2003	1 3	0 0	6 24	24.5 10.20	0.00000000	0.00900865
	0.00193705	0.00576173	0.04555107	0.15018181	0.20368581	0.12017707
	0.38184532	0.08185148				
2003	1 3	0 0	6 25	25.5 2.60	0.00000000	0.00000000
	0.00000000	0.03311641	0.05115135	0.14950034	0.27774722	0.13268709
	0.34825686	0.00754073				
2003	1 3	0 0	6 26	26.5 0.48	0.00000000	0.00000000
	0.00000000	0.04130292	0.00000000	0.00000000	0.00000000	0.08260584
	0.87609124	0.00000000				

2003	1 3	0 0	6 27	27.5 0.08	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 3	0 0	6 11	11.5 0.12	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 3	0 0	6 12	12.5 0.44	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 3	0 0	6 13	13.5 2.60	0.00000000	0.87325414
	0.12674586	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 3	0 0	6 14	14.5 4.84	0.00000000	0.82784853
	0.14609962	0.02605185	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 3	0 0	6 15	15.5 4.24	0.00000000	0.82524858
	0.14634598	0.02490015	0.00350529	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 3	0 0	6 16	16.5 3.52	0.00000000	0.91528400
	0.08471600	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 3	0 0	6 17	17.5 10.12	0.00000000	0.82911979
	0.13811037	0.03276984	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 3	0 0	6 18	18.5 8.08	0.00000000	0.70590326
	0.18379993	0.11029681	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 3	0 0	6 19	19.5 4.44	0.00000000	0.12849706
	0.38179877	0.42007401	0.06963017	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2004	1 3	0 0	6 20	20.5 5.16	0.00000000	0.06764562
	0.22718819	0.43632745	0.20513650	0.02123408	0.04246816	0.00000000
	0.00000000	0.00000000				
2004	1 3	0 0	6 21	21.5 10.08	0.00000000	0.02507256
	0.14317139	0.40119569	0.27665293	0.08143410	0.04737353	0.00000000
	0.02509980	0.00000000				
2004	1 3	0 0	6 22	22.5 14.36	0.00000000	0.01339372
	0.07334027	0.13251533	0.12700182	0.29782043	0.20631143	0.09216441
	0.05026100	0.00719159				
2004	1 3	0 0	6 23	23.5 19.20	0.00000000	0.00000000
	0.01271574	0.04461322	0.10214081	0.22098845	0.27593474	0.15398881
	0.15826834	0.03134988				
2004	1 3	0 0	6 24	24.5 8.68	0.00000000	0.00000000
	0.01698676	0.01580170	0.05125012	0.18765518	0.40400194	0.08129150
	0.18450322	0.05850957				
2004	1 3	0 0	6 25	25.5 1.84	0.00000000	0.00000000
	0.00000000	0.02532908	0.13645475	0.14911929	0.25845116	0.20716081
	0.15798550	0.06549941				
2004	1 3	0 0	6 26	26.5 0.28	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.36623068	0.00000000	0.00000000
	0.63376932	0.00000000				
2005	1 3	0 0	6 12	12.5 0.08	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2005	1 3	0 0	6 15	15.5 1.48	0.00000000	0.00000000
	0.91882170	0.00000000	0.08117830	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2005	1 3	0 0	6 16	16.5 7.36	0.00000000	0.02117241
	0.81569472	0.15807194	0.00506093	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2005	1 3	0 0	6 17	17.5 21.56	0.00000000	0.00643022
	0.78357060	0.16751096	0.03437875	0.00732624	0.00078323	0.00000000
	0.00000000	0.00000000				
2005	1 3	0 0	6 18	18.5 13.36	0.00000000	0.02142792
	0.74255130	0.18572045	0.03920476	0.00770222	0.00134353	0.00000000
	0.00204982	0.00000000				
2005	1 3	0 0	6 19	19.5 2.92	0.00000000	0.01819245
	0.64158675	0.08655097	0.16711887	0.08655097	0.00000000	0.00000000
	0.00000000	0.00000000				
2005	1 3	0 0	6 20	20.5 1.32	0.00000000	0.00000000
	0.18644387	0.21159555	0.37478461	0.11262507	0.07764151	0.00000000
	0.03690940	0.00000000				
2005	1 3	0 0	6 21	21.5 1.92	0.00000000	0.00000000
	0.10843217	0.09821136	0.57346402	0.14112353	0.07876893	0.00000000
	0.00000000	0.00000000				
2005	1 3	0 0	6 22	22.5 3.16	0.00000000	0.00000000
	0.00000000	0.03069061	0.47457942	0.15147470	0.13679679	0.12527947
	0.06263974	0.01853926				
2005	1 3	0 0	6 23	23.5 6.56	0.00000000	0.00000000
	0.02270702	0.01580238	0.01941793	0.16224316	0.18771401	0.09741119
	0.37852811	0.11617621				
2005	1 3	0 0	6 24	24.5 6.36	0.00000000	0.00000000
	0.00000000	0.00000000	0.01309994	0.06190098	0.12052820	0.25646018
	0.37407376	0.17393694				
2005	1 3	0 0	6 25	25.5 1.48	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.05049915	0.00000000	0.20199661
	0.52275381	0.22475042				
2005	1 3	0 0	6 26	26.5 0.20	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000				

2006	1 3	0 0	6 17	17.5 0.24	0.00000000	0.00000000
	0.00000000	0.51704397	0.48295603	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2006	1 3	0 0	6 18	18.5 4.80	0.00000000	0.00000000
	0.04347242	0.63966086	0.16481578	0.07602547	0.04062132	0.00000000
	0.01770207	0.01770207				
2006	1 3	0 0	6 19	19.5 14.92	0.00000000	0.00000000
	0.00727865	0.64061532	0.20355835	0.08308284	0.04645900	0.00000000
	0.01900585	0.00000000				
2006	1 3	0 0	6 20	20.5 4.60	0.00000000	0.00000000
	0.01204775	0.62924849	0.24556590	0.07757939	0.00612325	0.02943522
	0.00000000	0.00000000				
2006	1 3	0 0	6 21	21.5 0.72	0.00000000	0.00000000
	0.00000000	0.28199047	0.05286559	0.15688084	0.50826311	0.00000000
	0.00000000	0.00000000				
2006	1 3	0 0	6 22	22.5 0.32	0.00000000	0.00000000
	0.00000000	0.14380492	0.61156791	0.00000000	0.00000000	0.12231358
	0.12231358	0.00000000				
2006	1 3	0 0	6 23	23.5 0.52	0.00000000	0.00000000
	0.00000000	0.05102799	0.32632300	0.05102799	0.27081202	0.24529802
	0.05551098	0.00000000				
2006	1 3	0 0	6 24	24.5 0.64	0.00000000	0.00000000
	0.00000000	0.22881018	0.04759812	0.07557884	0.02379906	0.09519624
	0.52901755	0.00000000				
2006	1 3	0 0	6 25	25.5 0.20	0.00000000	0.00000000
	0.00000000	0.00000000	0.85825403	0.04463446	0.04463446	0.05247705
	0.00000000	0.00000000				
2006	1 3	0 0	6 26	26.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 3	0 0	6 16	16.5 0.04	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 3	0 0	6 17	17.5 2.16	0.00000000	0.00000000
	0.23740467	0.45780179	0.27618093	0.02861261	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 3	0 0	6 18	18.5 18.64	0.00000000	0.00000000
	0.07683540	0.57588439	0.31802187	0.02626425	0.00299409	0.00000000
	0.00000000	0.00000000				
2007	1 3	0 0	6 19	19.5 41.36	0.00000000	0.00000000
	0.03079650	0.50891739	0.39342307	0.05762182	0.00636761	0.00287361
	0.00000000	0.00000000				
2007	1 3	0 0	6 20	20.5 23.40	0.00000000	0.00000000
	0.00437442	0.32921600	0.48582684	0.14344751	0.02700847	0.00773240
	0.00239436	0.00000000				
2007	1 3	0 0	6 21	21.5 2.84	0.00000000	0.00000000
	0.01790312	0.06248941	0.60674578	0.22974585	0.08311583	0.00000000
	0.00000000	0.00000000				
2007	1 3	0 0	6 22	22.5 0.44	0.00000000	0.00000000
	0.00000000	0.21943393	0.48478081	0.10971697	0.18606829	0.00000000
	0.00000000	0.00000000				
2007	1 3	0 0	6 23	23.5 0.64	0.00000000	0.00000000
	0.00000000	0.00000000	0.09044068	0.34236015	0.31113120	0.12166964
	0.13439832	0.00000000				
2007	1 3	0 0	6 24	24.5 0.28	0.00000000	0.00000000
	0.00000000	0.00000000	0.23026346	0.26146231	0.00000000	0.09267026
	0.41560397	0.00000000				
2007	1 3	0 0	6 25	25.5 0.12	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.37093453	0.62906547				
2007	1 3	0 0	6 27	27.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000				
2008	1 3	0 0	6 17	17.5 0.88	0.00000000	0.00000000
	0.08076731	0.45003422	0.35683235	0.11236612	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 3	0 0	6 18	18.5 13.12	0.00000000	0.00000000
	0.01184838	0.32043582	0.46529163	0.19547765	0.00694651	0.00000000
	0.00000000	0.00000000				
2008	1 3	0 0	6 19	19.5 32.20	0.00000000	0.00000000
	0.00088424	0.15535935	0.57693437	0.24563050	0.01859373	0.00259781
	0.00000000	0.00000000				
2008	1 3	0 0	6 20	20.5 32.60	0.00000000	0.00000000
	0.00000000	0.05859962	0.52980520	0.34778716	0.05812338	0.00246186
	0.00322279	0.00000000				
2008	1 3	0 0	6 21	21.5 10.96	0.00000000	0.00000000
	0.00000000	0.01475106	0.36062992	0.47297610	0.10926727	0.02632704
	0.01604862	0.00000000				
2008	1 3	0 0	6 22	22.5 2.84	0.00000000	0.00000000
	0.00000000	0.03766021	0.19501245	0.36091074	0.24583760	0.12291880
	0.03766021	0.00000000				
2008	1 3	0 0	6 23	23.5 1.28	0.00000000	0.00000000
	0.00000000	0.00000000	0.21300267	0.33188750	0.22868898	0.19401355
	0.03240729	0.00000000				
2008	1 3	0 0	6 24	24.5 0.40	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.07480361	0.14173213	0.17913393
	0.60433033	0.00000000				
2008	1 3	0 0	6 25	25.5 0.08	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.79120760	0.00000000
	0.20879240	0.00000000				

2009	1 3	0 0	6 15	15.5 0.04	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	1 3	0 0	6 17	17.5 0.68	0.00000000	0.00000000
	0.00000000	0.42804400	0.48314281	0.03371438	0.00000000	0.05509881
	0.00000000	0.00000000				
2009	1 3	0 0	6 18	18.5 11.80	0.00000000	0.00000000
	0.02050733	0.12037526	0.46365604	0.31060975	0.08018280	0.00466882
	0.00000000	0.00000000				
2009	1 3	0 0	6 19	19.5 42.12	0.00000000	0.00000000
	0.00226916	0.03590519	0.36741479	0.37324927	0.18827612	0.02953106
	0.00335441	0.00000000				
2009	1 3	0 0	6 20	20.5 31.76	0.00000000	0.00000000
	0.00219593	0.01342498	0.21422056	0.43913111	0.25999418	0.06078386
	0.01024938	0.00000000				
2009	1 3	0 0	6 21	21.5 6.84	0.00000000	0.00000000
	0.00212453	0.00568681	0.10318651	0.44777766	0.31985777	0.10280451
	0.01856221	0.00000000				
2009	1 3	0 0	6 22	22.5 0.56	0.00000000	0.00000000
	0.00000000	0.00000000	0.04893710	0.22695408	0.46075579	0.08550180
	0.17785124	0.00000000				
2009	1 3	0 0	6 23	23.5 0.12	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.83888941	0.00000000	0.16111059
	0.00000000	0.00000000				
2009	1 3	0 0	6 24	24.5 0.04	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000				
2010	1 3	0 0	6 16	16.5 0.60	0.00000000	0.00000000
	0.76934842	0.23065158	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 3	0 0	6 17	17.5 0.68	0.00000000	0.00000000
	0.00000000	0.38467421	0.46130317	0.15402263	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 3	0 0	6 18	18.5 4.00	0.00000000	0.00000000
	0.00000000	0.16788306	0.16797091	0.46967651	0.17677450	0.01769502
	0.00000000	0.00000000				
2010	1 3	0 0	6 19	19.5 26.64	0.00000000	0.00000000
	0.00000000	0.04896280	0.27875622	0.38696978	0.18333325	0.08992010
	0.01205784	0.00000000				
2010	1 3	0 0	6 20	20.5 30.28	0.00000000	0.00000000
	0.00000000	0.01016513	0.16180533	0.40427596	0.30760247	0.09572460
	0.02042650	0.00000000				
2010	1 3	0 0	6 21	21.5 8.44	0.00000000	0.00000000
	0.00000000	0.00000000	0.17346398	0.35308126	0.28013180	0.16224675
	0.03107621	0.00000000				
2010	1 3	0 0	6 22	22.5 1.04	0.00000000	0.00000000
	0.00000000	0.00000000	0.20111446	0.39238525	0.07010256	0.26629518
	0.07010256	0.00000000				
2010	1 3	0 0	6 23	23.5 0.16	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000				
2011	1 3	0 0	6 14	14.5 0.08	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2011	1 3	0 0	6 15	15.5 0.04	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2011	1 3	0 0	6 17	17.5 0.40	0.00000000	0.51810958
	0.21835377	0.00000000	0.00000000	0.08819986	0.17533679	0.00000000
	0.00000000	0.00000000				
2011	1 3	0 0	6 18	18.5 0.92	0.00000000	0.00000000
	0.50596889	0.21929177	0.19223275	0.06856066	0.00000000	0.00000000
	0.01394593	0.00000000				
2011	1 3	0 0	6 19	19.5 3.64	0.00000000	0.00000000
	0.15072870	0.26068155	0.13777439	0.16189118	0.23719481	0.03802676
	0.01370261	0.00000000				
2011	1 3	0 0	6 20	20.5 18.92	0.00000000	0.00000000
	0.00859329	0.03904591	0.13922403	0.33680262	0.27486546	0.15650832
	0.04496036	0.00000000				
2011	1 3	0 0	6 21	21.5 16.28	0.00000000	0.00000000
	0.00422337	0.01197860	0.10077738	0.31338085	0.33280843	0.20914426
	0.02768710	0.00000000				
2011	1 3	0 0	6 22	22.5 3.16	0.00000000	0.00000000
	0.00000000	0.00000000	0.14846880	0.30437008	0.28564484	0.18671587
	0.07480041	0.00000000				
2011	1 3	0 0	6 23	23.5 0.56	0.00000000	0.00000000
	0.00000000	0.00000000	0.03268292	0.34533781	0.27886180	0.34311747
	0.00000000	0.00000000				
2005	2 8	0 0	7 11	11.5 0.02	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2005	2 8	0 0	7 13	13.5 0.02	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2005	2 8	0 0	7 15	15.5 0.06	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2005	2 8	0 0	7 16	16.5 0.80	0.35000000	0.65000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

2005	2	8	0	0	7	17	17.5	0.90	0.08888889	0.62222222	0.24444444	0.04444444	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	8	0	0	7	18	18.5	1.20	0.00000000	0.68333333	0.31666667	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	8	0	0	7	19	19.5	1.62	0.00000000	0.56790123	0.40740741	0.02469136	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	8	0	0	7	20	20.5	0.96	0.02083333	0.45833333	0.47916667	0.02083333	0.02083333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	8	0	0	7	21	21.5	0.28	0.00000000	0.50000000	0.42857143	0.00000000	0.07142857	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	8	0	0	7	22	22.5	0.06	0.00000000	0.66666667	0.33333333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	8	0	0	7	24	24.5	0.04	0.00000000	0.00000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.50000000	0.00000000
2005	2	8	0	0	7	25	25.5	0.08	0.00000000	0.25000000	0.00000000	0.25000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2005	2	8	0	0	7	26	26.5	0.02	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2007	2	8	0	0	7	16	16.5	0.06	0.00000000	0.33333333	0.66666667	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2007	2	8	0	0	7	17	17.5	0.20	0.00000000	0.00000000	0.80000000	0.20000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2007	2	8	0	0	7	18	18.5	0.48	0.00000000	0.08333333	0.70833333	0.20833333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2007	2	8	0	0	7	19	19.5	0.50	0.00000000	0.00000000	0.36000000	0.52000000	0.08000000	0.04000000	0.00000000	0.00000000	0.00000000	0.00000000
2007	2	8	0	0	7	20	20.5	1.42	0.00000000	0.00000000	0.16901408	0.66197183	0.14084507	0.02816901	0.00000000	0.00000000	0.00000000	0.00000000
2007	2	8	0	0	7	21	21.5	2.48	0.00000000	0.00000000	0.08870968	0.73387097	0.16935484	0.00806452	0.00000000	0.00000000	0.00000000	0.00000000
2007	2	8	0	0	7	22	22.5	1.70	0.00000000	0.00000000	0.00000000	0.77647059	0.21176471	0.01176471	0.00000000	0.00000000	0.00000000	0.00000000
2007	2	8	0	0	7	23	23.5	0.40	0.00000000	0.00000000	0.00000000	0.75000000	0.20000000	0.05000000	0.00000000	0.00000000	0.00000000	0.00000000
2007	2	8	0	0	7	24	24.5	0.12	0.00000000	0.00000000	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2007	2	8	0	0	7	25	25.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000
2008	1	8	0	0	7	9	9.5	0.20	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2008	1	8	0	0	7	10	10.5	0.26	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2008	1	8	0	0	7	11	11.5	0.08	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2008	1	8	0	0	7	16	16.5	0.08	0.00000000	0.00000000	0.75000000	0.25000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2008	1	8	0	0	7	17	17.5	0.24	0.00000000	0.00000000	0.41666667	0.58333333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2008	1	8	0	0	7	18	18.5	0.44	0.00000000	0.00000000	0.27272727	0.59090909	0.13636364	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2008	1	8	0	0	7	19	19.5	2.38	0.00000000	0.00840336	0.25210084	0.51260504	0.21848739	0.00840336	0.00000000	0.00000000	0.00000000	0.00000000
2008	1	8	0	0	7	20	20.5	3.80	0.00000000	0.00526316	0.11578947	0.45263158	0.40526316	0.02105263	0.00000000	0.00000000	0.00000000	0.00000000
2008	1	8	0	0	7	21	21.5	4.66	0.00000000	0.00000000	0.05150215	0.43347639	0.49356223	0.02145923	0.00000000	0.00000000	0.00000000	0.00000000
2008	1	8	0	0	7	22	22.5	1.76	0.00000000	0.00000000	0.03409091	0.40909091	0.51136364	0.04545455	0.00000000	0.00000000	0.00000000	0.00000000
2008	1	8	0	0	7	23	23.5	0.34	0.00000000	0.00000000	0.00000000	0.35294118	0.58823529	0.05882353	0.00000000	0.00000000	0.00000000	0.00000000

2008	1 8	0 0	7 24	24.5 0.16	0.00000000	0.00000000
	0.12500000	0.37500000	0.50000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 8	0 0	7 25	25.5 0.04	0.00000000	0.00000000
	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 8	0 0	7 12	12.5 0.02	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 8	0 0	7 14	14.5 0.02	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 8	0 0	7 15	15.5 0.06	0.00000000	0.66666667
	0.33333333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 8	0 0	7 16	16.5 0.12	0.16666667	0.50000000
	0.33333333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 8	0 0	7 17	17.5 0.16	0.00000000	0.62500000
	0.37500000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 8	0 0	7 18	18.5 0.08	0.00000000	0.00000000
	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 8	0 0	7 19	19.5 0.18	0.00000000	0.11111111
	0.11111111	0.44444444	0.11111111	0.22222222	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 8	0 0	7 20	20.5 1.36	0.00000000	0.00000000
	0.01470588	0.39705882	0.42647059	0.16176471	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 8	0 0	7 21	21.5 4.06	0.00000000	0.00000000
	0.01970443	0.25123153	0.44827586	0.25123153	0.02955665	0.00000000
	0.00000000	0.00000000				
2009	2 8	0 0	7 22	22.5 4.86	0.00000000	0.00411523
	0.01646091	0.18518519	0.45679012	0.25514403	0.07818930	0.00411523
	0.00000000	0.00000000				
2009	2 8	0 0	7 23	23.5 2.08	0.00000000	0.00000000
	0.00000000	0.17307692	0.46153846	0.30769231	0.05769231	0.00000000
	0.00000000	0.00000000				
2009	2 8	0 0	7 24	24.5 0.48	0.00000000	0.00000000
	0.00000000	0.12500000	0.37500000	0.41666667	0.04166667	0.04166667
	0.00000000	0.00000000				
2009	2 8	0 0	7 25	25.5 0.04	0.00000000	0.00000000
	0.00000000	0.50000000	0.00000000	0.50000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	2 8	0 0	7 26	26.5 0.08	0.00000000	0.00000000
	0.00000000	0.00000000	0.50000000	0.00000000	0.25000000	0.25000000
	0.00000000	0.00000000				
2010	2 8	0 0	7 14	14.5 0.04	0.00000000	0.50000000
	0.00000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	2 8	0 0	7 15	15.5 0.06	0.00000000	0.66666667
	0.33333333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	2 8	0 0	7 16	16.5 0.64	0.00000000	0.62500000
	0.34375000	0.03125000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	2 8	0 0	7 17	17.5 1.88	0.01063830	0.60638298
	0.29787234	0.06382979	0.02127660	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	2 8	0 0	7 18	18.5 2.78	0.02158273	0.43884892
	0.43165468	0.10071942	0.00719424	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	2 8	0 0	7 19	19.5 1.12	0.00000000	0.26785714
	0.50000000	0.21428571	0.01785714	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	2 8	0 0	7 20	20.5 0.24	0.00000000	0.08333333
	0.75000000	0.16666667	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	2 8	0 0	7 21	21.5 0.78	0.00000000	0.00000000
	0.05128205	0.23076923	0.43589744	0.20512821	0.07692308	0.00000000
	0.00000000	0.00000000				
2010	2 8	0 0	7 22	22.5 2.46	0.00000000	0.00000000
	0.04878049	0.17073171	0.42276423	0.26016260	0.08943089	0.00813008
	0.00000000	0.00000000				
2010	2 8	0 0	7 23	23.5 2.08	0.00000000	0.00961538
	0.03846154	0.17307692	0.40384615	0.29807692	0.04807692	0.02884615
	0.00000000	0.00000000				
2010	2 8	0 0	7 24	24.5 0.42	0.00000000	0.00000000
	0.00000000	0.14285714	0.52380952	0.23809524	0.09523810	0.00000000
	0.00000000	0.00000000				
2010	2 8	0 0	7 25	25.5 0.14	0.00000000	0.00000000
	0.00000000	0.00000000	0.42857143	0.28571429	0.28571429	0.00000000
	0.00000000	0.00000000				
2010	2 8	0 0	7 26	26.5 0.08	0.00000000	0.00000000
	0.00000000	0.00000000	0.75000000	0.00000000	0.25000000	0.00000000
	0.00000000	0.00000000				
2011	2 8	0 0	7 17	17.5 0.02	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				

2011	2 8	0 0	7 18	18.5 0.04	0.00000000	0.50000000
	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2011	2 8	0 0	7 19	19.5 0.92	0.00000000	0.17391304
	0.58695652	0.19565217	0.04347826	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2011	2 8	0 0	7 20	20.5 1.60	0.00000000	0.13750000
	0.62500000	0.15000000	0.07500000	0.00000000	0.01250000	0.00000000
	0.00000000	0.00000000				
2011	2 8	0 0	7 21	21.5 1.00	0.00000000	0.16000000
	0.40000000	0.26000000	0.14000000	0.00000000	0.04000000	0.00000000
	0.00000000	0.00000000				
2011	2 8	0 0	7 22	22.5 0.80	0.00000000	0.00000000
	0.27500000	0.17500000	0.12500000	0.20000000	0.20000000	0.02500000
	0.00000000	0.00000000				
2011	2 8	0 0	7 23	23.5 1.86	0.00000000	0.00000000
	0.03225806	0.15053763	0.32258065	0.29032258	0.15053763	0.05376344
	0.00000000	0.00000000				
2011	2 8	0 0	7 24	24.5 0.78	0.00000000	0.00000000
	0.02564103	0.10256410	0.35897436	0.33333333	0.17948718	0.00000000
	0.00000000	0.00000000				
2011	2 8	0 0	7 25	25.5 0.12	0.00000000	0.00000000
	0.16666667	0.16666667	0.33333333	0.00000000	0.33333333	0.00000000
	0.00000000	0.00000000				
2011	2 8	0 0	7 26	26.5 0.02	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	1 1	0 0	2 9	28 -1	0.00000000	0.03425732
	0.52874625	0.29851436	0.10918581	0.02197219	0.00732406	0.00000000
	0.00000000	0.00000000				
1983	1 1	0 0	2 9	28 -1	0.32307136	0.36349736
	0.28759989	0.02583139	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	1 1	0 0	2 9	28 -1	0.00000000	0.39271792
	0.54218533	0.06044075	0.00465601	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	1 1	0 0	2 9	28 -1	0.03000179	0.10805952
	0.63992813	0.21581105	0.00619951	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	1 1	0 0	2 9	28 -1	0.00047710	0.62245556
	0.25233700	0.11194555	0.01278478	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1988	1 1	0 0	2 9	28 -1	0.00000000	0.12505574
	0.67279491	0.15131912	0.04342634	0.00740390	0.00000000	0.00000000
	0.00000000	0.00000000				
1989	1 1	0 0	2 9	28 -1	0.00000000	0.54655870
	0.37044534	0.06072874	0.02024291	0.00202429	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	1 1	0 0	2 9	28 -1	0.00573614	0.19311663
	0.30210325	0.28107075	0.12810707	0.06118547	0.02676864	0.00191205
	0.00000000	0.00000000				
1991	1 1	0 0	2 9	28 -1	0.03173122	0.26038264
	0.43817079	0.16425572	0.06439571	0.02613159	0.00886608	0.00466636
	0.00139991	0.00000000				
1992	1 1	0 0	2 9	28 -1	0.00155159	0.41388673
	0.44142746	0.09891389	0.02637704	0.01357642	0.00349108	0.00038790
	0.00038790	0.00000000				
1993	1 1	0 0	2 9	28 -1	0.00410678	0.04722793
	0.49281314	0.40041068	0.04517454	0.00616016	0.00410678	0.00000000
	0.00000000	0.00000000				
1994	1 1	0 0	2 9	28 -1	0.02753304	0.46806167
	0.29735683	0.18392070	0.02202643	0.00110132	0.00000000	0.00000000
	0.00000000	0.00000000				
1995	1 1	0 0	2 9	28 -1	0.06525424	0.52457627
	0.35932203	0.04067797	0.01016949	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	1 1	0 0	2 9	28 -1	0.00359389	0.16681641
	0.52920036	0.25277029	0.04252770	0.00479185	0.00000000	0.00029949
	0.00000000	0.00000000				
1997	1 1	0 0	2 9	28 -1	0.00262037	0.41139862
	0.37307566	0.15198166	0.04913200	0.00884376	0.00294792	0.00000000
	0.00000000	0.00000000				
1998	1 1	0 0	2 9	28 -1	0.03224651	0.62307417
	0.22644214	0.06986743	0.03977069	0.00573271	0.00250806	0.00035829
	0.00000000	0.00000000				
1999	1 1	0 0	2 9	28 -1	0.01621622	0.65743243
	0.26216216	0.03986486	0.01824324	0.00405405	0.00202703	0.00000000
	0.00000000	0.00000000				
2000	1 1	0 0	2 9	28 -1	0.03112155	0.20845567
	0.41926013	0.31826189	0.01879037	0.00352319	0.00058720	0.00000000
	0.00000000	0.00000000				
2001	1 1	0 0	2 9	28 -1	0.12968875	0.22466081
	0.28571429	0.27174781	0.06384677	0.01955307	0.00359138	0.00119713
	0.00000000	0.00000000				
2002	1 1	0 0	2 9	28 -1	0.20615672	0.58115672
	0.17444030	0.02705224	0.01026119	0.00093284	0.00000000	0.00000000
	0.00000000	0.00000000				
2003	1 1	0 0	2 9	28 -1	0.20015954	0.37154431
	0.38020689	0.04279968	0.00453104	0.00075854	0.00000000	0.00000000
	0.00000000	0.00000000				

2004	1 1	0 0	2 9	28 -1	0.00364633	0.85532985
	0.11861492	0.01549868	0.00537504	0.00000000	0.00153518	0.00000000
	0.00000000	0.00000000				
2005	1 1	0 0	2 9	28 -1	0.12470065	0.39220988
	0.45276993	0.02734108	0.00238175	0.00039781	0.00019891	0.00000000
	0.00000000	0.00000000				
2006	1 1	0 0	2 9	28 -1	0.03562000	0.62963006
	0.29361438	0.04042041	0.00071515	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2007	1 1	0 0	3 9	28 -1	0.02852538	0.28168068
	0.56110374	0.12174517	0.00694503	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2008	1 1	0 0	4 9	28 -1	0.06278781	0.35370776
	0.50938004	0.06181156	0.01231283	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2009	1 1	0 0	4 9	28 -1	0.00163973	0.24119339
	0.62479218	0.12067906	0.01169563	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
2010	1 1	0 0	5 9	28 -1	0.05329297	0.71465179
	0.19723416	0.03320027	0.00000000	0.00000000	0.00162081	0.00000000
	0.00000000	0.00000000				
2011	1 1	0 0	5 9	28 -1	0.01541792	0.37887071
	0.43123696	0.16853691	0.00593750	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1981	2 2	0 0	2 9	28 -1	0.09875527	0.41799541
	0.35236430	0.10372733	0.02715770	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1982	2 2	0 0	2 9	28 -1	0.00000000	0.47427325
	0.42044410	0.09627772	0.00900493	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1983	2 2	0 0	2 9	28 -1	0.00000000	0.29366522
	0.66216346	0.03943441	0.00473691	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1984	2 2	0 0	2 9	28 -1	0.01371008	0.23433916
	0.66387413	0.08807663	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1985	2 2	0 0	2 9	28 -1	0.00270747	0.21427884
	0.67536557	0.10611700	0.00153112	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1986	2 2	0 0	2 9	28 -1	0.01334660	0.11339318
	0.62130800	0.23575696	0.01547382	0.00072144	0.00000000	0.00000000
	0.00000000	0.00000000				
1987	2 2	0 0	2 9	28 -1	0.00181665	0.45346716
	0.39110597	0.12743567	0.02348364	0.00250847	0.00018245	0.00000000
	0.00000000	0.00000000				
1988	2 2	0 0	2 9	28 -1	0.03345389	0.26311031
	0.56419530	0.10126582	0.03254973	0.00361664	0.00180832	0.00000000
	0.00000000	0.00000000				
1989	2 2	0 0	2 9	28 -1	0.01635112	0.58691910
	0.32788296	0.06454389	0.00430293	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000				
1990	2 2	0 0	2 9	28 -1	0.07449541	0.25834862
	0.32550459	0.19559633	0.09100917	0.02715596	0.02128440	0.00550459
	0.00110092	0.00000000				
1991	2 2	0 0	2 9	28 -1	0.11057692	0.36153846
	0.22740385	0.15865385	0.08028846	0.04230769	0.00961538	0.00673077
	0.00288462	0.00000000				
1992	2 2	0 0	2 9	28 -1	0.17489035	0.62883772
	0.14473684	0.03673246	0.01151316	0.00219298	0.00109649	0.00000000
	0.00000000	0.00000000				
1993	2 2	0 0	2 9	28 -1	0.17162698	0.46428571
	0.27876984	0.05357143	0.01785714	0.00992063	0.00396825	0.00000000
	0.00000000	0.00000000				
1994	2 2	0 0	2 9	28 -1	0.38175676	0.45024570
	0.10810811	0.05251843	0.00583538	0.00122850	0.00030713	0.00000000
	0.00000000	0.00000000				
1995	2 2	0 0	2 9	28 -1	0.27272727	0.46379045
	0.23472008	0.02362609	0.00462250	0.00051361	0.00000000	0.00000000
	0.00000000	0.00000000				
1996	2 2	0 0	2 9	28 -1	0.35497573	0.27912621
	0.26577670	0.07463592	0.01152913	0.01334951	0.00060680	0.00000000
	0.00000000	0.00000000				
1997	2 2	0 0	2 9	28 -1	0.17789292	0.30454807
	0.23316062	0.19861831	0.07196315	0.01151410	0.00230282	0.00000000
	0.00000000	0.00000000				
1998	2 2	0 0	2 9	28 -1	0.28506787	0.44434389
	0.22126697	0.03393665	0.01131222	0.00407240	0.00000000	0.00000000
	0.00000000	0.00000000				
1999	2 2	0 0	2 9	28 -1	0.26647564	0.48767908
	0.22005731	0.01833811	0.00630372	0.00057307	0.00057307	0.00000000
	0.00000000	0.00000000				
2000	2 2	0 0	2 9	28 -1	0.23019432	0.45490782
	0.26008969	0.04583956	0.00797210	0.00000000	0.00000000	0.00049826
	0.00049826	0.00000000				
2001	2 2	0 0	2 9	28 -1	0.64672897	0.23457944
	0.08457944	0.02803738	0.00467290	0.00140187	0.00000000	0.00000000
	0.00000000	0.00000000				
2002	2 2	0 0	2 9	28 -1	0.18098729	0.59544208
	0.17433522	0.03762278	0.00815786	0.00329984	0.00007746	0.00000000
	0.00007746	0.00000000				

```
2003    2      2      0      0      2      9      28     -1     0.83351604     0.04116990
        0.06930792    0.03300254    0.01468797    0.00389736    0.00353461    0.00088365
        0.00000000    0.00000000
2004    2      2      0      0      2      9      28     -1     0.08060821     0.83914782
        0.06660041    0.01140479    0.00131574    0.00092303    0.00000000    0.00000000
        0.00000000    0.00000000
2005    2      2      0      0      2      9      28     -1     0.53988364     0.36631445
        0.08502658    0.00500722    0.00129034    0.00088502    0.00070773    0.00044251
        0.00044251    0.00000000
2006    2      2      0      0      3      9      28     -1     0.19288374     0.66634948
        0.12648454    0.01372552    0.00055672    0.00000000    0.00000000    0.00000000
        0.00000000    0.00000000
2007    2      2      0      0      4      9      28     -1     0.42121226     0.43312015
        0.10571676    0.03390525    0.00543440    0.00061118    0.00000000    0.00000000
        0.00000000    0.00000000
2008    2      2      0      0      4      9      28     -1     0.19862191     0.52834154
        0.21532639    0.05558720    0.00212296    0.00000000    0.00000000    0.00000000
        0.00000000    0.00000000
2009    2      2      0      0      5      9      28     -1     0.44188440     0.43965621
        0.11294230    0.00372796    0.00178912    0.00000000    0.00000000    0.00000000
        0.00000000    0.00000000
2010    2      2      0      0      5      9      28     -1     0.50413221     0.32527711
        0.01749431    0.02599178    0.05290299    0.06526992    0.00755757    0.00068705
        0.00068705    0.00000000
2011    2      2      0      0      5      9      28     -1     0.19188445     0.35439115
        0.23322982    0.09922079    0.04725190    0.03465372    0.02791957    0.00967076
        0.00177783    0.00000000
1999    1      3      0      0      6      9      28     -1     0.00000000     0.00000000
        0.59151581    0.20074375    0.04758623    0.12952271    0.03063150    0.00000000
        0.00000000    0.00000000
2000    1      3      0      0      6      9      28     -1     0.00000000     0.00661753
        0.20659052    0.39144174    0.21353582    0.10961989    0.05157856    0.01292044
        0.00769551    0.00000000
2001    1      3      0      0      6      9      28     -1     0.00000000     0.01319829
        0.09882524    0.43321579    0.28807345    0.09650734    0.05247704    0.01444472
        0.00325813    0.00000000
2002    1      3      0      0      6      9      28     -1     0.00000000     0.00376606
        0.02888569    0.14173143    0.37497785    0.24597782    0.11747427    0.05690067
        0.02950284    0.00078337
2003    1      3      0      0      6      9      28     -1     0.00000000     0.02102307
        0.16425121    0.15811914    0.10310170    0.18273200    0.16023281    0.09892233
        0.09975929    0.01185845
2004    1      3      0      0      6      9      28     -1     0.00000000     0.18321082
        0.09913172    0.14855246    0.11107205    0.14671905    0.15717320    0.06784197
        0.07120698    0.01509176
2005    1      3      0      0      6      9      28     -1     0.00000000     0.01355971
        0.68754447    0.14499884    0.04911482    0.02077892    0.01635981    0.01781895
        0.03541923    0.01440524
2006    1      3      0      0      6      9      28     -1     0.00000000     0.00000000
        0.01497099    0.60873284    0.20905176    0.07984672    0.04903877    0.00985519
        0.02477402    0.00372971
2007    1      3      0      0      6      9      28     -1     0.00000000     0.00000000
        0.03684181    0.45391632    0.40243125    0.08105161    0.01657055    0.00464352
        0.00366742    0.00087752
2008    1      3      0      0      6      9      28     -1     0.00000000     0.00000000
        0.00238411    0.12203799    0.50165896    0.30430124    0.05144003    0.01114247
        0.00703520    0.00000000
2009    1      3      0      0      6      9      28     -1     0.00000000     0.00000000
        0.00497725    0.03834955    0.30673956    0.39095629    0.20858215    0.04278986
        0.00760533    0.00000000
2010    1      3      0      0      6      9      28     -1     0.00000000     0.00000000
        0.00486374    0.03556301    0.20782057    0.39064600    0.24531226    0.09814538
        0.01764903    0.00000000
2011    1      3      0      0      6      9      28     -1     0.00000000     0.00357124
        0.03311396    0.04935189    0.12486826    0.30299635    0.28571877    0.16388925
        0.03649028    0.00000000
2005    2      8      0      0      7      9      28     -1     0.06930693     0.58085809
        0.31023102    0.01980198    0.01320132    0.00330033    0.00000000    0.00000000
        0.00330033    0.00000000
2007    2      8      0      0      7      9      28     -1     0.00000000     0.00810811
        0.15945946    0.65405405    0.15945946    0.01891892    0.00000000    0.00000000
        0.00000000    0.00000000
2008    1      8      0      0      7      9      28     -1     0.03734440     0.00276625
        0.11341632    0.43568465    0.39004149    0.02074689    0.00000000    0.00000000
        0.00000000    0.00000000
2009    2      8      0      0      7      9      28     -1     0.00147059     0.02058824
        0.02647059    0.22205882    0.42794118    0.24852941    0.04852941    0.00441176
        0.00000000    0.00000000
2010    2      8      0      0      7      9      28     -1     0.00628931     0.24842767
        0.23427673    0.13679245    0.20754717    0.12264151    0.03773585    0.00628931
        0.00000000    0.00000000
2011    2      8      0      0      7      9      28     -1     0.00000000     0.08100559
        0.31843575    0.16759777    0.18435754    0.13687151    0.09497207    0.01675978
        0.00000000    0.00000000

0 #_N_MeanSize-at-Age_obs
#Yr Seas Flt/Svy Gender Part Ageerr Ignore datavector(female-male)
#                                          samplesize(female-male)
0 #_N_environ_variables
0 #_N_environ_obs
0 # N sizefreq methods to read
```

```
0 # no tag data

0 # no morphcomp data

999

ENDDATA
```

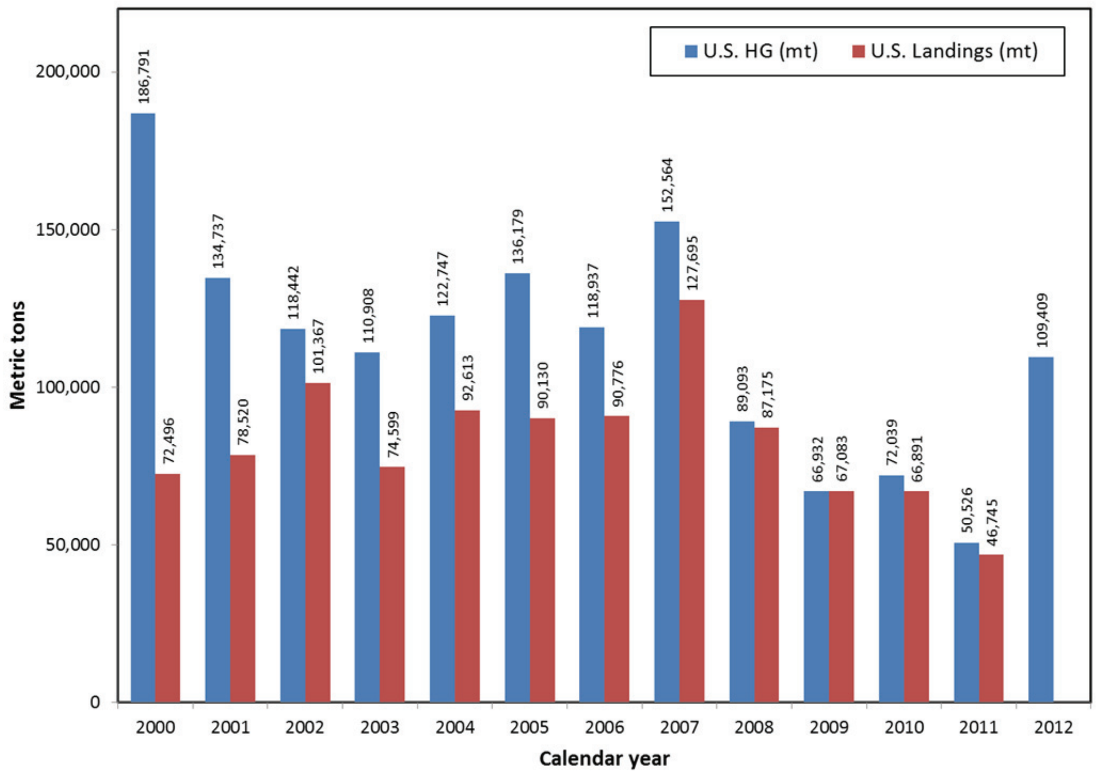

Figure 1a. U.S. harvest guidelines and landings since calendar year 2000.

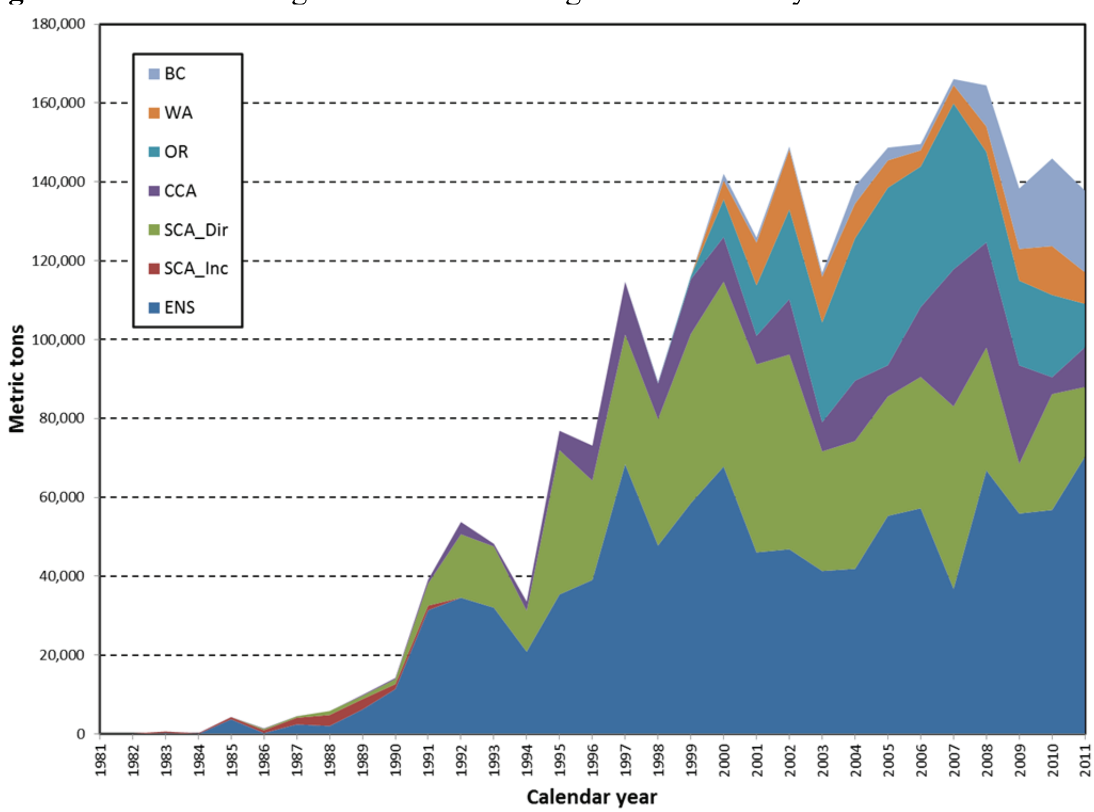

Figure 1b. Pacific sardine landings (mt) by major fishing region and calendar year.

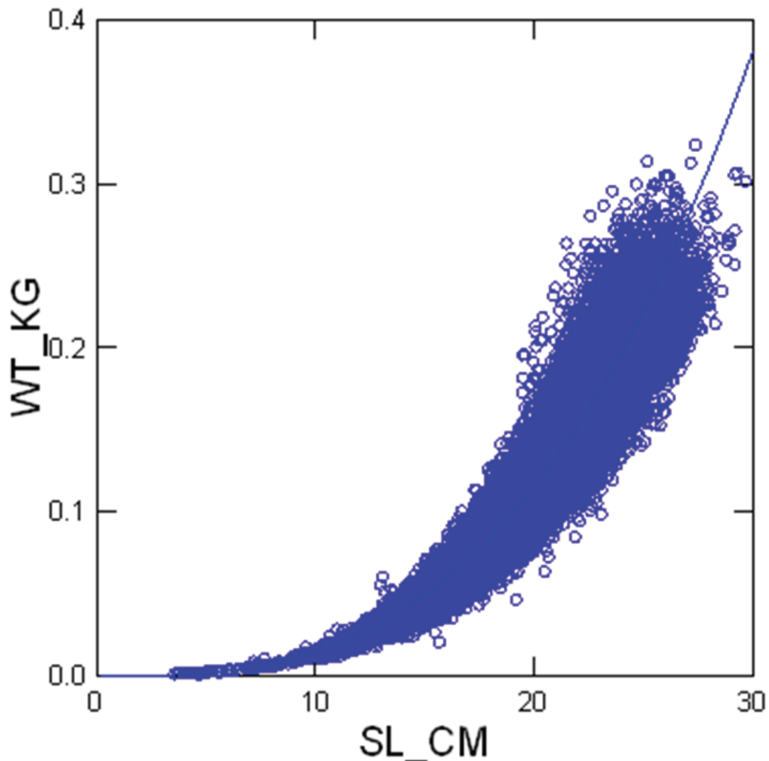

Figure 2a. Weight-at-length regression from fishery samples as applied in the base model, where: a = 1.68384E-05 and b = 2.94825 (n=155,814, R^2 = 0.928).

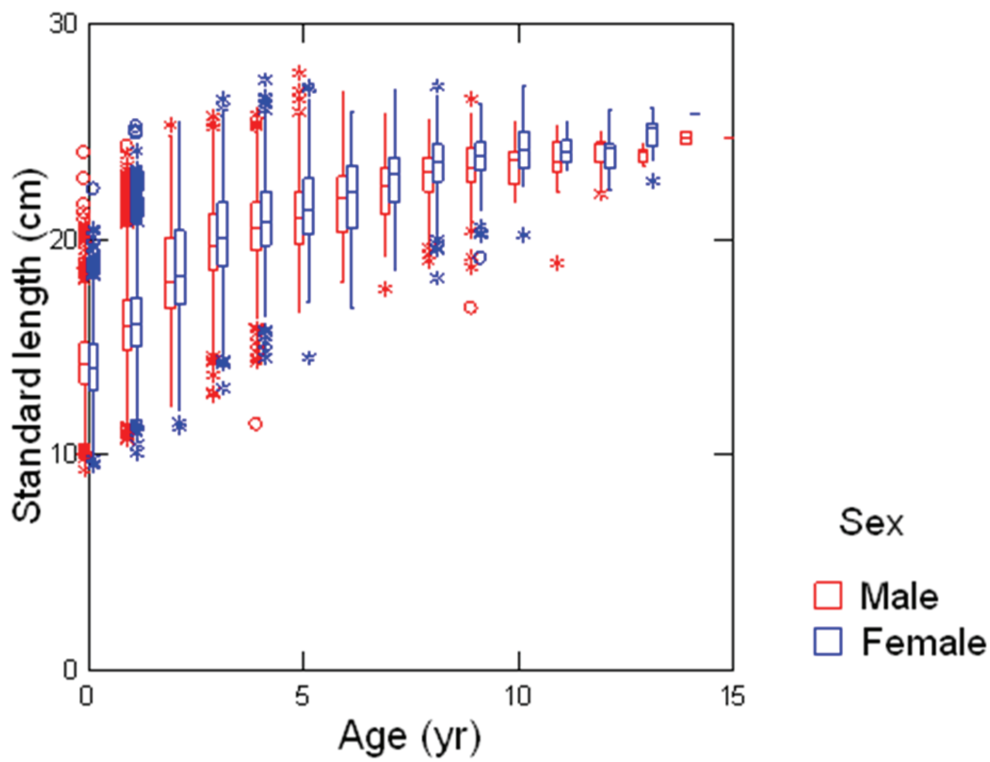

Figure 2b. Length-at-age by sex from fishery samples. Box symbols indicate median and quartile ranges for the raw data. The SS model is based on pooled sexes.

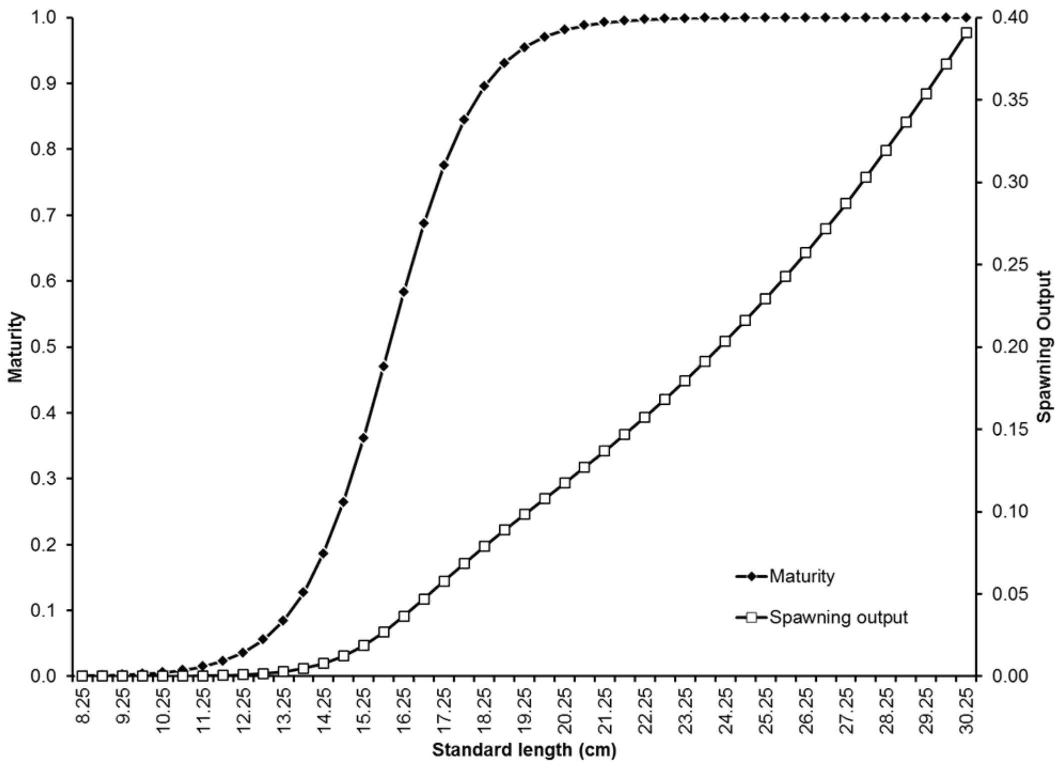

Figure 2c. Maturity (L_{50} = 15.88 cm) and spawning output as a function of length.

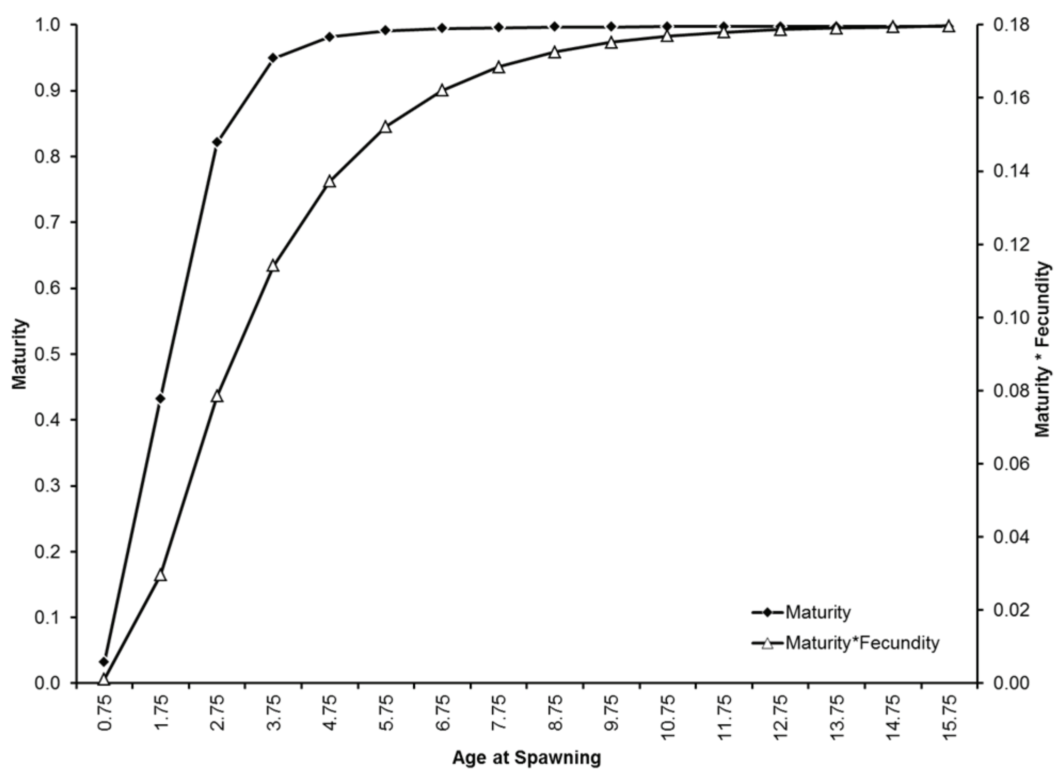

Figure 2d. Maturity and fecundity as a function of age, as derived from model X6e.

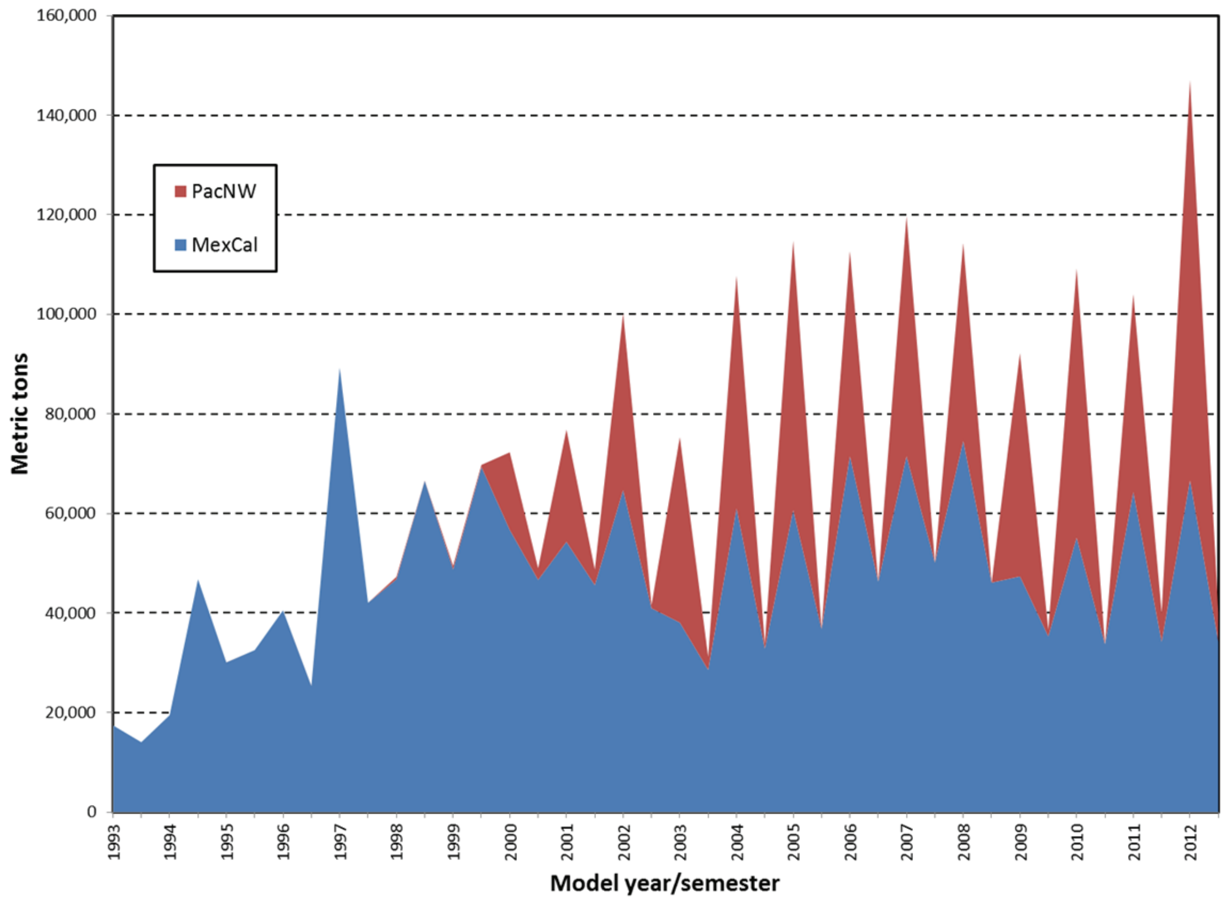

Figure 3. Pacific sardine landings (mt) by fishery, model year and semester as used in SS.

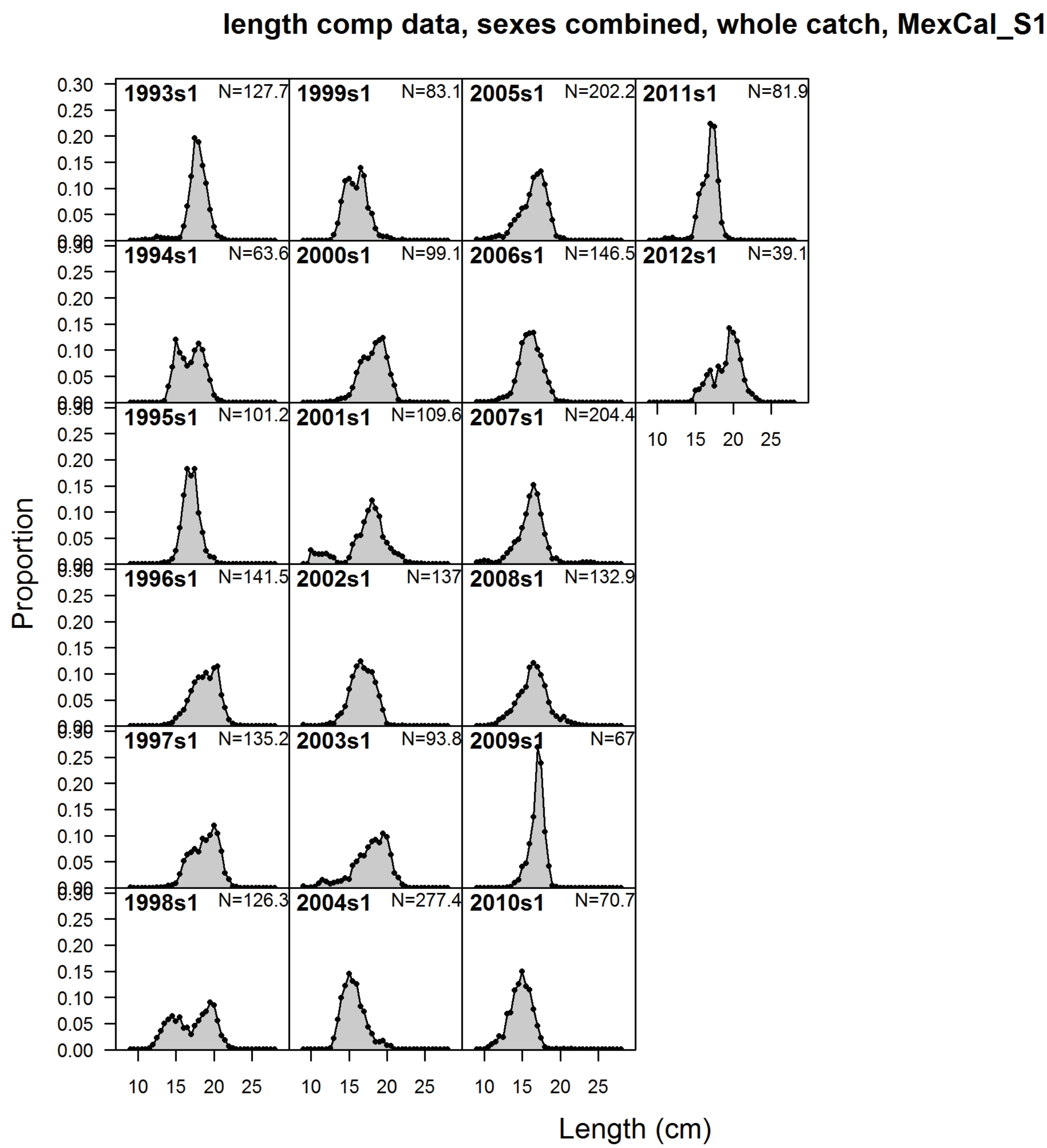

Figure 4a. Length-composition and effective sample size data for the MexCal_S1 fishery.

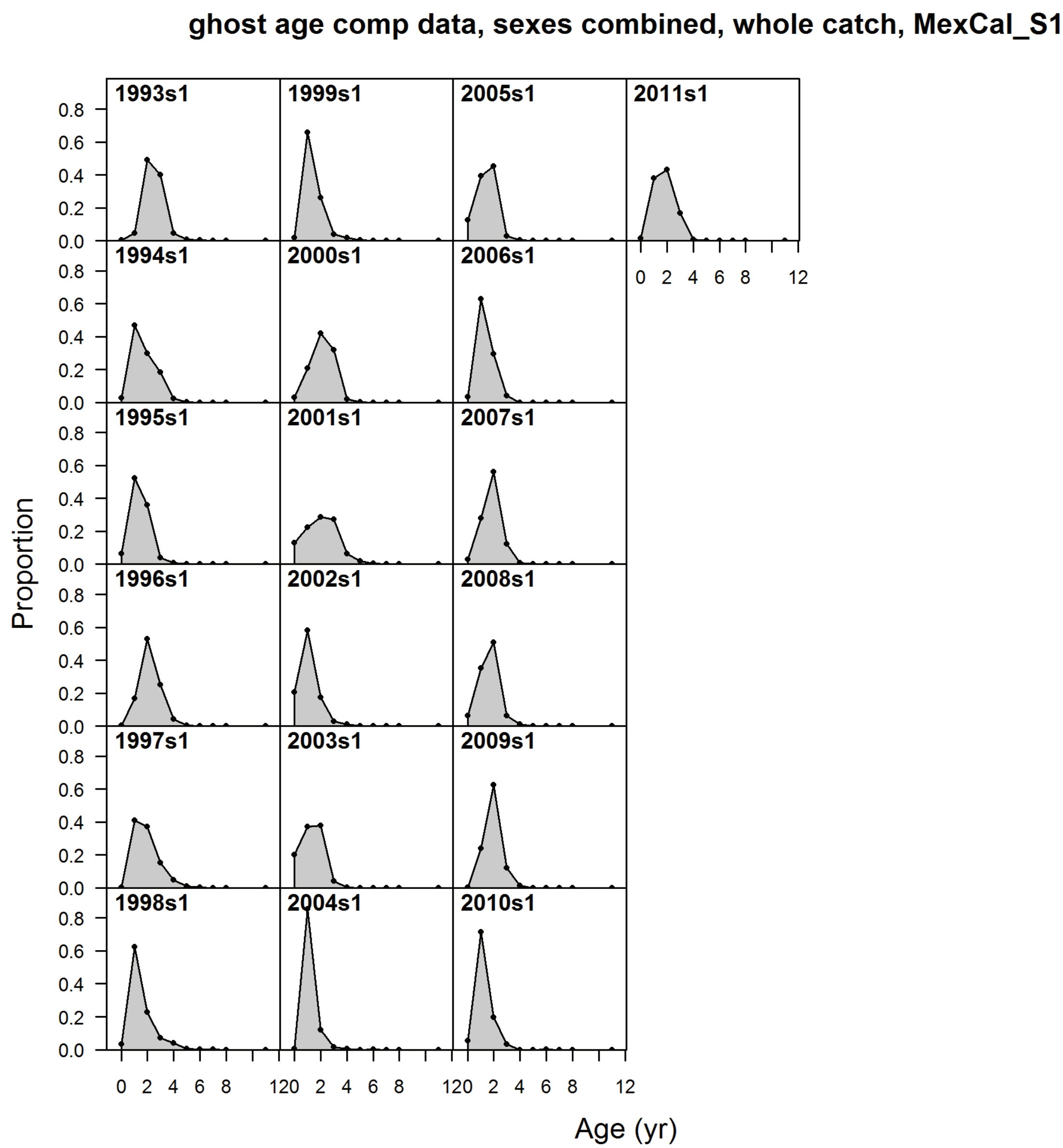

Figure 4b. Implied age-composition data for the MexCal-S1 fishery.

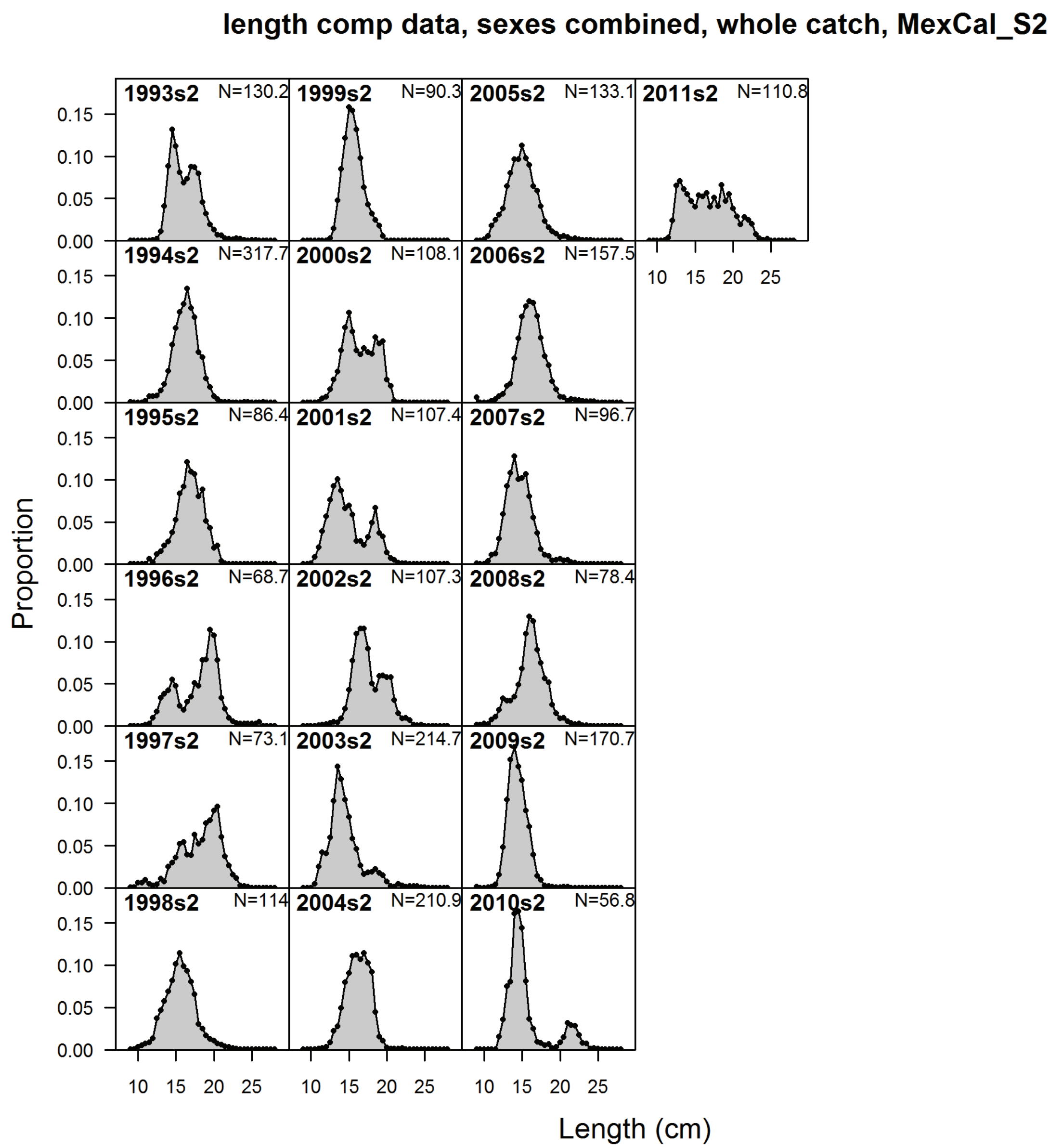

Figure 5a. Length-composition data and effective sample size for the MexCal_S2 fishery.

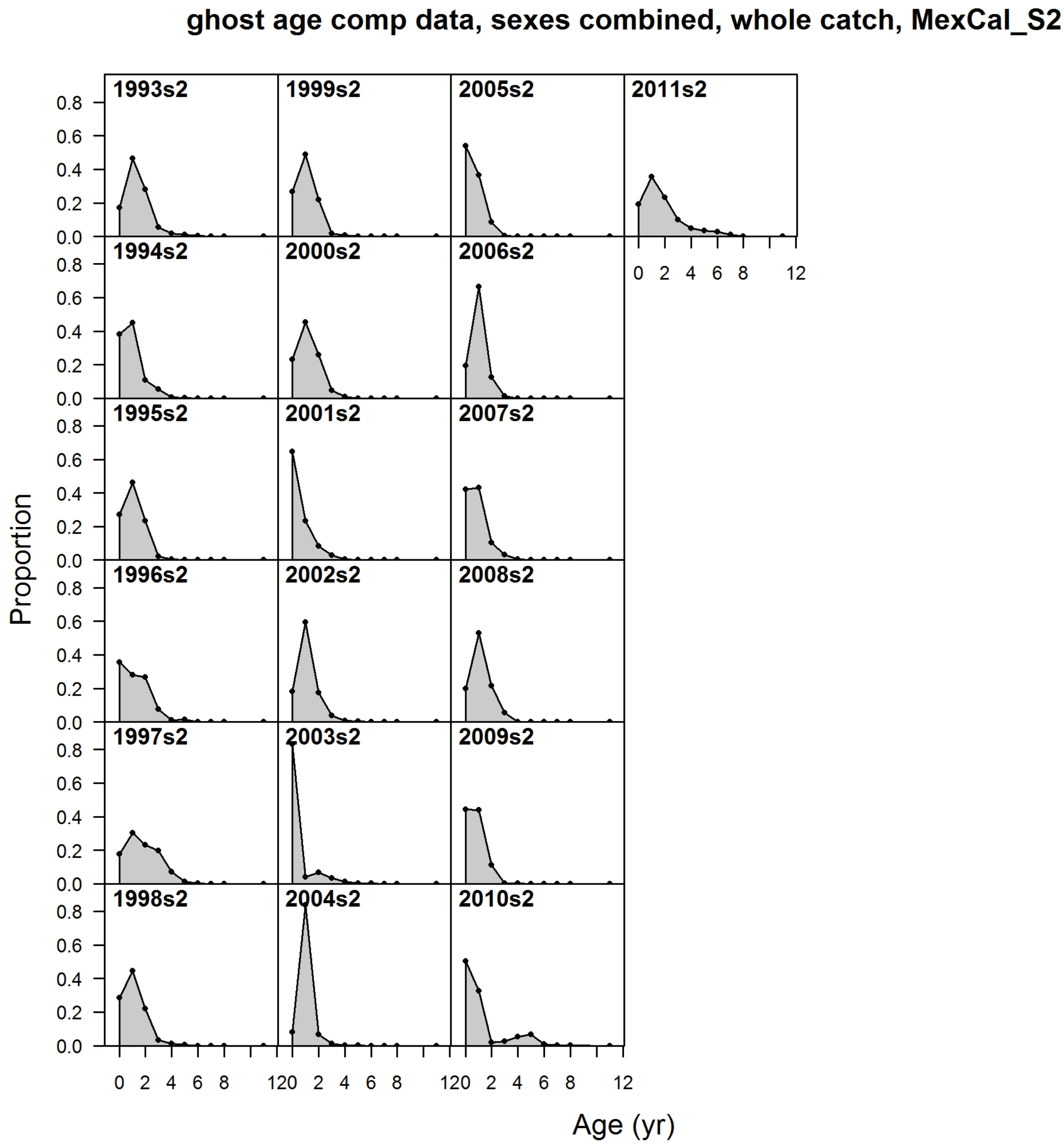

Figure 5b. Implied age-composition data for the MexCal_S2 fishery.

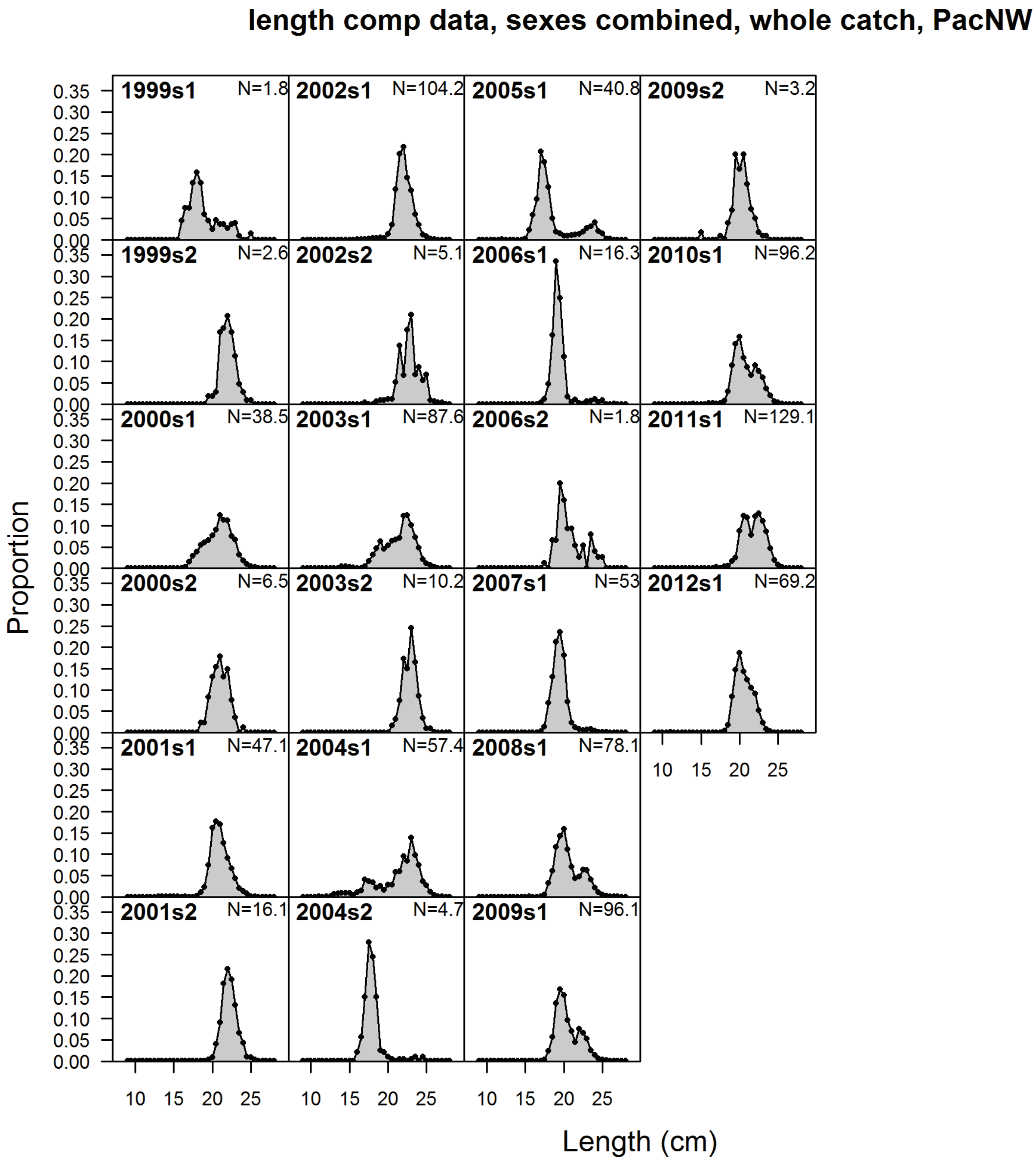

Figure 6a. Length-composition and effective sample size data for the PacNW fishery.

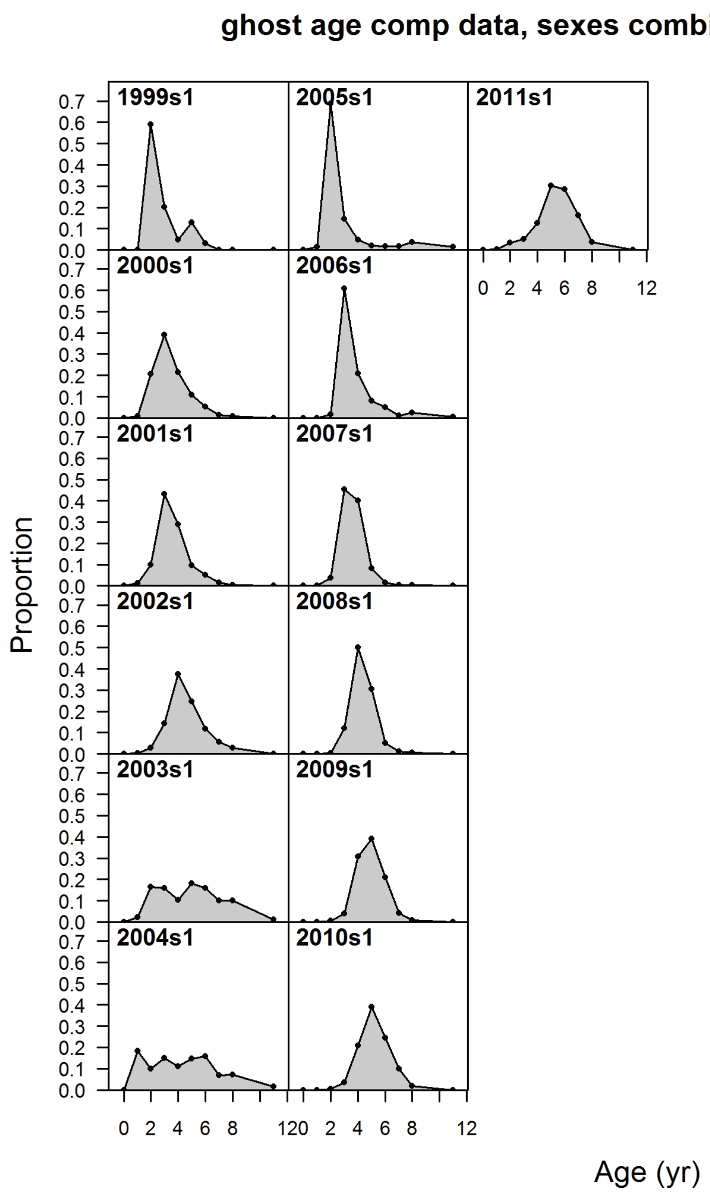

Figure 6b. Implied age-composition data for the PacNW fishery.

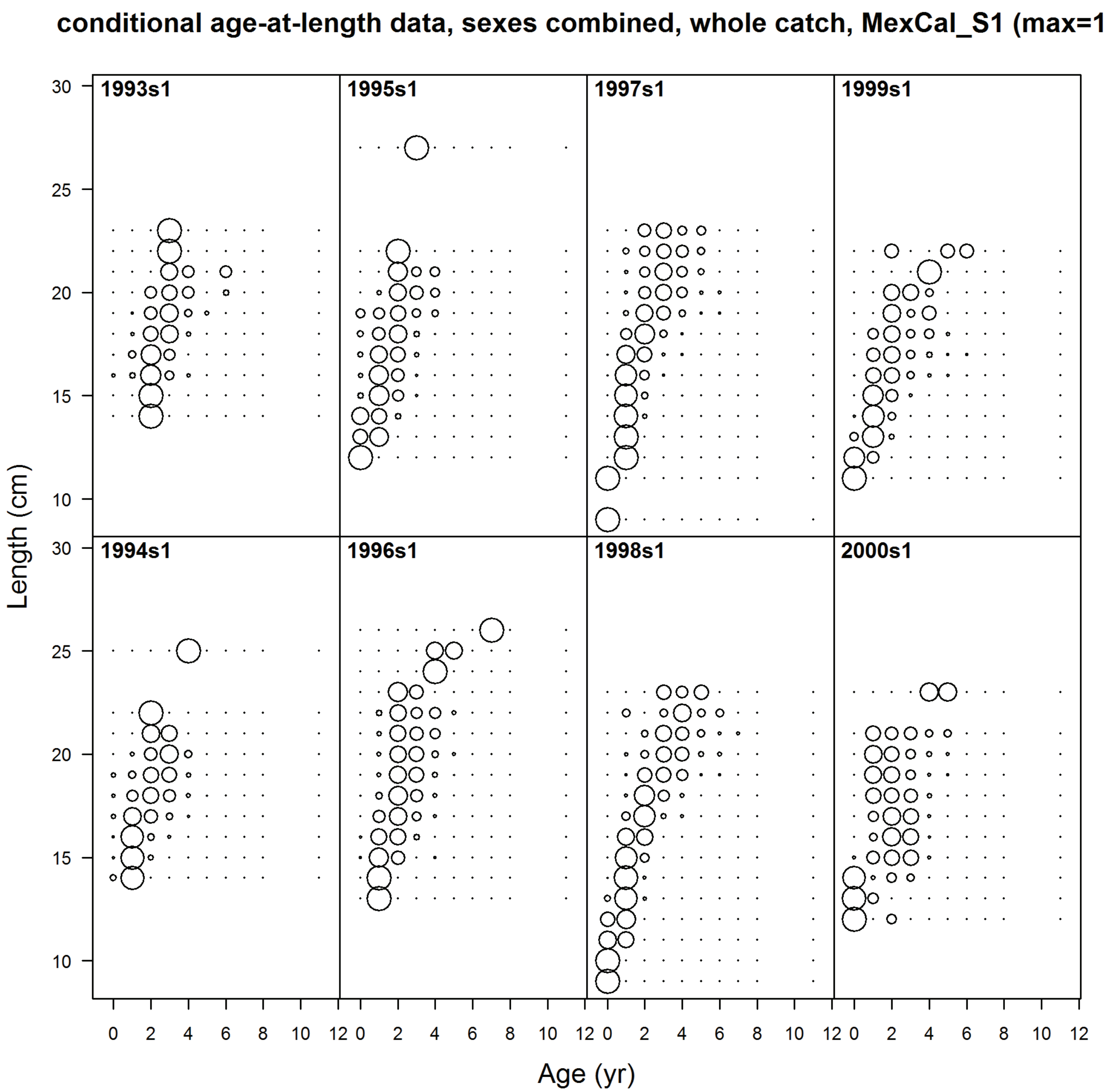

Figure 7. Conditional age-at-length data for the MexCal_S1 fishery, 1993-2000.

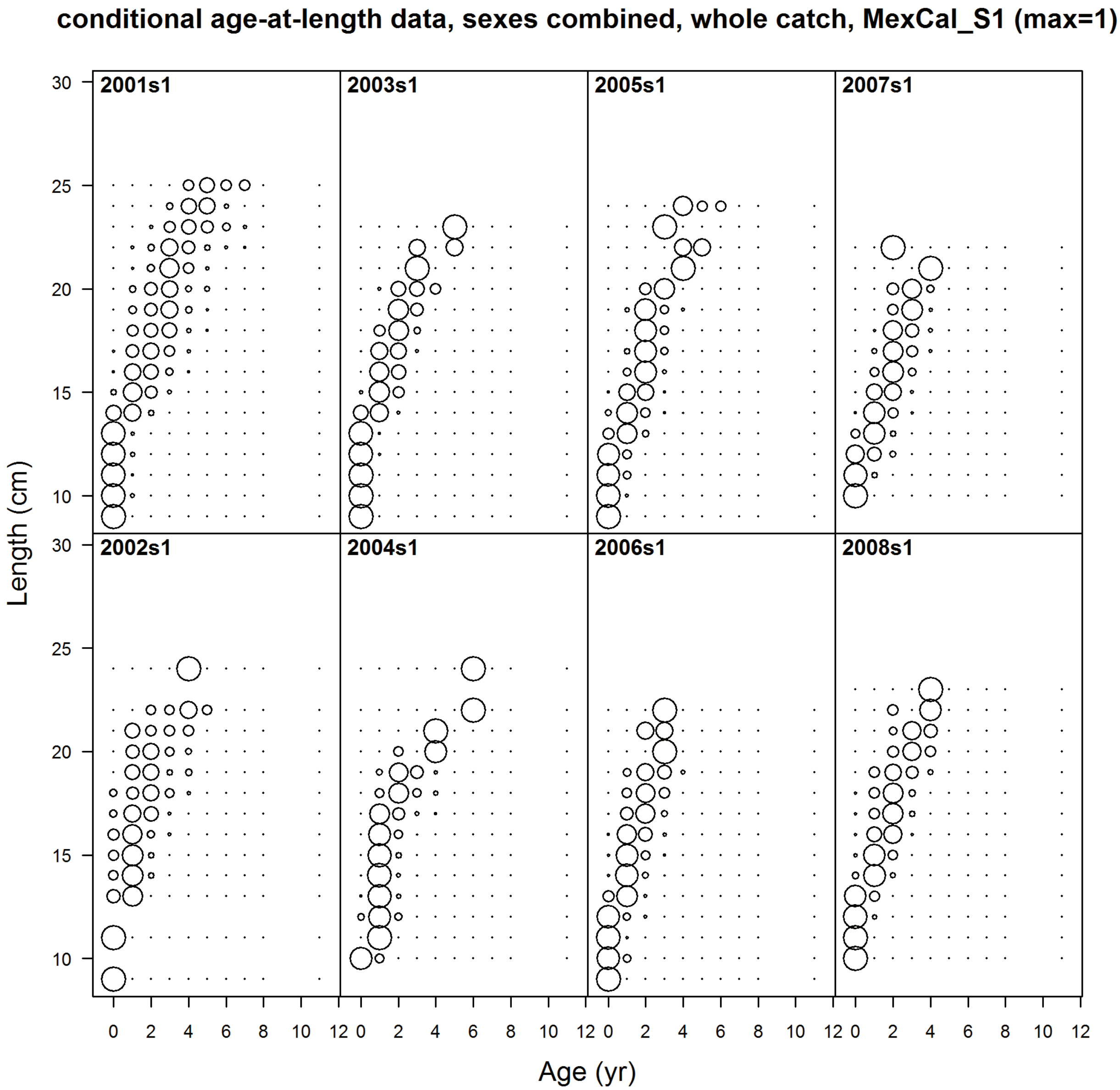

Figure 7 (cont'd). Conditional age-at-length data for the MexCal_S1 fishery, 2001-2008.

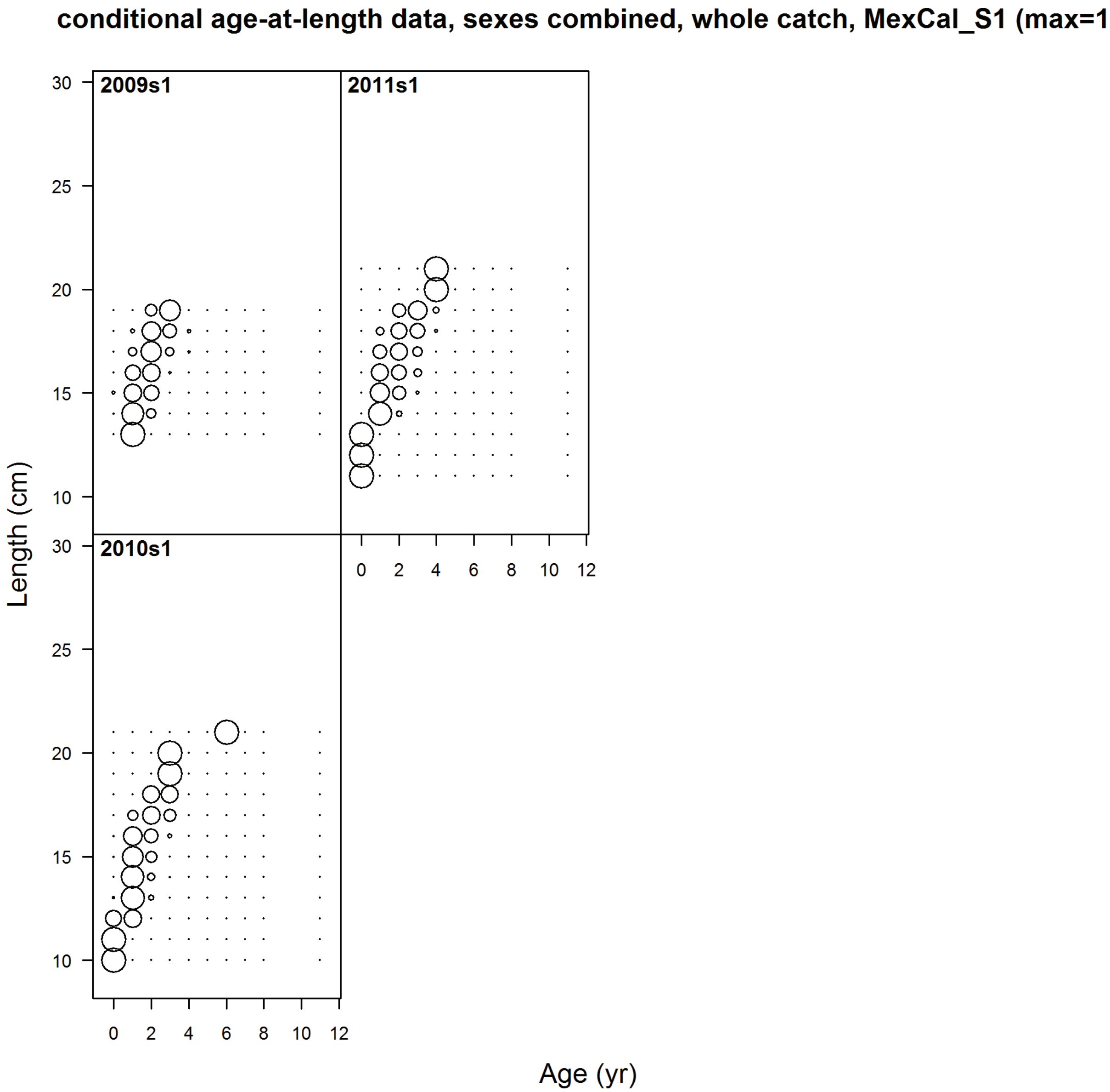

Figure 7 (cont'd). Conditional age-at-length data for the MexCal_S1 fishery, 2009-2011.

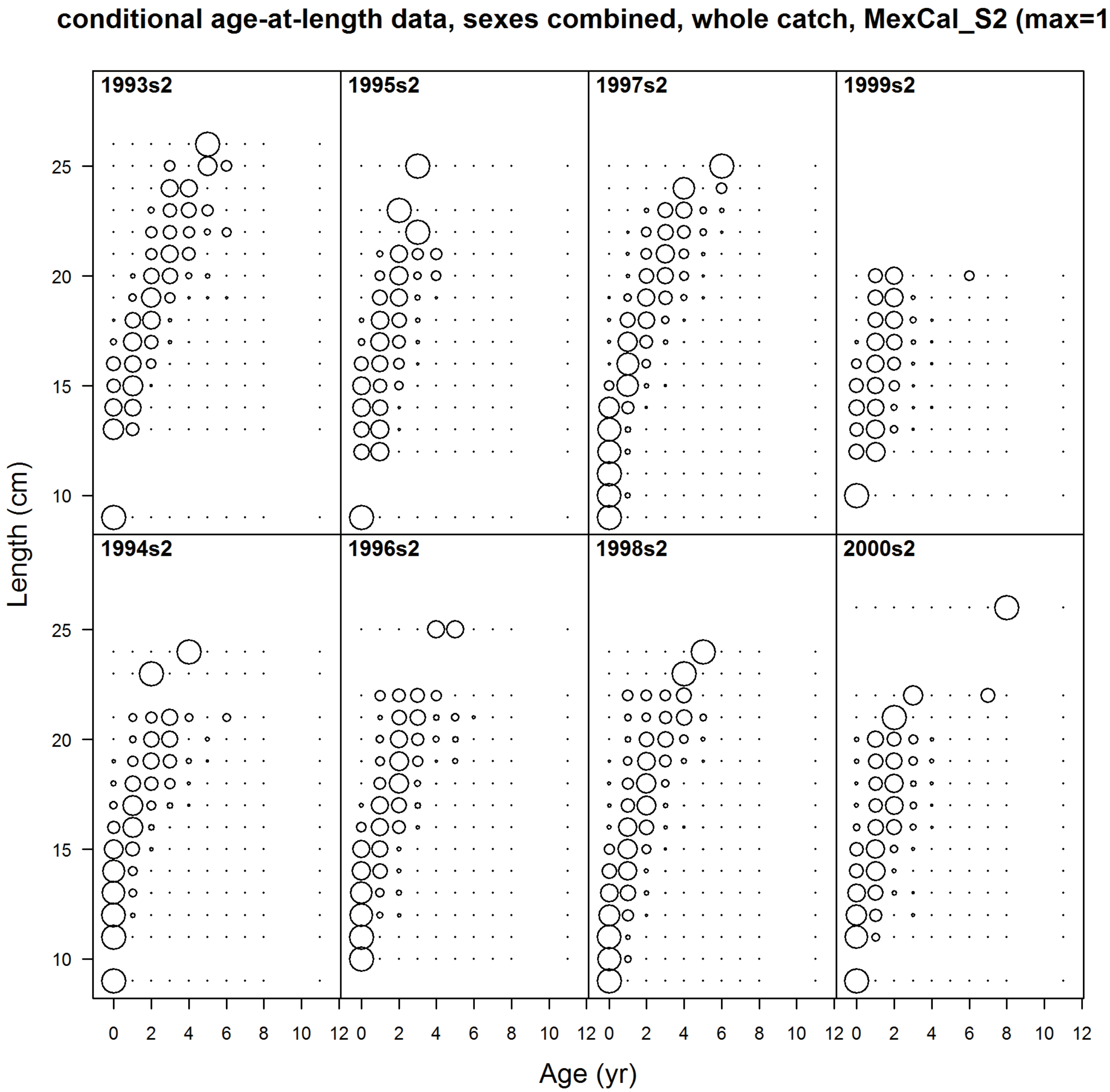

Figure 8. Conditional age-at-length data for the MexCal_S2 fishery, 1993-2000.

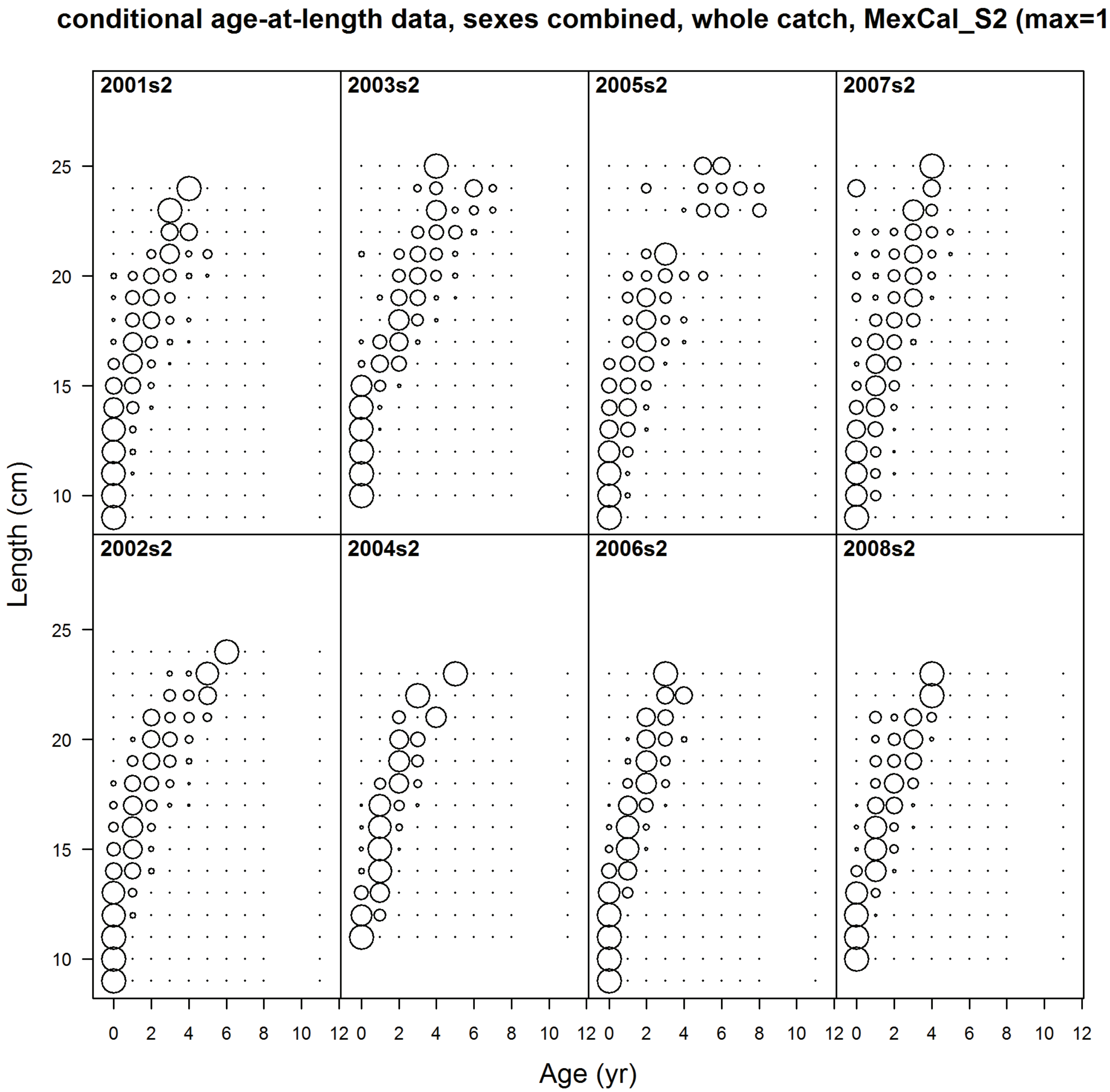

Figure 8 (cont'd). Conditional age-at-length data for the MexCal_S2 fishery, 2001-2008.

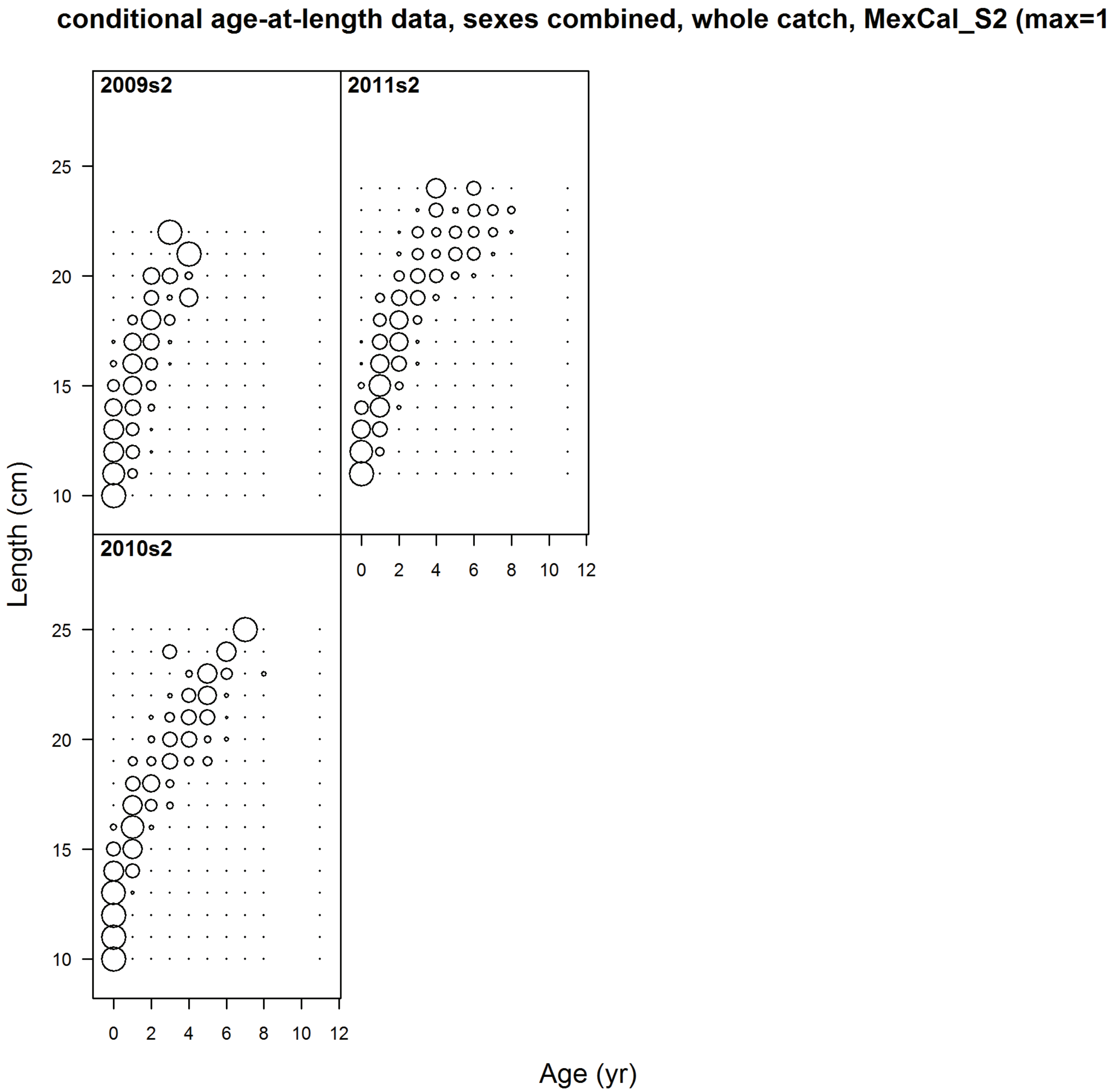

Figure 8 (cont'd). Conditional age-at-length data for the MexCal_S2 fishery, 2009-2011.

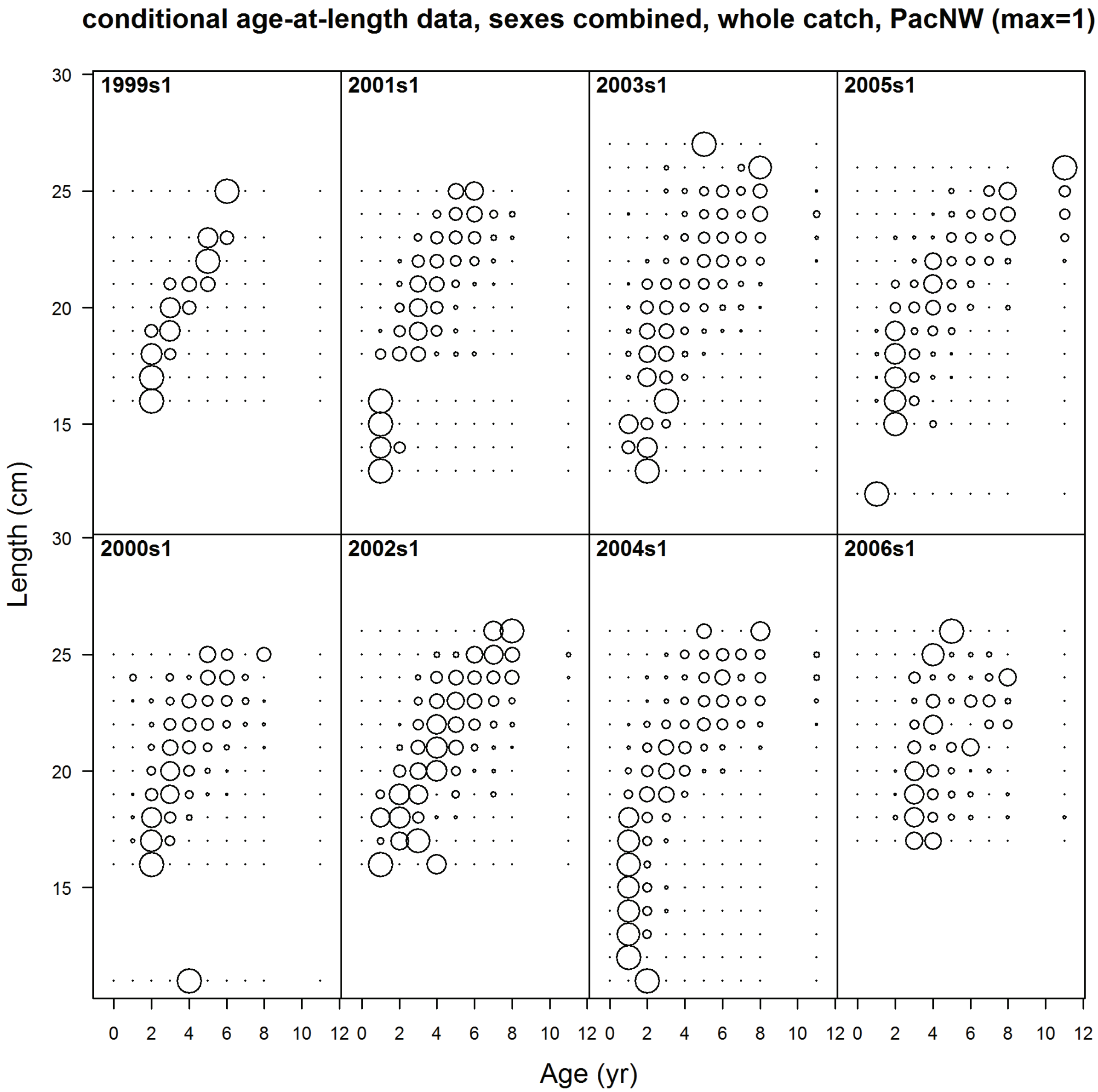

Figure 9. Conditional age-at-length data for the PacNW fishery, 1999-2006.

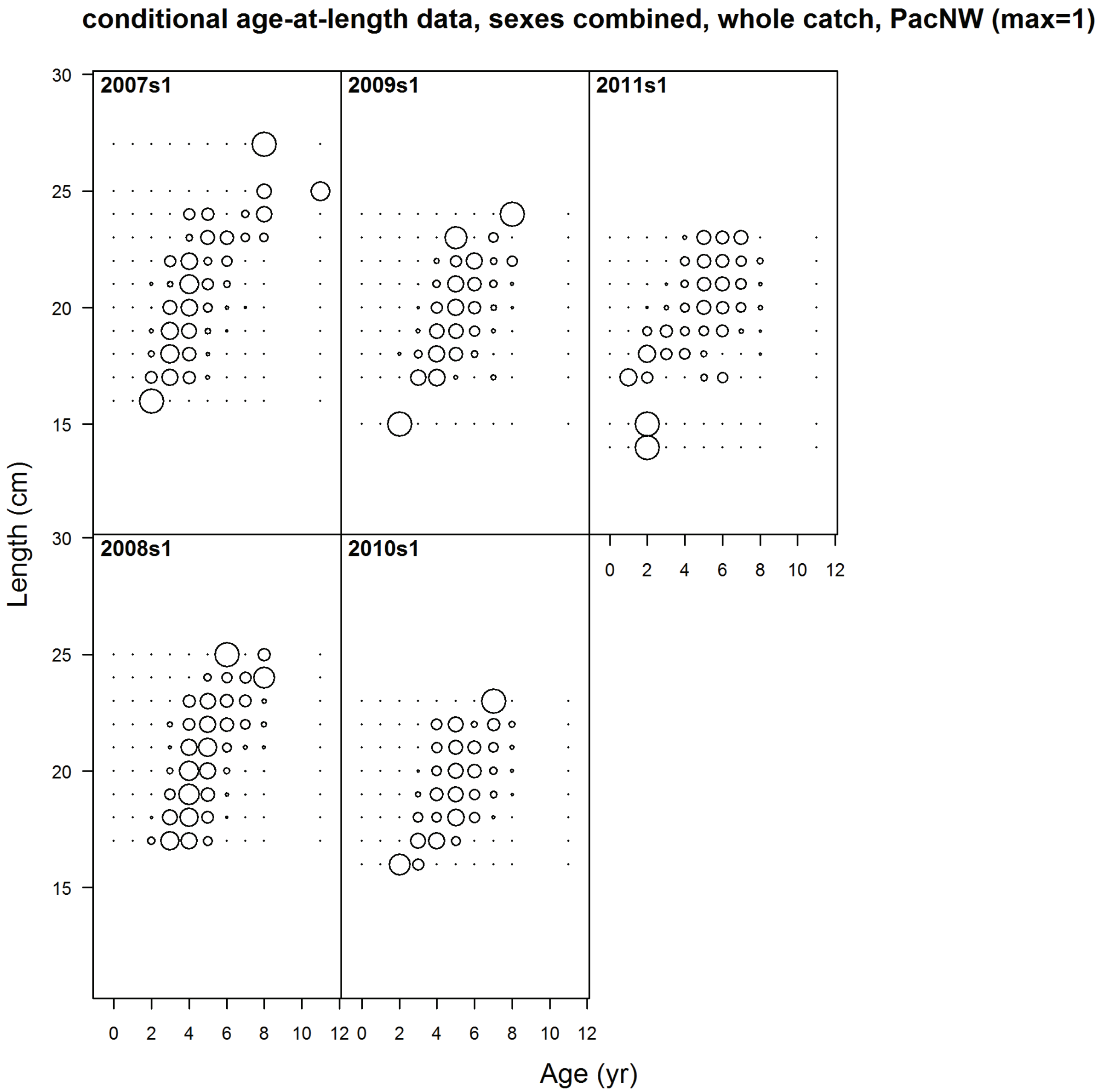

Figure 9 (cont'd). Conditional age-at-length data for the PacNW fishery, 2007-2011.

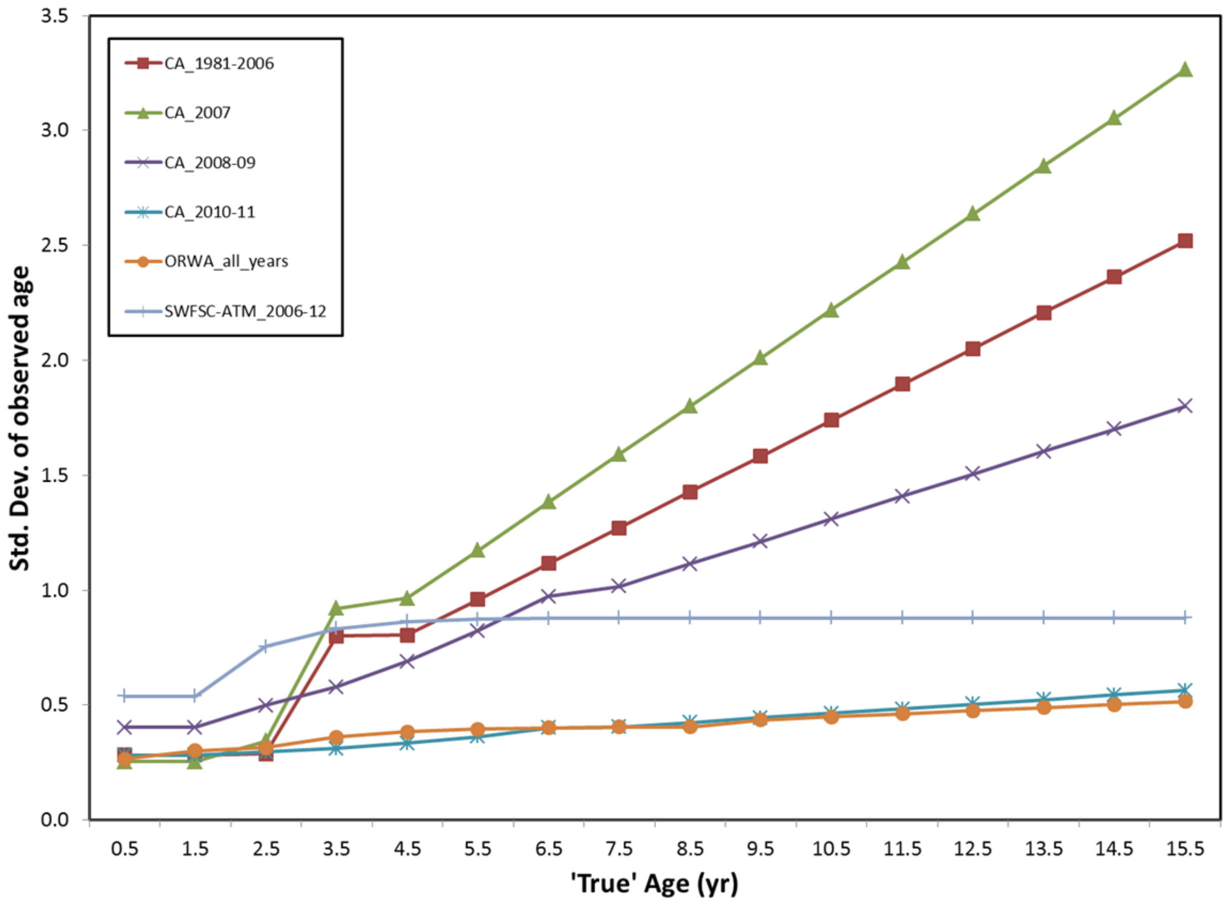

Figure 10. Laboratory- and year-specific ageing errors.

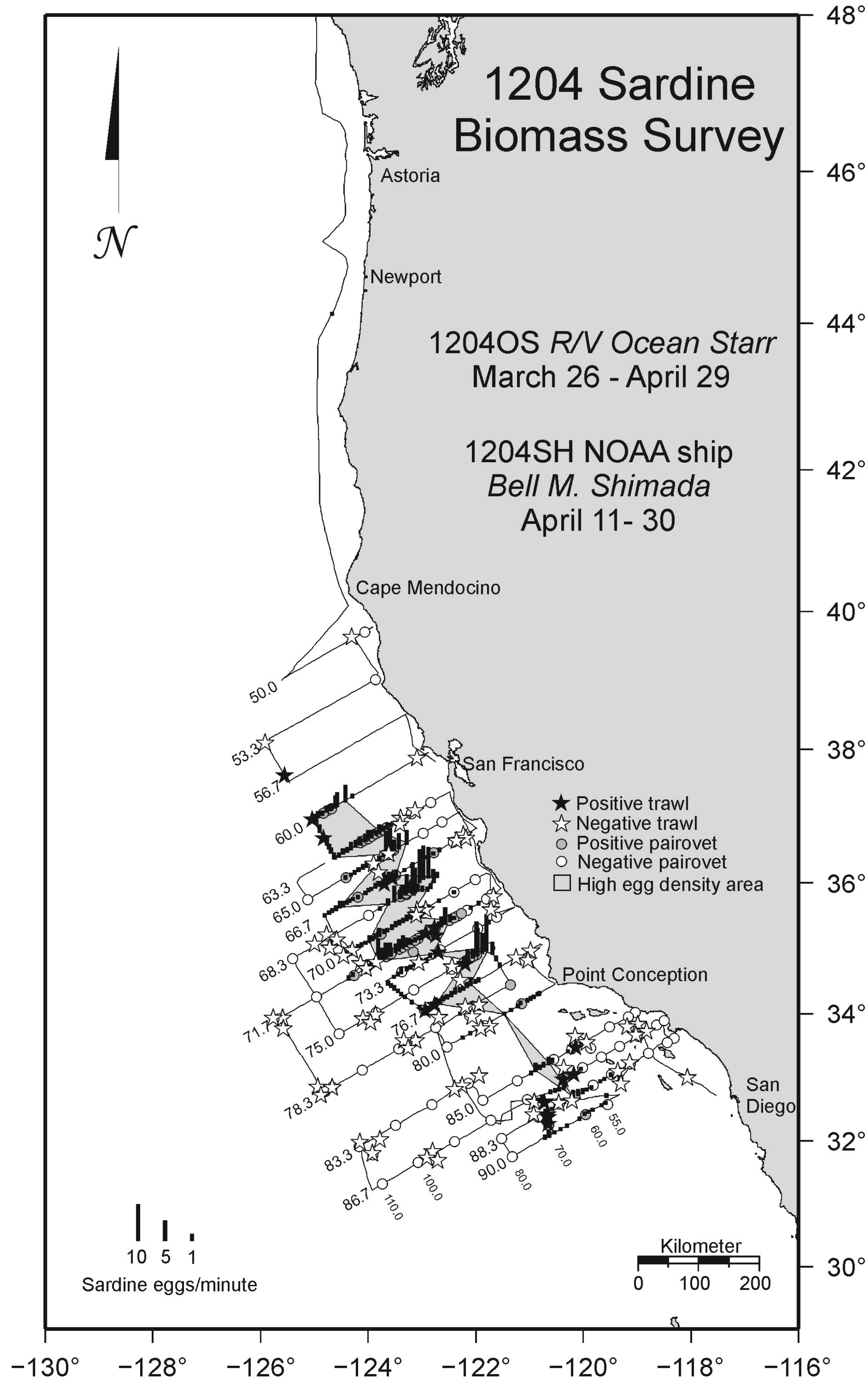

Figure 11a. Distribution of CUFES and pairovet ichthyoplankton collections and adult trawl samples from the SWFSC 1204 sardine survey, conducted onboard the R/V Ocean Starr and NOAA ship Bell M. Shimada during spring of 2012. Standard sampling area for the DEPM index is displayed on the following page.

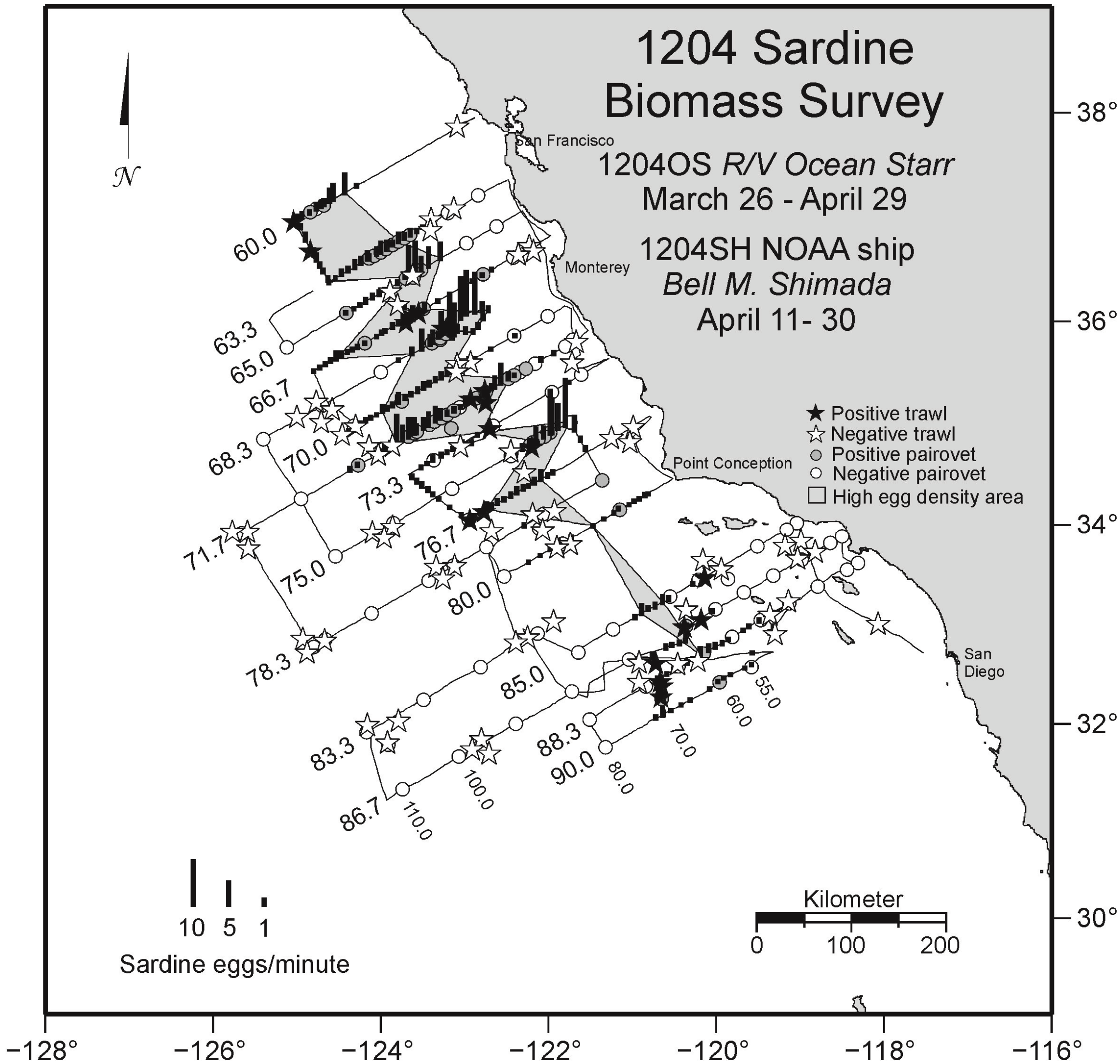

Figure 11b. Distribution of CUFES and pairovet ichthyoplankton collections and adult trawl samples from the SWFSC 1204 sardine survey in the standard sampling area for the DEPM index, conducted onboard the R/V Ocean Starr and NOAA ship Bell M. Shimada during spring of 2012.

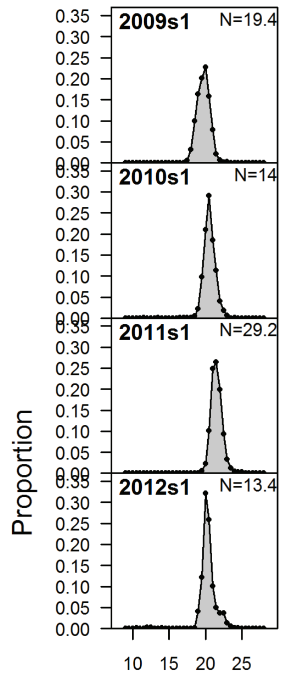

Figure 12. Length-composition data (SL-cm) for the aerial survey.

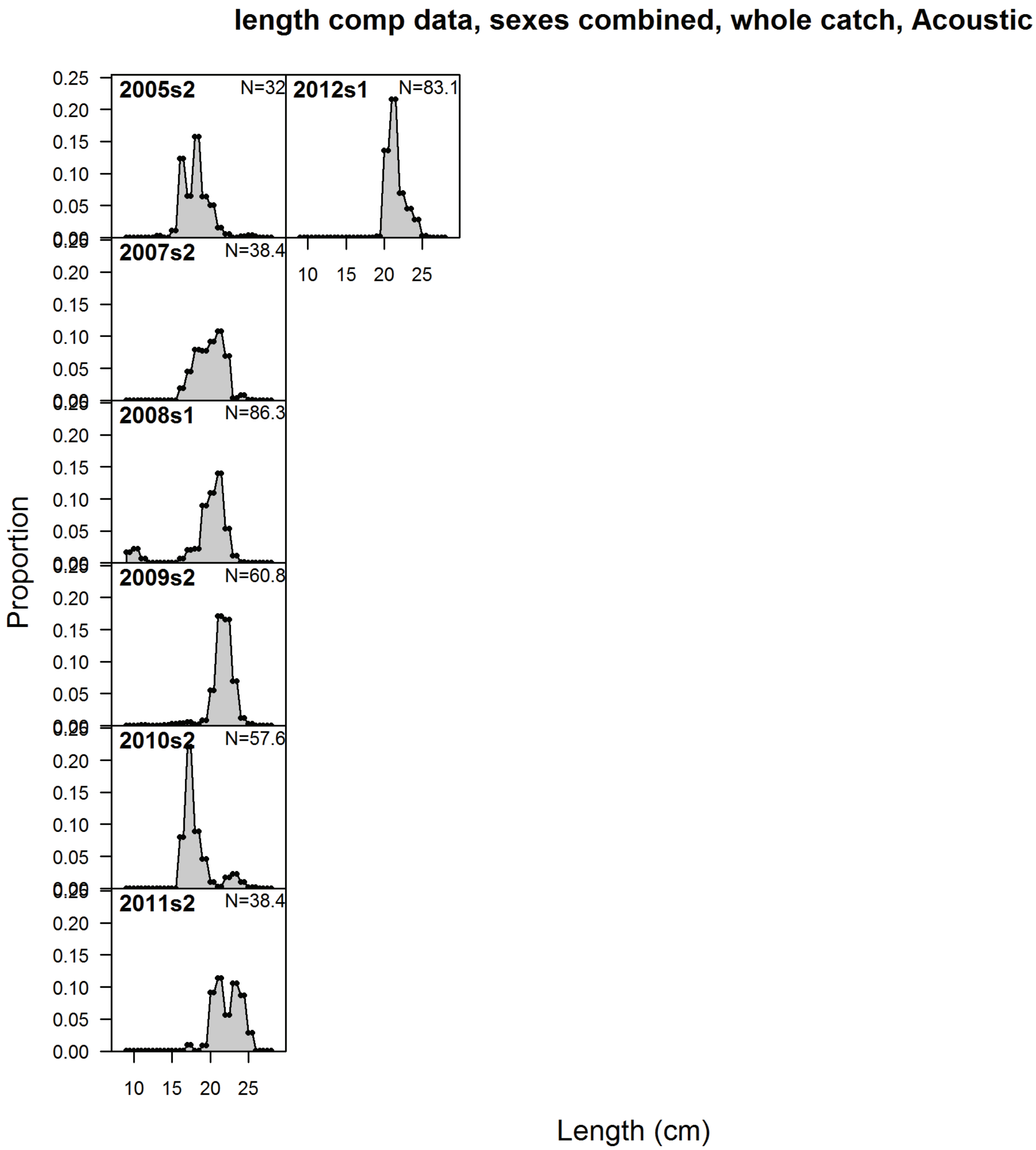

Figure 13a. Length-composition data (1-cm resolution) for the acoustic survey, 2005-2012.

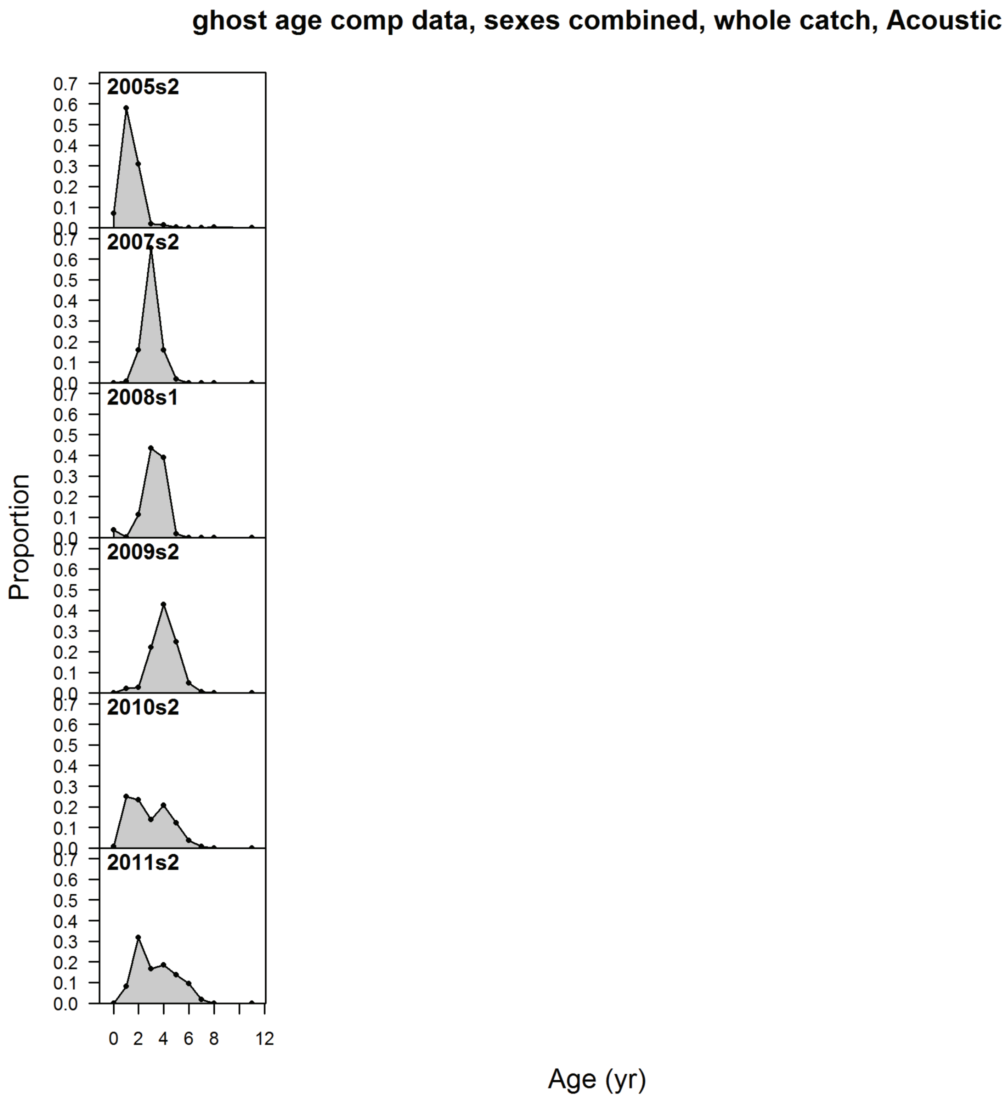

Figure 13b. . Implied age-composition data for the acoustic survey, 2005-2011.

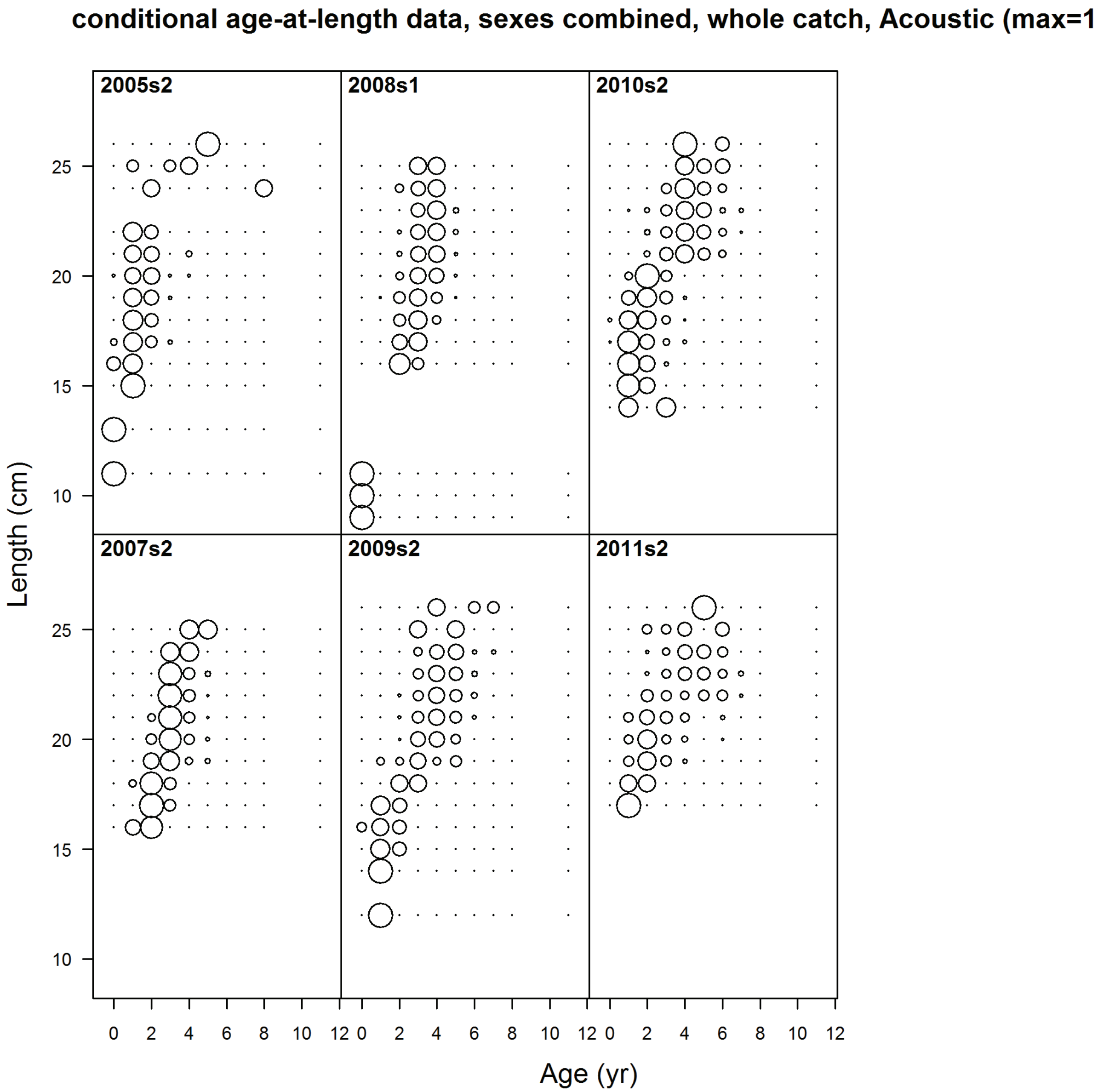

Figure 14. Conditional age-at-length data for the Acoustic-trawl survey, 2005-2011.

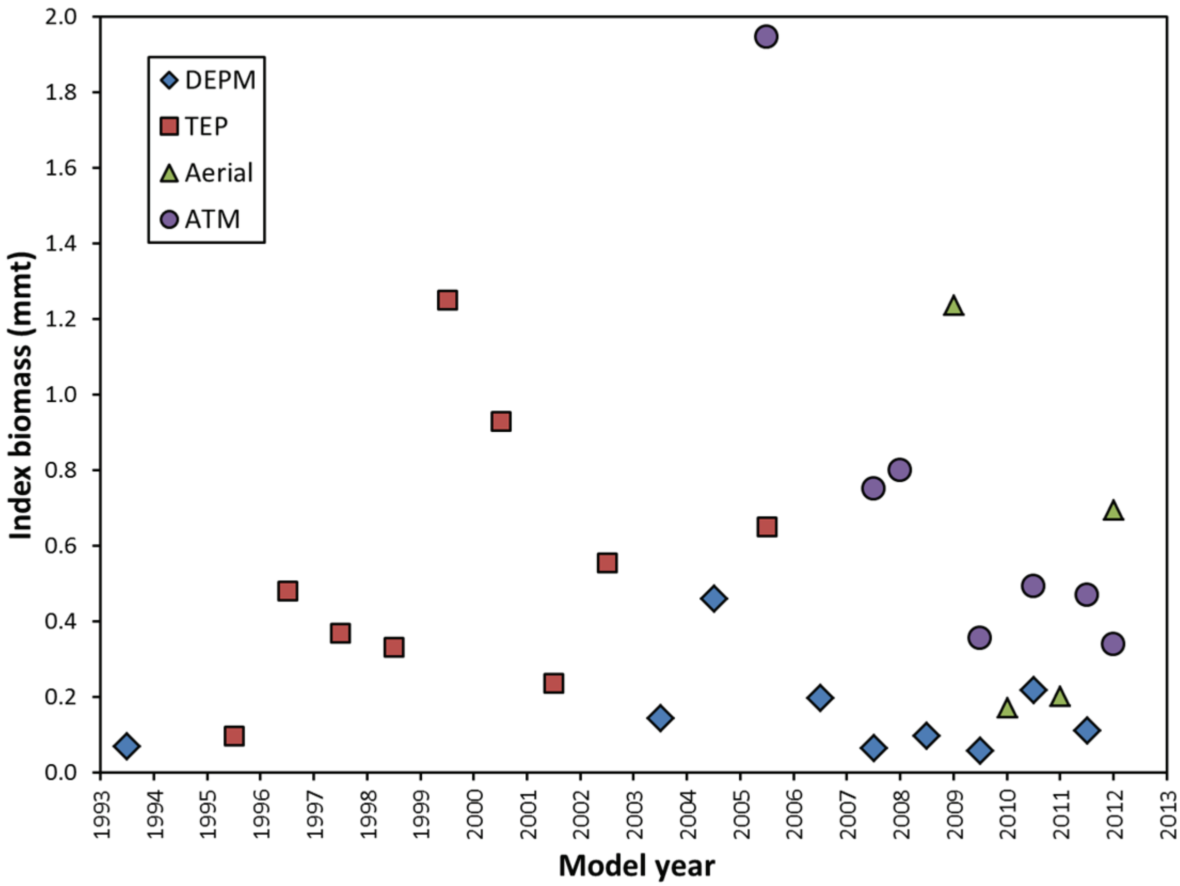

Figure 15. Survey indices of relative abundance (original values). TEP is modeled as total SSB, and DEPM as female SSB.

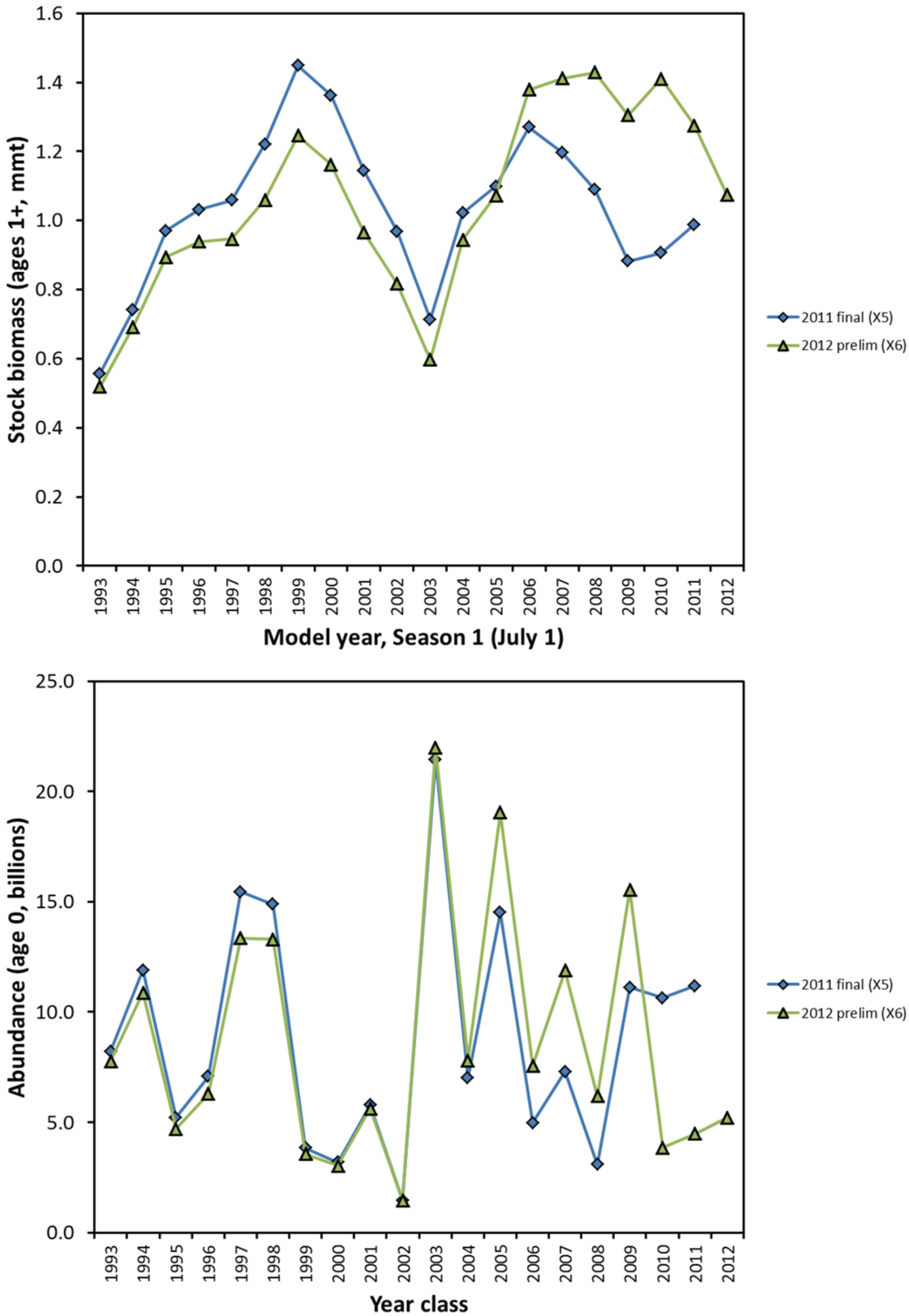

Figure 16. Stock biomass and recruitment for the final 2011 model (X5) and preliminary 2012 update model (X6).

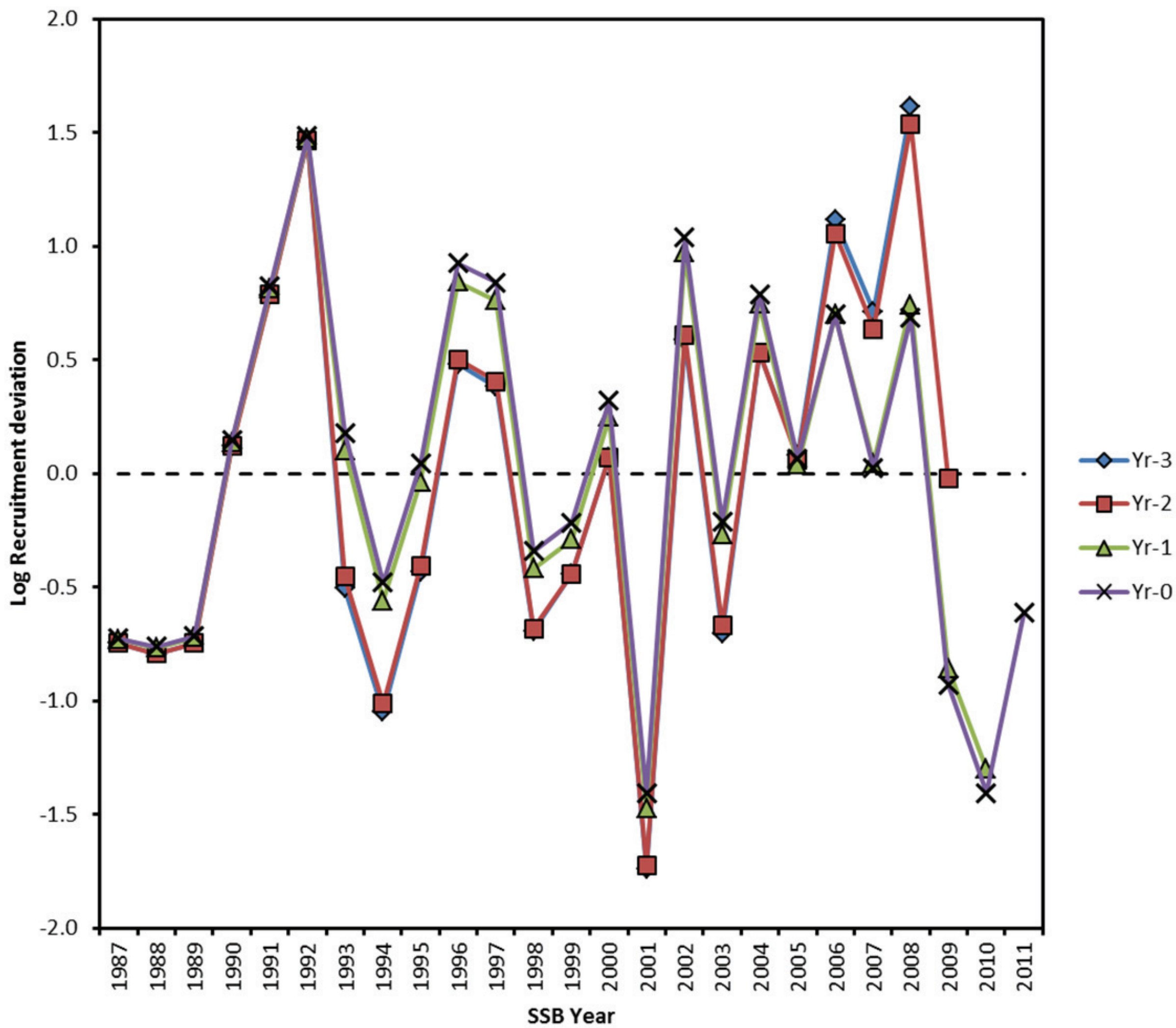

Figure 17. Profile on the last year for estimated recruitment deviations (end year -0, -1, -2, and -3) for preliminary model X6.

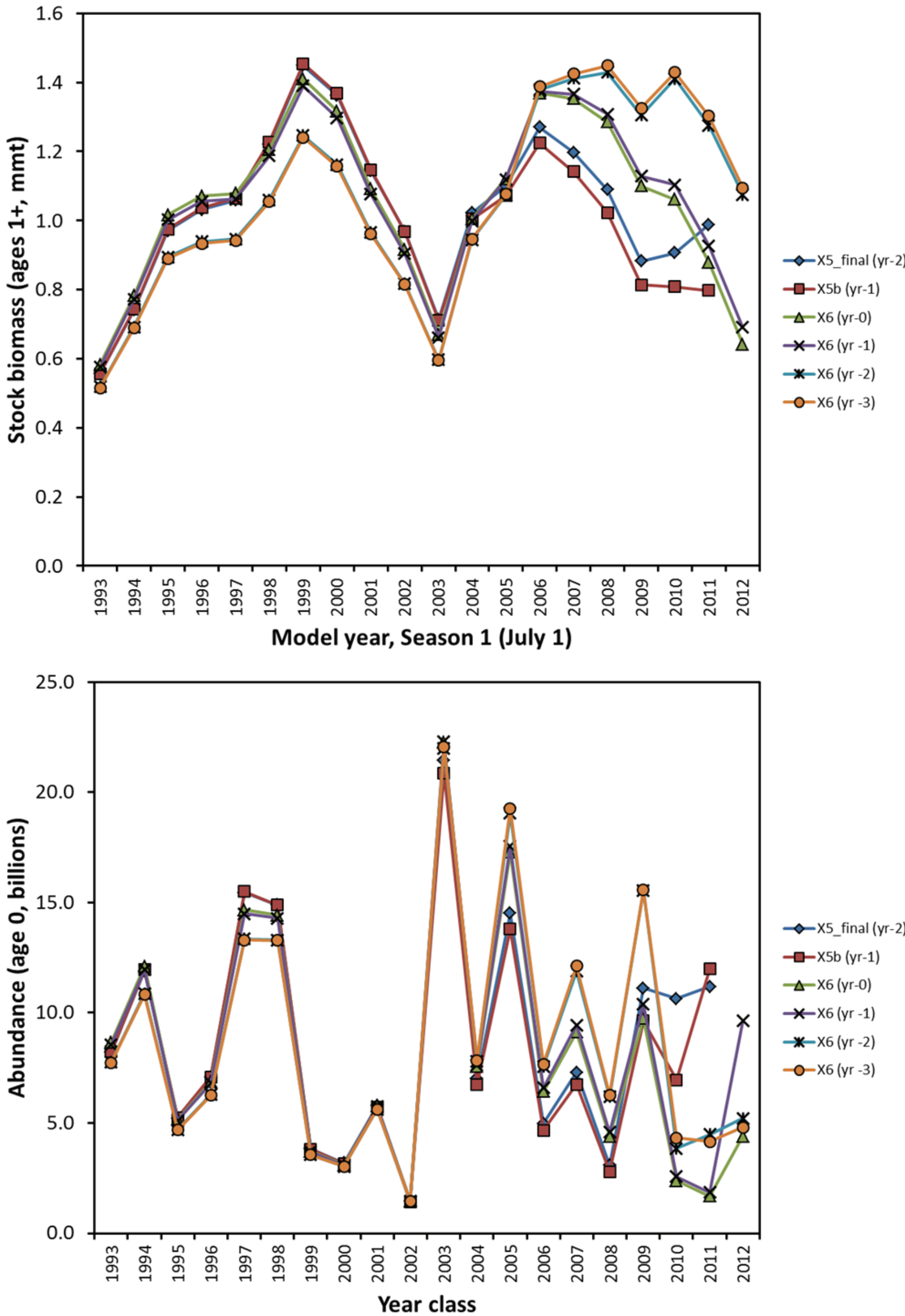

Figure 18. Stock biomass and recruitment for profile on the last year for estimated recruitment deviations (end year -0, -1, -2, and -3) for preliminary model X6.

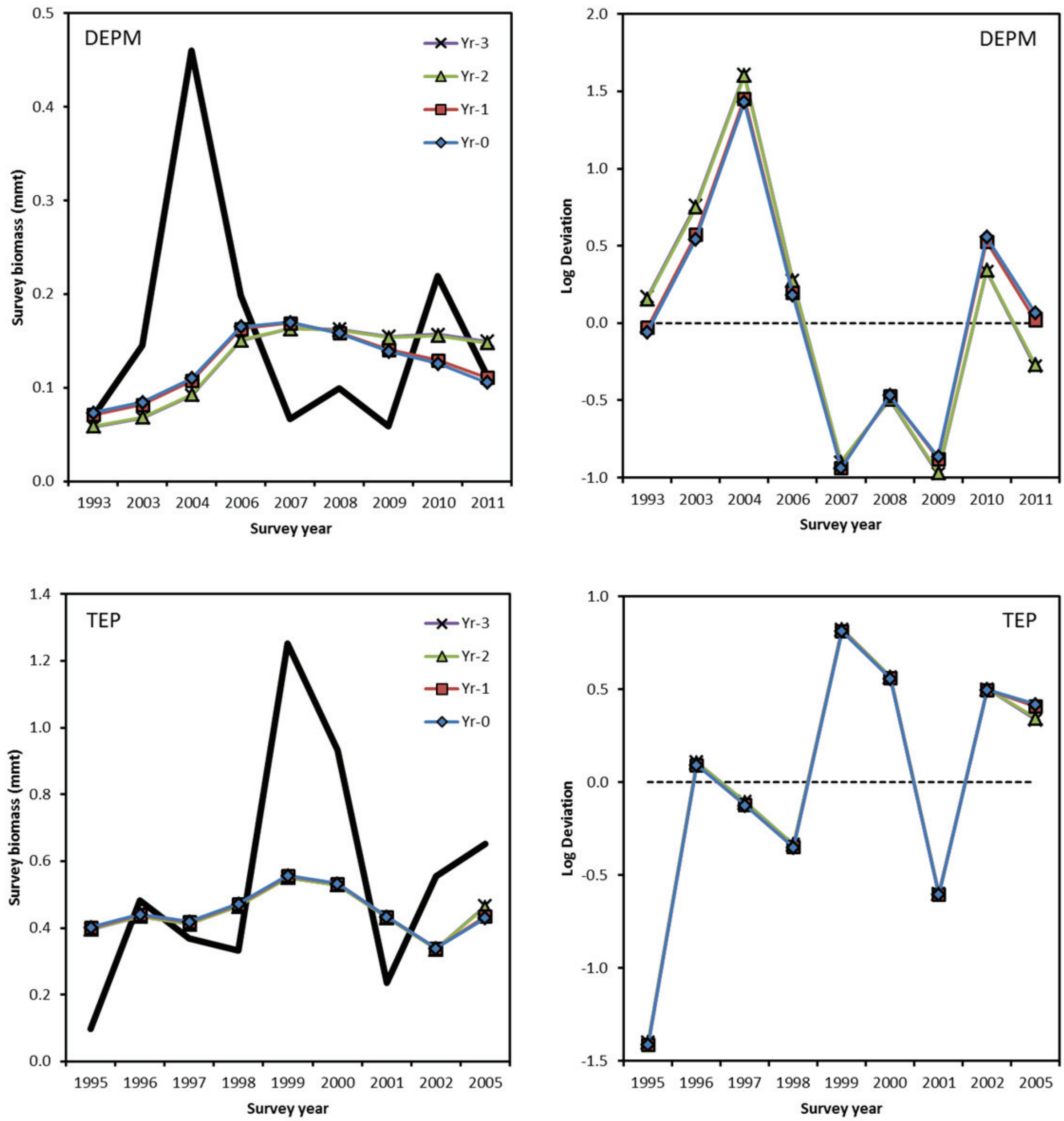

Figure 19. Preliminary model X6 fits to DEPM and TEP surveys for a profile on the last year for estimated recruitment deviations (end year -0, -1, -2, and -3).

