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Do migrants degrade coastal environments? Migration, natural resource extraction and poverty in North Sulawesi, Indonesia

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ABSTRACT

Recent literature on migration and the environment has identified key mediating variables such as how migrants extract resources from the environment for their livelihoods, the rate and efficiency of extraction, and the social and economic context within which their extraction occurs. This paper tests these theories in a new ecological setting using data from coastal fishing villages in North Sulawesi, Indonesia. We do not find as many differences between migrant and non-migrant families regarding destructive fishing behavior, technology and investment as might have been expected from earlier theories. Instead, the context and timing of migrant assimilation seems to be more important in explaining apparent associations of migration and environmental impacts than simply migrants themselves. This finding fits well with recent literature in the field of international migration and immigrant incorporation.

INTRODUCTION

Within the last ten to fifteen years, the field of population and the environment has grown rapidly. Theories have expanded from simplistic linear perspectives of population growth adversely affecting the environment (Ehrlich 1968; Malthus 1798) to more complex theories that incorporate mediating variables such as poverty, development, social institutions, and technologies (Jolly 1994; Marquette and Bilsborrow 1999; Panayotou 2000).

A subset of the literature on population and the environment is geared toward migration and the environment, most often the terrestrial environment. Researchers have proposed conceptual frameworks about population and environment interactions that include migration as part of a multi-phasic response to environmental change (Bilsborrow and Ogendo 1992), i.e. out-migration as a last resort after land has been overused and degraded. Conversely, some researchers have examined specific mechanisms through which migration, beyond contributing to simple population increase, may or may not adversely affect the environment. In these models, key mediating variables are how migrants extract resources from the environment for their livelihoods, the rate and efficiency of extraction, and the social and economic context within which their extraction occurs (Begossi 1998; Curran 2002; Curran and Agardy 2002; Curran, Kumar, Lutz, and Williams 2002; Jodha 1998; Katz 2000; Naylor, Bonine, Ewel, and Waguk 2002; Pretty and Ward 2001). Evaluating migrant impacts on the environment requires comparing their knowledge and technological skills, their wealth and their access to resources (broadly defined) with comparable attributes of non-migrants. Incorporating a mediating variables perspective in a model evaluating migrant impacts on the environment also requires drawing upon the migration literature and charting how migrants are incorporated into their destination communities, as well as understanding the endurance of their ties to places of origin (Curran 2002).

In the past, central research questions have been: To what extent does an ecological resource base attracts migrants (Curran 2002 ; Bilsborrow and Ogendo 1992; Bremner and Perez 2002; Dwyer and Minnegal 1999; Hunter 1998; Ruilai 1992); to what extent migrants differ from non-migrants in their ecologically destructive behavior (Bilsborrow 1992 ; Bilsborrow and Ogendo 1992; Pichon 1997; Pichon 1997; Sierra 1999); and, to what extent the capacity of social institutions is strained by migrant incorporation and serves as a more proximate explanation for resource degradation (Katz 2000; Bernacsek 1986; Bertram 1986; Bilsborrow and Carr 2000; Bilsborrow and DeLargy 1991; Connell and Conway 2000; Connell 1994; DeWalt and Rees 1994; Dwyer and Minnegal 1999; Ewell and Poleman 1980; Gould 1994; Jodha 1985; McIntosh 1993; Ostrom 1990). Most of these studies have examined the impact of migration on the terrestrial environment. In terrestrial environments the connection between the human "footprint" and environment can be made more clearly given the ability to link degradation to a particular landmark. Studies of more transient ecological systems, like those found in marine environments, are harder to link directly with human activities, population mobility, and social institutions.

Only recently have there been studies of migration and the marine environment (Bremner and Perez 2002; Curran 2002; Curran and Agardy 2002; Curran et al. 2002; Kramer, Simanjuntak, and Liese 2002). These studies focus on a variety of mediating factors to explain the relationship between migration and the environment, such as how technology, local knowledge, social institutions of kinship, and markets mediate resource extraction and consequent resource degradation or enhancement. Kinship or community governance, technology or local knowledge, and markets are particularly important for affecting resource extraction in common pool resource settings, like marine environments. In this study we look specifically at resource extraction from coral reefs and the above mediating factors, specifically the modes of incorporating migrants into local economies and social institutions, especially through marriage into local kinship, occupational niches and migrant enclaves, poverty, and resource extraction technologies.

Our study focuses upon migration to the Minahasa district of North Sulawesi, Indonesia and the status of the coral reefs in the area. The Minahasa district has a high proportion of migrants,[1] about 25% of our sample, with the vast majority from the nearby Sangihe-Talaud islands. Poverty levels are high and many are dependent upon the marine environment for their

[1] A migrant is defined in this study as a person born in another district.

livelihoods, supplemented with subsistence farming activities. The Minahasa district is located on a peninsula characterized by an extremely rich and diverse, although threatened, tropical marine ecosystem (see Figure 1). Travelers from around the world visit the world-renowned Bunaken Marine Park, located on the western side of the peninsula, to scuba dive among 2,500 species of fish and 70 genera of coral.

[Figure 1 about here]

In this analysis of migration and the marine environment, we pose three questions. First, how do villages differ in the quality of their resource base and their demographic composition? Second, given a particular ecological resource base, is household migrant status, differentiated by marriage between migrants and non-migrants, associated with different behaviors relating to resource extraction? Third, do migrant households extract resources from the environment because of their incorporation into particular sectors of the economy and migrant enclaves? To answer the first question we examine the correlation between the demographic, social, and behavioral context and the ecological resource base of fishing villages in North Sulawesi, Indonesia. To answer the second question we examine how a household's migrant status is associated with their resource extraction behavior and poverty level given the quality of the resource base. To answer the third question, we disaggregate the relationship between migrant households and fishing behavior by type of fishing sector niche.

Neither the questions nor the answers presume causality. Our attempt to answer these three questions provides a first glimpse at the relationship between migration and marine resource quality and extraction. We employ mixed methods to describe the ecological, social and demographic context through analysis of aggregate survey results and qualitative fieldwork data (collected during the summer of 2001) at the village level. At the household level, we first examine the bivariate relationship between migration and the environment. Then we pursue a multivariate analysis of household-based survey data to test for the association of resource extraction behavior, migration and ecological resource quality. We see a clear relationship of more migrants living in villages with poor coral reef quality, but the association between migrant status and destructive fishing behavior is mixed. Migrant status alone is not the main variable associated with poor environmental quality and the presence of more migrants in a community is not correlated with more destructive resource extraction techniques. We pursue a deeper examination of the social, economic and ecological context of the setting, paying particular attention to the context of the fishing environment and the ways in which migrants are incorporated into social institutions in places of destination. By doing so we bring theory from the literature about migration, specifically we incorporate the concept of modes of incorporation. As a result of our integration of concepts from migration theory, we suggest a nuanced perspective on whether and when to expect a negative relationship between migration and environment quality.

Background Literature

There is a popular consensus that migrants' resource-use and extraction strategies result in negative environmental impacts like widespread deforestation and resource depletion (Sierra 1999). However, the empirical evidence for this popular consensus is limited and suggests greater elaboration of a more complex theoretical model. Some of the mechanisms identified for inclusion in more complex models are: differential access and use of technologies, differential valuation of and knowledge about ecosystem components, differential economic resources, differential time horizons, differential incorporation into social institutions that would affect use of ecosystem services.

Others argue for a more proximate explanation which is that population growth and increased migration accelerate the collapse of common-property institutions (Katz 2000; Ostrom, Burger, Field, Norgaard, and Policansky 1999), which are common in marine resource systems (World Commission on Environment and Development 1987). Migration disrupts the bounded solidarity and enforceable trust governing relationships within communities (Palsson 1998) which limits free-rider problems associated with public goods, like those typically associated with marine ecosystems.

An important difference between migrants and non-migrants regarding resource extraction is the value and benefits that each group places on the resource, the level often being correlated with the amount of knowledge the group has about the resource and ecosystem. For example, non-indigenous resource users often show a lack of knowledge about tropical rainforest resources and values (Browder 1995), while on the other hand indigenous culture and knowledge structure indigenous people's behaviors such that ecological disruption is minimized and ecological resilience maximized (Begossi 1998).

Related to the differences between migrants and indigenous people is mis-application of resource extraction technologies. In the Amazon, settlers who recently migrated bring technology that they are familiar with, but are poorly adapted to the new landscape ecology. In addition, recent migrants have an expansionist attitude toward new land and opportunity, which coincides with a failure to consider long-term effects of resource-extraction and use on the ecosystem as a whole (Pichon 1997; World Bank 1992). According to a study on a coastal population of northeastern Brazil, technological changes imposed by outsiders without knowledge about the ecological and social context of the community are more likely to fail and decrease ecological resilience (Begossi 1998).

