

Norton Sound Red King Crab SAFE2018

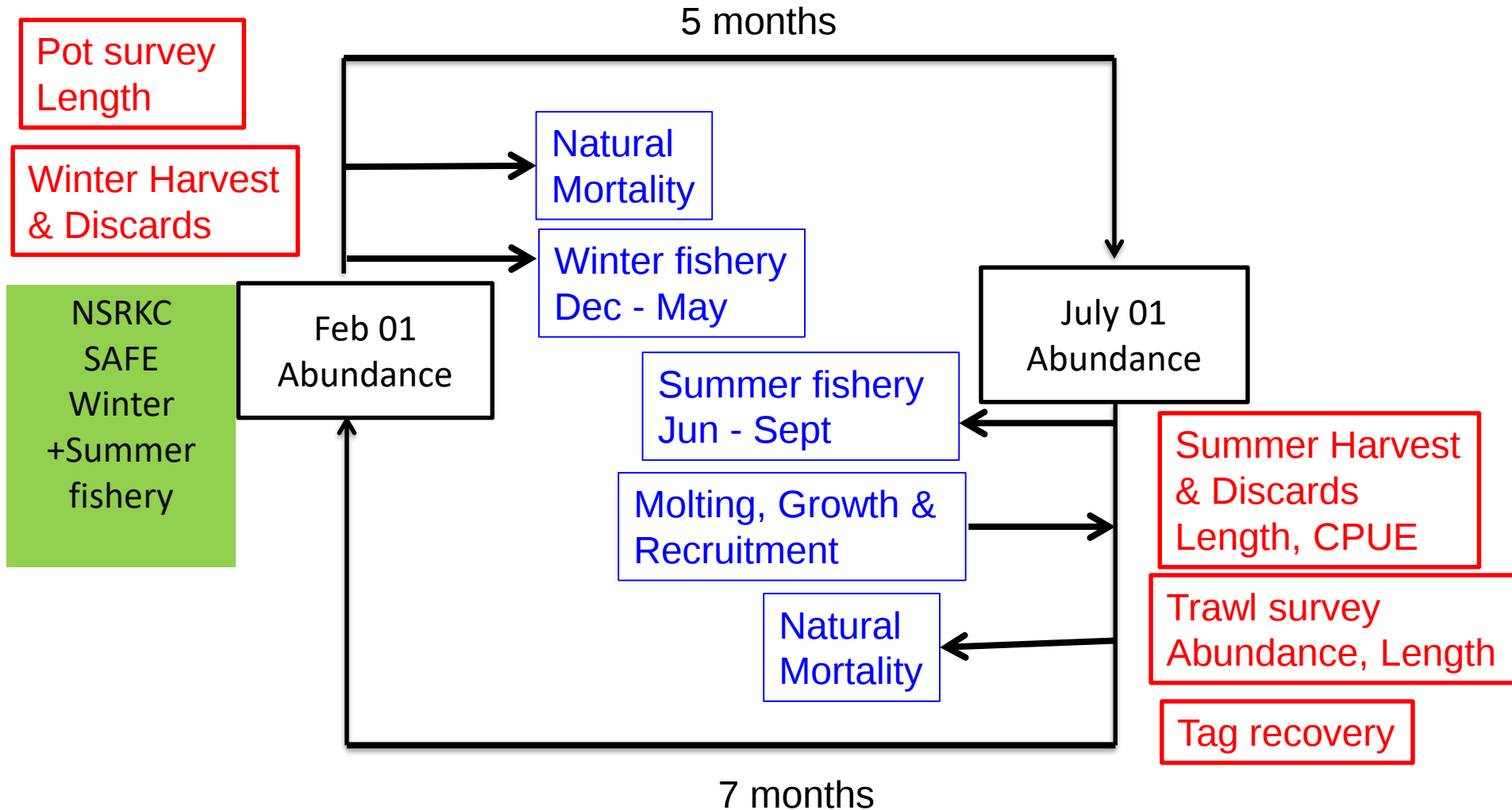
Jan 09 2018

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Jie Zheng
Alaska Department of Fish & Game
Division of Commercial Fisheries

NSRKC Stock Assessment Model

Modeling process

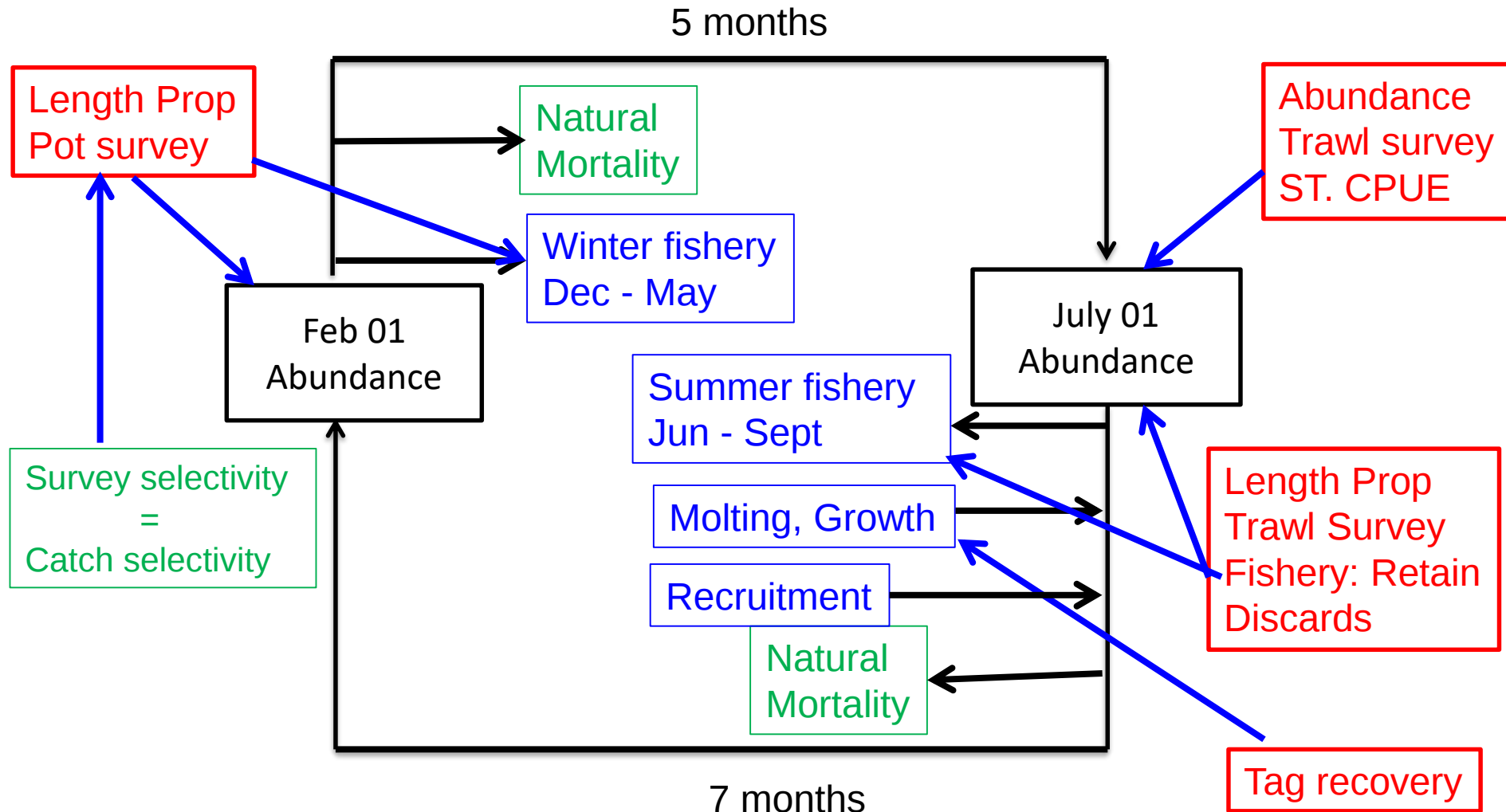
Available Data & model fit



NSRKC Stock Assessment Model

Modeling process

Available Data & model fit



Available Data

[illegible]

Assumptions

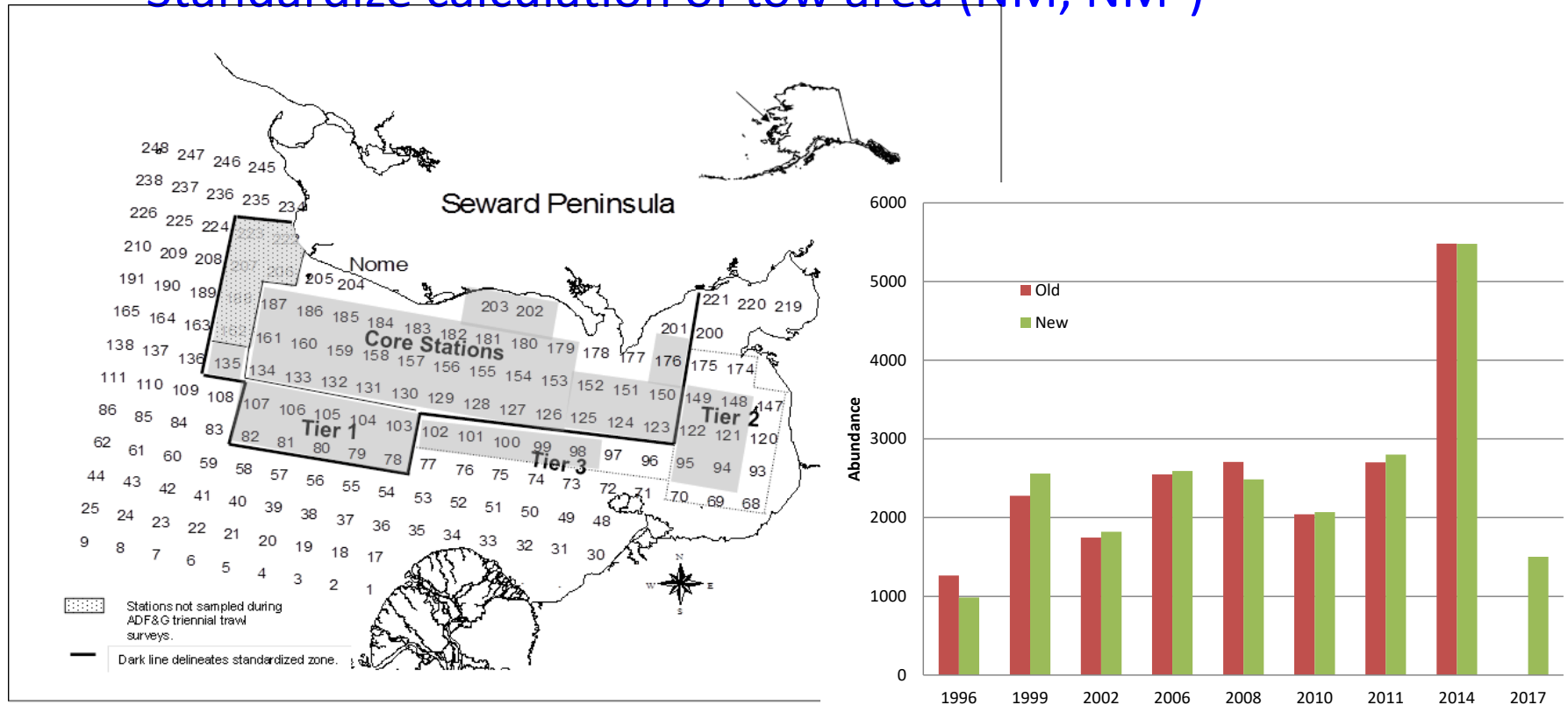
- $M = 0.18$ for length class 1-6, higher mortality of classes 7 and 8
- Same selectivity and catchability for New and Old Shells
- Discards mortality = 0.2
- Fishery harvests occur instantly:
 - Winter fishery: Feb 01: Nov – May
 - Summer fishery: July 01: Jun – Sept
- Winter catch selectivity = winter pot survey selectivity

Changes Fishery & Data

- Winter fishery 2017
 - Commercial: 26,008 (77,843 lb.) The highest ever.
 - Subsistence: 6,039 (15,097 lb.). About average.
- Summer commercial fishery 2017
 - 6/26-7/25: 135,322 (411,736 lb.)
- Total retained harvest: 167,369 (0.50 mill. lb.) < ABC (0.54 mill. lb.)
- All harvest data finalized.
- Standardized CPUE update (Appendix B)
- ADF&G 2017 trawl survey
 - 7/28-8/08: 1762.1 k, CV =0.22
- NOAA 2017 trawl survey :
 - 8/18-8/29: 1035.8 k, CV = 0.40
- Recalculation ADFG trawl survey abundance
- Changes in fishery regulation: None

Changes Fishery & Data

- Recalculation of ADFG trawl abundance update
 - Standardize survey stations
 - Assume zero crab in unsurveyed stations (All unmonitored stations are corners) (See Appendix E).
 - Remove re-towed survey data (original: take average)
 - Standardize calculation of tow area (NM, NM²)



