Supplementary Information

Table S1: This table includes values of AIC and percent deviance explained for all models for each species and stage evaluated during parameterization. We selected bolded models for projections.

Species	Model	Deviance	AIC
Pollock Eggs	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J)$	45.8%	32383
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS)$	48.7%	32232
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(J, by = T)$	49.4%	32198
	$\boldsymbol{g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(\phi, \lambda, by = T)}$	**52.9%**	**32014**
Pollock Larvae	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J)$	30.3%	29076
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS)$	44.6%	28457
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(J, by = T)$	50.1%	28192
	$\boldsymbol{g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(\phi, \lambda, by = T)}$	**53.1%**	**28067**
Flathead Sole Eggs	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J)$	44.0%	12746
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS)$	47.5%	12654
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(J, by = T)$	49.8%	12596
	$\boldsymbol{g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(\phi, \lambda, by = T)}$	**52.9%**	**12528**
Flathead Sole Larvae	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J)$	40.1%	7172
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS)$	59.8%	6766
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(J, by = T)$	65.1%	6634
	$\boldsymbol{g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(\phi, \lambda, by = T)}$	**68.6%**	**6569**
Yellowfin Sole Larvae	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J)$	46.8%	8019
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS)$	50.6%	7962
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(J, by = T)$	52.6%	7927
	$\boldsymbol{g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(\phi, \lambda, by = T)}$	**56.5%**	**7863**
Alaska Plaice Eggs	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J)$	45.6%	11130
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS)$	64.1%	10583
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(J, by = T)$	64.9%	10547
	$\boldsymbol{g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(\phi, \lambda, by = T)}$	**68.8%**	**10428**
Alaska Plaice Larvae	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J)$	64.3%	3659
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS)$	70.7%	3547
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(J, by = T)$	74.5%	3479
	$\boldsymbol{g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(\phi, \lambda, by = T)}$	**76.7%**	**3447**
Northern Rock Sole Larvae	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J)$	42.4%	12245
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS)$	49.0%	12032
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(J, by = T)$	51.0%	11993
	$\boldsymbol{g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(\phi, \lambda, by = T)}$	**52.0%**	**11985**
Pacific Cod Larvae	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J)$	44.4%	4914
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS)$	49.5%	4867
	$\boldsymbol{g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(J, by = T)}$	**54.9%**	**4754**
	$g(CPUE) = re(y) + te(\phi, \lambda) + s_1(J) + s_2(SST) + s_3(SSS) + s_4(\phi, \lambda, by = T)$	51.4%	4826

Table S2: Values correspond to the difference in mean square error for varying coefficient models compared to the base model containing varying coefficient terms. Positive values indicate an improvement with the inclusion of a varying coefficient term.

Species	Stage	Phenology	Geography
Walleye Pollock	Eggs	0.03	0.06
	Larvae	0.11	0.12
Flathead Sole	Eggs	0.04	0.06
	Larvae	0.23	0.22
Alaska Plaice	Eggs	0.19	0.23
	Larvae	0.18	0.21
Yellowfin Sole	Larvae	0.05	0.09
Northern Rock Sole	Larvae	0.07	0.08
Pacific Cod	Larvae	0.11	0.07

Table S3: Distance in kilometers between the COG of eggs and larval distributions for a given species for each time period. The shortest distance between a species' COGs out of the four time periods is highlighted.

Species	Time Period	Distance (km)
Walleye pollock	Hindcast	110.9
	2015-2039	68.9
	2040-2069	23.1
	2070-2099	35.1
Flathead Sole	Hindcast	56.8
	2015-2039	36.8
	2040-2069	112.2
	2070-2099	178.6
Alaska Plaice	Hindcast	249.6
	2015-2039	208.7
	2040-2069	124.3
	2070-2099	67.9

Table S4: Results of t-tests for rate of change bias. Negative mean values indicate a lag or movement away from the thermal COG while positive values indicate no lag.

