Enhanced Delta Smelt Monitoring

Preliminary Abundance Analysis

DRAFT

U.S. Fish and Wildlife Service

March 31, 2017

This analysis is preliminary and the results are subject to correction and revision. The following points should be taken into consideration when interpreting the results:

1. Delta smelt caught in the wings of the net (as opposed to the live box or cod end) were excluded from this analysis. Fish caught in the wings are indicated by a Gear Condition Code of 9.
2. Abundance estimates labeled **Total** exclude any strata that were not sampled in a given week.
3. The **Week** designations used here were defined out of convenience and are subject to change.
4. Enhanced delta smelt monitoring for adults is limited to mid-channel sampling by Kodiak trawl gear. Trawl gears may not accurately index the population if a large fraction is distributed in shallow waters. Sampling locations are restricted to areas of the delta with a depth of at least 8 feet at mean tide. The abundance estimation method assumes that the density in unsampleable areas (i.e., those with depth less than 8 feet) is the same as in sampleable areas.
5. The methods of analysis used here remain in development.

Update Log

January 14, 2017

- Different abundance estimation methods were applied to Weeks 1 – 3 and Week 4 because of model convergence issues.

January 20, 2017

- A new optimization method was used to estimate abundance estimates and overcome the issues in the last report. The updated method was applied to Weeks 1 - 5 and resulted in changes to past abundance estimates, particularly in Week 4. The updated method will be used in future reports unless otherwise noted.

January 27, 2017

- The method used to calculate confidence intervals in Table 2 was updated.
- Maps of average delta smelt catch densities by site were added.
- An abundance time series figure was added.
- An update log was added to reflect major changes made to this report between weeks.

February 3, 2017

- Sampling was cut short by fog and high winds, resulting in fewer sites in the "High Risk, Low Density" stratum than originally scheduled.

February 10, 2017 (End of Week 8)

- Previous reports incorrectly indicated that a total of 6 sites were visited in the "High Risk, Low Density" stratum during Week 4. The correct total is 7.
- Corrections to sample volumes have resulted in minor changes to abundance estimates from previous weeks.

February 17, 2017 (End of Week 9)

- Tables 3 and 4 were added.
- A minor correction was made to the confidence interval calculations for proportions.
- Sampling in the eastern portion of the "Low Risk, Low Density" stratum was limited due to flooding.

February 24, 2017 (End of Week 10)

- There is a discrepancy in the Week 8 abudandance estimates relative to previous reports. The cause is unknown.

March 3, 2017 (End of Week 11)

- The Week 8 issue from the last report was resolved. An incorrect number of maximum possible tows was being used in the low density strata calculations (10 was being used when it should have been 8). The reports from Weeks 8 and 9 used the incorrect value.

March 10, 2017 (End of Week 12)

- The EDSM caught only 4 delta smelt between 3/6 and 3/9. Low catches suggest either a very large, unlikely mortality event or, more likely, that the adult population has redistributed into shallow waters where they are unavailable to Kodiak trawl gear.

March 17, 2017 (End of Week 13)

- Results from past weeks have changed as a result of corrections to the database. The model results are sensitive to changes in input data, indicating that further refinements are needed.

March 24, 2017 (End of Week 14)

- Sampling was impacted by weather on Tuesday 3/21. Make-up sampling is scheduled for Friday 3/24.

March 31, 2017 (End of Week 15)

- Make-up sampling from 3/24 (Week 14) has been included in the estimates for Week 15 for consistency with what was done in previous reports.

Table 1: Abundance estimates by week. *No delta smelt were caught.

				Estimate and 95% CI		
Week	**Dates**	**Stratum**	**Num of Sites**	**Abundance**	**Lower Bound**	**Upper Bound**
1	Dec 15 - Dec 22	High Risk, High Density	12	3,446	1,200	7,861
		High Risk, Low Density	0	NA	NA	NA
		Low Risk, High Density	11	91,923	44,348	169,498
		Low Risk, Low Density	0	NA	NA	NA
		Total	23	95,369	47,213	172,672
2	Dec 27 - Dec 29	High Risk, High Density	10	11,243	5,403	20,786
		High Risk, Low Density	0	NA	NA	NA
		Low Risk, High Density	6	471,226	182,731	1,005,649

Table 1: Abundance estimates by week. *No delta smelt were caught.

				Estimate and 95% CI		
Week	**Dates**	**Stratum**	**Num of Sites**	**Abundance**	**Lower Bound**	**Upper Bound**
		Low Risk, Low Density	0	NA	NA	NA
		Total	16	482,468	191,249	1,015,259
3	Dec 30 - Jan 5	High Risk, High Density	15	24,350	13,618	40,326
		High Risk, Low Density	0	NA	NA	NA
		Low Risk, High Density	9	137,290	47,331	315,165
		Low Risk, Low Density	0	NA	NA	NA
		Total	24	161,640	65,125	336,588
4	Jan 6 - Jan 12	High Risk, High Density	11	2,495	884	5,633
		High Risk, Low Density	7	3,877	1,173	9,606
		Low Risk, High Density	3	253,743	83,929	597,118
		Low Risk, Low Density	0	NA	NA	NA
		Total	21	260,115	88,351	602,494
5	Jan 17 - Jan 19	High Risk, High Density	8	3,705	901	10,339
		High Risk, Low Density	0	NA	NA	NA
		Low Risk, High Density	8	70,983	26,418	155,463
		Low Risk, Low Density	0	NA	NA	NA
		Total	16	74,688	29,116	158,855
6	Jan 23 - Jan 26	High Risk, High Density	11	1,909	578	4,729
		High Risk, Low Density	0	NA	NA	NA
		Low Risk, High Density	12	115,339	48,069	234,929
		Low Risk, Low Density	0	NA	NA	NA
		Total	23	117,248	49,561	236,597
7	Jan 30 - Feb 2	High Risk, High Density	6	1,066	148	3,854
		High Risk, Low Density	2	0*	NA	NA
		Low Risk, High Density	6	62,769	9,971	214,211
		Low Risk, Low Density	7	6,619	1,037	22,726
		Total	21	70,454	13,274	222,822
8	Feb 6 - Feb 9	High Risk, High Density	6	3,353	786	9,536
		High Risk, Low Density	7	0*	NA	NA
		Low Risk, High Density	7	71,173	24,459	163,698
		Low Risk, Low Density	6	18,662	6,827	41,312
		Total	26	93,187	40,165	185,626
9	Feb 10 - Feb 16	High Risk, High Density	10	984	46	5,012
		High Risk, Low Density	7	0*	NA	NA
		Low Risk, High Density	7	0*	NA	NA
		Low Risk, Low Density	10	15,906	6,219	33,768
		Total	34	16,890	6,798	35,194
10	Feb 21 - Feb 23	High Risk, High Density	7	0*	NA	NA
		High Risk, Low Density	3	0*	NA	NA
		Low Risk, High Density	4	17,552	2,432	63,414
		Low Risk, Low Density	8	20,129	7,354	44,596

Table 1: Abundance estimates by week. *No delta smelt were caught.

				Estimate and 95% CI		
Week	**Dates**	**Stratum**	**Num of Sites**	**Abundance**	**Lower Bound**	**Upper Bound**
		Total	22	37,681	12,488	88,569
11	Feb 24 - Mar 2	High Risk, High Density	6	0*	NA	NA
		High Risk, Low Density	13	839	87	3,381
		Low Risk, High Density	11	14,271	2,397	47,533
		Low Risk, Low Density	14	11,012	5,032	21,086
		Total	44	26,122	9,038	59,839
12	Mar 6 - Mar 9	High Risk, High Density	8	1,715	402	4,875
		High Risk, Low Density	8	1,432	198	5,177
		Low Risk, High Density	8	0*	NA	NA
		Low Risk, Low Density	11	1,290	149	5,006
		Total	35	4,437	1,472	10,424
13	Mar 13 - Mar 16	High Risk, High Density	8	751	76	3,057
		High Risk, Low Density	8	0*	NA	NA
		Low Risk, High Density	9	0*	NA	NA
		Low Risk, Low Density	8	15,021	4,203	38,898
		Total	33	15,773	4,654	39,651
14	Mar 20 - Mar 23	High Risk, High Density	7	0*	NA	NA
		High Risk, Low Density	7	0*	NA	NA
		Low Risk, High Density	6	0*	NA	NA
		Low Risk, Low Density	9	0*	NA	NA
		Total	29	0*	NA	NA
15	Mar 24 - Mar 30	High Risk, High Density	6	0*	NA	NA
		High Risk, Low Density	9	0*	NA	NA
		Low Risk, High Density	3	0*	NA	NA
		Low Risk, Low Density	6	2,594	268	10,471
		Total	24	2,594	268	10,471

Tables 2 - 4 show various proportion estimates. In the captions HH, HL, LH, and LL are used to represent the "High Risk, High Density", "High Risk, Low Density", "Low Risk, High Density", and "Low Risk, Low Density" strata respectively, and $\hat{n}_{HH}$, $\hat{n}_{HL}$, $\hat{n}_{LH}$, and $\hat{n}_{LL}$ are used to represent abundance estimates in the indicated strata.

Table 2: Proportion of delta smelt in high density areas that are also in high risk areas, $\hat{p}_{HH} = \frac{\hat{n}_{HH}}{\hat{n}_{HH}+\hat{n}_{LH}}$, and proportion in high density areas that are also in low risk areas, $\hat{p}_{LH} = \frac{\hat{n}_{LH}}{\hat{n}_{HH}+\hat{n}_{LH}}$.

