

Low Propensity to Move and Marine Resource-Based Livelihood Choices for Coastal Communities in Southern Chile

H. Jo Albers, Carlos Chávez, Jorge Dresdner, Yanina Figueroa, and
Mauricio Leiva



Central America
 Research Program in Economics and Environment for Development in Central America Tropical Agricultural Research and Higher Education Center (CATIE)



Colombia
 The Research Group on Environmental, Natural Resource and Applied Economics Studies (REES-CEDE), Universidad de los Andes, Colombia



India
 Centre for Research on the Economics of Climate, Food, Energy, and Environment, (CECFEE), at Indian Statistical Institute, New Delhi, India



South Africa
 Environmental Economics Policy Research Unit (EPRU)
 University of Cape Town



Uganda
 Efd-Mak, School of Economics and Department of Agribusiness and Natural Resource Economics, Makerere University, Kampala



MAKERERE UNIVERSITY

Chile
 Research Nucleus on Environmental and Natural Resource Economics (NENRE)
 Universidad de Concepción



Ethiopia
 Environment and Climate Research Center (ECRC), Policy Studies Institute, Addis Ababa, Ethiopia



Kenya
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 Environmental Economics Program in China (EEPC)
 Peking University



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Nigeria
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Tanzania
 Environment for Development Tanzania
 University of Dar es Salaam



Vietnam
 University of Economics
 Ho Chi Minh City, Vietnam



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H. Jo Albers^a, Carlos Chávez^{b,d}, Jorge Dresdner^{c,d}, Yanina Figueroa^d
and Mauricio Leiva^c

^aDepartment of Economics, University of Wyoming, USA

^bFacultad de Economía y Negocios, Universidad de Talca, Chile

^cDepartamento de Economía, Universidad de Concepción, Chile

^dInterdisciplinary Center for Aquaculture Research (INCAR), Chile

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Abstract: In this paper, we describe and analyze an experience in the use of marine resources as a base for economic activities and development of coastal communities. According to the economic theory of the commons, Chile’s establishment of unique property and user rights for marine resources should reduce over-extraction pressure from open access and thereby improve sustainability of marine resources. In addition, these new institutions create a range of opportunities for people in coastal regions, which may combine to improve economic wellbeing, both by diversifying activities and increasing the economic value of marine activities. We examine the case of coastal communities in southern Chile that, due to the decline in traditional fisheries and the advent of new user rights, have changed their income-generating work toward new sets of marine activities. However, the effective use of these opportunities is bounded by the low propensity to move found in these communities. Our analysis is based on field work conducted during 2018, which included interviewing 25 qualified informants (artisanal fishers, leaders of fishers’ unions, and government officials) and a survey applied to a sample of 316 households in coastal communities of the Los Lagos region in southern Chile. We find diverse sets of marine-based income generation activities across households. The degree of diversification and the specific activities in which households engage vary over space depending on the environmental and biogeographic conditions and the institutional setting they face. The coastal population has a low propensity to move, which constitutes a cultural restriction that tends to generate segregated patterns of economic and labor activities in the studied area. Consistent with this finding, we find that variability in income across households is explained by household characteristics, the type of economic activity that households perform, and their geographical location.

Keywords: small-scale aquaculture, fisheries, income-generating activities, spatial and social heterogeneity, propensity to move, conservation and development policies

Low propensity to move and marine resource-based livelihood choices for coastal communities in southern Chile

1. Introduction

In this paper, we describe and analyze the use of marine resources as a base for economic activities and development of coastal communities. We present an empirical analysis that characterizes the marine resource-dependent economic decisions of individual households in coastal communities in southern Chile that, due to the decline in traditional fisheries and in response to new property and user rights, have moved toward diversified sets of marine activities. According to the economic theory of the commons, Chile's establishment of unique property rights for marine resources should reduce over-extraction pressure from open access and thereby improve sustainability of marine resources. In addition, these new institutions create a range of opportunities for people in coastal regions, which they may combine to improve economic wellbeing, by both diversifying activities and increasing the economic value of marine activities. However, to take advantage of these opportunities, coastal households often would have to move to new locations. The actual improvement in wellbeing will be conditioned by households' propensity to move. Moreover, to have access to different marine resources, households must be entitled with user rights. Because these rights are granted to particular households, the actual choices available to a specific household will be restricted by their entitlement to these rights and the distribution of marine resources over space. Our research focuses on the determinants of activity choices and income generation across households. We are interested in reflecting the impact of diverse resource management institutions, households' preferences over locations, and resource-based heterogeneity across settings in terms of income-generating opportunities.

The existing literature on group resource management in Chile typically focuses on the management of single or mixed species and on only one management regime (Aguilera et al., 2015; Castillo and Dresdner, 2013; Chávez et al., 2010, Defeo et al., 2016; Dresdner et al., 2015; Dresdner et al., 2005; Gelcich and Donlan, 2015; Gelcich, 2014; Gelcich et al., 2013; Jara et al., 2015; Quezada and Dresdner, 2014; Rosas et al., 2014; Santis and Chávez, 2014; Sobenes and Chávez, 2014). The coastal Chilean setting provides an interesting opportunity to broaden away from focusing on one resource management institution and

instead explore how various such institutions interact in coastal households' extraction and labor allocation decisions. Households' decisions reflect their individual set of income-generating opportunities, constraints, preferences, and institutions. Our research is unique in that it considers households' economic activity decisions over different marine resources, including small-scale aquaculture; reflects the overlapping resource institutions among fishers/coastal communities, rather than focusing on one resource management regime; and incorporates ecological and socioeconomic settings in coastal southern Chile to determine how people might react to policies depending on their specific conditions and opportunities. The paper builds on, and contributes to the literature on, household decision models for resource extraction across market and institutional settings, group resource-extraction decisions, and interactions among resource management institutions.

The results will inform the Chilean government on the possibilities and limitations of general policies aimed at promoting small-scale aquaculture. This information should help to target and tailor programs to individual coastal communities in ways that will improve the success of these programs in reducing poverty and promoting sustainable use of fish and coastal resources. The ability to target appropriate policies across a diverse region will increase efficiency and lead to a larger positive impact than could be attained with general policies across the region.

Our analysis is based on fieldwork conducted during 2018, which included interviewing 25 qualified informants (artisanal fishers, leaders of fishers' unions, and government officials) and a survey applied to a sample of 316 households in coastal communities of the Los Lagos region in southern Chile. Furthermore, we conduct econometric analysis of these survey data based on an economic decision framework to characterize the decisions of households in coastal communities, while reflecting the impact of resource management institutions and the heterogeneity across settings in terms of income-generating opportunities and biogeographic conditions. We examine these data to ground a discussion of several aspects of economic activity choices and income generation in this setting. First, we describe the differences in the number of activities and the specific activities and income levels accrued by households across both the territory and the user rights institutions, and we define biogeographic regions. Second, we analyze the propensity to move and change residence of the coastal population. Third, using the household data, we develop

regressions explaining the variability in economic activity selection and income generation across households as a function of household characteristics, user rights institutions and location.

The paper develops as follows. In the second section, we describe methodological aspects including interview and survey design, data collection process, and statistical analysis. We present and discuss results in the third section. The conclusions follow in the fourth section.

2. Methods and Data

In this section, we describe the methods and data for our empirical analysis. This description is complemented with information in the appendices of this paper. The article focuses on how households make choices over different sets of economic activities and how they generate income from these activities. Our basic view is that households make choices based on a series of restrictions (family, socioeconomic, institutional, and cultural) that are different in nature, where geographical location emerges as an important immediate driver. To study the drivers of households' choices over productive activity and income generation, the role of preferences and institutions in their decisions, and the location-specific sets of income-generating activities, we developed different activities. First, to obtain primary source data, we conducted semi-structured interviews with key stakeholders; we administered a specially designed survey to a sample of households; and we collected information on environmental/water characteristics in different locations of the territory under analysis. Our objective was to establish how individual households make choices across their sets of possible productive activities and income-generating activities, with particular emphasis on constraints, participation in groups, and perceptions of available institutions. We found that decisions are constrained by legal, institutional, economic, and cultural reasons. Specifically, cultural ties seem to be very strong with respect to location decisions. This introduces biogeographical (locational) characteristics into our analysis as an important restriction on the set of choices available to households. Second, based on stakeholder interviews, we expect that the sets of livelihood activities employed by households will vary by the biogeographic region and the types of user rights institutions utilized by the household. Therefore, we distribute the zoning of the region into biogeographic areas based on water

quality and location with respect to open-ocean or fjord settings. Third, we conduct econometric analysis of activity choices and income generation.

Fieldwork

We conducted 18 semi-structured interviews with 25 people during April 2018. The interviews were distributed across different communities to avoid concentration in particular geographical locations. Because government officials were also interviewed, some of the interviews were performed in the city of Puerto Montt, the capitol city of the Los Lagos region, and in the city of Valparaiso, home of the headquarters of both the National Fisheries and Aquaculture Service and the Undersecretary of Fisheries and Aquaculture of the Chilean government.

Also, during November and December 2018, we administered 316 surveys to a sample of individual households located in coastal communities in the Los Lagos region. We visited 73 fishing villages located in eight municipalities (or counties). As part of our data collection efforts, we also sampled seawater in 38 locations to define water characteristics including temperature, salinity, and dissolved oxygen. Figure 1 shows a map of the distribution of the locations where households were surveyed along the coastal areas of Los Lagos region.

Figure 1: Coastal communities visited and surveyed households in Los Lagos region, Chile



Source: Own design

Stakeholders' interviews

We designed and conducted personal (face to face) semi-structured interviews with different key stakeholders, including leaders of artisanal fishers organizations, organizational leaders from different fisher villages, relevant government officials working in fisheries and aquaculture regulatory agencies (central and regional level), artisanal fishers, and members of coastal communities who develop marine economic activities (shore/seafood collectors, small scale aquaculturists, etc.). The structured portion of the interviews included a set of questions applied to all people interviewed and then specific questions for each type of stakeholder.

