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Exploring Pathways to the Persistence of Community Engagement in Co-Management Across Social-Ecological Conditions

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ABSTRACT

Evaluating sustained community engagement in co-management is critical for designing durable governance with conservation potential, yet such persistence remains rarely assessed. We analyze 750 co-management initiatives established under Chile's Territorial Use Rights for Fishing policy (1998–2021), examining persistence across conditions theorized to shape collective action in social-ecological systems. Survival analysis shows that initiatives had a 75% probability of persisting beyond 15 years. Abandonment risk declined nonlinearly with initial exploitable abundance and increased with monitoring distances. Exploring combinations of variables through cluster analysis reveals that, while initiatives starting with high abundance showed the highest persistence, some initiatives with lower initial abundance also endured at comparable rates when combined with shorter monitoring distances, proximity to large markets, higher poverty, and stronger upwelling. These findings suggest diverse pathways to sustained community engagement in co-management, generate hypotheses for future research, and show how tracking persistence can inform strategies for durable and equitable conservation.

1 | Introduction

Incentivizing local communities to manage natural resources in partnership with governments and non-profits through co-management is a widely used strategy to balance natural resource access and conservation (Gurney et al. 2021; Obura et al. 2021). Co-management programs, including payments for ecosystem services and territorial user rights, have expanded globally (Clark et al. 2024; Mills et al. 2019) and are increasingly promoted to support area-based conservation targets such as protecting 30% of lands and waters by 2030· (Gurney et al. 2021; Obura et al. 2021). However, the effectiveness of these arrangements depends critically on sustained local community engagement in collective activities such as sustainable extraction, monitoring, and reporting. We refer to this sustained engagement as persistence.

Persistence matters because co-management institutions take time to deliver benefits, and interruptions in community partic-

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ipation or abandonment can undermine institutional continuity and potential conservation gains (Brooks 2017; Pienkowski et al. 2024). Examining persistence can reveal challenges and opportunities across time and space by integrating lessons from both enduring and abandoned initiatives (Pienkowski et al. 2024; Catalano et al. 2019). Persistence also signals co-management's value to resource users (Ostrom 2010), and tracking it provides a more accurate measure of conservation-relevant management than establishment alone (Golden Kroner et al. 2019; Pienkowski et al. 2026; Qin et al. 2024).

Co-management has been evaluated using diverse outcomes such as biomass, species richness, livelihoods, and equity (Cinner et al. 2012; Gelcich et al. 2019; Gutiérrez et al. 2011; Hajjar et al. 2021; Ruano-Chamorro et al. 2023). Yet major gaps remain in assessing the persistence of community engagement, limiting scalable program design and obscuring its contributions to conservation goals (Pienkowski et al. 2026). By defining resource boundaries and granting users authority over local rules, co-management can reduce competition and strengthen incentives for collective action, though its net benefits depend on local social and ecological conditions (Cinner et al. 2012; Gelcich et al. 2019).

Social-ecological systems (SES) research identifies variables that shape incentives for collective action in resource management, providing a foundation for understanding co-management persistence. These include resource system size and dynamics; users' group size; shared norms and knowledge; and resource importance, among others, as key factors influencing self-organization, while market integration and monitoring capacity further influence co-management outcomes (Cinner et al. 2012; Cinner et al. 2021; Elsler et al. 2022; Epstein et al. 2021; Oyanedel et al. 2018; Romero et al. 2022; Ostrom 2009).

Survival regression models can assess how these individual factors relate to persistence, but SES outcomes often depend on combinations of conditions rather than on single variables alone (Ostrom 2010; Gutiérrez et al. 2011; Epstein et al. 2021; Ostrom 2009; Rocha et al. 2020). For instance, while larger user groups may hinder collective action due to coordination challenges, they may enhance persistence when high management costs require broader resource pooling (Ostrom 2009). Such context dependency implies that similar outcomes may emerge through different configurations of factors. Machine learning approaches like cluster analysis provide a way to identify recurrent combinations of SES variables and examine how they relate to variation in persistence (Rocha et al. 2020).

