

Regional Trends in Adult and Juvenile western Steller sea lion counts, 2000-2008

AFSC examined regional trends in Steller sea lion adult and juvenile (non-pup) counts (at the 161 trend sites routinely surveyed since 1991) in the 2000s at three different spatial scales within the range of the western stock in AK:

- 1) Ten rookery cluster areas (RCAs) as defined for the fishery-sea lion-oceanographic analysis (labelled 1-10 from west to east)
- 2) Six NMML-defined sea lion areas that are also used in the Recovery Plan (eastern, central and western Gulf of Alaska (GOA) and Aleutian Islands (AI) areas) and
- 3) Three NMFS fishery management areas in the Aleutian Islands (543, 542, and 541).

The *general* relationship between RCAs, recovery plan areas and the three Aleutian fishery management areas is shown in the following diagram:

RCA	1	2	3	4	5	6	7	8	9	10
NMML	WAI	CAI			EAI	WGOA	CGOA		EGOA	
NMFS	543	542		541						

AFSC examined sea lion counts using three different methods:

- 1) A series of geometric Brownian motion (GDM) models were fit to each stock. This model allows for movement between areas and takes into account covariance between areas and within an area between years. The model was originally fit to all data collected 1991-2008 with separate decadal growth rates estimated, but all variance components are estimated using the entire time series. This analysis was done by D. Johnson (“An analysis of Steller sea lion population trends in the Western and Asian stocks in the 1990s and 2000s”).
- 2) Linear regression of the natural log of the count on the year. Growth rate is the slope of the line with 95% confidence bounds. This analysis was done by L. Fritz.
- 3) A model estimating abundance over time was defined simply to relate observed counts by area and rookery versus non-rookery sites. Variance estimates of annual abundances were derived via the Delta method (asymptotic approximations using ADModel Builder) and by running a Monte-Carlo Markov Chain to provide posterior marginal distributions of these quantities. This analysis was done by J. Ianelli (“Examining trend data in SSL counts by rookeries and haulouts”).

Results of the three analyses are shown in Table 1 & Figure 1 (RCAs), Table 2 & Figure 2 (NMML Recovery Plan areas), and Table 3 & Figure 3 (Aleutian fishery management areas).

All three methods reveal the same spatial trends in the non-pup count data:

- 1) For the RCA area data, relatively steep population decline in RCA 1 (-7 to -9% per year) and a gradually increasing trend to the east through RCA 7, with all three methods showing a decline in RCA 4 relative to this gradually increasing trend. Similarly, all three methods estimated that the non-pup counts have been stable in the 2000s in RCAs 8-9, while to the east (RCA 10) and west (RCA 7), non-pup counts increased at between 4-5% per year.
- 2) For the NMML-Recovery Plan area data, there was a gradual increase in the population trend from the western Aleutian Islands eastward through the western Gulf of Alaska, the

central Gulf of Alaska was estimated to be stable, and the eastern Gulf of Alaska was estimated to be increasing at approximately 5% per year.

- 3) For the NMFS Aleutian fishery management areas, there was a gradual increase in population trend from a steeply declining population in 543 to a stable population in 541 that resulted from each method.
- 4) **Estimated overall western DPS population rates of change for the three methods are as follows:**
 - a. Johnson: 1.5% per year (90% CI: -0.3%, 3.3%)
 - b. Fritz: 1.4% per year (95% CI: -0.7%, 3.4%)
 - c. Ianelli: “Results of overall trend indicate a modest but uncertain increase over the period 2000-2010 given the available data”. Ianelli’s Figure 1 from his report shows a slight increasing trend in overall numbers from 2000-2010 (starting at just over 25,000), but confidence bounds in 2010 span the initial starting value.

Each method uses a different approach to estimate trends at each of the examined spatial scales, each has their advantages and disadvantages, and each has, by and large, yielded the same overall conclusion. Johnson’s method likely best estimates variance since it captures both the potential for movement between areas and covariance between/within areas.

Table 1. Population trend estimated for each RCA by the three methods.