The set of general questions for the semi-structured interviews included four items: a) general questions related to marine activities, b) small-scale aquaculture activities, c) enforcement and compliance, and d) households' activities and allocation of labor time. The

specific questions varied across the type of interview, but included questions seeking to obtain more detailed information related to perceptions on marine economic activities, small-scale aquaculture, enforcement and compliance issues, organizational issues, and specific activities and allocation of labor. The interviews helped identify different productive zones, define relevant issues to analyze, and structure the household survey¹.

Household survey

The data used in our empirical analysis comes from a field survey administered to a sample of households from villages/coastal communities located across the ecologically and socioeconomically diverse Los Lagos region in southern Chile. The sample was selected by a two-step procedure. In the first step, we selected villages/coastal communities, and in the second step we chose households in these locations. The selection of villages/coastal communities followed an intentional selection procedure that chose the locations proportional to the available information about the total number of artisanal fishermen, so that the village sample was representative of the total fishermen in the selected area. The household selection procedure in each village consisted of contacting a local leader (i.e., president of a local union) to obtain basic information that allowed the enumerators to identify households within a resource rights holder group to be surveyed. Using a snowball approach, others households in the village were chosen using information from previously interviewed households about households both in and out of that resource rights holder organization.

The survey included several sections addressing different topics. The first section requested socio-demographic information as well as identification of economic activities performed by each household member. The second section asked for data on income sources and livelihood activities for each member of the household. In this section, we also requested information on the intensity of marine economic activities for each month of the last year. The third section inquired about the household productive assets for marine activities. The fourth section asked the households' respondents about the organizations to which each member belonged (type of organization, activities performed, perceptions about their

¹ We performed a content analysis of the results obtained from the interviews. There are many policy-oriented implications that were derived from this analysis that we do not discuss here. However, in Appendix 1 we present a summary of the main results obtained from this analysis.

organizations, etc.). The fifth section requested information regarding motivations for the household's choices of marine activities (type of marine resources, reasons to operate in a given location, etc.). The sixth section asked about respondents' perceptions of the biogeographic conditions under which the household selects and carries out its marine economic activities, as well as on previous experience with small aquaculture activities. Finally, in the seventh section, we included a set of question regarding perceptions on the problem of poaching, compliance behavior, and enforcement. The information presented and used in this paper is that considered relevant for the present research question.

User rights institutions

Chile has a 6,345 km long coastline with a highly productive marine ecosystem, mostly influenced by the Humboldt Current System. The main economically relevant fisheries and resource-dependent marine economic activities are regulated. There are several different institutions developed over time under which coastal producers must operate. The establishment of new user rights for marine resources is expected to contribute to reducing the pressure on these resources and improving their sustainability. Moreover, the advent of these rights should expand and diversify the range of economic opportunities available to people in the coastal areas, increase the value of marine activities, and improve people's wellbeing. The main marine user rights for coastal producers in Chile are Territorial User Rights (TURFs) for benthic resources, Collective Quotas (CQ) for artisanal organizations targeting mobile finfish, Marine Aquaculture Concessions (MAC) for aquaculture producers, and Special Permits (SP) for mussel seed collectors. In Appendix 2, we present a brief description of the main user rights in Chile.

It is common that coastal household are entitled to more than one of these user rights (overlapping rights). Moreover, there are several marine resources that still have open access, where artisanal fishermen with or with user rights participate. Thus, normally households' marine resource-based income stems from different species.

Econometric analysis

We are interested in studying the determinants of households' productive activity and income generation choices. These two choices are related, so we need to disentangle this relationship

to properly specify the econometric model. Our unit of analysis is the household and we assume that this unit takes decisions on where and how much time their members will spend productively, subject to several constraints. Conceptually, we look at the decisions of choosing activity and generating income as sequential. First, the household chooses the productive activities they will develop, and then how much time they will spend in each activity during the period being planned. We are aware that under some circumstances these might be considered as simultaneous decisions, but this does not seem a good approximation for the present study. The selection of productive activity is a long-term decision because it requires skills and capital and, in most cases, we are also considering user rights. In contrast, the decision on how much time to spend in one or another activity is a shorter-term decision, which might vary by temporal circumstances that do not affect the productive activity choice. Recalling that our database is cross-sectional, the productive activities should already have been selected when the income decisions were taken. Because activities are predetermined for the income generation process, we analyze the productive activity and income decisions sequentially.

The choice of productive activity is considered a multiple-choice problem. The household choose how to assign its labor time between different alternatives. Therefore, we use a multinomial logit model to estimate this decision. Drivers for the chosen productive activities are the household characteristics, such as the number of working age household members, age, experience, and formal education of the household members, and gender of the household head; access to user rights; and, as we will discuss later, biogeographical characteristics of the zone where the residence is located.

The income equation is determined by the household's characteristics (size, gender of head of the household), the household's human capital, chosen productive activities, and biogeographical characteristics of the zone where the residence is located. This specification assumes that the choice of productive activities is predetermined for the income decision and that biogeographical traits of the territory affect both the activity choice and income results.

3. Results

In this section, we present the insights from the data sets and analysis. First, we discuss the identification of different biogeographical zones. Then, we present the information from the

household survey, with special focus on the choice of productive activities and income by zones. Thereafter, we analyze the surveyed population's propensity to move. Finally, we present and discuss the results from the estimation of households' productive activity and income drivers.

3.1 Identification of Biogeographical Zones

One aspect that strikes observers of the productive marine activity in the Los Lagos region is that specific activities are concentrated in certain zones. Loco (wild abalone) extraction is concentrated in open sea coastal territories, mussel seed collection is done in natural grounds of inland waters, mussel aquaculture is found in relatively protected coastal areas, and fishing is done in the open sea. This spatial distribution is reflected in the main activities of the population located at or near these zones. This observation suggests that the natural characteristics met by the coastal population in their neighborhood will condition their activity choices². Therefore, we hypothesize that the natural conditions encountered in specific territories impose a restriction on the productive activities developed by households and that we should identify these zones for proper specification of the determinants of activity and income choices. We call these areas biogeographical zones.

We tested different ways to identify these zones. First, we identified eight biogeographic zones, based on the results obtained from the water characterization analysis (see Appendix 3), and considering the significant variations observed in the level of salinity across the seawater sample points, along with the geographic characteristics of the coast where sampled fishing villages are located (open ocean, estuaries, island, sound, bay, gulf).³ Second, we did a cluster analysis to incorporate social dimensions in the zone division. We tested different models that included the water characterization variables, as well as distance to the regional capital (Puerto Montt) from the different locations (as a way to consider travel costs and connectivity), open sea-exposed and non-exposed location, and population density.

² We are aware of the argument that, if the relative rewards are high enough to cover travel costs, then geographic segregation of households' economic activity should cease (see Becker, 1965, and Altonji and Paxson, 1992). We discuss in Section 3.3 why the obstacles to activity equalization might be higher than simply travel costs in this case.

³ Appendix 3 presents maps with information on the geographical distribution of water salinity, temperature, and dissolved oxygen by zones. Also, a summary of surveys by zone, municipality, and location of water sampling is presented in Table A3.1.

This resulted in a different zone allocation. Third, we also used a coarse distribution of marine areas in exposed, non-exposed, interior, and island areas. As an alternative distribution, we tested marine and estuarine areas. Fourth, we used the political-administrative division of the region in counties as a basis for zone identification. We tested all these different zone definitions in the preliminary estimations⁴. Based on the results obtained, we finally decided to retain the first definition based on water characterization results (salinity) along with geographic characteristics of the sampled fishing villages. Figure 2 identifies the eight zones.

⁴ We also interacted different environmental and institutional variables with the different zone definitions that we obtained, in order to better identify and characterize the origin of the zone effects. However, the results were not stable enough, so we decided to stick with the basic zone definitions.

Figure 2: Biogeographic Zones



3.2 Results from the Household Survey

Households' characteristics

Most households report that a man is the head of the family (82%). The mean number of members of the household is 3.4 ($\sigma = 1.6$) and the mean age of the household head is 52.9 ($\sigma = 12.1$). The majority of household heads have less than 8 years of formal schooling (70%). There is little variation in these traits in the different zones. This information suggests that, from a demographic perspective, the population is rather homogeneous. In Appendix 4, we present detailed information on basic household characteristics by zones.

Households' productive activities

By using the data from the households' survey, we characterize each household's productive activity choice. To simplify the choice set, we distinguish four types of productive activities (as main activity) over a period of time (year of reference): small-scale aquaculture related activities (A), extraction of benthic resources (B), fishing (F), and other activities (O). Small-scale aquaculture related activity includes mussel seeding, mussel growing, and algae cultivation. Fishing considers demersal and pelagic species. Extraction of benthic resources includes loco (wild abalone) but also other benthic resources' extraction. Other activities include different activities mostly not related to marine resources, except for "working in the salmon aquaculture industry".

Because different members of a household could perform different (main) activities in a period, a household could potentially be identified as performing any of the four previously identified activities or a combination of them⁵. Because the household can choose

⁵ We defined "main activity" as the one that employs a large share of the working time of the worker.

to perform one or more of these activities simultaneously, the choice set includes 15 different options: to choose all four activities (1), three activities (4 options), two activities (6 options), or one activity (4 options). We assume that all households choose one of these options.⁶

Table 1 summarizes the choice of productive activities of surveyed households by biogeographic zones. The results suggest that, while 70% of the households reported focusing on only one of the activities as the main activity, 30% of households reported that they performed diversified productive activities during the last 12 months prior to the survey interview. The most prominent individual activities are “fishing” and “extraction of benthic resources”. When it comes to households performing a combination of productive activities, the more relevant in terms of number of households involved are “extraction of benthic resources and other activities”, followed by “fishing and other activities”, “extraction of benthic resources and fishing”, and “small-scale aquaculture and other activities”.

