2022 preliminary Pribilof Islands red king crab assessment

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May 19, 2022

Crab Plan Team

1. **Stock**: Pribilof islands red king crab (PIRKC), *Paralithodes camtschaticus*.
2. **Catches**: Retained catches have not occurred since 1998/1999. Bycatch has been sporadic since the late 2000s. In general, total bycatch is a small fraction of the overfishing level (OFL).
3. **Stock biomass**: In recent years, observed mature male biomass (>120mm carapace length) peaked in 2015, however this peak in biomass does not appear to represent the actual dynamics of the stock. The size composition data suggest that a cohort established in the early 2000s and fluctuations seen over that period in biomass were likely due to observation error. A new cohort appears to have entered the population in 2018. The stock is not overfished based on a tier 4 specification of B_{MSY} revised in 2019.
4. **Recruitment**: Recruitment appears to be episodic and, depending on the model specification, three or four cohorts have passed through the population since the late 1980s.
5. **Recent management statistics**: PIRKC is now on a triennial assessment cycle and was last assessed in 2019. GMACS is now used as the preferred assessment model.

Summary of major changes

1. **Management**: This is the first assessment since PIRKC shifted to a triennial management cycle in 2019.
2. **Input data**: Survey and bycatch data were updated with the most recent data in this draft. Some small adjustments were made to the recent years of bycatch data after a new download from AKFIN. Data from 2022 will be incorporated into this draft for September.
3. **Assessment methodology**: GMACS was adopted in 2019 as the assessment methodology for this stock. B_{MSY} was redefined in 2019 as 35% of the average MMB observed from 2000-present, which was a period of no fishing.
4. **Assessment results**: Overfishing did not occur from 2019-2021 and the stock was not overfished as of the summer of 2021.

CPT and SSC comments/requests from 9/2019:

The CPT recommended the following for consideration in the future assessment:

CPT: "Examine the weighting of the length compositions used in the integrated model."

I incorporated two models that modified the weighting of the size composition data (somewhat arbitrarily) for illustrative purposes. Future work could include a more systematic exploration of weighting methodologies (e.g. Francis, McAllister-Ianelli, etc.).

CPT: "A potentially better estimate BMSY would be replay the stock dynamics using the integrated model under the assumption of F=0 (i.e., dynamic B0). BMSY could then be estimated by taking 35% of the average biomass for full period."

Functionality for dynamic B0 does not currently exist in GMACS, but this is on the list of improvements to make.

CPT: "Explore using ADF&G pot survey data for 2003, 2005, 2008, and 2011 in the assessment model."

These data are now in hand and a model incorporating these data will be presented in September.

CPT: "Evaluate the survey or fishery catches adjacent to the defined stock area to see they are indicative of movement into the Pribilof Islands area."

Maps of the survey densities of Bering Sea-wide red king crab and size composition data are now included. The spatio-temporal patterns in distribution provide some clue to the dynamics of interconnection between the crab observed in each of the three main districts in the eastern Bering Sea. I am outlining a proposal to model these dynamics with the goal of understanding how they may change under climate change.

The SSC comments included:

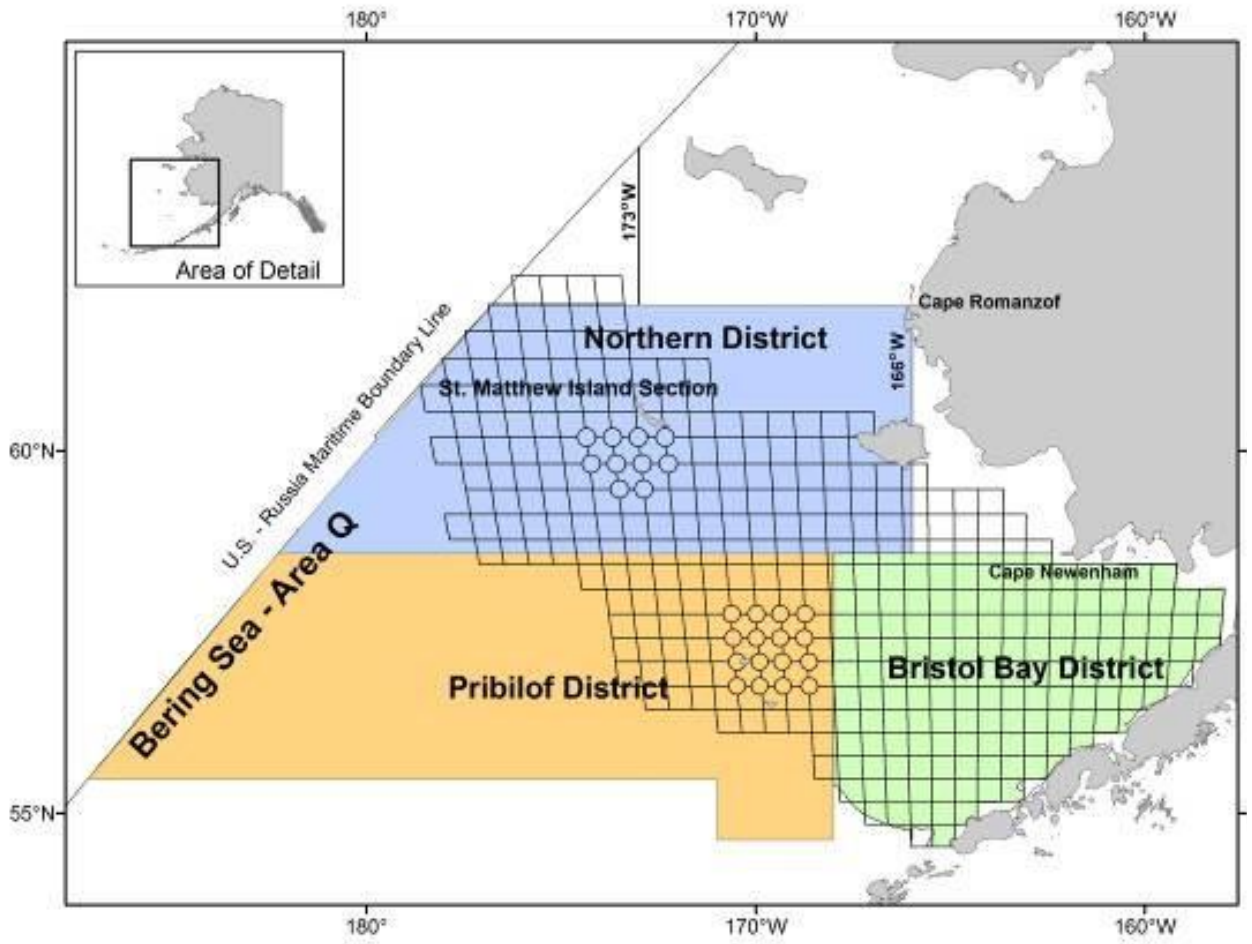
SSC: "The assessment should consider all relevant datasets. Available ADF&G pot survey data should be included."

In addition to the ADF&G pot survey, size composition data for the bycatch from observer data exist. These data will be presented in a model for September. Encouragingly, the cohorts that can be seen in the survey size composition data can be distinguished (though not as well) in the observer data. Incorporating these data should allow for the estimation of the bycatch selectivity rather than specifying it based on Bristol Bay red king crab.

SSC: "The SSC also raises the question whether Pribilof Islands red king crab are a separate stock. Reasons to raise this question include: (1) apparent lack of red king crab in the area in the 1970s and 1980s, (2) increases in stock abundance that do not seem biologically plausible, and (3) distribution of red king crab outside both the Bristol Bay and Pribilof Islands areas. Comparisons of size distributions may shed light on the sudden appearance of cohorts in the survey area."

See response to CPT above.

What are the meta-population dynamics of red king crab in the Bering Sea?