1996

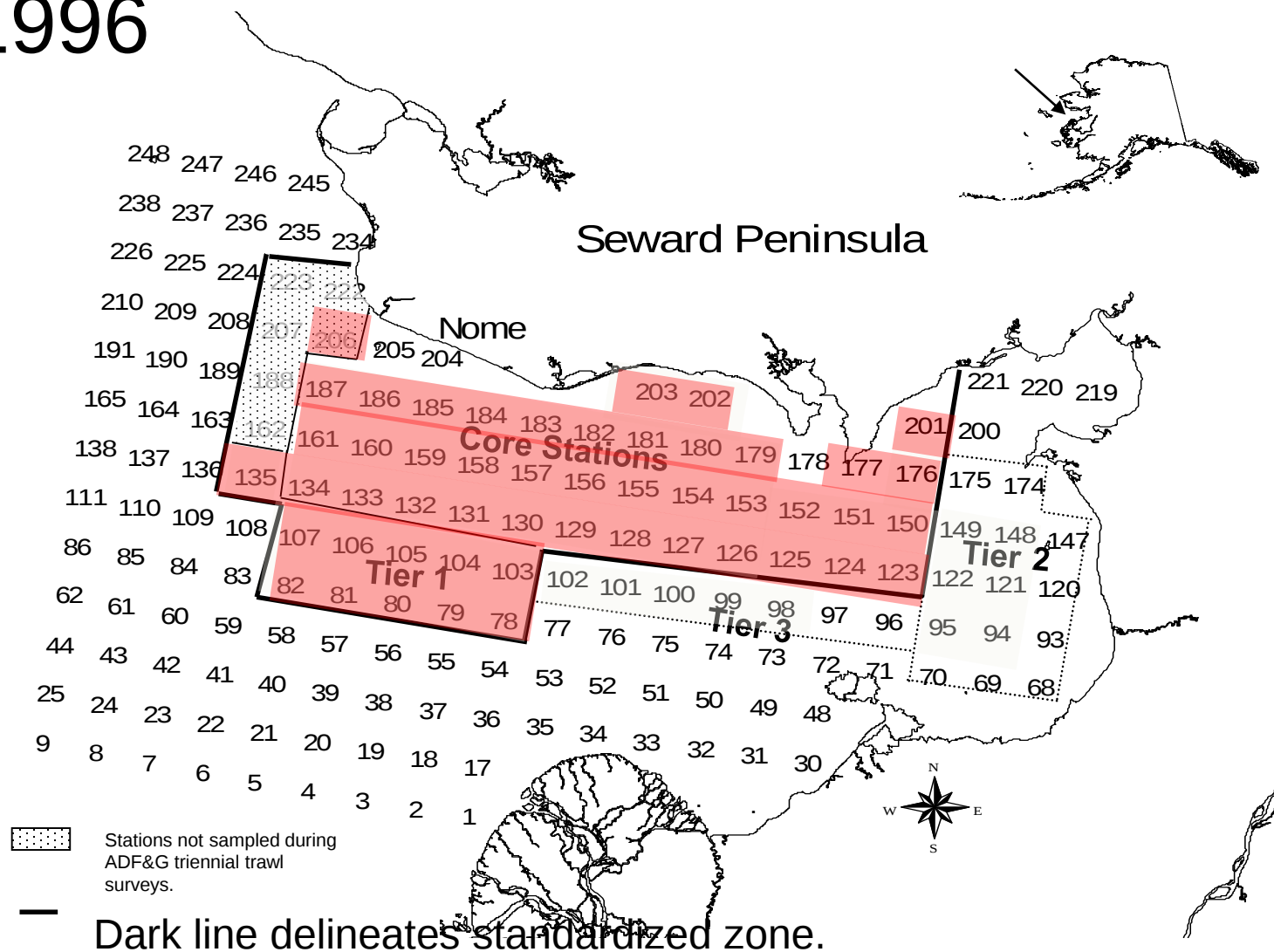


Figure 2- Station Map

1999

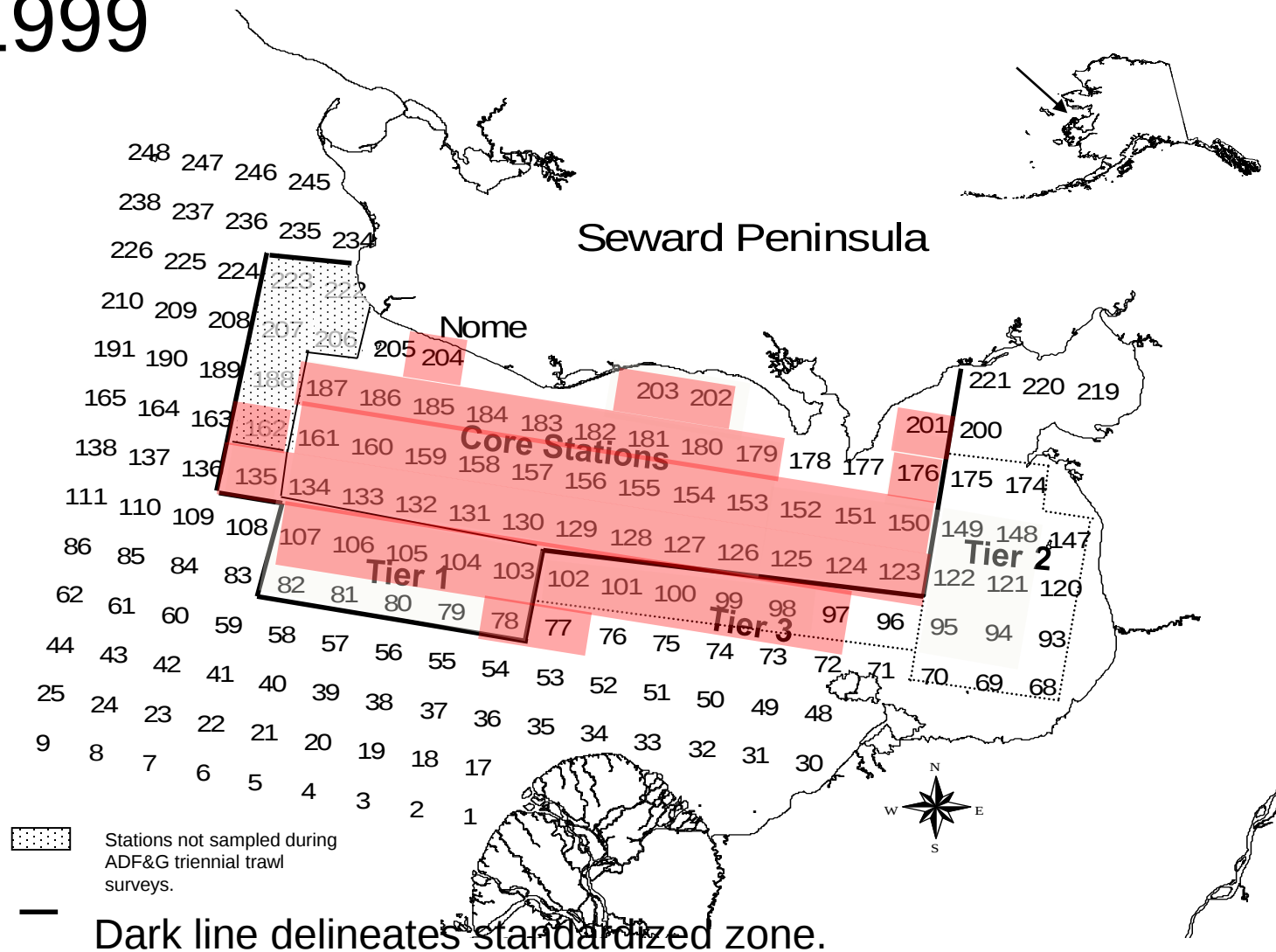


Figure 2- Station Map

2002

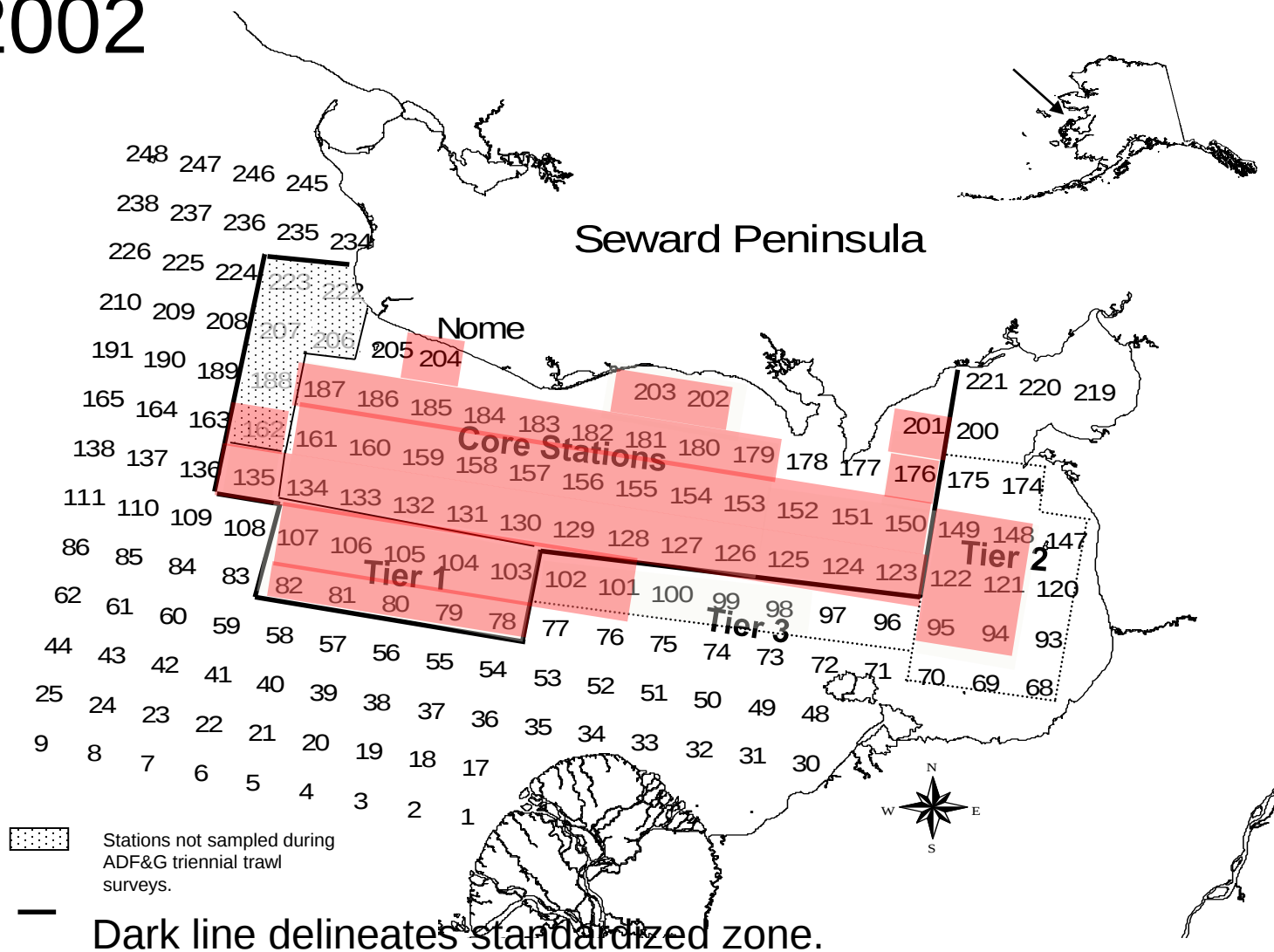


Figure 2- Station Map

2006

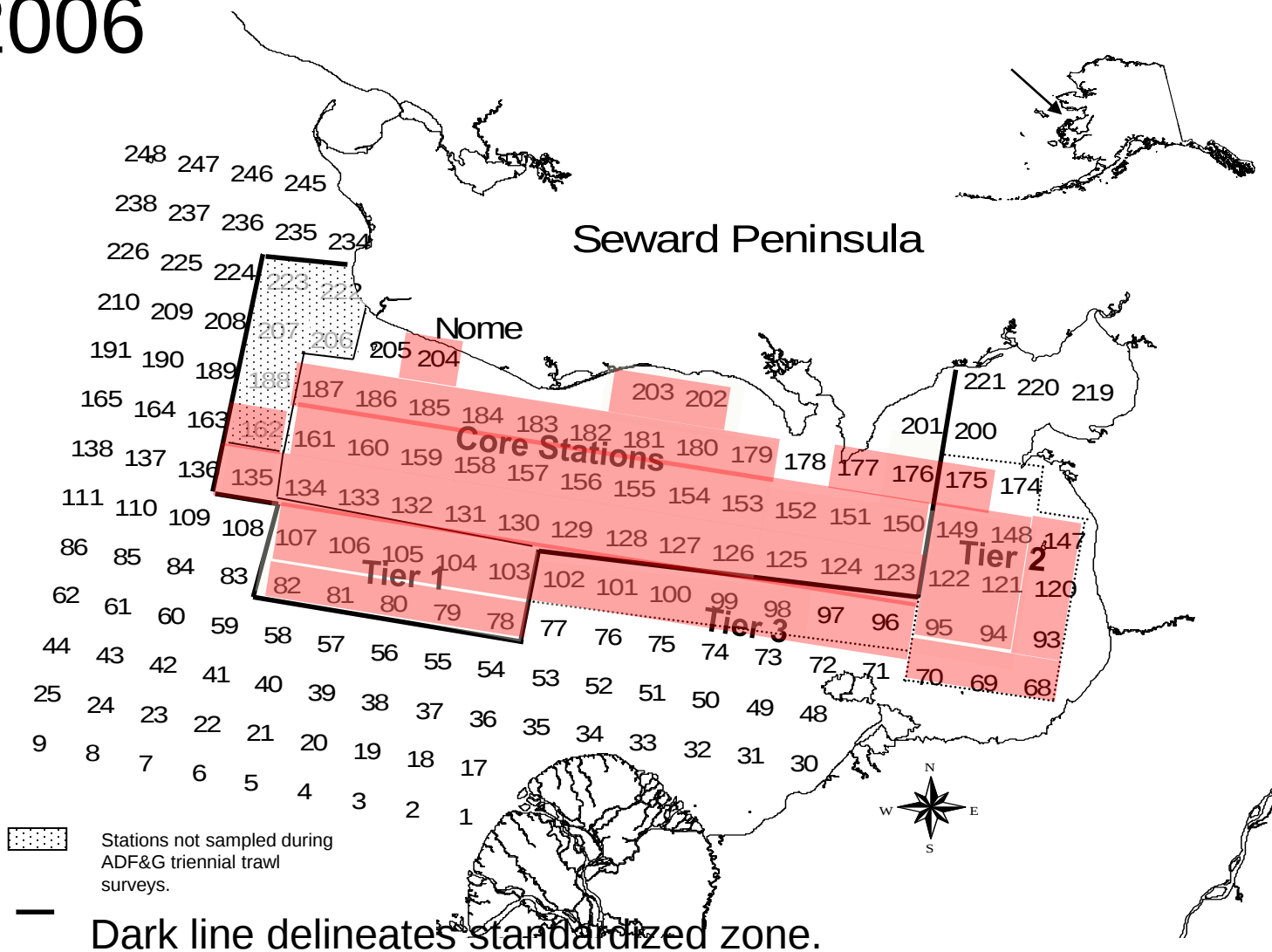


Figure 2- Station Map

2008

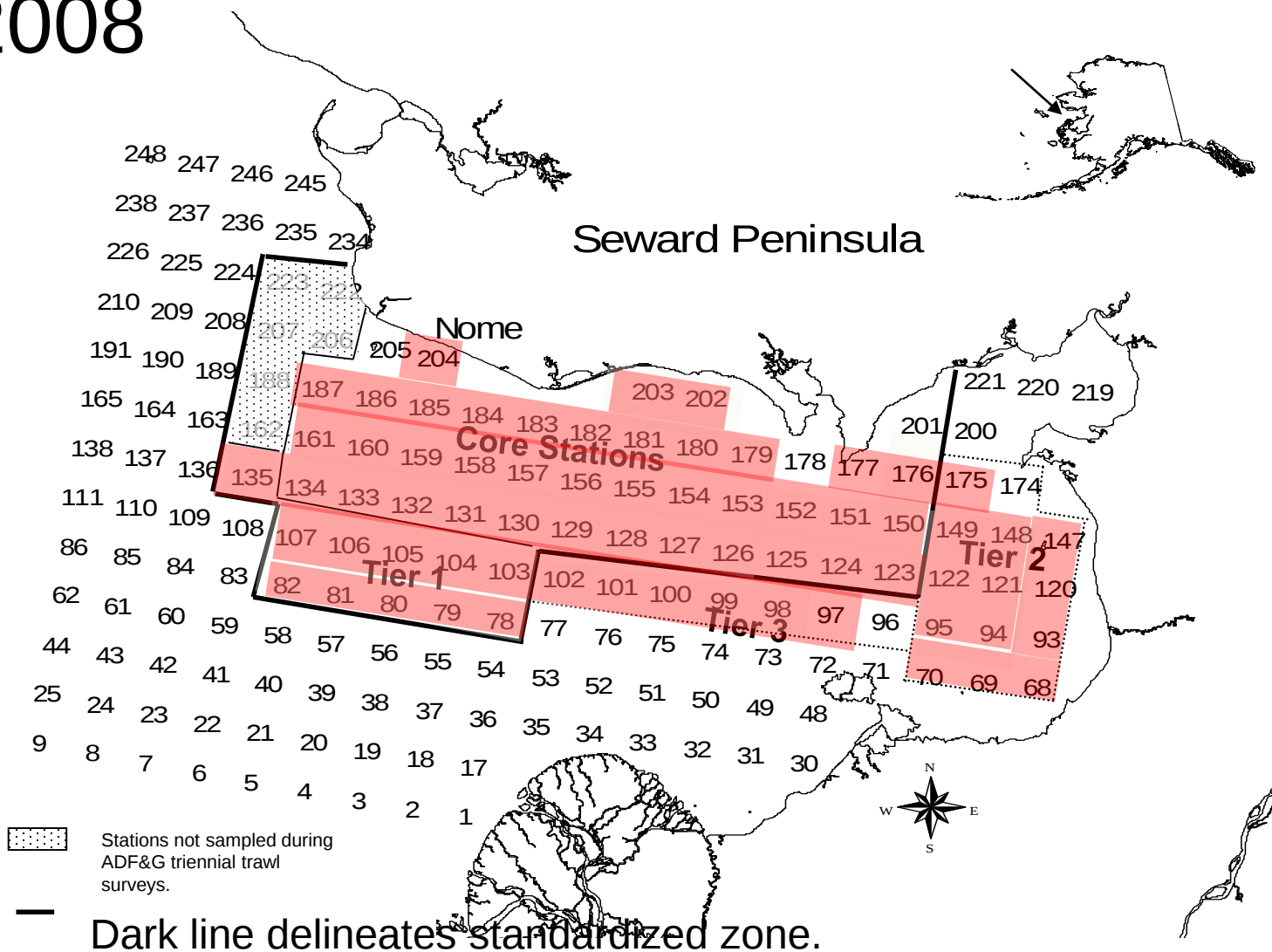


Figure 2- Station Map

2011

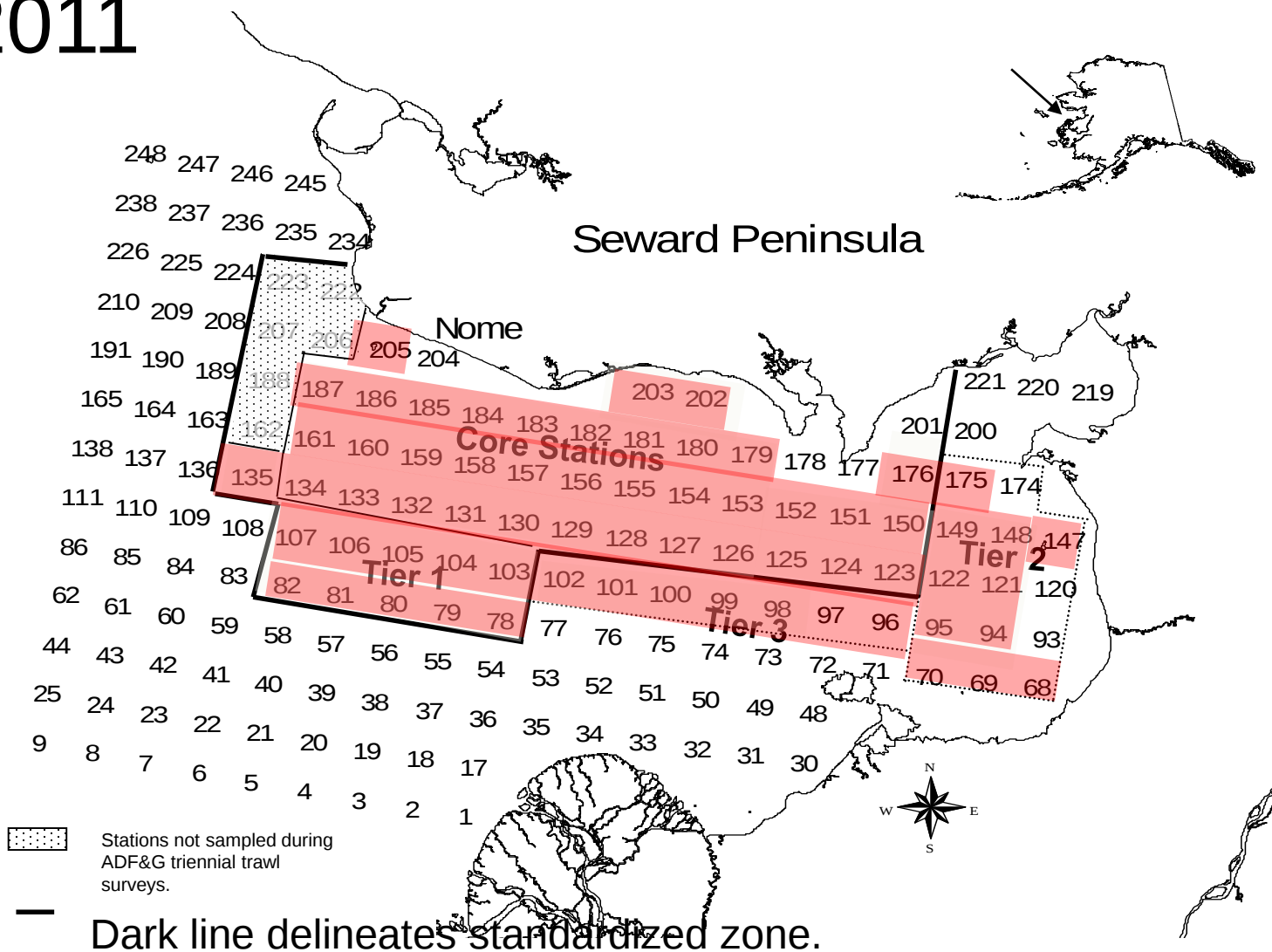


Figure 2- Station Map

2014

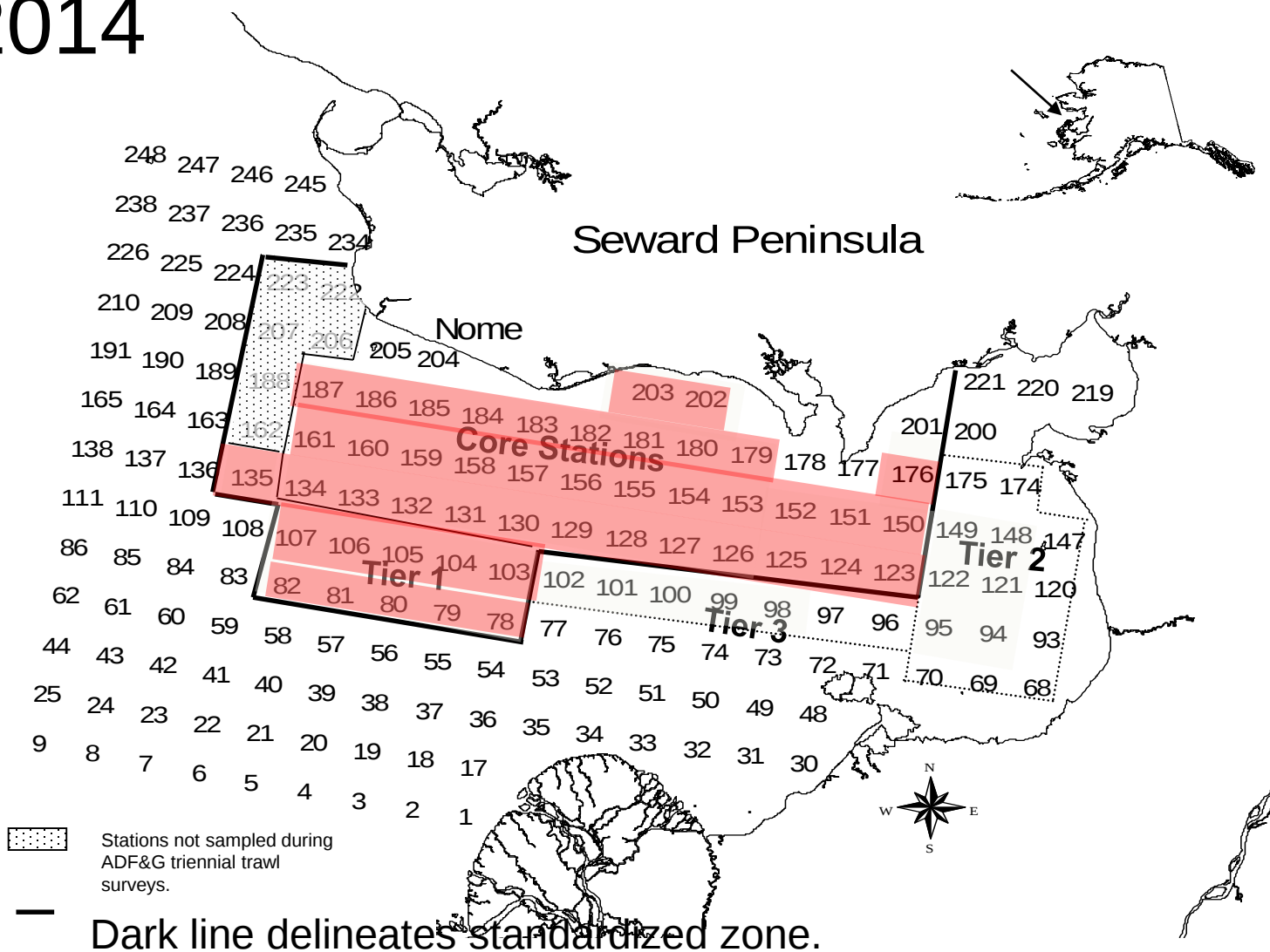