The diversification in terms of activities is also observed across the identified biogeographic zones. Considering all zones, the number of different activities being reported as performed by households is at least 4 out of 15 possible sets of activities. The highest numbers of different productive activities being reported by the surveyed households are performed in zone 7 and zone 8, with those households performing 10 and 8 out of the 15 possible activities, respectively.

Table 1: Number of households by productive activity and biogeographic zone.

Activity	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Total
Small scale aquaculture		2	1	8	5	13	2	8	39
Extrac. benthic resources	11	27	15	4	11		13		81
Fishing	2	4	2	14	32	5	19	17	95
Other activities	1	1	1		2	4	1		10
Small scale aquaculture and extrac. benthic resources		1						1	2
Small scale aquaculture and other activities		1	1	2		5	2	2	13

⁶ The set of 15 possible combinations of households’ activities is given by: (A, B, F, O, AB, AF, AO, BF, BO, FO, ABF, ABO, BFO, AFO, ABFO). The data we actually collected reduced these alternatives to 11 combinations.

Extrac. benthic resources and fishing				2	1		6	7	16
Extrac. benthic resources and other activities	2	10	12	1	8		4	1	38
Fishing and other activities		1		1	11	1	1	3	18
Small scale aquaculture, Extrac benthic resources, and fishing							1		1
Extrac. benthic resources, fishing, and other activities					1		1	1	3
Total	16	47	32	32	71	28	50	40	316

Source: Household survey

Within each of the productive activity categories reported in Table 1, there is significant variation across zones as to the specific activity undertaken and some specializations in activity/species within zones. For example, of the 55 households reporting the choice of “small-scale aquaculture” as either the only activity, or an activity performed jointly with other activities (the sum of rows 1, 5, 6, and 10 along the last column of Table 1), 35 households perform mussel seed collection, 11 are involved in mussel growth, and 7 cultivate algae. This indicates that there is variability within activity categories. Reflecting variability across zones in the specific activity within a category, most of mussel seed collection occurs in zone 6 and zone 8, the majority of mussel growth activity takes place in zone 4, and algae cultivation occurs largely in zone 2 and zone 5. “Fishing” activity performed by 133 households ($= 95 + 16 + 18 + 1 + 3$; see the last column in Table 4) demonstrates less variability, with 90% of fishing household harvesting one species (Austral Hake), with that activity performed mainly by households located in zones 4, 5, 7, and 8. The activity choice of “extraction of benthic resources” reflects diverse targeted resources across the 141 households ($= 81 + 2 + 16 + 38 + 1 + 3$; see the last column in Table 4) reporting this activity. Of those, 25 households report loco extraction, 38 algae extraction, and 84 other benthic resources. Loco extraction appears to be concentrated in zones 1, 2 and 3; most algae extraction is reported by households located in zone 2 and zone 5; and the extraction of other benthic resources is performed by households located in zone 7, zone 2, and zone 3. These data suggest that general categories of activities mask differences in the specific resource

activities undertaken by households and that the specific activities are focused in a small fraction of the eight zones.

To explore in more detail the choice of activities, we also analyzed the main productive activity reported by the head of the households across zones. In this analysis, we considered a complete disaggregation of the activity set previously described in Table 1. Table 2 presents the results of this analysis. Similar to the results at the household level, we observe that most of the fishing activity of the household head is based on one demersal species, namely Austral Hake. In addition, the extraction of benthic resources is mainly based on resources other than loco, and the small-scale aquaculture activities seem to be concentrated in mussel seed collection. Some of the reported productivity is concentrated by zones, as for fishing Austral Hake, loco extraction, and mussel seed collection (see Table 2).

Table 2: Number of households' heads by main productive activity and zone.

Productive Activity	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Total
1. Fishing-demersal (Austral Hake)		1		15	39	2	23	26	106
2. Fishing-pelagics			1			2	1		4
3. Extraction of Loco (wild Abalone)	4	11	6				1		22
4. Extraction of Algae	2	7	4		11		2		26
5. Fishing-other demersal species	2	4	1		2	1			10
6. Mussel seed collection			1	4	1	14	1	8	29
7. Mussel growth/fatening				3	1	1	1	1	7
8. Cultivation of algae		2			1		1		4
9. Extraction of other benthic res.	6	14	12	5	5		13	1	56
10. Work at salmon production Facility					2	1	3		6
11. Work at processing plant		1							1
12. Agriculture			3						3
16. Construction		1							1
17. Commerce	2					1			3
18. Hotel/restaurant						1			1
19. Transport						1			1
20. Other		2	2	1	3	1	3	1	13

No response	-	4	2	4	6	3	1	3	23
Total	16	47	32	32	71	28	50	40	316

Source: Household survey

Thus, we can conclude that the productive activities are diverse and distributed unevenly between households in the surveyed areas. Moreover, there seems to be a tendency to concentrate in single or few activities at the household and head of the household level. Finally, specific activities tend to be concentrated in certain zones.

Households' income

We observe significant variations in mean annual household income across zones and productive activities (Table 3). For example, considering households reporting only one type of activity, the highest level of income corresponds to “small-scale aquaculture” and “other activities” (not related to marine production/extraction), with mean annual per-capita income around US\$ 3,443 and US\$ 3,630, respectively. However, there are significant variations in the mean income from these two types of activities across zones. For example, while the mean annual per-capita income reported by households performing “small-scale aquaculture” activities in zone 8 is about US\$ 5,200, the amount for the same activity in zone 5 is less than US\$ 1,200 (Table 3).

The highest household mean annual per-capita income is found in zone 8, although strongly influenced by a few households reporting a high level of income related to “small-scale aquaculture and other activities”. Other zones with high household annual per-capita income are zone 6 and zone 4.

**Table 3: Annual households' per-capita income by productive activity and zone
(Figures in US \$; exchange rate 670 Ch \$ per 1 US \$)**

Activity	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Total
Small scale aquaculture		2,776	2,687	3,900	1,187	3,316	2,177	5,181	3,443
Extrac. benthic resource	1,545	1,282	2,268	616	1,758		1,225		1,794
Fishing	1,433	1,551	675	2,127	1,536	3,418	1,358	1,787	1,705
Other activities	203	2,955	1,356			7,751	3,060		3,630

Small scale aquaculture and extraction of benthic res		764							764
Small scale aquaculture and fishing								1,321	1,321
Small scale aquaculture and other activities		896	1,831	22,762		5,066	2,082	36,100	11,536
Small scale aquaculture, extraction of benthic res, and fishing							682		682
Extrac. benthic res and fishing				1,623	1,672		1,678	2,460	2,061
Extrac. benthic res and other activities	3,729	2,514	1,646	7,463	2,427		4,128	1,764	2,642
Extrac. benthic res, fishing, and other activities					896		2,580	1,679	1,718
Fishing and other activities		1,146			2,597	470	3,172	1,866	2,291
Total	1,970	1,607	1,917	3,760	1,751	4,179	1,597	4,290	2,480

Source: Household survey

There are large differences in per-capita income between different zones for the same activity. There are different possible factors that can help explain this. First, the activity label might be too wide and we might actually be comparing different specific activities. However, in some cases, we saw that the income generation was concentrated in specific species (e.g., Austral hake in fishing). Another factor could be the degree of effort displayed. The effort that the household expends on certain activities could be restricted by access to user rights. Finally, the availability of resources in the neighborhood could restrict the choice set for the household, if the cost of moving from the home location were high enough. The dispersion of income and the concentration of activities between households is our focus of analysis in the following.

3.3. Propensity to move

The households report a range of primary reasons to perform marine productive activities in the specific location, with 40% stating that the location was close to home, 19%

acknowledging low transportation costs, and 11% choosing the location due to the high productivity of the site. The majority of households (160) report that the head of the family was born in the same village where the survey took place (50.6 %). In 46 cases, the household head was born outside the village but in the same county (14.6%), while in 84 cases the household head was born outside the county but in the Los Lagos region (26.6%). Less than 10% of the household heads were born in other regions of the country. This result suggests low propensity to make geographic moves by the households' head.

