Spatial and temporal trends in the abundance and distribution of groundfish in pelagic waters of the eastern Gulf of Alaska during summer, 2011-2016

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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. Age-0 marine fish weight was estimated by multiplying the grand mean weight in a given year by the number captured at a station. Four groundfish species commonly captured in the trawl included: age-0 Pacific cod (*Gadus macrocephalus*), age-0 pollock (G*adus chalcogrammus*), arrowtooth flounder (*Atheresthes stomias*), and rockfish (*Sebastes sp.*).

Abundance and distribution (center of gravity and area occupied) were estimated for using the VAST package for multispecies version 1.1.0 (Thorson 2015; Thorson et al. 2016a, b, c) in RStudio version 1.0.136 and R software version 3.3.0 (R Core Team 2016). The abundance index is a standardized geostatistical index developed by Thorson et al. (2015, 2016a) 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 these groundfish species indicated above average abundance of arrowtooth flounder in 2012, above average abundance of age-0 Pacific cod in 2014, above average abundance of age-0 pollock during 2014, and an above average abundance of age-0 rockfish in 2016 (Figure 1-5, Table 1). Age-0 rockfish were the most abundant age-0 marine fish species in 2016 followed by pollock, Pacific cod, and arrowtooth flounder (Figure 1-5, Table 1).

Distribution of groundfish in pelagic waters varied among species and years (Figure 2-5). Age-0 Pacific cod were commonly distributed over the shelf (50-200 m bottom depth) and within 20 nm from shore. Age-0 pollock were more widely distributed, occupying shelf, slope, and basin domains (50-2000 m bottom depth). Age-0 rockfish were the most widely distributed species in the eastern Gulf of Alaska; occupying shelf, slope, and basin domains up to 100nm from shore. Arrowtooth flounder were typically found offshore, with the exception of in 2012.

Center of gravity indicated that age-0 Pacific cod were distributed farther north during recent warm years (2014-2015), whereas age-0 pollock, age-0 arrowtooth flounder, and age-0 rockfish

were not (Figure 6). Range expansion and contraction occurred for all species (Figure 7). Arrowtooth flounder expanded their range in the survey area during odd-numbered years, while the age-0 P cod occupied a larger area during even-numbered years (Figure 7). Age-0 pollock occupied a larger area during 2015. Age-0 rockfish occupied a larger area during cold years (2011-2013) and smaller area during warm years (2014-2016) (Figure 7).

Factors causing trends: Lower abundances of groundfish in pelagic waters during 2011 are believed to be in response to poor primary production (Strom et al. 2016) and an increased abundance of salps (Li et al. 2016), which further reduced the amount of plankton available transfer energy to upper trophic levels. Piscivorous predators not common to the eastern Gulf of Alaska were present in the eastern Gulf of Alaska during 2014, and 2015, presumably in response to unprecedented warming in the eastern Pacific Ocean commonly referred to as the 'Warm Blob' (Bond et al. 2015). Additional predation pressure by these warm water predators may have reduced the amount of age-0 marine fish that would have otherwise been present.

Implications: Lower abundances of groundfish in surface waters during 2011 indicate a change in productivity in pelagic waters that affected all species of age-0 marine fish. Warm conditions during 2014 and 2015 appeared to benefit age-0 pollock and Pacific cod, but not arrowtooth flounder or rockfish.

References:

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.

R Core Team 2016. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

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 72(5):1297-1310. doi:10.1093/icesjms/fsu243

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

Thorson, J.T., M.L. Pinsky, and E.J. Ward. 2016b. Model-based inference for estimating shifts in species distribution, area occupied and centre of gravity. Methods in Ecology and Evolution 7(8):990-1002.

Thorson, J.T., A. Rindorf, J. Gao, D.H. Hanselman, and H. Winker. 2016c. Density-dependent changes in effective area occupied for sea-bottom-associated marine fishes. Proceedings of the Royal Society B 283(1840):20161853.