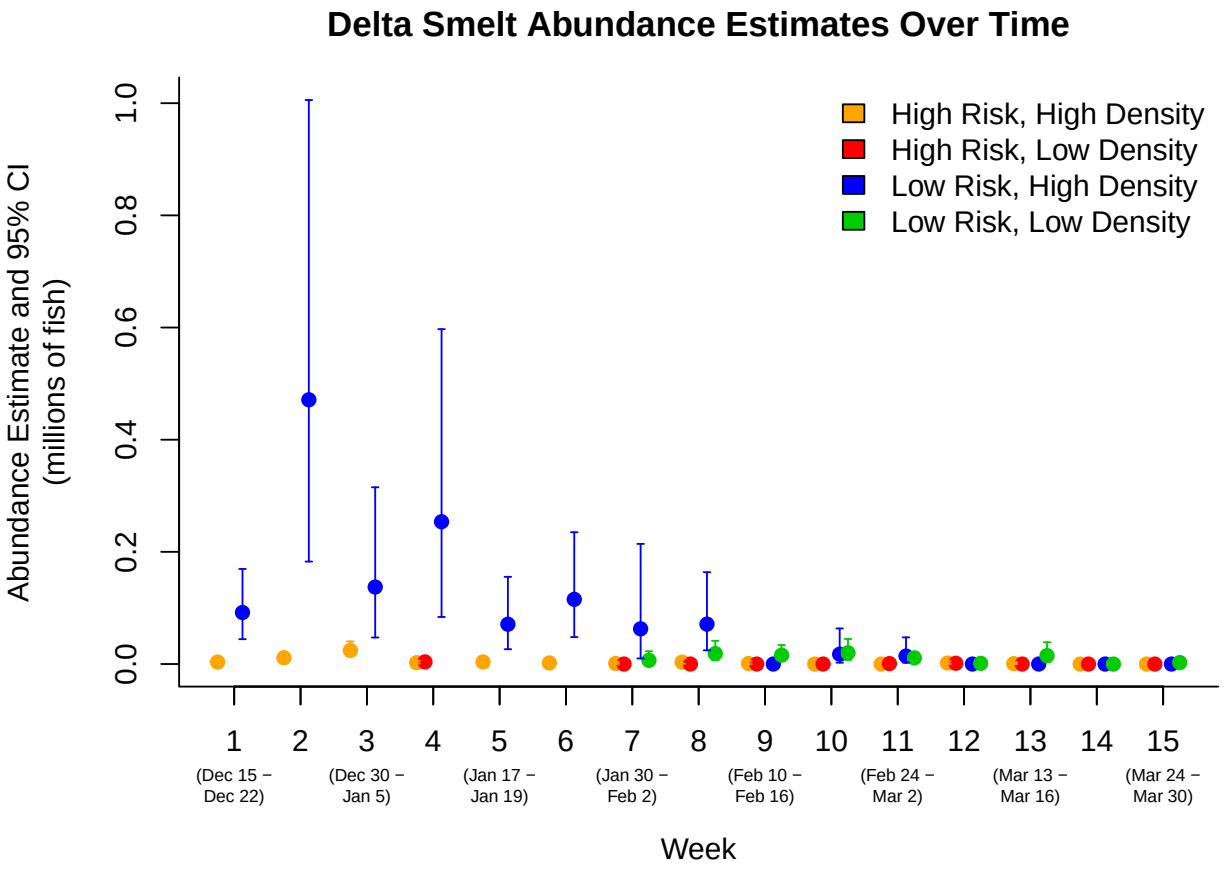
		$\hat{p}_{HH}$ **Estimate and 95% CI**			$\hat{p}_{LH}$ **Estimate and 95% CI**		
Week	**Dates**	**Proportion**	**Lower Bound**	**Upper Bound**	**Proportion**	**Lower Bound**	**Upper Bound**
1	Dec 15 - Dec 22	0.036	0.011	0.101	0.964	0.899	0.989
2	Dec 27 - Dec 29	0.023	0.008	0.068	0.977	0.932	0.992
3	Dec 30 - Jan 5	0.151	0.06	0.364	0.849	0.636	0.94
4	Jan 6 - Jan 12	0.01	0.003	0.037	0.99	0.963	0.997
5	Jan 17 - Jan 19	0.05	0.01	0.177	0.95	0.823	0.99
6	Jan 23 - Jan 26	0.016	0.004	0.055	0.984	0.945	0.996
7	Jan 30 - Feb 2	0.017	0.002	0.133	0.983	0.867	0.998
8	Feb 6 - Feb 9	0.045	0.009	0.172	0.955	0.828	0.991
9	Feb 10 - Feb 16	1	NA	NA	0	NA	NA
10	Feb 21 - Feb 23	0	NA	NA	1	NA	NA
11	Feb 24 - Mar 2	0	NA	NA	1	NA	NA
12	Mar 6 - Mar 9	1	NA	NA	0	NA	NA
13	Mar 13 - Mar 16	1	NA	NA	0	NA	NA
14	Mar 20 - Mar 23	NA	NA	NA	NA	NA	NA
15	Mar 24 - Mar 30	NA	NA	NA	NA	NA	NA

Table 3: Proportion of delta smelt in each stratum. For stratum i this is given by $\hat{p}_i = \frac{\hat{n}_i}{\hat{n}_{HH}+\hat{n}_{HL}+\hat{n}_{LH}+\hat{n}_{LL}}$. Weeks with one or more missing strata are omitted.

			Estimate and 95% CI		
Week	**Dates**	**Stratum**	**Proportion**	**Lower Bound**	**Upper Bound**
7	Jan 30 - Feb 2	High Risk, High Density	0.015	0.002	0.11
		High Risk, Low Density	0	NA	NA
		Low Risk, High Density	0.891	0.494	0.984
		Low Risk, Low Density	0.094	0.012	0.471
8	Feb 6 - Feb 9	High Risk, High Density	0.036	0.007	0.126
		High Risk, Low Density	0	NA	NA
		Low Risk, High Density	0.764	0.475	0.915
		Low Risk, Low Density	0.2	0.065	0.476
9	Feb 10 - Feb 16	High Risk, High Density	0.058	0.003	0.286
		High Risk, Low Density	0	NA	NA
		Low Risk, High Density	0	NA	NA
		Low Risk, Low Density	0.942	0.714	0.997
10	Feb 21 - Feb 23	High Risk, High Density	0	NA	NA
		High Risk, Low Density	0	NA	NA
		Low Risk, High Density	0.466	0.096	0.815
		Low Risk, Low Density	0.534	0.185	0.904
11	Feb 24 - Mar 2	High Risk, High Density	0	NA	NA
		High Risk, Low Density	0.032	0.003	0.162
		Low Risk, High Density	0.546	0.156	0.832
		Low Risk, Low Density	0.422	0.152	0.815
12	Mar 6 - Mar 9	High Risk, High Density	0.386	0.096	0.795
		High Risk, Low Density	0.323	0.052	0.742
		Low Risk, High Density	0	NA	NA
		Low Risk, Low Density	0.291	0.039	0.716
13	Mar 13 - Mar 16	High Risk, High Density	0.048	0.004	0.246
		High Risk, Low Density	0	NA	NA
		Low Risk, High Density	0	NA	NA
		Low Risk, Low Density	0.952	0.754	0.996
15	Mar 24 - Mar 30	High Risk, High Density	0	NA	NA
		High Risk, Low Density	0	NA	NA
		Low Risk, High Density	0	NA	NA
		Low Risk, Low Density	1	NA	NA

Table 4: Proportion of delta smelt in high risk strata, $\hat{p}_{HR} = \frac{\hat{n}_{HH}+\hat{n}_{HL}}{\hat{n}_{HH}+\hat{n}_{HL}+\hat{n}_{LH}+\hat{n}_{LL}}$, and proportion in low risk strata, $\hat{p}_{LR} = \frac{\hat{n}_{LH}+\hat{n}_{LL}}{\hat{n}_{HH}+\hat{n}_{HL}+\hat{n}_{LH}+\hat{n}_{LL}}$. Weeks with one or more missing strata are omitted.

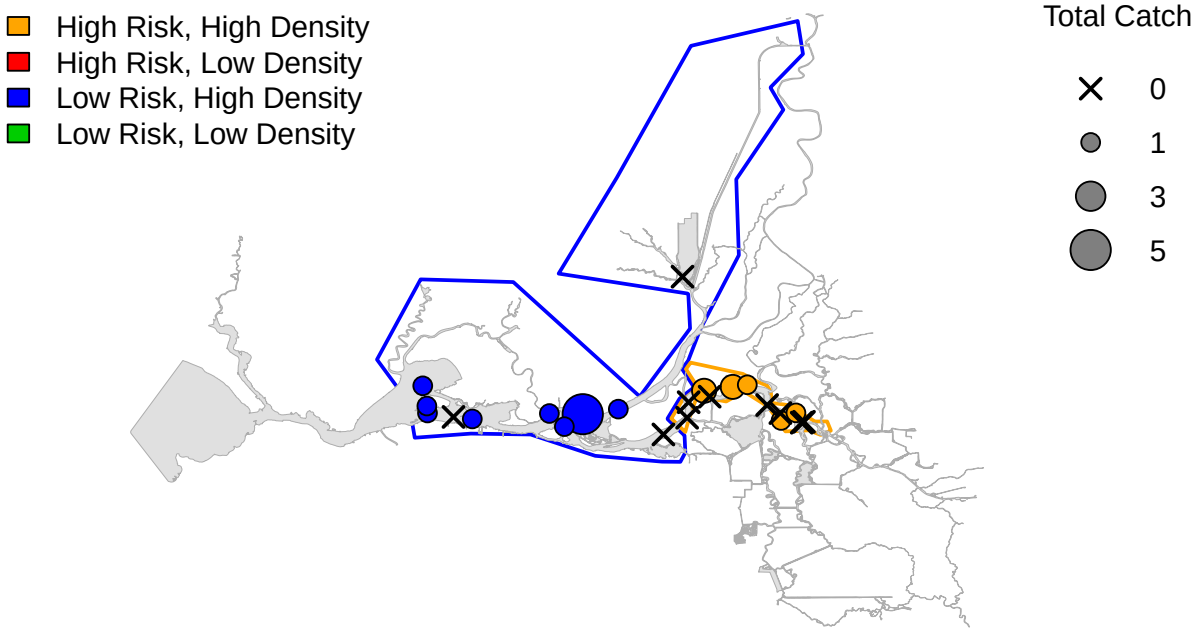
		$\hat{p}_{HR}$ **Estimate and 95% CI**			$\hat{p}_{LR}$ **Estimate and 95% CI**		
Week	**Dates**	**Proportion**	**Lower Bound**	**Upper Bound**	**Proportion**	**Lower Bound**	**Upper Bound**
7	Jan 30 - Feb 2	0.015	0.002	0.11	0.985	0.89	0.998
8	Feb 6 - Feb 9	0.036	0.007	0.126	0.964	0.874	0.993
9	Feb 10 - Feb 16	0.058	0.003	0.286	0.942	0.714	0.997
10	Feb 21 - Feb 23	0	NA	NA	1	NA	NA
11	Feb 24 - Mar 2	0.032	0.003	0.162	0.968	0.838	0.997
12	Mar 6 - Mar 9	0.709	0.284	0.961	0.291	0.039	0.716
13	Mar 13 - Mar 16	0.048	0.004	0.246	0.952	0.754	0.996
15	Mar 24 - Mar 30	0	NA	NA	1	NA	NA


Delta Smelt Abundance Estimates Over Time
High Risk, High Density
High Risk, Low Density
Low Risk, High Density
Low Risk, Low Density
Abundance Estimate and 95% CI
(millions of fish)
0.0
0.2
0.4
0.6
0.8
1.0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
(Dec 15 − Dec 22)
(Dec 30 − Jan 5)
(Jan 17 − Jan 19)
(Jan 30 − Feb 2)
(Feb 10 − Feb 16)
(Feb 24 − Mar 2)
(Mar 13 − Mar 16)
(Mar 24 − Mar 30)
Week

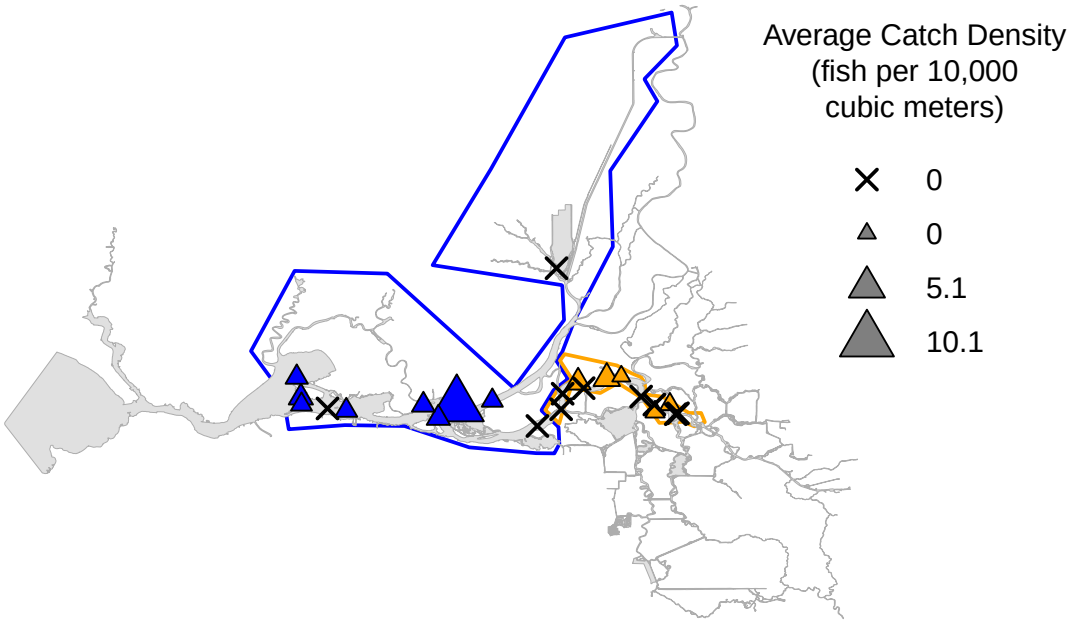
Week 1 (12/15/16 – 12/22/16)

