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Abstract.—*Silvetia compressa* is a common rocky intertidal fucoid that plays an important role in the community and has experienced widespread declines throughout California. The causes of these declines are unknown, but sea surface temperature (SST) is considered one of the dominant factors affecting intertidal algae. The 2015–2016 El Niño introduced anomalously high SSTs to southern California, which may have impacted rocky intertidal species. This study investigates temporal changes in abundance of *S. compressa* with respect to SST at 4 sites on San Clemente Island (SCI), California, from 2012 to 2016. Point-intercept data were used to quantify percent cover during biannual intertidal surveys. To correlate SST with changes in *S. compressa* percent cover, we utilized SST data collected approximately 50 km southeast of SCI from the National Data Buoy Center. Our results indicated significant declines in *S. compressa* in spring 2015 across all 4 sites following SST anomalies that began in 2014. Linear regression between *S. compressa* percent cover and the previous year's maximum SSTs showed a significant negative relationship, indicating that reduced abundance of *S. compressa* was moderately associated with elevated SSTs.

Resumen.—*Silvetia compressa* es un alga fucoide de la zona intermareal rocosa común que desempeña un papel importante en la comunidad y que ha sufrido una disminución generalizada en todo California. Las causas de su disminución se desconocen, sin embargo, la temperatura de la superficie del mar (SST, por sus siglas en inglés) se considera como uno de los factores principales que afectan a las algas intermareales. El Niño, en el año 2015–2016 introdujo, al sur de California, temperaturas superficiales del mar anormalmente altas que pudieron haber afectado a las especies intermareales rocosas. Este estudio investigó, desde el año 2012 hasta el 2016, los cambios temporales en la abundancia de *S. compressa* con relación a la temperatura de la superficie del mar, en cuatro sitios de la Isla San Clemente, California. Los datos sobre los puntos de intersección se utilizaron para cuantificar el porcentaje de cobertura durante los estudios intermareales bianuales. Para correlacionar la SST con los cambios en el porcentaje de la cobertura de *S. compressa*, utilizamos los datos de la SST del Centro Nacional de Datos de Boyas, colectados aproximadamente a 50 km al sureste de la Isla San Clemente. Nuestros resultados indicaron reducciones significativas de *S. compressa* en la primavera del año 2015 en los cuatro sitios, posterior a las anomalías que se registraron en la temperatura de la superficie del mar en el año 2014. La regresión lineal entre la cobertura porcentual de *S. compressa* y las SST máximas del año anterior mostraron una relación negativa significativa, indicando que la disminución en la cantidad de *S. compressa* se relaciona, moderadamente, con el aumento de la temperatura de la superficie del mar.

Silvetia compressa is a slow-growing, long-lived rockweed species that inhabits the mid rocky intertidal zone (Gunnill 1980, Sagarin et al. 1999, Minchinton and Raimondi 2005). This species reportedly ranges from British Columbia to Baja California (Abbott and Hollenberg 1976), but it is generally most common in central and southern California (Kozloff 1993, Blanchette et al. 2008). *Silvetia compressa* plays an important role in rocky intertidal zonation and community structure because its canopy-forming structures offer valuable habitat and protection for other organisms in the community (Bertness et al. 1999, Whitaker et al. 2010). However, this highly productive species has undergone

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widespread declines in abundance throughout California (Thom and Widdowson 1978, Raimondi et al. 1999, Sagarin et al. 1999, Goodson 2003, Gerrard 2005, Minchinton and Raimondi 2005). These declines have prompted efforts to restore the species but success has been limited and short term (Whitaker et al. 2010). Although the causes of widespread declines in *S. compressa* are unknown, many abiotic factors such as temperature, winter storms, sediment inundation, decreased nutrients, and/or higher desiccation stress from afternoon low tides can influence abundance of this species (Seapy and Littler 1982, Sapper and Murray 2003, Minchinton and Raimondi 2005).

Effects from large-scale oceanographic processes, such as El Niño/Southern Oscillation (ENSO), are also linked to impacts on rocky intertidal species (Wootton et al. 1996, Petraitis and Dudgeon 1999, Thompson et al. 2002, Petraitis et al. 2003). The effects of these events can be pervasive as sea surface temperature (SST) is considered one of the most important factors affecting algae (Carballo et al. 2002, Rivadeneira and Fernandez 2005, Jones et al. 2010, Belanger et al. 2012, Martínez et al. 2012, Teske et al. 2013, Assis et al. 2014, Lourenço et al. 2016, Saada et al. 2016). Along with increased SSTs, El Niño events typically result in higher wave energy from storms (Barnard et al. 2017) and less nutrient-rich coastal waters (Barber and Chavez 1983, Zhu et al. 2014) and can lead to severe changes in the intertidal community.

