Spatial and temporal trends in the abundance and distribution of juvenile Pacific salmon in the eastern Gulf of Alaska during summer, 2011-2016

Author and contact author: Jamal Moss, Wesley Strasburger, and Ellen Yasumiishi. Auke Bay Laboratories, AFSC, NOAA, 17109 Pt. Lena Loop Rd. Juneau AK 99801. jamal.moss@noaa.gov

Last updated: June 2017

Description of index: Pelagic fish were sampled using a trawl net towed in the upper 20 m of the eastern Gulf of Alaska during the Alaska Fisheries Science Center's Gulf of Alaska Assessment Surveys during summer, 2011-2016. Stations were approximately 10 nautical miles apart and a trawl was towed for approximately 30 minutes. The area swept by the trawl was estimated from horizontal net opening and distance towed. Fish catch was estimated in kilograms. Juvenile salmon weight was estimated by multiplying the grand mean weight in a given year by the number captured at a station.

Abundance, distribution, center of gravity, and area occupied were estimated for juvenile Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), pink (*O. gorbuscha*), and sockeye (*O. nerka*) salmon using the VAST package for multispecies version 1.1.0 (Thorson 2015; Thorson et al. 2016a, b, c) with RStudio version 0.99.896 and R software version 3.3.0 (R Project 2017). The abundance index is a standardized geostatistical index developed by Thorson et al. (2015, 2016) to estimate indices of abundance for stock assessments. We specified a gamma distribution and estimated spatial and spatio-temporal variation for both encounter probability and positive catch rate components at a spatial resolution of 100 knots. Parameter estimates were within the upper and lower bounds and final gradients were less than 0.0005.

Status and trends: Temporal trends in the estimated abundance of juvenile salmon indicated a recent increase in the productivity of pink, chum, and sockeye; a slight increase in coho and no change in Chinook (Figure 1, Table 1). Juvenile pink were the most abundant species followed chum, coho, sockeye and Chinook salmon (Figure 1, Table 1). Both juvenile pink and sockeye salmon had an alternating year pattern with higher abundances in even-numbered years. Juvenile salmon were typically less abundant during atypically warm years (2013-2015), except for in 2016 (Figure 1-5). Juvenile salmon were distributed nearshore in waters above the continental shelf (Figure 2-5). No distinct trend was observed in the latitudinal and longitudinal distribution of juvenile salmon during warm and cold years (Figure 6). Juvenile coho salmon were distributed farther north during even-numbered years (Figure 6). During the 2015 "warm blob" year, juvenile salmon distribution contracted relative to the other years.

Factors causing trends: Higher abundances of juvenile salmon during 2016 was likely due to a combination of higher odd- brood year pink salmon production and due to the dissipation of the warm water caused by the "warm blob".

Implications: Recent increases in the abundance of juvenile salmon in our survey area during later summer implies improved conditions for growth and survival of salmon from southeast Alaska, British Columbia and the Pacific Northwest lakes and rivers and/or a change in the distribution of juvenile salmon into our survey area during July. Juvenile indices may be an early indication for the numbers of returning adults to the region of origin.

Citations:

Bond, N.A., M.F. Cronin, H. Freeland, N. Mantua. 2015. Causes and impacts of the 2014 warm anomaly in the NE Pacific. Geophysical Research Letters 42(9): 3414-3420.

Li, K. A.J. Doubleday, M.D. Galbraith, and R.D. Hopcroft. 2016. High Abundance of salps in the Gulf of Alaska during 2011: A first record of bloom occurrence for the northern Gulf. Deep Sea Research Part II 132: 136-145.

Thorson, J.T., A.O. Shelton, E.J. Ward, and H.J. Skaug. 2015. Geostatistical delta-generalized linear mixed models improve precision for estimated abundance indices for West Coast groundfishes. ICES Journal of Marine Science; doi:10.1093/icesjms/fsu243

Thorson, J.T., and K. Kristensen, K. 2016a. Implementing a generic method for bias correction in statistical models using random effects, with spatial and population dynamics examples. Fish. Res. 175: 66-74. doi:10.1016/j.fishres.2015.11.016.
url: http://www.sciencedirect.com/science/article/pii/S0165783615301399

Thorson, J.T., Pinsky, M.L., and Ward, E.J., 2016b. Model-based inference for estimating shifts in species distribution, area occupied, and center of gravity. Methods Ecol. Evol. 7(8), 990-1008. doi:10.1111/2041-210X.12567. URL: http://onlinelibrary.wiley.com/doi/10.1111/2041-210X.12567/full

Thorson, J.T., Rindorf, A., Gao, J., Hanselman, D.H., and Winker, H. 2016c. Density-dependent changes in effective area occupied for sea-bottom-associated marine fishes. Proc R Soc B 283(1840): 20161853. doi:10.1098/rspb.2016.1853.
URL:http://rspb.royalsocietypublishing.org/content/283/1840/20161853.

