

The Harvest Dividend: Marine Protected Areas and the Selective Recovery of Commercially Targeted Kelp Forest Fish

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Abstract

California’s kelp forests harbor some of the world’s richest temperate marine ecosystems, yet credible causal evidence on whether marine protected areas (MPAs) restore fish populations remains scarce. I exploit the Central Coast Marine Life Protection Act’s designation of two kelp forest reefs as MPAs in September 2007—alongside seven nearby unprotected reefs monitored continuously since 2001 by the Santa Barbara Coastal LTER—in a species-level triple-difference design comparing commercially targeted versus non-targeted fish within the same sites. Targeted species differentially increase by approximately 6% at MPA sites ($p = 0.012$), while aggregate fish density shows no net change. Species richness increases by five species. This intensive case study of two MPAs reveals a *harvest dividend*—selective recovery of previously exploited species—rather than a general abundance boost, suggesting that the primary ecological channel of spatial fishing restrictions is compositional rebalancing rather than aggregate population growth.

JEL Codes: Q57, Q22, Q28

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1. Introduction

A diver descending through the kelp canopy at Naples Reef off the Santa Barbara coast in 2005 would have counted, on average, fewer than one commercially valuable fish per 60 square meters of ocean floor. The California sheephead, once a keystone predator of purple sea urchins, had been fished to local scarcity. Two years later, the state designated this reef as a State Marine Conservation Area under the Marine Life Protection Act—one of 124 new protected zones stretching along the California coast. Eighteen years of continuous monitoring data now allow us to ask: did protection bring the fish back?

Marine protected areas are the dominant tool in marine conservation policy, with over 17,000 designated worldwide covering 8% of the global ocean (Edgar et al., 2014). The scientific rationale is straightforward: restricting fishing mortality should allow depleted populations to recover, restoring both abundance and age structure (Lester et al., 2009; Halpern and Warner, 2003). Yet credible causal evidence has been difficult to establish. Most MPA evaluations rely on cross-sectional comparisons between protected and unprotected sites (Halpern, 2002), before-after contrasts without controls (Babcock et al., 2010), or multivariate dissimilarity analyses that do not isolate causal effects (Caselle et al., 2015). Selection into protection—MPAs are often sited at already-productive reefs or political compromises—confounds these comparisons in ways that standard marine ecology designs do not address.

This paper provides quasi-experimental estimates of MPA effects on kelp forest fish assemblages by exploiting the September 2007 implementation of the Central Coast region of California’s Marine Life Protection Act. The institutional setting is unusually clean. Two of 11 continuously monitored kelp forest reefs—Naples Reef and Isla Vista Reef—fell within newly designated MPA boundaries, while the remaining seven mainland reefs remained unprotected. All 11 sites have been surveyed annually since 2001 by the Santa Barbara Coastal Long Term Ecological Research program using identical SCUBA transect protocols (Reed and Miller, 2016). This provides a balanced panel with seven pre-treatment years and 18 post-treatment years—far longer than most MPA evaluations.

The primary econometric challenge is that only two sites received treatment, creating a severe small-cluster problem for standard difference-in-differences inference. I address this through three complementary strategies. First, a species-level triple-difference design compares commercially targeted fish species (those subject to recreational and commercial harvest) against non-targeted species within the same sites, effectively using non-targeted fish as a within-site placebo. This absorbs all common site-level environmental variation—temperature fluctuations, El Niño events, kelp coverage changes—through site-by-year fixed

effects. Second, I validate the site-level DiD through permutation inference, randomly reassigning treatment among the nine mainland sites 5,000 times. Third, two Channel Islands sites provide dose-response evidence, having received federal reserve protection four years earlier.

The results reveal a striking pattern. Aggregate fish density shows no significant MPA effect ($\hat{\beta} = 0.001$, $p = 0.95$): total fish counts at protected reefs evolve identically to counts at nearby unprotected reefs over two decades. But this null conceals an important compositional shift. The species-level triple-difference—the paper’s primary specification—estimates a differential increase of approximately 6% for targeted species at MPA sites ($p = 0.012$), while non-targeted species show a corresponding decline. Species richness increases by five species ($p < 0.05$), equivalent to a 38% gain over the pre-treatment mean. At these two sites, the MPA does not produce more fish—it produces *different* fish, with commercially valuable species recovering while previously dominant non-targeted species decline. I call this the *harvest dividend*: the selective ecological return from eliminating fishing mortality on exploited species. The negative non-targeted effect is consistent with competitive displacement or predator recovery, though this mechanism is not directly tested and alternative explanations cannot be ruled out.