Poverty has been routinely viewed as a major cause and effect of global environmental problems (World Commission on Environment and Development 1987). The poor and hungry often over-harvest and degrade their surrounding environment in order to survive. Time-horizons are much shorter for poor farmers or fishers, and migrants in new ecological frontiers are often associated with poverty. An impoverished migrant may not be able to practice sustainable resource extraction in order to ensure future environmental productivity when immediate consumption needs are so strong. Yet, this intensifies pressure on the environment and the poor find themselves locked in a downward spiral of environmental degradation leading to increased poverty (Leonard 1989).

The aforementioned literature theorizes that migrants differ in resource extraction and interactions within an ecosystem, at least in regard to land-use and land-change. Migrants, or non-indigenous resource users, most often disrupt the natural environment through resource extraction because they lack locally specific knowledge about ecological and social systems (Browder 1995), their technology may be inappropriate for the given ecological system (Begossi 1998), they have a shorter time horizon, often due to poverty, which reduces long term sustainability of the resource (Pichon 1997), and they have different consumption preferences. Nonetheless, empirical research does not show that migrants are consistently detrimental to the environment.

In an empirical study of a multi-ethnic region in Ecuador, Sierra (1999) did not find evidence of recent deforestation associated with new migrants (Sierra 1999). Other studies highlight systems with strong land tenure or social capital where migrants do not disrupt the environment (Hanna 1998; Palsson 1998) or the migrants are able to develop knowledge systems that are compatible to the new environment. Certain ecological or social conditions may be conducive to the poor becoming environmental activists rather than environmental degraders (Broad 1994). Thus, empirical evidence on migration, resource-use and extraction and impacts on the environment is mixed partly due to the fact that migration is an extremely complicated, non-linear process (Curran 2002).

Why do these counterfactuals in the migration and environment literature exist? As suggested earlier, varying social and ecological contexts structure the interactions between migrants and their environment and between migrants and social institutions. Plus, varying degrees of migrant incorporation into communities predict how different a migrant may act compared to a local. Indeed, the question of whether migrants disrupt common property resource management systems provides an excellent example of how social and ecological contexts play a significant role in conditioning the relationship between migration an environmental outcomes.

Most literature posits that migrants disrupt common property management systems. Migration is theorized to disrupt social bonds of obligation and trust which is central in regulating common property regimes (Curran 2002). Generally, migrants do not understand the norms and workings of common property systems and do not invest in long-term natural capital enhancement, hence the members of the community either fail to continue to regulate the common system or simply join in the race to extract the natural resources (Katz 2000; Ostrom et al. 1999). Nonetheless, common property systems may be successful if the community regulates access and creates incentives to invest in the long-term productivity of the resource base. Some argue that under certain conditions, common property institutions may be sufficiently robust to withstand demographic changes, such as migration. Ecological and social factors also weigh heavily on the probability of success of a common property system throughout the process of regulation and investment. For example, the resilience of the ecosystem may play a role; if an ecosystem can rebound quickly after heavy periods of resource use and extraction then the initial influx of migrants and their potential detrimental behaviors may not cause such a stir (assuming that migrants eventually conform to community norms). Social cohesion among migrants may help avoid the "tragedy of the commons", for instance, transmigrants (government sponsored migrants) in Indonesia had less of a negative impact on the environment compared to spontaneous migrants because they had greater collective action through greater embeddedness in political and social institutions (Bilsborrow 1992), as well as a bounded solidarity in a shared commonality as transmigrants. In addition, some systems are arranged to attract migrants (Bauer 1987), which may be the case in Minahasa, Indonesia, with the recruitment of migrants to work on large fishing vessels.

The manner in which migrants are incorporated into places of destination may determine the extent to which migrants disrupt common property resource management systems and thereby affect the deterioration of common pool resources and the environment. Modes of incorporation describe the reception of migrants in places of destination, from government policy towards migrants to public perceptions of migrants to the size and coherence of migrant ethnic enclaves already present in a destination (Portes 1998). Government policy (such as transmigration policies) can facilitate access to resources that ease settlement costs and lengthen time horizons, limiting stress on local environmental resources. Alternatively, government policy may be indifferent or hostile. In both cases, this may exacerbate the effect migrants have on an environmental resource base. The public's perceptions of migrants may be prejudiced or not. Prejudicial reactions to migrants may limit migrant access to jobs or resources. The pre-existence of large numbers of co-ethnics in a destination can help to consolidate migrant and ethnic control over particular occupational niches or localities, easily channeling new migrants into jobs (Waldinger 1995)or becoming so internally diversified within the community that migrants do not have to interact with indigenous locals outside of the enclave (Bailey and Waldinger 1991; Light 1984; Zhou 1992). This concentration of migrants may focus and narrow their impact on an environmental resource base. In the case of migrants to North Sulawesi from Sangihe-Talaud, there are strong ties among migrants within the community, a high degree of clustering in neighborhoods in Bitung city, a colonization of the large-scale fishing industry, and dense migrant networks extending back to the origin communities.

Another way in which migrants become incorporated into communities of destination is through marriage, which can facilitate migrant integration and be a source of both social (through increasing access to social networks) and cultural capital (through enhancement, understanding and awareness of the norms of behavior within a community (Bourdieu 1985; Coleman 1987; Portes 1998). Such integration may promote reciprocal trust, kinship and stronger social pressure to adhere to social norms, all of which promote common property resource management systems. When migrants intermarry into small, but dense communities, sea tenure regimes are maintained in the Solomon Islands (Aswani 2002). On the other hand, if migrant inter-marriage occurs in dispersed settlements, sea tenure regimes are compromised (Aswani 2002). Aswani's case study in the Solomon Islands challenges the notion that sea-tenure is weakened by population growth and migration alone. He hypothesizes that the higher the density of reciprocal ties among close kin or neighbors, the more likely that their land- and sea-use patterns will be conservative and the potential negative impact of migration or population growth will be diminished significantly.

The topic of kinship, specifically marriage, may be an important mechanism for understanding how common property management systems are maintained and continue to sustain common pool resource use and extraction. We address this topic in our analysis by defining household migration status migrant inter-marriage; i.e. marriage between two non-migrants, marriage between two migrants, and a mixed marriage of a migrant with a non-migrant.

Migration and Coastal Ecosystems

Rapid population growth in coastal regions was identified as one of the most important areas of concern for sustainable development and the environment at the 1992 United Nations Conference on Environment and Development. Indeed, a map of worldwide population distribution shows historical and contemporary trends of growing human settlements along coastal zones. As of 1994, an estimated 33.5% of the world's population lived within 100 vertical meters of sea level, but only 15.6% of all inhabited land lies below 100 m elevation (Cohen and Small 1998). Specifically with regards to coral reefs, almost half a billion people live within 100 kilometers of a coral reef and benefit from the production and protection these ecosystems provide, and nearly half of these people live in Southeast Asia (Bryant, Burke, McManus, and Spalding 1998). Additionally, much of the growing population near coastlines is due to in-migration and urbanization as opposed to natural population growth (Hinrichsen 1998).

Coastal areas are fragile yet quite valuable; for instance, coral reef ecosystems contribute in many ways to the health of people and nature. They are among the most valuable and diverse ecosystems on earth due to their environmental and economic services they provide to people, worth an estimated $375 billion each year (Costanza et al. 1997). Goods and services include invaluable biodiversity, seafood, new medicines, recreational value, and coastal protection. They are critical habitat and nursery grounds for 10-20% of the world's fisheries and are intricately connected with other important marine ecological systems such as mangrove forests, sea grass beds and the open ocean. Indeed, the health of coral reefs depends greatly on human activities, but the health and wellbeing of humans also depends greatly on coral reefs.

Global warming has been identified as the main threat to coral reefs (Pockley 2000). However, numerous other anthropogenic threats cause major damage. These include: over-fishing, fishing by explosion and poisoning, excessive sediment and nutrient run-off from urban and agricultural development (Pockley 2000), and most recently documented, human feces (Patterson et al. 2002).