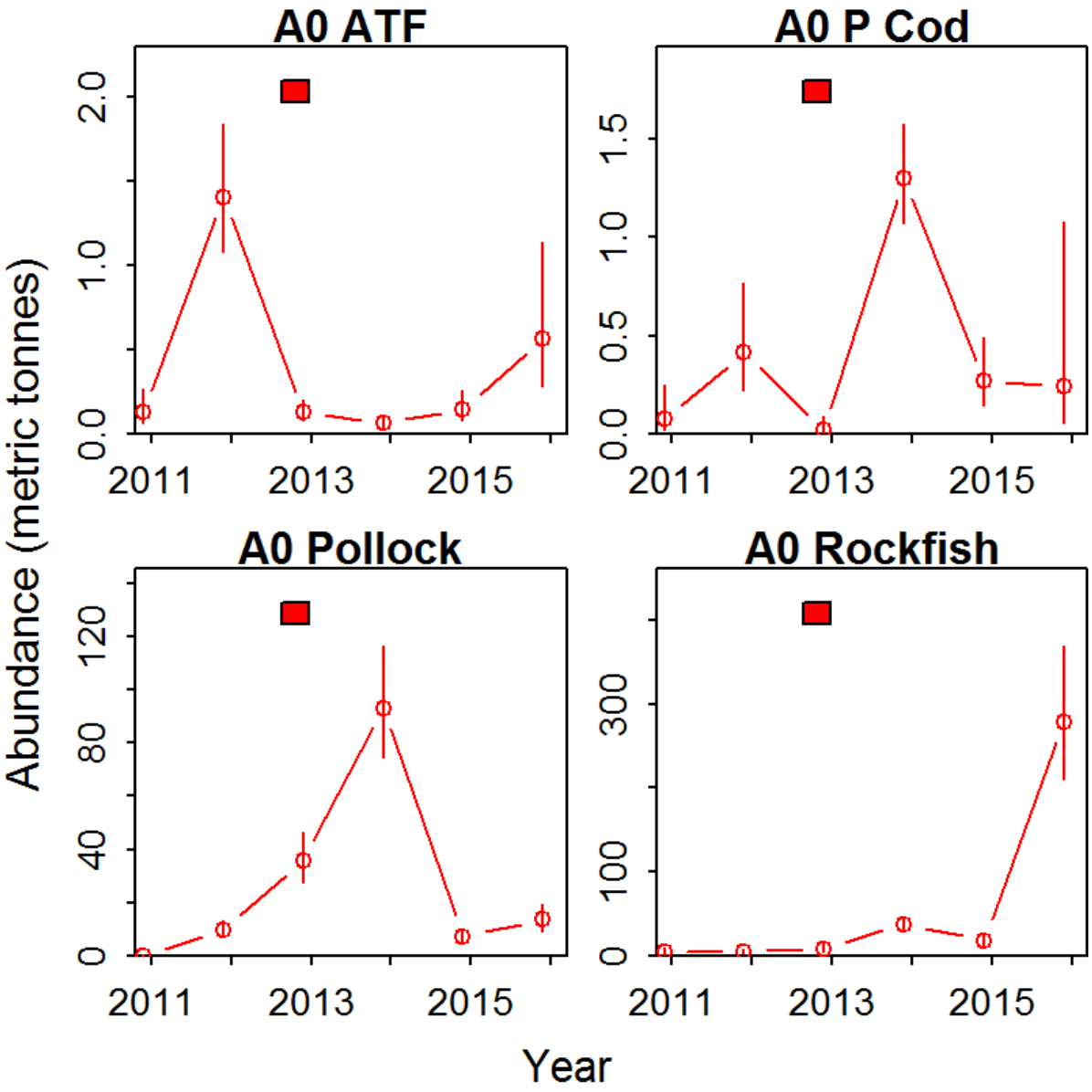

Figure 1. Index of abundance (metric tonnes) plus/minus 1 standard error for groundfish species in pelagic waters of the eastern Gulf of Alaska during summer, 2011-2016.