23 sites; 19 Delta Smelt total

Delta Smelt Total Catch by Site



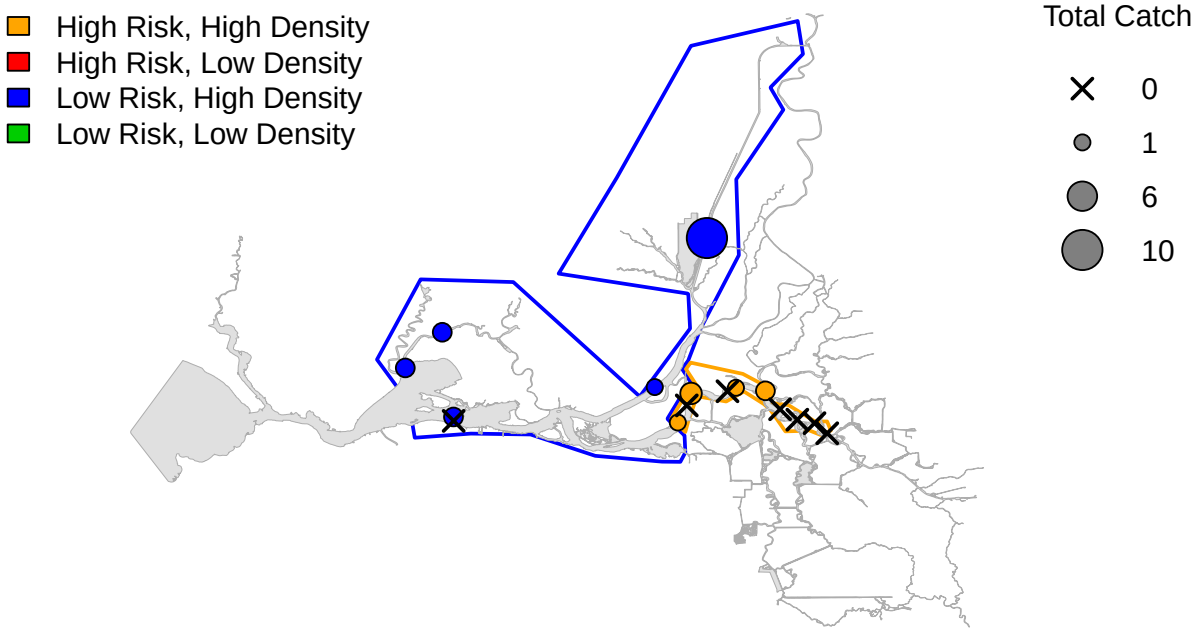
Delta Smelt Average Catch Density by Site



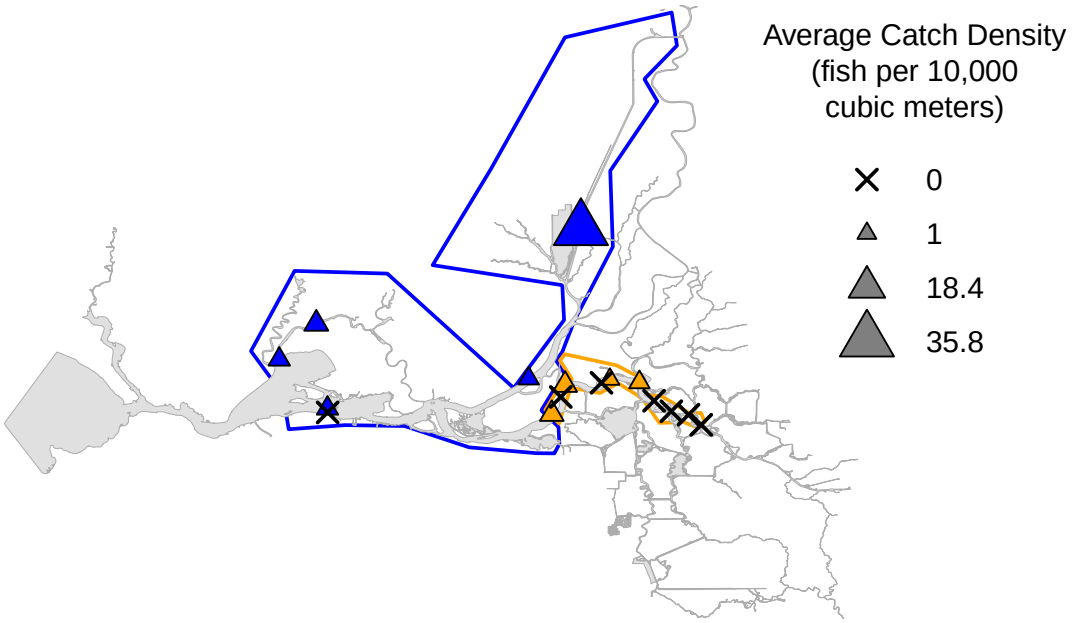
Week 2 (12/27/16 – 12/29/16)

16 sites; 24 Delta Smelt total

Delta Smelt Total Catch by Site



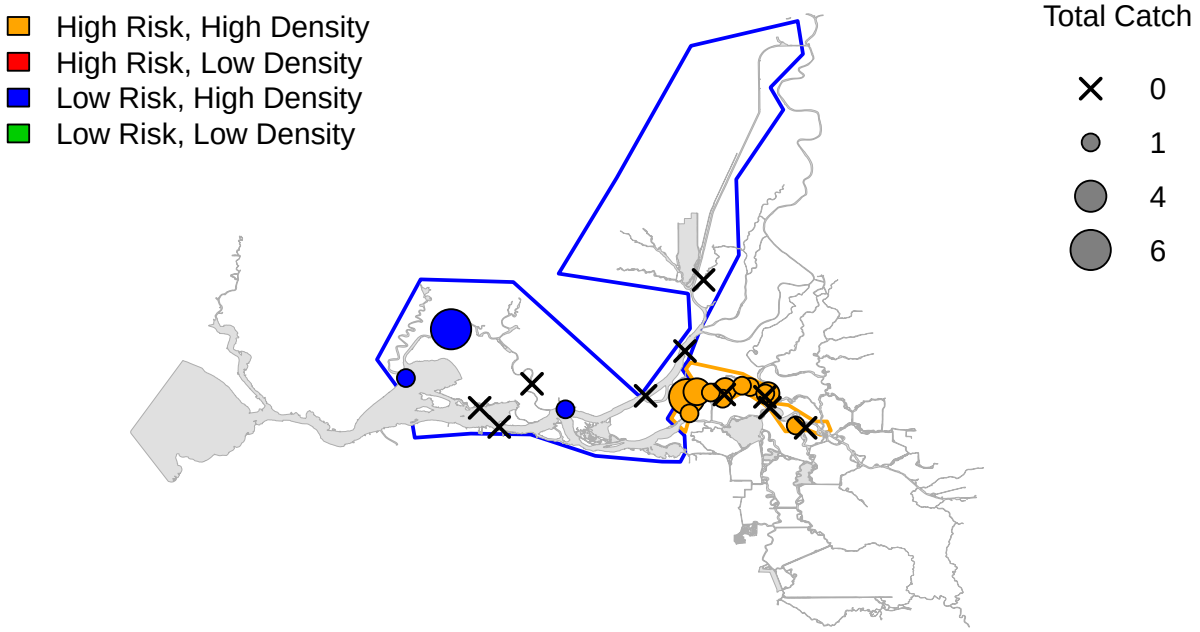
Delta Smelt Average Catch Density by Site



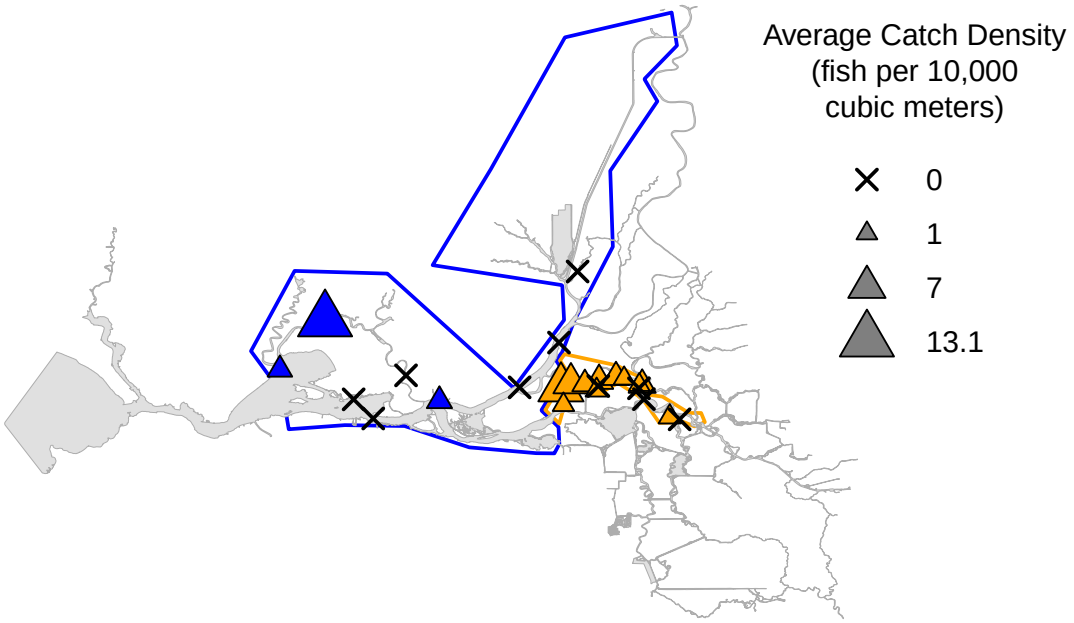
Week 3 (12/30/16 – 1/5/17)

24 sites; 27 Delta Smelt total

Delta Smelt Total Catch by Site



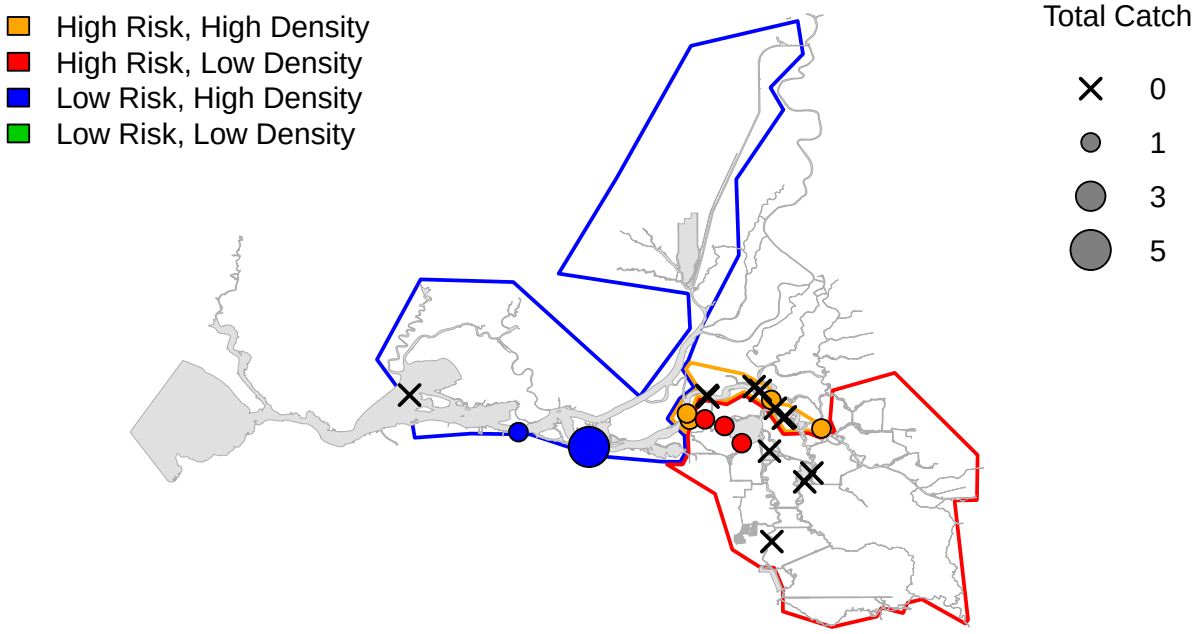
Delta Smelt Average Catch Density by Site



