Tables

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# Main Paper Tables

## Kelp Drivers Model

| term | 𝛘2 | df | p |
| --- | --- | --- | --- |
| urchin anomaly | 54.149 | 1 | 1.859e-13 |
| spring temperature anomaly | 4.588 | 1 | 3.219e-02 |
| lag summer temperature anomaly | 5.349 | 1 | 2.074e-02 |
| average urchins in subregion | 44.439 | 1 | 2.624e-11 |
| average spring temperature in subregion | 51.701 | 1 | 6.463e-13 |
| average lag summer temperature in subregion | 1.169 | 1 | 2.795e-01 |

Table 1. likelihood ratio tests of drivers of kelp abundance across the outer coast of Maine.

| term | estimate | SE | z | p |
| --- | --- | --- | --- | --- |
| Intercept | 7.678 | 0.863 | 8.897 | 5.745e-19 |
| urchin anomaly | -0.051 | 0.007 | -7.359 | 1.859e-13 |
| spring temperature anomaly | -0.216 | 0.101 | -2.142 | 3.219e-02 |
| lag summer temperature anomaly | -0.204 | 0.088 | -2.313 | 2.074e-02 |
| average urchins in subregion | 0.322 | 0.048 | 6.666 | 2.624e-11 |
| average spring temperature in subregion | -1.771 | 0.246 | -7.190 | 6.463e-13 |
| average lag summer temperature in subregion | 0.057 | 0.053 | 1.081 | 2.795e-01 |
| year sd | 0.405 |  |  |  |
| region sd | 0.000 |  |  |  |

Table 2. Coefficient estimates, SE, and z tests for the kelp drivers model.

# Supplementary Tables

## Sample Sizes for Kelp Analysis

| Year | Region | Sample Size |
| --- | --- | --- |
| 2001 | Downeast | 22 |
| 2002 | Downeast | 20 |
| 2003 | Downeast | 26 |
| 2004 | Downeast | 20 |
| 2005 | Downeast | 26 |
| 2006 | Downeast | 20 |
| 2007 | Downeast | 18 |
| 2008 | Downeast | 20 |
| 2009 | Downeast | 18 |
| 2010 | Downeast | 20 |
| 2011 | Downeast | 20 |
| 2012 | Downeast | 21 |
| 2013 | Downeast | 31 |
| 2014 | Downeast | 15 |
| 2015 | Downeast | 23 |
| 2016 | Downeast | 17 |
| 2017 | Downeast | 19 |
| 2018 | Downeast | 18 |
| 2001 | MDI | 1 |
| 2002 | MDI | 8 |
| 2003 | MDI | 11 |
| 2004 | MDI | 13 |
| 2005 | MDI | 12 |
| 2006 | MDI | 10 |
| 2007 | MDI | 9 |
| 2008 | MDI | 7 |
| 2009 | MDI | 5 |
| 2010 | MDI | 2 |
| 2011 | MDI | 8 |
| 2012 | MDI | 6 |
| 2013 | MDI | 7 |
| 2014 | MDI | 8 |
| 2015 | MDI | 7 |
| 2016 | MDI | 8 |
| 2017 | MDI | 15 |
| 2018 | MDI | 7 |
| 2001 | Penobscot Bay | 2 |
| 2002 | Penobscot Bay | 12 |
| 2003 | Penobscot Bay | 13 |
| 2004 | Penobscot Bay | 10 |
| 2005 | Penobscot Bay | 10 |
| 2006 | Penobscot Bay | 9 |
| 2007 | Penobscot Bay | 8 |
| 2008 | Penobscot Bay | 5 |
| 2009 | Penobscot Bay | 6 |
| 2010 | Penobscot Bay | 6 |
| 2011 | Penobscot Bay | 5 |
| 2012 | Penobscot Bay | 2 |
| 2013 | Penobscot Bay | 7 |
| 2014 | Penobscot Bay | 6 |
| 2015 | Penobscot Bay | 4 |
| 2016 | Penobscot Bay | 5 |
| 2017 | Penobscot Bay | 14 |
| 2018 | Penobscot Bay | 10 |
| 2001 | Midcoast | 4 |
| 2002 | Midcoast | 4 |
| 2003 | Midcoast | 8 |
| 2004 | Midcoast | 8 |
| 2005 | Midcoast | 9 |
| 2006 | Midcoast | 7 |
| 2007 | Midcoast | 6 |
| 2008 | Midcoast | 7 |
| 2009 | Midcoast | 5 |
| 2010 | Midcoast | 7 |
| 2011 | Midcoast | 5 |
| 2012 | Midcoast | 5 |
| 2013 | Midcoast | 8 |
| 2014 | Midcoast | 7 |
| 2015 | Midcoast | 3 |
| 2016 | Midcoast | 1 |
| 2017 | Midcoast | 2 |
| 2018 | Midcoast | 6 |
| 2001 | Casco Bay | 1 |
| 2002 | Casco Bay | 5 |
| 2003 | Casco Bay | 5 |
| 2004 | Casco Bay | 5 |
| 2005 | Casco Bay | 5 |
| 2006 | Casco Bay | 8 |
| 2007 | Casco Bay | 4 |
| 2008 | Casco Bay | 3 |
| 2009 | Casco Bay | 3 |
| 2010 | Casco Bay | 4 |
| 2011 | Casco Bay | 2 |
| 2012 | Casco Bay | 1 |
| 2018 | Casco Bay | 5 |
| 2001 | York | 5 |
| 2002 | York | 2 |
| 2003 | York | 4 |
| 2004 | York | 4 |
| 2005 | York | 4 |
| 2006 | York | 1 |
| 2007 | York | 4 |
| 2008 | York | 4 |
| 2009 | York | 4 |
| 2010 | York | 3 |
| 2011 | York | 3 |
| 2014 | York | 3 |