We compiled data on all 750 co-management initiatives launched under Chile's Territorial Use Rights for Fishing (TURF) policy between 1998 and 2021 to examine persistence. We first use survival analysis to assess national-scale persistence and evaluate how survival varies across individual SES features relevant to collective action. We then apply interpretable cluster analysis to identify and characterize recurrent combinations of features observed among long-persisting initiatives. Together, this approach highlights multiple pathways to persistence, generates hypotheses for future research, and underscores the practical value of tracking community engagement over time.

2 | Methods

2.1 | Research Setting

Chile's TURF policy, established in 1991 and implemented in 1997, grants formally organized fishing communities exclusive rights to harvest benthic resources in designated coastal areas (Gelcich et al. 2017). Designed to promote sustainable use by combining fisher and government capacities, the policy is praised as an influential co-management model, though it faces challenges related to noncompliance, inactivity, and weak surveillance linked to low economic returns and poaching (Oyanedel et al. 2018; Romero et al. 2022; Gelcich et al. 2017; K. J. Davis et al. 2017).

TURFs are granted to previously formalized fishing organizations that apply by submitting a project, including a baseline study and a management plan for a defined coastal area. Once approved by government authorities, the project results in a usage agreement granting the community exclusion rights over benthic resources within that area. In return, communities must comply with approved management plans, report catches, conduct surveillance, and hire consultants to prepare and submit annual reports that inform allowable catch levels. Failure to submit annual reports after a 3-year grace period is the primary cause of rights revocation, which reopens the area to *de facto* open access until reassigned (Article 21, Decree 355, Ministry of Economy, Chile).

2.2 | TURF Survival Probability at the National Level

Because annual report submission is both costly and legally required to maintain exclusion rights, we use submission records as a proxy for persistence. Using government administrative data, we collated survival time (in years) and status (active or abandoned) for all TURFs (unique fishing organization–area combinations) established in Chile between 1998 and 2021.

Survival time was measured from the year of the baseline study to the last submitted annual report plus a 3-year grace period as defined in the regulation, with the observation window capped at 2021 (Supporting Information S1). TURFs whose last annual report occurred in 2017 or earlier without a legal exemption were classified as abandoned. TURFs with a final annual report or exemption in 2018 or later (for which the following annual report would be expected in 2022 or beyond) were treated as right-censored.

For agreements revoked and later reinstated to the same community, the intervening inactive period was subtracted from survival time to capture cumulative years of actual compliance with reporting obligations ($n = 25$). We estimated national-level survival probabilities using the Kaplan–Meier estimator:

$$\boldsymbol{S}\left(\boldsymbol{t}_j\right) = \mathbf{S}\left(\mathbf{t}_{\mathrm{j}-1}\right) \times \left(1 - \frac{\boldsymbol{d}_j}{\boldsymbol{n}_j}\right) \tag{1}$$

where $S(t_j)$ represents the survival probability at age t_j, $S(t_{j-1})$ is the survival probability at the preceding age, d_j is the number of TURFs abandoned at t_j, and n_j is the number of TURFs at risk just before t_j. This non-parametric estimator accounts for right-censoring and yields survival probabilities at each TURF age. Analyses were conducted using the R package “survival” (Therneau 2024a).

2.3 | TURF Survival Variability across SES Variables for Collective Action

TURFs were characterized using features derived from collective-action theory in SES literature and selected based on context and scale suitability (Table 1, Supporting Information S2). Cox proportional hazards models were used to estimate the hazard of TURF abandonment as a function of these features. To account for spatial variability, we compared alternative specifications, including latitude as a continuous predictor and mixed-effects models with random intercepts at the administrative-region and ecoregional levels. We also evaluated models with and without quadratic terms for variables for which curvilinear relationships were theoretically expected. All predictors were mean-centered and standardized. Fixed- and mixed-effects Cox models were fitted using the R packages “survival” and “coxme,” respectively (Therneau 2024a; 2024b).

To examine how SES features co-occur in practice, we conducted a cluster analysis on transformed data excluding spatial variables, allowing spatial patterns to emerge endogenously (Supporting Information S3). The optimal clustering protocol was selected using internal validity and stability indices with the “clValid,” “RankAggreg,” and “NbClust” R packages, identifying k-means with three clusters as the preferred solution (Rocha et al. 2020) (Supporting Information S4).

