

# Potential climate change impacts on crab in the Bering Sea

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AK Stock assessments:

Snow crab

Pribilof Island red king crab

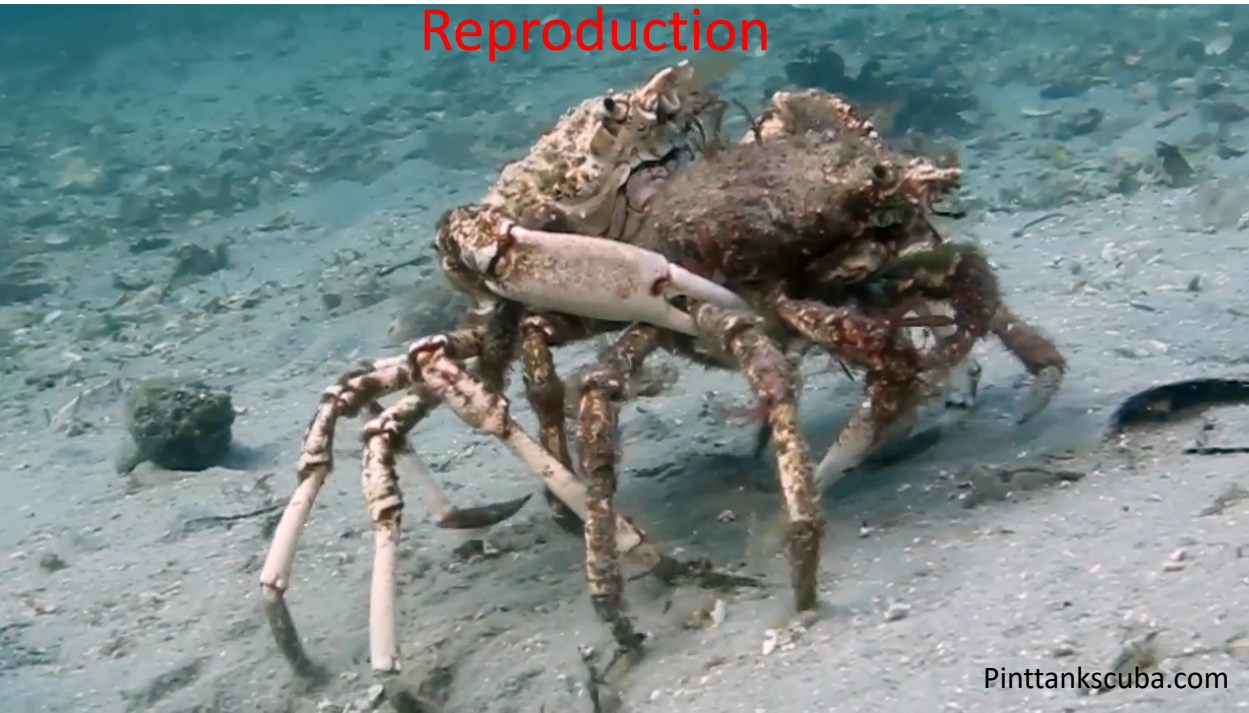


$$N_{t+1} = N_t + \textit{new} - \textit{death}$$

Natural mortality

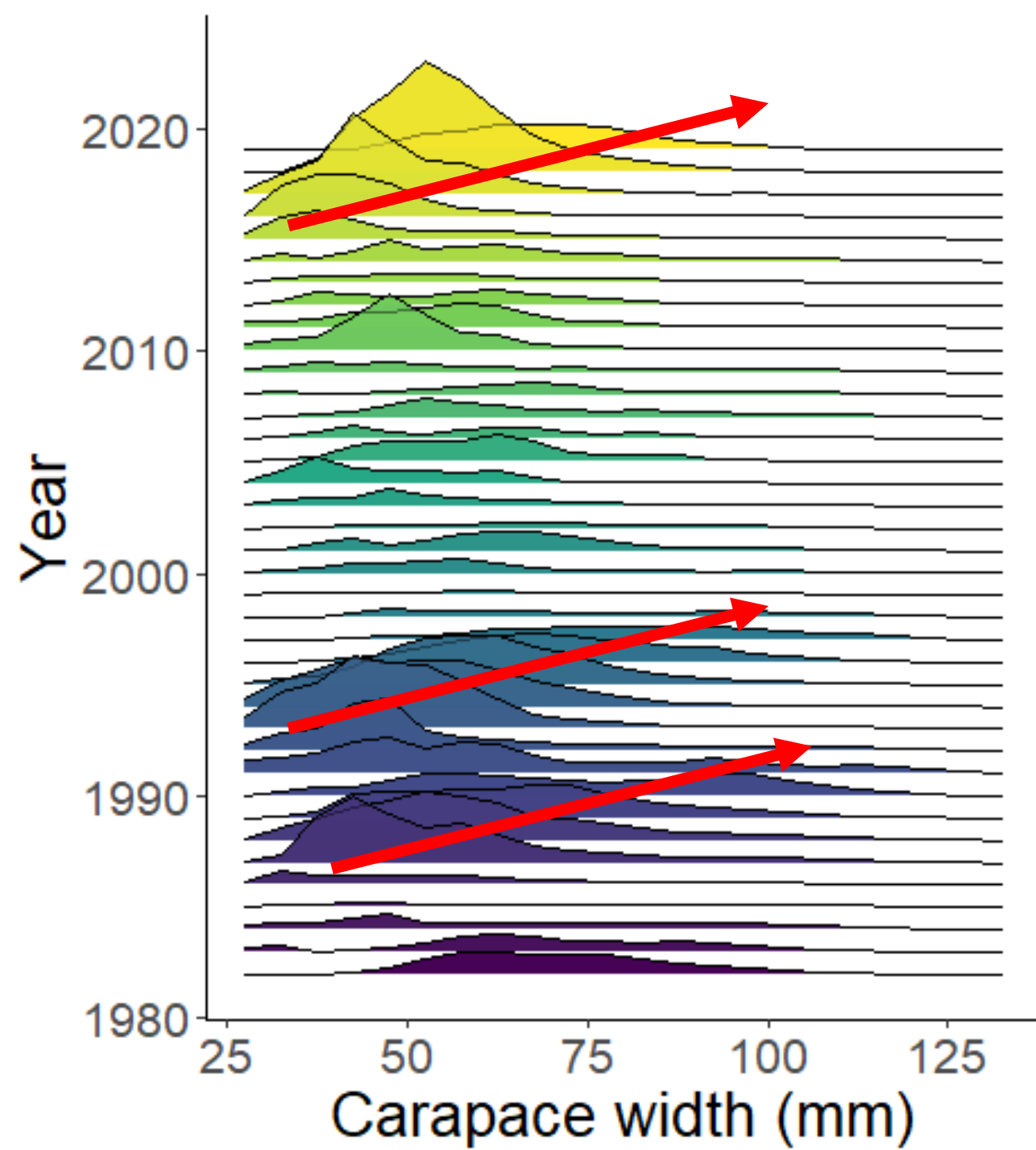


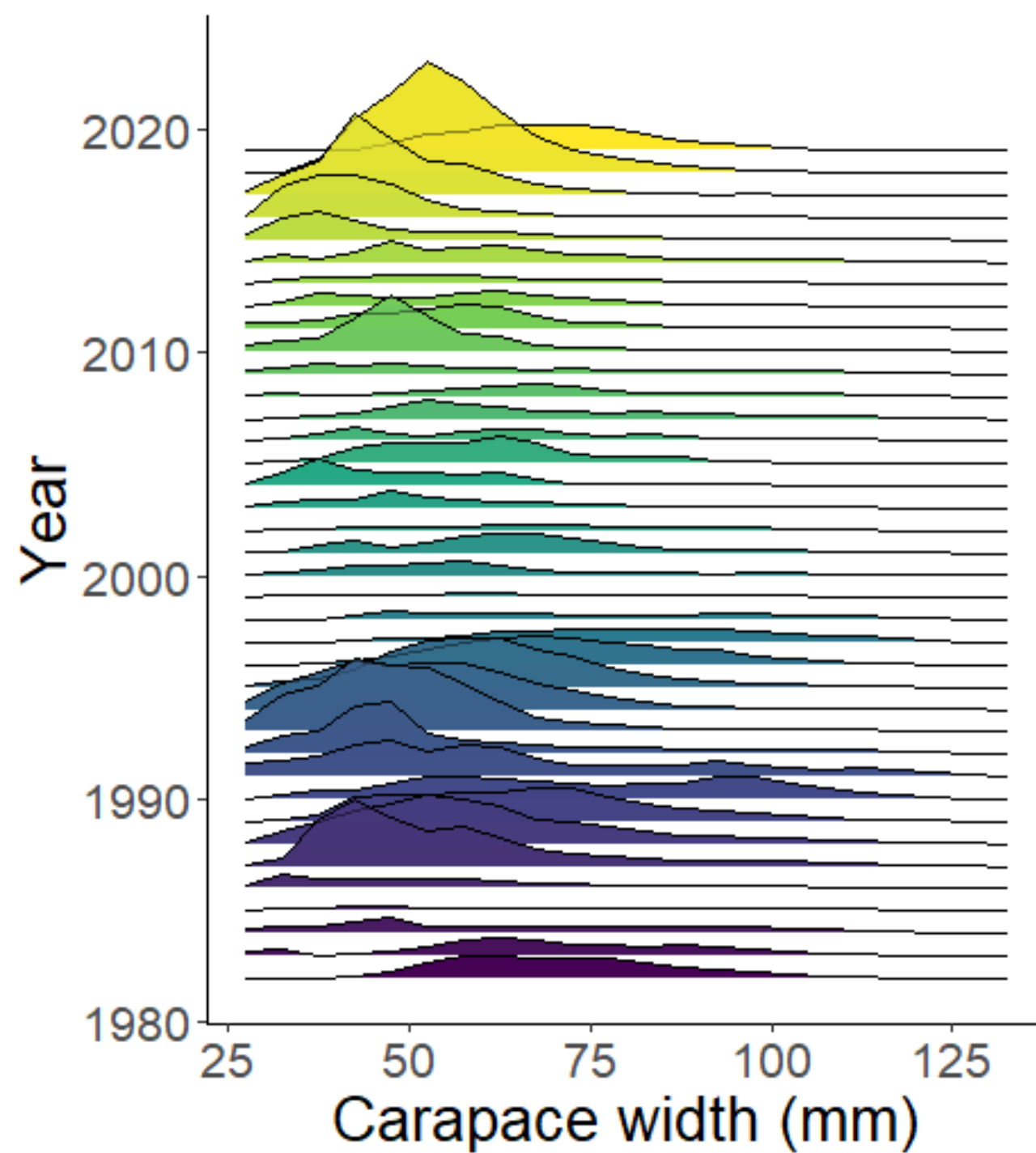
Reproduction



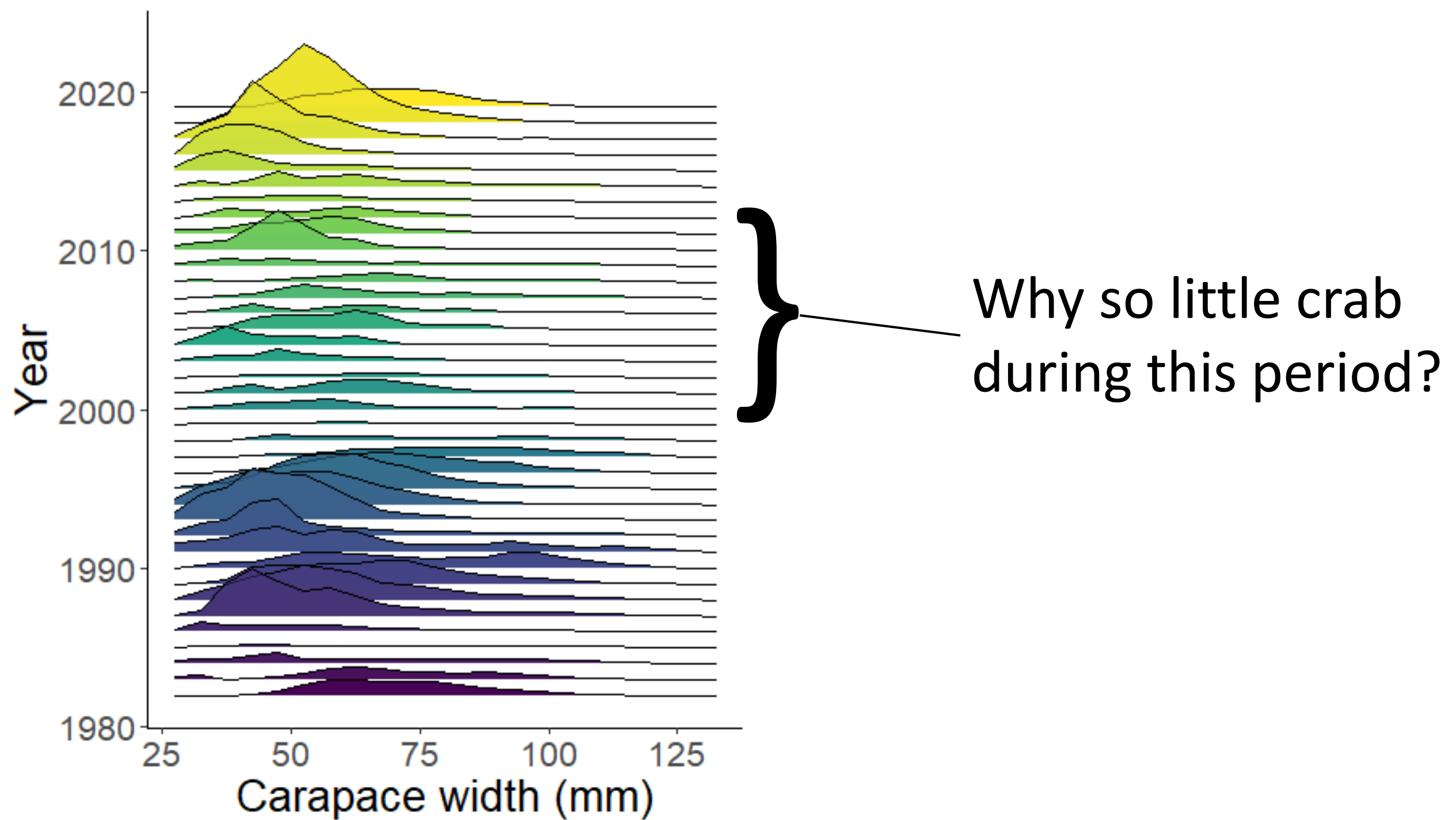
Growth









}  
Why were there  