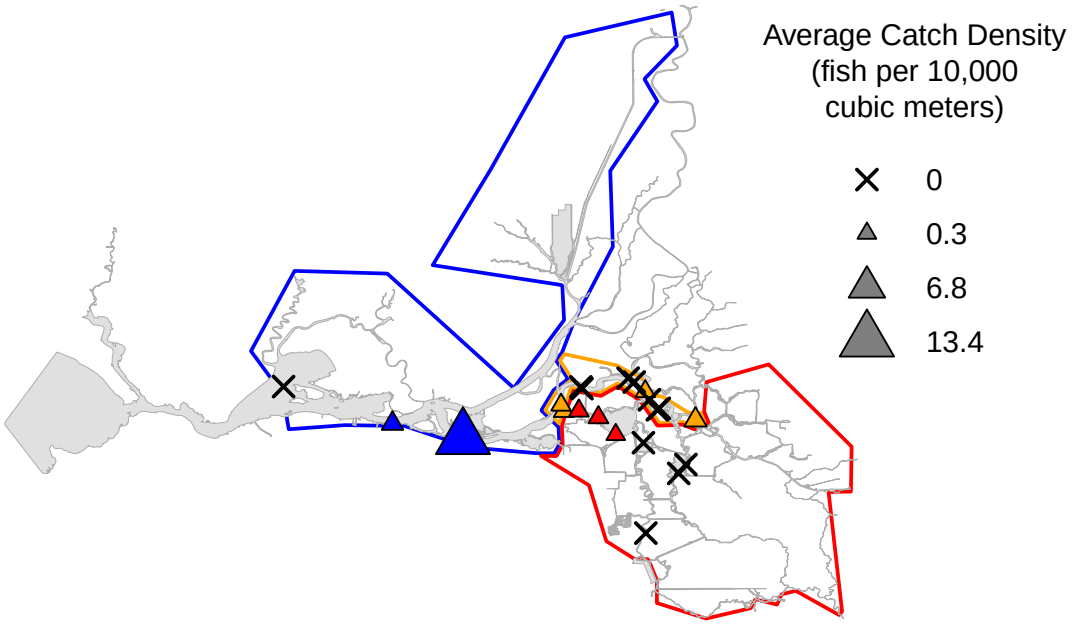
Week 4 (1/6/17 – 1/12/17)

21 sites; 13 Delta Smelt total

Delta Smelt Total Catch by Site



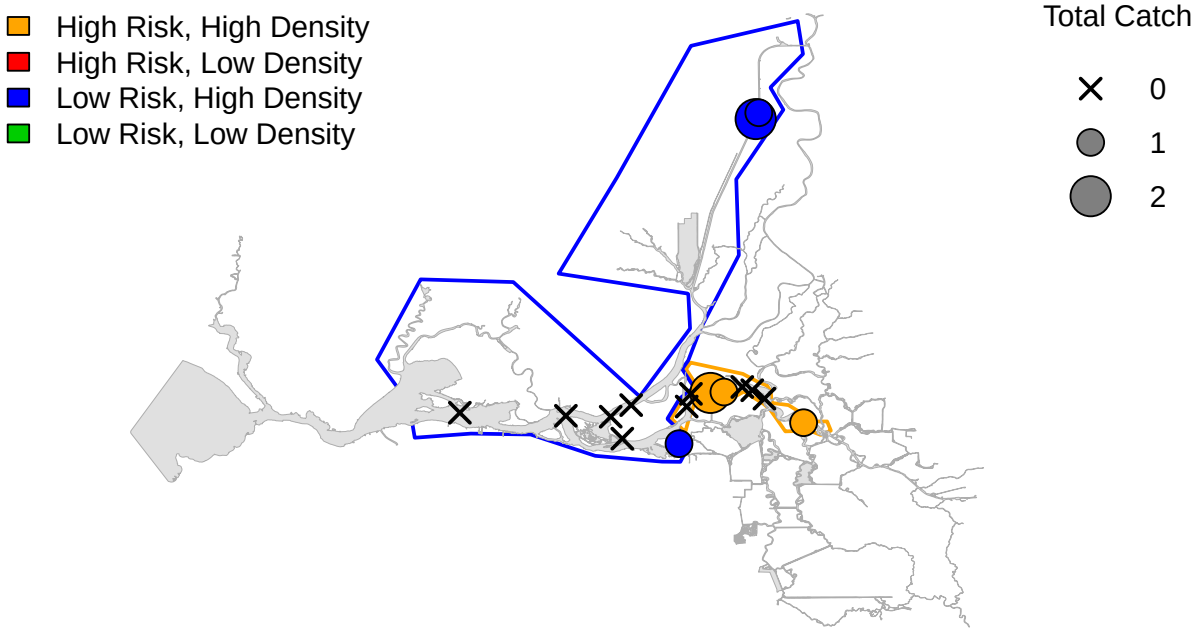
Delta Smelt Average Catch Density by Site



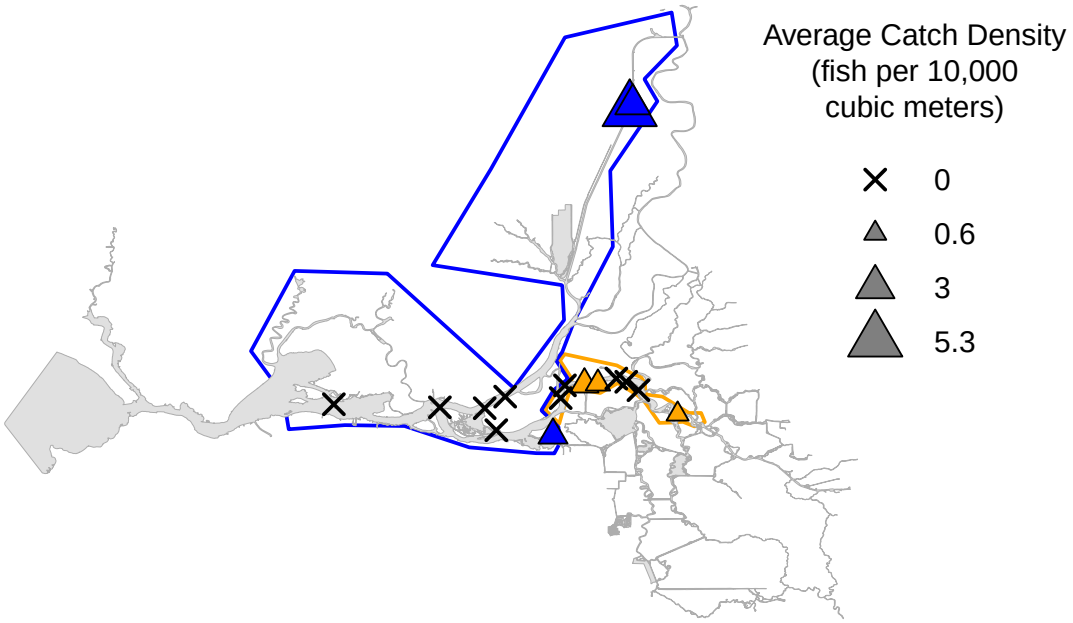
Week 5 (1/17/17 − 1/19/17)

16 sites; 8 Delta Smelt total

Delta Smelt Total Catch by Site



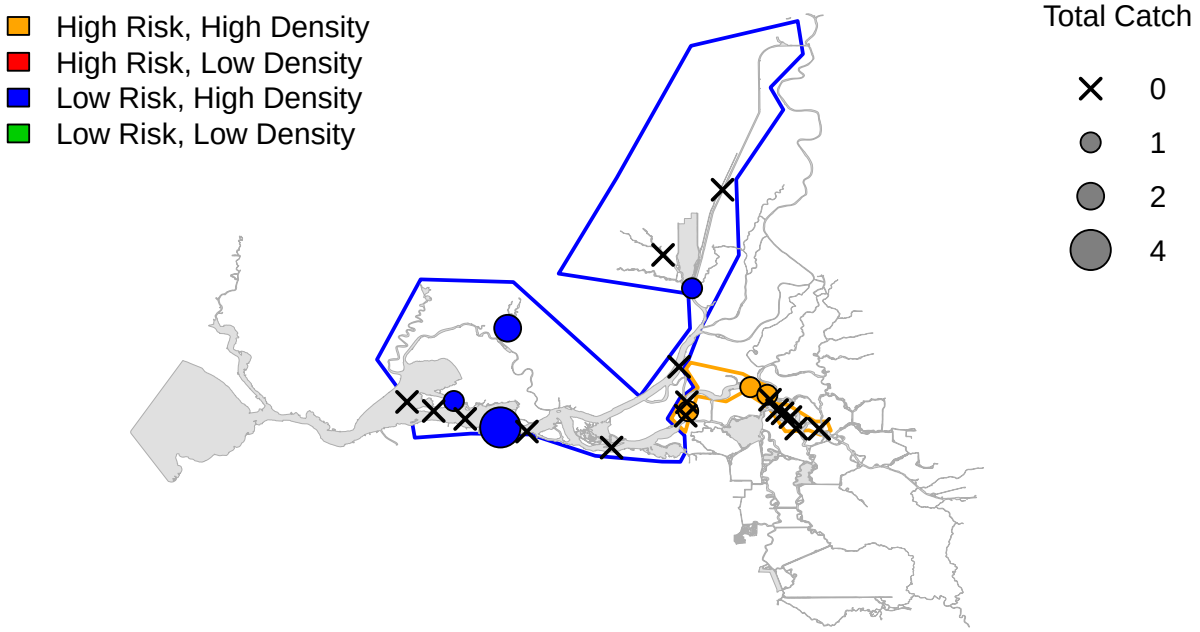
Delta Smelt Average Catch Density by Site



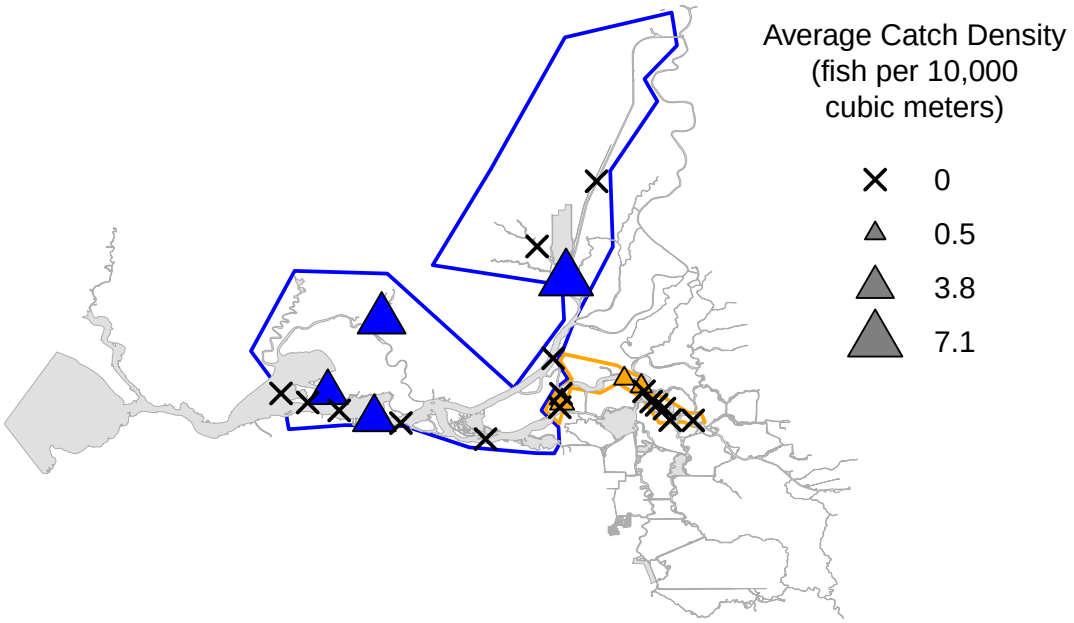
Week 6 (1/23/17 − 1/26/17)

