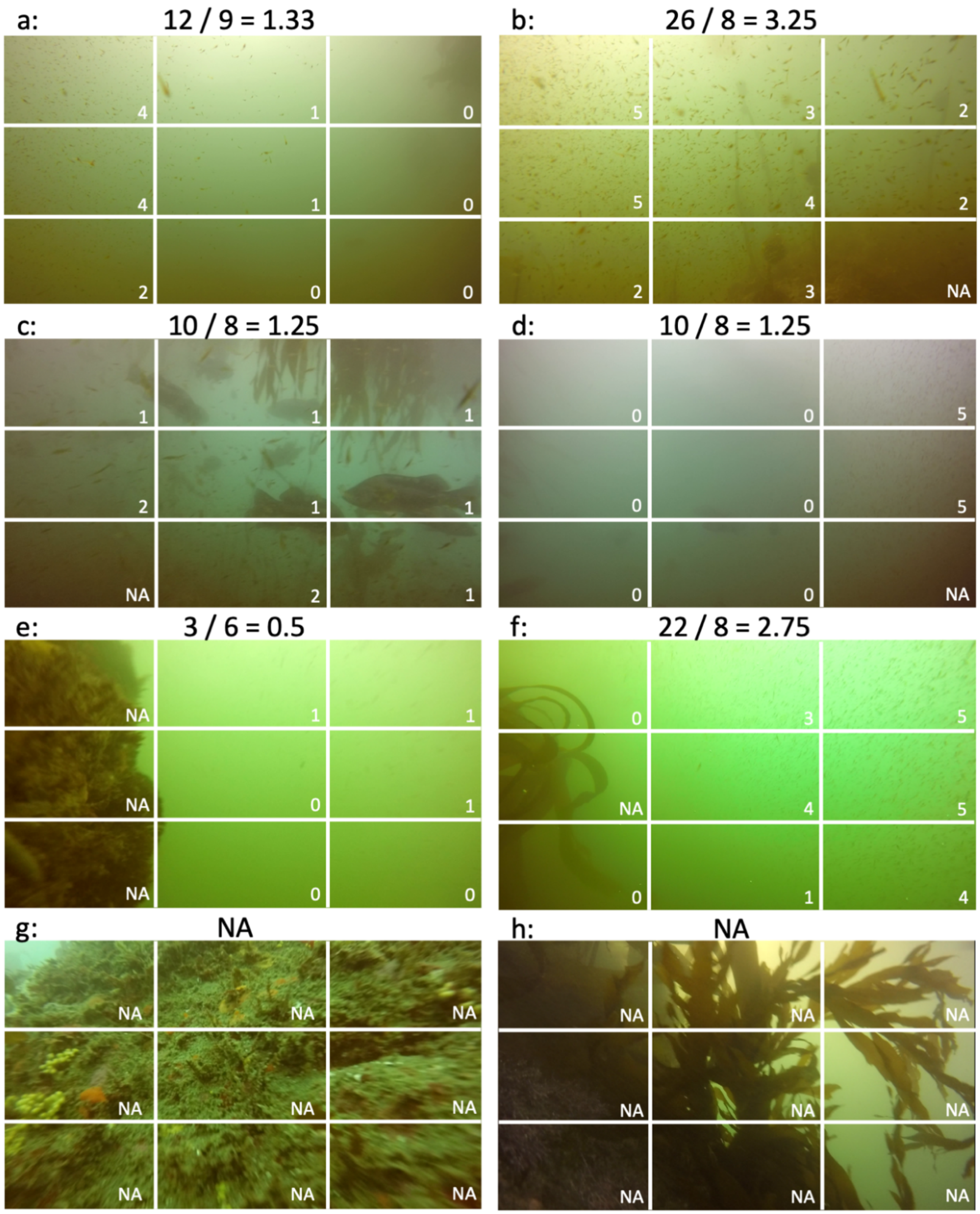

Figure S1: Examples of still images with overlaid 3x3 grid taken from GoPro videos for scoring relative zooplankton abundance following the methods described in Hildebrand et al. (2022). Panels a-h demonstrate abundance scoring on a scale of 0-5 (0 = no zooplankton present, 5 = highest zooplankton density, NA = indeterminable due to low light and/or other obstructions (Figure taken from Hildebrand et al. 2022)