Stage	***P-value***	***Mean Δ (°N)***
Hindcast	0.52	0.003
2015-2039	0.04	-0.010
2040-2069	0.08	-0.018
2070-2099	0.02	-0.012

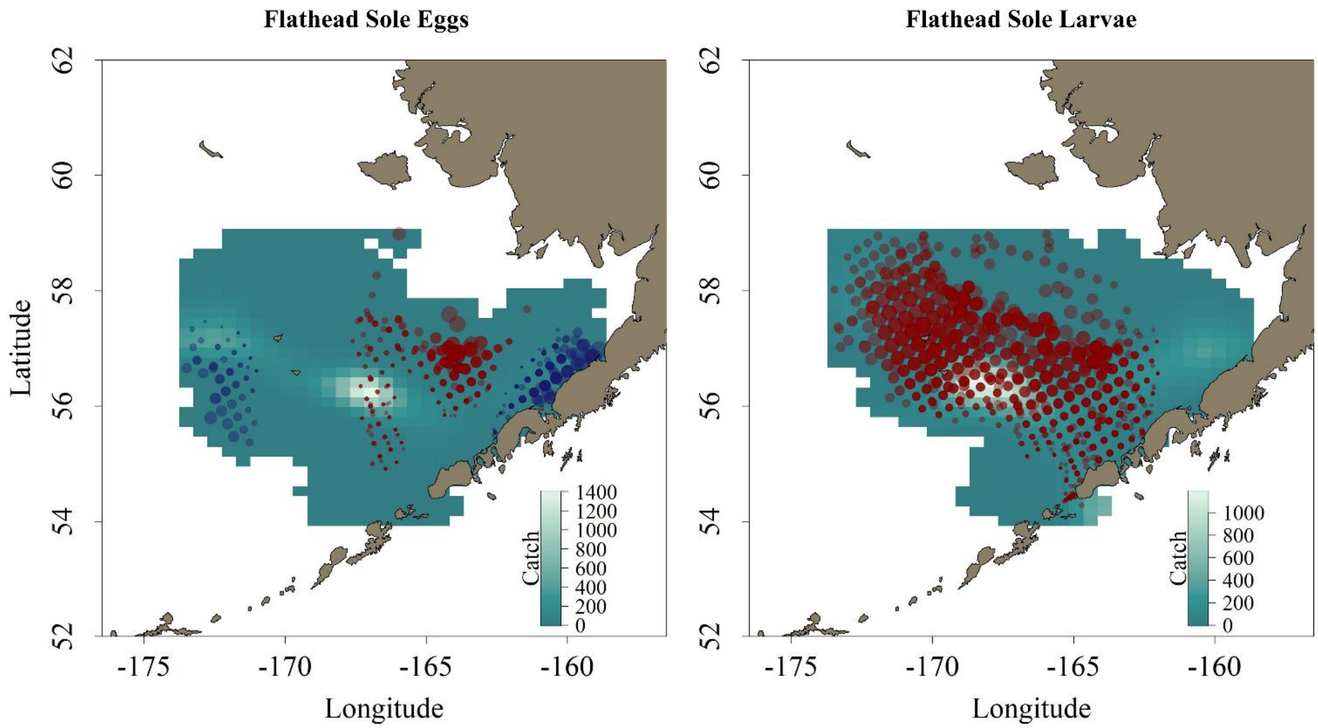

Figure S1: Maps of the effect of an increase in mean temperature on abundance of flathead sole eggs and larvae imposed over teal shading depicting their average predicted spatial distribution during the hindcast time period. Red bubbles indicate increases in abundance with an increase in temperature while blue bubbles indicate a decrease in abundance with a decrease in temperature. Bubble size indicates the magnitude of the effect of temperature. Areas without bubbles indicate no statistically significant change in abundance at that location with a change in temperature.

