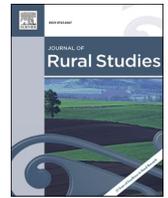




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The role of family in shaping adaptation and adaptive capacity in small-scale fishing communities: The yellow clam fishers in Uruguay

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ABSTRACT

Small-scale fisheries (SSFs) face numerous challenges, including resource overexploitation and precarious livelihoods due to limited or ineffective formal and institutional governance systems. In addressing the multifaceted challenges SSFs confront, such as climate change, biodiversity loss, and livelihood security, understanding their adaptive capacity becomes fundamental. Various social factors, including family dynamics, influence adaptive capacity. This paper presents an in-depth case study from Uruguay, examining the role of families in the yellow clam SSFs' adaptive capacity. It explores the influence of family ties and their impact on adaptation processes. The study draws on diverse datasets to highlight families' role in building adaptive capacity within SSFs. We find that family networks are a significant driver of other types of important social networks in communities (e.g., labor, governance, and knowledge). Additionally, family structures within communities influence key adaptive processes, such as the marketing of harvest within value chains. Our findings emphasize the significance of family as local, informal institutions and networks to strengthen capacity to manage diverse stressors and resources. Empirically, the paper sheds light on the intricate web of connections that are pivotal for the functioning of fisheries communities and the complex interplay between fisheries and family dynamics, and our work is important for informing policy interventions aimed at enhancing adaptive capacity through existing social capital.

1. Introduction

Small-scale fisheries (SSFs) face a number of interconnected challenges, including climate change, biodiversity loss, and livelihood security (Gill et al., 2023). SSFs, in contrast to industrial fisheries, often exemplify a deep-rooted attachment to place and potentially limited capacities to adapt to changing conditions (Blasiak et al., 2017; Chuenpagdee, 2011; Gianelli et al., 2021). Globally, small-scale fishers struggle to secure their livelihoods in the presence of rapid environmental change (Galappaththi et al., 2021). They often confront compound effects, even if they are not completely aware of the long-term root causes (Gianelli et al., 2021). These challenges are exacerbated by progressive environmental trends such as intense extreme events, increasing ocean temperatures, and altered rainfall regimes, which apply additional pressure on SSFs (Portner et al., 2014; Stott et al., 2016). Recognizing these changes and their underlying causes are key

conditions that enable fishers to adjust their behavior and assess potential adaptive responses. Thus, how fishers perceive, cope, adapt and ultimately transform to face rapid climate-induced changes is a central question for sustainability science (Cinner et al., 2018; Engle, 2011; Gianelli et al., 2021; Grunblatt and Alessa, 2017).

Adaptive capacity is a key component to help small-scale fishing communities adapt to climate and environmental change. Adaptive capacity is defined by the IPCC (2019:5) as “the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences”. Adaptive capacity in the social dimension of fisheries governance is composed of five domains: social organization, assets, flexibility, learning, and agency (Cinner et al., 2018). Assets include all the private and public resources actors can access in times of need (e.g., savings, technology, and health care) (Cinner et al., 2018; Smit and Wandel, 2006). Flexibility refers to the institutional or individual capacity for switching

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between adaptation strategies to deal with change (e.g., diversifying income sources) (Armitage and Plummer, 2010; Cinner et al., 2018; Engle and Lemos, 2010). Social organization describes how actors are interconnected, and whether such connections enable or inhibit cooperation, collective action, and knowledge sharing (e.g., building connections between the fishing industry and scientific organizations to create access to information that facilitates adaptation) (Bodin, 2017; Caceres et al., 2023; Cinner et al., 2018; Gianelli et al., 2021; Pittman and Armitage, 2017; Wishart Chu Foon et al., 2022). Learning refers to actors' capacities to generate and process information, and assess potential response strategies (e.g., being informed about the status of fish stocks) (Armitage et al., 2007; Cinner et al., 2018; Pahl-Wostl, 2009). Agency is the ability of actors to choose from multiple strategies when responding to environmental change, and to mobilize the other adaptive capacity domains (Andrews et al., 2021; Brown and Westaway, 2011; Cinner et al., 2018).

There are considerable theories regarding how adaptive capacity shapes SSFs adaptation to climate change in various contexts (Basurto et al., 2013; Cinner et al., 2018; Finkbeiner, 2015; García Lozano et al., 2019). However, we still urgently need to understand the local social processes that enable or hinder the emergence of adaptive capacity at the community level. This often involves studying how different households interact in the production of adaptive capacity. Of particular interest is how collective institutions can help guide and navigate adaptation to environmental change. While we know that groups such as fisheries cooperatives, collectives, and other local organizations play a key role in adaptation in SSFs (Basurto et al., 2013; Defeo et al., 2021; Finkbeiner, 2015; García Lozano et al., 2019), less is known about the role of informal institutions in shaping adaptive capacity.