Text S1. Explanation of kelp condition scoring categories from GoPro videos, adapted from Hildebrand et al. (2022)

Bull kelp (hereinafter ‘kelp’) health score was assigned to a sampling station by watching the entire GoPro video from a given sampling day. This qualitative method was chosen due to the fact that kelp could not be accurately described from a single still image within a video. The five kelp health categories were as follows: all damaged (AD), mostly damaged (MD), mostly healthy (MH), all healthy (AH), and no kelp (NK). Reference videos (found on FigShare at https://figshare.com/articles/media/Kelp_health_reference_videos/20419824?file=36513951) were used to ensure consistency in kelp health category assignments. The presence of kelp and the condition of both the kelp fronds and stipes were considered to assign one of these categories.AD was assigned if all kelp fronds and/or stalks were visibly damaged due to urchins (e.g., urchins actively feeding on stalks or extreme fraying of kelp fronds with many urchins seen nearby). MD was assigned if kelp frond and/or stalk damage was predominant, however if some healthy kelp (e.g., big bull kelp plants with long, intact fronds) were also visible. MH was assigned if most kelp fronds and stalks were long and intact, however if some unhealthy kelp (e.g., urchins actively feeding on stalks or extreme fraying of kelp fronds with many urchins seen nearby) were also visible. AH was assigned if all kelp stalks and/or fronds in the video were long and intact. NK was assigned if no kelp was visible (both fronds and stalks). For final analysis, condition categories were converted to a numerical score: NK = 1, AD = 2, MD = 3, MH = 4, AH = 5. We then calculated the mean kelp condition across all sampling stations within each site on each day.

Text S2: R Code for calculating wind stress

The northward wind stress component (τy) was calculated from the wind speed and direction recorded at the NOAA Buoy Station 46015, 28 km west of Port Orford (42°45'9" N 124°50'37" W; https://www.ndbc.noaa.gov/station_page.php?station=46015) following Large and Pond (1981) methods as described in Kochanski et al. (2006).

```
### Windstress and SST from offshore buoy

#Using data from the PO buoy 46015
#https://www.ndbc.noaa.gov/station_page.php?station=46015

buoy46015 <- read.csv("wmo_46015_c974_6b66_8915.csv")

buoy46015$time <- strptime(buoy46015$time, format = "%Y-%m-%d")
buoy46015_SST_WIND <- data.frame ("date" = as.Date(buoy46015$time),
                     "SST" = as.numeric(buoy46015$sea_water_temperature),
                     "V" = as.numeric(buoy46015$wind_speed),
                     "winddir" = as.numeric(buoy46015$wind_from_direction))

buoy46015_SST_WIND <- na.omit(buoy46015_SST_WIND)

p = 1.2
windstress = function(df){
  df1 = mutate(df,
         winddir.rad = winddir*(pi/180),
         u = -abs(V)*sin(winddir.rad),
         v = -abs(V)*cos(winddir.rad),
         C = ifelse(abs(V) < 11, 1.2*10^-3, (0.49+0.65*abs(V))*10^-3),
         tx = p*C*u*abs(V),
         ty = p*C*v*abs(V)
         )
  return(df1)
}

# run the function on the buoy 46015 data
windstress46015_df <- windstress(buoy46015_SST_WIND)
```