23 sites; 11 Delta Smelt total

Delta Smelt Total Catch by Site



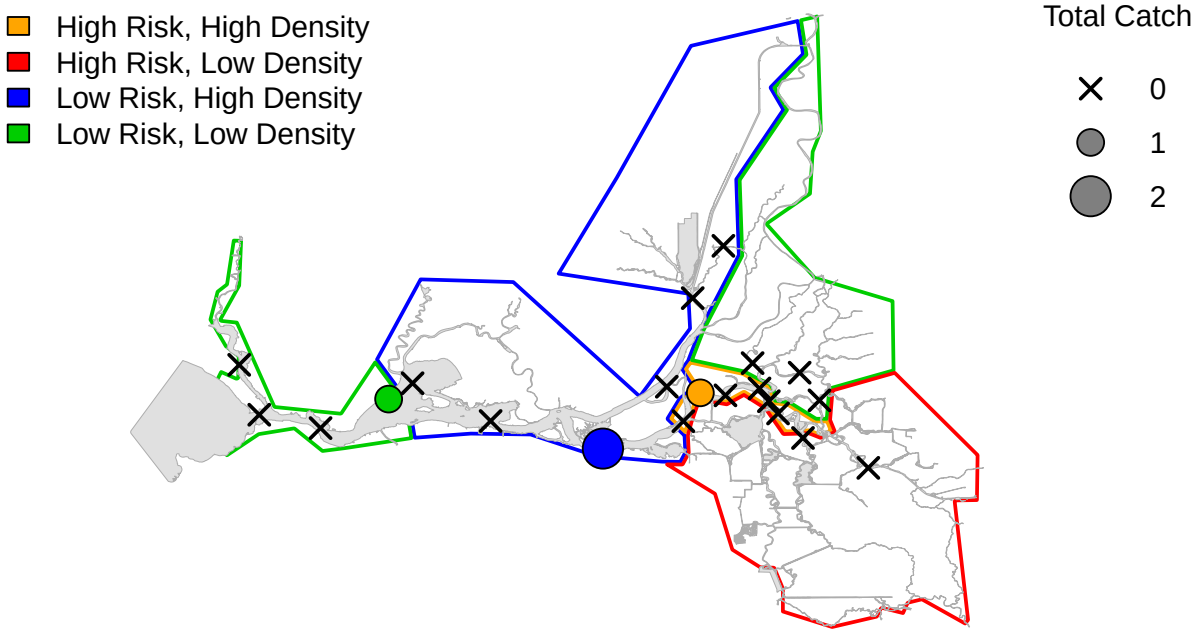
Delta Smelt Average Catch Density by Site



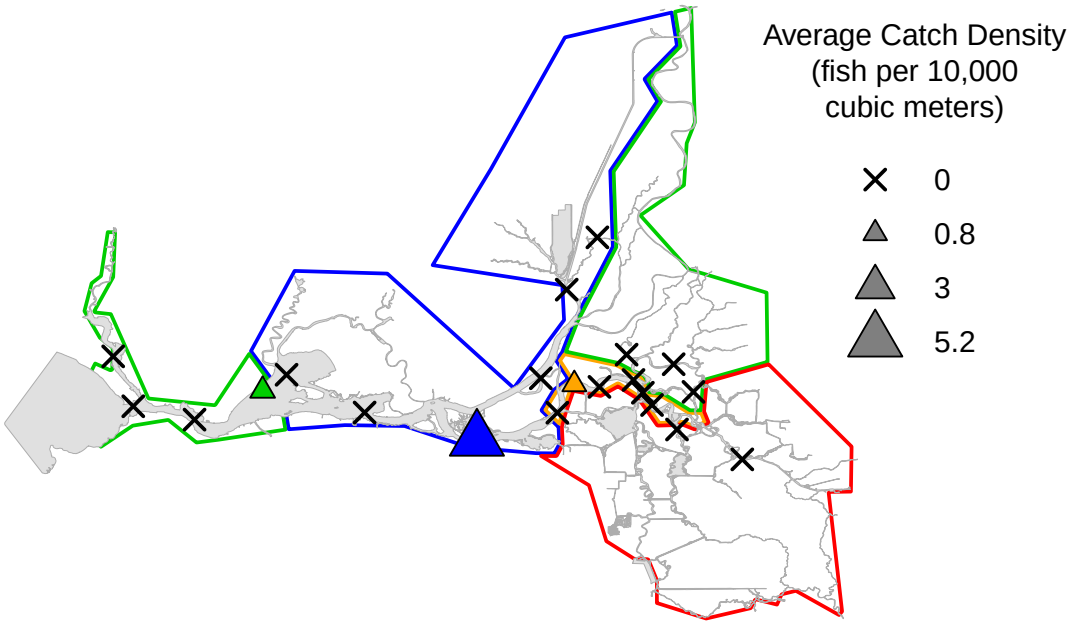
Week 7 (1/30/17 – 2/2/17)

21 sites; 4 Delta Smelt total

Delta Smelt Total Catch by Site



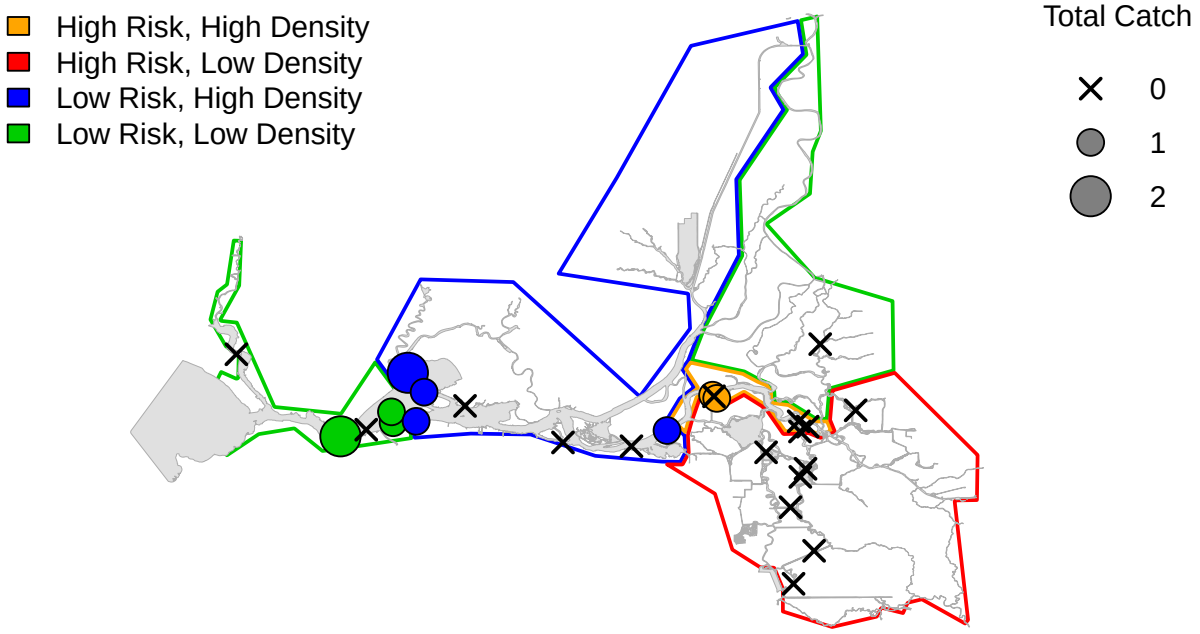
Delta Smelt Average Catch Density by Site



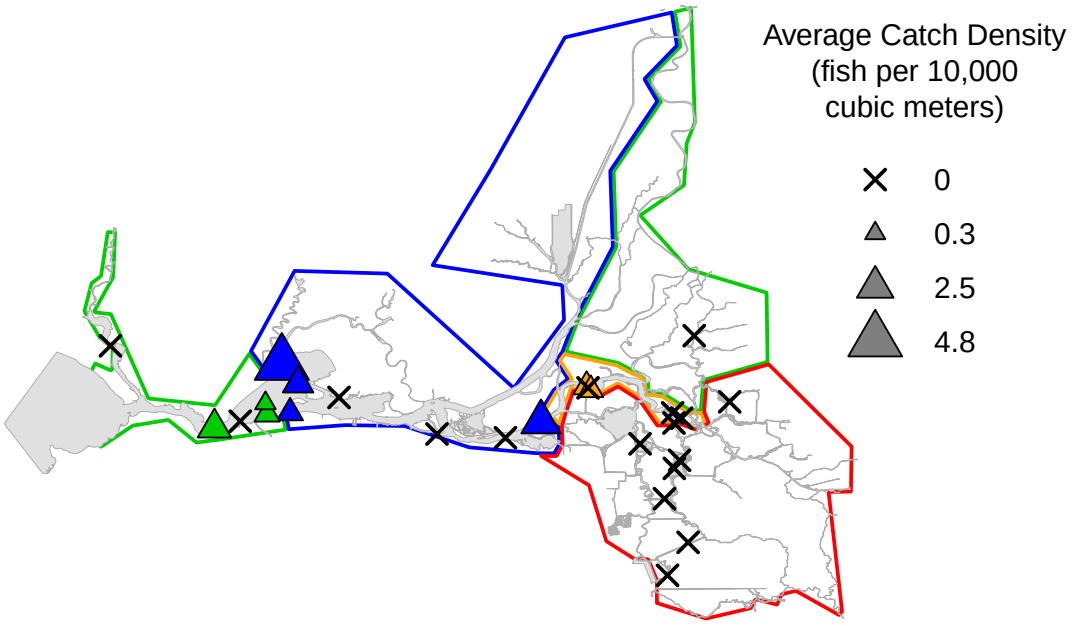
Week 8 (2/6/17 – 2/9/17)

26 sites; 11 Delta Smelt total

Delta Smelt Total Catch by Site



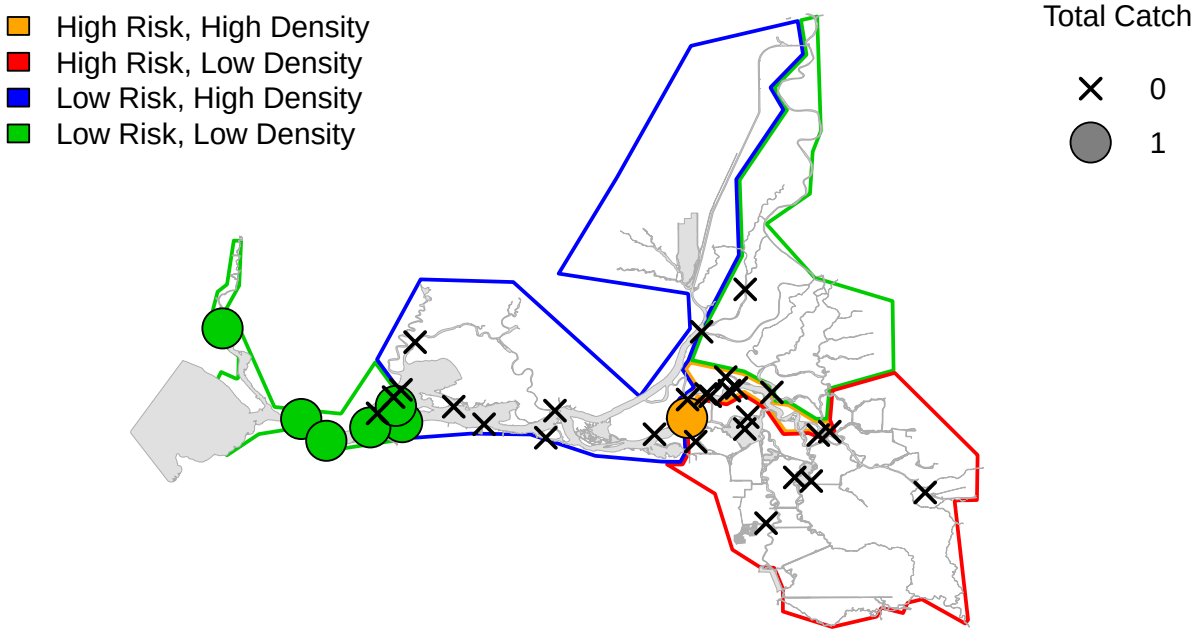
Delta Smelt Average Catch Density by Site