Strom, S.L., K.A. Fredrickson, K.J. Bright. 2016. Spring phytoplankton in the eastern coastal Gulf of Alaska: Photosynthesis and production during high and low bloom years. Deep Sea Research II 132:107-121.

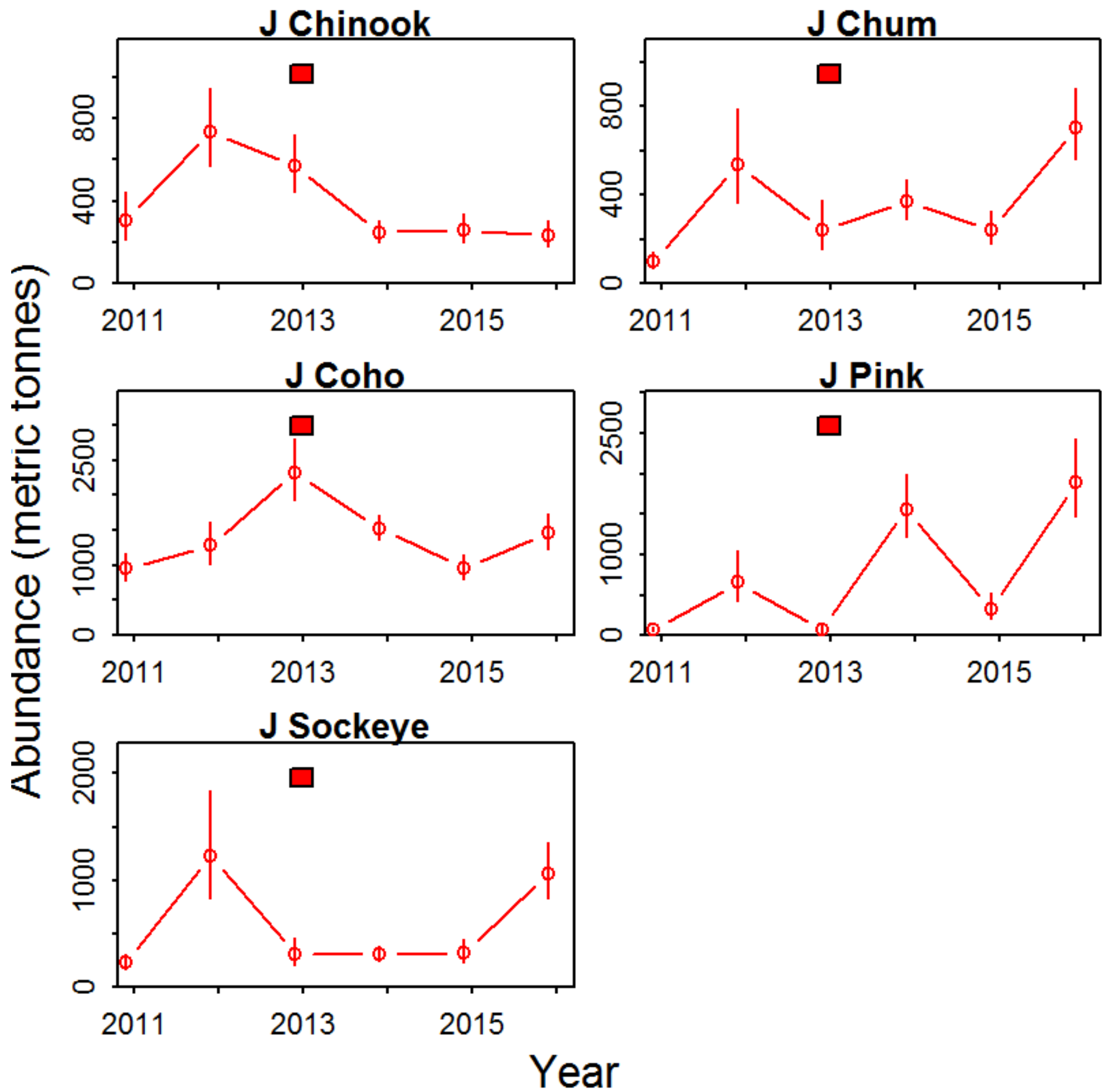