Figure 2- Station Map

2017

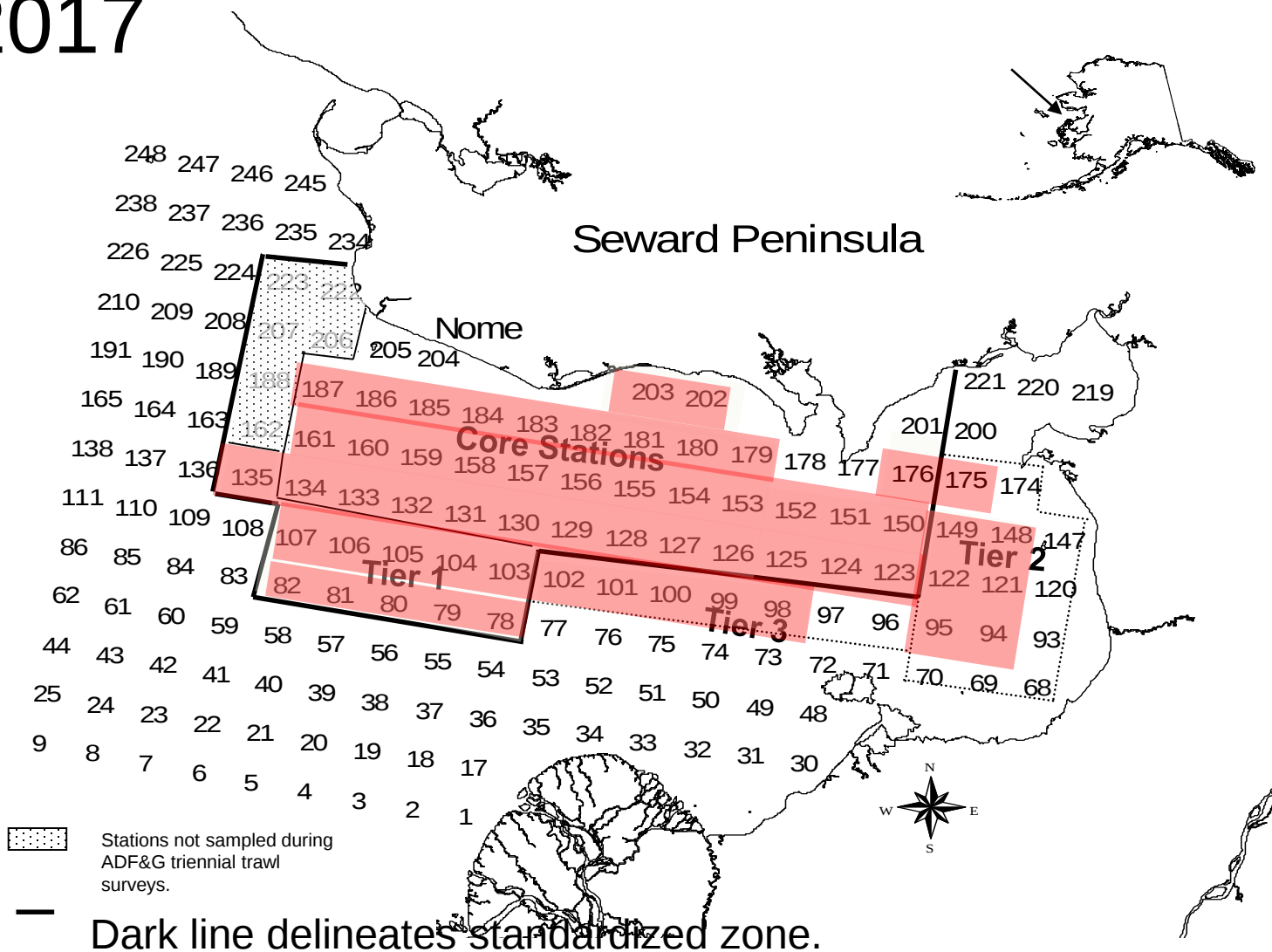


Figure 2- Station Map

Trawled All 8 Years

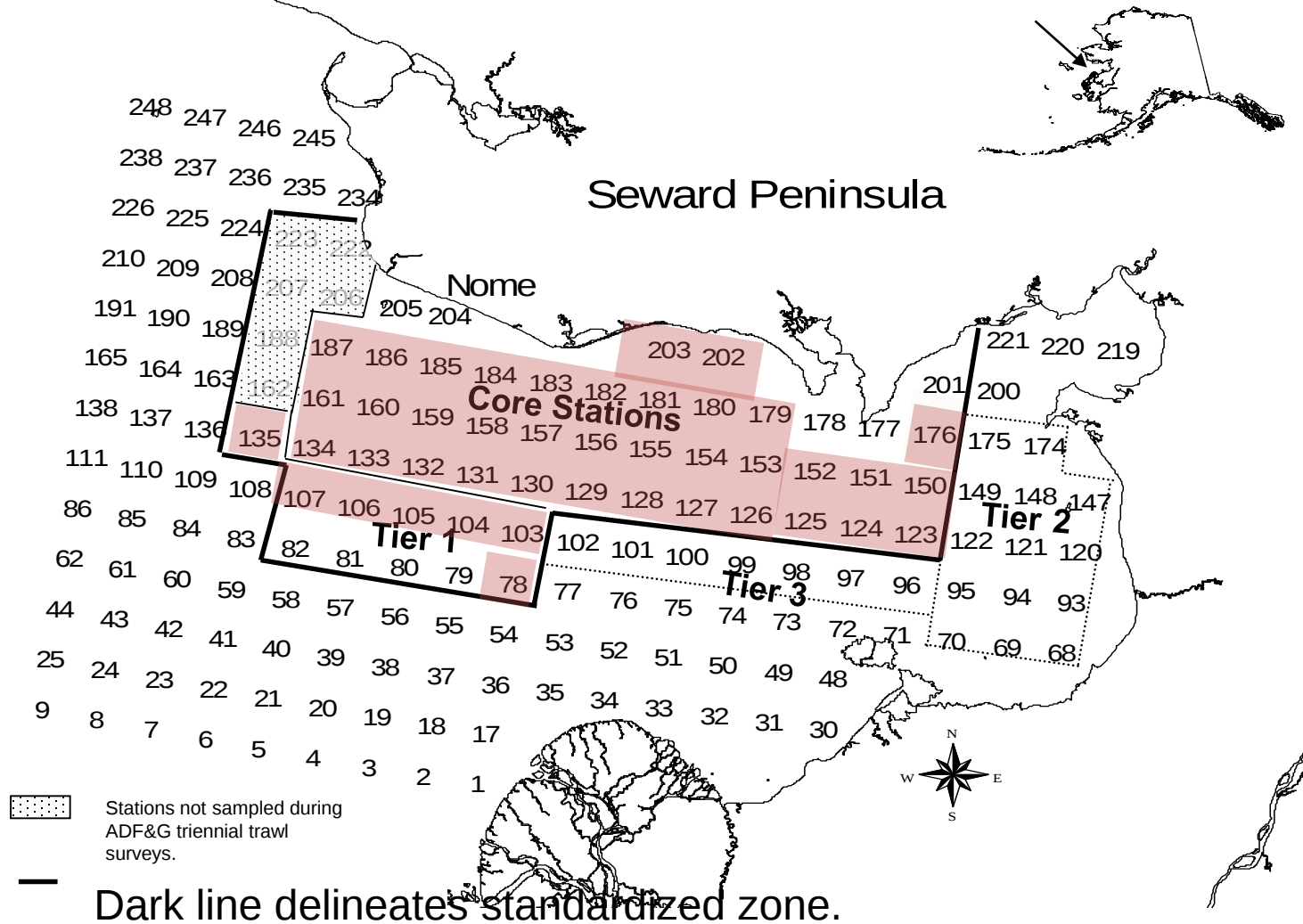


Figure 2- Station Map

Trawled 7 Years

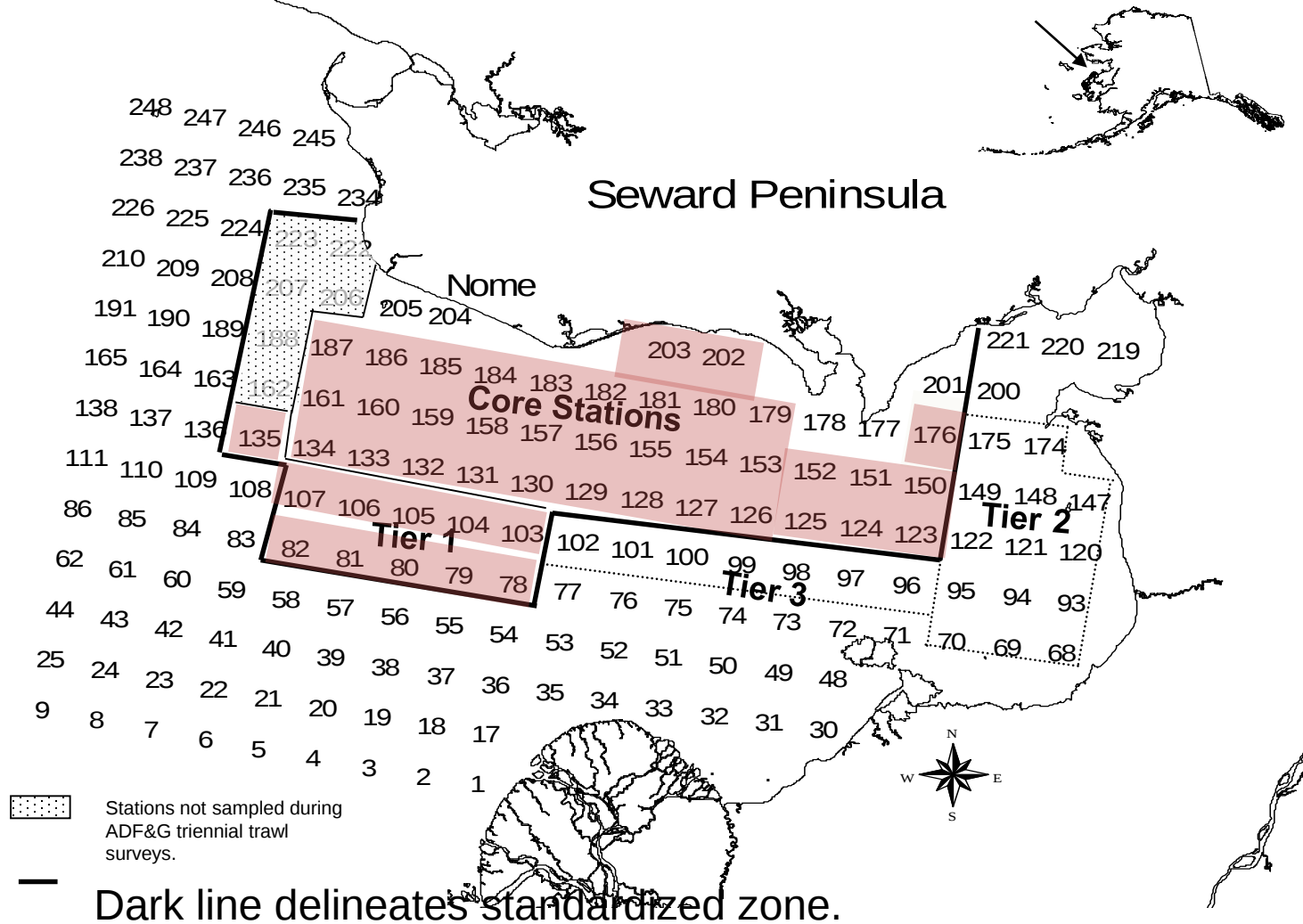


Figure 2- Station Map

Trawled 6 Years

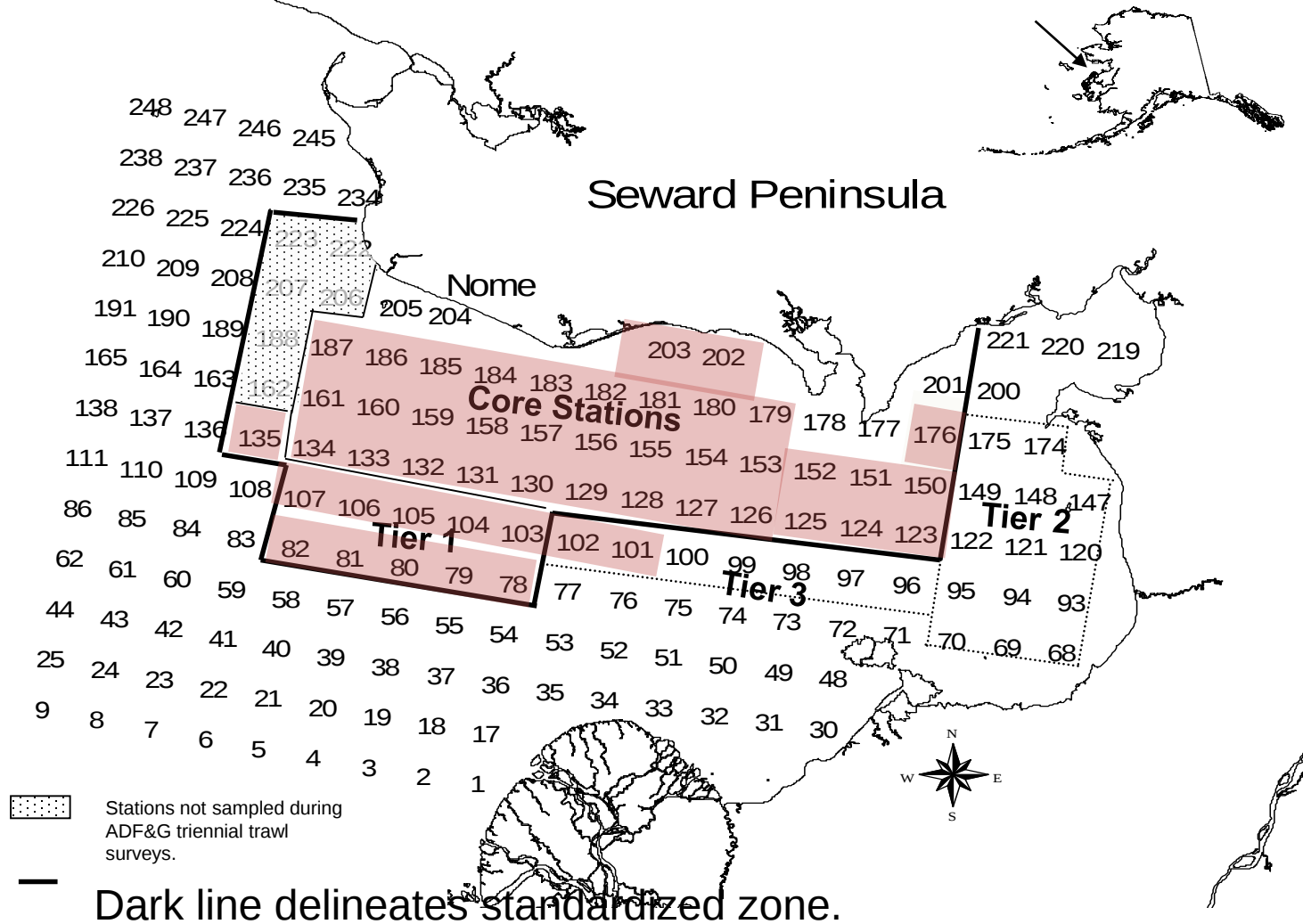


Figure 2- Station Map

Trawled 5 Years

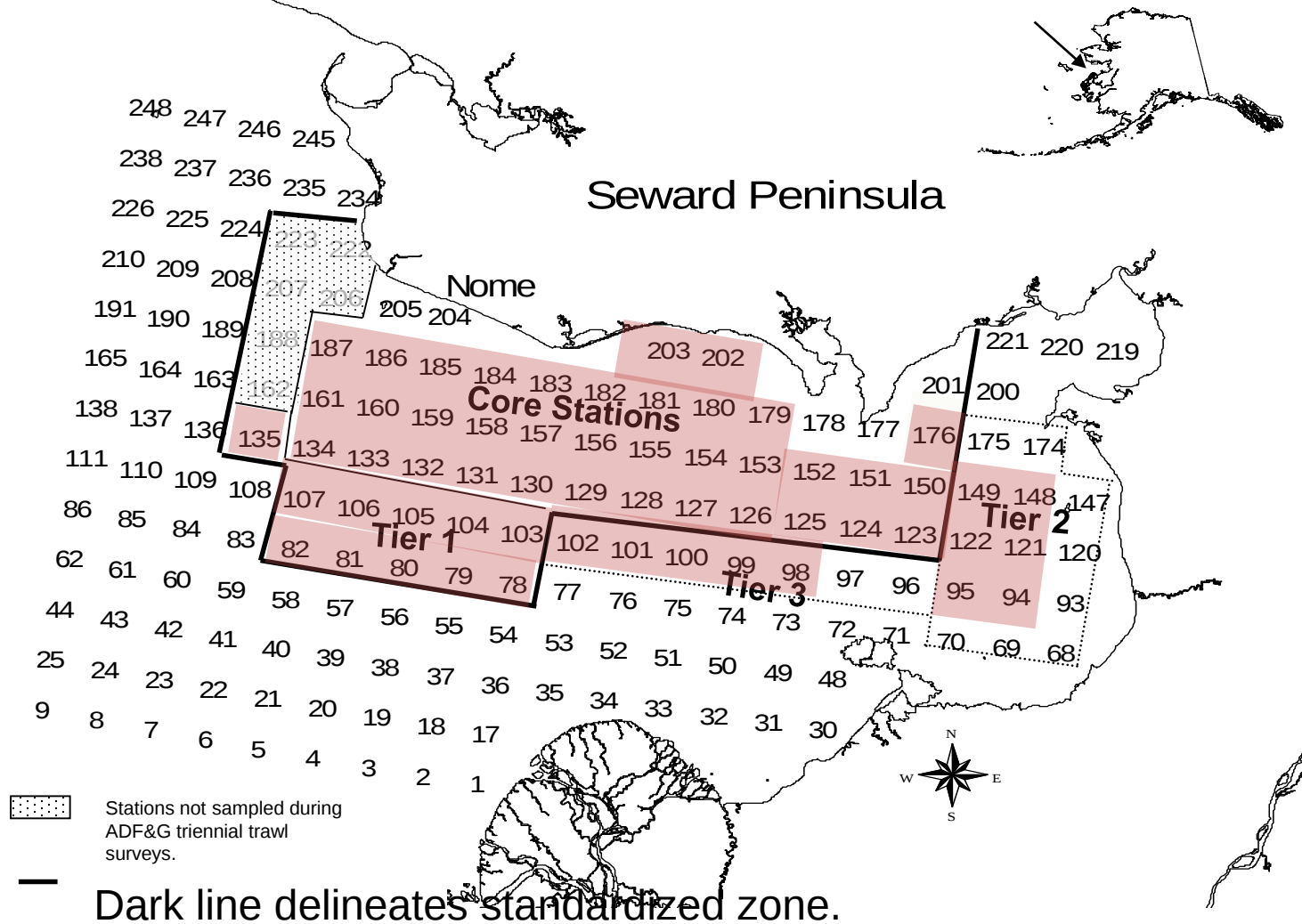
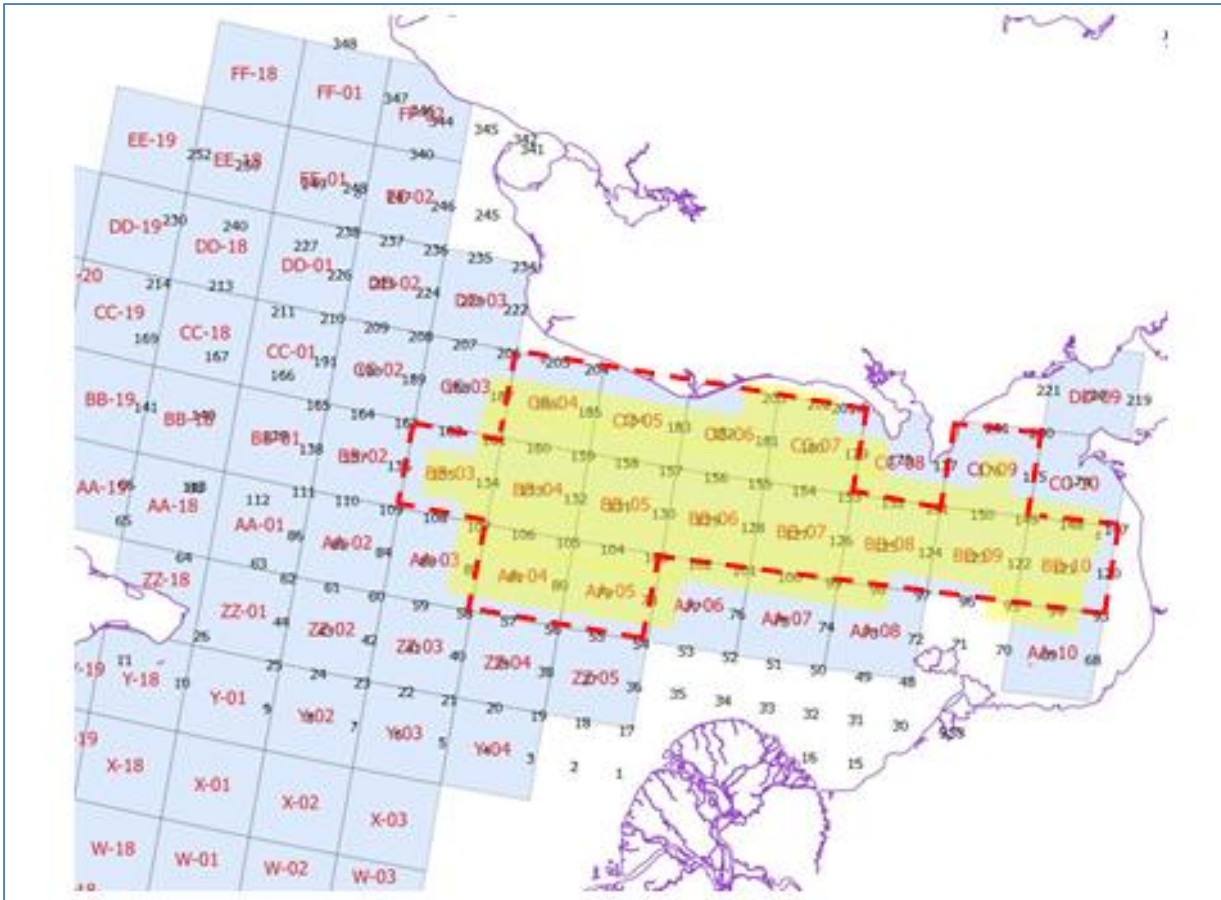