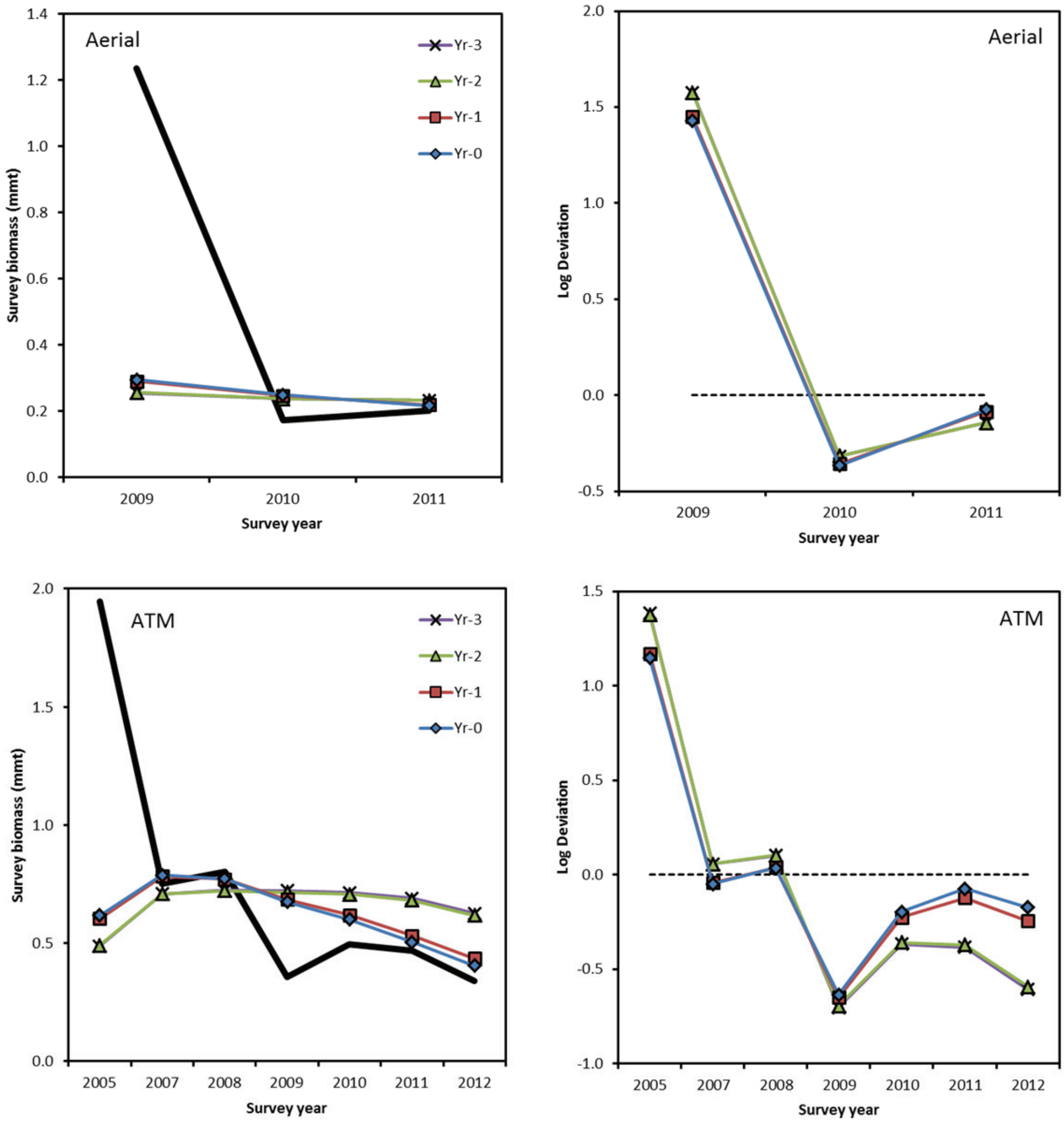

Figure 19 (cont'd). Preliminary model X6 fits to Aerial and ATM surveys for a profile on the last year for estimated recruitment deviations (end year -0, -1, -2, and -3).

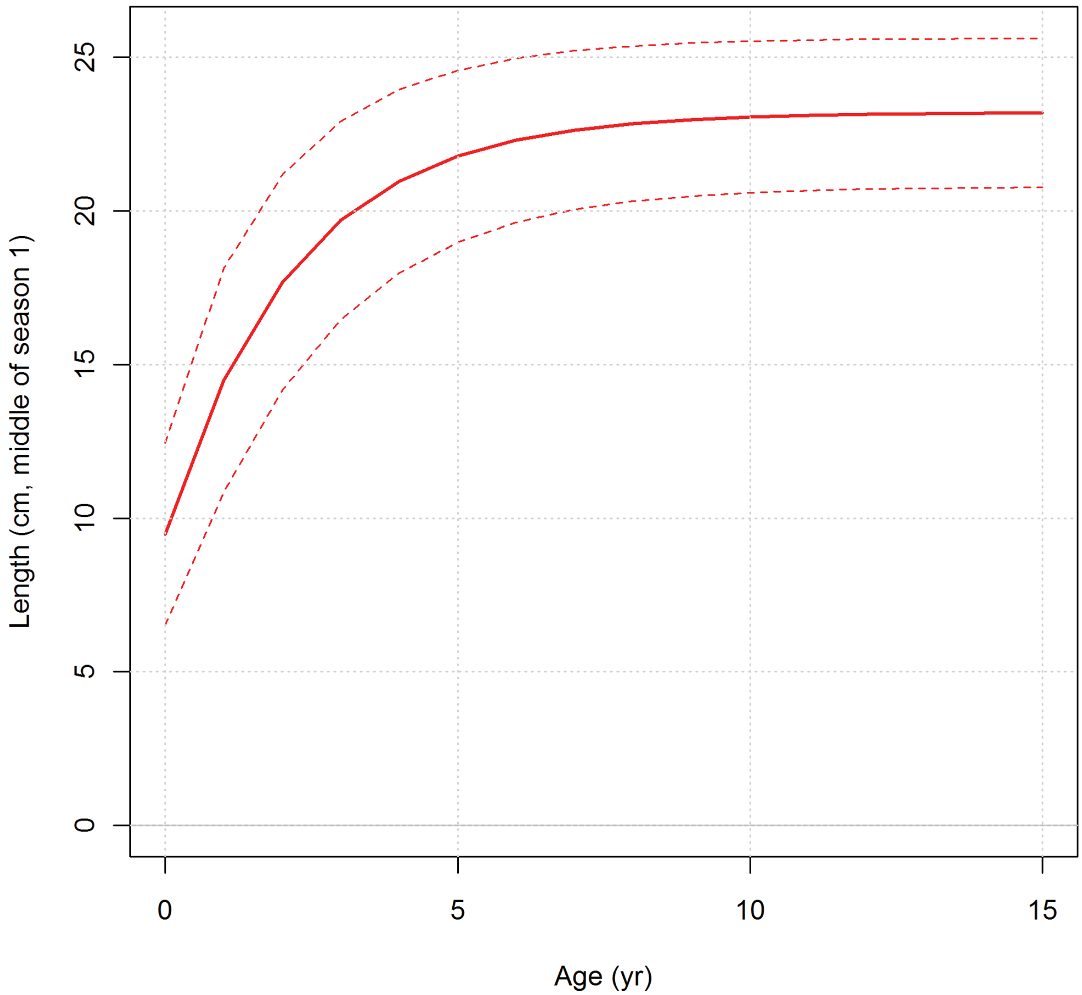

Figure 20. Length-at-age as estimated in model X6b ($L_{0.5yr}$ = 11.0, L_∞ = 23.2, K = 0.454).

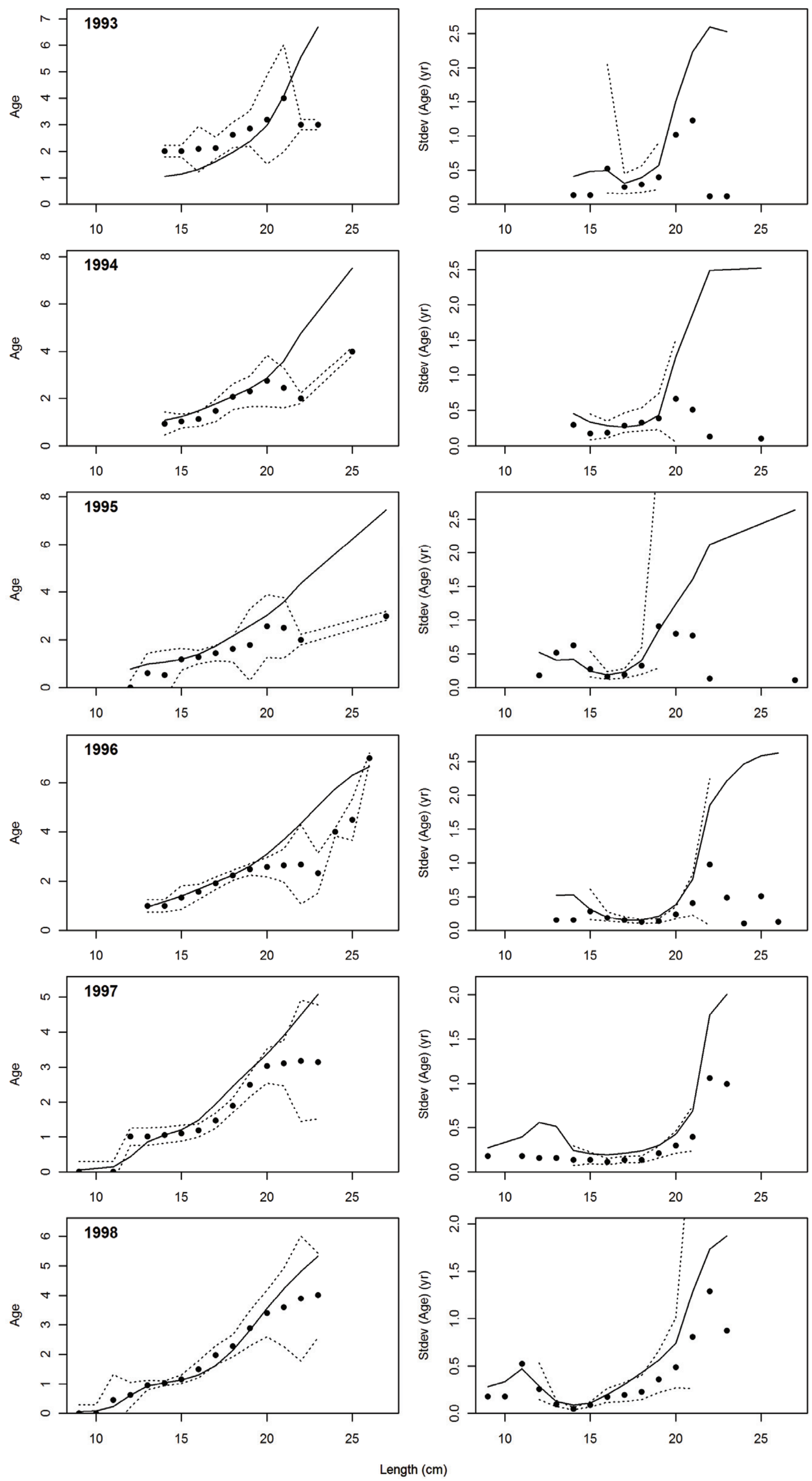

Figure 21. Model X6e fit to conditional age-at-length data, MexCal_S1, 1993-1998.

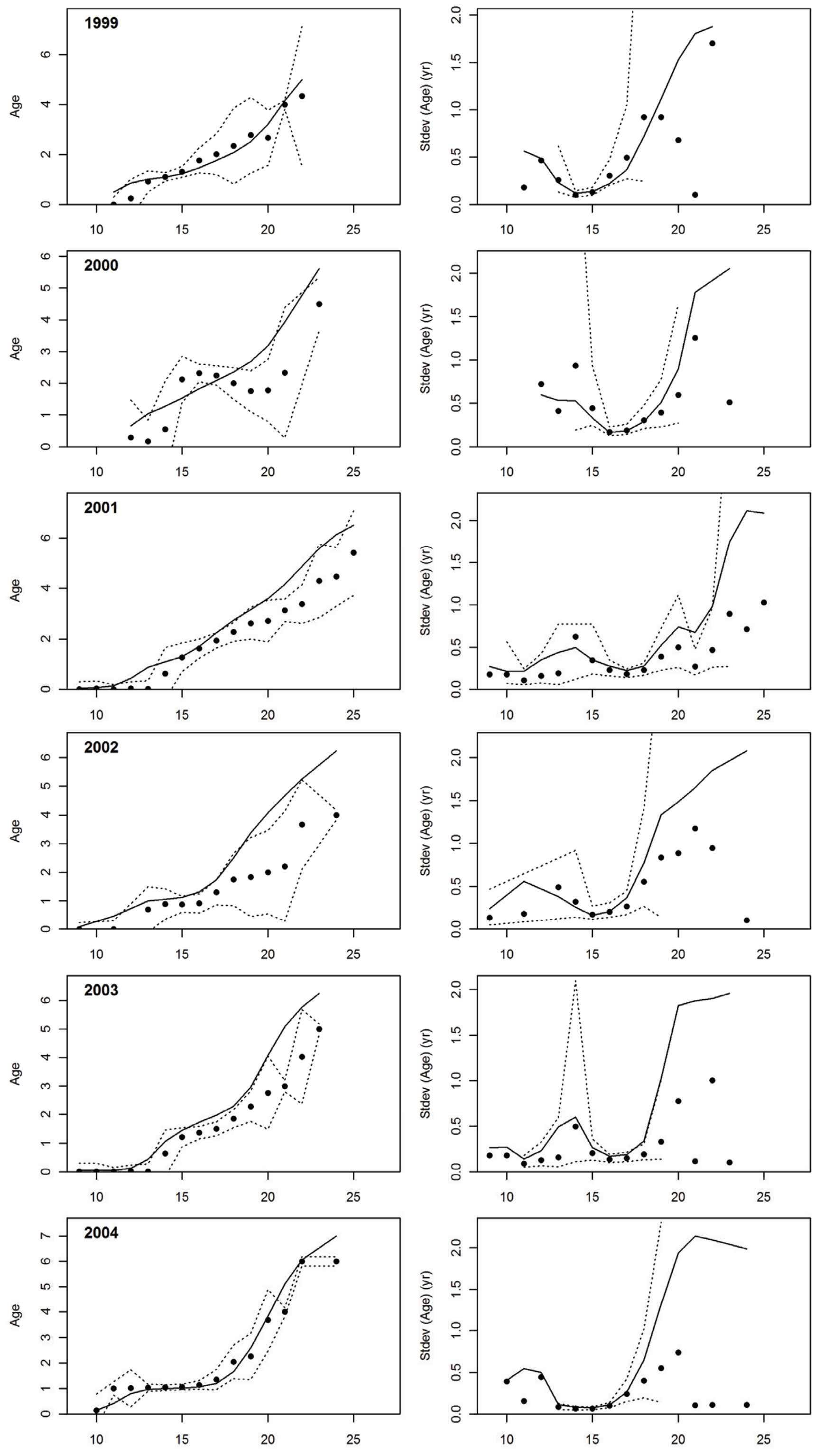

Figure 21 (cont'd). Model X6e fit to conditional age-at-length data, MexCal_S1, 1999-2004.

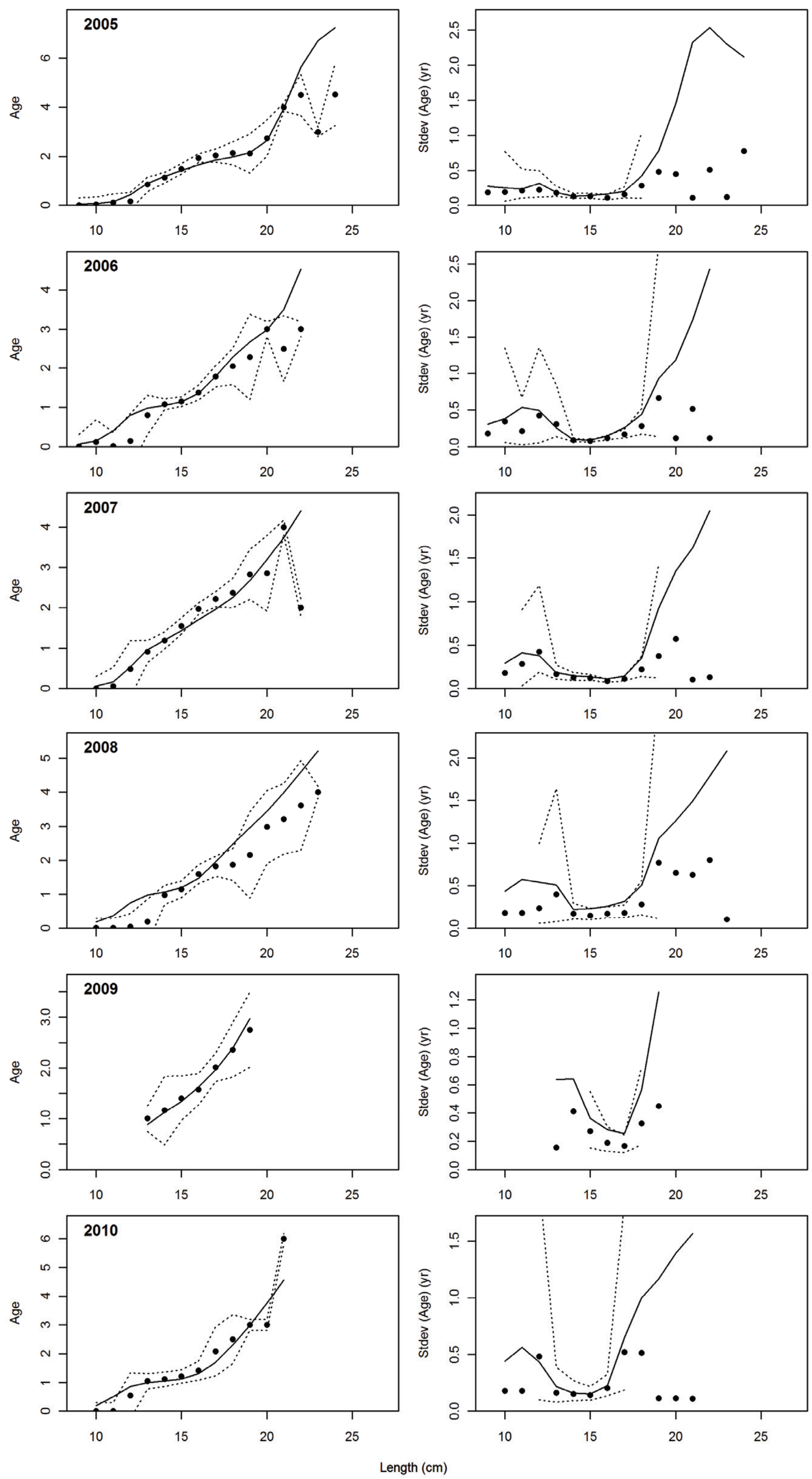

Figure 21 (cont'd). Model X6e fit to conditional age-at-length data, MexCal_S1, 2005-2010.

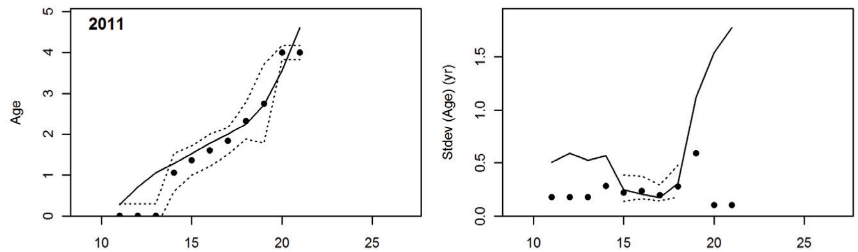

Figure 21 (cont'd). Model X6e fit to conditional age-at-length data, MexCal_S1, 2011.

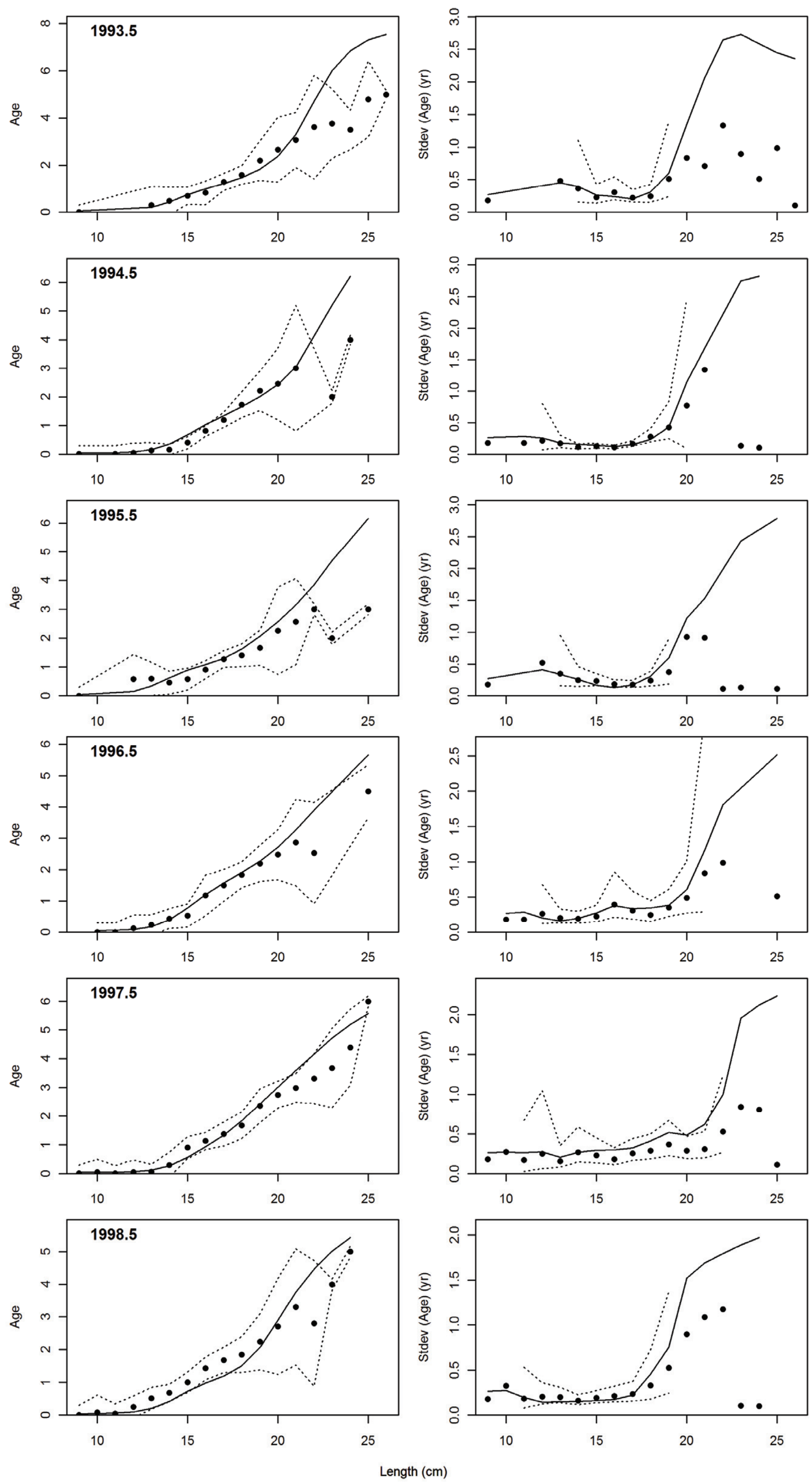

Figure 22. Model X6e fit to conditional age-at-length data, MexCal_S2, 1993-1998.

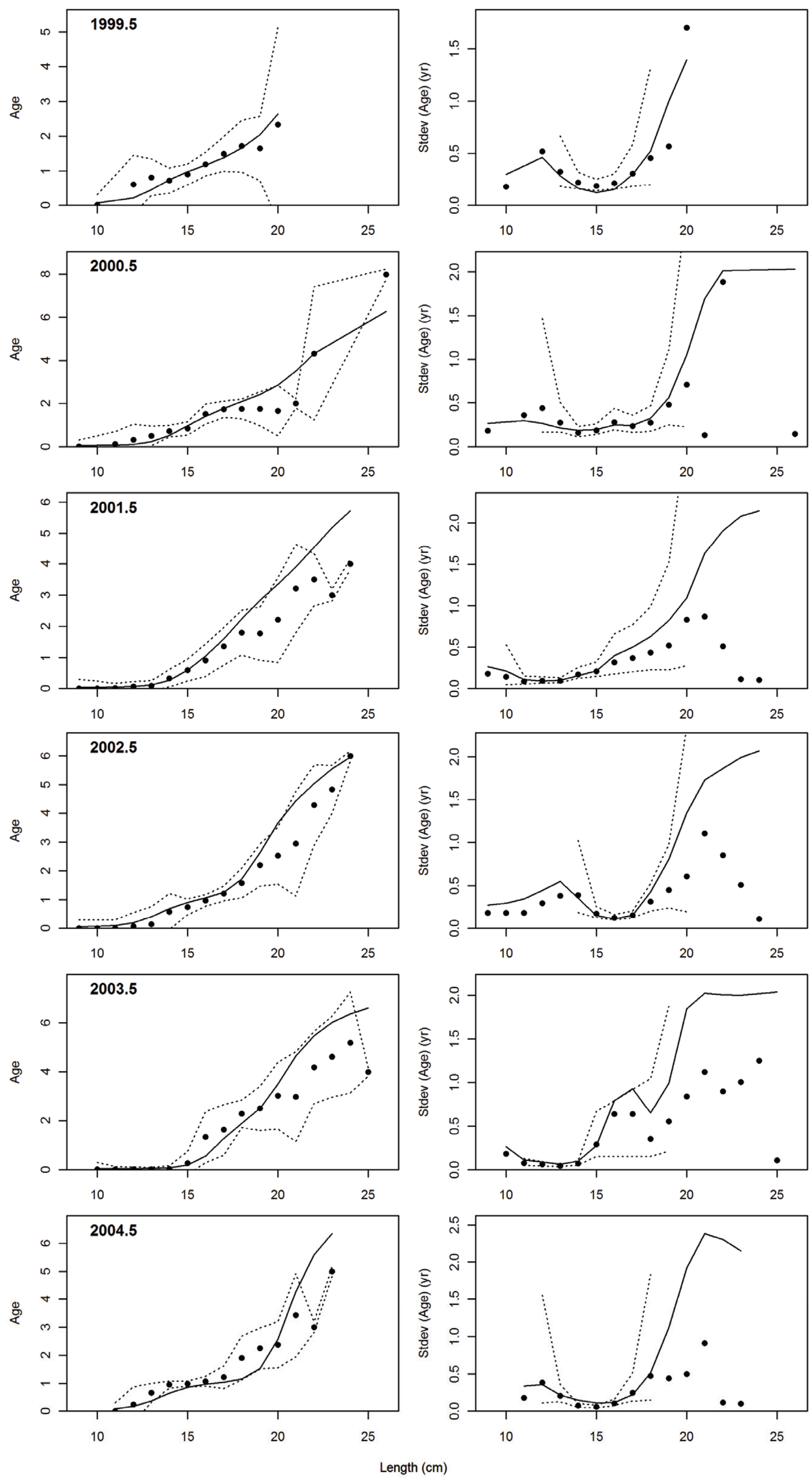

Figure 22 (cont'd). Model X6e fit to conditional age-at-length data, MexCal_S2, 1999-2004.

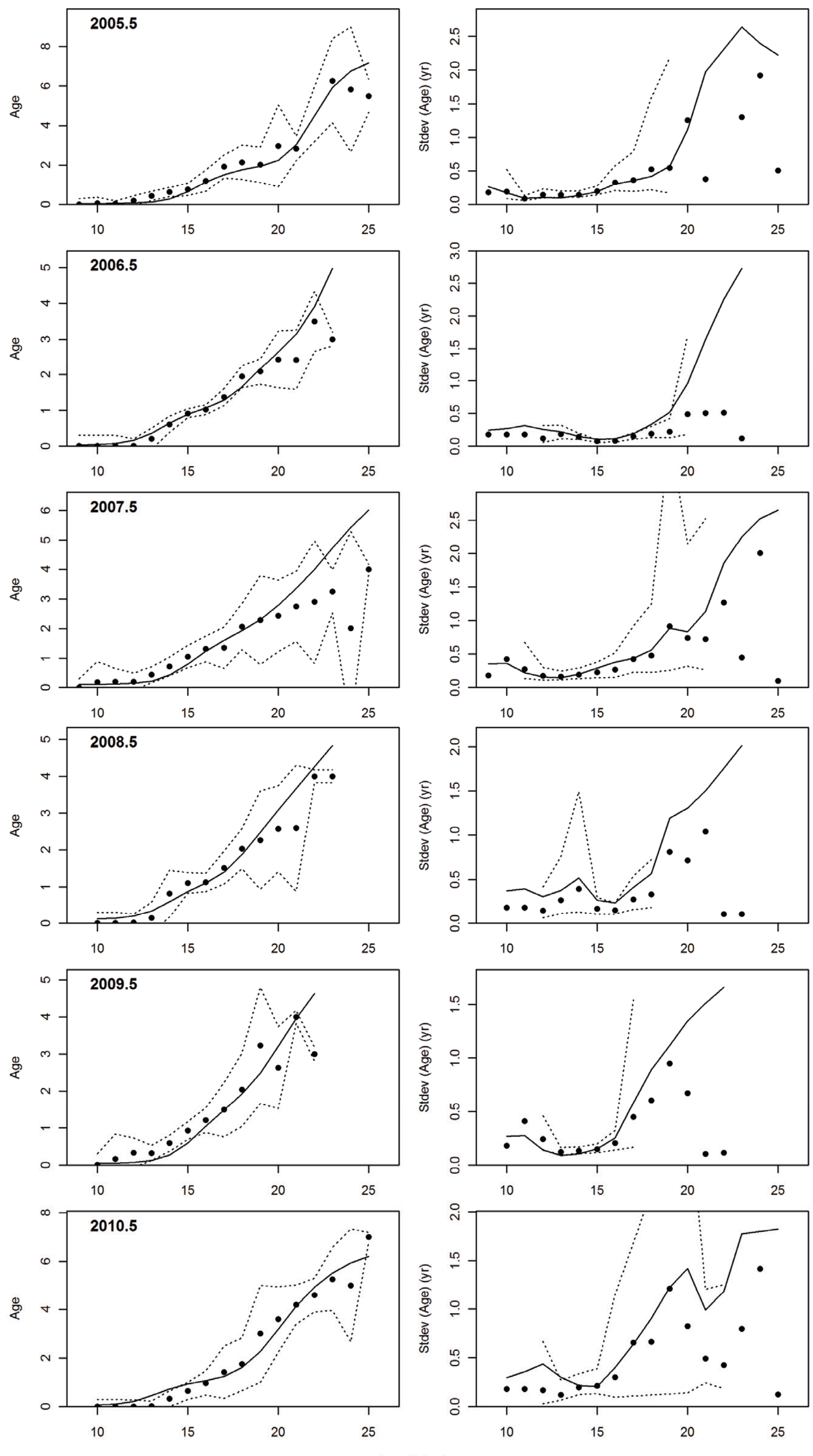

Figure 22 (cont'd). Model X6e fit to conditional age-at-length data, MexCal_S2, 2005-2010.

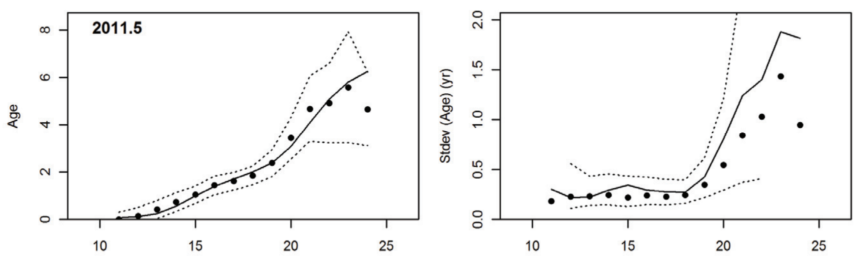

Figure 22 (cont'd). Model X6e fit to conditional age-at-length data, MexCal_S2, 2011.

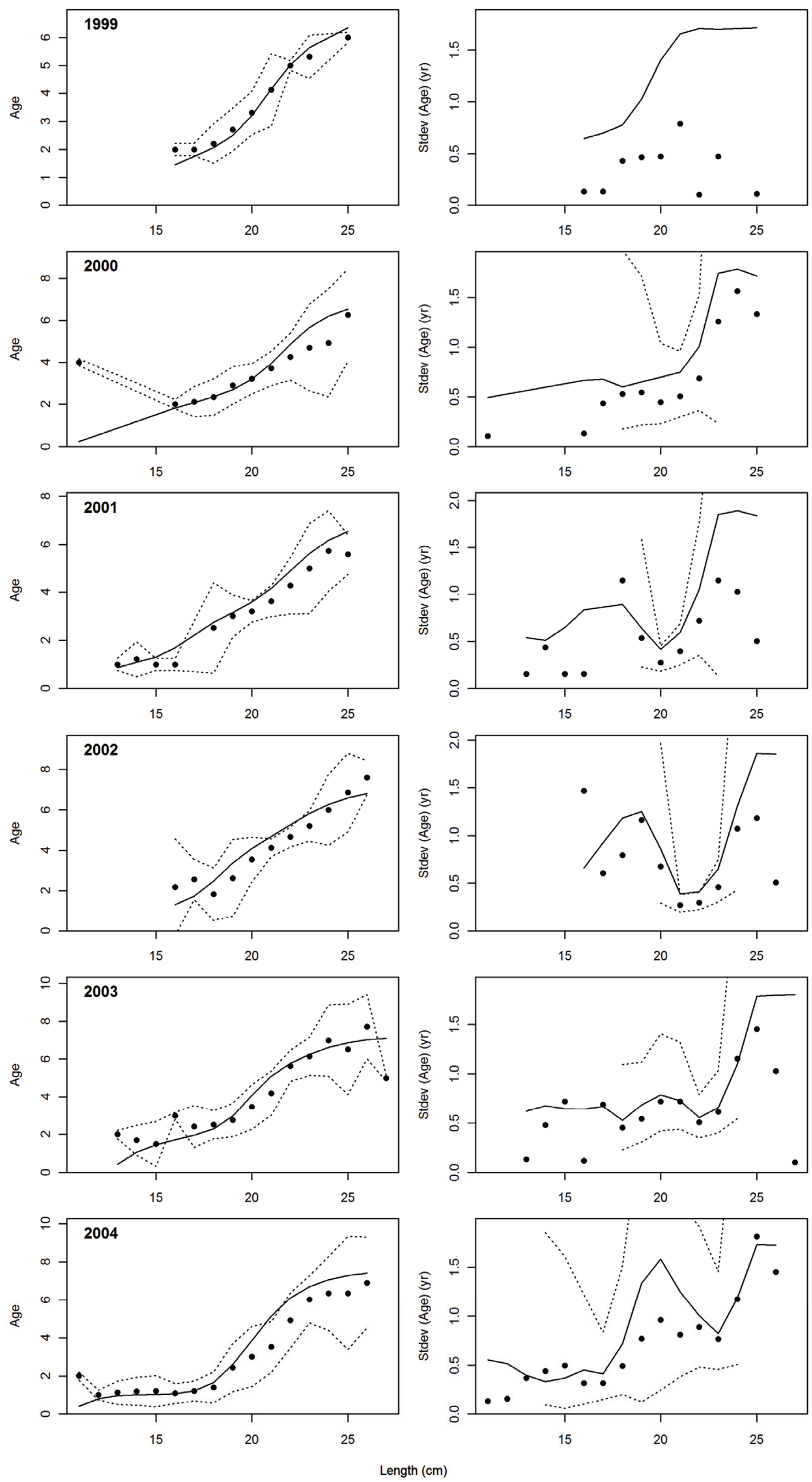

Figure 23. Model X6e fit to conditional age-at-length data, PacNW, 1999-2004.

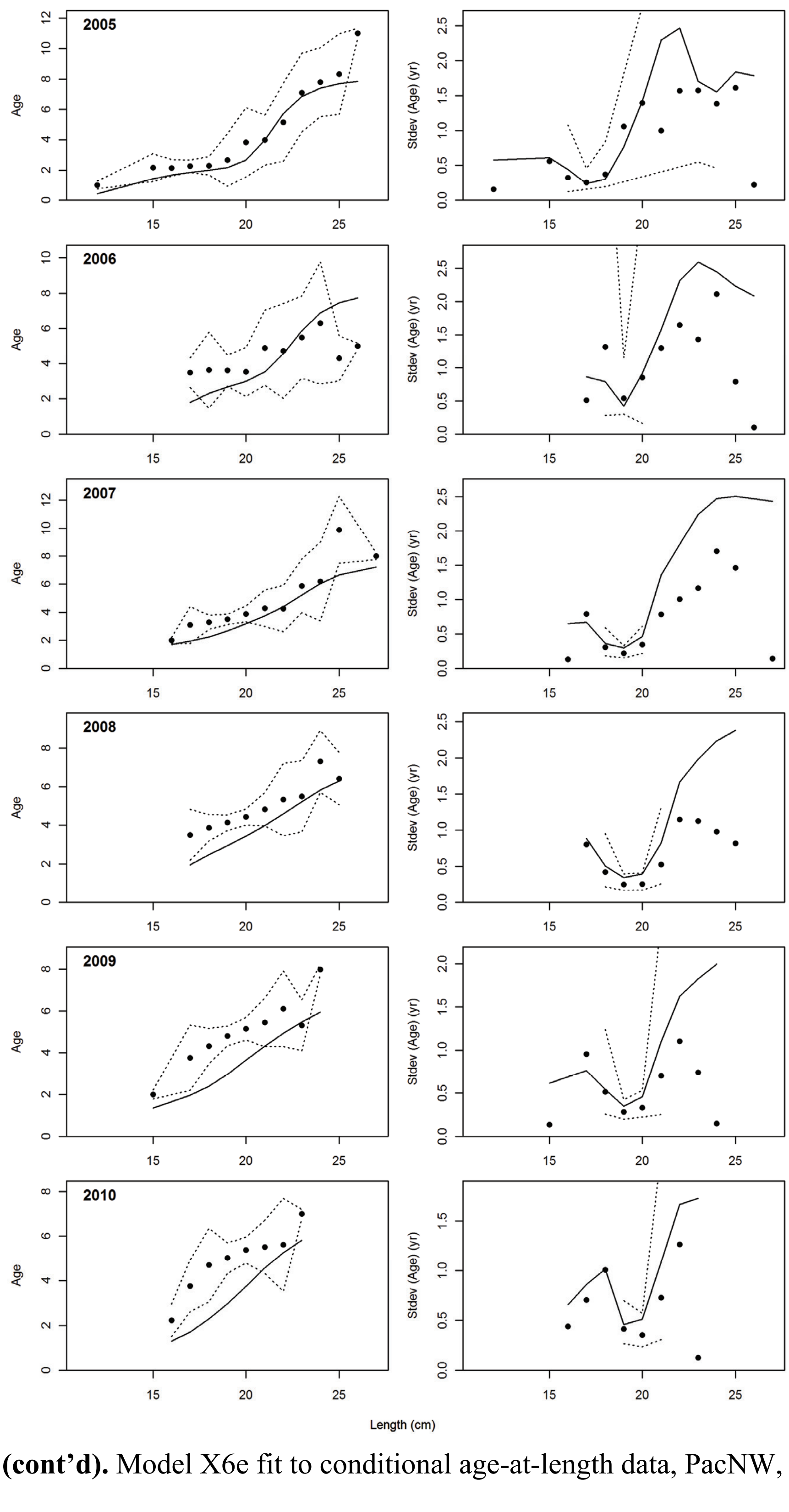

Figure 23 (cont'd). Model X6e fit to conditional age-at-length data, PacNW, 2005-2010.

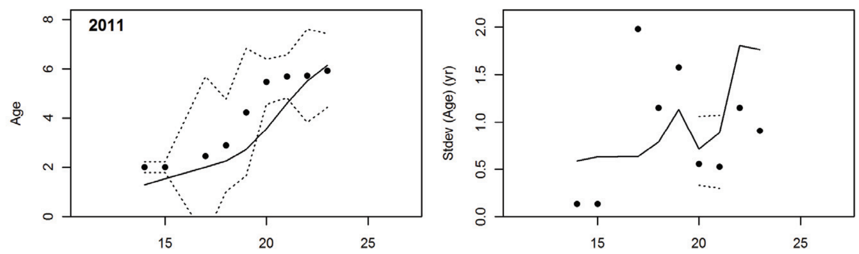

Figure 23 (cont'd). Model X6e fit to conditional age-at-length data, PacNW, 2011.

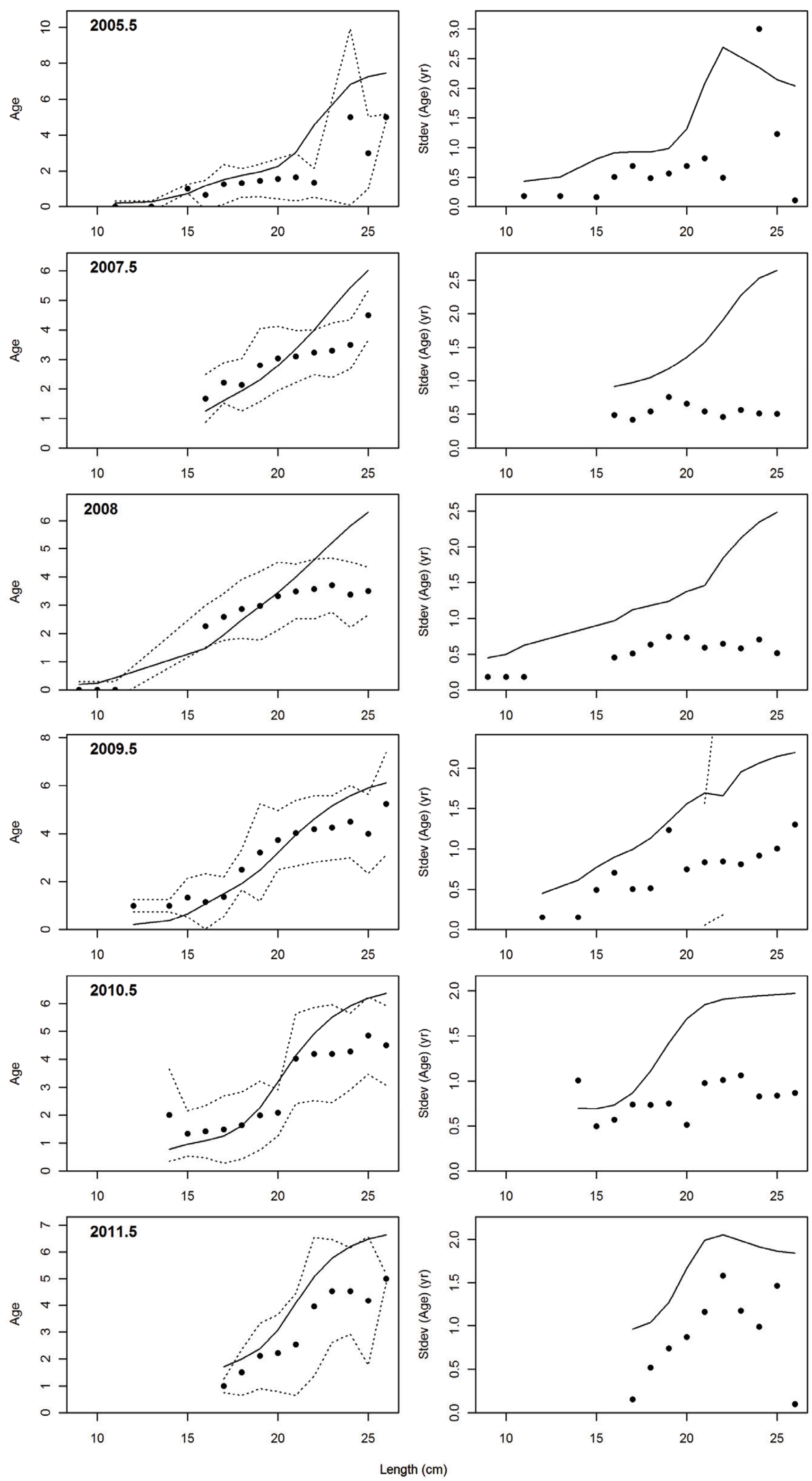

Figure 24. Model X6e fit to conditional age-at-length data, Acoustic survey, 2005-2011.

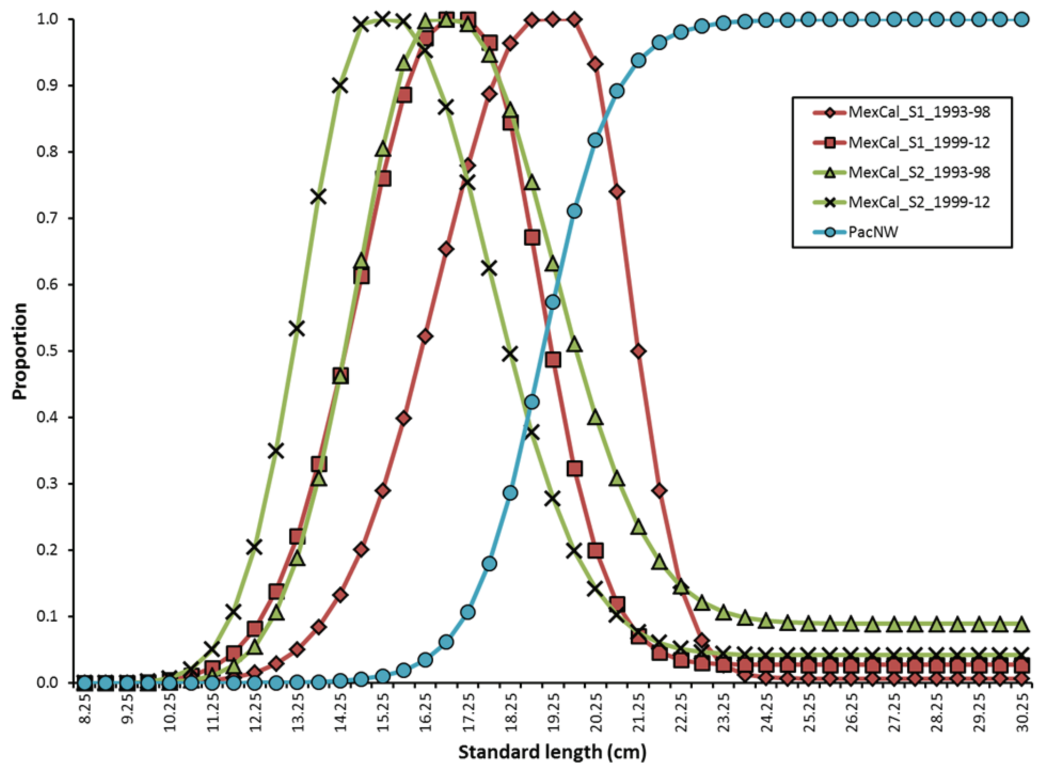

Figure 25a. Fishery length selectivities estimated in model X6e.

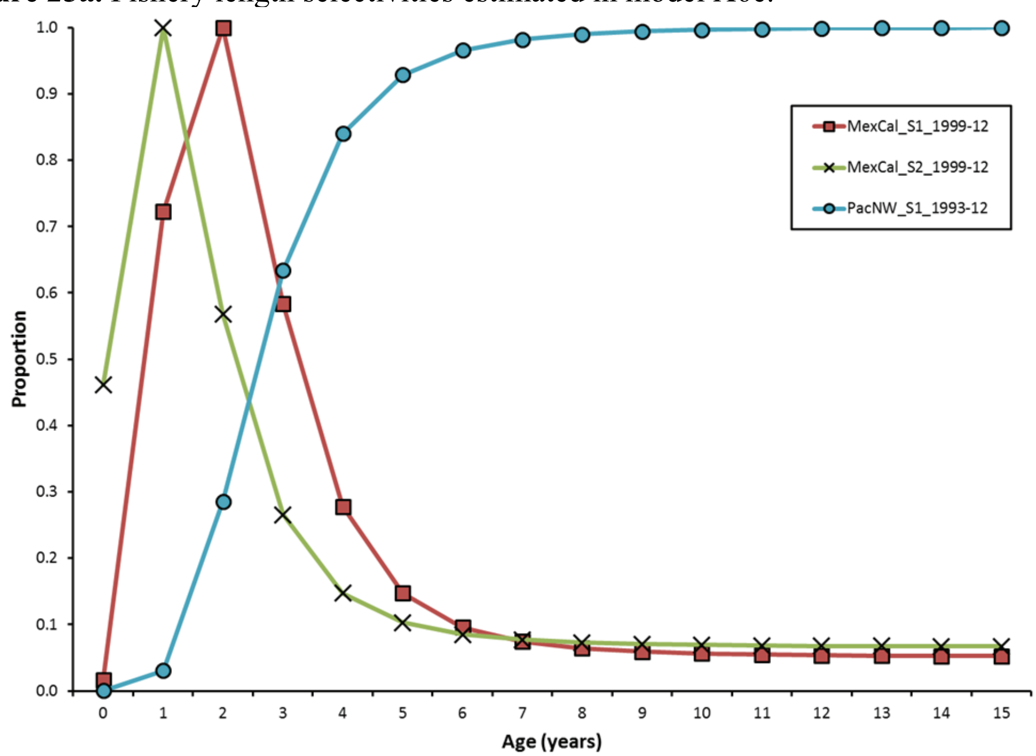

Figure 25b. Terminal period fishery age selectivities implied by the product of length selectivity and the ALK.

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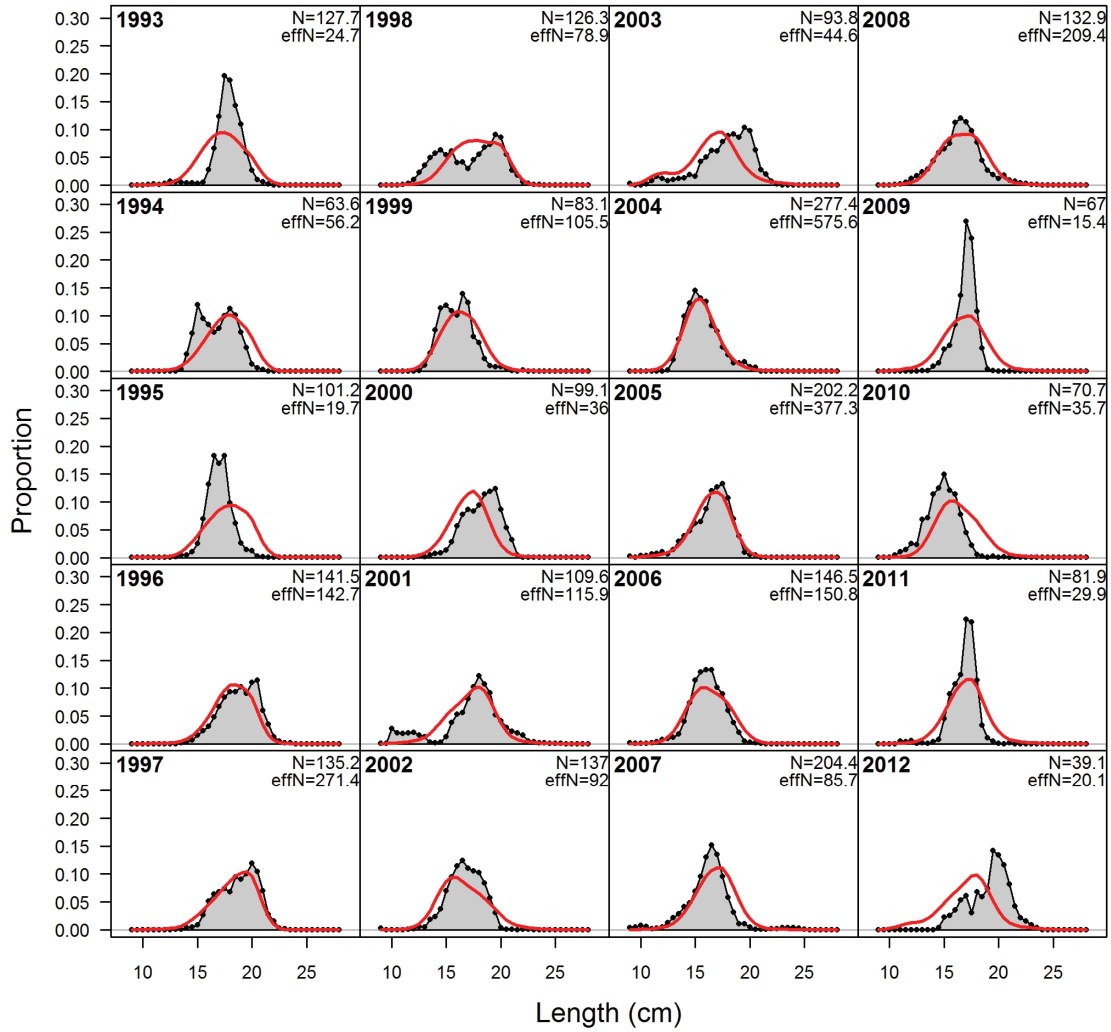

Figure 26a. Model X6e fits to MexCal_S1 length-frequency data (Season 1).

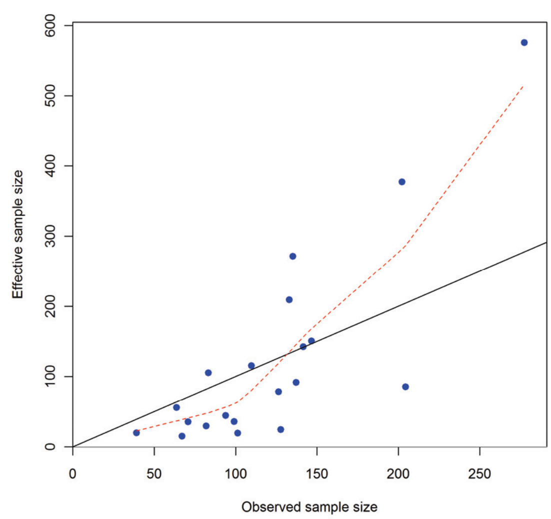

Figure 26b. Observed and effective sample sizes for MexCal_S1 length-frequencies.

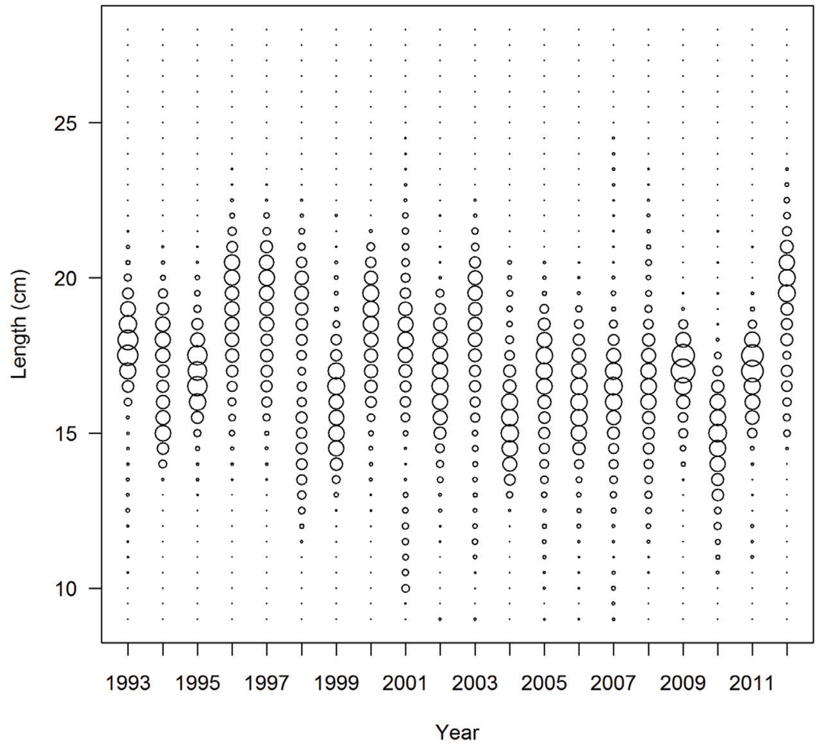

Figure 26c. Bubble plot of MexCal_S1 length-frequency data (Season 1).

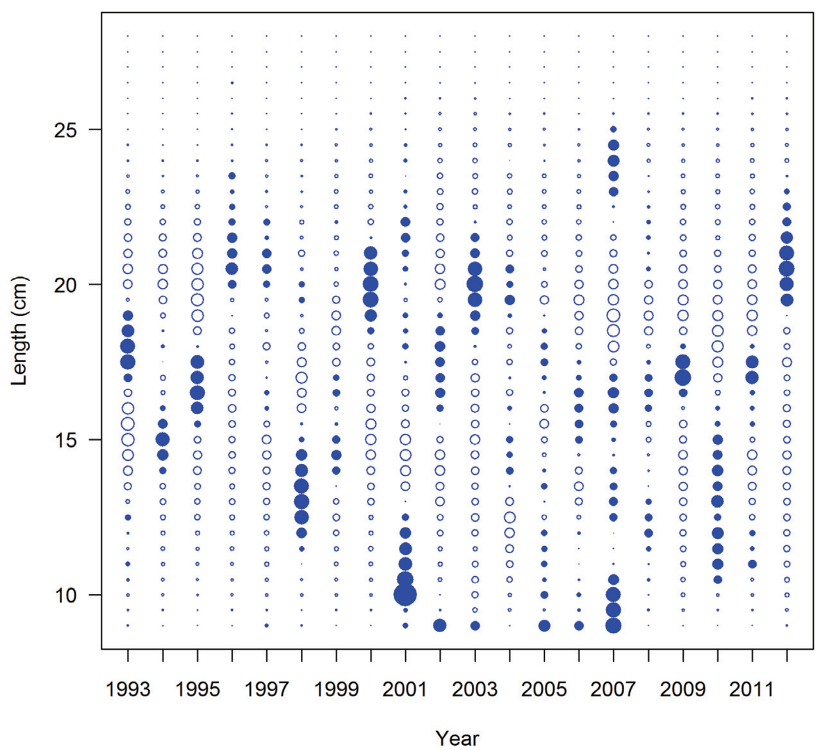

Figure 26d. Pearson residuals (max=9.01) for model X6b fit to MexCal_S1 length-frequencies.

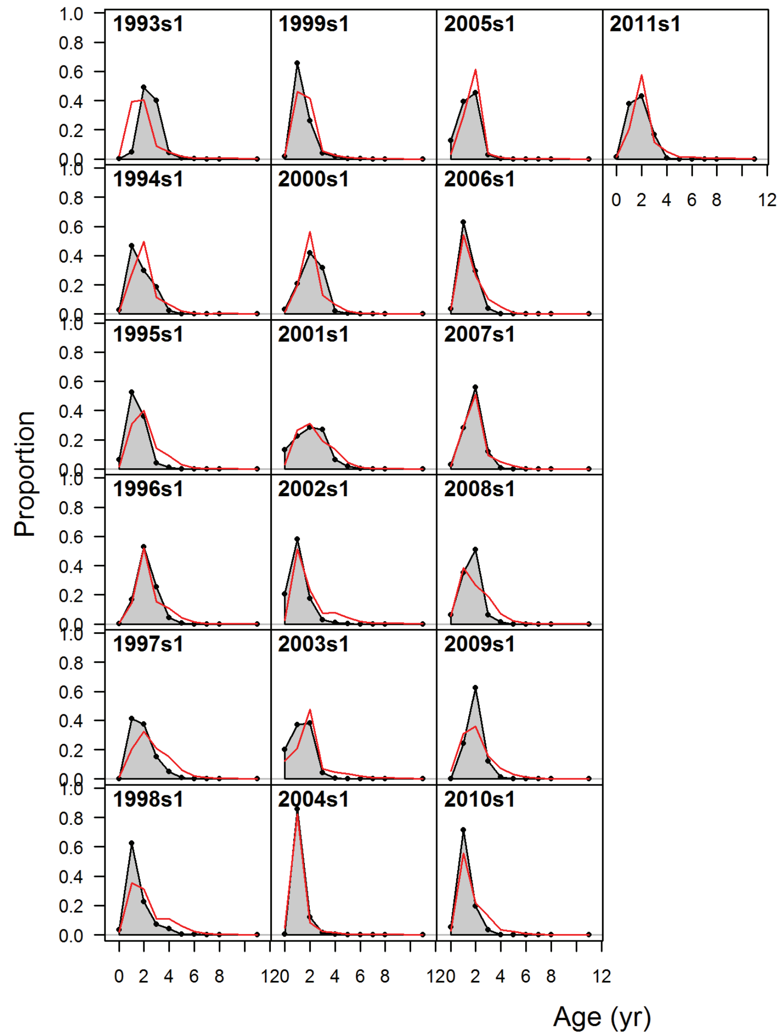

Figure 27a. Model X6e fits to MexCal_S1 implied age-frequency data (Season 1).

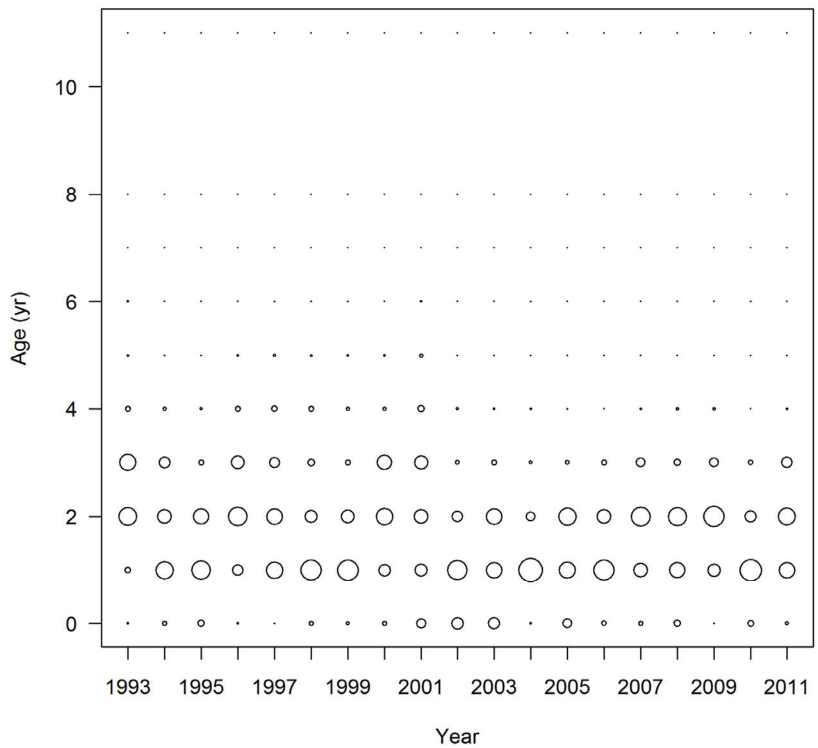

Figure 27b. Bubble plot of MexCal_S1 implied age-frequency data (Season 1).

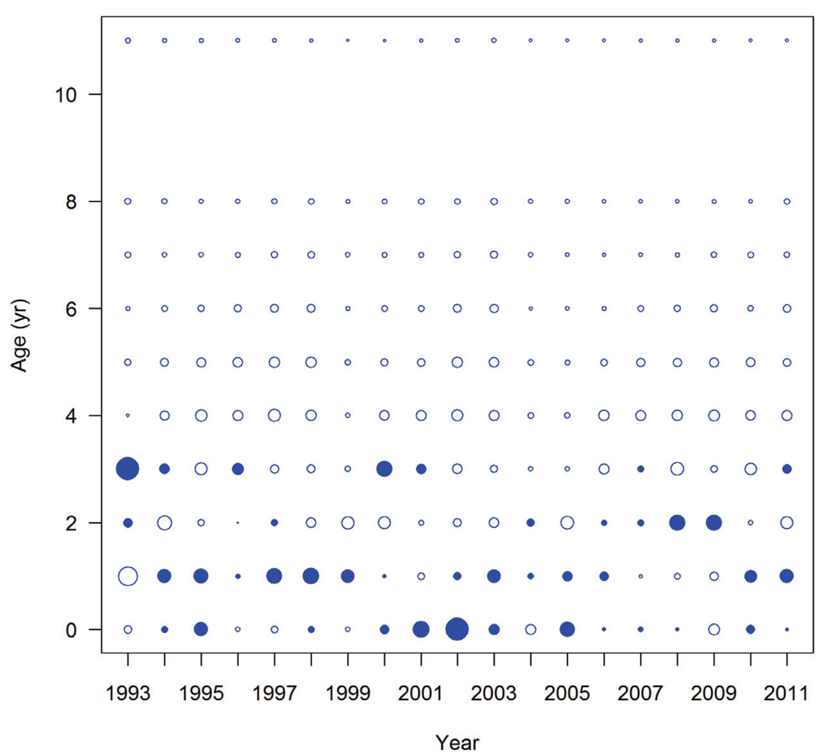

Figure 27c. Pearson residuals (max=1.12) for model X6e fit to MexCal_S1 implied age-frequencies.

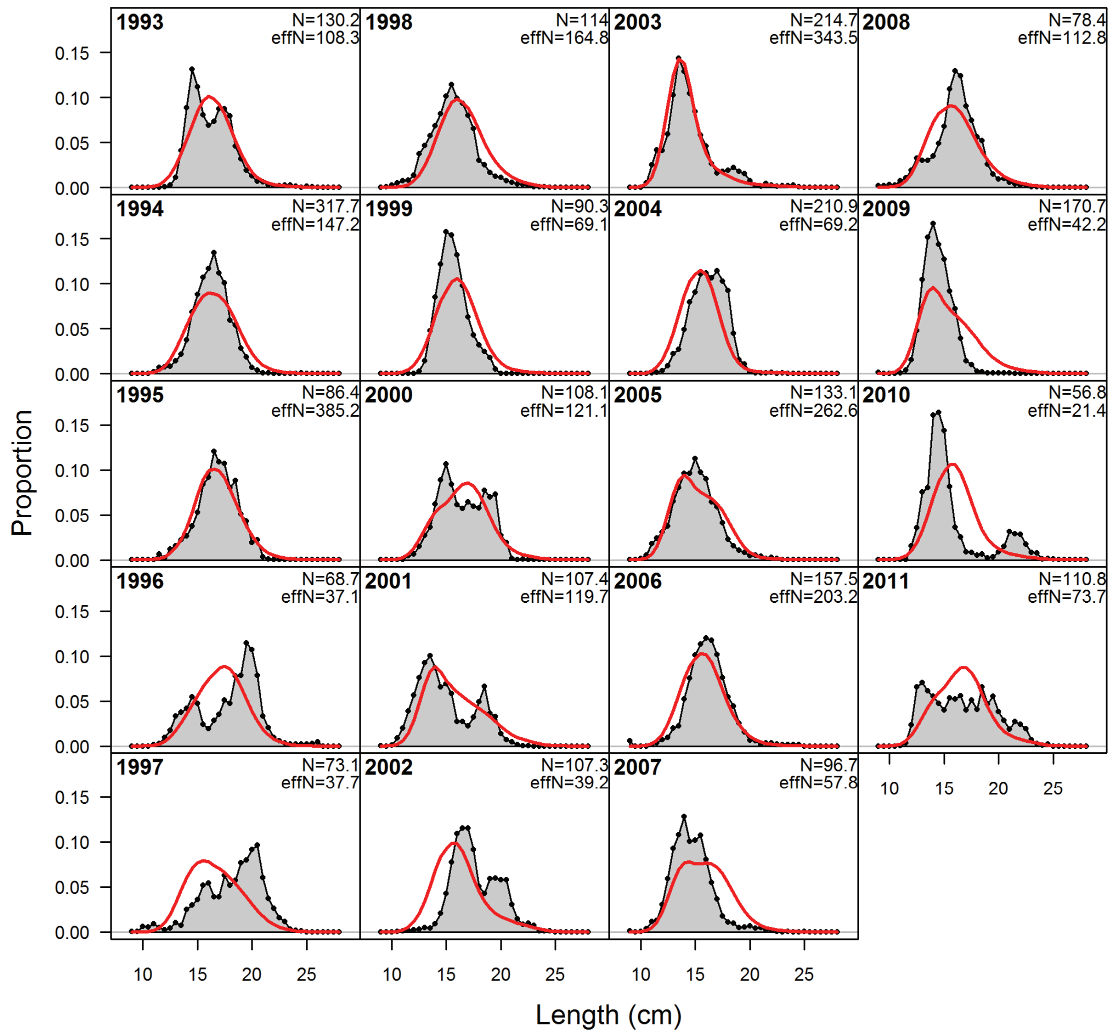

Figure 28a. Model X6e fits to MexCal_S2 length-frequency data (Season 2).

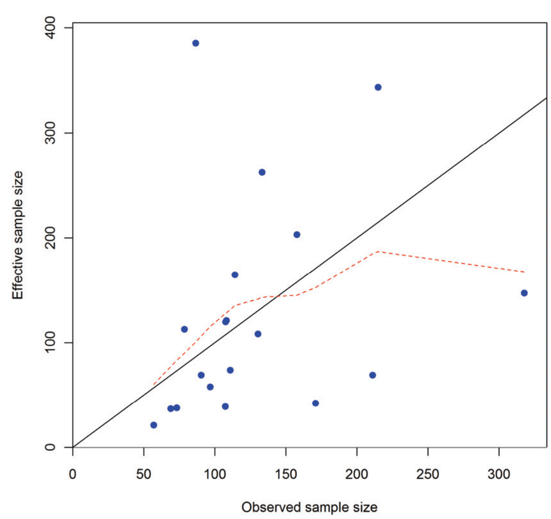

Figure 28b. Observed and effective sample sizes for MexCal_S2 fishery length-frequencies (X6e).

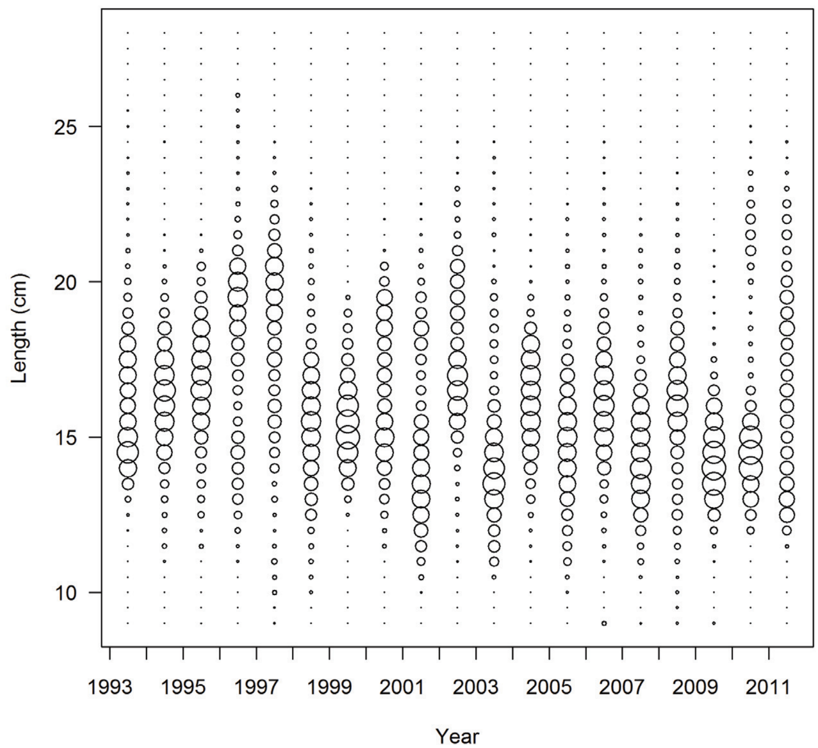

Figure 28c. Bubble plot of MexCal_S2 length-frequency data (Season 2).

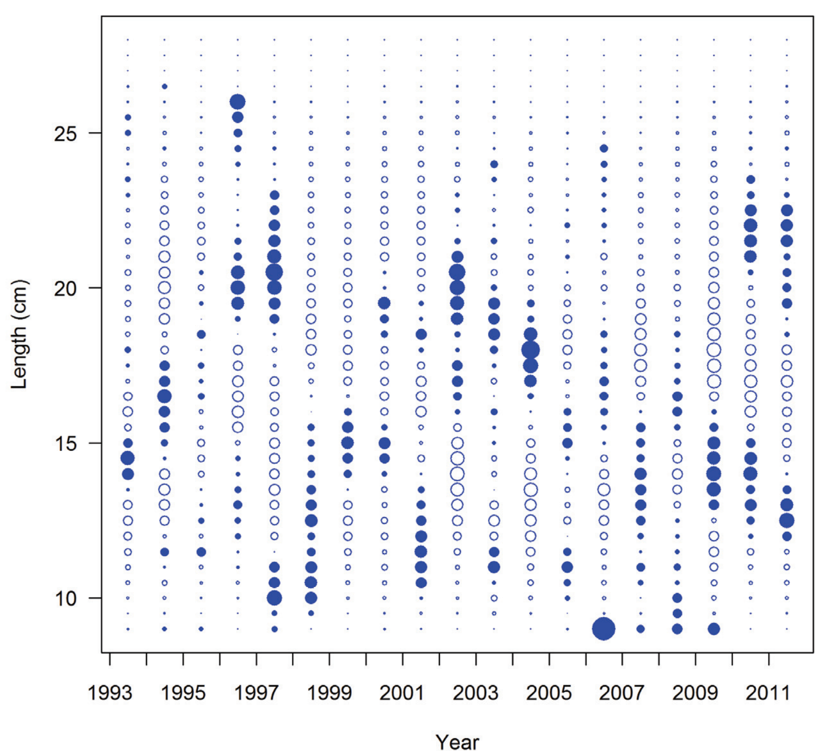

Figure 28d. Pearson residuals (max=7.28) for fit to MexCal_S2 length-frequency data.

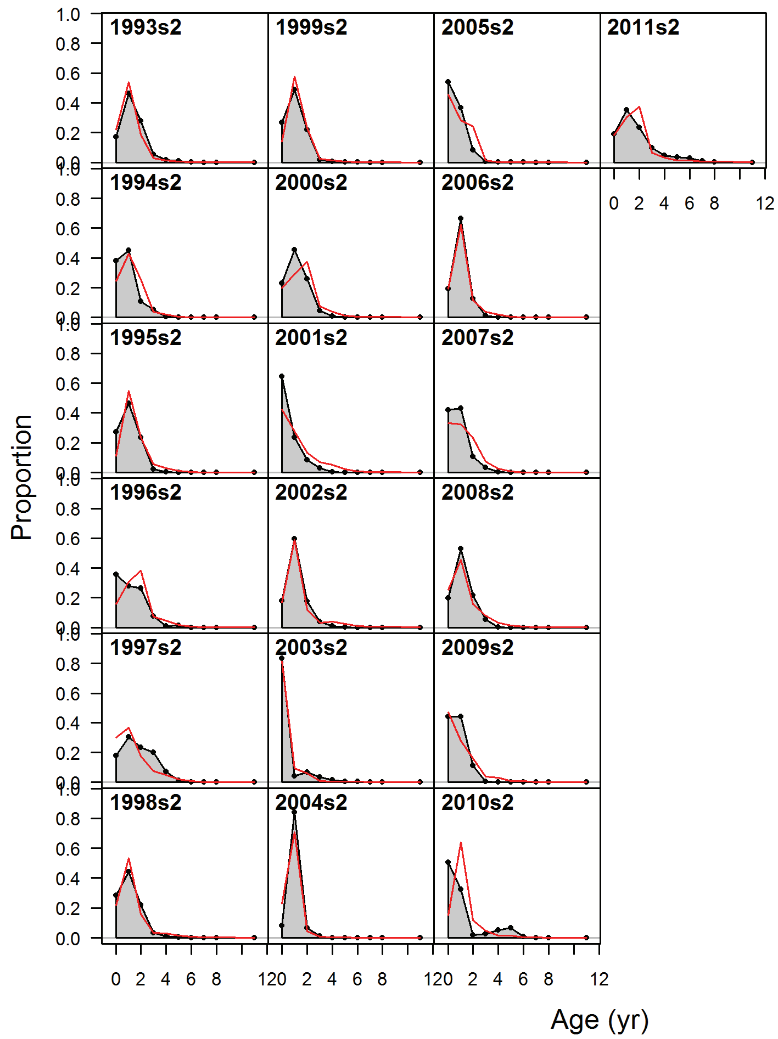

Figure 29a. Model X6e fits to MexCal_S2 implied age-frequency data (Season 2).

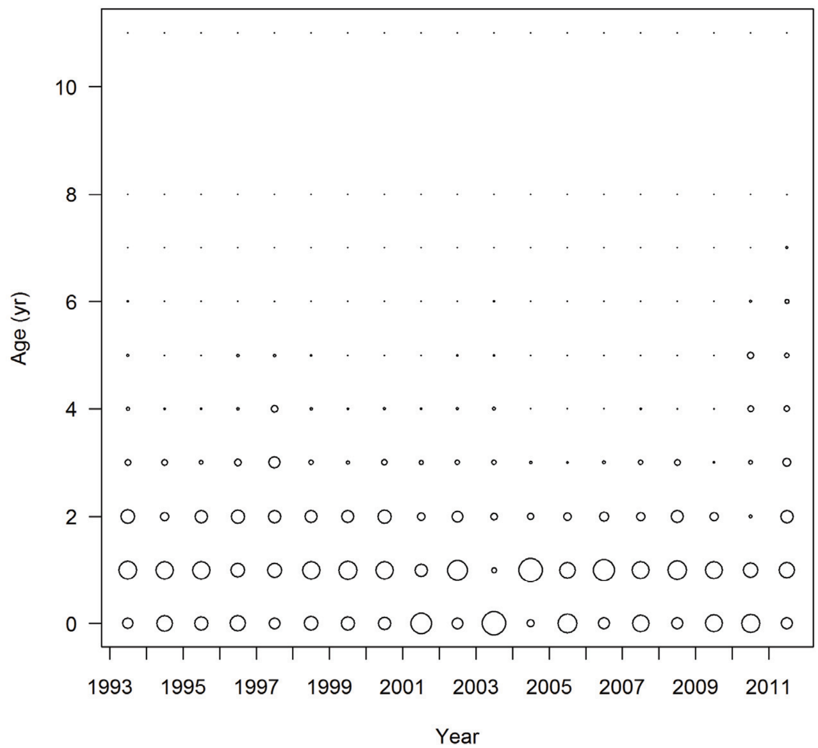

Figure 29b. Bubble plot of MexCal_S2 implied age-frequency data (Season 2).

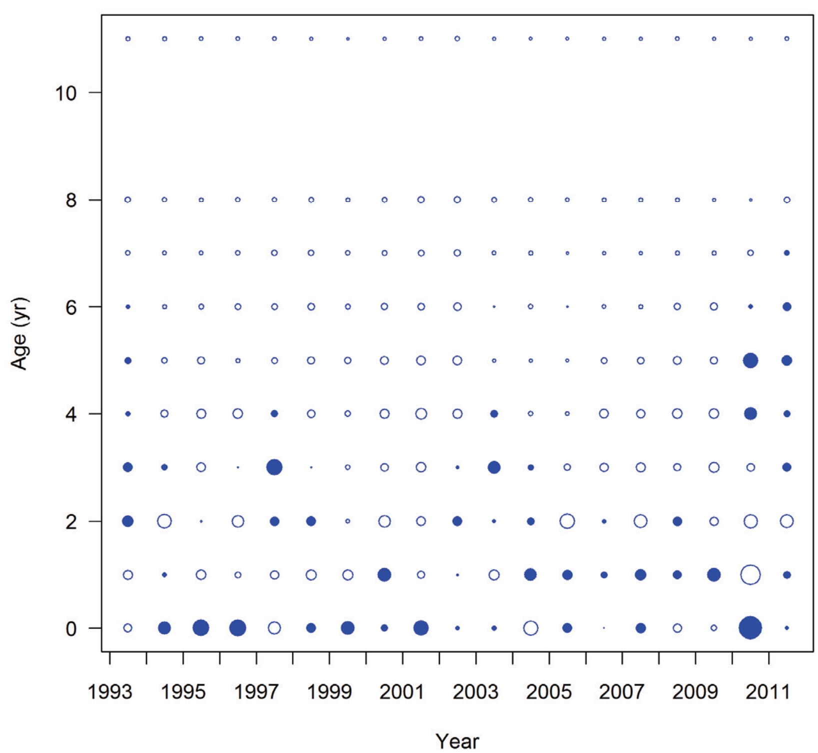

Figure 29c. Pearson residuals (max=0.99) for model X6e fit to MexCal_S2 implied age-frequency data.

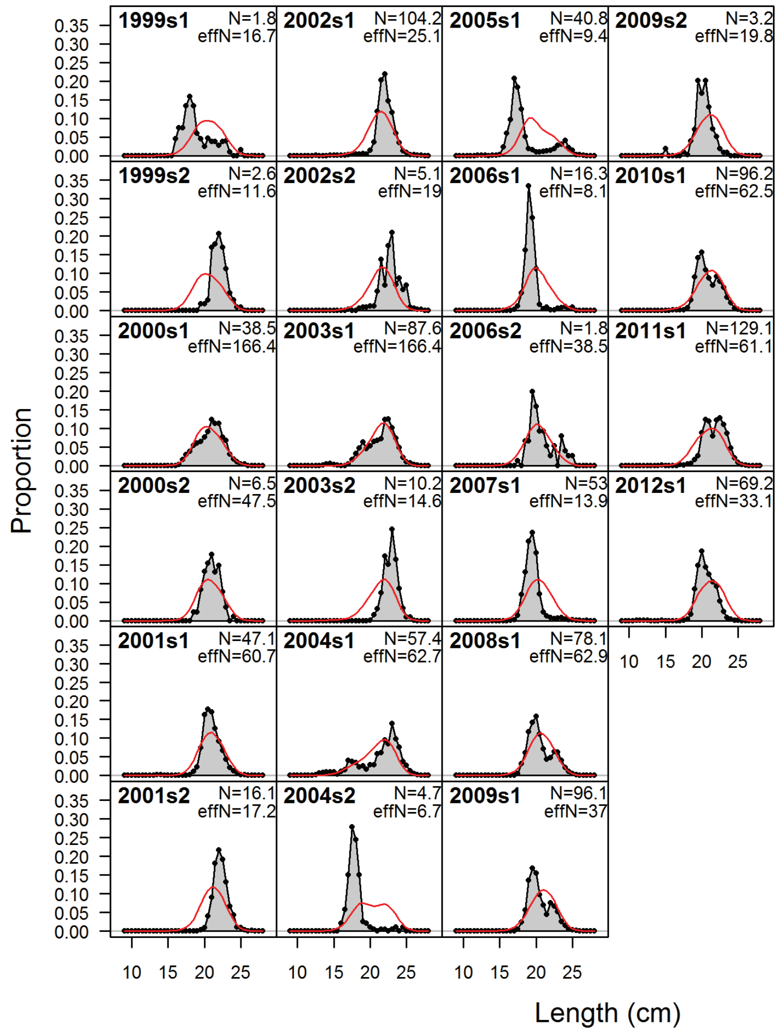

Figure 30a. Model X6e fits to PacNW length-frequency data.

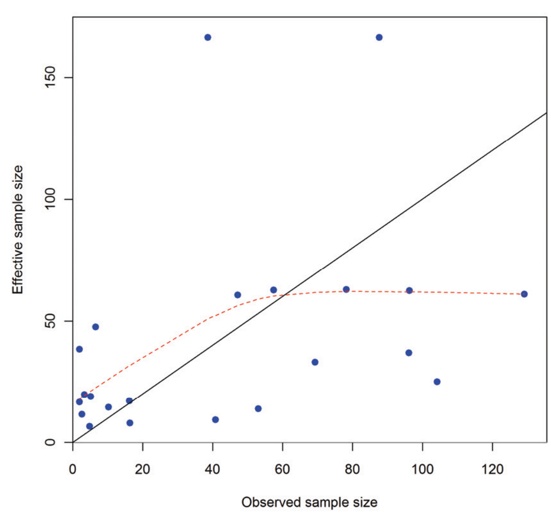

Figure 30b. Observed & effective sample sizes for PacNW fishery length-comps (X6e).

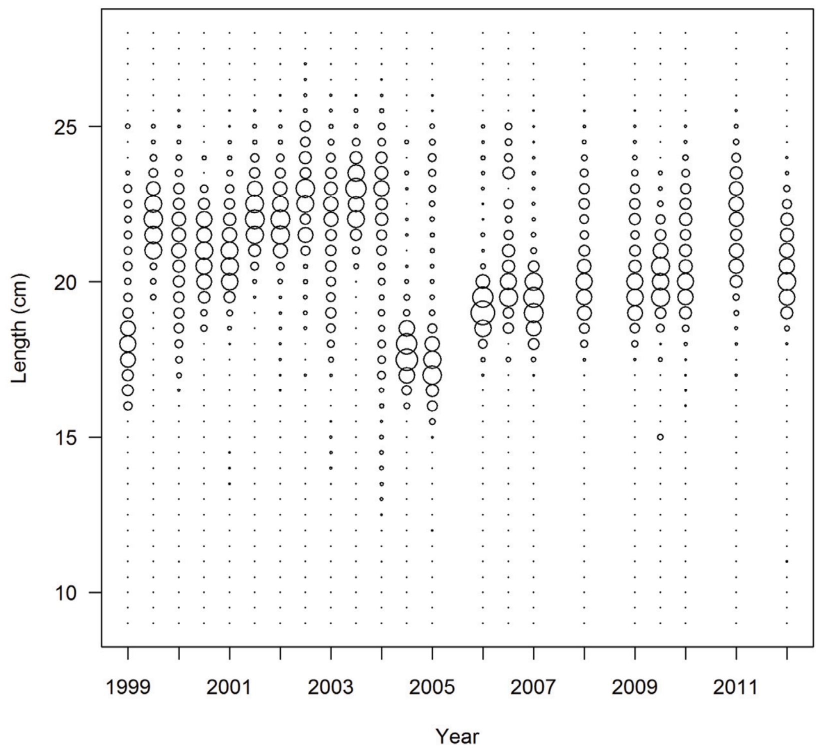

Figure 30c. Bubble plot of PacNW length-frequency data.

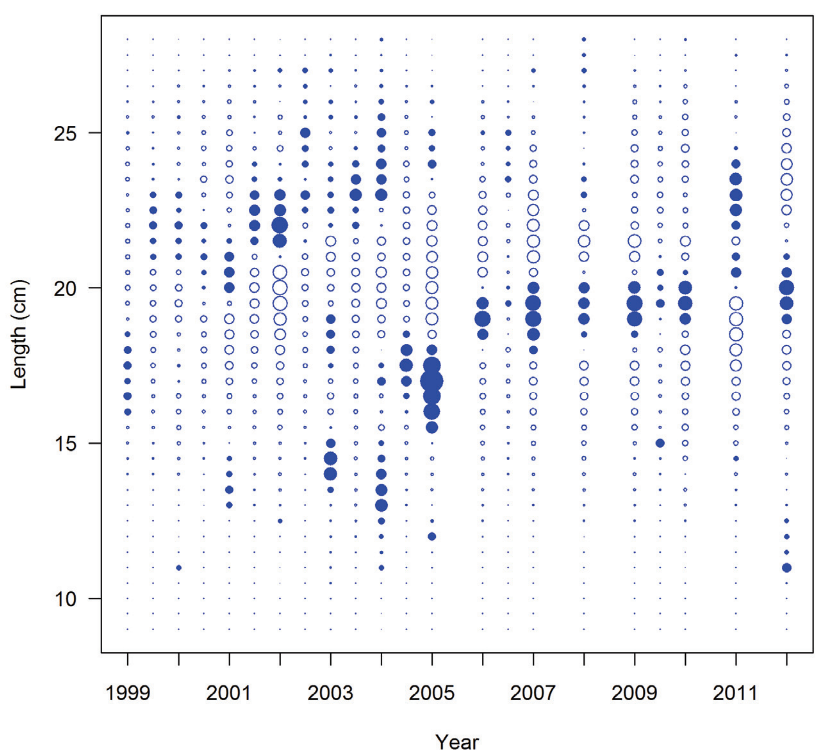

Figure 30d. Pearson residuals (max=6.78) for model X6b fit to PacNW length-frequency data.

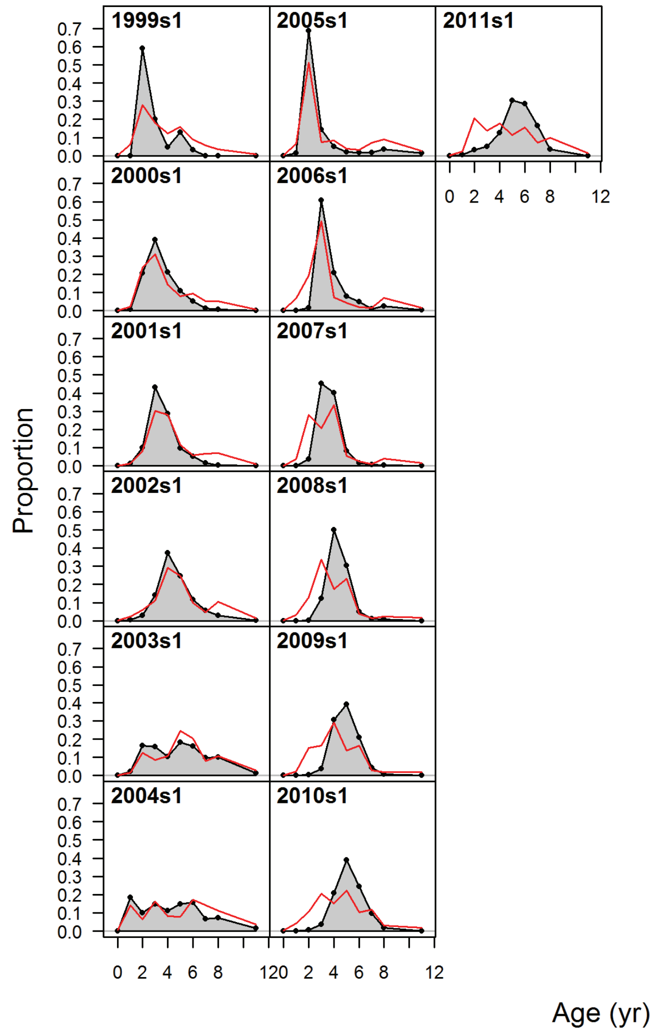

Figure 31a. Model X6e fits to implied age-frequency data for the PacNW fishery.

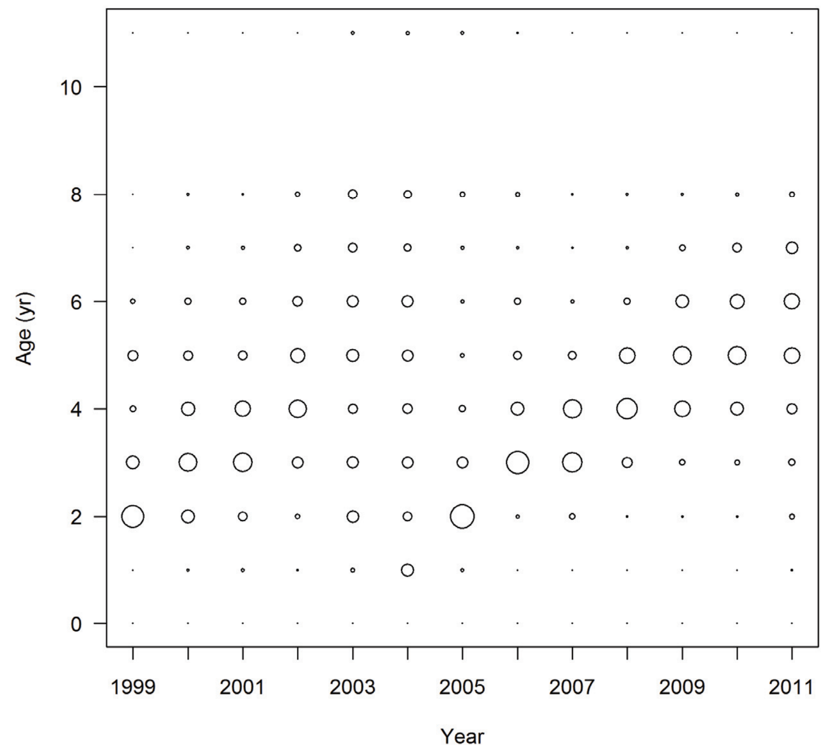

Figure 31b. Bubble plot of PacNW implied age-frequency data.

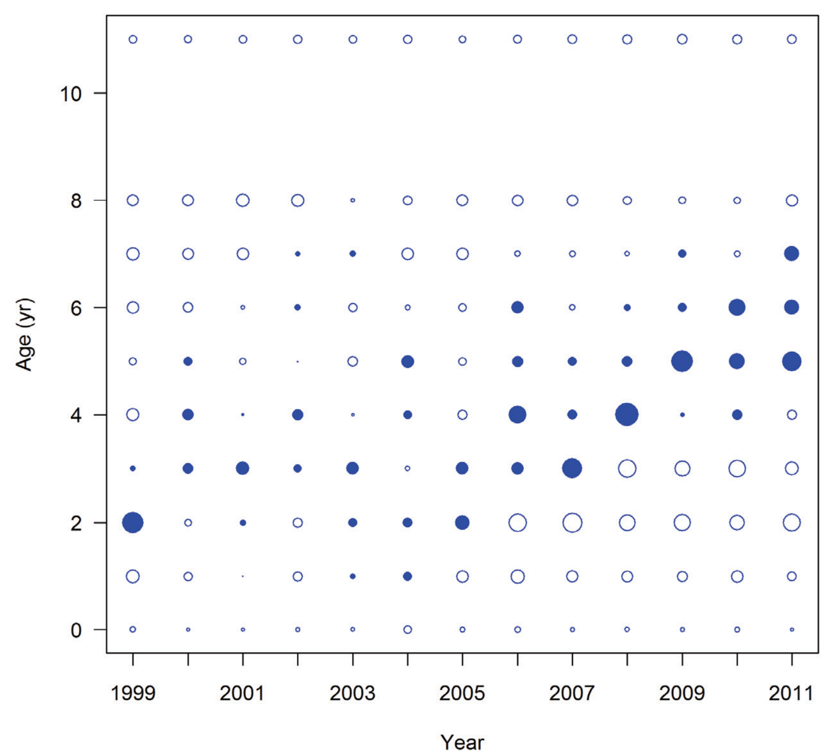

Figure 31c. Pearson residuals (max=0.86) for fit to PacNW implied age-frequency data.

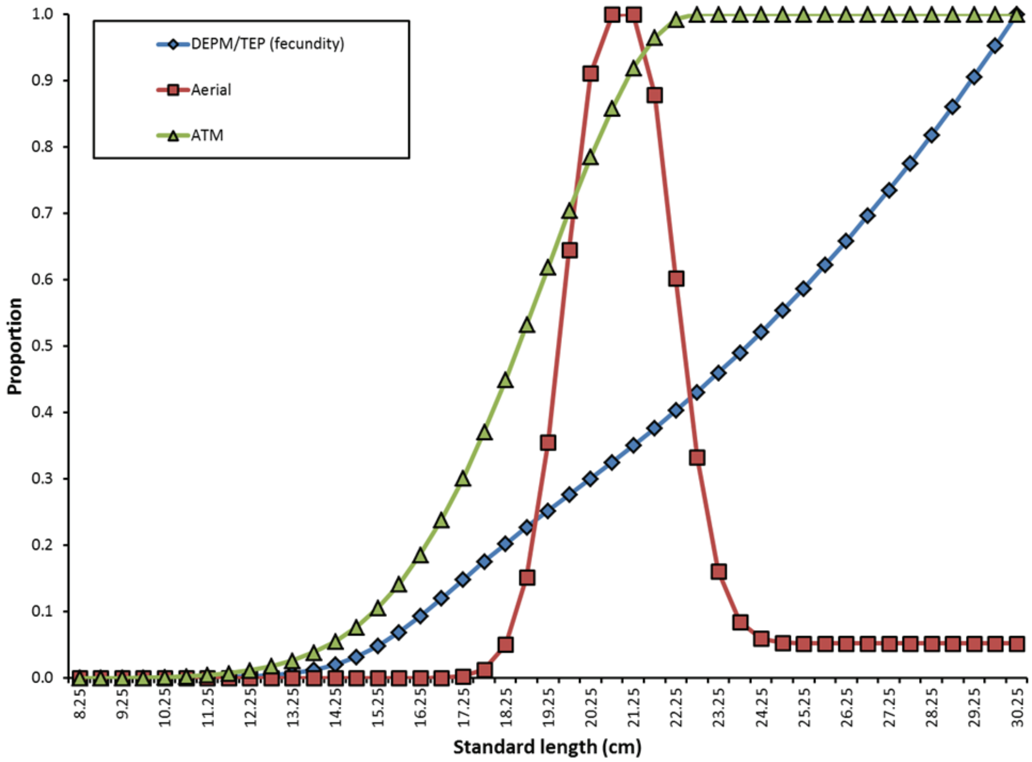

Figure 32a. Survey length selectivities estimated by model X6e.

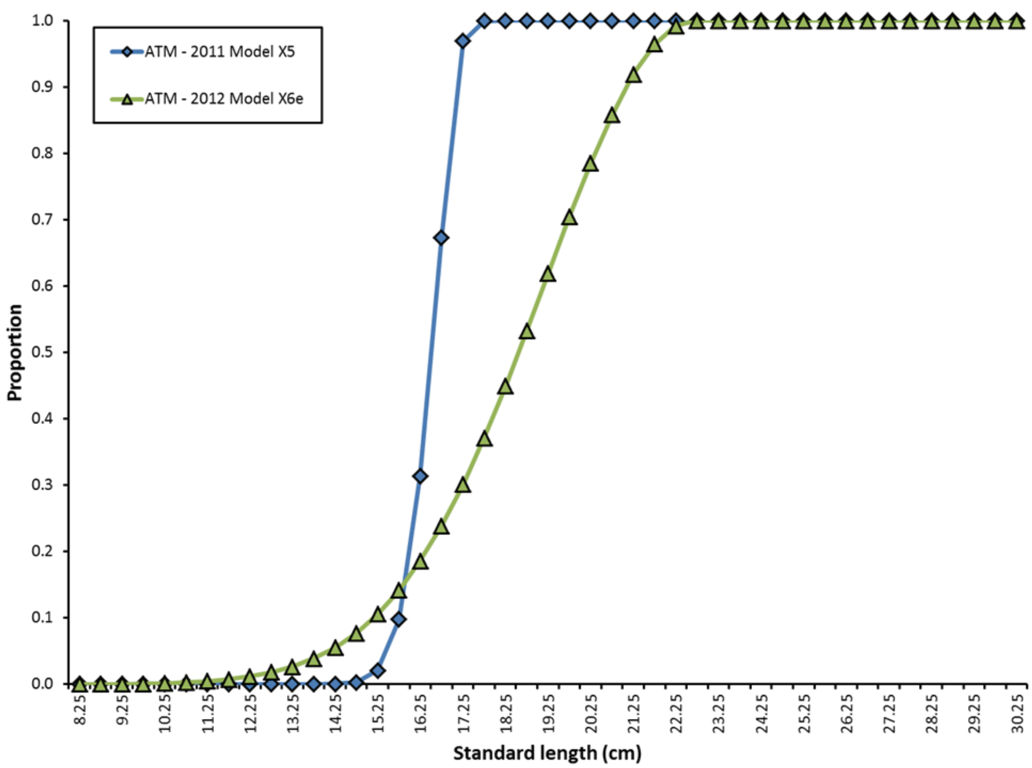

Figure 32b. ATM length selectivity estimated by 2011 model X5 and 2012 model X6e.

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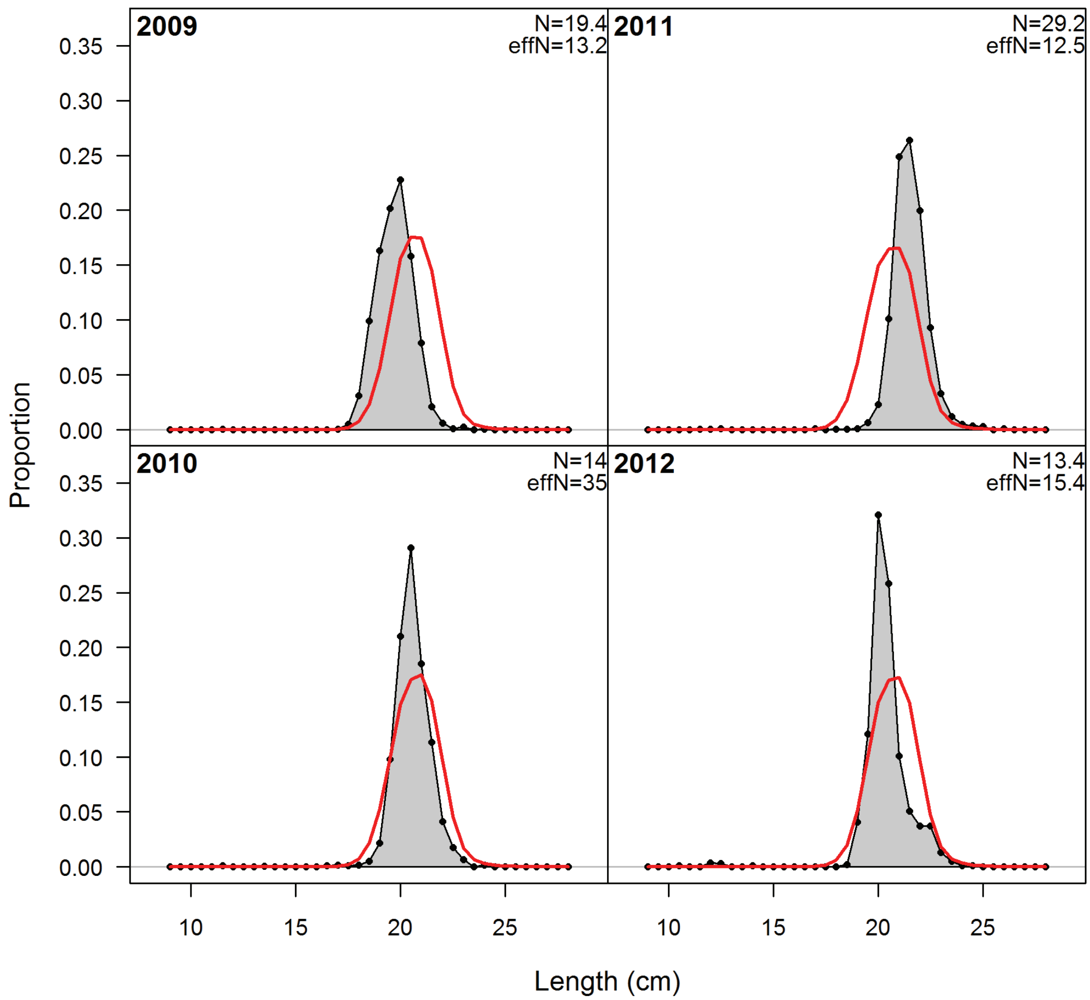


Figure 33a. Model X6e fits to Aerial survey length-frequency data.

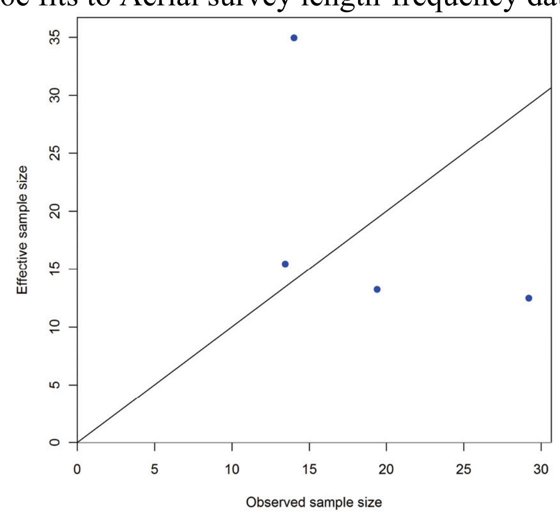


Figure 33b. Observed and effective sample sizes for Aerial survey fishery length-frequency data.

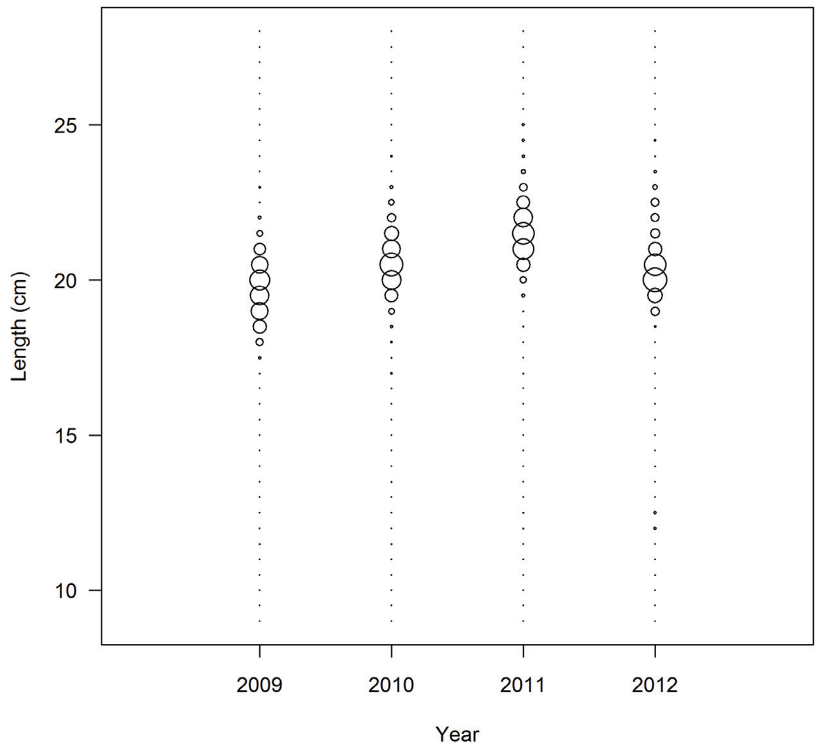


Figure 33c. Bubble plot of Aerial survey length-frequency data.

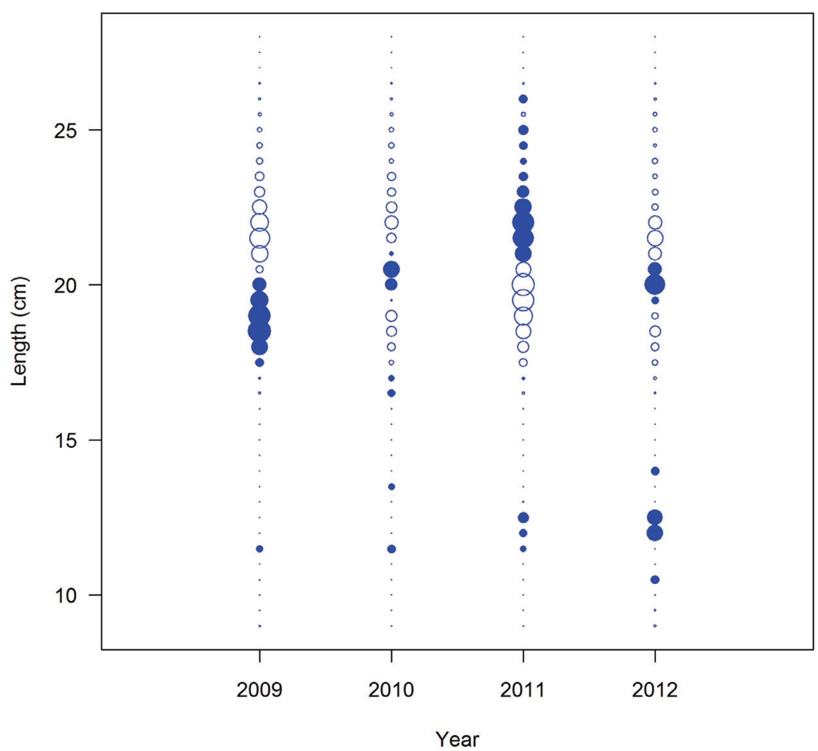


Figure 33d. Pearson residuals (max=2.25) for fit to Aerial survey length-frequency data.

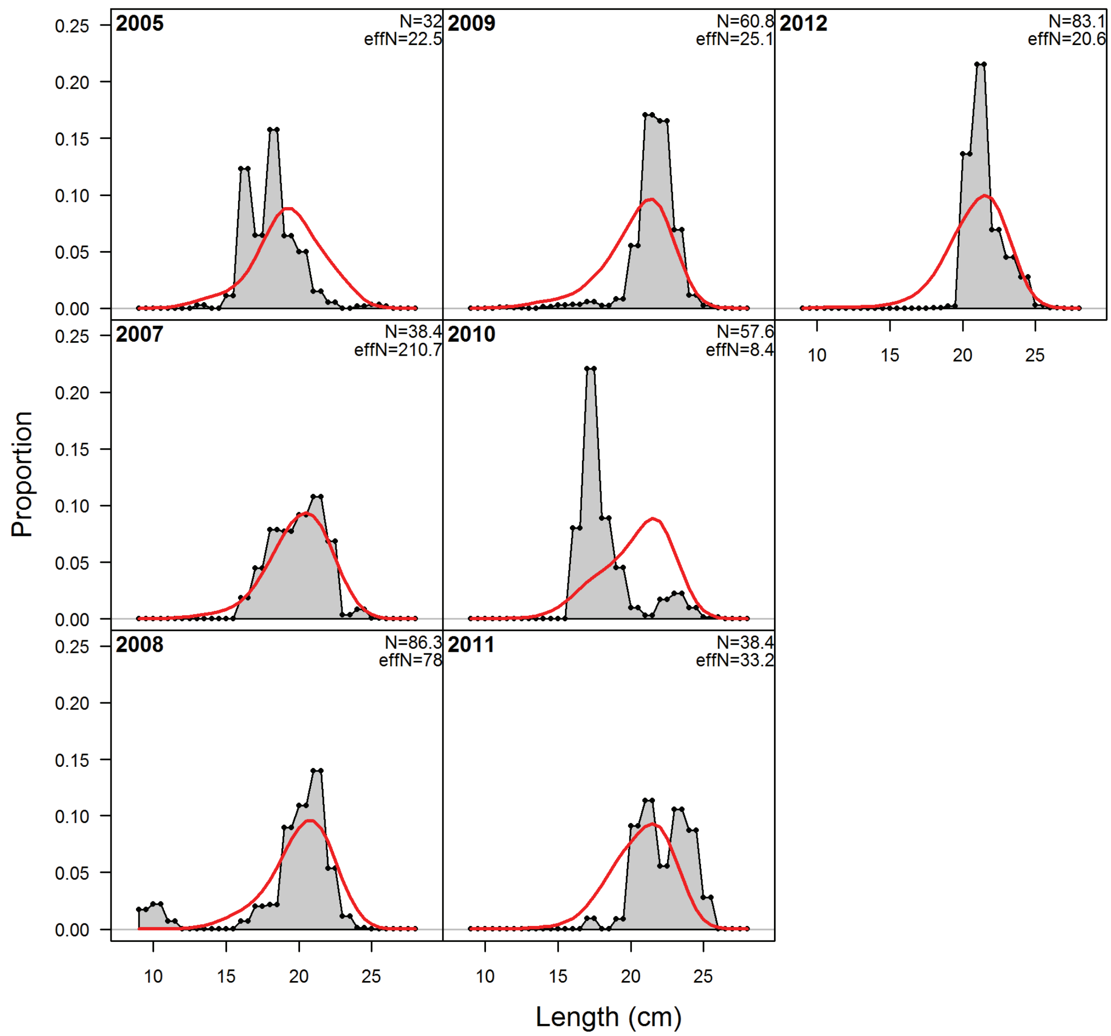


Figure 34a. Model X6e fits to Acoustic survey length-frequency data.

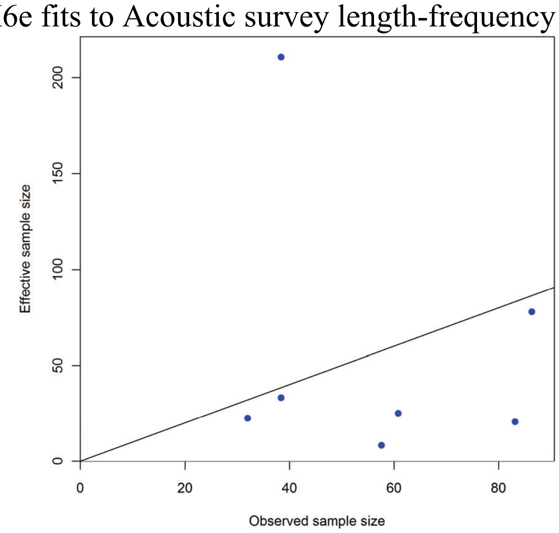


Figure 34b. Observed and effective sample sizes for Acoustic survey fishery length data.

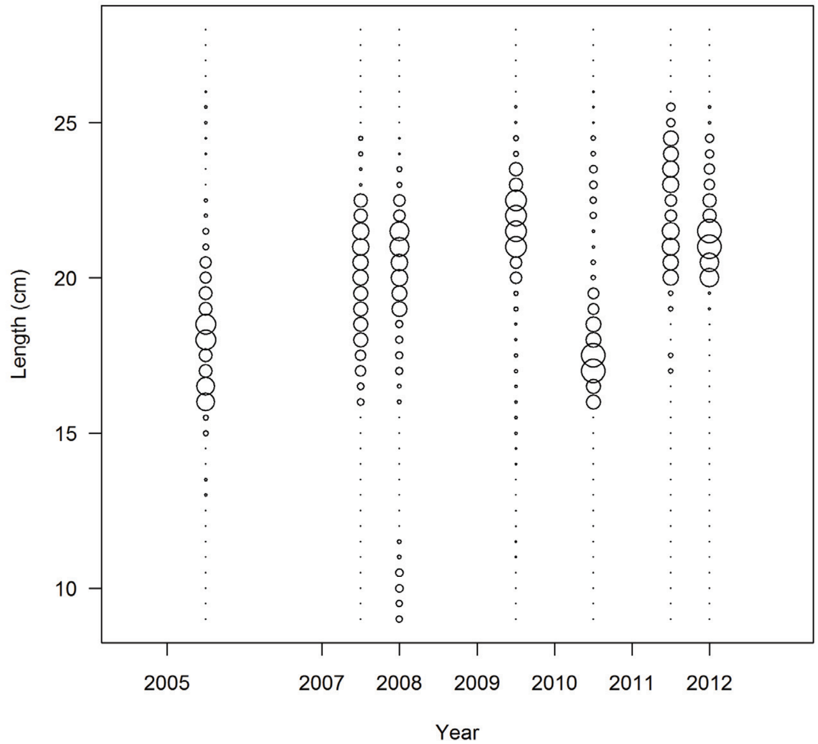


Figure 34c. Bubble plot of Acoustic survey length-frequency data.

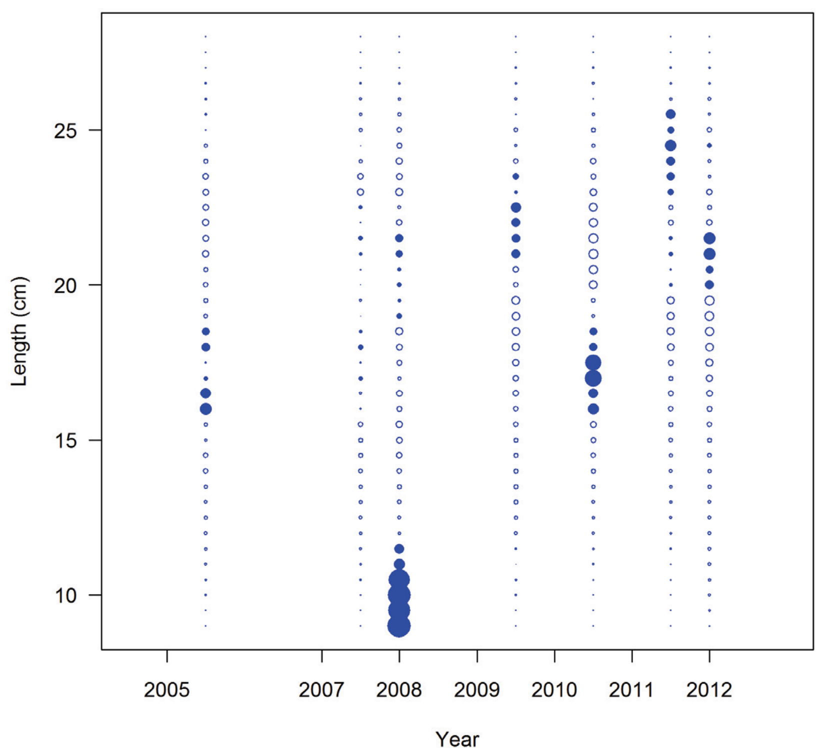


Figure 34d. Pearson residuals (max=14.78) for fit to Acoustic survey length-frequency data.

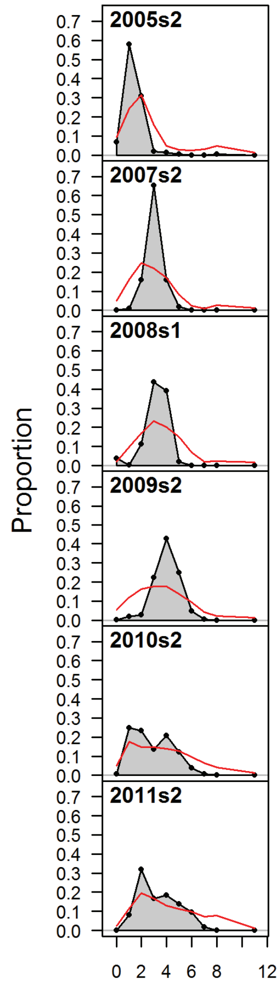


Figure 35a. Base model fits to Acoustic survey implied age-frequency data.

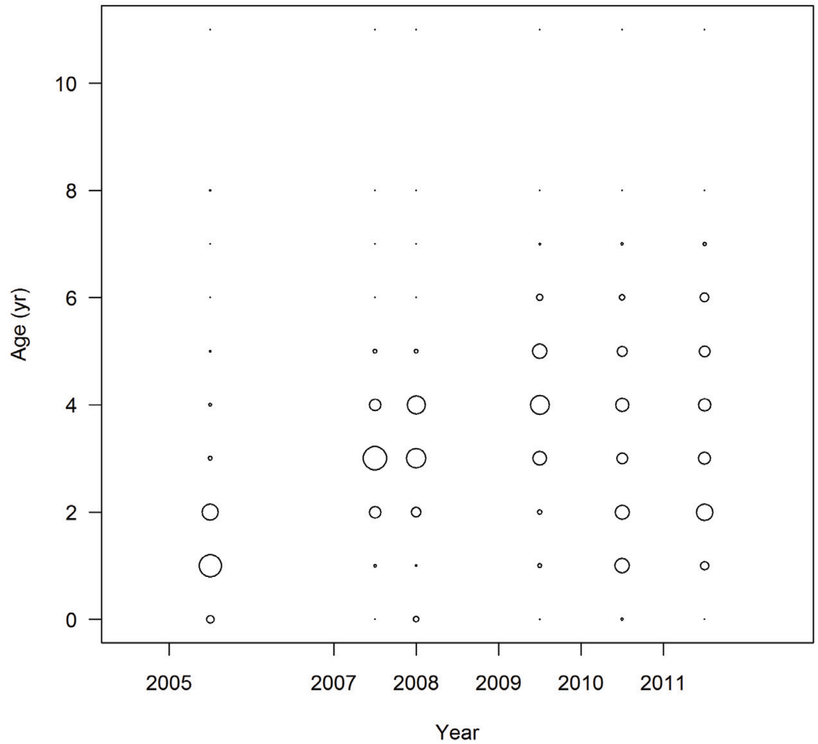


Figure 35b. Bubble plot of Acoustic survey implied age-frequency data.

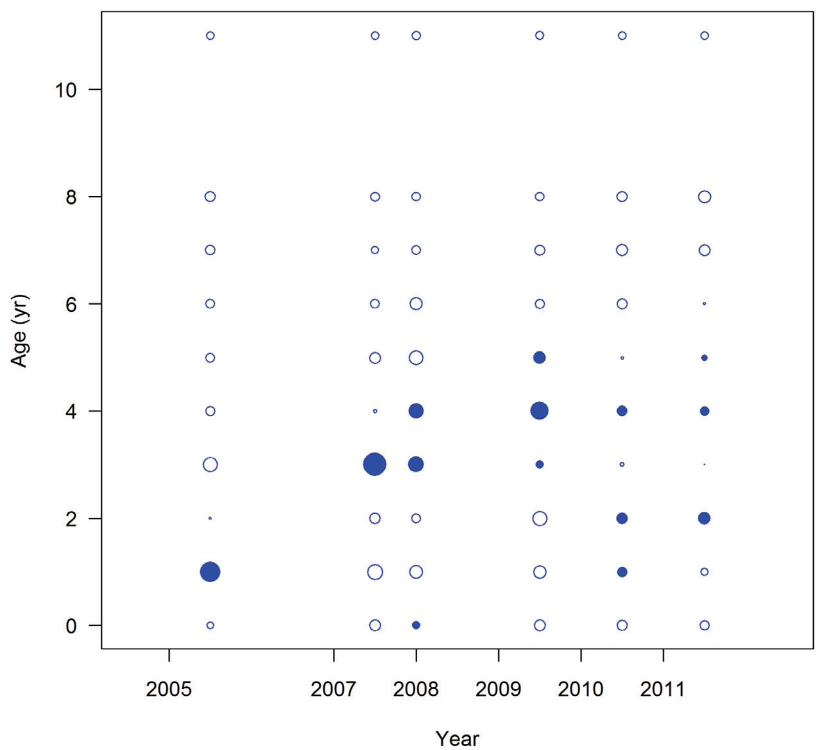


Figure 35c. Pearson residuals (max=1.05) for fit to Acoustic survey implied age-frequency data.

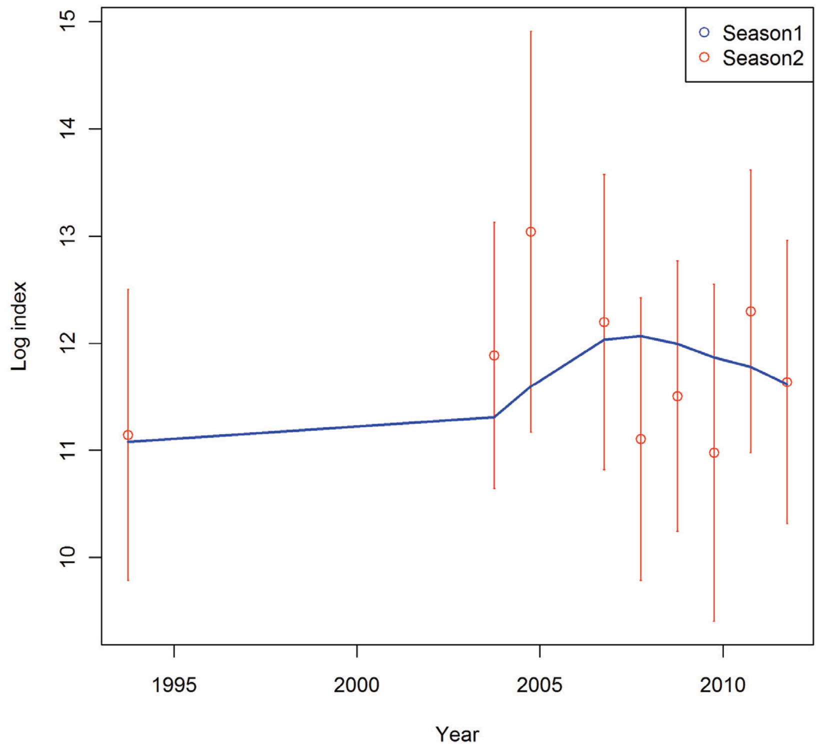


Figure 36a. Model X6e fit to the Daily Egg Production Method (DEPM) series of female SSB (*q*=0.166).

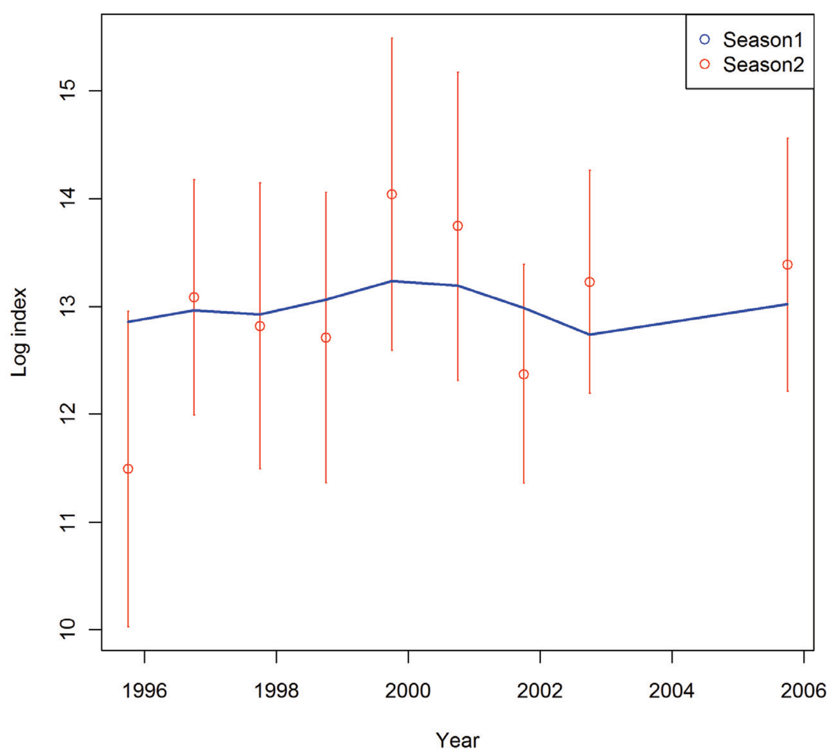


Figure 36b. Model X6e fit to the Total Egg Production (TEP) series of total SSB (*q*=0.539).

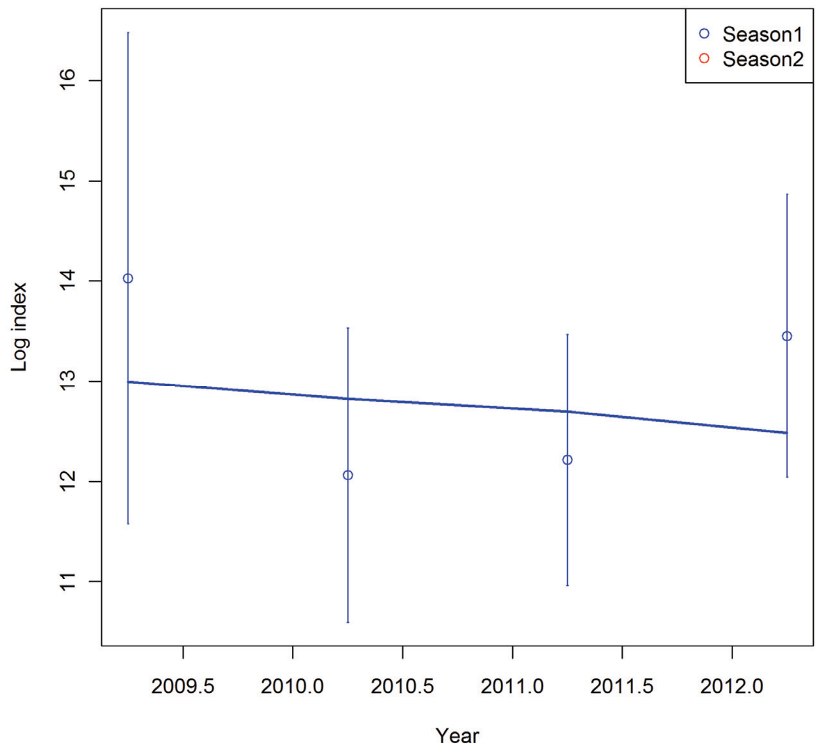


Figure 36c. Model X6e fit to Aerial survey estimates of biomass (q = 0.922).

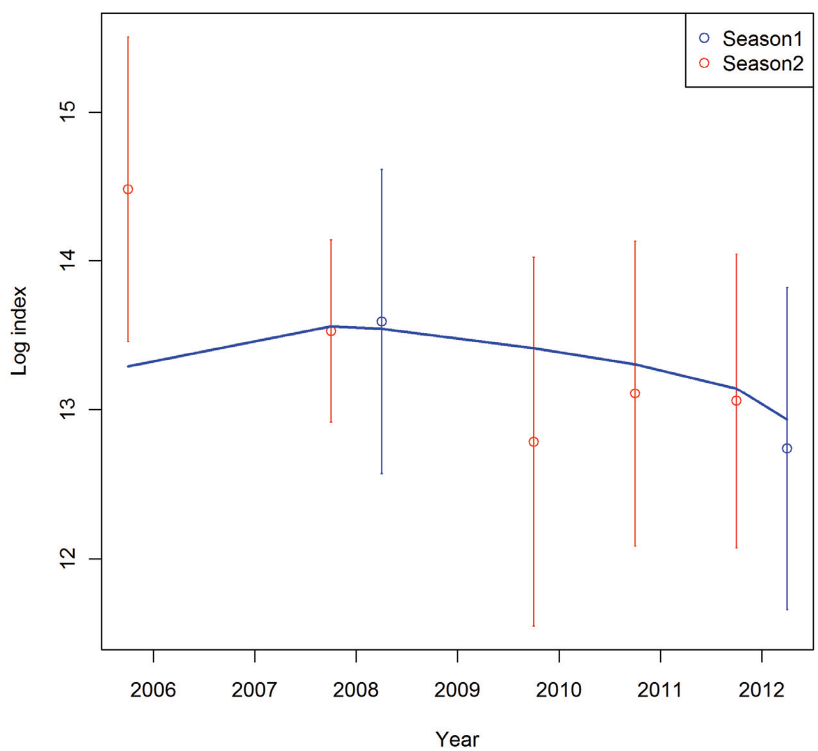


Figure 36d. Model X6e fit to the Acoustic survey biomass series (q = 1; fixed).

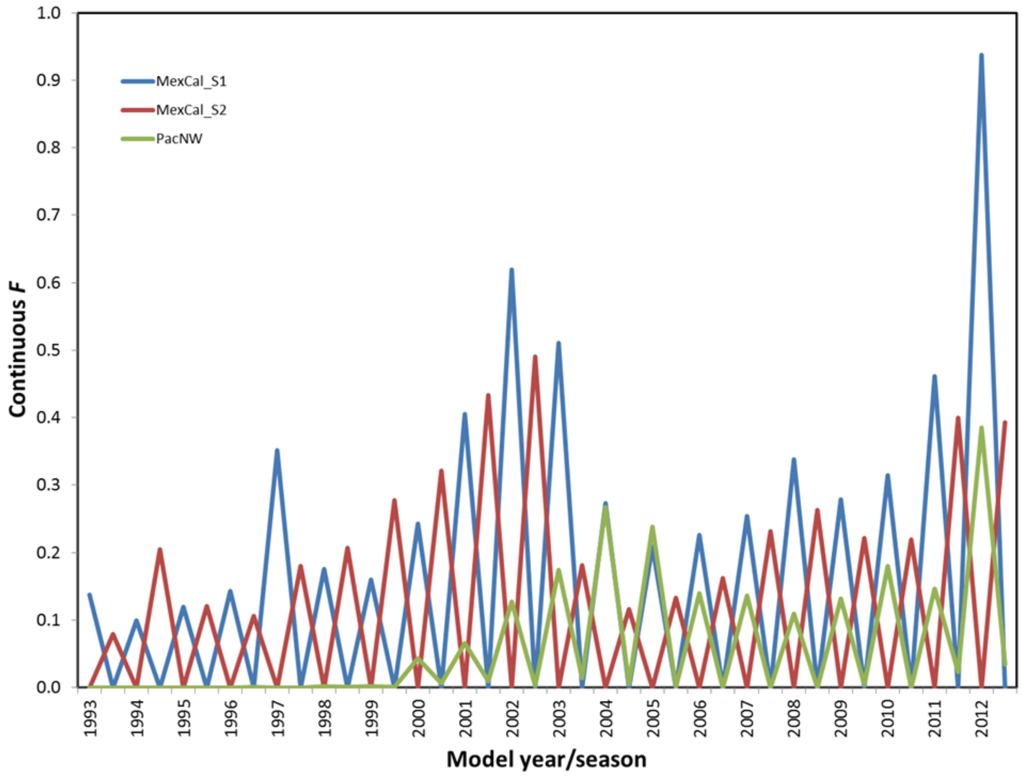


Figure 37a. Model X6e fishing mortality rate (continuous *F*; SS method 3) by fishery.

Figure 37b. Exploitation rate (CY landings / July total biomass) for model X6e.

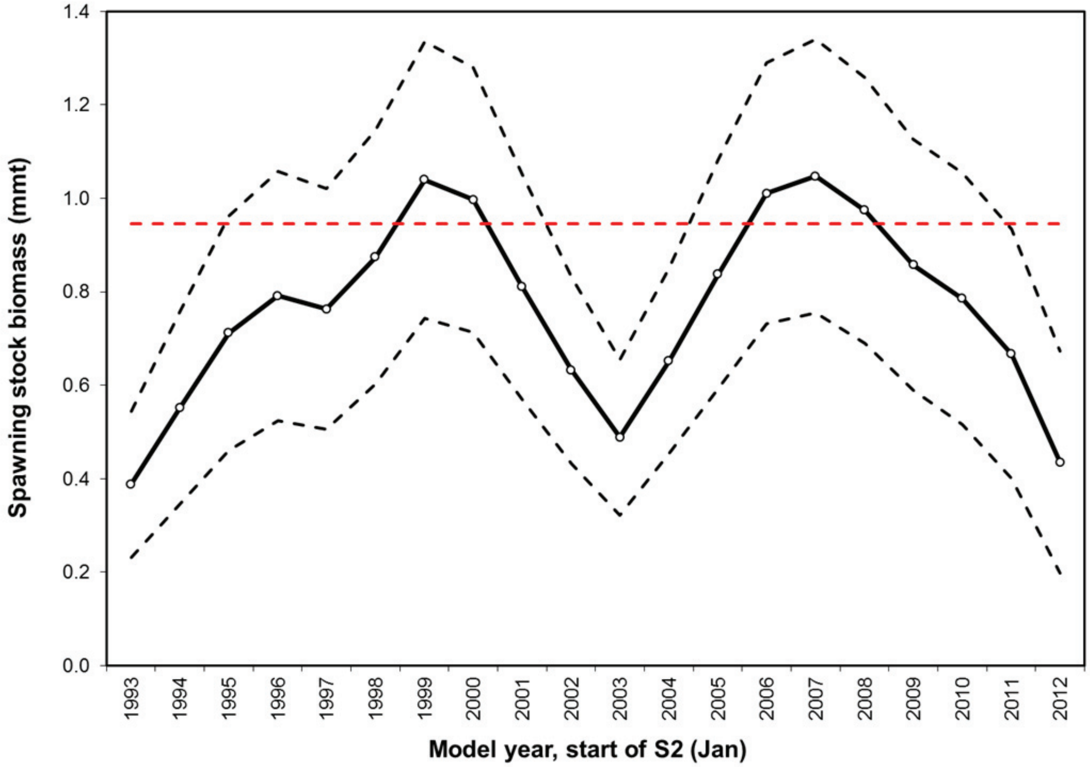


Figure 38a. Model X6e SSB with ~95% confidence intervals. Red line is SSB-zero.

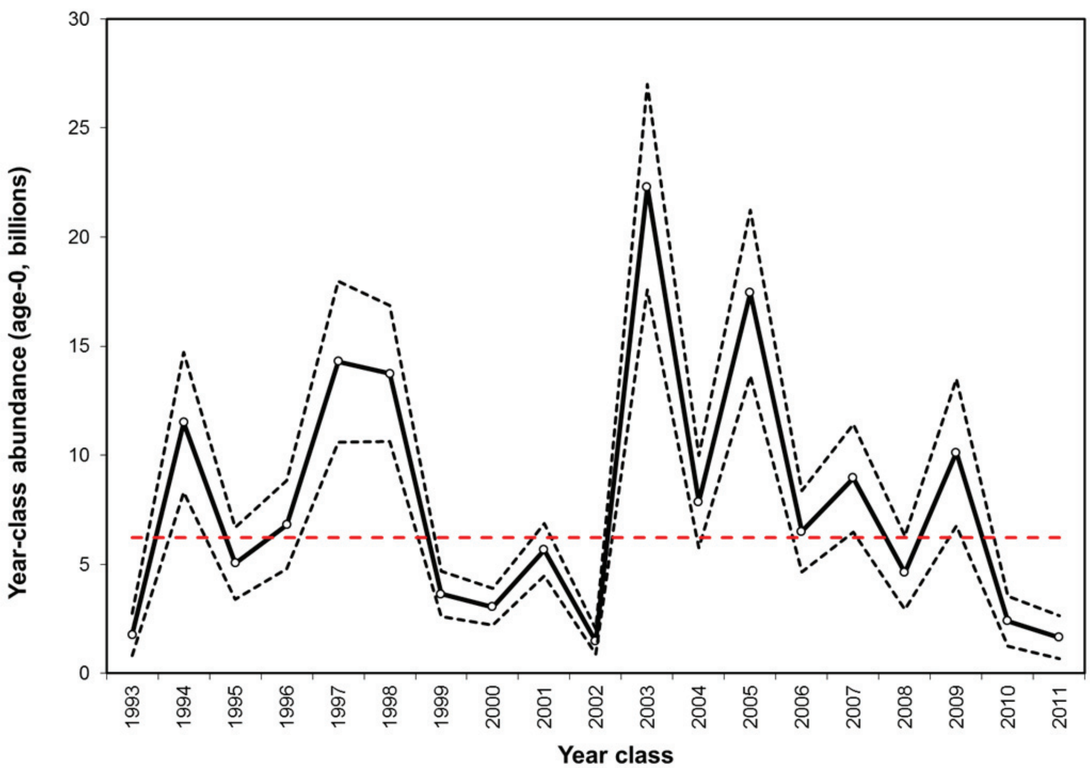


Figure 38b. Model X6e year-class abundance with ~95% confidence intervals. Red line is R-zero.

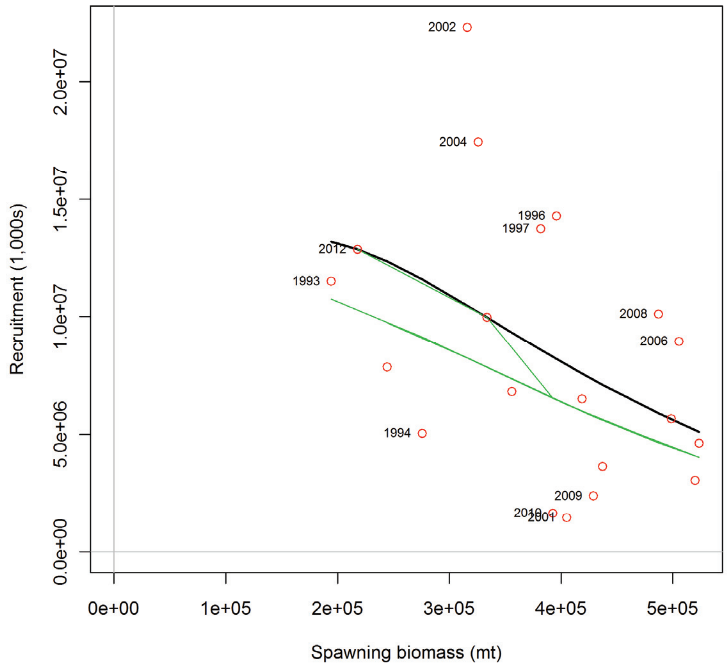


Figure 39a. Spawner-recruitment relationship for model X6b, showing Ricker function fit with bias correction. Steepness (h) = 2.785, R_0 = 6.22 billion age-0 fish, and σ_R = 0.727. Year labels indicate year of spawning season (S2) prior to recruitment season in the following S1, e.g. label '2002' is the SSB that produced the 2003 year-class.

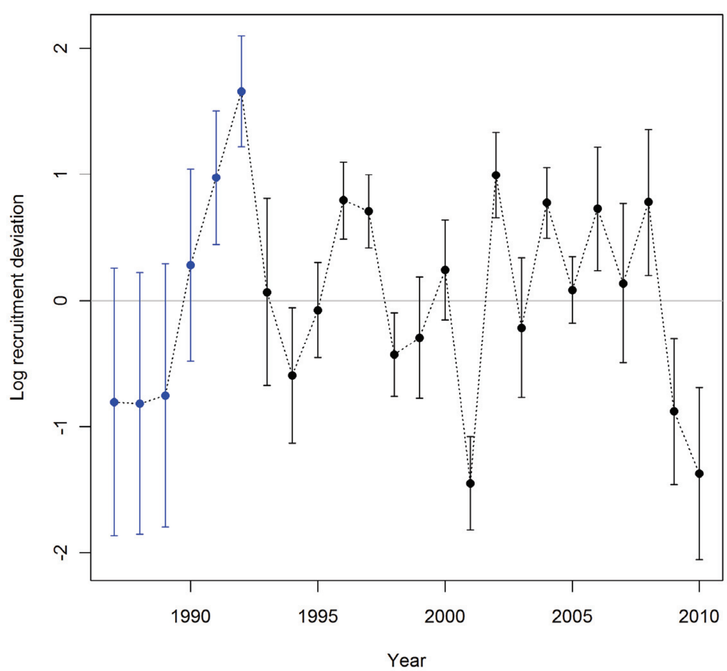


Figure 39b. Recruitment deviations and standard errors estimated in model X6e (σ_R = 0.727). Year labels represent year of SSB producing the subsequent year class.

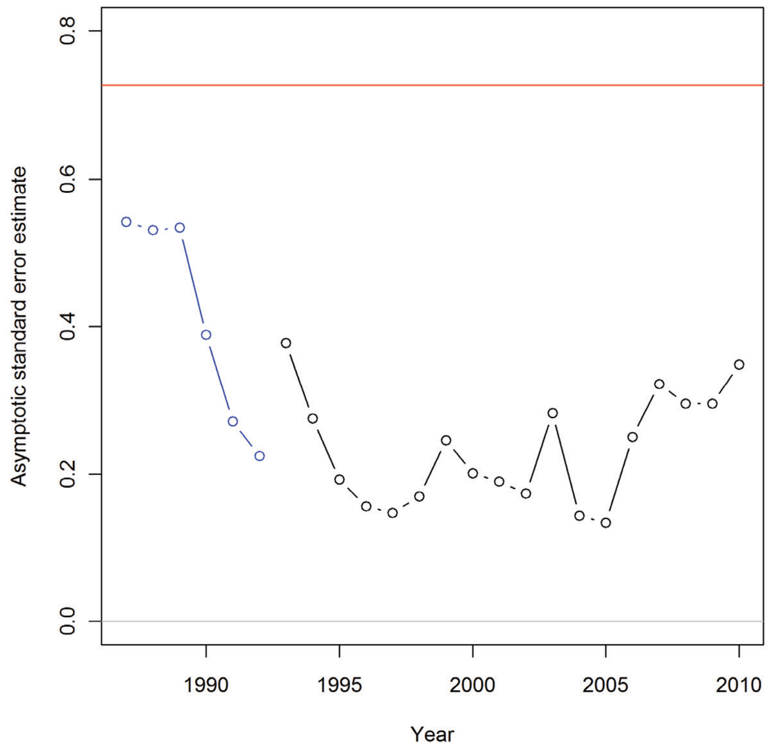


Figure 39c. Asymptotic standard errors for estimated recruitment deviations in model X6e.

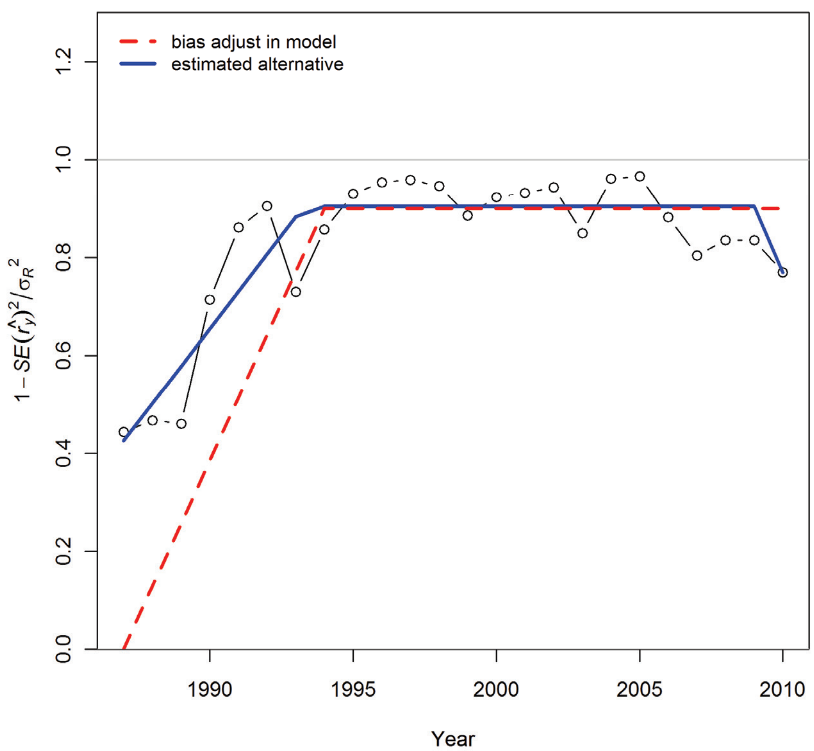


Figure 39d. S-R bias adjustment ramp applied in the model X6e.

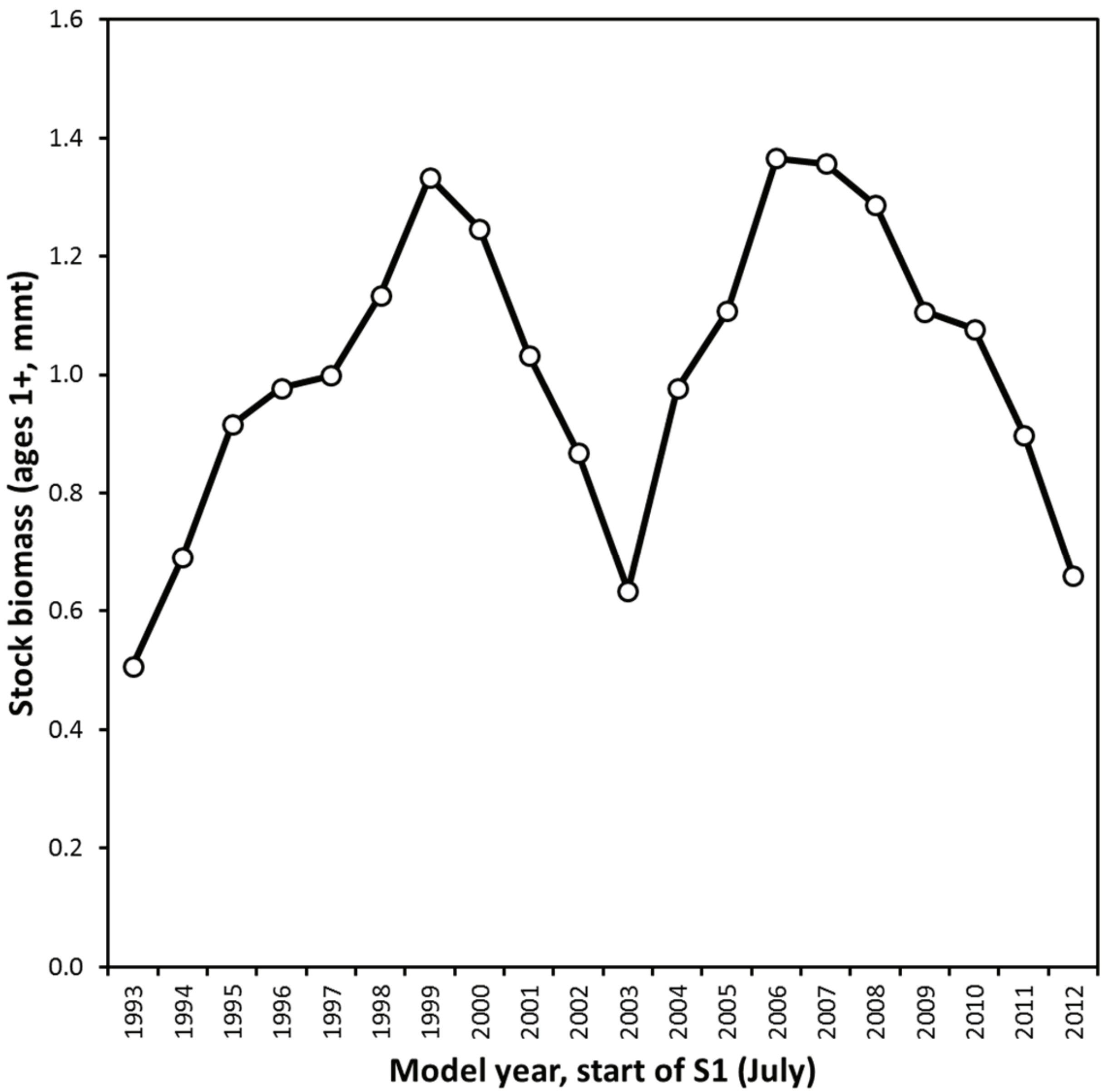


Figure 40. Model X6e stock biomass (ages 1+) used for annual management measures. Stock biomass was estimated to be 659,539 mt on July 1, 2012.