Figure 1. Index of abundance (metric tonnes) plus/minus 1 standard error for Pacific salmon in the eastern Gulf of Alaska during late summer, 2011-2016.

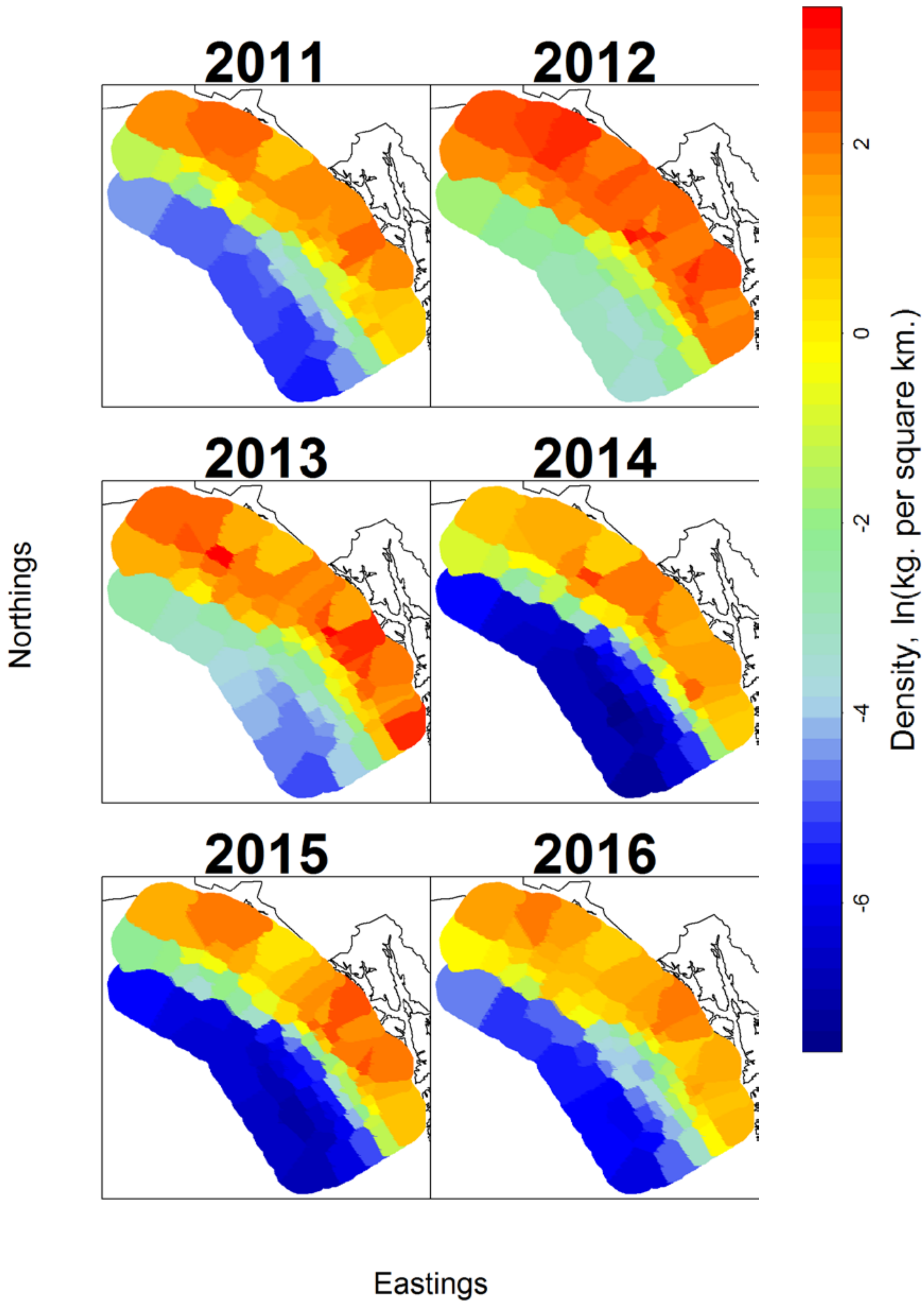

Figure 2. Predicted field densities of juvenile Chinook salmon in the eastern Gulf of Alaska during summer, 2011-2016.