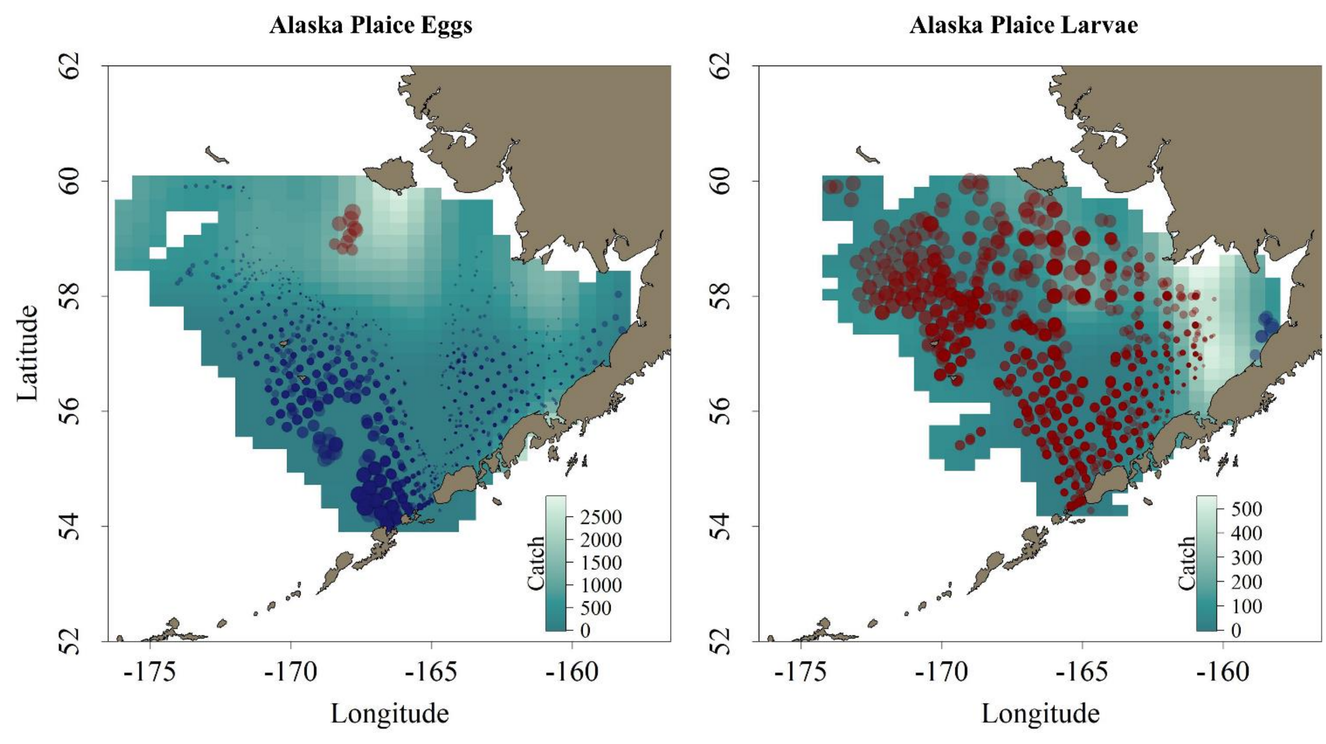

Figure S2: Same as Figure S1 for Alaska plaice.

