Pribilof Islands Red King Crab

Cody Szuwalski

Bob Foy

Jack Turnock

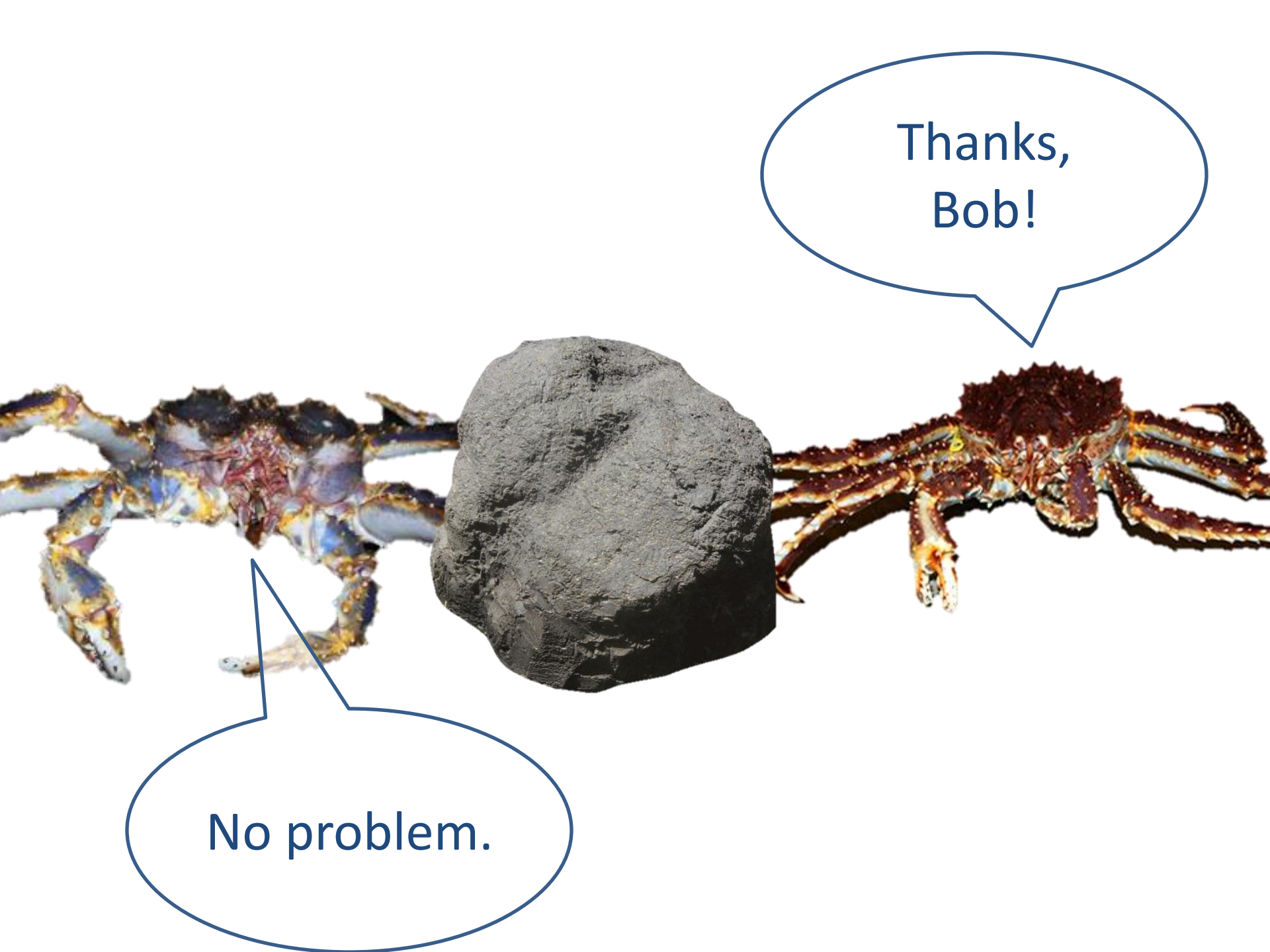
A comparison of three different assessment methods:

Assessment method	Harvest strategy
Weighted 3-year running average	Tier 4 HCR
Integrated assessment	Tier 4 HCR
Integrated assessment	Tier 3 HCR

OFLs:

RunAvg + Tier 4 > IntA + Tier 3 > IntA + Tier 4

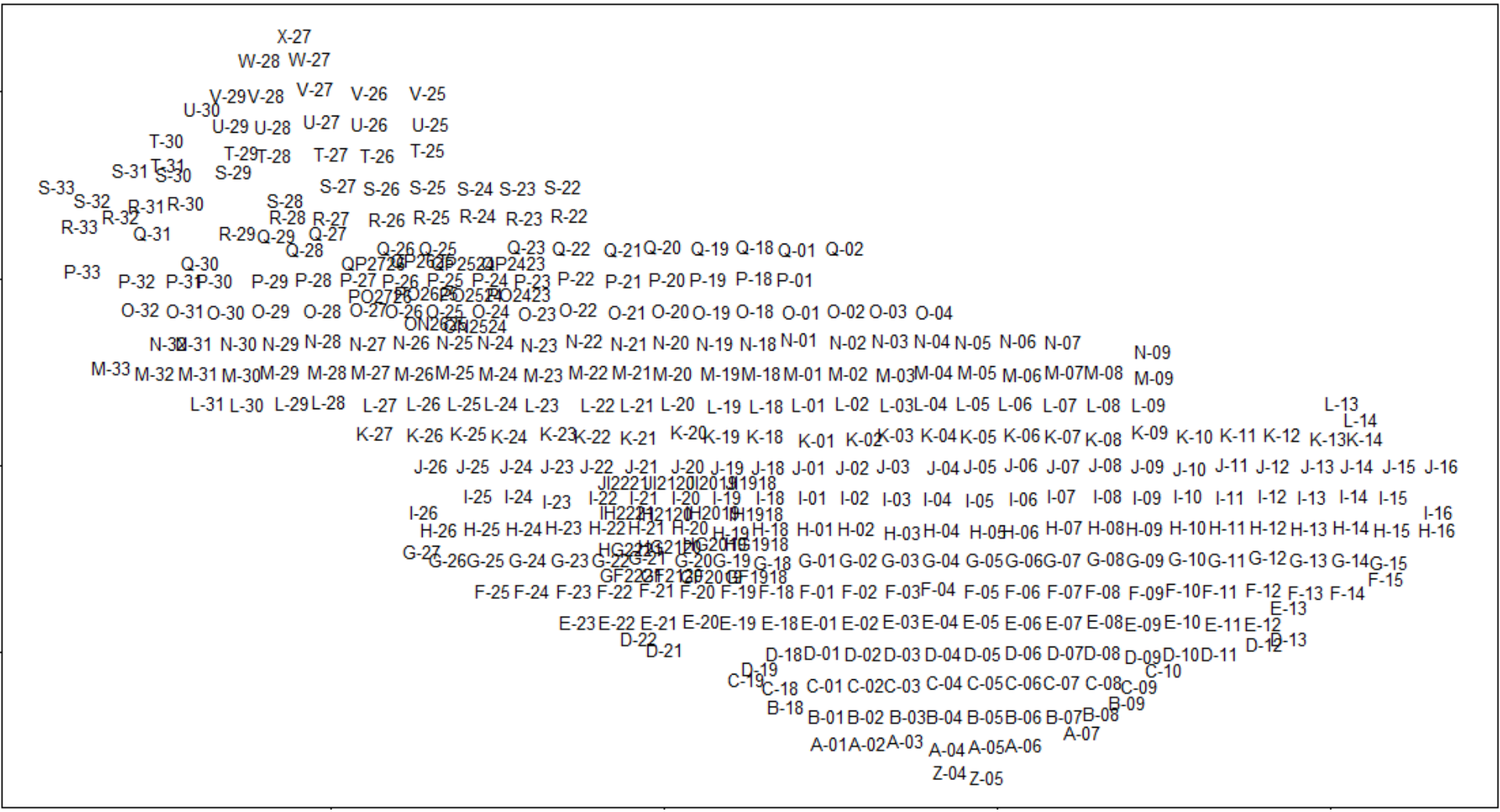
But, no directed fishery…


Thanks,
Bob!
No problem.

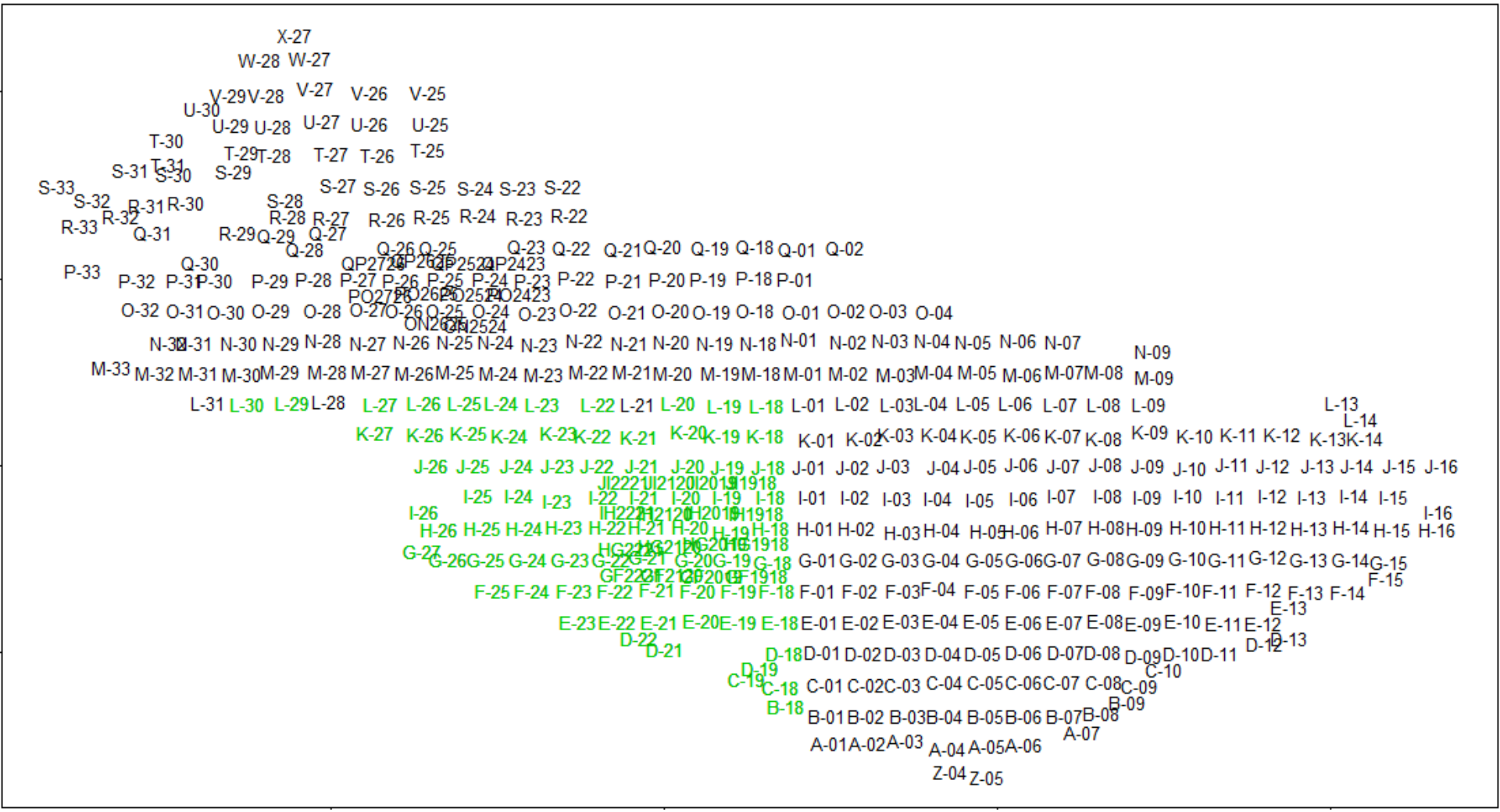
May CPT to do list

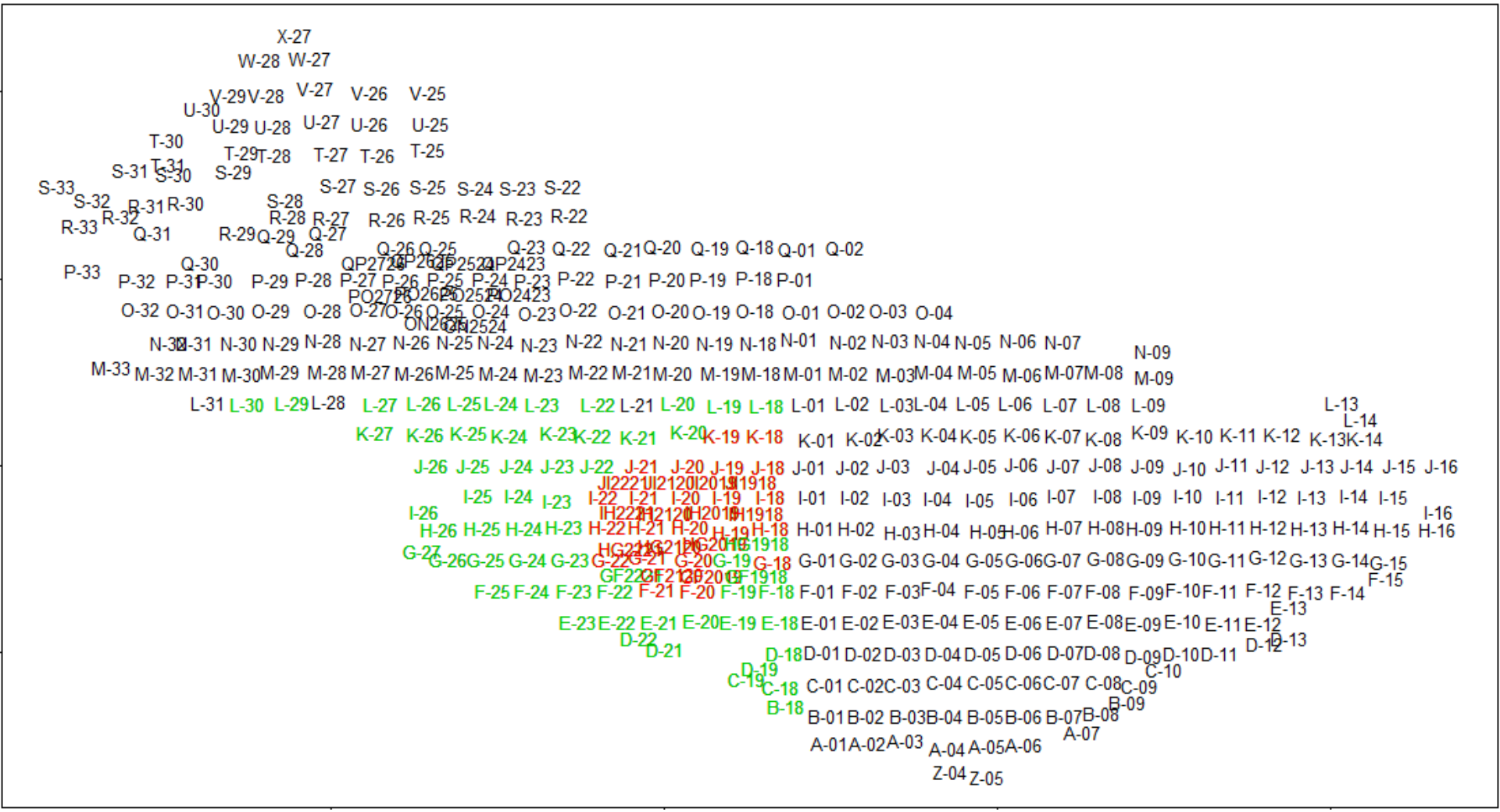
- *Add likelihood profile for survey catchability*
- *Initialize the model before the first year of data to reduce the number of parameters used*
- *Consider a more generalized growth model*
- *Do not calculate likelihood contributions for length-bins with very low frequency (~0)*
- *Explore sensitivities to the size of length bin*
- *Include lognormal confidence intervals for the survey estimates of numbers and biomass*
- *Consider ADFG pot survey data and retained catch size frequency data*
- *Include more detail on the model*

* Addressing May CPT comment

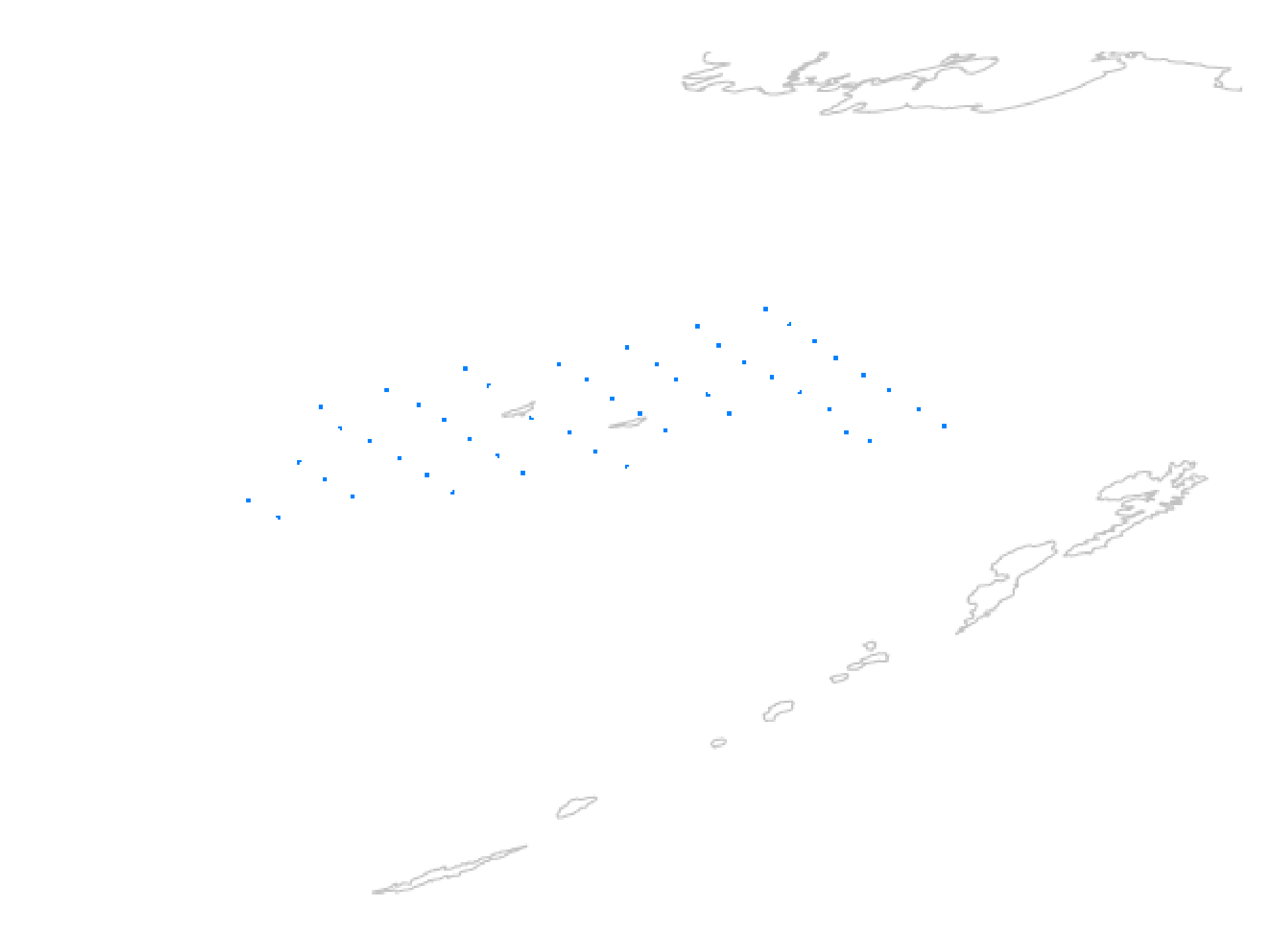

X-27
W-28 W-27
V-29 V-28 V-27 V-26 V-25
U-30
U-29 U-28 U-27 U-26 U-25
T-30
T-29 T-28 T-27 T-26 T-25
T-31
S-31 S-30 S-29
S-33
S-27 S-26 S-25 S-24 S-23 S-22
S-32
S-28
R-31 R-30
R-32
R-28 R-27 R-26 R-25 R-24 R-23 R-22
R-33
Q-31
R-29 Q-29 Q-27
Q-28
Q-26 Q-25 Q-23 Q-22 Q-21 Q-20 Q-19 Q-18 Q-01 Q-02
Q-30
P-33
P-32 P-31 P-30 P-29 P-28 P-27 P-26 P-25 P-24 P-23 P-22 P-21 P-20 P-19 P-18 P-01
O-32 O-31 O-30 O-29 O-28 O-27 O-26 O-25 O-24 O-23 O-22 O-21 O-20 O-19 O-18 O-01 O-02 O-03 O-04
N-31 N-30 N-29 N-28 N-27 N-26 N-25 N-24 N-23 N-22 N-21 N-20 N-19 N-18 N-01 N-02 N-03 N-04 N-05 N-06 N-07
N-09
M-33
M-32 M-31 M-30 M-29 M-28 M-27 M-26 M-25 M-24 M-23 M-22 M-21 M-20 M-19 M-18 M-01 M-02 M-03 M-04 M-05 M-06 M-07 M-08
M-09
L-31 L-30 L-29 L-28 L-27 L-26 L-25 L-24 L-23 L-22 L-21 L-20 L-19 L-18 L-01 L-02 L-03 L-04 L-05 L-06 L-07 L-08 L-09
L-13
L-14
K-27 K-26 K-25 K-24 K-23 K-22 K-21 K-20 K-19 K-18 K-01 K-02 K-03 K-04 K-05 K-06 K-07 K-08 K-09 K-10 K-11 K-12 K-13 K-14
J-26 J-25 J-24 J-23 J-22 J-21 J-20 J-19 J-18 J-01 J-02 J-03 J-04 J-05 J-06 J-07 J-08 J-09 J-10 J-11 J-12 J-13 J-14 J-15 J-16
I-25 I-24 I-23 I-22 I-21 I-20 I-19 I-18 I-01 I-02 I-03 I-04 I-05 I-06 I-07 I-08 I-09 I-10 I-11 I-12 I-13 I-14 I-15
I-26
I-16
H-26 H-25 H-24 H-23 H-22 H-21 H-20 H-19 H-18 H-01 H-02 H-03 H-04 H-05 H-06 H-07 H-08 H-09 H-10 H-11 H-12 H-13 H-14 H-15 H-16
G-27
G-26 G-25 G-24 G-23 G-22 G-21 G-20 G-19 G-18 G-01 G-02 G-03 G-04 G-05 G-06 G-07 G-08 G-09 G-10 G-11 G-12 G-13 G-14 G-15
F-15
F-25 F-24 F-23 F-22 F-21 F-20 F-19 F-18 F-01 F-02 F-03 F-04 F-05 F-06 F-07 F-08 F-09 F-10 F-11 F-12 F-13 F-14
E-13
E-23 E-22 E-21 E-20 E-19 E-18 E-01 E-02 E-03 E-04 E-05 E-06 E-07 E-08 E-09 E-10 E-11 E-12
D-22
D-13
D-21
D-18 D-01 D-02 D-03 D-04 D-05 D-06 D-07 D-08 D-09 D-10 D-11
D-19
C-10
C-19
C-18 C-01 C-02 C-03 C-04 C-05 C-06 C-07 C-08 C-09
B-09
B-18
B-01 B-02 B-03 B-04 B-05 B-06 B-07 B-08
A-07
A-01 A-02 A-03 A-04 A-05 A-06
Z-04 Z-05

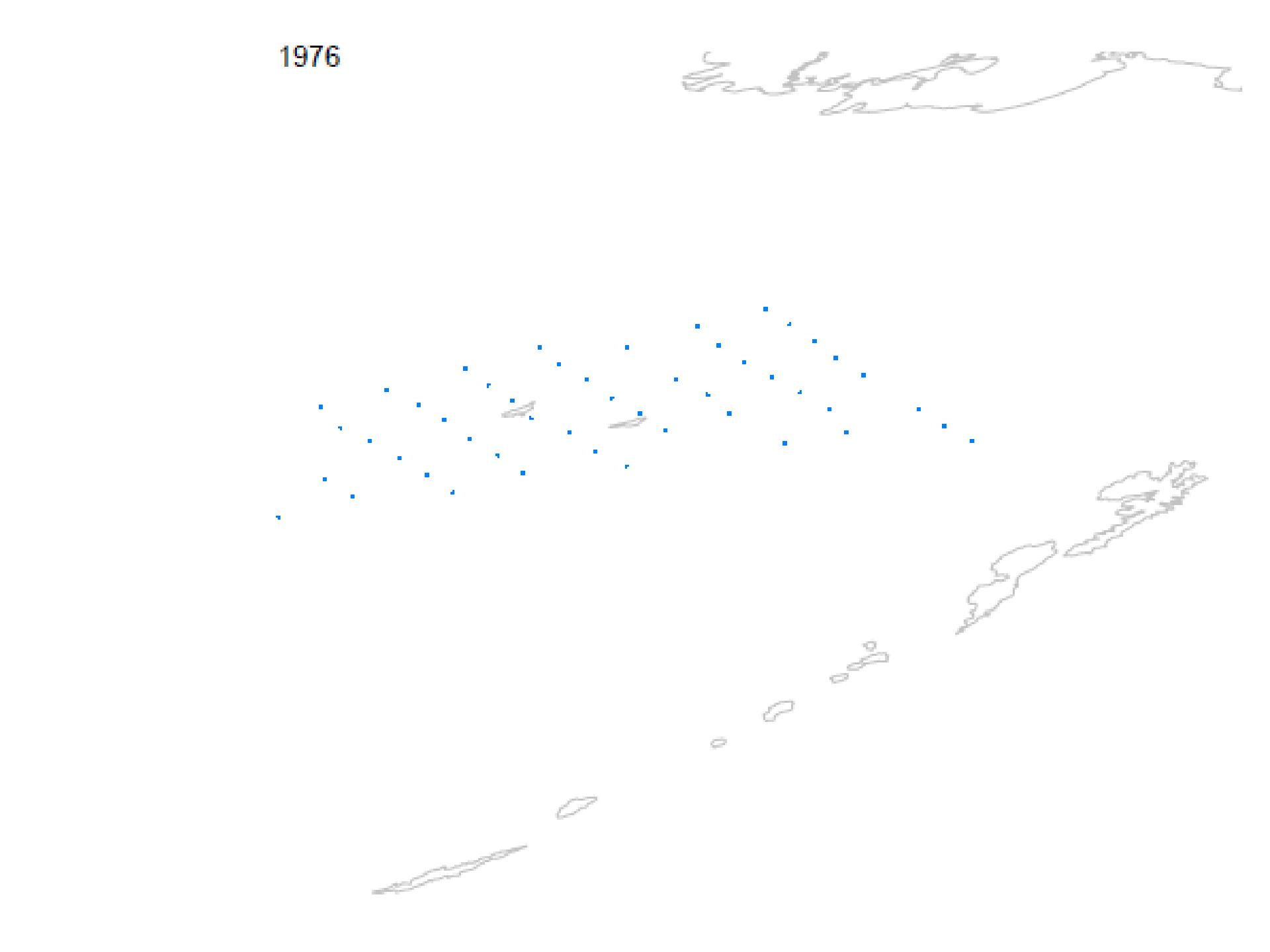
Pribilof district: south of 58.65 and west of -168

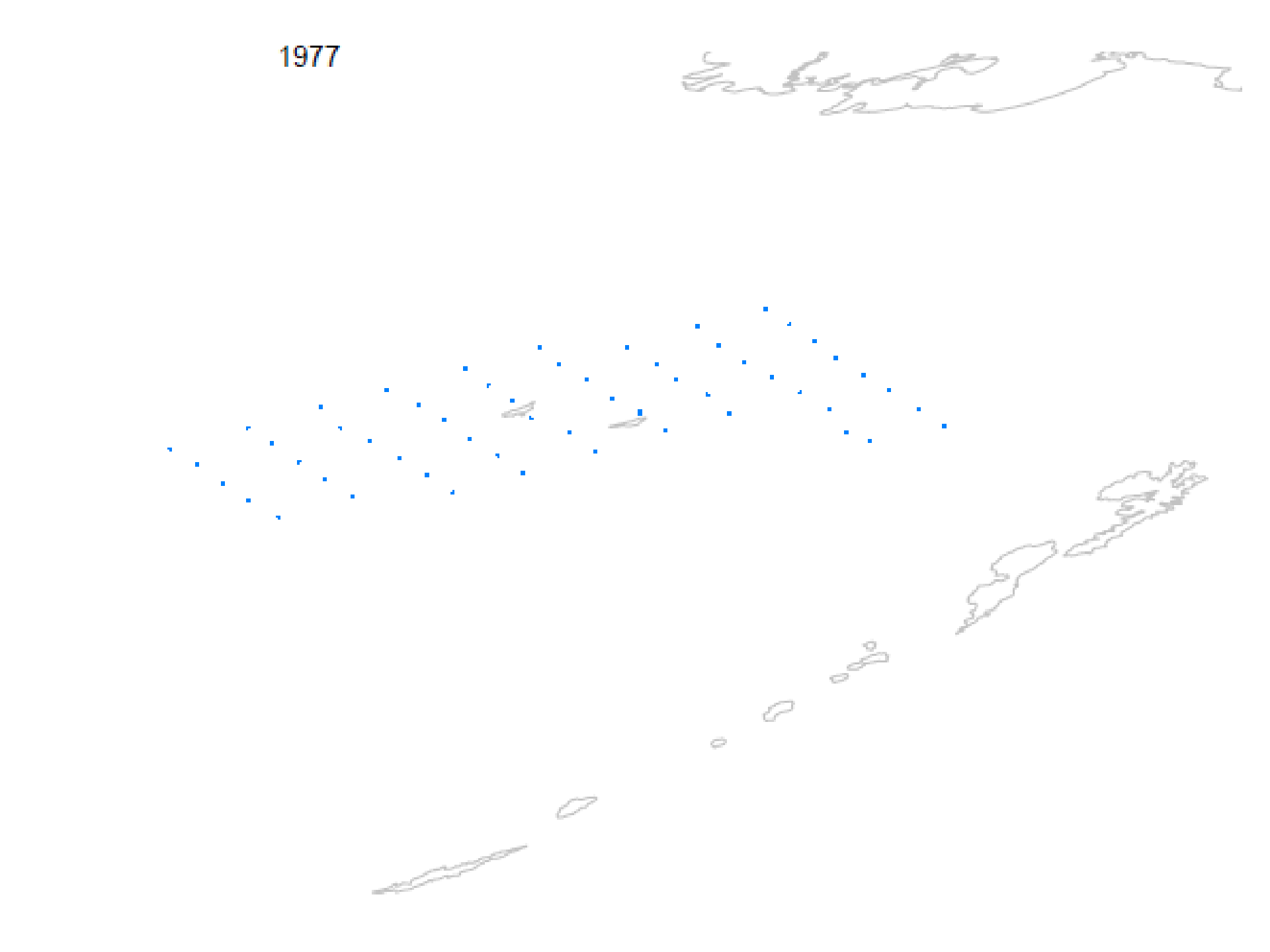


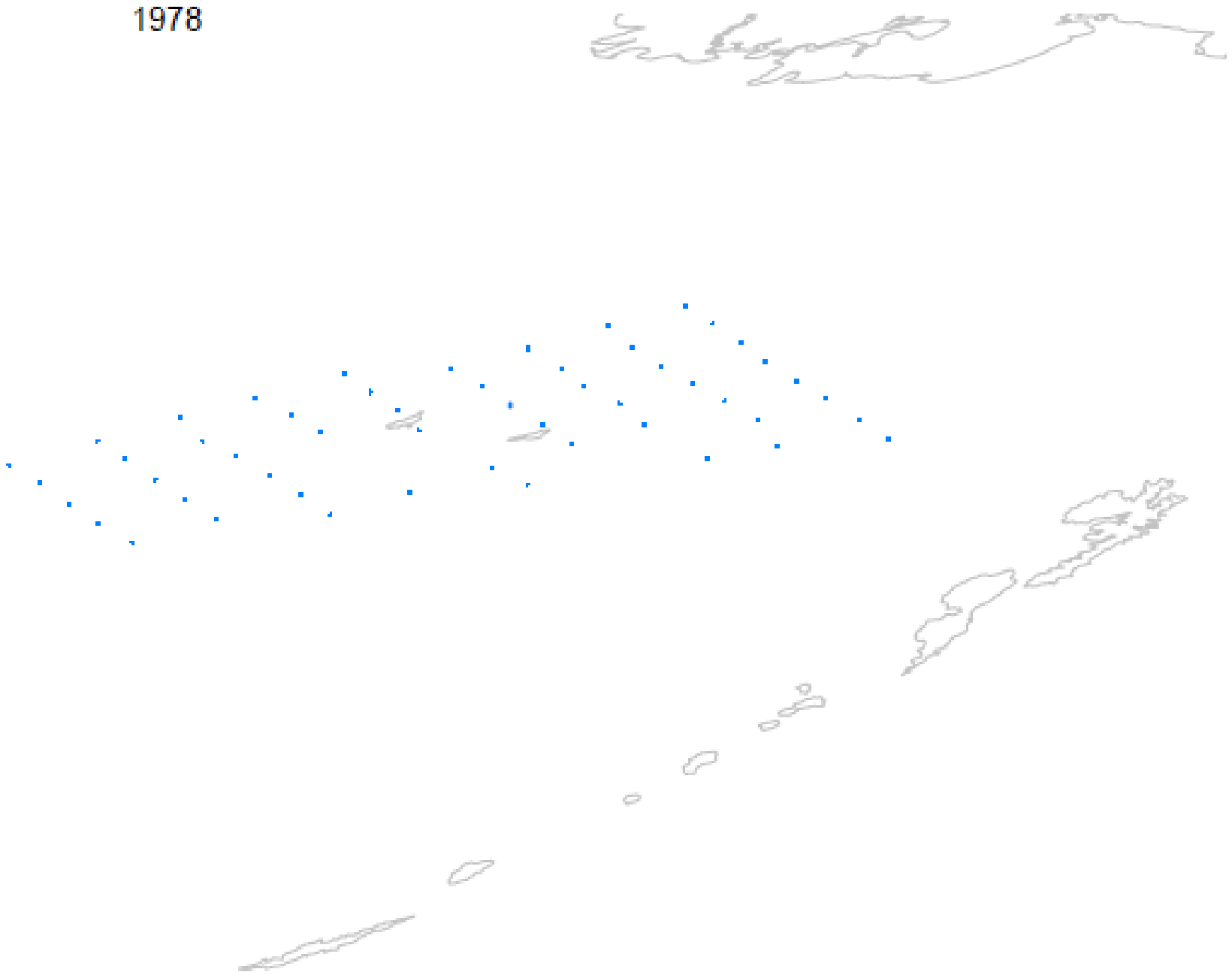


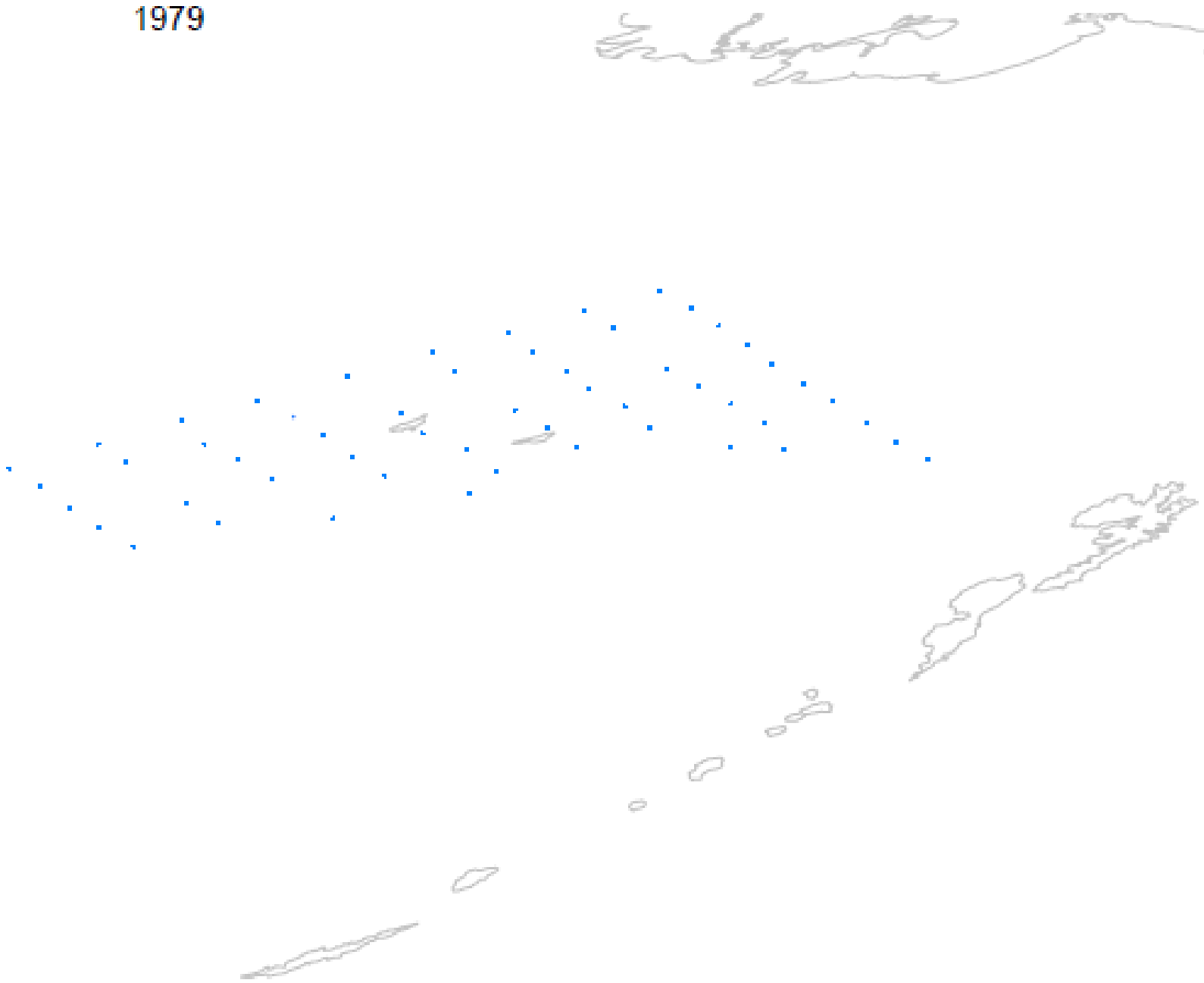
35 stations have ever reported a single red king crab
Belong to 22 of the 400^2 nm grids