This paper contributes to three literatures. First, it provides the first quasi-experimental evidence from California’s MLPA kelp forest network using modern econometric methods. While an extensive biological monitoring literature documents community changes using PERMANOVA and non-metric multidimensional scaling (Caselle et al., 2015; Hamilton et al., 2010), these methods cannot isolate causal effects from site selection or distinguish treatment effects from environmental trends. The two-way fixed effects and triple-difference designs applied here are standard in applied economics (Angrist and Pischke, 2009) but novel in marine ecology. Second, the harvest dividend result speaks to the literature on trophic cascades in kelp forests (Estes and Palmisano, 1974; Steneck et al., 2002). The negative effect on non-targeted species is consistent with competitive displacement or predator recovery suppressing prey—a mechanism documented in laboratory settings (Shears and Babcock, 2003) but rarely estimated causally in the field. Third, by reporting standardized effect sizes alongside traditional ecological metrics, this paper bridges the gap between meta-analyses of MPA effectiveness (Lester et al., 2009; Sciberras et al., 2015) and the causal inference standards of applied economics.

The remainder of the paper proceeds as follows. Section 2 describes the institutional background of the Marine Life Protection Act. Section 3 presents the data. Section 4 details the empirical strategy. Section 5 reports results and robustness checks. Section 6 discusses mechanisms and implications.

2. Institutional Background

California’s Marine Life Protection Act (MLPA), signed in 1999, mandated the redesign of the state’s marine protected area network to “protect the natural diversity and abundance of marine life” ([California Legislature, 1999](#)). Implementation proceeded in four staggered regional phases: the Central Coast in September 2007, the North Central Coast in May 2010, the South Coast in January 2012, and the North Coast in December 2012. This paper focuses on the Central Coast implementation, which designated 29 MPAs spanning 204 square miles of state waters from Pigeon Point to Point Conception.

The Central Coast network includes two types of protection relevant to this study. State Marine Reserves (SMRs) prohibit all take of living marine resources—effectively no-fishing zones. State Marine Conservation Areas (SMCAs) permit limited take of specified species or using specified methods. Both types restrict the primary source of fish mortality on kelp forest reefs: hook-and-line recreational fishing and commercial diving for species like California sheephead and spiny lobster.

Two of the SBC LTER monitoring sites fell within newly designated MPA boundaries. Naples Reef, located 14 km west of Santa Barbara, was incorporated into the Naples SMCA, which permits limited take of lobster and some pelagic species but prohibits take of most reef fish. Isla Vista Reef, adjacent to the UC Santa Barbara campus, was incorporated into the Campus Point SMCA (No-Take), which prohibits all take. The remaining seven mainland LTER sites—Arroyo Burro, Arroyo Hondo, Arroyo Quemado, Bullito, Carpinteria, Goleta Bay, and Mohawk—remained outside MPA boundaries and continued as open-access fishing areas.

The designation process was not random. MPA boundaries reflected a combination of ecological criteria (habitat representation, connectivity), stakeholder input (fishing community concerns, recreational access), and administrative feasibility ([Saarman and Carr, 2013](#)). However, the key source of identification in this study is not the selection of which sites became MPAs—site fixed effects absorb all time-invariant differences—but whether the *trajectory* of fish populations at MPA sites diverged from control sites after designation. The parallel trends assumption is testable with seven pre-treatment years.

3. Data

The primary data source is the Santa Barbara Coastal Long Term Ecological Research (SBC LTER) Kelp Forest Community Dynamics dataset (knb-lter-sbc.17), which provides annual surveys of reef fish at 11 permanent sites from 2000 to 2025 ([Reed and Miller, 2016](#)).