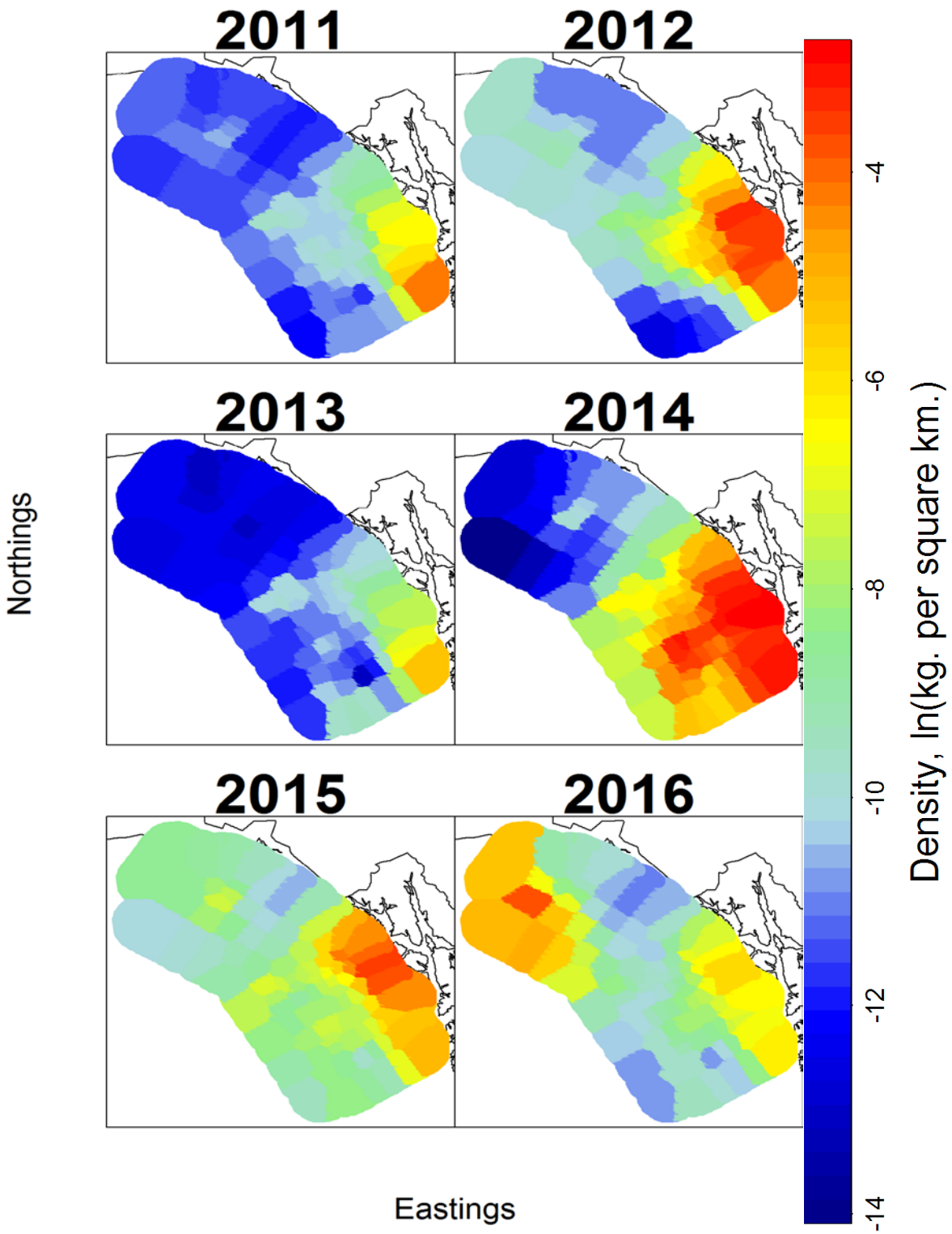

Figure 2. Predicted field densities of age-0 Pacific cod in pelagic waters of the eastern Gulf of Alaska during summer, 2011-2016.