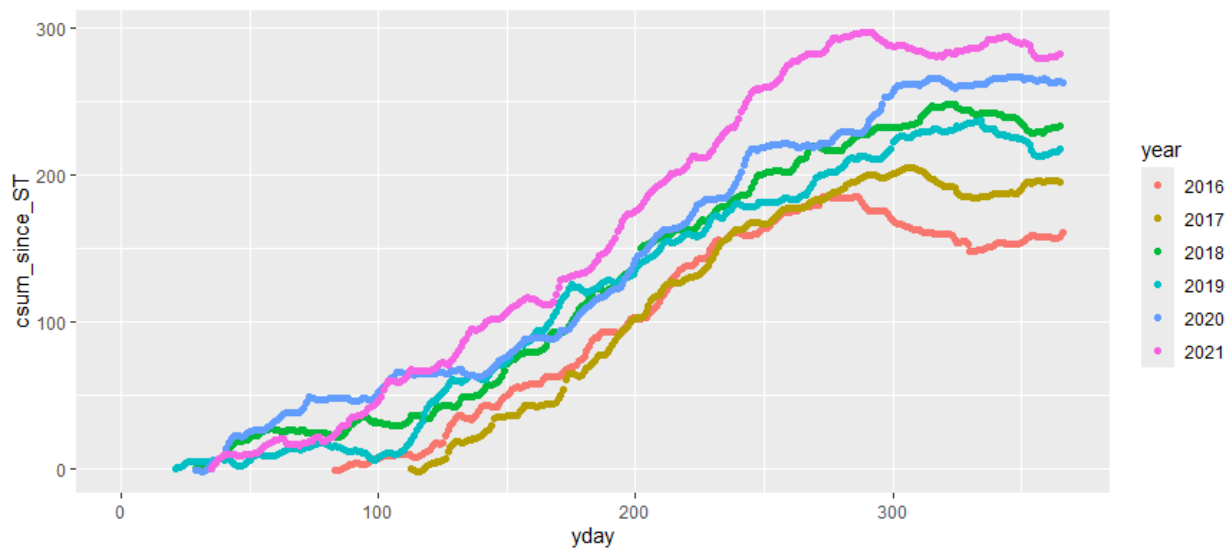

Figure S2: Scatterplot showing Cumulative CUTI since spring transition (csum_since_ST) over day of the year (yday), points are colored by year

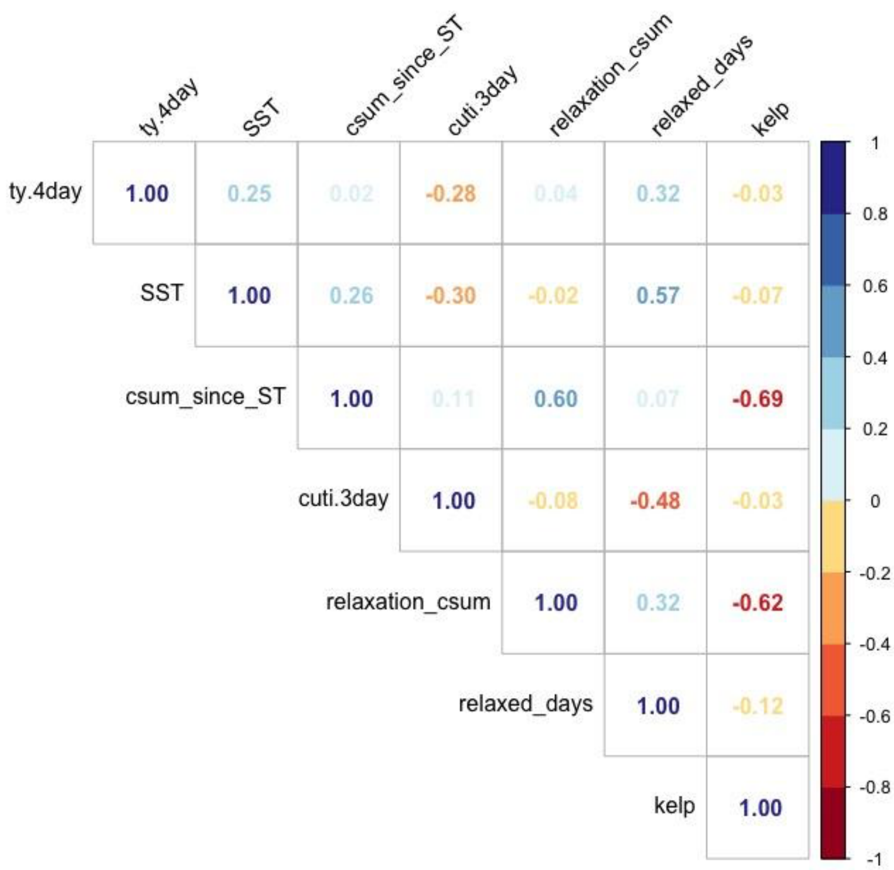

Figure S3: Pearson correlation plot showing environmental variables used in both BRT_{zoop} and BRT_{whale}. Environmental variables are described as follows: Wind stress at a 4-day lag (ty.4day), Sea surface temperature (SST), Cumulative CUTI since Spring Transition (csum_since_ST), CUTI values at a 3-day lag (cuti.3day), Relaxation events since Spring Transition (relaxation_csum), Number of recent relaxed days (relaxed_days), and Kelp health (kelp)