Family is both a key informal institution and a type of community-level network, which requires additional investigation in SSFs (Andrews et al., 2021; Terkla et al., 1988). Family ties can help enable collective action and knowledge sharing (Ahomka Yeboah, 2023). Family cohesion plays a strong role in family communication, which contributes to harmony, particularly in times when fishing areas are affected by extreme climate events and adverse situations (Ahomka Yeboah, 2023; Nelly Trevinyo-Rodríguez and Bontis, 2010). Self-monitoring and self-policing tend to be successful, particularly when there is an increased sense of ownership (e.g., allocation of TURFs for family groups) (Defeo et al., 2016; Méndez-Medina et al., 2020). The influence of cultural heritage derived from community founding members with strong family ties could be pivotal to promote successful adaptation actions (Cinner et al., 2018; Naranjo-Madrigal et al., 2015; Szymkowiak, 2020). According to Szymkowiak (2020), families build deep connections internally and with other fishing families in their community upon which they rely for support in the face of financial and emotional adversity. Therefore, the role of family as an informal institution and network can provide insights into the decision-making process that guide adaptation to the social-ecological changes that fishers experience.

A key important influence of family is on social capital. Networking social capital is important at the local level for understanding vulnerability and adaptive capacity (Adger, 2003; Cinner et al., 2018). Bonding social capital within families and households can be an important asset for coping with the impacts of extremes in weather and catastrophic events (Smith et al., 2012). Hence, networks and family ties potentially play important roles in enhancing adaptive capacity through local actions or interactions with the government, businesses or NGOs directly or indirectly to reduce the effects of stressor (Adger and Vincent, 2005; Pittman et al., 2011). However, this role is understudied and currently there is a dearth of research on the subject.

With this in mind, we examine an in-depth case study on the role of family in adaptive capacity from Uruguay. We draw on diverse data sets to examine the nuanced role of family in guiding adaptation. We tackle two main research questions. First, we examine how family ties influence key social networks regarding governance, knowledge, and labour

within the communities. These networks are often key determinants of adaptive capacity (Cinner et al., 2018). Second, we examine how families influence key adaptive decisions and outcomes, such as harvesting and sales decisions. Our results demonstrate the key role families play in adaptive capacity in a SSF of Uruguay. We discuss our findings' implications and help place our work within the broader literature on adaptive capacity.

2. Materials and methods

2.1. Case study

The yellow clam (*Mesodesma mactroides*) is a cool-water sedentary shellfish exploited by artisanal fishers using shovels and handpicking along 22 km of sandy beach from Barra del Chuy (33°40'S, 53°20'W) to La Coronilla (33°50'S, 53°27'W), Uruguay. The fishery has a long-standing history of collaborative management practices, including a *de facto* co-management system implemented between 1987 and 1994 in response to severe reductions in the yellow clam stock in late 80s. Several positive outcomes of the *de facto* co-management are well documented (Defeo et al., 2016), but most importantly, this approach helped to shape a social-ecological collective memory for future cooperative institutional arrangements (Gianelli et al., 2015, 2018).

Since 2009, an adaptive management strategy, involving fishers in stock assessment initiatives (e.g., community-based data collection program) and in several steps throughout the management cycle, has been adopted for the yellow clam fishery (Defeo et al., 2021; Gianelli et al., 2015, 2019, 2021). Several operational and spatial management tools were also introduced, including: (1) definition of a Functional Unit for Ecosystem based Fisheries Management (UFMEP by its acronym in Spanish); (2) a harvest season; (3) allocation of a restricted number of fishing licenses mainly allocated to local fishers with longer experience; (4) a total allowable catch (TAC) estimated using fishery-independent surveys; (5) individual non-transferable quotas, based on equal sharing of the TAC among fishers; and (6) restriction of fishing activities in areas reserved for recreation. Currently the fishing community is composed of 36 stable fishers (Bausero-Jorcín et al., 2024), 61% being men and 39% women. Both men and women have equal tenure rights (i.e. individual fishing licenses) and perform the same labor in the fishery. Fishing activity has a strong family tradition and most fishers develop the activity jointly with some family members, including young children and partners (Defeo, 1989; Pittman et al., 2019).