such big cohorts?  
}





## Climate change and the future productivity and distribution of crab in the Bering Sea

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Kirstin Holsman<sup>1</sup>, Jiwoo Lee<sup>5</sup>, William Stockhausen<sup>1</sup>, and Jie Zheng<sup>6</sup>

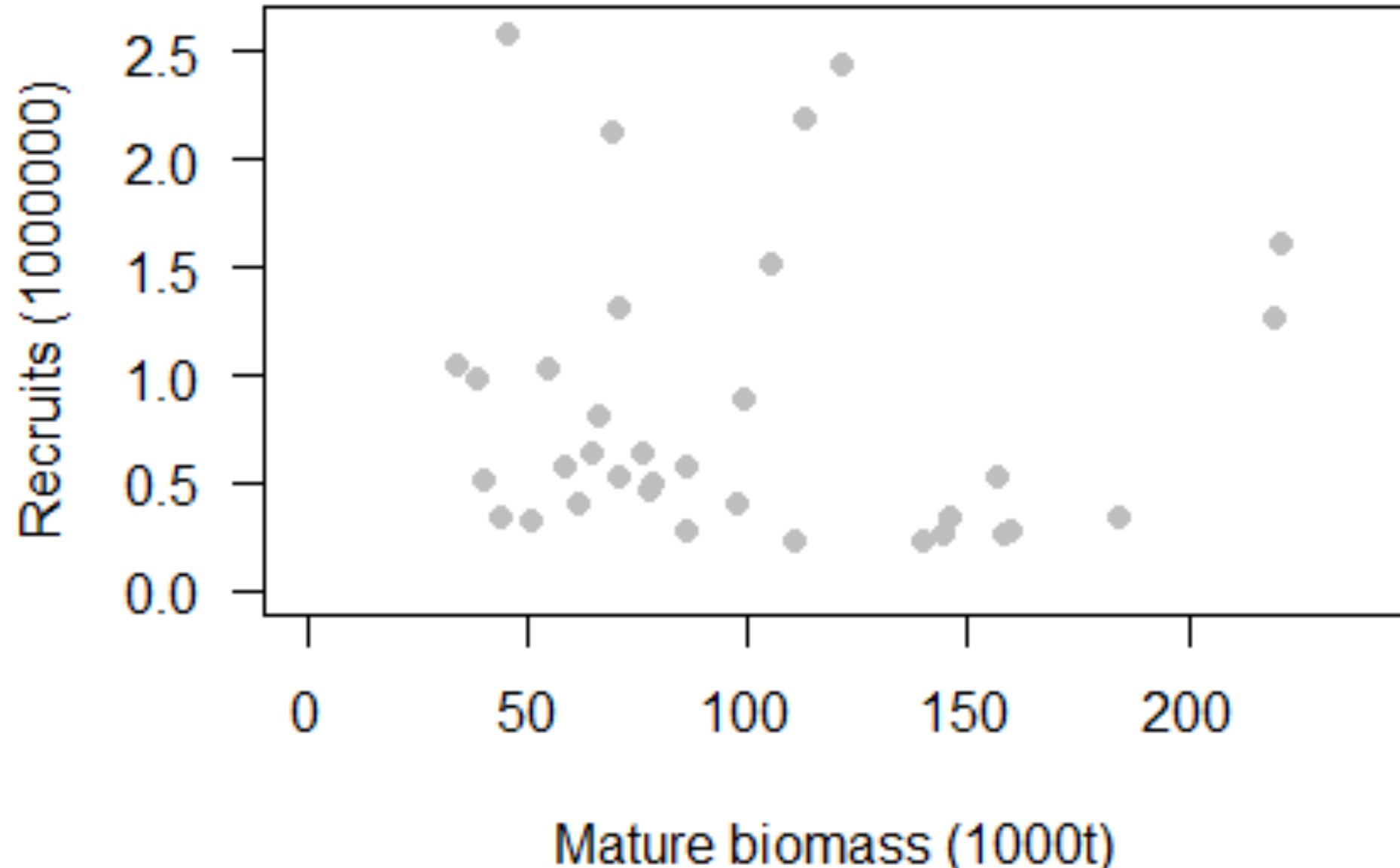
How have the distribution and productivity changed for the major crab stocks in the Bering Sea?

Can we explain any of these changes with environmental indices?