To identify the key features defining each cluster, we used interpretable clustering (Alvarez-Garcia et al. 2024). Specifically, we trained an Extreme Gradient Boosting classifier on pre-transformed TURF features to predict cluster labels using the “xgboost” R package (Supporting Information S5). This modeling approach makes no assumptions about the functional form linking features to cluster membership. We then used the “shapviz” package to extract local SHAP values and generate *beeswarm* plots to characterize cluster membership. SHAP values, derived from game-theoretic Shapley values, quantify each feature’s marginal contribution to cluster assignment (Alvarez-Garcia et al. 2024).

Kaplan–Meier survival curves were estimated for each cluster and compared using a log-rank test. We further applied a Cox model to estimate relative abandonment risk across clusters. All analyses were conducted in R version 4.4.1 (R Core Team 2024).

3 | Results

Of the 750 TURFs initiated during the study period, 168 were abandoned after ceasing mandatory annual report submissions beyond the 3-year grace period. TURFs establishment increase rapidly during the first decade of the policy, with the number of active TURFs plateauing at approximately 500 between 2009 and 2013, followed by slower growth thereafter (Figure 1A). Rather than sharp declines, abandonment occurred steadily beginning in the fourth year after policy implementation, coinciding with the expiration of the grace period for early TURFs. Spatially, abandoned TURFs were concentrated at southern latitudes, particularly south of 40°S, whereas active TURFs ($n = 582$) were more common between approximately 30°S and 40°S (Figure 1B).

The Kaplan–Meier estimator indicates a 75% probability of TURFs persisting beyond 15 years nationally (95% CI: 71%–78%; Figure 1C). The highest estimated annual abandonment risk (5.6%) occurred between the third and fourth years of age (Figure 1C, Supporting Information S6), corresponding to TURFs that were deemed active during the year of the baseline study and subsequent grace period but did not submit subsequent annual reports. Abandonment risk declines with TURF age, with survival probabilities leveling off after approximately 17 years (Figure 1C, Supporting Information S6).

The best-supported Cox model included quadratic terms and a random intercept for administrative region (Table 2). Abandonment risk varied nonlinearly with initial exploitable abundance, reaching a minimum at intermediate-high levels of abundance, and increased with longer monitoring distances (Table 2, Supporting Information S7). Linear specifications without quadratic terms captured similar directional effects (Supporting Information S8). Other covariates showed weaker or non-robust associations with persistence across specifications (Supporting Information S8).

TURF features exhibited a clustering tendency (Hopkins statistic = 0.75), with partial overlap among clusters (Supporting Information S9). Feature distributions differed across the three clusters (Figure 2A, descriptive statistics in Supporting Information S10 and pairwise comparisons in Supporting Information S11). Initial exploitable abundance was highest in cluster 1 (n = 169) and substantially lower in clusters 2 ($n = 410$) and 3 ($n = 180$). TURF area was also larger in cluster 1. Upwelling index was higher in clusters 1 and 2 relative to cluster 3.

Socioeconomic and spatial features further distinguished clusters. Cluster 2 was associated with older fishing communities, higher poverty levels, and shorter distances to markets and fishing coves. Cluster 3 exhibited the younger communities, lower poverty, smaller user groups, and greater distances to markets and coves. Cluster 1 generally occupies intermediate positions across these features.

Clusters unevenly distributed along the Chilean coast (Figure 2B,C, Kolmogorov–Smirnov tests, p-values < 0.001). No features showed strong correlation with others or with latitude (strongest $\rho = -0.43$, Supporting Information S12).

To identify the key features defining each cluster, we applied an interpretable clustering approach. The classifier used to interpret cluster structure achieved high performance (accuracy = 0.94, 95% CI = 0.90–0.97; sensitivity = 0.84–0.98; specificity = 0.94–0.99, Supporting Information S13). SHAP values quantify each feature’s contribution to cluster assignment. In Figure 3A, each point represents a TURF, and SHAP values indicate whether a given feature’s value (shown by color) increases (positive SHAP) or decreases (negative SHAP) the likelihood of membership in a given cluster. We identified dominant drivers of cluster membership as features with consistently large contributions ($|\mathrm{SHAP}| > 1$).

TABLE 1 | Operationalization of SES variables in the Chilean TURF context.