The impacts of climate change on this fishery are threatening the social-ecological system (SES). The yellow clam region in Uruguay is affected by one of the most important warming hotspots worldwide (Gianelli et al., 2021). This systematic increase in SST have been invoked as a main driver of the mass mortalities that decimated the yellow clam population throughout its geographic distribution range during the mid-1990s (Defeo et al., 2021). These mass mortality events drastically changed the livelihoods of fishers who depend mostly on clam harvesting as their main source of income. Immediately after mass mortalities, the government implemented a total fishery closure to rebuild the stock. Fishers responded by diversifying their livelihoods in local sectors of the economy (e.g., construction, agriculture and logging) or were forced to migrate from local communities. The SES was not prepared to cope with the drastic changes caused by mass mortalities, showing a low collective capacity to adapt to these perturbations and to minimize short-term welfare losses, both at government and community levels (Gianelli et al., 2021).

2.2. Data collection

This paper draws on a long-term dataset of interviews and surveys completed with fishers from 1984 to present. The dataset contains information on fishing practices, value chain characteristics, demographics, and other key social and ecological fisheries characteristics.

Table 1
ERGMs terms (Wang et al., 2014).

ERGM term	Diagram	Description
EdgeA		The number of ties in the network. This term is like an intercept in a logistic regression.
ASA		Alternating stars. This term captures the propensity for certain nodes to form social ties. It is similar to the concept of popularity.
ATA (triadic closure)		Alternating triangles. This term captures the tendency for dense or shared relationships to develop between nodes, which is often referred to as triadic closure (i.e., connections form between two nodes that share a connection to a third node).
Family_EdgeA		Dyadic covariate based on family networks. This term captures how the family network relates to the other focal networks.
Star4A		This term captures the propensity for nodes to form ties with four other nodes. It is similar to popularity.
Star5A		This term captures the propensity for nodes to form ties with five other nodes. It is similar to popularity.
AgeCov_ActivityA		Node covariate. This term captures the propensity for fishers of different ages to form ties. We operationalized age as a binary variable, where fishers older than the average age of 43 years old were assigned a '1' and fishers 43 years old or younger were assigned a '0'.

This dataset is augmented periodically with additional, targeted social data gathering techniques. Data on local social networks and adaptive capacity were gathered through interviews conducted between May and July 2017. The interviews lasted between 30 and 90 min and were usually conducted in an area chosen by the interviewee, mostly in their household. In total, 28 interviews were completed, which represents approximately 78% of licensed fishers (n = 36) and 90% of active fishers (n = 31). 40% of the survey participants were women and the remaining

Table 2
Exponential Random Graph Model results for governance network in the yellow clam small-scale fishery in Uruguay.

Effect	Diagram	Parameter estimate
EdgeA		-2.8931 ^a
ASA (popularity)		-0.4691
ATA (triadic closure)		1.3985 ^a
Family_EdgeA		1.2918 ^a

^a significant effect.

60% men. Three fishers declined to participate in the survey.

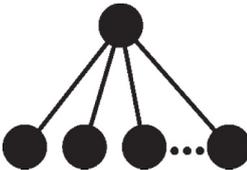
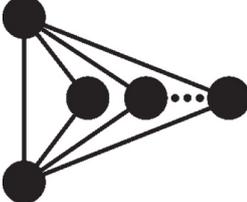
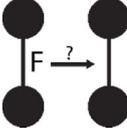
Respondents were asked with which other fisher, the top 10, they regularly discuss issues related to the management and governance of the fishery (governance network), labour sharing in the act of fishing (labour network), and knowledge sharing regarding fishing practices (knowledge network). A free-recall name generator technique was used to identify ties related to information exchange between fishers when addressing governance and management issues, allowing respondents to identify their network ties (Marsden, 2011). The limit of 10 for the name generator seems reasonable, as only four individuals reached this limit for both the governance and knowledge networks, and one individual reached this limit for the labour network. The family network was developed based on the interviews and confirmed with expert knowledge of family ties in the fishing community.

2.3. Data analysis

To understand how family ties influence key networks within communities, we analyzed the network data using Exponential Random Graph Models (ERGMs) (Lusher et al., 2012). ERGMs are a statistical approach to network analysis, which treats the observed network as the dependent variable and the independent variables are various micro-structures or motifs within the network that represent key social processes and contribute to the development of the network (Lusher et al., 2012). We used multiple micro-structures in our models (Table 1), which correspond to an intercept (EdgeA), popularity or the propensity for certain nodes to have a large number of ties (ASA, Star4A, Star5A), triangulation or triadic closure, which is the tendency for dense relationships to develop based on shared ties (ATA), and covariates related to the presence of family ties (Family_EdgeA) and the age of each fisher (AgeCov_ActivityA). These micro-structures are often called effects when used to model networks in ERGMs. We selected models based on their goodness of fit (see Supplementary Materials).