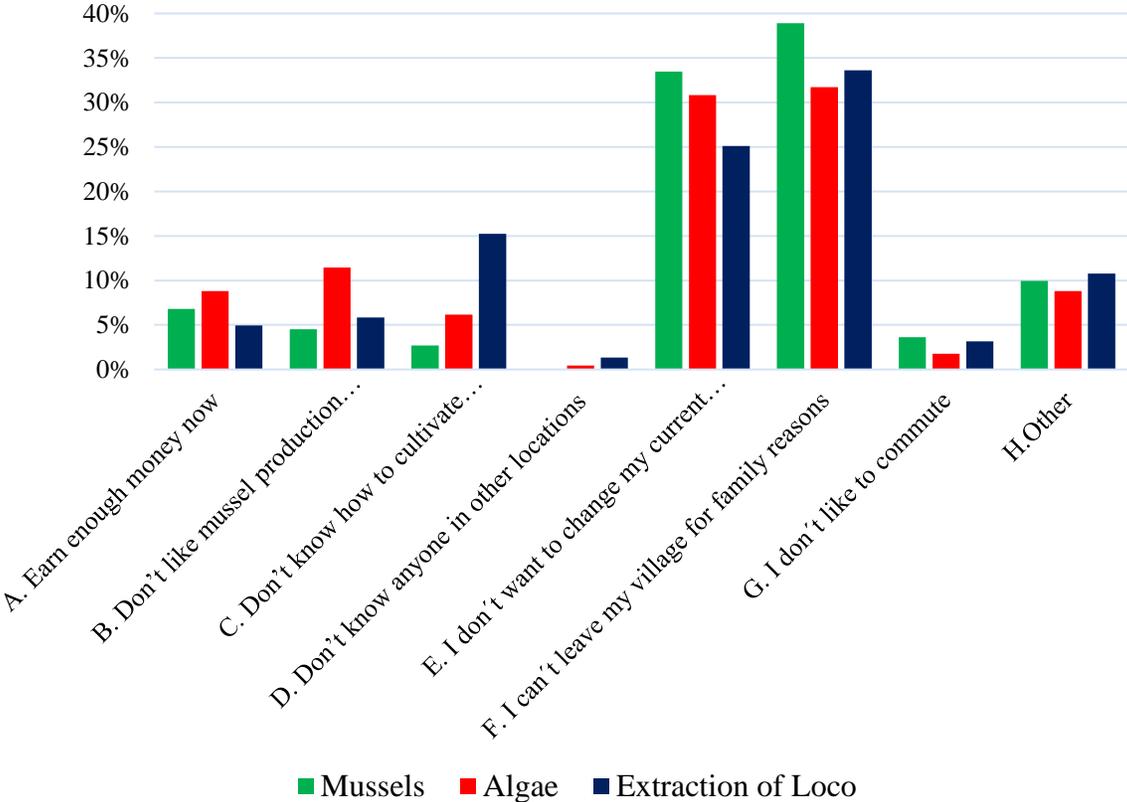
In the survey, we included a section of specific questions about the households' propensity to move. We designed hypothetical questions about how much income it would take for the respondent to accept a marine-based activity that implied travel to another location. In our hypothetical scenarios, we included a job opportunity related to three different resources: mussel growing, algae cultivation and wild abalone (loco) extraction. This was done with the purpose of checking if the propensity to move changed with the type of offered activity. Moreover, we asked about three different travel scenarios. The first one (scenario A) meant that the worker had to travel to a nearby village and work there eight hours a day during eight weeks. This allowed the respondent to travel and return home at the end of the day and was a commitment limited in time (pure travel cost). The second one (scenario B) implied traveling and staying at the work location over half of the year; it would be possible to go back home after the work ended. This scenario allowed the worker to maintain the residence and the family in its current location. The third one (scenario C) implied that the worker had to change his or her residence. This meant that he had to pay relocation costs. For each scenario, we presented the respondent a set of alternative payoffs that went from one-fifth of the minimum income level to four times the minimum income level. In the case of the third scenario that implied changing residence, the highest offered income went up to approximately eight times the minimum income level. We also complemented these hypothetical questions with a question, in the case the respondent did not want to move for any amount of income, about the reasons for this decision.

We did find some differences in the propensity to move depending on the resource, with a higher propensity to move for mussel growing, in comparison with algae cultivation and loco extraction. This difference remained true in all scenarios. However, the most striking result was that the propensity to move was very low, even in the scenario with the

highest compensation. For example, the percentage of answers of no interest in the job offer at any income level for scenario A were 37.1%, 50.6%, and 49.7% for mussels, algae, and loco options respectively. For scenario C, these figures increased to 70.2%, 72.6% and 71.7%. These results indicate the coastal population’s very low propensity to move. When we asked for the reasons for this low willingness to move, the most frequent answers were that respondents didn’t want to change their current lifestyle and did not want to leave their village for family reasons.

Figure 3 depicts the percentage of answers to the question of why respondents would not want to accept a job offer for mussel, algae and loco in the C scenario. As can be seen, between 72% and 58% of the answers are concentrated in the lifestyle and family reasons. In Appendix 5, the full results of these mobility questions are presented.

Figure 3: Reasons for not accepting a job offer in a location more than 200 kilometers distant



In summary, the population in the surveyed coastal areas shows a very low propensity to move. This propensity might be partially conditioned by the travel costs between different

places. Nevertheless, there definitely are also low preferences for changing location, which might be grounded in cultural ties to the place of origin, which prevent people from considering opportunities that might imply an improvement in their income situation. In this setting, their effective choice set of productive activities will be delimited by the opportunities found in their surroundings.

3.4. Regression results

We estimated a model composed of two relationships: activity-selection and income-generating equations. The model is recursive so we estimate the equations sequentially. To estimate the activity-selection equation, we use a multinomial choice model. The household can choose between alternative activities. To limit the number of alternatives, we use as a dependent variable the head of household's main activity. This reduces the number of alternatives to one main alternative per household. Moreover, to handle the number of activities, we aggregated the main marine resource-based productive activities and other options. Specifically, we identified the following main marine activities: “*fishing*”, including harvesting of all finfish species; “*loco*”, which includes specifically the extraction of loco; “*algae*”, incorporating cultivation and extraction of different algae species; “*mussel*”, which covers both seeding collection and mussel growing; and “*other benthic resources*”, including the harvesting of all benthic resources except for loco. To complete the list of alternatives, we included two categories: “*other productive alternatives*”, which includes miscellaneous productive activities such as salmon farming and processing, agriculture, livestock, mining, construction, transport, and the service sector; and “*without productive alternative*”, which means that the head of the household has no remunerative productive activity. As right-hand variables, we used characteristics of the head of the household and of the household, access to user rights, and controls for the location of the household.

The general estimated model was

$$[1] \quad \text{Prob} [Y_i=1]=f(\text{age}, \text{agesq}, \text{gender}, \text{schooling}, \text{institutions}, \text{zone}),$$

where Y_i is an indicator variable for the main activity of the household's head, age is the age of the household's head, agesq is the square of age that allows nonlinear effects of age on

activity selection, *gender* is the gender of the household's head (male=1, female=0), and *schooling* is a set of dummy variables identifying the level of formal schooling of the household's head. The variables included in this set are: *without education*, who are people without formal education; *primary school*, who are individuals who have attended primary education (complete or incomplete); *secondary school*, who have attended their secondary cycle (complete or incomplete); and *higher education*, who have gone through some type of higher education (more than 12 years schooling). The base is complete or incomplete primary education. *Institutions* is a set of dummy variables indicating if the household has access (1) or not (0) to marine user rights in its location. The options include *TURF*, *fishing* (quota), *marine concession*, and *special permit*. In the estimations, *concession* was used as the base category. Finally, *zone* is a set of dummy variables identifying biogeographic zones according to the original division of zones (see Figure 2)⁷. Zones run from 1 to 8, with *zone6* as the base zone. The model was estimated with multinomial logit. The results, in the form of marginal effects, are presented in Table 4.

Work experience, measured by *age* and *agesq*, does not seem to affect activity choices. *A priori*, there is no reason to expect a definite relationship between these variables, but it seemed relevant to control for different household characteristics that potentially could affect the results. *Gender*, in contrast, is significant at 5% or less for some activities. Noteworthy, if the head of the household is male, it will positively affect the probability of choosing fishing as the main activity and negatively affect the selection of algae, other benthic resources, other activities, and no paid activity, which fits well with the predominance of male workers in fishing and the more important participation of female workers in these other activities. The only schooling variables that were significant were *without education* and *higher education*. This result suggests that the formal mandatory primary and secondary cycles of schooling (12 years) do not have a differential impact on the choice of economic activity for the coastal population in the Los Lagos region. In the case of lack of formal education, this status decreased the probability of selecting the activity in benthic activities (excluding loco), mussel cultivation and other activities. In contrast, it increases the probability of working in the fishing industry, algae extraction, and not

⁷ We recall, as discussed in section 3.1, that we tested different ways to consider zoning. Finally, we selected binary variables for zones, because other forms did not improve our understanding of the zone effects.

developing any productive activity. This finding indicates that the formal skills requirements to enter fishing and algae activities are probably very low or non-existent, and constitute a good working alternative for unschooled people. As for household heads that have higher education, the selection probabilities increase for all alternatives, except for algae and not having any productive activity. This result probably relates to algae extraction being a low-reward activity with no entry barriers. It is interesting to note that both household heads without formal education and those with higher education increase their probability of selecting fishing as main activity. This outcome could be related to the heterogeneity existing in the fishing industry, both with respect to the value of the targeted species and the productivity characteristics of the fleets, which allows the existence of a heterogeneous crew.

Table 4. Marginal Effects: Multinomial Logit. Dependent Variable: Household Head's Activity

