Figure S1

Diagram

Description automatically generated

**Figure S1.** PRISMA diagram outlining search methods, number of papers excluded with reasons, and number of papers included with type of disease prevalence units reported. Note: dataset was limited to only percent prevalence metrics. Two effect sizes were removed *a posteriori* since the temperature dataset used to calculate Degree Heating Week did not include the years of their surveys.

Table S1

**Table S1.** Literature search string (in Scopus format) and its number of results in Web of Science Core Collection (WoS) and Scopus. Last row is search string used.

|  |  |  |
| --- | --- | --- |
| **Search String** | **WoS** | **Scopus** |
| TS=((coral\* OR octocoralli\* OR hexacoralli\* OR anthozo\* OR reef\* OR “hard coral” OR “stony coral” OR “calcareous coral” OR corallimorph\* OR scleractin\* OR zoanthari\* OR helioporac\*) AND (diseas\* OR pathoge\* OR syndrom\* OR plagu\* OR infect\*) AND (prevalen\* OR sever\* OR cover\* OR virulen\* OR resilien\*) AND (growth\* OR anomal\* OR band\* OR spot\* OR pox\* OR lesion\* OR blotch\* OR line\* OR tumor\* OR “tissue mortality” OR “tissue necrosis” OR “skeletal-ero\*”) AND (warming OR temperature OR “sea surface temperature\*” OR “surface temperature” OR “climate change” OR “climate stress\*”) AND (colour OR color OR pigment\* OR purple OR pink OR black OR yellow OR white OR dark OR red OR brown)) | 208 | 93 |
| TS=((\*coral\* OR octocoralli\* OR hexacoralli\* OR anthozo\* OR reef\* OR “hard coral” OR “stony coral” OR “calcareous coral” OR corallimorph\* OR scleractin\* OR zoanthari\* OR helioporac\*) AND (diseas\* OR pathoge\* OR syndrom\* OR plagu\* OR infect\*) AND (warm\* OR temperature OR “climate change” OR “climate stress\*” OR "thermal stress\*" OR thermal\* OR heat\*)) | 1084 | 924 |

Table S2

**Table S2.** Benchmark papers.

|  |  |  |
| --- | --- | --- |
| **Reference** | **Web of Science** | **Scopus** |
| Alvarez-Filip, L., Estrada-Saldívar, N., Pérez-Cervantes, E., Molina-Hernández, A. and González-Barrios, F.J., 2019. A rapid spread of the stony coral tissue loss disease outbreak in the Mexican Caribbean. PeerJ, 7, p.e8069. | x | x |
| Bruno, J.F., Selig, E.R., Casey, K.S., Page, C.A., Willis, B.L., Harvell, C.D., Sweatman, H. and Melendy, A.M., 2007. Thermal stress and coral cover as drivers of coral disease outbreaks. PLoS biology, 5(6), p.e124. | x | x |
| Gintert, B.E., Precht, W.F., Fura, R., Rogers, K., Rice, M., Precht, L.L., D’Alessandro, M., Croop, J., Vilmar, C. and Robbart, M.L., 2019. Regional coral disease outbreak overwhelms impacts from a local dredge project. Environmental monitoring and assessment, 191(10), pp.1-39. | x | x |
| Haapkylä, J., Melbourne-Thomas, J., Flavell, M. and Willis, B.L., 2010. Spatiotemporal patterns of coral disease prevalence on Heron Island, Great Barrier Reef, Australia. Coral Reefs, 29(4), pp.1035-1045. | x |  |
| Lamb, J.B. and Willis, B.L., 2011. Using coral disease prevalence to assess the effects of concentrating tourism activities on offshore reefs in a tropical marine park. Conservation Biology, 25(5), pp.1044-1052. | x |  |
| Maynard, J., Van Hooidonk, R., Eakin, C.M., Puotinen, M., Garren, M., Williams, G., Heron, S.F., Lamb, J., Weil, E., Willis, B. and Harvell, C.D., 2015. Projections of climate conditions that increase coral disease susceptibility and pathogen abundance and virulence. Nature Climate Change, 5(7), pp.688-694. | x |  |
| Onton, K., Page, C.A., Wilson, S.K., Neale, S. and Armstrong, S., 2011. Distribution and drivers of coral disease at Ningaloo reef, Indian Ocean. Marine Ecology Progress Series, 433, pp.75-84. | x |  |
| Page, C.A., Field, S.N., Pollock, F.J., Lamb, J.B., Shedrawi, G. and Wilson, S.K., 2017. Assessing coral health and disease from digital photographs and in situ surveys. Environmental monitoring and assessment, 189(1), pp.1-12. | x |  |
| Page, C.A., Baker, D.M., Harvell, C.D., Golbuu, Y., Raymundo, L., Neale, S.J., Rosell, K.B., Rypien, K.L., Andras, J.P. and Willis, B.L., 2009. Influence of marine reserves on coral disease prevalence. Diseases of Aquatic Organisms, 87(1-2), pp.135-150. | x | x |
| Randall, C.J., Jordán-Garza, A.G., Muller, E.M. and Van Woesik, R., 2014. Relationships between the history of thermal stress and the relative risk of diseases of Caribbean corals. Ecology, 95(7), pp.1981-1994. | x | x |
| Schleyer, M.H., Floros, C., Laing, S.C., Macdonald, A.H., Montoya-Maya, P.H., Morris, T., Porter, S.N. and Seré, M.G., 2018. What can South African reefs tell us about the future of high-latitude coral systems?. Marine pollution bulletin, 136, pp.491-507. | x |  |
| Van Woesik, R. and Randall, C.J., 2017. Coral disease hotspots in the Caribbean. Ecosphere, 8(5), p.e01814. | x | x |
| Walton, C.J., Hayes, N.K. and Gilliam, D.S., 2018. Impacts of a regional, multi-year, multi-species coral disease outbreak in Southeast Florida. Frontiers in Marine Science, 5, p.323. | x |  |