180°
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Area of Detail
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Cape Romanzof
Northern District
St. Matthew Island Section
166° W
U.S. - Russia Maritime Boundary Line
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Bering Sea - Area Q
Cape Newenham
Pribilof District
Bristol Bay District
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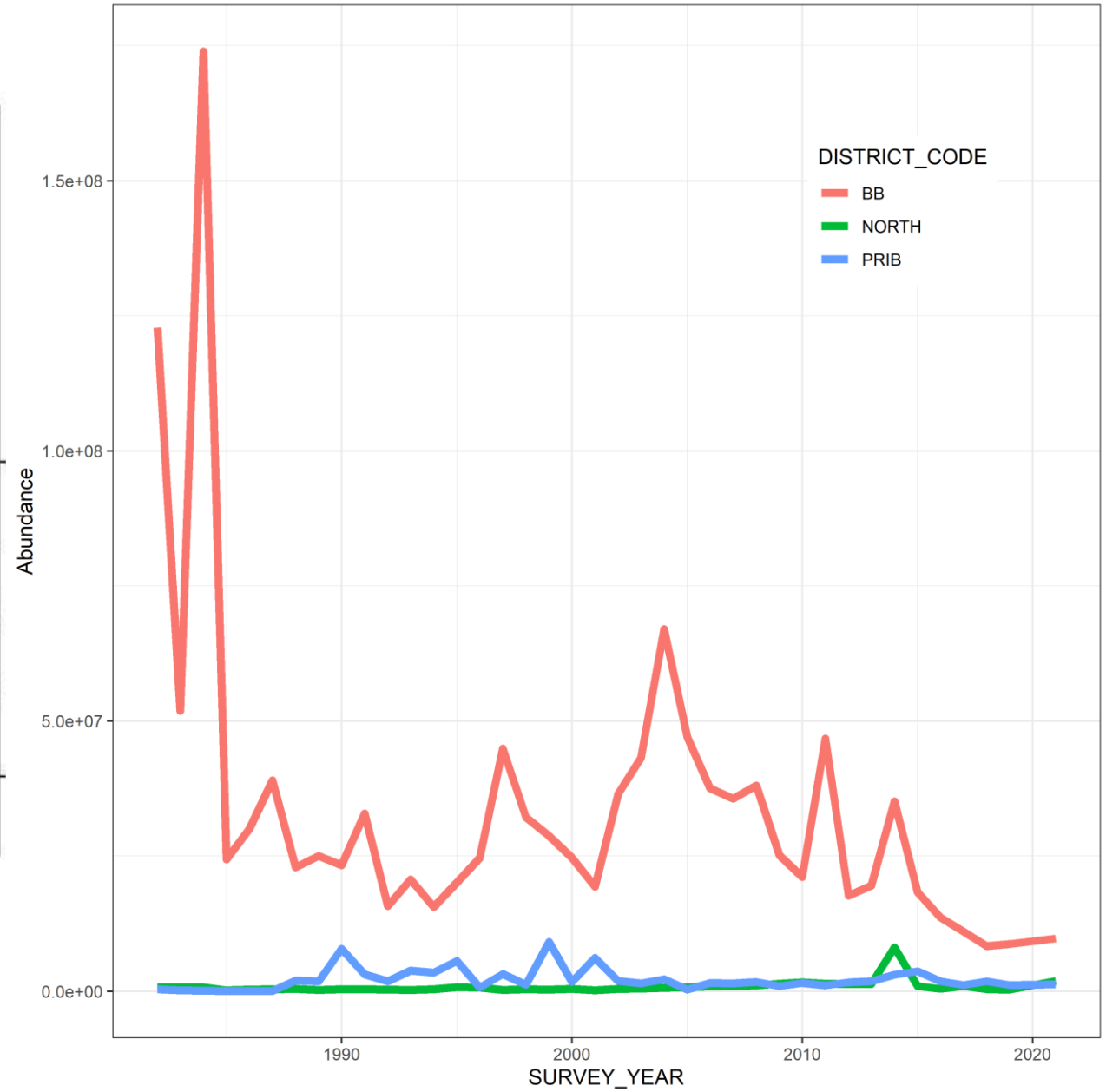
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1990
2000
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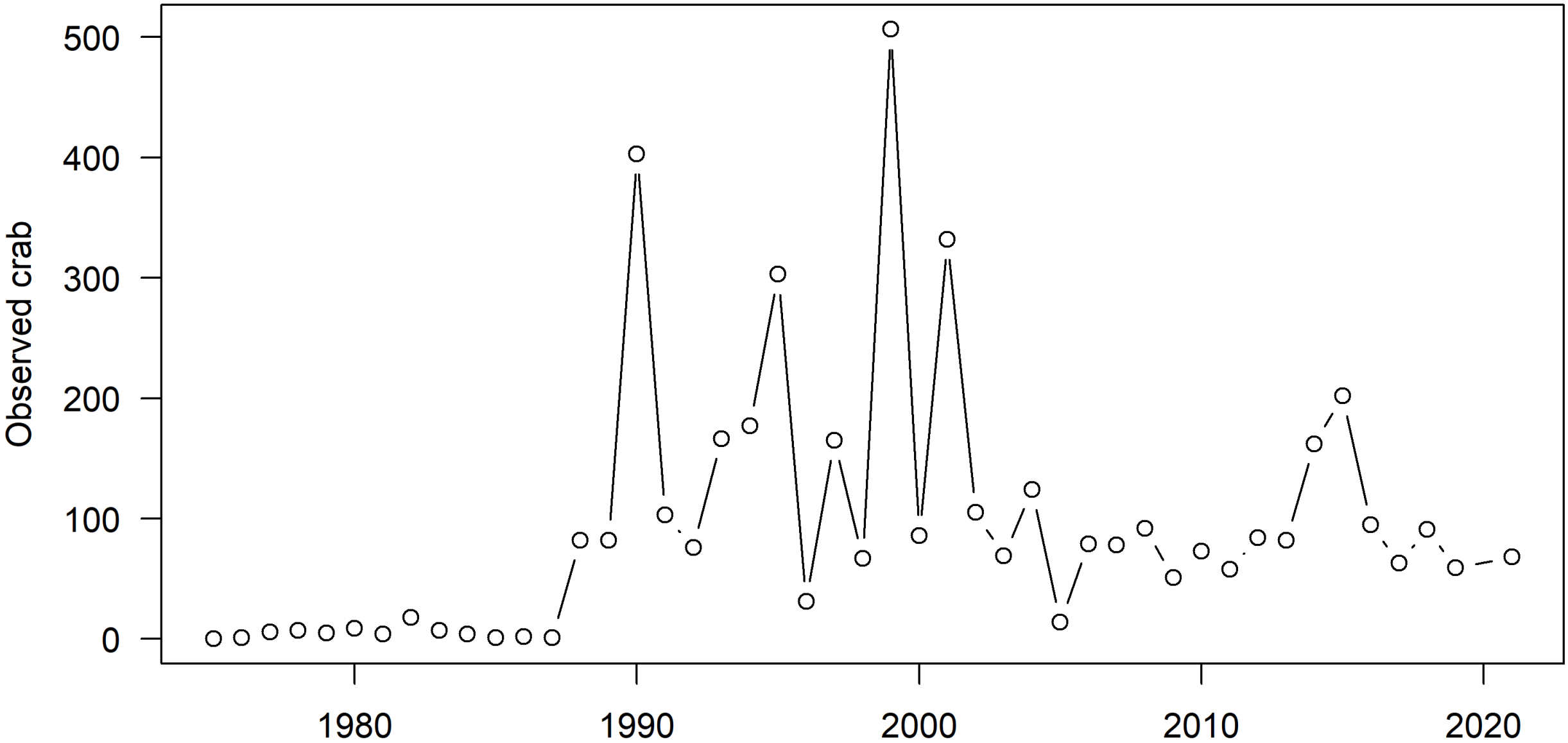
Observed crab
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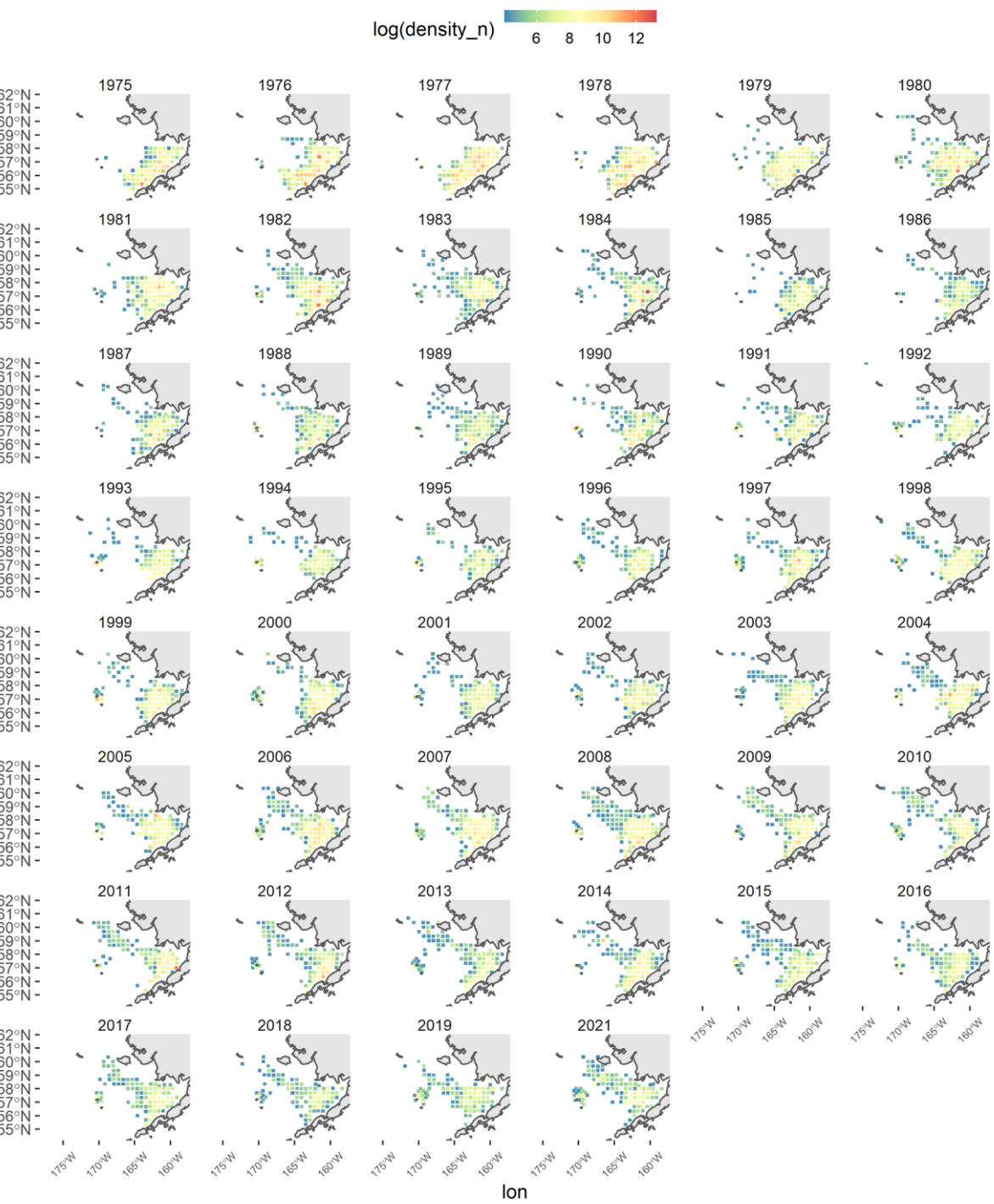
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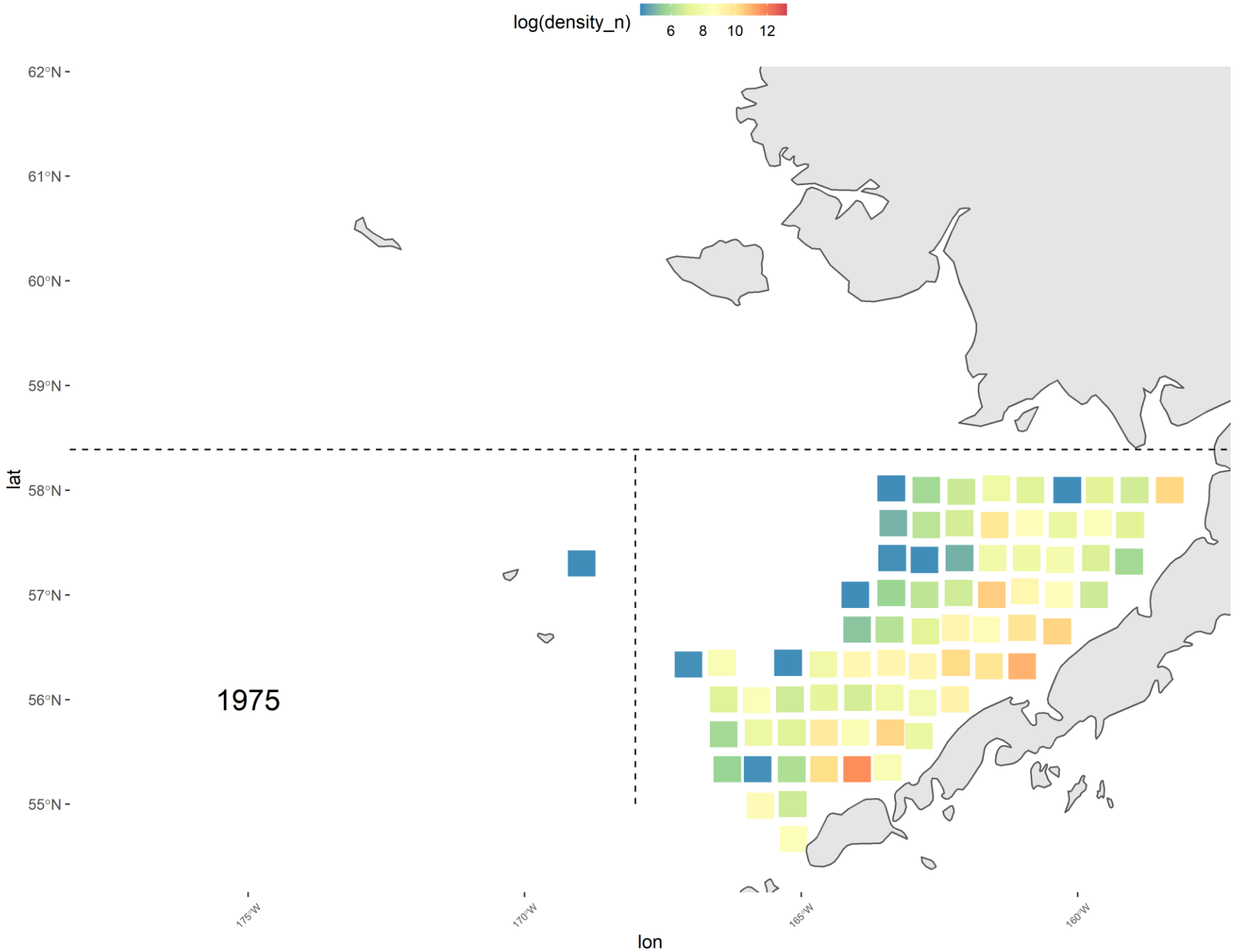
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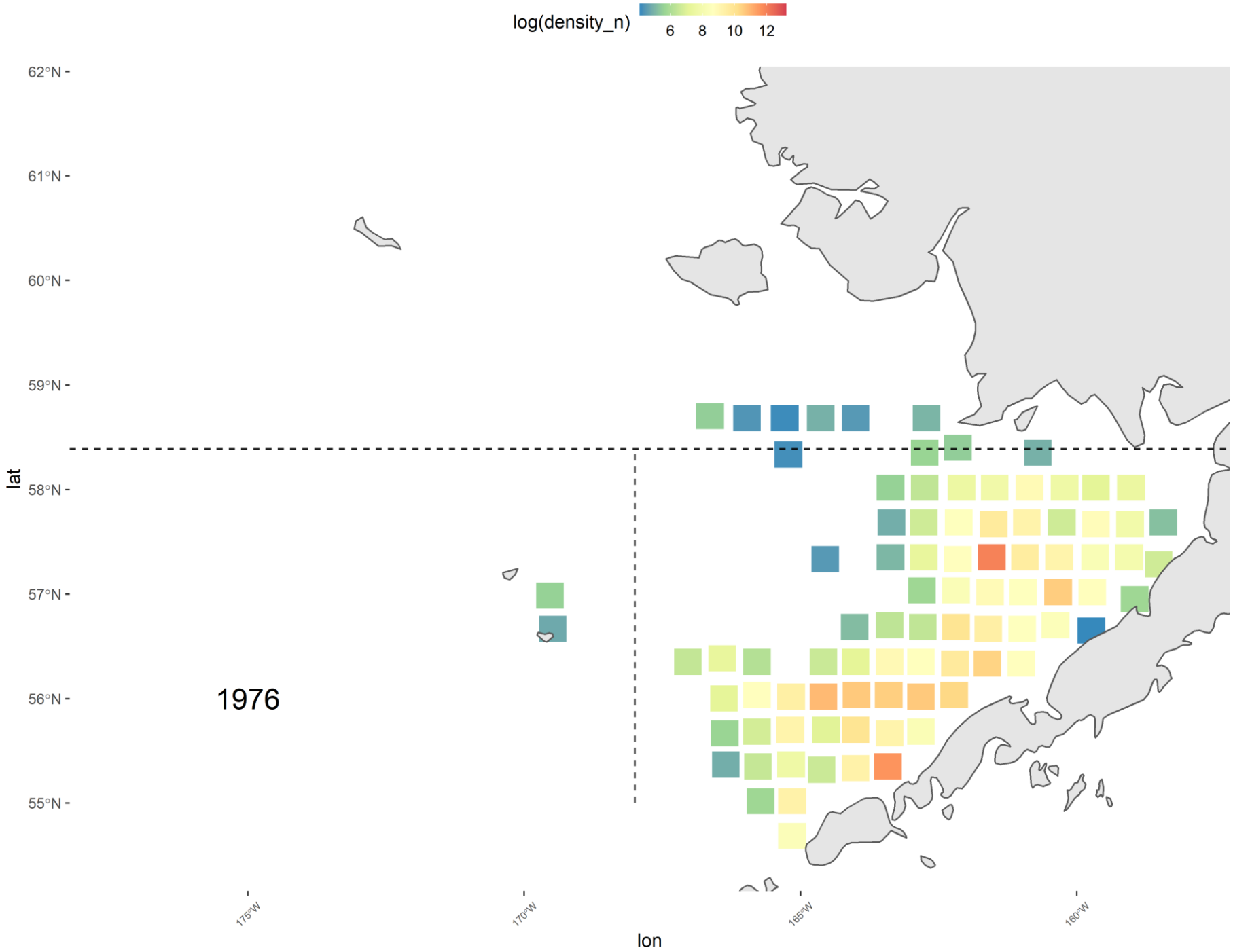
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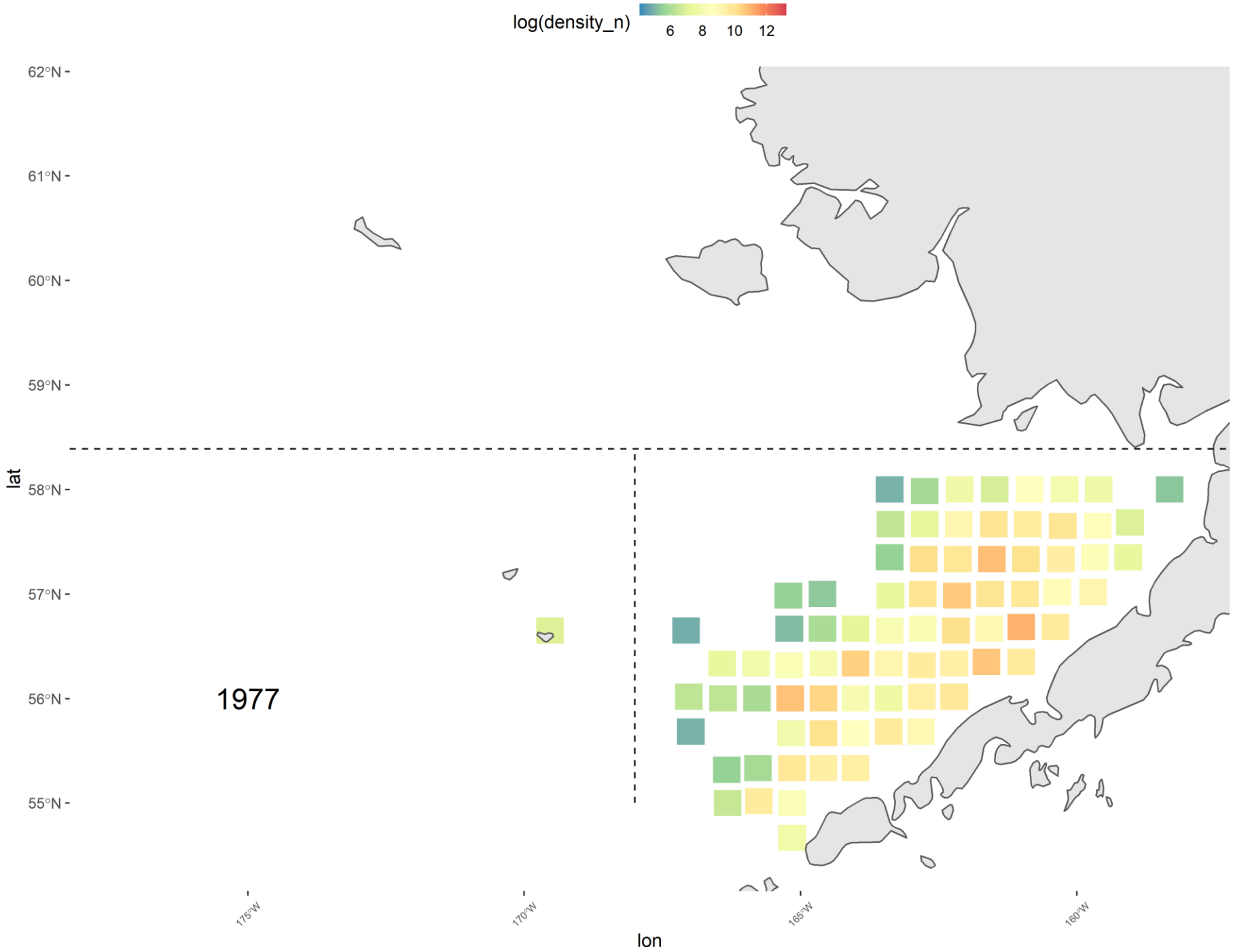
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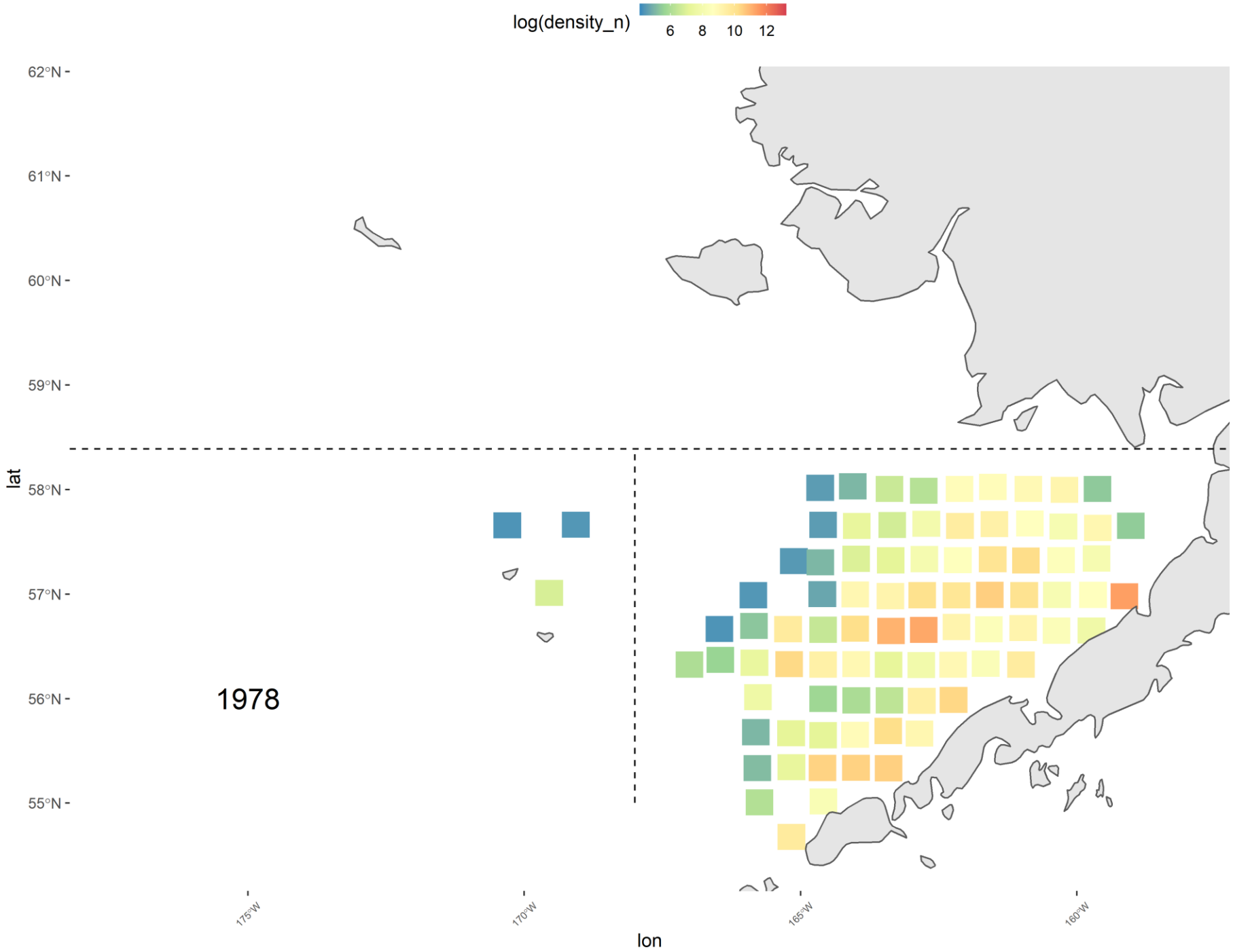
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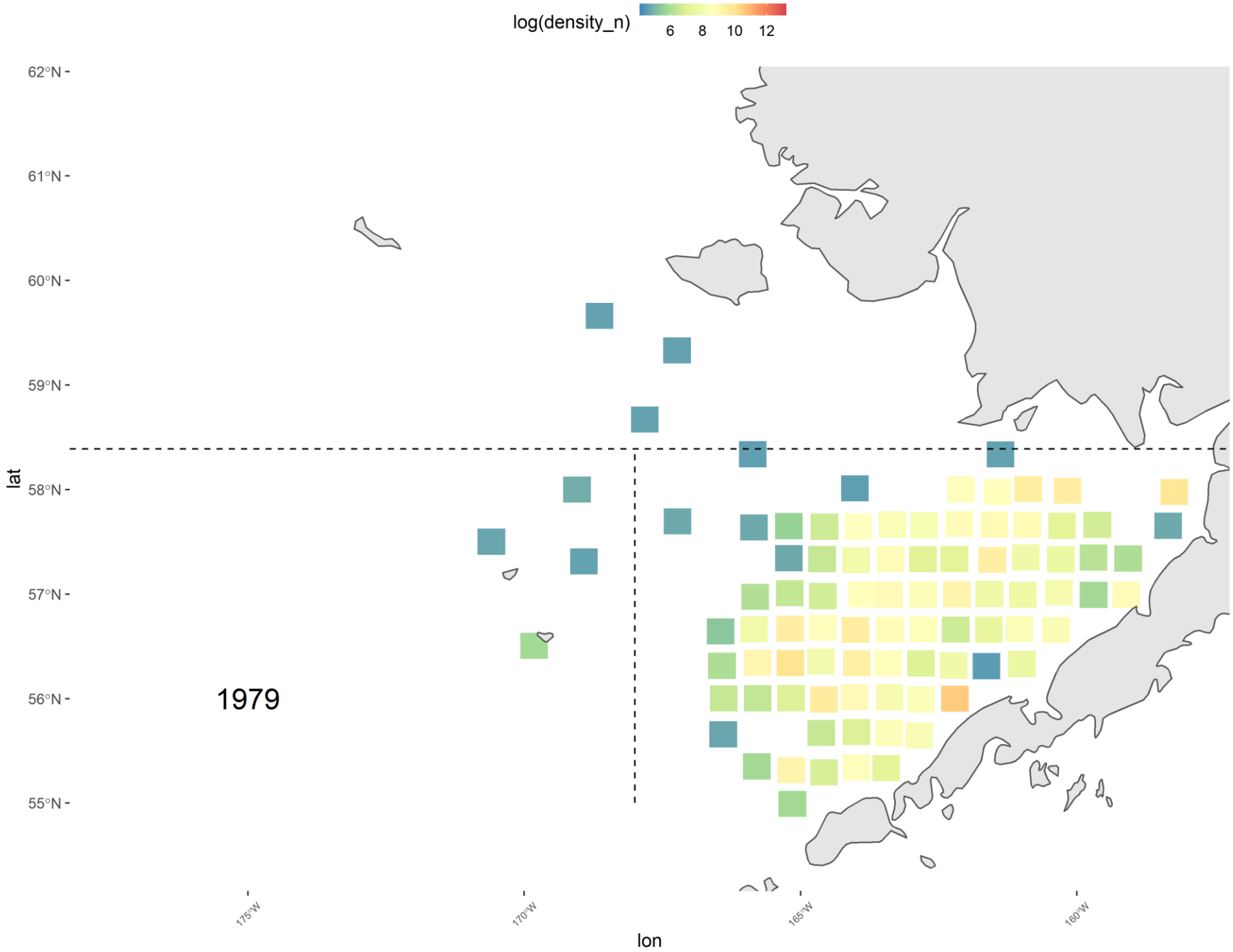
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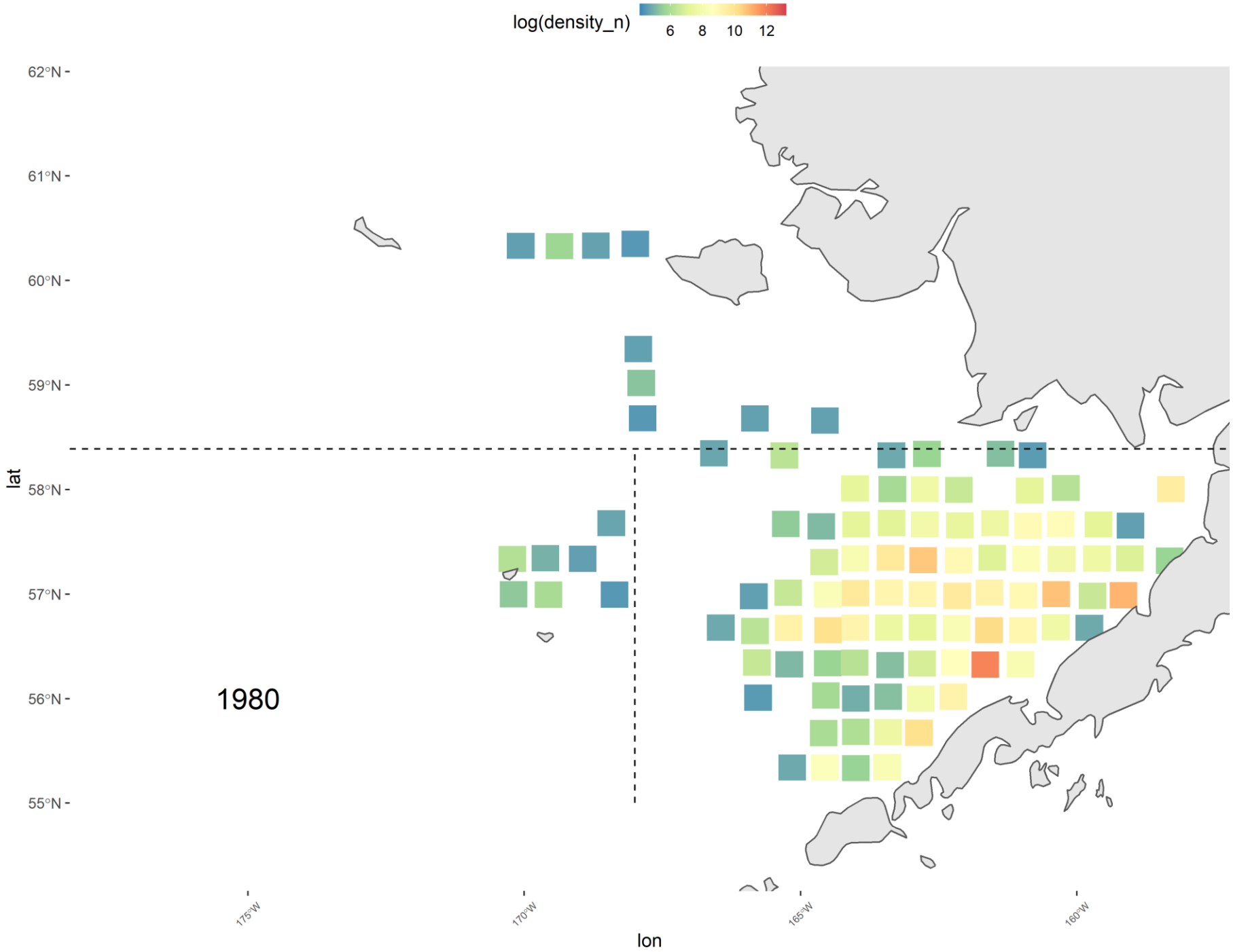
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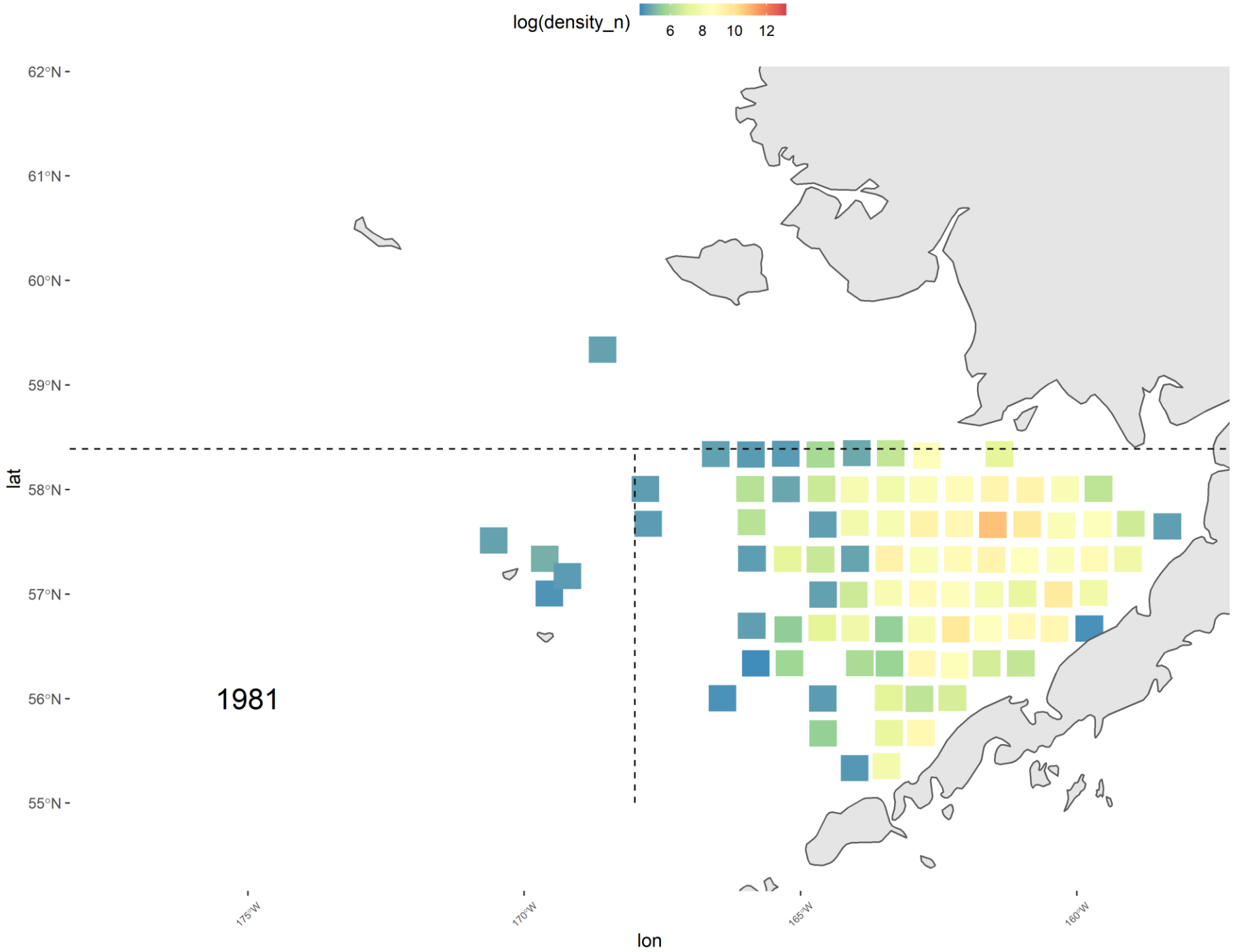
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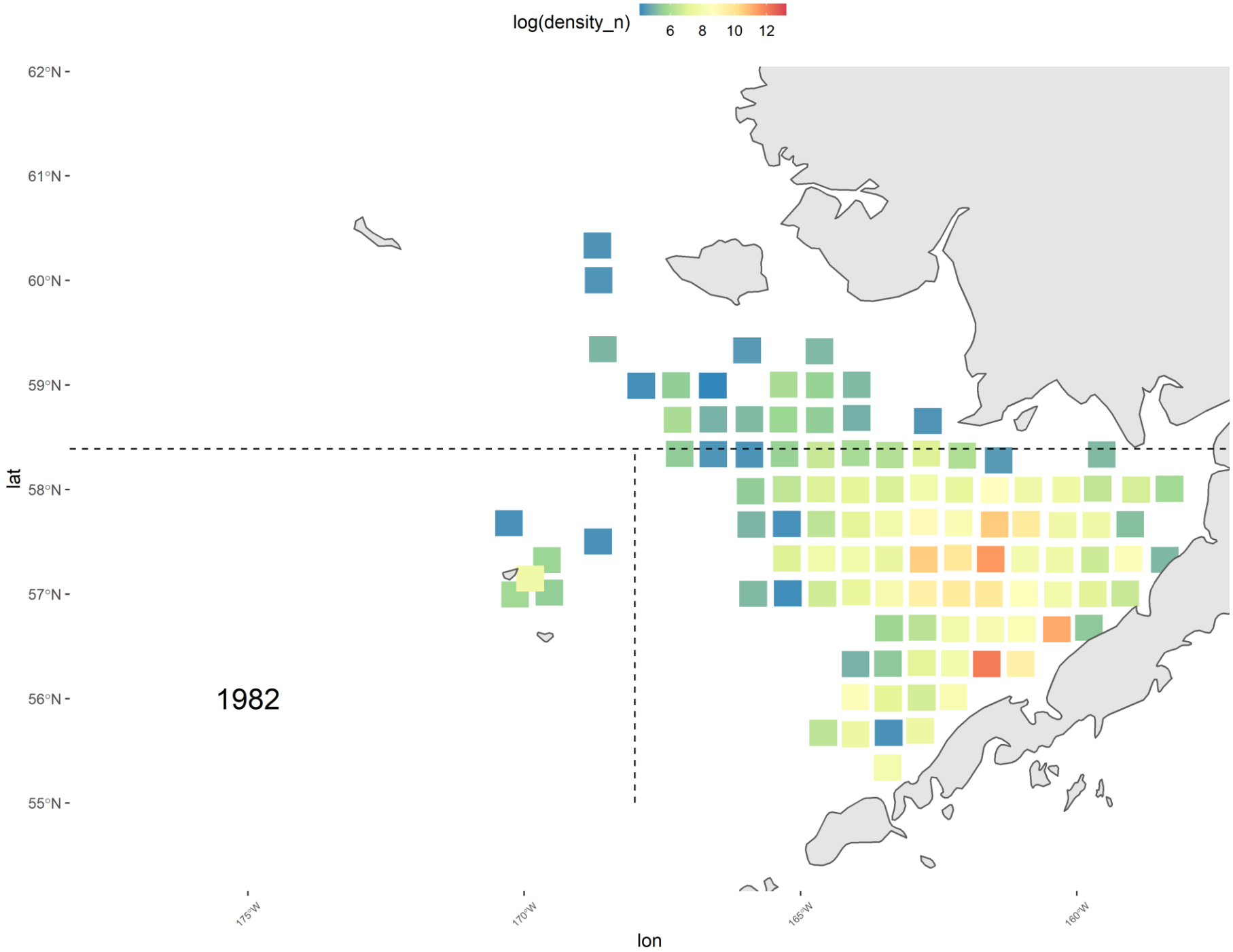
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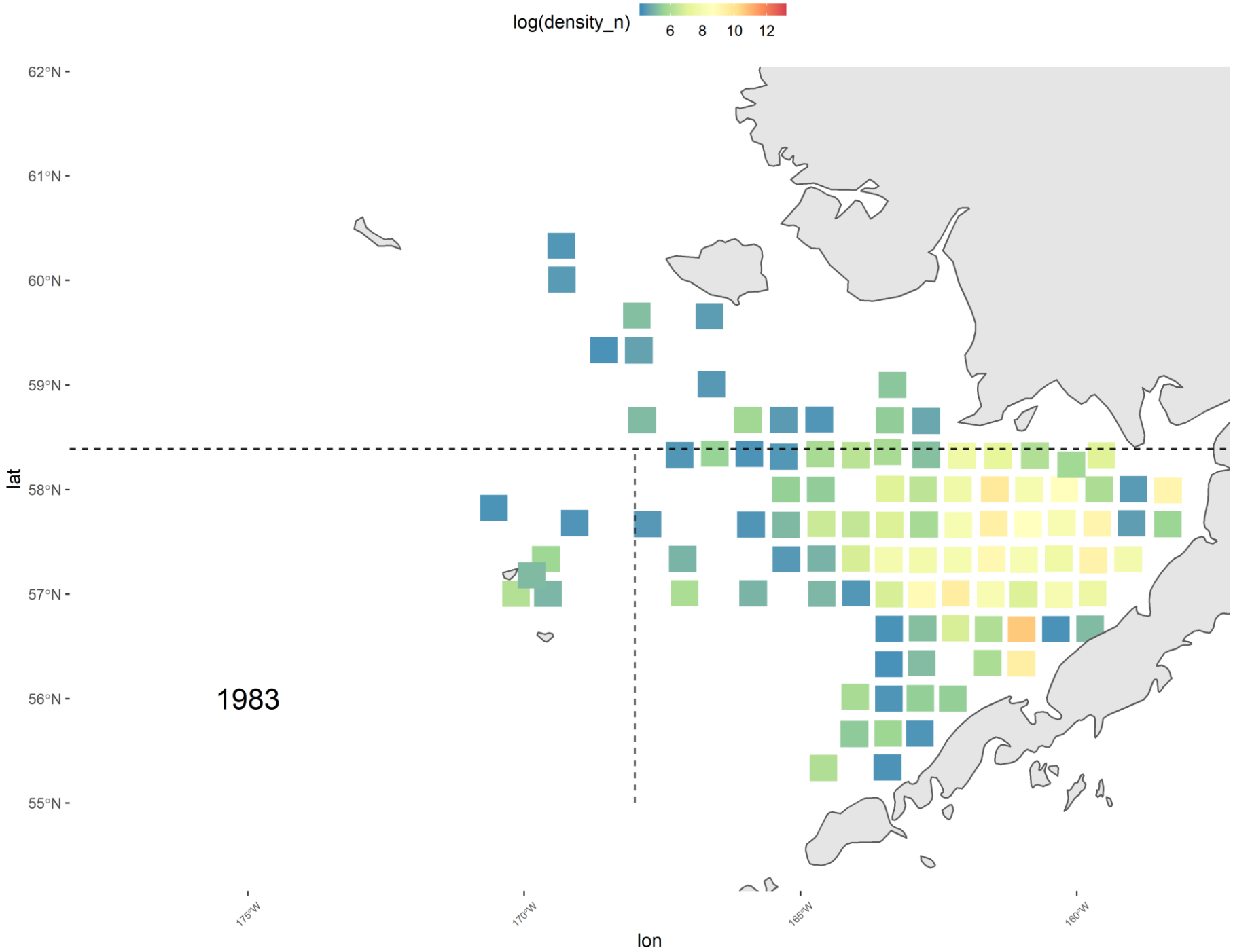
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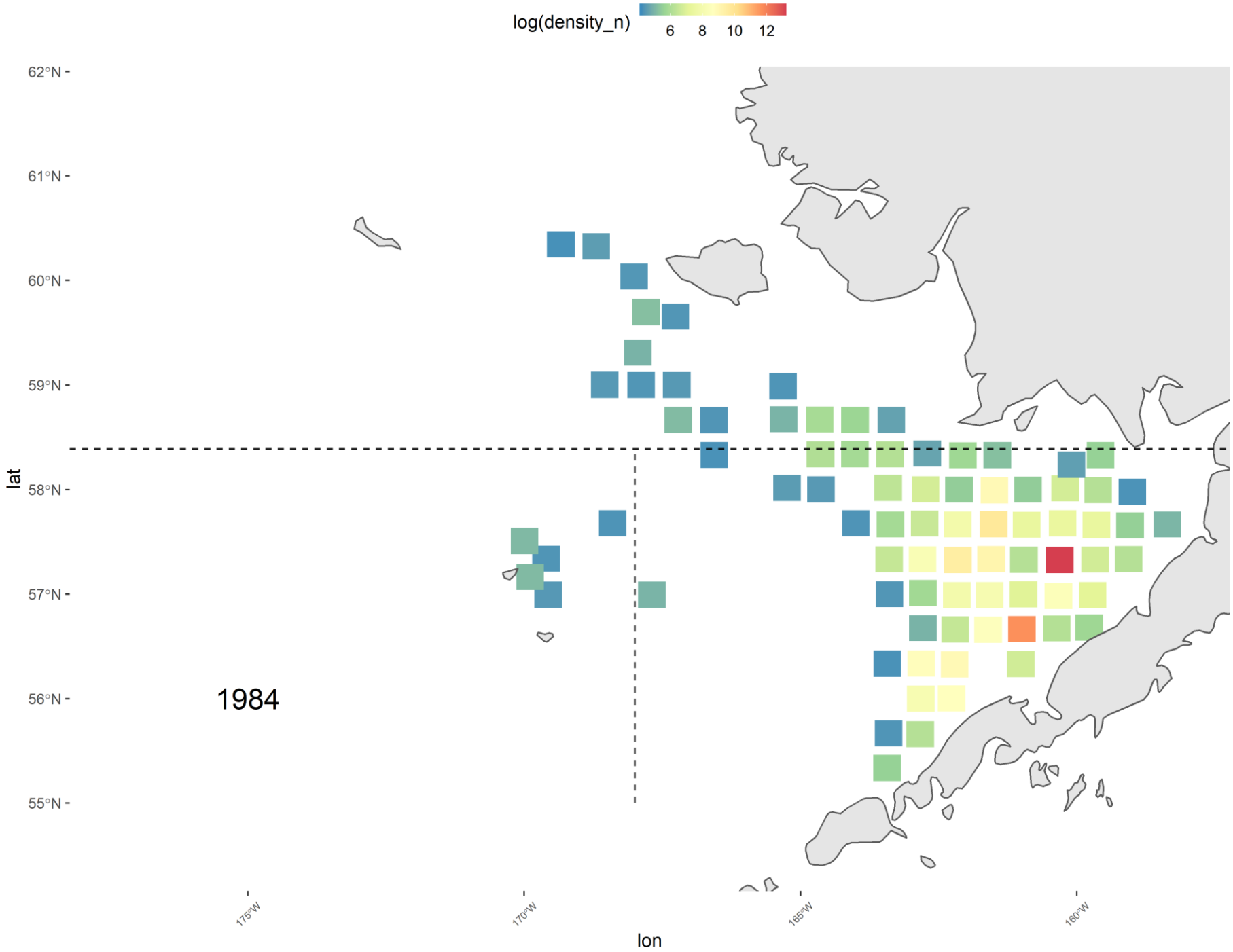
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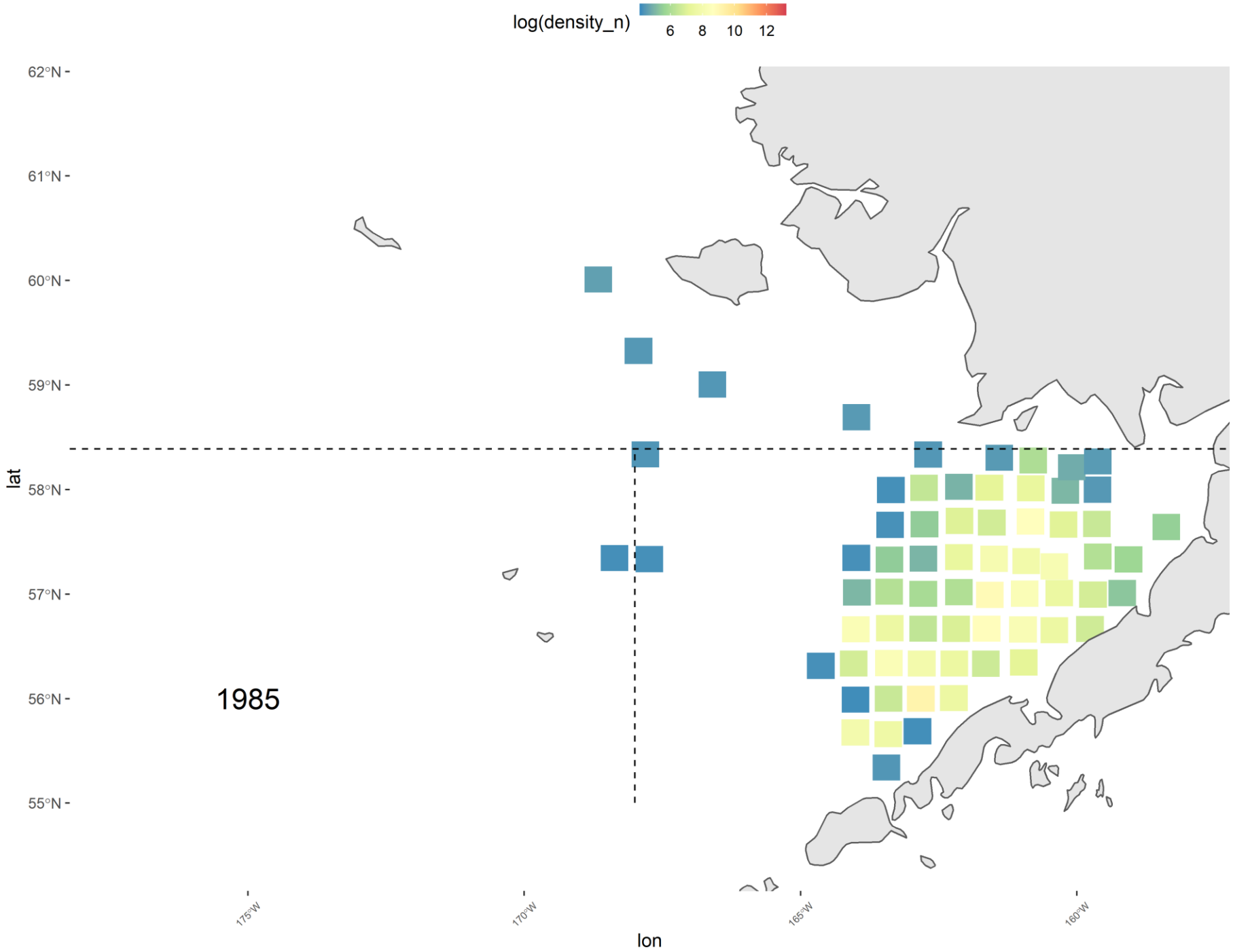