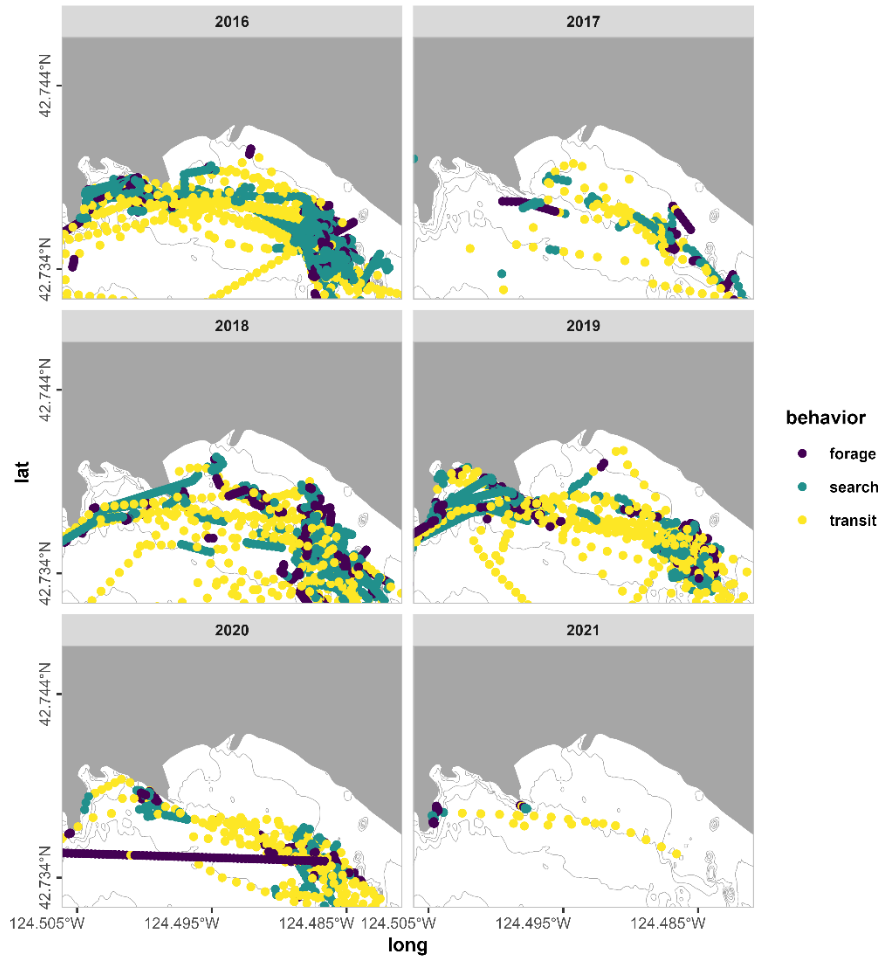

Figure S4: Whale activity within the sampling area during field season for 2016-2021. Whale locations are identified here by activity type: forage, search, or transit