Supplementary Table S1. Sample sizes of sites per region per year for use in the 5m kelp timeseries analysis and associated driver models.

## Kelp Timeseries Model at 10m

| term | df | 𝛘2 | p |
| --- | --- | --- | --- |
| year | 1 | 7.123 | 7.609e-03 |
| region | 5 | 25.784 | 9.828e-05 |
| year:region | 5 | 10.038 | 7.417e-02 |

Supplementary Table S2. likelihood ratio tests for trend analysis of kelp change over time at 10 m depth, in a model with an interaction. Note the interaction is not well supported. The logit coefficient of the relationship across all of Maine is -0.023.

## Sample Sizes for Composition Analysis

| Year | Region | Sample Size |
| --- | --- | --- |
| 2018 | York | 7 |
| 2004 | York | 16 |
| 2018 | Casco Bay | 5 |
| 2004 | Casco Bay | 11 |
| 2018 | Midcoast | 5 |
| 2004 | Midcoast | 24 |
| 2018 | Penobscot Bay | 7 |
| 2004 | Penobscot Bay | 21 |
| 2018 | MDI | 3 |
| 2004 | MDI | 6 |
| 2018 | Downeast | 5 |
| 2004 | Downeast | 4 |

Supplementary Table S3. Sample sizes of sites per region per year for use in assessing changes in macroalgal community composition between 2004 and 2018.

## Kelp Timeseries Model

| term | df | 𝛘2 | p |
| --- | --- | --- | --- |
| year | 1 | 111.837 | 3.880e-26 |
| region | 5 | 367.980 | 2.351e-77 |
| year:region | 5 | 14.210 | 1.433e-02 |

Supplementary Table S4. likelihood ratio tests for trend analysis of kelp change over time at 5 m depth.