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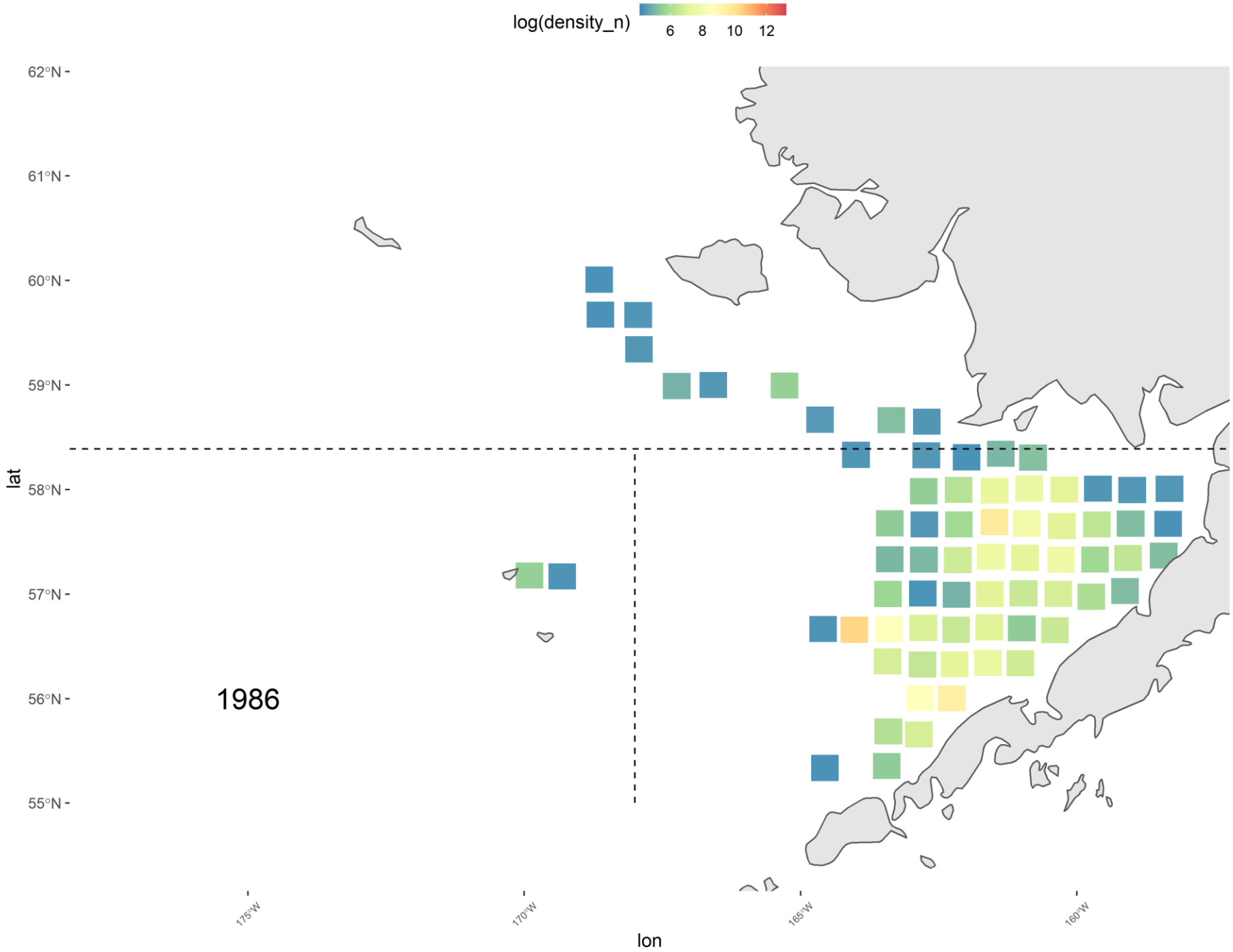
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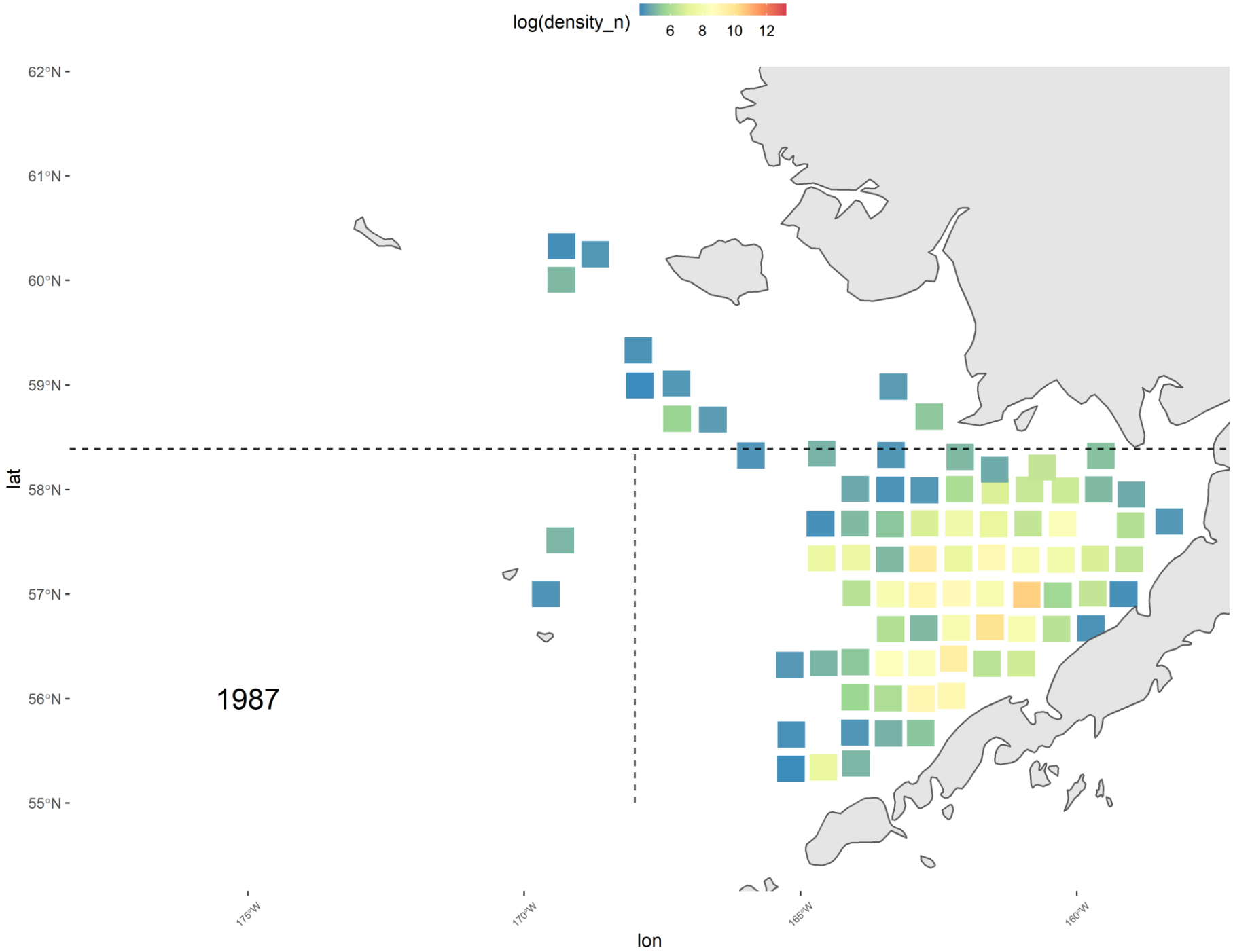
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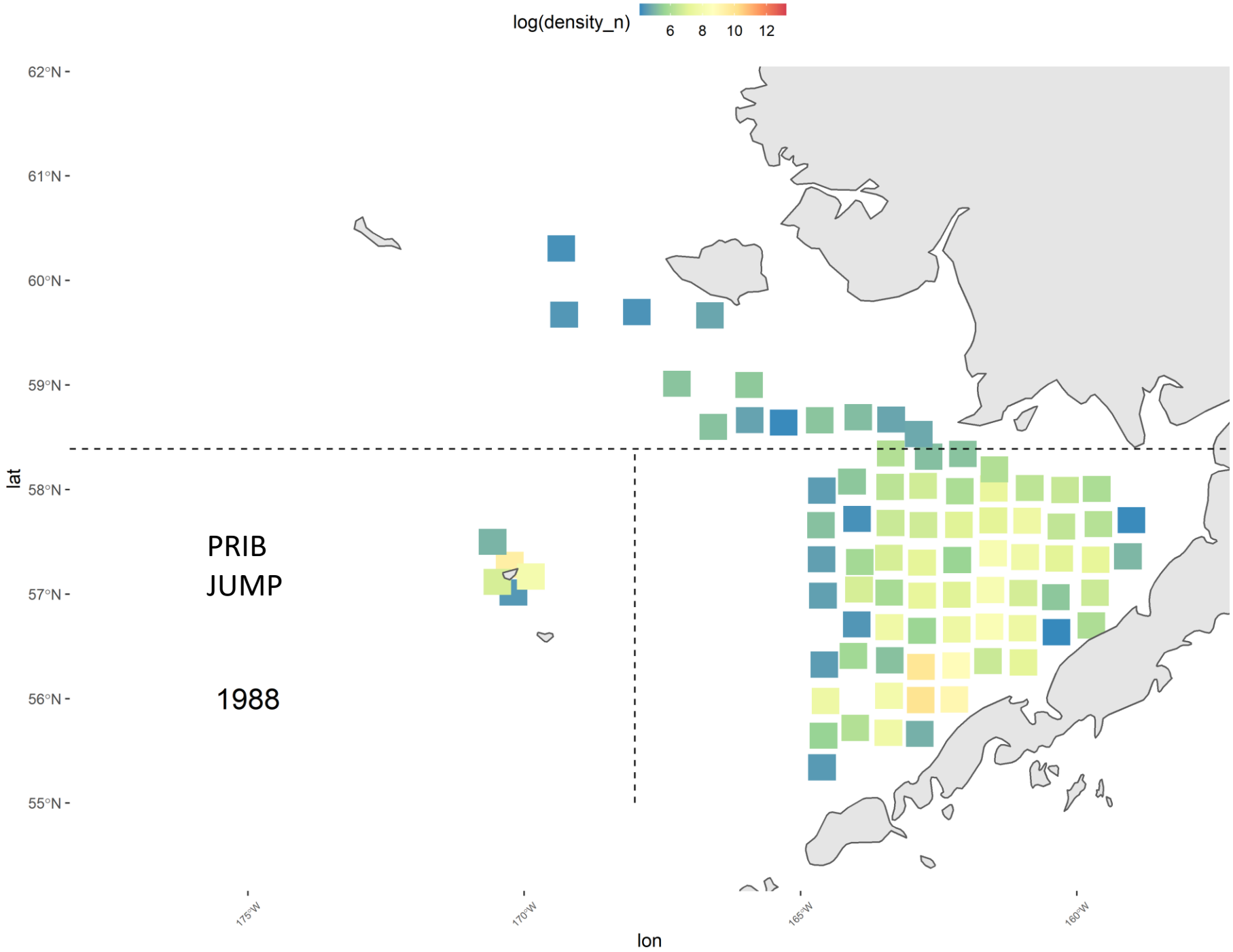
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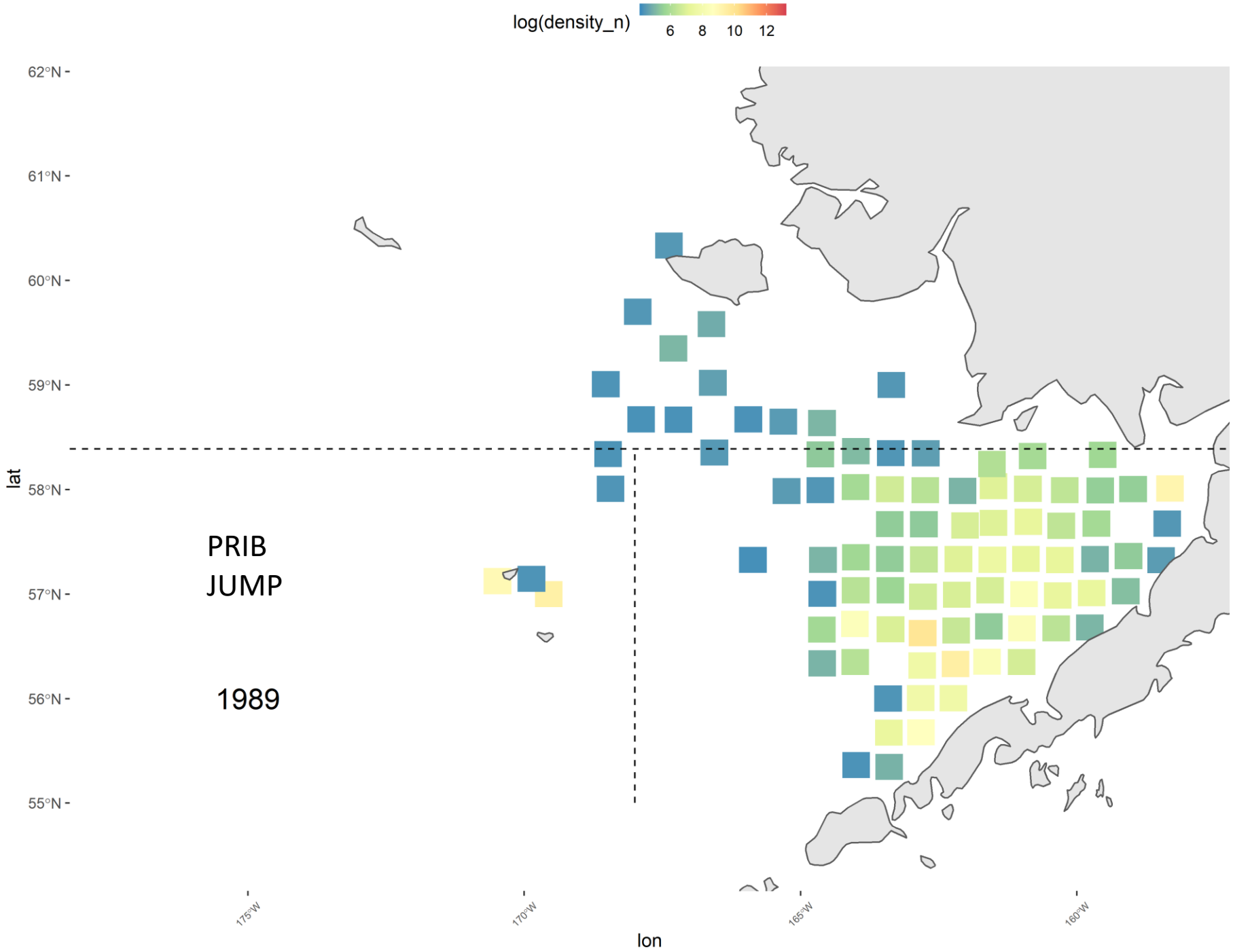
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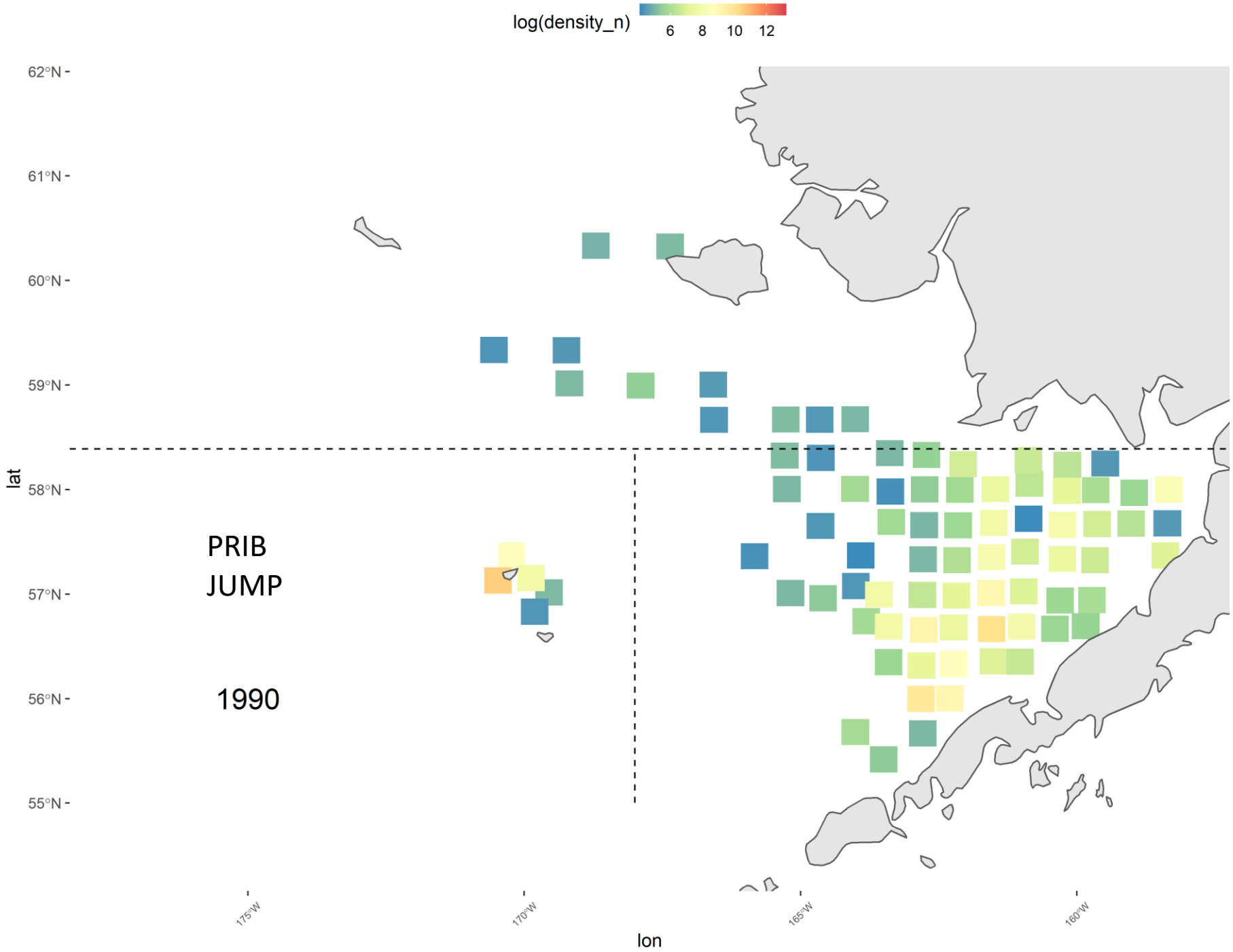
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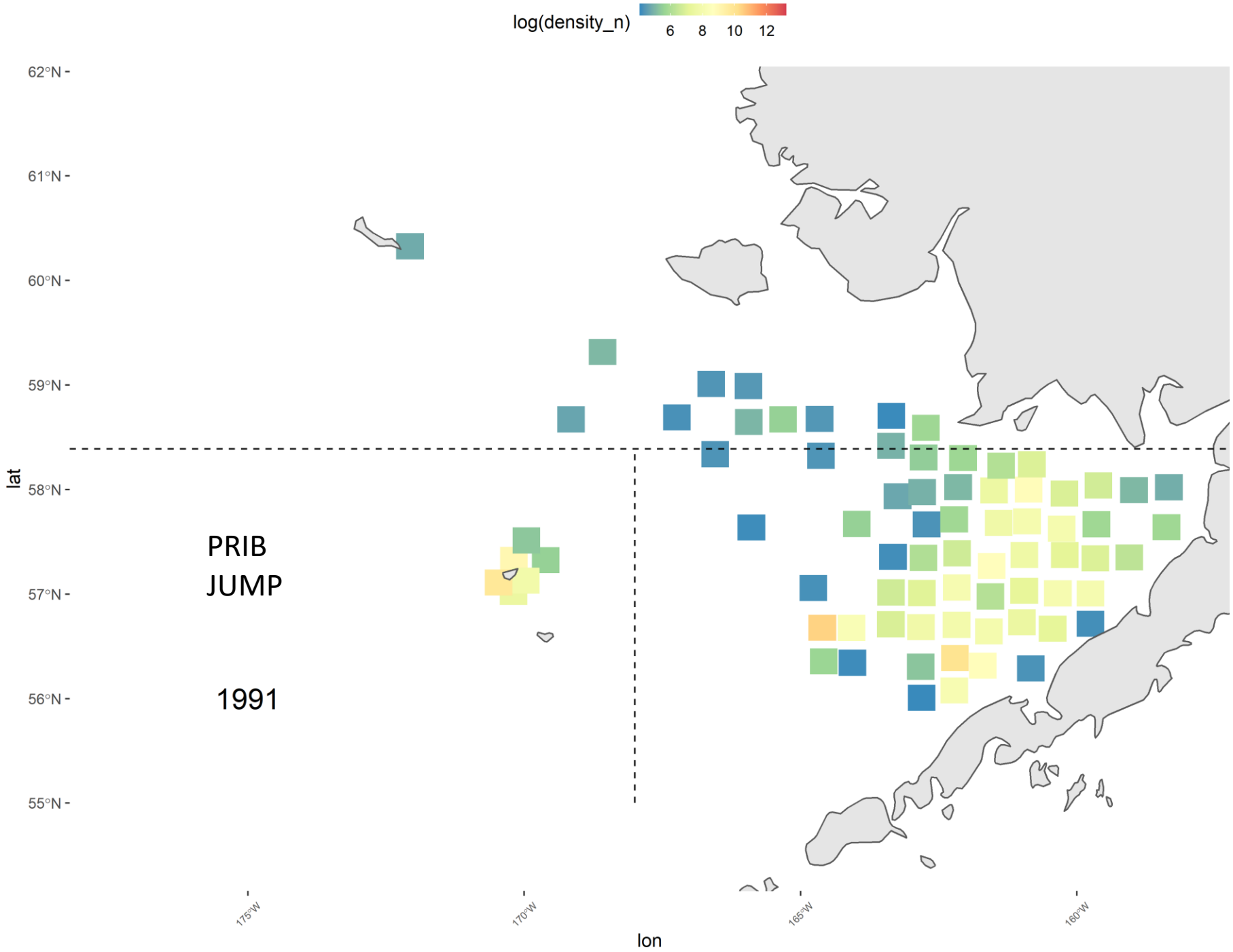
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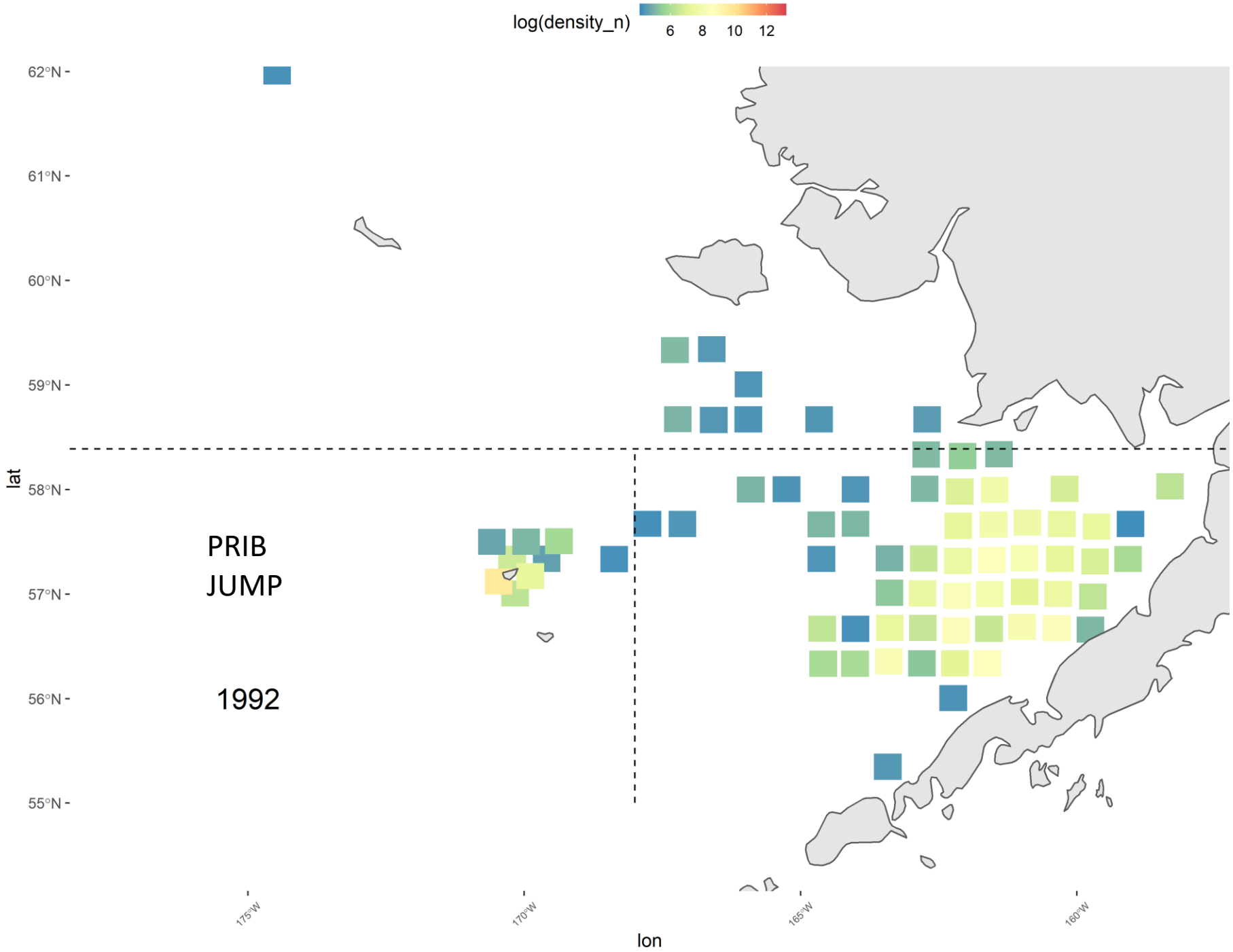
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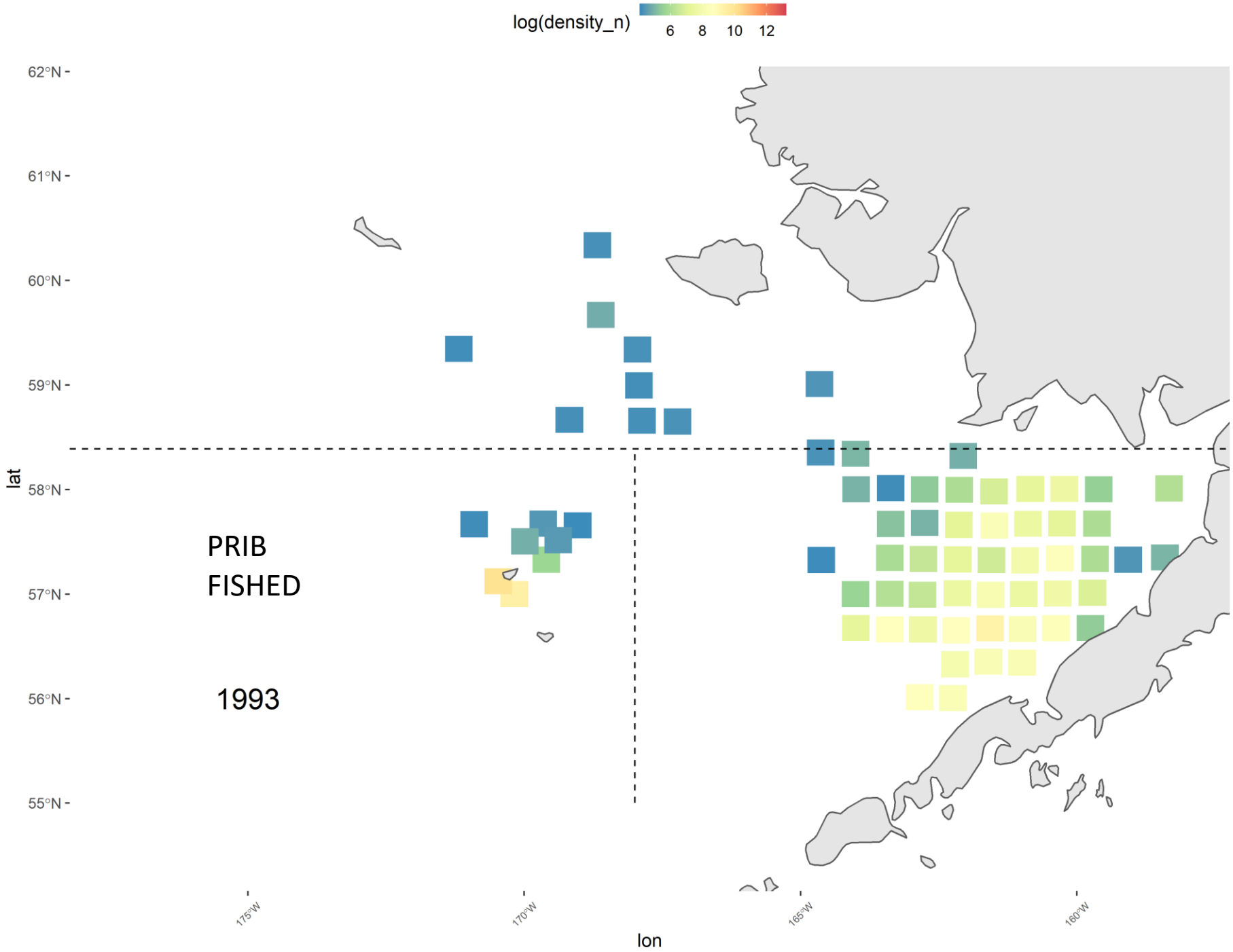
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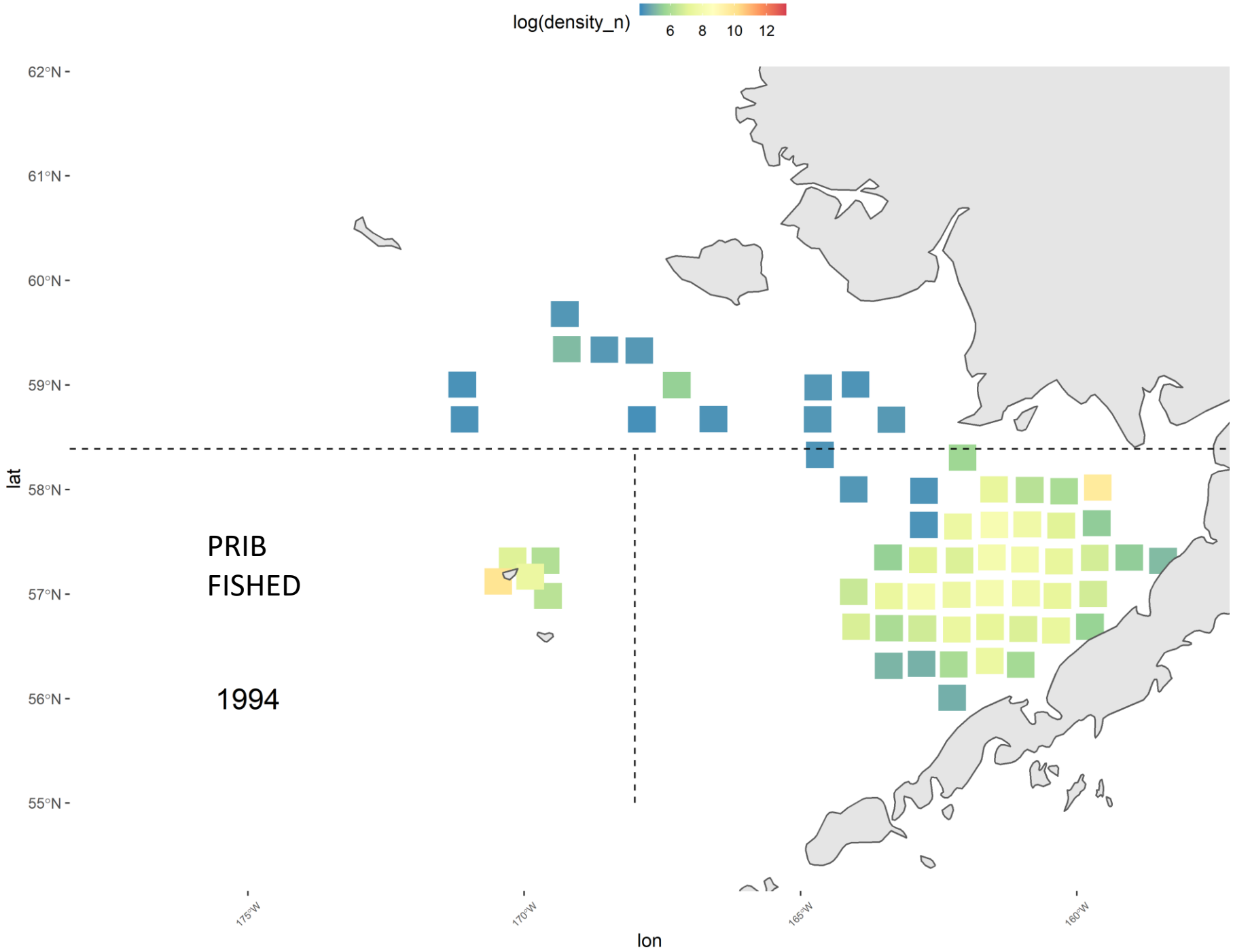
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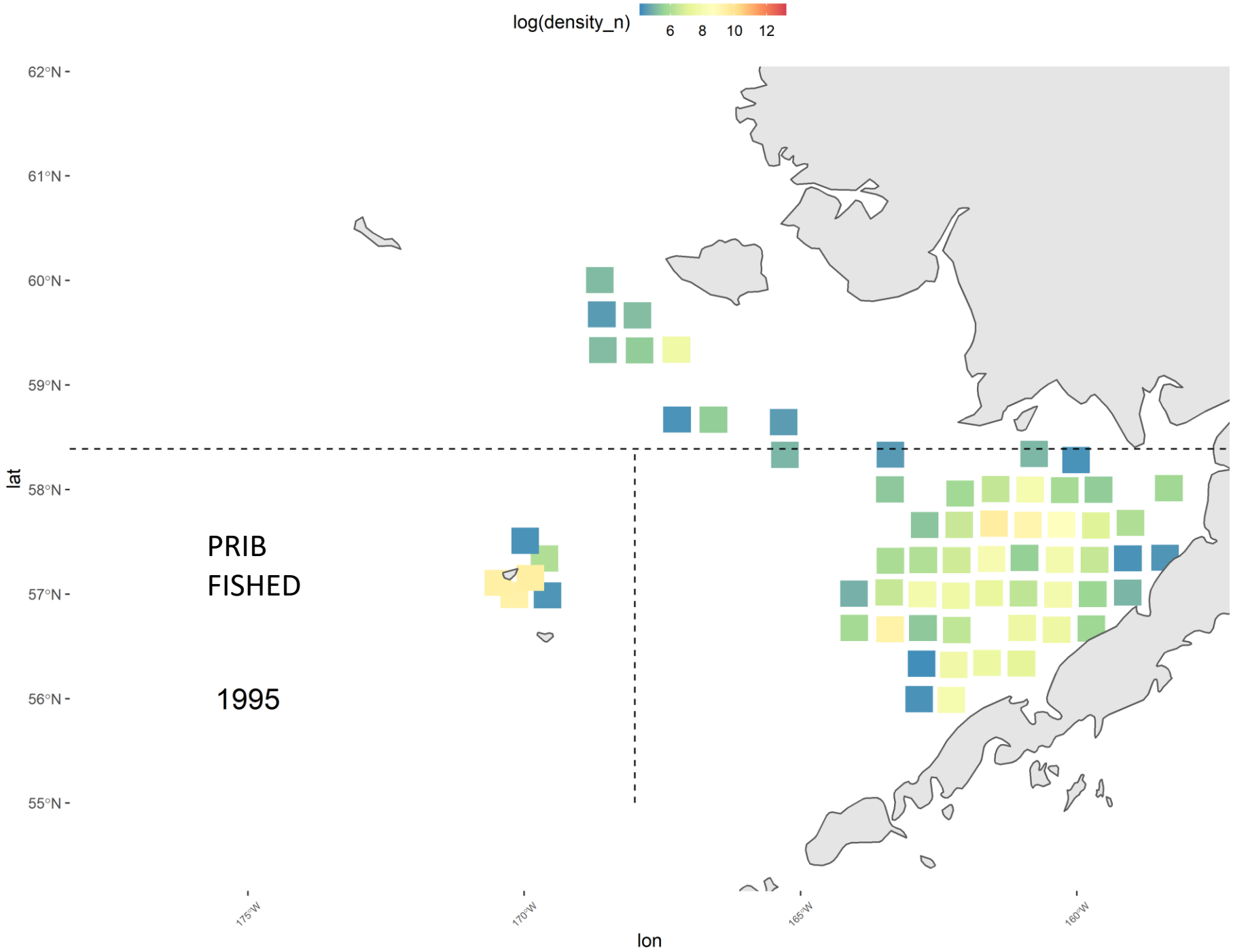
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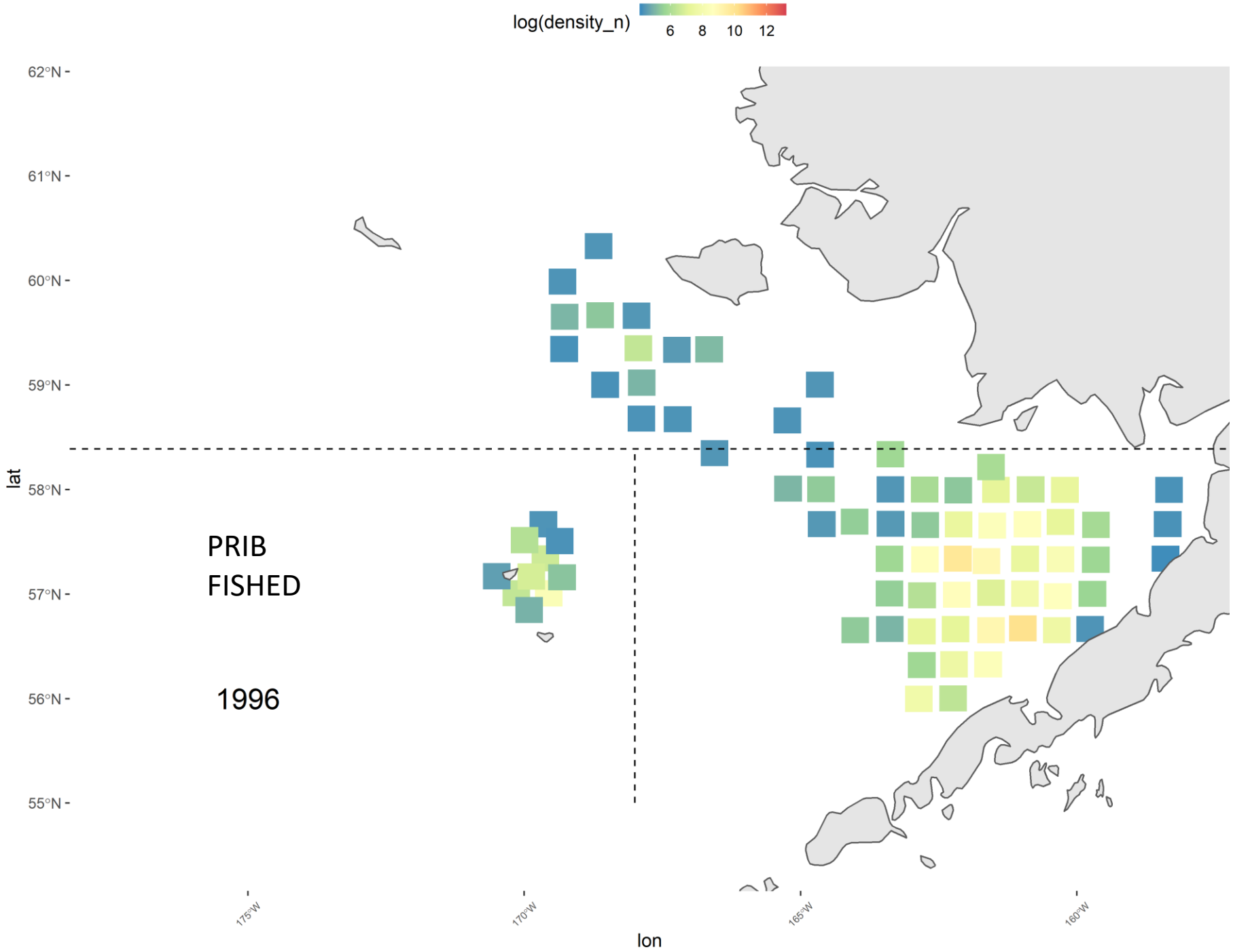
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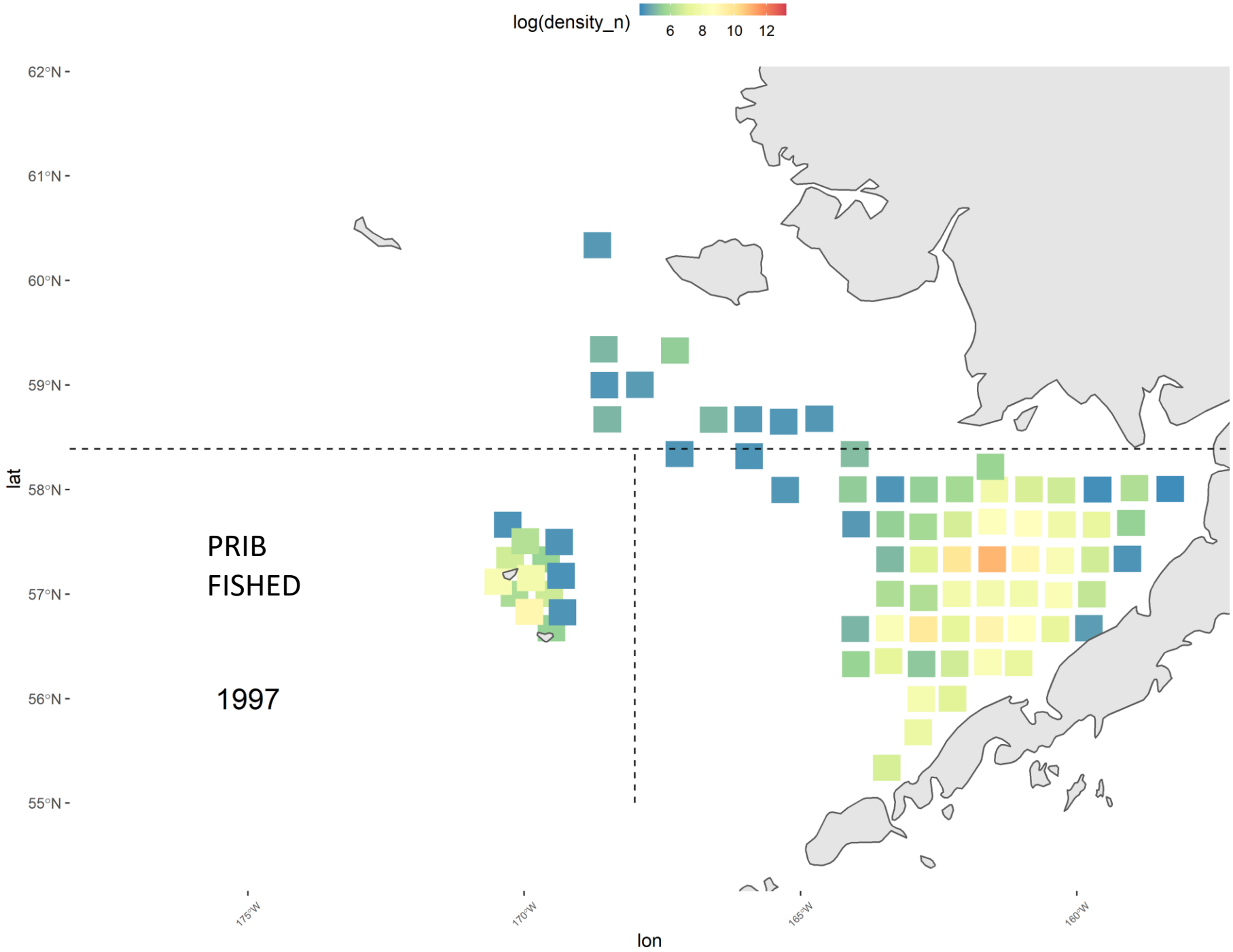
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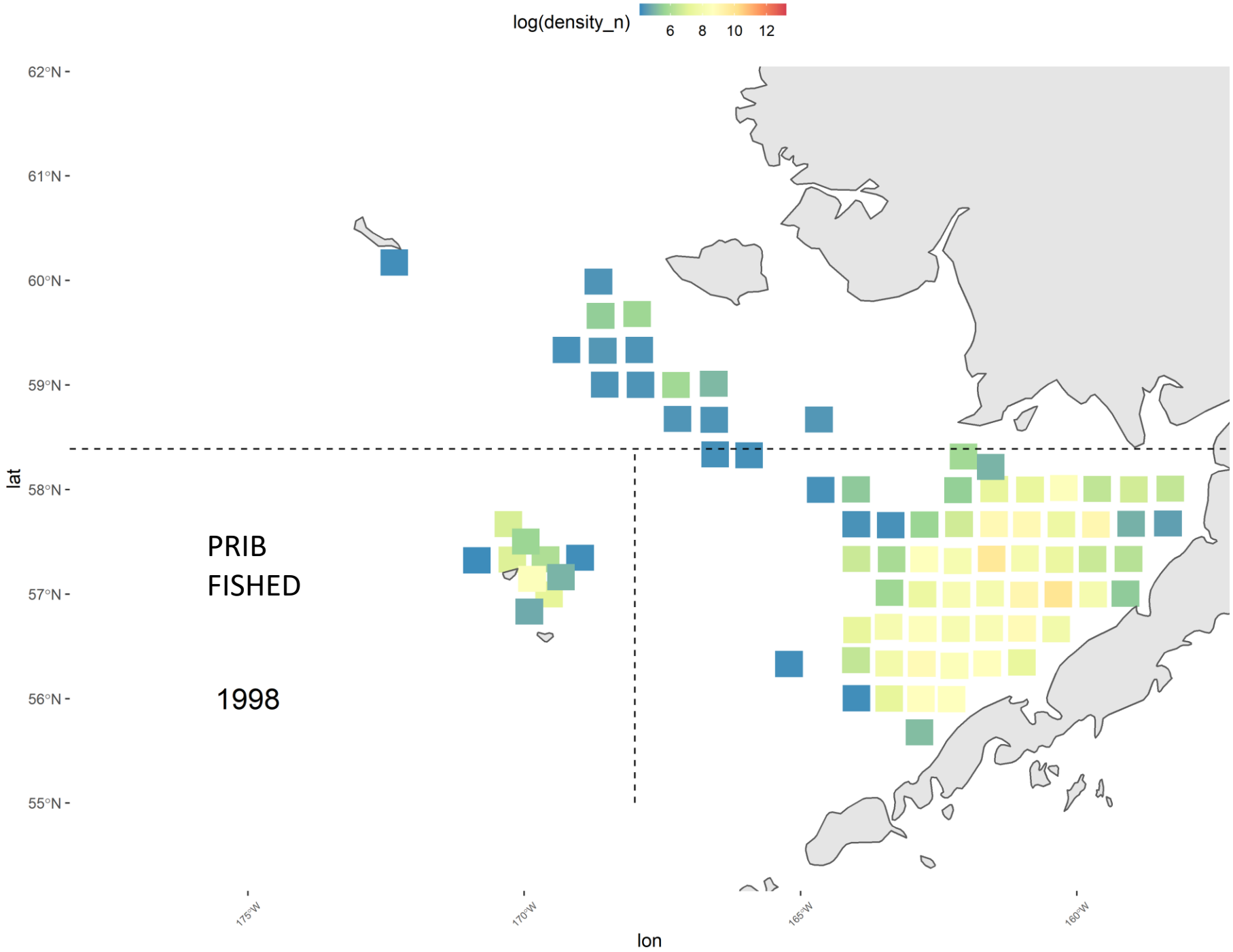
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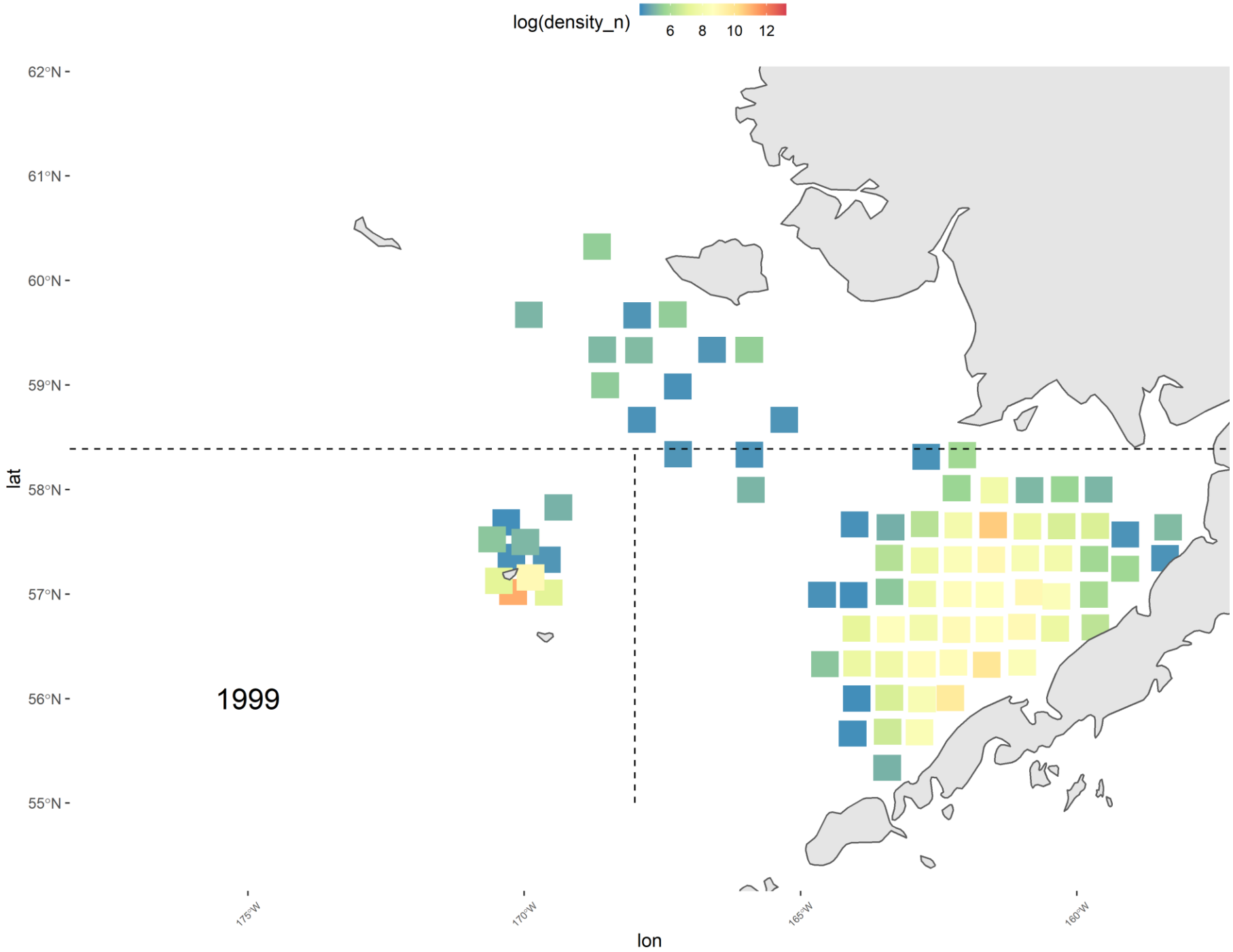
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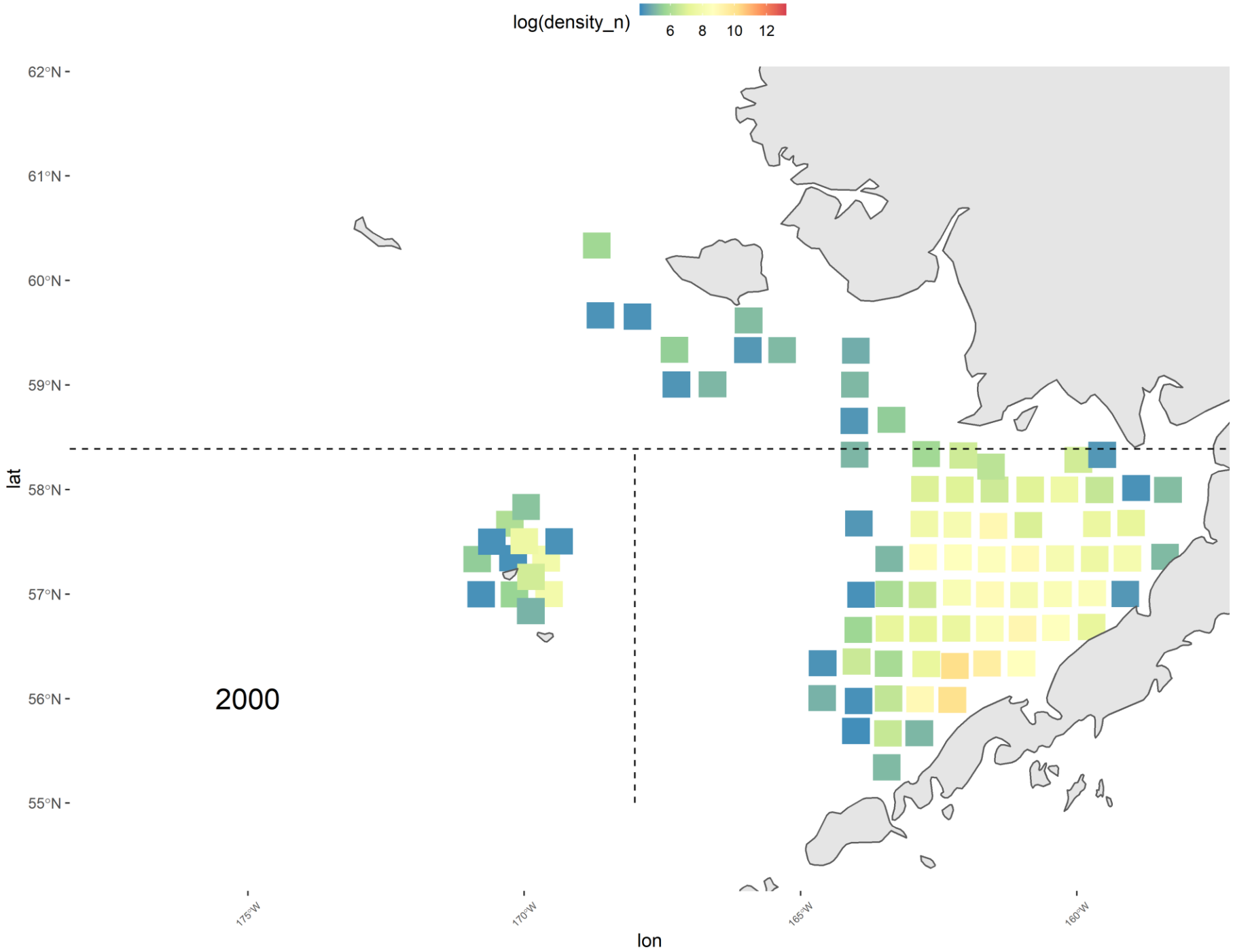
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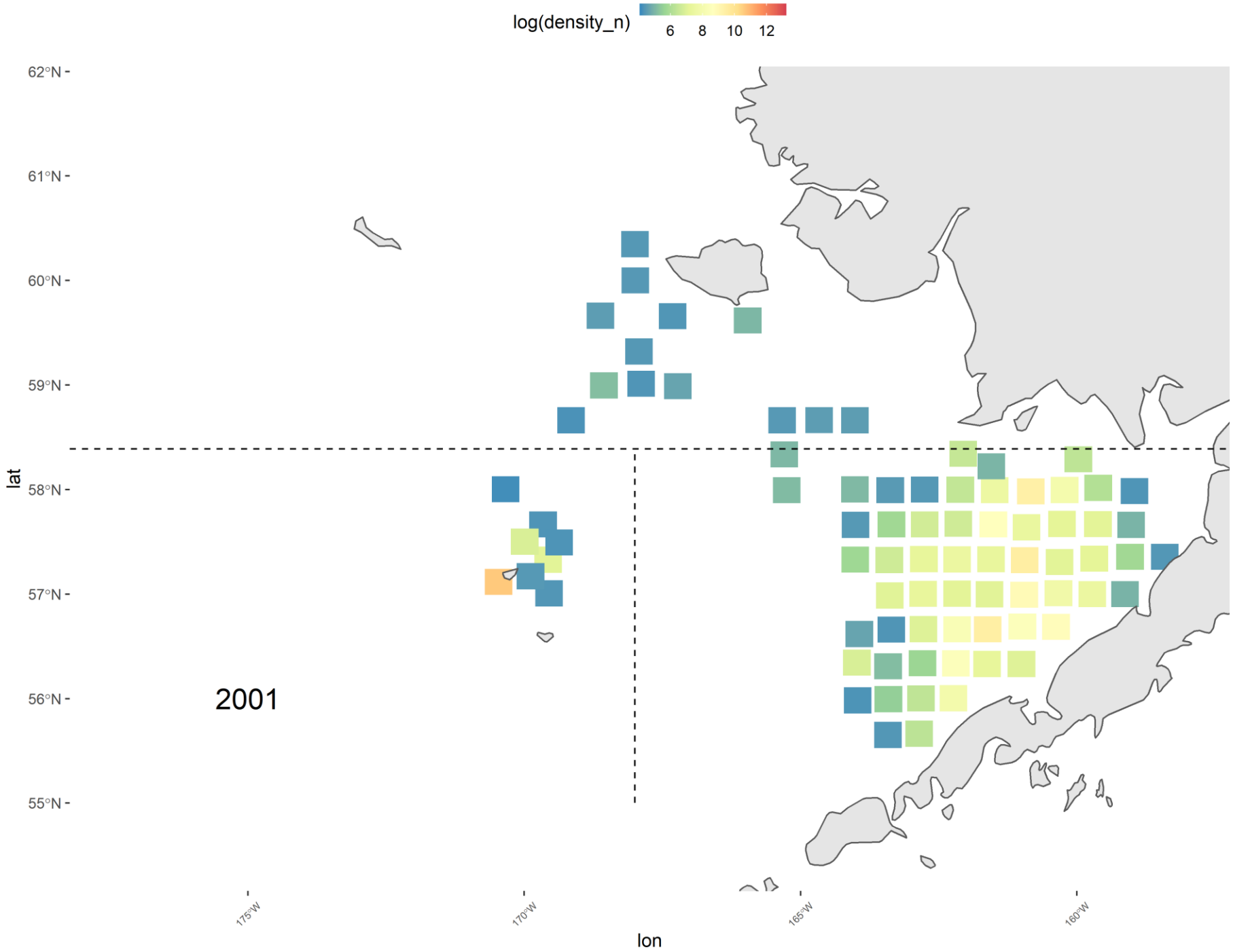
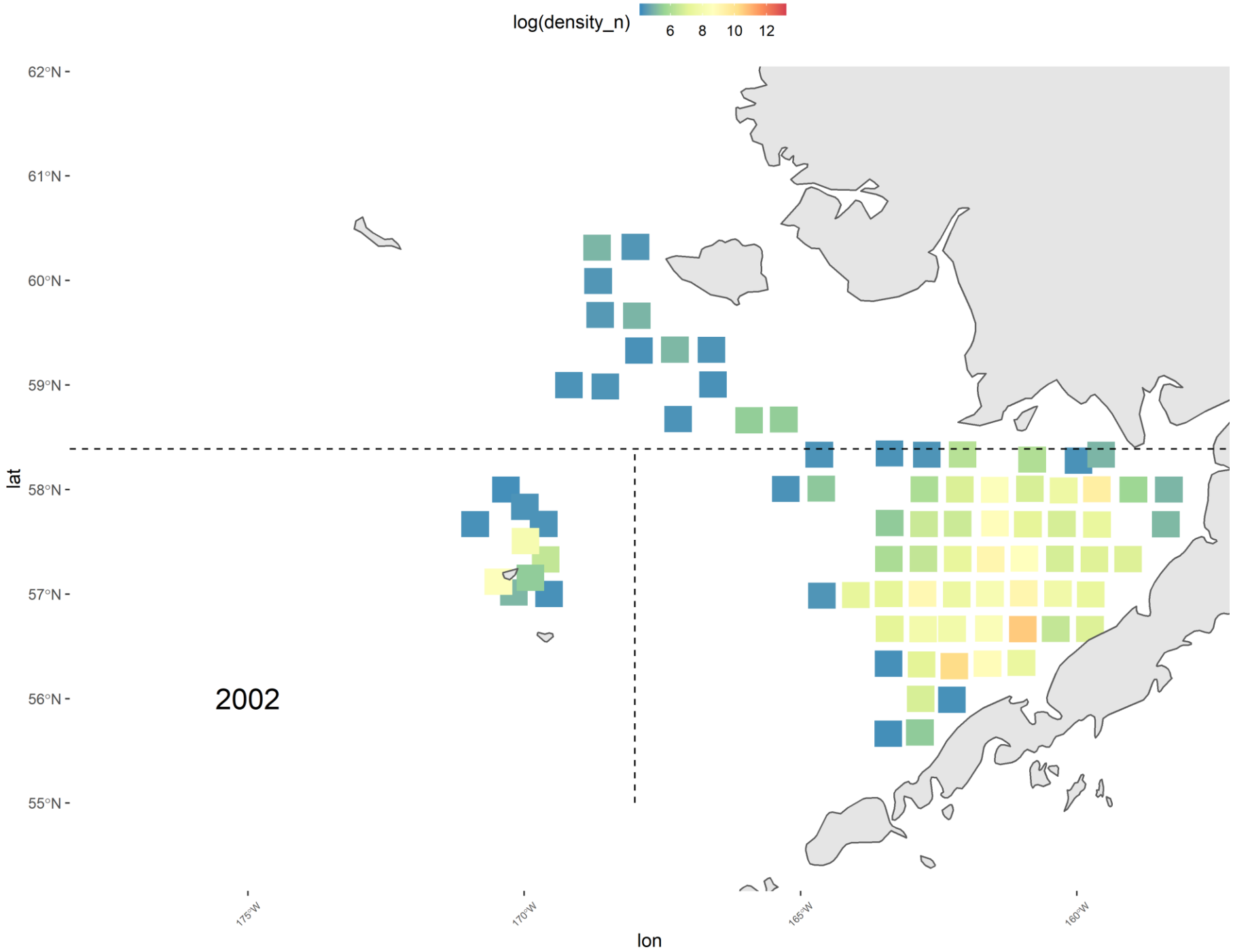
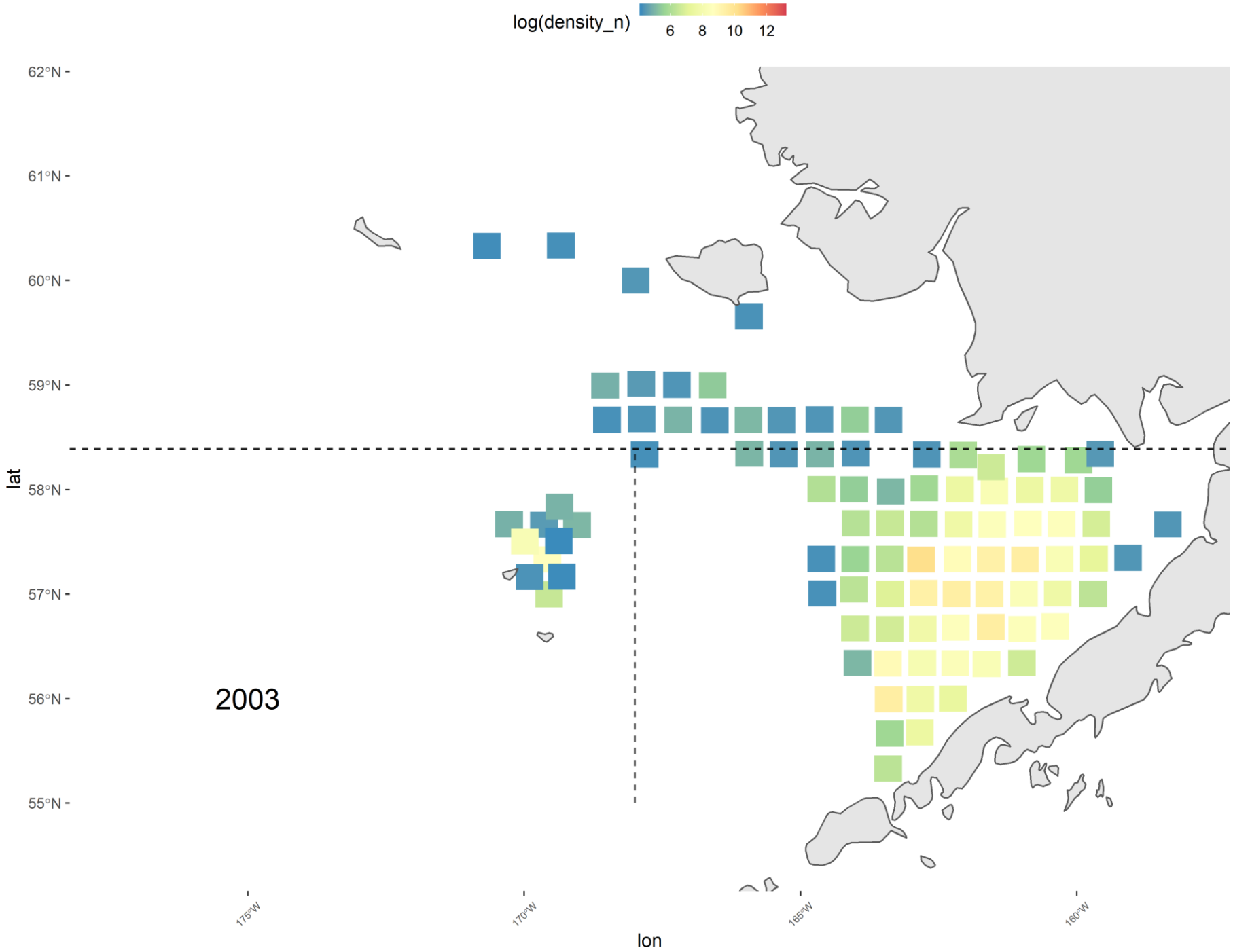
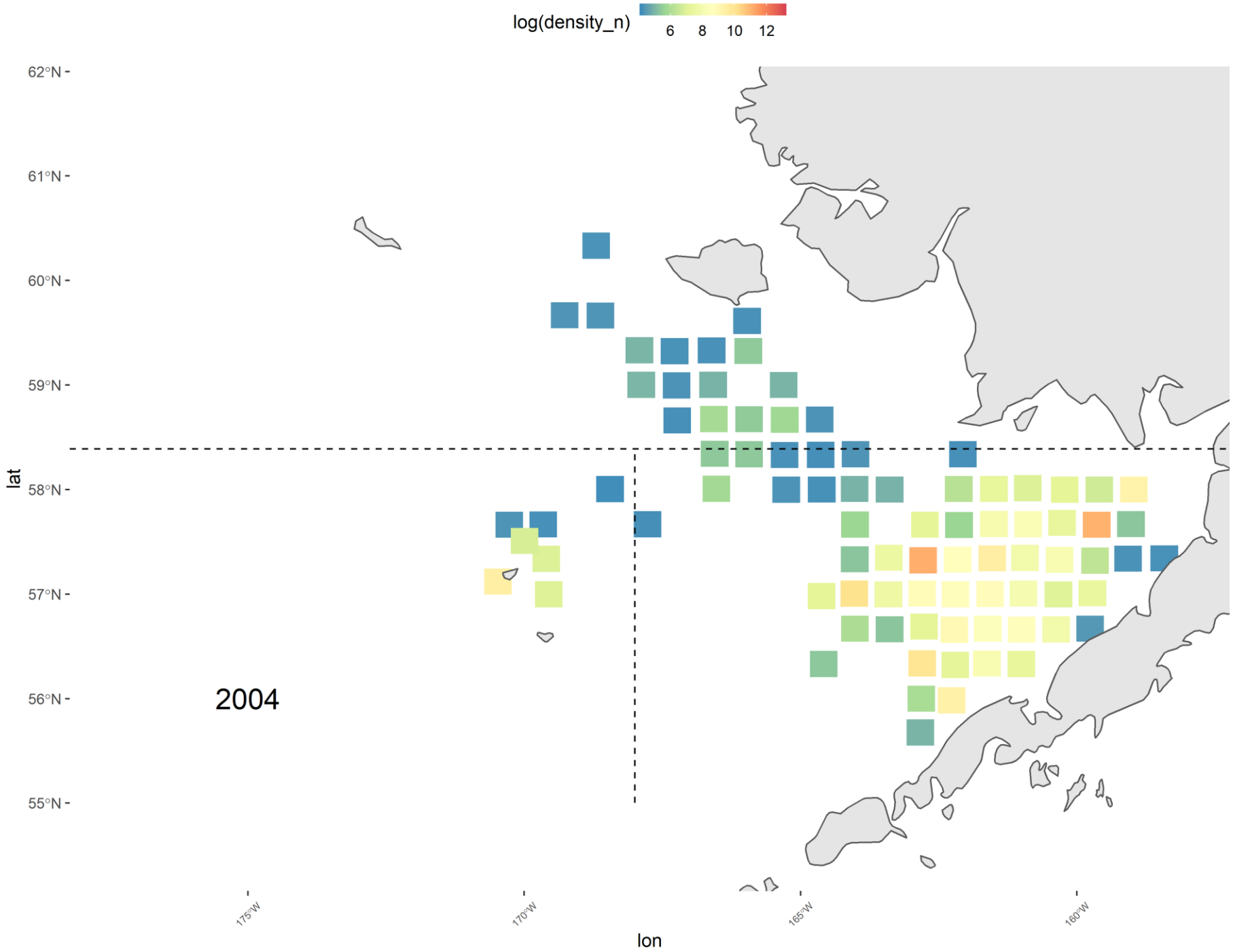
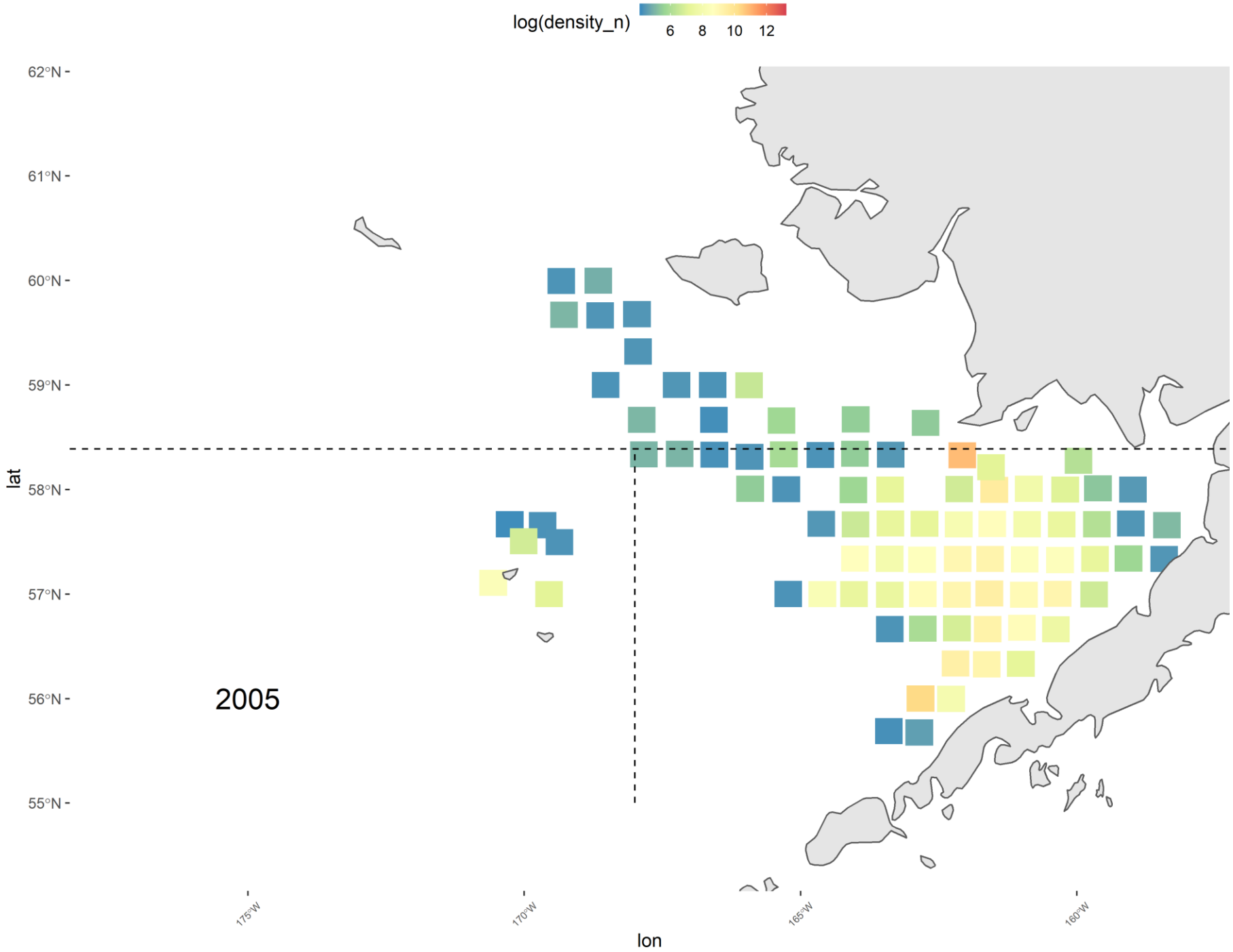
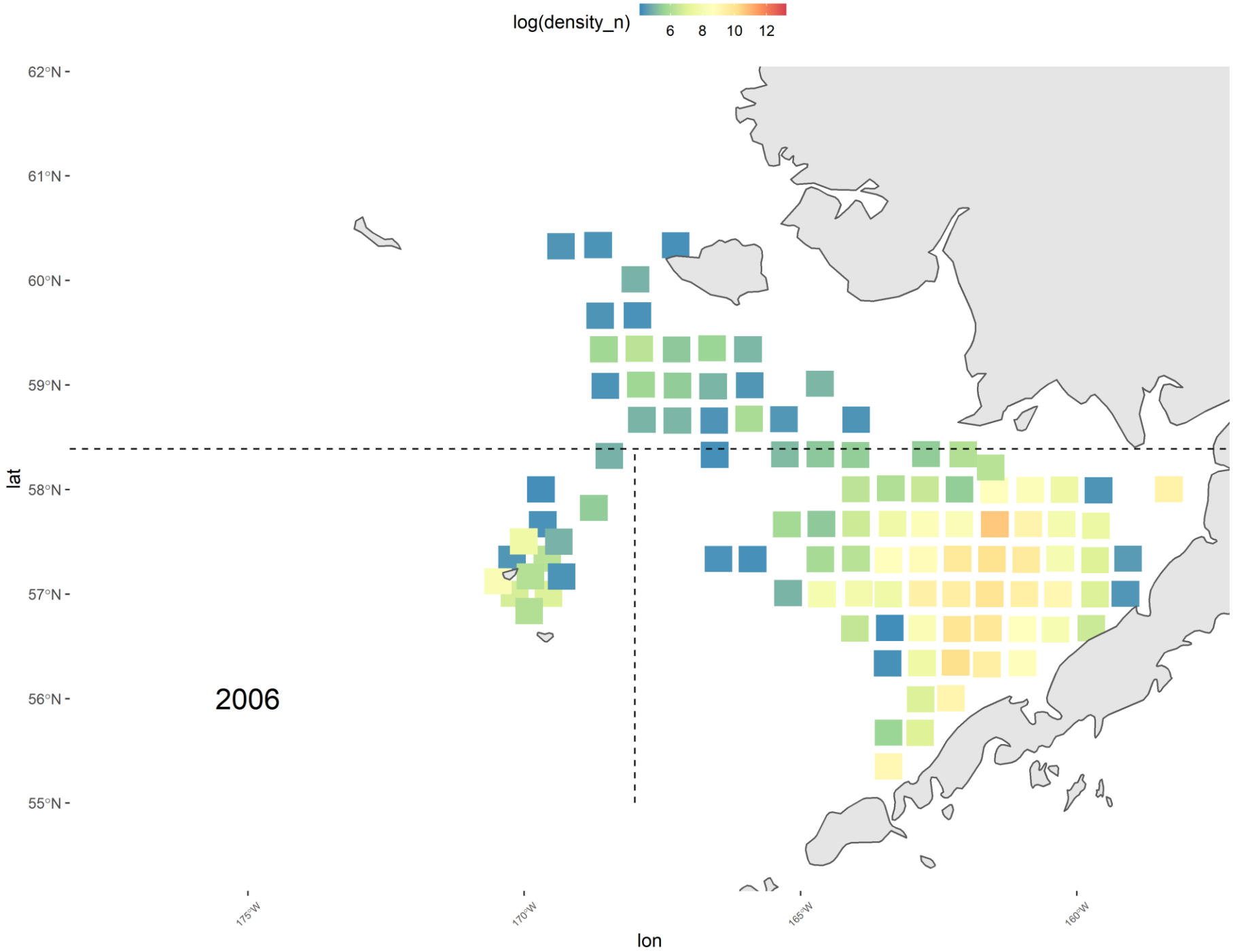