Figure S2

Diagram, text

Description automatically generated

**Figure S2.** Decision criteria used during abstract screening and their descriptions.

Figure S3

Diagram

Description automatically generated

**Figure S3.** Decision criteria used during full-text screening and their descriptions.

Table S3

**Table S3.** Included Papers.

|  |  |
| --- | --- |
| **Reference** | **DOI** |
| Kuta, K.G. and Richardson, L.L., 1996. Abundance and distribution of black band disease on coral reefs in the northern Florida Keys. Coral reefs, 15(4), pp.219-223. | 10.1007/BF01787455 |
| Raymundo, L.J., Licuanan, W.L. and Kerr, A.M., 2018. Adding insult to injury: Ship groundings are associated with coral disease in a pristine reef. PLoS One, 13(9), p.e0202939. | 10.1371/journal.pone.0202939 |
| Hein, M.Y., Lamb, J.B., Scott, C. and Willis, B.L., 2015. Assessing baseline levels of coral health in a newly established marine protected area in a global scuba diving hotspot. Marine Environmental Research, 103, pp.56-65. | 10.1016/j.marenvres.2014.11.008 |
| Page, C.A., Field, S.N., Pollock, F.J., Lamb, J.B., Shedrawi, G. and Wilson, S.K., 2017. Assessing coral health and disease from digital photographs and in situ surveys. Environmental monitoring and assessment, 189(1), pp.1-12. | 10.1007/s10661-016-5743-z |
| Yee, S.H., Santavy, D.L. and Barron, M.G., 2011. Assessing the effects of disease and bleaching on Florida Keys corals by fitting population models to data. Ecological Modelling, 222(7), pp.1323-1332. | 10.1016/j.ecolmodel.2011.01.009 |
| Aeby, G., Tribollet, A., Lasne, G. and Work, T., 2015. Assessing threats from coral and crustose coralline algae disease on the reefs of New Caledonia. Marine and Freshwater Research, 67(4), pp.455-465. | 10.1071/MF14151 |
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| Foley, J.E., Sokolow, S.H., Girvetz, E., Foley, C.W. and Foley, P., 2005. Spatial epidemiology of Caribbean yellow band syndrome in Montastrea spp. coral in the eastern Yucatan, Mexico. Hydrobiologia, 548(1), pp.33-40. | 10.1007/s10750-005-3619-2 |
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| Miller, J., Sweet, M.J., Wood, E. and Bythell, J., 2015. Baseline coral disease surveys within three marine parks in Sabah, Borneo. PeerJ, 3, p.e1391. | 10.7717/peerj.1391 |
| Raymundo, L.J., Halford, A.R., Maypa, A.P. and Kerr, A.M., 2009. Functionally diverse reef-fish communities ameliorate coral disease. Proceedings of the National Academy of Sciences, 106(40), pp.17067-17070. | 10.1073/pnas.0900365106 |
| Raymundo, L.J., Harvell, C.D. and Reynolds, T.L., 2003. Porites ulcerative white spot disease: description, prevalence, and host range of a new coral disease affecting Indo-Pacific reefs. Diseases of Aquatic Organisms, 56(2), pp.95-104. | 10.3354/dao056095 |
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| Haapkylä, J., Seymour, A.S., Trebilco, J. and Smith, D., 2007. Coral disease prevalence and coral health in the Wakatobi Marine Park, south-east Sulawesi, Indonesia. Journal of the Marine Biological Association of the united Kingdom, 87(2), pp.403-414. | 10.1017/S0025315407055828 |
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Table S4