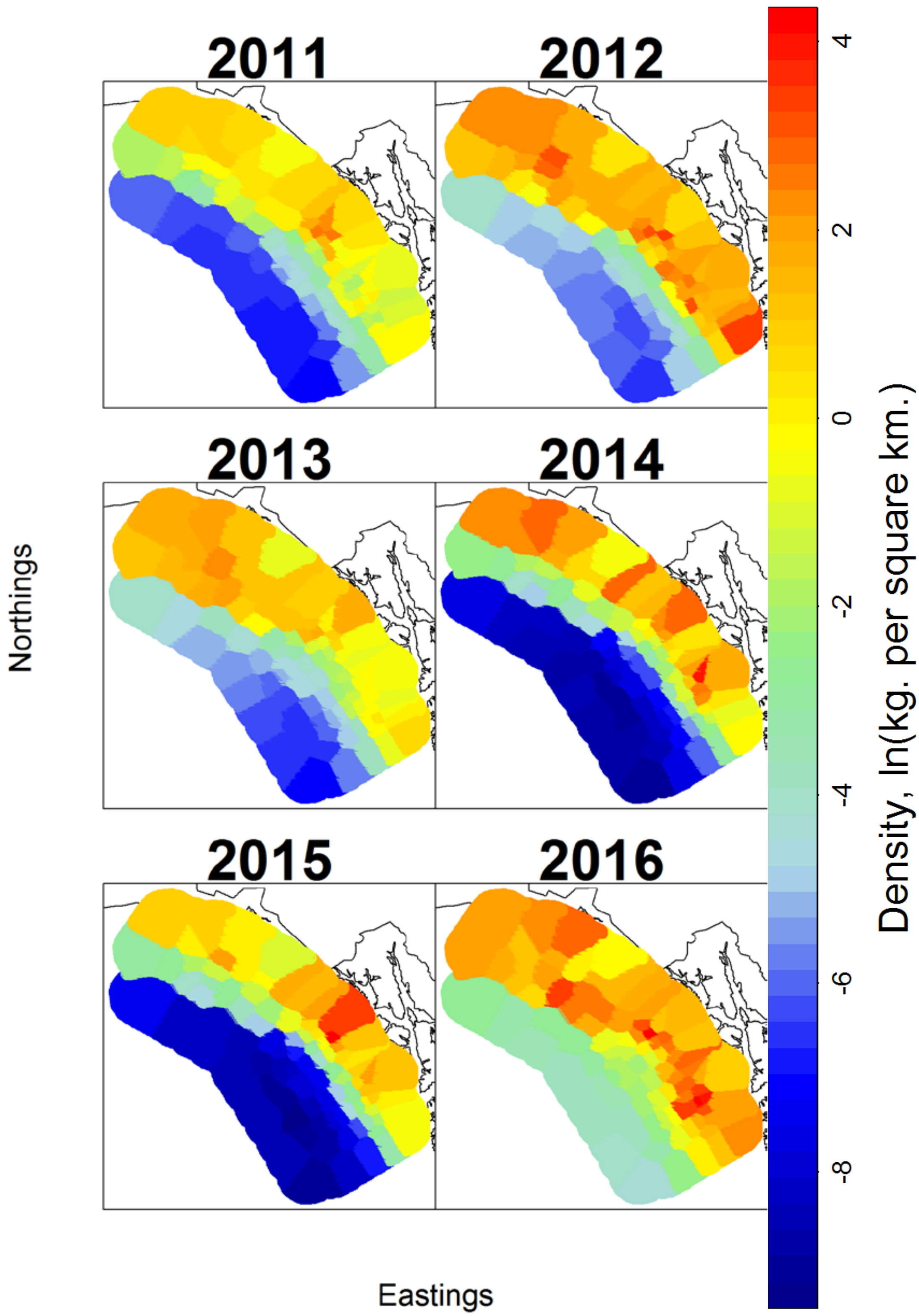

Figure 3. Predicted field densities of juvenile chum salmon in the eastern Gulf of Alaska during summer, 2011-2016.