## Temperature

| term | sumsq | df | f | p |
| --- | --- | --- | --- | --- |
| year | 11.7991777 | 1 | 15.800 | 1.439e-04 |
| region | 21.6122126 | 5 | 5.788 | 1.148e-04 |
| year:region | 0.5504499 | 5 | 0.147 | 9.803e-01 |
| Residuals | 65.7155498 | 88 |  | NA |

Supplementary Table S5. F Table results from spring temperature trend linear regression model.

| term | estimate | std. error | t | p |
| --- | --- | --- | --- | --- |
| (Intercept) | -164.46565746 | 88.92233454 | -1.850 | 6.774e-02 |
| year | 0.08436646 | 0.04424672 | 1.907 | 5.982e-02 |
| regionMDI | -28.12441167 | 125.75517150 | -0.224 | 8.236e-01 |
| regionPenobscot Bay | 56.24394148 | 123.70073620 | 0.455 | 6.505e-01 |
| regionMidcoast | 47.97334937 | 123.70073620 | 0.388 | 6.991e-01 |
| regionCasco Bay | 50.54886816 | 123.67099947 | 0.409 | 6.837e-01 |
| regionYork | 40.65779301 | 123.70073620 | 0.329 | 7.432e-01 |
| year:regionMDI | 0.01388899 | 0.06257431 | 0.222 | 8.249e-01 |
| year:regionPenobscot Bay | -0.02797927 | 0.06154742 | -0.455 | 6.505e-01 |
| year:regionMidcoast | -0.02375071 | 0.06154742 | -0.386 | 7.005e-01 |
| year:regionCasco Bay | -0.02477701 | 0.06154742 | -0.403 | 6.882e-01 |
| year:regionYork | -0.01968189 | 0.06154742 | -0.320 | 7.499e-01 |

Supplementary Table S6. Coefficient Table results from spring temperature trend linear regression model.

| term | sumsq | df | f | p |
| --- | --- | --- | --- | --- |
| year | 11.7991777 | 1 | 15.800 | 1.439e-04 |
| region | 21.6122126 | 5 | 5.788 | 1.148e-04 |
| year:region | 0.5504499 | 5 | 0.147 | 9.803e-01 |
| Residuals | 65.7155498 | 88 |  | NA |

Supplementary Table S7. F Table results from summer temperature trend linear regression model.

| term | estimate | std. error | t | p |
| --- | --- | --- | --- | --- |
| (Intercept) | -164.46565746 | 88.92233454 | -1.850 | 6.774e-02 |
| year | 0.08436646 | 0.04424672 | 1.907 | 5.982e-02 |
| regionMDI | -28.12441167 | 125.75517150 | -0.224 | 8.236e-01 |
| regionPenobscot Bay | 56.24394148 | 123.70073620 | 0.455 | 6.505e-01 |
| regionMidcoast | 47.97334937 | 123.70073620 | 0.388 | 6.991e-01 |
| regionCasco Bay | 50.54886816 | 123.67099947 | 0.409 | 6.837e-01 |
| regionYork | 40.65779301 | 123.70073620 | 0.329 | 7.432e-01 |
| year:regionMDI | 0.01388899 | 0.06257431 | 0.222 | 8.249e-01 |
| year:regionPenobscot Bay | -0.02797927 | 0.06154742 | -0.455 | 6.505e-01 |
| year:regionMidcoast | -0.02375071 | 0.06154742 | -0.386 | 7.005e-01 |
| year:regionCasco Bay | -0.02477701 | 0.06154742 | -0.403 | 6.882e-01 |
| year:regionYork | -0.01968189 | 0.06154742 | -0.320 | 7.499e-01 |

Supplementary Table S8. Coefficient Table results from summer temperature trend linear regression model.