Coral reefs grow slowly and are fragile. Even small disturbances, like fishermen standing on reef shelves to throw their nets or scuba divers touching and breaking parts of the coral, can kill large parts of the coral reef which then take years to grow back. More destructive fishing techniques involve dynamite, where the fisher drops the explosives underwater onto the reef and the shock sends dead fish floating to the surface while completely destroying the reef underneath. Non-structural damage can also be catastrophic for coral reef systems. Overexploitation of fish not only diminishes production of the harvested species, but also can seriously alter species composition and the biological structure of the ecosystem. All encompassing nets capture and kill many non-target species (by-catch) thus impacting harvest pressure on more than the species at hand. A change in the species structure from intensive fishing can cause a reef ecosystem to completely shift to a state of overgrown fleshy microalgae (Scheffer, Carpenter, Foley, Folke, and Walker 2001). These examples of small-scale anthropogenic disturbances to coral reefs, when rapidly compounded, have serious implications for long-term alteration, damage, and loss of productivity of the ecosystem (Paine, Tegner, and Johnson 1998).

Recent research attention upon migration to coastal areas and the impacts of migrants on coastal ecosystem quality, have not considered coral reefs. In the Galapagos islands, rapid exploitation of sea cucumbers has been blamed on migrant fisherman (Bremner and Perez 2002). Migrant fishers in the Galapagos introduced new fishing techniques and technology, such as the air compressor, in the early 1990's, and soon thereafter intensive fishing of sea cucumbers began. Now, the sea cucumber fishery is over-exploited and there are conflicts of interest about their future conservation. Other studies identify complex intervening variables between migration and the coastal environment, including biophysical characteristics of the marine system, dynamic fishery markets, and seasonal migrant flows (Marquette, Koranteng, Overa, and Bortei-Doku Aryeetey 2002), migrant remittances (Naylor et al. 2002) and shifting markets, politics and technologies in shrimp farming (Lebel et al. 2002). In all of the preceding cases, it is clear that whether migrants have a negative effect on the environment through resource extraction depends on more than simply an increase in numbers. Technology, knowledge systems, modes of incorporation, kinship, poverty, and resource valuation all play a role.

A Focus on Indonesia

Indonesia's extensive coastline and long history of migration makes it an ideal place to study the relationship between migration and coastal ecosystems. As the world's largest archipelago, Indonesia consists of more than 17,000 islands, even more at low tide, and is home to numerous endemic plants and animals. Much of the unique biodiversity is found near the 54,000 km of coastline, and subsequently, the livelihoods of a great portion of the population revolve around these areas.

Indonesia has a rich history of trade and human migration. Sulawesi, in particular, is of special interest because of its long history of accommodating western influences (Frank 1998; Jones 1977). The peninsula on which the Minahasa district is located, along with the Sangihe-Talaud islands, forms a natural bridge to the Philippines and has facilitated the movement of people and ideas for centuries. The Dutch capitalized on the district's strategic location during their colonialization and had a strong presence in the area until Indonesia's independence in the 1950's. Further back in history, Sulawesi played a central role in the Spice Island trade with the Portuguese. In general the people of Sulawesi are strongly oriented to the sea, primarily engaging in trade and subsistence fishing. For the past 50 years, work involving trade and fishing has been the primary reason for migration to the Minahasa district, and higher income is still the most popular reason for moving, according to our data. Recently, more and more refugees have been relocated to Minahasa from the nearby Moluccu islands due to severe political unrest.

The Sulu-Sulawesi marine ecosystem, situated between Sulawesi, Malaysia and the Philippines, is considered one of the most diverse marine communities in the world, supporting an abundance of fish and coral populations. As a long peninsula jutting out into this ecosystem, the Minahasa district serves as a fitting area to study the interactions between humans and the coastal environment. Not only do the fringing reefs attract and sustain important fauna, the geography of the island is also conducive to human settlements near the 960 km of coastline. No point on the mainland is greater than 90 km from the sea and the interior of the island is extremely rugged and mountainous. In sum, a unique demographic history coupled with the central importance of the coastal ecological system makes Sulawesi an important study site for an empirical analysis of migration and the marine environment.

The average population growth rate in the study area since 1980 is 1.56%, slightly lower than the national growth rate of 1.73%, although, due mainly to migration, the urban areas have a much higher rate of population growth (Japan International Cooperation Agency (JICA) 2001). The regional gross domestic product (RGDP) of North Sulawesi in 1999 was estimated at US$1.6 billion, among the lowest of Indonesian provinces, due in part to a high density of poor villages on the western coast. Major industries of the area include coconut oil, coconut flour, and fisheries. In addition, tourism to the Bunaken National Marine Park plays an important role in North Sulawesi economy.

Migration to the urban areas of our study area represents the beginning of an interesting road of migrant assimilation closely connected with social institutions and labor markets. Most migrants to Minahasa arrive by boat setting foot in either Manado or Bitung, the two main urban centers. Women often work as housemaids or as merchants; men begin as construction workers or work in the major industries listed above. Once they make enough money and become more assimilated to the new environment, they disperse to the smaller villages for a variety of reasons including: following family, looking for husbands or wives, to start a new business, or to live in a smaller town (results from qualitative fieldwork, 2001).

In fact, many fishermen from small islands in Sangihe-Talaud are recruited to work in the large pelagic fishing industry near Bitung. Some migrate with their family while some young men arrive alone. Thus for these fishers, the first stop is in urban areas where they work in large crew boats and fish farther away from the shore. Eventually, some are funneled into smaller villages and incorporated into those communities via inter-marriage. In these villages, the artisanal fishers work on a very different scale, on small crew boats and fishing near coral reefs. These varying modes of migrant incorporation into society may provide insight on how migrant behavior may or may not degrade the environment.

In this paper, we investigate whether migrant households are more highly associated with coral reef quality and whether the relationship is modified by resource extraction techniques, effort, poverty, and fisheries sector. We have purposely drawn double arrow lines connecting most of the concepts in our figure because we cannot disregard the fact that the cross-sectional data available to us limits our ability to disaggregate cause and effect. Nevertheless, we suspect that there will be an association between migrant households and behavior that is associated with lower environmental quality. Based on the literature, migrants are expected to use more destructive fishing technologies and expend more effort in order to harvest more fish. Migrants will, on average, spend less than non-migrants. These hypotheses are based on literature that claims that migrants are often poor and have shorter time horizons, thus in turn, unsustainably extract natural resources. However, the Indonesian context and the networks of migration that have evolved in the region also suggest that migrants, especially those from Sangihe-Talaud are concentrated in urban ethnic enclaves colonizing the labor market for the pelagic, industrial fisheries sector. However, subsequent intermarriage of migrants with indigenous locals and resettlement to more rural locations will diminish resource extractive behavioral differences between migrants and non-migrants.

[Figure 2 about here]

Data and Measures

Our primary quantitative data come from a survey conducted by researchers from Duke University and Bogor Agricultural University in Indonesia. In 1999, researchers surveyed 599 households in 17 coastal villages about household demographics and economics, migration experience, fishing behaviors and coastal resource use (Kramer et al. 2002).

The sample of households was obtained following stratified, multi-stage sampling methods. The target population was the marine fishing households in the district of Minahasa and the urban areas of Manado and Bitung. Within this area, sub-districts were stratified as east or west coast, and three sub-districts were selected randomly from each stratum. In the second stage of the sampling process, villages in the six sub-districts were chosen randomly, resulting in 17 villages. In the third and final sampling stage, interviewers were assigned a number of completed surveys per village based on population weights. The population weights were determined from population estimates for each village by using data the study team had previously collected from the leaders of Minahasa coastal villages. Once in a village, the interviewers established a sampling frame from listed households and randomly selected from the frame. If after repeated attempts they were unable to contact a selected household, the interviewers followed a standard replacement protocol. Fewer than 3% of selected households required replacement.

All of the respondents were male and almost all were the head of the household. When the respondent was married, the wife was also surveyed (only 12 respondents did not have a wife). Questions ranged from fishing practices, to migration status and experience, consumption, and general demographics.

During the summer of 2001, one of the authors conducted semi-structured interviews with migrants, family members of migrants, and non-migrants in the same coastal communities. Twenty-four people in six of the 17 villages from the original survey were interviewed. In addition, ten villagers were interviewed in the Sangihe-Talaud islands, another district of North Sulawesi between Sulawesi and the Philippines, and the source of 75% of the migrants to Minahasa. The semi-structured interviews were not randomly sampled, instead, villagers were selected if they were migrants or had close relations with migrants. The purpose of the interviews was to provide context to the survey data regarding migration.