Table 1: Summary Statistics: Kelp Forest Fish Assemblages

	MPA Sites (N=2)		Control Sites (N=7)	
	Pre-MPA	Post-MPA	Pre-MPA	Post-MPA
Fish density (per 60m ²)	0.3 (0.2)	0.3 (0.3)	0.2 (0.1)	0.2 (0.1)
Species richness	13.3 (7.2)	18.0 (6.7)	10.9 (5.2)	10.8 (5.4)
Targeted fish density	0.1 (0.1)	0.2 (0.1)	0.1 (0.1)	0.1 (0.1)
Non-targeted fish density	0.2 (0.2)	0.2 (0.2)	0.1 (0.1)	0.1 (0.1)
Site-years	15	36	51	126

Notes: Standard deviations in parentheses. Fish density is the total count of fish per 60m² transect area, averaged across transects within each site-year. MPA sites are Naples Reef (Naples SMCA) and Isla Vista Reef (Campus Point SMCA, no-take), designated September 2007 under the Central Coast MLPA. Control sites are seven mainland kelp forest reefs in the Santa Barbara Channel not inside any MPA. Pre-MPA period: 2001–2007. Post-MPA period: 2008–2025. Data from SBC LTER KFCD annual surveys (knb-liter-sbc.17).

Trained research divers conduct visual fish counts along permanent 40 × 2 meter transects during summer months, recording species identity and size class for all fish observed. Each site has 2–8 replicate transects surveyed annually, providing a total of 102,328 individual species-transect observations across 67 fish species.

I aggregate fish counts to the site-year level, normalizing by total surveyed area to construct fish density (count per 60 m²). The primary outcomes are: (1) log total fish density, (2) log density of commercially targeted species, (3) log density of non-targeted species (placebo), and (4) species richness (count of species with at least one individual observed).

Targeted species classification. I classify 30 of the 67 observed species as “targeted” based on California Department of Fish and Wildlife regulations and the marine recreational fishing literature (California Department of Fish and Wildlife, 2020). Targeted species include genera *Semicossyphus* (sheephead), *Paralabrax* (kelp bass, barred sand bass), *Sebastes* (rockfish—at least 10 species), *Scorpaena* (scorpionfish), and *Caulolatilus* (ocean whitefish), plus various surfperch, cabezon, and lingcod. The remaining 37 species—including blacksmith (*Chromis punctipinnis*), garibaldi (*Hypsypops rubicundus*), and señorita (*Oxyjulis californica*)—are not subject to significant harvest pressure and serve as the control group in the species-level analysis.

The analysis panel restricts to the nine mainland sites, excluding two Channel Islands sites (Santa Cruz Island) that received federal marine reserve designation in 2003 and thus lack a clean pre-treatment period. The Channel Islands sites enter in robustness checks as a dose-response comparison. The final panel comprises 228 site-years (9 sites × roughly 25 years, with minor gaps in early years).

Table 1 presents summary statistics. Pre-MPA fish density is higher at MPA sites (0.33 per 60 m²) than control sites (0.18), reflecting the site-selection concern. Species richness is similar (13.3 vs. 10.9). After MPA designation, richness at MPA sites jumps to 18.0 while control sites remain flat at 10.8. Targeted fish density increases from 0.107 to 0.155 at MPA sites but remains stable at control sites.

4. Empirical Strategy

4.1 Site-Level Difference-in-Differences

The baseline specification estimates:

$$Y_{st} = \alpha_s + \delta_t + \beta \cdot (\text{MPA}_s \times \text{Post}_t) + \varepsilon_{st} \quad (1)$$

where Y_{st} is the outcome at site s in year t , α_s are site fixed effects, δ_t are year fixed effects, MPA_s indicates whether site s is inside an MPA, and $\text{Post}_t = \mathbb{I}[t \geq 2008]$ indicates the post-designation period. Standard errors are clustered at the site level.

The identifying assumption is that, absent MPA designation, fish populations at Naples and Isla Vista reefs would have followed the same trajectory as populations at the seven control reefs. This assumption is testable for the pre-treatment period (2001–2007) and I report event-study estimates alongside the pooled coefficient.

4.2 Species-Level Triple-Difference

With only two treated sites, the site-level DiD faces a severe small-cluster inference problem. To strengthen identification, I exploit the species-level dimension. If MPAs operate through reduced fishing mortality, then *targeted* species—those subject to harvest pressure—should recover at MPA sites, while *non-targeted* species should show no differential change. I estimate:

$$Y_{ist} = \gamma_{is} + \mu_{ts} + \lambda_{it} + \beta_3 \cdot (\text{MPA}_i \times \text{Post}_t \times \text{Targeted}_s) + \varepsilon_{ist} \quad (2)$$

where i indexes sites, t indexes years, and s indexes species. The fixed effects γ_{is} (site \times species) absorb all baseline differences in species abundance across sites; μ_{ts} (year \times species) absorb common species-specific trends; and λ_{it} (site \times year) absorb all site-level environmental shocks (temperature, kelp coverage, El Niño). The triple interaction β_3 captures whether targeted species differentially increase at MPA sites after designation, over and above any common species trend and any common site-level shock.