Social-ecological system variable	Theoretical role in collective action	TURF feature (data source)	Operational definition	Feature justification
Resource system's size	Intermediate sizes are optimal; large systems increase management costs, while small ones limit resource flow (Ostrom 2009).	TURF area in hectares (computed from data from IDE Chile, 2021)	Size of the designated management area.	Captures the geographical extent of the area to be managed.
Resource system's dynamics	Intermediate productivity levels are optimal, whereas extreme depletion or rapid replenishment discourages management investment (Ostrom 2009).	1. Initial exploitable abundance (TURFs baseline studies). 2. Upwelling index (recreated from Anguita et al. [2020])	1. Mean initial exploitable abundance at TURF initiation, computed after Winsorizing and normalizing values within species across the entire sample. 2. The complement of the mean seasonal amplitude of sea surface temperature of the area between 2002 and 2018.	Initial exploitable abundance reflect the interaction between ecosystem productivity and fishing history, while upwelling is a major influence on benthic populations' dynamics on Chile's coast (Anguita et al. 2020).
Number of users	In high-cost management contexts, large groups can pool efforts, while in low-cost contexts, smaller groups benefit from lower transaction costs (Ostrom 2009).	Number of members (SERNAPESCA, 2013 and 2023)	Number of fishers registered as part of the community, averaged from 2013 and 2023 data. If there are multiple communities, their numbers are added together.	Reflects the number of people sharing the costs and benefits of TURF management.
Shared norms and SES knowledge	Lowers transaction costs and improves information for organizing effective collective action (Ostrom 2009).	Organizational age (SERNAPESCA, 2021)	Number of years elapsed since the fishing organization was formally registered as an organization, as of 2021. If multiple communities jointly applied for a TURF, age was set equal to the TURF's age.	Older organizations are more likely to have accumulated governance routines, shared practices, and social-ecological knowledge that facilitate effective resource management.
Resource importance	Enhances returns on collective action (Ostrom 2009) but also increases management costs due to higher pressure over resources (Epstein et al. 2021).	Mean poverty % (Ministry of Social Development, 2011, 2013, 2015, 2017, 2020).	Percent of population under income poverty in the TURF's municipality, averaged from 2011, 2013, 2015, 2017, and 2020.	Reflects greater reliance on natural resources, assuming that higher poverty levels increase dependence on direct resource use. (Fedele et al. 2021).
Market integration	Enhances returns on collective action (Ostrom 2009) but raises costs due to broader pressure over resources (Epstein et al. 2021) and weakens intrinsic motivations (Cinner et al. 2021).	Distance to the nearest large market (computed from IDE Chile, 2021)	Euclidean distance from the TURF centroid to the centroid of the nearest big city.	Captures the costs of accessing export markets and higher demand from densely populated areas (Cinner et al. 2018).
Monitoring costs	Monitoring reduces rule violations, free-riding, and poaching, increasing expected returns from collective action (Andrews et al. 2024).	Monitoring distance (computed from IDE Chile, 2021)	Euclidean distance from the TURF centroid to the centroid of the nearest officially recognized fishing cove.	Fishing coves are the primary landing sites and in-land operational bases of fishing communities. Greater distance from a TURF to the nearest cove generally reduces observability and increases the costs of patrolling the managed area (K. Davis et al. 2015).