To understand how family influences key outcomes and processes in communities, we mapped the individual-level variables in relation to network topologies. We completed a qualitative analysis, which

Table 3
Exponential Random Graph Model results for labour network in the yellow clam small-scale fishery in Uruguay.

Effect	Diagram	Parameter estimate
EdgeA		-0.3868
ASA (popularity)		-1.5333 ^a
ATA (triadic closure)		1.8071 ^a
Family_EdgeA		1.4919 ^a

^a significant effect.

demonstrates the high degree of overlap between key social process outcomes and family network topologies. We used the adoption of the innovation to sell catch to the processing plant as the key social process outcome variable and examine difference related to basic adoption (e.g., whether catch was sold to the processing plant) and the degree of adoption (e.g., the proportion of harvest sold to the processing plant). We chose qualitative techniques instead of quantitative for this second analysis due to the small number of families apparent in the community (n = 7), which is too small for statistical analysis.

3. Results

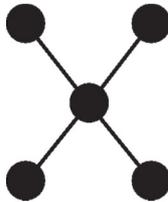
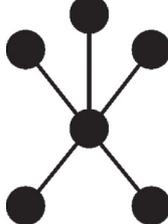
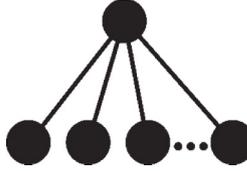
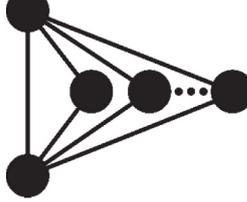
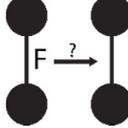
3.1. How do family ties influence key networks within communities?

“Since I was a kid, I [have] worked with my family in the fishery” – Respondent 7

Family ties were a significant predictor of governance networks (Table 2), labour networks (Table 3), and knowledge networks (Table 4)—being positively correlated with all three. They have the largest effect on knowledge networks, followed by labour networks, and governance networks, respectively. The ERGMs for the governance network and labour network were well fit using the same set of effects or network micro-structures. The ERGM for the knowledge network required the inclusion of various additional effects related to popularity and age to achieve an acceptable goodness of fit (Supplementary Materials).

Triadic closure was significant and positive in all three networks, which suggests that there is a high degree of clustering in the networks. Popularity was a significant effect in the labour network, but negative, which means that labour is evenly shared within the network (i.e., there is not a small set of individuals who give or receive labour to a larger number of their peers than others in the network).

Table 4
Exponential Random Graph Model results for knowledge network in the yellow clam small-scale fishery in Uruguay.

Effect	Diagram	Parameter estimate
EdgeA		4.9802
Star4A		0.007 ^a
Star5A		-0.0014
ASA (popularity)		-2.5869
ATA (triadic closure)		1.1995 ^a
AgeCov_ActivityA		0.0637
Family_EdgeA		2.1193 ^a

^a significant effect.

3.2. How does family influence key outcomes and processes?

Question: What would you like to see as the future for the Yellow Clam fishery 10 years from now?

“... young people, the relatives of fishers, working in the future in the fishery.” – Respondent 2

“... every fisher working and the clam processing plant working at full capacity.” – Respondent 11

The productivity of the processing plant and the renewal of the next generation of fishers are key, intertwined issues in the community. When asked what they would like to see for the future of the fishery, respondents noted the continued success of the processing plant and the engagement of youth in the fishery as critical issues. According to our analysis, families have a nuanced impact on the adoption of new

Table 5
The timing of adoption of selling to the yellow clam processing plant by each family.

Family	First season started
1	2013–14
2	2013–14
3	2016–17
4	2013–14
5	2013–14
6	2013–14
7	Never

innovations, which, in this case, refers to the practice of selling to the processing plant in the fishing community. Families may not influence the basic adoption of the innovation or serve as the primary catalyst for adoption (Table 5; Fig. 1). In the yellow clam fishery, family did not appear to influence the first season when a fisher started selling to the processing plant. Nonetheless, family did appear to influence the degree of adoption (i.e., how much they sell to the processing plant) (Fig. 2). There is almost a perfect correlation between family and degree of adoption; being part of family 2, 4 or 5 was a necessary condition to sell more than 50% of catch to the processing plant.