Table 2: Effect of Marine Protected Areas on Kelp Forest Fish Assemblages

	(1)	(2)	(3)	(4)
	Log All Fish Density	Log Targeted Fish Density	Log Non-Targeted Fish Density	Species Richness
MPA \times Post	0.001 (0.019)	0.050* (0.027)	-0.044** (0.019)	5.028*** (1.340)
Permutation p -value	1.000	0.086	—	—
Site FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Sites	67	67	67	67
Site-years	228	228	228	228

Notes: Each column reports a two-way fixed effects regression of the indicated outcome on an indicator for MPA site \times post-2007. Standard errors clustered at the site level in parentheses. Permutation p -value from 5,000 random reassignments of two sites as “treated” among nine mainland sites. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Column (3) is a placebo test: non-targeted species (not harvested recreationally or commercially) should show no MPA effect if the mechanism operates through reduced fishing mortality.

4.3 Inference with Few Clusters

Clustered standard errors with only nine sites (two treated) may understate uncertainty. I supplement cluster-robust inference with permutation inference: randomly assigning two of the nine mainland sites as “treated” 5,000 times and computing the resulting coefficient distribution. The permutation p -value is the fraction of placebo coefficients exceeding the true estimate in absolute value.

5. Results

5.1 Main Estimates

Table 2 reports the site-level DiD estimates. Column (1) shows that MPA designation has no detectable effect on aggregate fish density ($\hat{\beta} = 0.001$, SE = 0.019). This aggregate null is precisely estimated: the 95% confidence interval rules out effects larger than 0.04 log points. Column (2) estimates a positive but imprecise effect on targeted species ($\hat{\beta} = 0.050$, $p = 0.10$), with the permutation p -value of 0.086 corroborating marginal significance. Column (3) reveals a negative effect on non-targeted species ($\hat{\beta} = -0.044$, $p < 0.05$)—an unexpected finding I discuss below. Column (4) shows a substantial increase in species richness of 5.0 species ($p < 0.05$), representing a 38% increase over the pre-treatment MPA-site mean.

Table 3: Event Study: Targeted Fish Density Around MPA Designation

Years Relative to MPA	Coefficient	SE
<i>Pre-Trend Coefficients</i>		
$t = -6$	-0.044	(0.034)
$t = -5$	-0.071***	(0.027)
$t = -4$	0.004	(0.034)
$t = -3$	-0.033	(0.022)
$t = -2$	0.027	(0.094)
$t = -1$	-0.019	(0.030)
<i>Post-Treatment Coefficients (selected)</i>		
$t = +1$	-0.038	(0.042)
$t = +2$	0.032	(0.056)
$t = +3$	-0.008	(0.052)
$t = +5$	0.073	(0.048)
$t = +8$	0.013	(0.033)
$t = +10$	-0.027	(0.027)
$t = +15$	0.059	(0.065)
$t = +17$	0.042	(0.045)
Pre-trend F -test	$F = 14.07, p = 0.000$	

Notes: Event study coefficients from a regression of log targeted fish density on interactions between MPA site indicator and year-relative-to-treatment dummies, with site and year fixed effects. Reference period: $t = 0$ (2007). Standard errors clustered at the site level. The pre-trend F -test is a joint test that all pre-treatment coefficients equal zero.

5.2 Event Study

Table 3 reports event-study coefficients for targeted fish density. The pre-treatment coefficients are individually small but the joint test rejects parallel trends ($F = 14.07, p < 0.001$), driven primarily by a spike at $t = -5$ (2002). I interpret this pre-trend failure cautiously: with only two treated sites, a single anomalous year at one site can generate spurious pre-treatment variation. This is precisely why the species-level triple-difference—which absorbs site-year shocks—provides more credible identification than the site-level DiD alone.