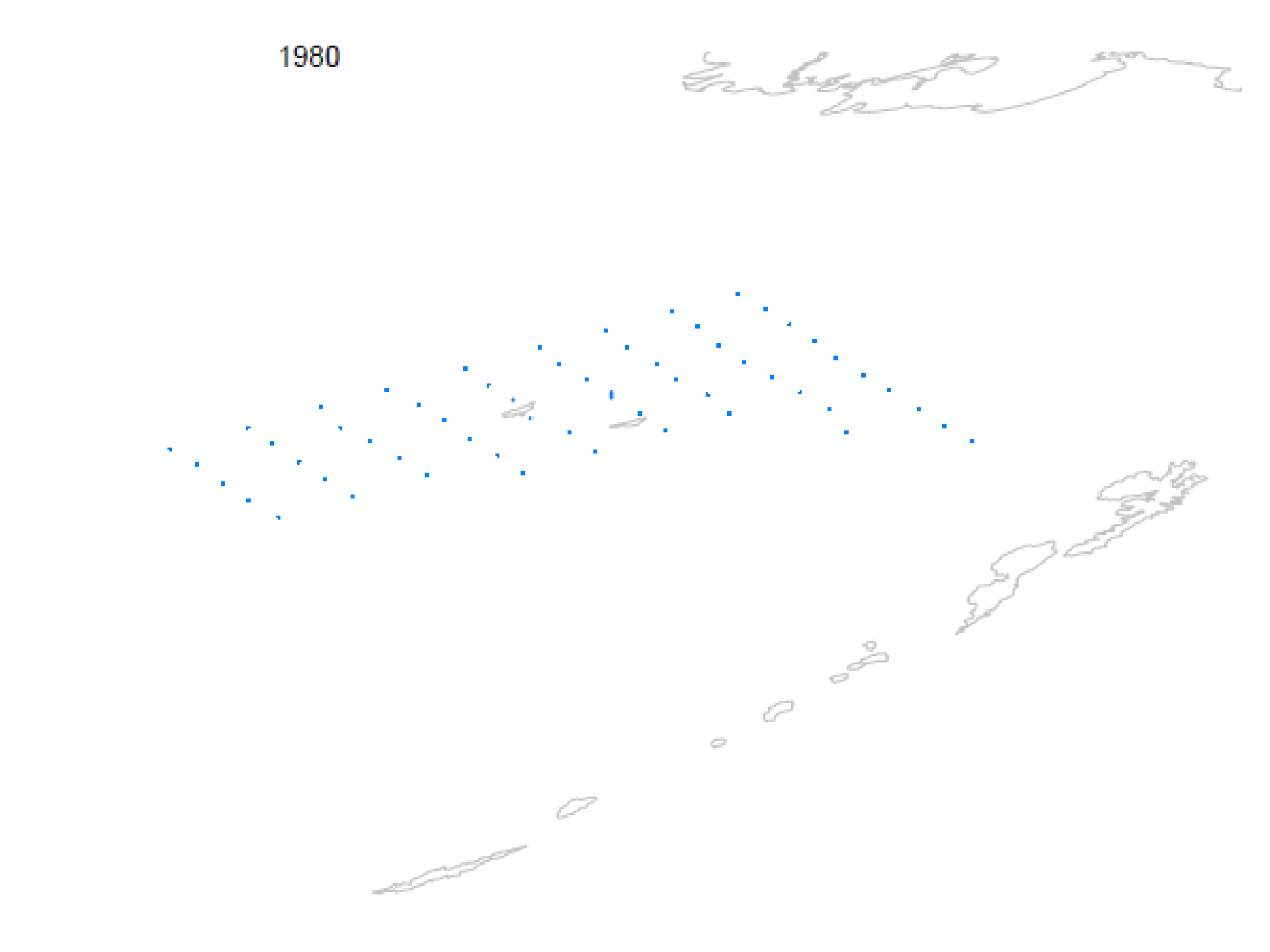


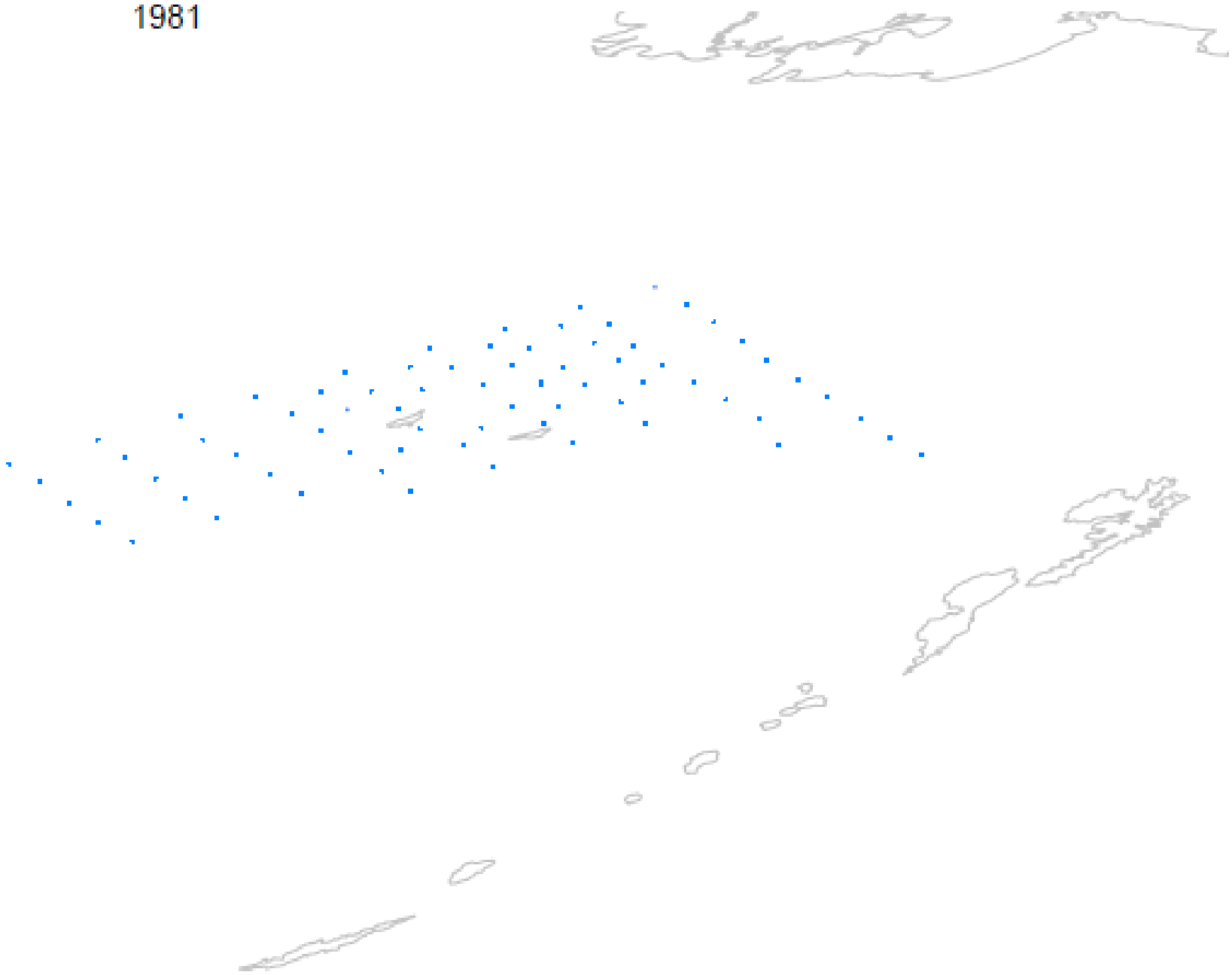

1976

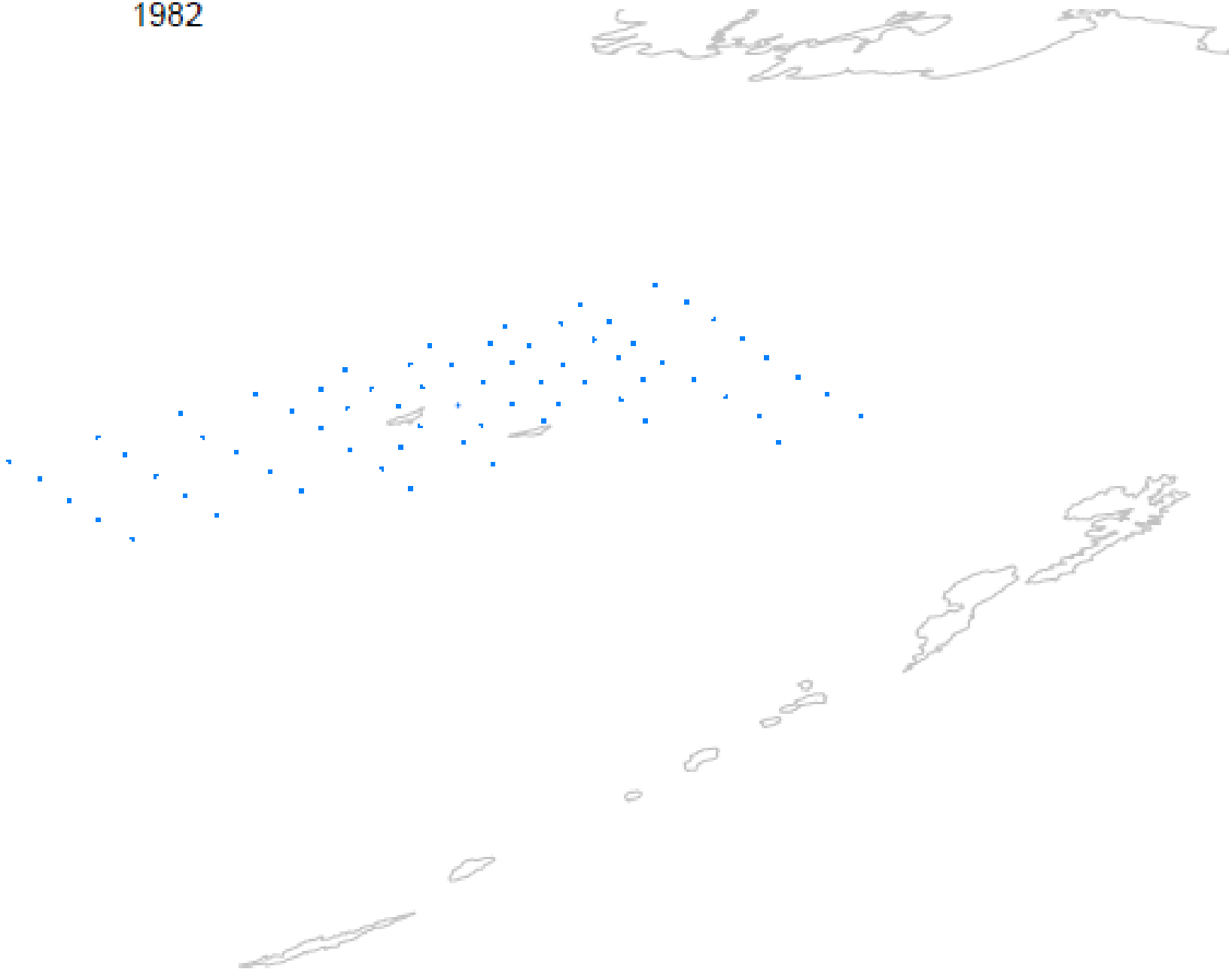

1977

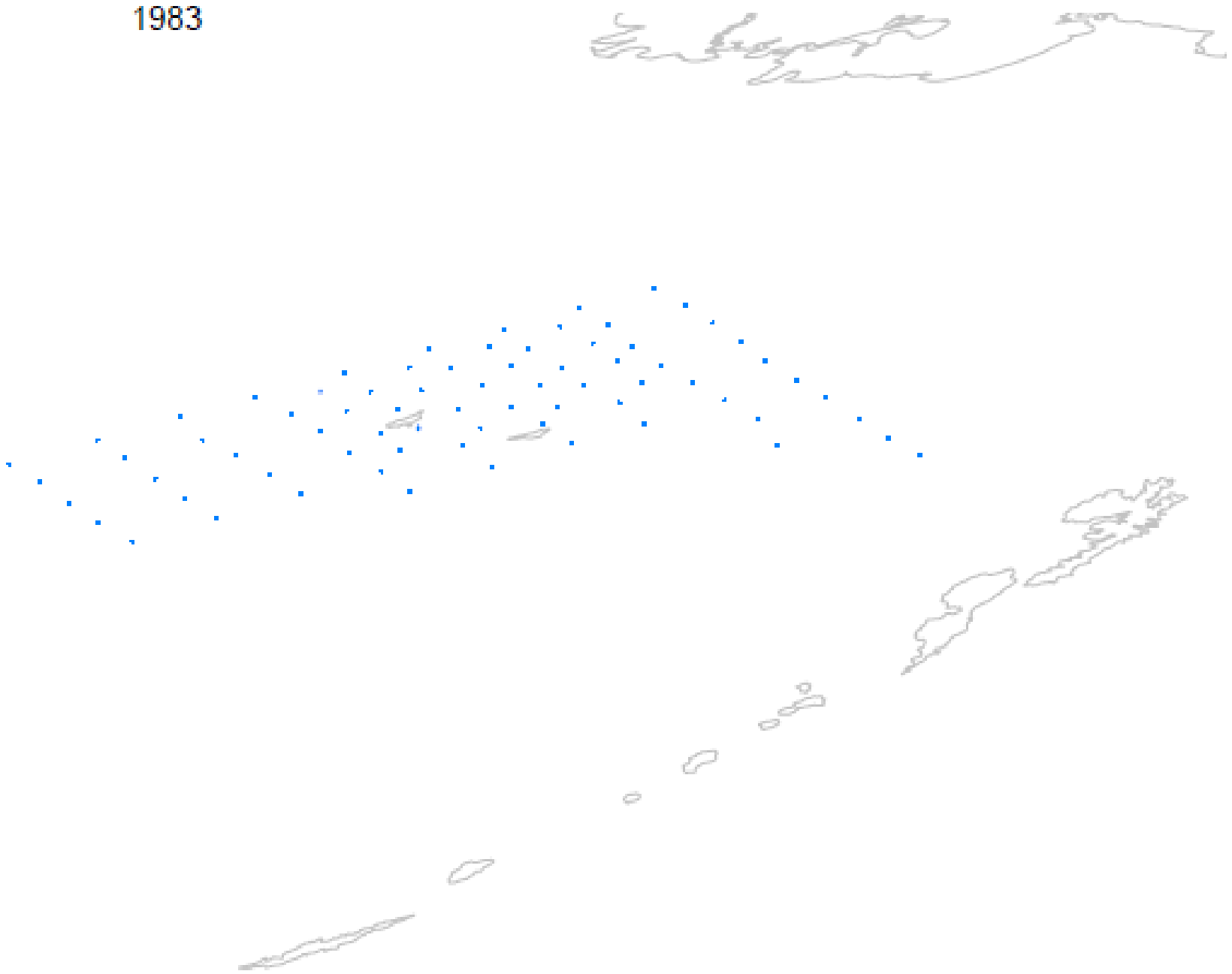

1978

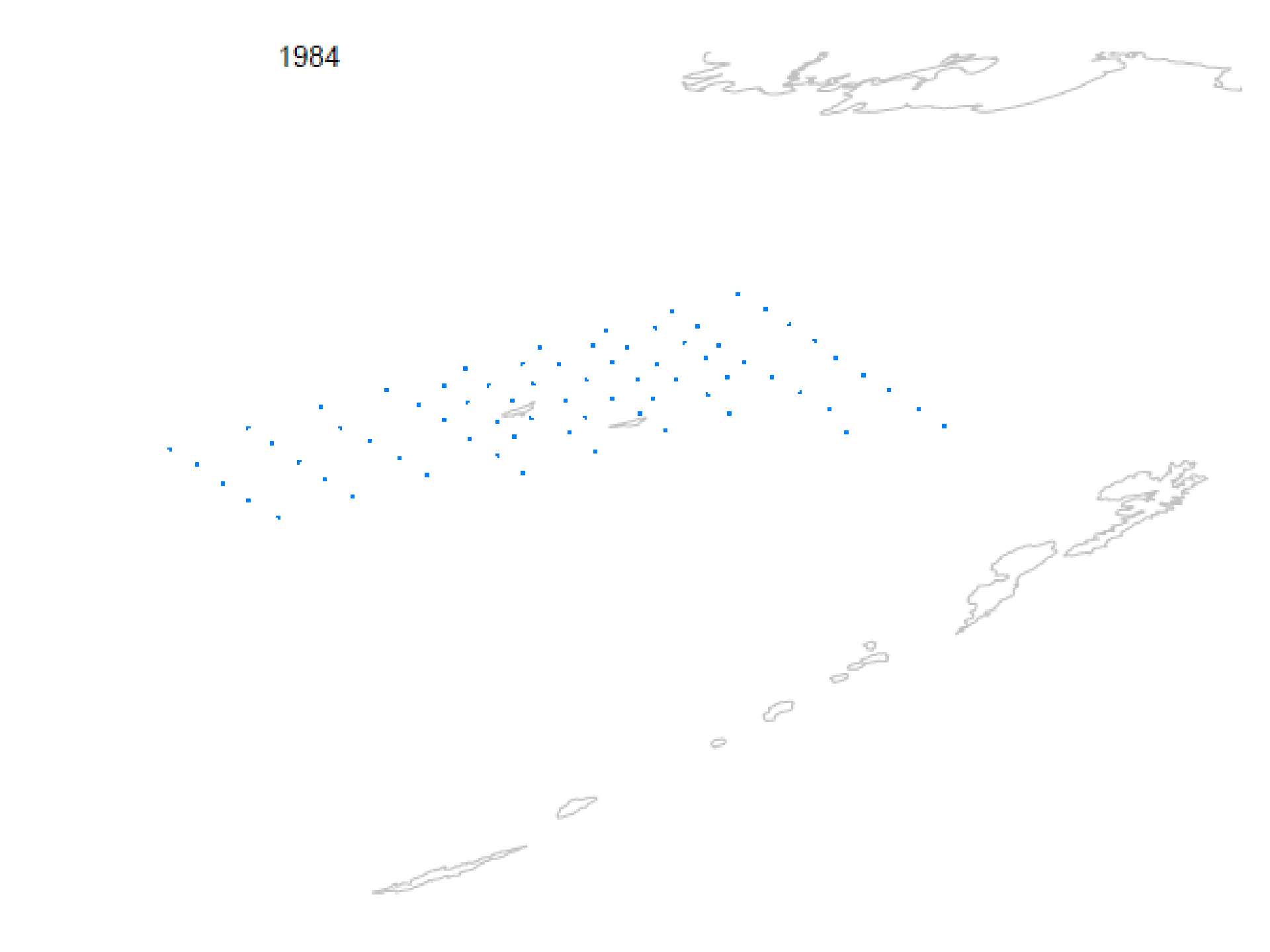

1979

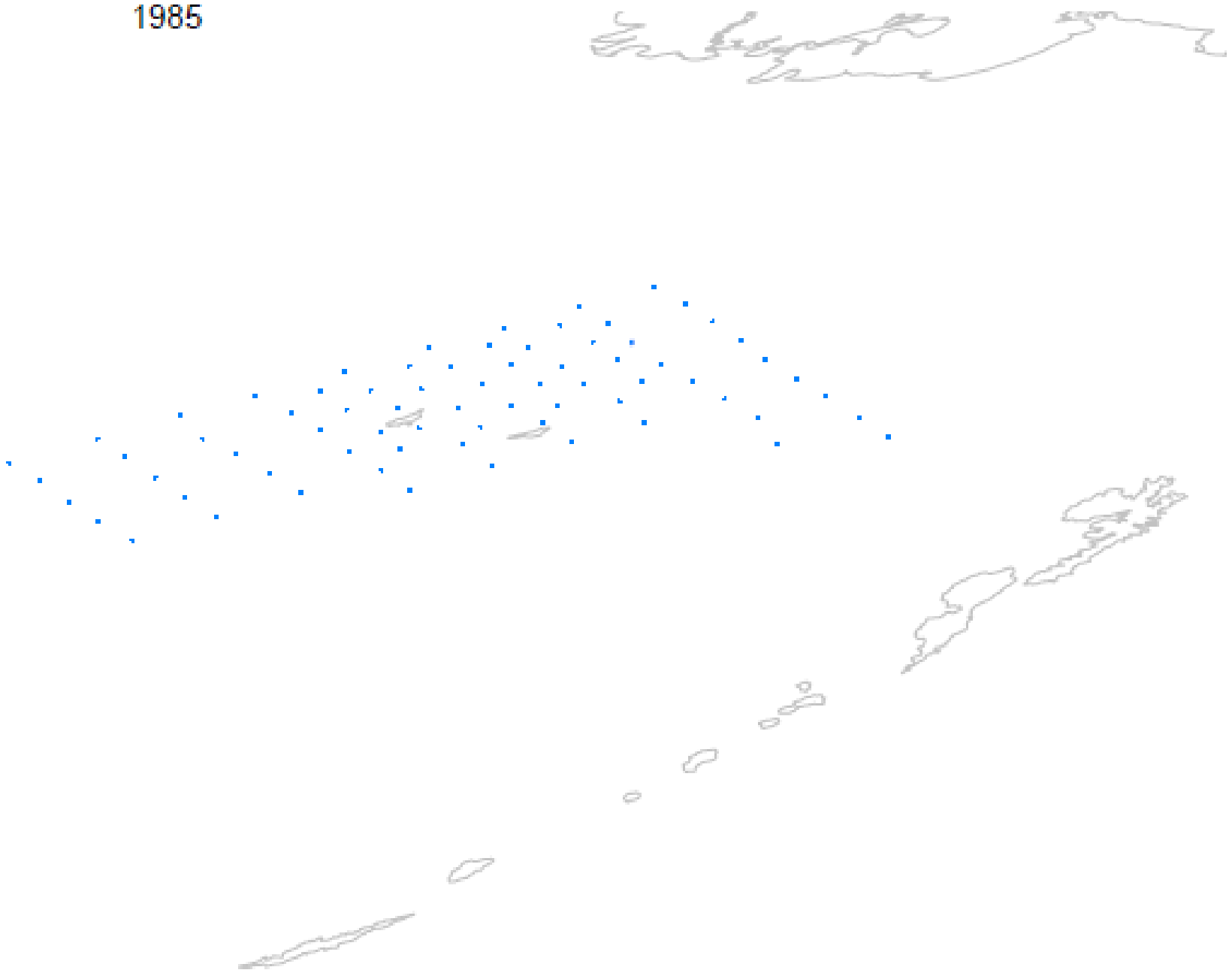

1980

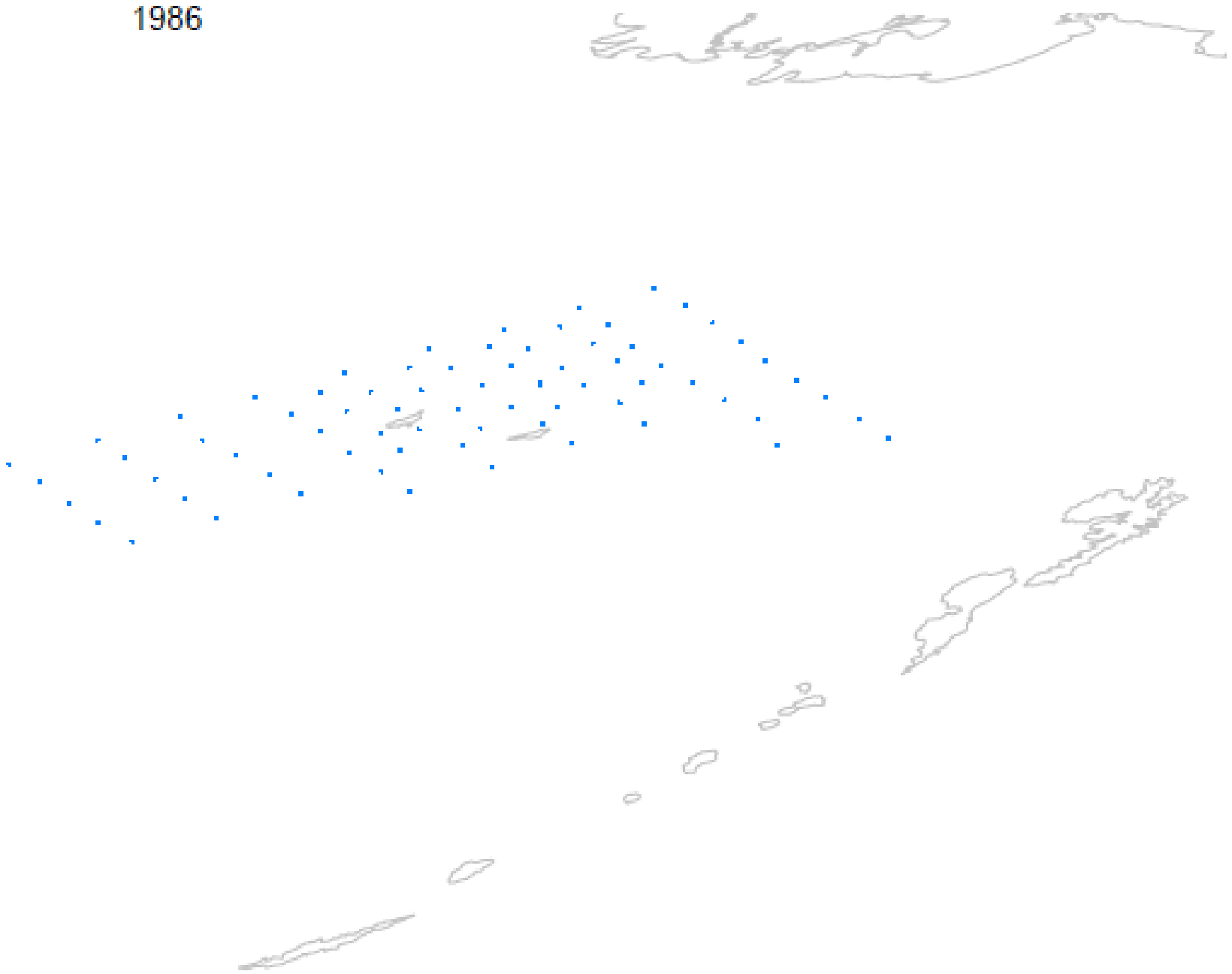

1981

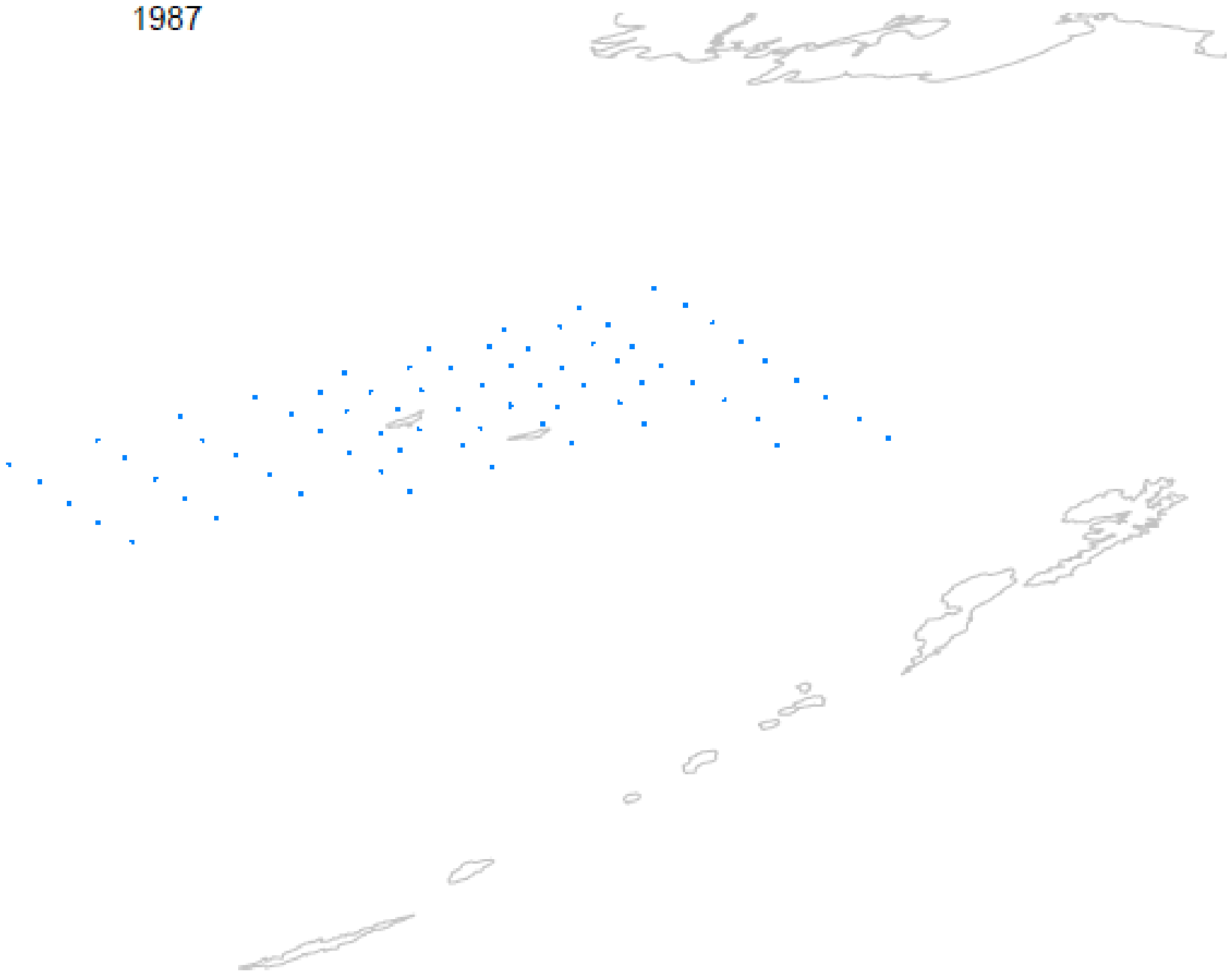

1982

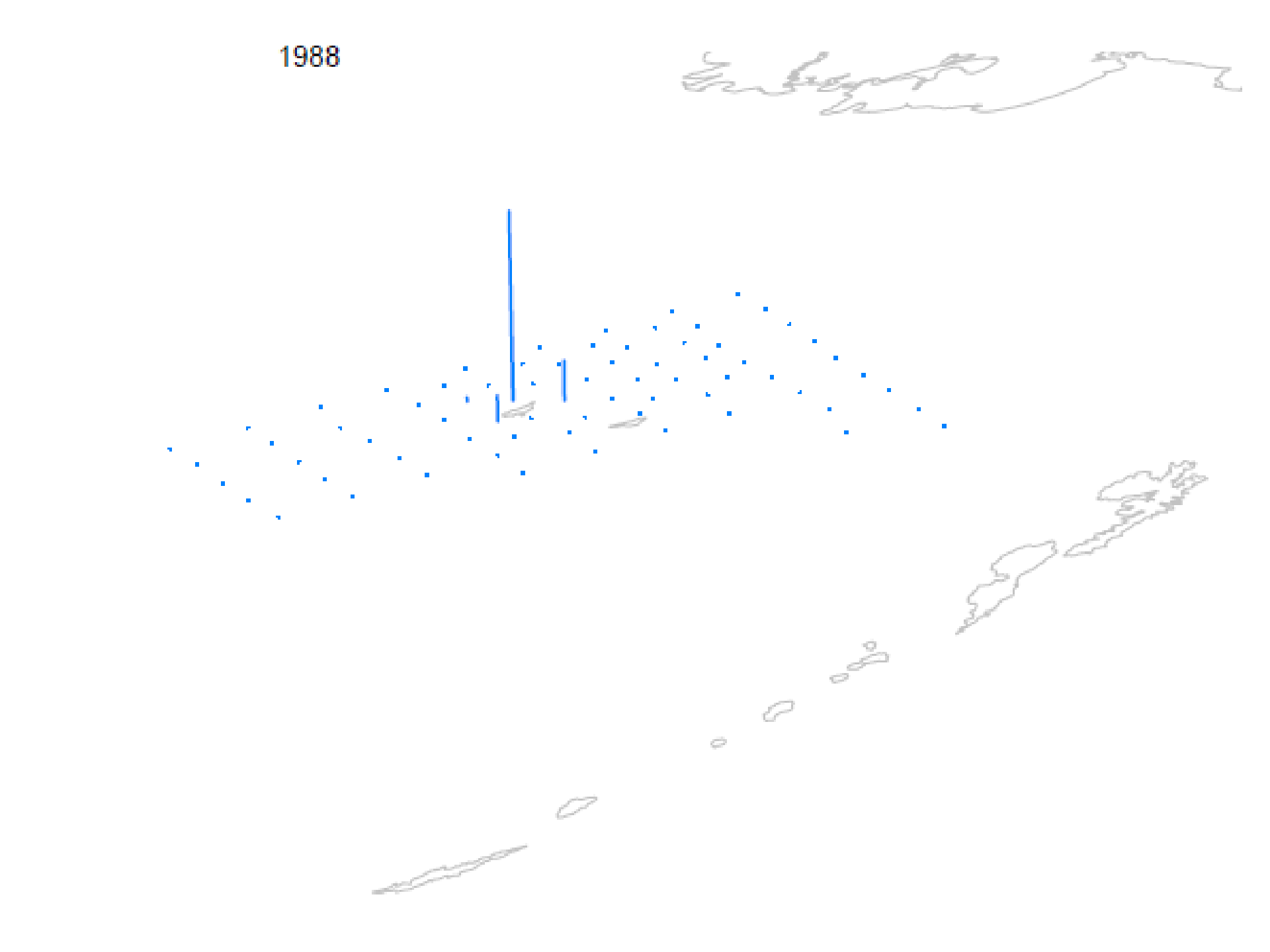

1983

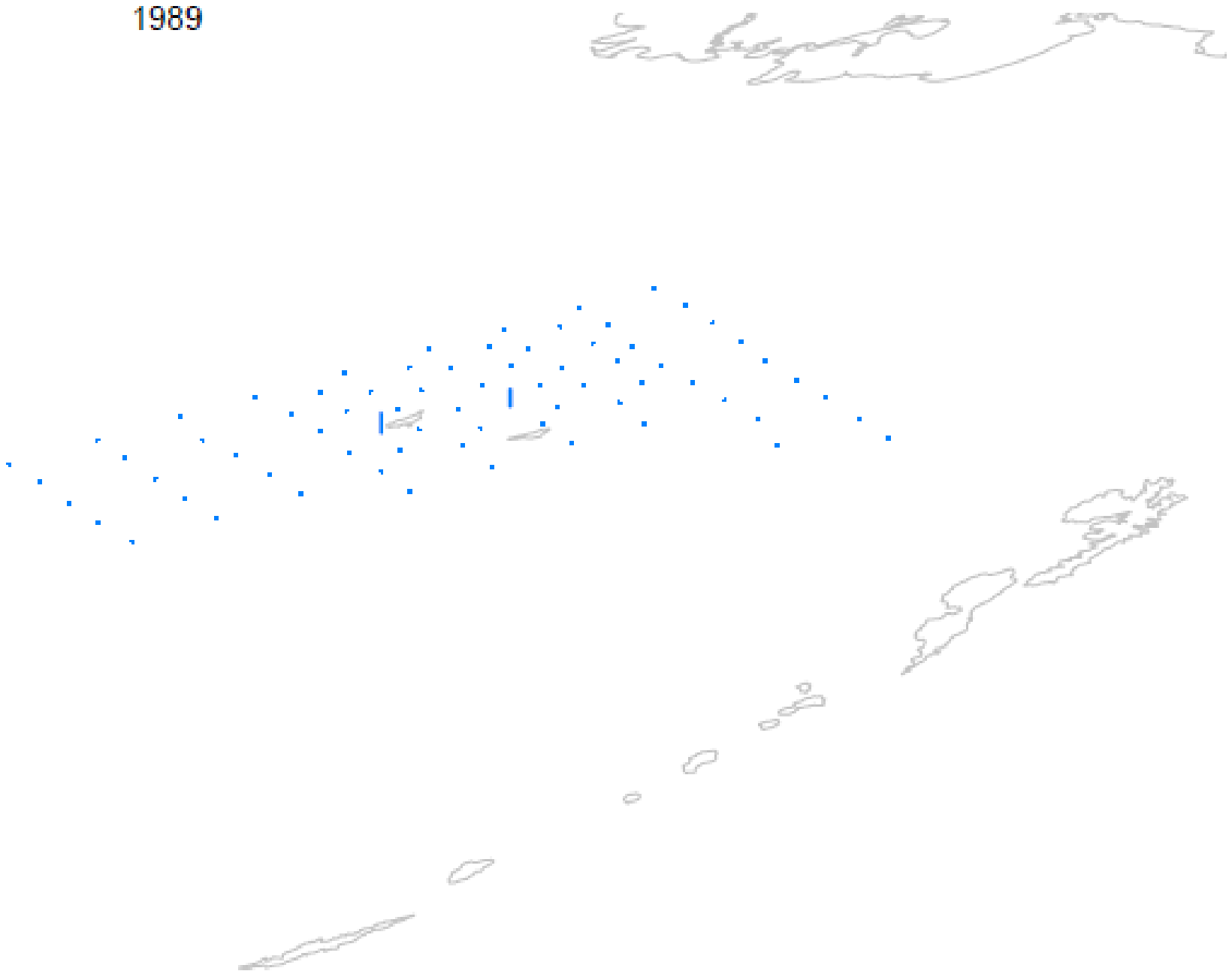

1984

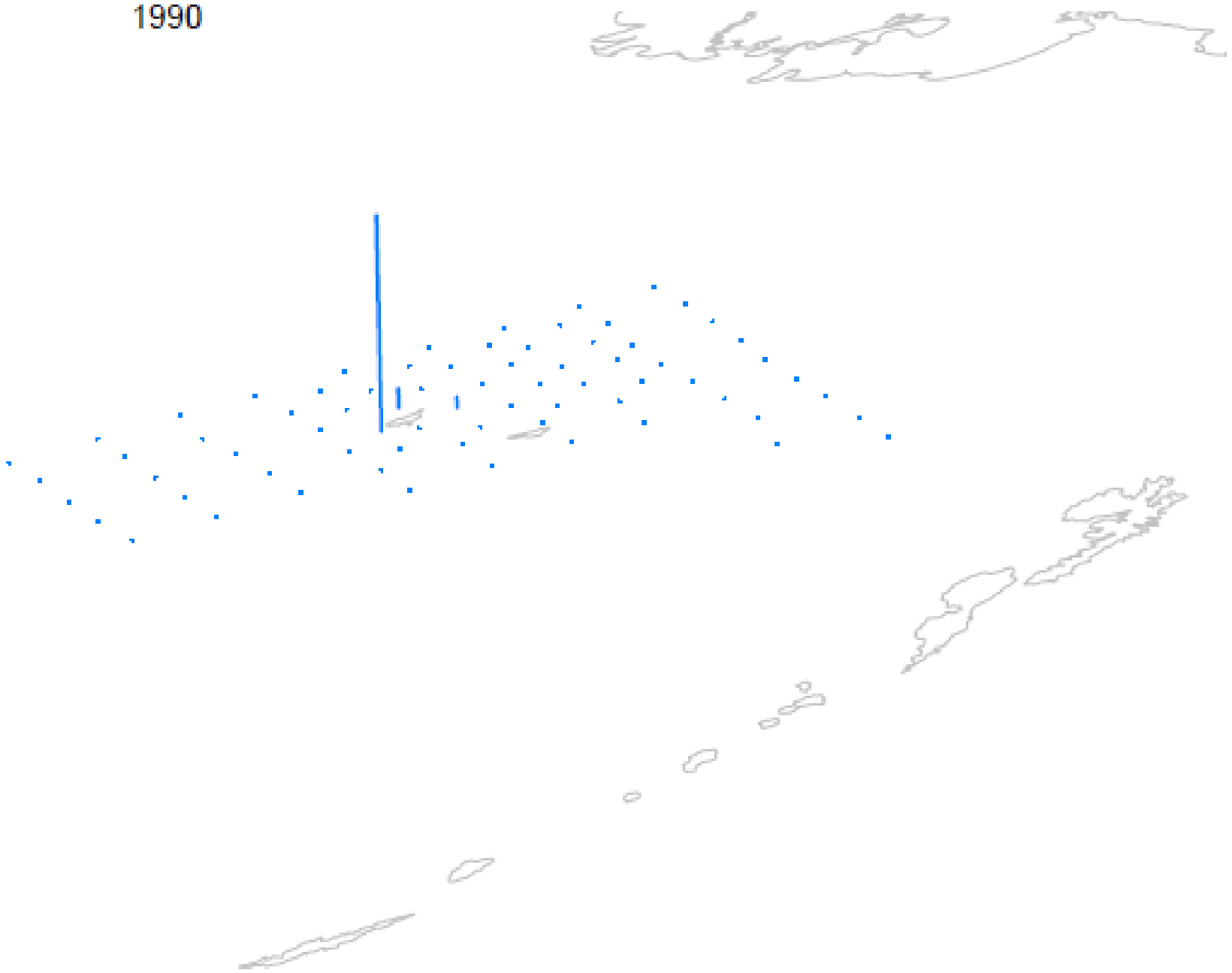

1985

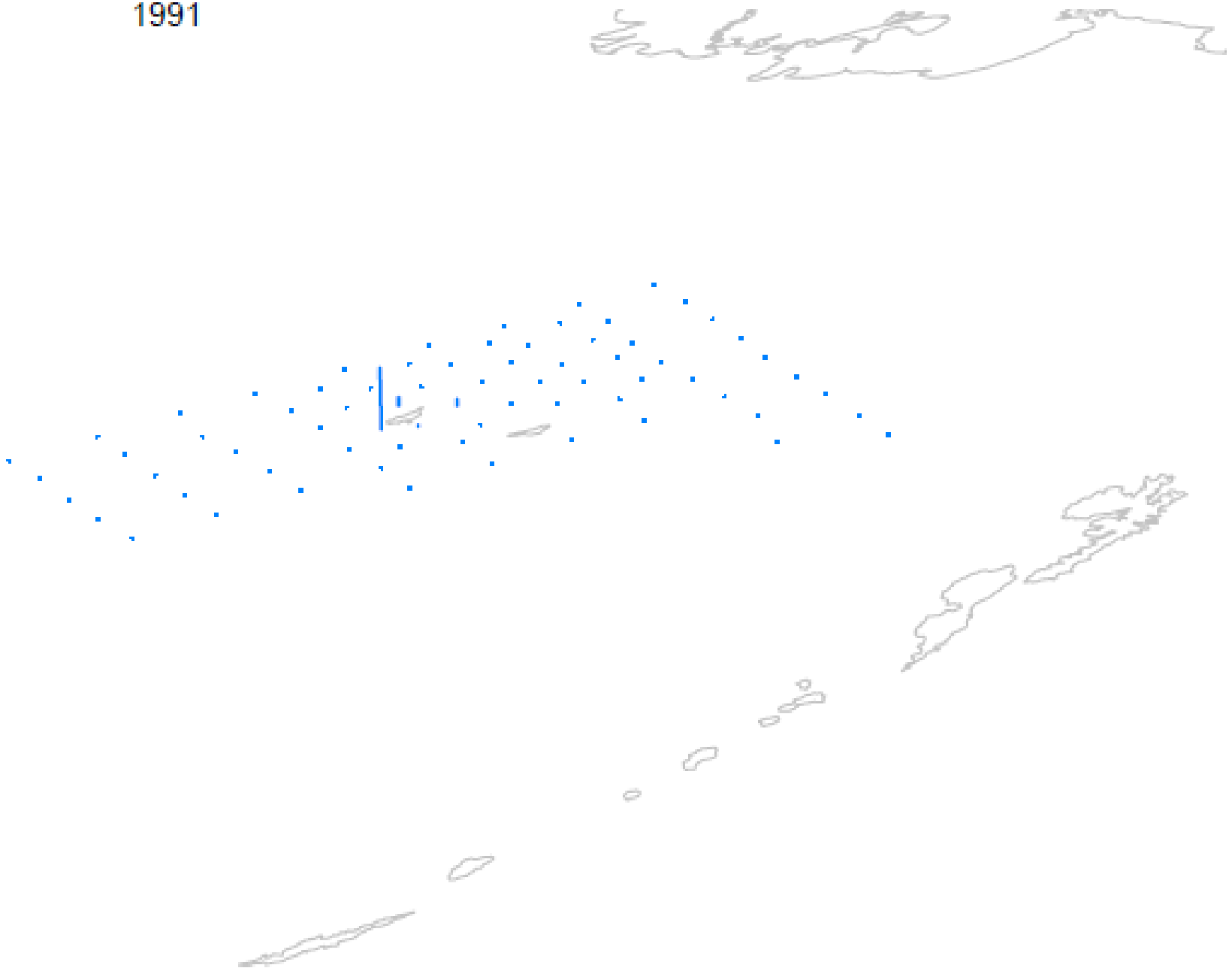

1986

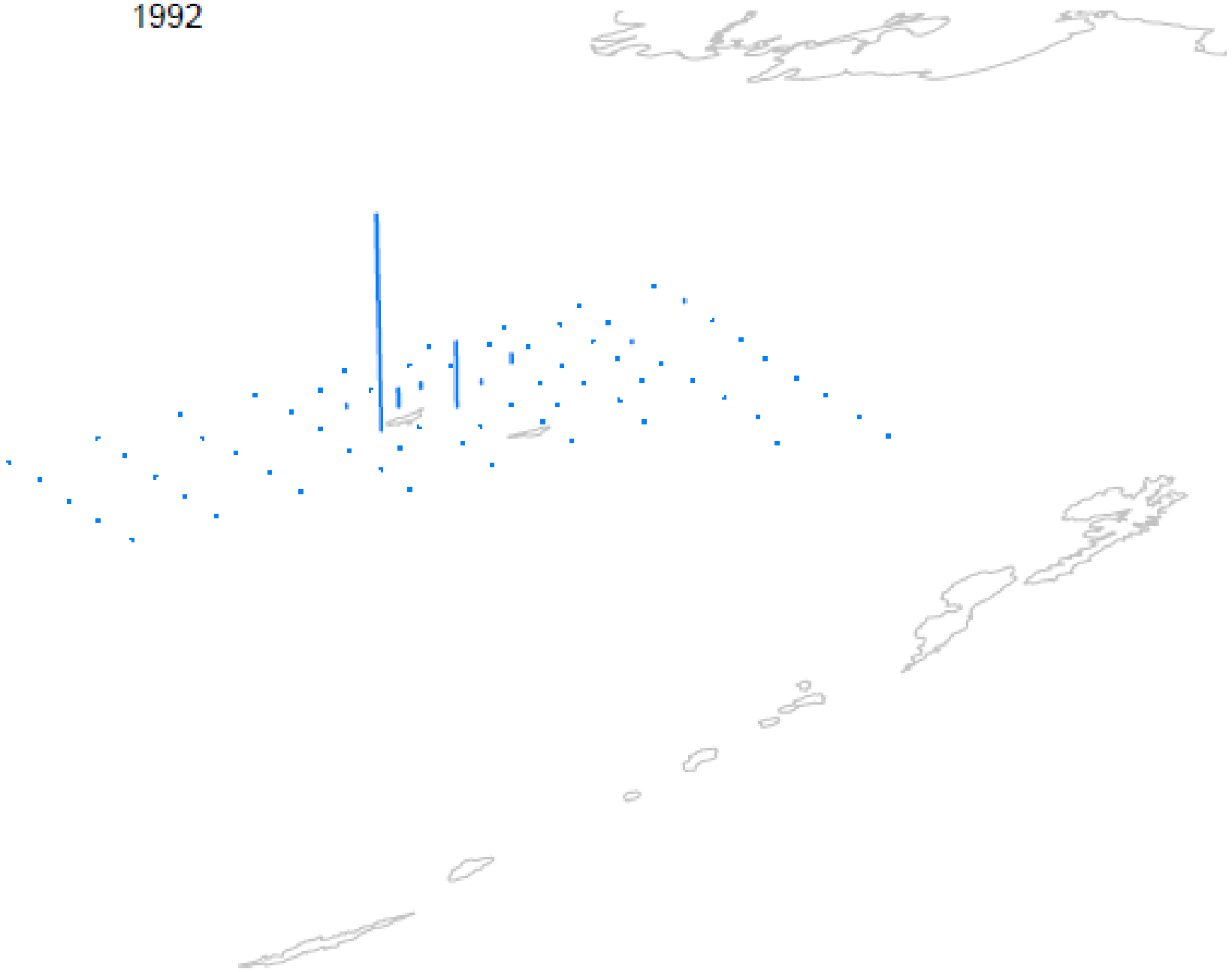

1987

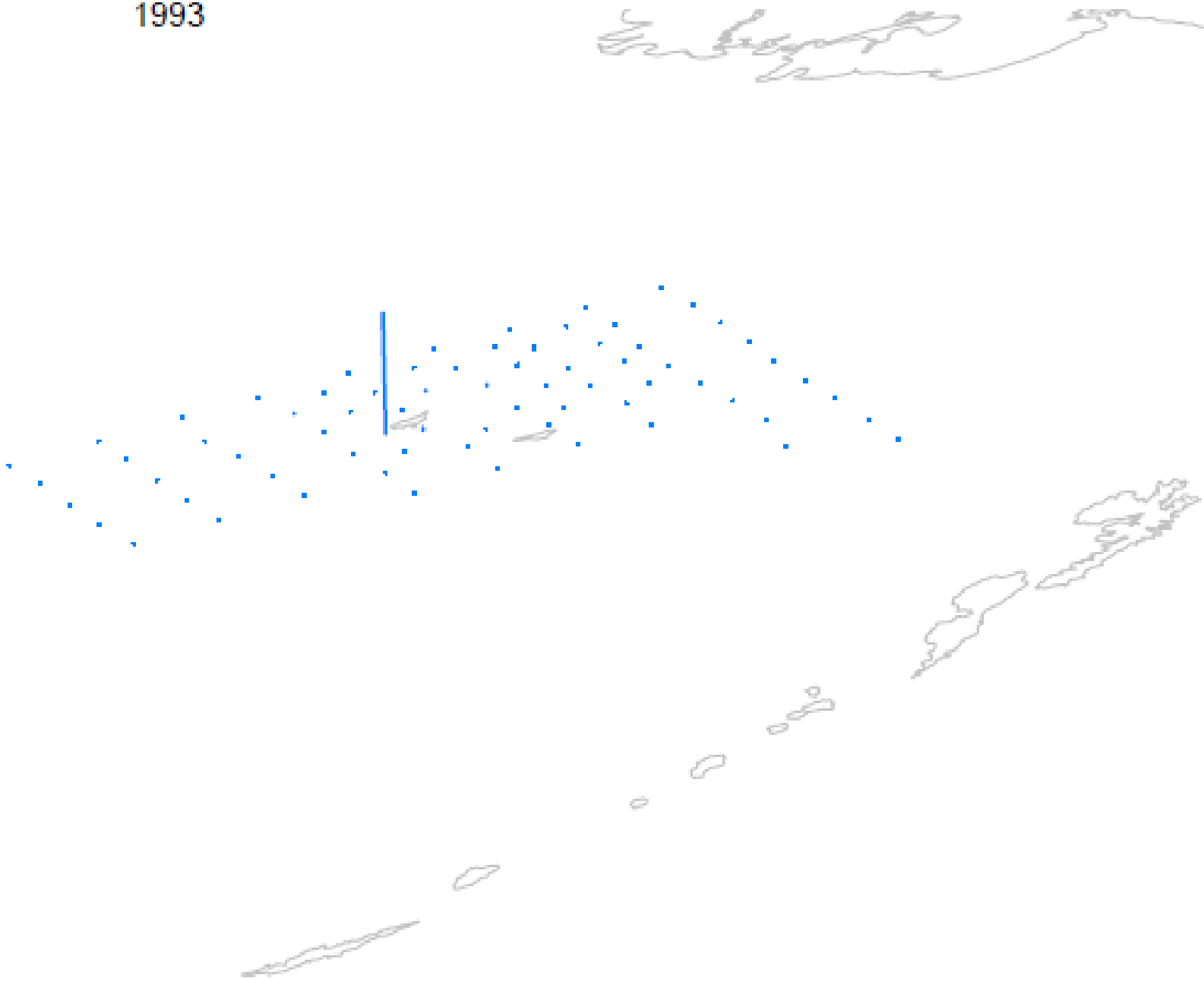

1988

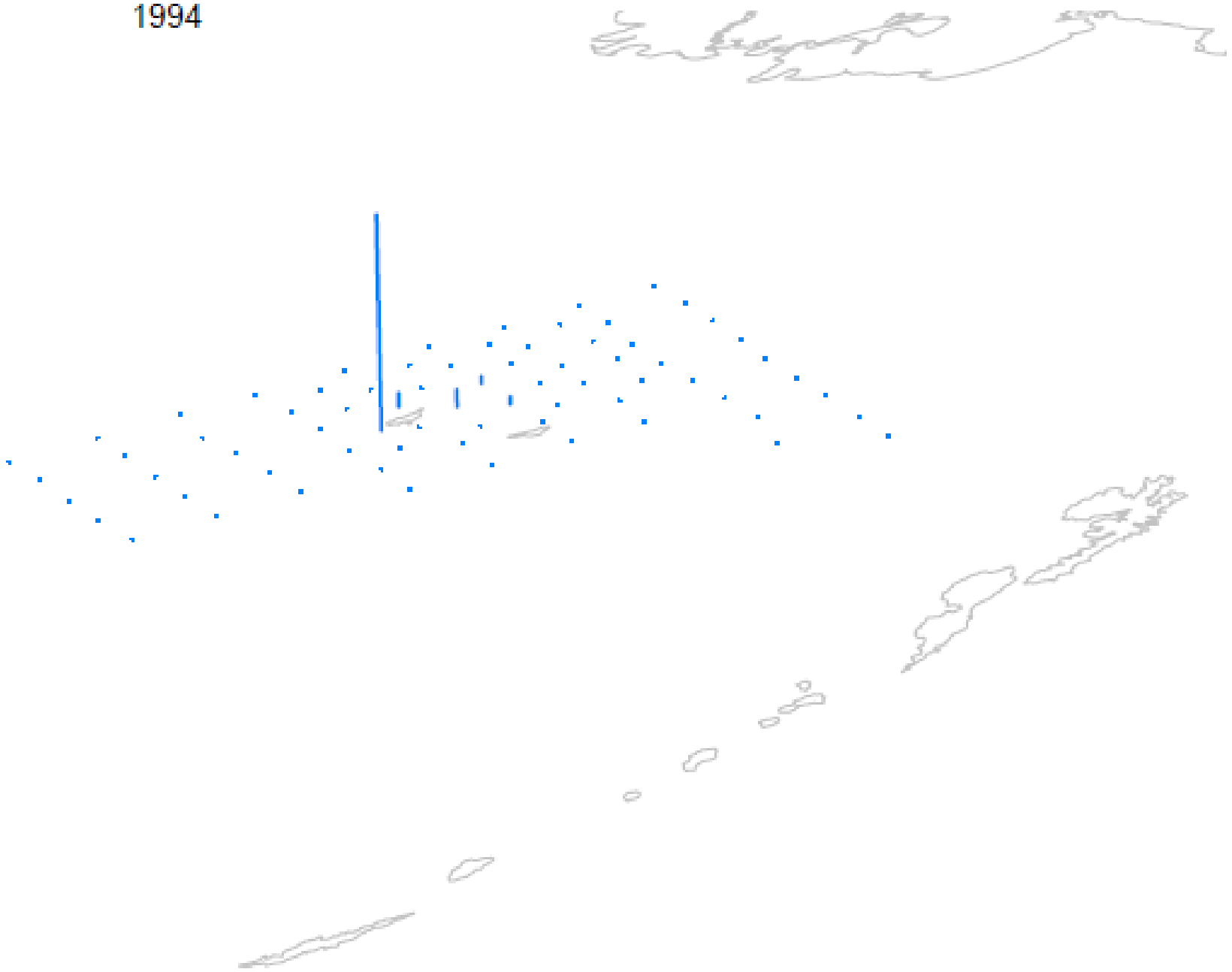

1989

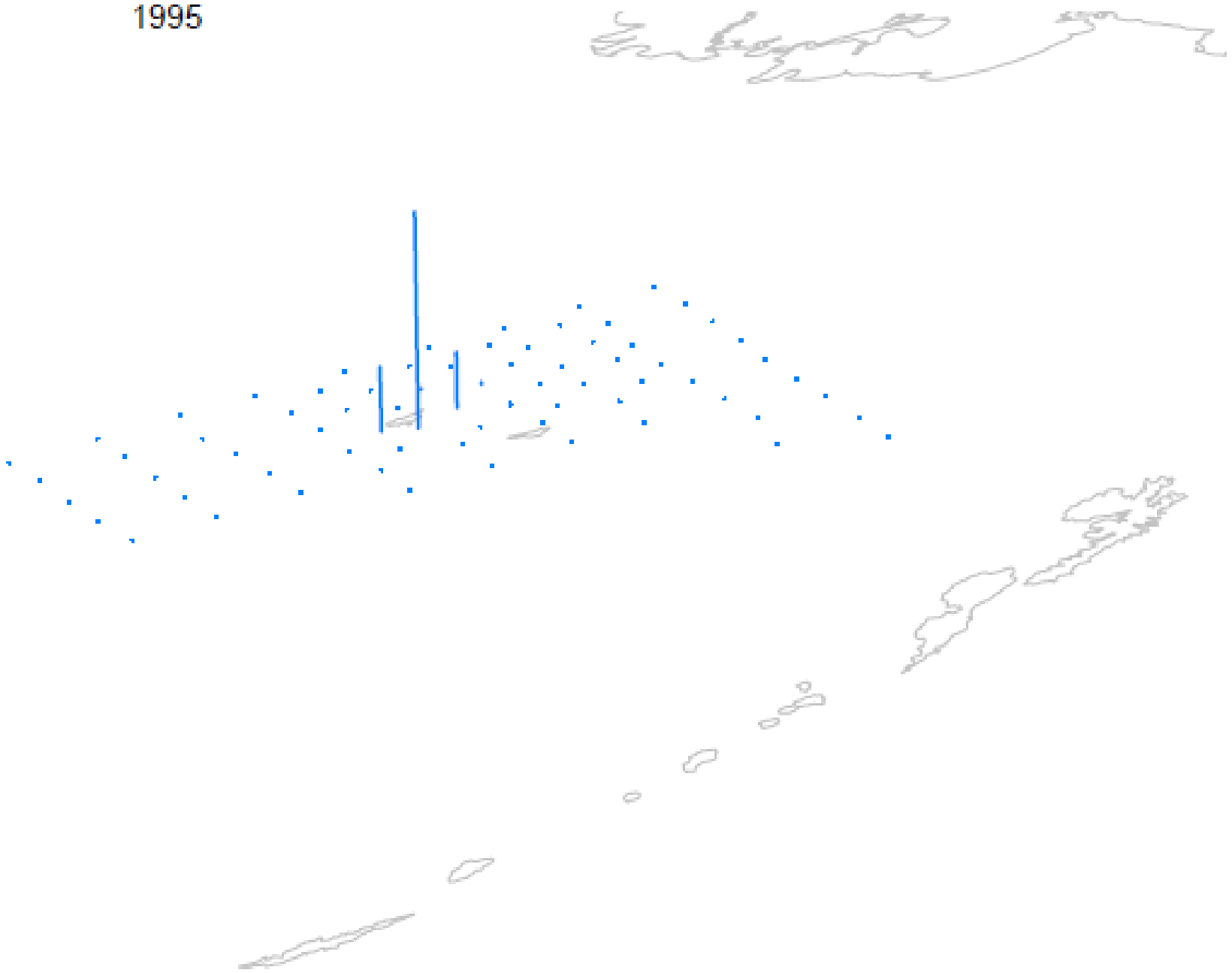

1990

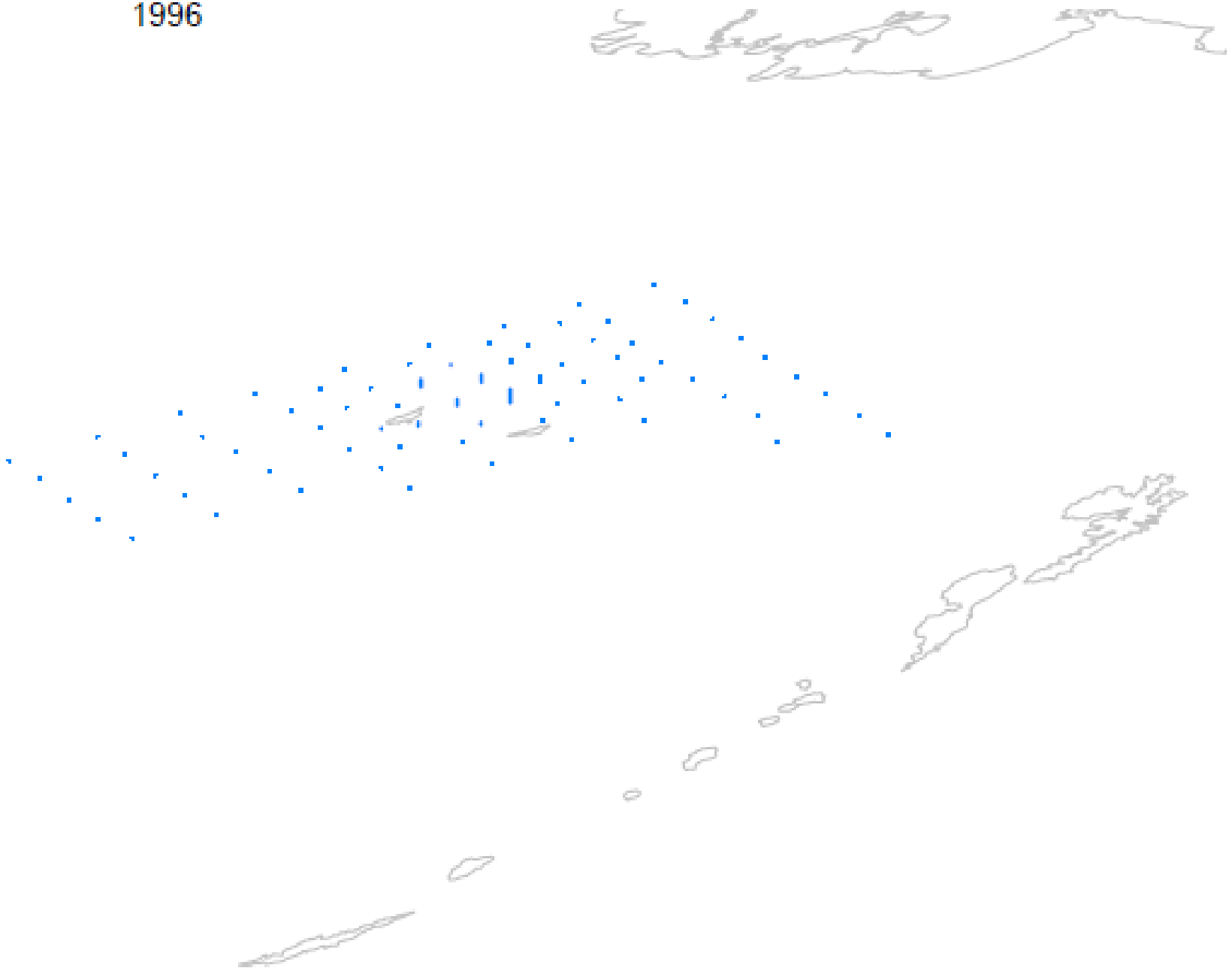

1991

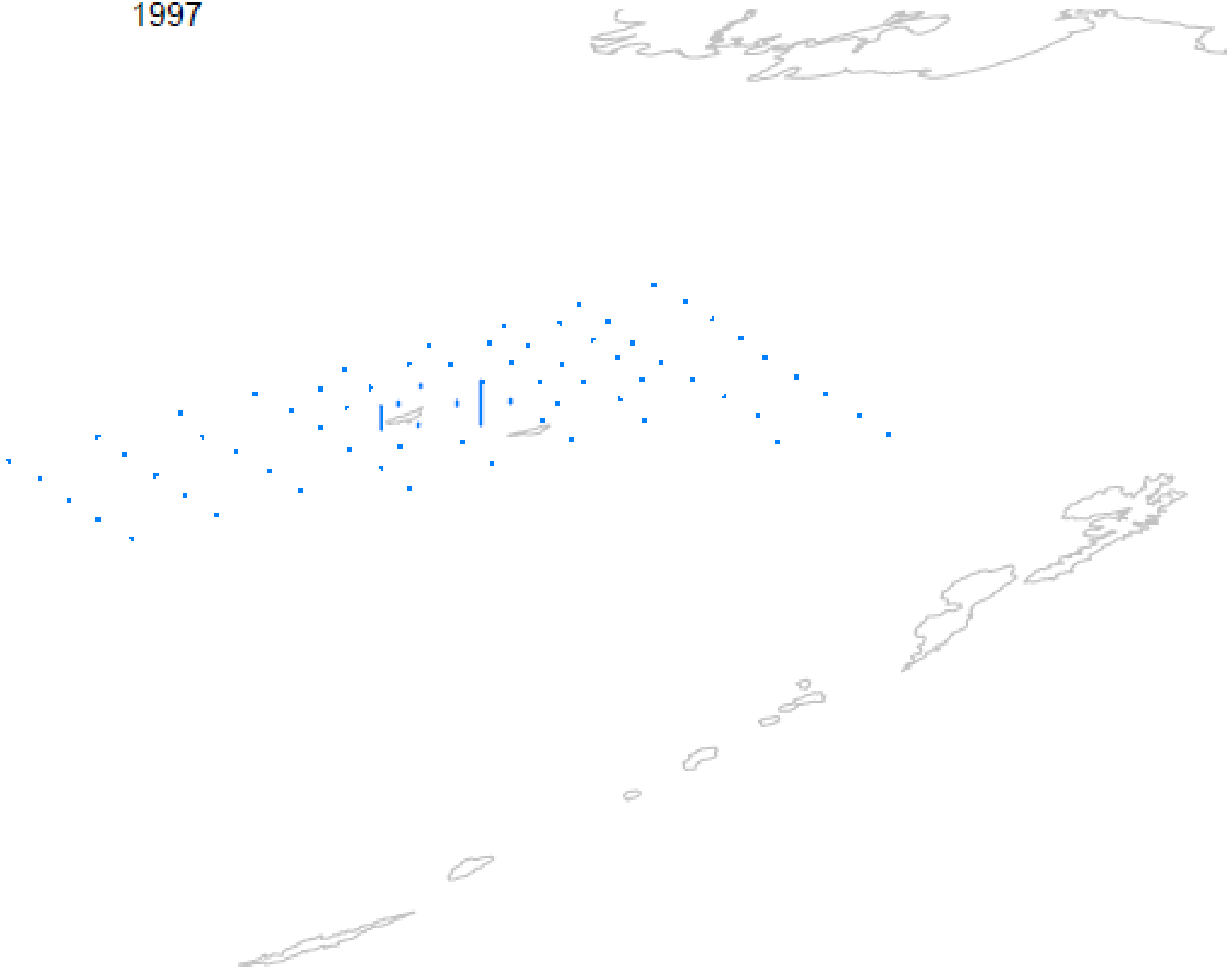

1992

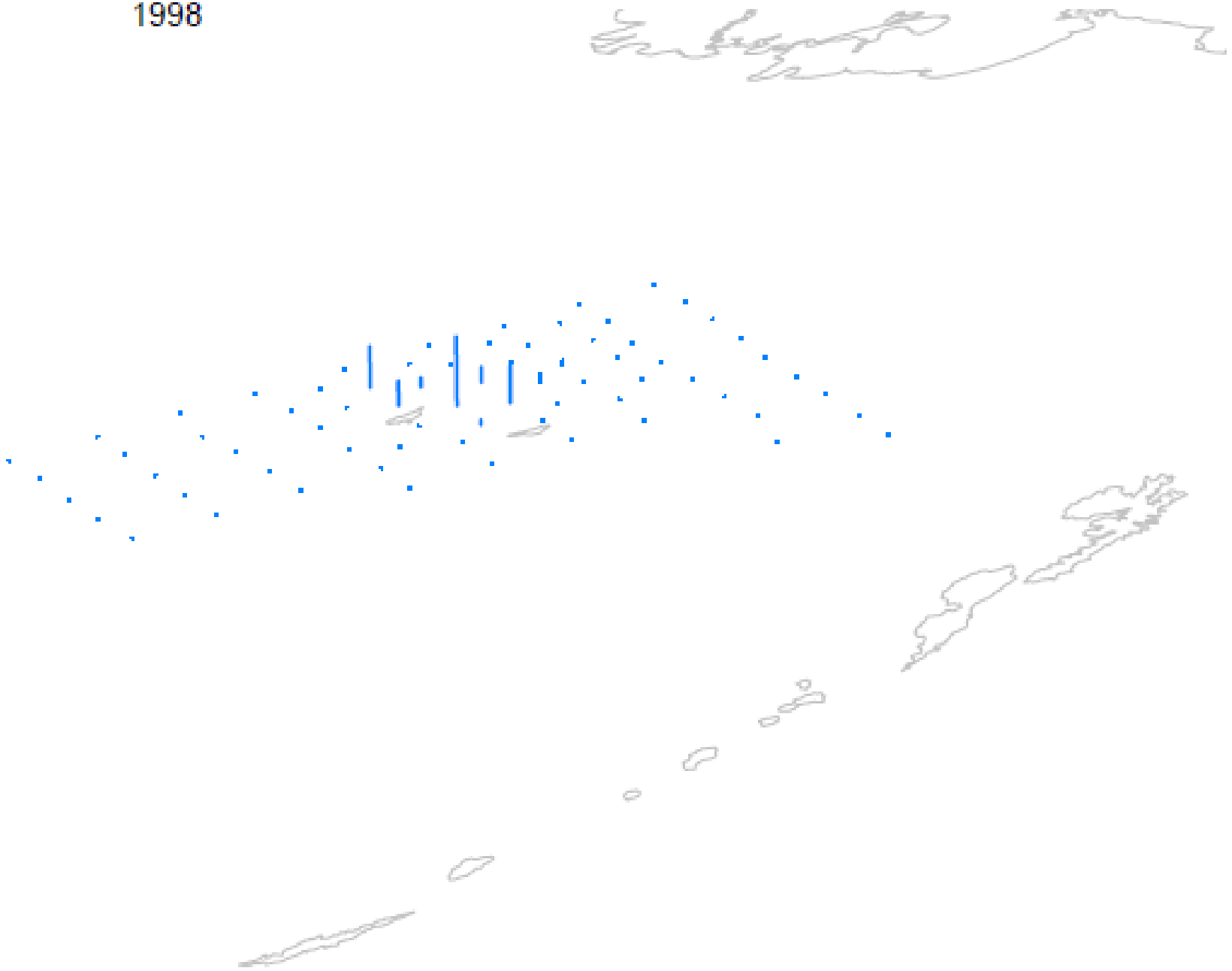