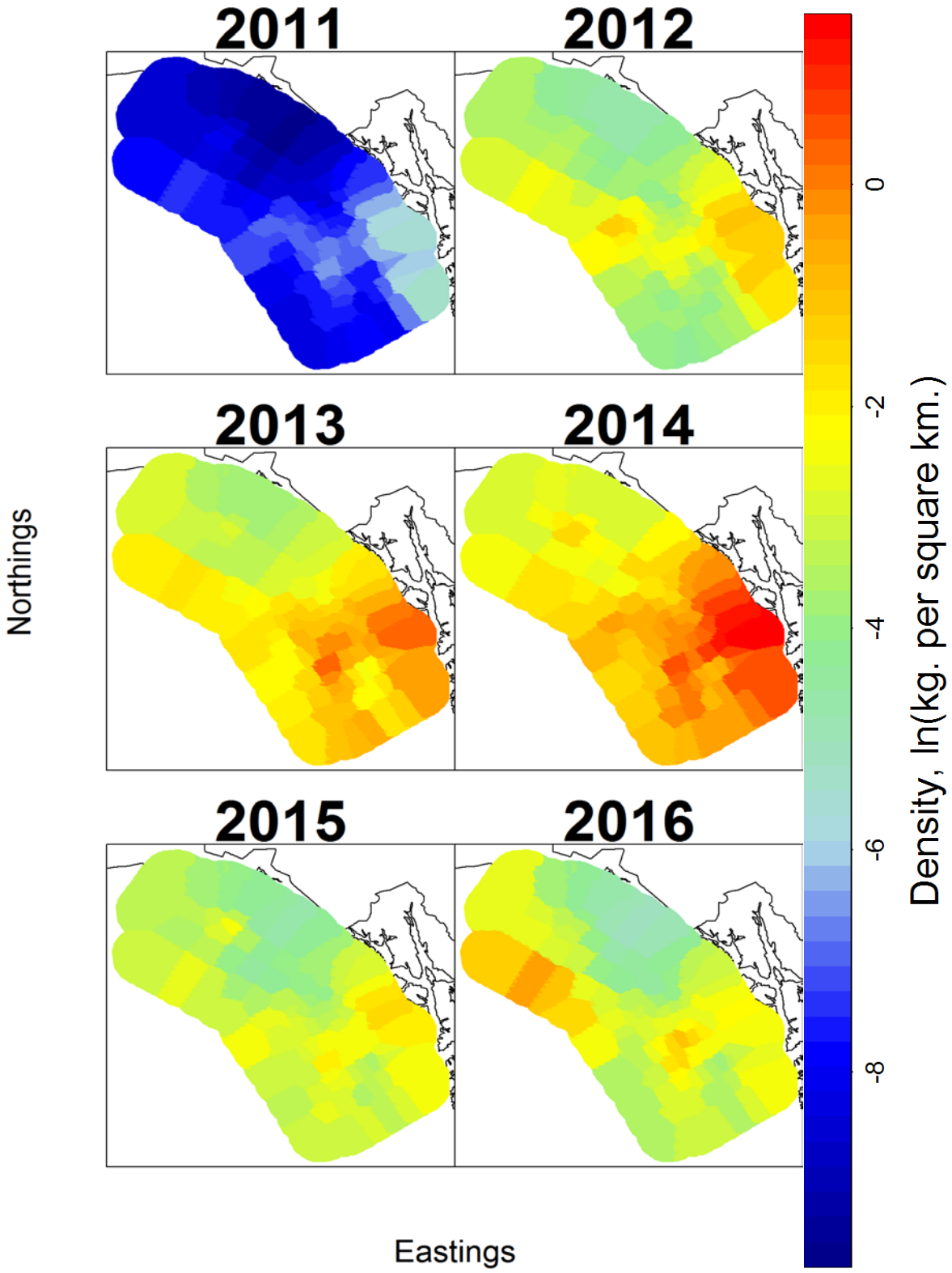

Figure 3. Predicted field densities of age-0 pollock in pelagic waters of the eastern Gulf of Alaska during summer, 2011-2016.