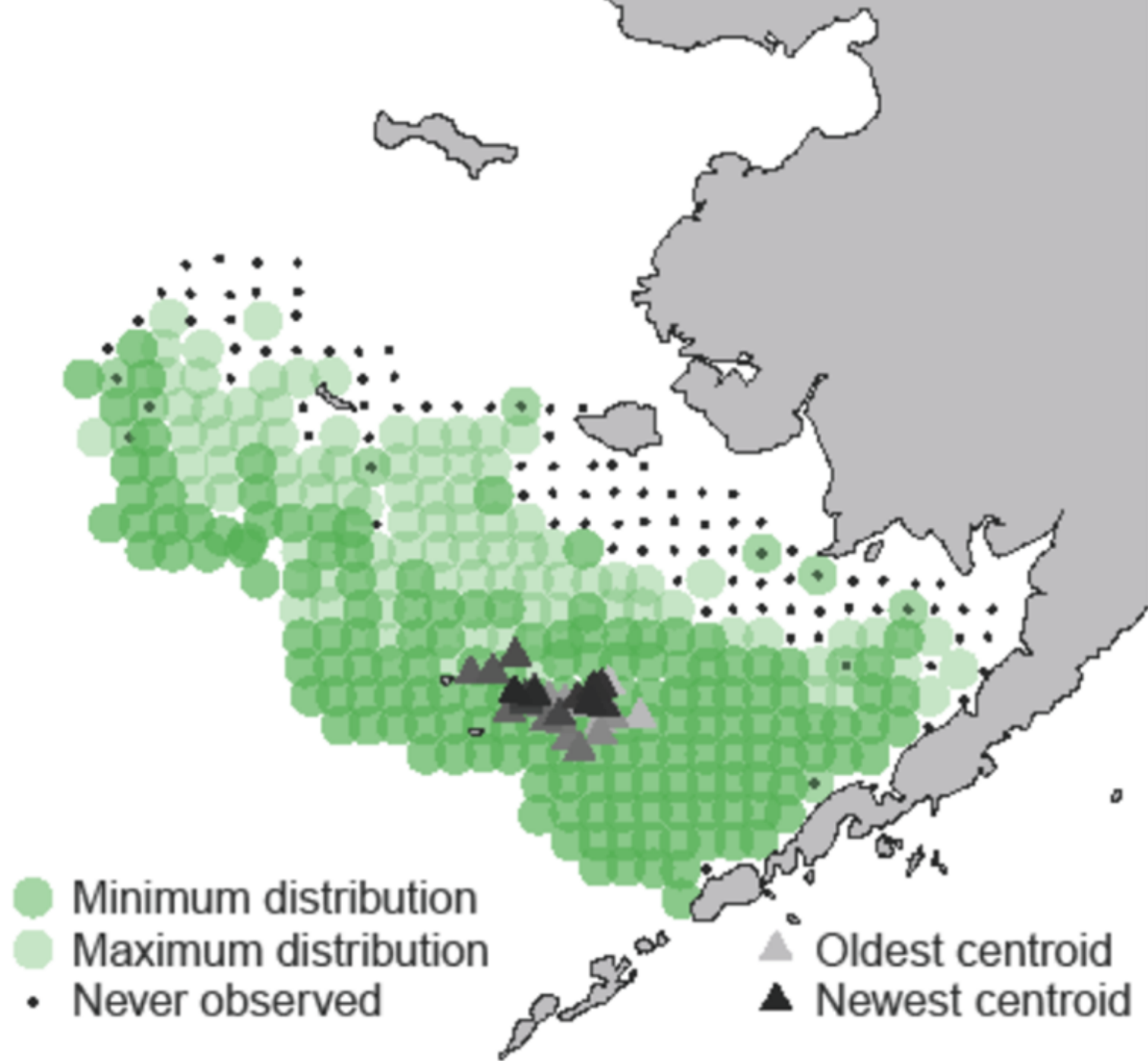
Can we project what might be expected of these stocks in the future given observed relationships?

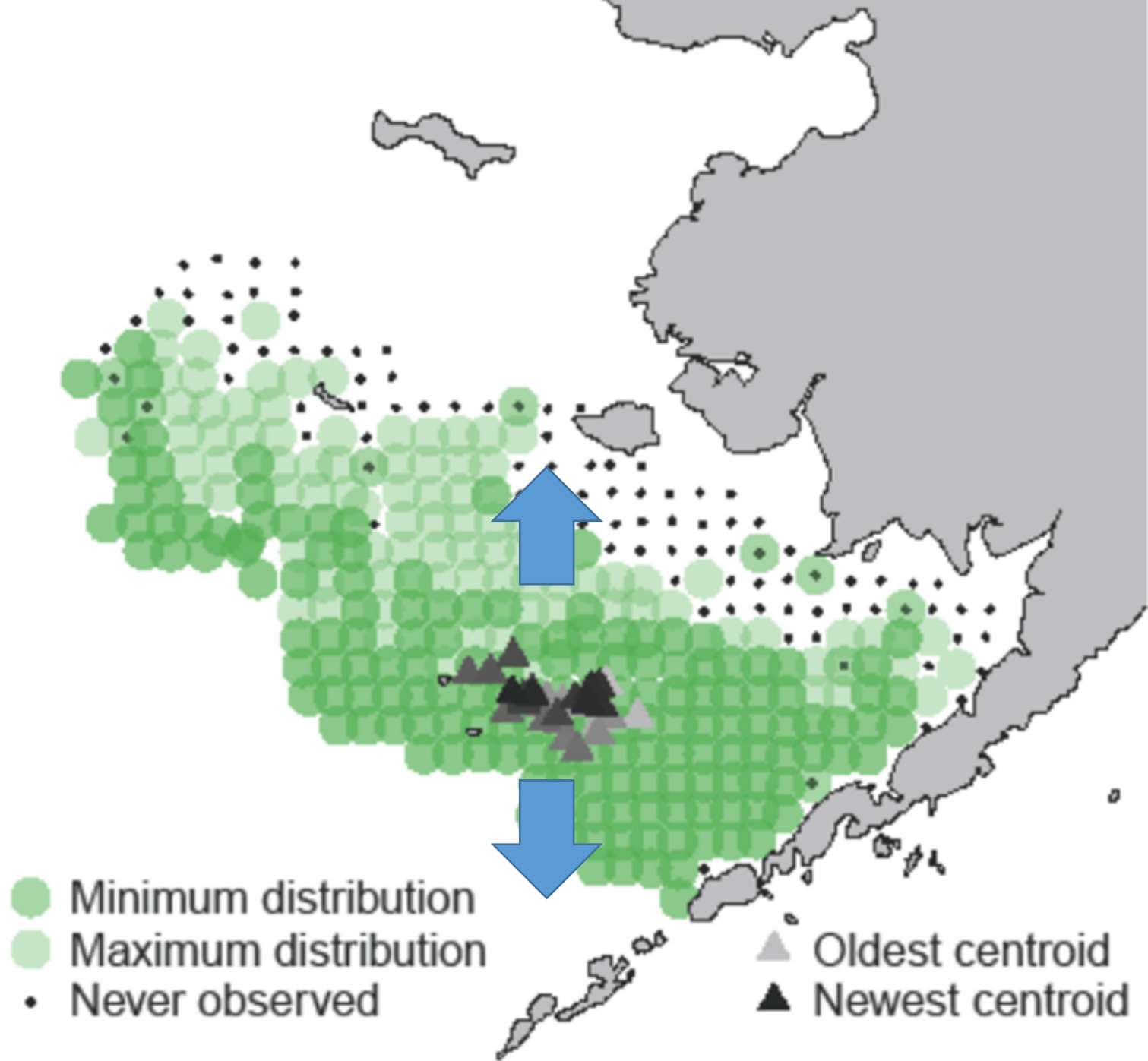
# Stock-recruit relationship

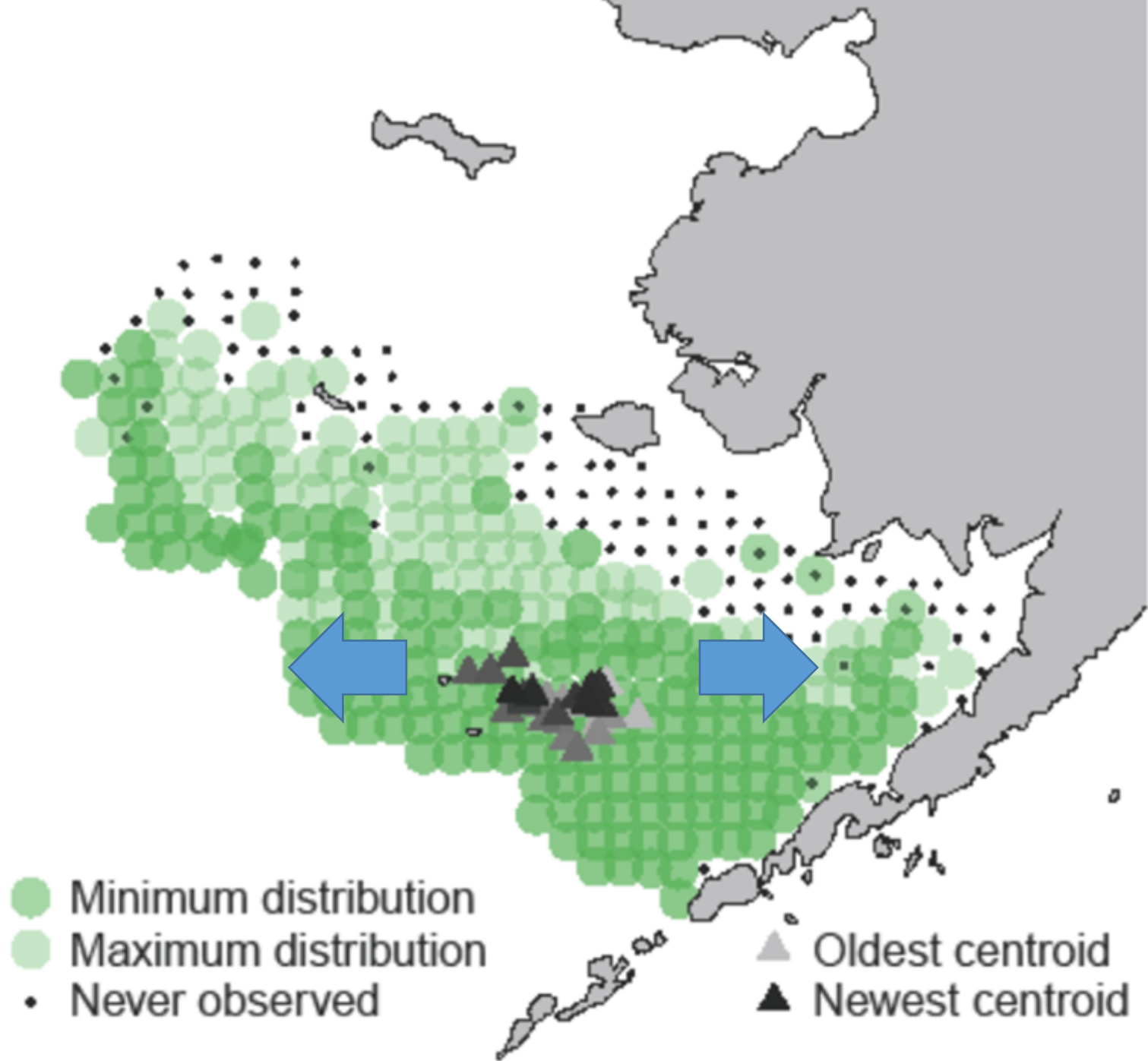
How many small crab result from a given biomass of spawning females?