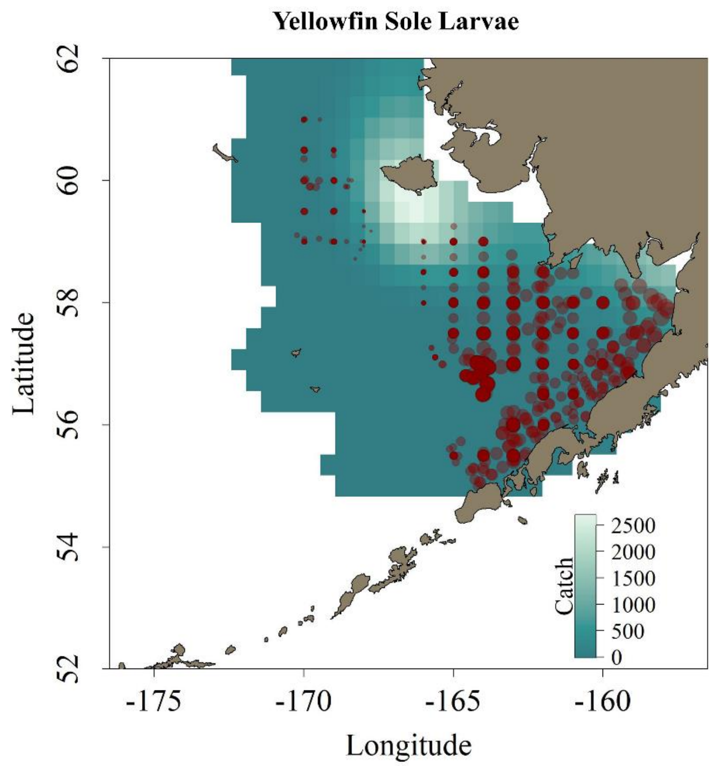

Figure S3: Same as Figure S1 for yellowfin sole.

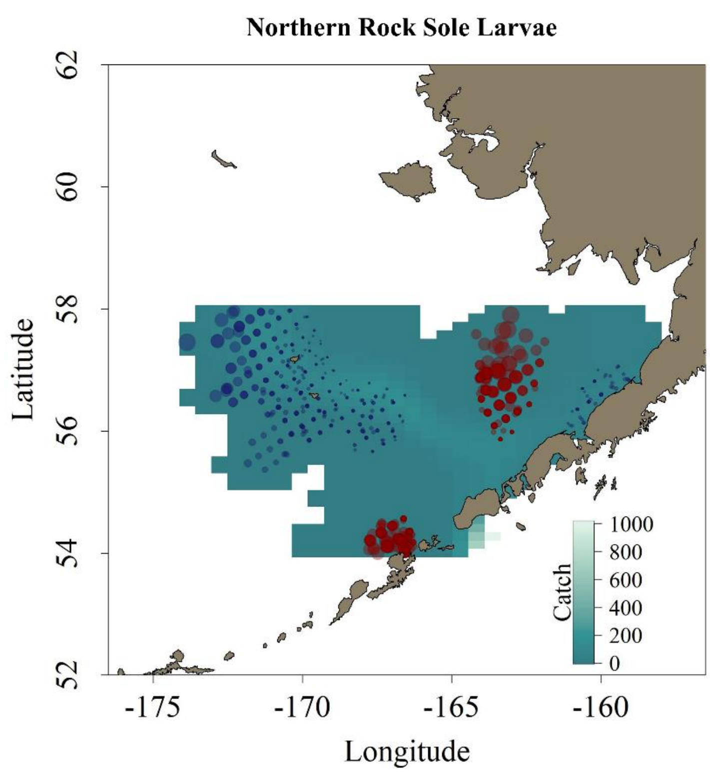

Figure S4: Same as Figure S1 for northern rock sole.