1993

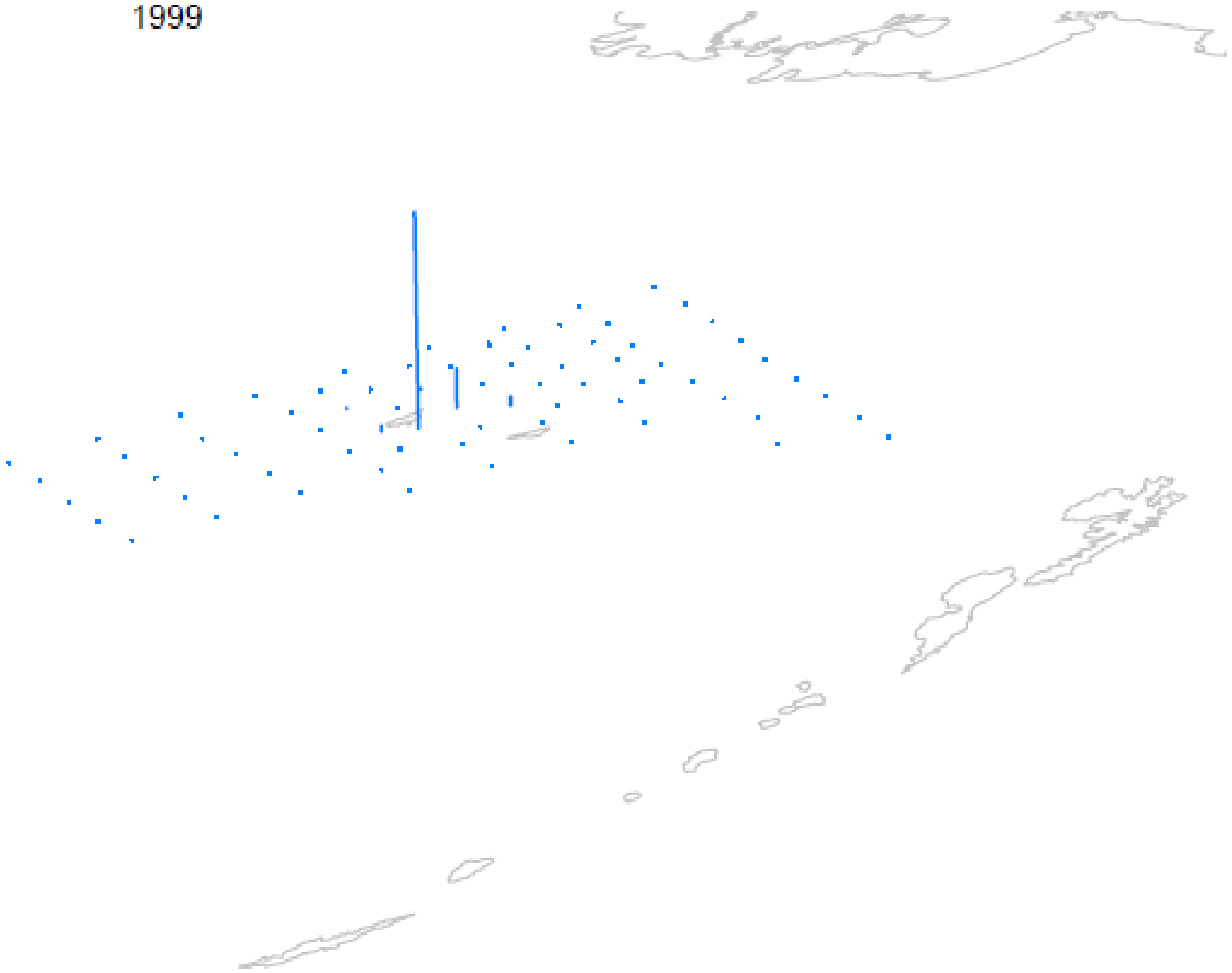

1994

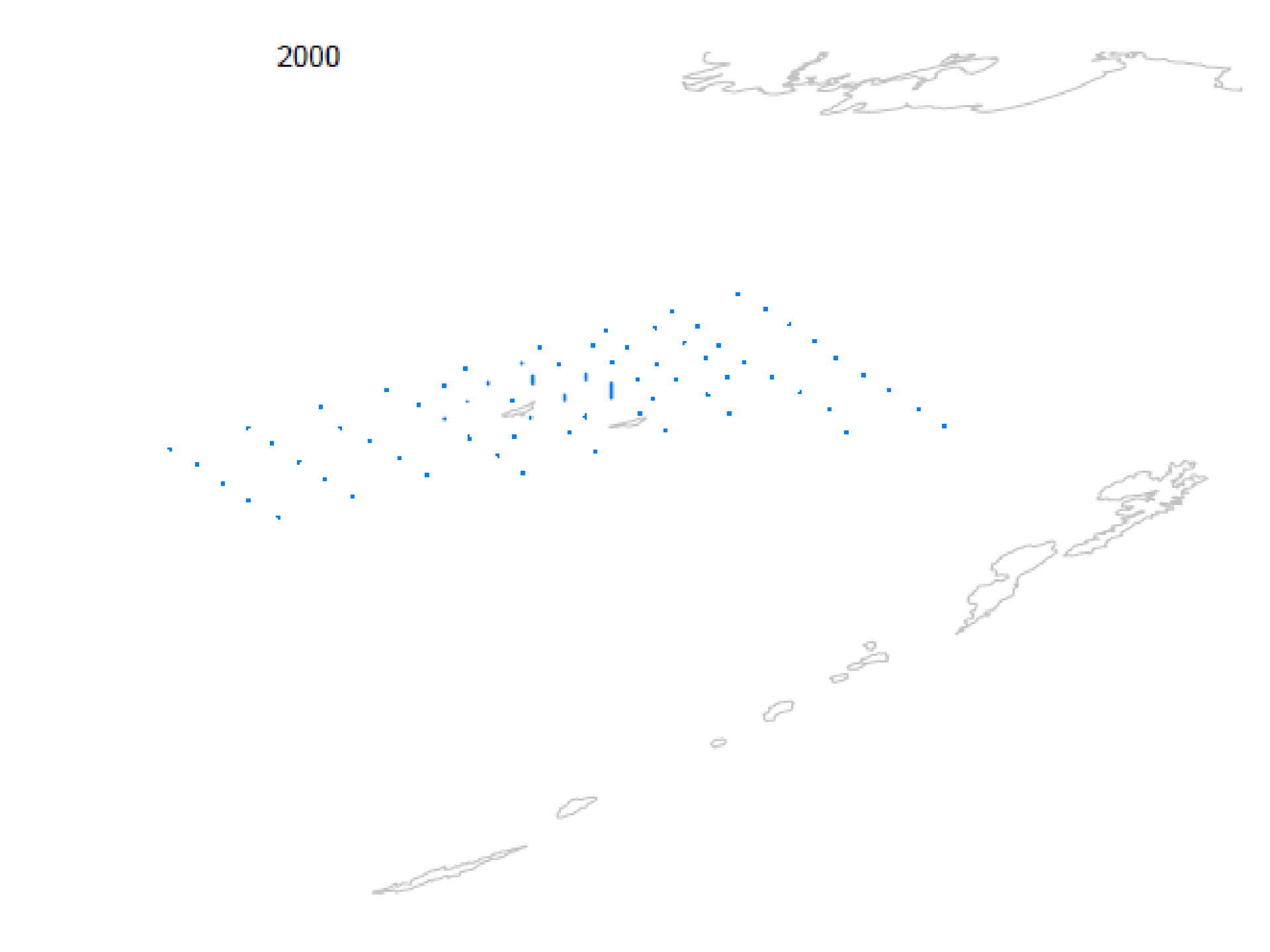

1995

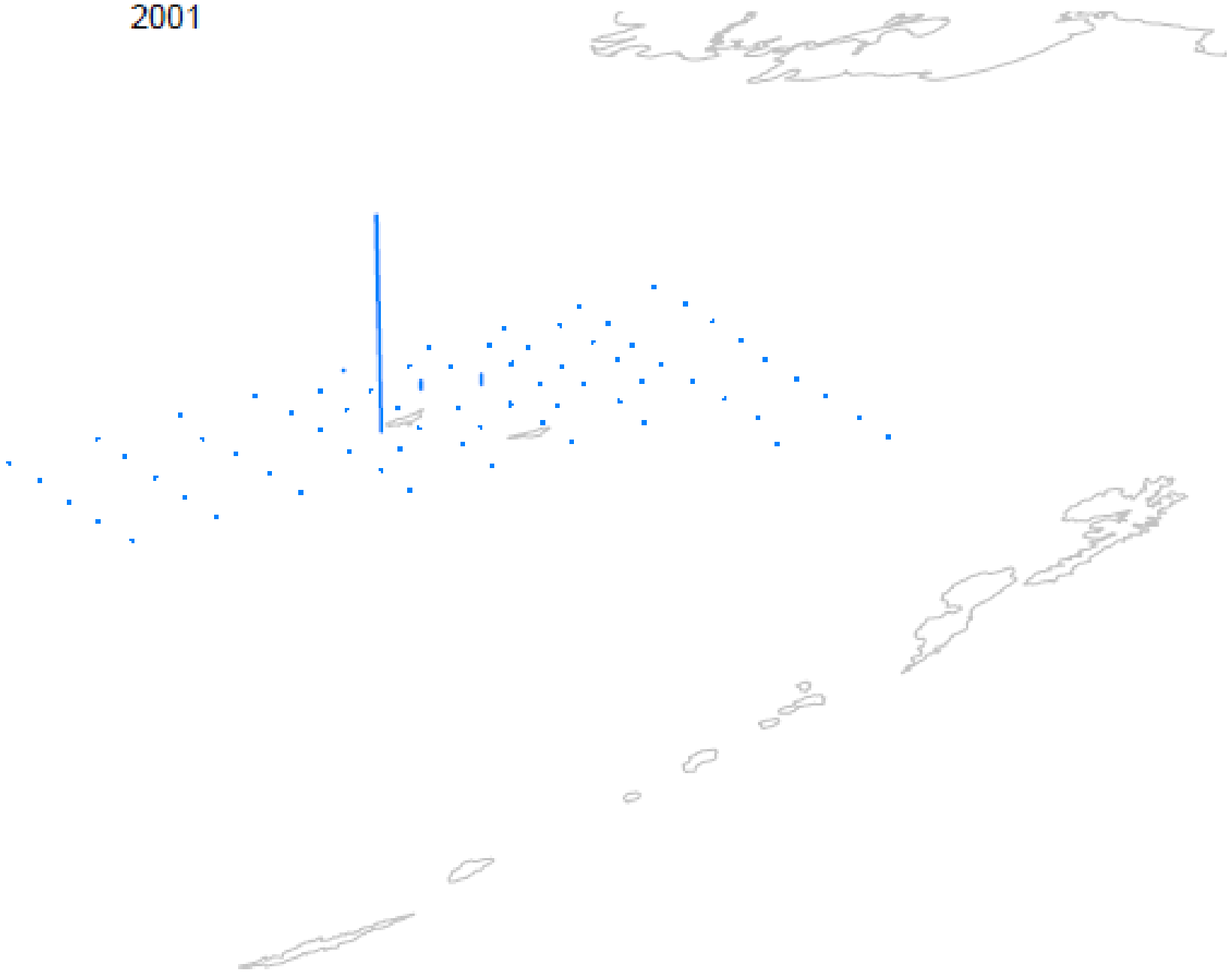

1996

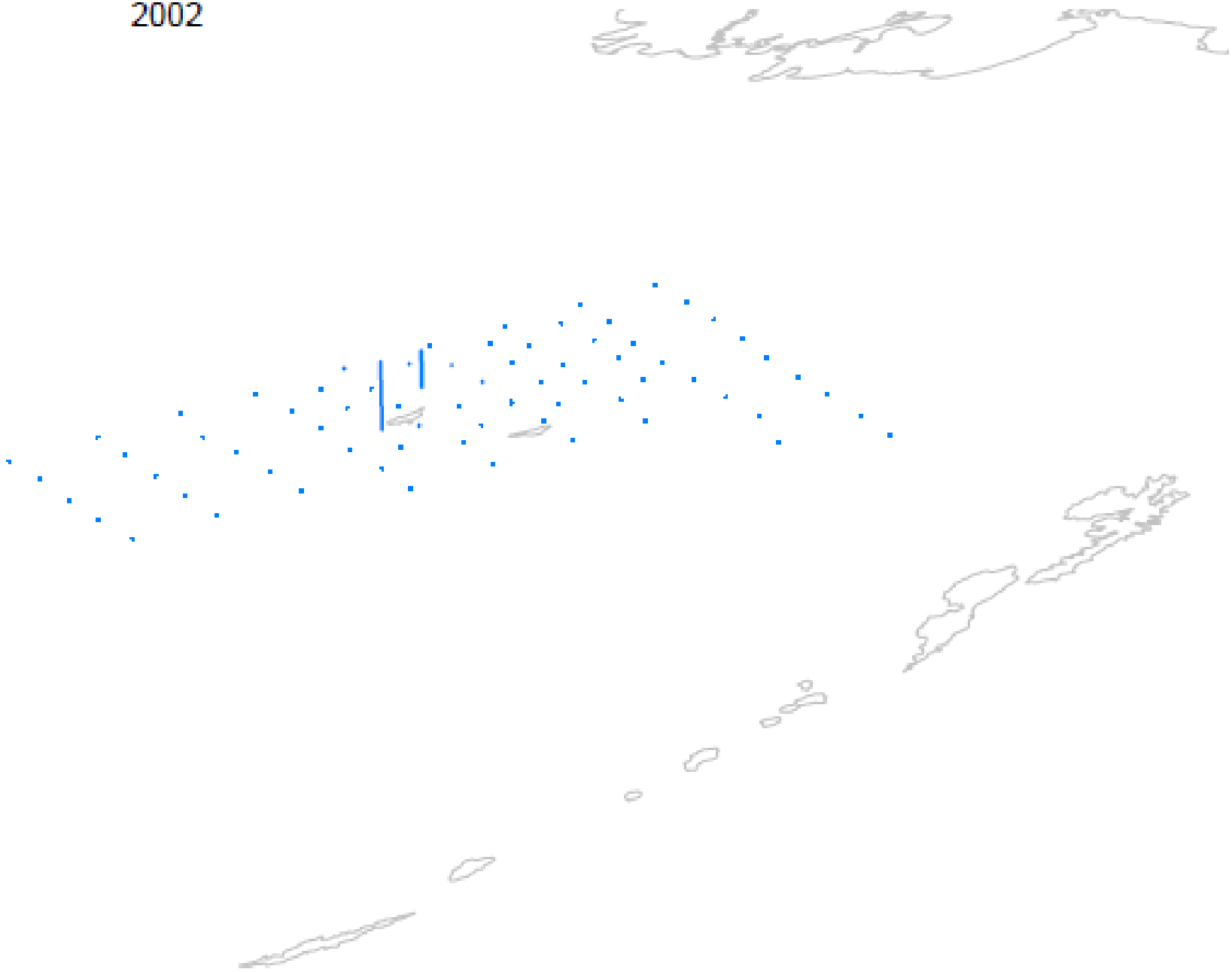

1997

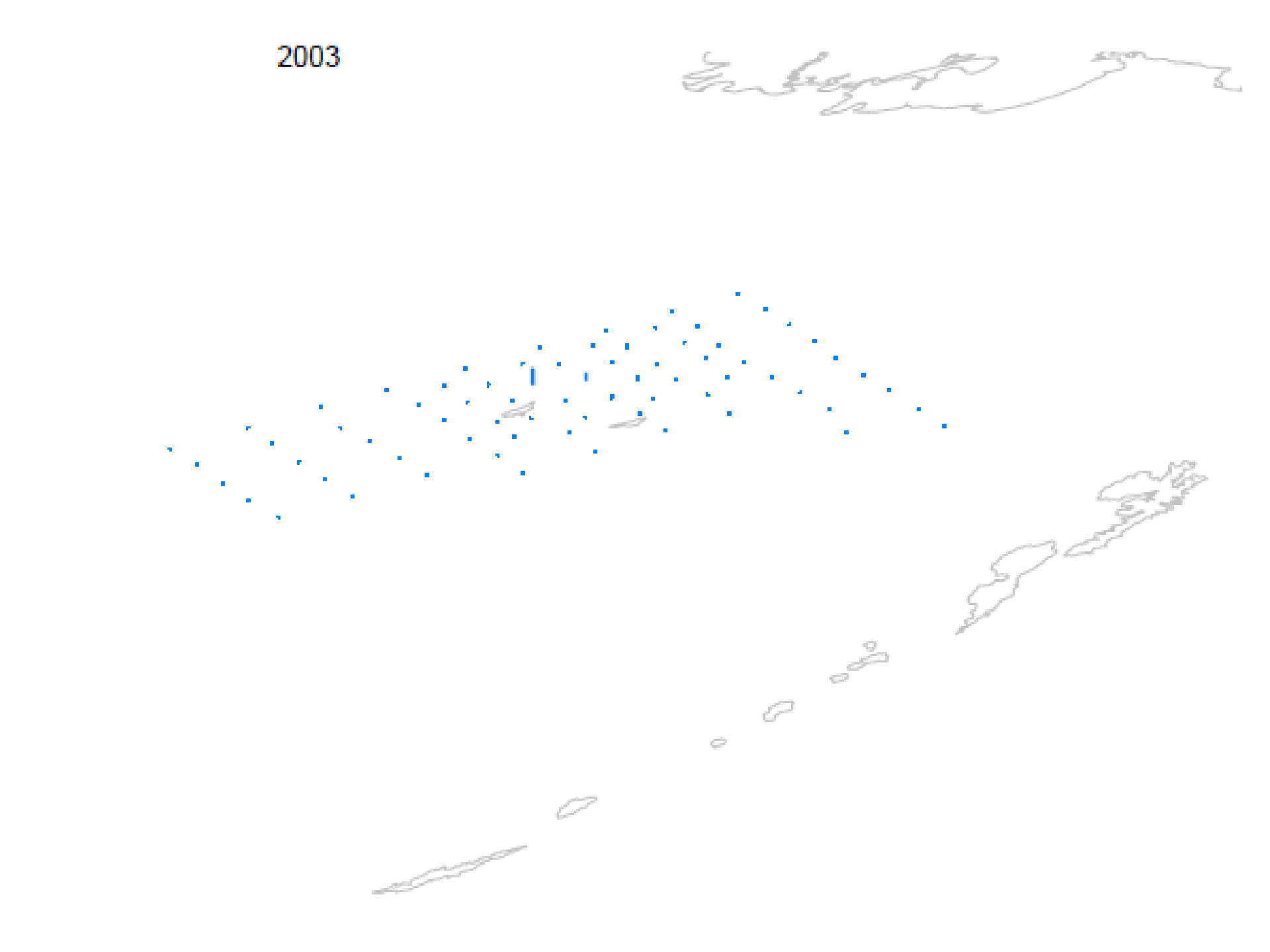

1998

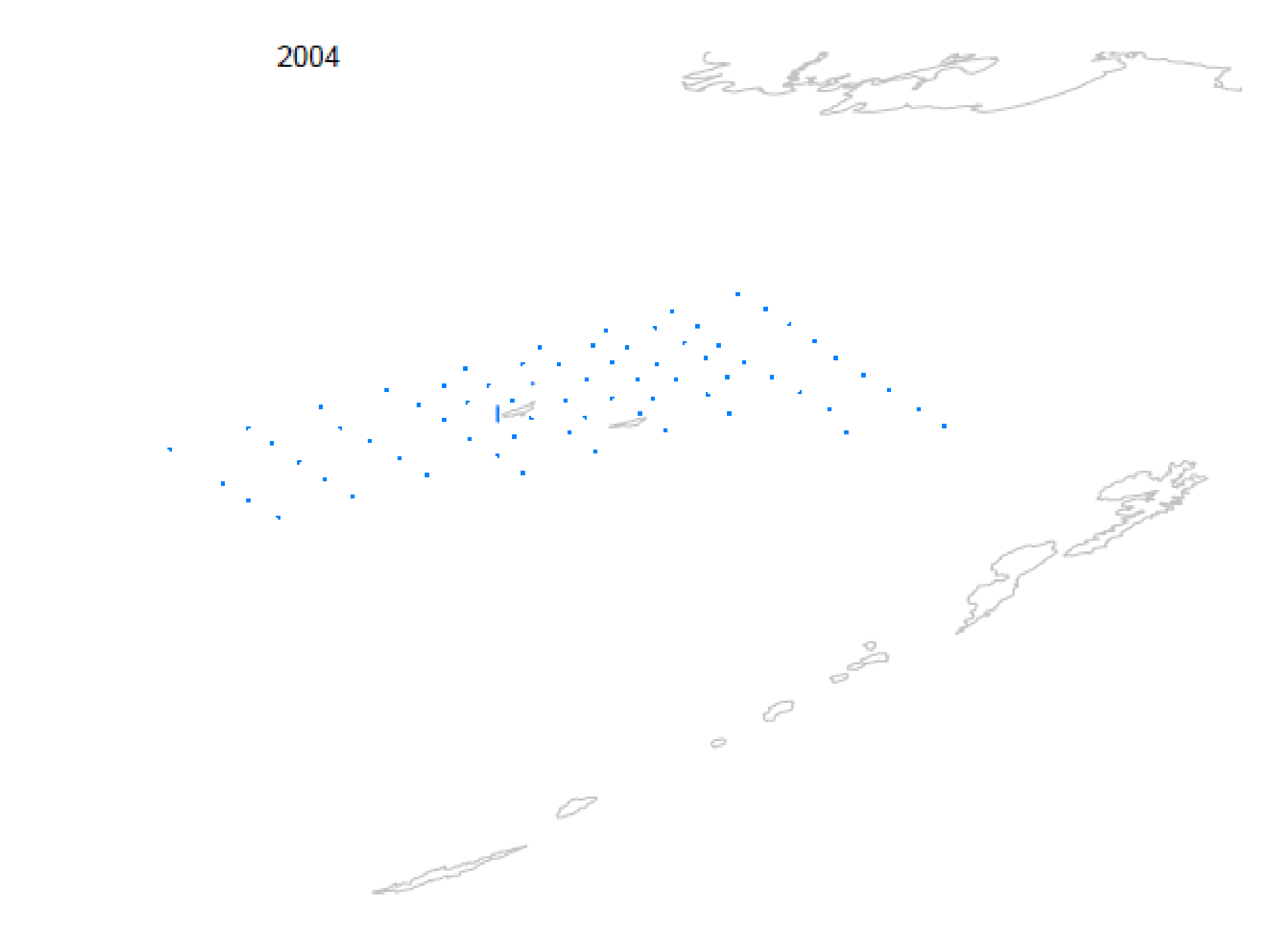

1999

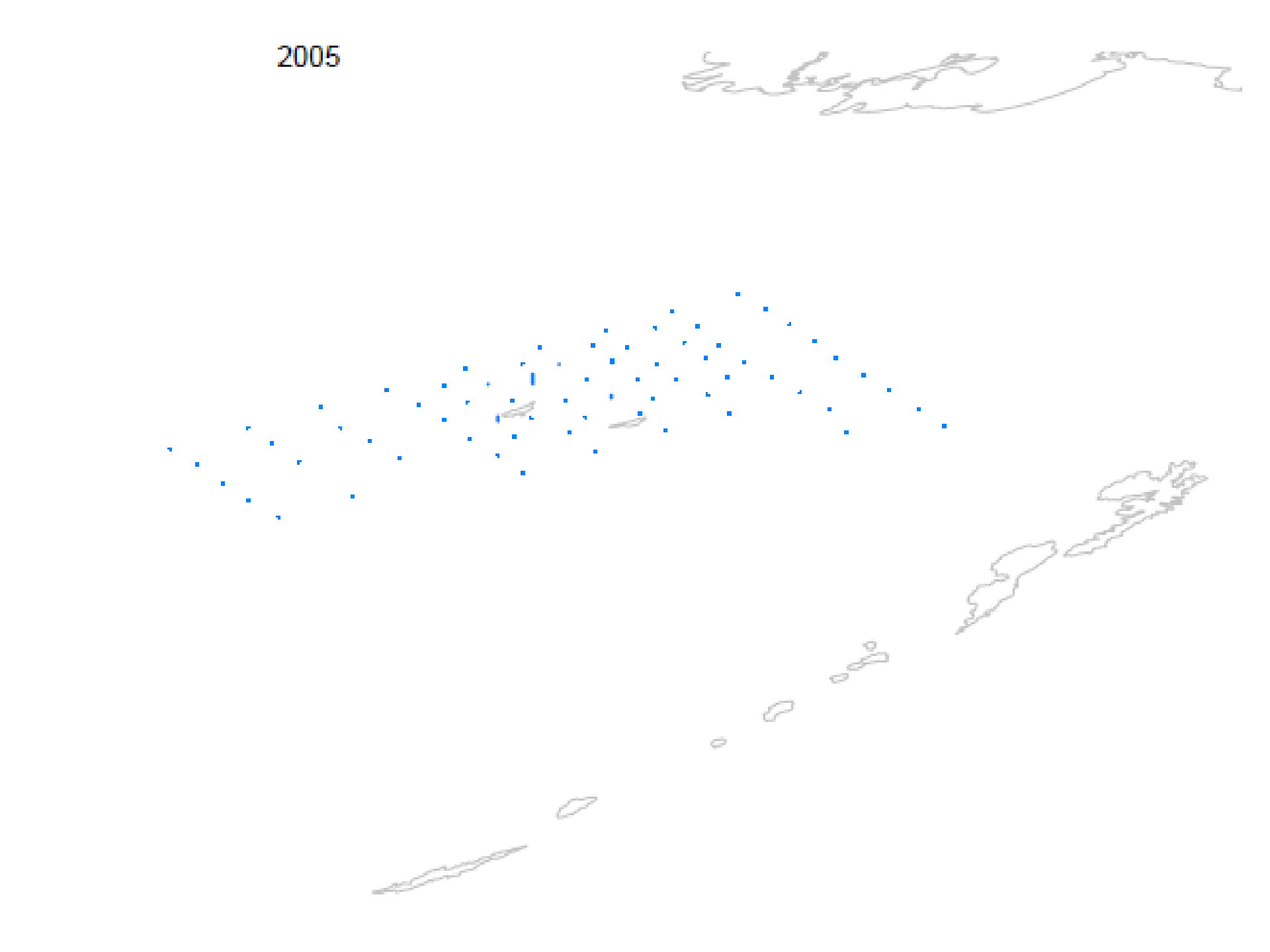

2000

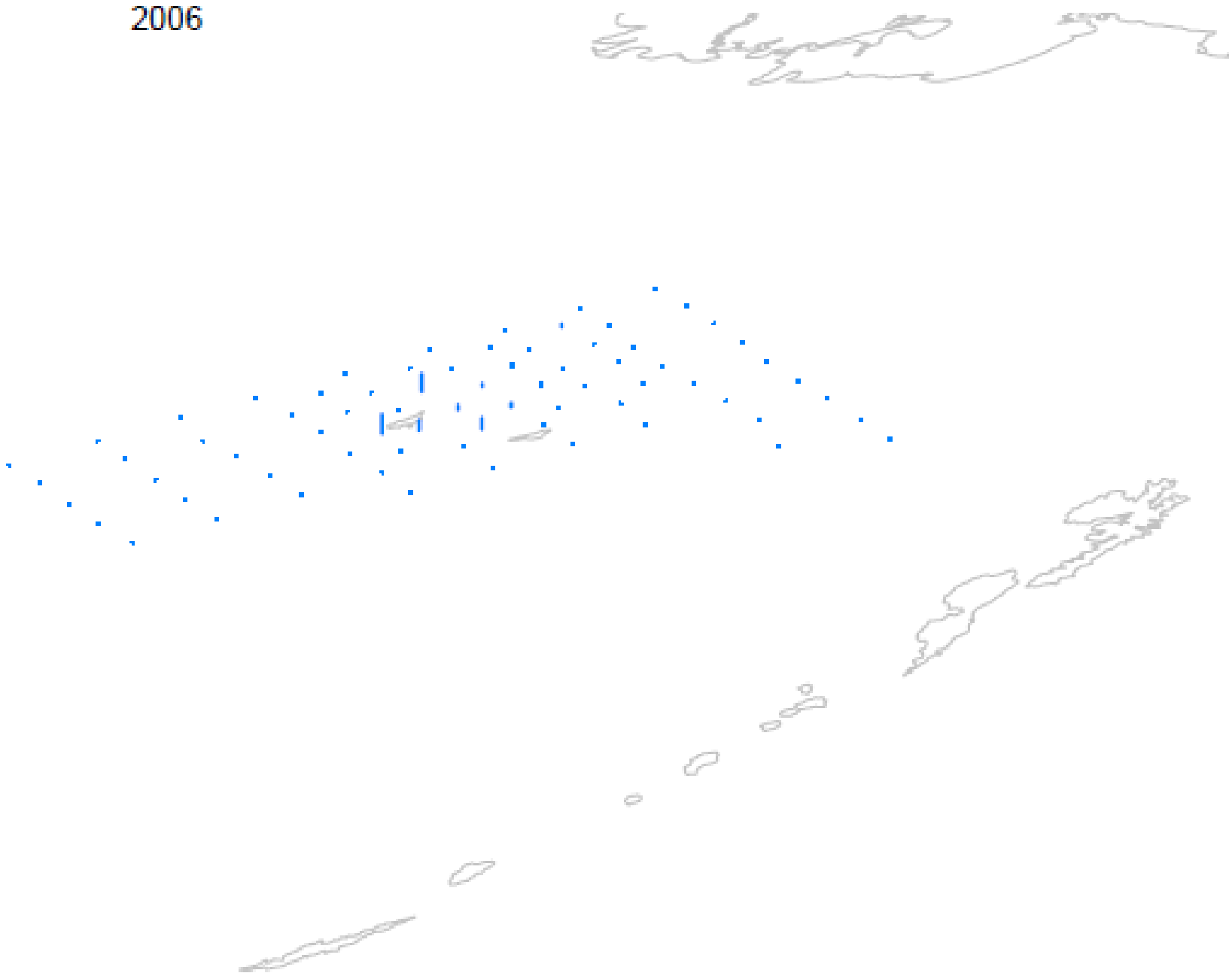

2001

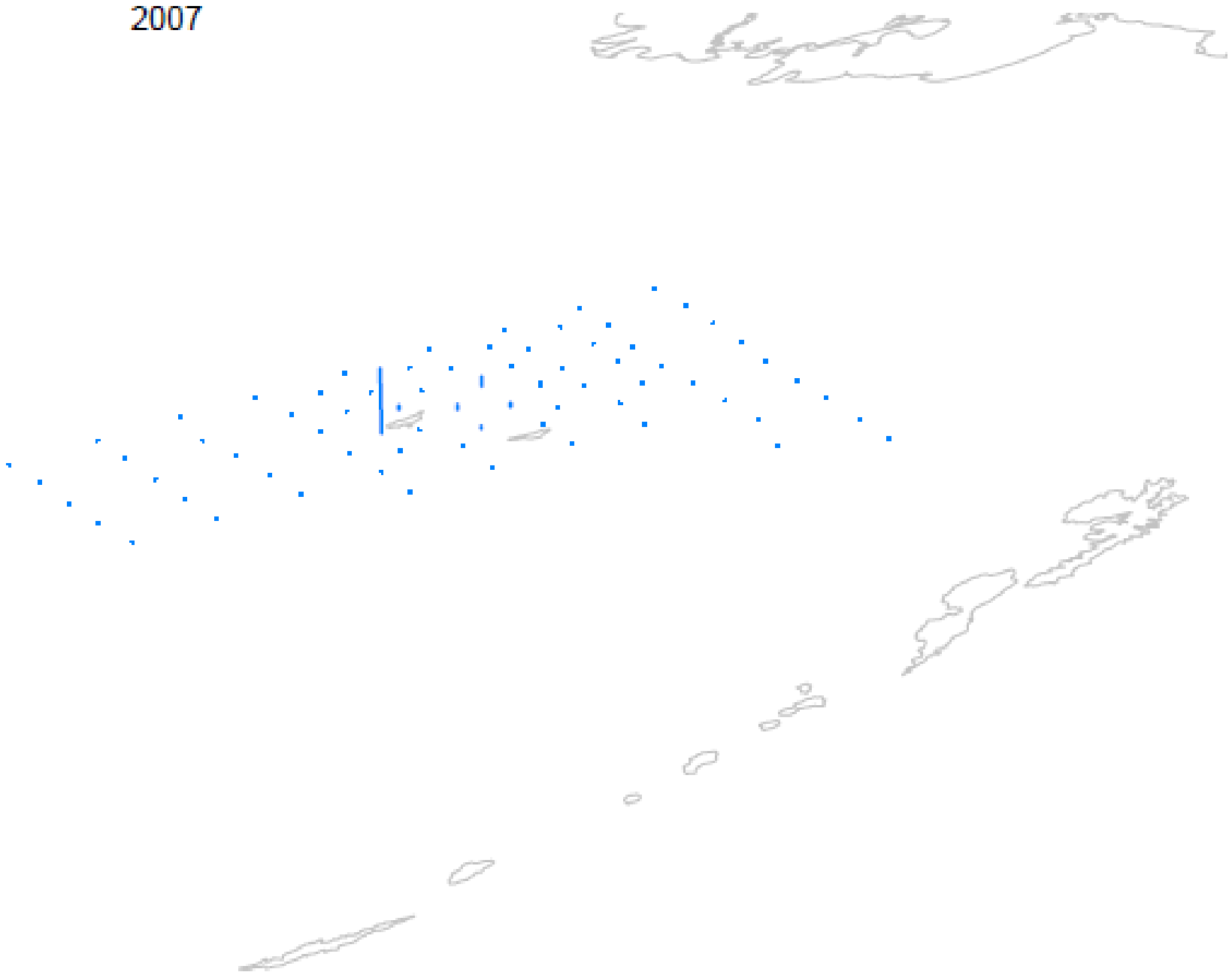

2002

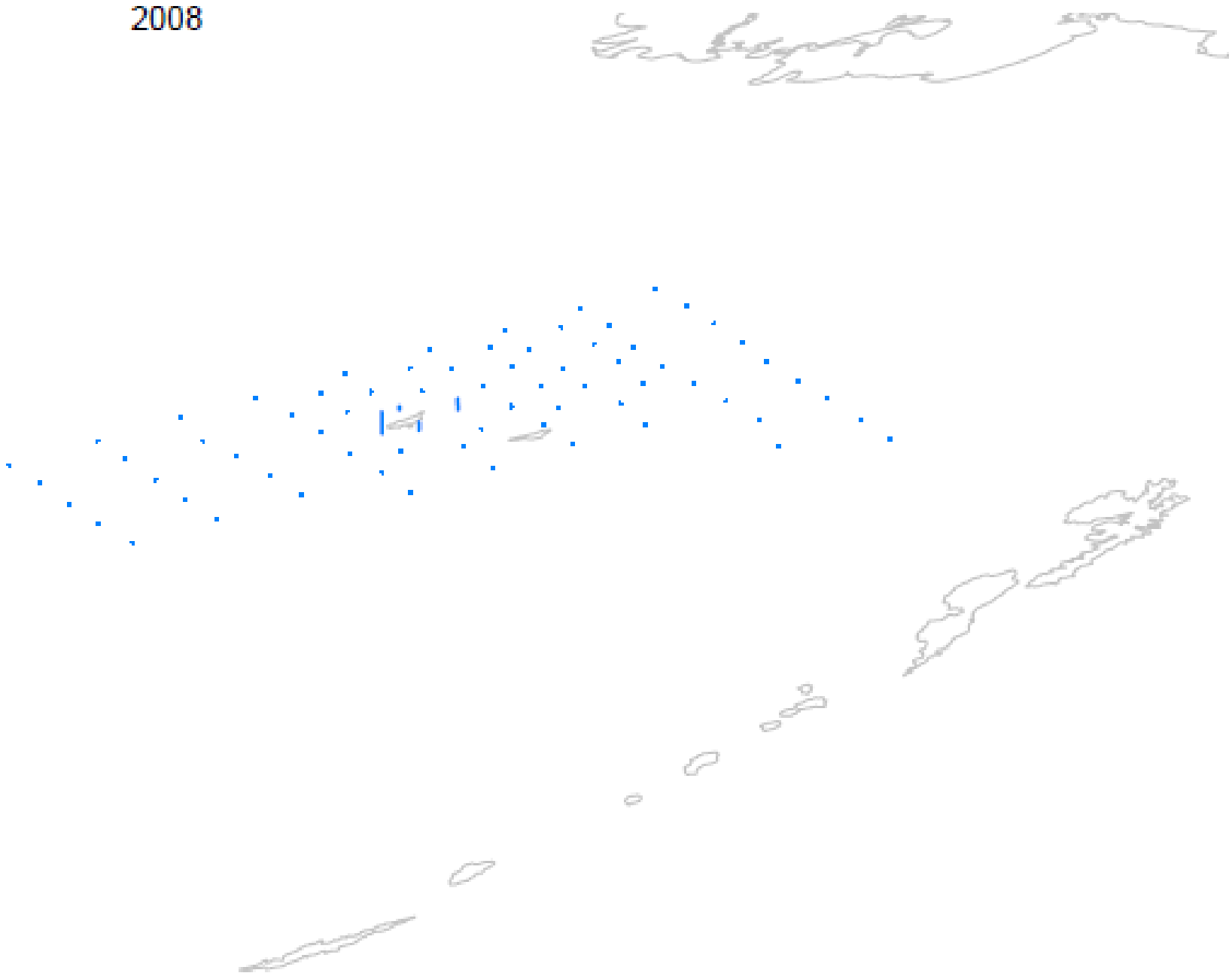

2003

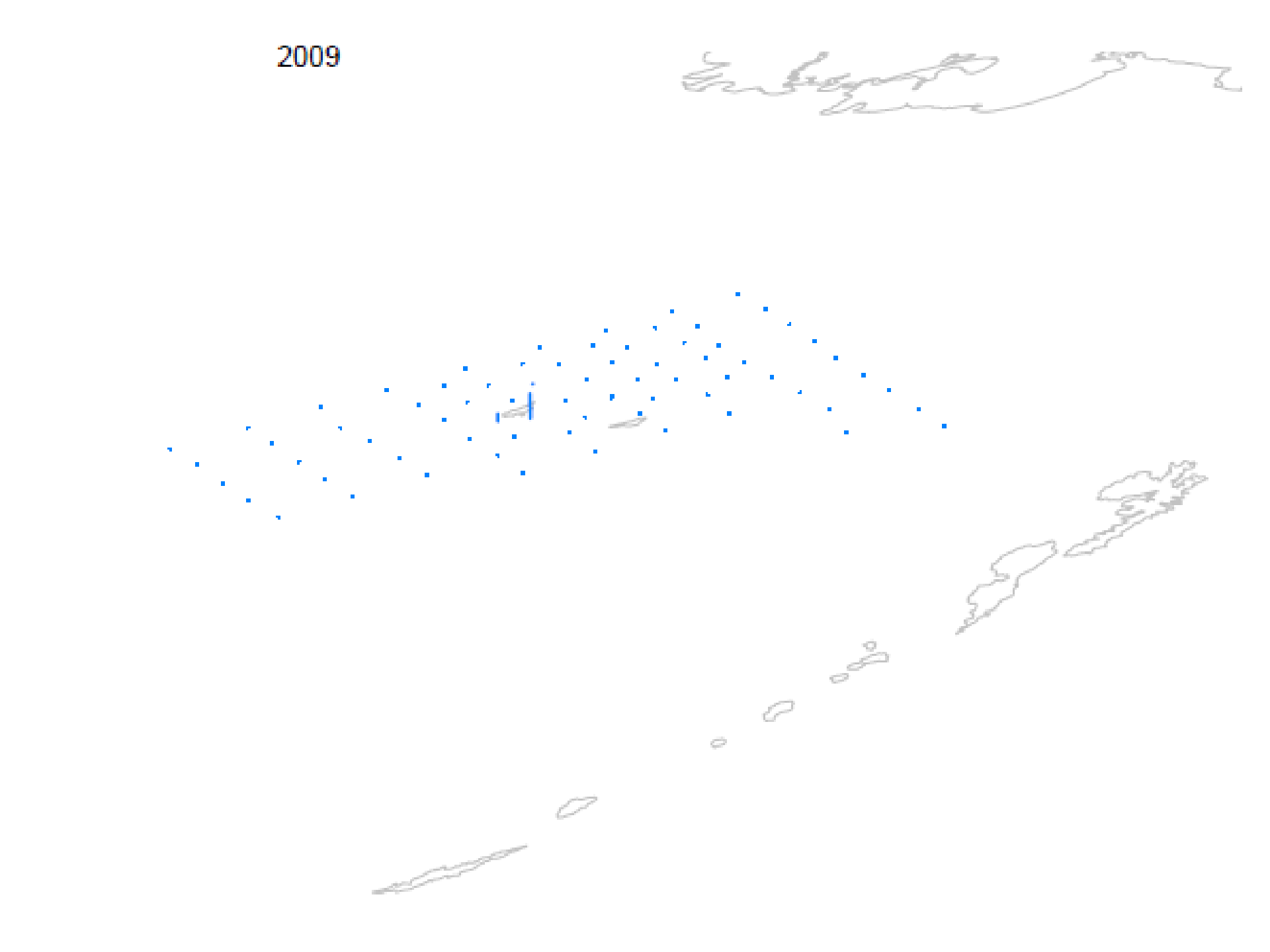

2004

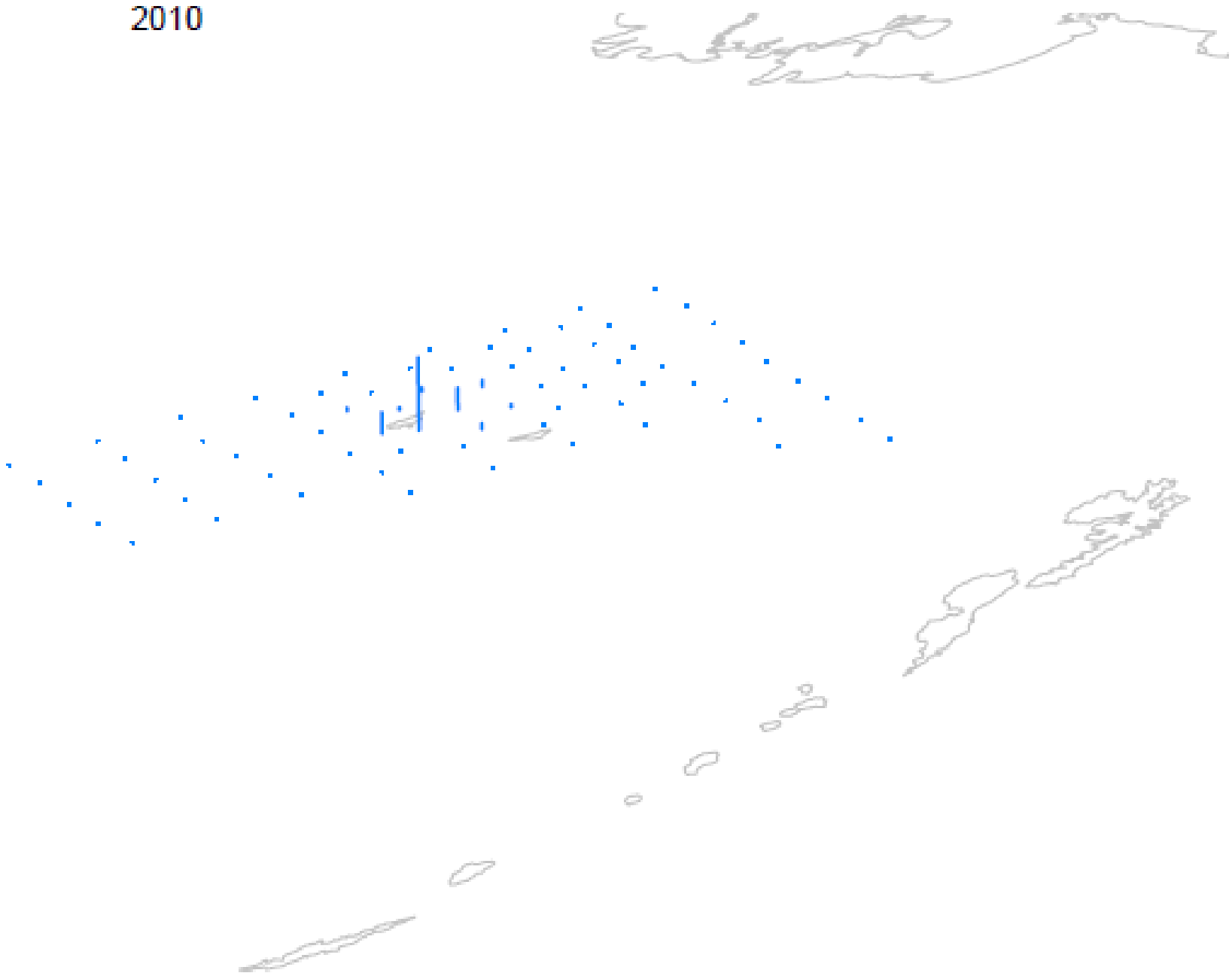

2005

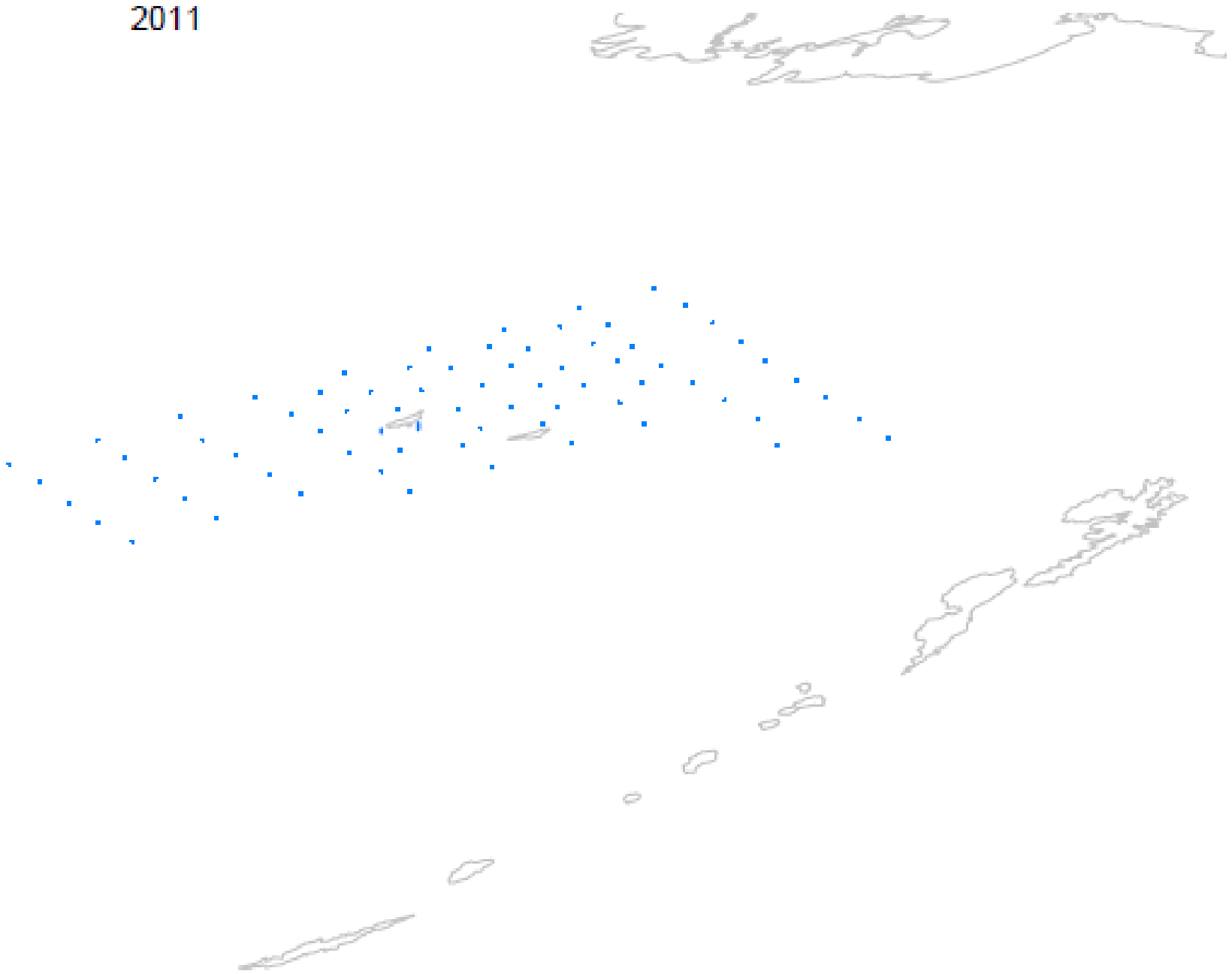

2006

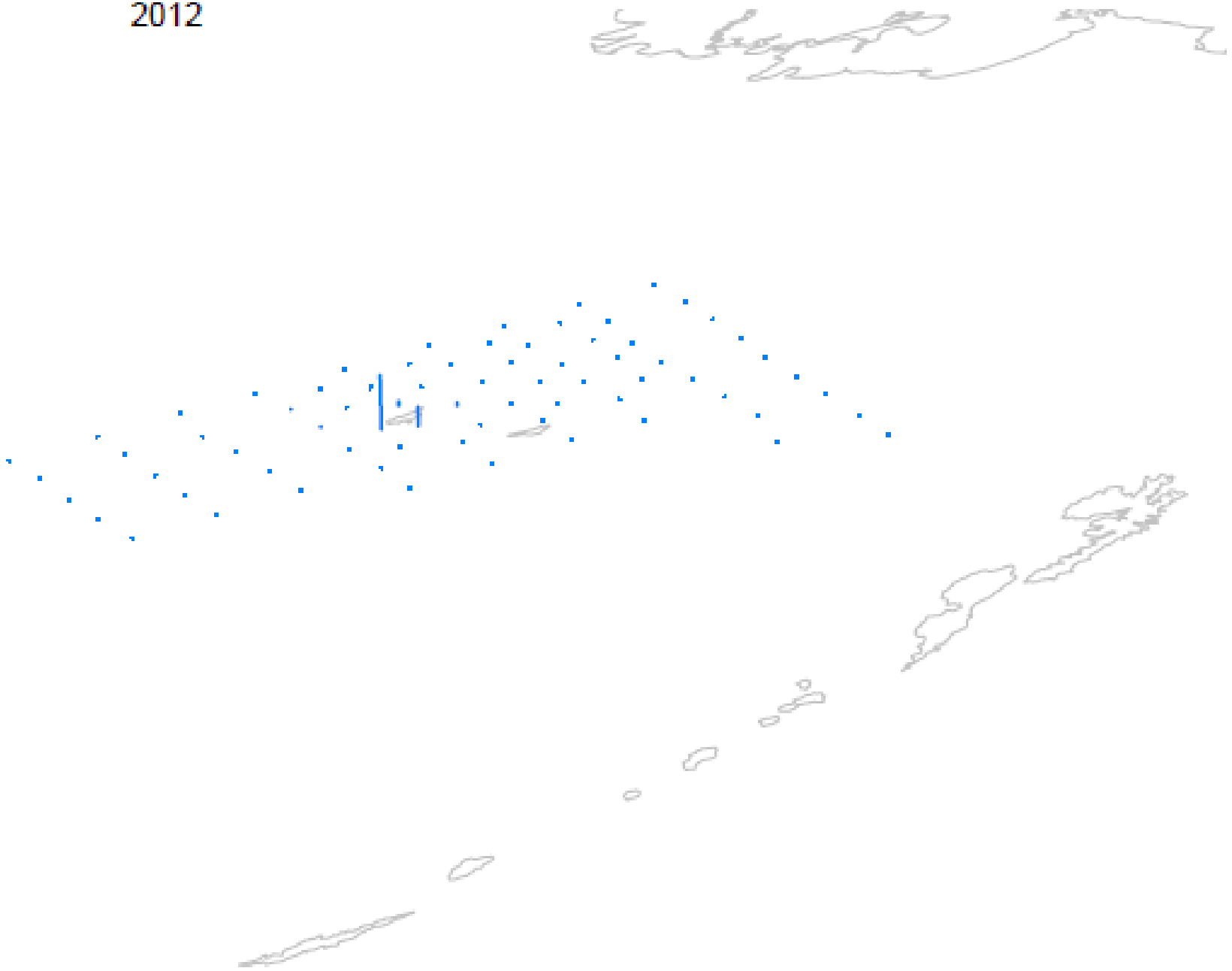

2007

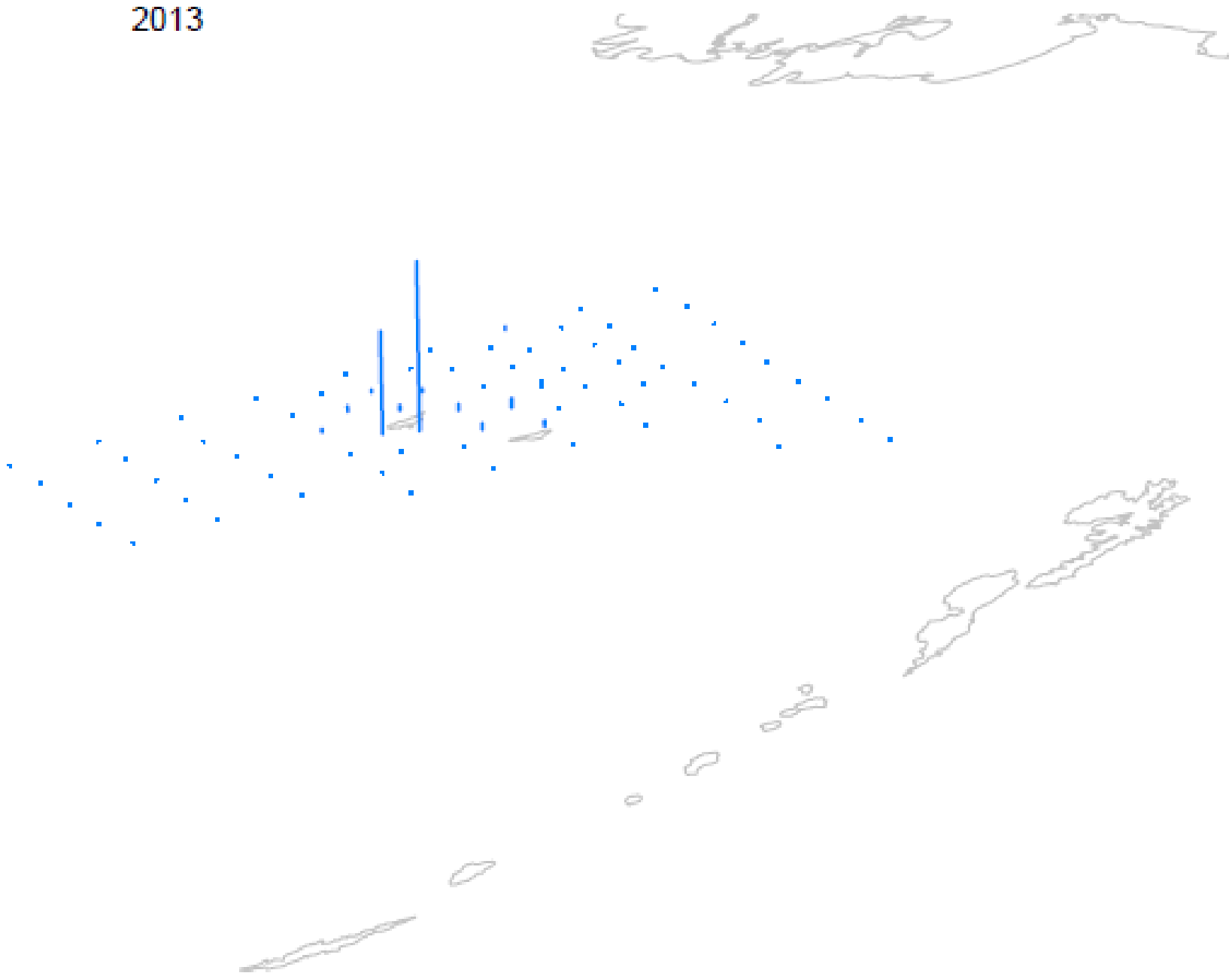

2008

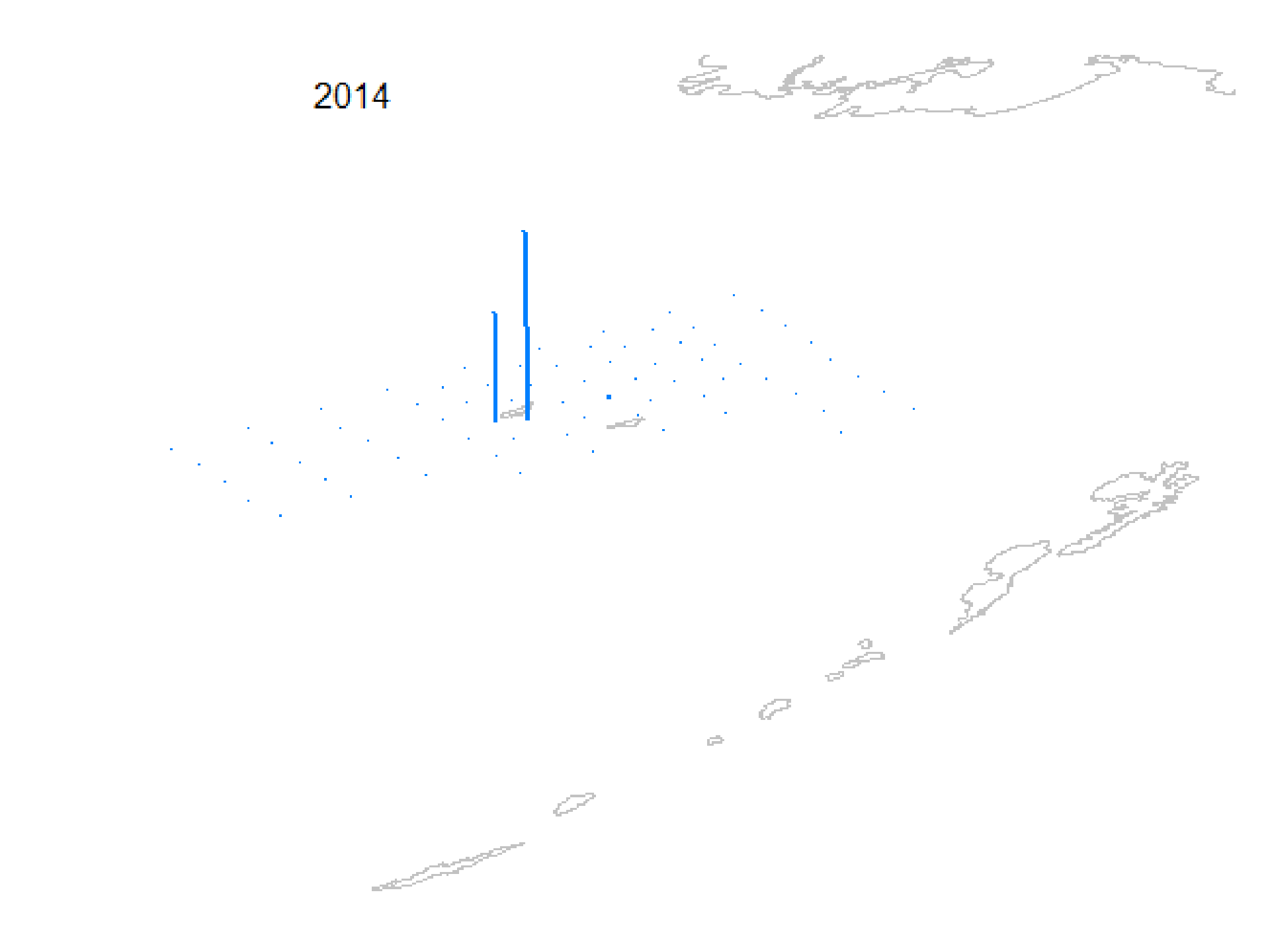

2009

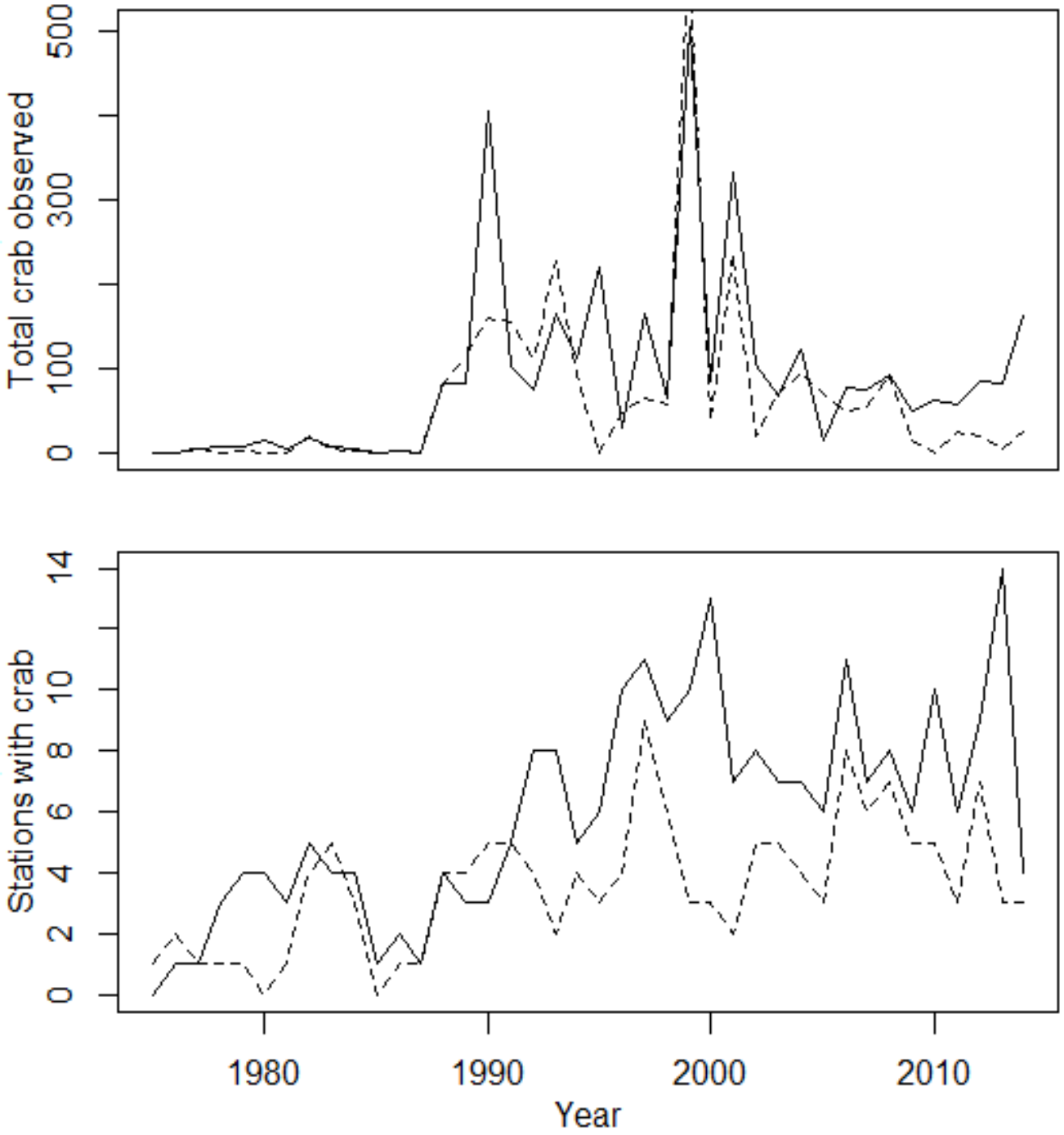

2010

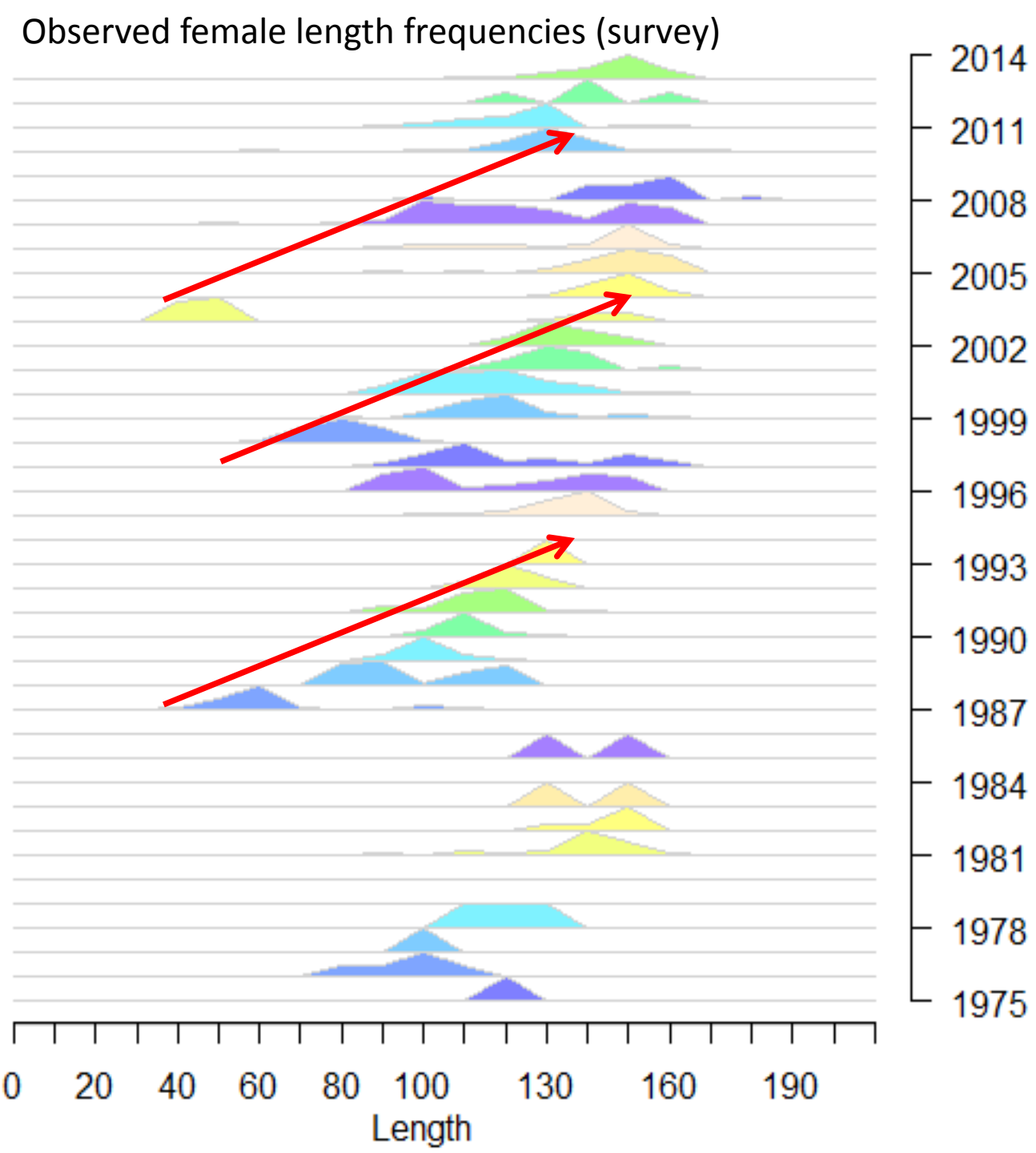

2011

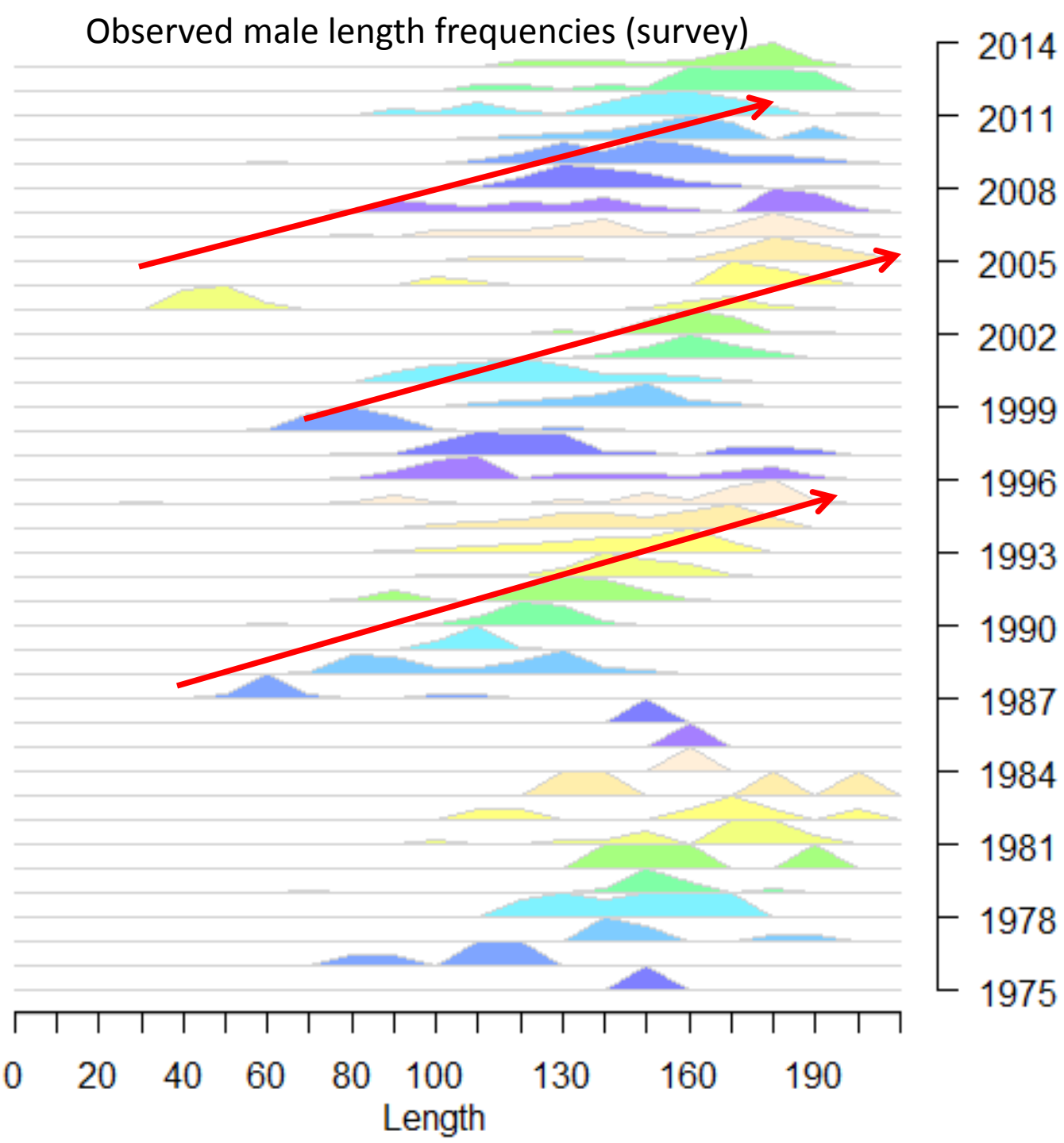