Figure 2- Station Map

Trawl Survey: ADFG vs. NMFS

- Survey Stations: ADFG 59: 100 nm², NMFS 18: 400 nm²
- Total area: ADFG 5868 nm², NMFS 6972 nm²



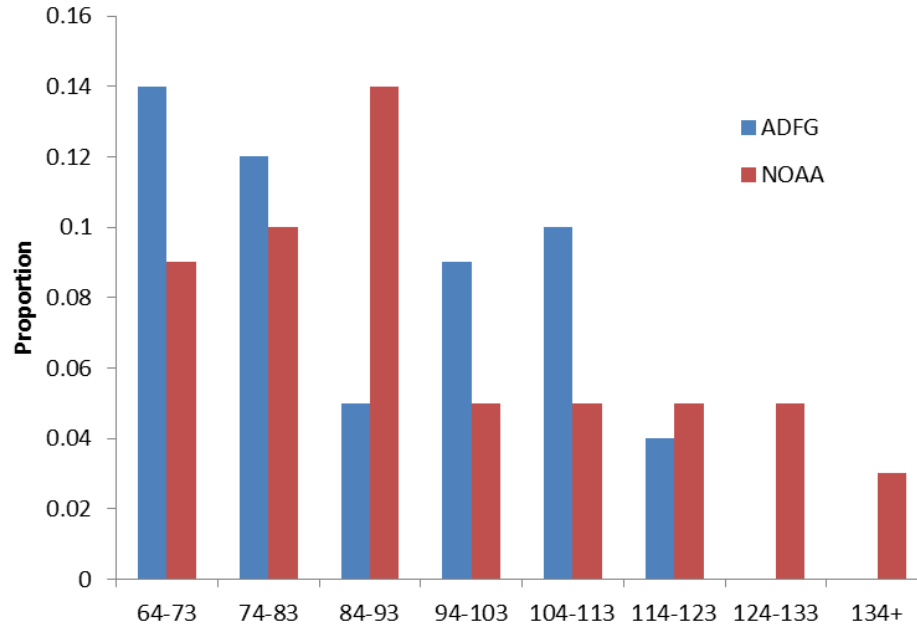
ADF&G 2017 trawl
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1762.1 k, CV = 0.22

NOAA 2017 trawl
survey : 8/18-8/29:
1035.8 k, CV = 0.40

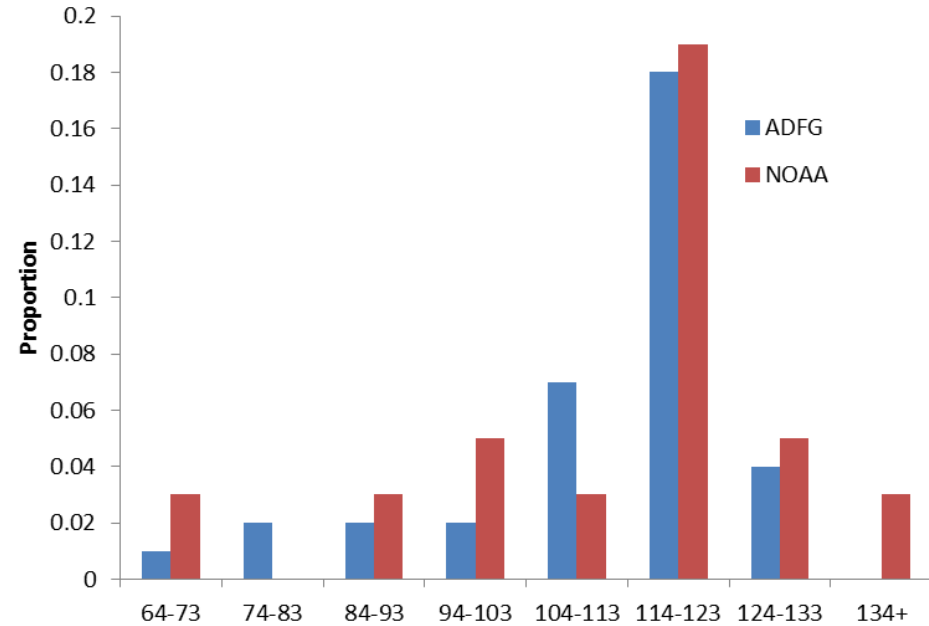
Trawl Survey: ADFG vs. NMFS

- Number of crabs sampled: ADFG 116, NMFS 58

New shell



Old shell



ADF&G 2017 trawl survey

7/28-8/08: 1762.1 k, CV = 0.22

NOAA 2017 trawl survey :

8/18-8/29: 1035.8 k, CV = 0.40

NSRKC Major Modeling Issues

- Under the size invariant M, the model overestimate abundance/proportion of large sized ($> 123\text{mm}$) crab.
 - Current Assumption: Higher M for large sized ($> 123\text{mm}$) crab
 - Pro: Model fits data better
 - Con: Biologically implausible
 - Alternative Assumptions
 - Faster-slower molting (model did not support: SAFE 2016)
 - Large crabs move out (implausible: SAFE 2017)
 - Higher M across all length (too high: $M \sim 0.44$: SAFE 2017)
 - Gradual mortality increase (SSC requests: Feb 2017, Alternative models)

Responses to CPT and SSC (Sept – Oct 2017)

- Include a graphic on where pot-pulls have been observed
 - Appendix D
- Conduct likelihood profile on the M
 - Appendix F
- Bring forward default model, model 3-5. Include results for 2014-2016 pot survey data
 - See alternative models.

Responses to CPT

- Breaking out natural mortality by size class for future model evaluation.

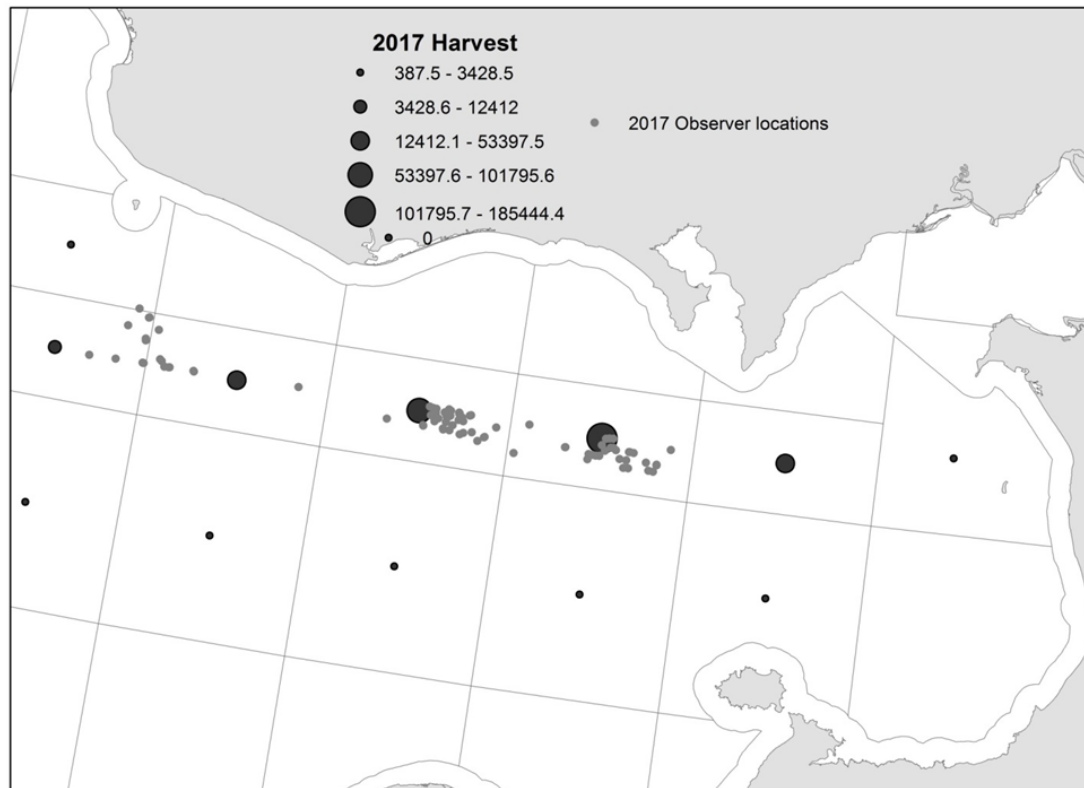
$$OFL = \sum_l \left[Legal_B_{w,l} \left(1 - e^{-(F_{OFL} + 0.42M_l)} - (1 - e^{-0.42M_l}) \left(\frac{1 - p(1 - e^{-(F_{OFL} + 0.42M_l)})}{1 - p(1 - e^{-0.42M_l})} \right) \right) \right]$$

Responses to CPT and SSC

- NSRKC observer program:
 - Ship on an available boat (by generosity of crabber)
 - Same crabbers every year.
 - Measure length-shell-sex of every catch (legal retain, legal discards, sublegal discards, female discards) from sampled pots
 - Data obtained
 - The number of sampled crab by length-shell-sex
 - CPUE (may be)
 - Data location
 - ADFG NS shared hard drive. EXCEL files....

Discards Observer coverage

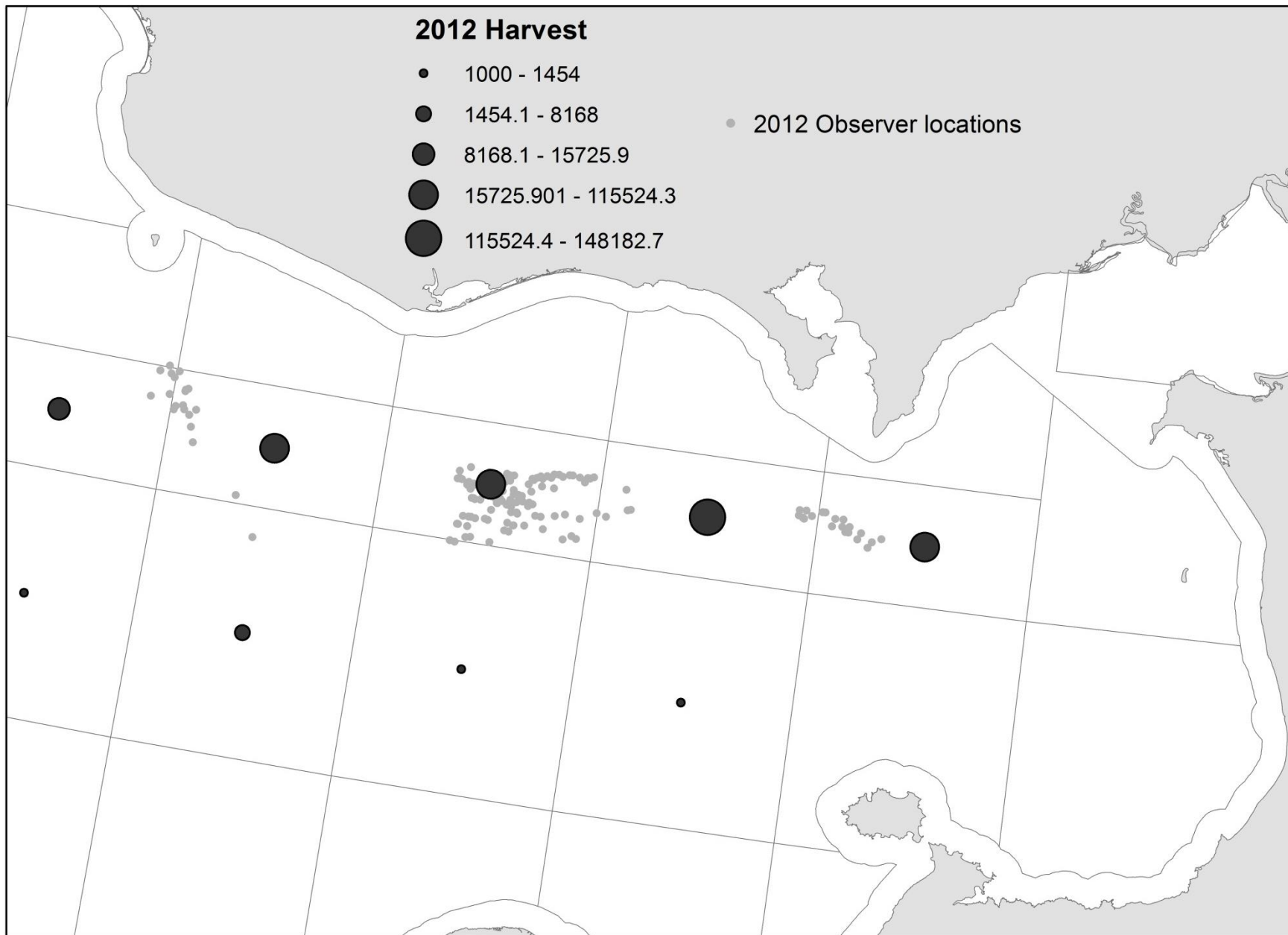
- Majority of observer coverage occurred where the majority of fisheries occurred. (Appendix D)
 - But coverage of ships are small: usually 4-5 /36-37 boats.



2012 Harvest

- 1000 - 1454
- 1454.1 - 8168
- 8168.1 - 15725.9
- 15725.901 - 115524.3
- 115524.4 - 148182.7