	Act_JH=Fishing	Act_JH=Ext_Loco	Act_JH=Algae	Act_JH=Mussels	Act_JH=Ot Bent res	Act_JH=Other Activity	Act_JH=With Activity
age	0.0016 (0.0124)	0.0005 (0.0071)	0.0088 (0.0111)	-0.0093 (0.0095)	0.0016 (0.0108)	-0.0084 (0.0056)	0.0053 (0.0089)
agesq	-0.0000 (0.0001)	-0.0000 (0.0001)	-0.0001 (0.0001)	0.0001 (0.0001)	-0.0000 (0.0001)	0.0001 (0.0001)	-0.0000 (0.0001)
gender	0.5720*** (0.1439)	0.0216 (0.0513)	-0.0992** (0.0443)	-0.0768 (0.0494)	-0.2186*** (0.0619)	-0.0809*** (0.0302)	-0.1181*** (0.0258)
without education	2.0367*** (0.2214)	-0.1448 (0.1177)	0.9628*** (0.1817)	-1.1580*** (0.1784)	-1.8232*** (0.2716)	-0.6468*** (0.1755)	0.7733*** (0.1538)
sec school (9 to 12)	-0.0317 (0.0505)	0.0120 (0.0319)	0.0445 (0.0437)	0.0171 (0.0360)	-0.0541 (0.0522)	0.0062 (0.0301)	0.0060 (0.0279)
high education	0.3839** (0.1541)	0.3141*** (0.0709)	-1.0891*** (0.1658)	0.2918*** (0.0724)	0.5003*** (0.1409)	0.2682*** (0.0865)	-0.6693*** (0.1383)
TURF	0.3291*** (0.1097)	0.1071** (0.0486)	0.0083 (0.1023)	0.1104* (0.0591)	0.3686*** (0.0902)	-1.0523*** (0.2029)	0.1289*** (0.0452)
MarineConcession	0.7422*** (0.1563)	0.5132*** (0.0931)	0.6598*** (0.1058)	0.3631*** (0.0783)	-1.9128*** (0.1905)	-0.6494*** (0.1554)	0.2838*** (0.0771)
SpecialPermit	0.1740 (0.1969)	-0.7882*** (0.1393)	0.4373*** (0.1181)	0.4454*** (0.0961)	0.7419*** (0.1359)	0.2171*** (0.0804)	-1.2276*** (0.2498)
Quota	1.8209*** (0.1664)	-0.4985*** (0.1077)	-0.7199*** (0.1337)	-0.7574*** (0.1299)	1.2701*** (0.1249)	-0.6631*** (0.1415)	-0.4521*** (0.1349)
zone1	-0.1843 (0.2037)	0.4428*** (0.0954)	0.8125*** (0.1501)	-1.2170*** (0.1946)	1.4780*** (0.1906)	-0.3226*** (0.1098)	-1.0092*** (0.2304)
zone2	-0.4124** (0.1712)	0.3816*** (0.0864)	0.7251*** (0.1277)	-1.5464*** (0.2106)	1.3278*** (0.1634)	-0.3730*** (0.0913)	-0.1027 (0.0900)
zone3	-1.1953*** (0.1688)	0.3591*** (0.0798)	0.6579*** (0.1260)	-0.3243*** (0.0641)	1.2439*** (0.1488)	-0.4194*** (0.0990)	-0.3221*** (0.0754)
zone4	-0.1049 (0.1530)	-0.4782*** (0.1045)	-0.9982*** (0.2517)	-0.1849*** (0.0409)	2.0374*** (0.1972)	-0.1862* (0.1004)	-0.0850 (0.0642)
zone5	-0.5450*** (0.1395)	-0.8878*** (0.1242)	0.9187*** (0.1459)	-0.3783*** (0.0612)	1.4929*** (0.1644)	-0.3374*** (0.0886)	-0.2631*** (0.0641)
zone7	-0.8165***	0.2367**	0.5908***	-0.3827***	1.1853***	-0.4482***	-0.3655***

	(0.1449)	(0.1019)	(0.1219)	(0.0718)	(0.1577)	(0.1069)	(0.0959)
zone8	-0.0637	-0.5157***	-0.6793***	-0.2046***	1.7709***	-0.1964*	-0.1113*
	(0.1284)	(0.1041)	(0.1094)	(0.0480)	(0.1921)	(0.1050)	(0.0586)
N	306	306	306	306	306	306	306

Note: *p<0.1; **p<0.05; ***p<0.01

Robust standard errors in parenthesis.

Households surveyed without members related to marine activities were not considered. Total number = 8.

There are several results related to the impact of user rights on economic activity choice. First, they do have a significant effect on these activity decisions. All types of user rights affect the probability of selecting the different activities in various ways. The general results indicate that having user rights for one resource not only affects the probability that the household will work with that resource but also with other marine resources. This suggests that, when a member in the household possesses a user right over a resource, the probability increases of selecting other marine resources as a productive activity. This might be possible because the household holds more than one user right or interacts with other households that possess other user rights. The point is that, in general, having a user right for one resource increases the probability that the household engages in activity with other marine resources⁸. The counterpart to this result is that, in general, holding a user right decreases the probability of choosing other (non-marine) activities. There are some exceptions to these results, which we will discuss. Second, there is heterogeneity between rights holders, which seems to depict different rights holder prototypes. Turf and marine concession holders seem to be rather similar, in the sense that holding the right increases the probabilities that they will engage in activities with the resources associated with that right (loco and benthic resources in the case of TURFs, and algae and mussels in the case of marine concessions), but also activities in other resources not associated with the right. The only exception is that the probability of working with other benthic resources decreases for marine right holders. These right holders also reduce their probability of exploring other activities. Special permit holders are similar to the TURF and marine concession holders, with two exceptions. They are less prone to extract loco and more prone to work in other activities. The first trait is probably related to access to productive places for loco extraction (mussel farming is an inland activity), but the second one suggests a less traditional and more entrepreneurial type of producer. Finally, fish quota holders are a different type of producer. They are fishers who belong to fishers' organizations (and hold collective quotas) and are specialized in fishing activities, but also can harvest other benthic resources that do not require TURF rights. They do not explore other marine or non-marine activities and are not retired from active productive life.

⁸ This hypothesis is important for how to consider mobility in the rural coastal zones. If the household depends on several resources, the decision to change residence is systemic. It includes the working opportunities of all household members and therefore it should not be considered as an individual project.

The zone variables show that the location of the household clearly matters for its choices of economic activity. There are significant results for most zone variables. The zone selected as the base is *zone6*. This zone is an estuary zone with very high natural productivity in the water, where households are dedicated to mussel farming and fishing. Moreover, since they are near the capitol city, they develop other activities, besides the marine activities. They earn high income in comparison with other zones. We mention this because the results of other zones are to be compared with this zone. We can identify different types of zones. Zones 1, 2, 3, and 7 are zones with significantly more loco, algae and other benthic resources extraction than *zone6*. In contrast, fishing, mussel, and other activity is lower in these zones than in the base zone. The same is true for zone 5, with the exception that loco extraction is even scarcer in this zone than in *zone6*. Zones 4 and 8 instead are zones with more activity in other benthic resources than the base zone, but less activity in all the rest of the activities, except for fishing. In the case of fishing, we cannot find a significant difference with the activity developed in zone 6.

Next, we estimate the following income generation model for the household,

$$[2] \quad \mathit{hhincome} = g(\mathit{characteristics\ of\ the\ household}, \mathit{main\ economic\ activity}, \mathit{zone}),$$

where *hhincome* is the log of annual income of the household including all income sources from working/performing economic activities. Among the household characteristics we include *age*, *agesq*, *gender*, and *schooling* dummies (the base is complete or incomplete primary school), which were defined previously. We also add some measures of the size, productive capacity, and diversification of the household. We included the following variables: *number_household*, *members_work*, and *number_occupations* represent the total members in the household, total number of working members in the household, and number of different occupations performed by the three main workers of the household, respectively. The first one is a measure of the size of the household and it is a scale variable for the level of income. The second one is a measure of the productive capacity to generate income in the household measured as the number of working members. The third one is a measure of the degree of diversification shown by the household. The more diverse households should be able to cover different income opportunities. We also included dummy variables for the main economic activity in the household, measured as the activity that generates the highest proportion of the household income. We included dummies for the same principal economic

activities estimated in the multinomial logit model. Note that, in our conceptual model, the choice of economic activity is predetermined for income determination. The selected base economic activity is *fishing. zone* was added to the model to capture additional income-generating effects that were additional to the ones that work through activity choice. The model was estimated with the minimum least squares method. We considered two alternative measures for household income: total income and labor income. The results did not change importantly between these two specifications, so we opted to present the results for labor income, which seems to be conceptually more in accordance with the basic view of the model. The results for two specifications of the model are presented in Table 5.

The results, in general, show the expected signs for the different variables. Although the coefficient of determination is low, that outcome is expected for cross-sectional estimates over a very heterogeneous population, as in this case. Nonetheless, the model “explains” an important part of the variability of the dependent variable.

age and *agesq*, as proxy variables for working experience, do not seem to add much to income determination. In any case, the relationship is very flat, suggesting that income does not change much with age. This result seems reasonable because the rules for sharing income in collective activities normally do not differentiate by experience gained by age but by the position in the collective work team.

In contrast, gender is highly significant. When the head of the household is male, household income increases by around 60% on average. This shows that when the household has a woman as head, the welfare conditions are inferior, *ceteris paribus*.

Scholarship shows a very flat relationship, but it does affect earned income. Households whose head has no formal education earn substantially less than households whose heads have some form of educational preparation. There are no significant results between the different educational levels, suggesting that income is unresponsive to the number of years of schooling, but that going to school makes a difference.

As expected, the number of household members, the number of workers, and the number of different activities developed in the household all are significant and have a positive effect on household income. Note that high multicollinearity between the number of workers and the number of different activities prevented us from presenting these results. The bigger families, with more working members and with diversified portfolios of activities,

have larger incomes than the small ones, suggesting the importance of size for the household enterprises in coastal areas.

Table 5. Econometric results-Determinants of Households' income. Household labor income

	Model (1)	Model (2)
Age	0.0447 (0.0329)	0.0318 (0.0330)
Agesq	-0.0005 (0.0003)	-0.0004 (0.0003)
without education	-1.2300*** (0.4489)	-1.2890*** (0.4879)
sec school (9 to 12)	-0.0846 (0.1703)	-0.0186 (0.1618)
high education	0.6588 (0.6182)	0.6740 (0.5793)
members_work	0.1377*** (0.0472)	
number_occupations		0.5193*** (0.0771)
number_household	0.1431** (0.0584)	0.1530*** (0.0566)
Gender	0.5709*** (0.1906)	0.6249*** (0.1837)
Algae	0.3345 (0.2402)	0.1177 (0.2194)
Extraction of Loco	0.5322* (0.2937)	0.2927 (0.3037)
Mussels	0.7592*** (0.2853)	0.7186** (0.2841)
Other benthonic res	0.3715* (0.1999)	0.2458 (0.1877)
other activity	1.0397*** (0.2709)	0.6452** (0.2735)
without activity	0.5714** (0.2368)	0.6507*** (0.2237)
zone1	-0.1870 (0.4846)	0.0343 (0.4905)
zone2	-0.0749 (0.4706)	-0.0077 (0.4656)
zone3	0.3494 (0.4751)	0.5277 (0.4785)
zone4	0.9064* (0.4726)	1.0524** (0.4752)
zone5	0.4186 (0.4450)	0.4778 (0.4473)
zone7	0.0522 (0.4361)	0.1418 (0.4398)

zone8	0.5824 (0.4380)	0.6077 (0.4310)
Constant	10.4379*** (1.3042)	10.3152*** (1.2815)
N	301	301
R2	0.2204	0.2997
Ajusted R2	0.1617	0.2470
Prob > chi2	0.0000	0.0000

Note: *p<0.1; **p<0.05; ***p<0.01

Robust standard errors in parentheses.