2012

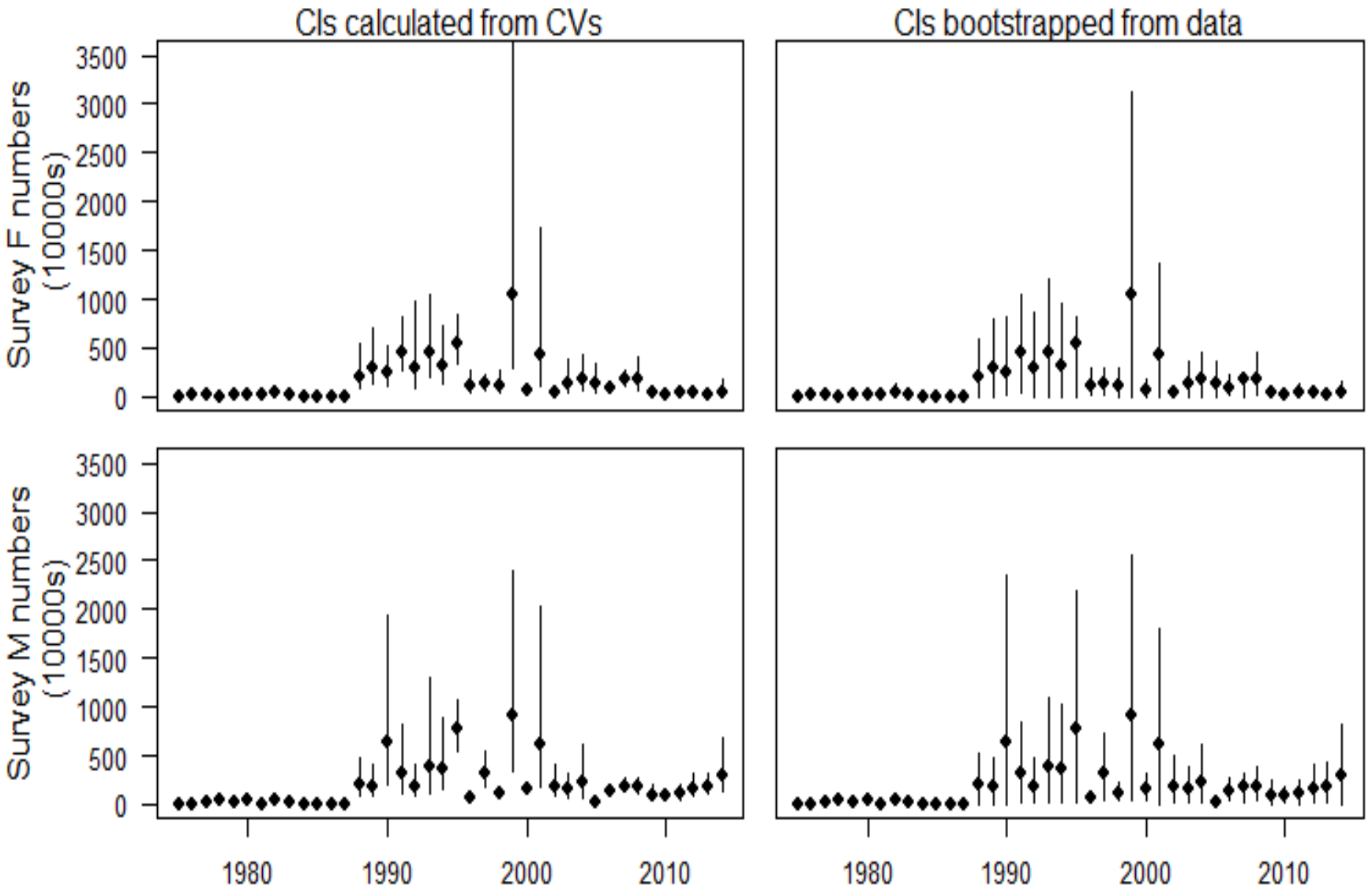

2013


2014


Total crab observed
0
100
300
500
Stations with crab
0
2
4
6
8
10
14
1980
1990
2000
2010
Year


Observed female length frequencies (survey)
2014
2011
2008
2005
2002
1999
1996
1993
1990
1987
1984
1981
1978
1975
0
20
40
60
80
100
130
160
190
Length


Observed male length frequencies (survey)
2014
2011
2008
2005
2002
1999
1996
1993
1990
1987
1984
1981
1978
1975
0
20
40
60
80
100
130
160
190
Length



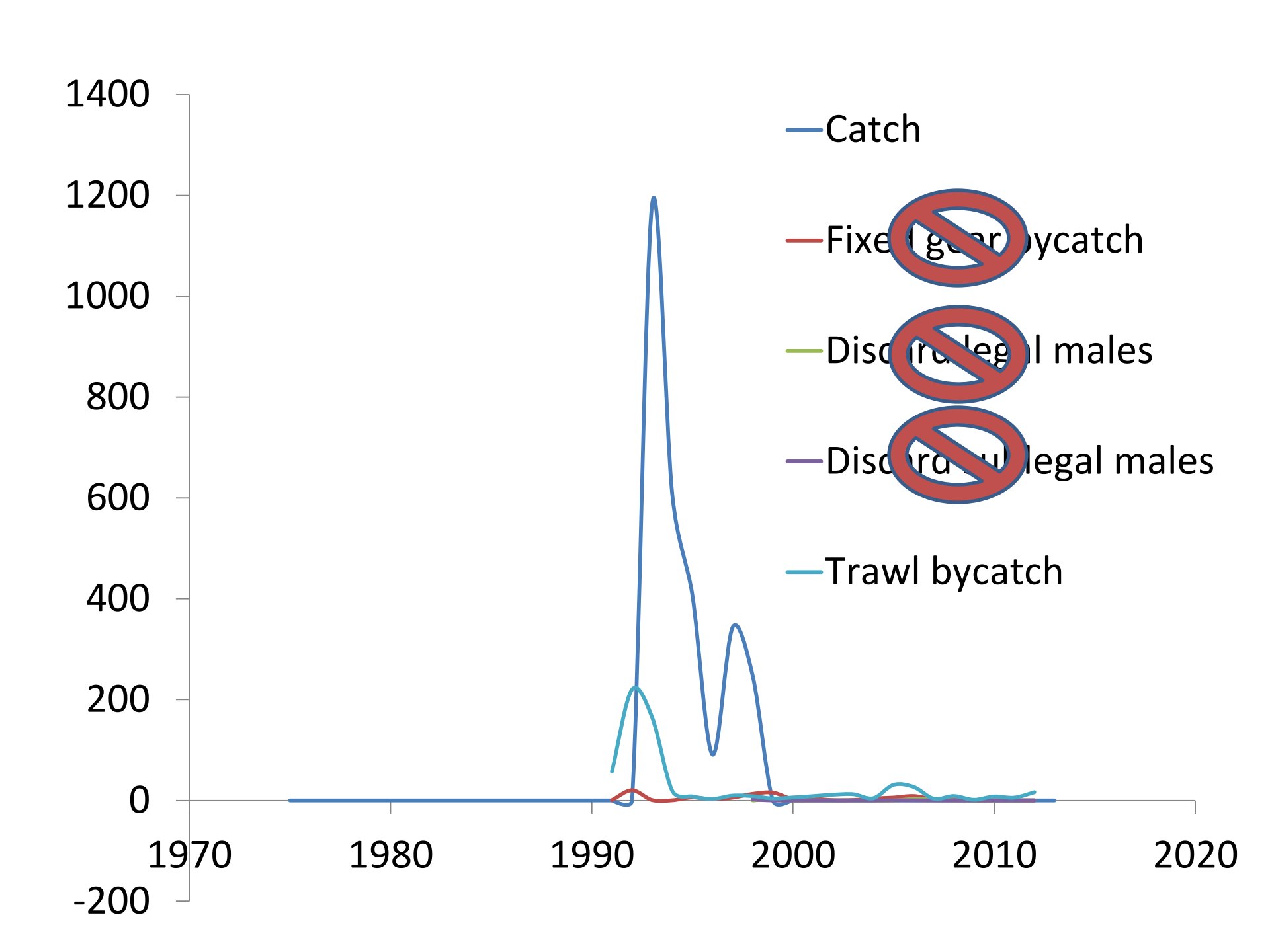
* Addressing May CPT comment

Included in assessment:

Source	Years
Survey index of abundance	1975-2014
Survey length frequencies	1975-2014
Catch in directed fishery	1993-1998
Bycatch in groundfish trawl fishery	1991-2013

Excluded from assessment:

Source	Years
Bycatch in crab pot fisheries	1998-2013
Bycatch in fixed gear groundfish fishery	1991-2013


1400
1200
1000
800
600
400