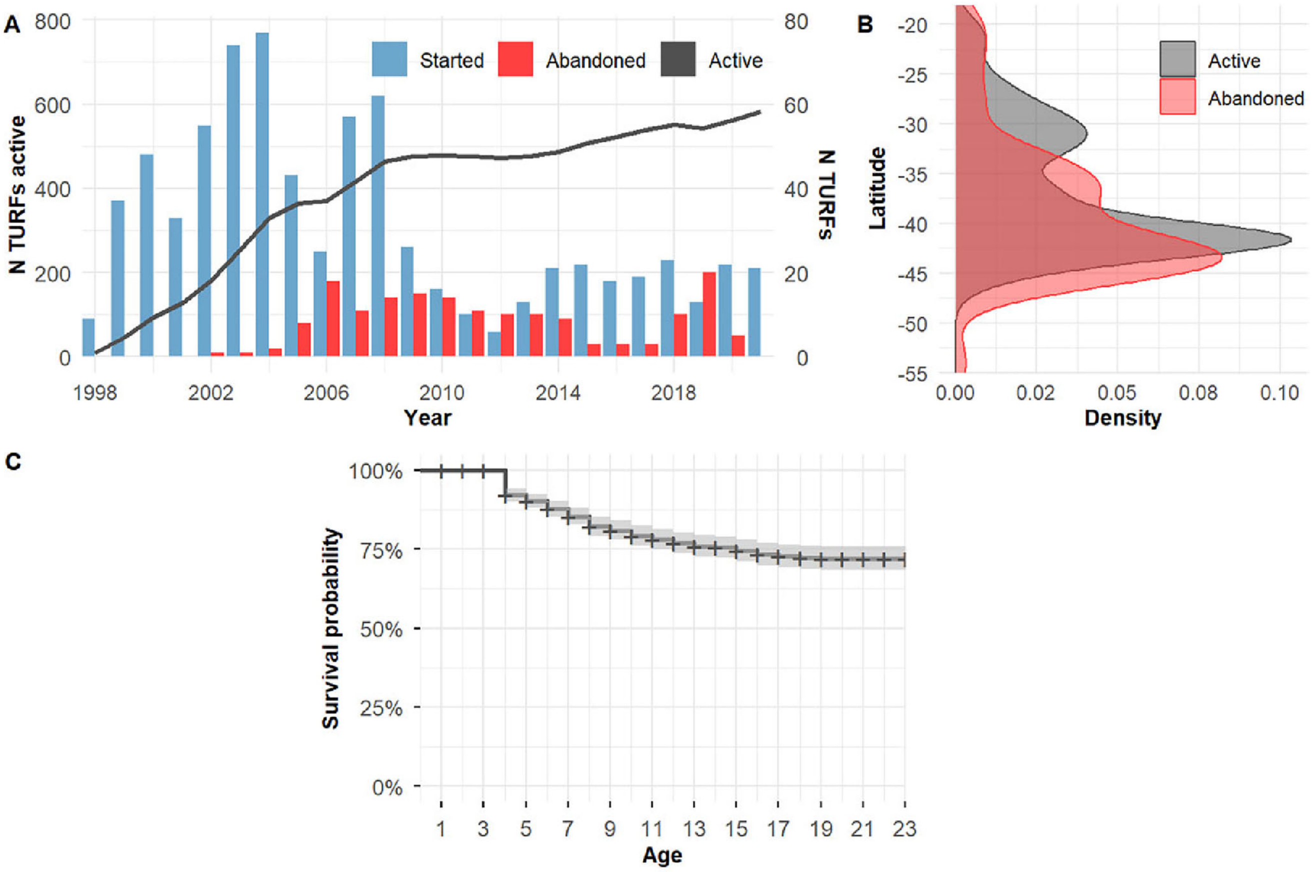

FIGURE 1 | TURF dynamics. (A) Annual number of active (line), abandoned, and started TURFs based on annual report submissions. No TURFs were classified as abandoned in the first 3 years due to the grace period following the initial report submission. The last year in which a TURF could be considered abandoned was 2020, corresponding to the last report submitted in 2017 plus the 3-year grace period. TURFs that submitted reports in 2018 or later were considered censored in the survival analysis. (B) Density distribution of abandoned ($n = 168$). and active ($n = 582$) TURFs along latitude. (C) Kaplan–Meier survival curve for all TURFs established in Chile between 1998 and 2021. Tick marks represent censored observations.

FIGURE 2 | TURF clusters based on features for collective action. (A) Boxplots showing the distribution of scaled TURFs features across clusters (clusters 1, 2, and 3 include $n = 169$, 401, and 180 TURFs, respectively). Higher values indicate greater feature magnitudes. Different letters above boxplots indicate statistically significant differences between clusters based on ANOVA followed by Tukey's post hoc test with correction multiple hypotheses testing. (B) Map showing the spatial distribution of TURFs colored by cluster along the Chilean coast. (C) Density distribution of clusters along latitude.