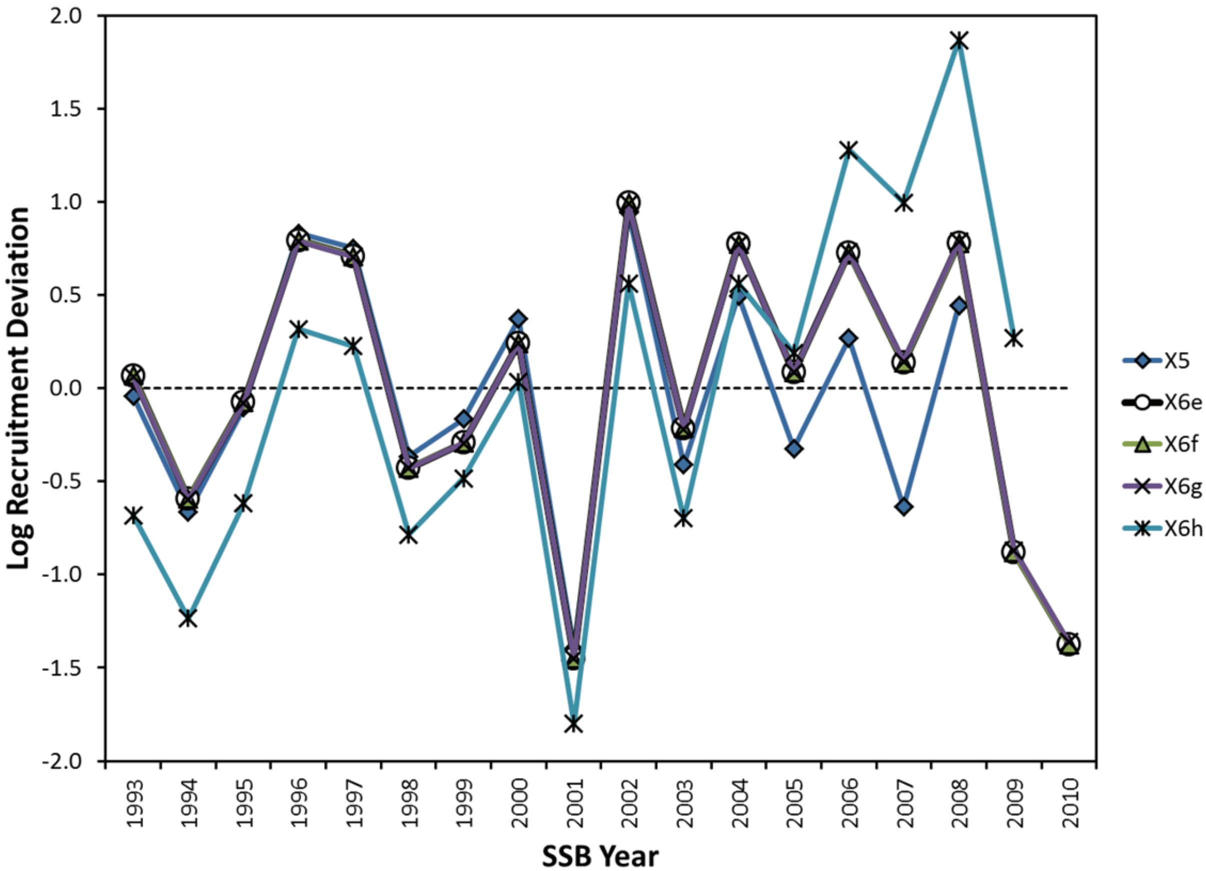
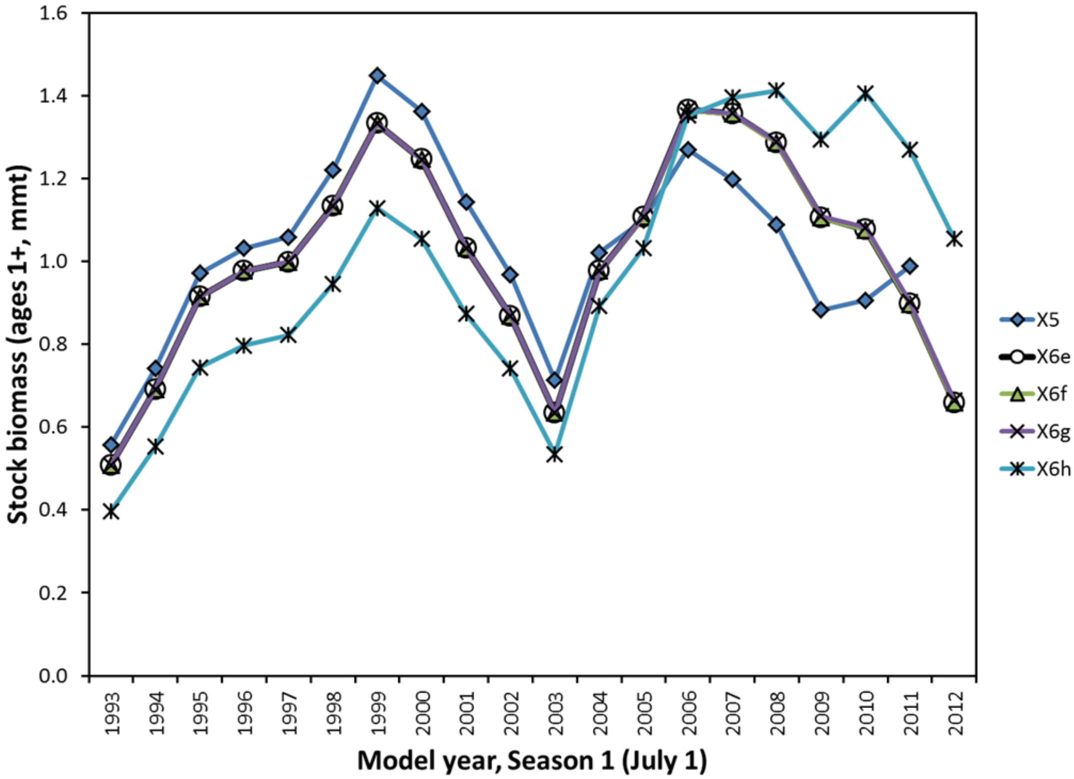


Figure 41. Estimated recruitment deviations from models X5, and X6e-h.



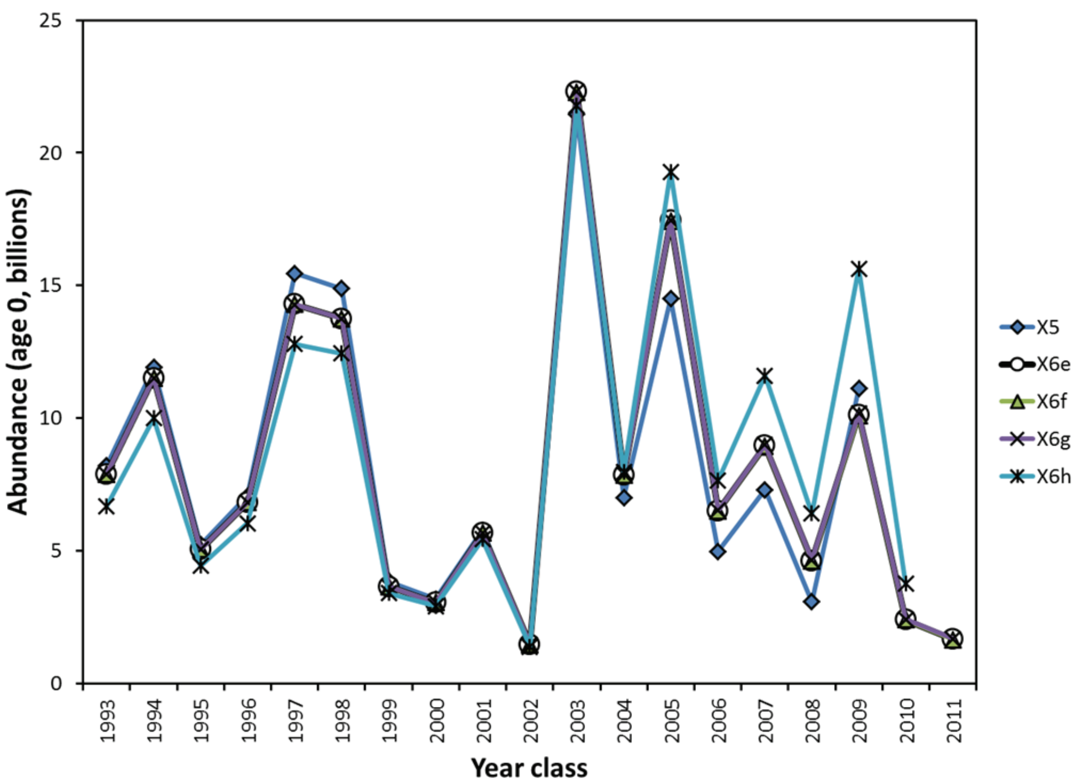


Figure 42. Stock biomass (upper) and recruitment (lower) for models X5 and X6e-h.

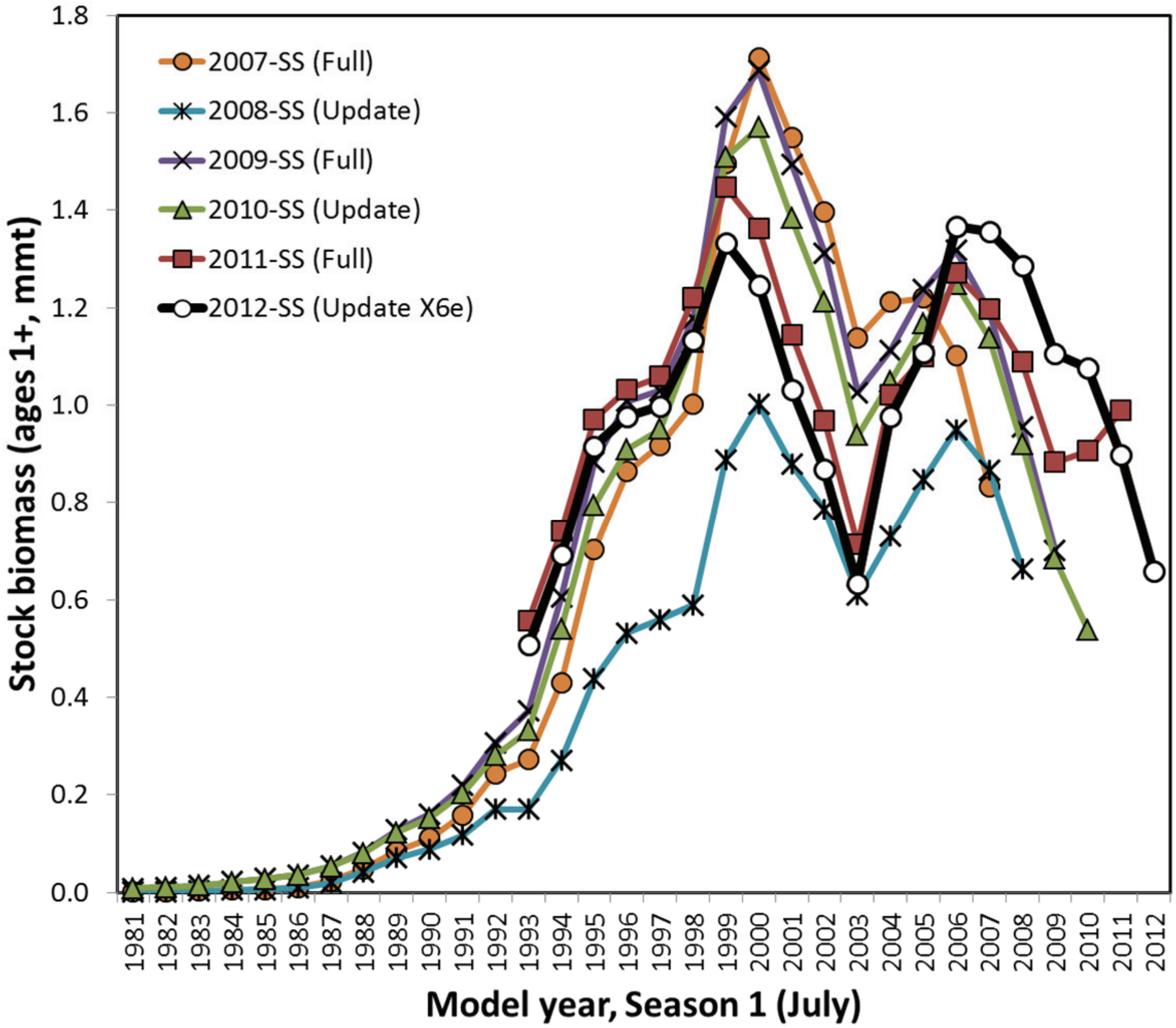


Figure 43a. Pacific sardine stock biomass (ages 1+) from the base model compared to range of models from the past five assessments.

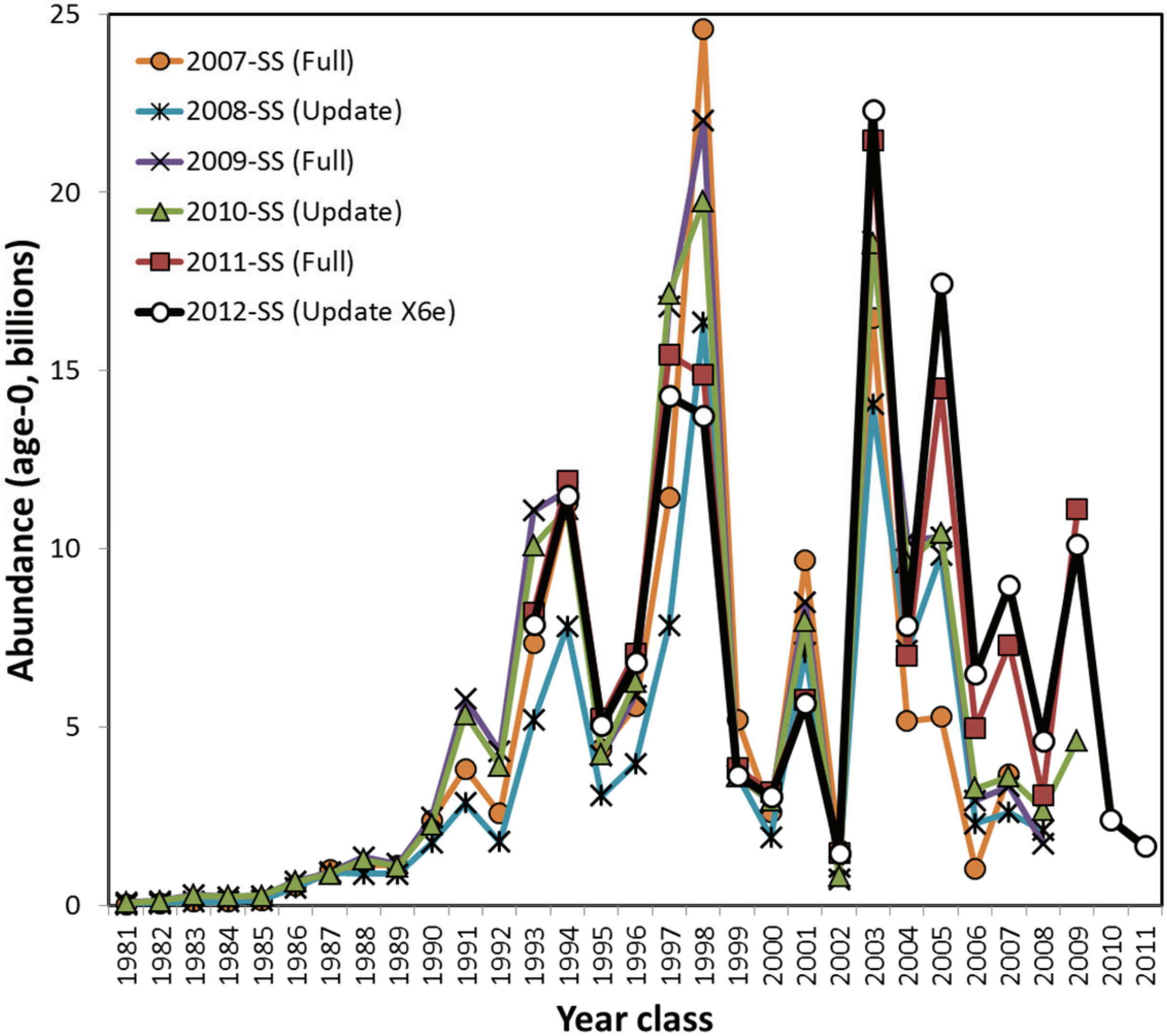


Figure 43b. Pacific sardine recruit (age-0) abundance from the base model compared to range of models from the past four assessments.

NATIONAL MARINE FISHERIES SERVICE REPORT

Mr. Mark Helvey, of the National Marine Fisheries Service Southwest Region (NMFS SWR), will provide the Council with a regulatory update. Dr. Russ Vetter, NMFS Southwest Fisheries Science Center, will provide an update on the spring and summer research surveys.

Council Task:

1. Discussion.

Reference Materials:

None.

Agenda Order:

a.	Agenda Item Overview	Kerry Griffin
b.	Regulatory Activities	Mark Helvey
c.	Fisheries Science Center Activities	Russ Vetter
d.	Reports and Comments of Advisory Bodies and Management Entities	
e.	Public Comment	
f.	Council Discussion	

PFMC
10/15/12

NATIONAL MARINE FISHERIES SERVICE REPORT ON COASTAL PELAGIC SPECIES REGULATORY ACTIVITIES

2012 Pacific Sardine Fishing Season:

For the 2012 Pacific sardine fishing season the initial Harvest Guideline (HG) that was allocated across the three allocation periods was 97,409 metric tons (mt). This number was reduced from the maximum HG by 12,000 mt: (i) 9,000 mt to satisfy the request for a treaty set-aside by the Quinault Indian Nation and (ii) 3,000 mt for the exempted fishing permit.

Of the 34,093 mt available for harvest in the 1st period, only 21,000 mt were landed.
Therefore approximately 13,000 mt were rolled from the 1st period into the second period making the preliminary harvest allocation for the second period (July 1-September 14) 52,000 metric tons.

Nearing this total, NMFS closed the 2nd period on August 23. Ultimately 51,769 mt were landed in the 2nd period, leaving approximately 200 mt from the 2nd period to be rolled into the third. Additionally, through consultation with the Quinault Indian Nation on September 12, the Tribe indicated that the full tribal set-aside of 9,000 mt would likely not be attained by the end of the fishing season. Based on this consultation, an additional 6,000 mt were also added to the 3rd period directed allocation total. Of the 3,000 mt allocated to the aerial survey EFP, approximately 100 mt went unused, also rolling into the 3rd allocation.

Therefore the announced preliminary directed harvest allocation for the 3rd period was 30,000 mt.

Table of initial harvest allocations:

	January 1-June 30	July 1-September 14	September 15 – December 31	Total
Total Seasonal Allocation	34,093 (35%)	38,964 (40%)	24,352 (25%)	97,409
Incidental Set Aside	1,000	1,000	1,000	3,000
Adjusted Directed Harvest Allocation	33,093	37,964	23,352	94,409

Quinault Indian Nation Sardine Request:

NMFS received a request from the Quinaults expressing their intention to again exercise their treaty rights to enter into the Pacific sardine fishery in 2013. NMFS is working with the Tribe in setting up a consultation with them prior to the Council meeting.

PFMC
11/02/12

Agenda Item G.1.b
Supplemental SWFSC PowerPoint
November 2012

NOAA SWFSC Council Report: November 4, 2012 Costa Mesa, CA

Topics:

1. Current Notions of Sardine Stocks and Seasonal Distribution

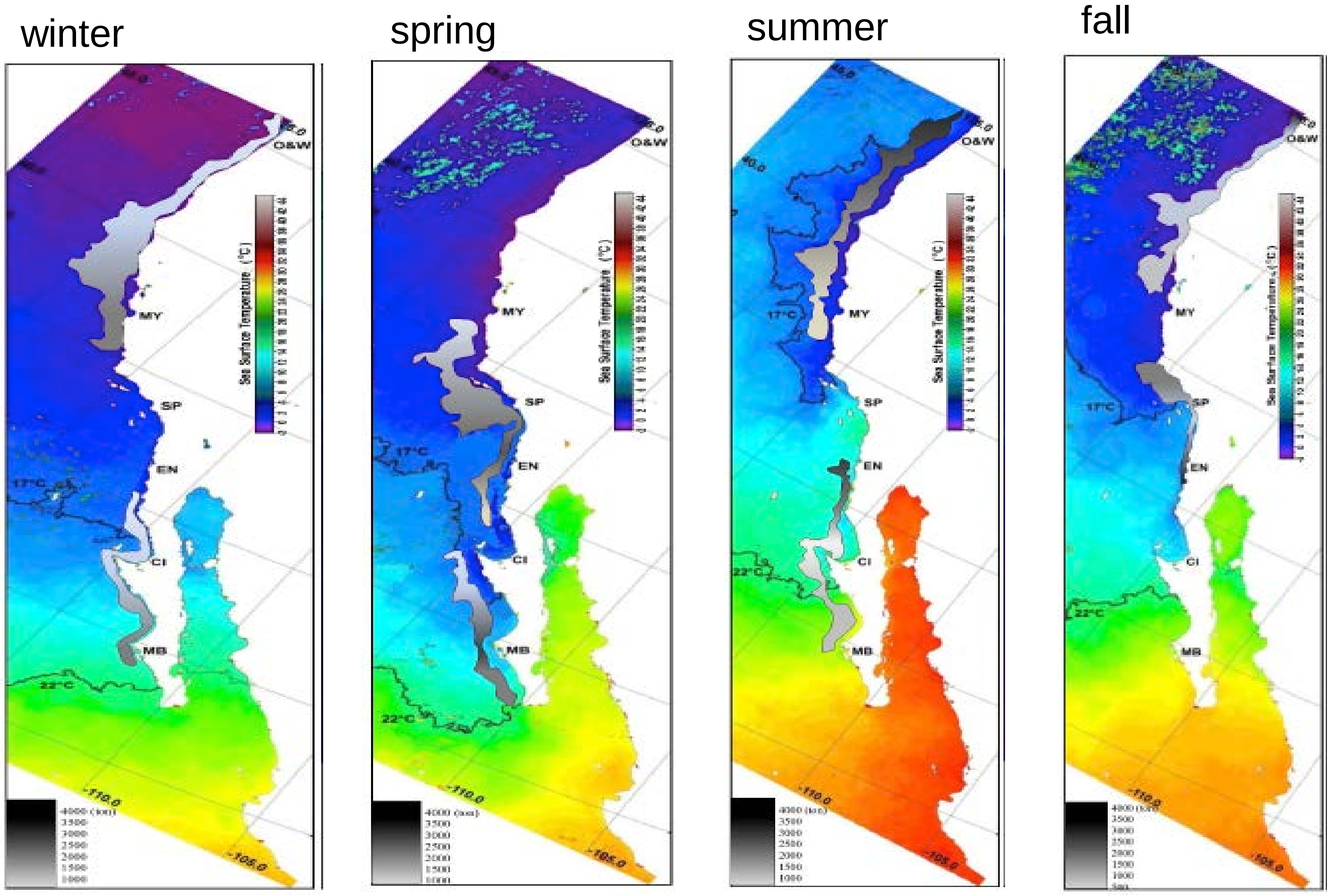
2. Realized Spring Survey Coverage and Results
    2.a. DEPM and egg survey results
    2.b. Acoustic-Trawl estimates

3. Planned Survey Pattern for Summer 2012
    3.a. Sardine Workshop Plan 11/11
    3.b. Sardine-Hake (SAKE) Plan 6/12

4. Realized Summer Survey Coverage and Results

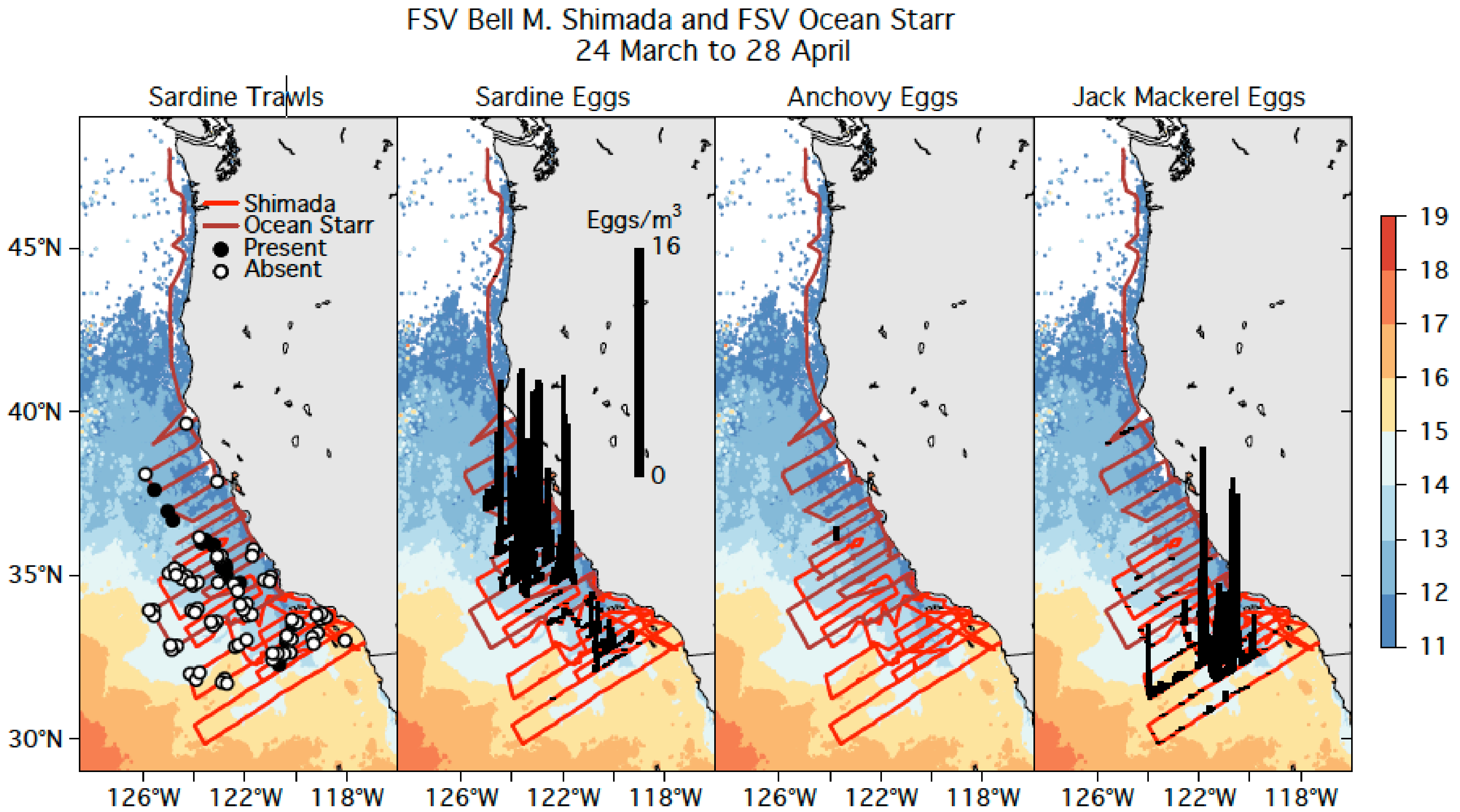
Results of Spring & Summer ATM Surveys

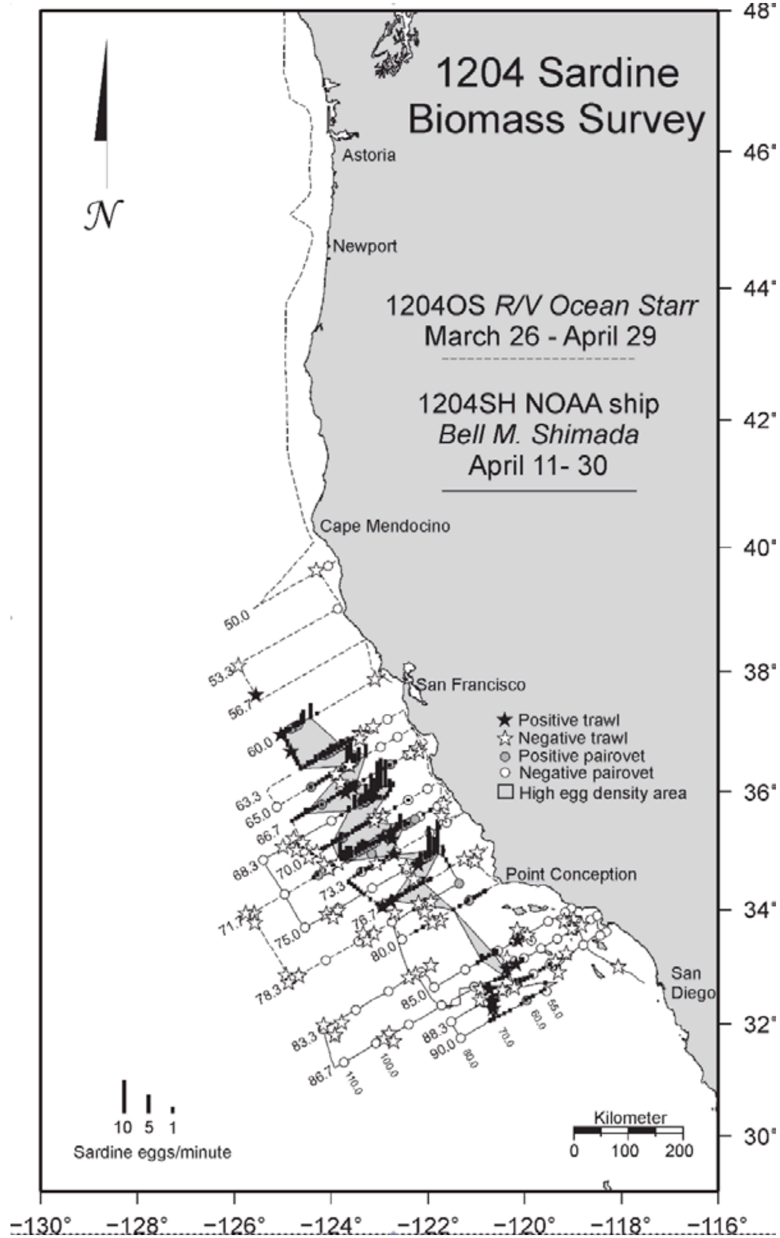
Topic 1. current notions on sardine stocks



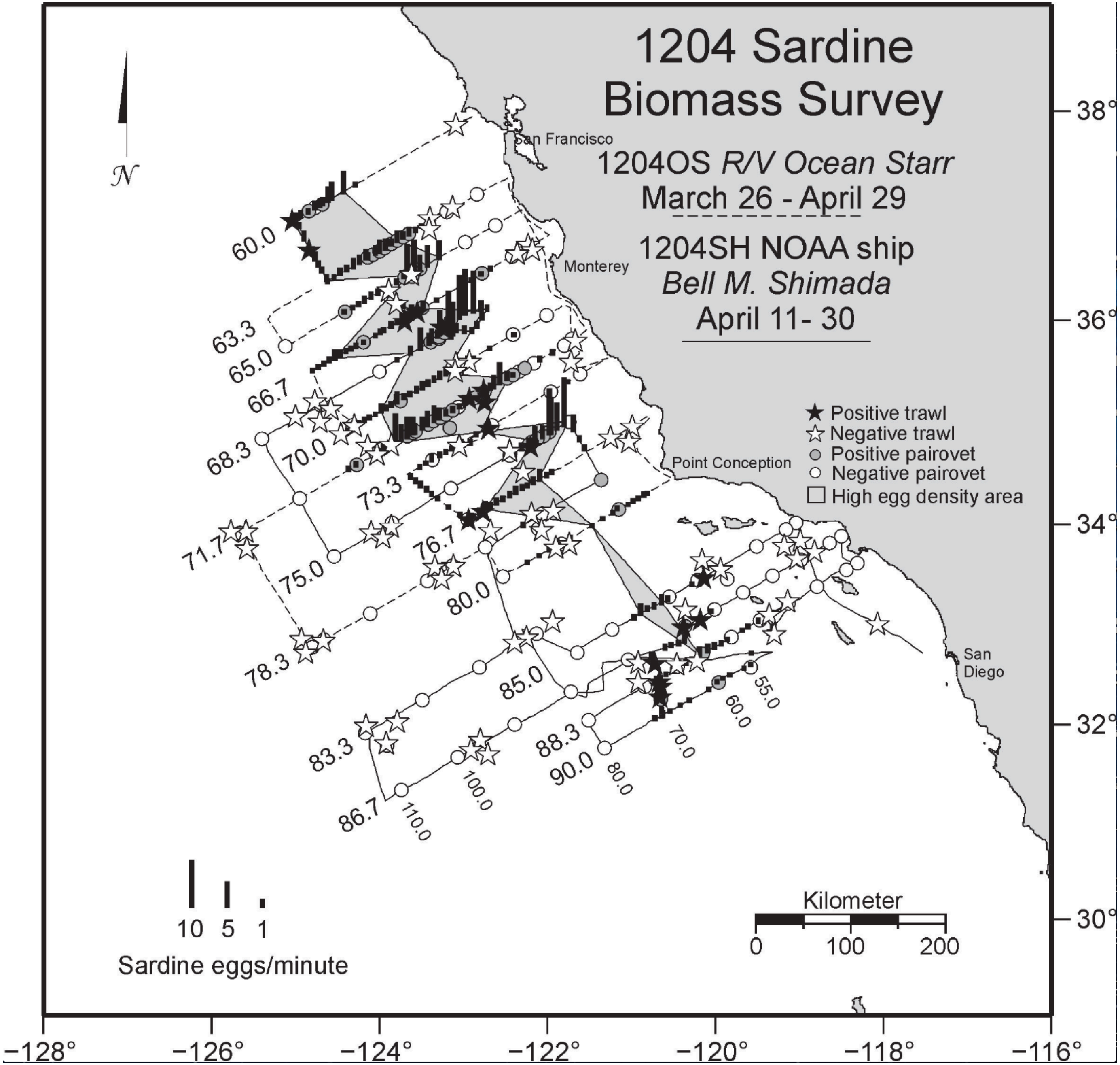
CONCEPTUAL MODELS OF PACIFIC SARDINE DISTRIBUTION IN THE CALIFORNIA CURRENT SYSTEM
Ricardo García Morales et al.

Topic 2. Realized Spring Survey execution and results





1204 Sardine
Biomass Survey
1204OS R/V Ocean Starr
March 26 - April 29
1204SH NOAA ship
Bell M. Shimada
April 11- 30
N
Astoria
Newport
Cape Mendocino
San Francisco
Point Conception
San Diego
Positive trawl
Negative trawl
Positive pairovet
Negative pairovet
High egg density area
10 5 1
Sardine eggs/minute
Kilometer
0 100 200
48°
46°
44°
42°
40°
38°
36°
34°
32°
30°
−130° −128° −126° −124° −122° −120° −118° −116°



1204 Sardine
Biomass Survey
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March 26 - April 29
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Bell M. Shimada
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San Francisco
Monterey
Point Conception
San Diego
Positive trawl
Negative trawl
Positive pairovet
Negative pairovet
High egg density area
N
60.0
63.3
65.0
66.7
68.3
70.0
71.7
73.3
75.0
76.7
78.3
80.0
83.3
85.0
86.7
88.3
90.0
110.0
100.0
80.0
70.0
60.0
55.0
10
5
1
Sardine eggs/minute
Kilometer
0
100
200
38°
36°
34°
32°
30°
−128°
−126°
−124°
−122°
−120°
−118°
−116°

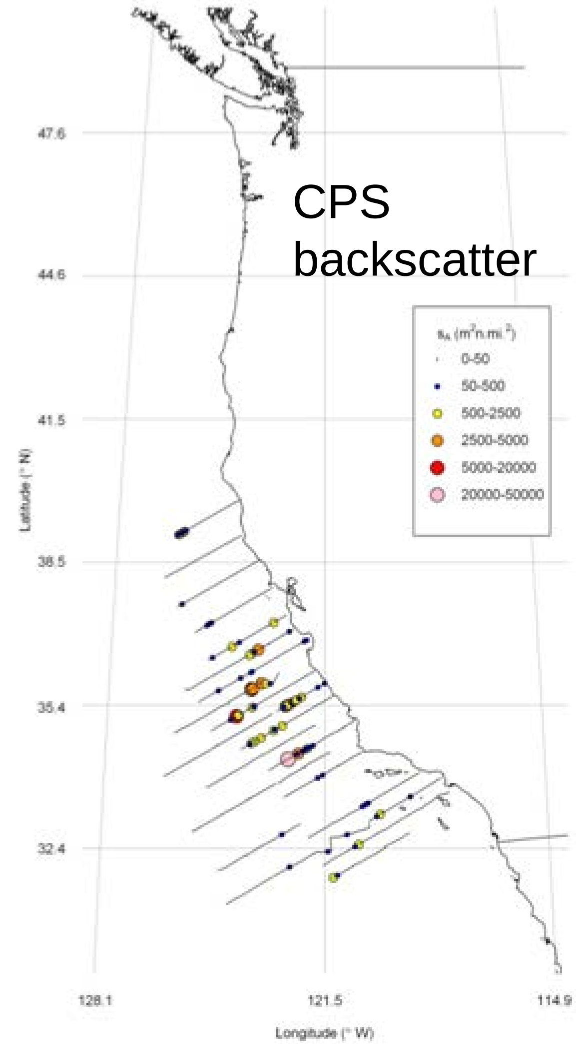
Topic 4. Executed Survey for Spring ATM and Summer 2012 SAKE

Acoustic-trawl estimates of sardine biomass off California during spring 2012

Juan Zwolinski, David A. Demer,
Beverly J. Macewicz,
George R. Cutter Jr., Kyle A. Byers,
Josiah S. Renfree, and Thomas S. Sessions

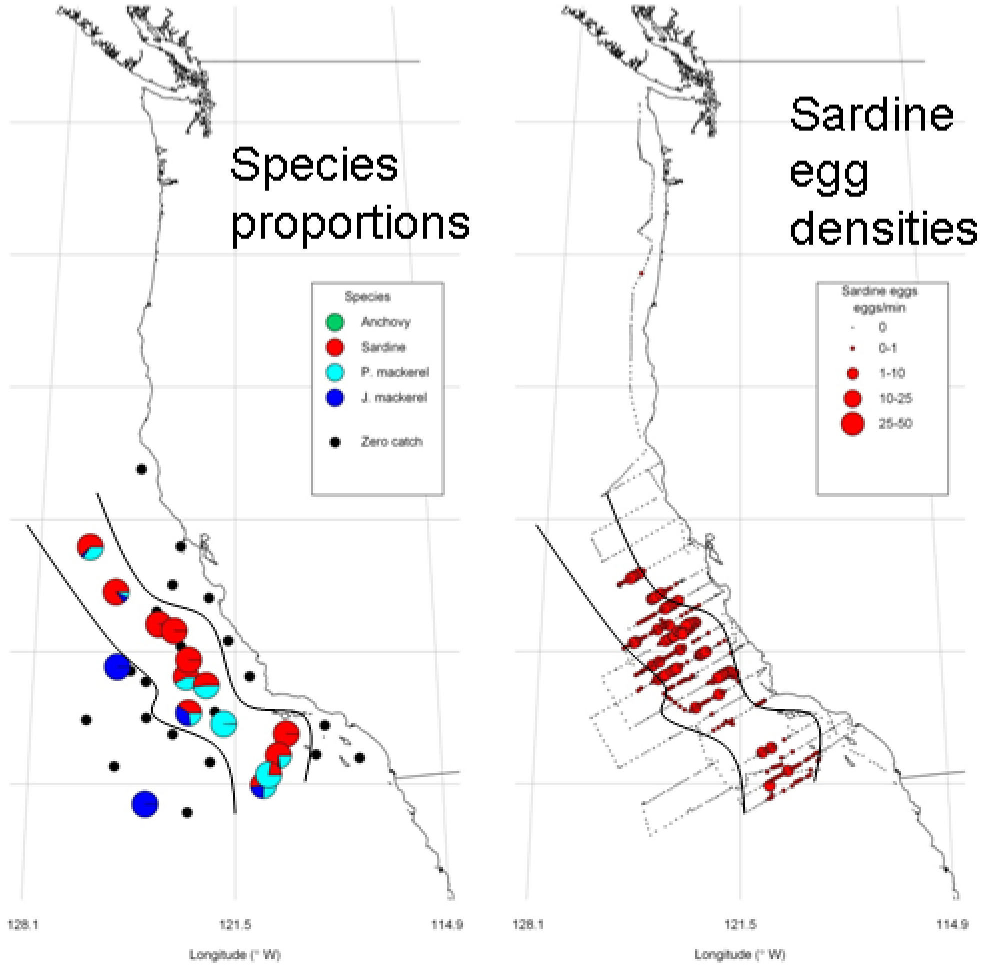
Spring 2012 Sampling

- Acoustic transects
  - Mexico Border to Cape Mendocino
  - 2,248 nm (51,327 nm$^{2)}$
  - Northern stock distribution
  - Sunrise to sunset
- Night and day
  - CUFES
  - Underway SST, SSS, & Chl-a
- Night
  - Surface trawl
  - CTD
  - Bongo
  - CalVet



Spring 2012 Results

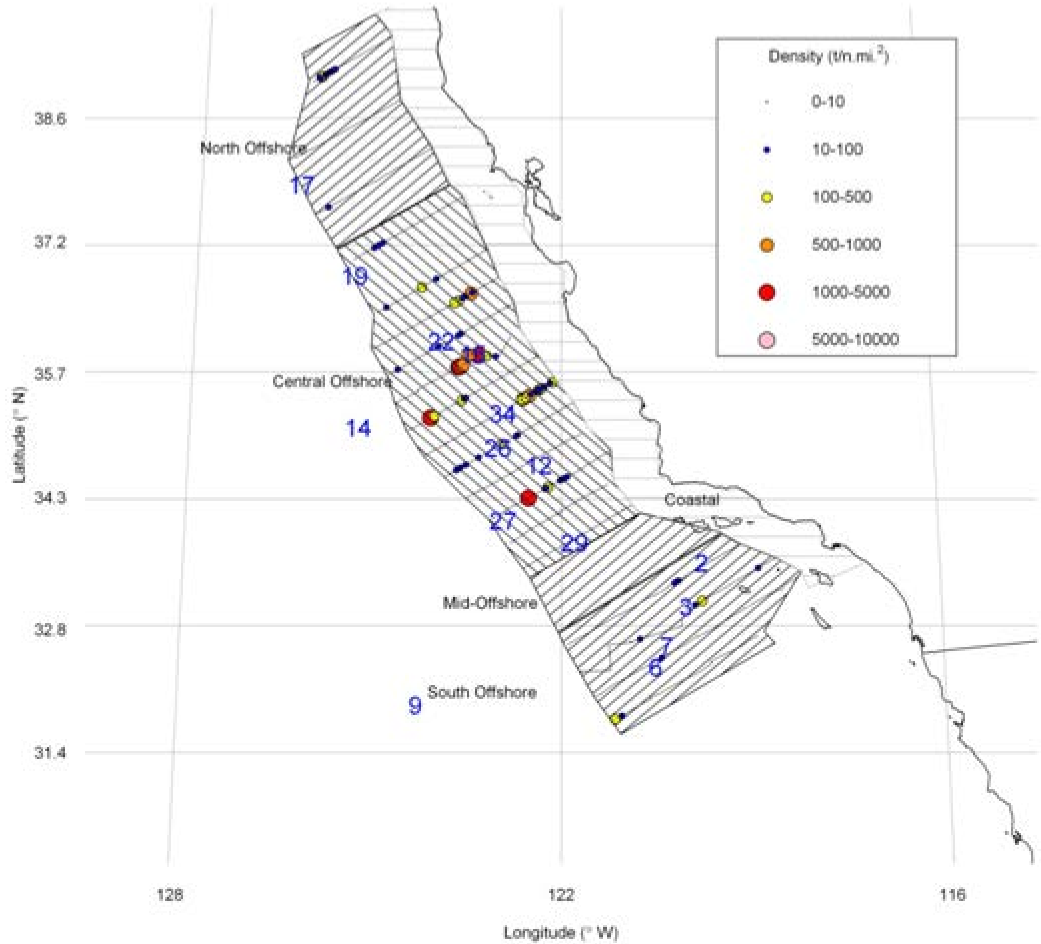
- Sparse trawl sampling
- Catches each night combined into clusters
- Apportion backscatter
  - CPS to species
  - Biomass to lengths
- No sardine
  - Coastal
  - Far-offshore
- Sardine-egg densities corroborate trawl catches



Spring 2012 Results

Sardine density
(t nm^{-2})

- 14 clusters
  - Included CPS
  - Median=17 sardine
- Strata definitions
  - Sampling intensity
  - CPS presence
  - Sardine eggs
- Four strata
  - North-offshore
  - Central-offshore
    - Most CPS
    - Half of the area
    - ~ 85% of stock
  - Mid-offshore
  - South-offshore

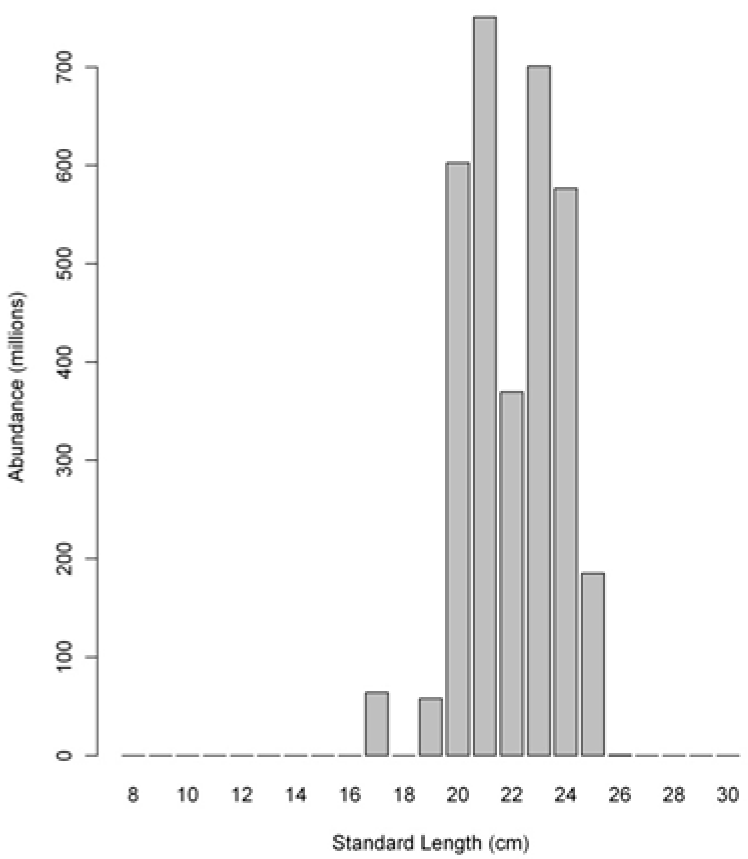


Results

Stratum		**Transects**		**Trawls**		**Sardine**		
Name	**Area (n.mi.)**	**Number**	**Distance (n.mi.)**	**CPS clusters**	**Number of sardine**	**Biomass (Mt)**	**95% confidence interval (Mt)**	***CV***
North-offshore	10283	3	236	1	61	0.032	0.000 – 0.069	95.6
Central-offshore	24846	12	1169	9	175	0.421	0.179 – 0.702	31.1
Mid-offshore	4444	0	0	0	0	0.003	0.00 – 0.005	38.4
South-offshore	11754	4	609	4	261	0.015	0.009 – 0.020	20.5
Total	**51327**	**19**	**2248**	**14**	**497**	**0.470**	**0.224 – 0.750**	**28.6**

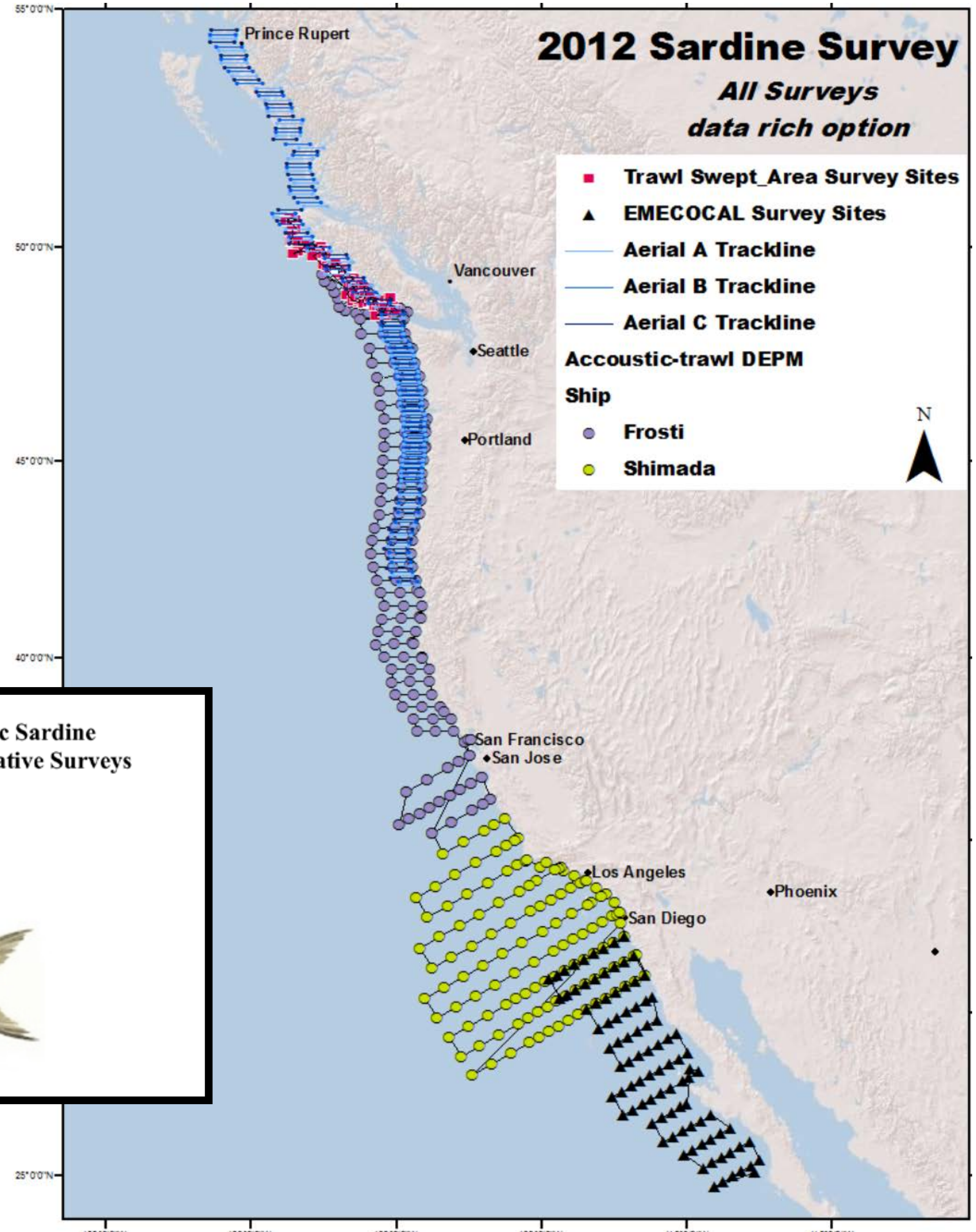
Spring 2012 Results

- Sardine biomass
  - 0.470 Mt
  - $CI_{95\%}$ = [0.224; 0.750]
  - CV = 28.6%
- Sardine standard lengths
  - Modes ~ 21 and 23 cm
  - Artifact of sparse sampling
  - Putative 2009 cohort
- Species and lengths
  - 9 clusters, 175 sardine
  - Mostly 3 clusters, 37 fish



Topic 3a: Planned 2012 CPS Summer Coastwide Survey Plans

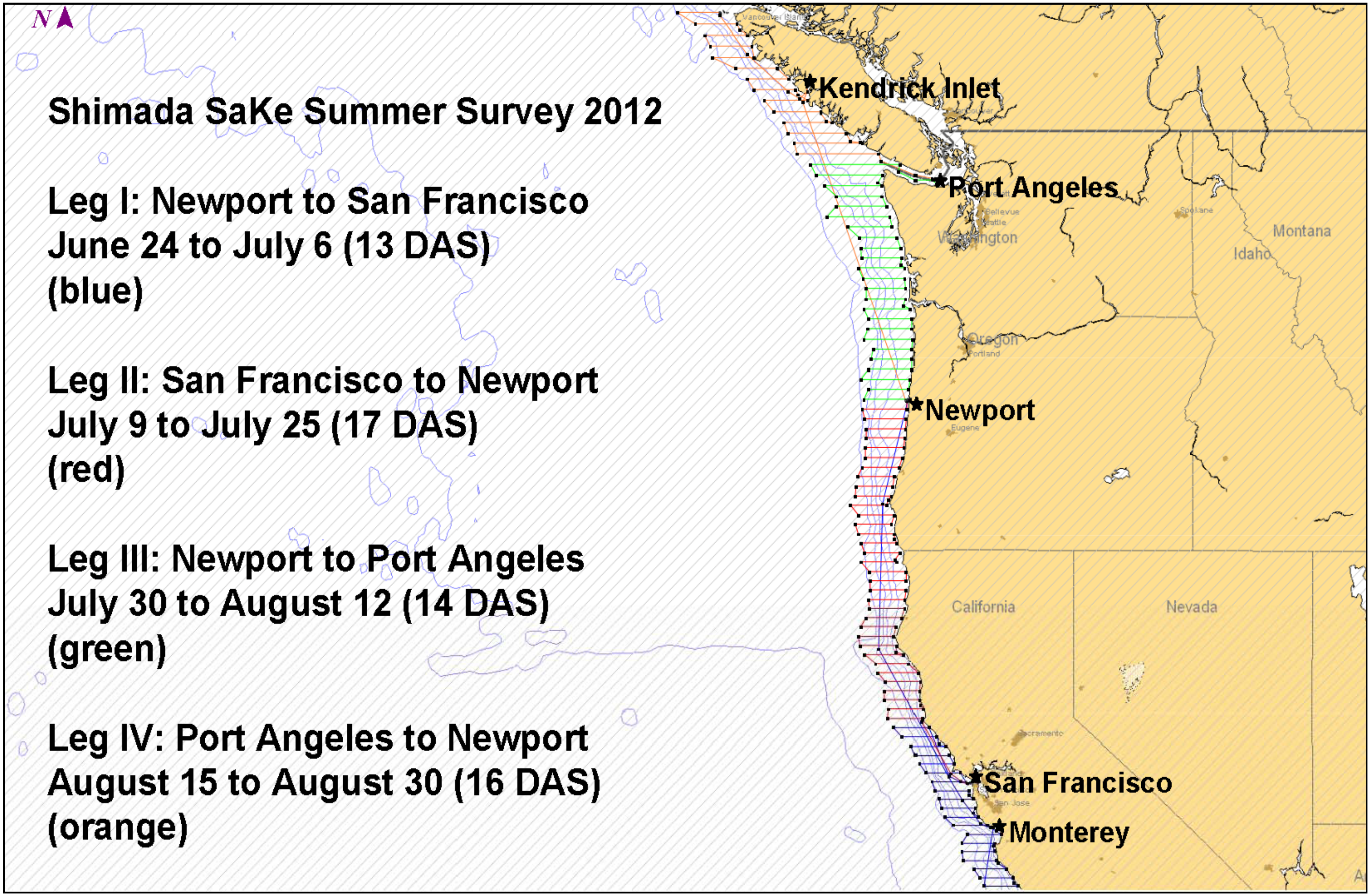
(originally presented at Costa Mesa, November 2011)

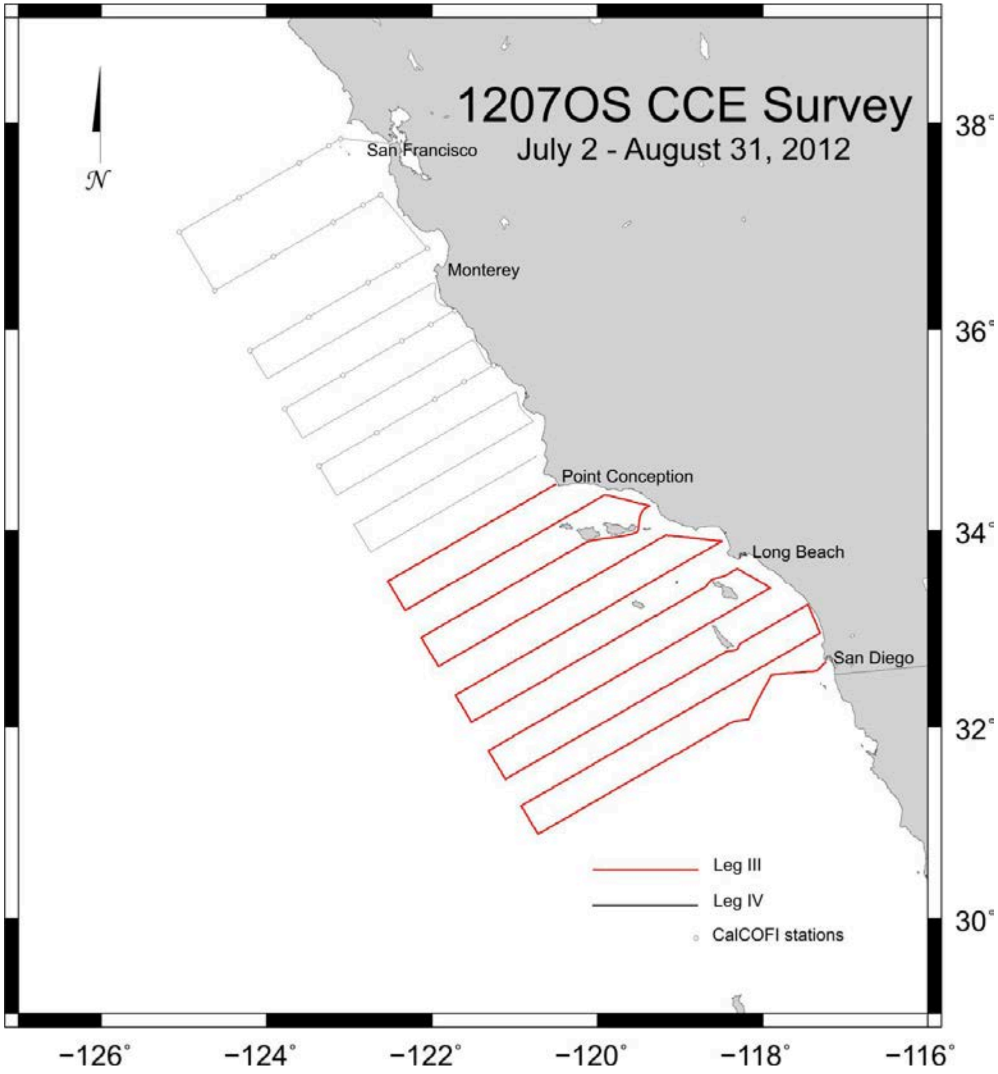



Workshop on Enhancing Stock Assessments of Pacific Sardine
in the California Current through Coordinated Comparative Surveys

May 23-24, 2011
La Jolla, California

Topic 3b. Update on Planned Summer Coastwide Tri-National Sardine Survey and combined Sardine/Hake survey of PNW and Canada, (presented San Mateo June 2012)





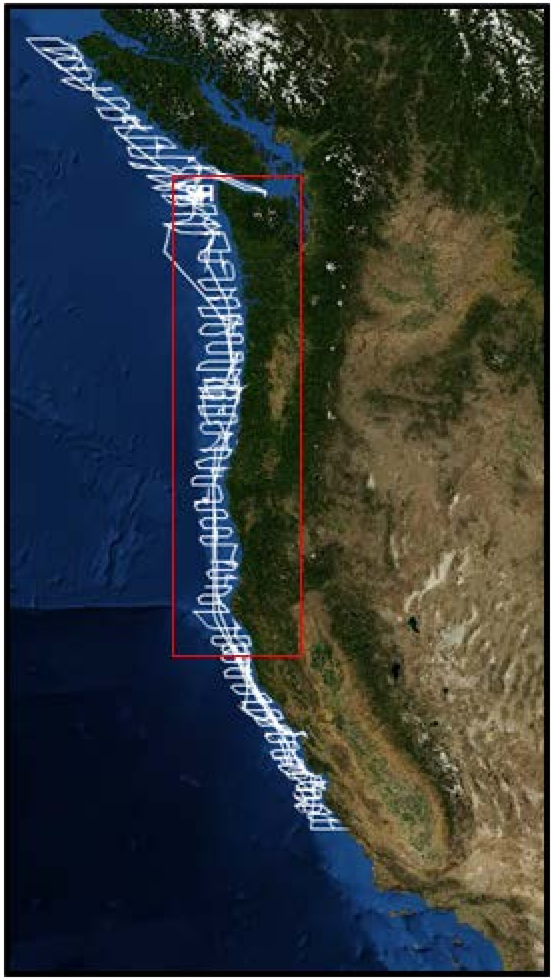
Appendix 2. . The vessel R/V *Ocean Starr* track lines for 1207OS Legs III and IV. Stations on leg III will be determined by the ship's distance covered during daylight hours:

Acoustic-trawl estimates of sardine biomass off the west coasts of the USA and Canada during summer 2012

Juan Zwolinski, David A. Demer,
Beverly J. Macewicz,
George R. Cutter Jr., Kyle A. Byers,
Josiah S. Renfree, and Thomas S. Sessions

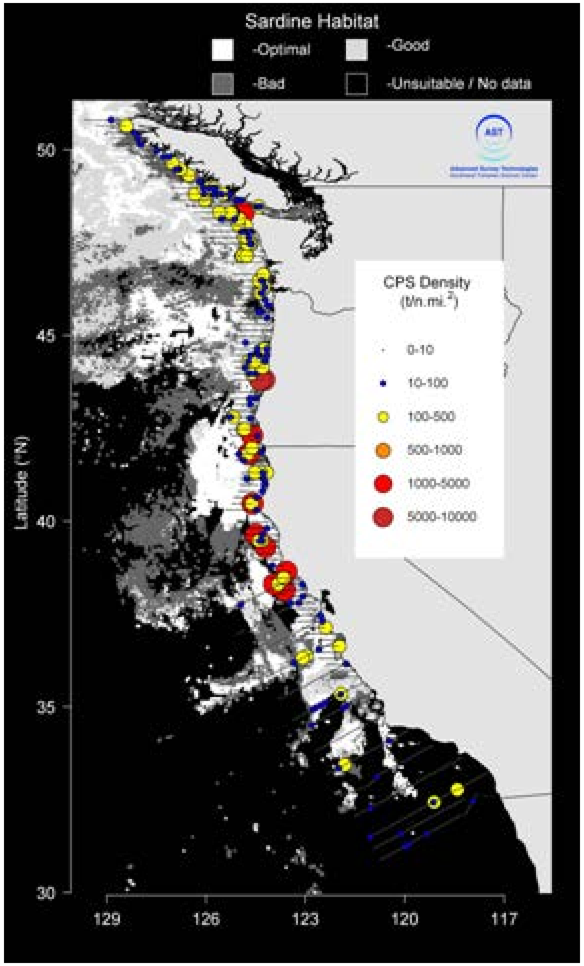
Summer 2012 Sampling

- 25 Jun–24 Aug 2012
- 85 E-W transects
  - 10-nm spacing
  - Piedras Blancas to Vancouver Island
  - 40–1500 m or 35 nm
  - 3,632 nm
  - 39,614 nm^2
  - Spanned northern stock distribution
- Acoustic and UCTD sunrise to sunset
- Trawl, CTD, Bongo, & CalVet during night
- SST, SSS, and Chl-a day and night



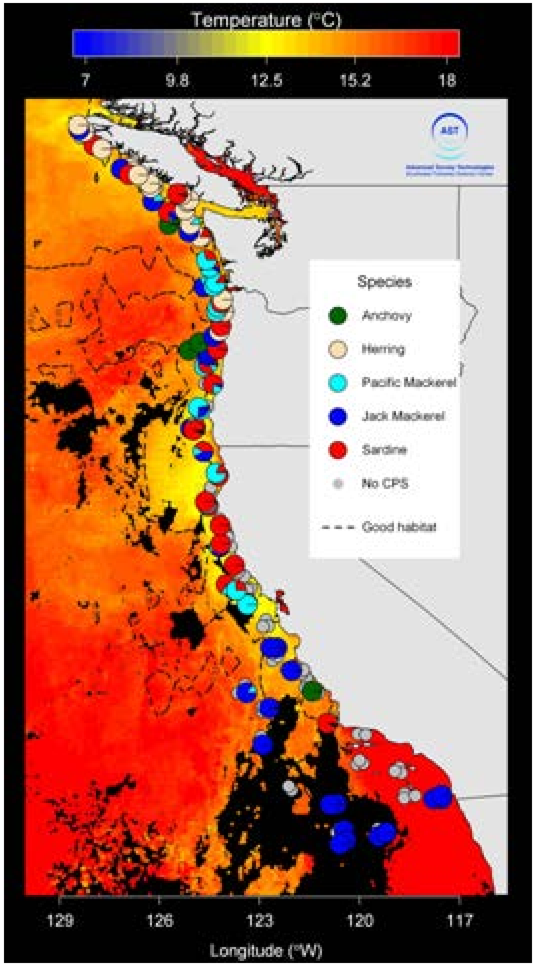
Summer 2012 Observations

- Bad sardine habitat along VI coast during August
- Relatively uniform but low CPS densities off WA and Vancouver Island
- Hot spots near Reedsport and Coos Bay, OR and the Strait of Juan de Fuca
- High CPS densities from central CA to central OR
- Low CPS densities south of Monterey (*Ocean Starr*)
- Unsuitable sardine habitat in the Southern California Bight



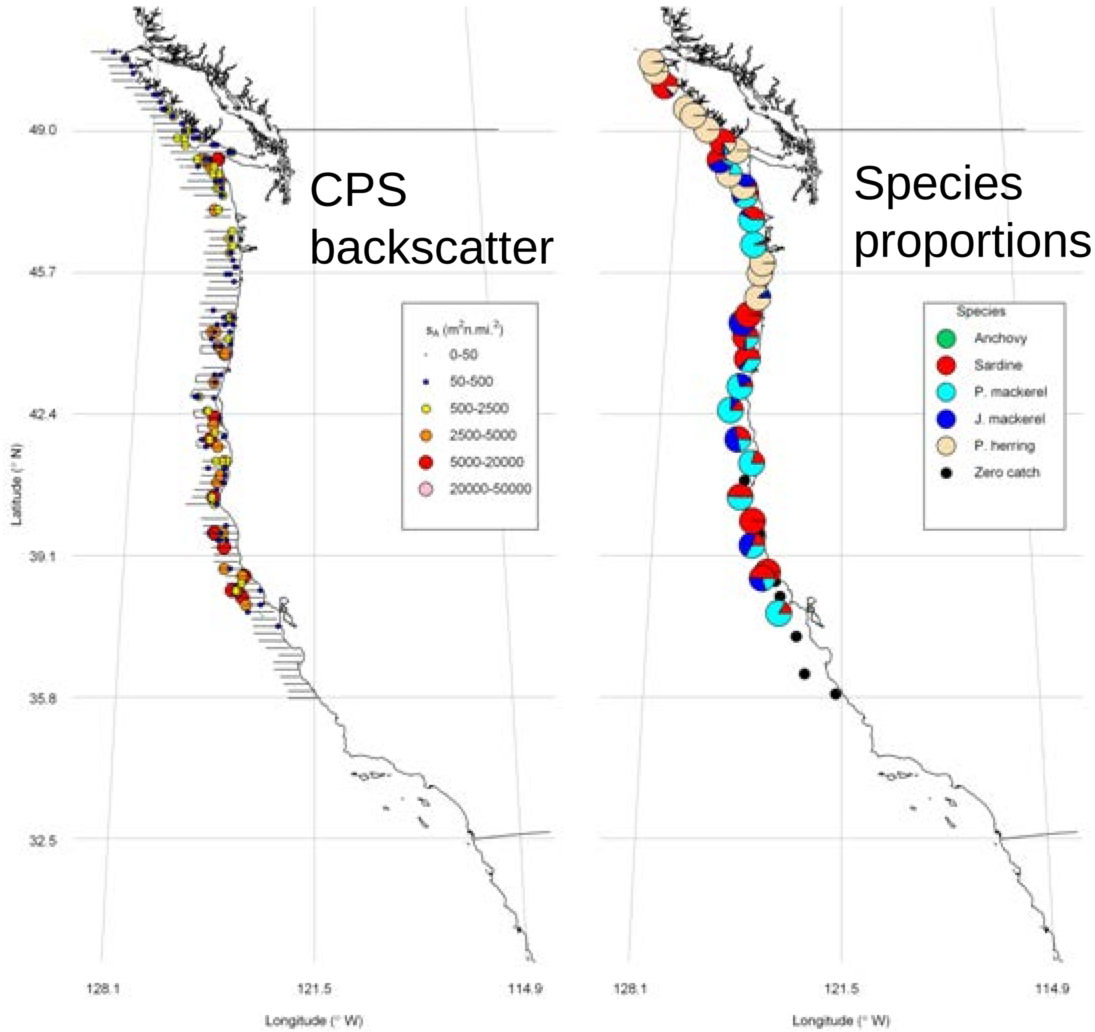
Summer 2012 Observations

- Species mixture increased with latitude
- Herring offshore of WA and Vancouver Island
- Anchovy patchy off central CA, central OR, and near the Strait of Juan de Fuca
- Sardine and Pacific mackerel mostly between central CA and central OR
- Jack mackerel mostly offshore of southern and central California



Summer 2012 ATM Processing

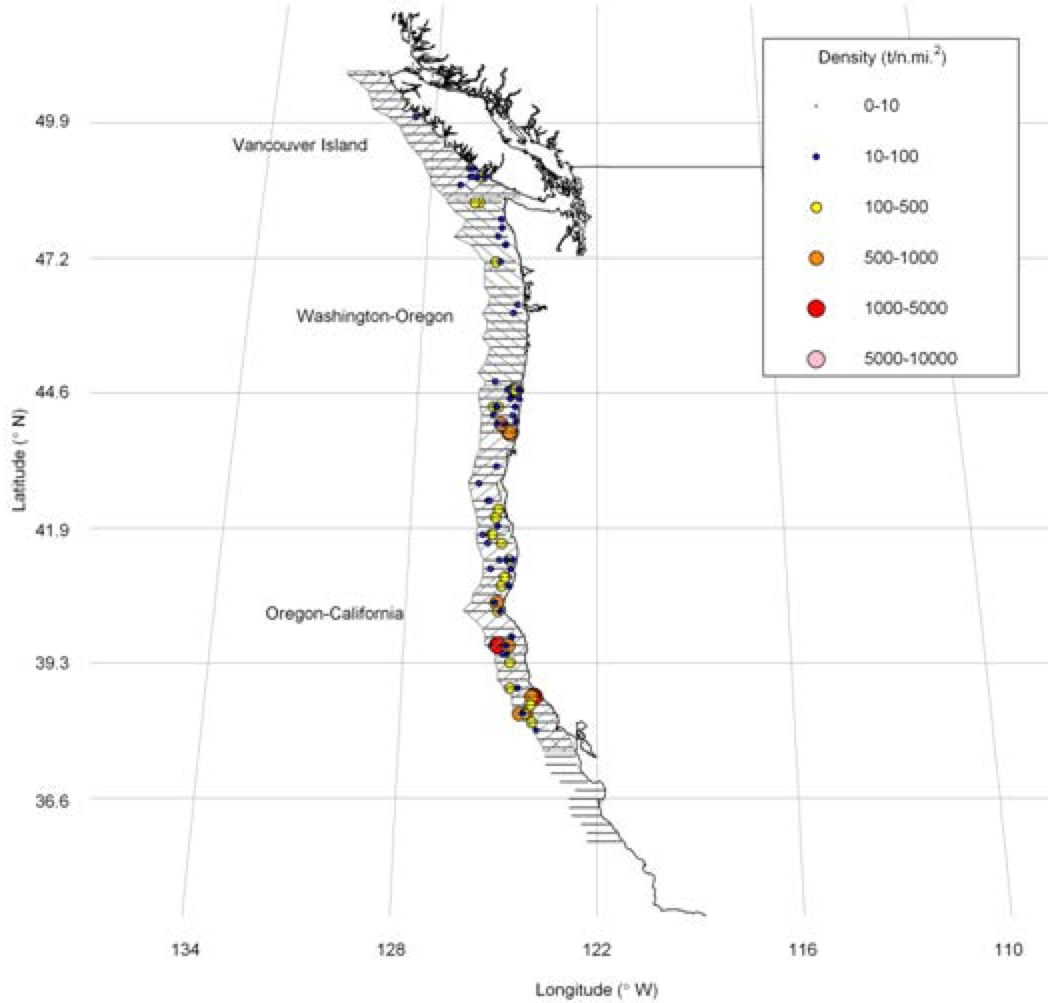
- CPS backscatter
  - Spectral match
  - < 70 m depth
- Trawl samples
  - 98 trawls
  - 31 CPS clusters
  - Sardine catches
    - Average = 274
    - Median = 7
  - Backscatter to species
  - Sardine biomass to lengths



Summer 2012 Results

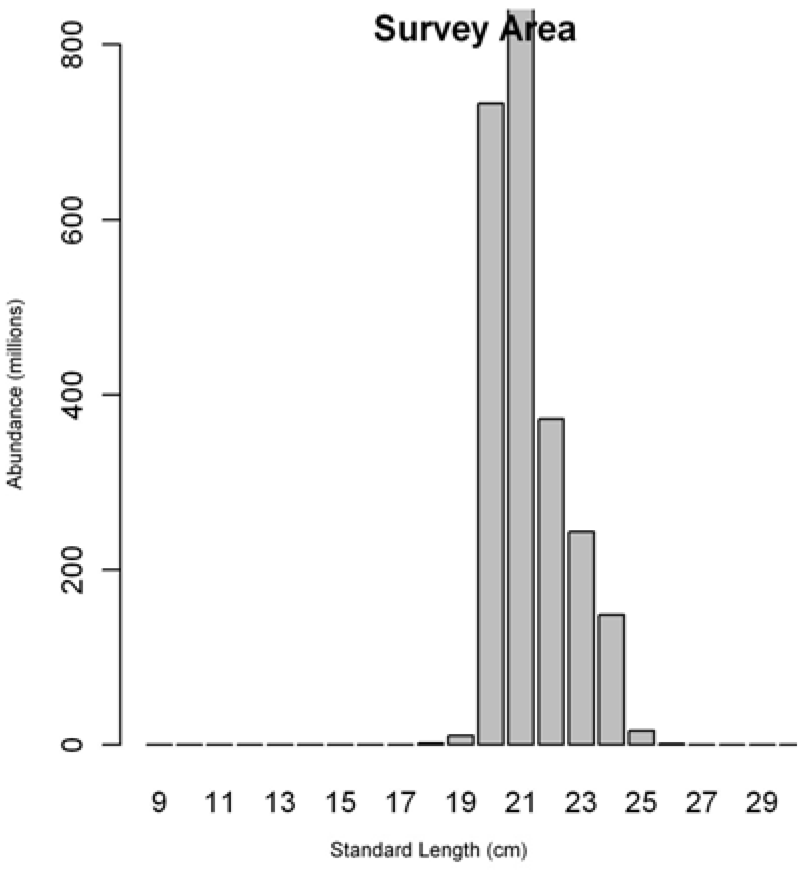
- Strata definitions
  - CPS density
  - Species composition
- Three strata
  - Vancouver Island
  - Washington-Oregon
  - Oregon-California
    - Most CPS
    - ~ 91% (0.309 Mt) of sardine stock

Sardine density ($t\ nm^{-2}$)



Summer 2012 Results

- Species and lengths
  - 31 clusters, 8,487 sardine
- Sardine biomass
  - 0.341 Mt
  - $CI_{95\%}$ = [0.188; 0.688 Mt]
  - CV = 33.4%
  - Patchy distribution
- Sardine lengths
  - Mode SL~21 cm
  - Putative 2009 cohort



Summer 2012 Results

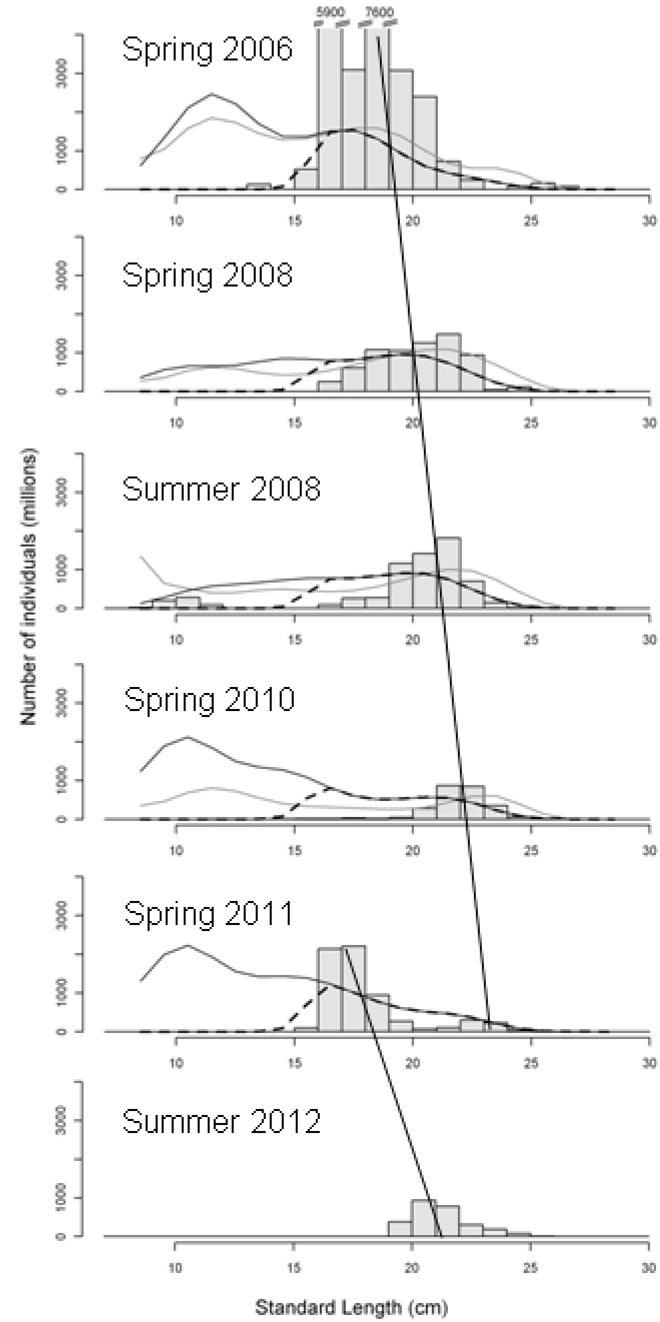
Stratum		**Transects**		**Trawls**		**Sardine**		
Name	**Area (n.mi.)**	**Number**	**Distance (n.mi.)**	**CPS clusters**	**Number of sardine**	**Biomass (Mt)**	**95% confidence interval (Mt)**	***CV***
Vancouver Island	7,370	15	698	8	1051	0.019	0.003 – 0.054	61.9
Washington -Oregon	10,832	20	915	9	3516	0.013	0.004 – 0.028	42.9
Oregon-California	17,295	39	1614	14	3920	0.309	0.151 – 0.650	37.3
Central California	4,169	11	390	0	0	0	NA	NA
Total	**39,666**	**85**	**3632**	**31**	**8487**	**0.341**	**0.188 – 0.688**	**33.4**

Successes & Compromises

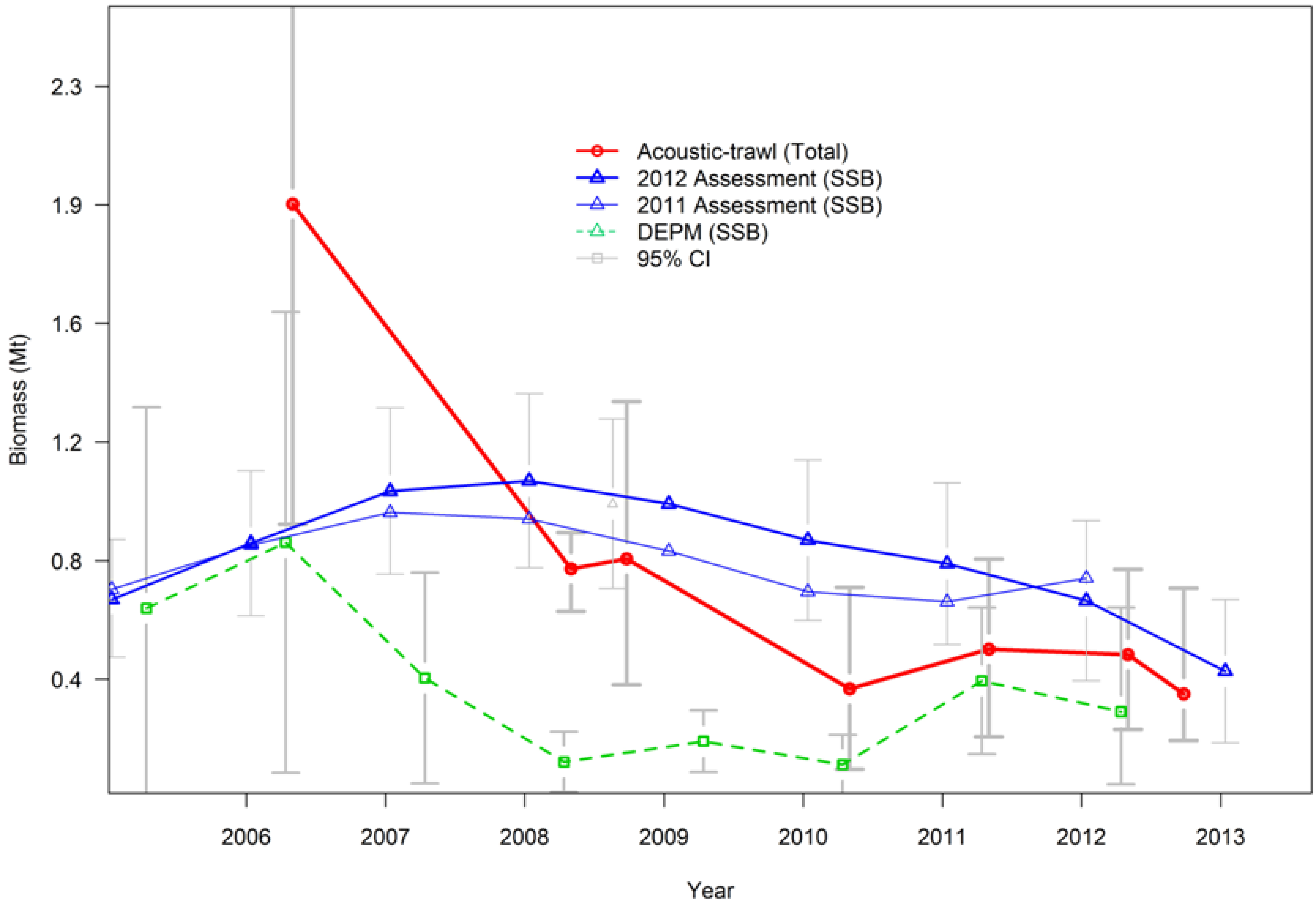
- Survey completed
- 85 transects spanned stock
- 98 surface trawls
- Some ME70
- Few CTDs, & Bongos
- No ADCP
- No CUFES / DEPM

2006-2012 Sardine Demographics

- Biomass-weighted lengths
- 2003/5 cohort 2006–2011
- 2009 cohort 2011–2012
- 2011 Assessment model demographics
- Correction for fitted selectivity assumption
- *SL*~12 cm only in summer 2008

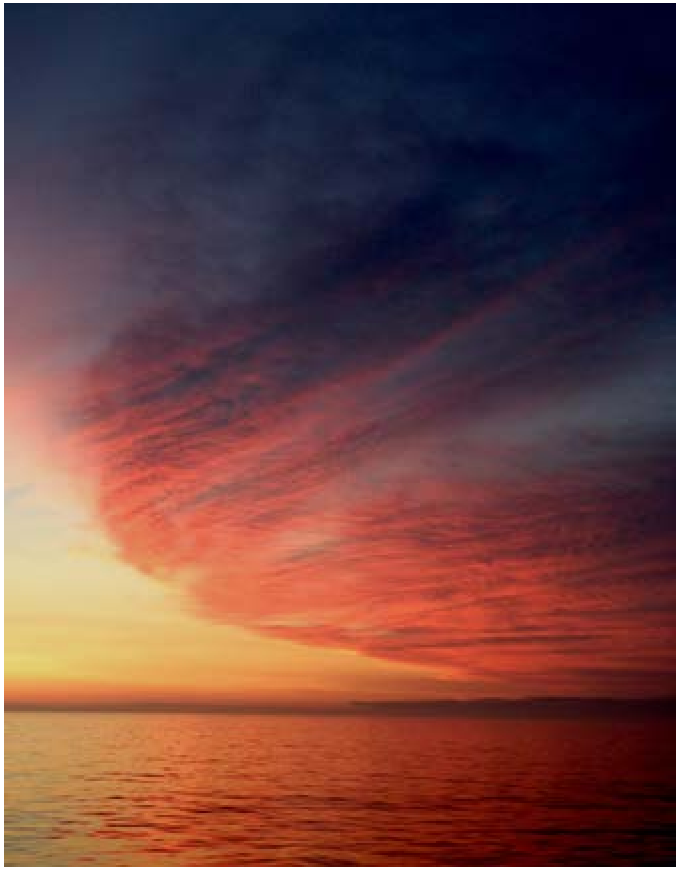


2006 – 2012 Results



Recommendations

- Increase trawl samples
- Monitor net performance
- Increase A-T sampling in the SCB and nearshore
- Increase oceanography, phytoplankton, zooplankton, and ichthyoplankton sampling
- Increase multibeam and add sonar sampling
- Telemeter acoustic data
- Incorporate fishery data



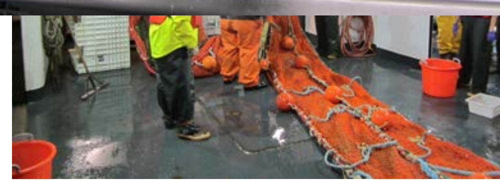












23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46

EXEMPTED FISHING PERMIT (EFP) PROCESS

The Coastal Pelagic Species (CPS) Fisheries Management Plan (FMP) allows for exempted fishing permit (EFP) activities to be conducted under a permit issued by the National Marine Fisheries Service (NMFS). However, there is currently no Council Operating Procedure (COP) outlining the process. In recent years, the Council has considered proposals to conduct EFP activities at the March and April meetings.

The proposed COP 23 calls for initial notification of proposed EFP activities at the November meeting, at the same time that sardine harvest specifications are set by the Council. In addition, it allows flexibility such that EFP research that has already been supported by the Council and conducted under a NMFS-issued EFP, could be considered in a more efficient manner.

The Council adopted a draft COP 23 for public review at the September 2012 meeting (provided as Agenda Item G.2.a, Attachment 1), and is scheduled to give final approval at the November 2012 meeting. No comments were received on the draft COP 23 as of the November Briefing Book deadline

Council Action:

1. Adopt Final EFP Process (COP 23).

Reference Materials:

1. Agenda Item G.2.a, Attachment 1: Draft Council Operating Procedure 23.

Agenda Order:

a. Agenda Item Overview — Kerry Griffin
b. Reports and Comments of Advisory Bodies and Management Entities
c. Public Comment
d. **Council Action:** Adopt Final EFP Process (Council Operating Procedure 23)

PFMC
10/16/12

23

DRAFT COUNCIL OPERATING PROCEDURE

Protocol for Consideration of Exempted Fishing Permits for Coastal Pelagic Species Fisheries

Approved by Council:

DEFINITION

An exempted fishing permit (EFP) is a one-year Federal permit, issued by the National Marine Fisheries Service, which authorizes a party to engage in an activity that is otherwise prohibited by the Magnuson-Stevens Fishery Conservation and Management Act or other fishery regulations, for the purpose of collecting limited experimental data. EFPs can be issued to Federal or state agencies, marine fish commissions, or other entities, including individuals. An EFP applicant need not be the owner or operator of the vessel(s) for which the EFP is requested. The NMFS Regional Administrator may require any level of industry-funded observer coverage for these permits.

PURPOSE

The specific objectives of the proposed exempted fishing activity may vary. The Pacific Fishery Management Council's (Council) fishery management plan (FMP) for coastal pelagic species (CPS) allows for EFPs, consistent with Federal regulations at 50 CFR§600.475. EFPs can be used to explore ways to improve stock surveys and assessments, encourage innovation and efficiency in the fisheries, or to evaluate current and proposed management measures.

GENERAL PROCESS

The Council process for considering and recommending CPS EFP proposals is an annual one that is synchronized with the decision-making process for establishing annual harvest specifications and management measures. The Council's EFP process begins at the November meeting, well in advance of EFP research that is likely to occur during the summer field season.

Any EFP proposals recommended for further consideration are typically given final consideration at the April meeting. The applicants should then submit the EFP application to the NMFS Southwest Region. Council staff will transmit the Council's recommendation directly to the NMFS Southwest Region. The Council may task the Scientific and Statistical Committee (SSC) or other advisors to do a more thorough review of refined EFP proposals that are recommended in November, prior to the April Council meeting. The CPS EFP proposal timeline is provided below. In all cases, EFP materials must be submitted prior to the briefing book deadline for the relevant Council meeting:

November Council meeting:

- Proponents of new EFP proposals (those that include new EFP research activities or research activities that are substantially different from previously-conducted EFP research) submit a preliminary proposal, consistent with Section A below, to the extent possible.
- Proponents of recurring EFP proposals (those that are substantially similar to previously-conducted EFP research) submit a letter of intent, with a copy of the final EFP proposal from the previous year. The letter of intent should specific the general timing, the amount of fish that will be requested, survey protocols, and purpose of the EFP research, along with any anticipated changes from the previous years' research.
- Council advisory bodies and the public may comment on proposals or letters of intent.

March Council meeting:

- New EFP proposals are considered by the Council and adopted for public review. Proponents submit a full proposal consistent with Section A below, and should be prepared to describe the proposal to the SSC, CPSMT, CPSAS, and the full Council.
- Council advisory bodies and the public may comment on proposals.

April Council meeting:

- Proponents of both new and recurring EFP research submit final versions of their proposals.
- The SSC, CPSMT, and CPSAS review the proposal(s) and submit a report to the Council.
- Council, Advisory Bodies, and the public may comment on proposals.
- The Council reviews the proposal(s) and takes final action regarding support for the EFP proposal.

A. Proposal Contents

1. EFP proposals must contain sufficient information for the Council to determine:
   a. There is adequate justification for an exemption to the regulations.
   b. The potential impacts of the exempted activity have been adequately identified.
   c. The exempted activity would be expected to provide information useful to management and use of CPS fishery resources.
2. Applicants must submit a completed application in writing that includes, but is not limited to, the following information:
   a. Date of application.
   b. Applicant's names, mailing addresses, and telephone numbers.
   c. A statement of the purpose and goals of the experiment for which an EFP is needed, including a general description of the arrangements for the disposition of all species harvested under the EFP.

d. Valid justification explaining why issuance of an EFP is warranted.

e. A statement of whether the proposed experimental fishing has broader significance than the applicant's individual goals.

f. A statement whether the applicant intend to continue the EFP activities for more than one year. NMFS issues EFPs for only one year at a time. However, if an EFP proposal has a multi-year focus, this information should be included in the proposal.

g. Number of vessels and processors covered under the EFP, as well as vessel names, skipper names, and vessel ID numbers and permit numbers.

h. A description of the species to be harvested under the EFP and the amount(s) of such harvest necessary to conduct the experiment; this description should include harvest estimates of impacts to non-target species.

i. A reasonable justification for the amount of EFP fish to be harvested. For statistical purposes, this could include a power analysis or other means to estimate a reasonable amount or number of fish. Any other justification that supports the amount of fish proposed for EFP activities should also be included.

j. A description of a mechanism, such as at-sea or dockside fishery monitoring, to ensure that the harvest or impact limits for targeted and incidental species are not exceeded; and are accurately accounted for and reported.

k. A description of the proposed data collection methods, including procedures to ensure and evaluate data quality during the experiment; and data analysis methodology and timeline of stages through completion.

l. A description of how vessels will be chosen to participate in the EFP.

m. For each vessel covered by the EFP, the approximate time(s) and place(s) fishing will take place, and the type, size, and amount of gear to be used.

n. The signature of the applicant.

3. The CPSMT, CPSAS, SSC, and/or Council may request additional information necessary for their consideration.

B. Review and Approval

1. Review of any proposals will include consideration the following questions:

   a. Is the application complete?

   b. Is the EFP proposal consistent with the goals and objectives of the CPS FMP?

   c. Can catch of target and impacts to non-target species be adequately monitored and reported in a timely manner?

   d. Does the EFP account for fishery mortalities, by species?

   e. Can the impact estimates of overfished and/or protected species be accommodated?

   f. Is the EFP proposal compatible with the Federal observer program effort?

g. What infrastructure is in place to monitor, process data, and administer the EFP?

h. How will achievement of the EFP objectives be measured?

i. What are the benefits to the fisheries management process?

j. If the EFP proposes to integrate the data into management, what is the appropriate process?

k. What is the funding source for catch monitoring?

l. Has there been coordination with appropriate state, tribal, and Federal enforcement, management, and science staff?

m. Are there any outstanding enforcement issues related to the proposed exempted regulation?

C. Report Contents

1. A final written report on the results of the EFP and the data collected must be presented in a timely manner, following completion of the EFP research activities.

   a. If the data collected under an EFP is intended to be used for stock assessment purposes, it must be submitted to the Stock Assessment Team in accordance with the Council's Terms of Reference for stock assessments. (Typically, this requires submitting the information at least four weeks in advance of the meeting at which the assessment will be reviewed.)

The final report should include:

a. A summary of the work completed.

b. An analysis of the data collected.

c. A description of any changes to protocols, field activities, or other changes to the EFP research.

d. Conclusions and/or recommendations.

Agenda Item G.2.b
Supplemental CPSAS Report
November 2012

COASTAL PELAGIC SPECIES ADVISORY SUBPANEL REPORT ON EXEMPTED FISHING PERMIT PROCESS

The Coastal Pelagic Species Advisory Subpanel (CPSAS) recommends that the Council adopt the revised Council Operating Procedure (COP) 23, as presented by the Coastal Pelagic Species Management Team (CPSMT), to establish an official process for CPS-related Exempted Fishing Permits (EFPs). This COP has been slightly modified from the draft COP the Council adopted for public review during the September 2012 meeting. These revisions are intended to reduce administrative time and costs, as well as the number of meetings required to review EFP proposals. This COP also better aligns procedures for approving CPS EFPs with processes currently utilized to assess EFPs under the Council's other FMPs.

PFMC
11/04/12

COASTAL PELAGIC SPECIES MANAGEMENT REPORT ON EXEMPTED FISHING PERMIT (EFP) PROCESS

At its April 2012 meeting, the Council expressed a desire for a more efficient process for considering and approving exempted fishing permit (EFP) proposals in coastal pelagic species (CPS) fisheries, and suggested a more streamlined EFP process. There is no existing Council Operating Procedure (COP) on the CPS EFP process, which has been guided by agenda planning. The EFP set-aside is typically adopted at the November meeting, with initial consideration of the EFP proposal(s) in March, and final action in April.

The CPSMT recommends that the Council adopt a two-meeting process, with preliminary consideration in November and final action in March for both ongoing and new EFP research. If deemed necessary, the Council would have the flexibility to schedule meetings at the April meeting to further consider EFP proposals.

This process allows for a more efficient consideration of EFP proposals. In addition, by requesting proposals in November, the Council will be better informed with regard to making sardine management decisions, especially with respect to decisions on an EFP set-aside.

The CPSMT recommends that the Council adopt the Draft COP 23 (Agenda Item G.2.a Attachment 1), incorporating the changes as described above. A strike-through version is appended on the following page of this report.

PFMC
11/04/12

Approved by Council:

DEFINITION

An exempted fishing permit (EFP) is a one-year Federal permit, issued by the National Marine Fisheries Service, which authorizes a party to engage in an activity that is otherwise prohibited by the Magnuson-Stevens Fishery Conservation and Management Act or other fishery regulations, for the purpose of collecting limited experimental data. EFPs can be issued to Federal or state agencies, marine fish commissions, or other entities, including individuals. An EFP applicant need not be the owner or operator of the vessel(s) for which the EFP is requested. The NMFS Regional Administrator may require any level of industry-funded observer coverage for these permits.

PURPOSE

The specific objectives of the proposed exempted fishing activity may vary. The Pacific Fishery Management Council's (Council) fishery management plan (FMP) for coastal pelagic species (CPS) allows for EFPs, consistent with Federal regulations at 50 CFR§600.475. EFPs can be used to explore ways to improve stock surveys and assessments, encourage innovation and efficiency in the fisheries, or to evaluate current and proposed management measures.

GENERAL PROCESS

The Council process for considering and recommending CPS EFP proposals is an annual one that is synchronized with the decision-making process for establishing annual harvest specifications and management measures. The Council's EFP process begins at the November meeting, well in advance of EFP research that is likely to occur during the summer field season.

Any EFP proposals recommended for further consideration are typically given final consideration at the March ~~April~~ meeting. The applicants should then submit the EFP application to the NMFS Southwest Region. Council staff will transmit the Council's recommendation directly to the NMFS Southwest Region. The Council may task the Scientific and Statistical Committee (SSC) or other advisors to do a more thorough review of specific ~~refined~~ EFP proposals ~~that are recommended in November~~, prior to the March ~~April~~ Council meeting. The CPS EFP proposal timeline is provided below. In all cases, EFP materials must be submitted prior to the briefing book deadline for the relevant Council meeting:

November Council meeting:

- Proponents of new EFP proposals (those that include new EFP research activities or research activities that are substantially different from previously-conducted EFP research) submit a full ~~preliminary~~ proposal, consistent with Section A below, ~~to the extent possible~~ and should be prepared to describe the proposal to the SSC, CPSMT, CPSAS, and the full Council. New EFP proposals are considered by the Council and may be adopted for public review.

- Proponents of recurring EFP proposals (those that are substantially similar to previously-conducted EFP research) submit a letter of intent, with a copy of the final EFP proposal from the previous year. The letter of intent should specific the general timing, the amount of fish that will be requested, survey protocols, and purpose of the EFP research, along with any anticipated changes from the previous years' research.
- Council advisory bodies and the public may comment on proposals ~~or letters of intent~~.

March Council meeting:

- Proponents of both new and recurring EFP research submit final versions of their proposals.
- The SSC, CPSMT, and CPSAS review the proposal(s) and submit a report to Council.
- ~~New EFP proposals are considered by the Council and adopted for public review. Proponents submit a full proposal consistent with Section A below, and should be prepared to describe the proposal to the SSC, CPSMT, CPSAS, and the full Council.~~
- Council advisory bodies and the public may comment on proposals.
- The Council reviews the proposal(s) and takes final action regarding support for the EFP proposal.

April Council meeting:

- As needed
- ~~Proponents of both new and recurring EFP research submit final versions of their proposals.~~
- ~~The SSC, CPSMT, and CPSAS review the proposal(s) and submit a report to the Council.~~
- ~~Council, Advisory Bodies, and the public may comment on proposals.~~
- ~~The Council reviews the proposal(s) and takes final action regarding support for the EFP proposal.~~

A. Proposal Contents

1. EFP proposals must contain sufficient information for the Council to determine:
   a. There is adequate justification for an exemption to the regulations.
   b. The potential impacts of the exempted activity have been adequately identified.
   c. The exempted activity would be expected to provide information useful to management and use of CPS fishery resources.
2. Applicants must submit a completed application in writing that includes, but is not limited to, the following information:
   a. Date of application.

   b. Applicant's names, mailing addresses, and telephone numbers.

   c. A statement of the purpose and goals of the experiment for which an EFP is needed, including a general description of the arrangements for the disposition of all species harvested under the EFP.

   d. Valid justification explaining why issuance of an EFP is warranted.

   e. A statement of whether the proposed experimental fishing has broader significance than the applicant's individual goals.

   f. A statement whether the applicant intend to continue the EFP activities for more than one year. NMFS issues EFPs for only one year at a time. However, if an EFP proposal has a multi-year focus, this information should be included in the proposal.

   g. Number of vessels and processors covered under the EFP, as well as vessel names, skipper names, and vessel ID numbers and permit numbers.

   h. A description of the species to be harvested under the EFP and the amount(s) of such harvest necessary to conduct the experiment; this description should include harvest estimates of impacts to non-target species.

   i. A reasonable justification for the amount of EFP fish to be harvested. For statistical purposes, this could include a power analysis or other means to estimate a reasonable amount or number of fish. Any other justification that supports the amount of fish proposed for EFP activities should also be included.

   j. A description of a mechanism, such as at-sea or dockside fishery monitoring, to ensure that the harvest or impact limits for targeted and incidental species are not exceeded; and are accurately accounted for and reported.

   k. A description of the proposed data collection methods, including procedures to ensure and evaluate data quality during the experiment; and data analysis methodology and timeline of stages through completion.

   l. A description of how vessels will be chosen to participate in the EFP.

   m. For each vessel covered by the EFP, the approximate time(s) and place(s) fishing will take place, and the type, size, and amount of gear to be used.

   n. The signature of the applicant.

3. The CPSMT, CPSAS, SSC, and/or Council may request additional information necessary for their consideration.

B. Review and Approval

1. Review of any proposals will include, but are not limited to, consideration the following questions:

   a. Is the application complete?

   b. Is the EFP proposal consistent with the goals and objectives of the CPS FMP?

c. Can catch of target and impacts to non-target species be adequately monitored and reported in a timely manner?

d. Does the EFP account for fishery mortalities, by species?

e. Can the impact estimates of overfished and/or protected species be accommodated?

f. Is the EFP proposal compatible with the Federal observer program effort?

g. What infrastructure is in place to monitor, process data, and administer the EFP?

h. How will achievement of the EFP objectives be measured?

i. What are the benefits to the fisheries management process?

j. If the EFP proposes to integrate the data into management, what is the appropriate process?

k. What is the funding source for catch monitoring?

l. Has there been coordination with appropriate state, tribal, and Federal enforcement, management, and science staff?

m. Are there any outstanding enforcement issues related to the proposed exempted regulation?

n. <u>Is the tonnage request appropriate?</u>

C. Report Contents

1. A final written report on the results of the EFP and the data collected must be presented in a timely manner, following completion of the EFP research activities.

    a. If the data collected under an EFP is intended to be used for stock assessment purposes, it must be submitted to the Stock Assessment Team in accordance with the Council's Terms of Reference for stock assessments. (Typically, this requires submitting the information at least four weeks in advance of the meeting at which the assessment will be reviewed.)

The final report should include:

a. A summary of the work completed.

b. An analysis of the data collected.

c. A description of any changes to protocols, field activities, or other changes to the EFP research.

d. Conclusions and/or recommendations.

SCIENTIFC AND STATISTICAL COMMITTEE REPORT ON EXEMPTED FISHING PERMIT (EFP) PROCESS

The Scientific and Statistical Committee (SSC) reviewed the draft Council Operating Procedure (COP) "Exempted Fishing Permit (EFP) Process" for coastal pelagic species (Agenda Item G.2) which allows for EFPs to be issued by National Marine Fisheries Service. The following modifications to the COP are recommended by the SSC.

The Review and Approval Process section should include an evaluation of the justification for the amount of fish requested.

Recurring EFPs should be reviewed for scientific content every few years to determine whether the information produced by those projects prove useful in long-term improvement of fishery management.

A process needs to be developed to assure that "substantially similar" recurring EFP proposals are adequately similar to the previous year's research. To qualify for an expedited EFP, it should, at a minimum, be similar in sample design, methods for determining sample sizes, and sampling and quantitative methods. The Coastal Pelagic Species Management Team should take the lead on this evaluation.

11/03/12

PACIFIC SARDINE STOCK ASSESSMENT AND MANAGEMENT FOR 2013, INCLUDING PRELIMINARY EFP PROPOSALS AND TRIBAL SET-ASIDE

At this meeting, the Council will hear a report on the 2012 Pacific sardine stock assessment update, adopt harvest specifications and management measures for the 2013 Pacific sardine fishing season, consider a preliminary notice of intent to conduct exempted fishing permit (EFP) research, and will consider a sardine survey for potential inclusion in future stock assessments.

In October 2012, the National Marine Fisheries Service (NMFS) Southwest Fisheries Science Center (SWFSC) produced an updated stock assessment for Pacific sardine. The assessment was reviewed in early October by members of the Scientific and Statistical Committee's (SSC) Coastal Pelagic Species (CPS) subcommittee, which reported to the full SSC. Full assessments for CPS stocks typically occur every two to three years, with updates conducted in the intervening years, based on the same methodology and assessment protocols used for the previous full assessment. The Executive Summary of the 2012 assessment update is included as Agenda Item G.3.b, Assessment Report. The full report will be available electronically as Agenda Item G.3.b, Supplemental Assessment Report 2. The 2012 assessment update utilized new abundance data from four indices of relative abundance: the SWFSC's daily and total egg production estimates of spawning biomass off California, the industry-led aerial sardine survey (Agenda Item G.3.a, Attachment 6), and acoustic-trawl method (ATM) estimates of biomass along the west coast. The ATM estimates used survey data from the SWFSC's spring and summer surveys. The summer survey was a joint hake-sardine coastwide research cruise, covering the entire west coast from the Mexico border to the northern tip of Vancouver Island. In October 2012, the results of the surveys and the full stock assessment were reviewed.

At the November Council meeting, the SSC will review the Pacific sardine assessment and make an overfishing limit (OFL) recommendation on which to base management measures. The Council will consider a range of acceptable biological catch (ABC) levels associated with various P* (risk of overfishing) alternatives, and will establish harvest measures, including an annual catch limit (ACL) and an annual catch target (ACT). In making these decisions, the Council should consider the Quinault request for a sardine harvest allocation (Agenda Item G.3.a, Attachment 1), and the Northwest Aerial Sardine Survey, LLC notice of intent to conduct EFP research (Agenda Item G.3.a, Attachment 2). The prior year's EFP application is also included electronically (Agenda Item G.3.a, Attachment 3).

Finally, the Council will consider the West Coast Vancouver Island (WCVI) Trawl Sardine Survey for use in future stock assessments (Agenda Item G.3.a Attachment 4). The WCVI survey was reviewed by a methodology review panel in May 2012 (Agenda Item G.3.a, Attachment 5).

<u>Council Action</u>:

1. Approve the Pacific Sardine Assessment and Pacific sardine OFL.

2. **Select P*, ABC, ACL and, if appropriate, ACT Specifications and Management Measures; Including Consideration of a Quinault Tribal Allocation, and EFP proposals.**
3. **Consider Approving the WCVI Survey for Use in Future Stock Assessment.**

Reference Materials:

1. Agenda Item G.3.a, Attachment 1: Letter from Ed Johnstone, Quinault Fisheries Policy Spokesperson, regarding the Quinault Indian Nation's intent to establish a tribal allocation and to participate in the 2013 Pacific sardine fishery.
2. Agenda Item G.3.a, Attachment 2: Notice of Intent to conduct EFP research, from Northwest Sardine Survey, LLC.
3. Agenda Item G.3.a, Attachment 3: Final EFP proposal for 2012 activities, from Northwest Sardine Survey, LLC. ***(Electronic only)***
4. Agenda Item G.3.a, Attachment 4: West Coast Vancouver Island (WCVI) Swept Area Trawl Survey Methodology. ***(Electronic only)***
5. Agenda Item G.3.a, Attachment 5: WCVI Methodology Review Panel Report.
6. Agenda Item G.3.a, Attachment 6: Northwest Aerial Sardine Survey – Sampling Results in 2012. **(*Electronic only*)**
7. Agenda Item G.3.b, Assessment Report: *Executive Summary*, *Assessment of the Pacific Sardine Resource in 2012 for U.S. Management in 2013.*
8. Agenda Item G.3.b, Supplemental Assessment Report 2: *Assessment of the Pacific Sardine Resource in 2012 for U.S. Management in 2013.* ***(Electronic only)***
9. Agenda Item G.3.d, Public Comment.

Agenda Order:

a. Agenda Item Overview — Kerry Griffin
b. Survey and Assessment Report — Kevin Hill
c. Reports and Comments of Advisory Bodies and Management Entities
d. Public Comment
e. **Council Action**: Approve West Coast Vancouver Island Survey for use in Future Stock Assessments; Review any Preliminary Proposals or Notice of Intent for EFPs in 2013; Adopt Final Pacific Sardine Stock Assessment and 2013 Management Measures.

PFMC
10/17/12

Quinault Indian Nation

POST OFFICE BOX 189 • TAHOLAH, WASHINGTON 98587 • TELEPHONE (360) 276-8211

September 12, 2012

Mr. Rod McInnis
Regional Administrator
Southwest Region, NMFS
501 W. Ocean Blvd. Suite 4200
Long Beach, CA 90802

Dear Mr. McInnis,

Per Title 50 of the Code of Federal Regulations (CFR), part 660, the Quinault Indian Nation intends to again exercise its treaty right to enter into the Pacific Sardine fishery in 2013.

§ 660.518 **Pacific Coast Treaty Indian Rights**
(a) Pacific Coast treaty Indian tribes have treaty rights to harvest CPS in their usual and accustomed fishing areas in U.S. waters.
(b) For the purposes of this section, "Pacific Coast treaty Indian tribes" and their "usual and accustomed fishing areas" are described at §660.324(b) and (c). **[NOTE: the updated, current citation for the "usual and accustomed fishing areas" is § 660.50(c)]**
(c) Boundaries of a tribe's fishing area may be revised as ordered by a Federal court.
(d) *Procedures.* The rights referred to in paragraph (a) of this section will be implemented in accordance with the procedures and requirements of the framework contained in Amendment 9 to the FMP and in this Subpart.
(1) The Secretary, after consideration of the tribal request, the recommendation of the Council, and the comments of the public, will implement Indian fishing rights.
(2) The rights will be implemented either through an allocation of fish that will be managed by the tribes or through regulations that will apply specifically to the tribal fisheries.
(3) An allocation or a regulation specific to the tribes shall be initiated by a written request from a Pacific Coast treaty Indian tribe to the NMFS Southwest Regional Administrator at least 120 days prior to the start of the fishing season as specified at §660.510 and will be subject to public review according to the procedures in §660.508(d).
(4) The Regional Administrator will announce the annual tribal allocation at the same time as the annual specifications.
(e) The Secretary recognizes the sovereign status and co-manager role of Indian tribes over shared Federal and tribal fishery resources. Accordingly, the Secretary will develop tribal allocations and regulations in consultation with the affected tribe(s) and, insofar as possible, with tribal consensus.
[66 FR 44987, Aug. 27, 2001]

Accordingly, Quinault anticipates a total of three treaty fishing vessels participating in the 2013 Sardine Fishery. At this time Quinault seeks 3,000 metric tonnes per vessel for a total of 9,000 metric tonnes to meet the needs of our fishers. However, this does not set precedent for determination of our treaty share of Pacific Sardines in the Quinault Indian Nation's Usual and Accustomed (U&A) marine fishing area which we believe to be 50% of the harvestable tonnage of fish available in any given year in our U&A. We anticipate the majority of our harvest will occur in the late summer and fall of 2013.

The Quinault Department of Fisheries will regulate our fishery and we look forward to working with NMFS to facilitate our entry into the Sardine fishery in an orderly manner consistent with Pacific Fisheries Management Council (PFMC) and NMFS management. We thank you for your assistance and stand ready to answer any questions you may have. Please contact me directly if you need further information at 360-276-8215 ext. 368.

Sincerely,

Ed Johnstone

Ed Johnstone,
Quinault Fisheries Policy Spokesperson

c.c. Dan Wolford, Chair, Pacific Fisheries Management Council
Phil Anderson, Director, Washington Department of Fish and Wildlife
Mark Helvey, Asst. Regional Administrator for Sustainable Fisheries
Judson Feder, Regional Counsel, Southwest Region

NOTICE OF INTENT TO CONDUCT EXEMPTED FISHING PERMIT ACTIVITIES

Northwest Sardine Survey, LLC
c/o Astoria Holdings
12 Bellweather Way, Suite 209
Bellingham, WA 98225

Dr. Donald McIssac
Executive Director
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, OR 97220

October 4, 2012

Dear Dr. McIssac:

As you know, the Northwest Sardine Survey, LLC has conducted an aerial sardine survey under exempted fishing permits (EFPs), approved by PFMC (Council) and granted by the National Marine Fisheries Service (NMFS), in recent years (2009, 2011, and 2012). This work has been used in stock assessments of Pacific sardine, to inform fisheries management.

We understand that the Council now has a streamlined process for reviewing recurring proposals; specifically: *"Proponents of* *recurring EFP proposals* *(those that are substantially similar to previously-conducted EFP research) submit a letter of intent, with a copy of the final EFP proposal from the previous year. The letter of intent should specific the general timing, the amount of fish that will be requested, survey protocols, and purpose of the EFP research, along with any anticipated changes from the previous years' research."* (Draft Council COP No. 23).

Please consider this our letter of intent to request an EFP to conduct the aerial sardine survey again in 2013. The timing, requested amount of fish (3000 mt), and survey protocols will be essentially the same as in 2012. A copy of our 2012 EFP application is attached.

Thank you for your consideration.

Sincerely,

Jerry Thon,
Principal, NWSS LLC

West Coast Aerial Sardine Survey

2012

Application for Exempted Fishing Permit

Applicant:

Northwest Sardine Survey, LLC
(Jerry Thon, Principal)

Science Advisor:

Tom Jagielo
Tom Jagielo, Consulting

Scientific Field Leader:

Ryan Howe

June 6, 2012

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I. 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.

To meet this need, an aerial survey methodology was developed and successfully tested in 2008 by the Northwest Sardine Survey (NWSS), an industry group based in the Pacific Northwest (Wespestad et al. 2009). A stock assessment review (STAR) panel approved the approach in May 2009, and an EFP application was submitted jointly by NWSS and the California Wetfish Producers Association (CWPA) to conduct a coastwide aerial sardine survey. Following approvals by PFMC and NMFS, work conducted under the 2009 sardine EFP resulted in a survey that extended from Cape Flattery, WA to Monterey Bay, CA (Jagielo et al. 2009). The results from that survey were reviewed by a STAR panel in September 2009 and were approved for use in the 2009 Pacific sardine stock assessment that was used for harvest management in 2010.

Subsequently, EFP applications were approved for aerial surveys conducted in 2010 (Cape Flattery through the California Bight – NWSS and CWPA) and in 2011 (Cape Flattery to the Oregon/California border - NWSS) (Jagielo et al 2010, 2011). Results from these surveys were approved by STAR panels and were used to inform the stock assessments used for management in 2011 and 2012.

The present EFP application is for survey work proposed by NWSS in 2012. As is 2011, the survey proposed for 2012 extends from Cape Flattery to the Oregon/California border and uses the same methodology employed by the previous aerial surveys (2009-2011). The purpose of this application is to document how the proposed survey meets the NMFS requirements for the approval of a Coastal Pelagic Species (CPS) EFP. Specifically, it provides: 1) the scientific study design, analytical methodologies, and a description of the overall logistics (in the main document that follows), 2) a detailed Field Operational Plan (Appendix I), and 3) a point by point discussion of how this EFP application follows the NMFS guidelines for preparation of an EFP application (Appendix II).

At its April 2012 meeting, the PFMC, approved the application as submitted by the NWSS. ***The NWSS now seeks NMFS approval in order to obtain access to 3,000 mt of sardine which is requested to be withheld from the directed fishery management measures for the West Coast sardine OY for the purpose of funding and conducting the survey in 2012.*** The request of 3,000 mt of sardine in 2012 represents an increase of 300 mt over that requested by NWSS in 2011. The additional amount of EFP sardine will potentially provide 1) increased funding to allow for a fourth survey airplane to conduct the aerial survey transects planned for 2012 in a timely manner, and 2) an increased sample size of point sets to help reduce the variance of the survey biomass estimate.

The NWSS-LLC will conduct aerial survey work and point sets from the Canadian border to the Oregon-California border (survey area). Additional aerial survey work may be conducted in Canada if approval is obtained from the Canadian government.

Scientific oversight for the Aerial Sardine Survey will be provided again by Mr. Tom Jagielo. Mr. Jagielo will have the primary responsibility to analyze the survey data and will report the results to Dr. Kevin Hill, National Marine Fisheries Service (NMFS), Southwest Fisheries Science Center (SFSC), in a form suitable for input to the stock assessment model. Mr. Ryan Howe will be responsible for oversight of scientific sampling in the field. Mr. Jerry Thon (NWSS) will oversee the day to day logistic activities of the survey, including deployment of vessels and aircraft as needed to accomplish the projects objectives. Mr. Chris Cearns (NWSS) will serve as the West Coast Aerial Survey project Single Point of Contact (SPC), to comply with NMFS reporting requirements for the survey.

II. Survey Design

The aerial sardine survey employs a two-stage sampling design. Stage 1 consists of aerial transect sampling to estimate the surface area (and ultimately the biomass) of individual sardine schools from quantitative aerial photogrammetry. Stage 2 involves at-sea sampling to quantify the relationship between individual school surface area and biomass. Sampling will be conducted in July (following closure of the directed fishery), through August, and potentially into early September of 2012. Logistical details of the survey are provided in Appendix I (West Coast Aerial Sardine Survey - 2012 Field Operational Plan).

Stage 1: Aerial Transect Survey

Logistics

The 2012 aerial survey employs the belt transect method using a systematic random sampling design; with each transect comprising a single sampling unit (Elzinga et al. 2001). Parallel transects will be conducted in an east-west orientation, generally parallel to the onshore-offshore gradient of sardine schools distributed along the coast.

Sampling in 2012 will again be conducted with different transect spacing in two separate strata. In the northern portion of the survey area (From Cape Flattery, WA southward to approximately Tillamook, OR), 31 transects are spaced 7.5 nautical miles apart. For the southern portion of the survey area (southward to the Oregon-California border) an additional 10 transects are spaced 15 nautical miles apart. In previous years (2009-2010) we found that the southern area accounted for only 1% of the sardine surface area measured; and in 2011, we found no sardine schools on transects in the southern area. While it is possible that sampling only the northern stratum could result in improved efficiency, continued sampling of the southern stratum will aid in the documentation of inter-annual variability in the southward spatial distribution of sardine in the northwest.

Three alternative fixed starting points five miles apart were established, and from these points, three sets of 41 transects were delineated for the survey. The order of conducting the three replicate sets will be chosen by randomly picking one set at a time without replacement. The east and west endpoints of each transect and corresponding shoreline position are given in Appendix I, Tables 1a-f and are mapped in Appendix I, Figures 1a-c for each of the three replicates (Set A, Set B, and Set C, respectively). Transects start at 3 miles from shore and extend westward for 35 statute miles in length. In addition to the 35 statute mile transect, the 3 statute mile segment directly eastward of each transect to the shore will be flown and photographed. Survey biomass will be estimated from the 35 statute mile transect data. Photographs from the shoreward segment will be used primarily to evaluate the potential need for future modification of the survey design.

Details regarding the airplanes and pilots participating in the survey, a description of the order in which transects will be flown to avoid "double counting", and other operational specifics are described in Appendix I.

Data Collection and Reduction

Each survey plane will be equipped with the same photogrammetric aerial digital camera mounting and data acquisition system that was used from 2009-2011 in the previous aerial surveys (Aerial Imaging Solutions; Appendix I, Adjunct 1). This integrated system will again be used to acquire digital images and to log transect data. The system records altitude, GPS position, and spotter observations, which are directly linked to the time stamped quantitative digital imagery. At the nominal survey altitude of 4,000 feet, the approximate width-swept by the camera with a 24 mm lens is 1,829 m (1.13 mi). Digital images will be collected with 80% overlap to ensure seamless photogrammetric coverage along transects.

A Transect Flight Log Form will be kept during the sampling of each transect for the purpose of documenting the observations of the pilot (Appendix I, Adjunct 2). Key notations will include 1) observations of school species identified and 2) documentation of any special conditions that could have an influence on interpreting the photographs.

In order to provide ground truth information and a cross comparison between survey aircraft, digital imagery of certain land-based features of known size (e.g., an airplane hangar, a football field, or a set of tennis courts) will again be collected at a series of altitudes ranging from 1,000 ft. to 4,000 ft. The observed vs. actual sizes of the objects will subsequently be compared to validate camera performance and to evaluate photogrammetric error.

Digital images from the survey will be analyzed to determine the number, size, and shape of sardine schools on each transect. Adobe *Photoshop Lightroom 3.0* software will be used to make the sardine schools visible. Measurements of sardine school size (m^2) and shape (circularity) will be made using Adobe *Photoshop CS5-Extended* software.

Transect readability will be scored for each transect analyzed. In the event that we are able to collect more than one set of transects in 2012 (it was only possible to complete one set in 2011), this procedure will be used to determine which transect set reflects the best (most clearly readable) sampling of the survey area.

Transect width will be 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 will be obtained by taking the average of *GCS* for all images collected on transect. Transect length will be obtained from the distance between start and stop endpoints using the GPS data logged by the data acquisition system.

Data Analysis

Estimation of total sardine biomass for the survey area will be accomplished in a 3 step process, requiring: 1) measurement of individual school surface area on sampled transects, 2) estimation of individual school biomass (from measured school surface area and estimated school density), and 3) transect sampling design theory for estimation of a population total.

Individual school surface area (a_i) will be measured on the photo-documented transects using the measurement tool feature of *Adobe Photoshop*, employing the photogrammetric relationships described above. Individual school density (d_i) is specific to school size and will be determined from the empirical relationship between surface area and biomass obtained from Stage 2 (point-set) sampling (described below). Individual school biomass

(b_i) is estimated as the product of school density and surface area ($b_i = d_i a_i$). The sum of individual school biomass (b_u) will then be determined for each transect (*u*). The mean sampled biomass for the study area ($\bar{b}$) is computed as:

$$\bar{b} = \frac{\sum_{u=1}^{n} b_u}{n}.$$

Total biomass for the study area ($\hat{B}$) will be estimated using the unbiased estimator for a population total (Stehman and Salzer 2000),

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

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

Individual School Biomass

The biomass of individual schools observed on the transects (b_i) will be 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 will be 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) is 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 will again be obtained by employing a bootstrapping procedure implemented with the R statistical programming language (Jagielo et al. 2011). The intent of the procedure is to propagate error from the point of school density estimation forward -- to the ultimate goal of total biomass estimation from the transect data.

Stage 2: At-Sea Point Set Sampling

Logistics

Empirical measurements of biomass will be obtained by conducting research hauls or “point sets” at sea. Point sets are 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 (Figure 1). Up to four purse seine vessels will participate in the survey under the direction of Mr. Thon. The identification and gear configuration of the participating vessels is given in Appendix I, Adjunct 3.

For the purposes of the aerial survey, a valid point set is defined as a sardine school that is: 1) first identified and quantitatively photographed by a survey pilot, and 2) subsequently captured in its entirety and landed by a survey purse seine vessel. The criteria that will be used for determining the acceptability of point sets for the school density analysis are given in Appendix I, Adjunct 4.

The point set sampling design is 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 is representative of schools found on the transects (to the extent logistically possible given operational constraints). Point sets will generally not be 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 are planned for 2012 (Appendix I; Table 2, page 12). Point sets will be distributed spatially throughout the area of sardine abundance, as observed on survey transects. In 2011 we improved the spatial distribution of point sets compared to previous surveys (Figure 2); however, we can do incrementally better by obtaining point sets further northward in 2012.

A new federal regulation restricts low altitude flights over specified zones within national marine sanctuaries. The Olympic Coast National Marine Sanctuary (OCNMS) is located within the proposed aerial sardine survey area. At the OCNMS, flights below 2000 feet are prohibited within one nautical mile of Flattery Rocks, Quillayute Needles, or Copalis National Wildlife Refuge, or within one nautical mile seaward from the coastal boundary of the sanctuary (Federal Register 2012). We do not anticipate the need to conduct point sets in these specified zones, so this minimum altitude restriction should not pose a constraint to survey operations.

For 2012 we propose to remove the constraint that point sets must be flown at the same altitude used for transect sampling. This constraint was originally recommended during an early STAR panel methodology review (PFMC 2009), as a means to validate species identification of schools photographed on transects. Subsequently, with three years of survey experience and 88 point sets completed at the nominal transect altitude of 4,000 ft, we have observed a point set species misidentification rate of zero. Unfavorable weather conditions have often resulted in ceiling altitudes well below 4,000 ft. during the brief time period allotted for the survey, and the number of workable days for conducting point sets has been negatively impacted. Relaxing the point set altitude constraint will enable us to better achieve other sampling objectives, including getting better (more representative) point set size and spatial distributions.

Data Collection and Reduction

For fully captured schools, the 1) total weight of the school, 2) numbers per unit weight, and 3) species composition will be determined from biological sampling of the point set hauls (see below). Additionally, school height in the water column will be recorded from vessel sonar and down-sounder equipment. Point set photographs will be analyzed to determine school surface area using the same procedure described above for analysis of sardine schools on survey transects.

Biological Sampling of Point Sets

Fishermen participating in the survey will keep the point set hauls in separate holds upon capture so that the tonnage of each aerially photographed and measured haul can be determined separately upon landing. Fish will be collected at fish processing plants upon landing. Samples will be collected from the unsorted catch while being pumped from the vessels. Fish will be taken systematically at the start, middle, and end of each set as it is pumped. The three samples will then be combined and a random subsample of fish (n = 50) will be taken from the pooled sample. Length, weight, sex, and maturity data will be collected for each sampled fish. Sardine weights will be taken using an electronic scale accurate to 0.5 gm; lengths will be taken using a millimeter length strip provided attached to a measuring board. Standard length is determined by measuring from sardine snout to the last vertebrae. Sardine maturity will be documented by referencing maturity codes (female- 4 point scale, male- 3 point scale) supplied by Beverly Macewicz NMFS, SWFSC (Appendix I, Table 3). Otoliths will be taken from a randomly selected 25 fish subsample for future age determination.

III. Survey Logistics

A description of: 1) the roles and responsibilities of project personnel, 2) EFP purse seine vessel selection, 3) the disposition of fish harvested under the EFP, and 4) the project budget, are provided below. Additionally, a detailed Field Operational Plan is presented in Appendix I, and a point by point discussion of NMFS EFP guidelines and requirements is presented in Appendix II.

Key Project Personnel: Roles and Responsibilities

Name:	Mr. Jerry Thon
Affiliation:	Principal, Northwest Sardine Survey, LLC
Address:	12 Bellwether Way, Suite 209, Bellingham, WA 98225
Email:	jthon2@msn.com
Phone:	(360) 201-8449
Role:	Industry Coordinator; EFP Applicant: NWSS-LLC

Responsibilities: Oversee day to day logistic activities of the survey, including deployment of vessels and aircraft as needed to accomplish the projects objectives. Coordinatate sale of EFP sardine with participating processors. Administrate EFP funds; direct funds as required to accomplish the projects scientific objectives. Contract with scientists, vessels, pilots, and others as needed to execute the project with scientific oversight from Mr. Jagielo (Science Advisor).

Name:	Mr. Tom Jagielo, MSc
Affiliation:	Tom Jagielo, Consulting
Email:	TomJagielo@msn.com
Phone:	(360) 791-9089

Role: Science Advisor

Responsibilities: Develop survey design. Provide scientific guidance and oversight for project execution. Analyze survey data. Provide survey results in a form suitable for use by NMFS/SWFSC in the Pacific sardine stock assessment. Prepare final report. Represent the project in public fora (e.g., PFMC, STAR panels, and SSC) to present and interpret scientific results from the survey.

Name: Mr. Ryan Howe, BSc
Affiliation: Consultant
Email: ryanhowe9@yahoo.com

Role: Scientific Field Leader

Responsibilities: Under direction of Mr. Jagielo, coordinate field data collection and ensure scientific validity of field data from the survey. Compile data for analysis. Provide leadership of photogrammetric analysis staff. Assist with survey data analysis, preparation of final report, and presentation of project results as appropriate and/or required.

EFP Purse Seine Vessel Selection

Our priorities for selecting vessels to participate under this EFP include: 1) vessels having the ability to separate the point sets into different hatches, 2) vessels committing to follow scientific protocol as directed during this study period, and 3) vessels that have installed or have the capacity to install or carry any electronic equipment necessary.

With the narrow time window for sampling it is desirable to have a field of boats we can draw on, in order to maximize the number of point sets we can bring in during optimum weather and sea conditions. These boats will only be used for point sets. Some vessels do not have recording sounders, but all vessels do have sonar's that can measure school height and log it. Having a slate of potential vessels to draw from removes the possibility of losing operational days from problems like engine failure. Being able to pick vessels from the list of available boats, and reporting the vessels that will be operating at any given time to local enforcement will help to meet the EFP goals efficiently and cost-effectively. We request approval to deploy up to seven vessels per 24 hour period (See Appendix I, Adjunct 3). Participating vessels may make EFP landings in either one or both states (Washington or Oregon).

Disposition of fish harvested under the EFP

Fish harvested under this EFP will be sold to help fund the sardine research described above. Participating processors receiving point set EFP product from sardine quota set-aside to NWSS-LLC will be identified prior to any fish deliveries made under this EFP, and they will process the fish by bid. Fish Tickets will be tabulated to verify that the sardine harvested under the EFP do not exceed the amount of harvest allocated for the research set-aside to the recipients, and that the amounts harvested correspond to the total of the amounts harvested while conducting the point set research.

Budget

An itemized budget is provided in Appendix II, Adjunct 2. The amount of funds that will be available to the project from the sale of sardine harvested and sold under the EFP is of necessity a rough estimate; this number will be refined as bids for processing are received and the amount of funds potentially available can be established. On the cost side, we have detailed components of the project that will be required to complete the work proposed. Field work always includes uncertainty (weather, fish availability, etc.) and contingency amounts have been included to attempt to address some of this uncertainty.

The financial structure of the project is as follows:

1. Funds derived from the capture and sale of the sardine research set-aside will be used to pay for the research to be conducted under this proposed EFP. The costs of the project will be the responsibility of the NWSS-LLC and will be paid for by the sale of the fish captured during the point sets.

2. Fishing vessels will be chartered by NWSS-LLC to catch the sardines during point sets and conduct echo soundings of fish schools with ES-60 or other suitable electronic equipment.

3. Participating processors will not profit on the sale of the EFP sardine quota; rather, they will process the fish at cost. The processor(s) for this project will be chosen after submitting bids. The lowest bid(s) will be accepted.

4. Airplanes conducting the photo surveys and assisting in point set captures will work under hourly rates or by contract to NWSS-LLC.

5. Equipment needs and operational costs, including scientific support, will be paid for by the NWSS-LLC from the sale of the 3,000 mt research quota. We anticipate the revenue from the fish sales will be sufficient to cover the costs to capture, process, and conduct the survey.

General Sampling Schedule

The survey fieldwork described above will most likely not commence until the second open fishery period (commencing on July 1, 2012) has concluded. In the past this has typically occurred prior to July 15th; however, the increased amount of the quota for 2012 (compared to recent years) could result in starting later for point set collection. It may be possible to commence transect sampling in early July (prior to the fishery closure), airplane availability and weather conditions. Every effort will be made to complete the data analysis in time to submit the results to the Pacific sardine stock assessment author (Dr. Kevin Hill) two weeks prior to the stock assessment review. In past years this has been held the first week in October.

IV. Exempted Fishery Permit Application - Conclusion

In summary, the proposed EFP will contribute substantially toward improving the data available to assess the sardine stock for management on the Pacific Coast. Building on the successful survey work conducted and used in the 2009, 2010, and 2011 stock assessments, the EFP research study in 2012 will enable us to obtain a fourth biomass estimate. The research set-aside of OY under the EFP will provide a reliable source of funds and will allow us to conduct our work in a controlled, methodical manner, separate from the race for fish, which ensues during the directed fishery. This will enable us to obtain a larger and more representative sample of point sets, needed to more precisely and accurately estimate sardine biomass.

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Figure 1. Plot showing sardine point set surface area-biomass relationship (mt/m^2 vs m^2), 2008-2011. Red – 2008; Green – 2009; Blue – 2010; Black (open squares) – 2011.

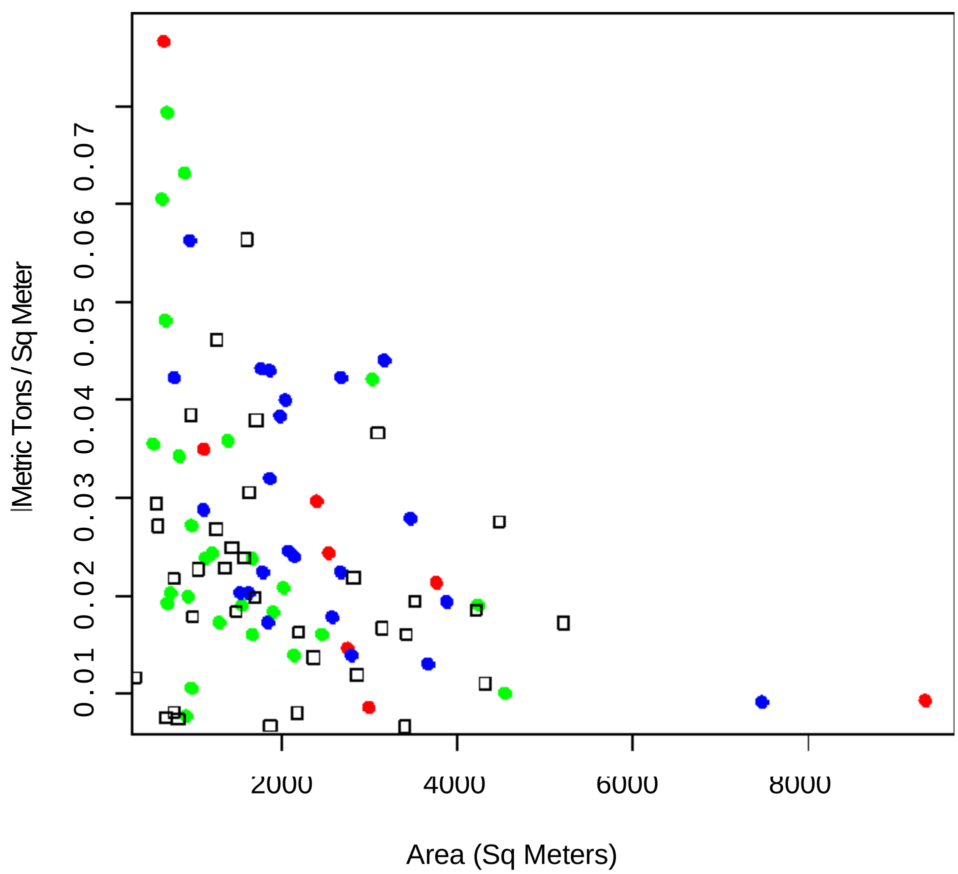
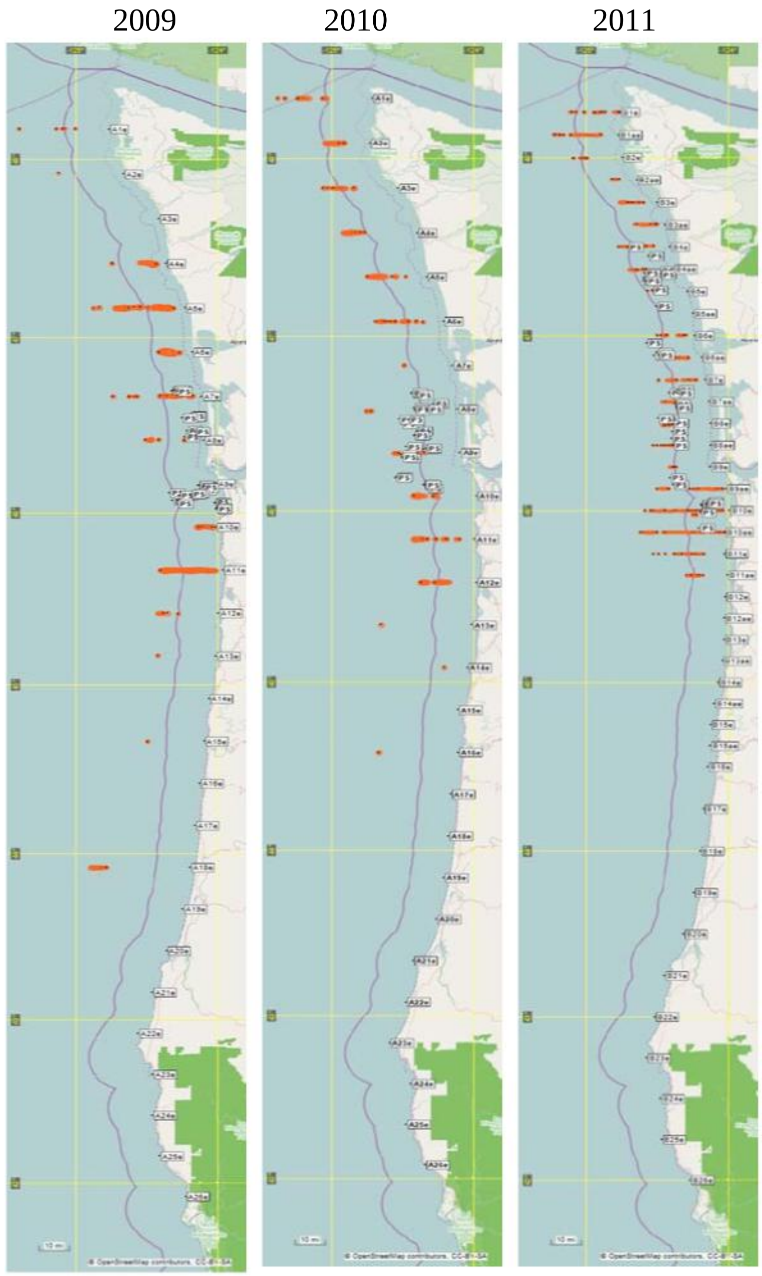


Figure 2. Map showing locations of point sets with respect to fish school locations on transects (2009-2011).



Appendix I

West Coast Aerial Sardine Survey

2012

Field Operational Plan

Industry Coordinator:

Northwest Sardine Survey, LLC
(Jerry Thon, Principal)

Science Advisor:

Tom Jagielo
Tom Jagielo, Consulting

Scientific Field Project Leader:

Ryan Howe

June 6, 2012

Aerial Transect Survey

Overall Aerial Survey Design

Mr. Jerry Thon will oversee the day to day logistic activities of the survey, including deployment of vessels and aircraft as needed to accomplish the projects objectives. To ensure clear communications among participants and other interested parties, the Single Point of Contact (SPC) person for 2012 survey field work will be Mr. Chris Cearns (NWSS), working under the direction of Mr. Thon.

Scientific field work will be conducted in Washington and Oregon by Mr. Ryan Howe with oversight from Mr. Tom Jagielo. Mr. Howe will lead the digital photograph analysis team and will archive all photographic and biological data.

Mr. Jagielo will be responsible for analyzing the survey data and will report the results to Dr. Kevin Hill, NMFS, SWFSC, in a form suitable for input to the stock assessment model. Mr. Howe will be available to help with data analysis as requested.

The 2012 aerial survey design consists of 41 transects spanning the area from Cape Flattery in the north to the Oregon-California border in the south (Table 1, Figure 1). Three replicate sets of transects have been identified for the survey in 2012; however, completion of at least one full set will be sufficient for biomass estimation. Sampling multiple sets will give us a better chance to get at least one full set under optimal sampling conditions. Survey coverage could potentially be extended northward into Canada -- if Canadian governmental approvals can be obtained.

Location of Transects

The east and west endpoints of each transect and corresponding shoreline position are given in Tables 1a-c and are mapped in Figures 1a-c for each of the three replicates (Set A, Set B, and Set C, respectively). Transects start at 3 miles from shore and extend westward for 35 statute miles in length. Transect spacing differs in the north (7.5 nautical miles) compared to the south (15 nautical miles) of the survey area. In addition to the 35 statute mile transect, the 3 statute mile segment directly eastward of each transect to the shore will be flown and photographed. Survey biomass will be estimated from the 35 statute mile transect data. Photographs from the shoreward segment will be used primarily to evaluate the need for future modification of the survey design.

Aerial Resources

Two Piper Super Cubs, one Cessna 337, and possibly a fourth (as yet unspecified) airplane will be used to conduct survey transects and point sets. Survey airplanes will be equipped with a Canon EOS 1Ds in an Aerial Imaging Solutions FMC mount system (Adjunct 1), installed inside the fuselage of the plane.

Use of Aerial Resources

Aerial resources will be coordinated by Mr. Thon (NWSS). To conduct a set, survey pilots will begin with transect number 1 at Cape Flattery in the north and will proceed to the southernmost transect off the southern Oregon coast. When operating together as a team, pilots will communicate via radio or cell phone. They will take a “leap-frog” approach: for example -- plane 1 will fly transects 1-5 while plane 2 is flying transects 6-10; then plane 1 will fly transects 11-15 while plane 2 flies Transects 16-20, and so on. The actual number of transects flown in a day by each plane will be determined jointly by the survey pilots and Mr. Thon and may be more or less than the example of five per plane given above.

Conditions Acceptable for Surveying

At the beginning of each potential survey day, the survey pilots will confer with Mr. Thon and will jointly judge if conditions will permit safe and successful surveying that day. Considering local conditions, they will also jointly determine the optimal time of day for surveying the area slated for coverage that day. Factors will include sea condition, sardine visibility, presence of cloud or fog cover, and other relevant criteria.

Transect Sampling

Prior to beginning a survey flight, the Pre-Flight Survey Checklist (Adjunct 2) will be completed for each aircraft. This will ensure that the camera system settings are fully operational for data collection. For example, it is crucial to have accurate GPS information in the log file. It is also crucial that the photograph number series is re-set to zero. Transects flown without the necessary survey data are not valid and cannot be analyzed.

The decision of when to start a new set of transects will be determined by Mr. Thon with input from Mr. Jagielo and/or others as requested. Transects will be flown at the nominal survey altitude of 4,000 ft. Transects may be flown starting at either the east end or the west end.

A Transect Flight Log Form (Adjunct 2) will be kept during the sampling of each transect for the purpose of documenting the observations of the pilot and/or onboard observers. Key notations will include observations of school species ID and documentation of any special conditions that could have an influence on interpreting photographs taken during transects.

Sardine are believed to migrate northward from California during the summer. Thus, to avoid the possibility of “double counting”, it is important that transects are conducted in a North-to-South progression. Once a transect (or a portion of a transect) has been flown, neither that transect, nor any transects to the north of that transect, may be flown again during that transect set in progress. It will be acceptable to skip transects or portions of transects if conditions require it (e.g. if better weather is available to the south of an area), but transects may not be “made up” once skipped during the sampling of a transect set. Once begun, the goal is to cover the full 41-transect set in as few days as possible.

Data Transfer

Photographs and FMC log files will be downloaded and forwarded for analysis and archival at the end of each survey day. At the end of each flight, the Scientific Field Project Leader (Mr. Howe) will verify that the camera and data collection system operated properly and that images collected are acceptable for analysis. Mr. Howe will collect data from the pilots and will coordinate the transfer and archival of all aerial survey data.

I. Point Set Sampling

Location, Number, and Size of Point Sets
Point sets are fully captured sardine schools landed by purse seiners approved and permitted for this research. Each set by a purse seiner will be directed by one of the survey pilots. Point sets will be made over as wide an area as feasible within the survey area, in order to distribute the sampling effort spatially. We anticipate that point sets could be landed into both Washington and Oregon ports in 2012.

Point sets will also be collected over a range of sizes, as set out in Table 2. The goal is to obtain 82 valid point sets in 2012.

Aerial Photography of Point Sets
The detailed protocol for point set sampling is given in Adjunct 4. Sardine schools to be captured for point sets will be first selected and identified by the survey pilot at the nominal survey altitude of 4,000 ft. When deemed necessary, and at the sole discretion of Mr. Jerry Thon in communication with the survey pilot, schools may (on occasion) be first selected and identified at altitudes lower than 4,000 ft. Following a discrete school selection, the pilot will descend to a lower altitude to better photograph the approach of the seiner to the school and set the seiner for capture of the school. Photographs will be taken before and during the vessels approach to the school for the point set capture. Each school selected by the pilot and photographed for a potential point set will be logged on the survey pilot's Point Set Flight Log Form (Adjunct 2). The species identification of the selected school will be verified by the captain of the purse seine vessel conducting the point set and will be logged on the Fisherman's Log Form (Adjunct 2). These records will be used to determine the rate of school mis-identification by spotter pilots in the field and by analysts viewing photographs.

Vessel Point Set Capture
The purse seine vessel will encircle (wrap) and fully capture the school selected by the survey pilot for the point set. Any school not "fully" captured will not be considered a valid point set for analysis. If a school is judged to be "nearly completely" captured (i.e., over 90% captured), it will be noted as such and will be included for analysis. Both the survey pilot and the purse seine captain will independently make note of the "percent captured" on their survey log forms for this purpose. Upon capture, sardine point sets will be held in separate holds for separate weighing and biological sampling of each set after landing.

Biological Sampling
Biological samples of individual point sets will be collected at the landing docks or at the fish processing plants upon landing. Fish will be systematically taken at the start, middle, and end of a delivered set. The three samples will then be combined and a random subsample of fish will be taken. The sample size will be n = 50 fish for each point set haul.

Length, weight, maturity, and otoliths will be sampled for each point set haul and will be documented on the Biological Sampling Form (Adjunct 2). Sardine weights will be taken using an electronic scale accurate to 0.5 gm. Sardine lengths will be taken using a millimeter length strip attached to a measuring board. Standard length will be determined by measuring from sardine snout to the last vertebrae. Sardine maturity will be established by referencing maturity codes (female- 4 point scale, male- 3 point scale) supplied by Beverly Macewicz NMFS, SWFSC. A subsample of 25 fish from each point set sample will be individually bagged, identified with sample number and frozen with other fish in the subsample, clearly identified as to point set number, vessel, and location captured and retained for collection of otoliths.

Hydroacoustic Sounding of School Height

School height will be measured for each point set. This may be obtained by using either the purse seine or other participating research vessels' hydroacoustic gear. The school height measurements to be recorded on the Fisherman's Log Form are: 1) depth in the water column of the top of the school, and 2) depth in the water column of the bottom of the school. Simrad ES-60 sounders will be installed on two purse seine vessels. Data collected by the ES-60 sounders will be backed-up daily and archived onshore.

Number and Size of Point Sets to be Captured

Point sets will be conducted for a range of school sizes (Table 2). Point sets will be targeted working in general from the smallest size category to the largest. Each day, spotter pilots will operate with an updated list of remaining school sizes needed for analysis. Each spotter pilot will use his experience to judge the biomass of sardine schools from the air, and will direct the purse seine vessel to capture schools of appropriate size. Following landing of the point sets at the dock, the actual school weights will be determined. Every effort will be made to ensure, as soon as possible, that successfully landed point sets were also successfully photographed. This will in general occur before the end of each fishing day. After verification of point set acceptability, the list of remaining school sizes needed from Table 2 will be updated accordingly for ongoing fishing. If schools are not available in the designated size range, point sets will be conducted on schools as close to the designated range as possible. Pumping large sets onto more than one vessel should be avoided, and should only be done in the accidental event that school size was grossly underestimated. Mr. Howe will oversee the gathering of point set landing data and will update the list daily. The total landed weight of point sets sampled will not exceed 3,000 mt.

Spatial Distribution of Point Sets

In order to distribute point sets spatially, sampling will occur both north and south of the Columbia River, and offshore vs. nearshore, as well. This could be facilitated by landing point sets in both Washington and Oregon ports in 2012. Quadrants have been established to facilitate spatial distribution of the point sets (Figure 2).

Landing Reporting Requirements

Cumulative point set landings will be updated by Mr. Chris Cearns (NWSS), who will report the running total daily to NMFS, as per the terms of the Exempted Fishing Permit. Also included in this daily report will be an estimate of the weight of all by-catch by species.

Other EFP Reporting Requirements

To ensure clear communications among participants and other interested parties, the single point of contact (SPC) person during 2012 survey field work will be Mr. Chris Cearns.

Mr. Cearns (under the direction of Mr. Thon) will also be responsible for providing other required reporting elements (as specified in the EFP permit) to NMFS. For example, a daily notice will be provided for enforcement giving 24 hour notice of vessels to be conducting point sets on any given day and will include vessel name, area to be fished, estimated departure time, estimated return time.

II. Calibration and Validation

Aerial Measurement Calibration
Each survey year, routine calibration is conducted to verify aerial measurements. A series of photographs will again be collected of a feature of known size (e.g. airplane hangars the Astoria, OR airport), from the altitudes of 1,000 ft, 2,000 ft, 3,000 ft, and 4,000 ft. For each altitude series, an aerial pass will be made to place the target onto the right, middle, and left portions of the photographic image.

Aerial Photographs and Sampling for Species Validation
The collection of reference photographs is updated each survey year, for the purpose of species identification. These photographs are used by the team of photograph analysts to continue to learn how to discern between sardine and other species as they appear on the aerial transect photographs.

Reference photographs will be taken at the nominal survey altitude of 4,000 ft for the purpose of species identification. The spotter pilots will find and photograph schooling fish other than sardine (e.g. mackerel, herring, smelt, anchovy, etc). For the actual schools photographed, a vessel at sea (typically a small, relatively fast boat) will collect a jig sample to document the species identification. This sampling will most likely occur in June, prior to commencement of the summer fishery opening.

Tables 1a -1f. Transect Sets A, B, and C.