200
0
-200
1970
1980
1990
2000
2010
2020
Catch
Fixed gear bycatch
Discard legal males
Discard sub legal males
Trawl bycatch

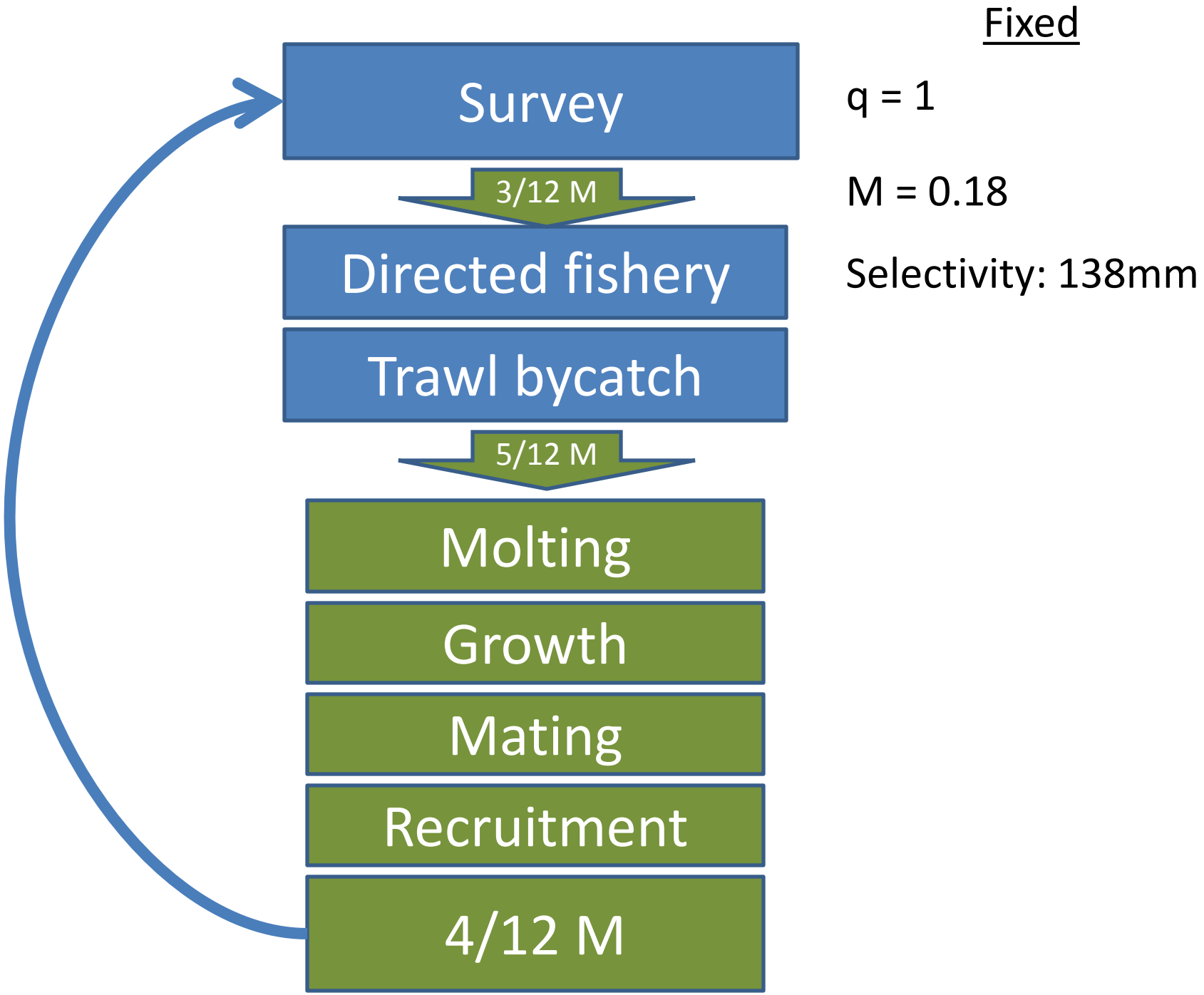
Model brief

- Very similar in structure to the snow crab assessment
- 5mm length bins (37.5-207.5)
- Males and females
- Maturity state
- Fixed survey catchability at 1, M at 0.18

- MCMC in ADMB was performed to characterize uncertainty in estimated and derived quantities

Fixed parameters (11 [down from 18**])**	**Number**
Natural mortality	1
Molting probability	3
Fishery selectivity	2
Weight	4
Survey catchability	1
Estimated parameters (87 [down from 142**])**	
Growth	6*
Proportion recruiting	2*
Log average recruitment	1
Log recruitment deviations	45*
Log average fishing mortality (directed)	1
Log fishing mortality deviations (directed)	6
Log average fishing mortality (trawl)	1
Log fishing mortality deviations (trawl)	23