The occurrence of El Niño is relatively regular in the northeastern Pacific Ocean, but the intensity and resulting impacts of these episodes can vary greatly (Huang et al. 2016). The 2015–2016 El Niño, which began in winter of 2015, is one of the strongest recent El Niños when considering SST anomalies (Huang et al. 2016, McClatchie et al. 2016). The conditions leading up to the 2015–2016 El Niño were unlike any other in recent history. Exceptionally high SST anomalies occurred throughout the North Pacific for approximately 2 years before the 2015–2016 El Niño began; this warm mass of water is known as "the blob" or marine heat wave (Jacox et al. 2016, McClatchie et al. 2016). North Pacific SSTs reached a record high in 2014 and 2015 (Bond et al. 2015, Zaba and Rudnick 2016). Due to the anomalous preceding temperature conditions, some oceanographic properties (wave energy) of the 2015–2016 El Niño were not as strong as those in previous El Niño events in southern California (McPhaden 2015, McClatchie et al. 2016, Barnard et al. 2017).

The effects of environmental stressors on algae during past El Niño events have been documented with nonuniform responses (Gunnill 1985, Seymour et al. 1985, Paine 1986, Tegner and Dayton 1987), but no studies, to our knowledge, have investigated changes in algae along the California coast in relationship to SST during the recent 2015–2016 El Niño. In this study we examine temporal changes in abundance for a common intertidal algal species, *S. compressa* (J.Agardh) E.Serrão, T.O.Cho, S.M.Boo & Brawley, at 4 distinct sites on San Clemente Island, California, from 2012 to 2016.

METHODS

Study Site

San Clemente Island (SCI) is the southernmost of 8 Channel Islands within the Southern California Bight (Fig. 1), a productive and diverse region ranging from Point Conception (Santa Barbara County, California) to just south of the border between the United States and Mexico (Littler et al. 1991, Dailey and Reish 1993). The island has been owned and managed by the U.S. Navy since the 1930s and is usually inaccessible to the general public. This, coupled with the island's distance from the mainland, has allowed for the preservation of a relatively pristine intertidal environment with limited anthropogenic inputs.

In 2010 the U.S. Navy established 4 rocky intertidal monitoring sites at SCI in different island ecoregions (Fig. 1; Tierra Data, Inc. 2011) in accordance with the Multi-Agency Rocky Intertidal Network (MARINe) guidelines (Engle 2008). SCI ecoregions are associated with variations in nearshore island bathymetry, substrate composition, and exposure to oceanic water masses and winds (U.S. Navy 2013).

West Cove (CLWC; 33°0′52.91″N, 118°36′22.37″W) is the westernmost point of the North Island Region at SCI. This site generally receives westerly wave exposure and prevailing WNW winds. Benches are composed of low sloping sedimentary rocks with
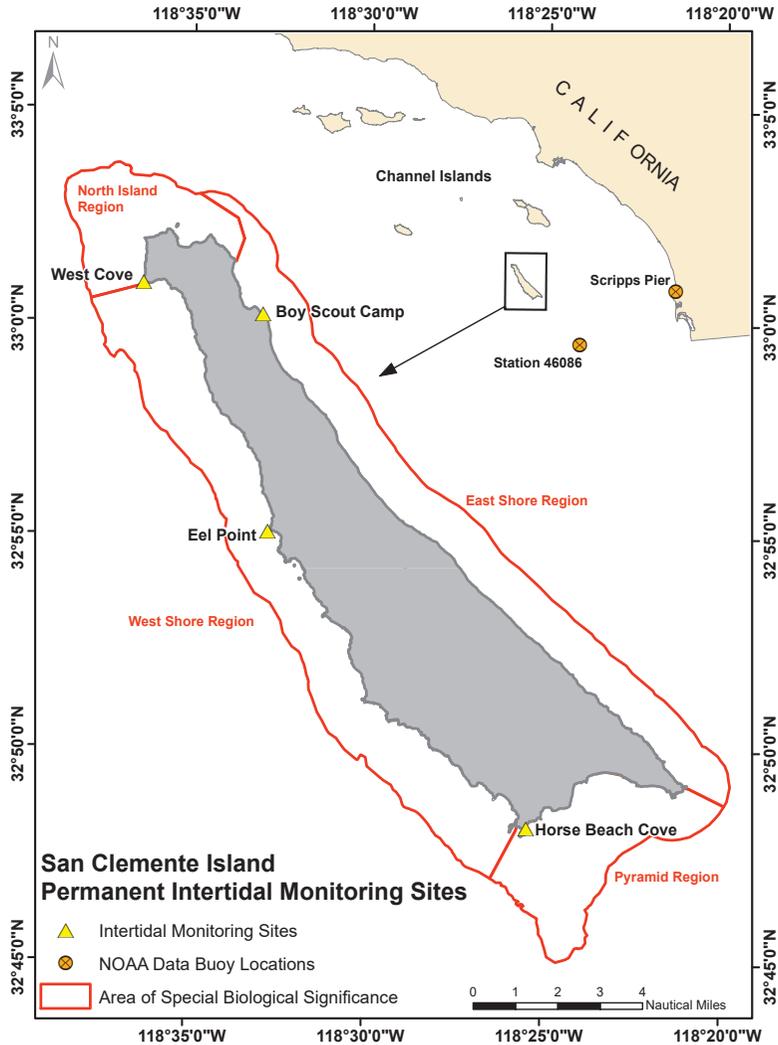
Fig. 1. Locations of measured SSTs (orange circles) within the Southern California Bight from NDBC station 46086 (32°29′27″ N, 118°2′5″ W) and SIO (Scripps) pier (32°52.0′ N, 117°15.5′ W). The inset map shows rocky intertidal monitoring sites (yellow triangles) at San Clemente Island: Boy Scout Camp (CLBS), Eel Point (CLEP), Horse Beach Cove (CLHBC), and West Cove (CLWC). Red lines indicate ecoregions that are represented by each site (CLBS, East Shore Region; CLEP, West Shore Region; CLHBC, Pyramid Region; and CLWC, North Island Region).