• 2012 Observer locations



2013 Harvest

• 686 - 2669

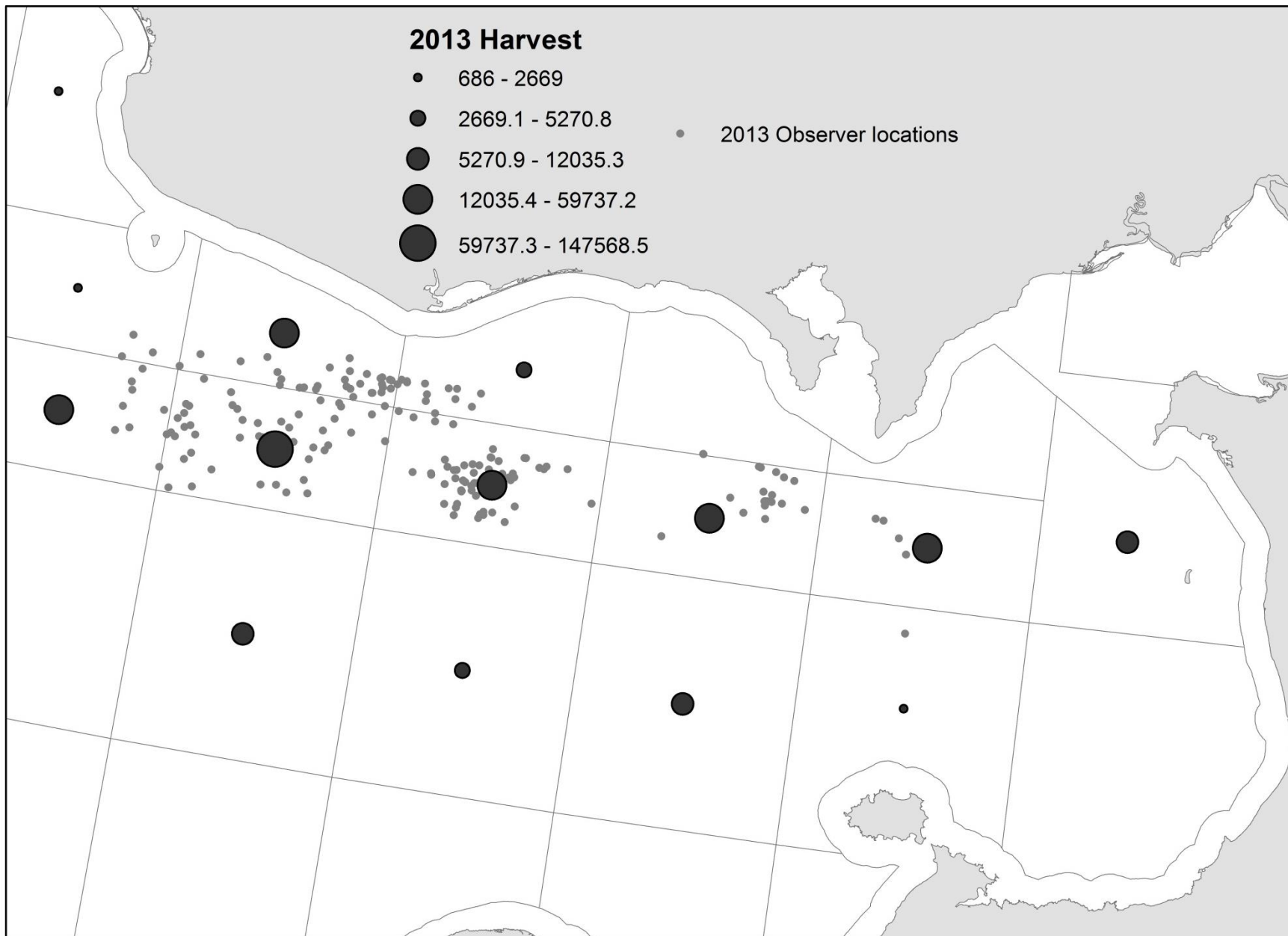
● 2669.1 - 5270.8

● 5270.9 - 12035.3

● 12035.4 - 59737.2

● 59737.3 - 147568.5

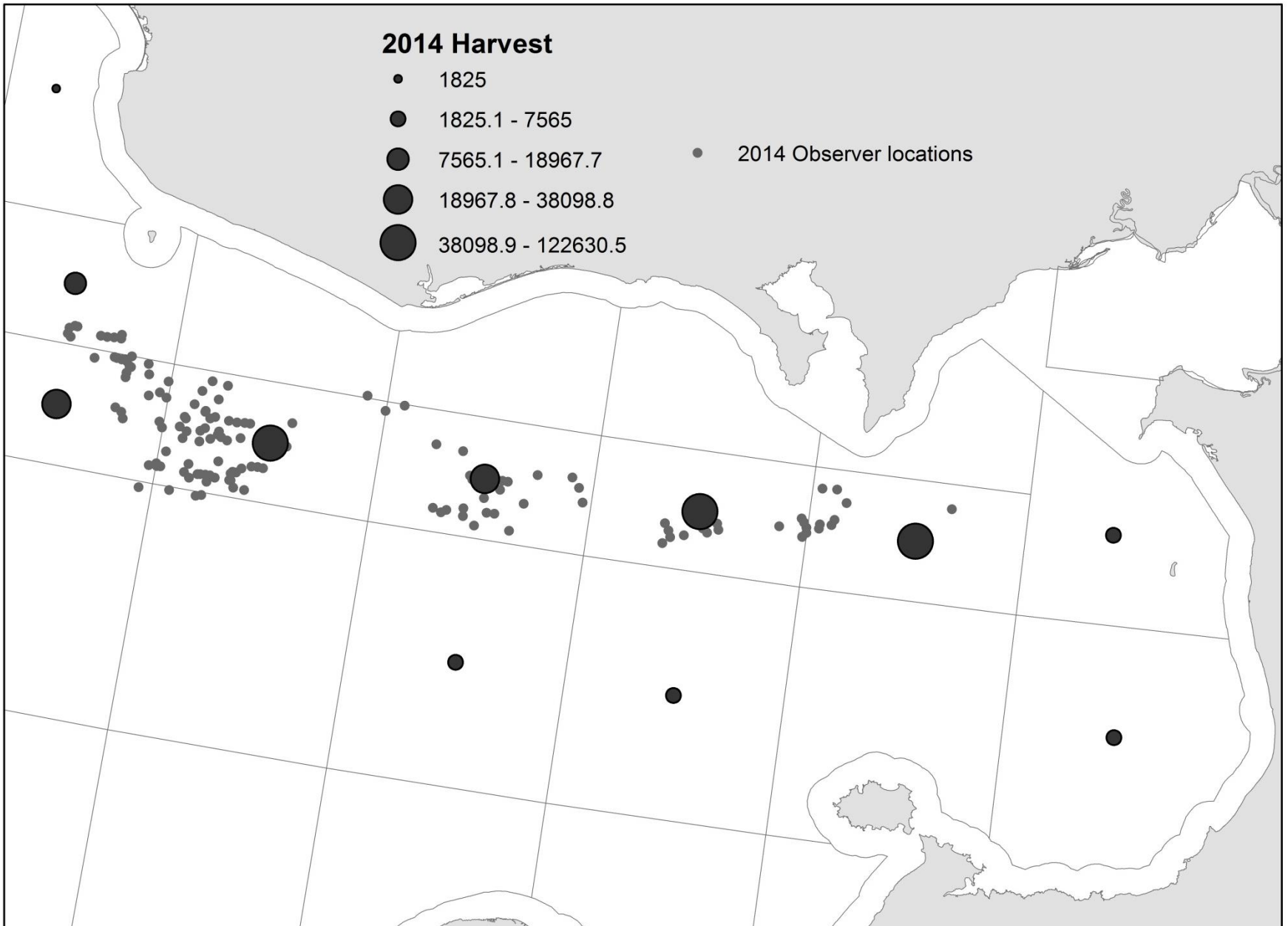
• 2013 Observer locations



2014 Harvest

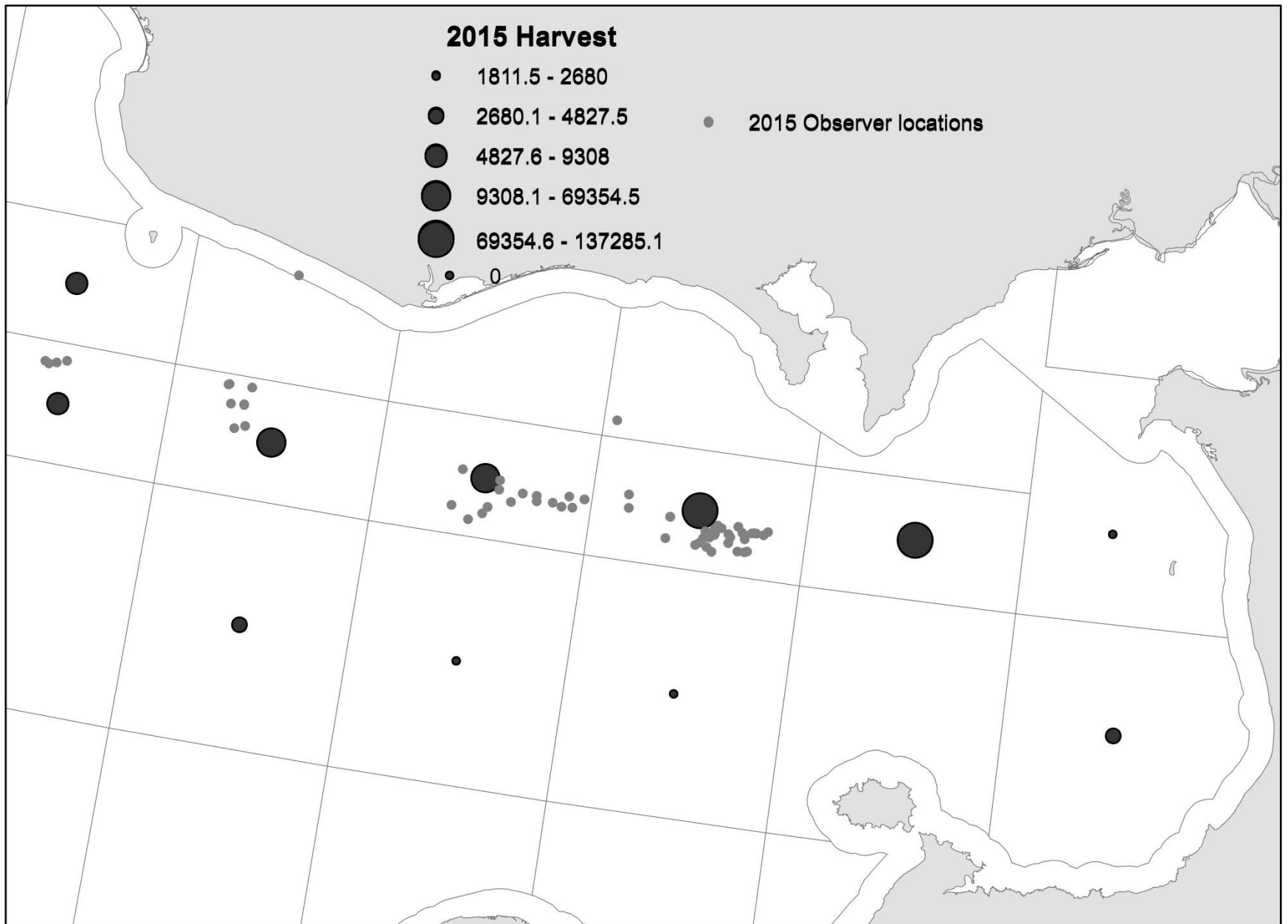
- 1825
- 1825.1 - 7565
- 7565.1 - 18967.7
- 18967.8 - 38098.8
- 38098.9 - 122630.5

• 2014 Observer locations



2015 Harvest

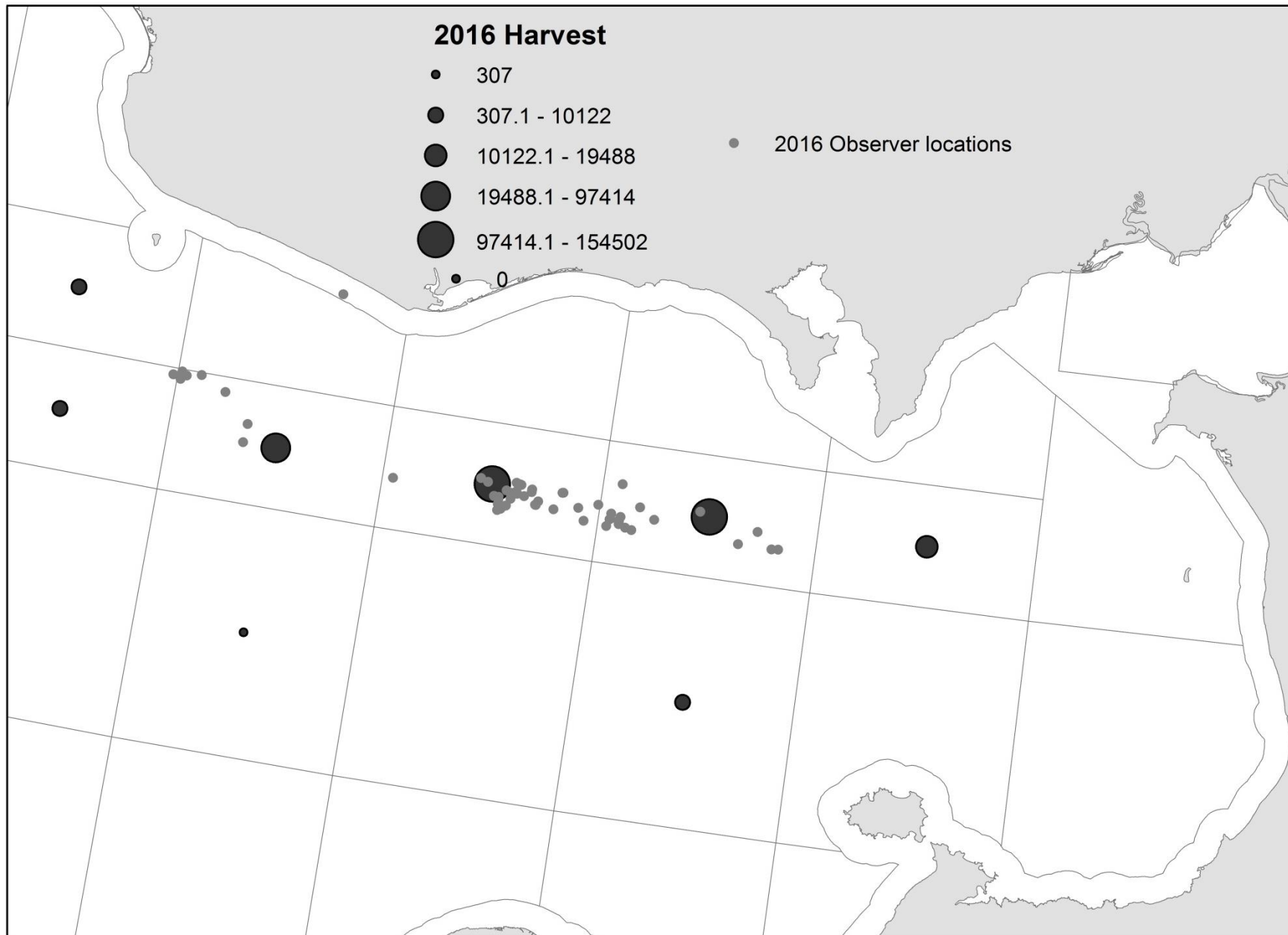
- 1811.5 - 2680
 - 2680.1 - 4827.5
 - 4827.6 - 9308
 - 9308.1 - 69354.5
 - 69354.6 - 137285.1
- 2015 Observer locations



2016 Harvest

- 307
- 307.1 - 10122
- 10122.1 - 19488
- 19488.1 - 97414
- 97414.1 - 154502

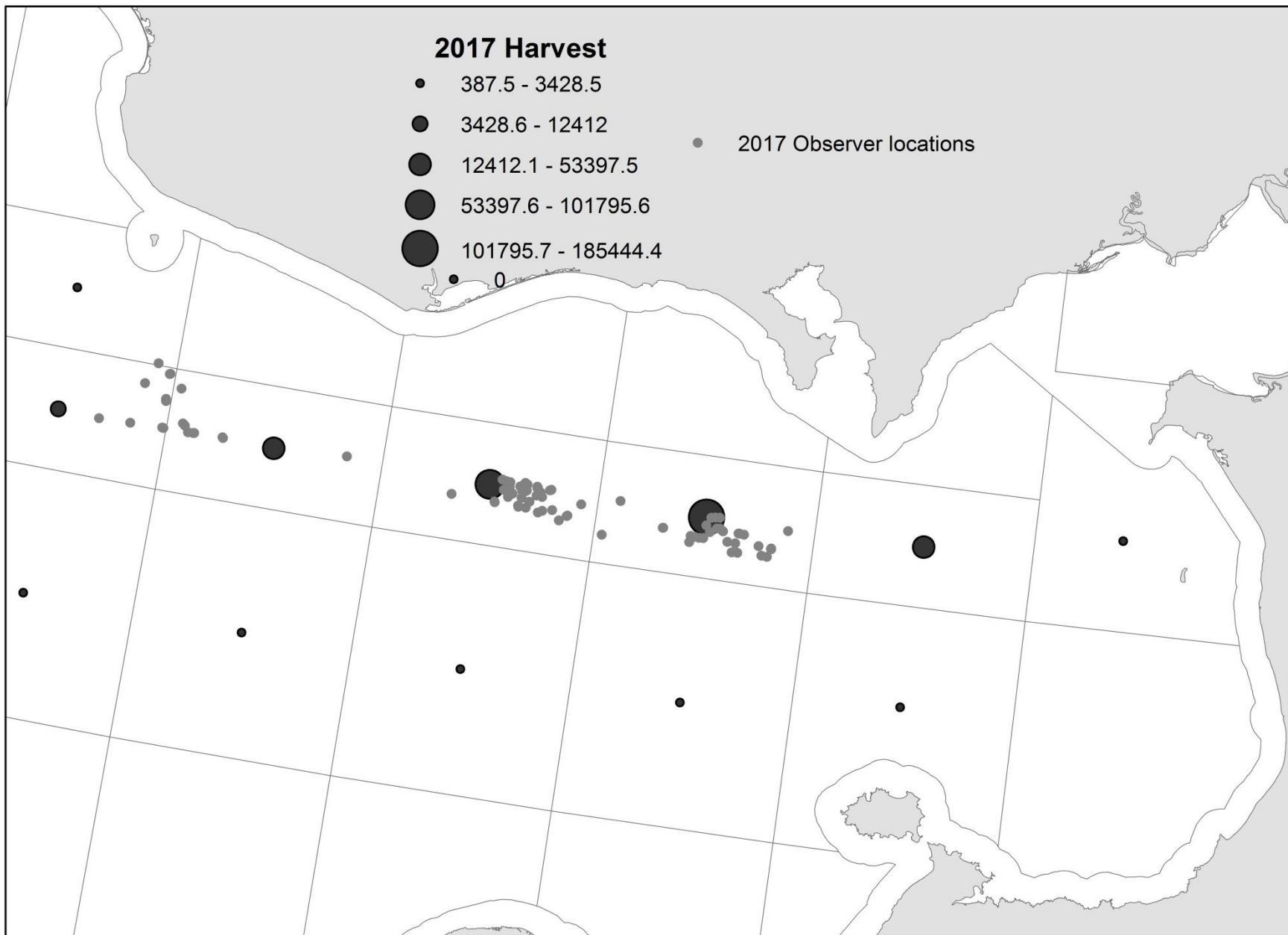
• 2016 Observer locations



2017 Harvest

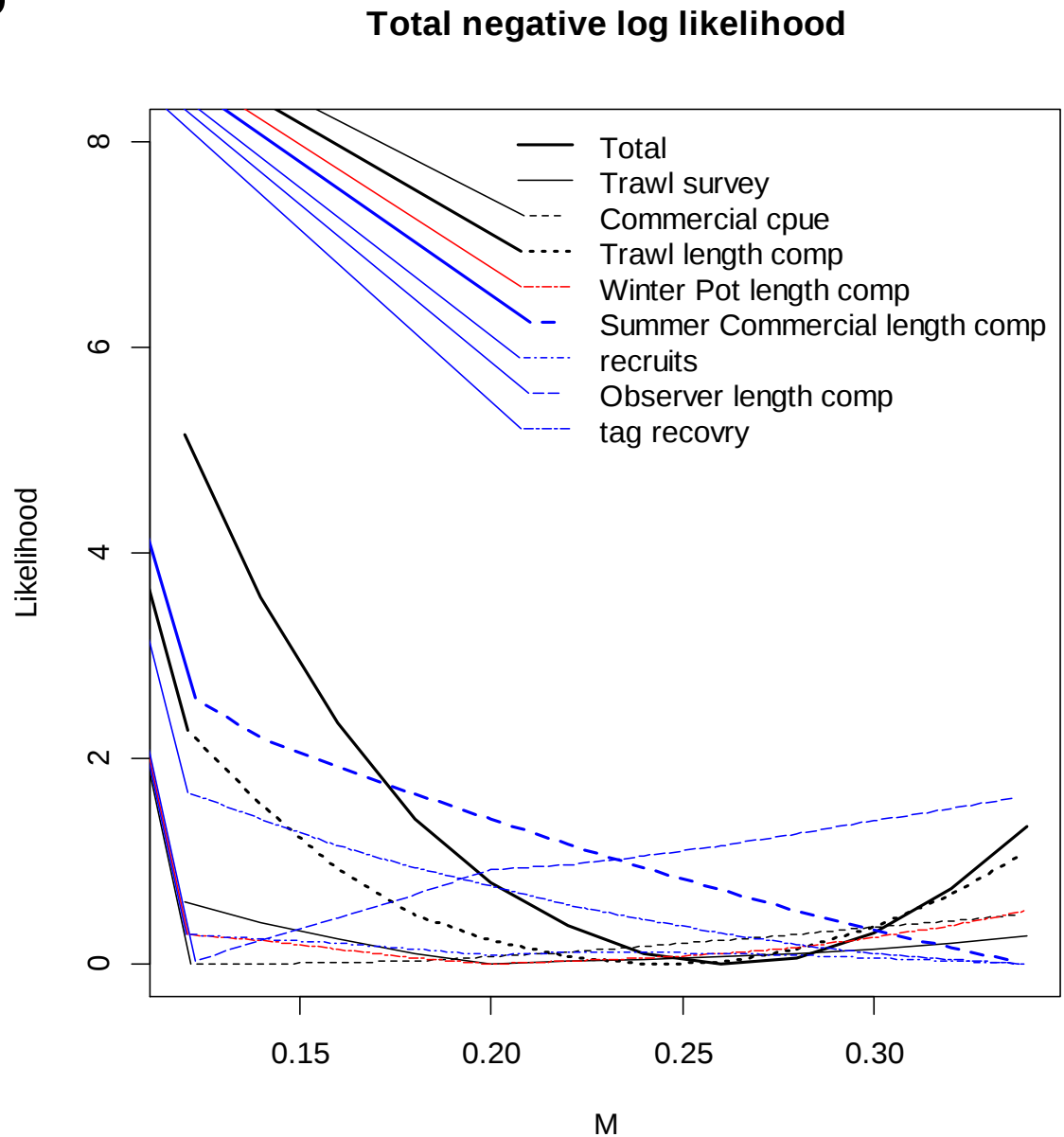
- 387.5 - 3428.5
- 3428.6 - 12412
- 12412.1 - 53397.5
- 53397.6 - 101795.6
- 101795.7 - 185444.4

• 2017 Observer locations



Responses to CPT

- Model still wants to go higher M .



Responses to CPT and SSC

- Alternative models 3,4,5,6

	fishery	M1 64+	M2 74+	M3 84+	M4 94+	M5 104+	M6 114+	M7 124+	M8 134+
Default	1p	0.18	0.18	0.18	0.18	0.18	0.18	0.18* ms1	0.18* ms1
Alt 3	2p	0.18	0.18	0.18	0.18	0.18	0.18	0.18* ms1	0.18* ms1
Alt 4	2p	0.18	0.18	0.18	0.18	0.18	0.18	0.18* ms1	0.18* ms2
Alt 5	2p	0.18	0.18	0.18	0.18	0.18	0.18* ms1	0.18* ms2	0.18* ms3
Alt 6	2p+sp	0.18	0.18	0.18	0.18	0.18	0.18	0.18* ms1	0.18* ms1

- Fishery selectivity function 1 vs. 2 parameters model

$$S_l = \frac{1}{1 + e^{(\phi(L_{\max} - L) + \ln(1/0.999 - 1))}}$$

$$S_l = \frac{1}{1 + e^{\phi 1(L - \phi 2)}}$$

Alternative models

- Alternative model 3-6: NLL

Model	Model 0	Model 3	Model 4	Model 5	Model 6
No. Parameters	67	68	69	70	68
Total	281.1	269.2	269.1	265.44	286.01
TSA	9.1	9.1	9.1	9.36	9.24
St.CPUE	-30.6	-30.7	-30.7	-30.4	-30.6
TLP	95.1	90.6	90.6	89.8	90.8
WLP	38.7	39.1	39.1	38.5	39.3
CLP	50.8	51.4	51.2	49.2	51.3
OBS	25.2	23.2	23.2	23.1	23.0
REC	13.6	14.0	13.9	14.5	16.5
TAG	79.2	72.5	72.6	71.3	72.5
SP					14.0
MMB(mil.lb)	4.08	3.94	3.95	3.91	4.00

Responses to CPT and SSC

- Alternative models 3,4,5,6

	fishery	M1 64+	M2 74+	M3 84+	M4 94+	M5 104+	M6 114+	M7 124+	M8 134+
Default	1p	0.18	0.18	0.18	0.18	0.18	0.18	0.58	0.58
Alt 3	2p	0.18	0.18	0.18	0.18	0.18	0.18	0.60	0.60
Alt 4	2p	0.18	0.18	0.18	0.18	0.18	0.18	0.58	0.63
Alt 5	2p	0.18	0.18	0.18	0.18	0.18	0.34	0.55	0.59
Alt 6	2p+sp	0.18	0.18	0.18	0.18	0.18	0.18	0.59	0.59