**Table S4.** Excluded papers during full-text screening stage and reasons for their exclusion.

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| **Reference** | **Reason for Exclusion** |
| Leão, Z.M.A.N., Kikuchi, R.K.P.D. and Oliveira, M.D.D.M.D., 2008. Branqueamento de corais nos recifes da Bahia e sua relação com eventos de anomalias térmicas nas águas superficiais do oceano. *Biota Neotropica*, 8, pp.69-82. | Not in English |
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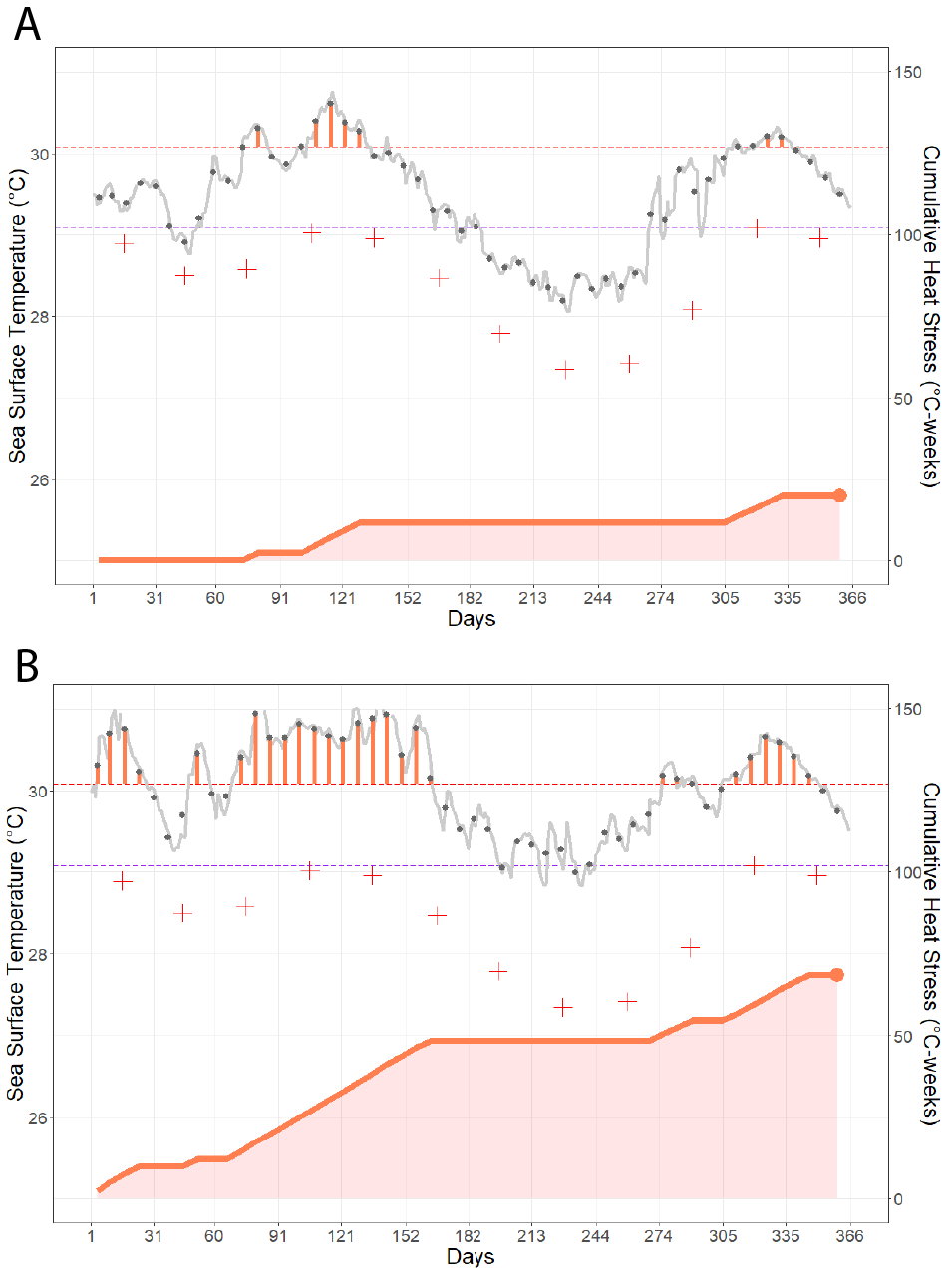
Figure S4

Chart, scatter chart

Description automatically generated

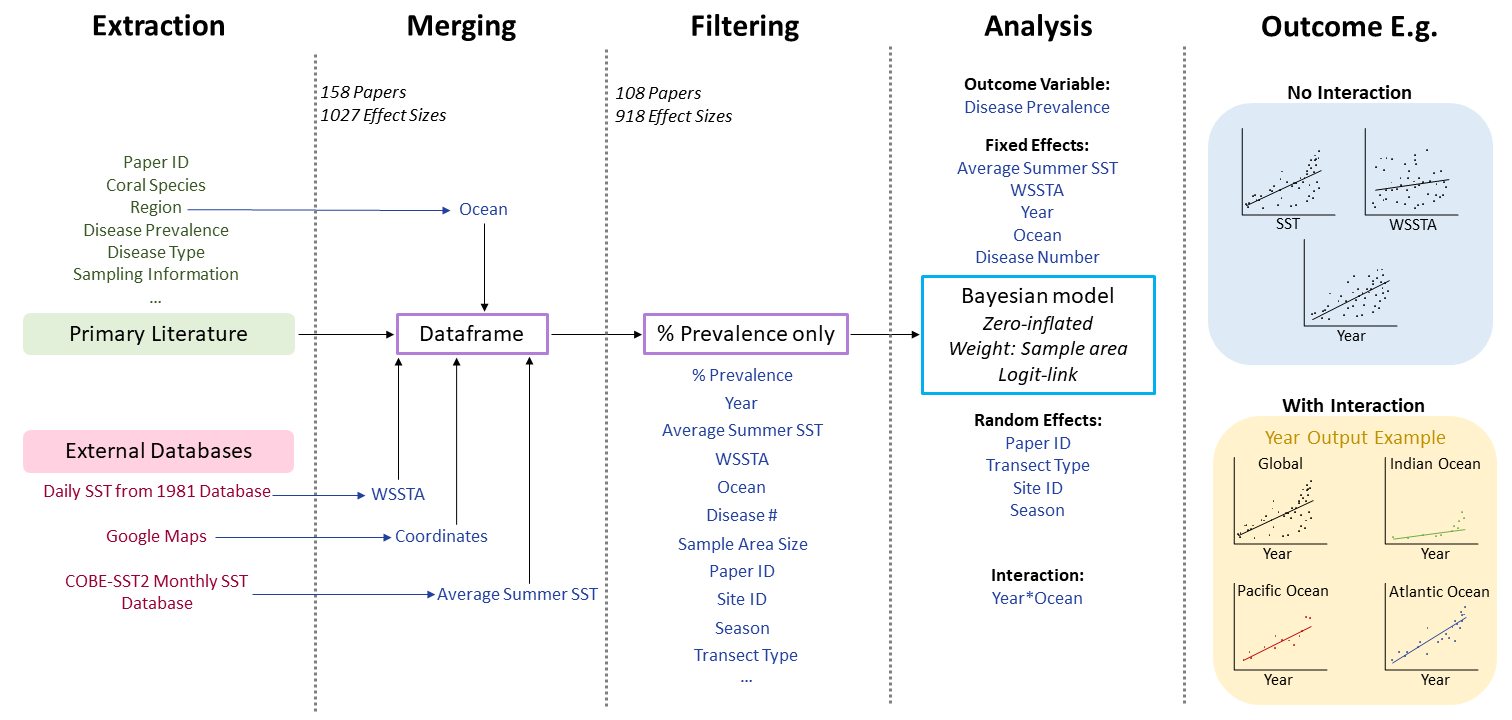
**Figure S4.** Correlation between average summer sea surface temperature (SST) and Year. Correlation = -0.019, CI = -0.084 – 0.046. p-value = 0.56.