Survey selectivity	2

* Addressing 3 May CPT comments


Fixed
Survey
q = 1
3/12 M
M = 0.18
Directed fishery
Selectivity: 138mm
Trawl bycatch
5/12 M
Molting
Growth
Mating
Recruitment
4/12 M

Survey

3/12 M

Directed fishery

Trawl bycatch

5/12 M

Molting

Growth

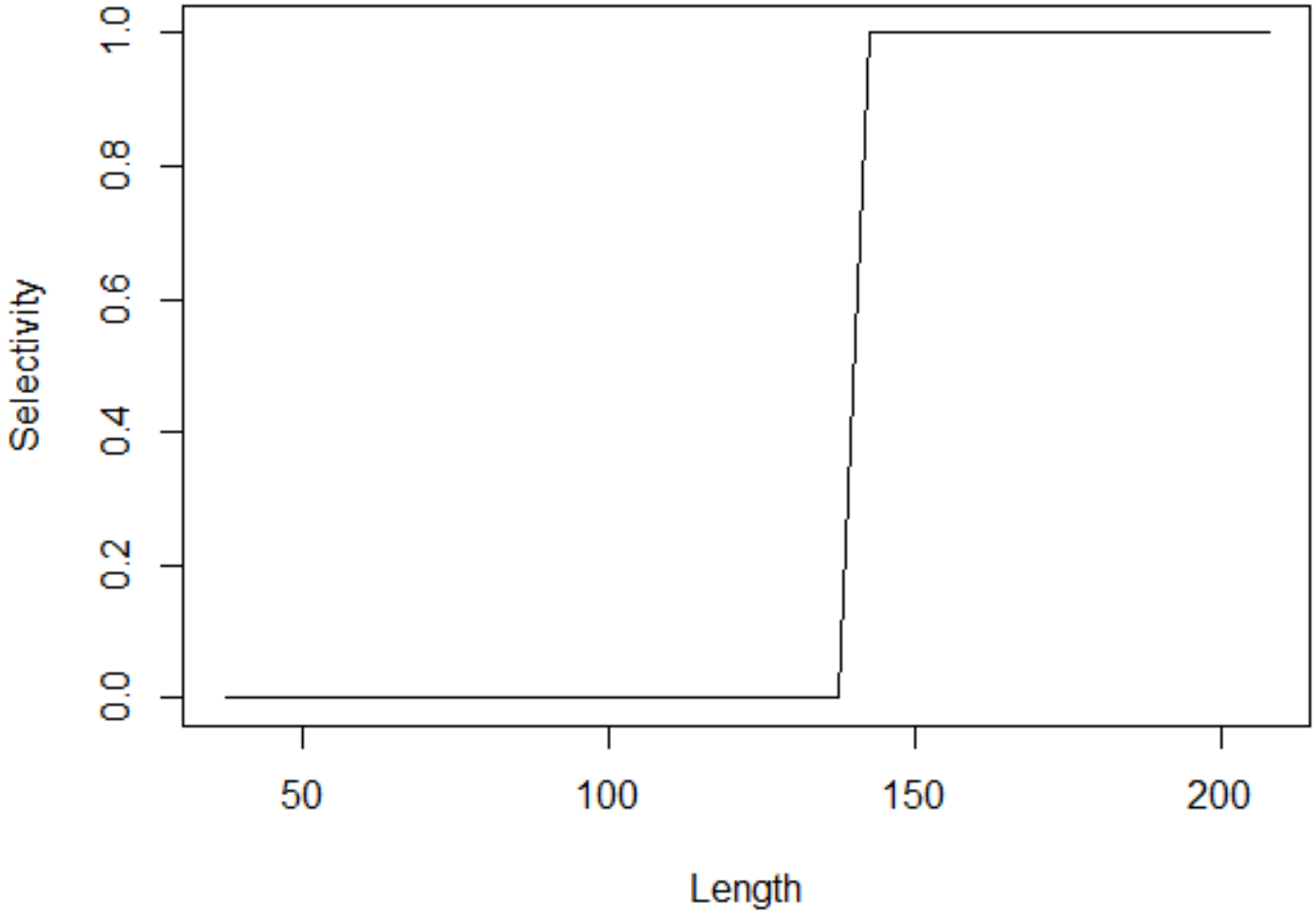
Mating

Recruitment

4/12 M

Directed fishery selectivity

(assumed)



Survey

3/12 M

Directed fishery

Trawl bycatch

5/12 M

Molting

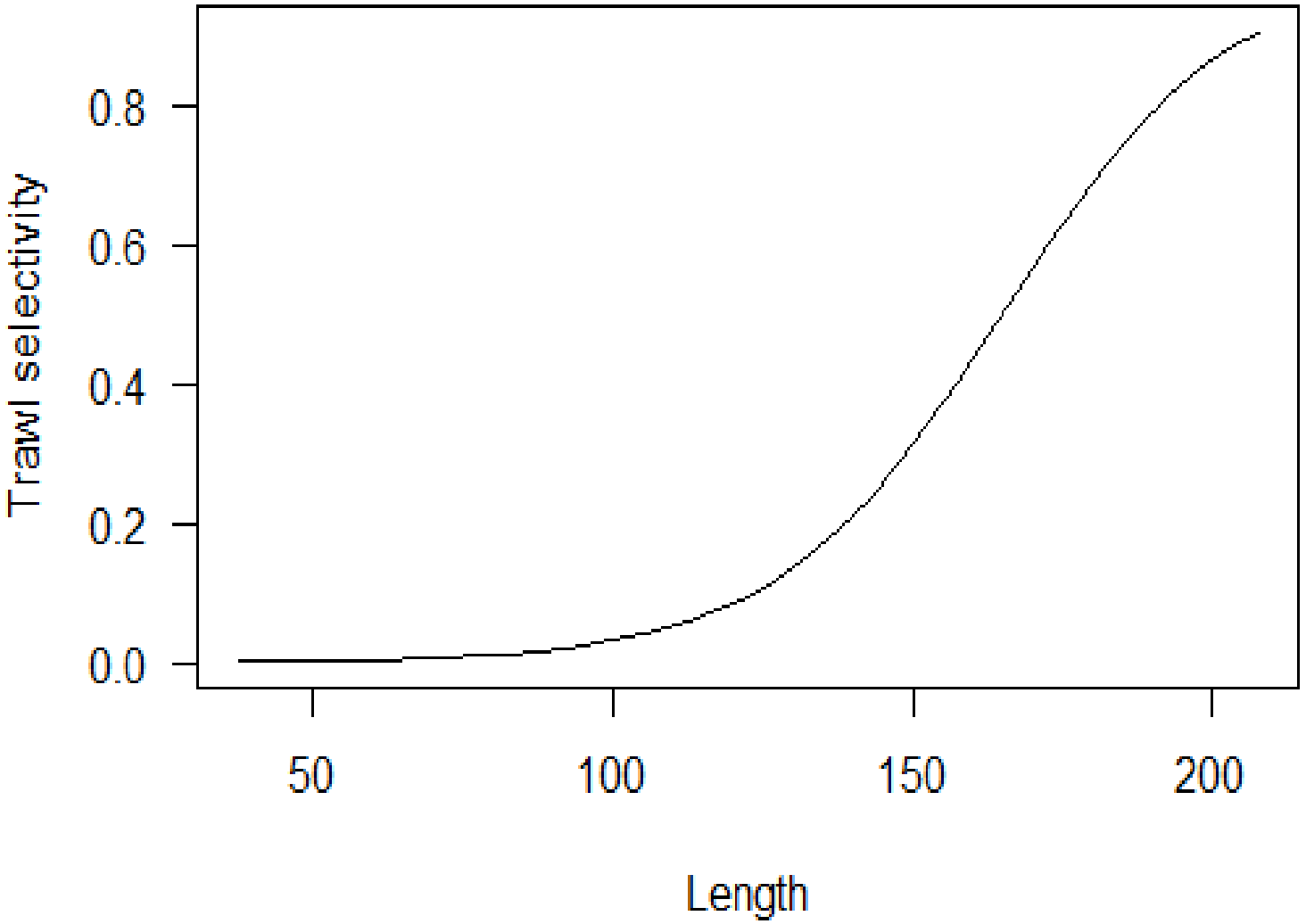
Growth

Mating

Recruitment

4/12 M

Non-pelagic trawl selectivity(assumed)



Survey

3/12 M

Directed fishery

Trawl bycatch

5/12 M

Molting

Growth

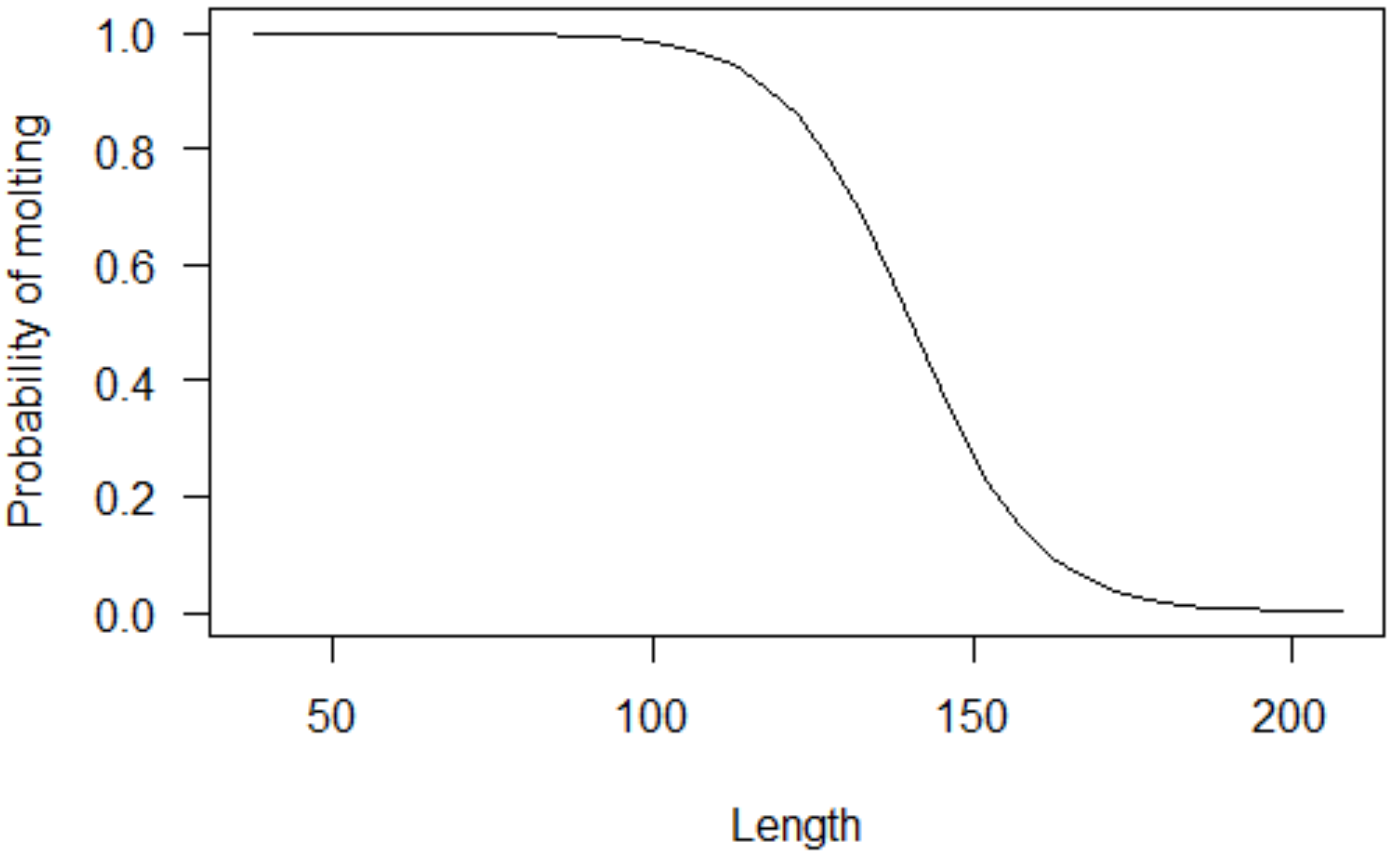
Mating

Recruitment

4/12 M

Molting probability (males)

[fixed]



Powell, G.C. 1967. Growth of king crabs in the vicinity of Kodiak Island, Alaska. Informational Leaflet 92, Alaska Department of Fish and Game, 58 p.