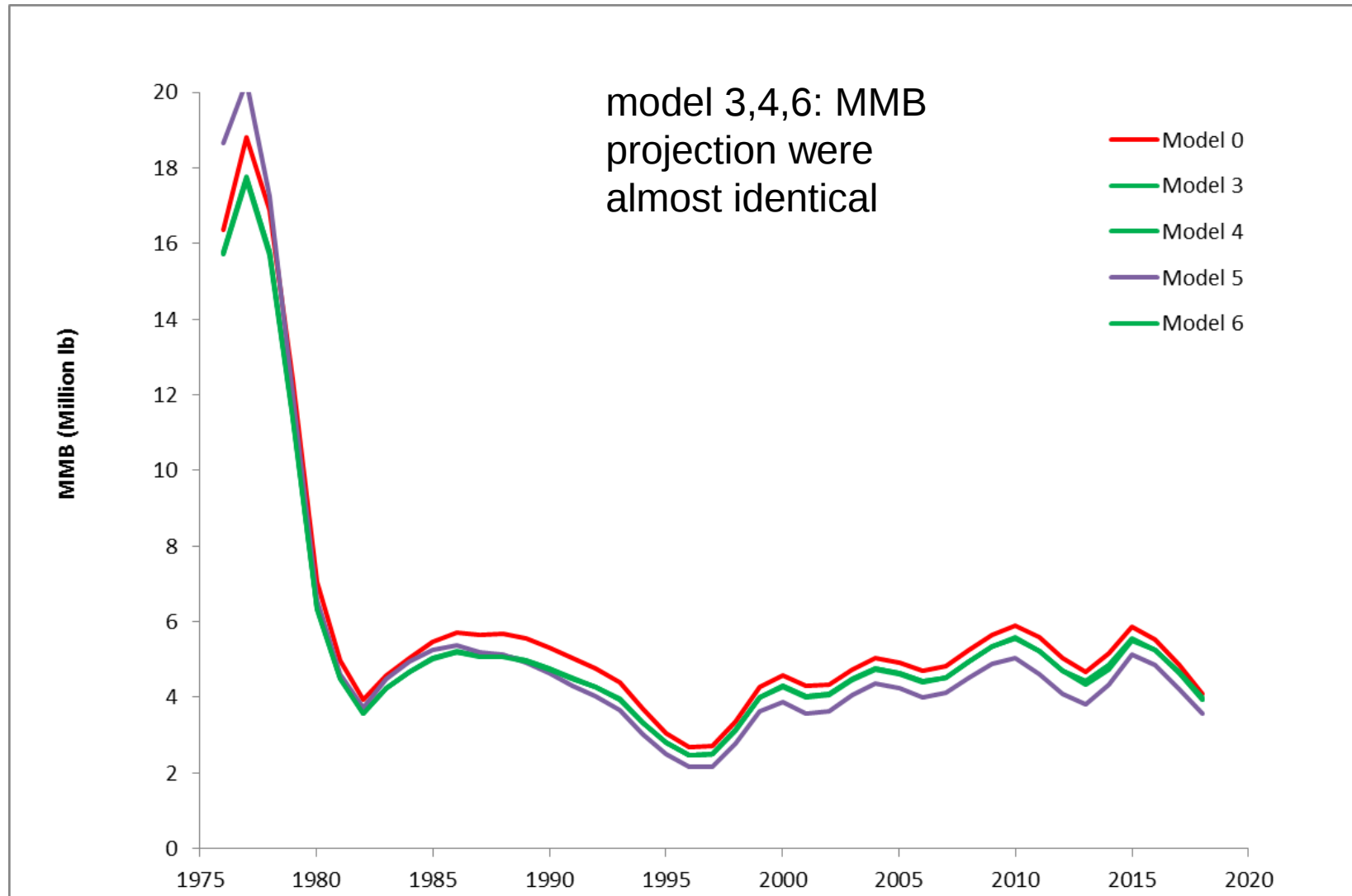
- Fishery selectivity function 1 vs. 2 parameters model

$$S_l = \frac{1}{1 + e^{(\phi(L_{\max} - L) + \ln(1/0.999 - 1))}}$$

$$S_l = \frac{1}{1 + e^{\phi 1(L - \phi 2)}}$$

Alternative models

- Alternative model 3-6: MMB projection



Search for balance

- **Model 0 vs. Model 3**
 - Major model fit improvement. (reduction 10 nll)
 - Slight decline in MMB projection and dynamics
- **Model 3 vs. Model 4 vs. Model 6**
 - No model fit improvement.
 - Identical MMB projection and dynamics
 - Probably more biologically realistic (model 4?)
 - Adding more data did not change anything (model 6)
- **Model 3 vs. Model 5 (reduction 4 nll)**
 - Slight model fit improvement.
 - Slight decline in MMB
 - More biologically realistic?

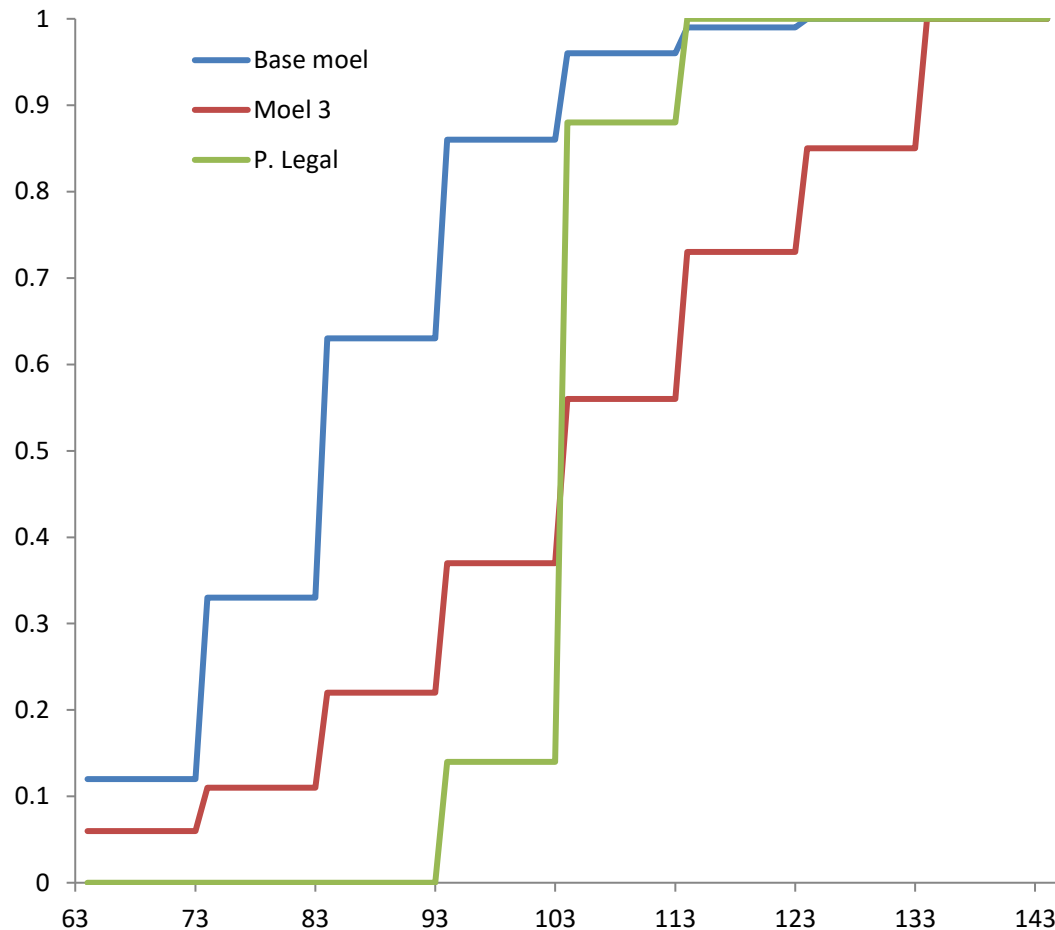
Alternative models

- Assessment model choice ~~Model 3~~ => Base Model

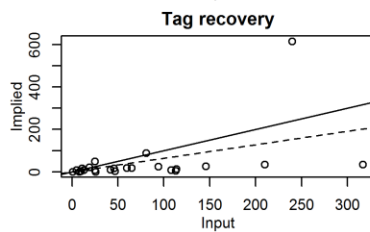
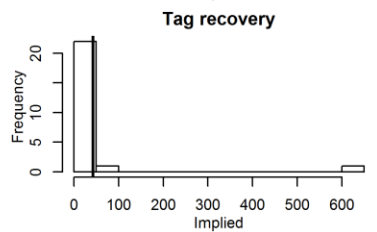
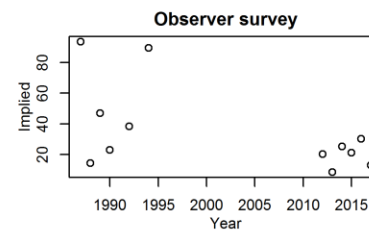
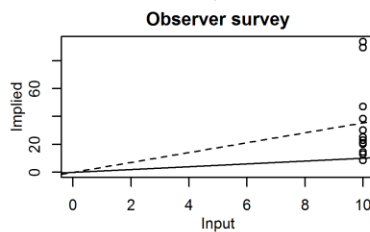
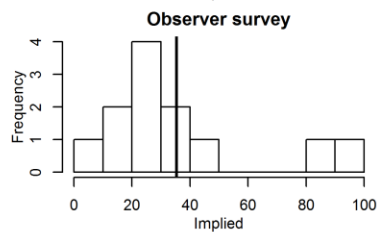
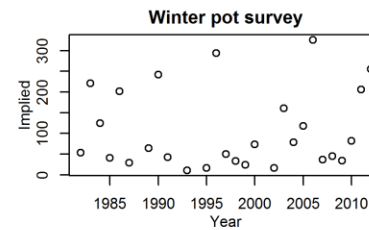
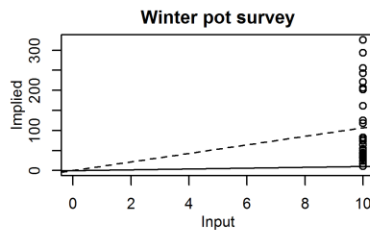
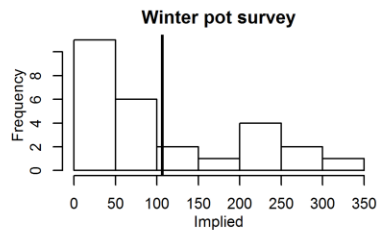
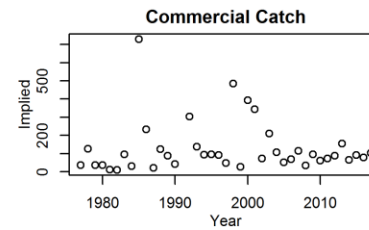
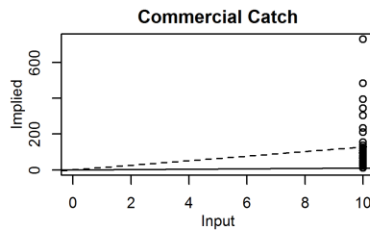
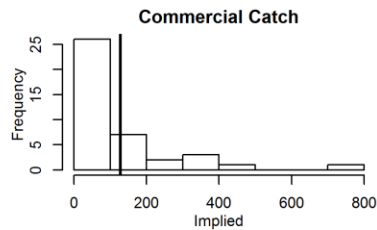
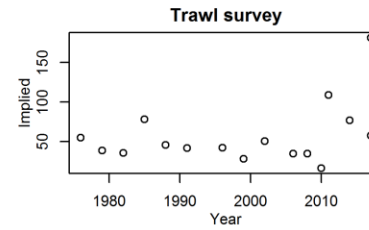
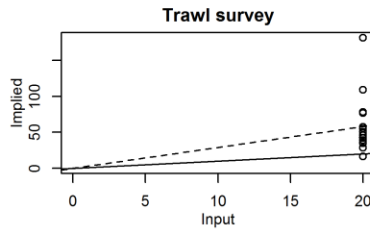
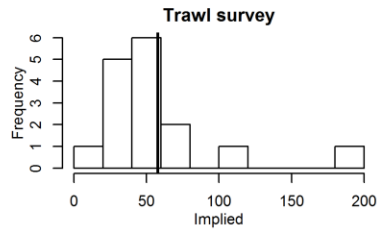
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TAG	79.2	72.5	72.6	71.3	72.5
SP					14.0
MMB(mil.lb)	4.08	3.94	3.95	3.91	4.00
Legal crab Catchable (mil.lb)	3.55	2.58	2.60	2.13	2.63
OFL(mil.lb)	0.75	0.57	0.58	0.51	0.60

1 parameter vs. 2 parameters fishery selectivity

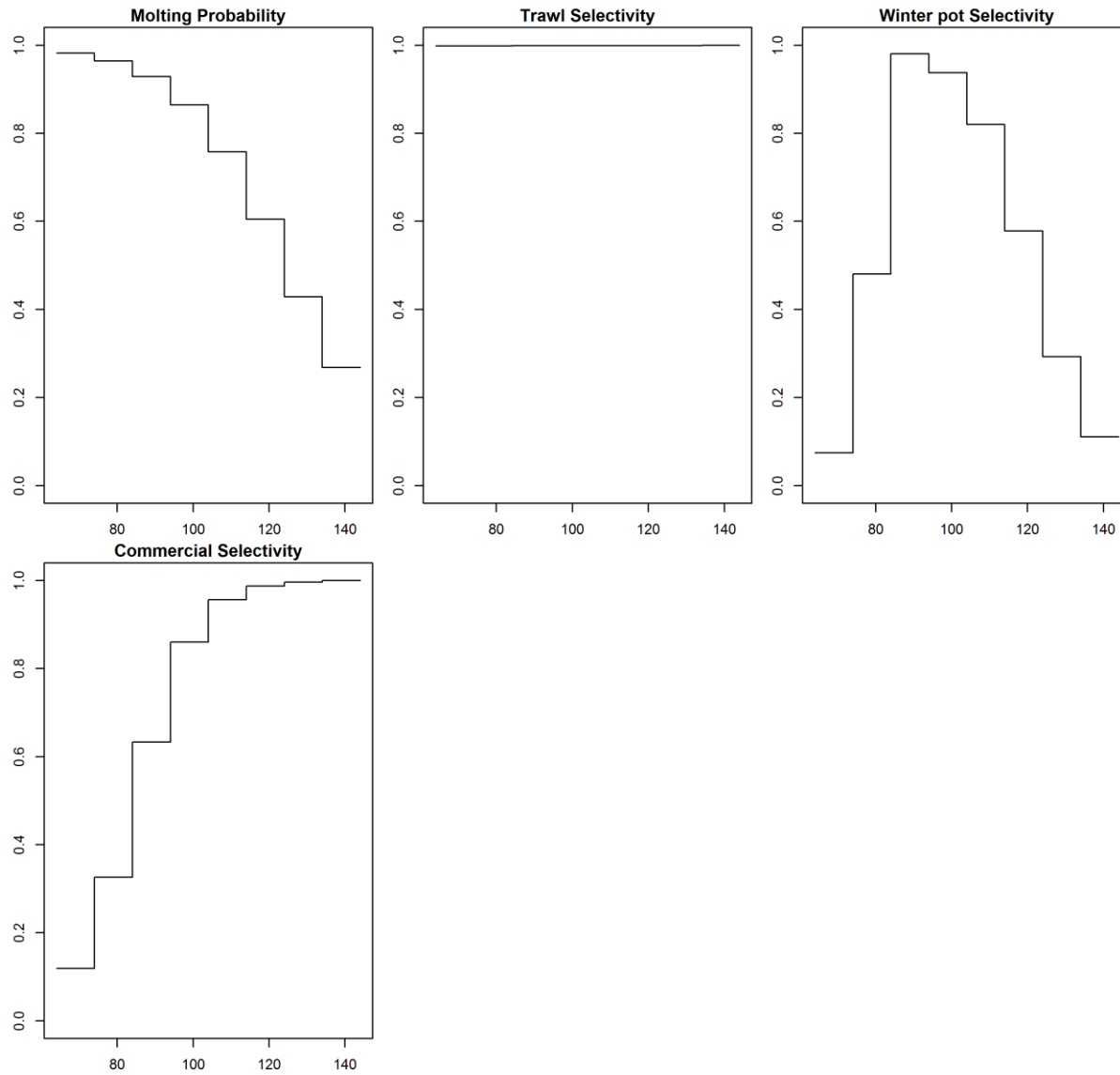
- Model 4 (2 parameters) predicts legal crabs are less catchable than baseline (1 parameter)