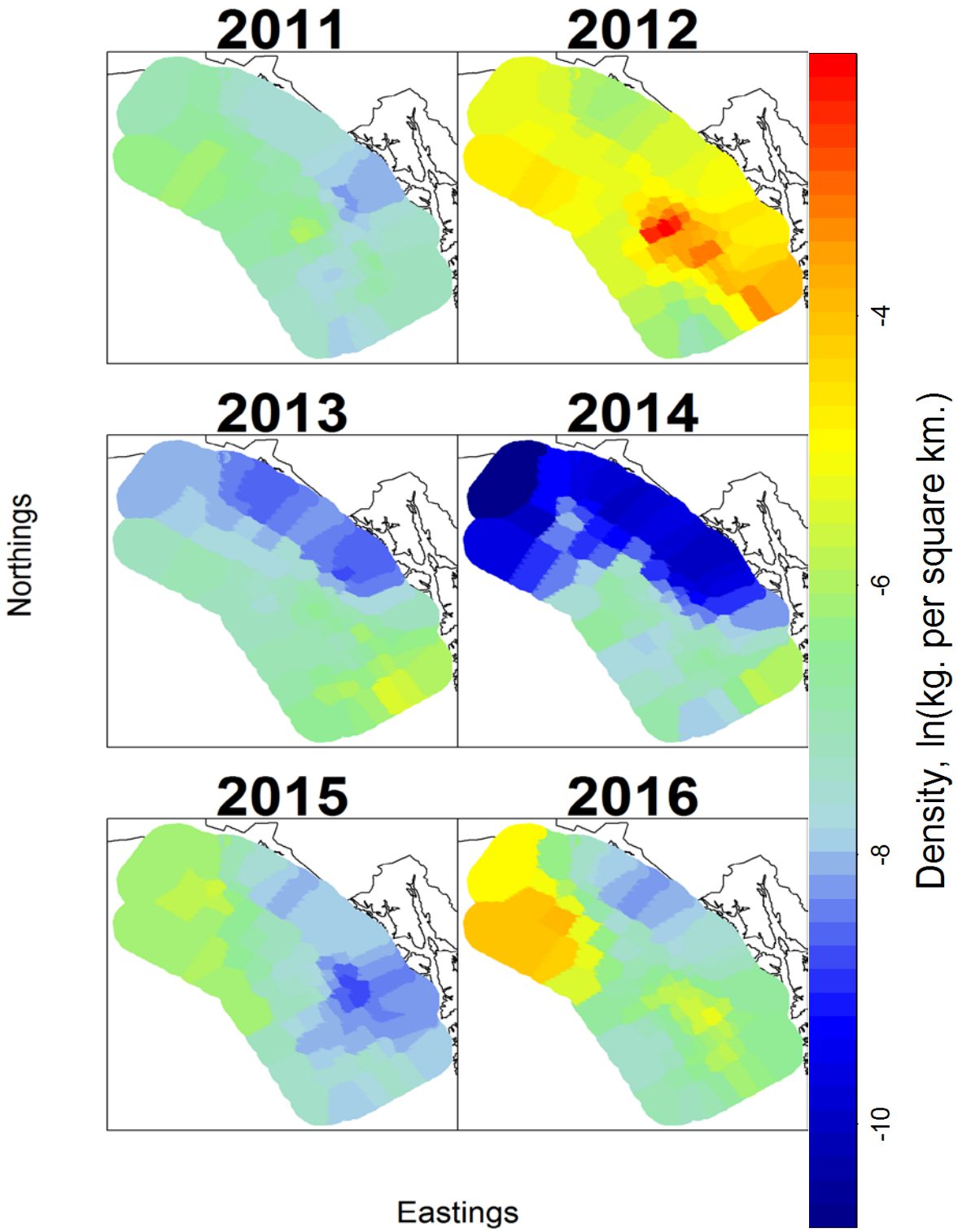

Figure 4. Predicted field densities of age-0 arrowtooth flounder in pelagic waters of the eastern Gulf of Alaska during summer, 2011-2016.