## Kelp Composition Model

| term | 𝛘2 | df | p |
| --- | --- | --- | --- |
| year | 33.748 | 4 | 8.392e-07 |
| region | 130.831 | 20 | 0.000e+00 |
| year:region | 52.283 | 20 | 1.035e-04 |

Supplementary Table S9. likelihood ratio tests for trend analysis of kelp species composition over time.

| species | term | 𝛘2 | df | p |
| --- | --- | --- | --- | --- |
| agar | region | 400.594 | 5 | 0.000e+00 |
| agar | year | 20.458 | 1 | 6.094e-06 |
| agar | year:region | 237.241 | 5 | 0.000e+00 |
| alar | region | 461.068 | 5 | 0.000e+00 |
| alar | year | 57.274 | 1 | 1.519e-13 |
| alar | year:region | 673.939 | 5 | 0.000e+00 |
| ldig | region | 504.662 | 5 | 0.000e+00 |
| ldig | year | 24.849 | 1 | 8.268e-07 |
| ldig | year:region | 687.397 | 5 | 0.000e+00 |
| sac | region | 434.305 | 5 | 0.000e+00 |
| sac | year | 27.916 | 1 | 2.534e-07 |
| sac | year:region | 1,176.377 | 5 | 0.000e+00 |

Supplementary Table S10. likelihood ratio tests for changes in individual kelp species over time with p-values corrected for false discovery rate.

| Species | Region | Mean Differerence from 2004 to 2018 | Lower 95% CI | Upper 95%CI |
| --- | --- | --- | --- | --- |
| agar | York | 0.048 | -2.223 | 2.734 |
| agar | Casco Bay | -2.562 | -5.780 | 0.598 |
| agar | Midcoast | -1.078 | -2.966 | 1.310 |
| agar | Penobscot Bay | -2.643 | -5.765 | 0.806 |
| agar | MDI | -7.278 | -14.083 | -1.902 |
| agar | Downeast | -2.609 | -8.933 | 2.345 |
| alar | York | -0.029 | -1.361 | 1.511 |
| alar | Casco Bay | -1.190 | -3.136 | 0.875 |
| alar | Midcoast | -0.277 | -1.681 | 1.526 |
| alar | Penobscot Bay | -3.547 | -5.849 | -1.220 |
| alar | MDI | -4.850 | -10.319 | 0.232 |
| alar | Downeast | -4.703 | -9.912 | -0.865 |
| ldig | York | -1.850 | -4.879 | 1.288 |
| ldig | Casco Bay | 2.190 | -2.549 | 9.109 |
| ldig | Midcoast | 12.895 | 2.241 | 28.644 |
| ldig | Penobscot Bay | 4.363 | -13.365 | 24.182 |
| ldig | MDI | 27.509 | -4.577 | 57.042 |
| ldig | Downeast | 51.973 | 27.044 | 72.443 |
| sac | York | 12.963 | -3.441 | 34.977 |
| sac | Casco Bay | -22.912 | -41.049 | -8.350 |
| sac | Midcoast | -10.114 | -25.661 | 10.093 |
| sac | Penobscot Bay | -0.360 | -9.717 | 12.178 |
| sac | MDI | 4.511 | -24.980 | 40.860 |
| sac | Downeast | -9.238 | -31.035 | 4.323 |

Supplementary Table S11. Posthoc comparisons of differences in kelp species within each subregion between 2004 and 2018. Differences derived via simulation, and as such we include the 95% CI for each.

## Understory Composition Model

| term | 𝛘2 | df | p |
| --- | --- | --- | --- |
| year | 16.732 | 13 | 2.118e-01 |
| region | 161.868 | 65 | 3.162e-10 |
| year:region | 127.609 | 65 | 5.766e-06 |

Supplementary Table S12. likelihood ratio tests for trend analysis of understory species composition over time.