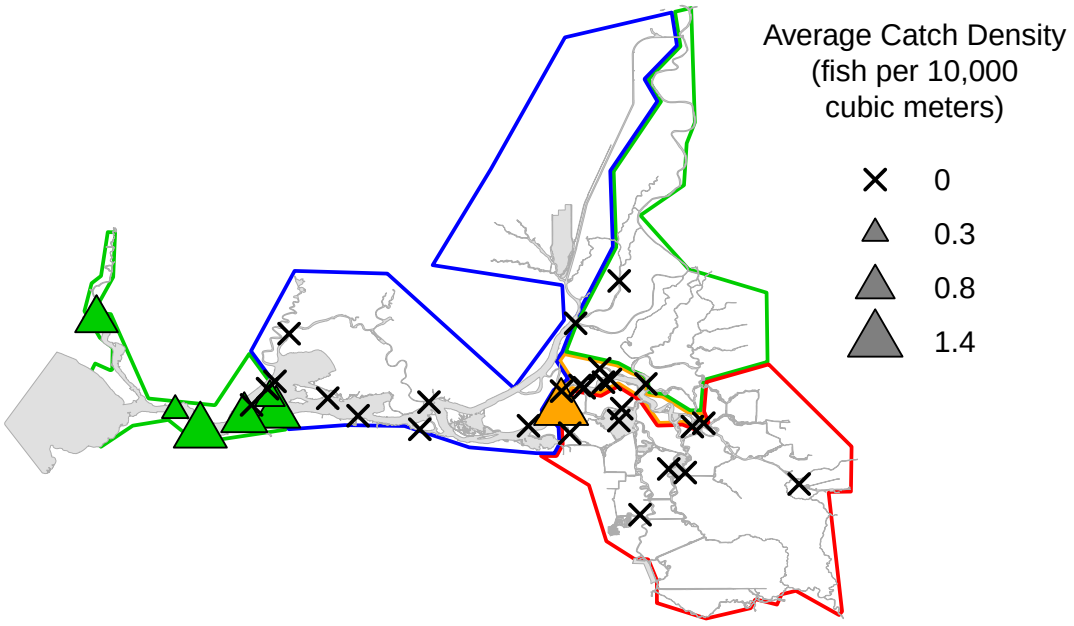
Week 9 (2/10/17 – 2/16/17)

34 sites; 7 Delta Smelt total

Delta Smelt Total Catch by Site



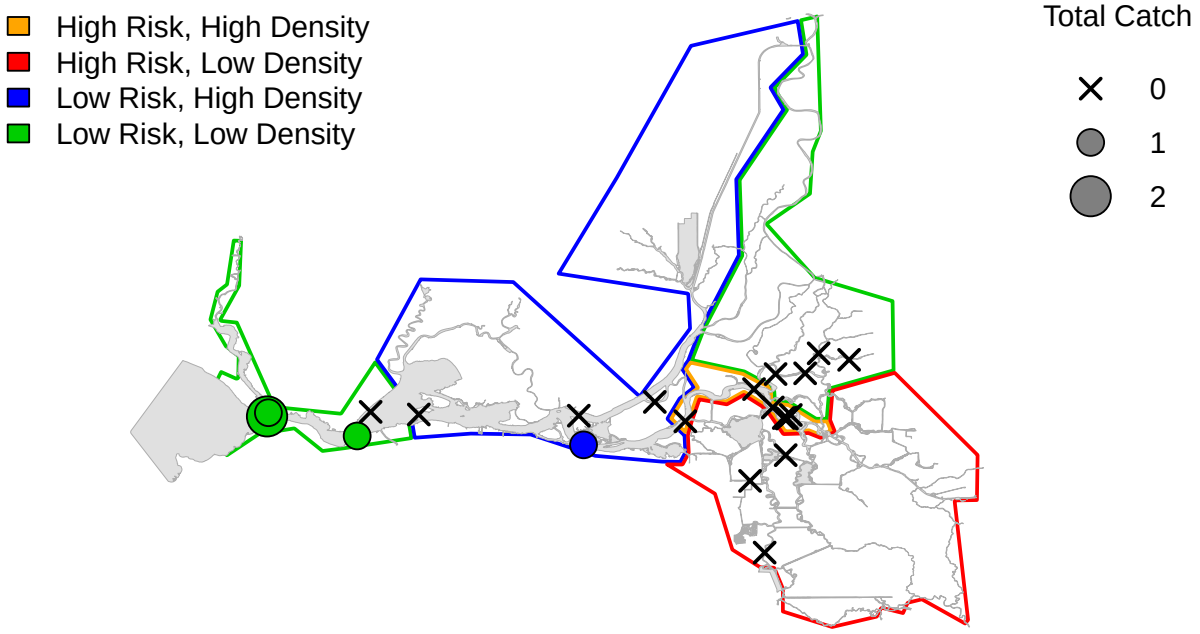
Delta Smelt Average Catch Density by Site



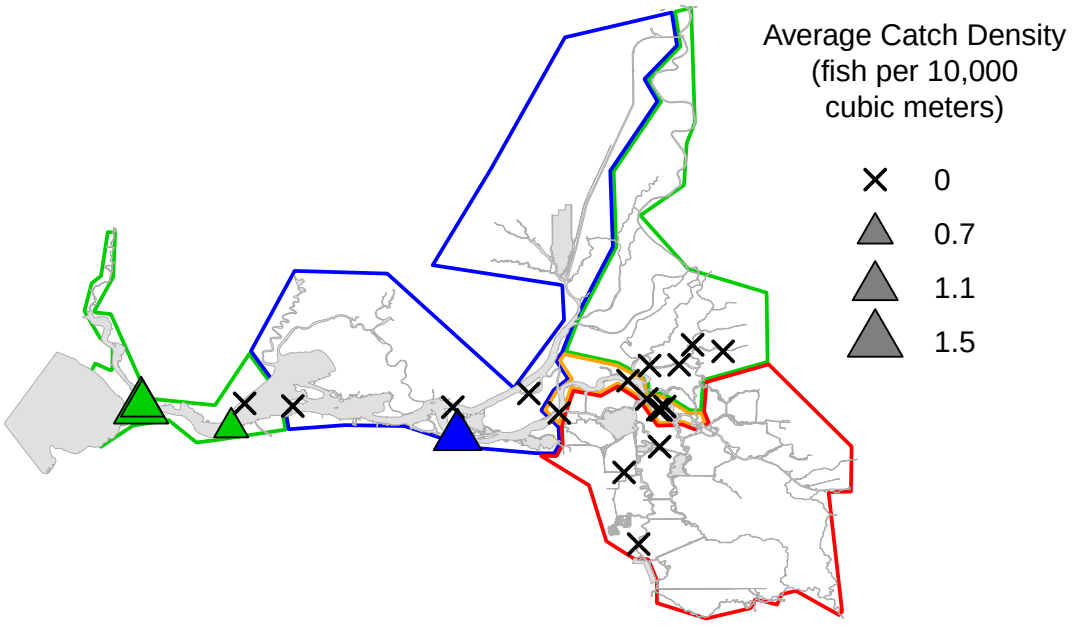
Week 10 (2/21/17 – 2/23/17)

22 sites; 5 Delta Smelt total

Delta Smelt Total Catch by Site



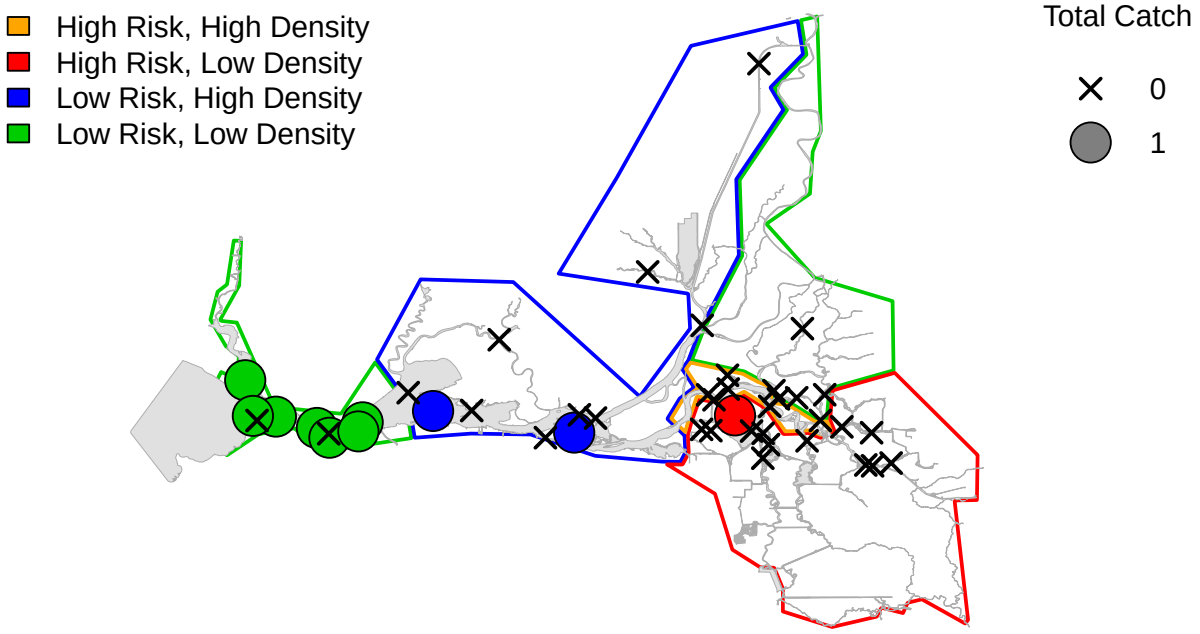
Delta Smelt Average Catch Density by Site



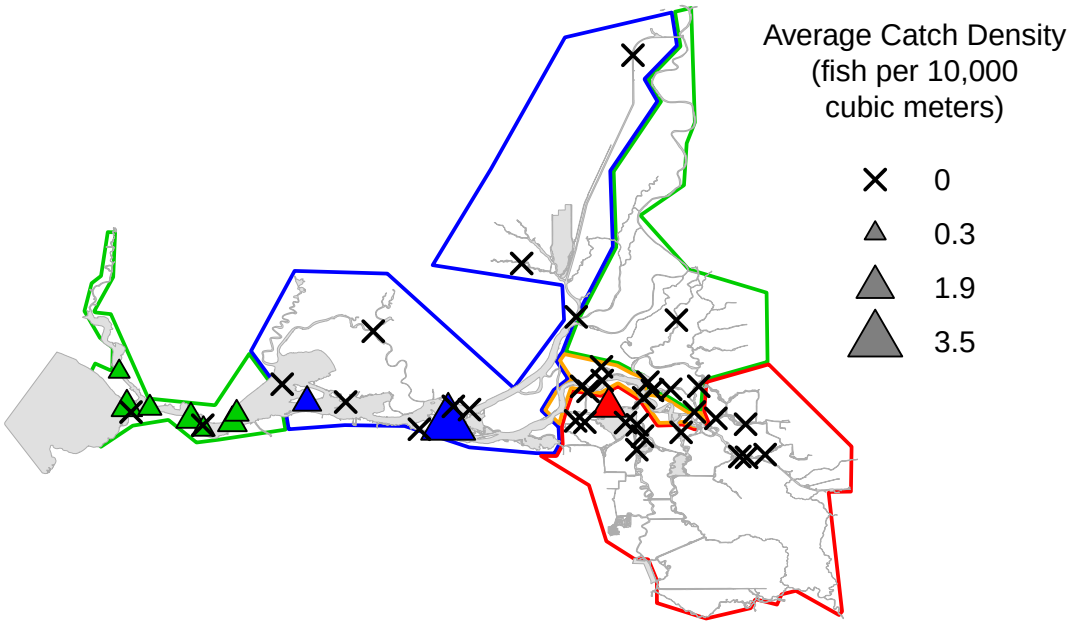
Week 11 (2/24/17 – 3/2/17)