Households without members related to marine activities were not considered.

Our results also show that the type of economic activity has an effect on household income. Except for *algae*, households that have as their main economic activity something other than *fishing* earn significantly more on average than the ones that have *fishing* as the main activity. Specifically, those households that have *other activities* as their main activity tend to earn on average more than the base activity. This differential in earnings should reflect basically the different relative rewards that the household obtains from different activities.

Finally, and as a more general check for locational conditions, we controlled for different zones in the regressions. The results show that households located in *zone4* on average earn more than households in other zones. This is the only zone where we find significant differences. Moreover, the quantitative difference is huge, between 90 to 100% of the household average income in *zone6*. This difference cannot be ascribed to household characteristics or the productive activities in which a household engages, since these are controlled for in the regression. One possible explanation is that the conditions in zone 4 generate significant positive results in the productive and income outcomes of the households. If we recall that zone 4 is where the capitol city, Puerto Montt, lies, the existence of agglomeration positive external effects could explain this result.

4. Conclusions

We have presented and analyzed the use of marine resources as a base for economic activities and development of coastal communities. We studied households' choices in selecting economic activities and in generating income from different sets of economic activities, and we characterize the role of preferences for residence, institutions, and

biogeographical characteristics in those decisions. We summarize some of the main conclusions

- Based on the results obtained from the water characterization analysis and geographical characteristics of the coast where sampled fishing villages are located, we identify eight biogeographic zones that are relevant to explaining activity choice and income generation.
- The population in the surveyed coastal areas shows a low propensity to move. This propensity reflects low preferences for changing residence and for traveling to another location, even when it would mean an improvement in the respondent's income. This low propensity to move constitutes a cultural restriction that segregates the development of activities and the labor market in the studied area.
- The productive activities are diverse and distributed unevenly between households in the surveyed areas. Specific activities tend to be concentrated in certain zones.
- Holding user rights over marine resources increases the probability that the household is engaged in activity using other marine resources.
- The results show significant impacts of biogeographic zones on economic activity choice for most zone variables. That is, given the household characteristics and distribution of user rights among the population, the location of the producer has an important impact on the selection of the activities the household will perform. One way of interpreting this is that the local environment conditions the decision set of the household because the grid of available resources and opportunities in the neighborhood are limited.
- Our analysis also considered the determinants of households' income generation, such as the role of institutions and spatial variation in biogeographic conditions across the region. We found diverse sets of marine-based income generation activities across households. Also, we observe significant variations in mean annual household income across zones and across productive activities.
- We found that environmental conditions affect household income, suggesting a direct effect on welfare opportunities of the coastal population. As a more general check for biogeographical and environmental conditions, our analysis considered controls for different zones.

- Finally, we also evaluated the effect of different institutions on household income. We found that households that have access to fishing quotas earn more than households that are dedicated to marine concessions. This finding highlights the importance of fishing in the studied region. In contrast, no income difference between concession and special permit holders appears in these data. However, in the case of TURF and other permit holders, the situation is less clear. Taken together, the results on income differences generated by access to different types of rights indicate that there are differences and that these differences are connected to the type of marine user right that the households hold.

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Appendix 1: Results from semi-structured interviews

In this appendix, we present the main results from textual analysis of the semi-structured interviews we performed during April 2018 with different stakeholders. The interviews were administered to artisanal fishers and small aquaculture producers, leaders of the organizations holding marine user rights, and government officials working at different regulatory and enforcement bodies at central and regional level. The information was analyzed with the Content Analysis method, which allowed us to organize the results in five categories of analysis. For each of them, we highlight the main results.

Lack of regulation for development of small-scale aquaculture activities

The interviewed stakeholders acknowledged the absence of a unified set of rules (a single law) for the development of small-scale aquaculture. They identified as problems, among others issues, a lack of definition regarding the characterization of the activity, rules of access, rights and responsibilities. This gap is particularly relevant because the profitability of different marine-based productive activities has been associated with changes in its diversification, consequently increasing the number of people involved and the pressure and competition for space and resources. In particular, biologically productive areas face more pressure. One problem is that the ex-ante evaluation of some user rights requests (marine concession, special permits) is carried out on an individual basis, without consideration of the carrying capacity in that location and the actions or numbers of other users. After several years of experience creating and allocating marine user rights, stakeholders claim that it appears necessary to include more planning on the use of marine space under biogeographical and socioeconomic considerations. This adjustment may include new steps that consider reallocation of production sites/facilities.

Markets for marine product

Interviewed stakeholders raised several issues related to the functioning of markets, structure, and requirements related to marine productive activities. For example, there are too few middlemen that contract with processors; for producers, there are potential gains from creating cooperatives of producers that trade or contract directly with processors. Also, it is necessary to better define protocols regarding quality standards/requirements to ensure compliance with national and international food safety standards; stakeholders claim that in

some cases the protocols are not known and that it is costly to comply for small-scale producers. There is also a need for market diversification and incentives/marketing to increase demand at the national level and in new international markets and to increase value added of marine resources (new products), in addition to a need for technical assistance.

Monitoring and enforcement to deter poaching

The interviewed stakeholders recognize that the performance of marine productive activities has increased income generation opportunities for those residents belonging to coastal communities that are “inside” the system, because they hold marine user rights either individually or through an organization. However, by their nature, these marine rights have created exclusion from resource extraction by people “outside” the system, which may trigger new problems, including those related to increasing inequality and reduced social cohesion in coastal communities.

Variation in productivity/abundance of resources and profitability of the marine activities over space, plus the exclusion of some agents who do not have marine user rights, creates incentives for poaching and the need for enforcement. Stakeholders describe the poaching threat as particularly critical for high value/high productive sites, such as loco fisheries.

Transition from traditional wild fishing to aquaculture

Interviewed stakeholders view the transition from fisheries to aquaculture as a slow and gradual process. In several cases, it is not a complete change or transition from fisher to aquaculture producer, but a diversification of activities, with some specific seasonal activities involved. They report that their main motivation for diversifying marine productive activities is the observed trend of decline in wild fisheries, which has reduced profitability of fishing activities. That trend motivates a search for new opportunities based on marine resources but permitting profitability and income generation. There is also a need for adaptation to new jobs. In particular, fishing activities create income right away (landing and selling fish) while aquaculture requires working through a production cycle with income generated at the end of that cycle. It was also acknowledged in the interviews that cultural capital and knowledge on marine activities might facilitate the transition to new marine activities. The most difficult

part of the transition concerns a lack of familiarity with the management, legal, and economic aspects of aquaculture production.

The stakeholder interviews reveal that women are more involved in small aquaculture activities than in wild fisheries. This may be due to the fact that it is easier to coordinate aquaculture with their other activities, and it could reflect that fewer women engage in the fishing activity itself, although many are involved with marketing of fish.

Age may also influence attitudes toward new marine-based activities. Younger people appear more open to explore/try new activities; however, these people are also more willing to migrate out of the coastal zones for education or other work.

Access/participation

For people without a particular property right (outsiders), access to membership in existing successful organizations holding marine user rights (TURFs and marine concessions) appears to be difficult or even impossible. People want to try to belong to these organizations to get access to marine resources, to reduce their effort in administrative activities, and to increase the chance of obtaining government support. However, current members (insiders) anticipate that bigger organizations imply less profitability and so they make it difficult for non-family new entrants to gain access to their unions.

Appendix 2: Marine User Rights for Coastal Producers in Chile

In this appendix, we briefly describe current marine user rights institutions for artisanal fishers in the country.

Territorial User Rights in Chilean Fisheries

In 1997, Chile implemented TURFs to allocate rights to manage benthic resources in a specific geographic space to fisher groups (Wilén et al., 2012). The TURFs, also known as benthic resource management areas (BRMAs), give local legal organizations of artisanal fishermen – cooperatives, unions, or guild associations – the responsibility for regulating and administering benthic resources, conflict control, and planning (Bonzon et al., 2010). The system aims to improve conservation and recovery of benthic fisheries and to enhance economic conditions for local fishermen (SUBPESCA, 1995). Since the TURFs regime's

introduction, nearly 800 BRMAs were approved, with more than 70% of BRMAs allocated to artisanal fishermen organizations (Chávez et al. 2010); 30,000 fishermen were registered (Gelcich et al., 2013); all legally caught locos (abalone) came from TURFs (Wilén et al. 2012; Bonzon et al., 2010); and at least 62 other species were extracted through the TURFs, including mollusks, crustaceans, and algae (Bonzon et al., 2010). The system has, in general, contributed to the recovery of benthic stocks, although with heterogeneous economic performance (Chávez et al., 2010). The existing TURFs provide an important institution to consider in the broader context of small-scale aquaculture because many BRMA fishermen organizations already undertake small-scale aquaculture activities and because BRMA groups can avoid time-consuming authorization procedures, since TURF rules permit aquaculture on up to 40% of the BRMA area.

Collective Quotas for Fishing-The Artisanal Extraction Regime

An alternative management regime for coastal mobile resources in Chile (not benthic resources, which are stationary) is a cooperative catch shares system (Bonzon, et al., 2013), called “Regimen Artesanal de Extracción” (RAE), that grants extraction rights to organized groups of fishermen. The rationale for this system is that collaborative action between fishermen can enhance efficiency in management when some types of externalities between fishermen might impact their individual productive performance (Baland and Platteau 2003; Holland 2015, Segerson, 2014). The RAE system was established in Chile in 2014 for some fisheries operating under a restricted access regime, as a means to distribute the artisanal share of the total allowable quota (TAQ). In the case of the Los Lagos region, one large artisanal fishery operating under RAE is the Austral hake fishery.