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2001
175°W
170°W
165°W
160°W
lon

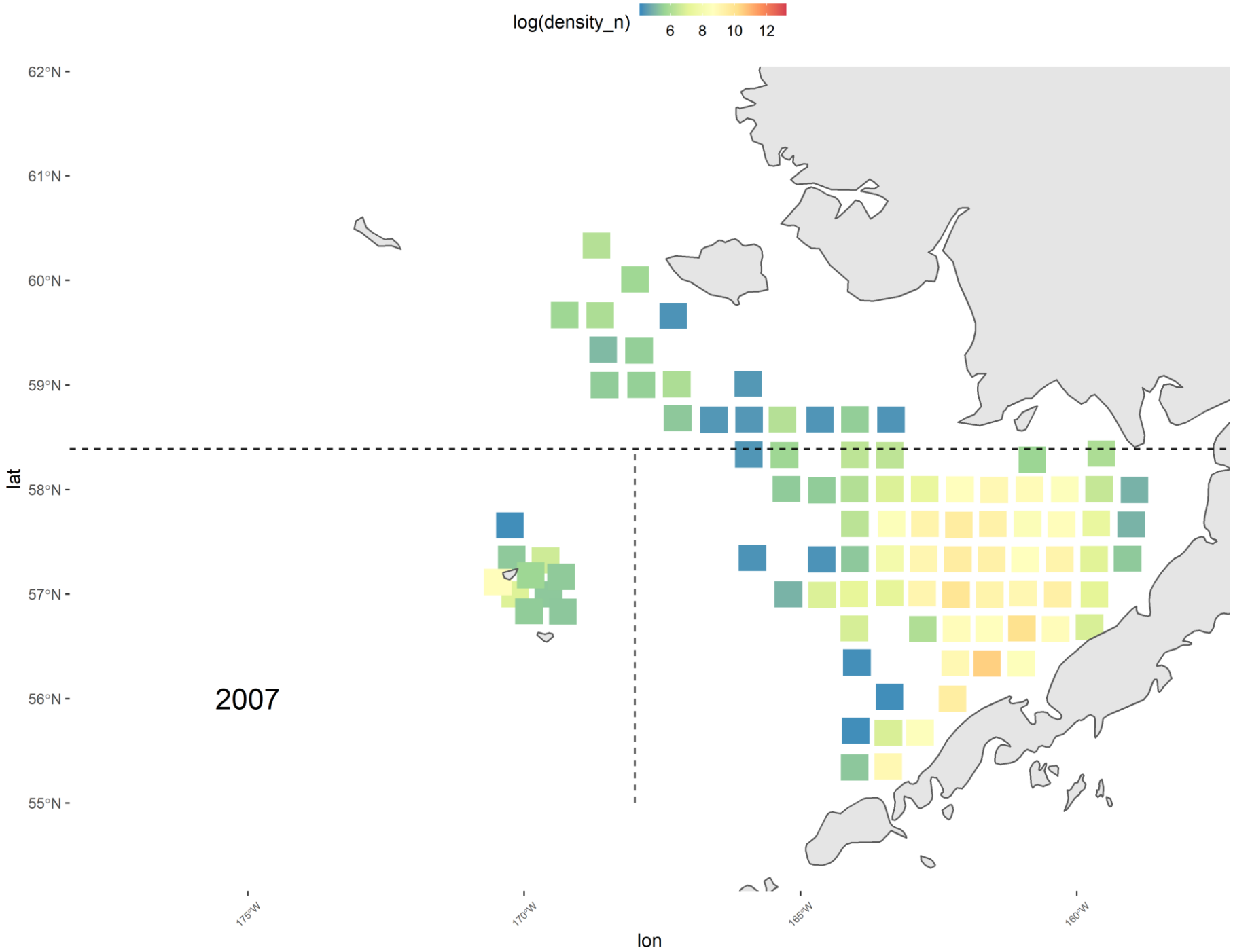

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2002
175°W
170°W
165°W
160°W
lon