abundant vertical and horizontal crevice habitat. Boulders are small to medium-sized with few moveable rocks.

Horse Beach Cove (CLHBC; 32°48′10.92″ N, 118°25′26.25″W) is located on the southern tip of the island within the Shore Bombardment Area (SHOBA). This site sits within the Pyramid Region and faces southward into the summer swells. However, this cove is well protected from strong NW winds that can hit the island. The site's substrate consists of igneous rock boulders with few rock benches.

During low tide, large tidepools can be found throughout the site. Overall, the site is composed of low- to moderate-relief rocky outcroppings that contain mostly horizontal fractures that drain to surge channels.

Boy Scout Camp (CLBS; 33°0′10.56″ N, 118°33′0.37″W) is located on the eastern (leeward) side of the island and sits approximately 800 m southeast of Wilson Cove Pier within the East Shore Region. The site is largely protected from oceanic swells and has little influence from sand and gravel movement.
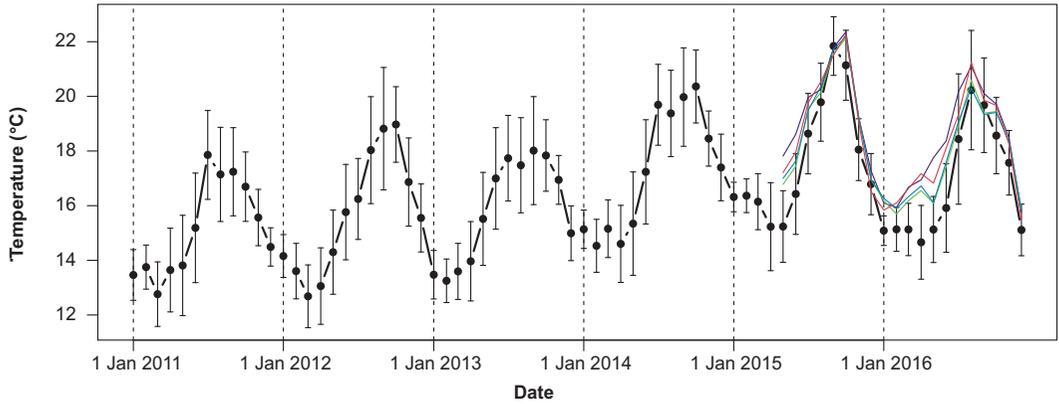
FIG. 2. Time series of monthly mean sea surface buoy temperatures recorded at NDBC station 46086 from 1 January 2011 to 31 December 2016. Error bars represent standard deviation (SD). Overlaid red, green, blue, and purple lines are mean monthly intertidal temperatures at CLHBC, CLEP, CLWC, and CLBS, respectively, from 1 May 2015 to 31 Dec 2016.

The entire area is surrounded by steep sloping terrain with large igneous outcroppings and erratic boulders sitting against a narrow band of offshore rocky reef.

Eel Point (CLEP; 32°55′4.14″N, 118°32′ 47.95″W) is located near the midpoint of the West Shore Region on the windward side of the island. The monitoring site lies below marine terraces and is positioned at the tip of Eel Point. The area is unprotected from offshore swells and is heavily exposed to the prevailing WNW winds. This site consists of a sedimentary substrate with numerous relief features—mostly vertical fractures and crevices—throughout.