Emi Yoda provided the third data source used in this analysis (Yoda 2001). Yoda interviewed the leading expert on the conditions of coral reefs in the Minahasa district, a marine ecologist who had conducted underwater research near most of the villages. A scale measuring live coral cover was assigned to each previously surveyed village: 1 = 75-100% live coral, 2 = 50-75% live coral, 3 = 25-50% live coral, and 4 = 0-25% live coral. In addition, the total area (km^2) of coral reef within a 5 km radius of each village was calculated using a nautical chart from the Indonesian Navy. Ideal environmental data would be more recent, spatially explicit and at a higher resolution, but these are the best available environmental data for the area at the given time.

We created an index of environmental quality based on these two variables to take into account both coral reef quantity and quality. Only one village out of 17 was ranked with a coral cover of two and none with a coral cover of one (from the aforementioned scale of one to four), so we grouped the data into a dichotomous variable with the values: *average*, representing live coral cover between 25% and 75%, and *poor*, representing live coral cover between 0 and 25%. Additionally, villages also differ according to the extent of coral reef area, thus it is important to find a variable that accounts for both quantity and quality. We averaged the amount of coral cover from each village, calculated the mean and categorized villages as either *large*, i.e. an area greater than the mean, or *small*, i.e. less coral cover than the mean. We combined these two classifications of the coral reef into an index of four outcomes reflecting the all possible combinations of quality and quantity: poor quality/small area, average quality/small area, poor quality/large area, and average quality/large area.

We measure migrant status at the household level, taking into account both the husband and wife's migrant status.[2] A respondent qualifies as a migrant if he was born in a different district. The three categories are 1) both husband and wife are migrants, 2) either husband or wife is migrant, and 3) neither husband or wife are migrants, hereafter referred to as two, one, or non-migrant households. By categorizing households in this way, we explicitly capture the degree to which migrant households are integrated into communities. We expect that those households where both husbands and wives are migrants behave significantly differently than households where either both are non-migrants or only one is a migrant. The integration of migrants through marriage increases their adherence to the norms of behavior associated with common property resource management, their access to local knowledge about the ecosystem, and their access to resources and appropriate technology. In the entire sample, 9.52% of households are two-migrant households, 28.71% of households have at least one migrant (husband or wife), and the remaining 61.77% have no migrants. Of the households where one person in the couple is a migrant 53% were male migrant households and 47% were female

[2] In the 12 cases where the respondent was not yet married we used the migrant status of the respondent only.

migrant households. We do not distinguish between male and female single migrant households in our analyses; the results were the same with the aggregated one-migrant household variable.

Regarding resource extraction, we look at three behaviors associated with resource extraction that might explain the differences between migrants and non-migrants and their association with coral reef quality. The variables are 1) the deployment of destructive fishing techniques, 2) the weekly fishing effort (in hours) performed by a household and 3) boat ownership. We chose these variables in an attempt to understand how migrants might be associated with varying coral reef quantity and quality.

Destructive fishing technique is measured with a question about whether fishers use gear considered destructive to coral reefs. The survey included questions that measured the kinds of fishing gear used most often. Answers ranged from hook and line (the most frequent response at 57% of total- data not shown), to numerous kinds of nets, to incredibly destructive dynamite (although only a few confessed to using dynamite, we assume that many others use it on occasion). We defined a dichotomous variable to stand for whether the primary gear used was detrimental to the environment or not. Gear defined as detrimental to the coastal environment include dynamite, encircling net, gillnet, and coastal net. Non-detrimental gear types, accounting for 68% of the sample, are hook and line, light fishing, diving and arrow hunting, trapping and flying fish net. This measure may not capture the varying degrees of damage caused by each type of gear but does distinguish between damaging and non-damaging activity. Bombing causes considerable collateral damage to other fish and coral. Nets are detrimental because the "by-catch" (non targeted species caught in the nets) is much larger than the more minimal "by-catch" from hooks and lines and the act of distributing nets over the sea can cause damage to the coral reef and other susceptible flora and fauna. Fly fishing nets are not destructive to coral reefs because they are used to catch pelagic fish (i.e. fish found in the open ocean).

The second resource extraction behavior is a linear measure of weekly fishing effort calculated by the number of hours spent fishing per week. The variable was chosen under the assumption that more effort put into fishing meant either lower quality coral reefs with less abundant resources or that more effort may cause more damage. This variable is not standardized to include the type of gear used;[3] nonetheless it contains interesting variation among the households. A household with two migrants spends an average of 102 hours per week on fishing, compared to 78 hours for a family with one migrant and merely 68 hours for a family with no migrants. This bivariate comparison is statistically significant based on a chi-square distribution (data not shown).

Our last resource extraction variable is boat ownership. We categorize boat ownership as a resource extraction behavior, but it is also closely linked with poverty and spending. Owning a boat may represent status and wealth, forward thinking, and long-term investment in productive, sustainable fishing.[4] Boat ownership may limit damage to coral reefs because it limits walking on coral, boat ownership also facilitates fishing in pelagic fisheries rather than coral reefs. About 23% of two-migrant households owned a boat, 49% of one-migrant households and 68% of households without any migrants owned a boat (data not shown). Whether a person owns a boat, they may still fish on or off of a boat. The size of the boat indicates the extent to which fishers can fish in pelagic waters and the amount of catch they can accommodate in any trip. Boat size, as measured by the number of crew, also indicates whether the fisher is part of an industrial fishing fleet oriented toward a global market or a subsistence or small scale, local market operation. Crew size ranged from one to 25 people, with clumping at two and ten. Effort and size of fish catch are both positively correlated with crew. We categorize boat type as either small (two or fewer crew members), medium (between two and ten members), and large (ten or more), with the assumption that large boats mostly fish in the open ocean.

Poverty is frequently difficult to measure in many less developed country settings; there are a variety of techniques and theories about how to calculate poverty levels. Since we are interested in the amount and variability of spending across households, we will not construct a poverty line for the sample. Nonetheless spending is associated with poverty, and we assume that the less a household spends the poorer they are. We used data from the survey regarding how much money the household spent on numerous items, including food, clothing, education,

[3] There is no clear way to weight the variable effort for gear-type. Nonetheless, an hour fishing while using nets may be more detrimental than an hour with a hand-held spear.
[4] Owning a boat may reflect the ability to be out at sea longer and possibly cause more damage, but we measure that directly with the fishing effort variable.

house maintenance, etc. From these data we calculate an aggregate measure of spending in Indonesian rupiah (the national currency), which sums all categories of spending per week and then transform the sum into the natural log.

Analytic Approach

The analysis is organized into three general sections. In the first we examine differences across villages. In the second we examine differences across households. And in the third we examine migrant households within particular types of fisheries sectors. In the first section we present results from a contextual analysis of the relationship between migration and ecosystem quality at the village level; trends in village populations are separated according to the quality and quantity of coral reefs in the area. In the second section we begin with a simple bivariate analysis describing the distribution of migrant households across types of villages. This lays the foundation for a set of multivariate analyses conducted at the household level to answer the question: Do migrants employ more destructive technologies, and are there poverty-level differences between migrant and non-migrant households? Finally, in the third section, we replicate the household level analysis, but do so within each of the fisheries sectors, specifically by whether the crew size reflects industrial fishing or subsistence/local market fishing. By accounting for how migrants are incorporated into social systems, such as marriage and labor markets in destinations we bring an added insight to previous theorizing and analysis of migration and the environment. The triangulation of our results from these analyses provides a nuanced perspective on whether and under what conditions migrants might be associated with lowered environmental quality, in this case coral reef quality.

1. Village-level analysis

Before we look at the household level relationships between migration and the environment, we explore the social and ecological context at the village. Tukey's simultaneous t-tests are used to compare means of individual and household level characteristics across villages. In addition, qualitative data from the first author's fieldwork complements the descriptive analysis, adding insights to our understanding about the place, the varying modes of incorporation of migrants into the local social systems, and the relationship between migration and coastal ecosystem quality. These analyses establish the relationship between migration and coral reef quality, as well as fisher behaviors with coral reef quality.

2. Household-level analyses

The goal of the household-level analysis is to evaluate whether certain behaviors of fishers and poverty are associated with migrant status. In other words, is degrading the environment through detrimental actions or extractive behavior characteristic of migrants, or simply of poverty? In our bivariate analysis we evaluate the relationship between migrant status and residence in a village with particular coral reef qualities. Our evaluation is based on a chi-square distribution.

In our subsequent multivariate analysis we test three models for predicting the odds of a particular resource extraction behavior and a household's poverty level. In the first model we evaluate the relationship between migrant household status and the dependent variables, in the second model we include demographic factors and the environmental quality of the coral reef, and in the third model we include fishing sector, or size of crew. For two of the resource extractive behaviors (destructive gear use and boat ownership) we employ a random effects logistic estimation technique. For the models of fishing effort we estimate a random effects linear equation. The dependent variables in the logistic models are 1) whether the fisher uses destructive fishing techniques, and 2) whether the household owns their own boat. The continuous dependent variable for the linear model is weekly fishing effort (hours). For the poverty models we also estimate a random effects linear equation.