Table 1a. Set A

	Survey	Transect	Transect Latitude		West End			East End			Shoreline		
Location	Area	Number	Lat Deg	Lat Min	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #
Washington	N	A1	48	20.000	125	29.30	A1w	124	43.71	A1e	124	39.81	A1s
Washington	N	A1a	48	12.500	125	30.98	A1aw	124	45.51	A1ae	124	41.61	A1as
Washington	N	A2	48	5.000	125	30.99	A2w	124	45.63	A2e	124	41.74	A2s
Washington	N	A2a	47	57.500	125	29.48	A2aw	124	44.24	A2ae	124	40.36	A2as
Washington	N	A3	47	50.000	125	21.05	A3w	124	35.91	A3e	124	32.04	A3s
Washington	N	A3a	47	42.500	125	13.82	A3aw	124	28.79	A3ae	124	24.93	A3as
Washington	N	A4	47	35.000	125	10.89	A4w	124	25.96	A4e	124	22.11	A4s
Washington	N	A4a	47	27.500	125	9.13	A4aw	124	24.30	A4ae	124	20.46	A4as
Washington	N	A5	47	20.000	125	5.89	A5w	124	21.17	A5e	124	17.33	A5s
Washington	N	A5a	47	12.500	125	0.98	A5aw	124	16.37	A5ae	124	12.54	A5as
Washington	N	A6	47	5.000	124	59.07	A6w	124	14.57	A6e	124	10.76	A6s
Washington	N	A6a	46	57.500	124	58.70	A6aw	124	14.30	A6ae	124	10.50	A6as
Washington	N	A7	46	50.000	124	54.58	A7w	124	10.28	A7e	124	6.49	A7s
Washington	N	A7a	46	42.500	124	52.93	A7aw	124	8.73	A7ae	124	4.95	A7as
Washington	N	A8	46	35.000	124	51.75	A8w	124	7.66	A8e	124	3.88	A8s
Washington	N	A8a	46	27.500	124	51.41	A8aw	124	7.42	A8ae	124	3.65	A8as
Washington	N	A9	46	20.000	124	51.77	A9w	124	7.87	A9e	124	4.11	A9s
Washington	N	A9a	46	12.500	124	47.63	A9aw	124	3.83	A9ae	124	0.08	A9as
Oregon	N	A10	46	5.000	124	43.80	A10w	124	0.10	A10e	123	56.36	A10s
Oregon	N	A10a	45	57.500	124	45.71	A10aw	124	2.11	A10ae	123	58.38	A10as
Oregon	N	A11	45	50.000	124	44.99	A11w	124	1.50	A11e	123	57.77	A11s
Oregon	N	A11a	45	42.500	124	43.65	A11aw	124	0.25	A11ae	123	56.53	A11as
Oregon	N	A12	45	35.000	124	44.22	A12w	124	0.91	A12e	123	57.20	A12s
Oregon	N	A12a	45	27.500	124	45.16	A12aw	124	1.95	A12ae	123	58.25	A12as
Oregon	N	A13	45	20.000	124	45.10	A13w	124	1.99	A13e	123	58.29	A13s
Oregon	N	A13a	45	12.500	124	44.94	A13aw	124	1.92	A13ae	123	58.23	A13as
Oregon	N	A14	45	5.000	124	46.96	A14w	124	4.03	A14e	124	0.36	A14s
Oregon	N	A14a	44	57.500	124	47.76	A14aw	124	4.93	A14ae	124	1.26	A14as
Oregon	N	A15	44	50.000	124	49.86	A15w	124	7.12	A15e	124	3.45	A15s
Oregon	N	A15a	44	42.500	124	49.95	A15aw	124	7.31	A15ae	124	3.65	A15as
Oregon	N	A16	44	35.000	124	50.38	A16w	124	7.83	A16e	124	4.18	A16s
Oregon	N	A17	44	20.000	124	52.00	A17w	124	9.63	A17e	124	6.00	A17s
Oregon	N	A18	44	5.000	124	53.44	A18w	124	11.25	A18e	124	7.63	A18s
Oregon	N	A19	43	50.000	124	55.46	A19w	124	13.45	A19e	124	9.84	A19s
Oregon	N	A20	43	35.000	124	58.98	A20w	124	17.14	A20e	124	13.55	A20s
Oregon	N	A21	43	20.000	125	7.59	A21w	124	25.92	A21e	124	22.35	A21s
Oregon	N	A22	43	5.000	125	11.18	A22w	124	29.67	A22e	124	26.12	A22s
Oregon	N	A23	42	50.000	125	18.75	A23w	124	37.41	A23e	124	33.87	A23s
Oregon	N	A24	42	35.000	125	8.28	A24w	124	27.11	A24e	124	23.59	A24s
Oregon	N	A25	42	20.000	125	10.20	A25w	124	29.20	A25e	124	25.68	A25s
Oregon	N	A26	42	5.000	125	3.86	A26w	124	23.02	A26e	124	19.52	A26s

Table 1b. Set B

	Survey	Transect	Transect Latitude		West End			East End			Shoreline		
Location	Area	Number	Lat Deg	Lat Min	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #
Washington	N	B1	48	15.000	125	30.91	B1w	124	45.40	B1e	124	41.50	B1s
Washington	N	B1a	48	7.500	125	31.79	B1aw	124	46.39	B1ae	124	42.50	B1as
Washington	N	B2	48	0.000	125	29.92	B2w	124	44.64	B2e	124	40.75	B2s
Washington	N	B2a	47	52.500	125	23.80	B2aw	124	38.62	B2ae	124	34.75	B2as
Washington	N	B3	47	45.000	125	15.09	B3w	124	30.02	B3e	124	26.16	B3s
Washington	N	B3a	47	37.500	125	11.56	B3aw	124	26.60	B3ae	124	22.74	B3as
Washington	N	B4	47	30.000	125	9.43	B4w	124	24.58	B4e	124	20.73	B4s
Washington	N	B4a	47	22.500	125	7.95	B4aw	124	23.20	B4ae	124	19.37	B4as
Washington	N	B5	47	15.000	125	1.78	B5w	124	17.13	B5e	124	13.31	B5s
Washington	N	B5a	47	7.500	124	59.49	B5aw	124	14.95	B5ae	124	11.13	B5as
Washington	N	B6	47	0.000	124	58.62	B6w	124	14.19	B6e	124	10.38	B6s
Washington	N	B6a	46	52.500	124	55.48	B6aw	124	11.15	B6ae	124	7.35	B6as
Washington	N	B7	46	45.000	124	53.93	B7w	124	9.70	B7e	124	5.91	B7s
Washington	N	B7a	46	37.500	124	52.05	B7aw	124	7.92	B7ae	124	4.14	B7as
Washington	N	B8	46	30.000	124	51.33	B8w	124	7.31	B8e	124	3.54	B8s
Washington	N	B8a	46	22.500	124	51.46	B8aw	124	7.53	B8ae	124	3.77	B8as
Washington	N	B9	46	15.000	124	51.41	B9w	124	7.59	B9e	124	3.83	B9s
Washington	N	B9a	46	7.500	124	44.62	B9aw	124	0.89	B9ae	123	57.14	B9as
Oregon	N	B10	46	0.000	124	43.24	B10w	123	59.61	B10e	123	55.87	B10s
Oregon	N	B10a	45	52.500	124	45.05	B10aw	124	1.51	B10ae	123	57.78	B10as
Oregon	N	B11	45	45.000	124	45.10	B11w	124	1.67	B11e	123	57.94	B11s
Oregon	N	B11a	45	37.500	124	43.78	B11aw	124	0.44	B11ae	123	56.73	B11as
Oregon	N	B12	45	30.000	124	44.58	B12w	124	1.34	B12e	123	57.63	B12s
Oregon	N	B12a	45	22.500	124	44.90	B12aw	124	1.76	B12ae	123	58.06	B12as
Oregon	N	B13	45	15.000	124	44.81	B13w	124	1.76	B13e	123	58.07	B13s
Oregon	N	B13a	45	7.500	124	45.43	B13aw	124	2.48	B13ae	123	58.79	B13as
Oregon	N	B14	45	0.000	124	47.23	B14w	124	4.36	B14e	124	0.69	B14s
Oregon	N	B14a	44	52.500	124	48.78	B14aw	124	6.01	B14ae	124	2.34	B14as
Oregon	N	B15	44	45.000	124	50.13	B15w	124	7.46	B15e	124	3.80	B15s
Oregon	N	B15a	44	37.500	124	50.24	B15aw	124	7.66	B15ae	124	4.01	B15as
Oregon	N	B16	44	30.000	124	51.11	B16w	124	8.62	B16e	124	4.97	B16s
Oregon	N	B17	44	15.000	124	52.78	B17w	124	10.47	B17e	124	6.84	B17s
Oregon	N	B18	44	0.000	124	54.02	B18w	124	11.88	B18e	124	8.27	B18s
Oregon	N	B19	43	45.000	124	56.45	B19w	124	14.49	B19e	124	10.90	B19s
Oregon	N	B20	43	30.000	125	0.71	B20w	124	18.92	B20e	124	15.34	B20s
Oregon	N	B21	43	15.000	125	8.59	B21w	124	26.92	B21e	124	23.35	B21s
Oregon	N	B22	43	0.000	125	12.51	B22w	124	31.07	B22e	124	27.52	B22s
Oregon	N	B23	42	45.000	125	15.75	B23w	124	34.46	B23e	124	30.93	B23s
Oregon	N	B24	42	30.000	125	9.74	B24w	124	28.63	B24e	124	25.11	B24s
Oregon	N	B25	42	15.000	125	9.03	B25w	124	28.08	B25e	124	24.57	B25s
Oregon	N	B26	42	0.000	124	56.96	B26w	124	16.17	B26e	124	12.67	B26s

Table 1c. Set C

	Survey	Transect	Transect Latitude		West End			East End			Shoreline		
Location	Area	Number	Lat Deg	Lat Min	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #
Washington	N	C1	48	10.000	125	33.23	C1w	124	47.80	C1e	124	43.91	C1s
Washington	N	C1a	48	2.500	125	30.14	C1aw	124	44.81	C1ae	124	40.93	C1as
Washington	N	C2	47	55.000	125	27.35	C2w	124	42.14	C2e	124	38.27	C2s
Washington	N	C2a	47	47.500	125	17.80	C2aw	124	32.70	C2ae	124	28.83	C2as
Washington	N	C3	47	40.000	125	12.56	C3w	124	27.57	C3e	124	23.71	C3s
Washington	N	C3a	47	32.500	125	10.08	C3aw	124	25.18	C3ae	124	21.34	C3as
Washington	N	C4	47	25.000	125	8.72	C4w	124	23.94	C4e	124	20.10	C4s
Washington	N	C4a	47	17.500	125	2.94	C4aw	124	18.26	C4ae	124	14.43	C4as
Washington	N	C5	47	10.000	125	0.13	C5w	124	15.56	C5e	124	11.73	C5s
Washington	N	C5a	47	2.500	124	58.74	C5aw	124	14.26	C5ae	124	10.45	C5as
Washington	N	C6	46	55.000	124	57.35	C6w	124	12.98	C6e	124	9.18	C6s
Washington	N	C6a	46	47.500	124	53.97	C6aw	124	9.71	C6ae	124	5.91	C6as
Washington	N	C7	46	40.000	124	52.16	C7w	124	8.00	C7e	124	4.21	C7s
Washington	N	C7a	46	32.500	124	51.45	C7aw	124	7.39	C7ae	124	3.61	C7as
Washington	N	C8	46	25.000	124	51.33	C8w	124	7.37	C8e	124	3.60	C8s
Washington	N	C8a	46	17.500	124	52.19	C8aw	124	8.33	C8ae	124	4.57	C8as
Washington	N	C9	46	10.000	124	45.89	C9w	124	2.13	C9e	123	58.38	C9s
Washington	N	C9a	46	2.500	124	43.18	C9aw	123	59.52	C9ae	123	55.78	C9as
Oregon	N	C10	45	55.000	124	45.64	C10w	124	2.08	C10e	123	58.35	C10s
Oregon	N	C10a	45	47.500	124	45.21	C10aw	124	1.74	C10ae	123	58.02	C10as
Oregon	N	C11	45	40.000	124	43.51	C11w	124	0.14	C11e	123	56.43	C11s
Oregon	N	C11a	45	32.500	124	44.06	C11aw	124	0.79	C11ae	123	57.08	C11as
Oregon	N	C12	45	25.000	124	44.58	C12w	124	1.40	C12e	123	57.70	C12s
Oregon	N	C12a	45	17.500	124	44.67	C12aw	124	1.59	C12ae	123	57.90	C12as
Oregon	N	C13	45	10.000	124	44.93	C13w	124	1.94	C13e	123	58.26	C13s
Oregon	N	C13a	45	2.500	124	46.84	C13aw	124	3.94	C13ae	124	0.27	C13as
Oregon	N	C14	44	55.000	124	48.17	C14w	124	5.37	C14e	124	1.70	C14s
Oregon	N	C14a	44	47.500	124	50.64	C14aw	124	7.93	C14ae	124	4.27	C14as
Oregon	N	C15	44	40.000	124	49.91	C15w	124	7.30	C15e	124	3.65	C15s
Oregon	N	C15a	44	32.500	124	50.65	C15aw	124	8.12	C15ae	124	4.48	C15as
Oregon	N	C16	44	25.000	124	51.18	C16w	124	8.74	C16e	124	5.11	C16s
Oregon	N	C17	44	10.000	124	52.90	C17w	124	10.64	C17e	124	7.02	C17s
Oregon	N	C18	43	55.000	124	54.64	C18w	124	12.56	C18e	124	8.95	C18s
Oregon	N	C19	43	40.000	124	57.85	C19w	124	15.95	C19e	124	12.35	C19s
Oregon	N	C20	43	25.000	125	3.13	C20w	124	21.40	C20e	124	17.82	C20s
Oregon	N	C21	43	10.000	125	9.61	C21w	124	28.05	C21e	124	24.48	C21s
Oregon	N	C22	42	55.000	125	14.93	C22w	124	33.55	C22e	124	30.00	C22s
Oregon	N	C23	42	40.000	125	10.57	C23w	124	29.34	C23e	124	25.81	C23s
Oregon	N	C24	42	25.000	125	10.24	C24w	124	29.18	C24e	124	25.66	C24s
Oregon	N	C25	42	10.000	125	6.07	C25w	124	25.18	C25e	124	21.67	C25s
Oregon	N	C26	41	55.000	124	56.53	C26w	124	15.80	C26e	124	12.31	C26s

Table 1d. Set A Canadian Transects

	Survey	Transect	Transect Latitude		West End			East End			Shoreline		
Location	Area	Number	Lat Deg	Lat Min	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #
Canada	CN	cnA1	48	35.000	125	30.02	cnA1w	124	44.22	cnA1e	124	40.29	cnA1s
Canada	CN	cnA2	48	50.000	126	9.18	cnA2w	125	23.15	cnA2e	125	19.20	cnA2s
Canada	CN	cnA3	49	5.000	126	42.25	cnA3w	125	55.98	cnA3e	125	52.02	cnA3s
Canada	CN	cnA4	49	20.000	127	4.75	cnA4w	126	18.25	cnA4e	126	14.26	cnA4s
Canada	CN	cnA5	49	35.000	127	31.47	cnA5w	126	44.73	cnA5e	126	40.73	cnA5s
Canada	CN	cnA6	49	50.000	127	54.49	cnA6w	127	7.51	cnA6e	127	3.48	cnA6s
Canada	CN	cnA7	50	5.000	128	40.48	cnA7w	127	53.26	cnA7e	127	49.21	cnA7s
Canada	CN	cnA8	50	20.000	128	50.05	cnA8w	128	2.58	cnA8e	127	58.51	cnA8s
Canada	CN	cnA9	50	35.000	129	5.73	cnA9w	128	18.01	cnA9e	128	13.92	cnA9s
Canada	CN	cnA10	50	50.000	129	4.71	cnA10w	128	16.74	cnA10e	128	12.63	cnA10s
Canada	CN	cnA11	51	5.000	128	31.37	cnA11w	127	43.13	cnA11e	127	39.00	cnA11s
Canada	CN	cnA12	51	20.000	128	39.13	cnA12w	127	50.63	cnA12e	127	46.48	cnA12s
Canada	CN	cnA13	51	35.000	129	0.41	cnA13w	128	11.65	cnA13e	128	7.47	cnA13s
Canada	CN	cnA14	51	50.000	129	9.27	cnA14w	128	20.24	cnA14e	128	16.03	cnA14s
Canada	CN	cnA15	52	5.000	129	15.18	cnA15w	128	25.88	cnA15e	128	21.66	cnA15s
Canada	CN	cnA16	52	20.000	129	38.12	cnA16w	128	48.54	cnA16e	128	44.29	cnA16s
Canada	CN	cnA17	52	35.000	130	2.84	cnA17w	129	12.98	cnA17e	129	8.71	cnA17s
Canada	CN	cnA18	52	50.000	130	16.03	cnA18w	129	25.88	cnA18e	129	21.58	cnA18s
Canada	CN	cnA19	53	5.000	130	38.77	cnA19w	129	48.34	cnA19e	129	44.01	cnA19s
Canada	CN	cnA20	53	20.000	131	4.57	cnA20w	130	13.84	cnA20e	130	9.49	cnA20s
Canada	CN	cnA21	53	35.000	131	28.20	cnA21w	130	37.17	cnA21e	130	32.80	cnA21s
Canada	CN	cnA22	53	50.000	131	36.53	cnA22w	130	45.20	cnA22e	130	40.80	cnA22s
Canada	CN	cnA23	54	5.000	131	33.54	cnA23w	130	41.90	cnA23e	130	37.48	cnA23s
Canada	CN	cnA24	54	20.000	131	26.95	cnA24w	130	35.00	cnA24e	130	30.55	cnA24s
Canada	CN	cnA25	54	35.000	132	2.78	cnA25w	131	10.51	cnA25e	131	6.03	cnA25s

Table 1e. Set B Canadian Transects

	Survey	Transect	Transect Latitude		West End			East End			Shoreline		
Location	Area	Number	Lat Deg	Lat Min	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #
Canada	CN	cnB1	48	30.000	125	33.41	cnB1w	124	47.68	cnB1e	124	43.76	cnB1s
Canada	CN	cnB2	48	45.000	125	57.61	cnB2w	125	11.65	cnB2e	125	7.71	cnB2s
Canada	CN	cnB3	49	0.000	126	30.47	cnB3w	125	44.28	cnB3e	125	40.32	cnB3s
Canada	CN	cnB4	49	15.000	126	56.32	cnB4w	126	9.90	cnB4e	126	5.92	cnB4s
Canada	CN	cnB5	49	30.000	127	24.28	cnB5w	126	37.62	cnB5e	126	33.62	cnB5s
Canada	CN	cnB6	49	45.000	127	49.17	cnB6w	127	2.27	cnB6e	126	58.25	cnB6s
Canada	CN	cnB7	50	0.000	128	10.98	cnB7w	127	23.84	cnB7e	127	19.80	cnB7s
Canada	CN	cnB8	50	15.000	128	39.58	cnB8w	127	52.20	cnB8e	127	48.14	cnB8s
Canada	CN	cnB9	50	30.000	129	0.01	cnB9w	128	12.38	cnB9e	128	8.29	cnB9s
Canada	CN	cnB10	50	45.000	129	15.83	cnB10w	128	27.94	cnB10e	128	23.84	cnB10s
Canada	CN	cnB11	51	0.000	128	24.13	cnB11w	127	35.99	cnB11e	127	31.86	cnB11s
Canada	CN	cnB12	51	15.000	128	38.03	cnB12w	127	49.62	cnB12e	127	45.47	cnB12s
Canada	CN	cnB13	51	30.000	128	58.26	cnB13w	128	9.59	cnB13e	128	5.42	cnB13s
Canada	CN	cnB14	51	45.000	129	0.72	cnB14w	128	11.78	cnB14e	128	7.59	cnB14s
Canada	CN	cnB15	52	0.000	129	7.13	cnB15w	128	17.92	cnB15e	128	13.70	cnB15s
Canada	CN	cnB16	52	15.000	129	18.98	cnB16w	128	29.49	cnB16e	128	25.25	cnB16s
Canada	CN	cnB17	52	30.000	129	53.92	cnB17w	129	4.15	cnB17e	128	59.89	cnB17s
Canada	CN	cnB18	52	45.000	130	11.91	cnB18w	129	21.86	cnB18e	129	17.57	cnB18s
Canada	CN	cnB19	53	0.000	130	35.44	cnB19w	129	45.10	cnB19e	129	40.79	cnB19s
Canada	CN	cnB20	53	15.000	130	58.66	cnB20w	130	8.02	cnB20e	130	3.68	cnB20s
Canada	CN	cnB21	53	30.000	131	21.16	cnB21w	130	30.23	cnB21e	130	25.86	cnB21s
Canada	CN	cnB22	53	45.000	131	22.07	cnB22w	130	30.84	cnB22e	130	26.45	cnB22s
Canada	CN	cnB23	54	0.000	131	36.01	cnB23w	130	44.47	cnB23e	130	40.05	cnB23s
Canada	CN	cnB24	54	15.000	131	21.17	cnB24w	130	29.32	cnB24e	130	24.88	cnB24s
Canada	CN	cnB25	54	30.000	131	55.50	cnB25w	131	3.34	cnB25e	130	58.87	cnB25s

Table 1f. Set C Canadian Transects

	Survey	Transect	Transect Latitude		West End			East End			Shoreline		
Location	Area	Number	Lat Deg	Lat Min	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #
Canada	CN	cnC1	48	25.000	125	33.09	cnC1w	124	47.44	cnC1e	124	43.52	cnC1s
Canada	CN	cnC2	48	40.000	125	40.56	cnC2w	124	54.67	cnC2e	124	50.74	cnC2s
Canada	CN	cnC3	48	55.000	126	18.86	cnC3w	125	32.75	cnC3e	125	28.80	cnC3s
Canada	CN	cnC4	49	10.000	126	51.29	cnC4w	126	4.95	cnC4e	126	0.97	cnC4s
Canada	CN	cnC5	49	25.000	127	25.40	cnC5w	126	38.82	cnC5e	126	34.83	cnC5s
Canada	CN	cnC6	49	40.000	127	43.17	cnC6w	126	56.35	cnC6e	126	52.34	cnC6s
Canada	CN	cnC7	49	55.000	128	3.03	cnC7w	127	15.97	cnC7e	127	11.94	cnC7s
Canada	CN	cnC8	50	10.000	128	42.20	cnC8w	127	54.90	cnC8e	127	50.84	cnC8s
Canada	CN	cnC9	50	25.000	128	48.14	cnC9w	128	0.59	cnC9e	127	56.51	cnC9s
Canada	CN	cnC10	50	40.000	129	12.56	cnC10w	128	24.76	cnC10e	128	20.66	cnC10s
Canada	CN	cnC11	50	55.000	128	52.06	cnC11w	128	4.00	cnC11e	127	59.88	cnC11s
Canada	CN	cnC12	51	10.000	128	39.54	cnC12w	127	51.22	cnC12e	127	47.08	cnC12s
Canada	CN	cnC13	51	25.000	128	48.18	cnC13w	127	59.60	cnC13e	127	55.43	cnC13s
Canada	CN	cnC14	51	40.000	129	2.29	cnC14w	128	13.44	cnC14e	128	9.26	cnC14s
Canada	CN	cnC15	51	55.000	129	8.30	cnC15w	128	19.18	cnC15e	128	14.97	cnC15s
Canada	CN	cnC16	52	10.000	129	24.51	cnC16w	128	35.11	cnC16e	128	30.88	cnC16s
Canada	CN	cnC17	52	25.000	129	40.03	cnC17w	128	50.36	cnC17e	128	46.10	cnC17s
Canada	CN	cnC18	52	40.000	130	8.07	cnC18w	129	18.11	cnC18e	129	13.83	cnC18s
Canada	CN	cnC19	52	55.000	130	26.33	cnC19w	129	36.09	cnC19e	129	31.78	cnC19s
Canada	CN	cnC20	53	10.000	130	52.13	cnC20w	130	1.60	cnC20e	129	57.27	cnC20s
Canada	CN	cnC21	53	25.000	131	15.43	cnC21w	130	24.60	cnC21e	130	20.24	cnC21s
Canada	CN	cnC22	53	40.000	131	18.96	cnC22w	130	27.83	cnC22e	130	23.45	cnC22s
Canada	CN	cnC23	53	55.000	131	39.54	cnC23w	130	48.10	cnC23e	130	43.69	cnC23s
Canada	CN	cnC24	54	10.000	131	45.12	cnC24w	130	53.38	cnC24e	130	48.94	cnC24s
Canada	CN	cnC25	54	25.000	131	44.31	cnC25w	130	52.25	cnC25e	130	47.79	cnC25s

Table 2. Distribution of point set sizes proposed for the 2012 Aerial Sardine Survey. Total weight is in metric tons.

Size (m^2)	Weight (mt)	Total Weight (mt)	Number of point sets
100	3.8	45.6	12
500	10.6	127.2	12
1000	17	204	12
2000	26.5	318	12
4000	51.9	622.8	12
8000	70.5	775.5	11
10000	82.1	903.1	11
		2996.2	82

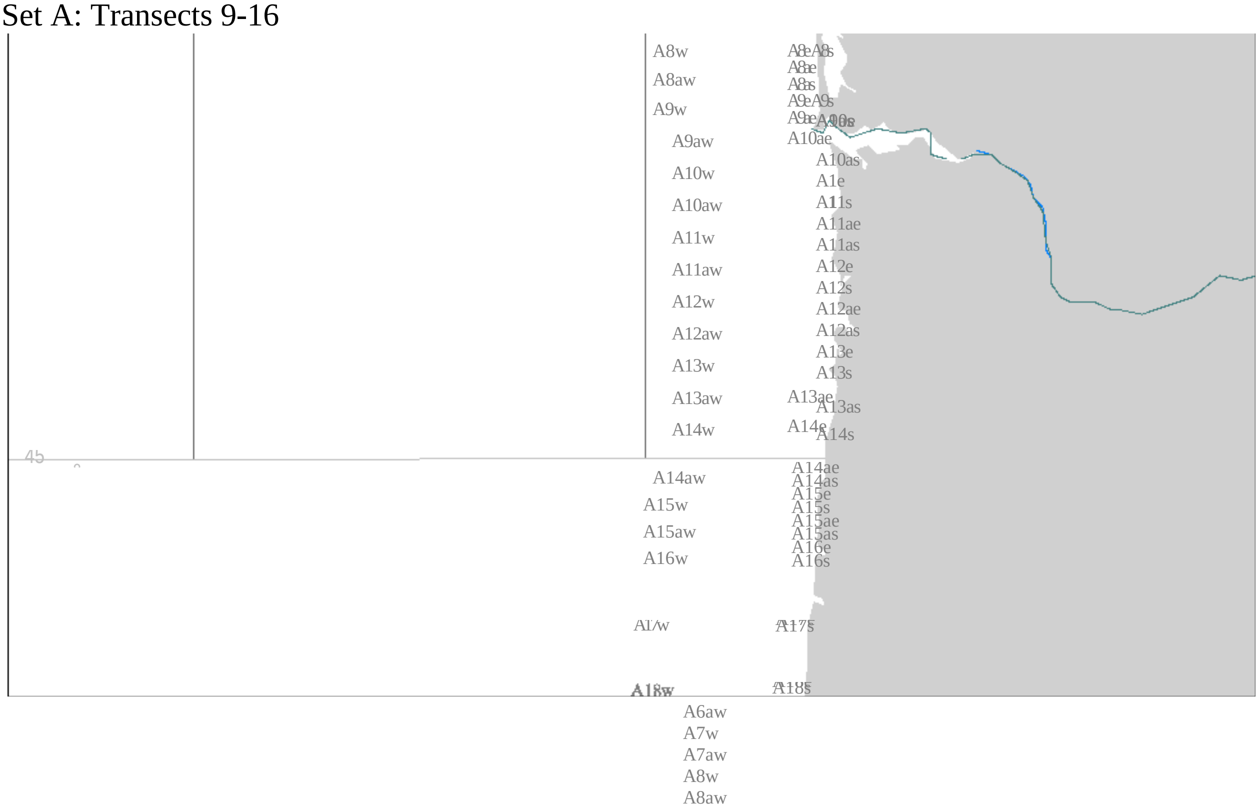
Table 3. Sardine maturity codes. Source: Beverly Macewicz NMFS, SWFSC.

Female maturity codes	Male maturity codes
1. Clearly immature- ovary is very small; no oocytes present	1. Clearly immature- testis is very small thin, knifed-shaped with flat edge
2. Intermediate- individual oocytes not visible but ovary is not clearly immature; includes maturing and regressed ovaries	2. Intermediate- no milt evident and is not a clear immature; includes maturing or regressed testis
3. Active- yolked oocytes visible; any size or amount as long as you can see them with the unaided eye in ovaries	3. Active- milt is present; either oozing from pore, in the duct, or when testis is cut with knife.
4. Hydrated oocytes present; yolked oocytes may be present	

Figure 1a. Maps showing locations of transects comprising Replicate Set A

Set A: Transects 1-8

Set A: Transects 9-16



28

Figure 1a, Continued. Maps showing locations of transects comprising Replicate SET A

Set A: Transects 17-26

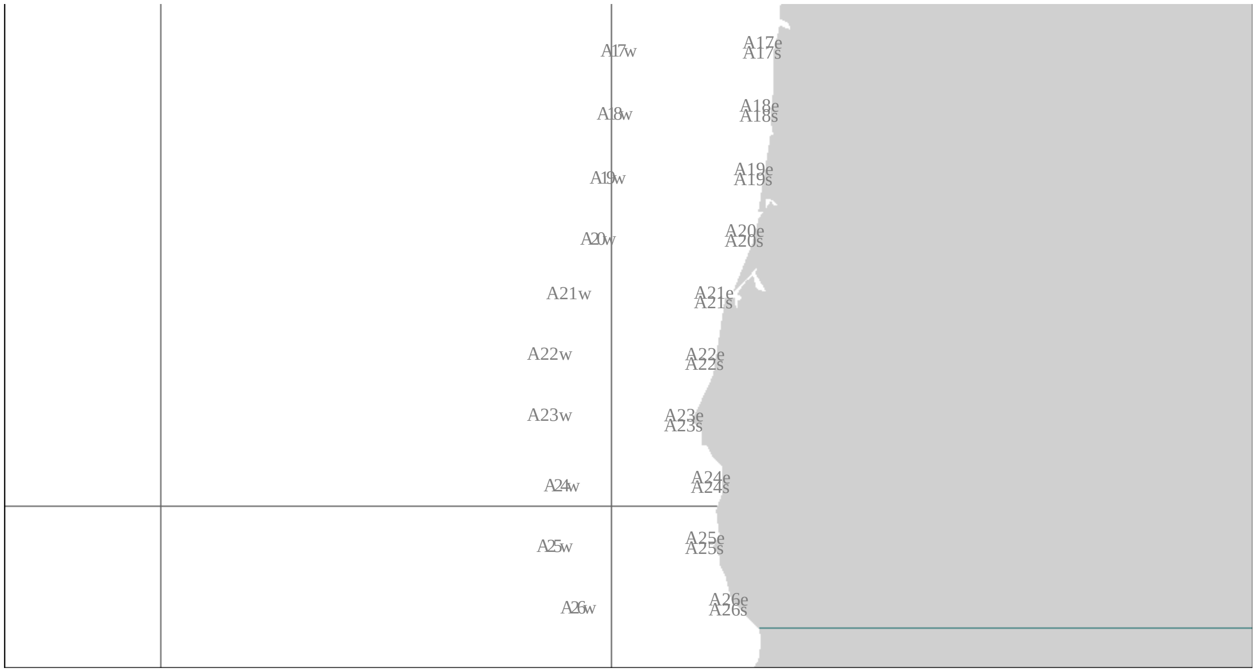


Figure 1b. Maps showing locations of transects comprising Replicate Set B

Set B: Transects 1-8

Set B: Transects 9-16

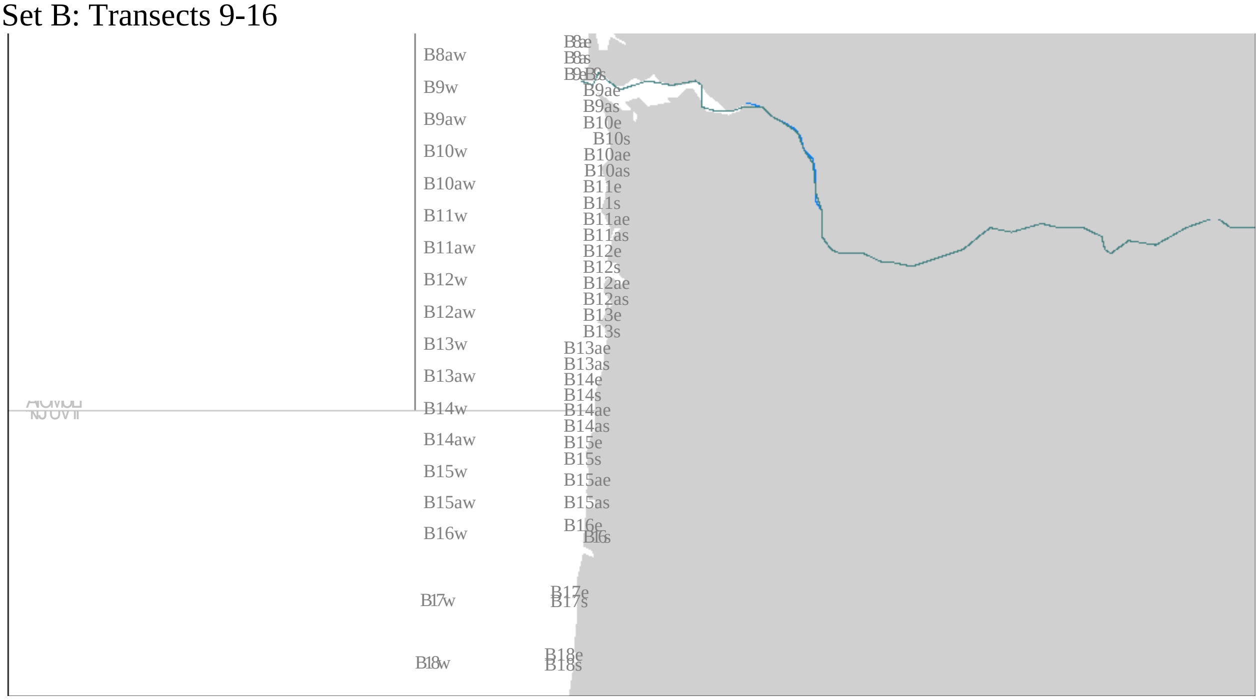


Figure 1b, Continued. Maps showing locations of transects comprising Replicate Set B

Set B: Transects 17-26

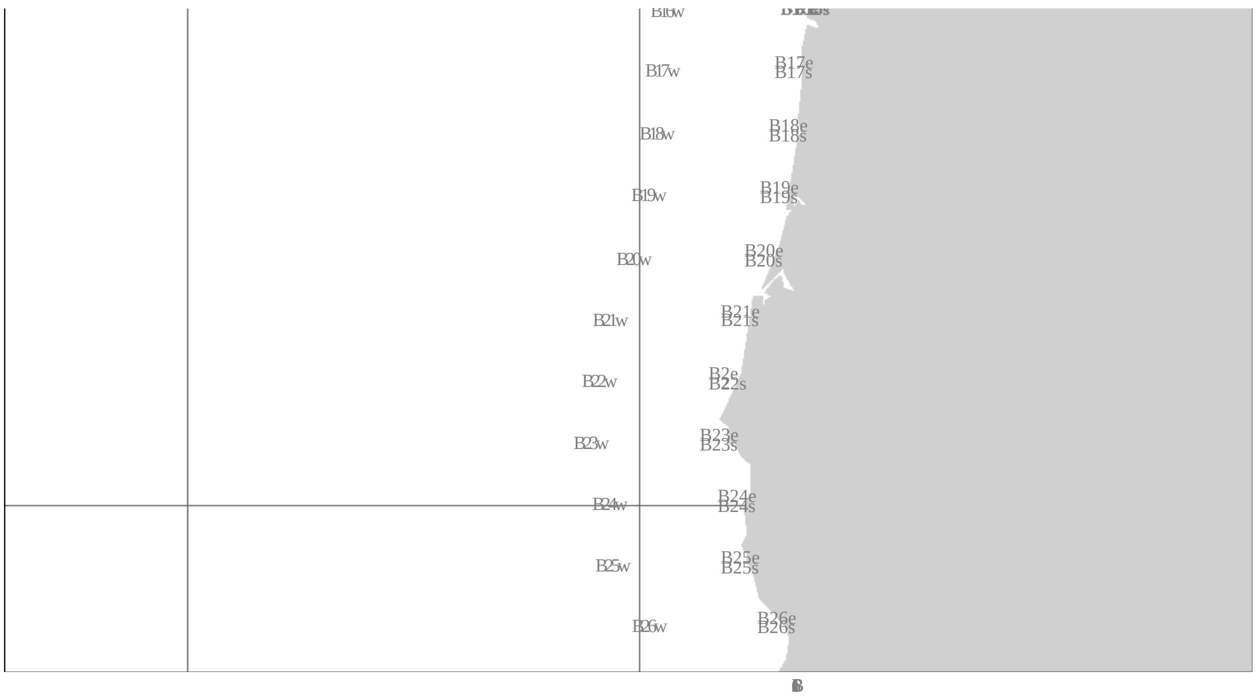
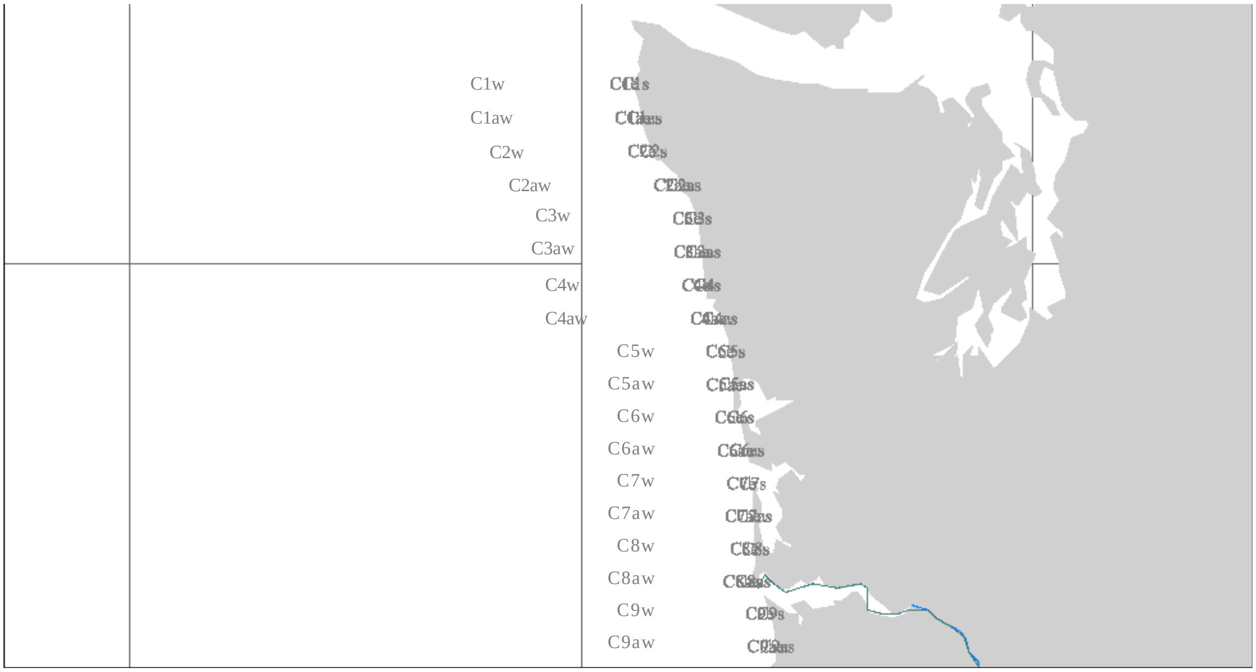
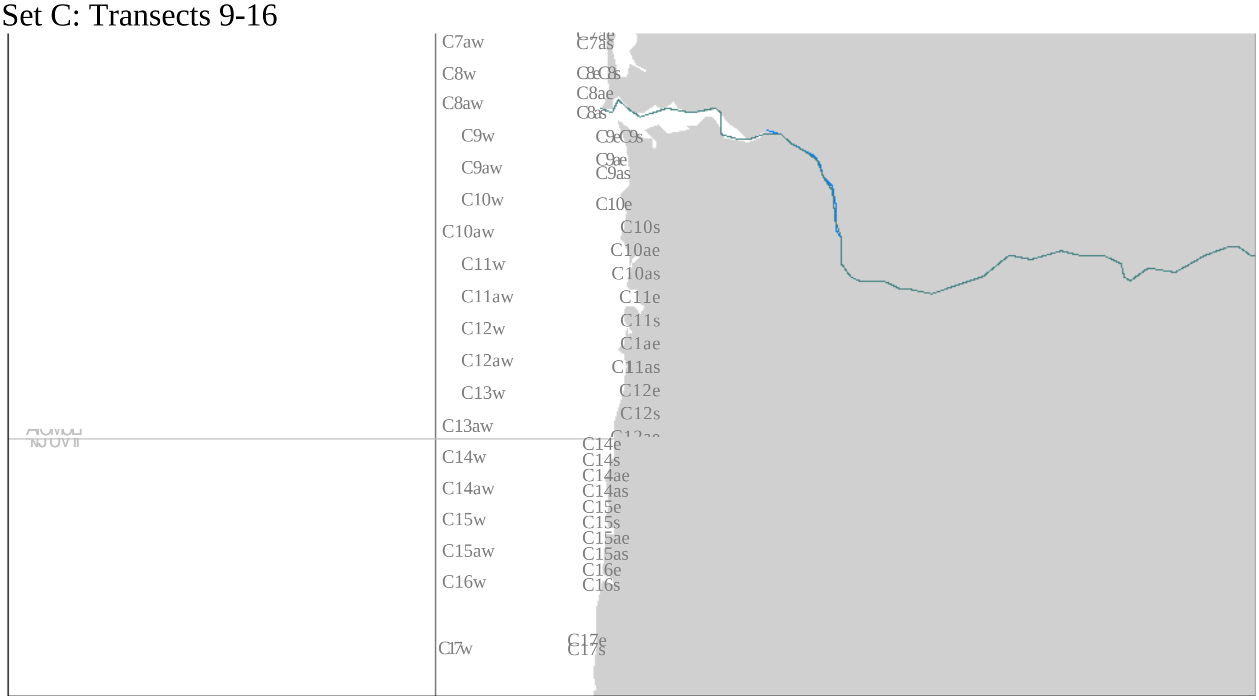


Figure 1c. Maps showing locations of transects comprising Replicate Set C

Set C: Transects 1-8



Set C: Transects 9-16



4.

5.
6.

Figure 1c, Continued. Maps showing locations of transects comprising Replicate Set C

Set C: Transects 17-26

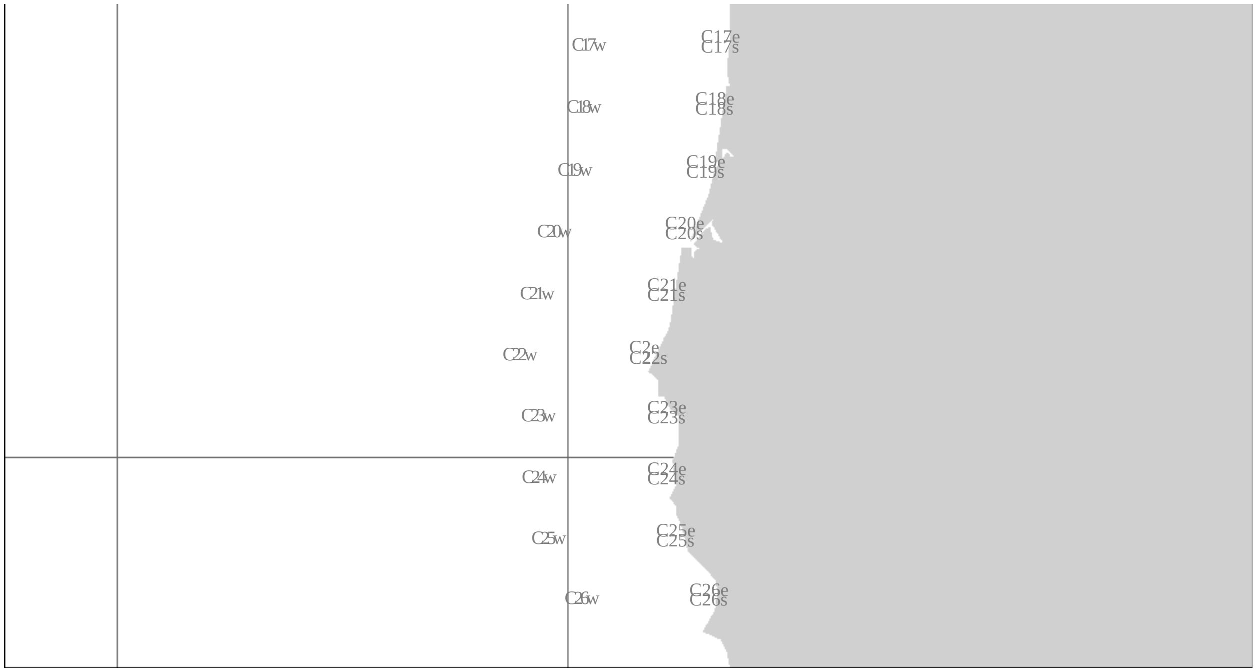
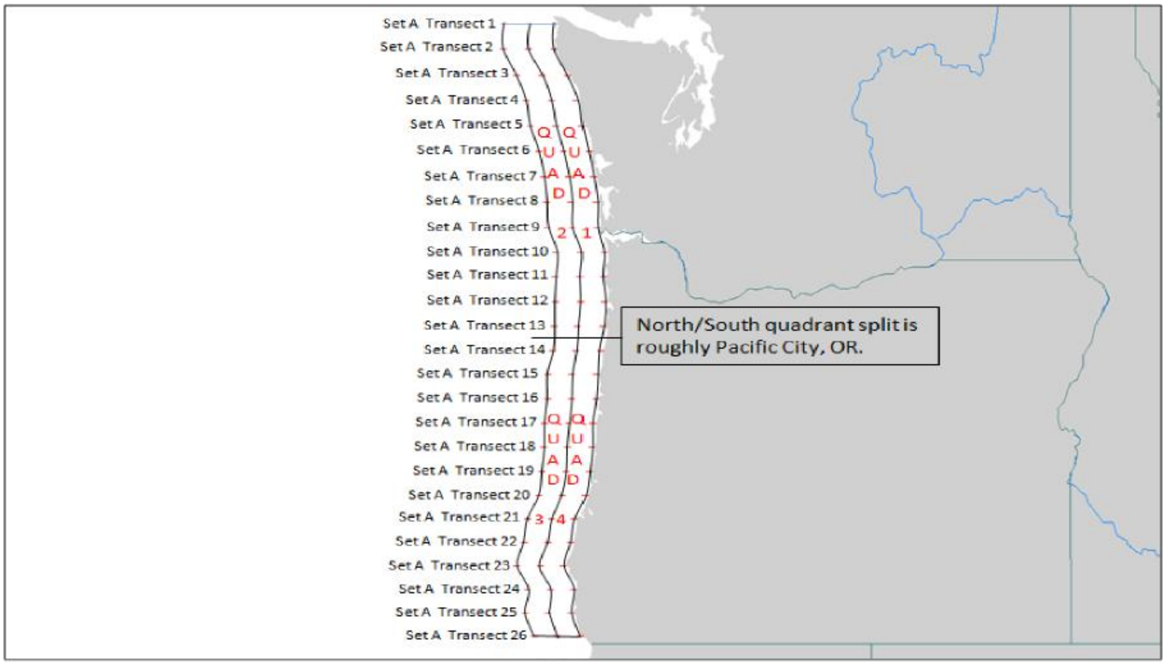
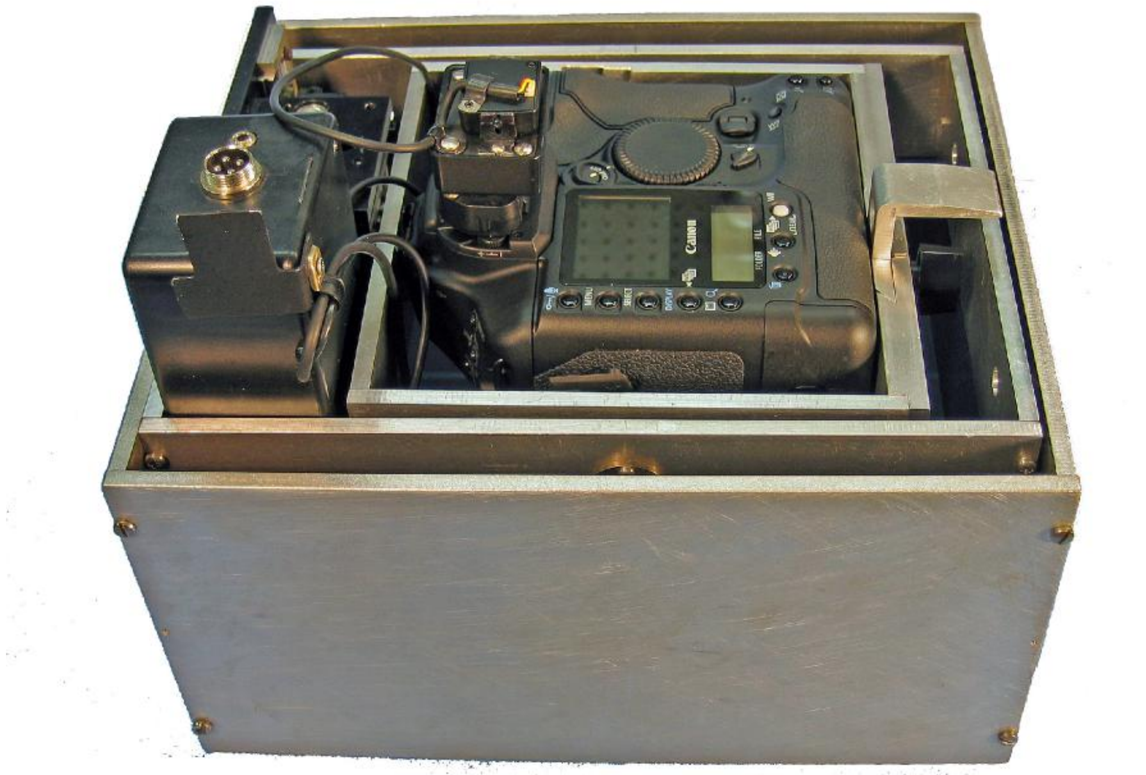


Figure 2. Maps showing quadrants for spatial distribution of point sets.



AERIAL IMAGING SOLUTIONS
FMC MOUNT SYSTEM



An aerial mount system for digital cameras that reduces image blur caused by the forward motion of the aircraft while the shutter is open. The mount and camera are connected to, and remotely controlled by, a program running on a customer-supplied (Windows-based) computer. Flight and camera parameters entered by the computer's operator determine the required forward motion compensation (FMC) and camera firing interval. The system also takes inputs from the customer-supplied GPS and radar altimeter and will, optionally, use these data to automatically determine the required FMC and firing interval. The system includes a remote viewfinder that displays the image seen through the camera's eyepiece on a small monitor to permit the computer operator to observe camera operation to ensure successful coverage of sites. It also includes a data acquisition system that interfaces with the camera, GPS, radar altimeter, and computer to record position and altitude readings as each frame is collected.

Appendix I, Adjunct 2. Field Data Forms

West Coast Sardine Survey

Camera Settings for 1Ds Mark III (Bigger Camera)

1. Press the MENU button located in the upper left corner of the camera, just above the LCD monitor.

    a. Turn the dial on the top right of the camera, near the shutter button, to scroll left though the menu tabs at the top of the monitor.

    b. Under the Shooting 1 tab, ensure that the White balance is set to “AWB” and that the Picture style is set to “Standard.”

    c. Scroll right and select the Shooting 2 tab. Under the Shooting 2 tab, set the image size to “L.”

    d. Scroll right and select the Set-up 1 tab. Set Auto power off to “Off”.

    e. Set File numbering to “Auto Reset”.

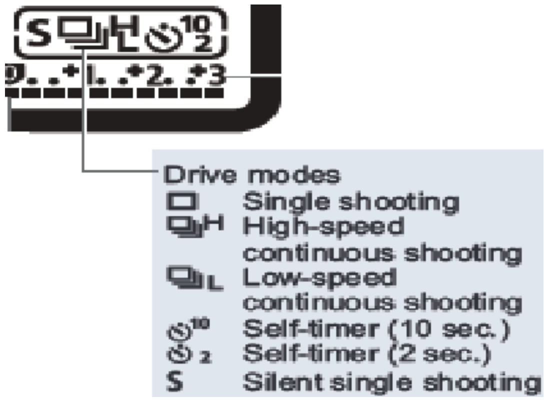
    f. Select Record Function+media/folder sel. and set the camera to “Auto switch media.” Set the camera to record first to the CF memory card (card number 1).

    g. Select Live View function settings. Select Live View shoot. Select “Disable”.

    h. Finally, select File name setting and change the User 1 setting to read “SP3_” for survey pilot 3, “SP4_ “ for survey pilot 4, and so forth. Photos will now be numbered SPx_001, SPx_002, and so on.

2. Set the lens focus mode switch located on the side of the lens to “M” and move the focusing ring toward the camera to engage it.

3. Press the AF DRIVE button located on the top left corner of the camera. Turn the scroll wheel to set the camera to “Single Shot”. The icon is a single rectangle, not “S”. “S” is silent mode, which will ruin your day! See below:



4. Press the MODE button located above the AF DRIVE button and rotate the scroll wheel to set the camera to "M." Wait for the AF drive display to time out, then turn the scroll wheel to set the Aperture to "4.0." Turn the dial to set the Shutter speed to "2000."

5. Press the ISO button located adjacent to the dial and turn the scroll wheel to set the ISO Speed to "400."

6. Ensure that the 3 cables plugged into the side of the camera are securely connected. The 3 connectors are: flash sync, remote, and mini USB.

   - The flash sync connector screws in. Make sure that it is screwed in all the way. It is ok to use long nosed pliers to tighten it if your fingers are too stubby. Just be gentle.

   - The remote connector is a push-pull locking connector. Press on the top rubber part to engage it. Pull on the silver outer ring to disengage it.

   - The mini USB simply plugs in.

West Coast Sardine Survey

Camera Settings for 5D Mark II (Smaller Camera)

1. Press the MENU button located in the upper left corner of the camera, just above the LCD monitor.

    a. Turn the dial on the top right of the camera, near the shutter button, to scroll left though the menu tabs at the top of the monitor.

    b. Ensure that the White balance is set to "AWB" and that the Picture style is set to "Standard."

    c. Set the image size to "L."

    d. Set Auto power off to "Off".

    e. Set File numbering to "Auto Reset".

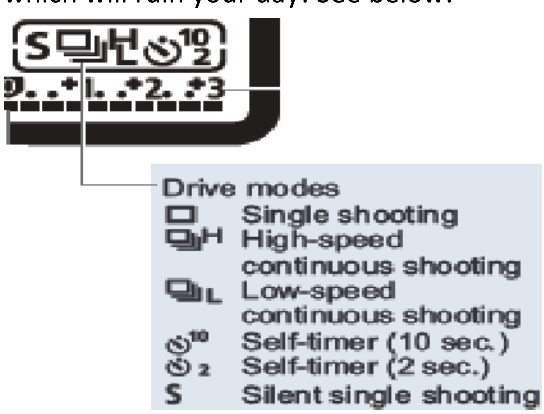
    f. Select Record Function+media/folder sel. and set the camera to "Auto switch media." Set the camera to record first to the CF memory card (card number 1).

    g. Select Live View function settings. Select Live View shoot. Select "Disable".

    h. Disable "Silent Mode" shooting.

2. Set the lens focus mode switch located on the side of the lens to "M" and move the focusing ring toward the camera to engage it.

3. Press the AF DRIVE button located on the top left corner of the camera. Turn the scroll wheel to set the camera to "Single Shot". The icon is a single rectangle, not "S". "S" is silent mode, which will ruin your day! See below:



4. Press the MODE button located above the AF DRIVE button and rotate the scroll wheel to set the camera to "M." Wait for the AF drive display to time out, then turn the scroll wheel to set the Aperture to "4.0." Turn the dial to set the Shutter speed to "2000."
5. Press the ISO button located adjacent to the dial and turn the scroll wheel to set the ISO Speed to "400."

6. Ensure that the 3 cables plugged into the side of the camera are securely connected. The 3 connectors are: flash sync, remote, and mini USB.

   - The flash sync connector screws in. Make sure that it is screwed in all the way. It is ok to use long nosed pliers to tighten it if your fingers are too stubby. Just be gentle.

   - The remote connector is a push-pull locking connector. Press on the top rubber part to engage it. Pull on the silver outer ring to disengage it.

   - The mini USB simply plugs in.

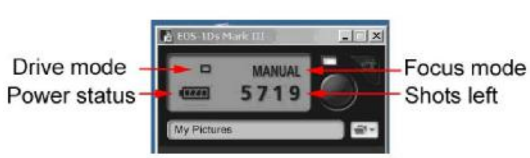
Pilot Checklist

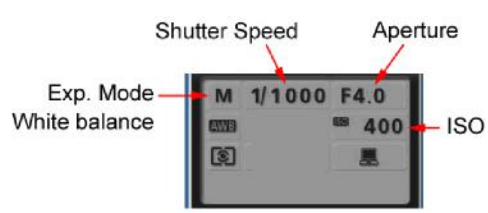
Pre-Flight

1. Check/clean the camera window
2. Check that batteries are fully charged.
3. Ensure that memory cards are installed and have sufficient space.
4. Ensure that a copy of the transect waypoint document is aboard aircraft.
5. Check GPS reading and enter waypoints if necessary.
6. Ensure that all mount system cables are properly connected.
7. Turn on camera, notebook computer, power inverter, and control unit.
8. Ensure the laptop sleep setting is set to "never."
9. Start FMC Mount, Remote Viewfinder, and EOS Utility programs on notebook computer. Note: make sure only one window is open for each of the previous programs, having more than one of any program open will cause problems with the camera system.
10. Adjust FMC Mount program settings, as necessary:
    - Altitude: TBD
    - Speed: TBD
    - Overlap: 80%
    - FMC: On
    - Frame count: 0 (Admin->Frame Count->ENTER "0")
11. Ensure that GPS/IMU is functioning.

    Note: the first time the GPS is used in a new location, it may take up to 25 minutes for the GPS to initialize.

12. Ensure that the camera viewfinder is displayed in the Remote Viewfinder window.
13. Check the camera settings using the EOS Utility. See below:





- Look for the rectangle for Drive mode and "MANUAL" for the Focus mode, to verify that the camera is in "Single Shot" mode and is set to manual focus.

- Verify that the Exp. Mode is "M" for manual exposure control and that the Shutter Speed, Aperture and ISO are set for proper exposure - normally, 1/2000, F4.0, and 400, respectively.

- Press "F9" in the FMC Mount program and verify that the camera fires. The frame counter in the FMC program should advance and that the Shots left indicator in the EOS Utility should subtract.

  WARNING: If the Shots left indicator in EOS Utility doesn't change when the camera fires, it indicates that the images are not being saved to the memory card in the camera. Go to "Preferences -> Remote Shooting", in EOS Utility and check the box "Save also on camera's memory card".

14. The following may be unnecessary:

i. Power OFF the mount system so that power does not spike when the airplane is started.
ii. Start the airplane.
iii. Power ON the mount system.
iv. Verify that the on-screen GPS positions approximately match the pilot's GPS.
v. Press "F9" to take a single photo and verify that all systems are working properly.

Mid-Flight

Upon approaching the beginning of a transect/point set, press "F5" (AUTO) to begin recording. Occasionally compare the Mount System GPS positions with the pilot's GPS. Also, remember to adjust the Mount System altitude and speed settings as necessary.

Post-Flight

After landing, the survey photos and FMC datalog will need to be downloaded. Please contact Mr. Ryan Howe to coordinate the download and archive for each survey day.

West Coast Aerial Sardine Survey

Transect Flight Log Form

Date: **Set:** **Pilot:** **Observer:** **Plane:**

Transect No.	Time	Start Photo No.	Latitude/Longitude	Altitude (ft)	Species Observed	Est. Tonnage (mt)	End Photo No.

Cloud Cover code	Glare code	Beaufort Wind Scale

Comments: ______________________________

Transect No.	Time	Start Photo No.	Latitude/Longitude	Altitude (ft)	Species Observed	Est. Tonnage (mt)	End Photo No.

Cloud Cover code	Glare code	Beaufort Wind Scale

Comments: ______________________________

Transect No.	Time	Start Photo No.	Latitude/Longitude	Altitude (ft)	Species Observed	Est. Tonnage (mt)	End Photo No.

Cloud Cover code	Glare code	Beaufort Wind Scale

Comments: ______________________________

Transect No.	Time	Start Photo No.	Latitude/Longitude	Altitude (ft)	Species Observed	Est. Tonnage (mt)	End Photo No.

Cloud Cover code	Glare code	Beaufort Wind Scale

Comments: ______________________________

Cloud Cover code: 1- Clear, **2**- Cloud Coverage <50%, **3**- Cloud Coverage >50%, **4**- No Visibility

Glare code: 1 - No glare, **2** - glare <50%, **3**- glare >50%, **4**- Cloud shadows <50%, **5**- Cloud shadows >50%, **6** - No visibility

Beaufort Wind Scale: Refer to attached Beaufort Wind Scale (0-12) to quantify sea state

West Coast Aerial Sardine Survey

Biological Sampling Form

Date Landed: Vessel:______________________ Sample No. ___________ Point Set No.

Date Sampled: _________Sampler: ____________________ Processor:____________ Sample Wt (kg):

Fish No.	Weight (g)	Std. Length (mm)	Sex (M/F)	Maturity Code	Otolith Vial No.
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Fish No.	Weight (g)	Std. Length (mm)	Sex (M/F)	Maturity Code	Otolith Vial No.
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
41					
42					
43					
44					
45					
46					
47					
48					
49					
50					

Comments:

West Coast Aerial Sardine Survey

Point Set Flight Log Form

Date: **Pilot:** **Plane:**

Processor: **Observer:**

Point Set No.	Time	Photo No.	Latitude/Longitude	Altitude (ft)	Vessel	Species Observed	% of School Captured	Est. school Tonnage (mt)

Comments:

Point Set No.	Time	Photo No.	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% of School Captured	Est. school Tonnage (mt)

Comments:

Point Set No.	Time	Photo No.	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% of School Captured	Est. school Tonnage (mt)

Comments

Point Set No.	Time	Photo No.	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% of School Captured	Est. school Tonnage (mt)

Comments:

Point Set No.	Time	Photo No.	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% of School Captured	Est. school Tonnage (mt)

Comments:

Point Set No.	Time	Photo No.	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% of School Captured	Est. school Tonnage (mt)

Comments:

West Coast Aerial Sardine Survey

Vessel Point Set Log

Date: ______________________________________**Captain:**

Vessel: **Processor:**

Hydroacoustic Gear

Type	Manufact.	Model	Frequency
Sounder			
Sonar			

Net Dimensions

Net Length (fath)	Net Depth (fath)	Mesh Size

School and Ocean Data

Point Set No.	Time	Latitude	Longitude	Depth to Top of School (fath)	Depth to Bottom of School (fath)	Ocean Depth (fath)	Temp.	Weather Condition

Captains Estimate and Delivery Information / Office Use Only

Point Set No.	Species Observed	% of school captured	Est. School Tonnage (mt)	Fish Hold (FP, FS, MP, MS, AP, AS)	Other Vessel utilized: Name, est. weight, fish hold	*Delivered Weight (mt)	*Fish Ticket Number

Comments:

Type Manufact. Model Frequency

Sounder

Sonar

Depth to Top Depth to Ocean

Point Set Weather

Time Latitude Longitude of School Bottom of Depth

No. Temp.

Condition

(fath) School (fath) (fath)

West Coast Aerial Sardine Survey
Survey Data Form Overview

The purpose of this document is to help guide us through each of the sardine survey data forms. If you are still unclear of what a field within a form is asking, please contact Mr. Ryan Howe for further clarification. Please have all survey forms completed and submitted to Mr. Howe by the end of each survey day.

Transect Flight Log Form

Aerial survey pilots will complete the Transect Flight Log Forms for each transect flown for each survey day. The information recorded on this form will help the photo analyst identify fish schools during the transect survey photo processing period, so be as detailed as possible while recording notes. *If a transect is skipped or aborted due to poor visibility or some other factor, please make a note of it on the Transect Flight Log Form and also let Mr. Howe know as early as possible.

Heading Information

- **Date** – Record the date that the transect is flown
- **Set** – Record which replicate SET is being flown
- **Pilot** – Name of pilot flying the transect
- **Observer** – Name of observer on board if any
- **Plane** – Type of aircraft flying the transect

Transect Data

- **Transect No.** – Record the transect number that is flown
- **Time** – Pilots are asked to log the time a fish school is observed along the survey transect
- **Start Photo No.** – Pilots are asked to log the photo number that corresponds with the school identified on that transect.
- **Latitude/Longitude** – Record the latitude and longitude of the school observed while flying the survey transect.
- **Altitude (ft)** – Record the altitude of the plane as it passes over the school observed
- **Species Observed –** Record the species observed on each transect. Use comments section for additional writing space as needed.
- **Estimated Tonnage (mt)** – Pilots are to estimate the observed tonnage of fish schools identified along the survey transect. If there are too many schools to estimate tonnage for each individual school, estimate the schools as a whole.
- **End Photo No**. – Pilots are asked to log the photo number that corresponds with the last school observed on that transect.

- **Cloud Cover code** – Pilots are asked to record the current cloud cover conditions while flying transects, using the following cloud cover scale: **1**- Clear, **2**- Cloud Coverage <50%, **3**- Cloud Coverage >50%, **4**- No Visibility
- **Glare code** – Pilots are asked to record the current glare conditions on the surface of the water using the following glare scale: **1**- No glare, **2**- glare <50%, **3**- glare >50%, **4**- Cloud shadows <50%, **5**- Cloud shadows >50%, **6**- No visibility
- **Beaufort Wind Scale**: Pilots are asked to refer to the Beaufort Wind Scale (0-12) to quantify sea state conditions during transect flights.
- **Comments** – Please write any additional information or notes in this section

Biological Sampling Form

Biological samples will be taken from landed point sets to collect individual fish data. This form is to be filled out by the person/s working up the biological sample. Please contact Mr. Howe with any questions or for further clarification.

Heading Information

- **Date Landed**– Record the date the point set was landed at the processing plant
- **Vessel** – Record the vessel name that delivered the point set catch
- **Sample No.** – Record the sample number consecutively as they occur during the 2011 season
- **Point Set No.** – Record the point set number that the biological sample corresponds to
- **Date Sampled** – Record the date the biological sample was worked up
- **Sampler** – Record the name of the person/s processing the biological sample
- **Processor** – Name of the fish processing plant the sample was collected at
- **Sample Wt. (kg)** – Record the total biological sample weight in kilograms

Biological Data

- **Weight (g)** – Record the individual fish weights using an electronic scale accurate to 0.5 gm
- **Standard (Std.) Length (mm)** – Record the length of each individual fish. Standard length is measured from the tip of fish snout to last vertebrae in millimeters.
- **Sex** – Record the sex of each individual fish (M = male ; F = female)
- **Maturity Code** – Record the maturity code that closely matches the maturity of the fish. Refer to Table. 3 of the Operational Plan for detailed sardine maturity codes.
- **Otolith vial No.** - The otolith vial number is determined by the following information: the point set number, fish number and the year date the otolith was collected. This information allows for easy reference to the individual fish information as needed.
  Example: Point set number 23 is being offloaded. You collect your biological sample from the processing plant. You have already determined which fish will be the otolith fish. It is a good idea to pre-label the capsules before working up the sample. So our otolith capsule would read **PS23F37-11** which again refers to **P**oint **S**et **23** and **F**ish number **37** of 50 collected in 20**11**.

- **Comments** – Please write any additional information or notes in this section.

Point Set Flight Log Form

During the survey, pilots are asked to record important point set information that will be used in the photo enhancement process. Each pilot is asked to fill out a new Point Set Flight Log Form each day point sets are attempted. The Point Set Flight Log Form allows for six point sets to be recorded on each form. Use additional Point Set Flight Log Forms as needed. Also on the form is a comments section for the pilot to include any other important details or notes.

Heading Information

- **Date** – Record the date the point sets are completed
- **Pilot** – Name of pilot setting the vessel for point sets
- **Plane** – Type of aircraft flying for point sets
- **Processor** – Name of the fish processing plant that the catch will be delivered to
- **Observer** – Name of observer onboard airplane if any

Point Set Flight Log Data

- **Point Set No.** – Number the point sets consecutively as they occur during the 2011 season
- **Time** – Record the time when the point set is attempted
- **Photo No.** - Pilots are asked to log the photo number that corresponds with the point set school that is identified and being targeted
- **Latitude/Longitude** - Record the latitude and longitude of the school being targeted for the point set
- **Altitude(ft)** – Record the altitude of the airplane for which species identification was made
- **Vessel** – Record the name of the vessel being set during each point set
- **Species Observed** – Record the species observed for each point set. Use comment section for additional writing space
- **% of School Captured** – Pilots are to estimate a percentage of point set school capture. Pilots estimated percent capture should be independent of captain's vessel estimate.
- **Estimated School Tonnage (mt)** – Pilots are to estimate the tonnage of the targeted fish school prior to setting on it.
- **Comments** – Please write any additional information or notes in this section.

Vessel Point Set Log Form

During the survey, vessel captains participating in the capture of point sets are asked to record important fish school data, ocean data, catch estimates and delivery information. Additional vessels may be utilized during point set operations, so be sure to include this information in the '**Other Vessel utilized**' field under the Captains Estimate and Delivery Information heading. If additional vessels are used to land a point set, please contact Mr. Howe.

*Heading Informatio*n

- **Date** – Record the date the point set is completed
- **Vessel** – Name of the vessel participating in the point set operations (also include any additional vessels that were utilized during a point set landing)
- **Captain** – Name of the person operating the vessel
- **Processor** –Name of the processing plant the point set catch will be delivered to

Vessel Log Data

Hydro acoustic Gear

- **Manufacturer –** Record the manufacturer name of the sounder and sonar being used during point set operations
- **Model –** Record the model number or series number of the sounder and sonar being used during point set operations
- **Frequency –** Record the frequency used for both the sounder and sonar during point-set operations

Net Dimensions

- **Net Length –** Record the length of the net (in fathoms) being used during point set operations
- **Net Depth –** Record the depth of the net (in fathoms) being used during point set operations
- **Mesh size –** Record the size of the net mesh (in inches) being used during point set operations

School and Ocean Data

- **Point Set No. –** Number the point sets consecutively as they occur during the 2011 season
- **Time –** Record the time the skiff was deployed from the vessel for point set capture
- **Latitude/Longitude –**Record the positional information related to the targeted point set school
- **Depth to Top of School (fm) –** Record the distance from the water surface to the top of the targeted point set school
- **Depth to Bottom of School (fm) –** Record the distance from the water surface to the bottom of the targeted point set school
- **Ocean Depth (fm) –** Record the ocean depth at which the point set occurred
- **Temperature –** Record the temperature of the water that the point set occurred in

- **Weather Condition –** Refer to the key at the bottom of the Vessel Point Set Log form for weather codes: **1**- calm, clear, **2** - light wind, good visibility, **3** - moderate wind, fair visibility, **4 -** poor fishing conditions.

Captains Estimate and Delivery Information

- **Species Observed** – Record the species observed for each point set
- **% of School captured** – Record the percentage of school captured. The captain's estimate will be independent of the pilot's estimated percent capture.
- **Estimated School Tonnage (mt)** – Record the estimated landed weight (mt)of the targeted point set
- **Fish Hold** – Record the fish hold that the point set is being held in for delivery. Below are abbreviations to be used for identifying which hold a specific point set is being held. Of course not all vessels will have six fish holds, use the fish hold code that best represents your vessels.

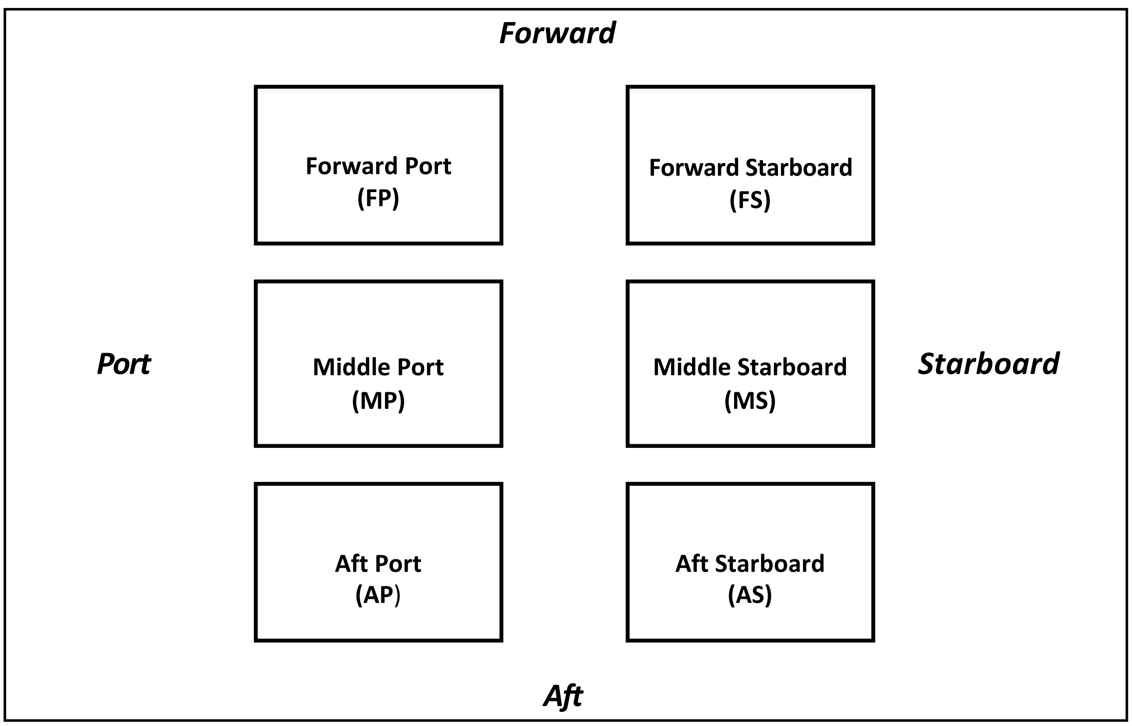


Diagram of fish hold abbreviations to be used on Fisherman's Log Form

- **Other Vessel utilized** – If an additional vessel is utilized to land a point set school, record the vessels name, estimated weight (mt) and in what holds the fish are being held. Use the comments section at the bottom of the form to report any additional information.
- ***Delivered Weight** (Office Use Only) – Leave this field blank. After the delivery is completed, the regional field coordinators will acquire this information from the processing plant manager.
- ***Fish Ticket Number** (Office Use Only) – Leave this field blank. The regional field coordinator will acquire this information from the processing plant manager.
- **Comments** – Please write any additional information or notes in this section.

Appendix I, Adjunct 3. Identification and gear configuration of participating vessels

Vessel Name	Skipper	Owner	USGS/OR Reg#	CPS/Sardine Permit #	Length	GRT	Holds	Capacity (Tons)
Pacific Pursuit	Keith Omey	Pacific Pursuit, LLC	OR873ABY	30920	73'	86	4	80
Lauren L. Kapp	Ryan Kapp	Mt. Hood Holdings LLC	OR072ACX	57008	72'	74	4	70
Pacific Raider	Nick Jerkovich	Nick Jerkovich	972638	57010	58'	75	2	55
Pacific Journey	Leaf Nelson	Stan Nelson	OR661ZK	36106	71'	98	4	78
Evermore	Arnold Burke	Gulf Vessel Management	248555	57009	82'	120	4	50
Sunrise	Roger Smith	Sunrise Fishing, Inc.	238918	57013	80.2'	129	2	65

Appendix I, Adjunct 3a. Identification of participating sardine processors

Fish processors in 2012 will be Astoria Holdings and Astoria Pacific.

Appendix I, Adjunct 4. Aerial Survey Point Set Protocol

1) Sardine schools to be captured for point sets will first be selected by the spotter pilot and photographed at the nominal survey altitude of 4,000 ft. If deemed necessary, and with the approval of Mr. Thon, the altitude for selection may be less than 4,000 ft. After selection, the pilot may descend to a lower altitude to continue photographing the school and setting the fishing vessel.
2) It is essential that any school selected for a point set is a discrete school and is of a size that can be captured in its entirety by the purse seine vessel; point set schools may not be a portion of a larger aggregation of fish.
3) To ensure standardization of methodology, the first set of point sets taken by each participating pilot will be reviewed to ascertain that they meet specified requirements. From that point forward, point set photos will be reviewed routinely to ensure that requirements are met.
4) A continuous series of photographs will be taken before and during the vessels approach to the school to document changes in school surface area before and during the process of point set capture. The photographs will be collected automatically by the camera set at 80% overlap.
5) Each school selected by the spotter pilot and photographed for a potential point set will be logged on the spotter pilots' Point Set Flight Log Form. The species identification of the selected school will be verified by the Captain of the purse seine vessel conducting the point set, and will be logged on the Fishermans' Log Form. These records will be used to determine the rate of school mis-identification by spotter pilots in the field. The purse seine vessel will wrap and fully capture the school selected by the spotter pilot for the point set. Any schools not "fully" captured will not be considered a valid point set for analysis.
6) If a school is judged to be "nearly completely" captured (i.e. over 90% captured), it will be noted as such and will be included for analysis. Both the spotter pilot and the purse seine vessel captain will independently make note of the "percent captured" on their survey log forms for this purpose.
7) Upon capture, sardine point sets will be held in separate holds for separate weighing and biological sampling at the dock.
8) Biological samples of individual point sets will be collected at fish processing plants upon landing. Samples will be collected from the unsorted catch while being pumped from the vessels. Fish will be systematically taken at the start, middle, and end of a delivery as it is pumped. The three samples will then be combined and a random subsample of fish will be taken. The sample size will be n = 50 fish for each point set haul.
9) Length, weight, maturity, and age structures will be sampled for each point set haul and will be documented on the Biological Sampling Form. Sardine weights will be taken using an electronic scale accurate to 0.5 gm. Sardine lengths will be taken using a millimeter length strip provided attached to a measuring board. Standard length will be determined by measuring from sardine snout to the last vertebrae. Sardine maturity will be established by referencing maturity codes (female- 4 point scale, male- 3 point scale). Otolith samples will be collected from n = 25 fish selected at random from each n = 50 fish point set sample for future age reading analysis. Alternatively, the 25 fish subsample

may be frozen (with individual fish identified as to sample number, point set, vessel and location captured, to link back to biological data) and sampled for otoliths at a later date.

10) School height will be measured for each point set. This may be obtained by using either the purse seine or other participating research vessels' hydroacoustic gear. The school height measurements to be recorded on the Fishermans' Log Form are: 1) depth in the water column of the top of the school, and 2) depth in the water column of the bottom of the school. Simrad ES-60 sounders will be installed on two purse seine vessels. Data collected by the ES-60 sounders will be backed-up daily and archived onshore.
11) Point sets will be conducted for a range of school sizes. Point sets will be targeted working in general from the smallest size category to the largest. The field director will oversee the gathering of point set landing data and will update the list of point sets needed (by size) daily for use by the spotter pilot. Each day, the spotter pilot will operate with an updated list of remaining school sizes needed for analysis. The spotter pilot will use his experience to judge the surface area of sardine schools from the air, and will direct the purse seine vessel to capture schools of the appropriate size. Following landing of the point sets at the dock, the actual school weights will be determined and the list of remaining school sizes needed will be updated accordingly for the next day of fishing. If schools are not available in the designated size range, point sets will be conducted on schools as close to the designated range as possible. Pumping large sets onto more than one vessel should be avoided, and should only be done in the accidental event that school size was grossly underestimated.
12) The Scientific Field Project Leader will also oversee the spatial distribution of point set sampling, to ensure adequate dispersal of point set data collection.
13) Photographs and FMCdatalogs of point sets will be forwarded from the field to Mr. Howe daily.
14) The total landed weight of point sets taken will not exceed the EFP allotment.
15) The following criteria will be used to exclude point sets from the density analysis (reasons used to deem a point set "unacceptable"). Mr. Howe will make the final determination of point set acceptability in the lab. A preliminary judgment will be made in the field, generally at the end of each day (or sooner), to ensure ongoing sampling is being properly accomplished.

1	Percent captured	School is judged to be less than 90% captured
2	No photograph -1	No photograph of vessel was documented (camera off)
3	No photograph -2	No photograph of vessel was documented (camera on)
4	No photograph -3	Photograph available, but late (vessel is already pursing the catch)
5	School not discrete	Sardine captured was only a portion of a larger school ("cookie cutter")
6	Mixed hauls	Multiple point sets were mixed in one hold

Appendix II

NMFS Guidelines: Coastal Pelagic Species Exempted Fishing Permit (EFP)

Aerial Sardine Survey

Application/Proposal Contents:

1. EFP application must contain sufficient information to determine that:

    a. There is adequate justification for an exemption to the regulations;

    Under this EFP, the West Coast Sardine Survey (a consortium of sardine industry participants) will perform a synoptic survey of the sardine biomass off the U.S. West Coast using aerial survey data in conjunction with fishing vessel observation data. This survey will continue the time series of data collection started in 2009 that provided information used in the PFMC Pacific sardine stock assessment. The PFMC has indicated support for the further development of this work, and has voted to set-aside a research allocation for the project.

    b. The potential impacts of the exempted activity have been adequately identified;

    Because the fishing, fishing locations, and quantities of fish requested in this EFP are addressed as part of the 2012 sardine harvest guideline as provided for in the CPS FMP, no additional unforeseen impacts are expected from this activity.

    c. The exempted activity would be expected to provide information useful to management and use of CPS fishery resources.

    <See: Introduction section of the Main Document>

2. Applicants must submit a completed application in writing that includes, but is not limited to, the following information:

    a. Date of application;

    [TBD]

    b. Applicant's names, mailing addresses, and telephone numbers;

    <See: Survey Logistics; Project Personnel: Roles and Responsibilities (Page 9 of Main Document) >

    c. A statement of the purpose and goals of the experiment for which an EFP is needed, including a general description of the arrangements for the disposition of all species harvested under the EFP;

<See Introduction (Page 2 of Main Document); Survey Logistics; Disposition of fish harvested under the EFP (Page 9 of Main Document)>

d. Identify a single project manager (the point of contact person responsible for overall coordination of the project from beginning to end), and other staff or organizations necessary to complete the project, including specific responsibilities related to technical, analytical, and management roles. Provide evidence that the work proposed is appropriate for the experience of the investigators.

To ensure clear communications among participants and other interested parties, the single point of contact person during 2012 survey field work will be Mr. Chris Cearns (NWSS).

<See also: 1) Survey Logistics; Project Personnel: Roles and Responsibilities (Page 7 and 8 of Main Document) and 2) Appendix II, Adjunct 2; Scientific Advisors: Resumes and Curriculums Vitae>

e. Valid justification explaining why issuance of an EFP is warranted;

In 2008, pilot work began in the Northwest to evaluate the quantitative aerial survey method with point sets collected during the summer period of open fishing. It was very difficult to collect the data in a deliberate, methodical manner during the frenetic pace that typically accompanies a derby-style fishery opening. The issuance of an EFP allows for a more controlled sampling process with the focus on research and data quality, and will help to ensure better and more complete study results while using industry resources. This approach worked well in 2009, 2010, and 2011.

f. A statement of whether the proposed experimental fishing has broader significance than the applicant's individual goals;

The research to be conducted under this EFP will further continue the time series of a new, scientifically rigorous survey of the Pacific sardine resource, and will again provide valuable Pacific sardine stock assessment data to the Council and to NOAA Fisheries. This information is considered a high priority research and data need by NOAA Fisheries. This survey methodology has been recommended by the Council and its sub-panels for use as an index of abundance in the PFMC Pacific sardine stock assessment.

g. An expected total duration of the EFP;

This EFP will be valid for one year, allowing for catching of Pacific sardine during the closed period between the second and third allocation periods in the 2012 season.

h. Number of vessels covered under the EFP as well as vessel names, skipper names, and vessel ID numbers and permit numbers;

<See: Appendix I, Adjunct 3; Identification and Gear Configuration of Participating EFP Vessels>

i. A description of the species (target and incidental) to be harvested under the EFP and quantitative justification for the amount(s) of such harvest necessary to conduct the experiment; this description should include harvest estimates of overfished species and protected species;

Under this EFP, participating vessels will target Pacific sardine exclusively. NWSS is proposing to the PFMC that 3,000 mt of Pacific sardine be deducted from the 2012 Harvest Guideline prior to allocation and set aside for the dedicated sardine research to be conducted under this EFP. If approved, the harvested quantity under this EFP will be limited to this Council recommended 3,000 mt set-aside.

Bycatch is generally low in CPS fisheries because most CPS vessels fish with roundhaul gear, which encircles schools of fish with nets. This gear targets specific schools, which usually contain only one species. The most common incidental catches in the CPS fishery are other CPS species; Pacific mackerel, jack mackerel, market squid, and northern anchovy, may be encountered in small numbers and will be retained if captured. Quantities of these other coastal pelagics species are expected to be nominal, and within the harvest guidelines for those species. Few other species are expected to be encountered or harvested under this EFP.

A quantitative analysis of sample size requirements was conducted in 2010 to justify the amount of sardine needed to accomplish the survey objectives (See: Sardine EFP Application for 2010 (WCSS 2010): Pages 11, and Appendix III.

j. A description of a mechanism, such as at-sea or dockside fishery monitoring, to ensure that the harvest limits for targeted and incidental species are not exceeded and are accurately accounted for, and reported;

Under this EFP, participating vessels will deliver all species harvested to participating processing/freezing facilities within the survey area. Each participating vessel and participating processing/freezing facility will be responsible for collecting and recording catch data for each species delivered. Each participant will be responsible for the issuing and reporting of fish tickets to State authorities, as required by law.

Each participant will also be required to report all catch and fish ticket data to the survey Scientific Field Project Leader on a daily basis. Daily reporting is necessary to achieve the project objectives as specified in the Survey Design section of the main document. Individual point set catches will be kept in separate vessel holds and will be individually weighed at the dock upon landing. These individual point set catch weights will be tallied by the Scientific Field Project Leader to monitor the attainment of the project sample size goals, which specify that point sets are to be collected in specific size categories (small and large) required under the survey design . This detailed accounting of daily catch will allow for a likewise detailed reporting to NMFS authorities and will ensure that the total sardine set aside amount of 3,000 mt will not be exceeded.

Any bycatch of other CPS species will be retained and a tally of the catch by species will be maintained by the Scientific Field Project Leader and reported to NMFS authorities on a daily basis to ensure that the harvest guidelines of incidental species taken are not exceeded. We do not expect more than a nominal amount of incidental species to be taken.

The PFMC website notes that, according to NMFS Biological Opinion, "... fishing activities conducted under the CPS FMP are not likely to jeopardize the continued existence of any endangered or threatened species." It is not expected that any fishing under this EFP would have any effect on any endangered or threatened species.

k. A description of the proposed data collection methods including procedures to ensure and evaluate data quality during the experiment and data analysis methodology and time line of stages through completion;

<See: 1) Survey Design and Survey Logistics sections of the Main Document, and 2) Appendix I: Field Operational Plan>

l. *A description of how vessels were chosen to participate in the EFP;*

<See: Page 8 of Main Document; EFP Purse Seine Vessel Selection>

m. For each vessel covered by the EFP, the approximate time(s) and place(s) fishing will take place, and the type, size, and amount of gear to be used;

Participating vessels will have the option to operate throughout the entire range of the survey region (from Cape Flattery, WA to the Oregon/California border).

<See: Appendix I, Adjunct 3: Identification and configuration of participating vessels>

n. Identify potential benefits to fisheries management and coastal communities;

Sardine industry participants assert, based on the observations of fishing vessels and spotter pilots, that the survey to be conducted under this EFP will show a significantly greater Pacific sardine biomass than has been estimated under previous stock assessment models. If this assertion is proven to be true, the Pacific sardine HG may be expected to increase over that called for under the current stock assessment model. In any event this survey methodology has been demonstrated to be a valuable second index of abundance to expand understanding of the Pacific sardine resource.

A greater HG would provide benefits to all Pacific sardine and other CPS fisheries industry participants, including the fishermen, processers, spotter pilots, and all those employed by them, as well as to the coastal communities that support these industries. Due to the reduced HG in 2008, fishing was limited to 135 days in the first seasonal allocation period, 38 days in the second seasonal allocation period, and 7 days in the third seasonal allocation period, resulting in 185 lost fishing days. Fishing seasons were further limited in 2009, [50 fishing days in the first period, 17 days in the second period, 8 days in the third period, and total prohibition on sardine retention on December 23, virtually eliminating fishing on the CPS complex including market squid]. Fishing was further limited in 2010. These closures precipitated even greater socio-economic impacts on communities. These lost fishing days mean reduced employment for fishing vessel and processing plant crews, and reduced income for coastal communities.

o. Discuss compatibility with existing seasons and other test fisheries, potential difficulties with processors or dealers, additional enforcement requirements, and potential negative impacts of the study (e.g., species listed under the Endangered Species Act, allocation shifts, shortened allocation periods, etc.);

The research set-aside for the aerial sardine survey is supported enthusiastically by the west coast sardine industry. Processors and dealers are supportive of this EFP; they are contributing a significant in-kind contribution to the research by processing the fish at cost and contributing the profit from the fish to the research. This EFP research set aside is part of the harvest guideline, and daily reports will be supplied to NMFS detailing the vessels fishing, their landing port(s) and amount of fish caught; no additional enforcement costs should be accrued.

p. Discuss ability to conduct proposed research - Identify the total costs (including collection of samples, data analysis, etc) associated with the research and sources of funding; identify any existing commitments for participation in, or funding of the project;

<See: Appendix II, Adjunct 2; Estimated Project Budget>

q. The signature of the applicant(s);

<See cover page>

Thomas H. Jagielo

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Employment

[2008-Present] Tom Jagielo, Consulting Seattle, WA

Fisheries Science Consultant *Recent Projects include:*

- Design an aerial survey to estimate menhaden abundance on the east coast of the U.S. for Virginia Institute of Marine Science.
- Design and execution of an aerial survey to estimate Pacific sardine abundance (Washington-Oregon–California) *for the* Pacific Fishery Management Council.
- Represent Oregon Department of Fish and Wildlife on the Scientific and Statistical Committee of the Pacific Fishery Management Council.
- Review and Evaluation of Annual Catch Limits and Accountability Measures proposed by Western Pacific Fishery Management Council *for the* NMFS Pacific Islands Regional Office, Honolulu, Hawaii.
- Literature review and evaluation of West Coast Spatial groundfish management *for the* Environmental Defense Fund.
- Marine Stewardship Council: Peer reviewer of Pacific Whiting certification; Literature search for West Coast Groundfish certification.

[1984-2008] Washington Dept. of Fish and Wildlife Olympia, WA

Senior Research Scientist

- Developed stock assessments and rebuilding analyses used by Pacific Fishery Management Council; Designed surveys and conducted undersea manned submersible research; Investigated groundfish movement, survival, and abundance.

[1979-1984] University of Washington Fish. Res. Institute Seattle, WA

Biologist

- Projects included: Foreign Fisheries Observer; *Limnology of Lake Roosevelt*; *Toutle River salmon survival; Seahurst Outfall Study.*

Education

[1988-1992] University of Washington Seattle, WA

Post MS Graduate Study

- Fishery Population Dynamics, Statistical Sampling and Estimation

[1986-1988] University of Washington Seattle, WA

Master of Science

- MS in Fisheries – Limnology of Lake Roosevelt, WA.

[1974-1977] Pennsylvania State University University Park, PA

Bachelor of Science

- BS in Biology and Marine Science

Selected Scientific
Statistical **Committees**

- Pacific Fishery Management Council Scientific and Committee: Chairman (2002-2003); Vice Chairman (2000-2001); Member: (1992-2008) and (2009-2011).

- US/Canada Groundfish Technical Subcommittee: Chairman (2003, 1987-1988); Member 1986-2008.

- PaCOOS – Pacific Coast Ocean Observation System: WDFW representative (2006-2008).

Selected Publications

Jagielo, T.H. 1988. The spatial, temporal, and bathymetric distribution of coastal lingcod trawl landings and effort in 1986. State of Wa. Dept. of Fish. Prog. Rept. No. 268. June 1988. 46 pp.

Jagielo, T.H. 1990. Movement of tagged lingcod, (*Ophiodon elongatus*), at Neah Bay, Washington. Fish. Bull. 88:815-820.

Jagielo, T.H. 1991. Synthesis of mark-recapture and fishery data to estimate open population parameters. *In* Creel and Angler Surveys in Fisheries Management, American Fisheries Society Symposium 12:492-506.

Jagielo, T.H. 1994. Assessment of lingcod (*Ophiodon elongatus*) in the area north of Cape Falcon (45^{0} 46' N.) and south of 49^{0} N. in 1994. *In* Pacific Fishery Management Council, 1994. Status of the Pacific Coast Groundfish Fishery Through 1994 and Recommended Acceptable Biological Catches for 1995. Appendix I. Pacific Fishery Management Council, Portland, Oregon.

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Jagielo, T. H., LeClair, L.L., and B.A. Vorderstrasse. 1996. Genetic variation and population structure of lingcod. Trans Amer. Fish Soc. 125(3).

Jagielo, T.H., Adams, P., Peoples, M., Rosenfield, S., Silberberg, K, and T. Laidig. 1997. Assessment of lingcod (Ophiodon elongatus) for the Pacific Fishery Management Council in 1997. SAFE, 1998. Pacific Fishery Management Council, Portland, Oregon.

Jagielo, T.H. 1999. Rebuilding analysis for lingcod. Report prepared for the Pacific Fishery Management Council, Portland, OR.

Jagielo, T.H. 1999. Movement, mortality, and size selectivity of sport and trawl caught lingcod (*Ophiodon elongatus*) off Washington. Trans. Amer. Fish. Soc. 128:31-48.

Jagielo, T.H., Vandenberg, D.V., Sneva, J., Rosenfield, and F. Wallace. 2000. Assessment of lingcod (Ophiodon elongatus) for the

Pacific Fishery Management Council in 2000. SAFE, 2001. Pacific Fishery Management Council, Portland, Oregon.

Kocak, D.M., Caimi, F.M., **Jagielo, T.H.** and J. Kloske. 2002. Laser Projection Photogrammetry and Video System for Quantification and Mensuration. Oceans 2002, Marine Technology Society. Biloxi MS.

Jagielo, T.H., Hoffmann, A, Tagart, J., and Zimmermann, M. 2003. Demersal groundfish densities in trawlable and untrawlable habitats off Washington: implications for the estimation of habitat bias in trawl surveys. Fish Bull. 101:545–565.

Jagielo, T.H. and F. R. Wallace. 2005. Assessment of Lingcod (*Ophiodon elongatus*) for the *Pacific Fishery Management Council* in 2005. *In* Stock Assessment and Fishery Evaluation. Pacific Fishery Management Council 2130 SW Fifth Ave. Suite 224, Portland, Ore. 97210.

Wallace, F., Tsou, T., **Jagielo, T**., and Cheng, Y.W. 2006. Status of Yelloweye Rockfish off the U.S. West Coast in 2006. *In* Stock Assessment and Fishery Evaluation. Pacific Fishery Management Council 2130 SW Fifth Ave. Suite 224, Portland, Ore. 97210

Jagielo, T.H., Hanan, D., and R. Howe. 2009. West Coast Aerial Sardine Survey. Sampling Results in 2009. Prepared for Northwest Sardine Survey and the California Wetfish Producers Association. Submitted to the Pacific Fishery Management Council, Portland, OR, October 14, 2009. 14p.

Jagielo, T. H., Hanan, D., Howe, R., and M. Mikesell. 2010. West Coast Aerial Sardine Survey. Sampling Results in 2010. Prepared for Northwest Sardine Survey and the California Wetfish Producers Association. Submitted to Pacific Fishery Management Council, Portland, OR, October 15, 2010. 51p.

Jagielo, T. H., Howe, R., and M. Mikesell. 2011.West Coast Aerial Sardine Survey. Sampling Results in 2011. Prepared for Northwest Sardine Survey. Submitted to Pacific Fishery Management Council, Portland, OR, October 13, 2011. 91p.

Ryan A. Howe

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Objective: To further my experience in the fisheries field while working with government agencies as well as public and private stakeholders.

Education: **University of Alaska**: Anchorage, AK
North Pacific Groundfish Observer
Program Level 1 Observer (October 2006)
Level 2 Observer (March 2008)

Michigan State University: East Lansing, MI
Bachelor of Science Degree (August 2006): Fisheries and Wildlife

Work Experience:

Scientific Field Lead
West Coast Aerial Sardine Survey: WA and OR *July 2008 – Present*

- Coordinate data collection of aerial sardine survey
- Interaction with state and federal agencies as well as public and private stakeholders
- Collect biological information routinely of Pacific sardine (*Sardinops sagax*)
- Enhancement and analysis of digital photos using Adobe Photoshop CS5 and Adobe Lightroom 3
- Oversee the aerial sardine survey photo analyst staff
- Experience with Canon EOS 1Ds camera in an Aerial Imaging Solutions FMC mount system

Fisheries Technician
Pacific Whiting Conservation Cooperative: Seattle, WA *May 2008 – May 2009*

- Collect biological information daily of Pacific Whiting (*Merluccius productus*) and other species (i.e. species I.D., length/weight, species retention and storage)
- Record raw data on deck forms and enter in Microsoft Excel daily
- Assist in Seabird CTD operations (conductivity, temperature, depth)
- Work with vessel operator and crew to accomplish project tasks

North Pacific Groundfish Observer
TechSea International Inc.: Seattle, WA *September 2006 – March 2008*

- Collect biological samples for species composition, sex, and weight for catch and bycatch for vessels fishing in the Bering Sea and Gulf of Alaska
- Collect and record fishing effort, location, gear type, and incidental take of prohibited species
- Record fishery interactions with marine mammals and seabirds.
- Interaction with state and federal agencies as well as public and private stakeholders

Fisheries Technician

Michigan State University: East Lansing, MI *June 2006 – August 2006*

- Electro-shocked streams in northwest and southwest Ontario, Canada for a Sea Lamprey (*Petromyzon marinus*) recruitment and population research project
- Maintained electro-shocking equipment and USGS vehicle provided for project.
- Recorded biological, positional and catch information of sampled transects.

Fisheries Technician

Michigan State University: East Lansing, MI *Fall 2005*

- Gained communication skills through interaction with hatchery biologists of the Michigan Department of Natural Resources.
- Collect biological samples of Chinook salmon (*Oncorhynchus tshawytscha*) for future genetic analysis and to check for the presence of bacterial kidney disease (BKD).

Appendix II, Adjunct 2. Estimated Project Budget

Estimated NWSS EFP Project Budget - 2012				Draft 1-31-2012				
REVENUES:								Extension
Estimated Revenue/mt (FOB container yard):		$ 675.00						
Estimated EFP sardine available (mt):		3,000						
Estimated project revenue:								$ 2,025,000
EXPENSES:						Weather		
Aerial Transects		# Transects	$/hr	Total/Set	Replicates	contingency	Total	
Flying the transects	41	3	$500	$61,500	3	1.25	$230,625	
Processing transect images	41	12	$25	$12,300	3		$36,900	
Point Sets	# Point sets	#Sets/V Day	$/V Day	# V Days				
Fishing Point sets on schools	82	2	$12,500	41			$512,500	
	Hours		$/Hr					
Flying the point sets	112		$300				$33,600	($813,625)
Scientific support costs:								
Science Oversight and Staff - compensation							$220,000	
Science Oversight and Staff - expenses							$40,000	
								($260,000)
Supplies and Equipment							$7,000	
								($7,000)
Accounting/bookkeeping							$5,000	
								($5,000)
10% contingency on operations							$108,063	
								($108,063)
PROJECT SUBTOTAL								**$831,313**
Estimated Processing Costs								
Estimated processing Cost/mt:	$ 300.00							**($900,000)**
NET Proceeds								**($68,688)**

Canadian west coast of Vancouver Island summer sardine research trawl surveys, 1999-2011, sardine catch density and length, sex and age data sets

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INTRODUCTION

The California Current northeast Pacific sardine (*Sardinops sagax*) population, when abundant, occupies coastal waters from Baja California to northern British Columbia (McFarlane and MacDougall 2001; Hill et al. 2011). This population has been shown to undergo long term cycles in abundance having disappeared from much of the west coast of North America in the late 1940s and not showing signs of recovery until the early 1980s (Ware 1999, MacCall 1979; Hill et al. 2011). Research sampling and commercial fishing have shown that during winter and spring months, most of the sardine population resides in waters off the California coast during periods of peak spawning activity (Hill et al 2010, 2011). Since the population has shown signs of recovery, a portion of the population migrates and occurs in northern areas of its range (Oregon, Washington and British Columbia) during late spring through fall months. Sardines caught in the more northern waters appear to represent larger and older components of the population and migratory patterns may be affected by age structure, population size and seasonal dynamics of oceanographic conditions, such as the 12ºC isotherm (Ware 2001; Hill et al 2010, 2011; Zwolinski et al 2011, 2012).

Sardines have been observed in catch compositions (as incidental catch) of Fisheries and Oceans Canada (DFO) research trawl surveys since the early 1990s and DFO resources directed at sardine research has gradually increased over the years as seasonal sardine occurrence has persisted or increased in British Columbia (B.C.) waters (Hargreaves et al. 1994; McFarlane and McDougall 2001; Schweigert and McFarlane 2009; Flostrand et al 2011). Consistencies in some key annual trawl fishing methods between years, such as seasonal timing, sub-regional coverage off the west coast of Vancouver Island (WCVI), and trawl depth ranges started to occur by 1999 at the same time as increasing commercial fishing interests and the development of research and commercial biological sampling programs.

Trends in DFO summer WCVI trawl survey sardine densities are believed to be informative descriptors for considering the intensity and extent of sardine migration in B.C. waters. Mean trawl densities either representing some form of regional stratification or from pooling tow density estimates over the region have been key observations used by DFO to depict changes in sardine distribution and abundance between years and for calculating regional biomass estimates associated with commercial harvest allowances (Schweigert and McFarlane 2001; DFO 2001; Schweigert et al 2009; DFO 2009, 2011, 2011a; Flostrand et al 2011, DFO 2012, 2012a).

To scale and fit recent estimates in sardine population assessment models, assessment methods have incorporated indices of abundances from several survey sources and sardine length and length at age data from biological samples have been pivotal in characterizing age compositions (MacCall 1979, Hill et al 1999, Hill et al 2010, 2011). This report attempts to describe DFO summer research trawl sampling methods and data sets considered by authors to be relevant forpossible inclusion in future California Current northeast Pacific sardine population assessments. This report describes sampling methods from summer (July and August) WCVI trawl surveys from 1999 to 2011 and resulting sardine catch density data and sardine length, sex and age samples collected from summer WCVI trawl surveys and summer (July and August) commercial sardine seine fishery catches. There are several inconsistencies in the time series and many details need to be considered, such as related to survey and commercial fishing patterns and sampling intensities.

METHODS

WCVI TRAWL SAMPLING

The geographic scope of the survey data was restricted to waters off or near the west coast of Vancouver Island (WCVI), within latitudes of 48 and 51.3 degrees and longitudes west of 124.6 degrees. Most trips represent sampling between the third week of July and the third week in August, although some early July sampling occurred in 1999 (Table 1). Only trawl data representing tow depths where the top of the head rope was less than 30m deep were included. In total, there are 792 trawl records meeting these criteria, 347 (43.8%) with positive sardine catches, collectively representing surveys from 1999 to 2011.

For all years except 2005, the research vessel *W.E. Ricker* (a 57.3 m steel stern trawler) was deployed; whereas in 2005, the FV *The Frosti* was chartered. For all years, the trawl net configuration consisted of a model 250/350/14 mid water rope trawl (Cantrawl Pacific Ltd., Richmond, B. C.) with trawl mouth dimensions being typically ~ 32m wide and ~14m high. Two Model P USA Jet doors (Cantrawl Pacific Ltd) were used in combination with the net to keep the mouth open. The head ropes were attached to large floats to maintain the trawl net near the surface. The mid-water trawl is made up of the four following sections: 1.) a heavy-duty front end of hexagonal web of 3/8 in. (9.5mm) and 5/16 in. (7.9mm) Tenex rope; 2.) a tapered body with 64 in. (163cm), 32 in. (81.3cm), 16 in. (40.6cm), 8 in. (20.3cm) and 4 in. (10.2cm) polypropylene sections; 3.) an intermediate section of 3 in. (7.6cm) polypropylene; and 4.) a codend of 1.5 in. (3.8cm) knotted nylon, lined with a 1/4 in. (6.4mm) mesh insert.

There is considerable variability in trawl depth, trawl survey spatial coverage, sampling intensity and patterns between survey years (Table 1, Figure 1). Where relevant (i.e. 1999 to 2005), trawl depths (from the head rope of the trawl net) have been grouped into two depth categories, less than 15m and 15-25m (Table 1). For years when both depth ranges were used, most tows were <15m. Prior to 2005, tows within the <15m range varied considerably within that range, whereas the top of the trawl head rope was estimated to be at nominal depths of 2-4 m below the surface for most tows in 2008 and all tows in 2005, 2006 and 2009-2011. Sampling occurred predominantly during the day (i.e. 7am-7pm) in 1999-2002 and in 2004. Sampling occurred predominantly at night (~9pm-6am) in 2006-2011. Both day and night sampling occurred in 2003 and 2005. Since 2006, surveys have been at night based on the understanding that schools are more likely to be near the surface and spread out over wider surface areas while sardines forage, therefore more conducive to trawl sampling. In all cases, acoustics were not used to target or detect schools for fishing purposes so all tows are considered “blind” with the vessel heading into the direction of any wind. Sampling generally occurred from north to south to minimize the possibility of fishing the same schools more than once during northward migrations.

From 1999 to 2009, line transects and ad hoc spatial patterns were applied but the 2002 and 2005 surveys had relatively low spatial coverage compared to other years (due to small sample sizes and clustered spacing) and no survey was conducted in 2007. For the 2010 and 2011 surveys, tow locations were randomly selected prior to the survey to try to minimize possible bias affecting biomass estimates (for example, sampling along environmental gradients). The 2010 survey design was based on a 10x10 km mapped grid extending approximately 2 to 52 km from shore with a range in latitude of 50.7ºN to 48.5°N, extending southward to within 10 km of the U.S. border. The 2011 survey design was based on an approximate 10x10km mapped grid extending throughout a core survey region (Appendix A). Grid intersections represented possible sampling stations and sampling effort was distributed evenly across a latitudinal gradient, by assuming that 70 to 75 stations would be sampled over 11 nights. Future surveys will likely follow a similar sampling design to what was done in 2011.

Most trawling occurred at tow speeds ranging from 4.5 to 5.5 knots, equivalent to 8.3 to 10.2 km/hour (Figure 2A) and no corrections were made for tides or sea state. Tow speeds were not recorded prior to 2002, but were for all other years. In total, tow speed was recorded for 593 of the 792 records and the mean tow speed (and standard deviation) is 4.9 (0.53) knots, equivalent to ~9.1 (1.0) km/hour. In order to estimate volume of water trawled by tow set, a tow speed of 5 knots was assumed for all records missing tow speeds.

The duration of each tow was recorded as the interval between end of net deployment and start of net retrieval. Trawl duration was recorded for all tows in the time series. Tow durations typically ranged from 20-40 minutes and the mean (and standard deviation) is ~27 (8.8) minutes (Figure 2B). Eleven tows were less than 10 minutes and four of those had notably high sardine catch densities. There were 3 tows with durations greater than 60 minutes (73-150 minutes), none of which caught sardines.

For each tow, fishing distance was estimated by multiplying tow speed by the time interval between end of net deployment and start of net retrieval. Most distances ranged within 2.5 and 5 km with a mean (and standard deviation) of 3.3 (1.1) km for cases where tow speed was recorded and 3.6 (1.1) km for all cases, including those with tow speed assumed to be 5knots (Figure 3).

For each tow, a measure of sardine catch density (tonnes/km^3) was calculated based on the total weight of sardines in a tow divided by an estimate of the volume of water swept during the fishing event (converted to km^3). Estimates of swept volumes were determined by multiplying the length and width of the trawl net by an estimate of the distance of each tow. For some tows, the Fishing Master noted operational dimensions of the trawl mouth differing from the net design (i.e. 32m wide and 14m high) due to water resistance and currents. These observations were based on acoustic sensors attached to the net mouth. In such cases, the operational net mouth dimensions noted by the Fishing Master were used to calculate volume trawled.

Total catch sizes up to approximately 2 tonnes were sorted by species and total weight of fresh sardines was measured at sea using a motion compensated scale, whereas for larger catch sizes, total amounts were visually estimated by the Fishing Master (with the aid of known calibrated cod end and hopper volumes) and a representative sample of the mixed catch was sorted and weighed by species. Subsequently, the proportion of the subsample comprised of sardine was extrapolated to estimate the amount of sardines in the total catch. Some summary information representing non-sardine trawl catch compositions from 2006-2011 night surveys is included in Appendix B.

BIOLOGICAL DATA: LENGTH, AGE AND SEX

Fork and standard length relationships

In order to derive sardine fork length and standard length relationships representing the time series, (i.e. conversion factors) frozen and fresh sardine length relationships were made using available data where both measurements were taken. The two relationships were based on: 1) fresh samples from the 2001 commercial seine fishery (1024 fish from 7 samples of 50-75 fish each) and the 2004 research trawl survey (664 fish from 6 samples of 10-150 fish each); and 2) frozen commercial seine fishery samples for years 2007-2011 (11,829 fish from 184 samples of 50-75 fish each). Regression equations for converting standard length to fork length and vice versa were derived and plots of fork versus standard length were prepared.

Year	Gear	Quality	# Fish	# Samples
2001	Trawl	Fresh	1024	7
2004	Seine	Fresh	664	6
2007	Seine	Frozen	898	19
2008	Seine	Frozen	2718	46
2009	Seine	Frozen	2921	44
2010	Seine	Frozen	2579	36
2011	Seine	Frozen	2713	39

Trawl survey length, age and sex data

For biological sampling of sardine, attempts to get a random selection of sardines involved collecting baskets of fish from the beginning, middle and end of conveyer belt loads of transported sardine from the hopper, where cod ends were emptied. The baskets were then further mixed by spitting each bucket in half and randomly combining the 1/2 baskets. Efforts were made to acquire representative samples from near-shore (<15 km), mid-distance from shore (15-30km) and offshore (i.e. 30-80 km) latitudinal regions off the WCVI when possible. Protocols to collect sardine sample data for fork length (in mm), sex, weight, maturity, stomachs and age (via otoliths) while a survey is underway have been based on cumulative spatial coverage, frequency and sizes of sardine catches. For tows when at least ~ 20kg of sardine were caught, fork length data from samples of 50-300 fish were collected. For ageing, samples of 30-75 whole fish have been frozen and processed in the lab after the survey. Otoliths were aged predominantly from surface reading methods, although some samples were also polished prior to reading (McFarlane et al 2010). Fork length and sex were also recorded for fish that were aged.

Histograms representing pooled freshly sampled fork length data, by survey year (not statistically weighted in any way) were prepared for this report. Histograms representing pooled sardine fork length and estimated age data from frozen samples were also prepared for this report. Sex ratios (fraction female) were derived for samples pooled by year and by fresh or frozen qualities.

<u>Commercial seine length and sex data</u>
Both fresh and frozen biological samples have been collected from commercial purse seine fishery catches. Prior to 2006, at sea observers collected fresh standard length samples, whereas since 2006, at sea observers collected fresh fork length samples. Sample sizes are typically 50-75 fish (recorded in mm). Length samples from at sea observer coverage represent 25-100% of the commercial seine trips per season. By trip, different fresh and frozen samples are often collected for different sub-areas of each main Pacific Fishery Management Area (PFMA). Frozen bucket samples of 50-75 fish are also collected for each combination of a PFMA, fishing week and fishing vessel. Appendix C summarizes approximate commercial seine fishery catch amounts by PFMA by year.

Histograms representing fork length data pooled by year (not weighted in any way) from July and August commercial fishing events off the WCVI (PFMAs 20-27 and 123-127) were prepared for this report to be compared with research trawl survey biological data. Data prior to 2006 was converted from standard length to fork length (using the equation FL= 1.01xSL +7.87, see Figure 7) Sex ratios (fraction female) were also derived for samples pooled by year.

RESULTS

TRAWL DENSITIES
Figure 1 shows the spatial patterns and relative sardine trawl catch densities for each survey year and Table 1 summarizes information on the number of tows by survey year, depth range, night versus day and the number of tows with sardines and. Figure 4 shows histograms of non-zero sardine trawl densities pooled by survey years and Table 2 and Figure 5 summarize information on sardine trawl density statistics from pooling all tow data by survey year. Based on both sample size and spatial coverage, surveys in 2002 and 2005 had the least coverage whereas surveys in 2008-2011 had the most (Table 2, Figure 1).

Trends in mean sardine densities by survey year show a decline from 1999 to 2003, then increasing to a notable peak for 2006, with varying values from 2008 to 2011 (Figure 5). Coefficients of variation are particularly high (>0.40) for means representing 1999 to 2004 survey data.

BIOLOGICAL DATA: LENGTH, AGE AND SEX

<u>Fork and standard length relationships</u>
Figures 6 and 7 show relationships between fork (FL) and standard (SL) lengths from pooled fresh and frozen sardine samples, respectively, summarized as:

Fresh (n=1,688 fish), R^2 = 0.89
FL= 1.04xSL + 4.12
SL= 0.843xFL + 25.4

Frozen (n=11,829 fish), R^2 = 0.97
FL= 1.01xSL + 7.87
SL= 0.959xFL -1.07

Trawl survey and commercial seine length, age and sex data

Table 3 summarizes information on sardine sample sizes and respective sex ratios (fraction female) for research trawl and commercial seine fishery sample trends represented in Figures 8 and 9. The fraction of females was greater than 50% for many sample groups and for all sample groups representing 2008-2011. By year, sex ratios representing either fresh or frozen, trawl or seine, are relatively similar. Years with the greatest variation in sex ratios between sample types are 2001 and 2004.

By year, comparisons of fork length trends representing fresh WCVI summer commercial seine fishery samples and fresh WCVI research trawl samples show relatively strong similarities for years 2001, 2003 and 2008-2011 (Figure 8). No direct comparisons could be made for years 2002 and 2006 since they lacked at least one sample source, the 2005 comparison was relatively poor but the seine fishery sample was relatively small (n=200).

By year, comparisons of fork length trends representing fresh WCVI research trawl samples and frozen WCVI research samples collected for ageing show relatively strong similarities for all years where comparisons could be made (2001-2006 and 2008-2011, Figure 9).

DISCUSSION

Whether or how the sardine trawl density data should be applied to generating relative or absolute biomass values requires considerable attention. Given some of the inconsistencies in the time series (regional coverage, day or night, tow depth ranges, sampling patterns, sampling intensities, different vessel in 2005), the authors recommend that the prospective role of the trawl survey data sets, with respect to possible inclusion into the population assessment model, is in the development of a relative index. Sampling inconsistencies between years may bias catch density trends, especially when density data are pooled by year with each trawl tow given equal weight. Additional analyses exploring trends in both sardine density and biological data under different stratifications schemes should be considered, and some of the survey data may be omitted if deemed incomparable to other years.

Methods of estimating regional biomass for DFO applications have incorporated several assumptions, some of which relate to: 1) the timing of the trawl survey and its ability to represent a seasonal average (typically over a 4-5 month period), 2) the survey vessel and trawl gear effects on sardine catchability, 3) assuming that average sardine trawl densities are representative throughout the region for an average depth of 30m, and 4) whether survey densities and spatial estimates are representative of sardine occurrence in inshore areas outside the survey region (Schweigert and McFarlane 2001; DFO 2001; Schweigert et al 2009; DFO 2009; Flostrand et al 2011, DFO 2011a; DFO 2012, 2012a). Unknowns associated with these and other assumptions invite debate. Recently, attention was given to defining a regional scope for a proposed core survey region and a randomized grid sampling scheme with aims of improving consistency in future inter-annual survey observations (Appendix A). The most recent seasonal biomass estimates of sardine into Canadian waters were based on years with night surveys and pooled all density data within the proposed core survey region so that all tow observations had equal statistical weight (Flostrand et al 2011, DFO 2012). The rationale for this was that there was no strong evidence of improving within-region variance of the 2006-2011 survey data from latitudinal and longitudinal stratification schemes and stratification schemes may be somewhat arbitrary unless auxiliary information was incorporated. It has been suggested that future work incorporate oceanographic data (i.e. SST, chlorophyll, from satellite records) to better define habitat features within and outside of a survey region, similar in principle to work done by Zwolinski et al (2011, 2012). This is because analyses aimed at depicting migration intensity and rates relative to the entire population but based solely on catch sampling data are limited.

In 2011, a Simrad EK60 echosounder equipped with 38 and 120 kHz transducers operated continuously during the WCVI research trawl survey and provided acoustic records of the night trawl sampling activities. Acoustic estimates of sardine densities by trawl tow were derived and comparisons were made between acoustic derived trawl densities (by frequency) and estimates of trawl catch densities. That was the first time a WCVI research trawl sardine survey incorporated acoustic sampling. The methods and findings are being drafted as part of a University of British Columbia masters project. Because some of the preliminary findings are relevant to this review, they are mentioned in this discussion with additional information included in an appendix. The acoustic observations showed that sardine density was greater above the trawl's foot rope path than below it. For a nominal head rope tow depth of 2-3 m and a net height of ~ 14m, maximum foot rope depths were ~ 17m. Therefore, extrapolating sardine trawl density estimates to deeper depths could introduce considerable positive bias. Acoustic data collected during future surveys should provide further insights into trawl fishing and biomass estimation methods but resources to analyse acoustic and trawl data need to be secured in order for this to occur.

Although uncertainties persist over the horizontal and vertical representation of trawl density observations over a defined region, there are other competing research interests. Within DFO and stakeholder discussions, it has been suggested that trawl survey efforts in the core survey region occur every two years, possibly with research observations outside of the core region being collected in between years. This suggestion is partly based on some disconnect between spatial and temporal occurrence of research trawl and commercial fishing activities.

Comparisons between trawl survey and commercial fishery fork length and sex ratio trends show many similarities. Since samples were not statistically weighted by commercial fishing intensity or trawl catch density, it is possible that some of the trends are not entirely representative or comparable. Future work should explore variability between individual fishing samples and statistical weighting schemes. It is also possible that some commercial fishery samples resulted from selective fishing to meet market demands. In addition to sardine seasonal distribution, sardine fishery catch locations are also governed by offloading locations, access to fish plants and scheduling of other fisheries (i.e. salmon and hake).

ACKNOWLEDGEMENTS

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Table 1. Summary of number of trawl tows (n) and positive tows with sardine catches (np) by survey year, date range, day or night sampling and tow depth range of trawl head rope (i.e. < 15m or 15-25m, and collectively <30m) . WER is abbreviation for the vessel the *W.E. Ricker*. Tow speeds assumed to be 5 knots for 1999-2001. In 1999, survey sampling partitioned into 4 periods.

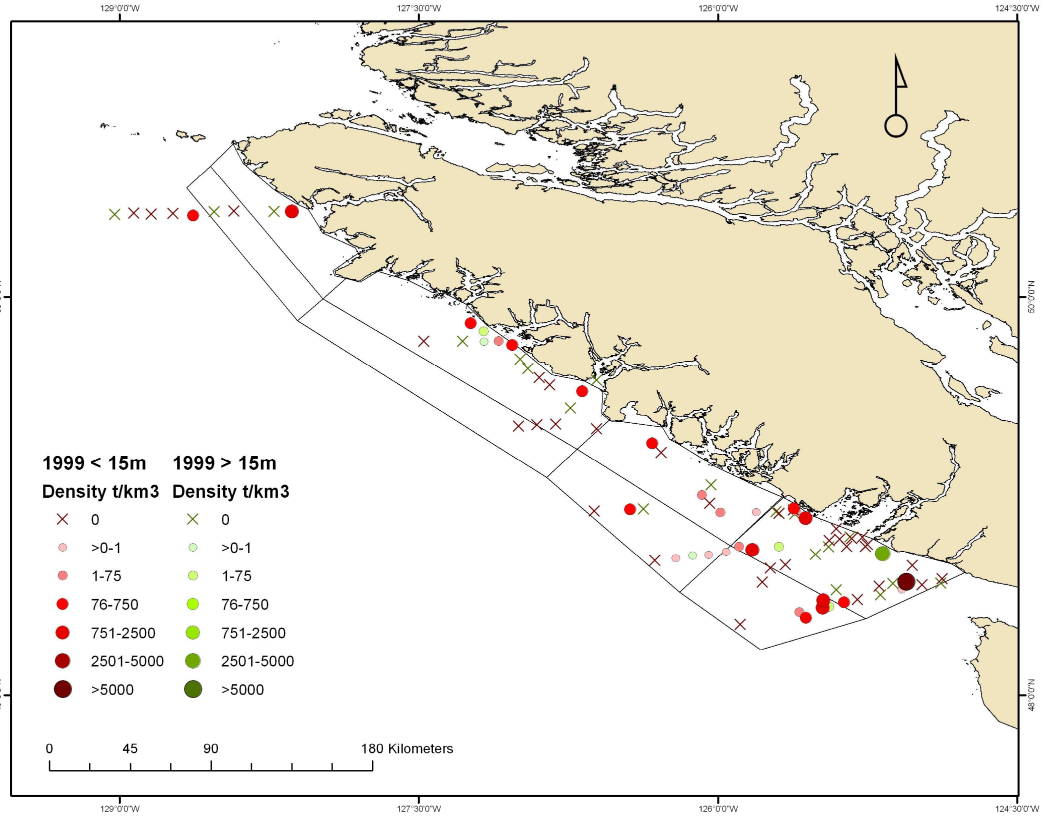
							Tow depth categories			
Year	**Vessel (survey)**	**StartDate**	**EndDate**	**Day or Night**	**n < 30m**	**np < 30m**	**n <15m**	**np <15m**	**n 15-25m**	**np 15-25m**
1999	WER (9902)	Jul 10	Jul 13	Day	25	5	17	4	8	1
1999	WER (9903)	Aug 3	Aug 8	Day	31	10	20	8	11	2
1999	WER (Ware)	Aug 11	Aug 14	Day	2	2	2	2	0	0
1999	WER (9933)	Aug 17	Aug 22	Day	27	15	21	12	6	3
1999	**WER (all)**				**85**	**32**	**60**	**26**	**25**	**6**
2000	**WER**	**Aug 1**	**Aug 7**	**Day**	**43**	**14**	**39**	**14**	**4**	**0**
2001	**WER**	**Jul 25**	**Aug 18**	**Day**	**65**	**19**	**53**	**15**	**12**	**4**
2002	**WER**	**Aug 9**	**Aug 13**	**Day**	**38**	**11**	**27**	**10**	**11**	**1**
2003	WER	Aug 6	Aug 18	Day	47	14	39	11	8	3
2003	WER	Aug 6	Aug 18	Night	17	1	14	0	3	1
2003	**WER (all)**				**64**	**15**	**53**	**11**	**11**	**4**
2004	**WER**	**Jul 21**	**Aug 2**	**Day**	**83**	**13**	**60**	**11**	**23**	**2**
2005	Frosti	Aug 5	Aug 13	Day	26	8	26	8	0	0
2005	Frosti	Aug 5	Aug 13	Night	27	19	27	19	0	0
2005	**Frosti (all)**				**53**	**27**	**53**	**27**	**0**	**0**
2006	**WER**	**Jul 31**	**Aug 7**	**Night**	**45**	**41**	**45**	**41**	**0**	**0**
2008	**WER**	**Jul 30**	**Aug 8**	**Night**	**69**	**42**	**68**	**41**	**1**	**1**
2009	**WER**	**Jul 22**	**Aug 5**	**Night**	**107**	**52**	**107**	**52**	**0**	**0**
2010	**WER**	**Jul 25**	**Aug 5**	**Night**	**72**	**40**	**72**	**40**	**0**	**0**
2011	**WER**	**Jul 17**	**Jul 31**	**Night**	**68**	**41**	**68**	**41**	**0**	**0**
All	**All**	**Jul 10**	**Aug 22**	**Both**	**792**	**347**	**705**	**329**	**87**	**18**

Table 2. Summary of sardine trawl catch density statistics from pooling all observations from tow depths < 30m (head rope) by survey year; n= sample size, p= proportion (positive sardine tows).

YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2008	2009	2010	2011
WCVI SAMPLING												
n.Tows < 30m	85	43	65	38	64	83	53	45	69	107	72	68
n.SardineTows	32	14	19	11	15	13	27	41	42	52	40	41
p. SardineTows	0.38	0.33	0.29	0.29	0.23	0.16	0.51	0.91	0.61	0.49	0.56	0.60
SARDINE DENSITY (t/km3)												
Mean	306.8	219.5	76.3	70.1	19.7	224.2	286.6	874.1	280.4	460.5	157.0	352.8
sd.sample	1401.4	1315.5	455.4	257.8	80.5	1153.3	743.2	1416.8	545.6	1007.4	510.1	777.8
se.mean	152.0	200.6	56.5	41.8	10.1	126.6	102.1	211.2	65.7	97.4	60.1	94.3
cv.mean	0.50	0.91	0.74	0.60	0.51	0.56	0.36	0.24	0.23	0.21	0.38	0.27
QUARTILES (t/km3)												
Min	0	0	0	0	0	0	0	0	0	0	0	0
Q.25	0	0	0	0	0	0	0	9.7	0	0	0	0
Median	0	0	0	0	0	0	0.2	204.1	1.0	0	0.2	0.4
Q.75	4.66	0.11	0.07	0.17	0	0	139.6	1357.6	251.4	530.0	58.5	275.0
Max	12106.1	8623.8	3513.0	1327.4	445.1	7621.3	2558.2	7466.3	2324.2	4977.8	3454.7	4714.4

Table 3. Biological sample summary and sex ratios (fraction female) from WCVI research trawl surveys and commercial seine fishery samples. Sample sizes relate to trends plotted in Figures 8 and 9. In 1999, all sardine research trawl samples were aged. In 1999, 2000 and 2006 no July or August WCVI commercial fishery samples were collected but in 2006 samples from PFMA 12 were. In 2000 no July or August trawl survey age samples were collected. F ratio = fraction females. SL: standard length; FL: fork length.

	YEAR	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
WCVI RESEARCH TRAWL SAMPLES														
FL	# Fish		651	480	956	884	565	5145	4201		3592	7698	4076	5146
fresh	# Samples		13	18	13	10	7	25	35		34	41	23	27
	Comments	all aged								no survey				
Sex (& FL)	# Fish		33	413	944	746	563	5144	4200		3592	4276	2100	2727
fresh	# Samples		13	18	13	10	7	25	35		34	38	22	26
	F ratio		0.57	0.46	0.49	0.49	0.54	0.53	0.54		0.62	0.58	0.56	0.59
	Comments	all aged								no survey				
FL, Age & Sex	# Fish	317		43	185	98	198	501	569		760	232	450	438
frozen	# Samples	7		1	2	2	4	8	8		11	5	9	10
	F ratio	0.59		0.32	0.51	0.54	0.61	0.58	0.57		0.61	0.62	0.58	0.59
	Comments		no WCVI JulAug							no survey				
SEINE FISHERY SAMPLES (WCVI July and August only)														
Sex (&FL or SL)	# Fish		584	1998		1526	1006	200	1314	204	5909	11156	17447	28397
fresh	# Samples		6	26		15	10	2	35	2	55	96	124	161
	SL or FL		SL	SL		SL	SL	SL	FL	FL	FL	FL	FL	FL
	F ratio		0.54	0.53		0.51	0.48	0.6	0.5	0.46	0.62	0.56	0.54	0.54
	Comments	no samples			no WCVI JulAug				PFMA 12					



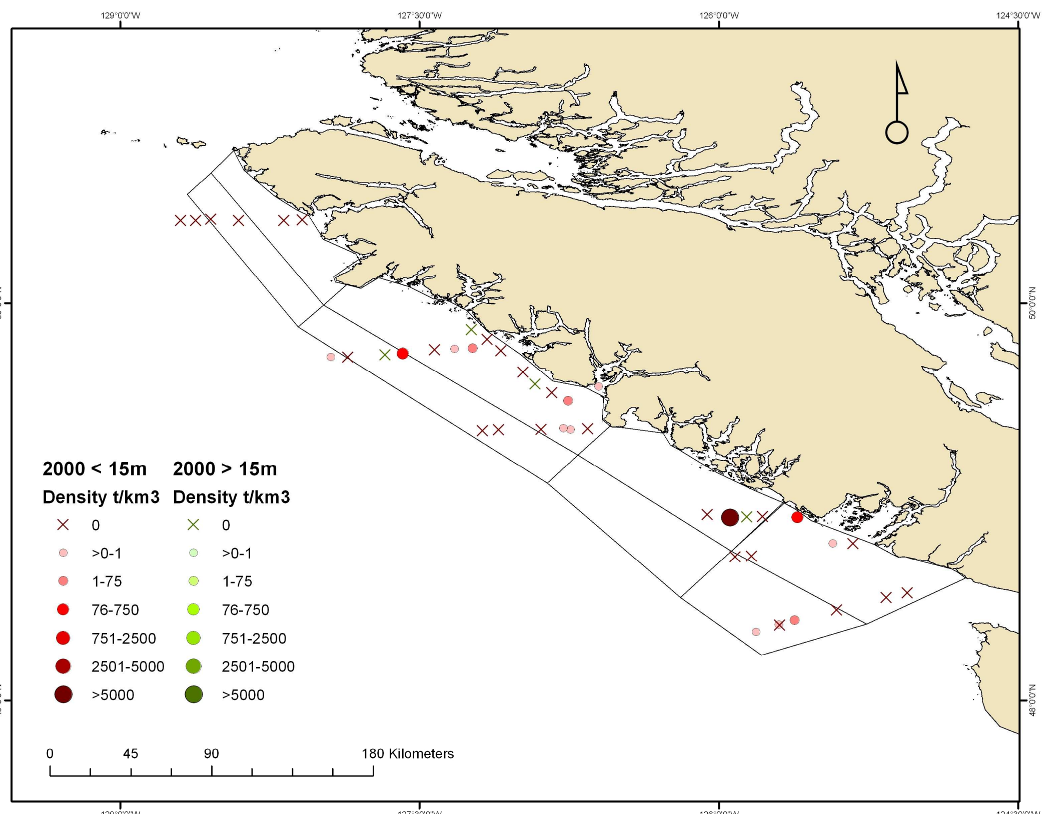
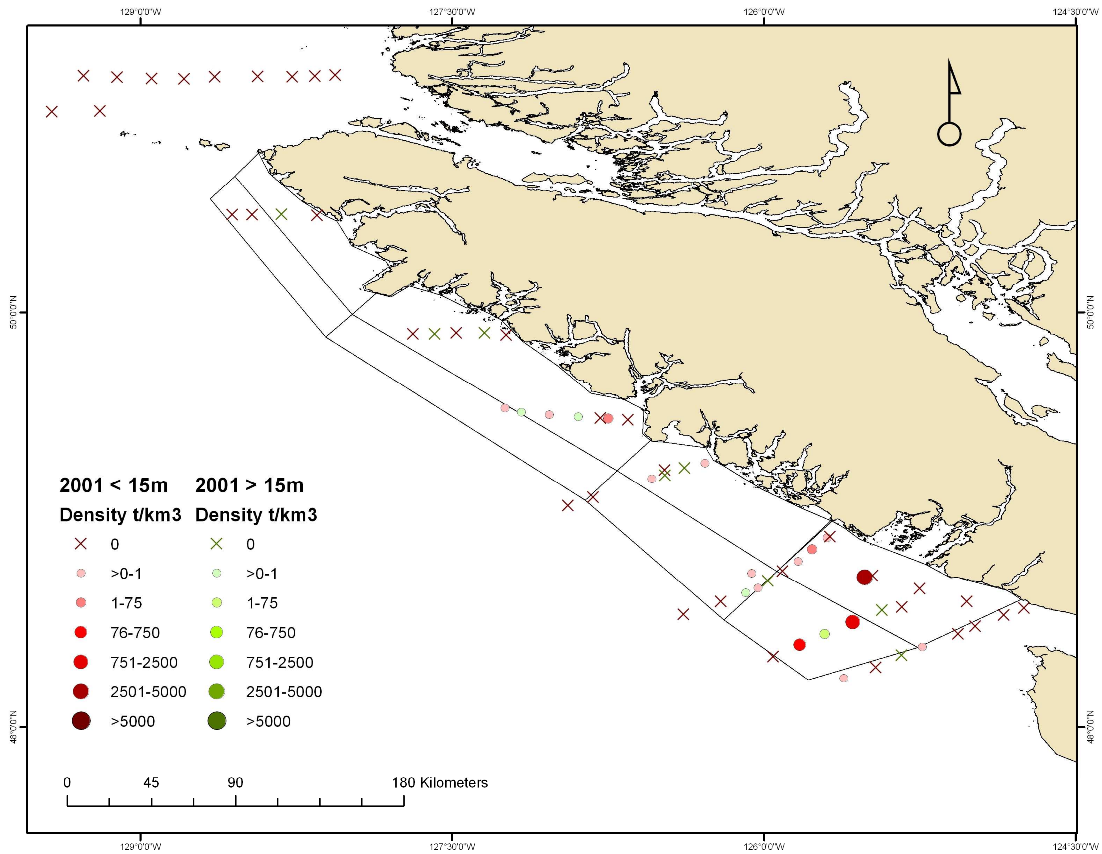
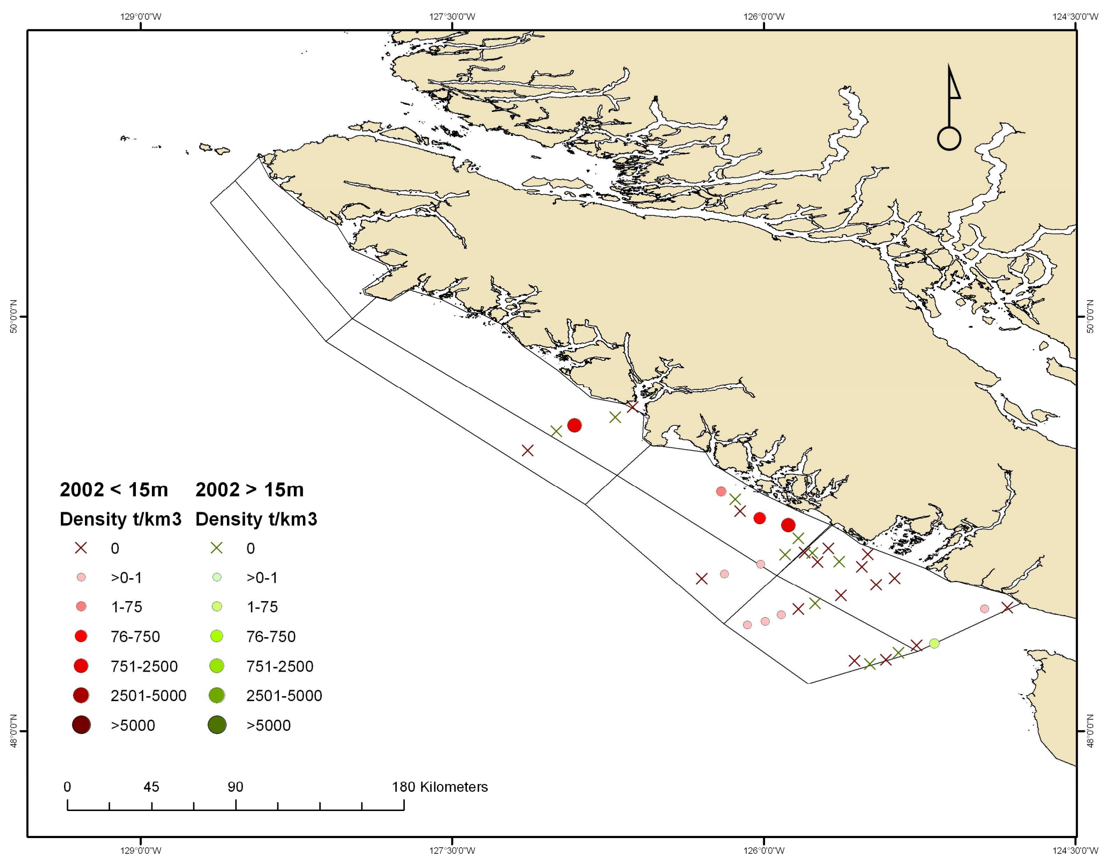


Figure 1. Maps of relative sardine catch densities (tonnes/km3) by survey year (1999-2011, no survey in 2007). Additional maps differentiating day and night fishing provided for 2003 and 2005.





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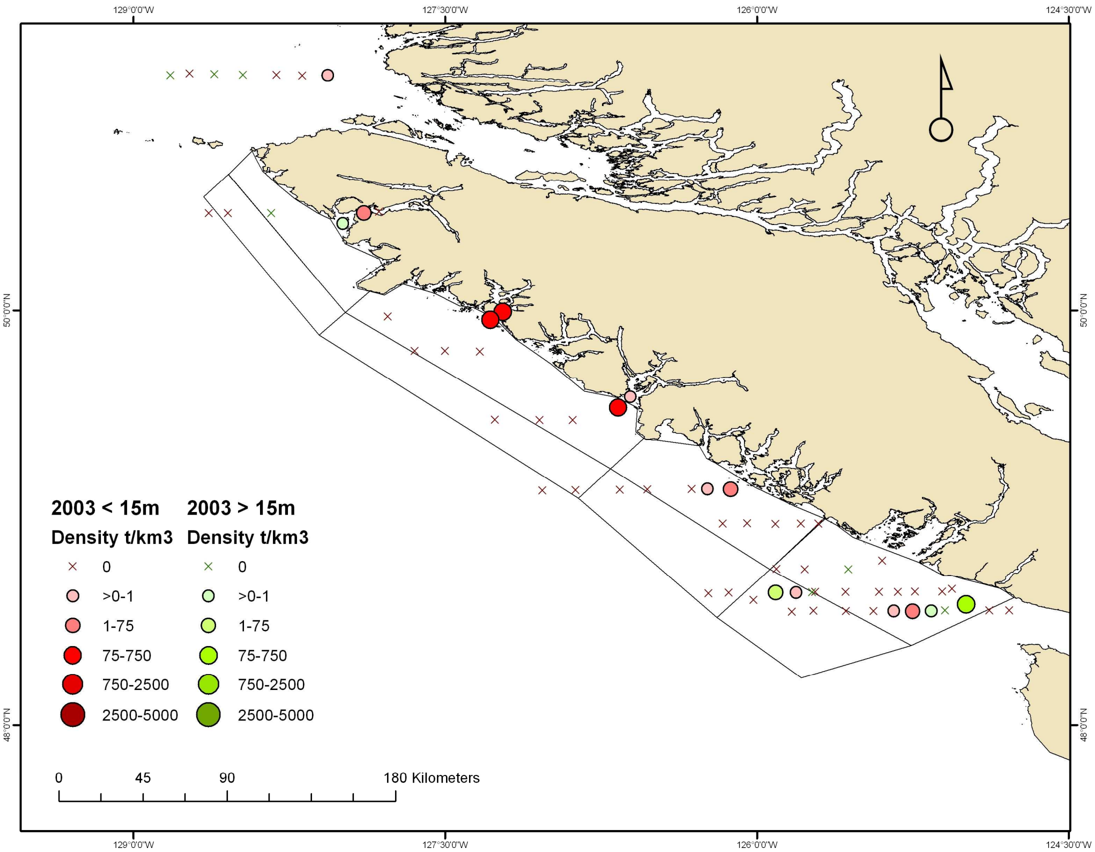

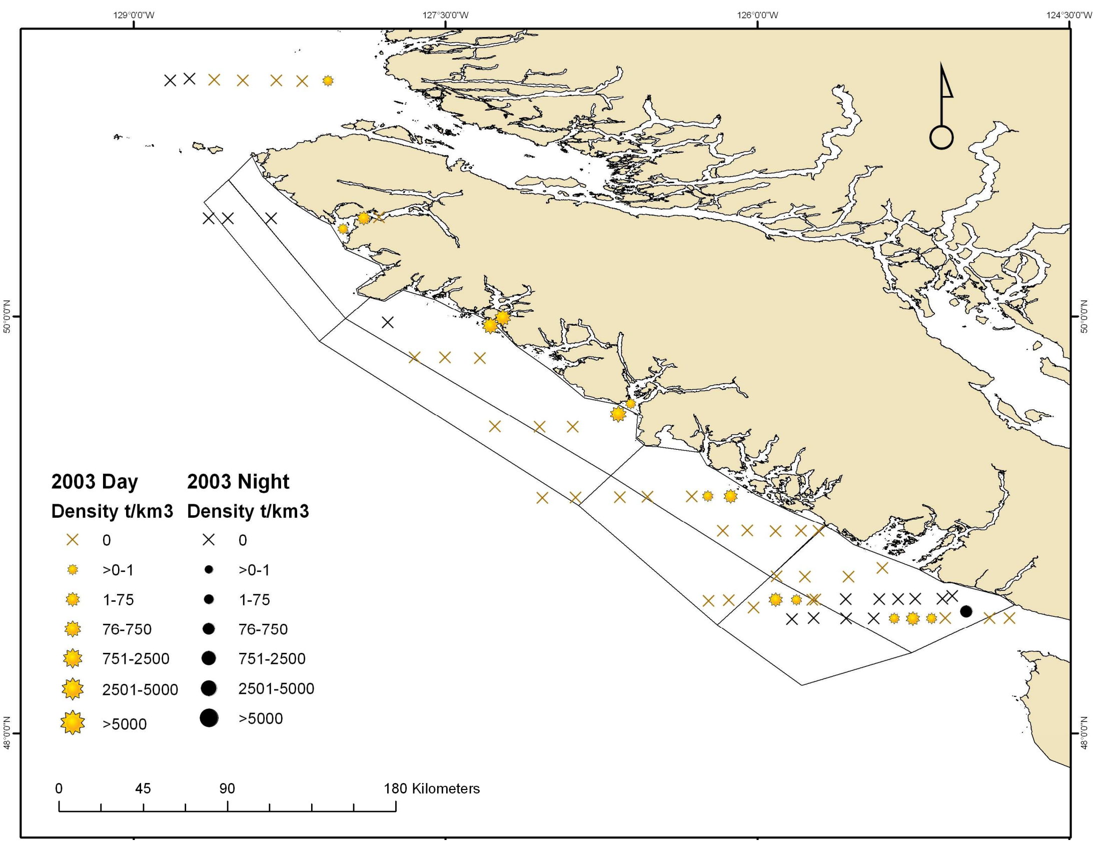

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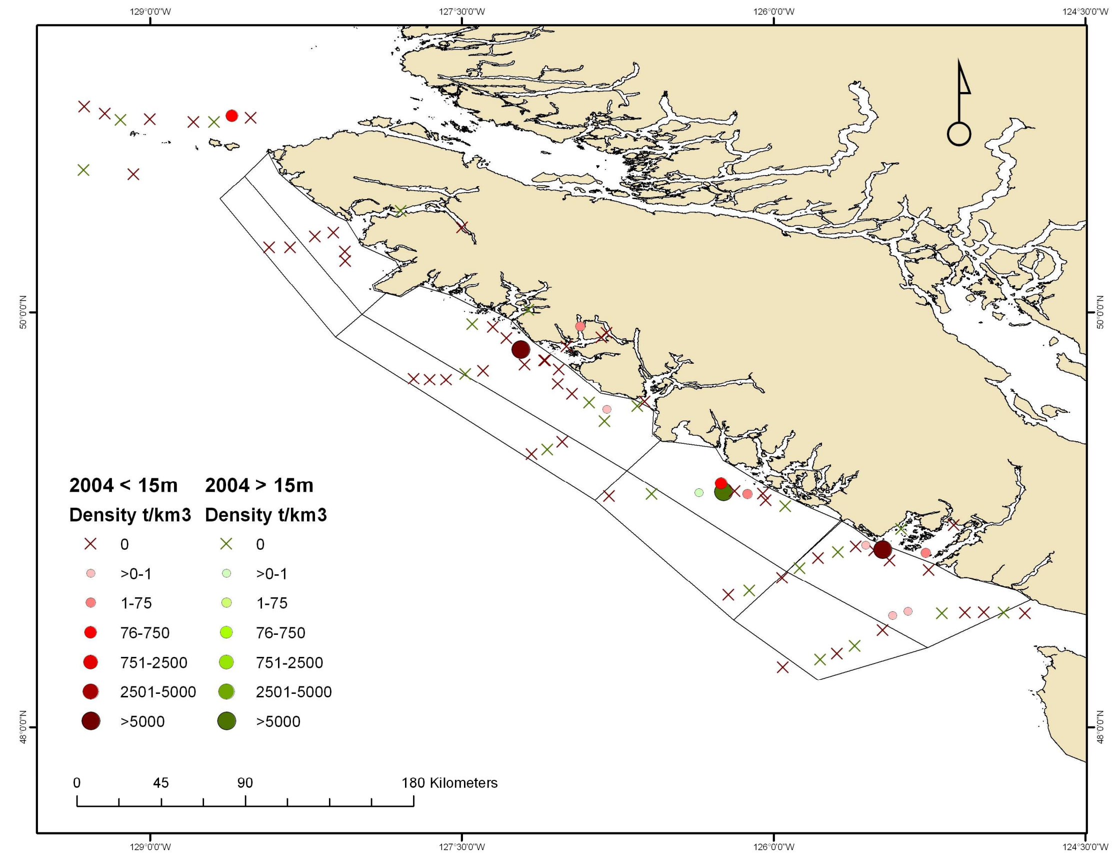

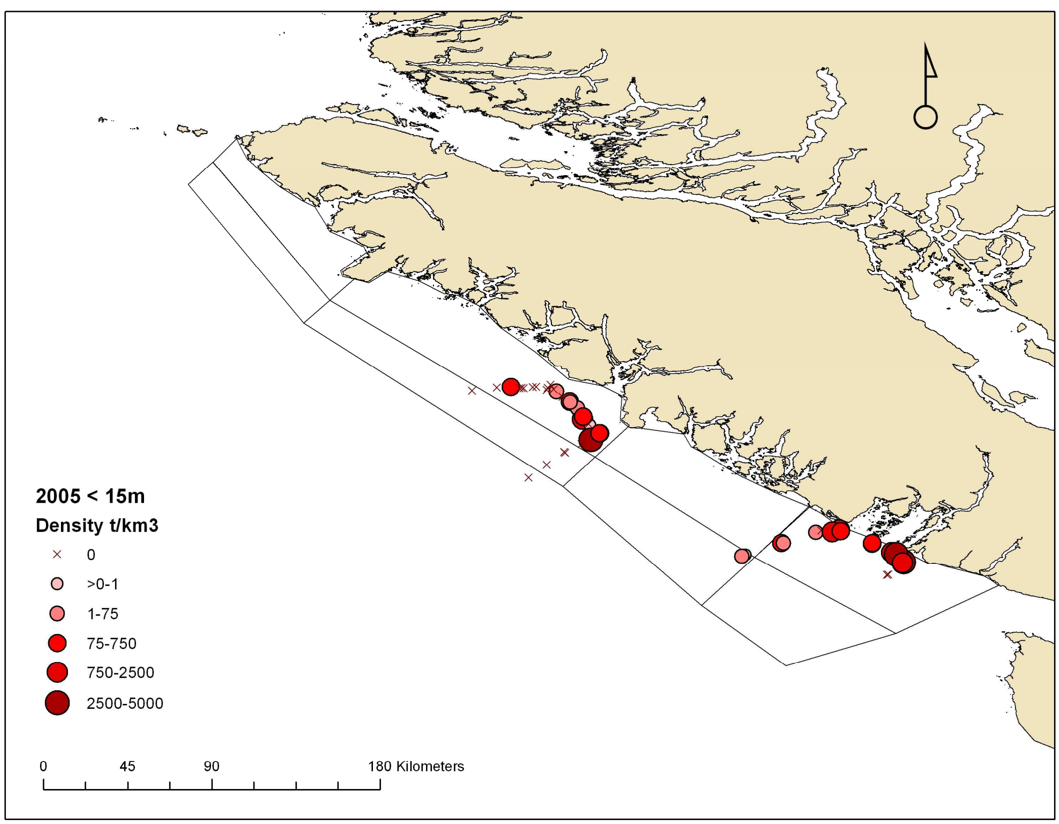

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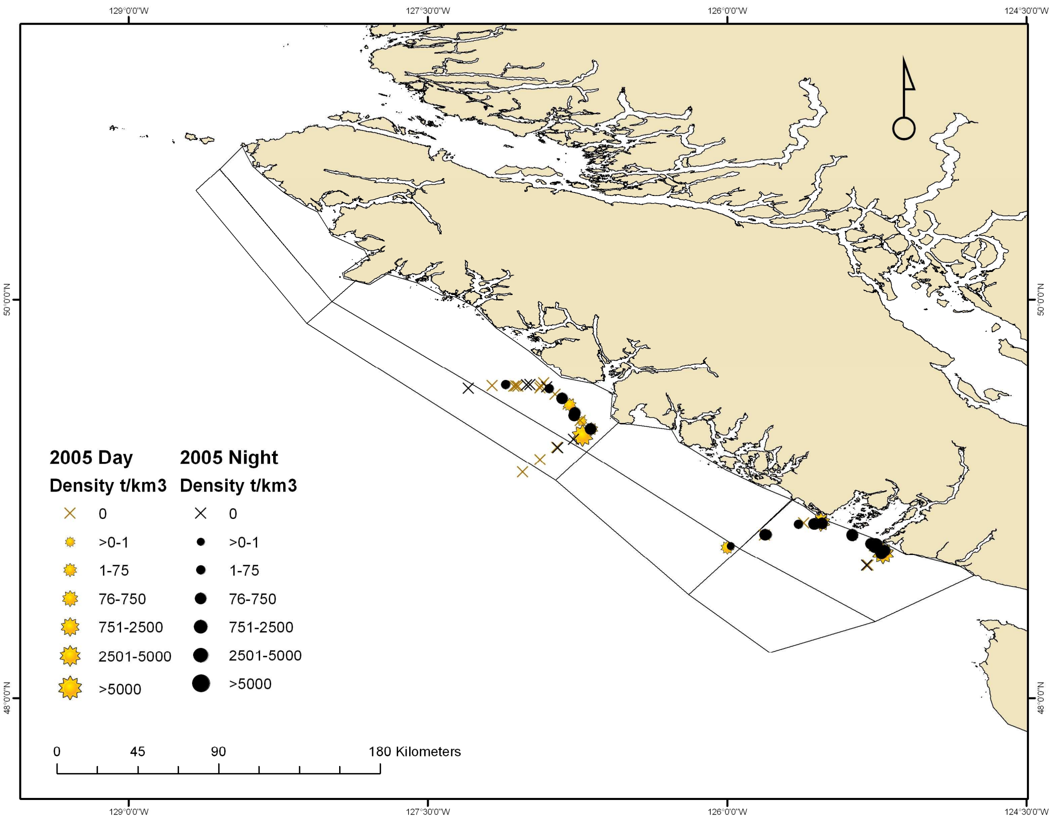

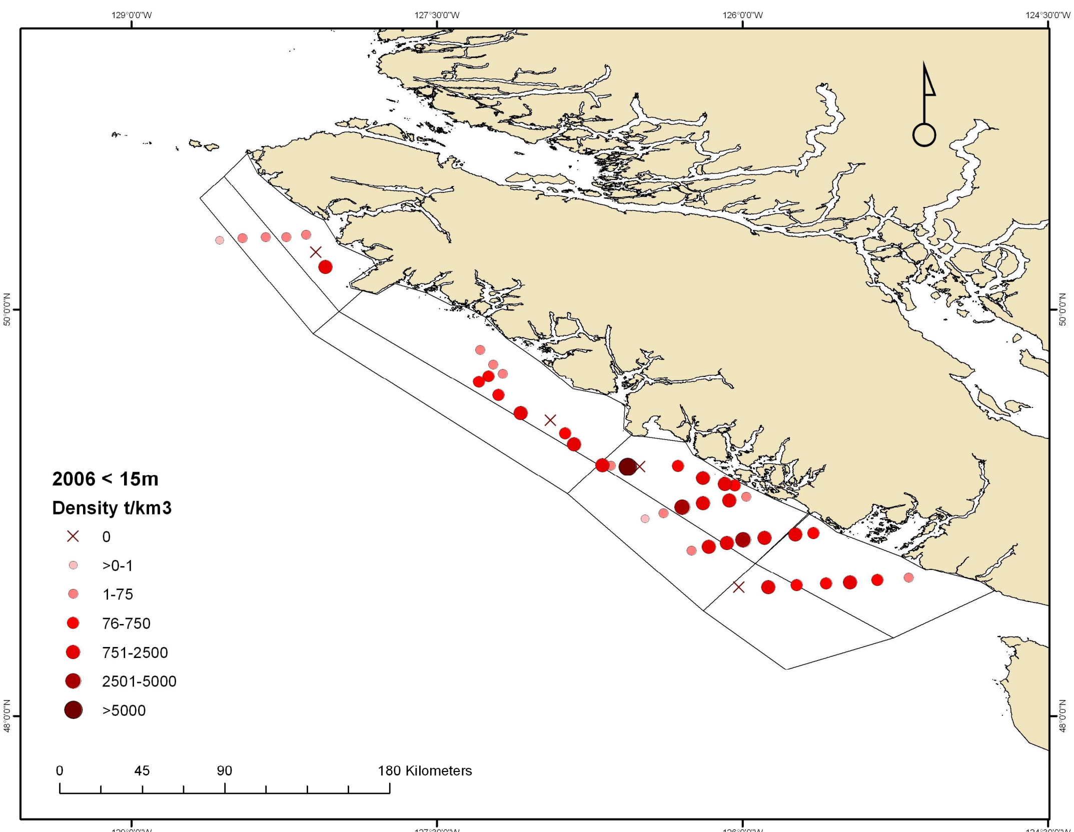

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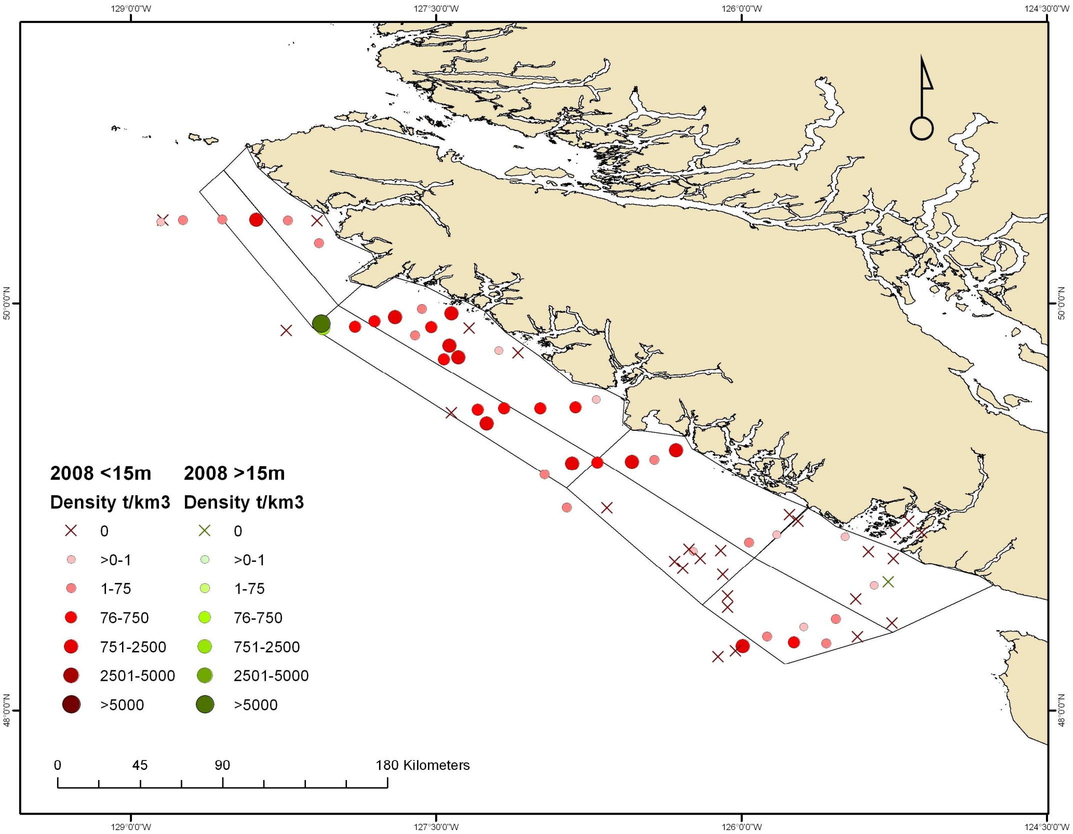

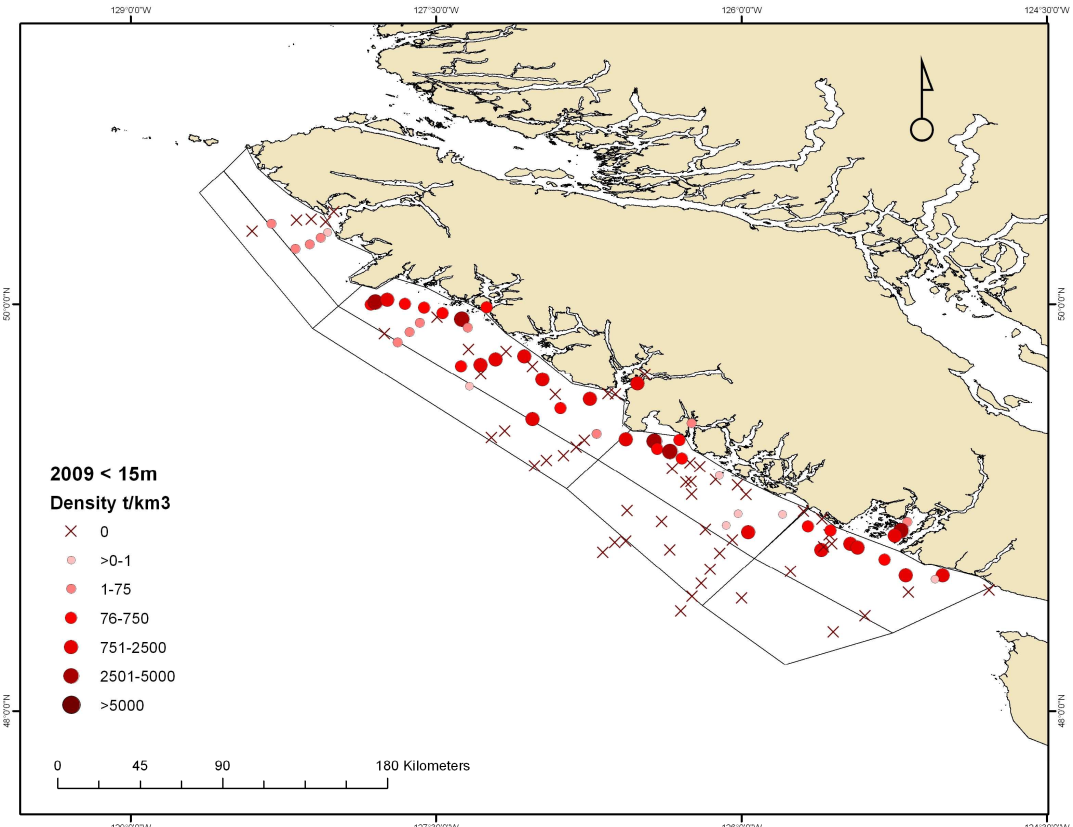

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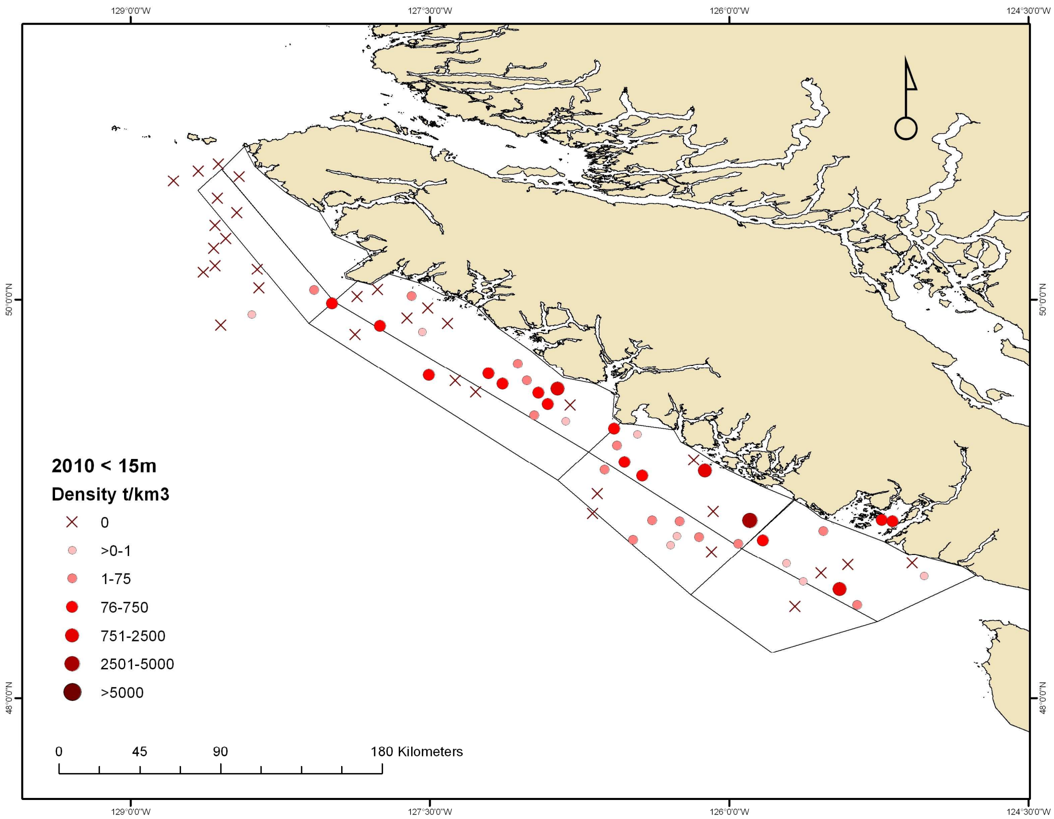

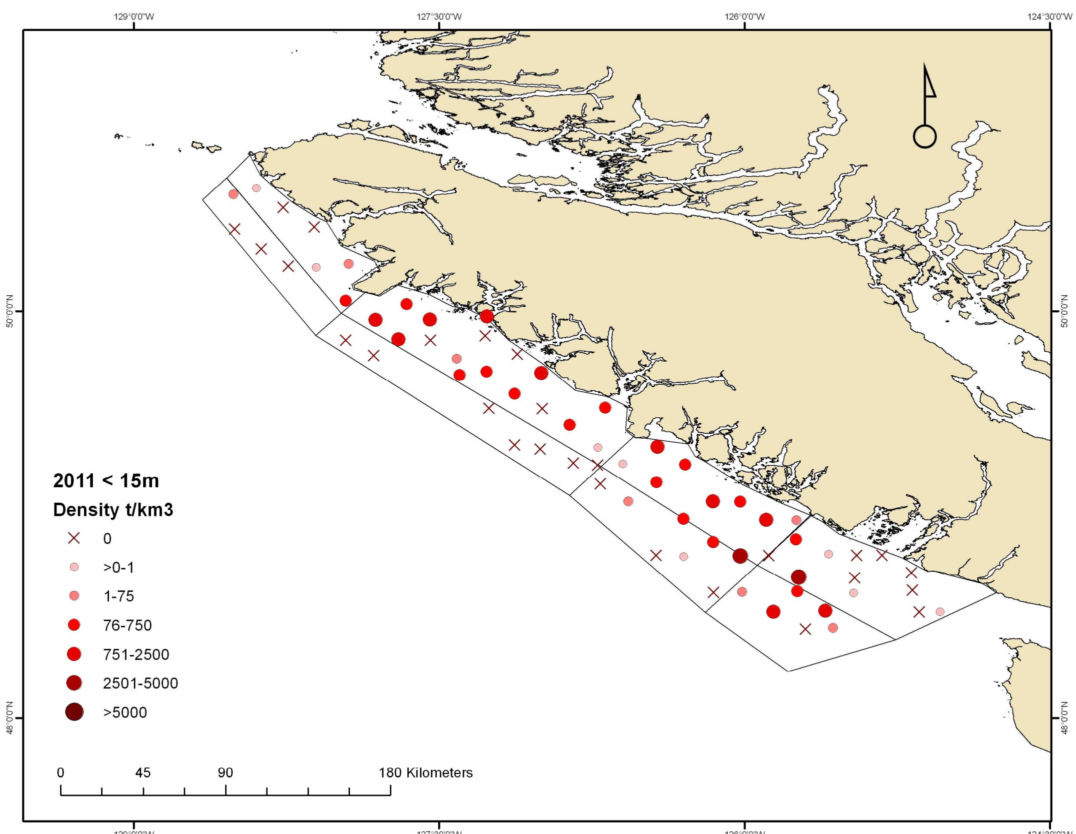

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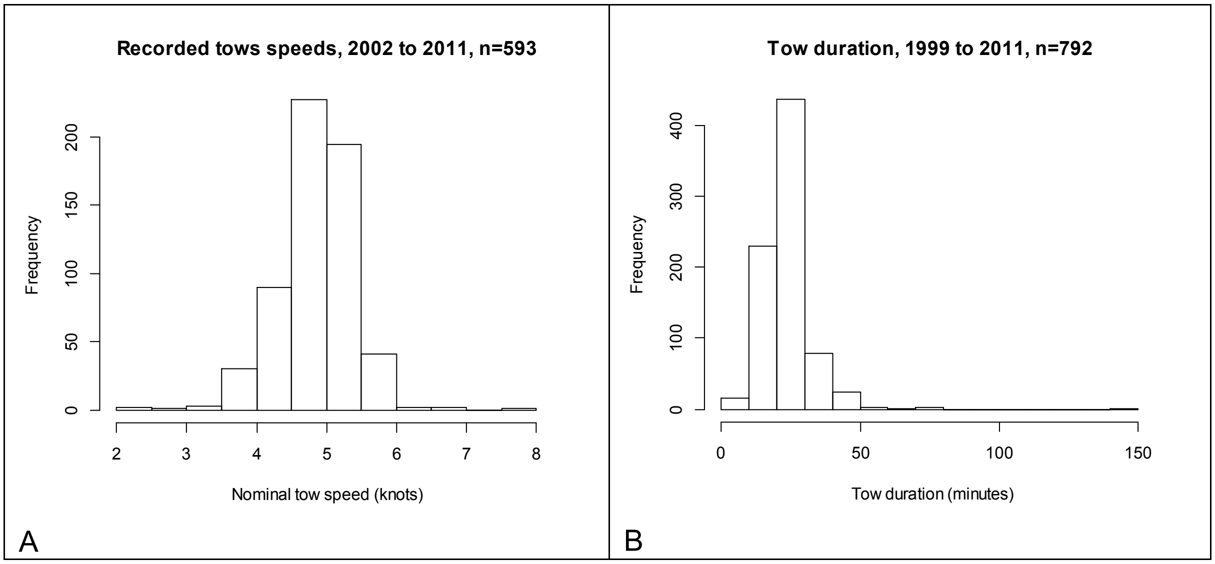


Figure 2. Histogram of A) recorded trawl tow speeds and B) tow durations. Tow speeds were not recorded prior to 2002, but were for all other years whereas tow durations (end of net deployment and start of retrieval) were recorded for all years and all tows.