	Johnson 90% CI		
	Median	90th	10th
RCA_1	-7.19%	-2.75%	-11.43%
RCA_2	-4.43%	0.15%	-8.79%
RCA_3	-1.00%	3.74%	-5.52%
RCA_4	-3.48%	1.14%	-7.89%
RCA_5	1.96%	6.84%	-2.70%
RCA_6	3.38%	8.33%	-1.34%
RCA_7	4.74%	9.76%	-0.04%
RCA_8	0.00%	4.78%	-4.57%
RCA_9	-0.14%	4.64%	-4.70%
RCA_10	5.39%	10.43%	0.57%

	Fritz 95% CI		
	Mean	95th	5th
RCA_1	-6.62%	1.39%	-15.09%
RCA_2	-4.39%	-0.14%	-8.83%
RCA_3	-1.02%	1.67%	-3.72%
RCA_4	-3.47%	3.57%	-10.63%
RCA_5	1.63%	4.19%	-0.95%
RCA_6	3.66%	4.47%	2.73%
RCA_7	4.51%	6.87%	1.95%
RCA_8	-0.57%	7.64%	-8.79%
RCA_9	-0.44%	9.31%	-10.18%
RCA_10	3.77%	7.50%	-0.09%

	Ianelli 90% CI		
	Median	90th	10th
RCA_1	-9.00%	-6.30%	-12.62%
RCA_2	-6.76%	-3.95%	-10.50%
RCA_3	-2.77%	0.05%	-6.34%
RCA_4	-6.86%	-4.40%	-10.21%
RCA_5	0.42%	3.08%	-3.11%
RCA_6	2.69%	5.30%	-0.58%
RCA_7	4.64%	7.21%	1.31%
RCA_8	-0.99%	1.77%	-4.55%
RCA_9	-0.91%	1.74%	-4.22%
RCA_10	4.08%	6.69%	0.84%

Table 2. Population trend estimated for each NMML Recovery Plan area by the three methods.

Johnson 90% CI	Rate	-90%	+90%
WAI	-7.19%	-11.63%	-2.52%
CAI	-1.82%	-4.20%	0.62%
EAI	3.22%	-1.72%	8.41%
WGOA	4.30%	-0.69%	9.55%
CGOA	-0.14%	-3.54%	3.39%
EGOA	5.07%	0.04%	10.35%

Fritz 95% CI	Rate	-95%	+95%
WAI	-6.62%	-15.09%	1.39%
CAI	-1.46%	-6.03%	3.10%
EAI	3.23%	1.61%	4.75%
WGOA	4.09%	-0.54%	8.56%
CGOA	-0.08%	-5.84%	5.68%
EGOA	4.75%	1.93%	7.35%

Ianelli 95% CI	Rate	-95%	+95%
WAI	-8.75%	-11.74%	-5.75%
CAI	-2.67%	-5.61%	0.30%
EAI	2.53%	-0.23%	5.20%
WGOA	3.80%	1.01%	6.65%
CGOA	-0.35%	-3.27%	2.47%
EGOA	4.49%	2.11%	6.89%

Table 3. Population trend estimated for each Aleutian Island fishery management area by the three methods.

Johnson 90% CI

	Median	-90%	+90%
543	-6.83%	-11.50%	-1.91%
542	-2.33%	-5.83%	1.29%
541	-0.39%	-3.95%	3.31%

Fritz 95% CI

	Median	-95%	+95%
543	-6.62%	-15.09%	1.39%
542	-2.11%	-4.81%	0.54%
541	-1.02%	-9.12%	7.08%

Ianelli 95% CI

	Median	-95%	+95%
543	-8.95%	-12.16%	-5.84%
542	-4.44%	-7.69%	-1.08%
541	-2.02%	-5.12%	1.09%

Figure 1. Population trend estimated for each RCA by the three methods.