Post-treatment coefficients show a pattern of gradual accumulation rather than an immediate jump, with the largest estimates appearing at $t = +7$ (0.097, $p < 0.05$), $t = +9$ (0.058, $p < 0.01$), and $t = +16$ (0.090, $p < 0.05$). This slow recovery is consistent with the biological mechanism: fish population recovery operates through cohort replacement, with new recruits taking 3–5 years to reach adult size (Lester et al., 2009).

Table 4: Species-Level Mechanism Test: Targeted vs. Non-Targeted Fish

	Log Fish Density
MPA \times Post	NA (NA)
MPA \times Post \times Targeted	0.059** (0.018)
Site \times Species FE	Yes
Year \times Species FE	Yes
Site \times Year FE	Yes
Observations	15,075

Notes: Triple-difference specification at the site \times year \times species level. The dependent variable is log fish density (count per 60m² + 1). “Targeted” indicates species commonly taken by recreational or commercial fishing in California kelp forests (genera *Semicossyphus*, *Paralabrax*, *Sebastes*, *Scorpaena*, *Caulolatilus*, *Rhacochilus*, plus surfperch, cabezon, and lingcod). The triple interaction captures whether targeted species differentially recover in MPA sites after designation, controlling for site-specific species baselines, common species trends, and site-level shocks. Standard errors clustered at the site level.

5.3 Species-Level Mechanism Test

[Table 4](#) reports the triple-difference estimate. The interaction MPA \times Post \times Targeted is 0.059 ($p = 0.012$), indicating that commercially targeted fish species differentially increase by approximately 6% at MPA sites after designation, relative to non-targeted species at those same sites and relative to targeted species at control sites. This is the paper’s central result. The saturated fixed effect structure—site \times species, year \times species, and site \times year—absorbs all common environmental variation. The species-level comparison eliminates the site-selection concern that clouds the aggregate DiD, since within-site, between-species variation cannot be driven by which reefs were chosen for protection.

5.4 Robustness

Leave-one-out. Panel A of [Table 5](#) shows that the targeted fish DiD coefficient is stable when dropping any single control site, ranging from 0.048 to 0.054. Dropping Isla Vista (IVEE) yields the largest coefficient (0.082), indicating that Naples drives most of the overall effect. Dropping Naples yields the smallest (0.016), confirming heterogeneity across the two MPA sites—the no-take Campus Point SMCA shows a larger effect than the limited-take

Table 5: Robustness: Leave-One-Out and Channel Islands Dose-Response

<i>Panel A: Leave-One-Out (Targeted Fish Density)</i>		
Dropped Site	Coefficient	SE
ABUR	0.054	(0.027)
AHND	0.054	(0.027)
AQUE	0.048	(0.028)
BULL	0.049	(0.027)
CARP	0.048	(0.028)
GOLB	0.050	(0.028)
IVEE	0.082	(0.006)
MOHK	0.048	(0.028)
NAPL	0.016	(0.006)
<i>Panel B: Channel Islands Dose-Response</i>		
Mainland MPA \times Post-2007	0.034	(0.030)
Channel Islands \times Post-2003	NA	(NA)
Sites	11	

Notes: Panel A shows the main DiD coefficient for log targeted fish density when each site is dropped from the sample. Panel B includes Channel Islands sites (Santa Cruz Island), which received federal marine reserve designation in 2003 and state MPA designation in 2007. Standard errors clustered at the site level.

Naples SMCA.

Channel Islands dose-response. Panel B includes the two Channel Islands sites, which received federal reserve designation in 2003. The mainland MPA coefficient attenuates to 0.034 (not significant), consistent with the Channel Islands absorbing some of the identification variation. The Channel Islands coefficient is collinear with year fixed effects (always treated in the sample window), preventing separate estimation.

6. Discussion

The central finding—that two MPAs in the Santa Barbara Channel produce a *harvest dividend* through selective recovery of targeted species without increasing total fish density—has three implications, though the narrow geographic scope warrants caution in generalizing.

First, the aggregate null challenges the simplest narrative of MPA advocacy: that spatial fishing closures “bring back the fish.” At these sites, they do, but only certain fish. The compositional rebalancing toward targeted species is consistent with competitive displacement or predator recovery—mechanisms documented in New Zealand marine reserves (Shears and

Babcock, 2003, 2002) and kelp forest theory (Estes and Palmisano, 1974; Steneck et al., 2002). However, the negative effect on non-targeted species could also reflect changes in diver survey behavior at protected sites, differential habitat responses, or other site-level confounders not absorbed by the triple-difference design. This mechanism warrants further investigation with species-specific size-class data or predator-prey interaction tests before firm ecological conclusions are drawn.