The RAE regulation (Reglamento del RAE, 2004) allows several potential assignment forms for the artisanal share of the TAQ: i.e., by geographic area, by fleet category, by vessel type according to size, by fishing cove, by artisanal organizations, or individually. However, the most important form, and the relevant one for the Austral hake fishery, has been the RAE by organization. If fishermen want to apply for this type of assignment, they must first constitute a formal fisher organization of vessel owners. This organization must enjoy legal status, maintain a list of members, and have democratic election of its leaders. The quota is assigned to the organization and not to the individual

members. Thus, the individual members do not have legal rights over the quota. Instead, the organization takes collective decisions over fishing and income distribution issues.

The RAE institution gives extraction rights to artisanal fishermen. In some cases, this might convert the fishing activity into a very profitable one, since catch security means that the fishermen can select and conserve better fish on their trip to port, increasing the value of their landings. Thus, RAE might provide an alternative that out-competes the development of small-scale aquaculture. In addition, however, the seasonality of fishing activities implies that the RAE might provide a profitable activity that is complementary in time to small scale aquaculture or other income activities for small-scale producers. By timing activities across the year, a producer can use a diverse set of activities to produce higher income than by focusing on only one activity.

Marine Aquaculture Concessions

Marine aquaculture concessions can be granted in areas defined as suitable for aquaculture activities by the Chilean authority. The application for the concession specifies the particular species for cultivation in the concession. The concession can be granted for 25 years, but is renewable. The system of concession granting is a demand-based system. The law stipulates specific reasons to deny the right, basically related to avoiding geographic overlap with other uses of the area. Because the applications are largely considered individually, there is no central planning on how the aquaculture activities should be distributed over the territory. The principal species groups that concentrate marine aquaculture concessions in the Los Lagos region are salmonids species, mussels, and algae.

Special Permits

The “special permits”, also called “minor permits” (or “permisos de escasa importancia” in Spanish) are short-term (less than one year), transitory user permits (must be renewed on a yearly basis), that give the holder territorial user rights to perform mussel seed collection. Because of its short-term validity, this type of user rights involves high levels of uncertainty and low security. For example, if the territory is requested under other types of permits, such as TURFs or marine concession, the application for this permit could be rejected. Despite its uncertainty and lack of security, the “special permit” presents some advantages in relation to other marine user rights available. Specifically, the permit can be approved in a very short

period of time (less than 45 days) and involves the payment of a very low fee (approximately US \$40 annually).

The holders of “special permits” are allowed to install mussel seed collectors in the spatial location defined in the permit. (The process for installing the collectors is regulated by the Supreme Decree No. 02, January 3, 2005, entitled “Reglamento Sobre Concesiones Marítimas”, particularly articles 4°, 5° and 27°). The formal procedure to allocate “special permits” includes a written authorization by the Office of Marine Territory and Commercial Navy (Dirección General de Territorio Marítimo y de Marina Mercante) or the Navy local office at any given port under the jurisdiction of the requested permit.

Overlapping Rights

One unique characteristic of the coastal institutions in Chile that the marine-focused economics literature does not yet address derives from the overlapping nature of marine resource rights from the perspective of the coastal households. For example, although a particular TURF may grant its member fishers the rights to extract benthic resources, fishers often also have other rights that give them access to other resources, such as wild fish extraction, mussel seed collection, and aquaculture activities. A proper understanding of how regulatory systems work when there exist overlapping rights has been lacking.⁹

⁹ Another, more recent type of marine user rights, which we learned about during the semi-structured interview field work, is the “Indigenous People’s Marine Coastal Territories” (“Espacios Marinos Costeros de Pueblos Originarios ECMPO”). Under this user rights regime, the indigenous people might request a delimited marine area whose administration is handed over to indigenous communities or associations of communities that can demonstrate customary use over the territory. The communities or associations should be recognized and registered in the Indigenous Affairs Commission (CONADI by its Spanish acronym). The community in charge must present an administration plan for the territory. This plan should include a description of all activities that will be performed and should identify the users of the space. Aquaculture activities might be one of the activities considered in this plan. The EMCPO rights are granted indefinitely. We found only one household that reported working in marine activities under this system.

Appendix 3: Water quality/Oceanographic sampling

During the administration of household surveys in coastal communities included in our sample, we also monitored physicochemical variables of water in nearby locations. We did so by using a multi-parameter sensor YSI-556 MPS (YSI Inc., USA) which was applied in water bodies near surveyed households where TURF, marine concessions, and special permits were located. This device allowed us to register temperature (°C), salinity (ppt), and dissolved oxygen (ml/l). We considered a total of 38 monitoring stations, distributed along the surveyed households' geographical territory. To standardize measures, we decided to use measurements at 1 meter deep. The sensor was stabilized, and then the variables of interest were measured and registered.

Figure A3.1: Water salinity at sample points



Figure A3.2: Water temperature at sample points



Figure A3.3: Dissolved oxygen at sample points



Table A3.1 Number of surveyed households, fishing villages visited, and water sample locations by county and biogeographic zone

Zone	County	Water sample	Village	# of surveys		
Zone 1	Los Muermos	Estaquilla	Estaquilla	6		
	Maullín	Carelmapu	Carelmapu	10		
Zone 2	Maullín	Amortajado	Amortajado	9		
			La Pasada	changue	5	
				el carrizo	2	
				La Pasada	5	
				Las conchillas	1	
				Lepihue	1	
				los coigues	3	
				Rivera Norte	1	
				Maullin	Maullin	9
					Ten Ten	11
			Zone 3	Ancud	Ancud	Caleta Pudeto
Muelle Ancud	1					
pudeto	5					
pudeto alto	1					
pudeto bajo	1					
Vista Hermosa	2					
Chepu	Chepu	7				
Punta corona	faro corona	2				
	POLOHUE MAR					
	BRAVA	1				
	Quetelmahue	chaular				1
		puente quilo				1
		pullihue				1
		quetalmahue				8
Zone 4	Calbuco	Calbuco caicaen				calbuco
			paso keno	3		
			calbuco la vega	LA VEGA	1	
			Isla Poluqui	Isla Puluqui	10	
			isla poluqui chope	chechil isla puluqui	1	
			San Agustin	san agustin	3	
			isla puluqui san ramon	ISLA TAUTIL	1	
				SAN RAMON	1	
			Zone 5	Puerto Montt	Anahuac	anahuac
Chaica	chaica	18				
	yervas buenas	2				
Isla Tenglo	isla tenglo	5				
	tenglo	2				

			tenglo centro	1
		La Arena	la arena	6
		Lenca	lenca	6
		Metri	estero metri	2
		Piedra azul	pedra azul	19
			Ralimo	1
		Quillaipe	Quillaipe	2
Zone 6	Cochamó	Cascajal	cascajal	5
			Pangalito	1
			punta cerapio	1
		Cochamo	cochamo	9
			el bosque	1
		Pueblo hundido	la lobada	2
			pueblo hundido	3
	Puerto Varas	Rollizo	rollizo	6
Zona 7	Hualaihué-North	Aulen	aulen	19
			Punta Nao	1
			Quildaco/Aulen	1
		Contao	Caleta Puerto Bonito	1
			Caleta Quiaca	1
			contao	4
			Sector el Cobre	1
		El Manzano	cheñue	3
		Hornopiren	Curamin	2
		La Posa	Caleta la Poza	1
			La Poza	2
		Queten	cupero	2
			hualaihue puerto	6
			Queten	3
		Rolecha	rolecha	3
Zona 8	Hualaihué-South	El Manzano	pichicolo	5
			puntilla de pichicolo	4
		Hornopiren	Hornopiren	15
		Manzano	El manzano	12
		pta Quillón	Puntilla Quillón	4
Total				316

Appendix 4: Survey basic information.

Table A4.1. Number of surveyed households, number of fishing villages visited, and number of water sample locations by county and biogeographical zone

Bioph zone	County	# Water sample	# Villages	# of surveys
Zone 1	Los Muermos and Maullín	2	2	16
Zone 2	Maullín	3	10	47
Zone 3	Ancud	4	13	32
Zone 4	Calbuco	6	8	32
Zone 5	Puerto Montt	8	12	71
Zone 6	Cochamó and Puerto Varas	4	8	28
Zone 7	Hualaihué	7	15	50
Zone 8	Hualaihué	4	5	40
Total		38	73	316

Households' characteristics

Most households report that a man is the head of the family (82%). The mean number of members of the household is 3.4 ($\sigma = 1.6$) and the mean age of the household head is 52.9 ($\sigma = 12.1$). The majority of household heads have less than 8 years of formal schooling (70%). Table 2 and Table 3 present this information by zones. The households report a range of primary reasons to perform marine productive activities in the specific location, with 40% stating that the location was close to home, 19% acknowledging low transportation costs, and 11% choosing the location due to the high productivity of the site. The majority of households (160) report that the head of the family was born in the same village where the survey took place (50.6 %). In 46 cases, the household head was born outside the village but in the same county (14.6%), while in 84 cases the household head was born outside the county but in the Los Lagos region (26.6%). Less than 10% of the household heads were born in other regions of the country. This result suggests the household heads' low propensity to make geographic moves.