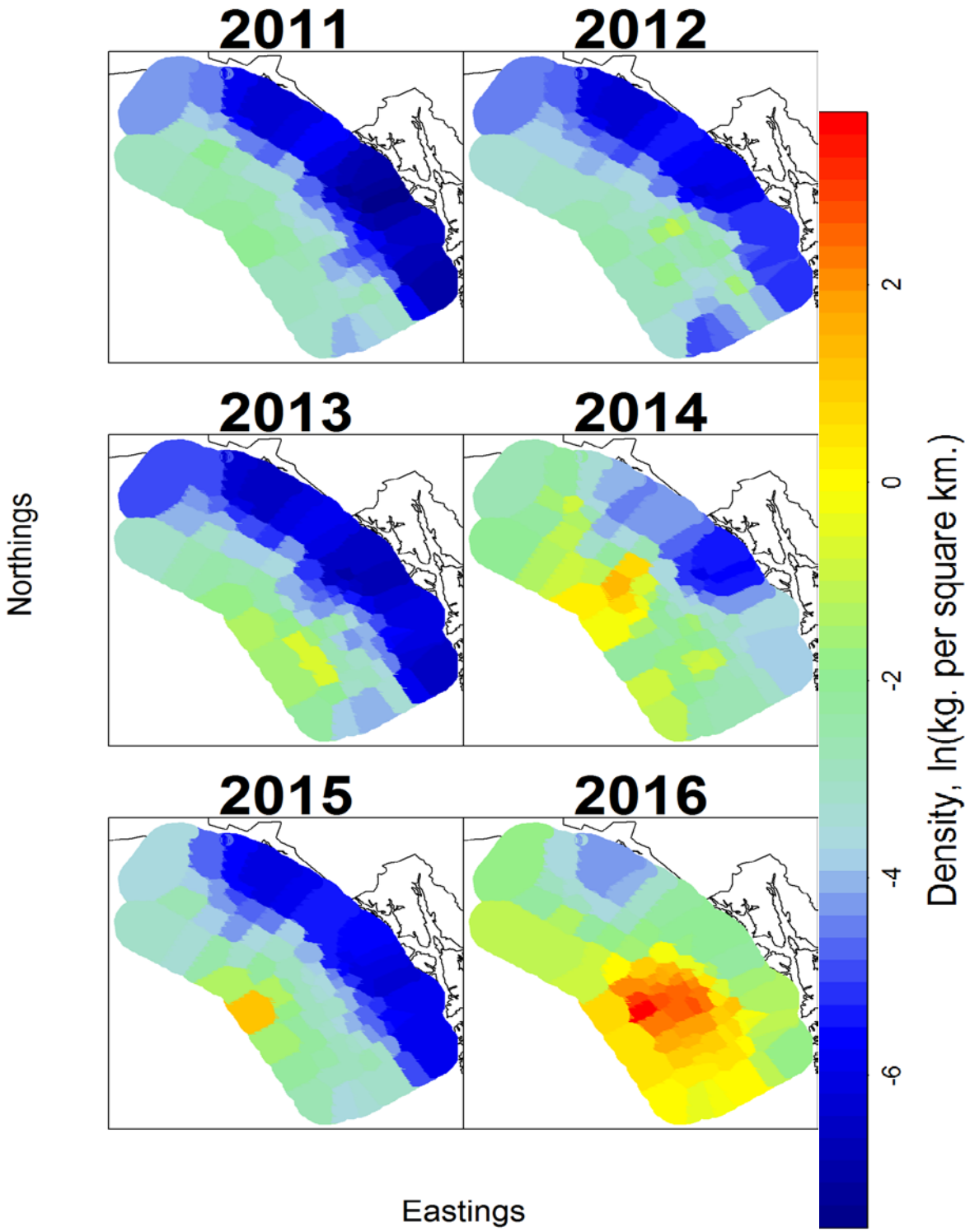

Figure 5. Predicted field densities of age-0 rockfish pelagic waters of the eastern Gulf of Alaska during summer, 2011-2016.