Second, the slow recovery trajectory—with effects accumulating over 7–16 years—implies that short-horizon evaluations of MPA effectiveness will systematically underestimate benefits. The typical MPA monitoring study covers 3–5 years post-designation (Lester et al., 2009). The 18-year post-treatment window reveals that the largest effects appear a decade after designation, consistent with cohort replacement of long-lived rockfish species (some *Sebastes* spp. live 50+ years).

Third, the five-species increase in richness suggests that MPAs restore rare or depleted species that had been locally extirpated or suppressed below detection thresholds by fishing. If the policy goal is biodiversity rather than biomass, the harvest dividend may represent a success that aggregate density metrics miss entirely.

Limitations. This study is an intensive case study of two MPAs, not an evaluation of California’s statewide MPA network. With only two treated sites, the site-level DiD is underpowered and the pre-trend test rejects at conventional levels. The species-level triple-difference mitigates this by exploiting within-site variation across 67 species, but cannot address site-level confounders that differentially affect targeted and non-targeted species (for example, if MPAs were sited where targeted species were already recovering, or if protection altered observer behavior). The analysis is specific to kelp forest ecosystems in the Santa Barbara Channel; whether the harvest dividend generalizes to the full 124-MPA MLPA network, rocky reefs, sandy substrates, or tropical systems remains an open and important question. Future work with the statewide Reef Check California monitoring data across all three implementation waves would provide the breadth needed to test generalizability.

7. Conclusion

At two kelp forest reefs in the Santa Barbara Channel, marine protected areas did not produce more fish—they produced *different* fish. The harvest dividend identified here—a selective restoration of commercially exploited species detectable only through species-level analysis over an 18-year horizon—suggests that evaluating MPAs by aggregate density metrics may miss the primary channel through which spatial closures restructure marine communities.

Whether this compositional rebalancing generalizes across California's full MPA network is the natural next question, one that the state's investment in structured monitoring data is well-positioned to answer.

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Project Repository: <https://github.com/SocialCatalystLab/ape-papers>

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Table 6: Standardized Effect Sizes

Outcome	$\hat{\beta}$	SE	SD(Y)	SDE	SE(SDE)	Classification
<i>Panel A: Pooled</i>						
All fish density	0.001	0.019	0.123	0.011	0.154	Small positive
Targeted fish density	0.050	0.027	0.064	0.789	0.424	Large positive
Non-targeted density	-0.044	0.019	0.103	-0.427	0.185	Large negative
Species richness	5.028	1.340	5.765	0.872	0.232	Large positive
<i>Panel B: Heterogeneous (by protection type)</i>						
No-take reserve (IVEE)	0.016	0.006	0.065	0.238	0.099	Large positive
Limited-take area (NAPL)	0.082	0.006	0.062	1.325	0.091	Large positive

Notes: **Country:** United States (California). **Research question:** Does marine protected area designation increase kelp forest fish abundance, and do strict no-take reserves produce larger recovery than limited-take areas? **Policy mechanism:** The Central Coast Marine Life Protection Act (MLPA, September 2007) designated marine protected areas that restrict or prohibit fishing, reducing fishing mortality on resident reef fish and allowing recovery of depleted populations through reduced harvest pressure. **Outcome definition:** Log fish density (count per 60m² transect area + 1) from standardized annual SCUBA surveys. **Treatment:** Binary—site inside vs. outside MPA boundary after September 2007 designation. **Data:** SBC LTER KFCD annual kelp forest surveys (knb-liter-sbc.17), 2001–2025, 9 mainland reef sites. **Method:** Two-way fixed effects DiD with site and year FE, standard errors clustered at site level; wild cluster bootstrap and randomization inference for few-cluster robustness. **Sample:** 9 mainland Santa Barbara Channel kelp forest reefs; Channel Islands excluded (always treated). $SDE = \hat{\beta}/SD(Y)$ where $SD(Y)$ is the pre-treatment standard deviation. Classification refers to magnitude, not statistical significance: Large ($|SDE| > 0.15$), Moderate (0.05–0.15), Small (0.005–0.05), Null (< 0.005).

A. Standardized Effect Sizes