Fixed-Plot Sampling

At each of the 4 sites, 5 replicate plots for *S. compressa*, along with other targeted species listed under the MARINe protocol, were established in a stratified, semirandom manner. The plots were placed throughout the species' zone of maximum abundance to monitor percent cover over time. Areas of high initial percent cover were chosen in order to detect significant declines from a large standing-stock baseline. Additionally, monitoring multiple targeted species at different zonations allow us to tease apart declines in species abundance versus elevational range shifts. Plots were sampled with a 50 cm × 75 cm (0.375 m^2) rectangular PVC quadrat using a grid of 100 evenly spaced points. At each point the sessile organism on the topmost layer was

identified and recorded. Sampling occurred during the spring and fall low tides from spring 2012 to fall 2016.

Sea Surface Temperature Data

Scripps Institute of Oceanography (SIO) has been collecting daily SST measurements at the end of Scripps Pier, California (32°52.0′ N, 117°15.5′ W), since 1916. The SIO data is recognized as one of the best long-term data sets available to evaluate temperature anomalies in southern California (Tegner and Dayton 1987). Because ENSO events are large in geographic scale, the SIO SST data is appropriate for evaluating SST anomalies considering that SCI and San Diego are categorized within the southern California biogeographic province (Fenberg et al. 2015). Using the SIO SST data, monthly anomalies were calculated for each month from 2011 to 2015 (2016 data are not yet available from SIO) from the difference of a 3-decade climatic normal (monthly averages from 1981 to 2010). We classified anomalous temperatures with 5 consecutive months above +0.5 °C as warm (El Niño) events or below −0.5 °C as cool (La Niña) events (Moore et al. 2017). The strength of each event was further categorized based on the absolute magnitude of SST anomalies at the following thresholds for 3 consecutive months: weak (0.5 to <1.0), moderate (1.0 to <1.5), and strong (>1.5).

To correlate SST with changes in *S. compressa* percent cover, we utilized data from the National Data Buoy Center (NDBC) station
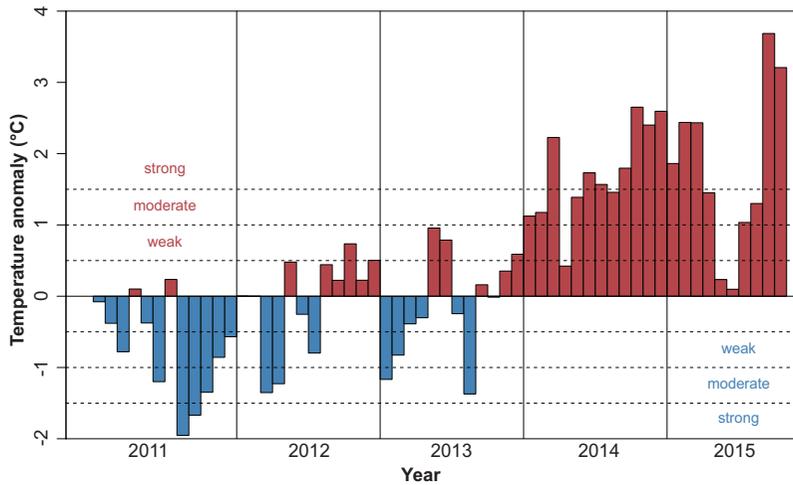
Fig. 3. Monthly anomalies of SST at the SIO pier (32°52.0′ N, 117°15.5′ W) from 2011 to 2015. Five consecutive months above 0.5 °C (El Niño) or below −0.5 °C (La Niña) are considered ENSO events. Strength of events are classified into the following thresholds for 3 consecutive months (absolute magnitude): weak (0.5 to <1.0), moderate (1.0 to <1.5), and strong (>1.5).

46086 (32°29′27″ N, 118°2′5″ W) which recorded SSTs approximately 50 km southeast of SCI. Intertidal temperature data were collected at each of the sites with HOBO TidbiT® v2 Data Loggers, but these were not installed until May 2015 and therefore do not cover the entirety of our survey efforts. For a qualitative comparison, the intertidal temperature data were plotted with the buoy data (Fig. 2).