Base model

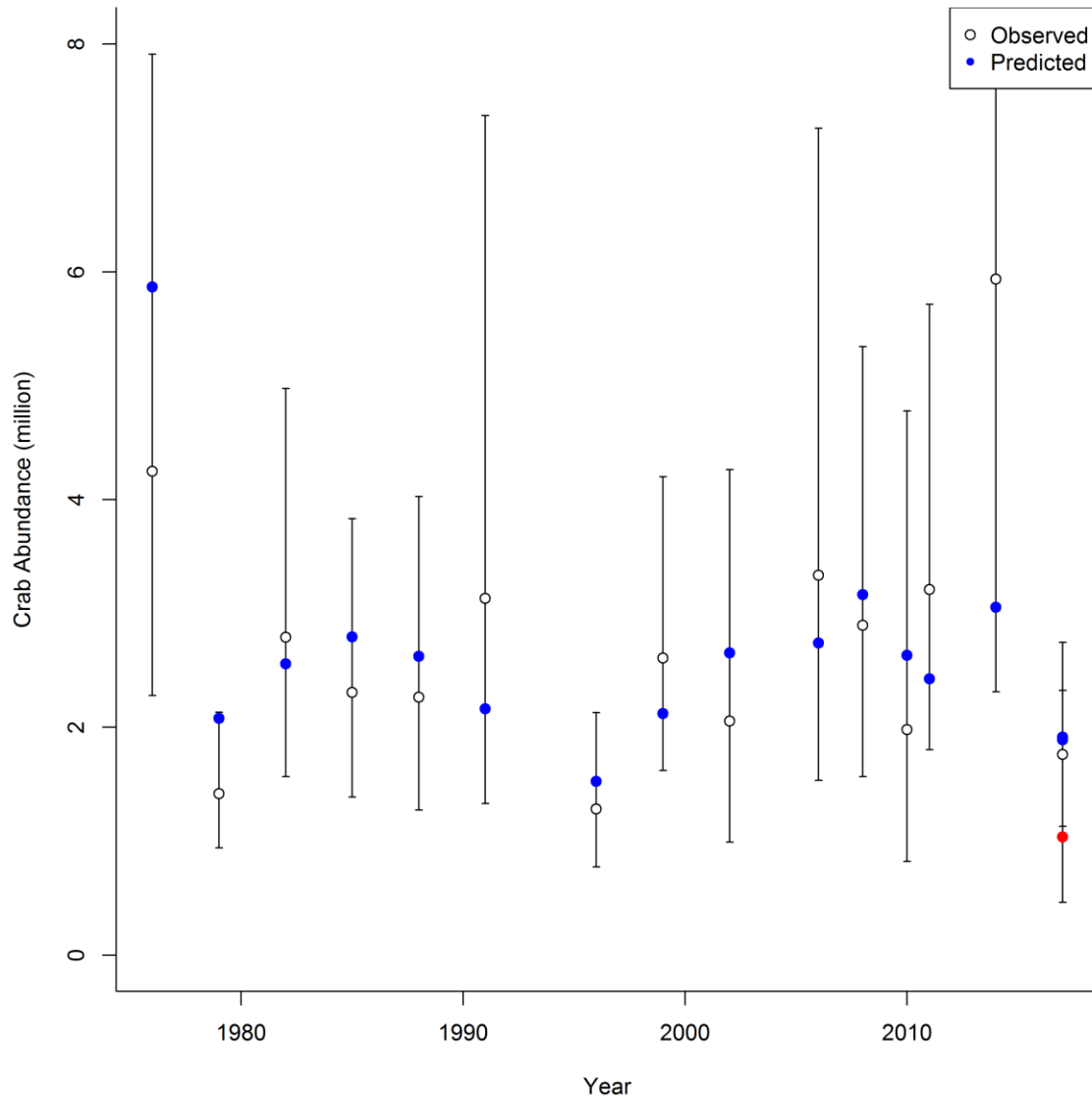


Base Model



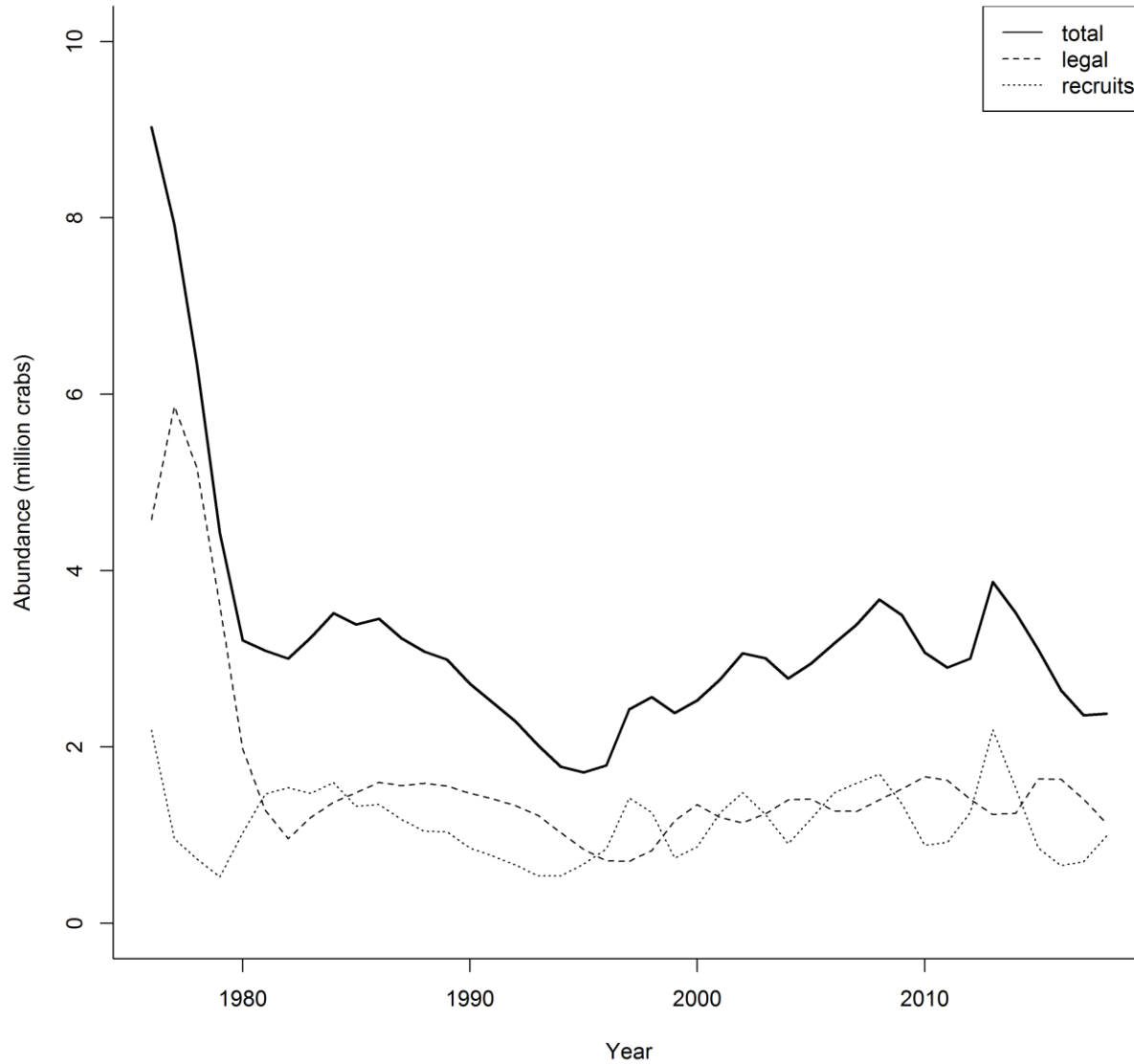
Base Model

Trawl survey crab abundance



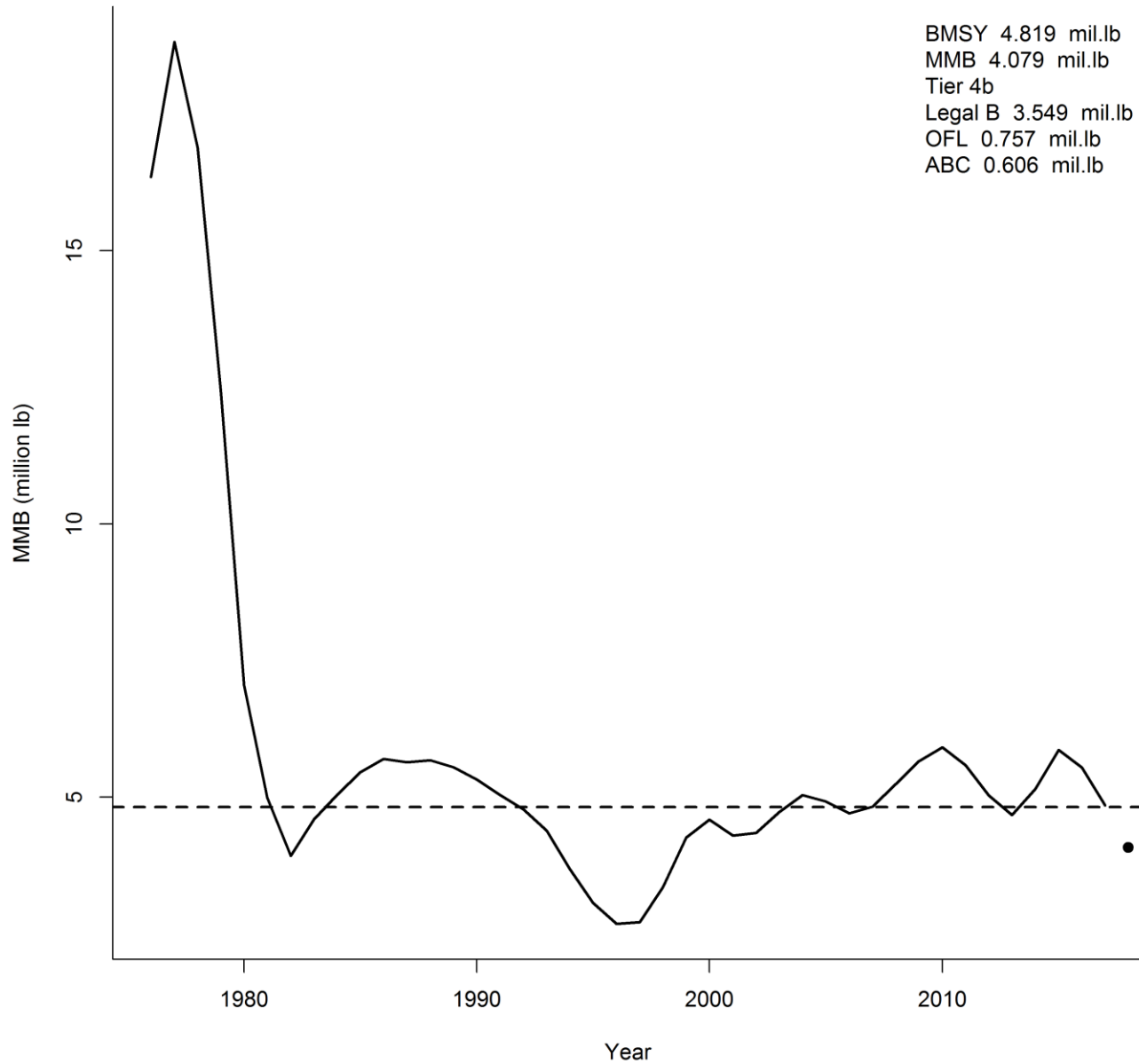
Base Model

Modeled crab abundance Feb 01



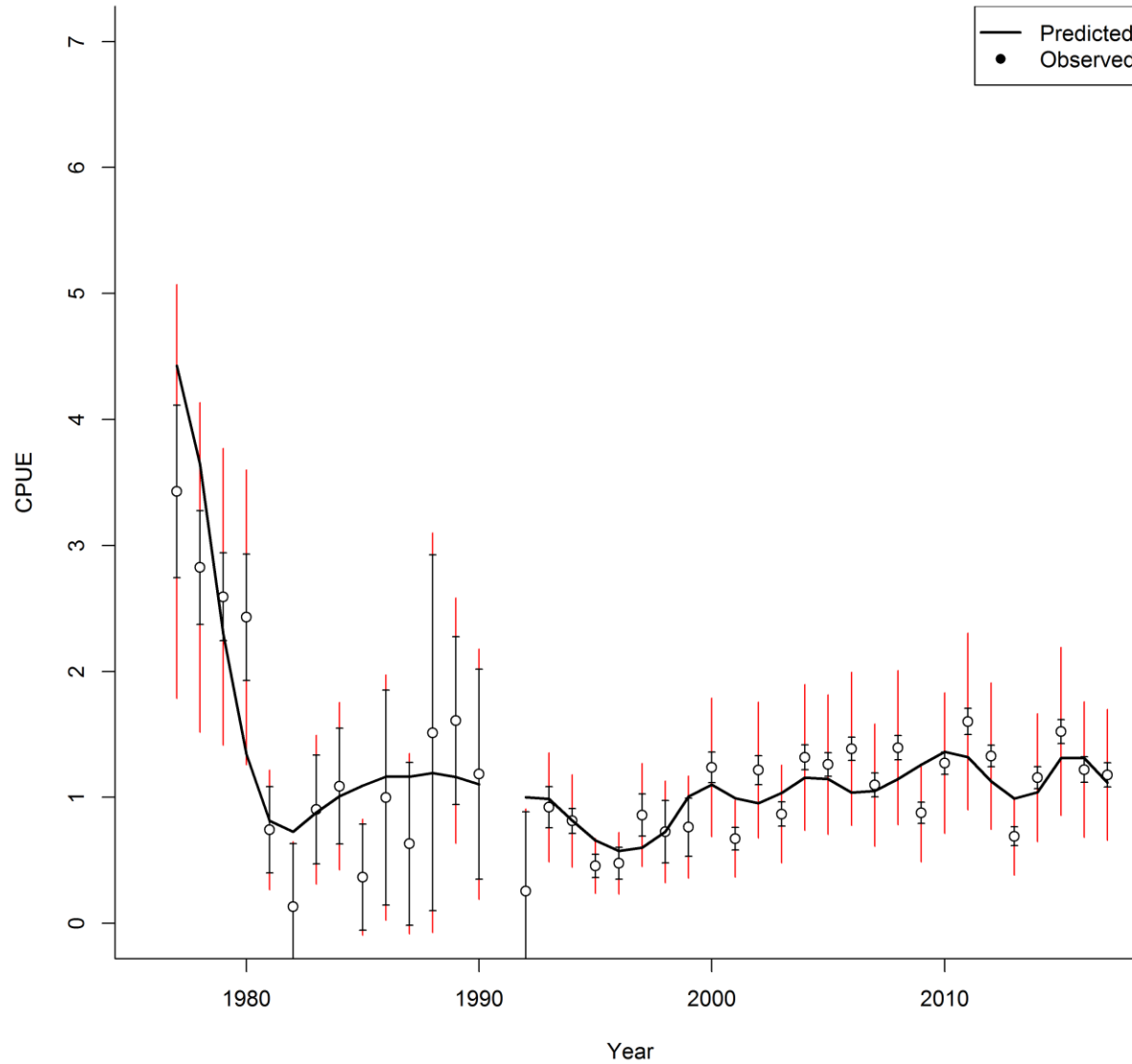
Base Model

MMB Feb 01



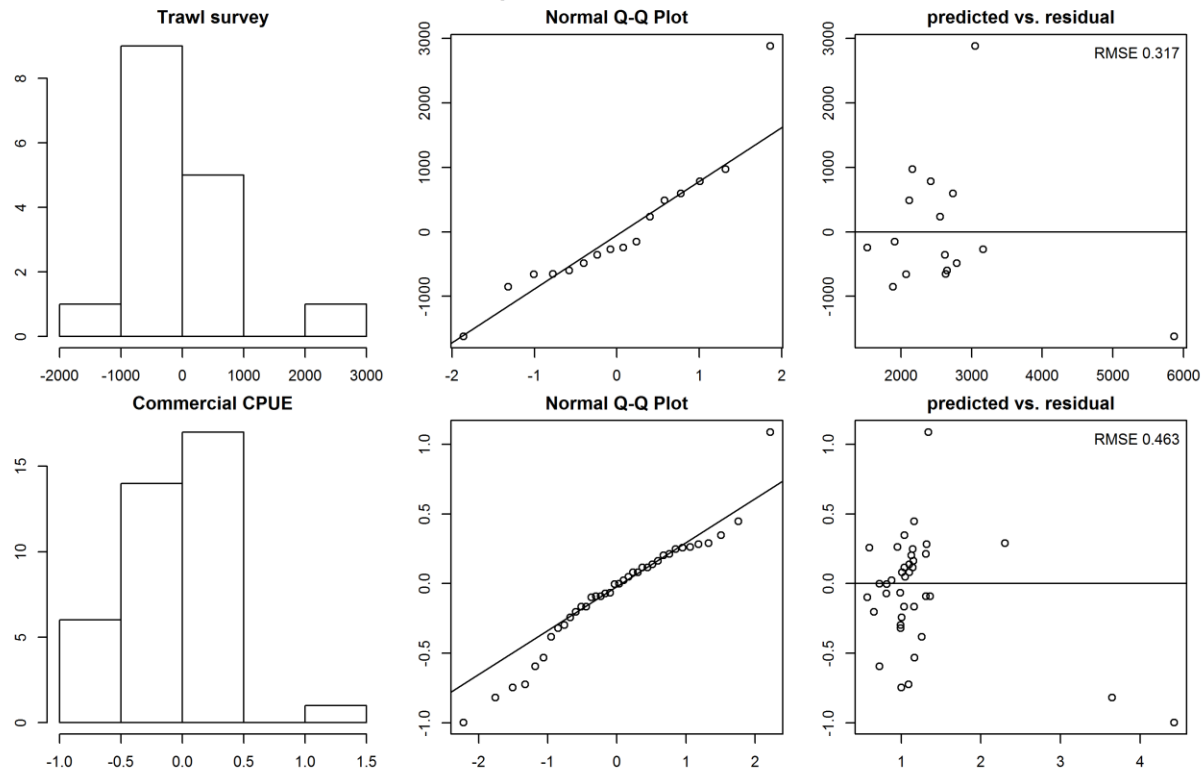
Base Model

Summer commercial standardized cpue

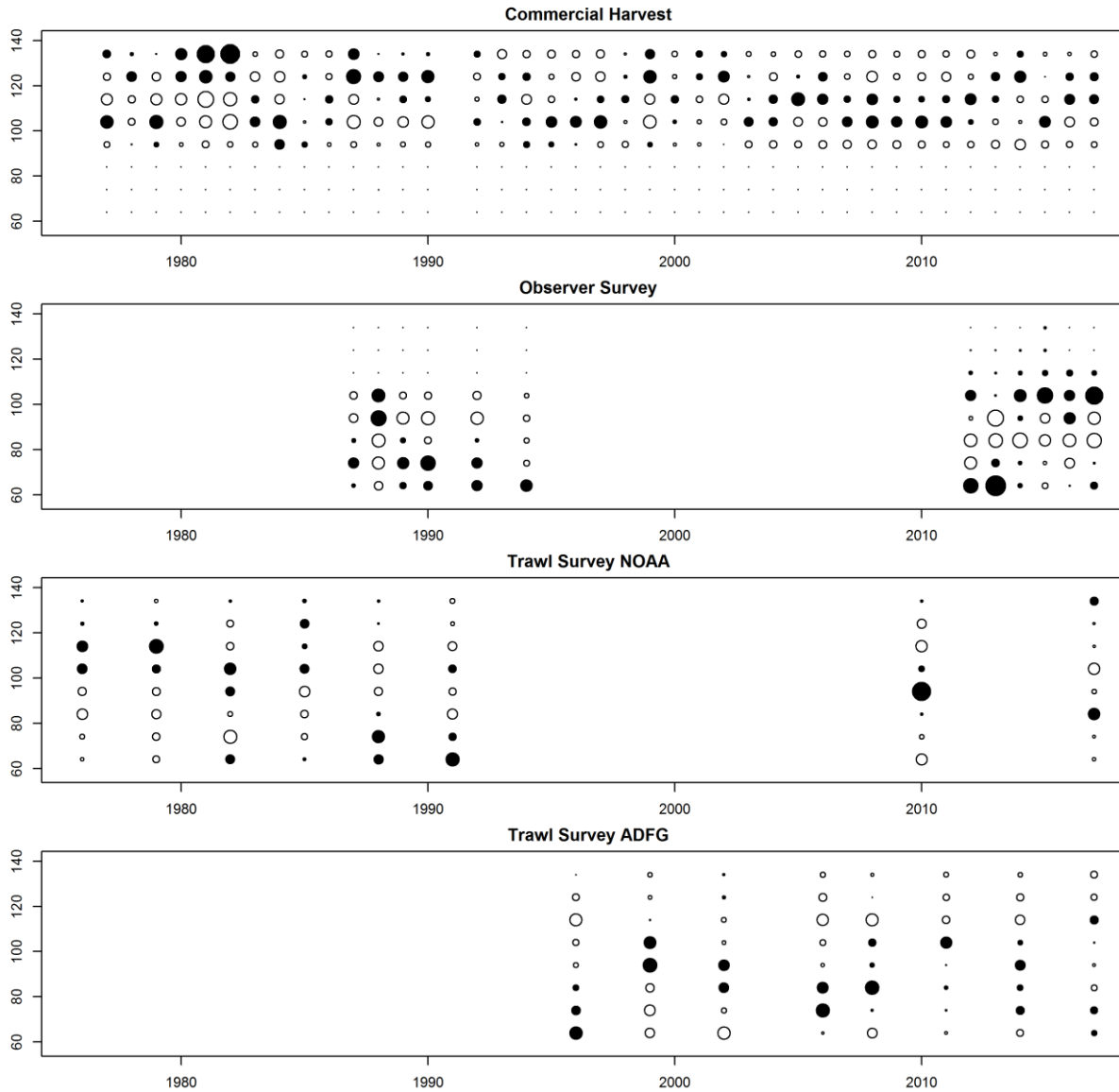


Base Model

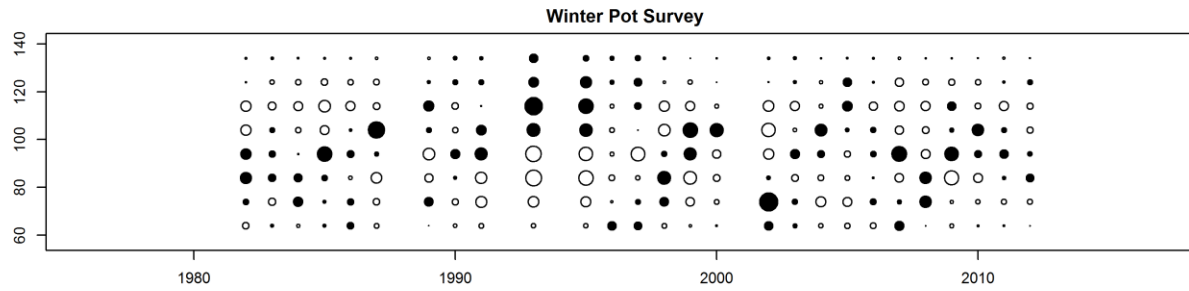
Residuals Histogram, Q-Q Plot, Predicted vs. Residual