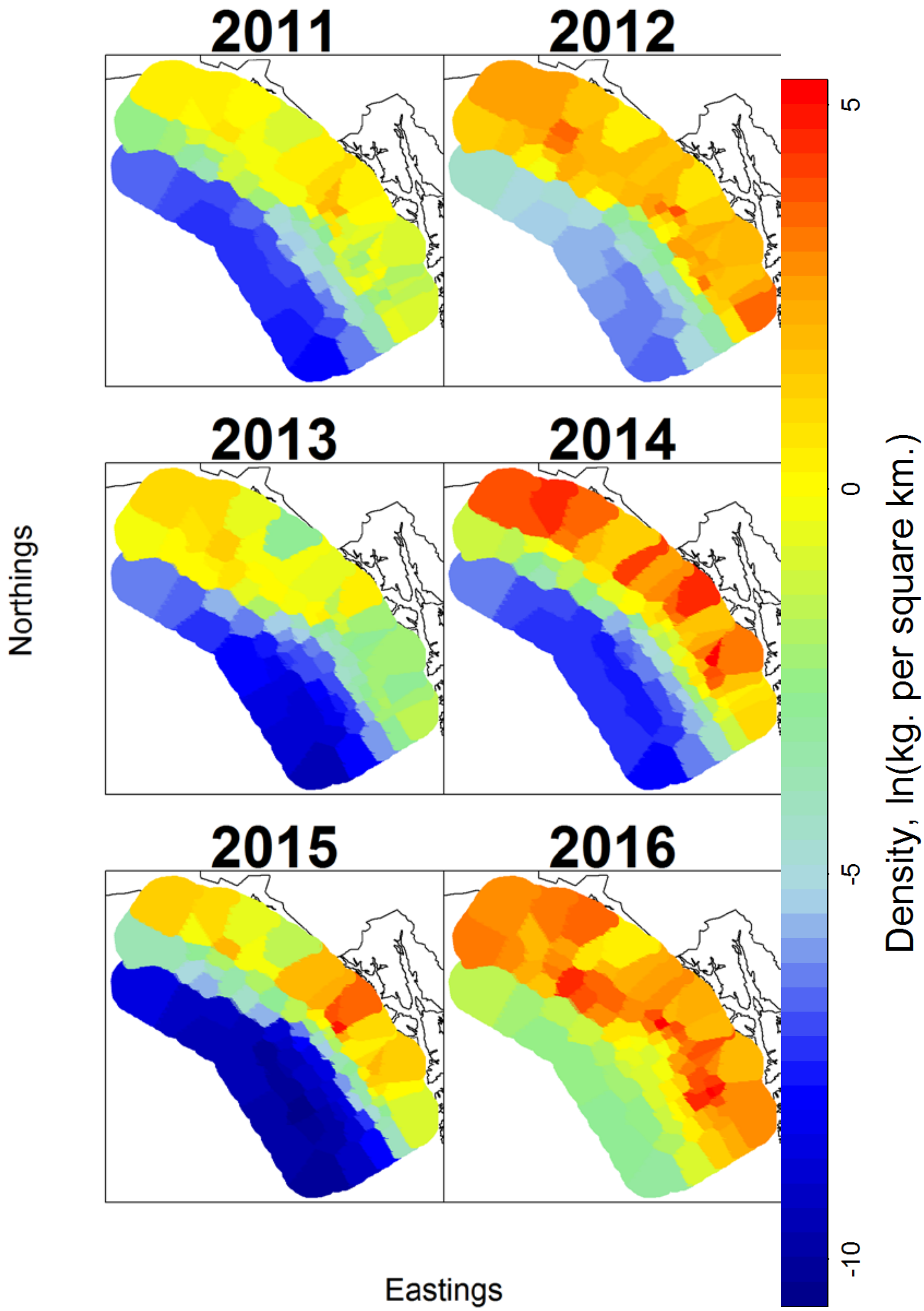

Figure 4. Predicted field densities of juvenile pink salmon in the eastern Gulf of Alaska during summer, 2011-2016.