Statistical Analyses

All statistical analyses were performed using R version 3.3.0 (R Development Core Team 2016). Nonparametric Kruskal–Wallis tests were used to compare SST minimum, mean, and maximum across years because the assumption of normality was not met (Shapiro–Wilk test: P < 0.05). Significant results were followed up with Dunn's post hoc tests to examine pairwise differences among years. After checking for and meeting assumptions of data normality (Shapiro–Wilk test: P > 0.05) and homoscedasticity (Fligner–Killeen test: P > 0.05), we used a parametric mixed-model ANOVA to evaluate differences in *S. compressa* percent cover over time, between seasons, and among sites. This statistical test was used instead of a repeated measures ANOVA as it can handle missing sampling gaps that were present at CLHBC (Fig. 4C). Year, season, and sites were fixed effects with plot as a random effect. Mixed-model ANOVA

was performed with the function "lme" in the R package "nlme" (Pinheiro et al. 2017). Statistically significant ANOVA results were followed up with a Tukey honest significant difference (HSD) test.

The relationship between *S. compressa* percent cover and the previous year's average daily maximum sea surface buoy temperature was examined using a linear regression with calculated 95% confidence interval bands. Levels of significance were established at 5%. Linear regression with synchronized timing between *S. compressa* percent cover and SST showed a unimodal relationship with *S. compressa* being most abundant under extreme low and high temperatures, which seemed unlikely for this species. We therefore chose to use the previous year's temperature to account for a possible lag response from *S. compressa*.

RESULTS

Sea Surface Temperature

A mix of positive but predominantly negative SST anomalies occurred from 2011 to 2013 (Fig. 3). Anomalous warm SSTs began in late 2013; with the exception of 3 months (April 2014 and May–June 2015), temperatures consistently stayed at least 1 °C above historic conditions through 2015. Although 2016 SST data were not available from SIO, anomalous SSTs continued through mid-2016
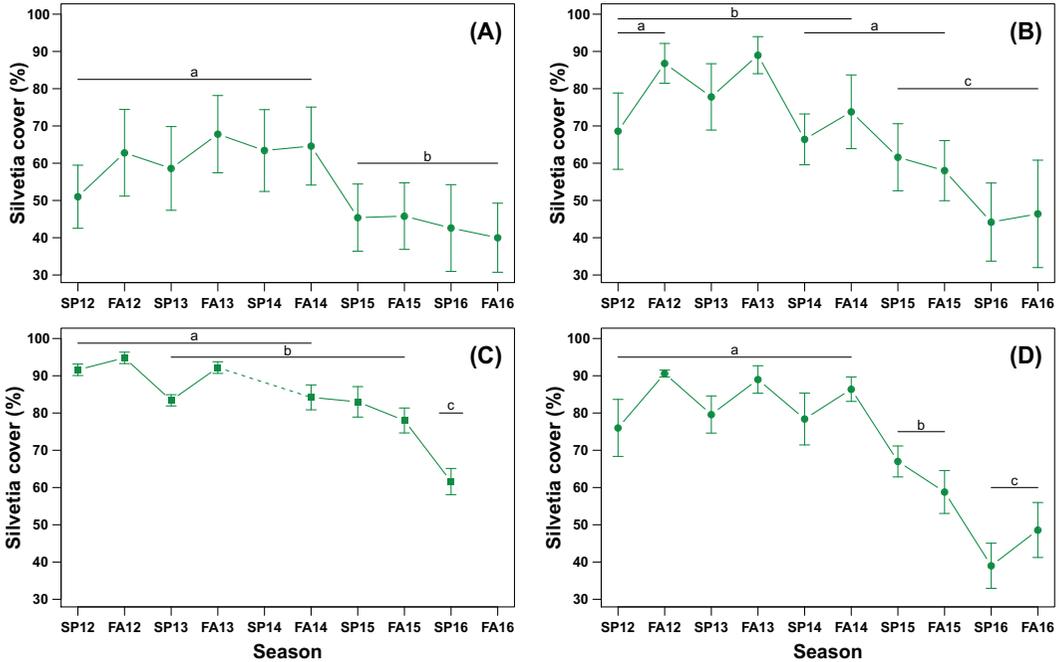
Fig. 4. Time series of mean *Silvetia compressa* percent cover sampled (*n* = 5) during spring and fall 2012 to 2016: **A,** CLBS; **B,** CLEP; **C,** CLHBC; **D,** CLWC. Lines under unique letters indicate statistically significant differences between years (Tukey HSD: *P* < 0.05). Error bars represent standard error (SE). Dashed lines indicate missing data.