Because households are clustered within villages we will employ random effects regression models.[5] We estimate the behavior of household i at village j, Y_{ij}, as a function of individual and household background variables, X_{ij}, a vector of village-level environmental characteristics, Z_{1j},

[5] In the following examples we use a linear regression model to illustrate our technique.

which do not vary across households within a village, a random variable z_j, and a random error term:

(1) $Y_{ij} = \beta X_{ij} + \gamma_1 Z_{1j} + z_j + \varepsilon_{ij}$,

β is the return to the individual and household background characteristics, and γ is the return to the village level characteristics. Assume that V_j is a vector of village level characteristics that do not vary across households; then this vector can be decomposed into measured characteristics, Z_{1j}, such as environmental characteristics included in the model, and unmeasured characteristics, Z_{2j}, such as social and cultural characteristics not included in the model. In equation (1), z_j is the random variable that denotes the unmeasured village level characteristics, Z_{2j}; in other words it acts as a random disturbance specific to a village. This adjusts the standard errors of coefficient and corrects for any bias associated with the correlated measurement error resulting from the clustering of households within villages.

3. Household analyses within fishing sectors

In our third set of analyses we separately estimate our second models for each of the dependent variables within each type of fishing sector. In effect we are testing an interaction between migrant status, incorporation into a fishing sector, and fishing behavior. We compare the extent to which migrant and non-migrant households behave differently or use different resource extractive techniques when they are located within similar types of fishing sectors. This yields greater insight about the relationship between migration and the environment, suggesting that the relationship is conditional upon modes of migrant incorporation.

Association Between Villages' Migrant Population, Fishing Behaviors, Poverty and Coral Reef Quality

Descriptive village-level data and the results of means comparison from the village level analysis are shown in Tables 1 and 2. In Table 1 villages in the four different types of coral reefs are compared in terms of migrant composition, demographic composition (age of household head and size of family), proportion practicing particular fishing behaviors, and mean spending levels. Although we cannot reach robust conclusions because of the small number of villages, the data do give us a sense of village level characteristics and village-to-village variation.

Table 1. Village level demographic, ecological and behavioral characteristics.

Variable	Small coral reef: Poor quality	Small coral reef: Average quality	Large coral reef: Poor quality	Large coral reef: Average quality
Village characteristics				
Number of villages	3	8	3	3
Average number of HH sampled	79	26	27.3	24
Average coral size (km^2)	1.667	1.150	5.340	12.097
Migrant status				
Proportion of HH with two migrants	0.186	0.037	0.000	0.000
Proportion of HH with one migrant	0.355	0.273	0.236	0.269
(Ref: HH with no migrants)	0.459	0.690	0.764	0.731
Household demographics				
Average age of respondent	37.318	39.663	41.856	38.665
Average family size	4.515	4.497	4.943	4.117
Fishing behavior				
Proportion of HH using destructive gear	0.451	0.185	0.290	0.190
Proportion of HH that own a boat	0.354	0.699	0.926	0.924
Average hours of fishing effort per HH	91.354	62.658	51.104	65.225
Crew Size (Proportion of HH that fish on a boath with…)				
<=2 members	0.278	0.748	0.501	0.925
3 to 10 members	0.120	0.190	0.451	0.068
(Ref: more than 10 members)	0.602	0.062	0.048	0.008
Poverty measure				
Natural log of HH spending (rupiah)	11.551	11.620	11.383	11.398

The majority of villages fall into the environmental category of small quantity and average quality coral reef (8 villages), while each of the other environmental categories consist of three villages each. On average, villages with a small amount of poor quality coral have larger populations.[6] The sampling procedure was proportional to the village population, thus those villages with poor quality and smaller coral reefs include an average of 79 households in their samples, compared with around 25 households in each of the other villages.

Regarding migration, the group of villages with small quantity and poor quality coral reefs stand apart from the others. On average, 18.6% of the households in these villages are composed of two migrants, while 35.5% are one-migrant households. On average, less than half of the households in these villages do not have any migrants. On the other hand, only 3.7% of households in villages with average quality and small quantity coral reefs are composed of two migrants on average, while 27.3% of the households in these villages have one migrant on average. In villages with a large quantity of coral, regardless of the quality, there are no two-migrant households. On average in these villages, the proportion of households composed of one migrant are 23.6% for villages with poor quality coral reef to 26.9% for villages with average quality coral reef.

Destructive gear use is most prevalent in villages with poor quality coral reefs. On average 29% of households in villages with large coral reefs of poor quality use destructive gear and on average 45.1% of households use destructive gears in villages with small coral reefs of poor quality. The percentage of households using destructive gear is less common in villages with average coral reef quality, near 19% on average for villages with small and large coral reefs.

Villages with poor quality and small coral reefs have the lowest percentage of households that own a boat (35.4%). Boat ownership almost doubles, on average, in villages with average quantity and small coral reefs. In the villages with large coral reefs, regardless of the quality of the coral reef, a vast majority of households own a boat. These data suggest that most of these households have invested in fishing as an occupation.

[6] The number of households sampled in each village is proportional to the population of the village.

As with the other two fishing behaviors, the villages with poor quality and small coral reefs stand apart from the other types of villages with regards to average hours of weekly fishing effort. On average, households in these villages spend 91 hours fishing per week. Households in villages with average quality coral, regardless of coral reef size, spend around 63-65 hours of fishing, while households in villages with poor quality and large coral reefs spend the least time fishing, at 51 hours for the average household.

Fishing on large boats with ten or more crew members is more common in villages located near small coral reefs of poor quality (60% of households). In these villages, on average 28% of the households fish using small vessels, while the rest fish on medium size boats with 3 to 10 members. On the other hand, the vast majority of households in villages with average quality coral reefs fish on small boats with less than two crew members: 75% in small/average villages and 93% in large/average villages. In villages located near large coral reefs of poor quality, about half of the households fish on small crew boats and half on medium crew boats. Generally, we only see large fishing boats in villages with poor small coral reefs of poorer quality, while the rest of the villages mostly fish on small and medium crew boats.

Average household spending is the highest in villages with average quality and small quantity coral reefs, followed by households in villages with poor quality and small quantity coral. Spending is the lowest in villages with large quantity coral reefs. These data coupled with the results from boat ownership, i.e. less spending but a higher prevalence of boats in villages with large coral reefs imply that these villages are generally more subsistence-oriented than the other types of villages.

We now look at the results from the Tukey t-tests (Table 2). Most of the significant differences emerge in comparisons involving villages with poor quality and small coral reefs, the first three columns of the table.

Table 2. Pairwise Comparison of Means: Results of Tukey's Simultaneous T-tests

	poor/large	average/small	average/large	average/small	average/large	average/large
Variable	poor/small	poor/small	poor/small	poor/large	average/small	poor/large
Village characteristics						
Number of villages						
Average number of HH sampled	** (-)	** (-)	** (-)			
Migrant status						
Proportion of HH with two migrants	** (-)	** (-)	** (-)			
Proportion of HH with one migrant						
(Ref: HH with no migrants)	** (+)	*(+)	*(+)			
Household demographics						
Average age of respondent						
Average family size						** (-)
Fishing behavior						
Proportion of HH using destructive gear			*(-)			
Proportion of HH that own a boat	** (+)	** (+)	** (+)			
Average hours of fishing effort per HH	** (-)	** (-)	* (-)			
Crew Size (Proportion of HH that fish on a boath with…)						
<=2 members	*(+)	**(+)	**(+)	**(+)		**(+)
3 to 10 members	**(+)			**(-)		**(-)
(Ref: more than 10 members)	**(-)	**(-)	**(-)			
Poverty measure						
Natural log of HH spending (ln rupia)					* (-)	

Note: ** significant at 5% level, * significant at 10% level

Most strikingly but perhaps not surprisingly, villages with poor coral reef quality and small quantity have a population three times larger than the other types of villages. Therefore, all three means test comparisons of population size in poor/small villages are significantly different from the other types of villages. In all cases the direction of the difference is negative, indicating the larger population size for the villages with poor quality and small reefs.

As expected, a significantly higher proportion of two-migrant households are in villages with poor quality and small coral reefs. Thus, similar to the previous comparison of population size, all t-tests involving proportions of two-migrant households in villages with poor quality and small coral reefs are significant and the direction of difference is negative. Unexpectedly, there are no significant differences in the proportion of one-migrant households amongst the villages, although the proportion of one-migrant households is much higher in villages with poor quality and small coral reefs (35.5%).