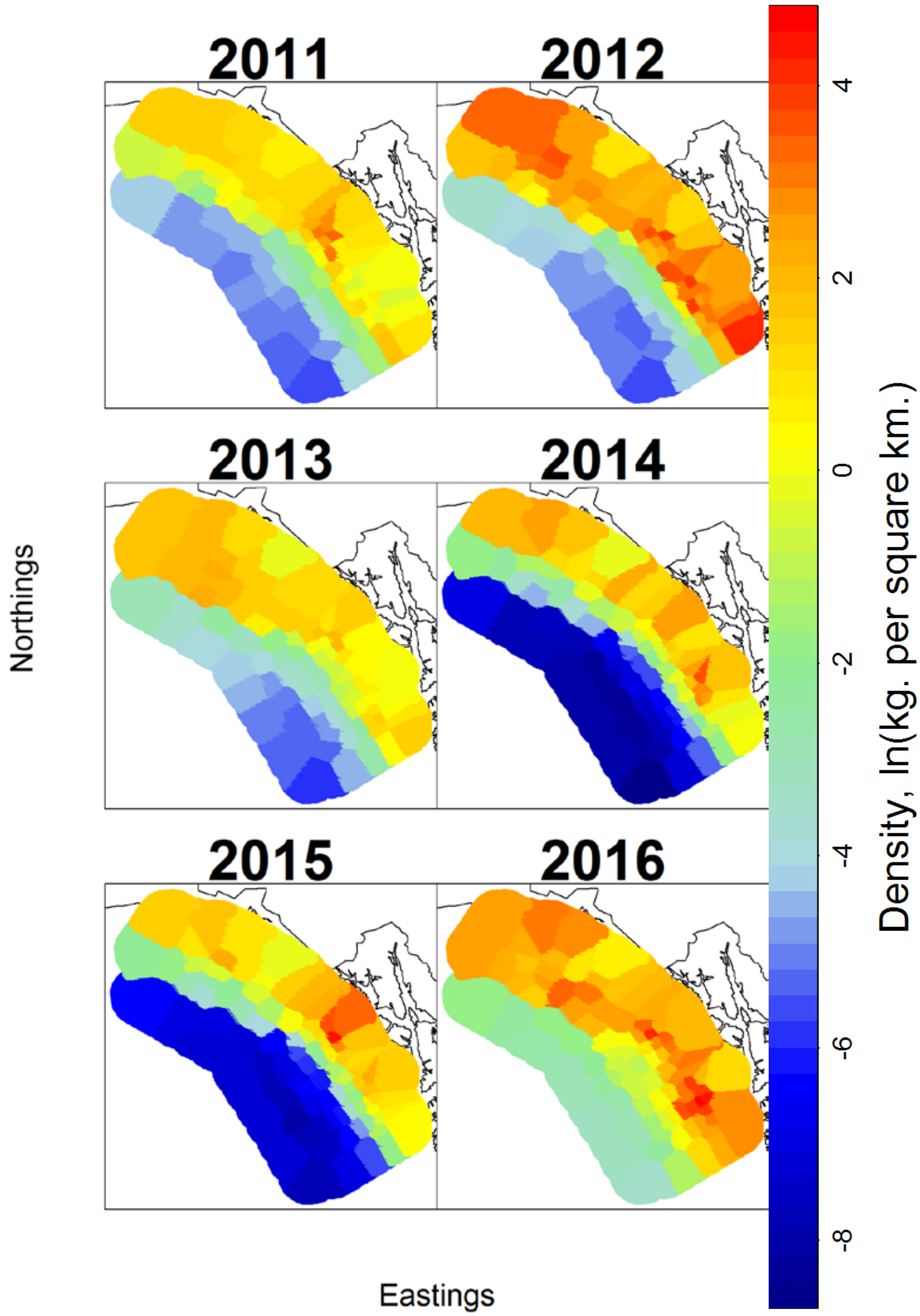

Figure 5. Predicted field densities of juvenile sockeye salmon in the eastern Gulf of Alaska during summer, 2011-2016.