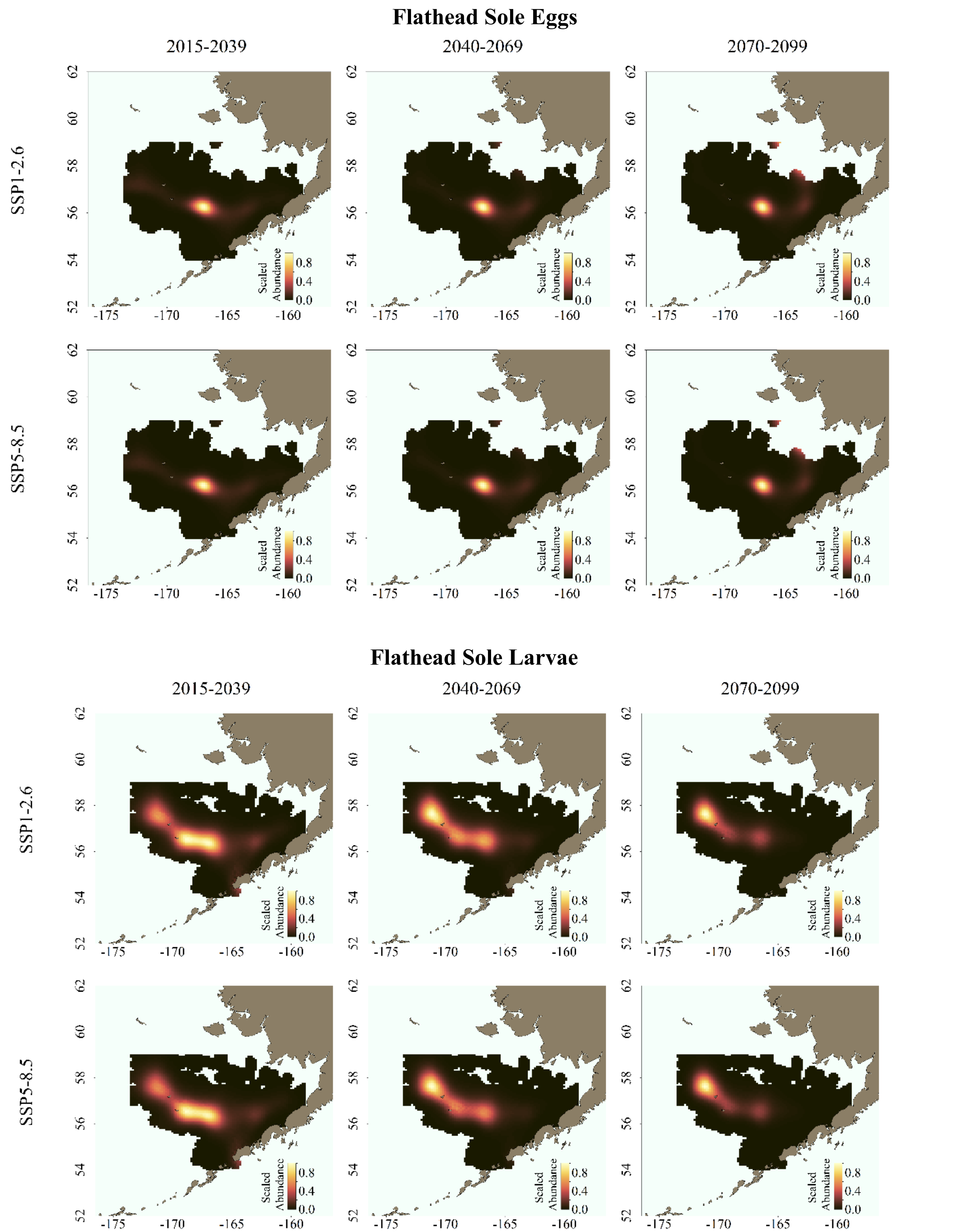

Figure S5: Maps of forecasted distributions of flathead sole eggs (top) and larvae (bottom) over the next century for three time periods for each SSP. Abundance is scaled from 0 to 1, with lighter colors indicating higher abundance. The projections using the three ESMs were averaged for each SSP and time period to create the final maps.