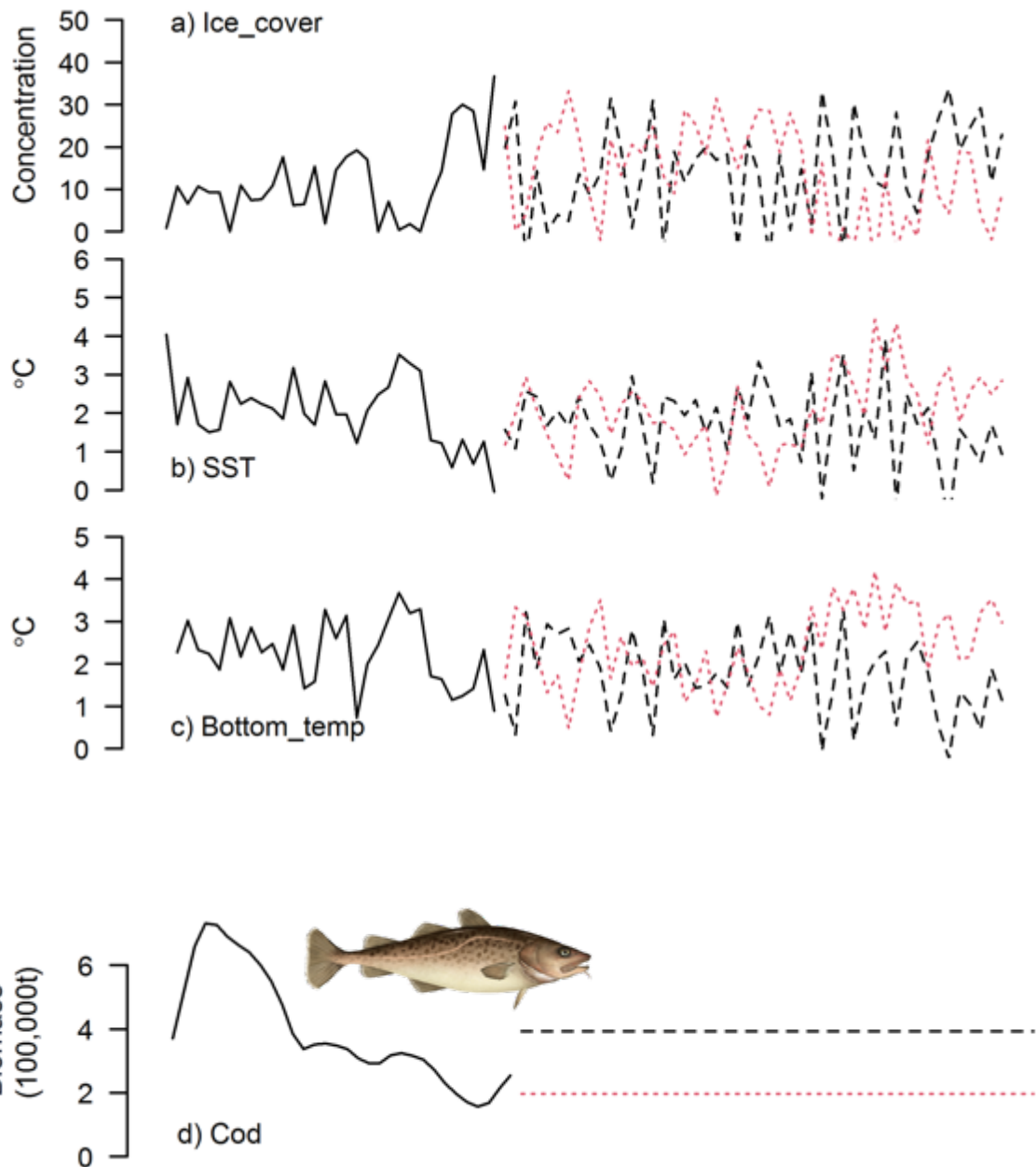




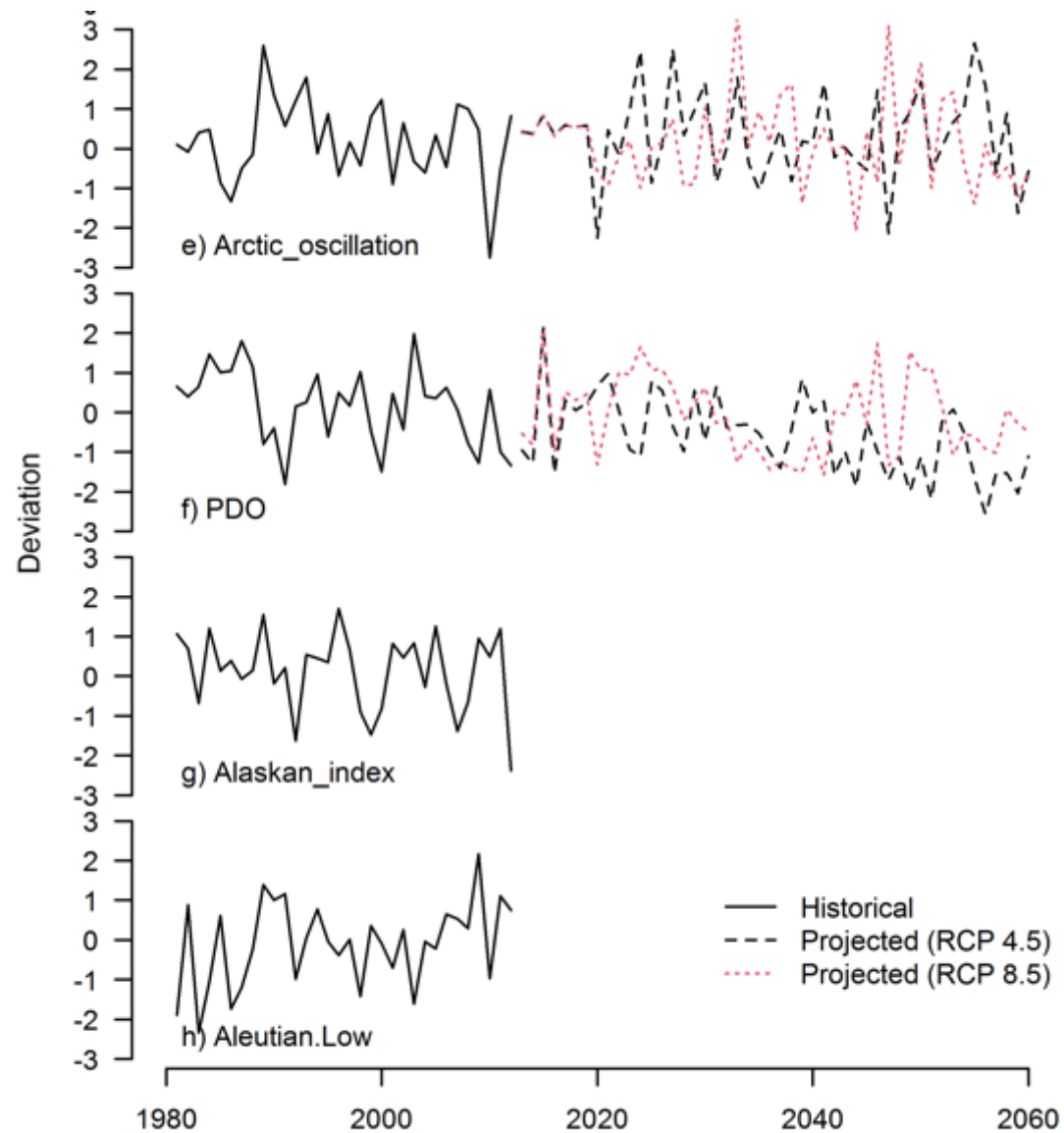




## LOCAL ENVIRONMENT