44 sites; 10 Delta Smelt total

Delta Smelt Total Catch by Site



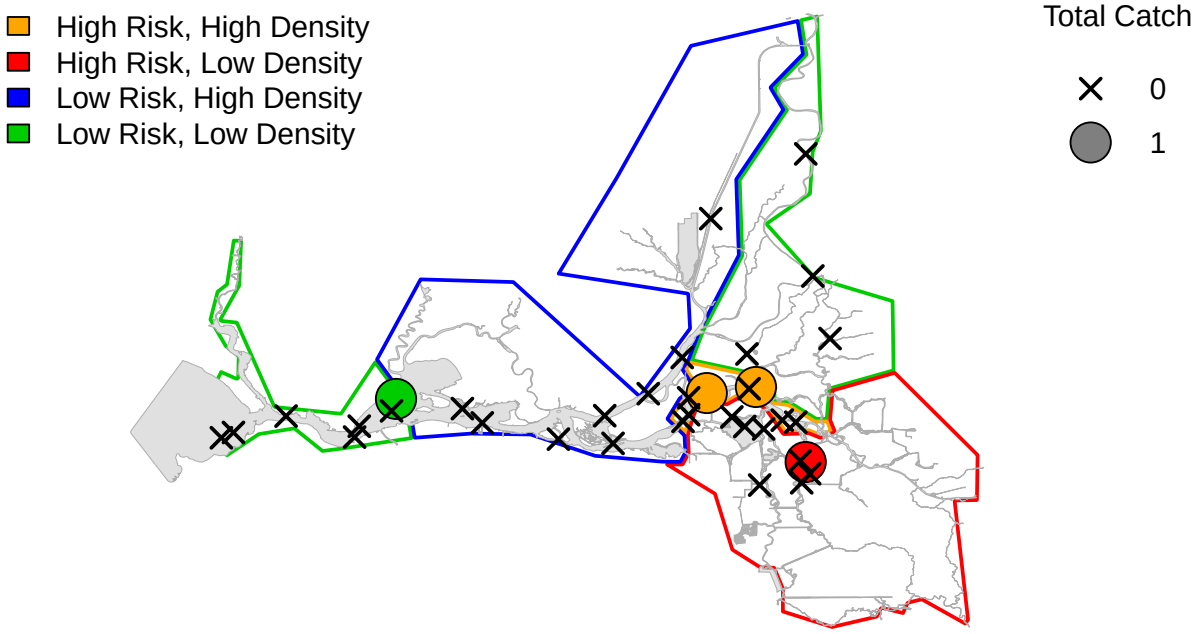
Delta Smelt Average Catch Density by Site



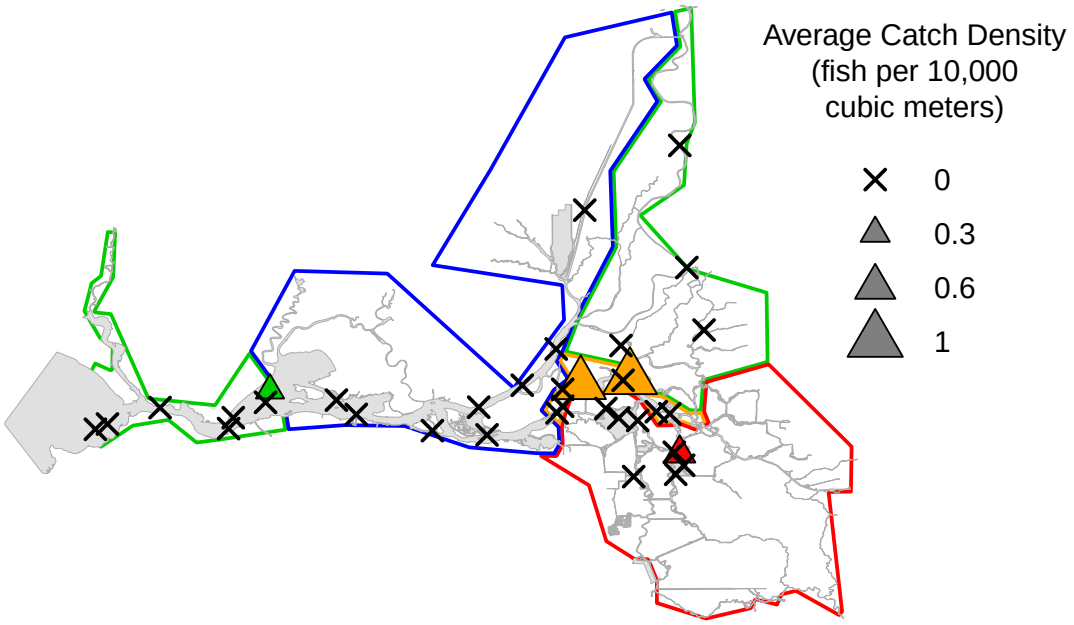
Week 12 (3/6/17 – 3/9/17)

35 sites; 4 Delta Smelt total

Delta Smelt Total Catch by Site



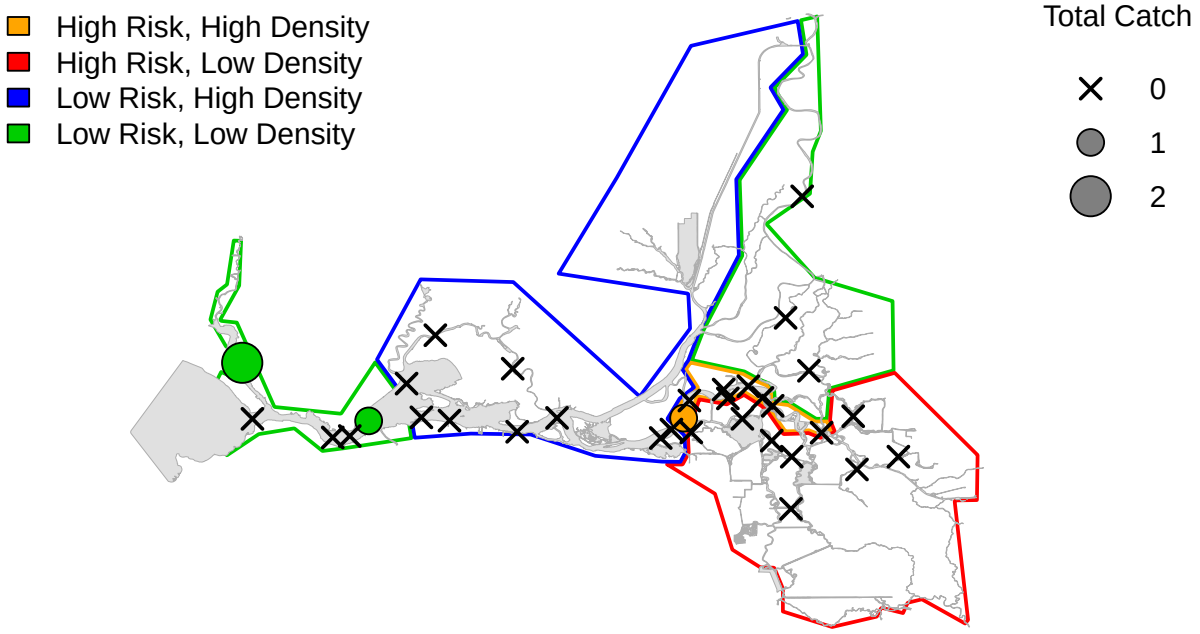
Delta Smelt Average Catch Density by Site



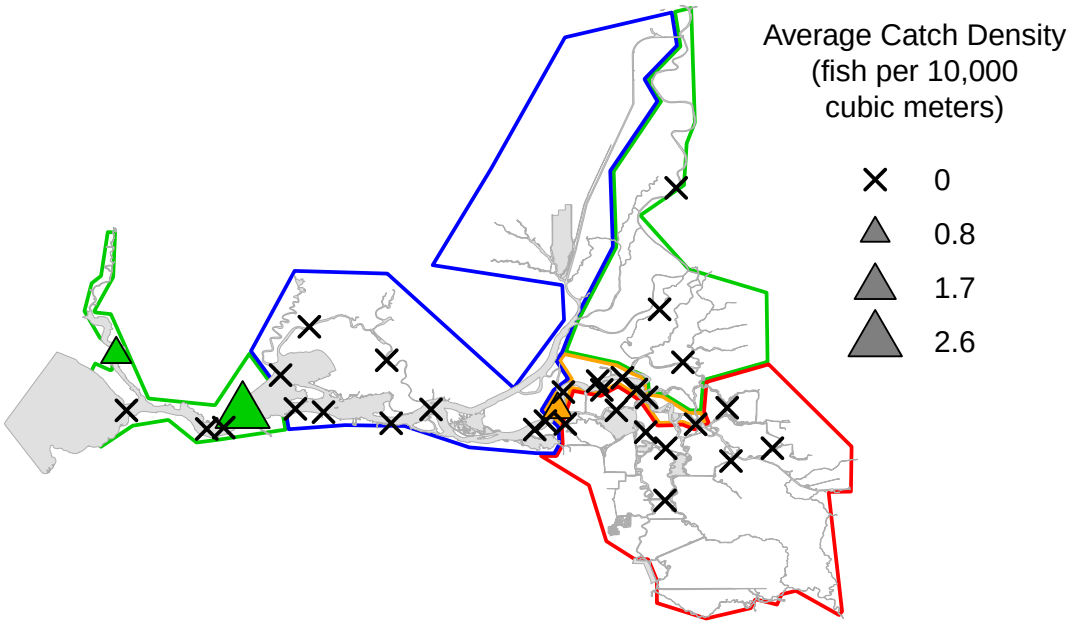
Week 13 (3/13/17 – 3/16/17)

33 sites; 4 Delta Smelt total

Delta Smelt Total Catch by Site



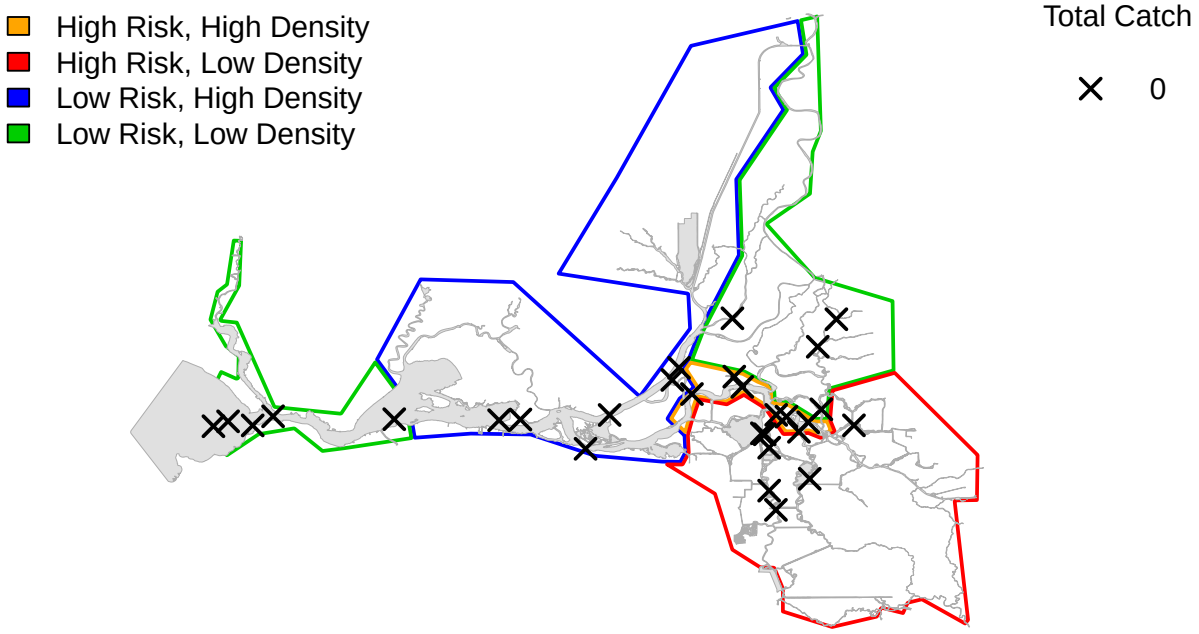
Delta Smelt Average Catch Density by Site