4. Discussion and conclusions

Conventional top down approaches in SSFs management has been shown to be ineffective (Hauzer et al., 2013; Jentoft, 2005). There remains little understanding of the effectiveness of alternative approaches including the role families and key individuals play in governance structures. Our research sheds light on the often underexplored and intricate intersection of fisheries and family dynamics, unveiling a web of connections that are central to understanding the functioning of fisheries communities. Families and key individuals offer a way to enhance local institutional strength and capacity to manage resources. Family knowledge, beliefs, and perceptions of resources are central in collectively designing, monitoring, and enforcing local regulations. Shellfish gatherers start practicing the activity early, are influenced by family and friends, and have traditional knowledge shared between

generations (de Jesus et al., 2024; Gianelli et al., 2021). This paper shows empirically how family ties influence other key networks in fishing communities (e.g., governance, knowledge sharing, and labour) and how family influences adaptation processes.

Our findings underscore how families work to facilitate information sharing, trust building, and serving as a foundational support system in the fisheries community, which is similar to other published studies (Galappaththi et al., 2022). The positive correlation among family ties and various community-level networks demonstrates how network structures moderate social variables to determine influence in adaptation processes, which aligns with existing theory (Cinner et al., 2018). Thus, indicating that family and key individuals are a driving force behind the cohesiveness and resilience of fishing communities through various mechanisms, including information and knowledge sharing (Suh and Nyiawung, 2023) and the preservation of tradition (de Juan et al., 2024).

In addition to families, our findings demonstrate triadic closure serves as a driving force in shaping communities. The presence of multiple, overlapping triangles in social networks is akin to cohesive sub-groups, as demonstrated by (Hunter and Handcock, 2006). This model not only influences knowledge-sharing but also signifies the presence of bonding social capital (Alexander et al., 2018; Burt, 2005). More broadly, social capital at the family level refers to the processes that facilitate cooperation, ultimately strengthening social relationships and supporting the development of conservation and adaptation measures (Alexander et al., 2018; Barnes et al., 2017; Bodin and Prell, 2011; Coleman, 2000; Eger et al., 2021; Grafton, 2005; Righi and Takács, 2018). For example, Marín et al. (2012) found that within a Chilean co-management system for benthic fisheries, there was a positive association between organizations possessing stronger bridging and linking social capital and greater management capacity, as well as a wider range of livelihood strategies.

Our paper shows that the family unit is fundamental to build local adaptive capacity, which contributes to building a sustainable future for SSFs. The positive relationship between family ties and governance, knowledge, and labour sharing networks exemplifies how families shape collaborative efforts and adaptive processes within SSF communities. Family units and triadic closures in SSF communities bridge the gap