Figure S5

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**Figure S5.** Visualization of calculations for Weekly Sea Surface Temperature Anomaly (WSSTA; metric adopted from Bruno et al., 2007) off the coast of Bali. WSSTA values here differ from values actually used in analysis – calculation for demonstration purposes only. Red crosses indicate the monthly means of the “long-term climatology”. Purple lines denote the maximum of the “long-term climatology”. Red lines denote 1°C above the maximum of the “long-term climatology,” otherwise known as the heat stress threshold. Grey dots connected by the grey line denote the weekly average sea surface temperatures (SST). Orange bars connecting grey dots to the red line indicate the weekly averages that exceed the heat stress threshold. The temperature values of these orange bars (y-axis on the left) are summed to calculate WSSTA. The orange trend line (y-axis on the right) tracks how heat stress accumulates throughout the year before reaching the orange dot which represents the WSSTA value utilized in our models. **A.** Example of WSSTA calculation from 2017 in which the amplitude of thermal anomaly is small and the anomaly time periods are short. This yields a smaller WSSTA value. **B.** Example of WSSTA calculation from 2016 in which the amplitude of thermal anomaly is larger and the anomaly time periods are long and frequent. This yields a much larger WSSTA value, reflecting the higher degree and length of heat stress the corals would experience at this reef in this year.

Figure S6

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**Figure S6.** Workflow diagram of data extraction and coding process. During the data extraction process, information is collected from the 120 included papers, as described in the methods section. This yields a total of 1027 effect sizes. Data extracted from included literature is merged with data extracted from outside databases. The information gathered from these outside databases are used to calculate average summer Sea Surface Temperature (SST) and Weekly Sea Surface Temperature Anomaly (WSSTA) during the extraction process. During the extraction phase, the extracted region of study variable is replaced with a more general “Ocean” metric which records the ocean basin in which the data was collected. This data-frame is then filtered for missing data, resulting in 918 effect sizes. From these effect sizes, relevant data (percent disease prevalence, year of survey, average summer SST, WSSTA, ocean, number of diseases included in prevalence, size of sample area, paper identification (ID), site ID, season in which the survey was conducted, and type of transect used to complete study; fully described in the figure and methods section) are utilized for Bayesian modeling. Year, Ocean, WSSTA, average summer SST, and disease number were included as fixed effects. Paper ID, site ID, season of survey, and transect type were included as random effects. In the interaction model, only Year and average summer SST interact with Ocean. The Bayesian models were weighted using the sample area size and included a logit link and zero-inflated portion to accommodate our data. Sample outputs are visualized using fake data. See Figure 2B,E,H and Figure 4 for plots using actual data.