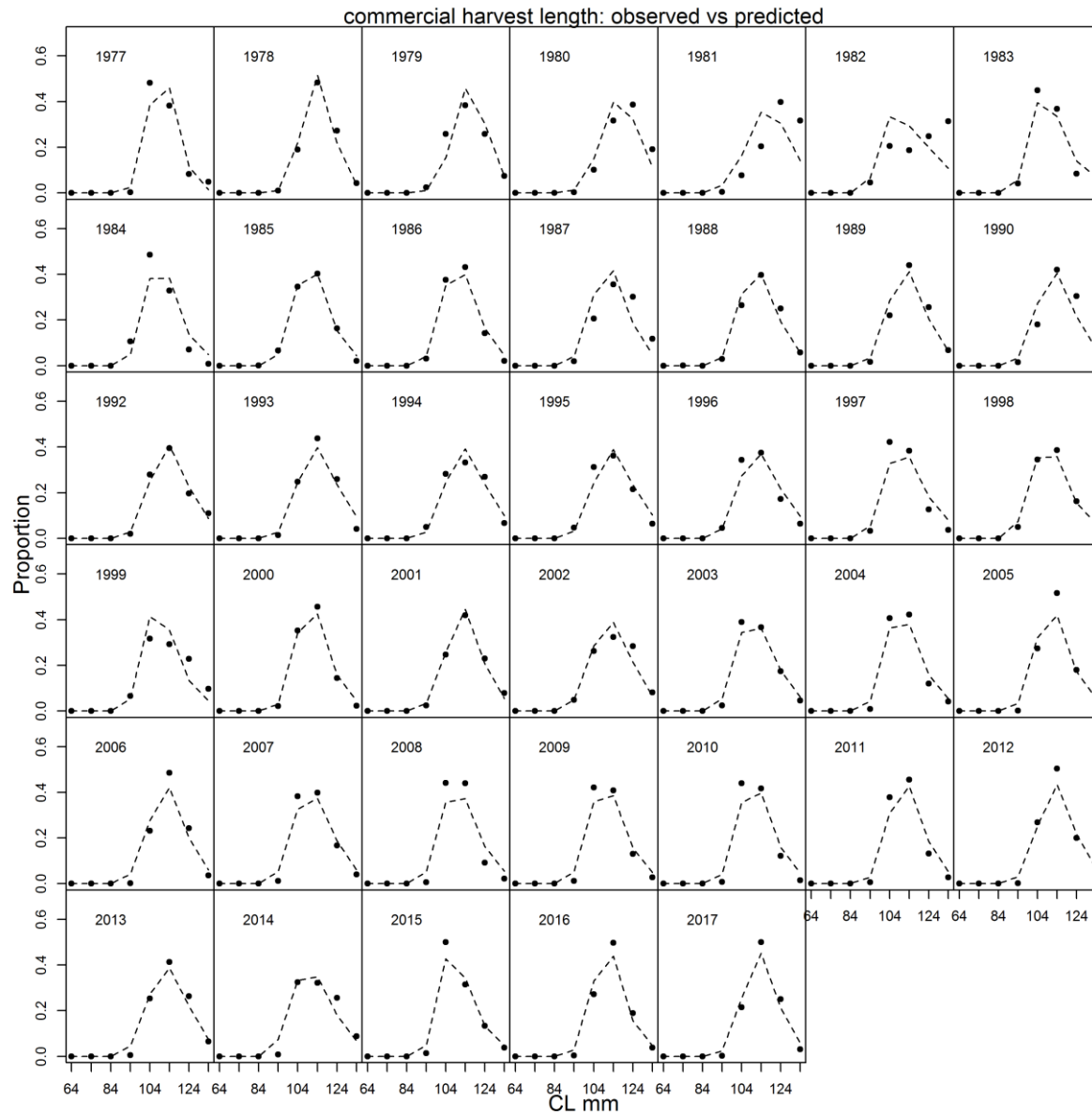
Base Model



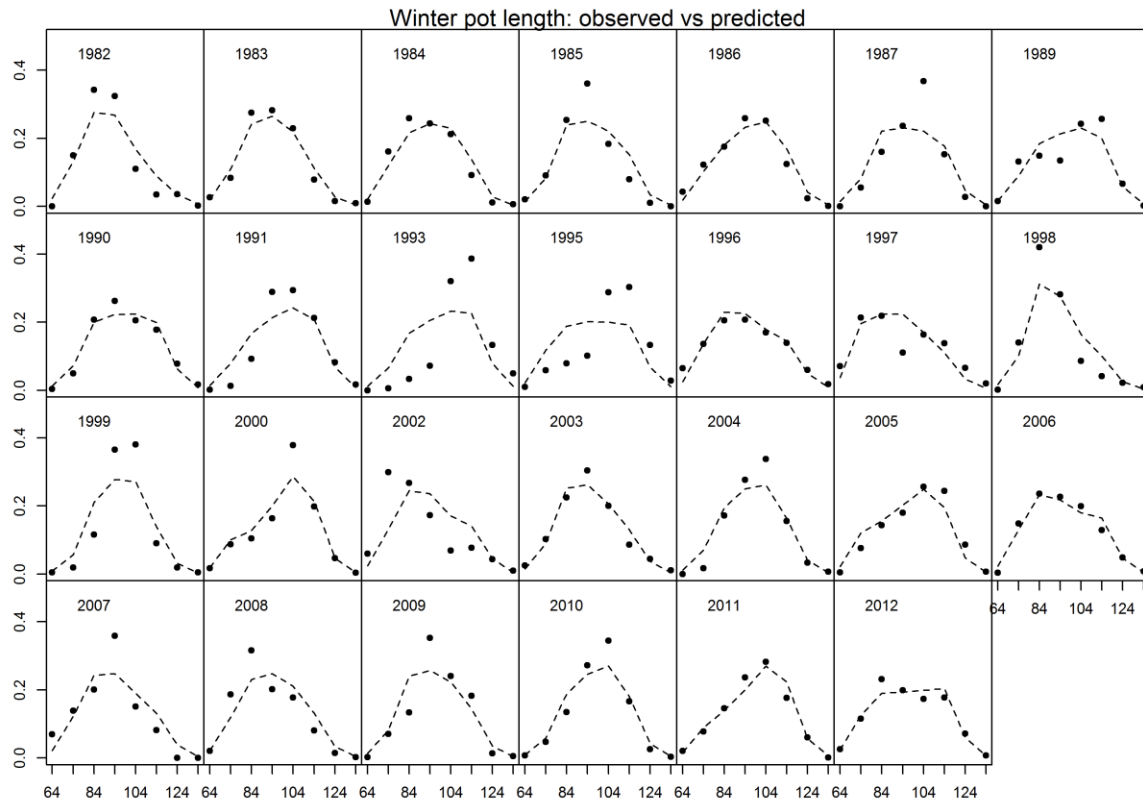
Base Model



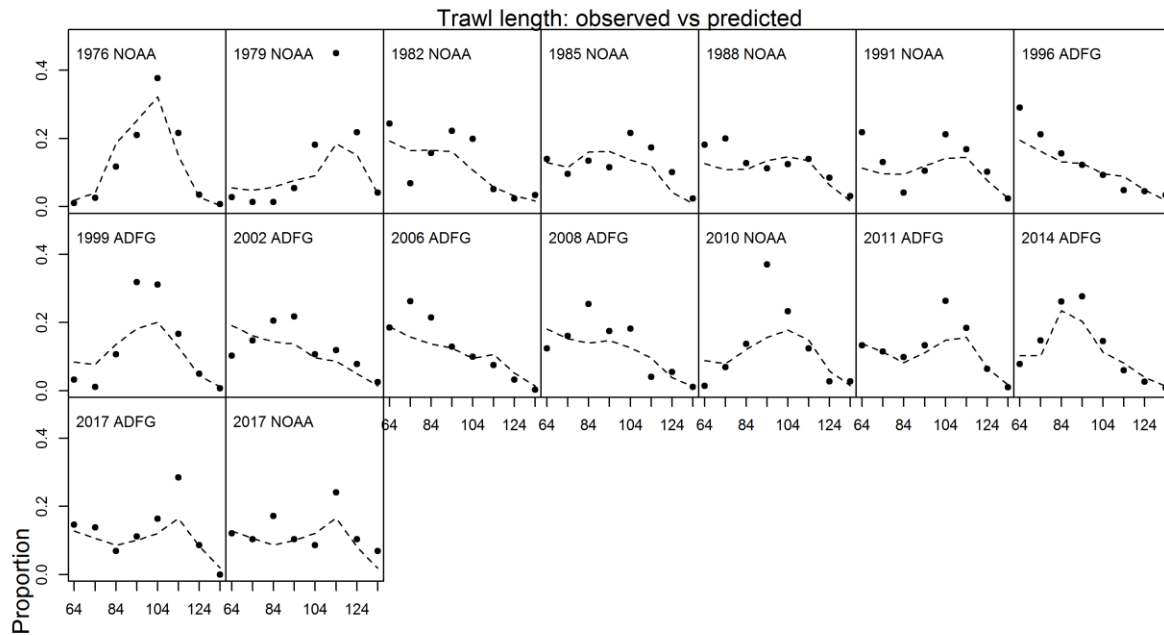
Base Model



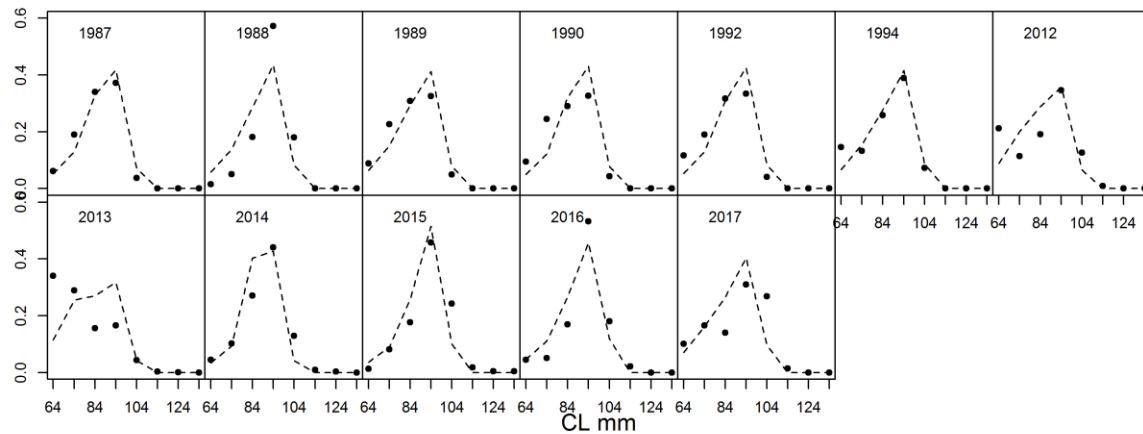
Base Model



Base Model

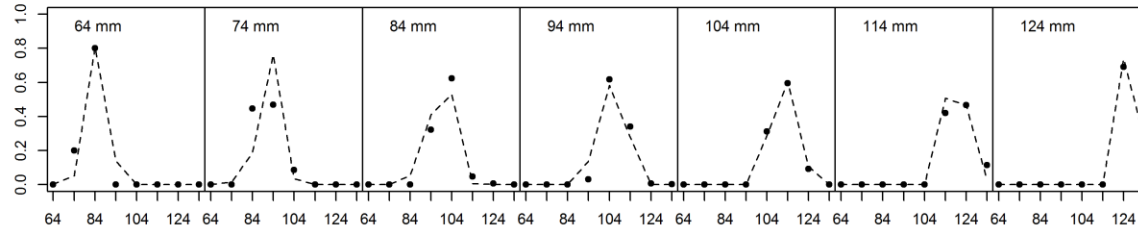


Discards length: observed vs predicted

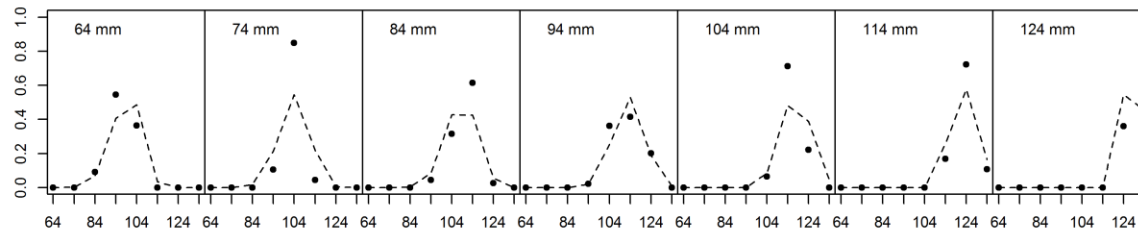


Base Model

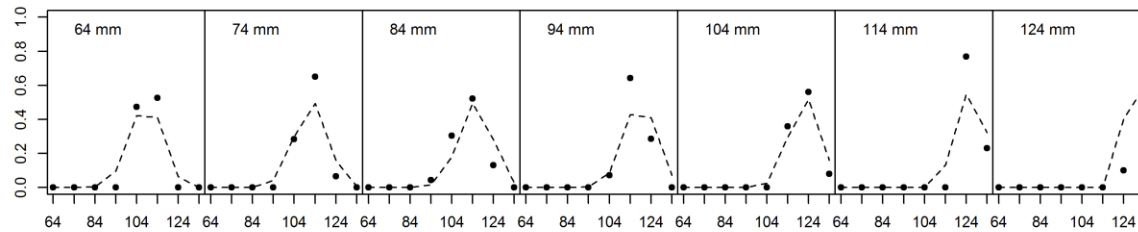
Tag recovery data observed vs predicted
Recovery after 1 year



Recovery after 2 years

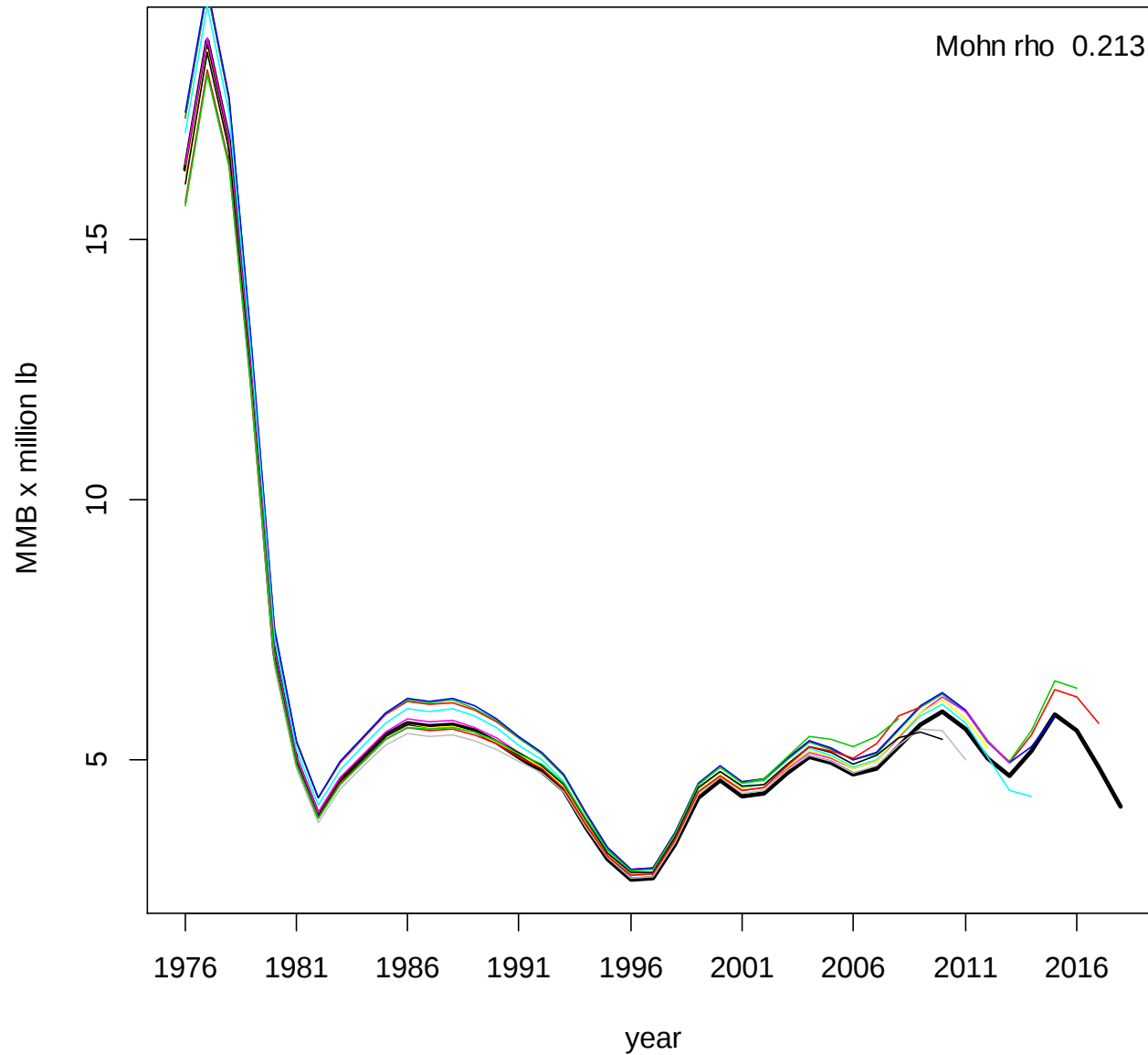


Recovery after 3 years

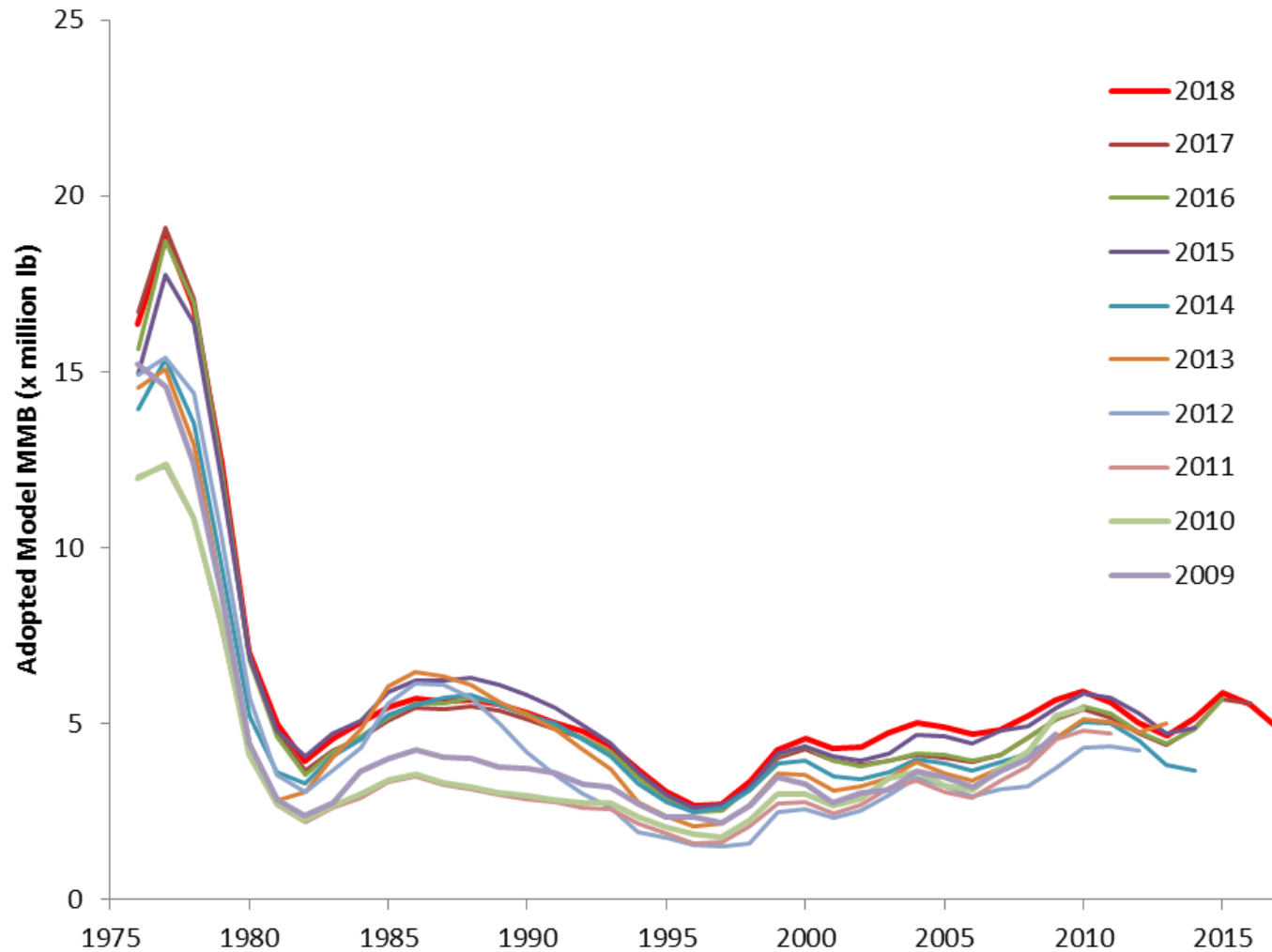


Base Model

Retrospective Analysis



Putting all together



OFL & ABC

- $B_{MSY \text{ Proxy}}$
 - Average MMB from 1980-2018 = 4.82 million lb
- MMB
 - MMB (2018) = 4.08 million lb
- $MMB < B_{MSY \text{ Proxy}}$: Tier 4b

$$F_{OFL,l} = \gamma M_l (B / B_{MSY \text{ prox}} - \alpha) / (1 - \alpha)$$

$$M_l = 0.18 \text{ (CL:63-123mm)}, 0.58 \text{ (CL: } \geq 124\text{mm)}$$

$$\gamma = 1, \alpha = 0.1$$

$$OFL_r = \sum_l \left[Legal_B_{w,l} \left(1 - e^{-(F_{OF,l} + 0.42M_l)} - (1 - e^{-0.42M_l}) \left(\frac{1 - p \cdot (1 - e^{-(F_{OFL,l} + 0.42M_l)})}{1 - p \cdot (1 - e^{-0.42M_l})} \right) \right) \right]$$

OFL & ABC

- $B_{\text{MSY Proxy}}$
 - Average MMB from 1980-2018 = 4.47 million lb
- MMB
 - MMB (2017) = 3.94 million lb
- $\text{MMB} < B_{\text{MSY Proxy}}$: Tier 4b
- Legal Male Biomass (Feb 01, 2019) : 3.55 million lb
- $\text{OFL}_r = 0.76$ million lb = 0.32 kMT

$$\text{ABC} = 0.8 * \text{OFL}_r = 0.61 \text{ million lb} = \mathbf{0.27 \text{ kMT}}$$