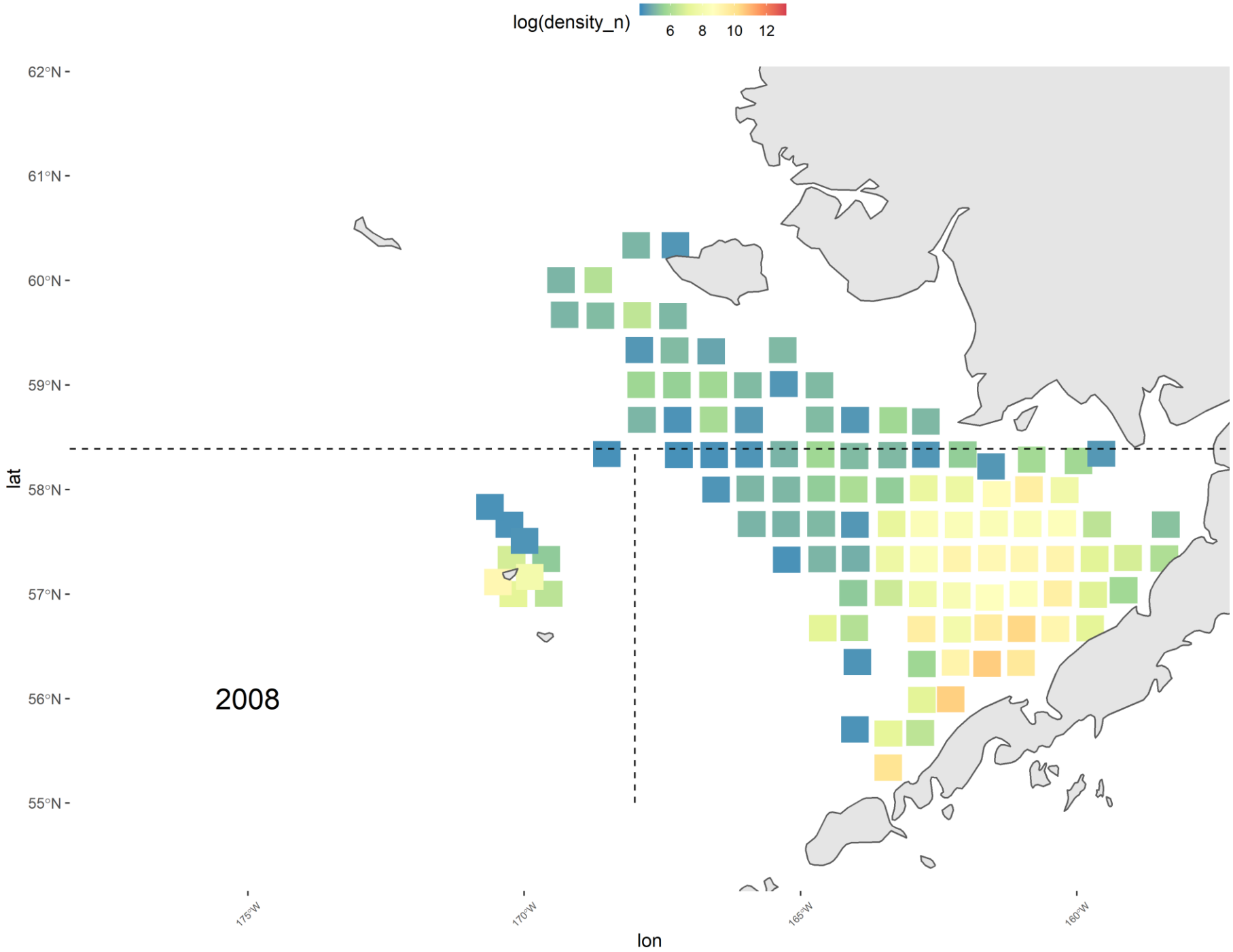

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2003
175°W
170°W
165°W
160°W
lon

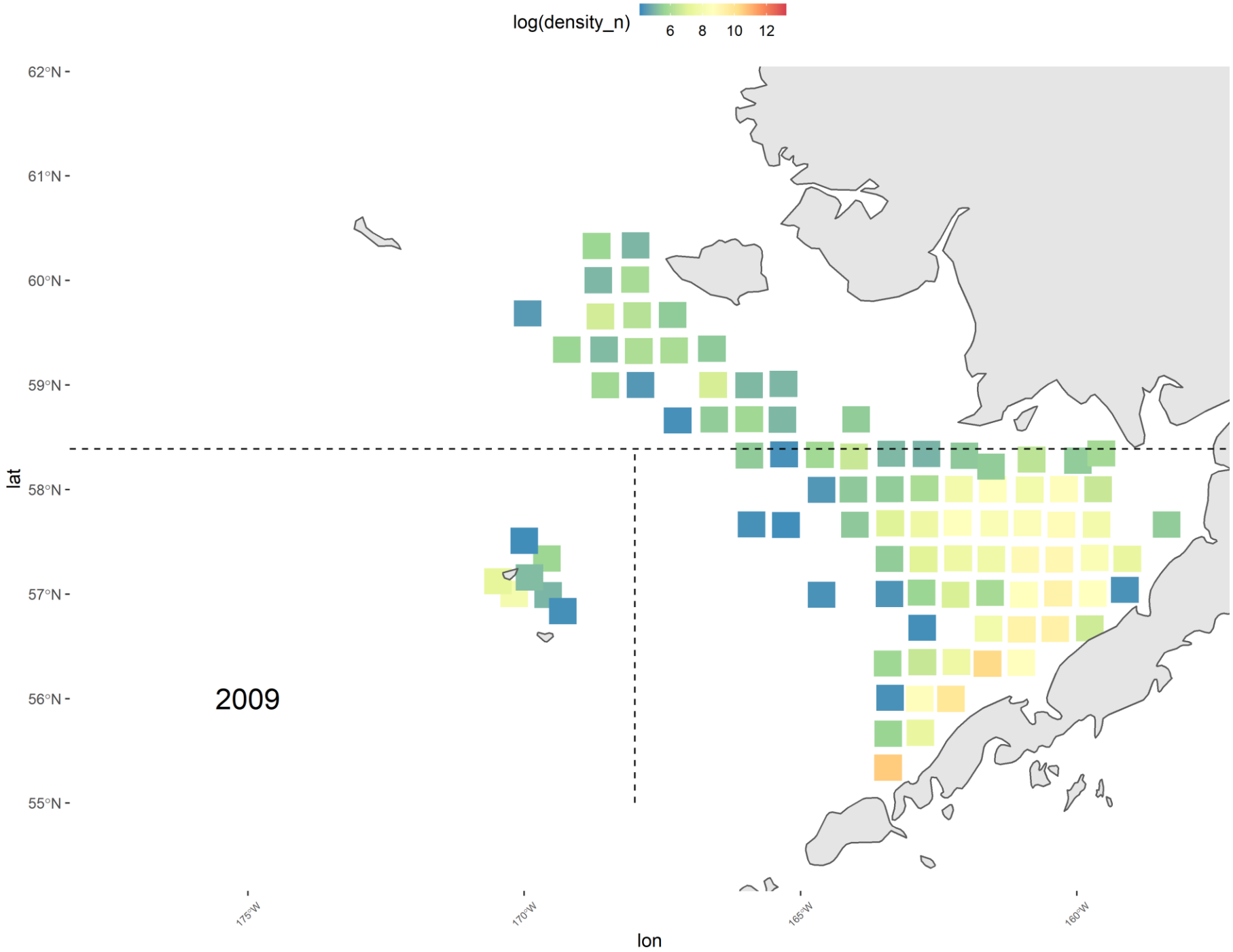

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2004
175°W
170°W
165°W
160°W
lon

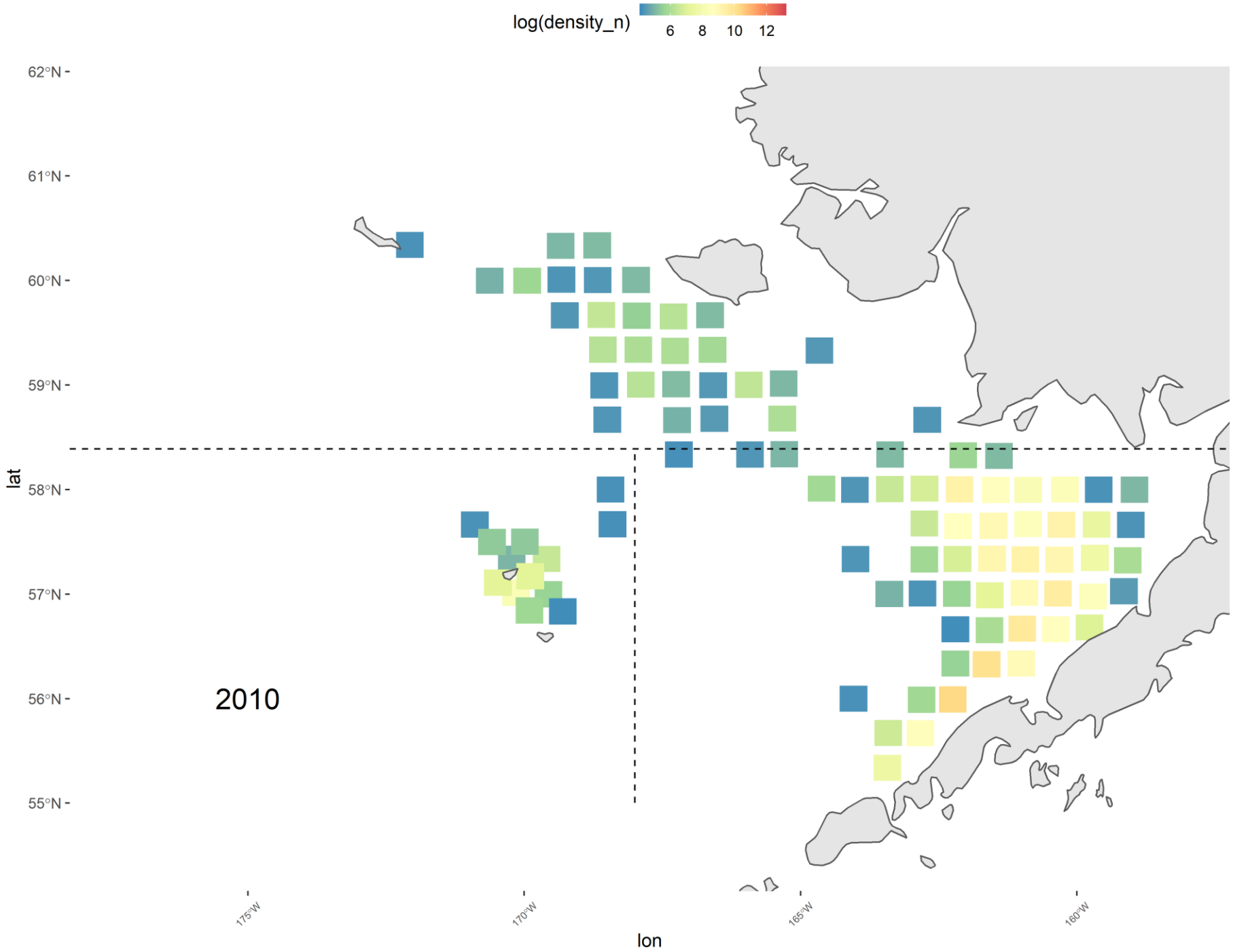

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2005
175°W
170°W
165°W
160°W
lon

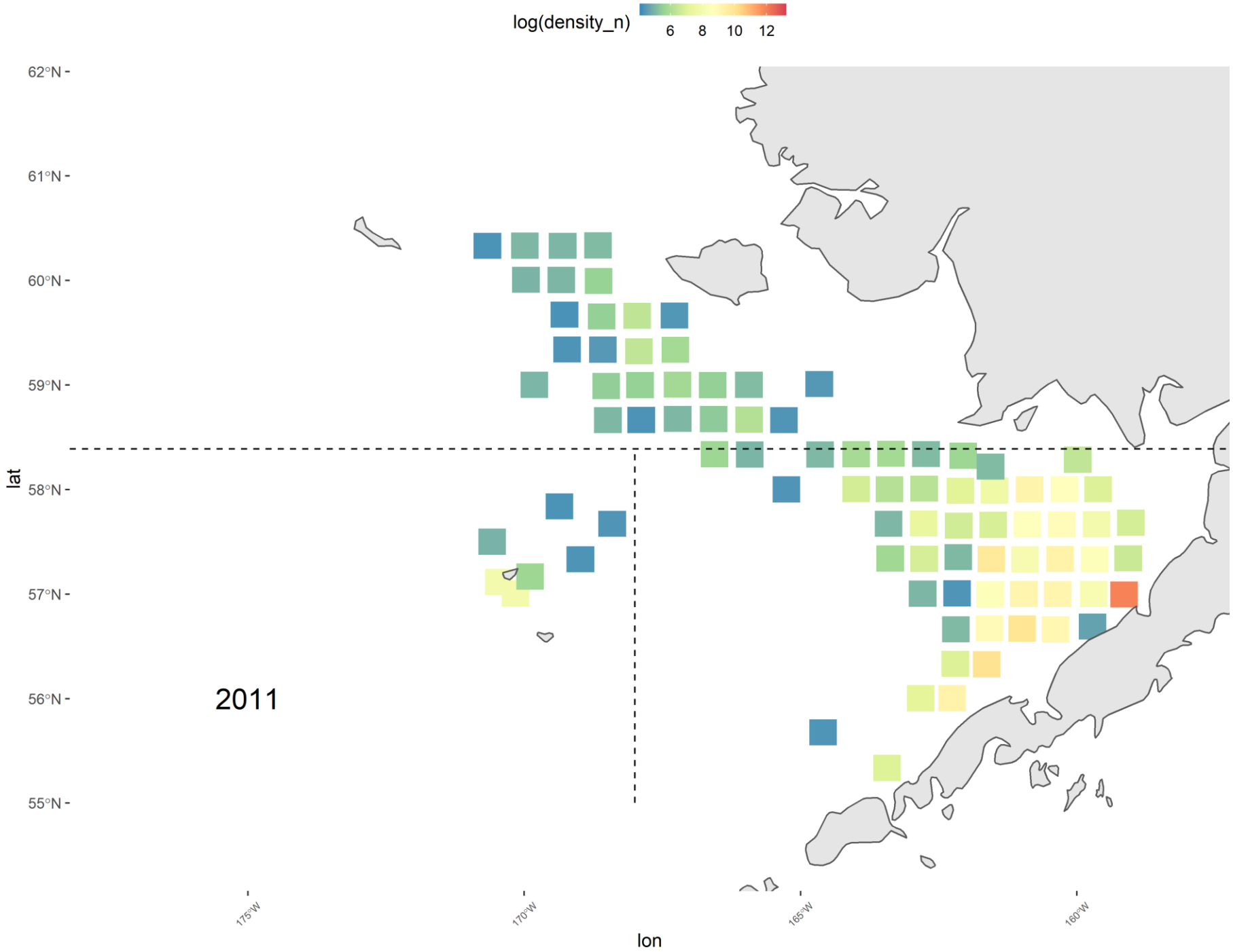

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2006
175°W
170°W
165°W
160°W
lon

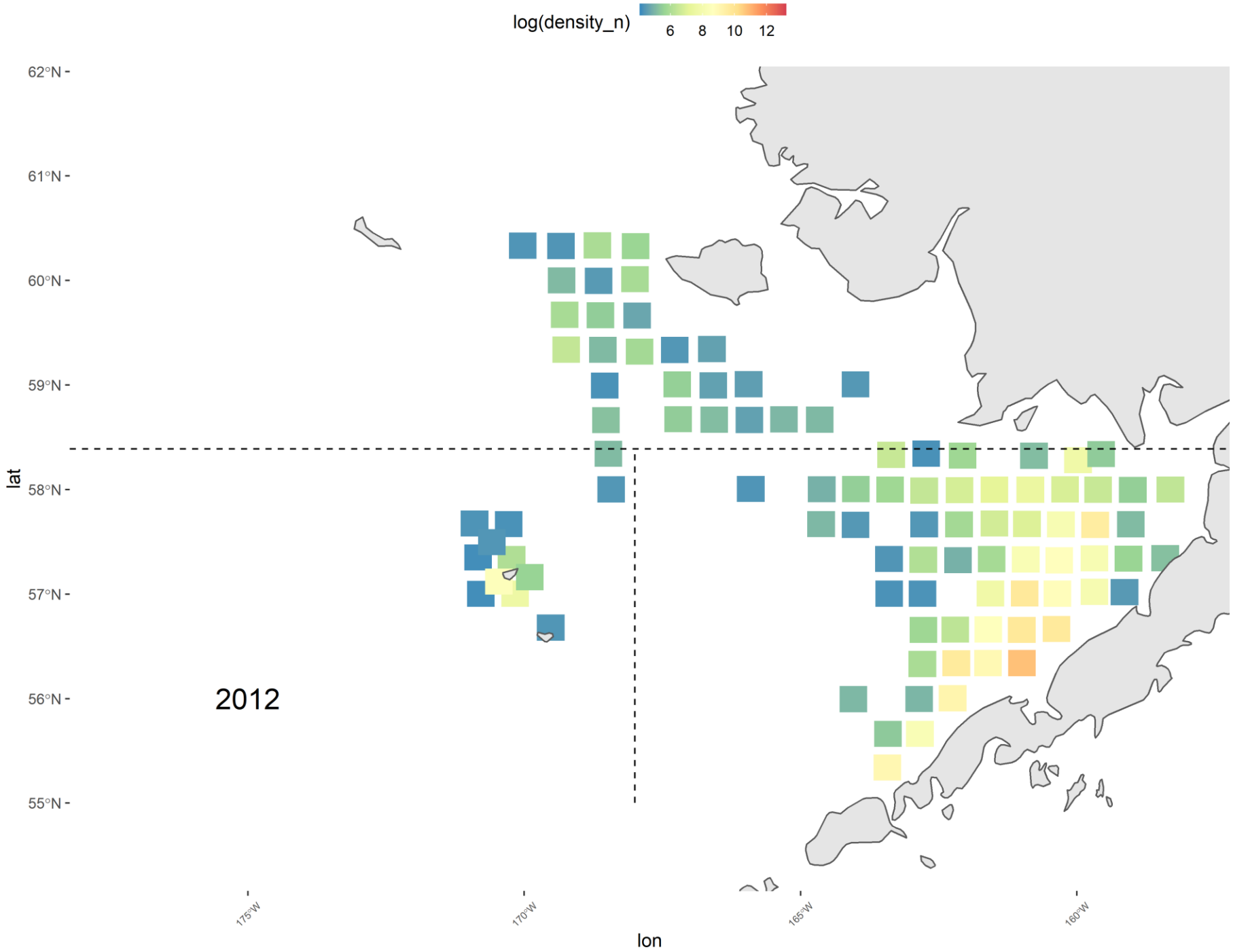

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2007
175°W
170°W
165°W
160°W
lon

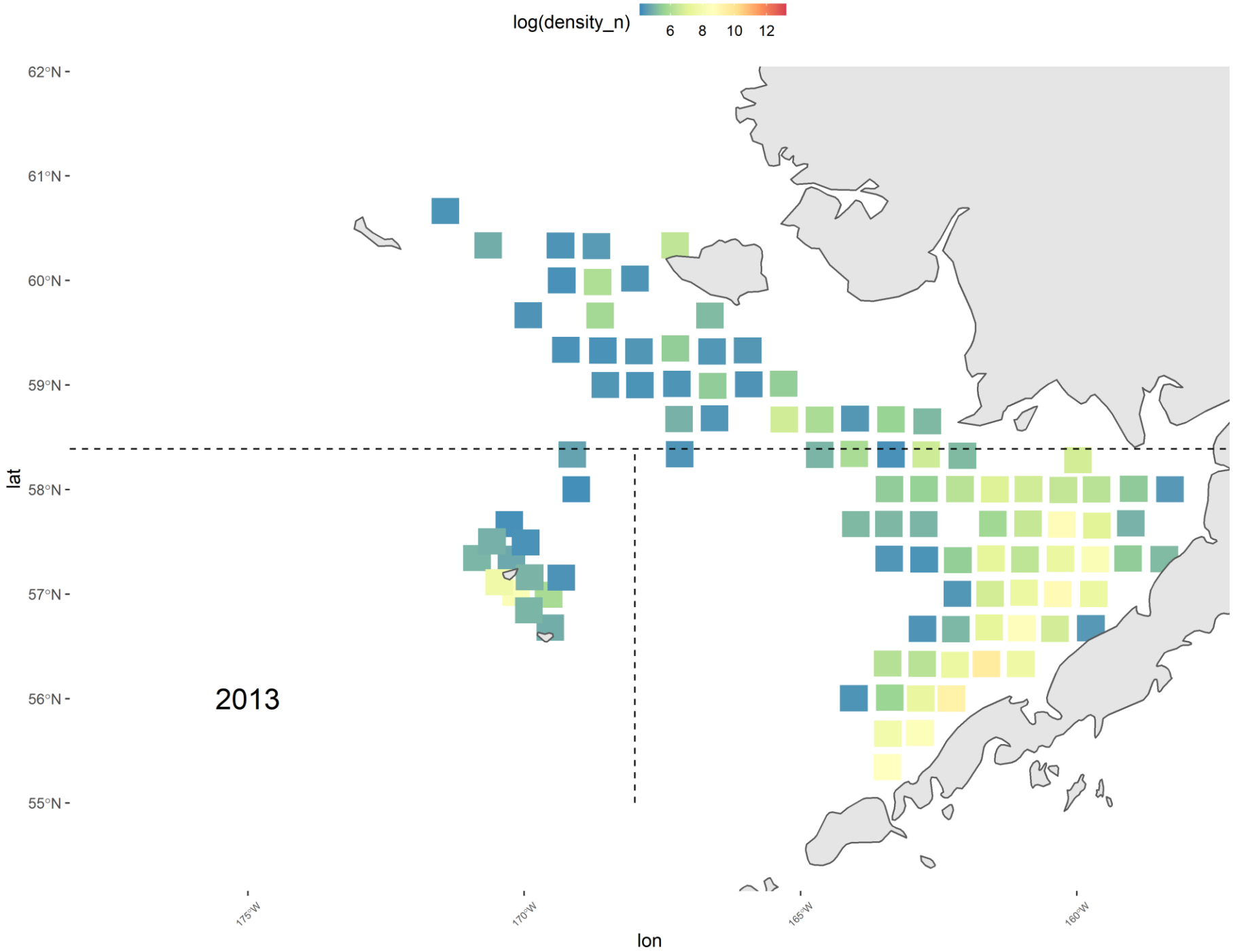

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2008
175°W
170°W
165°W
160°W
lon

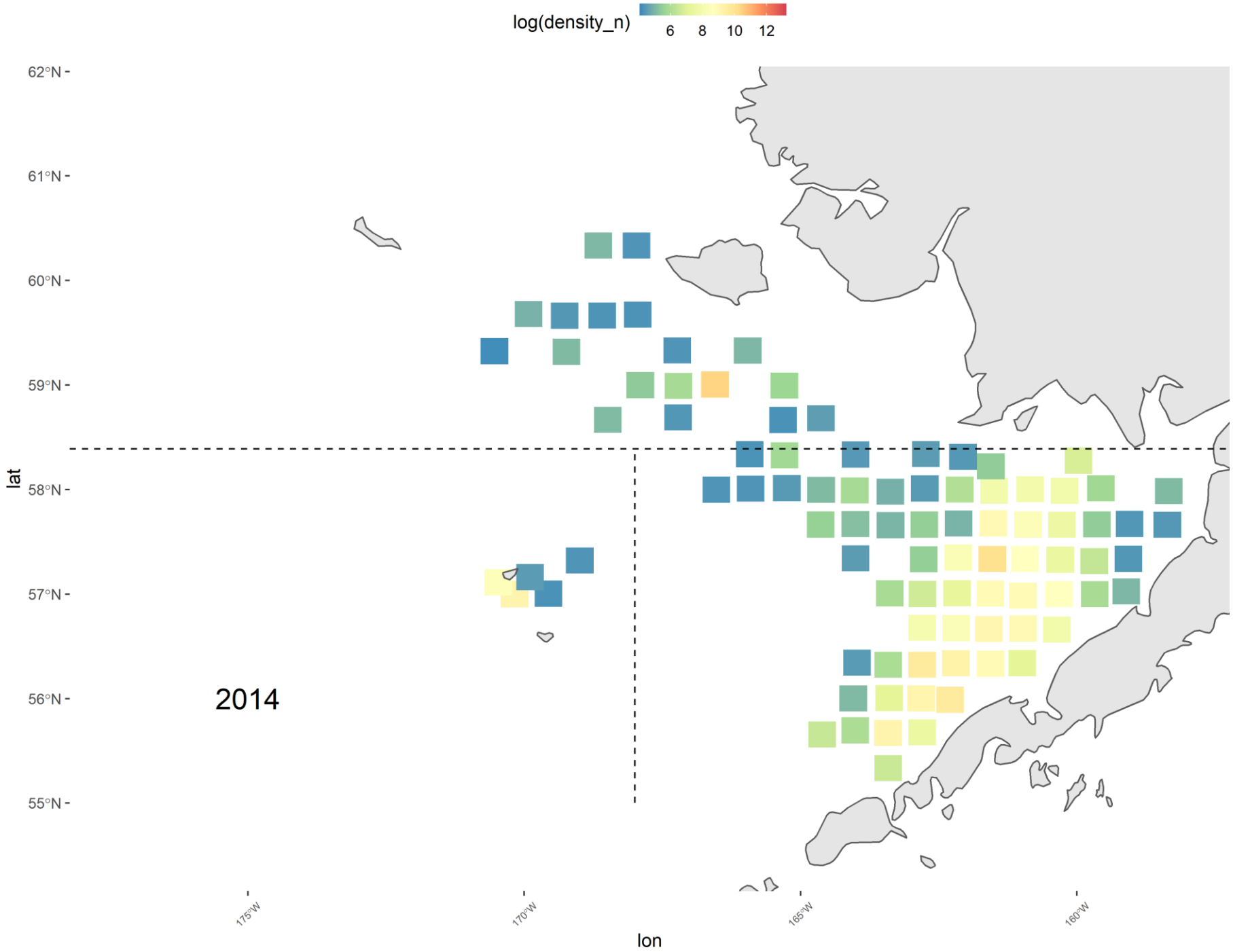

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2009
175°W
170°W
165°W
160°W
lon

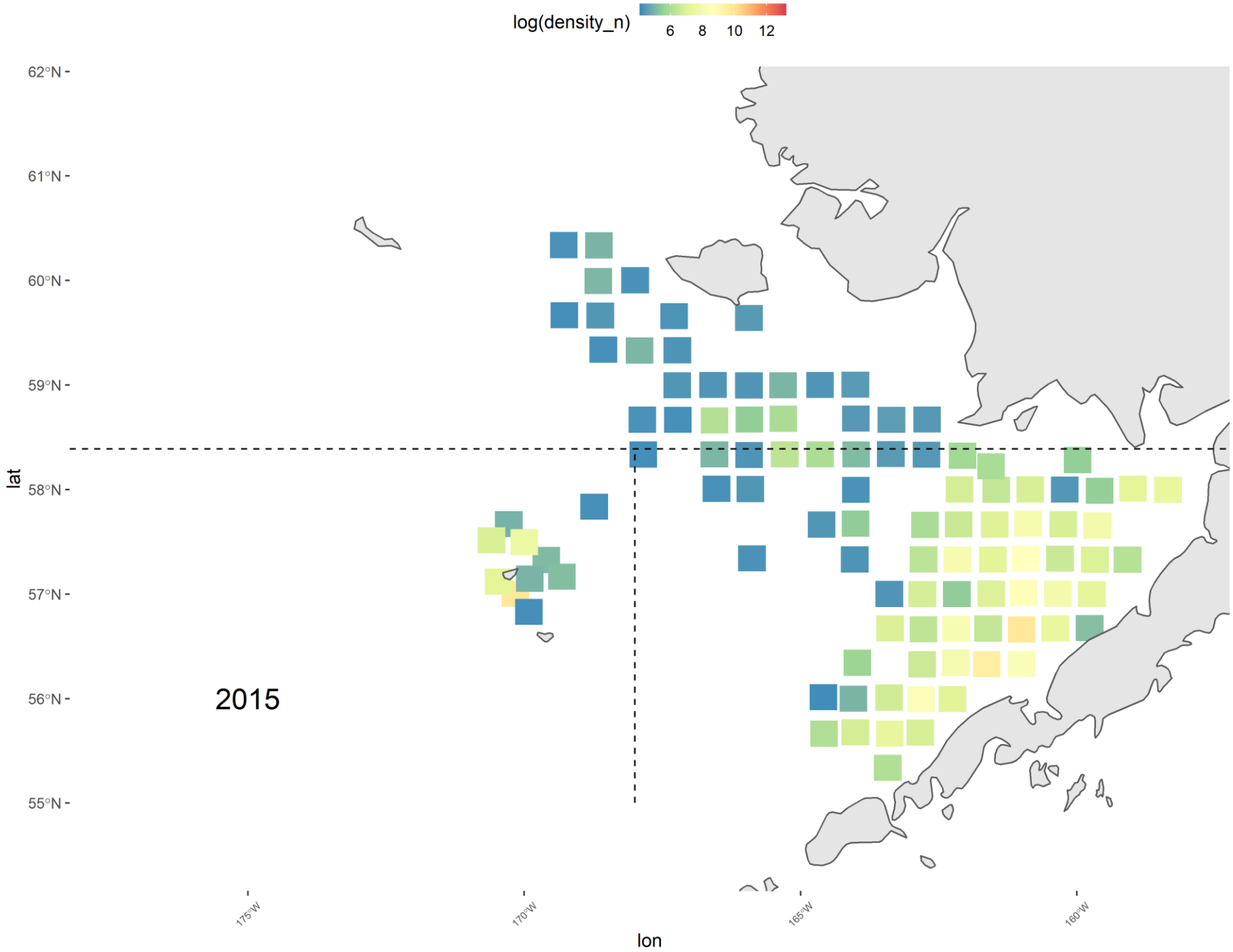

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2010
175°W
170°W
165°W
160°W
lon

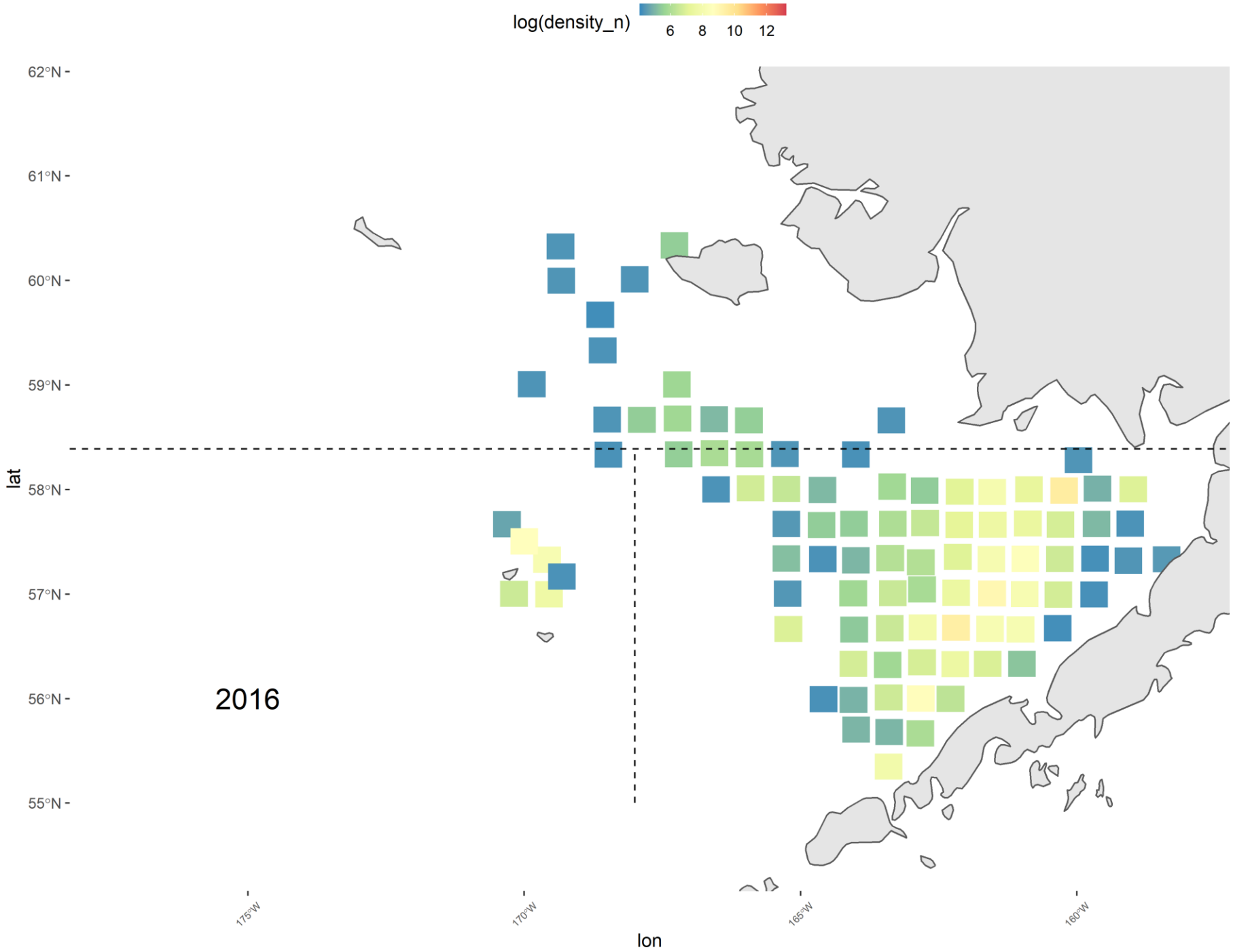

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2011
175°W
170°W
165°W
160°W
lon