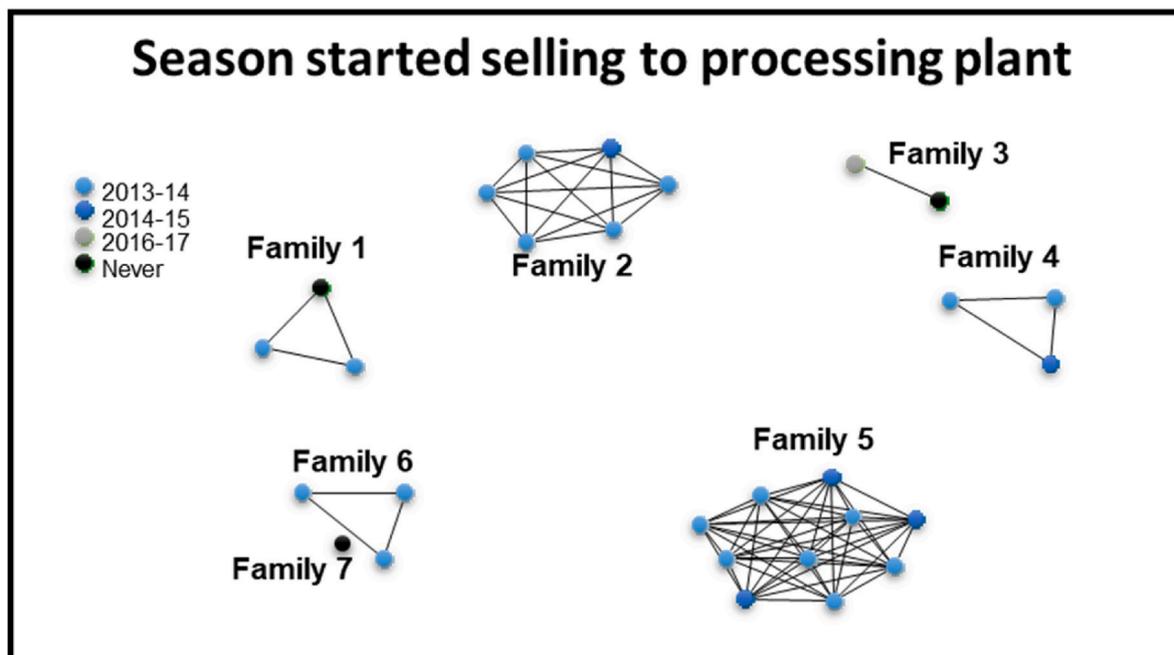


Fig. 1. The timing of adoption of selling to the processing plan by each family in the yellow clam small-scale fishery in Uruguay. The ties represent family relationships. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

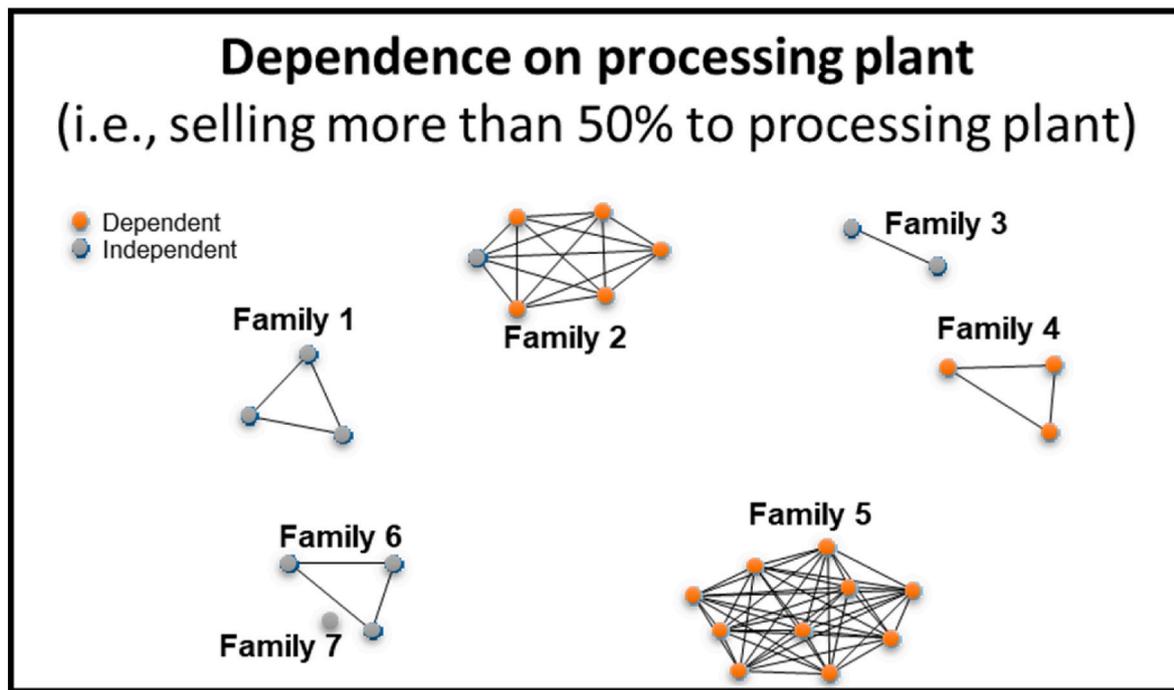


Fig. 2. Fishers' dependence on the processing plant by family in the yellow clam small-scale fishery in Uruguay. The ties represent family relationships. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

between local ecological knowledge and contemporary science, fostering capacity to navigate change (Gianelli et al., 2021).

CRedit authorship contribution statement

Farah El-Shayeb: Writing – review & editing, Writing – original draft. **Jeremy Pittman:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Gabriela Jorge-Romero:** Writing – review & editing, Writing – original draft, Visualization, Formal analysis. **Ignacio Gianelli:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis. **Omar Defeo:** Writing – review & editing, Writing – original draft, Supervision, Investigation, Funding acquisition.

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Declaration of interests

The authors have no conflicts of interest to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jrurstud.2025.103601>.

Data availability

The data that has been used is confidential.

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