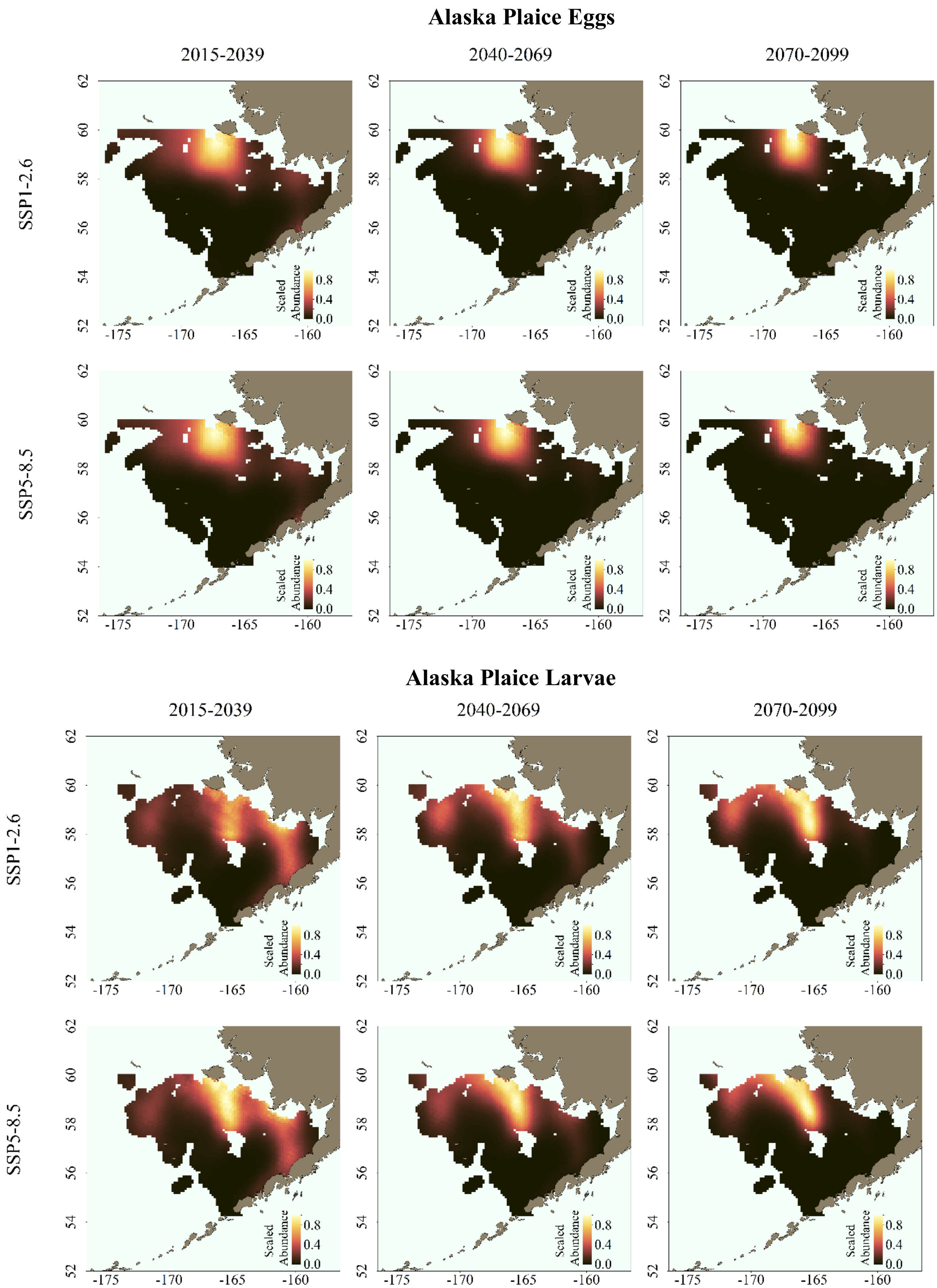

Figure S6: Same as Figure S5 but for Alaska plaice.