Table S5

**Table S5.** Meta-data table. Extracted variables and their definitions.

|  |  |
| --- | --- |
| **Variable** | **Definition** |
| **Bibliographic Data** | |
| Paper\_ID | Identification number to indicate which study is being examined |
| Author\_First | First author name written as Lastname FirstInitials |
| Authors\_Middle | Authors who are not the first or last author name written as Lastname FirstInitials; separated by commas if more than one |
| Author\_Last | Last author name written as Lastname FirstInitials |
| Year\_Published | Year paper was published |
| Title | Title of paper |
| Journal | Journal in which the paper was published |
| Volume | Volume of journal in which the paper was published |
| Issue | Issue of journal in which the paper was published |
| Pages | Pages of journal where paper was printed |
| DOI | DOI of paper, excluding “https://doi.org/” |
| Completed | Completion status of extracted data; 0 = not yet completed, 1 = completed |
| Requested | Request status of missing data; 0 = not requested, 1 = requested |
| Received | Receive status of missing data; 0 = waiting on reply, 1 = reply received or not needed |
| WhomReq | Name of person from whom data was requested, priority given to the name of the individual who replied with data, followed by others with whom extractor corresponded |
| Note | Notes on paper as a whole |
| **Effect Size Data** | |
| Effect\_ID | Identification number to indicate what effect size the data pertains to |
| Paper\_ID | Identification number to indicate which study is being examined |
| Site\_ID | Identification number to indicate what site the data was collected at for the study |
| Disease\_Prevalence | Disease prevalence metric as reported in paper |
| Unit\_Prevalence | Unit of disease prevalence as reported in paper (e.g., %, col/m2, etc.) |
| DiseasePrev\_SE | Standard error of disease prevalence; reported in paper or calculated from MetaDigitise |
| SourcePrev | Location of disease prevalence information in paper (e.g., Figure #, Section title, page #) |
| Year | Year disease survey conducted |
| Month | Month disease survey conducted (e.g., “Feb”, “Feb-Apr”, “Feb, Apr, Aug”) |
| SourceYear | Location of year information in paper (e.g., Figure #, Section title, page #) |
| Location | Location of survey as written in paper |
| SourceLocation | Location of location information in paper (e.g., Figure #, Section title, page #) |
| Region\_Hoegh-Guldberg | Location of survey as defined by regions outlined in Hoegh-Guldberg et al., 2017 |
| Region\_Kleypas | Location of survey as defined by regions outlined in Kleypas et al., 2008 |
| Lat | Latitude of survey location in decimal degrees |
| Lon | Longitude of survey location in decimal degrees |
| SourceLatLon | Location of latitude and longitude information acquired (e.g., paper Figure #, paper Section title, page #, GoogleMaps estimate) |
| SST\_C | Sea surface temperature in °C if reported in paper |
| SourceTemp | Location of sea surface temperature information in paper (e.g., Figure #, Section title, page #) |
| Notes | Notes on effect size data extraction |
| **Transect Data** | |
| Effect\_ID | Identification number to indicate what effect size the data pertains to |
| Paper\_ID | Identification number to indicate which study is being examined |
| Transect\_Type | Type of survey method conducted |
| Transect\_Num | Number of surveys conducted |
| Transect\_Length\_m | Length or diameter of survey area in meters |
| Transect\_Width\_m | Width of survey area (if applicable) in meters |
| Plot\_area\_m^2 | Area of each survey plot |
| SourceTransect | Location of survey method information in paper (e.g., Figure #, Section title, page #) |
| Notes | Notes on transect data extraction |
| **Moderator Data** | |
| Effect\_ID | Identification number to indicate what effect size the data pertains to |
| Paper\_ID | Identification number to indicate which study is being examined |
| DiseasePrev\_SD | Standard deviation of disease prevalence if reported in paper |
| SST\_SE | Standard error of sea surface temperature if reported in paper |
| SST\_SD | Standard deviation of sea surface temperature if reported in paper |
| Sample\_Area\_km^2 | Total area sampled; reported in study or calculated from transect data |
| Site\_Num | Number of sites examined in study |
| SourceSite\_Num | Location of site number information in paper (e.g., Figure #, Section title, page #) |
| Coral\_N | Number of coral individuals in survey area |
| Mixed\_Sp | 0 = single species; 1 = multiple species included in effect size |
| Notes | Notes on moderator data extraction |
| **Disease Data** | |
| Effect\_ID | Identification number to indicate what effect size the data pertains to |
| Paper\_ID | Identification number to indicate which study is being examined |
| Disease\_Num | Number of diseases identified in study |
| WS | White Syndrome; 0 = absence, 1 = presence |
| BBD | Black Band Disease; 0 = absence, 1 = presence |
| GA | Growth Anomalies; 0 = absence, 1 = presence |
| BrB | Brown Band Disease; 0 = absence, 1 = presence |
| SEB | Skeletal Eroding Band; 0 = absence, 1 = presence |
| UWS | Ulcerative White Syndrome; 0 = absence, 1 = presence |
| TL | Tissue Loss; 0 = absence, 1 = presence |
| DSS | Dark Spot Syndrome; 0 = absence, 1 = presence |
| WB | White Band Disease; 0 = absence, 1 = presence |
| YBD | Yellow Band Disease; 0 = absence, 1 = presence |
| WPx | White Pox; 0 = absence, 1 = presence |
| IMS | Intercostal Mortality Syndrome; 0 = absence, 1 = presence |
| Trema | Trematodiasis; 0 = absence, 1 = presence |
| Cyano | Cyanobacterial infection; 0 = absence, 1 = presence |
| PS | Pink Syndrome; 0 = absence, 1 = presence |
| AN | Atramentous Necrosis; 0 = absence, 1 = presence |
| PR | Pigmentation response; 0 = absence, 1 = presence |
| PUWS | Porites Ulcerative White Syndrome; 0 = absence, 1 = presence |
| DWS | Diploastrea White Spots; 0 = absence, 1 = presence |
| RBD | Red Band Disease; 0 = absence, 1 = presence |
| STGA | Skeletal Tissue Growth Anomalies; 0 = absence, 1 = presence |
| RM | Ridge Mortality; 0 = absence, 1 = presence |
| RW | Rapid Wasting; 0 = absence, 1 = presence |
| PLS | Pink Line Syndrome; 0 = absence, 1 = presence |
| PWPS | Porites White Patch Syndrome; 0 = absence, 1 = presence |
| CT | Compromised Tissue; 0 = absence, 1 = presence |
| PBT | Porites Bleaching with Tissue Loss; 0 = absence, 1 = presence |
| WPa | White Patch syndrome; 0 = absence, 1 = presence |
| Cilia | Ciliates infection; 0 = absence, 1 = presence |
| PBSS | Pink-Blue Spot Syndrome; 0 = absence, 1 = presence |
| GPD | Grey Patch Disease; 0 = absence, 1 = presence |
| Unknown | Disease unable to be identified during the study; 0 = absence, 1 = presence |
| Notes | Notes on disease data extraction |
| **Species Data** | |
| PaperID | Identification number to indicate which study is being examined |
| TaxonomicName | Scientific name of coral identified as reported in paper |
| Family | Family of \*coral identified as reported in ReefBase |
| Genus | Genus of coral identified as reported in ReefBase |
| Scientific Name | Scientific name of coral identified as reported in ReefBase |
| Source | Location of taxonomic information in paper (e.g., Figure #, Section title, page #) |
| Notes | Notes on species data extraction |