TABLE 1. Results of a Kruskal–Wallis test and Dunn's post hoc comparison for average monthly sea surface buoy temperature (°C) minimum, mean, and maximum using NDBC station 46086 across years from 2011 to 2016.

| Temperature | Year* | | | | | | χ^2 | *P* |
	2011	2012	2013	2014	2015	2016		
Minimum	11.583[a]	12.008	11.725[a]	12.792	13.992[b]	12.608	13.423	0.0197
Mean	15.135	15.671	15.817	17.272	17.664	16.720	11.092	0.0496
Maximum	18.950[a]	20.158	19.550	21.400	22.292[b]	20.608	13.783	0.0171

*Unique *a* and *b* superscripts indicate statistically significant differences between years (Dunn post hoc test: *P* < 0.05).

according to the National Oceanic and Atmospheric Administration Oceanic Niño Index (http://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php). Within this period, 7 consecutive months of particularly strong warm water conditions occurred at the end of 2014 through early 2015. Both 2014 and 2015 each had 4 months that were 2 °C above normal while anomalous SSTs peaked at +3.7 °C in September 2015.

Sea surface buoy data show monthly mean temperatures generally increasing from 2011 to 2015, with slight cooling in 2013 and 2016 (Fig. 2). A Kruskal–Wallis test indicated statistically significant differences over time for monthly minimum, mean, and maximum temperatures (Table 1). The interannual difference

TABLE 2. Results of mixed-model ANOVA of *Silvetia compressa* percent cover as a function of year, season, site, and their interactions. Boldface indicates significant *P* values. Numerator degrees of freedom are given.

Effect	df	*F* ratio	*P*
Year	1	95.828	**<0.0001**
Season	1	5.545	**0.0197**
Site	3	23.476	**<0.0001**
Year × Season	1	3.620	0.0588
Year × Site	3	2.148	0.0960
Season × Site	3	0.158	0.925
Year × Season × Site	3	0.343	0.794

in minimum SSTs was greatest between 2014 and 2015 (1.20 °C) and between 2013 and 2014 (1.07 °C). The largest interannual increase in SST mean (1.46 °C) and maximum (1.85 °C)
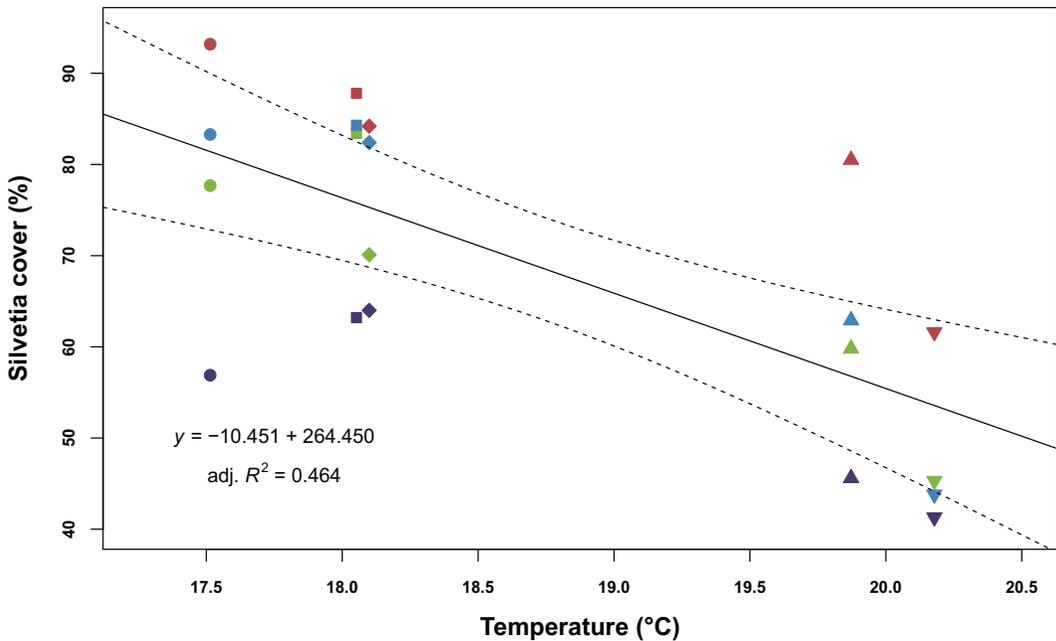
Fig. 5. Linear regression of *Silvetia compressa* percent cover sampled from 2012 to 2016 at CLBS (purple), CLEP (green), CLWC (blue), and CLHBC (red) against the previous year's average monthly maximum SST recorded from NDBC station 46086 (*n* = 20). Circles, squares, diamonds, triangles, and inverted triangles indicate SSTs recorded in 2011, 2012, 2013, 2014, and 2015, respectively. Dashed lines indicate 95% confidence interval bands.

occurred between 2013 and 2014. The lowest minimum, mean, and maximum SSTs were recorded in 2011 while all 3 were highest in 2015 (Fig. 2, Table 1). Dunn's post hoc tests indicated significant differences between 2011 and 2015 for maximum SSTs, while 2011 and 2013 were both equally different from 2015 for minimum SSTs. Visual comparison between intertidal (May 2015–December 2016) and NDBC buoy monthly mean SSTs show some similarities for the later months of 2015 and 2016 (Fig. 3). Buoy SSTs, however, underestimated intertidal temperatures for earlier months and the peak thermal highs. For the purpose of this study, the general trends in temperature increases and decreases from buoy data were assumed to be representative of intertidal temperatures.