Survey

3/12 M

Directed fishery

Trawl bycatch

5/12 M

Molting

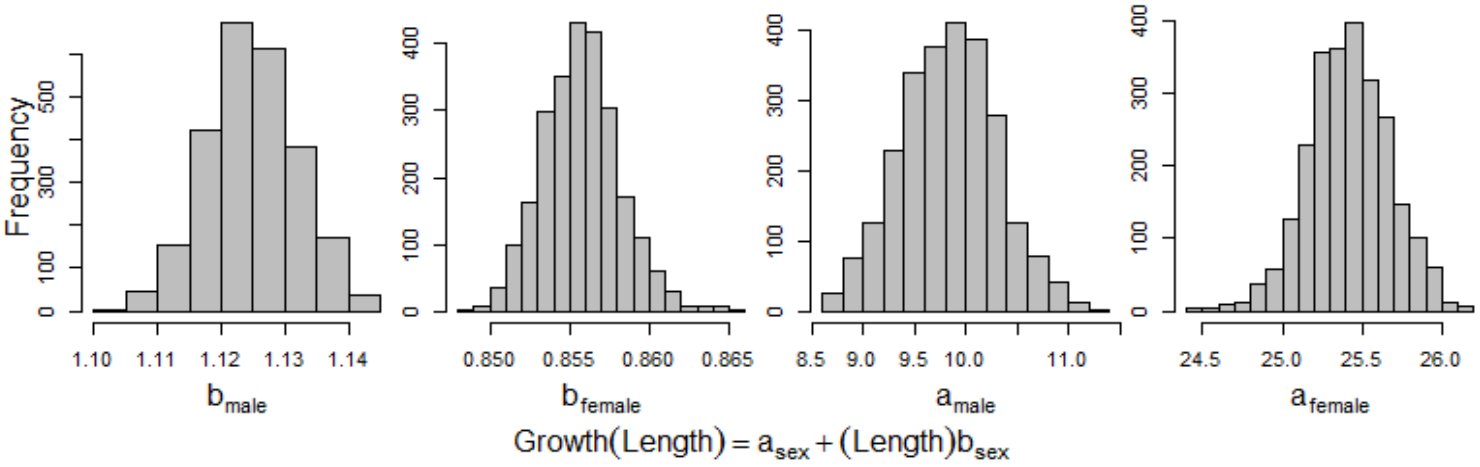
Growth

Mating

Recruitment

4/12 M

Estimated growth parameters



Female growth

(estimated)

Survey

3/12 M

Directed fishery

Trawl bycatch

5/12 M

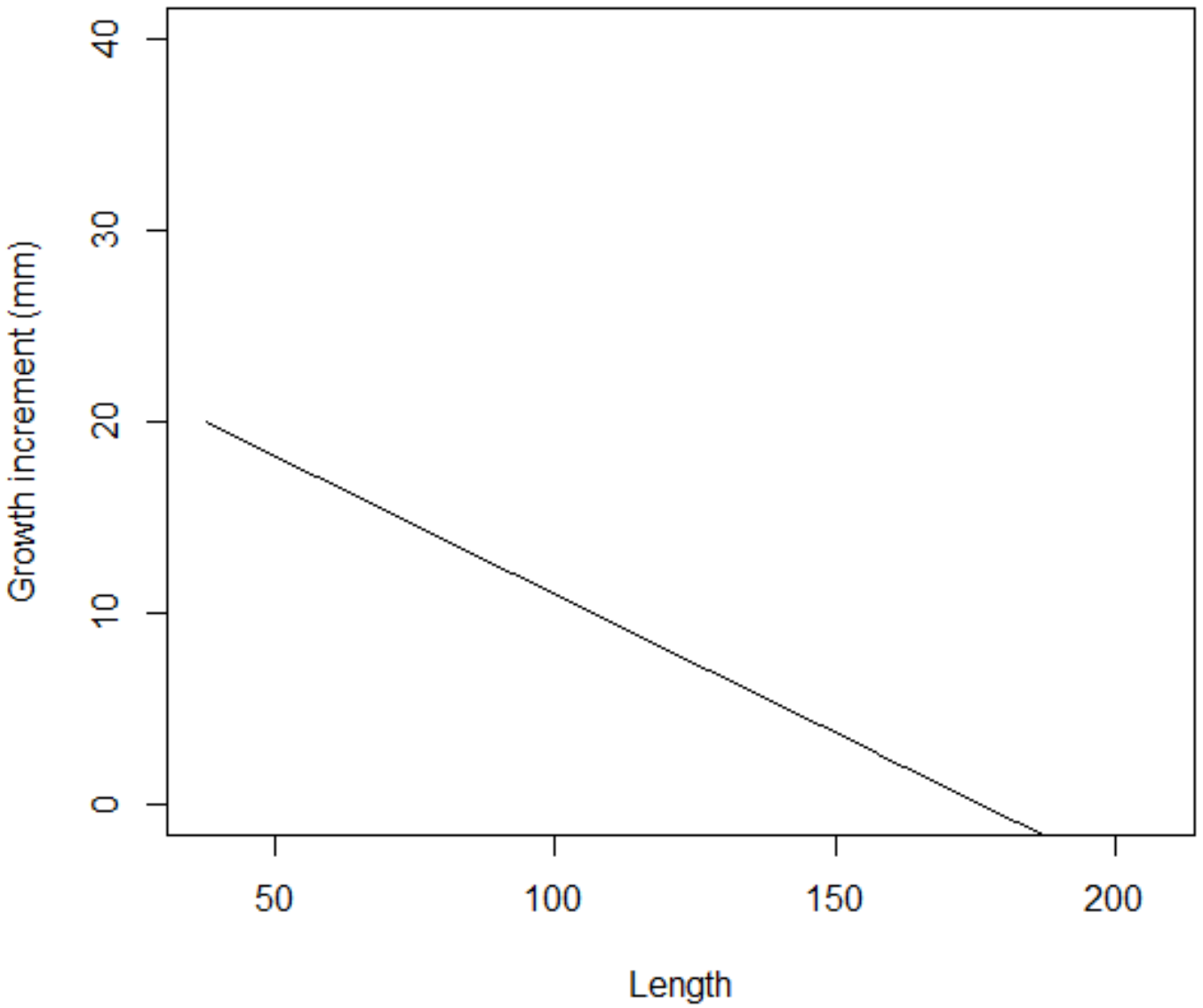
Molting

Growth

Mating

Recruitment

4/12 M



* Addressing May CPT comment

Survey

3/12 M

Directed fishery

Trawl bycatch

5/12 M

Molting

Growth

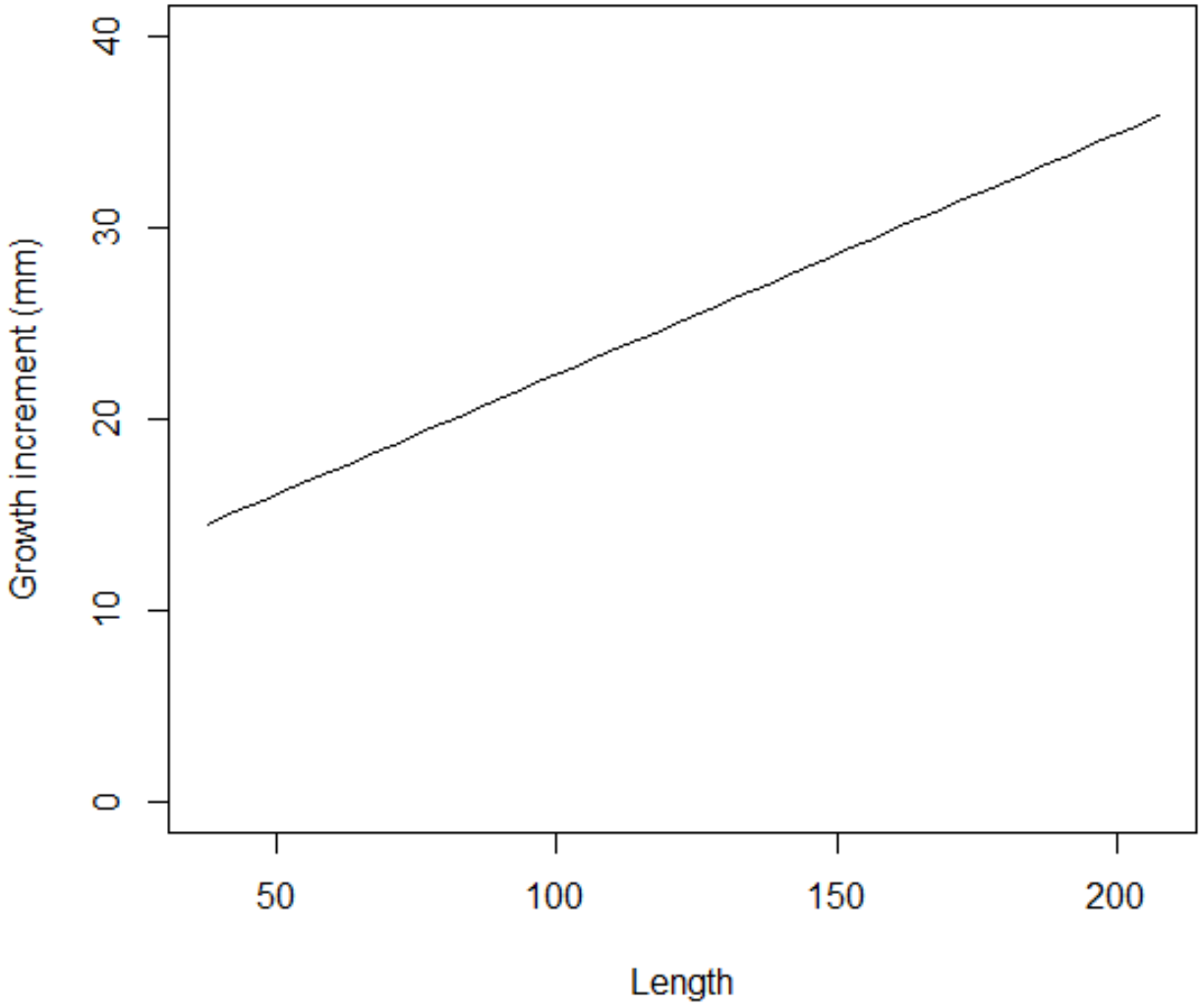
Mating

Recruitment

4/12 M

Male growth

(estimated)



* Addressing May CPT comment

Maturity

(fixed)

Survey

3/12 M

Directed fishery

Trawl bycatch

5/12 M

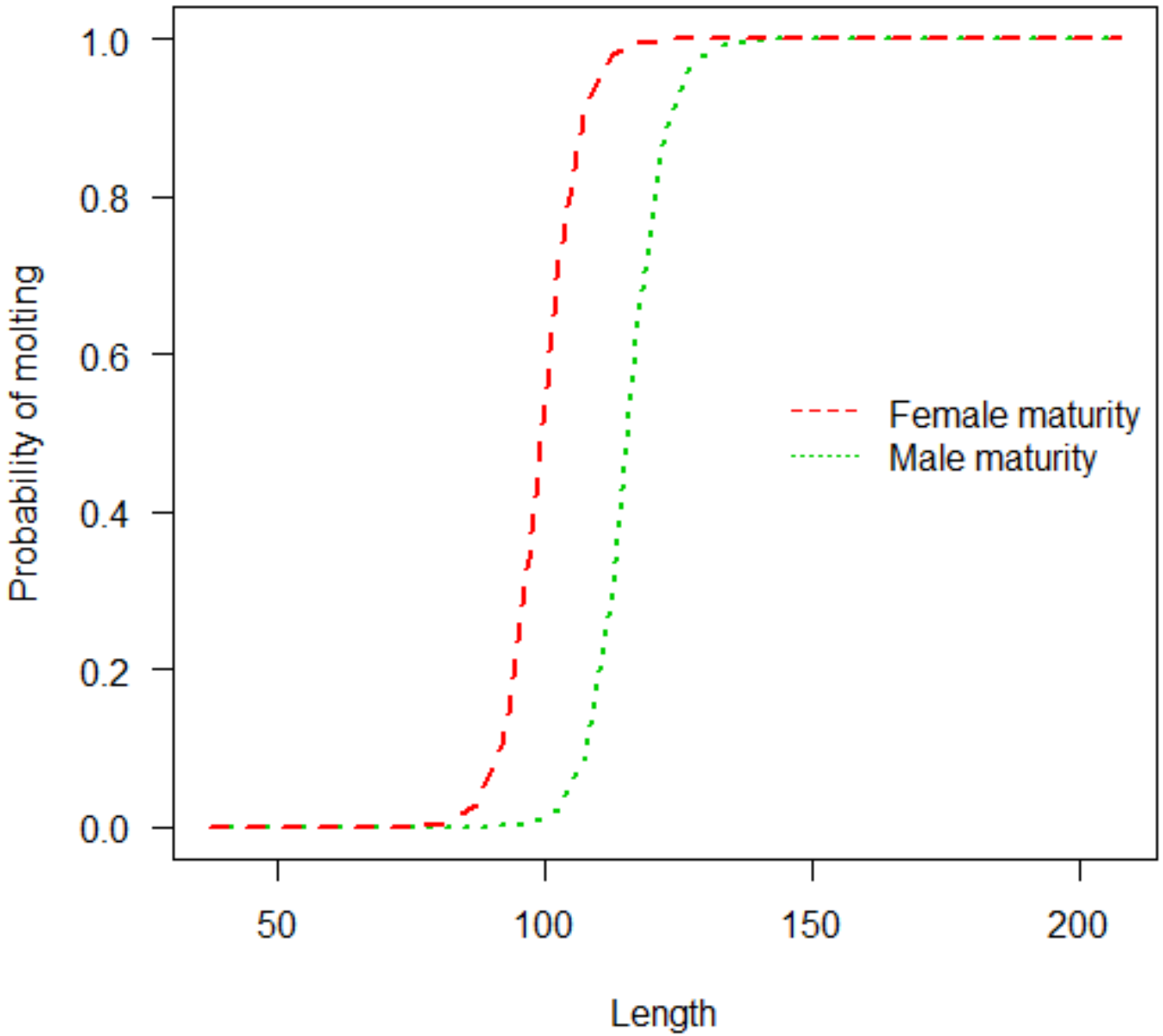
Molting

Growth

Mating

Recruitment

4/12 M



Survey

3/12 M

Directed fishery

Trawl bycatch

5/12 M

Molting

Growth

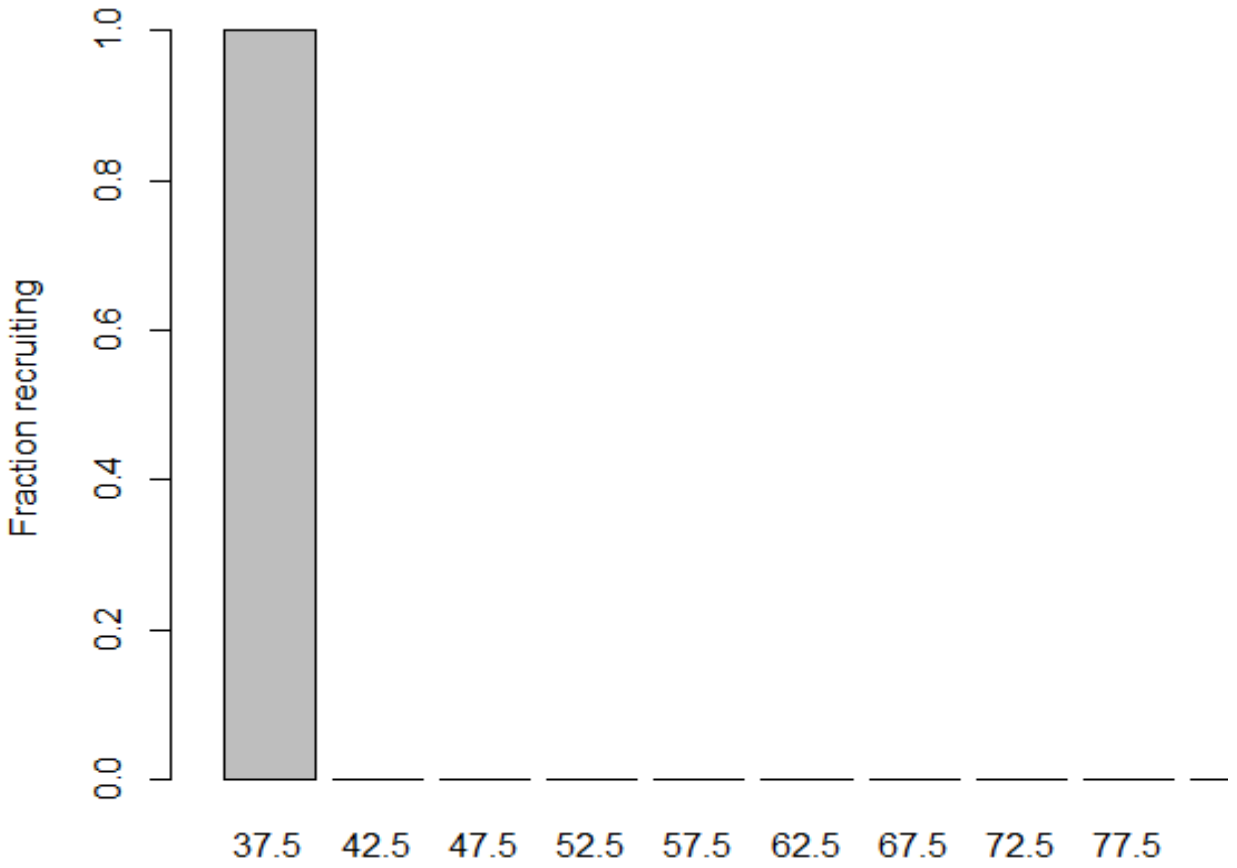
Mating

Recruitment

4/12 M

Fraction recruiting

(estimated)



* Addressing May CPT comment

Weighting

Likelihood

Sample size (γ) (18-200)

$$L_1 = \begin{cases} \sum_s \sum_y \sum_l -\gamma_y p^{obs}_{surv,l,y,s} \ln\left(p^{pred}_{surv,l,y,s} + \kappa\right) & if \;\; p^{obs}_{surv,l,y,s} \geq 0.01 \\ 0 & if \;\; p^{obs}_{surv,l,y,s} < 0.01 \end{cases}$$

CV (.36-1)

$$L_2 = \sum_y \frac{\left(\ln\left(N^{pred}_y + \kappa\right) - \ln\left(N^{obs}_y + \kappa\right)\right)^2}{\sqrt{\ln\left(CV_{y,surv}\right)^2 + 1}}$$

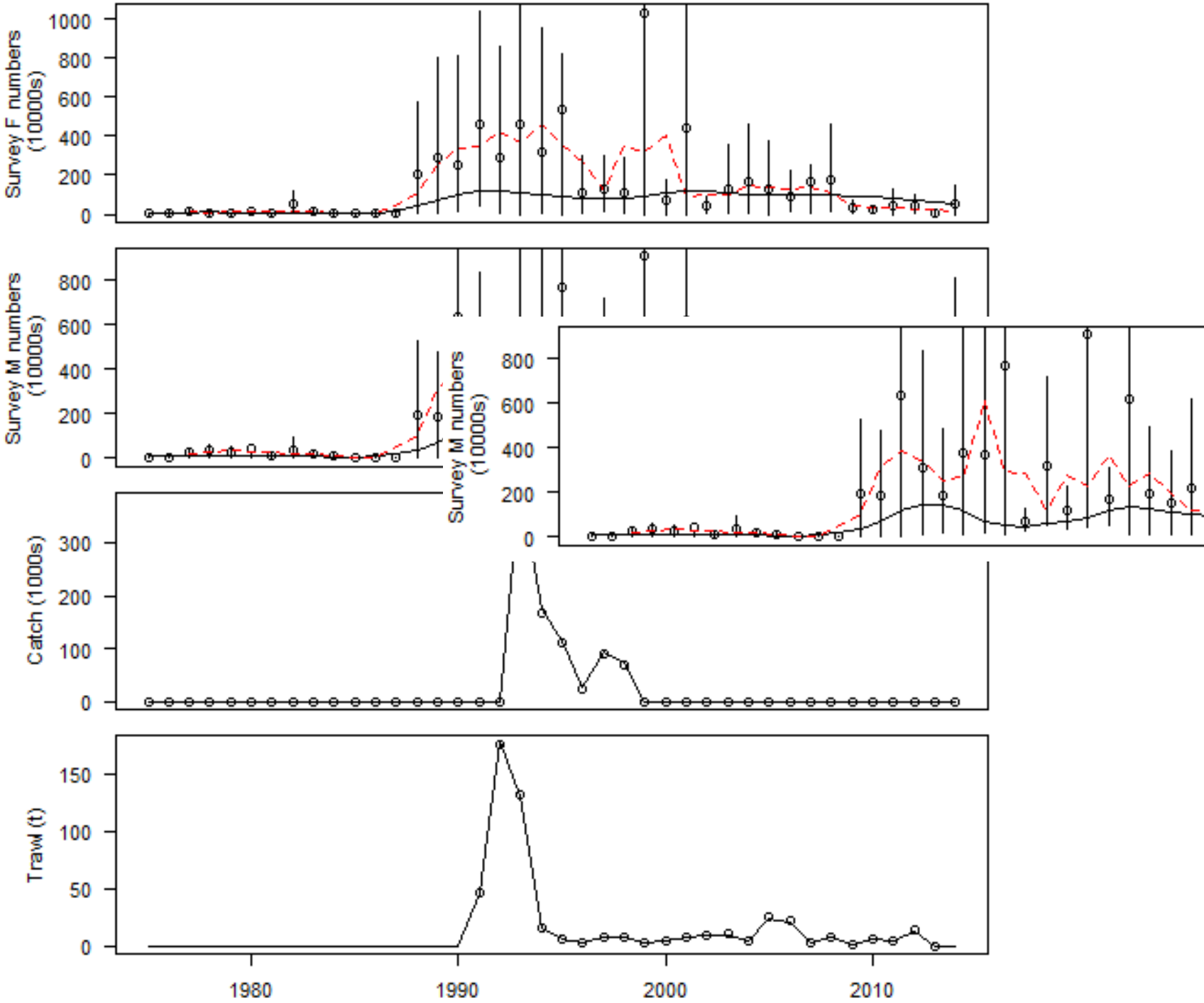
CV (0.005)

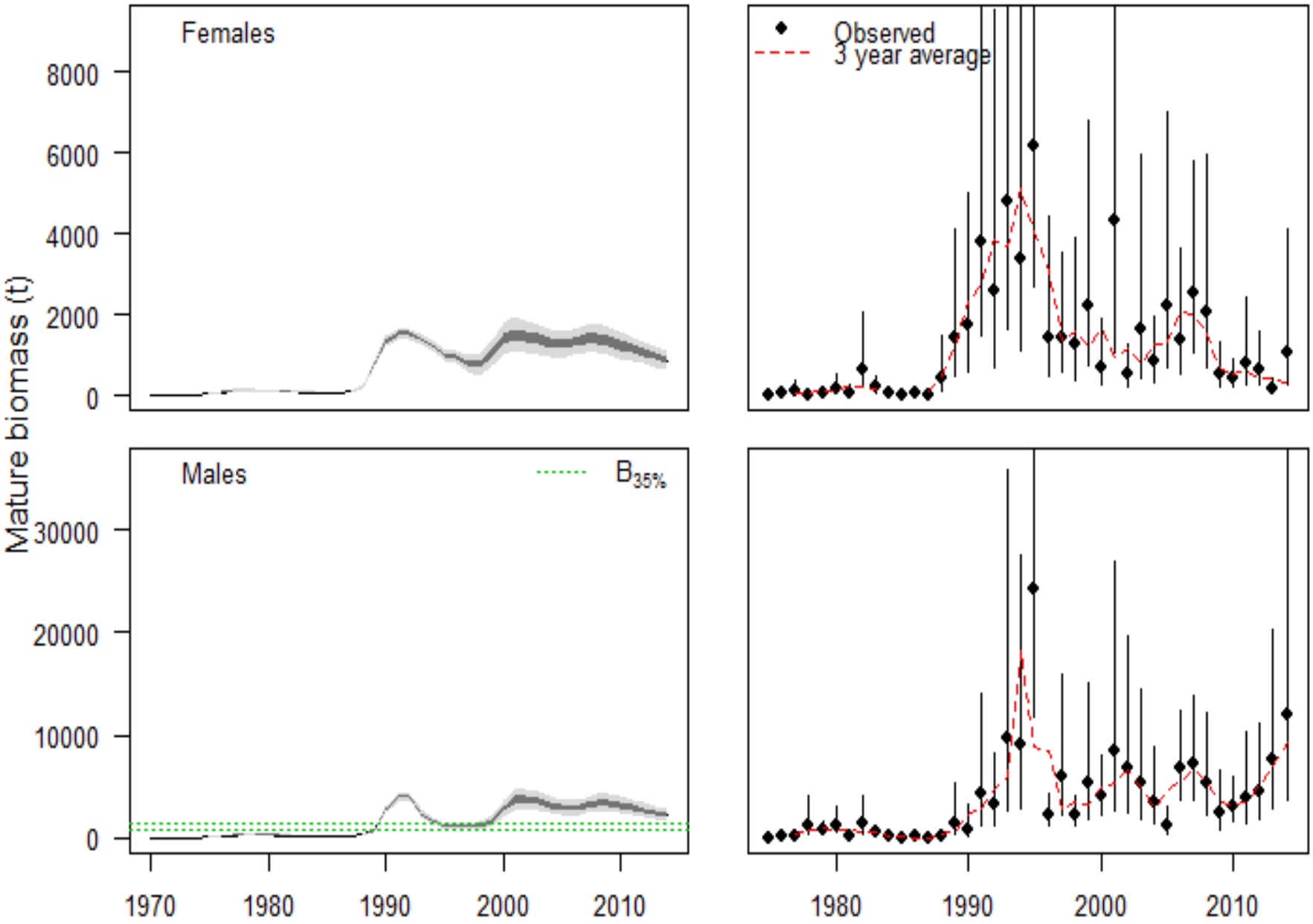
$$L_3 = \sum_y \frac{\left(\ln\left(C^{pred}_{y,dir} + \kappa\right) - \ln\left(C^{obs}_{y,dir} + \kappa\right)\right)^2}{\sqrt{\ln\left(CV_{y,dir}\right)^2 + 1}}$$

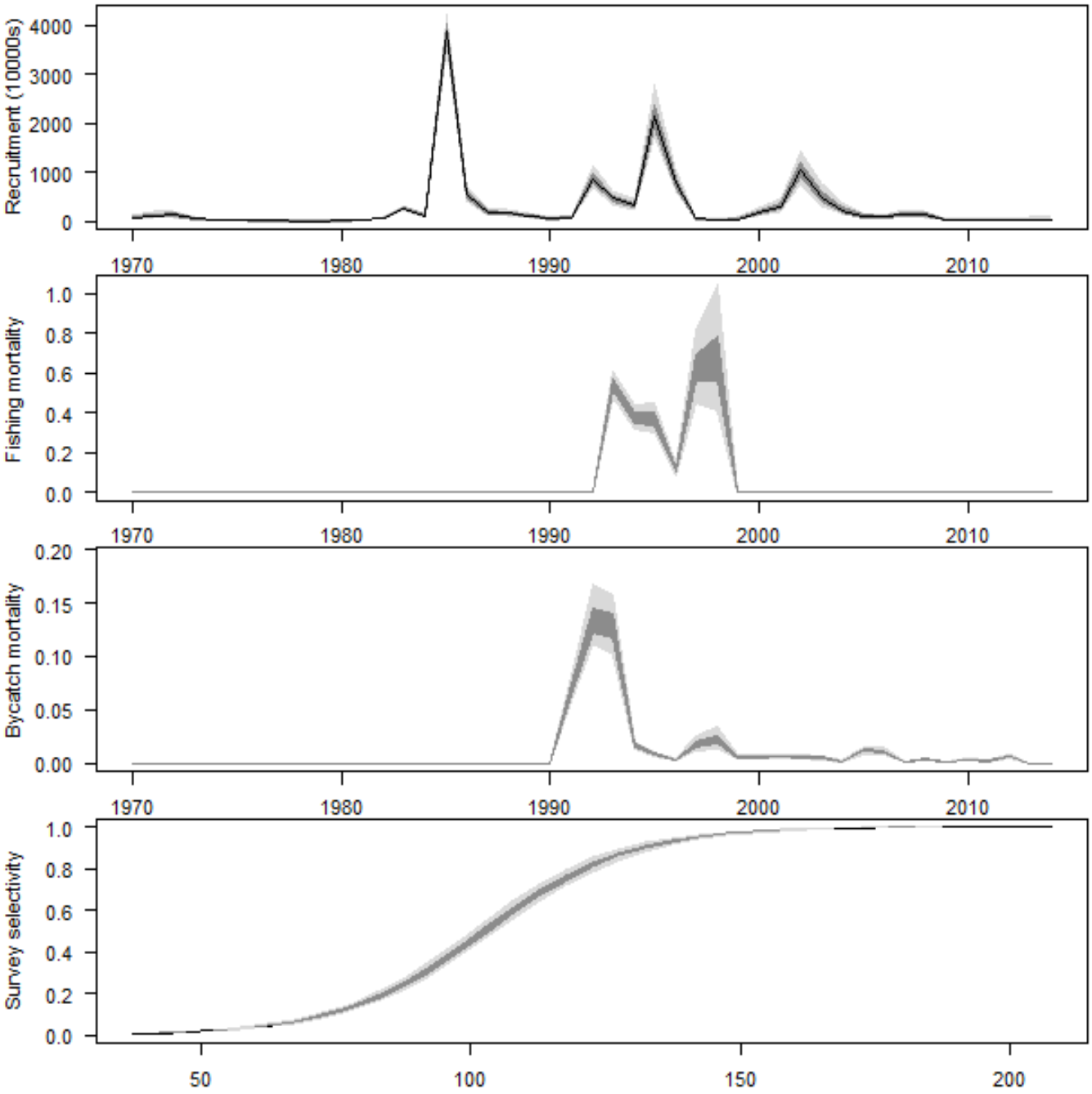
CV (0.05)

$$L_3 = \sum_y \frac{\left(\ln\left(C^{pred}_{y,trawl} + \kappa\right) - \ln\left(C^{obs}_{y,trawl} + \kappa\right)\right)^2}{\sqrt{\ln\left(CV_{y,trawl}\right)^2 + 1}}$$

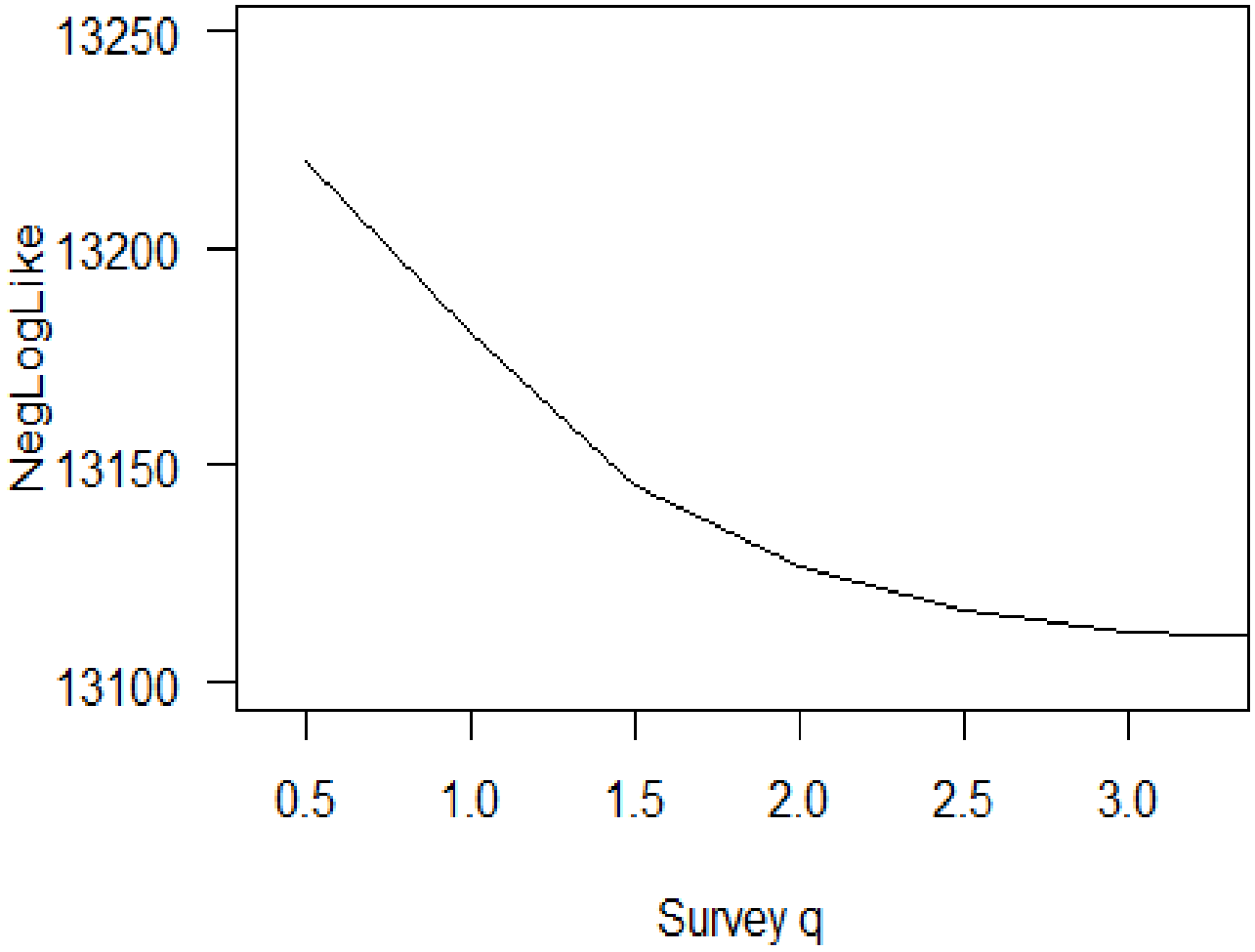
* Addressing May CPT comment


Survey F numbers (10000s)
0
200
400
600
800
1000
Survey M numbers (10000s)
0
200
400
600
800
Survey M numbers (10000s)
0
200
400
600
800
Catch (1000s)
0
100
200
300
Trawl (t)
0
50
100
150
1980
1990
2000
2010


Females
Males
$B_{35\%}$
Observed
3 year average
Mature biomass (t)
0
2000
4000
6000
8000
10000
20000
30000
1970
1980
1990
2000
2010

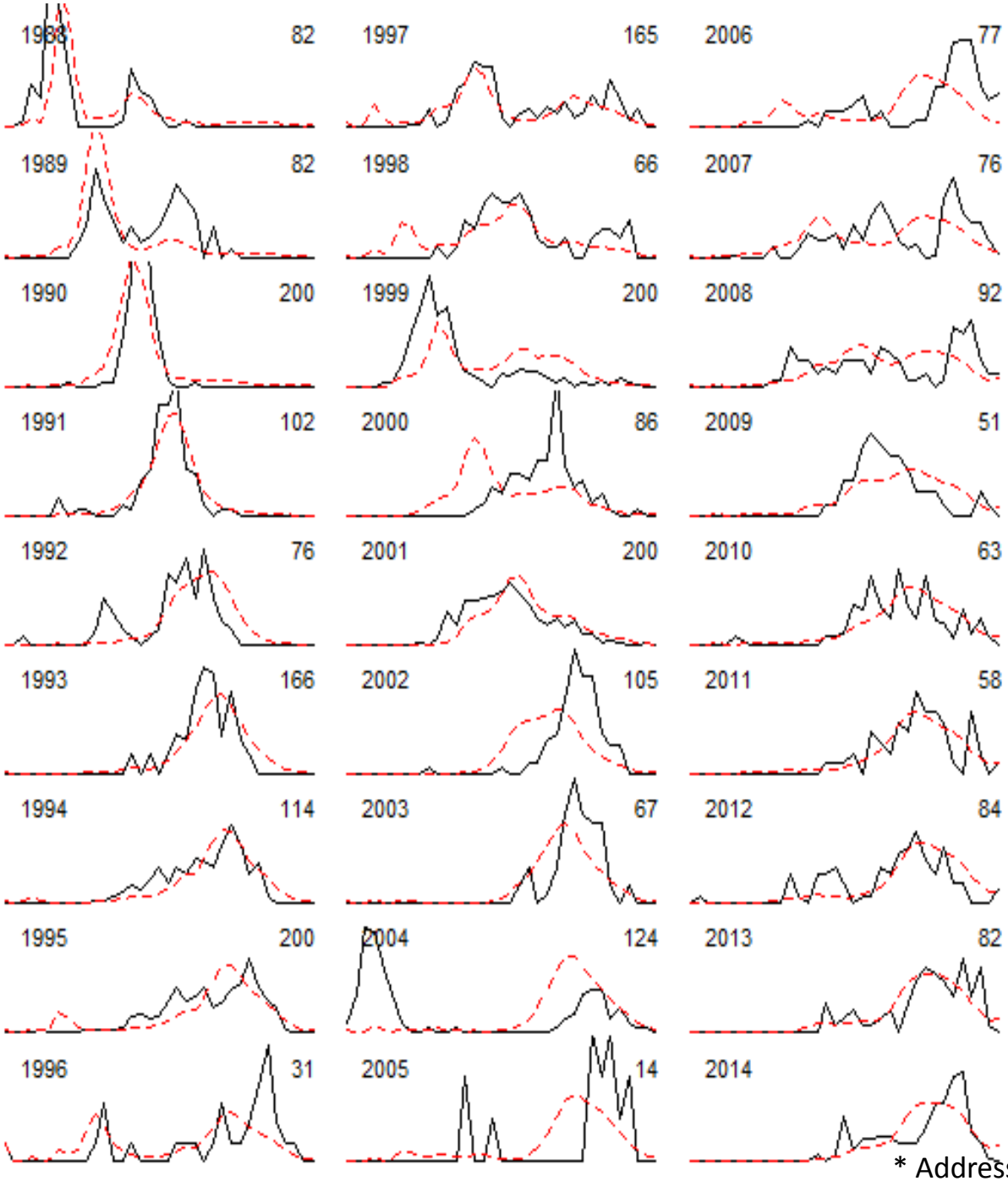

Recruitment (10000s)
0
1000
2000
3000
4000
1970
1980
1990
2000
2010
Fishing mortality
0.0
0.2
0.4
0.6
0.8
1.0
1970
1980
1990
2000
2010
Bycatch mortality
0.00
0.05
0.10
0.15
0.20
1970
1980
1990
2000
2010
Survey selectivity
0.0
0.2
0.4
0.6
0.8
1.0
50
100
150
200