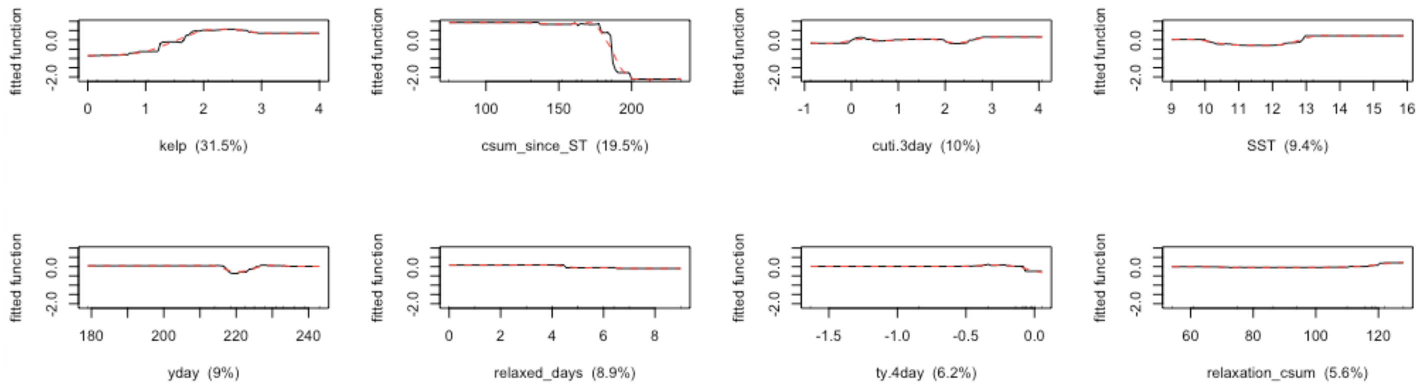

Figure S5: Functional relationship plot for each predictor variable for BRT_{zoop}, following established BRT model evaluation protocols (Elith et al., 2008); Wind stress at a 4-day lag (ty.4day), Sea surface temperature (SST), Cumulative CUTI since Spring Transition (csum_since_ST), CUTI values at a 3-day lag (cuti.3day), Relaxation events since Spring Transition (relaxation_csum), Number of recent relaxed days (relaxed_days), and Kelp health (kelp) and including day of the year (yday)