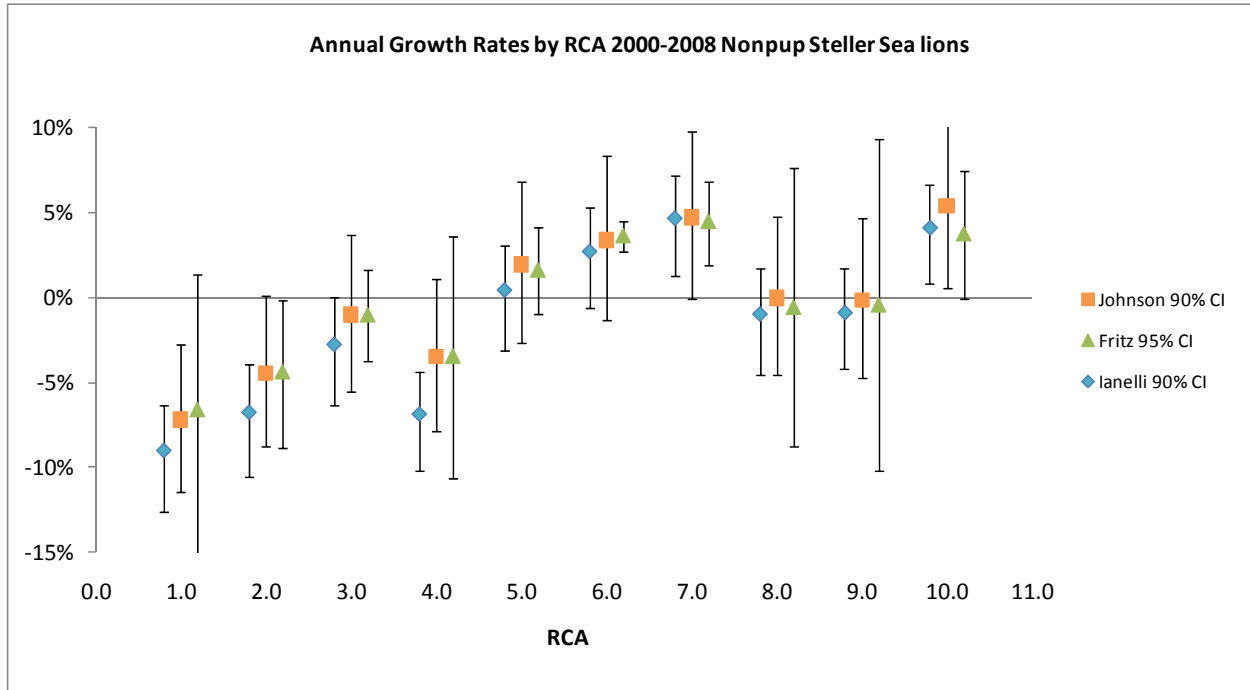


Figure 2. Population trend estimated for each NMML Recovery Plan area by the three methods.

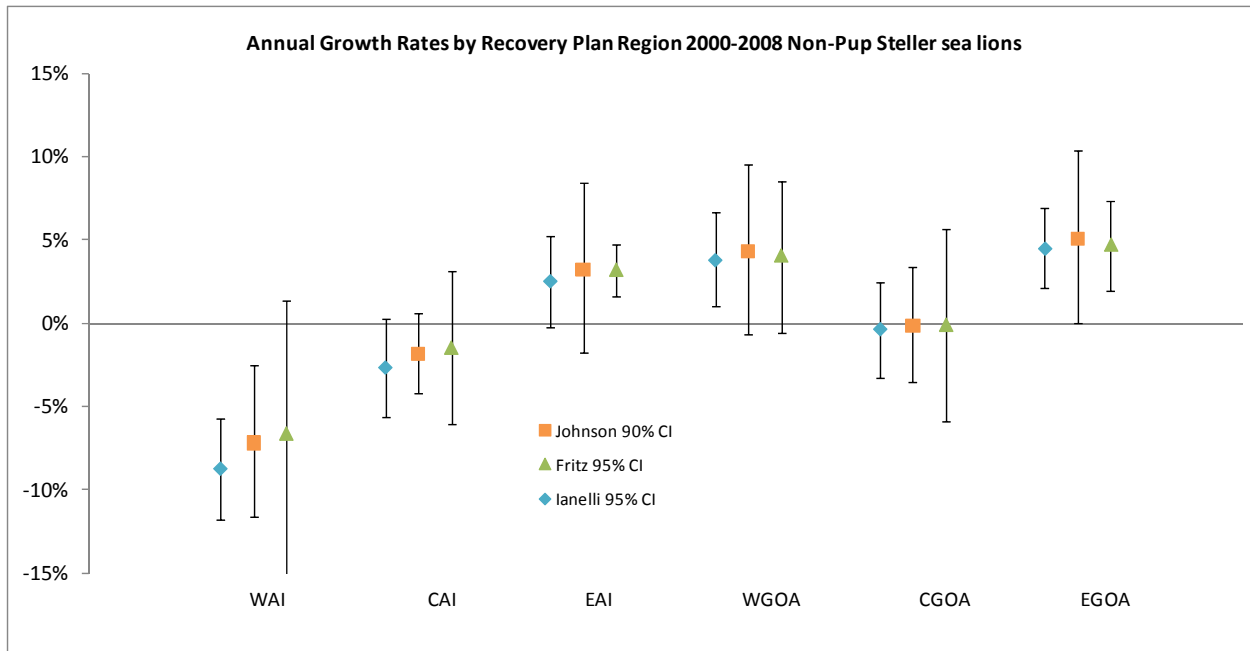


Figure 3. Population trend estimated for each Aleutian Island fishery management area by the three methods.