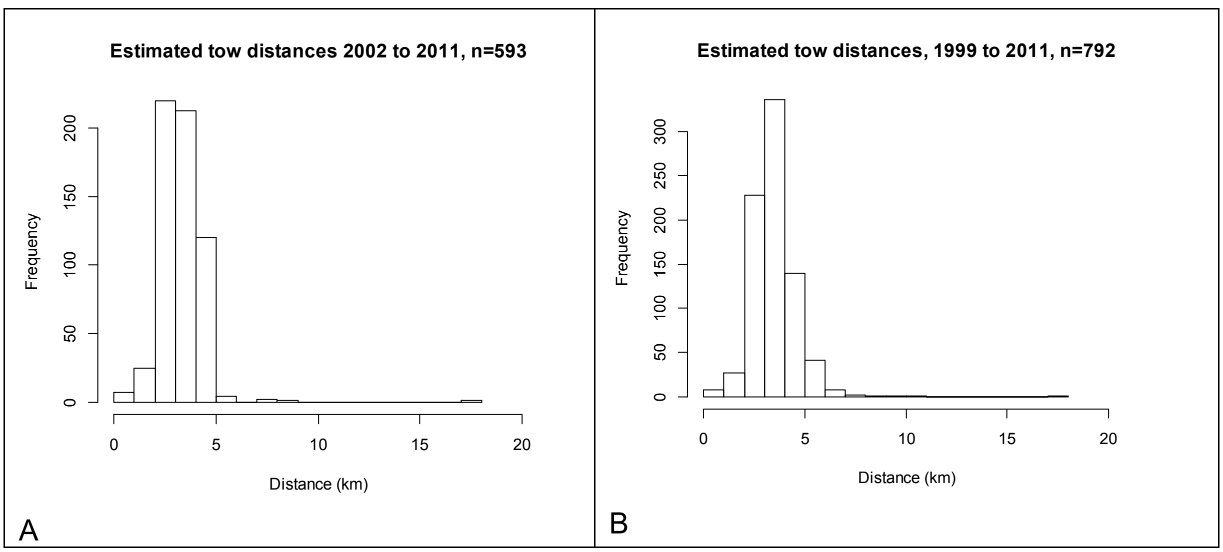


Figure 3 Histograms of estimated tow distances for A) cases where tow speed was recorded and B) for all cases (including records where tow speed was assumed to be 5knots).

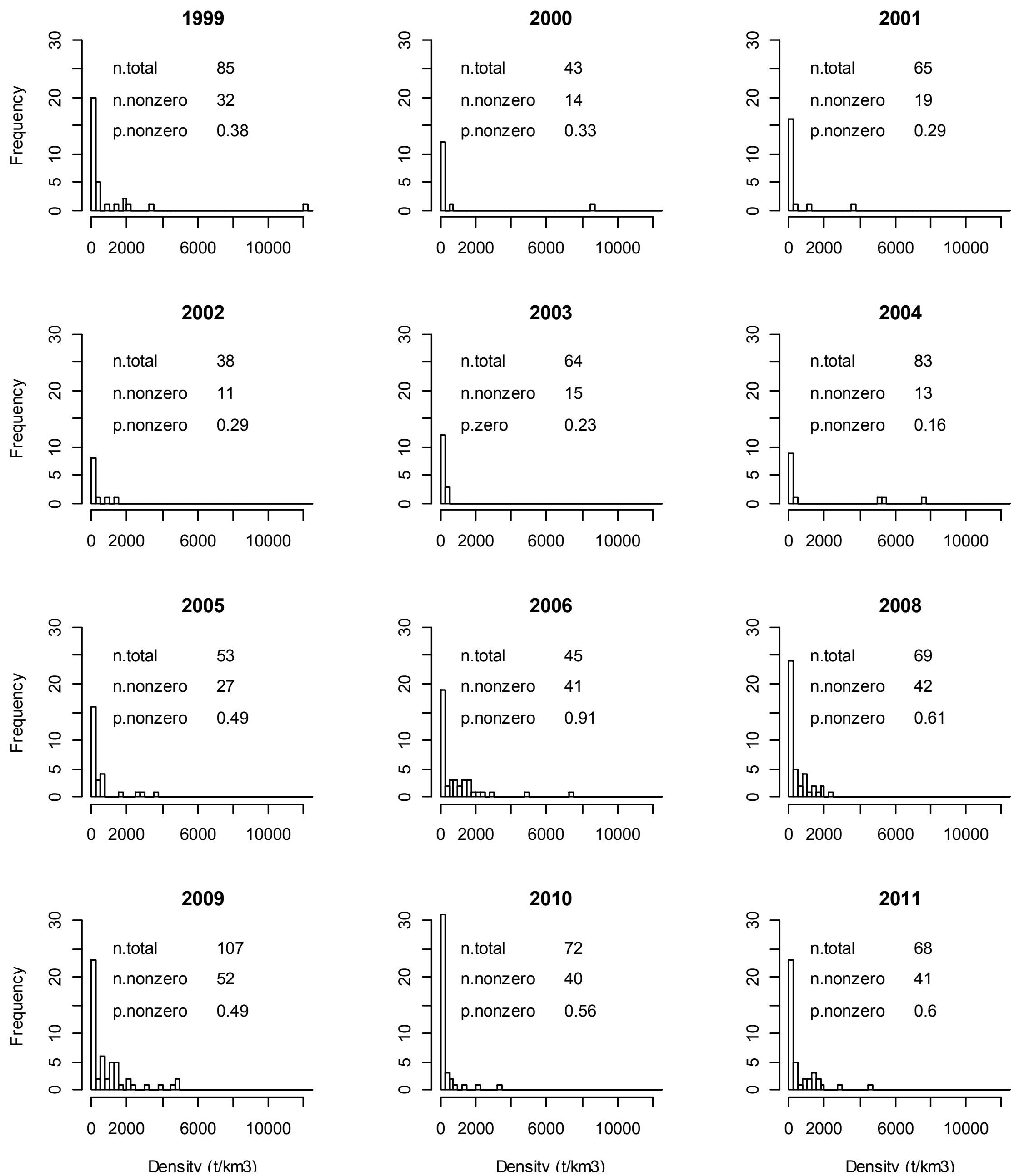
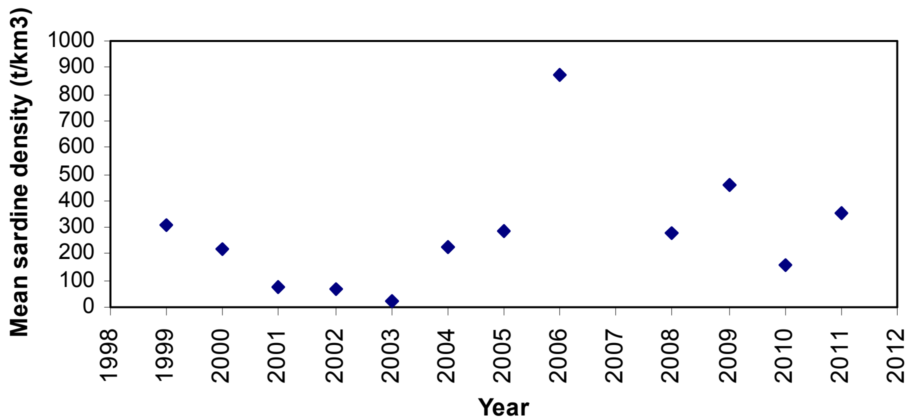
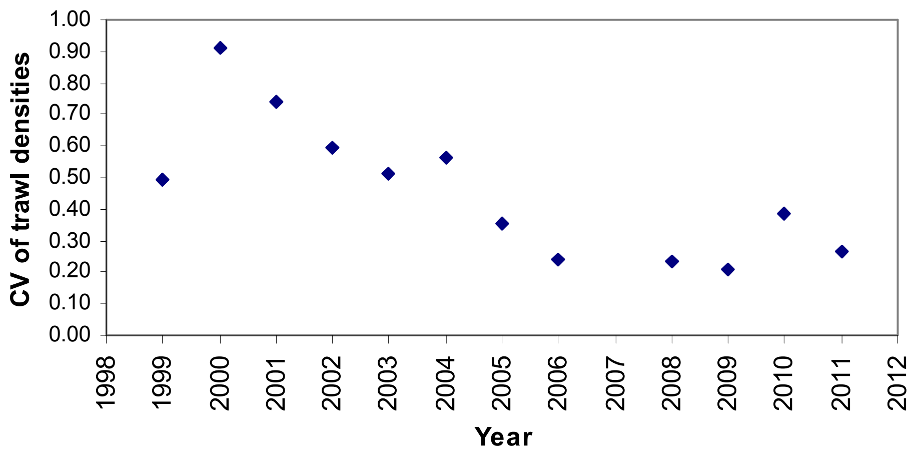


Figure 4. Histograms of non-zero sardine trawl survey catch densities and summary statistics representing day surveys 1997-2004 and night and day tows in 2005. Survey vessel for 1997-2004 was the RV *W.E. Ricker* and in 2005 the charter FV *Frosti* was used. Legend coding: n.total = number of tows, n.nonzero = number of tows with sardine catch; n.zero= number of tows without sardine catch; p.zero= proportion of samples with no sardines in catch. Bin size is 250.



A



B

Figure 5. WCVI summer trawl survey 1999-2011 mean sardine trawl densities (A) and corresponding coefficients of variation (B) from pooling all trawl tows by year. No survey in 2007.

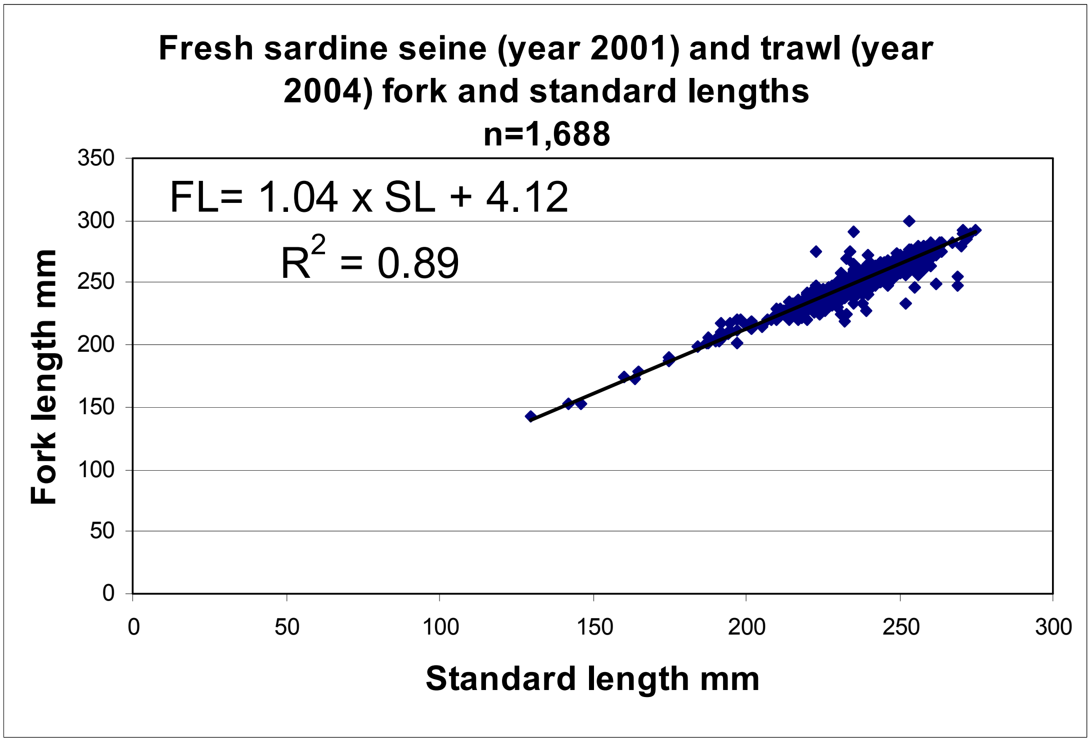


Figure 6. Fork (FL) and standard length (SL) relationship from fresh commercial B.C. purse seine sardine fishery samples collected from 2001 (representing all months and areas) and WCVI summer research trawl samples collected in 2004, where FL=1.04xSL +4.12 and SL= 0.843xFL + 25.4 (R^2=0.89)

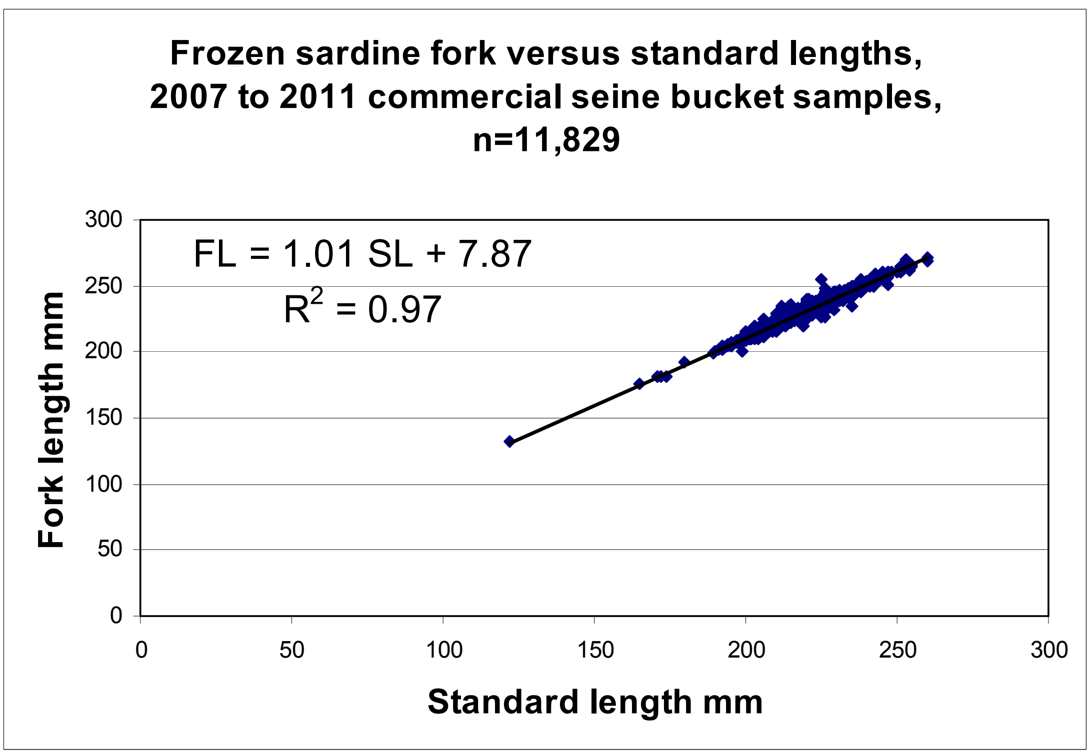


Figure 7. Fork (FL) and standard length (SL) relationship from frozen commercial B.C. purse seine sardine fishery samples collected from 2007-2011 seasons (representing all months and areas), where FL= 1.01xSL +7.87 and SL= 0.959xFL – 1.07 (R^2=0.97)

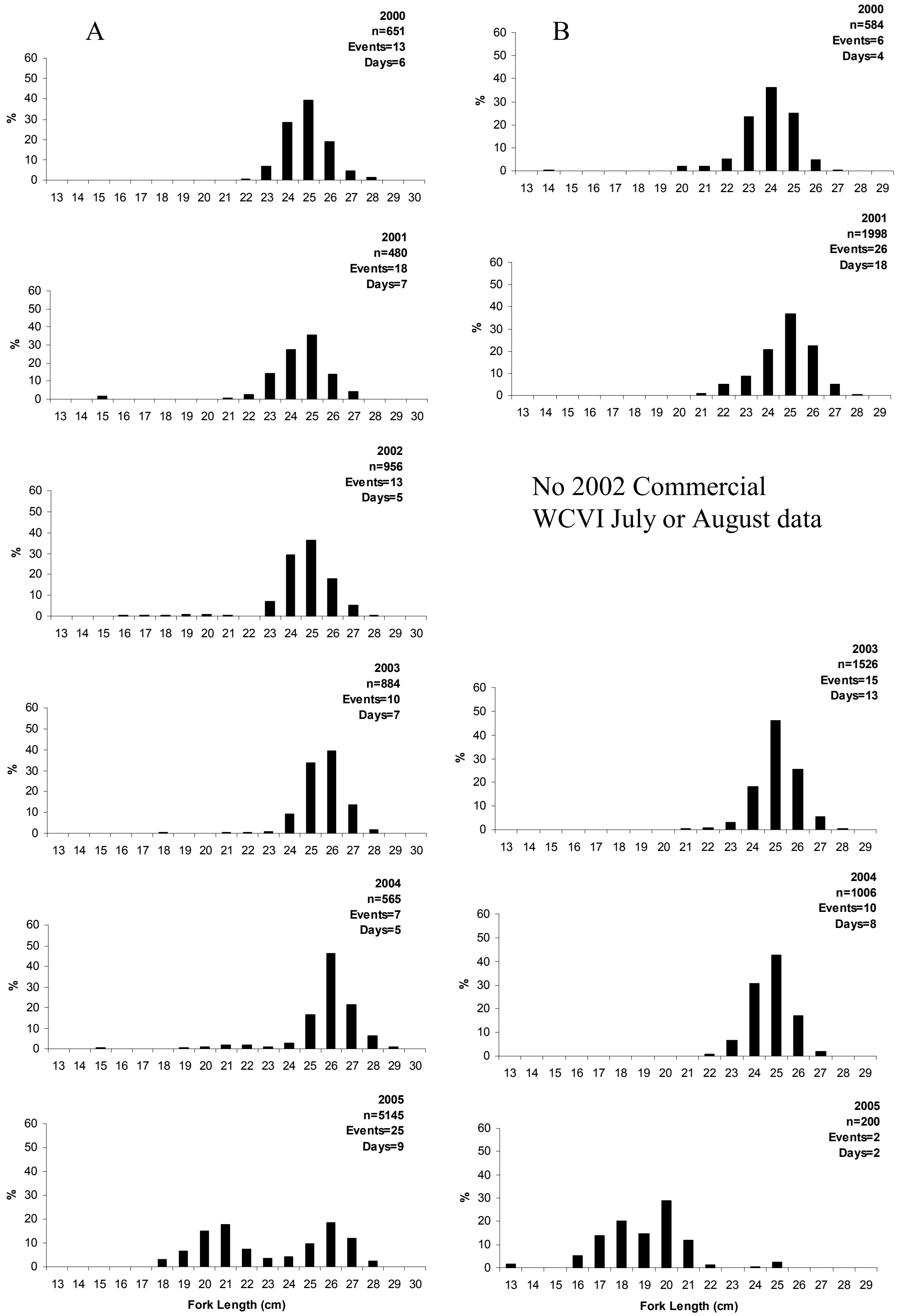


Figure 8. Sardine research trawl (A) and commercial fishery (B) fork length frequencies from pooling fresh samples by year (n is number of fish sampled). Commercial fishery 2000-2005 standard length (SL) data were converted to fork length (FL) using equation FL= 1.01xSL +7.87 (Figure 7). No WCVI July or August fresh research or commercial fishery samples collected in 1999, and no commercial fishery samples collected in 2002.

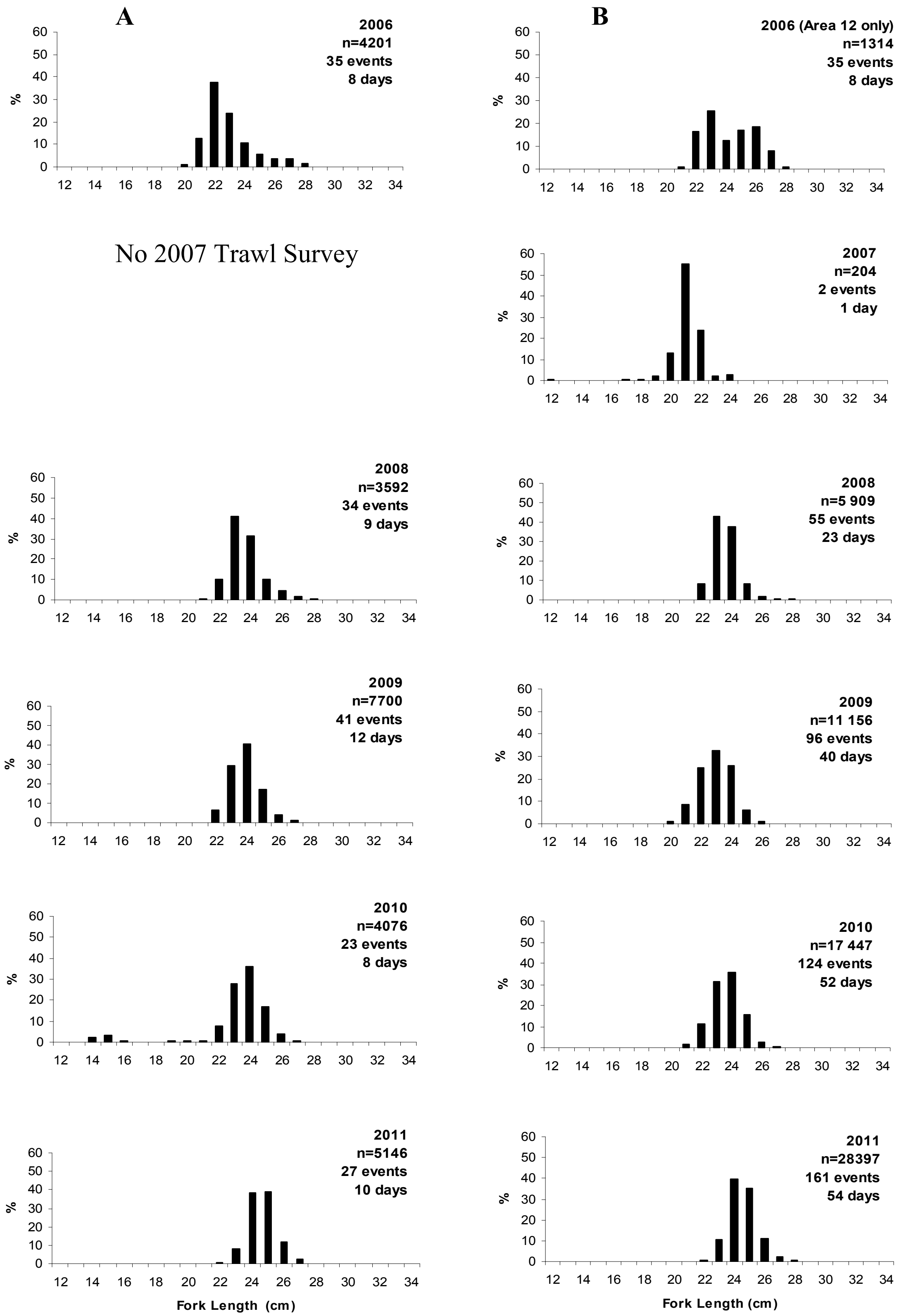
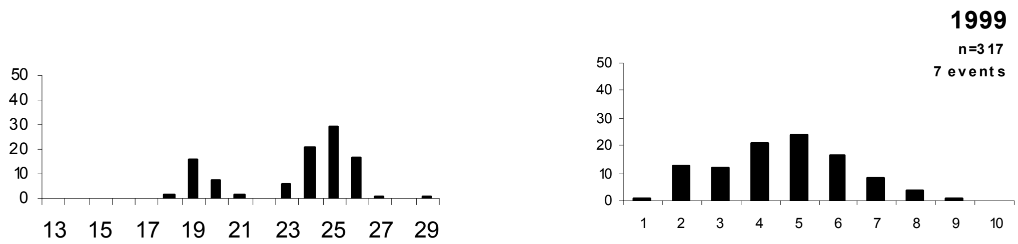


Figure 8. *Con't* . Sardine research trawl (A) and commercial fishery (B) fork length frequencies from pooling fresh samples by year (n is number of fish sampled). All 2006 commercial fishery lengths from PFMA 12 (outside WCVI) and no research trawl survey conducted in 2007.



No WCVI July or August trawl research survey samples aged.

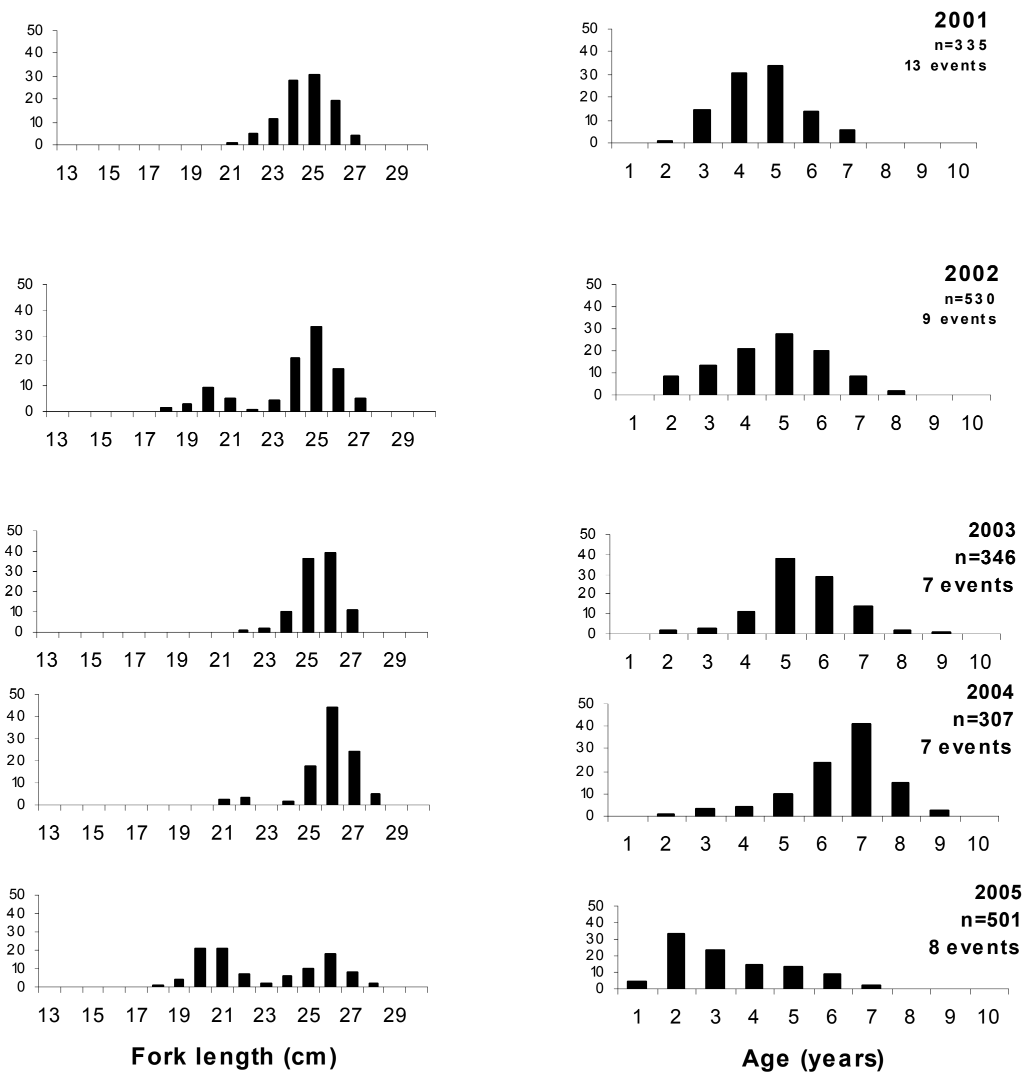


Figure 9A. Sardine fork length (cm) and age (years) trends from pooling frozen samples by year. Years 2001 and 2004 include both commercial fishery and research trawl samples and 2007 includes only commercial fishery samples. All other years are only from research trawl samples (see Figure 9B).

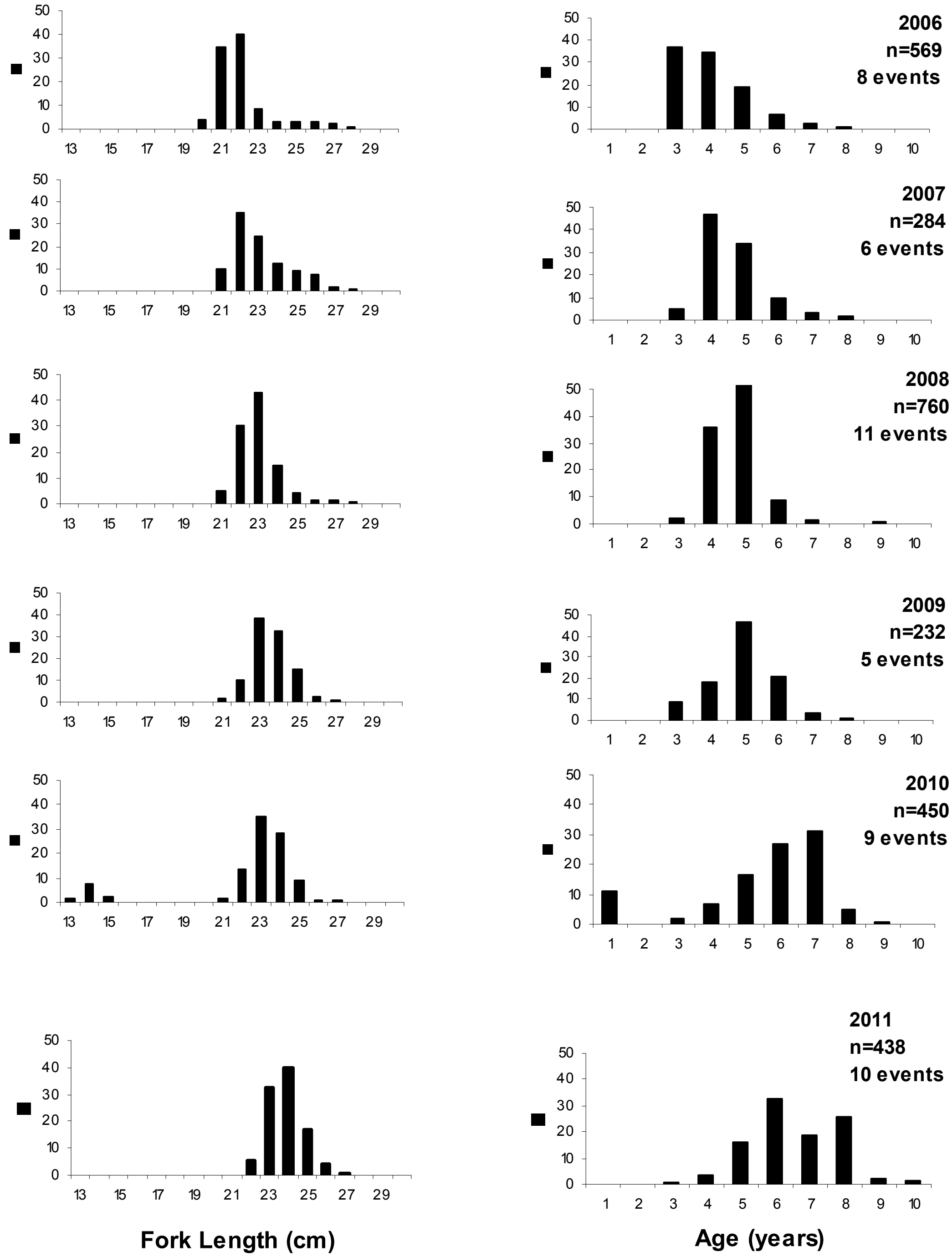


Figure 9A *Con't*.

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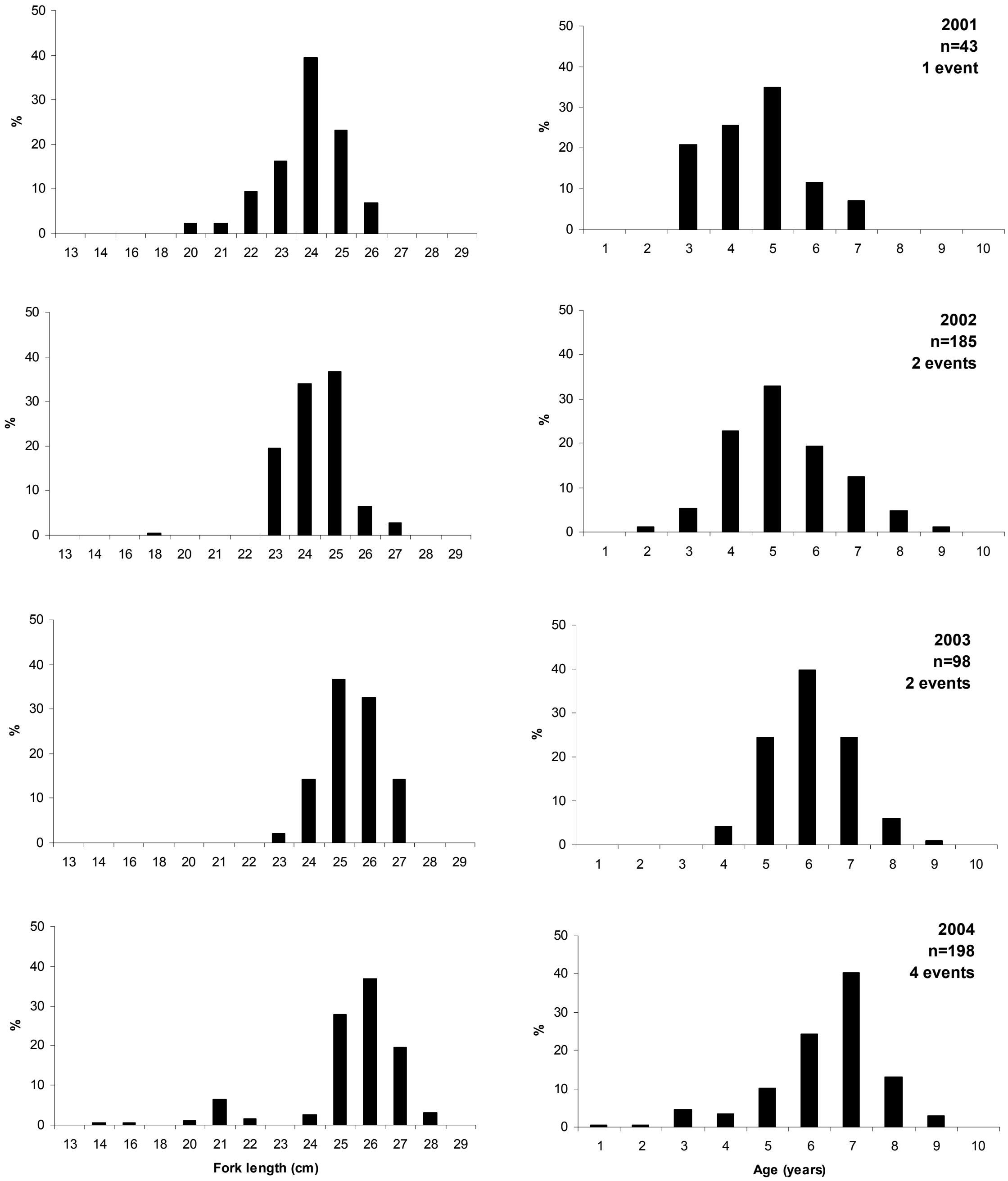


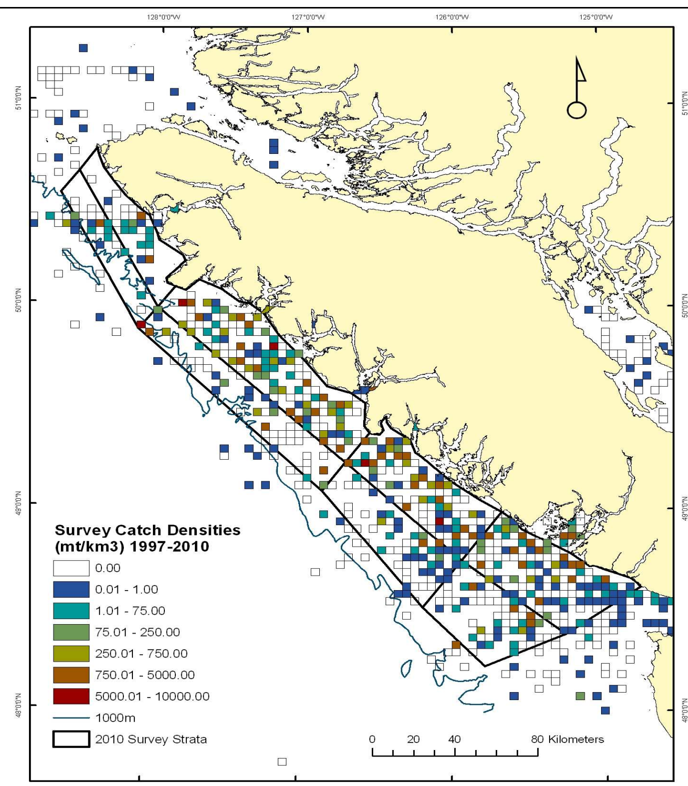
Figure 9B. Sardine research trawl survey fork length (cm) and age (years) trends from pooling frozen samples by year collected in 2001-2004 (data are subsamples of trends shown on Figure 9A)

APPENDIX A

Information on areas and boundaries of proposed core WCVI survey region

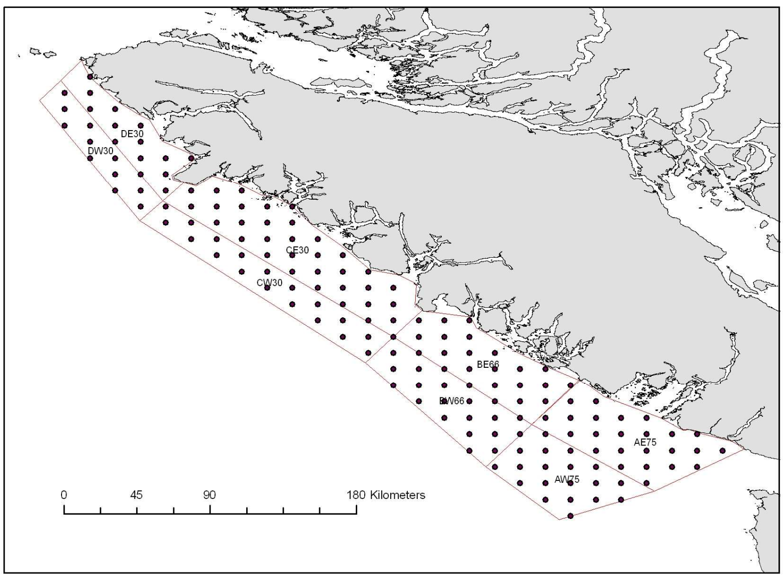
The outer boundaries of the proposed core survey region are based on an analysis which involved plotting sardine trawl catch densities from 1997-2010 survey observations within 4x4 km grid cells (Flostrand et al 2011). Out of the 875 tows represented, 428 caught sardines. Of the 428 positive tows, 366 or 86% represented waters directly west of WCVI headlands and within outer boundaries delineated in the figures below, where the western and northern boundaries of the core survey region were delineated where sardine catch was low (<10 tonnes/km^3) and a southern boundary was defined as the Canada-U.S. border. The core region extends approximately 75 km from shore parallel to the U.S. border and tapers northward to 30 km off the northwest corner of Vancouver Island and encompasses an area of 16,740.08 km^2. Inlets are not included because of and inconsistencies in sampling coverage in earlier surveys as well as sampling constraints for planning future surveys. The delineation of a core survey region and the application of random grid sampling at approximately even sampling intensity throughout the region are recent DFO survey design modifications, applied together for the first time in 2011.

Lattitude	Longitude
48.61447	-124.76319
48.38441	-125.25745
48.22833	-125.78589
48.9929	-125.67173
48.75003	-125.93668
48.51786	-126.19192
49.38214	-126.54505
49.23642	-126.70471
49.09365	-126.85909
50.09221	-127.86325
49.98897	-127.98023
49.88036	-128.10705
50.76803	-128.4292
50.65543	-128.54315
50.5463	-128.66259



APPENDIX A continued

STRATUM	Surface area (km^2)	Description
A (East) 75&66	2,582.0	Southeast zone, extending ~30-40km from shore
A (West) 75&66	1,924.7	Southwest zone, extending ~66-75km from shore
B (East) 66&40	2,246.2	South of Esperanza Pt, extending ~20-30 km from shore
B (West) 66&40	1,985.3	South of Esperanza Pt, extending ~40-66 km from shore
C (East) 40&30	3,378.5	South of Brooks Pen, extending ~15-20 km from shore
C (West) 40&30	2,150.2	South of Brooks Pen, extending ~30-40 km from shore
D (East) 30&30	1,336.2	Northeast zone, extending ~ 15 km from shore
D (West) 30&30	1,136.9	Northwest zone, extending ~ 30 km from shore
All	**16,740.1**	Core area for 2011 (and possibly future surveys)



Core survey region sampling grid (~10x10km spacing) applied in 2011 to randomly assign stations at approximately even sampling intensity over eight zones.

APPENDIX B

Summary of species caught during 2006 to 2011 WCVI night trawl survey, where total weight by species and survey year equalled or exceeded 1 kg. All trawl catches included in summary (i.e. some trawl depths > 30m and outside latitudinal and longitudinal criteria applied to data presented in main report).

Year	Species name	Positive Sets	Total Sets	Proportion Positive Sets	Total Weight (kg)	Average per positive set (kg)
2006	PACIFIC SARDINE	41	45	0.91	41255.1	1006.2
2006	PACIFIC HERRING	16	45	0.36	5252.1	328.3
2006	PACIFIC HAKE	7	45	0.16	1126.5	160.9
2006	SOCKEYE SALMON	31	45	0.69	1123.9	36.3
2006	CHINOOK SALMON	37	45	0.82	929.7	25.1
2006	NORTHERN ANCHOVY	8	45	0.18	739.4	92.4
2006	JACK MACKEREL	27	45	0.60	567.0	21.0
2006	COHO SALMON	21	45	0.47	307.4	14.6
2006	SPINY DOGFISH	14	45	0.31	133.9	9.6
2006	CHUB MACKEREL	10	45	0.22	31.4	3.1
2006	NATIVE TROUT	8	45	0.18	30.0	3.8
2006	REQUIEM SHARKS	1	45	0.02	23.9	23.9
2006	ARROWTOOTH FLOUNDER	10	45	0.22	17.7	1.8
2006	HUMBOLDT SQUID	4	45	0.09	6.9	1.7
2006	ATLANTIC SALMON	1	45	0.02	6.4	6.4
2006	PINK SALMON	4	45	0.09	6.2	1.6
2006	YELLOWTAIL ROCKFISH	3	45	0.07	3.2	1.1
2008	PACIFIC SARDINE	42	71	0.61	32528.2	774.8
2008	SPINY DOGFISH	15	71	0.21	10294.0	686.3
2008	NORTHERN ANCHOVY	17	71	0.24	3908.3	229.9
2008	JACK MACKEREL	22	71	0.31	1048.6	47.7
2008	OCEAN SUNFISH	5	71	0.07	1000.9	200.2
2008	COHO SALMON	26	71	0.37	834.1	32.1
2008	YOLDIAS	1	71	0.01	829.9	829.9
2008	CHINOOK SALMON	37	71	0.52	632.1	17.1
2008	PACIFIC HERRING	14	71	0.20	431.6	30.8
2008	SAND LANCES	5	71	0.07	221.0	44.2
2008	EUPHAUSIIDS	4	71	0.06	85.0	21.3
2008	SOCKEYE SALMON	11	71	0.15	77.5	7.0
2008	SALMONIDS	7	71	0.10	57.2	8.2
2008	ARROWTOOTH FLOUNDER	6	71	0.08	56.6	9.4
2008	PINK SALMON	10	71	0.14	52.4	5.2
2008	SOUPFIN SHARK	2	71	0.03	49.0	24.5
2008	SABLEFISH	15	71	0.21	46.8	3.1
2008	CHUM SALMON	4	71	0.06	33.5	8.4
2008	PACIFIC HAKE	9	71	0.13	30.3	3.4
2008	SALMON SHARK	1	71	0.01	28.2	28.2
2008	CHINOOK (JACKS)	1	71	0.01	16.8	16.8
2008	SMOOTHTONGUE	2	71	0.03	16.2	8.1
2008	YELLOWTAIL ROCKFISH	3	71	0.04	9.5	3.2
2008	LINGCOD	2	71	0.03	7.1	3.6
2008	CHUB MACKEREL	4	71	0.06	6.5	1.6
2008	LANTERNFISHES	6	71	0.08	6.0	1.0
2008	NORTHERN LAMPFISH	2	71	0.03	4.7	2.3
2008	HALFBANDED ROCKFISH	3	71	0.04	2.6	0.9
2008	JELLYFISH	4	71	0.06	1.7	0.4
2008	CANARY ROCKFISH	1	71	0.01	1.4	1.4
2009	PACIFIC SARDINE	52	109	0.49	48828.1	939.0
2009	PACIFIC HERRING	30	109	0.28	5032.5	167.8
2009	SPINY DOGFISH	21	109	0.19	3791.6	180.6
2009	HUMBOLDT SQUID	14	109	0.13	1872.2	133.7
2009	PINK SALMON	72	109	0.66	1769.3	24.6

APPENDIX B continued

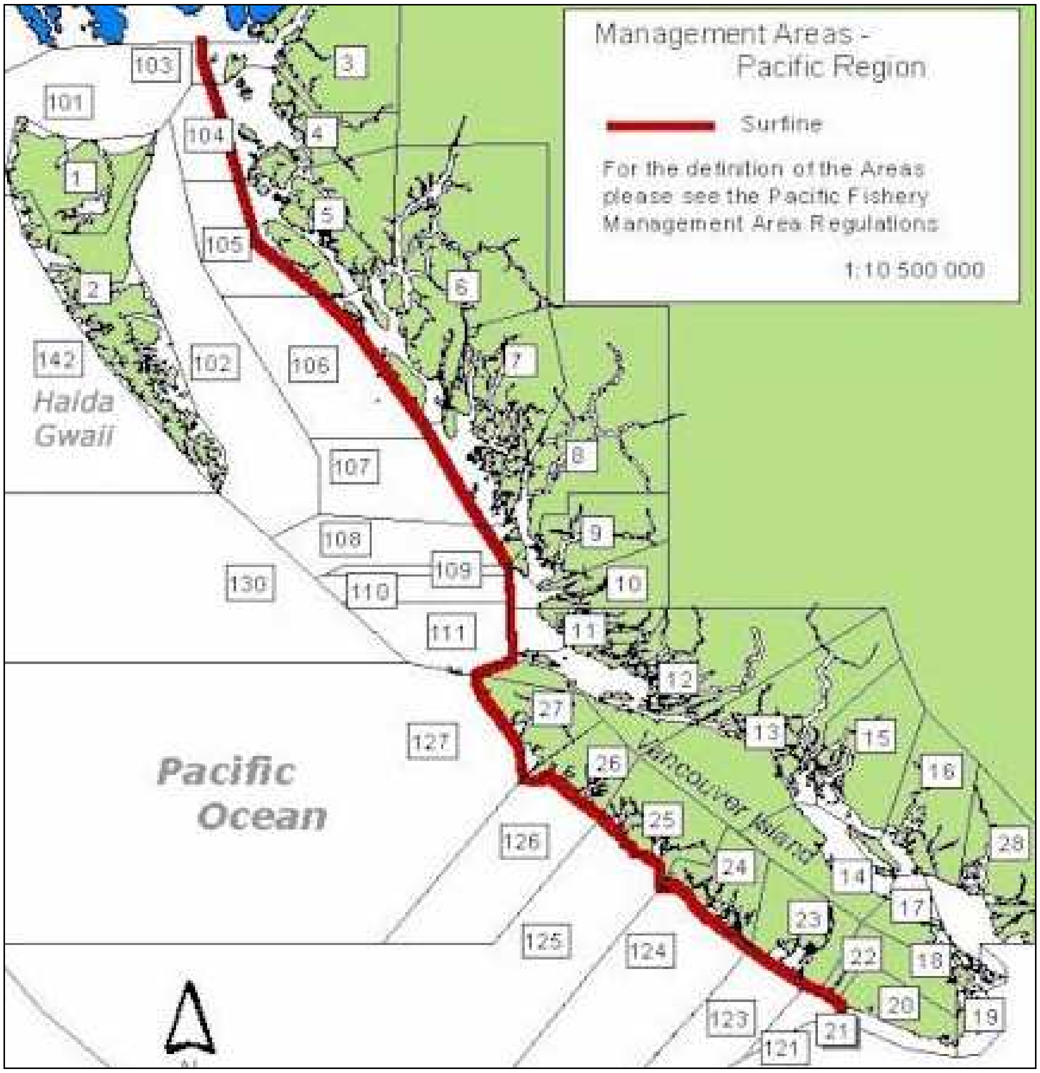
Year	Species name	Positive Sets	Total Sets	Proportion Positive Sets	Total Weight (kg)	Average per positive set (kg)
2009	COHO SALMON	67	109	0.61	1149.1	17.2
2009	CHINOOK SALMON	62	109	0.57	896.5	14.5
2009	PACIFIC HAKE	10	109	0.09	364.1	36.4
2009	SOCKEYE SALMON	29	109	0.27	229.9	7.9
2009	CHUM SALMON	11	109	0.10	135.7	12.3
2009	WHITEBAIT SMELT	7	109	0.06	128.6	18.4
2009	JELLYFISH	11	109	0.10	102.5	9.3
2009	JACK MACKEREL	5	109	0.05	89.6	17.9
2009	SALMON SHARK	2	109	0.02	51.1	25.5
2009	EULACHON	1	109	0.01	27.8	27.8
2009	SOUPFIN SHARK	1	109	0.01	23.9	23.9
2009	PINK SHRIMP	1	109	0.01	20.0	20.0
2009	EUPHAUSIIDS	7	109	0.06	19.2	2.7
2009	BLUE SHARK	7	109	0.06	15.0	2.1
2009	DUSKY ROCKFISH	5	109	0.05	14.1	2.8
2009	LINGCOD	2	109	0.02	11.2	5.6
2009	LANTERNFISHES	7	109	0.06	3.0	0.4
2009	PACIFIC SANDDAB	2	109	0.02	2.5	1.3
2009	NORTHERN LAMPFISH	2	109	0.02	2.1	1.1
2009	SQUIDS	5	109	0.05	2.0	0.4
2009	ARROWTOOTH FLOUNDER	1	109	0.01	1.6	1.6
2009	OCEAN SUNFISH	1	109	0.01	No Weight	NA
2009	THRESHER SHARKS	1	109	0.01	No Weight	NA
2010	PACIFIC SARDINE	40	72	0.56	13151.6	328.8
2010	PACIFIC HERRING	40	72	0.56	9519.3	238.0
2010	PACIFIC HAKE	29	72	0.40	1825.8	63.0
2010	ANCHOVIES	29	72	0.40	1635.8	56.4
2010	CHINOOK SALMON	49	72	0.68	1475.9	30.1
2010	SOCKEYE SALMON	45	72	0.63	1165.5	25.9
2010	DOGFISH SHARKS	7	72	0.10	926.6	132.4
2010	COHO SALMON	51	72	0.71	839.2	16.5
2010	JACK MACKEREL	12	72	0.17	258.8	21.6
2010	PINK SALMON	33	72	0.46	230.6	7.0
2010	JELLYFISH	21	72	0.29	215.9	10.3
2010	CHUM SALMON	22	72	0.31	136.3	6.2
2010	ARROWTOOTH FLOUNDER	8	72	0.11	84.3	10.5
2010	RAGFISH	1	72	0.01	33.3	33.3
2010	LINGCOD	2	72	0.03	16.9	8.5
2010	NORTHERN LAMPFISH	5	72	0.07	11.1	2.2
2010	PINK SHRIMP	2	72	0.03	10.4	5.2
2010	BIG SKATE	2	72	0.03	5.9	2.9
2010	SQUIDS	11	72	0.15	4.9	0.4
2010	EULACHON	10	72	0.14	3.5	0.4
2010	CHUB MACKEREL	2	72	0.03	1.9	1.0
2010	WOLF EEL	11	72	0.15	1.2	0.1
2011	PACIFIC SARDINE	41	68	0.60	27787.2	677.7
2011	PACIFIC HERRING	49	68	0.72	14029.0	286.3
2011	CHINOOK SALMON	44	68	0.65	1382.0	31.4
2011	SPINY DOGFISH	13	68	0.19	1084.0	83.4
2011	COHO SALMON	46	68	0.68	758.0	16.5
2011	PINK SALMON	50	68	0.74	731.0	14.6
2011	SOCKEYE SALMON	27	68	0.40	403.0	14.9
2011	NORTHERN ANCHOVY	8	68	0.12	200.0	25.0
2011	SALPS	14	68	0.21	135.0	9.6
2011	JELLYFISH	18	68	0.26	105.0	5.8
2011	CHUM SALMON	13	68	0.19	95.0	7.3
2011	PACIFIC SANDDAB	5	68	0.07	36.0	7.2

APPENDIX B continued

Year	Species name	Positive Sets	Total Sets	Proportion Positive Sets	Total Weight (kg)	Average per positive set (kg)
2011	JACK MACKEREL	8	68	0.12	30.0	3.8
2011	EULACHON	9	68	0.13	29.0	3.2
2011	ARROWTOOTH FLOUNDER	7	68	0.10	23.0	3.3
2011	EUPHAUSIIDS	9	68	0.13	19.0	2.1
2011	LANTERNFISHES	6	68	0.09	17.0	2.8
2011	SMELTS	5	68	0.07	15.0	3.0
2011	MOLAS	2	68	0.03	10.0	5.0
2011	SQUIDS	6	68	0.09	9.0	1.5
2011	PACIFIC HAKE	2	68	0.03	5.0	2.5
2011	CHUB MACKEREL	3	68	0.04	4.0	1.3
2011	RAINBOW TROUT	1	68	0.01	4.0	4.0
2011	PACIFIC SAND LANCE	7	68	0.10	3.0	0.4
2011	PINK SHRIMP	6	68	0.09	3.0	0.5
2011	ROCKFISHES	17	68	0.25	3.0	0.2
2011	WHITEBAIT SMELT	3	68	0.04	3.0	1.0
2011	SLENDER BARRACUDINA	10	68	0.15	2.0	0.2
2011	DUSKY ROCKFISH	1	68	0.01	1.0	1.0

APPENDIX C

Information on DFO Pacific Fishery Management Areas (PFMAs) and commercial sardine fishery catch amounts from 1999 to 2011.



Pacific Fishery Management Areas of Fisheries and Oceans Canada.

APPENDIX C continued.

Approximate commercial sardine fishery catch amounts (tonnes) by year and major DFO Pacific Fishery Management Area (PFMA). Most fishing occurred July through October.

PFMA	Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Mainland														
6		0	0	0	0	0	0	442.4	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0	26	0	0	0	0
8		8.2	55.3	85.3	0	0	0	0	0	0	358	564	18	0
9		0	0	0	0	0	0	44.2	0	25	522	3,370	1,925	0
10		352	0	0	370.1	0	80.7	0	0	0	1,421	3,196	1,049	0
11		0	0	0	0	0	0	114.4	0	0	0	0	0	0
12		345.6	79.8	40.8	54.4	0	0	2047.5	1,558	1,181	2,462	131	320	0
	Subtotal	*705.8*	*135.1*	*126.1*	*424.5*	*0*	*80.7*	*2648.5*	*1,558*	*1,232*	*4,764*	*7,262*	*3,312*	*0*
WCVI														
20		0	0	0	0	0	0	0	0	168	0	0	0	0
23		74.4	207.8	183.3	104.3	920.6	191.9	180.8	0	105	820	3,655	5,178	5,145
24		0	0	0	0	38.6	822.3	44.3	0	0	301	57	1,149	677
25		9.1	768.4	435.5	296.7	81.8	2266.2	19.6	0	1	2,025	3,188	6,008	5,787
26		244.9	145.2	68	40.8		829.2	0	0	0	1,179	249	133	1,593
27		99.8	302.1	394.6	147	36.2	68.5	80.1	0	0	0	0	3,486	1,694
121		0	0	40.8	0	0	0	0	0	0	0	0	0	77
123		0	0	19.1	0	0	0	213.7	0	0	1,346	916	3,185	4,683
124		0	0	0	0	0	0	44.4	0	0	0	0	46	703
125		0	0	0	0	0	0	0	0	0	0		42	199
126		0	0	0	0	0	0	0	0	0	0	0	0	62
	Subtotal	*428.2*	*1424*	*1141*	*588.8*	*1077.2*	*4178.1*	*582.9*	*0*	*274*	*5,671*	*8,065*	*19,227*	*20,621*
Annual catch		**1,134**	**1,559**	**1,267**	**1,013**	**1,077**	**4,259**	**3,231**	**1,558**	**1,506**	**10,434**	**15,326**	**22,539**	**20,620**
Total allowable catch					5,000	9,000	15,000	15,200	13,500	19,800	12,491	18,196	23,166	21,917

APPENDIX D

Preliminary findings from 2011 Simrad EK60 night sampling

Collaborators/authors:
Jonathon A. Graas, University of British Columbia, Faculty of Land and Food Systems; **Gary Melvin,** DFO, St. Andrews Biological Station; **Stéphane Gauthier,** DFO, Institute of Ocean Sciences; **Linnea Flostrand, Jake Schweigert and Gordon (Sandy) McFarlane**, DFO, Pacific Biological Station; **R. Scott McKinley**, The University of British Columbia / Center for Aquaculture and Environmental Research

Acoustic and trawl catch data from the 2011 Canadian sardine survey were analyzed to compare the two methodologies and approximate the species' vertical distribution within the near surface layer at night. Significant backscatter at 120 kHz was observed within the 38 kHz near-field safe range, suggesting fish were missed at 38 kHz. Sardine density was significantly greater above the trawl's foot rope path than below it, which challenges the assumption that sardine catch density determined in the upper 20 m of the water column can be extrapolated to 30 m (see Figure D1). No significant linear relationships between trawl-based density estimates and acoustic backscatter or density were found (see Figure D2). The lack of observed correlation could be due to a complex interaction of fish-vessel avoidance reactions, the effect of the near surface acoustic blind zone, small near surface sampling volume of the narrow acoustic beam, and patchy sardine distribution. The acoustic data may have detected several trawl tows where sardine was caught by the trawl net during net deployment and/or retrieval. Therefore identifying a potential source of error in that tow durations used for calculating tow distance and trawl densities may be underestimated, which would result in overestimating catch densities.

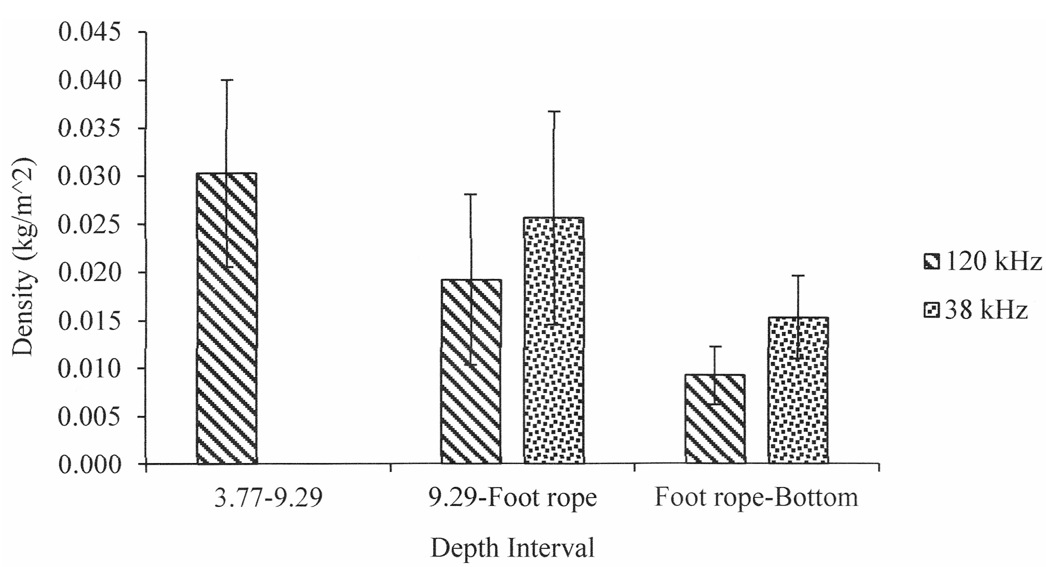
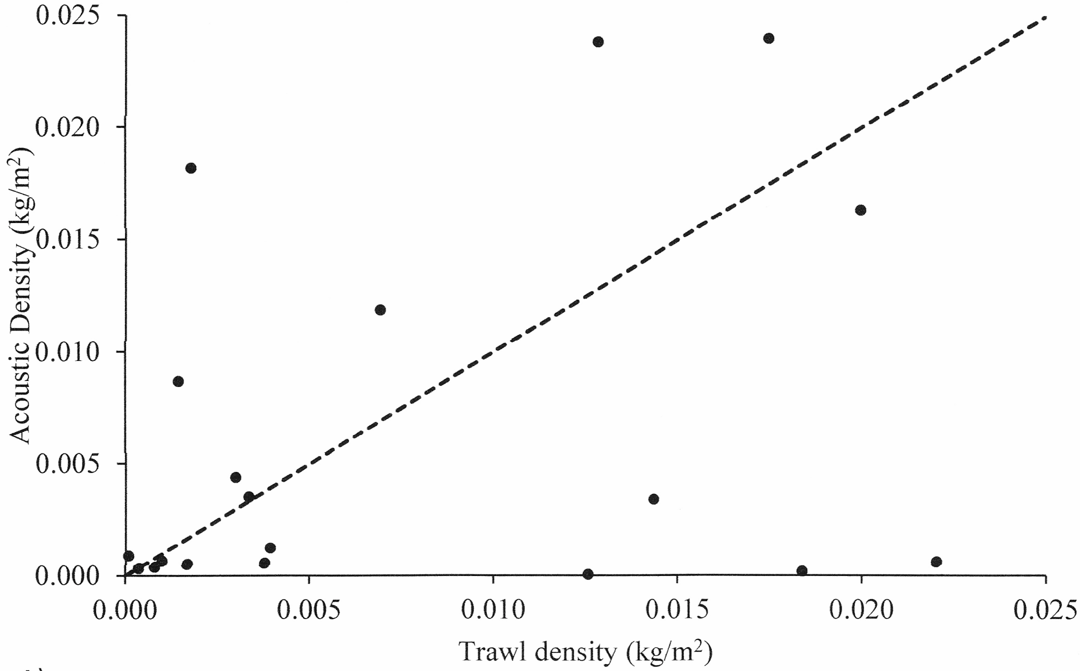
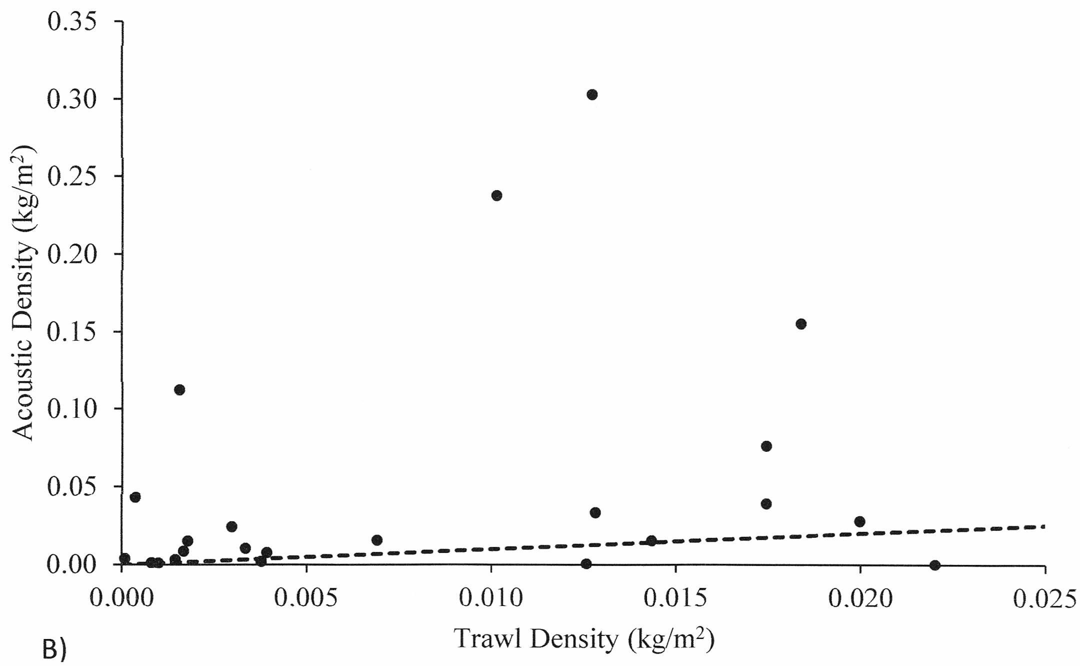


Figure D1. Average sardine density at 120 and 38 kHz between 3.77 – 9.29 m from the transducer, 9.29 m to the trawl foot rope, and foot rope to the bottom of the surface scattering layer. The foot rope and bottom of the surface scattering layer were on average 12.2 m and 21.03 m from the transducer respectively. There is no 38 kHz density between 3.77-9.29 m from the transducer since that depth range is within the 38 kHz near field. Standard error bars shown. At 120 kHz, sardine density was significantly greater above the foot rope than below it ($p=0.02$). The difference at 38 kHz was not as statistically significant.

APPENDIX D continued.



A)



B)

Figure D2. Comparisons between acoustic and trawl estimates of sardine density from 2011 WCVI night survey sampling. A) 38 kHz, and B) 120 kHz. Dashed line represents 1:1 ratio (no significant linear relationships observed).

Agenda Item G.3.a
Attachment 5
November 2012

Canada (Department of Fisheries and Oceans) Swept-Area Trawl Survey

Report of Methodology Review Panel Meeting

National Marine Fisheries Service (NMFS)
Southwest Fisheries Science Center (SWFSC)
La Jolla, California
29-31 May 2012

Methodology Review Panel Members:
André Punt (Chair), Scientific and Statistical Committee (SSC), University of Washington
Ray Conser, SSC, NMFS, Southwest Fisheries Science Center (SWFSC)
Olav Rune Godø, Center for Independent Experts (CIE)
John Simmonds, Center for Independent Experts (CIE)

Pacific Fishery Management Council (Council) Representatives:
Kirk Lynn, Coastal Pelagic Species Management Team (CPSMT)
Mike Okoniewski, Coastal Pelagic Species Advisory Subpanel (CPSAS)
Kerry Griffin, Pacific Fishery Management Council Staff (PFMC)

Technical Team:
Linnea Flostrand, DFO, Canada
Jake Schweigert, DFO, Canada
Kevin Hill, NMFS, SWFSC
Paul Crone, NMFS, SWFSC

OVERVIEW

A review of the surface trawl survey conducted by the Department of Fisheries and Oceans (DFO), Canada for estimating the abundance of Pacific sardine off Vancouver Island, Canada was conducted by a Methodology Review Panel (Panel), at the Southwest Fisheries Science Center (SWFSC) Torrey Pines Court Laboratory, La Jolla, CA, from 29-31 May 2012. The Panel followed the Council's Terms of Reference for Stock Assessment Methodology Reviews (April 2012 version).

Dr. André Punt opened the meeting and Dr. Francisco Werner, SWFSC Director, welcomed the participants. Dr. Punt noted that the aim of the review was to address six key questions: (a) are the design of the survey and the sampling methods appropriate?; (b) how are the raw data analysed to estimate a survey index and associated age- and length-composition information?; (c) how appropriate are the methods used to estimate the uncertainty associated with the data?; (d) can the survey index / age composition data be used in assessments and if so, how?; (e) what selectivity assumptions are appropriate for including the data in the assessment?; and (f) what are the implications of the survey being conducted at the current northern extent of the distribution of Pacific sardine? The reason for considering the final question is that availability of fish to the survey may be impacted by the timing of seasonal migrations and local environmental conditions. If availability of sardine to the survey varies from year to year, this may need to be accounted for in the assessment model, for example by allowing for time-varying survey catchability ('q'). Dr Punt noted that the 2012 assessment of Pacific sardine will be an 'update' assessment so data from the surface trawl survey could only be included in the next full sardine stock assessment.

The Panel reviewed the survey methodology and related analysis methods firstly in terms of whether the data collected can be used to estimate an index of abundance for the core area (operationally-defined as the eight strata used to analyse the data from the 2011 survey; Figure 1), then how the biomass for this area relates to the biomass north of the USA border and to stock-wide biomass, and finally, how time-varying migration impacts the interpretation of the data collected during the survey. The Panel did not review how the data from the survey are used to provide advice for management of the sardine fishery in Canada.

The Panel was provided with extensive background material, including a number of primary documents, through an FTP site two weeks prior to the review meeting. The proponents provided the Panel with a number of presentations including an overview of the survey, the data collected in the past, and aspects of the stock assessment for Pacific sardine.

The Panel identified several ways in which the survey can be improved, noting that the 2011 survey was based on a design and operational procedures that most closely match its recommendations. In contrast, earlier surveys were based on markedly different designs than that used for the 2011 survey. Implementing the Panel's suggestions will lead to changes to the survey design and analysis methods. However, the Panel cautions against continual changes to survey design if the aim is to develop a comparable series of biomass estimates.

The Chair thanked the SWFSC for hosting the meeting and the participants for the excellent and constructive atmosphere during the review, the results of which should help the Council and its advisory bodies determine the best available science for the assessment of Pacific sardine.

1. DISCUSSION AND REQUESTS MADE TO THE TECHNICAL TEAM DURING THE MEETING

A) Make plots of (i) density as a function of tow speed and (ii) density as a function of tow duration. Rationale: In principle, tow speed and duration should not be related to estimates of density. The plots will be useful diagnostics for examining some of the underlying assumptions. Response: There does not appear to be a relationship between tow duration or tow speed and density. However, there are some very short tow durations and there is concern that the density estimates for such tows may be positively biased by catches during setting and retrieval of the net.

B) What kind of sensor has been used for mensuration of the width of the trawl net mouth opening during a tow? Under what conditions would the fishing master estimate the width rather than rely upon the mensuration? Rationale: It appears that the fishing master estimates are used frequently. The Panel would like to have a better understanding of the instrumentation, and why the width measurements are not routinely used. Response: Additional information on gear configuration was provided (see Appendix 4).

C) Develop an index for 2006-11 using the eight survey strata developed for the 2011 survey (Figure 1). Compute and report the samples size and mean density for each stratum, and an overall density based on the area-weighted average density and CV. Rationale: Examination of the survey results to date (density estimates and survey length-frequencies) indicate that area stratification may be important for both mean and variance estimation. Response: Area-stratified densities differed from the raw densities in 2006 and 2009 (Table 1), although this was likely related to strata in which no sampling took place or the density was estimated to be zero. Unstratified and stratified mean estimates for other years were similar and the general trend of the index was not greatly affected, but the area-stratified index was less variable. The area-stratified approach is preferable especially given the differences in mean size of sardine from north to south.

D) Compute spatial autocorrelation between tow densities for 2006-11. Prioritize by starting with 2011 and work backwards in time. Rationale: If significant spatial autocorrelation exists, it should be fully accounted for in the variance estimates for the index of abundance. Response: Spatial autocorrelation is evident for the 2008-11 surveys (especially 2010-11), but not for earlier surveys (Figure 2). For 2008-09, variance should be estimated using geostatistics.

E) Provide summary statistics (mean densities and interquartile range) from the 2005 survey that may shed some light on day-night differences. Rationale: This may provide information related to using or dropping the surveys for 2004 and earlier. Response: CVs are large for both day and night sampling (>2). Mean estimated densities are quite similar. Nevertheless, sampling may be more efficient at night (sardine are less clustered at night) (see Section 2.2.3 for further discussion).

F) Provide a conceptual discussion of the factors that may potentially bias an index of abundance derived from the core area. For example, what is the effect of some portion of the population being north of the core area; offshore/inshore of the core area; at greater depth; etc. Consider possible inter-annual differences in migration rates, size and/or age-structure differences, etc. Rationale: To facilitate Panel discussion on how the trawl survey index might be used in the sardine stock assessment. Response: The proponents summarized the various factors that may affect the utility of an index. Considerable discussion ensued. The impact of migration on the interpretation of the estimates of abundance is a key factor. It is difficult (if not impossible) to estimate migration and abundance from a single survey because these factors are confounded. If the timing of migration into the core area differs greatly from year to year, the best approach may be to model the migration separately (e.g., using a model of potential habitat) and use the survey for abundance estimation only.

G) For 2006-11, plot catch rate vs. time of day by year. Rationale: To examine the effect of sunset and sunrise on catch rates. Response: Although a few large densities were observed near sunset and sunrise, this should not pose a major problem in developing an index of abundance.

H) Provide summary statistics and other information that may be useful for determining how many survey years could be in a potential index, e.g. 2002-11; 2006-11; 2010-11; other? What are the pros and cons? Rationale: It seems clear that not all survey years can be used as a single index. What subset is most defendable? Response: In terms of design, sample size, and consistent survey protocols, the 2011 survey is the best to date. The key question is how many survey years prior to 2011 should be included in an index. Incorporation of years prior to 2006 is questionable due to the predominance of daytime and deep tows during those surveys.

I) Provide plots of the length composition by 2011 survey strata and year (2006-11). Show results for the raw data and data weighted by tow densities. Rationale: To better understand the change in size composition over space and time. Response: As expected, mean size appears to increase from south to north (e.g., Figure 3). As such, length composition data weighted by the densities within stratum should be used in the sardine stock assessment.

J) For 2006-11, compare age 3+ and age 4+ biomass estimates from the last stock assessment with the respective biomass estimates from the trawl surveys using the core area developed for the 2011 survey. Rationale: To compare scale and trend from the survey with the estimates of overall sardine biomass. Response: The proponents provided plots of age 2+ and age 3+ population biomass estimates from the 2011 stock assessment vs. density estimates from the Canadian trawl survey, 2006-11. Results were also computed for the age 4+ biomass, but not plotted due to a negative correlation. No relationship was apparent between either the age 2+ nor the age 3+ biomass and the trawl survey biomass estimates. It was noted, however, that such comparisons are more properly done within a stock assessment model that simultaneously considers the selectivity properties of the trawl survey.

2. SUMMARY COMMMENTS ON THE TECHNICAL MERITS AND/OR DEFICIENCIES OF THE METHODOLOGY AND RECOMMENDATIONS FOR REMEDIES

2.1 Gear and Instrumentation

Sampling marine populations using trawls has wide application, and the need for operational standards has generated substantial international efforts to identify conventions that are applicable for most areas and conditions (Reid et al. 2007, ICES 2009). The Panel evaluated the survey equipment and protocols used in Canada relative to international standards.

Sampling of small pelagic fishes is challenging due to their high swimming speed and sensitivity to external stimuli, such as a moving and noisy trawling vessel (Misund 1999). The trawl net should include a large enough opening to allow a large volume of water to be sampled and should be constructed to allow high towing speed (>3.0 knots), thus enhancing catching efficiency. All surveys were conducted using a model 250/350/14 midwater rope trawl (Cantrawl Pacific Ltd., Richmond, B.C.). This is a relatively small pelagic trawl which appears easy and robust in routine operations. As such, it is an ideal survey trawl. Ropes and large meshes are used in the front part of the trawl opening, thus minimizing the resistance in water and allowing higher speed. Potentially, a disadvantage of this configuration is that the small size of the net may increase the probability of fish avoiding the gear (e.g., Suuronen et al. 1997, Misund 1999). The trawl is documented using drawings of trawl construction and rigging, including door specifications. However, some of the figures provided to the Panel were drawn by hand and were not always easy to interpret. The trawl construction should be included in the documentation of the survey standards.

Conducting swept-area surveys requires knowledge of trawl geometry to enable area or volume densities to be calculated. Trawls are sensitive to environmental conditions, such as strong currents and winds, as well as operational mistakes. These may seriously impact the trawl geometry (height and width) and thus, the trawl opening, which is basic information for estimating densities. Also, operating the trawl at depths in accordance with survey protocols is demanding. Thus, trawl instrumentation is normally used to ensure trawl operation according to certain standards (Walsh et al. 1991). The trawl net for the Canadian trawl survey is always equipped with one of three trawl sonars attached to the headline (Simrad FS-70, Westmar 770 SLED or Westmar 380 SLED). A third cable ensures continuous data stream and additional stretch to the headrope, which helps to stabilise the trawl opening. Trawl sonar is an ideal instrument for achieving a correct and constant trawl opening, and the trawl is probably functioning optimally when trawl opening is stable at target geometry. Also, this instrument draws the outline of the trawl, which is used to assess the amount of water filtered by the trawl. The footrope is expected to be directly under the headline, based on the construction of the trawl and its rigging as given in the trawl drawings. Assuming that the sonar is attached to the midpoint of the headline, it will draw the trawl opening at this part of the trawl, some meters behind the wingtips. The wingtips cover a wider area than that shown by the trawl sonar, and it could be argued that the trawl opening at the wingtips is more relevant for assessing densities because fish are probably herded by the wings. This would be an issue if catches are expressed as absolute densities, but is of minor importance for calculation of indices of relative abundance.

Operational protocols help in making decisions on the validity of tows. Without such protocols, ad hoc decisions by personnel on watch may lead to biased and variable results. There are fixed routines for operating the trawl at a standard tow location, but there seems to be no protocol for handling sonar observations with respect to the deviation from standard specification,e.g., no definitive protocols are in place regarding how much deviation from standard trawl net geometry can be tolerated, before the tow is discarded or stopped and repeated. Presently, this is a decision taken by the fishing master on watch. There is a need for operational specifications that describe acceptable variation in geometry measures, before trawling is terminated and repeated, to achieve standard operation of the gear (e.g., Walsh et al. 2009).

There are aspects of gear construction, rigging, and operational issues that were not mentioned in the report provided to the Panel. The experience gained in standardized bottom trawl surveys (e.g., Reid et al. 2007, ICES 2009, Walsh et al. 2009) represents excellent guidelines for how similar protocols might be developed for Canada's surface trawl survey. Trawling has been conducted at various depths during the history of the survey. However, effort has been concentrated on surface tows covering the depths to 15m in recent years. There is some evidence for occasional catches of sardine in deeper water. However, these catches could have occurred shallower than 15m during shooting and retrieval of the net. Studies of the vertical distribution of sardines using acoustics have found some fish below 15m (i.e. 2011 WCVI survey EK60 records). However, the bulk of the fish were found in surface waters. Thus, it seems reasonable to assume that the stock is concentrated in the upper 15m, and sampling could be designed accordingly. It would be useful to keep track of the vertical distribution of the population by studying the fractions of the acoustic backscattering of sardines found above and below 15m, given the fraction of fish below 15m likely changes over time, to some degree, due to prevailing oceanographic conditions.

Catches of marine organisms often show large diel variability. This represents a source of variability and bias depending on the survey strategy. Pelagic fish often distribute close to the surface at night, and concentrate in schools in deeper waters during the day. Tows were carried out during the day and at night before 2005, while only night tows have been conducted recently. The depth range of the population impacts the volume that should be used when estimating stock biomass, i.e., towing at night might reduce the volume in which the population is located. In addition, patchiness is normally much higher during the day when fish are schooling, which will typically increase sampling error. Both of these factors indicate that only trawling at night will lead to the most precise estimates.

There was no evidence of large day-night effects in the data from the 2005 survey. Nevertheless, the Panel **recommends** fishing only at night. Presently, day and night are defined by fixed hours. However, they should be defined with reference to solar elevation.

2.2 Calculation of density

A swept-area/volume assessment of fish density requires that the properties of the gear and its operation are known. The effective opening of the trawl (the area effectively herding fish into the trawl) needs to be defined, measured, and monitored. The opening of the trawl has been defined as the area covered by the trawl sonar in the case of the West Coast Vancouver Island (WCVI) surveys. As noted above, this is likely to be a smaller area than that over which fish are herded, but it is the ideal area to measure and monitor and thus, a good choice for calculating estimates of relative densities.

Distance towed is needed to calculate swept volume. This is based on GPS records of speed times tow duration in the WCVI surveys. However, this might be an imprecise estimate of distance towed due to uncertainty measuring tow speed. Such uncertainty may explain the large variation in tow speeds recorded during the surveys (although this variation may also be due to strong currents). A more precise measure of distance towed is the distance between the GPS position at start and stop, which avoids the need for an estimate of tow speed. Distance over the ground might be an imprecise measure of filtered volume if currents are strong. Nevertheless, it is probably better to use the distance over the ground than trying to assess filtered volume by, for example, recording the speed of water through the trawl. Such procedures need additional instrumentation, and measures of water speed through the trawl are often highly uncertain. The present procedure is to use a tow direction against wind, which is sensible given the need to maintain operational stability. This will cause some uncertainty related to the impact of current on the towed volume, i.e., it would be useful to record current direction and strength during each tow as an impact variable for later analysis.

The survey report describes instances when catching might have taken place during shooting/retrieval. Thus, the effective distance towed might be longer than that recorded. This is particularly a problem when distance towed varies. Catching during shooting/retrieval will affect short tows more than long tows. Consequently, tow duration should be kept as constant as possible and this issue should be borne in mind as a potential bias when analysing the data. Setting the tow start as soon as the standard opening is established and stopping the trawl when trawl geometry is distorted might be a way of minimizing these impacts. Catching during shooting and retrieval is particularly a problem if the distribution of the fish requires that trawling take place at various depths. In these cases, opening-closing devices could be a solution, although good techniques for fast swimmers, such as sardines might not be readily available.

One aspect of catchability (q) is the relationship between observed trawl density in relation to true density. While, in general, q might impact density by size, in the case of small pelagic fishes, it will predominantly impact density measures, while size selection is less important. In general, changes to the survey vessel, as took place in the WCVI survey in 2005, could introduce unpredictable changes in q. The trawl is towed at the surface for a certain distance in the case of the WCVI survey, so the major factors are expected to be associated with vessel avoidance (Gerlotto et al. 2004, Ona et al. 2007) and trawl avoidance (Suuronen et al. 1997). Quantification of these factors is often difficult due to unpredictable variability and difficulties in obtaining appropriate measurements. Nevertheless, the issue should not be ignored because the trawling in the WCVI survey takes place close to the surface, with a short distance between the vessel and the trawl. Some straightforward studies could be implemented to monitor avoidance. For example, a vertical profile of the fish distribution under the vessel can be obtained if the vessel acoustics are monitored continuously. Similarly, the trawl sonar could be used to establish a depth distribution profile in the mouth of the trawl. There are many sources of uncertainty when comparing those two profiles, i.e., large impacts in the zone between the vessel and the trawl could be identified, but probably not quantified. Further, dedicated studies of avoidance, as have been conducted for the CPS acoustic-trawl survey, would be useful to provide an overview of the impact of these problems. Small pelagic species are high performing swimmers. In this context, escapement at the end of the tow caused by fish swimming in front of the trawl until retrieval may be more significant for shorter tows. The variability of all these factors affecting q emphasizes the importance of the Panel's conclusion to keep tow duration as fixed as possible.

2.3 Use of historical surveys

The issue here is which surveys could form a useful time-series. There are a number of aspects to the organisation of data collection to be considered. The most important of these were identified to be the spatial distribution of the tows, and the changes in sampling by time of day and depth.

2.3.1 Tow locations.

The tow location design has changed over time. The surveys in 1999-2004, 2006, 2008 and 2009 generally followed similar approaches spatially. The 2005 survey was aimed primarily at comparing day and night tows, rather than achieving good spatial coverage. The surveys in 2010 and 2011 are based on random designs, but with a slightly different area basis. The primary question to address being can the data from these designs be used to estimate an index of abundance by year? The Panel considers that the sample data from the 2010 and 2011 surveys can be used directly based on the mean of the samples, over the design strata, because the tow locations for these years were specifically selected on a random basis. Also, the strata variances calculated from the samples for the surveys during 2010 and 2011 are unbiased estimates of the precision of the estimates.

The Panel noted that the 2005 survey had very poor spatial coverage and thus, the sample values cannot be relied upon to give either an unbiased estimate of abundance or variance.

The surveys during the other years followed a quasi-stratified transect strategy, with 5 or 6 sets of tows allocated in lines across the area in an approximately east-west direction. In addition to these tows, extra tows were added in a haphazard way. Raising the mean to the total survey area may lead to biased estimates of density and variance because the tows were not always located in the area in a way that is designed to be representative (e.g., stratified random or systematic). Inspection of the autocorrelation structure (Figure 2) suggests there is no spatial autocorrelation in the surveys for 1999-2005. Therefore, the samples for these years can be considered to be independently distributed in a statistical sense and consequently, the global mean and variance of the samples can be considered as representative.

There is evidence of autocorrelation between the observations during 2008 and 2009 (Figure 2). The spatial distribution of tows appears to differ across the area, particularly for 2009. The combination of differential spatial allocation and positive spatial autocorrelation suggests that the global mean and variance may be biased, although any biases may be small. Consequently, geostatistical analysis should be used to provide an unbiased estimate of mean and variance.

2.3.2 Trawl depth

The depth of trawl tows (quantified in terms of the depth of the headrope) was more variable prior to 2005 than after 2005. Indications are that there are differences in presence of sardine with depth. It is unclear how this might influence the mean density, but it is likely that variation in depth contributed to bias, to some degree, relative to the densities estimated in the more recent surveys. One solution is to filter the overall data set and use only the shallower tows from the earlier surveys for purposes of developing a potential time series.

2.3.3 Time of day

Tows were predominantly conducted during daylight before 2005, although night tows were also conducted on some trips. As noted above, catch-rates during the day appear to be more variable than at night. There is also a perception that the catches may be more representative during the night, given the fish are more dispersed and would see the trawl later than would be the case during the day (i.e., possibly, less net avoidance). The available resources during 2005 were used to evaluate the effect of sampling during the day and at night. This study indicated again that the presence / absence difference was greater during the day, but the standard deviations for day and night were rather similar (but higher during the day) and ultimately, the means were not significantly different. The 2005 survey was conducted on the *F/V* Frosti rather than the *R/V* Ricker. The Panel **agreed** that day and night data are different, but it is unclear by how much presently. More recent surveys have been carried out at night and CVs are generally lower than those from the earlier predominantly daytime surveys.

Given this range of differences pre/post 2005, the Panel **agreed** that the surveys prior to 2005 be considered potentially inconsistent with those from 2006 onwards, which necessarily hampers the utility of these data for developing a longer term time series of abundance indices for inclusion in formal stock assessments.

2.4 Definition of the core area

The primary spatial-related issue to address is how to specify the boundaries of a core area. If a survey is to be defined and tow locations set, the area must be defined either in advance or in a way that is coupled to the analysis. The current (2011) proposal for the core area (Figure 1) appears reasonably sensible, but could be modified slightly to make the rationale for the boundary more explicit, as well as allow one or two minor additional aspects to be further evaluated.

The southern boundaries for the survey are administrative, and should conform to the Canada/USA border. The eastern boundary should be as close to the coast of Vancouver Island as is practical. Fisheries typically operate inshore, including in some of the bays and inlets. It would be helpful to include areas covered by the fisheries, thus giving the survey direct relevance to those involved in the fishery, if possible. Use of a random placement grid (see below) could then be used to apportion tows to these areas appropriately. The northern and western boundaries should be in accordance with the substantive limits of the distribution of sardine. It is not possible to cover all areas in which sardine can occur, and excluding a small amount of low-density area is reasonable. No survey catches of sardine above 1 t/km^3 are reported north of Vancouver Island (Figure 1), and some catches at higher densities are observed a few miles south of this line. It seems reasonable to limit the northern extent of the core area by this geographically-located point. The westward extent of the survey is more difficult to specify.

Catches above 1 t/km^3 are observed out to 45 km and the 1,000 m depth contour (Figure 1). Finally, note that defining the survey boundary by the greater of these two criteria would result in an overall data set that contains all previously observed densities.

2.5 Influence of environment (habitat)

Sardine habitat is defined as waters between 12 and 16ºC off southern and central California. (Checkley et al., 2000; Lynn, 2003; Jacobson et al., 2005; Reiss et al., 2008; Zwolinski et al, 2011). High densities and spawning were observed off Oregon between 14 and 16 ºC (Emmett et al., 2005). The appearance of sardine off western Vancouver Island is associated with waters warmer than 12 ºC (Ware, 1999). A recent study based on egg presence and remotely-sensed information over a 12-year period (Zwolinski et al., 2011) further refined the envelope of sardine potential habitat, and identified oceanographic conditions that likely influenced the migrations and the seasonality of the fisheries, to some degree. The duration of the availability of sardine habitat off western Vancouver Island is shorter than that off Washington and Oregon, suggesting a 4 to 6-month sardine season.

Detailed analysis of the appearance of sardine off the Columbia River mouth suggests that sardine arrive, in general, 2 to 4 weeks after the arrival of the habitat, and peak densities occur generally 1 to 2 months later than this. Information on sardine arrival off western Vancouver Island and its relationship to the potential habitat has not yet been explored, and could benefit from data from 'scouting trips.' Fishery landings indicate that the peak abundance of sardine off Vancouver Island is delayed in relation to the peak of potential habitat, but other logistics affecting fleet behavior could be driving peak landings times observed in the fishery.

2.6 Stratification

The primary issue here is whether the core area should be split into strata and if so, at what scale? There is some evidence for different mean densities around the core area (Table 1). For example, the northern part of the region often has lower estimated densities. In addition, biological parameters change latitudinally (see below; Figure 3). If the variation in biological information is to be included in the analysis, some stratification is required to spatially assign / raise biomass and biological parameters. Currently, there is no straightforward way to set stratum boundaries in the overall data set to predictably reduce variance, but rather, the function of stratification is to spread sampling more evenly across the core area and allow regional estimates to be obtained. The current approach of eight strata allows sampling with strata and a similar number of samples within each stratum. This appears to be a reasonable approach, but it could be tested by simulation.

2.7 Trawl location design (random/ systematic)

The primary issue here is determination of the optimal placement of tows within the core area. The ICES held a workshop on survey design in 2005 in which a variety of designs were tested on simulated stock distributions with different spatial properties. Systematic and random punctual surveys were evaluated. The two simulated distributions (Section 2.1.1 of ICES (2005)) were used to evaluate the differences between a systematic survey design and a fully-random survey design. Two fields with properties similar to observed populations were used.

Field 1:

Coefficient of variation = 3.3
Mean fish density in the field of presence = 4 10^7 ind n.mi.$^{-2}$
Total abundance = 10^7 ind
Variogram = nugget effect (sill = 2.5 10^6 ind^2 n.mi.$^{-4}$) + spherical (sill = 8.3 10^6 ind^2 n.mi.$^{-4}$; range = 10 n.mi.); the nugget effect represents 23% of the total variance.

Field 2:

Coefficient of variation = 1.7
Mean fish density in the field of presence = 4 10^7 ind n.mi.$^{-2}$
Total abundance = 10^7 ind
Variogram = nugget effect (sill =0.23 10^6 ind^2 n.mi.$^{-4}$) + spherical (sill = 2.25 10^6 ind^2 n.mi.$^{-4}$; range =25 n.mi.); the nugget effect represents 9% of the total variance.

The two methods each with 1,000 different sampling realisations were defined as the following:

- **Systematic:** a regular grid of 64 points, arranged in an equally-spaced 8 by 8 grid, with a spacing of 1/8 of the survey dimension with a 2D random location on a scale of 1/8 by 1/8 of the dimension of the area; and
- **Random tow locations**: the procedure starts with 64 tows; the number of tows is then increased by adding new random tows and checking for time available using the travelling salesman algorithm until the maximum number possible in the time allocated is reached. The number of tows for each of the 1,000 random sampling realisations is given in Figure 4. This illustrates the increase in the number of samples that can be achieved with a random grid and a travelling salesman algorithm.

The results of the simulations were evaluated through examination of the distribution of the estimates of the total abundance for each method. These distributions are given separately for each simulated surface in Figure 5. The estimates of mean abundance are unbiased at $1*10^7$ for both methods and both simulated surfaces. Figure 5a shows the results from simulated surface 1, which has high variance and low spatial autocorrelation. In this case, the results indicate that the random survey design, which has the higher number of observations, has the lower root square error (RSE = 49%) and provides a more precise estimate than the systematic survey (RSE = 56%). Figure 5b shows the results for surface 2 with the lower variance and higher spatial autocorrelation. In contrast to surface 1, the improved precision due to even allocation of sampling with the systematic survey improves the estimate of abundance over the random survey. In this case, the systematic survey RSE is 14%, i.e., even with extra samples, the RSE for the random survey (23%) is poorer. These contrasting results for the two spatial distributions show that there is an interaction between spatial autocorrelation and sampling design. Further investigation of a wider range of surfaces with different properties would help to refine the parameters that influence when each survey strategy is the most efficient estimator of the abundance and variance.

The Panel was not aware of work that can explicitly determine the correct approach for the WCVI survey. It might be possible to simulate a range of spatial distributions based on the observations; however, this may not be necessary. The analyses of spatial variance carried out on the WCVI survey data from 1999 to 2011 suggest that there is spatial autocorrelation, but that this is limited to a distance that is a small proportion of the length of the core area. Consequently, it is likely that the WCVI is more like the low correlation surface tested during the ICES workshop, i.e., the ratio of range to the dimension of the area is more important than the absolute range. If this is the case, a random design augmented by an algorithm to maximise the number of tows would likely be the optimal choice. This supports the current approach of random tow allocation. The current methodology uses a 10 by 10 km grid for allocating ~3-5 km tows. It might be more appropriate to match the grid size to the trawl length. The Panel **reccomends** that the grid be generated before the survey is undertaken, and an algorthim developed to utilize the survey time optimally, including more travelling during the day which could increae the total number of tows which can be made during the survey.

2.8 Influence of migration (within area)

Evidence of temporal change in the population, which equates to changes during the survey, may influence how the data are collected. Migration of the stock is the most likely temporal issue, and this applies to any survey, whether by trawl or acoustic methods. The following approach is taken from Simmonds and MacLennan (2005) and rewritten in the context of trawl tows, rather than acoustic transects.

The movements of fish can be conceived as having two components, random motion and migration. In the former case, the fish swim at a particular speed in directions that change randomly with time. In the latter case, the fish swim consistently in the same direction. Simmonds et al. (2002) used a fine-scale model of North Sea herring schools, based on a spatial grid covering 120,000 km^2 with a node spacing of 40 m, to study the effect of fish movement on the results of simulated surveys. They found that reasonable amounts of random motion were unimportant to estimates of abundance or variance, but the effect of migration even at a modest speed could not be ignored. It is well known that some fish, such as Pacific sardine and related small pelagic species, migrate over long distances on an annual cycle. One factor in the survey design is the timing in relation to the migration cycle. The survey design should ensure that the surveyed area includes the entire stock. However, even if this condition is met, migration of the stock within the surveyed area can bias the abundance estimate. The extent of the bias depends on the direction of the migration in relation to the vessel motion.

Suppose the fish are migrating at speed v_f, and v_s is the speed at which the survey progresses in the direction of migration. If v_s is positive, this means that the fish tend to follow the vessel as it travels through the area. If the tows were drawn on a map whose frame of reference moved with the fish, the tows would be closer together than those on the geostationary map. Thus, the effective area applicable to the analysis is less than the actual area surveyed. The observed densities are unbiased, but since the abundance is the mean density multiplied by the effective area, the estimate of abundance **Error! Objects cannot be created from editing field codes.** is biased. The expected value of **Error! Objects cannot be created from editing field codes.** is:

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where Q is true abundance. If v_s is negative, this means that the fish tend to pass the vessel as it travels through the area and the bias is negative. Note that v_s is much smaller than the cruising speed of the vessel when the direction of vessel motion from tow to tow is generally perpendicular to the migration. For example, if the cruising speed is 5 m s^{-1}, and the rate of progress along the direction is reduced to 1/10 as the vessel zig-zags between tows and stops to fish, then the survey progresses at $v_s = 0.5$ m s^{-1}, a value which could well be comparable with v_f. Harden Jones (1968) suggests that herring are capable of migration speeds up to 0.6 m s^{-1}. The swimming capability of fish depends on their size, but adult herring and mackerel can sustain speeds around 1.0 m s^{-1} for long periods (He and Wardle 1988; Lockwood 1989).

The bias is greatly reduced if the survey can be run alternately with and against the migration, in which case:

and v_s is now nearer the cruising speed of the vessel. Taking the case as $v_f = 1$ m s^{-1} and $v_s = 5$ m s^{-1}, the bias is always an underestimate of 4%. In practice, the direction of the survey may be decided by other factors such as the coastline or depth contours. If the progress of the survey must be perpendicular to the migration, the surveyed area could be covered twice, in opposite directions, with the outward and return tows interleaved. Thus, the survey begins and ends at the same place. This need not be too costly in ship time if the place concerned is the home port. As regards the analysis, the best plan is to treat the outward and return sections as if they were replicate surveys, and to estimate the abundance as the average of the two results.

In the case of WCVI survey, it is likely that the only plausible approach is a single direction survey, either from north to south or vice versa because the vessel port of origin is east of Vancouver Island. In this case, v_s can be estimated from the survey timing. If v_f could be estimated, the potential bias could be calculated. The Panel **recommends** investigating the potential size of this effect for the WCVI survey.

2.9 Raising from tow to stratum density

The current approach assumes that the density estimates for 0-15 m are proportional to the area density. For computation of absolute biomass, the current approach for raising the observed trawl volume densities to the core area uses a standardized vertical extent of 30 m (e.g., Flostrand et al. 2011). The Panel **recommends** that this would benefit from further evaluation, and the vertical extent of sardine should be estimated. A number of approaches could be used, such as independent estimation, possibly using acoustics (see also Section 2.2).

The current method for raising area biomass density to the area of the strata is appropriate. Currently, the density estimates from the trawl are combined to calculate a global estimate of density, which is then raised to the abundance for the whole area. In contrast, currently the biological samples are treated so that each fish sampled has equal weight. The analyses presented show that there are annually repeatable trends in fish size with latitude (e.g., Figure 3), and indications of differences in sardine density, both latitudinally and onshore-offshore (Table 1). Combining all biological samples in the current way removes the influence of the catch rate, because the data are not weighted by the size of tows. An alternative is to raise the length and age distributions by the trawl-related density. The analysis carried out during the meeting suggests the differences are small (Figure 3), but weighting by tow size is nevertheless the preferred approach although care still needs to be taken when a small length-frequency sample is taken from a very large tow.

2.10 Estimating variance

Given the stratified random survey design, sample variance by stratum is the appropriate method to estimate the precision of the estimate of mean density. Bootstrap methods applied to tow data (including biological data) could be used to estimate overall sampling precision. If the design was to be replaced by a different tow allocation regime (e.g., systematic), a geostatistical estimator would be appropriate.

2.11 Abundance estimation

The estimate of total abundance for the core area is the sum of the estimates of total biomass for the individual strata, computed by multiplying the estimated stratum density by the stratum area. The sampling variance for the estimate of abundance is the sum of the sampling variances by stratum. The survey length-frequency should be the sum of the stratum-specific length-frequencies, where the stratum-specific length-frequencies are the sampled length-frequencies weighted by the estimates of density by tow. Given small sample sizes, the Panel **recommends** that the conditional age-at-length data for the survey be computed from the raw age-length data available.

2.12 Inclusion in future stock assessments

Several types of information (time series) calculated from the data collected during the WCVI survey could be included in the stock assessment for Pacific sardine: (a) the index of abundance; (b) the survey length-composition data; and (c) the survey conditional age-at-length data.

The index of abundance could be included in the assessment as an estimate of absolute abundance if it could be argued that catchability for at least one age- or length-class was known. However, given the nature of the survey area (i.e., the core area), any absolute abundance estimate would be primarily compromised by being limited to Canada waters, which do not contain the whole stock. In addition, there are other issues: (a) the survey does not extend far offshore and sufficiently far to the north to ensure the entire stock is covered; (b) uncertainty about the extrapolation of density estimates from the 15 m trawl samples to deeper in the water column; and (c) the inherent implications of bias by surveying north to south with a north-south migration. Based on all these aspects, the Panel did not see sufficient information to justify such an assumption at present and hence, **agreed** that the best use of biomass estimates from the survey would be as the basis for a relative index of abundance (i.e., catchability, q, estimated). The Panel noted that the index from the core area could be considered as an index of abundance, as long as the factors that relate survey-selected biomass to the expected index for the core area remain constant over time. However, time-varying proportions of potential sardine habitat (see Sections 2.4 and 2.7) suggest that this assumption is unlikely to be valid. The Panel identified two ways in which the problem of time-varying proportions of the population in the core area might be overcome: (a) the survey index can be assumed to be linearly related to survey-selected biomass, and the survey CVs increased to reflect among-year variability in the proportion of the survey-selected biomass in the core area; or (b) survey catchability can be allowed to vary over time, but be related to an independent measure of the proportion of the survey-selected biomass in the core area when the survey is conducted (e.g., be based on the output of a model of potential sardine habitat or sardine migration). The first of these options might effectively lead to the survey data being ignored within the assessment model, given the proportion migrating into Canadian waters may be highly variable. The Panel sees the second option as more desirable and **recommends** that work be undertaken to identify whether and how the model of potential sardine habitat can be used to provide an annual measure of relative survey catchability.

The surveys cover the more northerly component of the population, which is expected to include the largest and oldest sardine. As such, the Panel **recommends** that the survey be assumed to have an asymptotic (e.g., logistic) selectivity pattern, with an asymptote reflecting the maximum value at older ages. Size of sardine is observed to vary throughout the area. The Canada purse-seine fishery and the survey do not take place at exactly the same locations (the fishery tends to occur closer inshore). In this context, the Panel **recommends** that the fishery and survey selectivity patterns should be assumed to differ unless it can be shown otherwise, e.g., by comparing age and length distributions.

There are two approaches for including the available historical data from the WCVI surveys into the assessment: (a) start with the data for 2010 onwards and evaluate whether the model is able to mimic those data and, if so, consider including the data for 2006-09 as well, and (b) attempt to fit the entire time-series and if the model unable to do this, restrict the data to those for 2010 onwards. The Panel considers that data prior to 2006 may not be consistent (see above) and ultimately, not useful presently for conducting formal stock assessments. The advantage of option (a) is that it attempts to fit the 'best' data first. In contrast, option (b) focuses on a longer time series and reduces the probability of the model mimicking the data spuriously. An additional advantage of option (b) is that the Panel does not expect that the differences in survey design for the 2006-09 surveys from that for the 2010 and 2011 surveys will lead to marked biases in the estimates of biomass. Irrespective of which option is chosen, the assessment report needs to summarize the changes in survey design and protocol over time and explicitly discuss the consistency of the time series. Given that only the 2011 survey was conducted using what the Panel considers the 'best' design, the Panel **strongly recommends** that surveys be conducted during 2012 and 2013 to ensure that at least four years of comparable data are available if an assessment is conducted in 2013 (the next full assessment is currently scheduled for 2014).

The Panel **recommends** that the following tasks should be undertaken prior to inclusion of the data from WCVI survey in the stock assessment: (a) the sensitivity of the estimates of biomass should be explored to omitting very short and long tows, and extreme vessel speeds; (b) geostatistical methods should be applied to estimate abundance (only for the 2008 and 2009 surveys); and (c) measures of relative survey q for the WCVI area should be computed using the model of potential habitat.

The Panel **recommends** that either a spatial model be developed or Stock Synthesis be modified so that it is possible to fit simultaneously to two indices of abundance (aerial and WCVI surveys), which cover discrete areas such that the datum fitted is a weighted sum of each index (where the weighting factor is an estimated parameter). This feature will allow some of the impacts of migration to be accounted for (cancelled out). The Panel also **recommends** that the results of model fits be examined to assess whether the ageclasses predicted to be covered by the aerial and WCVI surveys are realistic.

3. AREAS OF DISAGREEMENT REGARDING PANEL RECOMMENDATIONS

There were no major areas of disagreement among Panel members nor between the proponents and the Panel.

4. UNRESOLVED PROBLEMS AND MAJOR UNCERTAINTIES

A) The major constraint on using the data from the survey in the assessment for Pacific sardine is how to determine the relative proportion of the total population biomass in the core area. There is evidence that this proportion varies among years. However, empirical estimates of the proportion of the total population in the survey area are not available.

B) The survey design (as well as the objective of the survey) has changed over time. Consequently, is not clear which estimates can be considered to be comparable (the effect of time-varying migration notwithstanding). The Panel **agrees** that the biomass estimates from the 2005 survey (which was conducted primarily to compare day and night tows and employed a different vessel than the remaining surveys) should not be included in the assessment. The data for the years 1999-2004 and 2006-11 are unlikely to be comparable owing to the tows being conducted primarily during the day before 2005 and at night from 2006 onwards. Further, approximately a third of the tows before 2005 were deep tows. The 2011 (and to a lesser extent 2010) survey was based on a random stratified design, but the surveys for 2006, 2008, and 2009 were based on transects.

5. COMMENTS BY THE CPSAS AND CPSMT REPESENTATIVES

The CPSAS representative was glad to see the Canada sardine trawl survey reviewed. The Panel and the representatives from Canada DFO did a thorough job evaluating the data and survey methods. The CPSAS representative and others in the sardine fishery have long felt that a large component of the sardine population inhabits Canada waters for much of the year. Fish size in the Canada fishery has usually been larger than that of the fish found in the Pacific Northwest fishery. A more comprehensive understanding of the Canada portion of the population and biology is necessary to accurately measure the entire sardine population off the West Coast, and establish appropriate harvest management practices. This review is an important step forward.

The CPSMT representative recognizes the survey team and review panel for their extensive preparation and hard work in conducting a productive and thorough review. The CPSMT representative noted several potential survey improvements and recommendations for inclusion of survey data in sardine assessment models. These include 1) continued use of the area strata scheme developed in 2011, 2) better-defined sampling protocols, and 3) developing habitat-abundance models for a time-varying catchability coefficient to reflect changing migratory patterns. The CPSMT representative also supported acoustic survey – swept-area trawl comparisons to validate WCVI survey results. The recommended use of the WCVI survey in future stock assessments with data on the northernmost component of the stock is a positive step in further informing northeast Pacific sardine stock status and management.

6. RECOMMENDATIONS FOR FUTURE RESEARCH AND DATA COLLECTION

The recommendations arising from the review follow (in priority order: H-high; M-medium; L-low; *-N/A).

1) Surveys should be conducted annually to ensure a time-series of comparable estimates is developed as quickly as possible. It is particularly important that surveys are conducted during 2012 and 2013 to ensure that at least four years of comparable data are available if an assessment is conducted in 2013. If it becomes necessary to conduct surveys every other year (rather than annually), it would be preferable to conduct the survey during a year in which a full stock assessment is conducted (H).
2) The following tasks should be undertaken prior to inclusion of the data from WCVI survey in the stock assessment: (a) the impact of ignoring short and long tows on the estimates of biomass should be explored, (b) geostatistical methods should be applied to estimate abundance (only for the 2008 and 2009 surveys), and (c) measures of relative survey q for the WCVI area should be computed using the model of potential habitat (H).
3) Consideration should be given to conducting an acoustic-trawl survey by towing at night and running acoustic transects during the day (H).
4) Trawl surveys should be conducted only at night (H).
5) Establish a trawl manual that describes how the gear is standardized, including trawl drawings and rigging that can be easily interpreted by users. This should be 'living' document, which is updated as needed. Develop and document standard routines for trawl operation that include better utilization of the trawl sonar output for standardizing and quality ensuring each tow (H).
6) Protocols for tow duration and speed should be established in advance of the survey (H).
7) Do not use GPS tow speed to compute tow length. Instead, use the start and stop points. If possible, ocean current velocities should be recorded for later impact studies (H).
8) The survey grid should be generated before the survey is undertaken and an algorthim developed to utilize the time optimally, including the use of longer intertow distances during the day (H).

9) For future surveys, create a larger number of potential tow locations so that the number of randomly drawn tows will represent a smaller percentage of possible tow locations (and more a random selection) (H).
10) The conditional age-at-length data for the survey should be computed from the raw age-length data points (without weighting), but the length-frequency data should be scaled to tow density, used to compute stratum length-frequencies and these summed to obtain the length-frequency for the entire survey (H).
11) Extend the USA habitat model northward to the Alaska border and use this model to provide a measure of the inter-annual component of relative survey catchability (H).
12) The WCVI survey should be assumed to have an asymptotic (e.g. logistic) selectivity pattern (H).
13) The Canadian fishery and WCVI survey selectivity patterns should be assumed to differ unless it can be shown otherwise (H).
14) The results of model fits should be examined to assess whether the age-classes predicted to be covered by the aerial and WCVI surveys are biologically plausible (H)
15) Evaluate the possibility of using trawl opening and closing devices in case trawling at various depths become necessary (M).
16) Investigate the potential magnitude of migration on survey bias (M).
17) Investigate the assumption of a standardized vertical extent of 30m (M).
18) Develop a process for measuring volume sampled (M).
19) Investigate the impact of variation in the depth of sardine. Monitor the depth distribution of sardine (i.e. using acoustics) and consider changing the depth profile of the trawls if this changes (M).
20) Develop a modeling framework which can address having data for two subsets of the total stock area (aerial and WCVI surveys), along with the consequences of time-varying migration. For example, (a) Stock Synthesis could be modified so that it is possible to fit simultaneously to two indices of abundance which cover discrete areas such that the datum fitted is a weighted sum of each index, or (b) a two-area model which explicitly includes areas could be developed (M).
21) Carry out avoidance studies to assess the potential impact of fish behaviour on the survey outcome. Over the short term, this would include comparing vertical profiles from vessel acoustics and the trawl sonar. Over the long term, more advanced studies, e.g. as done by the CPS acoustic-trawl survey team would be useful (L).
22) Should survey vessels change in the future, the impact of changes in survey catchability should be evaluated and monitored regularly, ideally using some form of calibration experiment. (*)
23) Compare daytime acoustic biomass estimates with trawl-based estimates taken at the same time. If this proves to be impractical, then compare daytime acoustic estimates with trawl estimates taken the previous night. (*)

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Table 1. Estimates of biomass and associated with sampling CVs using unstratified and stratified estimators.

(a) Estimates by stratum (estimates with CVs in parenthesis)

Stratum	Area	2006		2008		2009		2010		2011	
		N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
Ae	2582.0	7	527.5 (0.87)	7	0.0 (2.63)	17	464.4 (1.42)	9	267.4 (2.70)	12	412.4 (3.29)
Aw	1924.7	2	800.1 (1.41)	8	14.8 (2.49)	2	0.0	2	0.1 (1.41)	6	506.8 (1.28)
Be	2246.2	15	1817.7 (1.13)	6	304.6 (1.42)	22	584.6 (2.24)	10	489.5 (2.19)	9	455.0 (1.05)
Bw	1985.3	4	396.5 (1.94)	9	48.7 (3.00)	8	0.0	9	2.5 (1.21)	8	391.9 (2.46)
Ce	3378.5	10	407.2 (1.38)	15	612.6 (1.27)	28	737.4 (1.56)	18	186.8 (1.85)	17	504.5 (1.34)
Cw	2150.2	0		8	663.0 (1.07)	9	0.7 (2.78)	5	54.5 (1.43)	6	0.0
De	1336.2	4	249.0 (1.94)	3	21.1 (1.25)	8	12.1 (1.85)	1	0.0	6	31.2 (2.42)
Dw	1136.9	2	60.2 (0.01)	2	483.8 (1.20)	1	0.0	3	4.9 (1.73)	4	1.8 (2.00)

(b) Total abundance for the core area

Year	**Unstratified**	**Stratified**
2006	874.1 (0.24)	570.4 (0.24)
2008	280.4 (0.26)	291.7 (0.19)
2009	460.5 (0.22)	299.9 (0.21)
2010	157.0 (0.43)	152.3 (0.40)
2011	352.8 (0.27)	333.9 (0.26)

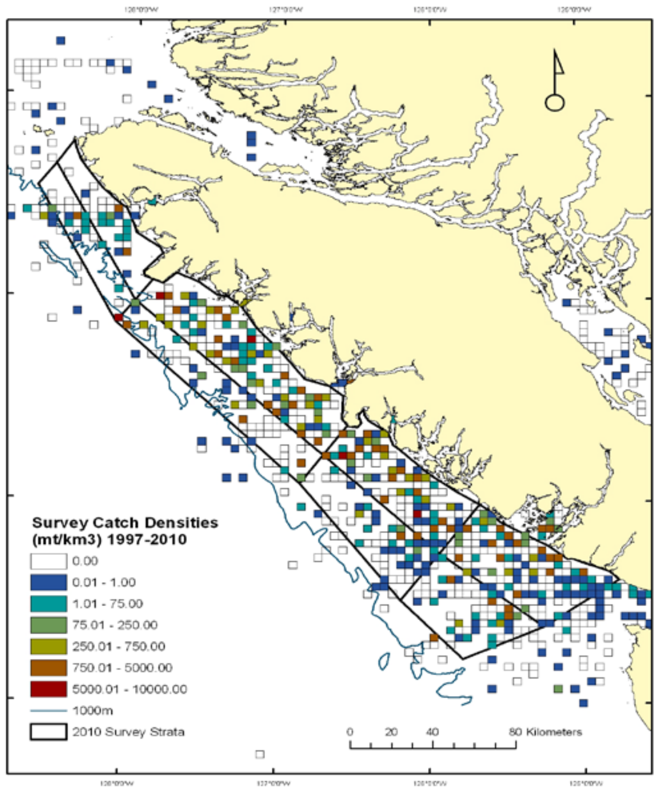


Figure 1. Mean sardine 1997-2010 trawl survey catch densities based on 4x4km sized grid cells and boundaries defining the core WCVI survey region applied in 2011.

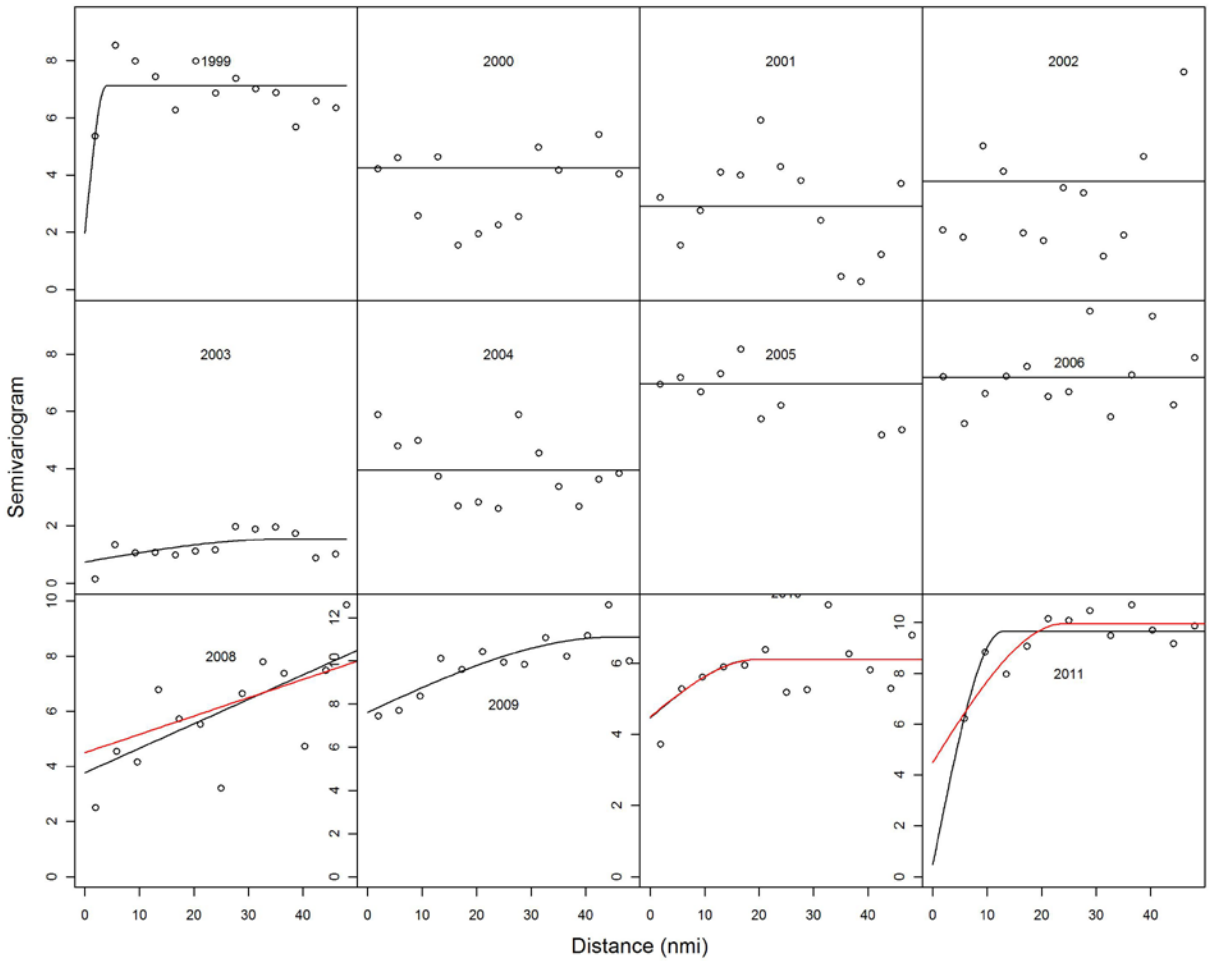


Figure 2. Empirical variograms for the surveys (dotted) and fitted parametric spherical variograms (lines).

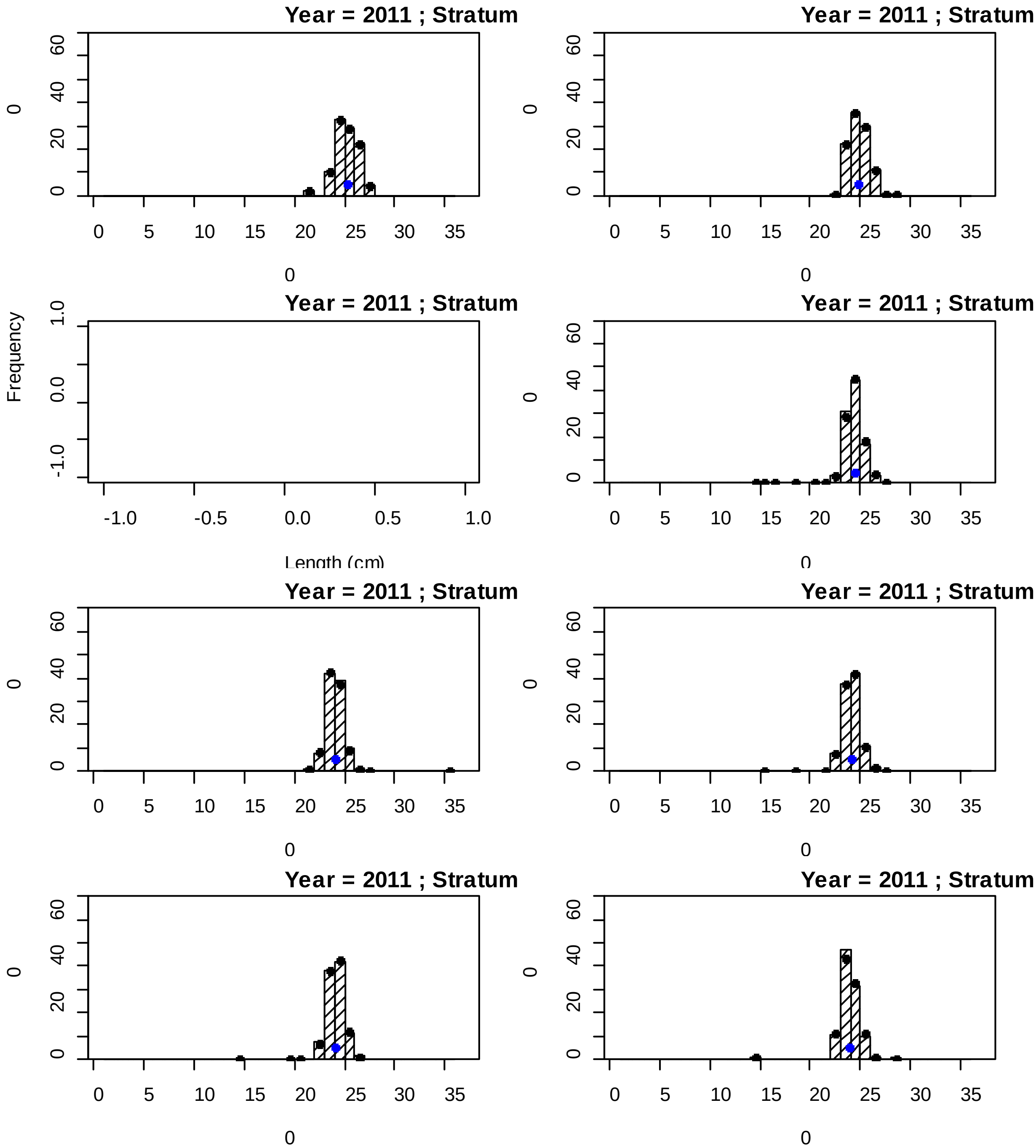


Figure 3. Length-frequencies for the 2011 survey. Results are shown when each fish length is given equal weight when constructing the length-frequency (bars; mean red dot), and in which the tow-specific length-frequencies are weighted by tow density (black dots; mean blue dot).

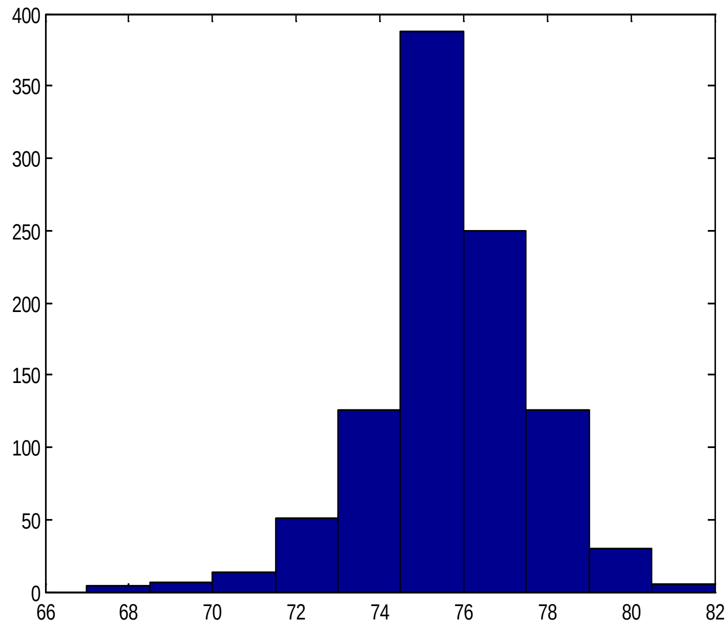
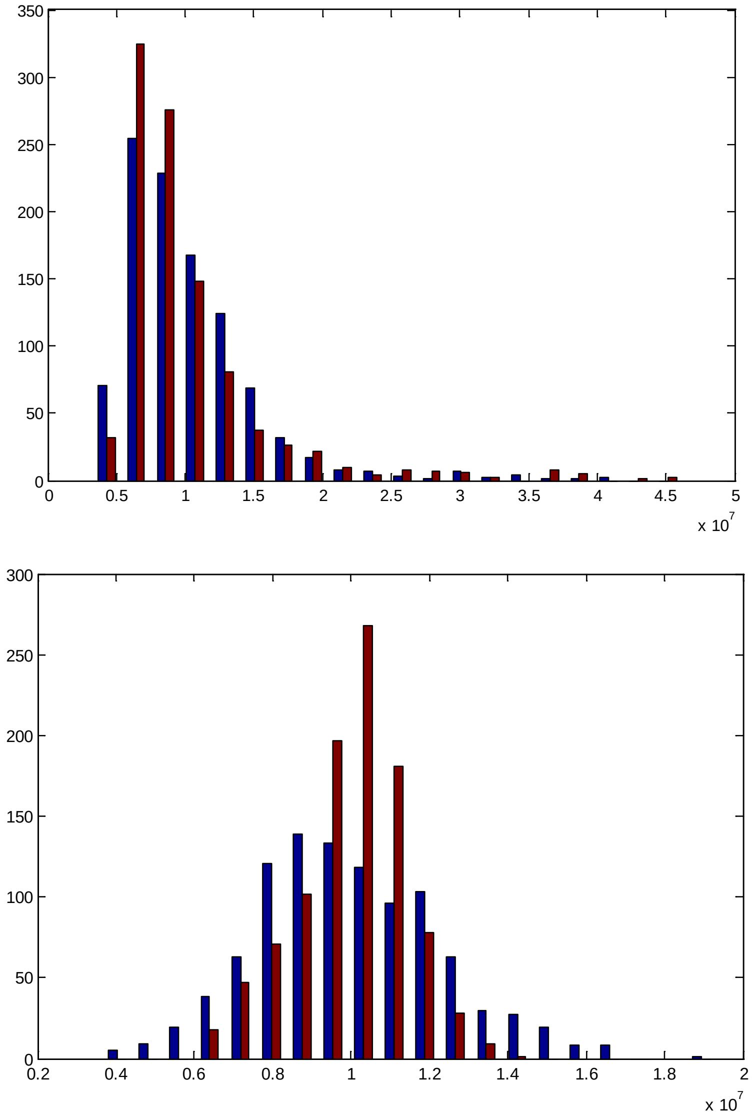


Figure 4. Number of randomly located tows in a fixed time with the minimum track obtained using the travelling salesman algorithm. (9 days with a survey speed of 10 knots and trawling time of 1.5 hours in a 14,400 N.mi^2 area) This compares with a systematic grid of 64 tows in the same time period.



.Figure 5. Frequency distribution of estimates of total abundance for a systematic survey design (red) and a random survey design (blue) for: a) a high variance, low correlation surface (upper panel); and b) a lower variance, but more correlated surface (lower panel).

Appendix 1: List of Participants

Methodology Review Panel Members:
André Punt (Chair), Scientific and Statistical Committee (SSC), University of Washington
Ray Conser, SSC, NMFS, Southwest Fisheries Science Center
Olav Rune Godø, Center for Independent Experts (CIE)
John Simmonds, Center for Independent Experts (CIE)

Pacific Fishery Management Council (Council) Representatives:
Kirk Lynn, Coastal Pelagic Species Management Team (CPSMT)
Mike Okoniewski, Coastal Pelagic Species Advisory Subpanel (CPSAS)
Kerry Griffin, Council Staff

Technical Team:
Linnea Flostrand, DFO, Canada
Jake Schweigert, DFO, Canada
Paul Crone, NMFS, SWFSC
Kevin Hill, NMFS, SWFSC

Others in Attendance
David Demer, NMFS, SWFSC
Emmanis Dorval, NMFS, SWFSC
Kristen Koch, NMFS, SWFSC
Nancy Lo, NMFS, SWFSC
Josh Lindsay, NMFS, SWFSC
Sarah Shoffler, NMFS, SWFSC
Dale Sweetnam, NMFS, SWFSC
Russ Vetter, NMFS, SWFSC
Cisco Werner, NMFS, SWFSC
Juan Zwolinski, NMFS, SWFSC

Appendix 2: Panel Biographical Summaries

André E. Punt is a Professor of Aquatic and Fishery Sciences at the University of Washington. He received his B.Sc, M.Sc and Ph.D. in Applied Mathematics at the University of Cape Town. Before joining the University of Washington, Dr Punt was a Principal Research Scientist with the CSIRO Division of Marine and Atmospheric Research. His research interests include the development and application of fisheries stock assessment techniques, bioeconomic modelling, and the evaluation of the performance of stock assessment methods and harvest control rules using the Management Strategy Evaluation approach. He has published over 200 papers in the peer-reviewed literature, along with over 400 technical reports. Dr Punt is currently a member of the Scientific and Statistical Committee of the Pacific Fishery Management Council, the Crab Plan Team of the North Pacific Fishery Management Council, and the Scientific Committee of the International Whaling Commission. He is the Associate Editor of the journals *Fisheries Research*, *Population Ecology*, and the *Journal of Applied Ecology*.

Ray Conser is a senior stock assessment scientist with NOAA Fisheries in La Jolla, CA. He received his B.Sc and M.Sc in Applied Mathematics, followed by a Ph.D. in Quantitative Fisheries at the University of Washington. Dr. Conser is a member of the Scientific and Statistical Committee of the Pacific Fishery Management Council. He has extensive experience conducting stock assessments on tunas, small pelagics, groundfish, and invertebrates in support of the U.S. Fishery Management Councils as well as international fishery management organizations (e.g. International Commission for the Conservation of Atlantic Tunas (ICCAT) and International Council for Exploration of the Sea (ICES) in the Atlantic Ocean and the International Scientific Committee (ISC) in the Pacific Ocean). He has chaired numerous stock assessment review panels and stock assessment working groups, and has served as the USA representative on international scientific advisory bodies. His research interests include the development and enhancement of stock assessment methods, fishery management control rules, and biological reference points.

Olav Rune Godø is a senior scientist at Institute of Marine Research. He received his Cand. real. in fisheries biology and his Ph.D. in marine survey methods, both from the University of Bergen. He has worked in the Demersal Fish Department, served as Section Head in the Pelagic Fish Department before building a new Survey Methods Department, all duties at the Institute of Marine Research. Presently he is Chair of a new IMR initiative in marine ecosystem acoustics and Norwegian representative of CCAMLR scientific committee. His research interests include trawl-acoustic survey methods, fish behavior, biophysical interaction, and fisheries-induced evolutionary changes. He has published about 70 papers in peer-reviewed journals, several book chapters, and numerous technical papers and reports. Dr Godø has served on the board of four research programs of the Research Council of Norway, has been a member of the scientific steering committee of the Census of Marine Life, and has been a member of a SCORE WG on observation methods. He has also been a member of several ICES working groups.

John Simmonds is an expert in fisheries surveys, and their use in the assessment of pelagic stocks and in fish stock management. His background is that of a senior fisheries scientist, Aberdeen, UK. Currently, he works under short term contract chairing the development of fisheries management plans for the European Commission Scientific committee, STECF. Before this, he worked in fisheries research for 39 years, mostly at FRS Marine Laboratory Aberdeen in Scotland and for the last two years at European Research Centre JRC, Ispra Italy. He has worked with acoustic and trawl surveys for pelagic species for more than 30 years and carried out stock assessments involving acoustic-trawl, trawl and egg surveys for more than 15 years. He is the author of a books on Geostatistics (2000) and Fisheries Acoustics (1991 and 2nd Edition 2005), and has been responsible for developing approaches for combining acoustic-trawl, trawl and ichthyoplankton surveys in assessments for North Sea herring. He has worked on absolute assessments based on Total Annual Egg Production methods for North Eastern Atlantic mackerel, and has been involved in acoustic-trawl surveys for sardine and/or anchovy off Morocco, and in the Persian Gulf, the South China Sea, Ecuador and Peru. Since 1990, John has developed extensive experience of fish stock assessment and fisheries management, chairing among other groups the ICES herring survey planning group 1991-95, the ICES Fisheries Acoustics working group 1993-96, the ICES herring assessment working group 1998-2000, and the ICES study group on Management Strategies from 2004-2009. He currently chairs the STECF group that prepares evaluations of historic performance of management plans and the impact assessments for new multi-annual fisheries management plans.

Appendix 3: Primary Documents Reviewed

Documents prepared for the meeting

Flostrand, L., Schweigert, J. and V. Hodes. 2012. Canadian west coast of Vancouver Island summer sardine research trawl surveys, 1999-2011, sardine catch density and length, sex and age data sets.

Appendix 4: Further Information Regarding Net Width Measurements

Jake Schweigert and Sandy McFarlane

1) A "third eye" sensor is attached to the headrope for every set. The sensor sweep can be set from 180-360 degrees and is generally run at 180.
2) Measurements for mouth width and height are taken directly from the monitor. The monitor is set it to a small grid (around 2-3 ft) and then used to measure both width and height. This is done a few times during each set and average measurements are recorded. The configuration of the net limits the basic mouth opening provided the net is fishing properly, e.g., if the height is greater the width will be slightly less.
3) The fishing master monitors the 3rd eye and ensures the mouth opening is proper. He can also tell if there may be a problem from the angle of the warps etc. If for any reason there is a tear in the mid or back sections of the net this would be observed and fixed on the retrieval. If it is a serious tear the set is scrubbed. However this rarely happens when surface trawling, unless you hit a tree.
4) The net mouth opening can change slightly depending on speed, tides etc. It is generally slightly oval in shape, the harder it is towed the more rectangular it becomes. Because of the limitations in net construction, changes in one dimension are generally compensated by changes in the other, and total mouth area is not changed to any great degree.
5) The only instrumentation is the 3rd eye, and it is easy to detect any problems. The net is observed on the monitor and a total blackout, to skipping pictures, etc, will indicate an instrumentation problem. Fishing gear failure can be seen on the monitor if, for instance, a "door" flips, or warps were hooked up wrong, one can tell immediately, also from the way the warps themselves are behaving. If the net is torn up, it is evident when the net is retrieved.

Agenda Item G.3.a
Attachment 6
Available on Council's Briefing Book Website and CD Only
November 2012

Northwest Aerial Sardine Survey

Sampling Results in 2012

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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. 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, and 2011 aerial sardine surveys were incorporated into the Pacific sardine stock assessment models that were used to set harvests for the 2010, 2011, and 2012 fishing years, respectively (Hill et al 2009, 2010, 2011).

This report describes work conducted in 2012 by NWSS off the coasts of Washington and Oregon, using the same methods that were applied in the aerial surveys conducted from 2009-2011 (Jagielo et al 2009; 2010; 2011). 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 (Appendix I).

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 delineated for the survey. The order of conducting the three replicate sets was chosen by randomly picking one set at a time without replacement. The first set chosen in 2012 was Set B, followed by Set C, and finally Set A. The starting and ending positions for these transects are given in the Field Operational Plan (Appendix I: Tables 1a-1c; pages 7-9).

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 also photo-documented for future evaluation. The spatial coverage of the survey design extended from the Canadian border in the north to the Oregon/California border in the south. 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. 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) (Appendix I: Tables 1a-1c; pages 7-9).

Two pilots participated in the 2012 survey; one operated a single engine airplane, and one operated a twin engine airplane (Appendix I; Adjunct 3b, page 36). The prevailing conceptual model of West Coast sardine movement holds that fish tend to move in a northward direction during summer. Thus, the transect sets were conducted as follows. Two survey pilots operated as a coordinated team. A "leap-frog" approach was taken such that southward progress was continually maintained. This approach enabled relatively rapid southward progress in order to avoid double counting of sardine schools, which were presumably travelling northward during the survey time period. It was acceptable to skip transects or portions of transects if conditions required it (e.g. if better observation conditions were available to the south of an area), but transects could not be "made up" once skipped during the sampling of a transect set.

Once begun, the goal was to cover the full number of transects in the set in as few days as possible, when conditions permitted. Transects were flown at the nominal survey altitude of 4,000 ft, and could be flown starting at either the east end or the west end. At the beginning of each potential survey day, the survey pilots conferred to jointly determine if conditions could permit safe and successful surveying that day. Factors taken into consideration included sea condition, the presence of cloud or fog cover, and other relevant factors as determined by the survey pilots. The goal was to conduct sampling on days when prevailing conditions could permit clear visibility of sardine schools on the ocean surface from an altitude of 4000 ft.

Each survey plane was again equipped with the same Aerial Imaging Solutions photogrammetric aerial digital camera mounting system and data acquisition system as used in the 2008-2011 work (Appendix I, page 20). 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 and a cross comparison between survey aircraft and photo-analysts, digital imagery of certain objects of known size (e.g. airplane hangars at the Astoria, OR airport) was collected at a series of altitudes ranging from 1000 ft. to 4000 ft. The observed vs. actual sizes of the objects were subsequently compared to evaluate photogrammetric error. In 2012, measurements were made by 7 photo-analysts (PA1-PA7), for calibration flights made by 2 survey pilots (SP1 and SP3). Average deviation was 12.0% for the two camera systems employed in the study. Deviations generally tended to increase with altitude, as expected.

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. Classification of transects according to readability criteria (described below) was also performed at this time.

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 by a team of resolvers, 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.

Transect Readability. Transects were classified using a three point scoring system to characterize the overall readability of the photographs used in the analysis. For each transect, all photos were reviewed and transects were assigned a single readability value of either: 1 (for few impediments to readability), 2 (for moderate impediments), or 3 (for substantial impediments). Specific conditions were also documented, which included: 1) cloud cover, 2) water turbidity, 3) sea-surface chop, and 4) excessive glare. Detailed comments were also recorded to further document transect-specific conditions.

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 (Appendix I: page 27). 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

Point Set Logistics

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. Five purse seine vessels participated in the 2012 survey. (Appendix I: Adjunct 3, page 36).

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 (Appendix I, page 37).

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 2012 (Table 2).

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 (Appendix I: page 30). 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 (Appendix I: page 29).

Biological Sampling. Species composition of the point sets and sardine biological parameters were determined from sampling the landings at the dock. Fishermen participating in the survey were instructed to keep the point set hauls in separate holds upon capture so the tonnage of each aerially photographed and measured haul could be determined separately upon landing. Samples were collected from the unsorted catch while being pumped from the vessels. Fish were taken systematically at the start, middle, and end of each delivery as it was pumped. The three samples were then combined and a random subsample of fish was taken from the pooled sample. Length, weight, sex, and maturity data were collected for each sampled fish. Sardine weights were taken using an electronic scale accurate to 0.5 gm; sardine lengths were taken using a millimeter length strip attached to a measuring board. Standard length was determined by measuring from sardine snout to the last vertebrae. Sardine maturity was documented by referencing maturity codes (female- 4 point scale, male- 3 point scale) supplied by Beverly Macewicz NMFS, SWFSC (Appendix I; Table 3, page 12). Observations were recorded on the Biological Sampling Form (Appendix I: page 28).

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 II.

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 II). 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) Steps 1-4 are conducted separately for sampling strata 1 and 2.
6) Bootstrap estimates of biomass for strata 1 and 2 were summed to obtain total biomass.
7) The standard error (SE) was calculated from the stored bootstrap estimates of biomass (4e).
8) CV was calculated as $CV = SE/\hat{B}$.

Survey Results

I. Aerial Transect Sampling

Transect Coverage in 2012

The order of conducting the three planned replicate sets was chosen by randomly picking one set at a time without replacement. The first set chosen in 2012 was Set B, followed by Set C, and finally Set A. Transect sampling in 2012 was conducted as follows. All 41 of the planned Set B transects were flown; beginning with transect number 1 in the north (on July 31st) and ending on with transect number 26 in the south (on August 22nd) (Figure 1a-1g). Fish were observed on 25 of the 41 transects sampled. Sampling of Set C was also attempted in 2012; however, this set was not completed due to weather and time constraints. A total of 14 Set C transects were flown, beginning with transect number 4a in the north (on August 19th), and ending with transect number 11 in the south (on August 21st). Because transect Set C was incomplete, it was not analyzed for sardine school measurements. Set A was not sampled in 2012 due to time constraints.

In summary, we were successful in completing one full transect set (Set B) for biomass estimation in 2012. Our estimate of biomass was derived from fish observed in two sampling strata: 1) the northern sampling stratum (transects 1 through 16; n = 31), and 2) the southern sampling stratum (transects 17 through 26; n = 10).

Transect Readability

Readability classifications for Set B transects 1- 26 are given in Table 1. Of the 41 transects sampled, impediments to readability were judged to be minor for 9 transects, moderate for 18 transects, and substantial for 14 transects. Among the major impediments to readability, sea-surface chop was a factor on 7 transects, clouds were a factor on 8 transects, turbidity was a factor on 11 transects, and glare was a factor on 13 transects.

Transect School Measurements

Two sets of measurements of individual sardine schools were completed independently by photo- analysts for all 25 of the Set B transects where sardine schools were observed in 2012.

Schools were not observed on 16 transects in 2012. A comparison of frequency histograms of individual school size measurements (surface area in m^2) are given in Figure 2 for sampling from 2009-2012. The shape of the distribution of school sizes in 2012 was similar to that observed in 2010 and 2011. The geographic (spatial) distribution of schools observed on transects in 2012 is shown in Figures 3a-3c.

School Detection and Measurement - Quality Assurance/Quality Control (QA/QC)
An integral part of our aerial survey QA/QC protocol consists of a detailed (school-by-school) comparison of the two sets of sardine school measurements that were obtained independently by two separate photo-analysts. We refer to this process as "transect resolution". In 2012 we examined between-reader differences in school detection and measurement for all 25 transects where fish were observed. The transect resolution process resulted in a final count of 4468 schools For Reading 1, and 4464 schools for Reading 2. For Reading 1, 822 schools were added (schools missed), and 421 schools were deleted (67 double counted; 354 deemed "not a school"). For Reading 2, 404 schools were added (schools missed), and 375 schools were deleted (74 double counted; 301 deemed "not a school").

Transect School Species Observations
Other than sardine, anchovy were the only other schooling species reported by the spotter pilots on flight logs in 2012. Only one occurrence of anchovy was recorded in 2012; anchovy schools were observed in N. Washington, in the surf, east of transect 3 (Figure 4).