Table S6

**Table S6.** Model selection with leave one out (LOO) comparison and widely applicable information criterion (WAIC). Each of these comparison methods identify the predictive accuracy of the model. The elpd\_loo value for Bayesian LOO estimates is the sum of individual point-wise log predictive densities. As a result, higher elpd\_loo values indicate a better predictive model (better predictive density). The WAIC value is the log pointwise predictive density converted to an estimate of deviance which describes the ability to apply these predictions to observations not fitted in the model (transferability of estimate parameters). As a result, lower WAIC values indicate a better predictive model (less deviance and transferability). Both values were calculated using functions from the *loo* package (loo\_compare and waic; (version 2.5.1; Vehtari et al., 2020). We selected our model based on the LOO comparison because for all models, over 40% of the p\_waic estimates (effective number of parameters) were greater than 0.4 and it is recommended to use LOO comparison instead. As a result, we selected the model with interactions between Ocean and average summer sea surface temperature (SST) and Ocean and Year.

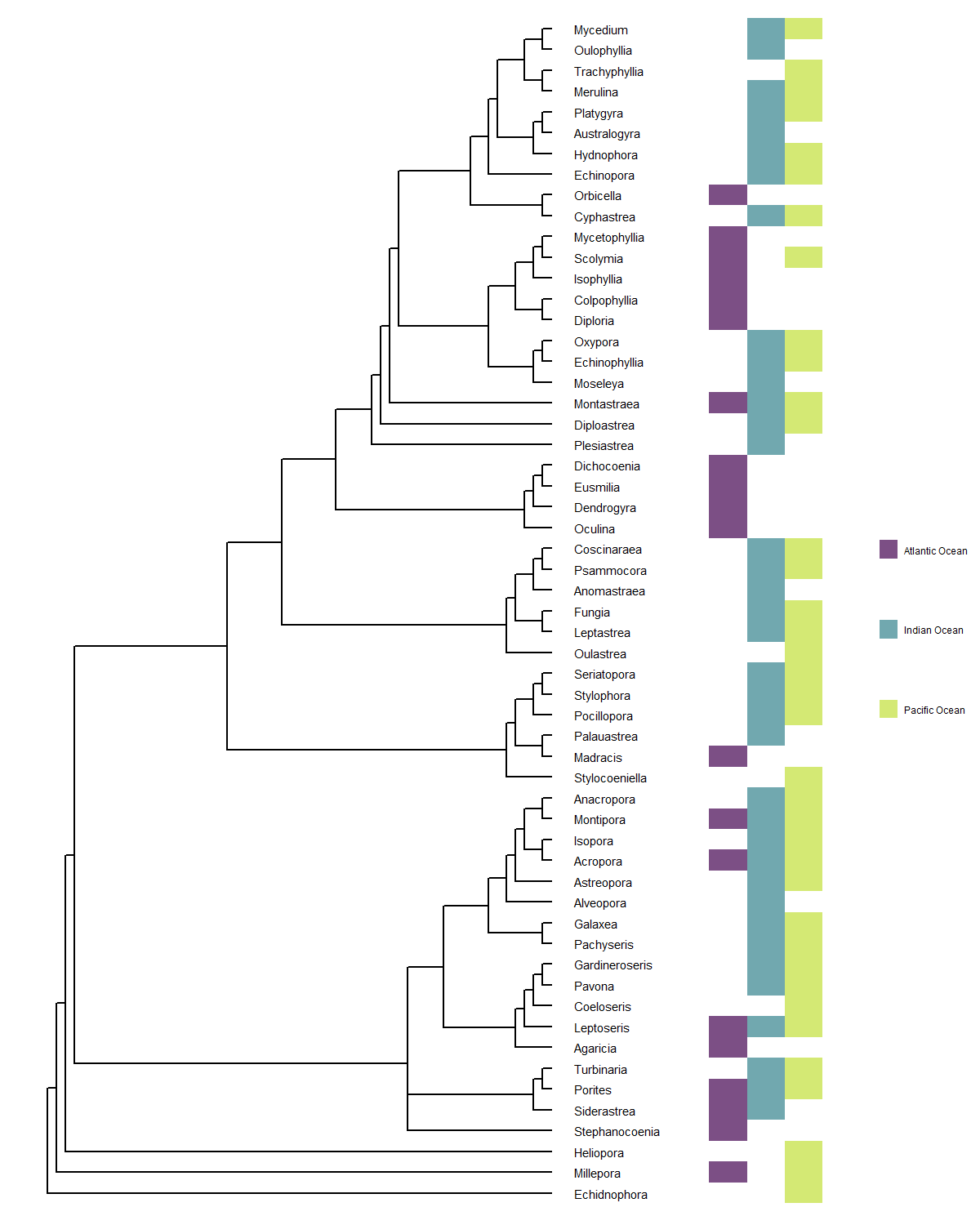
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Model** | **LOO Value**  **(elpd\_loo)** | **LOO Rank** | **WAIC Value** | **WAIC Rank** |
| No Interactions | 17660.1 | 1 | -35238.6 | 2 |
| All Interactions | 17628.0 | 8 | -35179.0 | 8 |
| Ocean interacts with average summer SST | 17648.6 | 3 | -35214.2 | 5 |
| Ocean interacts with WSSTA | 17640.0 | 5 | -35216.4 | 3 |
| Ocean interacts with Year | 17647.6 | 4 | -35241.4 | 1 |
| Ocean interacts with Year and average summer SST | 17652.4 | 2 | -35215.9 | 4 |
| Ocean interacts with average summer SST and WSSTA | 17635.9 | 7 | -35199.9 | 7 |
| Ocean interacts with Year and WSSTA | 17639.6 | 6 | -35204.0 | 6 |