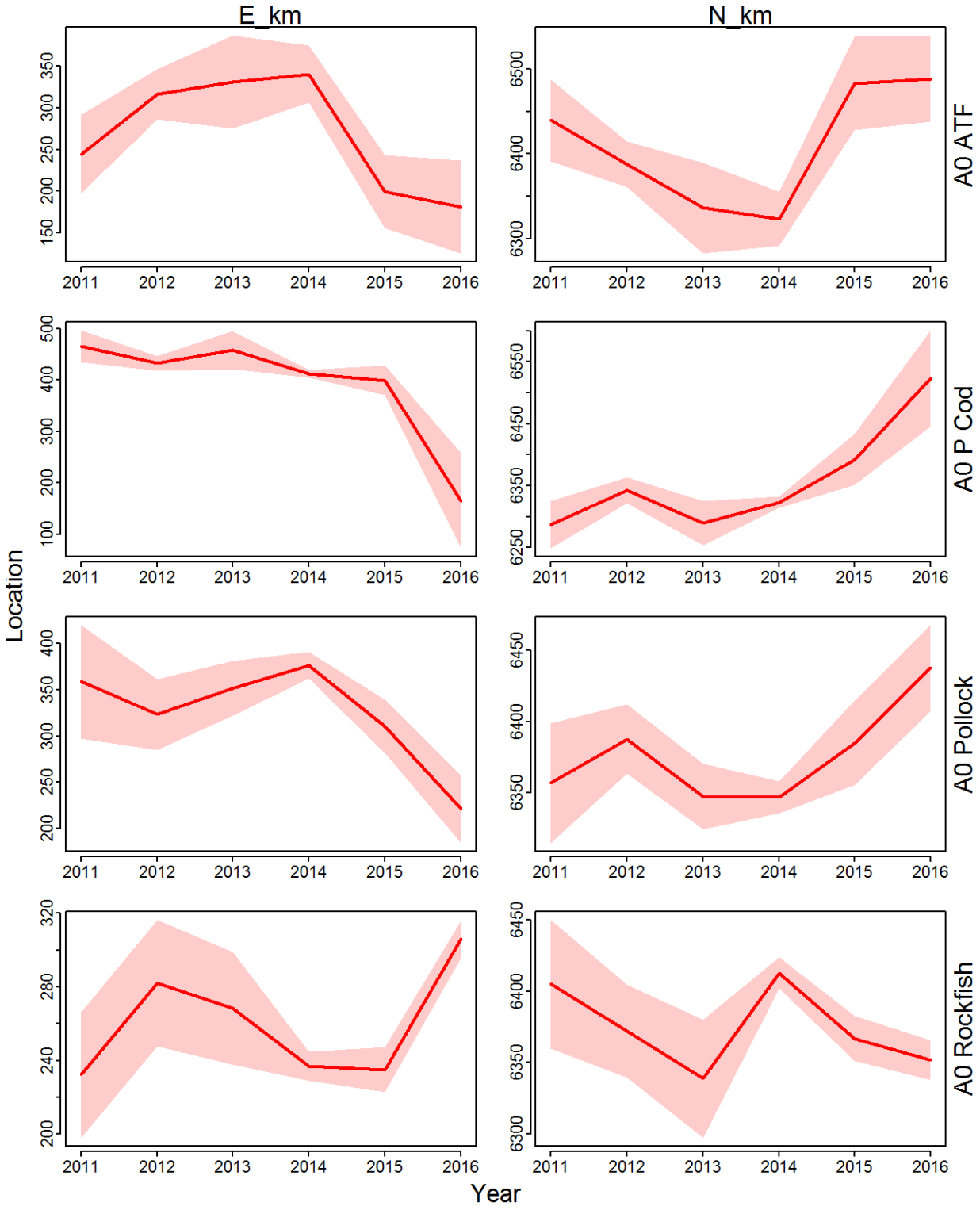

Figure 6. Center of gravity indicating temporal shifts in the mean east-to-west and north-to-south distribution plus/minus 1 standard error in UTM (km) for groundfish in pelagic waters of the eastern Gulf of Alaska during summer, 2011-2016.