Survey catchability likelihood profile



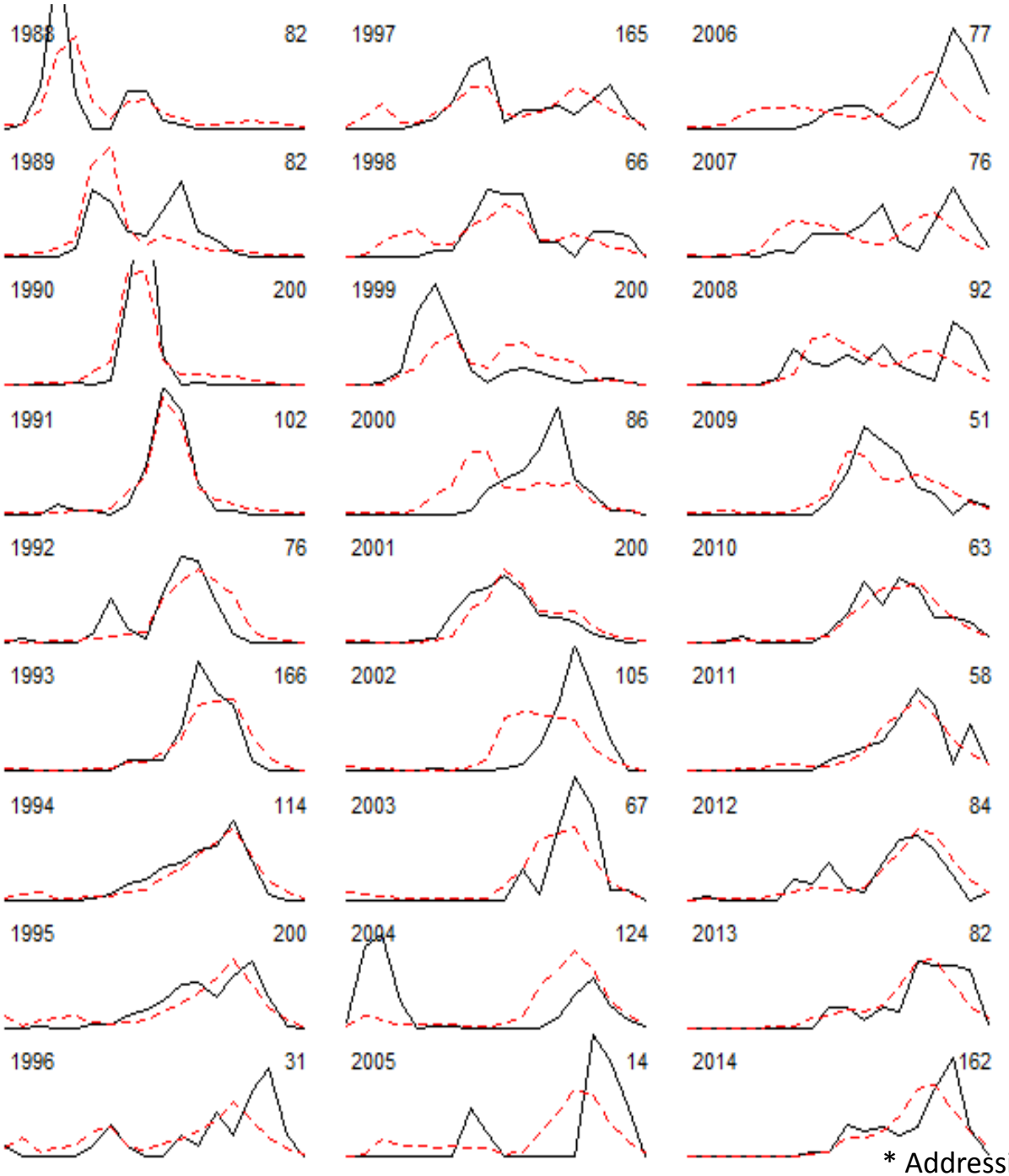
* Addressing May CPT comment

Males (5mm)



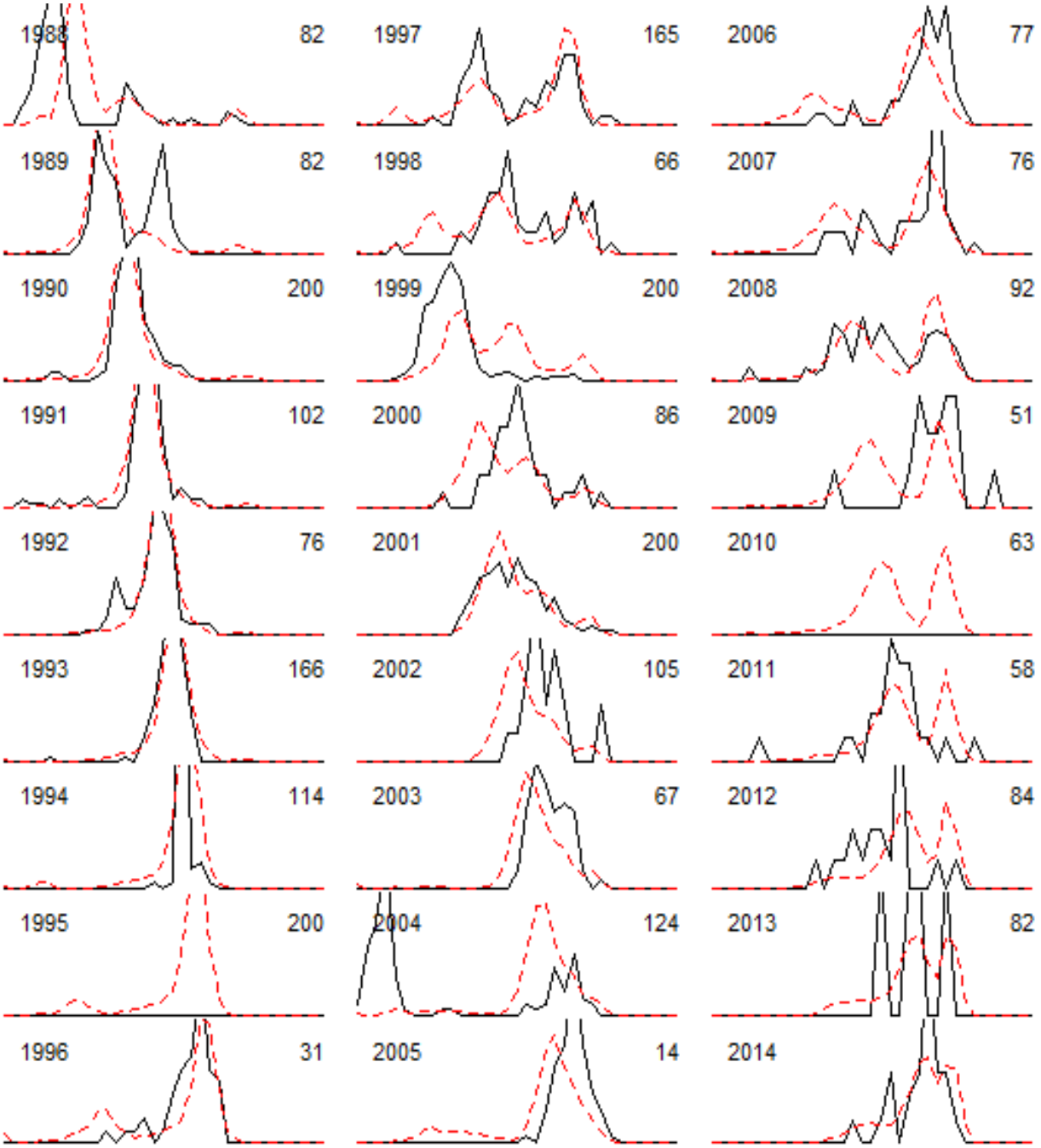
* Addressing May CPT comment

Males (10mm)



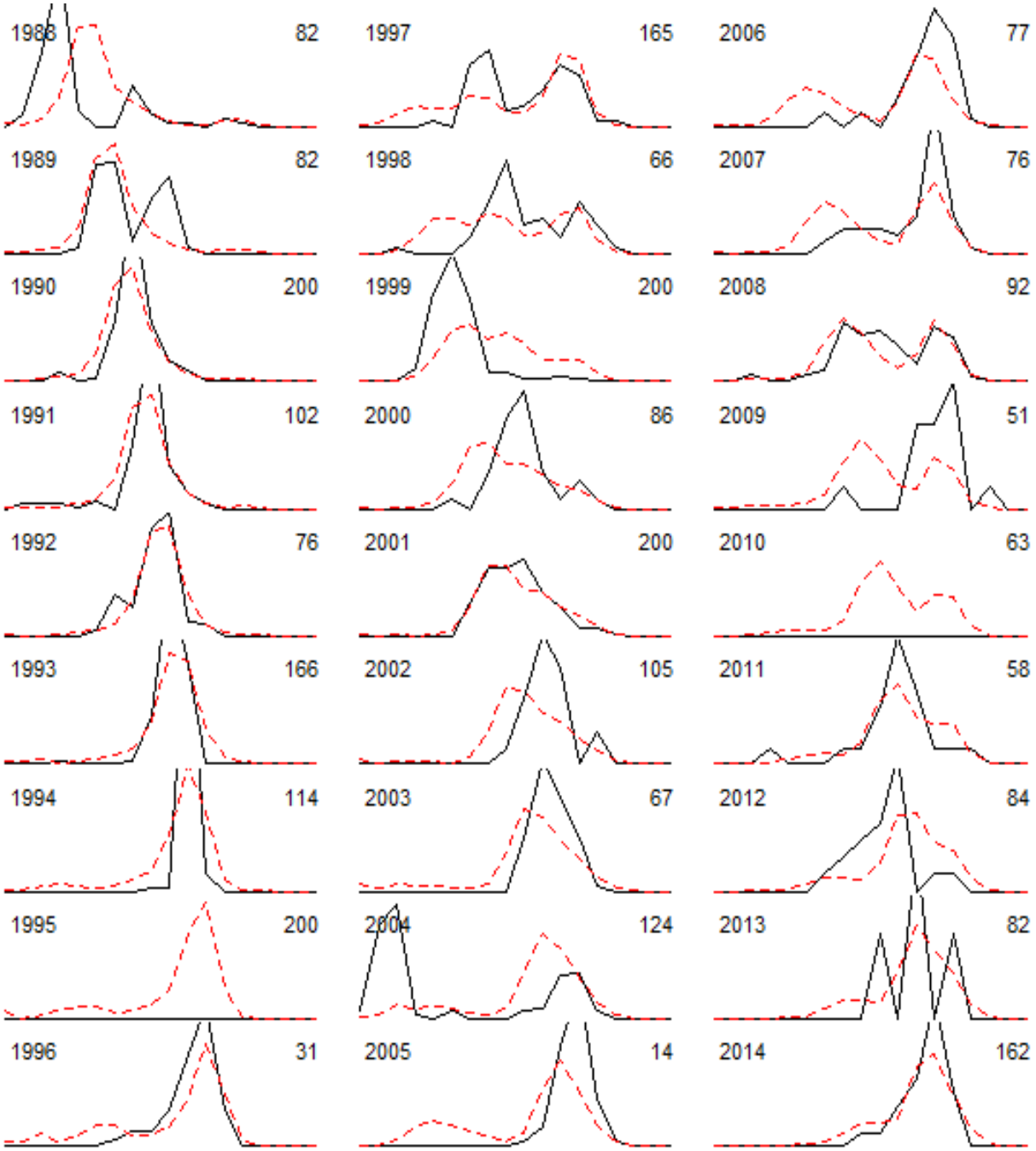
* Addressing May CPT comment

Females (5mm)



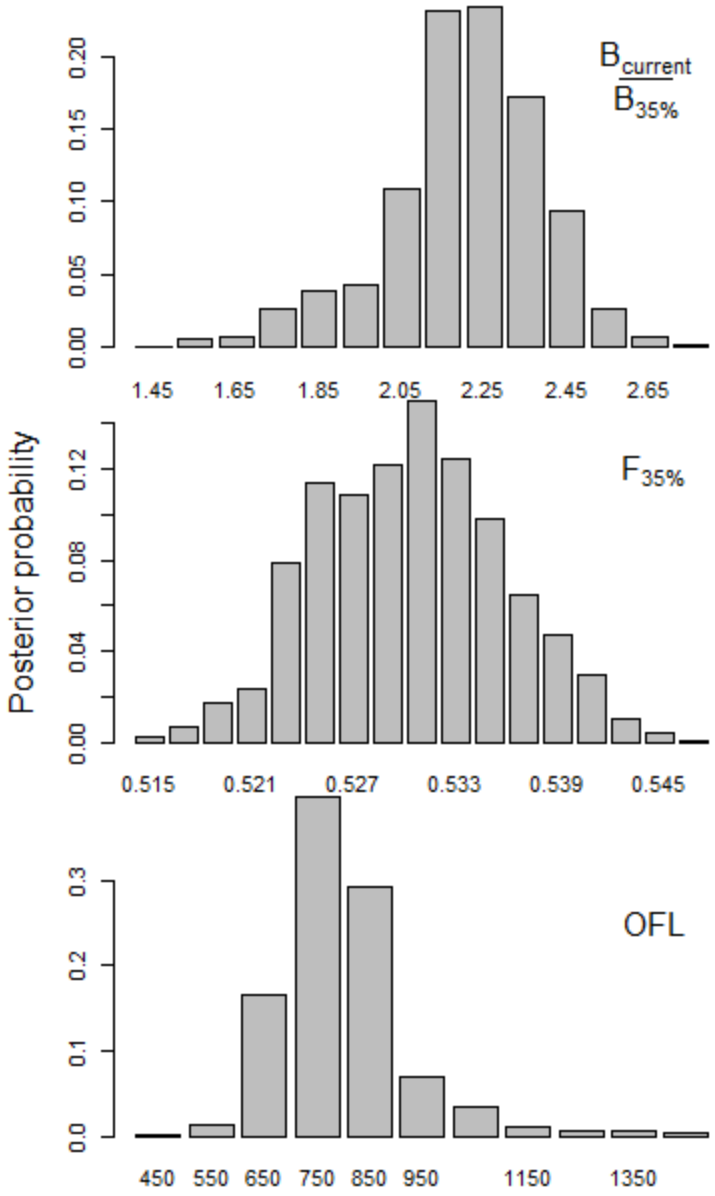
* Addressing May CPT comment

Females (10mm)

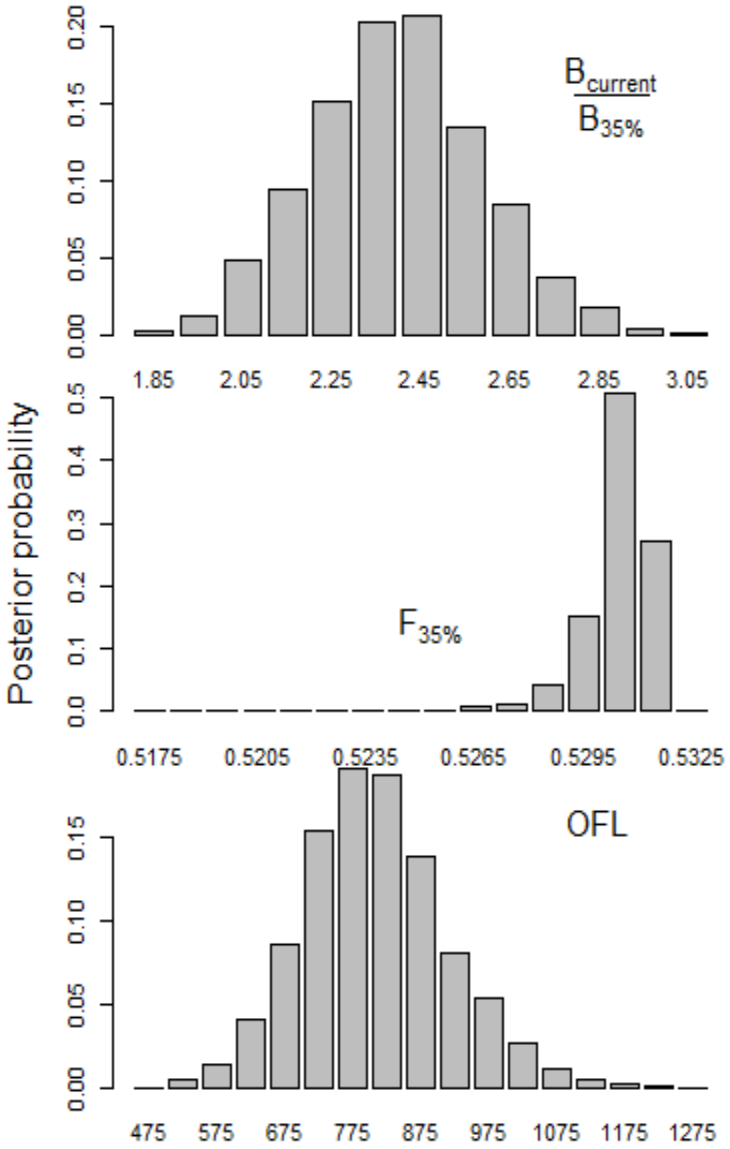


* Addressing May CPT comment

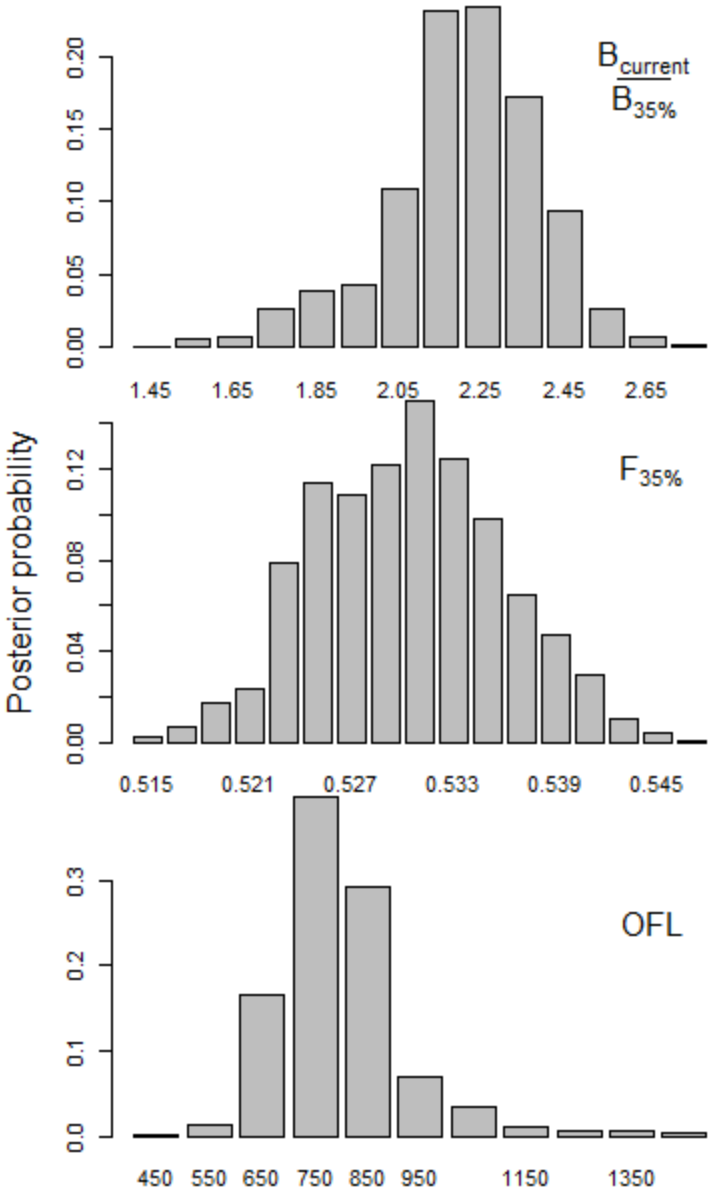
5mm; growth estimated



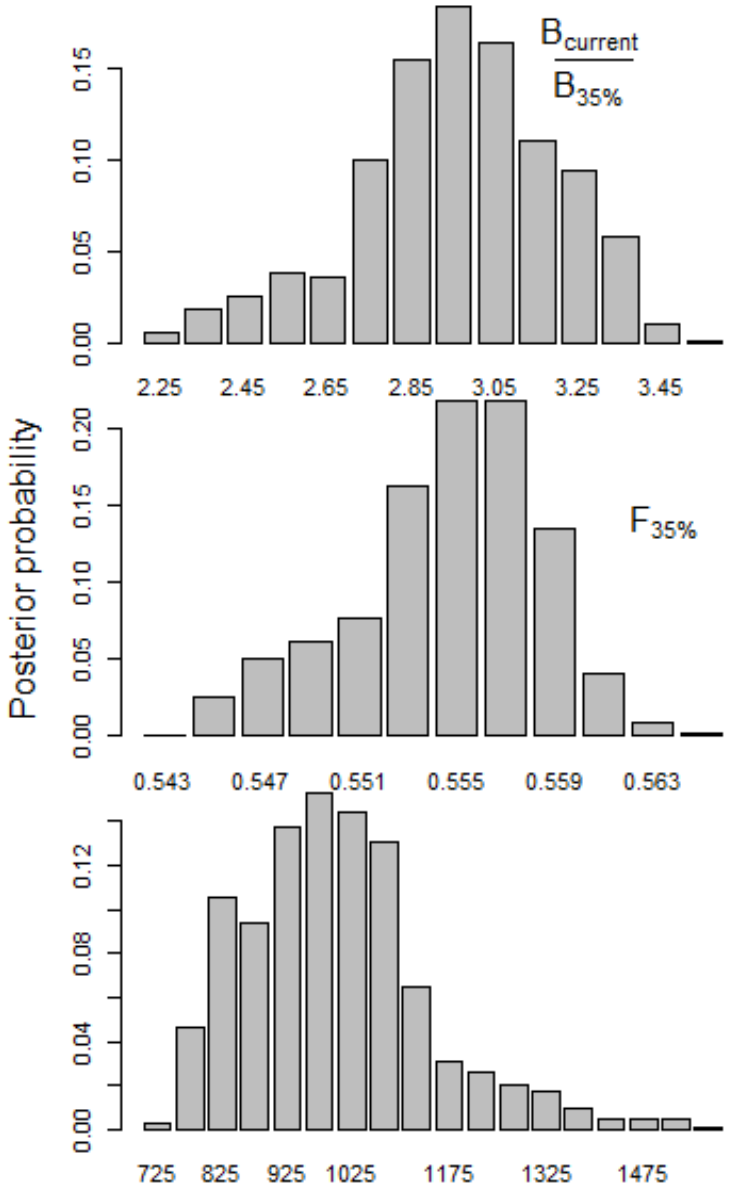
5mm; growth fixed



5mm; growth estimated

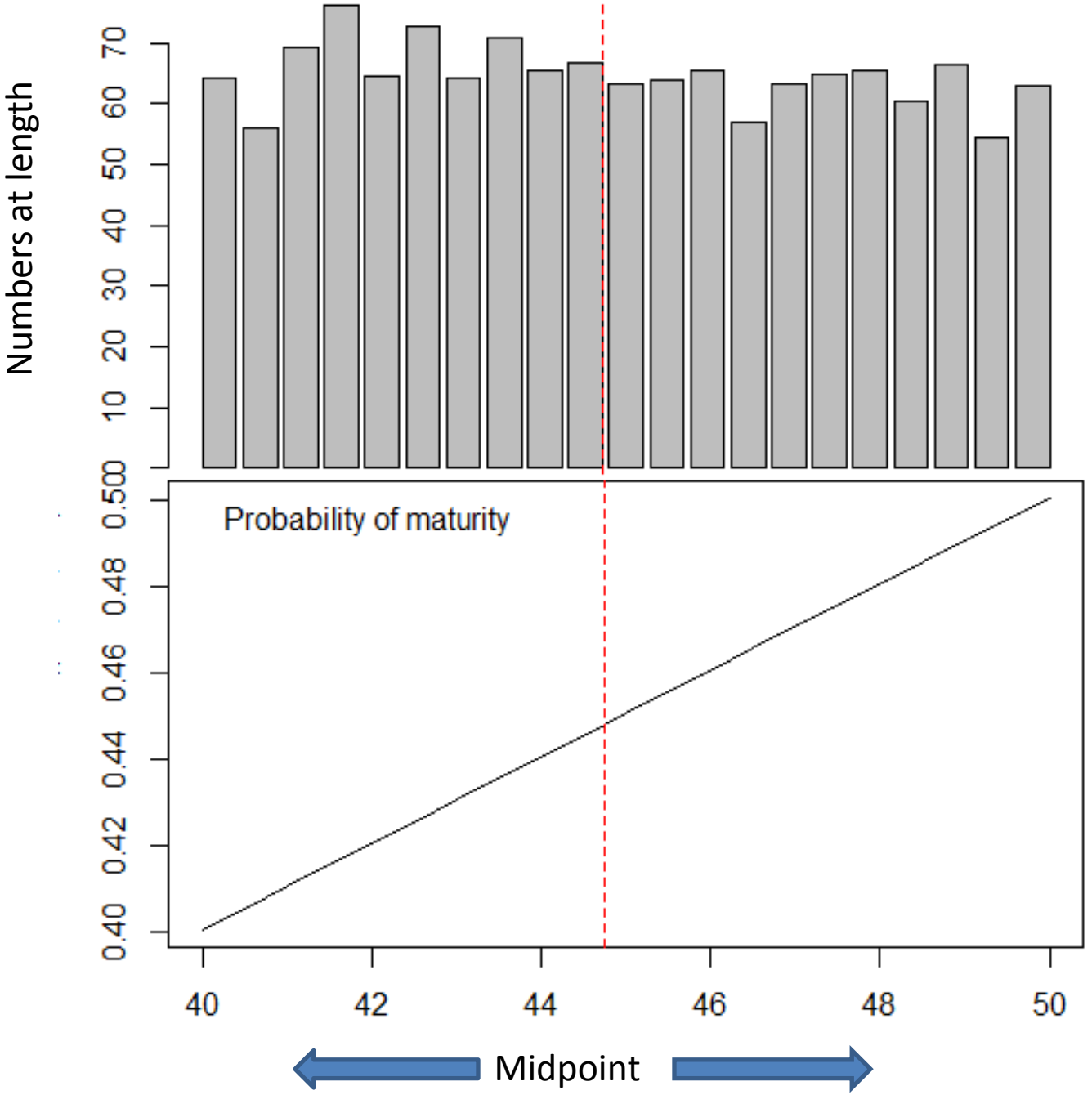


10mm; growth estimated

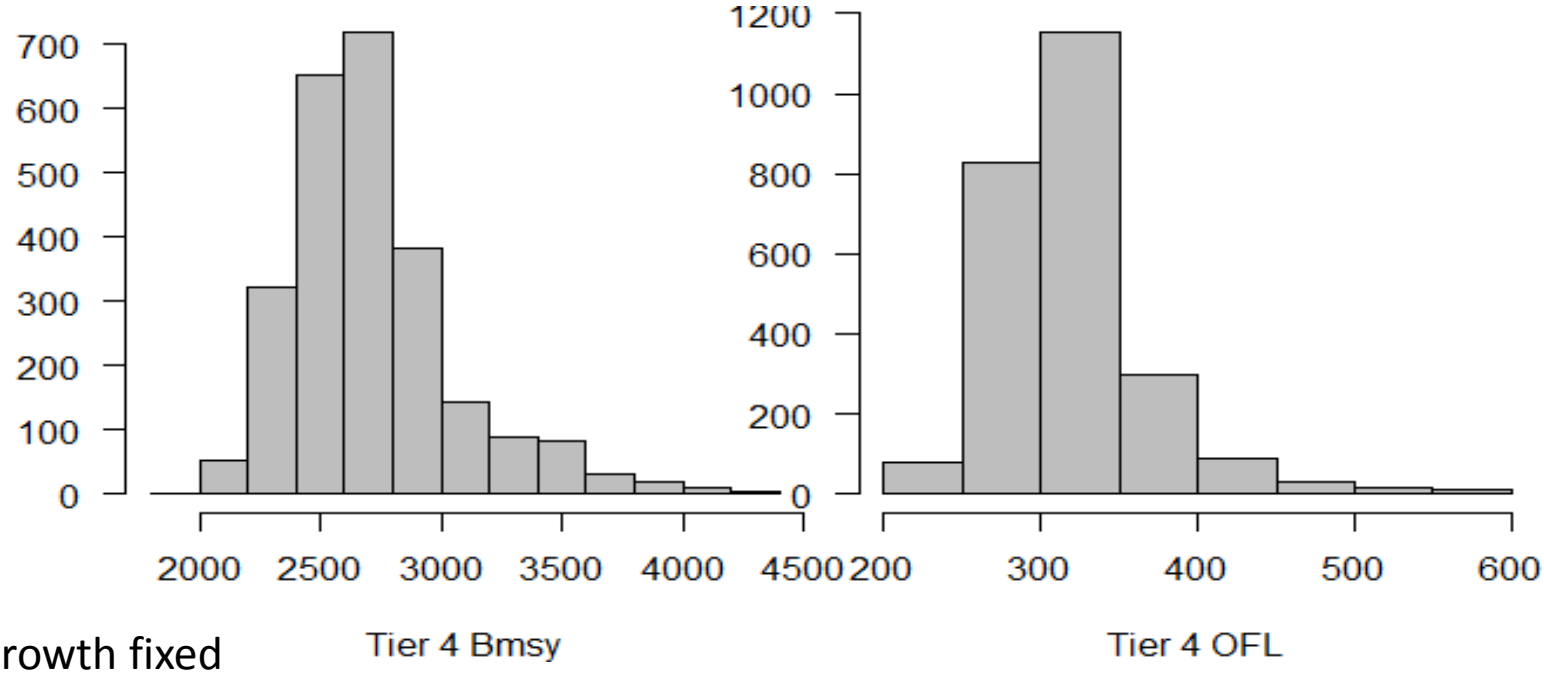


	5mm	10mm
b35	1034	952
MMB	2239	2588
OFL	801	948

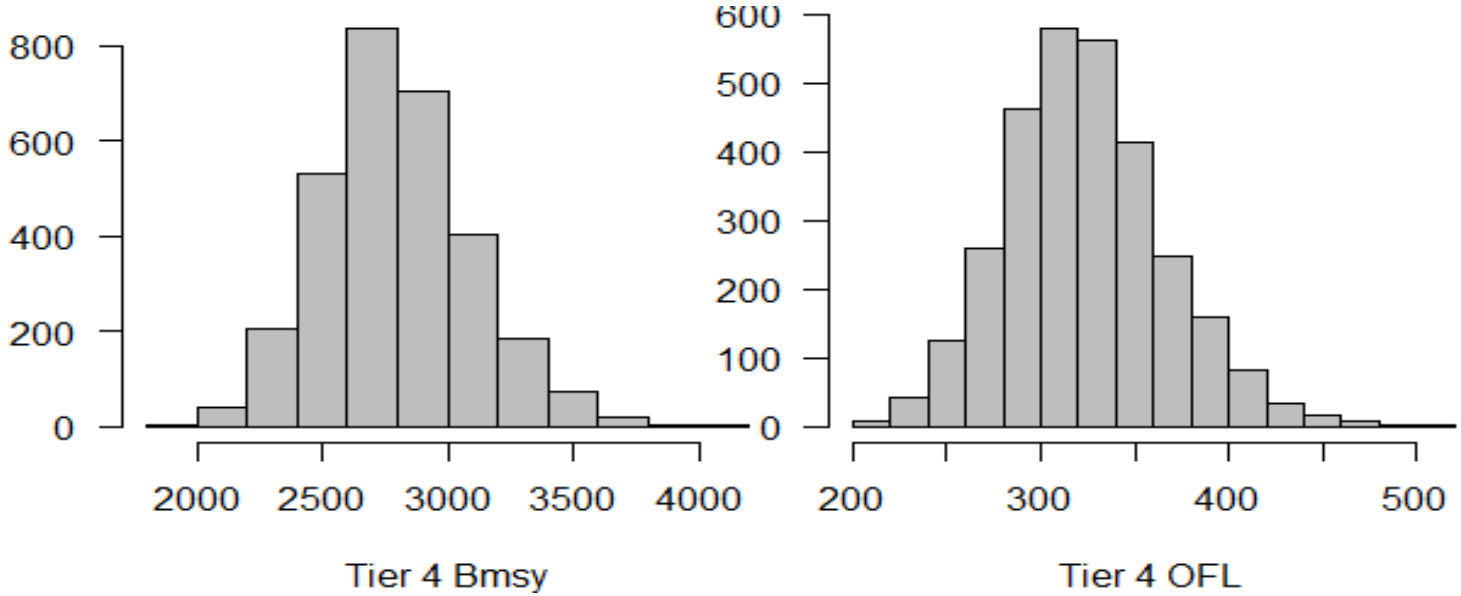
* Addressing May CPT comment

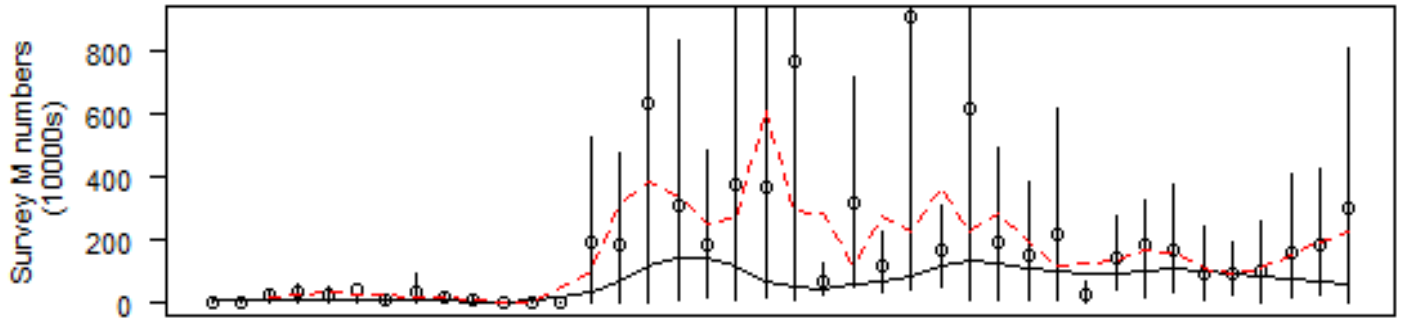

Numbers at length
10
20
30
40
50
60
70
Probability of maturity
0.40
0.42
0.44
0.46
0.48
0.500
40
42
44
46
48
50
Midpoint

5mm; growth estimated



5mm; growth fixed





Tier	Assessment Method	OFL	B_{MSY}	Cur. MMB	B/B_{MSY} (MMB)	γ	Years to define B_{MSY}	F_{MSY}	P*	ABC
4	Running Average	1359	5742	8894	1.55	1.0	1991/1992-2013/2014 (MMB)	0.18	0.49	1338
3	Integrated assessment	801	1034	2239	2.16	1.0	1983-present (recruitment)	0.53	0.49	771
4	Integrated assessment	320	2754	2239	0.81	1.0	1991/1992-2013/2014 (MMB)	0.18	0.49	311

May CPT to do list

- *Add likelihood profile for survey catchability* ✓
- *Initialize the model before the first year of data to reduce the number of parameters used* ✓
- *Consider a more generalized growth model* ✓
- *Do not calculate likelihood contributions for length-bins with very low frequency (~0)* ✓
- *Explore sensitivities to the size of length bin* ✓
- *Include lognormal confidence intervals for the survey estimates of numbers and biomass* ✓
- *Consider ADFG pot survey data and retained catch size frequency data* X
- *Include more detail on the model* ✓

Future issues

- Molting probability, growth, and M
- Bin sizes/midpoints
- Environmental influence on recruitment
- Markdown, github, GMACS?