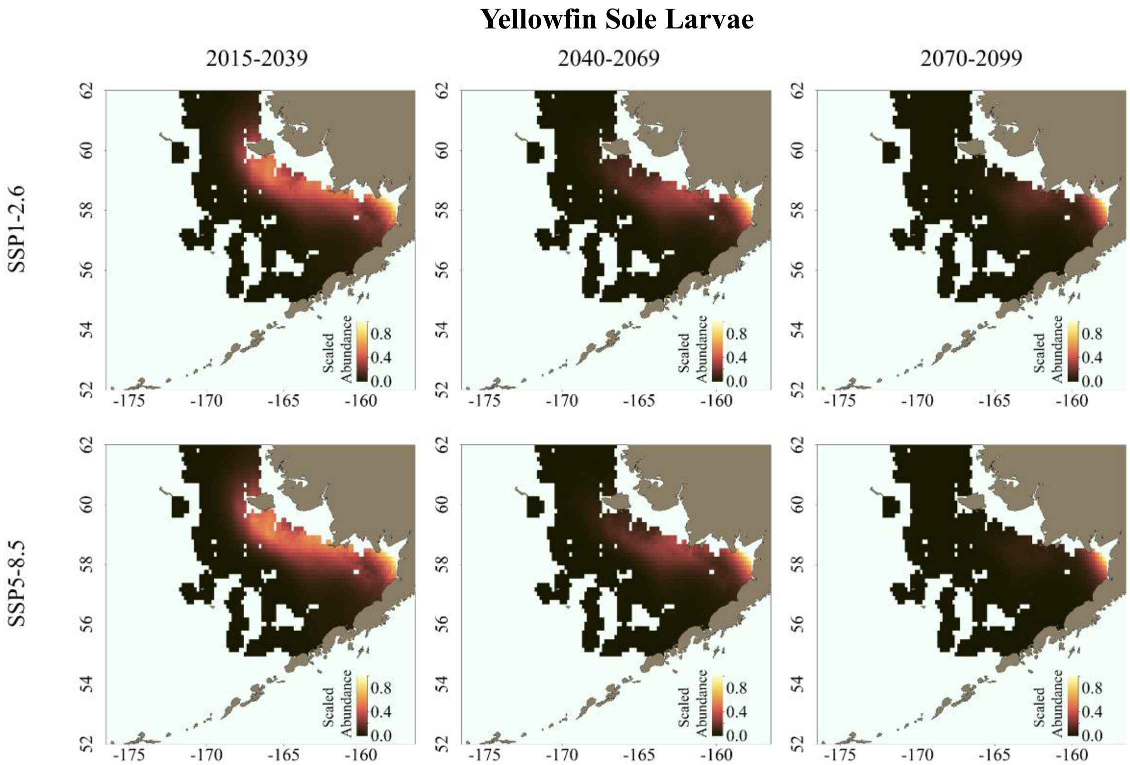

Figure S7: Same as Figure S5 but for yellowfin sole.