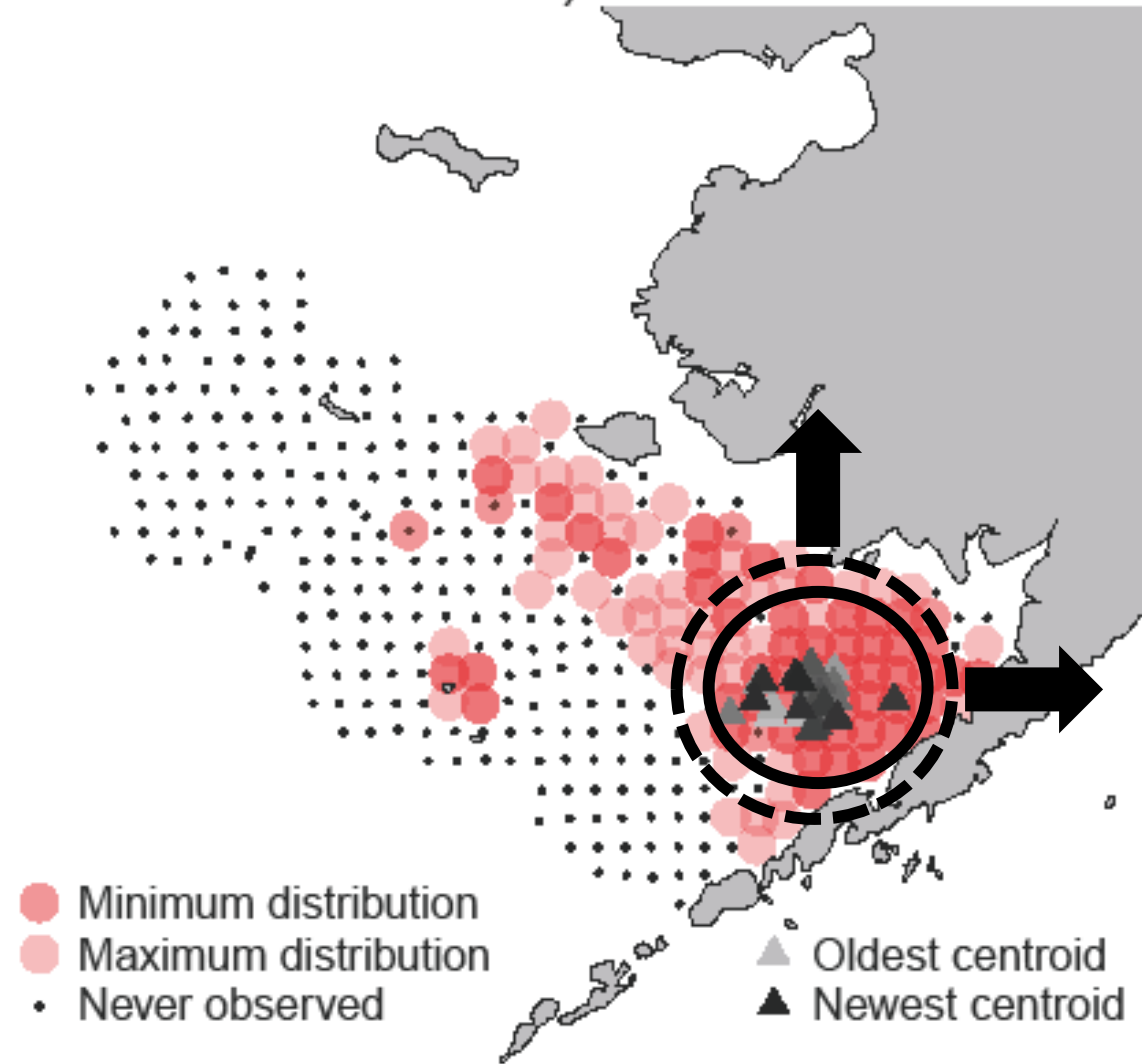
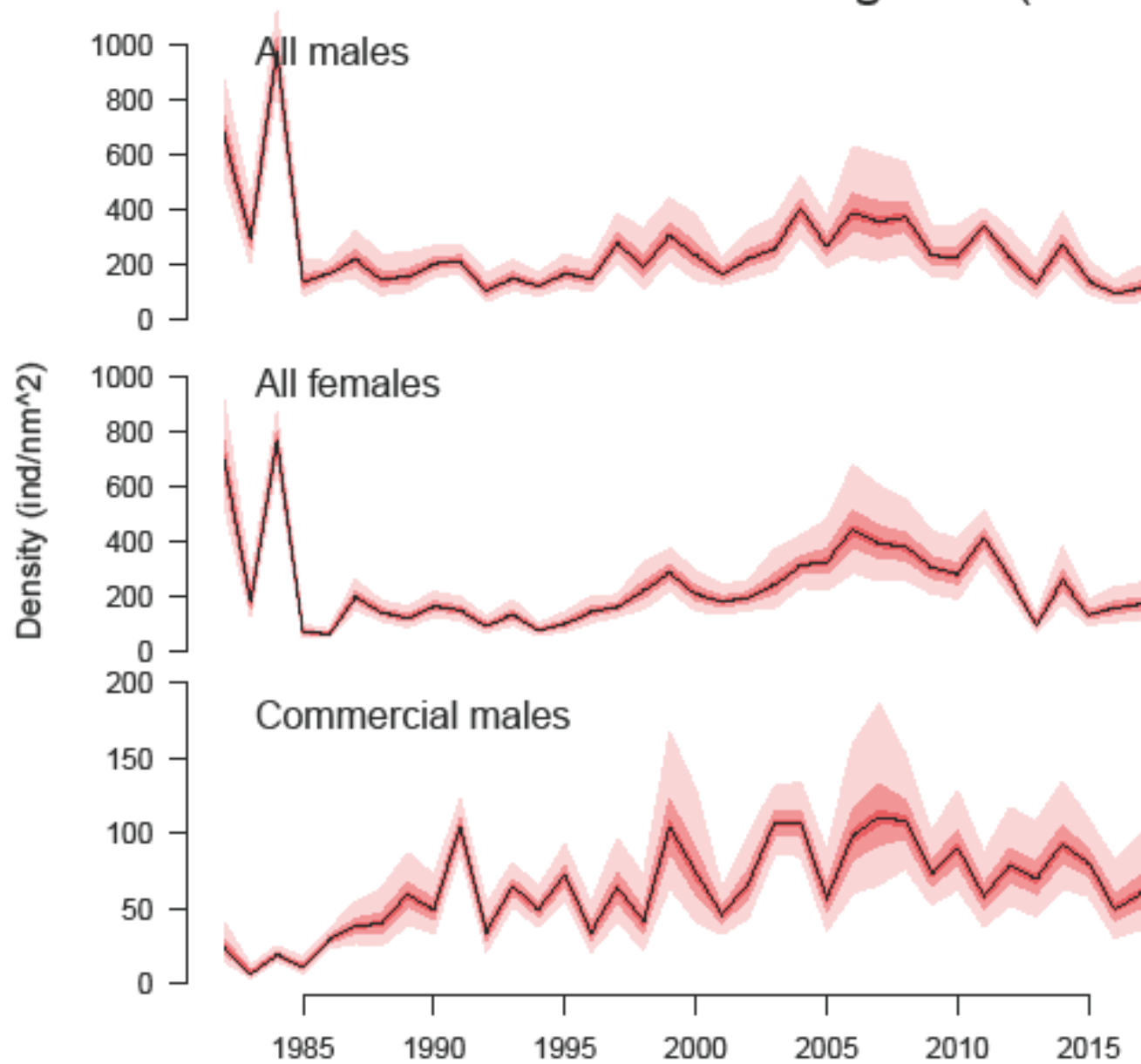
## LARGE SCALE ENVIRONMENT