Temporal Changes in *Silvetia compressa*

Comparison of *S. compressa* abundance between 2012 and 2016 showed an overall decline of 27.4%, 41.7%, 33.9%, and 47.4% at CLBS, CLEP, CLHBC, and CLWC, respectively. A mixed-model ANOVA revealed significant main effects of season, site, and year, but

their interactions were not significant on the dependent factor of *S. compressa* percent cover (Table 2). We observed a seasonal trend in which *S. compressa* was generally more abundant during the fall ($\bar{x}$ = 71.5%, SE = 2.4%) compared to the spring ($\bar{x}$ = 65.2%, SE = 2.2%). For the effect of site, Tukey HSD tests indicated pairwise differences in *S. compressa* abundance. Percent cover at CLEP ($\bar{x}$ = 67.3%, SE = 3.3%) and CLWC ($\bar{x}$ = 71.3%, SE = 2.9%) did not differ significantly from each other, but cover at CLHBC ($\bar{x}$ = 83.6%, SE = 1.8%) and CLBS ($\bar{x}$ = 54.2%, SE = 3.3%) were both significantly different from all other sites. Tukey HSD tests indicated significant declines in *S. compressa* in spring 2015 across all 4 sites (Fig. 4A–D), which followed increased SSTs that started in 2014 and persisted through 2015 (Fig. 2, Table 1). Tukey HSD tests revealed additional significant declines later in spring 2016 for CLEP, CLHBC, and CLWC (Fig. 4B–D). Linear regression between *S. compressa* percent cover and the previous year's maximum SSTs showed a significant negative relationship (adjusted R^2 = 0.464, *P* < 0.001) indicating

that reduced abundance of *S. compressa* was associated with elevated SSTs (Fig. 5). A moderate 46.4% of the variation in percent cover of *S. compressa* was explained by changes in SST.

DISCUSSION

In this study we show declines in *S. compressa* at SCI that span multiple seasons and sites. Two study sites (CLHBC and CLBS) were significantly different from all other sites with respect to percent cover of *S. compressa* (Table 2). This deviation could be attributed to a number of differences between these 2 areas. In the beginning of the study, CLBS had the lowest mean percent cover and CLHBC had the highest. These sites also occur in different island ecoregions (Fig. 1), with CLBS on the leeward side of the island and CLHBC on the most southern tip of the island, resulting in varied oceanographic conditions (wave exposure, currents, bathymetry). These 2 sites mostly consist of igneous rock, but they have different slope characteristics; the rock bench at CLBS is very steep, whereas the slope at CLHBC is moderate. It is likely that these physical differences in the sites were confounded with other factors that contributed to the decline in *S. compressa.* Percent cover of *S. compressa* was not significantly different between CLEP and CLWC. These sites are similar in slope, rock bench type, wave exposure, and species composition (Raimondi et al. 2017), in addition to beginning with approximately the same amount of *S. compressa* in the plots at the start of the study.

Regardless of site differences, we saw significant declines in *S. compressa* in spring of 2015 at every site, which may indicate that one or multiple processes impacted the rocky intertidal habitat at SCI. Effects of past ENSO events on marine species, including intertidal algae, have been documented, but due to the variability of El Niño and the rocky intertidal ecosystem, few have found a uniform link between biological changes and climatic anomalies (Gunnill 1985, Paine 1986, Tegner and Dayton 1987, Wootton et al. 1996, Navarrete et al. 2002, Thompson et al. 2002, Paine and Trimble 2004, Blanchette et al. 2009). To date, few studies have examined impacts on algal species from the most recent El Niño event (2015–2016) and the preceding anomalous SSTs in the intertidal ecosystem. The

decline in *S. compressa* follows the onset of SST anomalies in the southern California region, including SCI (Figs. 2, 3), but precedes the start of the 2015–2016 El Niño in winter of 2015. The decline in *S. compressa* abundance was recorded in spring of 2015, almost a year after the start of elevated SSTs. Gunnill (1985) reported that *S. compressa* standing stock was relatively stable during the 1982–1983 El Niño during which SSTs were generally 1–2 °C above average with a few months of normal or below-average SSTs. Similarly, in our study SST anomalies were considered moderate (1–1.5 °C above normal) for a majority of 2014, and *S. compressa* abundances demonstrated normal fluctuations. Strong temperature anomalies, greater than 2 °C above average, began in October 2014 and continued through March 2015, after which significant declines in *S. compressa* were observed. Additionally, a subsequent decrease in percent cover of *S. compressa* in spring of 2016 followed the highest recorded monthly average SST (22.3 °C) near SCI in September 2015 and the largest SST anomaly (3.69 °C) that occurred in September 2016. Thermal tolerance of *S. compressa* has not been well studied; however, the results of our study indicate that *S. compressa* may experience declines in abundance after prolonged exposure to SSTs that are 2 °C or higher above average.