| species | term | 𝛘2 | df | p |
| --- | --- | --- | --- | --- |
| ccrisp | region | 14.278 | 5 | 2.265e-02 |
| ccrisp | year | 19.233 | 1 | 3.008e-05 |
| ccrisp | year:region | 29.487 | 5 | 1.261e-04 |
| chaet | region | 10.114 | 5 | 7.807e-02 |
| chaet | year | 20.357 | 1 | 2.088e-05 |
| chaet | year:region | 28.655 | 5 | 1.261e-04 |
| codm | region | 10.240 | 5 | 7.807e-02 |
| codm | year | 9.813 | 1 | 2.503e-03 |
| codm | year:region | 3.965 | 5 | 8.009e-01 |
| coral | region | 29.974 | 5 | 4.850e-05 |
| coral | year | 2.160 | 1 | 1.417e-01 |
| coral | year:region | 28.497 | 5 | 1.261e-04 |
| desm | region | 11.781 | 5 | 5.476e-02 |
| desm | year | 4.462 | 1 | 3.755e-02 |
| desm | year:region | 13.566 | 5 | 6.049e-02 |
| palm | region | 2.897 | 5 | 7.159e-01 |
| palm | year | 7.920 | 1 | 6.356e-03 |
| palm | year:region | 11.681 | 5 | 9.358e-02 |
| phyc | region | 54.975 | 5 | 8.585e-10 |
| phyc | year | 27.592 | 1 | 6.492e-07 |
| phyc | year:region | 11.376 | 5 | 9.358e-02 |
| poly | region | 34.671 | 5 | 7.584e-06 |
| poly | year | 12.782 | 1 | 5.687e-04 |
| poly | year:region | 10.546 | 5 | 9.938e-02 |
| porph | region | 56.244 | 5 | 8.585e-10 |
| porph | year | 29.177 | 1 | 4.294e-07 |
| porph | year:region | 11.051 | 5 | 9.358e-02 |
| ptilo | region | 11.078 | 5 | 6.481e-02 |
| ptilo | year | 45.713 | 1 | 1.779e-10 |
| ptilo | year:region | 0.993 | 5 | 9.671e-01 |
| rhod | region | 27.732 | 5 | 1.068e-04 |
| rhod | year | 17.396 | 1 | 6.575e-05 |
| rhod | year:region | 2.768 | 5 | 9.564e-01 |
| sder | region | 19.816 | 5 | 2.931e-03 |
| sder | year | 13.007 | 1 | 5.687e-04 |
| sder | year:region | 0.942 | 5 | 9.671e-01 |
| ulva | region | 16.573 | 5 | 1.000e-02 |
| ulva | year | 7.688 | 1 | 6.568e-03 |
| ulva | year:region | 1.719 | 5 | 9.671e-01 |

Supplementary Table S13. likelihood ratio tests for changes in individual understory species over time with p-values corrected for false discovery rate.