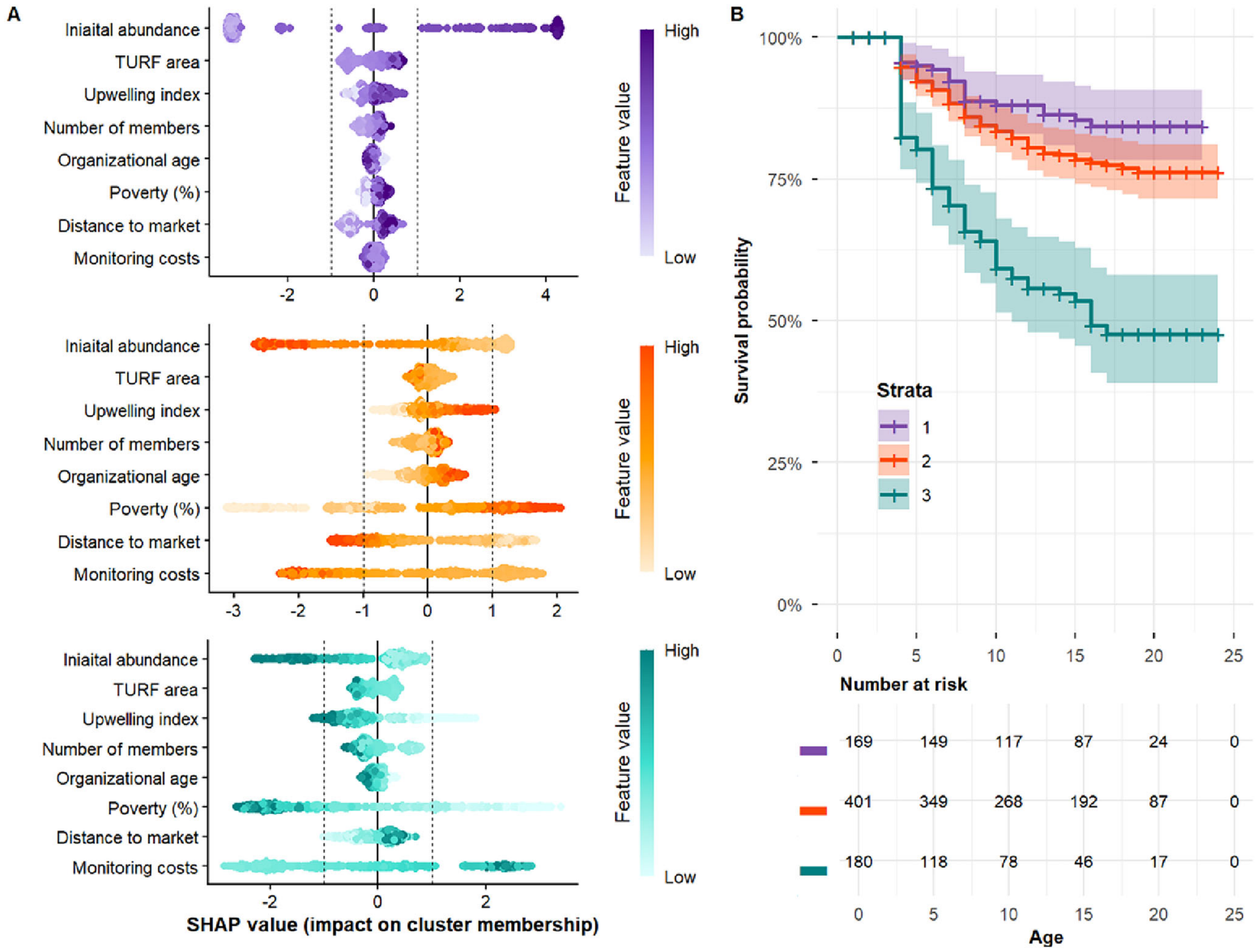

FIGURE 3 | Clusters' key features and survival. (A) Beeswarm plots showing the local SHAP values by features for each cluster. These values were extracted from an extreme gradient boosted model trained to predict cluster membership using original values of TURF features. (B) Survival curves estimated using the Kaplan–Meier estimator for each cluster, with the corresponding risk table shown below.

Initial exploitable abundance was the only feature contributing consistently to the definition of all clusters. Cluster 1 was primarily defined by high initial exploitable abundance, with higher values increasing membership likelihood (Figure 3A). Cluster 2 was characterized by low initial abundance combined with shorter monitoring distances and proximity to markets, higher poverty, and stronger upwelling. Cluster 3 was also driven by low initial exploitable abundance but was more strongly predicted by lower poverty, greater monitoring distance, and weaker upwelling.