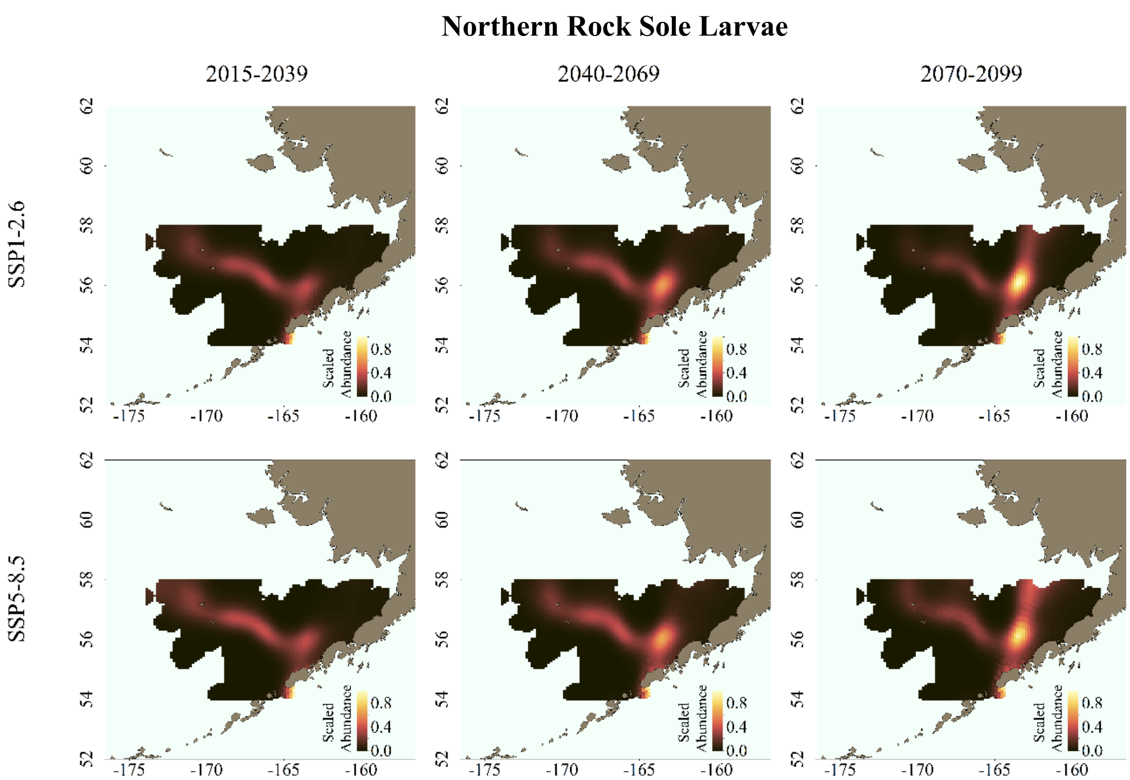

Figure S8: Same as Figure S5 but for northern rock sole.

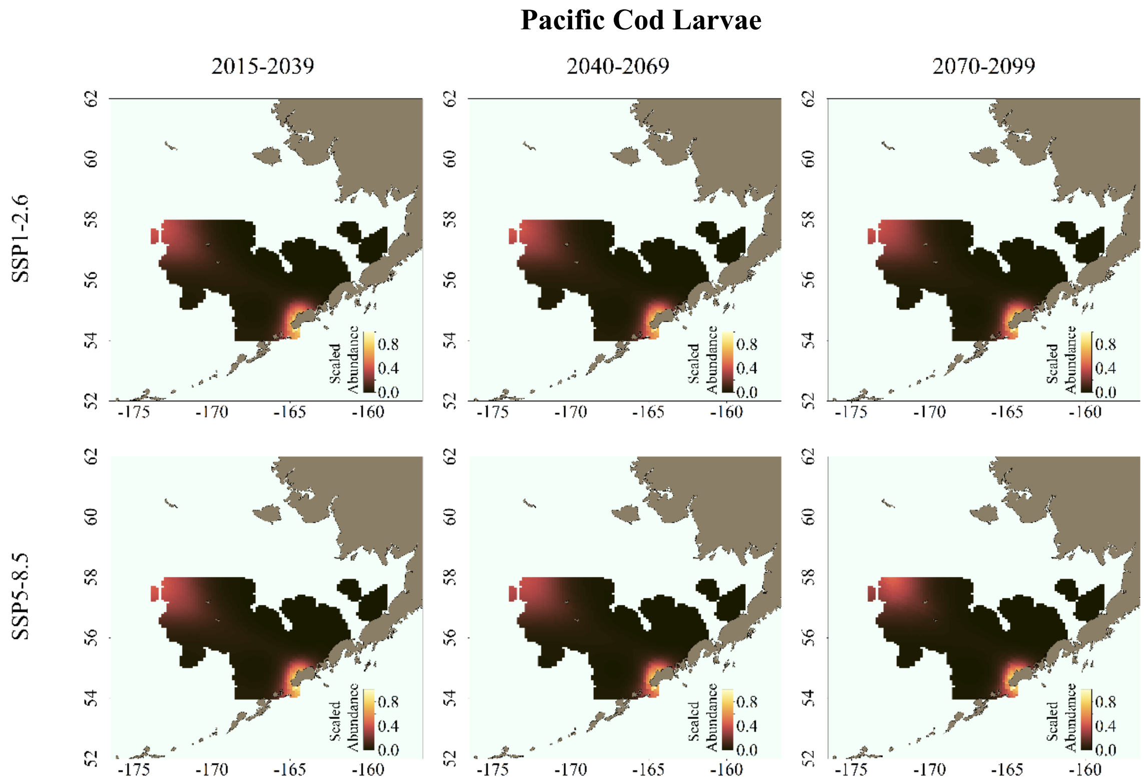

Figure S9: Same as Figure S5 but for Pacific cod.