Table A2. Households' composition and characteristics of the households' head by zones

Zone	Total	% Man head of hh	Mean # members hh	Mean age hh head
Zone 1	16	75%	3.0	53.4
Zone 2	47	81%	3.4	51.8
Zone 3	32	87%	3.4	52.0
Zone 4	32	66%	3.4	51.5
Zone 5	71	82%	3.4	54.9
Zone 6	28	82%	3.3	52.9
Zone 7	50	90%	3.3	51.9
Zone 8	40	85%	3.5	53.5
Total	316	82%	3.4	52.9

Table A3. Schooling of households' heads by zones

Zone	# without formal schooling	# Elementary education (1 to 8 years)	# secondary schooling (9 to 12 years)	Technical education	University level	n.r.	Total
Zone 1		9	6			1	16
Zone 2	2	30	14		1		47
Zone 3	1	23	7			1	32
Zone 4	2	24	6				32
Zone 5	3	52	14	1	1		71
Zone 6		12	14		1	1	28
Zone 7		36	12		2		50
Zone 8		31	7		1	1	40
Total	8	217	80	1	6	4	316

Appendix 5: Household Survey: Mobility choice questions

Situation A:

Consider an opportunity to be part of a concession producing mussel/algae collection/extraction of Loco in a location that is nearby, which would mean that you would need to be there 8 hours/day during 8 weeks/year

A.1 How much income would you need to make from that opportunity to induce you to participate?

(CLP)	Mussel			Algae			Extraction of Loco		
	Freq.	Percent	Cum.	Freq.	Percent	Cum.	Freq.	Percent	Cum.
Less than \$200,000	6	1.90%	1.90%	6	1.92%	1.92%	0	0.00%	0.00%
Between \$200,000 and \$500,000	124	39.37%	41.27%	88	28.21%	30.13%	52	16.56%	16.56%
More than \$500,000 up to \$2,000,000	68	21.59%	62.86%	60	19.23%	49.36%	106	33.76%	50.32%
Not interested	117	37.14%	100.00%	158	50.64%	100.00%	156	49.68%	100.00%
Total	315	100.00%		312	100.00%		314	100.00%	

A.2 If you are not interested, why not?

A.2	Mussel			Algae			Extraction of Loco		
	Freq.	Perc ent	Cu m.	Fre q.	Perc ent	Cu m.	Fre q.	Perc ent	Cu m.
1. Earn enough money now	14	12.17	12.17	18	11.54	11.54	12	7.69	7.69
2. Don't like mussel production /algae/extraction of loco	9	7.83	20	27	17.31	28.85	14	8.97	16.67
3. Don't know how to cultivate mussels/algae/extraction of loco	5	4.35	24.35	18	11.54	40.38	35	22.44	39.81
4. Don't know anyone in other locations	1	0.87	25.22	1	0.64	41.03	0	0.00	39.81
5. I don't want to change my current lifestyle	31	26.96	52.17	37	23.72	64.74	35	22.44	61.54
6. I can't leave my village for family reasons	33	28.78	80.87	33	21.15	85.89	36	23.08	84.62

7. I don't like to commute	5	4.35	85. 22	3	1.92	87. 82	8	5.13	89. 74
8. Other	17	14.7 8	100	19	12.1 8	100	16	10.2 6	100
Total	115	100		156	100		156	100	

Situation B:

Consider an opportunity to be part of a concession producing mussel/algae collection / extraction of Loco in a location that is 80 kms away, which would mean that you would need to be there 26 weeks during the year.

B.1 How much income would you need to make from that opportunity to induce you to participate without moving to that location?

(CLP)	Mussel			Algae			Extraction of Loco		
	Fre q.	Perce nt	Cum.	Fre q.	Perce nt	Cum.	Fre q.	Perce nt	Cum.
Less than \$200,000	0	0.00%	0.00%	0	0.00%	0.00%	0	0.00%	0.00%
Between \$200,000 and \$500,000	46	14.60 %	14.60 %	42	13.38 %	13.38 %	28	8.89%	8.89%
More than \$500,000 up to \$2,000,000	85	26.98 %	41.59 %	67	21.34 %	34.71 %	91	28.89 %	37.78 %
Not interested	184	58.41 %	100.00 %	205	65.29 %	100.00 %	196	62.22 %	100.00 %
Total	315	100.00 %		314	100.00 %		315	100.00 %	

B.2 If you are not interested, why not?

B.2	Mussel			Algae			Extraction of Loco		
	Fre q.	Perc ent	Cu m.	Fre q.	Perc ent	Cu m.	Fre q.	Perc ent	Cu m.
1. Earn enough money now	17	9.29	9.29	19	9.36	9.36	13	6.63	6.63
2. Don't like mussel production /algae/extraction of loco	10	5.46	14.75	28	13.79	23.15	13	6.63	13.27
3. Don't know how to cultivate mussels/algae/extraction of loco	6	3.28	18.03	14	6.9	30.05	33	16.84	30.1
4. Don't know anyone in other locations	0	0.00	18.03	2	0.99	31.03	1	0.51	30.61
5. I don't want to change my current lifestyle	63	34.43	52.46	61	30.05	61.08	44	22.45	53.06

6. I can't leave my village for family reasons	59	32.2 4	84. 7	53	26.1 1	87. 19	63	32.1 4	85. 2
7. I don't like to commute	9	4.92	89. 62	6	2.96	90. 15	6	3.06	88. 27
8. Other	19	10.3 8	100	20	9.85	100	23	11.7 3	100
Total	183	100		203	100		196	100	

Situation C:

How much income would you need to make from that opportunity to induce you to participate and move your household to a location more than 200 kilometers away?

C.1 How much income would you need to participate?

(CLP)	Mussel			Algae			Extraction of Loco		
	Fre q.	Percent	Cum.	Fre q.	Percent	Cum.	Fre q.	Percent	Cum.
Less than \$200,000	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%
Between \$200,000 and \$500,000	17	5.4%	5.4%	17	5.4%	5.4%	12	3.8%	3.8%
More than \$500,000 up to \$2,000,000	77	24.4%	29.8%	69	22.0%	27.4%	77	24.4%	28.3%
Not interested	221	70.2%	100.0%	228	72.6%	100.0%	226	71.7%	100.0%
Total	315	100.0%		314	100.0%		315	100.0%	

C.2 If you are not interested, why not?

C.2	Mussel			Algae			Extraction of Loco		
	Fre q.	Percent	Cum.	Fre q.	Percent	Cum.	Fre q.	Percent	Cum.
1. Earn enough money now	15	6.79	6.79	20	8.81	8.81	11	4.93	4.93
2. Don't like mussel production /algae/extraction of loco	10	4.52	11.31	26	11.45	20.26	13	5.83	10.76
3. Don't know how to cultivate mussels/algae/extraction of loco	6	2.71	14.03	14	6.17	26.43	34	15.25	26.01
4. Don't know anyone in other locations	0	0	14.03	1	0.44	26.87	3	1.35	27.35
5. I don't want to change my current lifestyle	74	33.48	47.51	70	30.84	57.71	56	25.11	52.47
6. I can't leave my village for family reasons	86	38.91	86.43	72	31.72	89.43	75	33.63	86.11

7. I don't like to commute	8	3.62	90.05	4	1.76	91.19	7	3.14	89.24
8. Other	22	9.95	100	20	8.81	100	24	10.76	100
Total	221	100		227	100		223	100	

Appendix 6: Marine productive activities throughout the year

We explored the pattern of marine activities performed by household heads during each month of the last 12-month period previous to the survey. Table A6 presents the percentage of household heads reporting that they performed a given activity in a given month with respect to the total number of household heads that report performing that activity at least once during the year. To complement this information, we also present the mean number of weeks that household heads report performing that activity per month (figures in parentheses). Inspection of these data suggests that almost all household heads reporting performing as a crew member or an aquaculturist are active during the spring season (Oct-Dec) with a slight reduction during the summer. The fraction of households performing the activity is reduced during autumn and winter. This pattern correlates well with the mean number of weeks per month that household heads perform these activities. While the mean number of weeks per month that household heads perform as a crew member or engages in small-scale aquaculture activities is about two during the spring, this is reduced to less than one week during the winter. Similar patterns are also observed for collectors (of seaweed and seafood), divers, and boat owners. However, in these latter activities, both the proportion of households that have been active in the activity each month and the number of weeks devoted to the activity are lower than in the cases of crew and aquaculturist activities. The results indicate that there are significant variations in marine activities performed throughout the year.

Table A6.1: Intensity of marine productive activities by month (Oct 2017-Sept 2018)

a,b

Activity	Oct-2017	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep-2018
Collector	66%	71%	71%	83%	80%	74%	57%	57%	60%	57%	40%	57%
	(1.3)	(1.5)	(1.4)	(1.8)	(1.7)	(1.5)	(1.0)	(1.0)	(1.1)	(1.0)	(0.7)	(1.0)
Diver	70%	70%	60%	90%	90%	80%	60%	60%	60%	50%	40%	50%
	(2.0)	(2.0)	(1.6)	(2.8)	(2.8)	(2.4)	(1.6)	(1.6)	(1.6)	(1.4)	(1.2)	(1.6)
Crew	92%	100%	100%	77%	69%	69%	62%	54%	46%	54%	54%	62%
	(2.2)	(2.3)	(2.2)	(1.5)	(1.2)	(1.2)	(0.9)	(0.8)	(0.8)	(0.8)	(0.8)	(1.0)
Boat own.	60%	60%	60%	67%	80%	73%	67%	53%	60%	53%	53%	53%

	(1.3)	(1.2)	(1.3)	(1.4)	(1.6)	(1.4)	(1.2)	(0.9)	(1.1)	(1.0)	(1.0)	(1.0)
Aquaculture	91%	91%	91%	82%	82%	73%	64%	64%	64%	64%	18%	36%
	(1.9)	(1.9)	(1.9)	(1.5)	(1.5)	(1.1)	(0.7)	(0.7)	(0.7)	(0.7)	(0.2)	(0.5)

^aPercentage of household heads reporting performing the activity in a specific month with respect to the total number of household heads that report performing that activity at least once during the year.

^bMean # of weeks that household heads report performing that activity per month, in parentheses.