In villages with poor quality coral reefs, the average age of respondents in villages with a small area of coral is 37.2, while the average age in villages with large area of coral is significantly older at 41.9 years. Yet when using the stringent Tukey's t-test, no significant difference of age emerges. As for family size, only one significant difference emerges. The average family size in villages with poor quality and large coral reefs is 4.94, while the average size in the other categories is 4.5 or less. We see a significant difference in the comparison of the two villages with large coral reefs. Households in villages with poor quality reefs are significantly larger than households in villages with average quality reefs.

Consistent with our expectations, households in villages with poor quality coral reefs use more destructive gear than households in villages with average quality coral reefs. Although the prevalence of destructive gear use in villages with poor quality and small coral reefs is greater than in villages with average quality and small coral reefs, the means comparison Tukey's t-test is not significant. The destructive gear use comparison between poor quality and small coral reef villages with villages that have average quality and large coral reefs is significant.

A significantly lower proportion of households in villages with poor quality coral reefs own their own boats. This may provide some support for the hypothesis that owning a boat represents investment in fishing as an occupation that requires the maintenance of marine resource quality. Villages with large coral reefs have the highest percentage of households that own a boat; this is the other evident trend regarding boat ownership. Therefore, all t-tests comparing the mean percentage of boat ownership in all other types of villages with villages that have poor quality and small coral reefs are significant and positive.

The last statistical test of fishing behavior also does not warrant surprise. Fishing effort is significantly higher for an average household in villages with poor quality and smaller coral reefs than in any other type of village. Therefore, as expected, all means comparisons t-tests of all other village types with villages that have poor quality and small coral reefs are significant and negative.

Similar to effort and boat ownership, households in villages with small reefs of poor quality stand apart from households in other villages. Members of these households work on small boats significantly less often than households in other villages. Villages with average quality coral reefs work on small boats more than in villages with poor quality coral reefs, in general. This hints at the type of fishing and livelihoods that these villages have come to rely on: small-scale coral reef fishing. Finally, members of households in villages with poor quality, large coral reefs tend to work on medium sized boats significantly more than any other type of boat as compared to members of households in other types of villages and ecological settings. These results reveal a general trend of larger sized fishing boats in villages with poor quality coral reefs and smaller boats in villages with average quality coral reefs.

The average natural log of spending is quite consistent among villages. The only significantly differences households in villages that have average quality and small coral reefs have significantly higher spending levels than villages that have average quality and larger coral reefs (11.6 vs. 11.4).

During qualitative fieldwork we learned that many respondents in the more urban villages work on large fishing boats that operate offshore. These companies rely on recruiting migrants, and often search for qualified fishers from far away islands. On one extremely remote Sangihe-Talaud island, we talked with numerous families whose sons were working on these large boats. This suggests that migrant impacts on their surroundings must be understood differently for those who work on a large boats and those who fish on a smaller scale. Pelagic fishermen on large boats exploit different resources than do small-scale fishermen, use different gear and live in different social settings. We explore the disparities between these two types of fishermen in the household-level analysis.

Many of the households that we visited in villages with average quality coral cover had migrant connections. Theory would suggest that villages with a high proportion of migrants might use different or destructive fishing technology, or technology incompatible with the local environment. In actuality, some of the elders in the high-percentage migrant communities helped build and repair small-scale fishing boats, but adopted the technology of the new village. The most influential factor regarding the migrant connections was the repeat and circular migration to and from the Sangihe-Talaud islands. Once extremely difficult, transportation to and from these islands is now quite easy, and many of the villagers travel to where the most lucrative work is at the time. For example, when we were conducting our fieldwork, many men were in the Sangihe-Talaud islands harvesting cloves, because the price per bag had recently increased dramatically. Later in the year, they would return to begin fishing again once it became more profitable. Thus it seems that migrants keep strong connections with their village of origin, especially when those connections can be exploited, but their residential investment strongly lies in their new homes.

In sum, the results of this village-level analysis suggest that more migrant households are in villages with worse environmental conditions, and destructive fishing behavior is associated with poor environmental conditions. Also, villages with poor environmental quality and small coral reefs have the lowest percentage of boat ownership, while villages with large coral reefs have the highest. Finally, fishing effort is highest in villages with poor quality and small coral reefs.

Household Fishing Behavior: Migrant Status and Fisheries Sector

A bivariate comparison of household migrant status and settlement near coral reefs, demonstrates that two-person migrant households are significantly more likely to settle near small coral reefs of poor quality than to settle in reefs with other characteristics (Table 3). One-person migrant households are also significantly more likely to be located near small coral reefs of poor quality than to be located in any other coral reef type. The vast majority of households in all of the other coral reef types have no migrants at all, although it is important to note that almost a quarter of households in villages associated with large coral reefs of poor quality have one migrant.

Table 3. Household Migrant Status and Village Coral Reef Conditions.

	Migrant status			
Coral reef conditions	*Two migrants* N	*One migrant* N	*No migrants* N	*Total* N
Small coral reef				
Poor quality	50	89	98	237
(row percent)	21.10	37.55	41.35	
Average quality	7	53	148	208
(row percent)	3.37	25.48	71.15	
Large coral reef				
Poor quality	0	18	64	82
(row percent)	0.00	21.95	78.05	
Average quality	0	12	60	72
(row percent)	0.00	16.67	83.33	
Total	57	172	370	599
(row percent)	9.52	28.71	61.77	

(Chi-square test significant at 1% level)

Thus far, we might conclude that migrant status is associated with lower quality coral reefs. However, caution must be asserted before presuming any causal relationship. Migration may cause deterioration in coral reef quality. Or, the relationship may be spurious, for example an urban area may attract migrants and side effects from urbanization may be the cause of coral reef destruction not the migrants. Or, migrants may move to places where coral reefs have deteriorated previously because these settlement areas are the only ones available. Although the following analysis does not completely solve the causal dilemma, it does attempt to answer questions about whether migrants behave differently than non-migrants with regard to resource extraction and whether migrants spend less (are poorer) than non-migrants. These factors are frequently cited as mediating the relationship between people and the environment.

Table 4 shows the results of estimating three random effects models for four outcomes: destructive gear use, weekly fishing effort, boat ownership and logged spending for the entire sample. Our discussion of results begins with the relationship between migrant status and the outcomes and we evaluate migrant status across all three models. We then describe the effects of the other variables in the models.

In model 1 migrant status does not appear to be significantly related to the use of destructive gear. The odds of two-migrant households using unsustainable fishing gear are 0.61 times as high as the odds of a non-migrant household, although this result is not statistically significant. One-migrant households have only slightly lower odds of using destructive gear than non-migrant households. Their odds of using destructive gear are reduced by 0.98 times relative to non-migrant households. In model 2 when we include education, age of the household head, family size, spending and coral reef quality and size as other factors in the model, the log-odds coefficient for two-migrant households becomes significant and the odds are even lower (the odds of using destructive gear among two-migrant households are now 0.40 times as high as non-migrant households). In model 3 we include our measure of fishing sector as a control (size of crew). When we do so, we find that the odds of a two-migrant household using destructive gear falls still further. The odds of a two-migrant household using destructive gear are lowered by 0.29 times that of a non-migrant household's odds of using destructive gear. Although the differences in the odds between one-migrant and non-migrant households increase, they are not significant in either model 2 or model 3.