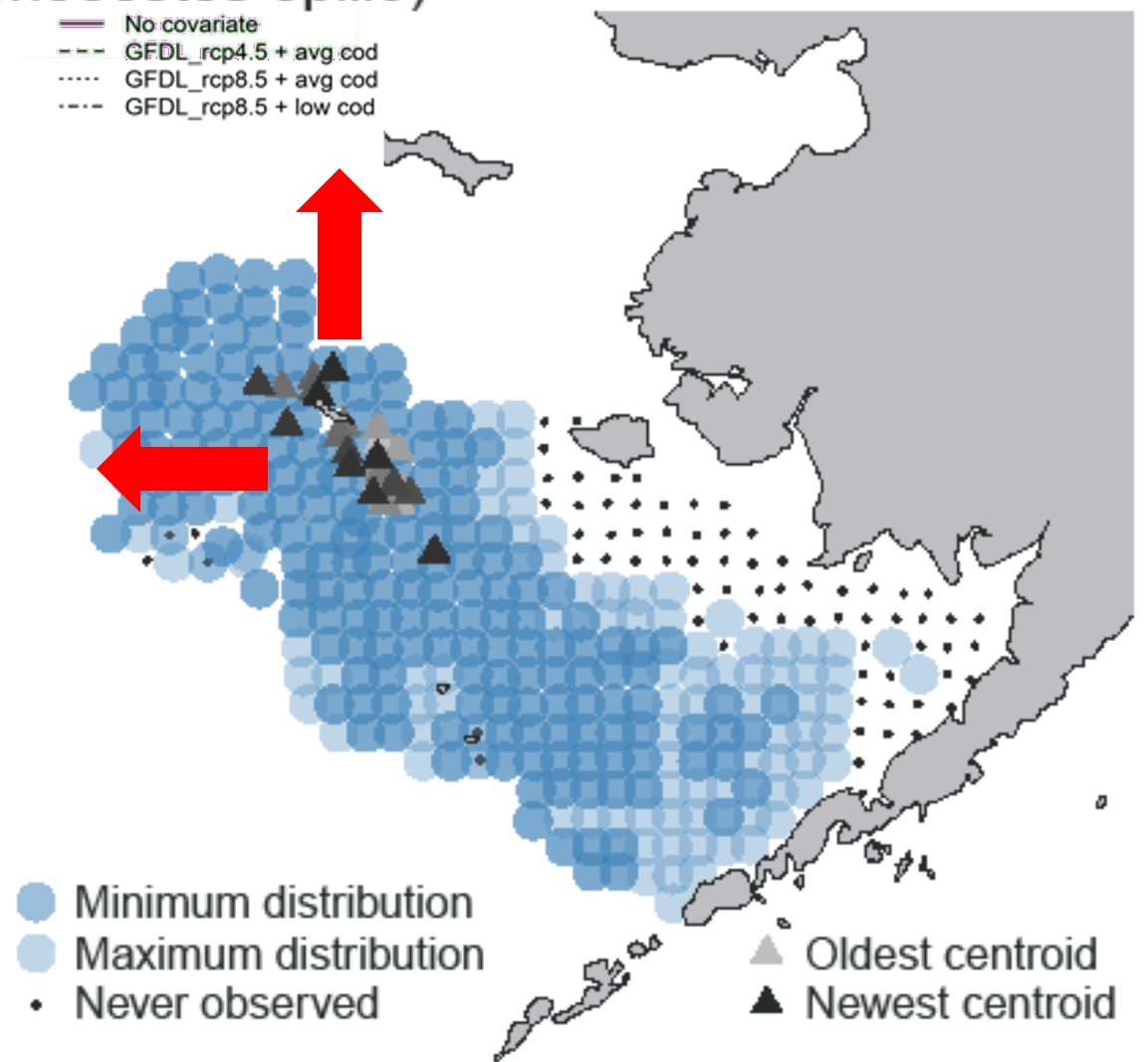
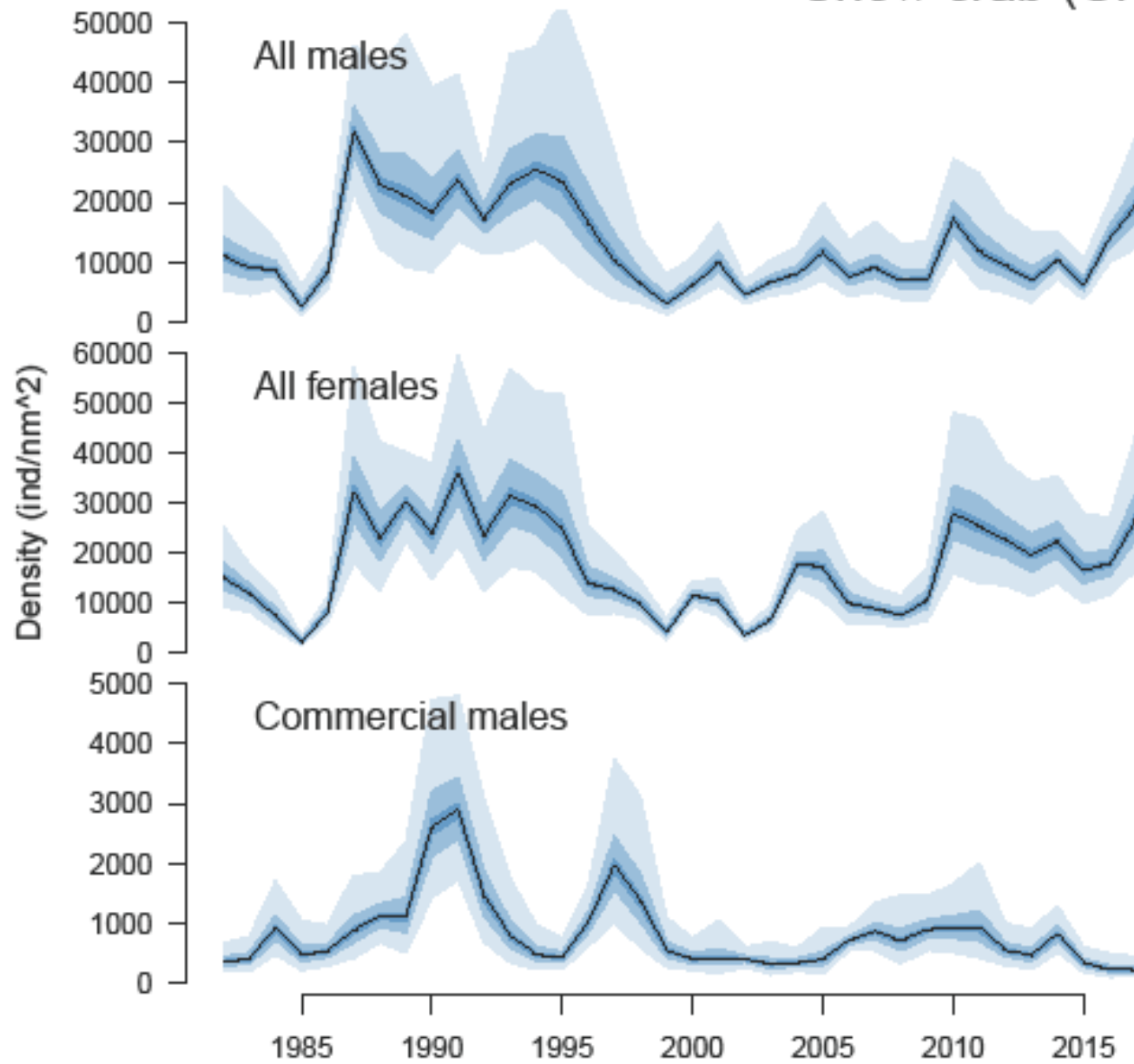
# 9 of 12 metrics could be explained by something in the environment

	Recruitment			Distribution			Latitude			Longitude		
Ice_cover + Cod + Aleutian.Low	0.80	-1.54	3.93	6.16	5.62	-0.80	0.96	7.66	-11.33	3.18	-8.97	3.14
SST + Cod + Aleutian.Low	1.19	-4.67	3.72	6.71	6.31	-2.07	-0.37	7.66	-1.93	3.02	-10.41	3.81
Bottom_temp + Cod + Aleutian.Low	1.78	-12.10	4.49	7.23	6.25	-6.39	2.29	7.62	0.98	2.48	-6.46	-0.82
Ice_cover + Cod + Arctic_oscillation	-4.74	0.45	0.62	7.01	8.06	-0.59	-1.39	7.91	-11.40	-5.65	-8.18	3.21
SST + Cod + Arctic_oscillation	-1.70	-4.14	2.29	7.65	8.26	-2.06	-5.15	7.82	-3.51	-6.84	-10.65	3.74
Bottom_temp + Cod + Arctic_oscillation	-3.94	-12.64	2.85	7.99	8.28	2.38	-0.25	7.92	0.93	-6.61	-5.92	0.55
Ice_cover + Cod + PDO	-3.50	0.45	4.08	6.94	8.27	-0.60	1.92	6.78	-10.17	4.18	-9.48	3.32
SST + Cod + PDO	0.66	-4.30	4.11	7.33	8.40	-2.09	-0.05	6.45	-3.07	3.75	-11.49	4.04
Bottom_temp + Cod + PDO	0.22	-13.17	4.85	7.50	8.40	2.16	2.20	6.93	-0.93	2.97	-8.32	0.30
Ice_cover + Cod + Alaskan_index	3.13	0.41	3.48	7.02	7.98	-0.57	3.28	7.02	-9.44	0.66	-9.97	2.55
SST + Cod + Alaskan_index	5.18	-4.75	3.40	7.49	8.38	-2.09	1.21	7.20	-0.16	0.61	-12.79	2.80
Bottom_temp + Cod + Alaskan_index	4.05	-13.75	4.10	7.71	8.39	2.17	4.08	6.97	2.92	0.40	-6.92	0.46
Ice_cover + Cod	2.46	-2.55	0.85	3.98	5.21	-3.67	0.61	4.84	-12.01	1.19	-10.96	0.30
SST + Cod	3.50	-7.15	0.85	4.57	5.33	-5.15	-1.71	4.74	-3.26	0.73	-13.05	0.95
Bottom_temp + Cod	1.61	-15.16	1.59	4.92	5.33	-0.72	1.59	4.84	-0.12	-0.09	-8.69	-2.48
Ice_cover + Aleutian.Low	-1.63	4.71	3.73	4.12	2.76	-1.83	0.49	5.11	-11.14	3.68	3.28	5.36
SST + Aleutian.Low	-0.18	1.88	2.17	4.52	3.28	-3.60	-0.04	4.96	-3.87	3.69	3.24	5.35
Bottom_temp + Aleutian.Low	-0.09	-12.27	3.62	4.72	3.22	2.51	0.96	5.16	-1.81	3.64	3.29	3.89
Ice_cover + Arctic_oscillation	-7.73	5.35	-0.41	4.72	5.11	-2.21	-3.57	5.13	-12.71	-7.78	1.90	3.87
SST + Arctic_oscillation	-4.04	1.89	0.08	5.09	5.17	-3.72	-6.48	4.94	-6.12	-8.37	1.30	3.89
Bottom_temp + Arctic_oscillation	-6.49	-12.30	1.12	5.26	5.19	2.02	-2.86	5.17	-2.12	-8.34	2.04	2.75
Ice_cover + PDO	-5.21	5.01	3.66	4.48	5.22	-1.91	1.56	3.93	-9.83	4.98	2.91	5.35
SST + PDO	0.07	-0.35	2.75	4.67	5.31	-3.70	0.81	3.51	-4.76	5.02	2.99	5.28
Bottom_temp + PDO	-0.97	-14.30	4.06	4.70	5.31	2.45	1.51	4.25	-3.48	4.70	2.96	4.08
Ice_cover + Alaskan_index	0.10	5.35	3.66	4.66	4.94	-1.79	3.41	4.44	-8.35	1.93	4.37	4.48
SST + Alaskan_index	2.63	0.69	2.60	4.92	5.29	-3.63	2.47	4.46	-1.44	2.28	3.91	4.08
Bottom_temp + Alaskan_index	1.37	-13.09	3.74	4.97	5.29	2.36	3.56	4.37	0.50	2.68	4.40	4.06
Ice_cover	-0.28	2.56	1.16	1.92	2.44	-4.59	1.09	2.46	-10.85	2.55	2.32	2.55
SST	1.10	-0.90	-0.02	2.30	2.52	-6.39	-0.11	2.23	-4.24	2.49	2.07	2.54
Bottom_temp	-0.82	-14.13	1.27	2.46	2.52	-0.27	1.28	2.51	-2.26	1.99	2.35	1.37
Cod	1.79	-4.32	1.33	2.37	2.57	-2.22	1.38	2.02	2.57	-0.66	-8.02	-1.33
Aleutian.Low	1.15	2.11	2.70	2.27	0.54	1.89	-1.70	2.35	-2.23	0.91	0.49	2.57
Arctic_oscillation	-5.40	2.60	0.61	2.56	2.42	2.20	-4.32	2.43	0.04	-10.54	-0.61	1.08
PDO	1.04	2.23	2.73	1.88	2.57	1.66	-1.13	1.87	-4.39	2.20	0.18	2.54
Alaskan_index	2.43	2.57	1.44	2.15	2.49	1.02	1.08	1.66	0.79	-0.12	2.34	1.80