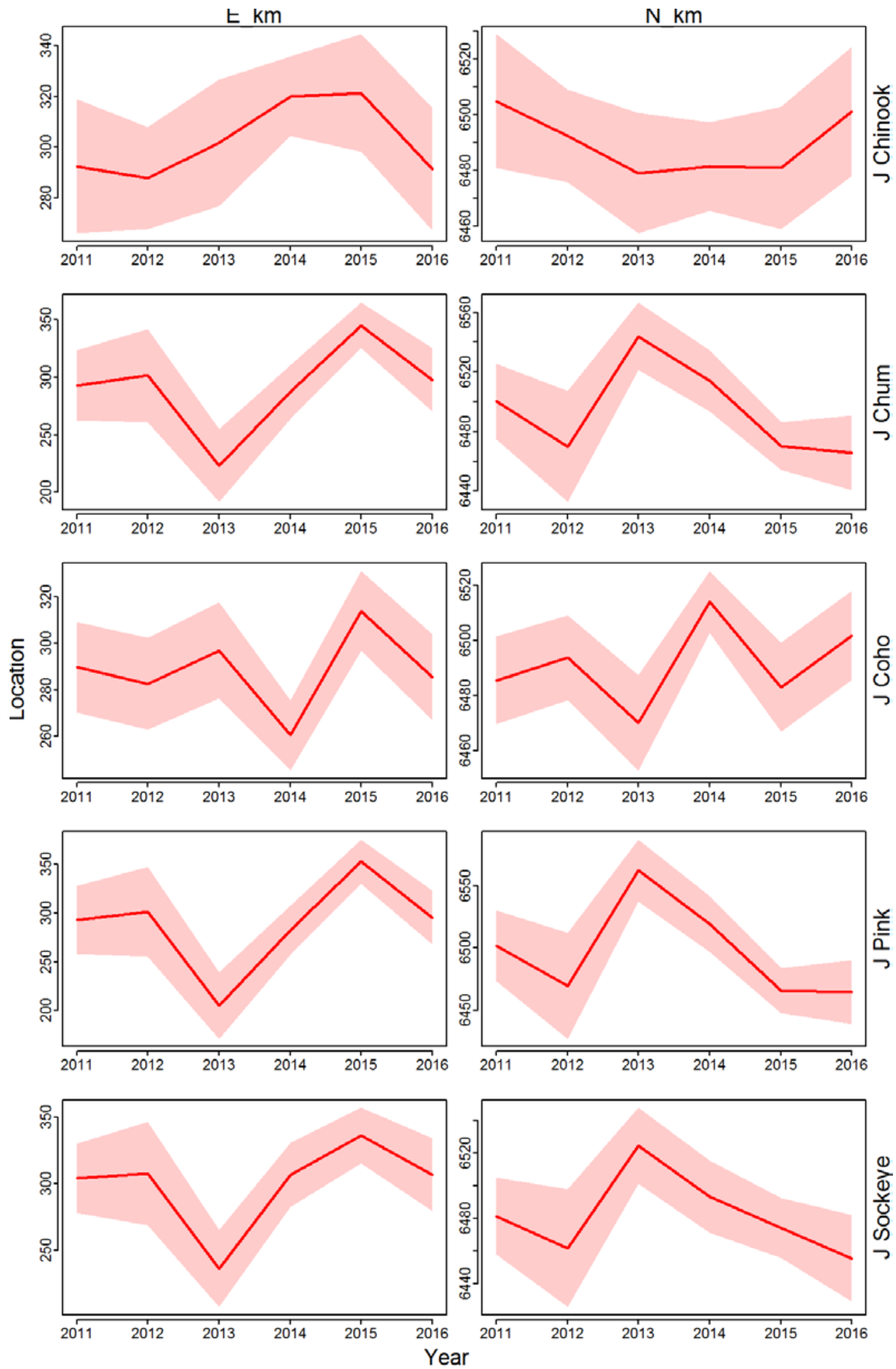

Figure 6. Center of gravity indicating temporal shifts in the mean east-to-west and north-to-south distribution plus/minus 1 standard error in UTM (km) for juvenile Pacific salmon on the eastern Bering Sea during late summer, 2002-2016.