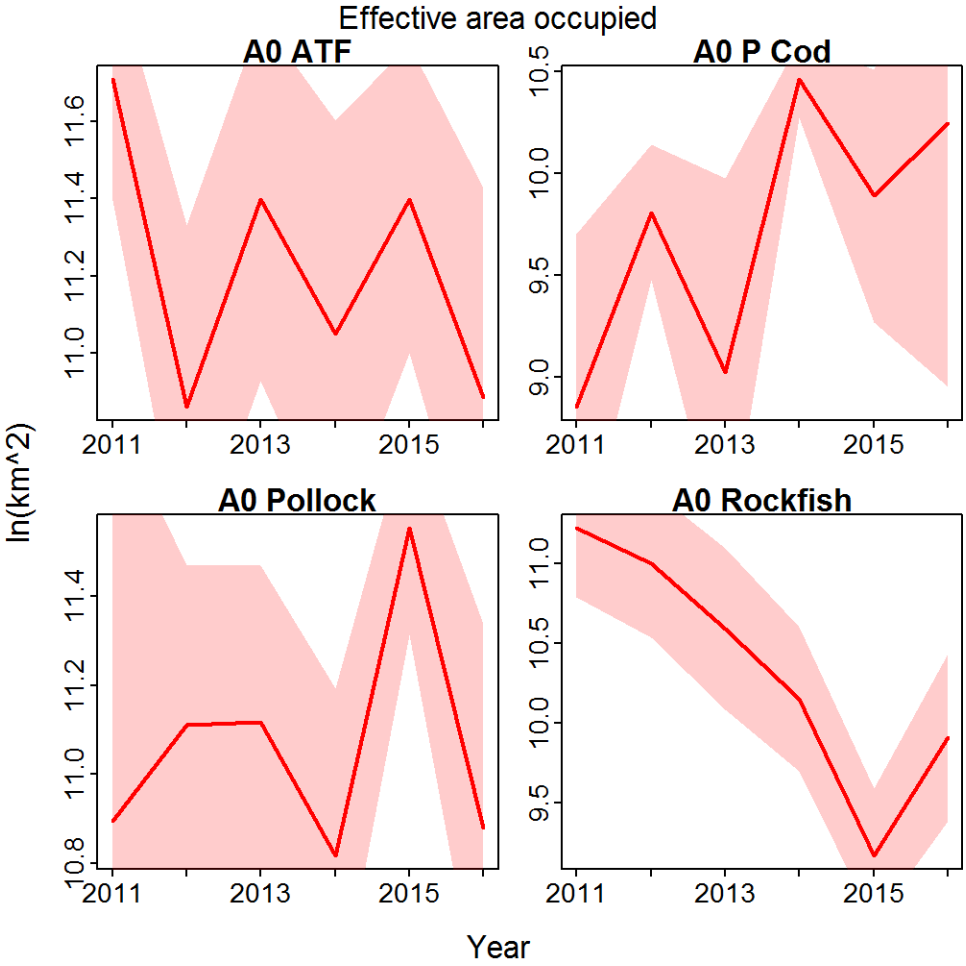

Figure 7. Effective area occupied (ln(km^2)) indicating range expansion/contraction plus/minus 1 standard error for groundfish in pelagic waters of the eastern Gulf of Alaska during summer, 2011-2016.

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

Category	Year	Estimate_metric_tons	SD_mt
ATF	2011	0.133288	0.091551
ATF	2012	1.407965	0.374294
ATF	2013	0.131508	0.058734
ATF	2014	0.066856	0.029269
ATF	2015	0.147957	0.084153
ATF	2016	0.569463	0.394218
P Cod	2011	0.075669	0.091373
P Cod	2012	0.415345	0.255209
P Cod	2013	0.023238	0.031646
P Cod	2014	1.297332	0.247807
P Cod	2015	0.271385	0.160566
P Cod	2016	0.244119	0.36297
Pollock	2011	0.091556	0.153961
Pollock	2012	9.549102	3.094399
Pollock	2013	35.83846	9.439356
Pollock	2014	93.13981	20.84864
Pollock	2015	7.290406	2.584512
Pollock	2016	13.53925	4.956674
Rockfish	2011	4.621313	3.351419
Rockfish	2012	4.6099	2.074678
Rockfish	2013	8.309468	4.901025
Rockfish	2014	37.79021	7.778197
Rockfish	2015	18.11566	7.017681
Rockfish	2016	278.8128	78.18626