Survival differed significantly across clusters (Figure 3B, log-rank test, p-value < 0.01). TURFs in cluster 3 exhibited the lowest persistence, with hazard of abandonment 4.24 times higher than that of cluster 1 (95% CI = [2.62, 6.86], $p < 0.001$). Abandonment risk did not differ significantly between clusters 1 and 2 (95% CI = [0.96, 2.47], $p = 0.075$). The proportional hazards assumption was satisfied ($X^2(2) = 0.62$, $p = 0.74$), and survival did not vary across establishment cohorts (Supporting Information S14). Results were robust to excluding reinstated TURFs (Supporting Information 15).

4 | Discussion

This study advances understanding of area-based conservation by examining community engagement in co-management under a nationwide policy. While Chilean TURFs generally show high persistence, outcomes vary across social–ecological conditions shaping collective action and across administrative regions, offering guidance for future research and policy aimed at sustaining co-management.

Our study is among the first to quantify community engagement persistence in resource management at a national scale (see also recent estimates from forest management in Nepal (Clark et al. 2025)). In Chile, TURFs exhibited a 75% probability of persisting beyond 15 years, with the highest termination risk occurring during early implementation. Because survival time includes the 3-year legal grace period prior to revocation, persistence may be modestly overestimated. Our analysis captures diverse co-management experiences, including benefits to users that extend beyond harvest security (Gelcich et al. 2019, 2017). However, the scarcity of comparable assessments limits the generalizability of

TABLE 2 | Cox proportional hazards model of TURF abandonment risk (hazard ratios) with regional random intercepts.

Variable	Hazard ratio
Initial exploitable abundance	0.40*** [0.27, 0.55]
Initial exploitable abundance^2	1.28*** [0.99, 1.54]
TURF area	1.30* [0.96, 2.02]
TURF area^2	0.98 [0.88, 1.02]
Upwelling index	1.16 [0.82, 1.64]
Upwelling index^2	1.08 [0.93, 1.23]
Number of members	0.81 [0.45, 1.10]
Number of members^2	1.05* [0.88, 1.29]
Organizational age	1.11 [0.91, 1.49]
Mean poverty	1.00 [0.78, 1.31]
Distance to nearest large market	1.08 [0.81, 1.44]
Monitoring distance	1.23*** [1.11, 2.33]
n	688
RE SD	0.85
AIC	1786.44

Notes: A total of 62 observations were deleted due to missingness. Hazard Ratios > 1 indicate higher abandonment risk, whereas Hazard Ratios < 1 indicate reduced risk. Confidence intervals are shown in brackets.
$^*p < 0.10$; $^{**}p < 0.05$; and $^{***}p < 0.01$.

these findings and highlights the need for further research on lasting community participation, especially as government-led policies face growing political uncertainty (Golden Kroner et al. 2019; Pienkowski et al. 2026).

Guided by collective action theory, we examined TURF survival across individual SES features and their combinations to refine hypotheses on persistence (Ostrom 2010; Ostrom 2009; Rocha et al. 2020). Cox models identified initial resource abundance and monitoring distance as the strongest predictors. Abandonment risk declined nonlinearly with abundance, reaching a minimum at intermediate–high levels, consistent with theoretical expectations linking ecological productivity and collective action (Ostrom 2009). Cluster-based survival patterns further showed that TURFs with low initial abundance can achieve comparable persistence when combined with short monitoring distances, high poverty, proximity to large markets, and strong upwelling. Together, these findings suggest that higher initial abundance provides early returns to help overcome the risky initial years, whereas in systems without immediate returns, persistence rely more strongly on broader SES conditions, including monitoring costs, resource dependence, market integration, and productivity.

Poaching is a major challenge for Chilean TURFs (Oyanedel et al. 2018; Romero et al. 2022; Quezada and Chan 2023), consistent with the strong negative effect of monitoring distance on TURF persistence. Examining how monitoring costs interact with poverty suggests potential mechanisms shaping persistence. Poverty can increase resource dependence, strengthening incentives for collective action among group members, but it can also reduce management benefits by intensifying pressure from outsiders (Epstein et al. 2021; Ostrom 2009; Fedele et al. 2021). In cluster 2, the combination of high poverty and low monitoring costs may explain higher persistence by facilitating outsiders' exclusion and peer monitoring under strong resource dependence. These patterns align with evidence linking resource dependence to participation in collective management (Jumbe and Angelsen 2007). This relationship is proposed to be stronger where self-organization enables the exclusion of outsiders, as in TURFs, and weaker in tenure systems that primarily restrict use among community members, such as customary closures (Cinner et al. 2012).