| Species | Region | Mean Differerence from 2004 to 2018 | Lower 95% CI | Upper 95%CI |
| --- | --- | --- | --- | --- |
| ccrisp | York | -2.913 | -2.945 | -2.880 |
| ccrisp | Casco Bay | 8.013 | 7.939 | 8.086 |
| ccrisp | Midcoast | 11.182 | 11.090 | 11.275 |
| ccrisp | Penobscot Bay | 14.876 | 14.760 | 14.993 |
| ccrisp | MDI | 1.250 | 1.232 | 1.268 |
| ccrisp | Downeast | -0.054 | -0.062 | -0.046 |
| chaet | York | 2.213 | 1.860 | 2.582 |
| chaet | Casco Bay | 1.214 | 0.826 | 1.643 |
| chaet | Midcoast | 0.127 | -0.151 | 0.426 |
| chaet | Penobscot Bay | 0.164 | -0.142 | 0.493 |
| chaet | MDI | 0.472 | 0.178 | 0.808 |
| chaet | Downeast | 0.182 | -0.093 | 0.492 |
| codm | York | -0.198 | -0.409 | 0.019 |
| codm | Casco Bay | -0.726 | -0.990 | -0.454 |
| codm | Midcoast | -0.354 | -0.616 | -0.075 |
| codm | Penobscot Bay | 0.003 | -0.269 | 0.291 |
| codm | MDI | 0.004 | -0.234 | 0.271 |
| codm | Downeast | 0.005 | -0.238 | 0.278 |
| coral | York | 8.360 | 7.423 | 9.364 |
| coral | Casco Bay | 4.291 | 3.658 | 4.986 |
| coral | Midcoast | 2.417 | 1.997 | 2.888 |
| coral | Penobscot Bay | 0.503 | 0.318 | 0.719 |
| coral | MDI | 1.500 | 1.239 | 1.792 |
| coral | Downeast | 5.253 | 4.517 | 6.052 |
| desm | York | 1.943 | 1.681 | 2.228 |
| desm | Casco Bay | -1.972 | -2.036 | -1.902 |
| desm | Midcoast | -0.240 | -0.386 | -0.067 |
| desm | Penobscot Bay | 3.906 | 3.351 | 4.518 |
| desm | MDI | -0.576 | -0.641 | -0.498 |
| desm | Downeast | -1.225 | -1.240 | -1.205 |
| palm | York | 0.115 | -0.131 | 0.369 |
| palm | Casco Bay | -0.782 | -1.090 | -0.464 |
| palm | Midcoast | 0.647 | 0.286 | 1.042 |
| palm | Penobscot Bay | -0.516 | -0.881 | -0.133 |
| palm | MDI | 0.789 | 0.429 | 1.180 |
| palm | Downeast | 0.504 | 0.172 | 0.877 |
| phyc | York | -5.079 | -5.401 | -4.769 |
| phyc | Casco Bay | -4.549 | -4.861 | -4.249 |
| phyc | Midcoast | -0.247 | -0.324 | -0.159 |
| phyc | Penobscot Bay | -1.001 | -1.063 | -0.941 |
| phyc | MDI | -0.231 | -0.299 | -0.153 |
| phyc | Downeast | 1.997 | 1.642 | 2.389 |
| poly | York | 37.393 | 37.289 | 37.496 |
| poly | Casco Bay | 3.217 | 3.166 | 3.267 |
| poly | Midcoast | 10.580 | 10.498 | 10.663 |
| poly | Penobscot Bay | 3.732 | 3.678 | 3.785 |
| poly | MDI | -5.050 | -5.066 | -5.035 |
| poly | Downeast | 11.586 | 11.504 | 11.668 |
| porph | York | -0.723 | -0.857 | -0.586 |
| porph | Casco Bay | -0.468 | -0.625 | -0.303 |
| porph | Midcoast | 0.613 | 0.436 | 0.797 |
| porph | Penobscot Bay | 1.757 | 1.273 | 2.316 |
| porph | MDI | -0.929 | -1.114 | -0.738 |
| porph | Downeast | 0.890 | 0.662 | 1.136 |
| ptilo | York | -0.921 | -1.189 | -0.643 |
| ptilo | Casco Bay | -3.477 | -3.836 | -3.118 |
| ptilo | Midcoast | -0.142 | -0.434 | 0.155 |
| ptilo | Penobscot Bay | -0.735 | -1.066 | -0.406 |
| ptilo | MDI | -0.457 | -0.737 | -0.160 |
| ptilo | Downeast | -0.659 | -0.966 | -0.321 |
| rhod | York | 0.265 | 0.014 | 0.525 |
| rhod | Casco Bay | 0.979 | 0.590 | 1.406 |
| rhod | Midcoast | 4.531 | 3.707 | 5.439 |
| rhod | Penobscot Bay | 2.134 | 1.595 | 2.719 |
| rhod | MDI | 1.005 | 0.642 | 1.391 |
| rhod | Downeast | 1.437 | 1.005 | 1.908 |
| ulva | York | -0.136 | -0.397 | 0.134 |
| ulva | Casco Bay | -0.064 | -0.351 | 0.237 |
| ulva | Midcoast | -0.087 | -0.419 | 0.265 |
| ulva | Penobscot Bay | 0.902 | 0.433 | 1.414 |
| ulva | MDI | -0.595 | -0.904 | -0.275 |
| ulva | Downeast | 0.146 | -0.177 | 0.498 |

Supplementary Table S14. Posthoc comparisons of differences in understory species within each subregion between 2004 and 2018. Differences derived via simulation, and as such we include the 95% CI for each.