II. Point Set Sampling

Point Set Coverage
At-sea sampling in 2012 resulted in the landing of 14 point sets deemed acceptable for the surface area-biomass analysis, collected between August 23rd and September 13th (Table 2a; Table 3). An additional 9 point sets were conducted but were not deemed acceptable for the surface area-biomass analysis. Reasons for an unacceptable evaluation included: 1) less than 90% of the school was captured (7 point sets), and 2) a legible photo of the school was not available (2 point sets). The location of acceptable point sets, shown with respect to the locations of sardine schools observed on transects in 2012, is given in Figure 5 (left panel). Point sets conducted in 2012 ranged from 46° 48.8′ N in the north, to 45º 58.5′ in the south and were limited in spatial coverage compared to fish school locations on the transects, which ranged from 47° 15.2′ in the north, to 43° 15.0′ in the south. By comparison, the location of biological samples taken from the fishery by NWSS in 2012 were more widely distributed, and ranged from 47° 11.1′ N in the north to 45° 54.4′ N in the south (Figure 5; right panel). The set of vessels sampled for fishery samples by NWSS in 2012 is essentially the same set of vessels used to conduct the point sets. A comparison of point set locations from 2009-2012 is given in Figure 6. A summary of additional landings made by NWSS in 2012 is given in Table 2b.

Point Set School Characteristics
Among all point sets conducted, ocean depth ranged from 33 to 73 fm and ocean temperatures varied from 55 to 62 degrees F; vertically, schools ranged from approximately 2 to 12 fm from the surface and averaged approximately 4 fm in height (Table 3). Point set species composition averaged 92.4 % sardine; Pacific mackerel dominated the remainder of the landings. The

distribution of maturity stage for female and male sardine is shown in Figure 7. Stage 2 (intermediate) maturity was most prominent for both sexes, followed by Stage 1 (immature). The distribution of weight (g) for female and male sardine is shown in Figure 8. Female sardine averaged 142.2 g and males averaged 136.0 g.

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 9; point sets collected in 2012 are shown by open black squares, for comparison with the other years. Fits of the MM model to 1) all of the data from 2008-2012 (solid black line) and 2) only the 2012 data (dashed black line) are shown in Figure 10.

III. Quantities for Input to the Pacific Sardine Stock Assessment

Weighted Length Composition

Vectors of weighted length frequency (sexes combined) were derived for input to the sardine stock assessment model. The raw length frequency data were weighted by the landed point set weights. The length distribution observed in 2012 is shifted slightly to the left when compared to the distribution observed in 2011 (Figure 11).

In 2012, point set samples (conducted from 8/23/2012 – 9/13/2012) were temporally offset from the aerial transect samples (conducted from 7/31 to 8/22). By contrast, fishery samples were collected prior to, during, and after the aerial transect sampling period. Length frequencies appeared to be similar for the point set and fishery samples (Figure 12). The number of point set samples (n = 23; 1150 fish) was considerably less than the number of fishery samples collected during the transect sampling period (n = 51; 2546 fish).

Total Biomass

Sardine biomass was estimated for the area from Cape Flattery, WA to the Oregon-California border in 2012. The total number of transects possible (N) was 229 for the northern sampling stratum (transects 1 through 16; n = 31 transects), and 137 for the southern sampling stratum (transects 17 through 26; n = 10 transects). Estimates of total biomass and associated CVs were computed two ways: 1) by using the full set of point set data from 2008-2012 (n = 123) and 2) by using only the data from 2012 (n = 14). Using all point sets, biomass was 696,251 mt (CV = 0.38); using only 2012 point sets, biomass was 906,680 mt (CV = 0.46) (Table 4).

Discussion

Point set and transect sampling activities in 2012 were delayed due to a protracted fishery during August. Though our routine survey activities started later in 2012 compared to previous years, we used the extra time in August to obtain a thorough sampling of the sardine fishery landing into the port of Astoria, OR.

For point set sampling to be representative of fish schools sampled on transects, it should ideally match transect sampling both spatially and temporally. Neither of these conditions aligned fully in 2012. Temporally, point set sampling occurred after transect sampling. Spatially, point set sampling was sparse and did not cover the full coastwide range where schools were observed on transects in 2012. By comparison, the fishery samples collected by NWSS in 2012 (although limited in their southern extent) provided substantially greater temporal and spatial coverage of the survey area where fish were observed (Figure 5). Though not conclusive, the similarity of length frequency distributions between the point set and fishery data sets suggests similar biological characteristics of sardine throughout the sampling period overall.

Our survey effort in 2012 again placed more sampling effort in the area from Cape Flattery, WA to Newport OR; by contrast, transects were spaced at a wider interval in the area south of Newport to the California border. This distribution of effort turned out to be a good one; it allowed us to document the southward extent of schools for comparison with previous years, but also placed most of our effort where the most fish were observed -- in the north.

In 2012, we again put a priority on obtaining at least one good set of transects under the most favorable conditions possible, rather than trying to get three full sets completed quickly. We have found that observation conditions can change on a daily, and even hourly, basis. Thus, striving for the best conditions (i.e. when sardine schools are most visible at the ocean surface, and are available for aerial photographing) is critical for survey consistency.

Biomass estimates in 2012 were higher than those observed in 2011, but were still substantially lower than those observed in 2009. The large year-to-year fluctuations in our aerial survey biomass estimates are most likely more reflective of variable survey catchability, rather than local changes in standing stock.

Also, variability in the surface area – biomass relationship is an important factor to consider when using our survey method to estimate sardine biomass. It is clear that a certain amount of scatter in the relationship will always persist; simply because surface area is a poor proxy for volume (i.e. we are measuring dynamic, three dimensional features in only two dimensions). Our collective results from 2008-2012 support the notion that the school surface area – biomass relationship can vary substantially with school size, and the relationship appears to be curvilinear in log space, with biomass per unit surface area declining as school surface area increases. If annual point set sample sizes were large enough, it would be desirable to calculate biomass using this relationship on a year-specific basis. However, with five years of data in hand, we have found that the overall variability in the surface area – biomass relationship is high and the full five-year data set (with larger sample size) probably best captures the true relationship.

As we have gained more experience with this survey method, it has become apparent that monitoring the readability of transect photographs is critical. By giving immediate feedback to the pilots, and also by taking heed of the pilot's advice regarding conditions that they can observe (but may not always be evident on the photographs), we have become more selective about when to conduct transect sampling. Being more selective about acceptable survey conditions results in completing substantially fewer transects over the course of the survey season, but can potentially yield more representative sampling.

Finally, our experience in 2012 again confirmed that conducting repeat readings of all transect measurements is an important component of a rigorous QA/QC protocol for this survey method.

We found that the process of reviewing the differences between readings improves the quality of the data and also provides valuable feedback to the photo-analysts to improve future performance.

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, Karen Lindsay, Jason Tobin, and Pat McCall) were essential to the project's success. The project also benefited greatly from the assistance of two student interns, Lyle Jennings and Amy Oppfelt, who also conducted photo analysis and aided with other project tasks.

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Figure 1a. Map of transect Set B, flown in 2012 (Transects 1 through 4a).

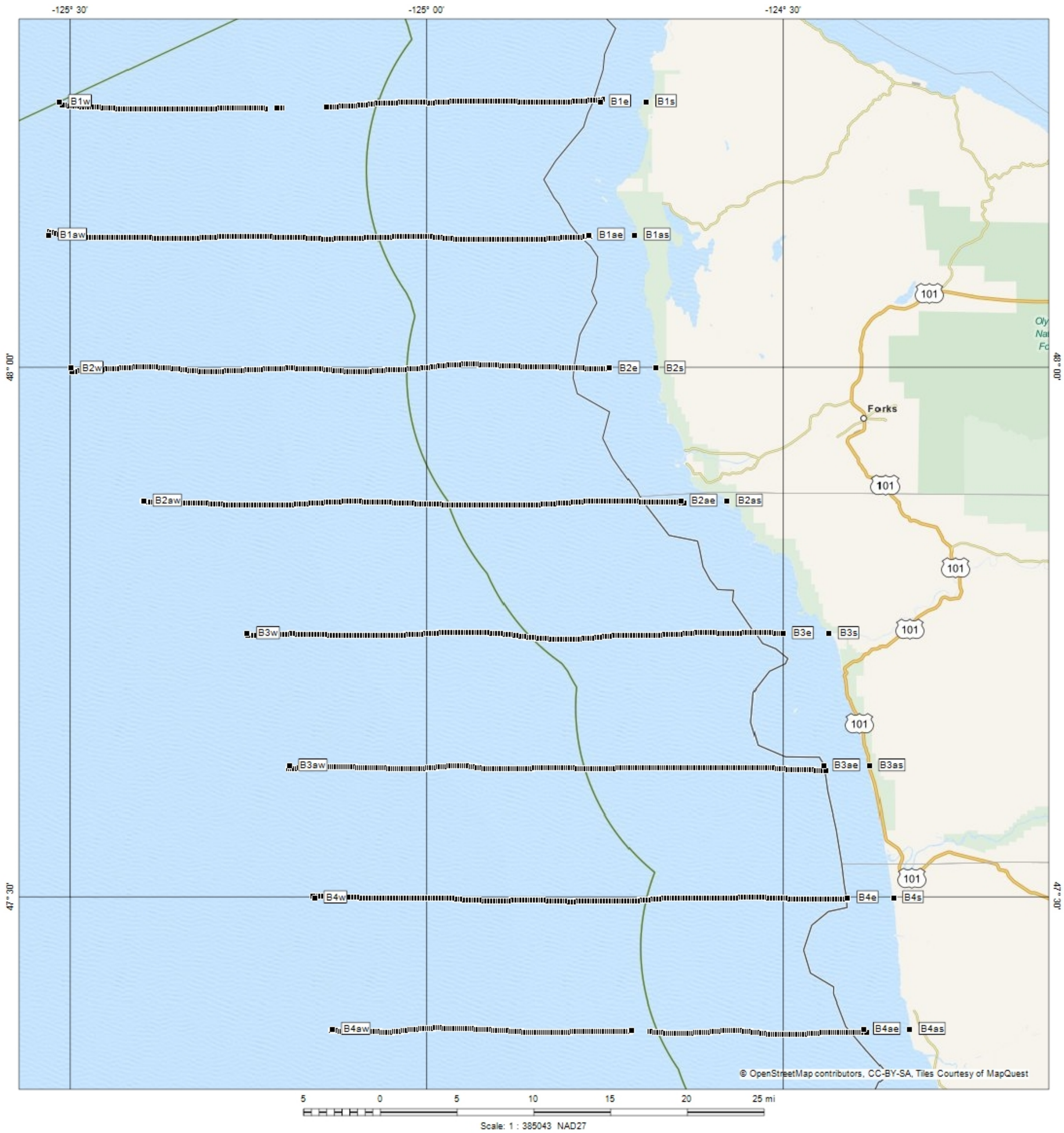


Figure 1b. Map of transect Set B, flown in 2012 (Transects 5 through 8a).

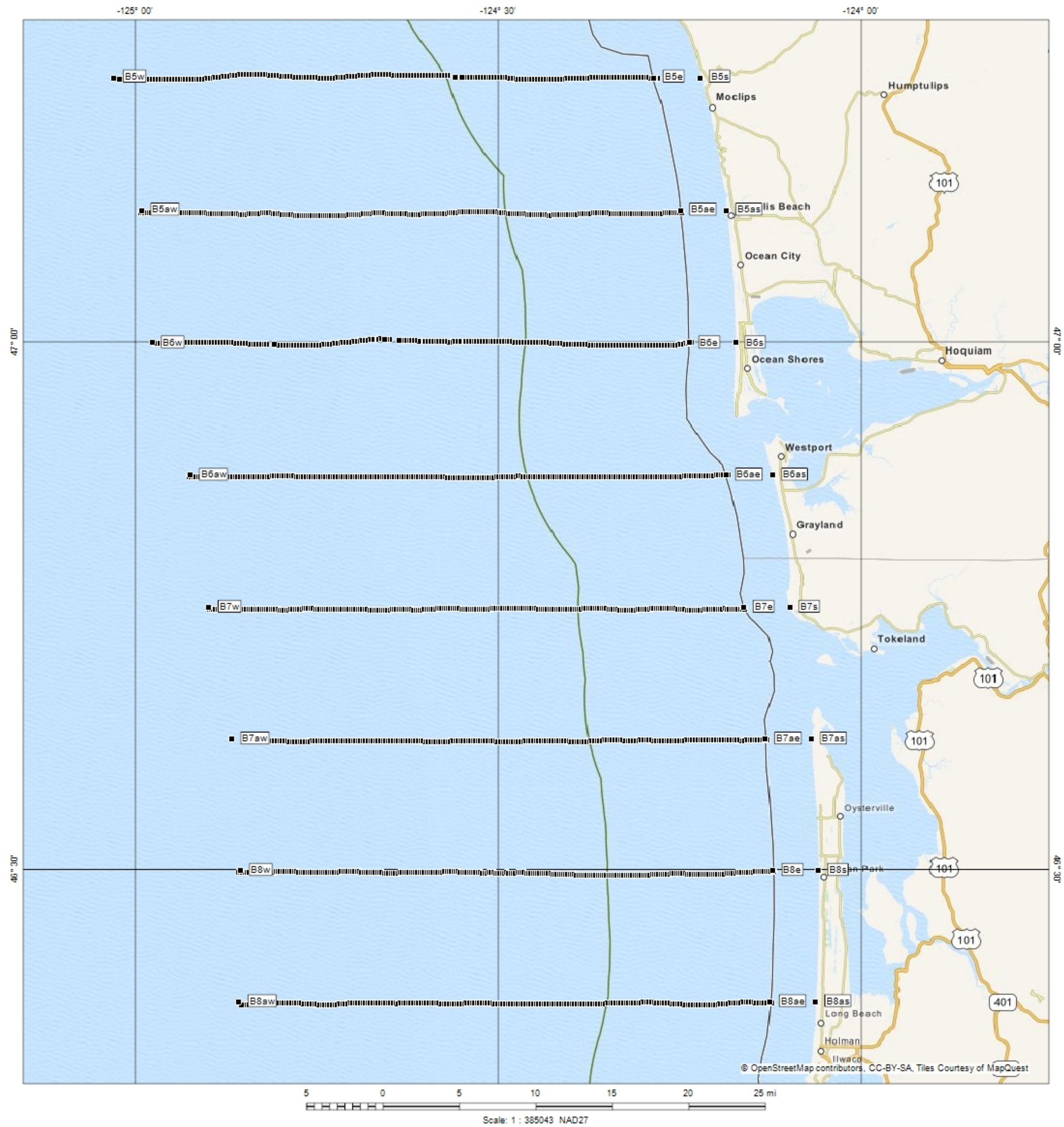


Figure 1c. Map of transect Set B, flown in 2012 (Transects 9 through 12a).

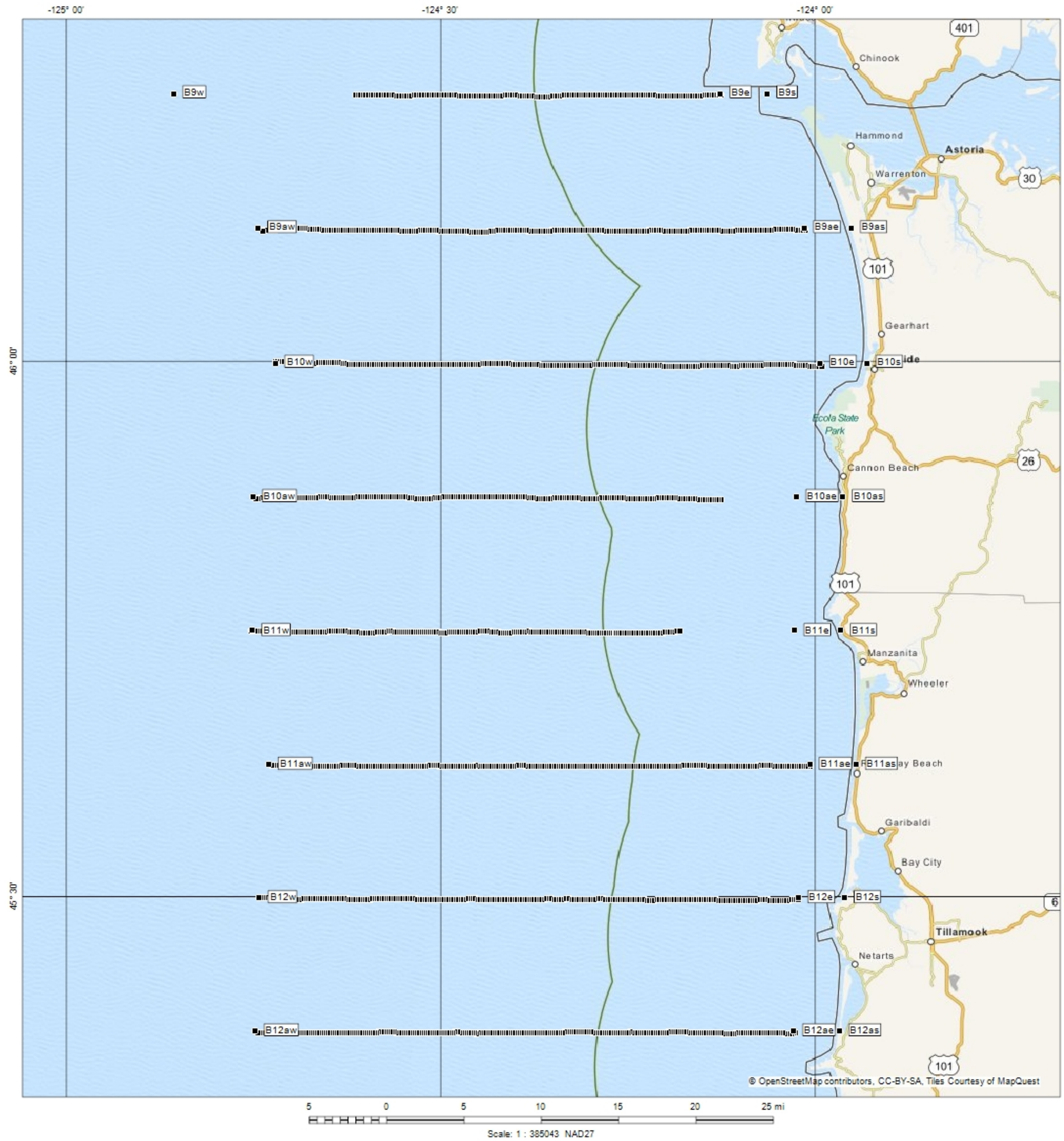


Figure 1d. Map of transect Set B, flown in 2012 (Transects 13 through 16).

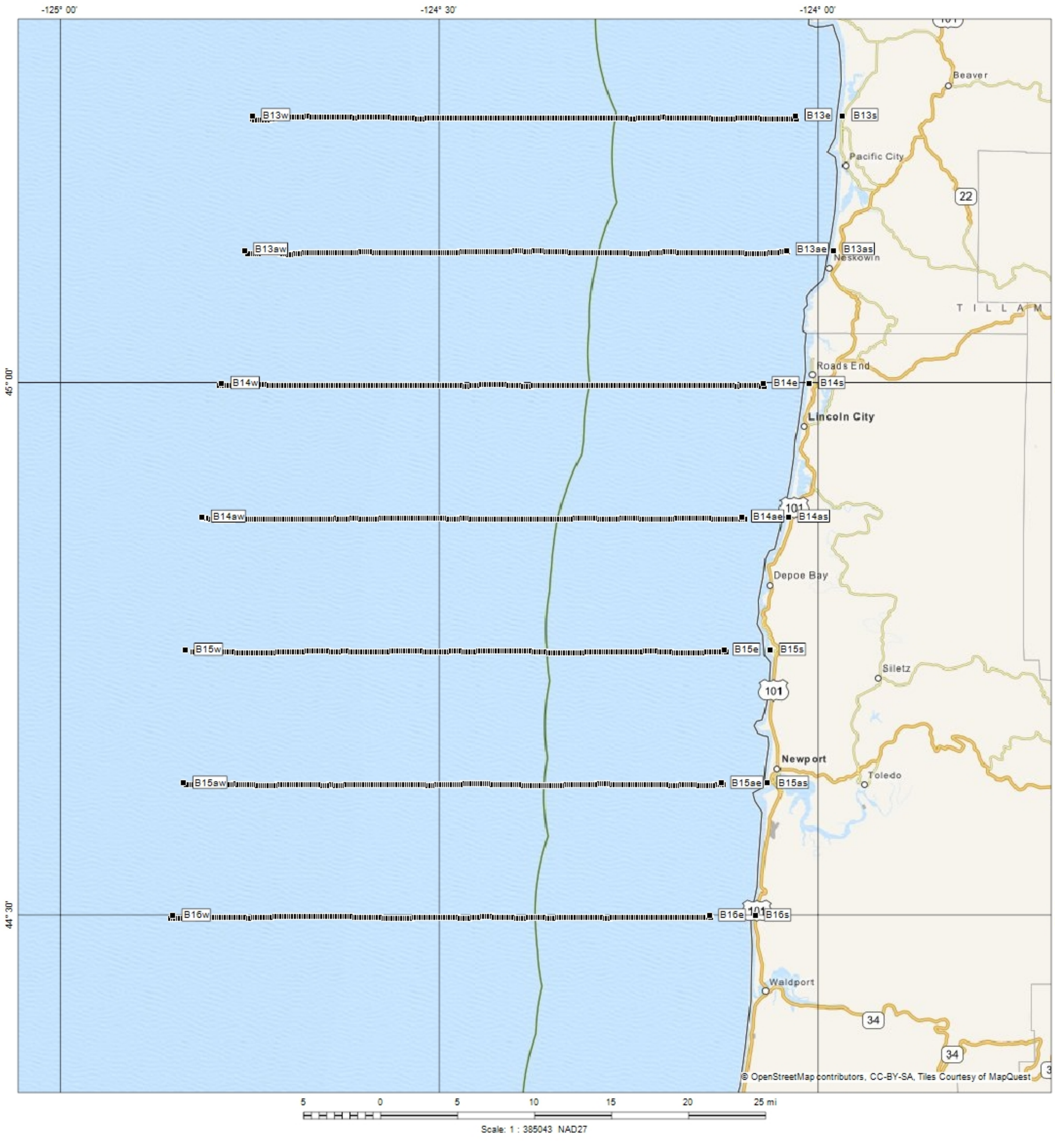


Figure 1e. Map of transect Set B, flown in 2012 (Transects 17 through 20).

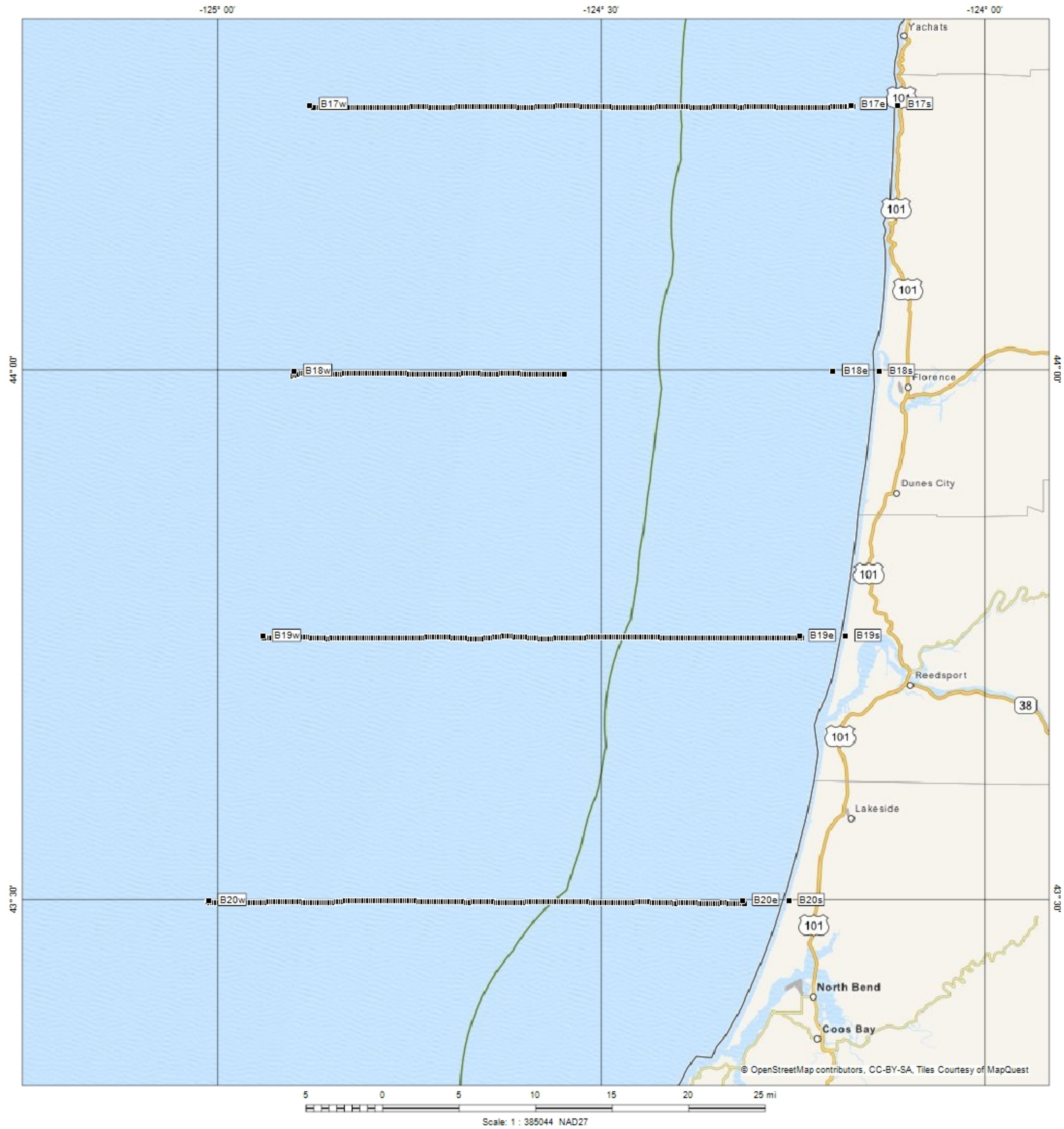


Figure 1f. Map of transect Set B, flown in 2012 (Transects 21 through 24).

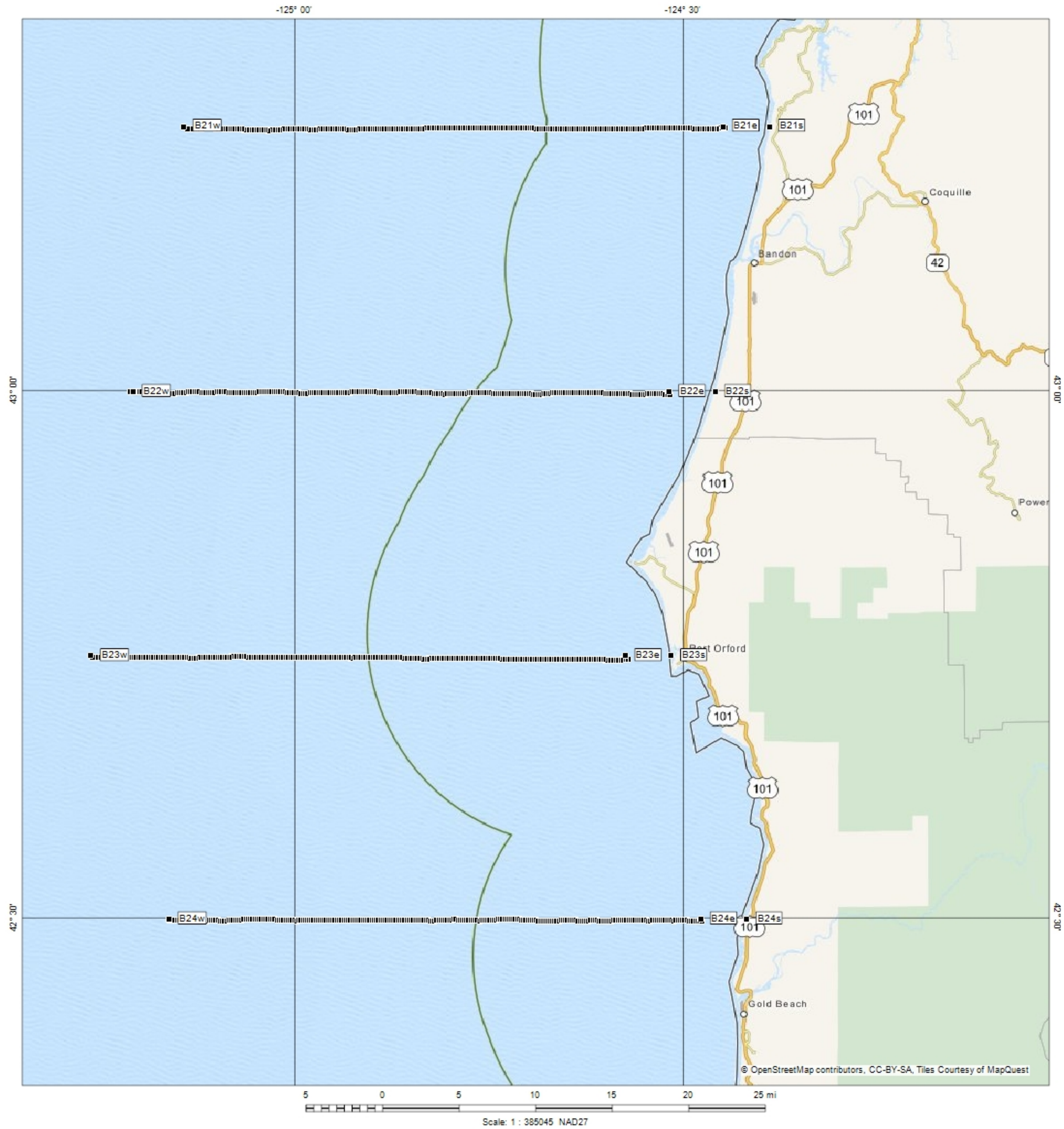


Figure 1g. Map of transect Set B, flown in 2012 (Transects 25 through 26).

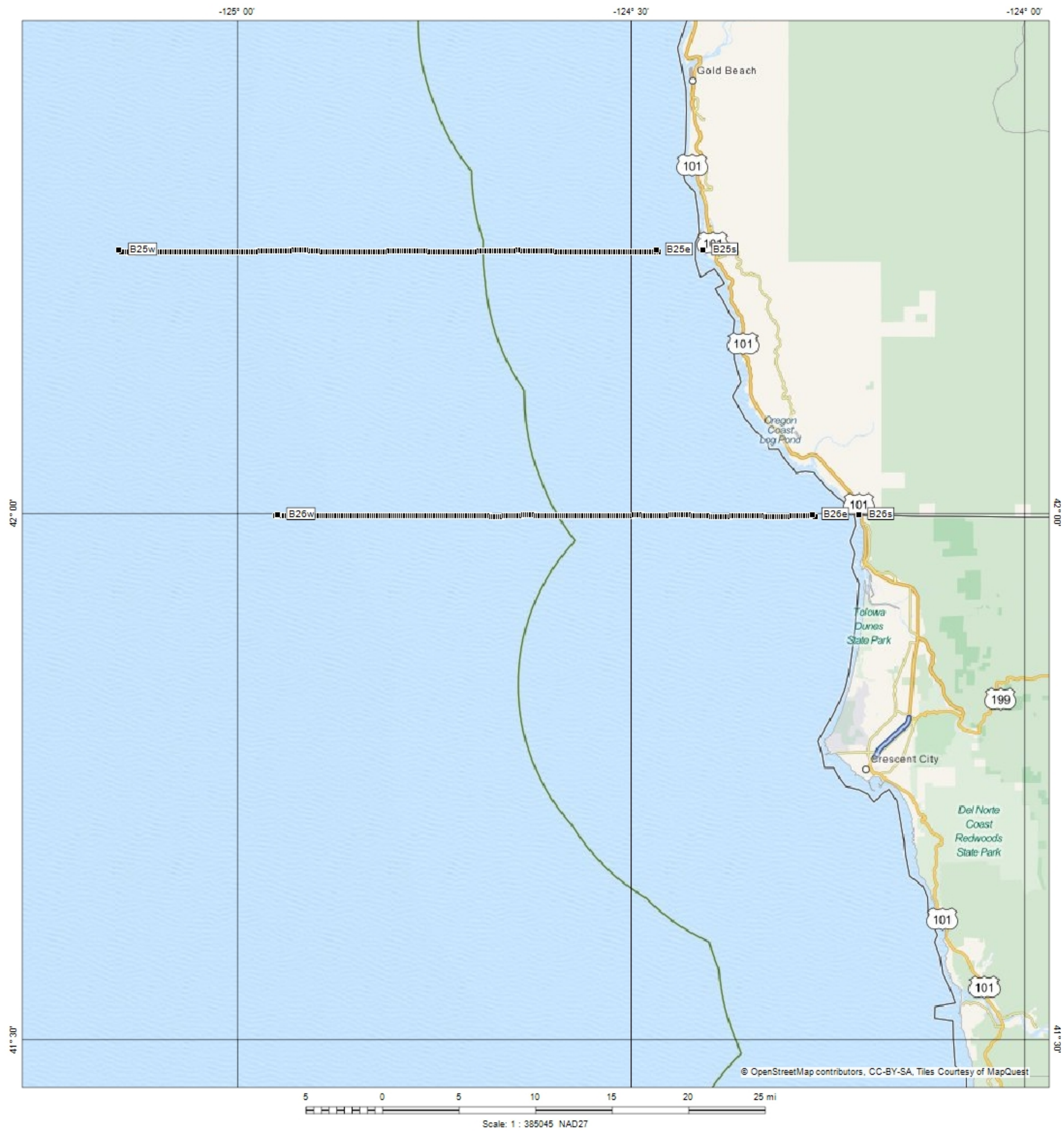


Figure 2. Size distribution of individual schools (surface area in m^2) sampled on transects, 2009-2012.

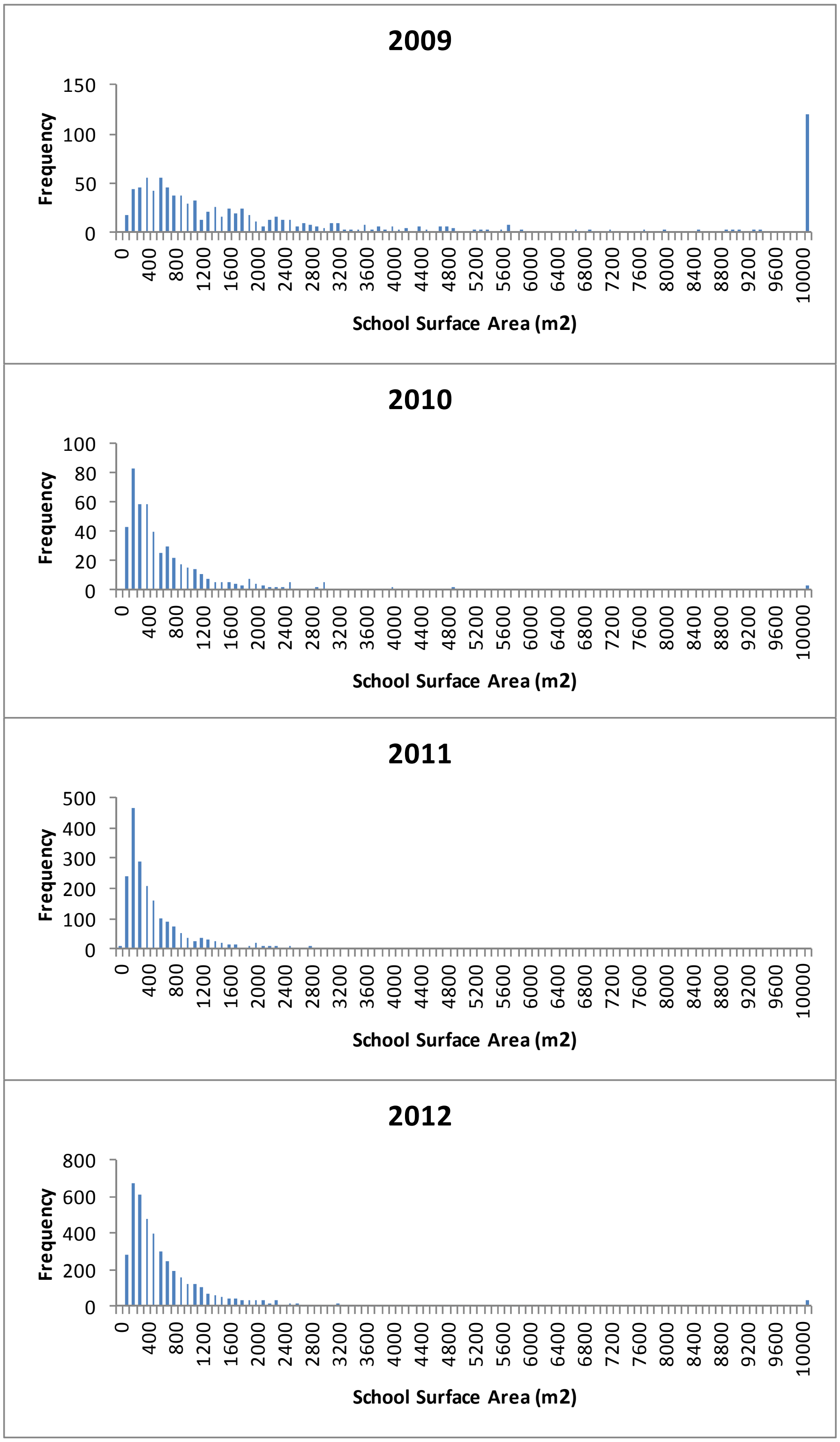


Figure 3a. Map showing locations of sardine schools in 2012: Transects 5a-11 (no schools were observed north of transect 5a). Circle sizes are proportional to sardine school surface area.

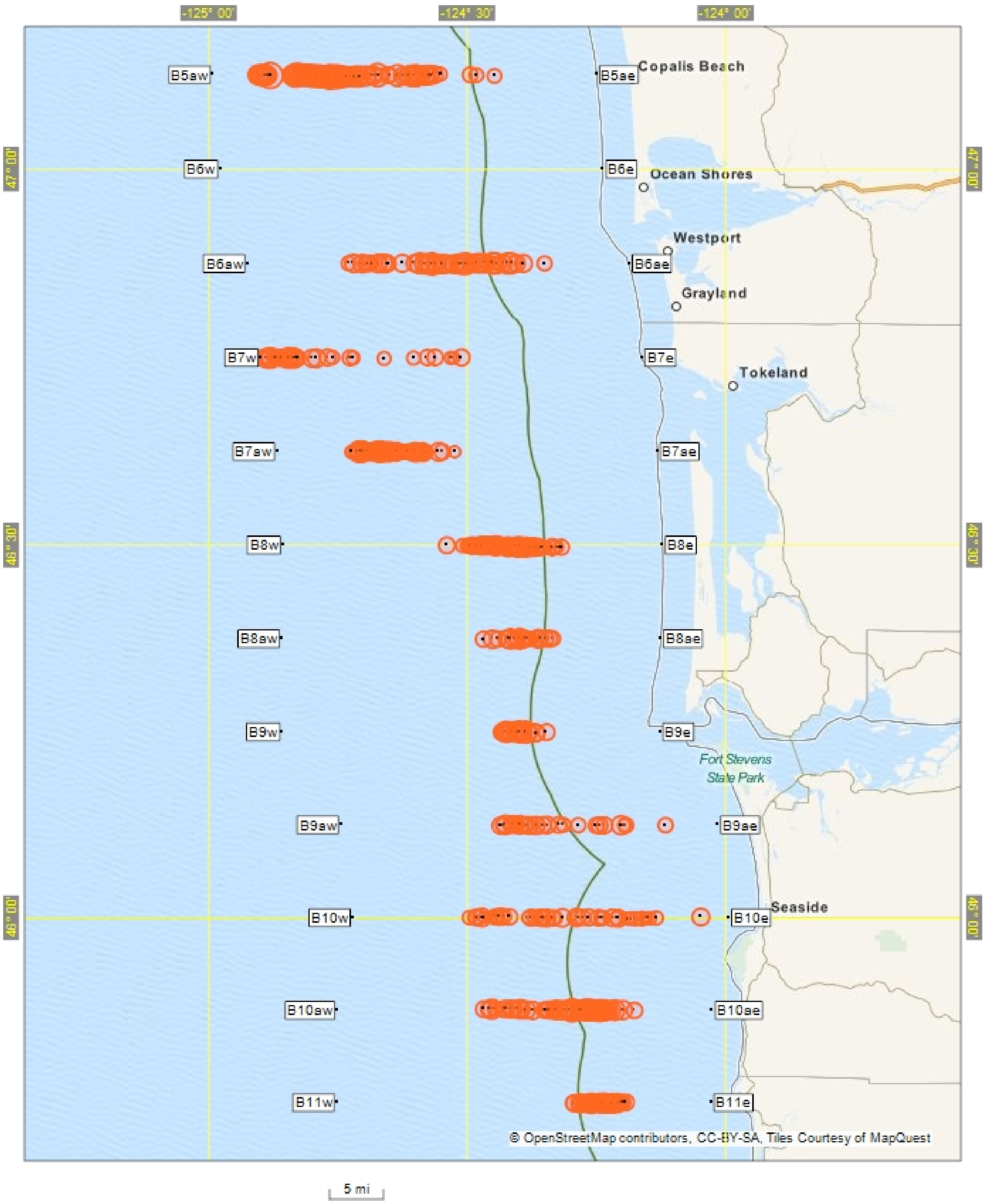


Figure 3b. Map showing locations of sardine schools in 2012: Transects 11a-17. Circle sizes are proportional to sardine school surface area.

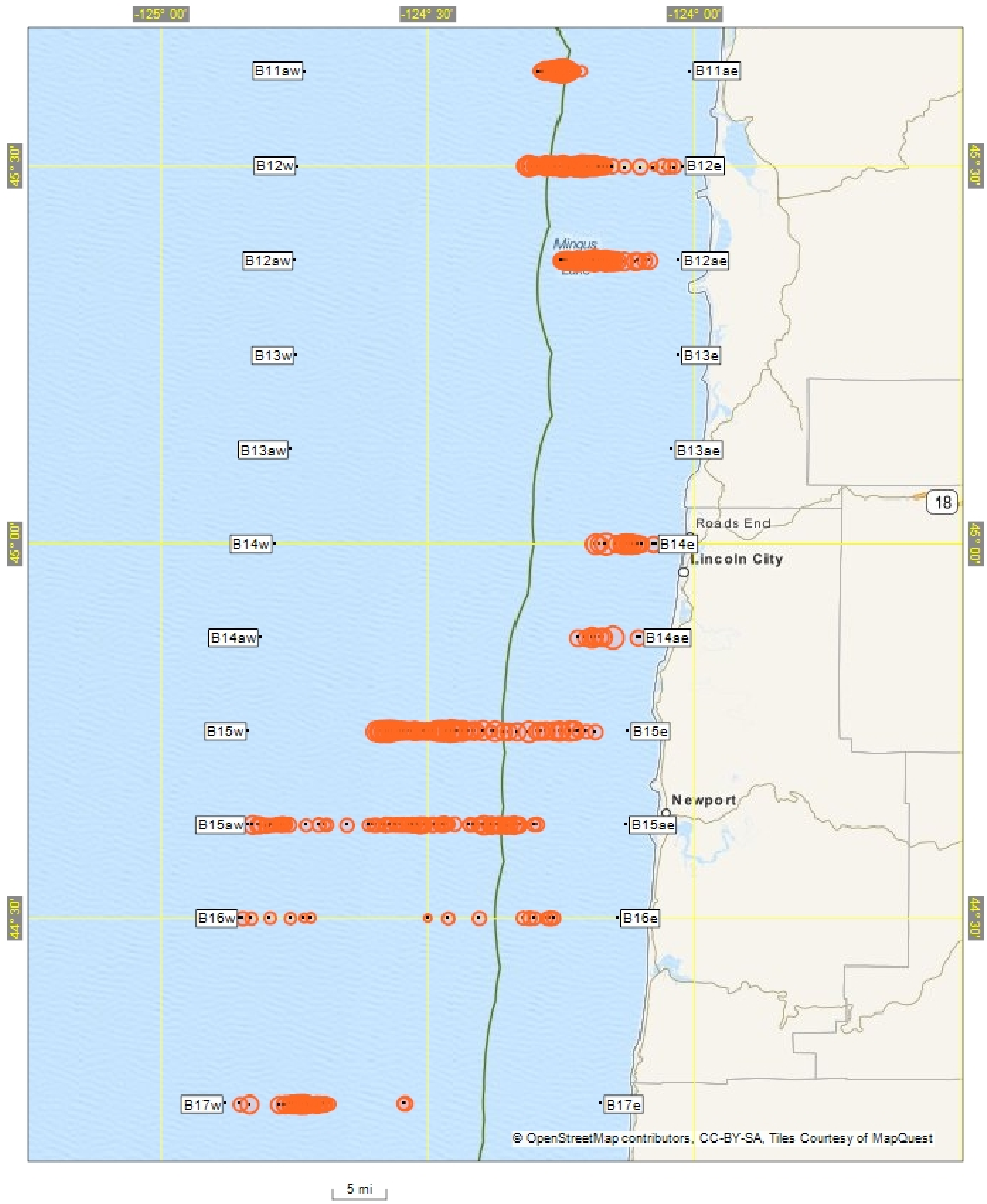


Figure 3c. Map showing locations of sardine schools in 2012: Transects 18-23 (no schools were observed south of transect 23). Circle sizes are proportional to sardine school surface area.

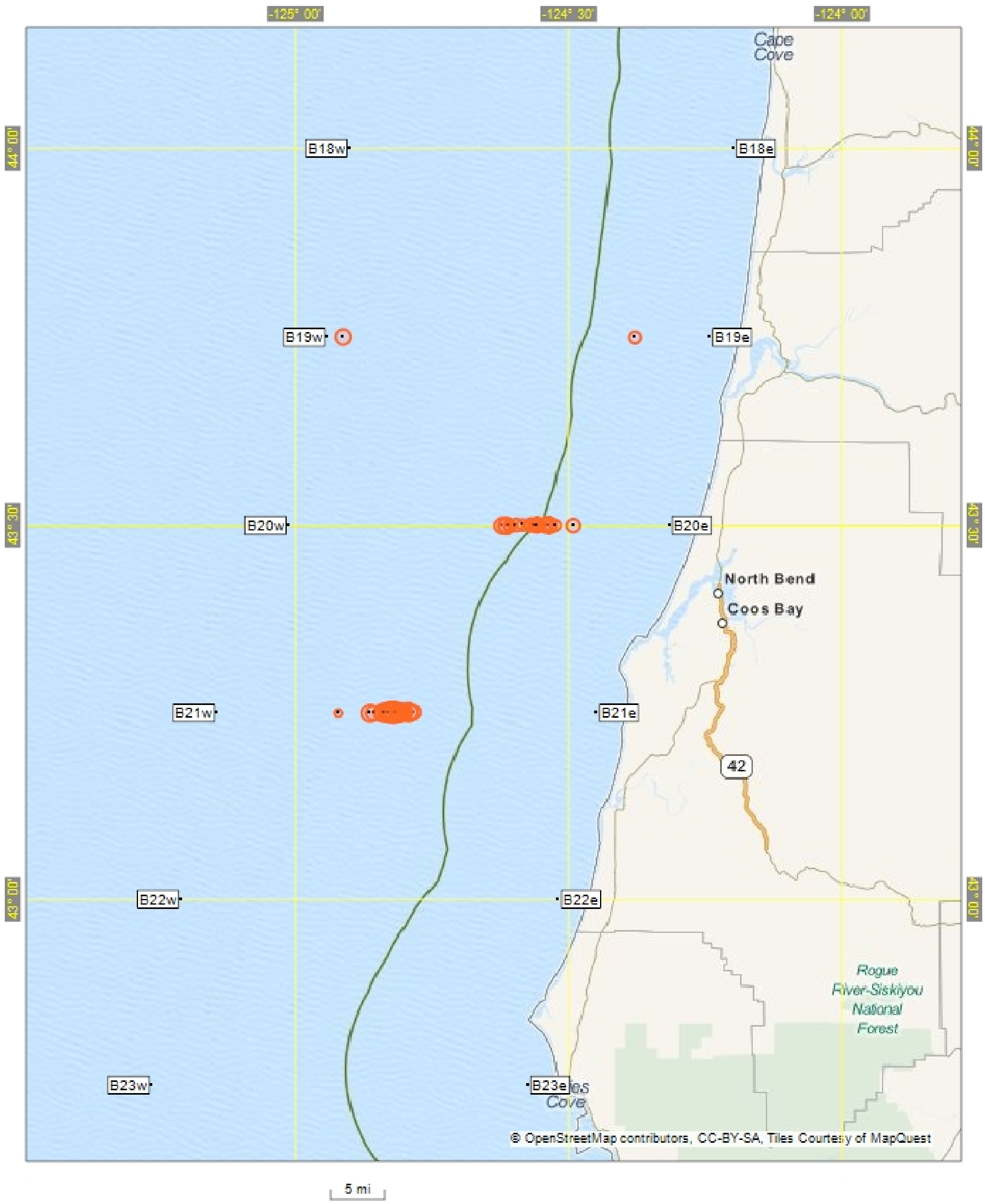


Figure 4. Location of transects and anchovy schools as reported on spotter pilot flight logs in 2012. Anchovy schools were reported at only one location in 2012; near the shoreline in N. Washington (designated by the symbol "A" on this figure).

Figure 5. Locations of point set samples in (left panel) and NWSS fishery samples (right panel) with respect to fish school locations on transects in 2012. Blue triangles: sample locations; Orange circles: sardine school locations on aerial survey transects.

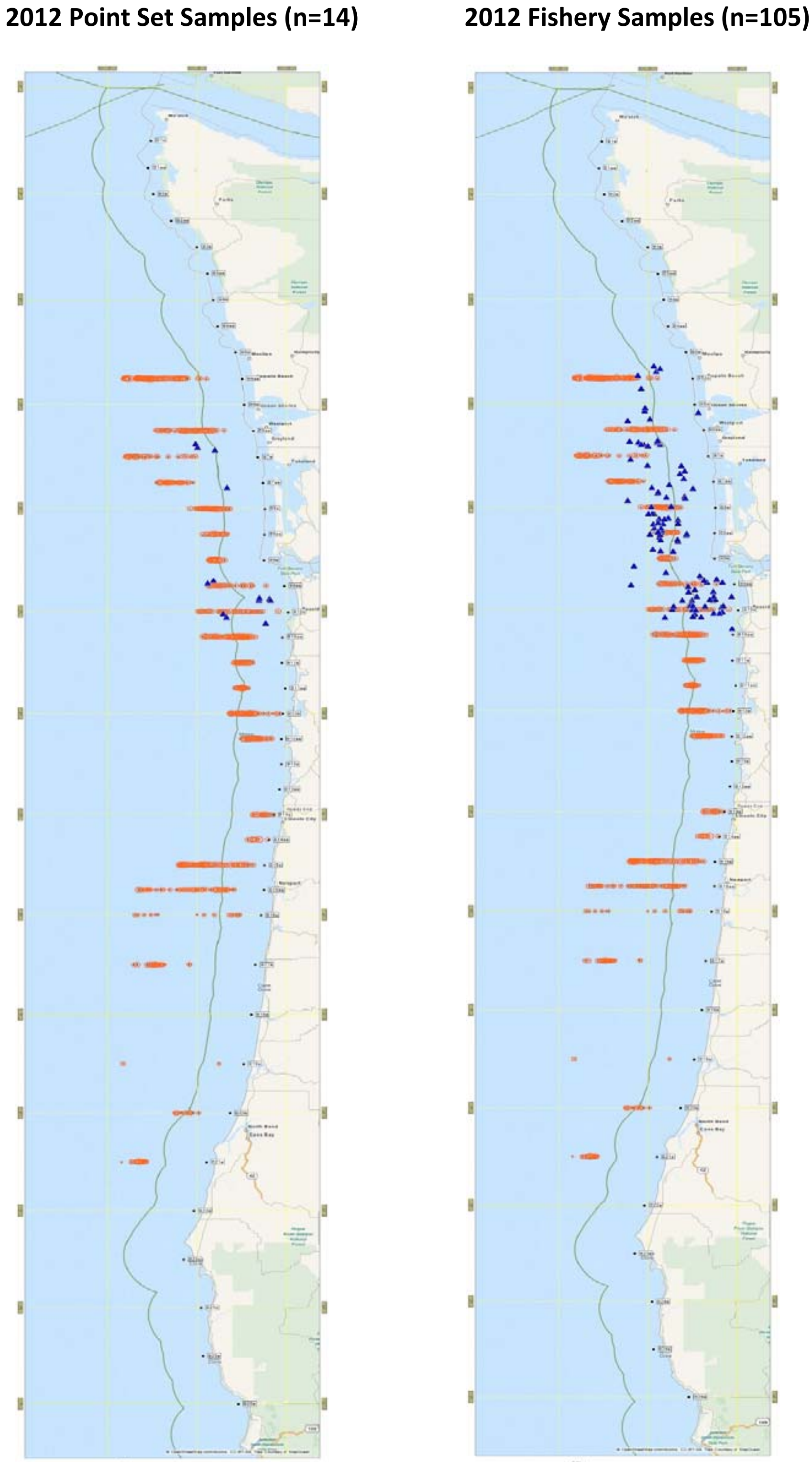


Figure 6. Locations of: 1) point sets (blue triangles) and 2) fish school locations on transects (red circles) (2009-2012).

2009 **2010** **2011** **2012**

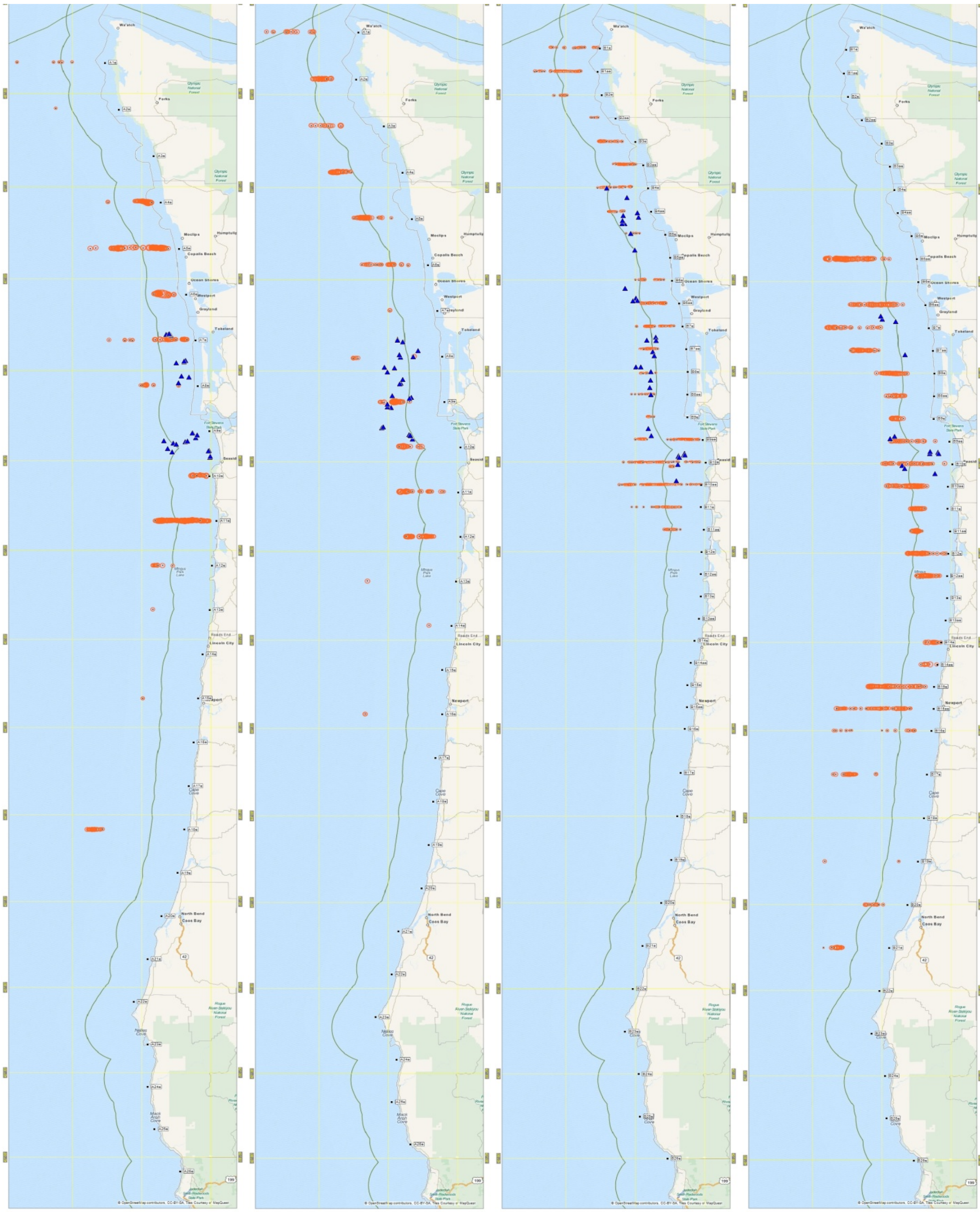
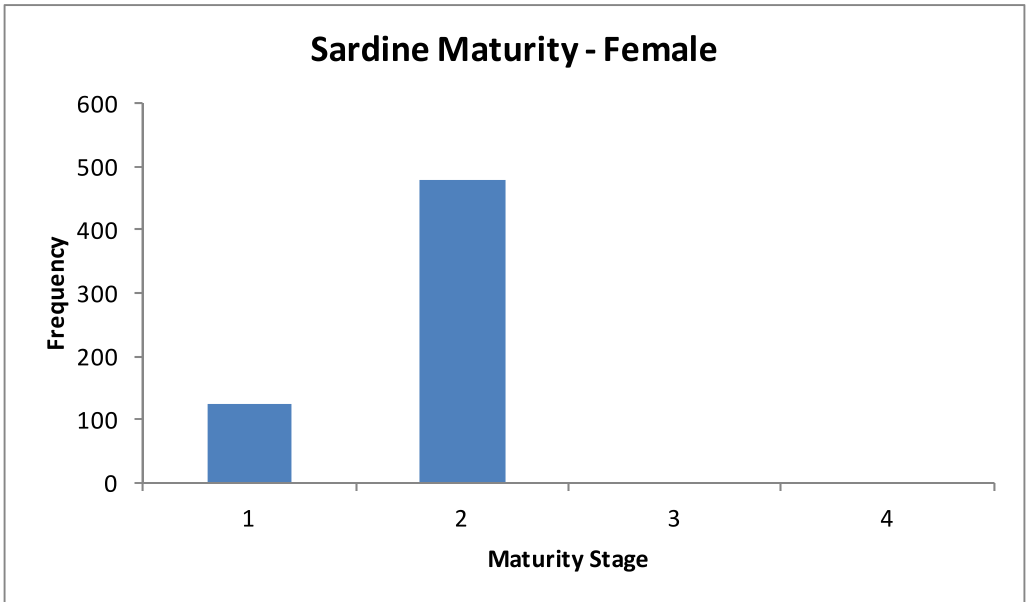


Figure 7. Frequency distribution of female and male sardine maturity stage sampled from point sets in 2012. Definitions of the maturity stages are summarized in Appendix I, Table 3, page 12).



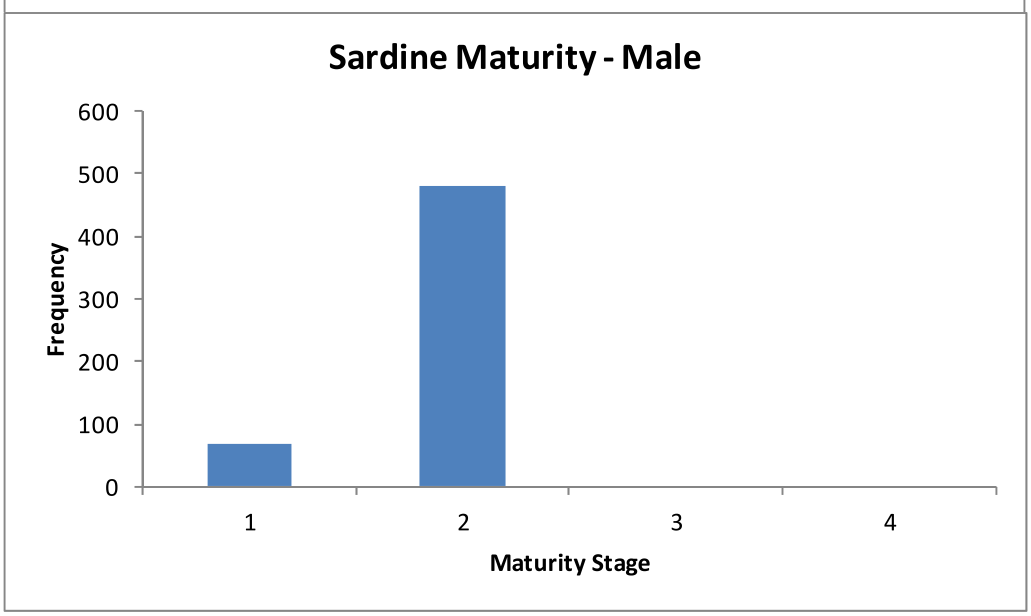


Figure 8. Frequency distribution of female and male sardine weight (g) sampled from point sets in 2012.

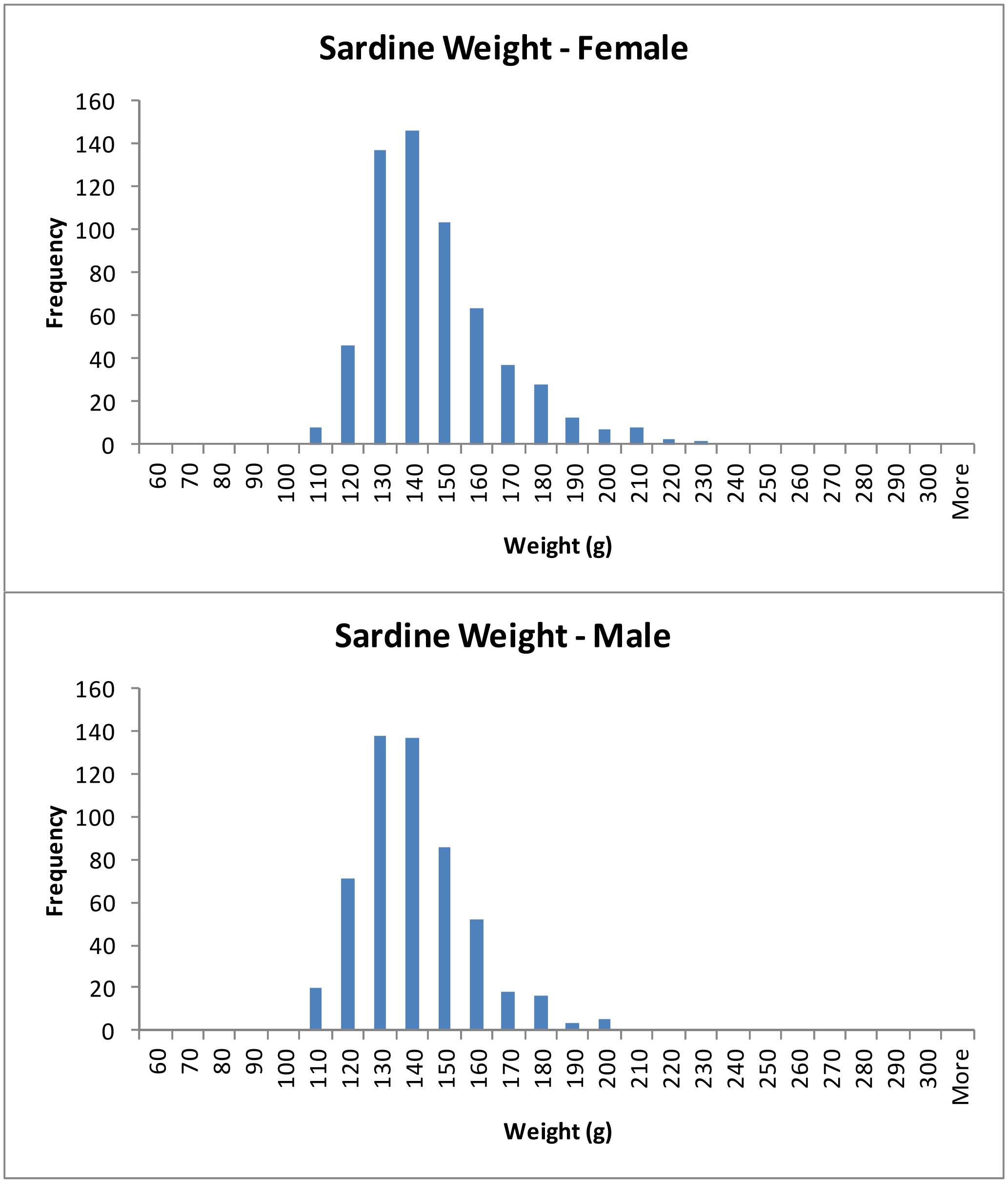


Figure 9. Plot showing sardine point set surface area-biomass relationship (mt/m^2 vs m^2), 2008-2012. Red – 2008; Green – 2009; Blue – 2010; Orange – 2011; Black (open squares) – 2012.

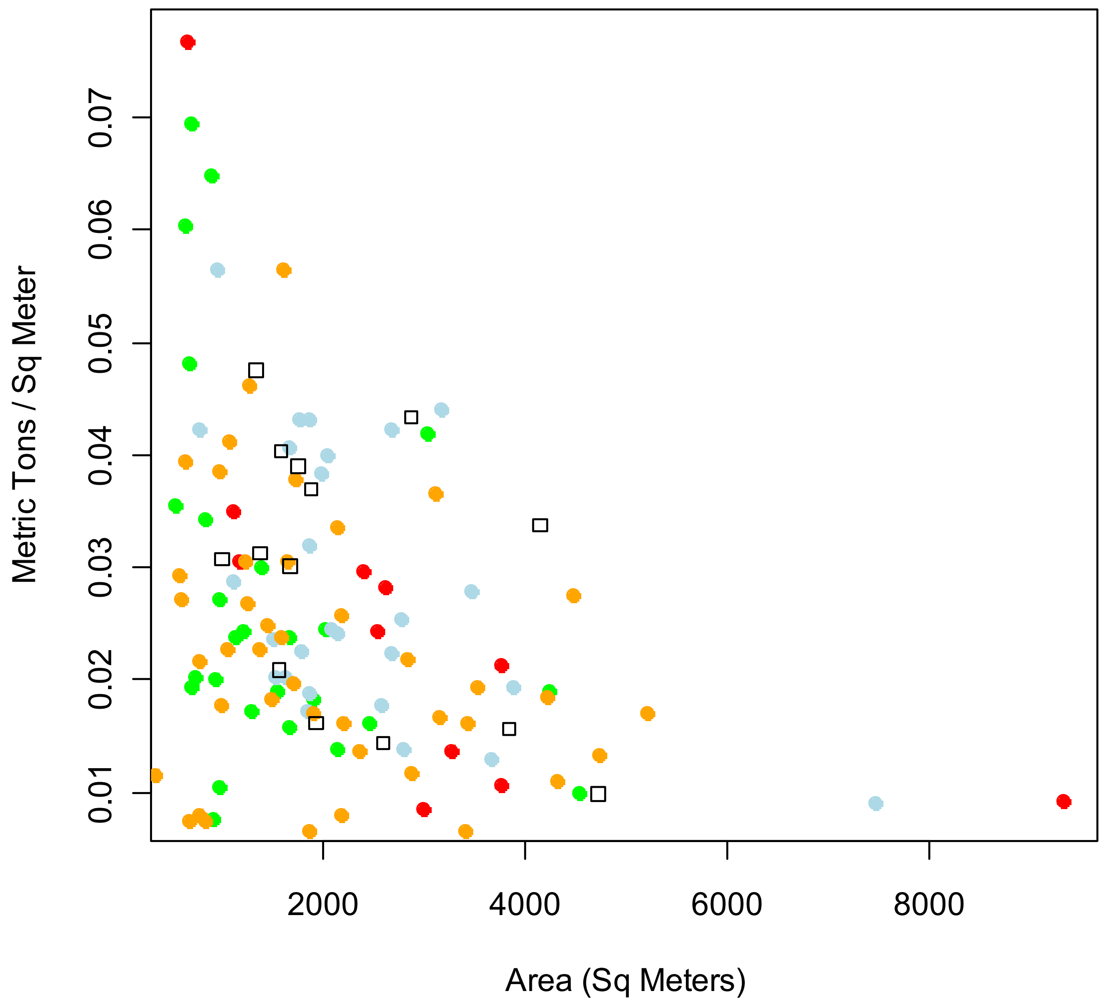


Figure 10. Plot showing fit of MM curve to point set data. 2008-2012 data pooled (green dots; solid black line). 2012 data alone (black squares; dashed black line).

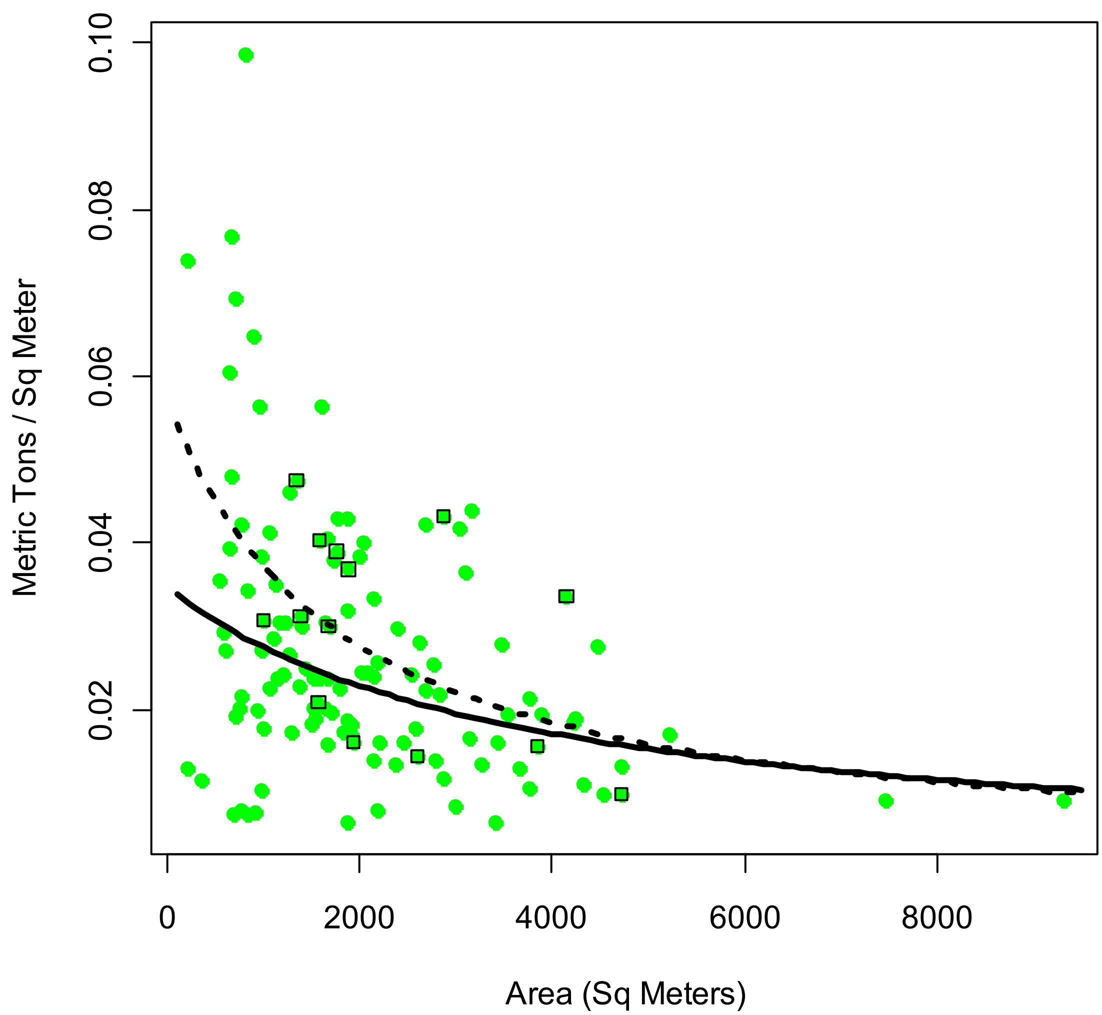


Figure 11. Weighted length frequency of sardine sampled from point sets (2009-2012).

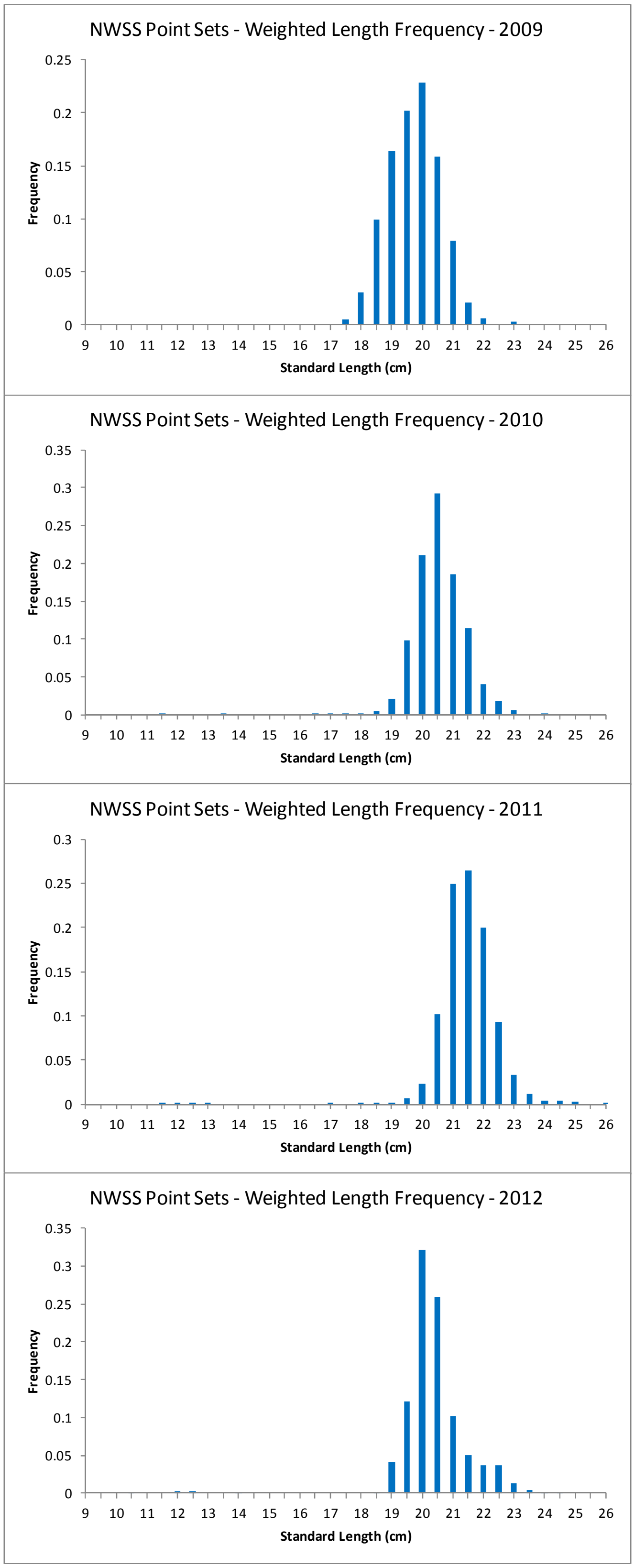


Figure 12. Weighted length frequencies of sardine sampled by NWSS in 2012. Top: All fishery samples; Middle: Selected fishery samples (7/31/2012 – 8/22/2012); Bottom: Point set samples.

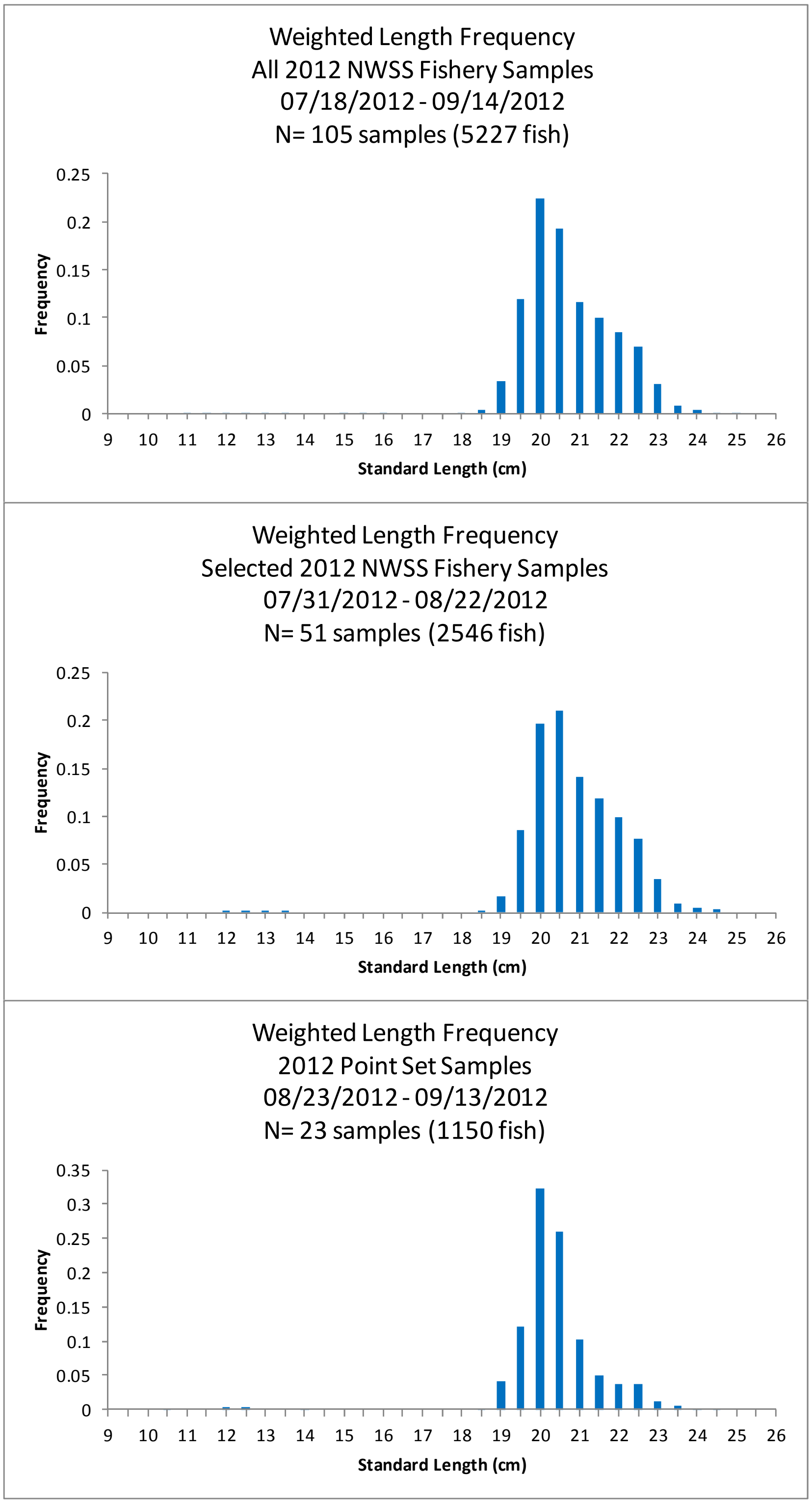


Table 1. Transect readability classifications: Set B, 2012.

Readability Classification Codes:

1 No impediments to readability. Glare may be present but it is accomodated by photo overlap coverage.

2 Moderate impediments. Could include: 1) clouds, 2) turbidity, 3) surface chop, 4) excessive glare

3 Substantial impediments. Over 50% of the transect photos are difficult to read.

2012 Set B						
Transect Number	Classification Code	Impediment Codes: Clouds	Turbidity	Chop	Glare	Notes
1	3	X				Clouds and cloud shadows: photos 147-270.
1a	3	X				Clouds and cloud shadows: photos 271-439.
2	3	X				Clouds and cloud shadows: photos 44-88 & 132-260.
2a	3	X				Clouds and cloud shadows: photos 262-397.
3	1					
3a	1					
4	2				X	Glare: photos 518-560; 646-718.
4a	2				X	Glare: photos 720-803 ; 853-890; 916-968.
5	2				X	Glare: photos 1017-1110; 1145-1200.
5a	3				X	Glare: photos 1202-1414.
6	2				X	Glare present but accomodated by by overlap. Schools thin and difficult to see school edges.
6a	2	X				Cloud and cloud shadows: photos 4-64.
7	2				X	Entire transect has significant glare on right side of photos; loss of ⅓ of surface visability.
7a	2		X			Photos 458-489: water begins to get dark making it difficult to filter out schools.
8	2			X		Surface chop throughout the entire transect. Darker water. Difficult to filter out schools.
8a	2		X	X		Surface chop and turbidity throughout entire transect. Difficult to filter out schools.
9	2		X			Photos 177-221: marbling and turbidity observed.
9a	1		X			Photos 575-601: marbling observed.
10	2	X				Significant glare on entire transect. Clouds and shadows on photos 647-669.
10a	2	X				Cloud shadows and marbling on photos 984-1050.
11	2	X				Cloud shadows and marbling on photos 1078-1147. Clouds on photos 1180-1191 & 1202-1245.
11a	3		X			Marbling throughout the transect. Very difficult to filter out schools.
12	3		X			Marbling throughout the transect. Very difficult to filter out schools.
12a	3		X			Marbling throughout the transect. Very difficult to filter out schools.
13	2				X	Significant glare throughout the entire transect.
13a	2				X	Significant glare throughout the entire transect.
14	2				X	Significant glare throughout the entire transect.
14a	3		X			Marbling throughout the transect. Very difficult to filter out schools.
15	3		X			Marbling throughout the transect. Very difficult to filter out schools.
15a	3		X			Marbling throughout the transect. Very difficult to filter out schools.
16	3		X			Marbling throughout the transect. Very difficult to filter out schools.
17	1					Some glare throughout transect.
18	1					
19	1					
20	1			X		Some surface chop throughout transect.
21	1					
22	1					
23	2			X		Significant surface chop throughout the entire transect.
24	2			X		Significant surface chop throughout the entire transect.
25	3			X	X	Significant surface chop and glare throughout the entire transect.
26	3			X	X	Significant surface chop and glare throughout the entire transect.

Table 2a. Summary of point sets planned, and accomplished in 2012, by size category.

Nominal Weight Bin (mt)	No. Planned	No. Completed	No. Successful	Weight (mt)
3.8	12	0	0	0.00
10.6	12	2	0	28.04
17.0	12	0	0	0.00
26.5	12	10	7	398.83
51.9	12	9	5	555.50
70.5	11	0	0	0.00
82.1	11	0	0	0.00
95	-	0	0	0.00
115	-	2	2	264.10
140	-	0	0	0.00
	82	23	14	1246.47

Table 2b. Summary of additional sardine sets by NWSS in 2012.

Nominal Weight Bin (mt)	No. Planned	No. Completed	Weight (mt)
3.8	-	1	10.74
11	-	1	15.47
17	-	1	20.30
26.5	-	3	110.86
51.9	-	14	857.13
70.5	-	2	146.38
82.1	-	1	0.00
95	-	1	102.28
115	-	2	264.23
140	-	1	146.10
		27	1673.49

Table 3. Summary of point sets conducted in 2012.

Date	Point Set ID	Evaluation	Rationale	Photo ID	Altitude (ft)	Latitude	Longitude	School Depth Top (fm)	School Depth Bottom (fm)	Ocean Depth (fm)	Ocean Temp (F)	Sardine (mt)	Pacific Mackerel (mt)	Total Fish (mt)	Fraction Sardine	School Surface Area (m^2)	Sardine Density (mt per m^2)
8/23/2012	LLK_08232012_1	Acceptable	100% Capture	SP3_1107	4064	46.7839	-124.4030	2.0	6.0	42.0	61.5	69.4	0.1	69.5	0.998	1882.1	0.0369
8/24/2012	PJ_08242012_1	Acceptable	100% Capture	SP3_0494	4003	45.9749	-124.3381	2.0	7.0	73.0	58.2	68.5	0.9	69.5	0.987	1759.3	0.0390
8/24/2012	PR_08242012_1	Acceptable	100% Capture	SP3_0201	3978	45.9921	-124.3569	2.0	8.0	70.0	60.0	43.4	1.7	45.1	0.962	1386.1	0.0313
8/26/2012	SR_08262012_1	Acceptable	100% Capture	SP3_0006	2907	46.1400	-124.4430	2.0	6.0	69.0	57.0	60.0	1.8	61.8	0.971	3843.6	0.0156
8/26/2012	PR_08262012_1	Acceptable	100% Capture	SP3_0341	2957	46.1530	-124.4093			68.0	57.0	139.8	5.1	144.9	0.965	4149.1	0.0337
8/28/2012	PP_08282012_1	Acceptable	100% Capture	SP3_0753	3006	45.9470	-124.1189	2.0	6.0	42.0	60.0	63.9	4.5	68.4	0.935	1346.6	0.0475
8/28/2012	SR_08282012_1	Acceptable	100% Capture	SP3_0370	2955	45.9748	-124.0791	2.0	7.0	42.0	59.0	37.4	16.7	54.2	0.691	2604.1	0.0144
8/28/2012	PJ_08282012_1	Acceptable	100% Capture	SP3_0034	2928	46.0655	-124.0971	5.0		35.6	58.2	30.9	4.5	35.4	0.872	1006.1	0.0307
8/29/2012	SR_08292012_1	Acceptable	100% Capture	SP3_1343	2979	46.7964	-124.4999	2.0	6.0	54.0	59.0	31.3	1.3	32.7	0.959	1934.8	0.0162
8/29/2012	PP_08292012_1	Acceptable	95% Capture	SP3_2181	3019	46.8138	-124.5087	2.0	6.0	49.0	62.0	46.9	6.4	53.3	0.879	4718.9	0.0099
9/1/2012	PR_09012012_1	Acceptable	95% Capture	SP3_0113	2982	46.0584	-124.0929	2.0	6.0	35.0	57.0	124.3	5.3	129.6	0.959	2871.1	0.0433
9/2/2012	PR_09022012_1	Acceptable	100% Capture	SP3_0064	3036	46.0574	-124.1560	2.0	6.0	43.0	56.5	50.5	2.6	53.1	0.951	1677.4	0.0301
9/2/2012	PJ_09022012_1	Acceptable	100% Capture	SP3_0845	2952	46.0680	-124.1530	2.0	7.0	45.0	57.0	32.8	2.7	35.4	0.924	1570.5	0.0209
9/13/2012	PR_09132012_1	Acceptable	100% Capture	SP3_0105	1415	46.6022	-124.3342	2.0	8.0	39.0	55.0	63.90	2.45	66.35	0.963	1585.8	0.0403
8/23/2012	SR_08232012_1	Not_Acceptable	20% Capture	SP3_0279	4199	46.3403	-124.3639	2.0	7.0	63.0	59.0	14.5	0.6	15.0	0.962		
8/23/2012	PJ_08232012_1	Not_Acceptable	15% Capture	SP3_1490	4055	46.8082	-124.4163			41.0	60.0	13.6	0.2	13.8	0.983		
8/24/2012	LLK_08242012_1	Not_Acceptable	No % indicated	SP3_0737	4006	45.9804	-124.3423	2.0	6.0	72.0	59.0	27.3	0.6	27.9	0.978		
8/29/2012	PJ_08292012_1	Not_Acceptable	80% Capture	SP3_0177	2961	46.7011	-124.3855			33.8	58.6	60.1	2.1	63.6	0.944		
8/31/2012	PR_08312012_1	Not_Acceptable	50% Capture	SP3_0893	3023	47.1811	-124.5015	2.0	10.0	33.0	56.0	61.4	0.3	61.7	0.995		
9/3/2012	SR_09032012_1	Not_Acceptable	Photo not legible	SP3_0218	1655	46.0609	-124.3157	2.0	10.0	60.0	59.0	49.1	14.2	63.4	0.775		
9/3/2012	PJ_09032012_1	Not_Acceptable	Photo not legible	SP3_0687	1735	46.0636	-124.3162				57.0	49.2	14.6	63.8	0.771		
9/13/2012	SR_09132012_1	Not_Acceptable	33% Capture	SP3_0577	1370	46.6037	-124.3425	2.0	12.0	46.0	57.0	52.5	0.7	53.3	0.987		
9/13/2012	PP_09132012_1	Not_Acceptable	70% Capture	SP3_0820	1401	46.6128	-124.3373	2.0	7.0	37.0	56.0	55.6	10.7	66.4	0.838		

Table 4. Estimates of total biomass in 2012.

Biomass (mt)	All Point Sets	2012 Point Sets Only
Stratum 1	646,563	840,300
Stratum 2	49,688	66,380
Total	696,251	906,680
CV	0.3798	0.4453

Appendix I

West Coast Aerial Sardine Survey

2012

Field Operational Plan

Industry Coordinator:

Northwest Sardine Survey, LLC
(Jerry Thon, Principal)

Science Advisor:

Tom Jagielo
Tom Jagielo, Consulting

Scientific Field Project Leader:

Ryan Howe

June 6, 2012

Aerial Transect Survey

Overall Aerial Survey Design

Mr. Jerry Thon will oversee the day to day logistic activities of the survey, including deployment of vessels and aircraft as needed to accomplish the projects objectives. To ensure clear communications among participants and other interested parties, the Single Point of Contact (SPC) person for 2012 survey field work will be Mr. Chris Cearns (NWSS), working under the direction of Mr. Thon.

Scientific field work will be conducted in Washington and Oregon by Mr. Ryan Howe with oversight from Mr. Tom Jagielo. Mr. Howe will lead the digital photograph analysis team and will archive all photographic and biological data.

Mr. Jagielo will be responsible for analyzing the survey data and will report the results to Dr. Kevin Hill, NMFS, SWFSC, in a form suitable for input to the stock assessment model. Mr. Howe will be available to help with data analysis as requested.

The 2012 aerial survey design consists of 41 transects spanning the area from Cape Flattery in the north to the Oregon-California border in the south (Table 1, Figure 1). Three replicate sets of transects have been identified for the survey in 2012; however, completion of at least one full set will be sufficient for biomass estimation. Sampling multiple sets will give us a better chance to get at least one full set under optimal sampling conditions. Survey coverage could potentially be extended northward into Canada -- if Canadian governmental approvals can be obtained.

Location of Transects

The east and west endpoints of each transect and corresponding shoreline position are given in Tables 1a-c and are mapped in Figures 1a-c for each of the three replicates (Set A, Set B, and Set C, respectively). Transects start at 3 miles from shore and extend westward for 35 statute miles in length. Transect spacing differs in the north (7.5 nautical miles) compared to the south (15 nautical miles) of the survey area. In addition to the 35 statute mile transect, the 3 statute mile segment directly eastward of each transect to the shore will be flown and photographed. Survey biomass will be estimated from the 35 statute mile transect data. Photographs from the shoreward segment will be used primarily to evaluate the need for future modification of the survey design.

Aerial Resources

Two Piper Super Cubs, one Cessna 337, and possibly a fourth (as yet unspecified) airplane will be used to conduct survey transects and point sets. Survey airplanes will be equipped with a Canon EOS 1Ds in an Aerial Imaging Solutions FMC mount system (Adjunct 1), installed inside the fuselage of the plane.

Use of Aerial Resources

Aerial resources will be coordinated by Mr. Thon (NWSS). To conduct a set, survey pilots will begin with transect number 1 at Cape Flattery in the north and will proceed to the southernmost transect off the southern Oregon coast. When operating together as a team, pilots will communicate via radio or cell phone. They will take a "leap-frog" approach: for example -- plane 1 will fly transects 1-5 while plane 2 is flying transects 6-10; then plane 1 will fly transects 11-15 while plane 2 flies Transects 16-20, and so on. The actual number of transects flown in a day by each plane will be determined jointly by the survey pilots and Mr. Thon and may be more or less than the example of five per plane given above.

Conditions Acceptable for Surveying

At the beginning of each potential survey day, the survey pilots will confer with Mr. Thon and will jointly judge if conditions will permit safe and successful surveying that day. Considering local conditions, they will also jointly determine the optimal time of day for surveying the area slated for coverage that day. Factors will include sea condition, sardine visibility, presence of cloud or fog cover, and other relevant criteria.

Transect Sampling

Prior to beginning a survey flight, the Pre-Flight Survey Checklist (Adjunct 2) will be completed for each aircraft. This will ensure that the camera system settings are fully operational for data collection. For example, it is crucial to have accurate GPS information in the log file. It is also crucial that the photograph number series is re-set to zero. Transects flown without the necessary survey data are not valid and cannot be analyzed.

The decision of when to start a new set of transects will be determined by Mr. Thon with input from Mr. Jagielo and/or others as requested. Transects will be flown at the nominal survey altitude of 4,000 ft. Transects may be flown starting at either the east end or the west end.

A Transect Flight Log Form (Adjunct 2) will be kept during the sampling of each transect for the purpose of documenting the observations of the pilot and/or onboard observers. Key notations will include observations of school species ID and documentation of any special conditions that could have an influence on interpreting photographs taken during transects.

Sardine are believed to migrate northward from California during the summer. Thus, to avoid the possibility of "double counting", it is important that transects are conducted in a North-to-South progression. Once a transect (or a portion of a transect) has been flown, neither that transect, nor any transects to the north of that transect, may be flown again during that transect set in progress. It will be acceptable to skip transects or portions of transects if conditions require it (e.g. if better weather is available to the south of an area), but transects may not be "made up" once skipped during the sampling of a transect set. Once begun, the goal is to cover the full 41-transect set in as few days as possible.

Data Transfer

Photographs and FMC log files will be downloaded and forwarded for analysis and archival at the end of each survey day. At the end of each flight, the Scientific Field Project Leader (Mr. Howe) will verify that the camera and data collection system operated properly and that images collected are acceptable for analysis. Mr. Howe will collect data from the pilots and will coordinate the transfer and archival of all aerial survey data.

I. Point Set Sampling

Location, Number, and Size of Point Sets
Point sets are fully captured sardine schools landed by purse seiners approved and permitted for this research. Each set by a purse seiner will be directed by one of the survey pilots. Point sets will be made over as wide an area as feasible within the survey area, in order to distribute the sampling effort spatially. We anticipate that point sets could be landed into both Washington and Oregon ports in 2012.

Point sets will also be collected over a range of sizes, as set out in Table 2. The goal is to obtain 82 valid point sets in 2012.

Aerial Photography of Point Sets
The detailed protocol for point set sampling is given in Adjunct 4. Sardine schools to be captured for point sets will be first selected and identified by the survey pilot at the nominal survey altitude of 4,000 ft. When deemed necessary, and at the sole discretion of Mr. Jerry Thon in communication with the survey pilot, schools may (on occasion) be first selected and identified at altitudes lower than 4,000 ft. Following a discrete school selection, the pilot will descend to a lower altitude to better photograph the approach of the seiner to the school and set the seiner for capture of the school. Photographs will be taken before and during the vessels approach to the school for the point set capture. Each school selected by the pilot and photographed for a potential point set will be logged on the survey pilot's Point Set Flight Log Form (Adjunct 2). The species identification of the selected school will be verified by the captain of the purse seine vessel conducting the point set and will be logged on the Fisherman's Log Form (Adjunct 2). These records will be used to determine the rate of school mis-identification by spotter pilots in the field and by analysts viewing photographs.

Vessel Point Set Capture
The purse seine vessel will encircle (wrap) and fully capture the school selected by the survey pilot for the point set. Any school not "fully" captured will not be considered a valid point set for analysis. If a school is judged to be "nearly completely" captured (i.e., over 90% captured), it will be noted as such and will be included for analysis. Both the survey pilot and the purse seine captain will independently make note of the "percent captured" on their survey log forms for this purpose. Upon capture, sardine point sets will be held in separate holds for separate weighing and biological sampling of each set after landing.

Biological Sampling
Biological samples of individual point sets will be collected at the landing docks or at the fish processing plants upon landing. Fish will be systematically taken at the start, middle, and end of a delivered set. The three samples will then be combined and a random subsample of fish will be taken. The sample size will be n = 50 fish for each point set haul.

Length, weight, maturity, and otoliths will be sampled for each point set haul and will be documented on the Biological Sampling Form (Adjunct 2). Sardine weights will be taken using an electronic scale accurate to 0.5 gm. Sardine lengths will be taken using a millimeter length strip attached to a measuring board. Standard length will be determined by measuring from sardine snout to the last vertebrae. Sardine maturity will be established by referencing maturity codes (female- 4 point scale, male- 3 point scale) supplied by Beverly Macewicz NMFS, SWFSC. A subsample of 25 fish from each point set sample will be individually bagged, identified with sample number and frozen with other fish in the subsample, clearly identified as to point set number, vessel, and location captured and retained for collection of otoliths.

Hydroacoustic Sounding of School Height
School height will be measured for each point set. This may be obtained by using either the purse seine or other participating research vessels' hydroacoustic gear. The school height measurements to be recorded on the Fisherman's Log Form are: 1) depth in the water column of the top of the school, and 2) depth in the water column of the bottom of the school. Simrad ES-60 sounders will be installed on two purse seine vessels. Data collected by the ES-60 sounders will be backed-up daily and archived onshore.

Number and Size of Point Sets to be Captured
Point sets will be conducted for a range of school sizes (Table 2). Point sets will be targeted working in general from the smallest size category to the largest. Each day, spotter pilots will operate with an updated list of remaining school sizes needed for analysis. Each spotter pilot will use his experience to judge the biomass of sardine schools from the air, and will direct the purse seine vessel to capture schools of appropriate size. Following landing of the point sets at the dock, the actual school weights will be determined. Every effort will be made to ensure, as soon as possible, that successfully landed point sets were also successfully photographed. This will in general occur before the end of each fishing day. After verification of point set acceptability, the list of remaining school sizes needed from Table 2 will be updated accordingly for ongoing fishing. If schools are not available in the designated size range, point sets will be conducted on schools as close to the designated range as possible. Pumping large sets onto more than one vessel should be avoided, and should only be done in the accidental event that school size was grossly underestimated. Mr. Howe will oversee the gathering of point set landing data and will update the list daily. The total landed weight of point sets sampled will not exceed 3,000 mt.

Spatial Distribution of Point Sets
In order to distribute point sets spatially, sampling will occur both north and south of the Columbia River, and offshore vs. nearshore, as well. This could be facilitated by landing point sets in both Washington and Oregon ports in 2012. Quadrants have been established to facilitate spatial distribution of the point sets (Figure 2).

Landing Reporting Requirements
Cumulative point set landings will be updated by Mr. Chris Cearns (NWSS), who will report the running total daily to NMFS, as per the terms of the Exempted Fishing Permit. Also included in this daily report will be an estimate of the weight of all by-catch by species.

Other EFP Reporting Requirements
To ensure clear communications among participants and other interested parties, the single point of contact (SPC) person during 2012 survey field work will be Mr. Chris Cearns.

Mr. Cearns (under the direction of Mr. Thon) will also be responsible for providing other required reporting elements (as specified in the EFP permit) to NMFS. For example, a daily notice will be provided for enforcement giving 24 hour notice of vessels to be conducting point sets on any given day and will include vessel name, area to be fished, estimated departure time, estimated return time.

II. Calibration and Validation

Aerial Measurement Calibration
Each survey year, routine calibration is conducted to verify aerial measurements. A series of photographs will again be collected of a feature of known size (e.g. airplane hangars the Astoria, OR airport), from the altitudes of 1,000 ft, 2,000 ft, 3,000 ft, and 4,000 ft. For each altitude series, an aerial pass will be made to place the target onto the right, middle, and left portions of the photographic image.

Aerial Photographs and Sampling for Species Validation
The collection of reference photographs is updated each survey year, for the purpose of species identification. These photographs are used by the team of photograph analysts to continue to learn how to discern between sardine and other species as they appear on the aerial transect photographs.

Reference photographs will be taken at the nominal survey altitude of 4,000 ft for the purpose of species identification. The spotter pilots will find and photograph schooling fish other than sardine (e.g. mackerel, herring, smelt, anchovy, etc). For the actual schools photographed, a vessel at sea (typically a small, relatively fast boat) will collect a jig sample to document the species identification. This sampling will most likely occur in June, prior to commencement of the summer fishery opening.

Tables 1a -1f. Transect Sets A, B, and C.

Table 1a. Set A

	Survey	Transect	Transect Latitude		West End			East End			Shoreline		
Location	Area	Number	Lat Deg	Lat Min	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #
Washington	N	A1	48	20.000	125	29.30	A1w	124	43.71	A1e	124	39.81	A1s
Washington	N	A1a	48	12.500	125	30.98	A1aw	124	45.51	A1ae	124	41.61	A1as
Washington	N	A2	48	5.000	125	30.99	A2w	124	45.63	A2e	124	41.74	A2s
Washington	N	A2a	47	57.500	125	29.48	A2aw	124	44.24	A2ae	124	40.36	A2as
Washington	N	A3	47	50.000	125	21.05	A3w	124	35.91	A3e	124	32.04	A3s
Washington	N	A3a	47	42.500	125	13.82	A3aw	124	28.79	A3ae	124	24.93	A3as
Washington	N	A4	47	35.000	125	10.89	A4w	124	25.96	A4e	124	22.11	A4s
Washington	N	A4a	47	27.500	125	9.13	A4aw	124	24.30	A4ae	124	20.46	A4as
Washington	N	A5	47	20.000	125	5.89	A5w	124	21.17	A5e	124	17.33	A5s
Washington	N	A5a	47	12.500	125	0.98	A5aw	124	16.37	A5ae	124	12.54	A5as
Washington	N	A6	47	5.000	124	59.07	A6w	124	14.57	A6e	124	10.76	A6s
Washington	N	A6a	46	57.500	124	58.70	A6aw	124	14.30	A6ae	124	10.50	A6as
Washington	N	A7	46	50.000	124	54.58	A7w	124	10.28	A7e	124	6.49	A7s
Washington	N	A7a	46	42.500	124	52.93	A7aw	124	8.73	A7ae	124	4.95	A7as
Washington	N	A8	46	35.000	124	51.75	A8w	124	7.66	A8e	124	3.88	A8s
Washington	N	A8a	46	27.500	124	51.41	A8aw	124	7.42	A8ae	124	3.65	A8as
Washington	N	A9	46	20.000	124	51.77	A9w	124	7.87	A9e	124	4.11	A9s
Washington	N	A9a	46	12.500	124	47.63	A9aw	124	3.83	A9ae	124	0.08	A9as
Oregon	N	A10	46	5.000	124	43.80	A10w	124	0.10	A10e	123	56.36	A10s
Oregon	N	A10a	45	57.500	124	45.71	A10aw	124	2.11	A10ae	123	58.38	A10as
Oregon	N	A11	45	50.000	124	44.99	A11w	124	1.50	A11e	123	57.77	A11s
Oregon	N	A11a	45	42.500	124	43.65	A11aw	124	0.25	A11ae	123	56.53	A11as
Oregon	N	A12	45	35.000	124	44.22	A12w	124	0.91	A12e	123	57.20	A12s
Oregon	N	A12a	45	27.500	124	45.16	A12aw	124	1.95	A12ae	123	58.25	A12as
Oregon	N	A13	45	20.000	124	45.10	A13w	124	1.99	A13e	123	58.29	A13s
Oregon	N	A13a	45	12.500	124	44.94	A13aw	124	1.92	A13ae	123	58.23	A13as
Oregon	N	A14	45	5.000	124	46.96	A14w	124	4.03	A14e	124	0.36	A14s
Oregon	N	A14a	44	57.500	124	47.76	A14aw	124	4.93	A14ae	124	1.26	A14as
Oregon	N	A15	44	50.000	124	49.86	A15w	124	7.12	A15e	124	3.45	A15s
Oregon	N	A15a	44	42.500	124	49.95	A15aw	124	7.31	A15ae	124	3.65	A15as
Oregon	N	A16	44	35.000	124	50.38	A16w	124	7.83	A16e	124	4.18	A16s
Oregon	N	A17	44	20.000	124	52.00	A17w	124	9.63	A17e	124	6.00	A17s
Oregon	N	A18	44	5.000	124	53.44	A18w	124	11.25	A18e	124	7.63	A18s
Oregon	N	A19	43	50.000	124	55.46	A19w	124	13.45	A19e	124	9.84	A19s
Oregon	N	A20	43	35.000	124	58.98	A20w	124	17.14	A20e	124	13.55	A20s
Oregon	N	A21	43	20.000	125	7.59	A21w	124	25.92	A21e	124	22.35	A21s
Oregon	N	A22	43	5.000	125	11.18	A22w	124	29.67	A22e	124	26.12	A22s
Oregon	N	A23	42	50.000	125	18.75	A23w	124	37.41	A23e	124	33.87	A23s
Oregon	N	A24	42	35.000	125	8.28	A24w	124	27.11	A24e	124	23.59	A24s
Oregon	N	A25	42	20.000	125	10.20	A25w	124	29.20	A25e	124	25.68	A25s
Oregon	N	A26	42	5.000	125	3.86	A26w	124	23.02	A26e	124	19.52	A26s

Table 1b. Set B

	Survey	Transect	Transect Latitude		West End			East End			Shoreline		
Location	Area	Number	Lat Deg	Lat Min	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #
Washington	N	B1	48	15.000	125	30.91	B1w	124	45.40	B1e	124	41.50	B1s
Washington	N	B1a	48	7.500	125	31.79	B1aw	124	46.39	B1ae	124	42.50	B1as
Washington	N	B2	48	0.000	125	29.92	B2w	124	44.64	B2e	124	40.75	B2s
Washington	N	B2a	47	52.500	125	23.80	B2aw	124	38.62	B2ae	124	34.75	B2as
Washington	N	B3	47	45.000	125	15.09	B3w	124	30.02	B3e	124	26.16	B3s
Washington	N	B3a	47	37.500	125	11.56	B3aw	124	26.60	B3ae	124	22.74	B3as
Washington	N	B4	47	30.000	125	9.43	B4w	124	24.58	B4e	124	20.73	B4s
Washington	N	B4a	47	22.500	125	7.95	B4aw	124	23.20	B4ae	124	19.37	B4as
Washington	N	B5	47	15.000	125	1.78	B5w	124	17.13	B5e	124	13.31	B5s
Washington	N	B5a	47	7.500	124	59.49	B5aw	124	14.95	B5ae	124	11.13	B5as
Washington	N	B6	47	0.000	124	58.62	B6w	124	14.19	B6e	124	10.38	B6s
Washington	N	B6a	46	52.500	124	55.48	B6aw	124	11.15	B6ae	124	7.35	B6as
Washington	N	B7	46	45.000	124	53.93	B7w	124	9.70	B7e	124	5.91	B7s
Washington	N	B7a	46	37.500	124	52.05	B7aw	124	7.92	B7ae	124	4.14	B7as
Washington	N	B8	46	30.000	124	51.33	B8w	124	7.31	B8e	124	3.54	B8s
Washington	N	B8a	46	22.500	124	51.46	B8aw	124	7.53	B8ae	124	3.77	B8as
Washington	N	B9	46	15.000	124	51.41	B9w	124	7.59	B9e	124	3.83	B9s
Washington	N	B9a	46	7.500	124	44.62	B9aw	124	0.89	B9ae	123	57.14	B9as
Oregon	N	B10	46	0.000	124	43.24	B10w	123	59.61	B10e	123	55.87	B10s
Oregon	N	B10a	45	52.500	124	45.05	B10aw	124	1.51	B10ae	123	57.78	B10as
Oregon	N	B11	45	45.000	124	45.10	B11w	124	1.67	B11e	123	57.94	B11s
Oregon	N	B11a	45	37.500	124	43.78	B11aw	124	0.44	B11ae	123	56.73	B11as
Oregon	N	B12	45	30.000	124	44.58	B12w	124	1.34	B12e	123	57.63	B12s
Oregon	N	B12a	45	22.500	124	44.90	B12aw	124	1.76	B12ae	123	58.06	B12as
Oregon	N	B13	45	15.000	124	44.81	B13w	124	1.76	B13e	123	58.07	B13s
Oregon	N	B13a	45	7.500	124	45.43	B13aw	124	2.48	B13ae	123	58.79	B13as
Oregon	N	B14	45	0.000	124	47.23	B14w	124	4.36	B14e	124	0.69	B14s
Oregon	N	B14a	44	52.500	124	48.78	B14aw	124	6.01	B14ae	124	2.34	B14as
Oregon	N	B15	44	45.000	124	50.13	B15w	124	7.46	B15e	124	3.80	B15s
Oregon	N	B15a	44	37.500	124	50.24	B15aw	124	7.66	B15ae	124	4.01	B15as
Oregon	N	B16	44	30.000	124	51.11	B16w	124	8.62	B16e	124	4.97	B16s
Oregon	N	B17	44	15.000	124	52.78	B17w	124	10.47	B17e	124	6.84	B17s
Oregon	N	B18	44	0.000	124	54.02	B18w	124	11.88	B18e	124	8.27	B18s
Oregon	N	B19	43	45.000	124	56.45	B19w	124	14.49	B19e	124	10.90	B19s
Oregon	N	B20	43	30.000	125	0.71	B20w	124	18.92	B20e	124	15.34	B20s
Oregon	N	B21	43	15.000	125	8.59	B21w	124	26.92	B21e	124	23.35	B21s
Oregon	N	B22	43	0.000	125	12.51	B22w	124	31.07	B22e	124	27.52	B22s
Oregon	N	B23	42	45.000	125	15.75	B23w	124	34.46	B23e	124	30.93	B23s
Oregon	N	B24	42	30.000	125	9.74	B24w	124	28.63	B24e	124	25.11	B24s
Oregon	N	B25	42	15.000	125	9.03	B25w	124	28.08	B25e	124	24.57	B25s
Oregon	N	B26	42	0.000	124	56.96	B26w	124	16.17	B26e	124	12.67	B26s

Table 1c. Set C

	Survey	Transect	Transect Latitude		West End			East End			Shoreline		
Location	Area	Number	Lat Deg	Lat Min	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #
Washington	N	C1	48	10.000	125	33.23	C1w	124	47.80	C1e	124	43.91	C1s
Washington	N	C1a	48	2.500	125	30.14	C1aw	124	44.81	C1ae	124	40.93	C1as
Washington	N	C2	47	55.000	125	27.35	C2w	124	42.14	C2e	124	38.27	C2s
Washington	N	C2a	47	47.500	125	17.80	C2aw	124	32.70	C2ae	124	28.83	C2as
Washington	N	C3	47	40.000	125	12.56	C3w	124	27.57	C3e	124	23.71	C3s
Washington	N	C3a	47	32.500	125	10.08	C3aw	124	25.18	C3ae	124	21.34	C3as
Washington	N	C4	47	25.000	125	8.72	C4w	124	23.94	C4e	124	20.10	C4s
Washington	N	C4a	47	17.500	125	2.94	C4aw	124	18.26	C4ae	124	14.43	C4as
Washington	N	C5	47	10.000	125	0.13	C5w	124	15.56	C5e	124	11.73	C5s
Washington	N	C5a	47	2.500	124	58.74	C5aw	124	14.26	C5ae	124	10.45	C5as
Washington	N	C6	46	55.000	124	57.35	C6w	124	12.98	C6e	124	9.18	C6s
Washington	N	C6a	46	47.500	124	53.97	C6aw	124	9.71	C6ae	124	5.91	C6as
Washington	N	C7	46	40.000	124	52.16	C7w	124	8.00	C7e	124	4.21	C7s
Washington	N	C7a	46	32.500	124	51.45	C7aw	124	7.39	C7ae	124	3.61	C7as
Washington	N	C8	46	25.000	124	51.33	C8w	124	7.37	C8e	124	3.60	C8s
Washington	N	C8a	46	17.500	124	52.19	C8aw	124	8.33	C8ae	124	4.57	C8as
Washington	N	C9	46	10.000	124	45.89	C9w	124	2.13	C9e	123	58.38	C9s
Washington	N	C9a	46	2.500	124	43.18	C9aw	123	59.52	C9ae	123	55.78	C9as
Oregon	N	C10	45	55.000	124	45.64	C10w	124	2.08	C10e	123	58.35	C10s
Oregon	N	C10a	45	47.500	124	45.21	C10aw	124	1.74	C10ae	123	58.02	C10as
Oregon	N	C11	45	40.000	124	43.51	C11w	124	0.14	C11e	123	56.43	C11s
Oregon	N	C11a	45	32.500	124	44.06	C11aw	124	0.79	C11ae	123	57.08	C11as
Oregon	N	C12	45	25.000	124	44.58	C12w	124	1.40	C12e	123	57.70	C12s
Oregon	N	C12a	45	17.500	124	44.67	C12aw	124	1.59	C12ae	123	57.90	C12as
Oregon	N	C13	45	10.000	124	44.93	C13w	124	1.94	C13e	123	58.26	C13s
Oregon	N	C13a	45	2.500	124	46.84	C13aw	124	3.94	C13ae	124	0.27	C13as
Oregon	N	C14	44	55.000	124	48.17	C14w	124	5.37	C14e	124	1.70	C14s
Oregon	N	C14a	44	47.500	124	50.64	C14aw	124	7.93	C14ae	124	4.27	C14as
Oregon	N	C15	44	40.000	124	49.91	C15w	124	7.30	C15e	124	3.65	C15s
Oregon	N	C15a	44	32.500	124	50.65	C15aw	124	8.12	C15ae	124	4.48	C15as
Oregon	N	C16	44	25.000	124	51.18	C16w	124	8.74	C16e	124	5.11	C16s
Oregon	N	C17	44	10.000	124	52.90	C17w	124	10.64	C17e	124	7.02	C17s
Oregon	N	C18	43	55.000	124	54.64	C18w	124	12.56	C18e	124	8.95	C18s
Oregon	N	C19	43	40.000	124	57.85	C19w	124	15.95	C19e	124	12.35	C19s
Oregon	N	C20	43	25.000	125	3.13	C20w	124	21.40	C20e	124	17.82	C20s
Oregon	N	C21	43	10.000	125	9.61	C21w	124	28.05	C21e	124	24.48	C21s
Oregon	N	C22	42	55.000	125	14.93	C22w	124	33.55	C22e	124	30.00	C22s
Oregon	N	C23	42	40.000	125	10.57	C23w	124	29.34	C23e	124	25.81	C23s
Oregon	N	C24	42	25.000	125	10.24	C24w	124	29.18	C24e	124	25.66	C24s
Oregon	N	C25	42	10.000	125	6.07	C25w	124	25.18	C25e	124	21.67	C25s
Oregon	N	C26	41	55.000	124	56.53	C26w	124	15.80	C26e	124	12.31	C26s

Table 1d. Set A Canadian Transects

	Survey	Transect	Transect Latitude		West End			East End			Shoreline		
Location	Area	Number	Lat Deg	Lat Min	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #
Canada	CN	cnA1	48	35.000	125	30.02	cnA1w	124	44.22	cnA1e	124	40.29	cnA1s
Canada	CN	cnA2	48	50.000	126	9.18	cnA2w	125	23.15	cnA2e	125	19.20	cnA2s
Canada	CN	cnA3	49	5.000	126	42.25	cnA3w	125	55.98	cnA3e	125	52.02	cnA3s
Canada	CN	cnA4	49	20.000	127	4.75	cnA4w	126	18.25	cnA4e	126	14.26	cnA4s
Canada	CN	cnA5	49	35.000	127	31.47	cnA5w	126	44.73	cnA5e	126	40.73	cnA5s
Canada	CN	cnA6	49	50.000	127	54.49	cnA6w	127	7.51	cnA6e	127	3.48	cnA6s
Canada	CN	cnA7	50	5.000	128	40.48	cnA7w	127	53.26	cnA7e	127	49.21	cnA7s
Canada	CN	cnA8	50	20.000	128	50.05	cnA8w	128	2.58	cnA8e	127	58.51	cnA8s
Canada	CN	cnA9	50	35.000	129	5.73	cnA9w	128	18.01	cnA9e	128	13.92	cnA9s
Canada	CN	cnA10	50	50.000	129	4.71	cnA10w	128	16.74	cnA10e	128	12.63	cnA10s
Canada	CN	cnA11	51	5.000	128	31.37	cnA11w	127	43.13	cnA11e	127	39.00	cnA11s
Canada	CN	cnA12	51	20.000	128	39.13	cnA12w	127	50.63	cnA12e	127	46.48	cnA12s
Canada	CN	cnA13	51	35.000	129	0.41	cnA13w	128	11.65	cnA13e	128	7.47	cnA13s
Canada	CN	cnA14	51	50.000	129	9.27	cnA14w	128	20.24	cnA14e	128	16.03	cnA14s
Canada	CN	cnA15	52	5.000	129	15.18	cnA15w	128	25.88	cnA15e	128	21.66	cnA15s
Canada	CN	cnA16	52	20.000	129	38.12	cnA16w	128	48.54	cnA16e	128	44.29	cnA16s
Canada	CN	cnA17	52	35.000	130	2.84	cnA17w	129	12.98	cnA17e	129	8.71	cnA17s
Canada	CN	cnA18	52	50.000	130	16.03	cnA18w	129	25.88	cnA18e	129	21.58	cnA18s
Canada	CN	cnA19	53	5.000	130	38.77	cnA19w	129	48.34	cnA19e	129	44.01	cnA19s
Canada	CN	cnA20	53	20.000	131	4.57	cnA20w	130	13.84	cnA20e	130	9.49	cnA20s
Canada	CN	cnA21	53	35.000	131	28.20	cnA21w	130	37.17	cnA21e	130	32.80	cnA21s
Canada	CN	cnA22	53	50.000	131	36.53	cnA22w	130	45.20	cnA22e	130	40.80	cnA22s
Canada	CN	cnA23	54	5.000	131	33.54	cnA23w	130	41.90	cnA23e	130	37.48	cnA23s
Canada	CN	cnA24	54	20.000	131	26.95	cnA24w	130	35.00	cnA24e	130	30.55	cnA24s
Canada	CN	cnA25	54	35.000	132	2.78	cnA25w	131	10.51	cnA25e	131	6.03	cnA25s

Table 1e. Set B Canadian Transects

	Survey	Transect	Transect Latitude		West End			East End			Shoreline		
Location	Area	Number	Lat Deg	Lat Min	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #
Canada	CN	cnB1	48	30.000	125	33.41	cnB1w	124	47.68	cnB1e	124	43.76	cnB1s
Canada	CN	cnB2	48	45.000	125	57.61	cnB2w	125	11.65	cnB2e	125	7.71	cnB2s
Canada	CN	cnB3	49	0.000	126	30.47	cnB3w	125	44.28	cnB3e	125	40.32	cnB3s
Canada	CN	cnB4	49	15.000	126	56.32	cnB4w	126	9.90	cnB4e	126	5.92	cnB4s
Canada	CN	cnB5	49	30.000	127	24.28	cnB5w	126	37.62	cnB5e	126	33.62	cnB5s
Canada	CN	cnB6	49	45.000	127	49.17	cnB6w	127	2.27	cnB6e	126	58.25	cnB6s
Canada	CN	cnB7	50	0.000	128	10.98	cnB7w	127	23.84	cnB7e	127	19.80	cnB7s
Canada	CN	cnB8	50	15.000	128	39.58	cnB8w	127	52.20	cnB8e	127	48.14	cnB8s
Canada	CN	cnB9	50	30.000	129	0.01	cnB9w	128	12.38	cnB9e	128	8.29	cnB9s
Canada	CN	cnB10	50	45.000	129	15.83	cnB10w	128	27.94	cnB10e	128	23.84	cnB10s
Canada	CN	cnB11	51	0.000	128	24.13	cnB11w	127	35.99	cnB11e	127	31.86	cnB11s
Canada	CN	cnB12	51	15.000	128	38.03	cnB12w	127	49.62	cnB12e	127	45.47	cnB12s
Canada	CN	cnB13	51	30.000	128	58.26	cnB13w	128	9.59	cnB13e	128	5.42	cnB13s
Canada	CN	cnB14	51	45.000	129	0.72	cnB14w	128	11.78	cnB14e	128	7.59	cnB14s
Canada	CN	cnB15	52	0.000	129	7.13	cnB15w	128	17.92	cnB15e	128	13.70	cnB15s
Canada	CN	cnB16	52	15.000	129	18.98	cnB16w	128	29.49	cnB16e	128	25.25	cnB16s
Canada	CN	cnB17	52	30.000	129	53.92	cnB17w	129	4.15	cnB17e	128	59.89	cnB17s
Canada	CN	cnB18	52	45.000	130	11.91	cnB18w	129	21.86	cnB18e	129	17.57	cnB18s
Canada	CN	cnB19	53	0.000	130	35.44	cnB19w	129	45.10	cnB19e	129	40.79	cnB19s
Canada	CN	cnB20	53	15.000	130	58.66	cnB20w	130	8.02	cnB20e	130	3.68	cnB20s
Canada	CN	cnB21	53	30.000	131	21.16	cnB21w	130	30.23	cnB21e	130	25.86	cnB21s
Canada	CN	cnB22	53	45.000	131	22.07	cnB22w	130	30.84	cnB22e	130	26.45	cnB22s
Canada	CN	cnB23	54	0.000	131	36.01	cnB23w	130	44.47	cnB23e	130	40.05	cnB23s
Canada	CN	cnB24	54	15.000	131	21.17	cnB24w	130	29.32	cnB24e	130	24.88	cnB24s
Canada	CN	cnB25	54	30.000	131	55.50	cnB25w	131	3.34	cnB25e	130	58.87	cnB25s

Table 1f. Set C Canadian Transects

	Survey	Transect	Transect Latitude		West End			East End			Shoreline		
Location	Area	Number	Lat Deg	Lat Min	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #	Long Deg	Long Min	Way Point #
Canada	CN	cnC1	48	25.000	125	33.09	cnC1w	124	47.44	cnC1e	124	43.52	cnC1s
Canada	CN	cnC2	48	40.000	125	40.56	cnC2w	124	54.67	cnC2e	124	50.74	cnC2s
Canada	CN	cnC3	48	55.000	126	18.86	cnC3w	125	32.75	cnC3e	125	28.80	cnC3s
Canada	CN	cnC4	49	10.000	126	51.29	cnC4w	126	4.95	cnC4e	126	0.97	cnC4s
Canada	CN	cnC5	49	25.000	127	25.40	cnC5w	126	38.82	cnC5e	126	34.83	cnC5s
Canada	CN	cnC6	49	40.000	127	43.17	cnC6w	126	56.35	cnC6e	126	52.34	cnC6s
Canada	CN	cnC7	49	55.000	128	3.03	cnC7w	127	15.97	cnC7e	127	11.94	cnC7s
Canada	CN	cnC8	50	10.000	128	42.20	cnC8w	127	54.90	cnC8e	127	50.84	cnC8s
Canada	CN	cnC9	50	25.000	128	48.14	cnC9w	128	0.59	cnC9e	127	56.51	cnC9s
Canada	CN	cnC10	50	40.000	129	12.56	cnC10w	128	24.76	cnC10e	128	20.66	cnC10s
Canada	CN	cnC11	50	55.000	128	52.06	cnC11w	128	4.00	cnC11e	127	59.88	cnC11s
Canada	CN	cnC12	51	10.000	128	39.54	cnC12w	127	51.22	cnC12e	127	47.08	cnC12s
Canada	CN	cnC13	51	25.000	128	48.18	cnC13w	127	59.60	cnC13e	127	55.43	cnC13s
Canada	CN	cnC14	51	40.000	129	2.29	cnC14w	128	13.44	cnC14e	128	9.26	cnC14s
Canada	CN	cnC15	51	55.000	129	8.30	cnC15w	128	19.18	cnC15e	128	14.97	cnC15s
Canada	CN	cnC16	52	10.000	129	24.51	cnC16w	128	35.11	cnC16e	128	30.88	cnC16s
Canada	CN	cnC17	52	25.000	129	40.03	cnC17w	128	50.36	cnC17e	128	46.10	cnC17s
Canada	CN	cnC18	52	40.000	130	8.07	cnC18w	129	18.11	cnC18e	129	13.83	cnC18s
Canada	CN	cnC19	52	55.000	130	26.33	cnC19w	129	36.09	cnC19e	129	31.78	cnC19s
Canada	CN	cnC20	53	10.000	130	52.13	cnC20w	130	1.60	cnC20e	129	57.27	cnC20s
Canada	CN	cnC21	53	25.000	131	15.43	cnC21w	130	24.60	cnC21e	130	20.24	cnC21s
Canada	CN	cnC22	53	40.000	131	18.96	cnC22w	130	27.83	cnC22e	130	23.45	cnC22s
Canada	CN	cnC23	53	55.000	131	39.54	cnC23w	130	48.10	cnC23e	130	43.69	cnC23s
Canada	CN	cnC24	54	10.000	131	45.12	cnC24w	130	53.38	cnC24e	130	48.94	cnC24s
Canada	CN	cnC25	54	25.000	131	44.31	cnC25w	130	52.25	cnC25e	130	47.79	cnC25s

Table 2. Distribution of point set sizes proposed for the 2012 Aerial Sardine Survey. Total weight is in metric tons.

Size (m^2)	Weight (mt)	Total Weight (mt)	Number of point sets
100	3.8	45.6	12
500	10.6	127.2	12
1000	17	204	12
2000	26.5	318	12
4000	51.9	622.8	12
8000	70.5	775.5	11
10000	82.1	903.1	11
		2996.2	82

Table 3. Sardine maturity codes. Source: Beverly Macewicz NMFS, SWFSC.

Female maturity codes	Male maturity codes
1. Clearly immature- ovary is very small; no oocytes present	1. Clearly immature- testis is very small thin, knifed-shaped with flat edge
2. Intermediate- individual oocytes not visible but ovary is not clearly immature; includes maturing and regressed ovaries	2. Intermediate- no milt evident and is not a clear immature; includes maturing or regressed testis
3. Active- yolked oocytes visible; any size or amount as long as you can see them with the unaided eye in ovaries	3. Active- milt is present; either oozing from pore, in the duct, or when testis is cut with knife.
4. Hydrated oocytes present; yolked oocytes may be present	

Figure 1a. Maps showing locations of transects comprising Replicate Set A

Set A: Transects 1-8

Set A: Transects 9-16

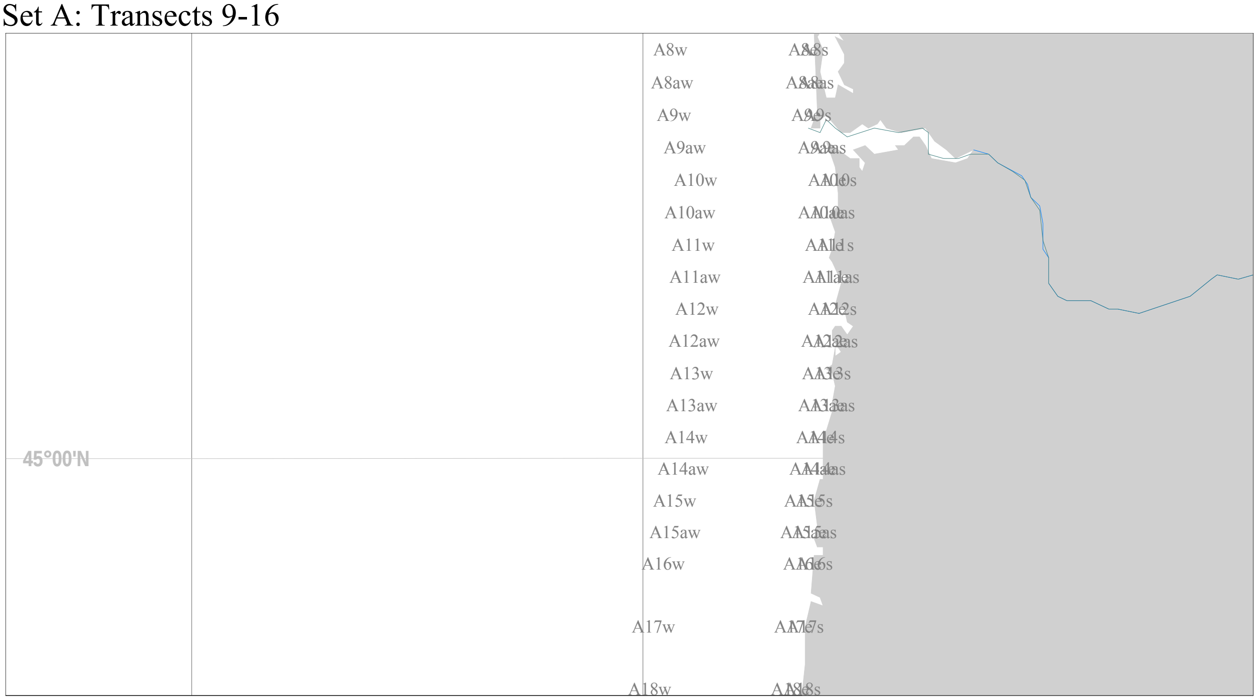


Figure 1a, Continued. Maps showing locations of transects comprising Replicate SET A

Set A: Transects 17-26

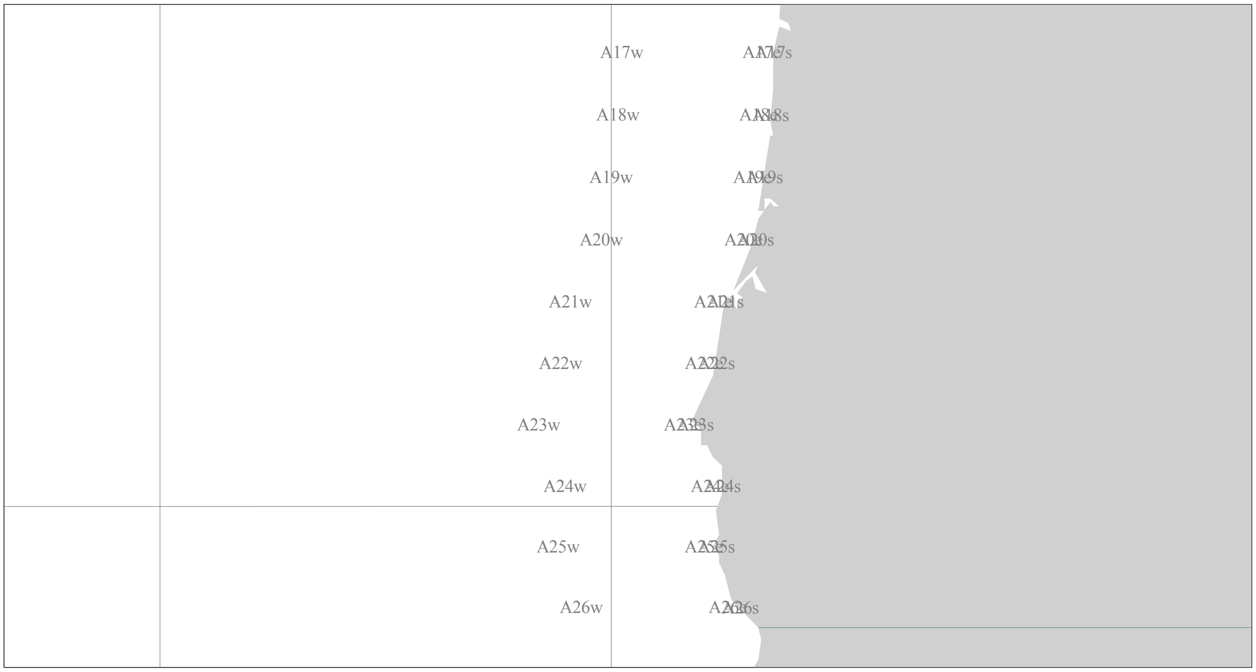


Figure 1b. Maps showing locations of transects comprising Replicate Set B

Set B: Transects 1-8

Set B: Transects 9-16

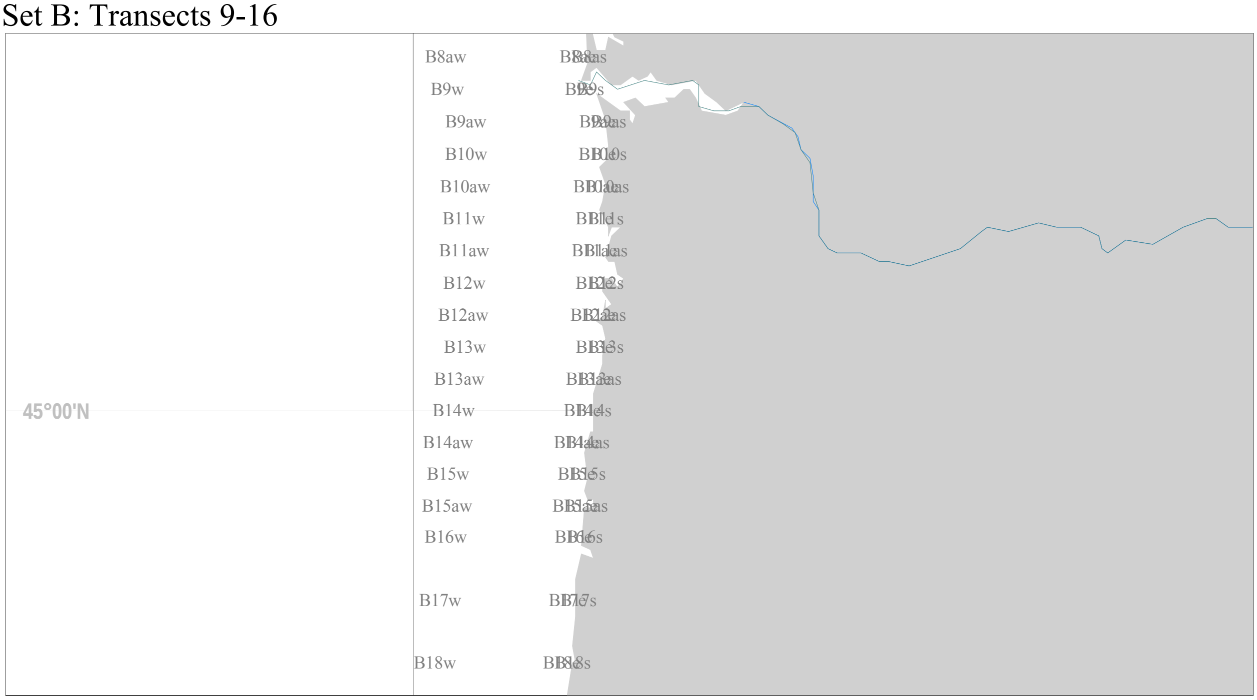


Figure 1b, Continued. Maps showing locations of transects comprising Replicate Set B

Set B: Transects 17-26

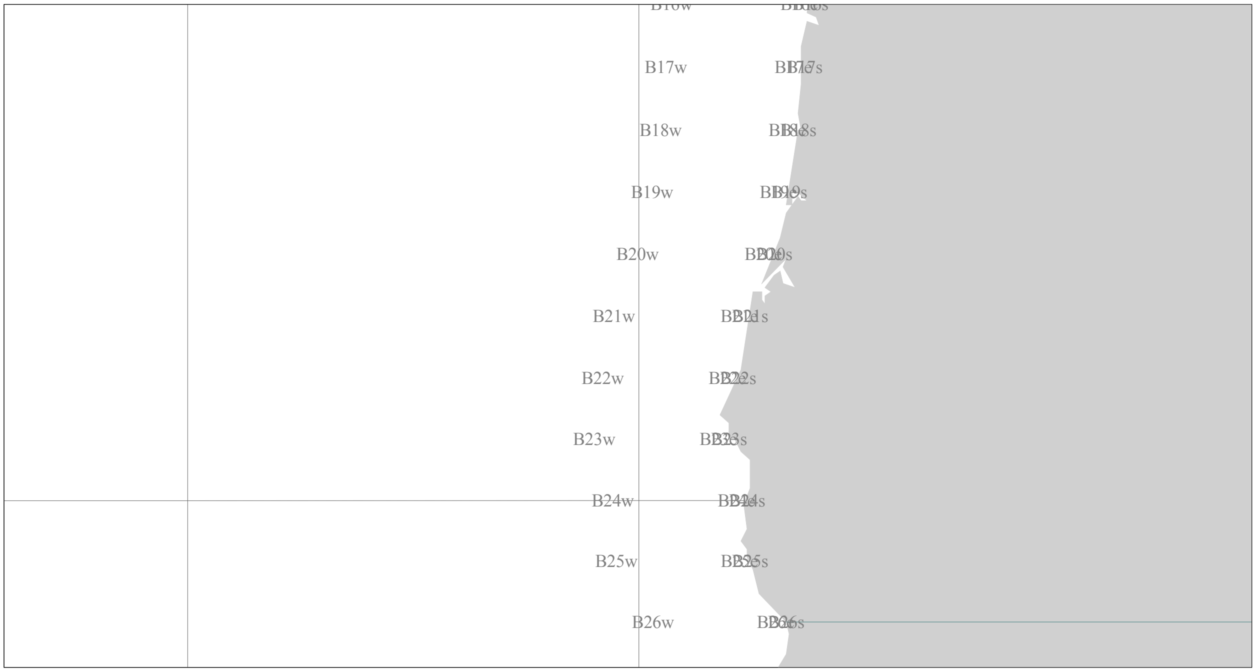
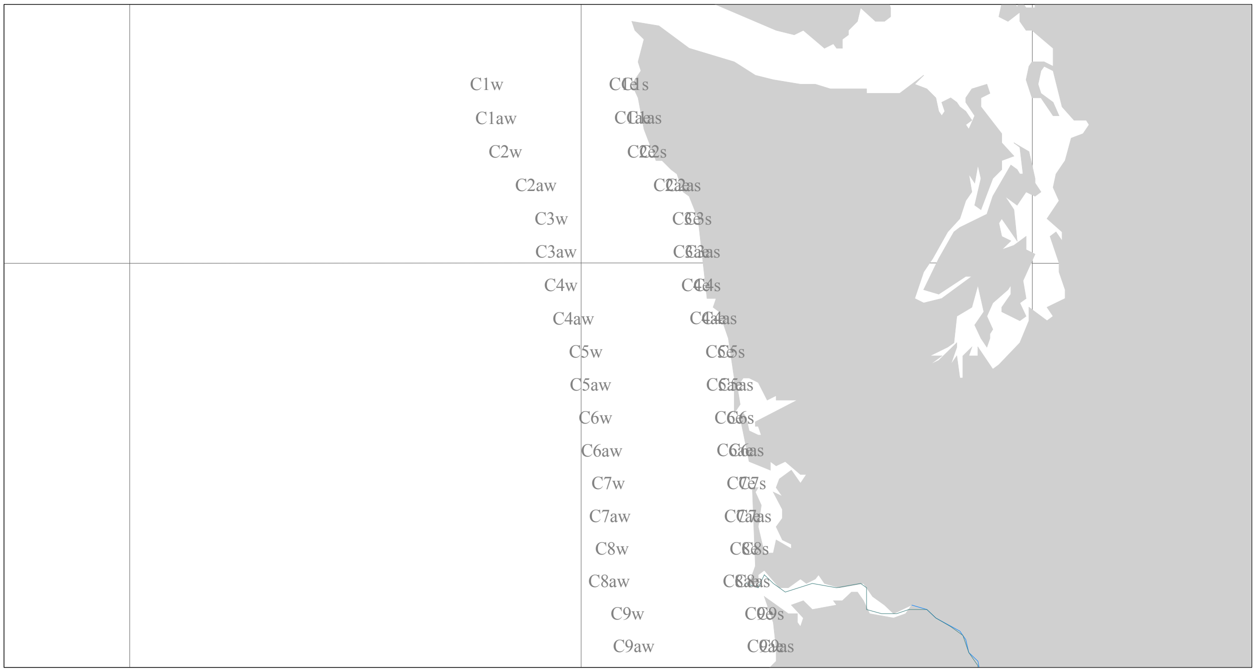


Figure 1c. Maps showing locations of transects comprising Replicate Set C

Set C: Transects 1-8



Set C: Transects 9-16

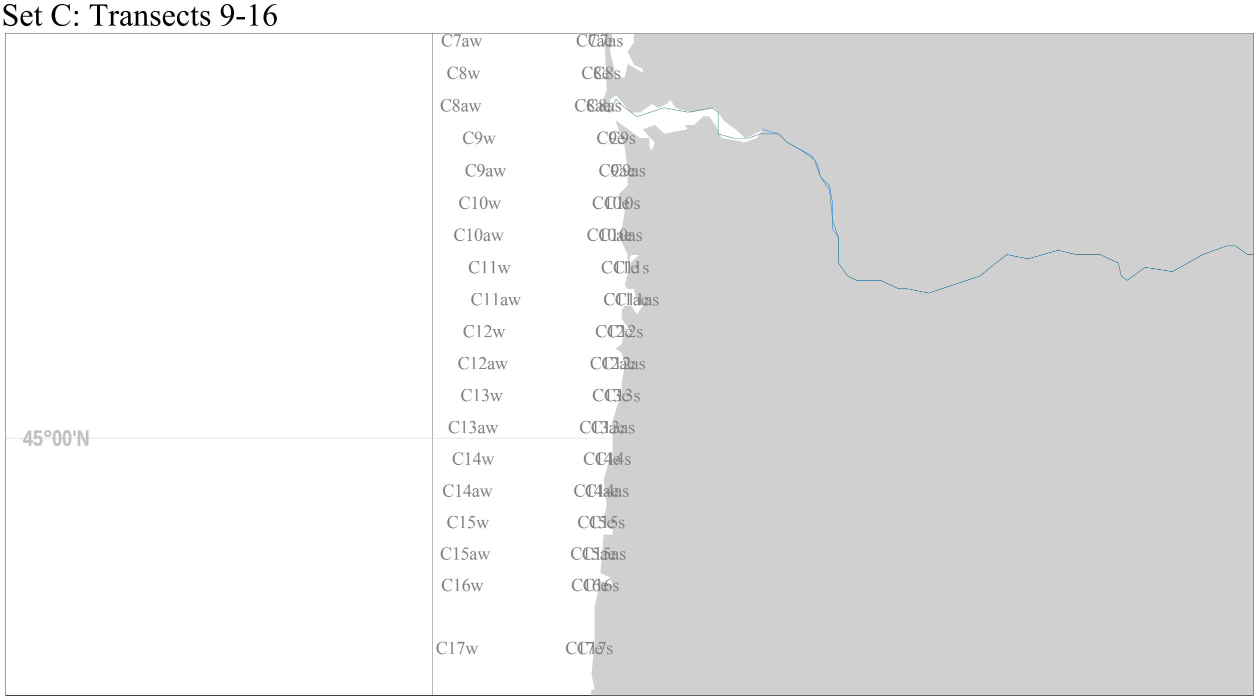


Figure 1c, Continued. Maps showing locations of transects comprising Replicate Set C

Set C: Transects 17-26

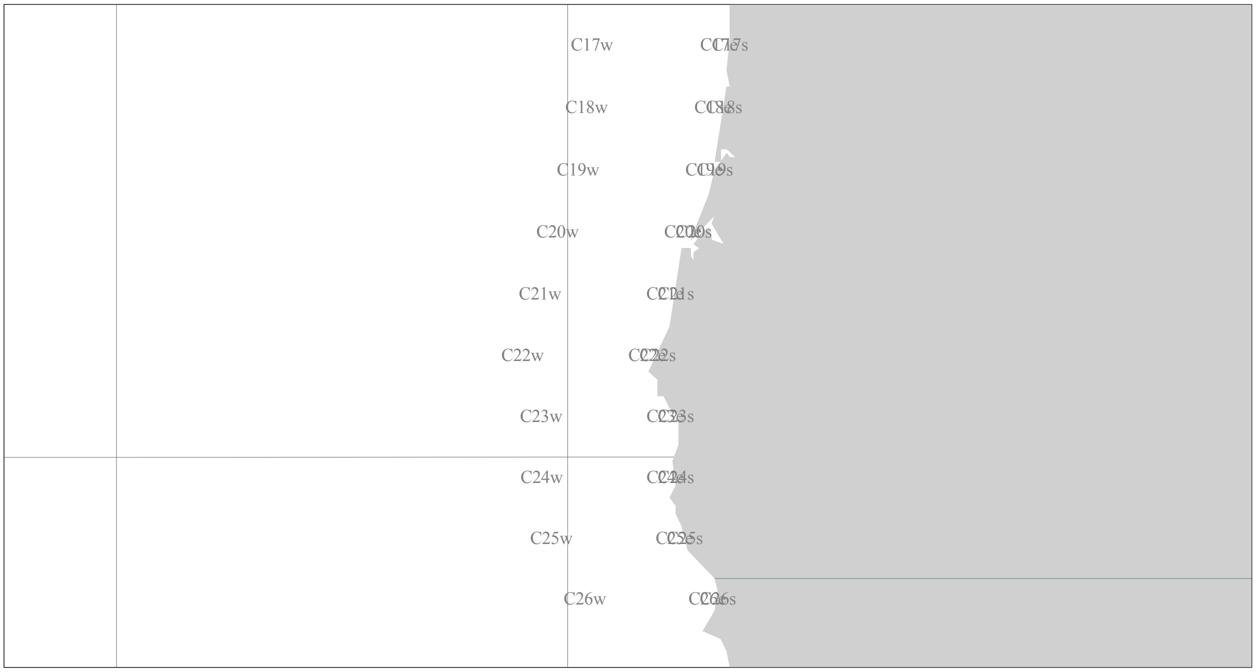
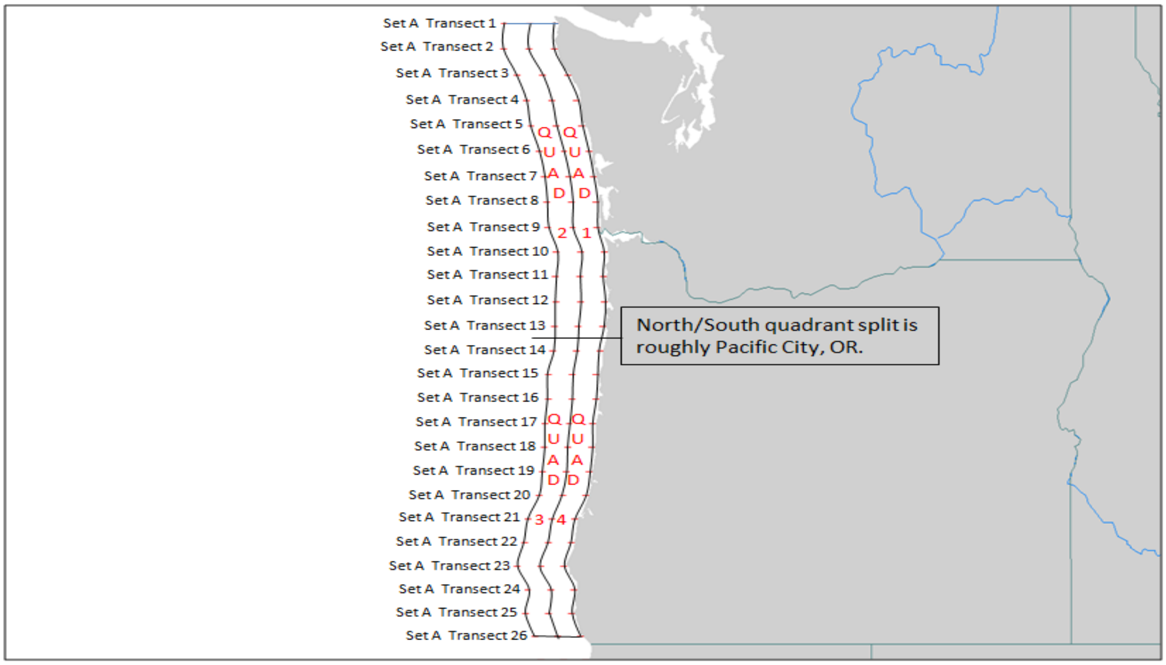
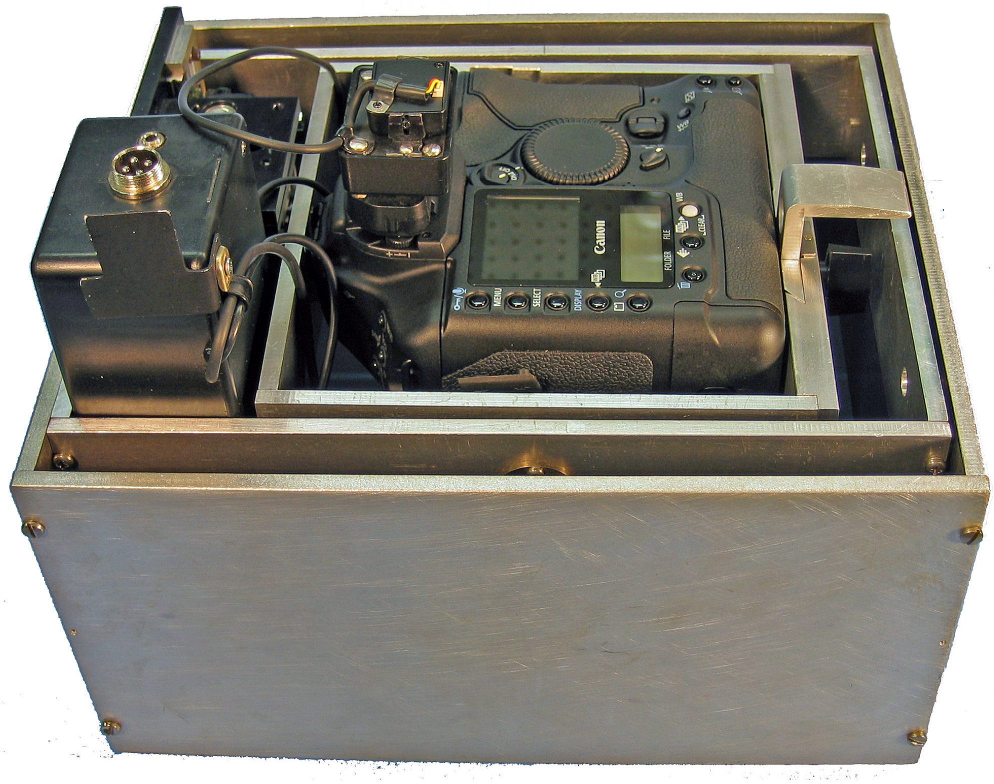


Figure 2. Maps showing quadrants for spatial distribution of point sets.



AERIAL IMAGING SOLUTIONS
FMC MOUNT SYSTEM



DESCRIPTION

An aerial mount system for digital cameras that reduces image blur caused by the forward motion of the aircraft while the shutter is open. The mount and camera are connected to, and remotely controlled by, a program running on a customer-supplied (Windows-based) computer. Flight and camera parameters entered by the computer's operator determine the required forward motion compensation (FMC) and camera firing interval. The system also takes inputs from the customer-supplied GPS and radar altimeter and will, optionally, use these data to automatically determine the required FMC and firing interval. The system includes a remote viewfinder that displays the image seen through the camera's eyepiece on a small monitor to permit the computer operator to observe camera operation to ensure successful coverage of sites. It also includes a data acquisition system that interfaces with the camera, GPS, radar altimeter, and computer to record position and altitude readings as each frame is collected.

Appendix I, Adjunct 2. Field Data Forms

West Coast Sardine Survey

Camera Settings for 1Ds Mark III (Bigger Camera)

1. Press the MENU button located in the upper left corner of the camera, just above the LCD monitor.

    a. Turn the dial on the top right of the camera, near the shutter button, to scroll left though the menu tabs at the top of the monitor.

    b. Under the Shooting 1 tab, ensure that the White balance is set to "AWB" and that the Picture style is set to "Standard."

    c. Scroll right and select the Shooting 2 tab. Under the Shooting 2 tab, set the image size to "L."

    d. Scroll right and select the Set-up 1 tab. Set Auto power off to "Off".

    e. Set File numbering to "Auto Reset".