Table S7

**Table S7.** List of diseases and how many effect sizes account for that disease (n = 918).

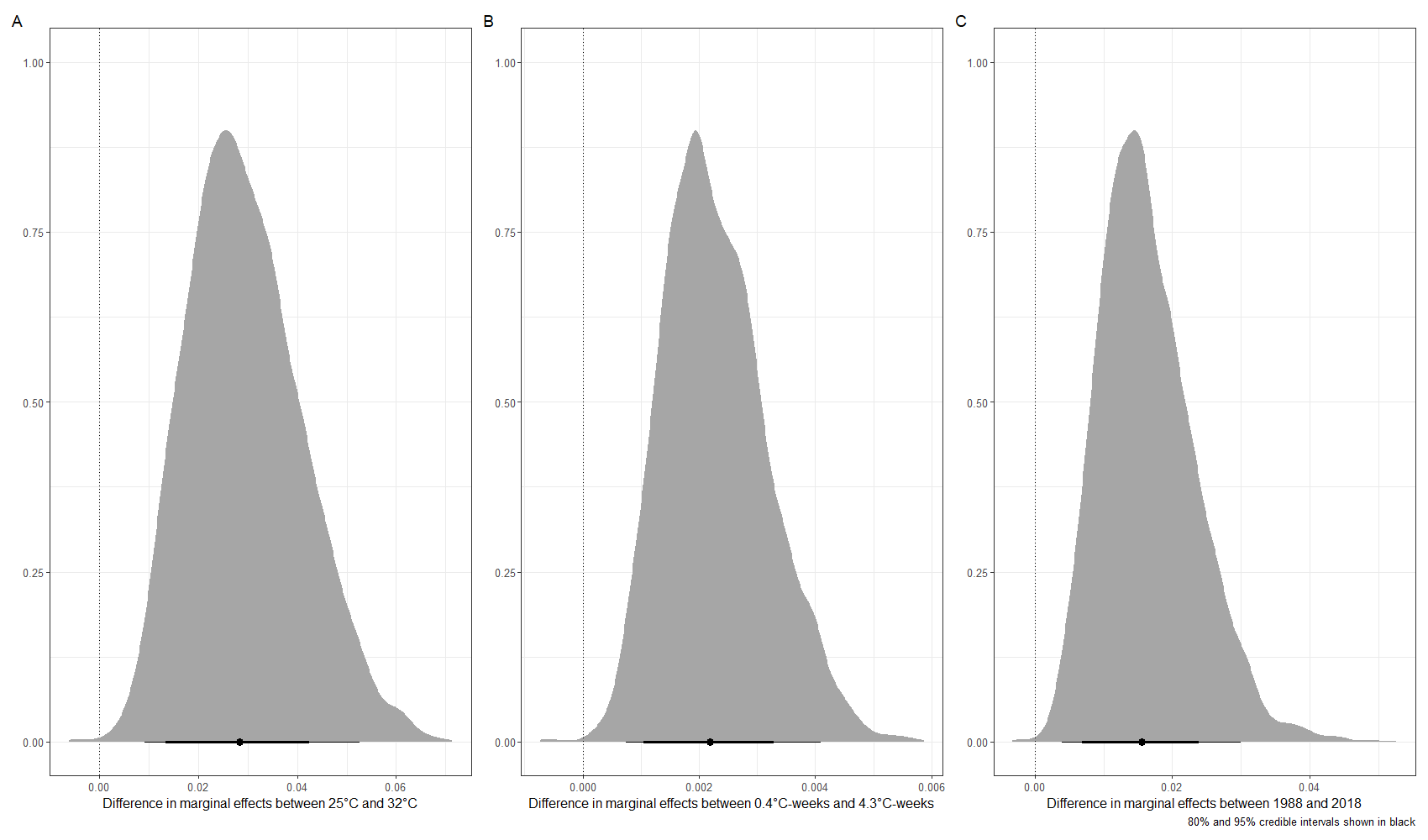
|  |  |  |
| --- | --- | --- |
| **Disease** | **Percent of Effect Sizes Included (n = 918)** | **Number of Effect Sizes Included** |
| White Syndrome | 30.4% | 279 |
| Black Band Disease | 30.0% | 275 |
| Yellow Band Disease | 22.3% | 205 |
| Dark Spot Syndrome | 15.4% | 141 |
| Growth Anomalies | 15.4% | 141 |
| White Band Disease | 10.6% | 97 |
| Skeletal Eroding Band | 6.0% | 55 |
| Brown Band Disease | 5.9% | 54 |
| Tissue Loss | 5.4% | 50 |
| Ulcerative White Syndrome | 5.4% | 50 |
| White Pox | 5.1% | 47 |
| Red Band Disease | 4.9% | 45 |
| Porites Ulcerative White Syndrome | 4.4% | 41 |
| Compromised Tissue | 4.4% | 40 |
| White Patch Syndrome | 4.0% | 37 |
| Pigmentation Response | 3.8% | 35 |
| Ciliates Infection | 3.7% | 34 |
| Cyanobacteria | 2.8% | 26 |
| Atramentous Necrosis | 2.5% | 23 |
| Pink Spot Syndrome | 2.0% | 18 |
| Diploastrea White Spots | 1.3% | 12 |
| Pink-Blue Spot Syndrome | 1.3% | 12 |
| Pink Line Syndrome | 1.1% | 10 |
| Porites White Patch Syndrome | 1.1% | 10 |
| Porites Bleaching with Tissue Loss | 1.1% | 10 |
| Grey Patch Disease | 0.7% | 6 |
| Unknown | 0.4% | 4 |
| Rapid Wasting | 0.3% | 3 |
| Ridge Mortality | 0.3% | 3 |
| Trematodiasis | 0.3% | 3 |
| Skeletal Tissue Growth Anomalies | 0.2% | 2 |
| Intercostal Mortality Syndrome | 0.1% | 1 |