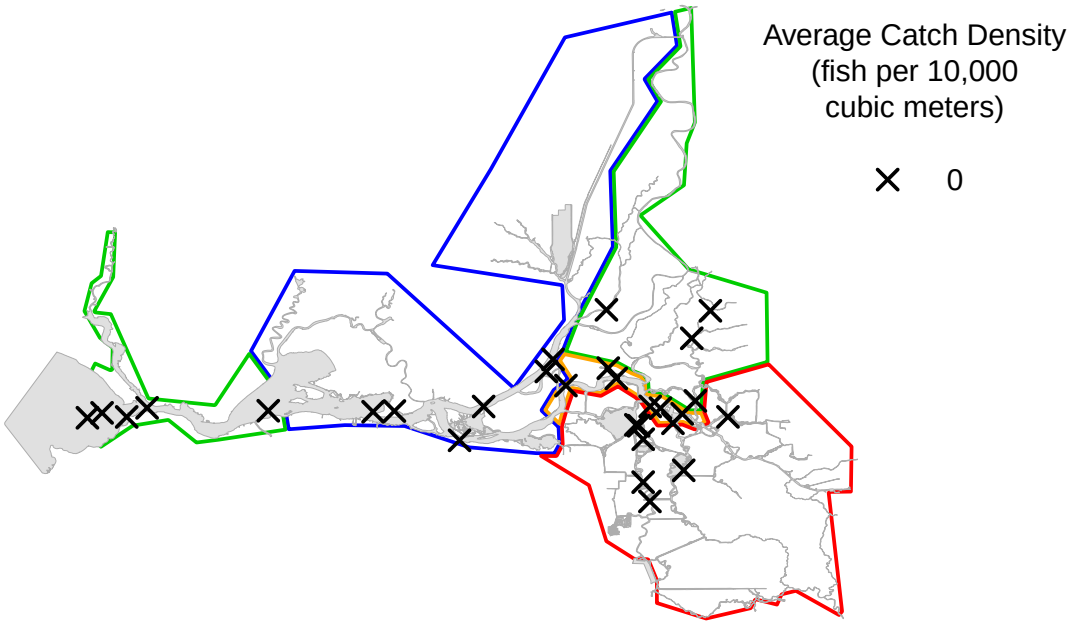
Week 14 (3/20/17 – 3/23/17)

29 sites; 0 Delta Smelt total

Delta Smelt Total Catch by Site



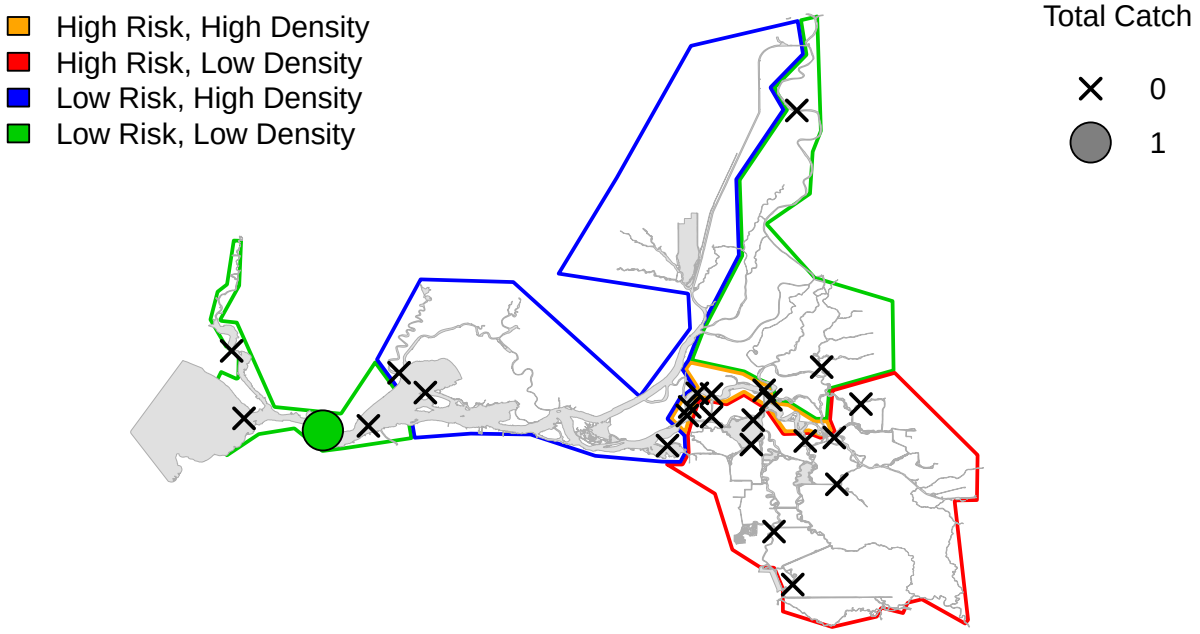
Delta Smelt Average Catch Density by Site



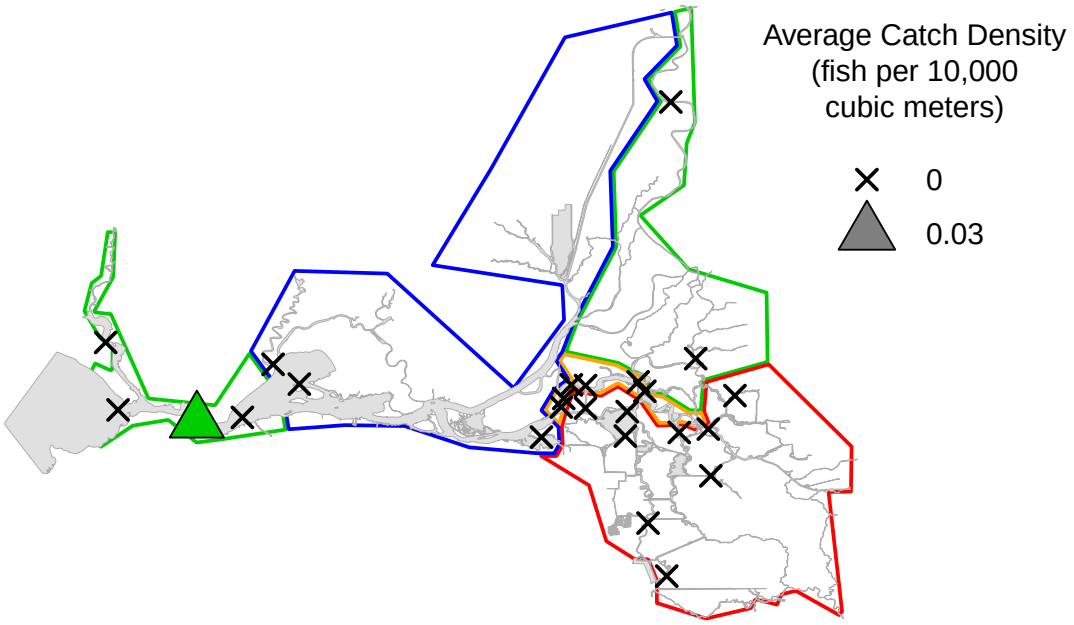
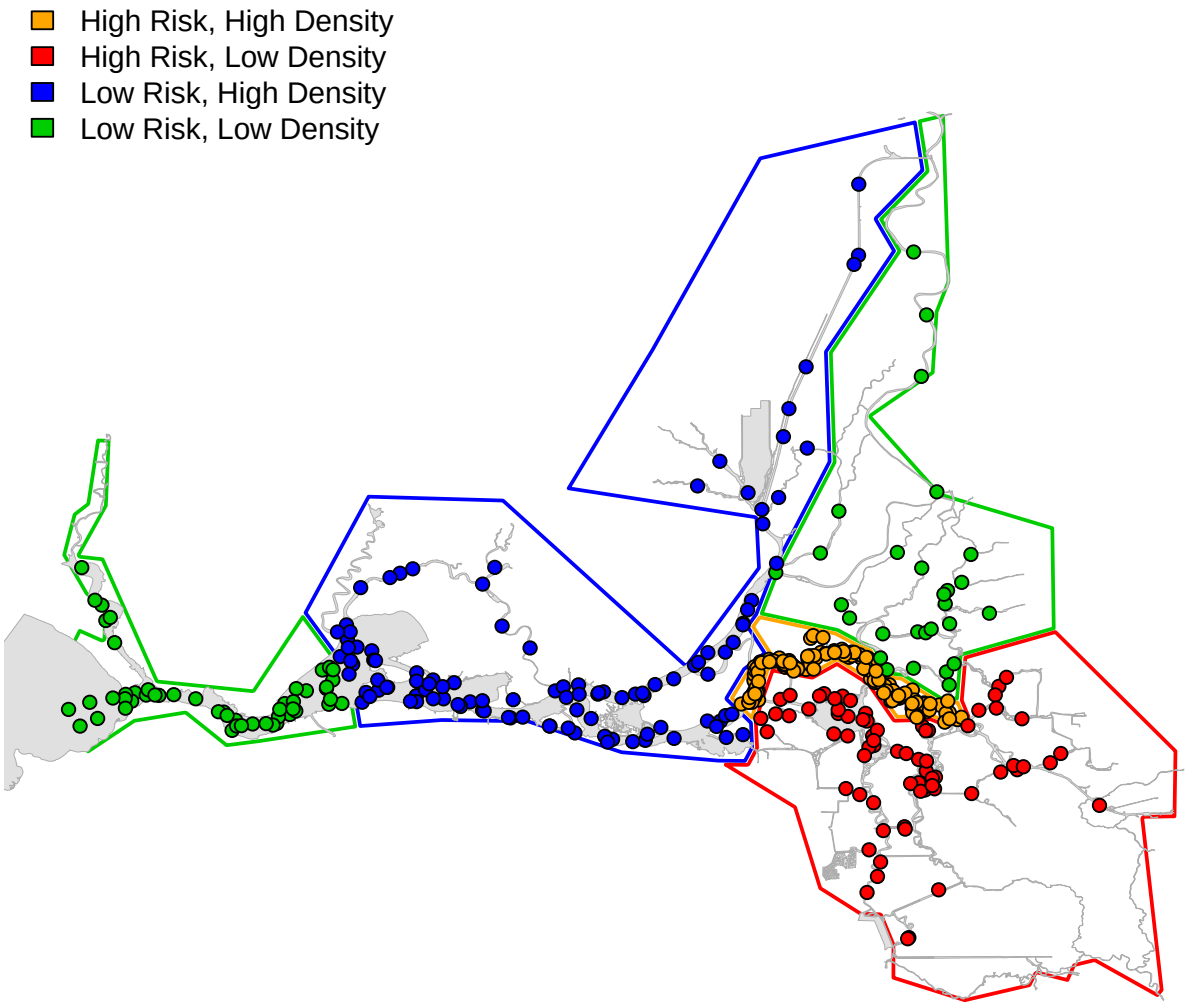
Week 15 (3/24/17 – 3/30/17)

24 sites; 1 Delta Smelt total

Delta Smelt Total Catch by Site



Delta Smelt Average Catch Density by Site



All Sampling Locations To Date