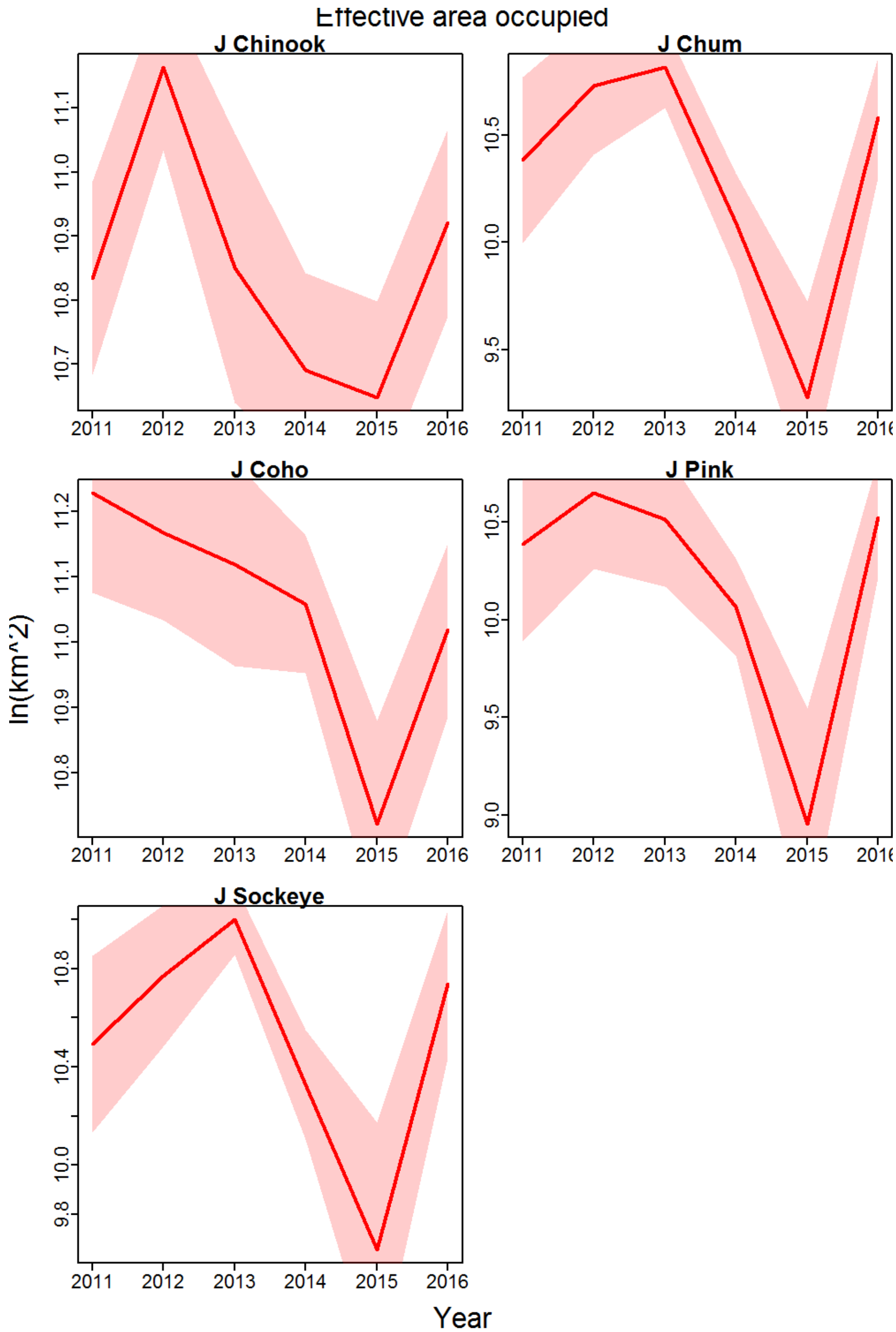

Figure 7. Effective area occupies (ln(km^2)) indicating range expansion/contraction plus/minus 1 standard error for juvenile Pacific salmon on the eastern Gulf of Alaska during summer, 2011-2016.

Table 1. Index of abundance (metric tonnes) plus/minus 1 standard error (SE) for Pacific salmon in the eastern Gulf of Alaska during summer, 2011-2016.

Year	Chinook	Chum	Pink	Sockeye
2011	307 (112)	102 (36)	69 (29)	229 (71)
2012	736 (188)	538 (207)	659 (301)	1,231 (490)
2013	568 (138)	242 (108)	67 (45)	309 (123)
2014	249 (51)	369 (88)	1,561 (388)	304 (73)
2015	261 (70)	240 (73)	324 (156)	319 (104)
2016	235 (62)	705 (160)	1887 (472)	1,053 (262)