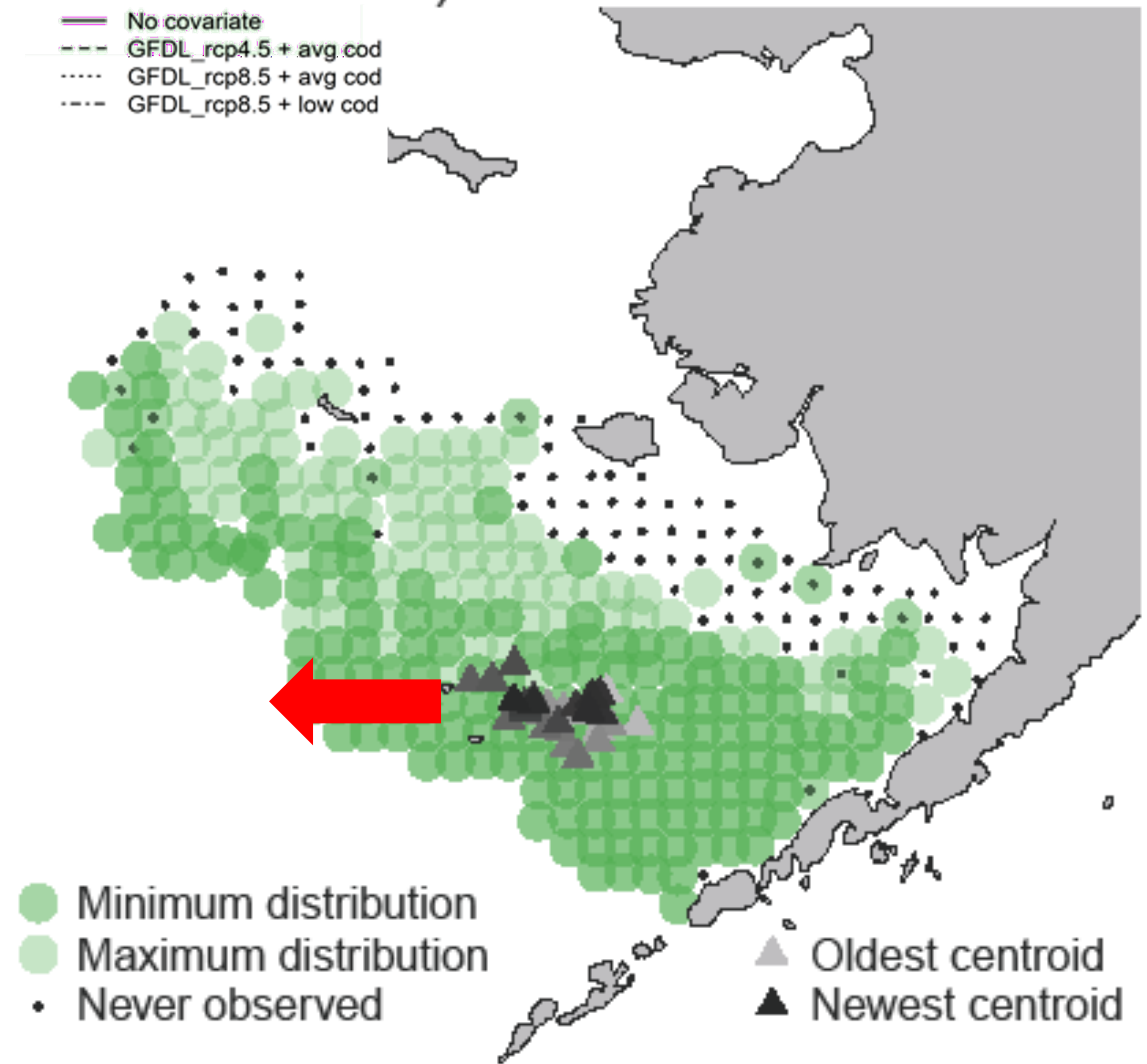
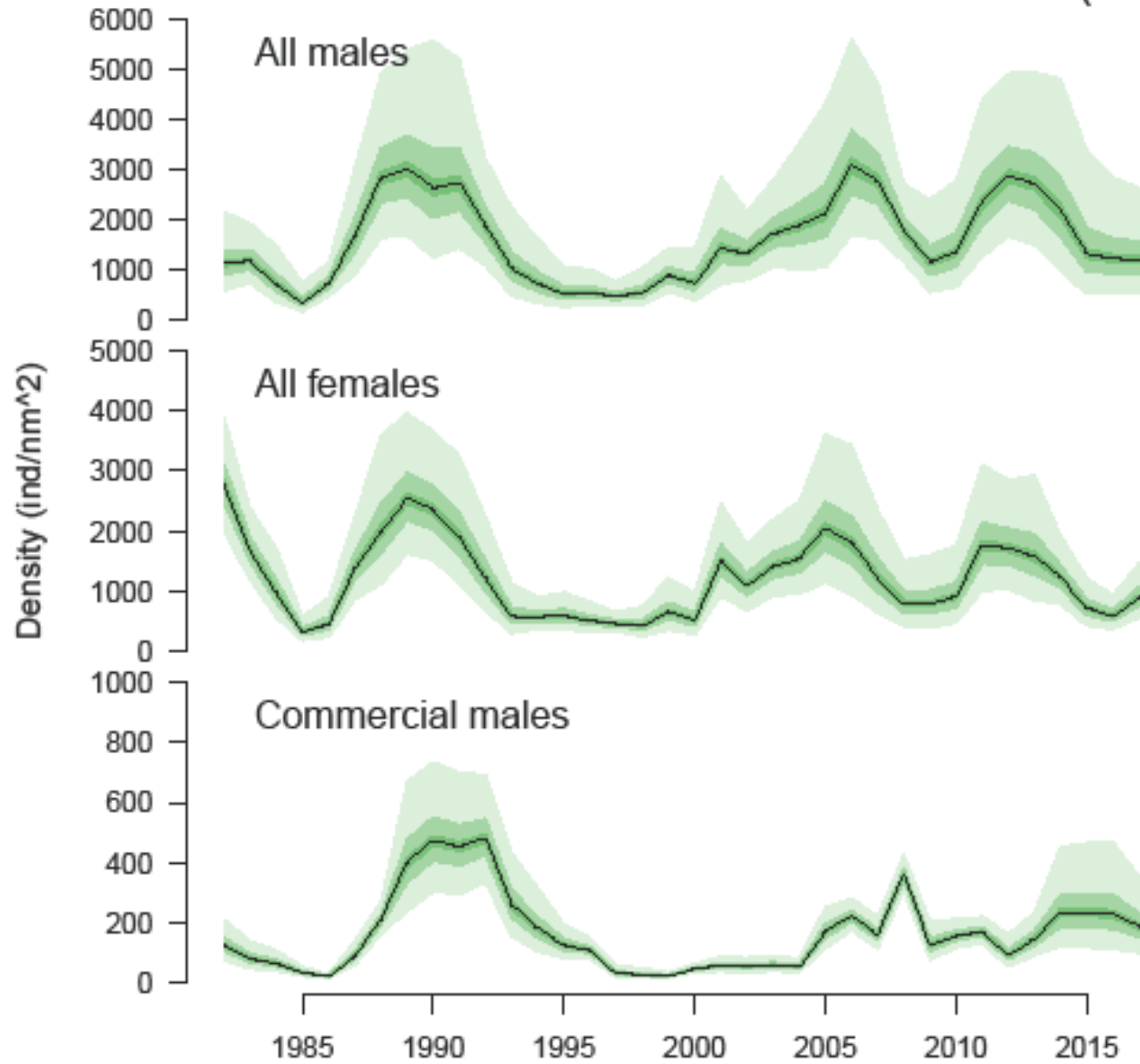
# Red king crab (*Paralithodes camtschaticus*)