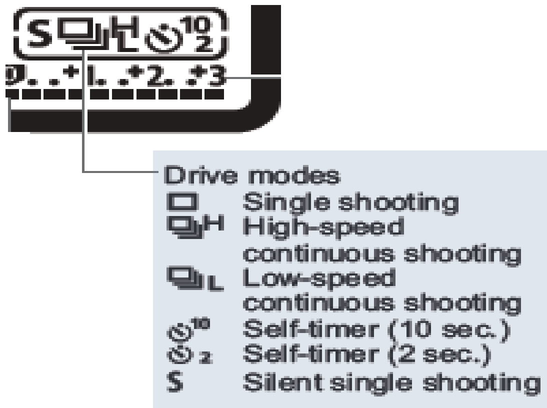
    f. Select Record Function+media/folder sel. and set the camera to "Auto switch media." Set the camera to record first to the CF memory card (card number 1).

    g. Select Live View function settings. Select Live View shoot. Select "Disable".

    h. Finally, select File name setting and change the User 1 setting to read "SP3_" for survey pilot 3, "SP4_ " for survey pilot 4, and so forth. Photos will now be numbered SPx_001, SPx_002, and so on.

2. Set the lens focus mode switch located on the side of the lens to "M" and move the focusing ring toward the camera to engage it.

3. Press the AF DRIVE button located on the top left corner of the camera. Turn the scroll wheel to set the camera to "Single Shot". The icon is a single rectangle, not "S". "S" is silent mode, which will ruin your day! See below:



4. Press the MODE button located above the AF DRIVE button and rotate the scroll wheel to set the camera to "M." Wait for the AF drive display to time out, then turn the scroll wheel to set the Aperture to "4.0." Turn the dial to set the Shutter speed to "2000."

5. Press the ISO button located adjacent to the dial and turn the scroll wheel to set the ISO Speed to "400."

6. Ensure that the 3 cables plugged into the side of the camera are securely connected. The 3 connectors are: flash sync, remote, and mini USB.

   - The flash sync connector screws in. Make sure that it is screwed in all the way. It is ok to use long nosed pliers to tighten it if your fingers are too stubby. Just be gentle.

   - The remote connector is a push-pull locking connector. Press on the top rubber part to engage it. Pull on the silver outer ring to disengage it.

   - The mini USB simply plugs in.

West Coast Sardine Survey

Camera Settings for 5D Mark II (Smaller Camera)

1. Press the MENU button located in the upper left corner of the camera, just above the LCD monitor.

    a. Turn the dial on the top right of the camera, near the shutter button, to scroll left though the menu tabs at the top of the monitor.

    b. Ensure that the White balance is set to "AWB" and that the Picture style is set to "Standard."

    c. Set the image size to "L."

    d. Set Auto power off to "Off".

    e. Set File numbering to "Auto Reset".

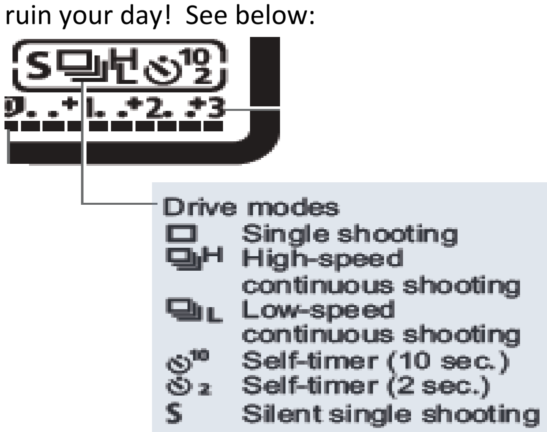
    f. Select Record Function+media/folder sel. and set the camera to "Auto switch media." Set the camera to record first to the CF memory card (card number 1).

    g. Select Live View function settings. Select Live View shoot. Select "Disable".

    h. Disable "Silent Mode" shooting.

2. Set the lens focus mode switch located on the side of the lens to "M" and move the focusing ring toward the camera to engage it.

3. Press the AF DRIVE button located on the top left corner of the camera. Turn the scroll wheel to set the camera to "Single Shot". The icon is a single rectangle, not "S". "S" is silent mode, which will ruin your day! See below:



4. Press the MODE button located above the AF DRIVE button and rotate the scroll wheel to set the camera to “M.” Wait for the AF drive display to time out, then turn the scroll wheel to set the Aperture to “4.0.” Turn the dial to set the Shutter speed to “2000.”
5. Press the ISO button located adjacent to the dial and turn the scroll wheel to set the ISO Speed to “400.”

6. Ensure that the 3 cables plugged into the side of the camera are securely connected. The 3 connectors are: flash sync, remote, and mini USB.

   - The flash sync connector screws in. Make sure that it is screwed in all the way. It is ok to use long nosed pliers to tighten it if your fingers are too stubby. Just be gentle.

   - The remote connector is a push-pull locking connector. Press on the top rubber part to engage it. Pull on the silver outer ring to disengage it.

   - The mini USB simply plugs in.

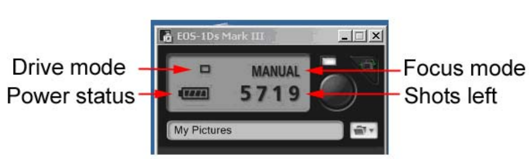
Pilot Checklist

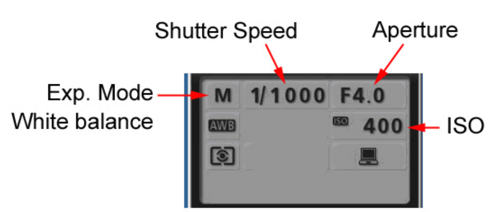
Pre-Flight

1. Check/clean the camera window
2. Check that batteries are fully charged.
3. Ensure that memory cards are installed and have sufficient space.
4. Ensure that a copy of the transect waypoint document is aboard aircraft.
5. Check GPS reading and enter waypoints if necessary.
6. Ensure that all mount system cables are properly connected.
7. Turn on camera, notebook computer, power inverter, and control unit.
8. Ensure the laptop sleep setting is set to "never."
9. Start FMC Mount, Remote Viewfinder, and EOS Utility programs on notebook computer.

   Note: make sure only one window is open for each of the previous programs, having more than one of any program open will cause problems with the camera system.
10. Adjust FMC Mount program settings, as necessary:
    - Altitude: TBD
    - Speed: TBD
    - Overlap: 80%
    - FMC: On
    - Frame count: 0 (Admin->Frame Count->ENTER "0")
11. Ensure that GPS/IMU is functioning.

    Note: the first time the GPS is used in a new location, it may take up to 25 minutes for the GPS to initialize.
12. Ensure that the camera viewfinder is displayed in the Remote Viewfinder window.
13. Check the camera settings using the EOS Utility. See below:





- Look for the rectangle for Drive mode and "MANUAL" for the Focus mode, to verify that the camera is in "Single Shot" mode and is set to manual focus.

- Verify that the Exp. Mode is "M" for manual exposure control and that the Shutter Speed, Aperture and ISO are set for proper exposure - normally, 1/2000, F4.0, and 400, respectively.

- Press "F9" in the FMC Mount program and verify that the camera fires. The frame counter in the FMC program should advance and that the Shots left indicator in the EOS Utility should subtract.

  WARNING: If the Shots left indicator in EOS Utility doesn't change when the camera fires, it indicates that the images are not being saved to the memory card in the camera. Go to "Preferences -> Remote Shooting", in EOS Utility and check the box "Save also on camera's memory card".

14. *The following may be unnecessary:*

    i. *Power OFF the mount system so that power does not spike when the airplane is started.*
    ii. *Start the airplane.*
    iii. *Power ON the mount system.*
    iv. *Verify that the on-screen GPS positions approximately match the pilot's GPS.*
    v. *Press "F9" to take a single photo and verify that all systems are working properly.*

Mid-Flight

Upon approaching the beginning of a transect/point set, press "F5" (AUTO) to begin recording. Occasionally compare the Mount System GPS positions with the pilot's GPS. Also, remember to adjust the Mount System altitude and speed settings as necessary.

Post-Flight

After landing, the survey photos and FMC datalog will need to be downloaded. Please contact Mr. Ryan Howe to coordinate the download and archive for each survey day.

West Coast Aerial Sardine Survey

Transect Flight Log Form

Date:___________ **Set:**__________ **Pilot:**_________________**Observer:**____________________ **Plane:**_________________

Transect No.	Time	Start Photo No.	Latitude/Longitude	Altitude (ft)	Species Observed	Est. Tonnage (mt)	End Photo No.

Cloud Cover code	Glare code	Beaufort Wind Scale

Comments: ____

____

Transect No.	Time	Start Photo No.	Latitude/Longitude	Altitude (ft)	Species Observed	Est. Tonnage (mt)	End Photo No.

Cloud Cover code	Glare code	Beaufort Wind Scale

Comments: ____

____

Transect No.	Time	Start Photo No.	Latitude/Longitude	Altitude (ft)	Species Observed	Est. Tonnage (mt)	End Photo No.

Cloud Cover code	Glare code	Beaufort Wind Scale

Comments: ____

____

Transect No.	Time	Start Photo No.	Latitude/Longitude	Altitude (ft)	Species Observed	Est. Tonnage (mt)	End Photo No.

Cloud Cover code	Glare code	Beaufort Wind Scale

Comments: ____

____

____

Cloud Cover code: **1**- Clear, **2**- Cloud Coverage <50%, **3**- Cloud Coverage >50%, **4**- No Visibility

Glare code: **1** - No glare, **2**- glare <50%, **3**- glare >50%, **4**- Cloud shadows <50%, **5**- Cloud shadows >50%, **6**- No visibility

Beaufort Wind Scale: Refer to attached Beaufort Wind Scale (0-12) to quantify sea state

West Coast Aerial Sardine Survey

Biological Sampling Form

Date Landed:__________ Vessel:______________________ Sample No.__________ Point Set No.____________

Date Sampled:_________ Sampler:_____________________Processor:____________ Sample Wt (kg):____________

Fish No.	Weight (g)	Std. Length (mm)	Sex (M/F)	Maturity Code	Otolith Vial No.
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Fish No.	Weight (g)	Std. Length (mm)	Sex (M/F)	Maturity Code	Otolith Vial No.
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
41					
42					
43					
44					
45					
46					
47					
48					
49					
50					

Comments:

West Coast Aerial Sardine Survey

Point Set Flight Log Form

Date:_______________ Pilot:_______________________ Plane:________________________

Processor:_______________________ Observer:____________________

Point Set No.	Time	Photo No.	Latitude/Longitude	Altitude (ft)	Vessel	Species Observed	% of School Captured	Est. school Tonnage (mt)

Comments:

Point Set No.	Time	Photo No.	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% of School Captured	Est. school Tonnage (mt)

Comments:

Point Set No.	Time	Photo No.	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% of School Captured	Est. school Tonnage (mt)

Comments

Point Set No.	Time	Photo No.	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% of School Captured	Est. school Tonnage (mt)

Comments:

Point Set No.	Time	Photo No.	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% of School Captured	Est. school Tonnage (mt)

Comments:

Point Set No.	Time	Photo No.	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% of School Captured	Est. school Tonnage (mt)

Comments:

West Coast Aerial Sardine Survey

Vessel Point Set Log

Date:_____________________________ **Captain:**____________________________

Vessel:____________________________ **Processor:**__________________________

Hydroacoustic Gear

Type	Manufact.	Model	Frequency
Sounder			
Sonar			

Net Dimensions

Net Length (fath)	Net Depth (fath)	Mesh Size

School and Ocean Data

Point Set No.	Time	Latitude	Longitude	Depth to Top of School (fath)	Depth to Bottom of School (fath)	Ocean Depth (fath)	Temp.	Weather Condition

Captains Estimate and Delivery Information / Office Use Only

Point Set No.	Species Observed	% of school captured	Est. School Tonnage (mt)	Fish Hold (FP, FS, MP, MS, AP, AS)	Other Vessel utilized: Name, est. weight, fish hold	*Delivered Weight (mt)	*Fish Ticket Number

Comments: ____

____

____

____

____

West Coast Aerial Sardine Survey
Survey Data Form Overview

The purpose of this document is to help guide us through each of the sardine survey data forms. If you are still unclear of what a field within a form is asking, please contact Mr. Ryan Howe for further clarification. Please have all survey forms completed and submitted to Mr. Howe by the end of each survey day.

Transect Flight Log Form

Aerial survey pilots will complete the Transect Flight Log Forms for each transect flown for each survey day. The information recorded on this form will help the photo analyst identify fish schools during the transect survey photo processing period, so be as detailed as possible while recording notes. *If a transect is skipped or aborted due to poor visibility or some other factor, please make a note of it on the Transect Flight Log Form and also let Mr. Howe know as early as possible.

Heading Information

- **Date** – Record the date that the transect is flown
- **Set** – Record which replicate SET is being flown
- **Pilot** – Name of pilot flying the transect
- **Observer** – Name of observer on board if any
- **Plane** – Type of aircraft flying the transect

Transect Data

- **Transect No.** – Record the transect number that is flown
- **Time** – Pilots are asked to log the time a fish school is observed along the survey transect
- **Start Photo No.** – Pilots are asked to log the photo number that corresponds with the school identified on that transect.
- **Latitude/Longitude** – Record the latitude and longitude of the school observed while flying the survey transect.
- **Altitude (ft)** – Record the altitude of the plane as it passes over the school observed
- **Species Observed –** Record the species observed on each transect. Use comments section for additional writing space as needed.
- **Estimated Tonnage (mt)** – Pilots are to estimate the observed tonnage of fish schools identified along the survey transect. If there are too many schools to estimate tonnage for each individual school, estimate the schools as a whole.
- **End Photo No**. – Pilots are asked to log the photo number that corresponds with the last school observed on that transect.

- **Cloud Cover code** – Pilots are asked to record the current cloud cover conditions while flying transects, using the following cloud cover scale: **1**- Clear, **2**- Cloud Coverage <50%, **3**- Cloud Coverage >50%, **4**- No Visibility
- **Glare code** – Pilots are asked to record the current glare conditions on the surface of the water using the following glare scale: **1**- No glare, **2**- glare <50%, **3**- glare >50%, **4**- Cloud shadows <50%, **5**- Cloud shadows >50%, **6**- No visibility
- **Beaufort Wind Scale**: Pilots are asked to refer to the Beaufort Wind Scale (0-12) to quantify sea state conditions during transect flights.
- **Comments** – Please write any additional information or notes in this section

Biological Sampling Form

Biological samples will be taken from landed point sets to collect individual fish data. This form is to be filled out by the person/s working up the biological sample. Please contact Mr. Howe with any questions or for further clarification.

Heading Information

- **Date Landed**– Record the date the point set was landed at the processing plant
- **Vessel** – Record the vessel name that delivered the point set catch
- **Sample No.** – Record the sample number consecutively as they occur during the 2011 season
- **Point Set No.** – Record the point set number that the biological sample corresponds to
- **Date Sampled** – Record the date the biological sample was worked up
- **Sampler** – Record the name of the person/s processing the biological sample
- **Processor** – Name of the fish processing plant the sample was collected at
- **Sample Wt. (kg)** – Record the total biological sample weight in kilograms

Biological Data

- **Weight (g)** – Record the individual fish weights using an electronic scale accurate to 0.5 gm
- **Standard (Std.) Length (mm)** – Record the length of each individual fish. Standard length is measured from the tip of fish snout to last vertebrae in millimeters.
- **Sex** – Record the sex of each individual fish (M = male ; F = female)
- **Maturity Code** – Record the maturity code that closely matches the maturity of the fish. Refer to Table. 3 of the Operational Plan for detailed sardine maturity codes.
- **Otolith vial No.** - The otolith vial number is determined by the following information: the point set number, fish number and the year date the otolith was collected. This information allows for easy reference to the individual fish information as needed.
  Example: Point set number 23 is being offloaded. You collect your biological sample from the processing plant. You have already determined which fish will be the otolith fish. It is a good idea to pre-label the capsules before working up the sample. So our otolith capsule would read **PS23F37-11** which again refers to **P**oint **S**et **23** and **F**ish number **37** of 50 collected in 20**11**.

- **Comments** – Please write any additional information or notes in this section.

Point Set Flight Log Form

During the survey, pilots are asked to record important point set information that will be used in the photo enhancement process. Each pilot is asked to fill out a new Point Set Flight Log Form each day point sets are attempted. The Point Set Flight Log Form allows for six point sets to be recorded on each form. Use additional Point Set Flight Log Forms as needed. Also on the form is a comments section for the pilot to include any other important details or notes.

Heading Information

- **Date** – Record the date the point sets are completed
- **Pilot** – Name of pilot setting the vessel for point sets
- **Plane** – Type of aircraft flying for point sets
- **Processor** – Name of the fish processing plant that the catch will be delivered to
- **Observer** – Name of observer onboard airplane if any

Point Set Flight Log Data

- **Point Set No.** – Number the point sets consecutively as they occur during the 2011 season
- **Time** – Record the time when the point set is attempted
- **Photo No.** - Pilots are asked to log the photo number that corresponds with the point set school that is identified and being targeted
- **Latitude/Longitude** - Record the latitude and longitude of the school being targeted for the point set
- **Altitude(ft)** – Record the altitude of the airplane for which species identification was made
- **Vessel** – Record the name of the vessel being set during each point set
- **Species Observed** – Record the species observed for each point set. Use comment section for additional writing space
- **% of School Captured** – Pilots are to estimate a percentage of point set school capture. Pilots estimated percent capture should be independent of captain's vessel estimate.
- **Estimated School Tonnage (mt)** – Pilots are to estimate the tonnage of the targeted fish school prior to setting on it.
- **Comments** – Please write any additional information or notes in this section.

Vessel Point Set Log Form

During the survey, vessel captains participating in the capture of point sets are asked to record important fish school data, ocean data, catch estimates and delivery information. Additional vessels may be utilized during point set operations, so be sure to include this information in the '**Other Vessel utilized**' field under the Captains Estimate and Delivery Information heading. If additional vessels are used to land a point set, please contact Mr. Howe.

Heading Information

- **Date** – Record the date the point set is completed
- **Vessel** – Name of the vessel participating in the point set operations (also include any additional vessels that were utilized during a point set landing)
- **Captain** – Name of the person operating the vessel
- **Processor** –Name of the processing plant the point set catch will be delivered to

Vessel Log Data

Hydro acoustic Gear

- **Manufacturer –** Record the manufacturer name of the sounder and sonar being used during point set operations
- **Model –** Record the model number or series number of the sounder and sonar being used during point set operations
- **Frequency –** Record the frequency used for both the sounder and sonar during point-set operations

Net Dimensions

- **Net Length –** Record the length of the net (in fathoms) being used during point set operations
- **Net Depth –** Record the depth of the net (in fathoms) being used during point set operations
- **Mesh size –** Record the size of the net mesh (in inches) being used during point set operations

School and Ocean Data

- **Point Set No. –** Number the point sets consecutively as they occur during the 2011 season
- **Time –** Record the time the skiff was deployed from the vessel for point set capture
- **Latitude/Longitude –**Record the positional information related to the targeted point set school
- **Depth to Top of School (fm) –** Record the distance from the water surface to the top of the targeted point set school
- **Depth to Bottom of School (fm) –** Record the distance from the water surface to the bottom of the targeted point set school
- **Ocean Depth (fm) –** Record the ocean depth at which the point set occurred
- **Temperature –** Record the temperature of the water that the point set occurred in

- **Weather Condition –** Refer to the key at the bottom of the Vessel Point Set Log form for weather codes: **1**- calm, clear, **2** - light wind, good visibility, **3** - moderate wind, fair visibility, **4 -** poor fishing conditions.

Captains Estimate and Delivery Information

- **Species Observed** – Record the species observed for each point set
- **% of School captured** – Record the percentage of school captured. The captain's estimate will be independent of the pilot's estimated percent capture.
- **Estimated School Tonnage (mt)** – Record the estimated landed weight (mt)of the targeted point set
- **Fish Hold** – Record the fish hold that the point set is being held in for delivery. Below are abbreviations to be used for identifying which hold a specific point set is being held. Of course not all vessels will have six fish holds, use the fish hold code that best represents your vessels.

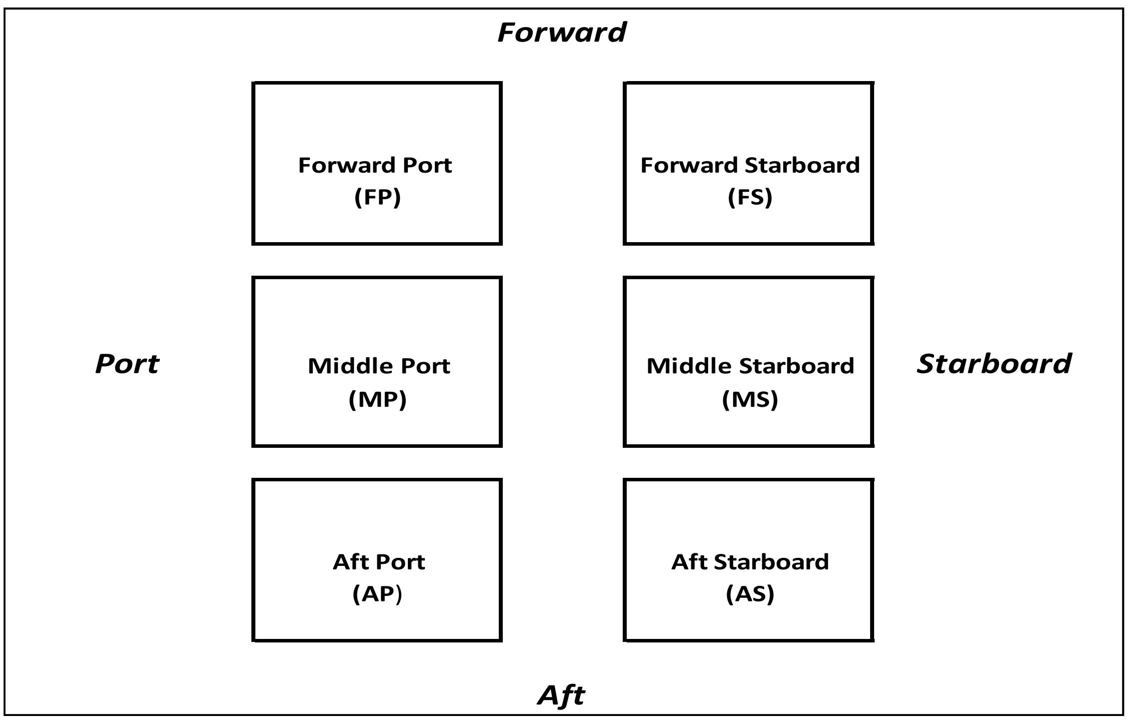


Diagram of fish hold abbreviations to be used on Fisherman's Log Form

- **Other Vessel utilized** – If an additional vessel is utilized to land a point set school, record the vessels name, estimated weight (mt) and in what holds the fish are being held. Use the comments section at the bottom of the form to report any additional information.
- ***Delivered Weight** (Office Use Only) – Leave this field blank. After the delivery is completed, the regional field coordinators will acquire this information from the processing plant manager.
- ***Fish Ticket Number** (Office Use Only) – Leave this field blank. The regional field coordinator will acquire this information from the processing plant manager.
- **Comments** – Please write any additional information or notes in this section.

Appendix I, Adjunct 3. Identification and gear configuration of participating vessels in 2012.

Vessel Name	Skipper	Owner	USGS/OR Reg#	CPS/Sardine Permit #	Length	GRT	Holds	Capacity (Tons)
Pacific Pursuit	Keith Omey	Pacific Pursuit, LLC	OR873ABY	30920	73'	86	4	80
Lauren L. Kapp	Ryan Kapp	Mt. Hood Holdings LLC	OR072ACX	57008	72'	74	4	70
Pacific Raider	Nick Jerkovich	Nick Jerkovich	972638	57010	58'	75	2	55
Pacific Journey	Leaf Nelson	Stan Nelson	OR661ZK	36106	71'	98	4	78
Evermore	Arnold Burke	Gulf Vessel Management	248555	57009	82'	120	4	50
Sunrise	Roger Smith	Sunrise Fishing, Inc.	238918	57013	80.2'	129	2	65

Appendix I, Adjunct 3a. Identification of participating sardine processors in 2012.

Fish processors in 2012 will be Astoria Holdings and Astoria Pacific.

Appendix I, Adjunct 3b. Identification of participating spotter pilots and aircraft in 2012.

Pilot ID	Pilot Name	Aircraft ID	Aircraft Type
Survey Pilot No.1 (SP1)	Frank Foode	N700AM	Cessna 336 Skymaster (twin engine)
Survey Pilot No.3 (SP3)	Pat Miller	N31B	Cessna 180

Appendix I, Adjunct 3c. Identification of photoanalysts in 2012.

Photo Analyst ID	Name
PA1	Pat McCall
PA2	Ryan Howe
PA3	Jason Tobin
PA4	Meghan Mikesell
PA5	Karen Lindsay
PA6	Amy Oppfelt
PA7	Lyle Jennings

Appendix I, Adjunct 4. Aerial Survey Point Set Protocol

1) Sardine schools to be captured for point sets will first be selected by the spotter pilot and photographed at the nominal survey altitude of 4,000 ft. If deemed necessary, and with the approval of Mr. Thon, the altitude for selection may be less than 4,000 ft. After selection, the pilot may descend to a lower altitude to continue photographing the school and setting the fishing vessel.
2) It is essential that any school selected for a point set is a discrete school and is of a size that can be captured in its entirety by the purse seine vessel; point set schools may not be a portion of a larger aggregation of fish.
3) To ensure standardization of methodology, the first set of point sets taken by each participating pilot will be reviewed to ascertain that they meet specified requirements. From that point forward, point set photos will be reviewed routinely to ensure that requirements are met.
4) A continuous series of photographs will be taken before and during the vessels approach to the school to document changes in school surface area before and during the process of point set capture. The photographs will be collected automatically by the camera set at 80% overlap.
5) Each school selected by the spotter pilot and photographed for a potential point set will be logged on the spotter pilots' Point Set Flight Log Form. The species identification of the selected school will be verified by the Captain of the purse seine vessel conducting the point set, and will be logged on the Fishermans' Log Form. These records will be used to determine the rate of school mis-identification by spotter pilots in the field. The purse seine vessel will wrap and fully capture the school selected by the spotter pilot for the point set. Any schools not "fully" captured will not be considered a valid point set for analysis.
6) If a school is judged to be "nearly completely" captured (i.e. over 90% captured), it will be noted as such and will be included for analysis. Both the spotter pilot and the purse seine vessel captain will independently make note of the "percent captured" on their survey log forms for this purpose.
7) Upon capture, sardine point sets will be held in separate holds for separate weighing and biological sampling at the dock.
8) Biological samples of individual point sets will be collected at fish processing plants upon landing. Samples will be collected from the unsorted catch while being pumped from the vessels. Fish will be systematically taken at the start, middle, and end of a delivery as it is pumped. The three samples will then be combined and a random subsample of fish will be taken. The sample size will be n = 50 fish for each point set haul.
9) Length, weight, maturity, and age structures will be sampled for each point set haul and will be documented on the Biological Sampling Form. Sardine weights will be taken using an electronic scale accurate to 0.5 gm. Sardine lengths will be taken using a millimeter length strip provided attached to a measuring board. Standard length will be determined by measuring from sardine snout to the last vertebrae. Sardine maturity will be established by referencing maturity codes (female- 4 point scale, male- 3 point scale). Otolith samples will be collected from n = 25 fish selected at random from each n = 50 fish point set sample for future age reading analysis. Alternatively, the 25 fish subsample

may be frozen (with individual fish identified as to sample number, point set, vessel and location captured, to link back to biological data) and sampled for otoliths at a later date.

10) School height will be measured for each point set. This may be obtained by using either the purse seine or other participating research vessels' hydroacoustic gear. The school height measurements to be recorded on the Fishermans' Log Form are: 1) depth in the water column of the top of the school, and 2) depth in the water column of the bottom of the school. Simrad ES-60 sounders will be installed on two purse seine vessels. Data collected by the ES-60 sounders will be backed-up daily and archived onshore.
11) Point sets will be conducted for a range of school sizes. Point sets will be targeted working in general from the smallest size category to the largest. The field director will oversee the gathering of point set landing data and will update the list of point sets needed (by size) daily for use by the spotter pilot. Each day, the spotter pilot will operate with an updated list of remaining school sizes needed for analysis. The spotter pilot will use his experience to judge the surface area of sardine schools from the air, and will direct the purse seine vessel to capture schools of the appropriate size. Following landing of the point sets at the dock, the actual school weights will be determined and the list of remaining school sizes needed will be updated accordingly for the next day of fishing. If schools are not available in the designated size range, point sets will be conducted on schools as close to the designated range as possible. Pumping large sets onto more than one vessel should be avoided, and should only be done in the accidental event that school size was grossly underestimated.
12) The Scientific Field Project Leader will also oversee the spatial distribution of point set sampling, to ensure adequate dispersal of point set data collection.
13) Photographs and FMCdatalogs of point sets will be forwarded from the field to Mr. Howe daily.
14) The total landed weight of point sets taken will not exceed the EFP allotment.
15) The following criteria will be used to exclude point sets from the density analysis (reasons used to deem a point set "unacceptable"). Mr. Howe will make the final determination of point set acceptability in the lab. A preliminary judgment will be made in the field, generally at the end of each day (or sooner), to ensure ongoing sampling is being properly accomplished.

1	Percent captured	School is judged to be less than 90% captured
2	No photograph -1	No photograph of vessel was documented (camera off)
3	No photograph -2	No photograph of vessel was documented (camera on)
4	No photograph -3	Photograph available, but late (vessel is already pursing the catch)
5	School not discrete	Sardine captured was only a portion of a larger school ("cookie cutter")
6	Mixed hauls	Multiple point sets were mixed in one hold

Appendix II. R algorithms used for calculating survey statistics.

```
#SetB2012s1: Computes biomass and CV estimate for Set B of the 2012 Survey
# [Stratum 1 (Transects 1-16)]
# Bootstraps two readings of school size
# Covariance on pointset data obtained from library 'MSVBAR'
cdata <- read.csv(file="cdata2012.csv")    #file of point set data

#Transects 1-16

transectdata <- read.csv(file="transectdata2012setbS1R1.csv")
#file of transect surface area data , Transects 1-16, reading 1
transectdata2 <- read.csv(file="transectdata2012setbS1R2.csv")
#file of transect surface area data , Transects 1-16, reading 2

 setb2012s1 = function(nboots,cdata,transectdata,transectdata2){
  #define function to convert area to bms - yint = y intercept
  #asymp = asymptote as x->infty, asymp/c = slope at orgin
  convert = function(yint, asymp, cc, x) {
    return((yint*cc+asymp*x)/(cc+x))}
  #control parameters for nonlinear fitting
  nls.control(maxiter = 5000,tol = 2e-6)
  ntransects <- 31
  xpanfactor  <- 229
  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 point set data
  plot(ObsDens~Area,data=cdata,ylab="Metric Tons/Sq Meter",
     xlab="Area (Sq Meters)",pch=19)
```

Appendix II, continued.

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

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

  #calculate total bms - reading 1
  tbmsR1 = xpanfactor*sum(transectbms1)/ntransects
  #calculate total bms - reading 2
  tbmsR2 = xpanfactor*sum(transectbms1R2)/ntransects
  tbms0 = (tbmsR1+tbmsR2)/2
  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)
```

Appendix II, continued.

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

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

    #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

    #calculated bms of this bootstrap
    bms[i] <- xpanfactor*sum(retransect)/ntransects
   }
   write.csv(bms,file="S1bms.csv")
   windows()
   #histogram of bootstrapped biomasses
   hist(bms,breaks=20,density=10,col='dark blue')
   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)

}
```

Appendix II, continued.

#SetB2012s2: Computes biomass and CV estimate for Set B of the 2012 Survey
[Stratum 2 (Transects 17-26)]

```
# Bootstraps two readings of school size
# Covariance on pointset data obtained from library 'MSVBAR'
cdata <- read.csv(file="cdata2012.csv")  #file of point set data

#Transects 17-26
#file of transect surface area data , Transects 17-26, reading 1
transectdata <- read.csv(file="transectdata2012setbS2R1.csv")
#file of transect surface area data , Transects 17-26, reading 2
transectdata2 <- read.csv(file="transectdata2012setbS2R2.csv")

 setb2012s2 = function(nboots,cdata,transectdata,transectdata2){
  #defines function to convert area to bms - yint = y intercept
  #asymp = asymptote as x->infty, asymp/c = slope at orgin
  convert = function(yint, asymp, cc, x) {
    return((yint*cc+asymp*x)/(cc+x))}
  #control parameters for nonlinear fitting
  nls.control(maxiter = 5000,tol = 2e-6)
  ntransects <- 10
  xpanfactor  <- 137
  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
```

Appendix II, continued.

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

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

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

write.csv(transectbms1,file="bmsStratum2Reading1.csv")
write.csv(transectbms1R2,file="bmsStratum2Reading2.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)

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

Appendix II, continued.

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

 #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

 #calculated bms of this bootstrap
 bms[i] <- xpanfactor*sum(retransect)/ntransects
}
write.csv(bms,file="S2bms.csv")
windows()
#histogram of bootstrapped biomasses
hist(bms,breaks=20,density=10,col='dark blue')
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)

}
```

Appendix II, continued.

#SetB2012t: Computes CV of TOTAL biomass estimate
#for Set B of the 2012 Survey
[Stratum 1 plus Stratum 2]

```
# Collects bootstrap estimates of biomass for Stratum 1 and Stratum 2
# Computes CV for the total estimate of biomass