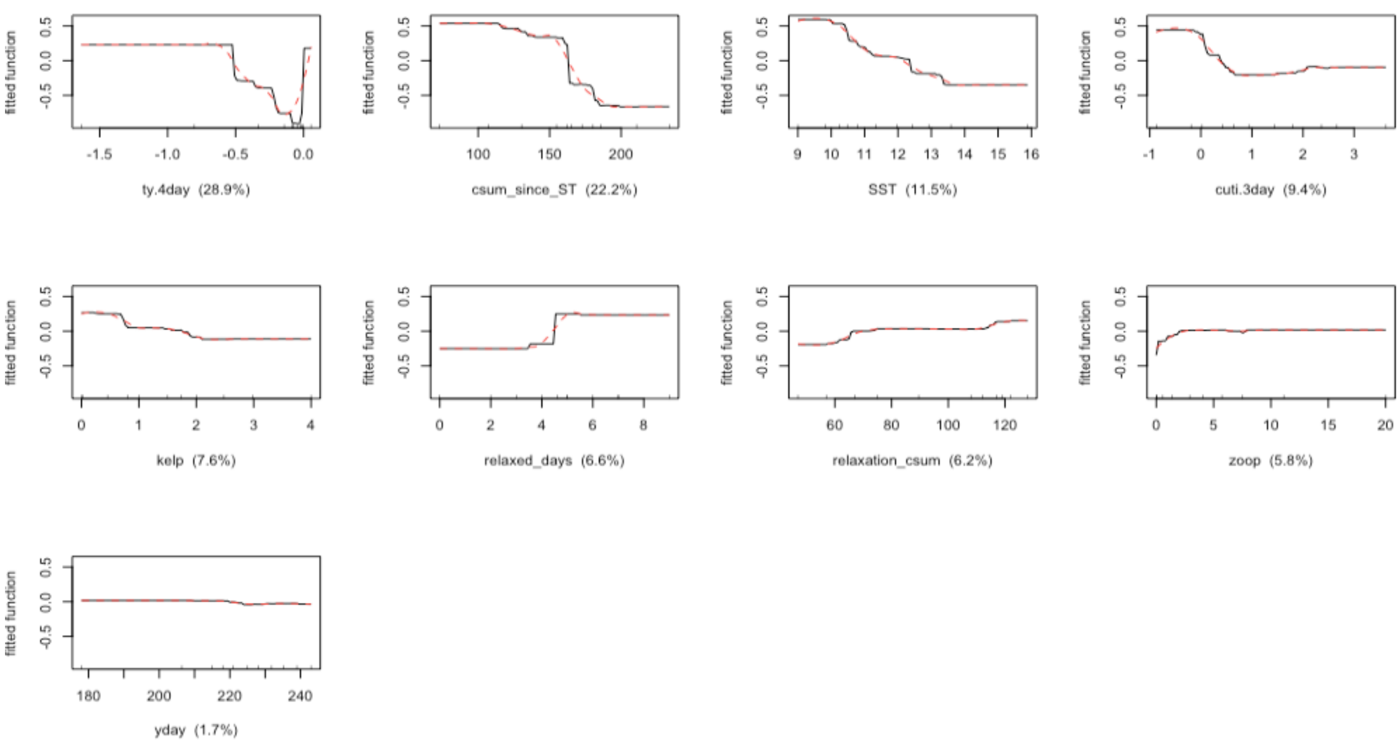

Figure S6: Functional relationship plot for each variable in BRT_{whale} model, following established BRT model evaluation protocols (Elith et al., 2008); Zooplankton abundance (zoop), Wind stress at a 4-day lag (ty.4day), Sea surface temperature (SST), Cumulative CUTI since Spring Transition (csum_since_ST), CUTI values at a 3-day lag (cuti.3day), Relaxation events since Spring Transition (relaxation_csum), Number of recent relaxed days (relaxed_days), and Kelp health (kelp) and including day of the year (yday)

Table S1: CUTI phenology table showing the year, day of physical spring transition index (STI), the CUTI value at STI (STI_CUTI), day of maximum CUTI (Max), maximum CUTI value (MAX_CUTI), last day of upwelling season (End), value of CUTI at last day of season (End_CUTI), and CUTI calculated mean for each year (Mean_CUTI); following established upwelling phenological definitions (Bograd et al., 2009l Oestreich et al. 2022)

Year	**STI**	**STI_CUTI**	**Max**	**Max_CUTI**	**End**	**End_CUTI**	**Mean_CUTI**
2016	83	-57.749	212	65.1058	277	126.2317	0.946035897
2017	113	-35.1426	233	117.8409	307	168.9235	1.048733333
2018	29	-12.8774	179	96.8435	319	232.8619	0.844690722
2019	21	-19.6521	115	6.5357	330	212.6342	0.758545161
2020	29	-2.4565	240	198.7354	348	263.6189	0.832515625
2021	35	-13.3853	192	142.3289	288	278.6699	1.168047244
2022	14	-7.7955	170	74.1133	331	194.7468	0.642459119

Table S2: Tables showing the interaction term sizes among predictor variables for BRT_{zoop} and BRT_{whale} following established BRT model evaluation protocols (Elith et al., 2008); A) BRT_{zoop} interactions among Wind stress at a 4-day lag (ty.4day), Sea surface temperature (SST), Cumulative CUTI since Spring Transition (csum_since_ST), CUTI values at a 3-day lag (cuti.3day), Relaxation events since Spring Transition (relaxation_csum), Number of recent relaxed days (relaxed_days), and Kelp health (kelp), B) BRT_{whale} interaction term sizes among Zooplankton abundance (zoop), Wind stress at a 4-day lag (ty.4day), Sea surface temperature (SST), Cumulative CUTI since Spring Transition (csum_since_ST), CUTI values at a 3-day lag (cuti.3day), Relaxation events since Spring Transition (relaxation_csum), Number of recent relaxed days (relaxed_days), and Kelp health (kelp)

A.	ty.4day	SST	cuti.3day	csum_since_ST	relaxation_csum	relaxed_days	kelp
ty.4day	0	0.15	0.22	2.99	0.01	0.02	0.08
SST	0	0	0.2	0.02	0.01	0.2	0.07
cuti.3day	0	0	0	0.84	0.11	1.21	0.07
csum_since_ST	0	0	0	0	27.03	0.83	2.3
relaxation_csum	0	0	0	0	0	0.03	3.7
relaxed_days	0	0	0	0	0	0	0.69
kelp	0	0	0	0	0	0	0

B.	zoop	ty.4day	SST	csum_since_ST	cuti.3day	relaxation_csum	relaxed_days	kelp
zoop	0	0	0.07	0.47	0.01	0	0	0
ty.4day	0	0	0.02	0.46	2.47	0.06	0.22	0
SST	0	0	0	0.2	1.06	0	7.22	0.05
csum_since_ST	0	0	0	0	0.03	2.23	0.05	2.99
cuti.3day	0	0	0	0	0	0.01	0	0
relaxation_csum	0	0	0	0	0	0	0	0
relaxed_days	0	0	0	0	0	0	0	0.13
kelp	0	0	0	0	0	0	0	0

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