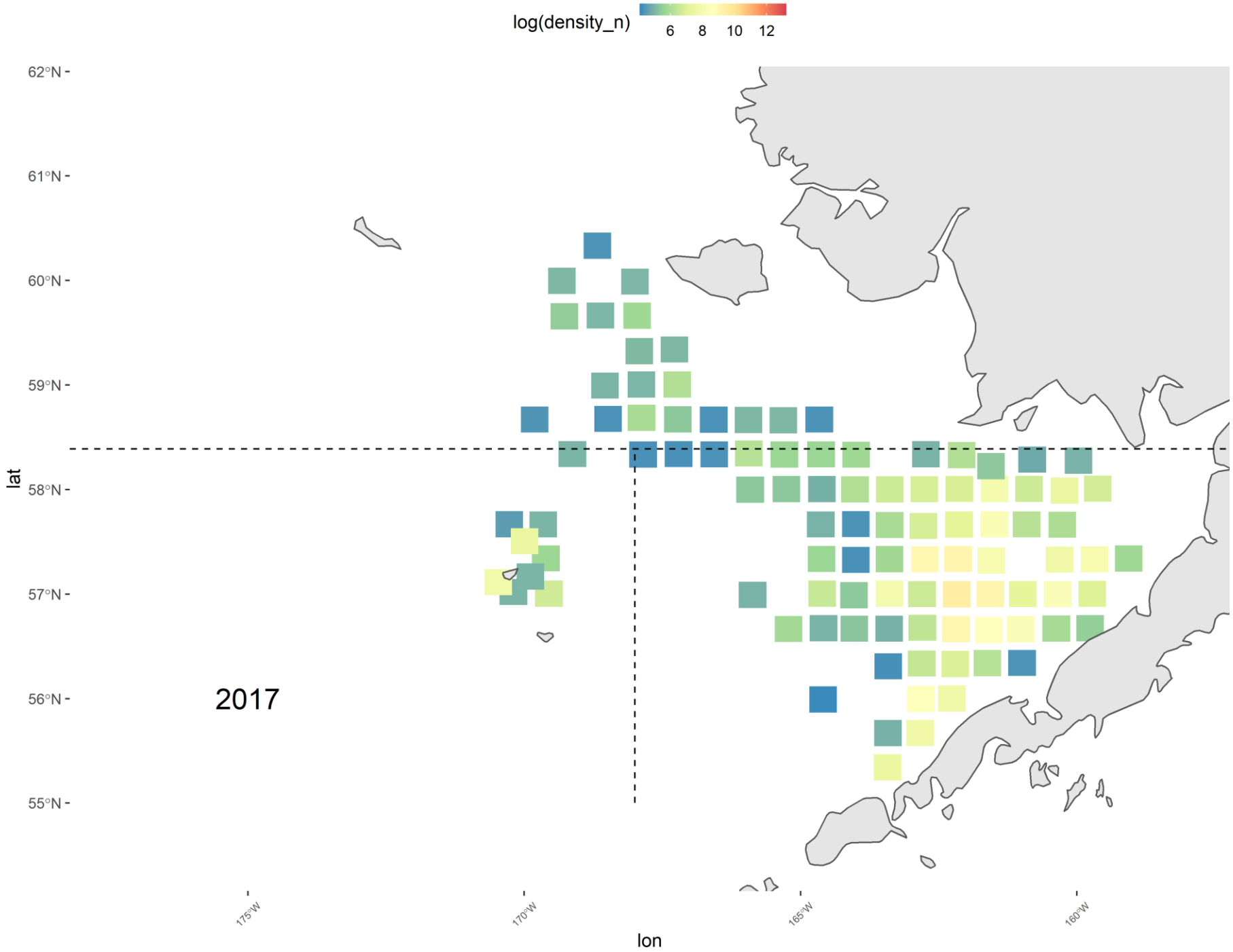

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2012
175°W
170°W
165°W
160°W
lon

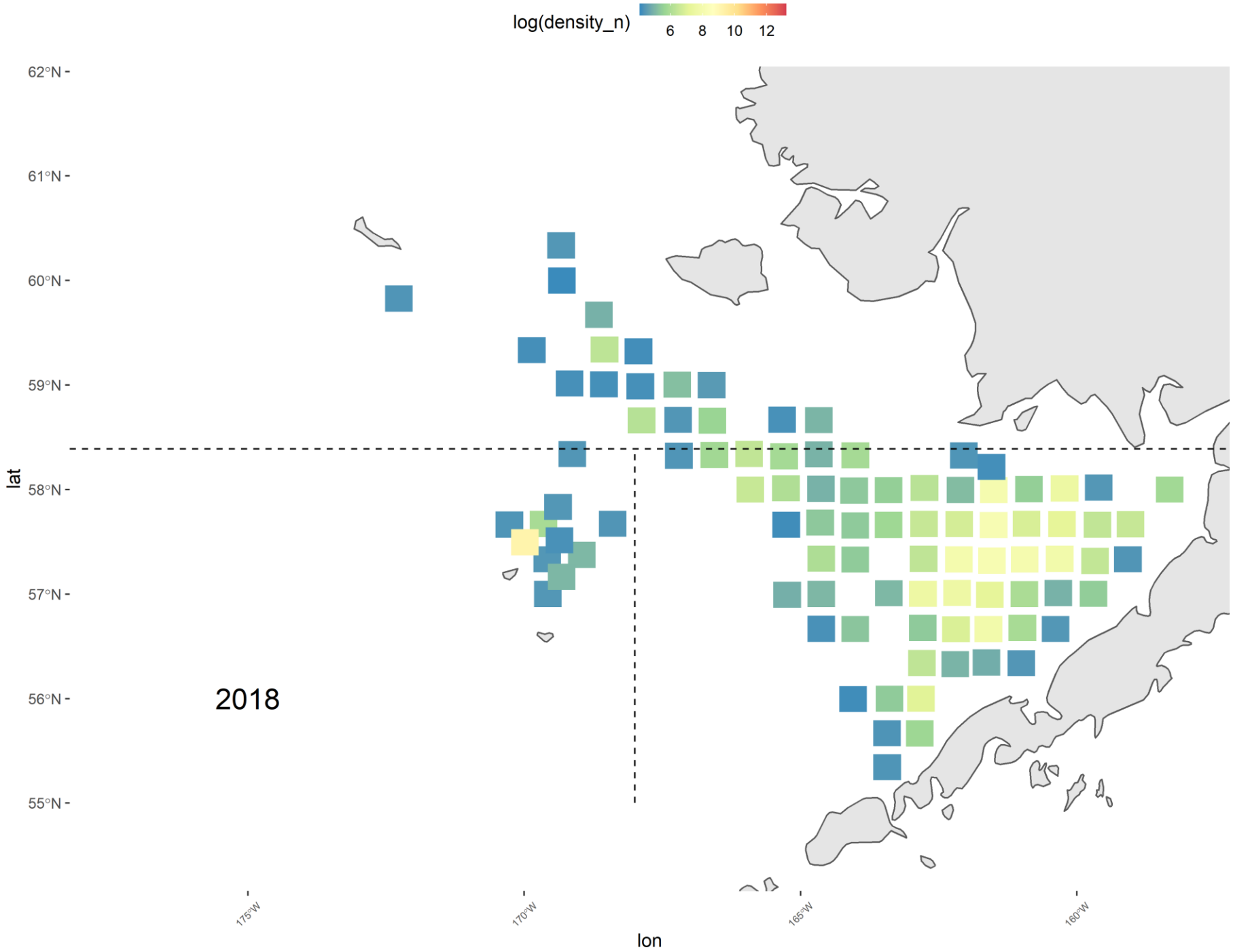

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2013
175°W
170°W
165°W
160°W
lon

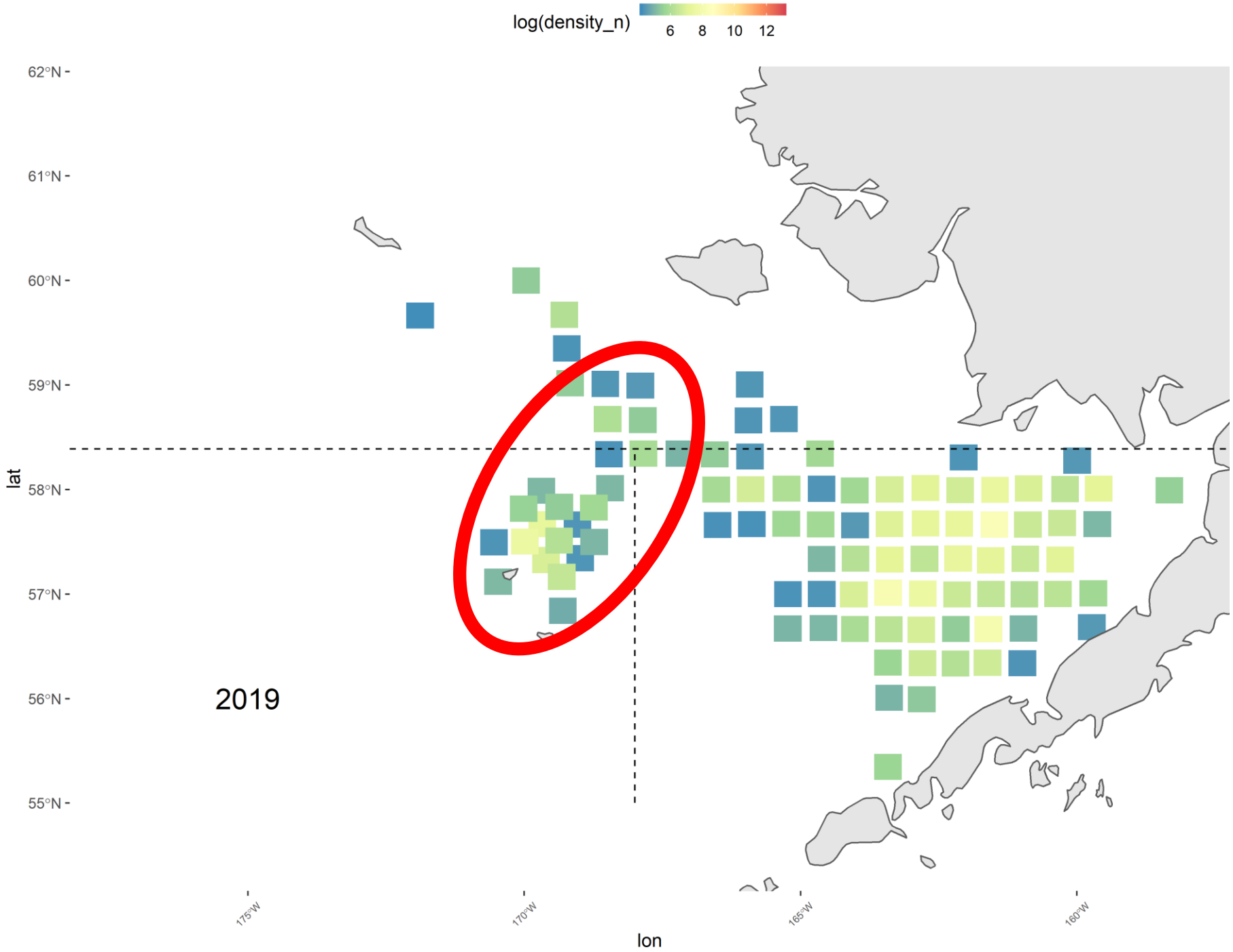

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2014
175°W
170°W
165°W
160°W
lon

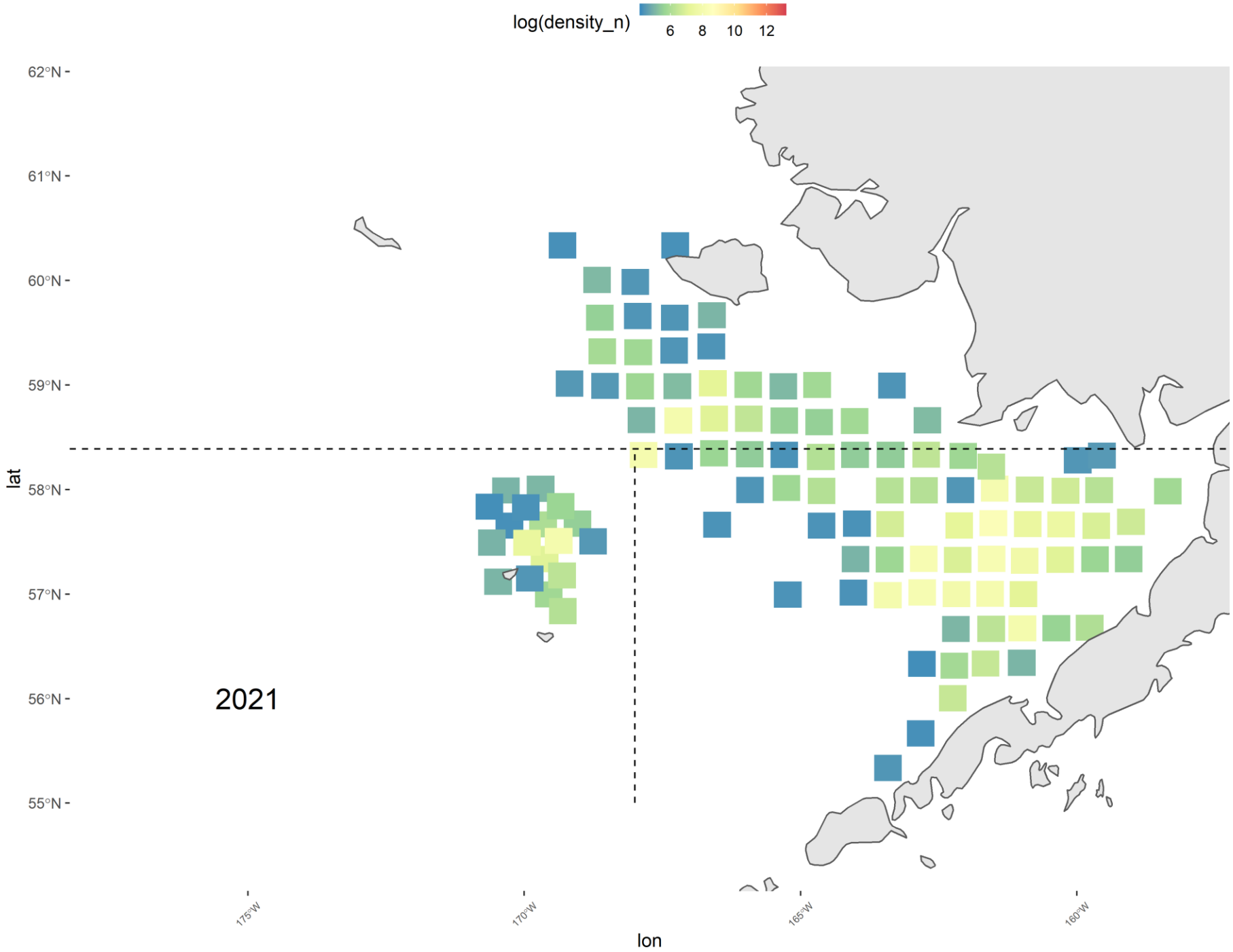

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2015
175°W
170°W
165°W
160°W
lon

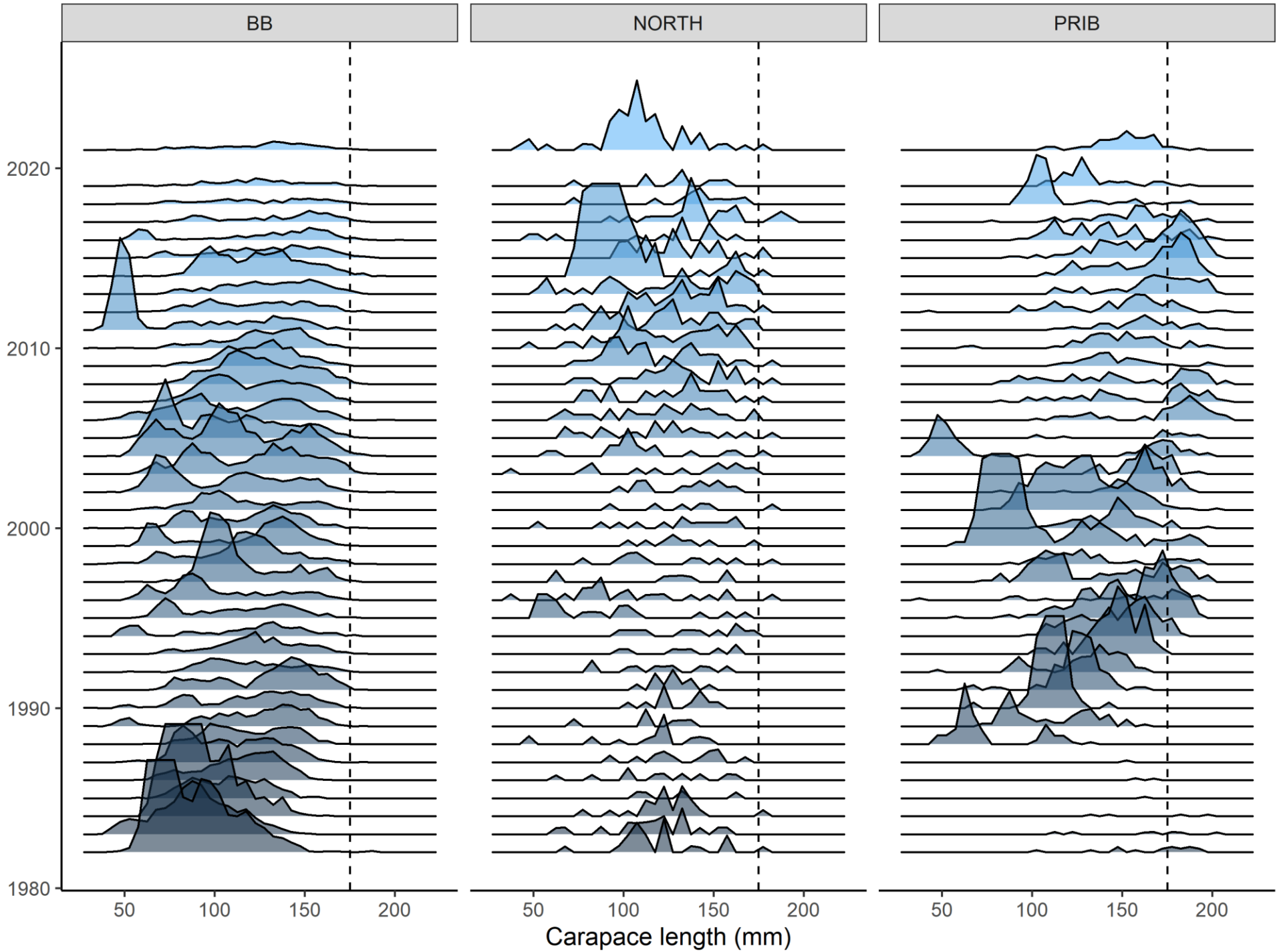

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2016
175°W
170°W
165°W
160°W
lon

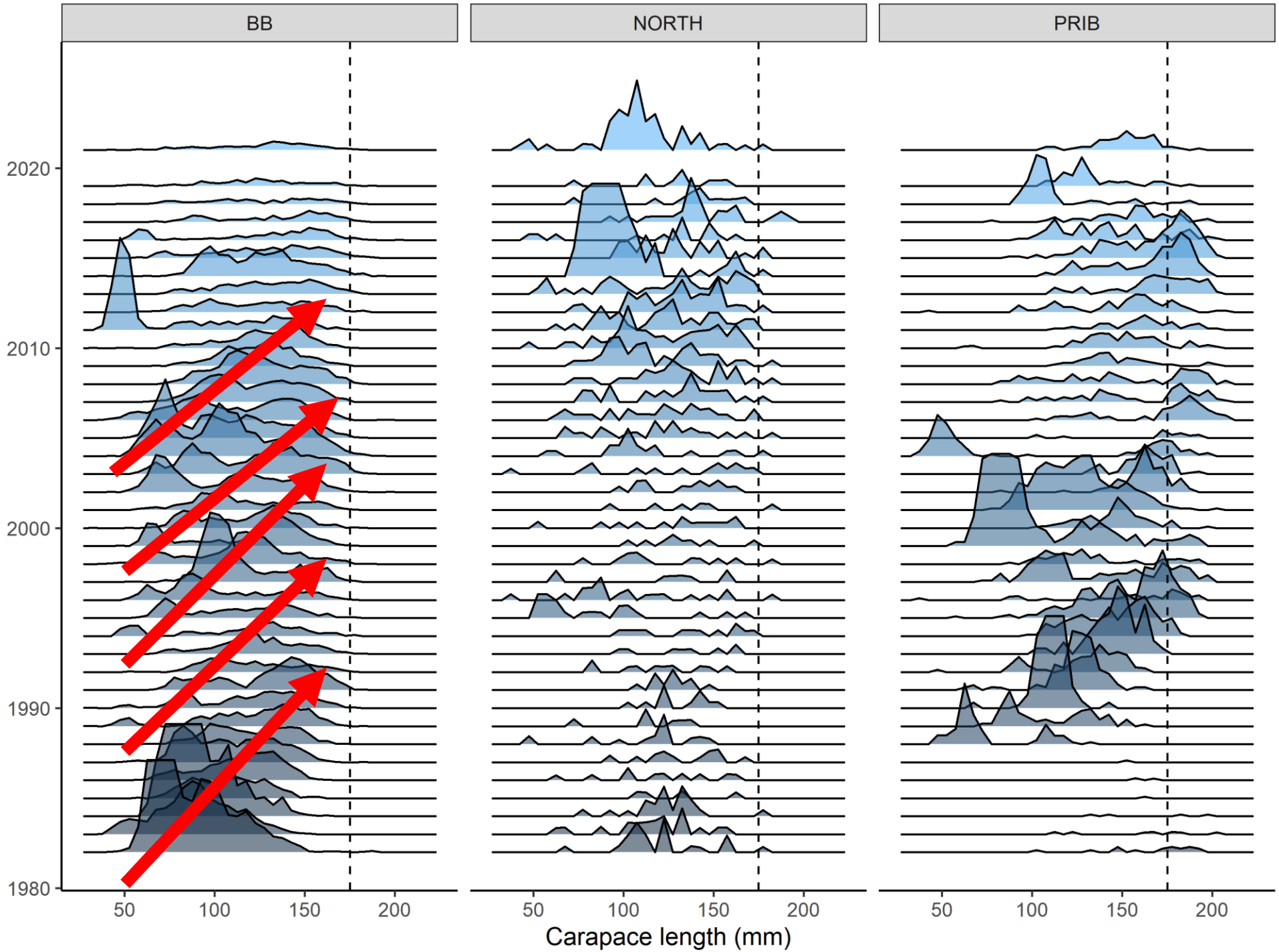

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2017
175°W
170°W
165°W
160°W
lon

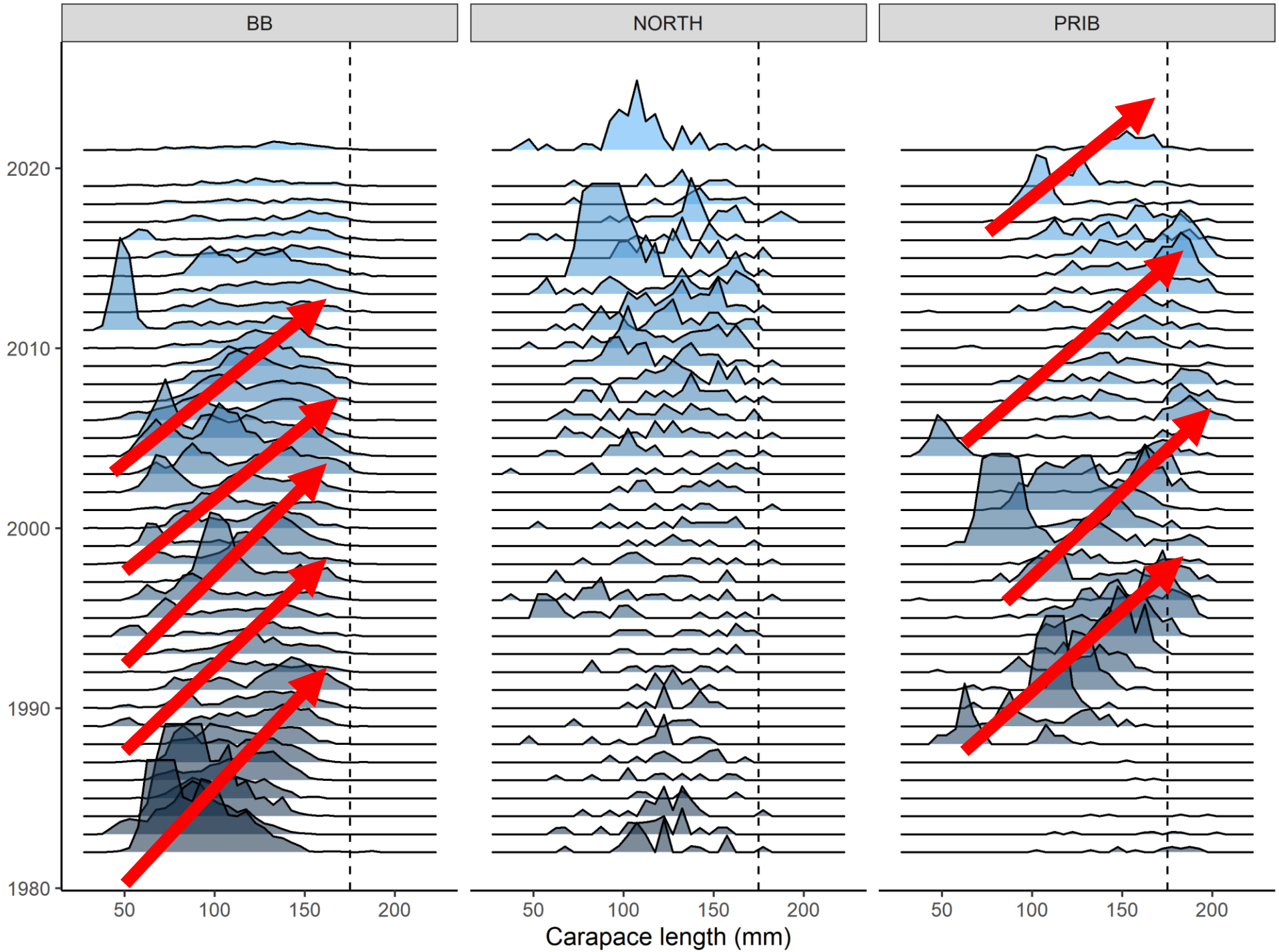

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2018
175°W
170°W
165°W
160°W
lon

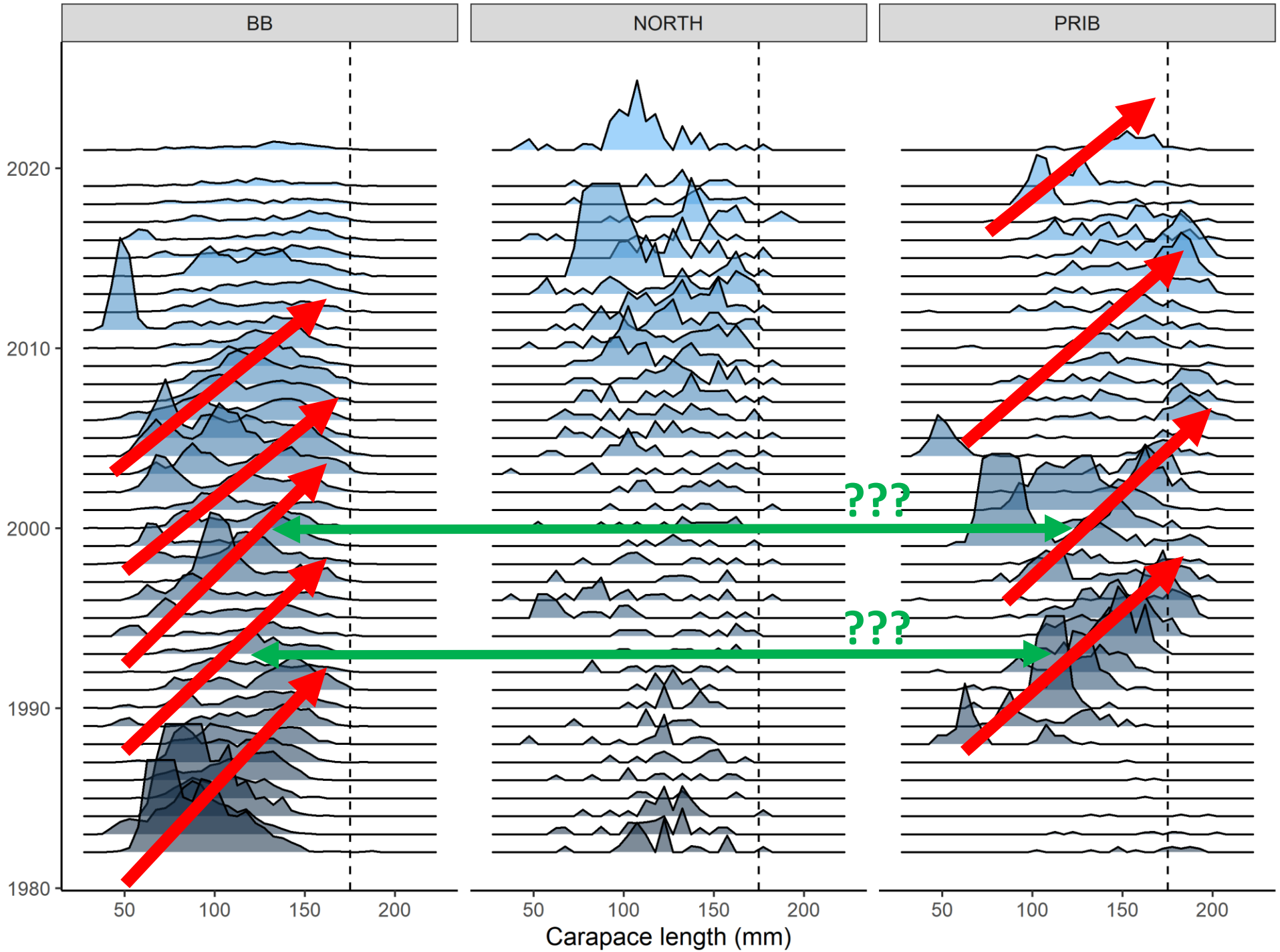

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2019
175°W
170°W
165°W
160°W
lon

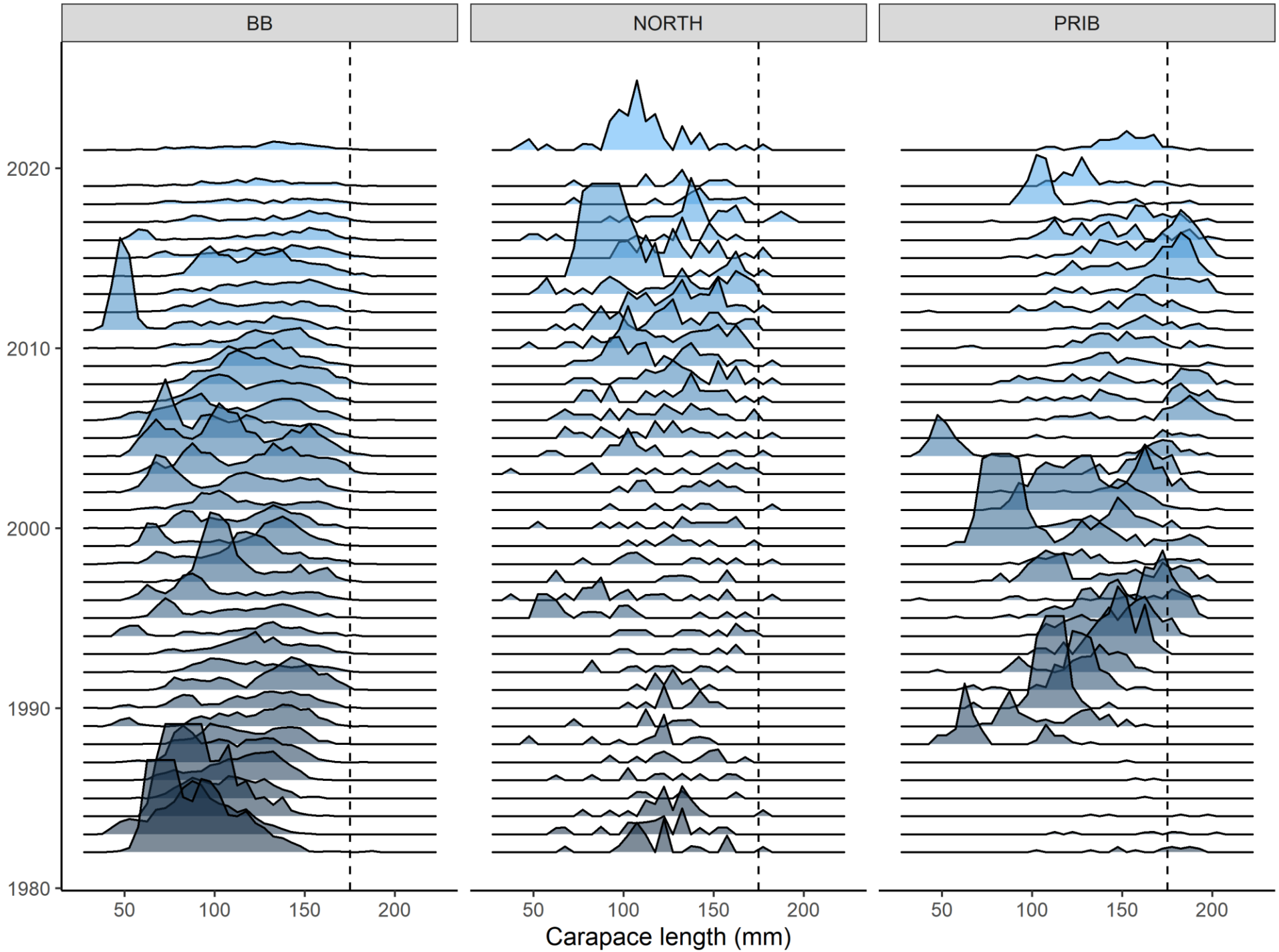

log(density_n)
6
8
10
12
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
lat
2021
175°W
170°W
165°W
160°W
lon