Table 4: F**our Random Effects Models on Destructive Gear Use, Fishing Effort, Boat ownership and the Natural Log of Spending (log-odds coefficients reported for logistice equations (standard errors))**

	Destructive gear (1 = yes) Logit model			**Fishing effort (hours per week)** Linear model			**Own a boat (1 = yes)** Logit model			**ln(Spending)** Linear model		
	Model 1	*Model 2*	*Model 3*	*Model 1*	*Model 2*	*Model 3*	*Model 1*	*Model 2*	*Model 3*	*Model 1*	*Model 2*	*Model 3*
Household migrant status												
Two migrants	-0.489	-0.922	-1.252	9.630	17.205	12.164	-0.234	-0.199	-0.280	-0.100	-0.141	-0.144
	(0.375)	(0.411)*	(0.454)**	(5.360)^{ms}	(5.540)**	(5.329)*	(0.427)	(0.493)	(0.570)	(0.064)	(0.059)*	(0.058)*
One migrant	-0.013	-0.189	-0.151	-1.362	1.385	-1.083	-0.052	0.042	0.024	0.099	0.063	0.068
	(0.238)	(0.249)	-0.277	(3.301)	(3.403)	(3.278)	(0.252)	(0.270)	(0.304)	(0.039)*	(0.036)^{ms}	(0.035)*
No migrants (reference)												
Education												
No schooling		-0.328	-0.211		-23.849	-30.521		4.787	4.784		-0.082	-0.055
		(1.206)	(1.431)		(18.579)	(17.846)^{ms}		(1.758)**	(1.703)**		(0.191)	(0.188)
Primary school		-1.593	-1.472		-11.432	-14.717		2.515	2.571		0.022	0.056
		(0.962)^{ms}	(1.143)		(14.527)	(13.950)		(1.332)^{ms}	(1.392)^{ms}		(0.149)	(0.146)
Secondary school		-1.837	-1.902		-11.580	-16.086		2.327	2.438		0.110	0.138
		(0.980)^{ms}	(1.163)		(14.722)	(14.145)		(1.355)^{ms}	(1.409)^{ms}		(0.151)	(0.148)
High school		-1.548	-1.813		-10.503	-17.312		2.143	2.372		-0.126	-0.096
		(0.993)	(1.179)		(14.985)	(14.409)		(1.372)	(1.433)^{ms}		(0.154)	(0.151)
University and higher (reference)												
Age (years)		0.015	0.013		-0.585	-0.543		0.034	0.036		0.002	0.002
		(0.010)	(0.011)		(0.1430)**	(0.137)**		(0.012)**	(0.012)**		(0.001)	(0.001)
Family size		0.085	0.096		0.656	0.673		0.019	0.038		0.096	0.093
		(0.073)	(0.080)		(1.022)	(0.978)		(0.080)	(0.085)		(0.010)**	(0.010)**
Natural log of spending		-0.073	-0.174		7.265	6.986		0.044	0.249			
		(0.292)	(0.329)		(3.731)^{ms}	(3.621)^{ms}		(0.294)	(0.355)			
Environment												
Poor quality, small area		0.835	1.047		22.993	1.948		-2.501	N/A		0.159	0.117
		(0.432)*	(0.544)^{ms}		(5.540)**	(5.494)		(0.471)**			(0.240)	(0.290)
Poor quality, large area		0.426	0.968		-19.368	-22.513		0.547	2.033		-0.067	-0.146
		(0.480)	(0.545)^{ms}		(6.170)**	(5.653)**		(0.574)	(0.797)*		(0.242)	(0.291)
Average quality, small area		-0.645	0.081		-2.352	-4.271		-1.407	N/A		0.214	0.184
		(0.528)	(0.645)		(5.374)	(4.825)		(0.472)**			(0.201)	(0.242)
Average quality, large area (reference)												

Cont. Table 4												
Boat and Crew Size (Fishing Sector)												
Small: <= 2 crew members			-3.002			-35.845			3.165			-0.054
			(0.405)**			(4.305)**			(0.414)**			(0.056)
Medium: 2 to 10 crew members			-1.083			-30.018			2.585			0.148
			(0.436)**			(5.153)**			(0.488)**			(0.065)*
Large: >= 10 crew members (reference)												
Observations	599	596	596	597	594	594	599	596	596	599	596	596
Number of groups	17	17	17	17	17	17	17	17	17	17	17	17
rho	0.355	0.203	0.318	0.213	0.005	0.000	0.638	0.381	0.243	0.271	0.385	0.492

** significant at 1%, * significant at 5%, ms = marginally significant at 10%

N/A: Environmental variables dropped due to collinearity with boat type variables.

Migrant status also explains some differences in weekly fishing effort. The odds that two-migrant households will increase their weekly fishing effort by one month are 22 times higher than for a non-migrant household. Although this relationship is marginally significant, it strengthens with the inclusion of the controls variables in model 2 and model 3. One-migrant households are not significantly different from non-migrant households with regards to fishing effort.

Migrant status has no statistically significant relationship with boat ownership in any of the models, although two-migrant households have lower odds of owning a boat than non-migrant households. Migrant status is associated significantly with spending levels. Two-migrant households have 10% lower spending levels than non-migrant households and one-migrant households have 10% higher spending levels than non-migrant households. The margin between two-migrant and non-migrant households widens with the inclusion of the control variables. The margin narrows between one-migrant and non-migrant household with the inclusion of the control variables.

Besides migrant status there are other factors that explain resource extraction and spending levels. Education is associated with boat ownership, but not at all or very weakly related to the other outcomes. All education attainment levels of household heads from no education to high school are positively associated with boat ownership relative to any post secondary schooling degree. However, the odds of boat ownership decrease for each increase in an educational category relative to post secondary schooling. Schooling is probably associated with investments in occupations and livelihoods outside of the fishing sector. Households with older household heads spend fewer weekly fishing hours, but are more likely to own a boat. Larger families are only significantly associated with slightly higher spending levels, not unexpectedly. Spending levels are positively associated with higher weekly hours of fishing. Again, the causality could be that greater fishing effort yields higher catches and greater capacity to spend.

Coral reef characteristics are also associated with resource extraction behaviors, but not with spending levels. Households in poor quality coral reefs are significantly more likely to use destructive fishing gear than households in average quality, large coral reefs. Households in poor quality, small coral reefs are more likely to expend more effort fishing than households in average quality, large coral reefs. But, this association disappears with the inclusion, in model 3, of our fishing sector measure (boat type and crew size). Households in poor quality, large coral reefs are much less likely to expend significant fishing effort than households in average quality, large coral reefs. Households in small coral reefs are significantly less likely to own boats compared with households in average quality, large coral reefs. But households in poor quality, large coral reefs are significantly more likely to own boats.

Fishing sector is also significantly associated with resource extractive behaviors and spending. Households associated with large boats and crews are more likely to engage in destructive fishing behaviors, expend more fishing effort, and not own a boat. They are also more likely to spend less than households working on medium size boats with medium size crews.

Random village effects are important factors in fully specified models for most of the outcomes. In the destructive gear use outcome, random village effects account for 31.8% of the variance. Random village effects accounts for 24.3% of the variance in boat ownership. Random village effects account for 49.2% of the variance explained in the final spending model. However, random village effects account for none of the variance explained in model 3 for fishing effort.

Next we look at the same four models split into separate samples- those consisting of small and medium sized crews (less than 10 members), and large crews (greater than 10 members). In essence, this distinguishes between those that fish on a small scale near coral reefs, and those that fish in the open ocean. Except for the spending model, the variable boat type consistently explained variation in the fishing behavior models. This, along with qualitative evidence of commercial fishing in the more urban villages, leads us to believe that labor markets and social institutions are more important in explaining environmental destruction than simply migration.

Table 5: Separate Regression Analyses within Fishing Sectors

	Destructive gear (1 = yes) Logit model		**Fishing effort** Linear model		**Own a boat (1 = yes)** Logit model		**ln(Sing)** Linear model	
	Small & Medium	**Large**	**Small & Medium**	**Large**	**Small & Medium**	**Large**	**Small & Medium**	**Large**
Household migrant status								
Two migrants	-1.010	-2.144	2.102	16.795	0.349	N/A[#]	-0.097	-0.143
	(0.824)	(0.793)**	(9.755)	(6.206)**	(0.810)		(0.102)	(0.077)[ms]
One migrant	-0.139	-1.046	-1.975	3.453	0.207	-0.972	0.020	0.129
	(0.326)	(0.600)[ms]	(4.077)	(5.248)	(0.207)	(1.116)	(0.042)	(0.065)*
No migrants (reference)								
Observations	418	178	417	177	418	179	418	178
Number of groups	17	9	17	9	17	9	17	9
rho	0.067	0.795	0.064	0.000	0.104	0.703	0.381	0.000

** significant at 1%, * significant at 5%, ms = marginally significant at 10%

No two-migrants households own a large fishing boat

Note: These models include the same controls as the models from Table 4.

Table 5 shows coefficients only for migrant variables, although the models include controls for education, age, family size, spending (except in the spending model), and coral reef characteristics. In brief, we observe that migrant households that work on small and medium boats do not have different fishing behaviors or different spending patterns than non-migrant households. All reported differences from Table 4 are due to migrants working on large fishing boats. Households with two migrants are significantly less likely to use destructive gear than are households with non-migrants when they work on large fishing boats. Similarly they spend more hours fishing per week and they spend less. The impact of migrants upon their environment and their use of particular resource extractive behaviors depends on the way in which they are incorporated into the destination community. Intermarriage appears to limit destructive or short-term extractive behaviors, but even more important, migrant colonization of the industrial fishing occupations explains much of the reason for their association with a lower level of coral reef quality. Also our results show that it is not necessarily migrants per se or household behavior that is associated with degraded coral reefs or destructive resource extractive behaviors, but types of fishing – specifically industrial fishing that relies on migrant labor to fulfill their contracts.