# tbms0 is the sum of point estimates for stratum 1 and stratum 2
tbms0 = 906680.0
#files with bootstrap biomass estimates
Stratum1bms <- read.csv(file="S1bms.csv")
Stratum2bms <- read.csv(file="S2bms.csv")
Totalbms = Stratum1bms$x + Stratum2bms$x
#write.csv(Totalbms,file="TotS1S2bms.csv")
#print(paste("TotS1S2bms = ", Totalbms))
print(Totalbms)
print(paste("SE = ",round(sd(Totalbms,na.rm=TRUE))),quote=F)
print(paste("CV = ",round(sd(Totalbms,na.rm=TRUE))/tbms0), quote=F)
#
```

ASSESSMENT OF THE PACIFIC SARDINE RESOURCE IN 2012 FOR U.S. MANAGEMENT IN 2013

(EXECUTIVE SUMMARY)

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EXECUTIVE SUMMARY

Stock

The Pacific sardine (*Sardinops sagax caerulea*) ranges from southeastern Alaska to the Gulf of California, México, and is thought to comprise three subpopulations. In this assessment, we modeled the hypothesized northern subpopulation which ranges seasonally from northern Baja California, México, to British Columbia, Canada, and up to 300 nm offshore. All U.S., Canada, and México (Ensenada) landings were assumed to be taken from this single northern stock. Future modeling efforts will explore a scenario where Ensenada and San Pedro catches are parsed into the northern and southern stocks using some objective criteria.

Catches

The assessment includes sardine landings from six major fishing regions: Ensenada (ENS), southern California (SCA), central California (CCA), Oregon (OR), Washington (WA), and British Columbia (BC).

Calendar year	ENS	SCA	CCA	OR	WA	BC	Total
2000	67,845	46,835	11,367	9,529	4,765	1,721	142,063
2001	46,071	47,662	7,241	12,780	10,837	1,266	125,857
2002	46,845	49,366	14,078	22,711	15,212	739	148,952
2003	41,342	30,289	7,448	25,258	11,604	978	116,919
2004	41,897	32,393	15,308	36,112	8,799	4,438	138,948
2005	55,323	30,253	7,940	45,008	6,929	3,232	148,684
2006	57,237	33,286	17,743	35,648	4,099	1,575	149,588
2007	36,847	46,199	34,782	42,052	4,663	1,522	166,065
2008	66,866	31,089	26,711	22,940	6,435	10,425	164,466
2009	55,911	12,561	25,015	21,482	8,025	15,334	138,328
2010	56,821	29,352	4,306	20,852	12,381	22,223	145,935
2011	70,336	17,642	10,072	11,023	8,008	20,719	137,801

Data and assessment

The assessment update was conducted using 'Stock Synthesis' version 3.21d and includes fishery and survey data collected from mid-1993 through mid-2012. The model is based on a July-June 'model year,' with two semester-based seasons per year (S1=Jul-Dec and S2=Jan-Jun). Catches and biological samples for the fisheries off Ensenada, southern and central California are pooled into a single 'MexCal' fleet, in which selectivity is modeled separately for each season (S1 and S2). Catches and biological samples from Oregon, Washington, and British Columbia were modeled as a single 'PacNW' fleet. Four indices of relative abundance from ongoing surveys were included in the base model: daily and total egg production estimates of spawning stock biomass off California (1994-2012), NWSS aerial survey estimates of biomass off Oregon and Washington (2009-2012), and acoustic-trawl method (ATM) estimates of biomass along the west coast (2006-2012). The catchability coefficient (q) for the ATM survey was fixed to a value of 1, with other survey qs freely estimated.

The following data were appended to the update model:

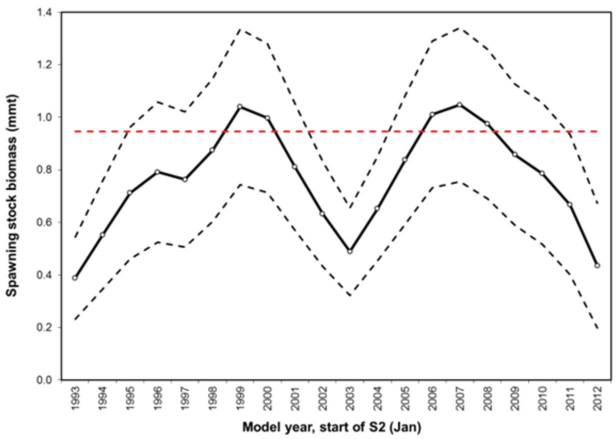
- Landings for 2010 and 2011 were replaced with final numbers for all fishing regions (ENS to BC).

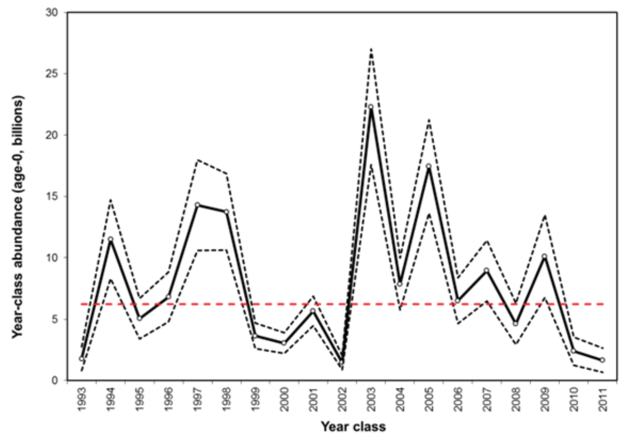
- Landings for 2012 were based on current information (year-to-date) and forecasted through the end of 2012 for fisheries from CA to BC. The ENS catch for 2012 was not available, so was assumed identical to 2011 tonnage.
- Length compositions from CA, OR, WA, and BC fisheries were updated and appended for model year 2011 and the first semester of model year 2012 (July-August 2012 samples). New length data were not available from the ENS fishery.
- Conditional age-at-length data from CA, OR, and WA were appended to model year 2011.
- Addition of the DEPM estimate of SSB from the spring 2012 survey off California.
- Addition of two ATM survey estimates of biomass from (1) the spring 2012 survey off California and (2) the summer 2012 coastwide survey (San Diego to Vancouver Island).
- Addition of the NWSS aerial survey biomass for summer 2012 (point sets pooled across survey years).

Spawning stock biomass and recruitment

Recruitment was modeled using the Ricker stock-recruitment relationship (σ_R=0.727). The estimate of steepness was high (h=2.79), and virgin recruitment (R_0) was estimated to be 6.22 billion age-0 fish. Virgin SSB was estimated to be 0.946 mmt. Spawning stock biomass (SSB) increased throughout the 1990s, peaking at 1.039 mmt in 1999 and 1.047 mmt in 2007. Recruitment (year-class abundance) peaked at 14.3 billion fish in 1997, 22.3 billion in 2003, 17.4 billion in 2005, and 10.1 billion in 2009. The 2010 and 2011 year classes were the weakest in recent history.

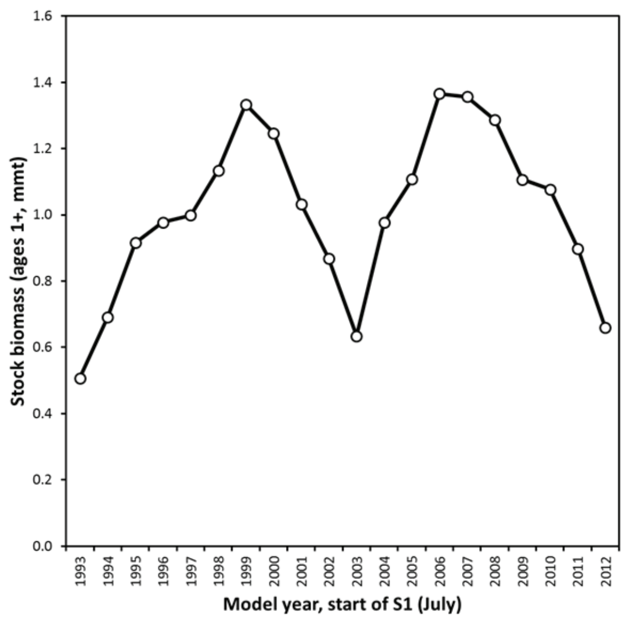
Model year	SSB (mt)	SSB Std Dev	Year class abundance (billions)	Recruits Std Dev
2000	996,883	142,069	3.050	0.423
2001	810,236	120,420	5.669	0.607
2002	632,173	99,976	1.469	0.289
2003	488,308	83,379	22.302	2.359
2004	651,419	99,112	7.863	1.054
2005	837,694	122,477	17.443	1.894
2006	1,010,840	139,967	6.505	0.931
2007	1,047,250	146,350	8.956	1.232
2008	974,298	142,150	4.621	0.836
2009	857,618	134,408	10.123	1.687
2010	785,170	135,020	2.396	0.568
2011	667,141	133,182	1.655	0.494
2012	435,351	118,835	---	---





Stock biomass

Stock biomass, used for calculating harvest specifications, is defined as the sum of the biomass for sardine aged 1 and older. Stock biomass increased rapidly throughout the 1990s, peaking at 1.33 mmt in 1999 and 1.37 mmt in 2006. Stock biomass was estimated to be 659,539 mt as of July 2012.



Exploitation status

Exploitation rate is defined as calendar year catch divided by total mid-year biomass (July-1, ages 0+). U.S. and total exploitation rates are as follows:

Calendar year	U.S.	Total
2000	5.68%	11.13%
2001	7.21%	11.56%
2002	11.48%	16.87%
2003	8.73%	13.68%
2004	8.78%	13.17%
2005	7.04%	11.61%
2006	6.35%	10.46%
2007	8.83%	11.49%
2008	6.54%	12.34%
2009	5.56%	11.47%
2010	6.08%	13.26%
2011	5.11%	15.07%

Harvest control rules

Harvest guideline

Using results from the update model 'X6e', the harvest guideline (HG) for the U.S. fishery in calendar year 2013 is 66,495 mt. The harvest control rule defined in Amendment 8 of the CPS-FMP was used to calculate the HG for 2013 (PFMC 1998). The HG is calculated as follows:

$$HG_{2013} = (BIOMASS_{2012} - CUTOFF) \bullet FRACTION \bullet DISTRIBUTION;$$

where HG_{2013} is the total U.S. (California, Oregon, and Washington) quota for 2013, $BIOMASS_{2012}$ is the estimated July 1, 2012 stock biomass (ages 1+) from the assessment (659,539 mt), CUTOFF (150,000 mt) is the lowest level of estimated biomass at which harvest is allowed, FRACTION (15%) is the percentage of biomass above the CUTOFF that can be harvested by the fisheries, and DISTRIBUTION (87%) is the average portion of BIOMASS assumed in U.S. waters. The U.S. HGs and catches since 2000 are displayed below. The HG for 2013 represents a 40% reduction from the 2012 HG.

OFL and ABC

The Magnuson-Stevens Reauthorization Act requires fishery managers to define an overfishing limit (OFL), allowable biological catch (ABC), and annual catch limit (ACLs) for species managed under federal FMPs. By definition, ABC must always be lower than the OFL based on uncertainty in the assessment approach. The PFMC's SSC recommended the '*P**' approach for buffering against scientific uncertainty when defining ABC, and this approach was adopted under Amendment 13 to the CPS-FMP.

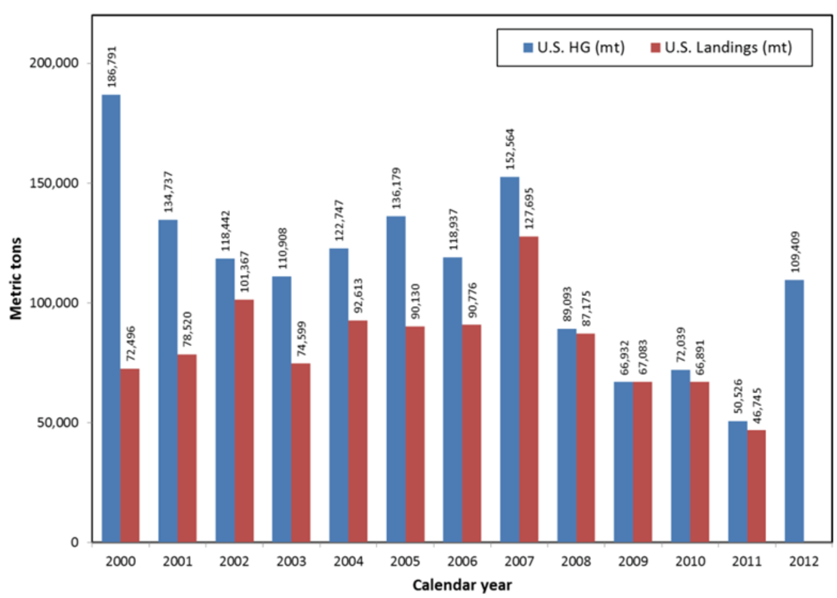
The estimated biomass of 659,539 mt (ages 1+), an F_{MSY} proxy of 0.18, and an estimated distribution of 87% of the stock in U.S. waters resulted in a U.S. OFL of 103,284 mt for 2013. For Pacific sardines, the Scientific and Statistical Committee (SSC) has recommended that scientific uncertainty (σ) be set to the maximum of either (1) the CV of the biomass estimate for the most recent year or (2) a default value of 0.36, which was based on uncertainty across full assessment models. The terminal year biomass CV was equal to 0.273 (σ =0.268); therefore σ

remained at the default value of 0.36. The Amendment 13 ABC buffer depends on the probability of overfishing (P^*) level chosen by the Council. Uncertainty buffers and ABCs associated with a range of discreet P^* values are presented in the table below.

Harvest Formula Parameters	Value			
BIOMASS (ages 1+, mt)	659,539			
Pstar (probability of overfishing)	0.45	0.40	0.30	0.20
$BUFFER_{Pstar}$ (Sigma=0.36)	0.95577	0.91283	0.82797	0.73861
F_{MSY}	0.18			
FRACTION	0.15			
CUTOFF (mt)	150,000			
DISTRIBUTION (U.S.)	0.87			

Amendment 13 Harvest Formulas	MT
OFL = BIOMASS * F_{MSY} * DISTRIBUTION	103,284
$ABC_{0.45}$ = BIOMASS * $BUFFER_{0.45}$ * F_{MSY} * DISTRIBUTION	98,716
$ABC_{0.40}$ = BIOMASS * $BUFFER_{0.40}$ * F_{MSY} * DISTRIBUTION	94,281
$ABC_{0.30}$ = BIOMASS * $BUFFER_{0.30}$ * F_{MSY} * DISTRIBUTION	85,515
$ABC_{0.20}$ = BIOMASS * $BUFFER_{0.20}$ * F_{MSY} * DISTRIBUTION	76,287
HG = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION	66,495

Management performance
U.S. HGs and catches since the onset of federal management are as follows:



Unresolved problems and major uncertainties

The SSC CPS-Subcommittee review focused on two areas of uncertainty in the assessment update: (1) a proposed change to the number of recruitment deviations estimated in the model; and (2) the appropriateness of the 2012 NWSS aerial survey estimate in the current model.

Estimation of recruitment deviations

Upon addition of size composition data to the update model, a noticeable change occurred in both the scale and trend of biomass and recruitments throughout the time series, with both estimated lower in the first half of the time series and higher in the latter half. This change persisted with the addition of other data, and was accompanied by a shift in the trend of recruitment deviations and a loss of fit to survey time series. To evaluate this change, the number of recruitment deviations being estimated in the model was profiled for end-year -0 to -3 years. The default setting in the update model was end-year -2, while previous assessments had estimated deviations through end-year -1.

There was a clear difference in recruitment deviation trends for models with end-year -0 or -1 compared to those with end-year -2 or -3. The difference was also obvious for recruitment and stock biomass estimates, where models for end-year -2 or -3 had noticeably lower estimates in earlier years and higher estimates for the final six years in comparison to models with end-year -0 or -1. Examination of log deviations [ln(Obs)-ln(Exp)] for modeled survey time series indicated degraded fits to the DEPM, aerial, and ATM time series when recruitments were estimated through end-year -2 or -3 compared to end-year -0 or -1.

To address this problem, the stock assessment team (STAT) strongly recommended returning to past practice of estimating recruitment deviations to end-year -1 instead of -2. While this resulted in a minor change to update model parameterization, the STAT considered this change necessary to correct a problem that was unknowingly introduced in the 2011 assessment model (Hill et al. 2011). The CPS-Subcommittee agreed to this proposed change during the review, so it was carried forward in update model 'X6e'.

2012 NWSS aerial survey

The 2012 aerial survey suffered from lack of representative point sets to inform the relationship between surface area and biomass. The number of acceptable point sets was smaller than usual (n=14), and there was no overlap between the conductance of aerial transects (stage 1) and point set sampling (stage 2). Moreover, the spatial representation of acceptable point sets was inadequate relative to the spatial distribution of sardine observed in the photographs. For these reasons, NWSS survey scientists proposed using a biomass estimate based on point set data pooled across survey years instead of year-specific point sets. Following critical discussion, the review panel concurred, and the STAT agreed (with reservations), to include the estimate based on point sets pooled across years in the update model (X6e) rather than discarding the 2012 aerial estimate in its entirety.

Research and data needs

The following model-related research recommendations are excerpted from reports of the 2011 and 2012 assessment reviews.

- Explore use of Canada DFO's mid-water trawl survey off Vancouver Island.
- Temperature-at-catch could provide insight into stock structure and the appropriate catch stream to use for assessments, because the southern subpopulation is thought to inhabit warmer water than the northern subpopulation. Conduct tests of sensitivity to alternative assumptions regarding the fraction of the MexCal (in particular, Ensenada and Southern California) catch that comes from the northern subpopulation.
- Explore models that consider a much longer time-period (e.g. 1931 onwards) to determine whether it is possible to model the protracted period and determine whether this leads to a more informative assessment and provides a broader context for evaluating changes in productivity.
- Consider a scenario that explicitly models the sex-structure of the population and the catch.
- Reconsider a model that has separate fleets for Mexico, California, Oregon-Washington and Canada.
- Develop a relationship between egg production and age that accounts for the duration of spawning, batch fecundity, etc. by age.
- Consider model configurations that use age compositions rather than length compositions and conditional age-at-length data, given evidence for time- and spatially-varying growth.
- Explore reasons for the discrepancy between the observed and expected proportions of old animals in the length and age compositions. Possible factors to consider in this investigation include ageing error / ageing bias and the way dome-shaped selectivity has been parameterized.
- Consider a Beverton-Holt or other spawner-recruit relationship in place of the Ricker to see if such a change will stabilize the model relative to the number of recent years of recruitments estimated, while providing a biologically realistic relationship.
- Consider the changes within and between years regarding targeting in developing appropriate fishery selectivities, as well as proper blockings and/or weighting of these data.
- Conduct a methods review to consider how best to use data from the aerial survey. Consider incorporating the aerial survey as a minimum estimate of total abundance.

ACRONYMS AND ABBREVIATIONS

ABC	acceptable biological catch
ALK	age-length key
ATM	Acoustic-trawl method
BC	British Columbia (Canada)
CA	California
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CCA	Central California fishery
CDFG	California Department of Fish and Game
CDFO	Canada Department of Fisheries and Oceans
CICIMAR	Centro Interdisciplinario de Ciencias Marinas
CONAPESCA	National Commission of Aquaculture and Fishing (México)
CPS	Coastal Pelagic Species
CPSAS	Coastal Pelagic Species Advisory Subpanel
CPSMT	Coastal Pelagic Species Management Team
CV	coefficient of variation
DEPM	Daily egg production method
ENS	Ensenada (México)
FMP	fishery management plan
HG	harvest guideline
INAPESCA	National Fisheries Institute (México)
Model Year	July 1 (year) to June 30 (year+1)
mt	metric tons
mmt	million metric tons
MexCal	southern 'fleet' based on ENS, SCA, and CCA fishery data
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
ODFW	Oregon Department of Fish and Wildlife
OFL	overfishing limit
OR	Oregon
PacNW	northern 'fleet' based on OR, WA, and BC fishery data
PFMC	Pacific Fishery Management Council
S1 & S2	Model Season 1 (Jul-Dec) and Season 2 (Jan-Jun)
SCA	Southern California fishery
SS	Stock Synthesis
SSB	spawning stock biomass
SSC	Scientific and Statistical Committee
SST	sea surface temperature
STAR	Stock Assessment Review
STAT	Stock Assessment Team
SWFSC	Southwest Fisheries Science Center
TEP	Total egg production
WA	Washington
WDFW	Washington Department of Fish and Wildlife

ASSESSMENT OF THE PACIFIC SARDINE RESOURCE IN 2012 FOR U.S. MANAGEMENT IN 2013

K.T. Hill, P.R. Crone, N.C.H. Lo, D.A. Demer, J.P. Zwolinski, and B.J. Macewicz
Fisheries Resources Division
Southwest Fisheries Science Center
NOAA National Marine Fisheries Service

Update Data & Model Change

Fishery data:

- Landings for 2010 and 2011 updated with final data; 2012 landings were based on information-to-date, forecast to year-end. ENS data not available for 2012, so assumed identical to 2011 landings;
- Length compositions from CA, OR, WA, and BC were updated (2011-1) and appended (2011-2 & 2012-1). New ENS length data not available since 2009;
- Conditional age-at-length (CA, OR, & WA) appended for model year 2011.

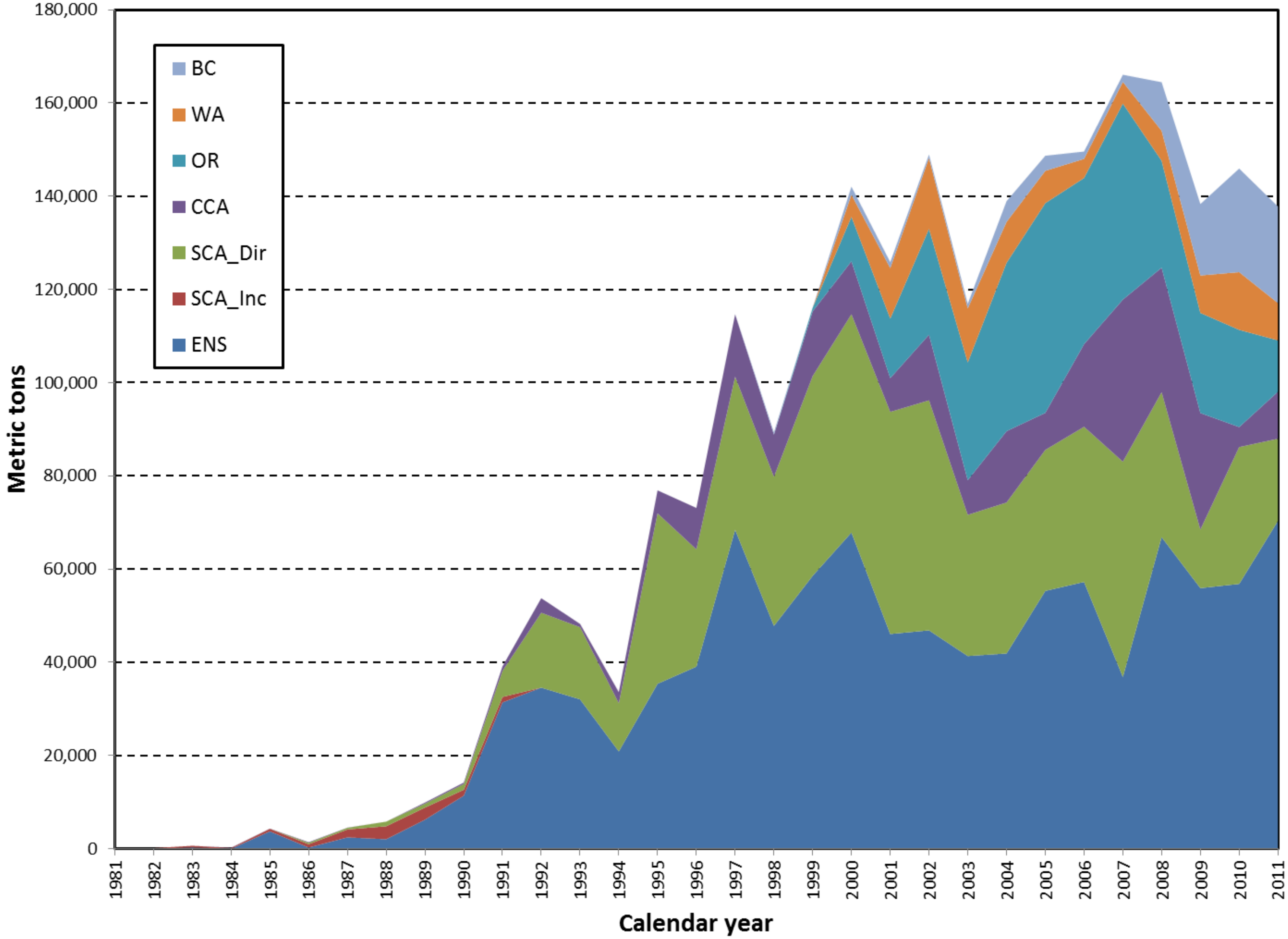
Survey data:

- DEPM estimate of SSB from the spring 2012 survey off California;
- Acoustic-trawl method (ATM) estimates of biomass from the spring 2012 survey (California) and summer 2012 survey (San Diego to Vancouver Island);
- NWSS aerial survey estimate from summer 2012.

Model change:

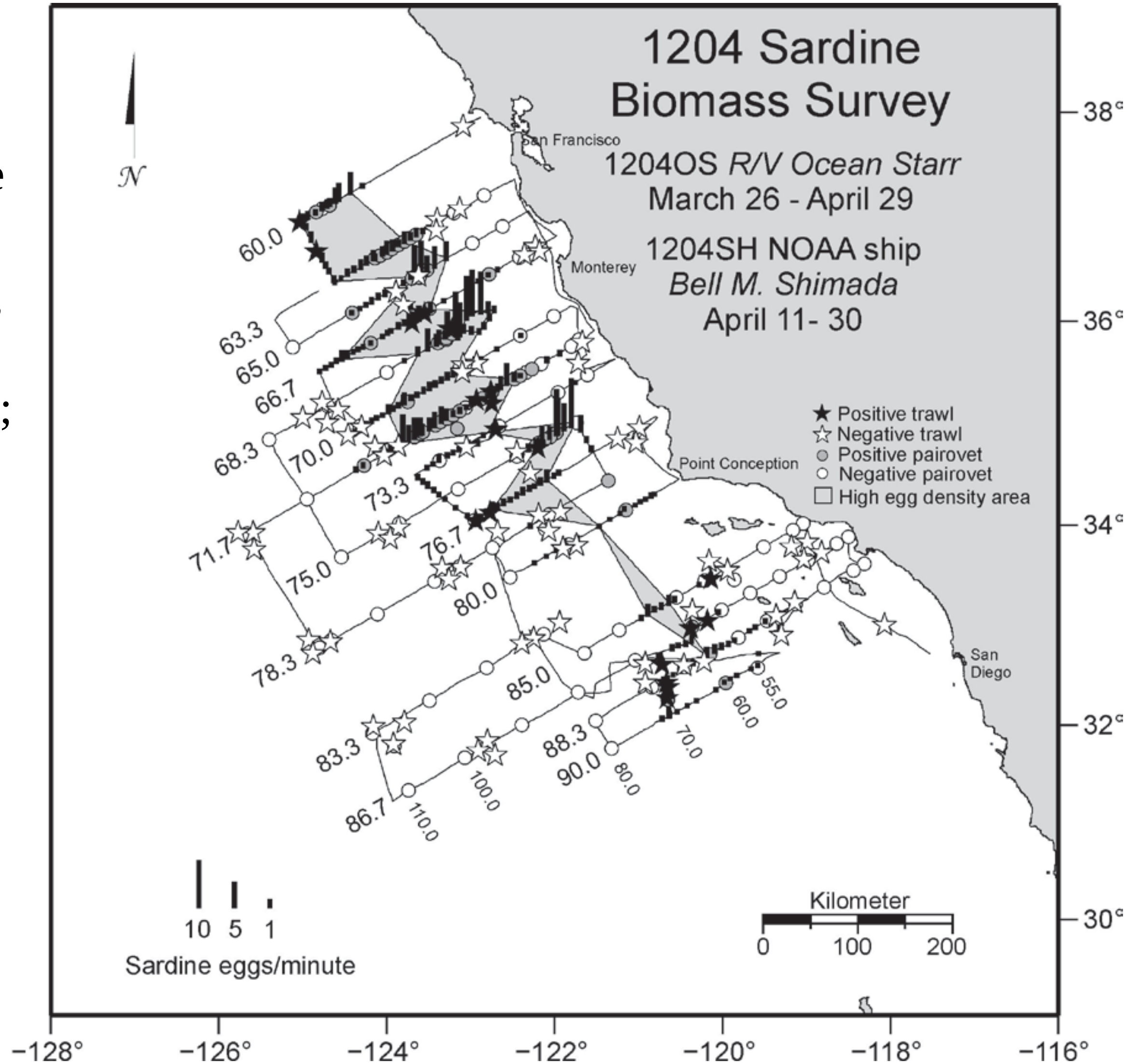
- Last year for estimated recruitment deviations changed from end-year -2 back to end-year -1; reviewed by SSC CPS Subcommittee in early October.

Landings by Fishing Area and Calendar



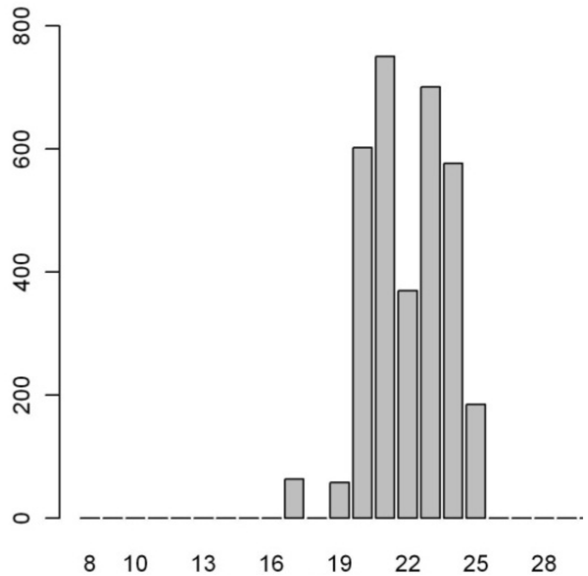
Spring 2012 DEPM Estimate

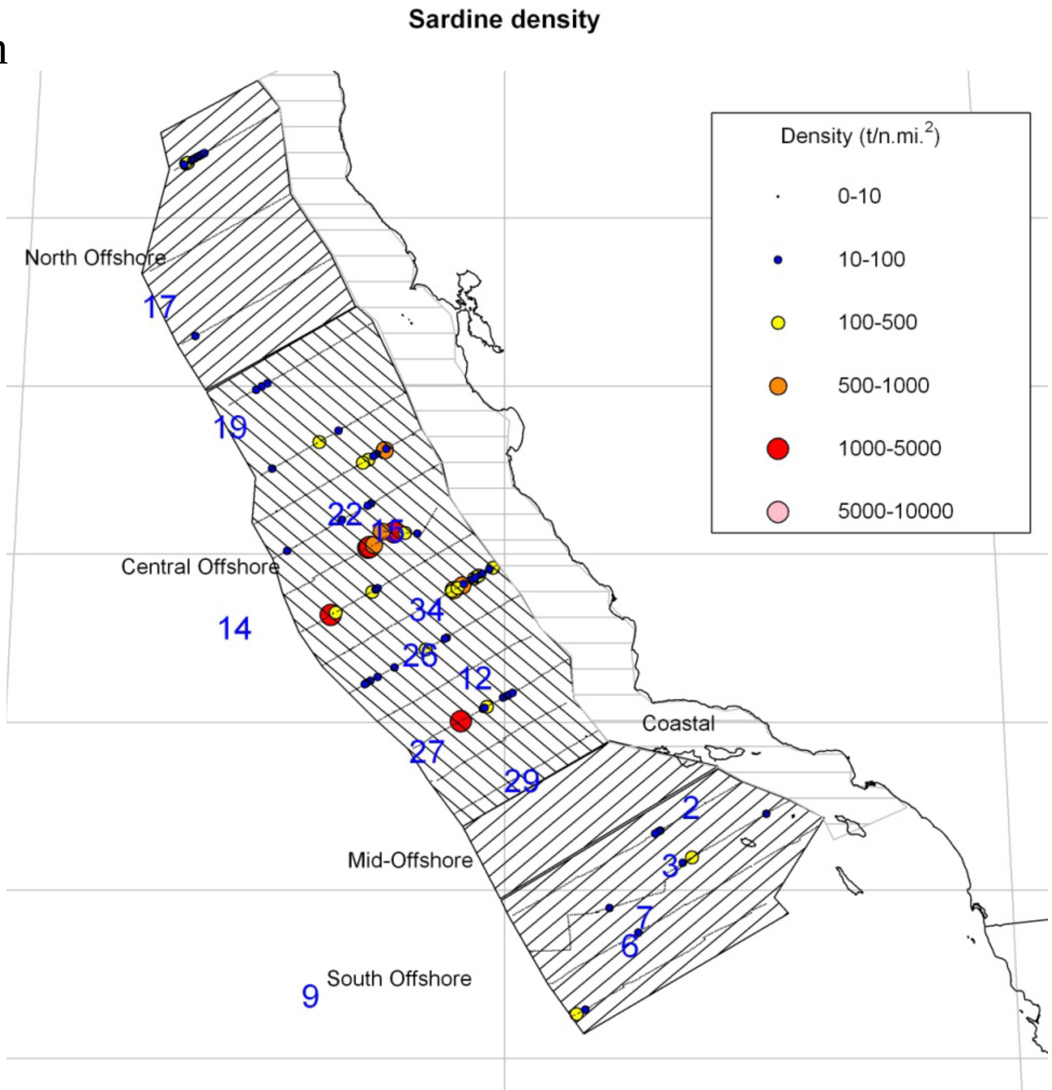
- Survey transects ranged from Ft. Bragg to San Diego;
- Eggs only observed within the core DEPM area (line 60 and south);
- 21 trawls were positive for sardine, 16 collections contained mature females for adult repro. parameters;
- Lower SSB primarily due to lower egg density (P_0) and smaller area (A) in the low density stratum (Region 2).
- SSB_{total} = 255,391 mt
- SSB_{female} = 113,178 mt
- Female SSB 48% lower than 2011, but higher than the 2008-2010 survey estimates;



Spring 2012 ATM Estimate

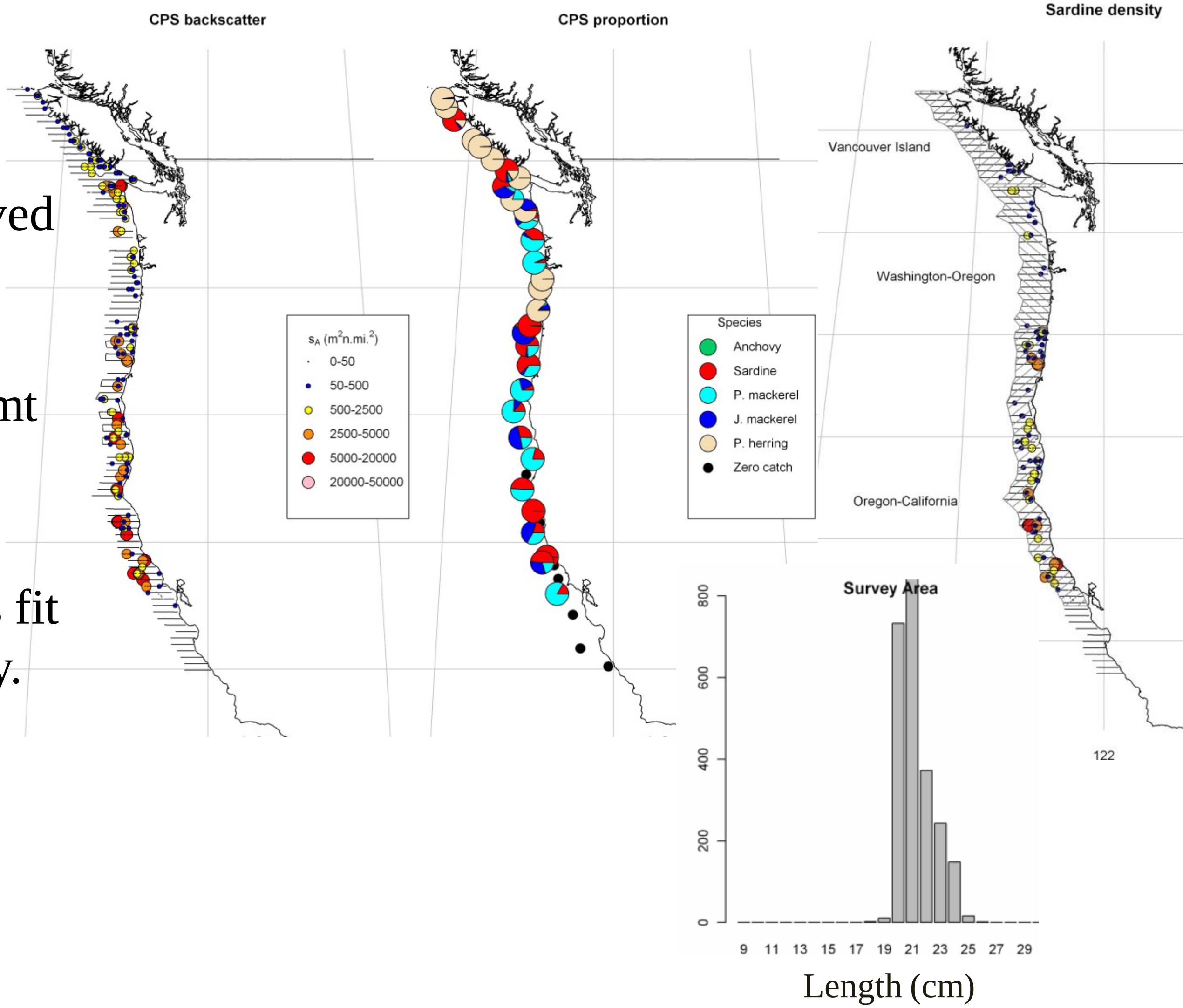
- 21 positive trawls grouped as 14 clusters
- Trawl compositions used to apportion total CPS backscatter densities by species;
- ATM biomass = 469,480 mt;
- Time series modeled with q=1;
- Length composition series fit with asymptotic selectivity.





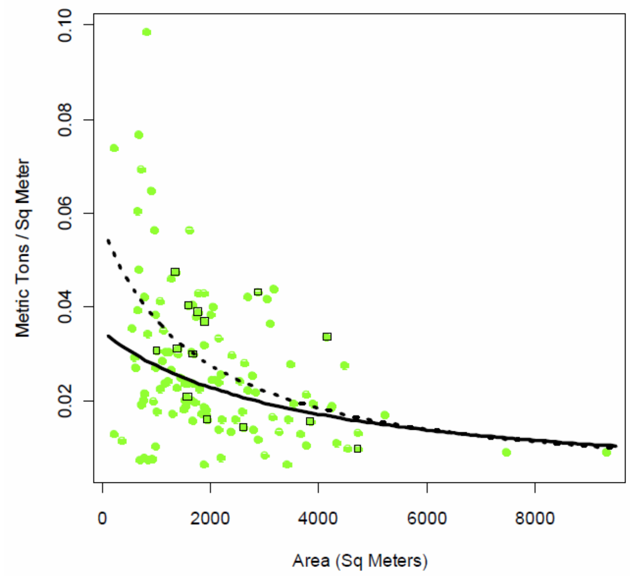
SWFSC Summer 2012 ATM Survey

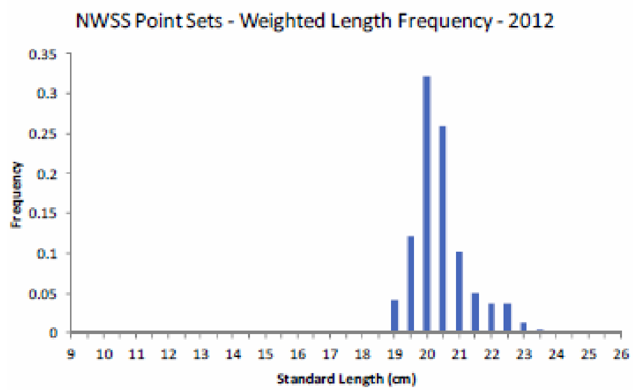
- 31 trawl clusters;
- Majority of sardine observed between S.F. and central Oregon;
- ATM biomass = 340,831 mt
- Time series modeled with q=1;
- Length composition series fit with asymptotic selectivity.

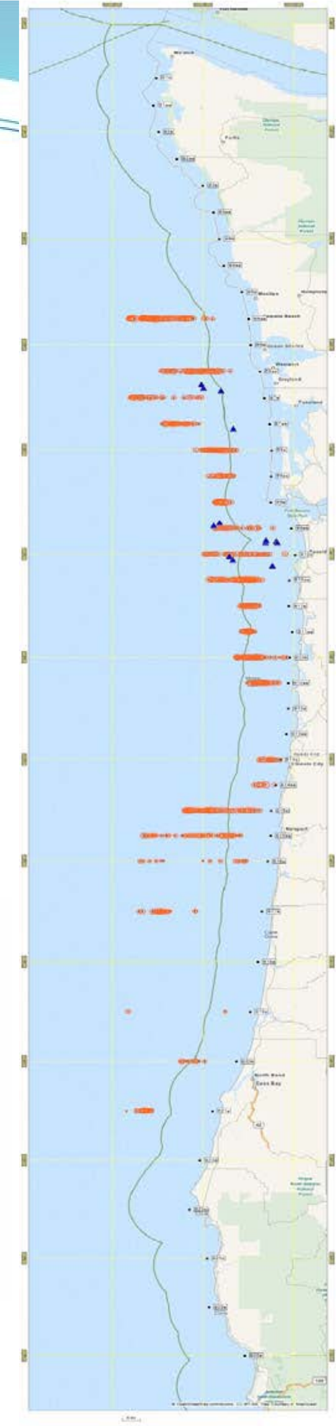


Summer 2012 - NWSS Aerial Survey

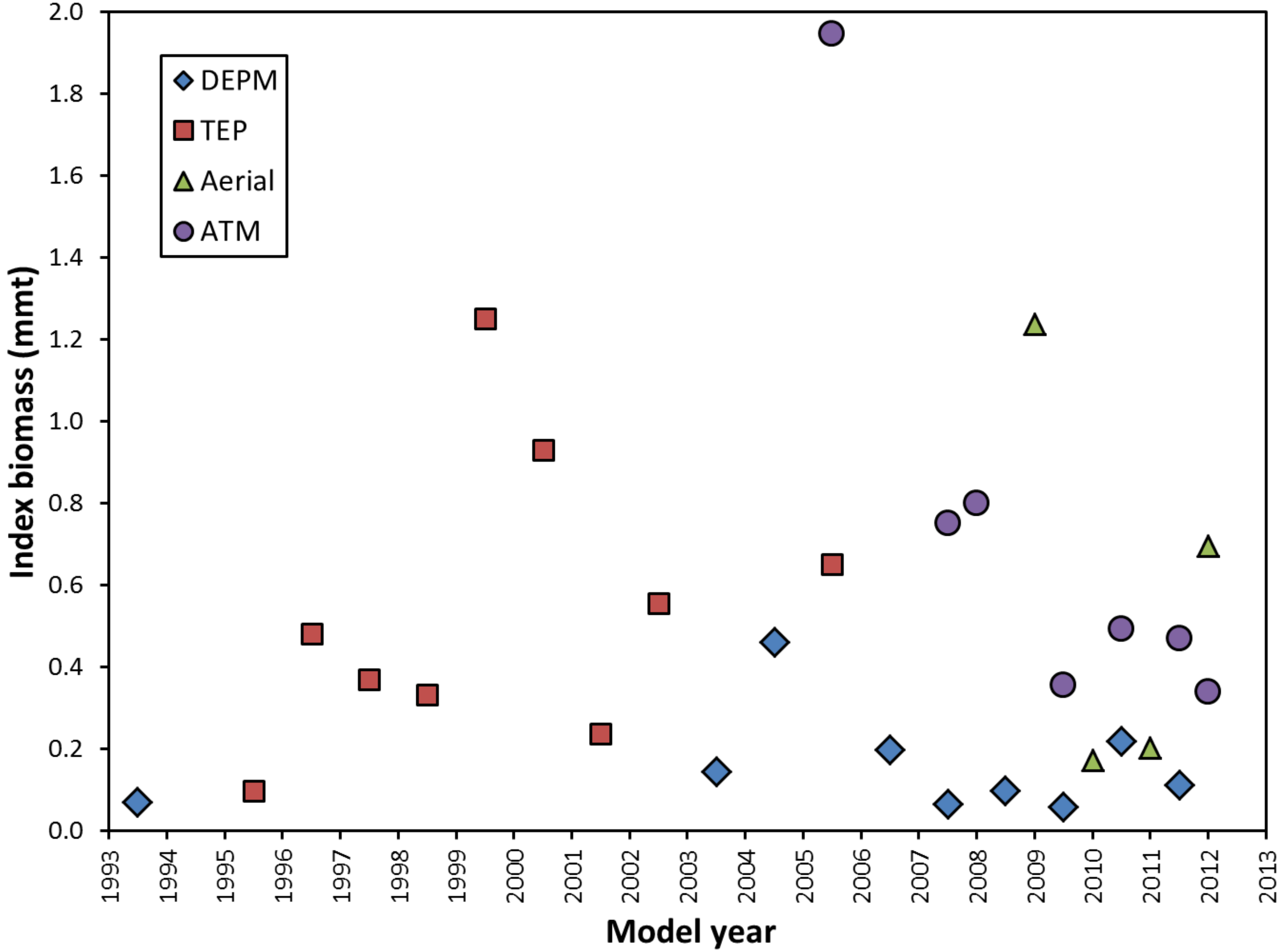
- Set ‘B’ photo transects conducted from 7/31 to 8/22;
- 14 acceptable point set samples conducted from 8/23 to 9/13;
- No temporal overlap between aerial transects and point sets;
- Point sets were limited in spatial coverage;
- Biomass (696,251 mt) used in update was based on point sets pooled across years.
- Length composition based on the 14 acceptable point sets;



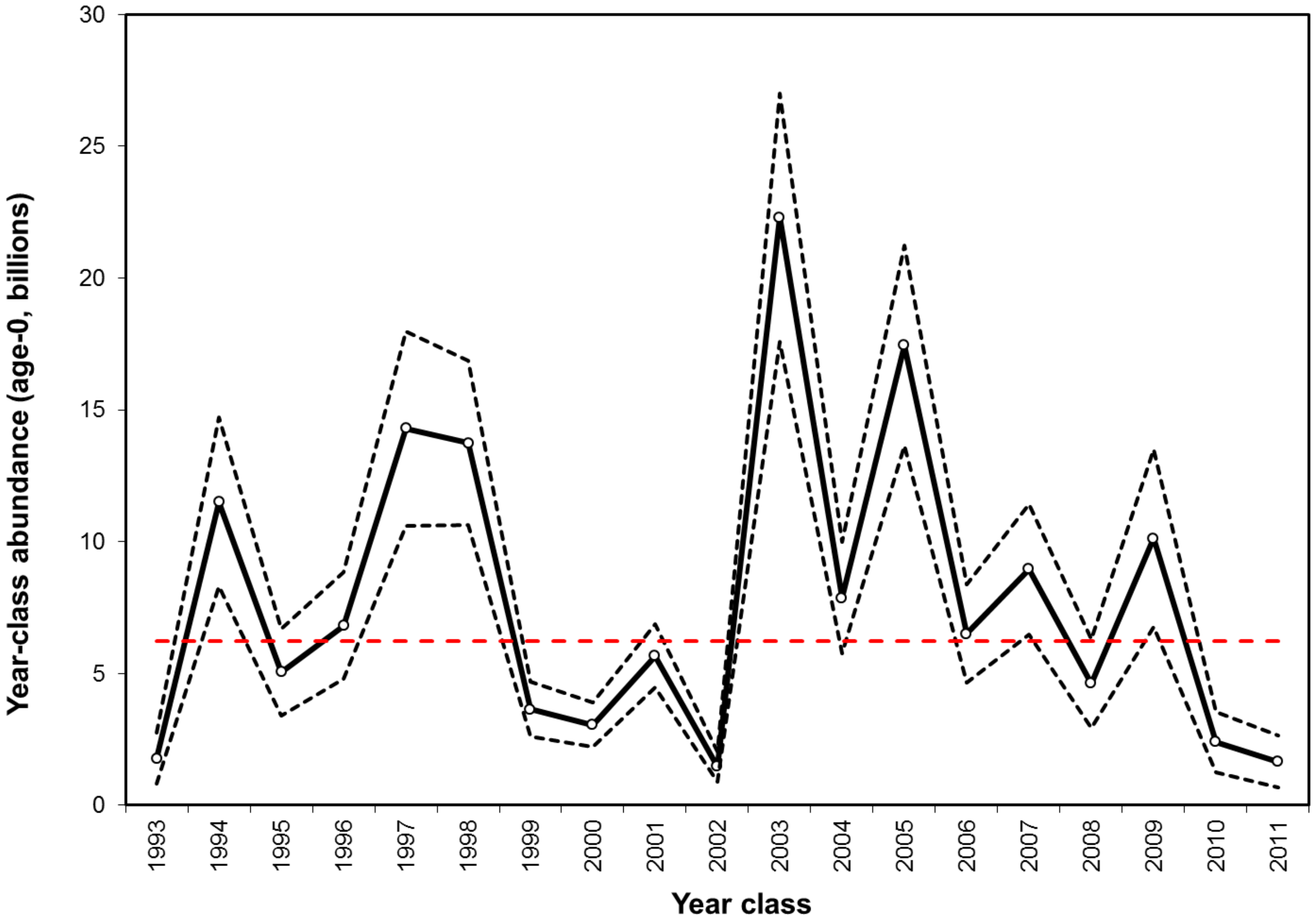




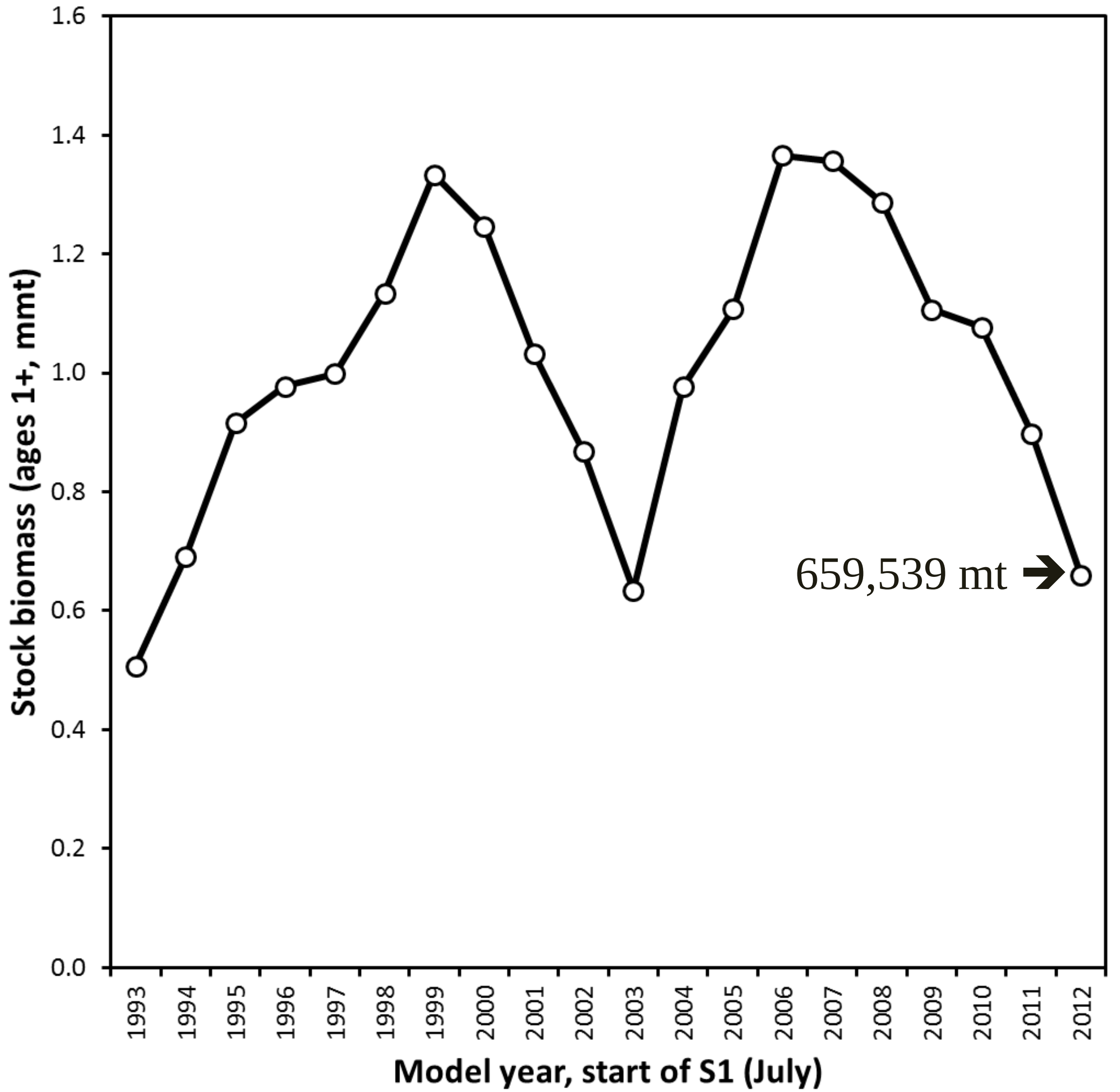
Survey Time Series



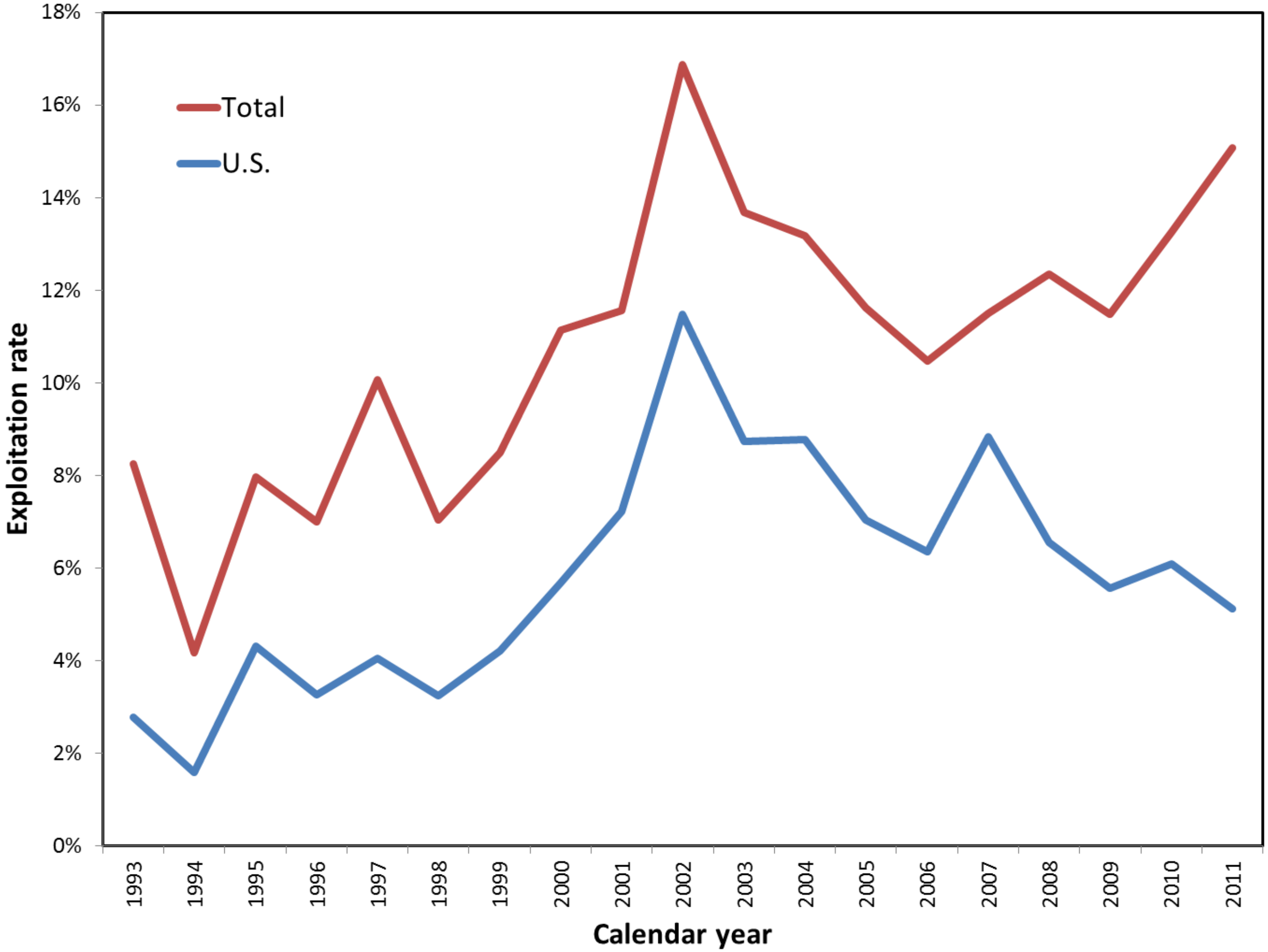
Recruitment Time Series



Estimated Stock Biomass Series from Model X6e



Exploitation Rate



HG, ABC, & OFL for 2013

Harvest Formula Parameters	Value			
BIOMASS (ages 1+, mt)	659,539			
P^* (probability of overfishing)	0.45	0.40	0.30	0.20
BUFFER_{P^*} (Sigma=0.36)	0.95577	0.91283	0.82797	0.73861
F_{MSY} (stochastic, SST-independent)	0.18			
FRACTION	0.15			
CUTOFF (mt)	150,000			
DISTRIBUTION (U.S.)	0.87			

Amendment 13 Harvest Formulas	MT
OFL = BIOMASS * F_{MSY} * DISTRIBUTION	103,284
$\text{ABC}_{0.45}$ = BIOMASS * $\text{BUFFER}_{0.45}$ * F_{MSY} * DISTRIBUTION	98,716
$\text{ABC}_{0.40}$ = BIOMASS * $\text{BUFFER}_{0.40}$ * F_{MSY} * DISTRIBUTION	94,281
$\text{ABC}_{0.30}$ = BIOMASS * $\text{BUFFER}_{0.30}$ * F_{MSY} * DISTRIBUTION	85,515
$\text{ABC}_{0.20}$ = BIOMASS * $\text{BUFFER}_{0.20}$ * F_{MSY} * DISTRIBUTION	76,287
HG = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION	66,495

COASTAL PELAGIC ADVISORY SUBPANEL REPORT ON PACIFIC SARDINE STOCK ASSESSMENT AND MANAGEMENT FOR 2013, INCLUDING PRELIMINARY EFP PROPOSALS AND TRIBAL SET-ASIDE

West Coast Vancouver Island Survey

The Coastal Pelagic Species Advisory Subpanel (CPSAS) recommends that the Council approve West Coast Vancouver Island (WCVI) Survey for use in future stock assessments, as appropriate. The subpanel further encourages continuation of the WCVI survey using the 2011/2012 methodology.

Exempted Fishing Permit Notice of Intent

The CPSAS unanimously supports an Exempted Fishing Permit (EFP) set aside of 3,000 mt for Pacific Northwest industry-supported research, to be deducted from the harvest guideline (HG) before it is allocated to fishing periods. The CPSAS would also like to recommend that any EFP set aside not utilized be re-allocated to the third period directed fishery.

Pacific Sardine Management for 2013

The CPSAS participated in a joint meeting with the CPSMT and the Scientific and Statistical Committee (SSC) where Dr. Kevin Hill presented the 2012 sardine stock assessment for use in the 2013 fishery. We thank the Stock Assessment Team for the enormous amount of work that went into completing this stock assessment update.

The CPSAS highlights the inconsistencies between the acoustic trawl methodology (ATM), the aerial survey, and the Pacific Northwest landings data. Although the aerial and acoustic surveys in Washington and northern Oregon were conducted generally in the same time and area, each recorded widely different quantitative values for sardine biomass. The 2012 aerial survey estimated a biomass of 906,680 mt for the Pacific Northwest.

In contrast, the biomass estimated from the acoustic trawl survey for Washington-Oregon was estimated to be only 13,335 mt. This estimate is significantly lower than actual landings (48,653 mt) made in the fishery during the summer fishing period. Given this discrepancy, the CPSAS questions whether the acoustic trawl data accurately assesses the full biomass. Possible deficiencies in the current acoustic trawl methodology include inability to survey the nearshore biomass, issues of vessel avoidance, and the placement of transducers, which appears to miss sardines in the upper 10 meters of the water column.

Of additional concern, is the fact that the acoustic surveys are currently assigned a catchability coefficient (q) of 1, which assumes this survey method ‘sees’ the entire biomass in the transects. The subpanel recommends the use of side-scanning sonar in these surveys, to further study vessel avoidance and number of sardine schools in proximity to the research vessel. In the absence of this option, we recommend sonar equipped fishing vessels to accompany the research vessel.

Sardine variability and dynamic swings in abundance are well documented over time. We appreciate the efforts of the stock assessment team (STAT) and Southwest Fisheries Science Center (SWFSC) to acknowledge these problems and work to resolve them in future surveys and stock assessments. Although this update is unable to make substantial changes to resolve the conflicts this year, as stipulated in the *Terms of Reference*, we are concerned that present survey methods do not accurately estimate the existing sardine biomass.

Based on the update assessment (model X6e) for management of the 2013 sardine fishery (Agenda Item G.3.b, Supplemental Assessment Report 2) the age 1+ biomass estimate from this assessment is 659,539 mt. The harvest control rule produces a harvest guideline (HG) of 66,495 mt, with allocation to continue as in 2012 and as appears below in the supplemental CPSMT Report, Table 2, with the exception noted below.

The CPSAS recommends that the incidental landing allowance in other CPS fisheries in 2013 be raised to no more than 40 percent Pacific sardine by weight, to account for the possibility of mixed-fish catches in the Pacific mackerel fishery, particularly in summer months. The CPSAS recommends that if the directed seasonal allocation and set-asides are reached, the retention of Pacific sardine be prohibited for the remainder of that sardine season.

Table 2. Preliminary allocation scheme for 2013 Pacific Sardine ACT

HG = 66,495 mt; Tribal Set-aside = 9,000 mt; Potential EFP set-aside = 3,000 mt Adjusted HG = 54,495 mt				
	Jan 1- Jun 30	Jul 1- Sep 14	Sep 15 – Dec 31	Total
Seasonal Allocation (mt)	19,073 (35%)	21,798 (40%)	13,624 (25%)	54,495
Incidental Set-Aside (mt)	1,000	1,000	1,000	3,000
Adjusted (Directed) Allocation (mt)	18,073	20,798	12,624	51,495

The CPSAS commends the effective in-season actions taken by the National Marine Fisheries Service (NMFS) to deal with surpluses or shortages in the directed and incidental seasonal allocations.

PFMC
11/04/12

COASTAL PELAGIC SPECIES MANAGEMENT TEAM REPORT ON
PACIFIC SARDINE STOCK ASSESSMENT AND MANAGEMENT FOR 2013

The Coastal Pelagic Species Management Team (CPSMT), the Coastal Pelagic Species Advisory Panel (CPSAS) and the Scientific and Statistical Committee (SSC) jointly received a presentation from Dr. Kevin Hill concerning the Pacific sardine stock assessment conducted in 2012. The CPSMT recommends that the Pacific Fishery Management Council (Council) adopt the update assessment (model X6e) for management of the 2013 sardine fishery (Agenda Item G.3.b, Supplemental Assessment Report 2). Based upon the 659,539 metric tons (mt) age 1+ biomass estimate from this assessment, the harvest control rule produces a harvest guideline (HG) of 66,495 mt (Table 1 below). The 2012 biomass estimate represents a 33 percent decrease from the full stock assessment previously adopted by the Council in November, 2011. The CPSMT notes the 2012 results of the Daily Egg Production Index and the hydroacoustic trawl surveys contributed to the decrease in the biomass estimate.

Harvest Specifications for 2013

Table 1 (below) contains the resulting overfishing limit and a range of acceptable biological catch values based on various P* (probability of overfishing) values. The CPSMT recommends that the annual catch limit equal the ABC resulting from the Council's P* choice, and that the HG/annual catch target be set equal to 66,495 mt. Considering the results of the full stock assessment conducted in 2011, the Council chose a P* of 0.40 for the 2012 fishery.

The Quinault Indian Nation (Agenda Item G.3.a, Attachment 1) requests 9,000 mt of Pacific sardine for their participation in the 2013 fishery, the same as requested for 2012. The CPSMT notes that 6,000 mt of the 2012 set-aside for the Quinault Indian Nation was not used and was released to the third fishing period. Acknowledging that a set-aside for the Quinault Indian Nation has yet to be determined, the CPSMT presents a preliminary allocation scheme for the 2013 fishery (Table 2 below) that incorporates a set-aside of 9,000 mt.

The Northwest Sardine Industry LLC has notified the Council (Agenda Item G.3.a, Attachment 2) it intends to request an exempted fishing permit (EFP) for 3,000 mt, the same as approved in 2012. Recognizing the Council will determine whether to approve the EFP at a future meeting, CPSMT recommends setting aside 3,000 mt for the Northwest sardine industry EFP, and this is reflected in Table 2.

Further, the CPSMT recommends any EFP set-aside not included in an EFP, as well as any EFP fish allocated but not utilized, should be re-allocated to the third period directed fishery. Finally, the CPSMT recommends that the incidental catch for CPS fisheries in each of the three allocation periods should be set to 1,000 mt (Table 2) and that the incidental landing allowance for CPS fisheries be no more than 40 percent Pacific sardine by weight.

Based on the values in Table 1, the CPSMT recommends adoption of the allocation scheme in Table 2.

Table 1. Pacific sardine harvest formula parameters for 2013.

Harvest Formula Parameters	Value			
BIOMASS (ages 1+, mt)	659,539			
P^* (probability of overfishing)	0.45	0.40	0.30	0.20
$BUFFER_{P^*}$ (Sigma=0.36)	0.95577	0.91283	0.82797	0.73861
F_{MSY}	0.18			
FRACTION	0.15			
CUTOFF (mt)	150,000			
DISTRIBUTION (U.S.)	0.87			

Harvest Formulas	MT
OFL = BIOMASS * F_{MSY} * DISTRIBUTION	103,284
$ABC_{0.45}$ = BIOMASS * $BUFFER_{0.45}$ * F_{MSY} * DISTRIBUTION	98,716
$ABC_{0.40}$ = BIOMASS * $BUFFER_{0.40}$ * F_{MSY} * DISTRIBUTION	94,281
$ABC_{0.30}$ = BIOMASS * $BUFFER_{0.30}$ * F_{MSY} * DISTRIBUTION	85,515
$ABC_{0.20}$ = BIOMASS * $BUFFER_{0.20}$ * F_{MSY} * DISTRIBUTION	76,287
HG = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION	66,495

Table 2. Preliminary allocation scheme for 2013 Pacific Sardine ACT

HG = 66,495 mt; Tribal set-aside = 9,000 mt; potential EFP set-aside = 3,000 mt Adjusted HG = 54,495 mt				
	Jan 1- Jun 30	Jul 1- Sep 14	Sep 15 – Dec 31	Total
Seasonal Allocation (mt)	19,073 (35%)	21,798 (40%)	13,624 (25%)	54,495
Incidental Set-Aside (mt)	1,000	1,000	1,000	3,000
Adjusted (Directed) Allocation (mt)	18,073	20,798	12,624	51,495

Recommendations for future actions

In regards to the industry-sponsored aerial survey in 2012, the CPSMT commends the EFP applicants for their efforts. The CPSMT understands that the duration of the fishing periods, weather and other logistical limitations precluded completing the survey as designed, resulting in relatively few data points useful in the stock assessment. However, while nearly the entire set-aside was utilized, a substantial portion was not used to achieve the scientific goals of the EFP. If approved for 2013, the CPSMT encourages the EFP applicants to improve utilization of the set-aside to achieve science goals.

A methodology review of the Canadian West Coast Vancouver Island Swept Area Trawl Survey was completed in 2012 (Agenda Item G.3.a, Attachment 5). The CPSMT supports the continuation of the West Coast Vancouver Island trawl sardine survey (WCVI), and that it be conducted as recommended in the review report. The panel considered the last two years of the survey (2010-2011) as the best data and stated the necessity of at least four years of data using the latest survey design and methods before including in a stock assessment. The CPSMT recommends the stock assessment team evaluate the time series when it comprises at least four estimates, at which time it could be included in a future stock assessment.

PFMC
11/04/12

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON THE PACIFIC SARDINE STOCK ASSESSMENT AND MANAGEMENT FOR 2013, INCLUDING PRELIMINARY EFP PROPOSALS AND TRIBAL SET-ASIDE

The Scientific and Statistical Committee (SSC) reviewed the 2012 update assessment of the northern subpopulation of Pacific sardine. Dr. Kevin Hill from the Southwest Fisheries Science Center (SWFSC) presented an overview of the assessment and discussed new data in the assessment, including the 2012 acoustic trawl (ATM), egg production (DEPM) and aerial surveys. The aerial survey used a slightly different methodology than used previously, with biomass estimates in the model derived from point sets pooled across years, with length data from 2012. The SWFSC conducted a spring DEPM survey and both spring (in California) and summer (from San Diego into Canada) ATM surveys. The estimate of spawning stock biomass in 2012 from the update assessment was 50 percent lower than the previous estimate for 2011, but higher than those for years 2008-10.

Several issues regarding the surveys were raised. The summer ATM survey found that trawls in the northern area had highly mixed species composition. There was a discrepancy between the biomass estimate in the northern (WA/OR) portion of the ATM survey area and the fishery landings (as well as the aerial survey estimate). Vessel avoidance and the acoustic transducer on the survey vessel missing fish on the surface were raised as possible explanations for this discrepancy. The aerial survey used the one complete set of transects (Set B) for school number and surface area estimates, while the point sets were taken after completion of the transacts rather than concurrently. More problematically, only 14 acceptable point sets were conducted, and they were not spatially representative of the sardine schools photographed during the transects. Given this lack of spatial coverage of the point sets, and the highly mixed Coastal Pelagic Species found in the ATM trawls in the same area as many of the photographed schools, there are potential species composition problems with the estimates derived from the aerial photographs. However, the composition of photographed schools and ATM trawls are not directly relatable, as the former are taken during the day and the latter at night when CPS are dispersed.

Dr. Owen Hamel of the SSC presented a report of the review panel that was convened to review the update assessment. The panel endorsed a change to the model that involved the use of recruitment deviations estimated through end year-1 and rather than end year-2, as it provided better fit to the data, and recommended that a base model (X6e) that incorporated this change be used for management in 2013.

The SSC notes that the current Harvest Control Rule uses the biomass estimate on July 1, 2012 to determine an overfishing limit and harvest guideline for the 2013 calendar year, thereby ignoring any change in biomass from July 1 to December 31, 2012. This could be consequential for this assessment, given the declining trend in abundance. The SSC suggests that future evaluations of the harvest control rule consider basing the OFL and HG on the biomass at the start of the fishing year, as is the case for other Council-managed fisheries. The SSC again emphasizes that there is little time between when data are provided to the Stock Assessment

Team (STAT) and the deadline for assessment completion, which raises multiple challenges for completing the assessment and conducting a review. This problem could be addressed by changing the start of the fishing year.

The SSC endorses the update assessment (model x6E) as the best available science for management in 2013 and further endorses the OFL=103,284 mt, and the sigma value of 0.36. The SSC notes that the relationship between temperature and stock productivity has not yet been clarified; using a constant F_{MSY} proxy was recommended in November 2011 as an interim measure only. Re-evaluation of the science used in the Harvest Control Rule parameters should be of highest priority for next year's assessment (see SSC statement F.4).

Dr. André Punt of the SSC provided an overview of the Methodology Review Panel that reviewed possible use of the Vancouver Island swept area trawl survey in management. This trawl survey has been conducted by the Department of Fisheries and Oceans (Canada) since 2002, but there have been serious issues of consistency in and adequacy of survey methodology. The 2010 survey was the first that was sufficiently close to the recommendations of the Methodology Review Panel to be appropriate for use in management. When several additional years of standardized data collection have occurred, the survey should be evaluated by the STAT and a STAR panel for use in assessment and management. The SSC further noted that coordination with US surveys could potentially increase the value of the Canadian survey. The SSC endorses the report and emphasizes that a time series derived from several more years of standardized survey methodology is necessary before the survey may be useful for management.

The SSC noted that a letter of intent to apply for an exempted fishing permit to continue the Northwest aerial sardine survey in 2013 was submitted. The survey has consistently failed to achieve adequate point sets to meet objectives specified in the sampling plan. While this might be partially addressed by scheduling changes, the SSC recommends a formal review of the survey methodology, following up on the issues raised in the 2007 STAR panel.

PFMC
11/04/12

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October 11, 2012

Mr. Dan Wolford, Chair
And Members of the Pacific Fishery Management Council
7700 NE Ambassador Place #200
Portland OR 97220-1384

RE: Agenda Item G.3.d: Pacific Sardine Stock Assessment and Management for 2013

Dear Mr. Wolford and Council members,

The California Wetfish Producers Association (CWPA) represents the majority of coastal pelagic species 'wetfish' fishermen and processors in California. As the designated CPS Advisory Subpanel representative to the sardine stock assessment update meeting, I appreciate your consideration of the concerns and issues that I raised on behalf of industry in the assessment update meeting document. In part:

• The model appears to be struggling to fit survey data vs. biological composition data from the fishery. Both aerial and acoustic surveys roughly overlapped the same time period in WA and northern OR, yet recorded widely different quantitative values for sardine biomass.

• The 2012 aerial survey estimated a biomass of 906,680 mt for the Pacific Northwest, although the 2012 aerial survey was unique: a relatively small sample size and short lag between transects and point sets. The increase in biomass was attributed to good viewing conditions in 2012 for the one transect set that was completed, illustrating the year-to-year variability in "catchability" in this survey method.

In contrast, the biomass estimated from acoustic trawl (ATM) measurements by stratum for Washington-Oregon (13,335 mt) is far lower than actual landings made in the fishery during the summer fishing period (the fishery attained the July 1-Sep. 14 allocation and closed on August 22). OR-WA landings for the period totaled 48,653 mt through August 27.

• Variability is apparent in all the indices employed to measure sardine abundance. Survey timing is critical, and each survey measures only a spot in time. Also critically important is the weighting attributed to various model components, i.e., surveys. The acoustic surveys are assigned a catchability coefficient (q) of 1, assuming that this survey method 'sees' the entire biomass. However, industry continues to voice concern that acoustic methods miss the upper 10 meters of the water column; the vessel avoidance issue has not been resolved satisfactorily. Nor do acoustic surveys capture the full extent of the nearshore area, i.e., the beach, where sardines are known to congregate in California.

• Two different states of nature seem to exist in this stock assessment update. The general trend in DEPM and acoustic surveys appear to be telling the same story, indicating a decline in biomass, but the aerial survey contradicts this, and the fishery is seeing length compositions that are not included in the surveys. This assessment update has highlighted the conflict in both scale and trend.

Sardine variability and dynamic swings in abundance are well documented over time. We appreciate the efforts of the STAT and SWFSC to acknowledge these problems and work to resolve them in future surveys and stock assessments, although this update is unable to make substantial changes to resolve the conflicts this year, as stipulated in the *Terms of Reference*. Thus, management measures for 2013 will continue the trend to down-weight the biomass estimate**. However, this will ensure a sustainable resource that is in no danger of overfishing.**

I want to re-emphasize this point for the Council. Contrary to allegations made by members of the environmental community, the visionary management adopted for CPS with Amendment 8, and carried forward to Amendment 13, is recognized by independent studies investigating global forage fisheries. One highly publicized study is the Lenfest Forage Fish Task Force report, which I note that Oceana referenced in recent public comment to this Council. Oceana's October 5, 2012 letter, subject Coastal Pelagic Species Management: Harvest Parameters Workshop, reiterated many of the allegations pressed in their Amendment 13 lawsuit, which is slated for hearing in San Francisco District Court on November 30.

In rebuttal, I again present to the Council the 'rest of the story' -- the story that Oceana and other forage fish advocates curiously do not tell**: the CPS fisheries in the California Current harvest less than two percent of forage production**, as illustrated in the attached graphs taken from the Lenfest Report appendices. The Atlantis California Current ecosystem model now under development by the Northwest and Southwest Fishery Science Centers corroborates these findings for large and small planktivorous 'forage' fish (which comprise only part of the total forage pool).

These findings, along with other independent research studies (i.e. Smith et al, 2011 – CA Current CPS fisheries have low ecosystem impact; Patrick et al, 2010 – CA Current CPS fisheries have lowest susceptibility to overfishing) provide credible evidence to support the CPS management team assessment that the current harvest control rules for sardine and other CPS are precautionary and have served well over the past decade. The low harvest rate, far below the MSY rate of other global forage fisheries, has sustained the spawning biomass for both industry and ecosystem needs.

Speaking of control rules, I also participated in the October 11 CPS management team teleconference, which discussed how to approach the SSC and Council directives to conduct a review of the harvest control parameters for sardine in a workshop format. I understand the management team may submit a statement for the briefing book, and the CPS advisory subpanel likely will submit a supplemental statement following discussion at our upcoming meeting. In the meantime, I would like to offer our support for the management team's general direction proposed, which is to focus this workshop primarily on the temperature-recruitment relationship, as well as other potential environment-recruit covariates, identifying possible oceanographic conditions or indices that could be used predict sardine spawning/recruitment processes. Findings could lead to a series of workshops in the future involving other CPS.

During the call, team members agreed that they would need to rely on a technical team of consultants outside the management team to help with analyses. I suggest that Dr. Richard Parrish be included on the technical team, along with Alec MacCall and Larry Jacobson, if available, all of whom participated in the original development of Amendment 8 control rules.

Thank you for your attention to these comments.

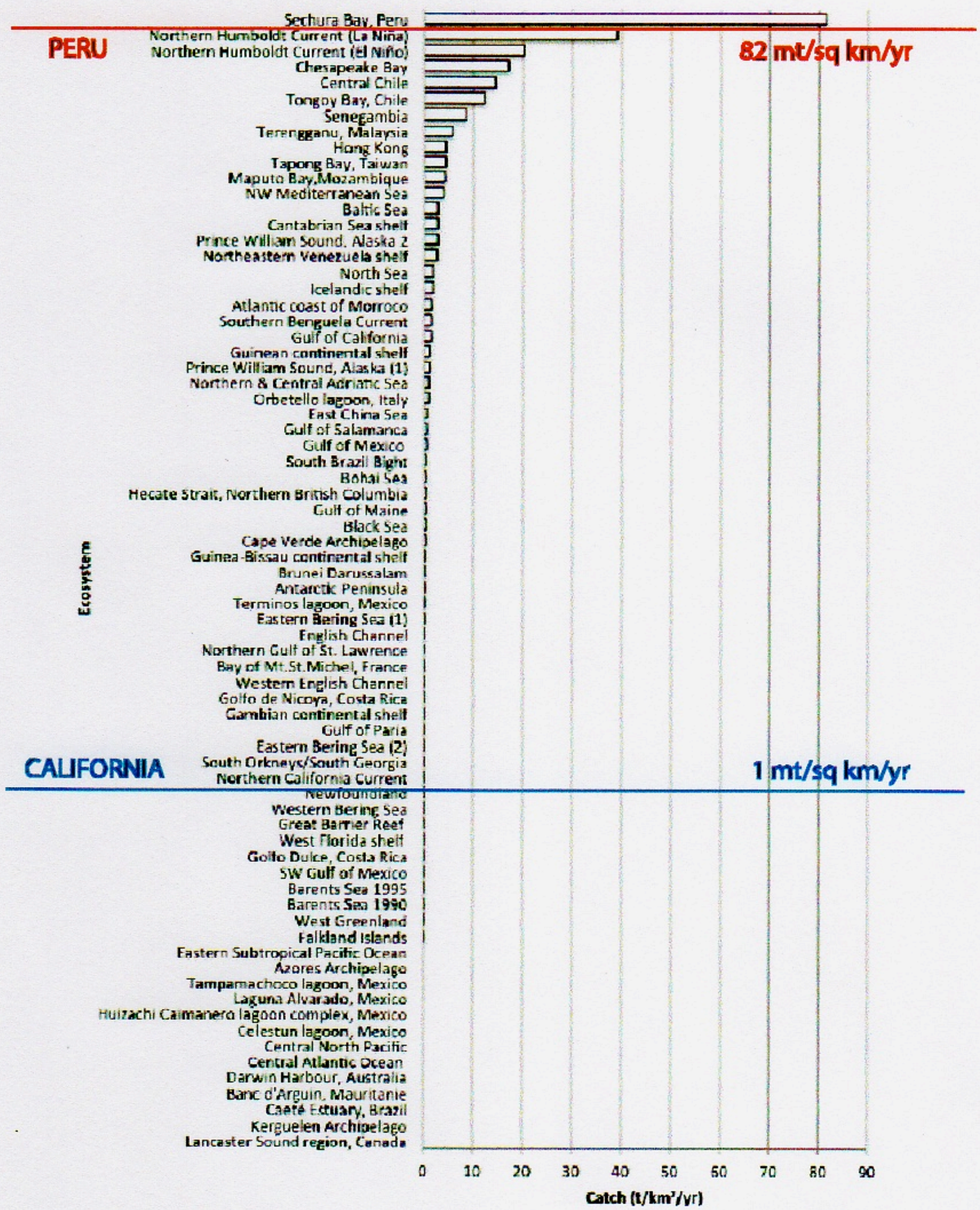
Best regards,

Diane Pleschner-Steele

Diane Pleschner-Steele
Executive Director

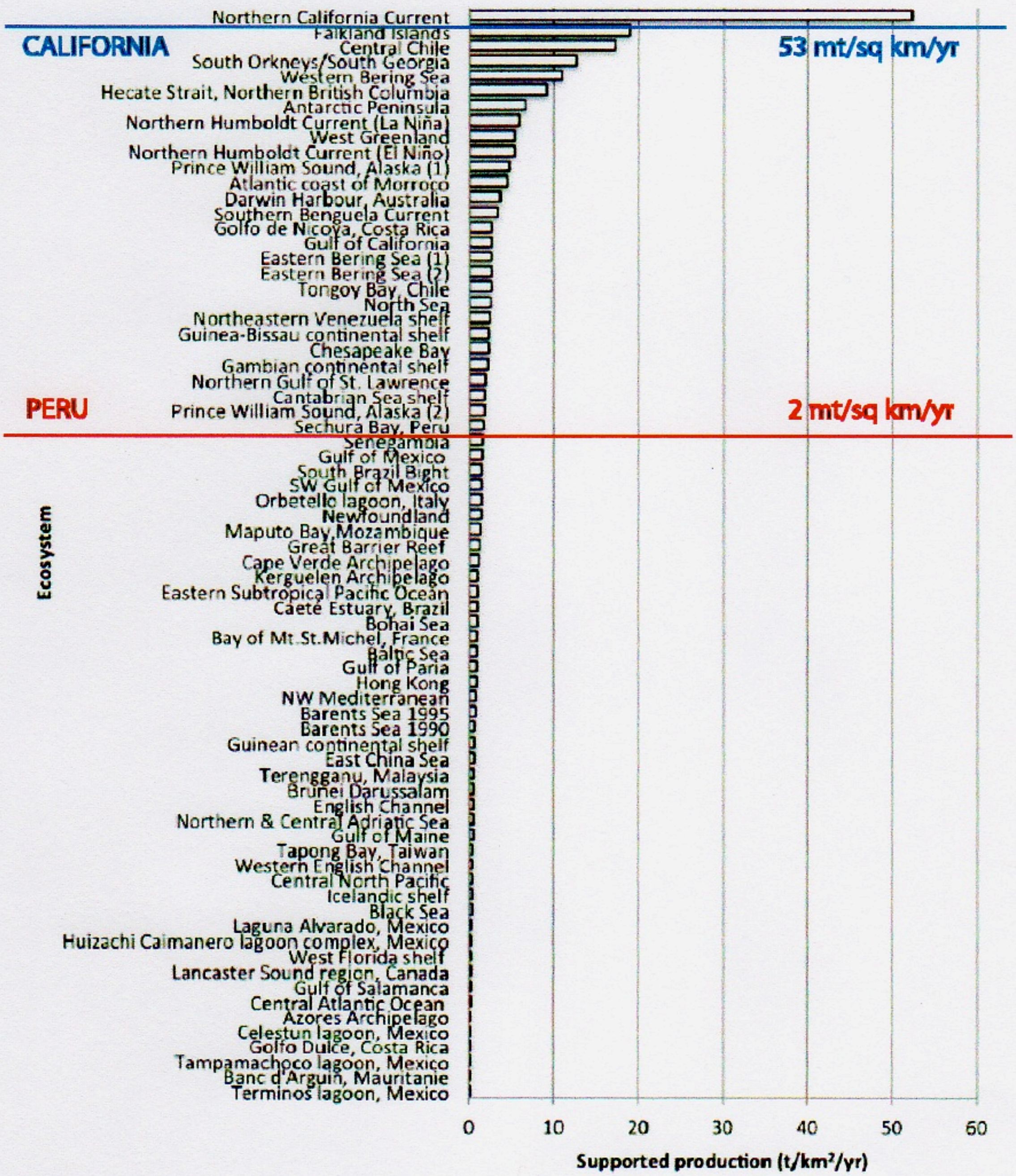
The Secura Bay, Peru fishery harvests 82 mt of forage fishes per sq. km per year
The California Current fishery harvests 1 mt of forage fishes per sq km per year

Figure E5.1
Forage Fish Catch Across all Ecopath Models by Volume.



Predators in the California Current consume 53 mt of forage fishes per sq km per year.
Predators in Sechura Bay, Peru consume 2 mt of forage fishes per sq km per year.

Figure E5.5
Supportive Contribution of Forage Fish to Ecosystem Predator Production Across all Ecopath Models.



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October 22, 2012

To: Pacific Fisheries Management Council
Dan Wolford, Chair

Re: Season start dates for the pacific sardine fishery

Mr. Chairman and Council Members,

I am seeking a change in the management measures for the pacific sardine fishery. When the harvest regulations were implemented the start dates did not seem problematic but some adjustment to these dates could improve the fishery. I request the Council consider modifying the 2nd season start date from July 1st to July 6th.

The July 1st start creates difficulty because the Independence Day holiday. Many companies have difficulty acquiring a sufficient workforce because many who could work choose to celebrate a National holiday. Additionally, shipping logistics become difficult as longshoremen take July 4th and 5th off.

I propose moving the 2nd season start date to July 6th. Beginning fishing on July 6th would eliminate the difficulty of attempting to operate on one of our Nation's most important holidays. I brought this issue up last year and proposed the second Monday in July but as that date moves around, and for ease of regulatory change, it seemed better to have something more concrete. Last November other opinions were brought up which may have confused things a bit, i.e. the start date should be August 1st, we should combine the last two periods together, or what about the potential delay for boats who wish to fish salmon in Alaska. This proposal should be simple enough to gain support from a large majority of the sardine industry. Moving the start back 5 days to make things easier for both the processors and fishermen shouldn't be that difficult.

I do not feel this change significantly alters the fishery nor would it give any advantage or disadvantage to any particular user group or region. It is just a simple suggestion which would alleviate some industry headache and help the fishery operate more smoothly.

Thank you for your consideration of this matter.
Regards,

Ryan Kapp

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October 23, 2012

Mr. Dan Wolford, Chair
Pacific Fishery Management Council
7700 NE Ambassador Place, Suite 101
Portland, OR 97220-1384

RE: **Coastal Pelagic Species: Pacific Sardine Management for 2013**

Dear Mr. Wolford and Council members:

Oceana requests that prior to taking any final action on the management of Pacific sardine fisheries for 2013, the Pacific Fishery Management Council and National Marine Fisheries Service conduct a full evaluation of the cumulative and synergistic impacts of harvesting Pacific sardine in the California Current ecosystem, consider ecological factors when determining Overfishing Limit (OFL), Acceptable Biological Catch (ABC) and Annual Catch Limit (ACL); revise current estimates of F_{MSY}, OFL, and Minimum Stock Size Threshold; and consider alternative harvest control rules in their entirety (DISTRIBUTION, CUTOFF, FRACTION, and MAXCAT). We continue to have serious and grave concerns with the management of Pacific sardine fisheries given the crucial ecological role of sardine in the marine ecosystem as prey for other commercial and recreationally important fish species, marine mammals and seabirds. The latest stock assessment[1] resulting in estimated biomass of 659,539 mt (age 1+) represents a 33% decline in the estimated population size from last year's assessment.

According to the current stock assessment, the Pacific sardine population has been in decline for the past six years, yet the 2012 harvest guideline was more than double than in the previous year. This should be highly concerning, especially given the Zwolinski and Demer (2012) study published earlier this year predicting a collapse of the Pacific sardine stock, and given observed high coastwide exploitation rates.[2]

The authors concluded

> **[a]larming is the repetition of the fishery's response to a declining sardine stock - progressively higher exploitation rates targeting the oldest, largest, and most fecund fish.**

The authors also identify a critical spawning stock biomass threshold of 740,000 metric tons (age 2+), below which, in combination with unfavorable environmental conditions, not only would stocks collapse, but with continued fishing pressure, would reduce the stock's ability to adapt and recover. This year's stock assessment finds a spawning stock biomass of 435,351 mt, below this critical biomass threshold.[3] The assessment also finds that the **2010 and 2011 year classes were the weakest in recent history**.[4]

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[1] Hill et al. 2012. Assessment of the Pacific sardine resource in 2012 for U.S. management in 2013. Agenda Item G.3.b. Pacific Fishery Management Council. November 2012.
[2] Zwolinski, J. and D.A. Demer. 2012. A cold oceanographic regime with high exploitation rates in the Northeast Pacific forecasts a collapse of the sardine stock. Proceedings of the National Academy of Sciences (PNAS) 109 (11). 4175-4180. Available at: http://www.pnas.org/content/early/2012/02/24/1113806109.full.pdf and PFMC, Agenda Item C.1b8, supplemental public comment. March 2012. http://www.pcouncil.org/wp-content/uploads/C1b_SUP_PC8_SHESTER_MAR2012BB.pdf.
[3] PFMC. November 2012. Agenda Item G.3 B. Sardine Assessment Report.
[4] PFMC. November 2012. Agenda Item G.3 B. Sardine Assessment Report.

Our concerns over stock collapse and the observed decline of the Pacific sardine population again call into question the fundamentals of Pacific sardine management. We have commented many times on the need to review and revise the harvest control rule for Pacific sardine, including comments provided in this briefing book under agenda item F.4.c, public comment (Oceana, October 5, 2012). In this letter we briefly summarize our concerns with the control rule, provide emphasis on F_{MSY} and the overfishing limit from our recent sardine modeling work, and we request that a full Environmental Impact Statement be prepared before the Council takes final action.

1. Optimum Yield

The Magnuson Stevens Act mandates that fisheries be managed to achieve Optimum Yield, which reflects an effort to balance fisheries production with the need to take into account the protection of marine ecosystems.[5] Hence, OY is prescribed as MSY as reduced by any relevant economic, social, or ecological factors.[6] While the law requires OY be assessed and specified in the FMP itself, the Council voted in September 2010 to amend the FMP (Amendment 13) to add language "to specify that the Council will include ecological considerations when reviewing and/or adopting SDCs, OFLs, ABCs, and ACLs."[7] We have grave concerns, however, the current Council process for setting catch levels is not set up to consider ecological factors—as evidenced by the stock assessment and recommended harvest formulas for OFL, ABC and ACLs.[8] Ecological and economic factors (including the opportunity cost of sardines as prey for other fish) need to be considered and evaluated prior to adopting any 2013 status determination criteria and catch levels. The Council should not take action until this is done.

2. F_{MSY} and OFL

We are concerned that the current Fmsy of 18% used by the Council to establish an Overfishing Limit (OFL) for Pacific sardine is based on a simulation model that does not reflect the best available science of Pacific sardine population dynamics.

For decades, fishery managers have recognized that the Pacific sardine population undergoes natural, periodic oscillations on a multi-decadal time scale.[9] Irrespective of fishing effort, sardine stock recruitment is thought to be highly productive during warmer ocean periods, while productivity declines during colder ocean periods.[10] This understanding was a key part of the original simulation modeling presented in Amendment 8 to the Coastal Pelagic Species FMP, and used as a basis for the harvest control rule currently employed.[11] In those simulations, sardine recruitment was determined by a functional relationship with temperature, which was modeled in an oscillatory, multi-decadal cycle. In Amendment 8, 'Stochastic *F*MSY' was defined as the value of FRACTION that maximizes average catch (i.e., equilibrium yield) in a stochastic simulation model when CUTOFF is equal to zero and MAXCAT is

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[5] 16 U.S.C. 1851 § 301(a)(1); *see also* 16 U.S.C. 1802 § 3(33).
[6] 16 U.S.C. 1802 § 3(33)(B). Emphasis added.
[7] PFMC Council Decisions June 12-17, 2010, at 9.
[8] PFMC. November 2012. Agenda Item G.3 B. Sardine Assessment Report.
[9] Baumgartner et al. 1992. Reconstruction of the history of Pacific sardine and northern anchovy populations over the past two millennia from sediments of the Santa Barbara Basin, California.
[10] Jacobson & MacCall (1995). Stock-recruitment models for Pacific sardine (*Sardinops sagax*). *Can. J. Fish. Aquat. Sci.* 52:566-577.
[11] PFMC. 1998. Amendment 8 (to the northern anchovy fishery management plan) incorporating a name change to: the coastal pelagic species fishery management plan. Pacific Fishery Management Council, Portland, OR. (Appendix B: http://www.pcouncil.org/wp-content/uploads/a8apdxb.pdf).

unlimited. Under this model, the stochastic *F*MSY was calculated at 12% as this constant fishing rate yielded the highest average catch given the way sardine population dynamics were modeled.

In the simulations, various harvest control rules were considered, including some that attempted to capitalize on the purported ability to predict sardine recruitment based on temperatures. This was the origin of the temperature-based fraction parameter, which established that the harvest rate above the cutoff (FRACTION) would vary from 5-15% based on sea surface temperatures as measured at Scripps Institute of Oceanography pier in La Jolla, California. The theory was that during more productive periods, the sardine population could withstand higher catch levels, under the assumption that these more productive periods could be predicted based on the temperature at Scripps Institute of Oceanography pier.

In 2010, McClatchie et al.[12] provided strong evidence that the use of the Scripps Institute of Oceanography pier temperatures was an inappropriate indicator of sardine productivity and should thus be removed from management. While this study essentially debunked the idea that fishery managers can predict sardine recruitment based on temperatures, it did not infer that there was no relationship between sardine productivity and the environment nor did it disprove the fundamental recognition that Pacific sardines undergo multi-decadal cycles of high and low natural productivity.

While Amendment 8 defined OFL and ABC as equal to the Harvest Guideline produced by the Option J Harvest Control Rule, these values were redefined in Amendment 13 with a temperature-based *F*MSY (and OFL) ranging from 2.00% to 19.85%.[13] However, in response to the McClatchie et al. 2010 findings, Appendix 4 of the 2011 Pacific sardine stock assessment "*Re-evaluation of Fmsy for Pacific sardine in the absence of an environmental covariate*" made a commendable attempt to develop a static *F*MSY value for sardine for the purpose of specifying OFL and ABC in the annual specifications process.[14] This Appendix updated the Amendment 8 simulation model in several ways with new data and information. While we generally support the effort to update this model, we are primarily concerned with the complete removal of Sea Surface Temperature (SST) effects on Stock-Recruitment calculations. Regardless of whether environmental conditions can be used to predict Pacific sardine productivity in the management context, the removal of SST effects altogether from the model represents a fundamental shift in the way sardine stocks are simulated, as it removes the long-term oscillations in recruitment. In other words, the Appendix 4 update simulates the sardine stock without periods of higher and lower recruitment. If it were true that sardines in fact do not undergo cyclic fluctuations as implied by the updated simulation model, there would be major implications for how we manage this stock.

Over the past several months, Oceana has obtained and conducted our own analysis of both the original Amendment 8 simulation model and the updated 2011 model. To illustrate our concern regarding the fundamental difference between the two models, we conducted identical simulations of the Pacific sardine population under each of the two models. For each simulation, we ran 500 iterations of the sardine biomass trajectory over a 100-year period with a starting biomass of 500,000 metric tons in the absence of fishing (however, similar trends are present with fishing). The figures below show the mean, median,

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[12] McClatchie, S. R. Goericke, G. Auad, and K. Hill. 2010. Re-assessment of the stock-recruit and temperature-recruit relationships for Pacific sardine (*Sardinops sagax*). *Can. J. Fish. Aq. Sci.* 67: 1782-1790.

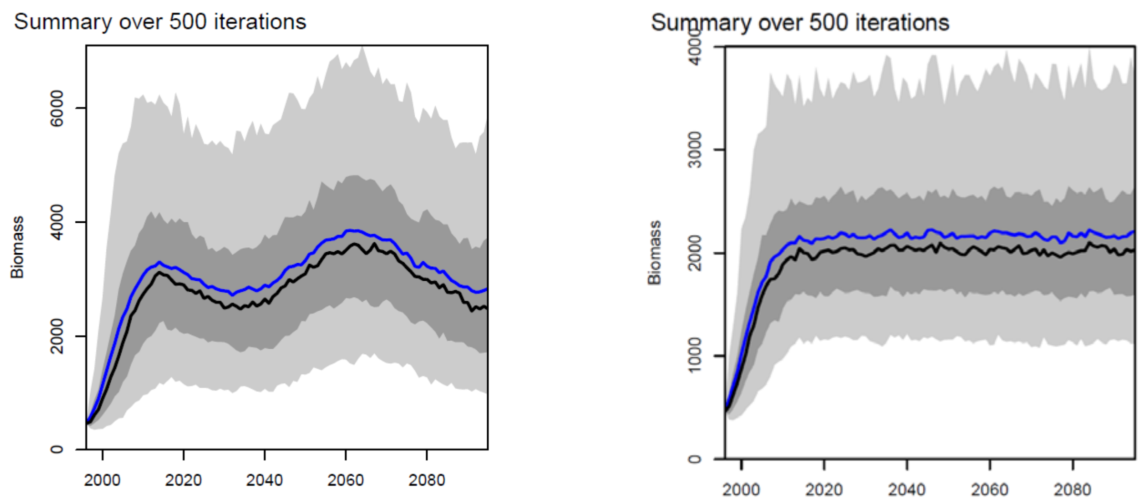
[13] PFMC. 2010. Measures for integrating new provisions of the Magnuson-Stevens Fishery Conservation and Management Act and National Standard 1 Guidelines into coastal pelagic species management. Amendment 13 to the Coastal Pelagic Species Fishery Management Plan. Partial Draft Environmental Assessment. Pacific Fishery Management Council, Portland, OR. (http://www.pcouncil.org/wpcontent/uploads/F2a_ATT1_DRAFT_EA_JUNE2010BB.pdf).

[14] Hill et al. 2011. Assessment of the Pacific sardine resource in 2011 for U.S. management in 2012. NOAA National Marine Fisheries Service. Appendix 4.

50% quantile, and 95% quantiles of the population trajectories. As is clearly indicated, the trajectories produced by the original amendment 8 parameters show a substantial oscillation with a period of approximately 60 years, which is roughly equivalent to the observed low-frequency oscillations presented in Baumgartner et al. (1992) and Zwolinski and Demer (2012), which are thought to correspond with the Pacific Decadal Oscillation. However, the updated simulation model produces an average trajectory that is static. While both simulation models include stochastic variability in annual sardine recruitment, the updated model does not reflect the oscillatory nature of these stocks.

A. Original Amendment 8 Parameters

B. 2011 Updated Parameters



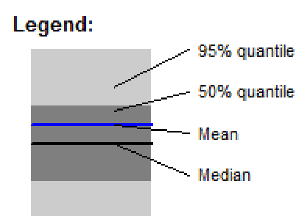


Figure: 100-year simulation model of Pacific sardine biomass trajectories based on (A) the original simulation model used in Amendment 8 to the CPS FMP and (B) the updated simulation model used in Appendix 4 of the 2011 Pacific sardine stock assessment. Sardine biomass is in Thousand Metric Tons. Figure and analysis by Oceana.

In our analysis of the difference between these models, we concur with the conclusion that the stochastic *F*MSY values changed from 12% in the original Amendment 8 model to 18% in the updated model. We also found that this 50% increase in the stochastic *F*MSY value results solely from the disabling of the SST effects on Stock-Recruitment, not from any of the other changes to the simulation model. Therefore, the removal of the oscillatory nature of the population, not the other model updates, explains the increase in stochastic *F*MSY.

Furthermore, our analysis indicates that there are other substantial ramifications of the removal of the SST effects. In particular, the effect of the CUTOFF component of the HCR is much more important in the original model with the oscillations than in the updated model where average recruitment is static. The intuition is that when the stock productivity oscillates, the CUTOFF serves to reduce catch rates when the stock is in the lower part of the cycle, allowing for a larger seed stock to recover the population as conditions become more productive, while the lack of oscillations largely eliminate the need to reduce catch rates, as low productivity is not sustained.

The point of these comments is not to discourage updates to the original simulation model. In fact, we continue to encourage a full update of the simulation model and a full Management Strategy Evaluation, which the SSC has recommended for the last five years. However, the Pacific sardine stock is currently undergoing in a substantial decline now as evidenced by multiple independent surveys, the 2012 draft stock assessment, and as predicted by the Zwolinski and Demer (2012) analysis. In fact, there has not been a decline in Pacific sardine populations to this degree since the collapse of the Cannery Row era.

Our main point is that the increase in stochastic F_{MSY} (and hence the OFL) in the 2011 analysis was the result of removing a fundamental component of sardine stock dynamics that violates the current scientific understanding that the stock undergoes prolonged periods of high and low productivity, rather than from the inclusion of more recent data on sardine productivity. At the minimum, this model should not provide the basis for setting OFLs. Until such time as a full re-evaluation of the simulation model can be conducted, peer-reviewed, and accepted by the SSC as best available science, the Council and SSC should consider the existing simulation model's estimate of 12% as the stochastic F_{MSY} for Pacific sardine. However, recall that the stochastic F_{MSY} simply reflects a constant rate regardless of whether sardines are in a high or low productivity phase. If the Council follows its own logic from Amendment 13, it should modify the Fmsy to reflect the current state of sardine productivity. Clearly, the current decline in sardine productivity indicates that the stock is in its lower quantile productivity phase, and thus adopt the lower quantile F_{MSY} of 2.00% to reflect the current state of reality.

3. DISTRIBUTION

The DISTRIBUTION factor in the Pacific sardine control rule (0.87) is based on the assumption that 87% of the stock is in U.S. waters, 13% of the stock is in Mexico waters and 0% is found off Canada.[15] Documents in this briefing book explain that there have been trawl surveys for sardine off Canada since 1999.[16] While the U.S. continues to assume zero percent of the stock is in Canada, despite this science, Canada assumes a sardine distribution of 27.2% to calculate catch levels for its fisheries.[17] The least rational and least scientifically defensible number to continue to use for the DISTRIBUTION factor for Canada is zero. According to the 2012 draft stock assessment, Mexico took 51% of the total coastwide catch in 2011. The ultimate result is that the assumed distribution factors by each of the individual three countries fishing sardines sums to far greater than 100%. In other words, 87% + 51% + 27% = 165%. Clearly, the current situation is significantly exceeding the Harvest Guidelines as indicated by the Harvest Control Rule in Amendment 8, thus failing to meet the intended management outcomes including the provision of sufficient forage. Just as in any international overfishing situation, no single fishing nation is solely responsible for overfishing; if the sum of all nations is overfishing, then every nation is overfishing. Continuing to use an out-of-date DISTRIBUTION factor risks overfishing and violates national standard two which states that conservation and management measures must be based upon the best scientific information available.[18]

4. CUTOFF, FRACTION, and MSST

As mentioned above and in other letters, a recent scientific paper by NMFS SW Fisheries Science Center researchers (Zwolinski and Demer 2012) published in the Proceedings of the National Academy of

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[15] CPS FMP Amendment 8, Appendix B, p. B-87-88.
[16] PFMC. Agenda Item G.3.a Attachment 4
[17] DFO. 2011. Evaluation of Pacific sardine (*Sardinops sagax*) stock assessment and harvest guidelines in British Columbia. DFO Can. Sci. Advis. Sec. Science Advisory Report. 2011/016.
[18] 16 U.S.C. 1851 MSA § 301(a)(2)

Sciences documents a "critical biomass" of 740,000 metric tons, below which the Pacific sardine stock is at risk of collapse. Among the clear implications of this threshold are that the current cutoff (150,000 mt, age 1+) and minimum stock size threshold (MSST) (50,000 mt) should be greater than 740,000 mt. Other science – and the national standard one guidelines – also support consideration of much higher thresholds.[19,20]

In particular, the Lenfest Forage Fish Task Force[21] recommended for Tier 2 forage fish stocks (for which stock assessments and quantitative estimates of impacts to predators are available) that management benchmarks should include a CUTOFF of greater than 40% of average biomass and that FRACTION should be less than ½ of F_{MSY}. Using the original Amendment 8 simulation model, this would mean a CUTOFF of at least 1,260,000 mt and a FRACTION of less than 6%.

One important observation of Zwolinski and Demer (2012) is that that the most recent peak in sardine biomass (1.039 mmt SSB in 1999 as estimated in the 2012 draft assessment) was nowhere near the historical peaks. The authors suggest that excessive fishing pressure during the previous sardine collapse increased the rate of collapse, delayed recovery, and ultimately prevented the population from recovering even close to its full potential. Their fundamental conclusion was that we are making the same mistakes all over again.

In conclusion, we believe that the Council is at a pivotal moment in sardine management. We have the opportunity to learn from past mistakes, heed the warning signs, and create an alternative management regime that maintains healthy fishing communities, provides adequate forage for predators, and minimizes the risk of overfishing. NMFS and the Council should immediately prepare a full Environmental Impact Statement on the proposed action before recommending catch levels for 2013, and initiate a full management strategy evaluation. The analysis should include alternatives with the OFL set at 2%, and alternative Harvest Control Rules that apply the Lenfest Recommendations, with opportunity for public review. There are too many scientific concerns and controversy to justify the adoption of a harvest guideline based on the existing control rule without a full assessment of the costs, impacts, best available science and full range of alternatives. We look forward to sharing our analyses with the Council and NMFS to assist in the development of alternative harvest control rules for consideration.

Thank you for your time and consideration of this important matter.

Sincerely,

Geoffrey Shester, Ph.D.
California Program Director

cc: Rod McInnis, NMFS Southwest Regional Administrator

---

[19] Curry, P.M., I.L. Boyd, S. Bonhommeau, T. Anker-Nilssen, R.J.M. Crawford, R.W. Furness, J.A. Mills, E.J. Murphy, H. Österblom, M. Paleczny, J.F. Piatt, J.P. Roux, L. Shannon, and W.J. Sydeman. 2011. Global Seabird Response to Forage Fish Depletion – One-Third for the Birds. *Science* (334)6063 1703-1706.

[20] 50 CFR § 600.310 (e)(2)(ii)(B) (MSSTs must be expressed in terms of spawning biomass or other measure of reproductive potential and should equal whichever is greater: one-half the MSY stock size, or the minimum stock size at which rebuilding to the MSY level would be expected to occur within 10 years.)

[21] Pikitch, E., Boersma, P.D., Boyd, I.L., Conover, D.O., Cury, P., Essington, T., Heppell, S.S., Houde, E.D., Mangel, M., Pauly, D., Plagányi, É., Sainsbury, K., and Steneck, R.S. 2012. Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs. Lenfest Ocean Program. Washington, DC. 108 pp.

Agenda Item G.3.d
Supplemental Public Comment 3
November 2012

EXCERPT FROM INTERVENOR-DEFENDANT BRIEF:
OPPOSITION TO PLAINTIFF MOTION FOR SUMMARY JUDGEMENT
RE: AMENDMENT 13

The following information is excerpted from Intervenor-Defendant's brief filed September 19, 2012, opposition to Plaintiff's (Oceana) Motion for Sumary Judgement, challenging Amendment 13 management measures, with particular reference to Pacific sardine.

B. Plaintiff's Claims Of Overfishing Have No Factual Support. Despite Plaintiff's continuing claims about overfishing (Pl. Opp. at 3-4), conspicuously absent from Pl. Opp. is any response to I-D Mem. comparing actual harvests to biomass levels and to the overfishing level ("OFL"). I-D Mem. at 4-6, 20-22, 24-25, 26-27. The current management program for coastal pelagic species ("CPS") is precautionary and conservative in the extreme – and is preventing overfishing in accordance with the MSA. Figures 1 and 2 graphically present the data.

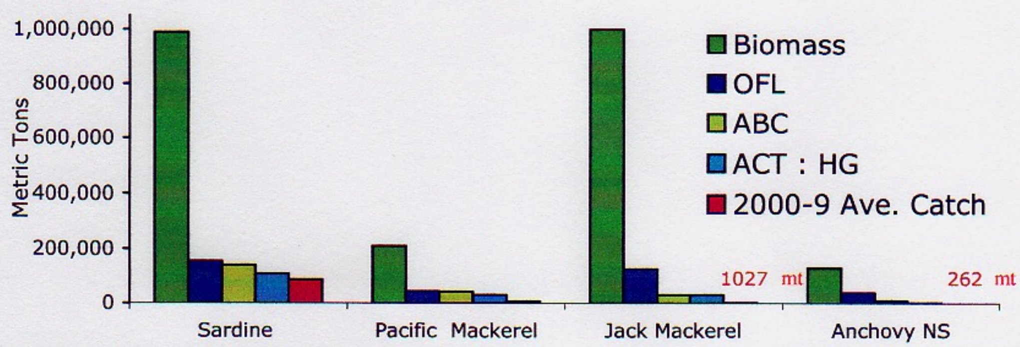


Figure 1. Current biomass estimates and reference points for CPS in the U.S. fishery: overfishing limit (OFL), acceptable biological catch (ABC), annual catch targets or harvest guideline (ACT/HG), and 2000-2009 average annual U.S. catch of CPS. Red numbers refer to catch in metric tons.

Note that the OFL and harvest guideline decline with the annual biomass estimate, and the US exploitation rate for the 2011 sardine fishery was 5.11 percent. The coastwide exploitation rate was 15.07 percent, while the temperature based maximum sustainable harvest rate for the 2013 season is 20.8% (Kevin Hill pers. comm.).

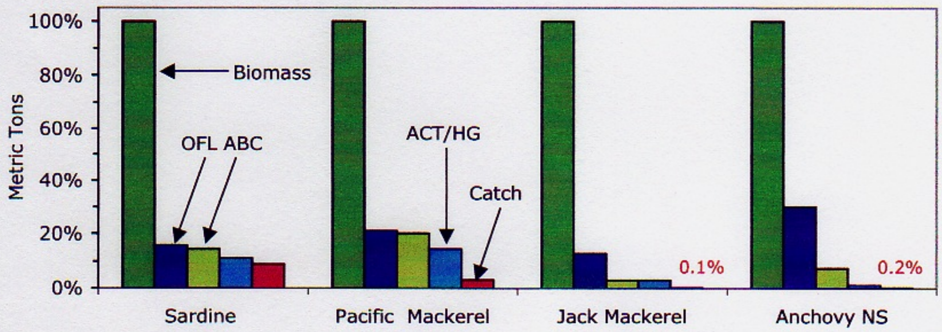


Figure 2. Current reference points for CPS shown as a percentage of current biomass: overfishing limit (OFL), acceptable biological catch (ABC), annual catch targets or harvest guide line (ACT/HG), and 2000-2009 average annual U.S. catch of CPS. Red numbers refer to % catch.

Sources for Figures 1 and 2.

	Anchovy Northern Subpopulation	
Biomass	130,000 mt	A.R. 273 at 16653
OFL	39,000 mt	A.R. 257 at 15546
ABC	9,750 mt	A.R. 257 at 15546
ACT : HG	1,500 mt	A.R. 257 at 15546
2000-9 Average U.S. Catch	262 mt	A.R. 269 at 16637
	Jack Mackerel	
Biomass	1,000,000 mt	A.R. 257 at 15546
OFL	126,000 mt	A.R. 257 at 15547
ABC	31,000 mt	A.R. 257 at 15547
ACT : HG	31,000 mt	A.R. 257 at 15547
2000-9 Average U.S. Catch	1,027 mt	A.R. 269 at 16631
	Pacific Mackerel	
2010-11 stock assessment biomass	211,126 mt	A.R. 257 at 15544
OFL	44,336 mt	A.R. 257 at 15544
ABC	42,375 mt	A.R. 257 at 15544
ACT : HG	30,386 mt	A.R. 257 at 15544
2000-9 Average U.S. Catch	6,603 mt	A.R. 258 at 15621
	Sardine	
2011 stock assessment biomass	988,385 mt	A.R. 291 at 16979
OFL	154,781 mt	A.R. 291 at 16979
ABC	141,289 mt	A.R. 291 at 16979
ACT : HG	109,409 mt	A.R. 291 at 16979
2000-9 Average U.S. Catch	88,212 mt	A.R. 291 at 16964

Mr. Dan Wolford, Chair Oct. 30 2012
Pacific Fishery Management Council
7200 NE Ambassador Place, Suite 101
Portland, OR 97220-1384

Re. Comments on Oceana's letter to Dan Wolford, Oct 23, 2012
Re: Coastal Pelagic Species: Pacific Sardine Management for 2013.

Dear Mr. Wolford and Council members.

Dr. Shester's letter re: Coastal Pelagic Species: Pacific Sardine Management for 2013, is full of contradictions. He references two papers concerning the relationship between SST and sardine productivity. The first (McClatchie et al 2010) suggests that sea surface temperature (SST) is not a valid index of sardine recruitment success; Oceana has sued NOAA because the Council has continued to use the Amendment 8 sardine model that includes SST in the calculation of recruitment. The second paper suggests that sardine is collapsing because of cold SST (Zwolinski and Demer 2012).

For two years Oceana has been telling everyone that the Amendment 8 sardine model has been 'rebutted' by the analysis that shows that SST at Scripps Pier is no longer statistically correlated with recruitment success in sardine. Now they have borrowed the Amendment 8 model and they conclude from their as yet unexplained preliminary analysis of this 'rebutted' model that the correct FRACTION for next year should be 2%.

Dr. Shester relies on the Zwolinski and Demer (2012) statement concerning the collapse of the early sardine fishery, i.e. "When the total biomass of age 2-y-plus individuals, comprising most of the spawning stock biomass, decreased below 0.74 million tons (Mt) in 1948 (Fig. 2C) (20), and most of the largest individuals had been removed by the fishery, sardine progressively disappeared from the fisheries off Canada and then off the northwest United States (6)."

I note that this statement is anecdotal in that it is based on a single occurrence, and it is impossible to tell if the abandonment of the Pacific Northwest was triggered by some as yet unexplained density-dependent factor, as suggested by Zwolinski and Demer (2012), or if it was caused by cold SST, or other environmental factors. I agree that the rich plankton blooms that occur in the Pacific Northwest during the summer and early fall are important to the adult sardine population and that the disappearance of sardine from the Pacific Northwest would certainly merit Council intervention. However, recent record landings in Canada and the large landings in the Pacific Northwest in 2012 clearly demonstrate that the sardine population has not abandoned the area as suggested by Zwolinski and Demer (2012), and sea surface temperatures have not declined to the levels that occurred during the collapse of the sardine population.

Also the years of the early recovery of sardine (i.e. 1980-1992) occurred when there were very limited numbers of sardine in the Pacific Northwest. This period obviously had very high reproductive success. Food in the spawning and nursery grounds in the area to the south of central California may therefore be more important in reproductive success than food in the feeding grounds in the Pacific Northwest.

Dr. Shester spends considerable effort discussing modeling methodology, and he stresses the importance of using “an osillatory, multi-decadal cycle” in modeling sardine. However, this contradicts his objections to the Amendment 8 sardine analyses as the best available science. Amendment 8 is the only fishery management model in the world that includes an oscillatory, multi-decadal cycle. He now states, "We are primarily concerned with the complete removal of Sea Surface Temperature (SST) effects on Stock-Recruitment calculations.” He then goes on to use the Lenfest Forage Fish Task Force recommendations (that are directed at fisheries harvesting at or above MSY) to recommend how sardines should be managed. He fails to point out that the stock-recruitment calculations used in the Lenfest study did not include an oscillatory, multi-decadal cycle. In fact this study did not include ANY variability in the stock-recruitment calculations. The fishery simulation models used in the Lenfest study were based on an implied assumption that the environment plays no role in recruitment and that recruitment is perfectly described by stock-recruitment relationships.

If Dr. Shester thinks that environmental variability is important, why does he recommend using a management strategy derived from population simulations using a steady-state ocean?

Dr. Shester apparently carried out his own preliminary analyses with a borrowed version of the model used in Amendment 8. Unfortunately he does not tell us what Emsy values his analyses produced, and he does not tell us what stock-recruitment relationships he used. According to the single figure in Dr. Shester’s letter, the original simulation model was compared to the updated model. The stock-recruitment relationships in these two models are very different; recruitment in the original model is dominated by the SST term, the updated model does not include an SST term and the Ricker models have different parameters. The two models are driven by stochastic time series derived from different time periods and the average SST in the Amendment 8 time series was colder than the average SST in the revised model. Dr. Shester’s analysis clearly shows that the original model is cyclical and the updated model is not; this is no surprise because this is clearly stated in the descriptions of the two models. Average unfished biomass in Dr. Shester’s figure varies cyclically between about 2.7 and 3.8 MMT in the first figure and is stable at about 2.3 MMT in the second figure. Oceana needs to explain the nearly 1 MMT difference in the average biomass of the two figures.

These figures are the only real information presented in the Oceana letter and they show biomass in population simulations with no fishery. Until Oceana documents their analyses it is impossible for the CPSMT or the SSC to determine if Oceana’s preliminary conclusion that the cyclic stochastic time series results in a 1 MMT higher average biomass and a 50% lower Emsy are valid.

As few of us were around when it happened, it is important to understand what actually occurred during the collapse of the sardine fishery and to compare this to what would have happen under the Amendment 8 harvest guideline.

The sardine biomass declined from 793,000 mt in 1949 to 3,000 mt in 1965, the average exploitation rate for age 4+ sardine during this period was 50.9% and only two years had exploitation rates below 36% (MacCall 1979, Table 2). If the present harvest guidelines had been in effect, the average exploitation rate for this period would have been 0.8%. Due to cold SSTs the FRACTION would have been 0.05 for all but the El Nino years of 1957-9 and except for 1949 and 1950, when the exploitation rates would have been 4.1% and 4.0%, the exploitation rate would never have exceeded 2.3%. There would have been no fishery in 10 of the 17 years. MacCall's analysis suggested that if the fishing mortality rate had been equal or less than F=0.25 the sardine population would not have collapsed. Note with a natural mortality rate of M=0.4, F=0.25 results in an exploitation rate of 18.4%; remarkably close to the revised estimate of Emsy used in the current stock assessment.

A close read of Dr. Shester's letter shows that NOW he apparently believes that the original Amendment 8 sardine model is presently the best available science. According to the most recent stock assessment, the Amendment 8 harvest guideline resulted in a maximum US harvest rate of 11.48% in 2002, and the 2011 U.S. harvest rate was only 5.11%. If the sardine stock declines further in the next few years the harvest guideline will cause the harvest rate to decline rapidly; if the stock increases the harvest guideline will increase harvest rates.

However, Dr. Shester's conclusion from his first and PRELIMINARY venture into modeling sardine is that the Council should immediately abandon the present harvest guideline, ignore the updated Fmsy analysis, and accept Dr. Shester's assumption that the sardine population is going to collapse.

As one of the authors of Amendment 8, I would like to point out that sardines have not abandoned the Pacific Northwest, and the present harvest guideline was designed so that the Council would not have to change the harvest rate every time the stock size changed.

Finally, Dr. Shester states, "we are primarily concerned with the complete removal of Sea Surface Temperature (SST) effects on Stock-Recruitment calculations". The temperature based maximum sustainable harvest rate for the 2013 season is 20.8% (pers. comm. Kevin Hill).

RHParrish

Richard H. Parrish
Fisheries Biologist.

Concerns with Proposed Pacific Sardine 2013 Harvest Specifications

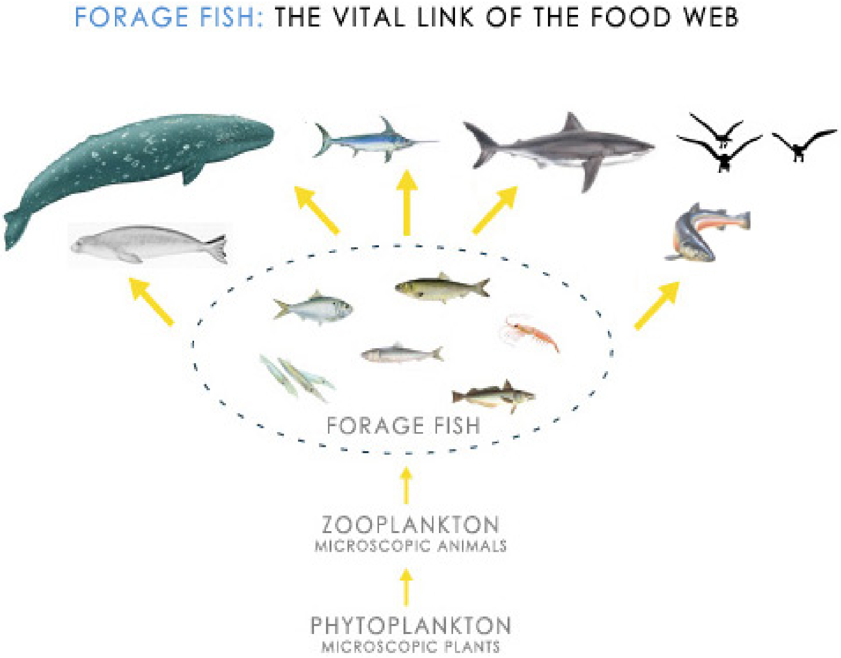
November 4, 2012

Presentation to the Pacific Fishery Management Council

Geoff Shester, Ph.D.
Oceana

Sardine is an Important Forage Species

- Key predators
  - Chinook salmon
  - Seabirds
  - Tunas, billfish, sharks
  - Whales and dolphins

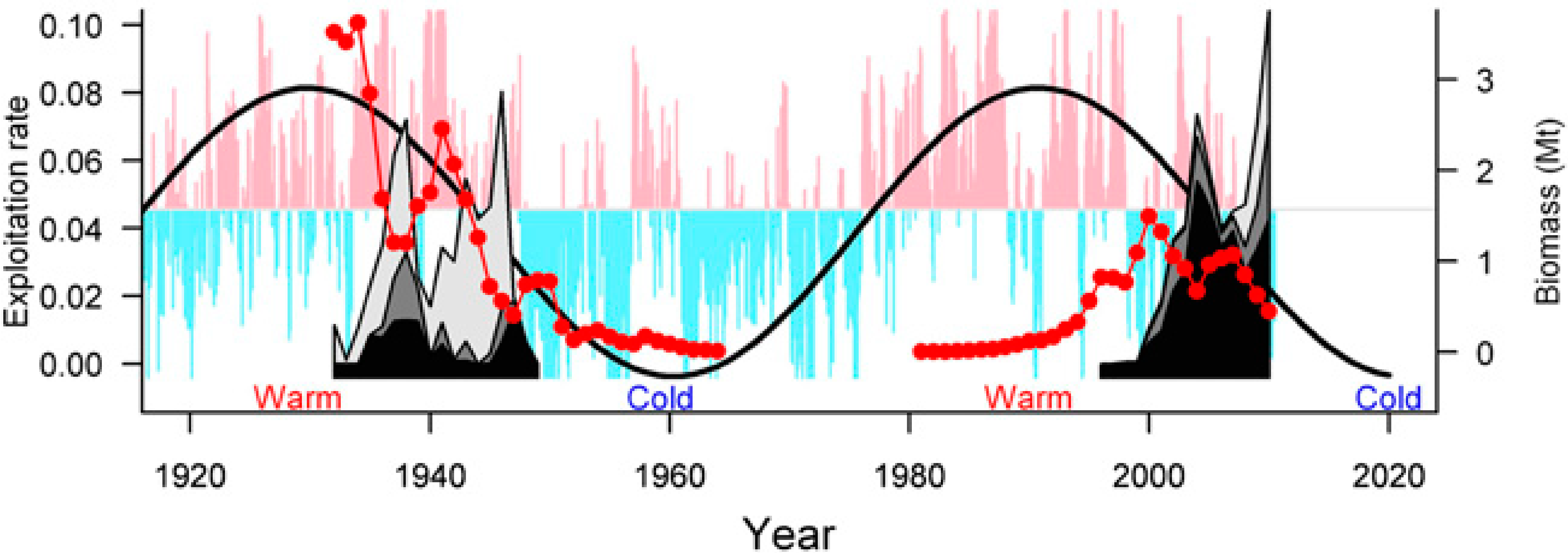


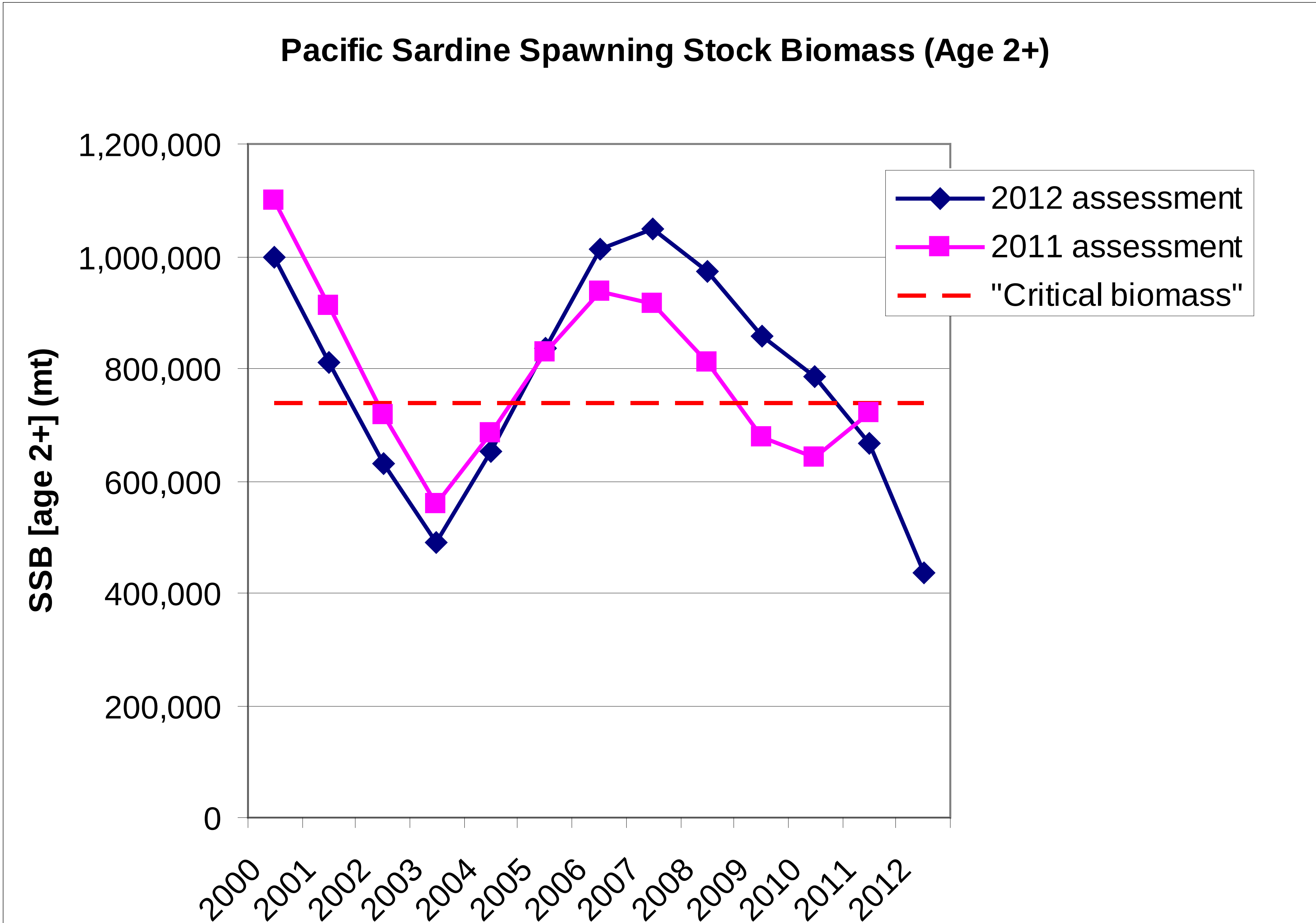
A cold oceanographic regime with high exploitation rates in the Northeast Pacific forecasts a collapse of the sardine stock

Juan P. Zwolinski[a,1] and David A. Demer[b,2]

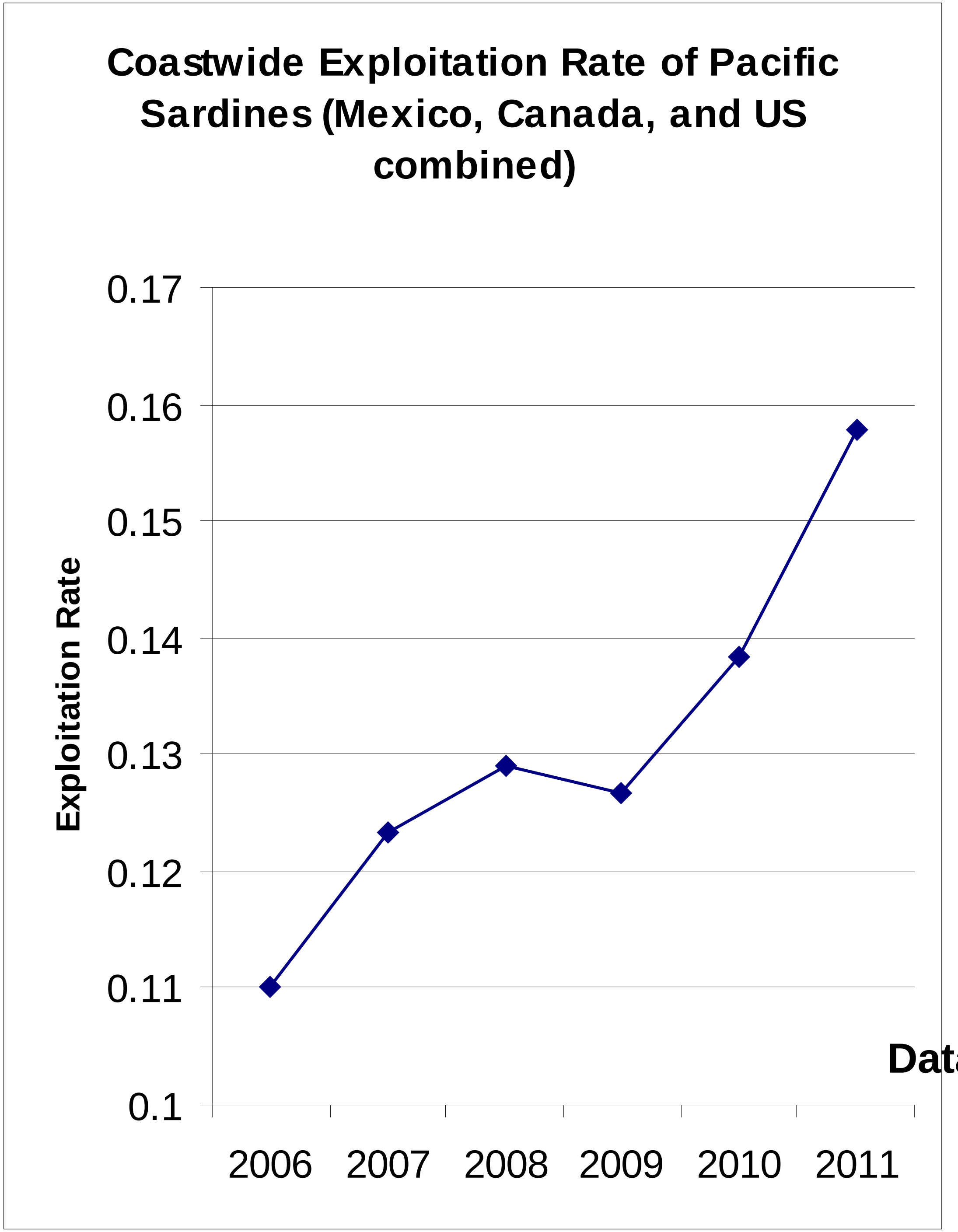
PNAS

Critical biomass (Age 2+): 740,000 MT
Fishing pressure: increases decline, delays recovery, reduces future peaks
Similar oceanographic and fishery trends to 1940s when sardine collapsed





Pacific Sardine Spawning Stock Biomass (Age 2+)
SSB [age 2+] (mt)
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2012 assessment
2011 assessment
"Critical biomass"



Data from 2012 Assessment

CPS FMP

- 4.8.2: Factors to be considered when setting annual harvest specifications:

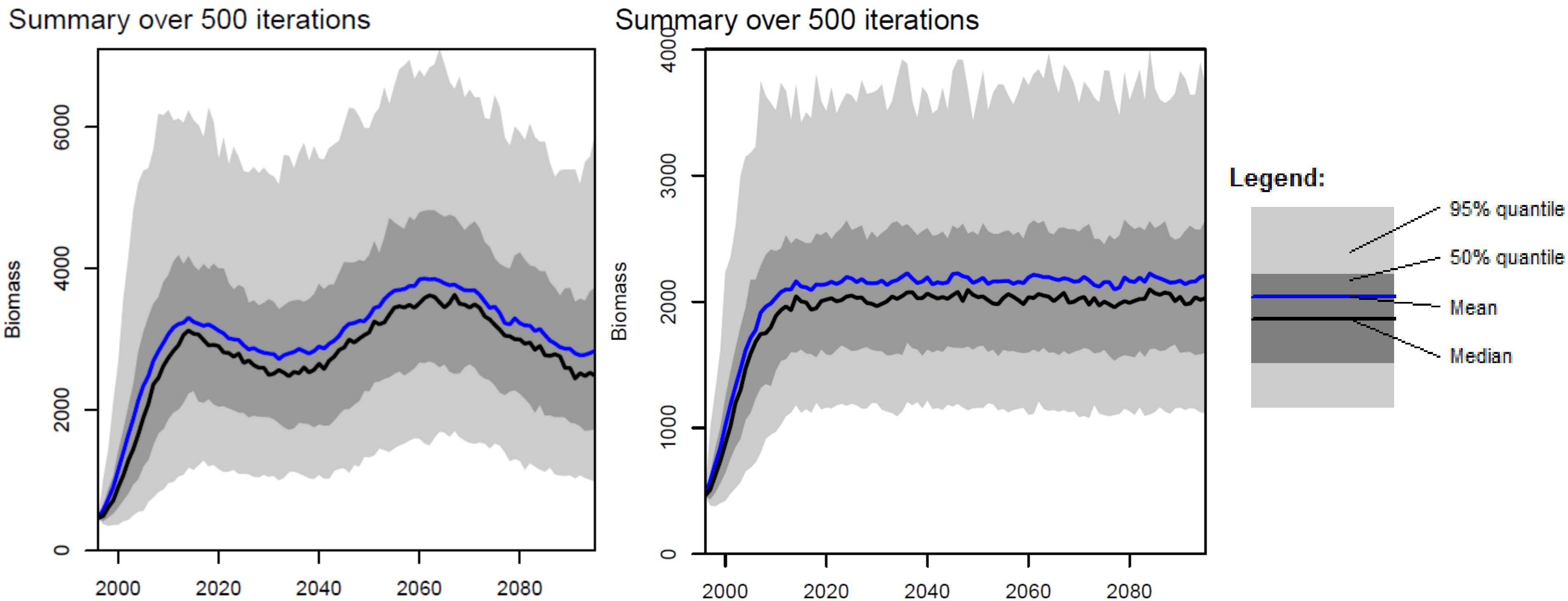
- “Information on ecological factors such as the status of the ecosystem, predator-prey interactions, or oceanographic conditions that may warrant additional ecosystem-based management considerations.”

OFL from Amend 13

- OFL = Biomass * Fmsy * Distribution
- Temperature Dependent
- Fmsy ranges from 2%-19% of Age 1+ Biomass
- 2% in years of low temperature (low productivity)

- **Proposed Temperature Independent Fmsy = 18%**
- **Deviation from Amendment 13 beginning in 2012**
- **Uncertainty not included in estimated sigma (σ) value**

- **Conclusion based on a model that doesn't reflect the known oscillatory nature of the stock – Significant uncertainty…**



Original Amend 8 Parameters: Stochastic Fmsy = 12%

2011 Updated Parameters Stochastic Fmsy = 18%

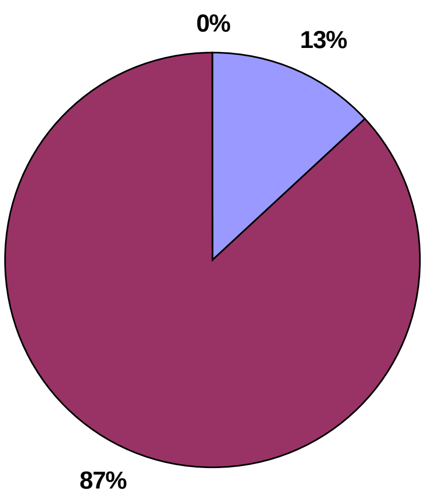
100 year simulation beginning at 500 TMT without fishing. Analysis by Oceana.

Overfishing Limit

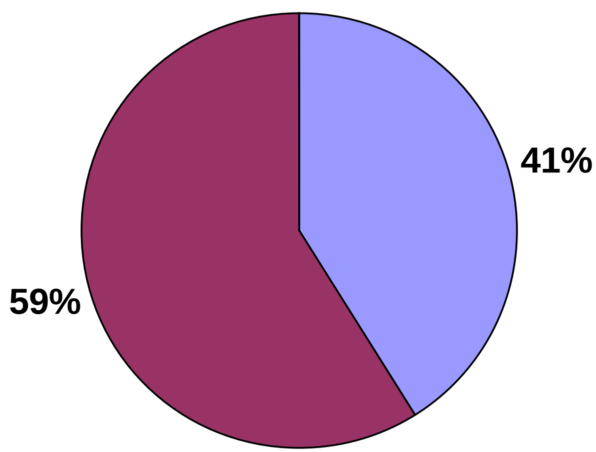
- OFL = Biomass * Fmsy * Distribution
- Sigma intended to reflect uncertainty in OFL
- However, sigma currently limited to uncertainty in Biomass only

Distribution

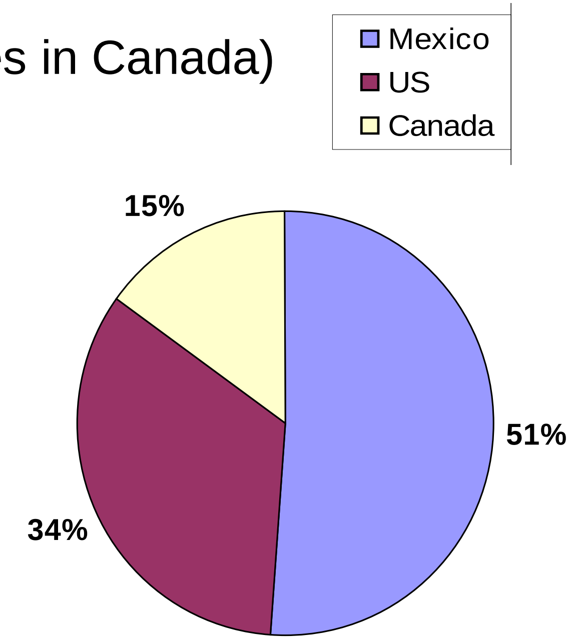
- Distribution is intended to reflect the proportion of the stock in U.S. waters
- Dictates proportion of the total harvest guideline to which the U.S. is entitled
- Current Assessment used in management based on single Coastwide stock
- Not based on best available science (i.e., zero sardines in Canada)



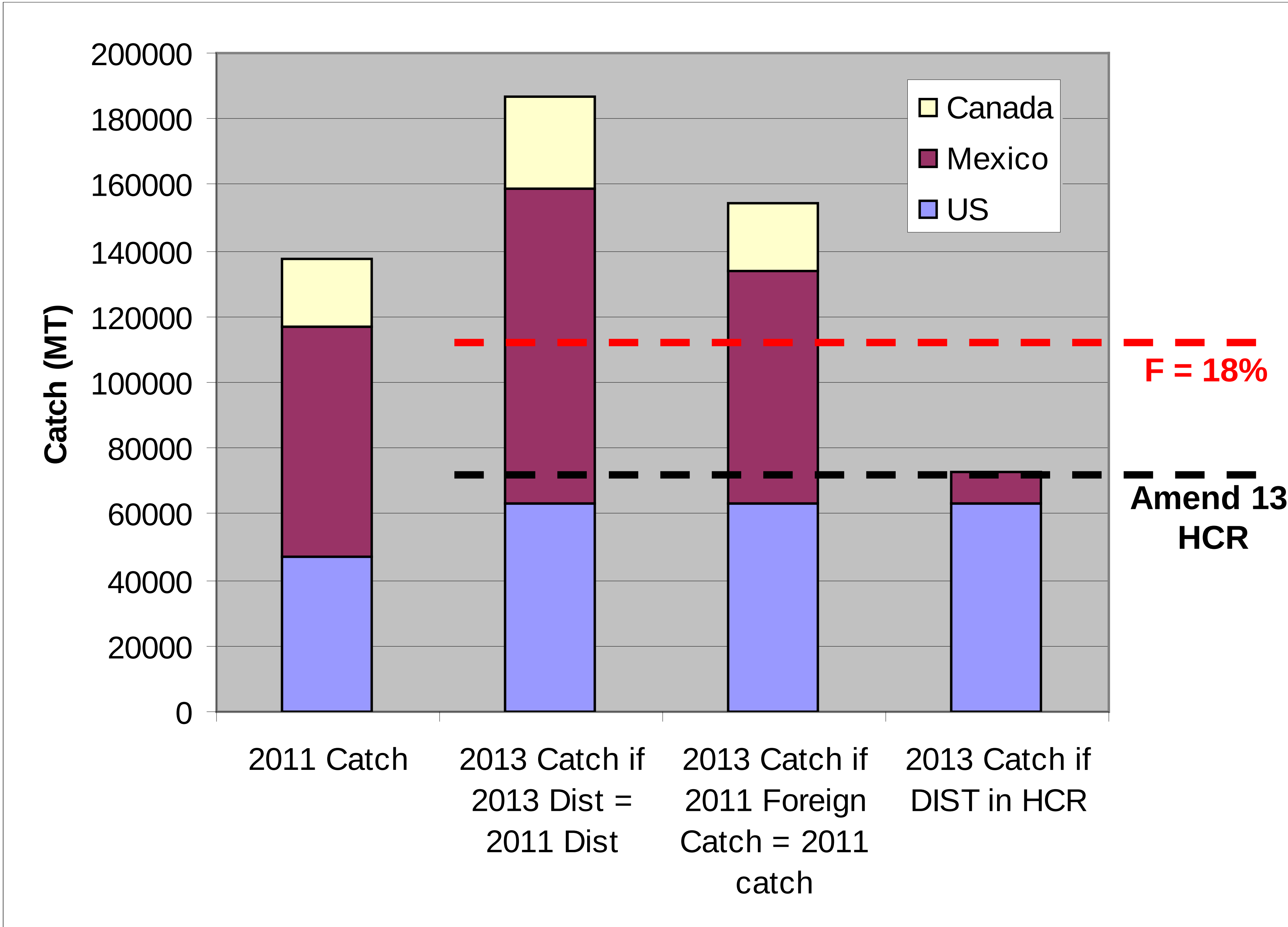
DISTRIBUTION used in Proposed 2013 US Harvest Guideline



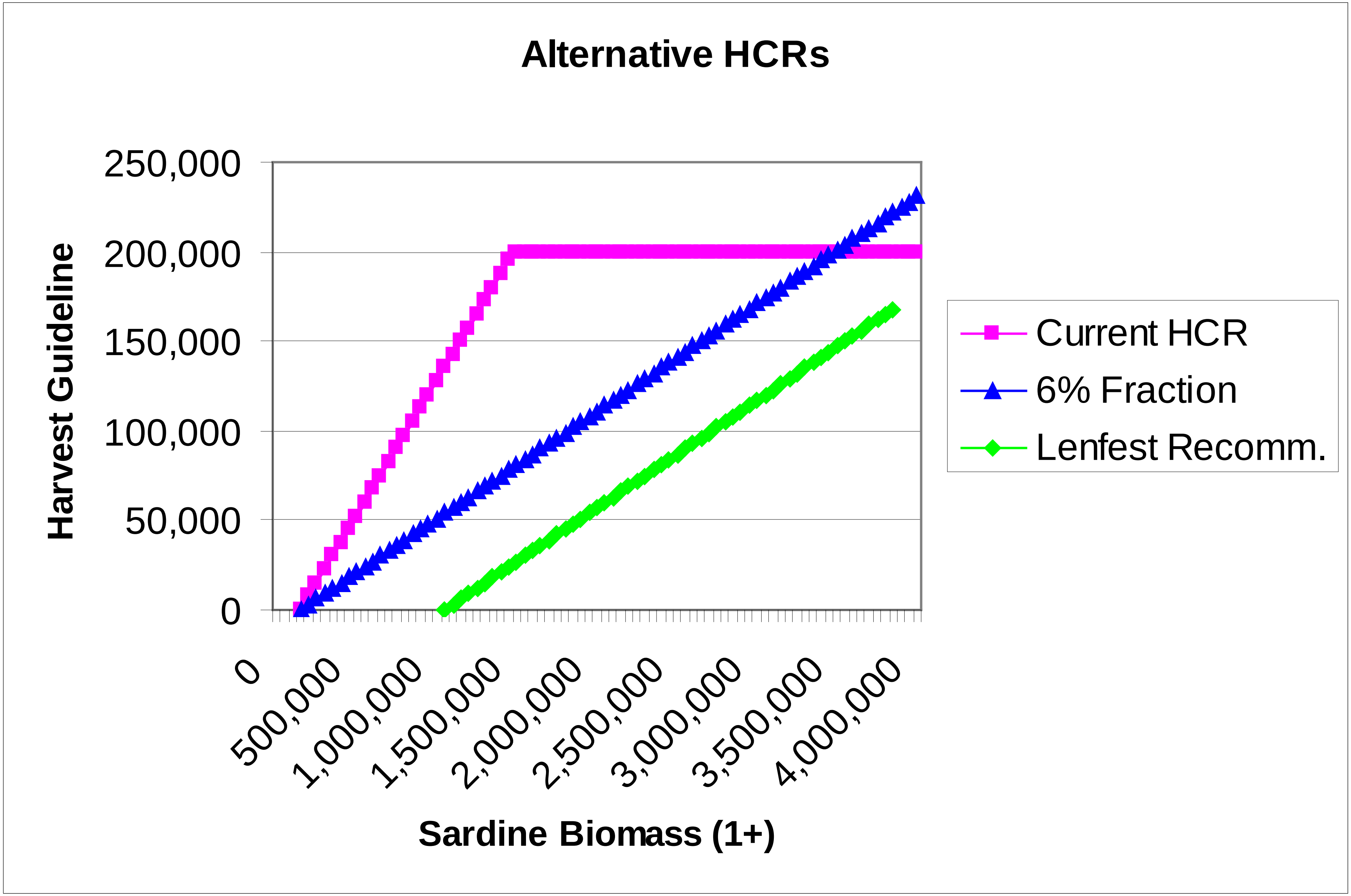
DISTRIBUTION used by California pre-2000



Actual DISTRIBUTION of Catch (2011)



Catch (MT)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Canada
Mexico
US
F = 18%
Amend 13 HCR
2011 Catch
2013 Catch if 2013 Dist = 2011 Dist
2013 Catch if 2011 Foreign Catch = 2011 catch
2013 Catch if DIST in HCR



Alternative HCRs
Harvest Guideline
250,000
200,000
150,000
100,000
50,000
0
0
500,000
1,000,000
1,500,000
2,000,000
2,500,000
3,000,000
3,500,000
4,000,000
Sardine Biomass (1+)
Current HCR
6% Fraction
Lenfest Recomm.

Alternatives not being considered

	Average Forage contribution*	Average Catch*	2013 HG
Proposed Harvest Guideline	618,000 MT	146,000 MT	66,495 MT
FRAC = 6%, DIST = 59%	745,000 MT	138,000 MT	18,307 MT
Lenfest Recomm.*	846,000 MT	106,000 MT	0 MT

*** As estimated using Amendment 8 Sardine Simulation Model**

Summary

- Sardine is a key forage species
- Proposed HG poses significant risk to the stock, coastal communities, and dependent predators
- Current HCR not based on best available science (i.e., temp-based fraction, distribution, forage)
- Uncertainty in OFL not accounted for in ABC
- Other alternatives need to be considered before taking final action

Agenda Item G.3.b
Supplemental Assessment Report 2
November 2012

(Available on Council's November Briefing Book WEBSITE only)

ASSESSMENT OF THE PACIFIC SARDINE RESOURCE IN 2012 FOR U.S. MANAGEMENT IN 2013

Kevin T. Hill, Paul R. Crone, Nancy C.H. Lo, David A. Demer,
Juan P. Zwolinski, and Beverly J. Macewicz

NOAA National Marine Fisheries Service
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, California, USA 92037

October 23, 2012

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ACRONYMS AND ABBREVIATIONS

ABC	acceptable biological catch
ALK	age-length key
ASAP	Age Structured Assessment Program
ATM	Acoustic-trawl method
BC	British Columbia (Canada)
CA	California
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CCA	Central California fishery
CDFG	California Department of Fish and Game
CDFO	Canada Department of Fisheries and Oceans
CICIMAR	Centro Interdisciplinario de Ciencias Marinas
CONAPESCA	National Commission of Aquaculture and Fishing (México)
CPS	Coastal Pelagic Species
CPSAS	Coastal Pelagic Species Advisory Subpanel
CPSMT	Coastal Pelagic Species Management Team
CV	coefficient of variation
DEPM	Daily egg production method
ENS	Ensenada (México)
FMP	fishery management plan
HG	harvest guideline
INAPESCA	National Fisheries Institute (México)
Model Year	July 1 (year) to June 30 (year+1)
mt	metric tons
mmt	million metric tons
MexCal	southern fleet based on ENS, SCA, and CCA fishery data
NMFS	National Marine Fisheries Service
NWSS	Northwest Sardine Survey
NOAA	National Oceanic and Atmospheric Administration
ODFW	Oregon Department of Fish and Wildlife
OFL	overfishing limit
OR	Oregon
PacNW	northern fleet based on OR, WA, and BC fishery data
PFMC	Pacific Fishery Management Council
S1 & S2	Model Season 1 (Jul-Dec) and Season 2 (Jan-Jun)
SAFE	Stock Assessment and Fishery Evaluation
SCA	Southern California fishery
SS	Stock Synthesis
SSB	spawning stock biomass
SSC	Scientific and Statistical Committee
SST	sea surface temperature
STAR	Stock Assessment Review
STAT	Stock Assessment Team
SWFSC	Southwest Fisheries Science Center
TEP	Total egg production
VPA	Virtual Population Analysis
WA	Washington
WDFW	Washington Department of Fish and Wildlife

EXECUTIVE SUMMARY

Stock

The Pacific sardine (*Sardinops sagax caerulea*) ranges from southeastern Alaska to the Gulf of California, México, and is thought to comprise three subpopulations. In this assessment, we modeled the hypothesized northern subpopulation, which ranges seasonally from northern Baja California, México to British Columbia, Canada, and up to 300 nm offshore. All landings in U.S., Canada, and México (Ensenada) were assumed to be taken from this single northern stock. Future modeling efforts will explore a scenario where Ensenada and San Pedro catches are parsed into the northern and southern stocks using some objective criteria.

Catches

The assessment includes sardine landings from six major fishing regions: Ensenada (ENS), southern California (SCA), central California (CCA), Oregon (OR), Washington (WA), and British Columbia (BC).

Calendar year	ENS	SCA	CCA	OR	WA	BC	Total
2000	67,845	46,835	11,367	9,529	4,765	1,721	142,063
2001	46,071	47,662	7,241	12,780	10,837	1,266	125,857
2002	46,845	49,366	14,078	22,711	15,212	739	148,952
2003	41,342	30,289	7,448	25,258	11,604	978	116,919
2004	41,897	32,393	15,308	36,112	8,799	4,438	138,948
2005	55,323	30,253	7,940	45,008	6,929	3,232	148,684
2006	57,237	33,286	17,743	35,648	4,099	1,575	149,588
2007	36,847	46,199	34,782	42,052	4,663	1,522	166,065
2008	66,866	31,089	26,711	22,940	6,435	10,425	164,466
2009	55,911	12,561	25,015	21,482	8,025	15,334	138,328
2010	56,821	29,352	4,306	20,852	12,381	22,223	145,935
2011	70,336	17,642	10,072	11,023	8,008	20,719	137,801

Data and Assessment

The assessment update was conducted using Stock Synthesis (SS), version 3.21d, and includes fishery and survey data collected from mid-1993 through mid-2012. The SS is based on a July-June model year, with two semester-based seasons per year (S1=Jul-Dec and S2=Jan-Jun). Catches and biological samples for the fisheries off ENS, SCA, and CCA were pooled into a single MexCal fleet, in which selectivity was modeled separately for each season (S1 and S2). Catches and biological samples from OR, WA, and BC were modeled as a single PacNW fleet. Four indices of relative abundance from ongoing surveys were included in the base model: daily and total egg production method (DEPM and TEPM) estimates of spawning stock biomass off CA (1994-2012), NWSS aerial survey estimates of biomass off OR and WA (2009-2012), and acoustic-trawl method (ATM) estimates of biomass along the west coast (2006-2012). The catchability coefficient (q) was fixed to a value of 1 for the ATM surveys and estimated without constraints for the other surveys.

The following data were appended to the update model.

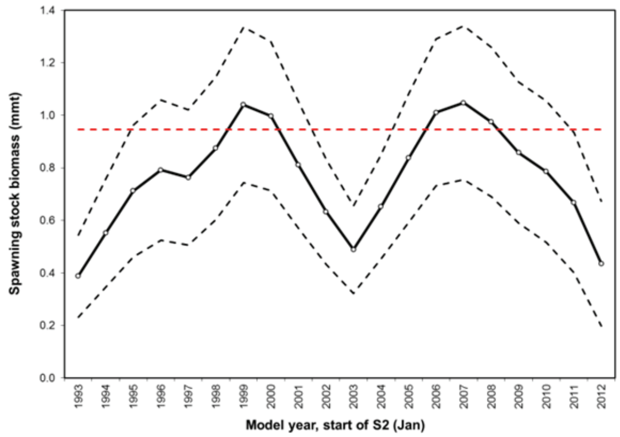
- Landings for 2010 and 2011 were replaced with final numbers for all fishing regions (ENS to BC).

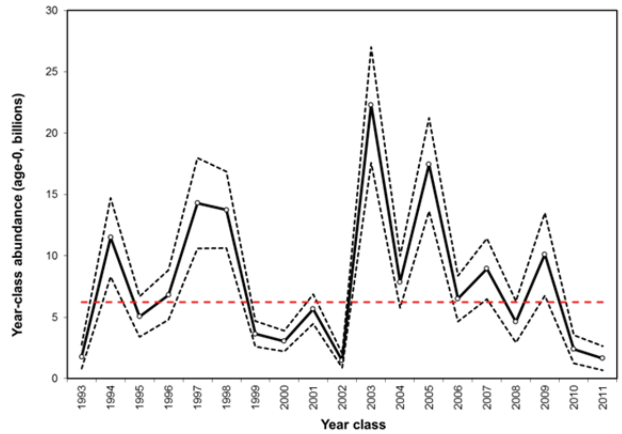
- Landings for 2012 were based on current information (year-to-date) and forecasted through the end of 2012 for fisheries from CA to BC. The ENS catch for 2012 was not available, so was assumed identical to the 2011 tonnage.
- Length compositions from SCA, CCA, OR, WA, and BC fisheries were updated and appended for model year 2011 and the first semester of model year 2012 (July-August 2012 samples). New length data were not available from the ENS fishery.
- Conditional age-at-length data from SCA, CCA, OR, and WA were appended to model year 2011;
- DEPM estimate of SSB from the spring 2012 survey off California were added.
- ATM-survey estimates of biomass from the spring 2012 survey off California; and the summer 2012 survey off the west coast from San Diego to Vancouver Island were added.
- The NWSS aerial survey estimate of biomass for summer 2012 (pooled point sets) was added.

Spawning Stock Biomass and Recruitment

Recruitment was modeled using the Ricker stock-recruitment relationship (σ_R=0.727). The estimate of steepness was high (*h*=2.79), and virgin recruitment (R_0) was estimated to be 6.22 billion age-0 fish. The virgin value of the spawning stock biomass (SSB) was estimated to be 0.946 mmt. SSB increased throughout the 1990s, peaking at 1.039 million metric tons (mmt) in 1999 and 1.047 mmt in 2007. Recruitment (year-class abundance) peaked at 14.3 billion fish in 1997, 22.3 billion in 2003, 17.4 billion in 2005, and 10.1 billion in 2009. The 2010 and 2011 year classes were the weakest in recent history.

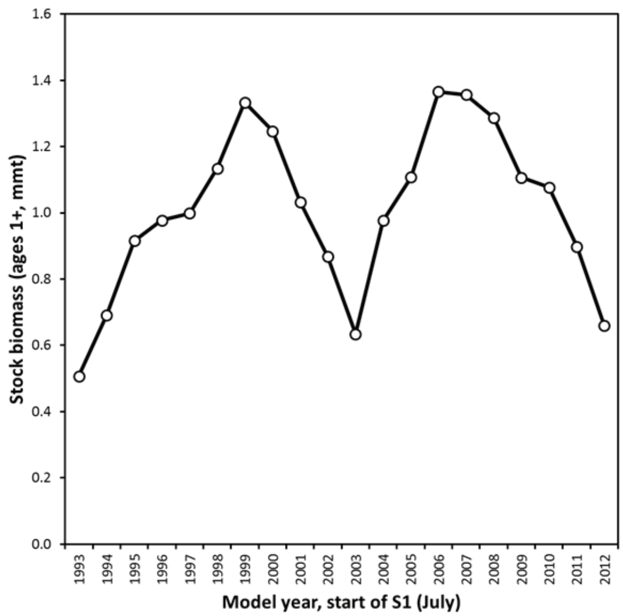
Model year	SSB (mt)	SSB Std Dev	Year class abundance (billions)	Recruits Std Dev
2000	996,883	142,069	3.050	0.423
2001	810,236	120,420	5.669	0.607
2002	632,173	99,976	1.469	0.289
2003	488,308	83,379	22.302	2.359
2004	651,419	99,112	7.863	1.054
2005	837,694	122,477	17.443	1.894
2006	1,010,840	139,967	6.505	0.931
2007	1,047,250	146,350	8.956	1.232
2008	974,298	142,150	4.621	0.836
2009	857,618	134,408	10.123	1.687
2010	785,170	135,020	2.396	0.568
2011	667,141	133,182	1.655	0.494
2012	435,351	118,835	---	---





Stock Biomass

Stock biomass, used for calculating harvest specifications, is defined as the sum of the biomasses for sardine ages one and older (age 1+). Stock biomass increased rapidly throughout the 1990s, peaking at 1.33 mmt in 1999 and 1.37 mmt in 2006. Stock biomass was estimated to be 659,539 mt as of July 2012.



Exploitation Status

Exploitation rate is defined as the calendar year catch divided by the total mid-year biomass (July-1, ages 0+). Modeled U.S. and total exploitation rates are as follows:

Calendar year	U.S.	Total
2000	5.68%	11.13%
2001	7.21%	11.56%
2002	11.48%	16.87%
2003	8.73%	13.68%
2004	8.78%	13.17%
2005	7.04%	11.61%
2006	6.35%	10.46%
2007	8.83%	11.49%
2008	6.54%	12.34%
2009	5.56%	11.47%
2010	6.08%	13.26%
2011	5.11%	15.07%

Harvest Control Rules

Harvest guideline

Using results from the update model X6e, the harvest guideline (HG) for the U.S. fishery in calendar year 2013 is 66,495 mt. The harvest control rule defined in Amendment 8 of the CPS-FMP was used to calculate the HG for 2013 (PFMC 1998). The HG was calculated as follows:

$$HG_{2013} = (BIOMASS_{2012} - CUTOFF) \bullet FRACTION \bullet DISTRIBUTION;$$

where HG_{2013} is the total U.S. (SCA, CCA, OR, and WA) quota for 2013; $BIOMASS_{2012}$ is the estimated July 1, 2012 stock biomass (ages 1+) from the assessment (659,539 mt); CUTOFF (150,000 mt) is the lowest level of estimated biomass at which harvest is allowed; FRACTION (15%) is the percentage of biomass above the CUTOFF that can be harvested by the fisheries; and DISTRIBUTION (87%) is the average portion of BIOMASS assumed in U.S. waters. The U.S. HG values and catches since 2000 are displayed below. The HG for 2013 is 40% lower than the 2012 HG.

OFL and ABC

The Magnuson-Stevens Reauthorization Act requires fishery managers to define an overfishing limit (OFL), allowable biological catch (ABC), and annual catch limit (ACL) for species managed under the federal management plan (FMP). By definition, ABC must always be lower than the OFL based on uncertainty in the assessment approach. The Science and Statistical Committee (SSC) of the Pacific Fisheries Management Council (PFMC) recommended the *P** buffer approach to mitigate scientific uncertainty when defining ABC, which was adopted under Amendment 13 to the coastal pelagic species (CPS) FMP.

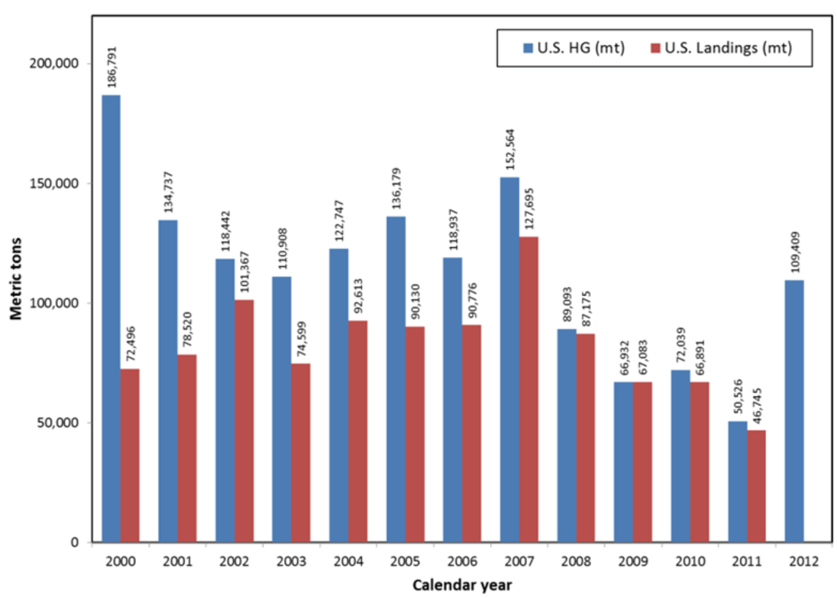
The estimated biomass of 659,539 mt (ages 1+), an F_{MSY} proxy of 0.18, and an estimated 87% of the stock in U.S. waters resulted in a U.S. OFL of 103,284 mt for 2013. For Pacific sardine, the SSC recommended setting scientific uncertainty (σ) to the maximum of either: (1) the coefficient of variation (CV) of the biomass estimate for the most recent year; or (2) a default value of 0.36, based on uncertainty across the full assessment models. The CV of the terminal year biomass was equal to 0.273 (σ =0.268); therefore, σ remained the default value 0.36. The P^* buffer (BUFFER$_{P*}$) depends on the probability of the overfishing level (P^*) chosen by the PFMC. Uncertainty buffers and ABC values associated with a range of discrete P^* values are:

Harvest Formula Parameters	Value			
BIOMASS (ages 1+, mt)	659,539			
P^* (probability of overfishing)	0.45	0.40	0.30	0.20
BUFFER$_{P*}$ (Sigma=0.36)	0.95577	0.91283	0.82797	0.73861
F_{MSY}	0.18			
FRACTION	0.15			
CUTOFF (mt)	150,000			
DISTRIBUTION (U.S.)	0.87			

Amendment 13 Harvest Formulas	MT
OFL = BIOMASS * F_{MSY} * DISTRIBUTION	103,284
ABC$_{0.45}$ = BIOMASS * BUFFER$_{0.45}$ * F_{MSY} * DISTRIBUTION	98,716
ABC$_{0.40}$ = BIOMASS * BUFFER$_{0.40}$ * F_{MSY} * DISTRIBUTION	94,281
ABC$_{0.30}$ = BIOMASS * BUFFER$_{0.30}$ * F_{MSY} * DISTRIBUTION	85,515
ABC$_{0.20}$ = BIOMASS * BUFFER$_{0.20}$ * F_{MSY} * DISTRIBUTION	76,287
HG = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION	66,495

Management performance

U.S. HG values and catches since the onset of federal management follow:



Unresolved Problems and Major Uncertainties

The SSC CPS-Subcommittee review focused on two areas of uncertainty in the assessment update: (1) a proposed change to the number of recruitment deviations estimated in the model; and (2) the appropriateness of the 2012 NWSS aerial survey estimate in the current model.

Estimation of recruitment deviations

Upon addition of size composition data to the update model, a noticeable change occurred in both the scale and trend of biomass and recruitments throughout the time series, with both estimated lower in the first half of the time series and higher in the latter half. This change persisted with the addition of other data, and was accompanied by a shift in the trend of recruitment deviations and a loss of fit to survey time series. To evaluate this change, the number of recruitment deviations being estimated in the model was profiled for end year -0 to -3 years. The default setting in the update model was end-year -2, while previous assessments had estimated deviations through end year -1.

There was a clear difference in recruitment deviation trends for models with end-year -0 or -1 compared to those with end-year -2 or -3. The difference was also obvious for recruitment and stock biomass estimates, where models for end-year -2 or -3 had noticeably lower estimates in earlier years and higher estimates for the final six years in comparison to models with end-year -0 or -1. Examination of log deviations [ln(Obs)-ln(Exp)] for modeled survey time series indicated degraded fits to the DEPM, aerial, and ATM time series when recruitments were estimated through end-year -2 or -3 compared to end-year -0 or -1.

To address this problem, the Stock Assessment Team (STAT) strongly recommended returning to past practice of estimating recruitment deviations to end-year -1 instead of -2. While this resulted in a minor change to update model parameterization, the STAT considered this change necessary to correct a problem that was unknowingly introduced in the 2011 assessment model (Hill et al. 2011). The CPS-Subcommittee agreed to this proposed change during the review, so it was carried forward in update model X6e.

2012 NWSS aerial survey

The 2012 aerial survey suffered from lack of representative point sets to inform the relationship between surface area and biomass. The number of acceptable point sets (n=14) was smaller than usual, and there was no spatial-temporal overlap between the aerial transects (stage 1) and point set sampling (stage 2). Moreover, the spatial representation of acceptable point sets was inadequate relative to the spatial distribution of putative sardine observed in the photographs. For these reasons, NWSS survey scientists proposed using a biomass estimate based on point set data pooled across survey years instead of year-specific point sets. Following critical discussion, the review panel and STAT reluctantly agreed to include the pooled estimate in X6e rather than discarding the 2012 aerial estimate in its entirety.

Research and Data Needs

The following model-related research recommendations are excerpted from reports of the 2011 and 2012 assessment reviews.

- Explore use of the results from the mid-water trawl surveys off Vancouver Island conducted by Canada's Department of Fisheries and Oceans (CDFO).
- Temperature-at-catch could provide insight into stock structure and the appropriate catch stream to use for assessments, because the southern subpopulation is thought to inhabit warmer water than the northern subpopulation. Conduct tests of sensitivity to alternative assumptions regarding the fraction of the MexCal (in particular, ENS and SCA) catch from the northern subpopulation.
- Explore models that consider a protracted time period (e.g., 1931 onwards) and evaluate if they provide more information and a broader context for evaluating changes in productivity.
- Explicitly model the sex-structure of the population and the catch.
- Reconsider a model that has separate fleets for Mexico, CA, OR-WA, and Canada.
- Develop a relationship between egg production and age that accounts for the duration of spawning and batch fecundity by age.
- Consider model configurations that use age compositions, rather than length compositions and conditional age-at-length data, given evidence for time- and spatially-varying growth.
- Explore reasons for the discrepancy between the observed and expected proportions of old animals in the length and age compositions. Possible factors include ageing error and bias, and parameterization of the dome-shaped selectivity.
- Explore if replacing the Ricker with a Beverton-Holt or other spawner-recruit relationship will stabilize the SS relative to the number of estimates of recent-years recruitments while providing a biologically realistic relationship.
- Consider the changes within and between years regarding targeting in developing appropriate fishery selectivities, as well as proper blocking and/or weighting of these data.
- Re-review the aerial survey method. Re-consider use of the aerial survey results as minimum estimates of total abundance.

PREFACE

The Pacific sardine resource is assessed each year in support of the Pacific Fishery Management Council (PFMC) process of recommending annual harvest specifications for the U.S. fishery. The following assessment update for 2013 management is based on data and methods described by Hill et al. (2011) and reviewed by a Stock Assessment Review (STAR) Panel during September 2011 (STAR 2011). The update was conducted using Stock Synthesis (SS), and includes the most recent data available from fishery-dependent and fishery-independent sources.

A draft assessment update was reviewed by members of the Scientific and Statistical Committee (SSC) Coastal Pelagic Species (CPS) Subcommittee during October 2-3, 2012. The CPS Subcommittee reviewed one minor change to model parameterization and one change to input data. The following report reflects changes agreed during that review and is intended for subsequent evaluation by the PFMC's advisory bodies at meetings to be held in November 2012, in Costa Mesa, CA.

INTRODUCTION

Distribution, Migration, Stock Structure, Management Units

Information regarding Pacific sardine (*Sardinops sagax caerulea*) biology and population dynamics is available in Clark and Marr (1955), Ahlstrom (1960), Murphy (1966), MacCall (1979), Leet et al. (2001), as well as references cited below.

The Pacific sardine has at times been the most abundant fish species in the California Current. When the population is large, it is abundant from the tip of Baja California (23^o N latitude) to southeastern Alaska (57^o N latitude) and throughout the Gulf of California. Occurrence tends to be seasonal in the northern extent of its range. When sardine abundance is low, as during the 1960s and 1970s, sardine do not occur in commercial quantities north of Baja California.

It is generally accepted that sardine off the West Coast of North America consists of three subpopulations or stocks. A northern subpopulation (northern Baja California to Alaska), a southern subpopulation (outer coastal Baja California to southern California), and a Gulf of California subpopulation were distinguished on the basis of serological techniques (Vrooman 1964) and in a study of temperature-at-capture (Felix-Uraga et al., 2004; 2005). An electrophoretic study (Hedgecock et al. 1989) showed, however, no genetic variation among sardine from central and southern California, the Pacific coast of Baja California, or the Gulf of California. Although the ranges of the northern and southern subpopulations overlap, the adult spawning stocks may move north and south in synchrony and do not overlap significantly. The northern subpopulation is exploited by fisheries off Canada, the U.S., and northern Baja California, and is included in the CPS Fishery Management Plan (CPS-FMP; PFMC 1998).

Pacific sardine probably migrated extensively during historical periods when abundance was high, moving north as far as British Columbia in the summer and returning to southern California and northern Baja California in the fall. Tagging studies indicate that the older and larger fish moved farther north (Janssen 1938, Clark & Janssen 1945). Migratory patterns were probably complex, and the timing and extent of movement were affected by oceanographic conditions (Hart 1973) and stock biomass. During the 1950s to 1970s, a period of reduced stock size and unfavorably cold sea surface temperatures apparently caused the stock to abandon the northern portion of its range. In recent decades, the combination of increased stock size and warmer sea surface temperatures resulted in the stock re-occupying areas off Central California, Oregon, Washington, and British Columbia, as well as distant-offshore areas off California. During a cooperative U.S.-U.S.S.R. research cruise for jack mackerel in 1991, several tons of sardine were collected 300 nm west of the Southern California Bight (SCB) (Macewicz and Abramenkoff 1993). Resumption of seasonal movement between the southern spawning habitat and the northern feeding habitat has been inferred by presence/absence of size classes in focused regional surveys (Lo et al. 2011), and measured directly using the acoustic-trawl method (Demer et al. 2012).

Life History Features Affecting Management

Pacific sardine may reach 41 cm in length, but are seldom longer than 30 cm. They may live up to 15 years, but fish in California commercial catches are usually younger than five years. Sardine are typically larger and two to three years older in regions off the Pacific Northwest. . There is evidence for regional variation in size-at-age, with size increasing from south to north and from inshore to offshore (Phillips 1948, Hill 1999). Size- and age-at-maturity may decline with a decrease in biomass, latitude, and temperature (Butler 1987). At relatively low biomass levels, sardine appear to be fully mature at age one, whereas at very high biomass levels only some of the two-year-olds are mature (MacCall 1979).

Until 1953, sardine fully recruited to the fishery when they were ages three and older (MacCall 1979). Recent fishery data indicate that sardine begin to recruit at age zero and are fully recruited to the southern California fishery (SCA) by age two. Age-dependent availability to the fishery likely depends upon the location of the fishery; young fish are unlikely to be fully available to fisheries located in the north, and old fish are less likely to be fully available to fisheries south of Point Conception.

Age-specific mortality estimates are available for the entire suite of life history stages (Butler et al. 1993). Mortality is high at the egg and yolk sac larvae stages (instantaneous rates in excess of 0.66 d^{-1}). The adult natural mortality rate has been estimated to be M=0.4 yr^{-1} (Murphy 1966; MacCall 1979) and 0.51 yr^{-1} (Clark and Marr 1955). A natural mortality rate of M=0.4 yr^{-1} means that 33% of the adult sardine stock would die each year of natural causes.

Pacific sardine spawn in loosely aggregated schools in the upper 50 meters of the water column. The northern subpopulation spawning begins in January off northern Baja California and ends by August off the Pacific Northwest (Oregon, Washington, and Vancouver Island), typically peaking off California in April. Sardine eggs are most abundant at sea-surface temperatures of 13 to 15 ^{o}C, and larvae are most abundant at 13 to 16 ^{o}C. The spatial and seasonal distribution of spawning is influenced by temperature. During periods of warm water, the center of sardine spawning shifts northward and spawning extends over a longer period of time (Butler 1987; Ahlstrom 1960). Recent spawning has been concentrated in the region offshore and north of Point Conception (Lo et al. 1996 & 2005). Sardine are oviparous, multiple-batch spawners, with annual fecundity that is indeterminate and age- or size-dependent (Macewicz et al. 1996).

Abundance, Recruitment, and Population Dynamics

Extreme natural variability is characteristic of clupeoid stocks such as the Pacific sardine (Cushing 1971). Estimates of sardine abundance from 300 AD through 1970 have been reconstructed from the deposition of fish scales in sediment cores from the Santa Barbara basin off SCA (Soutar and Issacs 1969, 1974; Baumgartner et al. 1992). Sardine populations existed throughout the period with biomass levels varying widely. Both sardine and anchovy populations tend to vary over periods of roughly 60 years, although sardine have varied more than anchovies. Estimates of sardine biomass inferred from scale-depositions in the 19th and 20th centuries suggest that it peaked at approximately six mmt in 1925 (Soutar and Isaacs 1969; Smith 1978).

Declines in sardine populations have lasting an average of 36 years and recoveries lasted an average of 30 years.

Sardine spawning biomass, estimated from catch-at-age analysis, averaged 3.5 mmt from 1932 through 1934, fluctuated from 1.2 to 2.8 mmt over the next ten years, then declined steeply from 1945 to 1965, with some short-term reversals following periods of particularly successful recruitment (Murphy 1966, MacCall 1979). During the 1960s and 1970s, spawning biomass levels were less than about five to ten thousand mt (Barnes et al. 1992). The sardine stock began to increase by an average rate of 27% per annum in the early 1980s (Barnes et al. 1992).

Pacific sardine recruitment is highly variable. Analyses of the sardine stock recruitment relationship have been controversial, with some studies showing a strong density-dependent relationship (production of young sardine decline at high levels of spawning biomass) and others finding no relationship (Clark and Marr 1955; Murphy 1966; MacCall 1979). Jacobson and MacCall (1995) found both density-dependent and environmental factors to be important.

Relevant History of the Fishery

The sardine fishery was first developed in response to demand for food during World War I. Landings increased from 1916 to 1936, peaking at over 700,000 mt. Pacific sardine supported the largest fishery in the western hemisphere during the 1930s and 1940s, with landings in BC, WA, OR, CA, and México. The population and fishery declined, beginning in the late 1940s and with some short-term reversals, to extremely low levels in the 1970s. There was a southward shift in catch as the fishery collapsed, with landings ceasing in the Pacific Northwest in 1947 through 1948, and in San Francisco in 1951 through 1952. Sardine were primarily reduced to fish meal, oil, and canned food, with small quantities used for bait.

In the early 1980s, sardine were taken incidentally with Pacific and jack mackerel in the SCA mackerel fishery. As sardine continued to increase in abundance, a directed purse-seine fishery was reestablished. The incidental fishery for sardine ended in 1991. Besides SCA and CCA, substantial quantities of Pacific sardine are now landed at OR, WA, BC, and ENS. Total annual harvest by the Mexican fishery is not regulated by quotas, but there is a minimum legal size limit.

Recent Management Performance

Management authority for the U.S. Pacific sardine fishery was transferred to the PFMC in January 2000. Pacific sardine was one of five species included in the federal CPS-FMP (PFMC 1998). The CPS-FMP includes harvest control rules intended to prevent Pacific sardine from being overfished and to maintain relatively high and consistent, long-term catch levels. Harvest control rules for sardine are provided at the end of this report. A thorough description of PFMC management actions for sardine, including HG values, may be found in the most recent CPS SAFE document (PFMC 2011). U.S. HG values and landings since 2000 are displayed in Table 1 and Figure 1a. Harvests at major fishing regions from ENS to BC are provided in Table 2 and Figure 1b.

ASSESSMENT DATA

Biological Parameters

Stock structure

For this assessment, we model the northern subpopulation (cold stock) that ranges from northern Baja California, México to British Columbia, Canada and extends up to 300 nm offshore (Macewicz and Abramenkoff 1993). Specifically, all landings, biological samples, and survey data collected between ENS and BC are assumed to be taken from a single stock. Future modeling scenarios may consider an alternative case that separates the catches in ENS and SCA into respective northern (cold) and southern (temperate) stocks using temperature-at-catch and otolith morphometric criteria proposed by Felix-Uraga et al. (2004, 2005). Subpopulation differences in growth, maturation, and natural mortality would also be taken into account.

Growth

The weight-at-length relationship for Pacific sardine (combined sexes) was modeled by the standard power function

$$W = a\,(L^b);$$

where W is weight (kg) at length L (cm), and a and b are regression coefficients. The coefficients, a = 1.68384e-05 and b = 2.94825 (corrected R^2 = 0.928; n = 155,814), were estimated from a least-squares fit to fishery samples collected from 1981 to 2011. These coefficients were fixed in all models (Figure 2a).

The largest recorded Pacific sardine was standard length SL = 41.0 cm (Eschmeyer et al. 1983), but the largest Pacific sardine commercially captured fish since 1981 was SL = 29.7 cm. The heaviest sardine weighed 0.323 kg. The oldest recorded Pacific sardine is 15 years, but commercially-caught Pacific sardine are typically less than seven years old.

Sardine ageing using otolith methods were first described by Walford and Mosher (1943) and elaborated by Yaremko (1996). Pacific sardine are routinely aged by fishery biologists in México, CA, and the PNW using annuli enumerated in whole sagittae. A birth date of July 1 is assumed when assigning year class. Lab-specific ageing errors were calculated and applied as described in Hill et al. (2011).

Sardine growth was first estimated outside the SS model to provide initial parameter values and CV values for length at Age_{min} (0.5 yrs), length at Age_{max} (15 yrs), and growth coefficient K. An analysis of size-at-age from fishery samples (1993-2010) did not indicate sexual dimorphism (Figure 2b), so a single-sex model was applied.

During the 2009 STAR panel, examination of residuals for the age- and length-composition data revealed that growth was apparently variable versus time. Specifically, there was evidence for a shift in growth rates in 1991. To address this in past assessments, growth parameters were modeled in two periods: 1981-1990 and 1991-2009 (Hill et al. 2009, 2010). It is still unclear whether the growth rate varied with density during the early stages of population recovery (compensatory growth), or another factor. For example, differences in size-at-age could be due to size-selective schooling, as many of the sardine were sampled from incidental catches (mixed with larger mackerel). Uncertainty in the modeled growth and representativeness of early samples are among several reasons for starting the base model in 1993.

Maturity
Maturity-at-length was estimated using sardine sampled from survey trawls conducted from 1986 to 2011. Their reproductive state was primarily established through histological examination, although some immature individuals were simply identified through gross visual inspection. Maturity parameters were estimated over two periods to match different SS model scenarios. The full range of available samples was included for models beginning in the early 1980s, resulting in an inflexion = 16.05 cm and slope = -0.78849. A subset of survey samples (1994 to 2011) was used to parameterize maturity in abbreviated SS models (e.g., the base model), where inflexion = 15.88 cm and slope = -0.90461. Parameters for the logistic maturity function:

$$\text{Maturity} = 1/(1+\exp(slope{*}L\text{-}L_{\text{inflexion}})))$$

were fixed in the SS. Fecundity was fixed at 1 egg/gram body weight. Resultant maturity- and fecundity-at-size and age during the spawning season, derived from the final base model, are presented in Figures 2c and 2d.

Natural mortality
The instantaneous rate of adult natural mortality was estimated to be $M = 0.4$ yr^{-1} (Murphy 1966; MacCall 1979) and 0.51 yr^{-1} (Clark and Marr 1955). A natural mortality rate of $M = 0.4$ yr^{-1} means that 33% of the stock die of natural causes each year. Consistent with all previous sardine assessments, the base model was parameterized with M = 0.4 yr^{-1} for all ages and years (Murphy 1966, Deriso et al. 1996, Hill et al. 1999).

Fishery Data

Overview
Commercial landings and biological samples were available from six regional fisheries operating off ENS, SCA, CCA, OR, WA, and BC. Biological samples typically (most but not all cases) included individual weight, length, sex, maturity, and otoliths for age estimation. Complete lists of available landings and port samples by fishing region, model year, and season are provided in Tables 2 and 3.

Fishery catches and compositions were compiled using the sardine's biological year (model year) to match the assumed July-1 birth date (See **Biological Parameters**, *Growth*). Each model year is labeled with the first of two calendar years spanned (e.g., model year 1993 includes data from July 1, 1993 through June 30, 1994). Fisheries data are aggregated into southern MexCal (ENS, SCA, and CCA) and northern PacNW (OR, WA, and BC) fleets, and span 1993 to 2012 in the update model. Catches and biological compositions were updated from agency sources described by Hill et al. (2011). Fisheries data are presented in Tables 1-4 and Figures 1-10.

Updated landings
Recent landings for each fishery were appended to the update model following Hill et al. (2011). Landings for calendar years 2010 and 2011 were updated with final numbers for all fishing regions (ENS to BC). Landings data for 2012 were based on current information (year-to-date) and forecast through the end of 2012 for fisheries from SCA to BC. ENS catch for 2012 was not available, so was substituted with 2011 tonnage. Landings by model year, semester, and fleet are presented in Table 4 and Figure 3.

Updated length and age compositions
Fishery length, conditional age-at-length, and implied (ghost) age compositions were updated following the methods in Hill et al. (2011). Length compositions for each fleet and semester were calculated from monthly catch-weighted-length observations. Length compositions ranged from SL = 9 to 28 cm with 0.5-cm bins. Length composition data from SCA to BC were updated and appended for model year 2011 and the first semester of model year 2012 (July-August 2012 samples). New length data from ENS have not been available since mid-2009. Length-compositions by fleet are displayed in Figures 4a, 5a, and 6a.

Conditional age-at-length compositions were also constructed using methods described in Hill et al. (2011). Age bins included 0, 1, 2, 3, 4, 5, 6, 7, 8-10, 11-15 (10 bins total). The age 11-15 bin served as an accumulator allowing growth to approach L_{∞}. Age-compositions were input as proportions of fish in 1-cm length bins. For this update, conditional age-at-length data from SCA to WA were appended to model year 2011. Conditional age-at-length compositions for each fleet are presented in Figures 7-9. Implied age compositions are presented adjacent to corresponding length compositions in Figures 4b, 5b, and 6b.

Ageing error vectors for fisheries data were unchanged from Hill et al. (2011) (Figure 10). Refer to Appendix 2 of Hill et al. (2011) for more details regarding age-reading data sets, model development, and assumptions.

Fishery-Independent Surveys

Overview
This assessment includes four time series obtained from fishery-independent surveys: 1) Daily Egg Production Method (DEPM) estimates of female spawning biomass; 2) Total Egg Production (TEP) estimates of total spawning biomass; 3) Aerial photogrammetric surveys of biomass; and 4) Acoustic-trawl method (ATM) surveys of biomass. . All of these surveys and estimation methods have been vetted through PFMC-SSC Methodology Reviews (panels included representatives from the PFMC-SSC and the Center for Independent Experts). For this update we include: 1) a new DEPM estimate of the SSB from the spring 2012 survey off CA; 2) ATM estimates of biomass from the spring 2012 survey off CA and the summer 2012 survey spanning San Diego to northern Vancouver Island, Canada; and 3) an Aerial survey estimate of biomass from the summer 2012 survey off OR and WA (Jagielo et al. 2012). These new survey data are presented in Tables 5-7 and Figures 11-15 of this report, as well as in Appendices A and B.

Daily egg production method spawning biomass

The spring 2012 DEPM survey was conducted aboard a chartered fishing vessel and a NOAA research vessel. The R/V *Ocean Starr* surveyed from March 26-April 29 and covered the area off of the west coast of US from Cape Flattery, WA to Point Conception, CA. Most of the stations off CA, located within the area north of San Francisco to Point Conception (CalCOFI lines 56.3 to 80.0), were sampled from April 5 to April 28. The NOAA ship *Bell M. Shimada* surveyed from April 11-April 30, and covered the area from San Diego, CA (CalCOFI line 90.0) to Monterey Bay (CalCOFI line 68.3). *Shimada* also occupied the primary CalCOFI lines, 76.7 to 93.3, from March 23 to April 7 for the spring CalCOFI cruise. During the DEPM and the CalCOFI surveys, CalVET tows, Bongo tows, and CUFES were conducted aboard both vessels while surface trawls were conducted only during the DEPM surveys. Data from DEPM sampling aboard both ships were included in the estimation of spawning biomass of Pacific sardine. Data from the CalCOFI survey during March, 2012 were not used due to the low number of positive catches (including sardine) in all nets.

The standard DEPM index area off California (San Diego to San Francisco; CalCOFI lines 95 to 60) was 270,991 km^2 (Figure 11). The egg production (P_0) estimate was 0.84/0.05m^2 (CV = 0.27). Although the area between Cape Mendocino and San Francisco was sampled by *Ocean Starr,* only two CUFES stations were positive for sardine eggs north of CalCOFI line 60 and only one trawl catch on line 56.2 included sardine. Female spawning biomass for the standard area was taken as the sum of female spawning biomass in regions 1 and 2 (Table 6). The female spawning biomass and the total spawning biomass (sum) for the standard DEPM area was estimated to be 113,178 mt (CV = 0.27) and 255,391 mt (CV = 0.32) respectively (Table 6).

Adult reproductive parameters for the survey area are presented in Table 7. The estimated daily specific fecundity was 16.14 (number of eggs/population weight (g)/day) using the following estimates of reproductive parameters from 126 mature female Pacific sardine collected from 16 positive trawls: *F*, mean batch fecundity, 38,682 eggs/batch (CV = 0.06); *S*, fraction spawning per day, 0.138 females spawning per day (CV = 0.24); W_f, mean female fish weight, 141.4 g (CV = 0.04); and *R*, sex ratio of females by weight, 0.429 (CV = 0.12). Since 2005, trawling has been conducted randomly or at CalCOFI stations, which resulted in sampling adult sardine in both high (Region 1) and low (Region 2) sardine egg-density areas. In 2012, the number of trawl catches including mature female sardine was the same in Region 1 and Region 2 (8 trawls).

The 2012 DEPM estimate is lower than that of 2011 (Tables 5 & 6, Figure 14), primarily due to lower egg production in Region 2 compared to past years. Yet, the spawning biomass in 2012 is larger than those in 2008-2010. In the SS, the DEPM series represents the female SSB (length selectivity option 30) in the middle of S2 (April).

Total egg production spawning biomass

Adult sardine samples are needed to calculate the daily specific fecundity for true DEPM estimates. Trawls were not always conducted during the egg production surveys. Beginning in 2007, we chose to include these data as a Total Egg Production (TEP) series, which is simply the product of egg density (P_0) and spawning area (km^2). Calculated TEP values are provided in Table 5 & 6 and displayed in Figure 15. TEP was also taken to represent relative SSB (length selectivity option 30) in the model, but in this case the female fraction was unknown (Tables 5 & 6; Figure 15).

Acoustic-trawl method biomass
The ATM time series is based on SWFSC surveys conducted along the Pacific coast since 2006 (Cutter and Demer 2008; Zwolinski et al. 2011 and 2012a-c). The acoustic-trawl surveys and estimation methods were reviewed by a panel in February 2011 and the results from these surveys have been incorporated into the assessment since 2011 (Hill et al. 2011).

Two new ATM-based biomass estimates were included in this update; one from the spring 2012 survey off CA and the other from the summer 2012 survey spanning San Diego to northern Vancouver Island, Canada. Biomass estimates and associated size distributions from these two surveys are described in detail by Zwolinski et al. (2012b,c; see Appendices A and B of this report). The ATM biomass series are presented in Table 5 and Figure 15, and the ATM length compositions are shown in Figure 13. The ATM biomass estimates were treated as absolute (q = 1) for the range of *SL* values observed in the trawls (Figure 13), which were modeled using asymptotic-length-selectivity assumptions.

A backlog of otoliths from survey trawls were aged, so conditional age-at-length distributions were added from surveys conducted in summer 2008, spring 2011, and spring 2012 (Figure 14). The ageing error vector used for the SWFSC trawl ages was also updated (Figure 10).

Aerial survey
The Pacific sardine industry (Northwest Sardine Survey, LLC; NWSS) funded aerial photogrammetric surveys of sardine abundance off the coast of OR and WA, beginning with a pilot survey in summer 2008. The pilot survey was critiqued by a PFMC-SSC Methodology Review panel in May 2009. Surveys were subsequently conducted during summer 2009 through 2012 (Jagielo et al. 2009-2012).

Aerial survey methods and results are described by Jagielo et al. (2009-2012). The Aerial survey employs two sampling elements: 1) high-resolution aerial photographs, collected using spotter planes, to estimate the number and surface areas of sardine schools; and 2) point sets on schools, deployed from fishing vessels, to estimate the relationship between surface area and biomass and the size composition of the schools. Weighted length compositions from the three surveys are displayed in Figure 12. The assessment fits aerial survey sizes with domed-selectivity assumptions and treats the time series as relative (Figure 15), i.e., q is estimated.

The 2012 aerial survey included an insufficient number of representative point sets to estimate the relationship between surface area and biomass. The number of acceptable point sets was smaller than usual (n=14), and there was no spatial-temporal overlap between the aerial transects (stage 1) and the point sets (stage 2). Moreover, the locations of acceptable point sets did not span the distribution of sardine observed in the photographs. For these reasons, NWSS survey scientists proposed using a biomass estimate based on point set data pooled across survey years instead of year-specific point sets. Following critical discussion, the review panel and STAT agreed to include the pooled estimate (696,251 mt) in the update model (X6e), rather than discarding the 2012 estimate in its entirety. Results from alternative models explored during the October 2012 review are presented in **Uncertainty and Sensitivity Analyses**.

ASSESSMENT MODEL

History of Modeling Approaches

The Pacific sardine population, prior to the collapse in the mid-1900s, was first modeled by Murphy (1966). MacCall (1979) refined Murphy's virtual population analysis (VPA) model using additional data and prorated portions of Mexican landings to exclude the southern subpopulation. Deriso et al. (1996) modeled the recovering population (1982 forward) using CANSAR, a modification of Deriso's (1985) CAGEAN model. CANSAR was subsequently modified by Jacobson (NOAA) into a *quasi* two-area model CANSAR-TAM to account for net losses from the core model area. CANSAR and CANSAR-TAM were used for annual stock assessments and management advice from 1996 through 2004 (e.g., Hill et al. 1999; Conser et al. 2003). In 2004, a STAR panel endorsed the use of an Age Structured Assessment Program (ASAP) model for routine assessments. ASAP was used for sardine assessment and management advice from 2005 to 2007 (Conser et al. 2003, 2004; Hill et al. 2006a,b). In 2007, a STAR panel reviewed and endorsed an assessment using Stock Synthesis 2 (Methot 2005, 2007), and the results were adopted for management in 2008 (Hill et al. 2007) as well as an update for 2009 management (Hill et al. 2008). The sardine model was transitioned to Stock Synthesis version 3.03a in 2009 (Methot 2009) and was again used for an updated assessment in 2010 (Hill et al. 2009 & 2010). Stock Synthesis version 3.21d was used for the 2011 full assessment (Hill et al. 2011).

Model Description

Assessment program with last revision date
Stock Synthesis version 3.21d (SS; Methot 2005, 2011) is based on AD Model Builder software (Otter Research 2001). The SS allows the integration of both size and age structure. The general estimation approach used in the SS accounts for most relevant sources of variability and expresses goodness of fit in terms of the original data, potentially allowing final estimates of model precision to capture most relevant sources of uncertainty.

SS comprises: 1) a population dynamics sub-model, where estimates of abundance, mortality, and growth are used to synthesize estimates of the true population; 2) an observation sub-model that defines various processes and filters to derive expected values for the different type of data; and 3) a statistical sub-model that quantifies the difference between observed data and their expected values and implements algorithms to search for the set of parameters that maximizes the goodness of fit. These sub-models are fully integrated, and the SS uses forward-algorithms, which begin estimation prior to or in the first year of available data and continues forward up to the last year of data (Methot 2005, 2011).

Definitions of fleets and areas
Data from major fishing regions are aggregated to represent southern and northern fleets. The southern MexCal fleet includes data from three major fishing areas at the southern end of the stock's distribution: northern Baja California (Ensenada, Mexico), southern California (Los Angeles to Santa Barbara), and central California (Monterey Bay). Fishing can occur throughout the year in the southern region. However, availability-at-size/age changes due to migration. Selectivity for the southern MexCal fleet was therefore modeled separately for seasons 1 and 2 (S1 & S2).

The PacNW fleet includes data from the northern range of the stock's distribution, where sardine are typically abundant between late spring and early fall. The PacNW fleet includes aggregate data from Oregon, Washington, and Vancouver Island (British Columbia, Canada). The majority of fishing in the northern region typically occurs between July and October (S1).

Selectivity assumptions
Length data from the MexCal and PacNW fleets were fit using a length-based selectivity. The MexCal fleet was fit using the domed selectivity (double-normal function), as we assumed that not all larger sardine were available to the Baja California and California fisheries from 1993 onward. At that stage in the population's recovery, large spawning events were observed off central California (Lo et al. 1996), and sardine were captured in trawls 300 nm off the California coast (Macewicz and Abramenkoff 1993). Selectivity for the MexCal fleet was estimated by season and in two time blocks (1993-1998, 1999-2012) to better account for both seasonal- and decadal-scale shifts in sardine availability to the southern region. PacNW fleet lengths were fit using asymptotic selectivity (simple logistic). Large sardine are typically found in the northern region, and it is assumed the largest sardine are best able to migrate to northern feeding habitats in summer.

Stock-recruitment constraints and components
Pacific sardine are believed to have a broad spawning season, beginning in January off northern Baja California and concluding by July off the Pacific Northwest. The SWFSC's annual egg production surveys are timed to capture the peak of spawning activity off the central and southern California coast during April. In SS, SSB was calculated at the beginning of S2 and recruitment was calculated in S1 of the subsequent model year (consistent with the July-1 birth date assumption) using the Ricker stock-recruitment function.

Virgin recruitment (R_0), initial recruitment offset (R_1), and steepness (h) were all freely estimated. Recruitment variability (σ_R) was initially set at the 2011 model value (0.622), and later fixed at 0.727 to match the model RMSE. Recruitment deviations were estimated as separate vectors for the early and main data periods. Early recruitment deviations for the initial population were estimated from beginning in 1987 (start year minus 6). A recruitment bias adjustment ramp was applied to the early period (Figure 39d).

The last year for the main recruitment deviations was set at 2010, which means that the 2011 year class was freely estimated from the data and the 2012 year class was derived from the Ricker curve. The number of recruitment deviations estimated from the final model year was changed from end-year -2 (per Hill et al. 2011) to end-year -1. Rationale for this change is documented in the following section '**PRELIMINARY UPDATE MODEL RUNS AND DIAGNOSTICS**'.

Selection of first modeled year and treatment of initial population
The initial population was calculated by estimating early recruitment deviations from 1987-1992, six years prior to the model start year. Initial F values were fixed to zero, following recommendations of the 2011 STAR panel (STAR 2011; request N).

Likelihood components and model parameters
A complete list of model parameters is provided in Table 9. The objective function for the base model included likelihood contributions from 1) fits to catch, 2) fits to the DEPM, TEP, Aerial, and Acoustic surveys; 3) fits to length compositions from the three fleets, Aerial and Acoustic surveys; 4) fits conditional age-at-length data from the three fleets and the Acoustic survey; 5) deviations about the spawner-recruit relationship; and 6) minor contributions from parameter soft-bound penalties (Table 9).

The update model (X6e) incorporates the following specifications:

- model year spans July 1-June 30 (July 1 birth date assumption);
- two seasons (S1=Jul-Dec and S2=Jan-Jun) (assessment years 1993 to 2012);
- sex is ignored;
- two fleets (MexCal, PacNW), with an annual selectivity pattern for the PacNW fleet, and seasonal selectivity patterns for the MexCal fleet;
- length-frequency and conditional age-at-length data for all fisheries;
- length-based, double-normal selectivity with time-blocking (1993-1998, 1999-2012) for the MexCal fleet; asymptotic length-selectivity for the PacNW fleet;
- Ricker stock-recruitment relationship with estimated steepness; σ_R = 0.727 (tuned);
- virgin (R_0) and initial recruitment offset (R_1) were estimated;
- spawning occurs in S2 and recruitment in S1;
- initial recruitment estimated; recruitment residuals estimated for SSB years 1987-2010;
- initial F set to 0 for all fleets;
- hybrid-F fishing mortality (option 3);
- M = 0.4 yr^{-1} for all ages;
- DEPM and TEP measures of spawning biomass; q estimated;
- aerial survey biomass, 2009-2012, q estimated, domed selectivity;
- acoustic survey biomass, 2006-2012, q=1, asymptotic selectivity.

Convergence criteria and status
The iterative process for determining numerical solutions in the model was continued until the difference between successive likelihood estimates was <0.00001. Final gradient for the update model was 0.0000221373.

PRELIMINARY MODEL RUNS AND DIAGNOSTICS

Addition of New Data to the Update Model

New data were sequentially added to the final 2011 model (X5) to examine sensitivity to each additional component, specifically: catch, length compositions, conditional age-at-length compositions, and survey estimates. Likelihoods and derived quantities for stepwise additions of data are presented in Table 8a. Upon addition of the first fishery length composition (MexCal_S1), a noticeable change occurred in both the scale and trend of biomass and recruitments throughout the time series. Specifically, biomass and recruitments were estimated lower in the first half of the time series and higher in the latter half (Figure 16). This change persisted with the addition of other data sources, and was accompanied by a shift in the trend of recruitment deviations and loss of fit to survey time series of abundance (Table 8a).

Profile of Last Year for Estimating Recruitment Deviations

To diagnose this change to model fit, we revisited the number of recruitment deviations being estimated by the model. The 2011 model was specified to estimate recruitment deviations until end year -2, i.e. the final two recruitments were drawn from the spawner-recruit curve (Hill et al. 2011). Models were run for a range of recruitment deviation end-years, where the last year ranged from model end-year -0, -1, -2, and -3.

There was a clear difference in recruitment deviation trends for models with end-year -0 or -1 compared to those with end-year -2 or -3 (Figure 17). This difference in trend is also obvious for recruitment and stock biomass estimates (Figure 18), where models for end-year -2 or -3 have noticeably lower estimates in earlier years and higher estimates for the final six years in comparison to models with end-year -0 or -1. Profiled model fits to survey time series are displayed in Figure 19. Examination of log deviations [ln(Obs)-ln(Exp)] indicated degraded fits to the DEPM, Aerial, and ATM time series when recruitments were estimated through end-year -2 or -3 compared to end-year -0 or -1 (Figure 19).

Update Model Change

To address the above problem, the STAT strongly recommend changing the last year for estimated recruitment deviations from model end-year -2 to end-year -1. While this results in a minor change to update model parameterization, this change was necessary to correct a problem that was unknowingly introduced in the 2011 assessment model (Hill et al. 2011).

Prior to the 2011 stock assessment, the last year for which recruitment deviations was estimated was consistently model end-year -1 (Hill et al. 2007-2010). Early in the process of conducting the 2011 assessment, the STAT had considerable difficulty identifying a model design that did not result in implausibly high F-rates (e.g. F ranging 3 to 4) in the terminal year(s). One change made to ameliorate this problem was to reduce the number of recruitment deviations estimated by one year (i.e., from end-year -1 to -2). The rationale for this change was that there was little information on recent recruitment available from the final years of survey or fishery data. Changing from end-year -1 to -2 appeared to provide more plausible model results. Additional changes to 2011 model designs (e.g., pooling fisheries, truncating the start year for the model) also improved model scaling issues, however, the change to number of recruitment deviation years (-2) remained in the final model design.

Given the degree of misfit introduced to the current update, it was decided to return to the past practice and estimate recruitment deviations to model end year -1. The update model based on this configuration will be referred to as model X6b. The following assessment update results are based on model X6b.

ASSESSMENT RESULTS

Update Model X6e

Parameter estimates and errors
Model X6e parameter estimates and standard errors are presented in Table 9. Most model parameters were within a reasonable range of bounds and had relatively small standard errors. Model X6f estimates are included for comparative purposes.

Growth
Modeled length-at-age is displayed in Figure 20. Length at age 0.5 was estimated to be 11.0 cm SL, L_∞ was 23.2 cm, and the growth coefficient K was 0.454. L_∞ was slightly lower and K was slightly higher than in the 2011 assessment (Hill et al. 2011). Standard deviations for the growth parameters are provided in Table 9. Fits to fleet and ATM survey conditional age-at-length data are shown in Figures 21-24. Most conditional age-at-length compositions fit reasonably well, with the exceptions of MexCal_S1 in 1993 and 2001-2003 (Figure 21) and PacNW in 2008-2011 (Figure 23).

Selectivity estimates and fits to composition data
Length selectivity estimates for each fleet and time period are displayed in Figure 25a. Implied age selectivities (product of length selectivity and the age-length key) for each fleet and period are shown in Figure 25b. The MexCal fleets (S1 & S2) captured progressively smaller fish between the early and latter time blocks (Figure 25a).

Model fits to fleet length frequencies, implied age-frequencies, Pearson residuals, and observed and effective samples sizes are displayed in Figures 26-31. Results are grouped by fleet so, for example, the reader can examine fits to length compositions, bubble plots of the input data, and bubble plots of Pearson residuals across facing pages. Corresponding fits to implied age compositions for the same fishery are found on the following two pages. Results indicate random residual patterns for most data and fleets. The PacNW fleet displayed notable residuals patterns for strong year classes (1997, 1998, and 2003) moving through the fishery (Figure 30-31).

Length selectivity estimates for each survey are displayed in Figure 32a. Selectivity for the ATM survey made a notable shift to larger sardine with the addition of two new length distributions (Figure 32b). The ATM survey selectivity is now similar to the shape estimated for the PacNW fleet (Figure 25a). Model fits to Aerial and Acoustic survey compositions, Pearson residuals, and observed and effective samples sizes are displayed in Figures 33-35. A clear trend is evident in the residual pattern for the Aerial length data (Figure 33). Fits to the Acoustic-trawl survey length and age data are likewise less than optimal (Figures 34-35).

Fits to indices
Model fits to the DEPM, TEP, Aerial and ATM survey time series are displayed in Figure 36a-d. Model expected values all fit within error bounds of the observed data, with the exception of the ATM estimate for model year 2005 (2006 survey), which was under-estimated by the model (Figure 36d). Catchability coefficient (q) for the DEPM series of female SSB was estimated at 0.17. The TEP series was best fit with q=0.54. The Aerial survey fit best with q=0.92.

Fishing mortality and exploitation rates
Harvest rates (catch per selected biomass, continuous-F) by fleet are displayed in Figure 37a. Instantaneous F estimates were all within a plausible range of values and less than 0.6 in most seasons. The F-rate for MexCal_S1 in 2012-1 was estimated relatively high (~0.95), however, there is uncertainty about this estimate as the total catch in 2012-1 is not yet known. Ensenada catch for this season is unknown and based on catch from the previous year. Size composition of the Ensenada catch in 2012-1 is also not known.

Exploitation rates (calendar year catch/total mid-year biomass, ages 0+) for the U.S. and total fisheries are displayed in Figure 37b. The U.S. exploitation rate trended upwards from 3% in 1993 to approximately 12% in 2002. Total exploitation rate peaked at 17% in 2002, and was about 15% in 2011.

Spawning stock biomass
Base model estimates of total SSB are presented in Tables 11-12 and Figure 38a. SSB increased throughout the 1990s, peaking at 1.04 mmt in 1999 (=Jan of calendar year 2000) and at 1.05 mmt in 2007. SSB-zero was approximately 0.946 mmt, a value consistent with previous SS assessment results (Hill et al. 2007, 2009-2011).

Recruitment
Time series of recruit (age-0) abundance are provided in Tables 11-12 and Figure 38b. Virgin recruitment (R_0) was estimated at 6.22 billion age-0 fish. Recruitment increased rapidly through the mid-1990s, peaking at 14.3 billion fish in 1997, 13.7 billion in 1998, and 22.3 billion fish in 2003. The 2009 year-class was estimated to be 10.1 billion fish. The 2010 and 2011 year classes were among the lowest in recent history (Table 11, Figure 38b).

Stock-recruitment relationship
The Ricker stock-recruitment relationship for the base model is displayed in Figure 39a. The estimate of steepness (h) was 2.79 for the base model (Table 9). Recruitment deviations for the main era were estimated from SSB years 1993 to 2010 (2011 Year Class) (Figure 39b). Sigma-R was fixed at 0.727 in the final tuned model. Asymptotic standard errors for recruitment deviations are displayed in Figure 39c and the S-R bias adjustment ramp is shown in Figure 39d.

Stock biomass for management
Stock biomass, used for setting management specifications, is defined as the sum of the biomass for ages 1 and older. Model estimates of stock biomass are provided in Table 12 and displayed in Figure 40. Stock biomass increased rapidly through the 1990s, peaking at 1.33 mmt in 1999 and 1.37 mmt in 2006. Stock biomass was estimated at 659,539 mt as of July 1, 2012 (HCR quantity), but is projected to be 454,683 mt as of January 1, 2013.

Uncertainty and Sensitivity Analyses

Models considered during the October 2012 review

The October 2012 update review focused primarily on two aspects of the assessment: 1) the number of recruitment deviations estimated until the model end-year, where end-year -1 was the STAT's proposed method and end-year -2 was the default method from 2011 (Hill et al. 2011); and 2) the 2012 aerial survey estimate and whether it's appropriate to use an estimate based on point set data from 2012 alone, or an estimate based on point-set data pooled from 2009-2012. The SSC-CPS Subcommittee requested several model variants to explore sensitivity to combinations of these parameterizations and aerial estimates, briefly summarized as follows:

Request E (model X6e, update presented in this report): Estimate recruitment deviations to end-year -1; include 2012 aerial survey based point-set data pooled across survey years and size composition from the 2012 point sets; model retuned.

Request F (model X6f): Estimate recruitment deviations to end-year -1; include 2012 aerial survey based 2012 point-set and size composition data; model retuned.

Request G (model X6g): Estimate recruitment deviations to end-year -1; include the full time series of pooled aerial survey estimates (2009-2012) and compositions from year-specific point sets; model retuned.

Request H (model X6h, strict update): Estimate recruitment deviations to end-year -2; include 2012 aerial survey based 2012 point-set and size composition data; model retuned.

Recruitment deviations from these model variants are displayed in Figure 41. Stock biomass and recruitment series for these models are presented in Figure 42. Estimates from the 2011 final assessment model X5 are included for comparison. Biomass and recruitment from models X6e, X6f, and X6g were nearly identical in terms of trend and scale. These three variants estimated recruitment deviations through end-year -1, and differed with respect to treatment of the aerial survey data. The assessment model is relatively insensitive to changes in aerial survey abundance, likely due to the relatively large survey CVs and additional model variance included to account for process error. As documented earlier in this report, the strict update model X6h displayed the greatest departure from the final 2011 model with respect to both trend and scale (Figures 40 and 42).

Historical analysis

Model X6e estimates of stock biomass and recruitment are compared to recent assessments in Figures 43a,b. Full and updated SS models from Hill et al. (2007-2011) were included in the comparison. Trends in biomass and recruitment were generally comparable among models, with the 2008 update model showing the greatest difference in scale.

HARVEST CONTROL RULES

Harvest Guideline

Using results from the update model X6e, the harvest guideline (HG) for the U.S. fishery in calendar year 2013 is 66,495 mt. The harvest control rule defined in Amendment 8 of the CPS-FMP was used to calculate the HG for 2013 (PFMC 1998). The HG was calculated as follows:

$$HG_{2013} = (BIOMASS_{2012} - CUTOFF) \bullet FRACTION \bullet DISTRIBUTION;$$

where HG_{2013} is the total U.S. (California, Oregon, and Washington) quota for 2013, $BIOMASS_{2012}$ is the estimated July 1, 2012 stock biomass (ages 1+) from the assessment (659,539 mt), CUTOFF (150,000 mt) is the lowest level of estimated biomass at which harvest is allowed, FRACTION (15%) is the percentage of biomass above the CUTOFF that can be harvested by the fisheries, and DISTRIBUTION (87%) is the average portion of BIOMASS assumed in U.S. waters. The U.S. HG values and catches since 2000 are displayed below. The HG for 2013 represents a 40% reduction from the 2012 HG.

OFL and ABC

The Magnuson-Stevens Reauthorization Act requires fishery managers to define an overfishing limit (OFL), allowable biological catch (ABC), and annual catch limit (ACLs) for species managed under federal FMPs. By definition, ABC must always be lower than the OFL based on uncertainty in the assessment approach. The PFMC's SSC recommended the P^* approach for buffering against scientific uncertainty when defining ABC, and this approach was adopted under Amendment 13 to the CPS-FMP.

The estimated biomass of 659,539 mt (ages 1+), an F_{MSY} proxy of 0.18, and an estimated distribution of 87% of the stock in U.S. waters resulted in a U.S. OFL of 103,284 mt for 2013. For Pacific sardine, the Science and Statistical Committee (SSC) has recommended that scientific uncertainty (σ) be set to the maximum of either (1) the CV of the biomass estimate for the most recent year or (2) a default value of 0.36, which was based on uncertainty across full assessment models. The terminal year biomass CV was equal to 0.273 (σ =0.268); therefore, σ remained at the default value of 0.36. The Amendment 13 ABC buffer depends on the probability of the overfishing level chosen by the Council (P^*). Uncertainty buffers and ABCs associated with a range of discreet P^* values are presented in Table 13.

RESEARCH AND DATA NEEDS

The following model-related research recommendations are excerpted from reports of the 2011 and 2012 assessment reviews.

- Explore use of Canada DFO's mid-water trawl survey off Vancouver Island.
- Temperature-at-catch could provide insight into stock structure and the appropriate catch stream to use for assessments, because the southern subpopulation is thought to inhabit warmer water than the northern subpopulation. Conduct tests of sensitivity to alternative assumptions regarding the fraction of the MexCal (in particular, Ensenada and Southern California) catch that comes from the northern subpopulation.
- Explore models that consider a much longer time period (e.g., 1931 onwards) to determine whether it is possible to model the protracted period and determine whether this leads to a more informative assessment and provides a broader context for evaluating changes in productivity.
- Consider a scenario that explicitly models the sex-structure of the population and the catch.
- Reconsider a model that has separate fleets for Mexico, CA, OR-WA, and Canada.
- Develop a relationship between egg production and age that accounts for the duration of spawning and batch fecundity by age.
- Consider model configurations that use age compositions, rather than length compositions and conditional age-at-length data, given evidence for time- and spatially-varying growth.
- Explore reasons for the discrepancy between the observed and expected proportions of old animals in the length and age compositions. Possible factors to consider in this investigation include ageing error / ageing bias and the way dome-shaped selectivity has been parameterized.
- Consider a Beverton-Holt or other spawner-recruit relationship in place of the Ricker to see if such a change will stabilize the model relative to the number of recent years of recruitments estimated, while providing a biologically realistic relationship.
- Consider the changes within and between years regarding targeting in developing appropriate fishery selectivities, as well as proper blocking and/or weighting of these data.
- Conduct a methods review to consider how best to use data from the aerial survey. Consider incorporating the aerial survey as a minimum estimate of total abundance.

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Table 1. Sardine harvest guidelines and U.S. landings since the onset of federal management.

Year	HG (mt)	Landings (mt)
2000	186,791	72,496
2001	134,737	78,520
2002	118,442	101,367
2003	110,908	74,599
2004	122,747	92,613
2005	136,179	90,130
2006	118,937	90,776
2007	152,564	127,695
2008	89,093	87,175
2009	66,932	67,083
2010	72,039	66,891
2011	50,526	46,745
2012	109,409	---

Table 2. Pacific sardine landings (mt) for major fishing regions off northern Baja California (Ensenada, Mexico), the United States, and British Columbia (Canada), calendar years 1981 to 2011\1.

Calendar year	ENS	SCA_Inc	SCA_Dir	CCA	OR	WA	BC	Grand Total
1981	0.0	5.8	0.0	0.0	0.0	0.0	0.0	5.8
1982	0.0	131.1	0.0	0.0	0.0	0.0	0.0	131.1
1983	273.6	352.4	0.0	0.0	0.0	0.0	0.0	626.0
1984	0.0	170.6	0.0	63.9	0.0	0.0	0.0	234.5
1985	3,722.3	558.6	0.0	34.4	0.0	0.0	0.0	4,315.2
1986	242.6	721.1	330.1	112.9	0.0	0.0	0.0	1,406.7
1987	2,431.6	1,691.8	363.9	38.9	0.0	0.0	0.0	4,526.2
1988	2,034.9	2,790.3	984.3	10.2	0.0	0.0	0.0	5,819.7
1989	6,224.2	2,605.1	838.2	237.7	0.0	0.0	0.0	9,905.2
1990	11,375.3	1,266.1	1,241.9	306.6	0.0	0.0	0.0	14,189.9
1991	31,391.8	1,174.9	5,599.1	975.7	0.0	0.0	0.0	39,141.5
1992	34,568.2	0.0	16,061.0	3,127.6	3.9	0.0	0.0	53,760.7
1993	32,044.9	0.0	15,487.7	704.5	0.2	0.0	0.0	48,237.3
1994	20,877.0	0.0	10,345.9	2,359.0	0.0	0.0	0.0	33,581.9
1995	35,396.2	0.0	36,561.4	4,927.9	0.0	0.0	22.7	76,908.1
1996	39,064.7	0.0	25,170.9	8,885.1	0.0	0.0	0.0	73,120.7
1997	68,439.0	0.0	32,836.8	13,360.8	0.0	0.0	70.8	114,707.3
1998	47,812.2	0.0	31,974.6	9,080.8	1.0	0.0	488.1	89,356.7
1999	58,569.4	0.0	42,863.0	13,884.0	775.1	0.0	24.5	116,115.9
2000	67,845.3	0.0	46,834.8	11,367.3	9,529.0	4,765.4	1,721.3	142,063.1
2001	46,071.3	0.0	47,661.7	7,241.4	12,780.0	10,837.0	1,265.9	125,857.3
2002	46,845.3	0.0	49,365.9	14,077.8	22,711.0	15,212.1	739.4	148,951.5
2003	41,341.8	0.0	30,289.1	7,448.3	25,258.0	11,603.9	977.7	116,918.7
2004	41,896.9	0.0	32,393.4	15,308.3	36,111.8	8,799.4	4,438.0	138,947.9
2005	55,322.5	0.0	30,252.6	7,940.1	45,008.1	6,929.0	3,231.8	148,684.2
2006	57,236.9	0.0	33,285.8	17,743.1	35,648.2	4,099.0	1,575.4	149,588.4
2007	36,846.8	0.0	46,198.6	34,782.1	42,052.3	4,662.5	1,522.3	166,064.6
2008	66,866.1	0.0	31,089.3	26,711.0	22,939.9	6,435.2	10,425.0	164,466.4
2009	55,911.2	0.0	12,561.1	25,015.0	21,481.6	8,025.2	15,334.3	138,328.4
2010	56,820.9	0.0	29,352.4	4,305.8	20,852.0	12,380.5	22,223.1	145,934.8
2011	70,336.5	0.0	17,641.8	10,071.8	11,023.4	8,008.4	20,718.8	137,800.7

\1 Southern and central California landings (incidental and directed) are from CDFG's monthly Wetfish tables, which included bucket sampling of mixed loads to account for incidental catches not included on landing receipts. OR and WA landings were obtained from the PacFIN database. British Columbia landings were provided by the Canada Department of Fisheries and Oceans. Ensenada (Mexico) landings were obtained from INAPESCA annual reports, INAPESCA scientists, and CONAPESCA (2005-2011).

Table 3. Pacific sardine landings (mt) and corresponding number of fish sampled (length data available for the assessment) for major fishing regions off northern Baja California (Mexico), the United States, and Canada, by model year and season, 1981 to 2012[\1\2]. Update model begins in 1993-1.

Model year	Model sem	ENS mt	ENS N_len	SCA Inc mt	SCA Inc N_fish	SCA Dir mt	SCA Dir N_fish	CCA mt	CCA N_fish	OR mt	OR N_fish	WA mt	WA N_fish	BC mt	BC N_len
1981	1	0	0	6	179	0	0	0	0	0	0	0	0	0	0
1981	2	0	0	57	204	0	0	0	0	0	0	0	0	0	0
1982	1	0	0	74	361	0	0	0	0	0	0	0	0	0	0
1982	2	150	0	263	580	0	0	0	0	0	0	0	0	0	0
1983	1	124	0	89	411	0	0	0	0	0	0	0	0	0	0
1983	2	0	0	159	188	0	0	0	0	0	0	0	0	0	0
1984	1	0	0	12	0	0	0	64	0	0	0	0	0	0	0
1984	2	3,174	0	312	214	0	0	10	0	0	0	0	0	0	0
1985	1	548	0	247	371	0	0	24	0	0	0	0	0	0	0
1985	2	99	0	530	482	325	297	65	0	0	0	0	0	0	0
1986	1	143	0	191	447	5	14	48	0	0	0	0	0	0	0
1986	2	975	0	918	767	364	289	22	0	0	0	0	0	0	0
1987	1	1,457	0	773	728	0	0	17	0	0	0	0	0	0	0
1987	2	620	0	2,028	1,365	984	762	8	0	0	0	0	0	0	0
1988	1	1,415	0	763	562	0	0	3	0	0	0	0	0	0	0
1988	2	461	34	1,081	810	838	262	235	0	0	0	0	0	0	0
1989	1	5,763	97	1,524	1,018	0	0	3	0	0	0	0	0	0	0
1989	2	5,900	73	645	556	1,242	588	245	0	0	0	0	0	0	0
1990	1	5,475	395	621	350	0	0	62	92	0	0	0	0	0	0
1990	2	9,271	1,216	601	441	4,481	1,514	90	113	0	0	0	0	0	0
1991	1	22,121	1,073	574	0	1,118	412	885	495	0	0	0	0	0	0
1991	2	3,327	469	0	0	5,884	912	1,113	221	0	0	0	0	0	0
1992	1	31,242	1,195	0	0	10,177	2,098	2,014	0	4	0	0	0	0	0
1992	2	18,648	853	0	0	11,759	1,585	369	0	0	0	0	0	0	0
1993	1	13,397	2,068	0	0	3,729	363	335	0	0	0	0	0	0	0
1993	2	5,712	816	0	0	7,738	785	629	0	0	0	0	0	0	0
1994	1	15,165	913	0	0	2,607	644	1,730	0	0	0	0	0	0	0
1994	2	18,227	958	0	0	28,122	3,024	443	0	0	0	0	0	0	0
1995	1	17,169	1,283	0	0	8,439	863	4,485	0	0	0	0	0	23	0
1995	2	15,666	665	0	0	14,409	1,492	2,486	271	0	0	0	0	0	0
1996	1	23,399	1,065	0	0	10,762	837	6,399	2,182	0	0	0	0	0	0
1996	2	13,498	534	0	0	11,524	1,441	343	49	0	0	0	0	44	0
1997	1	54,941	1,250	0	0	21,313	1,325	13,018	1,374	0	0	0	0	27	0
1997	2	20,239	458	0	0	19,094	1,482	2,747	124	1	0	0	0	0	0
1998	1	27,573	1,034	0	0	12,881	1,315	6,334	1,286	0	0	0	0	488	175
1998	2	34,760	1,461	0	0	24,050	1,514	7,741	348	50	31	0	0	24	165
1999	1	23,810	1,014	0	0	18,813	1,215	6,143	0	725	76	0	0	0	290
1999	2	33,933	1,156	0	0	34,119	1,457	1,285	0	205	106	62	0	162	0

Table 3 (cont'd). Pacific sardine landings (mt) and corresponding number of fish sampled (length data available for the assessment) for major fishing regions off northern Baja California (Mexico), the United States, and Canada, by model year and season, 1981 to 2012[\1\2]. Update model begins in 1993-1.

Model year	Model sem	ENS mt	ENS N_len	SCA Inc mt	SCA Inc N_fish	SCA Dir mt	SCA Dir N_fish	CCA mt	CCA N_fish	OR mt	OR N_fish	WA mt	WA N_fish	BC mt	BC N_len
2000	1	33,912	1,281	0	0	12,716	1,405	10,082	0	9,324	796	4,703	899	1,559	2,909
2000	2	16,545	1,145	0	0	29,343	1,699	774	92	2,288	168	49	100	0	648
2001	1	29,526	720	0	0	18,318	1,670	6,467	690	10,492	702	10,789	1,350	1,265	1,206
2001	2	17,422	930	0	0	26,621	1,621	1,575	302	2,724	250	412	419	1	300
2002	1	29,424	891	0	0	22,745	1,153	12,503	758	19,987	1,249	14,800	3,113	739	9,323
2002	2	15,514	460	0	0	20,380	1,739	5,086	471	503	25	94	186	0	300
2003	1	25,827	1,036	0	0	9,909	1,511	2,363	195	24,755	943	11,510	2,726	977	9,227
2003	2	11,213	5,028	0	0	15,232	1,669	2,146	197	2,204	124	235	298	180	0
2004	1	30,684	5,113	0	0	17,161	1,715	13,163	563	33,908	872	8,564	1,578	4,258	6,689
2004	2	17,323	4,191	0	0	15,419	1,756	115	23	692	50	324	147	0	0
2005	1	38,000	2,885	0	0	14,834	1,810	7,825	587	44,316	349	6,605	1,348	3,231	6,451
2005	2	17,601	1,336	0	0	17,158	3,322	2,033	1,530	102	0	0	0	0	0
2006	1	39,636	1,154	0	0	16,128	1,517	15,711	1,446	35,547	300	4,099	375	1,575	0
2006	2	13,981	553	0	0	26,344	1,789	6,013	1,138	0	75	0	0	0	0
2007	1	22,865	1,138	0	0	19,855	1,802	28,769	1,701	42,052	1,999	4,663	250	1,522	2,336
2007	2	23,488	1,080	0	0	24,127	1,318	2,515	370	0	0	0	0	0	0
2008	1	43,378	2,074	0	0	6,962	637	24,196	746	22,940	2,000	6,435	360	10,425	22,894
2008	2	25,783	1,251	0	0	9,251	497	11,080	497	0	0	0	0	0	0
2009	1	30,128	0	0	0	3,310	325	13,935	575	21,482	2,050	8,025	300	15,334	28,527
2009	2	12,989	0	0	0	19,457	1,550	2,909	925	437	84	511	50	0	200
2010	1	43,832	0	0	0	9,925	625	1,397	325	20,415	1,599	11,870	200	21,801	28,689
2010	2	18,514	0	0	0	12,526	549	2,713	275	0	0	0	0		0
2011	1	51,823	0	0	0	5,115	550	7,358	550	11,023	850	8,008	250	20,719	36,191
2011	2	18,514	0	0	0	12,053	1,207	3,673	400	2,874	0	2,971	0	0	0
2012	1	51,823	0	0	0	8,964	512	5,838	0	33,304	5,053	27,888	474	19,316	6,000

[\1] Southern and central California landings (incidental and directed) are from CDFG's monthly Wetfish tables, which included bucket sampling of mixed loads to account for incidental catches not included on landing receipts. OR and WA landings were obtained from the PacFIN database. British Columbia landings were provided by the Canada Department of Fisheries and Oceans. Ensenada (Mexico) landings were obtained from INAPESCA annual reports, INAPESCA scientists, and CONAPESCA (2005-2011).

[\2] Sardine lengths for the Oregon fishery in 2012-1 include fish measured by the NWSS (non-point set, n=4,628) and ODFW (n=425).

Table 4. Pacific sardine landings (mt) and effective sample sizes (ESS) by model year, semester, and fishery for the update model.

Model year	Model sem	MexCal mt	MexCal ESS	PacNW mt	PacNW ESS
1993	1	17,460.8	68.60	0.0	0.00
1993	2	14,078.9	75.58	0.0	0.00
1994	1	19,503.0	34.15	0.0	0.00
1994	2	46,792.1	184.41	0.0	0.00
1995	1	30,093.3	54.40	22.7	0.00
1995	2	32,561.2	50.12	0.0	0.00
1996	1	40,559.5	76.02	0.0	0.00
1996	2	25,364.6	39.90	43.5	0.00
1997	1	89,272.0	72.64	27.2	0.00
1997	2	42,079.7	42.44	0.8	0.00
1998	1	46,787.9	67.85	488.2	0.00
1998	2	66,550.5	66.15	74.4	0.00
1999	1	48,765.8	44.67	725.2	3.04
1999	2	69,337.6	52.39	429.6	4.24
2000	1	56,709.8	53.24	15,586.2	63.93
2000	2	46,662.7	62.74	2,336.9	10.72
2001	1	54,311.7	58.90	22,546.0	78.15
2001	2	45,617.1	62.32	3,136.8	26.75
2002	1	64,671.9	73.64	35,525.7	172.79
2002	2	40,979.6	62.30	597.3	8.44
2003	1	38,099.5	50.43	37,242.3	145.33
2003	2	28,590.5	124.63	2,618.4	16.88
2004	1	61,008.1	149.06	46,730.8	95.17
2004	2	32,857.3	122.39	1,016.3	7.88
2005	1	60,658.0	108.68	54,152.6	67.68
2005	2	36,791.2	77.23	101.7	0.00
2006	1	71,474.7	78.73	41,220.9	27.00
2006	2	46,338.3	91.44	0.0	3.00
2007	1	71,489.2	109.86	48,237.1	87.86
2007	2	50,130.3	56.13	0.0	0.00
2008	1	74,536.0	71.40	39,800.1	129.64
2008	2	46,113.9	45.51	0.0	0.00
2009	1	47,373.4	36.00	44,841.1	159.41
2009	2	35,325.5	99.08	1,369.7	5.36
2010	1	55,153.6	38.00	54,085.9	159.59
2010	2	33,753.6	32.96	0.1	0.00
2011	1	64,296.5	44.00	39,750.5	214.20
2011	2	34,239.8	64.28	5,844.4	0.00
2012	1	66,624.6	21.00	80,508.0	114.88
2012	2	34,239.8	0.00	5,844.4	0.00

Table 5. Fishery-independent indices of Pacific sardine relative abundance. Complete details regarding calculation of DEPM and TEP values can be found in Tables 6 and 7. In the SS model, indices had a lognormal error structure with units of standard error of $\log_e$(index). Variance of the observations was only available as a CV, so the S.E. was approximated as sqrt($\log_e(1+CV^2)$).

Model year-sem	DEPM	S.E. ln(index)	TEP	S.E. ln(index)	Aerial	S.E. ln(index)	Acoustic	S.E. ln(index)
1993-2	69,065	0.29	---	---	---	---	---	---
1995-2	---	---	97,923	0.40	---	---	---	---
1996-2	---	---	482,246	0.21	---	---	---	---
1997-2	---	---	369,775	0.33	---	---	---	---
1998-2	---	---	332,177	0.34	---	---	---	---
1999-2	---	---	1,252,539	0.39	---	---	---	---
2000-2	---	---	931,377	0.38	---	---	---	---
2001-2	---	---	236,660	0.17	---	---	---	---
2002-2	---	---	556,177	0.18	---	---	---	---
2003-2	145,274	0.23	---	---	---	---	---	---
2004-2	459,943	0.55	---	---	---	---	---	---
2005-2	---	---	651,994	0.25	---	---	1,947,063	0.30
2006-2	198,404	0.30	---	---	---	---	---	---
2007-2	66,395	0.27	---	---	---	---	751,075	0.09
2008-1	---	---	---	---	---	---	801,000	0.30
2008-2	99,162	0.24	---	---	---	---	---	---
2009-1			---	---	1,236,911	0.90	---	---
2009-2	58,447	0.40	---	---			357,006	0.41
2010-1			---	---	173,390	0.40	---	---
2010-2	219,386	0.27	---	---			493,672	0.30
2011-1	---	---	---	---	201,888	0.29	---	---
2011-2	113,178	0.27	---	---	---	---	469,480	0.28
2012-1	---	---	---	---	696,251	0.37	340,831	0.33

Table 6. The spawning biomass related parameters: daily egg production/0.05m^2 (P_0),daily mortality rate (z), survey area (km^2), two daily specific fecundities: (RSF/W), and (SF/W); s. biomass, female spawning biomass, total egg production (TEP) and sea surface temperature for 1986, 1987, 1994, 2004, 2005 and 2007-2012.

Calendar year	Season	Region	[1]P_0/0.05m^2 (cv)	Z (CV)	[2]RSF/W based on S_1	[3]RSF/W based on S_{12}	[3]FS/W based on S_{12}	[4]Area (km^2)	[5]S. biomass (cv)	S. biomass females (cv)	S. biomass females (Sum of R1andR2) (cv)	Total egg production (TEP)	Mean temper-ature (°C) for positive eggs	Mean temper-ature (°C) from Calvet
1986(Aug)	1986	[6]S	1.48(1)	1.59(0.5)	38.31	43.96	72.84	6478	4362 (1.00)	2632 (1)		9587.44		
		N	0.32(0.25)		8.9	13.34	23.89	5333	2558 (0.33)	1429 (0.28)		1706.56		
		whole	0.95(0.84)		23.61	29.89	49.97	11811	7767 (0.87)	4491 (0.86)	4061 (0.66)	11220.45	18.7	18.5
1987 (Jul)	1987	1	1.11(0.51)	0.66(0.4)	38.79	37.86	57.05	22259	13050 (0.58)	8661 (0.56)		24707.49		
		2	0					15443	0	0		0		
		whole	0.66(0.51)		38.79	37.86	57.05	37702	13143 (0.58)	8723 (0.56)	8661 (0.56)	25637.36	18.9	18.1
1994	1993	1	0.42(0.21)	0.12(0.91)	11.57	11.42	21.27	174880	128664 (0.30)	69065 (0.30)		73449.6		
		2	0(0)	-				205295	0	0		0		
		whole	0.193(0.21)		11.57	11.42	21.27	380175	128531 (0.31)	68994 (0.30)	69065 (0.30)	73373.775	14.3	14.7
2004	2003	1	3.92(0.23)	0.25(0.04)	27.03	26.2	42.37	68204	204118 (0.27)	126209 (0.26)		267359.68		
		2	0.16(0.43)		-	-	-	252416	30833 (0.45)	19065 (0.44)		40386.56		
		whole	0.96(0.24)		27.03	26.2	42.37	320620	234958 (0.28)	145297 (0.27)	145274 (0.23)	307795.2	13.4	13.7
2005	2004	1	8.14(0.4)	0.58(0.2)	31.49	25.6	46.52	46203	293863 (0.45)	161685 (0.42)		376092.42		
		2	0.53(0.69)		3.76	3.2	7.37	207417	686168 (0.86)	298258 (0.89)		109931.01		
		whole	1.92(0.42)		15.67	12.89	27.11	253620	755657 (0.52)	359209 (0.50)	459943 (0.60)	486950.4	14.21	14.1
2007	2006	1	1.32(0.2)	0.13(0.36)	12.06	13.37	27.54	142403	281128 (0.42)	136485 (0.36)		187971.96		
		2	0.56(0.46)		24.48	23.41	38.94	213756	102998 (0.67)	61919 (0.62)		119703.36		
		whole	0.86(0.26)		15.68	16.17	31.52	356159	380601 (0.39)	195279 (0.36)	198404 (0.31)	306296.74	13.7	13.6
2008	2007	1	1.45(0.18)	0.13(0.29)	57.4	53.89	68.54	53514	29798 (0.20)	22642 (0.19)		77595.3		
		2	0.202(0.32)		13.84	12.6	22.57	244435	78359 (0.45)	43753 (0.42)		49375.87		
		whole	0.43(0.21)		21.82	20.31	32.2	297949	126148 (0.40)	79576 (0.35)	66395 (0.28)	128118.07	13.1	13.1
2009	2008	1	1.76(0.22)	0.25(0.19)	19.50	20.37	36.12	74966	129520 (0.31)	73048 (0.29)		131940.16		
		2	0.15(0.27)		14.25	14.34	22.97	199929	41816 (0.38)	26114 (0.38)		29989.35		
		whole	0.59(0.22)		17.01	17.53	29.11	274895	185084 (0.28)	111444 (0.27)	99162 (0.24)	162188.05	13.6	13.5
2010	2009	1	1.70(0.22)	0.33(0.23)	21.08	24.02	51.56	27462	38875 (0.44)	18111 (0.39)		46685.4		
		2	0.22(0.42)		14.55	16.20	26.65	244311	66345 (0.58)	40336 (0.58)		53748.42		
		whole	0.36(0.29)		16.08	18.07	31.49	271773	108280 (0.46)	62131 (0.46)	58447 (0.42)	97838.28	13.7	13.9
2011	2010	1	5.57(0.24)	0.51(0.14)	19.03	24.26	41.16	41878	192332 (0.31)	113340 (0.30)		233260.5		
		2	0.487(0.33)		11.40	14.67	25.04	272603	181016 (0.48)	106046 (0.49)		132757.7		
		whole	1.16(0.26)		14.85	19.04	32.40	314481	383286 (0.32)	225155 (0.32)	219386 (0.28)	364798.0	13.5	13.6
2012	2011	1	5.28 (0.27)	0.66(0.11)	17.76	19.25	42.17	32322	177289 (0.37)	80930 (0.33)		170660.16		
		2	0.24 (0.27)		15.34	14.67	35.52	238669	78102 (0.60)	32248 (0.46)		57280.56		
		whole	0.84 (0.27)		16.14	16.14	37.65	270991	282110 (0.43)	120902 (0.36)	113178 (0.27)	227632.44	13.57	13.3

1: P_0 for the whole is the weighted average with area as the weight.

2. The estimates of adult parameters for the whole area were unstratified and RSF/W was based on original S_1 data of day-1 spawning females. For 2004, 27.03 was based on sex ratio= 0.618 while past biomass used RSF/W of 21.86 based on sex ratio = 0.5.(Lo et al. 2008)

3. The estimates of adult parameters for the whole area were unstratified. Batch fecundity was estimated with error term. For 1987 and 1994, estimates were based on S_1 using data of day-1 spawning females. For 2004, all trawls were in region 1 and value was applied to region 2,

4. Region 1, since 1997, is the area where the eggs/min from CUFES ≥1 and prior to 1997, is the area where the eggs/0.05m^2 >0 from CalVET tows

5: For the spawning biomasses, the estimates for the whole area uses unstratified adult parameters

6. Within southern and northern area, the survey area was stratified as Region 1 (eggs/0.05m2>0 with embedded zero) and Region 2 (zero eggs)

Table 7. Pacific sardine female adult parameters for surveys conducted in the standard daily egg production method (DEPM) sampling area off California (1994 includes females from off Mexico).

		1994	1997	2001	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012
Midpoint date of trawl survey		22-Apr	25-Mar	1-May	21-Apr	25-Apr	13-Apr	2-May	24-Apr	16-Apr	27-Apr	20-Apr	8-Apr	19-Apr
Beginning and ending dates of positive collections		04/15-05/07	03/12-04/06	05/01-05/02	04/18-04/23	04/22-04/27	03/31-04/24	05/01-05/07	04/19-04/30	04/13-04/27	04/17-05/06	04/12-04/27	03/23-04/25	04/08-04/28
N collections with mature females		37	4	2	6	16	14	7	14	12	29	17	30	16
N collection within Region 1		19	4	2	6	16	6	2	8	4	15	3	14	8
Average surface temperature (°C) at collection locations		14.36	14.28	12.95	12.75	13.59	14.18	14.43	13.6	12.4	12.93	13.62	13.12	13.18
Female fraction by weight	R	0.538	0.592	0.677	0.385	0.618	0.469	0.451	0.515	0.631	0.602	0.574	0.587	0.429
Average mature female weight (grams): with ovary	W_f	82.53	127.76	79.08	159.25	166.99	65.34	67.41	81.62	102.21	112.40	129.51	127.59	141.36
without ovary	W_{of}	79.33	119.64	75.17	147.86	156.29	63.11	64.32	77.93	97.67	106.93	121.34	119.38	131.58
Average batch fecundity[a] (mature females, oocytes)	F	24283	42002	22456	54403	55711	17662	18474	21760	29802	29790	39304	38369	38681
Relative batch fecundity (oocytes/g)		294	329	284	342	334	270	274	267	292	265	303	301	274
N mature females analyzed		583	77	9	23	290	175	86	203	187	467	313	244	126
N active mature females		327	77	9	23	290	148	72	187	177	463	310	244	125
Spawning fraction of mature females[b]	S	0.074	0.133	0.111	0.174	0.131	0.124	0.0698	0.114	0.1186	0.1098	0.1038	0.1078	0.1376
Spawning fraction of active females[c]	S_a	0.131	0.133	0.111	0.174	0.131	0.155	0.083	0.134	0.1187	0.1108	0.1048	0.1078	0.1388
Daily specific fecundity	$\frac{RSF}{W}$	11.7	25.94	21.3	22.91	27.04	15.67	8.62	15.68	21.82	17.53	18.07	19.04	16.14

[a] 1994-2001 estimates were calculated using F_b = -10858 + 439.53 W_{of} (Macewicz et al. 1996), 2004 used F_b = 356.46W_{of}. (Lo and Macewicz 2004), 2005 used F_b = -6085 + 376.28 W_{of} (Lo and Macewicz 2006), 2006 used F_b = -396 + 293.39 W_{of} (Lo et al. 2007a); 2007 used F_b = 279.23W_{of} (Lo et al. 2007b), 2008 used F_b = 305.14W_{of} (Lo et al. 2008), 2009 used F_b = -4598 + 326.78W_{of} + e (Lo et al. 2009), 2010 used F_b = 5136 + 287.37W_{of} + e (Lo et al. 2010), and 2011 used F_b = -2252 + 347.6W_{of} + e (Lo et al. 2009).

[b] Mature females include females that are active and those that are postbreeding (incapable of further spawning this season). S_1 was used for years prior to 2009 and S_{12} was used staring 2009.

[c] Active mature females are capable of spawning and have ovaries containing oocytes with yolk or postovulatory follicles less than 60 hours old

Table 8a. Likelihood components and derived quantities for the final 2011 model (X5) and preliminary update model X6a with stepwise addition of new data.

NEW DATA / PROCESS:	X5_final	+Catch	+MexCal_S1_len	+MexCal_S2_len	+PacNW_len	+All Fshy Lengths	+All Fshy CondAL	+DEPM	+ATM	X6a
Revised & New Catch										
MexCal_S1 Length Comp										
MexCal_S2 Length Comp										
PacNW Length Comp										
New Fishery CondAL Comps										
DEPM 2012 Estimate										
ATM 2012 Estimate & Comps										
Est RecDevs to End Year -2										
Est RecDevs to End Year -1										
Use 'X5_final' Var. Adj. & SigR										
Retune model (Adj. Vars. & SigR)										
LIKELIHOOD COMPONENT:	**X5_final**	**+Catch**	**+MexCal_S1_len**	**+MexCal_S2_len**	**+PacNW_len**	**+All Fshy Lengths**	**+All Fshy CondAL**	**+DEPM**	**+ATM**	**X6a**
DEPM Survey	0.37279	0.62202	1.21319	0.96228	0.63478	1.21570	1.34967	1.01326	1.23637	1.77398
TEP Survey	-0.02801	0.17266	-0.04059	-0.04490	0.13102	-0.01807	-0.04173	-0.04016	0.00329	-0.18193
Aerial Survey	0.03256	-0.00545	0.22167	0.11458	0.05910	0.22419	0.22305	0.22211	0.23258	0.46933
ATM Survey	-1.68802	-1.80720	0.30153	-0.26164	-1.45994	0.23750	0.36707	0.35975	0.74166	0.37066
Survey Subtotal	**-1.31068**	**-1.01796**	**1.69580**	**0.77033**	**-0.63505**	**1.65931**	**1.89806**	**1.55497**	**2.21390**	**2.43203**
MexCal_S1 Lengths	399.06	403.55	425.68	398.13	399.98	423.94	427.70	427.77	425.60	399.63
MexCal_S2 Lengths	318.83	325.10	324.52	352.04	322.62	346.83	349.83	349.82	351.81	333.71
PacNW Lengths	233.86	220.46	221.66	219.09	242.19	236.21	234.71	234.70	231.71	227.98
Aerial Lengths	19.14	17.49	18.04	17.64	18.04	17.88	17.46	17.46	17.01	19.00
ATM Lengths	89.66	88.58	95.54	90.31	88.09	95.47	96.94	96.95	140.16	178.17
Lengths Subtotal	**1060.54**	**1055.17**	**1085.43**	**1077.21**	**1070.92**	**1120.33**	**1126.65**	**1126.70**	**1166.29**	**1158.47**
MexCal_S1 CondAL	267.06	268.37	270.13	268.25	269.19	270.37	281.99	281.99	281.93	279.12
MexCal_S2 CondAL	231.06	230.65	233.56	232.48	232.44	235.97	241.26	241.27	240.50	236.30
PacNW CondAL	182.41	184.82	191.81	189.11	186.36	191.72	204.24	204.20	207.53	205.05
ATM CondAL	32.17	29.57	29.20	29.01	29.34	28.97	28.82	28.82	51.11	50.43
CondAL Subtotal	**712.70**	**713.41**	**724.70**	**718.85**	**717.32**	**727.04**	**756.30**	**756.28**	**781.07**	**770.90**
Catch	2.98E-10	2.50E-08	2.50E-08	2.50E-08	2.50E-08	2.50E-08	2.50E-08	2.50E-08	2.50E-08	2.50E-08
Recruitment	11.0596	11.6086	16.1047	13.1482	11.5448	15.9554	16.5304	16.5076	17.5333	18.5644
Parm_softbounds	0.00990076	0.00937793	0.00855647	0.00910637	0.00925356	0.00855483	0.00844848	0.00844603	0.00854344	0.0085694
TOTAL	**1783.00**	**1779.18**	**1827.94**	**1809.99**	**1799.16**	**1864.99**	**1901.39**	**1901.06**	**1967.11**	**1950.37**
DERIVED QUANTITIES:	**X5_final**	**+Catch**	**+MexCal_S1_len**	**+MexCal_S2_len**	**+PacNW_len**	**+All Fshy Lengths**	**+All Fshy CondAL**	**+DEPM**	**+ATM**	**X6a**
Ln(R0)	15.6444	15.6329	15.6277	15.6524	15.6245	15.6051	15.6314	15.6313	15.6293	15.6029
SSB-Virgin	968,738	943,048	927,914	958,594	930,449	905,585	926,223	926,127	928,343	899,121
Stock Biomass -1999 peak	1,448,190	1,442,590	1,267,130	1,348,920	1,380,660	1,236,690	1,245,020	1,246,210	1,245,960	1,137,660
Stock Biomass - 2011	988,385	715,305	1,325,230	1,035,190	867,696	1,219,090	1,266,840	1,264,640	1,275,550	1,261,710
Stock Biomass - 2012		786,668	1,170,560	966,134	909,272	1,052,190	1,100,780	1,098,840	1,075,510	1,048,210

Table 8b. Likelihood components and derived quantities for the final 2011 model (X5) and preliminary update model X6b with stepwise addition of new data.

NEW DATA / PROCESS:	X5_final	X5b	+Catch	+MexCal_S1_len	+MexCal_S2_len	+PacNW_len	+All Fshy Lengths	+All Fshy CondAL	+DEPM	+ATM	X6b
Revised & New Catch											
MexCal_S1 Length Comp											
MexCal_S2 Length Comp											
PacNW Length Comp											
New Fishery CondAL Comps											
DEPM 2012 Estimate											
ATM 2012 Estimate & Comps											
Est RecDevs to End Year -2											
Est RecDevs to End Year -1											
Use 'X5_final' Var. Adj. & SigR											
Retune model (var. adj. & SigR)											
LIKELIHOOD COMPONENT:	**X5_final**	**X5b**	**+Catch**	**+MexCal_S1_len**	**+MexCal_S2_len**	**+PacNW_len**	**+All Fshy Lengths**	**+All Fshy CondAL**	**+DEPM**	**+ATM**	**X6b**
DEPM Survey	0.37279	0.35261	1.21665	0.74850	1.07435	0.59203	0.87632	0.91448	0.47895	0.60990	0.75278
TEP Survey	-0.02801	0.07469	0.72922	0.05487	-0.68357	0.18015	0.04310	0.03969	0.03989	0.11112	-0.03133
Aerial Survey	0.03256	-0.00718	-0.12661	0.06035	0.09972	0.03494	0.12927	0.11097	0.11082	0.10745	0.19856
ATM Survey	-1.68802	-1.92198	1.22180	-1.04750	2.97970	-1.66549	-0.61471	-0.69126	-0.69256	-1.62523	-1.69143
Survey Subtotal	**-1.31068**	**-1.50186**	**3.04107**	**-0.18377**	**3.47020**	**-0.85837**	**0.43397**	**0.37388**	**-0.06290**	**-0.79675**	**-0.77142**
MexCal_S1 Lengths	399.06	393.62	403.98	427.02	431.16	399.95	425.15	428.97	428.98	427.23	399.74
MexCal_S2 Lengths	318.83	324.18	321.48	326.66	353.99	322.44	348.95	352.45	352.45	354.80	329.39
PacNW Lengths	233.86	241.11	217.15	219.51	223.19	241.50	236.42	235.08	235.08	232.86	219.17
Aerial Lengths	19.14	19.21	16.54	17.56	21.10	17.95	17.57	17.10	17.10	16.64	18.95
ATM Lengths	89.66	96.79	89.11	89.47	96.64	87.88	95.89	97.45	97.45	138.44	181.47
Lengths Subtotal	**1060.54**	**1074.90**	**1048.25**	**1080.22**	**1126.08**	**1069.72**	**1123.98**	**1131.05**	**1131.06**	**1169.96**	**1148.72**
MexCal_S1 CondAL	267.06	267.17	270.17	268.11	267.22	269.20	269.75	281.33	281.33	281.31	279.23
MexCal_S2 CondAL	231.06	231.63	233.00	232.13	230.96	232.49	234.66	238.99	238.99	238.08	234.47
PacNW CondAL	182.41	181.34	182.35	187.53	174.49	185.63	188.47	199.66	199.65	202.22	199.18
ATM CondAL	32.17	32.31	29.93	29.29	28.85	29.39	29.09	28.99	28.99	52.24	51.93
CondAL Subtotal	**712.70**	**712.44**	**715.45**	**717.06**	**701.52**	**716.71**	**721.96**	**748.96**	**748.96**	**773.85**	**764.81**
Catch	2.98E-10	2.98E-10	3.26E-02	2.50E-08	2.50E-08	2.50E-08	2.50E-08	2.50E-08	2.50E-08	2.50E-08	2.50E-08
Recruitment	11.0596	10.6768	15.1873	15.8437	30.7454	11.5568	14.0284	13.9987	13.9996	14.6745	14.5614
Parm_softbounds	0.00990076	0.00993435	0.0123514	0.0091628	0.0245871	0.00943035	0.00836934	0.00821469	0.00821439	0.00886692	0.00822824
TOTAL	**1783.00**	**1796.52**	**1781.98**	**1812.95**	**1861.84**	**1797.14**	**1860.41**	**1894.39**	**1893.96**	**1957.70**	**1927.33**
DERIVED QUANTITIES:	**X5_final**	**X5b**	**+Catch**	**+MexCal_S1_len**	**+MexCal_S2_len**	**+PacNW_len**	**+All Fshy Lengths**	**+All Fshy CondAL**	**+DEPM**	**+ATM**	**X6b**
Ln(R0)	15.6444	15.6091	15.4943	15.6339	15.2715	15.6017	15.6097	15.6283	15.6283	15.651	15.6411
SSB-Virgin	968,738	935,311	820,183	943,866	627,112	910,161	913,445	928,588	928,550	955,767	944,044
Stock Biomass -1999 peak	1,448,190	1,447,670	1,306,690	1,412,360	956,403	1,396,590	1,322,590	1,347,880	1,347,950	1,390,090	1,335,880
Stock Biomass - 2011	988,385	795,841	267,982	886,071	562,574	792,391	956,506	928,411	927,958	927,077	873,786
Stock Biomass - 2012	---		164,565	664,095	429,559	694,353	751,224	716,673	716,226	690,282	635,732

Table 9. Parameters and asymptotic standard deviations for models X6e and X6h.

					X6e (Proposed Update)		X6h (Strict Update)	
Parameter	Phase	Min	Max	Initial Value	Final Value	Std Dev	Final Value	Std Dev
NatM_p_1_Fem_GP_1	-3	0.3	0.7	0.4000	0.4000	_	0.4000	_
L_at_Amin_Fem_GP_1	3	3	15	10.0000	10.9665	0.1858	11.1034	0.1818
L_at_Amax_Fem_GP_1	3	20	30	25.0000	23.2048	0.1575	23.3654	0.1807
VonBert_K_Fem_GP_1	3	0.05	0.99	0.4000	0.4535	0.0207	0.4275	0.0208
CV_young_Fem_GP_1	3	0.05	0.3	0.1400	0.1591	0.0064	0.1542	0.0062
CV_old_Fem_GP_1	3	0.01	0.1	0.0500	0.0533	0.0025	0.0528	0.0027
Wtlen_1_Fem	-3	-3	3	0.0000	0.0000	_	0.0000	_
Wtlen_2_Fem	-3	-3	5	2.9483	2.9483	_	2.9483	_
Mat50%_Fem	-3	9	19	15.8800	15.8800	_	15.8800	_
Mat_slope_Fem	-3	-20	3	-0.9046	-0.9046	_	-0.9046	_
Eggs/kg_inter_Fem	-3	0	10	1.0000	1.0000	_	1.0000	_
Eggs/kg_slope_wt_Fem	-3	-1	5	0.0000	0.0000	_	0.0000	_
SR_LN(R0)	1	3	25	16.0000	15.6435	0.1235	15.6047	0.1614
SR_Ricker	6	0.2	4	2.5000	2.7851	0.6822	3.8917	0.6127
SR_sigmaR	-3	0	2	0.8595	0.7270	_	0.8900	_
SR_R1_offset	2	-15	15	0.0000	-1.2527	0.2345	-1.6447	0.2781
Early_InitAge_6	_	_	_	_	-0.8059	0.5421	-0.9150	0.6420
Early_InitAge_5	_	_	_	_	-0.8178	0.5304	-0.8885	0.6311
Early_InitAge_4	_	_	_	_	-0.7529	0.5339	-0.8000	0.6424
Early_InitAge_3	_	_	_	_	0.2814	0.3889	0.5584	0.4096
Early_InitAge_2	_	_	_	_	0.9744	0.2711	1.2557	0.2994
Early_InitAge_1	_	_	_	_	1.6596	0.2245	2.0101	0.2614
Main_RecrDev_1993	_	_	_	_	0.0677	0.3777	-0.6822	0.3283
Main_RecrDev_1994	_	_	_	_	-0.5934	0.2749	-1.2356	0.2290
Main_RecrDev_1995	_	_	_	_	-0.0763	0.1924	-0.6186	0.1644
Main_RecrDev_1996	_	_	_	_	0.7931	0.1563	0.3176	0.1427
Main_RecrDev_1997	_	_	_	_	0.7077	0.1476	0.2265	0.1219
Main_RecrDev_1998	_	_	_	_	-0.4282	0.1695	-0.7850	0.1789
Main_RecrDev_1999	_	_	_	_	-0.2932	0.2456	-0.4841	0.2760
Main_RecrDev_2000	_	_	_	_	0.2425	0.2011	0.0344	0.2252
Main_RecrDev_2001	_	_	_	_	-1.4505	0.1896	-1.8015	0.1913
Main_RecrDev_2002	_	_	_	_	0.9937	0.1734	0.5621	0.1591
Main_RecrDev_2003	_	_	_	_	-0.2141	0.2824	-0.6974	0.2815
Main_RecrDev_2004	_	_	_	_	0.7746	0.1432	0.5619	0.1637
Main_RecrDev_2005	_	_	_	_	0.0852	0.1342	0.1905	0.1482
Main_RecrDev_2006	_	_	_	_	0.7270	0.2499	1.2794	0.2113
Main_RecrDev_2007	_	_	_	_	0.1371	0.3220	0.9953	0.2649
Main_RecrDev_2008	_	_	_	_	0.7787	0.2952	1.8684	0.2117
Main_RecrDev_2009	_	_	_	_	-0.8785	0.2954	0.2684	0.2363
Main_RecrDev_2010	_	_	_	_	-1.3731	0.3487	_	_
Q_base_4_DEPM	5	-3	3	-1.3900	-1.7934	0.2763	-1.8314	0.3230
Q_base_5_TEP	5	-3	3	-0.6900	-0.6182	0.2554	-0.4305	0.2718
Q_base_6_TEP_full	5	-3	3	-0.6900	-0.6896	4921.5600	-0.6897	4921.5300
Q_base_7_Aerial	5	-3	3	0.0000	-0.0811	0.4355	-0.3482	0.4689
Q_base_8_Acoustic	-5	-3	3	0.0000	0.0000	_	0.0000	_

Table 9 (cont'd). Parameters and asymptotic standard deviations for models X6e and X6h.

					X6e (Proposed Update)		X6h (Strict Update)	
Parameter	Phase	Min	Max	Initial Value	Final Value	Std Dev	Final Value	Std Dev
SizeSel_1P_1_MexCal_S1	4	10	28	18.0000	18.8749	0.3525	19.0318	0.3678
SizeSel_1P_2_MexCal_S1	4	-5	3	3.0000	-3.2153	1.5193	-3.2169	1.5618
SizeSel_1P_3_MexCal_S1	4	-1	9	2.5000	2.3622	0.1459	2.3816	0.1435
SizeSel_1P_4_MexCal_S1	4	-1	9	4.0000	1.1244	0.4762	1.0574	0.5039
SizeSel_1P_5_MexCal_S1	-4	-10	10	-10.0000	-10.0000	_	-10.0000	_
SizeSel_1P_6_MexCal_S1	4	-10	10	10.0000	-4.9898	4.0663	-4.7099	3.5826
SizeSel_1P_1_MexCal_S1_BLK1repl_1999	4	10	28	18.0000	16.7351	0.1344	16.8495	0.1342
SizeSel_1P_2_MexCal_S1_BLK1repl_1999	-4	-5	3	-5.0000	-5.0000	_	-5.0000	_
SizeSel_1P_3_MexCal_S1_BLK1repl_1999	4	-1	9	2.5000	2.0874	0.0809	2.1208	0.0777
SizeSel_1P_4_MexCal_S1_BLK1repl_1999	4	-1	9	4.0000	1.6027	0.1328	1.6058	0.1416
SizeSel_1P_5_MexCal_S1_BLK1repl_1999	-4	-10	10	-10.0000	-10.0000	_	-10.0000	_
SizeSel_1P_6_MexCal_S1_BLK1repl_1999	4	-10	10	10.0000	-3.5588	0.3801	-3.3025	0.3905
SizeSel_2P_1_MexCal_S2	4	10	28	18.0000	16.3789	0.2361	16.4983	0.2500
SizeSel_2P_2_MexCal_S2	-4	-5	3	-4.9000	-4.9000	_	-4.9000	_
SizeSel_2P_3_MexCal_S2	4	-1	9	2.5000	1.7717	0.1511	1.8174	0.1516
SizeSel_2P_4_MexCal_S2	4	-1	9	4.0000	2.3041	0.2638	2.3318	0.2991
SizeSel_2P_5_MexCal_S2	-4	-10	10	-10.0000	-10.0000	_	-10.0000	_
SizeSel_2P_6_MexCal_S2	4	-10	10	10.0000	-2.3217	0.6494	-2.0878	0.6879
SizeSel_2P_1_MexCal_S2_BLK1repl_1999	4	10	28	18.0000	14.9456	0.1437	15.0525	0.1514
SizeSel_2P_2_MexCal_S2_BLK1repl_1999	-4	-5	3	-5.0000	-5.0000	_	-5.0000	_
SizeSel_2P_3_MexCal_S2_BLK1repl_1999	4	-1	9	2.5000	1.5236	0.1202	1.5845	0.1224
SizeSel_2P_4_MexCal_S2_BLK1repl_1999	4	-1	9	4.0000	2.2826	0.1212	2.3061	0.1367
SizeSel_2P_5_MexCal_S2_BLK1repl_1999	-4	-10	10	-10.0000	-10.0000	_	-10.0000	_
SizeSel_2P_6_MexCal_S2_BLK1repl_1999	4	-10	10	10.0000	-3.1325	0.3077	-2.8166	0.3215
SizeSel_3P_1_PacNW	4	10	28	18.0000	19.0048	0.2102	19.3382	0.2336
SizeSel_3P_2_PacNW	4	1	16	4.0000	2.4379	0.2262	2.5497	0.2224
SizeSel_7P_1_Aerial	4	10	28	18.0000	20.6811	0.3873	20.8118	0.3725
SizeSel_7P_2_Aerial	4	-5	3	3.0000	-4.9261	2.2396	-4.9028	2.8981
SizeSel_7P_3_Aerial	4	-1	9	2.5000	0.6824	0.4689	0.7251	0.4296
SizeSel_7P_4_Aerial	4	-1	9	4.0000	0.6204	0.7442	0.5587	0.7939
SizeSel_7P_5_Aerial	-4	-10	10	-10.0000	-10.0000	_	-10.0000	_
SizeSel_7P_6_Aerial	4	-10	10	10.0000	-2.9012	1.7414	-2.7426	1.7536
SizeSel_8P_1_Acoustic	4	10	28	18.0000	22.6937	0.7723	23.6833	1.0244
SizeSel_8P_2_Acoustic	-4	-5	3	3.0000	3.0000	_	3.0000	_
SizeSel_8P_3_Acoustic	4	-1	9	2.5000	3.2065	0.2388	3.2783	0.2734
SizeSel_8P_4_Acoustic	-4	-1	9	4.0000	4.0000	_	4.0000	_
SizeSel_8P_5_Acoustic	-4	-10	10	-10.0000	-10.0000	_	-10.0000	_
SizeSel_8P_6_Acoustic	-4	-10	10	10.0000	10.0000	_	10.0000	_

Table 10. Likelihood components and variance adjustments for model X6e.

COMPONENT	-log(L)	MexCal_S1	MexCal_S2	PacNW	DEPM	TEP	Aerial	ATM
Catch	2.50E-08	1.81E-15	1.89E-15	2.50E-08	---	---	---	---
Survey	0.32633	---	---	---	0.76879	-0.03804	1.20566	-1.61008
Length comp	1154.580	399.335	329.262	219.131	---	---	25.245	181.611
Age comp	765.245	279.312	234.644	199.385	---	---	---	51.904
Recruitment	14.431							
Parm softbounds	0.00890186							
TOTAL	1934.59							

INPUT VARIANCE ADJUSTMENTS	MexCal_S1	MexCal_S2	PacNW	DEPM	TEP	Aerial	Acoustic
Index_extra_CV	0.0000	0.0000	0.0000	0.4045	0.3480	0.3495	0.2219
effN_mult_Lencomp	1.8610	1.7230	0.6028	1.0000	1.0000	1.0000	3.1979
effN_mult_Agecomp	0.8000	0.8000	0.2500	1.0000	1.0000	1.0000	0.2500

Table 11. Derived SSB (mt) and recruits (year-class abundance, billions of age-0 fish) for model X6e. SSB estimates are calculated at the beginning of Season 2 of each model year, e.g. the 2012 value is SSB January 2013. Recruits are age-0 fish calculated at the beginning of each model year (July).

Model year	SSB (mt)	SSB Std Dev	Year class abundance (billions)	Recruits Std Dev
Virgin	945,899	119,452	6.222	0.768
1993	388,245	78,100	1.778	0.485
1994	551,312	102,844	11.511	1.611
1995	711,856	125,516	5.047	0.820
1996	791,590	133,290	6.813	1.017
1997	763,310	129,065	14.289	1.845
1998	874,376	135,624	13.749	1.556
1999	1,039,870	148,053	3.647	0.525
2000	996,883	142,069	3.050	0.423
2001	810,236	120,420	5.669	0.607
2002	632,173	99,976	1.469	0.289
2003	488,308	83,379	22.302	2.359
2004	651,419	99,112	7.863	1.054
2005	837,694	122,477	17.443	1.894
2006	1,010,840	139,967	6.505	0.931
2007	1,047,250	146,350	8.956	1.232
2008	974,298	142,150	4.621	0.836
2009	857,618	134,408	10.123	1.687
2010	785,170	135,020	2.396	0.568
2011	667,141	133,182	1.655	0.494
2012	435,351	118,835	---	---

Table 12. Pacific sardine biomass and population numbers-at-age (1,000s) by model year and semester for model X6e.

		BIOMASS (mt)			POPULATION NUMBERS-AT-AGE (1,000s of fish)										
Model year	Sem	Total (0+)	Age 1+	SSB	0 (R)	1	2	3	4	5	6	7	8	9	10+
VIRG	1	1,197,300	1,135,810	---	6,221,630	4,170,480	2,795,560	1,873,920	1,256,130	842,006	564,414	378,338	253,607	169,998	345,648
VIRG	2	1,175,590	1,067,760	945,899	5,093,840	3,414,500	2,288,810	1,534,240	1,028,430	689,376	462,103	309,757	207,636	139,183	282,993
INIT	1	342,122	324,550	---	1,777,790	1,191,690	798,814	535,461	358,930	240,598	161,278	108,108	72,467	48,576	98,767
INIT	2	335,917	305,106	270,285	1,455,530	975,674	654,014	438,398	293,867	196,985	132,043	88,511	59,331	39,771	80,863
1993	1	585,273	507,320	---	7,886,320	5,286,360	1,847,640	640,715	157,944	102,650	72,044	108,108	72,467	48,576	98,767
1993	2	649,205	512,551	388,245	6,455,680	4,251,030	1,438,680	497,427	124,287	81,810	57,884	87,263	58,648	39,373	80,176
1994	1	805,540	691,760	---	11,510,900	5,248,140	3,376,470	1,146,740	400,403	100,634	66,431	47,068	71,009	47,743	97,356
1994	2	888,287	688,818	551,312	9,423,140	4,241,270	2,665,770	903,431	318,545	80,802	53,652	38,142	57,652	38,805	79,217
1995	1	965,141	915,256	---	5,046,750	7,574,760	3,210,230	2,036,240	707,862	253,413	64,758	43,155	30,737	46,506	95,298
1995	2	994,010	906,558	711,856	4,131,320	6,105,730	2,516,260	1,591,940	559,922	202,676	52,158	34,898	24,912	37,743	77,443
1996	1	1,044,380	977,035	---	6,812,670	3,346,110	4,773,170	1,977,700	1,270,090	450,735	163,866	42,260	28,306	20,219	93,540
1996	2	1,027,940	909,888	791,590	5,576,760	2,689,010	3,709,840	1,532,430	997,993	358,875	131,569	34,094	22,899	16,382	75,910
1997	1	1,140,160	998,922	---	14,289,100	4,522,420	2,113,290	2,929,390	1,226,160	804,884	290,551	106,721	27,682	18,602	75,016
1997	2	1,120,450	872,910	763,310	11,693,800	3,536,260	1,521,680	2,093,410	907,014	615,088	226,684	84,255	22,002	14,843	60,110
1998	1	1,269,970	1,134,060	---	13,749,400	9,421,060	2,702,300	1,172,180	1,649,030	724,087	494,240	182,726	68,027	17,780	60,630
1998	2	1,330,240	1,092,000	874,376	11,254,600	7,538,010	2,074,490	896,197	1,282,470	572,318	394,696	146,787	54,831	14,359	49,071
1999	1	1,369,360	1,333,310	---	3,647,320	9,044,510	5,698,750	1,582,850	701,665	1,019,690	458,479	317,349	118,245	44,215	51,206
1999	2	1,347,510	1,284,360	1,039,870	2,983,330	7,098,220	4,399,130	1,251,550	564,673	826,816	372,860	258,407	96,339	36,035	41,744
2000	1	1,276,440	1,246,290	---	3,049,780	2,327,520	5,233,750	3,393,010	996,149	454,997	669,278	302,381	209,743	78,230	63,183
2000	2	1,154,980	1,102,200	996,883	2,493,340	1,786,080	3,897,410	2,602,560	781,648	360,503	532,289	240,868	167,196	62,384	50,400
2001	1	1,088,790	1,032,760	---	5,669,170	1,930,530	1,295,020	2,974,520	2,058,460	626,875	290,613	430,000	194,769	135,263	91,278
2001	2	964,916	866,902	810,236	4,630,320	1,418,600	905,815	2,188,520	1,574,230	487,386	227,406	337,380	153,006	106,326	71,786
2002	1	883,049	868,532	---	1,468,610	3,515,830	985,731	674,357	1,709,410	1,252,740	390,544	182,737	271,460	123,192	143,475
2002	2	733,949	708,590	632,173	1,197,970	2,439,090	631,992	464,897	1,246,670	935,826	294,482	138,324	205,850	93,501	108,968
2003	1	854,528	634,081	---	22,302,200	900,511	1,658,940	465,507	362,030	992,159	750,821	237,048	111,515	166,083	163,453
2003	2	885,642	500,300	488,308	18,203,900	642,464	1,099,520	323,721	261,889	729,878	555,918	175,978	82,886	123,518	121,618
2004	1	1,054,710	976,986	---	7,863,300	14,440,400	490,752	863,086	258,919	210,968	589,511	449,486	142,356	67,066	198,388
2004	2	1,076,280	940,223	651,419	6,427,430	10,955,900	350,264	613,480	184,674	150,684	421,193	321,155	101,709	47,915	141,729
2005	1	1,280,190	1,107,780	---	17,442,500	5,156,830	8,581,710	279,366	495,472	149,873	122,507	342,680	261,377	82,791	154,393
2005	2	1,305,540	1,003,630	837,694	14,262,800	3,980,280	6,293,550	203,051	359,839	108,802	88,903	248,620	189,602	60,050	111,973
2006	1	1,430,280	1,365,980	---	6,504,580	11,411,200	3,099,710	5,008,030	164,028	292,401	88,605	72,465	202,733	154,640	140,329
2006	2	1,393,330	1,280,750	1,010,840	5,318,320	8,782,450	2,291,220	3,741,190	123,907	221,924	67,366	55,131	154,284	117,700	106,819
2007	1	1,445,390	1,356,860	---	8,956,330	4,233,280	6,764,060	1,811,910	3,013,730	100,538	180,554	54,868	44,926	125,757	183,043
2007	2	1,349,220	1,194,230	1,047,250	7,321,700	3,233,880	4,950,250	1,346,650	2,272,820	76,293	137,331	41,772	34,216	95,797	139,457
2008	1	1,332,440	1,286,760	---	4,621,300	5,757,390	2,425,720	3,856,420	1,077,220	1,837,000	61,901	111,602	33,970	27,836	191,446
2008	2	1,199,830	1,119,900	974,298	3,775,980	4,303,520	1,728,230	2,839,430	814,645	1,405,150	47,558	85,896	26,167	21,451	147,580
2009	1	1,206,240	1,106,180	---	10,123,300	2,953,330	3,190,680	1,337,480	2,264,330	657,306	1,138,730	38,609	69,792	21,270	137,452
2009	2	1,118,950	943,793	857,618	8,274,510	2,241,660	2,315,750	990,319	1,706,750	499,220	867,340	29,442	53,247	16,232	104,919
2010	1	1,100,900	1,077,220	---	2,395,640	6,518,600	1,687,770	1,806,380	791,770	1,377,710	404,413	703,646	23,901	43,241	98,420
2010	2	976,323	934,882	785,170	1,957,700	4,897,010	1,200,640	1,307,350	582,851	1,021,520	300,662	523,677	17,796	32,203	73,313
2011	1	914,513	898,150	---	1,655,440	1,542,840	3,690,930	937,893	1,047,110	471,421	829,238	244,432	426,031	14,483	85,900
2011	2	759,325	730,713	667,141	1,351,640	1,115,670	2,500,570	664,808	769,969	352,111	623,112	184,128	321,285	10,928	64,852
2012	1	758,096	659,539	---	9,970,800	1,032,190	784,295	1,868,970	518,380	610,221	280,735	498,016	147,327	257,218	60,705
2012	2	626,521	454,683	435,351	8,117,810	655,552	431,552	1,110,970	329,138	398,477	185,295	330,138	97,855	171,010	40,399

Table 13. Pacific sardine harvest control rules for the 2013 management year based on stock biomass estimated in model X6e.

Harvest Formula Parameters	Value			
BIOMASS (ages 1+, mt)	659,539			
P^* (probability of overfishing)	0.45	0.40	0.30	0.20
$BUFFER_{P^*}$ (Sigma=0.36)	0.95577	0.91283	0.82797	0.73861
F_{MSY} (stochastic, SST-independent)	0.18			
FRACTION	0.15			
CUTOFF (mt)	150,000			
DISTRIBUTION (U.S.)	0.87			

Amendment 13 Harvest Formulas	MT
OFL = BIOMASS * F_{MSY} * DISTRIBUTION	103,284
$ABC_{0.45}$ = BIOMASS * $BUFFER_{0.45}$ * F_{MSY} * DISTRIBUTION	98,716
$ABC_{0.40}$ = BIOMASS * $BUFFER_{0.40}$ * F_{MSY} * DISTRIBUTION	94,281
$ABC_{0.30}$ = BIOMASS * $BUFFER_{0.30}$ * F_{MSY} * DISTRIBUTION	85,515
$ABC_{0.20}$ = BIOMASS * $BUFFER_{0.20}$ * F_{MSY} * DISTRIBUTION	76,287
HG = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION	66,495