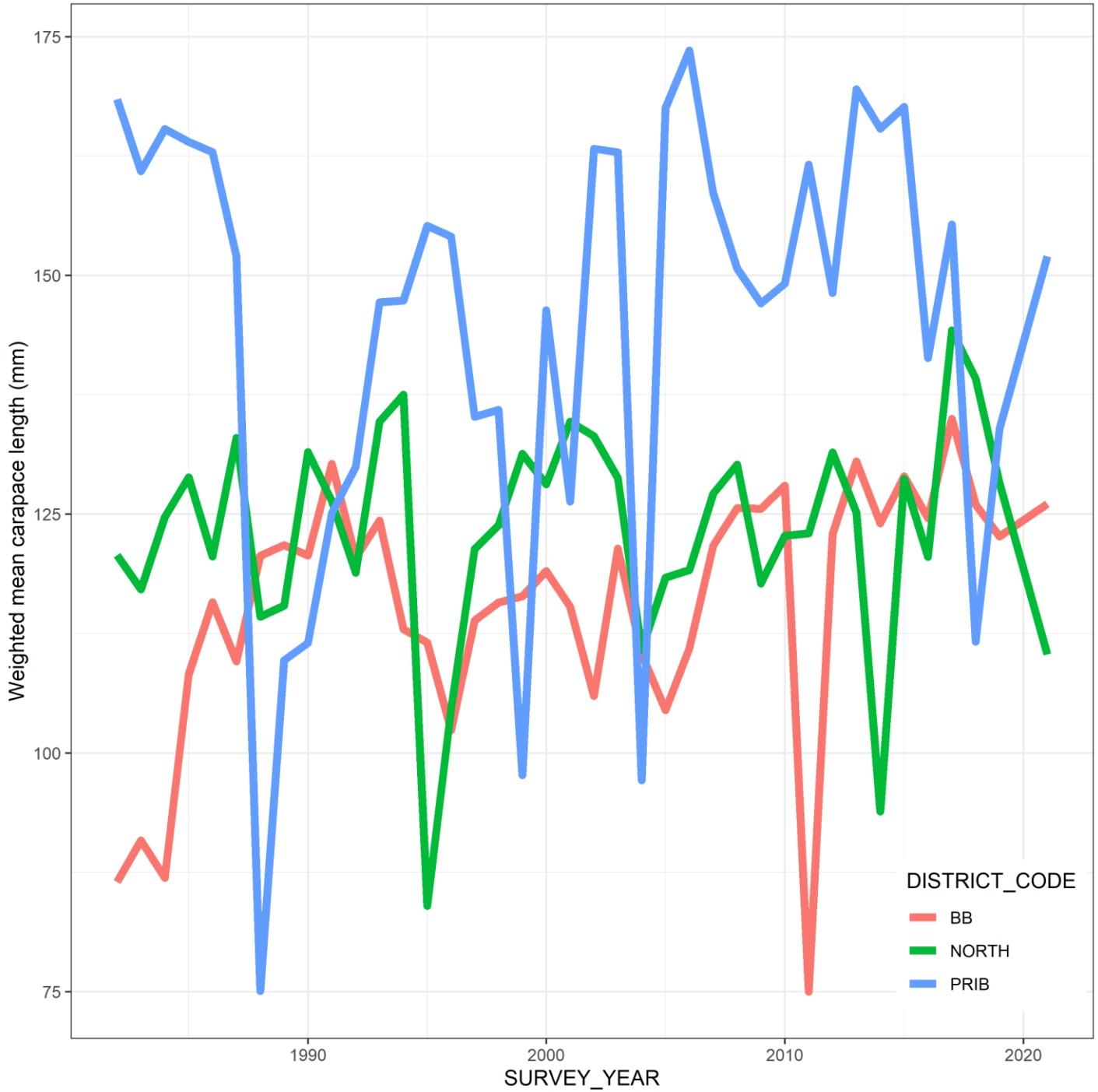

BB
NORTH
PRIB
2020
2010
2000
1990
1980
50
100
150
200
Carapace length (mm)


BB
NORTH
PRIB
2020
2010
2000
1990
1980
50
100
150
200
Carapace length (mm)


BB
NORTH
PRIB
2020
2010
2000
1990
1980
50
100
150
200
Carapace length (mm)


BB
NORTH
PRIB
2020
2010
2000
1990
1980
???
???
50
100
150
200
Carapace length (mm)

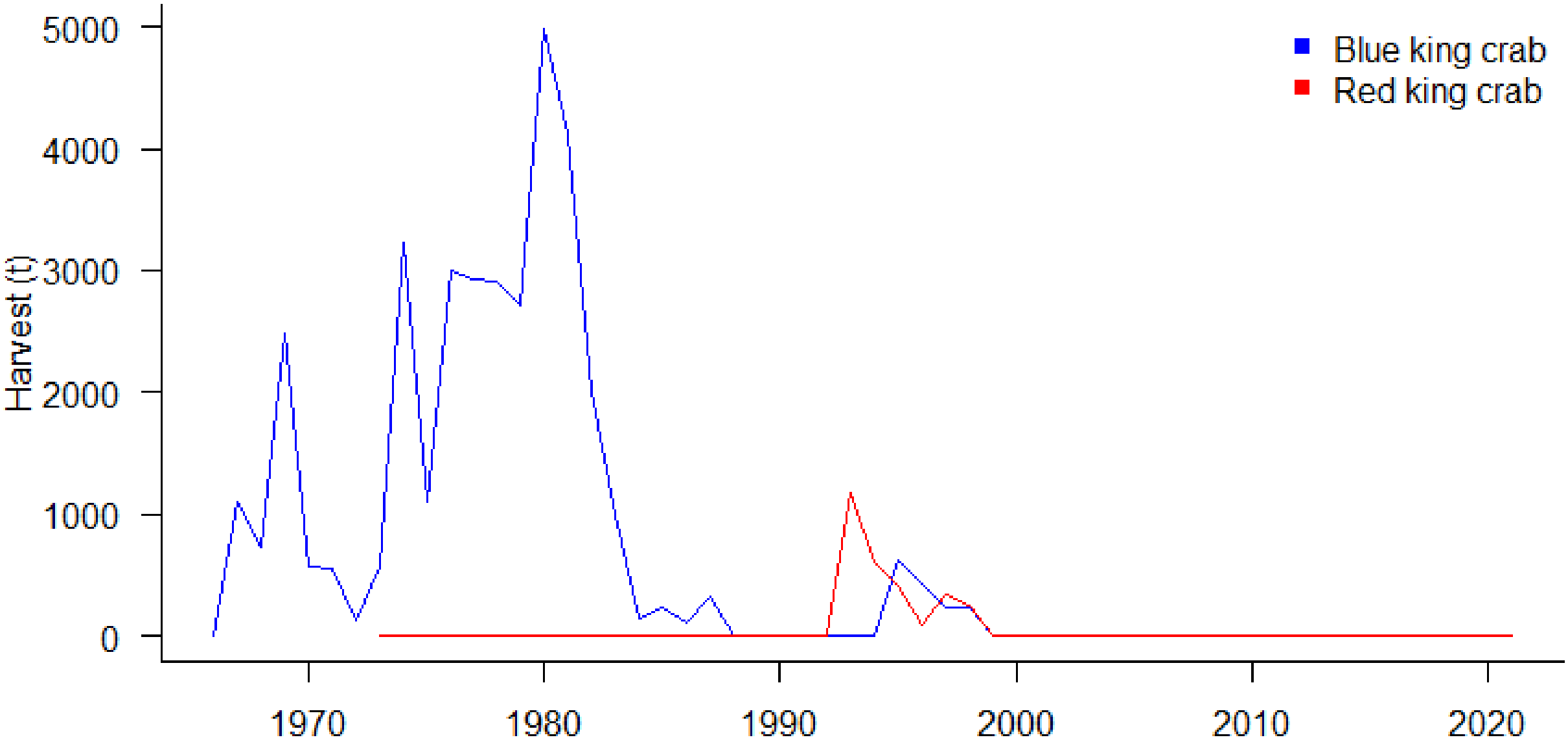

BB
NORTH
PRIB
2020
2010
2000
1990
1980
50
100
150
200
Carapace length (mm)

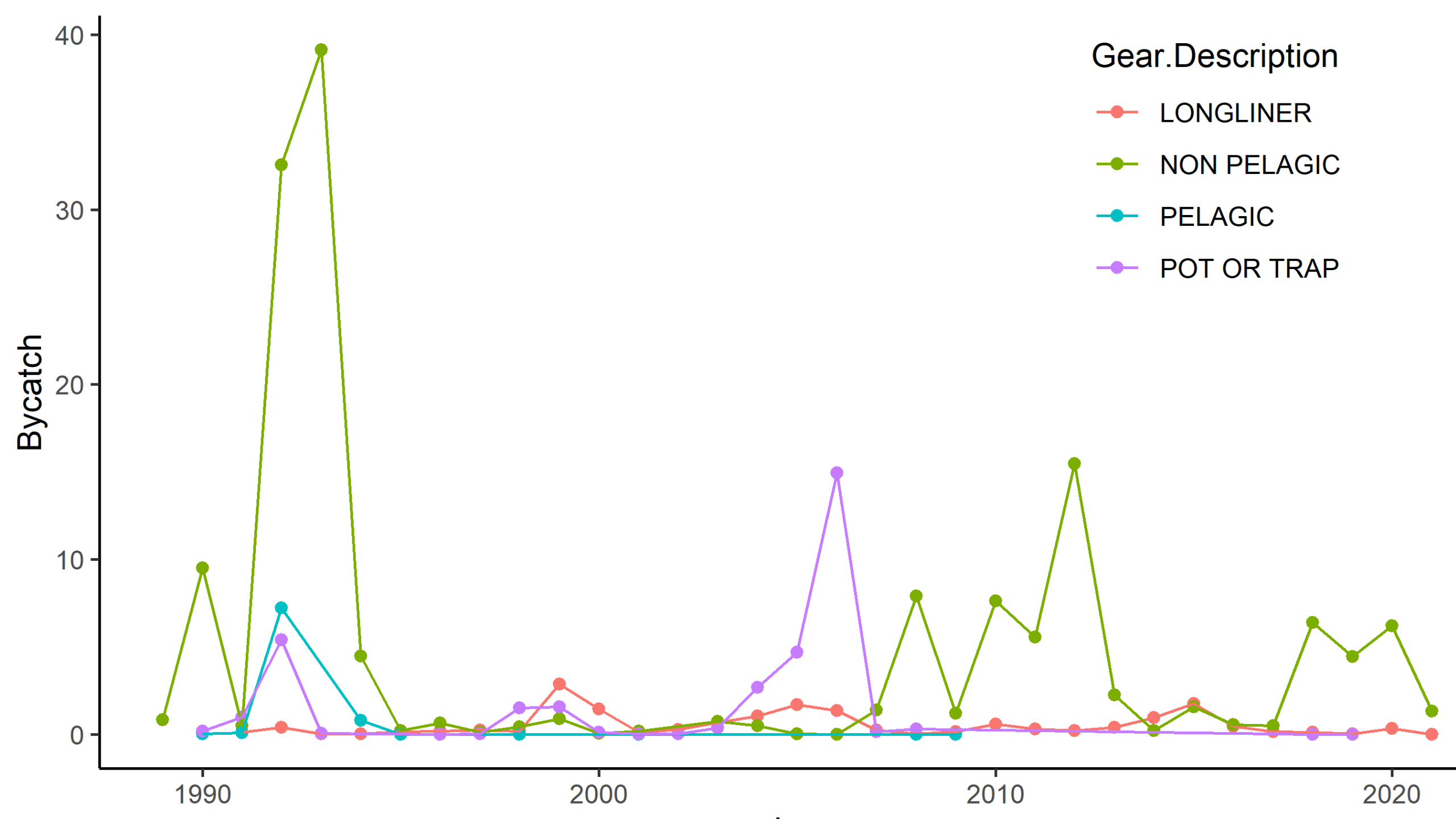


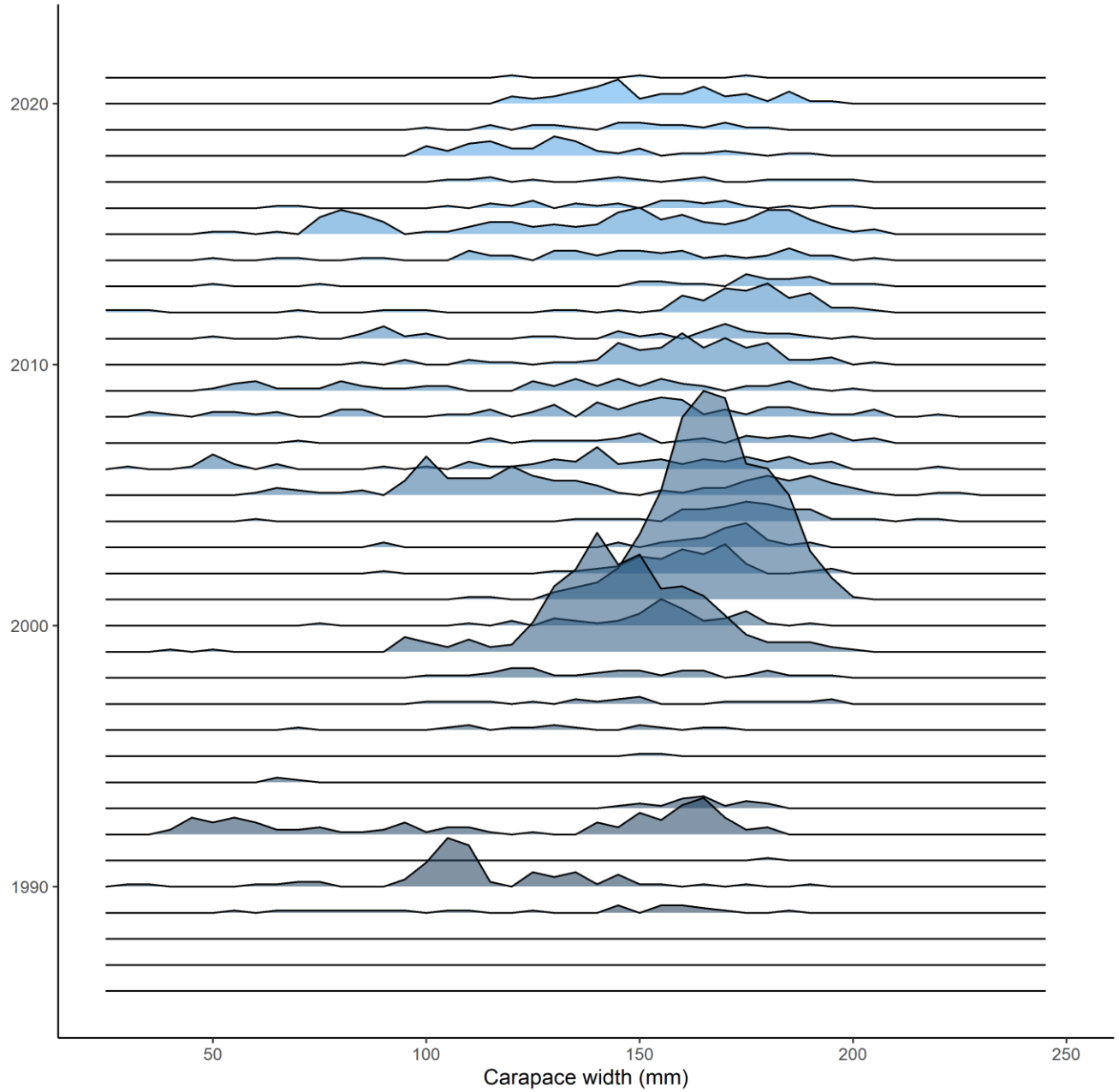
No significant correlations between mean size by district.

Climate change and meta-population dynamics of red king crab in the eastern Bering Sea

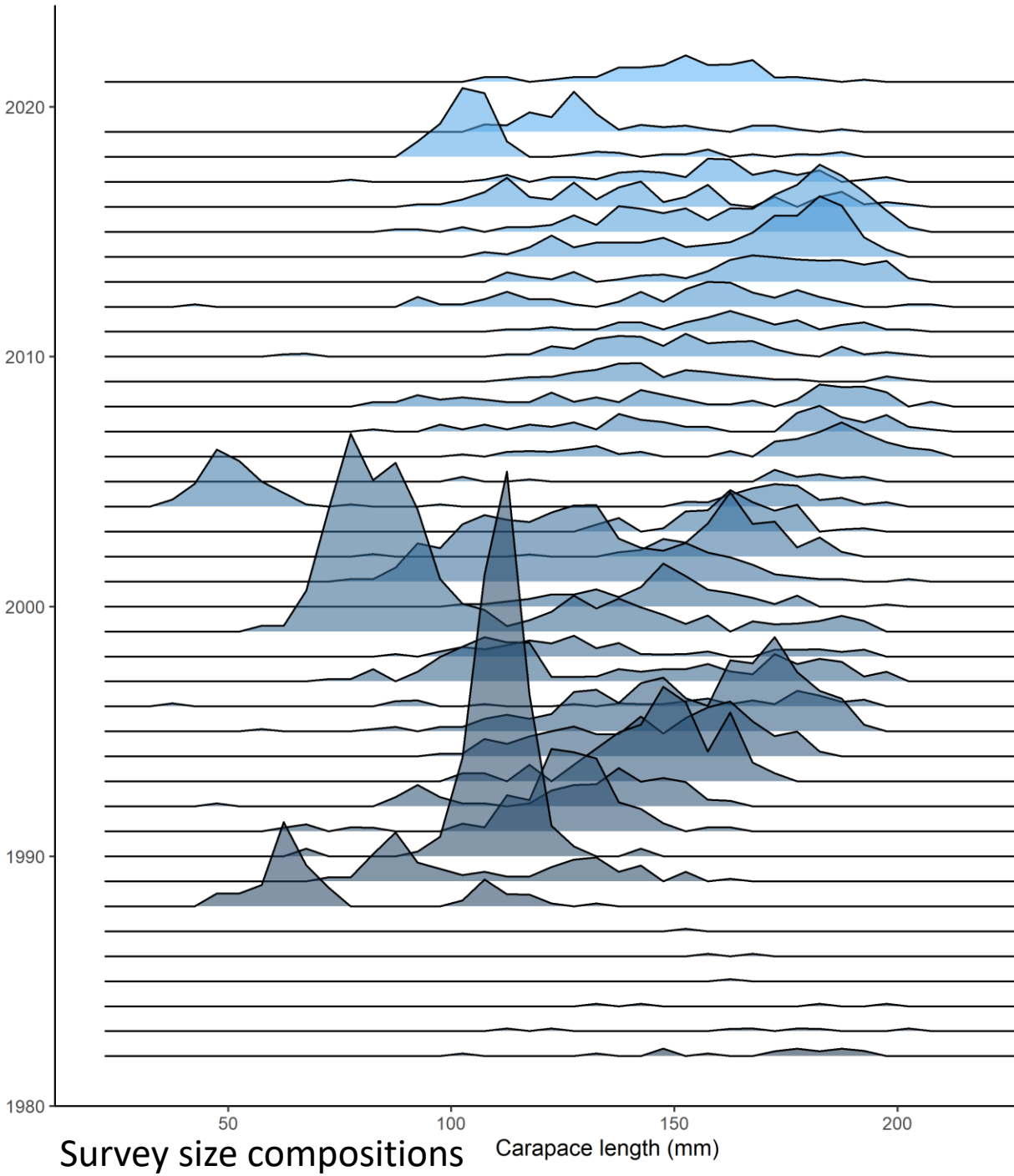
- Are recruitment events in the Pribilofs and Bristol Bay associated with one another?
- Are linkages between the areas related to migration or larval settlement?
- What conditions support linkages?
- What might these linkages look like under a changing climate?
- How do crab in the Northern District fit into this?


Harvest (t)
5000
4000
3000
2000
1000
0
1970
1980
1990
2000
2010
2020
Blue king crab
Red king crab

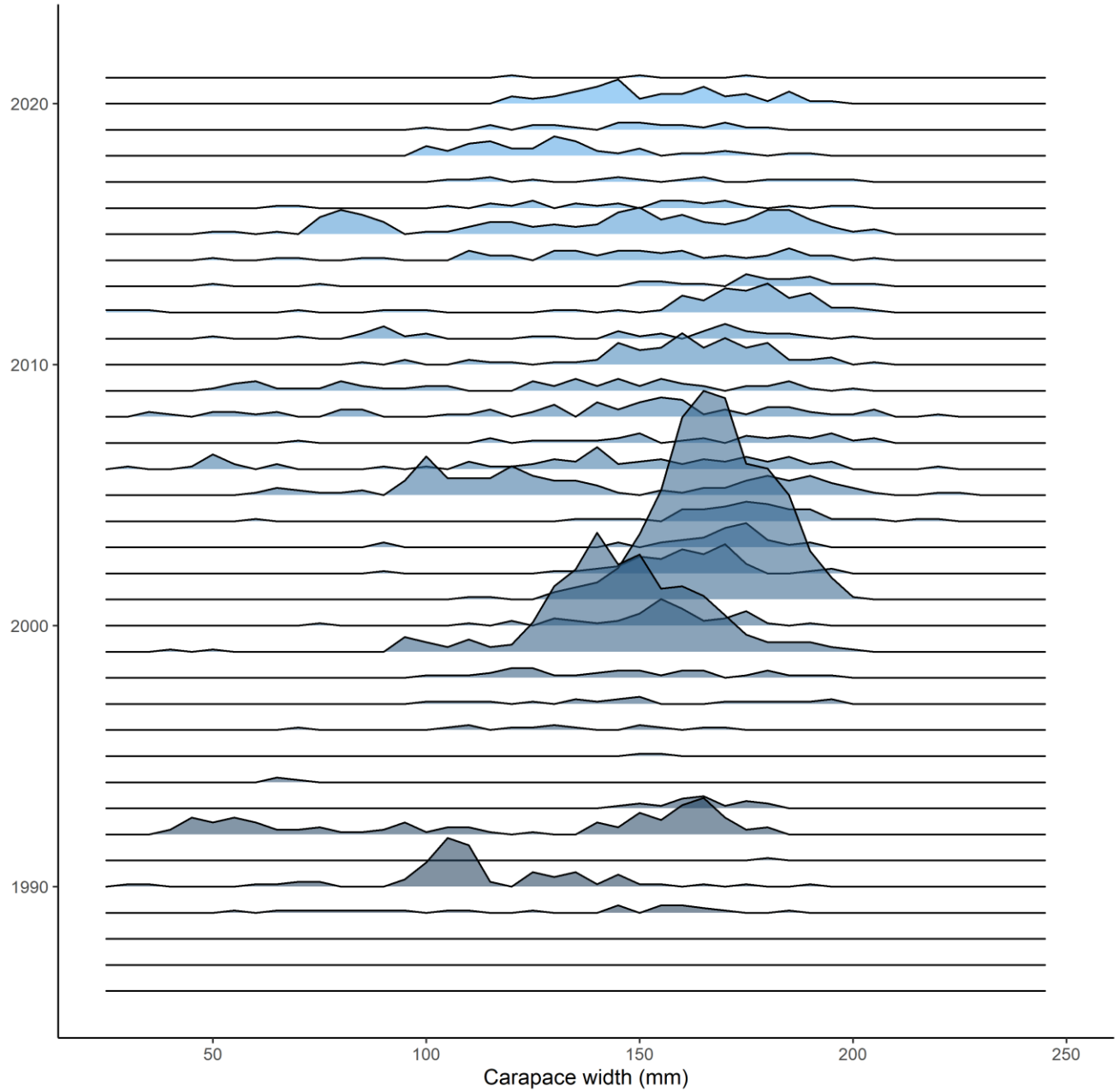

Gear.Description
LONGLINER
NON PELAGIC
PELAGIC
POT OR TRAP
Bycatch
40
30
20
10
0
1990
2000
2010
2020