Proximity to large markets is another key feature of cluster 2, whose TURFs exhibit high persistence despite low initial resource abundance. This contrasts with settings where self-organization does not necessarily confer exclusion rights and with traditional tenure systems in which market incentives often erode intrinsic motivations for collective action (Cinner et al. 2012; Cinner et al. 2021; Wintergalen and Molina 2025). In Chilean TURFs, however, commercial objectives are common. In this context, market integration may instead foster self-organization and collective management, particularly under strong leadership (Elsler et al. 2022; Epstein et al. 2021). Consistent with this interpretation, cluster 2 includes the oldest user groups, suggesting that organizational stability may help leverage commercial opportunities from sustained co-management.

The role of resource dynamics in shaping incentives for persistent community engagement emerges from patterns of initial abundance, upwelling, and persistence. Co-management often entails high upfront costs and delayed returns, consistent with the elevated termination risk observed during early TURF implementation. TURFs in cluster 1, characterized by high initial abundance, appear less constrained by these risks. Cluster 2 combines low initial abundance with strong upwelling, suggesting overexploited but inherently productive stocks where recovery can sustain engagement, especially under low monitoring costs. By contrast, in less productive areas with weaker upwelling (clusters 3), management and exclusion efforts may yield limited benefits, weakening incentives for persistence (Anguita et al. 2020).

Resource system size and group size have been linked to TURF outcomes in prior studies (Viana et al. 2019; Villaseñor-Derbez et al. 2019), yet they played a minor role in explaining variation in TURF persistence in our analysis. Shared norms and knowledge likewise showed little association with persistence, despite being recognized as key drivers of SES outcomes (Ostrom 2009). This likely reflects measurement limitations, as organizational age, used here as a proxy, may insufficiently capture variation in shared norms and knowledge. Poverty is also an imperfect proxy for resource dependence; it may influence persistence through multiple mechanisms, including constraints on financial and human capital required to fulfill legal reporting and monitoring obligations. Nonetheless, our results indicate higher persistence in poorer municipalities, suggesting that poverty may operate primarily through stronger resource dependence.

We were also unable to incorporate other key determinants of collective action, such as leadership and social capital (Gutiérrez et al. 2011; Elsler et al. 2022; Epstein et al. 2021; Ostrom 2009) due to the absence of reliable national-scale indicators. Cluster analysis was used to organize multidimensional heterogeneity and explore how combinations of SES conditions relate to persistence. These patterns are associative in nature and should be interpreted alongside Cox regression results showing strong regional effects. Future research using richer, locally grounded data and more flexible survival models could refine these findings and improve predictive accuracy across contexts.

Tracking persistence can guide interventions by type, timing, and location. Beyond surveillance and enforcement support identified in previous studies (Oyanedel et al. 2018; Romero et al. 2022; Quezada and Chan 2023), our results suggest that increasing market integration and ecological productivity, through measures such as habitat restoration or resource restocking, can help sustain long-term community engagement in Chilean TURFs. Regional heterogeneity in persistence likely reflects differences in regional government activity that shape co-management benefits through enforcement (Quezada and Chan 2023), highlighting regions where targeted support could yield gains in persistence. Interventions can be particularly valuable during the "risky early years" of TURF implementation. Persistence analysis can also reveal "bright spots," initiatives that persist beyond expectations and offer lessons for overcoming persistence challenges.

Globally, governments have committed to expanding area-based conservation measures, including community-based approaches, to 30% of lands and waters by 2030. Yet such ambitious targets will not deliver sustained benefits for people and nature unless initiatives persist over the long term. Our findings highlight the importance of examining how factors such as resource dependence, market integration, monitoring costs, and ecological dynamics combine to shape incentives for continued community participation, while underscoring the need to track disengagement as a core dimension of conservation progress. More broadly, this work emphasizes context-dependent and multifaceted nature of SES outcomes, which must inform policies for scalable, enduring, and equitable conservation.

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Data Availability Statement

The data and code that support the findings of this study are openly available at https://github.com/migriverah/turf_surv.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Supporting Information: conl70050-sup-0001-SuppMat.docx