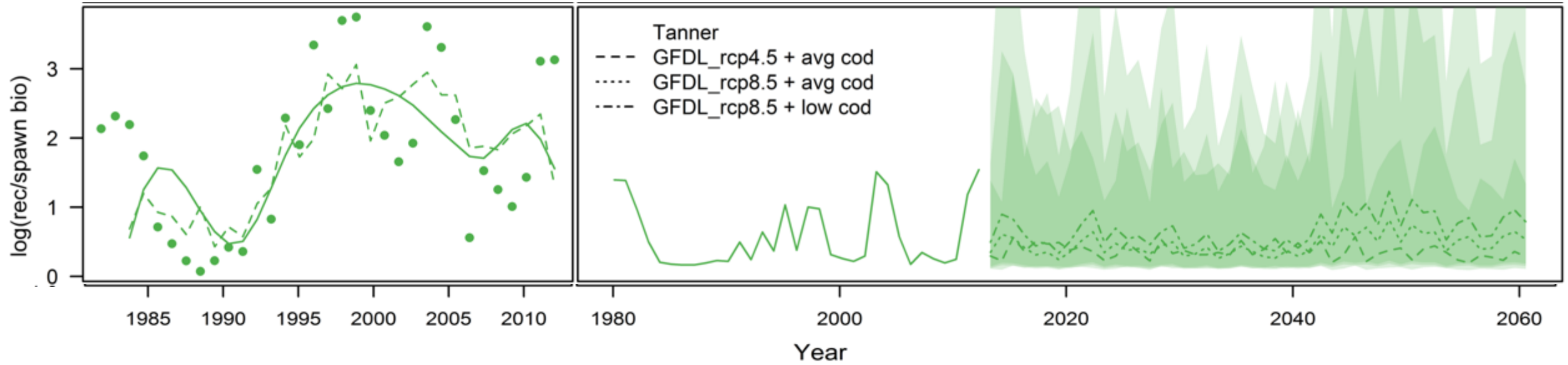
# Snow crab (*Chionoecetes opilio*)



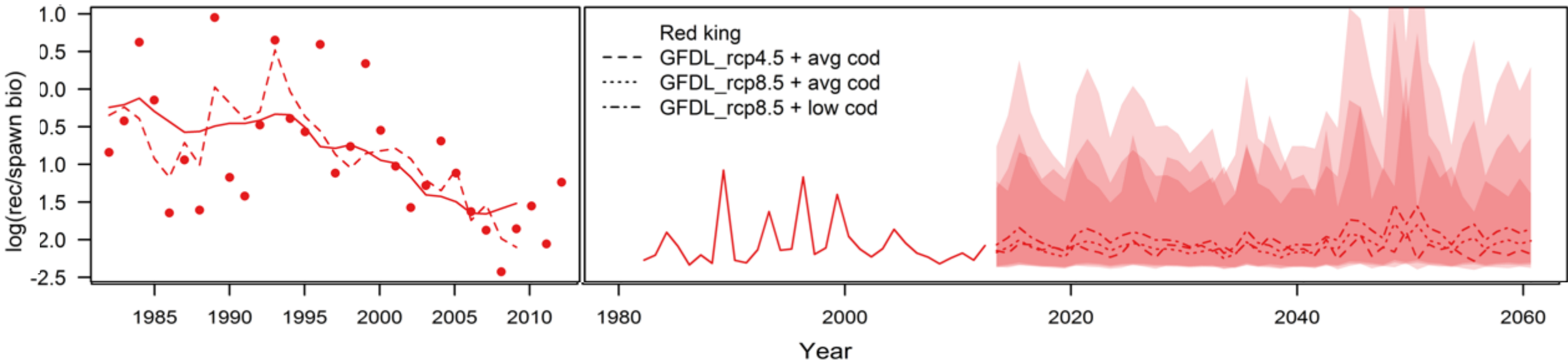
# Tanner crab (*Chionoecetes bairdi*)



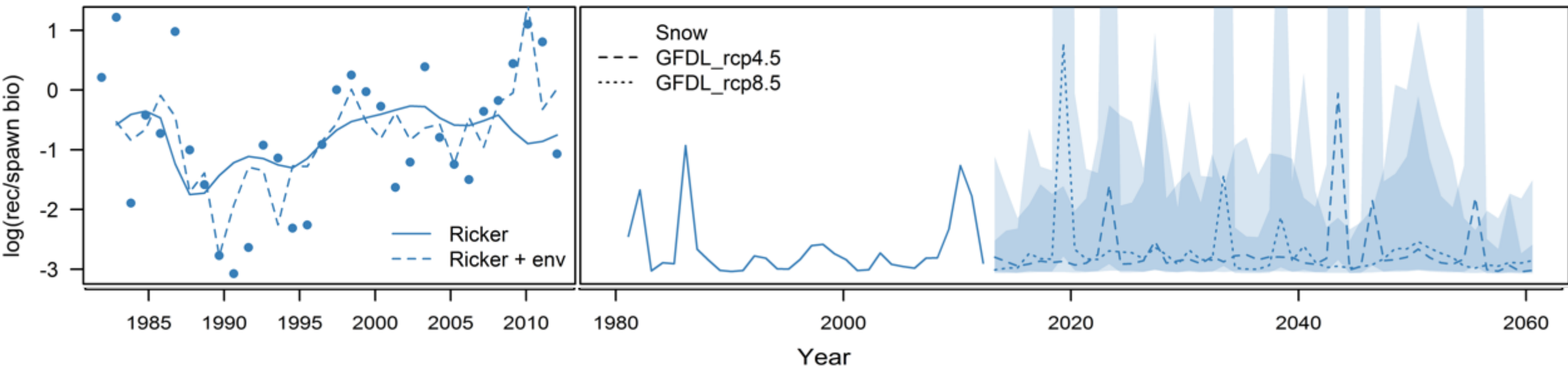




More productive long term related to projected increases in bottom temperature.

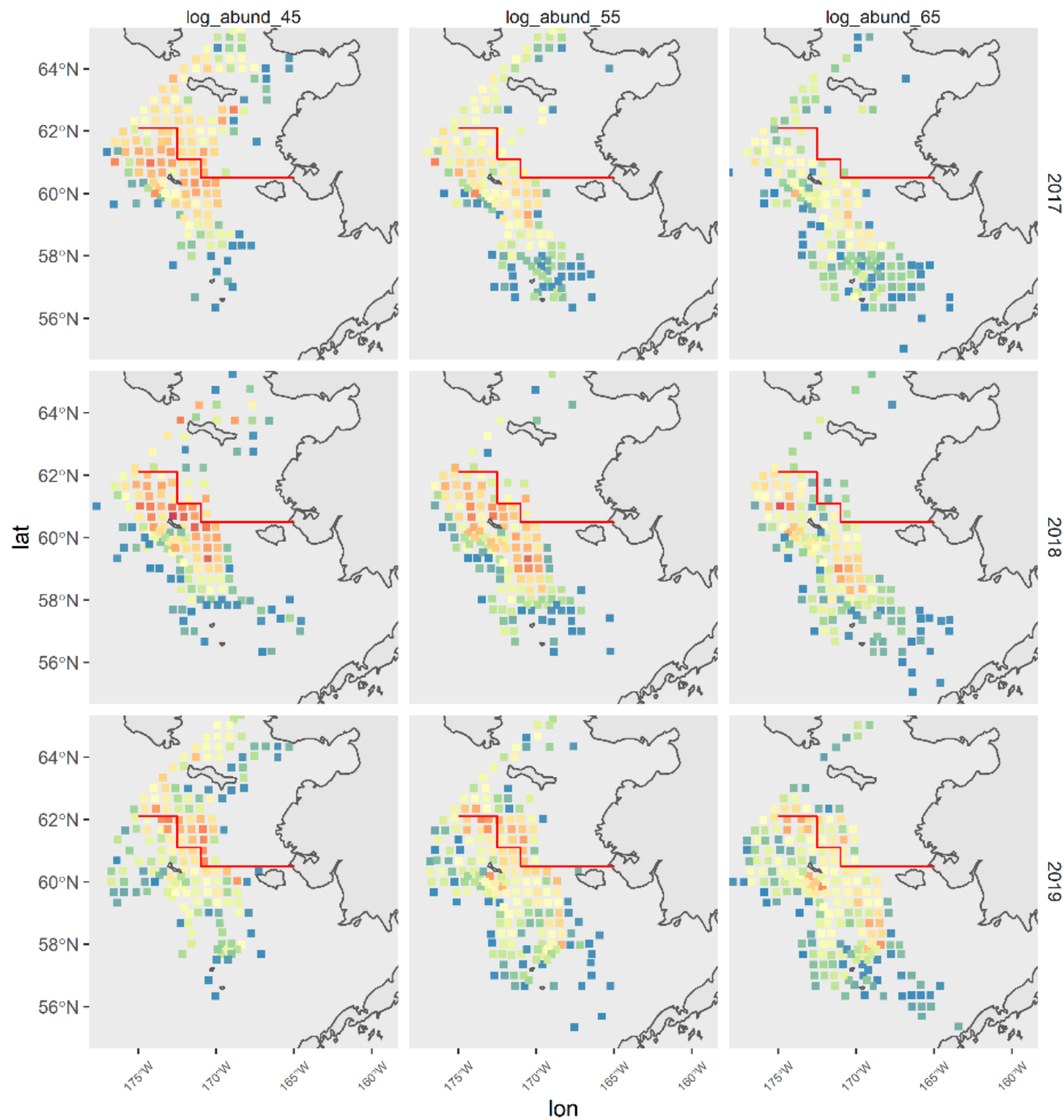


Marginally more productive long term related to projected decreases in ice cover.



Less productive in the long term in the current area due to decreased ice cover and changes in arctic oscillation

	Recruitment	North/South	East/West	Footprint
Tanner crab	+		W	
Red king crab	~	N	E	Contract
Snow crab	-	N		



- New fishing grounds may open in the NBS as the ice retreats.
- Prediction becomes much harder as you leave historically observed conditions.
- Ocean acidification is not considered in this analysis because the data were not available.

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