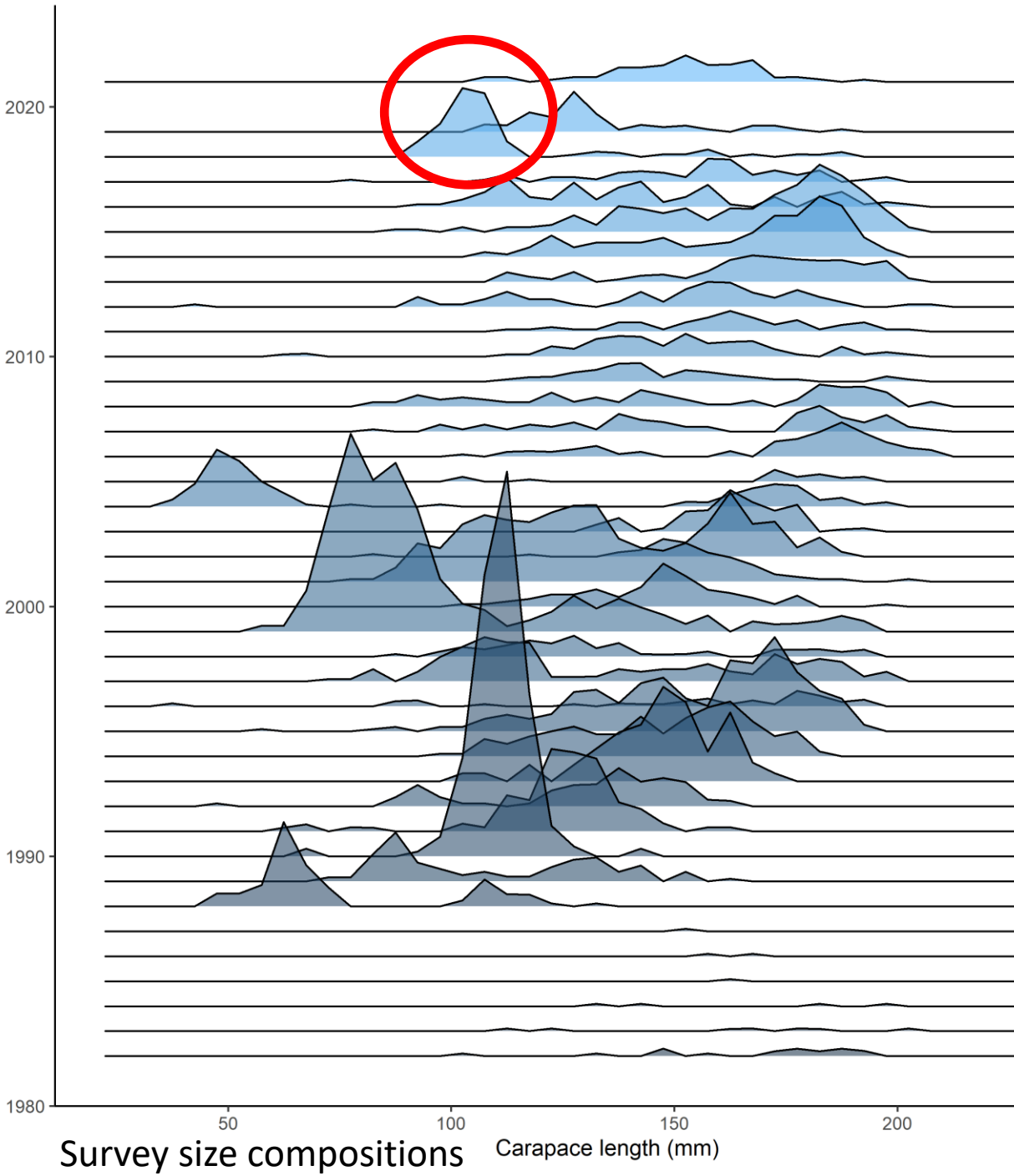
Observer data size compositions



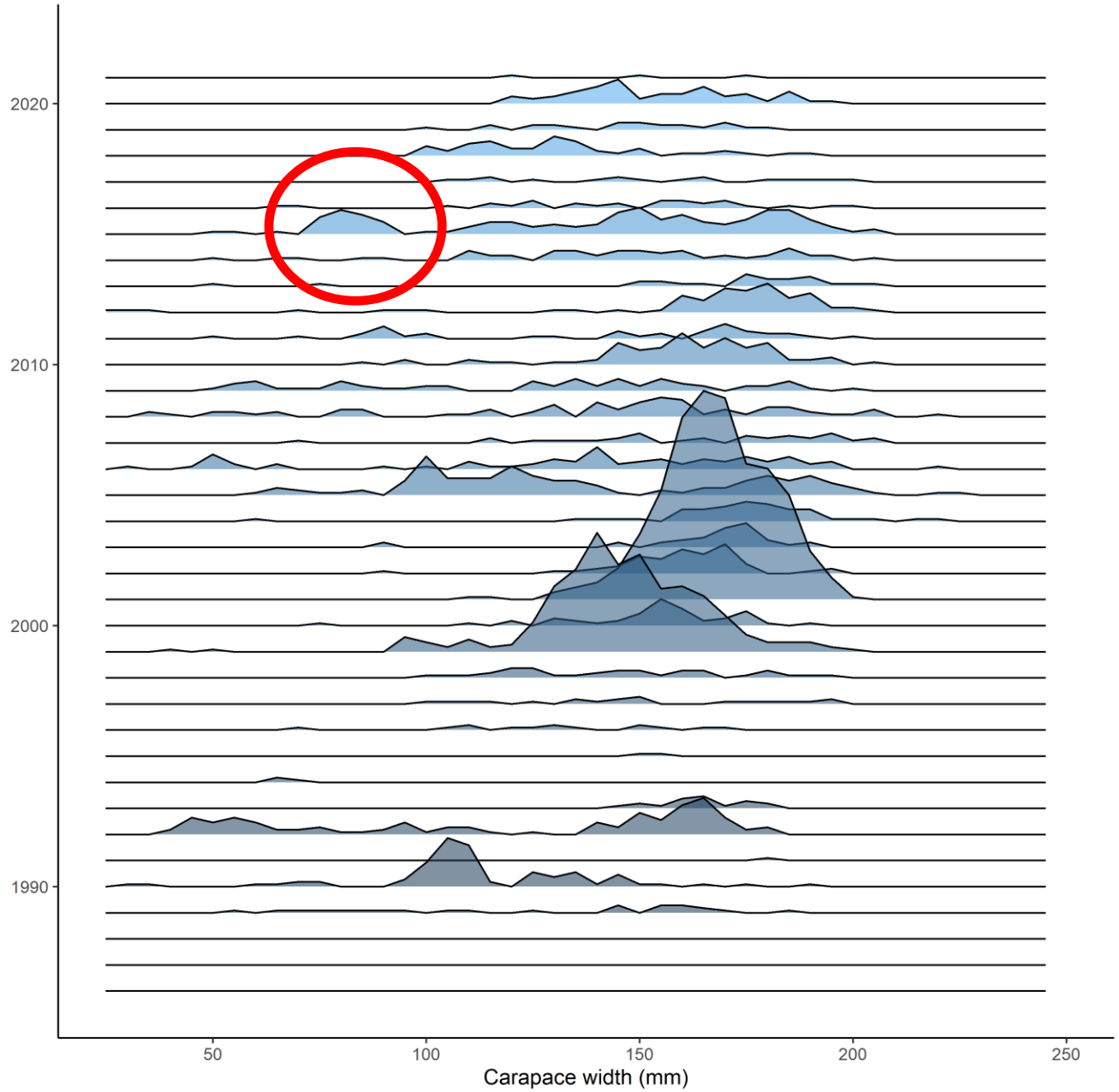
Survey size compositions



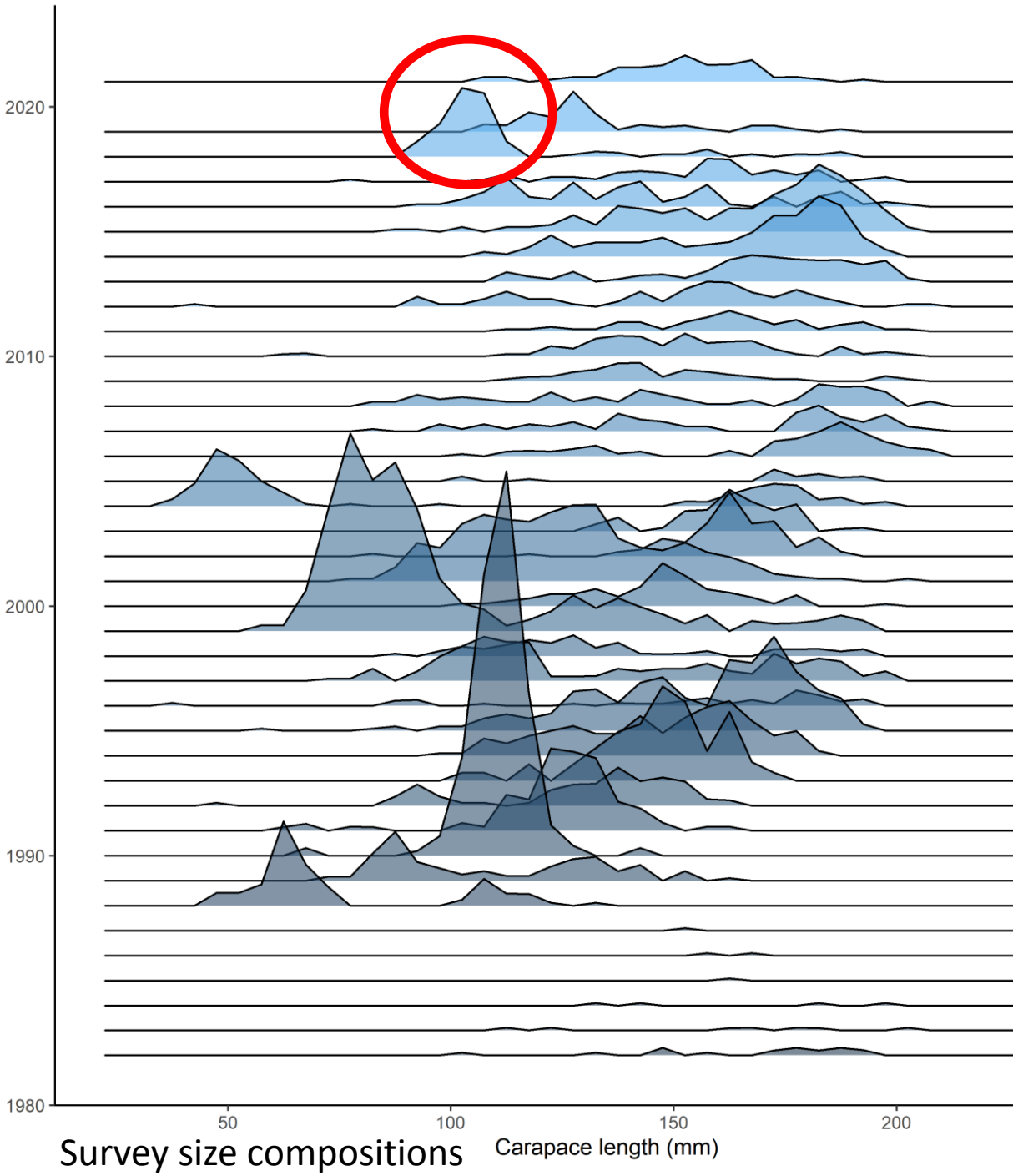
Observer data size compositions



Survey size compositions



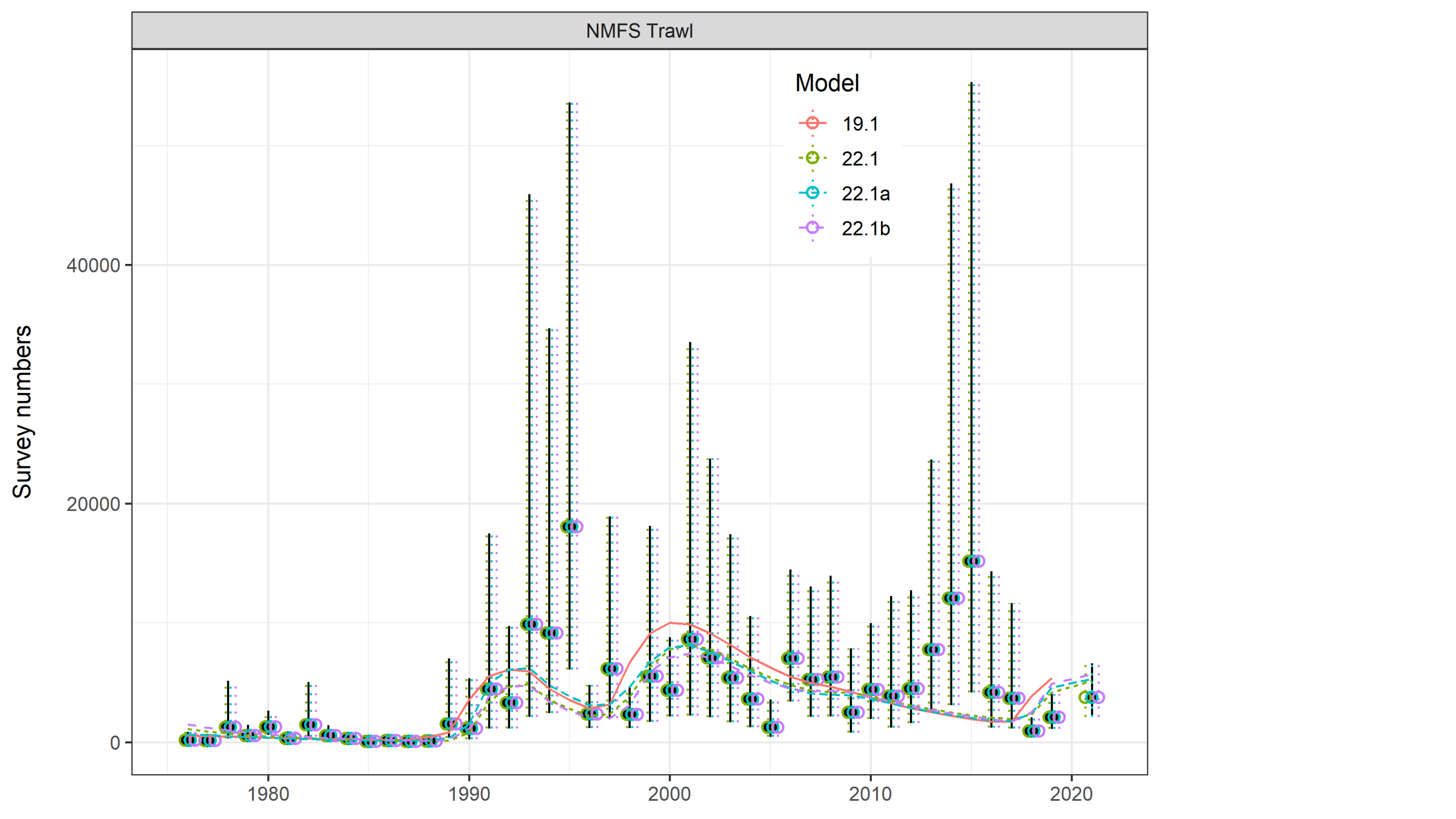
Observer data size compositions

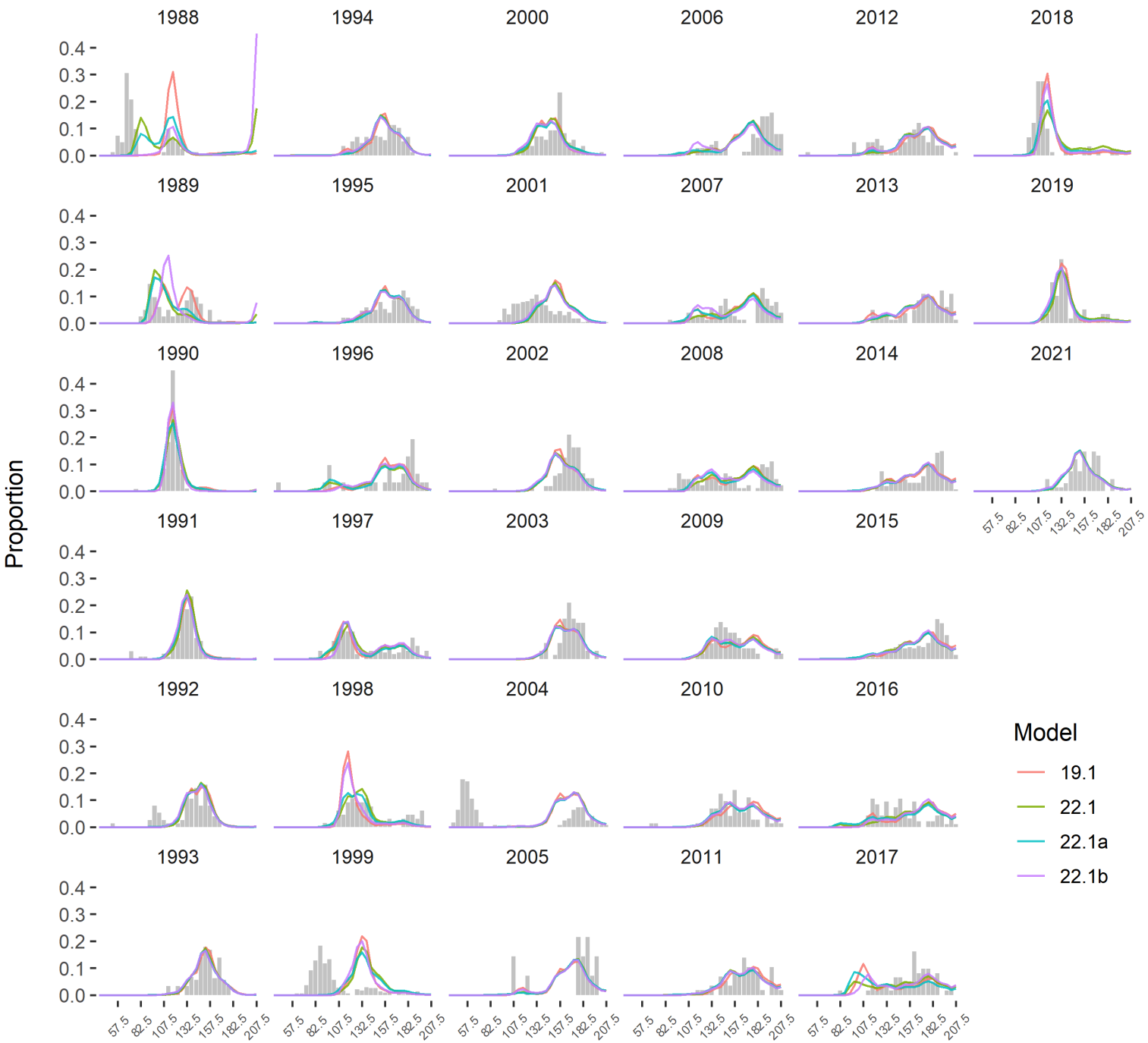


Survey size compositions

Models considered

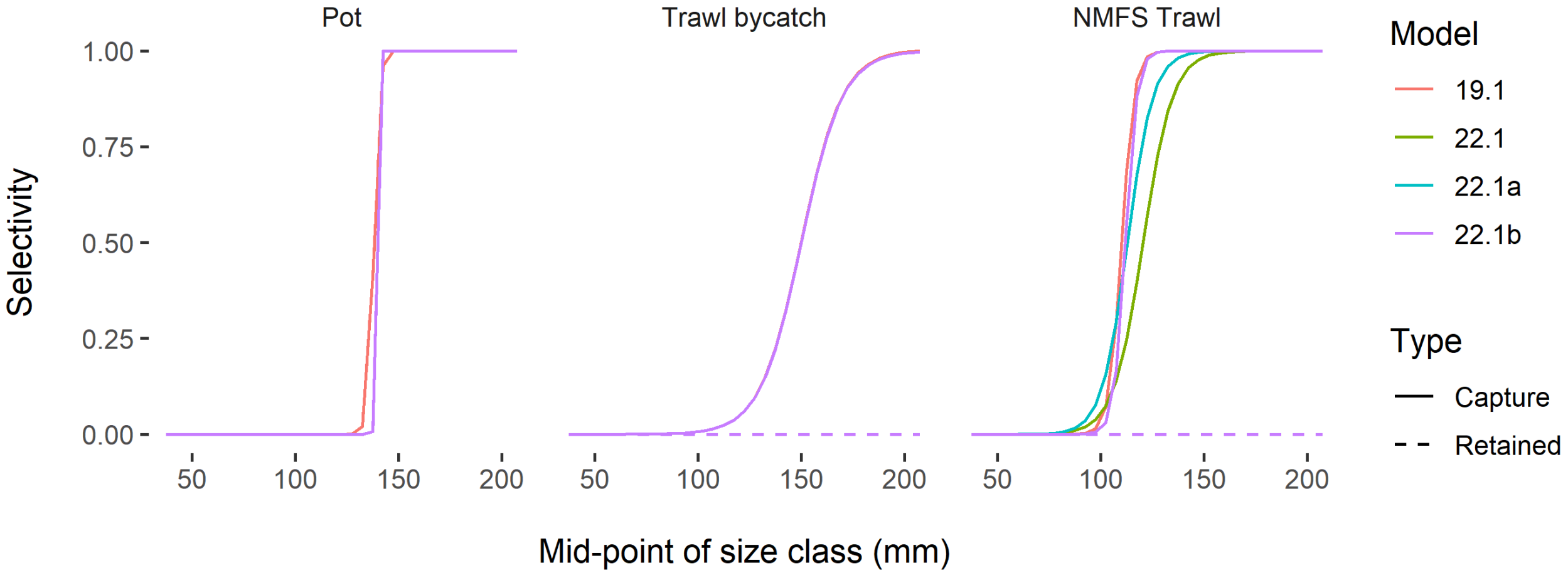
- 19.1: accepted GMACS model
- 22.1: 19.1 + updated data
- 22.1a: 22.1 + all size comp weights set to 50
- 22.1b: 22.1 + all size comp weights divided by 2


NMFS Trawl
Model
19.1
22.1
22.1a
22.1b
Survey numbers
40000
20000
0
1980
1990
2000
2010
2020



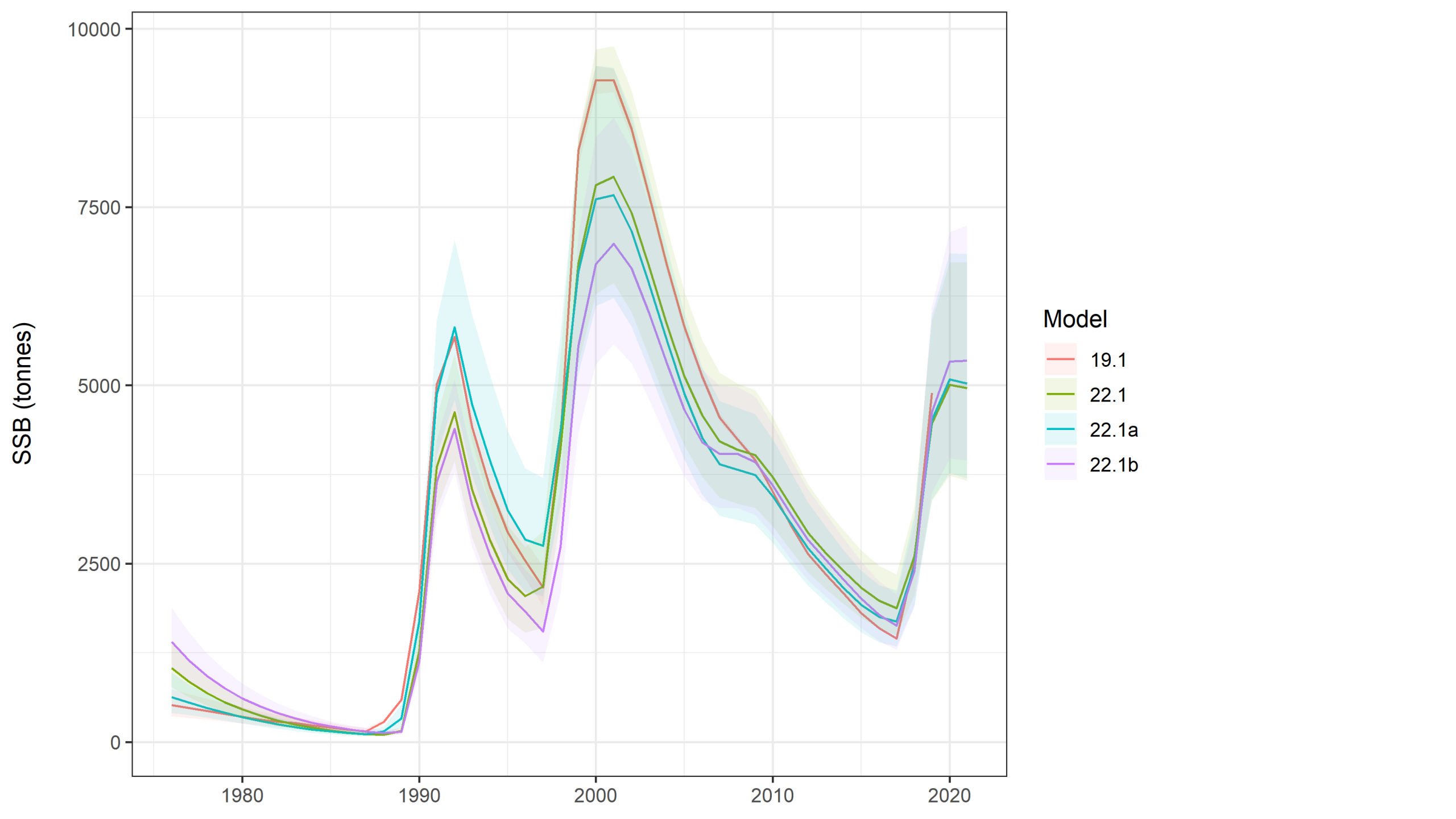
Initial year of size comps is poorly fit for two GMACS models

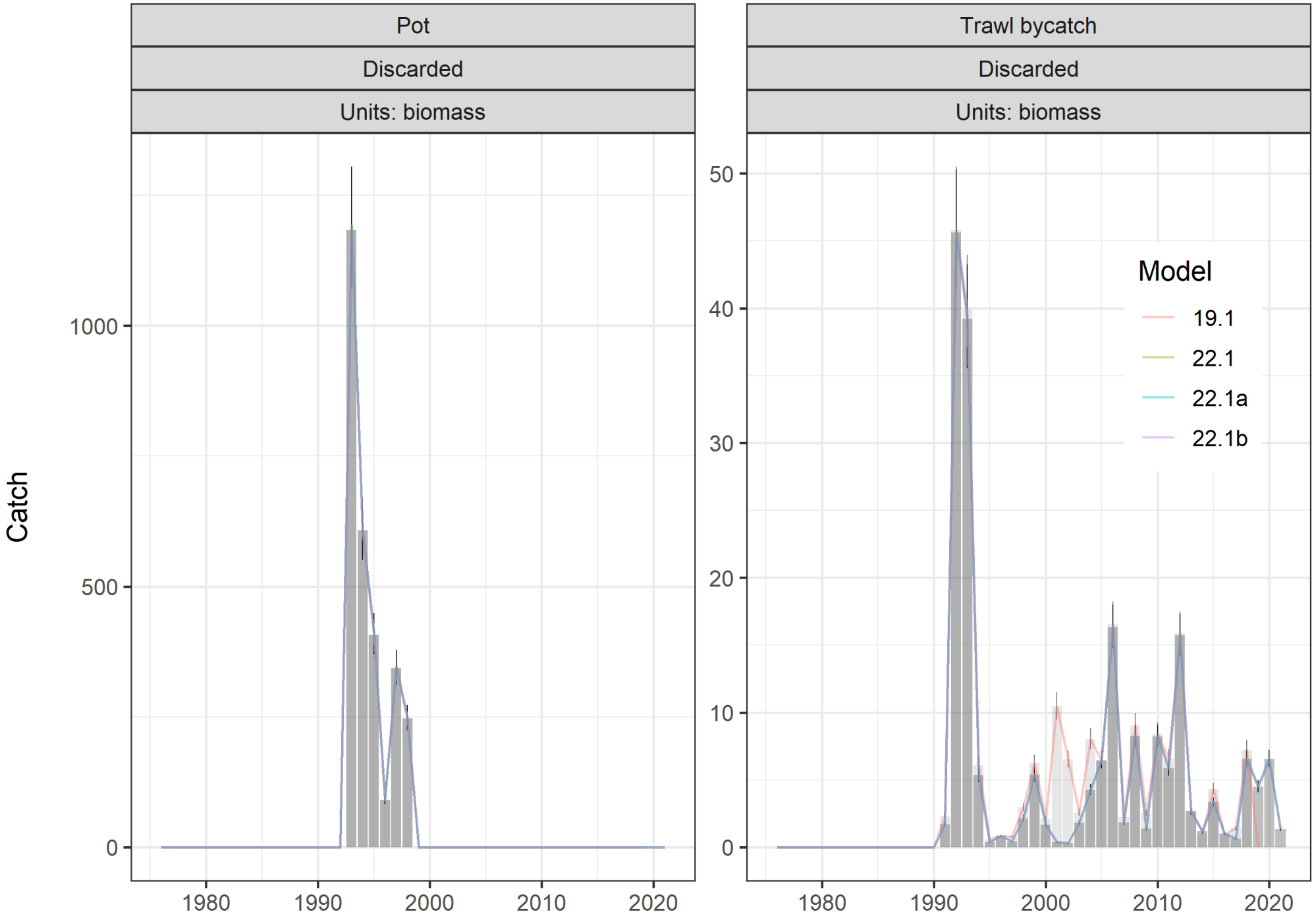
The rest of the years are similarly fit, with the largest differences seen in 1999 and 2018, which correspond to the appearances of new cohorts in the data.



Difference in directed fishery selectivity, in spite of same input parameters (tracking down why this is)

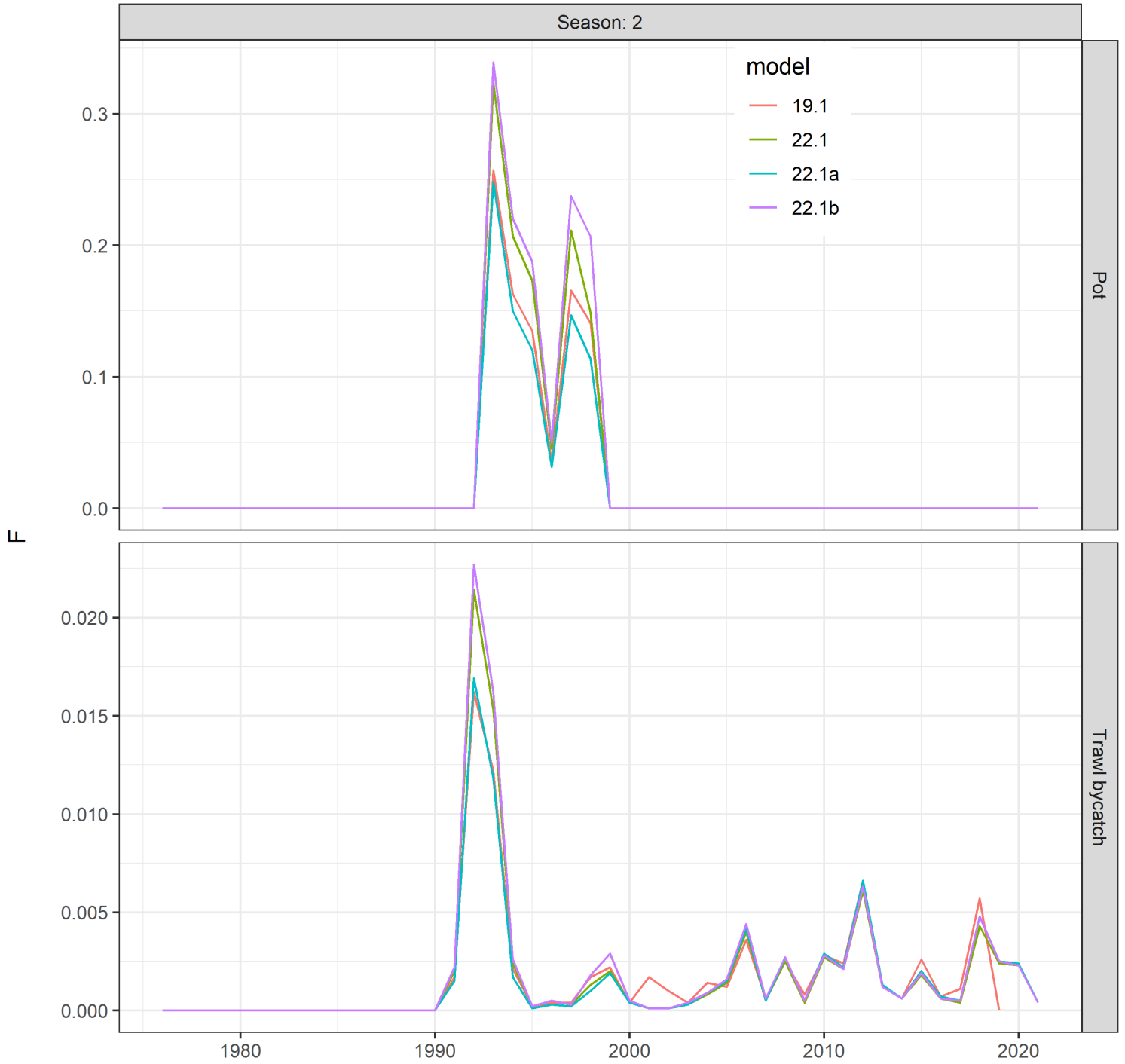
Fairly large differences in the NMFS survey selectivity.

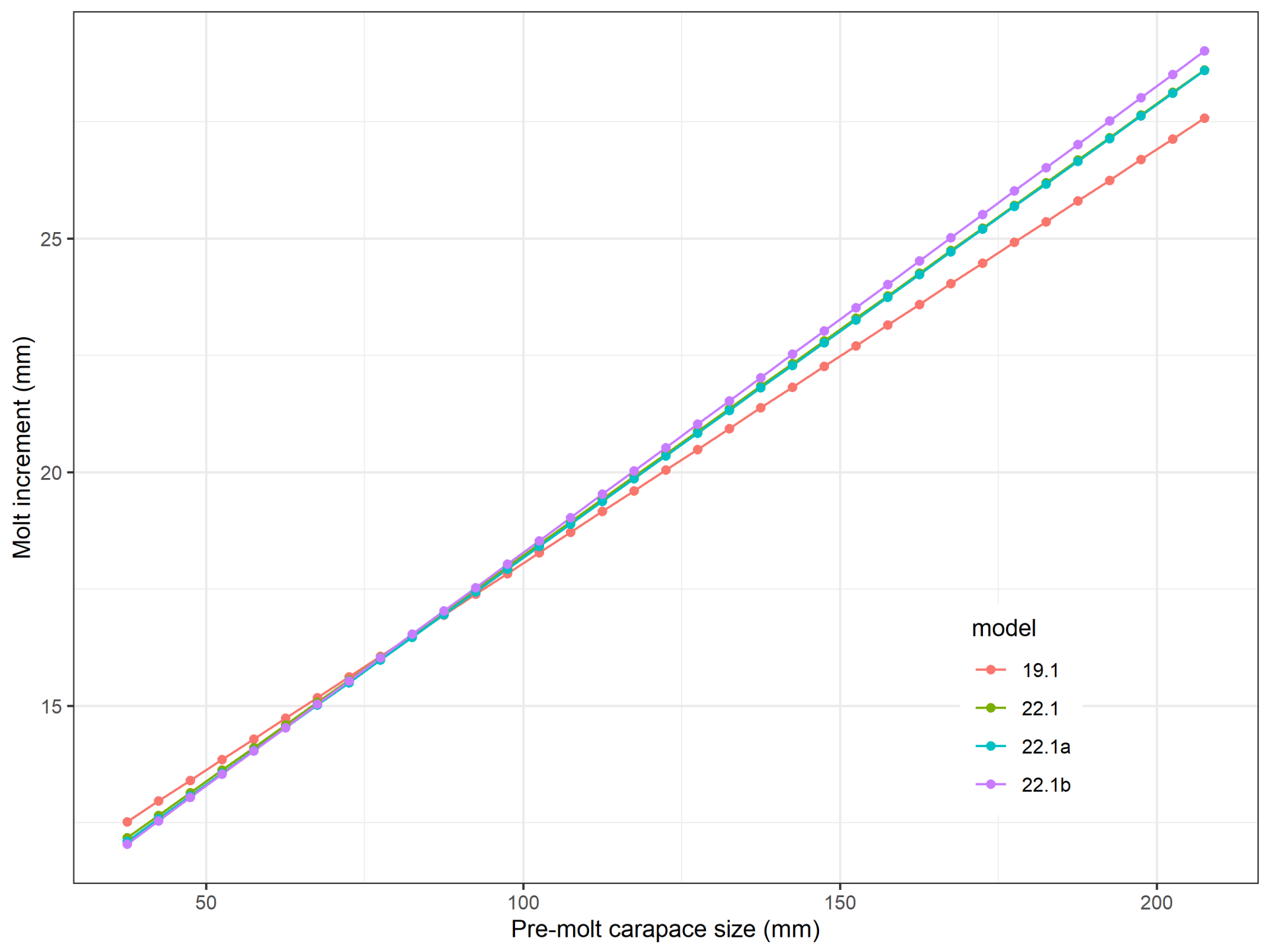

SSB (tonnes)
10000
7500
5000
2500
0
1980
1990
2000
2010
2020
Model
19.1
22.1
22.1a
22.1b

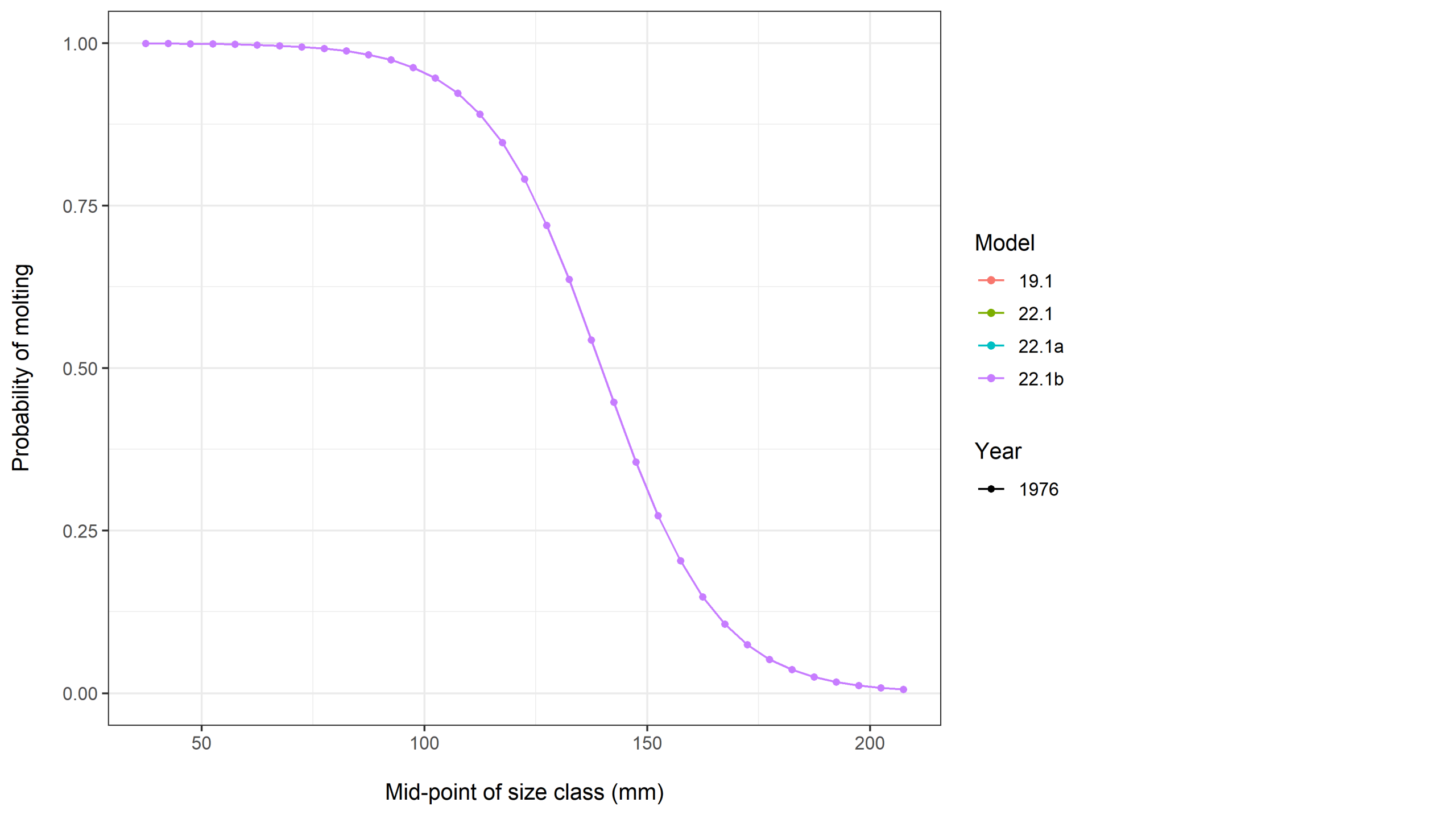


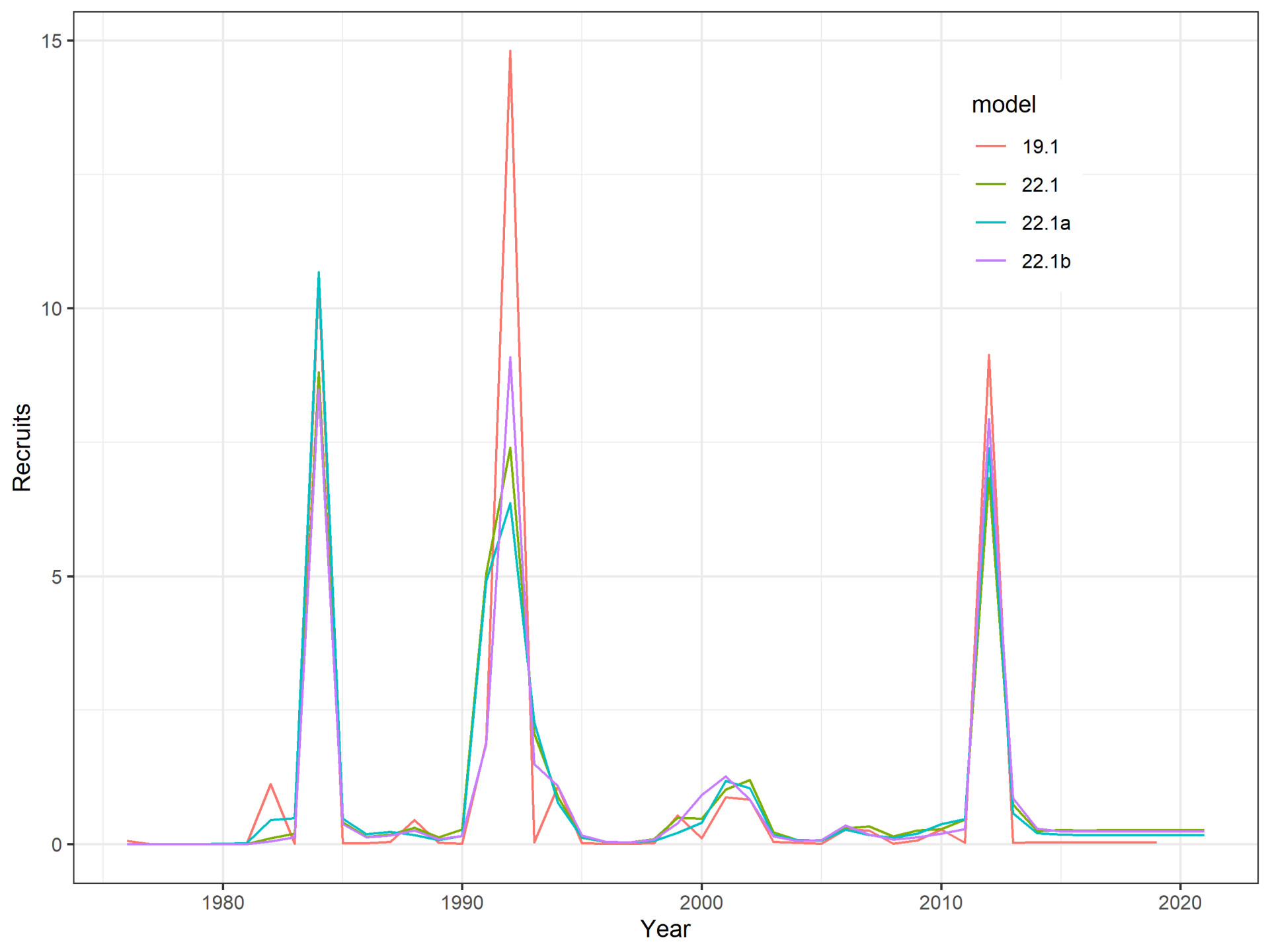
Difference in bycatch data in the early 2000s among models

All data are fit well.


Season: 2
model
19.1
22.1
22.1a
22.1b
Pot
Trawl bycatch
F
0.0
0.1
0.2
0.3
0.000
0.005
0.010
0.015
0.020
1980
1990
2000
2010
2020


Molt increment (mm)
25
20
15
50
100
150
200
Pre-molt carapace size (mm)
model
19.1
22.1
22.1a
22.1b


1.00
0.75
0.50
0.25
0.00
Probability of molting
50
100
150
200
Mid-point of size class (mm)
Model
19.1
22.1
22.1a
22.1b
Year
1976


model
19.1
22.1
22.1a
22.1b
Recruits
Year
0
5
10
15
1980
1990
2000
2010
2020

Year	Tier	BMSY	MMB	Status	FOFL	Years	M
2021/2022	4	1524	4963	3.257	0.21	2000-2020	0.21

- Biomass declined since last assessment
- MSST is also slightly lower based on revisions of the estimated biomass.
- The stock is 3.26x greater than the BMSY proxy.

- Overfishing is not occurring.
- The stock is not overfished.

Suggested models for September

- 19.1
- 22.1
- 22.1 + ADFG data
- 22.1 + trawl size comps (estimate bycatch selectivity)
- 22.1 + ADFG data + trawl size comps (estimate bycatch selectivity)

- Future thoughts: growth and probability of molting sensitivities