Discussion and Conclusion

Variation in ecosystems and the social and economic environment affects the population and environment relationship tremendously (Jones 1996). The connection between demography to the environment is not linear, and can be twisted and altered in numerous ways by mediating variables. In our analysis, we cannot identify the exact mediating variables but we do see that other factors besides migrant status affect resource extraction and use. The environmental variables in our model affected the other parameters and were often significant themselves. In general, our hunch is that ecological as well as social context matters more than migrant status, yet the two are interconnected.

Our methodological approach has been one of triangulation, given the limitations of our data. We have shown a clear relationship between migration and lower environmental quality, i.e. large numbers of migrants live in villages with poor quality coral reefs. In addition, more effort and destructive gear use are associated with poor coral reef quality. Owning a boat is associated with the quantity of coral reefs, and our analysis has shown that households in villages with poor environmental quality are less likely to own a boat, possibly representing a lack of long-term investment in fishing activities. However, once we condition our analysis on whether households are situated in the large, industrial fishing sector or the subsistence and local market sector, the latter being a fishing sector that is likely to directly impact coral reef quality, we find no difference between migrant and non-migrant behavior for households operating in the local market sector. In other words, we cannot conclude that migration is directly connected with poor environmental quality via destructive fishing behavior.

We find that migrant households are more likely to be found in villages with lower environmental quality. On a village scale, there are significant differences between villages in terms of the proportion of migrants, average household size, age, destructive gear use, boat ownership and hours of effort spent fishing, to name a few. These results suggest that migrant status and the aforementioned fishing behaviors are associated with poor environmental conditions. Our village analyses set the stage for our examination at the household level, of whether migrant resource extractive behaviors are significantly different from non-migrant behaviors. The results of our multivariate analyses for the full sample show a strong relationship between migrant status and higher fishing effort, a mixed relationship between migrant households and higher spending, but no significant relationship between migrant status and boat ownership and even a negative relationship with destructive gear use. However, we find that these associations are entirely associated with the fact that migrant households tend to work on large fishing boats with large crews, in other words they are incorporated into the industrial fishing sector rather than the subsistence sector. Modes of incorporation whether it is economic sector or intermarriage are important conditioning contexts for understanding the relationship of migration to the environment.

The relationship between migration and the environment is quite difficult to discern without time-series data. Consider a scenario where initially good, healthy coral with lots of fish attracts new migrants. Migrants arrive and after some time their behaviors may lead to a degraded environment, but then they might move on to another attractive, pristine location once the fish and natural resources have been exploited, and the cycle starts over. If this is true, a coefficient of zero in our cross-sectional analysis may not necessarily indicate that there is no effect; rather, the effects may work in opposite directions and offset each other: abundant resources attract migrants, but migrants degrade resources. Another hitch in our trying to disentangle this story is that migrants may adapt their behavior as time and surroundings change, or as they begin to incorporate into society. This last explanation is the key to clarifying the story of migrants, natural resource extraction and degradation in North Sulawesi.

Is the social context that we refer to simply poverty? Although households with two migrants do spend less, on average, than non-migrant households, one-migrant households spend more. Thus, poverty does play a large role, but we still cannot disentangle causality. Generally accepted theory suggests that poor migrant households may disturb the environment due to unsustainable decisions derived from their poverty; yet the poverty of migrant households is intricately woven with the social environment, inter-marriage and urbanity, which are mediating variables between migrants and their impacts on the environment.

Marriage between migrants and non-migrants does play an important role in this analysis. We often saw very different results for two-migrant households compared to one-migrant households. These results do suggest a fundamental difference between these types of households, generally in the sense that one-migrant households are more similar to non-migrant households than are two-migrant households.

Our contribution to the literature on migration and the environment is two-fold. First, we have extended previous theory and concepts to a different ecological setting where we also would have expected to see a relationship between migration and the environment. Second, we employ theories explaining the incorporation of migrants in relation to common property resources to predict and demonstrate why we do not find as many differences as might have been expected based on earlier theories about the effect of migrants upon ecological systems in their new destinations. We propose that migrants can become embedded into destination systems of social organization through their clustering in occupations or economic sectors (which may be the more proximate explanation for environmental quality) or through their marriage into destination communities. In our study, two-migrant households are involved in large urban industries, work on larger boats, are less assimilated into local contexts, and behave differently than non-migrant and one-migrant households. They are found predominantly in urban areas, while one-migrant households are more evenly spread out among all types of villages. Thus the context and timing of migrant assimilation seems to be more important in explaining apparent associations of migration and environmental impacts than simply migrants themselves. In other words, past literature suggest that migrants act differently than non-migrants regarding resource extraction, but the underlying reason for this apparent trend are the large scale institutions that attract migrants and inflict harm on the environment. When migrants are assimilated into communities via inter-marriage or gain kinship and social ties, our results suggest that there are no behavioral differences that imply migrants degrade coastal environments.

The field of migration and the environment is new and growing, yet still nascent in both the quality of both demographic and ecological data, the complexity of empirical analyses, and the theories employed to explain empirical puzzles, paradoxes or counterintuitive findings. We suggest that studies of migration in relation to the environment need to more carefully consider the ways in which migrants are incorporated into the destination society and social relations – especially those aspects of social organization that affect the interaction of humans with their environment. We also suggest that disentangling the relationship requires temporal depth, as well as spatial and social variability. This study, although not tackling the issue of causality, is a useful first step in addressing the relationship between migrants, their behaviors and the effects on the marine environment. Further research could incorporate longitudinal data and more precise measurement of concepts, behaviors, and conditions from both society and the environment.

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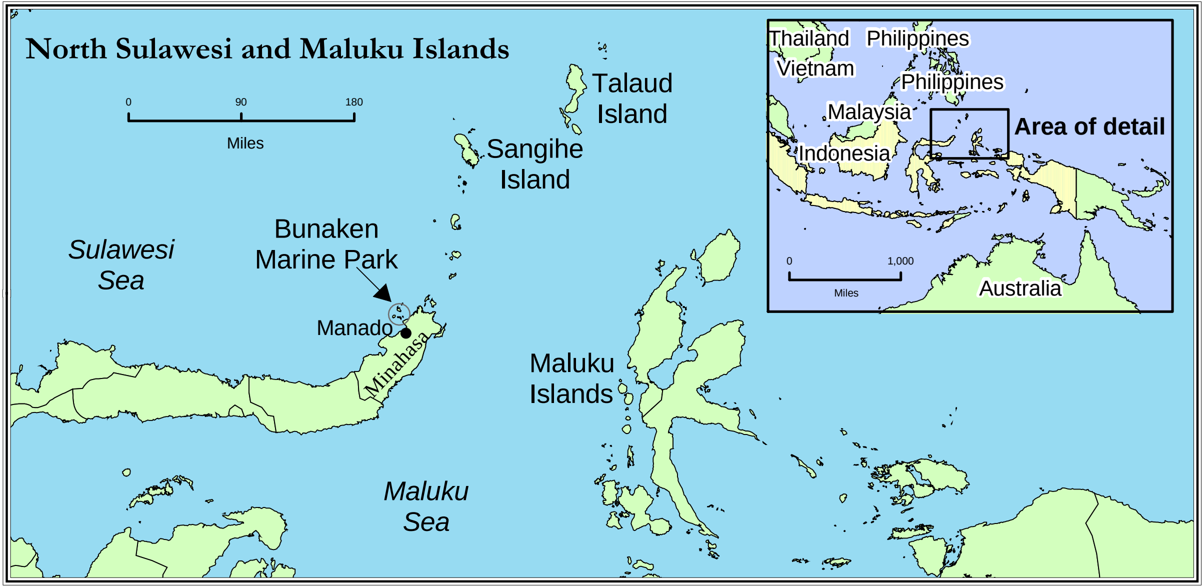
North Sulawesi and Maluku Islands
0
90
180
Miles
Talaud Island
Sangihe Island
Bunaken Marine Park
Sulawesi Sea
Manado
Minahasa
Maluku Islands
Maluku Sea
Thailand
Philippines
Vietnam
Philippines
Malaysia
Indonesia
Area of detail
0
1,000
Miles
Australia

Figure 2: Conceptual Framework Relating Migrants to Environmental Quality in North Sulawesi, Indonesia