Figure S7



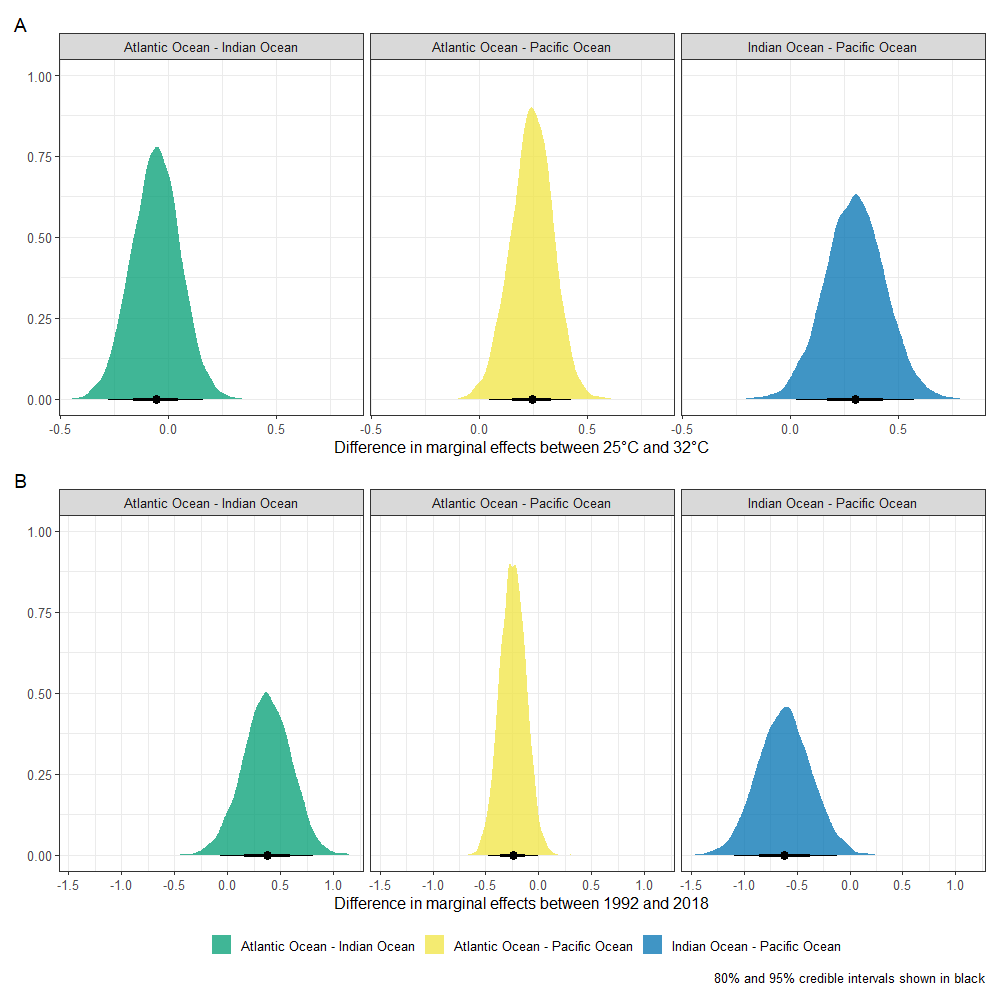
**Figure S7.** Phylogenetic tree of all genera examined. Heatmap denotes ocean in which each genus was surveyed (Atlantic Ocean colored in dark purple, Indian Ocean colored in teal blue, Pacific Ocean colored in yellow-green).

Figure S8



**Figure S8.** Marginal contrasts. 80% and 95% credible intervals shown in black. **A.** Contrast for maximum (32oC) and minimum (25oC) values of average summer sea surface temperature. **B.** Contrast for maximum (4.3oC-weeks) and minimum (0.4oC-weeks) values of weekly sea surface temperature anomaly. **C.** Contrast for maximum (2018) and minimum (1992) values of year.

Figure S9



**Figure S9.** Marginal contrasts between oceans from interaction model. 80% and 95% credible intervals shown in black. **A.** Marginal contrasts for the interaction between average summer sea surface temperature (SST) and Ocean. **B.** Marginal contrasts for the interaction between Year and Ocean.