In addition to higher SSTs, other factors associated with El Niño events, such as increased storm intensity and frequency and nutrient changes, can affect intertidal algae populations (Gunnill 1980, 1985, Barber and Chavez 1983, Gunnarsson and Ingolfsson 1995, Wootton et al. 1996, Zhu et al. 2014). Gunnill's (1985) results indicate that *S. compressa* survived the intense 1982–1983 El Niño storms if it was attached to solid substratum. Additionally, the storms associated with the 2015–2016 El Niño caused extreme coastal flooding and erosion, but the wave energy flux was not as high as previous events (1982–1983, 1997–1998) (Barnard et al. 2017), indicating that declines in *S. compressa* may not be related to El Niño storm events.

During an El Niño, warmer waters provide nutrient-limited and less productive conditions than would typically occur along the U.S. west coast (Barber and Chavez 1983). Nutrient limitation can cause decreases in intertidal

algae biomass (Wootton et al. 1996). Despite unusually strong upwelling-driving winds in late 2015 (Jacox et al. 2016), 2016 nutrient and primary productivity were suppressed (Jacox et al. 2016, McClatchie et al. 2016, Gomez-Ocampo et al. 2017) and may have contributed to declines of *S. compressa* at SCI.

Changes in algal abundance can often be attributed to anthropogenic effects such as trampling (Brosnan and Crumrine 1994, Denis and Murray 2001) and eutrophication (Thompson et al. 2002, Worm and Lotze 2006). SCI's intertidal habitat, however, is closed to the public and access is restricted amongst military personnel. Additionally, SCI is designated as a California Area of Special Biological Significance, which entails compliance with regulations to ensure the maintenance of natural water quality conditions. Results from previous monitoring efforts have concluded that variability among intertidal communities can be attributed to normal fluctuations and that there are no indications of direct impacts associated with navy activities (California State Water Resources Control Board, Division of Water Quality 2012). Thus, it is unlikely that trampling or nutrient pollution contributed to *S. compressa* declines throughout SCI.

In this study we found a moderate negative relationship between SSTs and *S. compressa* abundance. With multiple confounding factors due to sites occurring in different ecoregions and the unknown effects of numerous abiotic and biotic variables, it is difficult to understand specific causal processes that influence *S. compressa* abundance at SCI. Future studies should incorporate manipulative experiments to attempt to tease out the effects of temperature on *S. compressa.* It is anticipated that future climatic events may cause changes in algal distribution patterns where brown macroalgae species are replaced with red algal turf-forming species (Thompson et al. 2002). SCI falls within the Ensenadian province, as described by Hall (1960, 1964) and Valentine (1966). This province is the warmest biogeographic regime of the Channel Islands (Blanchette et al. 2008) where *S. compressa* may be existing at its thermal limit and may be at risk for extirpation due to significant temperature effects within the intertidal ecosystem (Thompson et al. 2002, Helmuth et al. 2006). The loss of algal canopy, which provides habitat heterogeneity and protection for other organisms beneath the understory (Whitaker et al. 2010), may have cascading effects throughout various trophic levels (Thompson et al. 2002).

The navy's natural resource monitoring objective at SCI is to conserve rocky intertidal communities and to sustain an ecological community that improves the ecosystem's resilience to natural and anthropogenic effects. Long-term monitoring provides the ability to identify natural seasonal and annual variations within the intertidal community as well as an opportunity to observe climatic anomalies and their impacts (Thibault and Brown 2008). Although long-term monitoring is valuable, these types of observational studies may not provide the level of certainty that manipulative experimentation can illustrate. Because of these limitations, long-term monitoring should be integrated with specific experimental studies that include controls, randomization, and replication in order to examine the relationships between organisms and environmental stressors. The intensity of a suite of climatic factors (temperature, ultraviolet light, sea level, and wave exposure) will continue to increase throughout the 21st century (Pachauri et al. 2014). Undoubtedly, these changes will affect intertidal community structures, species abundances, and ecosystem processes (Thompson et al. 2002, Helmuth et al. 2006, Thibault and Brown 2008, Blanchette et al. 2009). Results gained from this study will provide a baseline to support evaluation of the possible effects of global changes.

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